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The revision list summarizes the locations of revisions and additions. Details should always be checked by referring to the relevant text.

8

H8/3847R Group, H8/3847S Group, H8/38347 Group, H8/38447 Group Hardware Manual

Renesas 8-Bit Single-Chip Microcomputer H8 Family/H8/300L Super Low Power Series

H8/3847R Group	H8/3842R	H8/38347 Group	H8/38342
	H8/3843R		H8/38343
	H8/3844R		H8/38344
	H8/3845R		H8/38345
	H8/3846R		H8/38346
	H8/3847R		H8/38347
	H8/3847S Group		H8/3844S
	H8/3845S	H8/38443	
	H8/3846S	H8/38444	
	H8/3847S	H8/38445	
		H8/38446	
			H8/38447

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Preface

The H8/3847R Group, H8/3847S Group, H8/38347 Group, and H8/38447 Group are a high-performance single-chip microcomputers that integrate peripheral functions necessary for system configuration with an H8/300L CPU core.

The on-chip peripheral functions include ROM, RAM, six timers, 14-bit PWM, a serial communication interface (SCI), an A/D converter, LCD controller/driver, and I/O ports, providing an ideal configuration as a microcomputer for embedding in sophisticated control systems. PROM (ZTAT™*1), Flash memory (F-ZTAT™*2) and mask ROM are available as on-chip ROM, enabling users to respond quickly and flexibly to changing application specifications and the demands of the transition from initial to full-fledged volume production.

Notes: 1. ZTAT is a trademark of Renesas Technology Corp.
2. F-ZTAT is a trademark of Renesas Technology Corp.

Intended Readership: This manual is intended for users undertaking the design of an application system using the H8/3847R Group, H8/3847S Group, H8/38347 Group, and H8/38447 Group. Readers using this manual require a basic knowledge of electrical circuits, logic circuits, and microcomputers.

Purpose: The purpose of this manual is to give users an understanding of the hardware functions and electrical characteristics of the H8/3847R Group, H8/3847S Group, H8/38347 Group, and H8/38447 Group. Details of execution instructions can be found in the H8/300L Series Programming Manual, which should be read in conjunction with the present manual.

Using this Manual:

- For an overall understanding of the H8/3847R Group, H8/3847S Group, H8/38347 Group, H8/38447 Group's functions

Follow the Table of Contents. This manual is broadly divided into sections on the CPU, system control functions, peripheral functions, and electrical characteristics.

- For a detailed understanding of CPU functions

Refer to the separate publication H8/300L Series Programming Manual.

Note on bit notation: Bits are shown in high-to-low order from left to right.

Notes: The following limitations apply when using the on-chip emulator for program development and debugging.

1. Pin P24 is reserved for use exclusively by the on-chip emulator and cannot be used for other operations.
2. Pins P25, P26, and P27 cannot be used. In order to use these pins it is necessary to install additional hardware on the user board.
3. The address area from H'E000 to H'FFFF is used by the on-chip emulator and therefore cannot be accessed by the user.
4. The address area from H'F300 to H'F6FF must not be accessed under any circumstances.
5. When the on-chip emulator is used, pin P24 functions as an I/O pin, pins P25 and P26 function as input pins, and pin P27 functions as an output pin.
6. During a break, the watchdog timer continues to operate. Therefore, an internal reset is generated if an overflow occurs during the break.

Related Material: The latest information is available at our Web Site. Please make sure that you have the most up-to-date information available.
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User's Manuals on the H8/3847:

Manual Title	Document No.
H8/3847R Group, H8/3847S Group, H8/38347 Group, H8/38447 Group Hardware Manual	This manual
H8/300L Series Programming Manual	REJ09B0214-0200

User's manuals for development tools:

Manual Title	Document No.
C/C++ Compiler, Assembler, Optimizing Linkage Editor User's Manual	REJ10B0161-0100
H8S, H8/300 Series Simulator/Debugger User's Manual	REJ10B0211-0200
High-Performance Embedded Workshop User's Manual	ADE-702-201
H8S, H8/300 Series High-Performance Embedded Workshop, High-Performance Debugging Interface User's Manual	ADE-702-231

Application Note:

Manual Title

Document No.

H8/300L Series Application Note

ADE-502-065

Main Revisions for this Edition

Item	Page	Revision (See Manual for Details)
All	—	“Under development” indication deleted from H8/38447 Group
Preface	iv	Added

Notes:

6. During a break, the watchdog timer continues to operate. Therefore, an internal reset is generated if an overflow occurs during the break.

1.3.2 Pin Functions	33	Table amended					
		Type	Symbol	Pin No.	I/O	Name and Functions	
Table 1.6 Pin Functions				FP-100B TFP-100B			
				TFP-100G	FP-100A	Input	
		System control	TEST	14	17	Input	Test pin: This pin is reserved and cannot be used. It should be connected to V _{SS} .

8.3.1 Overview	213	Description amended
		Port 2 is an 8-bit I/O port. Figure 8.2 shows its pin configuration.
		In the F-ZTAT version, the on-chip pull-up MOS for pin P2 ₄ is on during the reset period. It turns off and normal operation resumes after the reset is cleared. The pull-up MOS is controlled by hardware; it cannot be manipulated by a user program. This should be considered when making connections to external circuitry. Note that the mask ROM and ZTAT versions do not have this function.

8.3.4 Pin States	218	Table and notes amended																																								
Table 8.7 Port 2 Pin States		<table border="1"> <thead> <tr> <th>Pins</th> <th>Reset</th> <th>Sleep</th> <th>Subsleep</th> <th>Standby</th> <th>Watch</th> <th>Subactive</th> <th>Active</th> </tr> </thead> <tbody> <tr> <td>P2₇ to P2₅</td> <td>High-impedance</td> <td>Retains previous state</td> <td>Retains previous state</td> <td>High-impedance</td> <td>Retains previous state</td> <td>Functional</td> <td>Functional</td> </tr> <tr> <td>P2₄^{*1}</td> <td>Pull-up MOS on</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>P2₄^{*2} P2₃</td> <td>High-impedance</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>P2₂/SO₁ P2₁/SI₁ P2₀/SCK₁</td> <td>High-impedance</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table>	Pins	Reset	Sleep	Subsleep	Standby	Watch	Subactive	Active	P2 ₇ to P2 ₅	High-impedance	Retains previous state	Retains previous state	High-impedance	Retains previous state	Functional	Functional	P2 ₄ ^{*1}	Pull-up MOS on							P2 ₄ ^{*2} P2 ₃	High-impedance							P2 ₂ /SO ₁ P2 ₁ /SI ₁ P2 ₀ /SCK ₁	High-impedance						
	Pins	Reset	Sleep	Subsleep	Standby	Watch	Subactive	Active																																		
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P2 ₂ /SO ₁ P2 ₁ /SI ₁ P2 ₀ /SCK ₁	High-impedance																																									
		Notes: 1. Applies to the F-ZTAT version of the H8/38347 Group and H8/38447 Group.																																								
		2. Applies to H8/3847R Group and H8/3847S Group. Also applies to the mask ROM version of the H8/38347 Group and H8/38447 Group.																																								

Item	Page	Revision (See Manual for Details)						
8.15.1 The Management of the Un-Use Terminal	256	Description amended <ul style="list-style-type: none"> If an unused pin is an output pin, handle it in one of the following ways: <ul style="list-style-type: none"> Set the output of the unused pin to high and pull it up to V_{CC} with an external resistor of approximately 100 kΩ. Set the output of the unused pin to low and pull it down to V_{SS} with an external resistor of approximately 100 kΩ. 						
15.8.2 DC Characteristics	519, 525	Table and notes amended						
Table 15.26 DC Characteristics		<table border="1"> <thead> <tr> <th>Item</th> <th>Symbol</th> <th>Applicable Pins</th> </tr> </thead> <tbody> <tr> <td>Pull-up MOS current</td> <td>-I_p</td> <td>P1₀ to P1₇, P2₄^{*6}, P3₀ to P3₇, P5₀ to P5₇, P6₀ to P6₇</td> </tr> </tbody> </table> <p>Notes:</p> <ol style="list-style-type: none"> Except current which flows to the pull-up MOS or output buffer Voltage maintained in standby mode Applies to the F-ZTAT version. The specified values for this pin in reference values. 	Item	Symbol	Applicable Pins	Pull-up MOS current	-I _p	P1 ₀ to P1 ₇ , P2 ₄ ^{*6} , P3 ₀ to P3 ₇ , P5 ₀ to P5 ₇ , P6 ₀ to P6 ₇
Item	Symbol	Applicable Pins						
Pull-up MOS current	-I _p	P1 ₀ to P1 ₇ , P2 ₄ ^{*6} , P3 ₀ to P3 ₇ , P5 ₀ to P5 ₇ , P6 ₀ to P6 ₇						
C.2 Block Diagrams of Port 2	634	Figure title amended						
Figure C.2 (a-1) Port 2 Block Diagram (Pins P2 ₇ to P2 ₃ , Not Including P2 ₄ in the F-ZTAT Version of the H8/38347 Group and H8/38447 Group)								
Figure C.2 (a-2) Port 2 Block Diagram (Pin P2 ₄ in the F-ZTAT Version of the H8/38347 Group and H8/38447 Group)	635	Newly added						

Item	Page	Revision (See Manual for Details)				
Appendix D Port States in the Different Processing States	660	Table and notes amended <table border="1"> <thead> <tr> <th data-bbox="434 161 479 185">Port</th> <th data-bbox="549 161 611 185">Reset</th> </tr> </thead> <tbody> <tr> <td data-bbox="434 197 539 221">P2₇ to P2₀</td> <td data-bbox="549 197 679 248">High-impedance^{*3}</td> </tr> </tbody> </table>	Port	Reset	P2 ₇ to P2 ₀	High-impedance ^{*3}
Port	Reset					
P2 ₇ to P2 ₀	High-impedance ^{*3}					
Table D.1 Port States Overview		<p>Notes: 1. High level output when MOS pull-up is in on state.</p> <p>2. Reset output from P3₂ pin only (H8/3847R Group and H8/3847S Group).</p> <p>3. On-chip pull-up MOS turns on for pin P24 only (F-ZTAT Version of the H8/38347 Group and H8/38447 Group).</p>				

Contents

Section 1	Overview	1
1.1	Overview	1
1.2	Internal Block Diagram	7
1.3	Pin Arrangement and Functions	9
1.3.1	Pin Arrangement	9
1.3.2	Pin Functions	32
Section 2	CPU	39
2.1	Overview	39
2.1.1	Features	39
2.1.2	Address Space	40
2.1.3	Register Configuration	41
2.2	Register Descriptions	42
2.2.1	General Registers	42
2.2.2	Control Registers	42
2.2.3	Initial Register Values	44
2.3	Data Formats	44
2.3.1	Data Formats in General Registers	45
2.3.2	Memory Data Formats	46
2.4	Addressing Modes	47
2.4.1	Addressing Modes	47
2.4.2	Effective Address Calculation	49
2.5	Instruction Set	53
2.5.1	Data Transfer Instructions	55
2.5.2	Arithmetic Operations	57
2.5.3	Logic Operations	58
2.5.4	Shift Operations	59
2.5.5	Bit Manipulations	61
2.5.6	Branching Instructions	65
2.5.7	System Control Instructions	67
2.5.8	Block Data Transfer Instruction	68
2.6	Basic Operational Timing	70
2.6.1	Access to On-Chip Memory (RAM, ROM)	70
2.6.2	Access to On-Chip Peripheral Modules	71
2.7	CPU States	73
2.7.1	Overview	73
2.7.2	Program Execution State	75

2.7.3	Program Halt State	75
2.7.4	Exception-Handling State	75
2.8	Memory Map	76
2.8.1	Memory Map	76
2.9	Application Notes	83
2.9.1	Notes on Data Access	83
2.9.2	Notes on Bit Manipulation	85
2.9.3	Notes on Use of the EEPMOV Instruction	92
Section 3 Exception Handling		93
3.1	Overview	93
3.2	Reset	93
3.2.1	Overview	93
3.2.2	Reset Sequence	93
3.2.3	Interrupt Immediately after Reset	94
3.3	Interrupts	95
3.3.1	Overview	95
3.3.2	Interrupt Control Registers	97
3.3.3	External Interrupts	107
3.3.4	Internal Interrupts	108
3.3.5	Interrupt Operations	108
3.3.6	Interrupt Response Time	113
3.4	Application Notes	114
3.4.1	Notes on Stack Area Use	114
3.4.2	Notes on Rewriting Port Mode Registers	115
3.4.3	Method for Clearing Interrupt Request Flags	118
Section 4 Clock Pulse Generators		119
4.1	Overview	119
4.1.1	Block Diagram	119
4.1.2	System Clock and Subclock	119
4.2	System Clock Generator	120
4.3	Subclock Generator	122
4.4	Prescalers	125
4.5	Note on Oscillators	126
4.5.1	Definition of Oscillation Stabilization Wait Time	127
4.5.2	Notes on Use of Crystal Oscillator Element (Excluding Ceramic Oscillator Element)	129

Section 5	Power-Down Modes	131
5.1	Overview.....	131
5.1.1	System Control Registers.....	134
5.2	Sleep Mode	138
5.2.1	Transition to Sleep Mode.....	138
5.2.2	Clearing Sleep Mode.....	139
5.2.3	Clock Frequency in Sleep (Medium-Speed) Mode.....	139
5.3	Standby Mode	140
5.3.1	Transition to Standby Mode.....	140
5.3.2	Clearing Standby Mode	140
5.3.3	Oscillator Settling Time after Standby Mode is Cleared	140
5.3.4	Standby Mode Transition and Pin States	141
5.3.5	Notes on External Input Signal Changes before/after Standby Mode.....	142
5.4	Watch Mode.....	144
5.4.1	Transition to Watch Mode	144
5.4.2	Clearing Watch Mode	144
5.4.3	Oscillator Settling Time after Watch Mode is Cleared.....	144
5.4.4	Notes on External Input Signal Changes before/after Watch Mode	144
5.5	Subsleep Mode.....	145
5.5.1	Transition to Subsleep Mode	145
5.5.2	Clearing Subsleep Mode.....	145
5.6	Subactive Mode	146
5.6.1	Transition to Subactive Mode.....	146
5.6.2	Clearing Subactive Mode.....	146
5.6.3	Operating Frequency in Subactive Mode.....	146
5.7	Active (Medium-Speed) Mode	147
5.7.1	Transition to Active (Medium-Speed) Mode.....	147
5.7.2	Clearing Active (Medium-Speed) Mode.....	147
5.7.3	Operating Frequency in Active (Medium-Speed) Mode.....	147
5.8	Direct Transfer	148
5.8.1	Overview of Direct Transfer	148
5.8.2	Direct Transition Times	149
5.8.3	Notes on External Input Signal Changes before/after Direct Transition.....	151
5.9	Module Standby Mode.....	152
5.9.1	Setting Module Standby Mode	152
5.9.2	Clearing Module Standby Mode	152
5.9.3	Usage Note.....	154
Section 6	ROM.....	155
6.1	Overview.....	155

6.1.1	Block Diagram.....	156
6.2	PROM Mode (H8/3847R).....	157
6.2.1	Setting to PROM Mode.....	157
6.2.2	Socket Adapter Pin Arrangement and Memory Map.....	157
6.3	Programming (H8/3847R).....	160
6.3.1	Writing and Verifying.....	160
6.3.2	Programming Precautions.....	165
6.4	Reliability of Programmed Data.....	166
6.5	Flash Memory Overview.....	167
6.5.1	Features.....	167
6.5.2	Block Diagram.....	168
6.5.3	Block Configuration.....	168
6.5.4	Register Configuration.....	170
6.6	Descriptions of Registers of the Flash Memory.....	171
6.6.1	Flash Memory Control Register 1 (FLMCR1).....	171
6.6.2	Flash Memory Control Register 2 (FLMCR2).....	174
6.6.3	Erase Block Register (EBR).....	174
6.6.4	Flash Memory Power Control Register (FLPWCR).....	175
6.6.5	Flash Memory Enable Register (FENR).....	176
6.7	On-Board Programming Modes.....	177
6.7.1	Boot Mode.....	178
6.7.2	Programming/Erasing in User Program Mode.....	180
6.8	Flash Memory Programming/Erasing.....	180
6.8.1	Program/Program-Verify.....	181
6.8.2	Erase/Erase-Verify.....	184
6.8.3	Interrupt Handling when Programming/Erasing Flash Memory.....	184
6.9	Program/Erase Protection.....	186
6.9.1	Hardware Protection.....	186
6.9.2	Software Protection.....	186
6.9.3	Error Protection.....	186
6.10	Programmer Mode.....	187
6.10.1	Socket Adapter.....	187
6.10.2	Programmer Mode Commands.....	187
6.10.3	Memory Read Mode.....	190
6.10.4	Auto-Program Mode.....	193
6.10.5	Auto-Erase Mode.....	195
6.10.6	Status Read Mode.....	196
6.10.7	Status Polling.....	198
6.10.8	Programmer Mode Transition Time.....	199
6.10.9	Notes on Memory Programming.....	199

6.11	Power-Down States for Flash Memory.....	200
Section 7 RAM.....		201
7.1	Overview.....	201
7.1.1	Block Diagram.....	201
Section 8 I/O Ports.....		203
8.1	Overview.....	203
8.2	Port 1.....	205
8.2.1	Overview.....	205
8.2.2	Register Configuration and Description.....	205
8.2.3	Pin Functions.....	210
8.2.4	Pin States.....	211
8.2.5	MOS Input Pull-Up.....	212
8.3	Port 2.....	213
8.3.1	Overview.....	213
8.3.2	Register Configuration and Description.....	213
8.3.3	Pin Function.....	217
8.3.4	Pin States.....	218
8.4	Port 3.....	219
8.4.1	Overview.....	219
8.4.2	Register Configuration and Description.....	219
8.4.3	Pin Functions.....	223
8.4.4	Pin States.....	225
8.4.5	MOS Input Pull-Up.....	225
8.5	Port 4.....	226
8.5.1	Overview.....	226
8.5.2	Register Configuration and Description.....	226
8.5.3	Pin Functions.....	228
8.5.4	Pin States.....	229
8.6	Port 5.....	230
8.6.1	Overview.....	230
8.6.2	Register Configuration and Description.....	230
8.6.3	Pin Functions.....	232
8.6.4	Pin States.....	233
8.6.5	MOS Input Pull-Up.....	233
8.7	Port 6.....	234
8.7.1	Overview.....	234
8.7.2	Register Configuration and Description.....	234
8.7.3	Pin Functions.....	236

8.7.4	Pin States.....	236
8.7.5	MOS Input Pull-Up.....	237
8.8	Port 7.....	238
8.8.1	Overview.....	238
8.8.2	Register Configuration and Description.....	238
8.8.3	Pin Functions.....	240
8.8.4	Pin States.....	240
8.9	Port 8.....	241
8.9.1	Overview.....	241
8.9.2	Register Configuration and Description.....	241
8.9.3	Pin Functions.....	243
8.9.4	Pin States.....	243
8.10	Port 9.....	244
8.10.1	Overview.....	244
8.10.2	Register Configuration and Description.....	244
8.10.3	Pin Functions.....	246
8.10.4	Pin States.....	247
8.11	Port A.....	248
8.11.1	Overview.....	248
8.11.2	Register Configuration and Description.....	248
8.11.3	Pin Functions.....	250
8.11.4	Pin States.....	250
8.12	Port B.....	251
8.12.1	Overview.....	251
8.12.2	Register Configuration and Description.....	251
8.13	Port C.....	252
8.13.1	Overview.....	252
8.13.2	Register Configuration and Description.....	252
8.14	Input/Output Data Inversion Function.....	253
8.14.1	Overview.....	253
8.14.2	Register Configuration and Descriptions.....	253
8.14.3	Note on Modification of Serial Port Control Register.....	256
8.15	Application Note.....	256
8.15.1	The Management of the Un-Use Terminal.....	256
Section 9 Timers.....		257
9.1	Overview.....	257
9.2	Timer A.....	258
9.2.1	Overview.....	258
9.2.2	Register Descriptions.....	260

9.2.3	Timer Operation.....	264
9.2.4	Timer A Operation States	265
9.2.5	Application Note	265
9.3	Timer C	266
9.3.1	Overview.....	266
9.3.2	Register Descriptions	268
9.3.3	Timer Operation.....	271
9.3.4	Timer C Operation States.....	273
9.3.5	Usage Note.....	274
9.4	Timer F.....	275
9.4.1	Overview.....	275
9.4.2	Register Descriptions	278
9.4.3	CPU Interface.....	285
9.4.4	Operation	288
9.4.5	Application Notes	291
9.5	Timer G.....	294
9.5.1	Overview.....	294
9.5.2	Register Descriptions	296
9.5.3	Noise Canceler	301
9.5.4	Operation	302
9.5.5	Application Notes	306
9.5.6	Timer G Application Example.....	311
9.6	Watchdog Timer	312
9.6.1	Overview.....	312
9.6.2	Register Descriptions	313
9.6.3	Timer Operation.....	317
9.6.4	Watchdog Timer Operation States	319
9.7	Asynchronous Event Counter (AEC).....	320
9.7.1	Overview.....	320
9.7.2	Register Descriptions	322
9.7.3	Operation	327
9.7.4	Asynchronous Event Counter Operation Modes.....	329
9.7.5	Application Notes	329
Section 10 Serial Communication Interface		331
10.1	Overview.....	331
10.2	SCI1	332
10.2.1	Overview.....	332
10.2.2	Register Descriptions	334
10.2.3	Operation	340

10.2.4	Operation in SSB Mode	343
10.2.5	Interrupt Source	346
10.2.6	Application Notes	346
10.3	SCI3	347
10.3.1	Overview	347
10.3.2	Register Descriptions	351
10.3.3	Operation	374
10.3.4	Interrupts	403
10.3.5	Application Notes	404
Section 11 14-Bit PWM		409
11.1	Overview	409
11.1.1	Features	409
11.1.2	Block Diagram	410
11.1.3	Pin Configuration	410
11.1.4	Register Configuration	411
11.2	Register Descriptions	411
11.2.1	PWM Control Register (PWCR)	411
11.2.2	PWM Data Registers U and L (PWDRU, PWDRL)	413
11.2.3	Clock Stop Register 2 (CKSTPR2)	414
11.3	Operation	415
11.3.1	Operation	415
11.3.2	PWM Operation Modes	416
Section 12 A/D Converter		417
12.1	Overview	417
12.1.1	Features	417
12.1.2	Block Diagram	418
12.1.3	Pin Configuration	419
12.1.4	Register Configuration	419
12.2	Register Descriptions	420
12.2.1	A/D Result Registers (ADRRH, ADRL)	420
12.2.2	A/D Mode Register (AMR)	420
12.2.3	A/D Start Register (ADSR)	422
12.2.4	Clock Stop Register 1 (CKSTPR1)	423
12.3	Operation	424
12.3.1	A/D Conversion Operation	424
12.3.2	Start of A/D Conversion by External Trigger Input	424
12.3.3	A/D Converter Operation Modes	425
12.4	Interrupts	425

12.5	Typical Use	425
12.6	Application Notes	428
12.6.1	Application Notes	428
12.6.2	Permissible Signal Source Impedance	429
12.6.3	Influences on Absolute Precision.....	429
Section 13	LCD Controller/Driver	431
13.1	Overview.....	431
13.1.1	Features.....	431
13.1.2	Block Diagram.....	432
13.1.3	Pin Configuration.....	433
13.1.4	Register Configuration.....	433
13.2	Register Descriptions	434
13.2.1	LCD Port Control Register (LPCR).....	434
13.2.2	LCD Control Register (LCR).....	436
13.2.3	LCD Control Register 2 (LCR2).....	438
13.2.4	Clock Stop Register 2 (CKSTPR2).....	440
13.3	Operation.....	441
13.3.1	Settings up to LCD Display	441
13.3.2	Relationship between LCD RAM and Display	444
13.3.3	Luminance Adjustment Function (V_0 Pin).....	452
13.3.4	Low-Power-Consumption LCD Drive System	453
13.3.5	Operation in Power-Down Modes	457
13.3.6	Boosting the LCD Drive Power Supply.....	458
13.3.7	Connection to HD66100	459
Section 14	Power Supply Circuit.....	461
14.1	Overview.....	461
14.2	When Using Internal Power Supply Step-Down Circuit.....	461
14.3	When Not Using Internal Power Supply Step-Down Circuit.....	462
14.4	H8/3847S Group	462
14.5	Notes on Switching from the H8/3847R to the H8/38347 or H8/38447	462
Section 15	Electrical Characteristics.....	463
15.1	H8/3847R Group Absolute Maximum Ratings (Regular Specifications).....	463
15.2	H8/3847R Electrical Characteristics (Regular Specifications)	464
15.2.1	Power Supply Voltage and Operating Range.....	464
15.2.2	DC Characteristics	467
15.2.3	AC Characteristics	472
15.2.4	A/D Converter Characteristics.....	477

15.2.5	LCD Characteristics	478
15.3	H8/3847R Group Absolute Maximum Ratings (Wide-range Specification)	480
15.4	H8/3847R Electrical Characteristics (Wide-range Specification)	481
15.4.1	Power Supply Voltage and Operating Range	481
15.4.2	DC Characteristics	484
15.4.3	AC Characteristics	489
15.4.4	A/D Converter Characteristics	494
15.4.5	LCD Characteristics	495
15.5	H8/3847S Group Absolute Maximum Ratings	497
15.6	H8/3847S Group Electrical Characteristics	498
15.6.1	Power Supply Voltage and Operating Range	498
15.6.2	DC Characteristics	500
15.6.3	AC Characteristics	505
15.6.4	A/D Converter Characteristics	510
15.6.5	LCD Characteristics	511
15.7	Absolute Maximum Ratings of H8/38347 Group and H8/38447 Group	513
15.8	Electrical Characteristics of H8/38347 Group and H8/38447 Group	514
15.8.1	Power Supply Voltage and Operating Ranges	514
15.8.2	DC Characteristics	517
15.8.3	AC Characteristics	526
15.8.4	A/D Converter Characteristics	530
15.8.5	LCD Characteristics	531
15.8.6	Flash Memory Characteristics	532
15.9	Operation Timing	535
15.10	Output Load Circuit	539
15.11	Resonator	540
15.12	Usage Note	541
Appendix A CPU Instruction Set		543
A.1	Instructions	543
A.2	Operation Code Map	551
A.3	Number of Execution States	553
Appendix B Internal I/O Registers		560
B.1	Addresses	560
B.2	Functions	564
Appendix C I/O Port Block Diagrams		630
C.1	Block Diagrams of Port 1	630
C.2	Block Diagrams of Port 2	634

C.3	Block Diagrams of Port 3.....	639
C.4	Block Diagrams of Port 4.....	648
C.5	Block Diagram of Port 5.....	652
C.6	Block Diagram of Port 6.....	653
C.7	Block Diagram of Port 7.....	654
C.8	Block Diagrams of Port 8.....	655
C.9	Block Diagram of Port 9.....	656
C.10	Block Diagram of Port A.....	657
C.11	Block Diagram of Port B.....	658
C.12	Block Diagram of Port C.....	659
Appendix D	Port States in the Different Processing States.....	660
Appendix E	List of Product Codes.....	661
Appendix F	Package Dimensions.....	668
Appendix G	Specifications of Chip Form.....	672
Appendix H	Form of Bonding Pads.....	674
Appendix I	Specifications of Chip Tray.....	677

Figures

Section 1 Overview

Figure 1.1 (1)	Block Diagram (H8/3847R Group and H8/3847S Group)	7
Figure 1.1 (2)	Block Diagram (H8/38347 Group and H8/38447 Group)	8
Figure 1.2	Pin Arrangement (FP-100B, TFP-100B and TFP-100G: Top View)	10
Figure 1.3	Pin Arrangement (FP-100A: Top View)	11
Figure 1.4	Bonding Pad Location Diagram of H8/3847R Group (Mask ROM Version) (Top View)	12
Figure 1.5	Bonding Pad Location Diagram of H8/3847S Group (Mask ROM Version) (Top View)	17
Figure 1.6	Bonding Pad Location Diagram of HCD64F38347 and HCD64F38447 (Top View)	22
Figure 1.7	Bonding Pad Location Diagram of H8/38347 Group (Mask ROM Version) and H8/38447 Group (Mask ROM Version) (Top View).....	27

Section 2 CPU

Figure 2.1	CPU Registers	41
Figure 2.2	Stack Pointer.....	42
Figure 2.3	Register Data Formats	45
Figure 2.4	Memory Data Formats	46
Figure 2.5	Data Transfer Instruction Codes	56
Figure 2.6	Arithmetic, Logic, and Shift Instruction Codes	60
Figure 2.7	Bit Manipulation Instruction Codes.....	63
Figure 2.8	Branching Instruction Codes	66
Figure 2.9	System Control Instruction Codes	68
Figure 2.10	Block Data Transfer Instruction Code	69
Figure 2.11	On-Chip Memory Access Cycle.....	70
Figure 2.12	On-Chip Peripheral Module Access Cycle (2-State Access).....	71
Figure 2.13	On-Chip Peripheral Module Access Cycle (3-State Access).....	72
Figure 2.14	CPU Operation States	74
Figure 2.15	State Transitions	75
Figure 2.16 (1)	H8/3842R, H8/38342 and H8/38442 Memory Map	77
Figure 2.16 (2)	H8/3843R, H8/38343 and H8/38443 Memory Map	78
Figure 2.16 (3)	H8/3844R, H8/3844S, H8/38344 and H8/38444 Memory Map	79
Figure 2.16 (4)	H8/3845R, H8/3845S, H8/38345 and H8/38445 Memory Map	80
Figure 2.16 (5)	H8/3846R, H8/3846S, H8/38346 and H8/38446 Memory Map	81
Figure 2.16 (6)	H8/3847R, H8/3847S, H8/38347 and H8/38447 Memory Map	82

Figure 2.17	Data Size and Number of States for Access to and from On-Chip Peripheral Modules	84
Figure 2.18	Timer Configuration Example	86

Section 3 Exception Handling

Figure 3.1	Reset Sequence	94
Figure 3.2	Block Diagram of Interrupt Controller	108
Figure 3.3	Flow Up to Interrupt Acceptance	110
Figure 3.4	Stack State after Completion of Interrupt Exception Handling	111
Figure 3.5	Interrupt Sequence	112
Figure 3.6	Operation when Odd Address is Set in SP	114
Figure 3.7	Port Mode Register Setting and Interrupt Request Flag Clearing Procedure	117

Section 4 Clock Pulse Generators

Figure 4.1	Block Diagram of Clock Pulse Generators	119
Figure 4.2	Typical Connection to Crystal Oscillator	120
Figure 4.3	Typical Connection to Ceramic Oscillator	120
Figure 4.4	Board Design of Oscillator Circuit	121
Figure 4.5	External Clock Input (Example)	121
Figure 4.6	Typical Connection to 32.768 kHz/38.4 kHz Crystal Oscillator (Subclock)	122
Figure 4.7	Equivalent Circuit of 32.768 kHz/38.4 kHz Crystal Oscillator	122
Figure 4.8	Pin Connection when not Using Subclock	123
Figure 4.9 (a)	Pin Connection when Inputting External Clock (H8/38347R Group and H8/3847S Group)	123
Figure 4.9 (b)	Pin Connection when Inputting External Clock (H8/38347 Group and H8/38447 Group)	124
Figure 4.10	Example of Crystal and Ceramic Oscillator Element Arrangement	126
Figure 4.11	Negative Resistance Measurement and Circuit Modification Suggestions	127
Figure 4.12	Oscillation Stabilization Wait Time	128

Section 5 Power-Down Modes

Figure 5.1	Mode Transition Diagram	132
Figure 5.2	Standby Mode Transition and Pin States	141
Figure 5.3	External Input Signal Capture when Signal Changes before/after Standby Mode or Watch Mode	143

Section 6 ROM

Figure 6.1	ROM Block Diagram (H8/3844R, H8/3844S, H8/38344 and H8/38444)	156
Figure 6.2	Socket Adapter Pin Correspondence (with HN27C101)	158
Figure 6.3	H8/3847R Memory Map in PROM Mode	159

Figure 6.4	High-Speed, High-Reliability Programming Flow Chart	161
Figure 6.5	PROM Write/Verify Timing.....	164
Figure 6.6	Recommended Screening Procedure	166
Figure 6.7	Block Diagram of Flash Memory	168
Figure 6.8	Flash Memory Block Configuration.....	169
Figure 6.9	Programming/Erasing Flowchart Example in User Program Mode	180
Figure 6.10	Program/Program-Verify Flowchart.....	182
Figure 6.11	Erase/Erase-Verify Flowchart	185
Figure 6.12	Socket Adapter Pin Correspondence Diagram	189
Figure 6.13	Timing Waveforms for Memory Read after Memory Write	191
Figure 6.14	Timing Waveforms in Transition from Memory Read Mode to Another Mode.....	192
Figure 6.15	\overline{CE} and \overline{OE} Enable State Read Timing Waveforms.....	192
Figure 6.16	\overline{CE} and \overline{OE} Clock System Read Timing Waveforms	193
Figure 6.17	Auto-Program Mode Timing Waveforms.....	194
Figure 6.18	Auto-Erase Mode Timing Waveforms	196
Figure 6.19	Status Read Mode Timing Waveforms.....	197
Figure 6.20	Oscillation Stabilization Time, Boot Program Transfer Time, and Power-Down Sequence.....	199

Section 7 RAM

Figure 7.1	RAM Block Diagram (H8/3844R, H8/3844S, H8/38344 and H8/38444).....	201
------------	--	-----

Section 8 I/O Ports

Figure 8.1	Port 1 Pin Configuration.....	205
Figure 8.2	Port 2 Pin Configuration.....	213
Figure 8.3	Port 3 Pin Configuration.....	219
Figure 8.4	Port 4 Pin Configuration.....	226
Figure 8.5	Port 5 Pin Configuration.....	230
Figure 8.6	Port 6 Pin Configuration.....	234
Figure 8.7	Port 7 Pin Configuration.....	238
Figure 8.8	Port 8 Pin Configuration.....	241
Figure 8.9	Port 9 Pin Configuration.....	244
Figure 8.10	Port A Pin Configuration	248
Figure 8.11	Port B Pin Configuration	251
Figure 8.12	Port C Pin Configuration	252
Figure 8.13	Input/Output Data Inversion Function.....	253

Section 9 Timers

Figure 9.1	Block Diagram of Timer A.....	259
------------	-------------------------------	-----

Figure 9.2	Block Diagram of Timer C	267
Figure 9.3	Block Diagram of Timer F	276
Figure 9.4	Write Access to TCR (CPU → TCF)	286
Figure 9.5	Read Access to TCF (TCF → CPU).....	287
Figure 9.6	TMOFH/TMOFL Output Timing.....	289
Figure 9.7	Clear Interrupt Request Flag when Interrupt Factor Generation Signal is Valid	293
Figure 9.8	Block Diagram of Timer G.....	295
Figure 9.9	Noise Canceler Block Diagram	301
Figure 9.10	Noise Canceler Timing (Example).....	302
Figure 9.11	Input Capture Input Timing (without Noise Cancellation Function).....	304
Figure 9.12	Input Capture Input Timing (with Noise Cancellation Function).....	304
Figure 9.13	Timing of Input Capture by Input Capture Input.....	305
Figure 9.14	TCG Clear Timing.....	305
Figure 9.15	Port Mode Register Manipulation and Interrupt Enable Flag Clearing Procedure.....	310
Figure 9.16	Timer G Application Example.....	311
Figure 9.17	Block Diagram of Watchdog Timer	312
Figure 9.18	Typical Watchdog Timer Operations (Example).....	318
Figure 9.19	Block Diagram of Asynchronous Event Counter	321
Figure 9.20	Example of Software Processing when Using ECH and ECL as 16-Bit Event Counter.....	327
Figure 9.21	Example of Software Processing when Using ECH and ECL as 8-Bit Event Counters.....	328

Section 10 Serial Communication Interface

Figure 10.1	SCI1 Block Diagram	333
Figure 10.2	Transfer Format	340
Figure 10.3	Example of SSB Connections.....	343
Figure 10.4	Transfer Format (When SNC1 = 0, SNC0 = 1, MRKON = 1)	344
Figure 10.5	HOLD TAIL and LATCH TAIL Output Waveforms	344
Figure 10.6	SCI3 Block Diagram	349
Figure 10.7 (a)	RDRF Setting and RXI Interrupt.....	378
Figure 10.7 (b)	TDRE Setting and TXI Interrupt	378
Figure 10.7 (c)	TEND Setting and TEI Interrupt	378
Figure 10.8	Data Format in Asynchronous Communication	379
Figure 10.9	Phase Relationship between Output Clock and Transfer Data (Asynchronous Mode) (8-bit data, parity, 2 stop bits).....	381
Figure 10.10	Example of SCI3 Initialization Flowchart.....	382
Figure 10.11	Example of Data Transmission Flowchart (Asynchronous Mode).....	383

Figure 10.12	Example of Operation when Transmitting in Asynchronous Mode (8-bit data, parity, 1 stop bit).....	384
Figure 10.13	Example of Data Reception Flowchart (Asynchronous Mode).....	385
Figure 10.14	Example of Operation when Receiving in Asynchronous Mode (8-bit data, parity, 1 stop bit).....	388
Figure 10.15	Data Format in Synchronous Communication.....	389
Figure 10.16	Example of Data Transmission Flowchart (Synchronous Mode).....	391
Figure 10.17	Example of Operation when Transmitting in Synchronous Mode.....	392
Figure 10.18	Example of Data Reception Flowchart (Synchronous Mode).....	393
Figure 10.19	Example of Operation when Receiving in Synchronous Mode.....	394
Figure 10.20	Example of Simultaneous Data Transmission/Reception Flowchart (Synchronous Mode).....	395
Figure 10.21	Example of Inter-Processor Communication Using Multiprocessor Format (Sending data H'AA to receiver A).....	397
Figure 10.22	Example of Multiprocessor Data Transmission Flowchart.....	398
Figure 10.23	Example of Operation when Transmitting Using Multiprocessor Format (8-bit data, multiprocessor bit, 1 stop bit).....	399
Figure 10.24	Example of Multiprocessor Data Reception Flowchart.....	400
Figure 10.25	Example of Operation when Receiving Using Multiprocessor Format (8-bit data, multiprocessor bit, 1 stop bit).....	402
Figure 10.26	Receive Data Sampling Timing in Asynchronous Mode.....	406
Figure 10.27	Relation between RDR Read Timing and Data.....	407

Section 11 14-Bit PWM

Figure 11.1	Block Diagram of the 14 bit PWM.....	410
Figure 11.2	PWM Output Waveform.....	416

Section 12 A/D Converter

Figure 12.1	Block Diagram of the A/D Converter.....	418
Figure 12.2	External Trigger Input Timing.....	424
Figure 12.3	Typical A/D Converter Operation Timing.....	426
Figure 12.4	Flow Chart of Procedure for Using A/D Converter (Polling by Software).....	427
Figure 12.5	Flow Chart of Procedure for Using A/D Converter (Interrupts Used).....	428
Figure 12.6	Analog Input Circuit Example.....	429

Section 13 LCD Controller/Driver

Figure 13.1	Block Diagram of LCD Controller/Driver.....	432
Figure 13.2	Example of A Waveform with 1/2 Duty and 1/2 Bias.....	439
Figure 13.3	Handling of LCD Drive Power Supply when Using 1/2 Duty.....	441
Figure 13.4	Examples of LCD Power Supply Pin Connections.....	442

Figure 13.5	LCD RAM Map with Segments Not Externally Expanded (1/4 Duty)	444
Figure 13.6	LCD RAM Map with Segments Not Externally Expanded (1/3 Duty)	445
Figure 13.7	LCD RAM Map with Segments Not Externally Expanded (1/2 Duty)	446
Figure 13.8	LCD RAM Map with Segments Not Externally Expanded (Static Mode)	447
Figure 13.9	LCD RAM Map with Segment Externally Expanded (SGX = "1", SGS3 to SGS0 = "0000" 1/4 duty)	448
Figure 13.10	LCD RAM Map with Segment Externally Expanded (SGX = "1", SGS3 to SGS0 = "0000" 1/3 duty)	449
Figure 13.11	LCD RAM Map with Segment Externally Expanded (SGX = "1", SGS3 to SGS0 = "0000" 1/2 duty)	450
Figure 13.12	LCD RAM Map with Segment Externally Expanded (SGX = "1", SGS3 to SGS0 = "0000" static)	451
Figure 13.13	LCD Drive Power Supply Unit	452
Figure 13.14	Example of Low-Power-Consumption LCD Drive Operation	454
Figure 13.15	Output Waveforms for Each Duty Cycle (A Waveform)	455
Figure 13.16	Output Waveforms for Each Duty Cycle (B Waveform)	456
Figure 13.17	Connection of External Split-Resistance	458
Figure 13.18	Connection to HD66100	460

Section 14 Power Supply Circuit

Figure 14.1	Power Supply Connection when Internal Step-Down Circuit is Used	461
Figure 14.2	Power Supply Connection when Internal Step-Down Circuit is Not Used	462

Section 15 Electrical Characteristics

Figure 15.1	Clock Input Timing	535
Figure 15.2	$\overline{\text{RES}}$ Low Width	535
Figure 15.3	Input Timing	535
Figure 15.4	UD Pin Minimum Modulation Width Timing	536
Figure 15.5	SCI1 Input/Output Timing	536
Figure 15.6	SCK3 Input Clock Timing	537
Figure 15.7	SCI3 Synchronous Mode Input/Output Timing	537
Figure 15.8	Segment Expansion Signal Timing	538
Figure 15.9	Output Load Condition	539
Figure 15.10	Resonator Equivalent Circuit	540
Figure 15.11	Recommended Resonators	540

Appendix C I/O Port Block Diagrams

Figure C.1 (a)	Port 1 Block Diagram (Pins P1 ₇ to P1 ₄)	630
Figure C.1 (b)	Port 1 Block Diagram (Pin P1 ₃)	631
Figure C.1 (c)	Port 1 Block Diagram (Pin P1 ₂ , P1 ₁)	632

Figure C.1 (d) Port 1 Block Diagram (Pin P1 ₀).....	633
Figure C.2 (a-1) Port 2 Block Diagram (Pins P2 ₇ to P2 ₃ , Not Including P2 ₄ in the F-ZTAT Version of the H8/38347 Group and H8/38447 Group).....	634
Figure C.2 (a-2) Port 2 Block Diagram (Pin P2 ₄ in the F-ZTAT Version of the H8/38347 Group and H8/38447 Group).....	635
Figure C.2 (b) Port 2 Block Diagram (Pin P2 ₂).....	636
Figure C.2 (c) Port 2 Block Diagram (Pin P2 ₁).....	637
Figure C.2 (d) Port 2 Block Diagram (Pin P2 ₀).....	638
Figure C.3 (a) Port 3 Block Diagram (Pin P3 ₇ to P3 ₆).....	639
Figure C.3 (b) Port 3 Block Diagram (Pin P3 ₅).....	640
Figure C.3 (c) Port 3 Block Diagram (Pin P3 ₄).....	641
Figure C.3 (d) Port 3 Block Diagram (Pin P3 ₃).....	642
Figure C.3 (e-1) Port 3 Block Diagram (Pin P3 ₂ , H8/3847R Group and H8/3847S Group).....	643
Figure C.3 (e-2) Port 3 Block Diagram (Pin P3 ₂ , H8/38347 Group and H8/38447 Group).....	644
Figure C.3 (f-1) Port 3 Block Diagram (Pin P3 ₁ , H8/3847R Group and H8/3847S Group).....	645
Figure C.3 (f-2) Port 3 Block Diagram (Pin P3 ₁ , H8/38347 Group and H8/38447 Group).....	646
Figure C.3 (g) Port 3 Block Diagram (Pin P3 ₀).....	647
Figure C.4 (a) Port 4 Block Diagram (Pin P4 ₃).....	648
Figure C.4 (b) Port 4 Block Diagram (Pin P4 ₂).....	649
Figure C.4 (c) Port 4 Block Diagram (Pin P4 ₁).....	650
Figure C.4 (d) Port 4 Block Diagram (Pin P4 ₀).....	651
Figure C.5 Port 5 Block Diagram.....	652
Figure C.6 Port 6 Block Diagram.....	653
Figure C.7 Port 7 Block Diagram.....	654
Figure C.8 Port 8 Block Diagram.....	655
Figure C.9 Port 9 Block Diagram.....	656
Figure C.10 Port A Block Diagram.....	657
Figure C.11 Port B Block Diagram.....	658
Figure C.12 Port C Block Diagram.....	659

Appendix F Package Dimensions

Figure F.1 FP-100A Package Dimensions.....	668
Figure F.2 FP-100B Package Dimensions.....	669
Figure F.3 TFP-100B Package Dimensions.....	670
Figure F.4 TFP-100G Package Dimensions.....	671

Appendix G Specifications of Chip Form

Figure G.1 Chip Sectional Figure.....	672
Figure G.2 Chip Sectional Figure.....	672
Figure G.3 Chip Sectional Figure.....	673

Figure G.4 Chip Sectional Figure 673

Appendix H Form of Bonding Pads

Figure H.1 Bonding Pad Form..... 674
Figure H.2 Bonding Pad Form..... 675
Figure H.3 Bonding Pad Form..... 676

Appendix I Specifications of Chip Tray

Figure I.1 Specifications of Chip Tray..... 677
Figure I.2 Specifications of Chip Tray..... 678
Figure I.3 Specifications of Chip Tray..... 679
Figure I.4 Specifications of Chip Tray..... 680

Tables

Section 1 Overview

Table 1.1	Features	2
Table 1.2	Bonding Pad Coordinates of H8/3847R Group (Mask ROM Version).....	13
Table 1.3	Bonding Pad Coordinates of H8/3847S Group (Mask ROM Version)	18
Table 1.4	Bonding Pad Coordinates of HCD64F38347 and HCD64F38447	23
Table 1.5	Bonding Pad Coordinates of H8/38347 Group (Mask ROM Version) and H8/38447 Group (Mask ROM Version).....	28
Table 1.6	Pin Functions.....	32

Section 2 CPU

Table 2.1	Addressing Modes.....	47
Table 2.2	Effective Address Calculation.....	50
Table 2.3	Instruction Set	53
Table 2.4	Data Transfer Instructions	55
Table 2.5	Arithmetic Instructions.....	57
Table 2.6	Logic Operation Instructions.....	58
Table 2.7	Shift Instructions	59
Table 2.8	Bit-Manipulation Instructions	61
Table 2.9	Branching Instructions	65
Table 2.10	System Control Instructions	67
Table 2.11	Block Data Transfer Instruction	68
Table 2.12	Registers with Shared Addresses.....	90
Table 2.13	Registers with Write-Only Bits	91

Section 3 Exception Handling

Table 3.1	Exception Handling Types and Priorities.....	93
Table 3.2	Interrupt Sources and Their Priorities	96
Table 3.3	Interrupt Control Registers.....	97
Table 3.4	Interrupt Wait States.....	113
Table 3.5	Conditions Under which Interrupt Request Flag is Set to 1	116

Section 5 Power-Down Modes

Table 5.1	Operating Modes	131
Table 5.2	Internal State in Each Operating Mode	133
Table 5.3	System Control Registers	134
Table 5.4	Clock Frequency and Settling Time (Times are in ms).....	141
Table 5.5	Setting and Clearing Module Standby Mode by Clock Stop Register.....	153

Section 6 ROM

Table 6.1	Setting to PROM Mode.....	157
Table 6.2	Socket Adapter.....	157
Table 6.3	Mode Selection in PROM Mode (H8/3847R).....	160
Table 6.4	DC Characteristics.....	162
Table 6.5	AC Characteristics.....	163
Table 6.6	Register Configuration.....	170
Table 6.7	Division of Blocks to Be Erased.....	175
Table 6.8	Setting Programming Modes.....	177
Table 6.9	Boot Mode Operation.....	179
Table 6.10	Oscillating Frequencies (f_{OSC}) for which Automatic Adjustment of LSI Bit Rate Is Possible.....	179
Table 6.11	Reprogram Data Computation Table.....	183
Table 6.12	Additional-Program Data Computation Table.....	183
Table 6.13	Programming Time.....	183
Table 6.14	Command Sequence in Programmer Mode.....	188
Table 6.15	AC Characteristics in Transition to Memory Read Mode.....	190
Table 6.16	AC Characteristics in Transition from Memory Read Mode to Another Mode.....	191
Table 6.17	AC Characteristics in Memory Read Mode.....	192
Table 6.18	AC Characteristics in Auto-Program Mode.....	194
Table 6.19	AC Characteristics in Auto-Erase Mode.....	195
Table 6.20	AC Characteristics in Status Read Mode.....	197
Table 6.21	Status Read Mode Return Codes.....	198
Table 6.22	Status Polling Output Truth Table.....	198
Table 6.23	Stipulated Transition Times to Command Wait State.....	199
Table 6.24	Flash Memory Operating States.....	200

Section 8 I/O Ports

Table 8.1	Port Functions.....	203
Table 8.2	Port 1 Registers.....	205
Table 8.3	Port 1 Pin Functions.....	210
Table 8.4	Port 1 Pin States.....	211
Table 8.5	Port 2 Registers.....	213
Table 8.6	Port 2 Pin Functions.....	217
Table 8.7	Port 2 Pin States.....	218
Table 8.8	Port 3 Registers.....	219
Table 8.9	Port 3 Pin Functions.....	223
Table 8.10	Port 3 Pin States.....	225
Table 8.11	Port 4 Registers.....	226
Table 8.12	Port 4 Pin Functions.....	228

Table 8.13	Port 4 Pin States	229
Table 8.14	Port 5 Registers	230
Table 8.15	Port 5 Pin Functions	232
Table 8.16	Port 5 Pin States	233
Table 8.17	Port 6 Registers	234
Table 8.18	Port 6 Pin Functions	236
Table 8.19	Port 6 Pin States	236
Table 8.20	Port 7 Registers	238
Table 8.21	Port 7 Pin Functions	240
Table 8.22	Port 7 Pin States	240
Table 8.23	Port 8 Registers	241
Table 8.24	Port 8 Pin Functions	243
Table 8.25	Port 8 Pin States	243
Table 8.26	Port 9 Registers	244
Table 8.27	Port 9 Pin Functions	246
Table 8.28	Port 9 Pin States	247
Table 8.29	Port A Registers	248
Table 8.30	Port A Pin Functions	250
Table 8.31	Port A Pin States	250
Table 8.32	Port B Register	251
Table 8.33	Port C Register	252
Table 8.34	Register Configuration	253

Section 9 Timers

Table 9.1	Timer Functions	257
Table 9.2	Pin Configuration	259
Table 9.3	Timer A Registers	260
Table 9.4	Timer A Operation States	265
Table 9.5	Pin Configuration	267
Table 9.6	Timer C Registers	268
Table 9.7	Timer C Operation States	273
Table 9.8	Pin Configuration	277
Table 9.9	Timer F Registers	277
Table 9.10	Timer F Operation Modes	290
Table 9.11	Pin Configuration	296
Table 9.12	Timer G Registers	296
Table 9.13	Timer G Operation Modes	306
Table 9.14	Internal Clock Switching and TCG Operation	307
Table 9.15	Input Capture Input Signal Input Edges Due to Input Capture Input Pin Switching, and Conditions for Their Occurrence	309

Table 9.16	Input Capture Input Signal Input Edges Due to Noise Canceler Function Switching, and Conditions for Their Occurrence	309
Table 9.17	Watchdog Timer Registers	313
Table 9.18	Watchdog Timer Operation States	319
Table 9.19	Pin Configuration	321
Table 9.20	Asynchronous Event Counter Registers	322
Table 9.21	Asynchronous Event Counter Operation Modes	329

Section 10 Serial Communication Interface

Table 10.1	Overview of SCI Functions	331
Table 10.2	SCI1 Pin Configuration	334
Table 10.3	Registers	334
Table 10.4	Pin Configuration	350
Table 10.5	Registers	350
Table 10.6	Examples of BRR Settings for Various Bit Rates (Asynchronous Mode) (1)	365
Table 10.6	Examples of BRR Settings for Various Bit Rates (Asynchronous Mode) (2)	366
Table 10.7	Relation between n and Clock	366
Table 10.8	Maximum Bit Rate for Each Frequency (Asynchronous Mode)	367
Table 10.9	Examples of BRR Settings for Various Bit Rates (Synchronous Mode) (1)	368
Table 10.9	Examples of BRR Settings for Various Bit Rates (Synchronous Mode) (2)	369
Table 10.10	Relation between n and Clock	370
Table 10.11	SMR Settings and Corresponding Data Transfer Formats	375
Table 10.12	SMR and SCR3 Settings and Clock Source Selection	376
Table 10.13	Transmit/Receive Interrupts	377
Table 10.14	Data Transfer Formats (Asynchronous Mode)	380
Table 10.15	Receive Error Detection Conditions and Receive Data Processing	387
Table 10.16	SCI3 Interrupt Requests	403
Table 10.17	SSR Status Flag States and Receive Data Transfer	404

Section 11 14-Bit PWM

Table 11.1	Pin Configuration	410
Table 11.2	Register Configuration	411
Table 11.3	PWM Operation Modes	416

Section 12 A/D Converter

Table 12.1	Pin Configuration	419
Table 12.2	Register Configuration	419
Table 12.3	A/D Converter Operation Modes	425

Section 13 LCD Controller/Driver

Table 13.1	Pin Configuration	433
Table 13.2	LCD Controller/Driver Registers	433
Table 13.3	Output Levels	457
Table 13.4	Power-Down Modes and Display Operation.....	457

Section 15 Electrical Characteristics

Table 15.1	Absolute Maximum Ratings.....	463
Table 15.2	DC Characteristics.....	467
Table 15.3	Control Signal Timing.....	472
Table 15.4	Serial Interface (SCI1) Timing.....	475
Table 15.5	Serial Interface (SCI3-1, SCI3-2) Timing	476
Table 15.6	A/D Converter Characteristics	477
Table 15.7	LCD Characteristics	478
Table 15.8	Segment External Expansion AC Characteristics.....	479
Table 15.9	Absolute Maximum Ratings.....	480
Table 15.10	DC Characteristics.....	484
Table 15.11	Control Signal Timing.....	489
Table 15.12	Serial Interface (SCI1) Timing.....	492
Table 15.13	Serial Interface (SCI3-1, SCI3-2) Timing	493
Table 15.14	A/D Converter Characteristics	494
Table 15.15	LCD Characteristics	495
Table 15.16	Segment External Expansion AC Characteristics.....	496
Table 15.17	Absolute Maximum Ratings.....	497
Table 15.18	DC Characteristics.....	500
Table 15.19	Control Signal Timing.....	505
Table 15.20	Serial Interface (SCI1) Timing.....	508
Table 15.21	Serial Interface (SCI3-1, SCI3-2) Timing	509
Table 15.22	A/D Converter Characteristics	510
Table 15.23	LCD Characteristics	511
Table 15.24	Segment External Expansion AC Characteristics.....	512
Table 15.25	Absolute Maximum Ratings.....	513
Table 15.26	DC Characteristics.....	517
Table 15.27	Control Signal Timing.....	526
Table 15.28	Serial Interface (SCI1) Timing.....	528
Table 15.29	Serial Interface (SCI3) Timing.....	529
Table 15.30	A/D Converter Characteristics	530
Table 15.31	LCD Characteristics	531
Table 15.32	Flash Memory Characteristics.....	532

Appendix A CPU Instruction Set

Table A.1 Instruction Set 544
Table A.2 Operation Code Map 552
Table A.3 Number of Cycles in Each Instruction 554
Table A.4 Number of Cycles in Each Instruction 555

Appendix E List of Product Codes

Table E.1 Product Code Lineup..... 661



Section 1 Overview

1.1 Overview

The H8/300L Series is a series of single-chip microcomputers (MCU: microcomputer unit), built around the high-speed H8/300L CPU and equipped with peripheral system functions on-chip.

Within the H8/300L Series, the H8/3847R Group, H8/3847S Group, H8/38347 Group, and H8/38447 Group comprise single-chip microcomputers equipped with an LCD (liquid crystal display) controller/driver. Other on-chip peripheral functions include six types of timers, a 14-bit pulse width modulator (PWM), three serial communication interface channels, and an A/D converter. Together, these functions make the H8/3847R Group, H8/3847S Group, H8/38347 Group, and H8/38447 Group ideally suited for embedded applications in systems requiring low power consumption and LCD display. Also available are models incorporating 16 Kbytes to 60 Kbytes of ROM and 1 Kbyte to 2 Kbytes of RAM on-chip.

The H8/3847R is also available in a ZTAT™*1 version with on-chip PROM which can be programmed as required by the user.

The H8/38347 and H8/38447 are available in a F-ZTAT™*2 version with on-chip flash memory that can be programmed on-board.

Table 1.1 summarizes the features of the H8/3847R Group, H8/3847S Group, H8/38347 Group, and H8/38447 Group.

Notes: 1. ZTAT (Zero Turn Around Time) is a trademark of Renesas Technology Corp.
2. F-ZTAT is a trademark of Renesas Technology Corp.

Table 1.1 Features

Item	Description
CPU	<p>High-speed H8/300L CPU</p> <ul style="list-style-type: none"> • General-register architecture General registers: Sixteen 8-bit registers (can be used as eight 16-bit registers) • Operating speed <ul style="list-style-type: none"> — Max. operating speed: 8 MHz — Add/subtract: 0.25 μs (operating at 8 MHz) — Multiply/divide: 1.75 μs (operating at 8 MHz) — Can run on 32.768 kHz or 38.4 kHz subclock • Instruction set compatible with H8/300 CPU <ul style="list-style-type: none"> — Instruction length of 2 bytes or 4 bytes — Basic arithmetic operations between registers — MOV instruction for data transfer between memory and registers • Typical instructions <ul style="list-style-type: none"> — Multiply (8 bits \times 8 bits) — Divide (16 bits \div 8 bits) — Bit accumulator — Register-indirect designation of bit position
Interrupts	<p>37 interrupt sources</p> <ul style="list-style-type: none"> • 13 external interrupt sources (IRQ₄ to IRQ₀, WKP₇ to WKP₀) • 24 internal interrupt sources
Clock pulse generators	<p>Two on-chip clock pulse generators</p> <ul style="list-style-type: none"> • System clock pulse generator: <ul style="list-style-type: none"> — Maximum 16 MHz (H8/3847R Group, H8/38347 Group, and H8/38447 Group) — Maximum 10 MHz (H8/3847S Group) • Subclock pulse generator: 32.768 kHz, 38.4 kHz

Item	Description
Power-down modes	<ul style="list-style-type: none">• Seven power-down modes• Sleep (high-speed) mode• Sleep (medium-speed) mode• Standby mode• Watch mode• Subsleep mode• Subactive mode• Active (medium-speed) mode
Memory	Large on-chip memory <ul style="list-style-type: none">• H8/3842R, H8/38342, H8/38442: 16-Kbyte ROM, 1-Kbyte RAM• H8/3843R, H8/38343, H8/38443: 24-Kbyte ROM, 1-Kbyte RAM• H8/3844R, H8/3844S, H8/38344, H8/38444: 32-Kbyte ROM, 2-Kbyte RAM• H8/3845R, H8/3845S, H8/38345, H8/38445: 40-Kbyte ROM, 2-Kbyte RAM• H8/3846R, H8/3846S, H8/38346, H8/38446: 48-Kbyte ROM, 2-Kbyte RAM• H8/3847R, H8/3847S, H8/38347, H8/38447: 60-Kbyte ROM, 2-Kbyte RAM
I/O ports	84 pins <ul style="list-style-type: none">• 71 I/O pins• 13 input pins

Item	Description
Timers	<p>Six on-chip timers</p> <ul style="list-style-type: none">• Timer A: 8-bit timer Count-up timer with selection of eight internal clock signals divided from the system clock (ϕ)* and four clock signals divided from the watch clock (ϕ_w)*• Asynchronous event counter: 16-bit timer<ul style="list-style-type: none">— Count-up timer able to count asynchronous external events independently of the MCU's internal clocks• Timer C: 8-bit timer<ul style="list-style-type: none">— Count-up/down timer with selection of seven internal clock signals or event input from external pin— Auto-reloading• Timer F: 16-bit timer<ul style="list-style-type: none">— Can be used as two independent 8-bit timers— Count-up timer with selection of four internal clock signals or event input from external pin— Provision for toggle output by means of compare-match function• Timer G: 8-bit timer<ul style="list-style-type: none">— Count-up timer with selection of four internal clock signals— Incorporates input capture function (built-in noise canceler)• Watchdog timer<ul style="list-style-type: none">— Reset signal generated by overflow of 8-bit counter
Serial communication interface	<p>Three serial communication interface channels on chip</p> <ul style="list-style-type: none">• SCI1: Synchronous serial interface Choice of 8-bit or 16-bit transfer data• SCI3-1: 8-bit synchronous/asynchronous serial interface Incorporates multiprocessor communication function• SCI3-2: 8-bit synchronous/asynchronous serial interface Incorporates multiprocessor communication function
14-bit PWM	<p>Pulse-division PWM output for reduced ripple</p> <ul style="list-style-type: none">• Can be used as a 14-bit D/A converter by connecting to an external low-pass filter.

Item	Description
A/D converter	Successive approximations using a resistance ladder <ul style="list-style-type: none"><li data-bbox="284 161 627 185">• 12-channel analog input pins<li data-bbox="284 201 771 225">• Conversion time: $31/\phi$ or $62/\phi$ per channel
LCD controller/driver	LCD controller/driver equipped with a maximum of 40 segment pins and four common pins <ul style="list-style-type: none"><li data-bbox="284 312 840 336">• Choice of four duty cycles (static, 1/2, 1/3, or 1/4)<li data-bbox="284 352 1129 371">• Segment pins can be switched to general-purpose port function in 8-bit units

Item	Description				
	Mask ROM Version	ZTAT Version	F-ZTAT Version	Package	ROM/RAM Size (Byte)
Product lineup	HD6433847R	HD6473847R	HD64F38347	FP-100A (H8/3847R only)	60 K/2 K
	HD6433847S		HD64F38447	FP-100B	
	HD64338347			TFP-100B	
	HD64338447			TFP-100G Die	
	HD6433846R	—	—	FP-100A (H8/3846R only)	48 K/2 K
	HD6433846S			FP-100B	
	HD64338346			TFP-100B	
	HD64338446			TFP-100G Die	
	HD6433845R	—	—	FP-100A (H8/3845R only)	40 K/2 K
	HD6433845S			FP-100B	
	HD64338345			TFP-100B	
	HD64338445			TFP-100G Die	
	HD6433844R	—	HD64F38344	FP-100A (H8/3844R only)	32 K/2 K
	HD6433844S		HD64F38444	FP-100B	
	HD64338344			TFP-100B	
	HD64338444			TFP-100G Die (Mask ROM version only)	
	HD6433843R	—	—	FP-100A (H8/3843R only)	24 K/1 K
	HD64338343			FP-100B	
	HD64338443			TFP-100B TFP-100G Die	
	HD6433842R	—	—	FP-100A (H8/3842R only)	16 K/1 K
	HD64338342			FP-100B	
	HD64338442			TFP-100B TFP-100G Die	

See appendix E for a list of product codes.

Note: * See section 4, Clock Pulse Generators, for the definition of ϕ and ϕ_w .

1.2 Internal Block Diagram

Figure 1.1 (1) shows a block diagram of the H8/3847R Group and H8/3847S Group.

Figure 1.1 (2) shows a block diagram of the H8/38347 Group and H8/38447 Group.

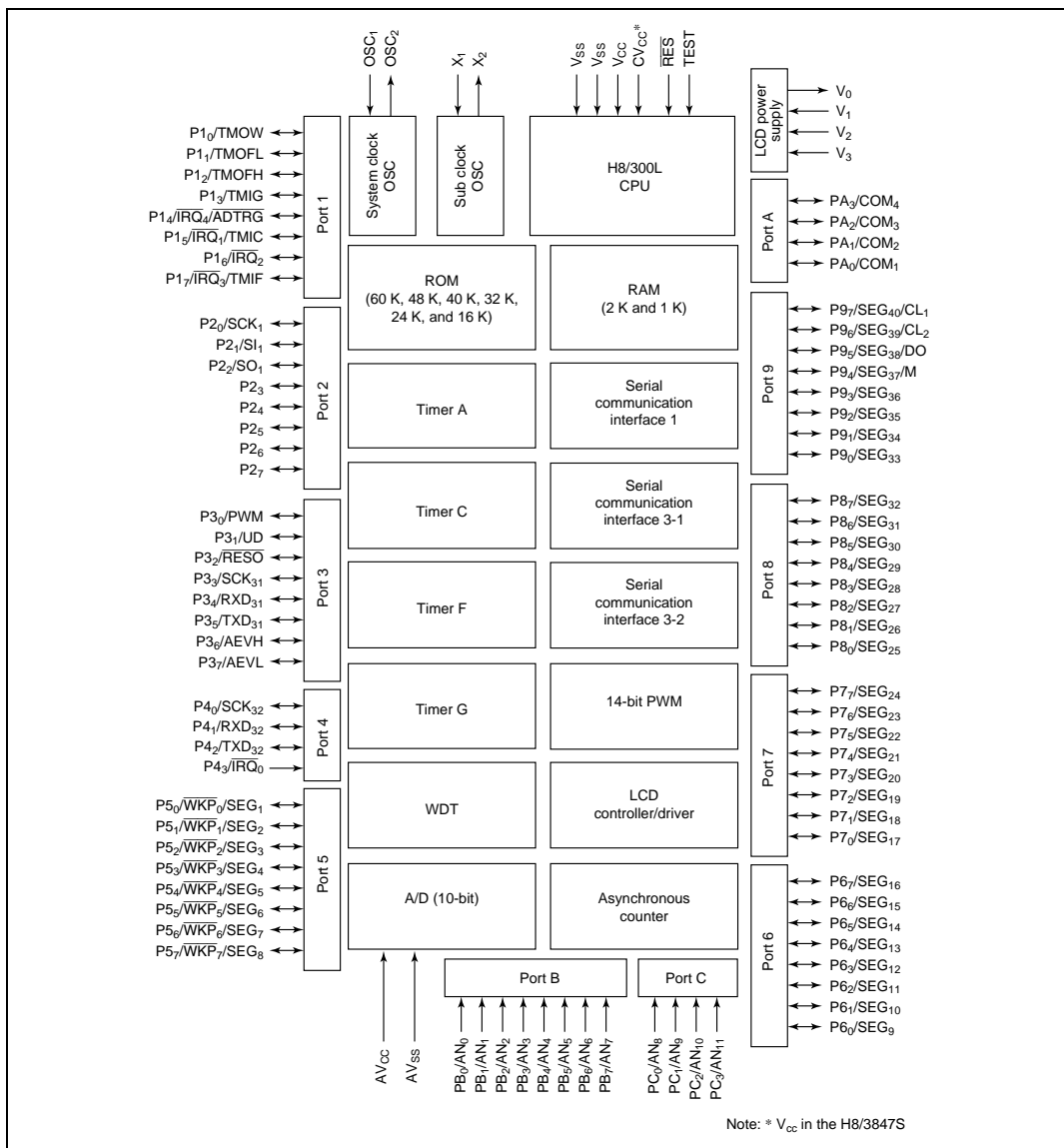


Figure 1.1 (1) Block Diagram (H8/3847R Group and H8/3847S Group)

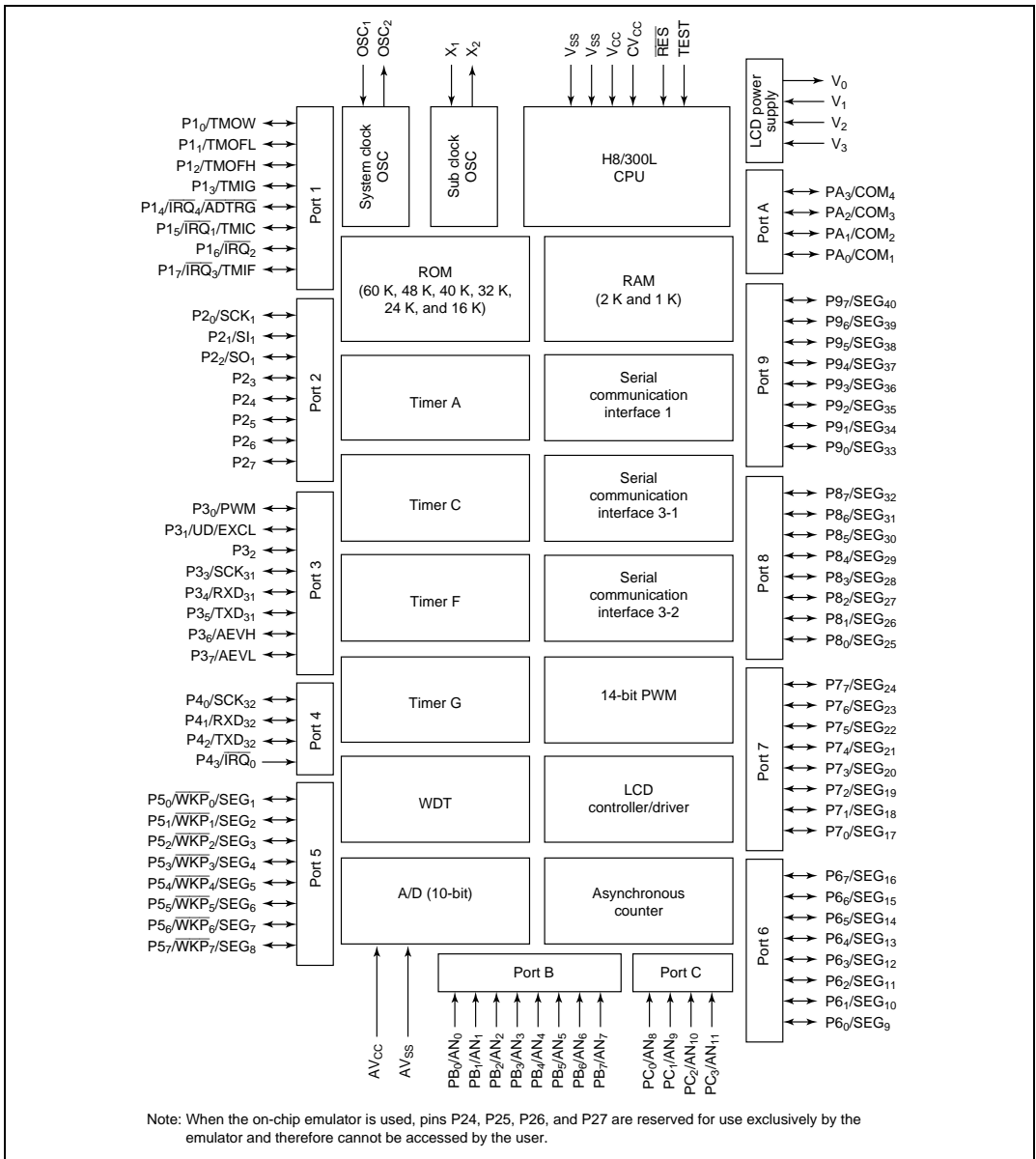


Figure 1.1 (2) Block Diagram (H8/38347 Group and H8/38447 Group)

1.3 Pin Arrangement and Functions

1.3.1 Pin Arrangement

The pin arrangements of the H8/3847R Group, H8/3847S Group, H8/38347 Group, and H8/38447 Group are shown in figures 1.2 and 1.3 (figure 1.3 only applies to the H8/3847R Group). The bonding pad location diagram of the H8/3847R Group (Mask ROM version) is shown in figure 1.4. The bonding pad coordinates of the H8/3847R Group (Mask ROM version) are given in table 1.2. The bonding pad location diagram of the H8/3847S Group (Mask ROM version) is shown in figure 1.5. The bonding pad coordinates of the H8/3847S Group (Mask ROM version) are given in table 1.3.

The bonding pad location diagram of the HCD64F38347 and HCD64F38447 is shown in figure 1.6. The bonding pad coordinates of the HCD64F38347 and HCD64F38447 are given in table 1.4.

The bonding pad location diagram of the H8/38347 Group (Mask ROM version) and H8/38447 Group (Mask ROM version) is shown in figure 1.7. The bonding pad coordinates of the H8/38347 Group (Mask ROM version) and H8/38447 Group (Mask ROM version) are given in table 1.5.

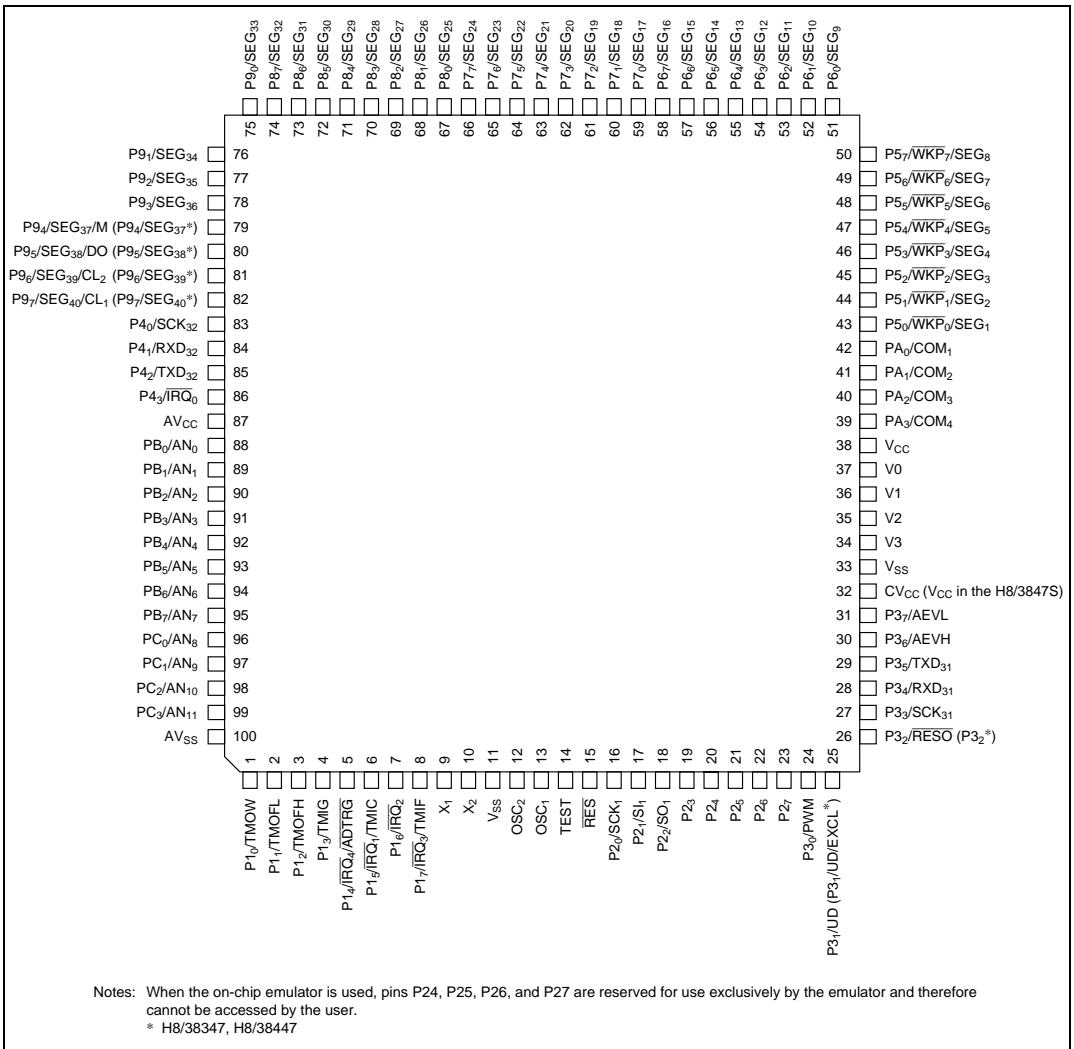


Figure 1.2 Pin Arrangement (FP-100B, TFP-100B and TFP-100G: Top View)

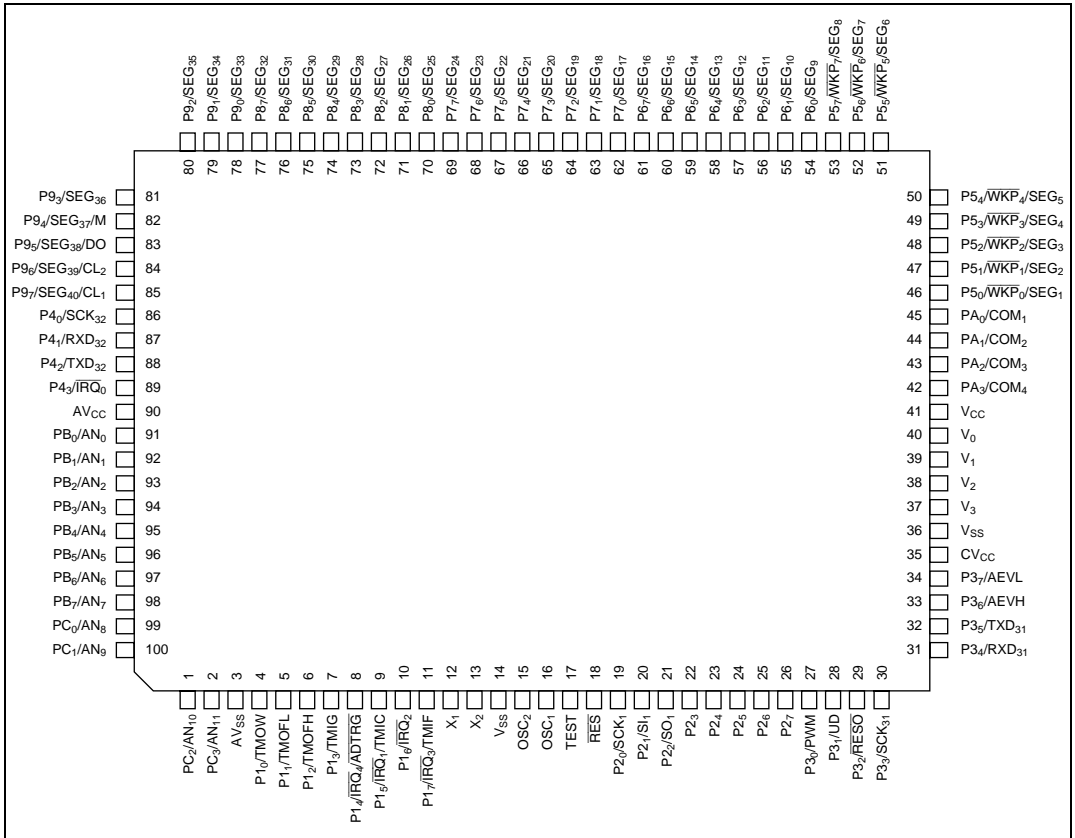


Figure 1.3 Pin Arrangement (FP-100A: Top View)

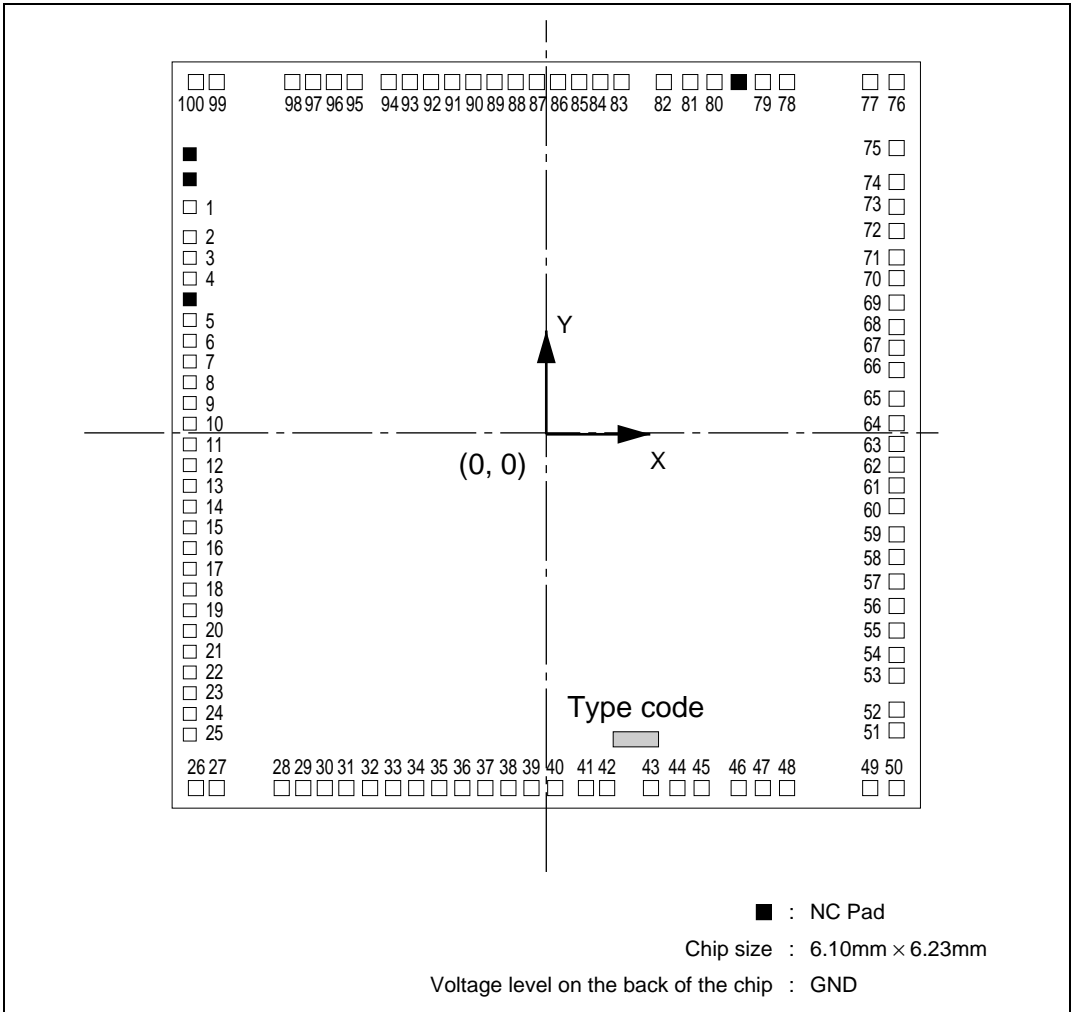


Figure 1.4 Bonding Pad Location Diagram of H8/3847R Group (Mask ROM Version) (Top View)

Table 1.2 Bonding Pad Coordinates of H8/3847R Group (Mask ROM Version)

Pad No.	Pad Name	Coordinates*	
		X (μm)	Y (μm)
1	P1 ₀ /TMOW	-2866	1939
2	P1 ₁ /TMOFL	-2866	1694
3	P1 ₂ /TMOFH	-2866	1500
4	P1 ₃ /TMIG	-2866	1326
5	P1 ₄ / $\overline{\text{IRQ}}_4/\text{ADTRG}$	-2866	984
6	P1 ₅ / $\overline{\text{IRQ}}_1/\text{TMIC}$	-2866	810
7	P1 ₆ / $\overline{\text{IRQ}}_2$	-2866	636
8	P1 ₇ / $\overline{\text{IRQ}}_3/\text{TMIF}$	-2866	462
9	X ₁	-2866	288
10	X ₂	-2866	116
11	V _{SS}	-2866	-56
12	OSC ₂	-2866	-228
13	OSC ₁	-2866	-402
14	TEST	-2866	-576
15	$\overline{\text{RES}}$	-2866	-749
16	P2 ₀ /SCK ₁	-2866	-920
17	P2 ₁ /SI ₁	-2866	-1094
18	P2 ₂ /SO ₁	-2866	-1266
19	P2 ₃	-2866	-1440
20	P2 ₄	-2866	-1612
21	P2 ₅	-2866	-1785
22	P2 ₆	-2866	-1969
23	P2 ₇	-2866	-2153
24	P3 ₀ /PWM	-2866	-2327
25	P3 ₁ /UD	-2866	-2503
26	P3 ₂ / $\overline{\text{RESO}}$	-2866	-2931
27	P3 ₃ /SCK ₃₁	-2669	-2931
28	P3 ₄ /RXD ₃₁	-2142	-2931
29	P3 ₅ /TXD ₃₁	-1971	-2931
30	P3 ₆ /AEVH	-1798	-2931

Pad No.	Pad Name	Coordinates*	
		X (μm)	Y (μm)
31	P3 ₇ /AEVL	-1624	-2931
32	CV _{CC}	-1413	-2931
33	V _{SS}	-1213	-2931
34	V3	-1017	-2931
35	V2	-844	-2931
36	V1	-672	-2931
37	V0	-496	-2931
38	V _{CC}	-320	-2931
39	PA ₃ /COM ₄	-112	-2931
40	PA ₂ /COM ₃	76	-2931
41	PA ₁ /COM ₂	320	-2931
42	PA ₀ /COM ₁	544	-2931
43	P5 ₀ $\overline{\text{WKP}}$ ₀ /SEG ₁	842	-2931
44	P5 ₁ $\overline{\text{WKP}}$ ₁ /SEG ₂	1069	-2931
45	P5 ₂ $\overline{\text{WKP}}$ ₂ /SEG ₃	1256	-2931
46	P5 ₃ $\overline{\text{WKP}}$ ₃ /SEG ₄	1641	-2931
47	P5 ₄ $\overline{\text{WKP}}$ ₄ /SEG ₅	1829	-2931
48	P5 ₅ $\overline{\text{WKP}}$ ₅ /SEG ₆	2017	-2931
49	P5 ₆ $\overline{\text{WKP}}$ ₆ /SEG ₇	2648	-2931
50	P5 ₇ $\overline{\text{WKP}}$ ₇ /SEG ₈	2865	-2931
51	P6 ₀ /SEG ₉	2866	-2484
52	P6 ₁ /SEG ₁₀	2866	-2296
53	P6 ₂ /SEG ₁₁	2866	-2061
54	P6 ₃ /SEG ₁₂	2866	-1846
55	P6 ₄ /SEG ₁₃	2866	-1658
56	P6 ₅ /SEG ₁₄	2866	-1430
57	P6 ₆ /SEG ₁₅	2866	-1244
58	P6 ₇ /SEG ₁₆	2866	-1056
59	P7 ₀ /SEG ₁₇	2866	-828
60	P7 ₁ /SEG ₁₈	2866	-640
61	P7 ₂ /SEG ₁₉	2866	-452
62	P7 ₃ /SEG ₂₀	2866	-264

Pad No.	Pad Name	Coordinates*	
		X (μm)	Y (μm)
63	P7 ₄ /SEG ₂₁	2866	-76
64	P7 ₅ /SEG ₂₂	2866	112
65	P7 ₆ /SEG ₂₃	2866	300
66	P7 ₇ /SEG ₂₄	2866	528
67	P8 ₀ /SEG ₂₅	2866	756
68	P8 ₁ /SEG ₂₆	2866	944
69	P8 ₂ /SEG ₂₇	2866	1132
70	P8 ₃ /SEG ₂₈	2866	1318
71	P8 ₄ /SEG ₂₉	2866	1506
72	P8 ₅ /SEG ₃₀	2866	1694
73	P8 ₆ /SEG ₃₁	2866	1882
74	P8 ₇ /SEG ₃₂	2866	2070
75	P9 ₀ /SEG ₃₃	2866	2367
76	P9 ₁ /SEG ₃₄	2866	2931
77	P9 ₂ /SEG ₃₅	2654	2931
78	P9 ₃ /SEG ₃₆	1998	2931
79	P9 ₄ /SEG ₃₇ /M	1803	2931
80	P9 ₅ /SEG ₃₈ /DO	1396	2931
81	P9 ₆ /SEG ₃₉ /CL ₂	1209	2931
82	P9 ₇ /SEG ₄₀ /CL ₁	977	2931
83	P4 ₀ /SCK ₃₂	631	2931
84	P4 ₁ /RXD ₃₂	456	2931
85	P4 ₂ /TXD ₃₂	284	2931
86	P4 ₃ /IRQ ₀	109	2931
87	AV _{CC}	-64	2931
88	PB ₀ /AN ₀	-236	2931
89	PB ₁ /AN ₁	-409	2931
90	PB ₂ /AN ₂	-581	2931
91	PB ₃ /AN ₃	-753	2931
92	PB ₄ /AN ₄	-925	2931
93	PB ₅ /AN ₅	-1097	2931
94	PB ₆ /AN ₆	-1268	2931

Pad No.	Pad Name	Coordinates*	
		X (μm)	Y (μm)
95	PB ₇ /AN ₇	-1532	2931
96	PC ₀ /AN ₈	-1704	2931
97	PC ₁ /AN ₉	-1876	2931
98	PC ₂ /AN ₁₀	-2048	2931
99	PC ₃ /AN ₁₁	-2658	2931
100	AV _{SS}	-2866	2931

Note: * These values show the coordinates of the centers of pads. The accuracy is $\pm 5 \mu\text{m}$. The home-point position is the chip's center and the center is located at half the distance between the upper and lower pads and left and right pads.

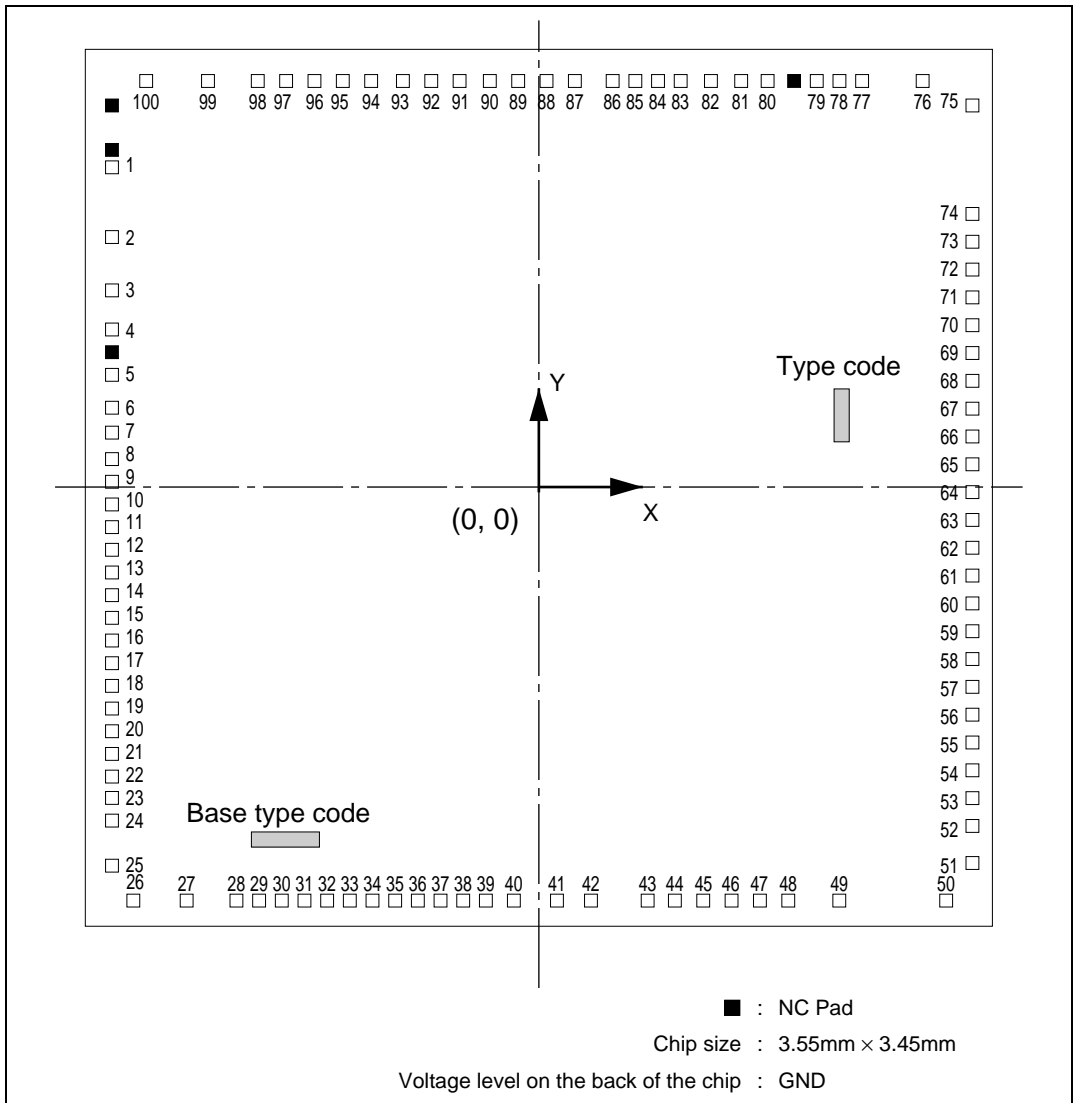


Figure 1.5 Bonding Pad Location Diagram of H8/3847S Group (Mask ROM Version) (Top View)

Table 1.3 Bonding Pad Coordinates of H8/3847S Group (Mask ROM Version)

Pad No.	Pad Name	Coordinates*	
		X (μm)	Y (μm)
1	P1 ₀ /TMOW	-1655	1260
2	P1 ₁ /TMOFL	-1655	999
3	P1 ₂ /TMOFH	-1655	799
4	P1 ₃ /TMIG	-1655	629
5	P1 ₄ / $\overline{\text{IRQ}}_4/\overline{\text{ADTRG}}$	-1655	451
6	P1 ₅ / $\overline{\text{IRQ}}_1/\text{TMIC}$	-1655	334
7	P1 ₆ / $\overline{\text{IRQ}}_2$	-1655	226
8	P1 ₇ / $\overline{\text{IRQ}}_3/\text{TMIF}$	-1655	122
9	X ₁	-1655	37
10	X ₂	-1655	-48
11	V _{SS}	-1655	-138
12	OSC ₂	-1655	-223
13	OSC ₁	-1655	-308
14	TEST	-1655	-393
15	$\overline{\text{RES}}$	-1655	-478
16	P2 ₀ /SCK ₁	-1655	-563
17	P2 ₁ /SI ₁	-1655	-648
18	P2 ₂ /SO ₁	-1655	-733
19	P2 ₃	-1655	-818
20	P2 ₄	-1655	-903
21	P2 ₅	-1655	-988
22	P2 ₆	-1655	-1073
23	P2 ₇	-1655	-1158
24	P3 ₀ /PWM	-1655	-1243
25	P3 ₁ /UD	-1655	-1480
26	P3 ₂ / $\overline{\text{RESO}}$	-1580	-1605
27	P3 ₃ /SCK ₃₁	-1357	-1605
28	P3 ₄ /RXD ₃₁	-1178	-1605
29	P3 ₅ /TXD ₃₁	-1093	-1605
30	P3 ₆ /AEVH	-992	-1605

Pad No.	Pad Name	Coordinates*	
		X (μm)	Y (μm)
31	P3 ₇ /AEVL	-906	-1605
32	V _{CC}	-821	-1605
33	V _{SS}	-736	-1605
34	V3	-651	-1605
35	V2	-566	-1605
36	V1	-481	-1605
37	V0	-396	-1605
38	V _{CC}	-310	-1605
39	PA ₃ /COM ₄	-215	-1605
40	PA ₂ /COM ₂	-85	-1605
41	PA ₁ /COM ₁	64	-1605
42	PA ₀ /COM ₀	197	-1605
43	P5 ₀ /WKP ₀ /SEG ₁	421	-1605
44	P5 ₁ /WKP ₁ /SEG ₂	528	-1605
45	P5 ₂ /WKP ₂ /SEG ₃	635	-1605
46	P5 ₃ /WKP ₃ /SEG ₄	742	-1605
47	P5 ₄ /WKP ₄ /SEG ₅	849	-1605
48	P5 ₅ /WKP ₅ /SEG ₆	957	-1605
49	P5 ₆ /WKP ₆ /SEG ₇	1154	-1605
50	P5 ₇ /WKP ₇ /SEG ₈	1570	-1605
51	P6 ₀ /SEG ₉	1655	-1527
52	P6 ₁ /SEG ₁₀	1655	-1294
53	P6 ₂ /SEG ₁₁	1655	-1209
54	P6 ₃ /SEG ₁₂	1655	-1117
55	P6 ₄ /SEG ₁₃	1655	-1010
56	P6 ₅ /SEG ₁₄	1655	-903
57	P6 ₆ /SEG ₁₅	1655	-796
58	P6 ₇ /SEG ₁₆	1655	-689
59	P7 ₀ /SEG ₁₇	1655	-559
60	P7 ₁ /SEG ₁₈	1655	-452
61	P7 ₂ /SEG ₁₉	1655	-345
62	P7 ₃ /SEG ₂₀	1655	-237

Pad No.	Pad Name	Coordinates*	
		X (μm)	Y (μm)
63	P7 ₄ /SEG ₂₁	1655	-130
64	P7 ₅ /SEG ₂₂	1655	-23
65	P7 ₆ /SEG ₂₃	1655	84
66	P7 ₇ /SEG ₂₄	1655	191
67	P8 ₀ /SEG ₂₅	1655	317
68	P8 ₁ /SEG ₂₆	1655	424
69	P8 ₂ /SEG ₂₇	1655	532
70	P8 ₃ /SEG ₂₈	1655	639
71	P8 ₄ /SEG ₂₉	1655	746
72	P8 ₅ /SEG ₃₀	1655	853
73	P8 ₆ /SEG ₃₁	1655	960
74	P8 ₇ /SEG ₃₂	1655	1067
75	P9 ₀ /SEG ₃₃	1655	1527
76	P9 ₁ /SEG ₃₄	1466	1605
77	P9 ₂ /SEG ₃₅	1230	1605
78	P9 ₃ /SEG ₃₆	1145	1605
79	P9 ₄ /SEG ₃₇ /M	1060	1605
80	P9 ₅ /SEG ₃₈ /DO	854	1605
81	P9 ₆ /SEG ₃₉ /CL ₂	747	1605
82	P9 ₇ /SEG ₄₀ /CL ₁	640	1605
83	P4 ₀ /SCK ₃₂	524	1605
84	P4 ₁ /RXD ₃₂	439	1605
85	P4 ₂ /TXD ₃₂	354	1605
86	P4 ₃ /IRQ ₀	269	1605
87	AV _{CC}	101	1605
88	PB ₀ /AN ₀	16	1605
89	PB ₁ /AN ₁	-92	1605
90	PB ₂ /AN ₂	-207	1605
91	PB ₃ /AN ₃	-319	1605
92	PB ₄ /AN ₄	-431	1605
93	PB ₅ /AN ₅	-543	1605
94	PB ₆ /AN ₆	-655	1605

Pad No.	Pad Name	Coordinates*	
		X (μm)	Y (μm)
95	PB ₇ /AN ₇	-767	1605
96	PC ₀ /AN ₈	-879	1605
97	PC ₁ /AN ₉	-991	1605
98	PC ₂ /AN ₁₀	-1103	1605
99	PC ₃ /AN ₁₁	-1290	1605
100	AV _{SS}	-1523	1605

Note: * These values show the coordinates of the centers of pads. The accuracy is $\pm 5 \mu\text{m}$. The home-point position is the chip's center and the center is located at half the distance between the upper and lower pads and left and right pads.

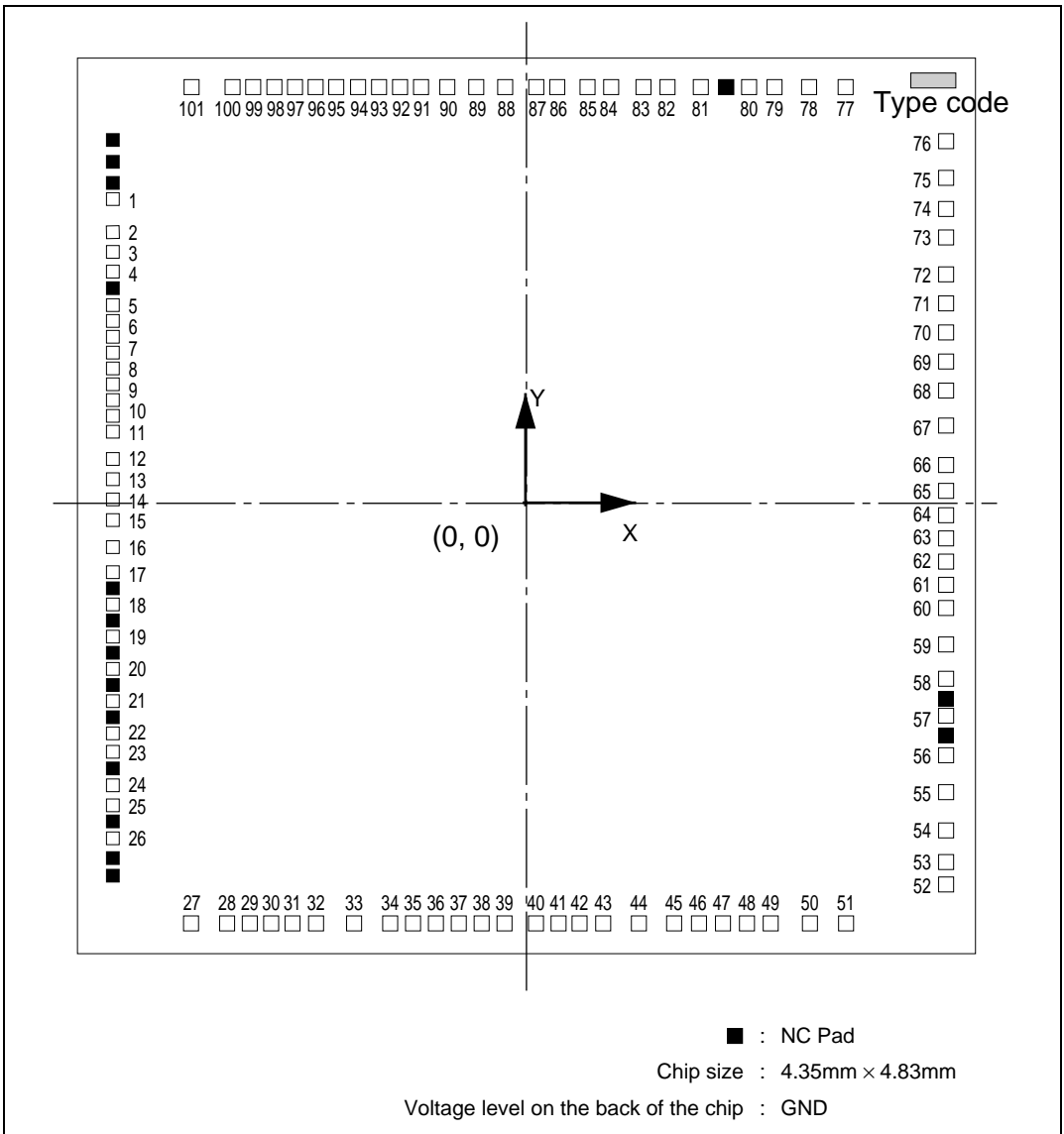


Figure 1.6 Bonding Pad Location Diagram of HCD64F38347 and HCD64F38447 (Top View)

Table 1.4 Bonding Pad Coordinates of HCD64F38347 and HCD64F38447

Pad No.	Pad Name	Coordinates*	
		X (μm)	Y (μm)
1	P1 ₀ /TMOW	-2056	1570
2	P1 ₁ /TMOFL	-2056	1360
3	P1 ₂ /TMOFH	-2056	1259
4	P1 ₃ /TMIG	-2056	1158
5	P1 ₄ / $\overline{\text{IRQ}}_4$ /ADTRG	-2056	941
6	P1 ₅ / $\overline{\text{IRQ}}_1$ /TMIC	-2056	839
7	P1 ₆ / $\overline{\text{IRQ}}_2$	-2056	737
8	P1 ₇ / $\overline{\text{IRQ}}_3$ /TMIF	-2056	635
9	X ₁	-2056	533
10	X ₂	-2056	431
11	V _{SS}	-2056	329
12	V _{SS}	-2056	193
13	OSC ₂	-2056	106
14	OSC ₁	-2056	20
15	TEST	-2056	-66
16	$\overline{\text{RES}}$	-2056	-244
17	P2 ₀ /SCK ₁	-2056	-402
18	P2 ₁ /SI ₁	-2056	-574
19	P2 ₂ /SO ₁	-2056	-747
20	P2 ₃	-2056	-919
21	P2 ₄	-2056	-1091
22	P2 ₅	-2056	-1263
23	P2 ₆	-2056	-1349
24	P2 ₇	-2056	-1521
25	P3 ₀ /PWM	-2056	-1607
26	P3 ₁ /UD/EXCL	-2056	-1779
27	P3 ₂	-1777	-2295
28	P3 ₃ /SCK ₃₁	-1530	-2295
29	P3 ₄ /RXD ₃₁	-1382	-2295
30	P3 ₅ /TXD ₃₁	-1280	-2295
31	P3 ₆ /AEVH	-1178	-2295

Pad No.	Pad Name	Coordinates*	
		X (μm)	Y (μm)
32	P3 ₇ /AEVL	-1076	-2295
33	CV _{CC}	-896	-2295
34	V _{SS}	-710	-2295
35	V3	-584	-2295
36	V2	-483	-2295
37	V1	-382	-2295
38	V0	-281	-2295
39	V _{CC}	-145	-2295
40	PA ₃ /COM ₄	51	-2295
41	PA ₂ /COM ₃	176	-2295
42	PA ₁ /COM ₂	301	-2295
43	PA ₀ /COM ₁	441	-2295
44	P5 ₀ /WKP ₀ /SEG1	604	-2295
45	P5 ₁ /WKP ₁ /SEG2	775	-2295
46	P5 ₂ /WKP ₂ /SEG3	883	-2295
47	P5 ₃ /WKP ₃ /SEG4	1022	-2295
48	P5 ₄ /WKP ₄ /SEG5	1147	-2295
49	P5 ₅ /WKP ₅ /SEG6	1302	-2295
50	P5 ₆ /WKP ₆ /SEG7	1530	-2295
51	P5 ₇ /WKP ₇ /SEG8	1777	-2295
52	P6 ₀ /SEG9	2056	-1955
53	P6 ₁ /SEG10	2056	-1830
54	P6 ₂ /SEG11	2056	-1651
55	P6 ₃ /SEG12	2056	-1481
56	P6 ₄ /SEG13	2056	-1300
57	P6 ₅ /SEG14	2056	-1111
58	P6 ₆ /SEG15	2056	-879
59	P6 ₇ /SEG16	2056	-671
60	P7 ₀ /SEG17	2056	-505
61	P7 ₁ /SEG18	2056	-380
62	P7 ₂ /SEG19	2056	-255

Pad No.	Pad Name	Coordinates*	
		X (μm)	Y (μm)
63	P7 ₃ /SEG20	2056	-130
64	P7 ₄ /SEG21	2056	-6
65	P7 ₅ /SEG22	2056	119
66	P7 ₆ /SEG23	2056	244
67	P7 ₇ /SEG24	2056	457
68	P8 ₀ /SEG25	2056	660
69	P8 ₁ /SEG26	2056	784
70	P8 ₂ /SEG27	2056	909
71	P8 ₃ /SEG28	2056	1034
72	P8 ₄ /SEG29	2056	1159
73	P8 ₅ /SEG30	2056	1378
74	P8 ₆ /SEG31	2056	1503
75	P8 ₇ /SEG32	2056	1627
76	P9 ₀ /SEG33	2056	1840
77	P9 ₁ /SEG34	1777	2295
78	P9 ₂ /SEG35	1530	2295
79	P9 ₃ /SEG36	1302	2295
80	P9 ₄ /SEG37	1147	2295
81	P9 ₅ /SEG38	901	2295
82	P9 ₆ /SEG39	728	2295
83	P9 ₇ /SEG40	603	2295
84	P4 ₀ /SCK ₃₂	451	2295
85	P4 ₁ /RXD ₃₂	350	2295
86	P4 ₂ /TXD ₃₂	175	2295
87	P4 ₃ /IRQ ₀	73	2295
88	AV _{CC}	-155	2295
89	PB ₀ /AN ₀	-290	2295
90	PB ₁ /AN ₁	-440	2295
91	PB ₂ /AN ₂	-588	2295
92	PB ₃ /AN ₃	-695	2295
93	PB ₄ /AN ₄	-801	2295
94	PB ₅ /AN ₅	-890	2295

Pad No.	Pad Name	Coordinates*	
		X (μm)	Y (μm)
95	PB ₆ /AN ₆	-996	2295
96	PB ₇ /AN ₇	-1102	2295
97	PC ₀ /AN ₈	-1208	2295
98	PC ₁ /AN ₉	-1313	2295
99	PC ₂ /AN ₁₀	-1419	2295
100	PC ₃ /AN ₁₁	-1530	2295
101	AV _{SS}	-1777	2295

Note: * These values show the coordinates of the centers of pads. The accuracy is $\pm 5 \mu\text{m}$. The home-point position is the chip's center and the center is located at half the distance between the upper and lower pads and left and right pads. Pad numbers 11, 12, and 34 are power supply (V_{SS}) pads and must be connected. They should not be left open. Pad number 15 (TEST) must be connected to the V_{SS} position. The device will not operate properly if the pads are not connected as indicated.

Table 1.5 Bonding Pad Coordinates of H8/38347 Group (Mask ROM Version) and H8/38447 Group (Mask ROM Version)

Pad No.	Pad Name	Coordinates*	
		X (μm)	Y (μm)
1	P1 ₀ /TMOW	-1658	1349
2	P1 ₁ /TMOFL	-1658	1191
3	P1 ₂ /TMOFH	-1658	1104
4	P1 ₃ /TMIG	-1658	1006
5	P1 ₄ / $\overline{\text{IRQ}}_4/\overline{\text{ADTRG}}$	-1658	907
6	P1 ₅ / $\overline{\text{IRQ}}_1/\text{TMIC}$	-1658	751
7	P1 ₆ / $\overline{\text{IRQ}}_2$	-1658	653
8	P1 ₇ / $\overline{\text{IRQ}}_3/\text{TMIF}$	-1658	555
9	X ₁	-1658	456
10	X ₂	-1658	358
11	V _{SS}	-1658	232
12	OSC ₂	-1658	88
13	OSC ₁	-1658	-11
14	TEST	-1658	-113
15	$\overline{\text{RES}}$	-1658	-212
16	P2 ₀ /SCK ₁	-1658	-393
17	P2 ₁ /SI ₁	-1658	-491
18	P2 ₂ /SO ₁	-1658	-590
19	P2 ₃	-1658	-688
20	P2 ₄	-1658	-786
21	P2 ₅	-1658	-884
22	P2 ₆	-1658	-983
23	P2 ₇	-1658	-1081
24	P3 ₀ /PWM	-1658	-1168
25	P3 ₁ /UD/EXCL	-1658	-1337
26	P3 ₂	-1629	-1767
27	P3 ₃ /SCK ₃₁	-1300	-1767
28	P3 ₄ /RXD ₃₁	-1202	-1767
29	P3 ₅ /TXD ₃₁	-1103	-1767
30	P3 ₆ /AEVH	-1005	-1767

Pad No.	Pad Name	Coordinates*	
		X (μm)	Y (μm)
31	P3 ₇ /AEVL	-907	-1767
32	CV _{CC}	-742	-1767
33	V _{SS}	-625	-1767
34	V3	-508	-1767
35	V2	-416	-1767
36	V1	-324	-1767
37	V0	-207	-1767
38	V _{CC}	-21	-1767
39	PA ₃ /COM ₄	107	-1767
40	PA ₂ /COM ₃	232	-1767
41	PA ₁ /COM ₂	356	-1767
42	PA ₀ /COM ₁	481	-1767
43	P5 ₀ / $\overline{\text{WKP}}_0$ /SEG1	637	-1767
44	P5 ₁ / $\overline{\text{WKP}}_1$ /SEG2	762	-1767
45	P5 ₂ / $\overline{\text{WKP}}_2$ /SEG3	887	-1767
46	P5 ₃ / $\overline{\text{WKP}}_3$ /SEG4	1012	-1767
47	P5 ₄ / $\overline{\text{WKP}}_4$ /SEG5	1158	-1767
48	P5 ₅ / $\overline{\text{WKP}}_5$ /SEG6	1245	-1767
49	P5 ₆ / $\overline{\text{WKP}}_6$ /SEG7	1332	-1767
50	P5 ₇ / $\overline{\text{WKP}}_7$ /SEG8	1483	-1767
51	P6 ₀ /SEG9	1658	-1483
52	P6 ₁ /SEG10	1658	-1335
53	P6 ₂ /SEG11	1658	-1210
54	P6 ₃ /SEG12	1658	-1085
55	P6 ₄ /SEG13	1658	-960
56	P6 ₅ /SEG14	1658	-836
57	P6 ₆ /SEG15	1658	-711
58	P6 ₇ /SEG16	1658	-586
59	P7 ₀ /SEG17	1658	-459
60	P7 ₁ /SEG18	1658	-334
61	P7 ₂ /SEG19	1658	-209
62	P7 ₃ /SEG20	1658	-85

Pad No.	Pad Name	Coordinates*	
		X (μm)	Y (μm)
63	P7 ₄ /SEG21	1658	40
64	P7 ₅ /SEG22	1658	165
65	P7 ₆ /SEG23	1658	290
66	P7 ₇ /SEG24	1658	414
67	P8 ₀ /SEG25	1658	602
68	P8 ₁ /SEG26	1658	727
69	P8 ₂ /SEG27	1658	852
70	P8 ₃ /SEG28	1658	976
71	P8 ₄ /SEG29	1658	1101
72	P8 ₅ /SEG30	1658	1226
73	P8 ₆ /SEG31	1658	1351
74	P8 ₇ /SEG32	1658	1475
75	P9 ₀ /SEG33	1658	1613
76	P9 ₁ /SEG34	1500	1767
77	P9 ₂ /SEG35	1290	1767
78	P9 ₃ /SEG36	1202	1767
79	P9 ₄ /SEG37	1066	1767
80	P9 ₅ /SEG38	941	1767
81	P9 ₆ /SEG39	816	1767
82	P9 ₇ /SEG40	692	1767
83	P4 ₀ /SCK ₃₂	574	1767
84	P4 ₁ /RXD ₃₂	476	1767
85	P4 ₂ /TXD ₃₂	377	1767
86	P4 ₃ /IRQ ₀	279	1767
87	AV _{CC}	126	1767
88	PB ₀ /AN ₀	-25	1767
89	PB ₁ /AN ₁	-131	1767
90	PB ₂ /AN ₂	-237	1767
91	PB ₃ /AN ₃	-343	1767
92	PB ₄ /AN ₄	-449	1767
93	PB ₅ /AN ₅	-554	1767
94	PB ₆ /AN ₆	-660	1767

Pad No.	Pad Name	Coordinates*	
		X (μm)	Y (μm)
95	PB ₇ /AN ₇	-766	1767
96	PC ₀ /AN ₈	-872	1767
97	PC ₁ /AN ₉	-978	1767
98	PC ₂ /AN ₁₀	-1084	1767
99	PC ₃ /AN ₁₁	-1190	1767
100	AV _{SS}	-1629	1767

Note: * These values show the coordinates of the centers of pads. The accuracy is $\pm 5 \mu\text{m}$. The home-point position is the chip's center and the center is located at half the distance between the upper and lower pads and left and right pads. Pad numbers 11, 33, and 100 are power supply (V_{SS}) pads and must be connected. They should not be left open. Pad number 14 (TEST) must be connected to the V_{SS} position. The device will not operate properly if the pads are not connected as indicated.

1.3.2 Pin Functions

Table 1.6 outlines the pin functions of the H8/3847R Group, H8/3847S Group, H8/38347 Group, and H8/38447 Group.

Table 1.6 Pin Functions

Type	Symbol	Pin No.		I/O	Name and Functions
		FP-100B TFP-100B TFP-100G	FP-100A		
Power source pins	V_{CC}	38	41	Input	Power supply: All V_{CC} pins should be connected to the system power supply. See section 14, Power Supply Circuit, for a CV_{CC} pin (V_{CC} pin in the H8/3847S Group).
	CV_{CC}	32	35		
	V_{SS}	11 33	14 36	Input	Ground: All V_{SS} pins should be connected to the system power supply (0 V).
	AV_{CC}	87	90	Input	Analog power supply: This is the power supply pin for the A/D converter. When the A/D converter is not used, connect this pin to the system power supply.
	AV_{SS}	100	3	Input	Analog ground: This is the A/D converter ground pin. It should be connected to the system power supply (0V).
	V_0	37	40	Output	LCD power supply: These are the power supply pins for the LCD controller/driver. They incorporate a power supply split-resistance, and are normally used with V_0 and V_1 shorted.
	V_1	36	39	Input	
	V_2	35	38		
	V_3	34	37		

Type	Symbol	Pin No.		I/O	Name and Functions
		FP-100B TFP-100G	FP-100A		
Clock pins	OSC ₁	13	16	Input	These pins connect to a crystal or ceramic oscillator, or can be used to input an external clock. See section 4, Clock Pulse Generators, for a typical connection diagram.
	OSC ₂	12	15	Output	
	X ₁	9	12	Input	These pins connect to a 32.768 kHz or 38.4 kHz crystal oscillator. Output See section 4, Clock Pulse Generators, for a typical connection diagram.
	X ₂	10	13		
	EXCL	25	—	Input	These pins are used to input a 32.768 kHz or 38.4 kHz external clock. See section 4, Clock Pulse Generators, for a connection example. This function is only available on the H8/38347 Group and H8/38447 Group.
System control	$\overline{\text{RES}}$	15	18	Input	Reset: When this pin is driven low, the chip is reset
	$\overline{\text{RESO}}$	26	29	Output	Reset output: Outputs the CPU internal reset signal. This function is not implemented in the H8/38347 Group and H8/38447 Group.
	TEST	14	17	Input	Test pin: This pin is reserved and cannot be used. It should be connected to V _{SS} .
Interrupt pins	$\overline{\text{IRQ}}_0$	86	89	Input	IRQ interrupt request 0 to 4: These are input pins for edge-sensitive external interrupts, with a selection of rising or falling edge.
	$\overline{\text{IRQ}}_1$	6	9		
	$\overline{\text{IRQ}}_2$	7	10		
	$\overline{\text{IRQ}}_3$	8	11		
	$\overline{\text{IRQ}}_4$	5	8		
	$\overline{\text{WKP}}_7$ to $\overline{\text{WKP}}_0$	50 to 43	53 to 46	Input	Wake-up interrupt request 0 to 7: These are input pins for rising or falling- edge-sensitive external interrupts.

Type	Symbol	Pin No.		I/O	Name and Functions
		FP-100B TFP-100B TFP-100G	FP-100A		
Timer pins	TMOW	1	4	Output	Clock output: This is an output pin for waveforms generated by the timer A output circuit.
	AEVL	31	34	Input	Asynchronous event counter event input: This is an event input pin for input to the asynchronous event counter.
	AEVH	30	33		
	TMIC	6	9	Input	Timer C event input: This is an event input pin for input to the timer C counter.
	UD	25	28	Input	Timer C up/down select: This pin selects up- or down-counting for the timer C counter. The counter operates as a down-counter when this pin is high, and as an up-counter when low.
	TMIF	8	11	Input	Timer F event input: This is an event input pin for input to the timer F counter.
	TMOFL	2	5	Output	Timer FL output: This is an output pin for waveforms generated by the timer FL output compare function.
	TMOFH	3	6	Output	Timer FH output: This is an output pin for waveforms generated by the timer FH output compare function.
TMIG	4	7	Input	Timer G capture input: This is an input pin for timer G input capture.	
14-bit PWM pin	PWM	24	27	Output	14-bit PWM output: This is an output pin for waveforms generated by the 14-bit PWM
I/O ports	PB ₇ to PB ₀	95 to 88	98 to 91	Input	Port B: This is an 8-bit input port.
	PC ₃ to PC ₀	99 to 96	2, 1, 100, 99	Input	Port C: This is a 4-bit input port.
	P4 ₃	86	89	Input	Port 4 (bit 3): This is a 1-bit input port.
	P4 ₂ to P4 ₀	85 to 83	88 to 86	I/O	Port 4 (bits 2 to 0): This is a 3-bit I/O port. Input or output can be designated for each bit by means of port control register 4 (PCR4).

Type	Symbol	Pin No.		I/O	Name and Functions
		FP-100B TFP-100B	FP-100A		
I/O ports	PA ₃ to PA ₀	39 to 42	42 to 45	I/O	Port A: This is a 4-bit I/O port. Input or output can be designated for each bit by means of port control register A (PCRA).
	P ₁₇ to P ₁₀	8 to 1	11 to 4	I/O	Port 1: This is an 8-bit I/O port. Input or output can be designated for each bit by means of port control register 1 (PCR1).
	P ₂₇ to P ₂₀	23 to 16	26 to 19	I/O	Port 2: This is an 8-bit I/O port. Input or output can be designated for each bit by means of port control register 2 (PCR2). When the on-chip emulator is used, pins P ₂₄ , P ₂₅ , P ₂₆ , and P ₂₇ are reserved for use exclusively by the emulator and therefore cannot be accessed by the user. With the F-ZTAT version, pull up pin P ₂₄ to high level to cancel a reset in the in the user mode.
	P ₃₇ to P ₃₀	31 to 24	34 to 27	I/O	Port 3: This is an 8-bit I/O port. Input or output can be designated for each bit by means of port control register 3 (PCR3).
	P ₅₇ to P ₅₀	50 to 43	53 to 46	I/O	Port 5: This is an 8-bit I/O port. Input or output can be designated for each bit by means of port control register 5 (PCR5).
	P ₆₇ to P ₆₀	58 to 51	61 to 54	I/O	Port 6: This is an 8-bit I/O port. Input or output can be designated for each bit by means of port control register 6 (PCR6).
	P ₇₇ to P ₇₀	66 to 59	69 to 62	I/O	Port 7: This is an 8-bit I/O port. Input or output can be designated for each bit by means of port control register 7 (PCR7).

Type	Symbol	Pin No.			Name and Functions
		FP-100B TFP-100B TFP-100G	FP-100A	I/O	
I/O ports	P8 ₇ to P8 ₀	74 to 67	77 to 70	I/O	Port 8: This is an 8-bit I/O port. Input or output can be designated for each bit by means of port control register 8 (PCR8).
	P9 ₇ to P9 ₀	82 to 75	85 to 78	I/O	Port 9: This is an 8-bit I/O port. Input or output can be designated for each bit by means of port control register 9 (PCR9).
Serial communication interface (SCI)	SI ₁	17	20	Input	SCI1 receive data input: This is the SCI1 data input pin.
	SO ₁	18	21	Output	SCI1 transmit data output: This is the SCI1 data output pin.
	SCK ₁	16	19	I/O	SCI1 clock I/O: This is the SCI1 clock I/O pin.
	RXD ₃₁	28	31	Input	SCI3-1 receive data input: This is the SCI31 data input pin.
	TXD ₃₁	29	32	Output	SCI3-1 transmit data output: This is the SCI31 data output pin.
	SCK ₃₁	27	30	I/O	SCI3-1 clock I/O: This is the SCI31 clock I/O pin.
	RXD ₃₂	84	87	Input	SCI3-2 receive data input: This is the SCI32 data input pin.
	TXD ₃₂	85	88	Output	SCI3-2 transmit data output: This is the SCI32 data output pin.
A/D converter	AN ₁₁ to AN ₀	99 to 88	2,1 100 to 91	Input	Analog input channels 11 to 0: These are analog data input channels to the A/D converter
	ADTRG	5	8	Input	A/D converter trigger input: This is the external trigger input pin to the A/D converter

Type	Symbol	Pin No.		I/O	Name and Functions
		FP-100B TFP-100B	FP-100A		
LCD controller/ driver	COM ₄ to COM ₁	39 to 42	42 to 45	Output	LCD common output: These are the LCD common output pins.
	SEG ₄₀ to SEG ₁	82 to 43	85 to 46	Output	LCD segment output: These are the LCD segment output pins.
	CL ₁	82	85	Output	LCD latch clock: This is the display data latch clock output pin for external expansion of the segment. This function is not implemented in the H8/38347 Group and H8/38447 Group.
	CL ₂	81	84	Output	LCD shift clock: This is the display data shift clock output pin for external expansion of the segment. This function is not implemented in the H8/38347 Group and H8/38447 Group.
	DO	80	83	Output	LCD serial data output: This is the serial display data output pin for external expansion of the segment. This function is not implemented in the H8/38347 Group and H8/38447 Group.
M	79	82	Output	LCD alternating signal: This is the LCD alternating signal output pin for external expansion of the segment. This function is not implemented in the H8/38347 Group and H8/38447 Group.	

Section 2 CPU

2.1 Overview

The H8/300L CPU has sixteen 8-bit general registers, which can also be paired as eight 16-bit registers. Its concise instruction set is designed for high-speed operation.

2.1.1 Features

Features of the H8/300L CPU are listed below.

- General-register architecture
Sixteen 8-bit general registers, also usable as eight 16-bit general registers
- Instruction set with 55 basic instructions, including:
 - Multiply and divide instructions
 - Powerful bit-manipulation instructions
- Eight addressing modes
 - Register direct
 - Register indirect
 - Register indirect with displacement
 - Register indirect with post-increment or pre-decrement
 - Absolute address
 - Immediate
 - Program-counter relative
 - Memory indirect
- 64-Kbyte address space
- High-speed operation
 - All frequently used instructions are executed in two to four states
 - High-speed arithmetic and logic operations
 - 8- or 16-bit register-register add or subtract: 0.25 μ s*
 - 8 \times 8-bit multiply: 1.75 μ s*
 - 16 \div 8-bit divide: 1.75 μ s*

- Low-power operation modes
 - SLEEP instruction for transfer to low-power operation

Note: * These values are at $\phi = 8$ MHz.

2.1.2 Address Space

The H8/300L CPU supports an address space of up to 64 Kbytes for storing program code and data.

See section 2.8, Memory Map, for details of the memory map.

2.1.3 Register Configuration

Figure 2.1 shows the register structure of the H8/300L CPU. There are two groups of registers: the general registers and control registers.

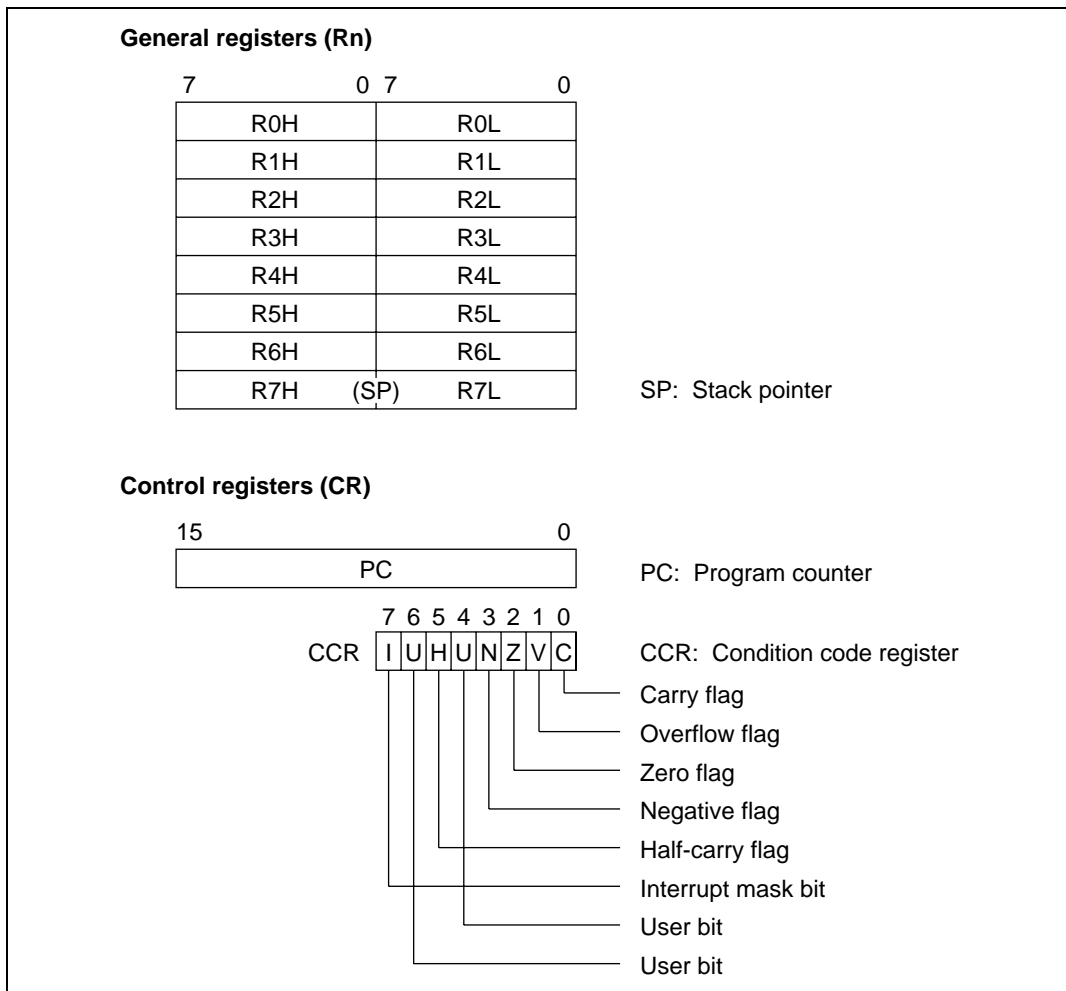


Figure 2.1 CPU Registers

2.2 Register Descriptions

2.2.1 General Registers

All the general registers can be used as both data registers and address registers.

When used as data registers, they can be accessed as 16-bit registers (R0 to R7), or the high bytes (R0H to R7H) and low bytes (R0L to R7L) can be accessed separately as 8-bit registers.

When used as address registers, the general registers are accessed as 16-bit registers (R0 to R7).

R7 also functions as the stack pointer (SP), used implicitly by hardware in exception processing and subroutine calls. When it functions as the stack pointer, as indicated in figure 2.2, SP (R7) points to the top of the stack.

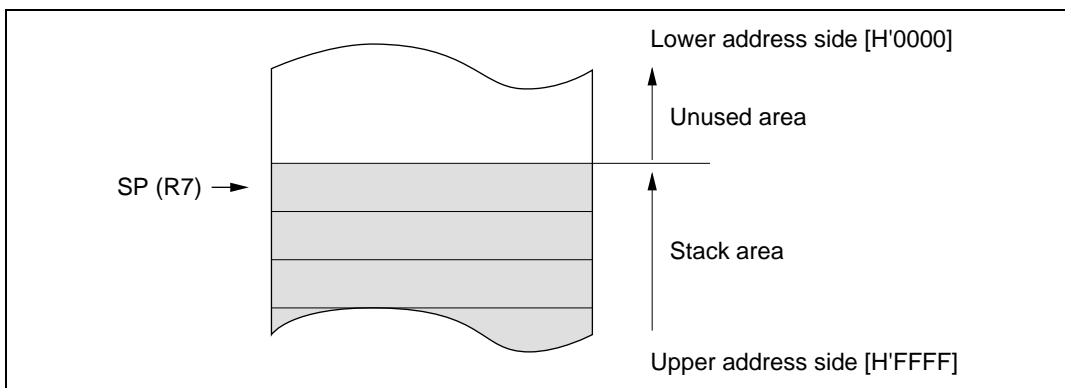


Figure 2.2 Stack Pointer

2.2.2 Control Registers

The CPU control registers include a 16-bit program counter (PC) and an 8-bit condition code register (CCR).

Program Counter (PC): This 16-bit register indicates the address of the next instruction the CPU will execute. All instructions are fetched 16 bits (1 word) at a time, so the least significant bit of the PC is ignored (always regarded as 0).

Condition Code Register (CCR): This 8-bit register contains internal status information, including the interrupt mask bit (I) and half-carry (H), negative (N), zero (Z), overflow (V), and carry (C) flags. These bits can be read and written by software (using the LDC, STC, ANDC,

ORC, and XORC instructions). The N, Z, V, and C flags are used as branching conditions for conditional branching (Bcc) instructions.

Bit 7—Interrupt Mask Bit (I): When this bit is set to 1, interrupts are masked. This bit is set to 1 automatically at the start of exception handling. The interrupt mask bit may be read and written by software. For further details, see section 3.3, Interrupts.

Bit 6—User Bit (U): Can be used freely by the user.

Bit 5—Half-Carry Flag (H): When the ADD.B, ADDX.B, SUB.B, SUBX.B, CMP.B, or NEG.B instruction is executed, this flag is set to 1 if there is a carry or borrow at bit 3, and is cleared to 0 otherwise.

The H flag is used implicitly by the DAA and DAS instructions.

When the ADD.W, SUB.W, or CMP.W instruction is executed, the H flag is set to 1 if there is a carry or borrow at bit 11, and is cleared to 0 otherwise.

Bit 4—User Bit (U): Can be used freely by the user.

Bit 3—Negative Flag (N): Indicates the most significant bit (sign bit) of the result of an instruction.

Bit 2—Zero Flag (Z): Set to 1 to indicate a zero result, and cleared to 0 to indicate a non-zero result.

Bit 1—Overflow Flag (V): Set to 1 when an arithmetic overflow occurs, and cleared to 0 at other times.

Bit 0—Carry Flag (C): Set to 1 when a carry occurs, and cleared to 0 otherwise. Used by:

- Add instructions, to indicate a carry
- Subtract instructions, to indicate a borrow
- Shift and rotate instructions, to store the value shifted out of the end bit

The carry flag is also used as a bit accumulator by bit manipulation instructions.

Some instructions leave some or all of the flag bits unchanged.

Refer to the H8/300L Series Programming Manual for the action of each instruction on the flag bits.

2.2.3 Initial Register Values

When the CPU is reset, the program counter (PC) is initialized to the value stored at address H'0000 in the vector table, and the I bit in the CCR is set to 1. The other CCR bits and the general registers are not initialized. In particular, the stack pointer (R7) is not initialized. The stack pointer should be initialized by software, by the first instruction executed after a reset.

2.3 Data Formats

The H8/300L CPU can process 1-bit data, 4-bit (BCD) data, 8-bit (byte) data, and 16-bit (word) data.

- Bit manipulation instructions operate on 1-bit data specified as bit n in a byte operand ($n = 0, 1, 2, \dots, 7$).
- All arithmetic and logic instructions except ADDS and SUBS can operate on byte data.
- The MOV.W, ADD.W, SUB.W, CMP.W, ADDS, SUBS, MULXU (8 bits \times 8 bits), and DIVXU (16 bits \div 8 bits) instructions operate on word data.
- The DAA and DAS instructions perform decimal arithmetic adjustments on byte data in packed BCD form. Each nibble of the byte is treated as a decimal digit.

2.3.1 Data Formats in General Registers

Data of all the sizes above can be stored in general registers as shown in figure 2.3.

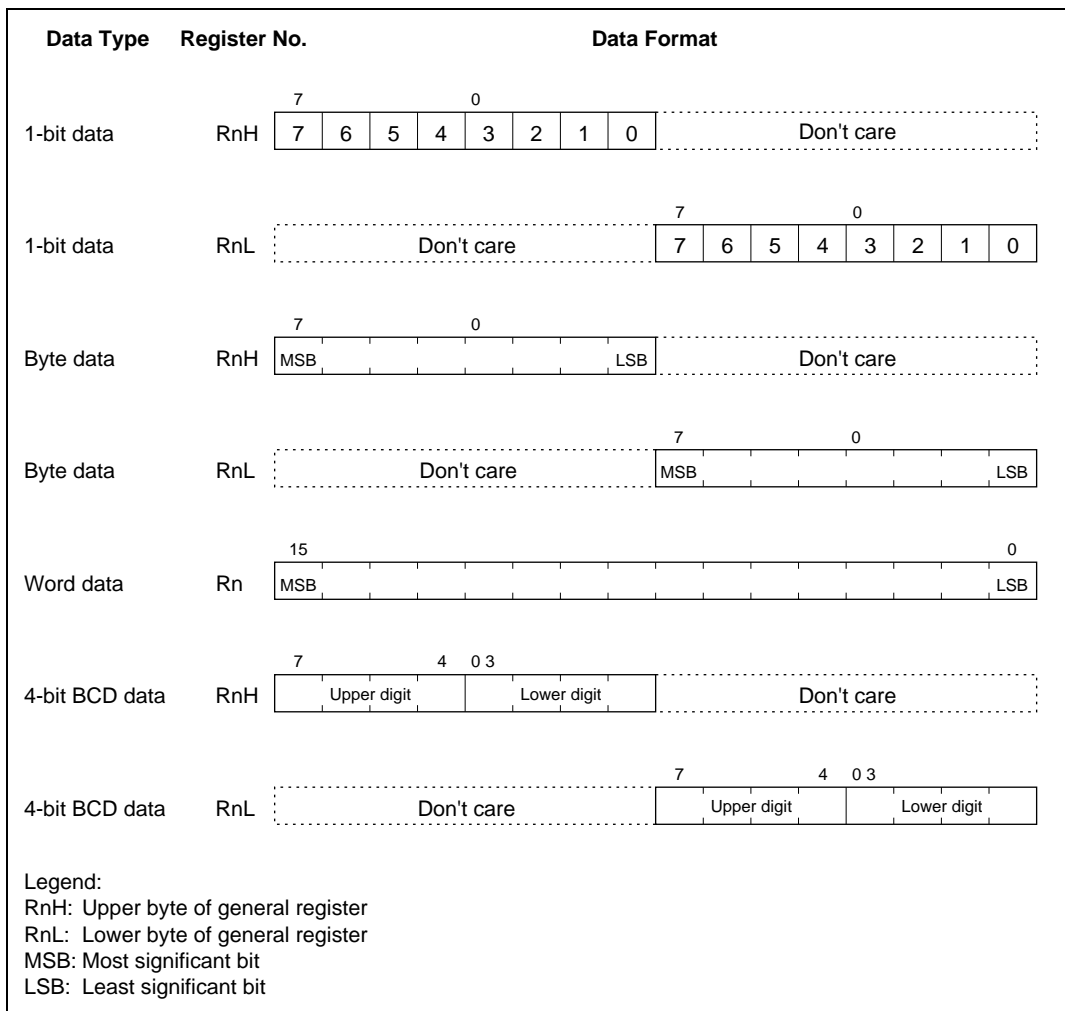


Figure 2.3 Register Data Formats

2.3.2 Memory Data Formats

Figure 2.4 indicates the data formats in memory. The H8/300L CPU can access word data stored in memory (MOV.W instruction), but the word data must always begin at an even address. If word data starting at an odd address is accessed, the least significant bit of the address is regarded as 0, and the word data starting at the preceding address is accessed. The same applies to instruction codes.

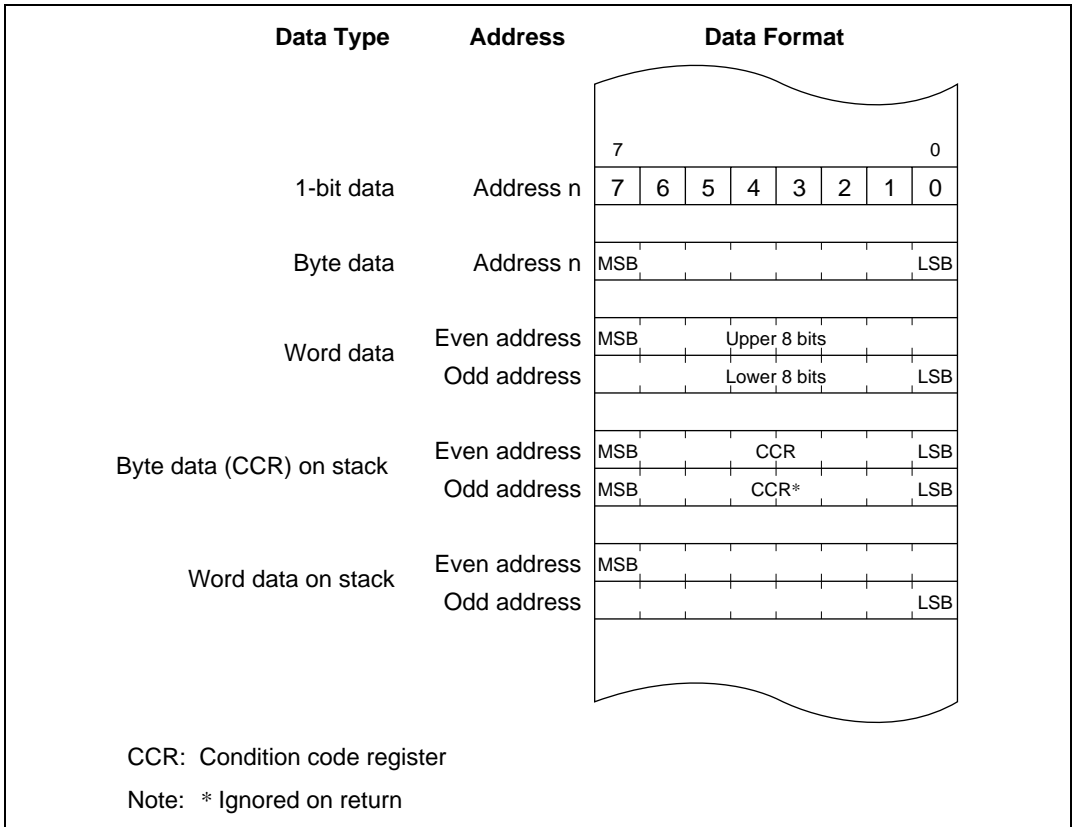


Figure 2.4 Memory Data Formats

When the stack is accessed using R7 as an address register, word access should always be performed. When the CCR is pushed on the stack, two identical copies of the CCR are pushed to make a complete word. When they are restored, the lower byte is ignored.

2.4 Addressing Modes

2.4.1 Addressing Modes

The H8/300L CPU supports the eight addressing modes listed in table 2.1. Each instruction uses a subset of these addressing modes.

Table 2.1 Addressing Modes

No.	Address Modes	Symbol
1	Register direct	Rn
2	Register indirect	@Rn
3	Register indirect with displacement	@(d:16, Rn)
4	Register indirect with post-increment	@Rn+
	Register indirect with pre-decrement	@-Rn
5	Absolute address	@aa:8 or @aa:16
6	Immediate	#xx:8 or #xx:16
7	Program-counter relative	@(d:8, PC)
8	Memory indirect	@@aa:8

- 1. Register Direct—Rn:** The register field of the instruction specifies an 8- or 16-bit general register containing the operand.

Only the MOV.W, ADD.W, SUB.W, CMP.W, ADDS, SUBS, MULXU (8 bits × 8 bits), and DIVXU (16 bits ÷ 8 bits) instructions have 16-bit operands.

- 2. Register Indirect—@Rn:** The register field of the instruction specifies a 16-bit general register containing the address of the operand in memory.
- 3. Register Indirect with Displacement—@(d:16, Rn):** The instruction has a second word (bytes 3 and 4) containing a displacement which is added to the contents of the specified general register to obtain the operand address in memory.

This mode is used only in MOV instructions. For the MOV.W instruction, the resulting address must be even.

4. Register Indirect with Post-Increment or Pre-Decrement—@Rn+ or @-Rn:

- Register indirect with post-increment—@Rn+

The @Rn+ mode is used with MOV instructions that load registers from memory.

The register field of the instruction specifies a 16-bit general register containing the address of the operand. After the operand is accessed, the register is incremented by 1 for MOV.B or 2 for MOV.W. For MOV.W, the original contents of the 16-bit general register must be even.

- Register indirect with pre-decrement—@-Rn

The @-Rn mode is used with MOV instructions that store register contents to memory.

The register field of the instruction specifies a 16-bit general register which is decremented by 1 or 2 to obtain the address of the operand in memory. The register retains the decremented value. The size of the decrement is 1 for MOV.B or 2 for MOV.W. For MOV.W, the original contents of the register must be even.

- #### 5. Absolute Address—@aa:8 or @aa:16:
- The instruction specifies the absolute address of the operand in memory.

The absolute address may be 8 bits long (@aa:8) or 16 bits long (@aa:16). The MOV.B and bit manipulation instructions can use 8-bit absolute addresses. The MOV.B, MOV.W, JMP, and JSR instructions can use 16-bit absolute addresses.

For an 8-bit absolute address, the upper 8 bits are assumed to be 1 (H'FF). The address range is H'FF00 to H'FFFF (65280 to 65535).

- #### 6. Immediate—#xx:8 or #xx:16:
- The instruction contains an 8-bit operand (#xx:8) in its second byte, or a 16-bit operand (#xx:16) in its third and fourth bytes. Only MOV.W instructions can contain 16-bit immediate values.

The ADDS and SUBS instructions implicitly contain the value 1 or 2 as immediate data. Some bit manipulation instructions contain 3-bit immediate data in the second or fourth byte of the instruction, specifying a bit number.

- #### 7. Program-Counter Relative—@(d:8, PC):
- This mode is used in the Bcc and BSR instructions. An 8-bit displacement in byte 2 of the instruction code is sign-extended to 16 bits and added to the program counter contents to generate a branch destination address. The possible branching range is -126 to +128 bytes (-63 to +64 words) from the current address. The displacement should be an even number.

- #### 8. Memory Indirect—@@aa:8:
- This mode can be used by the JMP and JSR instructions. The second byte of the instruction code specifies an 8-bit absolute address. The word located at this address contains the branch destination address.

The upper 8 bits of the absolute address are assumed to be 0 (H'00), so the address range is from H'0000 to H'00FF (0 to 255). Note that with the H8/300L Series, the lower end of the address area is also used as a vector area. See section 3.3, Interrupts, for details on the vector area.

If an odd address is specified as a branch destination or as the operand address of a MOV.W instruction, the least significant bit is regarded as 0, causing word access to be performed at the address preceding the specified address. See section 2.3.2, Memory Data Formats, for further information.

2.4.2 Effective Address Calculation

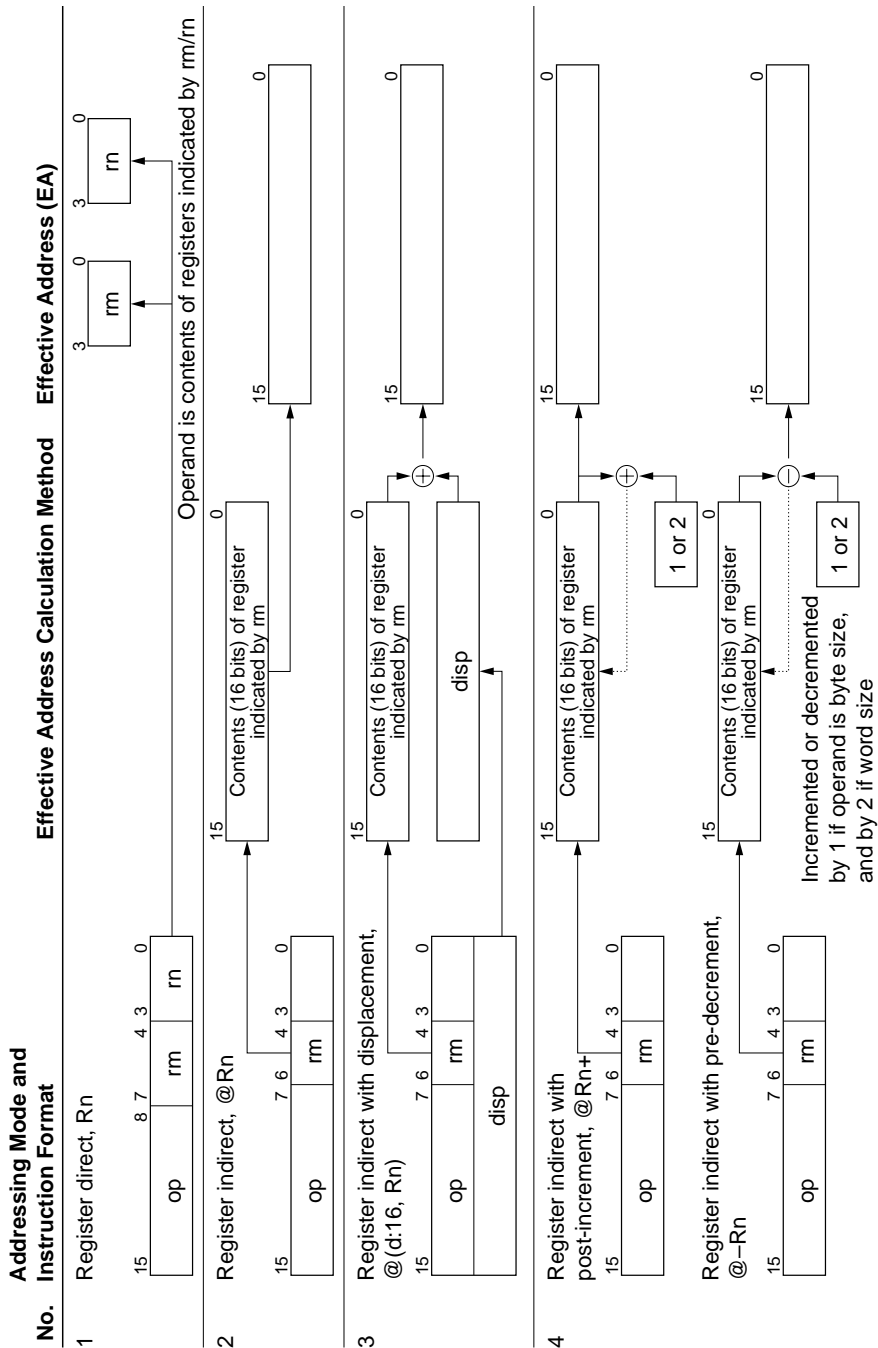
Table 2.2 shows how effective addresses are calculated in each of the addressing modes.

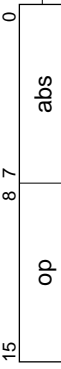
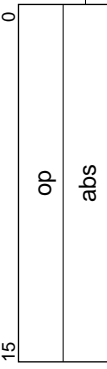
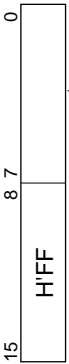

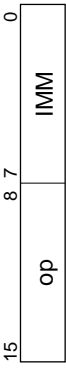

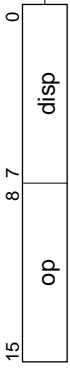
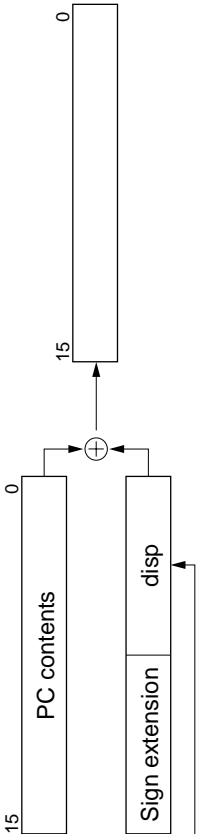
Arithmetic and logic instructions use register direct addressing (1). The ADD.B, ADDX, SUBX, CMP.B, AND, OR, and XOR instructions can also use immediate addressing (6).

Data transfer instructions can use all addressing modes except program-counter relative (7) and memory indirect (8).

Bit manipulation instructions can use register direct (1), register indirect (2), or 8-bit absolute addressing (5) to specify the operand. Register indirect (1) (BSET, BCLR, BNOT, and BTST instructions) or 3-bit immediate addressing (6) can be used independently to specify a bit position in the operand.

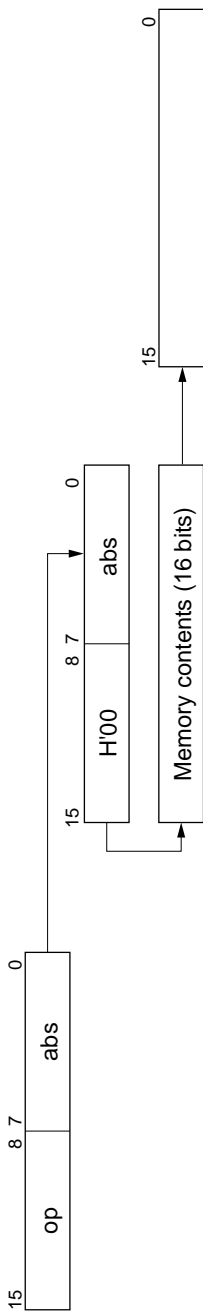
Table 2.2 Effective Address Calculation



No.	Addressing Mode and Instruction Format	Effective Address Calculation Method	Effective Address (EA)
5	<p data-bbox="161 1225 181 1410">Absolute address @aa:8</p>  <p data-bbox="305 1326 326 1410">@aa:16</p> 	 	
6	<p data-bbox="479 1299 499 1410">Immediate #xx:8</p>  <p data-bbox="618 1337 639 1410">#xx:16</p> 	<p data-bbox="611 100 632 507">Operand is 1- or 2-byte immediate data</p>	
7	<p data-bbox="795 1150 816 1410">Program-counter relative @(d:8, PC)</p> 		

No.	Addressing Mode and Instruction Format	Effective Address Calculation Method	Effective Address (EA)
-----	--	--------------------------------------	------------------------

8	Memory indirect, @@aa:8		
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Legend:

rm, rn: Register field
 op: Operation field
 disp: Displacement
 IMM: Immediate data
 abs: Absolute address

2.5 Instruction Set

The H8/300L Series can use a total of 55 instructions, which are grouped by function in table 2.3.

Table 2.3 Instruction Set

Function	Instructions	Number
Data transfer	MOV, PUSH* ¹ , POP* ¹	1
Arithmetic operations	ADD, SUB, ADDX, SUBX, INC, DEC, ADDS, SUBS, DAA, DAS, MULXU, DIVXU, CMP, NEG	14
Logic operations	AND, OR, XOR, NOT	4
Shift	SHAL, SHAR, SHLL, SHLR, ROTL, ROTR, ROTXL, ROTXR	8
Bit manipulation	BSET, BCLR, BNOT, BTST, BAND, BIAN, BOR, BIOR, BXOR, BIXOR, BLD, BILD, BST, BIST	14
Branch	Bcc* ² , JMP, BSR, JSR, RTS	5
System control	RTE, SLEEP, LDC, STC, ANDC, ORC, XORC, NOP	8
Block data transfer	EEPMOV	1
		Total: 55

Notes: 1. PUSH Rn is equivalent to MOV.W Rn, @-SP.

POP Rn is equivalent to MOV.W @SP+, Rn. The same applies to the machine language.

2. Bcc is a conditional branch instruction in which cc represents a condition code.

The following sections give a concise summary of the instructions in each category, and indicate the bit patterns of their object code. The notation used is defined next.

Notation

Rd	General register (destination)
Rs	General register (source)
Rn	General register
(EAd), <Ead>	Destination operand
(EAs), <Eas>	Source operand
CCR	Condition code register
N	N (negative) flag of CCR
Z	Z (zero) flag of CCR
V	V (overflow) flag of CCR
C	C (carry) flag of CCR
PC	Program counter
SP	Stack pointer
#IMM	Immediate data
disp	Displacement
+	Addition
-	Subtraction
×	Multiplication
÷	Division
^	AND logical
∨	OR logical
⊕	Exclusive OR logical
→	Move
~	Logical negation (logical complement)
:3	3-bit length
:8	8-bit length
:16	16-bit length
(), < >	Contents of operand indicated by effective address

2.5.1 Data Transfer Instructions

Table 2.4 describes the data transfer instructions. Figure 2.5 shows their object code formats.

Table 2.4 Data Transfer Instructions

Instruction	Size*	Function
MOV	B/W	(EAs) → Rd, Rs → (EAd) Moves data between two general registers or between a general register and memory, or moves immediate data to a general register. The Rn, @Rn, @(d:16, Rn), @aa:16, #xx:16, @-Rn, and @Rn+ addressing modes are available for word data. The @aa:8 addressing mode is available for byte data only. The @-R7 and @R7+ modes require word operands. Do not specify byte size for these two modes.
POP	W	@SP+ → Rn Pops a 16-bit general register from the stack. Equivalent to MOV.W @SP+, Rn.
PUSH	W	Rn → @-SP Pushes a 16-bit general register onto the stack. Equivalent to MOV.W Rn, @-SP.

Note: * Size: Operand size
 B: Byte
 W: Word

Certain precautions are required in data access. See section 2.9.1, Notes on Data Access, for details.

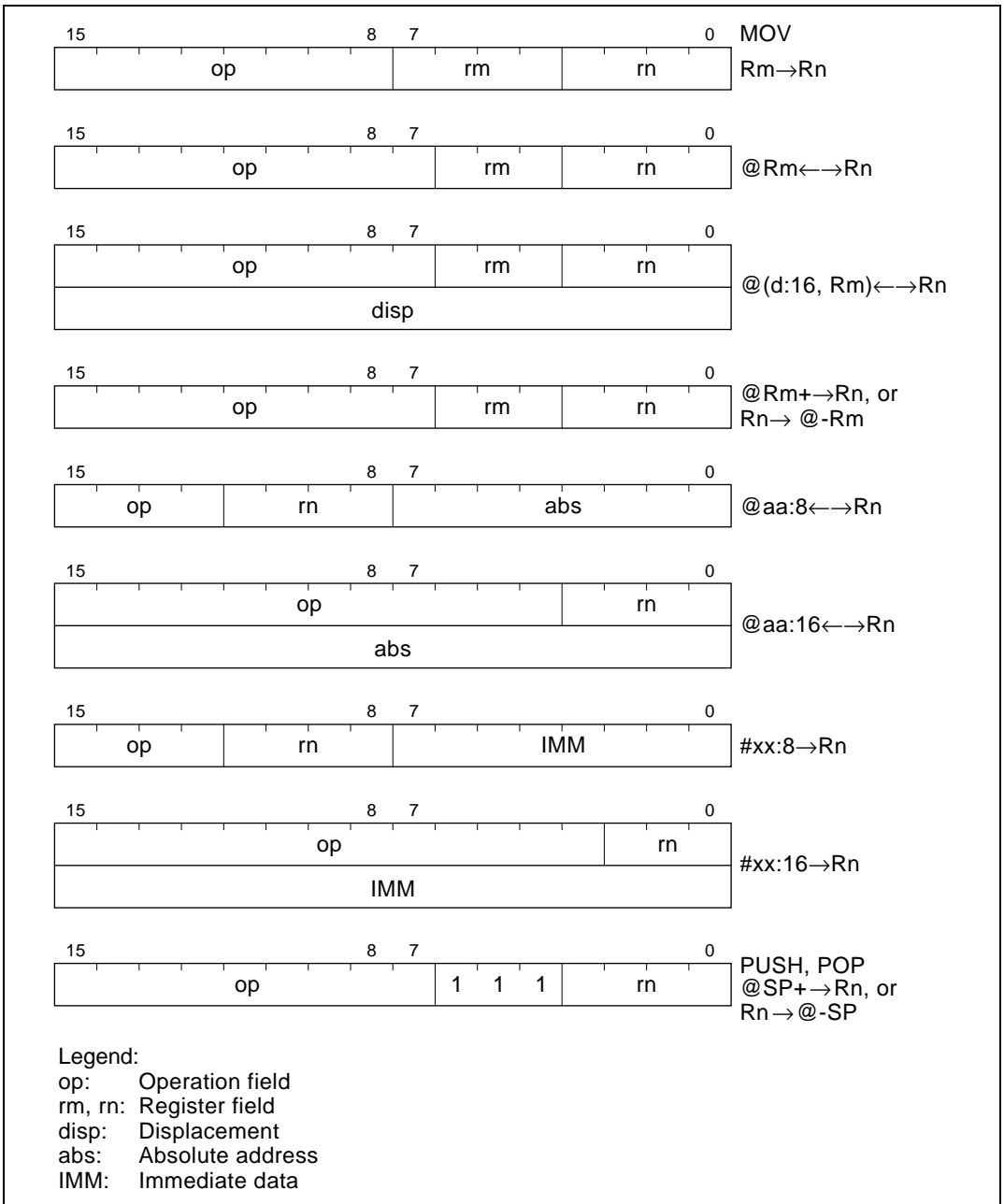


Figure 2.5 Data Transfer Instruction Codes

2.5.2 Arithmetic Operations

Table 2.5 describes the arithmetic instructions.

Table 2.5 Arithmetic Instructions

Instruction	Size*	Function
ADD SUB	B/W	$Rd \pm Rs \rightarrow Rd$, $Rd + \#IMM \rightarrow Rd$ Performs addition or subtraction on data in two general registers, or addition on immediate data and data in a general register. Immediate data cannot be subtracted from data in a general register. Word data can be added or subtracted only when both words are in general registers.
ADDX SUBX	B	$Rd \pm Rs \pm C \rightarrow Rd$, $Rd \pm \#IMM \pm C \rightarrow Rd$ Performs addition or subtraction with carry or borrow on byte data in two general registers, or addition or subtraction on immediate data and data in a general register.
INC DEC	B	$Rd \pm 1 \rightarrow Rd$ Increments or decrements a general register by 1.
ADDS SUBS	W	$Rd \pm 1 \rightarrow Rd$, $Rd \pm 2 \rightarrow Rd$ Adds or subtracts 1 or 2 to or from a general register
DAA DAS	B	Rd decimal adjust $\rightarrow Rd$ Decimal-adjusts (adjusts to 4-bit BCD) an addition or subtraction result in a general register by referring to the CCR
MULXU	B	$Rd \times Rs \rightarrow Rd$ Performs 8-bit \times 8-bit unsigned multiplication on data in two general registers, providing a 16-bit result
DIVXU	B	$Rd \div Rs \rightarrow Rd$ Performs 16-bit \div 8-bit unsigned division on data in two general registers, providing an 8-bit quotient and 8-bit remainder
CMP	B/W	$Rd - Rs$, $Rd - \#IMM$ Compares data in a general register with data in another general register or with immediate data, and indicates the result in the CCR. Word data can be compared only between two general registers.
NEG	B	$0 - Rd \rightarrow Rd$ Obtains the two's complement (arithmetic complement) of data in a general register

Note: * Size: Operand size

B: Byte

W: Word

2.5.3 Logic Operations

Table 2.6 describes the four instructions that perform logic operations.

Table 2.6 Logic Operation Instructions

Instruction	Size*	Function
AND	B	$Rd \wedge Rs \rightarrow Rd$, $Rd \wedge \#IMM \rightarrow Rd$ Performs a logical AND operation on a general register and another general register or immediate data
OR	B	$Rd \vee Rs \rightarrow Rd$, $Rd \vee \#IMM \rightarrow Rd$ Performs a logical OR operation on a general register and another general register or immediate data
XOR	B	$Rd \oplus Rs \rightarrow Rd$, $Rd \oplus \#IMM \rightarrow Rd$ Performs a logical exclusive OR operation on a general register and another general register or immediate data
NOT	B	$\sim Rd \rightarrow Rd$ Obtains the one's complement (logical complement) of general register contents

Note: * Size: Operand size

B: Byte

2.5.4 Shift Operations

Table 2.7 describes the eight shift instructions.

Table 2.7 Shift Instructions

Instruction	Size*	Function
SHAL SHAR	B	Rd shift → Rd Performs an arithmetic shift operation on general register contents
SHLL SHLR	B	Rd shift → Rd Performs a logical shift operation on general register contents
ROTL ROTR	B	Rd rotate → Rd Rotates general register contents
ROTXL ROTXR	B	Rd rotate through carry → Rd Rotates general register contents through the C (carry) bit

Note: * Size: Operand size

B: Byte

Figure 2.6 shows the instruction code format of arithmetic, logic, and shift instructions.

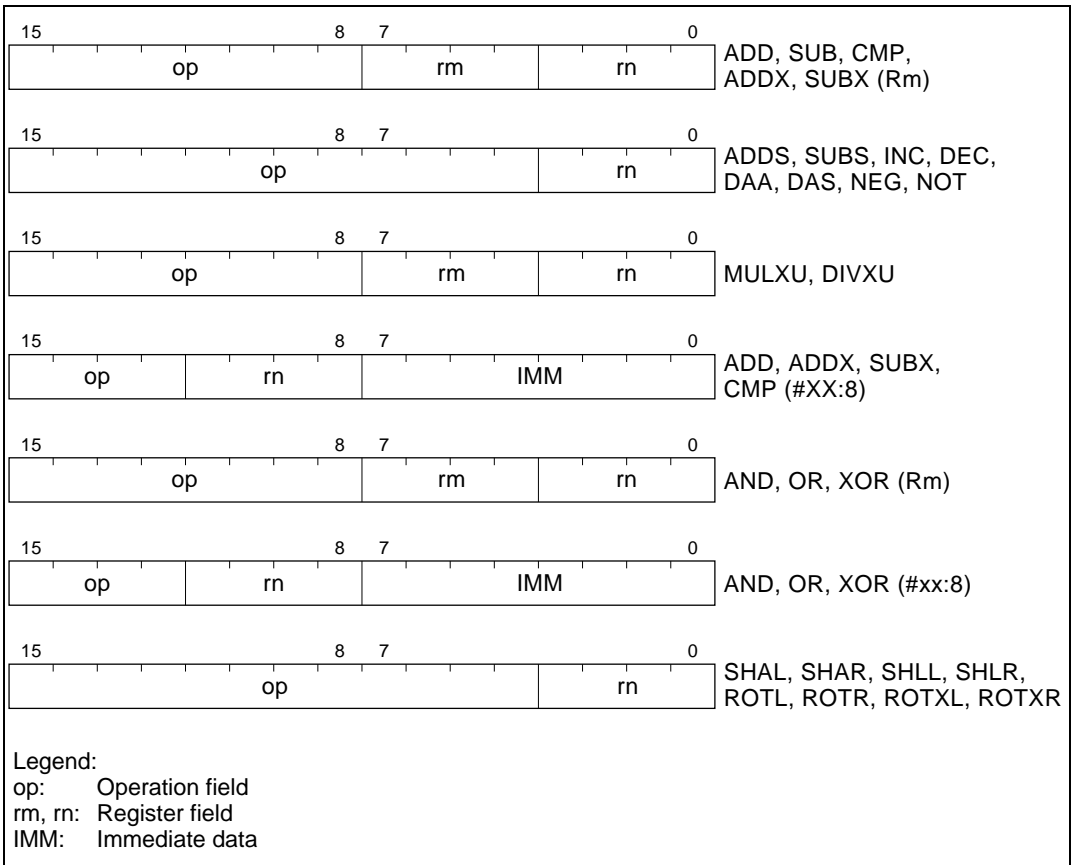


Figure 2.6 Arithmetic, Logic, and Shift Instruction Codes

2.5.5 Bit Manipulations

Table 2.8 describes the bit-manipulation instructions. Figure 2.7 shows their object code formats.

Table 2.8 Bit-Manipulation Instructions

Instruction	Size*	Function
BSET	B	$1 \rightarrow (\text{<bit-No.> of <EAd>})$ Sets a specified bit in a general register or memory to 1. The bit number is specified by 3-bit immediate data or the lower three bits of a general register.
BCLR	B	$0 \rightarrow (\text{<bit-No.> of <EAd>})$ Clears a specified bit in a general register or memory to 0. The bit number is specified by 3-bit immediate data or the lower three bits of a general register.
BNOT	B	$\sim (\text{<bit-No.> of <EAd>}) \rightarrow (\text{<bit-No.> of <EAd>})$ Inverts a specified bit in a general register or memory. The bit number is specified by 3-bit immediate data or the lower three bits of a general register.
BTST	B	$\sim (\text{<bit-No.> of <EAd>}) \rightarrow Z$ Tests a specified bit in a general register or memory and sets or clears the Z flag accordingly. The bit number is specified by 3-bit immediate data or the lower three bits of a general register.
BAND	B	$C \wedge (\text{<bit-No.> of <EAd>}) \rightarrow C$ ANDs the C flag with a specified bit in a general register or memory, and stores the result in the C flag.
BIAND	B	$C \wedge [\sim (\text{<bit-No.> of <EAd>})] \rightarrow C$ ANDs the C flag with the inverse of a specified bit in a general register or memory, and stores the result in the C flag. The bit number is specified by 3-bit immediate data.
BOR	B	$C \vee (\text{<bit-No.> of <EAd>}) \rightarrow C$ ORs the C flag with a specified bit in a general register or memory, and stores the result in the C flag.
BIOR	B	$C \vee [\sim (\text{<bit-No.> of <EAd>})] \rightarrow C$ ORs the C flag with the inverse of a specified bit in a general register or memory, and stores the result in the C flag. The bit number is specified by 3-bit immediate data.

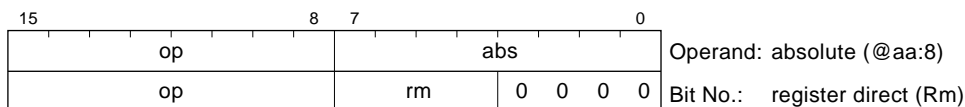
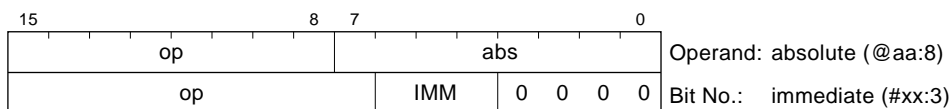
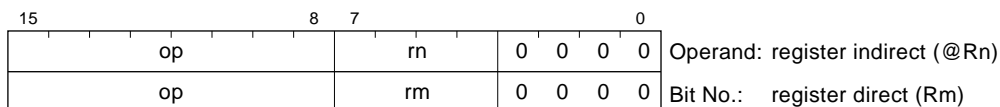
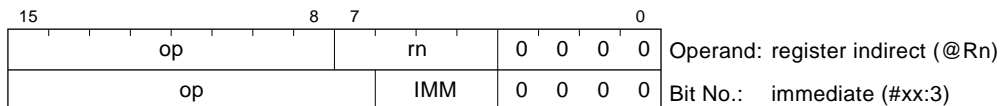
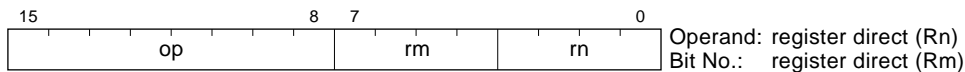
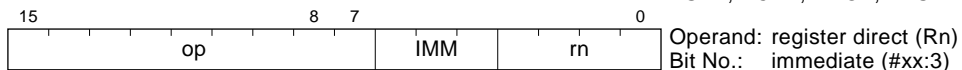
Note: * Size: Operand size
 B: Byte

Instruction	Size*	Function
BXOR	B	$C \oplus (\text{<bit-No.> of <EAd>}) \rightarrow C$ XORs the C flag with a specified bit in a general register or memory, and stores the result in the C flag.
BIXOR	B	$C \oplus [\sim(\text{<bit-No.> of <EAd>})] \rightarrow C$ XORs the C flag with the inverse of a specified bit in a general register or memory, and stores the result in the C flag. The bit number is specified by 3-bit immediate data.
BLD	B	$(\text{<bit-No.> of <EAd>}) \rightarrow C$ Copies a specified bit in a general register or memory to the C flag.
BILD	B	$\sim(\text{<bit-No.> of <EAd>}) \rightarrow C$ Copies the inverse of a specified bit in a general register or memory to the C flag. The bit number is specified by 3-bit immediate data.
BST	B	$C \rightarrow (\text{<bit-No.> of <EAd>})$ Copies the C flag to a specified bit in a general register or memory.
BIST	B	$\sim C \rightarrow (\text{<bit-No.> of <EAd>})$ Copies the inverse of the C flag to a specified bit in a general register or memory. The bit number is specified by 3-bit immediate data.

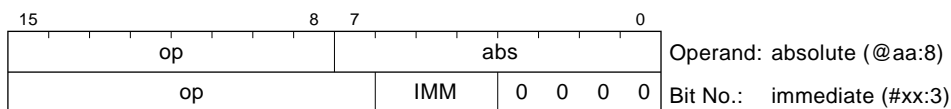
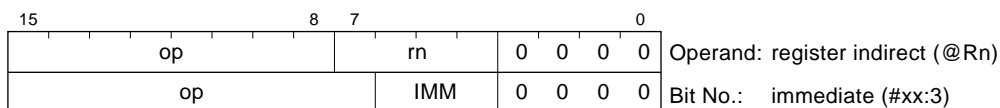
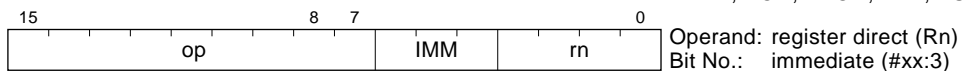
Note: * Size: Operand size
 B: Byte

Certain precautions are required in bit manipulation. See section 2.9.2, Notes on Bit Manipulation, for details.

BSET, BCLR, BNOT, BTST



BAND, BOR, BXOR, BLD, BST



Legend:

op: Operation field
rm, rn: Register field
abs: Absolute address
IMM: Immediate data

Figure 2.7 Bit Manipulation Instruction Codes

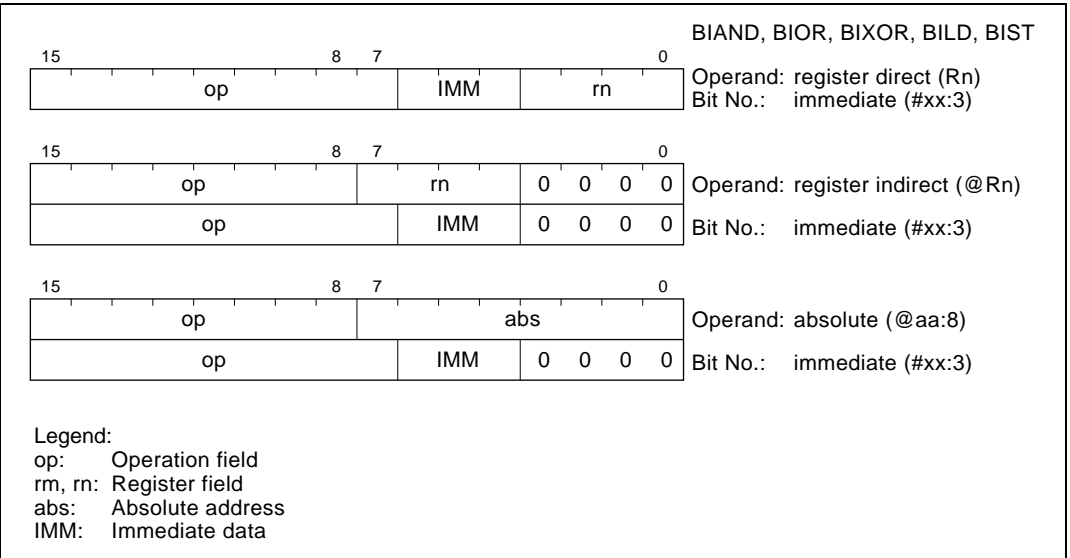


Figure 2.7 Bit Manipulation Instruction Codes (cont)

2.5.6 Branching Instructions

Table 2.9 describes the branching instructions. Figure 2.8 shows their object code formats.

Table 2.9 Branching Instructions

Instruction	Size	Function																																																			
Bcc	—	Branches to the designated address if condition cc is true. The branching conditions are given below.																																																			
		<table border="1"> <thead> <tr> <th>Mnemonic</th> <th>Description</th> <th>Condition</th> </tr> </thead> <tbody> <tr> <td>BRA (BT)</td> <td>Always (true)</td> <td>Always</td> </tr> <tr> <td>BRN (BF)</td> <td>Never (false)</td> <td>Never</td> </tr> <tr> <td>BHI</td> <td>High</td> <td>$C \vee Z = 0$</td> </tr> <tr> <td>BLS</td> <td>Low or same</td> <td>$C \vee Z = 1$</td> </tr> <tr> <td>BCC (BHS)</td> <td>Carry clear (high or same)</td> <td>$C = 0$</td> </tr> <tr> <td>BCS (BLO)</td> <td>Carry set (low)</td> <td>$C = 1$</td> </tr> <tr> <td>BNE</td> <td>Not equal</td> <td>$Z = 0$</td> </tr> <tr> <td>BEQ</td> <td>Equal</td> <td>$Z = 1$</td> </tr> <tr> <td>BVC</td> <td>Overflow clear</td> <td>$V = 0$</td> </tr> <tr> <td>BVS</td> <td>Overflow set</td> <td>$V = 1$</td> </tr> <tr> <td>BPL</td> <td>Plus</td> <td>$N = 0$</td> </tr> <tr> <td>BMI</td> <td>Minus</td> <td>$N = 1$</td> </tr> <tr> <td>BGE</td> <td>Greater or equal</td> <td>$N \oplus V = 0$</td> </tr> <tr> <td>BLT</td> <td>Less than</td> <td>$N \oplus V = 1$</td> </tr> <tr> <td>BGT</td> <td>Greater than</td> <td>$Z \vee (N \oplus V) = 0$</td> </tr> <tr> <td>BLE</td> <td>Less or equal</td> <td>$Z \vee (N \oplus V) = 1$</td> </tr> </tbody> </table>	Mnemonic	Description	Condition	BRA (BT)	Always (true)	Always	BRN (BF)	Never (false)	Never	BHI	High	$C \vee Z = 0$	BLS	Low or same	$C \vee Z = 1$	BCC (BHS)	Carry clear (high or same)	$C = 0$	BCS (BLO)	Carry set (low)	$C = 1$	BNE	Not equal	$Z = 0$	BEQ	Equal	$Z = 1$	BVC	Overflow clear	$V = 0$	BVS	Overflow set	$V = 1$	BPL	Plus	$N = 0$	BMI	Minus	$N = 1$	BGE	Greater or equal	$N \oplus V = 0$	BLT	Less than	$N \oplus V = 1$	BGT	Greater than	$Z \vee (N \oplus V) = 0$	BLE	Less or equal	$Z \vee (N \oplus V) = 1$
Mnemonic	Description	Condition																																																			
BRA (BT)	Always (true)	Always																																																			
BRN (BF)	Never (false)	Never																																																			
BHI	High	$C \vee Z = 0$																																																			
BLS	Low or same	$C \vee Z = 1$																																																			
BCC (BHS)	Carry clear (high or same)	$C = 0$																																																			
BCS (BLO)	Carry set (low)	$C = 1$																																																			
BNE	Not equal	$Z = 0$																																																			
BEQ	Equal	$Z = 1$																																																			
BVC	Overflow clear	$V = 0$																																																			
BVS	Overflow set	$V = 1$																																																			
BPL	Plus	$N = 0$																																																			
BMI	Minus	$N = 1$																																																			
BGE	Greater or equal	$N \oplus V = 0$																																																			
BLT	Less than	$N \oplus V = 1$																																																			
BGT	Greater than	$Z \vee (N \oplus V) = 0$																																																			
BLE	Less or equal	$Z \vee (N \oplus V) = 1$																																																			
JMP	—	Branches unconditionally to a specified address																																																			
BSR	—	Branches to a subroutine at a specified address																																																			
JSR	—	Branches to a subroutine at a specified address																																																			
RTS	—	Returns from a subroutine																																																			

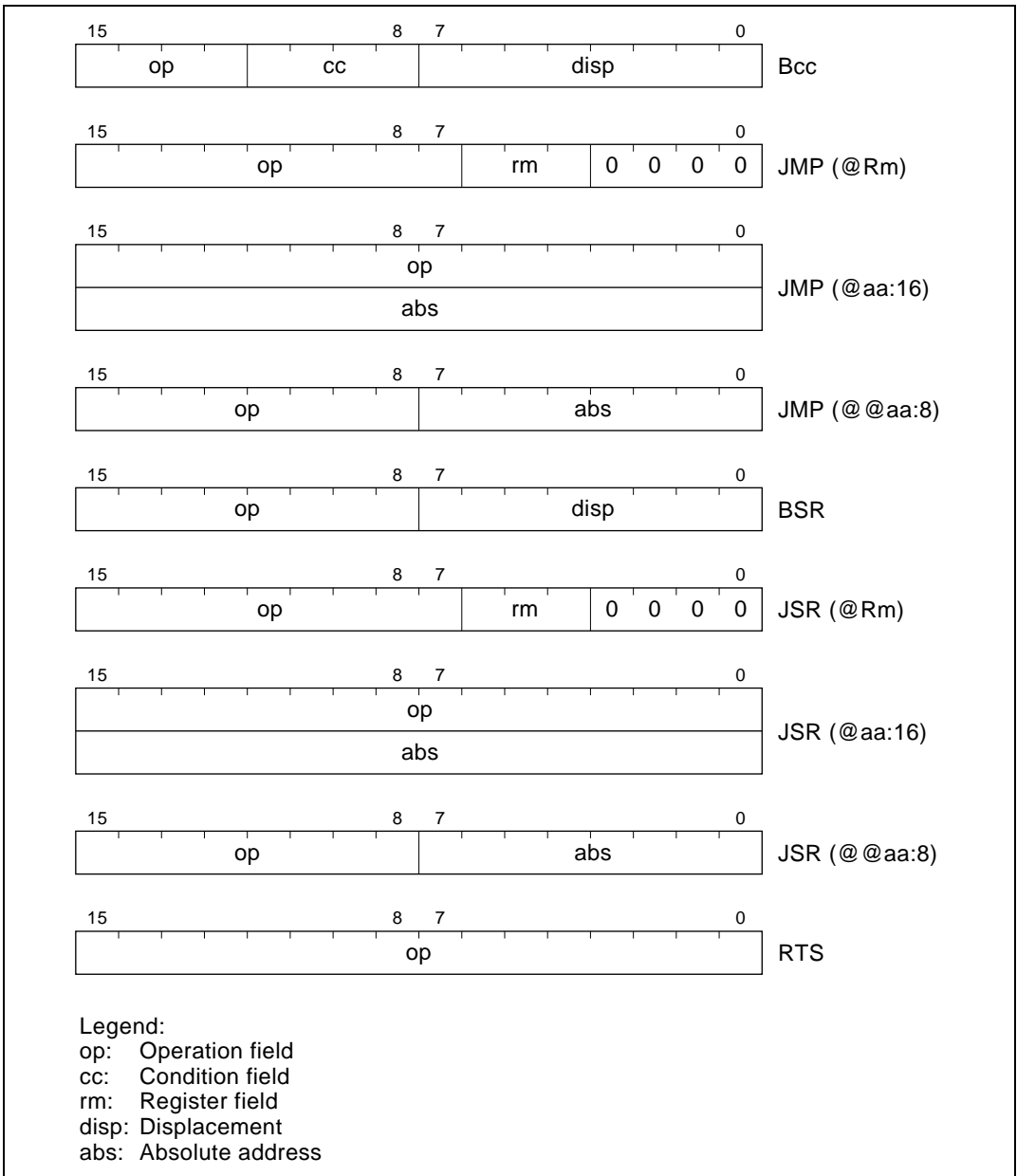


Figure 2.8 Branching Instruction Codes

2.5.7 System Control Instructions

Table 2.10 describes the system control instructions. Figure 2.9 shows their object code formats.

Table 2.10 System Control Instructions

Instruction	Size*	Function
RTE	—	Returns from an exception-handling routine
SLEEP	—	Causes a transition from active mode to a power-down mode. See section 5, Power-Down Modes, for details.
LDC	B	$R_s \rightarrow CCR$, $\#IMM \rightarrow CCR$ Moves immediate data or general register contents to the condition code register
STC	B	$CCR \rightarrow R_d$ Copies the condition code register to a specified general register
ANDC	B	$CCR \wedge \#IMM \rightarrow CCR$ Logically ANDs the condition code register with immediate data
ORC	B	$CCR \vee \#IMM \rightarrow CCR$ Logically ORs the condition code register with immediate data
XORC	B	$CCR \oplus \#IMM \rightarrow CCR$ Logically exclusive-ORs the condition code register with immediate data
NOP	—	$PC + 2 \rightarrow PC$ Only increments the program counter

Note: * Size: Operand size
B: Byte

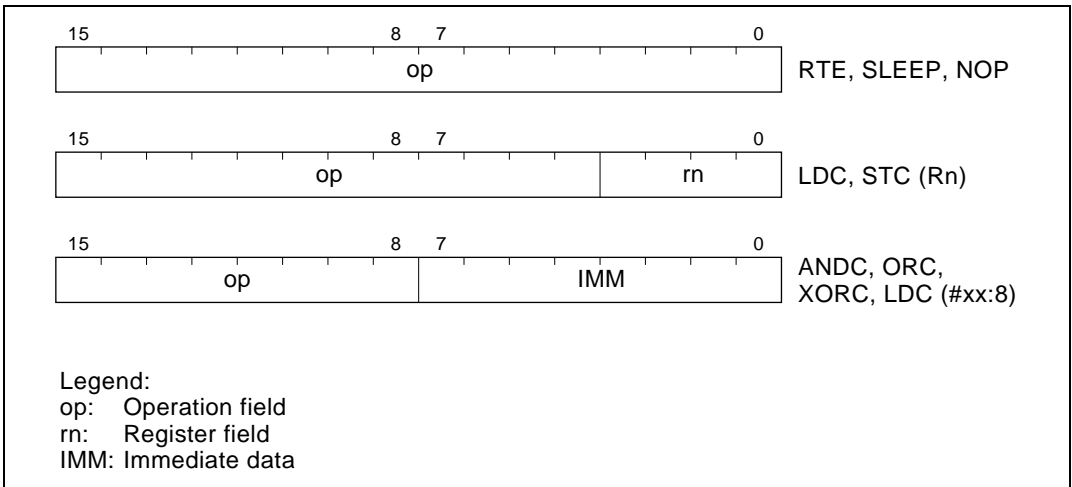


Figure 2.9 System Control Instruction Codes

2.5.8 Block Data Transfer Instruction

Table 2.11 describes the block data transfer instruction. Figure 2.10 shows its object code format.

Table 2.11 Block Data Transfer Instruction

Instruction	Size	Function
EPPMOV	—	<p>If R4L \neq 0 then</p> <p>repeat @R5+ \rightarrow @R6+ R4L - 1 \rightarrow R4L</p> <p>until R4L = 0</p> <p>else next;</p> <p>Block transfer instruction. Transfers the number of data bytes specified by R4L from locations starting at the address indicated by R5 to locations starting at the address indicated by R6. After the transfer, the next instruction is executed.</p>

Certain precautions are required in using the EPPMOV instruction. See section 2.9.3, Notes on Use of the EPPMOV Instruction, for details.

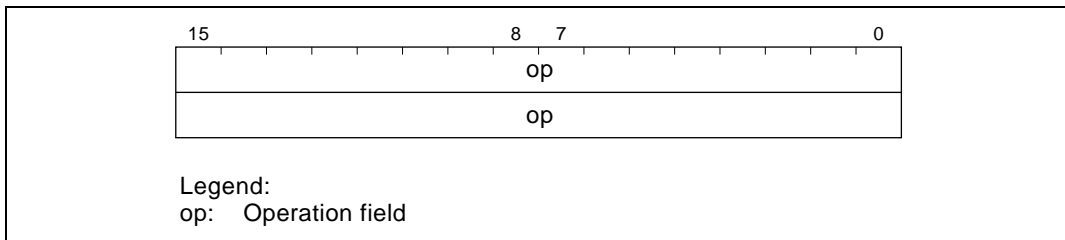


Figure 2.10 Block Data Transfer Instruction Code

2.6 Basic Operational Timing

CPU operation is synchronized by a system clock (ϕ) or a subclock (ϕ_{SUB}). For details on these clock signals see section 4, Clock Pulse Generators. The period from a rising edge of ϕ or ϕ_{SUB} to the next rising edge is called one state. A bus cycle consists of two states or three states. The cycle differs depending on whether access is to on-chip memory or to on-chip peripheral modules.

2.6.1 Access to On-Chip Memory (RAM, ROM)

Access to on-chip memory takes place in two states. The data bus width is 16 bits, allowing access in byte or word size. Figure 2.11 shows the on-chip memory access cycle.

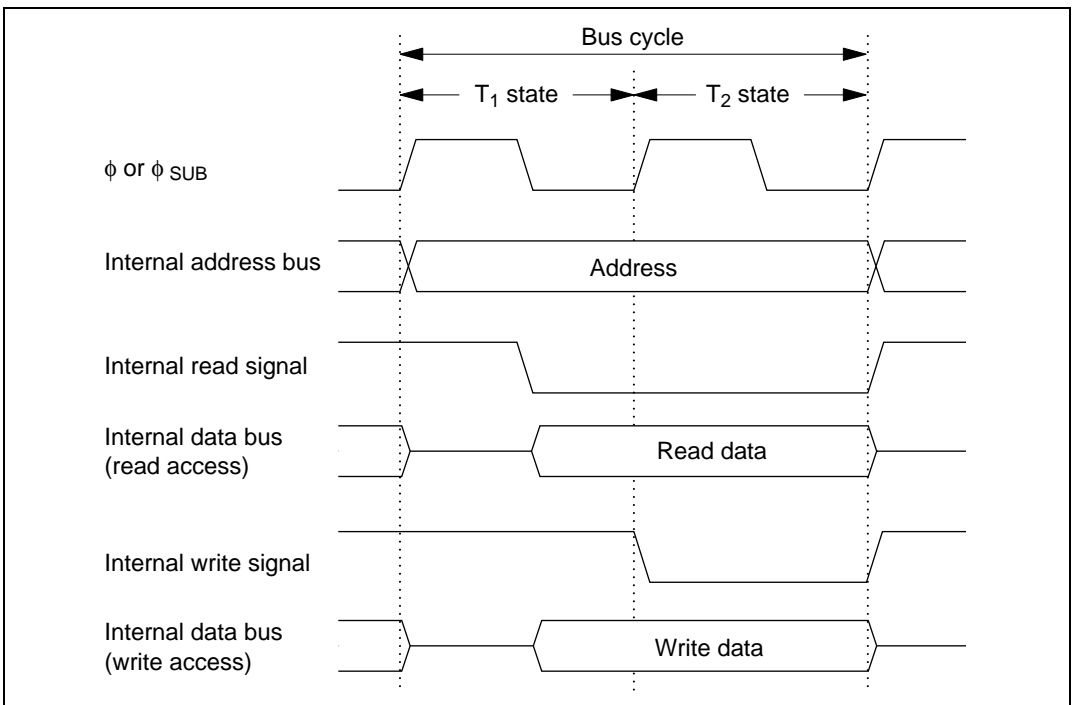


Figure 2.11 On-Chip Memory Access Cycle

2.6.2 Access to On-Chip Peripheral Modules

On-chip peripheral modules are accessed in two states or three states. The data bus width is 8 bits, so access is by byte size only. This means that for accessing word data, two instructions must be used. Figures 2.12 and 2.13 show the on-chip peripheral module access cycle.

Two-state access to on-chip peripheral modules

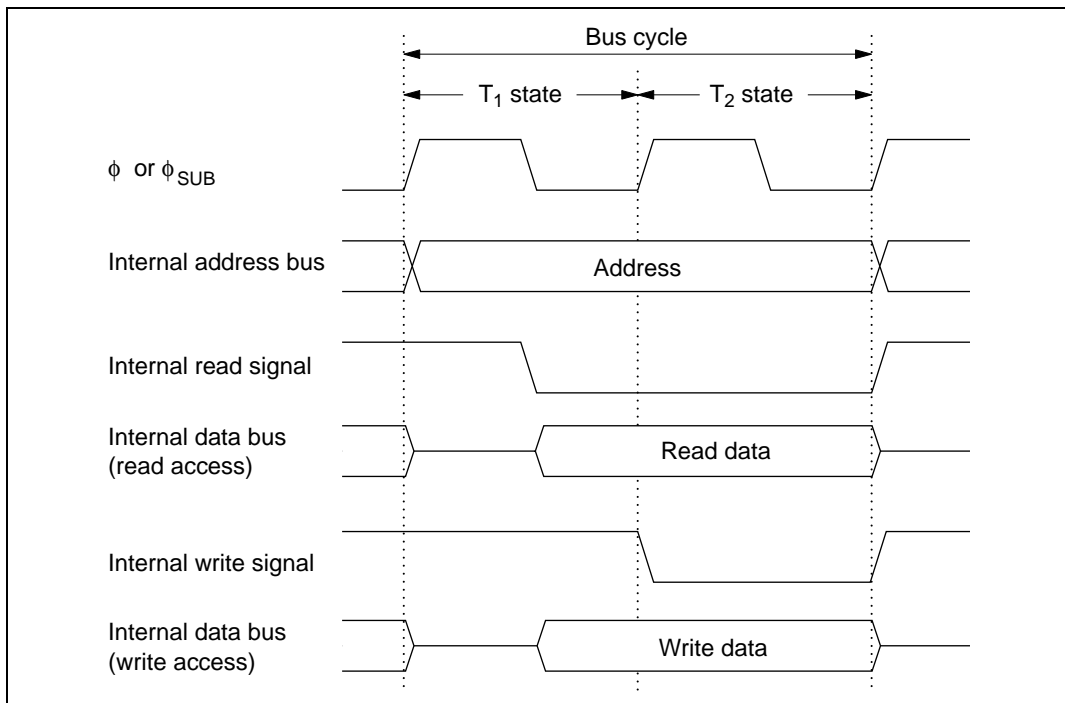


Figure 2.12 On-Chip Peripheral Module Access Cycle (2-State Access)

Three-state access to on-chip peripheral modules

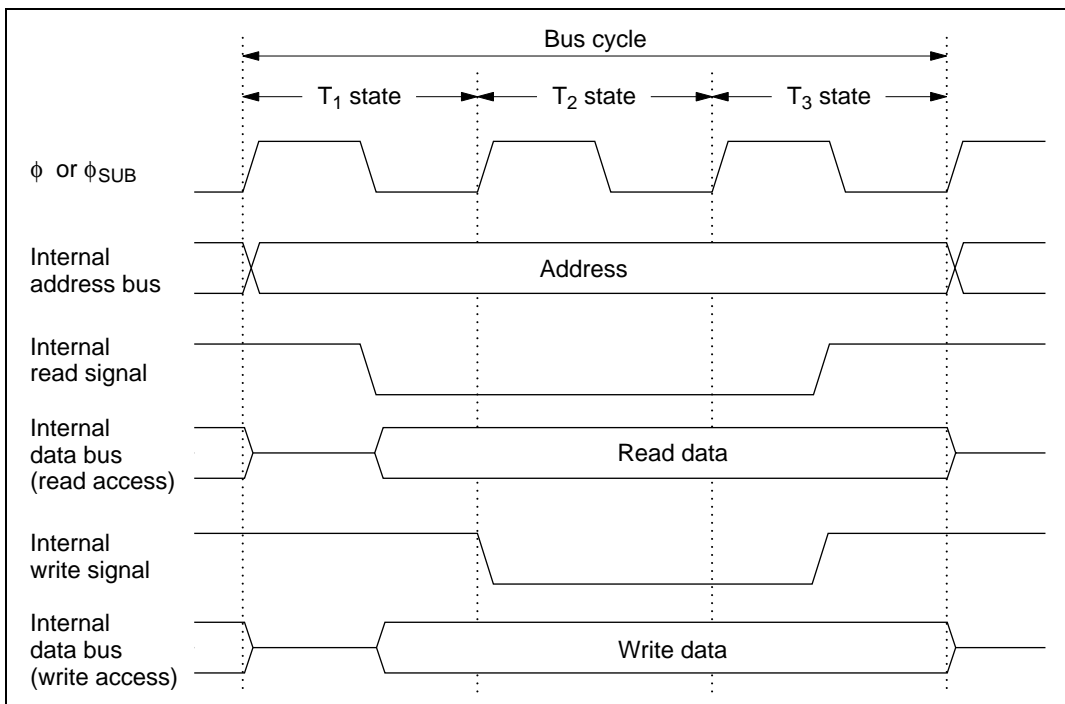


Figure 2.13 On-Chip Peripheral Module Access Cycle (3-State Access)

2.7 CPU States

2.7.1 Overview

There are four CPU states: the reset state, program execution state, program halt state, and exception-handling state. The program execution state includes active (high-speed or medium-speed) mode and subactive mode. In the program halt state there are a sleep (high-speed or medium-speed) mode, standby mode, watch mode, and sub-sleep mode. These states are shown in figure 2.14. Figure 2.15 shows the state transitions.

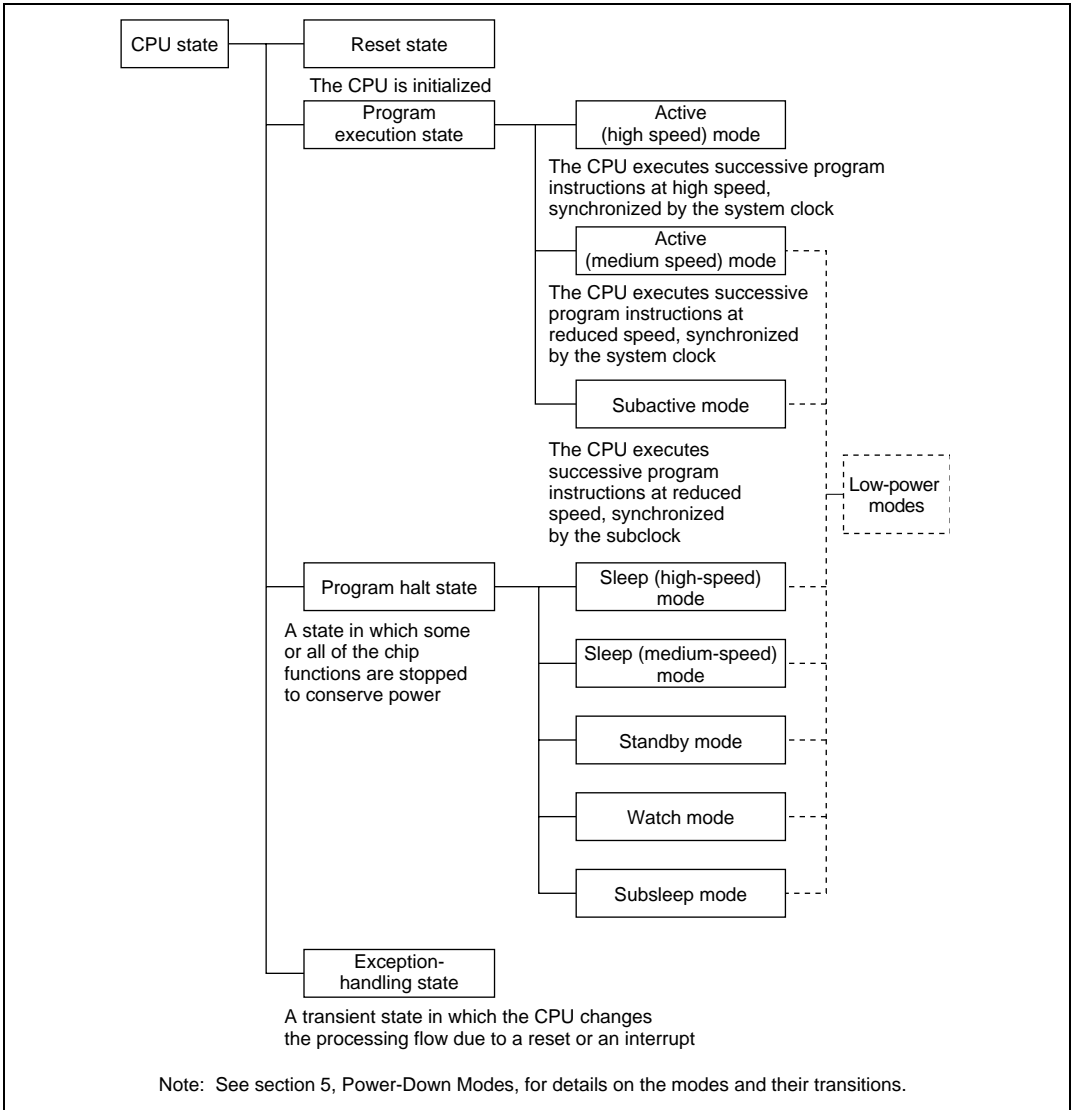


Figure 2.14 CPU Operation States

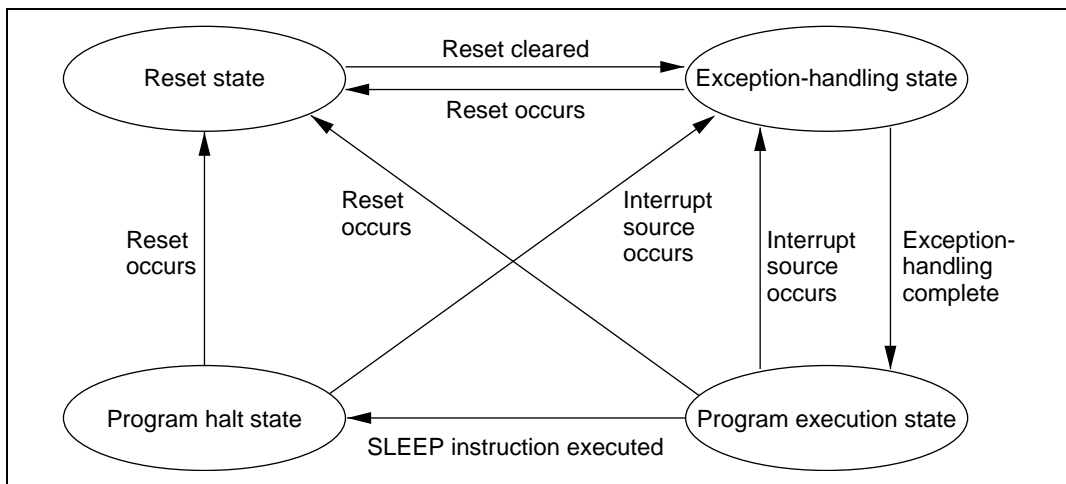


Figure 2.15 State Transitions

2.7.2 Program Execution State

In the program execution state the CPU executes program instructions in sequence.

There are three modes in this state, two active modes (high speed and medium speed) and one subactive mode. Operation is synchronized with the system clock in active mode (high speed and medium speed), and with the subclock in subactive mode. See section 5, Power-Down Modes for details on these modes.

2.7.3 Program Halt State

In the program halt state there are five modes: two sleep modes (high speed and medium speed), standby mode, watch mode, and subsleep mode. See section 5, Power-Down Modes for details on these modes.

2.7.4 Exception-Handling State

The exception-handling state is a transient state occurring when exception handling is started by a reset or interrupt and the CPU changes its normal processing flow. In exception handling caused by an interrupt, SP (R7) is referenced and the PC and CCR values are saved on the stack.

For details on interrupt handling, see section 3.3, Interrupts.

2.8 Memory Map

2.8.1 Memory Map

The memory map of the H8/3842R, H8/38342, and H8/38442 is shown in figure 2.16 (1), that of the H8/3843R, H8/38343, and H8/38443 in figure 2.16 (2), that of the H8/3844R, H8/3844S, H8/38344, and H8/38444 in figure 2.16 (3), that of the H8/3845R, H8/3845S, H8/38345, and H8/38445 in figure 2.16 (4), that of the H8/3846R, H8/3846S, H8/38346, and H8/38446 in figure 2.16 (5), and that of the H8/3847R, H8/3847S, H8/38347, and H8/38447 in figure 2.16 (6).

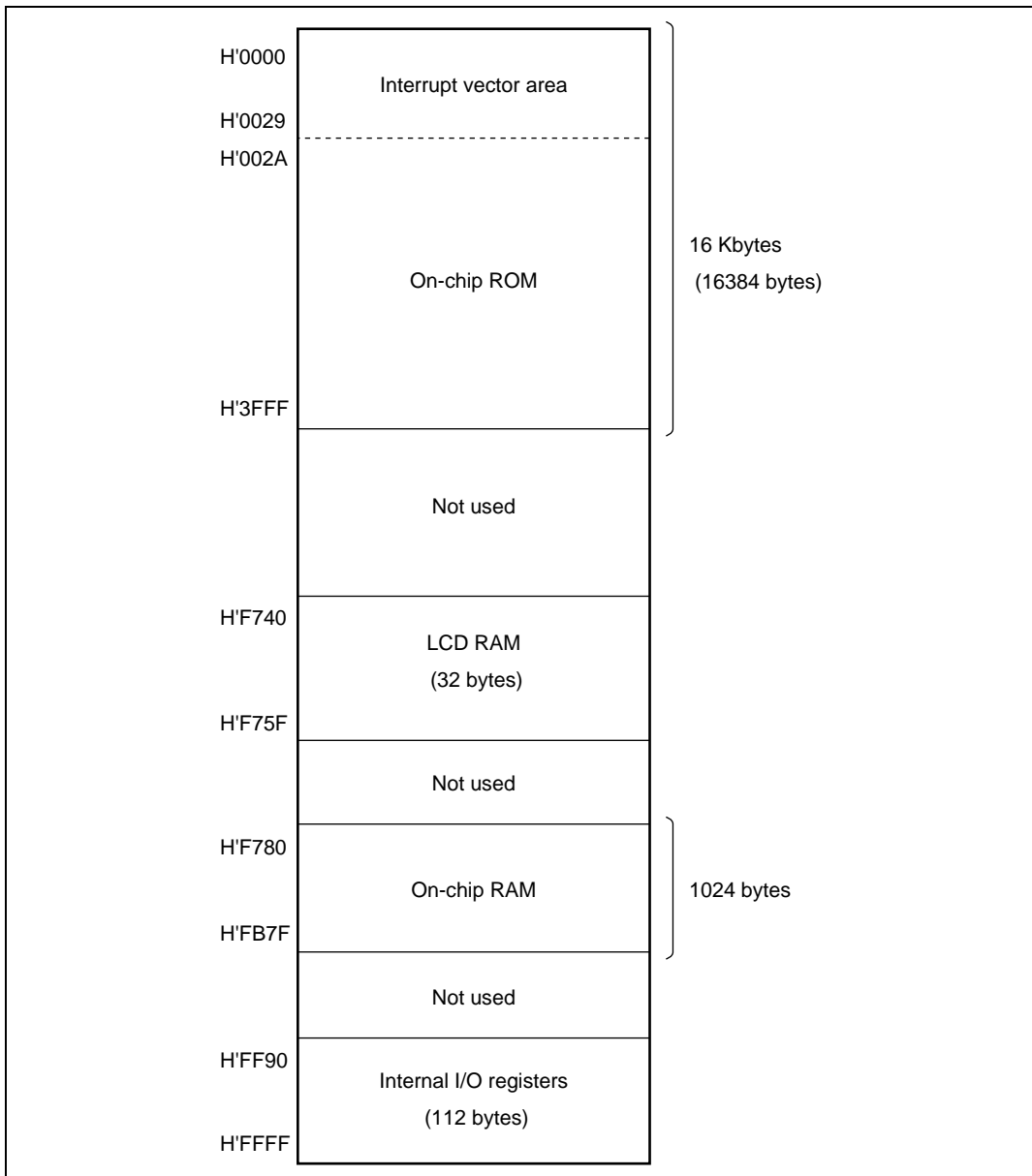


Figure 2.16 (1) H8/3842R, H8/38342 and H8/38442 Memory Map

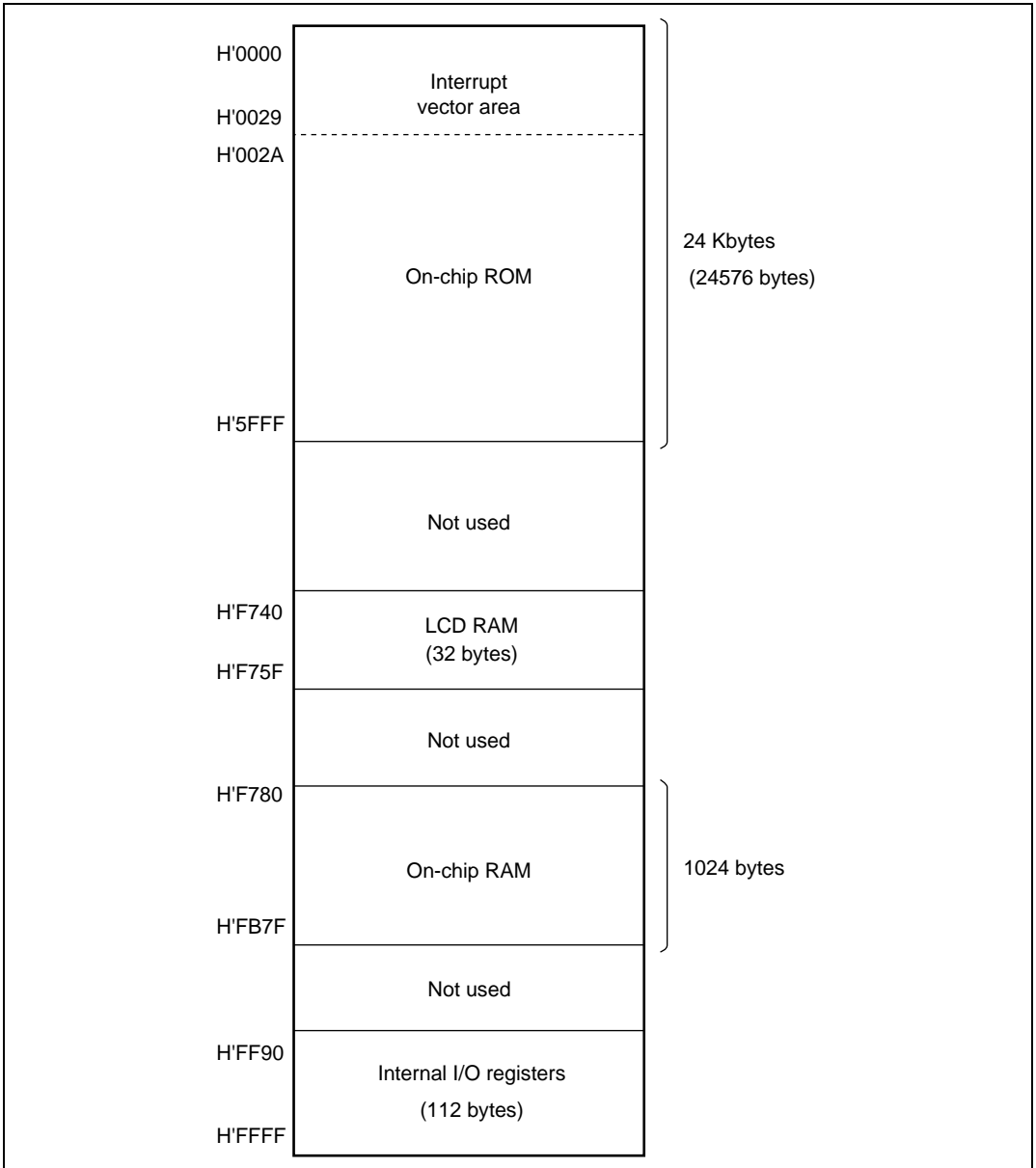


Figure 2.16 (2) H8/3843R, H8/38343 and H8/38443 Memory Map

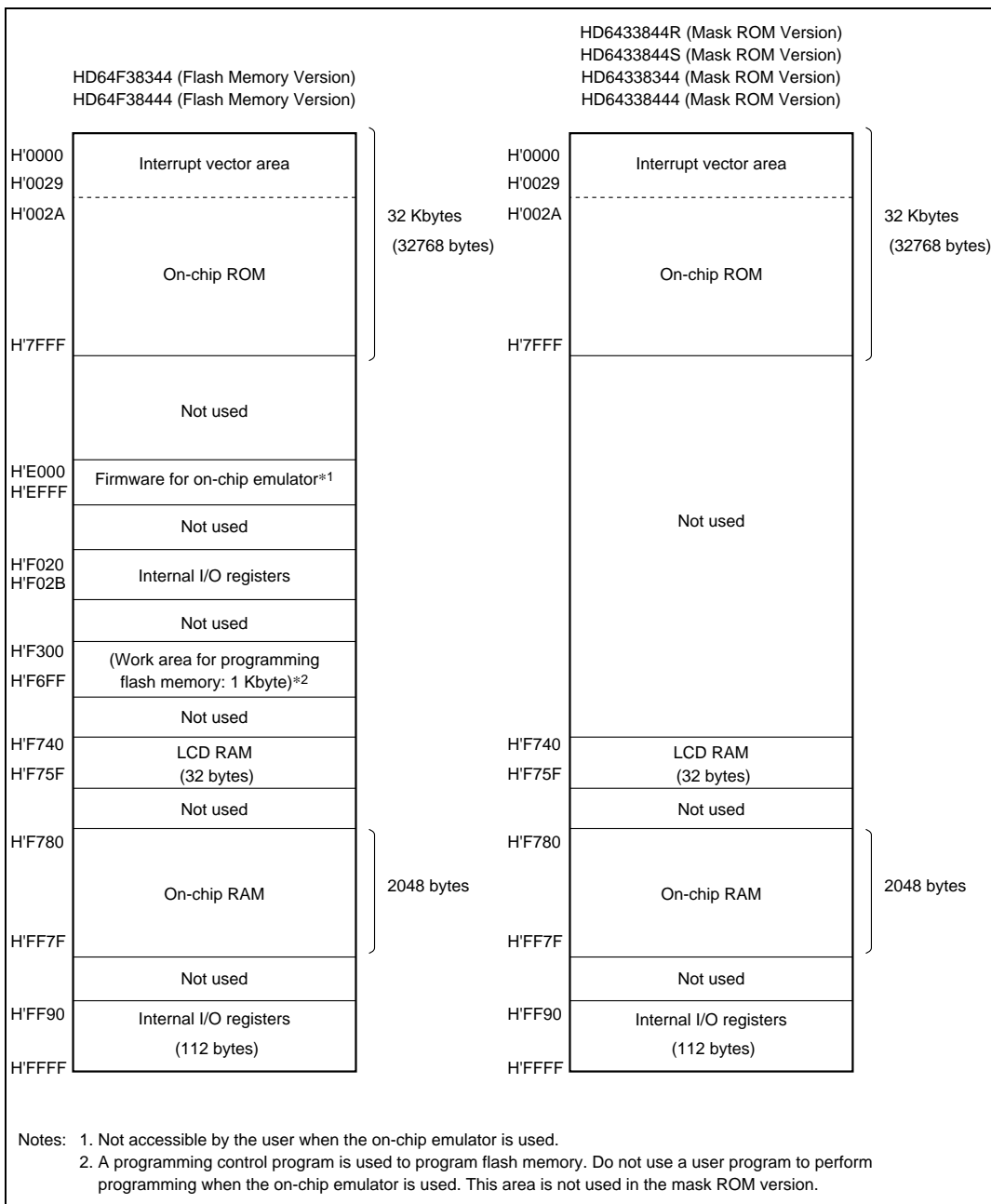


Figure 2.16 (3) H8/3844R, H8/3844S, H8/38344 and H8/38444 Memory Map

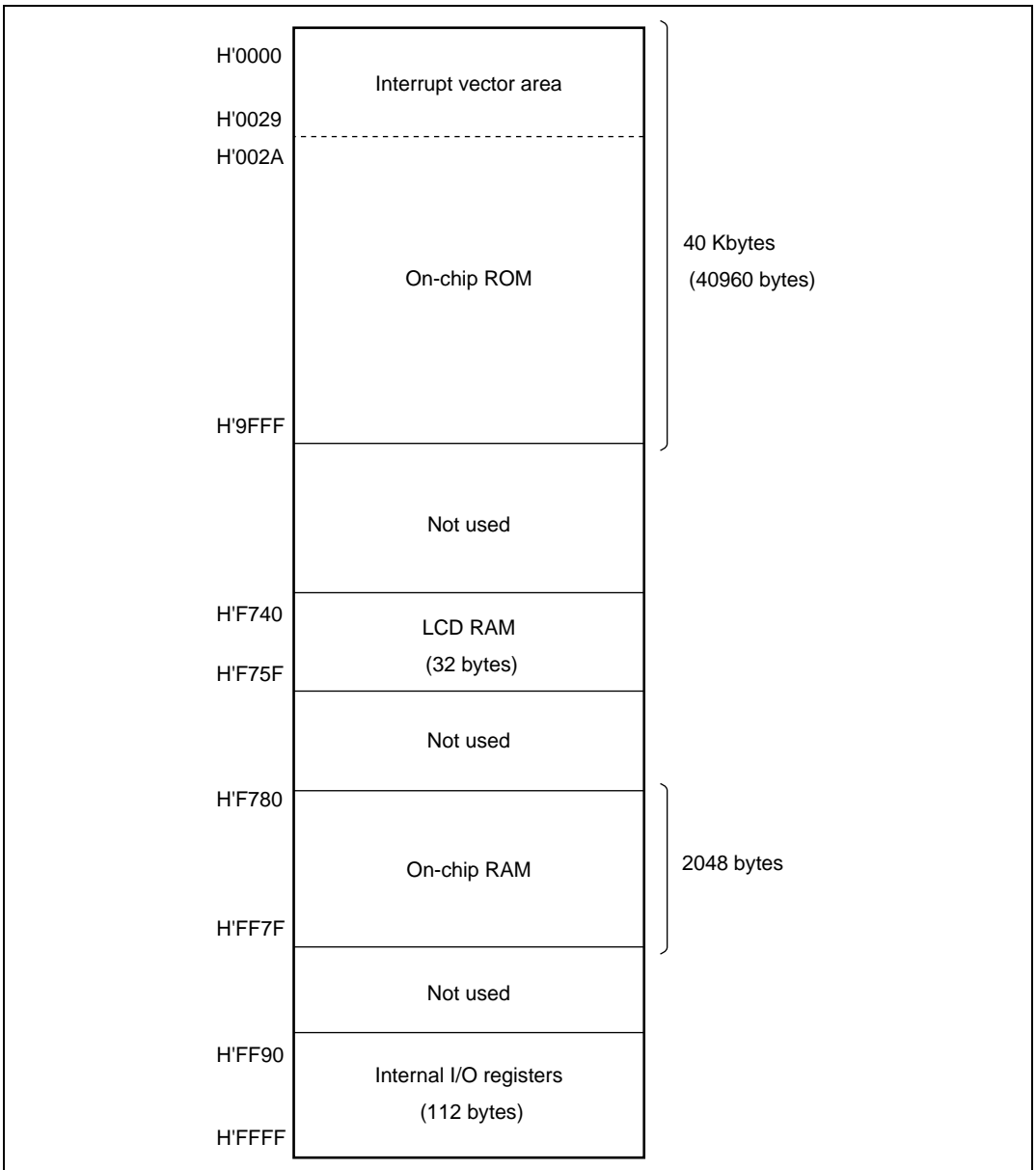


Figure 2.16 (4) H8/3845R, H8/3845S, H8/38345 and H8/38445 Memory Map

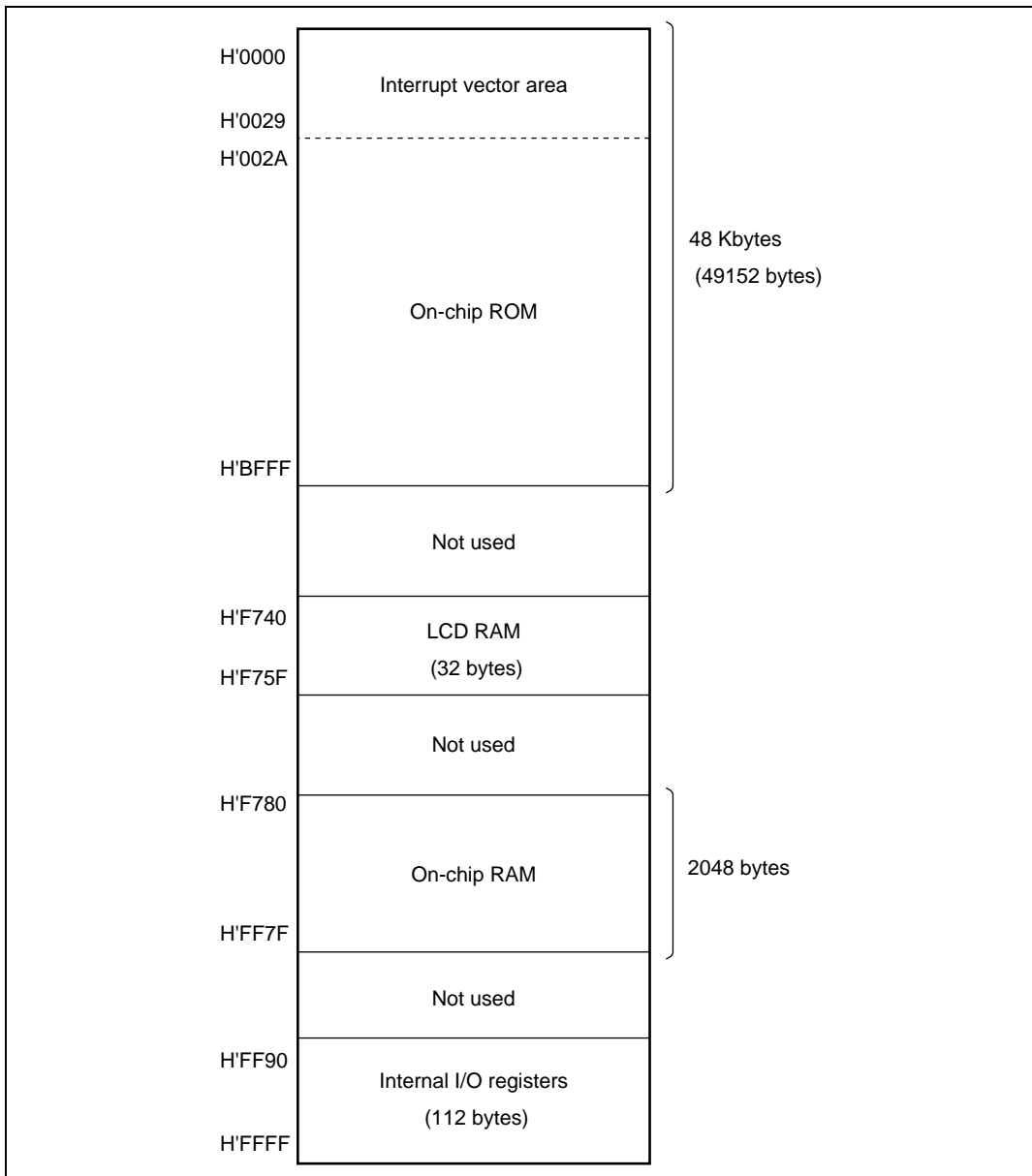


Figure 2.16 (5) H8/3846R, H8/3846S, H8/38346 and H8/38446 Memory Map

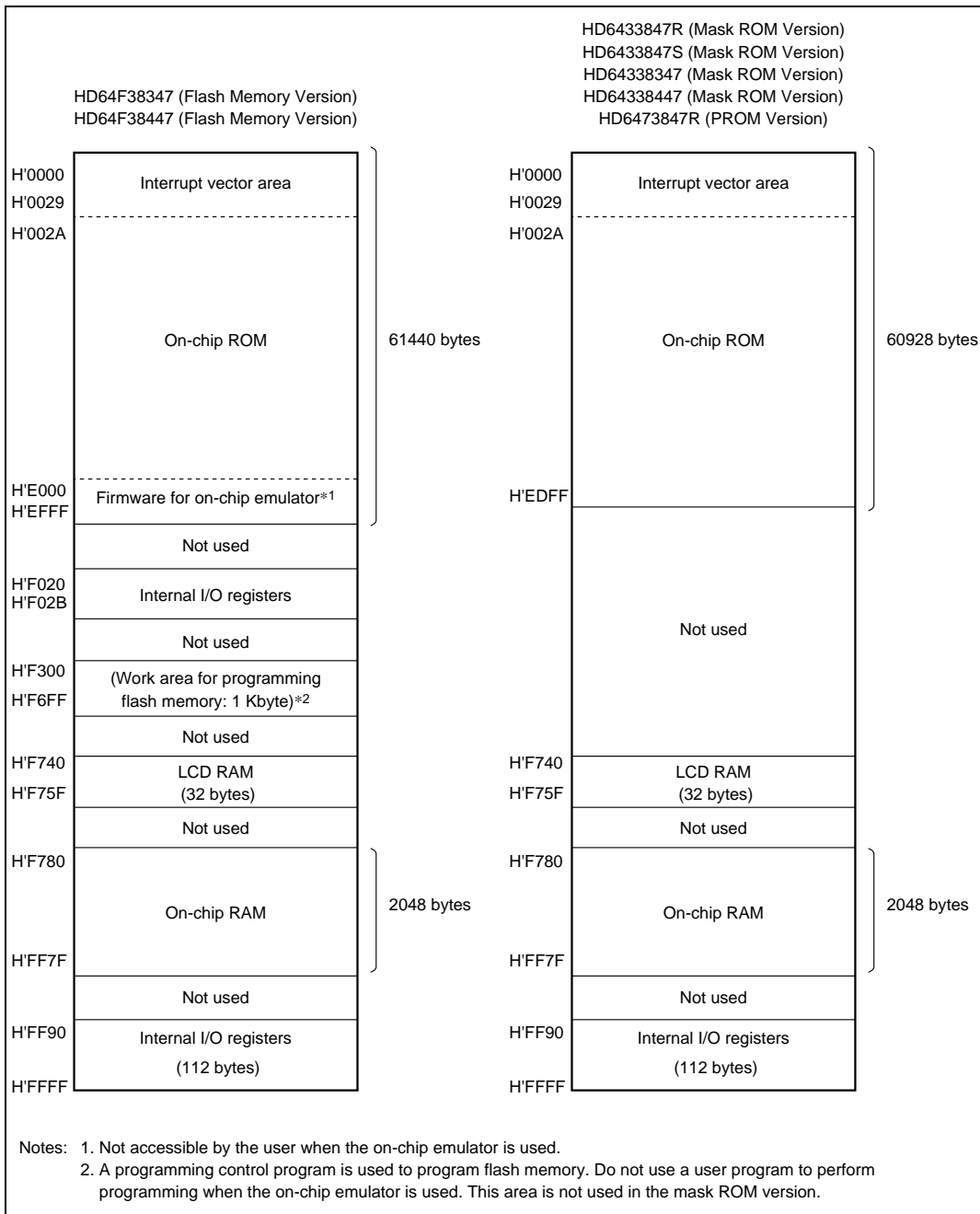


Figure 2.16 (6) H8/3847R, H8/3847S, H8/38347 and H8/38447 Memory Map

2.9 Application Notes

2.9.1 Notes on Data Access

1. Access to Empty Areas:

The address space of the H8/300L CPU includes empty areas in addition to the RAM, registers, and ROM areas available to the user. If these empty areas are mistakenly accessed by an application program, the following results will occur.

Data transfer from CPU to empty area:

The transferred data will be lost. This action may also cause the CPU to misoperate.

Data transfer from empty area to CPU:

Unpredictable data is transferred.

2. Access to Internal I/O Registers:

Internal data transfer to or from on-chip modules other than the ROM and RAM areas makes use of an 8-bit data width. If word access is attempted to these areas, the following results will occur.

Word access from CPU to I/O register area:

Upper byte: Will be written to I/O register.

Lower byte: Transferred data will be lost.

Word access from I/O register to CPU:

Upper byte: Will be written to upper part of CPU register.

Lower byte: Unpredictable data will be written to lower part of CPU register.

Byte size instructions should therefore be used when transferring data to or from I/O registers other than the on-chip ROM and RAM areas. Figure 2.17 shows the data size and number of states in which on-chip peripheral modules can be accessed.

		Access		States				
		Word	Byte					
H'0000	Interrupt vector area (42 bytes)	○	○	2				
H'0029								
H'002A	On-chip ROM	○	○	2				
H'7FFF								
					Not used	—	—	—
H'F740					LCD RAM (20 bytes)	○	○	2
H'F753	Not used	—	—	—				
H'F780	On-chip RAM	○	○	2				
H'FF7F								
	Not used	—	—	—				
H'FF90	Internal I/O registers (112 bytes)	×	○	2				
		H'FF98 to H'FF9F	×	○	3			
			×	○	2			
		H'FFA8 to H'FFAF	×	○	3			
H'FFFF		×	○	2				

Note: The H8/3844R, H8/3844S, H8/38344, and H8/38444 are shown as an example.

Figure 2.17 Data Size and Number of States for Access to and from On-Chip Peripheral Modules

2.9.2 Notes on Bit Manipulation

The BSET, BCLR, BNOT, BST, and BIST instructions read one byte of data, modify the data, then write the data byte again. Special care is required when using these instructions in cases where two registers are assigned to the same address, in the case of registers that include write-only bits, and when the instruction accesses an I/O port.

Order of Operation		Operation
1	Read	Read byte data at the designated address
2	Modify	Modify a designated bit in the read data
3	Write	Write the altered byte data to the designated address

1. Bit Manipulation in Two Registers Assigned to the Same Address

Example 1: timer load register and timer counter

Figure 2.18 shows an example in which two timer registers share the same address. When a bit manipulation instruction accesses the timer load register and timer counter of a reloadable timer, since these two registers share the same address, the following operations take place.

Order of Operation		Operation
1	Read	Timer counter data is read (one byte)
2	Modify	The CPU modifies (sets or resets) the bit designated in the instruction
3	Write	The altered byte data is written to the timer load register

The timer counter is counting, so the value read is not necessarily the same as the value in the timer load register. As a result, bits other than the intended bit in the timer load register may be modified to the timer counter value.

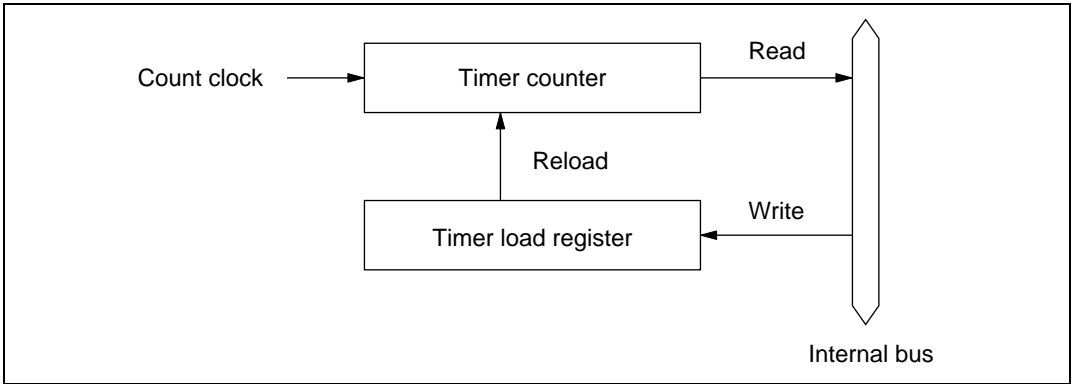


Figure 2.18 Timer Configuration Example

Example 2: BSET instruction executed designating port 3

$P3_7$ and $P3_6$ are designated as input pins, with a low-level signal input at $P3_7$ and a high-level signal at $P3_6$. The remaining pins, $P3_5$ to $P3_0$, are output pins and output low-level signals. In this example, the BSET instruction is used to change pin $P3_0$ to high-level output.

[A: Prior to executing BSET]

	P3₇	P3₆	P3₅	P3₄	P3₃	P3₂	P3₁	P3₀
Input/output	Input	Input	Output	Output	Output	Output	Output	Output
Pin state	Low level	High level	Low level	Low level	Low level	Low level	Low level	Low level
PCR3	0	0	1	1	1	1	1	1
PDR3	1	0	0	0	0	0	0	0

[B: BSET instruction executed]

```
BSET  #0 , @PDR3
```

The BSET instruction is executed designating port 3.

[C: After executing BSET]

	P3₇	P3₆	P3₅	P3₄	P3₃	P3₂	P3₁	P3₀
Input/output	Input	Input	Output	Output	Output	Output	Output	Output
Pin state	Low level	High level	Low level	Low level	Low level	Low level	Low level	High level
PCR3	0	0	1	1	1	1	1	1
PDR3	0	1	0	0	0	0	0	1

[D: Explanation of how BSET operates]

When the BSET instruction is executed, first the CPU reads port 3.

Since P3₇ and P3₆ are input pins, the CPU reads the pin states (low-level and high-level input). P3₅ to P3₀ are output pins, so the CPU reads the value in PDR3. In this example PDR3 has a value of H'80, but the value read by the CPU is H'40.

Next, the CPU sets bit 0 of the read data to 1, changing the PDR3 data to H'41. Finally, the CPU writes this value (H'41) to PDR3, completing execution of BSET.

As a result of this operation, bit 0 in PDR3 becomes 1, and P3₀ outputs a high-level signal. However, bits 7 and 6 of PDR3 end up with different values.

To avoid this problem, store a copy of the PDR3 data in a work area in memory. Perform the bit manipulation on the data in the work area, then write this data to PDR3.

[A: Prior to executing BSET]

```
MOV. B #H' 80 , R0L
MOV. B R0L , @RAM0
MOV. B R0L , @PDR3
```

The PDR3 value (H'80) is written to a work area in memory (RAM0) as well as to PDR3.

	P3₇	P3₆	P3₅	P3₄	P3₃	P3₂	P3₁	P3₀
Input/output	Input	Input	Output	Output	Output	Output	Output	Output
Pin state	Low level	High level	Low level	Low level	Low level	Low level	Low level	Low level
PCR3	0	0	1	1	1	1	1	1
PDR3	1	0	0	0	0	0	0	0
RAM0	1	0	0	0	0	0	0	0

[B: BSET instruction executed]

BSET	#0	,	@RAM0
------	----	---	-------

The BSET instruction is executed designating the PDR3 work area (RAM0).

[C: After executing BSET]

MOV. B	@RAM0,	R0L
MOV. B	R0L,	@PDR3

The work area (RAM0) value is written to PDR3.

	P3 ₇	P3 ₆	P3 ₅	P3 ₄	P3 ₃	P3 ₂	P3 ₁	P3 ₀
Input/output	Input	Input	Output	Output	Output	Output	Output	Output
Pin state	Low level	High level	Low level	Low level	Low level	Low level	Low level	High level
PCR3	0	0	1	1	1	1	1	1
PDR3	1	0	0	0	0	0	0	1
RAM0	1	0	0	0	0	0	0	1

2. Bit Manipulation in a Register Containing a Write-only Bit

Example 3: BCLR instruction executed designating port 3 control register PCR3

As in the examples above, P3₇ and P3₆ are input pins, with a low-level signal input at P3₇ and a high-level signal at P3₆. The remaining pins, P3₅ to P3₀, are output pins that output low-level signals. In this example, the BCLR instruction is used to change pin P3₀ to an input port. It is assumed that a high-level signal will be input to this input pin.

[A: Prior to executing BCLR]

	P3 ₇	P3 ₆	P3 ₅	P3 ₄	P3 ₃	P3 ₂	P3 ₁	P3 ₀
Input/output	Input	Input	Output	Output	Output	Output	Output	Output
Pin state	Low level	High level	Low level	Low level	Low level	Low level	Low level	Low level
PCR3	0	0	1	1	1	1	1	1
PDR3	1	0	0	0	0	0	0	0

[B: BCLR instruction executed]

```
BSET    #0    ,    @PCR3
```

The BCLR instruction is executed designating PCR3.

[C: After executing BCLR]

	P3₇	P3₆	P3₅	P3₄	P3₃	P3₂	P3₁	P3₀
Input/output	Output	Output	Output	Output	Output	Output	Output	Input
Pin state	Low level	High level	Low level	Low level	Low level	Low level	Low level	High level
PCR3	1	1	1	1	1	1	1	0
PDR3	1	0	0	0	0	0	0	0

[D: Explanation of how BCLR operates]

When the BCLR instruction is executed, first the CPU reads PCR3. Since PCR3 is a write-only register, the CPU reads a value of H'FF, even though the PCR3 value is actually H'3F.

Next, the CPU clears bit 0 in the read data to 0, changing the data to H'FE. Finally, this value (H'FE) is written to PCR3 and BCLR instruction execution ends.

As a result of this operation, bit 0 in PCR3 becomes 0, making P3₀ an input port. However, bits 7 and 6 in PCR3 change to 1, so that P3₇ and P3₆ change from input pins to output pins.

To avoid this problem, store a copy of the PCR3 data in a work area in memory. Perform the bit manipulation on the data in the work area, then write this data to PCR3.

[A: Prior to executing BCLR]

```
MOV. B  #H'3F  ,  R0L
MOV. B  R0L    ,  @RAM0
MOV. B  R0L    ,  @PCR3
```

The PCR3 value (H'3F) is written to a work area in memory (RAM0) as well as to PCR3.

	P3₇	P3₆	P3₅	P3₄	P3₃	P3₂	P3₁	P3₀
Input/output	Input	Input	Output	Output	Output	Output	Output	Output
Pin state	Low level	High level	Low level	Low level	Low level	Low level	Low level	Low level
PCR3	0	0	1	1	1	1	1	1
PDR3	1	0	0	0	0	0	0	0
RAM0	0	0	1	1	1	1	1	1

[B: BCLR instruction executed]

BCLR	#0	,	@RAM0
------	----	---	-------

The BCLR instruction is executed designating the PCR3 work area (RAM0).

[C: After executing BCLR]

MOV. B	@RAM0,	R0L
MOV. B	R0L,	@PCR3

The work area (RAM0) value is written to PCR3.

	P3 ₇	P3 ₆	P3 ₅	P3 ₄	P3 ₃	P3 ₂	P3 ₁	P3 ₀
Input/output	Input	Input	Output	Output	Output	Output	Output	Output
Pin state	Low level	High level	Low level	Low level	Low level	Low level	Low level	High level
PCR3	0	0	1	1	1	1	1	0
PDR3	1	0	0	0	0	0	0	0
RAM0	0	0	1	1	1	1	1	0

Table 2.12 lists the pairs of registers that share identical addresses. Table 2.13 lists the registers that contain write-only bits.

Table 2.12 Registers with Shared Addresses

Register Name	Abbr.	Address
Timer counter and timer load register C	TCC/TLC	H'FFB5
Port data register 1*	PDR1	H'FFD4
Port data register 2*	PDR2	H'FFD5
Port data register 3*	PDR3	H'FFD6
Port data register 4*	PDR4	H'FFD7
Port data register 5*	PDR5	H'FFD8
Port data register 6*	PDR6	H'FFD9
Port data register 7*	PDR7	H'FFDA
Port data register 8*	PDR8	H'FFDB
Port data register 9*	PDR9	H'FFDC
Port data register A*	PDRA	H'FFDD

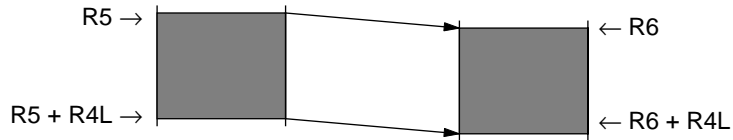
Note: * Port data registers have the same addresses as input pins.

Table 2.13 Registers with Write-Only Bits

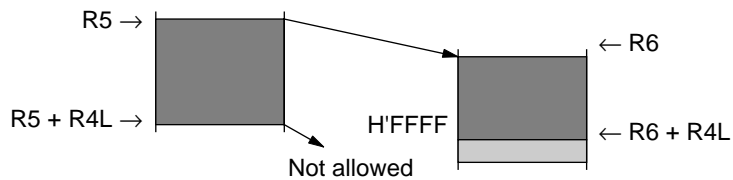
Register Name	Abbr.	Address
Port control register 1	PCR1	H'FFE4
Port control register 2	PCR2	H'FFE5
Port control register 3	PCR3	H'FFE6
Port control register 4	PCR4	H'FFE7
Port control register 5	PCR5	H'FFE8
Port control register 6	PCR6	H'FFE9
Port control register 7	PCR7	H'FFEA
Port control register 8	PCR8	H'FFEB
Port control register 9	PCR9	H'FFEC
Port control register A	PCRA	H'FFED
Timer control register F	TCRF	H'FFB6
PWM control register	PWCR	H'FFD0
PWM data register U	PWDRU	H'FFD1
PWM data register L	PWDL	H'FFD2

2.9.3 Notes on Use of the EEPMOV Instruction

- The EEPMOV instruction is a block data transfer instruction. It moves the number of bytes specified by R4L from the address specified by R5 to the address specified by R6.



- When setting R4L and R6, make sure that the final destination address (R6 + R4L) does not exceed H'FFFF. The value in R6 must not change from H'FFFF to H'0000 during execution of the instruction.



Section 3 Exception Handling

3.1 Overview

Exception handling is performed in the H8/3847R Group when a reset or interrupt occurs. Table 3.1 shows the priorities of these two types of exception handling.

Table 3.1 Exception Handling Types and Priorities

Priority	Exception Source	Time of Start of Exception Handling
High	Reset	Exception handling starts as soon as the reset state is cleared
↑	Interrupt	When an interrupt is requested, exception handling starts after execution of the present instruction or the exception handling in progress is completed
Low		

3.2 Reset

3.2.1 Overview

A reset is the highest-priority exception. The internal state of the CPU and the registers of the on-chip peripheral modules are initialized.

3.2.2 Reset Sequence

As soon as the $\overline{\text{RES}}$ pin goes low, all processing is stopped and the chip enters the reset state.

To make sure the chip is reset properly, observe the following precautions.

- At power on: Hold the $\overline{\text{RES}}$ pin low until the clock pulse generator output stabilizes.
- Resetting during operation: Hold the $\overline{\text{RES}}$ pin low for at least 10 system clock cycles.

Reset exception handling takes place as follows.

- The CPU internal state and the registers of on-chip peripheral modules are initialized, with the I bit of the condition code register (CCR) set to 1.
- The PC is loaded from the reset exception handling vector address (H'0000 to H'0001), after which the program starts executing from the address indicated in PC.

When system power is turned on or off, the $\overline{\text{RES}}$ pin should be held low.

Figure 3.1 shows the reset sequence starting from $\overline{\text{RES}}$ input.

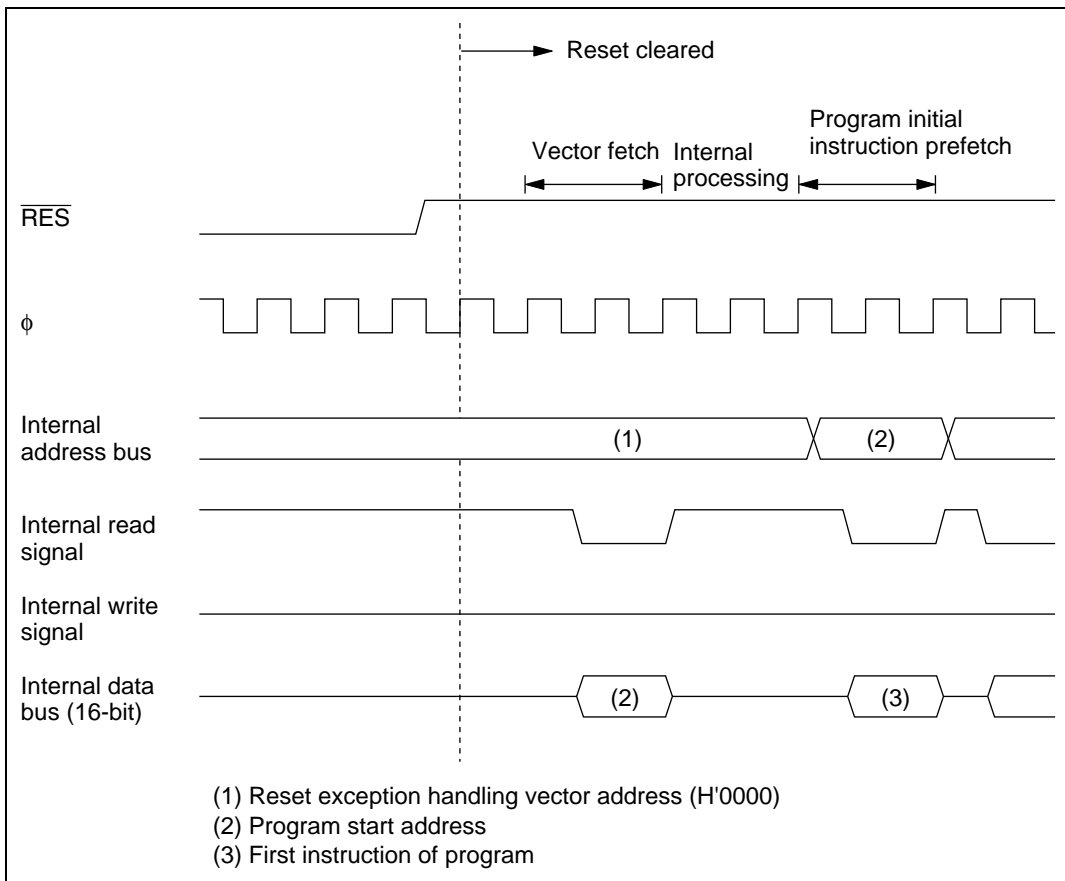


Figure 3.1 Reset Sequence

3.2.3 Interrupt Immediately after Reset

After a reset, if an interrupt were to be accepted before the stack pointer (SP: R7) was initialized, PC and CCR would not be pushed onto the stack correctly, resulting in program runaway. To prevent this, immediately after reset exception handling all interrupts are masked. For this reason, the initial program instruction is always executed immediately after a reset. This instruction should initialize the stack pointer (e.g. `MOV.W #xx: 16, SP`).

3.3 Interrupts

3.3.1 Overview

The interrupt sources include 13 external interrupts (IRQ₄ to IRQ₀, WKP₇ to WKP₀) and 24 internal interrupts from on-chip peripheral modules. Table 3.2 shows the interrupt sources, their priorities, and their vector addresses. When more than one interrupt is requested, the interrupt with the highest priority is processed.

The interrupts have the following features:

- Internal and external interrupts can be masked by the I bit in CCR. When the I bit is set to 1, interrupt request flags can be set but the interrupts are not accepted.
- IRQ₄ to IRQ₀ and WKP₇ to WKP₀ can be set to either rising edge sensing or falling edge sensing.

Table 3.2 Interrupt Sources and Their Priorities

Interrupt Source	Interrupt	Vector Number	Vector Address	Priority
RES	Reset	0	H'0000 to H'0001	High
Watchdog timer				↑ ↓ Low
IRQ ₀	IRQ ₀	4	H'0008 to H'0009	
IRQ ₁	IRQ ₁	5	H'000A to H'000B	
IRQ ₂	IRQ ₂	6	H'000C to H'000D	
IRQ ₃	IRQ ₃	7	H'000E to H'000F	
IRQ ₄	IRQ ₄	8	H'0010 to H'0011	
WKP ₀	WKP ₀	9	H'0012 to H'0013	
WKP ₁	WKP ₁			
WKP ₂	WKP ₂			
WKP ₃	WKP ₃			
WKP ₄	WKP ₄			
WKP ₅	WKP ₅			
WKP ₆	WKP ₆			
WKP ₇	WKP ₇			
SCI1	SCI1 transfer complete	10	H'0014 to H'0015	
Timer A	Timer A overflow	11	H'0016 to H'0017	
Asynchronous counter	Asynchronous counter overflow	12	H'0018 to H'0019	
Timer C	Timer C overflow or underflow	13	H'001A to H'001B	
Timer FL	Timer FL compare match Timer FL overflow	14	H'001C to H'001D	
Timer FH	Timer FH compare match Timer FH overflow	15	H'001E to H'001F	
Timer G	Timer G input capture Timer G overflow	16	H'0020 to H'0021	
SCI3-1	SCI3-1 transmit end SCI3-1 transmit data empty SCI3-1 receive data full SCI3-1 overrun error SCI3-1 framing error SCI3-1 parity error	17	H'0022 to H'0023	
SCI3-2	SCI3-2 transmit end SCI3-2 transmit data empty SCI3-2 receive data full SCI3-2 overrun error SCI3-2 framing error SCI3-2 parity error	18	H'0024 to H'0025	
A/D	A/D conversion end	19	H'0026 to H'0027	
(SLEEP instruction executed)	Direct transfer	20	H'0028 to H'0029	

Note: Vector addresses H'0002 to H'0007 are reserved and cannot be used.

3.3.2 Interrupt Control Registers

Table 3.3 lists the registers that control interrupts.

Table 3.3 Interrupt Control Registers

Name	Abbreviation	R/W	Initial Value	Address
IRQ edge select register	IEGR	R/W	H'E0	H'FFF2
Interrupt enable register 1	IENR1	R/W	H'00	H'FFF3
Interrupt enable register 2	IENR2	R/W	H'00	H'FFF4
Interrupt request register 1	IRR1	R/W*	H'20	H'FFF6
Interrupt request register 2	IRR2	R/W*	H'00	H'FFF7
Wakeup interrupt request register	IWPR	R/W*	H'00	H'FFF9
Wakeup edge select register	WEGR	R/W	H'00	H'FF90

Note: * Write is enabled only for writing of 0 to clear a flag.

1. IRQ Edge Select Register (IEGR)

Bit	7	6	5	4	3	2	1	0
	—	—	—	IEG4	IEG3	IEG2	IEG1	IEG0
Initial value	1	1	1	0	0	0	0	0
Read/Write	—	—	—	R/W	R/W	R/W	R/W	R/W

IEGR is an 8-bit read/write register used to designate whether pins $\overline{\text{IRQ}}_4$ to $\overline{\text{IRQ}}_0$ are set to rising edge sensing or falling edge sensing.

Bits 7 to 5: Reserved bits

Bits 7 to 5 are reserved: they are always read as 1 and cannot be modified.

Bit 4: IRQ_4 edge select (IEG4)

Bit 4 selects the input sensing of the $\overline{\text{IRQ}}_4$ pin and $\overline{\text{ADTRG}}$ pin.

Bit 4

IEG4	Description
0	Falling edge of $\overline{\text{IRQ}}_4$ and $\overline{\text{ADTRG}}$ pin input is detected (initial value)
1	Rising edge of $\overline{\text{IRQ}}_4$ and $\overline{\text{ADTRG}}$ pin input is detected

Bit 3: IRQ₃ edge select (IEG3)

Bit 3 selects the input sensing of the $\overline{\text{IRQ}}_3$ pin and TMIF pin.

Bit 3

IEG3	Description	
0	Falling edge of $\overline{\text{IRQ}}_3$ and TMIF pin input is detected	(initial value)
1	Rising edge of $\overline{\text{IRQ}}_3$ and TMIF pin input is detected	

Bit 2: IRQ₂ edge select (IEG2)

Bit 2 selects the input sensing of pin $\overline{\text{IRQ}}_2$.

Bit 2

IEG2	Description	
0	Falling edge of $\overline{\text{IRQ}}_2$ pin input is detected	(initial value)
1	Rising edge of $\overline{\text{IRQ}}_2$ pin input is detected	

Bit 1: IRQ₁ edge select (IEG1)

Bit 3 selects the input sensing of the $\overline{\text{IRQ}}_1$ pin and TMIC pin.

Bit 1

IEG1	Description	
0	Falling edge of $\overline{\text{IRQ}}_1$ and TMIC pin input is detected	(initial value)
1	Rising edge of $\overline{\text{IRQ}}_1$ and TMIC pin input is detected	

Bit 0: IRQ₀ edge select (IEG0)

Bit 0 selects the input sensing of pin $\overline{\text{IRQ}}_0$.

Bit 0

IEG0	Description	
0	Falling edge of $\overline{\text{IRQ}}_0$ pin input is detected	(initial value)
1	Rising edge of $\overline{\text{IRQ}}_0$ pin input is detected	

2. Interrupt Enable Register 1 (IENR1)

Bit	7	6	5	4	3	2	1	0
	IENTA	IENS1	IENWP	IEN4	IEN3	IEN2	IEN1	IEN0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

IENR1 is an 8-bit read/write register that enables or disables interrupt requests.

Bit 7: Timer A interrupt enable (IENTA)

Bit 7 enables or disables timer A overflow interrupt requests.

Bit 7

IENTA	Description
0	Disables timer A interrupt requests (initial value)
1	Enables timer A interrupt requests

Bit 6: SCI1 interrupt enable (IENS1)

Bit 6 enables or disables SCI1 transfer complete interrupt requests.

Bit 6

IENS1	Description
0	Disables SCI1 interrupt requests (initial value)
1	Enables SCI1 interrupt requests

Bit 5: Wakeup interrupt enable (IENWP)

Bit 5 enables or disables \overline{WKP}_7 to \overline{WKP}_0 interrupt requests.

Bit 5

IENWP	Description
0	Disables \overline{WKP}_7 to \overline{WKP}_0 interrupt requests (initial value)
1	Enables \overline{WKP}_7 to \overline{WKP}_0 interrupt requests

Bits 4 to 0: IRQ₄ to IRQ₀ interrupt enable (IEN₄ to IEN₀)

Bits 4 to 0 enable or disable IRQ₄ to IRQ₀ interrupt requests.

Bit n

IEN _n	Description	
0	Disables interrupt requests from pin $\overline{\text{IRQ}}_n$	(initial value)
1	Enables interrupt requests from pin $\overline{\text{IRQ}}_n$	

(n = 4 to 0)

3. Interrupt Enable Register 2 (IENR2)

Bit	7	6	5	4	3	2	1	0
	IENDT	IENAD	—	IENTG	IENTFH	IENTFL	IENTC	IENEC
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

IENR2 is an 8-bit read/write register that enables or disables interrupt requests.

Bit 7: Direct transfer interrupt enable (IENDT)

Bit 7 enables or disables direct transfer interrupt requests.

Bit 7

IENDT	Description	
0	Disables direct transfer interrupt requests	(initial value)
1	Enables direct transfer interrupt requests	

Bit 6: A/D converter interrupt enable (IENAD)

Bit 6 enables or disables A/D converter interrupt requests.

Bit 6

IENAD	Description	
0	Disables A/D converter interrupt requests	(initial value)
1	Enables A/D converter interrupt requests	

Bit 5: Reserved bit

Bit 5 is a readable/writable reserved bit. It is initialized to 0 by a reset.

Bit 4: Timer G interrupt enable (IENTG)

Bit 4 enables or disables timer G input capture or overflow interrupt requests.

Bit 4

IENTG	Description	
0	Disables timer G interrupt requests	(initial value)
1	Enables timer G interrupt requests	

Bit 3: Timer FH interrupt enable (IENTFH)

Bit 3 enables or disables timer FH compare match and overflow interrupt requests.

Bit 3

IENTFH	Description	
0	Disables timer FH interrupt requests	(initial value)
1	Enables timer FH interrupt requests	

Bit 2: Timer FL interrupt enable (IENTFL)

Bit 2 enables or disables timer FL compare match and overflow interrupt requests.

Bit 2

IENTFL	Description	
0	Disables timer FL interrupt requests	(initial value)
1	Enables timer FL interrupt requests	

Bit 1: Timer C interrupt enable (IENTC)

Bit 1 enables or disables timer C overflow and underflow interrupt requests.

Bit 1

IENTC	Description	
0	Disables timer C interrupt requests	(initial value)
1	Enables timer C interrupt requests	

Bit 0: Asynchronous event counter interrupt enable (IENEC)

Bit 0 enables or disables asynchronous event counter interrupt requests.

Bit 0

IENEC	Description	
0	Disables asynchronous event counter interrupt requests	(initial value)
1	Enables asynchronous event counter interrupt requests	

For details of SCI3-1 and SCI3-2 interrupt control, see 6. Serial control register 3 (SCR3) in section 10.3.2.

4. Interrupt Request Register 1 (IRR1)

Bit	7	6	5	4	3	2	1	0
	IRR10	IRR11	IRR12	IRR13	IRR14	—	IRRS1	IRR1A
Initial value	0	0	0	0	0	1	0	0
Read/Write	R/(W)*	R/(W)*	R/(W)*	R/(W)*	R/(W)*	—	R/(W)*	R/(W)*

Note: * Only a write of 0 for flag clearing is possible

IRR1 is an 8-bit read/write register, in which a corresponding flag is set to 1 when a timer A, SCI1, or IRQ₄ to IRQ₀ interrupt is requested. The flags are not cleared automatically when an interrupt is accepted. It is necessary to write 0 to clear each flag.

Bit 7: Timer A interrupt request flag (IRR1A)**Bit 7**

IRR1A	Description	
0	Clearing condition: When IRR1A = 1, it is cleared by writing 0	(initial value)
1	Setting condition: When the timer A counter value overflows from H'FF to H'00	

Bit 6: SCI1 interrupt request flag (IRRS1)

Bit 6 IRRS1	Description	
0	Clearing condition: When IRRS1 = 1, it is cleared by writing 0	(initial value)
1	Setting condition: When SCI1 completes transfer	

Bit 5: Reserved bit

Bit 5 is reserved; it is always read as 1 and cannot be modified.

Bits 4 to 0: IRQ₄ to IRQ₀ interrupt request flags (IRRI4 to IRRIO)

Bit n IRRIn	Description	
0	Clearing condition: When IRRIn = 1, it is cleared by writing 0	(initial value)
1	Setting condition: When pin \overline{IRQn} is designated for interrupt input and the designated signal edge is input	

(n = 4 to 0)

5. Interrupt Request Register 2 (IRR2)

Bit	7	6	5	4	3	2	1	0
	IRRDT	IRRAD	—	IRRTG	IRRTFH	IRRTFL	IRRTC	IRREC
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/(W)*	R/(W)*	R/W	R/(W)*	R/(W)*	R/(W)*	R/(W)*	R/(W)*

Note: * Only a write of 0 for flag clearing is possible

IRR2 is an 8-bit read/write register, in which a corresponding flag is set to 1 when a direct transfer, A/D converter, Timer G, Timer FH, Timer FC, or Timer C interrupt is requested. The flags are not cleared automatically when an interrupt is accepted. It is necessary to write 0 to clear each flag.

Bit 7: Direct transfer interrupt request flag (IRRDT)**Bit 7**

IRRDT	Description	
0	Clearing condition: When IRRDT = 1, it is cleared by writing 0	(initial value)
1	Setting condition: When a direct transfer is made by executing a SLEEP instruction while DTON = 1 in SYSCR2	

Bit 6: A/D converter interrupt request flag (IRRAD)**Bit 6**

IRRAD	Description	
0	Clearing condition: When IRRAD = 1, it is cleared by writing 0	(initial value)
1	Setting condition: When A/D conversion is completed and ADSF is cleared to 0 in ADSR	

Bit 5: Reserved bit

Bit 5 is a readable/writable reserved bit. It is initialized to 0 by a reset.

Bit 4: Timer G interrupt request flag (IRRTG)**Bit 4**

IRRTG	Description	
0	Clearing condition: When IRRTG = 1, it is cleared by writing 0	(initial value)
1	Setting condition: When the TMIG pin is designated for TMIG input and the designated signal edge is input, and when TCG overflows while OVIE is set to 1 in TMG	

Bit 3: Timer FH interrupt request flag (IRRTFH)**Bit 3**

IRRTFH	Description	
0	Clearing condition: When IRRTFH = 1, it is cleared by writing 0	(initial value)
1	Setting condition: When TCFH and OCRFH match in 8-bit timer mode, or when TCF (TCFL, TCFH) and OCRF (OCRFL, OCRFH) match in 16-bit timer mode	

Bit 2: Timer FL interrupt request flag (IRRTFL)**Bit 2**

IRRTFL	Description	
0	Clearing condition: When IRRTFL= 1, it is cleared by writing 0	(initial value)
1	Setting condition: When TCFL and OCRFL match in 8-bit timer mode	

Bit 1: Timer C interrupt request flag (IRRTC)**Bit 1**

IRRTC	Description	
0	Clearing condition: When IRRTC= 1, it is cleared by writing 0	(initial value)
1	Setting condition: When the timer C counter value overflows (from H'FF to H'00) or underflows (from H'00 to H'FF)	

Bit 0: Asynchronous event counter interrupt request flag (IRREC)**Bit 0**

IRREC	Description	
0	Clearing condition: When IRREC = 1, it is cleared by writing 0	(initial value)
1	Setting condition: When ECH overflows in 16-bit counter mode, or ECH or ECL overflows in 8-bit counter mode	

6. Wakeup Interrupt Request Register (IWPR)

Bit	7	6	5	4	3	2	1	0
	IWPF7	IWPF6	IWPF5	IWPF4	IWPF3	IWPF2	IWPF1	IWPF0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/(W)*	R/(W)*	R/(W)*	R/(W)*	R/(W)*	R/(W)*	R/(W)*	R/(W)*

Note: * All bits can only be written with 0, for flag clearing.

IWPR is an 8-bit read/write register containing wakeup interrupt request flags. When one of pins \overline{WKP}_7 to \overline{WKP}_0 is designated for wakeup input and a rising or falling edge is input at that pin, the corresponding flag in IWPR is set to 1. A flag is not cleared automatically when the corresponding interrupt is accepted. Flags must be cleared by writing 0.

Bits 7 to 0: Wakeup interrupt request flags (IWPF7 to IWPF0)

Bit n IWPFn	Description
0	Clearing condition: When IWPFn = 1, it is cleared by writing 0
1	Setting condition: When pin \overline{WKP}_n is designated for wakeup input and a rising or falling edge is input at that pin

(n = 7 to 0)

7. Wakeup Edge Select Register (WEGR)

Bit	7	6	5	4	3	2	1	0
	WKEGS7	WKEGS6	WKEGS5	WKEGS4	WKEGS3	WKEGS2	WKEGS1	WKEGS0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

WEGR is an 8-bit read/write register that specifies rising or falling edge sensing for pins \overline{WKP}_n .

WEGR is initialized to H'00 by a reset.

Bit n: $\overline{WK}Pn$ edge select (WKEGSn)

Bit n selects $\overline{WK}Pn$ pin input sensing.

Bit n WKEGSn	Description	
0	$\overline{WK}Pn$ pin falling edge detected	(initial value)
1	$\overline{WK}Pn$ pin rising edge detected	

(n = 7 to 0)

3.3.3 External Interrupts

There are 13 external interrupts: IRQ_4 to IRQ_0 and WKP_7 to WKP_0 .

1. Interrupts WKP_7 to WKP_0

Interrupts WKP_7 to WKP_0 are requested by either rising or falling edge input to pins $\overline{WK}P_7$ to $\overline{WK}P_0$. When these pins are designated as pins $\overline{WK}P_7$ to $\overline{WK}P_0$ in port mode register 5 and a rising or falling edge is input, the corresponding bit in IWPR is set to 1, requesting an interrupt. Recognition of wakeup interrupt requests can be disabled by clearing the IENWP bit to 0 in IENR1. These interrupts can all be masked by setting the I bit to 1 in CCR.

When WKP_7 to WKP_0 interrupt exception handling is initiated, the I bit is set to 1 in CCR. Vector number 9 is assigned to interrupts WKP_7 to WKP_0 . All eight interrupt sources have the same vector number, so the interrupt-handling routine must discriminate the interrupt source.

2. Interrupts IRQ_4 to IRQ_0

Interrupts IRQ_4 to IRQ_0 are requested by input signals to pins $\overline{IR}Q_4$ to $\overline{IR}Q_0$. These interrupts are detected by either rising edge sensing or falling edge sensing, depending on the settings of bits IEG_4 to IEG_0 in IEGR.

When these pins are designated as pins $\overline{IR}Q_4$ to $\overline{IR}Q_0$ in port mode register 3 and 1 and the designated edge is input, the corresponding bit in IRR1 is set to 1, requesting an interrupt. Recognition of these interrupt requests can be disabled individually by clearing bits IEN4 to IEN0 to 0 in IENR1. These interrupts can all be masked by setting the I bit to 1 in CCR.

When IRQ_4 to IRQ_0 interrupt exception handling is initiated, the I bit is set to 1 in CCR. Vector numbers 8 to 4 are assigned to interrupts IRQ_4 to IRQ_0 . The order of priority is from IRQ_0 (high) to IRQ_4 (low). Table 3.2 gives details.

3.3.4 Internal Interrupts

There are 24 internal interrupts that can be requested by the on-chip peripheral modules. When a peripheral module requests an interrupt, the corresponding bit in IRR1 or IRR2 is set to 1. Recognition of individual interrupt requests can be disabled by clearing the corresponding bit in IENR1 or IENR2. All these interrupts can be masked by setting the I bit to 1 in CCR. When internal interrupt handling is initiated, the I bit is set to 1 in CCR. Vector numbers from 20 to 10 are assigned to these interrupts. Table 3.2 shows the order of priority of interrupts from on-chip peripheral modules.

3.3.5 Interrupt Operations

Interrupts are controlled by an interrupt controller. Figure 3.2 shows a block diagram of the interrupt controller. Figure 3.3 shows the flow up to interrupt acceptance.

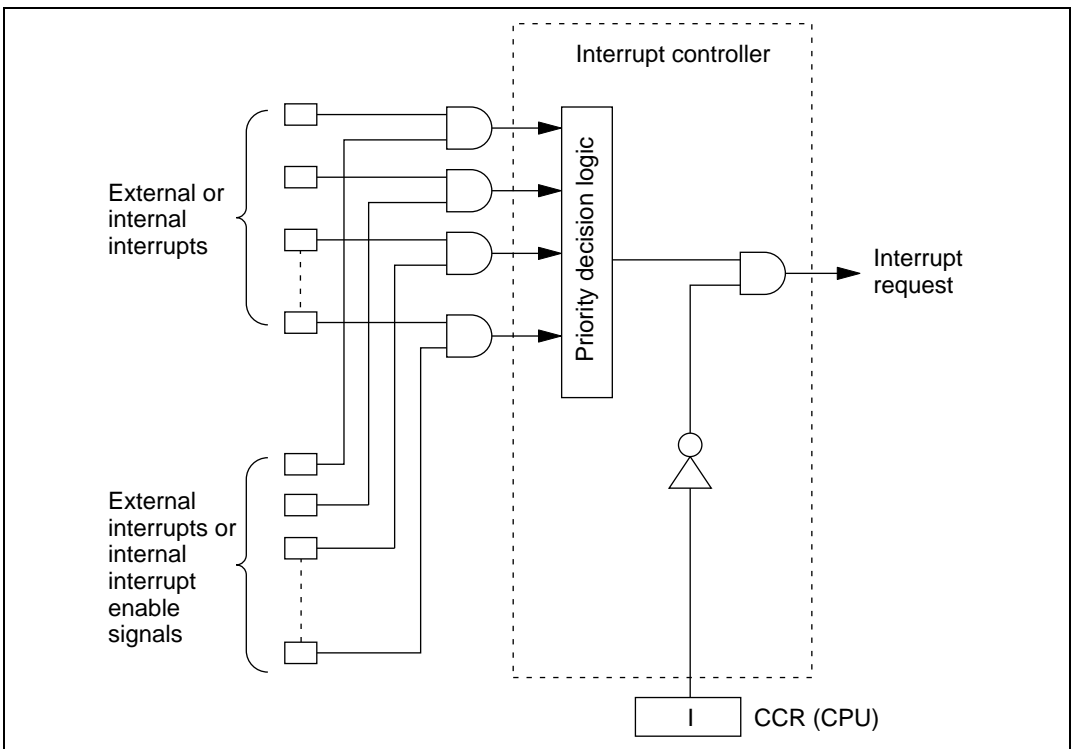


Figure 3.2 Block Diagram of Interrupt Controller

Interrupt operation is described as follows.

- When an interrupt condition is met while the interrupt enable register bit is set to 1, an interrupt request signal is sent to the interrupt controller.
- When the interrupt controller receives an interrupt request, it sets the interrupt request flag.
- From among the interrupts with interrupt request flags set to 1, the interrupt controller selects the interrupt request with the highest priority and holds the others pending. (Refer to table 3.2 for a list of interrupt priorities.)
- The interrupt controller checks the I bit of CCR. If the I bit is 0, the selected interrupt request is accepted; if the I bit is 1, the interrupt request is held pending.
- If the interrupt is accepted, after processing of the current instruction is completed, both PC and CCR are pushed onto the stack. The state of the stack at this time is shown in figure 3.4. The PC value pushed onto the stack is the address of the first instruction to be executed upon return from interrupt handling.
- The I bit of CCR is set to 1, masking further interrupts.
- The vector address corresponding to the accepted interrupt is generated, and the interrupt handling routine located at the address indicated by the contents of the vector address is executed.

- Notes:
1. When disabling interrupts by clearing bits in an interrupt enable register, or when clearing bits in an interrupt request register, always do so while interrupts are masked ($I = 1$).
 2. If the above clear operations are performed while $I = 0$, and as a result a conflict arises between the clear instruction and an interrupt request, exception processing for the interrupt will be executed after the clear instruction has been executed.

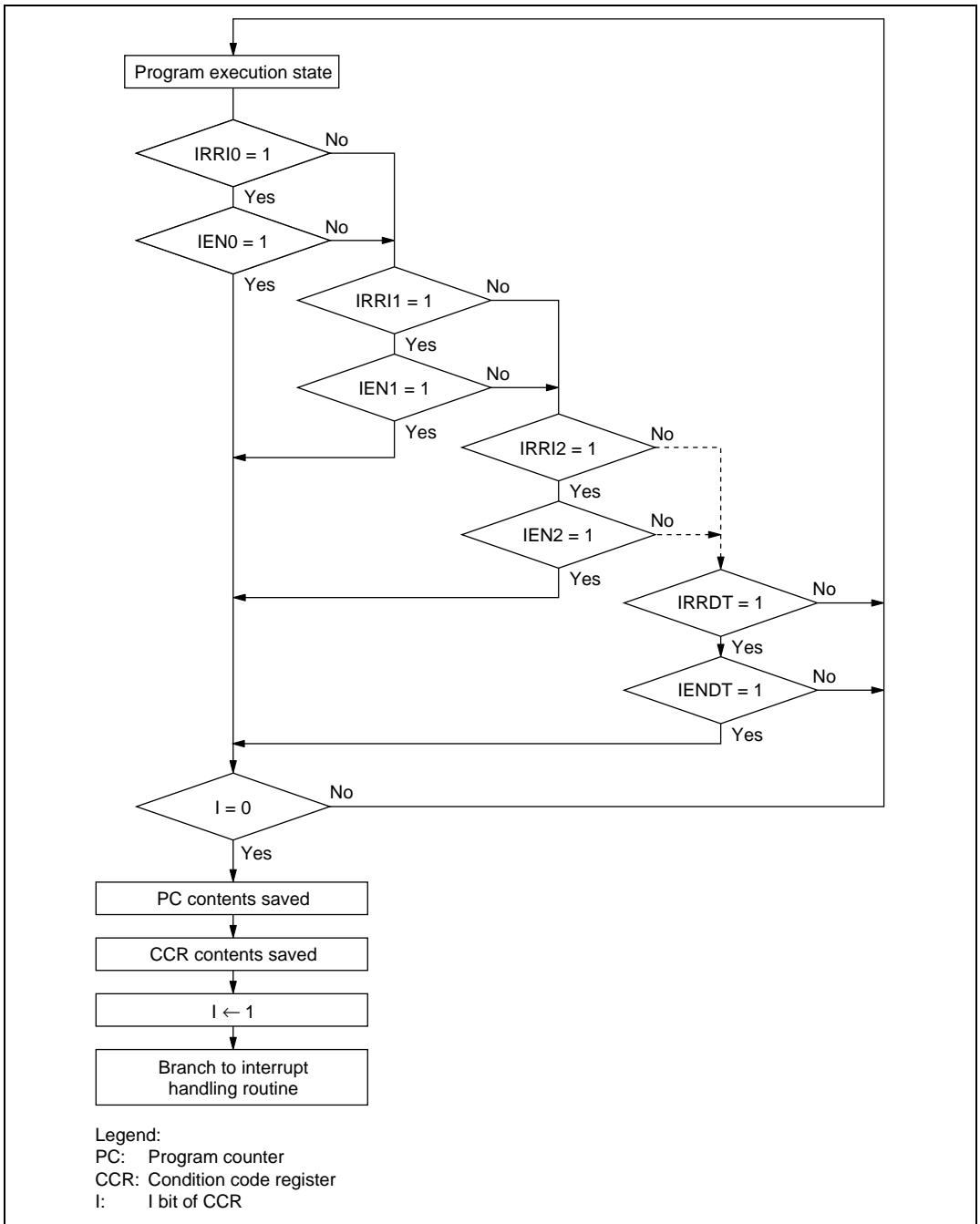


Figure 3.3 Flow Up to Interrupt Acceptance

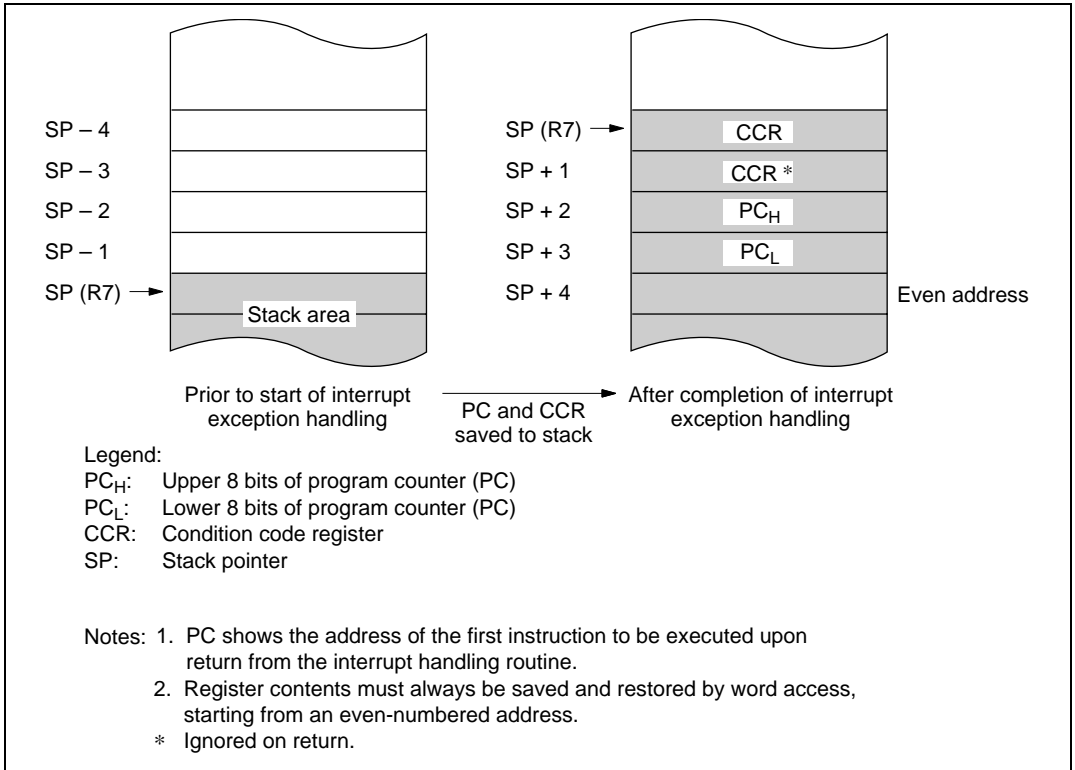


Figure 3.4 Stack State after Completion of Interrupt Exception Handling

Figure 3.5 shows a typical interrupt sequence.

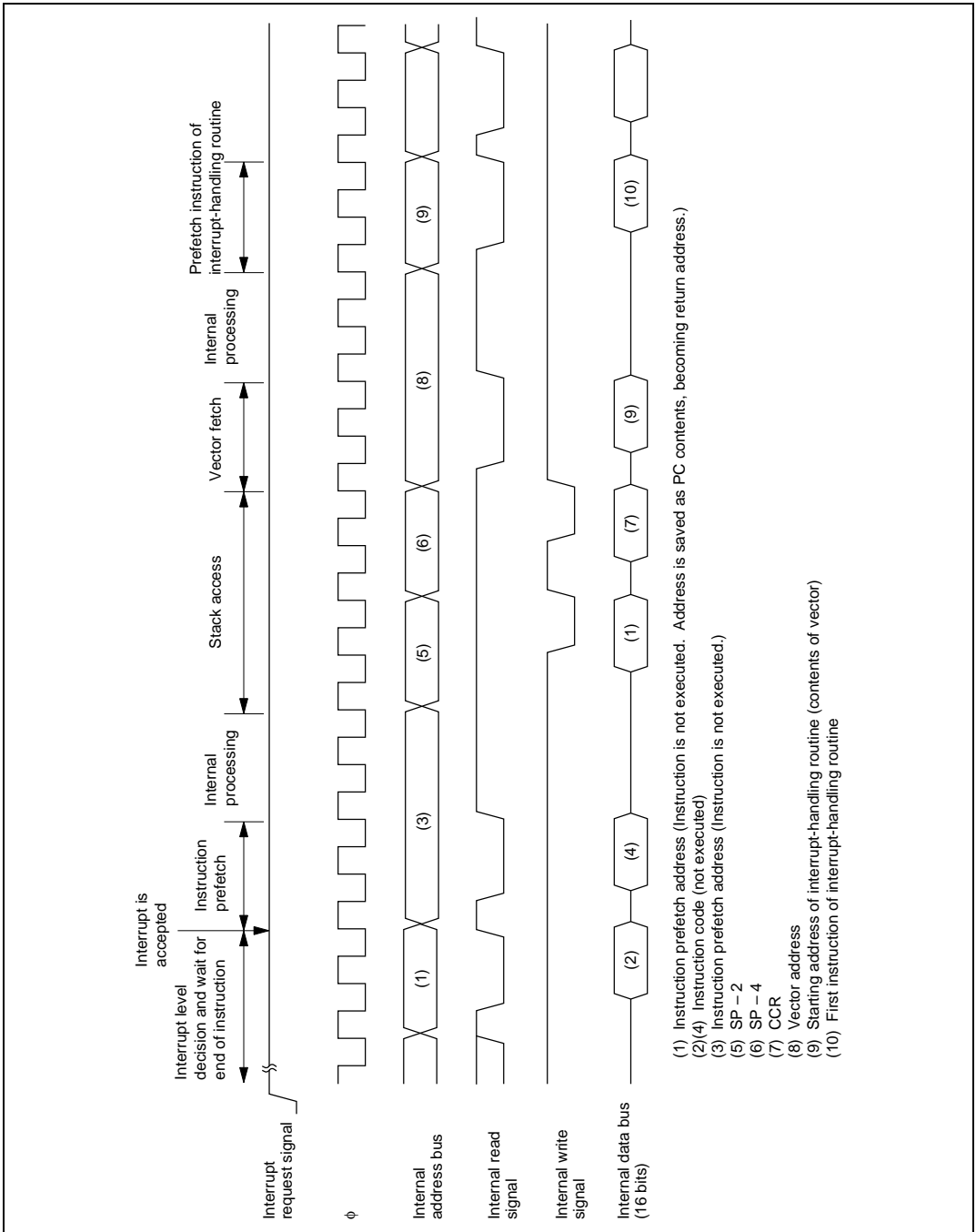


Figure 3.5 Interrupt Sequence

3.3.6 Interrupt Response Time

Table 3.4 shows the number of wait states after an interrupt request flag is set until the first instruction of the interrupt handler is executed.

Table 3.4 Interrupt Wait States

Item	States	Total
Waiting time for completion of executing instruction*	1 to 13	15 to 27
Saving of PC and CCR to stack	4	
Vector fetch	2	
Instruction fetch	4	
Internal processing	4	

Note: * Not including EEPMOV instruction.

3.4 Application Notes

3.4.1 Notes on Stack Area Use

When word data is accessed in the H8/3847R Group, the least significant bit of the address is regarded as 0. Access to the stack always takes place in word size, so the stack pointer (SP: R7) should never indicate an odd address. Use PUSH Rn (MOV.W Rn, @-SP) or POP Rn (MOV.W @SP+, Rn) to save or restore register values.

Setting an odd address in SP may cause a program to crash. An example is shown in figure 3.6.

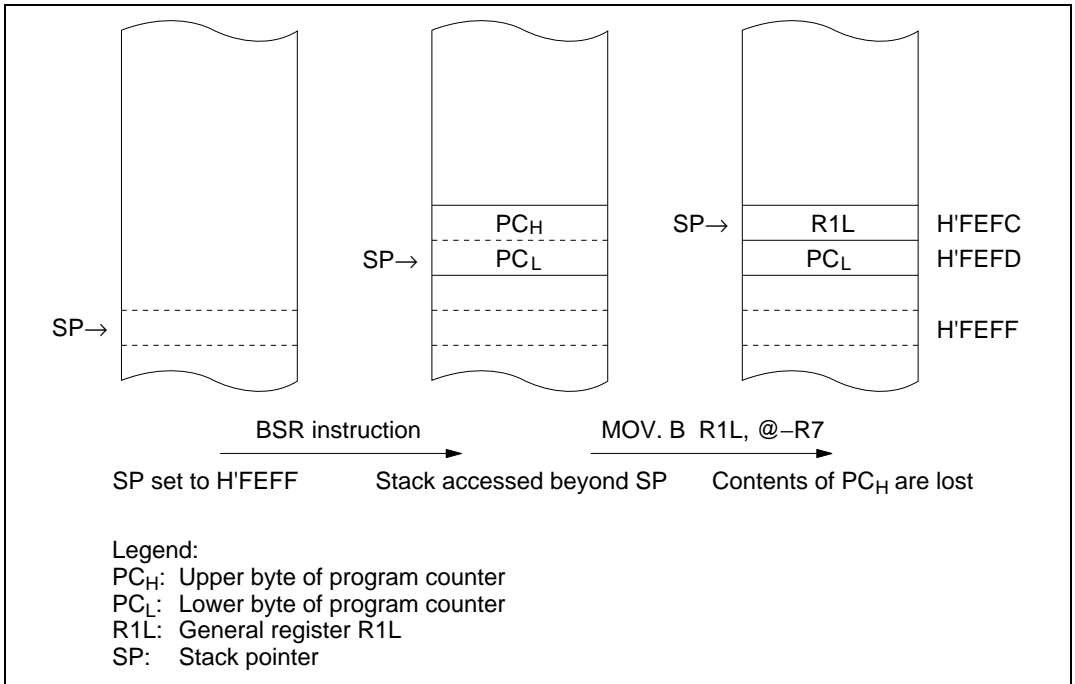


Figure 3.6 Operation when Odd Address is Set in SP

When CCR contents are saved to the stack during interrupt exception handling or restored when RTE is executed, this also takes place in word size. Both the upper and lower bytes of word data are saved to the stack; on return, the even address contents are restored to CCR while the odd address contents are ignored.

3.4.2 Notes on Rewriting Port Mode Registers

When a port mode register is rewritten to switch the functions of external interrupt pins, the following points should be observed.

When an external interrupt pin function is switched by rewriting the port mode register that controls pins $\overline{\text{IRQ}}_4$ to $\overline{\text{IRQ}}_0$, $\overline{\text{WKP}}_7$ to $\overline{\text{WKP}}_0$, the interrupt request flag may be set to 1 at the time the pin function is switched, even if no valid interrupt is input at the pin. Be sure to clear the interrupt request flag to 0 after switching pin functions. Table 3.5 shows the conditions under which interrupt request flags are set to 1 in this way.

Table 3.5 Conditions Under which Interrupt Request Flag is Set to 1

Interrupt Request Flags Set to 1		Conditions
IRR1	IRRI4	When PMR1 bit IRQ4 is changed from 0 to 1 while pin \overline{IRQ}_4 is low and IEGR bit IEG4 = 0.
		When PMR1 bit IRQ4 is changed from 1 to 0 while pin \overline{IRQ}_4 is low and IEGR bit IEG4 = 1.
IRRI3		When PMR1 bit IRQ3 is changed from 0 to 1 while pin \overline{IRQ}_3 is low and IEGR bit IEG3 = 0.
		When PMR1 bit IRQ3 is changed from 1 to 0 while pin \overline{IRQ}_3 is low and IEGR bit IEG3 = 1.
IRRI2		When PMR1 bit IRQ2 is changed from 0 to 1 while pin \overline{IRQ}_2 is low and IEGR bit IEG2 = 0.
		When PMR1 bit IRQ2 is changed from 1 to 0 while pin \overline{IRQ}_2 is low and IEGR bit IEG2 = 1.
IRRI1		When PMR1 bit IRQ1 is changed from 0 to 1 while pin \overline{IRQ}_1 is low and IEGR bit IEG1 = 0.
		When PMR1 bit IRQ1 is changed from 1 to 0 while pin \overline{IRQ}_1 is low and IEGR bit IEG1 = 1.
IRRI0		When PMR3 bit IRQ0 is changed from 0 to 1 while pin \overline{IRQ}_0 is low and IEGR bit IEG0 = 0.
		When PMR3 bit IRQ0 is changed from 1 to 0 while pin \overline{IRQ}_0 is low and IEGR bit IEG0 = 1.
IWPR	IWPF7	When PMR5 bit WKP7 is changed from 0 to 1 while pin \overline{WKP}_7 is low.
	IWPF6	When PMR5 bit WKP6 is changed from 0 to 1 while pin \overline{WKP}_6 is low.
	IWPF5	When PMR5 bit WKP5 is changed from 0 to 1 while pin \overline{WKP}_5 is low.
	IWPF4	When PMR5 bit WKP4 is changed from 0 to 1 while pin \overline{WKP}_4 is low.
	IWPF3	When PMR5 bit WKP3 is changed from 0 to 1 while pin \overline{WKP}_3 is low.
	IWPF2	When PMR5 bit WKP2 is changed from 0 to 1 while pin \overline{WKP}_2 is low.
	IWPF1	When PMR5 bit WKP1 is changed from 0 to 1 while pin \overline{WKP}_1 is low.
	IWPF0	When PMR5 bit WKP0 is changed from 0 to 1 while pin \overline{WKP}_0 is low.

Figure 3.7 shows the procedure for setting a bit in a port mode register and clearing the interrupt request flag.

When switching a pin function, mask the interrupt before setting the bit in the port mode register. After accessing the port mode register, execute at least one instruction (e.g., NOP), then clear the interrupt request flag from 1 to 0. If the instruction to clear the flag is executed immediately after the port mode register access without executing an intervening instruction, the flag will not be cleared.

An alternative method is to avoid the setting of interrupt request flags when pin functions are switched by keeping the pins at the high level so that the conditions in table 3.5 do not occur.

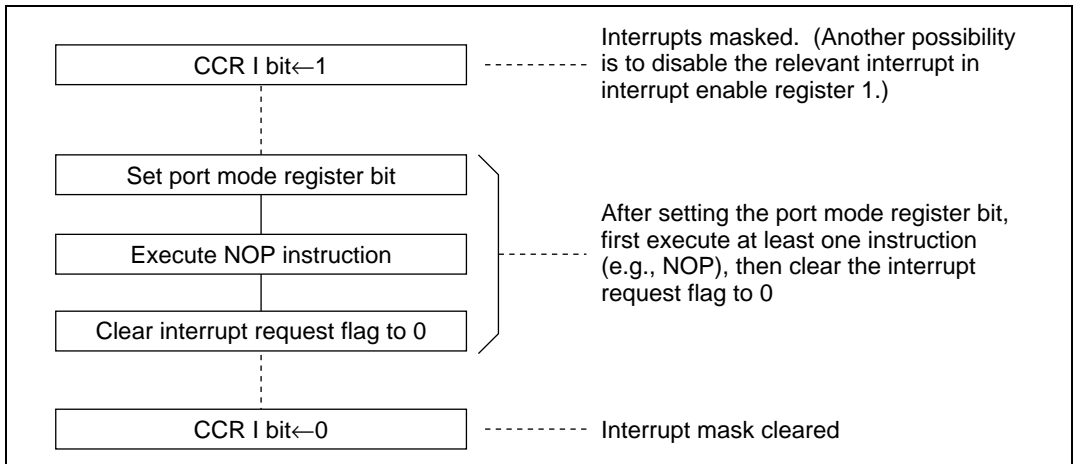


Figure 3.7 Port Mode Register Setting and Interrupt Request Flag Clearing Procedure

3.4.3 Method for Clearing Interrupt Request Flags

Use the recommended method, given below when clearing the flags of interrupt request registers (IRR1, IRR2, IWPR).

- Recommended method

Use a single instruction to clear flags. The bit control instruction and byte-size data transfer instruction can be used. Two examples of program code for clearing IRR1 (bit 1 of IRR1) are given below.

```
BCLR #1, @IRR1:8
MOV.B R1L, @IRR1:8 (set the value of R1L to B'11111101)
```

- Example of a malfunction

When flags are cleared with multiple instructions, other flags might be cleared during execution of the instructions, even though they are currently set, and this will cause a malfunction.

Here is an example in which IRR10 is cleared and disabled in the process of clearing IRR1 (bit 1 of IRR1).

```
MOV.B @IRR1:8,R1L ..... IRR10 = 0 at this time
AND.B #B'11111101,R1L ..... Here, IRR10 = 1
MOV.B R1L,@IRR1:8 ..... IRR10 is cleared to 0
```

In the above example, it is assumed that an IRQ0 interrupt is generated while the AND.B instruction is executing.

The IRQ0 interrupt is disabled because, although the original objective is clearing IRR1, IRR10 is also cleared.

Section 4 Clock Pulse Generators

4.1 Overview

Clock oscillator circuitry (CPG: clock pulse generator) is provided on-chip, including both a system clock pulse generator and a subclock pulse generator. The system clock pulse generator consists of a system clock oscillator and system clock dividers. The subclock pulse generator consists of a subclock oscillator circuit and a subclock divider.

4.1.1 Block Diagram

Figure 4.1 shows a block diagram of the clock pulse generators.

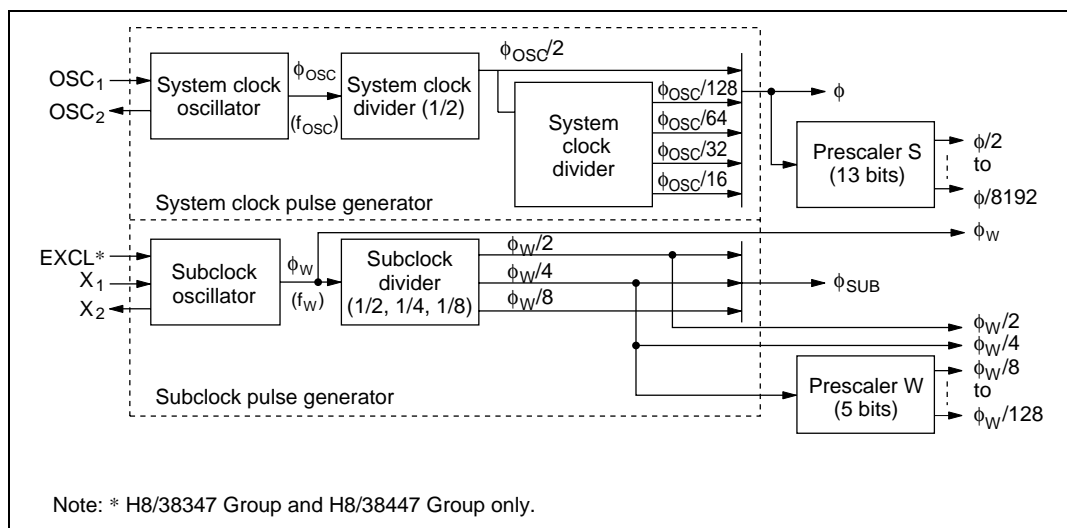


Figure 4.1 Block Diagram of Clock Pulse Generators

4.1.2 System Clock and Subclock

The basic clock signals that drive the CPU and on-chip peripheral modules are ϕ and ϕ_{SUB} . Four of the clock signals have names: ϕ is the system clock, ϕ_{SUB} is the subclock, ϕ_{OSC} is the oscillator clock, and ϕ_W is the watch clock.

The clock signals available for use by peripheral modules are $\phi/2$, $\phi/4$, $\phi/8$, $\phi/16$, $\phi/32$, $\phi/64$, $\phi/128$, $\phi/256$, $\phi/512$, $\phi/1024$, $\phi/2048$, $\phi/4096$, $\phi/8192$, ϕ_W , $\phi_W/2$, $\phi_W/4$, $\phi_W/8$, $\phi_W/16$, $\phi_W/32$, $\phi_W/64$, and $\phi_W/128$. The clock requirements differ from one module to another.

4.2 System Clock Generator

Clock pulses can be supplied to the system clock divider either by connecting a crystal or ceramic oscillator, or by providing external clock input.

1. Connecting a Crystal Oscillator

Figure 4.2 shows a typical method of connecting a crystal oscillator. For information on recommended resonators, see the product AC characteristics listed in section 15, Electrical Characteristics. Please consult with the resonator manufacturer when selecting a resonator model.

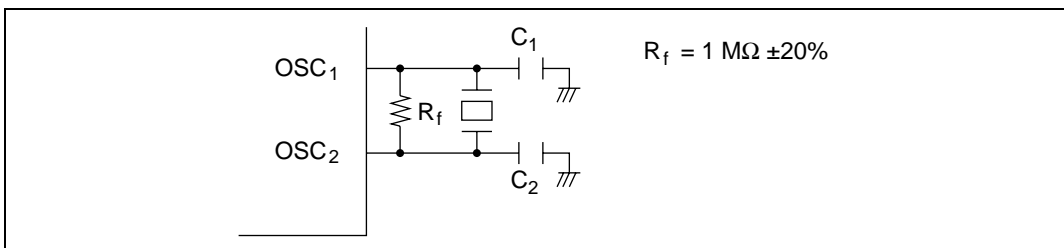


Figure 4.2 Typical Connection to Crystal Oscillator

2. Connecting a Ceramic Oscillator

Figure 4.3 shows a typical method of connecting a ceramic oscillator. For information on recommended resonators, see the product AC characteristics listed in section 15, Electrical Characteristics. Please consult with the resonator manufacturer when selecting a resonator model.

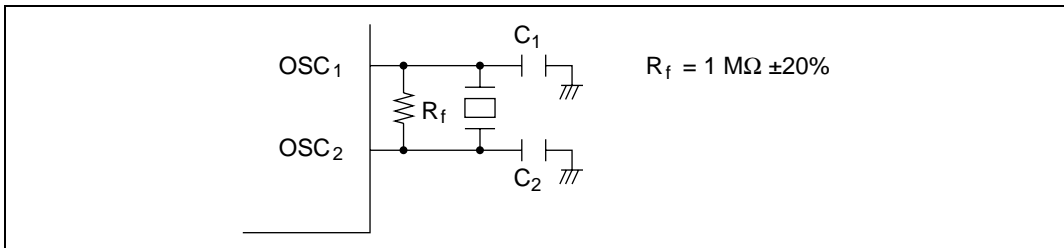


Figure 4.3 Typical Connection to Ceramic Oscillator

3. Notes on Board Design

When generating clock pulses by connecting a crystal or ceramic oscillator, pay careful attention to the following points.

Avoid running signal lines close to the oscillator circuit, since the oscillator may be adversely affected by induction currents. (See figure 4.4.)

The board should be designed so that the oscillator and load capacitors are located as close as possible to pins OSC₁ and OSC₂.

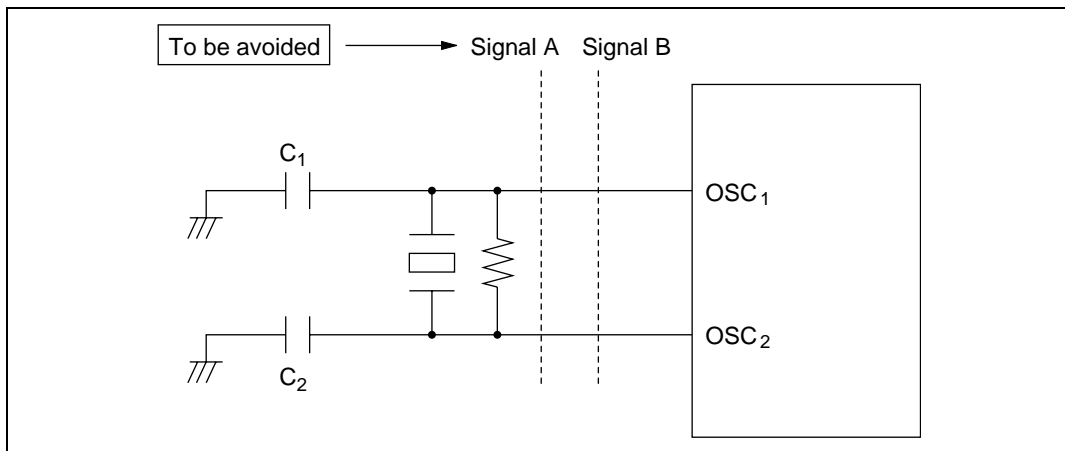


Figure 4.4 Board Design of Oscillator Circuit

4. External Clock Input Method

Connect an external clock signal to pin OSC₁, and leave pin OSC₂ open. Figure 4.5 shows a typical connection.

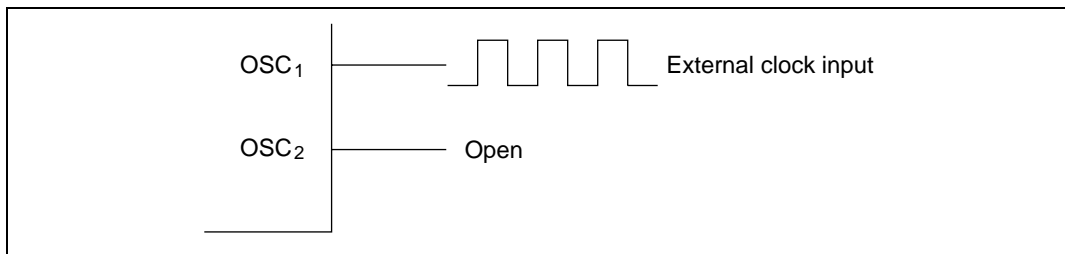


Figure 4.5 External Clock Input (Example)

Frequency

Oscillator Clock (ϕ_{osc})

Duty cycle

45% to 55%

Note: The circuit parameters above are recommended by the crystal or ceramic oscillator manufacturer.

The circuit parameters are affected by the crystal or ceramic oscillator and floating capacitance when designing the board. When using the oscillator, consult with the crystal or ceramic oscillator manufacturer to determine the circuit parameters.

4.3 Subclock Generator

1. Connecting a 32.768 kHz/38.4 kHz Crystal Oscillator

Clock pulses can be supplied to the subclock divider by connecting a 32.768 kHz/38.4 kHz crystal oscillator, as shown in figure 4.6. Follow the same precautions as noted under 3. notes on board design for the system clock in section 4.2.

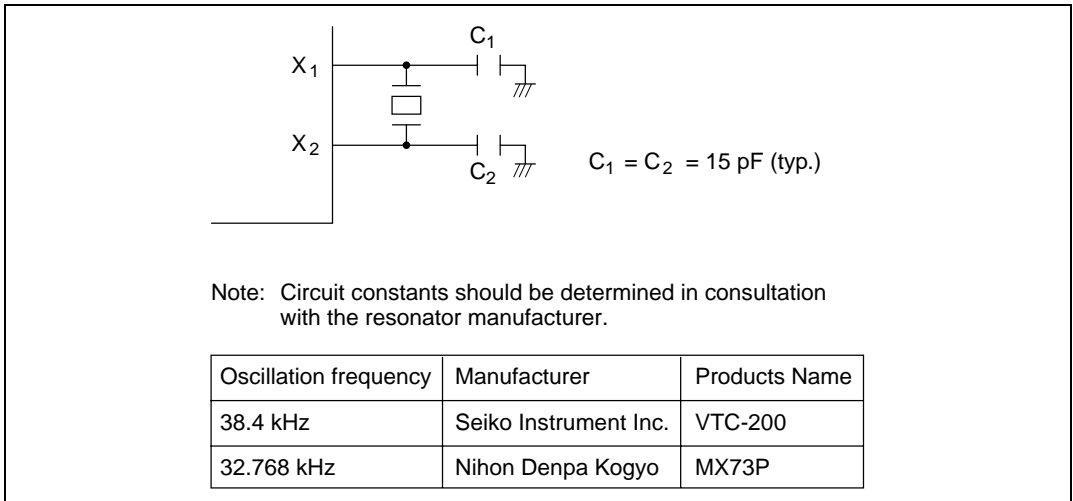


Figure 4.6 Typical Connection to 32.768 kHz/38.4 kHz Crystal Oscillator (Subclock)

Figure 4.7 shows the equivalent circuit of the 32.768 kHz/38.4 kHz crystal oscillator.

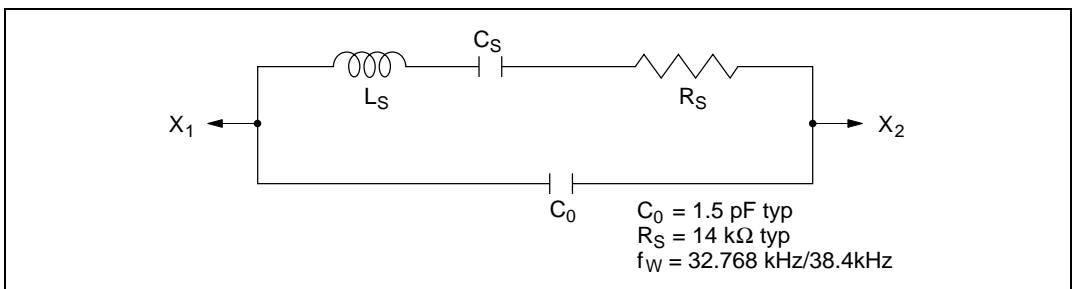


Figure 4.7 Equivalent Circuit of 32.768 kHz/38.4 kHz Crystal Oscillator

2. Pin Connection when Not Using Subclock

When the subclock is not used, connect pin X_1 to GND and leave pin X_2 open, as shown in figure 4.8.

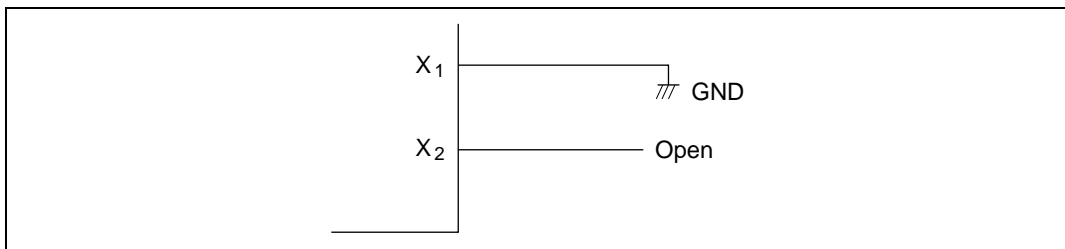
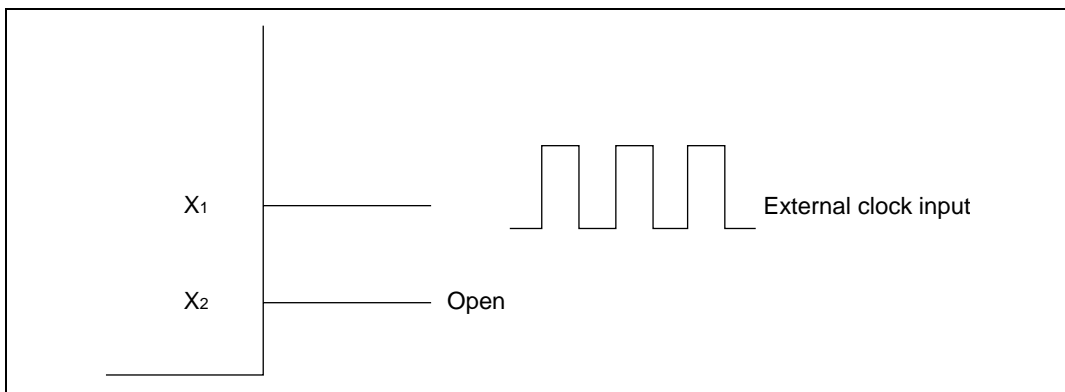


Figure 4.8 Pin Connection when not Using Subclock

3. External Clock Input

- H8/3847R Group and H8/3847S Group

Connect the external clock to the X_1 pin and leave the X_2 pin open, as shown in figure 4.9 (a).



**Figure 4.9 (a) Pin Connection when Inputting External Clock
(H8/38347R Group and H8/3847S Group)**

Frequency

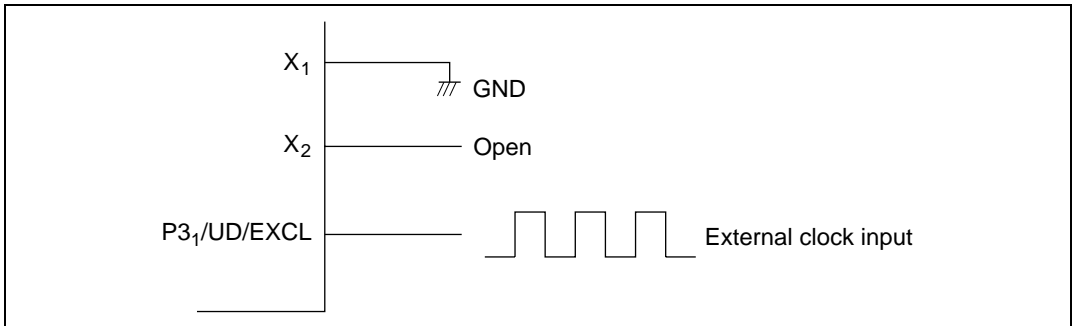
Subclock (ϕ_w)

Duty

45% to 55%

- H8/38347 Group and H8/38447 Group

Connect pin X_1 to GND and leave pin X_2 open. Input an external clock to pin EXCL. Set bit EXCL in register PMR2 to 1 to supply the external clock to the internal components of the device. A connection example is shown in figure 4.9 (b).



**Figure 4.9 (b) Pin Connection when Inputting External Clock
(H8/38347 Group and H8/38447 Group)**

Frequency	Subclock (ϕ_w)
Duty	45% to 55%

4. Notes on H8/38347 and H8/38447

In the H8/38347 and H8/38447 the subclock oscillator input pin is controlled by the EXCL bit in the PMR2 register. When EXCL is cleared to 0 the X_1 pin (resonator connection only) is used, and when EXCL is set to 1 the EXCL pin (external clock only) is used. Caution is necessary when switching from the H8/3847R to a program. Writing 1 to bit 7 in PMR2 (empty bit with initial value 1 on H8/3847R) selects EXCL as the input pin, so no subclock is supplied internally even if a resonator is connected. Furthermore, P31 becomes unusable. To prevent this it is necessary to change the program so that 0 is written to the EXCL bit.

4.4 Prescalers

The H8/3847R Group is equipped with two on-chip prescalers having different input clocks (prescaler S and prescaler W). Prescaler S is a 13-bit counter using the system clock (ϕ) as its input clock. Its prescaled outputs provide internal clock signals for on-chip peripheral modules. Prescaler W is a 5-bit counter using a 32.768 kHz or 38.4 kHz signal divided by 4 ($\phi_W/4$) as its input clock. Its prescaled outputs are used by timer A as a time base for timekeeping.

1. Prescaler S (PSS)

Prescaler S is a 13-bit counter using the system clock (ϕ) as its input clock. It is incremented once per clock period.

Prescaler S is initialized to H'0000 by a reset, and starts counting on exit from the reset state.

In standby mode, watch mode, subactive mode, and subsleep mode, the system clock pulse generator stops. Prescaler S also stops and is initialized to H'0000.

The CPU cannot read or write prescaler S.

The output from prescaler S is shared by timer A, timer C, timer F, timer G, SCI1, SCI3-1, SC3-2, the A/D converter, the LCD controller, the watchdog timer, and the 14-bit PWM. The divider ratio can be set separately for each on-chip peripheral function.

In active (medium-speed) mode the clock input to prescaler S is $\phi_{osc}/16$, $\phi_{osc}/32$, $\phi_{osc}/64$, or $\phi_{osc}/128$.

2. Prescaler W (PSW)

Prescaler W is a 5-bit counter using a 32.768 kHz/38.4 kHz signal divided by 4 ($\phi_W/4$) as its input clock.

Prescaler W is initialized to H'00 by a reset, and starts counting on exit from the reset state.

Even in standby mode, watch mode, subactive mode, or subsleep mode, prescaler W continues functioning so long as clock signals are supplied to pins X1 and X2.

Prescaler W can be reset by setting 1s in bits TMA3 and TMA2 of timer mode register A (TMA).

Output from prescaler W can be used to drive timer A, in which case timer A functions as a time base for timekeeping.

4.5 Note on Oscillators

Oscillator characteristics are closely related to board design and should be carefully evaluated by the user in mask ROM, ZTAT™ and F-ZTAT™ versions, referring to the examples shown in this section. Oscillator circuit constants will differ depending on the oscillator element, stray capacitance in its interconnecting circuit, and other factors. Suitable constants should be determined in consultation with the oscillator element manufacturer. Design the circuit so that the oscillator element never receives voltages exceeding its maximum rating.

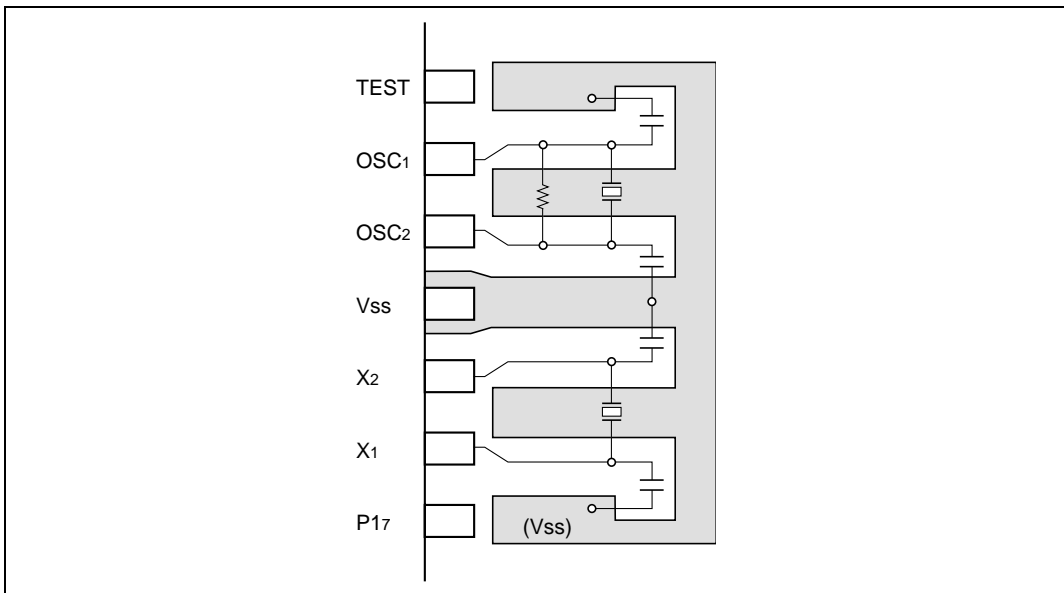


Figure 4.10 Example of Crystal and Ceramic Oscillator Element Arrangement

Figure 4.11 (1) shows an example measuring circuit with the negative resistance suggested by the oscillator manufacturer. Note that if the negative resistance of the circuit is less than that suggested by the oscillator manufacturer, it may be difficult to start the main oscillator.

If it is determined that oscillation is not occurring because the negative resistance is lower than the level suggested by the oscillator manufacturer, the circuit may be modified as shown in figure 4.11 (2) through (4). Which of the modification suggestions to use and the capacitor capacitance should be decided based upon an evaluation of factors such as the negative resistance and the frequency deviation.

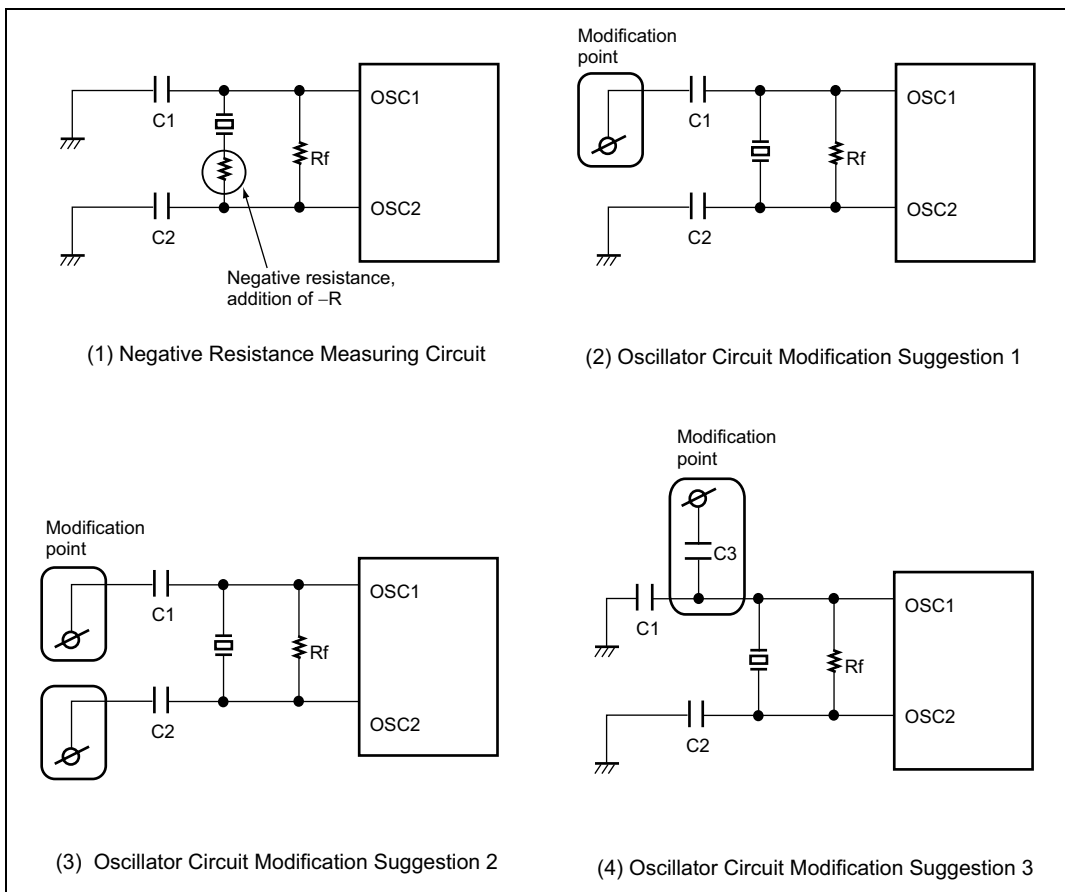


Figure 4.11 Negative Resistance Measurement and Circuit Modification Suggestions

4.5.1 Definition of Oscillation Stabilization Wait Time

Figure 4.12 shows the oscillation waveform (OSC2), system clock (ϕ), and microcomputer operating mode when a transition is made from standby mode, watch mode, or subactive mode, to active (high-speed/medium-speed) mode, with an oscillator element connected to the system clock oscillator.

As shown in figure 4.12, as the system clock oscillator is halted in standby mode, watch mode, and subactive mode, when a transition is made to active (high-speed/medium-speed) mode, the sum of the following two times (oscillation stabilization time and wait time) is required.

1. Oscillation Stabilization Time (t_{re})

The time from the point at which the system clock oscillator oscillation waveform starts to change when an interrupt is generated, until the amplitude of the oscillation waveform increases and the oscillation frequency stabilizes.

2. Wait Time

The time required for the CPU and peripheral functions to begin operating after the oscillation waveform frequency and system clock have stabilized.

The wait time setting is selected with standby timer select bits 2 to 0 (STS2 to STS0) (bits 6 to 4 in system control register 1 (SYSCR1)).

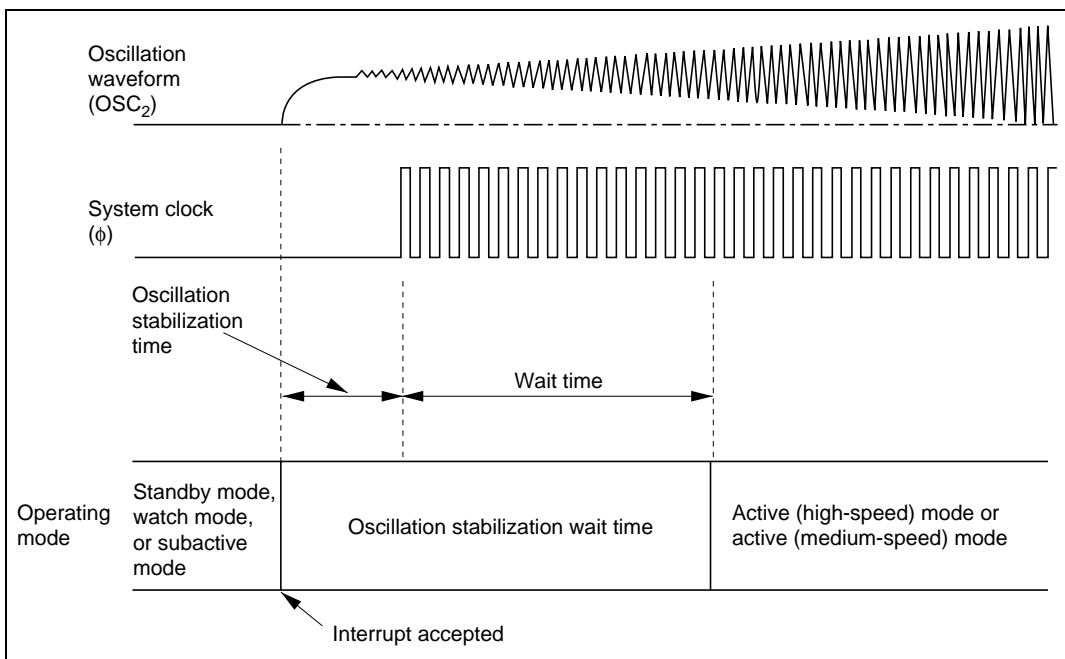


Figure 4.12 Oscillation Stabilization Wait Time

When standby mode, watch mode, or subactive mode is cleared by an interrupt or reset, and a transition is made to active (high-speed/medium-speed) mode, the oscillation waveform begins to change at the point at which the interrupt is accepted. Therefore, when an oscillator element is connected in standby mode, watch mode, or subactive mode, since the system clock oscillator is halted, the time from the point at which this oscillation waveform starts to change until the

amplitude of the oscillation waveform increases and the oscillation frequency stabilizes—that is, the oscillation stabilization time—is required.

The oscillation stabilization time in the case of these state transitions is the same as the oscillation stabilization time at power-on (the time from the point at which the power supply voltage reaches the prescribed level until the oscillation stabilizes), specified by "oscillation stabilization time t_{rc} " in the AC characteristics.

Meanwhile, once the system clock has halted, a wait time of at least 8 states is necessary in order for the CPU and peripheral functions to operate normally.

Thus, the time required from interrupt generation until operation of the CPU and peripheral functions is the sum of the above described oscillation stabilization time and wait time. This total time is called the oscillation stabilization wait time, and is expressed by equation (1) below.

Oscillation stabilization wait time = oscillation stabilization time + wait time

$$= t_{rc} + (8 \text{ to } 131,072 \text{ states}) \dots\dots\dots (1)$$

Therefore, when a transition is made from standby mode, watch mode, or subactive mode, to active (high-speed/medium-speed) mode, with an oscillator element connected to the system clock oscillator, careful evaluation must be carried out on the installation circuit before deciding on the oscillation stabilization wait time. In particular, since the oscillation stabilization time is affected by installation circuit constants, stray capacitance, and so forth, suitable constants should be determined in consultation with the oscillator element manufacturer.

4.5.2 Notes on Use of Crystal Oscillator Element (Excluding Ceramic Oscillator Element)

When a microcomputer operates, the internal power supply potential fluctuates slightly in synchronization with the system clock. Depending on the individual crystal oscillator element characteristics, the oscillation waveform amplitude may not be sufficiently large immediately after the oscillation stabilization wait time, making the oscillation waveform susceptible to influence by fluctuations in the power supply potential. In this state, the oscillation waveform may be disrupted, leading to an unstable system clock and erroneous operation of the microcomputer.

If erroneous operation occurs, change the setting of standby timer select bits 2 to 0 (STS2 to STS0) (bits 6 to 4 in system control register 1 (SYSCR1)) to give a longer wait time.

For example, if erroneous operation occurs with a wait time setting of 16 states, check the operation with a wait time setting of 8,192 states or more.

If the same kind of erroneous operation occurs after a reset as after a state transition, hold the $\overline{\text{RES}}$ pin low for a longer period.

Section 5 Power-Down Modes

5.1 Overview

This LSI has nine modes of operation after a reset. These include eight power-down modes, in which power dissipation is significantly reduced. Table 5.1 gives a summary of the nine operating modes.

Table 5.1 Operating Modes

Operating Mode	Description
Active (high-speed) mode	The CPU and all on-chip peripheral functions are operable on the system clock in high-speed operation
Active (medium-speed) mode	The CPU and all on-chip peripheral functions are operable on the system clock in low-speed operation
Subactive mode	The CPU is operable on the subclock in low-speed operation
Sleep (high-speed) mode	The CPU halts. On-chip peripheral functions are operable on the system clock
Sleep (medium-speed) mode	The CPU halts. On-chip peripheral functions operate at a frequency of 1/64, 1/32, 1/16, or 1/8 of the system clock frequency
Subsleep mode	The CPU halts. The time-base function of timer A, timer C, timer G, timer F, WDT, SCI1, SCI3-1, SCI3-2, AEC, and LCD controller/driver are operable on the subclock.
Watch mode	The CPU halts. The time-base function of timer A, timer F, timer G, AEC, and LCD controller/driver are operable on the subclock.
Standby mode	The CPU and all on-chip peripheral functions halt
Module standby mode	Individual on-chip peripheral functions specified by software enter standby mode and halt

Of these nine operating modes, all but the active (high-speed) mode are power-down modes. In this section the two active modes (high-speed and medium speed) will be referred to collectively as active mode.

Figure 5.1 shows the transitions among these operation modes. Table 5.2 indicates the internal states in each mode.

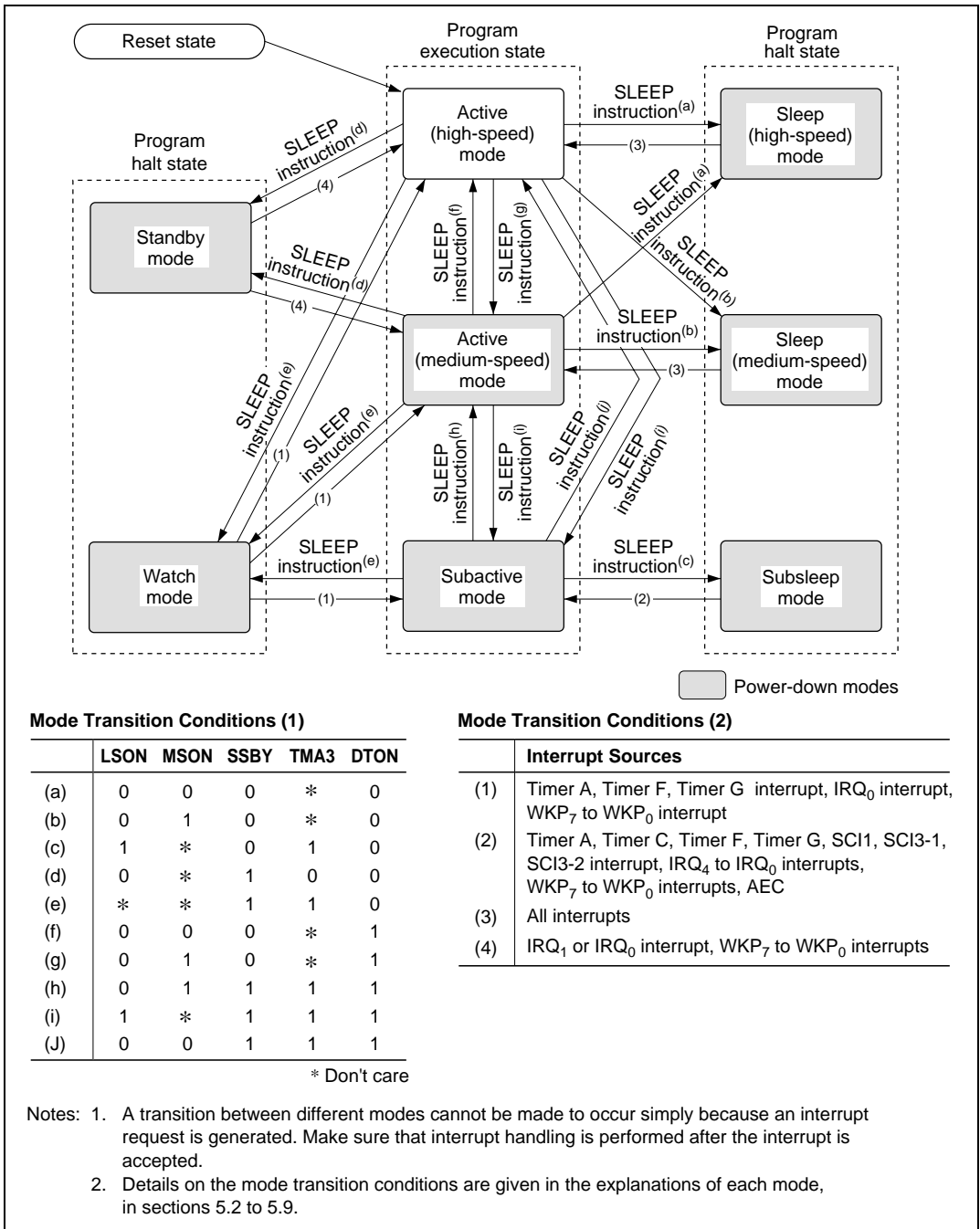


Figure 5.1 Mode Transition Diagram

Table 5.2 Internal State in Each Operating Mode

Function	Active Mode		Sleep Mode		Watch Mode	Subactive Mode	Subsleep Mode	Standby Mode	
	High-Speed	Medium-Speed	High-Speed	Medium-Speed					
System clock oscillator	Functions	Functions	Functions	Functions	Halted	Halted	Halted	Halted	
Subclock oscillator	Functions	Functions	Functions	Functions	Functions	Functions	Functions	Functions	
CPU operations	Instructions	Functions	Functions	Halted	Halted	Functions	Functions	Halted	
	RAM			Retained	Retained	Retained		Retained	
	Registers								
	I/O ports							Retained* ¹	
External interrupts	IRQ ₀	Functions	Functions	Functions	Functions	Functions	Functions	Functions	
	IRQ ₁					Retained* ⁶			
	IRQ ₂							Retained* ⁶	
	IRQ ₃								
	IRQ ₄								
	WKP ₀	Functions	Functions	Functions	Functions	Functions	Functions	Functions	
	WKP ₁								
	WKP ₂								
	WKP ₃								
	WKP ₄								
Peripheral functions	Timer A	Functions	Functions	Functions	Functions	Functions* ⁵	Functions* ⁵	Functions* ⁵	Retained
	Asynchronous counter					Functions* ⁸	Functions	Functions	Functions* ⁸
	Timer C					Retained	Functions/Retained* ²	Functions/Retained* ²	Retained
	WDT						Functions/Retained* ⁷	Retained	
	Timer G, Timer F					Functions/Retained* ⁹	Functions/Retained* ²	Functions/Retained* ²	
	SCI1					Retained	Functions/Retained* ⁹	Functions/Retained* ⁹	Retained
	SCI3-1, SCI3-2					Reset	Functions/Retained* ³	Functions/Retained* ³	Reset
	PWM					Retained	Retained	Retained	Retained
	A/D converter					Retained	Retained	Retained	Retained
	LCD					Functions/Retained* ⁴	Functions/Retained* ⁴	Functions/Retained* ⁴	Retained

- Notes:
1. Register contents are retained, but output is high-impedance state.
 2. Functions if an external clock or the $\phi_{W/4}$ internal clock is selected; otherwise halted and retained.
 3. Functions if $\phi_{W/2}$ is selected as the internal clock; otherwise halted and retained.
 4. Functions if ϕ_{W} or $\phi_{W/2}$ or $\phi_{W/4}$ is selected as the operating clock; otherwise halted and retained.
 5. Functions if the timekeeping time-base function is selected.
 6. External interrupt requests are ignored. Interrupt request register contents are not altered.
 7. Functions if $\phi_{W/32}$ is selected as the internal clock; otherwise halted and retained.
 8. Incrementing is possible, but interrupt generation is not.
 9. Functions if the $\phi_{W/4}$ internal clock is selected; otherwise halted and retained.

5.1.1 System Control Registers

The operation mode is selected using the system control registers described in table 5.3.

Table 5.3 System Control Registers

Name	Abbreviation	R/W	Initial Value	Address
System control register 1	SYSCR1	R/W	H'07	H'FFF0
System control register 2	SYSCR2	R/W	H'F0	H'FFF1

1. System Control Register 1 (SYSCR1)

Bit	7	6	5	4	3	2	1	0
	SSBY	STS2	STS1	STS0	LSON	—	MA1	MA0
Initial value	0	0	0	0	0	1	1	1
Read/Write	R/W	R/W	R/W	R/W	R/W	—	R/W	R/W

SYSCR1 is an 8-bit read/write register for control of the power-down modes.

Upon reset, SYSCR1 is initialized to H'07.

Bit 7: Software standby (SSBY)

This bit designates transition to standby mode or watch mode.

Bit 7

SSBY	Description
0	<ul style="list-style-type: none"> When a SLEEP instruction is executed in active mode, a transition is made to sleep mode (initial value) When a SLEEP instruction is executed in subactive mode, a transition is made to subsleep mode
1	<ul style="list-style-type: none"> When a SLEEP instruction is executed in active mode, a transition is made to standby mode or watch mode When a SLEEP instruction is executed in subactive mode, a transition is made to watch mode

Bits 6 to 4: Standby timer select 2 to 0 (STS2 to STS0)

These bits designate the time the CPU and peripheral modules wait for stable clock operation after exiting from standby mode or watch mode to active mode due to an interrupt. The designation should be made according to the operating frequency so that the waiting time is at least equal to the oscillation settling time.

Bit 6 STS2	Bit 5 STS1	Bit 4 STS0	Description
0	0	0	Wait time = 8,192 states (initial value)
0	0	1	Wait time = 16,384 states
0	1	0	Wait time = 32,768 states
0	1	1	Wait time = 65,536 states
1	0	0	Wait time = 131,072 states
1	0	1	Wait time = 2 states (External clock input mode)
1	1	0	Wait time = 8 states
1	1	1	Wait time = 16 states

Note: When inputting the external clock, set the standby timer select to the external clock input mode. Also, when not using the external clock, do not set the standby timer select to the external clock input mode.

Bit 3: Low speed on flag (LSON)

This bit chooses the system clock (ϕ) or subclock (ϕ_{SUB}) as the CPU operating clock when watch mode is cleared. The resulting operation mode depends on the combination of other control bits and interrupt input.

Bit 3 LSON	Description
0	The CPU operates on the system clock (ϕ) (initial value)
1	The CPU operates on the subclock (ϕ_{SUB})

Bits 2: Reserved bits

Bit 2 is reserved: it is always read as 1 and cannot be modified.

Bits 1 and 0: Active (medium-speed) mode clock select (MA1, MA0)

Bits 1 and 0 choose $\phi_{osc}/128$, $\phi_{osc}/64$, $\phi_{osc}/32$, or $\phi_{osc}/16$ as the operating clock in active (medium-speed) mode and sleep (medium-speed) mode. MA1 and MA0 should be written in active (high-speed) mode or subactive mode.

Bit 1 MA1	Bit 0 MA0	Description
0	0	$\phi_{osc}/16$
0	1	$\phi_{osc}/32$
1	0	$\phi_{osc}/64$
1	1	$\phi_{osc}/128$ (initial value)

2. System Control Register 2 (SYSCR2)

Bit	7	6	5	4	3	2	1	0
	—	—	—	NESEL	DTON	MSON	SA1	SA0
Initial value	1	1	1	1	0	0	0	0
Read/Write	—	—	—	R/W	R/W	R/W	R/W	R/W

SYSCR2 is an 8-bit read/write register for power-down mode control.

Bits 7 to 5: Reserved bits

These bits are reserved; they are always read as 1, and cannot be modified.

Bit 4: Noise elimination sampling frequency select (NESEL)

This bit selects the frequency at which the watch clock signal (ϕ_w) generated by the subclock pulse generator is sampled, in relation to the oscillator clock (ϕ_{osc}) generated by the system clock pulse generator. When $\phi_{osc} = 2$ to 16 MHz, clear NESEL to 0.

Bit 4 NESEL	Description
0	Sampling rate is $\phi_{osc}/16$
1	Sampling rate is $\phi_{osc}/4$ (initial value)

Bit 3: Direct transfer on flag (DTON)

This bit designates whether or not to make direct transitions among active (high-speed), active (medium-speed) and subactive mode when a SLEEP instruction is executed. The mode to which the transition is made after the SLEEP instruction is executed depends on a combination of this and other control bits.

Bit 3 DTON	Description
0	<ul style="list-style-type: none"> When a SLEEP instruction is executed in active mode, a transition is made to standby mode, watch mode, or sleep mode (initial value) When a SLEEP instruction is executed in subactive mode, a transition is made to watch mode or subsleep mode
1	<ul style="list-style-type: none"> When a SLEEP instruction is executed in active (high-speed) mode, a direct transition is made to active (medium-speed) mode if SSBY = 0, MSON = 1, and LSON = 0, or to subactive mode if SSBY = 1, TMA3 = 1, and LSON = 1 When a SLEEP instruction is executed in active (medium-speed) mode, a direct transition is made to active (high-speed) mode if SSBY = 0, MSON = 0, and LSON = 0, or to subactive mode if SSBY = 1, TMA3 = 1, and LSON = 1 When a SLEEP instruction is executed in subactive mode, a direct transition is made to active (high-speed) mode if SSBY = 1, TMA3 = 1, LSON = 0, and MSON = 0, or to active (medium-speed) mode if SSBY = 1, TMA3 = 1, LSON = 0, and MSON = 1

Bit 2: Medium speed on flag (MSON)

After standby, watch, or sleep mode is cleared, this bit selects active (high-speed) or active (medium-speed) mode.

Bit 2 MSON	Description
0	Operation in active (high-speed) mode (initial value)
1	Operation in active (medium-speed) mode

Bits 1 and 0: Subactive mode clock select (SA1 and SA0)

These bits select the CPU clock rate ($\phi_W/2$, $\phi_W/4$, or $\phi_W/8$) in subactive mode. SA1 and SA0 cannot be modified in subactive mode.

Bit 1 SA1	Bit 0 SA0	Description	
0	0	$\phi_W/8$	(initial value)
0	1	$\phi_W/4$	
1	*	$\phi_W/2$	

Note: * Don't care

5.2 Sleep Mode

5.2.1 Transition to Sleep Mode

1. Transition to Sleep (High-Speed) Mode

The system goes from active mode to sleep (high-speed) mode when a SLEEP instruction is executed while the SSBY and LSON bits in SYSCR1 are cleared to 0 and the MSON and DTON bits in SYSCR2 are also cleared to 0. In sleep mode CPU operation is halted but the on-chip peripheral functions. CPU register contents are retained.

2. Transition to Sleep (Medium-Speed) Mode

The system goes from active mode to sleep (medium-speed) mode when a SLEEP instruction is executed while the SSBY and LSON bits in SYSCR1 are cleared to 0, the MSON bit in SYSCR2 is set to 1, and the DTON bit in SYSCR2 is cleared to 0. In sleep (medium-speed) mode, as in sleep (high-speed) mode, CPU operation is halted but the on-chip peripheral functions are operational. The clock frequency in sleep (medium-speed) mode is determined by the MA1 and MA0 bits in SYSCR1. CPU register contents are retained.

The CPU may operate at a 1/2 state faster timing at transition to sleep (medium-speed) mode.

5.2.2 Clearing Sleep Mode

Sleep mode is cleared by any interrupt (timer A, timer C, timer F, timer G, asynchronous counter, IRQ₄ to IRQ₀, WKP₇ to WKP₀, SCI1, SCI3-1, SCI3-2, or A/D converter), or by input at the $\overline{\text{RES}}$ pin.

- Clearing by interrupt

When an interrupt is requested, sleep mode is cleared and interrupt exception handling starts. A transition is made from sleep (high-speed) mode to active (high-speed) mode, or from sleep (medium-speed) mode to active (medium-speed) mode. Sleep mode is not cleared if the I bit of the condition code register (CCR) is set to 1 or the particular interrupt is disabled in the interrupt enable register.

To synchronize the interrupt request signal with the system clock, up to $2/\phi$ (s) delay may occur after the interrupt request signal occurrence, before the interrupt exception handling start.

- Clearing by $\overline{\text{RES}}$ input

When the $\overline{\text{RES}}$ pin goes low, the CPU goes into the reset state and sleep mode is cleared.

5.2.3 Clock Frequency in Sleep (Medium-Speed) Mode

Operation in sleep (medium-speed) mode is clocked at the frequency designated by the MA1 and MA0 bits in SYSCR1.

5.3 Standby Mode

5.3.1 Transition to Standby Mode

The system goes from active mode to standby mode when a SLEEP instruction is executed while the SSBY bit in SYSCR1 is set to 1, the LSON bit in SYSCR1 is cleared to 0, and bit TMA3 in TMA is cleared to 0. In standby mode the clock pulse generator stops, so the CPU and on-chip peripheral modules stop functioning, but as long as the rated voltage is supplied, the contents of CPU registers, on-chip RAM, and some on-chip peripheral module registers are retained. On-chip RAM contents will be further retained down to a minimum RAM data retention voltage. The I/O ports go to the high-impedance state.

5.3.2 Clearing Standby Mode

Standby mode is cleared by an interrupt (IRQ₁ or IRQ₀), WKP₇ to WKP₀ or by input at the $\overline{\text{RES}}$ pin.

- Clearing by interrupt
When an interrupt is requested, the system clock pulse generator starts. After the time set in bits STS2 to STS0 in SYSCR1 has elapsed, a stable system clock signal is supplied to the entire chip, standby mode is cleared, and interrupt exception handling starts. Operation resumes in active (high-speed) mode if MSON = 0 in SYSCR2, or active (medium-speed) mode if MSON = 1. Standby mode is not cleared if the I bit of CCR is set to 1 or the particular interrupt is disabled in the interrupt enable register.
- Clearing by $\overline{\text{RES}}$ input
When the $\overline{\text{RES}}$ pin goes low, the system clock pulse generator starts. After the pulse generator output has stabilized, if the $\overline{\text{RES}}$ pin is driven high, the CPU starts reset exception handling. Since system clock signals are supplied to the entire chip as soon as the system clock pulse generator starts functioning, the $\overline{\text{RES}}$ pin should be kept at the low level until the pulse generator output stabilizes.

5.3.3 Oscillator Settling Time after Standby Mode is Cleared

Bits STS2 to STS0 in SYSCR1 should be set as follows.

- When a crystal oscillator is used
The table below gives settings for various operating frequencies. Set bits STS2 to STS0 for a waiting time at least as long as the oscillation settling time.

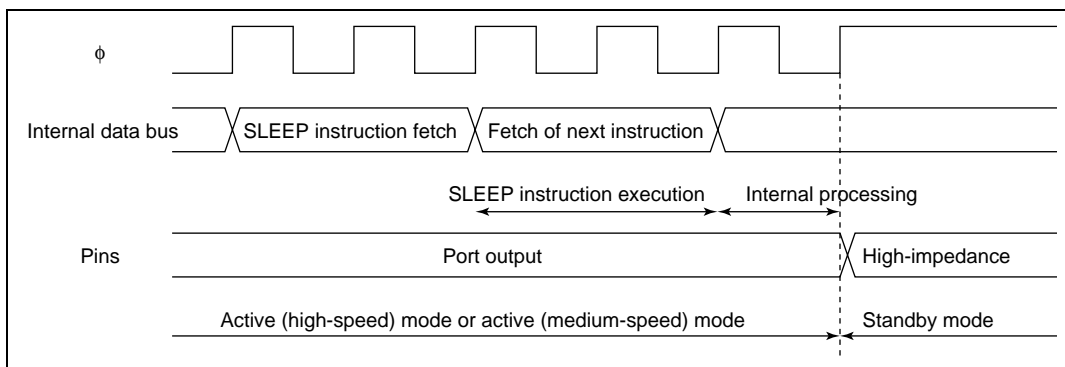
Table 5.4 Clock Frequency and Settling Time (Times are in ms)

STS2	STS1	STS0	Waiting Time	2 MHz	1 MHz
0	0	0	8,192 states	4.1	8.2
0	0	1	16,384 states	8.2	16.4
0	1	0	32,768 states	16.4	32.8
0	1	1	65,536 states	32.8	65.5
1	0	0	131,072 states	65.5	131.1
1	0	1	2 states (not available)	0.001	0.002
1	1	0	8 states	0.004	0.008
1	1	1	16 states	0.008	0.016

- When an external clock is used
STS2 = 1, STS1 = 0, and STS0 = 1 are recommended. Other values can be set, but with other settings, operation may start before the standby time is over.

5.3.4 Standby Mode Transition and Pin States

When a SLEEP instruction is executed in active (high-speed) mode or active (medium-speed) mode while bit SSBY is set to 1 and bit LSON is cleared to 0 in SYSCR1, and bit TMA3 is cleared to 0 in TMA, a transition is made to standby mode. At the same time, pins go to the high-impedance state (except pins for which the pull-up MOS is designated as on). Figure 5.2 shows the timing in this case.

**Figure 5.2 Standby Mode Transition and Pin States**

5.3.5 Notes on External Input Signal Changes before/after Standby Mode

1. When external input signal changes before/after standby mode or watch mode

When an external input signal such as $\overline{\text{IRQ}}$ or $\overline{\text{WKP}}$ is input, both the high- and low-level widths of the signal must be at least two cycles of system clock ϕ or subclock ϕ_{SUB} (referred to together in this section as the internal clock). As the internal clock stops in standby mode and watch mode, the width of external input signals requires careful attention when a transition is made via these operating modes.

2. When external input signals cannot be captured because internal clock stops

The case of falling edge capture is illustrated in figure 5.3

As shown in the case marked "Capture not possible," when an external input signal falls immediately after a transition to active (high-speed or medium-speed) mode or subactive mode, after oscillation is started by an interrupt via a different signal, the external input signal cannot be captured if the high-level width at that point is less than $2 t_{\text{cyc}}$ or $2 t_{\text{subcyc}}$.

3. Recommended timing of external input signals

To ensure dependable capture of an external input signal, high- and low-level signal widths of at least $2 t_{\text{cyc}}$ or $2 t_{\text{subcyc}}$ are necessary before a transition is made to standby mode or watch mode, as shown in "Capture possible: case 1."

External input signal capture is also possible with the timing shown in "Capture possible: case 2" and "Capture possible: case 3," in which a $2 t_{\text{cyc}}$ or $2 t_{\text{subcyc}}$ level width is secured.

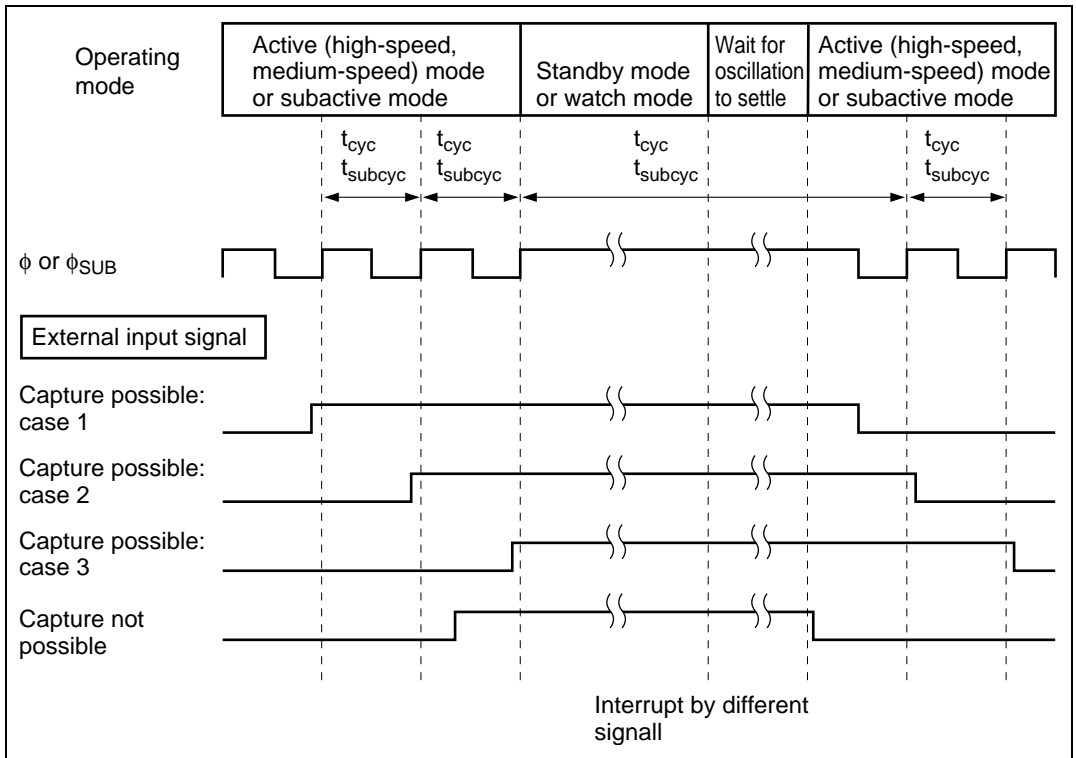


Figure 5.3 External Input Signal Capture when Signal Changes before/after Standby Mode or Watch Mode

4. Input pins to which these notes apply:

\overline{IRQ}_4 to \overline{IRQ}_0 , \overline{WKP}_7 to \overline{WKP}_0 , \overline{ADTRG} , \overline{TMIC} , \overline{TMIF} , \overline{TMIG}

5.4 Watch Mode

5.4.1 Transition to Watch Mode

The system goes from active or subactive mode to watch mode when a SLEEP instruction is executed while the SSBY bit in SYSCR1 is set to 1 and bit TMA3 in TMA is set to 1.

In watch mode, operation of on-chip peripheral modules is halted except for timer A, timer F, timer G, AEC, and the LCD controller/driver (for which operation or halting can be set) is halted. As long as a minimum required voltage is applied, the contents of CPU registers, the on-chip RAM and some registers of the on-chip peripheral modules, are retained. I/O ports keep the same states as before the transition.

5.4.2 Clearing Watch Mode

Watch mode is cleared by an interrupt (timer A, timer F, timer G, IRQ₀, or WKP₇ to WKP₀) or by input at the $\overline{\text{RES}}$ pin.

- Clearing by interrupt

When watch mode is cleared by interrupt, the mode to which a transition is made depends on the settings of LSON in SYSCR1 and MSON in SYSCR2. If both LSON and MSON are cleared to 0, transition is to active (high-speed) mode; if LSON = 0 and MSON = 1, transition is to active (medium-speed) mode; if LSON = 1, transition is to subactive mode. When the transition is to active mode, after the time set in SYSCR1 bits STS2 to STS0 has elapsed, a stable clock signal is supplied to the entire chip, watch mode is cleared, and interrupt exception handling starts. Watch mode is not cleared if the I bit of CCR is set to 1 or the particular interrupt is disabled in the interrupt enable register.

- Clearing by $\overline{\text{RES}}$ input

Clearing by $\overline{\text{RES}}$ pin is the same as for standby mode; see 2. Clearing by $\overline{\text{RES}}$ pin in section 5.3.2, Clearing Standby Mode.

5.4.3 Oscillator Settling Time after Watch Mode is Cleared

The waiting time is the same as for standby mode; see section 5.3.3, Oscillator Settling Time after Standby Mode is Cleared.

5.4.4 Notes on External Input Signal Changes before/after Watch Mode

See section 5.3.5, Notes on External Input Signal Changes before/after Standby Mode.

5.5 Subsleep Mode

5.5.1 Transition to Subsleep Mode

The system goes from subactive mode to subsleep mode when a SLEEP instruction is executed while the SSBY bit in SYSCR1 is cleared to 0, LSON bit in SYSCR1 is set to 1, and TMA3 bit in TMA is set to 1. In subsleep mode, operation of on-chip peripheral modules other than the A/D converter, PWM and WDT is halted. As long as a minimum required voltage is applied, the contents of CPU registers, the on-chip RAM and some registers of the on-chip peripheral modules are retained. I/O ports keep the same states as before the transition.

5.5.2 Clearing Subsleep Mode

Subsleep mode is cleared by an interrupt (timer A, timer C, timer F, timer G, asynchronous counter, SCI1, SCI3-2, SCI3-1, IRQ₄ to IRQ₀, WKP₇ to WKP₀) or by a low input at the $\overline{\text{RES}}$ pin.

- Clearing by interrupt

When an interrupt is requested, subsleep mode is cleared and interrupt exception handling starts. Subsleep mode is not cleared if the I bit of CCR is set to 1 or the particular interrupt is disabled in the interrupt enable register.

To synchronize the interrupt request signal with the subclock, up to $2/\phi_{\text{SUB}}$ (s) delay may occur after the interrupt request signal occurrence, before the interrupt exception handling start.

- Clearing by $\overline{\text{RES}}$ input

Clearing by $\overline{\text{RES}}$ pin is the same as for standby mode; see 2. Clearing by $\overline{\text{RES}}$ pin in section 5.3.2, Clearing Standby Mode.

5.6 Subactive Mode

5.6.1 Transition to Subactive Mode

Subactive mode is entered from watch mode if a timer A, timer F, timer G, IRQ₀, or WKP₇ to WKP₀ interrupt is requested while the LSON bit in SYSCR1 is set to 1. From subsleep mode, subactive mode is entered if a timer A, timer C, timer F, timer G, asynchronous counter, SCI1, SCI3-1, SCI3-2, IRQ₄ to IRQ₀, or WKP₇ to WKP₀ interrupt is requested. A transition to subactive mode does not take place if the I bit of CCR is set to 1 or the particular interrupt is disabled in the interrupt enable register.

5.6.2 Clearing Subactive Mode

Subactive mode is cleared by a SLEEP instruction or by a low input at the $\overline{\text{RES}}$ pin.

- Clearing by SLEEP instruction
If a SLEEP instruction is executed while the SSBY bit in SYSCR1 is set to 1 and TMA3 bit in TMA is set to 1, subactive mode is cleared and watch mode is entered. If a SLEEP instruction is executed while SSBY = 0 and LSON = 1 in SYSCR1 and TMA3 = 1 in TMA, subsleep mode is entered. Direct transfer to active mode is also possible; see section 5.8, Direct Transfer, below.
- Clearing by $\overline{\text{RES}}$ pin
Clearing by $\overline{\text{RES}}$ pin is the same as for standby mode; see 2. Clearing by $\overline{\text{RES}}$ pin in section 5.3.2.

5.6.3 Operating Frequency in Subactive Mode

The operating frequency in subactive mode is set in bits SA1 and SA0 in SYSCR2. The choices are $\phi_w/2$, $\phi_w/4$, and $\phi_w/8$.

5.7 Active (Medium-Speed) Mode

5.7.1 Transition to Active (Medium-Speed) Mode

If the $\overline{\text{RES}}$ pin is driven low, active (medium-speed) mode is entered. If the LSON bit in SYSCR2 is set to 1 while the LSON bit in SYSCR1 is cleared to 0, a transition to active (medium-speed) mode results from IRQ₀, IRQ₁, or WKP₇ to WKP₀ interrupts in standby mode, timer A, timer F, timer G, IRQ₀, or WKP₇ to WKP₀ interrupts in watch mode, or any interrupt in sleep mode. A transition to active (medium-speed) mode does not take place if the I bit of CCR is set to 1 or the particular interrupt is disabled in the interrupt enable register.

The CPU may operate at a 1/2 state faster timing at transition to active (medium-speed) mode.

5.7.2 Clearing Active (Medium-Speed) Mode

Active (medium-speed) mode is cleared by a SLEEP instruction.

- Clearing by SLEEP instruction

A transition to standby mode takes place if the SLEEP instruction is executed while the SSBY bit in SYSCR1 is set to 1, the LSON bit in SYSCR1 is cleared to 0, and the TMA3 bit in TMA is cleared to 0. The system goes to watch mode if the SSBY bit in SYSCR1 is set to 1 and bit TMA3 in TMA is set to 1 when a SLEEP instruction is executed.

When both SSBY and LSON are cleared to 0 in SYSCR1 and a SLEEP instruction is executed, sleep mode is entered. Direct transfer to active (high-speed) mode or to subactive mode is also possible. See section 5.8, Direct Transfer, below for details.

- Clearing by $\overline{\text{RES}}$ pin

When the $\overline{\text{RES}}$ pin is driven low, a transition is made to the reset state and active (medium-speed) mode is cleared.

5.7.3 Operating Frequency in Active (Medium-Speed) Mode

Operation in active (medium-speed) mode is clocked at the frequency designated by the MA1 and MA0 bits in SYSCR1.

5.8 Direct Transfer

5.8.1 Overview of Direct Transfer

The CPU can execute programs in three modes: active (high-speed) mode, active (medium-speed) mode, and subactive mode. A direct transfer is a transition among these three modes without the stopping of program execution. A direct transfer can be made by executing a SLEEP instruction while the DTON bit in SYSCR2 is set to 1. After the mode transition, direct transfer interrupt exception handling starts.

If the direct transfer interrupt is disabled in interrupt enable register 2, a transition is made instead to sleep mode or watch mode. Note that if a direct transition is attempted while the I bit in CCR is set to 1, sleep mode or watch mode will be entered, and it will be impossible to clear the resulting mode by means of an interrupt.

- Direct transfer from active (high-speed) mode to active (medium-speed) mode
When a SLEEP instruction is executed in active (high-speed) mode while the SSBY and LSON bits in SYSCR1 are cleared to 0, the MSON bit in SYSCR2 is set to 1, and the DTON bit in SYSCR2 is set to 1, a transition is made to active (medium-speed) mode via sleep mode.
- Direct transfer from active (medium-speed) mode to active (high-speed) mode
When a SLEEP instruction is executed in active (medium-speed) mode while the SSBY and LSON bits in SYSCR1 are cleared to 0, the MSON bit in SYSCR2 is cleared to 0, and the DTON bit in SYSCR2 is set to 1, a transition is made to active (high-speed) mode via sleep mode.
- Direct transfer from active (high-speed) mode to subactive mode
When a SLEEP instruction is executed in active (high-speed) mode while the SSBY and LSON bits in SYSCR1 are set to 1, the DTON bit in SYSCR2 is set to 1, and the TMA3 bit in TMA is set to 1, a transition is made to subactive mode via watch mode.
- Direct transfer from subactive mode to active (high-speed) mode
When a SLEEP instruction is executed in subactive mode while the SSBY bit in SYSCR1 is set to 1, the LSON bit in SYSCR1 is cleared to 0, the MSON bit in SYSCR2 is cleared to 0, the DTON bit in SYSCR2 is set to 1, and the TMA3 bit in TMA is set to 1, a transition is made directly to active (high-speed) mode via watch mode after the waiting time set in SYSCR1 bits STS2 to STS0 has elapsed.

- Direct transfer from active (medium-speed) mode to subactive mode
When a SLEEP instruction is executed in active (medium-speed) while the SSBY and LSON bits in SYSCR1 are set to 1, the DTON bit in SYSCR2 is set to 1, and the TMA3 bit in TMA is set to 1, a transition is made to subactive mode via watch mode.
- Direct transfer from subactive mode to active (medium-speed) mode
When a SLEEP instruction is executed in subactive mode while the SSBY bit in SYSCR1 is set to 1, the LSON bit in SYSCR1 is cleared to 0, the MSON bit in SYSCR2 is set to 1, the DTON bit in SYSCR2 is set to 1, and the TMA3 bit in TMA is set to 1, a transition is made directly to active (medium-speed) mode via watch mode after the waiting time set in SYSCR1 bits STS2 to STS0 has elapsed.

5.8.2 Direct Transition Times

1. Time for direct transition from active (high-speed) mode to active (medium-speed) mode

A direct transition from active (high-speed) mode to active (medium-speed) mode is performed by executing a SLEEP instruction in active (high-speed) mode while bits SSBY and LSON are both cleared to 0 in SYSCR1, and bits MSON and DTON are both set to 1 in SYSCR2. The time from execution of the SLEEP instruction to the end of interrupt exception handling (the direct transition time) is given by equation (1) below.

$$\text{Direct transition time} = \{ (\text{Number of SLEEP instruction execution states}) + (\text{number of internal processing states}) \} \times (\text{tcyc before transition}) + (\text{number of interrupt exception handling execution states}) \times (\text{tcyc after transition}) \dots\dots\dots (1)$$

Example: Direct transition time = $(2 + 1) \times 2\text{tosc} + 14 \times 16\text{tosc} = 230\text{tosc}$ (when $\phi/8$ is selected as the CPU operating clock)

Notation:

tosc: OSC clock cycle time

tcyc: System clock (ϕ) cycle time

2. Time for direct transition from active (medium-speed) mode to active (high-speed) mode

A direct transition from active (medium-speed) mode to active (high-speed) mode is performed by executing a SLEEP instruction in active (medium-speed) mode while bits SSBY and LSON are both cleared to 0 in SYSCR1, and bit MSON is cleared to 0 and bit DTON is set to 1 in SYSCR2. The time from execution of the SLEEP instruction to the end of interrupt exception handling (the direct transition time) is given by equation (2) below.

$$\text{Direct transition time} = \{ (\text{Number of SLEEP instruction execution states}) + (\text{number of internal processing states}) \} \times (\text{tcyc before transition}) + (\text{number of interrupt exception handling execution states}) \times (\text{tcyc after transition}) \dots\dots\dots (2)$$

Example: Direct transition time = $(2 + 1) \times 16\text{tosc} + 14 \times 2\text{tosc} = 76\text{tosc}$ (when $\phi/8$ is selected as the CPU operating clock)

Notation:

tosc: OSC clock cycle time

tcyc: System clock (ϕ) cycle time

3. Time for direct transition from subactive mode to active (high-speed) mode

A direct transition from subactive mode to active (high-speed) mode is performed by executing a SLEEP instruction in subactive mode while bit SSBY is set to 1 and bit LSON is cleared to 0 in SYSCR1, bit MSON is cleared to 0 and bit DTON is set to 1 in SYSCR2, and bit TMA3 is set to 1 in TMA. The time from execution of the SLEEP instruction to the end of interrupt exception handling (the direct transition time) is given by equation (3) below.

$$\text{Direct transition time} = \{ (\text{Number of SLEEP instruction execution states}) + (\text{number of internal processing states}) \} \times (\text{tsubcyc before transition}) + \{ (\text{wait time set in STS2 to STS0}) + (\text{number of interrupt exception handling execution states}) \} \times (\text{tcyc after transition}) \dots\dots\dots (3)$$

Example: Direct transition time = $(2 + 1) \times 8\text{tw} + (8192 + 14) \times 2\text{tosc} = 24\text{tw} + 16412\text{tosc}$ (when $\phi w/8$ is selected as the CPU operating clock, and wait time = 8192 states)

Notation:

tosc: OSC clock cycle time

tw: Watch clock cycle time

tcyc: System clock (ϕ) cycle time

tsubcyc: Subclock (ϕ_{SUB}) cycle time

4. Time for direct transition from subactive mode to active (medium-speed) mode

A direct transition from subactive mode to active (medium-speed) mode is performed by executing a SLEEP instruction in subactive mode while bit SSBY is set to 1 and bit LSON is cleared to 0 in SYSCR1, bits MSON and DTON are both set to 1 in SYSCR2, and bit TMA3 is set to 1 in TMA. The time from execution of the SLEEP instruction to the end of interrupt exception handling (the direct transition time) is given by equation (4) below.

$$\text{Direct transition time} = \{ (\text{Number of SLEEP instruction execution states}) + (\text{number of internal processing states}) \} \times (\text{tsubcyc before transition}) + \{ (\text{wait time set in STS2 to STS0}) + (\text{number of interrupt exception handling execution states}) \} \times (\text{tcyc after transition}) \quad \dots\dots\dots (4)$$

Example: Direct transition time = $(2 + 1) \times 8t_w + (8192 + 14) \times 16t_{osc} = 24t_w + 131296t_{osc}$
(when $\phi_w/8$ or ϕ_8 is selected as the CPU operating clock, and wait time = 8192 states)

Notation:

tosc: OSC clock cycle time
 tw: Watch clock cycle time
 tcyc: System clock (ϕ) cycle time
 tsubcyc: Subclock (ϕ_{SUB}) cycle time

5.8.3 Notes on External Input Signal Changes before/after Direct Transition

1. Direct transition from active (high-speed) mode to subactive mode
 Since the mode transition is performed via watch mode, see section 5.3.5, Notes on External Input Signal Changes before/after Standby Mode.
2. Direct transition from active (medium-speed) mode to subactive mode
 Since the mode transition is performed via watch mode, see section 5.3.5, Notes on External Input Signal Changes before/after Standby Mode.
3. Direct transition from subactive mode to active (high-speed) mode
 Since the mode transition is performed via watch mode, see section 5.3.5, Notes on External Input Signal Changes before/after Standby Mode.
4. Direct transition from subactive mode to active (medium-speed) mode
 Since the mode transition is performed via watch mode, see section 5.3.5, Notes on External Input Signal Changes before/after Standby Mode.

5.9 Module Standby Mode

5.9.1 Setting Module Standby Mode

Module standby mode is set for individual peripheral functions. All the on-chip peripheral modules can be placed in module standby mode. When a module enters module standby mode, the system clock supply to the module is stopped and operation of the module halts. This state is identical to standby mode.

Module standby mode is set for a particular module by setting the corresponding bit to 0 in clock stop register 1 (CKSTPR1) or clock stop register 2 (CKSTPR2). (See table 5.5.)

5.9.2 Clearing Module Standby Mode

Module standby mode is cleared for a particular module by setting the corresponding bit to 1 in clock stop register 1 (CKSTPR1) or clock stop register 2 (CKSTPR2). (See table 5.5.)

Following a reset, clock stop register 1 (CKSTPR1) and clock stop register 2 (CKSTPR2) are both initialized to H'FF.

Table 5.5 Setting and Clearing Module Standby Mode by Clock Stop Register

Register Name	Bit Name	Operation
CKSTPR1	TACKSTP	1 Timer A module standby mode is cleared
		0 Timer A is set to module standby mode
	TCCKSTP	1 Timer C module standby mode is cleared
		0 Timer C is set to module standby mode
	TFCKSTP	1 Timer F module standby mode is cleared
		0 Timer F is set to module standby mode
	TGCKSTP	1 Timer G module standby mode is cleared
		0 Timer G is set to module standby mode
	ADCKSTP	1 A/D converter module standby mode is cleared
		0 A/D converter is set to module standby mode
S1CKSTP	1 SCI1 module standby mode is cleared	
	0 SCI1 is set to module standby mode	
S32CKSTP	1 SCI3-2 module standby mode is cleared	
	0 SCI3-2 is set to module standby mode	
S31CKSTP	1 SCI3-1 module standby mode is cleared	
	0 SCI3-1 is set to module standby mode	
CKSTPR2	LDCKSTP	1 LCD module standby mode is cleared
		0 LCD is set to module standby mode
	PWCKSTP	1 PWM module standby mode is cleared
		0 PWM is set to module standby mode
	WDCKSTP	1 Watchdog timer module standby mode is cleared
		0 Watchdog timer is set to module standby mode
	AECKSTP	1 Asynchronous event counter module standby mode is cleared
		0 Asynchronous event counter is set to module standby mode

Note: For details of module operation, see the sections on the individual modules.

5.9.3 Usage Note

If, due to the timing with which a peripheral module issues interrupt requests, the module in question is set to module standby mode before an interrupt is processed, the module will stop with the interrupt request still pending. In this situation, interrupt processing will be repeated indefinitely unless interrupts are prohibited.

It is therefore necessary to ensure that no interrupts are generated when a module is set to module standby mode. The surest way to do this is to specify the module standby mode setting only when interrupts are prohibited (interrupts prohibited using the interrupt enable register or interrupts masked using bit CCR-I).

Section 6 ROM

6.1 Overview

The H8/3842R, H8/38342, and H8/38442 have 16 Kbytes of mask ROM, the H8/3843R, H8/38343, and H8/38443 have 24 Kbytes of mask ROM, the H8/3844R, H8/3844S, H8/38344, and H8/38444 have 32 Kbytes of mask ROM, the H8/3845R, H8/3845S, H8/38345, and H8/38445 have 40 Kbytes of mask ROM, the H8/3846R, H8/3846S, H8/38346, and H8/38446 have 48 Kbytes of mask ROM, and the H8/3847R, H8/3847S, H8/38347, and H8/38447 have 60 Kbytes of mask ROM on-chip. The ROM is connected to the CPU by a 16-bit data bus, allowing high-speed two-state access for both byte data and word data. The H8/3847R has a ZTAT™ version with 60-Kbyte PROM.

The H8/3847S Group does not have a ZTAT™ version. The H8/3847R ZTAT™ version must be used.

The F-ZTAT™ versions of the H8/38347 and H8/38447 are equipped with 60 Kbytes of flash memory. The F-ZTAT™ versions of the H8/38344 and H8/38444 are equipped with 32 Kbytes of flash memory.

6.1.1 Block Diagram

Figure 6.1 shows a block diagram of the on-chip ROM.

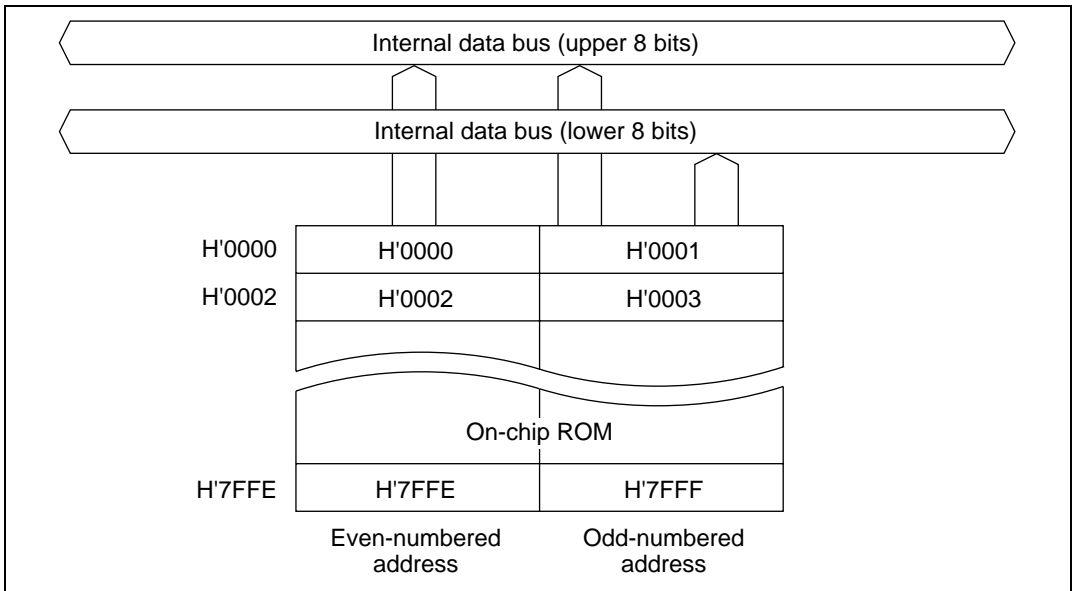


Figure 6.1 ROM Block Diagram (H8/3844R, H8/3844S, H8/38344 and H8/38444)

6.2 PROM Mode (H8/3847R)

6.2.1 Setting to PROM Mode

If the on-chip ROM is PROM, setting the chip to PROM mode stops operation as a microcontroller and allows the PROM to be programmed in the same way as the standard HN27C101 EPROM. However, page programming is not supported. Table 6.1 shows how to set the chip to PROM mode.

Table 6.1 Setting to PROM Mode

Pin Name	Setting
TEST	High level
PB ₄ /AN ₄	Low level
PB ₅ /AN ₅	
PB ₆ /AN ₆	High level

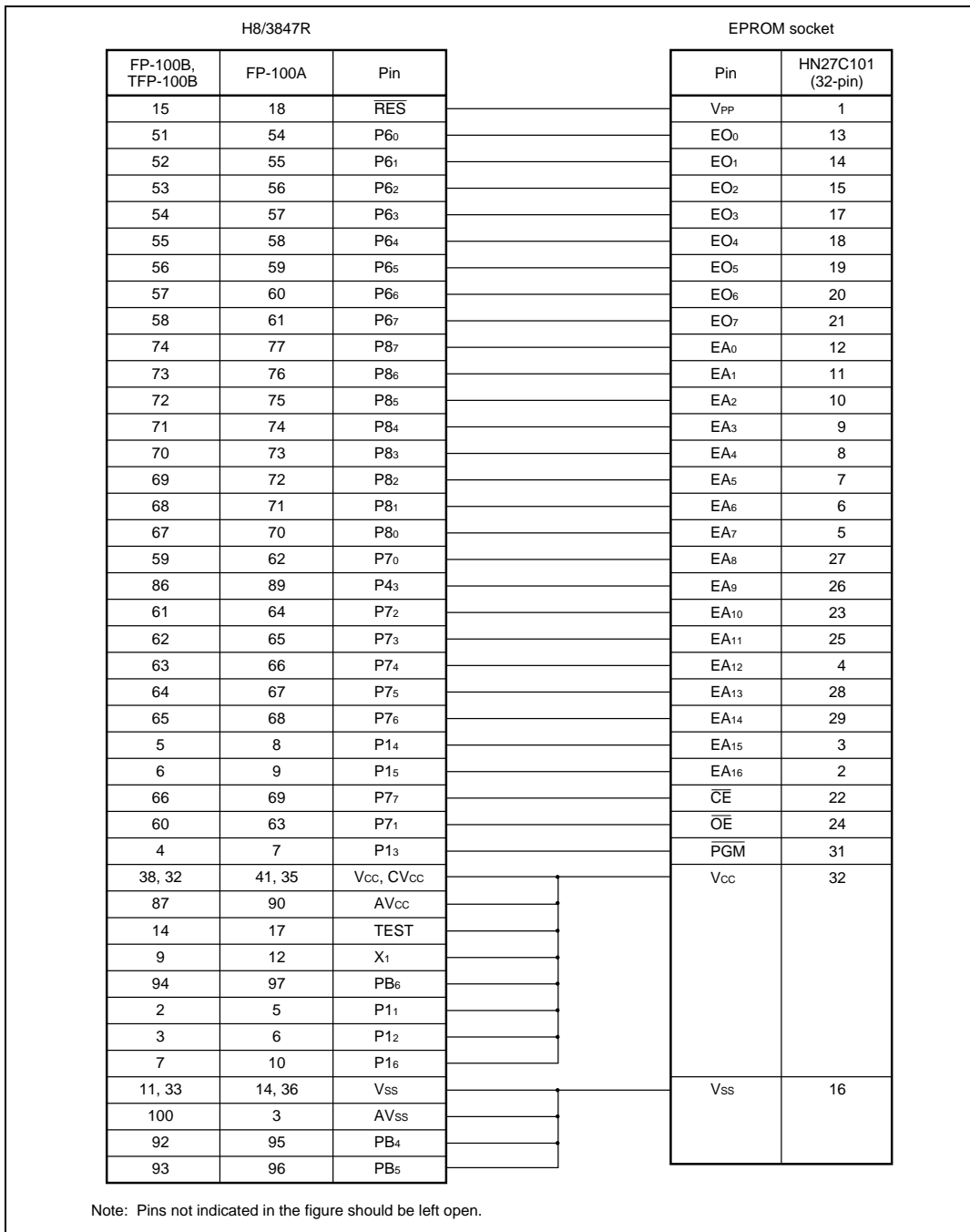
6.2.2 Socket Adapter Pin Arrangement and Memory Map

A standard PROM programmer can be used to program the PROM. A socket adapter is required for conversion to 32 pins, as listed in table 6.2.

Figure 6.2 shows the pin-to-pin wiring of the socket adapter. Figure 6.3 shows a memory map.

Table 6.2 Socket Adapter

Package	Socket Adapter Model (Manufacturer)
100-pin (FP-100B)	ME3887ESHS1H (MINATO)
	H7388BQ100D3201 (DATA-I/O)
100-pin (FP-100A)	ME3887ESFS1H (MINATO)
	H7388AQ100D3201 (DATA-I/O)
100-pin (TFP-100B)	ME3887ESNS1H (MINATO)
	H7388BT100D3201 (DATA-I/O)
100-pin (TFP-100G)	ME3887ESMS1H (MINATO)
	H7388GT100D3201 (DATA-I/O)



Note: Pins not indicated in the figure should be left open.

Figure 6.2 Socket Adapter Pin Correspondence (with HN27C101)

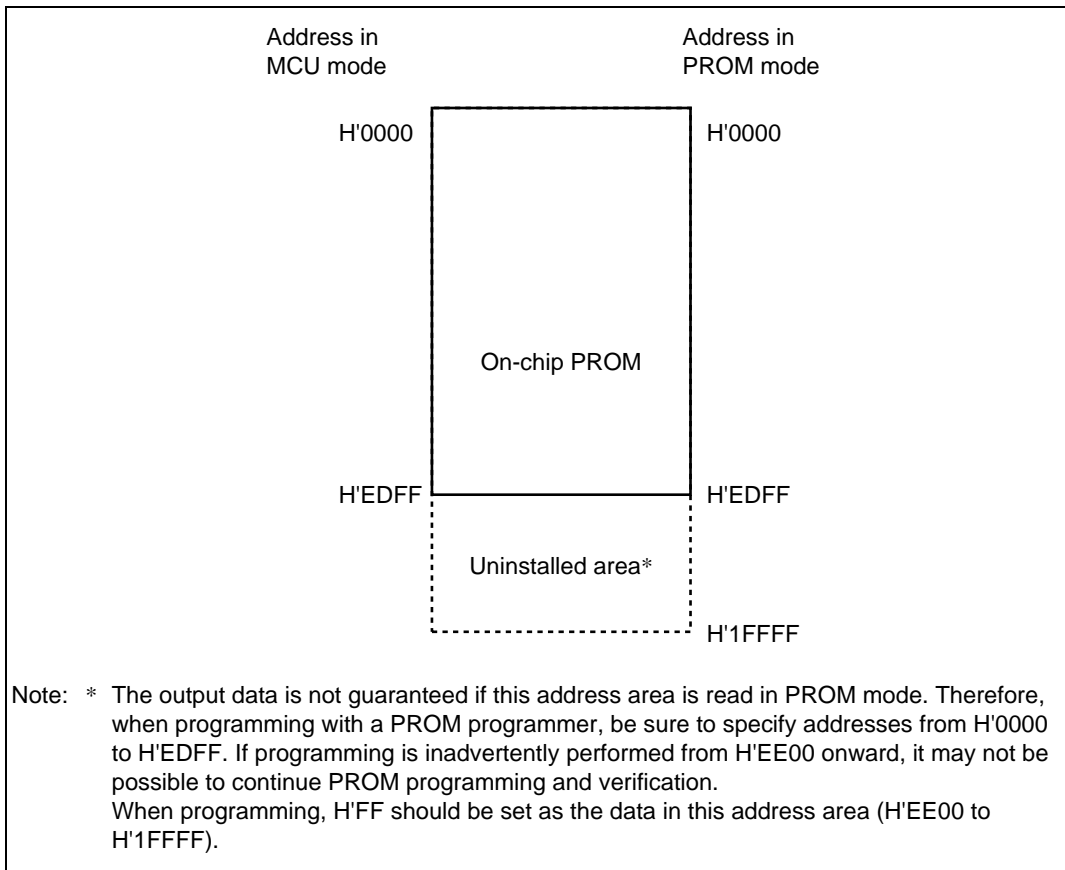


Figure 6.3 H8/3847R Memory Map in PROM Mode

6.3 Programming (H8/3847R)

The write, verify, and other modes are selected as shown in table 6.3 in PROM mode. (H8/3847R)

Table 6.3 Mode Selection in PROM Mode (H8/3847R)

Mode	Pins			V_{PP}	V_{CC}	EO ₇ to EO ₀	EA ₁₆ to EA ₀
	\overline{CE}	\overline{OE}	\overline{PGM}				
Write	L	H	L	V_{PP}	V_{CC}	Data input	Address input
Verify	L	L	H	V_{PP}	V_{CC}	Data output	Address input
Programming disabled	L	L	L	V_{PP}	V_{CC}	High impedance	Address input
	L	H	H				
	H	L	L				
	H	H	H				

Legend:

- L: Low level
- H: High level
- V_{PP} : V_{PP} level
- V_{CC} : V_{CC} level

The specifications for writing and reading are identical to those for the standard HN27C101 EPROM. However, page programming is not supported, and so page programming mode must not be set. A PROM programmer that only supports page programming mode cannot be used. When selecting a PROM programmer, ensure that it supports high-speed, high-reliability byte-by-byte programming. Also, be sure to specify addresses from H'0000 to H'EDFF.

6.3.1 Writing and Verifying

An efficient, high-speed, high-reliability method is available for writing and verifying the PROM data. This method achieves high speed without voltage stress on the device and without lowering the reliability of written data. The basic flow of this high-speed, high-reliability programming method is shown in figure 6.4.

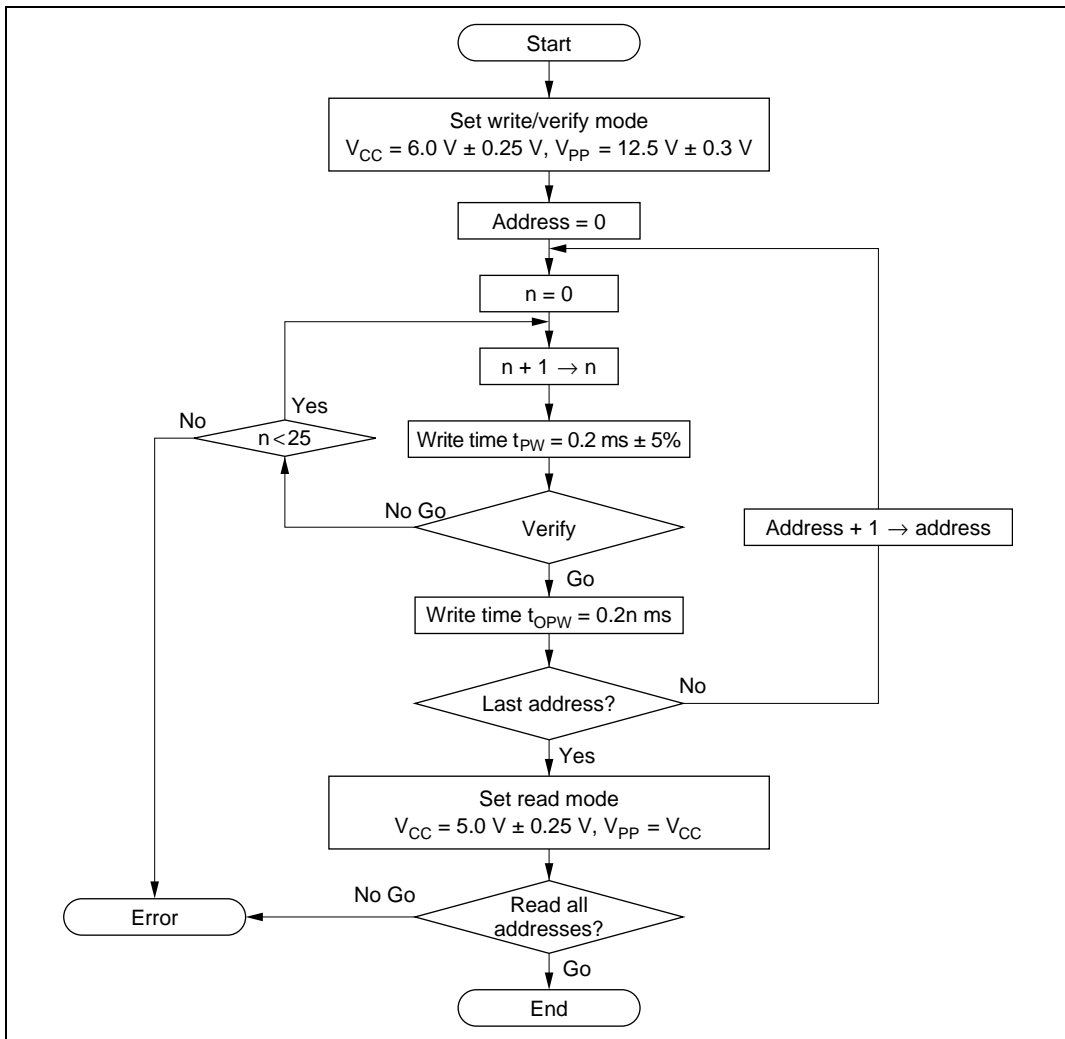


Figure 6.4 High-Speed, High-Reliability Programming Flow Chart

Tables 6.4 and 6.5 give the electrical characteristics in programming mode.

Table 6.4 DC Characteristics

(Conditions: $V_{CC} = 6.0 \text{ V} \pm 0.25 \text{ V}$, $V_{PP} = 12.5 \text{ V} \pm 0.3 \text{ V}$, $V_{SS} = 0 \text{ V}$, $T_a = 25^\circ\text{C} \pm 5^\circ\text{C}$)

Item		Symbol	Min	Typ	Max	Unit	Test Condition
Input high-level voltage	EO ₇ to EO ₀ , EA ₁₆ to EA ₀ $\overline{\text{OE}}$, $\overline{\text{CE}}$, $\overline{\text{PGM}}$	V _{IH}	2.4	—	V _{CC} + 0.3	V	
Input low-level voltage	EO ₇ to EO ₀ , EA ₁₆ to EA ₀ $\overline{\text{OE}}$, $\overline{\text{CE}}$, $\overline{\text{PGM}}$	V _{IL}	-0.3	—	0.8	V	
Output high-level voltage	EO ₇ to EO ₀	V _{OH}	2.4	—	—	V	I _{OH} = -200 μA
Output low-level voltage	EO ₇ to EO ₀	V _{OL}	—	—	0.45	V	I _{OL} = 0.8 mA
Input leakage current	EO ₇ to EO ₀ , EA ₁₆ to EA ₀ $\overline{\text{OE}}$, $\overline{\text{CE}}$, $\overline{\text{PGM}}$	I _{LI}	—	—	2	μA	V _{in} = 5.25 V/0.5 V
V _{CC} current		I _{CC}	—	—	40	mA	
V _{PP} current		I _{PP}	—	—	40	mA	

Table 6.5 AC Characteristics(Conditions: $V_{CC} = 6.0\text{ V} \pm 0.25\text{ V}$, $V_{PP} = 12.5\text{ V} \pm 0.3\text{ V}$, $T_a = 25^\circ\text{C} \pm 5^\circ\text{C}$)

Item	Symbol	Min	Typ	Max	Unit	Test Condition
Address setup time	t_{AS}	2	—	—	μs	Figure 6.5* ¹
\overline{OE} setup time	t_{OES}	2	—	—	μs	
Data setup time	t_{DS}	2	—	—	μs	
Address hold time	t_{AH}	0	—	—	μs	
Data hold time	t_{DH}	2	—	—	μs	
Data output disable time	t_{DF} ^{*2}	—	—	130	μs	
V_{PP} setup time	t_{VPS}	2	—	—	μs	
Programming pulse width	t_{PW}	0.19	0.20	0.21	ms	
\overline{PGM} pulse width for overwrite programming	t_{OPW} ^{*3}	0.19	—	5.25	ms	
\overline{CE} setup time	t_{CES}	2	—	—	μs	
V_{CC} setup time	t_{VCS}	2	—	—	μs	
Data output delay time	t_{OE}	0	—	200	ns	

Notes: 1. Input pulse level: 0.45 V to 2.2 V

Input rise time/fall time $\leq 20\text{ ns}$

Timing reference levels Input: 0.8 V, 2.0 V

Output: 0.8 V, 2.0 V

- t_{DF} is defined at the point at which the output is floating and the output level cannot be read.
- t_{OPW} is defined by the value given in figure 6.4, High-Speed, High-Reliability Programming Flow Chart.

Figure 6.5 shows a PROM write/verify timing diagram.

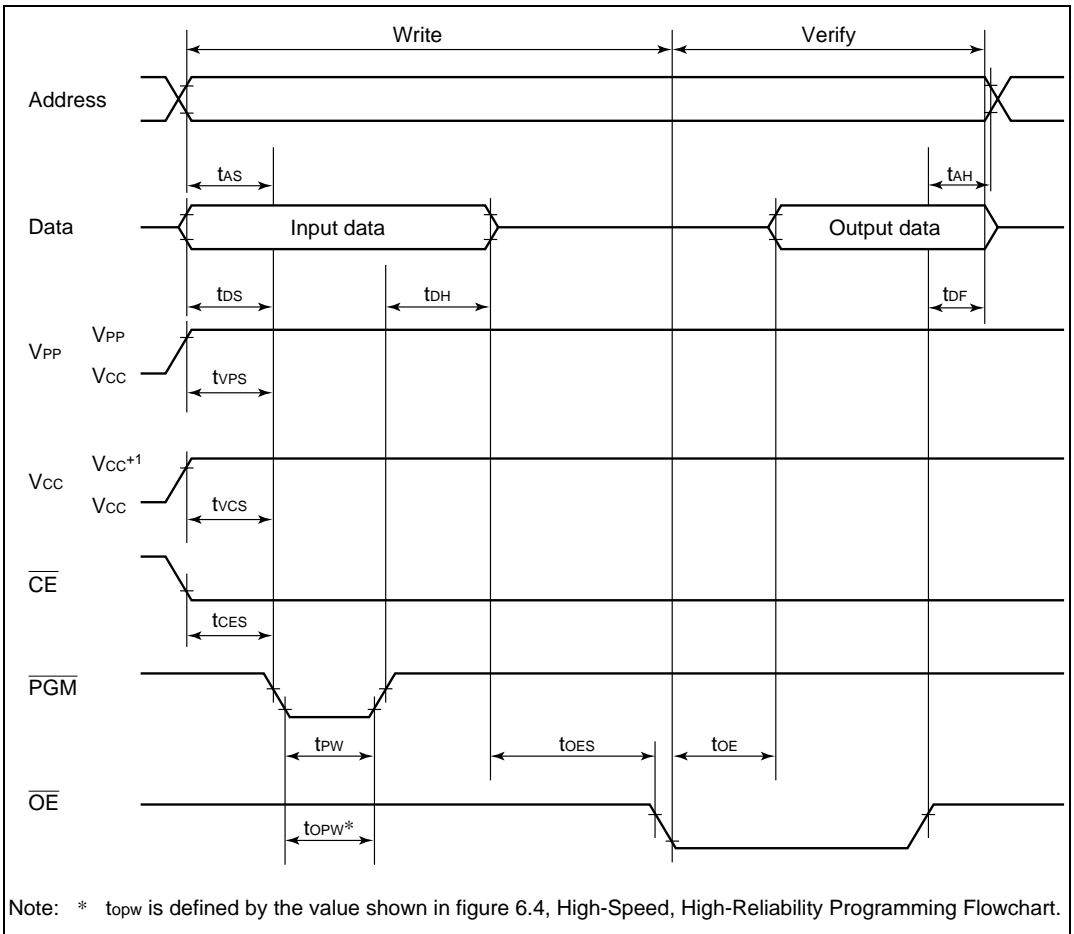


Figure 6.5 PROM Write/Verify Timing

6.3.2 Programming Precautions

- Use the specified programming voltage and timing.
- The programming voltage in PROM mode (V_{PP}) is 12.5 V. Use of a higher voltage can permanently damage the chip. Be especially careful with respect to PROM programmer overshoot.
- Setting the PROM programmer to Renesas specifications for the HN27C101 will result in correct V_{PP} of 12.5 V.
- Make sure the index marks on the PROM programmer socket, socket adapter, and chip are properly aligned. If they are not, the chip may be destroyed by excessive current flow. Before programming, be sure that the chip is properly mounted in the PROM programmer.
- Avoid touching the socket adapter or chip while programming, since this may cause contact faults and write errors.
- Take care when setting the programming mode, as page programming is not supported.
- When programming with a PROM programmer, be sure to specify addresses from H'0000 to H'EDFF. If programming is inadvertently performed from H'EE00 onward, it may not be possible to continue PROM programming and verification. When programming, H'FF should be set as the data in address area H'EE00 to H'1FFFF.

6.4 Reliability of Programmed Data

A highly effective way to improve data retention characteristics is to bake the programmed chips at 150°C, then screen them for data errors. This procedure quickly eliminates chips with PROM memory cells prone to early failure.

Figure 6.6 shows the recommended screening procedure.

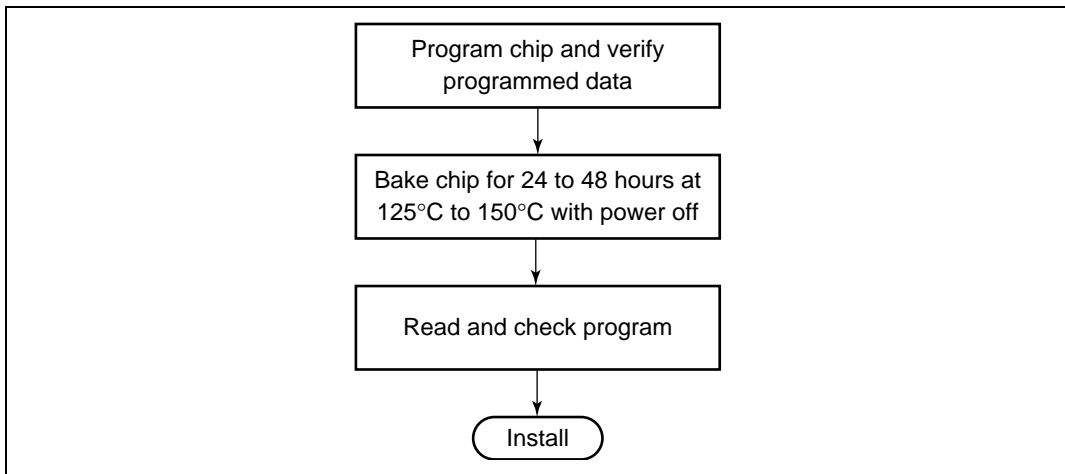


Figure 6.6 Recommended Screening Procedure

If a series of programming errors occurs while the same PROM programmer is in use, stop programming and check the PROM programmer and socket adapter for defects. Please inform Renesas Technology of any abnormal conditions noted during or after programming or in screening of program data after high-temperature baking.

6.5 Flash Memory Overview

6.5.1 Features

The features of the 60 Kbytes or 32 Kbytes of flash memory built into the F-ZTAT versions are summarized below.

- Programming/erase methods
 - The flash memory is programmed 128 bytes at a time. Erase is performed in single-block units. The 60-Kbyte flash memory is configured as follows: 1 Kbyte \times 4 blocks, 28 Kbytes \times 1 block, 16 Kbytes \times 1 block, 8 Kbytes \times 1 block and 4 Kbytes \times 1 block. The 32-Kbyte flash memory is configured as follows: 1 Kbyte \times 4 blocks, 28 Kbytes \times 1 block. To erase the entire flash memory, each block must be erased in turn.
- Reprogramming capability
 - The flash memory can be reprogrammed up to 1,000 times.
- On-board programming
 - On-board programming/erasing can be done in boot mode, in which the boot program built into the chip is started to erase or program of the entire flash memory. In normal user program mode, individual blocks can be erased or programmed.
- Programmer mode
 - Flash memory can be programmed/erased in programmer mode using a PROM programmer, as well as in on-board programming mode.
- Automatic bit rate adjustment
 - For data transfer in boot mode, this LSI's bit rate can be automatically adjusted to match the transfer bit rate of the host.
- Programming/erasing protection
 - Sets software protection against flash memory programming/erasing.
- Power-down mode
 - The power supply circuit is partly halted in the subactive mode and can be read in the power-down mode.

6.5.2 Block Diagram

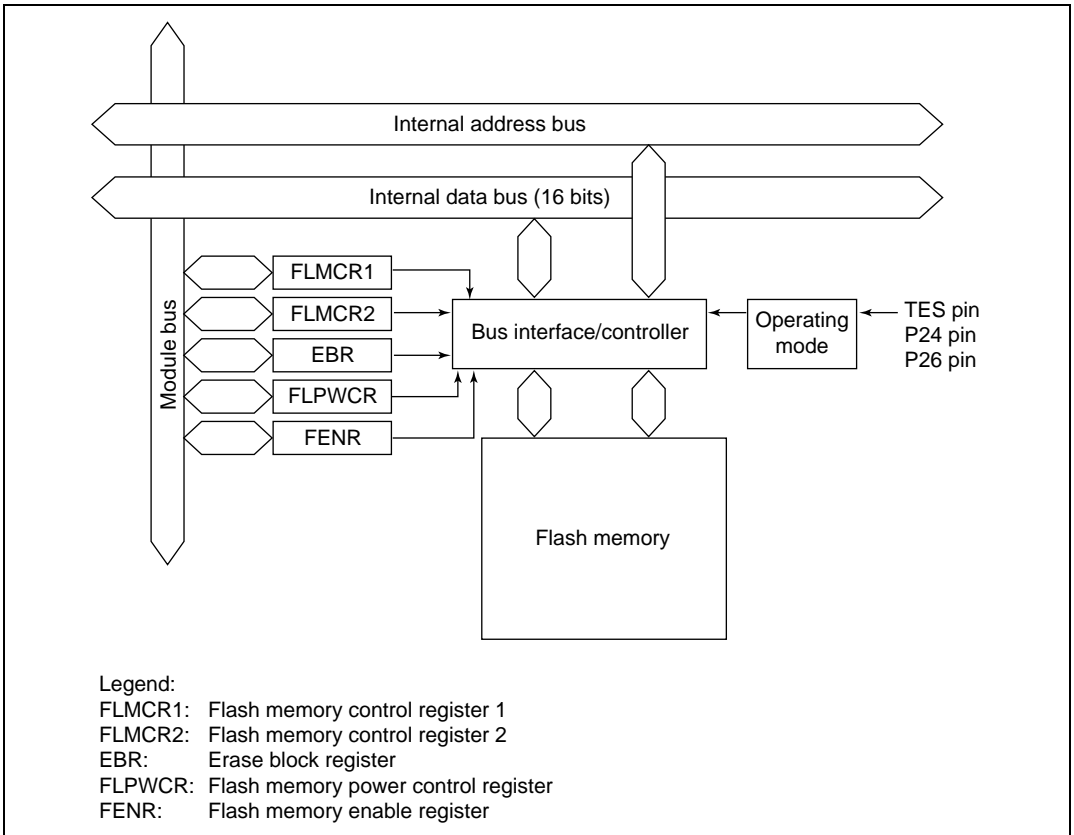


Figure 6.7 Block Diagram of Flash Memory

6.5.3 Block Configuration

Figure 6.8 shows the block configuration of flash memory. The thick lines indicate erasing units, the narrow lines indicate programming units, and the values are addresses. The flash memory is divided into 1 Kbyte \times 4 blocks, 28 Kbytes \times 1 block, 16 Kbytes \times 1 block, 8 Kbytes \times 1 block and 4 Kbytes \times 1 block. Erasing is performed in these units. Programming is performed in 128-byte units starting from an address with lower eight bits H'00 or H'80.

Erase unit 1 Kbyte	H'0000	H'0001	H'0002	← Programming unit: 128 bytes →	H'007F
	H'0080	H'0081	H'0082		H'00FF
	H'0380	H'0381	H'0382		H'03FF
Erase unit 1 Kbyte	H'0400	H'0401	H'0402	← Programming unit: 128 bytes →	H'047F
	H'0480	H'0481	H'0482		H'04FF
	H'0780	H'0781	H'0782		H'07FF
Erase unit 1 Kbyte	H'0800	H'0801	H'0802	← Programming unit: 128 bytes →	H'087F
	H'0880	H'0881	H'0882		H'080F
	H'0B80	H'0B81	H'0B82		H'0BFF
Erase unit 1 Kbyte	H'0C00	H'0C01	H'0C02	← Programming unit: 128 bytes →	H'0C7F
	H'0C80	H'0C81	H'0C82		H'0CFF
	H'0F80	H'0F81	H'0F82		H'0FFF
Erase unit 28 Kbytes	H'1000	H'1001	H'1002	← Programming unit: 128 bytes →	H'107F
	H'1080	H'1081	H'1082		H'10FF
	H'7F80	H'7F81	H'7F82		H'7FFF
Erase unit 16 Kbyte	H'8000	H'8001	H'8002	← Programming unit: 128 bytes →	H'807F
	H'8080	H'8081	H'8082		H'8CFF
	H'BF80	H'BF81	H'BF82		H'BFFF
Erase unit 8 Kbyte	H'C000	H'C001	H'C002	← Programming unit: 128 bytes →	H'C07F
	H'C080	H'C081	H'C082		H'CCFF
	H'DF80	H'DF81	H'DF82		H'DFFF
Erase unit 4 Kbyte	H'E000	H'E001	H'E002	← Programming unit: 128 bytes →	H'E07F
	H'E080	H'E081	H'E082		H'ECFF
	H'EF80	H'EF81	H'EF82		H'EFFF

Figure 6.8 Flash Memory Block Configuration

6.5.4 Register Configuration

Table 6.6 lists the register configuration to control the flash memory when the built in flash memory is effective.

Table 6.6 Register Configuration

Register Name	Abbreviation	R/W	Initial Value	Address
Flash memory control register 1	FLMCR1	R/W	H'00	H'F020
Flash memory control register 2	FLMCR2	R	H'00	H'F021
Flash memory power control register	FLPWCR	R/W	H'00	H'F022
Erase block register	EBR	R/W	H'00	H'F023
Flash memory enable register	FENR	R/W	H'00	H'F02B

Note: FLMCR1, FLMCR2, FLPWCR, EBR, and FENR are 8 bit registers. Only byte access is enabled which are two-state access. These registers are dedicated to the product in which flash memory is included. The product in which PROM or ROM is included does not have these registers. When the corresponding address is read in these products, the value is undefined. A write is disabled.

6.6 Descriptions of Registers of the Flash Memory

6.6.1 Flash Memory Control Register 1 (FLMCR1)

Bit	7	6	5	4	3	2	1	0
	—	SWE	ESU	PSU	EV	PV	E	P
Initial value	0	0	0	0	0	0	0	0
Read/Write	—	R/W	R/W	R/W	R/W	R/W	R/W	R/W

FLMCR1 is a register that makes the flash memory change to program mode, program-verify mode, erase mode, or erase-verify mode. For details on register setting, refer to section 6.8, Flash Memory Programming/Erasing. By setting this register, the flash memory enters program mode, erase mode, program-verify mode, or erase-verify mode. Read the data in the state that bits 6 to 0 of this register are cleared when using flash memory as normal built-in ROM.

Bit 7—Reserved

This bit is always read as 0 and cannot be modified.

Bit 6—Software Write Enable (SWE)

This bit is to set enabling/disabling of programming/enabling of flash memory (set when bits 5 to 0 and the EBR register are to be set).

Bit 6

SWE

Description

0	Programming/erasing is disabled. Other FLMCR1 register bits and all EBR bits cannot be set. (initial value)
1	Flash memory programming/erasing is enabled.

Bit 5—Erase Setup (ESU)

This bit is to prepare for changing to erase mode. Set this bit to 1 before setting the E bit to 1 in FLMCR1 (do not set SWE, PSU, EV, PV, E, and P bits at the same time).

Bit 5 ESU	Description	
0	The erase setup state is cancelled	(initial value)
1	The flash memory changes to the erase setup state. Set this bit to 1 before setting the E bit to 1 in FLMCR1.	

Bit 4—Program Setup (PSU)

This bit is to prepare for changing to program mode. Set this bit to 1 before setting the P bit to 1 in FLMCR1 (do not set SWE, ESU, EV, PV, E, and P bits at the same time).

Bit 4 PSU	Description	
0	The program setup state is cancelled	(initial value)
1	The flash memory changes to the program setup state. Set this bit to 1 before setting the P bit to 1 in FLMCR1.	

Bit 3—Erase-Verify (EV)

This bit is to set changing to or cancelling erase-verify mode (do not set SWE, ESU, PSU, PV, E, and P bits at the same time).

Bit 3 EV	Description	
0	Erase-verify mode is cancelled	(initial value)
1	The flash memory changes to erase-verify mode	

Bit 2—Program-Verify (PV)

This bit is to set changing to or cancelling program-verify mode (do not set SWE, ESU, PSU, EV, E, and P bits at the same time).

Bit 2

PV	Description
0	Program-verify mode is cancelled (initial value)
1	The flash memory changes to program-verify mode

Bit 1—Erase (E)

This bit is to set changing to or cancelling erase mode (do not set SWE, ESU, PSU, EV, PV, and P bits at the same time).

Bit 1

E	Description
0	Erase mode is cancelled (initial value)
1	When this bit is set to 1, while the SWE = 1 and ESU = 1, the flash memory changes to erase mode.

Bit 0—Program (P)

This bit is to set changing to or cancelling program mode (do not set SWE, ESU, PSU, EV, PV, and E bits at the same time).

Bit 0

P	Description
0	Program mode is cancelled (initial value)
1	When this bit is set to 1, while the SWE = 1 and PSU = 1, the flash memory changes to program mode.

6.6.2 Flash Memory Control Register 2 (FLMCR2)

Bit	7	6	5	4	3	2	1	0
	FLER	—	—	—	—	—	—	—
Initial value	0	0	0	0	0	0	0	0
Read/Write	R	—	—	—	—	—	—	—

FLMCR2 is a register that displays the state of flash memory programming/erasing. FLMCR2 is a read-only register, and should not be written to.

Bit 7—Flash Memory Error (FLER)

This bit is set when the flash memory detects an error and goes to the error-protection state during programming or erasing to the flash memory. See section 6.9.3, Error Protection, for details.

Bit 7

FLER	Description
0	The flash memory operates normally. (initial value)
1	Indicates that an error has occurred during an operation on flash memory (programming or erasing).

Bits 6 to 0—Reserved

These bits are always read as 0 and cannot be modified.

6.6.3 Erase Block Register (EBR)

Bit	7	6	5	4	3	2	1	0
	EB7	EB6	EB5	EB4	EB3	EB2	EB1	EB0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

EBR specifies the flash memory erase area block. EBR is initialized to H'00 when the SWE bit in FLMCR1 is 0. Do not set more than one bit at a time, as this will cause all the bits in EBR to be automatically cleared to 0. When each bit is set to 1 in EBR, the corresponding block can be erased. Other blocks change to the erase-protection state. See table 6.7 for the method of dividing blocks of the flash memory. When the whole bits are to be erased, erase them in turn in unit of a block.

Table 6.7 Division of Blocks to Be Erased

EBR	Bit Name	Block (Size)	Address
0	EB0	EB0 (1 Kbyte)	H'0000 to H'03FF
1	EB1	EB1 (1 Kbyte)	H'0400 to H'07FF
2	EB2	EB2 (1 Kbyte)	H'0800 to H'0BFF
3	EB3	EB3 (1 Kbyte)	H'0C00 to H'0FFF
4	EB4	EB4 (28 Kbytes)	H'1000 to H'7FFF
5	EB5	EB5 (16 Kbyte)	H'8000 to H'BFFF
6	EB6	EB6 (8 Kbyte)	H'C000 to H'DFFF
7	EB7	EB7 (4 Kbytes)	H'E000 to H'FFFF

6.6.4 Flash Memory Power Control Register (FLPWCR)

Bit	7	6	5	4	3	2	1	0
PDWND	—	—	—	—	—	—	—	—
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	—	—	—	—	—	—	—

FLPWCR enables or disables a transition to the flash memory power-down mode when the LSI switches to subactive mode. The power supply circuit can be read in the subactive mode, although it is partly halted in the power-down mode.

Bit 7—Power-down Disable (PDWND)

This bit selects the power-down mode of the flash memory when a transition to the subactive mode is made.

Bit 7

PDWND	Description
0	When this bit is 0 and a transition is made to the subactive mode, the flash memory enters the power-down mode. (initial value)
1	When this bit is 1, the flash memory remains in the normal mode even after a transition is made to the subactive mode.

Bits 6 to 0—Reserved

These bits are always read as 0 and cannot be modified.

6.6.5 Flash Memory Enable Register (FENR)

Bit	7	6	5	4	3	2	1	0
	FLSHE	—	—	—	—	—	—	—
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	—	—	—	—	—	—	—

FENR controls CPU access to the flash memory control registers, FLMCR1, FLMCR2, EBR, and FLPWCR.

Bit 7—Flash Memory Control Register Enable (FLSHE)

This bit controls access to the flash memory control registers.

Bit 7

FLSHE	Description
0	Flash memory control registers cannot be accessed (initial value)
1	Flash memory control registers can be accessed

Bits 6 to 0—Reserved

These bits are always read as 0 and cannot be modified.

6.7 On-Board Programming Modes

There are two modes for programming/erasing of the flash memory; boot mode, which enables on-board programming/erasing, and programmer mode, in which programming/erasing is performed with a PROM programmer. On-board programming/erasing can also be performed in user program mode. At reset-start in reset mode, the device changes to a mode depending on the TEST pin settings, P24 pin settings, and input level of each port, as shown in table 6.8. The input level of each pin must be defined four states before the reset ends.

When changing to boot mode, the boot program built into this LSI is initiated. The boot program transfers the programming control program from the externally-connected host to on-chip RAM via SCI32. After erasing the entire flash memory, the programming control program is executed. This can be used for programming initial values in the on-board state or for a forcible return when programming/erasing can no longer be done in user program mode. In user program mode, individual blocks can be erased and programmed by branching to the user program/erase control program prepared by the user.

Table 6.8 Setting Programming Modes

TEST	P24	P26	PB0	PB1	PB2	LSI State after Reset End
0	1	X	X	X	X	User Mode
0	0	1	X	X	X	Boot Mode
1	X	X	0	0	0	Programmer Mode

X: Don't care

6.7.1 Boot Mode

Table 6.9 shows the boot mode operations between reset end and branching to the programming control program. The device uses SCI32 in the boot mode.

1. When boot mode is used, the flash memory programming control program must be prepared in the host beforehand. Prepare a programming control program in accordance with the description in section 6.8, Flash Memory Programming/Erasing.
2. SCI3 should be set to asynchronous mode, and the transfer format as follows: 8-bit data, 1 stop bit, and no parity. The inversion function of TXD and RXD pins by the SPCR register is set to "Not to be inverted," so do not put the circuit for inverting a value between the host and this LSI.
3. When the boot program is initiated, the chip measures the low-level period of asynchronous SCI communication data (H'00) transmitted continuously from the host. The chip then calculates the bit rate of transmission from the host, and adjusts the SCI3 bit rate to match that of the host. The reset should end with the RXD pin high. The RXD and TXD pins should be pulled up on the board if necessary. After the reset is complete, it takes approximately 100 states before the chip is ready to measure the low-level period.
4. After matching the bit rates, the chip transmits one H'00 byte to the host to indicate the completion of bit rate adjustment. The host should confirm that this adjustment end indication (H'00) has been received normally, and transmit one H'55 byte to the chip. If reception could not be performed normally, initiate boot mode again by a reset. Depending on the host's transfer bit rate and system clock frequency of this LSI, there will be a discrepancy between the bit rates of the host and the chip. To operate the SCI properly, set the host's transfer bit rate and system clock frequency of this LSI within the ranges listed in table 6.10.
5. In boot mode, a part of the on-chip RAM area is used by the boot program. The area H'F780 to H'FEF is the area to which the programming control program is transferred from the host. The boot program area cannot be used until the execution state in boot mode switches to the programming control program.
6. Before branching to the programming control program, the chip terminates transfer operations by SCI3 (by clearing the RE and TE bits in SCR to 0), however the adjusted bit rate value remains set in BRR. Therefore, the programming control program can still use it for transfer of write data or verify data with the host. The TXD pin is high (PCR42 = 1, P42 = 1). The contents of the CPU general registers are undefined immediately after branching to the programming control program. These registers must be initialized at the beginning of the programming control program, as the stack pointer (SP), in particular, is used implicitly in subroutine calls, etc.
7. Boot mode can be cleared by a reset. End the reset after driving the reset pin low, waiting at least 20 states, and then setting the TEST pin and P24 pin. Boot mode is also cleared when a WDT overflow occurs.

8. Do not change the TEST pin and P24 pin input levels in boot mode.

Table 6.9 Boot Mode Operation

Item	Host Operation	LSI Operation
	Processing Contents	Processing Contents
		Branches to boot program at reset-start.
Bit rate adjustment	Continuously transmits data H'00 at specified bit rate.	<ul style="list-style-type: none"> Measures low-level period of receive data H'00. Calculates bit rate and sets it in BRR of SCI3. Transmits data H'00 to the host to indicate that the adjustment has ended.
Flash memory erase	Transmits data H'55 when data H'00 is received and no error occurs.	Checks flash memory data, erases all flash memory blocks in case of written data existing, and transmits data H'AA to host. (If erase could not be done, transmits data H'FF to host and aborts operation.)
Transfer of programming control program	Transmits number of bytes (N) of programming control program to be transferred as 2-byte data (low-order byte following high-order byte)	Echobacks the 2-byte received data to host.
Transfer of programming control program (repeated for N times)	Transmits 1-byte of programming control program	Echobacks received data to host and also transfers it to RAM.
Execution of Programming control program		Transmits 1-byte data H'AA to host. Branches to programming control program transferred to on-chip RAM and starts execution.

Table 6.10 Oscillating Frequencies (f_{OSC}) for which Automatic Adjustment of LSI Bit Rate Is Possible

Product Group	Host Bit Rate	Oscillating Frequencies (f_{OSC}) Range of LSI
H8/38347F-ZTAT	19,200 bps	16 MHz
H8/38344F-ZTAT	9,600 bps	8 to 16 MHz
H8/38447F-ZTAT	4,800 bps	6 to 16 MHz
H8/38444F-ZTAT	2,400 bps	2 to 16 MHz
	1,200 bps	2 to 16 MHz

6.7.2 Programming/Erasing in User Program Mode

The term user mode refers to the status when a user program is being executed. On-board programming/erasing of an individual flash memory block can also be performed in user program mode by branching to a user program/erase control program. The user must set branching conditions and provide on-board means of supplying programming data. The flash memory must contain the user program/erase control program or a program that provides the user program/erase control program from external memory. As the flash memory itself cannot be read during programming/erasing, transfer the user program/erase control program to on-chip RAM, as in boot mode. Figure 6.9 shows a sample procedure for programming/erasing in user program mode. Prepare a user program/erase control program in accordance with the description in section 6.8, Flash Memory Programming/Erasing.

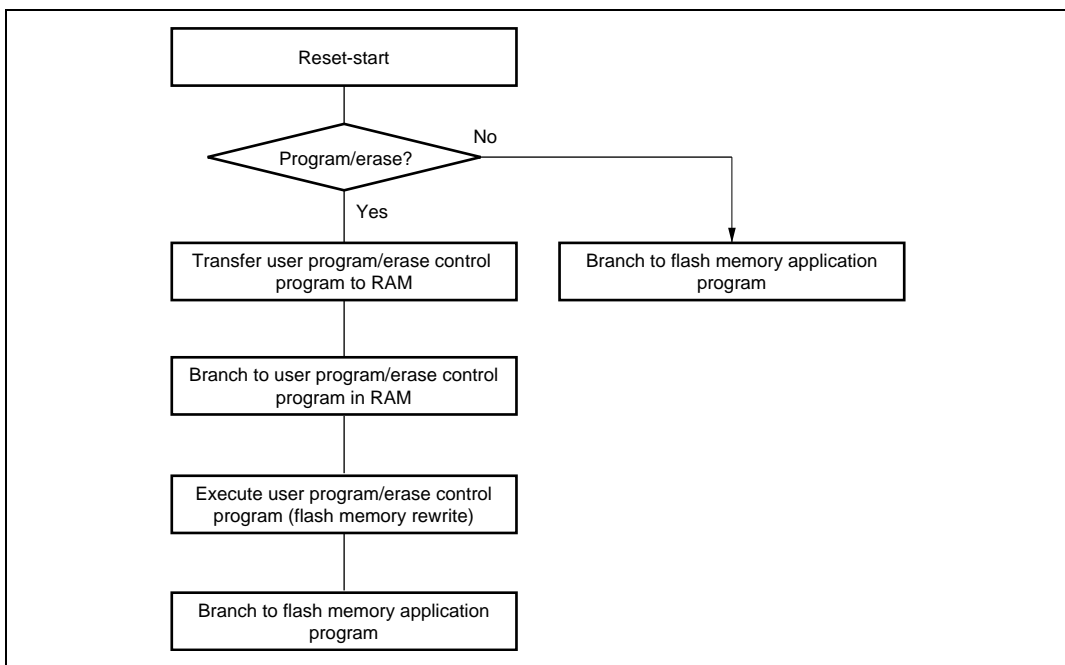


Figure 6.9 Programming/Erasing Flowchart Example in User Program Mode

6.8 Flash Memory Programming/Erasing

A software method using the CPU is employed to program and erase flash memory in the on-board programming modes. Depending on the FLMCR1 setting, the flash memory operates in one of the following four modes: Program mode, program-verify mode, erase mode, and erase-verify mode. The programming control program in boot mode and the user program/erase control

program in user program mode use these operating modes in combination to perform programming/erasing. Flash memory programming and erasing should be performed in accordance with the descriptions in section 6.8.1, Program/Program-Verify and section 6.8.2, Erase/Erase-Verify, respectively.

6.8.1 Program/Program-Verify

When writing data or programs to the flash memory, the program/program-verify flowchart shown in figure 6.10 should be followed. Performing programming operations according to this flowchart will enable data or programs to be written to the flash memory without subjecting the chip to voltage stress or sacrificing program data reliability.

1. Programming must be done to an empty address. Do not reprogram an address to which programming has already been performed.
2. Programming should be carried out 128 bytes at a time. A 128-byte data transfer must be performed even if writing fewer than 128 bytes. In this case, H'FF data must be written to the extra addresses.
3. Prepare the following data storage areas in RAM: A 128-byte programming data area, a 128-byte reprogramming data area, and a 128-byte additional-programming data area. Perform reprogramming data computation according to table 6.11, and additional programming data computation according to table 6.12.
4. Consecutively transfer 128 bytes of data in byte units from the reprogramming data area or additional-programming data area to the flash memory. The program address and 128-byte data are latched in the flash memory. The lower 8 bits of the start address in the flash memory destination area must be H'00 or H'80.
5. The time during which the P bit is set to 1 is the programming time. Figure 6.12 shows the allowable programming times.
6. The watchdog timer (WDT) is set to prevent overprogramming due to program runaway, etc. An overflow cycle of approximately 6.6 ms is allowed.
7. For a dummy write to a verify address, write 1-byte data H'FF to an address whose lower 1 bit is b'0. Verify data can be read in word size from the address to which a dummy write was performed.
8. The maximum number of repetitions of the program/program-verify sequence of the same bit is 1,000.

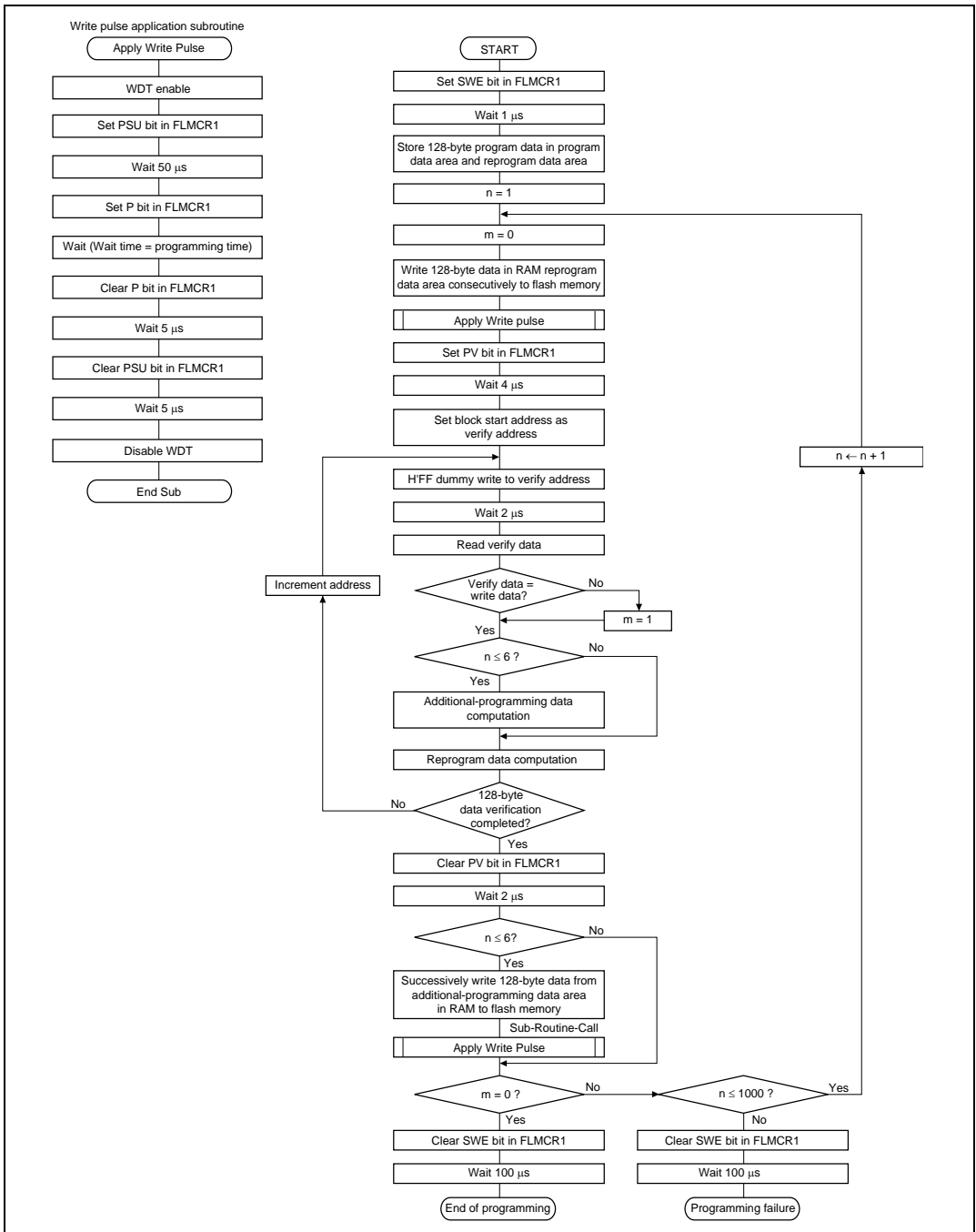


Figure 6.10 Program/Program-Verify Flowchart

Table 6.11 Reprogram Data Computation Table

Program Data	Verify Data	Reprogram Data	Comments
0	0	1	Programming completed
0	1	0	Reprogram bit
1	0	1	—
1	1	1	Remains in erased state

Table 6.12 Additional-Program Data Computation Table

Reprogram Data	Verify Data	Additional-Program Data	Comments
0	0	0	Additional-program bit
0	1	1	No additional programming
1	0	1	No additional programming
1	1	1	No additional programming

Table 6.13 Programming Time

n (Number of Writes)	Programming Time	In Additional Programming	Comments
1 to 6	30	10	
7 to 1,000	200	—	

Note: Time shown in μ s.

6.8.2 Erase/Erase-Verify

When erasing flash memory, the erase/erase-verify flowchart shown in figure 6.11 should be followed.

1. Prewriting (setting erase block data to all 0s) is not necessary.
2. Erasing is performed in block units. Make only a single-bit specification in the erase block register (EBR). To erase multiple blocks, each block must be erased in turn.
3. The time during which the E bit is set to 1 is the flash memory erase time.
4. The watchdog timer (WDT) is set to prevent overerasing due to program runaway, etc. An overflow cycle of approximately 19.8 ms is allowed.
5. For a dummy write to a verify address, write 1-byte data H'FF to an address whose lower 1 bit is b'0. Verify data can be read in word size from the address to which a dummy write was performed.
6. If the read data is not erased successfully, set erase mode again, and repeat the erase/erase-verify sequence as before. The maximum number of repetitions of the erase/erase-verify sequence is 100.

6.8.3 Interrupt Handling when Programming/Erasing Flash Memory

All interrupts, are disabled while flash memory is being programmed or erased, or while the boot program is executing, for the following three reasons:

1. Interrupt during programming/erasing may cause a violation of the programming or erasing algorithm, with the result that normal operation cannot be assured.
2. If interrupt exception handling starts before the vector address is written or during programming/erasing, a correct vector cannot be fetched and the CPU malfunctions.
3. If an interrupt occurs during boot program execution, normal boot mode sequence cannot be carried out.

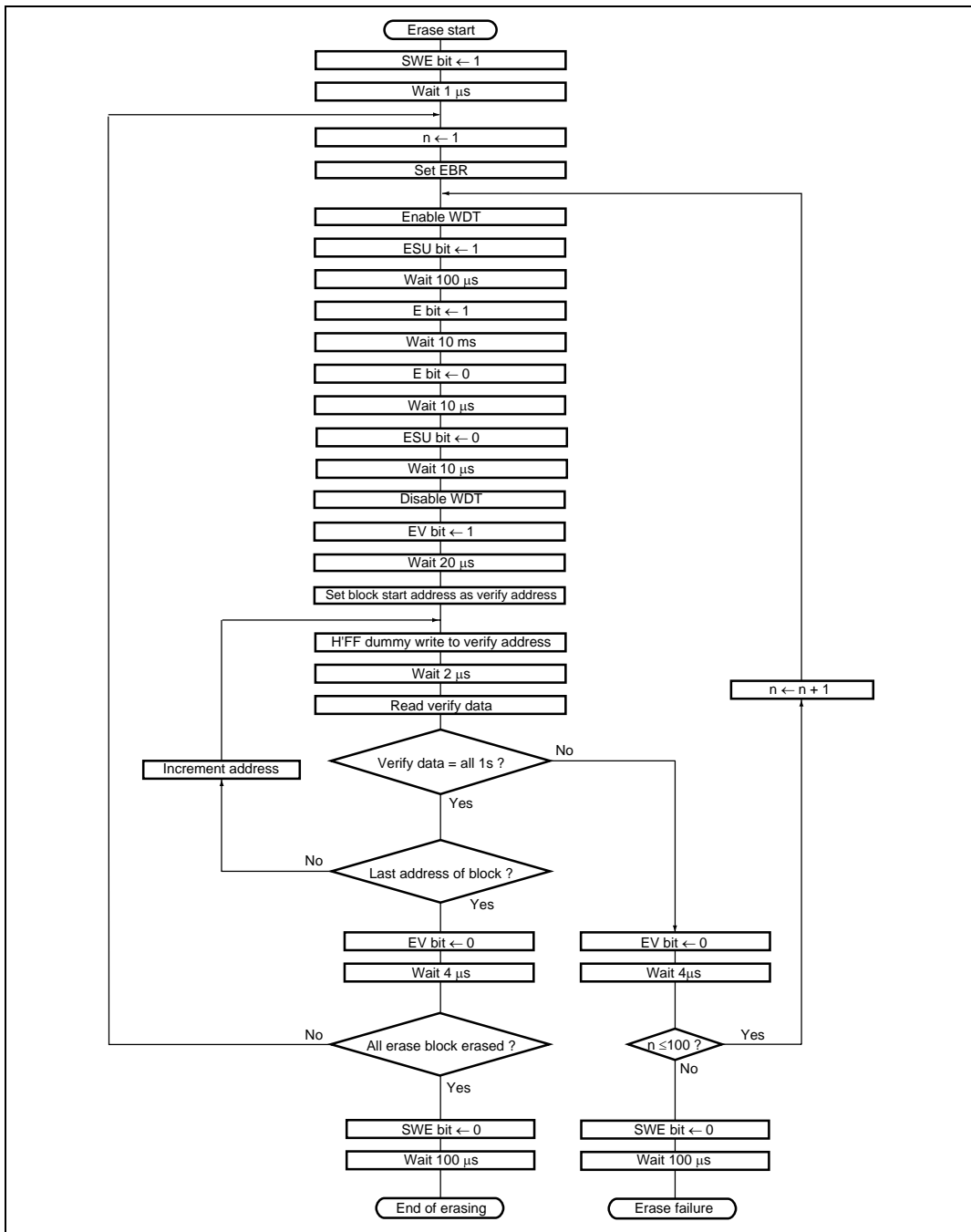


Figure 6.11 Erase/Eraser-Verify Flowchart

6.9 Program/Erase Protection

There are three kinds of flash memory program/erase protection; hardware protection, software protection, and error protection.

6.9.1 Hardware Protection

Hardware protection refers to a state in which programming/erasing of flash memory is forcibly disabled or aborted because of a transition to reset, subactive mode, subsleep mode, watch mode, or standby mode. Flash memory control register 1 (FLMCR1), flash memory control register 2 (FLMCR2), and erase block register (EBR) are initialized. In a reset via the $\overline{\text{RES}}$ pin, the reset state is not entered unless the $\overline{\text{RES}}$ pin is held low until oscillation stabilizes after powering on. In the case of a reset during operation, hold the $\overline{\text{RES}}$ pin low for the $\overline{\text{RES}}$ pulse width specified in the AC Characteristics section.

6.9.2 Software Protection

Software protection can be implemented against programming/erasing of all flash memory blocks by clearing the SWE bit in FLMCR1. When software protection is in effect, setting the P or E bit in FLMCR1 does not cause a transition to program mode or erase mode. By setting the erase block register (EBR), erase protection can be set for individual blocks. When EBR is set to H'00, erase protection is set for all blocks.

6.9.3 Error Protection

In error protection, an error is detected when CPU runaway occurs during flash memory programming/erasing, or operation is not performed in accordance with the program/erase algorithm, and the program/erase operation is aborted. Aborting the program/erase operation prevents damage to the flash memory due to overprogramming or overerasing.

When the following errors are detected during programming/erasing of flash memory, the FLER bit in FLMCR2 is set to 1, and the error protection state is entered.

- When the flash memory of the relevant address area is read during programming/erasing (including vector read and instruction fetch)
- Immediately after exception handling excluding a reset during programming/erasing
- When a SLEEP instruction is executed during programming/erasing

The FLMCR1, FLMCR2, and EBR settings are retained, however program mode or erase mode is aborted at the point at which the error occurred. Program mode or erase mode cannot be re-entered

by re-setting the P or E bit. However, PV and EV bit setting is enabled, and a transition can be made to verify mode. Error protection can be cleared only by a power-on reset.

6.10 Programmer Mode

In programmer mode, a PROM programmer can be used to perform programming/erasing via a socket adapter, just as a discrete flash memory. Use a PROM programmer that supports the MCU device type with the on-chip Renesas Technology (former Hitachi Ltd.) 64-Kbyte flash memory (F-ZTAT64V3). A 10-MHz input clock is required. For the conditions for transition to programmer mode, see table 6.8.

6.10.1 Socket Adapter

The socket adapter converts the pin allocation of the F-ZTAT device to that of the discrete flash memory HN28F101. The address of the on-chip flash memory is H'0000 to H'FFFF. Figure 6.12 shows a socket-adapter-pin correspondence diagram.

6.10.2 Programmer Mode Commands

The following commands are supported in programmer mode.

- Memory Read Mode
- Auto-Program Mode
- Auto-Erase Mode
- Status Read Mode

Status polling is used for auto-programming, auto-erasing, and status read modes. In status read mode, detailed internal information is output after the execution of auto-programming or auto-erasing. Table 6.14 shows the sequence of each command. In auto-programming mode, 129 cycles are required since 128 bytes are written at the same time. In memory read mode, the number of cycles depends on the number of address write cycles (n).

Table 6.14 Command Sequence in Programmer Mode

Command Name	Number of Cycles	1st Cycle			2nd Cycle		
		Mode	Address	Data	Mode	Address	Data
Memory read	1 + n	Write	X	H'00	Read	RA	Dout
Auto-program	129	Write	X	H'40	Write	WA	Din
Auto-erase	2	Write	X	H'20	Write	X	H'20
Status read	2	Write	X	H'71	Write	X	H'71

n: the number of address write cycles

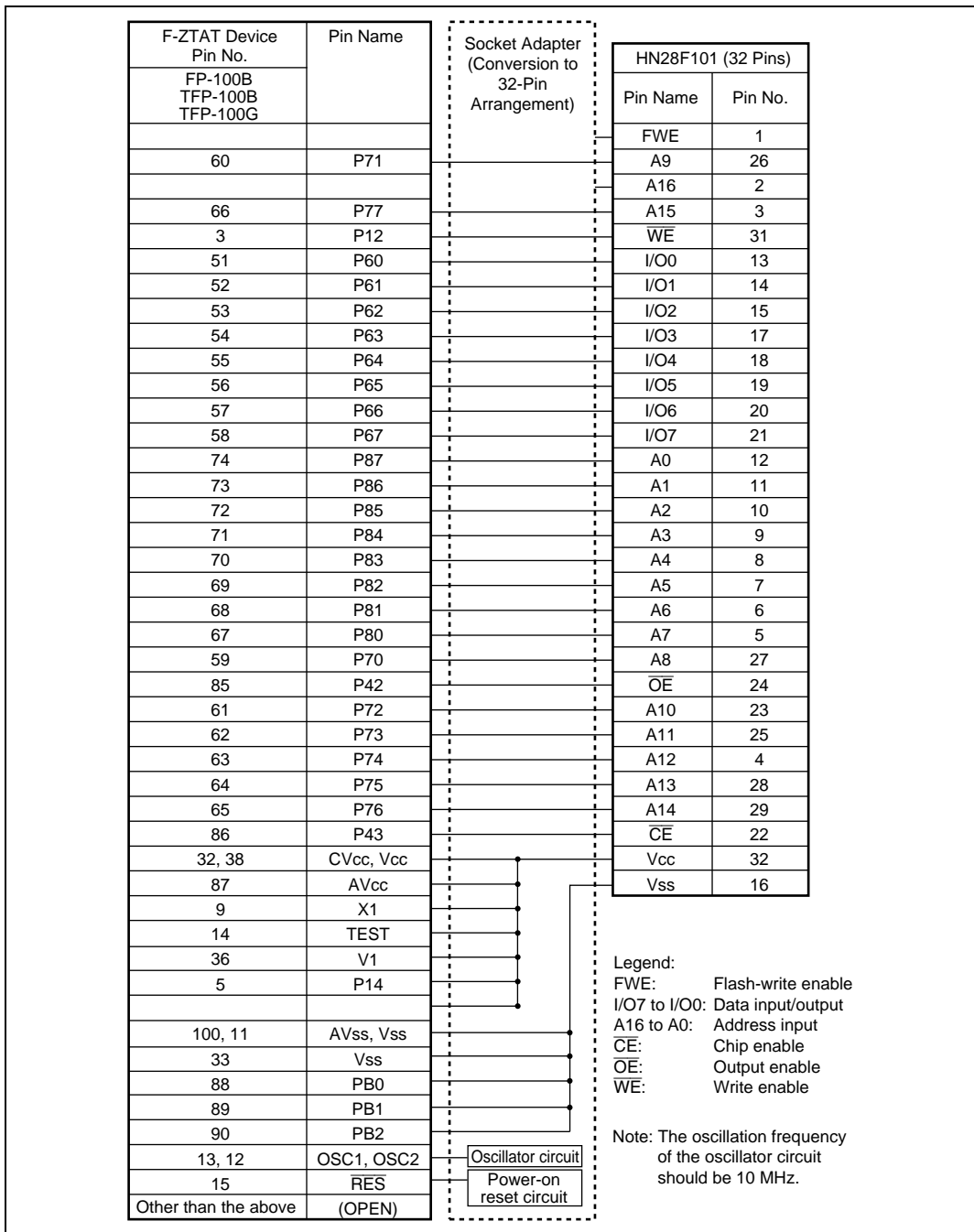


Figure 6.12 Socket Adapter Pin Correspondence Diagram

6.10.3 Memory Read Mode

1. After completion of auto-program/auto-erase/status read operations, a transition is made to the command wait state. When reading memory contents, a transition to memory read mode must first be made with a command write, after which the memory contents are read. Once memory read mode has been entered, consecutive reads can be performed.
2. In memory read mode, command writes can be performed in the same way as in the command wait state.
3. After powering on, memory read mode is entered.
4. Tables 6.14 to 6.16 show the AC characteristics.

Table 6.15 AC Characteristics in Transition to Memory Read Mode

Conditions: $V_{CC} = 3.3 \text{ V} \pm 0.3 \text{ V}$, $V_{SS} = 0 \text{ V}$, $T_a = 25^\circ\text{C} \pm 5^\circ\text{C}$

Item	Symbol	Min	Max	Unit	Notes
Command write cycle	t_{nxtc}	20	—	μs	Figure 6.13
$\overline{\text{CE}}$ hold time	t_{ceh}	0	—	ns	
$\overline{\text{CE}}$ setup time	t_{ces}	0	—	ns	
Data hold time	t_{dh}	50	—	ns	
Data setup time	t_{ds}	50	—	ns	
Write pulse width	t_{wep}	70	—	ns	
$\overline{\text{WE}}$ rise time	t_r	—	30	ns	
$\overline{\text{WE}}$ fall time	t_f	—	30	ns	

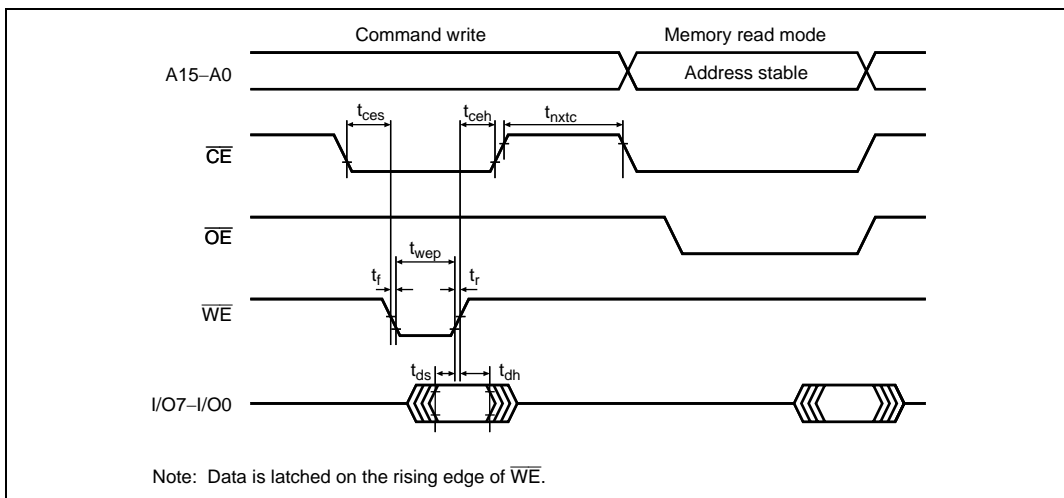


Figure 6.13 Timing Waveforms for Memory Read after Memory Write

Table 6.16 AC Characteristics in Transition from Memory Read Mode to Another Mode

Conditions: $V_{CC} = 3.3 \text{ V} \pm 0.3 \text{ V}$, $V_{SS} = 0 \text{ V}$, $T_a = 25^\circ\text{C} \pm 5^\circ\text{C}$

Item	Symbol	Min	Max	Unit	Notes
Command write cycle	t_{nxtc}	20	—	μs	Figure 6.14
\overline{CE} hold time	t_{ceh}	0	—	ns	
\overline{CE} setup time	t_{ces}	0	—	ns	
Data hold time	t_{dh}	50	—	ns	
Data setup time	t_{ds}	50	—	ns	
Write pulse width	t_{wep}	70	—	ns	
\overline{WE} rise time	t_r	—	30	ns	
\overline{WE} fall time	t_f	—	30	ns	

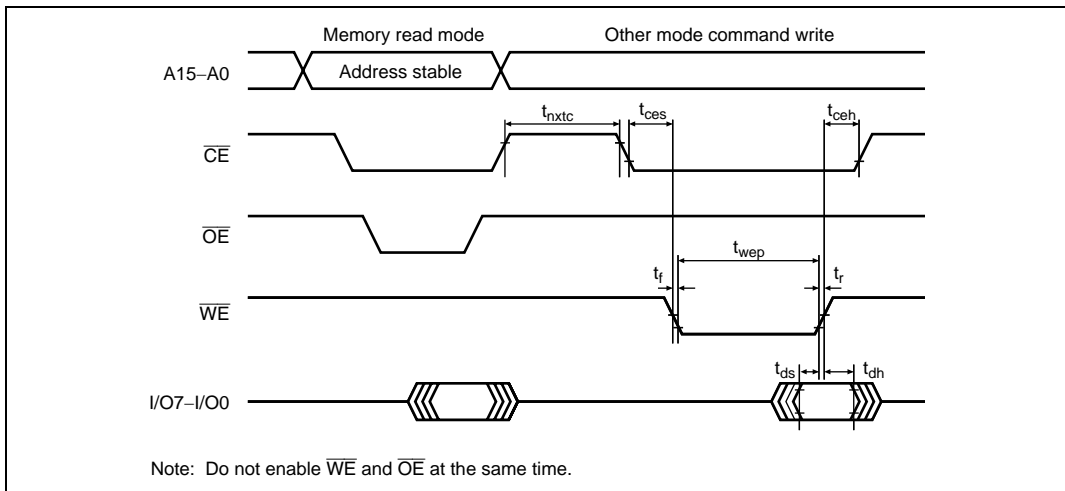


Figure 6.14 Timing Waveforms in Transition from Memory Read Mode to Another Mode

Table 6.17 AC Characteristics in Memory Read Mode

Conditions: $V_{CC} = 3.3\text{ V} \pm 0.3\text{ V}$, $V_{SS} = 0\text{ V}$, $T_a = 25^\circ\text{C} \pm 5^\circ\text{C}$

Item	Symbol	Min	Max	Unit	Notes
Access time	t_{acc}	—	20	μs	Figure 6.15
\overline{CE} output delay time	t_{ce}	—	150	ns	Figure 6.16
\overline{OE} output delay time	t_{oe}	—	150	ns	
Output disable delay time	t_{df}	—	100	ns	
Data output hold time	t_{oh}	5	—	ns	

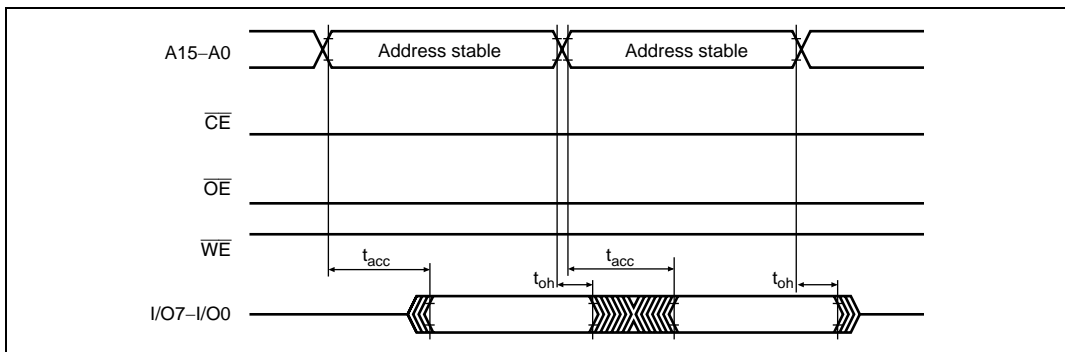


Figure 6.15 \overline{CE} and \overline{OE} Enable State Read Timing Waveforms

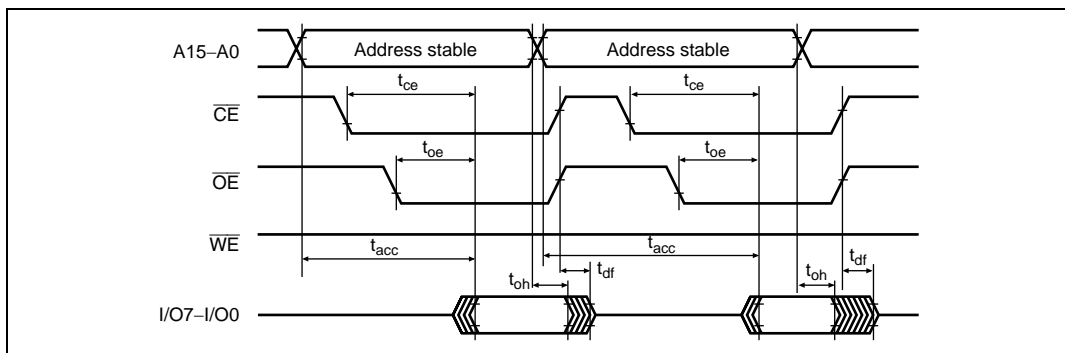


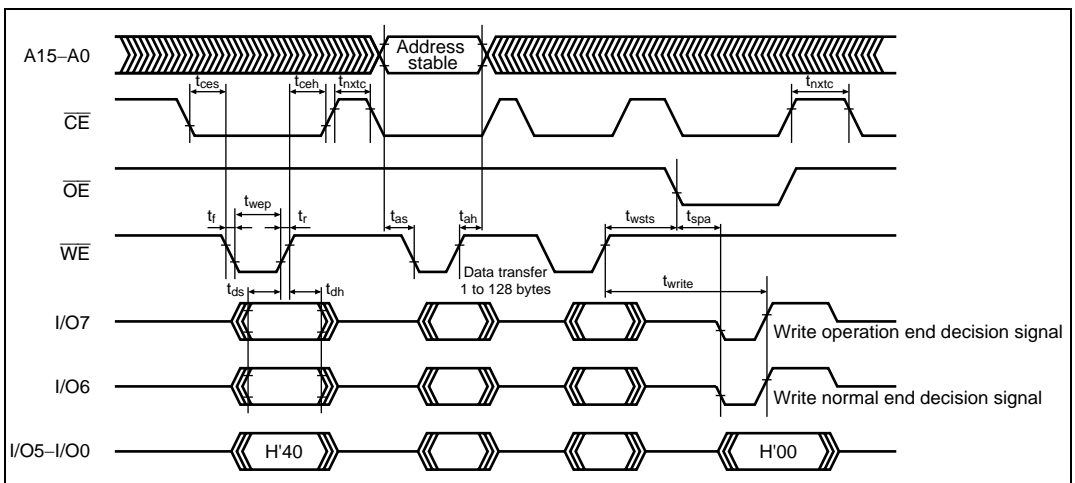
Figure 6.16 $\overline{\text{CE}}$ and $\overline{\text{OE}}$ Clock System Read Timing Waveforms

6.10.4 Auto-Program Mode

1. When reprogramming previously programmed addresses, perform auto-erasing before auto-programming.
2. Perform auto-programming once only on the same address block. It is not possible to program an address block that has already been programmed.
3. In auto-program mode, 128 bytes are programmed simultaneously. This should be carried out by executing 128 consecutive byte transfers. A 128-byte data transfer is necessary even when programming fewer than 128 bytes. In this case, H'FF data must be written to the extra addresses.
4. The lower 7 bits of the transfer address must be low. If a value other than an effective address is input, processing will switch to a memory write operation but a write error will be flagged.
5. Memory address transfer is performed in the second cycle (figure 6.17). Do not perform transfer after the third cycle.
6. Do not perform a command write during a programming operation.
7. Perform one auto-program operation for a 128-byte block for each address. Two or more additional programming operations cannot be performed on a previously programmed address block.
8. Confirm normal end of auto-programming by checking I/O6. Alternatively, status read mode can also be used for this purpose (I/O7 status polling uses the auto-program operation end decision pin).
9. Status polling I/O6 and I/O7 pin information is retained until the next command write. As long as the next command write has not been performed, reading is possible by enabling $\overline{\text{CE}}$ and $\overline{\text{OE}}$.
10. Table 6.18 shows the AC characteristics.

Table 6.18 AC Characteristics in Auto-Program ModeConditions: $V_{CC} = 3.3\text{ V} \pm 0.3\text{ V}$, $V_{SS} = 0\text{ V}$, $T_a = 25^\circ\text{C} \pm 5^\circ\text{C}$

Item	Symbol	Min	Max	Unit	Notes
Command write cycle	t_{nxtc}	20	—	μs	Figure 6.17
$\overline{\text{CE}}$ hold time	t_{ceh}	0	—	ns	
$\overline{\text{CE}}$ setup time	t_{ces}	0	—	ns	
Data hold time	t_{dh}	50	—	ns	
Data setup time	t_{ds}	50	—	ns	
Write pulse width	t_{wep}	70	—	ns	
Status polling start time	t_{wsts}	1	—	ms	
Status polling access time	t_{spa}	—	150	ns	
Address setup time	t_{as}	0	—	ns	
Address hold time	t_{ah}	60	—	ns	
Memory write time	t_{write}	1	3000	ms	
$\overline{\text{WE}}$ rise time	t_r	—	30	ns	
$\overline{\text{WE}}$ fall time	t_f	—	30	ns	

**Figure 6.17 Auto-Program Mode Timing Waveforms**

6.10.5 Auto-Erase Mode

1. Auto-erase mode supports only entire memory erasing.
2. Do not perform a command write during auto-erasing.
3. Confirm normal end of auto-erasing by checking I/O6. Alternatively, status read mode can also be used for this purpose (I/O7 status polling uses the auto-erase operation end decision pin).
4. Status polling I/O6 and I/O7 pin information is retained until the next command write. As long as the next command write has not been performed, reading is possible by enabling $\overline{\text{CE}}$ and $\overline{\text{OE}}$.
5. Table 6.19 shows the AC characteristics.

Table 6.19 AC Characteristics in Auto-Erase Mode

Conditions: $V_{CC} = 3.3 \text{ V} \pm 0.3 \text{ V}$, $V_{SS} = 0 \text{ V}$, $T_a = 25^\circ\text{C} \pm 5^\circ\text{C}$

Item	Symbol	Min	Max	Unit	Notes
Command write cycle	t_{nxtc}	20	—	μs	Figure 6.18
$\overline{\text{CE}}$ hold time	t_{ceh}	0	—	ns	
$\overline{\text{CE}}$ setup time	t_{ces}	0	—	ns	
Data hold time	t_{dh}	50	—	ns	
Data setup time	t_{ds}	50	—	ns	
Write pulse width	t_{wep}	70	—	ns	
Status polling start time	t_{ests}	1	—	ms	
Status polling access time	t_{spa}	—	150	ns	
Memory erase time	t_{erase}	100	40000	ms	
$\overline{\text{WE}}$ rise time	t_{r}	—	30	ns	
$\overline{\text{WE}}$ fall time	t_{f}	—	30	ns	

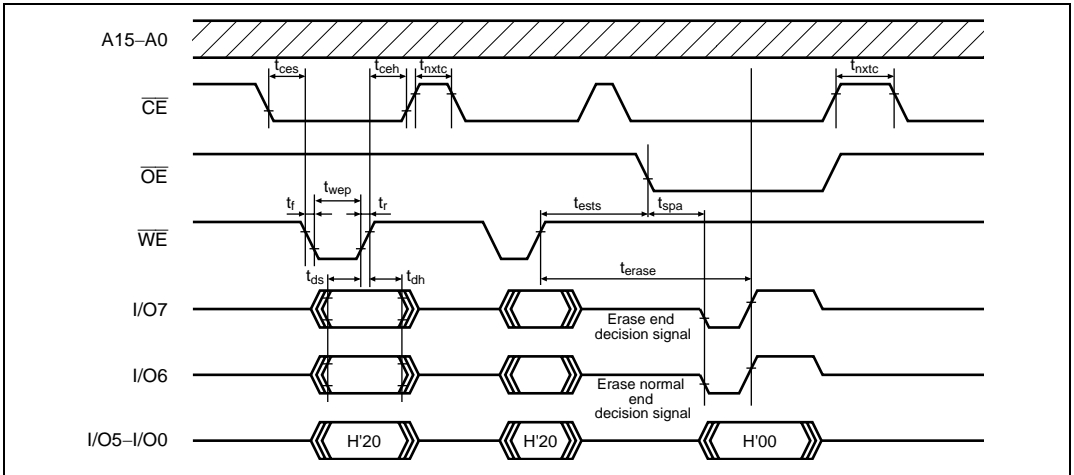


Figure 6.18 Auto-Erase Mode Timing Waveforms

6.10.6 Status Read Mode

1. Status read mode is provided to identify the kind of abnormal end. Use this mode when an abnormal end occurs in auto-program mode or auto-erase mode.
2. The return code is retained until a command write other than a status read mode command write is executed.
3. Table 6.20 shows the AC characteristics and 6.20 shows the return codes.

Table 6.20 AC Characteristics in Status Read ModeConditions: $V_{CC} = 3.3\text{ V} \pm 0.3\text{ V}$, $V_{SS} = 0\text{ V}$, $T_a = 25^\circ\text{C} \pm 5^\circ\text{C}$

Item	Symbol	Min	Max	Unit	Notes
Read time after command write	t_{nxtc}	20	—	μs	Figure 6.19
$\overline{\text{CE}}$ hold time	t_{ceh}	0	—	ns	
$\overline{\text{CE}}$ setup time	t_{ces}	0	—	ns	
Data hold time	t_{dh}	50	—	ns	
Data setup time	t_{ds}	50	—	ns	
Write pulse width	t_{wep}	70	—	ns	
$\overline{\text{OE}}$ output delay time	t_{oe}	—	150	ns	
Disable delay time	t_{df}	—	100	ns	
$\overline{\text{CE}}$ output delay time	t_{ce}	—	150	ns	
$\overline{\text{WE}}$ rise time	t_r	—	30	ns	
$\overline{\text{WE}}$ fall time	t_f	—	30	ns	

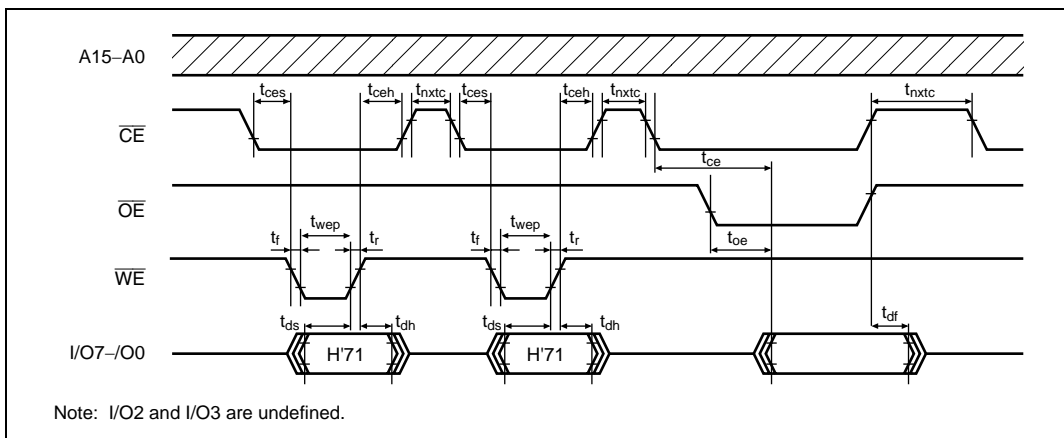
**Figure 6.19 Status Read Mode Timing Waveforms**

Table 6.21 Status Read Mode Return Codes

Pin Name	Initial Value	Indications
I/O7	0	1: Abnormal end 0: Normal end
I/O6	0	1: Command error 0: Otherwise
I/O5	0	1: Programming error 0: Otherwise
I/O4	0	1: Erasing error 0: Otherwise
I/O3	0	—
I/O2	0	—
I/O1	0	1: Over counting of writing or erasing 0: Otherwise
I/O0	0	1: Effective address error 0: Otherwise

6.10.7 Status Polling

1. The I/O7 status polling flag indicates the operating status in auto-program/auto-erase mode.
2. The I/O6 status polling flag indicates a normal or abnormal end in auto-program/auto-erase mode.

Table 6.22 Status Polling Output Truth Table

I/O7	I/O6	I/O0 to 5	Status
0	0	0	During internal operation
1	0	0	Abnormal end
1	1	0	Normal end
0	1	0	—

6.10.8 Programmer Mode Transition Time

Commands cannot be accepted during the oscillation stabilization period or the programmer mode setup period. After the programmer mode setup time, a transition is made to memory read mode.

Table 6.23 Stipulated Transition Times to Command Wait State

Item	Symbol	Min	Max	Unit	Notes
Oscillation stabilization time(crystal oscillator)	T_{osc1}	10	—	ms	Figure 6.20
Oscillation stabilization time(ceramic oscillator)	T_{osc1}	5	—	ms	
Programmer mode setup time	T_{bmv}	10	—	ms	
Vcc hold time	T_{dwn}	0	—	ms	

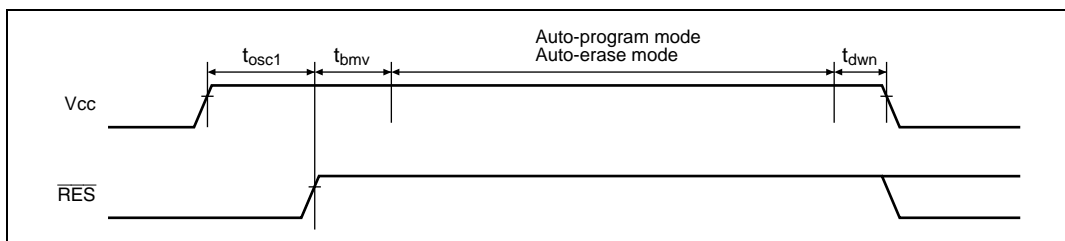


Figure 6.20 Oscillation Stabilization Time, Boot Program Transfer Time, and Power-Down Sequence

6.10.9 Notes on Memory Programming

1. When performing programming using programmer mode on a chip that has been programmed/erased in an on-board programming mode, auto-erasing is recommended before carrying out auto-programming.
2. The flash memory is initially in the erased state when the device is shipped by Renesas Technology. For other chips for which the erasure history is unknown, it is recommended that auto-erasing be executed to check and supplement the initialization (erase) level.

6.11 Power-Down States for Flash Memory

In user mode, the flash memory will operate in either of the following states:

- Normal operating mode
The flash memory can be read and written to at high speed.
- Power-down operating mode
The power supply circuit of the flash memory is partly halted and can be read under low power consumption.
- Standby mode
All flash memory circuits are halted.

Table 6.24 shows the correspondence between the operating modes of this LSI and the flash memory. In subactive mode, the flash memory can be set to operate in power-down mode with the PDWND bit in FLPWCR. When the flash memory returns to its normal operating state from power-down mode or standby mode, a period to stabilize the power supply circuits that were stopped is needed. When the flash memory returns to its normal operating state, bits STS2 to STS0 in SYSCR1 must be set to provide a wait time of at least 20 μ s, even when the external clock is being used.

Table 6.24 Flash Memory Operating States

LSI Operating State	Flash Memory Operating State	
	PDWND = 0 (Initial value)	PDWND = 1
Active mode	Normal operating mode	Normal operating mode
Subactive mode	Power-down mode	Normal operating mode
Sleep mode	Normal operating mode	Normal operating mode
Subsleep mode	Standby mode	Standby mode
Standby mode	Standby mode	Standby mode
Watch mode	Standby mode	Standby mode

Section 7 RAM

7.1 Overview

The H8/3842R, H8/3843R, H8/38342, H8/38343, H8/38442, and H8/38443 have 1 Kbytes of high-speed static RAM, and H8/3844R, H8/3844S, H8/38344, H8/38444, H8/3845R, H8/3845S, H8/38345, H8/38445, H8/3846R, H8/3846S, H8/38346, H8/38446, H8/3847R, H8/3847S, H8/38347, and H8/38447 have 2 Kbytes of high-speed static RAM on-chip. The RAM is connected to the CPU by a 16-bit data bus, allowing high-speed 2-state access for both byte data and word data.

7.1.1 Block Diagram

Figure 7.1 shows a block diagram of the on-chip RAM.

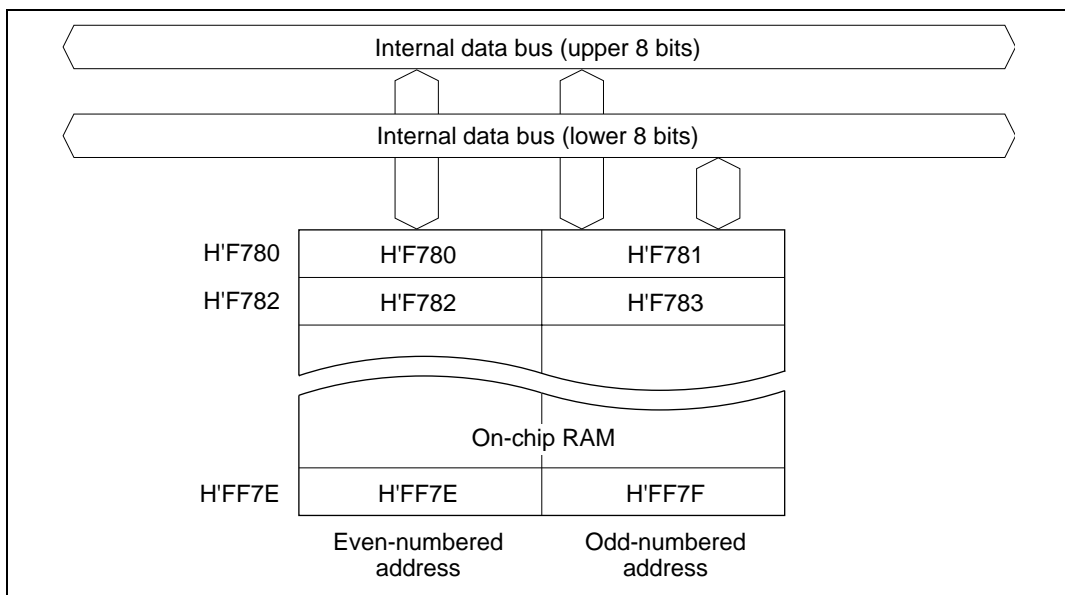


Figure 7.1 RAM Block Diagram (H8/3844R, H8/3844S, H8/38344 and H8/38444)

Section 8 I/O Ports

8.1 Overview

The H8/3847R Group, H8/3847S Group and H8/38347 Group are provided with eight 8-bit I/O ports, one 4-bit I/O port, one 3-bit I/O port, one 8-bit input-only port, one 4-bit input-only port, and one 1-bit input-only port. Table 8.1 indicates the functions of each port.

Each port has of a port control register (PCR) that controls input and output, and a port data register (PDR) for storing output data. Input or output can be assigned to individual bits. See section 2.9.2, Notes on Bit Manipulation, for information on executing bit-manipulation instructions to write data in PCR or PDR.

Ports 5, 6, 7, 8, 9, and A are also used as liquid crystal display segment and common pins, selectable in 8-bit units.

Block diagrams of each port are given in Appendix C, I/O Port Block Diagrams

Table 8.1 Port Functions

Port	Description	Pins	Other Functions	Function Switching Registers
Port 1	<ul style="list-style-type: none"> • 8-bit I/O port • MOS input pull-up option 	P1 ₇ to P1 ₅ / $\overline{\text{IRQ}}_3$ to $\overline{\text{IRQ}}_1$ /TMIF, TMIC	External interrupts 3 to 1 Timer event interrupts TMIF, TMIC	PMR1, TCRF, TMC
		P1 ₄ / $\overline{\text{IRQ}}_4$ / $\overline{\text{ADTRG}}$	External interrupt 4 and A/D converter external trigger	PMR1, AMR
		P1 ₃ /TMIG	Timer G input capture input	PMR1
		P1 ₂ , P1 ₁ / TMOFH, TMOFL	Timer F output compare output	PMR1
		P1 ₀ /TMOW	Timer A clock output	PMR1
Port 2	<ul style="list-style-type: none"> • 8-bit I/O port • Open-drain output option 	P2 ₀ /SCK ₁ P2 ₁ /SI ₁ P2 ₂ /SO ₁	SCI1 data output (SO ₁), data input (SI ₁), clock input/output (SCK ₁)	PMR2
		P2 ₇ to P2 ₃	None	
	<ul style="list-style-type: none"> • Large-current port (H8/3847R Group, H8/38347 Group and H8/38447 Group) 			

Port	Description	Pins	Other Functions	Function Switching Registers
Port 3	<ul style="list-style-type: none"> 8-bit I/O port MOS input pull-up option Large-current port (H8/3847R Group, H8/38347 Group and H8/38447 Group) 	P3 ₇ /AEVL P3 ₆ /AEVH P3 ₅ /TXD ₃₁ P3 ₄ /RXD ₃₁ P3 ₃ /SCK ₃₁	SCI3-1 data output (TXD ₃₁), data input (RXD ₃₁), clock input/output (SCK ₃₁), and asynchronous counter event inputs AEVL, AEVH	PMR3 SCR31 SMR31
		P3 ₂ /RESO* ¹ P3 ₁ /UD/EXCL* ² P3 ₀ /PWM	Reset output* ¹ , timer C count-up/down select input, and 14-bit PWM output, external subclock input* ²	PMR2 PMR3
Port 4	<ul style="list-style-type: none"> 1-bit input port 3-bit I/O port 	P4 ₃ /IRQ ₀	External interrupt 0	PMR3
		P4 ₂ /TXD ₃₂ P4 ₁ /RXD ₃₂ P4 ₀ /SCK ₃₂	SCI3-2 data output (TXD ₃₂), data input (RXD ₃₂), clock input/output (SCK ₃₂)	SCR32 SMR32
Port 5	<ul style="list-style-type: none"> 8-bit I/O port MOS input pull-up option 	P5 ₇ to P5 ₀ / WKP ₇ to WKP ₀ / SEG ₈ to SEG ₁	Wakeup input (WKP ₇ to WKP ₀), segment output (SEG ₈ to SEG ₁)	PMR5 LPCR
Port 6	<ul style="list-style-type: none"> 8-bit I/O port MOS input pull-up option 	P6 ₇ to P6 ₀ / SEG ₁₆ to SEG ₉	Segment output (SEG ₁₆ to SEG ₉)	LPCR
Port 7	8-bit I/O port	P7 ₇ to P7 ₀ / SEG ₂₄ to SEG ₁₇	Segment output (SEG ₂₄ to SEG ₁₇)	LPCR
Port 8	8-bit I/O port	P8 ₇ to P8 ₀ / SEG ₃₂ to SEG ₂₅	Segment output (SEG ₃₂ to SEG ₂₅)	LPCR
Port 9	8-bit I/O port	P9 ₇ /SEG ₄₀ /CL ₁ * ³ P9 ₆ /SEG ₃₉ /CL ₂ * ³ P9 ₅ /SEG ₃₈ /DO* ³ P9 ₄ /SEG ₃₇ /M* ³ P9 ₃ to P9 ₀ / SEG ₃₆ to SEG ₃₃	<ul style="list-style-type: none"> Segment output (SEG₄₀ to SEG₃₇) Latch clock (CL₁)*³, shift clock (CL₂)*³, display data (DO)*³ and alternating signal (M)*³ for external expansion of segment Segment output (SEG₃₆ to SEG₃₃) 	LPCR
Port A	4-bit I/O port	PA ₃ to PA ₀ / COM ₄ to COM ₁	Common output (COM ₄ to COM ₁)	LPCR
Port B	8-bit input port	PB ₇ to PB ₀ / AN ₇ to AN ₀	A/D converter analog input	AMR
Port C	4-bit input port	PC ₃ to PC ₀ / AN ₁₁ to AN ₈	A/D converter analog input	AMR

Notes: 1. The RESO function is not implemented in the H8/38347 Group and H8/38447 Group.
 2. The EXCL function is only implemented in the H8/38347 Group and H8/38447 Group.
 3. The external expansion function for LCD segments is not implemented in the H8/38347 Group and H8/38447 Group.

8.2 Port 1

8.2.1 Overview

Port 1 is an 8-bit I/O port. Figure 8.1 shows its pin configuration.

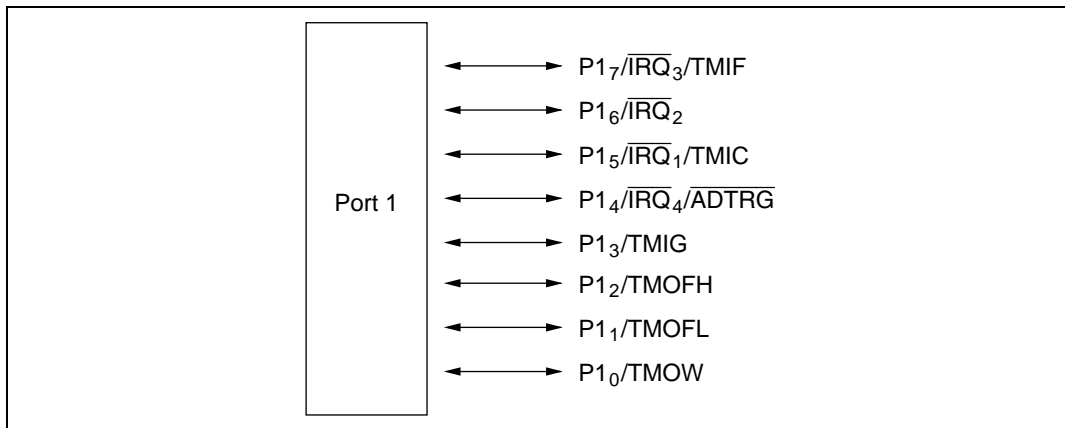


Figure 8.1 Port 1 Pin Configuration

8.2.2 Register Configuration and Description

Table 8.2 shows the port 1 register configuration.

Table 8.2 Port 1 Registers

Name	Abbr.	R/W	Initial Value	Address
Port data register 1	PDR1	R/W	H'00	H'FFD4
Port control register 1	PCR1	W	H'00	H'FFE4
Port pull-up control register 1	PUCR1	R/W	H'00	H'FFE0
Port mode register 1	PMR1	R/W	H'00	H'FFC8

1. Port Data Register 1 (PDR1)

Bit	7	6	5	4	3	2	1	0
	P1 ₇	P1 ₆	P1 ₅	P1 ₄	P1 ₃	P1 ₂	P1 ₁	P1 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

PDR1 is an 8-bit register that stores data for port 1 pins P1₇ to P1₀. If port 1 is read while PCR1 bits are set to 1, the values stored in PDR1 are read, regardless of the actual pin states. If port 1 is read while PCR1 bits are cleared to 0, the pin states are read.

Upon reset, PDR1 is initialized to H'00.

2. Port Control Register 1 (PCR1)

Bit	7	6	5	4	3	2	1	0
	PCR1 ₇	PCR1 ₆	PCR1 ₅	PCR1 ₄	PCR1 ₃	PCR1 ₂	PCR1 ₁	PCR1 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	W	W	W	W	W	W	W	W

PCR1 is an 8-bit register for controlling whether each of the port 1 pins P1₇ to P1₀ functions as an input pin or output pin. Setting a PCR1 bit to 1 makes the corresponding pin an output pin, while clearing the bit to 0 makes the pin an input pin. The settings in PCR1 and in PDR1 are valid only when the corresponding pin is designated in PMR1 as a general I/O pin.

Upon reset, PCR1 is initialized to H'00.

PCR1 is a write-only register, which is always read as all 1s.

3. Port Pull-up Control Register 1 (PUCR1)

Bit	7	6	5	4	3	2	1	0
	PUCR1 ₇	PUCR1 ₆	PUCR1 ₅	PUCR1 ₄	PUCR1 ₃	PUCR1 ₂	PUCR1 ₁	PUCR1 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

PUCR1 controls whether the MOS pull-up of each of the port 1 pins P1₇ to P1₀ is on or off. When a PCR1 bit is cleared to 0, setting the corresponding PUCR1 bit to 1 turns on the MOS pull-up for the corresponding pin, while clearing the bit to 0 turns off the MOS pull-up.

Upon reset, PUCR1 is initialized to H'00.

4. Port Mode Register 1 (PMR1)

Bit	7	6	5	4	3	2	1	0
	IRQ3	IRQ2	IRQ1	IRQ4	TMIG	TMOFH	TMOFL	TMOW
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

PMR1 is an 8-bit read/write register, controlling the selection of pin functions for port 1 pins.

Upon reset, PMR1 is initialized to H'00.

Bit 7: P1₇/ $\overline{\text{IRQ}}_3$ /TMIF pin function switch (IRQ3)

This bit selects whether pin P1₇/ $\overline{\text{IRQ}}_3$ /TMIF is used as P1₇ or as $\overline{\text{IRQ}}_3$ /TMIF.

Bit 7

IRQ3	Description
0	Functions as P1 ₇ I/O pin (initial value)
1	Functions as $\overline{\text{IRQ}}_3$ /TMIF input pin

Note: Rising or falling edge sensing can be designated for $\overline{\text{IRQ}}_3$ /TMIF. For details on TMIF settings, see 3. Timer Control Register F (TCRF) in section 9.4.2.

Bit 6: P1₆/ $\overline{\text{IRQ}}_2$ pin function switch (IRQ2)

This bit selects whether pin P1₆/ $\overline{\text{IRQ}}_2$ is used as P1₆ or as $\overline{\text{IRQ}}_2$.

Bit 6

IRQ2	Description
0	Functions as P1 ₆ I/O pin (initial value)
1	Functions as $\overline{\text{IRQ}}_2$ input pin

Note: Rising or falling edge sensing can be designated for $\overline{\text{IRQ}}_2$.

Bit 5: P1₅/ $\overline{\text{IRQ}}_1$ /TMIC pin function switch (IRQ1)

This bit selects whether pin P1₅/ $\overline{\text{IRQ}}_1$ /TMIC is used as P15 or as $\overline{\text{IRQ}}_1$ /TMIC.

Bit 5

IRQ1	Description	
0	Functions as P1 ₅ I/O pin	(initial value)
1	Functions as $\overline{\text{IRQ}}_1$ /TMIC input pin	

Note: Rising or falling edge sensing can be designated for $\overline{\text{IRQ}}_1$ /TMIC.

For details of TMIC pin setting, see 1. Timer mode register C (TMC) in section 9.3.2.

Bit 4: P1₄/ $\overline{\text{IRQ}}_4$ / $\overline{\text{ADTRG}}$ pin function switch (IRQ4)

This bit selects whether pin P1₄/ $\overline{\text{IRQ}}_4$ / $\overline{\text{ADTRG}}$ is used as P1₄ or as $\overline{\text{IRQ}}_4$ / $\overline{\text{ADTRG}}$.

Bit 4

IRQ4	Description	
0	Functions as P1 ₄ I/O pin	(initial value)
1	Functions as $\overline{\text{IRQ}}_4$ / $\overline{\text{ADTRG}}$ input pin	

Note: For details of $\overline{\text{ADTRG}}$ pin setting, see section 12.3.2, Start of A/D Conversion by External Trigger Input.

Bit 3: P1₃/TMIG pin function switch (TMIG)

This bit selects whether pin P1₃/TMIG is used as P1₃ or as TMIG.

Bit 3

TMIG	Description	
0	Functions as P1 ₃ I/O pin	(initial value)
1	Functions as TMIG input pin	

Bit 2: P1₂/TMOFH pin function switch (TMOFH)

This bit selects whether pin P1₂/TMOFH is used as P1₂ or as TMOFH.

Bit 2

TMOFH	Description	
0	Functions as P1 ₂ I/O pin	(initial value)
1	Functions as TMOFH output pin	

Bit 1: P1₁/TMOFL pin function switch (TMOFL)

This bit selects whether pin P1₁/TMOFL is used as P1₁ or as TMOFL.

Bit 1

TMOFL	Description	
0	Functions as P1 ₁ I/O pin	(initial value)
1	Functions as TMOFL output pin	

Bit 0: P1₀/TMOW pin function switch (TMOW)

This bit selects whether pin P1₀/TMOW is used as P1₀ or as TMOW.

Bit 0

TMOW	Description	
0	Functions as P1 ₀ I/O pin	(initial value)
1	Functions as TMOW output pin	

8.2.3 Pin Functions

Table 8.3 shows the port 1 pin functions.

Table 8.3 Port 1 Pin Functions

Pin	Pin Functions and Selection Method			
P17/ $\overline{\text{IRQ}}_3$ /TMIF	The pin function depends on bit IRQ3 in PMR1, bits CKSL2 to CKSL0 in TCRF, and bit PCR17 in PCR1.			
	IRQ3	0		1
	PCR17	0	1	*
	CKSL2 to CKSL0	*		Not 0** 0**
	Pin function	P17 input pin	P17 output pin	$\overline{\text{IRQ}}_3$ input pin $\overline{\text{IRQ}}_3$ /TMIF input pin
	Note: When this pin is used as the TMIF input pin, clear bit IEN3 to 0 in IENR1 to disable the $\overline{\text{IRQ}}_3$ interrupt.			
P16/ $\overline{\text{IRQ}}_2$	The pin function depends on bits IRQ2 in PMR1 and bit PCR16 in PCR1.			
	IRQ2	0		1
	PCR16	0	1	*
	Pin function	P16 input pin	P16 output pin	$\overline{\text{IRQ}}_2$ input pin
P15/ $\overline{\text{IRQ}}_1$ TMIC	The pin function depends on bit IRQ1 in PMR1, bits TMC2 to TMC0 in TMC, and bit PCR15 in PCR1.			
	IRQ1	0		1
	PCR15	0	1	*
	TMC2 to TMC0	*		Not 111 111
	Pin function	P15 input pin	P15 output pin	$\overline{\text{IRQ}}_1$ input pin $\overline{\text{IRQ}}_1$ /TMIC input pin
	Note: When this pin is used as the TMIC input pin, clear bit IEN1 to 0 in IENR1 to disable the $\overline{\text{IRQ}}_1$ interrupt.			
P14/ $\overline{\text{IRQ}}_4$ ADTRG	The pin function depends on bit IRQ4 in PMR1, bit TRGE in AMR, and bit PCR14 in PCR1.			
	IRQ4	0		1
	PCR14	0	1	*
	TRGE	*		0 1
	Pin function	P14 input pin	P14 output pin	$\overline{\text{IRQ}}_4$ input pin $\overline{\text{IRQ}}_4$ /ADTRG input pin
	Note: When this pin is used as the ADTRG input pin, clear bit IEN4 to 0 in IENR1 to disable the $\overline{\text{IRQ}}_4$ interrupt.			

Pin Pin Functions and Selection Method

P1 ₃ /TMIG	The pin function depends on bit TMIG in PMR1 and bit PCR1 ₃ in PCR1.			
	TMIG	0		1
	PCR1 ₃	0	1	*
	Pin function	P1 ₃ input pin	P1 ₃ output pin	TMIG input pin
P1 ₂ /TMOFH	The pin function depends on bit TMOFH in PMR1 and bit PCR1 ₂ in PCR1.			
	TMOFH	0		1
	PCR1 ₂	0	1	*
	Pin function	P1 ₂ input pin	P1 ₂ output pin	TMOFH output pin
P1 ₁ /TMOFL	The pin function depends on bit TMOFL in PMR1 and bit PCR1 ₁ in PCR1.			
	TMOFL	0		1
	PCR1 ₁	0	1	*
	Pin function	P1 ₁ input pin	P1 ₁ output pin	TMOFL output pin
P1 ₀ /TMOW	The pin function depends on bit TMOW in PMR1 and bit PCR1 ₀ in PCR1.			
	TMOW	0		1
	PCR1 ₀	0	1	*
	Pin function	P1 ₀ input pin	P1 ₀ output pin	TMOW output pin

*: Don't care

8.2.4 Pin States

Table 8.4 shows the port 1 pin states in each operating mode.

Table 8.4 Port 1 Pin States

Pins	Reset	Sleep	Subsleep	Standby	Watch	Subactive	Active
P1 ₇ /IRQ ₃ /TMIF	High-impedance	Retains previous state	Retains previous state	High-impedance*	Retains previous state	Functional	Functional
P1 ₆ /IRQ ₂							
P1 ₅ /IRQ ₁ /TMIC							
P1 ₄ /IRQ ₄ /ADTRG							
P1 ₃ /TMIG							
P1 ₂ /TMOFH							
P1 ₁ /TMOFL							
P1 ₀ /TMOW							

Note: * A high-level signal is output when the MOS pull-up is in the on state.

8.2.5 MOS Input Pull-Up

Port 1 has a built-in MOS input pull-up function that can be controlled by software. When a PCR1 bit is cleared to 0, setting the corresponding PUCR1 bit to 1 turns on the MOS input pull-up for that pin. The MOS input pull-up function is in the off state after a reset.

PCR1 _n	0	0	1
PUCR1 _n	0	1	*
MOS input pull-up	Off	On	Off

(n = 7 to 0)

*: Don't care

8.3 Port 2

8.3.1 Overview

Port 2 is an 8-bit I/O port. Figure 8.2 shows its pin configuration.

In the F-ZTAT version, the on-chip pull-up MOS for pin P2₄ is on during the reset period. It turns off and normal operation resumes after the reset is cleared. The pull-up MOS is controlled by hardware; it cannot be manipulated by a user program. This should be considered when making connections to external circuitry. Note that the mask ROM and ZTAT versions do not have this function.

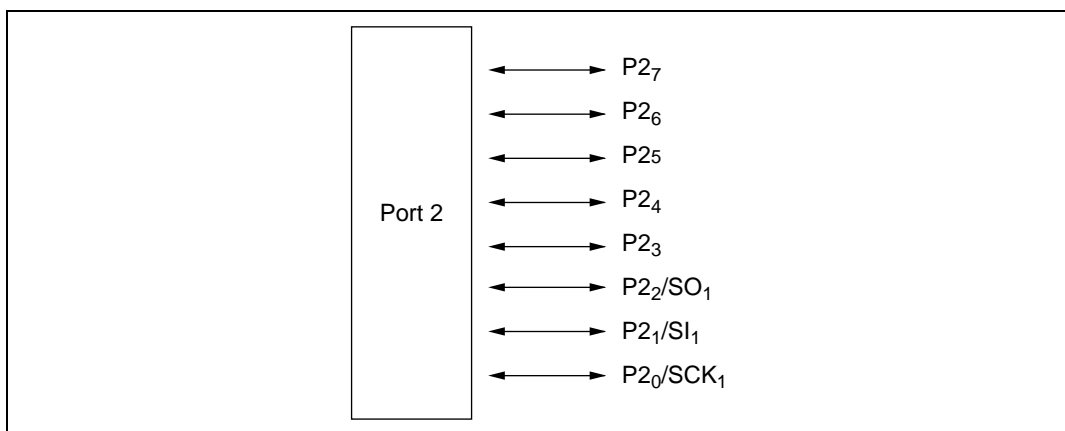


Figure 8.2 Port 2 Pin Configuration

8.3.2 Register Configuration and Description

Table 8.5 shows the port 2 register configuration.

Table 8.5 Port 2 Registers

Name	Abbr.	R/W	Initial Value	Address
Port data register 2	PDR2	R/W	H'00	H'FFD5
Port control register 2	PCR2	W	H'00	H'FFE5
Port mode register 2	PMR2	R/W	H'D8*	H'FFC9
Port mode register 4	PMR4	R/W	H'00	H'FFCB

Note: * H'58 in the H8/38347 Group and H8/38447 Group.

1. Port Data Register 2 (PDR2)

Bit	7	6	5	4	3	2	1	0
	P2 ₇	P2 ₆	P2 ₅	P2 ₄	P2 ₃	P2 ₂	P2 ₁	P2 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

PDR2 is an 8-bit register that stores data for port 2 pins P2₇ to P2₀. If port 2 is read while PCR2 bits are set to 1, the values stored in PDR2 are read, regardless of the actual pin states. If port 2 is read while PCR2 bits are cleared to 0, the pin states are read.

Upon reset, PDR2 is initialized to H'00.

2. Port Control Register 2 (PCR2)

Bit	7	6	5	4	3	2	1	0
	PCR2 ₇	PCR2 ₆	PCR2 ₅	PCR2 ₄	PCR2 ₃	PCR2 ₂	PCR2 ₁	PCR2 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	W	W	W	W	W	W	W	W

PCR2 is an 8-bit register for controlling whether each of the port 2 pins P2₇ to P2₀ functions as an input pin or output pin. Setting a PCR2 bit to 1 makes the corresponding pin an output pin, while clearing the bit to 0 makes the pin an input pin. The settings in PCR2 and PDR2 are valid only when the corresponding pin is designated in PMR1 as a general I/O pin.

Upon reset, PCR2 is initialized to H'00.

PCR2 is a write-only register, which is always read as all 1s.

3. Port Mode Register 2 (PMR2)

- H8/3847R Group, H8/3847S Group

Bit	7	6	5	4	3	2	1	0
	—	—	POF1	—	—	SO1	SI1	SCK1
Initial value	1	1	0	1	1	0	0	0
Read/Write	—	—	R/W	—	—	R/W	R/W	R/W

PMR2 is an 8-bit read/write register that controls the selection of pin functions for port 2 pins P2₀, P2₁, and P2₃, and the PMOS on/off state for the P2₂/SO₁ pin.

Upon reset, PMR2 is initialized to H'D8.

- H8/38347 Group and H8/38447 Group

Bit	7	6	5	4	3	2	1	0
	EXCL	—	POF1	—	—	SO1	SI1	SCK1
Initial value	0	1	0	1	1	0	0	0
Read/Write	R/W	—	R/W	—	—	R/W	R/W	R/W

PMR2 is an 8-bit read/write register that controls the selection of pin functions for pins P2₀, P2₁, and P2₃, the PMOS on/off state for the P2₂/SO₁ pin, and external clock input to pin P31.

Upon reset, PMR2 is initialized to H'58.

- H8/3847R Group and H8/3847S Group

Bit 7: Reserved bit

Bit 7 is reserved. It is always read as 1 and cannot be modified.

- H8/38347 Group and H8/38447 Group

Bit 7: P31/UD/EXCL pin function switch (EXCL)

This bit selects whether pin P31/UD/EXCL is used as P31/UD or as EXCL. When the pin is used as EXCL an external clock should be input to it. See section 4, Clock Pulse Generators, for a connection example.

Bit 7

EXCL	Description	
0	Functions as P31/UD I/O pin	(initial value)
1	Functions as EXCL input pin	

Bits 6, 4, and 3: Reserved bits

Bits 6, 4, and 3 are reserved; they are always read as 1 and cannot be modified.

Bit 5: P2₂/SO₁ pin PMOS control (POF1)

This bit controls the on/off state of the P2₂/SO₁ pin output buffer PMOS.

Bit 5

POF1	Description	
0	CMOS output	(initial value)
1	NMOS open-drain output	

Bit 2: P2₂/SO₁ pin function switch (SO1)

This bit selects whether pin P2₂/SO₁ is used as P2₂ or as SO₁.

Bit 2

SO1	Description	
0	Functions as P2 ₂ I/O pin	(initial value)
1	Functions as SO ₁ output pin	

Bit 1: P2₁/SI₁ pin function switch (SI1)

This bit selects whether pin P2₁/SI₁ is used as P2₁ or as SI₁.

Bit 1

SI1	Description	
0	Functions as P2 ₁ I/O pin	(initial value)
1	Functions as SI ₁ input pin	

Bit 0: P2₀/SCK₁ pin function switch (SCK1)

This bit selects whether pin P2₀/SCK₁ is used as P2₀ or as SCK₁.

Bit 0

SCK1	Description	
0	Functions as P2 ₀ I/O pin	(initial value)
1	Functions as SCK ₁ I/O pin	

4. Port Mode Register 4 (PMR4)

Bit	7	6	5	4	3	2	1	0
	NMOD7	NMOD6	NMOD5	NMOD4	NMOD3	NMOD2	NMOD1	NMOD0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

PMR4 is an 8-bit read/write register that controls whether individual port 2 pins are CMOS outputs or NMOS open-drain outputs when 1 is set in PCR2.

Upon reset, PMR4 is initialized to H'00.

Bit n: NMOS open-drain output select (NMODn)

These bits select NMOS open-drain output when pin P2_n is used as an output pin.

Bit n NMODn	Description	
0	CMOS output	(initial value)
1	NMOS open-drain output	

(n = 7 to 0)

8.3.3 Pin Function

Table 8.6 shows the port 2 pin functions.

Table 8.6 Port 2 Pin Functions

Pin	Pin Functions and Selection Method		
P2 ₇ to P2 ₃	The pin function depends on the corresponding bit in PCR2.		
		(n = 7 to 3)	
	PCR2 _n	0	1
	Pin function	P2 _n input pin	P2 _n output pin
P2 ₂ /SO ₁	The pin function depends on bit SO1 in PMR2 and bit PCR2 ₂ in PCR2.		
	SO1	0	1
	PCR2 ₂	0	1
	Pin function	P2 ₂ input pin	P2 ₂ output pin
P2 ₁ /SI ₁	The pin function depends on bit SI1 in PMR2 and bit PCR2 ₁ in PCR2.		
	SI1	0	1
	PCR2 ₁	0	1
	Pin function	P2 ₁ input pin	P2 ₁ output pin
P2 ₀ /SCK ₁	The pin function depends on bit SCK1 in PMR2 and bit PCR2 ₀ in PCR2.		
	SCK1	0	1
	PCR2 ₀	0	1
	Pin function	P2 ₀ input pin	P2 ₀ output pin

*: Don't care

8.3.4 Pin States

Table 8.7 shows the port 2 pin states in each operating mode.

Table 8.7 Port 2 Pin States

Pins	Reset	Sleep	Subsleep	Standby	Watch	Subactive	Active
P2 ₇ to P2 ₅	High-impedance	Retains previous state	Retains previous state	High-impedance	Retains previous state	Functional	Functional
P2 ₄ ^{*1}	Pull-up MOS on						
P2 ₄ ^{*2} P2 ₃	High-impedance						
P2 ₂ /SO ₁ P2 ₁ /SI ₁ P2 ₀ /SCK ₁	High-impedance						

- Notes: 1. Applies to the F-ZTAT version of the H8/38347 Group and H8/38447 Group.
 2. Applies to H8/3847R Group and H8/3847S Group. Also applies to the mask ROM version of the H8/38347 Group and H8/38447 Group.

8.4 Port 3

8.4.1 Overview

Port 3 is an 8-bit I/O port, configured as shown in figure 8.3.

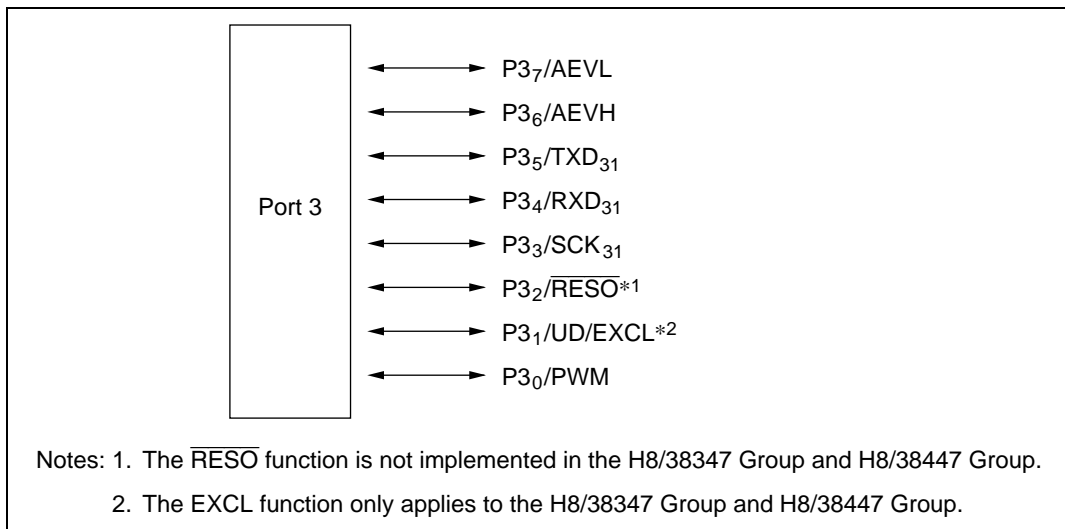


Figure 8.3 Port 3 Pin Configuration

8.4.2 Register Configuration and Description

Table 8.8 shows the port 3 register configuration.

Table 8.8 Port 3 Registers

Name	Abbr.	R/W	Initial Value	Address
Port data register 3	PDR3	R/W	H'00	H'FFD6
Port control register 3	PCR3	W	H'00	H'FFE6
Port pull-up control register 3	PUCR3	R/W	H'00	H'FFE1
Port mode register 2	PMR2	R/W	H'D8*	H'FFC9
Port mode register 3	PMR3	R/W	H'04	H'FFCA

Note: * H'58 in the H8/38347 Group and H8/38447 Group.

1. Port Data Register 3 (PDR3)

Bit	7	6	5	4	3	2	1	0
	P3 ₇	P3 ₆	P3 ₅	P3 ₄	P3 ₃	P3 ₂	P3 ₁	P3 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

PDR3 is an 8-bit register that stores data for port 3 pins P3₇ to P3₀. If port 3 is read while PCR3 bits are set to 1, the values stored in PDR3 are read, regardless of the actual pin states. If port 3 is read while PCR3 bits are cleared to 0, the pin states are read.

Upon reset, PDR3 is initialized to H'00.

2. Port Control Register 3 (PCR3)

Bit	7	6	5	4	3	2	1	0
	PCR3 ₇	PCR3 ₆	PCR3 ₅	PCR3 ₄	PCR3 ₃	PCR3 ₂	PCR3 ₁	PCR3 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	W	W	W	W	W	W	W	W

PCR3 is an 8-bit register for controlling whether each of the port 3 pins P3₇ to P3₀ functions as an input pin or output pin. Setting a PCR3 bit to 1 makes the corresponding pin an output pin, while clearing the bit to 0 makes the pin an input pin. The settings in PCR3 and in PDR3 are valid only when the corresponding pin is designated in PMR3 as a general I/O pin.

Upon reset, PCR3 is initialized to H'00.

PCR3 is a write-only register, which is always read as all 1s.

3. Port Pull-up Control Register 3 (PUCR3)

Bit	7	6	5	4	3	2	1	0
	PUCR3 ₇	PUCR3 ₆	PUCR3 ₅	PUCR3 ₄	PUCR3 ₃	PUCR3 ₂	PUCR3 ₁	PUCR3 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

PUCR3 controls whether the MOS pull-up of each of the port 3 pins P3₇ to P3₀ is on or off. When a PCR3 bit is cleared to 0, setting the corresponding PUCR3 bit to 1 turns on the MOS pull-up for the corresponding pin, while clearing the bit to 0 turns off the MOS pull-up.

Upon reset, PUCR3 is initialized to H'00.

4. Port Mode Register 3 (PMR3)

Bit	7	6	5	4	3	2	1	0
	AEVL	AEVH	WDCKS	NCS	IRQ0	RESO*	UD	PWM
Initial value	0	0	0	0	0	1	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

PMR3 is an 8-bit read/write register, controlling the selection of pin functions for port 3 pins.

Upon reset, PMR3 is initialized to H'04.

Note: * The RESO bit is not implemented in the H8/38347 Group and H8/38447 Group.

Bit 7: P3₇/AEVL pin function switch (AEVL)

This bit selects whether pin P3₇/AEVL is used as P3₇ or as AEVL.

Bit 7

AEVL	Description
0	Functions as P3 ₇ I/O pin (initial value)
1	Functions as AEVL input pin

Bit 6: P3₆/AEVH pin function switch (AEVH)

This bit selects whether pin P3₆/AEVH is used as P3₆ or as AEVH.

Bit 6

AEVH	Description
0	Functions as P3 ₆ I/O pin (initial value)
1	Functions as AEVH input pin

Bit 5: Watchdog timer source clock select (WDCKS)

This bit selects the watchdog timer source clock.

Bit 5

WDCKS	Description
0	ϕ /8192 selected (initial value)
1	ϕ_w /32 selected

Bit 4: TMIG noise canceler select (NCS)

This bit controls the noise canceler for the input capture input signal (TMIG).

Bit 4

NCS	Description	
0	Noise cancellation function not used	(initial value)
1	Noise cancellation function used	

Bit 3: P4₃/ $\overline{\text{IRQ}}_0$ pin function switch (IRQ0)

This bit selects whether pin P4₃/ $\overline{\text{IRQ}}_0$ is used as P4₃ or as $\overline{\text{IRQ}}_0$.

Bit 3

$\overline{\text{IRQ}}_0$	Description	
0	Functions as P4 ₃ input pin	(initial value)
1	Functions as $\overline{\text{IRQ}}_0$ input pin	

Bit 2: P3₂/ $\overline{\text{RESO}}$ pin function switch (RESO)

This bit selects whether pin P3₂/ $\overline{\text{RESO}}$ is used as P3₂ or as $\overline{\text{RESO}}$.

Bit 2

$\overline{\text{RESO}}$	Description	
0	Functions as P3 ₂ I/O pin	
1	Functions as $\overline{\text{RESO}}$ output pin	(initial value)

In the H8/38347 Group and H8/38447 Group this bit is reserved and cannot be written to.

Bit 1: P3₁/UD pin function switch (UD)

This bit selects whether pin P3₁/UD is used as P3₁ or as UD.

Bit 1

UD	Description	
0	Functions as P3 ₁ I/O pin	(initial value)
1	Functions as UD input pin	

In the H8/38347 Group and H8/38447 Group this pin is a combined P31/UD/EXCL pin. Refer to the description of port mode register 2 in 8.3, Port 2, for details on switching to the EXCL pin function.

Bit 0: P3₀/PWM pin function switch (PWM)

This bit selects whether pin P3₀/PWM is used as P3₀ or as PWM.

Bit 0 PWM	Description	
0	Functions as P3 ₀ I/O pin	(initial value)
1	Functions as PWM output pin	

8.4.3 Pin Functions

Table 8.9 shows the port 3 pin functions.

Table 8.9 Port 3 Pin Functions

Pin	Pin Functions and Selection Method		
P3 ₇ /AEVL	The pin function depends on bit SO1 in PMR3 and bit PCR3 ₂ in PCR3.		
	AEVL	0	
	PCR3 ₇	0	1
	Pin function	P3 ₇ input pin	P3 ₇ output pin
P3 ₆ /AEVH	The pin function depends on bit AEVH in PMR3 and bit PCR3 ₆ in PCR3.		
	AEVH	0	
	PCR3 ₆	0	1
	Pin function	P3 ₆ input pin	P3 ₆ output pin
P3 ₅ /TXD ₃₁	The pin function depends on bit TE in SCR3-1, bit SPC31 in SPCR, and bit PCR3 ₅ in PCR3.		
	SPC31	0	
	TE	0	
	PCR3 ₅	0	1
	Pin function	P3 ₅ input pin	P3 ₅ output pin
P3 ₄ /RXD ₃₁	The pin function depends on bit RE in SCR3-1 and bit PCR3 ₄ in PCR3.		
	RE	0	
	PCR3 ₄	0	1
	Pin function	P3 ₄ input pin	P3 ₄ output pin

Pin Pin Functions and Selection Method

P3₃/SCK₃₁ The pin function depends on bits CKE1, CKE0, and SMR31 in SCR3-1 and bit PCR3₃ in PCR3.

CKE1	0			1
CKE0	0		1	*
COM3 ₁	0		1	*
PCR3 ₃	0	1	*	
Pin function	P3 ₃ input pin	P3 ₃ output pin	SCK ₃₁ output pin	SCK ₃₁ input pin

P3₂/RESO
(H8/3847R,
H8/3847S) • H8/3847R Group, H8/3847S Group
The pin function depends on bit RESO in PMR3 and bit PCR3₂ in PCR3.

RESO	0		1
PCR3 ₂	0	1	*
Pin function	P3 ₂ input pin	P3 ₂ output pin	RESO output pin

P3₂
(H8/38347,
H8/38447) • H8/38347 Group, H8/38447 Group
The pin function depends on bit PCR3₂ in PCR3.

PCR3 ₂	0	1
Pin function	P3 ₂ input pin	P3 ₂ output pin

P3₁/UD
(H8/3847R,
H8/3847S) • H8/3847R Group, H8/3847S Group
The pin function depends on bit UD in PMR3 and bit PCR3₁ in PCR3.

UD	0		1
PCR3 ₁	0	1	*
Pin function	P3 ₁ input pin	P3 ₁ output pin	UD input pin

P3₁/UD/EXCL
(H8/38347,
H8/38447) • H8/38347 Group, H8/38447 Group
The pin function depends on bit EXCL in PMR2, bit UD in PMR3, and bit PCR3₁ in PCR3.

EXCL	0			1
UD	0		1	*
PCR3 ₁	0	1	*	*
Pin function	P3 ₁ input pin	P3 ₁ output pin	UD input pin	EXCL input pin

P3₀/PWM The pin function depends on bit PWM in PMR3 and bit PCR3₀ in PCR3.

PWM	0			1
PCR3 ₀	0	1	*	
Pin function	P3 ₀ input pin	P3 ₀ output pin	PWM output pin	

*: Don't care

8.4.4 Pin States

Table 8.10 shows the port 3 pin states in each operating mode.

Table 8.10 Port 3 Pin States

Pins	Reset	Sleep	Subsleep	Standby	Watch	Subactive	Active
P3 ₇ /AEVL	High-impedance	Retains previous state	Retains previous state	High-impedance ^{*1}	Retains previous state	Functional	Functional
P3 ₆ /AEVH							
P3 ₅ /TXD ₃₁							
P3 ₄ /RXD ₃₁							
P3 ₃ /SCK ₃₁							
P3 ₂ /RESO ^{*2}	Reset output						
P3 ₂ ^{*3}	High-impedance						
P3 ₁ /UD ^{*2}							
P3 ₁ /UD/EXCL ^{*3}							
P3 ₀ /PWM							

Notes: 1. A high-level signal is output when the MOS pull-up is in the on state.

2. Applies to H8/3847R Group and H8/3847S Group.

3. Applies to H8/38347 Group and H8/38447 Group.

8.4.5 MOS Input Pull-Up

Port 3 has a built-in MOS input pull-up function that can be controlled by software. When a PCR3 bit is cleared to 0, setting the corresponding PUCR3 bit to 1 turns on the MOS pull-up for that pin. The MOS pull-up function is in the off state after a reset.

PCR3 _n	0	0	1
PUCR3 _n	0	1	*
MOS input pull-up	Off	On	Off

(n = 7 to 0)

*: Don't care

8.5 Port 4

8.5.1 Overview

Port 4 is a 3-bit I/O port and 1-bit input port, configured as shown in figure 8.4.

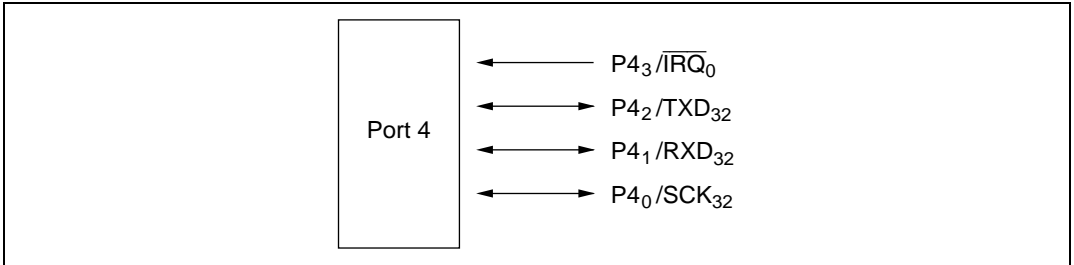


Figure 8.4 Port 4 Pin Configuration

8.5.2 Register Configuration and Description

Table 8.11 shows the port 4 register configuration.

Table 8.11 Port 4 Registers

Name	Abbr.	R/W	Initial Value	Address
Port data register 4	PDR4	R/W	H'F8	H'FFD7
Port control register 4	PCR4	W	H'F8	H'FFE7

1. Port Data Register 4 (PDR4)

Bit	7	6	5	4	3	2	1	0
	—	—	—	—	P4 ₃	P4 ₂	P4 ₁	P4 ₀
Initial value	1	1	1	1	1	0	0	0
Read/Write	—	—	—	—	R	R/W	R/W	R/W

PDR4 is an 8-bit register that stores data for port 4 pins P4₂ to P4₀. If port 4 is read while PCR4 bits are set to 1, the values stored in PDR4 are read, regardless of the actual pin states. If port 4 is read while PCR4 bits are cleared to 0, the pin states are read.

Upon reset, PDR4 is initialized to H'F8.

2. Port Control Register 4 (PCR4)

Bit	7	6	5	4	3	2	1	0
	—	—	—	—	—	PCR4 ₂	PCR4 ₁	PCR4 ₀
Initial value	1	1	1	1	1	0	0	0
Read/Write	—	—	—	—	—	W	W	W

PCR4 is an 8-bit register for controlling whether each of port 4 pins P4₂ to P4₀ functions as an input pin or output pin. Setting a PCR4 bit to 1 makes the corresponding pin an output pin, while clearing the bit to 0 makes the pin an input pin. PCR4 and PDR4 settings are valid when the corresponding pins are designated for general-purpose input/output by SCR3-2.

Upon reset, PCR4 is initialized to H'F8.

PCR4 is a write-only register, which always reads all 1s.

8.5.3 Pin Functions

Table 8.12 shows the port 4 pin functions.

Table 8.12 Port 4 Pin Functions

Pin	Pin Functions and Selection Method				
P4 ₃ / $\overline{\text{IRQ}}_0$	The pin function depends on bit IRQ0 in PMR3.				
	IRQ0	0		1	
	Pin function	P4 ₃ input pin		$\overline{\text{IRQ}}_0$ input pin	
P4 ₂ /TXD ₃₂	The pin function depends on bit TE in SCR3-2, bit SPC32 in SPCR, and bit PCR4 ₂ in PCR4.				
	SPC32	0		1	
	TE	0		1	
	PCR4 ₂	0	1	*	
	Pin function	P4 ₂ input pin	P4 ₂ output pin	TXD ₃₂ output pin	
P4 ₁ /RXD ₃₂	The pin function depends on bit RE in SCR3-2 and bit PCR4 ₁ in PCR4.				
	RE	0		1	
	PCR4 ₁	0	1	*	
	Pin function	P4 ₁ input pin	P4 ₁ output pin	RXD ₃₂ input pin	
P4 ₀ /SCK ₃₂	The pin function depends on bits CKE1 and CKE0 in SCR3-2, bit COM32 in SMR32, and bit PCR4 ₀ in PCR4.				
	CKE1	0		1	
	CKE0	0		1	
	COM32	0		1	*
	PCR4 ₀	0	1	*	*
	Pin function	P4 ₀ input pin	P4 ₀ output pin	SCK ₃₂ output pin	SCK ₃₂ input pin

*: Don't care

8.5.4 Pin States

Table 8.13 shows the port 4 pin states in each operating mode.

Table 8.13 Port 4 Pin States

Pins	Reset	Sleep	Subsleep	Standby	Watch	Subactive	Active
P4 ₃ /IRQ ₀	High-impedance	Retains previous state	Retains previous state	High-impedance	Retains previous state	Functional	Functional
P4 ₂ /TXD ₃₂							
P4 ₁ /RXD ₃₂							
P4 ₀ /SCK ₃₂							

8.6 Port 5

8.6.1 Overview

Port 5 is an 8-bit I/O port, configured as shown in figure 8.5.

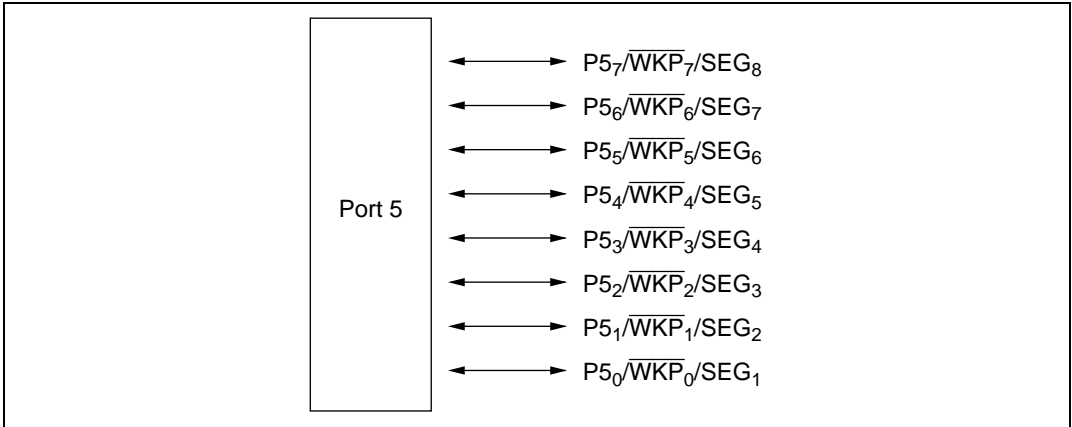


Figure 8.5 Port 5 Pin Configuration

8.6.2 Register Configuration and Description

Table 8.14 shows the port 5 register configuration.

Table 8.14 Port 5 Registers

Name	Abbr.	R/W	Initial Value	Address
Port data register 5	PDR5	R/W	H'00	H'FFD8
Port control register 5	PCR5	W	H'00	H'FFE8
Port pull-up control register 5	PUCR5	R/W	H'00	H'FFE2
Port mode register 5	PMR5	R/W	H'00	H'FFCC

1. Port Data Register 5 (PDR5)

Bit	7	6	5	4	3	2	1	0
	P5 ₇	P5 ₆	P5 ₅	P5 ₄	P5 ₃	P5 ₂	P5 ₁	P5 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

PDR5 is an 8-bit register that stores data for port 5 pins P5₇ to P5₀. If port 5 is read while PCR5 bits are set to 1, the values stored in PDR5 are read, regardless of the actual pin states. If port 5 is read while PCR5 bits are cleared to 0, the pin states are read.

Upon reset, PDR5 is initialized to H'00.

2. Port Control Register 5 (PCR5)

Bit	7	6	5	4	3	2	1	0
	PCR5 ₇	PCR5 ₆	PCR5 ₅	PCR5 ₄	PCR5 ₃	PCR5 ₂	PCR5 ₁	PCR5 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	W	W	W	W	W	W	W	W

PCR5 is an 8-bit register for controlling whether each of the port 5 pins P5₇ to P5₀ functions as an input pin or output pin. Setting a PCR5 bit to 1 makes the corresponding pin an output pin, while clearing the bit to 0 makes the pin an input pin. PCR5 and PDR5 settings are valid when the corresponding pins are designated for general-purpose input/output by PMR5 and bits SGS3 to SGS0 in LPCR.

Upon reset, PCR5 is initialized to H'00.

PCR5 is a write-only register, which is always read as all 1s.

3. Port Pull-Up Control Register 5 (PUCR5)

Bit	7	6	5	4	3	2	1	0
	PUCR5 ₇	PUCR5 ₆	PUCR5 ₅	PUCR5 ₄	PUCR5 ₃	PUCR5 ₂	PUCR5 ₁	PUCR5 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

PUCR5 controls whether the MOS pull-up of each of port 5 pins P5₇ to P5₀ is on or off. When a PCR5 bit is cleared to 0, setting the corresponding PUCR5 bit to 1 turns on the MOS pull-up for the corresponding pin, while clearing the bit to 0 turns off the MOS pull-up.

Upon reset, PUCR5 is initialized to H'00.

4. Port Mode Register 5 (PMR5)

Bit	7	6	5	4	3	2	1	0
	WKP ₇	WKP ₆	WKP ₅	WKP ₄	WKP ₃	WKP ₂	WKP ₁	WKP ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

PMR5 is an 8-bit read/write register, controlling the selection of pin functions for port 5 pins.

Upon reset, PMR5 is initialized to H'00.

Bit n: P5_n/ $\overline{\text{WKP}}_n$ /SEG_{n+1} pin function switch (WKP_n)

When pin P5_n/ $\overline{\text{WKP}}_n$ /SEG_{n+1} is not used as SEG_{n+1}, these bits select whether the pin is used as P5_n or $\overline{\text{WKP}}_n$.

Bit n WKP _n	Description
0	Functions as P5 _n I/O pin (initial value)
1	Functions as $\overline{\text{WKP}}_n$ input pin

(n = 7 to 0)

Note: For use as SEG_{n+1}, see section 13.2.1, LCD Port Control Register (LPCR).

8.6.3 Pin Functions

Table 8.15 shows the port 5 pin functions.

Table 8.15 Port 5 Pin Functions

Pin	Pin Functions and Selection Method			
P5 ₇ / $\overline{\text{WKP}}_7$ / SEG ₈ to P5 ₀ / $\overline{\text{WKP}}_0$ / SEG ₁	The pin function depends on bit WKP _n in PMR5, bit PCR5 _n in PCR5, and bits SEG8 to SGS3 to SGS0 in LPCR.			
	SGS3 to SGS0	0***		1***
	WKP _n	0	1	*
	PCR5 _n	0	1	*
	Pin function	P5 _n input pin	P5 _n output pin	$\overline{\text{WKP}}_n$ input pin SEG _{n+1} output pin

*: Don't care

8.6.4 Pin States

Table 8.16 shows the port 5 pin states in each operating mode.

Table 8.16 Port 5 Pin States

Pins	Reset	Sleep	Subsleep	Standby	Watch	Subactive	Active
P5 ₇ / \overline{WKP}_7 / SEG ₈ to P5 ₀ / \overline{WKP}_0 /SEG ₁	High-impedance	Retains previous state	Retains previous state	High-impedance*	Retains previous state	Functional	Functional

Note: * A high-level signal is output when the MOS pull-up is in the on state.

8.6.5 MOS Input Pull-Up

Port 5 has a built-in MOS input pull-up function that can be controlled by software. When a PCR5 bit is cleared to 0, setting the corresponding PUCR5 bit to 1 turns on the MOS pull-up for that pin. The MOS pull-up function is in the off state after a reset.

PCR5 _n	0	0	1
PUCR5 _n	0	1	*
MOS input pull-up	Off	On	Off

(n = 7 to 0)

*: Don't care

8.7 Port 6

8.7.1 Overview

Port 6 is an 8-bit I/O port. The port 6 pin configuration is shown in figure 8.6.

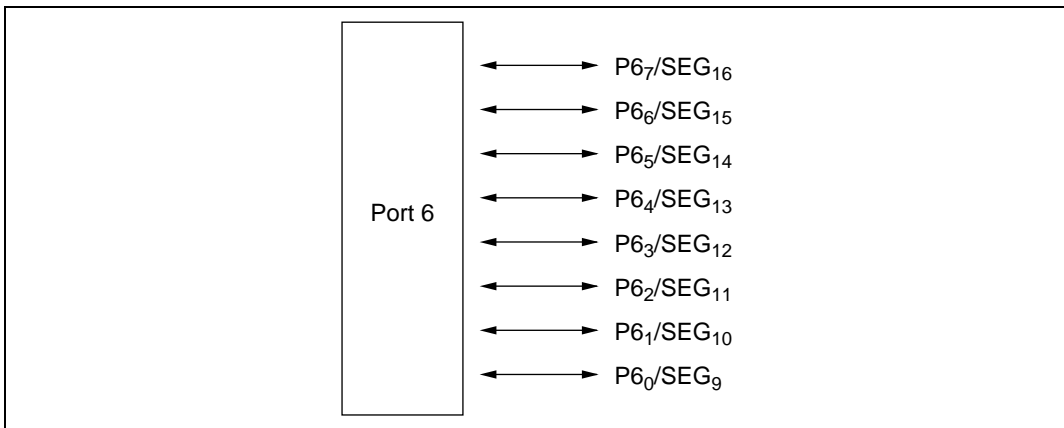


Figure 8.6 Port 6 Pin Configuration

8.7.2 Register Configuration and Description

Table 8.17 shows the port 6 register configuration.

Table 8.17 Port 6 Registers

Name	Abbr.	R/W	Initial Value	Address
Port data register 6	PDR6	R/W	H'00	H'FFD9
Port control register 6	PCR6	W	H'00	H'FFE9
Port pull-up control register 6	PUCR6	R/W	H'00	H'FFE3

1. Port Data Register 6 (PDR6)

Bit	7	6	5	4	3	2	1	0
	P6 ₇	P6 ₆	P6 ₅	P6 ₄	P6 ₃	P6 ₂	P6 ₁	P6 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

PDR6 is an 8-bit register that stores data for port 6 pins P6₇ to P6₀.

If port 6 is read while PCR6 bits are set to 1, the values stored in PDR6 are read, regardless of the actual pin states. If port 6 is read while PCR6 bits are cleared to 0, the pin states are read.

Upon reset, PDR6 is initialized to H'00.

2. Port Control Register 6 (PCR6)

Bit	7	6	5	4	3	2	1	0
	PCR6 ₇	PCR6 ₆	PCR6 ₅	PCR6 ₄	PCR6 ₃	PCR6 ₂	PCR6 ₁	PCR6 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	W	W	W	W	W	W	W	W

PCR6 is an 8-bit register for controlling whether each of the port 6 pins P6₇ to P6₀ functions as an input pin or output pin.

Setting a PCR6 bit to 1 makes the corresponding pin (P6₇ to P6₀) an output pin, while clearing the bit to 0 makes the pin an input pin. PCR6 and PDR6 settings are valid when the corresponding pins are designated for general-purpose input/output by bits SGS3 to SGS0 in LPCR.

Upon reset, PCR6 is initialized to H'00.

PCR6 is a write-only register, which always reads all 1s.

3. Port Pull-Up Control Register 6 (PUCR6)

Bit	7	6	5	4	3	2	1	0
	PUCR6 ₇	PUCR6 ₆	PUCR6 ₅	PUCR6 ₄	PUCR6 ₃	PUCR6 ₂	PUCR6 ₁	PUCR6 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

PUCR6 controls whether the MOS pull-up of each of the port 6 pins P6₇ to P6₀ is on or off. When a PCR6 bit is cleared to 0, setting the corresponding PUCR6 bit to 1 turns on the MOS pull-up for the corresponding pin, while clearing the bit to 0 turns off the MOS pull-up.

Upon reset, PUCR6 is initialized to H'00.

8.7.3 Pin Functions

Table 8.18 shows the port 6 pin functions.

Table 8.18 Port 6 Pin Functions

Pin	Pin Functions and Selection Method		
P6 ₇ /SEG ₁₆ to P6 ₀ /SEG ₉	The pin function depends on bit PCR6 _n in PCR6 and bits SGS3 to SGS0 in LPCR.		
	(n = 7 to 0)		
	SGS3 to SGS0	00**, 010*	011**, 1***
	PCR6 _n	0	1
	Pin function	P6 _n input pin	P6 _n output pin
			SEG _{n+9} output pin

*: Don't care

8.7.4 Pin States

Table 8.19 shows the port 6 pin states in each operating mode.

Table 8.19 Port 6 Pin States

Pins	Reset	Sleep	Subsleep	Standby	Watch	Subactive	Active
P6 ₇ /SEG ₁₆ to P6 ₀ /SEG ₉	High-impedance	Retains previous state	Retains previous state	High-impedance*	Retains previous state	Functional	Functional

Note: * A high-level signal is output when the MOS pull-up is in the on state.

8.7.5 MOS Input Pull-Up

Port 6 has a built-in MOS pull-up function that can be controlled by software. When a PCR6 bit is cleared to 0, setting the corresponding PUCR6 bit to 1 turns on the MOS pull-up for that pin. The MOS pull-up function is in the off state after a reset.

PCR6 _n	0	0	1
PUCR6 _n	0	1	*
MOS input pull-up	Off	On	Off

(n = 7 to 0)

*: Don't care

8.8 Port 7

8.8.1 Overview

Port 7 is an 8-bit I/O port, configured as shown in figure 8.7.

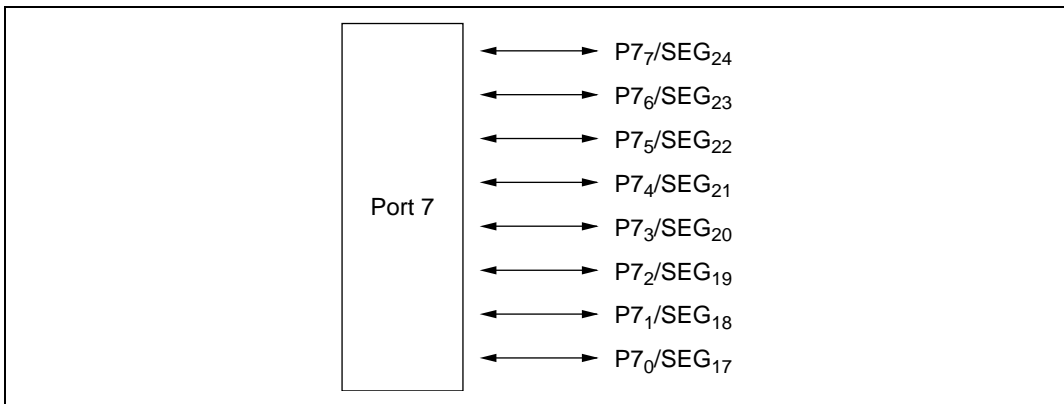


Figure 8.7 Port 7 Pin Configuration

8.8.2 Register Configuration and Description

Table 8.20 shows the port 7 register configuration.

Table 8.20 Port 7 Registers

Name	Abbr.	R/W	Initial Value	Address
Port data register 7	PDR7	R/W	H'00	H'FFDA
Port control register 7	PCR7	W	H'00	H'FFEA

1. Port Data Register 7 (PDR7)

Bit	7	6	5	4	3	2	1	0
	P7 ₇	P7 ₆	P7 ₅	P7 ₄	P7 ₃	P7 ₂	P7 ₁	P7 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

PDR7 is an 8-bit register that stores data for port 7 pins P7₇ to P7₀. If port 7 is read while PCR7 bits are set to 1, the values stored in PDR7 are read, regardless of the actual pin states. If port 7 is read while PCR7 bits are cleared to 0, the pin states are read.

Upon reset, PDR7 is initialized to H'00.

2. Port Control Register 7 (PCR7)

Bit	7	6	5	4	3	2	1	0
	PCR7 ₇	PCR7 ₆	PCR7 ₅	PCR7 ₄	PCR7 ₃	PCR7 ₂	PCR7 ₁	PCR7 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	W	W	W	W	W	W	W	W

PCR7 is an 8-bit register for controlling whether each of the port 7 pins P7₇ to P7₀ functions as an input pin or output pin. Setting a PCR7 bit to 1 makes the corresponding pin an output pin, while clearing the bit to 0 makes the pin an input pin. PCR7 and PDR7 settings are valid when the corresponding pins are designated for general-purpose input/output by bits SGS3 to SGS0 in LPCR.

Upon reset, PCR7 is initialized to H'00.

PCR7 is a write-only register, which always reads as all 1s.

8.8.3 Pin Functions

Table 8.21 shows the port 7 pin functions.

Table 8.21 Port 7 Pin Functions

Pin	Pin Functions and Selection Method		
P7 ₇ /SEG ₂₄ to P7 ₀ /SEG ₁₇	The pin function depends on bit PCR7 _n in PCR7 and bits SGS3 to SGS0 in LPCR.		
	(n = 7 to 0)		
	SGS3 to SGS0	00**	
	PCR7 _n	0	1
	Pin function	P7 _n input pin	P7 _n output pin
			01**, 1***
			*
			SEG _{n+17} output pin

*: Don't care

8.8.4 Pin States

Table 8.22 shows the port 7 pin states in each operating mode.

Table 8.22 Port 7 Pin States

Pins	Reset	Sleep	Subsleep	Standby	Watch	Subactive	Active
P7 ₇ /SEG ₂₄ to P7 ₀ /SEG ₁₇	High-impedance	Retains previous state	Retains previous state	High-impedance	Retains previous state	Functional	Functional

8.9 Port 8

8.9.1 Overview

Port 8 is an 8-bit I/O port configured as shown in figure 8.8.

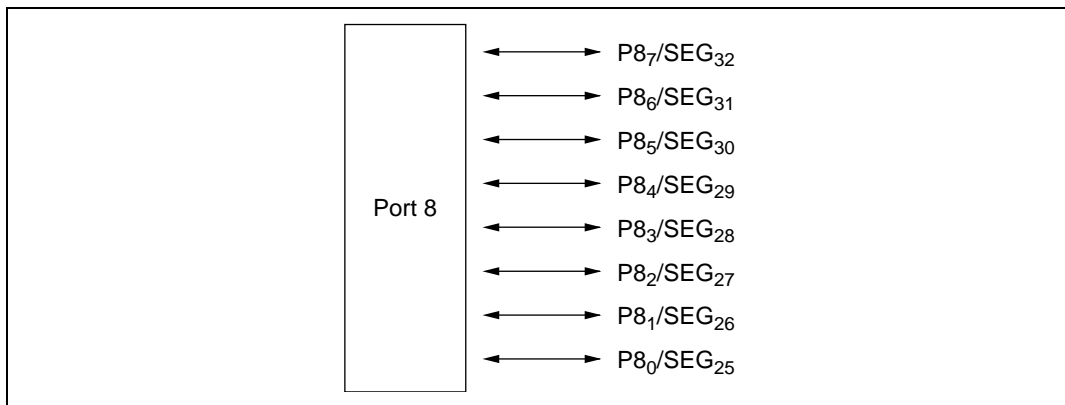


Figure 8.8 Port 8 Pin Configuration

8.9.2 Register Configuration and Description

Table 8.23 shows the port 8 register configuration.

Table 8.23 Port 8 Registers

Name	Abbr.	R/W	Initial Value	Address
Port data register 8	PDR8	R/W	H'00	H'FFDB
Port control register 8	PCR8	W	H'00	H'FFEB

1. Port Data Register 8 (PDR8)

Bit	7	6	5	4	3	2	1	0
	P8 ₇	P8 ₆	P8 ₅	P8 ₄	P8 ₃	P8 ₂	P8 ₁	P8 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

PDR8 is an 8-bit register that stores data for port 8 pins P8₇ to P8₀. If port 8 is read while PCR8 bits are set to 1, the values stored in PDR8 are read, regardless of the actual pin states. If port 8 is read while PCR8 bits are cleared to 0, the pin states are read.

Upon reset, PDR8 is initialized to H'00.

2. Port Control Register 8 (PCR8)

Bit	7	6	5	4	3	2	1	0
	PCR8 ₇	PCR8 ₆	PCR8 ₅	PCR8 ₄	PCR8 ₃	PCR8 ₂	PCR8 ₁	PCR8 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	W	W	W	W	W	W	W	W

PCR8 is an 8-bit register for controlling whether each of the port 8 pins P8₇ to P8₀ functions as an input or output pin. Setting a PCR8 bit to 1 makes the corresponding pin an output pin, while clearing the bit to 0 makes the pin an input pin. PCR8 and PDR8 settings are valid when the corresponding pins are designated for general-purpose input/output by bits SGS3 to SGS0 in LPCR.

Upon reset, PCR8 is initialized to H'00.

PCR8 is a write-only register, which is always read as all 1s.

8.9.3 Pin Functions

Table 8.24 shows the port 8 pin functions.

Table 8.24 Port 8 Pin Functions

Pin	Pin Functions and Selection Method		
P8 ₇ /SEG ₃₂ to P8 ₀ /SEG ₂₅	The pin function depends on bit PCR _{8n} in PCR8 and bits SGS3 to SGS0 in LPCR.		
	(n = 7 to 0)		
	SGS3 to SGS0	000*	
	PCR _{8n}	0	1
	Pin function	P8 _n input pin	P8 _n output pin
			001*, 01**, 1***
			*
			SEG _{n+25} output pin

*: Don't care

8.9.4 Pin States

Table 8.25 shows the port 8 pin states in each operating mode.

Table 8.25 Port 8 Pin States

Pins	Reset	Sleep	Subsleep	Standby	Watch	Subactive	Active
P8 ₇ /SEG ₃₂ to P8 ₀ /SEG ₂₅	High-impedance	Retains previous state	Retains previous state	High-impedance	Retains previous state	Functional	Functional

8.10 Port 9

8.10.1 Overview

Port 9 is an 8-bit I/O port. Figure 8.9 shows its pin configuration.

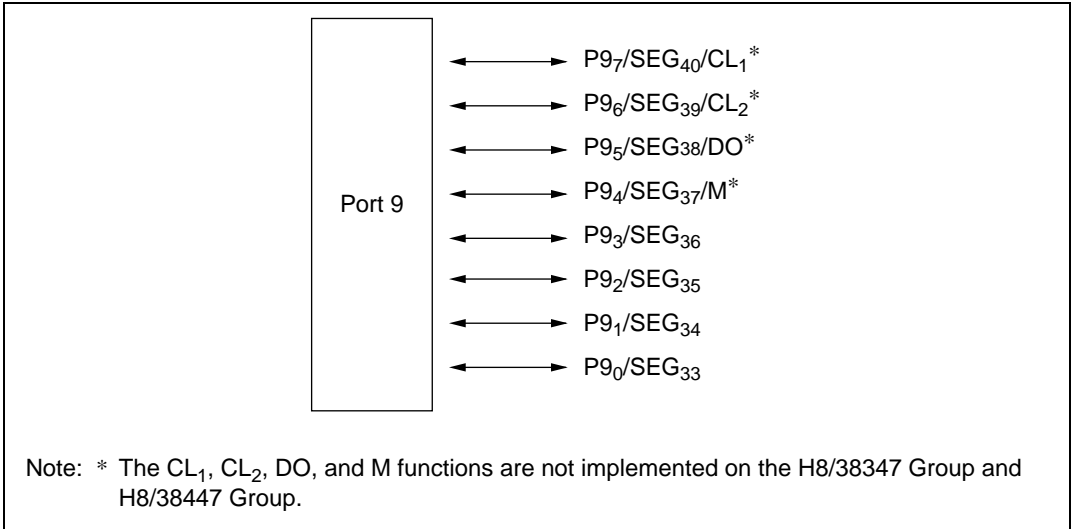


Figure 8.9 Port 9 Pin Configuration

8.10.2 Register Configuration and Description

Table 8.26 shows the port 9 register configuration.

Table 8.26 Port 9 Registers

Name	Abbr.	R/W	Initial Value	Address
Port data register 9	PDR9	R/W	H'00	H'FFDC
Port control register 9	PCR9	R	H'00	H'FFEC

1. Port Data Register 9 (PDR9)

Bit	7	6	5	4	3	2	1	0
	P9 ₇	P9 ₆	P9 ₅	P9 ₄	P9 ₃	P9 ₂	P9 ₁	P9 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

PDR9 is an 8-bit register that stores data for port 9 pins P9₇ to P9₀. If port 9 is read while PCR9 bits are set to 1, the values stored in PDR9 are read, regardless of the actual pin states. If port 9 is read while PCR9 bits are cleared to 0, the pin states are read.

Upon reset, PDR9 is initialized to H'00.

2. Port Control Register 9 (PCR9)

Bit	7	6	5	4	3	2	1	0
	PCR9 ₇	PCR9 ₆	PCR9 ₅	PCR9 ₄	PCR9 ₃	PCR9 ₂	PCR9 ₁	PCR9 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	W	W	W	W	W	W	W	W

PCR9 is an 8-bit register for controlling whether each of the port 9 pins P9₇ to P9₀ functions as an input pin or output pin. Setting a PCR9 bit to 1 makes the corresponding pin an output pin, while clearing the bit to 0 makes the pin an input pin. The settings in PCR9 and PDR9 are valid only when the corresponding pin is designated by bits SGS3 to SGS0 in LPCR as a general I/O pin.

Upon reset, PCR9 is initialized to H'00.

PCR9 is a write-only register, which is always read as all 1s.

8.10.3 Pin Functions

Table 8.27 shows the port 9 pin functions. The SGX = 0 setting also functions on the H8/38347 and H8/38447.

Table 8.27 Port 9 Pin Functions

Pin	Pin Functions and Selection Method				
P9 ₇ /SEG ₄₀ /CL ₁	The pin function depends on bit PCR9 ₇ in PCR9 and bits SGX and SGS3 to SGS0 in LPCR.				
	SGS3 to SGS0	0000		Not 0000	0000
	SGX	0		0	1
	PCR9 ₇	0	1	*	*
	Pin function	P9 ₇ input pin	P9 ₇ output pin	SEG ₄₀ output pin	CL ₁ output pin
P9 ₆ /SEG ₃₉ /CL ₂	The pin function depends on bit PCR9 ₆ in PCR9 and bits SGX and SGS3 to SGS0 in LPCR.				
	SGS3 to SGS0	0000		Not 0000	0000
	SGX	0		0	1
	PCR9 ₆	0	1	*	*
	Pin function	P9 ₆ input pin	P9 ₆ output pin	SEG ₃₉ output pin	CL ₂ output pin
P9 ₅ /SEG ₃₈ /DO	The pin function depends on bit PCR9 ₅ in PCR9 and bits SGX and SGS3 to SGS0 in LPCR.				
	SGS3 to SGS0	0000		Not 0000	0000
	SGX	0		0	1
	PCR9 ₅	0	1	*	*
	Pin function	P9 ₅ input pin	P9 ₅ output pin	SEG ₃₈ output pin	DO output pin
P9 ₄ /SEG ₃₇ /M	The pin function depends on bit PCR9 ₄ in PCR9 and bits SGX and SGS3 to SGS0 in LPCR.				
	SGS3 to SGS0	0000		Not 0000	0000
	SGX	0		0	1
	PCR9 ₄	0	1	*	*
	Pin function	P9 ₄ input pin	P9 ₄ output pin	SEG ₃₇ output pin	M output pin

*: Don't care

Pin Pin Functions and Selection Method

P9₃/SEG₃₆ to P9₀/SEG₃₃ The pin function depends on bit PCR_{9n} in PCR9 and bits SGS3 to SGS0 in LPCR.

(n = 3 to 0)

SGS3 to SGS0	0000		Not 0000
PCR _{9n}	0	1	*
Pin function	P9 _n input pin	P9 _n output pin	SEG _{n+33} output pin

*: Don't care

8.10.4 Pin States

Table 8.28 shows the port 9 pin states in each operating mode.

Table 8.28 Port 9 Pin States

Pins	Reset	Sleep	Subsleep	Standby	Watch	Subactive	Active
P9 ₇ /SEG ₄₀ /CL ₁	High-	Retains	Retains	High-	Retains	Functional	Functional
P9 ₆ /SEG ₃₉ /CL ₂	impedance	previous	previous	impedance	previous		
P9 ₅ /SEG ₃₈ /DO		state	state		state		
P9 ₄ /SEG ₃₇ /M							
P9 ₃ /SEG ₃₆ to P9 ₀ /SEG ₃₃							

8.11 Port A

8.11.1 Overview

Port A is a 4-bit I/O port, configured as shown in figure 8.10.

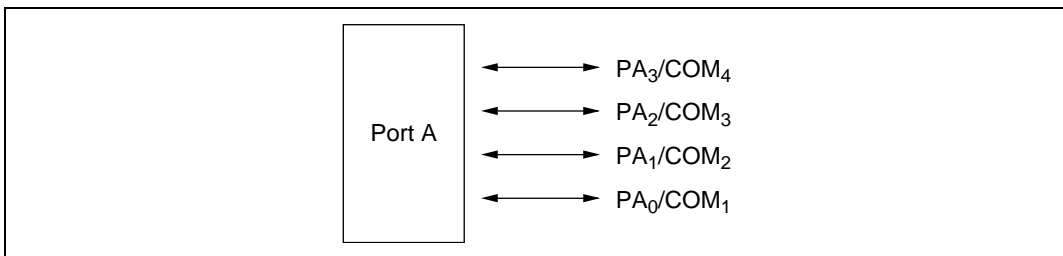


Figure 8.10 Port A Pin Configuration

8.11.2 Register Configuration and Description

Table 8.29 shows the port A register configuration.

Table 8.29 Port A Registers

Name	Abbr.	R/W	Initial Value	Address
Port data register A	PDRA	R/W	H'F0	H'FFDD
Port control register A	PCRA	W	H'F0	H'FFED

1. Port Data Register A (PDRA)

Bit	7	6	5	4	3	2	1	0
	—	—	—	—	PA ₃	PA ₂	PA ₁	PA ₀
Initial value	1	1	1	1	0	0	0	0
Read/Write	—	—	—	—	R/W	R/W	R/W	R/W

PDRA is an 8-bit register that stores data for port A pins PA₃ to PA₀. If port A is read while PCRA bits are set to 1, the values stored in PDRA are read, regardless of the actual pin states. If port A is read while PCRA bits are cleared to 0, the pin states are read.

Upon reset, PDRA is initialized to H'F0.

2. Port Control Register A (PCRA)

Bit	7	6	5	4	3	2	1	0
	—	—	—	—	PCRA ₃	PCRA ₂	PCRA ₁	PCRA ₀
Initial value	1	1	1	1	0	0	0	0
Read/Write	—	—	—	—	R/W	R/W	R/W	R/W

PCRA controls whether each of port A pins PA₃ to PA₀ functions as an input pin or output pin. Setting a PCRA bit to 1 makes the corresponding pin an output pin, while clearing the bit to 0 makes the pin an input pin. PCRA and PDRA settings are valid when the corresponding pins are designated for general-purpose input/output by LPCR.

Upon reset, PCRA is initialized to H'F0.

PCRA is a write-only register, which always reads all 1s.

8.11.3 Pin Functions

Table 8.30 shows the port A pin functions.

Table 8.30 Port A Pin Functions

Pin	Pin Functions and Selection Method		
PA ₃ /COM ₄	The pin function depends on bit PCRA ₃ in PCRA and bits SGS3 to SGS0.		
	SGS3 to SGS0	0000	
	PCRA ₃	0	1
	Pin function	PA ₃ input pin	PA ₃ output pin
PA ₂ /COM ₃	The pin function depends on bit PCRA ₂ in PCRA and bits SGS3 to SGS0.		
	SGS3 to SGS0	0000	
	PCRA ₂	0	1
	Pin function	PA ₂ input pin	PA ₂ output pin
PA ₁ /COM ₂	The pin function depends on bit PCRA ₁ in PCRA and bits SGS3 to SGS0.		
	SGS3 to SGS0	0000	
	PCRA ₁	0	1
	Pin function	PA ₁ input pin	PA ₁ output pin
PA ₀ /COM ₁	The pin function depends on bit PCRA ₀ in PCRA and bits SGS3 to SGS0.		
	SGS3 to SGS0	0000	
	PCRA ₀	0	1
	Pin function	PA ₀ input pin	PA ₀ output pin

*: Don't care

8.11.4 Pin States

Table 8.31 shows the port A pin states in each operating mode.

Table 8.31 Port A Pin States

Pins	Reset	Sleep	Subsleep	Standby	Watch	Subactive	Active
PA ₃ /COM ₄	High-impedance	Retains previous state	Retains previous state	High-impedance	Retains previous state	Functional	Functional
PA ₂ /COM ₃							
PA ₁ /COM ₂							
PA ₀ /COM ₁							

8.12 Port B

8.12.1 Overview

Port B is an 8-bit input-only port, configured as shown in figure 8.11.

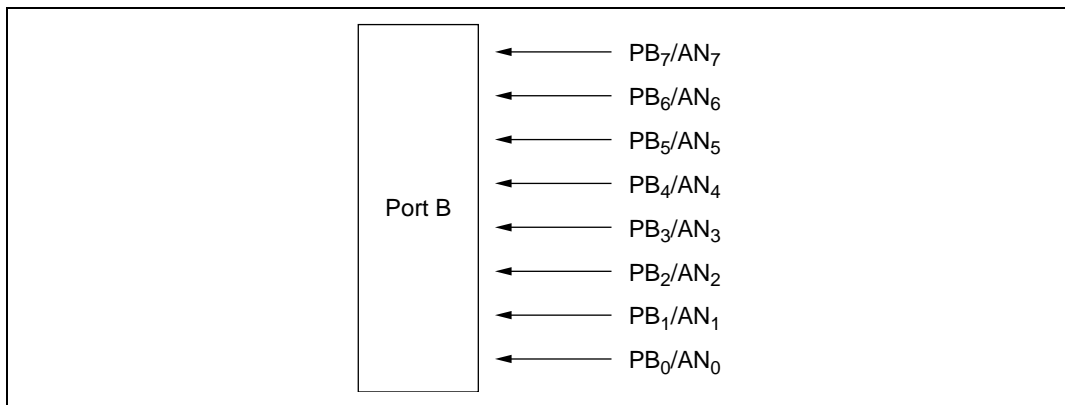


Figure 8.11 Port B Pin Configuration

8.12.2 Register Configuration and Description

Table 8.32 shows the port B register configuration.

Table 8.32 Port B Register

Name	Abbr.	R/W	Address
Port data register B	PDRB	R	H'FFDE

1. Port Data Register B (PDRB)

Bit	7	6	5	4	3	2	1	0
	PB ₇	PB ₆	PB ₅	PB ₄	PB ₃	PB ₂	PB ₁	PB ₀
Read/Write	R	R	R	R	R	R	R	R

Reading PDRB always gives the pin states. However, if a port B pin is selected as an analog input channel for the A/D converter by AMR bits CH3 to CH0, that pin reads 0 regardless of the input voltage.

8.13 Port C

8.13.1 Overview

Port C is a 4-bit input-only port, configured as shown in figure 8.12.

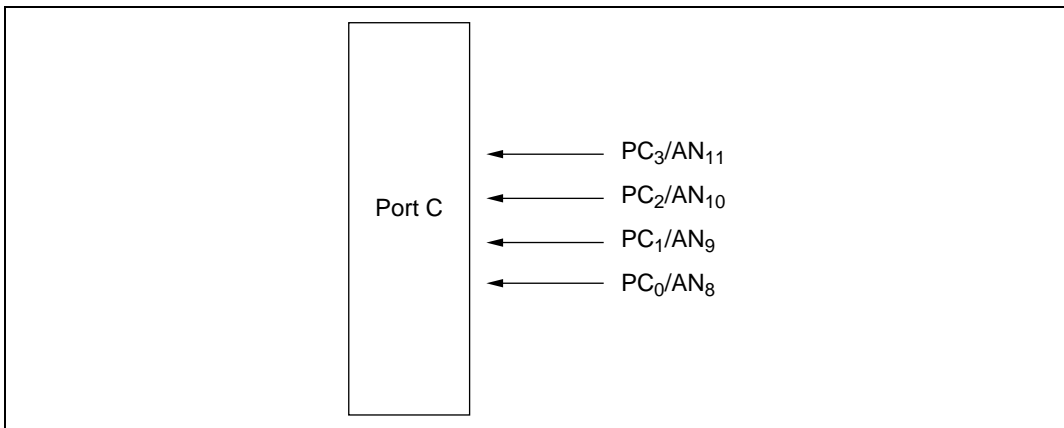


Figure 8.12 Port C Pin Configuration

8.13.2 Register Configuration and Description

Table 8.33 shows the port C register configuration.

Table 8.33 Port C Register

Name	Abbr.	R/W	Address
Port data register C	PDRC	R	H'FFDF

1. Port Data Register C (PDRC)

Bit	7	6	5	4	3	2	1	0
	—	—	—	—	PC ₃	PC ₂	PC ₁	PC ₀
Read/Write	—	—	—	—	R	R	R	R

Reading PDRC always gives the pin states.

Reading the pin for which an analog input channel is selected by the AMR CH3 to CH0 of the A/D converter, "0" is read regardless of the input voltage.

8.14 Input/Output Data Inversion Function

8.14.1 Overview

With input pins RXD_{31} , and RXD_{32} , and output pins TXD_{31} and TXD_{32} , the data can be handled in inverted form.

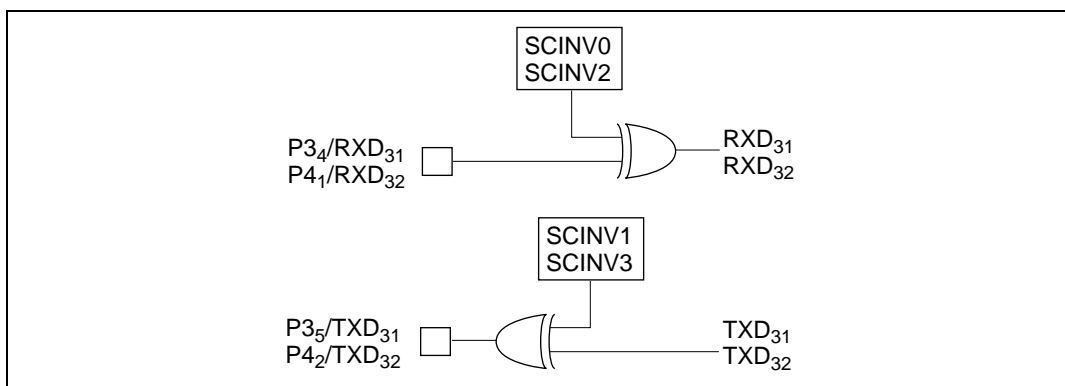


Figure 8.13 Input/Output Data Inversion Function

8.14.2 Register Configuration and Descriptions

Table 8.34 shows the registers used by the input/output data inversion function.

Table 8.34 Register Configuration

Name	Abbr.	R/W	Address
Serial port control register	SPCR	R/W	H'FF91

1. Serial Port Control Register (SPCR)

Bit	7	6	5	4	3	2	1	0
	—	—	SPC32	SPC31	SCINV3	SCINV2	SCINV1	SCINV0
Initial value	1	1	0	0	0	0	0	0
Read/Write	—	—	R/W	R/W	R/W	R/W	R/W	R/W

SPCR is an 8-bit readable/writable register that performs RXD₃₁, RXD₃₂, TXD₃₁, and TXD₃₂ pin input/output data inversion switching. SPCR is initialized to H'C0 by a reset.

Bits 7 and 6: Reserved bits

Bits 7 and 6 are reserved; they are always read as 1 and cannot be modified.

Bit 5: P4₂/TXD₃₂ pin function switch (SPC32)

This bit selects whether pin P4₂/TXD₃₂ is used as P4₂ or as TXD₃₂.

Bit 5

SPC32	Description	
0	Functions as P4 ₂ I/O pin	(initial value)
1	Functions as TXD ₃₂ output pin*	

Note: * Set the TE bit in SCR3 after setting this bit to 1.

Bit 4: P3₅/TXD₃₁ pin function switch (SPC31)

This bit selects whether pin P3₅/TXD₃₁ is used as P3₅ or as TXD₃₁.

Bit 4

SPC31	Description	
0	Functions as P3 ₅ I/O pin	(initial value)
1	Functions as TXD ₃₁ output pin*	

Note: * Set the TE bit in SCR3 after setting this bit to 1.

Bit 3: TXD₃₂ pin output data inversion switch

Bit 3 specifies whether or not TXD₃₂ pin output data is to be inverted.

Bit 3

SCINV3	Description	
0	TXD ₃₂ output data is not inverted	(initial value)
1	TXD ₃₂ output data is inverted	

Bit 2: RXD₃₂ pin input data inversion switch

Bit 2 specifies whether or not RXD₃₂ pin input data is to be inverted.

Bit 2

SCINV2	Description	
0	RXD ₃₂ input data is not inverted	(initial value)
1	RXD ₃₂ input data is inverted	

Bit 1: TXD₃₁ pin output data inversion switch

Bit 1 specifies whether or not TXD₃₁ pin output data is to be inverted.

Bit 1

SCINV1	Description	
0	TXD ₃₁ output data is not inverted	(initial value)
1	TXD ₃₁ output data is inverted	

Bit 0: RXD₃₁ pin input data inversion switch

Bit 0 specifies whether or not RXD₃₁ pin input data is to be inverted.

Bit 0

SCINV0	Description	
0	RXD ₃₁ input data is not inverted	(initial value)
1	RXD ₃₁ input data is inverted	

8.14.3 Note on Modification of Serial Port Control Register

When a serial port control register is modified, the data being input or output up to that point is inverted immediately after the modification, and an invalid data change is input or output. When modifying a serial port control register, do so in a state in which data changes are invalidated.

8.15 Application Note

8.15.1 The Management of the Un-Use Terminal

If an I/O pin not used by the user system is floating, pull it up or down.

- If an unused pin is an input pin, handle it in one of the following ways:
 - Pull it up to V_{CC} with an on-chip pull-up MOS.
 - Pull it up to V_{CC} with an external resistor of approximately 100 k Ω .
 - Pull it down to V_{SS} with an external resistor of approximately 100 k Ω .
 - For a pin also used by the A/D converter, pull it up to AV_{CC} .
- If an unused pin is an output pin, handle it in one of the following ways:
 - Set the output of the unused pin to high and pull it up to V_{CC} with an external resistor of approximately 100 k Ω .
 - Set the output of the unused pin to low and pull it down to V_{SS} with an external resistor of approximately 100 k Ω .

Section 9 Timers

9.1 Overview

This LSI provides six timers: timers A, C, F, G, and a watchdog timer, and an asynchronous event counter. The functions of these timers are outlined in table 9.1.

Table 9.1 Timer Functions

Name	Functions	Internal Clock	Event Input Pin	Waveform Output Pin	Remarks
Timer A	• 8-bit interval timer	$\phi/8$ to $\phi/8192$	—	—	
	• Interval function	(8 choices)			
	• Time base	$\phi_W/128$ (choice of 4 overflow periods)			
	• Clock output	$\phi/4$ to $\phi/32$ ϕ_W , $\phi_W/4$ to $\phi_W/32$ (9 choices)	—	TMOW	
Timer C	• 8-bit timer	$\phi/4$ to $\phi/8192$, $\phi_W/4$	TMIC	—	Up-count/ down-count controllable by software or hardware
	• Interval function	(7 choices)			
	• Event counting function				
	• Up-count/down-count selectable				
Timer F	• 16-bit timer	$\phi/4$ to $\phi/32$, $\phi_W/4$	TMIF	TMOFL	
	• Event counting function	(4 choices)		TMOFH	
	• Also usable as two independent 8-bit timers				
	• Output compare output function				
Timer G	• 8-bit timer	$\phi/2$ to $\phi/64$, $\phi_W/4$	TMIG	—	Counter clearing option Built-in capture input signal noise canceler
	• Input capture function	(4 choices)			
	• Interval function				
Watchdog timer	• Reset signal generated when 8-bit counter overflows	$\phi/8192$ $\phi_W/32$	—	—	

Name	Functions	Internal Clock	Event Input Pin	Waveform Output Pin	Remarks
Asynchronous event counter	<ul style="list-style-type: none"> • 16-bit counter • Also usable as two independent 8-bit counters • Counts events asynchronous to ϕ and ϕ_w 	—	AEVL AEVH	—	

9.2 Timer A

9.2.1 Overview

Timer A is an 8-bit timer with interval timing and real-time clock time-base functions. The clock time-base function is available when a 32.768 kHz crystal oscillator is connected. A clock signal divided from 32.768 kHz, from 38.4 kHz (if a 38.4 kHz crystal oscillator is connected), or from the system clock, can be output at the TMOW pin.

1. Features

Features of timer A are given below.

- Choice of eight internal clock sources ($\phi/8192$, $\phi/4096$, $\phi/2048$, $\phi/512$, $\phi/256$, $\phi/128$, $\phi/32$, $\phi/8$).
- Choice of four overflow periods (1 s, 0.5 s, 0.25 s, 31.25 ms) when timer A is used as a clock time base (using a 32.768 kHz crystal oscillator).
- An interrupt is requested when the counter overflows.
- Any of nine clock signals can be output at the TMOW pin: 32.768 kHz divided by 32, 16, 8, or 4 (1 kHz, 2 kHz, 4 kHz, 8 kHz, 32.768 kHz) or 38.4 kHz divided by 32, 16, 8, or 4 (1.2 kHz, 2.4 kHz, 4.8 kHz, 9.6 kHz, 38.4 kHz), and the system clock divided by 32, 16, 8, or 4.
- Use of module standby mode enables this module to be placed in standby mode independently when not used.

2. Block Diagram

Figure 9.1 shows a block diagram of timer A.

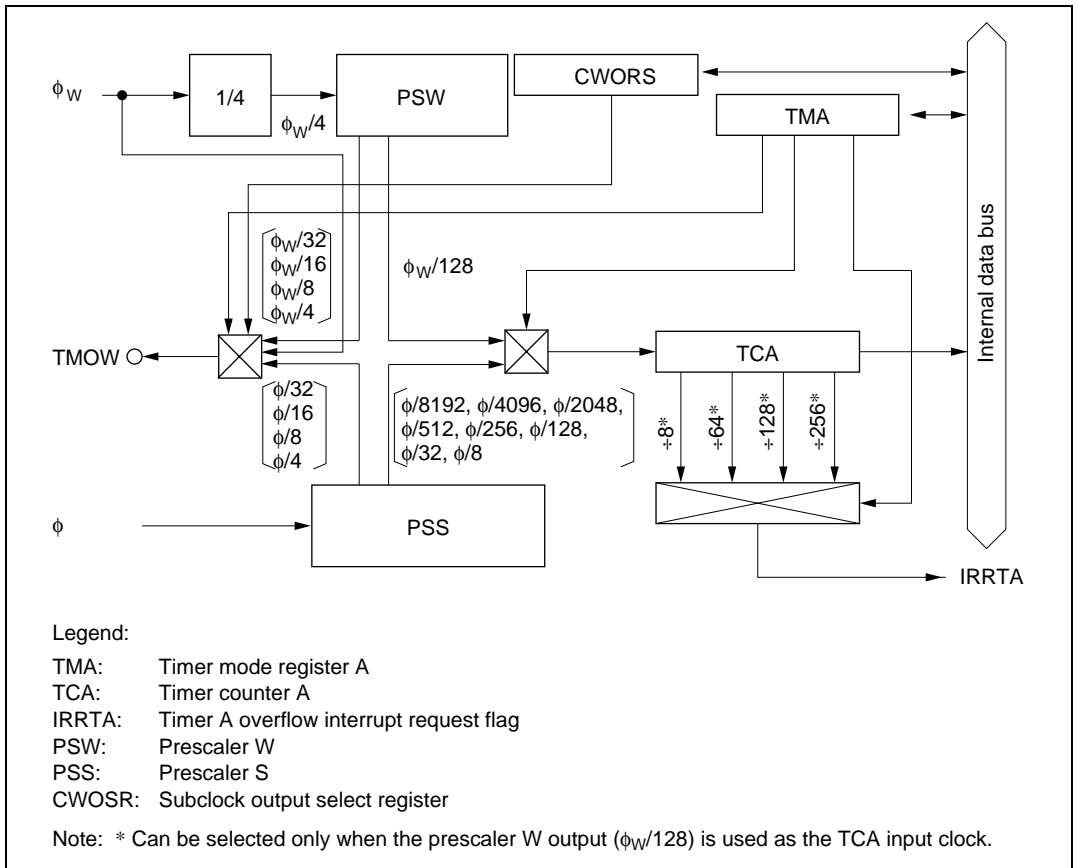


Figure 9.1 Block Diagram of Timer A

3. Pin Configuration

Table 9.2 shows the timer A pin configuration.

Table 9.2 Pin Configuration

Name	Abbr.	I/O	Function
Clock output	TMOW	Output	Output of waveform generated by timer A output circuit

4. Register Configuration

Table 9.3 shows the register configuration of timer A.

Table 9.3 Timer A Registers

Name	Abbr.	R/W	Initial Value	Address
Timer mode register A	TMA	R/W	H'10	H'FFB0
Timer counter A	TCA	R	H'00	H'FFB1
Clock stop register 1	CKSTPR1	R/W	H'FF	H'FFFA
Subclock output select register	CWOSR	R/W	H'FE	H'FF92

9.2.2 Register Descriptions

1. Timer Mode Register A (TMA)

Bit	7	6	5	4	3	2	1	0
	TMA7	TMA6	TMA5	—	TMA3	TMA2	TMA1	TMA0
Initial value	0	0	0	1	0	0	0	0
Read/Write	R/W	R/W	R/W	—	R/W	R/W	R/W	R/W

TMA is an 8-bit read/write register for selecting the prescaler, input clock, and output clock.

Upon reset, TMA is initialized to H'10.

Bits 7 to 5: Clock output select (TMA7 to TMA5)

Bits 7 to 5 choose which of eight clock signals is output at the TMOW pin. The system clock divided by 32, 16, 8, or 4 can be output in active mode and sleep mode. A 32.768 kHz or 38.4 kHz signal divided by 32, 16, 8, or 4 can be output in active mode, sleep mode, and subactive mode. ϕ_w is output in all modes except the reset state.

CWOSR		TMA			Clock Output
CWOS	Bit 7 TMA7	Bit 6 TMA6	Bit 5 TMA5		
0	0	0	0	$\phi/32$	(initial value)
			1	$\phi/16$	
		1	0	$\phi/8$	
			1	$\phi/4$	
	1	0	0	$\phi_w/32$	
			1	$\phi_w/16$	
		1	0	$\phi_w/8$	
			1	$\phi_w/4$	
1	*	*	*	ϕ_w	

*: Don't care

Bit 4: Reserved bit

Bit 4 is reserved; it is always read as 1, and cannot be modified.

Bits 3 to 0: Internal clock select (TMA3 to TMA0)

Bits 3 to 0 select the clock input to TCA. The selection is made as follows.

Bit 3 TMA3	Bit 2 TMA2	Bit 1 TMA1	Bit 0 TMA0	Description		
				Prescaler and Divider Ratio or Overflow Period	Function	
0	0	0	0	PSS, $\phi/8192$	(initial value)	Interval timer
			1	PSS, $\phi/4096$		
		1	0	PSS, $\phi/2048$		
			1	PSS, $\phi/512$		
	1	0	0	PSS, $\phi/256$		
			1	PSS, $\phi/128$		
		1	0	PSS, $\phi/32$		
			1	PSS, $\phi/8$		
1	0	0	0	PSW, 1 s	Clock time base (when using 32.768 kHz)	
			1	PSW, 0.5 s		
		1	0	PSW, 0.25 s		
			1	PSW, 0.03125 s		
	1	0	0	PSW and TCA are reset		
			1			
		1	0			
			1			

2. Timer Counter A (TCA)

Bit	7	6	5	4	3	2	1	0
	TCA7	TCA6	TCA5	TCA4	TCA3	TCA2	TCA1	TCA0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R	R	R	R	R	R	R	R

TCA is an 8-bit read-only up-counter, which is incremented by internal clock input. The clock source for input to this counter is selected by bits TMA3 to TMA0 in timer mode register A (TMA). TCA values can be read by the CPU in active mode, but cannot be read in subactive mode. When TCA overflows, the IRRTA bit in interrupt request register 1 (IRR1) is set to 1.

TCA is cleared by setting bits TMA3 and TMA2 of TMA to 11.

Upon reset, TCA is initialized to H'00.

3. Clock Stop Register 1 (CKSTPR1)

Bit:	7	6	5	4	3	2	1	0
	S1CKSTP	S31CKSTP	S32CKSTP	ADCKSTP	TGCKSTP	TFCKSTP	TCCKSTP	TACKSTP
Initial value:	1	1	1	1	1	1	1	1
Read/Write:	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

CKSTPR1 is an 8-bit read/write register that performs module standby mode control for peripheral modules. Only the bit relating to timer A is described here. For details of the other bits, see the sections on the relevant modules.

Bit 0: Timer A module standby mode control (TACKSTP)

Bit 0 controls setting and clearing of module standby mode for timer A.

TACKSTP	Description
0	Timer A is set to module standby mode
1	Timer A module standby mode is cleared (initial value)

4. Subclock Output Select Register (CWOSR)

Bit:	7	6	5	4	3	2	1	0
	—	—	—	—	—	—	—	CWOS
Initial value:	1	1	1	1	1	1	1	0
Read/Write:	R	R	R	R	R	R	R	R/W

CWOSR is an 8-bit read/write register that selects the clock to be output from the TMOW pin.

CWOSR is initialized to H'FE by a reset.

Bits 7 to 1: Reserved bits

Bits 7 to 1 are reserved; they are always read as 1 and cannot be modified.

Bit 0: TMOW pin clock select (CWOS)

Bit 0 selects the clock to be output from the TMOW pin.

Bit 0

CWOS	Description	
0	Clock output from timer A is output (see TMA)	(initial value)
1	ϕ_W is output	

9.2.3 Timer Operation

1. Interval Timer Operation

When bit TMA3 in timer mode register A (TMA) is cleared to 0, timer A functions as an 8-bit interval timer.

Upon reset, TCA is cleared to H'00 and bit TMA3 is cleared to 0, so up-counting and interval timing resume immediately. The clock input to timer A is selected by bits TMA2 to TMA0 in TMA; any of eight internal clock signals output by prescaler S can be selected.

After the count value in TCA reaches H'FF, the next clock signal input causes timer A to overflow, setting bit IRRTA to 1 in interrupt request register 1 (IRR1). If IENTA = 1 in interrupt enable register 1 (IENR1), a CPU interrupt is requested.*

At overflow, TCA returns to H'00 and starts counting up again. In this mode timer A functions as an interval timer that generates an overflow output at intervals of 256 input clock pulses.

Note: * For details on interrupts, see section 3.3, Interrupts.

2. Real-time Clock Time Base Operation

When bit TMA3 in TMA is set to 1, timer A functions as a real-time clock time base by counting clock signals output by prescaler W. The overflow period of timer A is set by bits TMA1 and TMA0 in TMA. A choice of four periods is available. In time base operation (TMA3 = 1), setting bit TMA2 to 1 clears both TCA and prescaler W to their initial values of H'00.

3. Clock Output

Setting bit TMOW in port mode register 1 (PMR1) to 1 causes a clock signal to be output at pin TMOW. Nine different clock output signals can be selected by means of bits TMA7 to TMA5 in TMA and bit CWOSR in CWOSR. The system clock divided by 32, 16, 8, or 4 can be output in active mode and sleep mode. A 32.768 kHz or 38.4 kHz signal divided by 32, 16, 8, or 4 can be output in active mode, sleep mode, watch mode, subactive mode, and subsleep mode. The 32.768 kHz or 38.4 kHz clock is output in all modes except the reset state.

9.2.4 Timer A Operation States

Table 9.4 summarizes the timer A operation states.

Table 9.4 Timer A Operation States

Operation Mode		Reset	Active	Sleep	Watch	Sub-active	Sub-sleep	Standby	Module Standby
TCA	Interval	Reset	Functions	Functions	Halted	Halted	Halted	Halted	Halted
	Clock time base	Reset	Functions	Functions	Functions	Functions	Functions	Halted	Halted
TMA	CWOSR	Reset	Functions	Retained	Retained	Functions	Retained	Retained	Retained

Note: When the real-time clock time base function is selected as the internal clock of TCA in active mode or sleep mode, the internal clock is not synchronous with the system clock, so it is synchronized by a synchronizing circuit. This may result in a maximum error of $1/\phi$ (s) in the count cycle.

9.2.5 Application Note

When bit 0 (TACKSTP) of the clock stop register 1 (CKSTPR1) is cleared to 0, bit 3 (TMA3) of the timer mode register A (TMA) cannot be rewritten.

Set bit 0 (TACKSTP) of the clock stop register 1 (CKSTPR1) to 1 before rewriting bit 3 (TMA3) of the timer mode register A (TMA).

9.3 Timer C

9.3.1 Overview

Timer C is an 8-bit timer that increments each time a clock pulse is input. This timer has two operation modes, interval and auto reload.

1. Features

Features of timer C are given below.

- Choice of seven internal clock sources ($\phi/8192$, $\phi/2048$, $\phi/512$, $\phi/64$, $\phi/16$, $\phi/4$, $\phi_W/4$) or an external clock (can be used to count external events).
- An interrupt is requested when the counter overflows.
- Up/down-counter switching is possible by hardware or software.
- Subactive mode and subsleep mode operation is possible when $\phi_W/4$ is selected as the internal clock, or when an external clock is selected.
- Use of module standby mode enables this module to be placed in standby mode independently when not used.

2. Block Diagram

Figure 9.2 shows a block diagram of timer C.

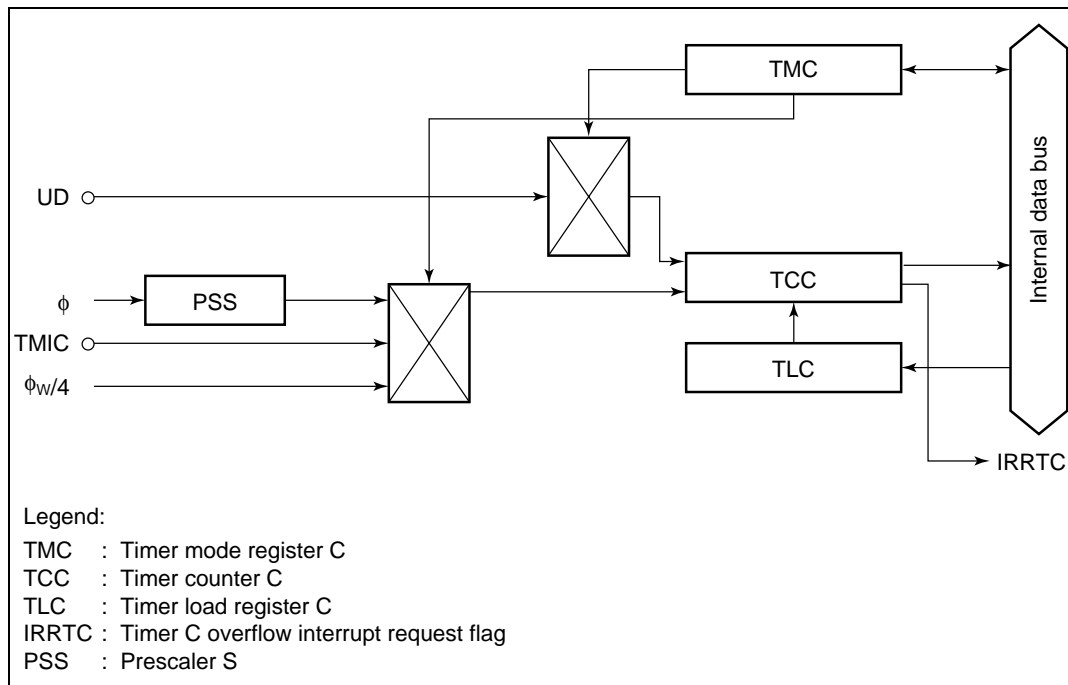


Figure 9.2 Block Diagram of Timer C

3. Pin Configuration

Table 9.5 shows the timer C pin configuration.

Table 9.5 Pin Configuration

Name	Abbr.	I/O	Function
Timer C event input	TMIC	Input	Input pin for event input to TCC
Timer C up/down-count selection	UD	Input	Timer C up/down select

4. Register Configuration

Table 9.6 shows the register configuration of timer C.

Table 9.6 Timer C Registers

Name	Abbr.	R/W	Initial Value	Address
Timer mode register C	TMC	R/W	H'18	H'FFB4
Timer counter C	TCC	R	H'00	H'FFB5
Timer load register C	TLC	W	H'00	H'FFB5
Clock stop register 1	CKSTPR1	R/W	H'FF	H'FFFA

9.3.2 Register Descriptions

1. Timer Mode Register C (TMC)

Bit	7	6	5	4	3	2	1	0
	TMC7	TMC6	TMC5	—	—	TMC2	TMC1	TMC0
Initial value	0	0	0	1	1	0	0	0
Read/Write	R/W	R/W	R/W	—	—	R/W	R/W	R/W

TMC is an 8-bit read/write register for selecting the auto-reload function and input clock, and performing up/down-counter control.

Upon reset, TMC is initialized to H'18.

Bit 7: Auto-reload function select (TMC7)

Bit 7 selects whether timer C is used as an interval timer or auto-reload timer.

Bit 7

TMC7	Description
0	Interval timer function selected (initial value)
1	Auto-reload function selected

Bits 6 and 5: Counter up/down control (TMC6, TMC5)

Selects whether TCC up/down control is performed by hardware using UD pin input, or whether TCC functions as an up-counter or a down-counter.

Bit 6 TMC6	Bit 5 TMC5	Description
0	0	TCC is an up-counter (initial value)
0	1	TCC is a down-counter
1	*	Hardware control by UD pin input UD pin input high: Down-counter UD pin input low: Up-counter

*: Don't care

Bits 4 and 3: Reserved bits

Bits 4 and 3 are reserved; they are always read as 1 and cannot be modified.

Bits 2 to 0: Clock select (TMC2 to TMC0)

Bits 2 to 0 select the clock input to TCC. For external event counting, either the rising or falling edge can be selected.

Bit 2 TMC2	Bit 1 TMC1	Bit 0 TMC0	Description
0	0	0	Internal clock: $\phi/8192$ (initial value)
0	0	1	Internal clock: $\phi/2048$
0	1	0	Internal clock: $\phi/512$
0	1	1	Internal clock: $\phi/64$
1	0	0	Internal clock: $\phi/16$
1	0	1	Internal clock: $\phi/4$
1	1	0	Internal clock: $\phi_W/4$
1	1	1	External event (TMC): rising or falling edge*

Note: * The edge of the external event signal is selected by bit IEG1 in the IRQ edge select register (IEGR). See 1. IRQ edge select register (IEGR) in section 3.3.2 for details. IRQ1 must be set to 1 in port mode register 1 (PMR1) before setting 111 in bits TMC2 to TMC0.

2. Timer Counter C (TCC)

Bit	7	6	5	4	3	2	1	0
	TCC7	TCC6	TCC5	TCC4	TCC3	TCC2	TCC1	TCC0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R	R	R	R	R	R	R	R

TCC is an 8-bit read-only up-counter, which is incremented by internal clock or external event input. The clock source for input to this counter is selected by bits TMC2 to TMC0 in timer mode register C (TMC). TCC values can be read by the CPU at any time.

When TCC overflows from H'FF to H'00 or to the value set in TLC, or underflows from H'00 to H'FF or to the value set in TLC, the IRRTC bit in IRR2 is set to 1.

TCC is allocated to the same address as TLC.

Upon reset, TCC is initialized to H'00.

3. Timer Load Register C (TLC)

Bit	7	6	5	4	3	2	1	0
	TLC7	TLC6	TLC5	TLC4	TLC3	TLC2	TLC1	TLC0
Initial value	0	0	0	0	0	0	0	0
Read/Write	W	W	W	W	W	W	W	W

TLC is an 8-bit write-only register for setting the reload value of timer counter C (TCC).

When a reload value is set in TLC, the same value is loaded into timer counter C as well, and TCC starts counting up from that value. When TCC overflows or underflows during operation in auto-reload mode, the TLC value is loaded into TCC. Accordingly, overflow/underflow periods can be set within the range of 1 to 256 input clocks.

The same address is allocated to TLC as to TCC.

Upon reset, TLC is initialized to H'00.

4. Clock Stop Register 1 (CKSTPR1)

Bit:	7	6	5	4	3	2	1	0
	S1CKSTP	S31CKSTP	S32CKSTP	ADCKSTP	TGCKSTP	TFCKSTP	TCCKSTP	TACKSTP
Initial value:	1	1	1	1	1	1	1	1
Read/Write:	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

CKSTPR1 is an 8-bit read/write register that performs module standby mode control for peripheral modules. Only the bit relating to timer C is described here. For details of the other bits, see the sections on the relevant modules.

Bit 1: Timer C module standby mode control (TCCKSTP)

Bit 1 controls setting and clearing of module standby mode for timer C.

TCCKSTP	Description
0	Timer C is set to module standby mode
1	Timer C module standby mode is cleared (initial value)

9.3.3 Timer Operation

1. Interval Timer Operation

When bit TMC7 in timer mode register C (TMC) is cleared to 0, timer C functions as an 8-bit interval timer.

Upon reset, TCC is initialized to H'00 and TMC to H'18, so TCC continues up-counting as an interval up-counter without halting immediately after a reset. The timer C operating clock is selected from seven internal clock signals output by prescalers S and W, or an external clock input at pin TMIC. The selection is made by bits TMC2 to TMC0 in TMC.

TCC up/down-count control can be performed either by software or hardware. The selection is made by bits TMC6 and TMC5 in TMC.

After the count value in TCC reaches H'FF (H'00), the next clock input causes timer C to overflow (underflow), setting bit IRRTC to 1 in IRR2. If IENTC = 1 in interrupt enable register 2 (IENR2), a CPU interrupt is requested.

At overflow (underflow), TCC returns to H'00 (H'FF) and starts counting up (down) again.

During interval timer operation ($TMC7 = 0$), when a value is set in timer load register C (TLC), the same value is set in TCC.

Note: For details on interrupts, see section 3.3, Interrupts.

2. Auto-reload Timer Operation

Setting bit TMC7 in TMC to 1 causes timer C to function as an 8-bit auto-reload timer. When a reload value is set in TLC, the same value is loaded into TCC, becoming the value from which TCC starts its count.

After the count value in TCC reaches H'FF (H'00), the next clock signal input causes timer C to overflow/underflow. The TLC value is then loaded into TCC, and the count continues from that value. The overflow/underflow period can be set within a range from 1 to 256 input clocks, depending on the TLC value.

The clock sources, up/down control, and interrupts in auto-reload mode are the same as in interval mode.

In auto-reload mode ($TMC7 = 1$), when a new value is set in TLC, the TLC value is also set in TCC.

3. Event Counter Operation

Timer C can operate as an event counter, counting rising or falling edges of an external event signal input at pin TMIC. External event counting is selected by setting bits TMC2 to TMC0 in timer mode register C to all 1s (111).

When timer C is used to count external event input, bit IRQ_1 in PMR1 should be set to 1 and bit IEN_1 in IENR1 cleared to 0 to disable interrupt IRQ_1 requests.

4. TCC Up/Down Control by Hardware

With timer C, TCC up/down control can be performed by UD pin input. When bit TMC6 is set to 1 in TMC, TCC functions as an up-counter when UD pin input is high, and as a down-counter when low.

When using UD pin input, set bit UD to 1 in PMR3.

9.3.4 Timer C Operation States

Table 9.7 summarizes the timer C operation states.

Table 9.7 Timer C Operation States

Operation Mode		Reset	Active	Sleep	Watch	Sub-active	Sub-sleep	Standby	Module Standby
TCC	Interval	Reset	Functions	Functions	Halted	Functions/ Halted*	Functions/ Halted*	Halted	Halted
	Auto reload	Reset	Functions	Functions	Halted	Functions/ Halted*	Functions/ Halted*	Halted	Halted
TMC		Reset	Functions	Retained	Retained	Functions	Retained	Retained	Retained

Note: * When $\phi_w/4$ is selected as the TCC internal clock in active mode or sleep mode, since the system clock and internal clock are mutually asynchronous, synchronization is maintained by a synchronization circuit. This results in a maximum count cycle error of $1/\phi$ (s). When the counter is operated in subactive mode or subsleep mode, either select $\phi_w/4$ as the internal clock or select an external clock. The counter will not operate on any other internal clock. If $\phi_w/4$ is selected as the internal clock for the counter when $\phi_w/8$ has been selected as subclock ϕ_{SUB} , the lower 2 bits of the counter operate on the same cycle, and the operation of the least significant bit is unrelated to the operation of the counter.

9.3.5 Usage Note

Note the following regarding the operation of timer C.

(1) Counting errors caused by external event input

Timer counter errors may occur under the following conditions.

Conditions

- An external event (TMIC) is used in subsleep mode.

Symptom

- The counter increments or decrements twice for a single external event input.

Approximate rate of occurrence

The approximate rate of occurrence in cases where the external event input is not synchronized with internal operation is defined by the following equation.

$$\text{Approximate rate of occurrence } P = 30 \text{ ns} / t_{\text{subcyc}}$$

For example, if $t_{\text{subcyc}} = 61.06 \mu\text{s}$ (subclock $\phi_w/2$), $P = 0.0005$ (0.05%). If 2,000 external event inputs occur, there is a likelihood that one of them will cause the counter to increment or decrement twice (+2 or -2).

The symptom described is caused by the internal circuit configuration of the device and therefore difficult to avoid. Therefore, it is not advisable to use the clock counter for applications requiring a high degree of accuracy.

9.4 Timer F

9.4.1 Overview

Timer F is a 16-bit timer with a built-in output compare function. As well as counting external events, timer F also provides for counter resetting, interrupt request generation, toggle output, etc., using compare match signals. Timer F can also be used as two independent 8-bit timers (timer FH and timer FL).

1. Features

Features of timer F are given below.

- Choice of four internal clock sources ($\phi/32$, $\phi/16$, $\phi/4$, $\phi w/4$) or an external clock (can be used as an external event counter)
- TMOFH pin (TMOFL pin) toggle output provided using a single compare match signal (toggle output initial value can be set)
- Counter resetting by a compare match signal
- Two interrupt sources: one compare match, one overflow
- Can operate as two independent 8-bit timers (timer FH and timer FL) (in 8-bit mode).

	Timer FH 8-Bit Timer*	Timer FL 8-Bit Timer/Event Counter
Internal clock	Choice of 4 ($\phi/32$, $\phi/16$, $\phi/4$, $\phi w/4$)	
Event input	—	TMIF pin
Toggle output	One compare match signal, output to TMOFH pin (initial value settable)	One compare match signal, output to TMOFL pin (initial value settable)
Counter reset	Counter can be reset by compare match signal	
Interrupt sources	One compare match One overflow	

Note: * When timer F operates as a 16-bit timer, it operates on the timer FL overflow signal.

- Operation in watch mode, subactive mode, and subsleep mode
When $\phi w/4$ is selected as the internal clock, timer F can operate in watch mode, subactive mode, and subsleep mode.
- Use of module standby mode enables this module to be placed in standby mode independently when not used.

2. Block Diagram

Figure 9.3 shows a block diagram of timer F.

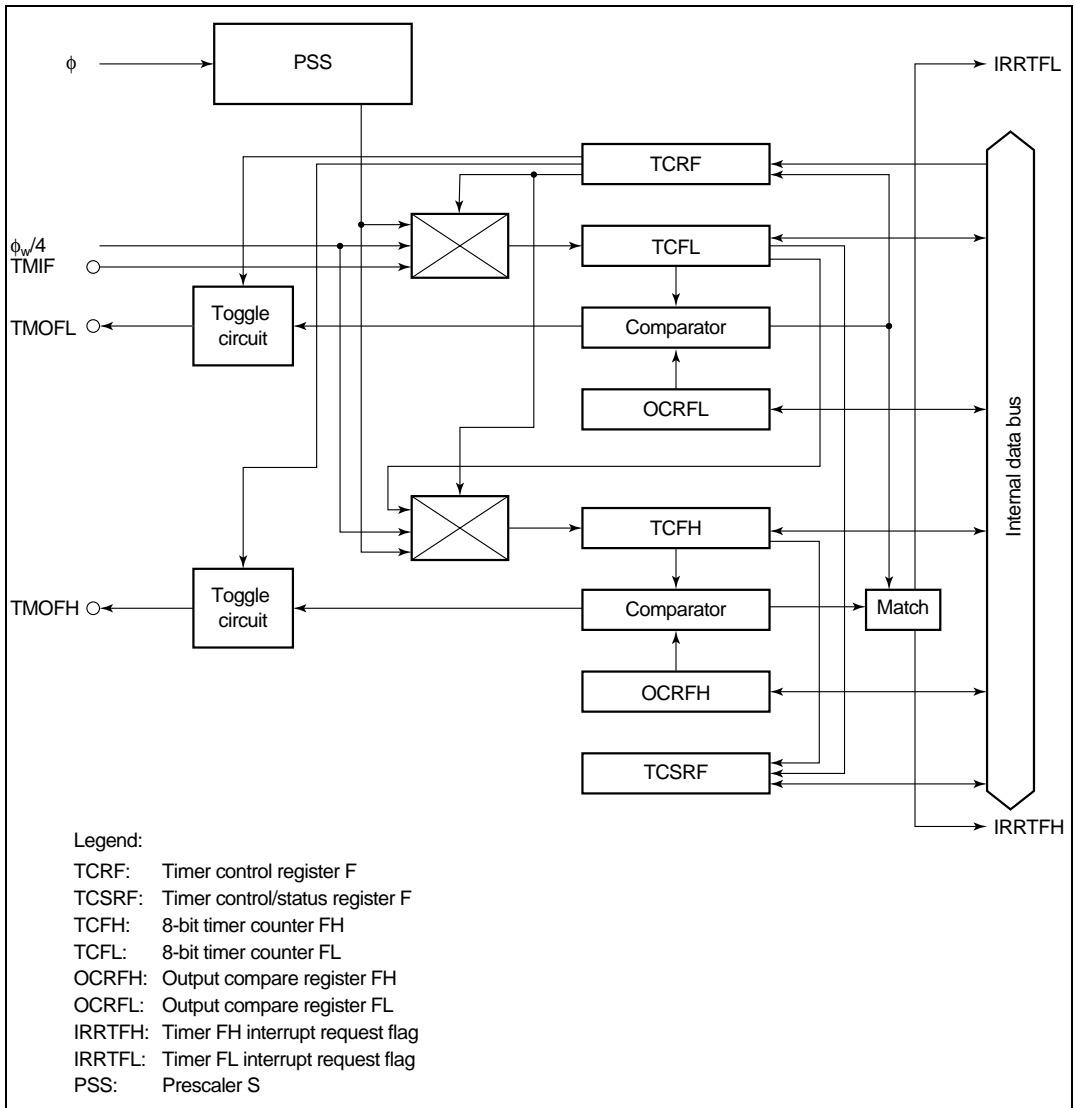


Figure 9.3 Block Diagram of Timer F

3. Pin Configuration

Table 9.8 shows the timer F pin configuration.

Table 9.8 Pin Configuration

Name	Abbr.	I/O	Function
Timer F event input	TMIF	Input	Event input pin for input to TCFL
Timer FH output	TMOFH	Output	Timer FH toggle output pin
Timer FL output	TMOFL	Output	Timer FL toggle output pin

4. Register Configuration

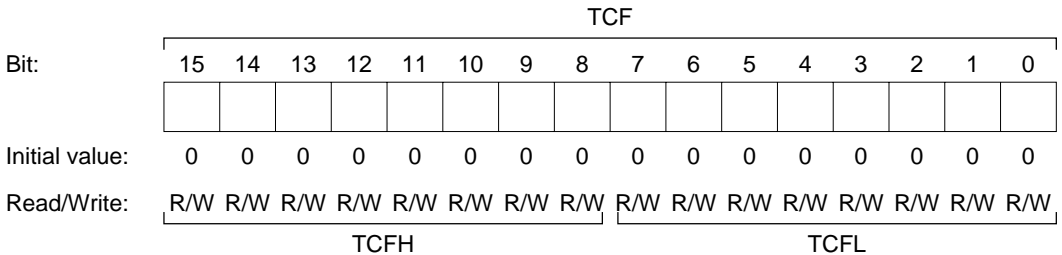
Table 9.9 shows the register configuration of timer F.

Table 9.9 Timer F Registers

Name	Abbr.	R/W	Initial Value	Address
Timer control register F	TCRF	W	H'00	H'FFB6
Timer control/status register F	TCSRF	R/W	H'00	H'FFB7
8-bit timer counter FH	TCFH	R/W	H'00	H'FFB8
8-bit timer counter FL	TCFL	R/W	H'00	H'FFB9
Output compare register FH	OCRFH	R/W	H'FF	H'FFBA
Output compare register FL	OCRFL	R/W	H'FF	H'FFBB
Clock stop register 1	CKSTPR1	R/W	H'FF	H'FFFA

9.4.2 Register Descriptions

1. 16-bit Timer Counter (TCF) 8-bit Timer Counter (TCFH) 8-bit Timer Counter (TCFL)



TCF is a 16-bit read/write up-counter configured by cascaded connection of 8-bit timer counters TCFH and TCFL. In addition to the use of TCF as a 16-bit counter with TCFH as the upper 8 bits and TCFL as the lower 8 bits, TCFH and TCFL can also be used as independent 8-bit counters.

TCFH and TCFL can be read and written by the CPU, but when they are used in 16-bit mode, data transfer to and from the CPU is performed via a temporary register (TEMP). For details of TEMP, see section 9.4.3, CPU Interface.

TCFH and TCFL are each initialized to H'00 upon reset.

a. 16-bit mode (TCF)

When CKSH2 is cleared to 0 in TCRF, TCF operates as a 16-bit counter. The TCF input clock is selected by bits CKSL2 to CKSL0 in TCRF.

TCF can be cleared in the event of a compare match by means of CCLR in TCSR.

When TCF overflows from H'FFFF to H'0000, OVFH is set to 1 in TCSR. If OVIEH in TCSR is 1 at this time, IRRTFH is set to 1 in IRR2, and if IENTFH in IENR2 is 1, an interrupt request is sent to the CPU.

b. 8-bit mode (TCFL/TCFH)

When CKSH2 is set to 1 in TCRF, TCFH and TCFL operate as two independent 8-bit counters. The TCFH (TCFL) input clock is selected by bits CKSH2 to CKSH0 (CKSL2 to CKSL0) in TCRF.

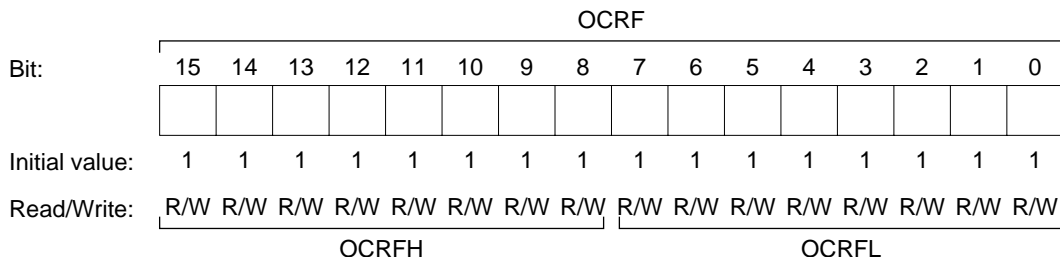
TCFH (TCFL) can be cleared in the event of a compare match by means of CCLR (CCLR) in TCSR.

When TCFH (TCFL) overflows from H'FF to H'00, OVFH (OVFL) is set to 1 in TCSR. If OVIEH (OVIEL) in TCSR is 1 at this time, IRRTFH (IRRTFL) is set to 1 in IRR2, and if IENTFH (IENTFL) in IENR2 is 1, an interrupt request is sent to the CPU.

2. 16-bit Output Compare Register (OCRF)

8-bit Output Compare Register (OCRFH)

8-bit Output Compare Register (OCRFL)



OCRF is a 16-bit read/write register composed of the two registers OCRFH and OCRFL. In addition to the use of OCRF as a 16-bit register with OCRFH as the upper 8 bits and OCRFL as the lower 8 bits, OCRFH and OCRFL can also be used as independent 8-bit registers.

OCRFH and OCRFL can be read and written by the CPU, but when they are used in 16-bit mode, data transfer to and from the CPU is performed via a temporary register (TEMP). For details of TEMP, see section 9.4.3, CPU Interface.

OCRFH and OCRFL are each initialized to H'FF upon reset.

a. 16-bit mode (OCRF)

When CKSH2 is cleared to 0 in TCRF, OCRF operates as a 16-bit register. OCRF contents are constantly compared with TCF, and when both values match, CMFH is set to 1 in TCSR. At the same time, IRRTFH is set to 1 in IRR2. If IENTFH in IENR2 is 1 at this time, an interrupt request is sent to the CPU.

Toggle output can be provided from the TMOFH pin by means of compare matches, and the output level can be set (high or low) by means of TOLH in TCRF.

b. 8-bit mode (OCRFH/OCRFL)

When CKSH2 is set to 1 in TCRF, OCRFH and OCRFL operate as two independent 8-bit registers. OCRFH contents are compared with TCFH, and OCRFL contents are with TCFL. When the OCRFH (OCRFL) and TCFH (TCFL) values match, CMFH (CMFL) is set to 1 in TCSR. At the same time, IRRTFH (IRRFL) is set to 1 in IRR2. If IENTFH (IENTFL) in IENR2 is 1 at this time, an interrupt request is sent to the CPU.

Toggle output can be provided from the TMOFH pin (TMOFL pin) by means of compare matches, and the output level can be set (high or low) by means of TOLH (TOLL) in TCRF.

3. Timer Control Register F (TCRF)

Bit:	7	6	5	4	3	2	1	0
	TOLH	CKSH2	CKSH1	CKSH0	TOLL	CKSL2	CKSL1	CKSL0
Initial value:	0	0	0	0	0	0	0	0
Read/Write:	W	W	W	W	W	W	W	W

TCRF is an 8-bit write-only register that switches between 16-bit mode and 8-bit mode, selects the input clock from among four internal clock sources or external event input, and sets the output level of the TMOFH and TMOFL pins.

TCRF is initialized to H'00 upon reset.

Bit 7: Toggle output level H (TOLH)

Bit 7 sets the TMOFH pin output level. The output level is effective immediately after this bit is written.

Bit 7

TOLH	Description
0	Low level (initial value)
1	High level

Bits 6 to 4: Clock select H (CKSH2 to CKSH0)

Bits 6 to 4 select the clock input to TCFH from among four internal clock sources or TCFL overflow.

Bit 6 CKSH2	Bit 5 CKSH1	Bit 4 CKSH0	Description
0	0	0	16-bit mode, counting on TCFL overflow signal (initial value)
0	0	1	
0	1	0	
0	1	1	Not available
1	0	0	Internal clock: counting on $\phi/32$
1	0	1	Internal clock: counting on $\phi/16$
1	1	0	Internal clock: counting on $\phi/4$
1	1	1	Internal clock: counting on $\phi w/4$

Bit 3: Toggle output level L (TOLL)

Bit 3 sets the TMOFL pin output level. The output level is effective immediately after this bit is written.

Bit 3

TOLL	Description	
0	Low level	(initial value)
1	High level	

Bits 2 to 0: Clock select L (CKSL2 to CKSL0)

Bits 2 to 0 select the clock input to TCFL from among four internal clock sources or external event input.

Bit 2 CKSL2	Bit 1 CKSL1	Bit 0 CKSL0	Description	
0	0	0	Counting on external event (TMIF) rising/falling edge*	(initial value)
0	0	1		
0	1	0		
0	1	1	Not available	
1	0	0	Internal clock: counting on $\phi/32$	
1	0	1	Internal clock: counting on $\phi/16$	
1	1	0	Internal clock: counting on $\phi/4$	
1	1	1	Internal clock: counting on $\phi w/4$	

Note: * External event edge selection is set by IEG3 in the IRQ edge select register (IEGR). For details, see 1. IRQ edge select register (IEGR) in section 3.3.2.

Note that the timer F counter may increment if the setting of IRQ3 in port mode register 1 (PMR1) is changed from 0 to 1 while the TMIF pin is low in order to change the TMIF pin function.

4. Timer Control/Status Register F (TCSR F)

Bit:	7	6	5	4	3	2	1	0
	OVFH	CMFH	OVIEH	CCLR H	OVFL	CMFL	OVIEL	CCLR L
Initial value:	0	0	0	0	0	0	0	0
Read/Write:	R/(W)*	R/(W)*	R/W	R/W	R/(W)*	R/(W)*	R/W	R/W

Note: * Bits 7, 6, 3, and 2 can only be written with 0, for flag clearing.

TCSR F is an 8-bit read/write register that performs counter clear selection, overflow flag setting, and compare match flag setting, and controls enabling of overflow interrupt requests.

TCSR F is initialized to H'00 upon reset.

Bit 7: Timer overflow flag H (OVFH)

Bit 7 is a status flag indicating that TCFH has overflowed from H'FF to H'00. This flag is set by hardware and cleared by software. It cannot be set by software.

Bit 7

OVFH	Description
0	Clearing condition: After reading OVFH = 1, cleared by writing 0 to OVFH (initial value)
1	Setting condition: Set when TCFH overflows from H'FF to H'00

Bit 6: Compare match flag H (CMFH)

Bit 6 is a status flag indicating that TCFH has matched OCRFH. This flag is set by hardware and cleared by software. It cannot be set by software.

Bit 6

CMFH	Description
0	Clearing condition: After reading CMFH = 1, cleared by writing 0 to CMFH (initial value)
1	Setting condition: Set when the TCFH value matches the OCRFH value

Bit 5: Timer overflow interrupt enable H (OVIEH)

Bit 5 selects enabling or disabling of interrupt generation when TCFH overflows.

Bit 5**OVIEH****Description**

0	TCFH overflow interrupt request is disabled	(initial value)
1	TCFH overflow interrupt request is enabled	

Bit 4: Counter clear H (CCLRH)

In 16-bit mode, bit 4 selects whether TCF is cleared when TCF and OCRF match.

In 8-bit mode, bit 4 selects whether TCFH is cleared when TCFH and OCRFH match.

Bit 4**CCLRH****Description**

0	16-bit mode: TCF clearing by compare match is disabled 8-bit mode: TCFH clearing by compare match is disabled	(initial value)
1	16-bit mode: TCF clearing by compare match is enabled 8-bit mode: TCFH clearing by compare match is enabled	

Bit 3: Timer overflow flag L (OVFL)

Bit 3 is a status flag indicating that TCFL has overflowed from H'FF to H'00. This flag is set by hardware and cleared by software. It cannot be set by software.

Bit 3**OVFL****Description**

0	Clearing condition: After reading OVFL = 1, cleared by writing 0 to OVFL	(initial value)
1	Setting condition: Set when TCFL overflows from H'FF to H'00	

Bit 2: Compare match flag L (CMFL)

Bit 2 is a status flag indicating that TCFL has matched OCRFL. This flag is set by hardware and cleared by software. It cannot be set by software.

Bit 2

CMFL	Description	
0	Clearing condition: After reading CMFL = 1, cleared by writing 0 to CMFL	(initial value)
1	Setting condition: Set when the TCFL value matches the OCRFL value	

Bit 1: Timer overflow interrupt enable L (OVIEL)

Bit 1 selects enabling or disabling of interrupt generation when TCFL overflows.

Bit 1

OVIEL	Description	
0	TCFL overflow interrupt request is disabled	(initial value)
1	TCFL overflow interrupt request is enabled	

Bit 0: Counter clear L (CCLRL)

Bit 0 selects whether TCFL is cleared when TCFL and OCRFL match.

Bit 0

CCLRL	Description	
0	TCFL clearing by compare match is disabled	(initial value)
1	TCFL clearing by compare match is enabled	

5. Clock Stop Register 1 (CKSTPR1)

Bit:	7	6	5	4	3	2	1	0
	S1CKSTP	S31CKSTP	S32CKSTP	ADCKSTP	TGCKSTP	TFCKSTP	TCCKSTP	TACKSTP
Initial value:	1	1	1	1	1	1	1	1
Read/Write:	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

CKSTPR1 is an 8-bit read/write register that performs module standby mode control for peripheral modules. Only the bit relating to timer F is described here. For details of the other bits, see the sections on the relevant modules.

Bit 2: Timer F module standby mode control (TFCKSTP)

Bit 2 controls setting and clearing of module standby mode for timer F.

TFCKSTP	Description
0	Timer F is set to module standby mode
1	Timer F module standby mode is cleared (initial value)

9.4.3 CPU Interface

TCF and OCRF are 16-bit read/write registers, but the CPU is connected to the on-chip peripheral modules by an 8-bit data bus. When the CPU accesses these registers, it therefore uses an 8-bit temporary register (TEMP).

In 16-bit mode, TCF read/write access and OCRF write access must be performed 16 bits at a time (using two consecutive byte-size MOV instructions), and the upper byte must be accessed before the lower byte. Data will not be transferred correctly if only the upper byte or only the lower byte is accessed.

In 8-bit mode, there are no restrictions on the order of access.

1. Write Access

Write access to the upper byte results in transfer of the upper-byte write data to TEMP. Next, write access to the lower byte results in transfer of the data in TEMP to the upper register byte, and direct transfer of the lower-byte write data to the lower register byte.

Figure 9.4 shows an example in which H'AA55 is written to TCF.

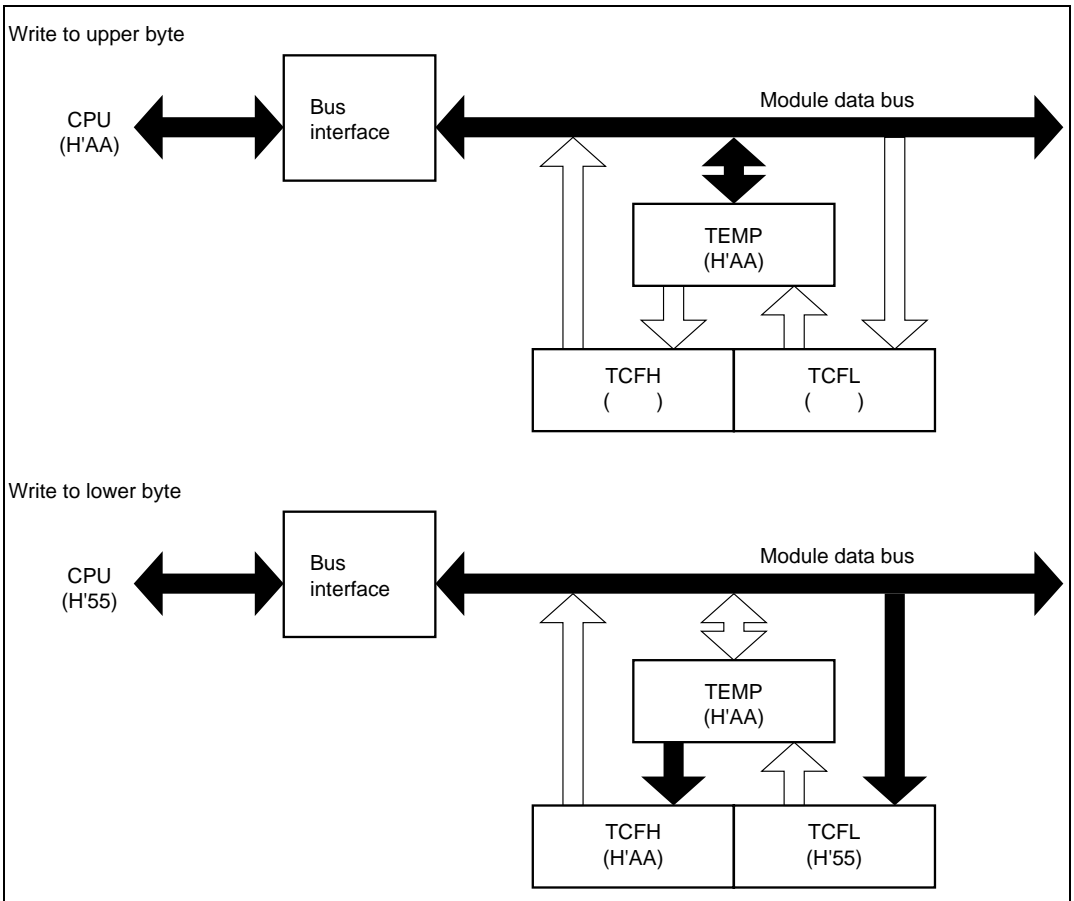


Figure 9.4 Write Access to TCR (CPU → TCF)

2. Read Access

In access to TCF, when the upper byte is read the upper-byte data is transferred directly to the CPU and the lower-byte data is transferred to TEMP. Next, when the lower byte is read, the lower-byte data in TEMP is transferred to the CPU.

In access to OCRF, when the upper byte is read the upper-byte data is transferred directly to the CPU. When the lower byte is read, the lower-byte data is transferred directly to the CPU.

Figure 9.5 shows an example in which TCF is read when it contains H'AAFF.

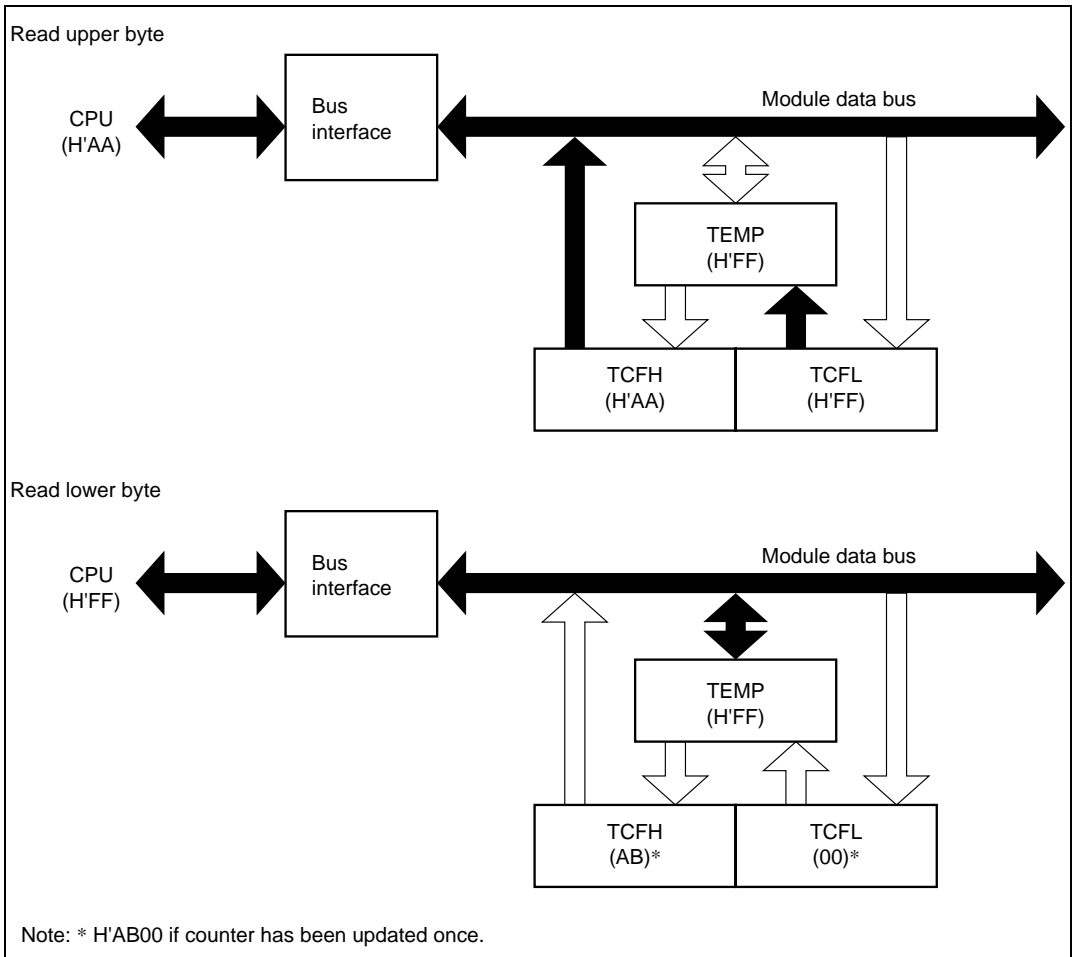


Figure 9.5 Read Access to TCF (TCF → CPU)

9.4.4 Operation

Timer F is a 16-bit counter that increments on each input clock pulse. The timer F value is constantly compared with the value set in output compare register F, and the counter can be cleared, an interrupt requested, or port output toggled, when the two values match. Timer F can also function as two independent 8-bit timers.

1. Timer F Operation

Timer F has two operating modes, 16-bit timer mode and 8-bit timer mode. The operation in each of these modes is described below.

a. Operation in 16-bit timer mode

When CKSH2 is cleared to 0 in timer control register F (TCRF), timer F operates as a 16-bit timer.

Following a reset, timer counter F (TCF) is initialized to H'0000, output compare register F (OCRF) to H'FFFF, and timer control register F (TCRF) and timer control/status register F (TCSR) to H'00. The counter starts incrementing on external event (TMIF) input. The external event edge selection is set by IEG3 in the IRQ edge select register (IEGR).

The timer F operating clock can be selected from four internal clocks or an external clock by means of bits CKSL2 to CKSL0 in TCRF.

OCRF contents are constantly compared with TCF, and when both values match, CMFH is set to 1 in TCSR. If IENTFH in IENR2 is 1 at this time, an interrupt request is sent to the CPU, and at the same time, TMOFH pin output is toggled. If CCLRH in TCSR is 1, TCF is cleared. TMOFH pin output can also be set by TOLH in TCRF.

When TCF overflows from H'FFFF to H'0000, OVFH is set to 1 in TCSR. If OVIEH in TCSR and IENTFH in IENR2 are both 1, an interrupt request is sent to the CPU.

b. Operation in 8-bit timer mode

When CKSH2 is set to 1 in TCRF, TCF operates as two independent 8-bit timers, TCFH and TCFL. The TCFH/TCFL input clock is selected by CKSH2 to CKSH0/CKSL2 to CKSL0 in TCRF.

When the OCRFH/OCRFL and TCFH/TCFL values match, CMFH/CMFL is set to 1 in TCSR. If IENTFH/IENTFL in IENR2 is 1, an interrupt request is sent to the CPU, and at the same time, TMOFH pin/TMOFL pin output is toggled. If CCLRH/CCLRL in TCSR is 1, TCFH/TCFL is cleared. TMOFH pin/TMOFL pin output can also be set by TOLH/TOLL in TCRF.

When TCFH/TCFL overflows from H'FF to H'00, OVFH/OVFL is set to 1 in TCSR. If OVIEH/OVIEL in TCSR and IENTFH/IENTFL in IENR2 are both 1, an interrupt request is sent to the CPU.

2. TCF Increment Timing

TCF is incremented by clock input (internal clock or external event input).

a. Internal clock operation

Bits CKSH2 to CKSH0 or CKSL2 to CKSL0 in TCRF select one of four internal clock sources ($\phi/32$, $\phi/16$, $\phi/4$, or $\phi_w/4$) created by dividing the system clock (ϕ or ϕ_w).

b. External event operation

External event input is selected by clearing CKSL2 to 0 in TCRF. TCF can increment on either the rising or falling edge of external event input. External event edge selection is set by IEG3 in the interrupt controller's IEGR register. An external event pulse width of at least 2 system clocks (ϕ) is necessary. Shorter pulses will not be counted correctly.

3. TMOFH/TMOFL Output Timing

In TMOFH/TMOFL output, the value set in TOLH/TOLL in TCRF is output. The output is toggled by the occurrence of a compare match. Figure 9.6 shows the output timing.

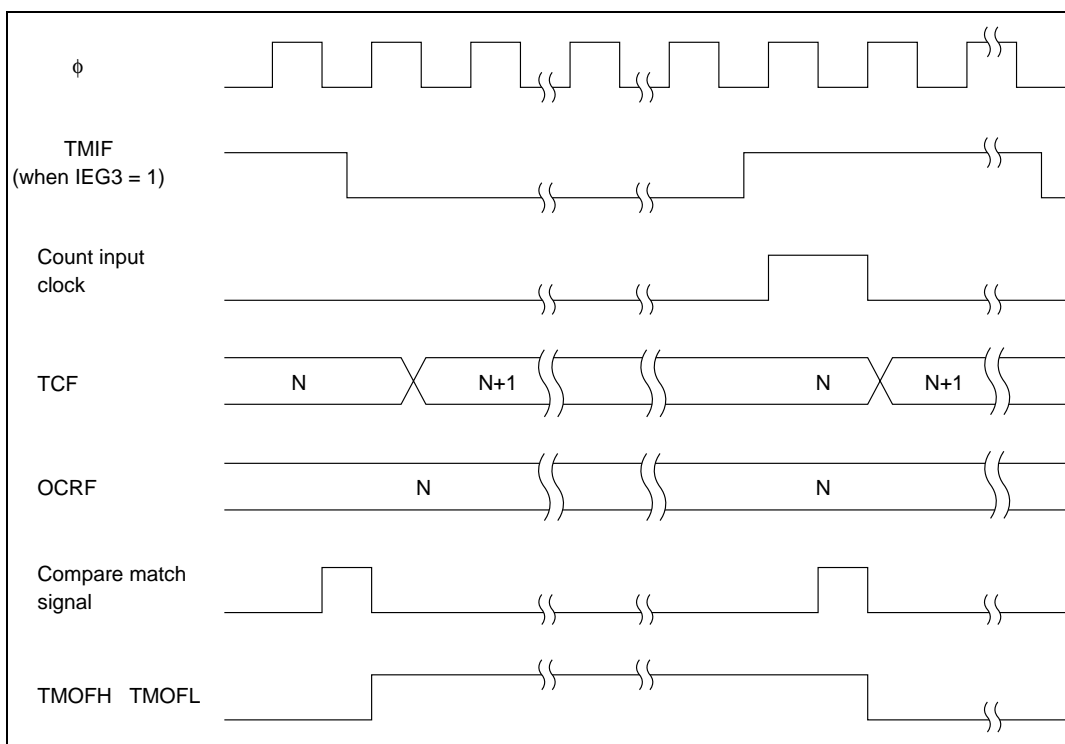


Figure 9.6 TMOFH/TMOFL Output Timing

4. TCF Clear Timing

TCF can be cleared by a compare match with OCRF.

5. Timer Overflow Flag (OVF) Set Timing

OVF is set to 1 when TCF overflows from H'FFFF to H'0000.

6. Compare Match Flag set Timing

The compare match flag (CMFH or CMFL) is set to 1 when the TCF and OCRF values match. The compare match signal is generated in the last state during which the values match (when TCF is updated from the matching value to a new value). When TCF matches OCRF, the compare match signal is not generated until the next counter clock.

7. Timer F Operation Modes

Timer F operation modes are shown in table 9.10.

Table 9.10 Timer F Operation Modes

Operation Mode	Reset	Active	Sleep	Watch	Subactive	Subsleep	Standby	Module Standby
TCF	Reset	Functions	Functions	Functions/ Halted*	Functions/ Halted*	Functions/ Halted*	Halted	Halted
OCRF	Reset	Functions	Held	Held	Functions	Held	Held	Held
TCRF	Reset	Functions	Held	Held	Functions	Held	Held	Held
TCSRFB	Reset	Functions	Held	Held	Functions	Held	Held	Held

Note: * When $\phi_w/4$ is selected as the TCF internal clock in active mode or sleep mode, since the system clock and internal clock are mutually asynchronous, synchronization is maintained by a synchronization circuit. This results in a maximum count cycle error of $1/\phi$ (s). When the counter is operated in subactive mode, watch mode, or subsleep mode, $\phi_w/4$ must be selected as the internal clock. The counter will not operate if any other internal clock is selected.

9.4.5 Application Notes

The following types of contention and operation can occur when timer F is used.

1. 16-bit Timer Mode

In toggle output, TMOFH pin output is toggled when all 16 bits match and a compare match signal is generated. If a TCRF write by a MOV instruction and generation of the compare match signal occur simultaneously, TOLH data is output to the TMOFH pin as a result of the TCRF write. TMOFL pin output is unstable in 16-bit mode, and should not be used; the TMOFL pin should be used as a port pin.

If an OCRFL write and compare match signal generation occur simultaneously, the compare match signal is invalid. However, if the written data and the counter value match, a compare match signal will be generated at that point. As the compare match signal is output in synchronization with the TCFL clock, a compare match will not result in compare match signal generation if the clock is stopped.

Compare match flag CMFH is set when all 16 bits match and a compare match signal is generated. Compare match flag CMFL is set if the setting conditions for the lower 8 bits are satisfied.

When TCF overflows, OVFH is set. OVFL is set if the setting conditions are satisfied when the lower 8 bits overflow. If a TCFL write and overflow signal output occur simultaneously, the overflow signal is not output.

2. 8-bit Timer Mode

a. TCFH, OCRFH

In toggle output, TMOFH pin output is toggled when a compare match occurs. If a TCRF write by a MOV instruction and generation of the compare match signal occur simultaneously, TOLH data is output to the TMOFH pin as a result of the TCRF write.

If an OCRFH write and compare match signal generation occur simultaneously, the compare match signal is invalid. However, if the written data and the counter value match, a compare match signal will be generated at that point. The compare match signal is output in synchronization with the TCFH clock.

If a TCFH write and overflow signal output occur simultaneously, the overflow signal is not output.

b. TCFL, OCRFL

In toggle output, TMOFL pin output is toggled when a compare match occurs. If a TCRF write by a MOV instruction and generation of the compare match signal occur simultaneously, TOLL data is output to the TMOFL pin as a result of the TCRF write.

If an OCRFL write and compare match signal generation occur simultaneously, the compare match signal is invalid. However, if the written data and the counter value match, a compare match signal will be generated at that point. As the compare match signal is output in synchronization with the TCFL clock, a compare match will not result in compare match signal generation if the clock is stopped.

If a TCFL write and overflow signal output occur simultaneously, the overflow signal is not output.

3. Clear Timer FH, Timer FL Interrupt Request Flags (IRRTFH, IRRTFL), Timer Overflow Flags H, L (OVFH, OVFL) and Compare Match Flags H, L (CMFH, CMFL)

When $\phi_w/4$ is selected as the internal clock, “Interrupt factor generation signal” will be operated with ϕ_w and the signal will be outputted with ϕ_w width. And, “Overflow signal” and “Compare match signal” are controlled with 2 cycles of ϕ_w signals. Those signals are outputted with 2 cycles width of ϕ_w (figure 9.7)

In active (high-speed, medium-speed) mode, even if you cleared interrupt request flag during the term of validity of “Interrupt factor generation signal”, same interrupt request flag is set. (figure 9.7 (1)) And, you cannot be cleared timer overflow flag and compare match flag during the term of validity of “Overflow signal” and “Compare match signal”.

For interrupt request flag is set right after interrupt request is cleared, interrupt process to one time timer FH, timer FL interrupt might be repeated. (figure 9.7 (2)) Therefore, to definitely clear interrupt request flag in active (high-speed, medium-speed) mode, clear should be processed after the time that calculated with below (1) formula. And, to definitely clear timer overflow flag and compare match flag, clear should be processed after read timer control status register F (TCSRFF) after the time that calculated with below (1) formula. For ST of (1) formula, please substitute the longest number of execution states in used instruction. (10 states of RTE instruction when MULXU, DIVXU instruction is not used, 14 states when MULXU, DIVXU instruction is used) In subactive mode, there are not limitation for interrupt request flag, timer overflow flag, and compare match flag clear.

The term of validity of “Interrupt factor generation signal”

= 1 cycle of ϕ_w + waiting time for completion of executing instruction
 + interrupt time synchronized with $\phi = 1/\phi_w + ST \times (1/\phi) + (2/\phi)$ (second).....(1)

ST: Executing number of execution states

Method 1 is recommended to operate for time efficiency.

Method 1

1. Prohibit interrupt in interrupt handling routine (set IENFH, IENFL to 0).
2. After program process returned normal handling, clear interrupt request flags (IRRTFH, IRRTFL) after more than that calculated with (1) formula.
3. After read timer control status register F (TCSR F), clear timer overflow flags (OVFH, OVFL) and compare match flags (CMFH, CMFL).
4. Operate interrupt permission (set IENFH, IENFL to 1).

Method 2

1. Set interrupt handling routine time to more than time that calculated with (1) formula.
2. Clear interrupt request flags (IRRTFH, IRRTFL) at the end of interrupt handling routine.
3. After read timer control status register F (TCSR F), clear timer overflow flags (OVFH, OVFL) and compare match flags (CMFH, CMFL).

All above attentions are also applied in 16-bit mode and 8-bit mode.

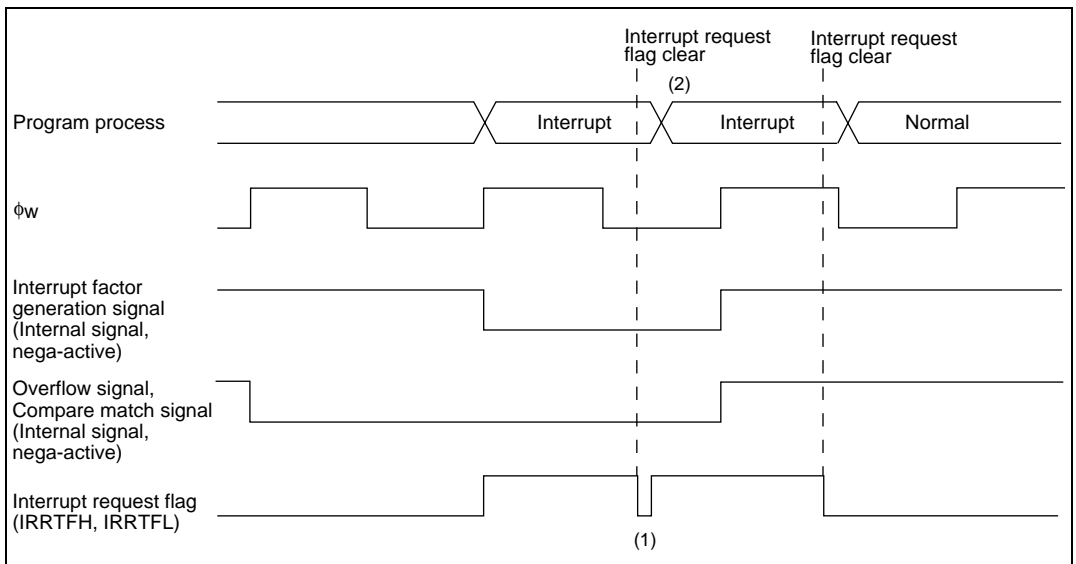


Figure 9.7 Clear Interrupt Request Flag when Interrupt Factor Generation Signal is Valid

4. Timer Counter (TCF) Read/Write

When $\phi w/4$ is selected as the internal clock in active (high-speed, medium-speed) mode, write on TCF is impossible. And, when read TCF, as the system clock and internal clock are mutually asynchronous, TCF synchronizes with synchronization circuit. This results in a maximum TCF read value error of ± 1 .

When read/write TCF in active (high-speed, medium-speed) mode is needed, please select internal clock except for $\phi w/4$ before read/write.

In subactive mode, even $\phi w/4$ is selected as the internal clock, normal read/write TCF is possible.

9.5 Timer G

9.5.1 Overview

Timer G is an 8-bit timer with dedicated input capture functions for the rising/falling edges of pulses input from the input capture input pin (input capture input signal). High-frequency component noise in the input capture input signal can be eliminated by a noise canceler, enabling accurate measurement of the input capture input signal duty cycle. If input capture input is not set, timer G functions as an 8-bit interval timer.

1. Features

Features of timer G are given below.

- Choice of four internal clock sources ($\phi/64$, $\phi/32$, $\phi/2$, $\phi w/4$)
- Dedicated input capture functions for rising and falling edges
- Level detection at counter overflow
It is possible to detect whether overflow occurred when the input capture input signal was high or when it was low.
- Selection of whether or not the counter value is to be cleared at the input capture input signal rising edge, falling edge, or both edges
- Two interrupt sources: one input capture, one overflow. The input capture input signal rising or falling edge can be selected as the interrupt source.
- A built-in noise canceler eliminates high-frequency component noise in the input capture input signal.
- Watch mode, subactive mode and subsleep mode operation is possible when $\phi w/4$ is selected as the internal clock.

- Use of module standby mode enables this module to be placed in standby mode independently when not used.

2. Block Diagram

Figure 9.8 shows a block diagram of timer G.

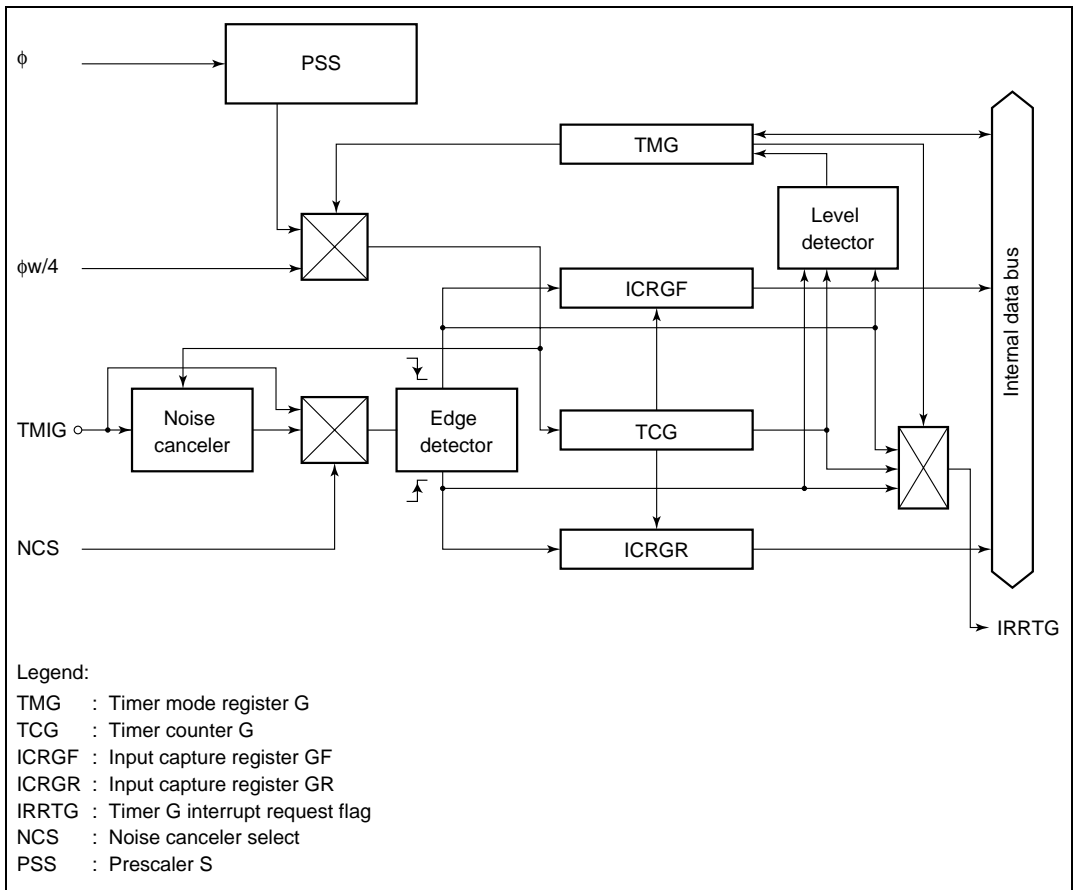


Figure 9.8 Block Diagram of Timer G

3. Pin Configuration

Table 9.11 shows the timer G pin configuration.

Table 9.11 Pin Configuration

Name	Abbr.	I/O	Function
Input capture input	TMIG	Input	Input capture input pin

4. Register Configuration

Table 9.12 shows the register configuration of timer G.

Table 9.12 Timer G Registers

Name	Abbr.	R/W	Initial Value	Address
Timer control register G	TMG	R/W	H'00	H'FFBC
Timer counter G	TCG	—	H'00	—
Input capture register GF	ICRGF	R	H'00	H'FFBD
Input capture register GR	ICRGR	R	H'00	H'FFBE
Clock stop register 1	CKSTPR1	R/W	H'FF	H'FFFA

9.5.2 Register Descriptions

1. Timer Counter (TCG)

Bit:	7	6	5	4	3	2	1	0
	TCG7	TCG6	TCG5	TCG4	TCG3	TCG2	TCG1	TCG0
Initial value:	0	0	0	0	0	0	0	0
Read/Write:	—	—	—	—	—	—	—	—

TCG is an 8-bit up-counter which is incremented by clock input. The input clock is selected by bits CKS1 and CKS0 in TMG.

TMIG in PMR1 is set to 1 to operate TCG as an input capture timer, or cleared to 0 to operate TCG as an interval timer*. In input capture timer operation, the TCG value can be cleared by the rising edge, falling edge, or both edges of the input capture input signal, according to the setting made in TMG.

When TCG overflows from H'FF to H'00, if OVIE in TMG is 1, IRRTG is set to 1 in IRR2, and if IENTG in IENR2 is 1, an interrupt request is sent to the CPU.

For details of the interrupt, see section 3.3, Interrupts.

TCG cannot be read or written by the CPU. It is initialized to H'00 upon reset.

Note: * An input capture signal may be generated when TMIG is modified.

2. Input Capture Register GF (ICRGF)

Bit:	7	6	5	4	3	2	1	0
	ICRGF7	ICRGF6	ICRGF5	ICRGF4	ICRGF3	ICRGF2	ICRGF1	ICRGF0
Initial value:	0	0	0	0	0	0	0	0
Read/Write:	R	R	R	R	R	R	R	R

ICRGF is an 8-bit read-only register. When a falling edge of the input capture input signal is detected, the current TCG value is transferred to ICRGF. If IIEGS in TMG is 1 at this time, IRRTG is set to 1 in IRR2, and if IENTG in IENR2 is 1, an interrupt request is sent to the CPU.

For details of the interrupt, see section 3.3, Interrupts.

To ensure dependable input capture operation, the pulse width of the input capture input signal must be at least 2ϕ or $2\phi_{SUB}$ (when the noise canceler is not used).

ICRGF is initialized to H'00 upon reset.

3. Input Capture Register GR (ICRGR)

Bit:	7	6	5	4	3	2	1	0
	ICRGR7	ICRGR6	ICRGR5	ICRGR4	ICRGR3	ICRGR2	ICRGR1	ICRGR0
Initial value:	0	0	0	0	0	0	0	0
Read/Write:	R	R	R	R	R	R	R	R

ICRGR is an 8-bit read-only register. When a rising edge of the input capture input signal is detected, the current TCG value is transferred to ICRGR. If IIEGS in TMG is 1 at this time, IRRTG is set to 1 in IRR2, and if IENTG in IENR2 is 1, an interrupt request is sent to the CPU.

For details of the interrupt, see section 3.3, Interrupts.

To ensure dependable input capture operation, the pulse width of the input capture input signal must be at least 2ϕ or $2\phi_{SUB}$ (when the noise canceler is not used).

ICRGR is initialized to H'00 upon reset.

4. Timer Mode Register G (TMG)

Bit:	7	6	5	4	3	2	1	0
	OVFH	OVFL	OVIE	IIEGS	CCLR1	CCLR0	CKS1	CKS0
Initial value:	0	0	0	0	0	0	0	0
Read/Write:	R/(W)*	R/(W)*	R/W	R/W	R/W	R/W	R/W	R/W

Note: * Bits 7 and 6 can only be written with 0, for flag clearing.

TMG is an 8-bit read/write register that performs TCG clock selection from four internal clock sources, counter clear selection, and edge selection for the input capture input signal interrupt request, controls enabling of overflow interrupt requests, and also contains the overflow flags.

TMG is initialized to H'00 upon reset.

Bit 7: Timer overflow flag H (OVFH)

Bit 7 is a status flag indicating that TCG has overflowed from H'FF to H'00 when the input capture input signal is high. This flag is set by hardware and cleared by software. It cannot be set by software.

Bit 7

OVFH	Description	
0	Clearing condition: After reading OVFH = 1, cleared by writing 0 to OVFH	(initial value)
1	Setting condition: Set when TCG overflows from H'FF to H'00	

Bit 6: Timer overflow flag L (OVFL)

Bit 6 is a status flag indicating that TCG has overflowed from H'FF to H'00 when the input capture input signal is low, or in interval operation. This flag is set by hardware and cleared by software. It cannot be set by software.

Bit 6 OVFL	Description	
0	Clearing condition: After reading OVFL = 1, cleared by writing 0 to OVFL	(initial value)
1	Setting condition: Set when TCG overflows from H'FF to H'00	

Bit 5: Timer overflow interrupt enable (OVIE)

Bit 5 selects enabling or disabling of interrupt generation when TCG overflows.

Bit 5 OVIE	Description	
0	TCG overflow interrupt request is disabled	(initial value)
1	TCG overflow interrupt request is enabled	

Bit 4: Input capture interrupt edge select (IIEGS)

Bit 4 selects the input capture input signal edge that generates an interrupt request.

Bit 4 IIEGS	Description	
0	Interrupt generated on rising edge of input capture input signal	(initial value)
1	Interrupt generated on falling edge of input capture input signal	

Bits 3 and 2: Counter clear 1 and 0 (CCLR1, CCLR0)

Bits 3 and 2 specify whether or not TCG is cleared by the rising edge, falling edge, or both edges of the input capture input signal.

Bit 3 CCLR1	Bit 2 CCLR0	Description	
0	0	TCG clearing is disabled	(initial value)
0	1	TCG cleared by falling edge of input capture input signal	
1	0	TCG cleared by rising edge of input capture input signal	
1	1	TCG cleared by both edges of input capture input signal	

Bits 1 and 0: Clock select (CKS1, CKS0)

Bits 1 and 0 select the clock input to TCG from among four internal clock sources.

Bit 1 CKS1	Bit 0 CKS0	Description	
0	0	Internal clock: counting on $\phi/64$	(initial value)
0	1	Internal clock: counting on $\phi/32$	
1	0	Internal clock: counting on $\phi/2$	
1	1	Internal clock: counting on $\phi w/4$	

5. Clock Stop Register 1 (CKSTPR1)

Bit:	7	6	5	4	3	2	1	0
	S1CKSTP	S31CKSTP	S32CKSTP	ADCKSTP	TGCKSTP	TFCKSTP	TCKSTP	TACKSTP
Initial value:	1	1	1	1	1	1	1	1
Read/Write:	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

CKSTPR1 is an 8-bit read/write register that performs module standby mode control for peripheral modules. Only the bit relating to timer G is described here. For details of the other bits, see the sections on the relevant modules.

Bit 3: Timer G module standby mode control (TGCKSTP)

Bit 3 controls setting and clearing of module standby mode for timer G.

TGCKSTP	Description
0	Timer G is set to module standby mode
1	Timer G module standby mode is cleared (initial value)

9.5.3 Noise Canceler

The noise canceler consists of a digital low-pass filter that eliminates high-frequency component noise from the pulses input from the input capture input pin. The noise canceler is set by NCS* in PMR3.

Figure 9.9 shows a block diagram of the noise canceler.

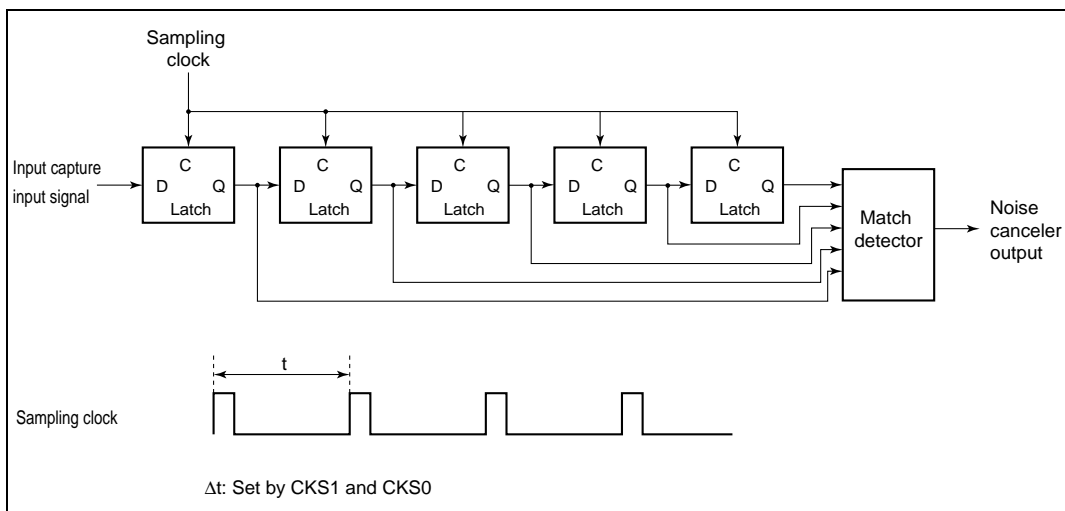


Figure 9.9 Noise Canceler Block Diagram

The noise canceler consists of five latch circuits connected in series and a match detector circuit. When the noise cancellation function is not used ($NCS = 0$), the system clock is selected as the sampling clock. When the noise cancellation function is used ($NCS = 1$), the sampling clock is the internal clock selected by CKS1 and CKS0 in TMG, the input capture input is sampled on the rising edge of this clock, and the data is judged to be correct when all the latch outputs match. If all the outputs do not match, the previous value is retained. After a reset, the noise canceler output is initialized when the falling edge of the input capture input signal has been sampled five times.

Therefore, after making a setting for use of the noise cancellation function, a pulse with at least five times the width of the sampling clock is a dependable input capture signal. Even if noise cancellation is not used, an input capture input signal pulse width of at least 2ϕ or $2\phi_{SUB}$ is necessary to ensure that input capture operations are performed properly.

Note: * An input capture signal may be generated when the NCS bit is modified.

Figure 9.10 shows an example of noise canceler timing.

In this example, high-level input of less than five times the width of the sampling clock at the input capture input pin is eliminated as noise.

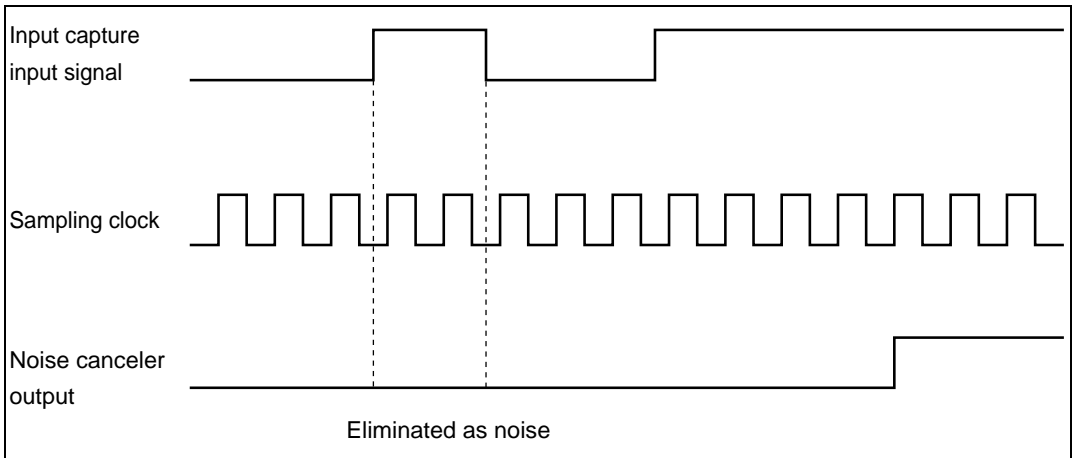


Figure 9.10 Noise Canceler Timing (Example)

9.5.4 Operation

Timer G is an 8-bit timer with built-in input capture and interval functions.

1. Timer G Functions

Timer G is an 8-bit up-counter with two functions, an input capture timer function and an interval timer function.

The operation of these two functions is described below.

a. Input capture timer operation

When the TMIG bit is set to 1 in port mode register 1 (PMR1), timer G functions as an input capture timer*.

In a reset, timer mode register G (TMG), timer counter G (TCG), input capture register GF (ICRGF), and input capture register GR (ICRGR) are all initialized to H'00.

Following a reset, TCG starts incrementing on the $\phi/64$ internal clock.

The input clock can be selected from four internal clock sources by bits CKS1 and CKS0 in TMG.

When a rising edge/falling edge is detected in the input capture signal input from the TMIG pin, the TCG value at that time is transferred to ICRGR/ICRGF. When the edge selected by IIEGS in TMG is input, IRRTG is set to 1 in IRR2, and if the IENTG bit in IENR2 is 1 at this time, an interrupt request is sent to the CPU. For details of the interrupt, see section 3.3, Interrupts.

TCG can be cleared by a rising edge, falling edge, or both edges of the input capture signal, according to the setting of bits CCLR1 and CCLR0 in TMG. If TCG overflows when the input capture signal is high, the OVFH bit is set in TMG; if TCG overflows when the input capture signal is low, the OVFL bit is set in TMG. If the OVIE bit in TMG is 1 when these bits are set, IRRTG is set to 1 in IRR2, and if the IENTG bit in IENR2 is 1, timer G sends an interrupt request to the CPU. For details of the interrupt, see section 3.3, Interrupts.

Timer G has a built-in noise canceler that enables high-frequency component noise to be eliminated from pulses input from the TMIG pin. For details, see section 9.5.3, Noise Canceler.

Note: * An input capture signal may be generated when TMIG is modified.

b. Interval timer operation

When the TMIG bit is cleared to 0 in PMR1, timer G functions as an interval timer.

Following a reset, TCG starts incrementing on the $\phi/64$ internal clock. The input clock can be selected from four internal clock sources by bits CKS1 and CKS0 in TMG. TCG increments on the selected clock, and when it overflows from H'FF to H'00, the OVFL bit is set to 1 in TMG. If the OVIE bit in TMG is 1 at this time, IRRTG is set to 1 in IRR2, and if the IENTG bit in IENR2 is 1, timer G sends an interrupt request to the CPU. For details of the interrupt, see section 3.3, Interrupts.

2. Increment Timing

TCG is incremented by internal clock input. Bits CKS1 and CKS0 in TMG select one of four internal clock sources ($\phi/64$, $\phi/32$, $\phi/2$, or $\phi_w/4$) created by dividing the system clock (ϕ) or watch clock (ϕ_w).

3. Input Capture Input Timing

a. Without noise cancellation function

For input capture input, dedicated input capture functions are provided for rising and falling edges.

Figure 9.11 shows the timing for rising/falling edge input capture input.

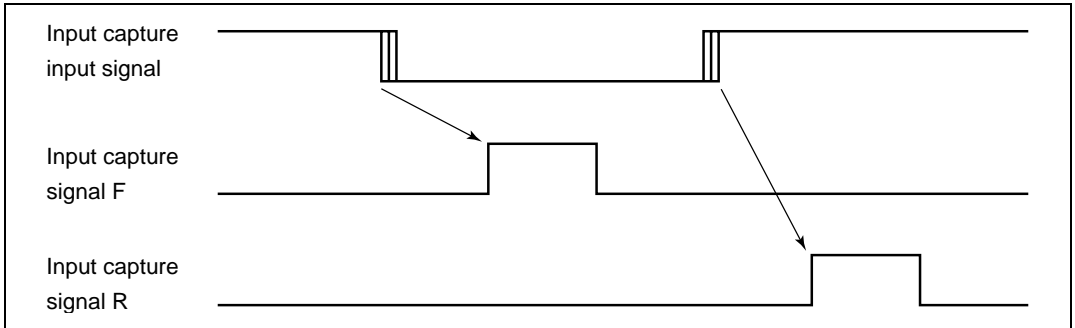


Figure 9.11 Input Capture Input Timing (without Noise Cancellation Function)

b. With noise cancellation function

When noise cancellation is performed on the input capture input, the passage of the input capture signal through the noise canceler results in a delay of five sampling clock cycles from the input capture input signal edge.

Figure 9.12 shows the timing in this case.

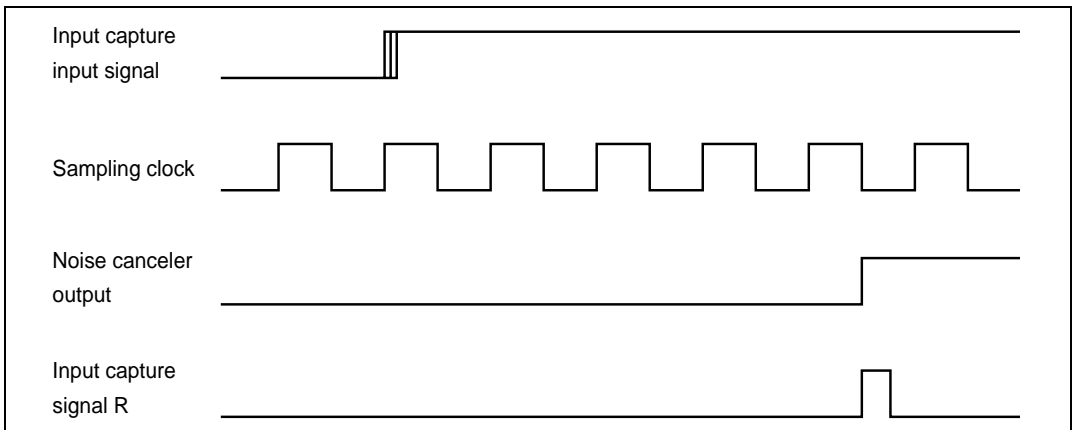


Figure 9.12 Input Capture Input Timing (with Noise Cancellation Function)

4. Timing of Input Capture by Input Capture Input

Figure 9.13 shows the timing of input capture by input capture input

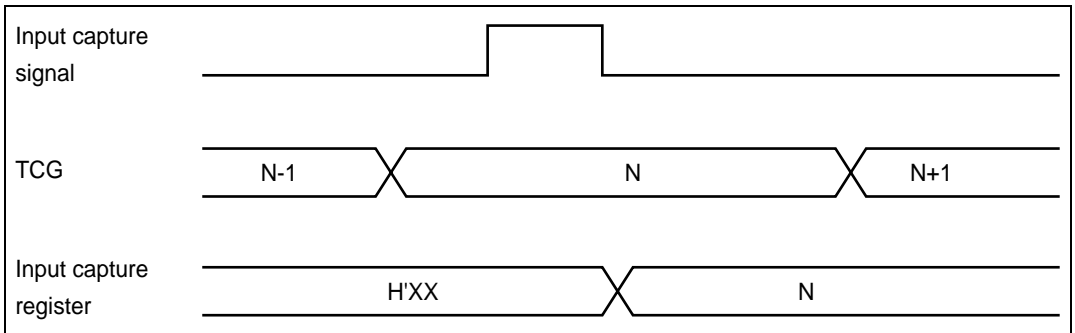


Figure 9.13 Timing of Input Capture by Input Capture Input

5. TCG Clear Timing

TCG can be cleared by the rising edge, falling edge, or both edges of the input capture input signal.

Figure 9.14 shows the timing for clearing by both edges.

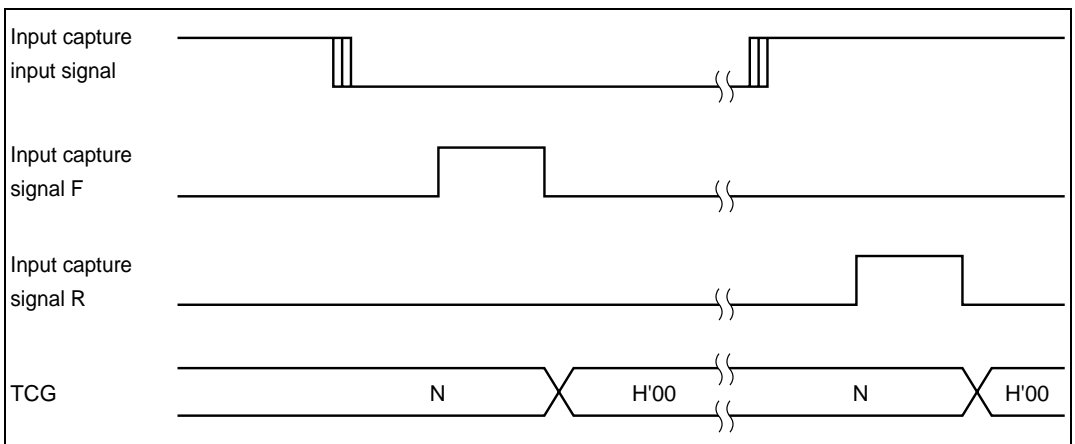


Figure 9.14 TCG Clear Timing

6. Timer G Operation Modes

Timer G operation modes are shown in table 9.13.

Table 9.13 Timer G Operation Modes

Operation Mode		Reset	Active	Sleep	Watch	Subactive	Subsleep	Standby	Module Standby
TCG	Input capture	Reset	Functions*	Functions*	Functions/ halted*	Functions/ halted*	Functions/ halted*	Halted	Halted
	Interval	Reset	Functions*	Functions*	Functions/ halted*	Functions/ halted*	Functions/ halted*	Halted	Halted
ICRGF		Reset	Functions*	Functions*	Functions/ halted*	Functions/ halted*	Functions/ halted*	Held	Held
ICRGR		Reset	Functions*	Functions*	Functions/ halted*	Functions/ halted*	Functions/ halted*	Held	Held
TMG		Reset	Functions	Held	Held	Functions	Held	Held	Held

Note: * When $\phi_w/4$ is selected as the TCG internal clock in active mode or sleep mode, since the system clock and internal clock are mutually asynchronous, synchronization is maintained by a synchronization circuit. This results in a maximum count cycle error of $1/\phi$ (s). When $\phi_w/4$ is selected as the TCG internal clock in watch mode, TCG and the noise canceler operate on the $\phi_w/4$ internal clock without regard to the ϕ subclock ($\phi_w/8$, $\phi_w/4$, $\phi_w/2$). Note that when another internal clock is selected, TCG and the noise canceler do not operate, and input of the input capture input signal does not result in input capture.

To operate the timer G in subactive mode or subsleep mode, select $\phi_w/4$ as the TCG internal clock and $\phi_w/2$ as the subclock ϕ_{SUB} . Note that when other internal clock is selected, or when $\phi_w/8$ or $\phi_w/4$ is selected as the subclock ϕ_{SUB} , TCG and the noise canceler do not operate.

9.5.5 Application Notes

1. Internal Clock Switching and TCG Operation

Depending on the timing, TCG may be incremented by a switch between difference internal clock sources. Table 9.14 shows the relation between internal clock switchover timing (by write to bits CKS1 and CKS0) and TCG operation.

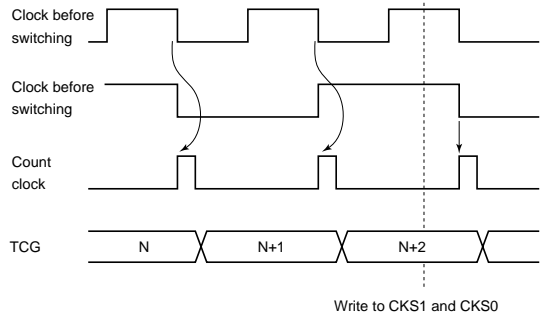
When TCG is internally clocked, an increment pulse is generated on detection of the falling edge of an internal clock signal, which is divided from the system clock (ϕ) or subclock (ϕ_w). For this reason, in a case like No. 3 in table 9.14 where the switch is from a high clock signal to a low clock signal, the switchover is seen as a falling edge, causing TCG to increment.

Table 9.14 Internal Clock Switching and TCG Operation

No.	Clock Levels Before and After Modifying Bits CKS1 and CKS0	TCG Operation
1	Goes from low level to low level	<p data-bbox="763 501 931 517">Write to CKS1 and CKS0</p>
2	Goes from low level to high level	<p data-bbox="892 829 1060 845">Write to CKS1 and CKS0</p>
3	Goes from high level to low level	<p data-bbox="819 1158 988 1174">Write to CKS1 and CKS0</p>

**No. Clock Levels Before and After
Modifying Bits CKS1 and CKS0**

4 Goes from high level to high level

TCG Operation


Note: * The switchover is seen as a falling edge, and TCG is incremented.

2. Notes on Port Mode Register Modification

The following points should be noted when a port mode register is modified to switch the input capture function or the input capture input noise canceler function.

- Switching input capture input pin function

Note that when the pin function is switched by modifying TMIG in port mode register 1 (PMR1), which performs input capture input pin control, an edge will be regarded as having been input at the pin even though no valid edge has actually been input. Input capture input signal input edges, and the conditions for their occurrence, are summarized in table 9.15.

Table 9.15 Input Capture Input Signal Input Edges Due to Input Capture Input Pin Switching, and Conditions for Their Occurrence

Input Capture Input Signal Input Edge	Conditions
Generation of rising edge	When TMIG is modified from 0 to 1 while the TMIG pin is high
	When NCS is modified from 0 to 1 while the TMIG pin is high, then TMIG is modified from 0 to 1 before the signal is sampled five times by the noise canceler
Generation of falling edge	When TMIG is modified from 1 to 0 while the TMIG pin is high
	When NCS is modified from 0 to 1 while the TMIG pin is low, then TMIG is modified from 0 to 1 before the signal is sampled five times by the noise canceler
	When NCS is modified from 0 to 1 while the TMIG pin is high, then TMIG is modified from 1 to 0 after the signal is sampled five times by the noise canceler

Note: When the P1₃ pin is not set as an input capture input pin, the timer G input capture input signal is low.

- Switching input capture input noise canceler function

When performing noise canceler function switching by modifying NCS in port mode register 3 (PMR3), which controls the input capture input noise canceler, TMIG should first be cleared to 0. Note that if NCS is modified without first clearing TMIG, an edge will be regarded as having been input at the pin even though no valid edge has actually been input. Input capture input signal input edges, and the conditions for their occurrence, are summarized in table 9.16.

Table 9.16 Input Capture Input Signal Input Edges Due to Noise Canceler Function Switching, and Conditions for Their Occurrence

Input Capture Input Signal Input Edge	Conditions
Generation of rising edge	When the TMIG pin level is switched from low to high while TMIG is set to 1, then NCS is modified from 0 to 1 before the signal is sampled five times by the noise canceler
Generation of falling edge	When the TMIG pin level is switched from high to low while TMIG is set to 1, then NCS is modified from 1 to 0 before the signal is sampled five times by the noise canceler

When the pin function is switched and an edge is generated in the input capture input signal, if this edge matches the edge selected by the input capture interrupt select (IIEGS) bit, the interrupt request flag will be set to 1. The interrupt request flag should therefore be cleared to 0 before use. Figure 9.15 shows the procedure for port mode register manipulation and interrupt request flag clearing. When switching the pin function, set the interrupt-disabled state before manipulating the port mode register, then, after the port mode register operation has been performed, wait for the time required to confirm the input capture input signal as an input capture signal (at least two system clocks when the noise canceler is not used; at least five sampling clocks when the noise canceler is used), before clearing the interrupt enable flag to 0. There are two ways of preventing interrupt request flag setting when the pin function is switched: by controlling the pin level so that the conditions shown in tables 9.15 and 9.16 are not satisfied, or by setting the opposite of the generated edge in the IIEGS bit in TMG.

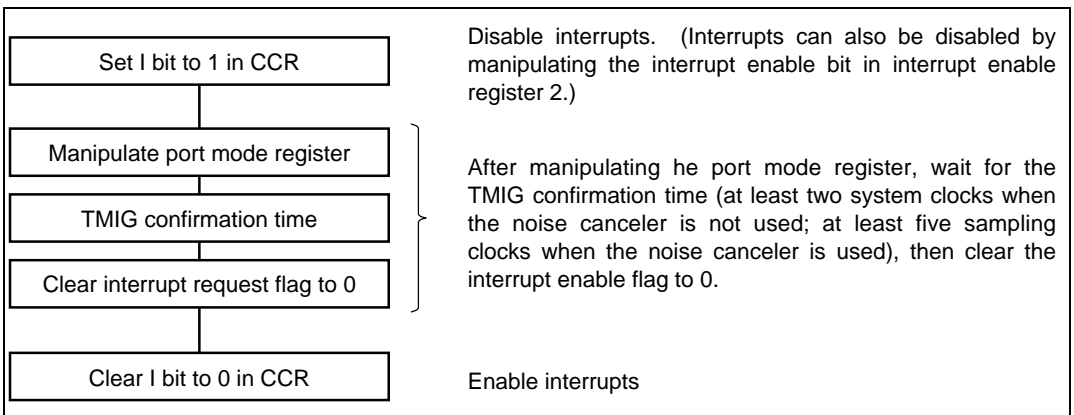


Figure 9.15 Port Mode Register Manipulation and Interrupt Enable Flag Clearing Procedure

9.5.6 Timer G Application Example

Using timer G, it is possible to measure the high and low widths of the input capture input signal as absolute values. For this purpose, CCLR1 and CCLR0 should both be set to 1 in TMG.

Figure 9.16 shows an example of the operation in this case.

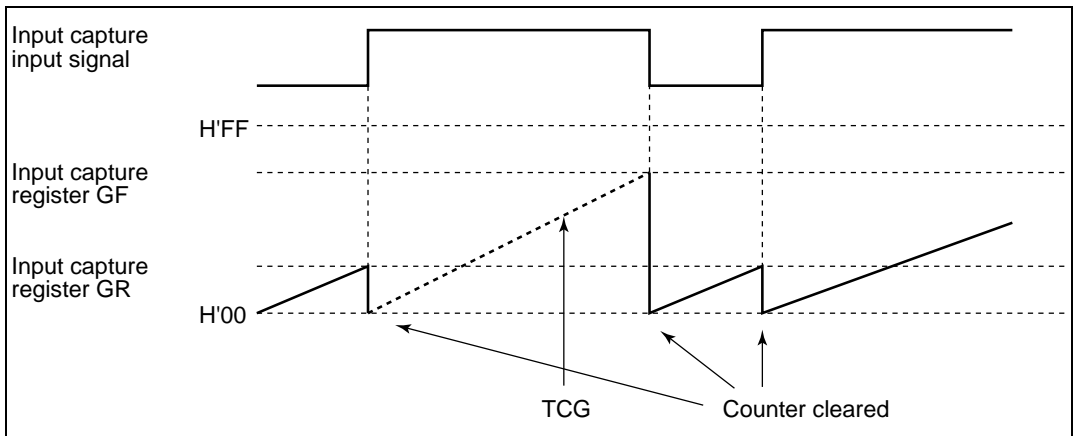


Figure 9.16 Timer G Application Example

9.6 Watchdog Timer

9.6.1 Overview

The watchdog timer has an 8-bit counter that is incremented by an input clock. If a system runaway allows the counter value to overflow before being rewritten, the watchdog timer can reset the chip internally.

1. Features

Features of the watchdog timer are given below.

- Incremented by internal clock source ($\phi/8192$ or $\phi_w/32$).
- A reset signal is generated when the counter overflows. The overflow period can be set from from 1 to 256 times $8192/\phi$ or $32/\phi_w$ (from approximately 4 ms to 1000 ms when $\phi = 2.00$ MHz).
- Use of module standby mode enables this module to be placed in standby mode independently when not used.

2. Block Diagram

Figure 9.17 shows a block diagram of the watchdog timer.

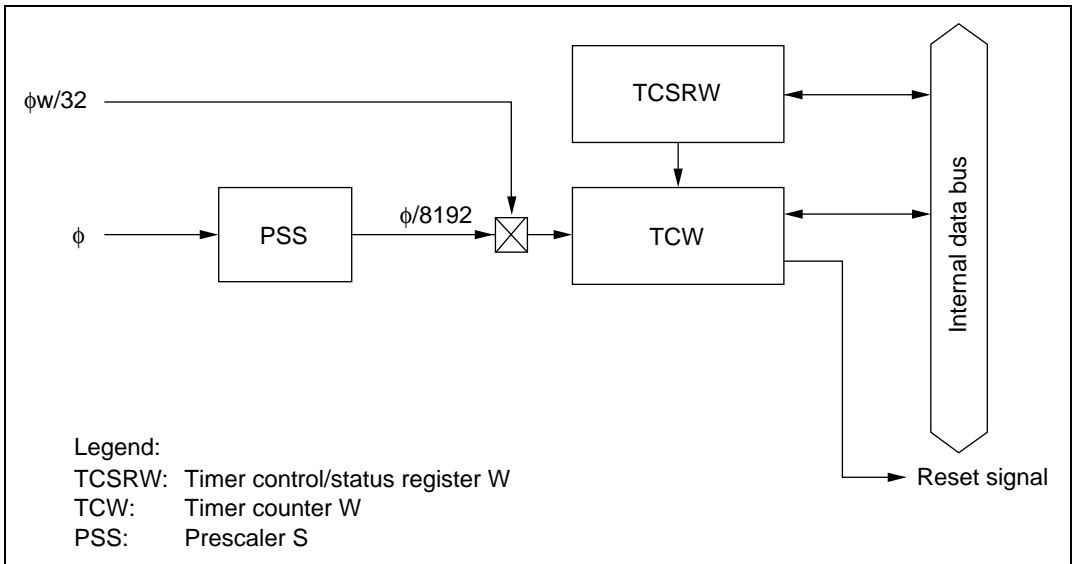


Figure 9.17 Block Diagram of Watchdog Timer

3. Register Configuration

Table 9.17 shows the register configuration of the watchdog timer.

Table 9.17 Watchdog Timer Registers

Name	Abbr.	R/W	Initial Value	Address
Timer control/status register W	TCSRW	R/W	H'AA	H'FFB2
Timer counter W	TCW	R/W	H'00	H'FFB3
Clock stop register 2	CKSTP2	R/W	H'FF	H'FFFB
Port mode register 3	PMR3	R/W	H'00	H'FFCA

9.6.2 Register Descriptions

1. Timer Control/Status Register W (TCSRW)

Bit	7	6	5	4	3	2	1	0
	B6WI	TCWE	B4WI	TCSRWE	B2WI	WDON	B0WI	WRST
Initial value	1	0	1	0	1	0	1	0
Read/Write	R	R/(W)*	R	R/(W)*	R	R/(W)*	R	R/(W)*

Note: * Write is permitted only under certain conditions, which are given in the descriptions of the individual bits.

TCSRW is an 8-bit read/write register that controls write access to TCW and TCSRW itself, controls watchdog timer operations, and indicates operating status.

Bit 7: Bit 6 write inhibit (B6WI)

Bit 7 controls the writing of data to bit 6 in TCSRW.

Bit 7

B6WI	Description
0	Bit 6 is write-enabled
1	Bit 6 is write-protected (initial value)

This bit is always read as 1. Data written to this bit is not stored.

Bit 6: Timer counter W write enable (TCWE)

Bit 6 controls the writing of data to TCW.

Bit 6

TCWE	Description	
0	Data cannot be written to TCW	(initial value)
1	Data can be written to TCW	

Bit 5: Bit 4 write inhibit (B4WI)

Bit 5 controls the writing of data to bit 4 in TCSRW.

Bit 5

B4WI	Description	
0	Bit 4 is write-enabled	
1	Bit 4 is write-protected	(initial value)

This bit is always read as 1. Data written to this bit is not stored.

Bit 4: Timer control/status register W write enable (TCSRWE)

Bit 4 controls the writing of data to TCSRW bits 2 and 0.

Bit 4

TCSRWE	Description	
0	Data cannot be written to bits 2 and 0	(initial value)
1	Data can be written to bits 2 and 0	

Bit 3: Bit 2 write inhibit (B2WI)

Bit 3 controls the writing of data to bit 2 in TCSRW.

Bit 3

B2WI	Description	
0	Bit 2 is write-enabled	
1	Bit 2 is write-protected	(initial value)

This bit is always read as 1. Data written to this bit is not stored.

Bit 2: Watchdog timer on (WDON)

Bit 2 enables watchdog timer operation.

Bit 2

WDON	Description	
0	Watchdog timer operation is disabled Clearing condition: Reset, or when TCSRWE = 1 and 0 is written in both B2WI and WDON	(initial value)
1	Watchdog timer operation is enabled Setting condition: When TCSRWE = 1 and 0 is written in B2WI and 1 is written in WDON	

Counting starts when this bit is set to 1, and stops when this bit is cleared to 0.

Bit 1: Bit 0 write inhibit (B0WI)

Bit 1 controls the writing of data to bit 0 in TCSRW.

Bit 1

B0WI	Description	
0	Bit 0 is write-enabled	
1	Bit 0 is write-protected	(initial value)

This bit is always read as 1. Data written to this bit is not stored.

Bit 0: Watchdog timer reset (WRST)

Bit 0 indicates that TCW has overflowed, generating an internal reset signal. The internal reset signal generated by the overflow resets the entire chip. WRST is cleared to 0 by a reset from the RES pin, or when software writes 0.

Bit 0

WRST	Description	
0	Clearing condition: Reset by $\overline{\text{RES}}$ pin When TCSRWE = 1, and 0 is written in both B0WI and WRST	
1	Setting condition: When TCW overflows and an internal reset signal is generated	

2. Timer Counter W (TCW)

Bit	7	6	5	4	3	2	1	0
	TCW7	TCW6	TCW5	TCW4	TCW3	TCW2	TCW1	TCW0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

TCW is an 8-bit read/write up-counter, which is incremented by internal clock input. The input clock is $\phi/8192$ or $\phi w/32$. The TCW value can always be written or read by the CPU.

When TCW overflows from H'FF to H'00, an internal reset signal is generated and WRST is set to 1 in TCSRW. Upon reset, TCW is initialized to H'00.

3. Clock Stop Register 2 (CKSTPR2)

Bit	7	6	5	4	3	2	1	0
	—	—	—	—	AECKSTP	WDCKSTP	PWCKSTP	LDCKSTP
Initial value	1	1	1	1	1	1	1	1
Read/Write	—	—	—	—	R/W	R/W	R/W	R/W

CKSTPR2 is an 8-bit read/write register that performs module standby mode control for peripheral modules. Only the bit relating to the watchdog timer is described here. For details of the other bits, see the sections on the relevant modules.

Bit 2: Watchdog timer module standby mode control (WDCKSTP)

Bit 2 controls setting and clearing of module standby mode for the watchdog timer.

WDCKSTP	Description
0	Watchdog timer is set to module standby mode
1	Watchdog timer module standby mode is cleared (initial value)

Note: WDCKSTP is valid when the WDON bit is cleared to 0 in timer control/status register W (TCSRW). If WDCKSTP is set to 0 while WDON is set to 1 (during watchdog timer operation), 0 will be set in WDCKSTP but the watchdog timer will continue its watchdog function and will not enter module standby mode. When the watchdog function ends and WDON is cleared to 0 by software, the WDCKSTP setting will become valid and the watchdog timer will enter module standby mode.

4. Port Mode Register 3 (PMR3)

Bit	7	6	5	4	3	2	1	0
	—	—	—	—	AECKSTP	WDCKSTP	PWCKSTP	LDCKSTP
Initial value	1	1	1	1	1	1	1	1
Read/Write	—	—	—	—	R/W	R/W	R/W	R/W

PMR3 is an 8-bit read/write register, mainly controlling the selection of pin functions for port 3 pins. Only the bit relating to the watchdog timer is described here. For details of the other bits, see section 8, I/O Ports.

Bit 5: Watchdog timer source clock select (WDCKS)

WDCKS	Description
0	$\phi/8192$ selected (initial value)
1	$\phi_w/32$ selected

9.6.3 Timer Operation

The watchdog timer has an 8-bit counter (TCW) that is incremented by clock input ($\phi/8192$ or $\phi_w/32$). The input clock is selected by bit WDCKS in port mode register 3 (PMR3): $\phi/8192$ is selected when WDCKS is cleared to 0, and $\phi_w/32$ when set to 1. When TCSRWE = 1 in TCSRW, if 0 is written in B2WI and 1 is simultaneously written in WDON, TCW starts counting up. When the TCW count value reaches H'FF, the next clock input causes the watchdog timer to overflow, and an internal reset signal is generated one base clock (ϕ or ϕ_{SUB}) cycle later. The internal reset signal is output for 512 clock cycles of the ϕ_{OSC} clock. It is possible to write to TCW, causing TCW to count up from the written value. The overflow period can be set in the range from 1 to 256 input clocks, depending on the value written in TCW.

Figure 9.18 shows an example of watchdog timer operations.

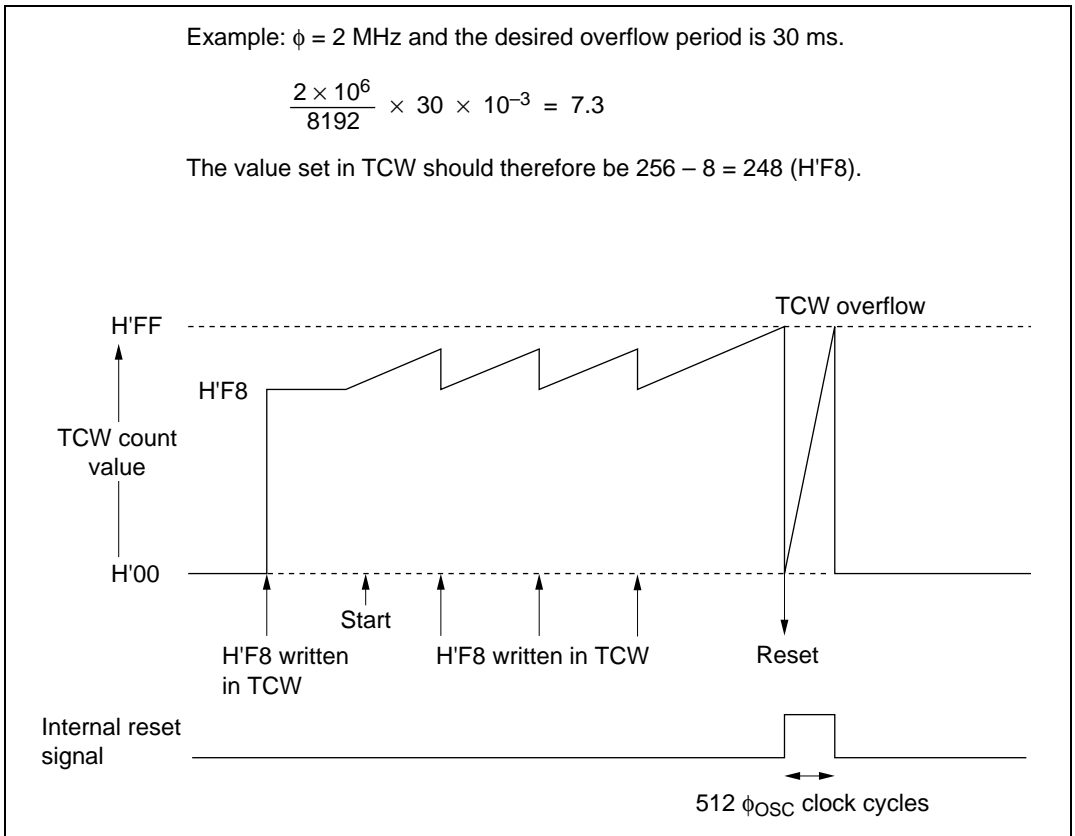


Figure 9.18 Typical Watchdog Timer Operations (Example)

9.6.4 Watchdog Timer Operation States

Table 9.18 summarizes the watchdog timer operation states.

Table 9.18 Watchdog Timer Operation States

Operation Mode	Reset	Active	Sleep	Watch	Subactive	Subsleep	Standby	Module Standby
TCW	Reset	Functions	Functions	Halted	Functions/ Halted*	Halted	Halted	Halted
TCSRW	Reset	Functions	Functions	Retained	Functions/ Halted*	Retained	Retained	Retained

Note: * Functions when $\phi w/32$ is selected as the input clock.

9.7 Asynchronous Event Counter (AEC)

9.7.1 Overview

The asynchronous event counter is incremented by external event clock input.

1. Features

Features of the asynchronous event counter are given below.

- Can count asynchronous events
- Can count external events input asynchronously without regard to the operation of base clocks ϕ and ϕ_{SUB} .
- The counter has a 16-bit configuration, enabling it to count up to 65536 (2^{16}) events.
- Can also be used as two independent 8-bit event counter channels.
- Counter resetting and halting of the count-up function controllable by software
- Automatic interrupt generation on detection of event counter overflow
- Use of module standby mode enables this module to be placed in standby mode independently when not used.

2. Block Diagram

Figure 9.19 shows a block diagram of the asynchronous event counter.

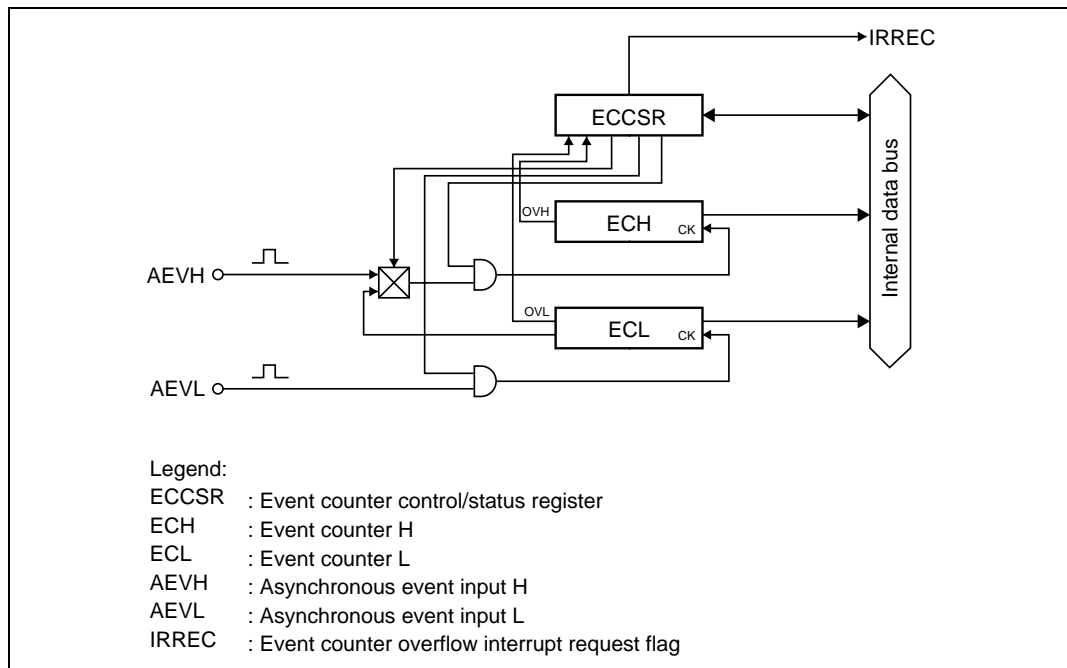


Figure 9.19 Block Diagram of Asynchronous Event Counter

3. Pin Configuration

Table 9.19 shows the asynchronous event counter pin configuration.

Table 9.19 Pin Configuration

Name	Abbr.	I/O	Function
Asynchronous event input H	AEVH	Input	Event input pin for input to event counter H
Asynchronous event input L	AEVL	Input	Event input pin for input to event counter L

4. Register Configuration

Table 9.20 shows the register configuration of the asynchronous event counter.

Table 9.20 Asynchronous Event Counter Registers

Name	Abbr.	R/W	Initial Value	Address
Event counter control/status register	ECCSR	R/W	H'00	H'FF95
Event counter H	ECH	R	H'00	H'FF96
Event counter L	ECL	R	H'00	H'FF97
Clock stop register 2	CKSTP2	R/W	H'FF	H'FFFB

9.7.2 Register Descriptions

1. Event Counter Control/Status Register (ECCSR)

Bit	7	6	5	4	3	2	1	0
	OVH	OVL	—	CH2	CUEH	CUEL	CRCH	CRCL
Initial Value	0	0	0	0	0	0	0	0
Read/Write	R/(W)*	R/(W)*	R/W	R/W	R/W	R/W	R/W	R/W

Note: * Bits 7 and 6 can only be written with 0, for flag clearing.

ECCSR is an 8-bit read/write register that controls counter overflow detection, counter resetting, and halting of the count-up function.

ECCSR is initialized to H'00 upon reset.

Bit 7: Counter overflow flag H (OVH)

Bit 7 is a status flag indicating that ECH has overflowed from H'FF to H'00. This flag is set when ECH overflows. It is cleared by software but cannot be set by software. OVH is cleared by reading it when set to 1, then writing 0.

When ECH and ECL are used as a 16-bit event counter with CH2 cleared to 0, OVH functions as a status flag indicating that the 16-bit event counter has overflowed from H'FFFF to H'0000.

Bit 7

OVH	Description	
0	ECH has not overflowed Clearing condition: After reading OVH = 1, cleared by writing 0 to OVH	(initial value)
1	ECH has overflowed Setting condition: Set when ECH overflows from H'FF to H'00	

Bit 6: Counter overflow flag L (OVL)

Bit 6 is a status flag indicating that ECL has overflowed from H'FF to H'00. This flag is set when ECL overflows. It is cleared by software but cannot be set by software. OVL is cleared by reading it when set to 1, then writing 0.

Bit 6

OVL	Description	
0	ECL has not overflowed Clearing condition: After reading OVL = 1, cleared by writing 0 to OVL	(initial value)
1	ECL has overflowed Setting condition: Set when ECL overflows from H'FF to H'00 while CH2 is set to 1	

Bit 5: Reserved bit

Bit 5 is reserved; it can be read and written, and is initialized to 0 upon reset.

Bit 4: Channel select (CH2)

Bit 4 selects whether ECH and ECL are used as a single-channel 16-bit event counter or as two independent 8-bit event counter channels. When CH2 is cleared to 0, ECH and ECL function as a 16-bit event counter which is incremented each time an event clock is input to the AEVL pin as asynchronous event input. In this case, the overflow signal from ECL is selected as the ECH input clock. When CH2 is set to 1, ECH and ECL function as independent 8-bit event counters which are incremented each time an event clock is input to the AEVH or AEVL pin, respectively, as asynchronous event input.

Bit 4

CH2	Description
0	ECH and ECL are used together as a single-channel 16-bit event counter (initial value)
1	ECH and ECL are used as two independent 8-bit event counter channels

Bit 3: Count-up enable H (CUEH)

Bit 3 enables event clock input to ECH. When 1 is written to this bit, event clock input is enabled and increments the counter. When 0 is written to this bit, event clock input is disabled and the ECH value is held. The AEVH pin or the ECL overflow signal can be selected as the event clock source by bit CH2.

Bit 3

CUEH	Description
0	ECH event clock input is disabled ECH value is held (initial value)
1	ECH event clock input is enabled

Bit 2: Count-up enable L (CUEL)

Bit 3 enables event clock input to ECL. When 1 is written to this bit, event clock input is enabled and increments the counter. When 0 is written to this bit, event clock input is disabled and the ECL value is held.

Bit 2**CUEL****Description**

0	ECL event clock input is disabled ECL value is held	(initial value)
1	ECL event clock input is enabled	

Bit 1: Counter reset control H (CRCH)

Bit 1 controls resetting of ECH. When this bit is cleared to 0, ECH is reset. When 1 is written to this bit, the counter reset is cleared and the ECH count-up function is enabled.

Bit 1**CRCH****Description**

0	ECH is reset	(initial value)
1	ECH reset is cleared and count-up function is enabled	

Bit 0: Counter reset control L (CRCL)

Bit 0 controls resetting of ECL. When this bit is cleared to 0, ECL is reset. When 1 is written to this bit, the counter reset is cleared and the ECL count-up function is enabled.

Bit 0**CRCL****Description**

0	ECL is reset	(initial value)
1	ECL reset is cleared and count-up function is enabled	

2. Event Counter H (ECH)

Bit	7	6	5	4	3	2	1	0
	ECH7	ECH6	ECH5	ECH4	ECH3	ECH2	ECH1	ECH0
Initial Value	0	0	0	0	0	0	0	0
Read/Write	R	R	R	R	R	R	R	R

ECH is an 8-bit read-only up-counter that operates either as an independent 8-bit event counter or as the upper 8-bit up-counter of a 16-bit event counter configured in combination with ECL. Either the external asynchronous event AEVH pin or the overflow signal from lower 8-bit counter ECL can be selected as the input clock source by bit CH2. ECH can be cleared to H'00 by software, and is also initialized to H'00 upon reset.

3. Event Counter L (ECL)

ECL is an 8-bit read-only up-counter that operates either as an independent 8-bit event counter or as the lower 8-bit up-counter of a 16-bit event counter configured in combination with ECH. The event clock from the external asynchronous event AEVL pin is used as the input clock source. ECL can be cleared to H'00 by software, and is also initialized to H'00 upon reset.

Bit	7	6	5	4	3	2	1	0
	ECL7	ECL6	ECL5	ECL4	ECL3	ECL2	ECL1	ECL0
Initial Value	0	0	0	0	0	0	0	0
Read/Write	R	R	R	R	R	R	R	R

4. Clock Stop Register 2 (CKSTPR2)

Bit	7	6	5	4	3	2	1	0
	—	—	—	—	AECKSTP	WDCKSTP	PWCKSTP	LDCKSTP
Initial value	1	1	1	1	1	1	1	1
Read/Write	—	—	—	—	R/W	R/W	R/W	R/W

CKSTPR2 is an 8-bit read/write register that performs module standby mode control for peripheral modules. Only the bit relating to the asynchronous event counter is described here. For details of the other bits, see the sections on the relevant modules.

Bit 3: Asynchronous event counter module standby mode control (AECKSTP)

Bit 3 controls setting and clearing of module standby mode for the asynchronous event counter.

AECKSTP	Description
0	Asynchronous event counter is set to module standby mode
1	Asynchronous event counter module standby mode is cleared (initial value)

9.7.3 Operation

1. 16-bit Event Counter Operation

When bit CH2 is cleared to 0 in ECCSR, ECH and ECL, operate as a 16-bit event counter. Figure 9.20 shows an example of the software processing when ECH and ECL are used as a 16-bit event counter.

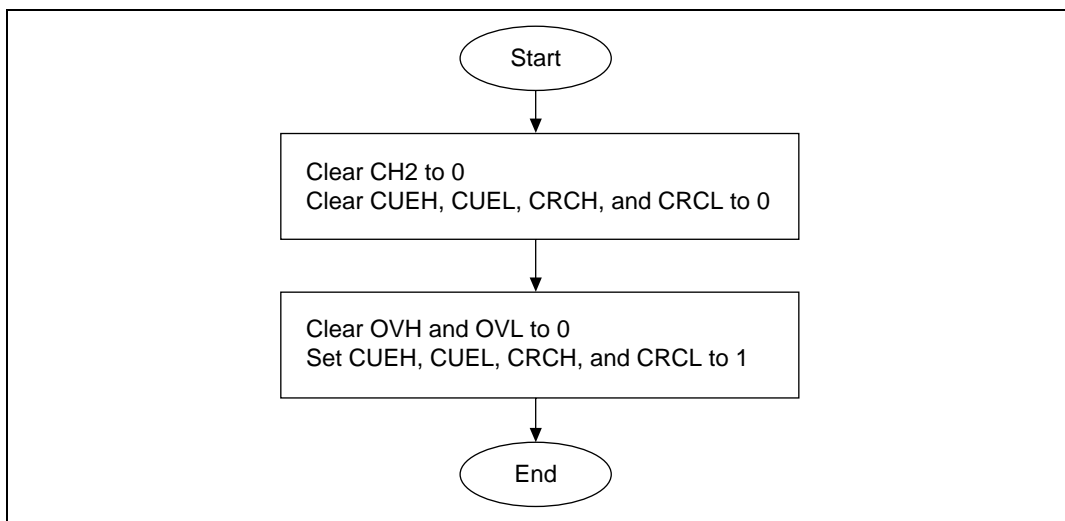


Figure 9.20 Example of Software Processing when Using ECH and ECL as 16-Bit Event Counter

As CH2 is cleared to 0 by a reset, ECH and ECL operate as a 16-bit event counter after a reset. They can also be used as a 16-bit event counter by carrying out the software processing shown in the example in figure 9.20. The operating clock source is asynchronous event input from the AEVL pin. When the next clock is input after the count value reaches H'FF in both ECH and ECL, ECH and ECL overflow from H'FFFF to H'0000, the OVH flag is set to 1 in ECCSR, the ECH and ECL count values each return to H'00, and counting up is restarted. When overflow

occurs, the IRREC bit is set to 1 in IRR2. If the IENEC bit in IENR2 is 1 at this time, an interrupt request is sent to the CPU.

2. 8-bit Event Counter Operation

When bit CH2 is set to 1 in ECCSR, ECH and ECL operate as independent 8-bit event counters. Figure 9.21 shows an example of the software processing when ECH and ECL are used as 8-bit event counters.

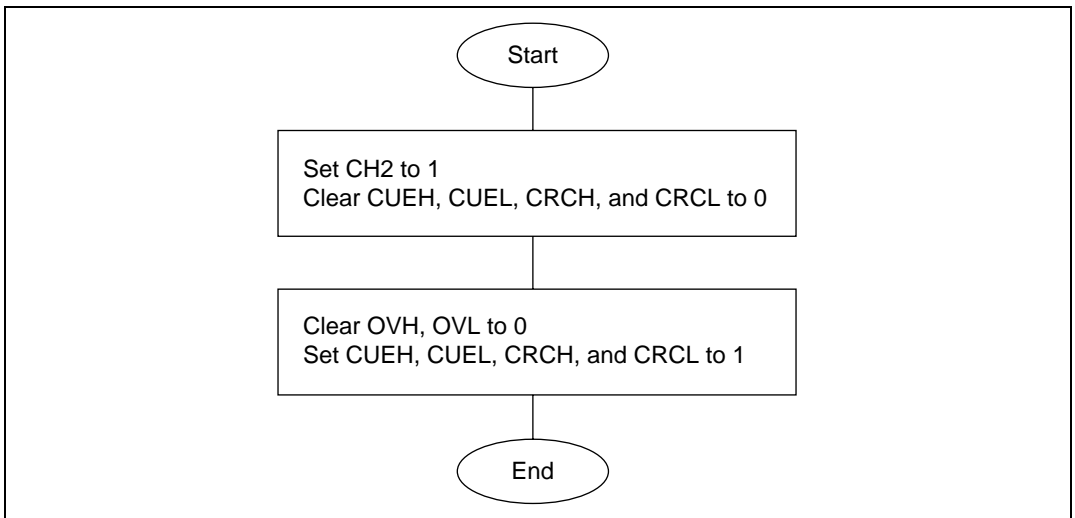


Figure 9.21 Example of Software Processing when Using ECH and ECL as 8-Bit Event Counters

ECH and ECL can be used as 8-bit event counters by carrying out the software processing shown in the example in figure 9.21. The 8-bit event counter operating clock source is asynchronous event input from the AEVH pin for ECH, and asynchronous event input from the AEVL pin for ECL. When the next clock is input after the ECH count value reaches H'FF, ECH overflows, the OVH flag is set to 1 in ECCSR, the ECH count value returns to H'00, and counting up is restarted. Similarly, when the next clock is input after the ECL count value reaches H'FF, ECL overflows, the OVL flag is set to 1 in ECCSR, the ECL count value returns to H'00, and counting up is restarted. When overflow occurs, the IRREC bit is set to 1 in IRR2. If the IENEC bit in IENR2 is 1 at this time, an interrupt request is sent to the CPU.

9.7.4 Asynchronous Event Counter Operation Modes

Asynchronous event counter operation modes are shown in table 9.21.

Table 9.21 Asynchronous Event Counter Operation Modes

Operation Mode	Reset	Active	Sleep	Watch	Subactive	Subsleep	Standby	Module Standby
ECCSR	Reset	Functions	Functions	Held*	Functions	Functions	Held*	Held
ECH	Reset	Functions	Functions	Functions*	Functions	Functions	Functions*	Halted
ECL	Reset	Functions	Functions	Functions*	Functions	Functions	Functions*	Halted

Note: * When an asynchronous external event is input, the counter increments but the counter overflow H/L flags are not affected.

9.7.5 Application Notes

1. When reading the values in ECH and ECL, the correct value will not be returned if the event counter increments during the read operation. Therefore, if the counter is being used in the 8-bit mode, clear bits CUEH and CUEL in ECCSR to 0 before reading ECH or ECL. If the counter is being used in the 16-bit mode, clear CUEL only to 0 before reading ECH or ECL.
2. In the H8/3847R Group, if the internal power supply step-down circuit is not used, the maximum clock frequency to be input to the AEVH and AEVL pins is 16 MHz when $V_{cc} = 4.5$ to 5.5 V, 10 MHz when $V_{cc} = 2.7$ to 5.5 V, and 4 MHz when $V_{cc} = 1.8$ to 5.5 V. If the internal power step-down circuit is used, the maximum clock frequency to be input is 10 MHz when $V_{cc} = 2.7$ to 5.5 V, and 4 MHz when $V_{cc} = 1.8$ to 5.5 V. In the H8/3847S Group, the maximum clock frequency to be input is 10 MHz when $V_{cc} = 2.7$ to 3.6 V, and 4 MHz when $V_{cc} = 1.8$ to 3.6 V. In the H8/38347 Group and H8/38447 Group, the maximum clock frequency to be input is 16 MHz when $V_{cc} = 2.7$ to 5.5 V. In addition, ensure that the high and low widths of the clock are at least 32 ns. The duty cycle is immaterial.

Mode		Maximum AEVH/AEVL Pin Input Clock Frequency
16-bit mode		H8/3847R Group
8-bit mode	Active (high-speed), sleep (high-speed)	<ul style="list-style-type: none"> When not using the internal step-down circuit <ul style="list-style-type: none"> $V_{CC} = 4.5$ to 5.5 V/16 MHz $V_{CC} = 2.7$ to 5.5 V/10 MHz $V_{CC} = 1.8$ to 5.5 V/4 MHz When using the internal step-down circuit <ul style="list-style-type: none"> $V_{CC} = 2.7$ to 5.5 V/10 MHz $V_{CC} = 1.8$ to 5.5 V/4 MHz
		H8/3847S Group <ul style="list-style-type: none"> $V_{CC} = 2.7$ to 3.6 V/10 MHz $V_{CC} = 1.8$ to 3.6 V/4 MHz
		H8/38347 Group <ul style="list-style-type: none"> $V_{CC} = 2.7$ to 5.5 V/16 MHz
		H8/38447 Group <ul style="list-style-type: none"> $V_{CC} = 4.5$ to 5.5 V/16 MHz $V_{CC} = 2.7$ to 5.5 V/10 MHz
8-bit mode	Active (medium-speed), sleep (medium-speed)	$(\phi/16)$ $2 \cdot f_{OSC}$ $(\phi/32)$ f_{OSC} $(\phi/64)$ $1/2 \cdot f_{OSC}$ $(\phi/128)$ $1/4 \cdot f_{OSC}$
	$f_{OSC} = 1$ MHz to 16 MHz	
8-bit mode	Watch, subactive, subsleep, standby	$(\phi_w/2)$ 1000 kHz $(\phi_w/4)$ 500 kHz $(\phi_w/8)$ 250 kHz
	$\phi_w = 32.768$ kHz or 38.4 kHz	

3. When using the clock in the 16-bit mode, set CUEH to 1 first, then set CRCH to 1 in ECCSR. Or, set CUEH and CRCH simultaneously before inputting the clock. After that, do not change the CUEH value while using in the 16-bit mode. Otherwise, an error counter increment may occur. Also, to reset the counter, clear CRCH and CRCL to 0 simultaneously or clear CRCL and CRCH to 0 sequentially, in that order.

Section 10 Serial Communication Interface

10.1 Overview

This LSI is provided with three serial communication interface (SCI) channels. The functions of the three SCI channels are summarized in table 10.1.

Table 10.1 Overview of SCI Functions

SCI Name	Functions	Features
SCI1	Synchronous serial transfer functions <ul style="list-style-type: none"> •Choice of transfer data length (8 or 16 bits) •Continuous clock output function 	<ul style="list-style-type: none"> •Choice of 8 internal clocks ($\phi/1024$ to $\phi/4$, $\phi_W/4$) or external clock •Open-drain output option •Interrupt generated on completion of transfer
SCI31, SCI32	Synchronous serial transfer functions <ul style="list-style-type: none"> •8-bit transfer data length •Transmission/reception/simultaneous transmission and reception Asynchronous serial transfer functions <ul style="list-style-type: none"> •Multiprocessor communication function •Choice of transfer data length (5 or 7 or 8 bits) •Choice of stop bit length (1 or 2 bits) •Parity addition function 	<ul style="list-style-type: none"> •On-chip baud rate generator •Receive error detection •Break detection •Interrupt generated on completion of transfer or in case of error

10.2 SCI1

10.2.1 Overview

Serial communication interface 1 (SCI1) can carry out 8-bit or 16-bit serial data transfer in synchronous mode. It is also provided with a communication function called a Synchronized Serial Bus (SSB) that enables a number of ICs to be controlled.

1. Features

Features of SCI1 are listed below.

- Choice of 8-bit or 16-bit transfer data length
- Choice of 8 internal clocks ($\phi/1024$, $\phi/256$, $\phi/64$, $\phi/32$, $\phi/16$, $\phi/8$, $\phi/4$, or $\phi_W/4$) or external clock as clock source
- Interrupt request generated on completion of transfer
- Choice of hold mode or latch mode in SSB mode

2. Block Diagram

Figure 10.1 shows a block diagram of SCI1.

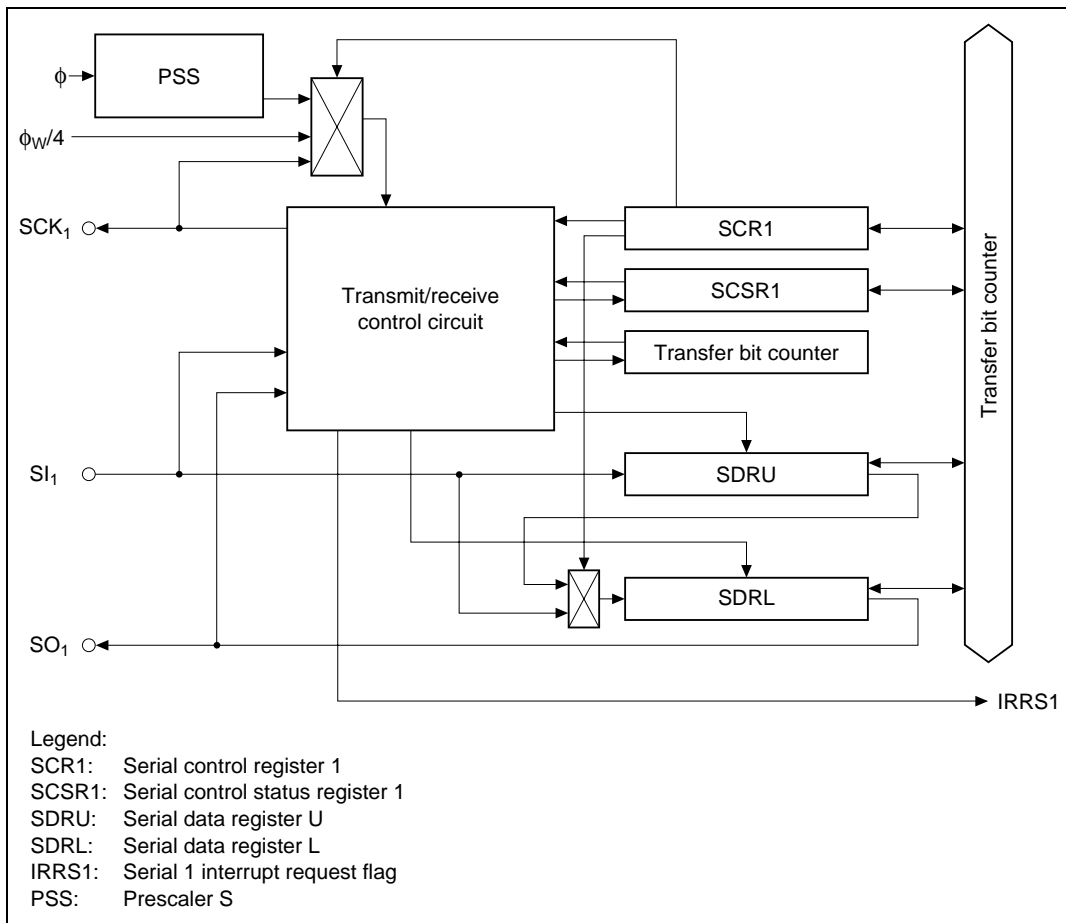


Figure 10.1 SCI1 Block Diagram

3. Pin Configuration

Table 10.2 shows the SCI1 pin configuration.

Table 10.2 SCI1 Pin Configuration

Name	Abbr.	I/O	Function
SCI1 clock	SCK ₁	I/O	SCI1 clock input/output
SCI1 data input	SI ₁	Input	SCI1 receive data input
SCI1 data output	SO ₁	Output	SCI1 transmit data output

4. Register Configuration

Table 10.3 shows the SCI1 register configuration.

Table 10.3 Registers

Name	Abbr.	R/W	Initial Value	Address
Serial control register 1	SCR1	R/W	H'00	H'FFA0
Serial control status register 1	SCSR1	R/W	H'9C	H'FFA1
Serial data register U	SDRU	R/W	Undefined	H'FFA2
Serial data register L	SDRL	R/W	Undefined	H'FFA3
Clock stop register 1	CKSTPR1	R/W	H'FF	H'FFFA

10.2.2 Register Descriptions

1. Serial Control Register 1 (SCR1)

Bit	7	6	5	4	3	2	1	0
	SNC1	SNC0	MRKON	LTCH	CKS3	CKS2	CKS1	CKS0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

SCR1 is an 8-bit read/write register that controls the operating mode, serial clock source, and prescaler division ratio.

Upon reset, SCR1 is initialized to H'00. If this register is written to during transfer, transfer will be halted.

Bits 7 and 6: Operating mode select 1 and 0 (SNC1, SNC0)

Bits 7 and 6 select the operating mode.

Bit 7 SNC1	Bit 6 SNC0	Description	
0	0	8-bit synchronous mode	(initial value)
0	1	16-bit synchronous mode	
1	0	Continuous clock output mode* ¹	
1	1	Reserved* ²	

- Notes: 1. Use pins SI₁ and SO₁ as ports.
2. Do not set bits SNC1 and SNC0 to 11.

Bit 5: TAIL MARK control (MRKON)

Bit 5 controls tail mark output after transfer of 8-bit or 16-bit data.

Bit 5 MRKON	Description	
0	TAIL MARK is not output (synchronous mode)	(initial value)
1	TAIL MARK is output (SSB mode)	

Bit 4: LATCH TAIL select (LTCH)

Bit 4 selects whether LATCH TAIL or HOLD TAIL is output as the tail mark when MRKON = 1 (i.e. in SSB mode).

Bit 4 LTCH	Description	
0	HOLD TAIL is output	(initial value)
1	LATCH TAIL is output	

Bit 3: Clock source select 3 (CKS3)

Bit 3 selects the clock source to be supplied and sets the SCK₁ pin to input or output mode.

Bit 3

CKS3	Description
0	Clock source is prescaler S, SCK ₁ is output pin (initial value)
1	Clock source is external clock, SCK ₁ is input pin

Bits 2 to 0: Clock select 2 to 0 (CKS2 to CKS0)

When CKS3 is cleared to 0, bits 2 to 0 selects the prescaler division ratio and the serial clock cycle.

Bit 2 CKS2	Bit 1 CKS1	Bit 0 CKS0	Prescaler Division Ratio	Serial Clock Cycle $\phi = 2.5 \text{ MHz}$
0	0	0	$\phi/1024$ (initial value)	409.6 μs
0	0	1	$\phi/256$	102.4 μs
0	1	0	$\phi/64$	25.6 μs
0	1	1	$\phi/32$	12.8 μs
1	0	0	$\phi/16$	6.4 μs
1	0	1	$\phi/8$	3.2 μs
1	1	0	$\phi/4$	1.6 μs
1	1	1	$\phi_w/4$	122 μs

2. Serial Control Status Register 1 (SCSR1)

Bit	7	6	5	4	3	2	1	0
	—	SOL	ORER	—	—	—	MTRF	STF
Initial value	1	0	0	1	1	1	0	0
Read/Write	—	R/W	R/(W)*	—	—	—	R	R/W

Note: * Only a write of 0 for flag clearing is possible.

SCSR1 is an 8-bit register that indicates the operational and error status of SCI1.

Upon reset, SCSR1 is initialized to H'9C.

Bit 7: Reserved bit

Bits 7 is reserved; it is always read as 1 and cannot be modified.

Bit 6: Extension data bit (SOL)

The SOL bit changes the output level of the SO₁ pin. When read, SOL returns the output level of the SO₁ pin. After transfer is completed, SO₁ pin output retains the value of the last bit of the transmit data, and therefore the SO₁ pin output level can be changed by manipulating this bit before or after transmission. However, the SOL bit setting becomes invalid when the next transmission starts*. Therefore, when changing the SO₁ pin output level after transmission, a write operation must be performed on the SOL bit each time transmission is completed. Writing to this register during data transfer will cause incorrect operation, so this register should not be manipulated during transmission.

Note: * The SOL bit setting is also invalid in SSB mode.

Bit 6

SOL	Description	
0	Read	SO ₁ pin output level is low (initial value)
	Write	Changes SO ₁ pin output to low level
1	Read	SO ₁ pin output level is high
	Write	Changes SO ₁ pin output to high level

Bit 5: Overrun error flag (ORER)

Bit 5 indicates that an overrun error has occurred when using an external clock. If extra pulses are superimposed on the regular serial clock due to extraneous noise, etc., the transfer data cannot be guaranteed. If the clock is input after transfer is completed, this will be interpreted as an overrun state and this bit will be set to 1.

Bit 5

ORER	Description	
0	Clearing condition: After reading ORER = 1, cleared by writing 0 to ORER	(initial value)
1	Setting condition: When an external clock is used and the clock is input after transfer is completed	

Bits 4 to 2: Reserved bits

Bits 4 to 2 are reserved; they are always read as 0 and cannot be modified.

Bit 1: Tail mark transmission flag (MTRF)

When MRKON = 1, bit 1 indicates that a tail mark is being transmitted. MTRF is a read-only bit, and cannot be modified.

Bit 1

MTRF	Description	
0	Idle state, or 8-bit/16-bit data transfer in progress	(initial value)
1	Tail mark transmission in progress	

Bit 0: Start flag (STF)

The STF bit controls the start of transfer operations. SCI1 transfer operation is started when this bit is set to 1.

STF remains set to 1 during transfer and while SCI1 is waiting for a start bit, and is cleared to 0 when transfer ends.

Bit 0

STF	Description		
0	Read	Transfer operation stopped	(initial value)
	Write	Invalid	
1	Read	Transfer operation in progress	
	Write	Starts transfer operation	

3. Serial Data Register U (SDRU)

Bit	7	6	5	4	3	2	1	0
	SDRU7	SDRU6	SDRU5	SDRU4	SDRU3	SDRU2	SDRU1	SDRU0
Initial value	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

SDRU is an 8-bit read/write register used as the data register for the upper 8 bits in 16-bit transfer (while SDRL is used for the lower 8 bits).

The data written into SDRU is output to SDRL in LSB-first order. In the replacement process, data is input LSB-first from the SI₁ pin, and the data is shifted in the MSB → LSB direction.

SDRU read/write operations must only be performed after data transmission/reception has been completed. Data contents are not guaranteed if read/write operations are executed while data transmission/reception is in progress.

The value of SDRU is undefined upon reset.

4. Serial Data Register L (SDRL)

Bit	7	6	5	4	3	2	1	0
	SDRL7	SDRL6	SDRL5	SDRL4	SDRL3	SDRL2	SDRL1	SDRL0
Initial value	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

SDRL is an 8-bit read/write register used as the data register in 8-bit transfer, and as the data register for the lower 8 bits in 16-bit transfer (while SDRU is used for the upper 8 bits).

In 8-bit transfer, the data written into SDRL is output from the SO₁ pin in LSB-first order. In the replacement process, data is input LSB-first from the SI₁ pin, and the data is shifted in the MSB → LSB direction.

The operation in 16-bit transfer is the same as for 8-bit transfer, except that the input data is taken from SDRU.

SDRL read/write operations must only be performed after data transmission/reception has been completed. Data contents are not guaranteed if read/write operations are executed while data transmission/reception is in progress.

The value of SDRL is undefined upon reset.

5. Clock Stop Register 1 (CKSTPR1)

Bit	7	6	5	4	3	2	1	0
	S1CKSTP	S31CKSTP	S32CKSTP	ADCKSTP	TGCKSTP	TFCKSTP	TCKCKSTP	TACKSTP
Initial value	1	1	1	1	1	1	1	1
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

CKSTPR1 is an 8-bit read/write register that performs module standby mode control for peripheral modules. Only the bit relating to SC11 is described here. For details of the other bits, see the sections on the relevant modules.

Bit 7: SCI1 module standby mode control (S1CKSTP)

Bit 7 controls setting and clearing of module standby mode for SCI1.

Bit 7

S1CKSTP	Description
0	SCI1 is set to module standby mode*
1	SCI1 module standby mode is cleared (initial value)

Note: * Setting to module standby mode resets SCR1, SCSR1, SDRU, and SDRL.

10.2.3 Operation

Either 8-bit or 16-bit transfer data can be selected as the transfer format. An internal clock or external clock can be selected as the clock source. When an external clock is used, overrun errors can be detected.

1. Clock

The serial clock can be selected from 8 internal clocks or an external clock. When an internal clock is selected, the SCK₁ pin functions as the clock output pin. When continuous clock output mode is set (SNC1, SNC0 = 10 in SCR1), the clock selected by bits CKS2 to CKS0 ($\phi/1024$ to $\phi_W/4$) is output continuously from the SCK₁ pin. When an external clock is selected, the SCK₁ pin functions as the clock input pin.

2. Data Transfer Format

The SCI1 transfer format is shown in figure 10.2. LSB-first transfer is used (i.e. transmission and reception are performed starting with the least significant bit of the transfer data). Transfer data is output from one falling edge of the serial clock until the next falling edge. Receive data is latched at the rising edge of the serial clock.

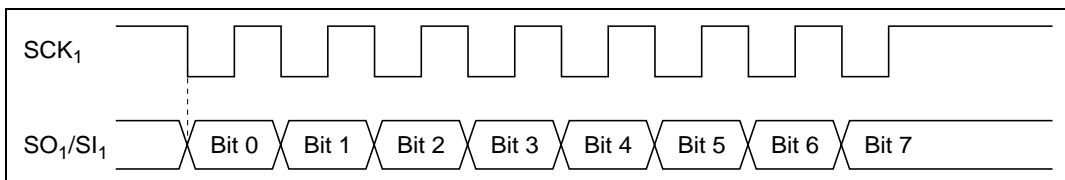


Figure 10.2 Transfer Format

3. Data Transfer Operations

Transmitting: The procedure for transmitting data is as follows.

- (1) Set both SO1 and SCK1 to 1 in PMR2 to designate the SO₁ and SCK₁ pin functions. If necessary, also designate the SO₁ pin as an NMOS open-drain output with bit POF1 in PMR2.
- (2) Clear SNC1 in SCR1 to 0, clear or set SNC0 to 0 or 1, and clear MRKON to 0, to select 8-bit synchronous mode or 16-bit synchronous mode, and select the serial clock with bits CKS3 to CKS0. When data is written to SCR1 with MRKON in SCR1 cleared to 0, the internal state of SCII is initialized.
- (3) Write the transfer data to SDRL/SDRU.
8-bit transfer mode: SDRL
16-bit transfer mode: Upper byte to SDRU, lower byte to SDRL
- (4) When STF is set to 1 in SCSR1, SCII starts operating and transmit data is output from the SO1 pin.
- (5) After transmission is completed, IRRS1 is set to 1 in IRR1.

When an internal clock is used, the serial clock is output from the SCK₁ pin simultaneously with transmit data output. When transmission ends, the serial clock is not output until the start flag is next set to 1. During this interval, the SO₁ pin continuously outputs the last bit of the previous data.

When an external clock is used, data is transmitted in synchronization with the clock input from the SCK₁ pin. If the serial clock continues to be input after the end of transmission, this is regarded as an overrun state, and the ORER flag is set to 1 in SCSR1 (consequently, transmission is not performed).

While transmission is halted, the output value of the SO₁ pin can be changed by means of the SOL bit in SCSR1.

Receiving: The procedure for receiving data is as follows.

- (1) Set both SII and SCK1 to 1 in PMR2 to designate the SI₁ and SCK₁ pin functions.
- (2) Clear SNC1 in SCR1 to 0, clear or set SNC0 to 0 or 1, and clear MRKON to 0, to select 8-bit synchronous mode or 16-bit synchronous mode, and select the serial clock with bits CKS3 to CKS0. When data is written to SCR1 with MRKON in SCR1 cleared to 0, the internal state of SCII is initialized.
- (3) When STF is set to 1 in SCSR1, SCII starts operating and receive data is taken in from the SII pin.
- (4) After reception is completed, IRRS1 is set to 1 in IRR1.

(5) Read the transfer data from SDRL/SDRU.

8-bit transfer mode: SDRL

16-bit transfer mode: Upper byte from SDRU, lower byte from SDRL

(6) If the serial clock continues to be input after the end of reception, this is regarded as an overrun state, and the ORER flag is set to 1 in SCSR1 (consequently, reception is not performed).

Simultaneous transmitting and receiving: The procedure for simultaneously transmitting and receiving data is as follows.

(1) Set SO1, SI1, and SCK1 all to 1 in PMR2 to designate the SO1, SI1, and SCK1 pin functions. If necessary, also designate the SO1 pin as an NMOS open-drain output with bit POF1 in PMR2.

(2) Clear SNC1 in SCR1 to 0, clear or set SNC0 to 0 or 1, and clear MRKON to 0, to select 8-bit synchronous mode or 16-bit synchronous mode, and select the serial clock with bits CKS3 to CKS0. When data is written to SCR1 with MRKON in SCR1 cleared to 0, the internal state of SCII is initialized.

(3) Write the transfer data to SDRL/SDRU.

8-bit transfer mode: SDRL

16-bit transfer mode: Upper byte to SDRU, lower byte to SDRL

(4) When STF is set to 1 in SCSR1, SCII starts operating and transmit data is output from the SO1 pin, or receive data is input from the SI1 pin.

(5) After transmission/reception is completed, IRRS1 is set to 1 in IRR1.

(6) Read the transfer data from SDRL/SDRU.

8-bit transfer mode: SDRL

16-bit transfer mode: Upper byte from SDRU, lower byte from SDRL

When an internal clock is used, the serial clock is output from the SCK1 pin simultaneously with transmit data output. When transmission ends, the serial clock is not output until the start flag is next set to 1. During this interval, the SO1 pin continuously outputs the last bit of the previous data.

When an external clock is used, data is transmitted and received in synchronization with the clock input from the SCK1 pin. If the serial clock continues to be input after the end of transmission/reception, this is regarded as an overrun state, and the ORER flag is set to 1 in SCSR1 (consequently, transmission/reception is not performed).

While transmission is halted, the output value of the SO1 pin can be changed by means of the SOL bit in SCSR1.

10.2.4 Operation in SSB Mode

SSB communication uses two lines, SCL (Serial Clock) and SDA (Serial Data), and enables a number of ICs to be controlled when connected as shown in figure 10.3.

In SSB mode, a tail mark is attached and transmitted following an 8-bit or 16-bit data transfer. Either HOLD TAIL or LATCH TAIL can be selected as the tail mark.

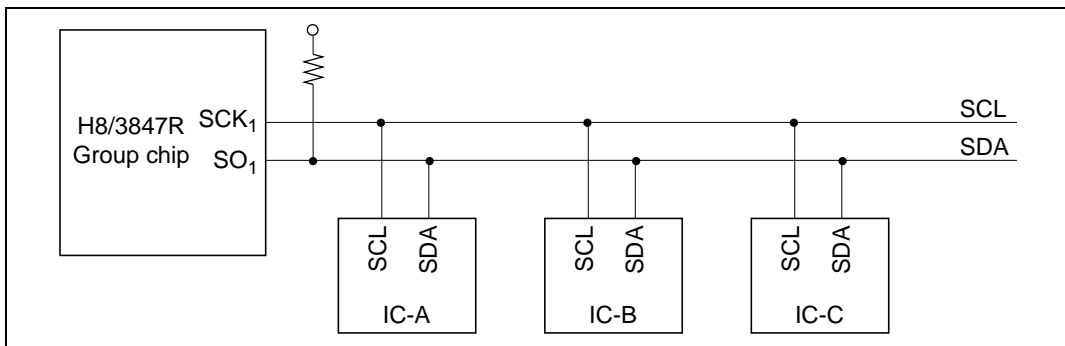


Figure 10.3 Example of SSB Connections

1. Clock

The serial clock can be selected from 8 internal clocks or an external clock, but since the H8/3847 Group chip provides the clock output, an external clock should not be selected. The transfer rate can be selected with bits CKS2 to CKS0 in SCR1; since this is also the tail mark transfer rate, the setting should provide for a serial clock cycle of at least 2 μ s.

2. Data Transfer Format

The SCI1 transfer format is shown in figure 10.4. LSB-first transfer is used (i.e. transmission is performed starting with the least significant bit of the transfer data). A tail mark is added after an 8-bit or 16-bit transfer.

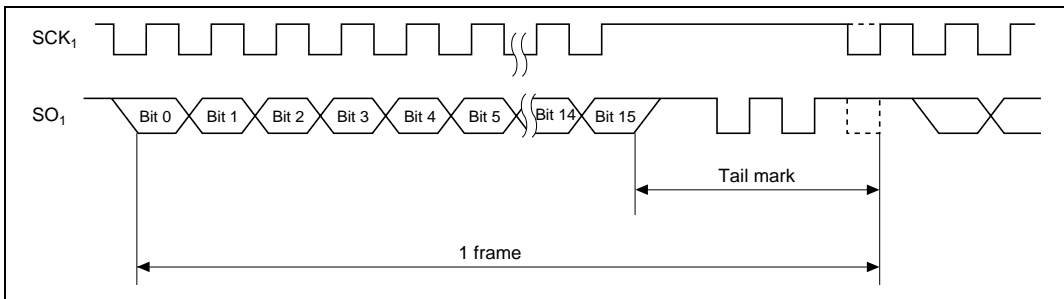


Figure 10.4 Transfer Format (When SNC1 = 0, SNC0 = 1, MRKON = 1)

3. Tail Mark

There are two tail marks: HOLD TAIL and LATCH TAIL. The output waveforms of HOLD TAIL and LATCH TAIL are shown in figure 10.5. Time t in figure 10.5 is determined by the serial clock cycle set by bits CKS2 to CKS0 in SCR1.

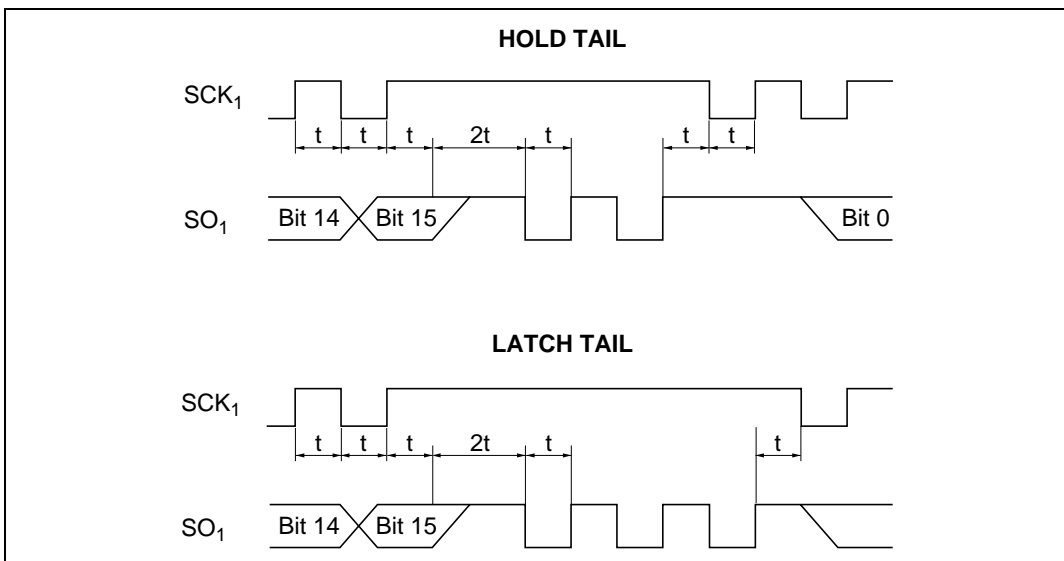


Figure 10.5 HOLD TAIL and LATCH TAIL Output Waveforms

4. Transmitting

The procedure for transmitting data is as follows.

- (1) Set SOL to 1 in SCSR1.
- (2) Set both SO1 and SCK1 to 1 in PMR2 to designate the SO₁ and SCK₁ pin functions. Set POF1 to 1 in PMR2 to designate the SO₁ pin as an NMOS open-drain output.
- (3) Clear SNC1 in SCR1 to 0, and clear or set SNC0 to 0 or 1, to select 8-bit mode or 16-bit mode. Set MRKON to 1 in SCR1 to select SSB mode.
- (4) Write the transfer data to SDRL/SDRU. Set the tail mark with LTCH in SCR1.
8-bit transfer mode: SDRL
16-bit transfer mode: Upper byte to SDRU, lower byte to SDRL
- (5) When STF is set to 1 in SCSR1, SCI1 starts operating and transmit data is output from the SO₁ pin.
- (6) After 8-bit or 16-bit data has been transmitted, STF is reset to 0 in SCSR1 and at the same time IRRS1 is set to 1 in IRR2. Following data transmission, the selected tail mark is output. MTRF is set to 1 in SCSR1 during tail mark output.

Data can be transmitted continuously by repeating steps (4) to (6). Ensure that SCI1 is in the idle state before modifying the MRKON bit in SCR1.

10.2.5 Interrupt Source

SCI1 has one interrupt source: transfer completion.

When SCI1 completes transfer, IRRS1 is set to 1 in IRR1. The SCI1 interrupt source can be enabled or disabled by the IENS1 bit in IENR1.

For details, see section 3.3, Interrupts.

10.2.6 Application Notes

- (1) When SCK_1 is designated as an input pin and an external clock is selected as the clock source, the external clock must not be input before transfer operation is started by setting STF to 1 in SCSR1.
- (2) In subactive or subsleep mode, SCI1 can be used only when the CPU operation clock is $\phi_w/2$.
- (3) Do not read or write to SCSR1 during serial transfer. Use one of the following methods to confirm that serial transfer has ended.
 - (a) Use SCI1 interrupt exception handling.

Set IENS1 to 1 in IENR1, and execute interrupt exception handling.
 - (b) Perform IRR1 polling.

Confirm that IRRS1 has been set to 1 in IRR1 while SCI interrupts are disabled (IENS1 = 0 in IEHR1).

10.3 SCI3

10.3.1 Overview

In addition to SCI1, this LSI has two serial communication interfaces, SCI3-1 and SCI3-2, with identical functions. In this manual, the generic term SCI3 is used to refer to both of these SCIs.

Serial communication interface 3 (SCI3) can carry out serial data communication in either asynchronous or synchronous mode. It is also provided with a multiprocessor communication function that enables serial data to be transferred among processors.

1. Features

Features of SCI3 are listed below.

- Choice of asynchronous or synchronous mode for serial data communication
 - Asynchronous mode

Serial data communication is performed asynchronously, with synchronization provided character by character. In this mode, serial data can be exchanged with standard asynchronous communication LSIs such as a Universal Asynchronous Receiver/Transmitter (UART) or Asynchronous Communication Interface Adapter (ACIA). A multiprocessor communication function is also provided, enabling serial data communication among processors.

There is a choice of 16 data transfer formats.

Data length	7, 8, 5 bits
Stop bit length	1 or 2 bits
Parity	Even, odd, or none
Multiprocessor bit	"1" or "0"
Receive error detection	Parity, overrun, and framing errors
Break detection	Break detected by reading the RXD _{3X} pin level directly when a framing error occurs

— Synchronous mode

Serial data communication is synchronized with a clock. In this mode, serial data can be exchanged with another LSI that has a synchronous communication function.

Data length	8 bits
Receive error detection	Overrun errors

• Full-duplex communication

Separate transmission and reception units are provided, enabling transmission and reception to be carried out simultaneously. The transmission and reception units are both double-buffered, allowing continuous transmission and reception.

- On-chip baud rate generator, allowing any desired bit rate to be selected
- Choice of an internal or external clock as the transmit/receive clock source
- Six interrupt sources: transmit end, transmit data empty, receive data full, overrun error, framing error, and parity error

2. Block Diagram

Figure 10.6 shows a block diagram of SCI3.

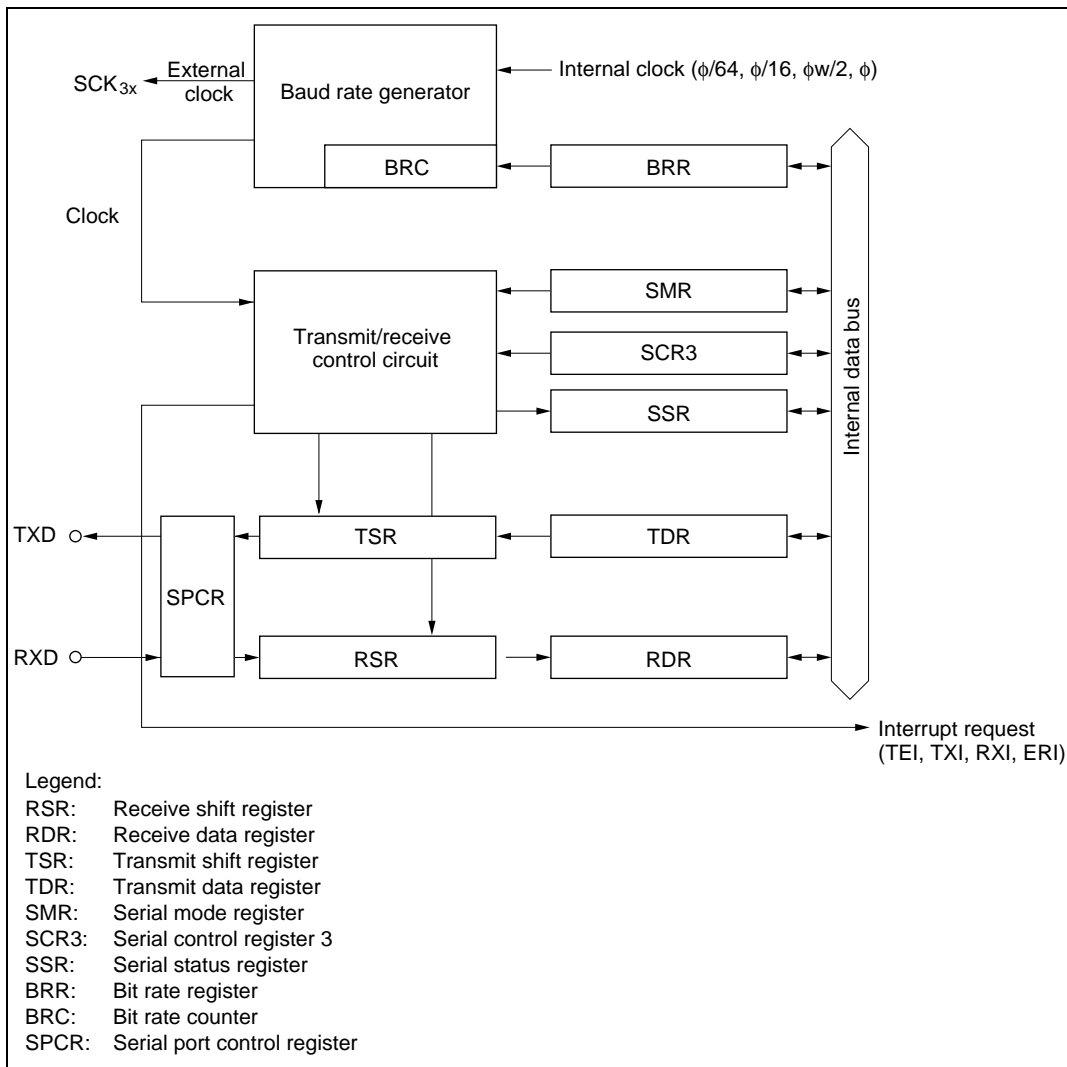


Figure 10.6 SCI3 Block Diagram

3. Pin Configuration

Table 10.4 shows the SCI3 pin configuration.

Table 10.4 Pin Configuration

Name	Abbr.	I/O	Function
SCI3 clock	SCK _{3X}	I/O	SCI3 clock input/output
SCI3 receive data input	RXD _{3X}	Input	SCI3 receive data input
SCI3 transmit data output	TXD _{3X}	Output	SCI3 transmit data output

4. Register Configuration

Table 10.5 shows the SCI3 register configuration.

Table 10.5 Registers

Name	Abbr.	R/W	Initial Value	Address
Serial mode register	SMR	R/W	H'00	H'FFA8/FF98
Bit rate register	BRR	R/W	H'FF	H'FFA9/FF99
Serial control register 3	SCR3	R/W	H'00	H'FFAA/FF9A
Transmit data register	TDR	R/W	H'FF	H'FFAB/FF9B
Serial data register	SSR	R/W	H'84	H'FFAC/FF9C
Receive data register	RDR	R	H'00	H'FFAD/FF9D
Transmit shift register	TSR	Protected	—	—
Receive shift register	RSR	Protected	—	—
Bit rate counter	BRC	Protected	—	—
Clock stop register 1	CKSTPR1	R/W	H'FF	H'FFFA
Serial port control register	SPCR	R/W	H'C0	H'FF91

10.3.2 Register Descriptions

1. Receive Shift Register (RSR)

Bit	7	6	5	4	3	2	1	0
Read/Write	—	—	—	—	—	—	—	—

RSR is a register used to receive serial data. Serial data input to RSR from the RXD_{3X} pin is set in the order in which it is received, starting from the LSB (bit 0), and converted to parallel data. When one byte of data is received, it is transferred to RDR automatically.

RSR cannot be read or written directly by the CPU.

2. Receive Data Register (RDR)

Bit	7	6	5	4	3	2	1	0
	RDR7	RDR6	RDR5	RDR4	RDR3	RDR2	RDR1	RDR0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R	R	R	R	R	R	R	R

RDR is an 8-bit register that stores received serial data.

When reception of one byte of data is finished, the received data is transferred from RSR to RDR, and the receive operation is completed. RSR is then able to receive data. RSR and RDR are double-buffered, allowing consecutive receive operations.

RDR is a read-only register, and cannot be written by the CPU.

RDR is initialized to H'00 upon reset, and in standby, watch or module standby mode.

3. Transmit Shift Register (TSR)

Bit	7	6	5	4	3	2	1	0
Read/Write	—	—	—	—	—	—	—	—

TSR is a register used to transmit serial data. Transmit data is first transferred from TDR to TSR, and serial data transmission is carried out by sending the data to the TXD_{3X} pin in order, starting from the LSB (bit 0). When one byte of data is transmitted, the next byte of transmit data is transferred to TDR, and transmission started, automatically. Data transfer from TDR to TSR is not performed if no data has been written to TDR (if bit TDRE is set to 1 in the serial status register (SSR)).

TSR cannot be read or written directly by the CPU.

4. Transmit Data Register (TDR)

Bit	7	6	5	4	3	2	1	0
	TDR7	TDR6	TDR5	TDR4	TDR3	TDR2	TDR1	TDR0
Initial value	1	1	1	1	1	1	1	1
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

TDR is an 8-bit register that stores transmit data. When TSR is found to be empty, the transmit data written in TDR is transferred to TSR, and serial data transmission is started. Continuous transmission is possible by writing the next transmit data to TDR during TSR serial data transmission.

TDR can be read or written by the CPU at any time.

TDR is initialized to H'FF upon reset, and in standby, watch or module standby mode.

5. Serial Mode Register (SMR)

Bit	7	6	5	4	3	2	1	0
	COM	CHR	PE	PM	STOP	MP	CKS1	CKS0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

SMR is an 8-bit register used to set the serial data transfer format and to select the clock source for the baud rate generator.

SMR can be read or written by the CPU at any time.

SMR is initialized to H'00 upon reset, and in standby, watch or module standby mode.

Bit 7: Communication mode (COM)

Bit 7 selects whether SCI3 operates in asynchronous mode or synchronous mode.

Bit 7

COM	Description
0	Asynchronous mode (initial value)
1	Synchronous mode

Bit 6: Character length (CHR)

Bit 6 selects either 7 or 8 bits as the data length to be used in asynchronous mode. In synchronous mode the data length is always 8 bits, irrespective of the bit 6 setting.

Bit 6

CHR	Description
0	8-bit data/5-bit data* ² (initial value)
1	7-bit data* ¹ /5-bit data* ²

Notes: 1. When 7-bit data is selected, the MSB (bit 7) of TDR is not transmitted.

2. When 5-bit data is selected, set both PE and MP to 1. The three most significant bits (bits 7, 6, and 5) of TDR are not transmitted.

Bit 5: Parity enable (PE)

Bit 5 selects whether a parity bit is to be added during transmission and checked during reception in asynchronous mode. In synchronous mode parity bit addition and checking is not performed, irrespective of the bit 5 setting.

Bit 5

PE	Description
0	Parity bit addition and checking disabled ^{*2} (initial value)
1	Parity bit addition and checking enabled ^{*1,*2}

- Notes:
1. When PE is set to 1, even or odd parity, as designated by bit PM, is added to transmit data before it is sent, and the received parity bit is checked against the parity designated by bit PM.
 2. For the case where 5-bit data is selected, see table 10.11.

Bit 4: Parity mode (PM)

Bit 4 selects whether even or odd parity is to be used for parity addition and checking. The PM bit setting is only valid in asynchronous mode when bit PE is set to 1, enabling parity bit addition and checking. The PM bit setting is invalid in synchronous mode, and in asynchronous mode if parity bit addition and checking is disabled.

Bit 4

PM	Description
0	Even parity ^{*1} (initial value)
1	Odd parity ^{*2}

- Notes:
1. When even parity is selected, a parity bit is added in transmission so that the total number of 1 bits in the transmit data plus the parity bit is an even number; in reception, a check is carried out to confirm that the number of 1 bits in the receive data plus the parity bit is an even number.
 2. When odd parity is selected, a parity bit is added in transmission so that the total number of 1 bits in the transmit data plus the parity bit is an odd number; in reception, a check is carried out to confirm that the number of 1 bits in the receive data plus the parity bit is an odd number.

Bit 3: Stop bit length (STOP)

Bit 3 selects 1 bit or 2 bits as the stop bit length is asynchronous mode. The STOP bit setting is only valid in asynchronous mode. When synchronous mode is selected the STOP bit setting is invalid since stop bits are not added.

Bit 3**STOP****Description**

0	1 stop bit* ¹	(initial value)
1	2 stop bits* ²	

Notes: 1. In transmission, a single 1 bit (stop bit) is added at the end of a transmit character.
 2. In transmission, two 1 bits (stop bits) are added at the end of a transmit character.

In reception, only the first of the received stop bits is checked, irrespective of the STOP bit setting. If the second stop bit is 1 it is treated as a stop bit, but if 0, it is treated as the start bit of the next transmit character.

Bit 2: Multiprocessor mode (MP)

Bit 2 enables or disables the multiprocessor communication function. When the multiprocessor communication function is disabled, the parity settings in the PE and PM bits are invalid. The MP bit setting is only valid in asynchronous mode. When synchronous mode is selected the MP bit should be set to 0. For details on the multiprocessor communication function, see section 10.3.3,4, Multiprocessor Communication Function.

Bit 2**MP****Description**

0	Multiprocessor communication function disabled*	(initial value)
1	Multiprocessor communication function enabled*	

Note: * For the case where 5-bit data is selected, see table 10.11.

Bits 1 and 0: Clock select 1, 0 (CKS1, CKS0)

Bits 1 and 0 choose $\phi/64$, $\phi/16$, $\phi/2$, or ϕ as the clock source for the baud rate generator.

For the relation between the clock source, bit rate register setting, and baud rate, see 8, Bit rate register (BRR).

Bit 1 CKS1	Bit 0 CKS0	Description
0	0	ϕ clock (initial value)
0	1	$\phi_W/2$ clock ^{*1} / ϕ_W clock ^{*2}
1	0	$\phi/16$ clock
1	1	$\phi/64$ clock

Notes: 1. $\phi_W/2$ clock is selected in active (medium- and high-speed) or sleep (medium- and high-speed) mode.

2. ϕ_W clock is selected in subactive or subsleep mode. SCI3 can be used only when the $\phi_W/2$ is selected as the CPU clock in subactive or subsleep mode.

6. Serial Control Register 3 (SCR3)

Bit	7	6	5	4	3	2	1	0
	TIE	RIE	TE	RE	MPIE	TEIE	CKE1	CKE0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

SCR3 is an 8-bit register for selecting transmit or receive operation, the asynchronous mode clock output, interrupt request enabling or disabling, and the transmit/receive clock source.

SCR3 can be read or written by the CPU at any time.

SCR3 is initialized to H'00 upon reset, and in standby, watch or module standby mode.

Bit 7: Transmit interrupt enable (TIE)

Bit 7 selects enabling or disabling of the transmit data empty interrupt request (TXI) when transmit data is transferred from the transmit data register (TDR) to the transmit shift register (TSR), and bit TDRE in the serial status register (SSR) is set to 1.

TXI can be released by clearing bit TDRE or bit TIE to 0.

Bit 7

TIE	Description	
0	Transmit data empty interrupt request (TXI) disabled	(initial value)
1	Transmit data empty interrupt request (TXI) enabled	

Bit 6: Receive interrupt enable (RIE)

Bit 6 selects enabling or disabling of the receive data full interrupt request (RXI) and the receive error interrupt request (ERI) when receive data is transferred from the receive shift register (RSR) to the receive data register (RDR), and bit RDRF in the serial status register (SSR) is set to 1. There are three kinds of receive error: overrun, framing, and parity.

RXI can be released by clearing bit RDRF or the FER, PER, or OER error flag to 0, or by clearing bit RIE to 0.

Bit 6

RIE	Description	
0	Receive data full interrupt request (RXI) and receive error interrupt request (ERI) disabled	(initial value)
1	Receive data full interrupt request (RXI) and receive error interrupt request (ERI) enabled	

Bit 5: Transmit enable (TE)

Bit 5 selects enabling or disabling of the start of transmit operation.

Bit 5

TE	Description
0	Transmit operation disabled* ¹ (TXD pin is I/O port) (initial value)
1	Transmit operation enabled* ² (TXD pin is transmit data pin)

Notes: 1. Bit TDRE in SSR is fixed at 1.

2. When transmit data is written to TDR in this state, bit TDR in SSR is cleared to 0 and serial data transmission is started. Be sure to carry out serial mode register (SMR) settings, and setting of bit SPC31 or SPC32 in SPCR, to decide the transmission format before setting bit TE to 1.

Bit 4: Receive enable (RE)

Bit 4 selects enabling or disabling of the start of receive operation.

Bit 4

RE	Description
0	Receive operation disabled* ¹ (RXD pin is I/O port) (initial value)
1	Receive operation enabled* ² (RXD pin is receive data pin)

Notes: 1. Note that the RDRF, FER, PER, and OER flags in SSR are not affected when bit RE is cleared to 0, and retain their previous state.

2. In this state, serial data reception is started when a start bit is detected in asynchronous mode or serial clock input is detected in synchronous mode. Be sure to carry out serial mode register (SMR) settings to decide the reception format before setting bit RE to 1.

Bit 3: Multiprocessor interrupt enable (MPIE)

Bit 3 selects enabling or disabling of the multiprocessor interrupt request. The MPIE bit setting is only valid when asynchronous mode is selected and reception is carried out with bit MP in SMR set to 1. The MPIE bit setting is invalid when bit COM is set to 1 or bit MP is cleared to 0.

Bit 3**MPIE****Description**

0	Multiprocessor interrupt request disabled (normal receive operation) (initial value) Clearing condition: When data is received in which the multiprocessor bit is set to 1
1	Multiprocessor interrupt request enabled*

Note: * Receive data transfer from RSR to RDR, receive error detection, and setting of the RDRF, FER, and OER status flags in SSR is not performed. RXI, ERI, and setting of the RDRF, FER, and OER flags in SSR, are disabled until data with the multiprocessor bit set to 1 is received. When a receive character with the multiprocessor bit set to 1 is received, bit MPBR in SSR is set to 1, bit MPIE is automatically cleared to 0, and RXI and ERI requests (when bits TIE and RIE in serial control register 3 (SCR3) are set to 1) and setting of the RDRF, FER, and OER flags are enabled.

Bit 2: Transmit end interrupt enable (TEIE)

Bit 2 selects enabling or disabling of the transmit end interrupt request (TEI) if there is no valid transmit data in TDR when MSB data is to be sent.

Bit 2**TEIE****Description**

0	Transmit end interrupt request (TEI) disabled (initial value)
1	Transmit end interrupt request (TEI) enabled*

Note: * TEI can be released by clearing bit TDRE to 0 and clearing bit TEND to 0 in SSR, or by clearing bit TEIE to 0.

Bits 1 and 0: Clock enable 1 and 0 (CKE1, CKE0)

Bits 1 and 0 select the clock source and enabling or disabling of clock output from the SCK_{3X} pin. The combination of CKE1 and CKE0 determines whether the SCK_{3X} pin functions as an I/O port, a clock output pin, or a clock input pin.

The CKE0 bit setting is only valid in case of internal clock operation (CKE1 = 0) in asynchronous mode. In synchronous mode, or when external clock operation is used (CKE1 = 1), bit CKE0 should be cleared to 0.

After setting bits CKE1 and CKE0, set the operating mode in the serial mode register (SMR).

For details on clock source selection, see table 10.12 in 10.3.3.1, Overview.

Bit 1	Bit 0	Description
CKE1	CKE0	Communication Mode
0	0	Asynchronous
		Synchronous
0	1	Asynchronous
		Synchronous
1	0	Asynchronous
		Synchronous
1	1	Asynchronous
		Synchronous

Internal clock	External clock	Reserved
I/O port* ¹	Clock input* ³	
Serial clock output* ¹	Serial clock input	
Clock output* ²		

Notes: 1. Initial value

2. A clock with the same frequency as the bit rate is output.

3. Input a clock with a frequency 16 times the bit rate.

7. Serial Status Register (SSR)

Bit	7	6	5	4	3	2	1	0
	TDRE	RDRF	OER	FER	PER	TEND	MPBR	MPBT
Initial value	1	0	0	0	0	1	0	0
Read/Write	R/(W)*	R/(W)*	R/(W)*	R/(W)*	R/(W)*	R	R	R/W

Note: * Only a write of 0 for flag clearing is possible.

SSR is an 8-bit register containing status flags that indicate the operational status of SCI3, and multiprocessor bits.

SSR can be read or written by the CPU at any time, but only a write of 1 is possible to bits TDRE, RDRF, OER, PER, and FER. In order to clear these bits by writing 0, 1 must first be read.

Bits TEND and MPBR are read-only bits, and cannot be modified.

SSR is initialized to H'84 upon reset, and in standby, module standby, or watch mode.

Bit 7: Transmit data register empty (TDRE)

Bit 7 indicates that transmit data has been transferred from TDR to TSR.

Bit 7

TDRE	Description
0	Transmit data written in TDR has not been transferred to TSR Clearing conditions: After reading TDRE = 1, cleared by writing 0 to TDRE When data is written to TDR by an instruction
1	Transmit data has not been written to TDR, or transmit data written in TDR has been transferred to TSR Setting conditions: When bit TE in SCR3 is cleared to 0 When data is transferred from TDR to TSR (initial value)

Bit 6: Receive data register full (RDRF)

Bit 6 indicates that received data is stored in RDR.

Bit 6

RDRF	Description
0	There is no receive data in RDR (initial value) Clearing conditions: After reading RDRF = 1, cleared by writing 0 to RDRF When RDR data is read by an instruction
1	There is receive data in RDR Setting condition: When reception ends normally and receive data is transferred from RSR to RDR

Note: If an error is detected in the receive data, or if the RE bit in SCR3 has been cleared to 0, RDR and bit RDRF are not affected and retain their previous state.

Note that if data reception is completed while bit RDRF is still set to 1, an overrun error (OER) will result and the receive data will be lost.

Bit 5: Overrun error (OER)

Bit 5 indicates that an overrun error has occurred during reception.

Bit 5

OER	Description	
0	Reception in progress or completed* ¹ Clearing condition: After reading OER = 1, cleared by writing 0 to OER	(initial value)
1	An overrun error has occurred during reception* ² Setting condition: When reception is completed with RDRF set to 1	

- Notes:
1. When bit RE in SCR3 is cleared to 0, bit OER is not affected and retains its previous state.
 2. RDR retains the receive data it held before the overrun error occurred, and data received after the error is lost. Reception cannot be continued with bit OER set to 1, and in synchronous mode, transmission cannot be continued either.

Bit 4: Framing error (FER)

Bit 4 indicates that a framing error has occurred during reception in asynchronous mode.

Bit 4

FER	Description	
0	Reception in progress or completed* ¹ Clearing condition: After reading FER = 1, cleared by writing 0 to FER	(initial value)
1	A framing error has occurred during reception Setting condition: When the stop bit at the end of the receive data is checked for a value of 1 at the end of reception, and the stop bit is 0* ²	

- Notes:
1. When bit RE in SCR3 is cleared to 0, bit FER is not affected and retains its previous state.
 2. Note that, in 2-stop-bit mode, only the first stop bit is checked for a value of 1, and the second stop bit is not checked. When a framing error occurs the receive data is transferred to RDR but bit RDRF is not set. Reception cannot be continued with bit FER set to 1. In synchronous mode, neither transmission nor reception is possible when bit FER is set to 1.

Bit 3: Parity error (PER)

Bit 3 indicates that a parity error has occurred during reception with parity added in asynchronous mode.

**Bit 3
PER**

	Description	
0	Reception in progress or completed* ¹ Clearing condition: After reading PER = 1, cleared by writing 0 to PER	(initial value)
1	A parity error has occurred during reception* ² Setting condition: When the number of 1 bits in the receive data plus parity bit does not match the parity designated by bit PM in the serial mode register (SMR)	

- Notes: 1. When bit RE in SCR3 is cleared to 0, bit PER is not affected and retains its previous state.
2. Receive data in which it a parity error has occurred is still transferred to RDR, but bit RDRF is not set. Reception cannot be continued with bit PER set to 1. In synchronous mode, neither transmission nor reception is possible when bit FER is set to 1.

Bit 2: Transmit end (TEND)

Bit 2 indicates that bit TDRE is set to 1 when the last bit of a transmit character is sent.

Bit 2 is a read-only bit and cannot be modified.

**Bit 2
TEND**

	Description	
0	Transmission in progress Clearing conditions: After reading TDRE = 1, cleared by writing 0 to TDRE When data is written to TDR by an instruction	
1	Transmission ended Setting conditions: When bit TE in SCR3 is cleared to 0 When bit TDRE is set to 1 when the last bit of a transmit character is sent	(initial value)

Bit 1: Multiprocessor bit receive (MPBR)

Bit 1 stores the multiprocessor bit in a receive character during multiprocessor format reception in asynchronous mode.

Bit 1 is a read-only bit and cannot be modified.

Bit 1

MPBR	Description
0	Data in which the multiprocessor bit is 0 has been received* (initial value)
1	Data in which the multiprocessor bit is 1 has been received

Note: * When bit RE is cleared to 0 in SCR3 with the multiprocessor format, bit MPBR is not affected and retains its previous state.

Bit 0: Multiprocessor bit transfer (MPBT)

Bit 0 stores the multiprocessor bit added to transmit data when transmitting in asynchronous mode. The bit MPBT setting is invalid when synchronous mode is selected, when the multiprocessor communication function is disabled, and when not transmitting.

Bit 0

MPBT	Description
0	A 0 multiprocessor bit is transmitted (initial value)
1	A 1 multiprocessor bit is transmitted

8. Bit Rate Register (BRR)

Bit	7	6	5	4	3	2	1	0
	BRR7	BRR6	BRR5	BRR4	BRR3	BRR2	BRR1	BRR0
Initial value	1	1	1	1	1	1	1	1
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

BRR is an 8-bit register that designates the transmit/receive bit rate in accordance with the baud rate generator operating clock selected by bits CKS1 and CKS0 of the serial mode register (SMR).

BRR can be read or written by the CPU at any time.

BRR is initialized to H'FF upon reset, and in standby, module standby, or watch mode.

Table 10.6 shows examples of BRR settings in asynchronous mode. The values shown are for active (high-speed) mode.

Table 10.6 Examples of BRR Settings for Various Bit Rates (Asynchronous Mode) (1)

		OSC													
		32.8 kHz			38.4 kHz			2 MHz			2.4576 MHz		4 MHz		
Bit Rate (bit/s)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)	n	N	Error (%)
150	as error exceeds		0	3	0	2	12	0.16	3	3	0	2	25	0.16	
200	3%		0	2	0	0	155	0.16	3	2	0	—	—	—	
250			—	—	—	0	124	0	0	153	-0.26	0	249	0	
300			0	1	0	0	103	0.16	3	1	0	2	12	0.16	
600			0	0	0	0	51	0.16	3	0	0	0	103	0.16	
1200			—	—	—	0	25	0.16	2	1	0	0	51	0.16	
2400			—	—	—	0	12	0.16	2	0	0	0	25	0.16	
4800			—	—	—	—	—	—	0	7	0	0	12	0.16	
9600			—	—	—	—	—	—	0	3	0	—	—	—	
19200			—	—	—	—	—	—	0	1	0	—	—	—	
31250			—	—	—	0	0	0	—	—	—	0	1	0	
38400			—	—	—	—	—	—	0	0	0	—	—	—	

Table 10.6 Examples of BRR Settings for Various Bit Rates (Asynchronous Mode) (2)

Bit Rate (bit/s)	OSC					
	10 MHz			16 MHz		
	n	N	Error (%)	n	N	Error (%)
110	2	88	-0.25	2	141	0.03
150	2	64	0.16	2	103	0.16
200	2	48	-0.35	2	77	0.16
250	2	38	0.16	2	62	-0.79
300	—	—	—	2	51	0.16
600	—	—	—	2	25	0.16
1200	0	129	0.16	0	207	0.16
2400	0	64	0.16	0	103	0.16
4800	—	—	—	0	51	0.16
9600	—	—	—	0	25	0.16
19200	—	—	—	0	12	0.16
31250	0	4	0	0	7	0
38400	—	—	—	—	—	—

- Notes: 1. The setting should be made so that the error is not more than 1%.
 2. The value set in BRR is given by the following equation:

$$N = \frac{\text{OSC}}{(64 \times 2^{2n} \times B)} - 1$$

where

B: Bit rate (bit/s)

N: Baud rate generator BRR setting ($0 \leq N \leq 255$)

OSC: Value of ϕ_{OSC} (Hz)

n: Baud rate generator input clock number ($n = 0, 2, \text{ or } 3$)

(The relation between n and the clock is shown in table 10.7.)

Table 10.7 Relation between n and Clock

n	Clock	SMR Setting	
		CKS1	CKS0
0	ϕ	0	0
0	$\phi_W/2^{*1}/\phi_W^{*2}$	0	1
2	$\phi/16$	1	0
3	$\phi/64$	1	1

- Notes:
1. $\phi_W/2$ clock is selected in active (medium- and high-speed) or sleep (medium- and high-speed) mode.
 2. ϕ_W clock is selected in subactive or subsleep mode. SCI3 can be used only when the $\phi_W/2$ is selected as the CPU clock in subactive or subsleep mode.
 3. The error in table 10.6 is the value obtained from the following equation, rounded to two decimal places.

$$\text{Error (\%)} = \frac{B \text{ (rate obtained from } n, N, \text{OSC)} - R \text{ (bit rate in left-hand column in table 10.6.)}}{R \text{ (bit rate in left-hand column in table 10.6.)}} \times 100$$

Table 10.8 shows the maximum bit rate for each frequency. The values shown are for active (high-speed) mode.

Table 10.8 Maximum Bit Rate for Each Frequency (Asynchronous Mode)

OSC (MHz)	Maximum Bit Rate (bit/s)	Setting	
		n	N
0.0384*	600	0	0
2	31250	0	0
2.4576	38400	0	0
4	62500	0	0
10	156250	0	0
16	250000	0	0

Note: * When SMR is set up to CKS1 = "0", CKS0 = "1".

Table 10.9 shows examples of BRR settings in synchronous mode. The values shown are for active (high-speed) mode.

Table 10.9 Examples of BRR Settings for Various Bit Rates (Synchronous Mode) (1)

Bit Rate (bit/s)	OSC								
	38.4 kHz			2 MHz			4 MHz		
	n	N	Error	n	N	Error	n	N	Error
200	0	23	0	—	—	—	—	—	—
250	—	—	—	—	—	—	2	124	0
300	2	0	0	—	—	—	—	—	—
500			—	—	—	—	—	—	
1k			0	249	0	—	—	—	
2.5k			0	99	0	0	199	0	
5k			0	49	0	0	99	0	
10k			0	24	0	0	49	0	
25k			0	9	0	0	19	0	
50k			0	4	0	0	9	0	
100k			—	—	—	0	4	0	
250k			0	0	0	0	1	0	
500k						0	0	0	
1M									

Table 10.9 Examples of BRR Settings for Various Bit Rates (Synchronous Mode) (2)

Bit Rate (bit/s)	OSC					
	10 MHz			16 MHz		
	n	N	Error	n	N	Error
200	—	—	—	—	—	—
250	—	—	—	3	124	0
300	—	—	—	—	—	—
500	—	—	—	2	249	0
1k	—	—	—	2	124	0
2.5k	—	—	—	2	49	0
5k	0	249	0	2	24	0
10k	0	124	0	0	199	0
25k	0	49	0	0	79	0
50k	0	24	0	0	39	0
100k	—	—	—	0	19	0
250k	0	4	0	0	7	0
500k	—	—	—	0	3	0
1M	—	—	—	0	1	0

Blank: Cannot be set.

— : A setting can be made, but an error will result.

Notes: The value set in BRR is given by the following equation:

$$N = \frac{\text{OSC}}{(8 \times 2^{2n} \times B)} - 1$$

where

B: Bit rate (bit/s)

N: Baud rate generator BRR setting ($0 \leq N \leq 255$)

OSC: Value of ϕ_{OSC} (Hz)

n: Baud rate generator input clock number ($n = 0, 2, \text{ or } 3$)

(The relation between n and the clock is shown in table 10.10.)

Table 10.10 Relation between n and Clock

n	Clock	SMR Setting	
		CKS1	CKS0
0	ϕ	0	0
0	$\phi_W/2^{*1}/\phi_W^{*2}$	0	1
2	$\phi/16$	1	0
3	$\phi/64$	1	1

- Notes:
- $\phi_W/2$ clock is selected in active (medium- and high-speed) or sleep (medium- and high-speed) mode.
 - ϕ_W clock is selected in subactive or subsleep mode. SCI3 can be used only when the $\phi_W/2$ is selected as the CPU operation clock in subactive or subsleep mode.

9. Clock Stop Register 1 (CKSTPR1)

Bit	7	6	5	4	3	2	1	0
	S1CKSTP	S31CKSTP	S32CKSTP	ADCKSTP	TGCKSTP	TFCKSTP	TCCKSTP	TACKSTP
Initial value	1	1	1	1	1	1	1	1
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

CKSTPR1 is an 8-bit read/write register that performs module standby mode control for peripheral modules. Only the bits relating to SCI3 are described here. For details of the other bits, see the sections on the relevant modules.

Bit 6: SCI3-1 module standby mode control (S31CKSTP)

Bit 6 controls setting and clearing of module standby mode for SCI31.

S31CKSTP Description

0	SCI3-1 is set to module standby mode*	
1	SCI3-1 module standby mode is cleared	(initial value)

Note: * Setting to module standby mode resets all the registers in SCI31.

Bit 5: SCI3-2 module standby mode control (S32CKSTP)

Bit 5 controls setting and clearing of module standby mode for SCI32.

S32CKSTP Description

0	SCI3-2 is set to module standby mode*	
1	SCI3-2 module standby mode is cleared	(initial value)

Note: * Setting to module standby mode resets all the registers in SCI32.

10. Serial Port Control Register (SPCR)

Bit	7	6	5	4	3	2	1	0
	—	—	SPC32	SPC31	SCINV3	SCINV2	SCINV1	SCINV0
Initial value	1	1	0	0	0	0	0	0
Read/Write	—	—	R/W	R/W	R/W	R/W	R/W	R/W

SPCR is an 8-bit readable/writable register that performs RXD₃₁, RXD₃₂, TXD₃₁, and TXD₃₂ pin input/output data inversion switching. SPCR is initialized to H'C0 by a reset.

Bits 7 to 6: Reserved bits

Bits 7 to 6 are reserved; they are always read as 1 and cannot be modified.

Bit 5: P4₂/TXD₃₂ pin function switch (SPC32)

This bit selects whether pin P4₂/TXD₃₂ is used as P4₂ or as TXD₃₂.

Bit 5**SPC32****Description**

	Description	
0	Functions as P4 ₂ I/O pin	(initial value)
1	Functions as TXD ₃₂ output pin*	

Note: * Set the TE bit in SCR3 after setting this bit to 1.

Bit 4: P3₅/TXD₃₁ pin function switch (SPC31)

This bit selects whether pin P3₅/TXD₃₁ is used as P3₅ or as TXD₃₁.

Bit 4**SPC31****Description**

	Description	
0	Functions as P3 ₅ I/O pin	(initial value)
1	Functions as TXD ₃₁ output pin*	

Note: * Set the TE bit in SCR3 after setting this bit to 1.

Bit 3: TXD₃₂ pin output data inversion switch

Bit 3 specifies whether or not TXD₃₂ pin output data is to be inverted.

Bit 3**SCINV3****Description**

0	TXD ₃₂ output data is not inverted	(initial value)
1	TXD ₃₂ output data is inverted	

Bit 2: RXD₃₂ pin input data inversion switch

Bit 2 specifies whether or not RXD₃₂ pin input data is to be inverted.

Bit 2

SCINV2	Description	
0	RXD ₃₂ input data is not inverted	(initial value)
1	RXD ₃₂ input data is inverted	

Bit 1: TXD₃₁ pin output data inversion switch

Bit 1 specifies whether or not TXD₃₁ pin output data is to be inverted.

Bit 1

SCINV1	Description	
0	TXD ₃₁ output data is not inverted	(initial value)
1	TXD ₃₁ output data is inverted	

Bit 0: RXD₃₁ pin input data inversion switch

Bit 0 specifies whether or not RXD₃₁ pin input data is to be inverted.

Bit 0

SCINV0	Description	
0	RXD ₃₁ input data is not inverted	(initial value)
1	RXD ₃₁ input data is inverted	

10.3.3 Operation

1. Overview

SCI3 can perform serial communication in two modes: asynchronous mode in which synchronization is provided character by character, and synchronous mode in which synchronization is provided by clock pulses. The serial mode register (SMR) is used to select asynchronous or synchronous mode and the data transfer format, as shown in table 10.11.

The clock source for SCI3 is determined by bit COM in SMR and bits CKE1 and CKE0 in SCR3, as shown in table 10.12.

a. Asynchronous mode

- Choice of 5-, 7-, or 8-bit data length
- Choice of parity addition, multiprocessor bit addition, and addition of 1 or 2 stop bits. (The combination of these parameters determines the data transfer format and the character length.)
- Framing error (FER), parity error (PER), overrun error (OER), and break detection during reception
- Choice of internal or external clock as the clock source

When internal clock is selected: SCI3 operates on the baud rate generator clock, and a clock with the same frequency as the bit rate can be output.

When external clock is selected: A clock with a frequency 16 times the bit rate must be input. (The on-chip baud rate generator is not used.)

b. Synchronous mode

- Data transfer format: Fixed 8-bit data length
- Overrun error (OER) detection during reception
- Choice of internal or external clock as the clock source

When internal clock is selected: SCI3 operates on the baud rate generator clock, and a serial clock is output.

When external clock is selected: The on-chip baud rate generator is not used, and SCI3 operates on the input serial clock.

Table 10.11 SMR Settings and Corresponding Data Transfer Formats

SMR					Data Transfer Format				
bit 7 COM	bit 6 CHR	bit 2 MP	bit 5 PE	bit 3 STOP	Mode	Data Length	Multiprocessor Bit	Parity Bit	Stop Bit Length
0	0	0	0	0	Asynchronous mode	8-bit data	No	No	1 bit
0	0	0	0	1				2 bits	
0	0	0	1	0					Yes
0	0	0	1	1				2 bits	
0	1	0	0	0		7-bit data	No		No
0	1	0	0	1				2 bits	
0	1	0	1	0					Yes
0	1	0	1	1				2 bits	
0	0	1	0	0		8-bit data	Yes		No
0	0	1	0	1				2 bits	
0	0	1	1	0	5-bit data	No			1 bit
0	0	1	1	1				2 bits	
0	1	1	0	0	7-bit data	Yes			1 bit
0	1	1	0	1				2 bits	
0	1	1	1	0	5-bit data	No	Yes		1 bit
0	1	1	1	1				2 bits	
1	*	0	*	*	Synchronous mode	8-bit data	No		No

*: Don't care

Table 10.12 SMR and SCR3 Settings and Clock Source Selection

SMR		SCR3				
bit 7	bit 1	bit 0		Transmit/Receive Clock		
COM	CKE1	CKE0	Mode	Clock Source	SCK _{3X}	Pin Function
0	0	0	Asynchronous mode	Internal	I/O port (SCK _{3X} pin not used)	
0	0	1			Outputs clock with same frequency as bit rate	
0	1	0		External	Outputs clock with frequency 16 times bit rate	
1	0	0	Synchronous mode	Internal	Outputs serial clock	
1	1	0		External	Inputs serial clock	
0	1	1	Reserved (Do not specify these combinations)			
1	0	1				
1	1	1				

c. Interrupts and continuous transmission/reception

SCI3 can carry out continuous reception using RXI and continuous transmission using TXI. These interrupts are shown in table 10.13.

Table 10.13 Transmit/Receive Interrupts

Interrupt	Flags	Interrupt Request Conditions	Notes
RXI	RDRF RIE	When serial reception is performed normally and receive data is transferred from RSR to RDR, bit RDRF is set to 1, and if bit RIE is set to 1 at this time, RXI is enabled and an interrupt is requested. (See figure 10.7 (a).)	The RXI interrupt routine reads the receive data transferred to RDR and clears bit RDRF to 0. Continuous reception can be performed by repeating the above operations until reception of the next RSR data is completed.
TXI	TDRE TIE	When TSR is found to be empty (on completion of the previous transmission) and the transmit data placed in TDR is transferred to TSR, bit TDRE is set to 1. If bit TIE is set to 1 at this time, TXI is enabled and an interrupt is requested. (See figure 10.7 (b).)	The TXI interrupt routine writes the next transmit data to TDR and clears bit TDRE to 0. Continuous transmission can be performed by repeating the above operations until the data transferred to TSR has been transmitted.
TEI	TEND TEIE	When the last bit of the character in TSR is transmitted, if bit TDRE is set to 1, bit TEND is set to 1. If bit TEIE is set to 1 at this time, TEI is enabled and an interrupt is requested. (See figure 10.7 (c).)	TEI indicates that the next transmit data has not been written to TDR when the last bit of the transmit character in TSR is sent.

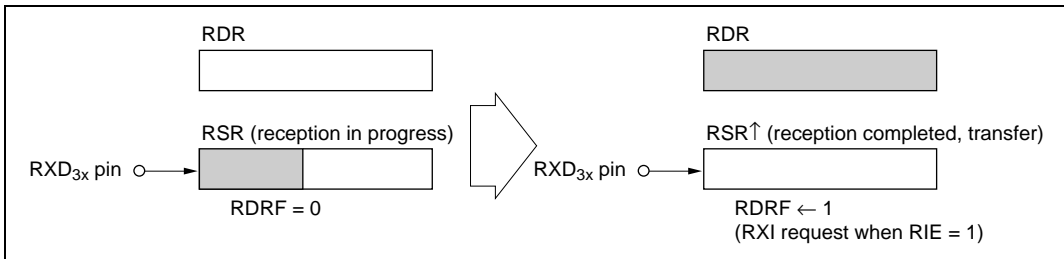


Figure 10.7 (a) RDRF Setting and RXI Interrupt

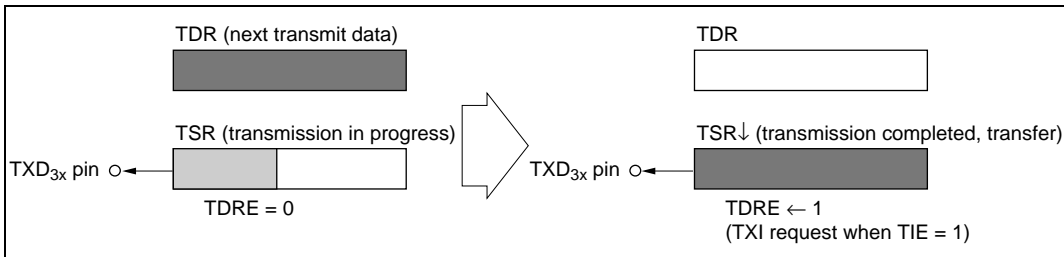


Figure 10.7 (b) TDRE Setting and TXI Interrupt

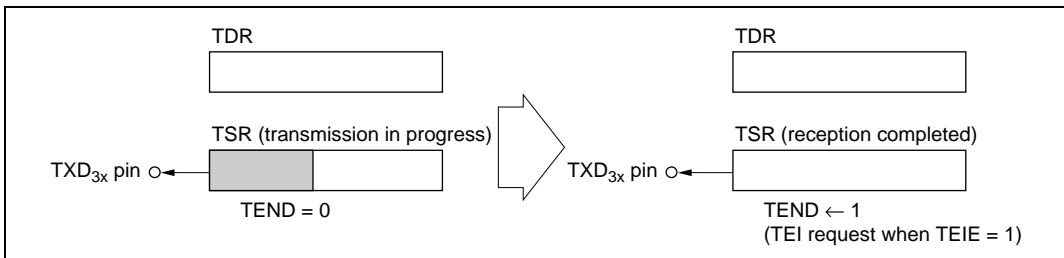


Figure 10.7 (c) TEND Setting and TEI Interrupt

2. Operation in Asynchronous Mode

In asynchronous mode, serial communication is performed with synchronization provided character by character. A start bit indicating the start of communication and one or two stop bits indicating the end of communication are added to each character before it is sent.

SCI3 has separate transmission and reception units, allowing full-duplex communication. As the transmission and reception units are both double-buffered, data can be written during transmission and read during reception, making possible continuous transmission and reception.

a. Data transfer format

The general data transfer format in asynchronous communication is shown in figure 10.8.

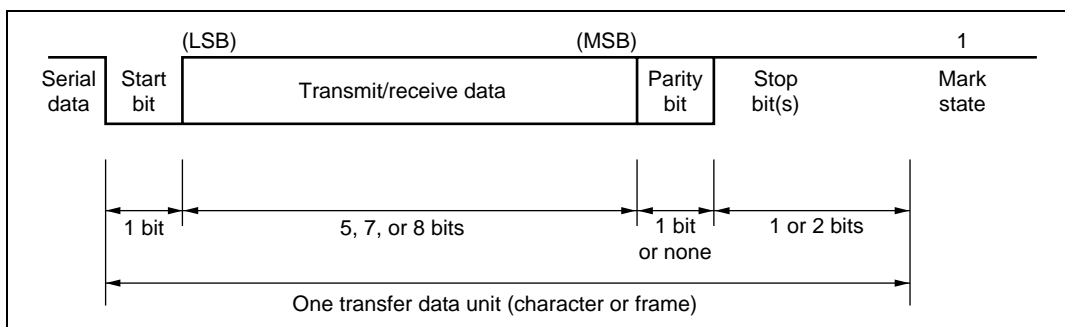


Figure 10.8 Data Format in Asynchronous Communication

In asynchronous communication, the communication line is normally in the mark state (high level). SCI3 monitors the communication line and when it detects a space (low level), identifies this as a start bit and begins serial data communication.

One transfer data character consists of a start bit (low level), followed by transmit/receive data (LSB-first format, starting from the least significant bit), a parity bit (high or low level), and finally one or two stop bits (high level).

In asynchronous mode, synchronization is performed by the falling edge of the start bit during reception. The data is sampled on the 8th pulse of a clock with a frequency 16 times the bit period, so that the transfer data is latched at the center of each bit.

Table 10.14 shows the 16 data transfer formats that can be set in asynchronous mode. The format is selected by the settings in the serial mode register (SMR).

Table 10.14 Data Transfer Formats (Asynchronous Mode)

SMR				Serial Data Transfer Format and Frame Length													
CHR	PE	MP	STOP	1	2	3	4	5	6	7	8	9	10	11	12		
0	0	0	0	S	8-bit data								STOP				
0	0	0	1	S	8-bit data								STOP	STOP			
0	0	1	0	S	8-bit data								MPB	STOP			
0	0	1	1	S	8-bit data								MPB	STOP	STOP		
0	1	0	0	S	8-bit data								P	STOP			
0	1	0	1	S	8-bit data								P	STOP	STOP		
0	1	1	0	S	5-bit data					STOP							
0	1	1	1	S	5-bit data					STOP	STOP						
1	0	0	0	S	7-bit data						STOP						
1	0	0	1	S	7-bit data						STOP	STOP					
1	0	1	0	S	7-bit data						MPB	STOP					
1	0	1	1	S	7-bit data						MPB	STOP	STOP				
1	1	0	0	S	7-bit data						P	STOP					
1	1	0	1	S	7-bit data						P	STOP	STOP				
1	1	1	0	S	5-bit data					P	STOP						
1	1	1	1	S	5-bit data					P	STOP	STOP					

Legend:

S: Start bit

STOP: Stop bit

P: Parity bit

MPB: Multiprocessor bit

b. Clock

Either an internal clock generated by the baud rate generator or an external clock input at the SCK_{3X} pin can be selected as the SCI3 transmit/receive clock. The selection is made by means of bit COM in SMR and bits SCE1 and CKE0 in SCR3. See table 10.12 for details on clock source selection.

When an external clock is input at the SCK_{3X} pin, the clock frequency should be 16 times the bit rate.

When SCI3 operates on an internal clock, the clock can be output at the SCK_{3X} pin. In this case the frequency of the output clock is the same as the bit rate, and the phase is such that the clock rises at the center of each bit of transmit/receive data, as shown in figure 10.9.

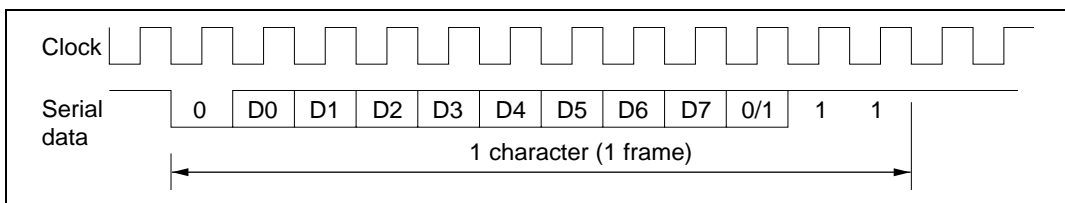


Figure 10.9 Phase Relationship between Output Clock and Transfer Data (Asynchronous Mode) (8-bit data, parity, 2 stop bits)

c. Data transfer operations

- SCI3 initialization

Before data is transferred on SCI3, bits TE and RE in SCR3 must first be cleared to 0, and then SCI3 must be initialized as follows.

Note: If the operation mode or data transfer format is changed, bits TE and RE must first be cleared to 0.

When bit TE is cleared to 0, bit TDRE is set to 1.

Note that the RDRF, PER, FER, and OER flags and the contents of RDR are retained when RE is cleared to 0.

When an external clock is used in asynchronous mode, the clock should not be stopped during operation, including initialization. When an external clock is used in synchronous mode, the clock should not be supplied during operation, including initialization.

Figure 10.10 shows an example of a flowchart for initializing SCI3.

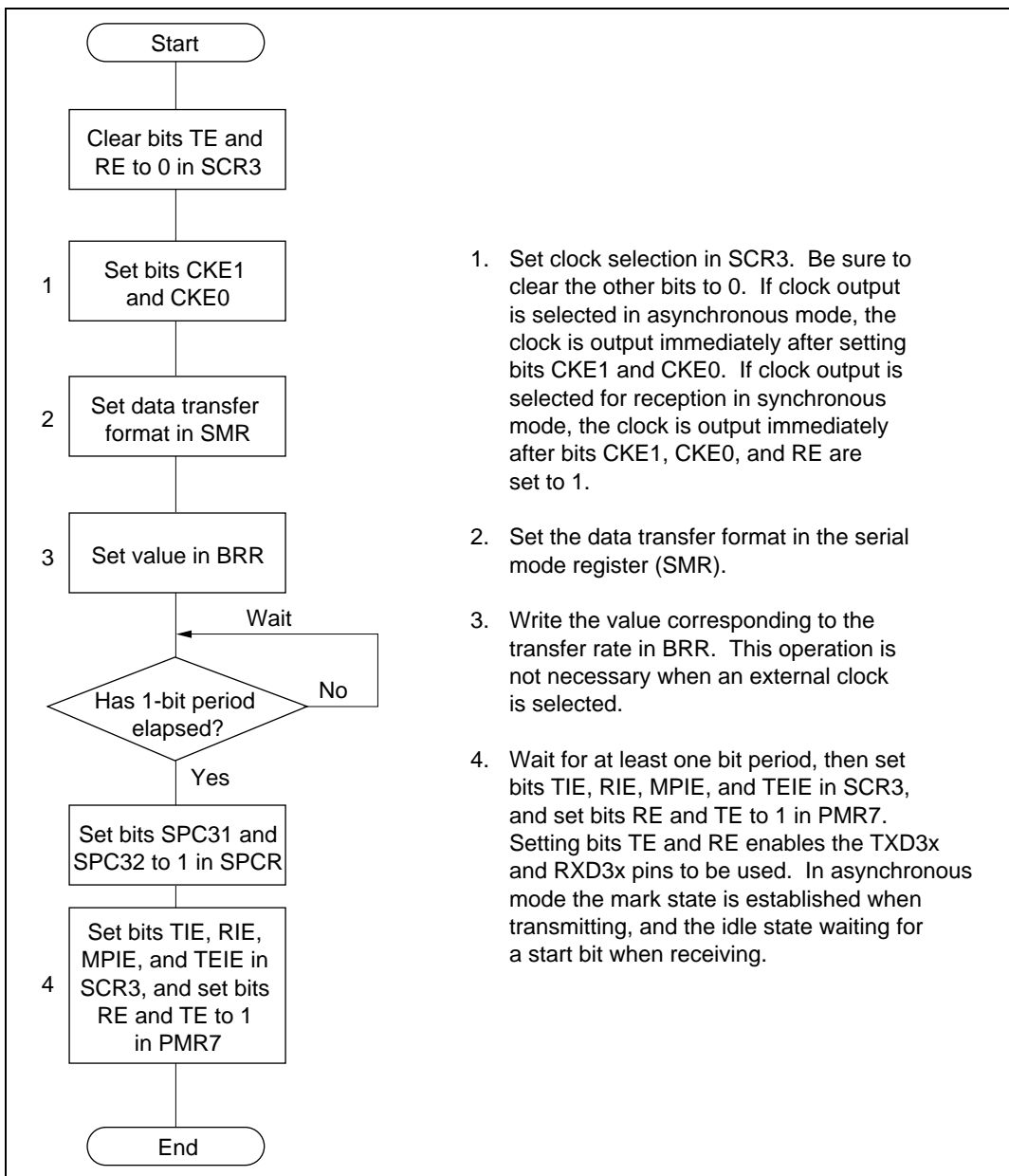


Figure 10.10 Example of SCI3 Initialization Flowchart

- Transmitting

Figure 10.11 shows an example of a flowchart for data transmission. This procedure should be followed for data transmission after initializing SCI3.

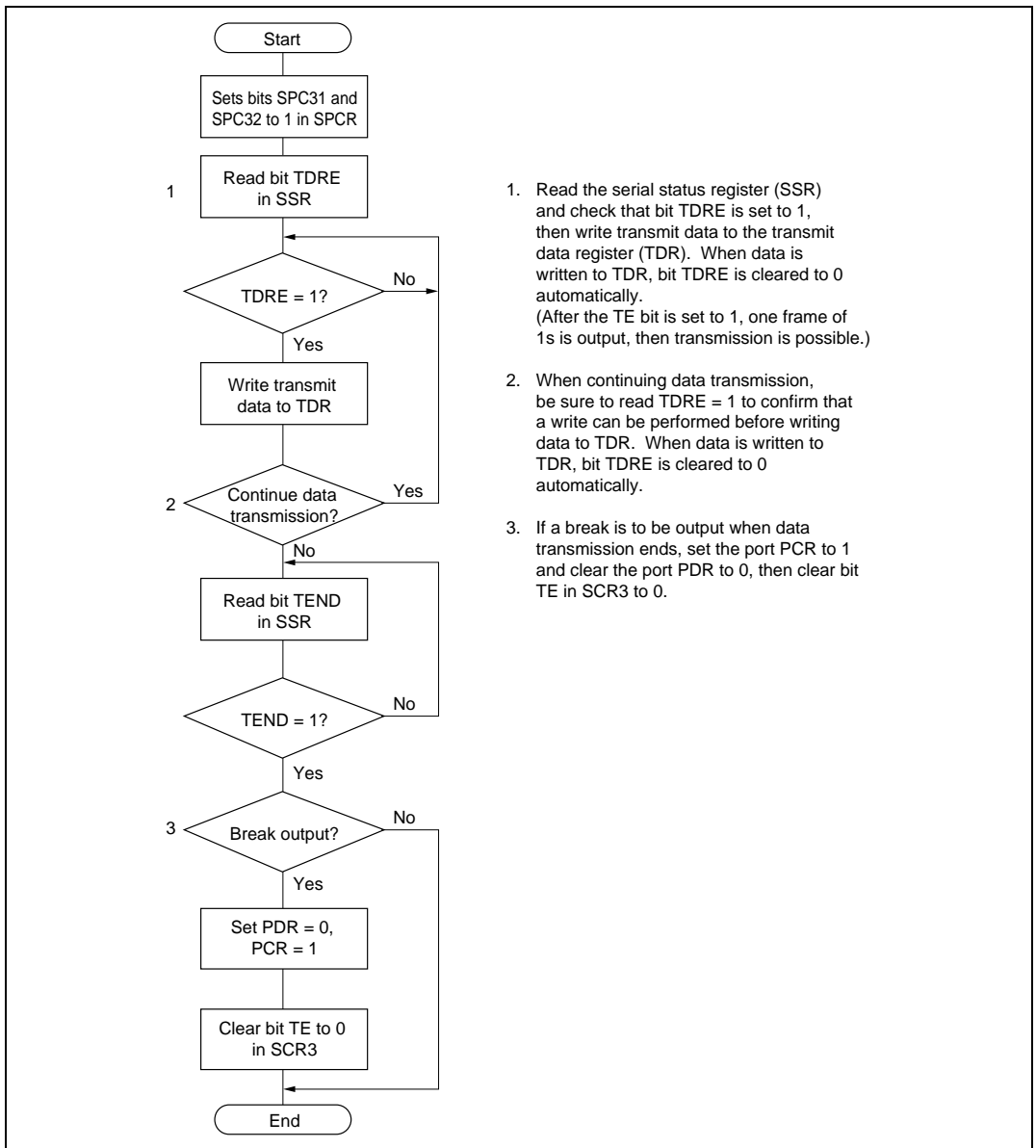


Figure 10.11 Example of Data Transmission Flowchart (Asynchronous Mode)

SCI3 operates as follows when transmitting data.

SCI3 monitors bit TDRE in SSR, and when it is cleared to 0, recognizes that data has been written to TDR and transfers data from TDR to TSR. It then sets bit TDRE to 1 and starts transmitting. If bit TIE in SCR3 is set to 1 at this time, a TXI request is made.

Serial data is transmitted from the TXD3x pin using the relevant data transfer format in table 10.14. When the stop bit is sent, SCI3 checks bit TDRE. If bit TDRE is cleared to 0, SCI3 transfers data from TDR to TSR, and when the stop bit has been sent, starts transmission of the next frame. If bit TDRE is set to 1, bit TEND in SSR bit is set to 1 the mark state, in which 1s are transmitted, is established after the stop bit has been sent. If bit TEIE in SCR3 is set to 1 at this time, a TEI request is made.

Figure 10.12 shows an example of the operation when transmitting in asynchronous mode.

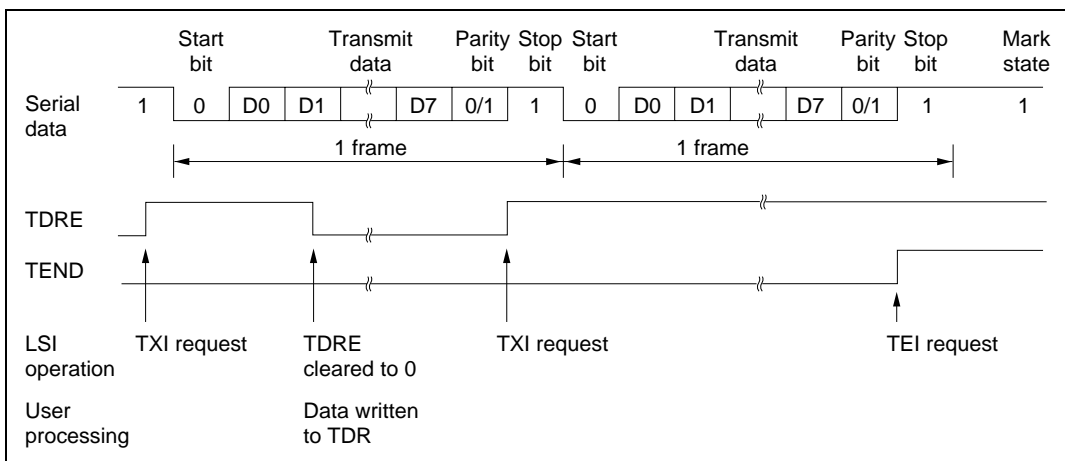


Figure 10.12 Example of Operation when Transmitting in Asynchronous Mode (8-bit data, parity, 1 stop bit)

- Receiving

Figure 10.13 shows an example of a flowchart for data reception. This procedure should be followed for data reception after initializing SCI3.

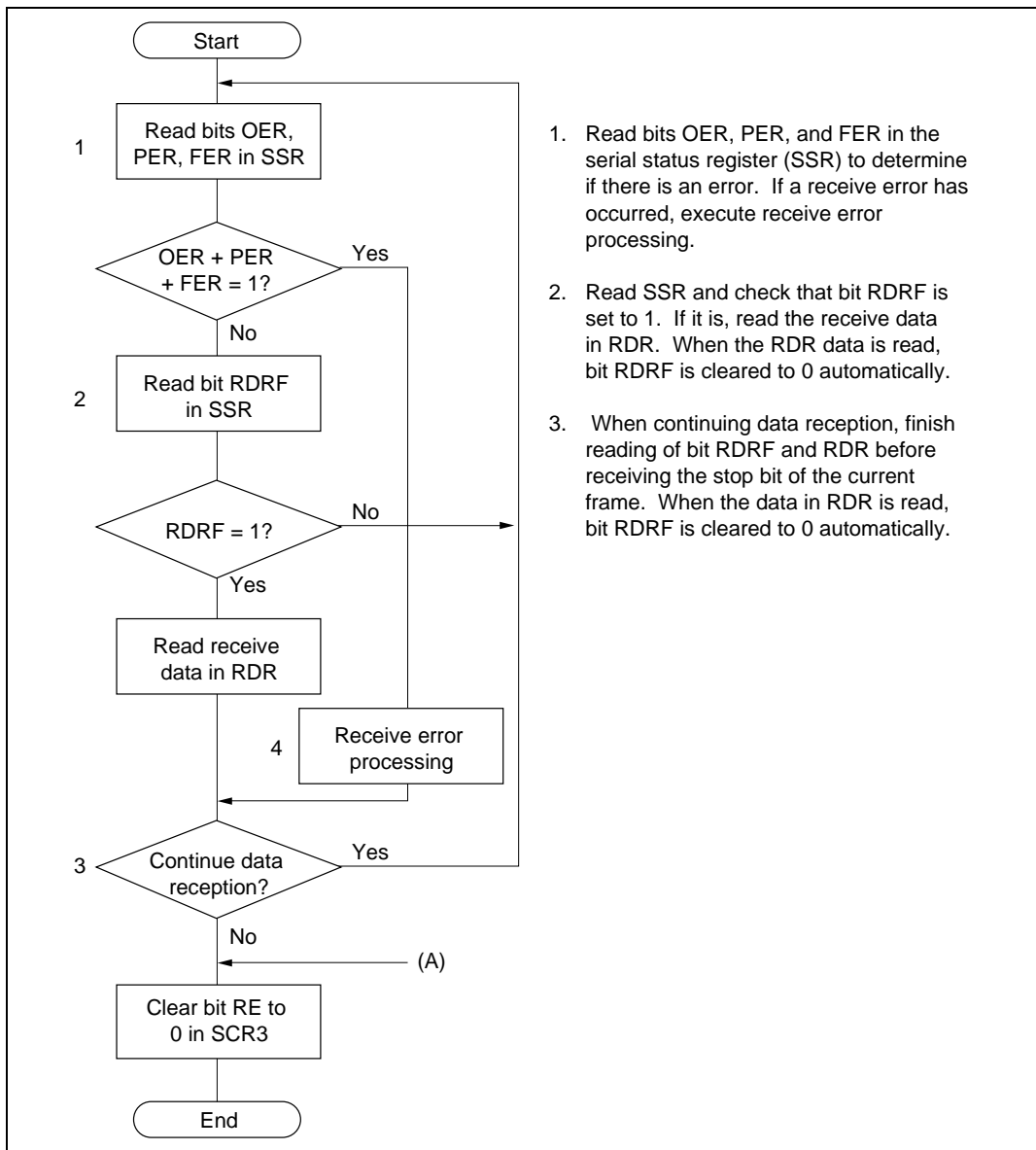


Figure 10.13 Example of Data Reception Flowchart (Asynchronous Mode)

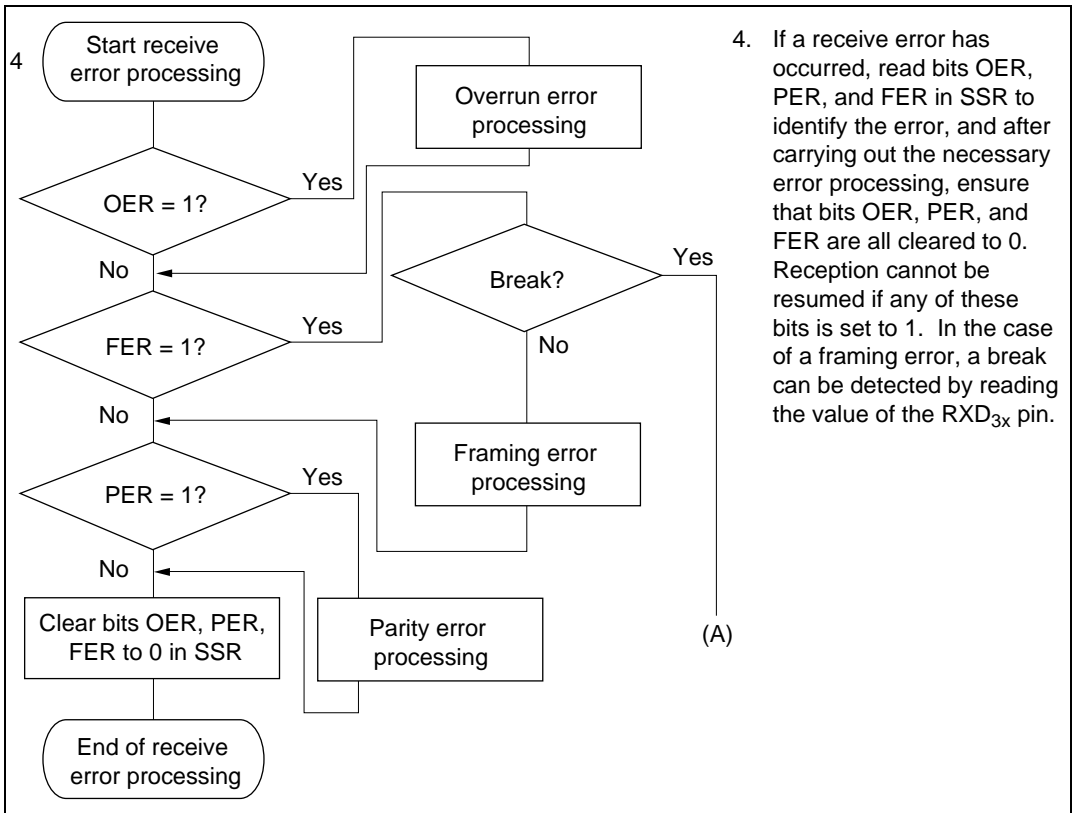


Figure 10.13 Example of Data Reception Flowchart (Asynchronous Mode) (cont)

SCI3 operates as follows when receiving data.

SCI3 monitors the communication line, and when it detects a 0 start bit, performs internal synchronization and begins reception. Reception is carried out in accordance with the relevant data transfer format in table 10.14. The received data is first placed in RSR in LSB-to-MSB order, and then the parity bit and stop bit(s) are received. SCI3 then carries out the following checks.

- Parity check
SCI3 checks that the number of 1 bits in the receive data conforms to the parity (odd or even) set in bit PM in the serial mode register (SMR).
- Stop bit check
SCI3 checks that the stop bit is 1. If two stop bits are used, only the first is checked.
- Status check
SCI3 checks that bit RDRF is set to 0, indicating that the receive data can be transferred from RSR to RDR.

If no receive error is found in the above checks, bit RDRF is set to 1, and the receive data is stored in RDR. If bit RIE is set to 1 in SCR3, an RXI interrupt is requested. If the error checks identify a receive error, bit OER, PER, or FER is set to 1 depending on the kind of error. Bit RDRF retains its state prior to receiving the data. If bit RIE is set to 1 in SCR3, an ERI interrupt is requested.

Table 10.15 shows the conditions for detecting a receive error, and receive data processing.

Note: No further receive operations are possible while a receive error flag is set. Bits OER, FER, PER, and RDRF must therefore be cleared to 0 before resuming reception.

Table 10.15 Receive Error Detection Conditions and Receive Data Processing

Receive Error	Abbr.	Detection Conditions	Receive Data Processing
Overrun error	OER	When the next data receive operation is completed while bit RDRF is still set to 1 in SSR	Receive data is not transferred from RSR to RDR
Framing error	FER	When the stop bit is 0	Receive data is transferred from RSR to RDR
Parity error	PER	When the parity (odd or even) set in SMR is different from that of the received data	Receive data is transferred from RSR to RDR

Figure 10.14 shows an example of the operation when receiving in asynchronous mode.

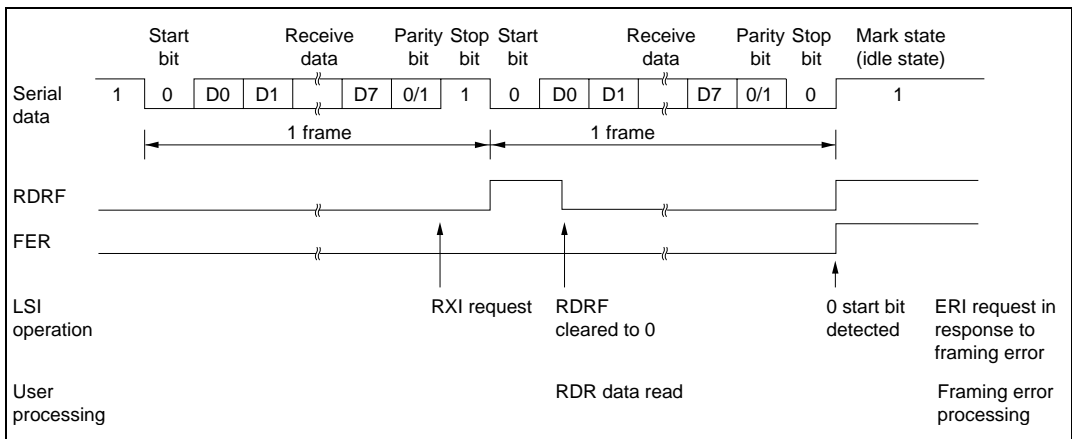


Figure 10.14 Example of Operation when Receiving in Asynchronous Mode (8-bit data, parity, 1 stop bit)

3. Operation in Synchronous Mode

In synchronous mode, SCI3 transmits and receives data in synchronization with clock pulses. This mode is suitable for high-speed serial communication.

SCI3 has separate transmission and reception units, allowing full-duplex communication with a shared clock.

As the transmission and reception units are both double-buffered, data can be written during transmission and read during reception, making possible continuous transmission and reception.

a. Data transfer format

The general data transfer format in synchronous communication is shown in figure 10.15.

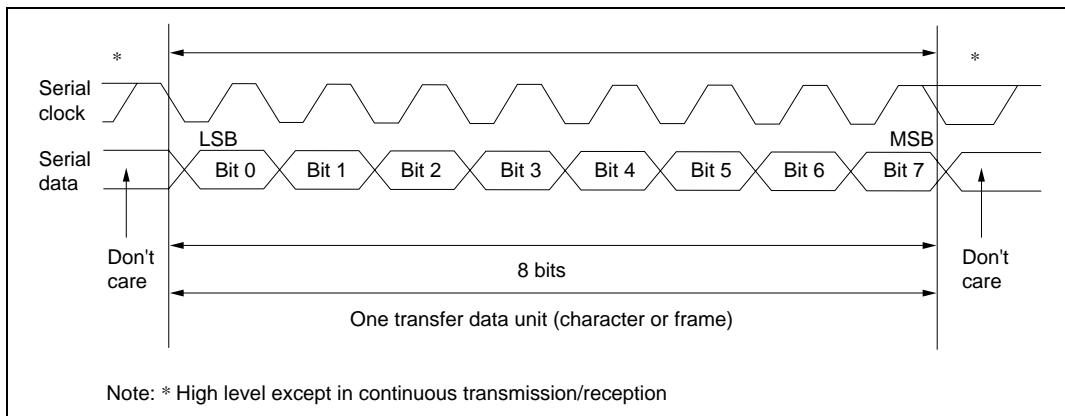


Figure 10.15 Data Format in Synchronous Communication

In synchronous communication, data on the communication line is output from one falling edge of the serial clock until the next falling edge. Data confirmation is guaranteed at the rising edge of the serial clock.

One transfer data character begins with the LSB and ends with the MSB. After output of the MSB, the communication line retains the MSB state.

When receiving in synchronous mode, SCI3 latches receive data at the rising edge of the serial clock.

The data transfer format uses a fixed 8-bit data length.

Parity and multiprocessor bits cannot be added.

b. Clock

Either an internal clock generated by the baud rate generator or an external clock input at the SCK_{3x} pin can be selected as the SCI3 serial clock. The selection is made by means of bit COM in SMR and bits CKE1 and CKE0 in SCR3. See table 10.12 for details on clock source selection.

When SCI3 operates on an internal clock, the serial clock is output at the SCK_{3x} pin. Eight pulses of the serial clock are output in transmission or reception of one character, and when SCI3 is not transmitting or receiving, the clock is fixed at the high level.

c. Data transfer operations

- SCI3 initialization

Data transfer on SCI3 first of all requires that SCI3 be initialized as described in “SCI initialization” under 10.3.3, 2. c. Data transfer operations, and shown in figure 10.10.

- Transmitting

Figure 10.16 shows an example of a flowchart for data transmission. This procedure should be followed for data transmission after initializing SCI3.

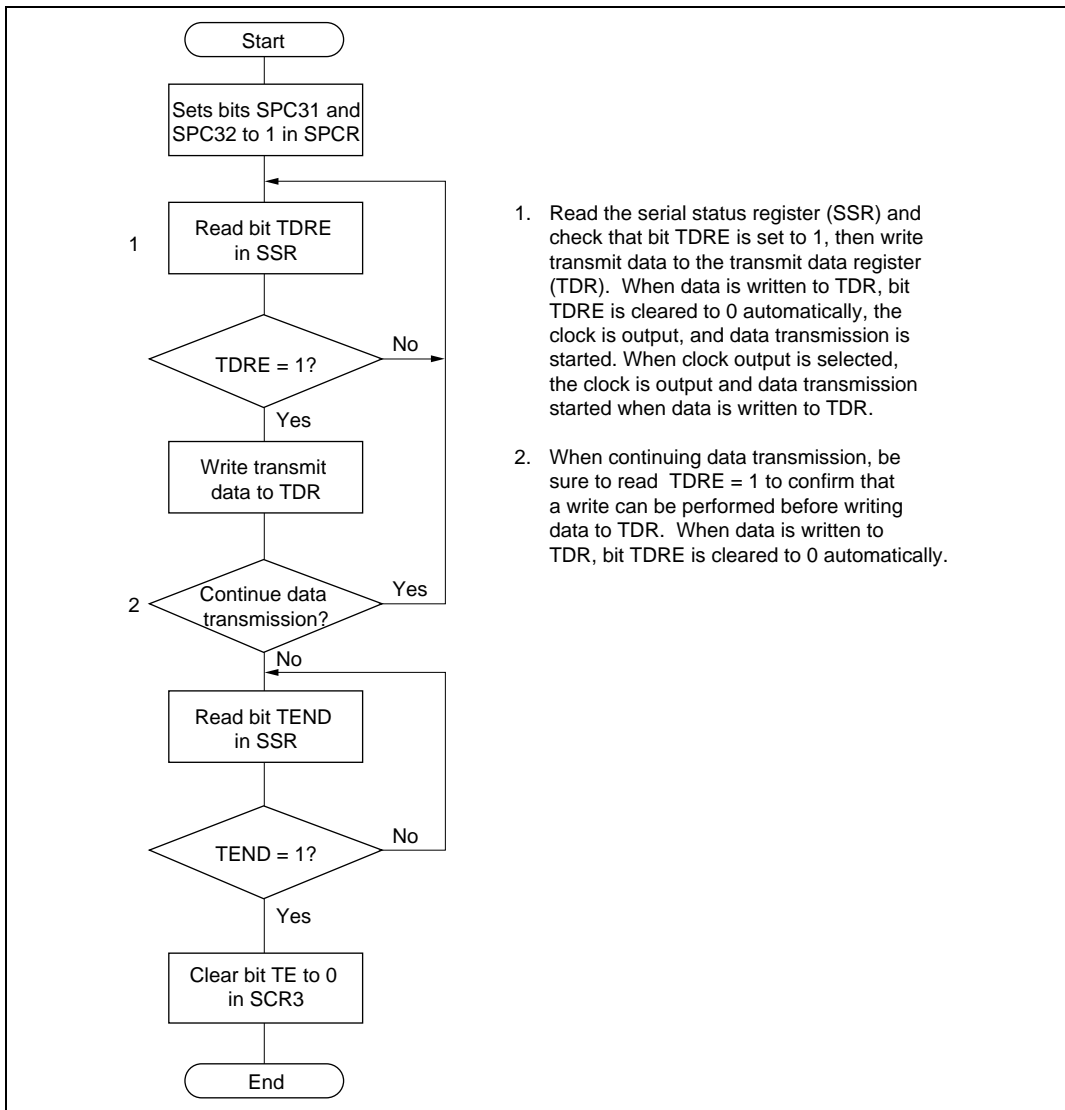


Figure 10.16 Example of Data Transmission Flowchart (Synchronous Mode)

SCI3 operates as follows when transmitting data.

SCI3 monitors bit TDRE in SSR, and when it is cleared to 0, recognizes that data has been written to TDR and transfers data from TDR to TSR. It then sets bit TDRE to 1 and starts transmitting. If bit TIE in SCR3 is set to 1 at this time, a TXI request is made.

When clock output mode is selected, SCI3 outputs 8 serial clock pulses. When an external clock is selected, data is output in synchronization with the input clock.

Serial data is transmitted from the TXD3x pin in order from the LSB (bit 0) to the MSB (bit 7). When the MSB (bit 7) is sent, checks bit TDRE. If bit TDRE is cleared to 0, SCI3 transfers data from TDR to TSR, and starts transmission of the next frame. If bit TDRE is set to 1, SCI3 sets bit TEND to 1 in SSR, and after sending the MSB (bit 7), retains the MSB state. If bit TEIE in SCR3 is set to 1 at this time, a TEI request is made.

After transmission ends, the SCK pin is fixed at the high level.

Note: Transmission is not possible if an error flag (OER, FER, or PER) that indicates the data reception status is set to 1. Check that these error flags are all cleared to 0 before a transmit operation.

Figure 10.17 shows an example of the operation when transmitting in synchronous mode.

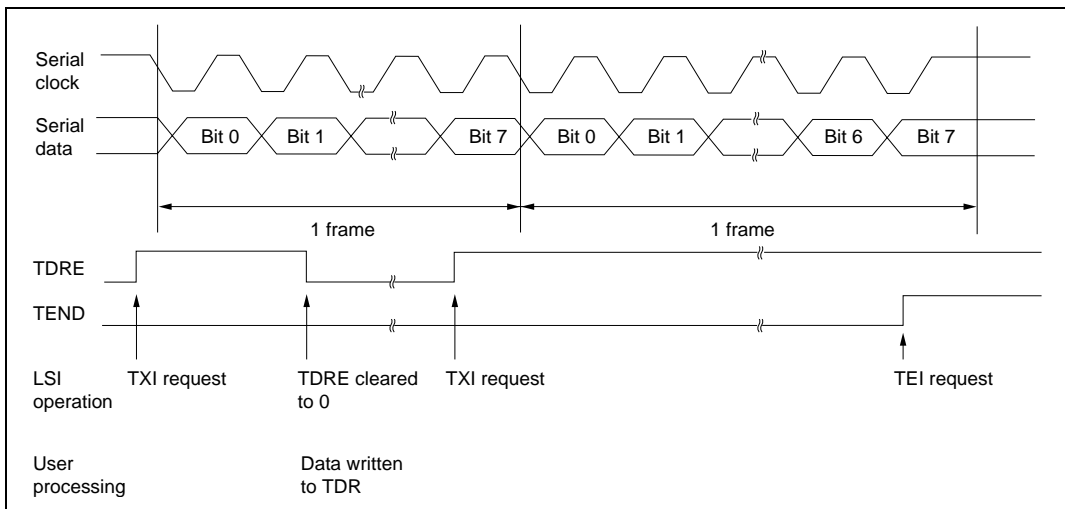


Figure 10.17 Example of Operation when Transmitting in Synchronous Mode

- Receiving

Figure 10.18 shows an example of a flowchart for data reception. This procedure should be followed for data reception after initializing SCI3.

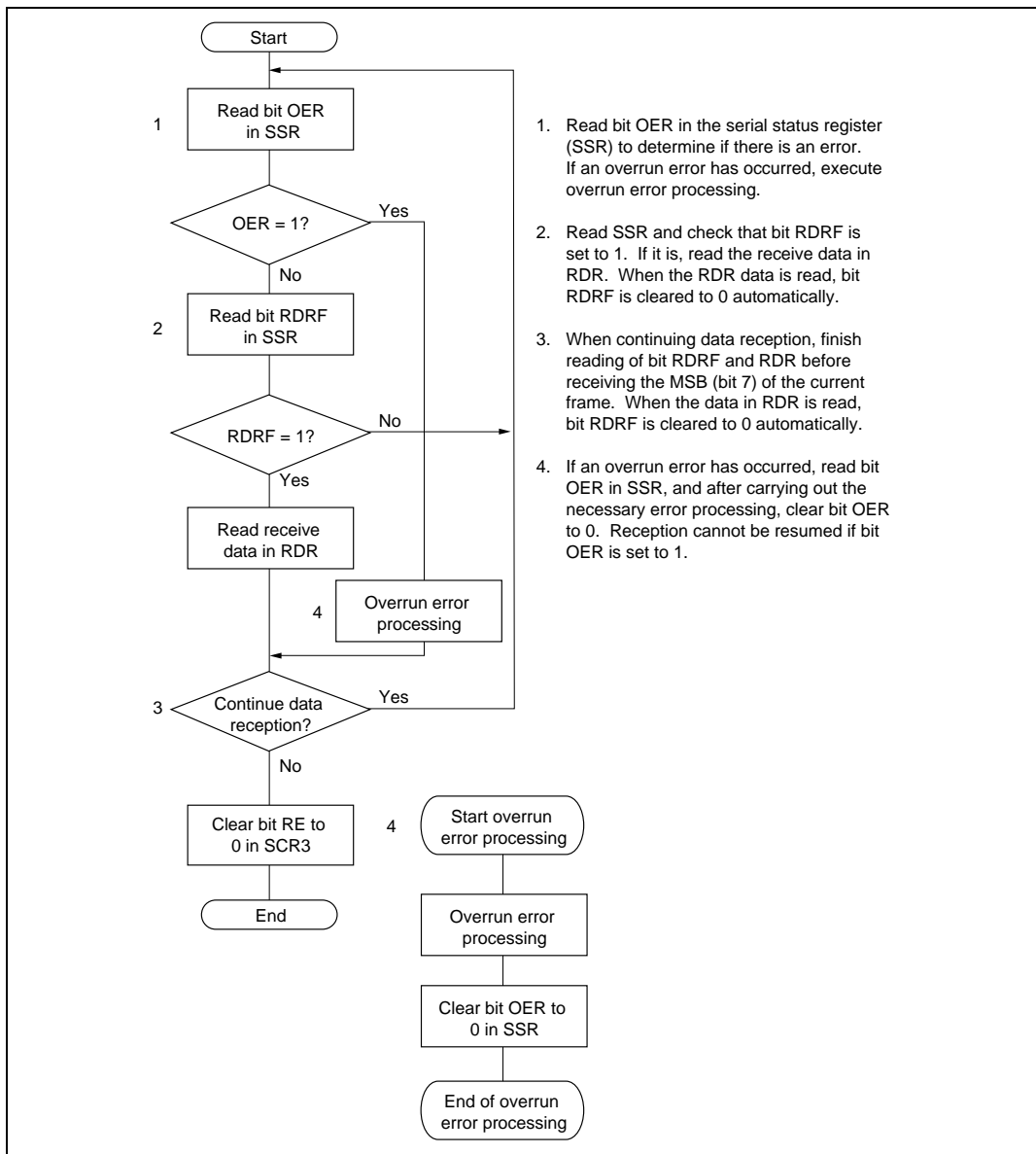


Figure 10.18 Example of Data Reception Flowchart (Synchronous Mode)

SCI3 operates as follows when receiving data.

SCI3 performs internal synchronization and begins reception in synchronization with the serial clock input or output.

The received data is placed in RSR in LSB-to-MSB order.

After the data has been received, SCI3 checks that bit RDRF is set to 0, indicating that the receive data can be transferred from RSR to RDR.

If this check shows that there is no overrun error, bit RDRF is set to 1, and the receive data is stored in RDR. If bit RIE is set to 1 in SCR3, an RXI interrupt is requested. If the check identifies an overrun error, bit OER is set to 1.

Bit RDRF remains set to 1. If bit RIE is set to 1 in SCR3, an ERI interrupt is requested.

See table 10.15 for the conditions for detecting a receive error, and receive data processing.

Note: No further receive operations are possible while a receive error flag is set. Bits OER, FER, PER, and RDRF must therefore be cleared to 0 before resuming reception.

Figure 10.19 shows an example of the operation when receiving in synchronous mode.

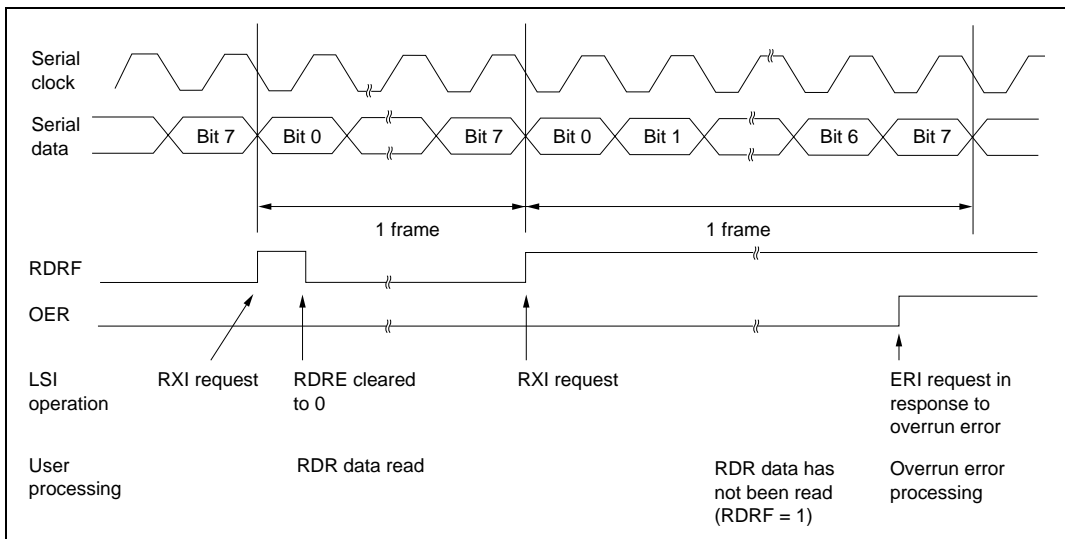


Figure 10.19 Example of Operation when Receiving in Synchronous Mode

- Simultaneous transmit/receive

Figure 10.20 shows an example of a flowchart for a simultaneous transmit/receive operation. This procedure should be followed for simultaneous transmission/reception after initializing SCI3.

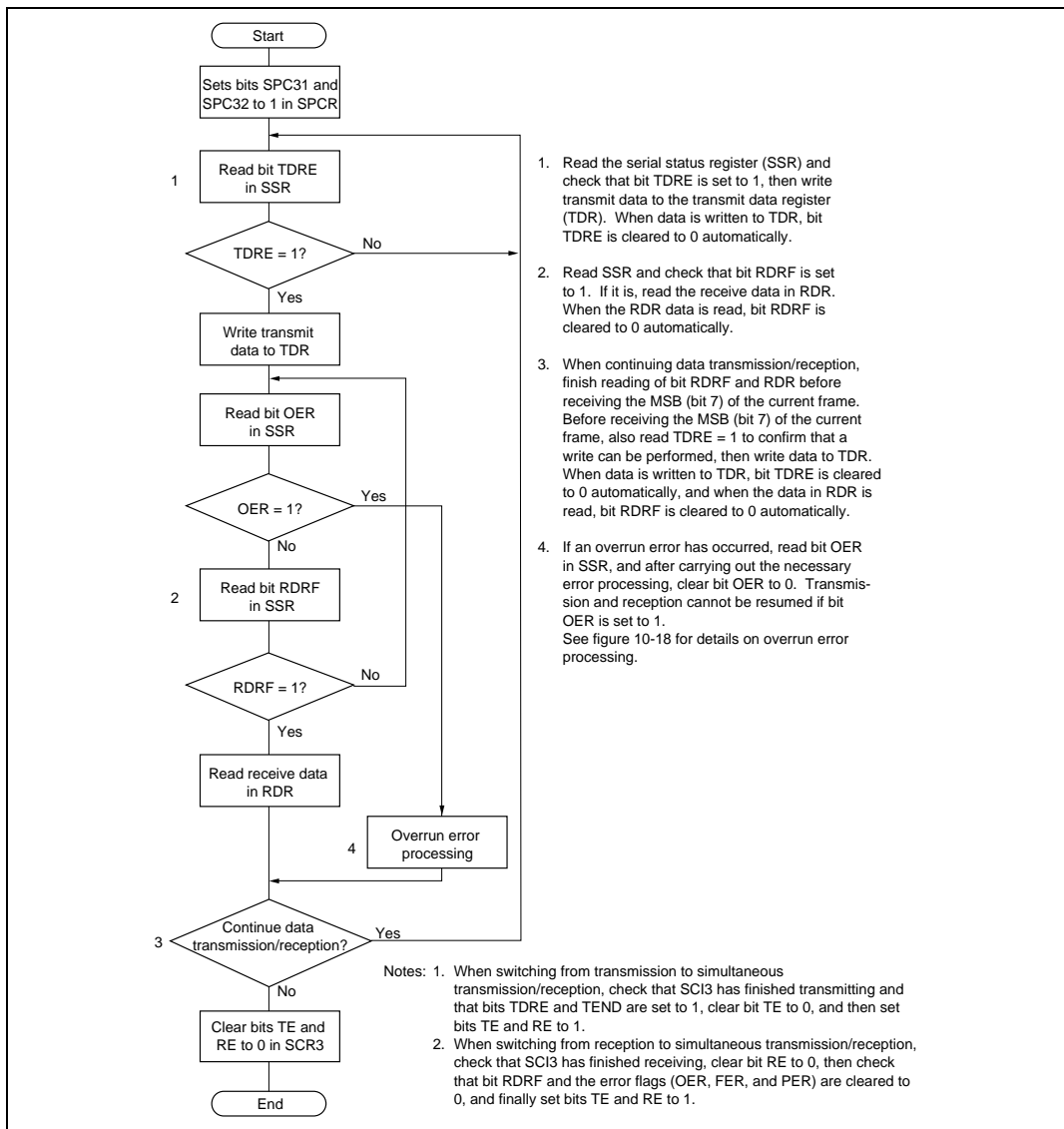


Figure 10.20 Example of Simultaneous Data Transmission/Reception Flowchart (Synchronous Mode)

4. Multiprocessor Communication Function

The multiprocessor communication function enables data to be exchanged among a number of processors on a shared communication line. Serial data communication is performed in asynchronous mode using the multiprocessor format (in which a multiprocessor bit is added to the transfer data).

In multiprocessor communication, each receiver is assigned its own ID code. The serial communication cycle consists of two cycles, an ID transmission cycle in which the receiver is specified, and a data transmission cycle in which the transfer data is sent to the specified receiver. These two cycles are differentiated by means of the multiprocessor bit, 1 indicating an ID transmission cycle, and 0, a data transmission cycle.

The sender first sends transfer data with a 1 multiprocessor bit added to the ID code of the receiver it wants to communicate with, and then sends transfer data with a 0 multiprocessor bit added to the transmit data. When a receiver receives transfer data with the multiprocessor bit set to 1, it compares the ID code with its own ID code, and if they are the same, receives the transfer data sent next. If the ID codes do not match, it skips the transfer data until data with the multiprocessor bit set to 1 is sent again.

In this way, a number of processors can exchange data among themselves.

Figure 10.21 shows an example of communication between processors using the multiprocessor format.

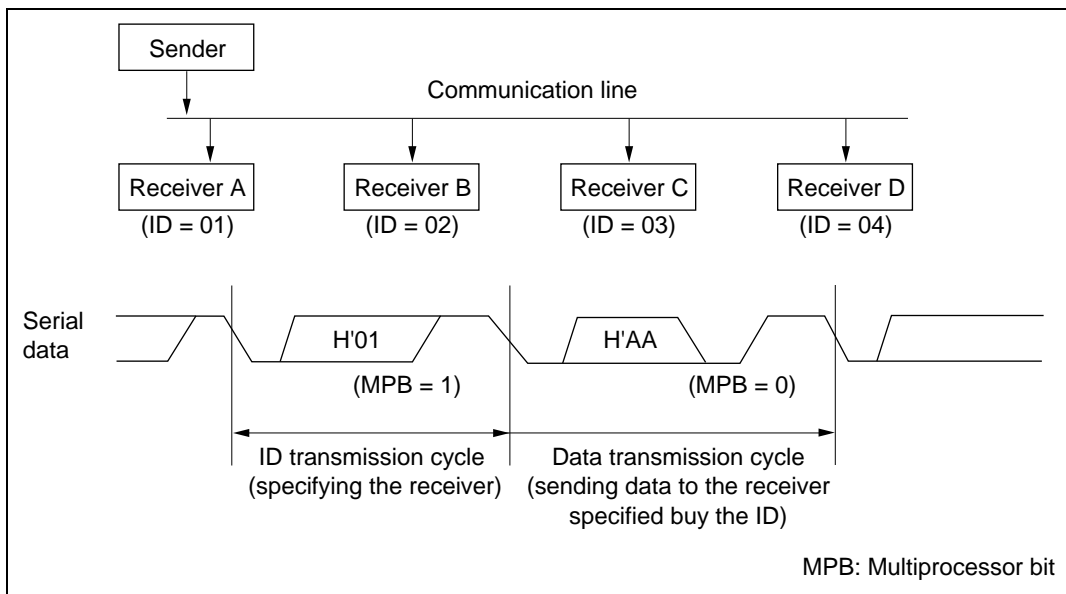


Figure 10.21 Example of Inter-Processor Communication Using Multiprocessor Format (Sending data H'AA to receiver A)

There is a choice of four data transfer formats. If a multiprocessor format is specified, the parity bit specification is invalid. See table 10.14 for details.

For details on the clock used in multiprocessor communication, see section 10.3.3, 2. Operation in Asynchronous Mode.

- Multiprocessor transmitting

Figure 10.22 shows an example of a flowchart for multiprocessor data transmission. This procedure should be followed for multiprocessor data transmission after initializing SCI3.

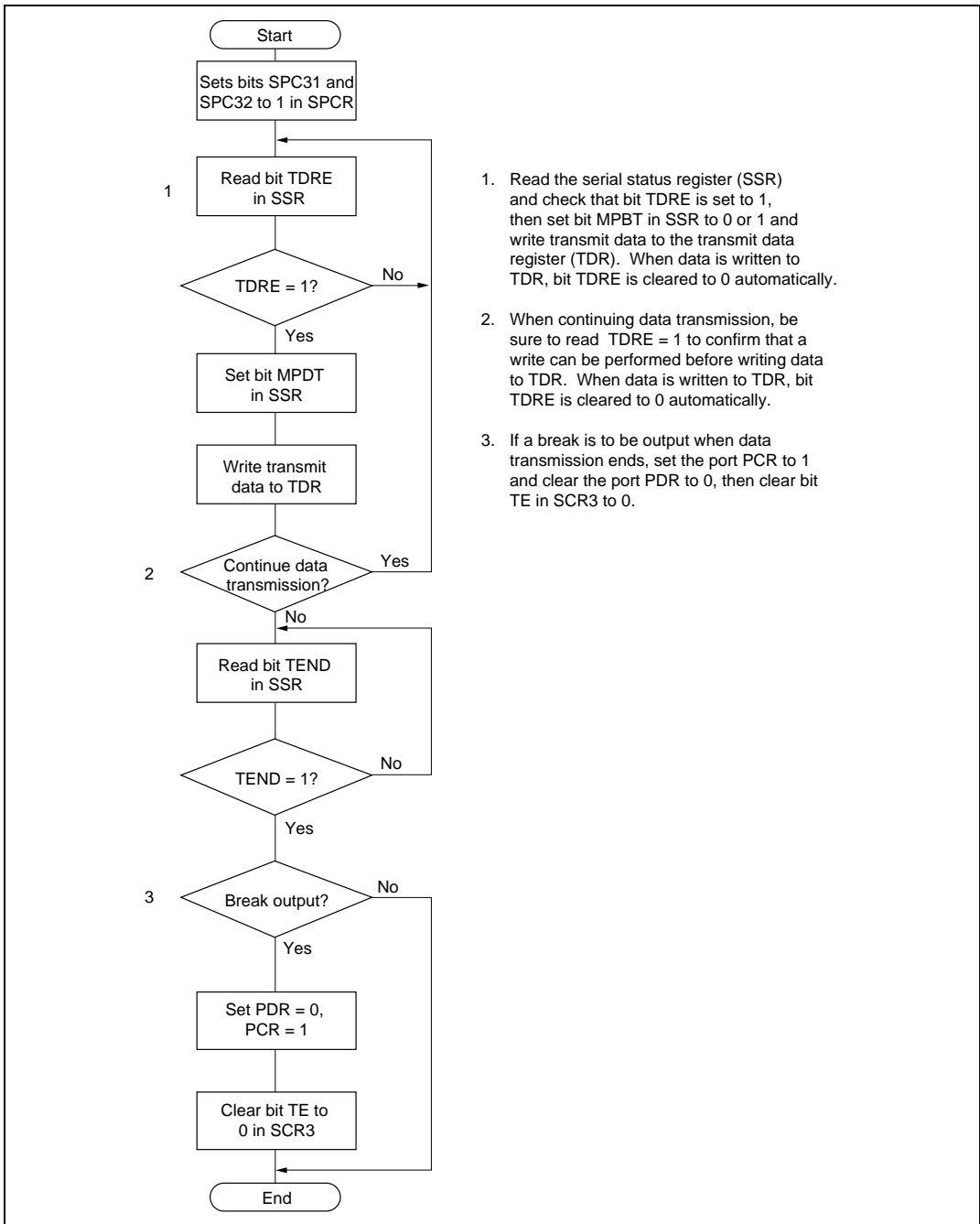


Figure 10.22 Example of Multiprocessor Data Transmission Flowchart

SCI3 operates as follows when transmitting data.

SCI3 monitors bit TDRE in SSR, and when it is cleared to 0, recognizes that data has been written to TDR and transfers data from TDR to TSR. It then sets bit TDRE to 1 and starts transmitting. If bit TIE in SCR3 is set to 1 at this time, a TXI request is made.

Serial data is transmitted from the TXD pin using the relevant data transfer format in table 10.14. When the stop bit is sent, SCI3 checks bit TDRE. If bit TDRE is cleared to 0, SCI3 transfers data from TDR to TSR, and when the stop bit has been sent, starts transmission of the next frame. If bit TDRE is set to 1 bit TEND in SSR bit is set to 1, the mark state, in which 1s are transmitted, is established after the stop bit has been sent. If bit TEIE in SCR3 is set to 1 at this time, a TEI request is made.

Figure 10.23 shows an example of the operation when transmitting using the multiprocessor format.

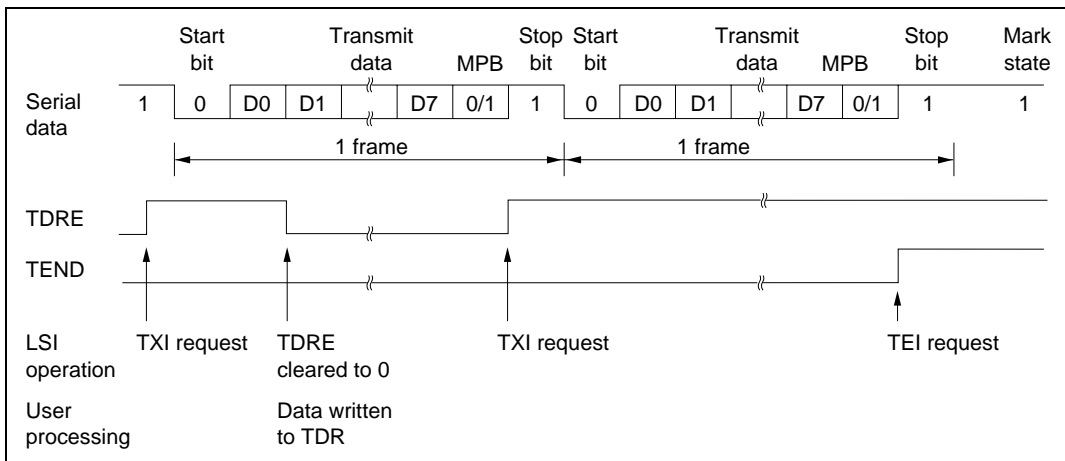


Figure 10.23 Example of Operation when Transmitting Using Multiprocessor Format (8-bit data, multiprocessor bit, 1 stop bit)

- Multiprocessor receiving

Figure 10.24 shows an example of a flowchart for multiprocessor data reception. This procedure should be followed for multiprocessor data reception after initializing SCI3.

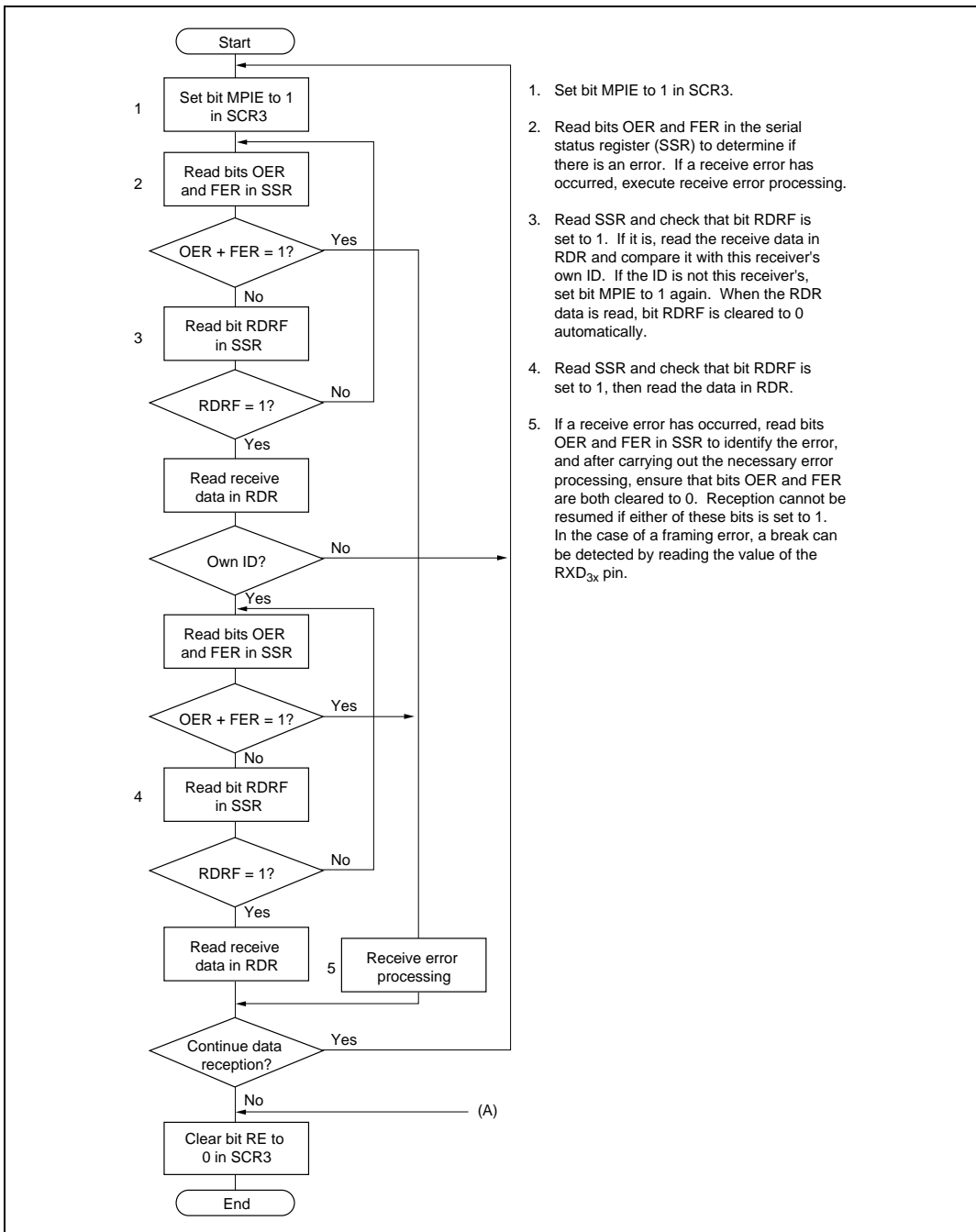


Figure 10.24 Example of Multiprocessor Data Reception Flowchart

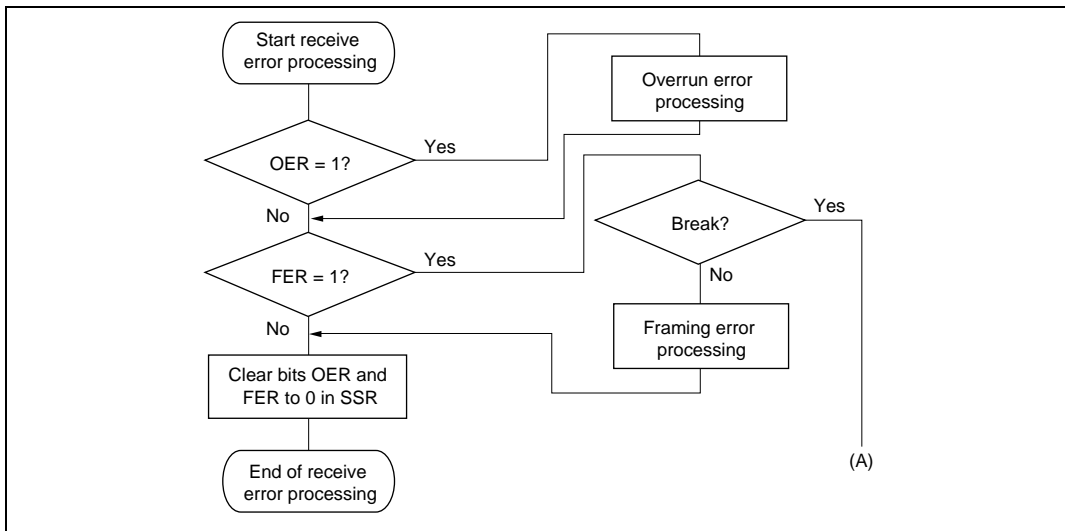


Figure 10.24 Example of Multiprocessor Data Reception Flowchart (cont)

Figure 10.25 shows an example of the operation when receiving using the multiprocessor format.

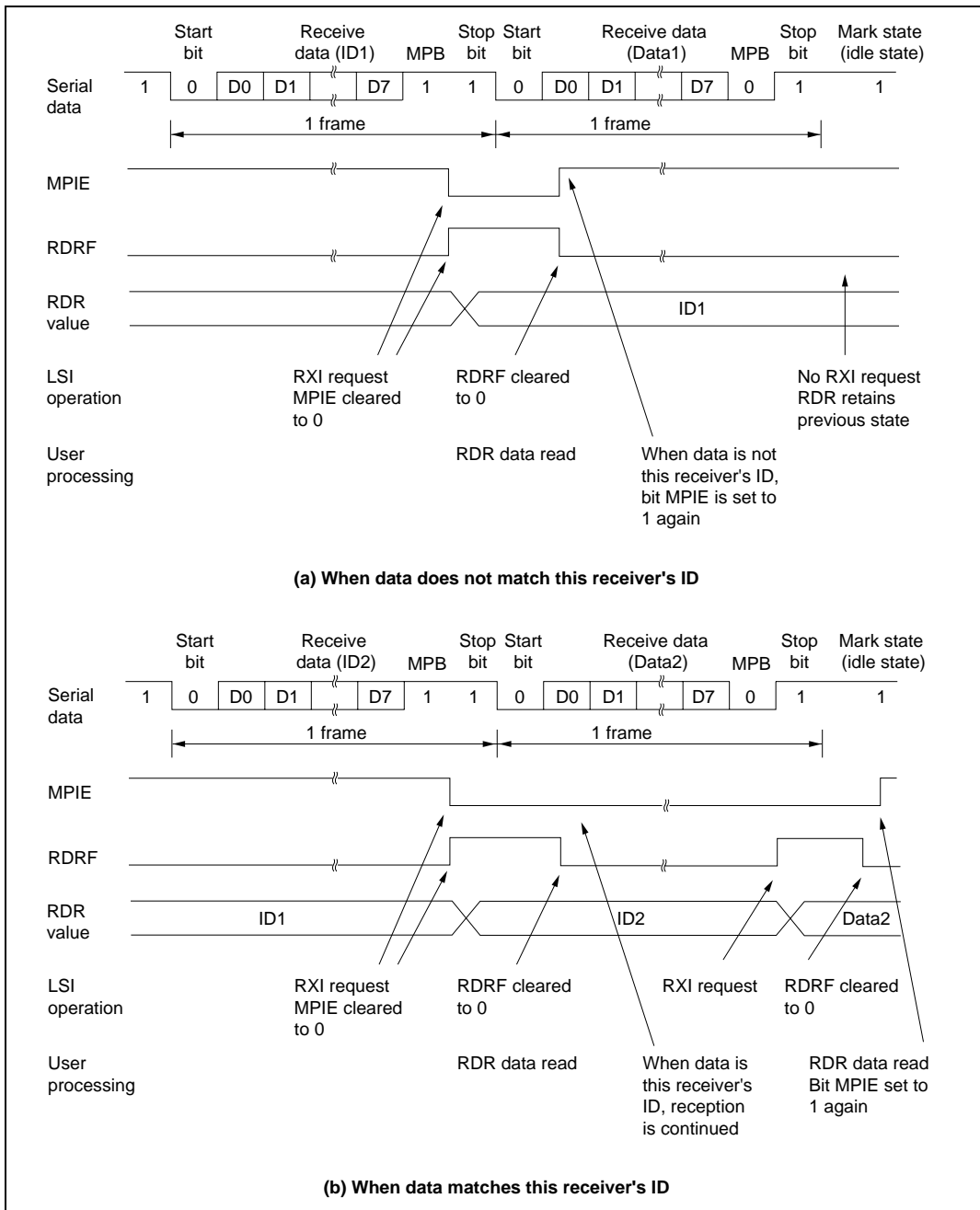


Figure 10.25 Example of Operation when Receiving Using Multiprocessor Format (8-bit data, multiprocessor bit, 1 stop bit)

10.3.4 Interrupts

SCI3 can generate six kinds of interrupts: transmit end, transmit data empty, receive data full, and three receive error interrupts (overrun error, framing error, and parity error). These interrupts have the same vector address.

The various interrupt requests are shown in table 10.16.

Table 10.16 SCI3 Interrupt Requests

Interrupt Abbr.	Interrupt Request	Vector Address
RXI	Interrupt request initiated by receive data full flag (RDRF)	H'0022/H'0024
TXI	Interrupt request initiated by transmit data empty flag (TDRE)	
TEI	Interrupt request initiated by transmit end flag (TEND)	
ERI	Interrupt request initiated by receive error flag (OER, FER, PER)	

Each interrupt request can be enabled or disabled by means of bits TIE and RIE in SCR3.

When bit TDRE is set to 1 in SSR, a TXI interrupt is requested. When bit TEND is set to 1 in SSR, a TEI interrupt is requested. These two interrupts are generated during transmission.

The initial value of bit TDRE in SSR is 1. Therefore, if the transmit data empty interrupt request (TXI) is enabled by setting bit TIE to 1 in SCR3 before transmit data is transferred to TDR, a TXI interrupt will be requested even if the transmit data is not ready.

Also, the initial value of bit TEND in SSR is 1. Therefore, if the transmit end interrupt request (TEI) is enabled by setting bit TEIE to 1 in SCR3 before transmit data is transferred to TDR, a TEI interrupt will be requested even if the transmit data has not been sent.

Effective use of these interrupt requests can be made by having processing that transfers transmit data to TDR carried out in the interrupt service routine.

To prevent the generation of these interrupt requests (TXI and TEI), on the other hand, the enable bits for these interrupt requests (bits TIE and TEIE) should be set to 1 after transmit data has been transferred to TDR.

When bit RDRF is set to 1 in SSR, an RXI interrupt is requested, and if any of bits OER, PER, and FER is set to 1, an ERI interrupt is requested. These two interrupt requests are generated during reception.

For further details, see section 3.3, Interrupts.

10.3.5 Application Notes

The following points should be noted when using SCI3.

1. Relation between Writes to TDR and bit TDRE

Bit TDRE in the serial status register (SSR) is a status flag that indicates that data for serial transmission has not been prepared in TDR. When data is written to TDR, bit TDRE is cleared to 0 automatically. When SCI3 transfers data from TDR to TSR, bit TDRE is set to 1.

Data can be written to TDR irrespective of the state of bit TDRE, but if new data is written to TDR while bit TDRE is cleared to 0, the data previously stored in TDR will be lost if it has not yet been transferred to TSR. Accordingly, to ensure that serial transmission is performed dependably, you should first check that bit TDRE is set to 1, then write the transmit data to TDR once only (not two or more times).

2. Operation when a Number of Receive Errors Occur Simultaneously

If a number of receive errors are detected simultaneously, the status flags in SSR will be set to the states shown in table 10.17. If an overrun error is detected, data transfer from RSR to RDR will not be performed, and the receive data will be lost.

Table 10.17 SSR Status Flag States and Receive Data Transfer

SSR Status Flags				Receive Data Transfer	
RDRF*	OER	FER	PER	RSR → RDR	Receive Error Status
1	1	0	0	×	Overrun error
0	0	1	0	○	Framing error
0	0	0	1	○	Parity error
1	1	1	0	×	Overrun error + framing error
1	1	0	1	×	Overrun error + parity error
0	0	1	1	○	Framing error + parity error
1	1	1	1	×	Overrun error + framing error + parity error

○ : Receive data is transferred from RSR to RDR.
 × : Receive data is not transferred from RSR to RDR.

Note: * Bit RDRF retains its state prior to data reception. However, note that if RDR is read after an overrun error has occurred in a frame because reading of the receive data in the previous frame was delayed, RDRF will be cleared to 0.

3. Break Detection and Processing

When a framing error is detected, a break can be detected by reading the value of the RXD_{3X} pin directly. In a break, the input from the RXD_{3X} pin becomes all 0s, with the result that bit FER is set and bit PER may also be set.

SCI3 continues the receive operation even after receiving a break. Note, therefore, that even though bit FER is cleared to 0 it will be set to 1 again.

4. Mark State and Break Detection

When bit TE is cleared to 0, the TXD_{3X} pin functions as an I/O port whose input/output direction and level are determined by PDR and PCR. This fact can be used to set the TXD_{3X} pin to the mark state, or to detect a break during transmission.

To keep the communication line in the mark state (1 state) until bit TE is set to 1, set PCR = 1 and PDR = 1. Since bit TE is cleared to 0 at this time, the TXD_{3X} pin functions as an I/O port and 1 is output.

To detect a break, clear bit TE to 0 after setting PCR = 1 and PDR = 0.

When bit TE is cleared to 0, the transmission unit is initialized regardless of the current transmission state, the TXD_{3X} pin functions as an I/O port, and 0 is output from the TXD_{3X} pin.

5. Receive Error Flags and Transmit Operation (Synchronous Mode Only)

When a receive error flag (OER, PER, or FER) is set to 1, transmission cannot be started even if bit TDRE is cleared to 0. The receive error flags must be cleared to 0 before starting transmission.

Note also that receive error flags cannot be cleared to 0 even if bit RE is cleared to 0.

6. Receive Data Sampling Timing and Receive Margin in Asynchronous Mode

In asynchronous mode, SCI3 operates on a basic clock with a frequency 16 times the transfer rate. When receiving, SCI3 performs internal synchronization by sampling the falling edge of the start bit with the basic clock. Receive data is latched internally at the 8th rising edge of the basic clock. This is illustrated in figure 10.26.

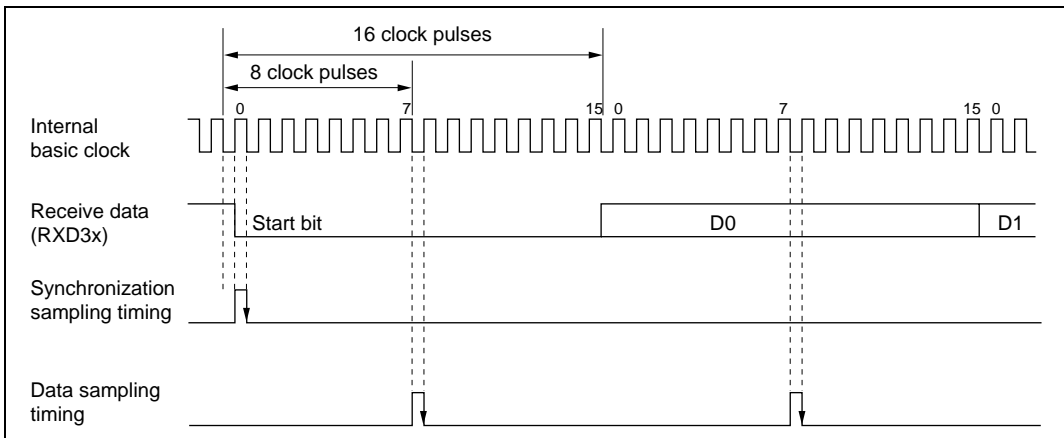


Figure 10.26 Receive Data Sampling Timing in Asynchronous Mode

Consequently, the receive margin in asynchronous mode can be expressed as shown in equation (1).

$$M = \left\{ \left(0.5 - \frac{1}{2N} \right) - \frac{D - 0.5}{N} - (L - 0.5) F \right\} \times 100 \text{ [%]} \quad \dots \text{Equation (1)}$$

where

M: Receive margin (%)

N: Ratio of bit rate to clock ($N = 16$)

D: Clock duty ($D = 0.5$ to 1.0)

L: Frame length ($L = 9$ to 12)

F: Absolute value of clock frequency deviation

Substituting 0 for F (absolute value of clock frequency deviation) and 0.5 for D (clock duty) in equation (1), a receive margin of 46.875% is given by equation (2).

When $D = 0.5$ and $F = 0$,

$$\begin{aligned} M &= \left\{ 0.5 - 1/(2 \times 16) \right\} \times 100 \text{ [%]} \\ &= 46.875\% \quad \dots \text{Equation (2)} \end{aligned}$$

However, this is only a computed value, and a margin of 20% to 30% should be allowed when carrying out system design.

7. Relation between RDR Reads and Bit RDRF

In a receive operation, SCI3 continually checks the RDRF flag. If bit RDRF is cleared to 0 when reception of one frame ends, normal data reception is completed. If bit RDRF is set to 1, this indicates that an overrun error has occurred.

When the contents of RDR are read, bit RDRF is cleared to 0 automatically. Therefore, if bit RDR is read more than once, the second and subsequent read operations will be performed while bit RDRF is cleared to 0. Note that, when an RDR read is performed while bit RDRF is cleared to 0, if the read operation coincides with completion of reception of a frame, the next frame of data may be read. This is illustrated in figure 10.27.

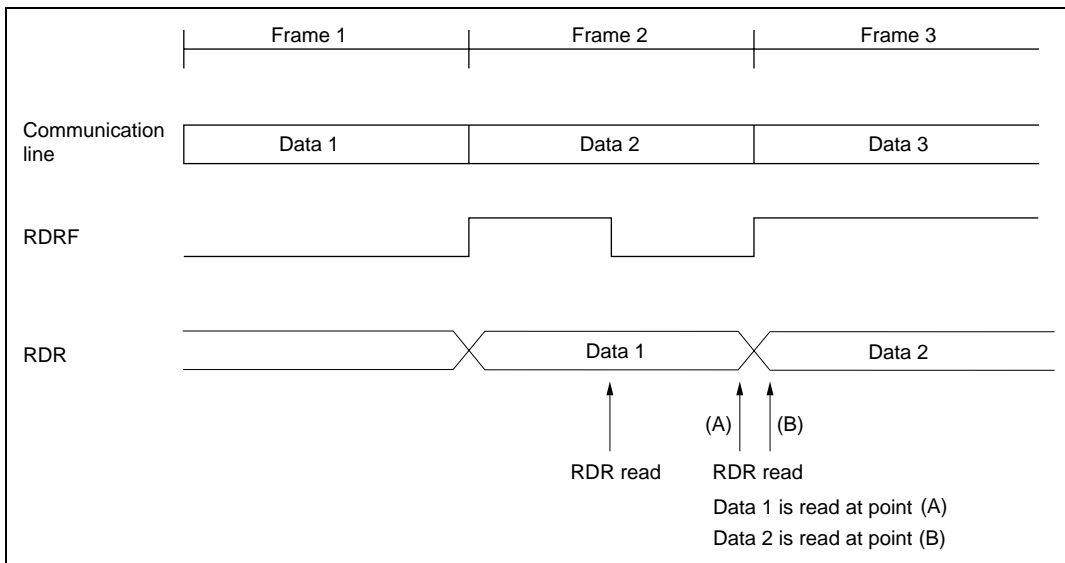


Figure 10.27 Relation between RDR Read Timing and Data

In this case, only a single RDR read operation (not two or more) should be performed after first checking that bit RDRF is set to 1. If two or more reads are performed, the data read the first time should be transferred to RAM, etc., and the RAM contents used. Also, ensure that there is sufficient margin in an RDR read operation before reception of the next frame is completed. To be precise in terms of timing, the RDR read should be completed before bit 7 is transferred in synchronous mode, or before the STOP bit is transferred in asynchronous mode.

8. Transmission and Reception Operation at State Transition

Make sure state transition operation is performed after transmission and reception operations are completed.

9. Cautions on Switching of SCK_{3X} Pin Function

If the function of the SCK_{3X} pin is switched from clock output to I/O port after using the SCI3 in clock synchronization mode, the “low” level is output in a moment (1/2 of the system clock ϕ) at the SCK_{3X} pin function switching.

This momentary “low” level output can be avoided in either of the following two methods:

a. When disabling SCK_{3X} pin clock output

When stopping signal transmission, clear the bits TE and RE in SCR3, and set the CKE1 bit to “1” and the CKE0 bit to “0” simultaneously with a single command.

In this case, use the COM bit in SMR set at “1”. This means it cannot be used as an I/O port. Also, to avoid intermediate potential from being applied to the SCK_{3X} pin, pull up the line connected to the SCK_{3X} pin to V_{CC} potential with a resistance, or supply an output from other devices.

b. When switching the SCK_{3X} pin function from clock output to I/O port

When stopping signal transmission,

(1) Clear the bits TE and RE in SCR3, and set the CKE1 bit to “1” and the CKE0 bit to “0” simultaneously with a single command.

(2) Then, clear the COM bit in SMR to “0”.

(3) Finally, clear the bits CKE1 and CKE0 in SCR3 to “0”. Avoid intermediate potential from being applied to the SCK_{3X} pin.

10. Setting in Subactive and Subsleep Modes

In subactive or subsleep mode, SCI3 can be used only when the $\phi_w/2$ is selected as the CPU clock. Set the SA1 bit in SYSCR2 to “1”.

Section 11 14-Bit PWM

11.1 Overview

This LSI is provided with a 14-bit PWM (pulse width modulator) on-chip, which can be used as a D/A converter by connecting a low-pass filter.

11.1.1 Features

Features of the 14-bit PWM are as follows.

- Choice of two conversion periods

Any of the following four conversion periods can be chosen:

131,072/ ϕ , with a minimum modulation width of 8/ ϕ (PWCR1 = 1, PWCR0 = 1)

65,536/ ϕ , with a minimum modulation width of 4/ ϕ (PWCR1 = 1, PWCR0 = 0)

32,768/ ϕ , with a minimum modulation width of 2/ ϕ (PWCR1 = 0, PWCR0 = 1)

16,384/ ϕ , with a minimum modulation width of 1/ ϕ (PWCR1 = 0, PWCR0 = 0)

- Pulse division method for less ripple
- Use of module standby mode enables this module to be placed in standby mode independently when not used.

11.1.2 Block Diagram

Figure 11.1 shows a block diagram of the 14-bit PWM.

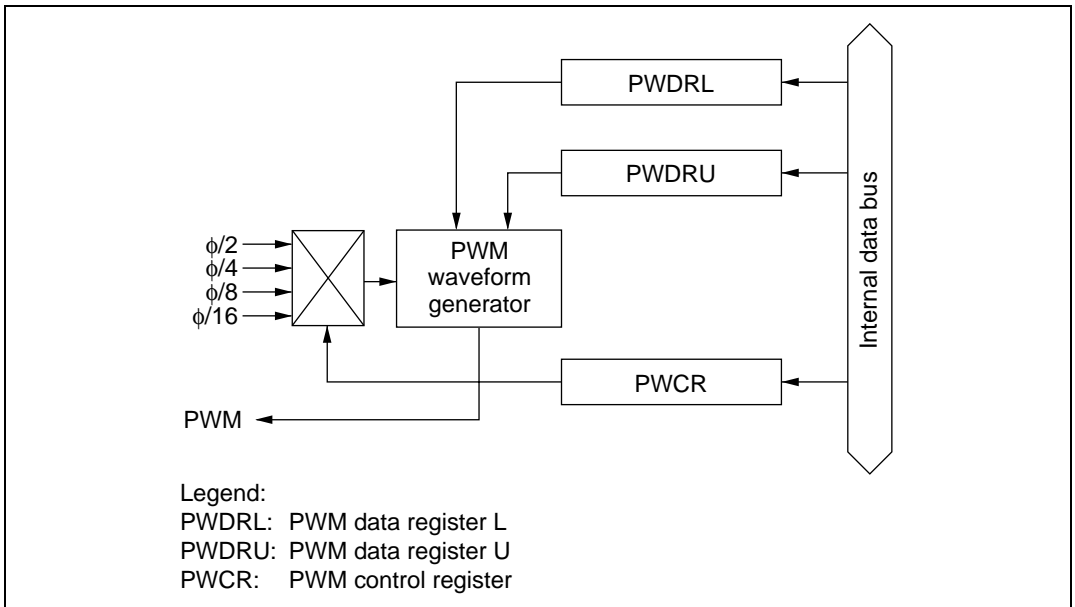


Figure 11.1 Block Diagram of the 14 bit PWM

11.1.3 Pin Configuration

Table 11.1 shows the output pin assigned to the 14-bit PWM.

Table 11.1 Pin Configuration

Name	Abbr.	I/O	Function
PWM output pin	PWM	Output	Pulse-division PWM waveform output

11.1.4 Register Configuration

Table 11.2 shows the register configuration of the 14-bit PWM.

Table 11.2 Register Configuration

Name	Abbr.	R/W	Initial Value	Address
PWM control register	PWCR	W	H'FC	H'FFD0
PWM data register U	PWDRU	W	H'C0	H'FFD1
PWM data register L	PWDRL	W	H'00	H'FFD2
Clock stop register 2	CKSTPR2	R/W	H'FF	H'FFFB

11.2 Register Descriptions

11.2.1 PWM Control Register (PWCR)

Bit	7	6	5	4	3	2	1	0
	—	—	—	—	—	—	PWCR1	PWCR0
Initial value	1	1	1	1	1	1	0	0
Read/Write	—	—	—	—	—	—	W	W

PWCR is an 8-bit write-only register for input clock selection.

Upon reset, PWCR is initialized to H'FC.

Bits 7 to 2: Reserved bits

Bits 7 to 2 are reserved; they are always read as 1, and cannot be modified.

Bits 1 and 0: Clock select 1 and 0 (PWCR1, PWCR0)

Bits 1 and 0 select the clock supplied to the 14-bit PWM. These bits are write-only bits; they are always read as 1.

Bit 1 PWCR1	Bit 0 PWCR0	Description
0	0	The input clock is $\phi/2$ ($t\phi^* = 2/\phi$) (initial value) The conversion period is $16,384/\phi$, with a minimum modulation width of $1/\phi$
0	1	The input clock is $\phi/4$ ($t\phi^* = 4/\phi$) The conversion period is $32,768/\phi$, with a minimum modulation width of $2/\phi$
1	0	The input clock is $\phi/8$ ($t\phi^* = 8/\phi$) The conversion period is $65,536/\phi$, with a minimum modulation width of $4/\phi$
1	1	The input clock is $\phi/16$ ($t\phi^* = 16/\phi$) The conversion period is $131,072/\phi$, with a minimum modulation width of $8/\phi$

Note: * Period of PWM input clock.

11.2.2 PWM Data Registers U and L (PWDRU, PWDRL)

PWDRU

Bit	7	6	5	4	3	2	1	0
	—	—	PWDRU5	PWDRU4	PWDRU3	PWDRU2	PWDRU1	PWDRU0
Initial value	1	1	0	0	0	0	0	0
Read/Write	—	—	W	W	W	W	W	W

PWDRL

Bit	7	6	5	4	3	2	1	0
	PWDRL7	PWDRL6	PWDRL5	PWDRL4	PWDRL3	PWDRL2	PWDRL1	PWDRL0
Initial value	0	0	0	0	0	0	0	0
Read/Write	W	W	W	W	W	W	W	W

PWDRU and PWDRL form a 14-bit write-only register, with the upper 6 bits assigned to PWDRU and the lower 8 bits to PWDRL. The value written to PWDRU and PWDRL gives the total high-level width of one PWM waveform cycle.

When 14-bit data is written to PWDRU and PWDRL, the register contents are latched in the PWM waveform generator, updating the PWM waveform generation data. The 14-bit data should always be written in the following sequence:

1. Write the lower 8 bits to PWDRL.
2. Write the upper 6 bits to PWDRU.

PWDRU and PWDRL are write-only registers. If they are read, all bits are read as 1.

Upon reset, PWDRU and PWDRL are initialized to H'C000.

11.2.3 Clock Stop Register 2 (CKSTPR2)

Bit	7	6	5	4	3	2	1	0
	—	—	—	—	AECKSTP	WDCKSTP	PWCKSTP	LDCKSTP
Initial value	1	1	1	1	1	1	1	1
Read/Write	—	—	—	—	R/W	R/W	R/W	R/W

CKSTPR2 is an 8-bit read/write register that performs module standby mode control for peripheral modules. Only the bit relating to the PWM is described here. For details of the other bits, see the sections on the relevant modules.

Bit 1: PWM module standby mode control (PWCKSTP)

Bit 1 controls setting and clearing of module standby mode for the PWM.

PWCKSTP	Description
0	PWM is set to module standby mode
1	PWM module standby mode is cleared (initial value)

11.3 Operation

11.3.1 Operation

When using the 14-bit PWM, set the registers in the following sequence.

1. Set bit PWM in port mode register 3 (PMR3) to 1 so that pin P3₀/PWM is designated for PWM output.
2. Set bits PWCR1 and PWCR0 in the PWM control register (PWCR) to select a conversion period of 131,072/ ϕ (PWCR1 = 1, PWCR0 = 1), 65,536/ ϕ (PWCR1 = 1, PWCR0 = 0), 32,768/ ϕ (PWCR1 = 0, PWCR0 = 1), or 16,384/ ϕ (PWCR1 = 0, PWCR0 = 0).
3. Set the output waveform data in PWM data registers U and L (PWDRU/L). Be sure to write in the correct sequence, first PWDRL then PWDRU. When data is written to PWDRU, the data in these registers will be latched in the PWM waveform generator, updating the PWM waveform generation in synchronization with internal signals.

One conversion period consists of 64 pulses, as shown in figure 11.2. The total of the high-level pulse widths during this period (T_H) corresponds to the data in PWDRU and PWDRL. This relation can be represented as follows.

$$T_H = (\text{data value in PWDRU and PWDRL} + 64) \times t_{\phi}/2$$

where t_{ϕ} is the PWM input clock period: 2/ ϕ (PWCR = H'0), 4/ ϕ (PWCR = H'1), 8/ ϕ (PWCR = H'2), or 16/ ϕ (PWCR = H'3).

Example: Settings in order to obtain a conversion period of 32,768 μ s:

When PWCR1 = 0 and PWCR0 = 0, the conversion period is 16,384/ ϕ , so ϕ must be 0.5 MHz. In this case, $t_{fn} = 512 \mu$ s, with 1/ ϕ (resolution) = 2.0 μ s.

When PWCR1 = 0 and PWCR0 = 1, the conversion period is 32,768/ ϕ , so ϕ must be 1 MHz. In this case, $t_{fn} = 512 \mu$ s, with 2/ ϕ (resolution) = 2.0 μ s.

When PWCR1 = 1 and PWCR0 = 0, the conversion period is 65,536/ ϕ , so ϕ must be 2 MHz. In this case, $t_{fn} = 512 \mu$ s, with 4/ ϕ (resolution) = 2.0 μ s.

Accordingly, for a conversion period of 32,768 μ s, the system clock frequency (ϕ) must be 0.5 MHz, 1 MHz, or 2 MHz.

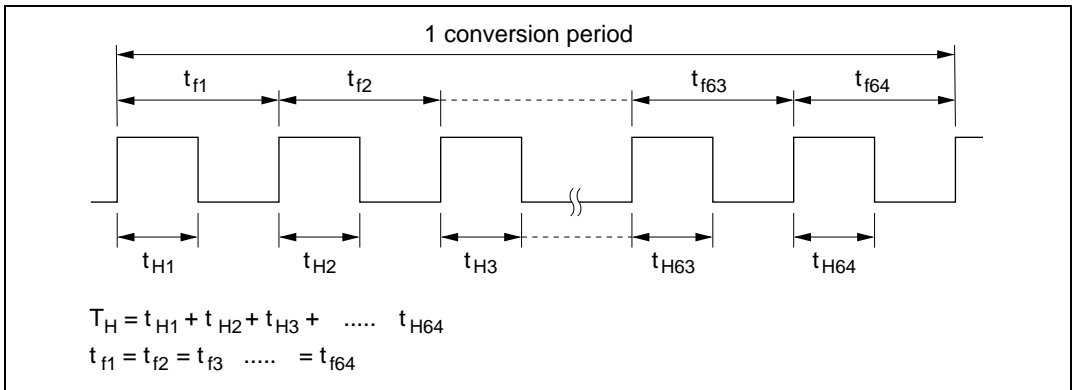


Figure 11.2 PWM Output Waveform

11.3.2 PWM Operation Modes

PWM operation modes are shown in table 11.3.

Table 11.3 PWM Operation Modes

Operation Mode	Reset	Active	Sleep	Watch	Subactive	Subsleep	Standby	Module Standby
PWCR	Reset	Functions	Functions	Held	Held	Held	Held	Held
PWDRU	Reset	Functions	Functions	Held	Held	Held	Held	Held
PWDRL	Reset	Functions	Functions	Held	Held	Held	Held	Held

Section 12 A/D Converter

12.1 Overview

This LSI includes on-chip a resistance-ladder-based successive-approximation analog-to-digital converter, and can convert up to 12 channels of analog input.

12.1.1 Features

The A/D converter has the following features.

- 10-bit resolution
- 12 input channels
- Conversion time: approx. 12.4 μ s per channel (at 5 MHz operation)
- Built-in sample-and-hold function
- Interrupt requested on completion of A/D conversion
- A/D conversion can be started by external trigger input
- Use of module standby mode enables this module to be placed in standby mode independently when not used.

12.1.2 Block Diagram

Figure 12.1 shows a block diagram of the A/D converter.

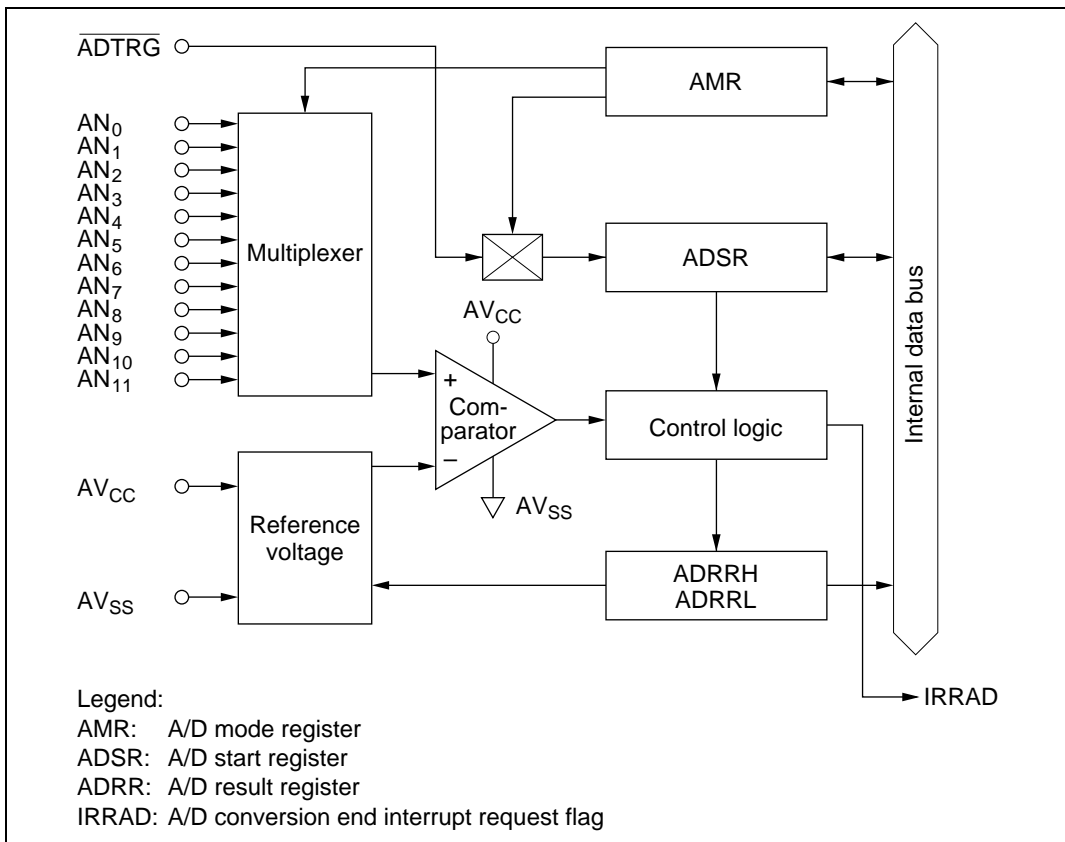


Figure 12.1 Block Diagram of the A/D Converter

12.1.3 Pin Configuration

Table 12.1 shows the A/D converter pin configuration.

Table 12.1 Pin Configuration

Name	Abbr.	I/O	Function
Analog power supply	AV _{CC}	Input	Power supply and reference voltage of analog part
Analog ground	AV _{SS}	Input	Ground and reference voltage of analog part
Analog input 0	AN ₀	Input	Analog input channel 0
Analog input 1	AN ₁	Input	Analog input channel 1
Analog input 2	AN ₂	Input	Analog input channel 2
Analog input 3	AN ₃	Input	Analog input channel 3
Analog input 4	AN ₄	Input	Analog input channel 4
Analog input 5	AN ₅	Input	Analog input channel 5
Analog input 6	AN ₆	Input	Analog input channel 6
Analog input 7	AN ₇	Input	Analog input channel 7
Analog input 8	AN ₈	Input	Analog input channel 8
Analog input 9	AN ₉	Input	Analog input channel 9
Analog input 10	AN ₁₀	Input	Analog input channel 10
Analog input 11	AN ₁₁	Input	Analog input channel 11
External trigger input	ADTRG	Input	External trigger input for starting A/D conversion

12.1.4 Register Configuration

Table 12.2 shows the A/D converter register configuration.

Table 12.2 Register Configuration

Name	Abbr.	R/W	Initial Value	Address
A/D mode register	AMR	R/W	H'30	H'FFC6
A/D start register	ADSR	R/W	H'7F	H'FFC7
A/D result register H	ADRRH	R	Not fixed	H'FFC4
A/D result register L	ADRRL	R	Not fixed	H'FFC5
Clock stop register 1	CKSTPRT1	R/W	H'FF	H'FFFA

12.2 Register Descriptions

12.2.1 A/D Result Registers (ADRRH, ADRL)

Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
	ADR9	ADR8	ADR7	ADR6	ADR5	ADR4	ADR3	ADR2	ADR1	ADR0	—	—	—	—	—	—
Initial value	Not fixed	Not fixed	Not fixed	Not fixed	Not fixed	Not fixed	Not fixed	Not fixed	Not fixed	Not fixed	—	—	—	—	—	—
Read/Write	R	R	R	R	R	R	R	R	R	R	—	—	—	—	—	—
	ADRRH								ADRL							

ADRRH and ADRL together comprise a 16-bit read-only register for holding the results of analog-to-digital conversion. The upper 8 bits of the data are held in ADRRH, and the lower 2 bits in ADRL.

ADRRH and ADRL can be read by the CPU at any time, but the ADRRH and ADRL values during A/D conversion are not fixed. After A/D conversion is complete, the conversion result is stored as 10-bit data, and this data is held until the next conversion operation starts.

ADRRH and ADRL are not cleared on reset.

12.2.2 A/D Mode Register (AMR)

Bit	7	6	5	4	3	2	1	0
	CKS	TRGE	—	—	CH3	CH2	CH1	CH0
Initial value	0	0	1	1	0	0	0	0
Read/Write	R/W	R/W	—	—	R/W	R/W	R/W	R/W

AMR is an 8-bit read/write register for specifying the A/D conversion speed, external trigger option, and the analog input pins.

Upon reset, AMR is initialized to H'30.

Bit 7: Clock select (CKS)

Bit 7 sets the A/D conversion speed.

Bit 7 CKS	Conversion Period	Conversion Time (Active (High-Speed) Mode)*	
		$\phi = 1 \text{ MHz}$	$\phi = 5 \text{ MHz}$
0	$62/\phi$ (initial value)	62 μs	12.4 μs
1	$31/\phi$	31 μs	—

Note: * For information on conversion time settings for which operation is guaranteed, see section 15, Electrical Characteristics.

Bit 6: External trigger select (TRGE)

Bit 6 enables or disables the start of A/D conversion by external trigger input.

Bit 6 TRGE	Description
0	Disables start of A/D conversion by external trigger (initial value)
1	Enables start of A/D conversion by rising or falling edge of external trigger at pin $\overline{\text{ADTRG}}^*$

Note: * The external trigger ($\overline{\text{ADTRG}}$) edge is selected by bit IEG4 of IEGR. See 1. IRQ edge select register (IEGR) in section 3.3.2 for details.

Bits 5 and 4: Reserved bits

Bits 5 and 4 are reserved; they are always read as 1, and cannot be modified.

Bits 3 to 0: Channel select (CH3 to CH0)

Bits 3 to 0 select the analog input channel.

The channel selection should be made while bit ADSF is cleared to 0.

Bit 3 CH3	Bit 2 CH2	Bit 1 CH1	Bit 0 CH0	Analog Input Channel	
0	0	*	*	No channel selected	(initial value)
0	1	0	0	AN ₀	
0	1	0	1	AN ₁	
0	1	1	0	AN ₂	
0	1	1	1	AN ₃	
1	0	0	0	AN ₄	
1	0	0	1	AN ₅	
1	0	1	0	AN ₆	
1	0	1	1	AN ₇	
1	1	0	0	AN ₈	
1	1	0	1	AN ₉	
1	1	1	0	AN ₁₀	
1	1	1	1	AN ₁₁	

*: Don't care

12.2.3 A/D Start Register (ADSR)

Bit	7	6	5	4	3	2	1	0
ADSF	—	—	—	—	—	—	—	—
Initial value	0	1	1	1	1	1	1	1
Read/Write	R/W	—	—	—	—	—	—	—

The A/D start register (ADSR) is an 8-bit read/write register for starting and stopping A/D conversion.

A/D conversion is started by writing 1 to the A/D start flag (ADSF) or by input of the designated edge of the external trigger signal, which also sets ADSF to 1. When conversion is complete, the converted data is set in ADDRHH and ADDRLL, and at the same time ADSF is cleared to 0.

Bit 7: A/D start flag (ADSF)

Bit 7 controls and indicates the start and end of A/D conversion.

Bit 7

ADSF	Description
0	Read: Indicates the completion of A/D conversion (initial value) Write: Stops A/D conversion
1	Read: Indicates A/D conversion in progress Write: Starts A/D conversion

Bits 6 to 0: Reserved bits

Bits 6 to 0 are reserved; they are always read as 1, and cannot be modified.

12.2.4 Clock Stop Register 1 (CKSTPR1)

Bit	7	6	5	4	3	2	1	0
	S1CKSTP	S31CKSTP	S32CKSTP	ADCKSTP	TGCKSTP	TFCKSTP	TCCKSTP	TACKSTP
Initial value	1	1	1	1	1	1	1	1
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

CKSTPR1 is an 8-bit read/write register that performs module standby mode control for peripheral modules. Only the bit relating to the A/D converter is described here. For details of the other bits, see the sections on the relevant modules.

Bit 4: A/D converter module standby mode control (ADCKSTP)

Bit 4 controls setting and clearing of module standby mode for the A/D converter.

ADCKSTP	Description
0	A/D converter is set to module standby mode
1	A/D converter module standby mode is cleared (initial value)

12.3 Operation

12.3.1 A/D Conversion Operation

The A/D converter operates by successive approximations, and yields its conversion result as 10-bit data.

A/D conversion begins when software sets the A/D start flag (bit ADSF) to 1. Bit ADSF keeps a value of 1 during A/D conversion, and is cleared to 0 automatically when conversion is complete.

The completion of conversion also sets bit IRRAD in interrupt request register 2 (IRR2) to 1. An A/D conversion end interrupt is requested if bit IENAD in interrupt enable register 2 (IENR2) is set to 1.

If the conversion time or input channel needs to be changed in the A/D mode register (AMR) during A/D conversion, bit ADSF should first be cleared to 0, stopping the conversion operation, in order to avoid malfunction.

12.3.2 Start of A/D Conversion by External Trigger Input

The A/D converter can be made to start A/D conversion by input of an external trigger signal. External trigger input is enabled at pin $\overline{\text{ADTRG}}$ when bit IRQ4 in PMR1 is set to 1 and bit TRGE in AMR is set to 1. Then when the input signal edge designated in bit IEG4 of interrupt edge select register (IEGR) is detected at pin $\overline{\text{ADTRG}}$, bit ADSF in ADSR will be set to 1, starting A/D conversion.

Figure 12.2 shows the timing.

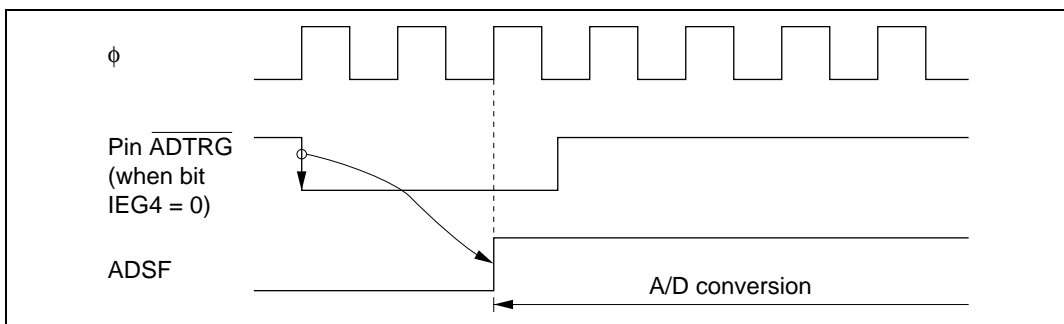


Figure 12.2 External Trigger Input Timing

12.3.3 A/D Converter Operation Modes

A/D converter operation modes are shown in table 12.3.

Table 12.3 A/D Converter Operation Modes

Operation Mode	Reset	Active	Sleep	Watch	Subactive	Subsleep	Standby	Module Standby
AMR	Reset	Functions	Functions	Held	Held	Held	Held	Held
ADSR	Reset	Functions	Functions	Held	Held	Held	Held	Held
ADRRH	Held*	Functions	Functions	Held	Held	Held	Held	Held
ADRRL	Held*	Functions	Functions	Held	Held	Held	Held	Held

Note: * Undefined in a power-on reset.

12.4 Interrupts

When A/D conversion ends (ADSF changes from 1 to 0), bit IRRAD in interrupt request register 2 (IRR2) is set to 1.

A/D conversion end interrupts can be enabled or disabled by means of bit IENAD in interrupt enable register 2 (IENR2).

For further details see section 3.3, Interrupts.

12.5 Typical Use

An example of how the A/D converter can be used is given below, using channel 1 (pin AN1) as the analog input channel. Figure 12.3 shows the operation timing.

1. Bits CH3 to CH0 of the A/D mode register (AMR) are set to 0101, making pin AN1 the analog input channel. A/D interrupts are enabled by setting bit IENAD to 1, and A/D conversion is started by setting bit ADSF to 1.
2. When A/D conversion is complete, bit IRRAD is set to 1, and the A/D conversion result is stored in ADRRH and ADRRL. At the same time ADSF is cleared to 0, and the A/D converter goes to the idle state.
3. Bit IENAD = 1, so an A/D conversion end interrupt is requested.
4. The A/D interrupt handling routine starts.
5. The A/D conversion result is read and processed.

6. The A/D interrupt handling routine ends.

If AD_SF is set to 1 again afterward, A/D conversion starts and steps 2 to 6 take place.

Figures 12.4 and 12.5 show flow charts of procedures for using the A/D converter.

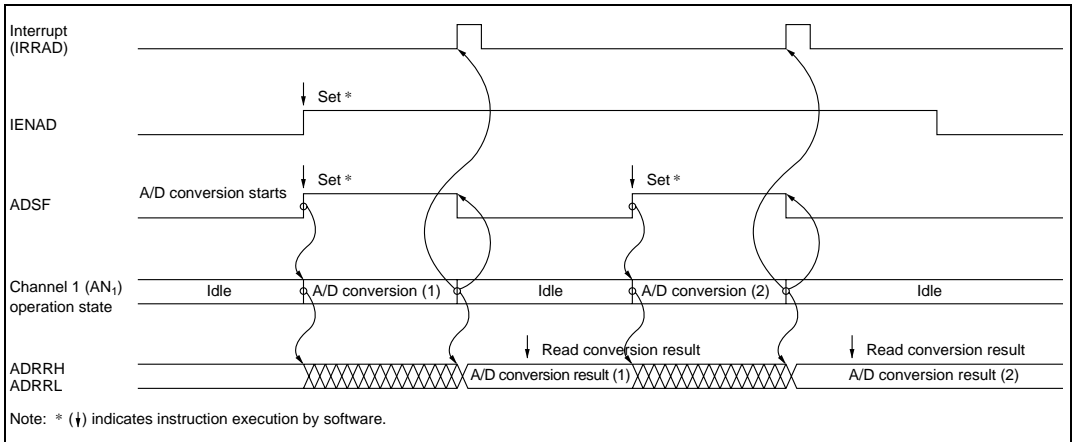


Figure 12.3 Typical A/D Converter Operation Timing

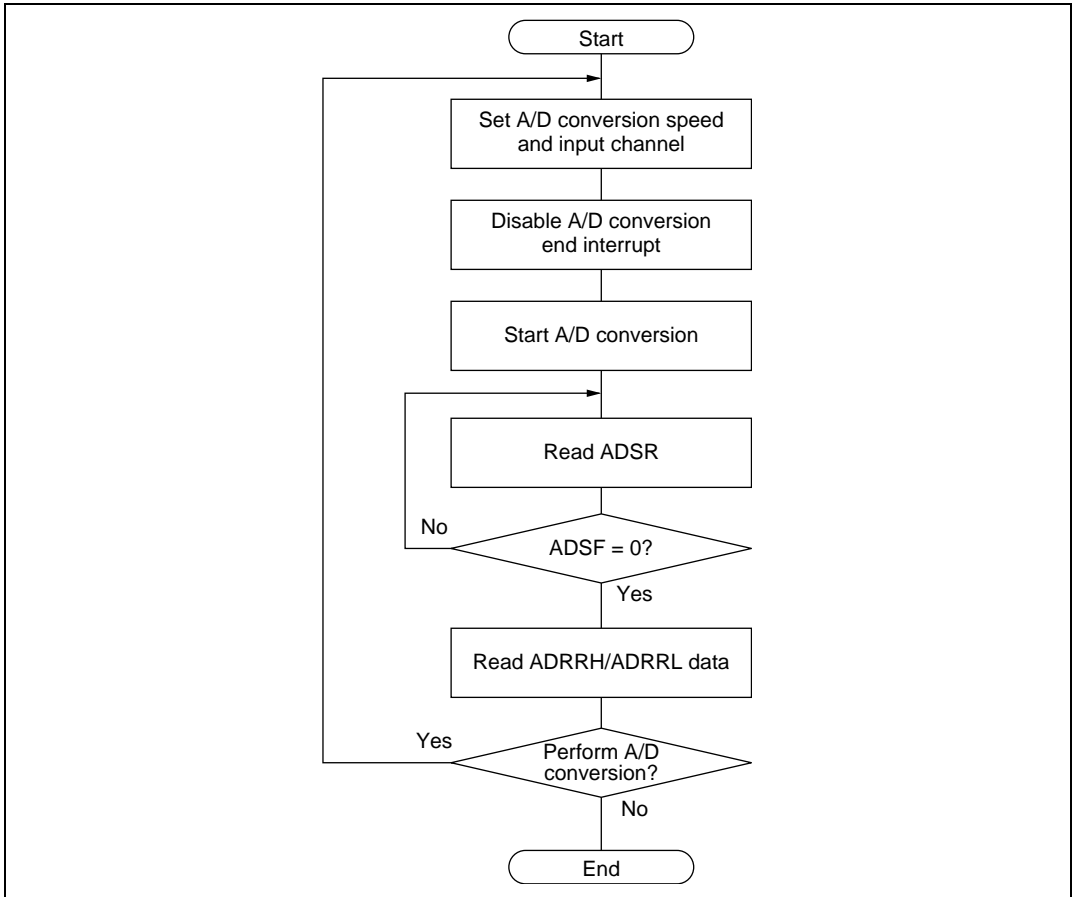


Figure 12.4 Flow Chart of Procedure for Using A/D Converter (Polling by Software)

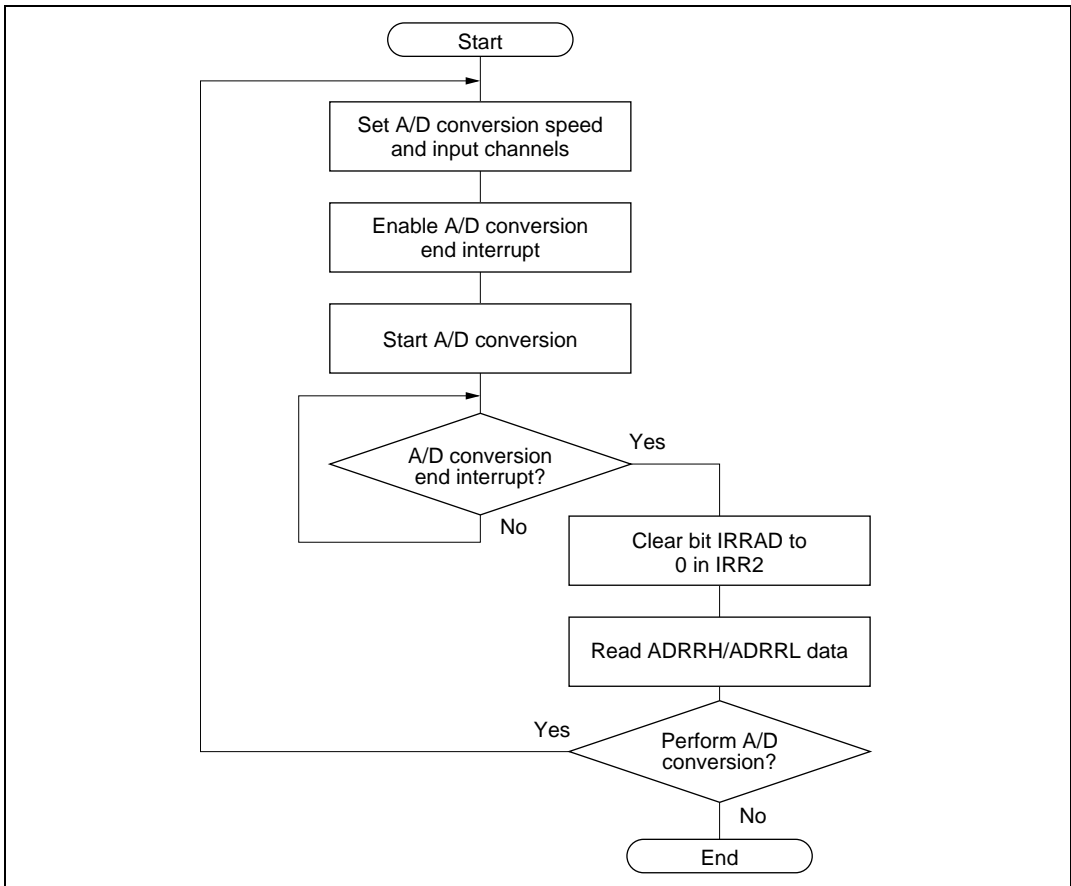


Figure 12.5 Flow Chart of Procedure for Using A/D Converter (Interrupts Used)

12.6 Application Notes

12.6.1 Application Notes

- Data in ADDRHH and ADDRLL should be read only when the A/D start flag (ADSF) in the A/D start register (ADSR) is cleared to 0.
- Changing the digital input signal at an adjacent pin during A/D conversion may adversely affect conversion accuracy.
- When A/D conversion is started after clearing module standby mode, wait for 10 ϕ clock cycles before starting.

- In active mode or sleep mode, analog power supply current (I_{STOP1}) flows into the ladder resistance even when the A/D converter is not operating. Therefore, if the A/D converter is not used, it is recommended that AV_{CC} be connected to the system power supply and the ADCKSTP (A/D converter module standby mode control) bit be cleared to 0 in clock stop register 1 (CKSTPR1).

12.6.2 Permissible Signal Source Impedance

This LSI's analog input is designed such that conversion precision is guaranteed for an input signal for which the signal source impedance is 10 k Ω or less. This specification is provided to enable the A/D converter's sample-and-hold circuit input capacitance to be charged within the sampling time; if the sensor output impedance exceeds 10 k Ω , charging may be insufficient and it may not be possible to guarantee A/D conversion precision. However, a large capacitance provided externally, the input load will essentially comprise only the internal input resistance of 10 k Ω , and the signal source impedance is ignored. However, as a low-pass filter effect is obtained in this case, it may not be possible to follow an analog signal with a large differential coefficient (e.g., 5 mV/ μ s or greater) (see figure 12.6). When converting a high-speed analog signal, a low-impedance buffer should be inserted.

12.6.3 Influences on Absolute Precision

Adding capacitance results in coupling with GND, and therefore noise in GND may adversely affect absolute precision. Be sure to make the connection to an electrically stable GND.

Care is also required to ensure that filter circuits do not interfere with digital signals or act as antennas on the mounting board.

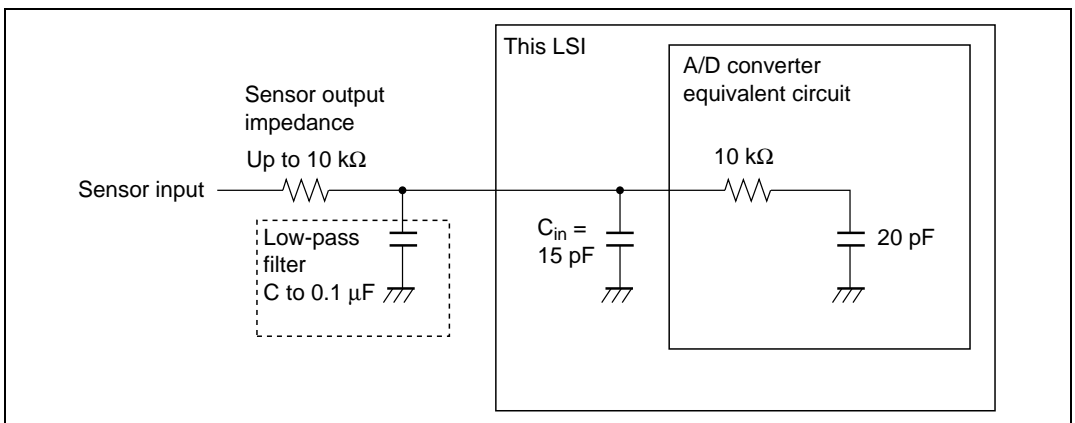


Figure 12.6 Analog Input Circuit Example

Section 13 LCD Controller/Driver

13.1 Overview

This LSI has an on-chip segment type LCD control circuit, LCD driver, and power supply circuit, enabling it to directly drive an LCD panel.

13.1.1 Features

Features of the LCD controller/driver are given below.

- Display capacity

Duty Cycle	Internal Driver	Segment External Expansion Driver*
Static	40 seg	256 seg
1/2	40 seg	128 seg
1/3	40 seg	64 seg
1/4	40 seg	64 seg

Note: * The external expansion function for LCD segments is not implemented in the H8/38347 Group and H8/38447 Group.

- LCD RAM capacity
8 bits × 32 bytes (256 bits)
- Word access to LCD RAM
- All eight segment output pins can be used individually as port pins.
- Common output pins not used because of the duty cycle can be used for common double-buffering (parallel connection).
- Display possible in operating modes other than standby mode
- Choice of 11 frame frequencies
- Built-in power supply split-resistance, supplying LCD drive power
- Use of module standby mode enables this module to be placed in standby mode independently when not used.
- A or B waveform selectable by software

13.1.2 Block Diagram

Figure 13.1 shows a block diagram of the LCD controller/driver.

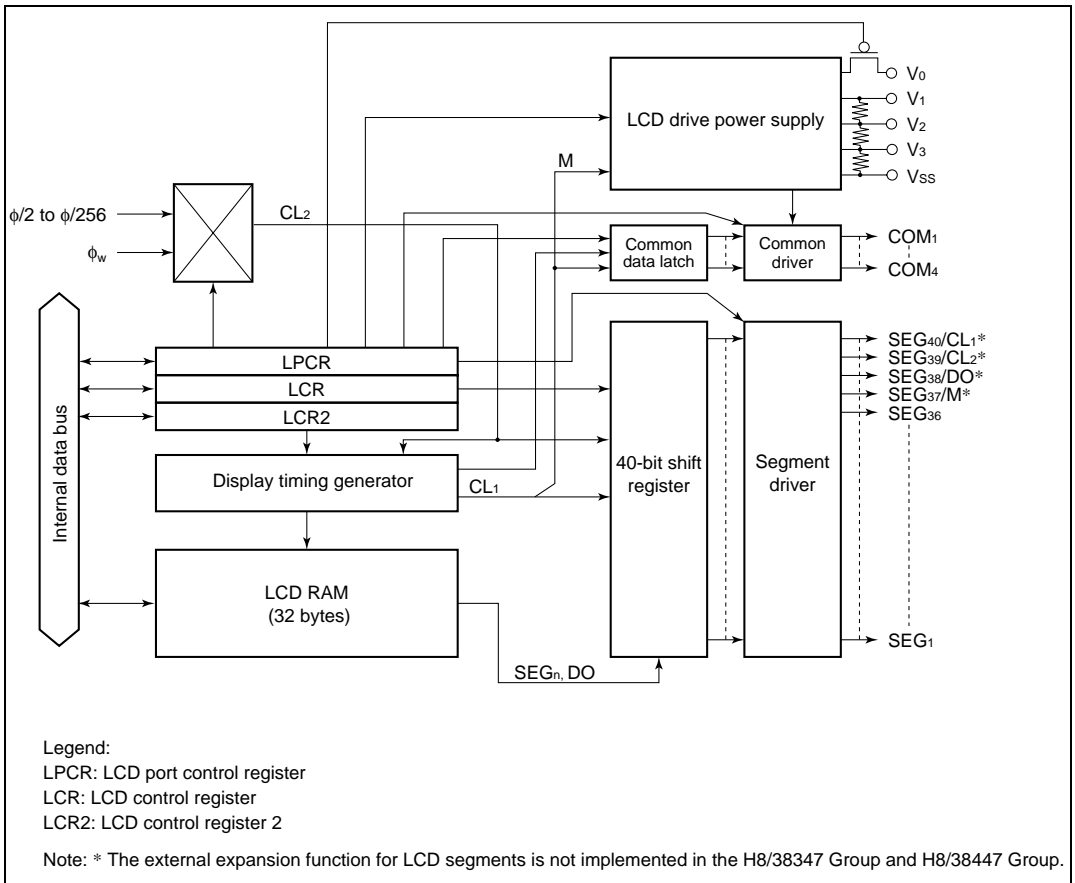


Figure 13.1 Block Diagram of LCD Controller/Driver

13.1.3 Pin Configuration

Table 13.1 shows the LCD controller/driver pin configuration.

Table 13.1 Pin Configuration

Name	Abbr.	I/O	Function
Segment output pins	SEG ₄₀ to SEG ₁	Output	LCD segment drive pins All pins are multiplexed as port pins (setting programmable)
Common output pins	COM ₄ to COM ₁	Output	LCD common drive pins Pins can be used in parallel with static or 1/2 duty
Segment external expansion signal pin*	CL ₁	Output	Multiplexed as the display data latch clock, SEG ₄₀
	CL ₂	Output	Multiplexed as the display data shift clock, SEG ₃₉
	M	Output	Multiplexed as the LCD alternating signal, SEG ₃₇
	DO	Output	Multiplexed as the serial display data, SEG ₃₈
LCD power supply pins	V ₀ , V ₁ , V ₂ , V ₃	—	Used when a bypass capacitor is connected externally, and when an external power supply circuit is used

Note: * The external expansion function for LCD segments is not implemented in the H8/38347 Group and H8/38447 Group.

13.1.4 Register Configuration

Table 13.2 shows the register configuration of the LCD controller/driver.

Table 13.2 LCD Controller/Driver Registers

Name	Abbr.	R/W	Initial Value	Address
LCD port control register	LPCR	R/W	H'00	H'FFC0
LCD control register	LCR	R/W	H'80	H'FFC1
LCD control register 2	LCR2	R/W	H'60	H'FFC2
LCD RAM	—	R/W	Undefined	H'F740 to H'F753
Clock stop register 2	CKSTPR2	R/W	H'FF	H'FFFB

13.2 Register Descriptions

13.2.1 LCD Port Control Register (LPCR)

Bit	7	6	5	4	3	2	1	0
	DTS1	DTS0	CMX	SGX	SGS3	SGS2	SGS1	SGS0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

LPCR is an 8-bit read/write register which selects the duty cycle and LCD driver pin functions.

LPCR is initialized to H'00 upon reset.

Bits 7 to 5: Duty cycle select 1 and 0 (DTS1, DTS0), common function select (CMX)

The combination of DTS1 and DTS0 selects static, 1/2, 1/3, or 1/4 duty. CMX specifies whether or not the same waveform is to be output from multiple pins to increase the common drive power when not all common pins are used because of the duty setting.

Bit 7 DTS1	Bit 6 DTS0	Bit 5 CMX	Duty Cycle	Common Drivers	Notes
0	0	0	Static	COM ₁ (initial value)	Do not use COM ₄ , COM ₃ , and COM ₂ .
0	0	1		COM ₄ to COM ₁	COM ₄ , COM ₃ , and COM ₂ output the same waveform as COM ₁ .
0	1	0	1/2 duty	COM ₂ to COM ₁	Do not use COM ₄ and COM ₃ .
0	1	1		COM ₄ to COM ₁	COM ₄ outputs the same waveform as COM ₃ , and COM ₂ outputs the same waveform as COM ₁ .
1	0	0	1/3 duty	COM ₃ to COM ₁	Do not use COM ₄ .
1	0	1		COM ₄ to COM ₁	Do not use COM ₄ .
1	1	0	1/4 duty	COM ₄ to COM ₁	—
1	1	1			

Bit 4: Expansion Signal Selection (SGX)

Bit 4 (SGX) selects whether the SEG₄₀/CL₁, SEG₃₉/CL₂, SEG₃₈/DO, and SEG₃₇/M pins are used as segment pins (SEG₄₀ to SEG₃₇) or as segment external expansion signal pins (CL₁, CL₂, DO, and M). In the H8/38347 Group and H8/38447 Group this bit should be left at its initial value and not written to. Changing the value of this bit may prevent the SEG/COM signal from operating normally.

Bit 4

SGX	Description	
0	SEG ₄₀ to SEG ₃₇ pins*	(initial value)
1	CL ₁ , CL ₂ , DO, and M pins	

Note: * Functions as ports when SGS3 to SGS0 are set at "0000".

Bits 3 to 0: Segment driver select 3 to 0 (SGS3 to SGS0)

Bits 3 to 0 select the segment drivers to be used. The SGX = 0 setting is selected on the H8/38347 and H8/38447.

					Function of Pins SEG₄₀ to SEG₁					
Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	SEG₄₀	SEG₃₂	SEG₂₄	SEG₁₆	SEG₈	
SGX	SGS3	SGS2	SGS1	SGS0	to	to	to	to	to	Notes
					SEG₃₃	SEG₂₅	SEG₁₇	SEG₉	SEG₁	
0	0	0	0	0	Port	Port	Port	Port	Port	(initial value)
0	0	0	0	1	SEG	Port	Port	Port	Port	
0	0	0	1	*	SEG	SEG	Port	Port	Port	
0	0	1	0	*	SEG	SEG	SEG	Port	Port	
0	0	1	1	*	SEG	SEG	SEG	SEG	Port	
0	1	*	*	*	SEG	SEG	SEG	SEG	SEG	
1	0	0	0	0	Port(*1)	Port	Port	Port	Port	
1	0	0	0	1	Do not use					
1	0	0	1	*						
1	0	1	*	*						
1	1	*	*	*						

*: Don't care

Note: 1. SEG₄₀ to SEG₃₇ are external expansion pins.

13.2.2 LCD Control Register (LCR)

Bit	7	6	5	4	3	2	1	0
	—	PSW	ACT	DISP	CKS3	CKS2	CKS1	CKS0
Initial value	1	0	0	0	0	0	0	0
Read/Write	—	R/W	R/W	R/W	R/W	R/W	R/W	R/W

LCR is an 8-bit read/write register which performs LCD drive power supply on/off control and display data control, and selects the frame frequency.

LCR is initialized to H'80 upon reset.

Bit 7: Reserved bit

Bit 7 is reserved; it is always read as 1 and cannot be modified.

Bit 6: LCD drive power supply on/off control (PSW)

Bit 6 can be used to turn the LCD drive power supply off when LCD display is not required in a power-down mode, or when an external power supply is used. When the ACT bit is cleared to 0, or in standby mode, the LCD drive power supply is turned off regardless of the setting of this bit.

Bit 6

PSW	Description
0	LCD drive power supply off (initial value)
1	LCD drive power supply on

Bit 5: Display function activate (ACT)

Bit 5 specifies whether or not the LCD controller/driver is used. Clearing this bit to 0 halts operation of the LCD controller/driver. The LCD drive power supply is also turned off, regardless of the setting of the PSW bit. However, register contents are retained.

Bit 5

ACT	Description
0	LCD controller/driver operation halted (initial value)
1	LCD controller/driver operates

Bit 4: Display data control (DISP)

Bit 4 specifies whether the LCD RAM contents are displayed or blank data is displayed regardless of the LCD RAM contents.

**Bit 4
DISP****Description**

0	Blank data is displayed	(initial value)
1	LCD RAM data is display	

Bits 3 to 0: Frame frequency select 3 to 0 (CKS3 to CKS0)

Bits 3 to 0 select the operating clock and the frame frequency. In subactive mode, watch mode, and subsleep mode, the system clock (ϕ) is halted, and therefore display operations are not performed if one of the clocks from $\phi/2$ to $\phi/256$ is selected. If LCD display is required in these modes, ϕ_w , $\phi_w/2$, or $\phi_w/4$ must be selected as the operating clock.

Bit 3 CKS3	Bit 2 CKS2	Bit 1 CKS1	Bit 0 CKS0	Operating Clock	Frame Frequency* ²	
					$\phi = 2 \text{ MHz}$	$\phi = 250 \text{ kHz}$ * ¹
0	*	0	0	ϕ_w	128 Hz* ³ (initial value)	
0	*	0	1	$\phi_w/2$	64 Hz* ³	
0	*	1	*	$\phi_w/4$	32 Hz* ³	
1	0	0	0	$\phi/2$	—	244 Hz
1	0	0	1	$\phi/4$	977 Hz	122 Hz
1	0	1	0	$\phi/8$	488 Hz	61 Hz
1	0	1	1	$\phi/16$	244 Hz	30.5 Hz
1	1	0	0	$\phi/32$	122 Hz	—
1	1	0	1	$\phi/64$	61 Hz	—
1	1	1	0	$\phi/128$	30.5 Hz	—
1	1	1	1	$\phi/256$	—	—

*: Don't care

- Notes: 1. This is the frame frequency in active (medium-speed, $\phi_{osc}/16$) mode when $\phi = 2 \text{ MHz}$.
 2. When 1/3 duty is selected, the frame frequency is 4/3 times the value shown.
 3. This is the frame frequency when $\phi_w = 32.768 \text{ kHz}$.

13.2.3 LCD Control Register 2 (LCR2)

Bit	7	6	5	4	3	2	1	0
	DTS1	DTS0	CMX	SGX	SGS3	SGS2	SGS1	SGS0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

LCR2 is an 8-bit read/write register which controls switching between the A waveform and B waveform, and selects the duty cycle of the charge/discharge pulses which control disconnection of the power supply split-resistance from the power supply circuit.

LCR2 is initialized to H'60 upon reset.

Bit 7: A waveform/B waveform switching control (LCDAB)

Bit 7 specifies whether the A waveform or B waveform is used as the LCD drive waveform.

Bit 7

LCDAB	Description	
0	Drive using A waveform	(initial value)
1	Drive using B waveform	

Bits 6 and 5: Reserved bits

Bits 6 and 5 are reserved; they are always read as 1 and cannot be modified.

Bit 4: Reserved bit

Bit 4 is reserved; it is always read as 0 and must not be written with 1.

Bits 3 to 0: Charge/discharge pulse duty cycle select (CDS3 to CDS0)

Bit 3 CDS3	Bit 2 CDS2	Bit 1 CDS1	Bit 0 CDS0	Duty Cycle	Notes
0	0	0	0	1	Fixed high (initial value)
0	0	0	1	1/8	
0	0	1	0	2/8	
0	0	1	1	3/8	
0	1	0	0	4/8	
0	1	0	1	5/8	
0	1	1	0	6/8	
0	1	1	1	0	Fixed low
1	0	*	*	1/16	
1	1	*	*	1/32	

*: Don't care

Bits 3 to 0 select the duty cycle while the power supply split-resistance is connected to the power supply circuit.

When a 0 duty cycle is selected, the power supply split-resistance is permanently disconnected from the power supply circuit, so power should be supplied to pins V_1 , V_2 , and V_3 by an external circuit.

Figure 13.2 shows the waveform of the charge/discharge pulses. The duty cycle is T_c/T_w .

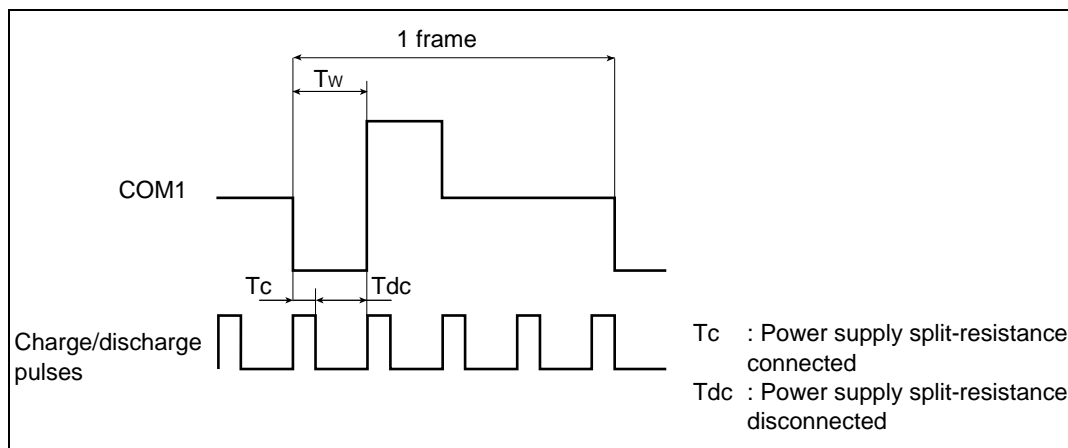


Figure 13.2 Example of A Waveform with 1/2 Duty and 1/2 Bias

13.2.4 Clock Stop Register 2 (CKSTPR2)

Bit	7	6	5	4	3	2	1	0
	—	—	—	—	AECKSTP	WDCKSTP	PWCKSTP	LDCKSTP
Initial value	1	1	1	1	1	1	1	1
Read/Write	—	—	—	—	R/W	R/W	R/W	R/W

CKSTPR2 is an 8-bit read/write register that performs module standby mode control for peripheral modules. Only the bit relating to the LCD controller/driver is described here. For details of the other bits, see the sections on the relevant modules.

Bit 0: LCD controller/driver module standby mode control (LDCKSTP)

Bit 0 controls setting and clearing of module standby mode for the LCD controller/driver.

Bit 0

LDCKSTP	Description
0	LCD controller/driver is set to module standby mode
1	LCD controller/driver module standby mode is cleared (initial value)

13.3 Operation

13.3.1 Settings up to LCD Display

To perform LCD display, the hardware and software related items described below must first be determined.

1. Hardware Settings

a. Using 1/2 duty

When 1/2 duty is used, interconnect pins V_2 and V_3 as shown in figure 13.3.

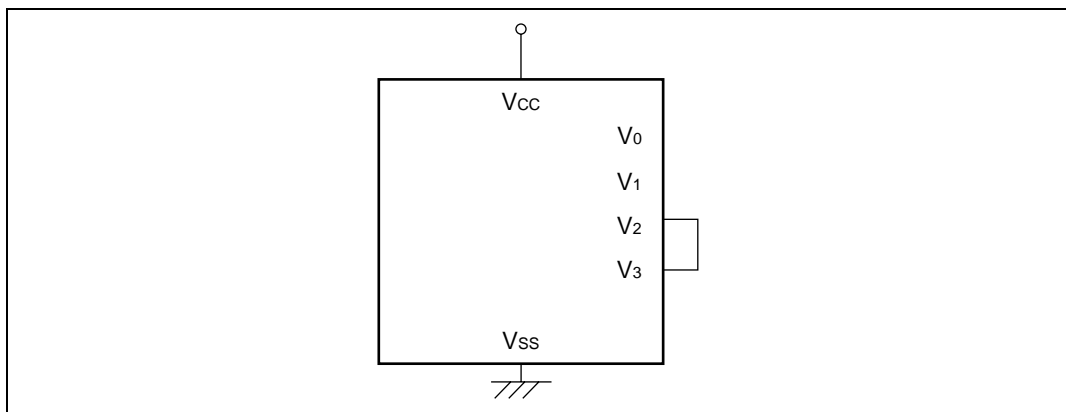


Figure 13.3 Handling of LCD Drive Power Supply when Using 1/2 Duty

b. Large-panel display

As the impedance of the built-in power supply split-resistance is large, it may not be suitable for driving a large panel. If the display lacks sharpness when using a large panel, refer to section 13.3.6, Boosting the LCD Drive Power Supply. When static or 1/2 duty is selected, the common output drive capability can be increased. Set CMX to 1 when selecting the duty cycle. In this mode, with a static duty cycle pins COM₄ to COM₁ output the same waveform, and with 1/2 duty the COM₁ waveform is output from pins COM₂ and COM₁, and the COM₂ waveform is output from pins COM₄ and COM₃.

c. Luminance adjustment function (V_0 pin)

Connecting a resistance between the V_0 and V_1 pins enables the luminance to be adjusted. For details, see section 13.3.3, Luminance Adjustment Function (V_0 Pin).

d. LCD drive power supply setting

With this LSI, there are two ways of providing LCD power: by using the on-chip power supply circuit, or by using an external circuit.

When the on-chip power supply circuit is used for the LCD drive power supply, the V_0 and V_1 pins should be interconnected externally, as shown in figure 13.4 (a).

When an external power supply circuit is used for the LCD drive power supply, connect the external power supply to the V_1 pin, and short the V_0 pin to V_{CC} externally, as shown in figure 13.4 (b).

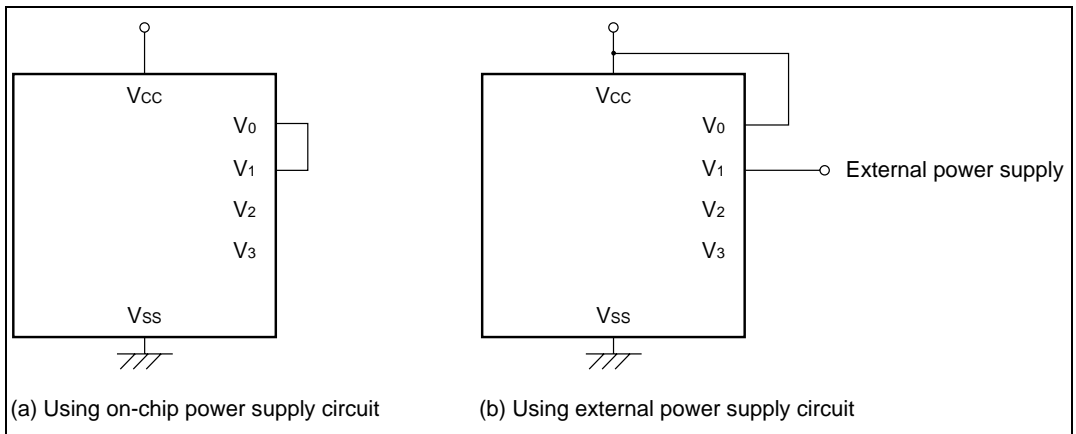


Figure 13.4 Examples of LCD Power Supply Pin Connections

e. Low-power-consumption LCD drive system

Use of a low-power-consumption LCD drive system enables the power consumption required for LCD drive to be optimized. For details, see section 13.3.4, Low-Power-Consumption LCD Drive System.

f. External expansion of segment

Segment can be expanded by externally connecting the HD66100. For details, see section 13.3.7, Connection to HD66100.

2. Software Settings

a. Duty selection

Any of four duty cycles—static, 1/2 duty, 1/3 duty, or 1/4 duty—can be selected with bits DTS1 and DTS0.

b. Segment selection

The segment drivers to be used can be selected with bits SGS₃ to SGS₀.

c. Frame frequency selection

The frame frequency can be selected by setting bits CKS₃ to CKS₀. The frame frequency should be selected in accordance with the LCD panel specification. For the clock selection method in watch mode, subactive mode, and subsleep mode, see section 13.3.5, Operation in Power-Down Modes.

d. A or B waveform selection

Either the A or B waveform can be selected as the LCD waveform to be used by means of LCDAB.

13.3.2 Relationship between LCD RAM and Display

The relationship between the LCD RAM and the display segments differs according to the duty cycle. LCD RAM maps for the different duty cycles with the segment not externally expanded are shown in figures 13.5 to 13.8, and ones with the segments externally expanded are shown in figures 13.9 to 13.12.

After setting the registers required for display, data is written to the part corresponding to the duty cycle using the same kind of instruction as for ordinary RAM, and display is started automatically when turned on. Word- or byte-access instructions can be used for RAM setting.

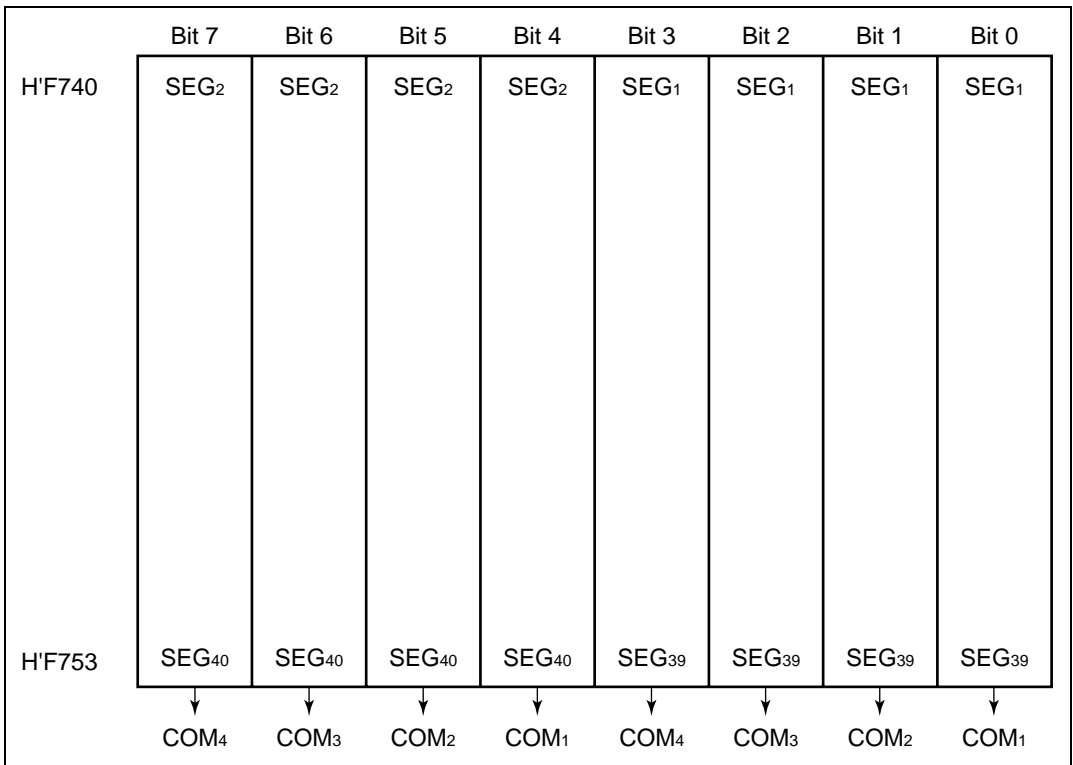


Figure 13.5 LCD RAM Map with Segments Not Externally Expanded (1/4 Duty)

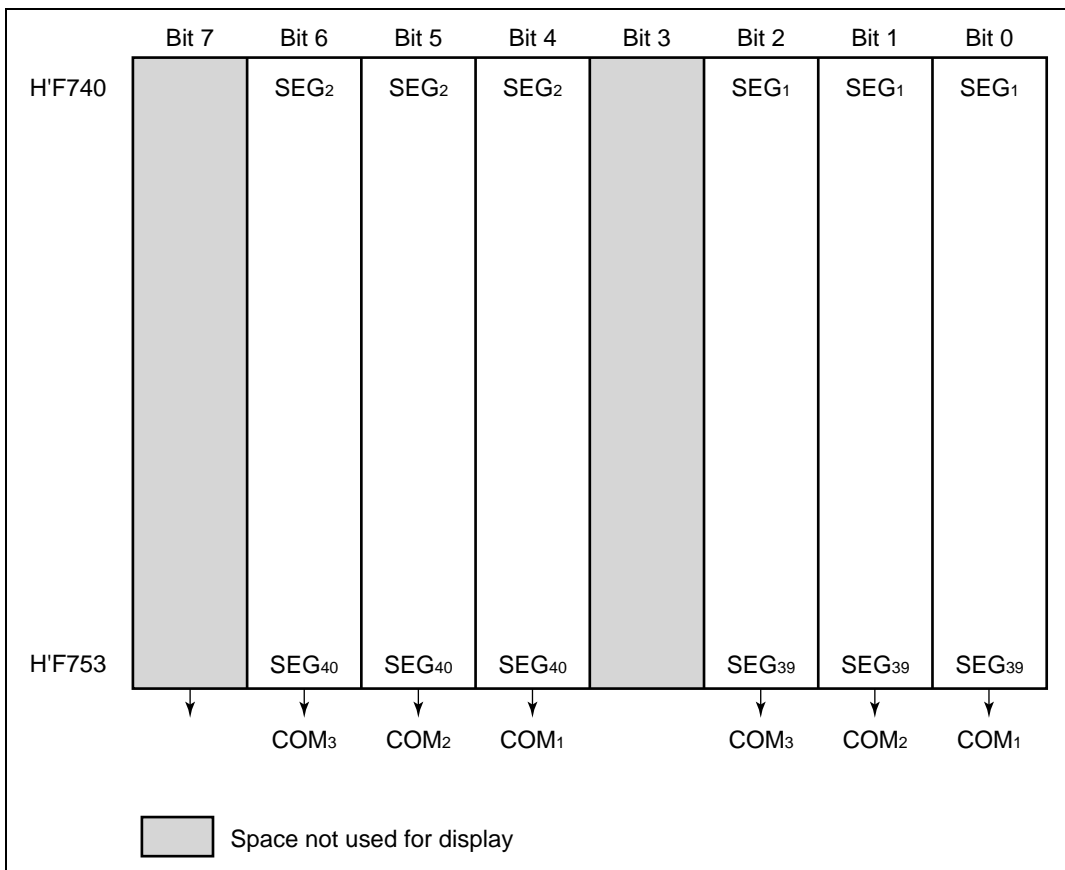


Figure 13.6 LCD RAM Map with Segments Not Externally Expanded (1/3 Duty)

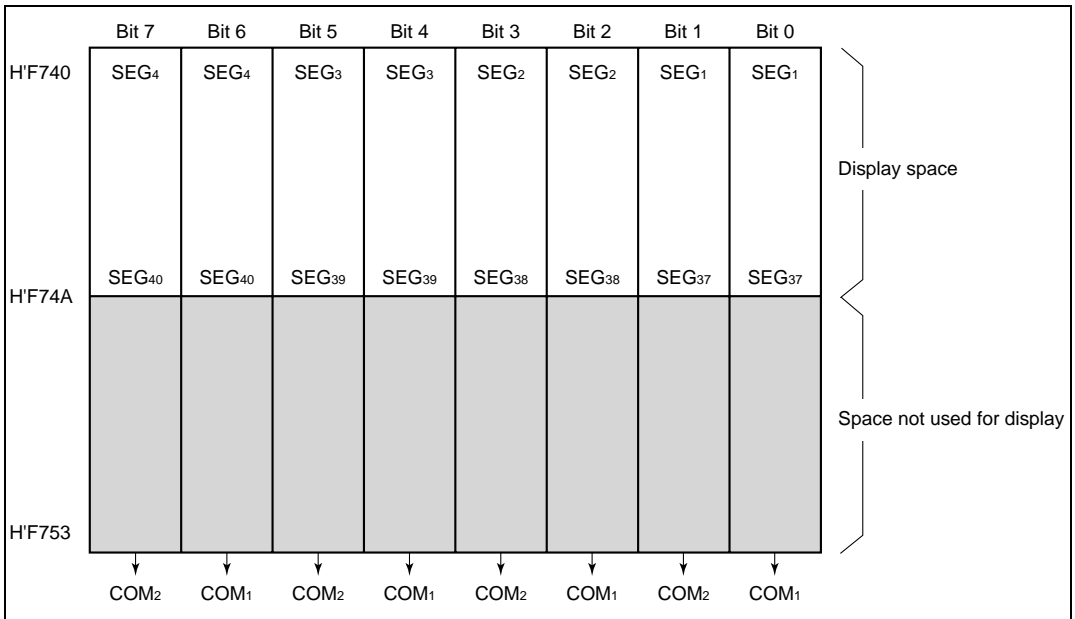


Figure 13.7 LCD RAM Map with Segments Not Externally Expanded (1/2 Duty)

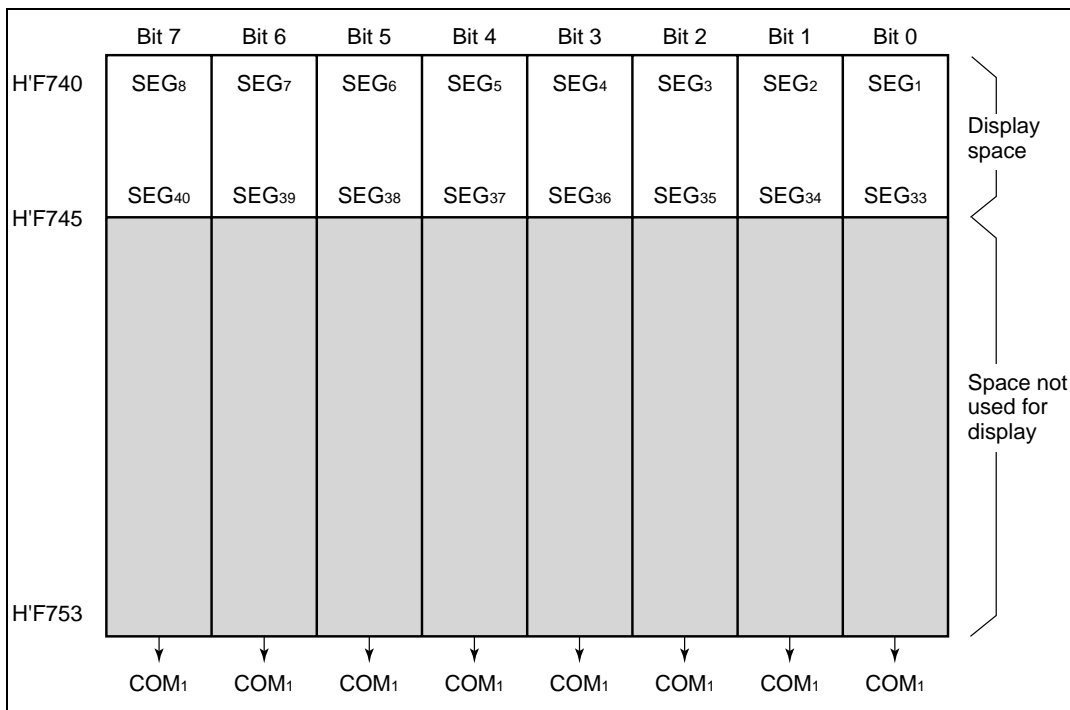
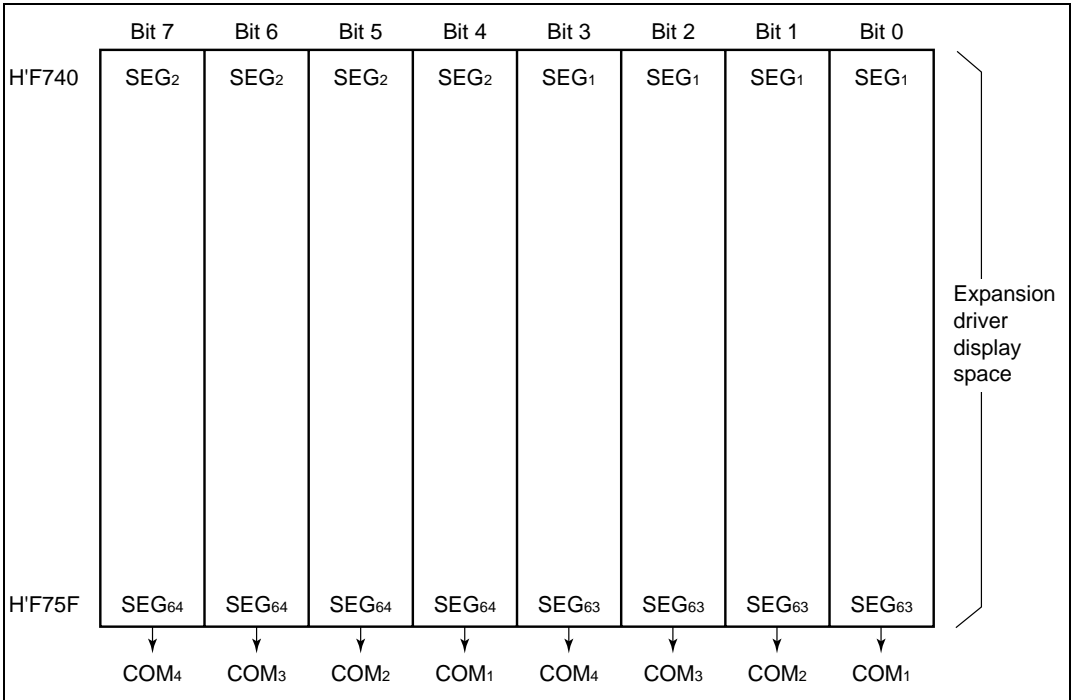


Figure 13.8 LCD RAM Map with Segments Not Externally Expanded (Static Mode)



**Figure 13.9 LCD RAM Map with Segment Externally Expanded
(SGX = "1", SGS3 to SGS0 = "0000" 1/4 duty)**

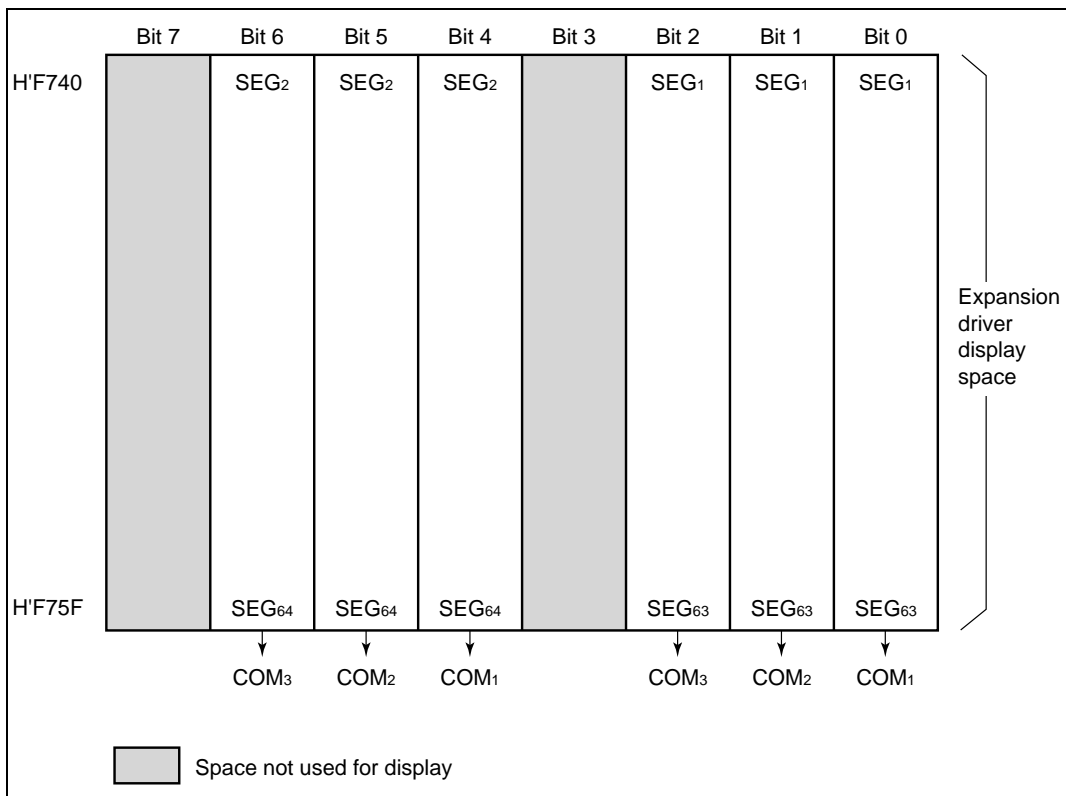
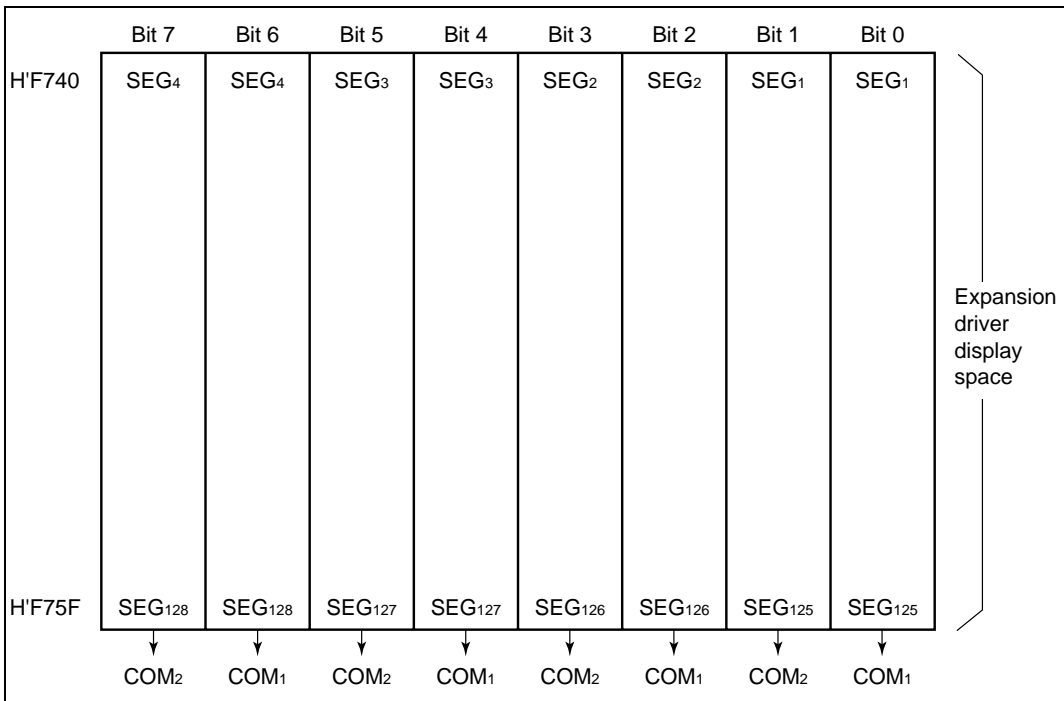
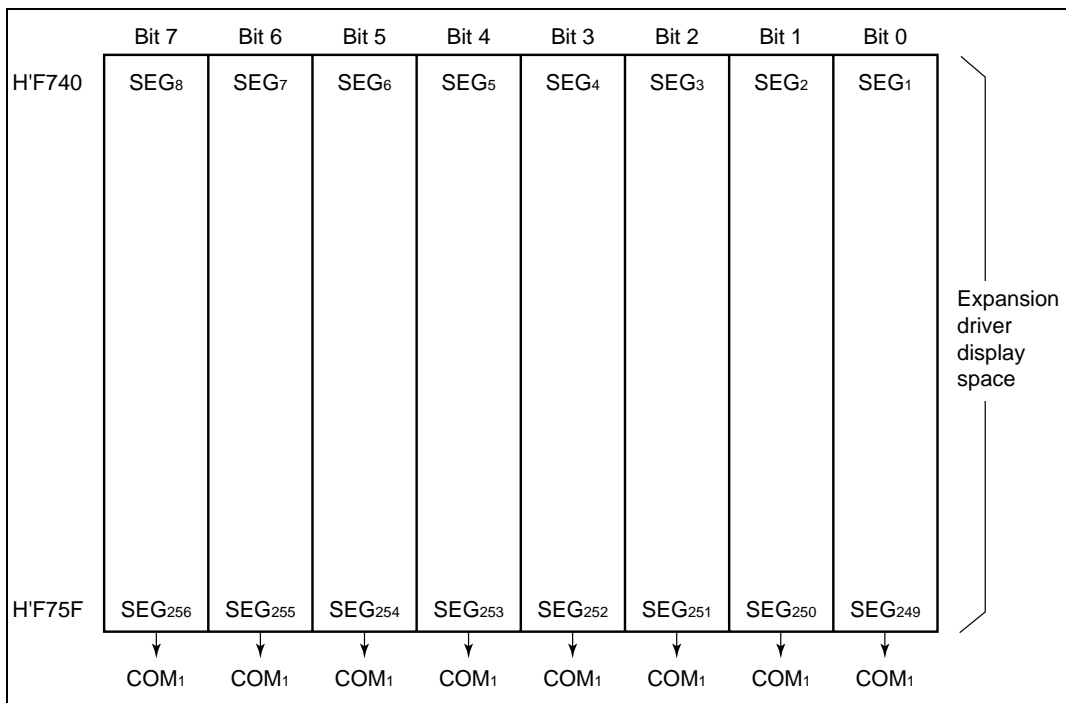


Figure 13.10 LCD RAM Map with Segment Externally Expanded
 (SGX = "1", SGS3 to SGS0 = "0000" 1/3 duty)



**Figure 13.11 LCD RAM Map with Segment Externally Expanded
(SGX = "1", SGS3 to SGS0 = "0000" 1/2 duty)**



**Figure 13.12 LCD RAM Map with Segment Externally Expanded
(SGX = "1", SGS3 to SGS0 = "0000" static)**

13.3.3 Luminance Adjustment Function (V_0 Pin)

Figure 13.13 shows a detailed block diagram of the LCD drive power supply unit.

The voltage output to the V_0 pin is V_{CC} . When this voltage is used directly as the LCD drive power supply, the V_0 and V_1 pins should be shorted. Also, connecting a variable resistance, R , between the V_0 and V_1 pins makes it possible to adjust the voltage applied to the V_1 pin, and so to provide luminance adjustment for the LCD panel.

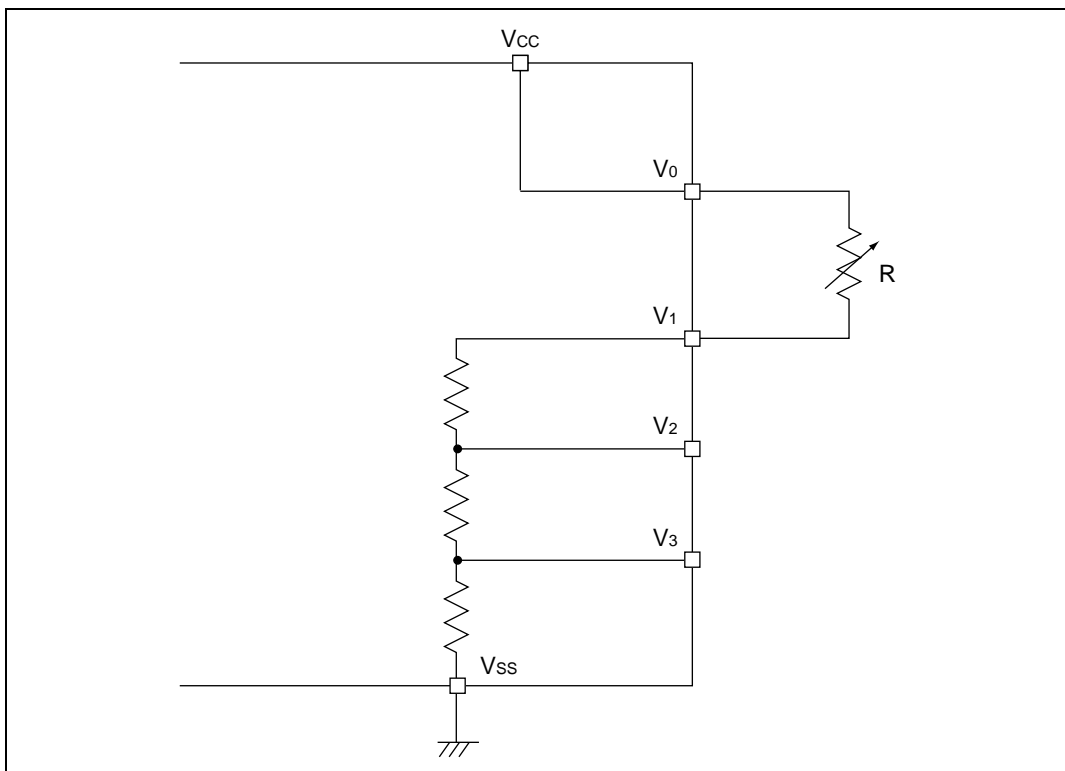


Figure 13.13 LCD Drive Power Supply Unit

13.3.4 Low-Power-Consumption LCD Drive System

The use of the built-in split-resistance is normally the easiest method for implementing the LCD power supply circuit, but since the built-in resistance is fixed, a certain direct current flows constantly from the built-in resistance's V_{CC} to V_{SS} . As this current does not depend on the current dissipation of the LCD panel, if an LCD panel with a small current dissipation is used, a wasteful amount of power will be consumed. The H8/3847R Group is equipped with a function to minimize this waste of power. Use of this function makes it possible to achieve the optimum power supply circuit for the LCD panel's current dissipation.

1. Principles

1. Capacitors are connected as external circuits to LCD power supply pins V1, V2, and V3, as shown in figure 13.14.
2. The capacitors connected to V1, V2, and V3 are repeatedly charged and discharged in the cycle shown in figure 13.14, maintaining the potentials.
3. At this time, the charged potential is a potential corresponding to the V1, V2, and V3 pins, respectively. (For example, with 1/3 bias drive, the charge for V2 is 2/3 that of V1, and that for V3 is 1/3 that of V1.)
4. Power is supplied to the LCD panel by means of the charges accumulated in these capacitors.
5. The capacitances and charging/discharging periods of these capacitors are therefore determined by the current dissipation of the LCD panel.
6. The charging and discharging periods can be selected by software.

2. Example of operation (with 1/3 bias drive)

1. During charging period T_c in the figure, the potential is divided among pins V1, V2, and V3 by the built-in split-resistance (the potential of V2 being 2/3 that of V1, and that of V3 being 1/3 that of V1), as shown in figure 13.14, and external capacitors C1, C2, and C3 are charged. The LCD panel is continues to be driven during this time.
2. In the following discharging period, T_{dc} , charging is halted and the charge accumulated in each capacitor is discharged, driving the LCD panel.
3. At this time, a slight voltage drop occurs due to the discharging; optimum values must be selected for the charging period and the capacitor capacitances to ensure that this does not affect the driving of the LCD panel.
4. In this way, the capacitors connected to V1, V2, and V3 are repeatedly charged and discharged in the cycle shown in figure 13.14, maintaining the potentials and continuously driving the LCD panel.

5. As can be seen from the above description, the capacitances and charging/discharging periods of the capacitors are determined by the current dissipation of the LCD panel used. The charging/discharging periods can be selected with bits CDS3 to CDS0.
6. The actual capacitor capacitances and charging/discharging periods must be determined experimentally in accordance with the current dissipation requirements of the LCD panel. An optimum current value can be selected, in contrast to the case in which a direct current flows constantly in the built-in split-resistance.

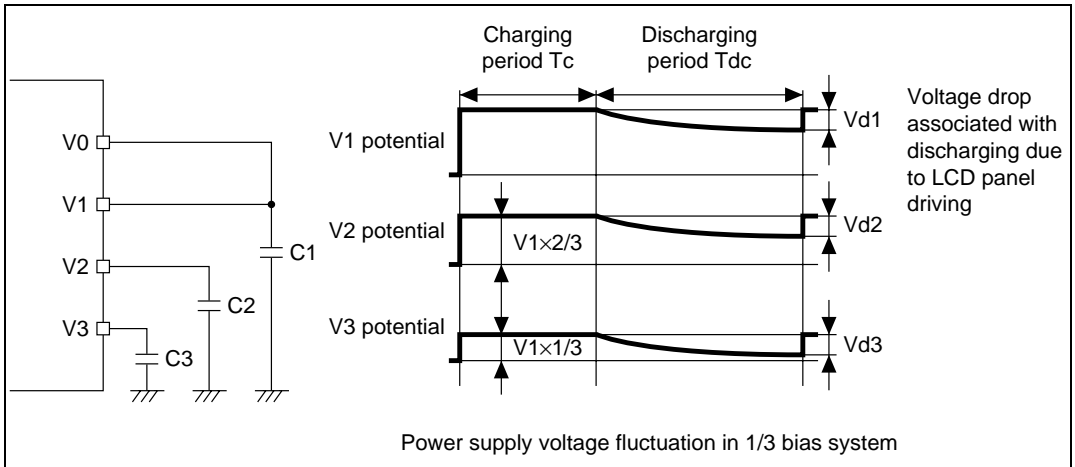


Figure 13.14 Example of Low-Power-Consumption LCD Drive Operation

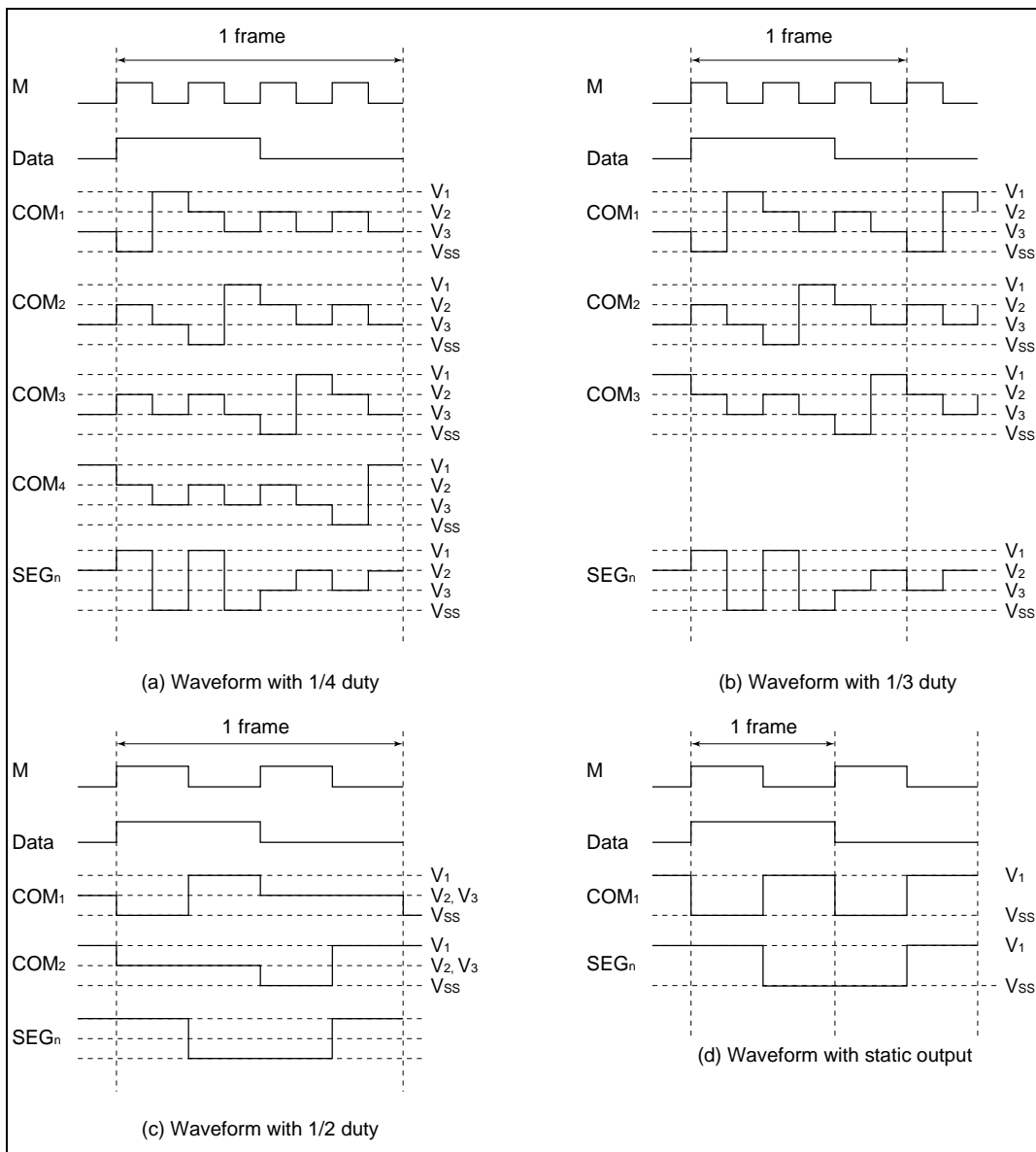


Figure 13.15 Output Waveforms for Each Duty Cycle (A Waveform)

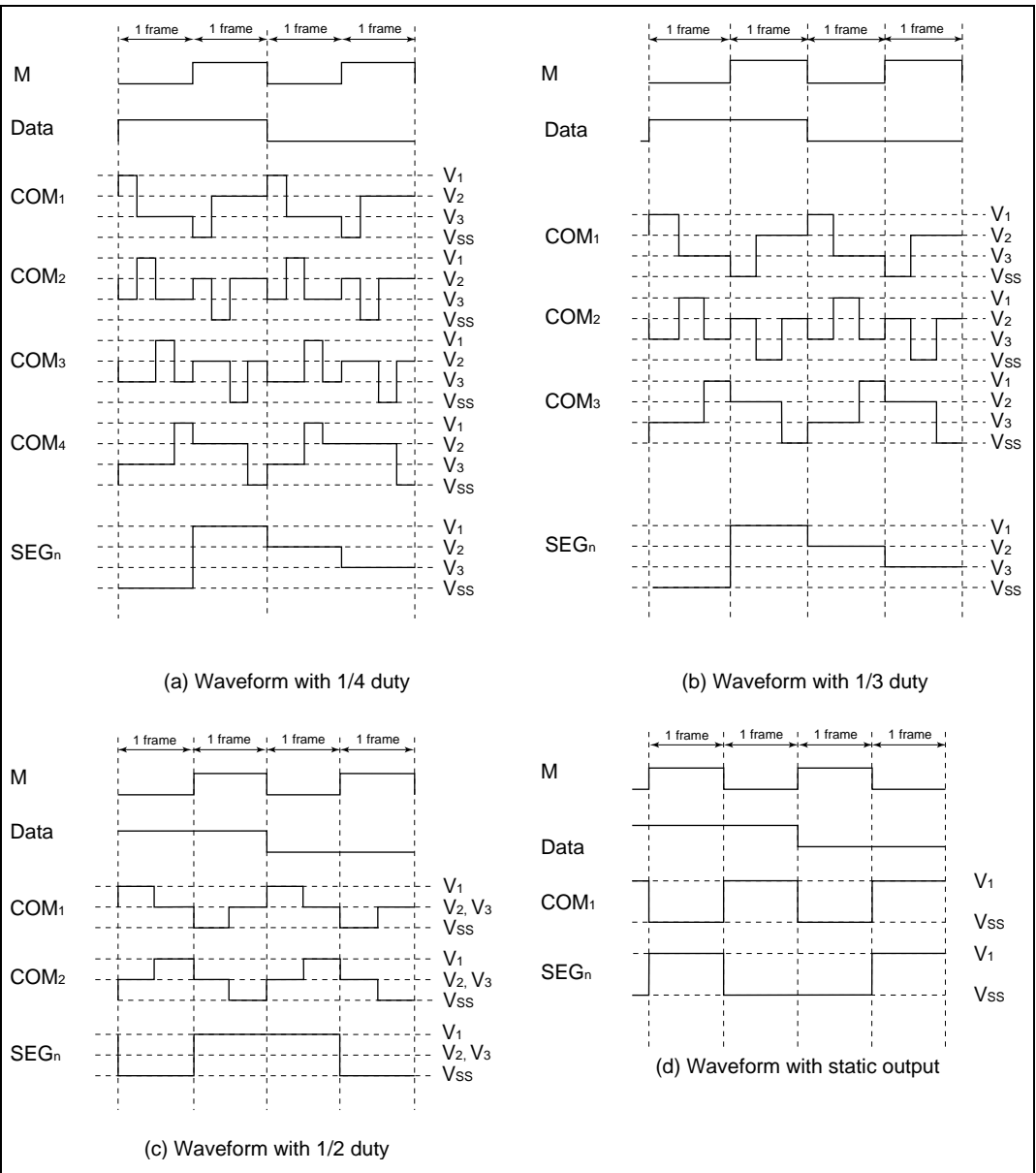


Figure 13.16 Output Waveforms for Each Duty Cycle (B Waveform)

Table 13.3 Output Levels

Data		0	0	1	1
M		0	1	0	1
Static	Common output	V_1	V_{SS}	V_1	V_{SS}
	Segment output	V_1	V_{SS}	V_{SS}	V_1
1/2 duty	Common output	V_2, V_3	V_2, V_3	V_1	V_{SS}
	Segment output	V_1	V_{SS}	V_{SS}	V_1
1/3 duty	Common output	V_3	V_2	V_1	V_{SS}
	Segment output	V_2	V_3	V_{SS}	V_1
1/4 duty	Common output	V_3	V_2	V_1	V_{SS}
	Segment output	V_2	V_3	V_{SS}	V_1

13.3.5 Operation in Power-Down Modes

In this LSI, the LCD controller/driver can be operated even in the power-down modes. The operating state of the LCD controller/driver in the power-down modes is summarized in table 13.4.

In subactive mode, watch mode, and subsleep mode, the system clock oscillator stops, and therefore, unless ϕ_w , $\phi_w/2$, or $\phi_w/4$ has been selected by bits CKS3 to CKS0, the clock will not be supplied and display will halt. Since there is a possibility that a direct current will be applied to the LCD panel in this case, it is essential to ensure that ϕ_w , $\phi_w/2$, or $\phi_w/4$ is selected. In active (medium-speed) mode, the system clock is switched, and therefore CKS3 to CKS0 must be modified to ensure that the frame frequency does not change.

Table 13.4 Power-Down Modes and Display Operation

Mode		Reset	Active	Sleep	Watch	Subactive	Subsleep	Standby	Module Standby
Clock	ϕ	Runs	Runs	Runs	Stops	Stops	Stops	Stops	Stops ^{*4}
	ϕ_w	Runs	Runs	Runs	Runs	Runs	Runs	Stops ^{*1}	Stops ^{*4}
Display operation	ACT = "0"	Stops	Stops	Stops	Stops	Stops	Stops	Stops ^{*2}	Stops
	ACT = "1"	Stops	Functions	Functions	Functions ^{*3}	Functions ^{*3}	Functions ^{*3}	Stops ^{*2}	Stops

- Notes:
1. The subclock oscillator does not stop, but clock supply is halted.
 2. The LCD drive power supply is turned off regardless of the setting of the PSW bit.
 3. Display operation is performed only if ϕ_w , $\phi_w/2$, or $\phi_w/4$ is selected as the operating clock.
 4. The clock supplied to the LCD stops.

13.3.6 Boosting the LCD Drive Power Supply

When a large panel is driven, the on-chip power supply capacity may be insufficient. In this case, the power supply impedance must be reduced. This can be done by connecting bypass capacitors of around 0.1 to 0.3 μF to pins V_1 to V_3 , as shown in figure 13.17, or by adding a split-resistance externally.

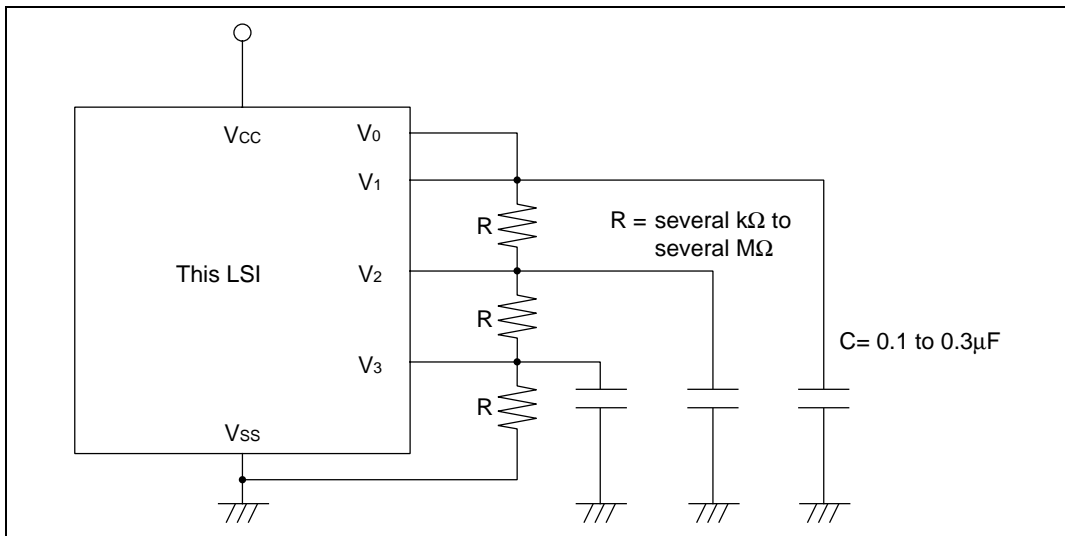


Figure 13.17 Connection of External Split-Resistance

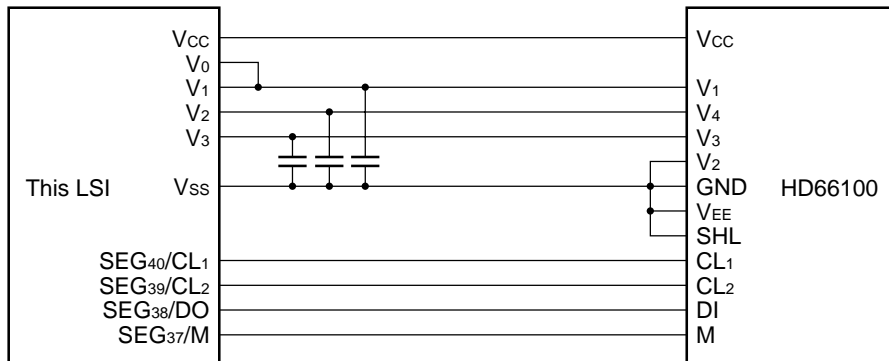
13.3.7 Connection to HD66100

If the segments are to be expanded externally, an HD66100 should be connected. Connecting one HD66100 provides 80-segment expansion. When carrying out external expansion, select the external expansion signal function of pins SEG₄₀ to SEG₃₇ with the SGX bit in LPCR, and set bits SGS3 to SGS0 to 0000. Data is output externally from SEG₁ of the LCD RAM. SEG₃₆ to SEG₁ function as ports.

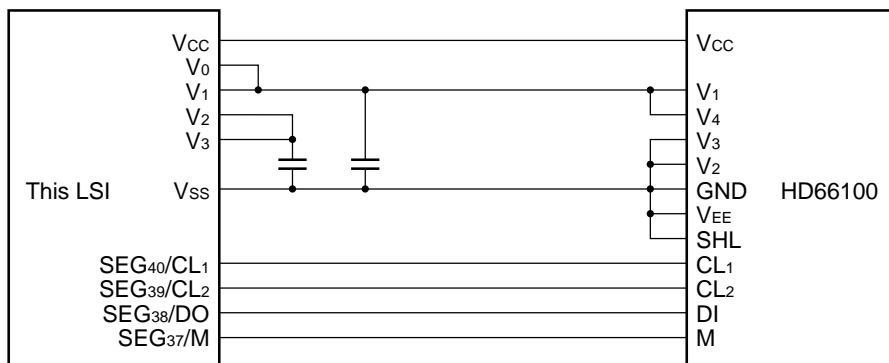
Figure 13.18 shows examples of connection to an HD66100. The output level is determined by a combination of the data and the M pin output, but these combinations differ from those in the HD66100. Table 13.3 shows the output levels of the LCD drive power supply, and figures 13.15 and 13.16 show the common and segment waveforms for each duty cycle.

When ACT is cleared to 0, operation stops with CL₂ = 0, CL₁ = 0, M = 0, and DO at the data value (1 or 0) being output at that instant. In standby mode, the expansion pins go to the high-impedance (floating) state.

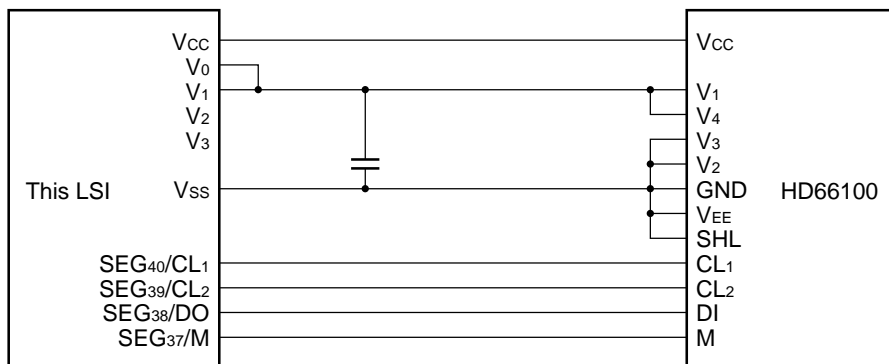
When external expansion is implemented, the load in the LCD panel increases and the on-chip power supply may not provide sufficient current capacity. In this case, measures should be taken as described in section 13.3.6, Boosting the LCD Drive Power Supply.



(a) 1/3 bias, 1/4 duty or 1/3 duty



(b) 1/2 duty



(c) Static

Figure 13.18 Connection to HD66100

Section 14 Power Supply Circuit

14.1 Overview

H8/3847R Group, H8/38347 Group and H8/38447 Group incorporate an internal power supply step-down circuit. Use of this circuit enables the internal power supply to be fixed at a constant level of approximately 3.0 V to 3.2 V, independently of the voltage of the power supply connected to the external V_{CC} pin. As a result, the current consumed when an external power supply is used at 3.0 V or above can be held down to virtually the same low level as when used at approximately 3.0 V. If the external power supply is 3.0 V or below, the internal voltage will be practically the same as the external voltage. It is, of course, also possible to use the same level of external power supply voltage and internal power supply voltage without using the internal power supply step-down circuit.

14.2 When Using Internal Power Supply Step-Down Circuit

Connect the external power supply to the V_{CC} pin, and connect a capacitance of approximately 0.1 μF , in the case of the H8/3847R, or approximately 0.33 μF , in the case of the H8/38347 or H8/38447, between CV_{CC} and V_{SS} , as shown in figure 14.1. The internal step-down circuit is made effective simply by adding this external circuit. In the external circuit interface, the external power supply voltage connected to V_{CC} and the GND potential connected to V_{SS} are the reference levels. For example, for port input/output levels, the V_{CC} level is the reference for the high level, and the V_{SS} level is that for the low level. The LCD power supply and A/D converter analog power supply are not affected by the internal step-down circuit.

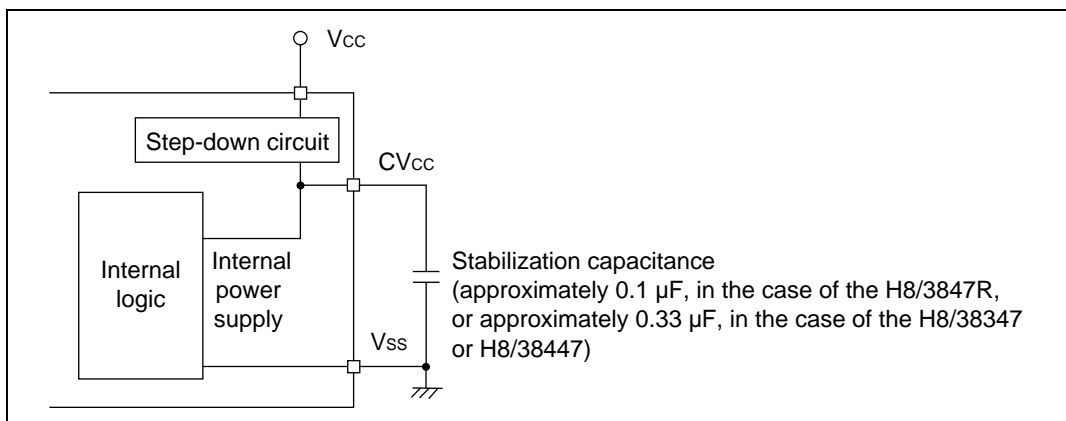


Figure 14.1 Power Supply Connection when Internal Step-Down Circuit is Used

14.3 When Not Using Internal Power Supply Step-Down Circuit

When the internal power supply step-down circuit is not used, connect the external power supply to the CV_{CC} pin and V_{CC} pin, as shown in figure 14.2. The external power supply is then input directly to the internal power supply. The permissible range for the power supply voltage is 1.8 V to 5.5 V for the H8/3847R Group and 2.7 V to 3.6 V for the H8/38347 Group and H8/38447 Group. Normally, however, the internal power supply step-down circuit should be used. Operation cannot be guaranteed if a voltage outside this range is input.

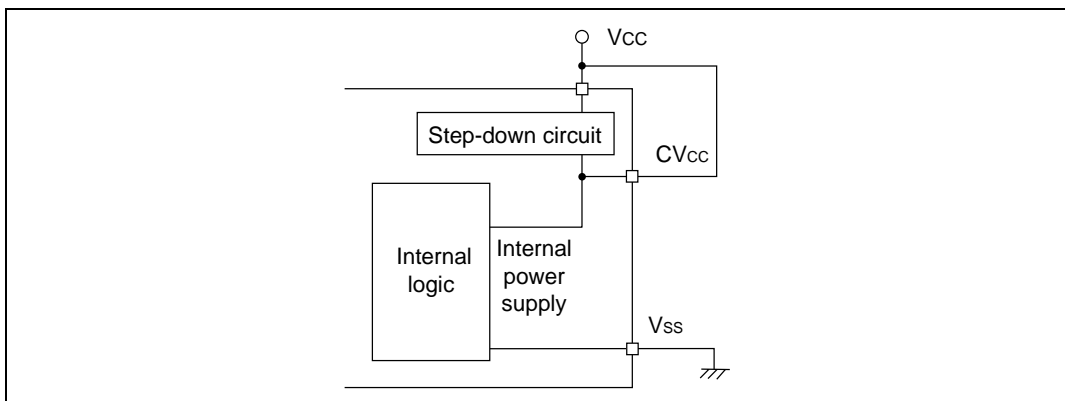


Figure 14.2 Power Supply Connection when Internal Step-Down Circuit is Not Used

14.4 H8/3847S Group

The H8/3847S Group has two V_{CC} pins, which should be interconnected externally.

14.5 Notes on Switching from the H8/3847R to the H8/38347 or H8/38447

Examine the following with regard to the power supply circuit.

- (1) If the internal power supply step-down circuit was used on the H8/3847R

The stabilization capacitance value differs between the products. It is necessary to change the value from 0.1 μF (H8/3847R) to 0.33 μF (H8/38347 or H8/38447). Note that these values are rough guidelines and it is still necessary to confirm system operation.

- (2) If the internal power supply step-down circuit was not used on the H8/3847R

Use of the internal power supply step-down circuit of the H8/38347 or H8/38447 is recommended. Furthermore, operation at a V_{CC} of 3.6 V or greater is not guaranteed if the internal power supply step-down circuit is not used. It is therefore necessary to change the CV_{CC} connection to use the internal power supply step-down circuit.

Section 15 Electrical Characteristics

15.1 H8/3847R Group Absolute Maximum Ratings (Regular Specifications)

Table 15.1 lists the absolute maximum ratings.

Table 15.1 Absolute Maximum Ratings

Item	Symbol	Value	Unit	Notes
Power supply voltage	V_{CC}	-0.3 to +7.0	V	*1
Analog power supply voltage	AV_{CC}	-0.3 to +7.0	V	
Programming voltage	V_{PP}	-0.3 to +13.0	V	
Input voltage	Ports other than Ports B and C	V_{in}	-0.3 to $V_{CC} + 0.3$	V
	Ports B and C	AV_{in}	-0.3 to $AV_{CC} + 0.3$	V
Operating temperature	T_{opr}	-20 to +75*2	°C	
Storage temperature	T_{stg}	-55 to +125	°C	

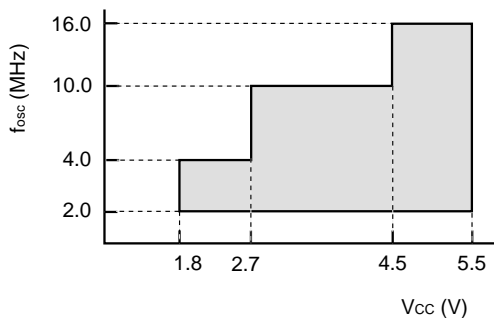
- Notes: 1. Permanent damage may occur to the chip if maximum ratings are exceeded. Normal operation should be under the conditions specified in Electrical Characteristics. Exceeding these values can result in incorrect operation and reduced reliability.
2. The operating temperature is the temperature range in which power (voltage V_{cc} shown in "Electrical Characteristics") can be applied to the chip.

15.2 H8/3847R Electrical Characteristics (Regular Specifications)

15.2.1 Power Supply Voltage and Operating Range

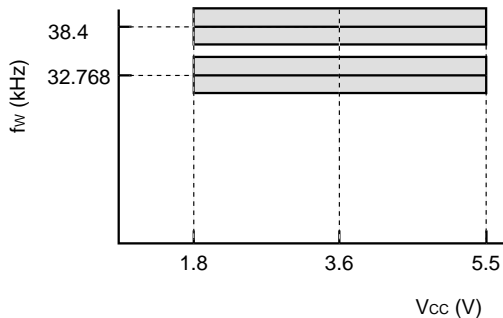
The power supply voltage and operating range of the H8/3847R Group are indicated by the shaded region in the figures.

1. Power supply voltage and oscillator frequency range

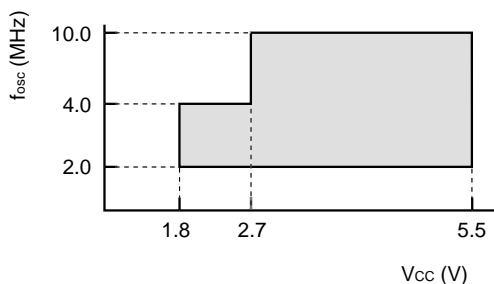


- Active (high-speed) mode
- Sleep (high-speed) mode
- Internal power supply step-down circuit not used

Note: f_{osc} is the oscillator frequency. When external clocks are used, f_{osc}=1MHz is the minimum.



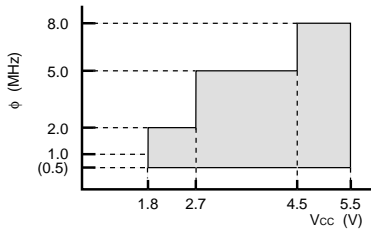
- All operating modes



- Active (high-speed) mode
- Sleep (high-speed) mode
- Internal power supply step-down circuit used

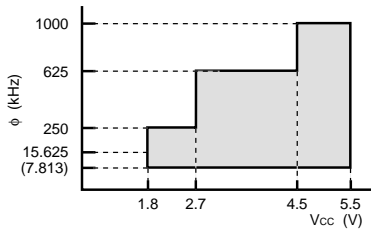
Note: f_{osc} is the oscillator frequency. When external clocks are used, f_{osc}=1MHz is the minimum.

2. Power supply voltage and operating frequency range



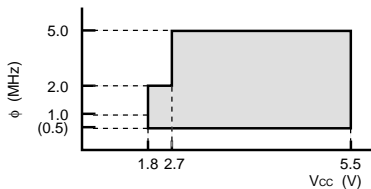
- Active (high-speed) mode
- Sleep (high-speed) mode (except CPU)
- Internal power supply step-down circuit not used

Note: Figures in parentheses are the minimum operating frequency of a case external clocks are used.
When using an oscillator, the minimum operating frequency is $\phi=1\text{MHz}$.



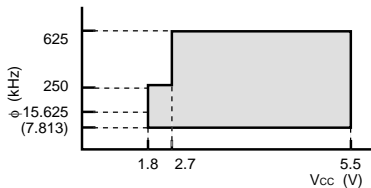
- Active (medium-speed) mode (except A/D converter)
- Sleep (medium-speed) mode (except A/D converter)
- Internal power supply step-down circuit not used

Note: Figures in parentheses are the minimum operating frequency of a case external clocks are used.
When using an oscillator, the minimum operating frequency is $\phi=15.625\text{kHz}$.



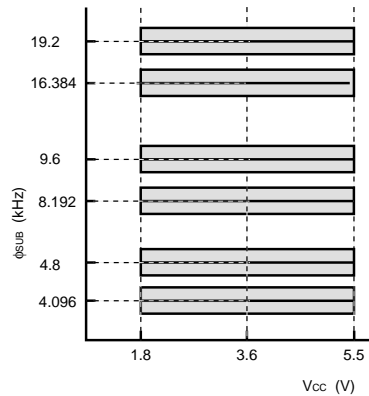
- Active (high-speed) mode
- Sleep (high-speed) mode (except CPU)
- Internal power supply step-down circuit used

Note: Figures in parentheses are the minimum operating frequency of a case external clocks are used.
When using an oscillator, the minimum operating frequency is $\phi=1\text{MHz}$.



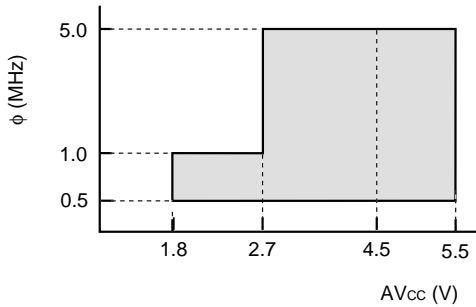
- Active (medium-speed) mode (except A/D converter)
- Sleep (medium-speed) mode (except A/D converter)
- Internal power supply step-down circuit used

Note: Figures in parentheses are the minimum operating frequency of a case external clocks are used.
When using an oscillator, the minimum operating frequency is $\phi=15.625\text{kHz}$.

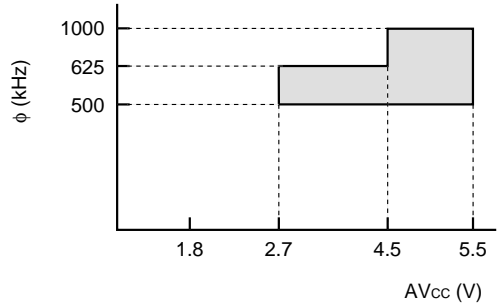


- Subactive mode
- Subsleep mode (except CPU)
- Watch mode (except CPU)

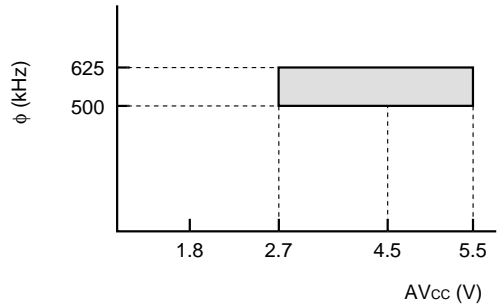
3. Analog power supply voltage and A/D converter operating range



- Active (high-speed) mode
- Sleep (high-speed) mode
- Internal power supply step-down circuit not used and used



- Active (medium-speed) mode
- Sleep (medium-speed) mode
- Internal power supply step-down circuit not used



- Active (medium-speed) mode
- Sleep (medium-speed) mode
- Internal power supply step-down circuit not used

15.2.2 DC Characteristics

Table 15.2 lists the DC characteristics.

Table 15.2 DC Characteristics

$V_{CC} = 1.8\text{ V to }5.5\text{ V}$, $AV_{CC} = 1.8\text{ V to }5.5\text{ V}$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_a = -20^\circ\text{C to }+75^\circ\text{C}^{*4}$
(including subactive mode) unless otherwise indicated.

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Notes
			Min	Typ	Max			
Input high voltage	V_{IH}	RES, WKP ₀ to WKP ₇ , IRQ ₀ to IRQ ₄ , AEVL, AEVH, TMIC, TMIF, TMIG, SCK ₁ , SCK ₃₁ , SCK ₃₂ , ADTRG	0.8 V_{CC}	—	$V_{CC} + 0.3$	V	$V_{CC} = 4.0\text{ V to }5.5\text{ V}$	
			0.9 V_{CC}	—	$V_{CC} + 0.3$		Except the above	
		SI ₁ , RXD ₃₁ , RXD ₃₂ , UD	0.7 V_{CC}	—	$V_{CC} + 0.3$	V	$V_{CC} = 4.0\text{ V to }5.5\text{ V}$	
			0.8 V_{CC}	—	$V_{CC} + 0.3$		Except the above	
		OSC ₁	0.8 V_{CC}	—	$V_{CC} + 0.3$	V	$V_{CC} = 4.0\text{ V to }5.5\text{ V}$	
			0.9 V_{CC}	—	$V_{CC} + 0.3$		Except the above	
		X ₁	0.9 V_{CC}	—	$V_{CC} + 0.3$	V	$V_{CC} = 1.8\text{ V to }5.5\text{ V}$	
		P1 ₀ to P1 ₇ , P2 ₀ to P2 ₇ , P3 ₀ to P3 ₇ , P4 ₀ to P4 ₃ ,	0.7 V_{CC}	—	$V_{CC} + 0.3$	V	$V_{CC} = 4.0\text{ V to }5.5\text{ V}$	
		P5 ₀ to P5 ₇ , P6 ₀ to P6 ₇ , P7 ₀ to P7 ₇ , P8 ₀ to P8 ₇ , P9 ₀ to P9 ₇ , PA ₀ to PA ₃	0.8 V_{CC}	—	$V_{CC} + 0.3$		Except the above	
		PB ₀ to PB ₇ ,	0.7 V_{CC}	—	$AV_{CC} + 0.3$		$V_{CC} = 4.0\text{ V to }5.5\text{ V}$	
	PC ₀ to PC ₃	0.8 V_{CC}	—	$AV_{CC} + 0.3$		Except the above		

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Notes
			Min	Typ	Max			
Input low voltage	V_{IL}	\overline{RES} , \overline{WKP}_0 to \overline{WKP}_7 , \overline{IRQ}_0 to \overline{IRQ}_4 , AEVL, AEVH, TMIC, TMIF,	-0.3	—	$0.2 V_{CC}$	V	$V_{CC} = 4.0 \text{ V to } 5.5 \text{ V}$	
		TMIG, SCK_1 , SCK_{31} , SCK_{32} , ADTRG	-0.3	—	$0.1 V_{CC}$		Except the above	
	SI_1 , RXD_{31} , RXD_{32} , UD	-0.3	—	$0.3 V_{CC}$	V	$V_{CC} = 4.0 \text{ V to } 5.5 \text{ V}$		
		-0.3	—	$0.2 V_{CC}$		Except the above		
	OSC ₁	-0.3	—	0.2	V	Internal power supply step-down circuit used		
		-0.3	—	$0.2 V_{CC}$	V	$V_{CC} = 4.0 \text{ V to } 5.5 \text{ V}$		
		-0.3	—	$0.1 V_{CC}$		Except the above		
	X1	-0.3	—	$0.1 V_{CC}$	V	$V_{CC} = 1.8 \text{ V to } 5.5 \text{ V}$		
	P1 ₀ to P1 ₇ , P2 ₀ to P2 ₇ , P3 ₀ to P3 ₇ , P4 ₀ to P4 ₃ , P5 ₀ to P5 ₇ , P6 ₀ to P6 ₇ ,	-0.3	—	$0.3 V_{CC}$	V	$V_{CC} = 4.0 \text{ V to } 5.5 \text{ V}$		
		P7 ₀ to P7 ₇ , P8 ₀ to P8 ₇ , P9 ₀ to P9 ₇ , PA ₀ to PA ₃ , PB ₀ to PB ₇ , PC ₀ to PC ₃	-0.3	—	$0.2 V_{CC}$		Except the above	
Output high voltage	V_{OH}	P1 ₀ to P1 ₇ , P2 ₀ to P2 ₇ , P3 ₀ to P3 ₇ , P4 ₀ to P4 ₂ ,	$V_{CC} - 1.0$	—	—	V	$V_{CC} = 4.0 \text{ V to } 5.5 \text{ V}$ $-I_{OH} = 1.0 \text{ mA}$	
		P5 ₀ to P5 ₇ , P6 ₀ to P6 ₇ , P7 ₀ to P7 ₇ , P8 ₀ to P8 ₇ ,	$V_{CC} - 0.5$	—	—		$V_{CC} = 4.0 \text{ V to } 5.5 \text{ V}$ $-I_{OH} = 0.5 \text{ mA}$	
		P9 ₀ to P9 ₇ , PA ₀ to PA ₃	$V_{CC} - 0.3$	—	—		$-I_{OH} = 0.1 \text{ mA}$	
Output low voltage	V_{OL}	P1 ₀ to P1 ₇ , P4 ₀ to P4 ₂	—	—	0.6	V	$V_{CC} = 4.0 \text{ V to } 5.5 \text{ V}$ $I_{OL} = 1.6 \text{ mA}$	
			—	—	0.5		$I_{OL} = 0.4 \text{ mA}$	
		P5 ₀ to P5 ₇ , P6 ₀ to P6 ₇ , P7 ₀ to P7 ₇ , P8 ₀ to P8 ₇ , P9 ₀ to P9 ₇ , PA ₀ to PA ₃	—	—	0.5		$I_{OL} = 0.4 \text{ mA}$	
			P2 ₀ to P2 ₇ , P3 ₀ to P3 ₇	—	—	1.5		$V_{CC} = 4.0 \text{ V to } 5.5 \text{ V}$ $I_{OL} = 10 \text{ mA}$
		—		—	0.6		$V_{CC} = 4.0 \text{ V to } 5.5 \text{ V}$ $I_{OL} = 1.6 \text{ mA}$	
		—	—	0.5		$I_{OL} = 0.4 \text{ mA}$		

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Notes
			Min	Typ	Max			
Input/ output leak- age current	I _{IL}	RES, P4 ₃	—	—	20.0	μA	V _{IN} = 0.5 V to	*2
			—	—	1.0		V _{CC} – 0.5 V	*1
	OSC ₁ , X ₁ , P1 ₀ to P1 ₇ , P2 ₀ to P2 ₇ , P3 ₀ to P3 ₇ , P4 ₀ to P4 ₂ , P5 ₀ to P5 ₇ , P6 ₀ to P6 ₇ , P7 ₀ to P7 ₇ , P8 ₀ to P8 ₇ , P9 ₀ to P9 ₇ , PA ₀ to PA ₃		—	—	1.0	μA	V _{IN} = 0.5 V to	
		PB ₀ to PB ₇ , PC ₀ to PC ₃	—	—	1.0		V _{IN} = 0.5 V to AV _{CC} – 0.5 V	
Pull-up MOS current	–I _p	P1 ₀ to P1 ₇ , P3 ₀ to P3 ₇ ,	50.0	—	300.0	μA	V _{CC} = 5 V, V _{IN} = 0 V	
		P5 ₀ to P5 ₇ , P6 ₀ to P6 ₇	—	35.0	—		V _{CC} = 2.7 V, V _{IN} = 0 V	Refer- ence value
Input capaci- tance	C _{IN}	All input pins except power supply, RES, P4 ₃ , PB ₀ to PB ₇	—	—	15.0	pF	f = 1 MHz, V _{IN} = 0 V, Ta = 25°C	
		RES	—	—	80.0			*2
			—	—	15.0			*1
		P4 ₃	—	—	50.0			*2
			—	—	15.0			*1
		PB ₀ to PB ₇	—	—	15.0			
Active mode current dissi- pation	I _{OPE1}	V _{CC}	—	4.5	6.5	mA	Active (high-speed) mode V _{CC} = 5 V, f _{OSC} = 10 MHz	*3 *5 *6
	I _{OPE2}	V _{CC}	—	1.3	2.0			Active (medium- speed) mode V _{CC} = 5 V, f _{OSC} = 10 MHz, φ _{OSC} /128
Sleep mode current dissi- pation	I _{SLLEEP}	V _{CC}	—	2.5	4.0	mA	V _{CC} = 5 V, f _{OSC} = 10 MHz	*3 *5 *6

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Notes
			Min	Typ	Max			
Sub-active mode current dissipation	I_{SUB}	V_{CC}	—	15	30	μA	$V_{CC} = 2.7 V$, LCD on 32 kHz crystal oscillator ($\phi_{SUB} = \phi_{W/2}$)	*3 *5 *6
			—	8	—			μA
Sub-sleep mode current dissipation	I_{SUBSP}	V_{CC}	—	7.5	16	μA	$V_{CC} = 2.7 V$, LCD on 32 kHz crystal oscillator ($\phi_{SUB} = \phi_{W/2}$)	
Watch mode current dissipation	I_{WATCH}	V_{CC}	—	2.8	6.0	μA	$V_{CC} = 2.7 V$, 32 kHz crystal oscillator LCD not used	*3 *5 *6
Stand-by mode current dissipation	I_{STBY}	V_{CC}	—	1.0	5.0	μA	32 kHz crystal oscillator not used	*3 *5
RAM data retaining voltage	V_{RAM}	V_{CC}	1.5	—	—	V		*3 *5
Allowable output low current (per pin)	I_{OL}	Output pins except ports 2 and 3	—	—	2.0	mA	$V_{CC} = 4.0 V$ to $5.5 V$	
		Ports 2 and 3	—	—	10.0			$V_{CC} = 4.0 V$ to $5.5 V$
		All output pins	—	—	0.5			
Allowable output low current (total)	ΣI_{OL}	Output pins except ports 2 and 3	—	—	40.0	mA	$V_{CC} = 4.0 V$ to $5.5 V$	
		Ports 2 and 3	—	—	80.0			$V_{CC} = 4.0 V$ to $5.5 V$
		All output pins	—	—	20.0			

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Notes
			Min	Typ	Max			
Allowable output high current (per pin)	$-I_{OH}$	All output pins	—	—	2.0	mA	$V_{CC} = 4.0 \text{ V to } 5.5 \text{ V}$	
			—	—	0.2		Except the above	
Allowable output high current (total)	$\Sigma -I_{OH}$	All output pins	—	—	15.0	mA	$V_{CC} = 4.0 \text{ V to } 5.5 \text{ V}$	
			—	—	10.0		Except the above	

Notes: Connect the TEST pin to V_{SS} .

1. Applies to the Mask ROM products.
2. Applies to the HD6473847R.
3. Pin states during current measurement.

Mode	\overline{RES} Pin	Internal State	Other Pins	LCD Power Supply	Oscillator Pins
Active (high-speed) mode	V_{CC}	Only CPU Operates	V_{CC}	Halted	System clock oscillator: Crystal
Active (medium-speed) mode					Subclock oscillator: Pin $X_1 = \text{GND}$
Sleep mode	V_{CC}	Only timers operate	V_{CC}		
Subactive mode	V_{CC}	Only CPU Operates	V_{CC}	Halted	System clock oscillator: crystal
Subsleep mode	V_{CC}	Only timers operate, CPU stops	V_{CC}	Halted	Subclock oscillator: crystal
Watch mode	V_{CC}	Only time base operates, CPU stops	V_{CC}	Halted	
Standby mode	V_{CC}	CPU and timers both stop	V_{CC}	Halted	System clock oscillator: crystal Subclock oscillator: Pin $X_1 = \text{GND}$

4. The guaranteed temperature as an electrical characteristic for Die products is 75°C.
5. Excludes current in pull-up MOS transistors and output buffers.
6. When internal step-down circuit is used.

15.2.3 AC Characteristics

Table 15.3 lists the control signal timing, and tables 15.4 and 15.5 list the serial interface timing.

Table 15.3 Control Signal Timing

$V_{CC} = 1.8\text{ V to }5.5\text{ V}$, $AV_{CC} = 1.8\text{ V to }5.5\text{ V}$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_a = -20^\circ\text{C to }+75^\circ\text{C}^{*4}$
(including subactive mode) unless otherwise indicated.

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Reference Figure
			Min	Typ	Max			
System clock oscillation frequency	f_{OSC}	OSC ₁ , OSC ₂	2	—	16	MHz	$V_{CC} = 4.5\text{ V to }5.5\text{ V}$	*2
			2	—	10		$V_{CC} = 2.7\text{ V to }5.5\text{ V}$	
			2	—	4		$V_{CC} = 1.8\text{ V to }5.5\text{ V}$	
OSC clock (ϕ_{OSC}) cycle time	t_{OSC}	OSC ₁ , OSC ₂	62.5	—	500 (1000)	ns	$V_{CC} = 4.5\text{ V to }5.5\text{ V}$	Figure 15.1 *2 *3
			100	—	500 (1000)		$V_{CC} = 2.7\text{ V to }5.5\text{ V}$	
			250	—	500 (1000)		$V_{CC} = 1.8\text{ V to }5.5\text{ V}$	
System clock (ϕ) cycle time	t_{cyc}		2	—	128	t_{OSC}		
			—	—	244.1			
Subclock oscillation frequency	f_W	X ₁ , X ₂	—	32.768 or 38.4	—	kHz		
Watch clock (ϕ_W) cycle time	t_W	X ₁ , X ₂	—	30.5 or 26.0	—	μs	Figure 15.1	
Subclock (ϕ_{SUB}) cycle time	t_{subcyc}		2	—	8	t_W	*1	
Instruction cycle time			2	—	—	t_{cyc} t_{subcyc}		
Oscillation stabilization time	t_{rc}	OSC ₁ , OSC ₂	—	20	45	μs	Figure 15.10 $V_{CC} = 2.2\text{ V to }5.5\text{ V}$	Figure 15.10 *2
			—	0.1	8	ms	Figure 15.10 $V_{CC} = 2.2\text{ V to }5.5\text{ V}$	Figure 15.10
			—	—	50	ms	Except the above	
		X ₁ , X ₂	—	—	2.0	s		

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Reference Figure
			Min	Typ	Max			
External clock high width	t_{CPH}	OSC ₁	25	—	—	ns	$V_{CC} = 4.5\text{ V to }5.5\text{ V}$	Figure 15.1 *2
			40	—	—		$V_{CC} = 2.7\text{ V to }5.5\text{ V}$	
			100	—	—		$V_{CC} = 1.8\text{ V to }5.5\text{ V}$	
		X ₁	—	15.26 or 13.02	—	μs		
External clock low width	t_{CPL}	OSC ₁	25	—	—	ns	$V_{CC} = 4.5\text{ V to }5.5\text{ V}$	Figure 15.1 *2
			40	—	—		$V_{CC} = 2.7\text{ V to }5.5\text{ V}$	
			100	—	—		$V_{CC} = 1.8\text{ V to }5.5\text{ V}$	
		X ₁	—	15.26 or 13.02	—	μs		
External clock rise time	t_{CPr}	OSC ₁	—	—	6	ns	$V_{CC} = 4.5\text{ V to }5.5\text{ V}$	Figure 15.1 *2
			—	—	10		$V_{CC} = 2.7\text{ V to }5.5\text{ V}$	
			—	—	25		$V_{CC} = 1.8\text{ V to }5.5\text{ V}$	
		X ₁	—	—	55.0	ns	Figure 15.1	
External clock fall time	t_{CPl}	OSC ₁	—	—	6	ns	$V_{CC} = 4.5\text{ V to }5.5\text{ V}$	Figure 15.1 *2
			—	—	10		$V_{CC} = 2.7\text{ V to }5.5\text{ V}$	
			—	—	25		$V_{CC} = 1.8\text{ V to }5.5\text{ V}$	
		X ₁	—	—	55.0	ns	Figure 15.1	
Pin $\overline{\text{RES}}$ low width	t_{REL}	$\overline{\text{RES}}$	10	—	—	t_{cyc}		Figure 15.2
Input pin high width	t_{IH}	$\overline{\text{IRQ}}_0$ to $\overline{\text{IRQ}}_4$, WKP ₀ to WKP ₇ , $\overline{\text{ADTRG}}$, TMIC, TMIF, TMIG, AEVL, AEVH	2	—	—	t_{cyc} t_{subcyc}		Figure 15.3

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Reference Figure
			Min	Typ	Max			
Input pin low width	t_{IL}	\overline{IRQ}_0 to \overline{IRQ}_4 , 2 \overline{WKP}_0 to \overline{WKP}_7 , ADTRG, TMIC, TMIF, TMIG, AEVL, AEVH	4	—	—	t_{cyc} t_{subcyc}		Figure 15.3
UD pin minimum modulation width	t_{UDH} t_{UDL}	UD	4	—	—	t_{cyc} t_{subcyc}		Figure 15.4

- Notes:
1. Selected with SA1 and SA0 of system clock control register 2 (SYSCR2).
 2. When internal power supply step-down circuit is not used.
 3. Figures in parentheses are the maximum t_{OSC} rate with external clock input.
 4. The guaranteed temperature as an electrical characteristic for Die products is 75°C.

Table 15.4 Serial Interface (SCI1) Timing

$V_{CC} = 1.8\text{ V to }5.5\text{ V}$, $AV_{CC} = 1.8\text{ V to }5.5\text{ V}$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_a = -20^{\circ}\text{C to }+75^{\circ}\text{C}^{*2}$ unless otherwise indicated

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Reference Figure
			Min	Typ	Max			
Input clock cycle	$t_{S\text{cyc}}$	SCK ₁	4	—	—	t_{cyc}		Figure 15.5
Input clock high width	$t_{S\text{CKH}}$	SCK ₁	0.4	—	—	$t_{S\text{cyc}}$		Figure 15.5
Input clock low width	$t_{S\text{CKL}}$	SCK ₁	0.4	—	—	$t_{S\text{cyc}}$		Figure 15.5
Input clock rise time	$t_{S\text{CKr}}$	SCK ₁	—	—	60.0	ns	$V_{CC} = 4.0\text{ V to }5.5\text{ V}$	Figure 15.5 ^{*1}
			—	—	80.0	ns	Except the above	Figure 15.5
Input clock fall time	$t_{S\text{CKf}}$	SCK ₁	—	—	60.0	ns	$V_{CC} = 4.0\text{ V to }5.5\text{ V}$	Figure 15.5 ^{*1}
			—	—	80.0	ns	Except the above	Figure 15.5
Serial output data delay time	$t_{S\text{OD}}$	SO ₁	—	—	200.0	ns	$V_{CC} = 4.0\text{ V to }5.5\text{ V}$	Figure 15.5 ^{*1}
			—	—	350.0	ns	Except the above	Figure 15.5
Serial input data setup time	$t_{S\text{IS}}$	SI ₁	200.0	—	—	ns	$V_{CC} = 4.0\text{ V to }5.5\text{ V}$	Figure 15.5 ^{*1}
			400.0	—	—	ns	Except the above	Figure 15.5
Serial input data hold time	$t_{S\text{IH}}$	SI ₁	200.0	—	—	ns	$V_{CC} = 4.0\text{ V to }5.5\text{ V}$	Figure 15.5 ^{*1}
			400.0	—	—	ns	Except the above	Figure 15.5

Notes: 1. When internal power supply step-down circuit is not used.

2. The guaranteed temperature as an electrical characteristic for Die products is 75°C.

Table 15.5 Serial Interface (SCI3-1, SCI3-2) Timing

$V_{CC} = 1.8\text{ V to }5.5\text{ V}$, $AV_{CC} = 1.8\text{ V to }5.5\text{ V}$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_a = -20^{\circ}\text{C to }+75^{\circ}\text{C}^{*2}$
(including subactive mode) unless otherwise indicated.

Item	Symbol	Values			Unit	Test Conditions	Reference Figure	
		Min	Typ	Max				
Input clock cycle	Asynchronous	t_{Scyc}	4	—	—	t_{cyc} or	Figure 15.6	
	Synchronous		6	—	—	t_{subcyc}		
Input clock pulse width		t_{SCKW}	0.4	—	0.6	t_{Scyc}	Figure 15.6	
Transmit data delay time (synchronous)		t_{TXD}	—	—	1	t_{cyc} or	$V_{CC} = 4.0\text{ V to }5.5\text{ V}$ Except the above	Figure 15.7
			—	—	1	t_{subcyc}		
Receive data setup time (synchronous)		t_{RXS}	200.0	—	—	ns	$V_{CC} = 4.0\text{ V to }5.5\text{ V}$ Except the above	Figure 15.7* ¹
			400.0	—	—			Figure 15.7
Receive data hold time (synchronous)		t_{RXH}	200.0	—	—	ns	$V_{CC} = 4.0\text{ V to }5.5\text{ V}$ Except the above	Figure 15.7* ¹
			400.0	—	—			Figure 15.7

Notes: 1. When internal power supply step-down circuit is not used

2. The guaranteed temperature as an electrical characteristic for Die products is 75°C.

15.2.4 A/D Converter Characteristics

Table 15.6 shows the A/D converter characteristics.

Table 15.6 A/D Converter Characteristics

$V_{CC} = 1.8\text{ V to }5.5\text{ V}$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_a = -20^\circ\text{C to }+75^\circ\text{C}^{*6}$ unless otherwise indicated.

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Notes
			Min	Typ	Max			
Analog power supply voltage	AV_{CC}	AV_{CC}	1.8	—	5.5	V		*1
Analog input voltage	AV_{IN}	AN_0 to AN_{11}	-0.3	—	$AV_{CC} + 0.3\text{ V}$			
Analog power supply current	AI_{OPE}	AV_{CC}	—	—	1.5	mA	$AV_{CC} = 5.0\text{ V}$	*2 Reference value
	AI_{STOP1}	AV_{CC}	—	600	—	μA		
	AI_{STOP2}	AV_{CC}	—	—	5	μA	*3	
Analog input capacitance	$CAIN$	AN_0 to AN_{11}	—	—	15.0	pF		
Allowable signal source impedance	$RAIN$		—	—	10.0	k Ω		
Resolution (data length)			—	—	10	bit		
Nonlinearity error			—	—	± 2.5	LSB	$AV_{CC} = 2.7\text{ V to }5.5\text{ V}$ $V_{CC} = 2.7\text{ V to }5.5\text{ V}$	*4
			—	—	± 5.5		$AV_{CC} = 2.0\text{ V to }5.5\text{ V}$ $V_{CC} = 2.0\text{ V to }5.5\text{ V}$	
			—	—	± 7.5		Except the above	
Quantization error			—	—	± 0.5	LSB		
Absolute accuracy			—	—	± 3.0	LSB	$AV_{CC} = 2.7\text{ V to }5.5\text{ V}$ $V_{CC} = 2.7\text{ V to }5.5\text{ V}$	*4
			—	—	± 6.0		$AV_{CC} = 2.0\text{ V to }5.5\text{ V}$ $V_{CC} = 2.0\text{ V to }5.5\text{ V}$	
			—	—	± 8.0		Except the above	
Conversion time			12.4	—	124	μs	$AV_{CC} = 2.7\text{ V to }5.5\text{ V}$ $V_{CC} = 2.7\text{ V to }5.5\text{ V}$	*4
			62	—	124		Except the above	

- Notes: 1. Set $AV_{CC} = V_{CC}$ when the A/D converter is not used.
 2. AI_{STOP1} is the current in active and sleep modes while the A/D converter is idle.
 3. AI_{STOP2} is the current at reset and in standby, watch, subactive, and subsleep modes while the A/D converter is idle.
 4. When internal power supply step-down circuit is not used.
 5. Conversion time: 62 μs
 6. The guaranteed temperature as an electrical characteristic for Die products is 75°C.

15.2.5 LCD Characteristics

Table 15.7 shows the LCD characteristics.

Table 15.7 LCD Characteristics

$V_{CC} = 1.8\text{ V to }5.5\text{ V}$, $AV_{CC} = 1.8\text{ V to }5.5\text{ V}$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_a = -20^\circ\text{C to }+75^\circ\text{C}$ *³
(including subactive mode) unless otherwise indicated.

Item	Symbol	Applicable Pins	Values			Unit	Test Conditions	Notes
			Min	Typ	Max			
Segment driver drop voltage	V_{DS}	SEG ₁ to SEG ₄₀	—	—	0.6	V	$I_D = 2\ \mu\text{A}$ $V_1 = 2.7\text{ V to }5.5\text{ V}$	*1
Common driver drop voltage	V_{DC}	COM ₁ to COM ₄	—	—	0.3	V	$I_D = 2\ \mu\text{A}$ $V_1 = 2.7\text{ V to }5.5\text{ V}$	*1
LCD power supply split-resistance	R_{LCD}		0.5	3.0	9.0	M Ω	Between V_1 and V_{SS}	
Liquid crystal display voltage	V_{LCD}	V_1	2.2	—	5.5	V		*2

- Notes: 1. The voltage drop from power supply pins V_1 , V_2 , V_3 , and V_{SS} to each segment pin or common pin.
2. When the liquid crystal display voltage is supplied from an external power source, ensure that the following relationship is maintained: $V_1 \geq V_2 \geq V_3 \geq V_{SS}$.
3. The guaranteed temperature as an electrical characteristic for Die products is 75°C .

Table 15.8 Segment External Expansion AC Characteristics

$V_{CC} = 1.8\text{ V to }5.5\text{ V}$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_a = -20^{\circ}\text{C to }+75^{\circ}\text{C}^{*2}$ (including subactive mode) unless otherwise indicated.

Item	Symbol	Applicable Pins	Values			Unit	Test Conditions	Reference Figure
			Min	Typ	Max			
Clock high width	t_{CWH}	CL ₁ , CL ₂	800.0	—	—	ns	*1	Figure 15.8
Clock low width	t_{CWL}	CL ₂	800.0	—	—	ns	*1	Figure 15.8
Clock setup time	t_{CSU}	CL ₁ , CL ₂	500.0	—	—	ns	*1	Figure 15.8
Data setup time	t_{SU}	DO	300.0	—	—	ns	*1	Figure 15.8
Data retaining time	t_{DH}	DO	300.0	—	—	ns	*1	Figure 15.8
M delay time	t_{DM}	M	-1000.0	—	1000.0	ns	*1	Figure 15.8
Clock rise/fall time	t_{CT}	CL ₁ , CL ₂	—	—	170.0	ns		Figure 15.8

Notes: 1. When the frame frequency is set at 488 Hz to 30.5 Hz.

2. The guaranteed temperature as an electrical characteristic for Die products is 75°C.

15.3 H8/3847R Group Absolute Maximum Ratings (Wide-range Specification)

Table 15.9 lists the absolute maximum ratings.

Table 15.9 Absolute Maximum Ratings

Item	Symbol	Value	Unit	
Power supply voltage	V_{CC}	-0.3 to +7.0	V	
Analog power supply voltage	AV_{CC}	-0.3 to +7.0	V	
Programming voltage	V_{PP}	-0.3 to +13.0	V	
Input voltage	Ports other than Ports B and C	V_{in}	-0.3 to $V_{CC} + 0.3$	V
	Ports B and C	AV_{in}	-0.3 to $AV_{CC} + 0.3$	V
Operating temperature	T_{opr}	-40 to +85	°C	
Storage temperature	T_{stg}	-55 to +125	°C	

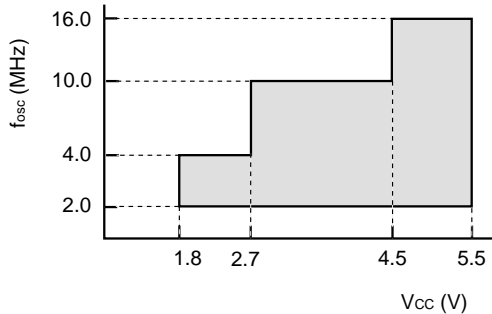
Note: Permanent damage may occur to the chip if maximum ratings are exceeded. Normal operation should be under the conditions specified in Electrical Characteristics. Exceeding these values can result in incorrect operation and reduced reliability.

15.4 H8/3847R Electrical Characteristics (Wide-range Specification)

15.4.1 Power Supply Voltage and Operating Range

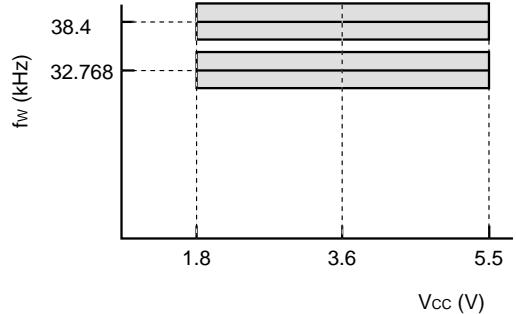
The power supply voltage and operating range are indicated by the shaded region in the figures.

1. Power supply voltage and oscillator frequency range

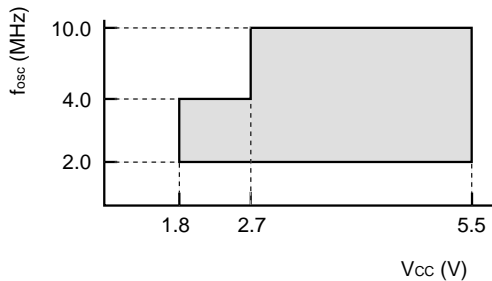


- Active (high-speed) mode
- Sleep (high-speed) mode
- Internal power supply step-down circuit not used

Note: f_{osc} is the oscillator frequency. When external clocks are used, $f_{osc}=1$ MHz is the minimum.



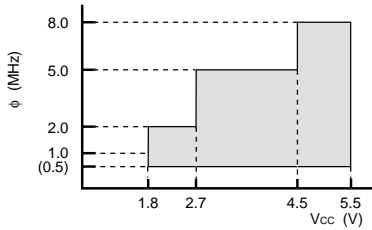
- All operating modes



- Active (high-speed) mode
- Sleep (high-speed) mode
- Internal power supply step-down circuit used

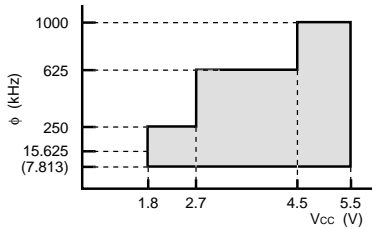
Note: f_{osc} is the oscillator frequency. When external clocks are used, $f_{osc}=1$ MHz is the minimum.

2. Power supply voltage and operating frequency range



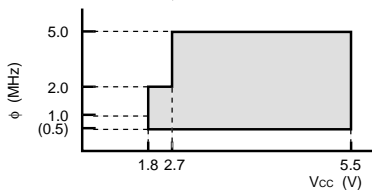
- Active (high-speed) mode
- Sleep (high-speed) mode (except CPU)
- Internal power supply step-down circuit not used

Note: Figures in parentheses are the minimum operating frequency of a case external clocks are used. When using an oscillator, the minimum operating frequency is $\phi=1$ MHz.



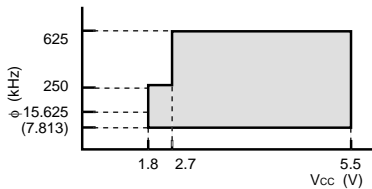
- Active (medium-speed) mode (except A/D converter)
- Sleep (medium-speed) mode (except A/D converter)
- Internal power supply step-down circuit not used

Note: Figures in parentheses are the minimum operating frequency of a case external clocks are used. When using an oscillator, the minimum operating frequency is $\phi=15.625$ KHz.



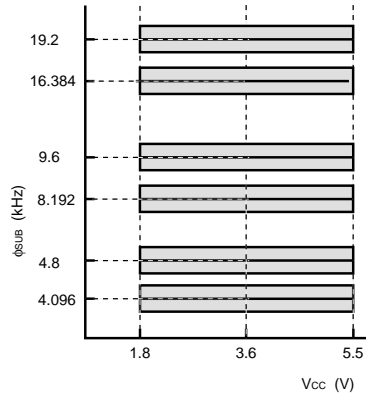
- Active (high-speed) mode
- Sleep (high-speed) mode (except CPU)
- Internal power supply step-down circuit used

Note: Figures in parentheses are the minimum operating frequency of a case external clocks are used. When using an oscillator, the minimum operating frequency is $\phi=1$ MHz.



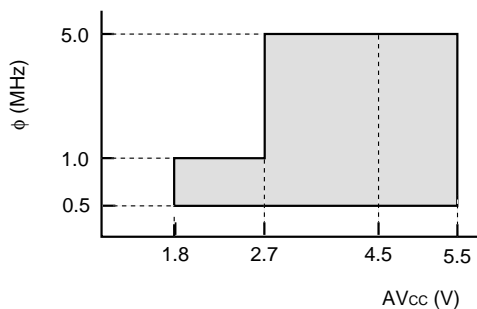
- Active (medium-speed) mode (except A/D converter)
- Sleep (medium-speed) mode (except A/D converter)
- Internal power supply step-down circuit used

Note: Figures in parentheses are the minimum operating frequency of a case external clocks are used. When using an oscillator, the minimum operating frequency is $\phi=15.625$ KHz.

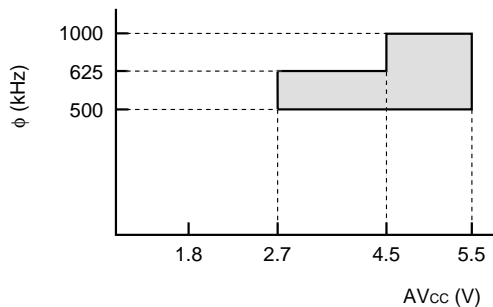


- Subactive mode
- Subsleep mode (except CPU)
- Watch mode (except CPU)

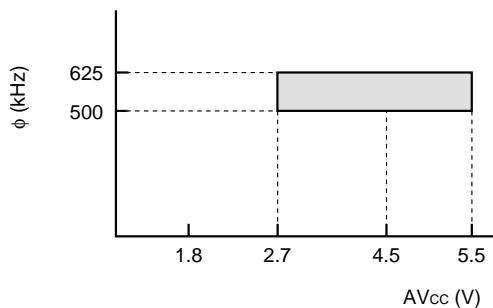
3. Analog power supply voltage and A/D converter operating range



- Active (high-speed) mode
- Sleep (high-speed) mode
- Internal power supply step-down circuit not used and used



- Active (medium-speed) mode
- Sleep (medium-speed) mode
- Internal power supply step-down circuit not used



- Active (medium-speed) mode
- Sleep (medium-speed) mode
- Internal power supply step-down circuit not used

15.4.2 DC Characteristics

Table 15.10 lists the DC characteristics.

Table 15.10 DC Characteristics

$V_{CC} = 1.8\text{ V to }5.5\text{ V}$, $AV_{CC} = 1.8\text{ V to }5.5\text{ V}$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_a = -40^\circ\text{C to }+85^\circ\text{C}$ (including subactive mode) unless otherwise indicated.

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Notes
			Min	Typ	Max			
Input high voltage	V_{IH}	\overline{RES} , \overline{WKP}_0 to \overline{WKP}_7 , \overline{IRQ}_0 to \overline{IRQ}_4 , \overline{AEVL} , \overline{AEVH} , \overline{TMIC} , \overline{TMIF} ,	$0.8 V_{CC}$	—	$V_{CC} + 0.3$	V	$V_{CC} = 4.0\text{ V to }5.5\text{ V}$	
		\overline{TMIG} , \overline{SCK}_1 , \overline{SCK}_{31} , \overline{SCK}_{32} , \overline{ADTRG}	$0.9 V_{CC}$	—	$V_{CC} + 0.3$			
		\overline{SI}_1 , \overline{RXD}_{31} , \overline{RXD}_{32} , \overline{UD}	$0.7 V_{CC}$	—	$V_{CC} + 0.3$	V	$V_{CC} = 4.0\text{ V to }5.5\text{ V}$	Except the above
			$0.8 V_{CC}$	—	$V_{CC} + 0.3$			
		\overline{OSC}_1	$0.8 V_{CC}$	—	$V_{CC} + 0.3$	V	$V_{CC} = 4.0\text{ V to }5.5\text{ V}$	Except the above
			$0.9 V_{CC}$	—	$V_{CC} + 0.3$			
		X_1	$0.9 V_{CC}$	—	$V_{CC} + 0.3$	V	$V_{CC} = 1.8\text{ V to }5.5\text{ V}$	
		$P1_0$ to $P1_7$, $P2_0$ to $P2_7$, $P3_0$ to $P3_7$, $P4_0$ to $P4_3$,	$0.7 V_{CC}$	—	$V_{CC} + 0.3$	V	$V_{CC} = 4.0\text{ V to }5.5\text{ V}$	
		$P5_0$ to $P5_7$, $P6_0$ to $P6_7$, $P7_0$ to $P7_7$, $P8_0$ to $P8_7$, $P9_0$ to $P9_7$, PA_0 to PA_3	$0.8 V_{CC}$	—	$V_{CC} + 0.3$		Except the above	
		PB_0 to PB_7 ,	$0.7 V_{CC}$	—	$AV_{CC} + 0.3$		$V_{CC} = 4.0\text{ V to }5.5\text{ V}$	
PC_0 to PC_3	$0.8 V_{CC}$	—	$AV_{CC} + 0.3$		Except the above			

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Notes
			Min	Typ	Max			
Input low voltage	V _{IL}	$\overline{\text{RES}}$, $\overline{\text{WKP}}_0$ to $\overline{\text{WKP}}_7$, $\overline{\text{IRQ}}_0$ to $\overline{\text{IRQ}}_4$, AEVL, AEVH, TMIC, TMIF,	-0.3	—	0.2 V _{CC}	V	V _{CC} = 4.0 V to 5.5 V	
		TMIG, SCK ₁ , SCK ₃₁ , SCK ₃₂ , ADTRG	-0.3	—	0.1 V _{CC}		Except the above	
		SI ₁ , RXD ₃₁ , RXD ₃₂ , UD	-0.3	—	0.3 V _{CC}	V	V _{CC} = 4.0 V to 5.5 V	
			-0.3	—	0.2 V _{CC}		Except the above	
		OSC ₁	-0.3	—	0.2	V	Internal power supply step-down circuit used	
			-0.3	—	0.2 V _{CC}	V	V _{CC} = 4.0 V to 5.5 V	
			-0.3	—	0.1 V _{CC}		Except the above	
		X1	-0.3	—	0.1 V _{CC}	V	V _{CC} = 1.8 V to 5.5 V	
		P1 ₀ to P1 ₇ , P2 ₀ to P2 ₇ , P3 ₀ to P3 ₇ , P4 ₀ to P4 ₃ , P5 ₀ to P5 ₇ , P6 ₀ to P6 ₇ ,	-0.3	—	0.3 V _{CC}	V	V _{CC} = 4.0 V to 5.5 V	
		P7 ₀ to P7 ₇ , P8 ₀ to P8 ₇ , P9 ₀ to P9 ₇ , PA ₀ to PA ₃ , PB ₀ to PB ₇ , PC ₀ to PC ₃	-0.3	—	0.2 V _{CC}		Except the above	
Output high voltage	V _{OH}	P1 ₀ to P1 ₇ , P2 ₀ to P2 ₇ , P3 ₀ to P3 ₇ , P4 ₀ to P4 ₂ ,	V _{CC} - 1.0	—	—	V	V _{CC} = 4.0 V to 5.5 V -I _{OH} = 1.0 mA	
		P5 ₀ to P5 ₇ , P6 ₀ to P6 ₇ , P7 ₀ to P7 ₇ , P8 ₀ to P8 ₇ ,	V _{CC} - 0.5	—	—		V _{CC} = 4.0 V to 5.5 V -I _{OH} = 0.5 mA	
		P9 ₀ to P9 ₇ , PA ₀ to PA ₃	V _{CC} - 0.3	—	—		-I _{OH} = 0.1 mA	
Output low voltage	V _{OL}	P1 ₀ to P1 ₇ , P4 ₀ to P4 ₂	—	—	0.6	V	V _{CC} = 4.0 V to 5.5 V I _{OL} = 1.6 mA	
			—	—	0.5		I _{OL} = 0.4 mA	
		P5 ₀ to P5 ₇ , P6 ₀ to P6 ₇ , P7 ₀ to P7 ₇ , P8 ₀ to P8 ₇ , P9 ₀ to P9 ₇ , PA ₀ to PA ₃	—	—	0.5		I _{OL} = 0.4 mA	
		P2 ₀ to P2 ₇ , P3 ₀ to P3 ₇	—	—	1.5		V _{CC} = 4.0 V to 5.5 V I _{OL} = 10 mA	
			—	—	0.6		V _{CC} = 4.0 V to 5.5 V I _{OL} = 1.6 mA	
			—	—	0.5		I _{OL} = 0.4 mA	

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Notes
			Min	Typ	Max			
Input/output leakage current	$ I_{IL} $	\overline{RES} , P4 ₃	—	—	20.0	μA	$V_{IN} = 0.5\text{ V}$ to $V_{CC} - 0.5\text{ V}$	*2
			—	—	1.0		$V_{CC} - 0.5\text{ V}$	*1
		OSC ₁ , X ₁ , P1 ₀ to P1 ₇ , P2 ₀ to P2 ₇ , P3 ₀ to P3 ₇ , P4 ₀ to P4 ₂ , P5 ₀ to P5 ₇ , P6 ₀ to P6 ₇ , P7 ₀ to P7 ₇ , P8 ₀ to P8 ₇ , P9 ₀ to P9 ₇ , PA ₀ to PA ₃	—	—	1.0	μA	$V_{IN} = 0.5\text{ V}$ to $V_{CC} - 0.5\text{ V}$	
		PB ₀ to PB ₇ , PC ₀ to PC ₃	—	—	1.0		$V_{IN} = 0.5\text{ V}$ to $AV_{CC} - 0.5\text{ V}$	
Pull-up MOS current	-I _p	P1 ₀ to P1 ₇ , P3 ₀ to P3 ₇	50.0	—	300.0	μA	$V_{CC} = 5\text{ V}$, $V_{IN} = 0\text{ V}$	
		P5 ₀ to P5 ₇ , P6 ₀ to P6 ₇	—	35.0	—		$V_{CC} = 2.7\text{ V}$, $V_{IN} = 0\text{ V}$	Reference value
Input capacitance	C _{IN}	All input pins except power supply, RES, P4 ₃ , PB ₀ to PB ₇	—	—	15.0	pF	f = 1 MHz, $V_{IN} = 0\text{ V}$, Ta = 25°C	
		\overline{RES}	—	—	80.0			*2
			—	—	15.0			*1
		P4 ₃	—	—	50.0			*2
			—	—	15.0			*1
		PB ₀ to PB ₇	—	—	15.0			
Active mode current dissipation	I _{OP1}	V _{CC}	—	4.5	6.5	mA	Active (high-speed) mode $V_{CC} = 5\text{ V}$, f _{OSC} = 10 MHz	*3
								*4
	I _{OP2}	V _{CC}	—	1.3	2.0	mA	Active (medium-speed) mode $V_{CC} = 5\text{ V}$, f _{OSC} = 10 MHz, φ _{OSC} /128	*5
								*3
Sleep mode current dissipation	I _{SLEEP}	V _{CC}	—	2.5	4.0	mA	$V_{CC} = 5\text{ V}$, f _{OSC} = 10 MHz	*4
								*5

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Notes
			Min	Typ	Max			
Sub-active mode current dissipation	I_{SUB}	V_{CC}	—	15	30	μA	$V_{CC} = 2.7 V$, LCD on 32 kHz crystal oscillator ($\phi_{SUB} = \phi_W/2$)	*3 *4 *5
			—	8	—			$V_{CC} = 2.7 V$, LCD on 32 kHz crystal oscillator ($\phi_{SUB} = \phi_W/8$)
Sub-sleep mode current dissipation	I_{SUBSP}	V_{CC}	—	7.5	16	μA	$V_{CC} = 2.7 V$, LCD on 32 kHz crystal oscillator ($\phi_{SUB} = \phi_W/2$)	*3 *4 *5
Watch mode current dissipation	I_{WATCH}	V_{CC}	—	2.8	6.0	μA	$V_{CC} = 2.7 V$, 32 kHz crystal oscillator LCD not used	*3 *4 *5
Stand-by mode current dissipation	I_{STBY}	V_{CC}	—	1.0	5.0	μA	32 kHz crystal oscillator not used	*3 *4
RAM data retaining voltage	V_{RAM}	V_{CC}	1.5	—	—	V		*3 *4
Allowable output low current (per pin)	I_{OL}	Output pins except ports 2 and 3	—	—	2.0	mA	$V_{CC} = 4.0 V$ to 5.5 V	
		Ports 2 and 3	—	—	10.0			$V_{CC} = 4.0 V$ to 5.5 V
		All output pins	—	—	0.5			
Allowable output low current (total)	$\sum I_{OL}$	Output pins except ports 2 and 3	—	—	40.0	mA	$V_{CC} = 4.0 V$ to 5.5 V	
		Ports 2 and 3	—	—	80.0			$V_{CC} = 4.0 V$ to 5.5 V
		All output pins	—	—	20.0			

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Notes
			Min	Typ	Max			
Allowable output high current (per pin)	$-I_{OH}$	All output pins	—	—	2.0	mA	$V_{CC} = 4.0\text{ V to }5.5\text{ V}$	
			—	—	0.2		Except the above	
Allowable output high current (total)	$\Sigma -I_{OH}$	All output pins	—	—	15.0	mA	$V_{CC} = 4.0\text{ V to }5.5\text{ V}$	
			—	—	10.0		Except the above	

Notes: Connect the TEST pin to V_{SS} .

1. Applies to the Mask ROM products.
2. Applies to the HD6473847R.
3. Pin States during Current Dissipation Measurement

Mode	\overline{RES} Pin	Internal State	Other Pins	LCD Power Supply	Oscillator Pins
Active (high-speed) mode	V_{CC}	Only CPU Operates	V_{CC}	Halted	System clock oscillator: Crystal
Active (medium-speed) mode					Subclock oscillator: Pin $X_1 = GND$
Sleep mode	V_{CC}	Only timers operate	V_{CC}		
Subactive mode	V_{CC}	Only CPU Operates	V_{CC}	Halted	System clock oscillator: crystal
Subsleep mode	V_{CC}	Only timers operate, CPU stops	V_{CC}	Halted	Subclock oscillator: crystal
Watch mode	V_{CC}	Only time base operates, CPU stops	V_{CC}	Halted	crystal
Standby mode	V_{CC}	CPU and timers both stop	V_{CC}	Halted	System clock oscillator: crystal Subclock oscillator: Pin $X_1 = GND$

4. Excludes current in pull-up MOS transistors and output buffers.
5. When internal step-down circuit is used.

15.4.3 AC Characteristics

Table 15.11 lists the control signal timing, and tables 15.12 and 15.13 list the serial interface timing.

Table 15.11 Control Signal Timing

$V_{CC} = 1.8\text{ V to }5.5\text{ V}$, $AV_{CC} = 1.8\text{ V to }5.5\text{ V}$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_a = -40^\circ\text{C to }+85^\circ\text{C}$
(including subactive mode) unless otherwise indicated.

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Reference Figure
			Min	Typ	Max			
System clock oscillation frequency	f_{OSC}	OSC ₁ , OSC ₂	2	—	16	MHz	$V_{CC} = 4.5\text{ V to }5.5\text{ V}$	*2
			2	—	10		$V_{CC} = 2.7\text{ V to }5.5\text{ V}$	
			2	—	4		$V_{CC} = 1.8\text{ V to }5.5\text{ V}$	
OSC clock (ϕ_{OSC}) cycle time	t_{OSC}	OSC ₁ , OSC ₂	62.5	—	500 (1000)	ns	$V_{CC} = 4.5\text{ V to }5.5\text{ V}$	Figure 15.1 *2 *3
			100	—	500 (1000)		$V_{CC} = 2.7\text{ V to }5.5\text{ V}$	
			250	—	500 (1000)		$V_{CC} = 1.8\text{ V to }5.5\text{ V}$	
System clock (ϕ) cycle time	t_{cyc}		2	—	128	t_{OSC}		
			—	—	244.1			
Subclock oscillation frequency	f_W	X ₁ , X ₂	—	32.768 or 38.4	—	kHz		
Watch clock (ϕ_W) cycle time	t_W	X ₁ , X ₂	—	30.5 or 26.0	—	μs	Figure 15.1	
Subclock (ϕ_{SUB}) cycle time	t_{subcyc}		2	—	8	t_W		*1
Instruction cycle time			2	—	—	t_{cyc} t_{subcyc}		
Oscillation stabilization time	t_{rc}	OSC ₁ , OSC ₂	—	20	45	μs	Figure 15.10 $V_{CC} = 2.2\text{ V to }5.5\text{ V}$	Figure 15.10 *2
			—	0.1	8	ms	Figure 15.10 $V_{CC} = 2.2\text{ V to }5.5\text{ V}$	
			—	—	50	ms	Except the above	
		X ₁ , X ₂	—	—	2.0	s		

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Reference Figure
			Min	Typ	Max			
External clock high width	t_{CPH}	OSC ₁	25	—	—	ns	$V_{CC} = 4.5\text{ V to }5.5\text{ V}$	Figure 15.1 *2
			40	—	—		$V_{CC} = 2.7\text{ V to }5.5\text{ V}$	
			100	—	—		$V_{CC} = 1.8\text{ V to }5.5\text{ V}$	
		X ₁	—	15.26 or 13.02	—	μs		
External clock low width	t_{CPL}	OSC ₁	25	—	—	ns	$V_{CC} = 4.5\text{ V to }5.5\text{ V}$	Figure 15.1 *2
			40	—	—		$V_{CC} = 2.7\text{ V to }5.5\text{ V}$	
			100	—	—		$V_{CC} = 1.8\text{ V to }5.5\text{ V}$	
		X ₁	—	15.26 or 13.02	—	μs		
External clock rise time	t_{CPr}	OSC ₁	—	—	6	ns	$V_{CC} = 4.5\text{ V to }5.5\text{ V}$	Figure 15.1 *2
			—	—	10		$V_{CC} = 2.7\text{ V to }5.5\text{ V}$	
			—	—	25		$V_{CC} = 1.8\text{ V to }5.5\text{ V}$	
		X ₁	—	—	55.0	ns	Figure 15.1	
External clock fall time	t_{CPf}	OSC ₁	—	—	6	ns	$V_{CC} = 4.5\text{ V to }5.5\text{ V}$	Figure 15.1 *2
			—	—	10		$V_{CC} = 2.7\text{ V to }5.5\text{ V}$	
			—	—	25		$V_{CC} = 1.8\text{ V to }5.5\text{ V}$	
		X ₁	—	—	55.0	ns	Figure 15.1	
Pin $\overline{\text{RES}}$ low width	t_{REL}	$\overline{\text{RES}}$	10	—	—	t_{cyc}		Figure 15.2
Input pin high width	t_{IH}	$\overline{\text{IRQ}}_0$ to $\overline{\text{IRQ}}_4$, WKP ₀ to WKP ₇ , ADTRG, TMIC, TMIF, TMIG, AEVL, AEVH	2	—	—	t_{cyc} t_{subcyc}		Figure 15.3

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Reference Figure
			Min	Typ	Max			
Input pin low width	t_{IL}	\overline{IRQ}_0 to \overline{IRQ}_4 , 2 \overline{WKP}_0 to \overline{WKP}_7 , \overline{ADTRG} , TMIC, TMIF, TMIG, AEVL, AEVH	2	—	—	t_{cyc} t_{subcyc}		Figure 15.3
UD pin minimum modulation width	t_{UDH} t_{UDL}	UD	4	—	—	t_{cyc} t_{subcyc}		Figure 15.4

- Notes:
1. Selected with SA1 and SA0 of system clock control register 2 (SYSCR2).
 2. When internal power supply step-down circuit is not used.
 3. Figures in parentheses are the maximum t_{OSC} rate with external clock input.

Table 15.12 Serial Interface (SCI1) Timing

$V_{CC} = 1.8\text{ V to }5.5\text{ V}$, $AV_{CC} = 1.8\text{ V to }5.5\text{ V}$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_a = -40^\circ\text{C to }+85^\circ\text{C}$ unless otherwise indicated

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Reference Figure
			Min	Typ	Max			
Input clock cycle	$t_{S_{cyc}}$	SCK ₁	4	—	—	t_{cyc}		Figure 15.5
Input clock high width	$t_{S_{CKH}}$	SCK ₁	0.4	—	—	$t_{S_{cyc}}$		Figure 15.5
Input clock low width	$t_{S_{CKL}}$	SCK ₁	0.4	—	—	$t_{S_{cyc}}$		Figure 15.5
Input clock rise time	$t_{S_{CKr}}$	SCK ₁	—	—	60.0	ns	$V_{CC} = 4.0\text{ V to }5.5\text{ V}$	Figure 15.5*
			—	—	80.0	ns	Except the above	Figure 15.5
Input clock fall time	$t_{S_{CKf}}$	SCK ₁	—	—	60.0	ns	$V_{CC} = 4.0\text{ V to }5.5\text{ V}$	Figure 15.5*
			—	—	80.0	ns	Except the above	Figure 15.5
Serial output data delay time	$t_{S_{OD}}$	SO ₁	—	—	200.0	ns	$V_{CC} = 4.0\text{ V to }5.5\text{ V}$	Figure 15.5*
			—	—	350.0	ns	Except the above	Figure 15.5
Serial input data setup time	$t_{S_{IS}}$	SI ₁	200.0	—	—	ns	$V_{CC} = 4.0\text{ V to }5.5\text{ V}$	Figure 15.5*
			400.0	—	—	ns	Except the above	Figure 15.5
Serial input data hold time	$t_{S_{IH}}$	SI ₁	200.0	—	—	ns	$V_{CC} = 4.0\text{ V to }5.5\text{ V}$	Figure 15.5*
			400.0	—	—	ns	Except the above	Figure 15.5

Note: * When internal power supply step-down circuit is not used.

Table 15.13 Serial Interface (SCI3-1, SCI3-2) Timing

$V_{CC} = 1.8\text{ V to }5.5\text{ V}$, $AV_{CC} = 1.8\text{ V to }5.5\text{ V}$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_a = -40^{\circ}\text{C to }+85^{\circ}\text{C}$ unless otherwise indicated.

Item	Symbol	Values			Unit	Test Conditions	Reference Figure
		Min	Typ	Max			
Input clock cycle	Asynchronous	t_{Scyc}	4	—	—	t_{cyc} Or	Figure 15.6
	Synchronous		6	—	—	t_{subcyc}	
Input clock pulse width		t_{SCKW}	0.4	—	0.6	t_{Scyc}	Figure 15.6
Transmit data delay time (synchronous)		t_{TXD}	—	—	1	t_{cyc} Or	Figure 15.7
			—	—	1	t_{subcyc}	
Receive data setup time (synchronous)		t_{RXS}	200.0	—	—	ns	Figure 15.7*
			400.0	—	—		Figure 15.7
Receive data hold time (synchronous)		t_{RXH}	200.0	—	—	ns	Figure 15.7*
			400.0	—	—		Figure 15.7

Note: * When internal power supply step-down circuit is not used

15.4.4 A/D Converter Characteristics

Table 15.14 shows the A/D converter characteristics.

Table 15.14 A/D Converter Characteristics

$V_{CC} = 1.8\text{ V to }5.5\text{ V}$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_a = -40^\circ\text{C to }+85^\circ\text{C}$ unless otherwise indicated.

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Notes
			Min	Typ	Max			
Analog power supply voltage	AV_{CC}	AV_{CC}	1.8	—	5.5	V		*1
Analog input voltage	AV_{IN}	AN_0 to AN_{11}	-0.3	—	$AV_{CC} + 0.3\text{ V}$			
Analog power supply current	AI_{OPE}	AV_{CC}	—	—	1.5	mA	$AV_{CC} = 5.0\text{ V}$	
	AI_{STOP1}	AV_{CC}	—	600	—	μA		*2 Reference value
	AI_{STOP2}	AV_{CC}	—	—	5	μA		*3
Analog input capacitance	CA_{IN}	AN_0 to AN_{11}	—	—	15.0	pF		
Allowable signal source impedance	RA_{IN}		—	—	10.0	k Ω		
Resolution (data length)			—	—	10	bit		
Nonlinearity error			—	—	± 2.5	LSB	$AV_{CC} = 2.7\text{ V to }5.5\text{ V}$ $V_{CC} = 2.7\text{ V to }5.5\text{ V}$	*4
			—	—	± 5.5		$AV_{CC} = 2.0\text{ V to }5.5\text{ V}$ $V_{CC} = 2.0\text{ V to }5.5\text{ V}$	
			—	—	± 7.5		Except the above	*5
			—	—	± 0.5	LSB		
Absolute accuracy			—	—	± 3.0	LSB	$AV_{CC} = 2.7\text{ V to }5.5\text{ V}$ $V_{CC} = 2.7\text{ V to }5.5\text{ V}$	*4
			—	—	± 6.0		$AV_{CC} = 2.0\text{ V to }5.5\text{ V}$ $V_{CC} = 2.0\text{ V to }5.5\text{ V}$	
			—	—	± 8.0		Except the above	*5
			—	—	± 0.5	LSB		
Conversion time			12.4	—	124	μs	$AV_{CC} = 2.7\text{ V to }5.5\text{ V}$ $V_{CC} = 2.7\text{ V to }5.5\text{ V}$	*4
			62	—	124		Except the above	

- Notes: 1. Set $AV_{CC} = V_{CC}$ when the A/D converter is not used.
 2. AI_{STOP1} is the current in active and sleep modes while the A/D converter is idle.
 3. AI_{STOP2} is the current at reset and in standby, watch, subactive, and subsleep modes while the A/D converter is idle.
 4. When internal power supply step-down circuit is not used.
 5. Conversion time: 62 μs

15.4.5 LCD Characteristics

Table 15.15 shows the LCD characteristics.

Table 15.15 LCD Characteristics

$V_{CC} = 1.8\text{ V to }5.5\text{ V}$, $AV_{CC} = 1.8\text{ V to }5.5\text{ V}$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_a = -40^\circ\text{C to }+85^\circ\text{C}$
(including subactive mode) unless otherwise indicated.

Item	Symbol	Applicable Pins	Values			Unit	Test Conditions	Notes
			Min	Typ	Max			
Segment driver drop voltage	V_{DS}	SEG ₁ to SEG ₄₀	—	—	0.6	V	$I_D = 2\ \mu\text{A}$ $V_1 = 2.7\text{ V to }5.5\text{ V}$	*1
Common driver drop voltage	V_{DC}	COM ₁ to COM ₄	—	—	0.3	V	$I_D = 2\ \mu\text{A}$ $V_1 = 2.7\text{ V to }5.5\text{ V}$	*1
LCD power supply split-resistance	R_{LCD}		0.5	3.0	9.0	M Ω	Between V_1 and V_{SS}	
Liquid crystal display voltage	V_{LCD}	V_1	2.2	—	5.5	V		*2

- Notes: 1. The voltage drop from power supply pins V_1 , V_2 , V_3 , and V_{SS} to each segment pin or common pin.
2. When the liquid crystal display voltage is supplied from an external power source, ensure that the following relationship is maintained: $V_1 \geq V_2 \geq V_3 \geq V_{SS}$.

Table 15.16 Segment External Expansion AC Characteristics

$V_{CC} = 1.8\text{ V to }5.5\text{ V}$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $T_a = -40^{\circ}\text{C to }+85^{\circ}\text{C}$ (including subactive mode) unless otherwise indicated.

Item	Symbol	Applicable Pins	Values			Unit	Test Conditions	Reference Figure
			Min	Typ	Max			
Clock high width	t_{CWH}	CL ₁ , CL ₂	800.0	—	—	ns	*	Figure 15.8
Clock low width	t_{CWL}	CL ₂	800.0	—	—	ns	*	Figure 15.8
Clock setup time	t_{CSU}	CL ₁ , CL ₂	500.0	—	—	ns	*	Figure 15.8
Data setup time	t_{SU}	DO	300.0	—	—	ns	*	Figure 15.8
Data retaining time	t_{DH}	DO	300.0	—	—	ns	*	Figure 15.8
M delay time	t_{DM}	M	-1000.0	—	1000.0	ns	*	Figure 15.8
Clock rise/fall time	t_{CT}	CL ₁ , CL ₂	—	—	170.0	ns		Figure 15.8

Note: * When the frame frequency is set at 488 Hz to 30.5 Hz.

15.5 H8/3847S Group Absolute Maximum Ratings

Table 15.17 lists the absolute maximum ratings.

Table 15.17 Absolute Maximum Ratings

Item	Symbol	Value	Unit	Notes
Power supply voltage	V_{CC}	-0.3 to +4.3	V	*1
Analog power supply voltage	AV_{CC}	-0.3 to +4.3	V	
Input voltage	Ports other than Port B, C	V_{in}	-0.3 to $V_{CC} + 0.3$	V
	Port B, C	AV_{in}	-0.3 to $AV_{CC} + 0.3$	V
Operating temperature	T_{opr}	-20 to +75 (Regular specifications)	°C	
		-40 to +85 (wide-range specifications)		
		+75 (products shipped as chips)*2		
Storage temperature	T_{stg}	-55 to +125	°C	

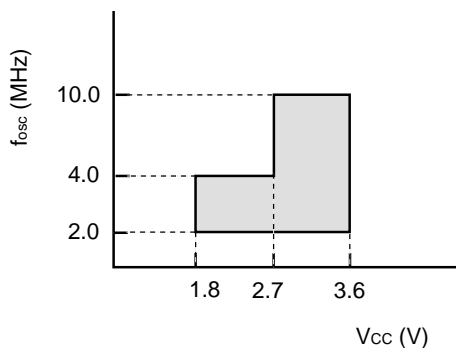
- Note:
1. Permanent damage may occur to the chip if maximum ratings are exceeded. Normal operation should be under the conditions specified in Electrical Characteristics. Exceeding these values can result in incorrect operation and reduced reliability.
 2. Power may be applied when the temperature is between -20 and +75°C.

15.6 H8/3847S Group Electrical Characteristics

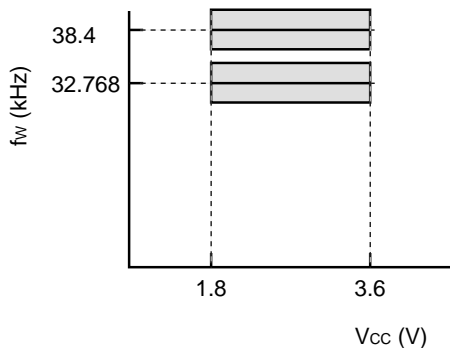
15.6.1 Power Supply Voltage and Operating Range

The power supply voltage and operating range are indicated by the shaded region in the figures.

1. Power supply voltage and oscillator frequency range



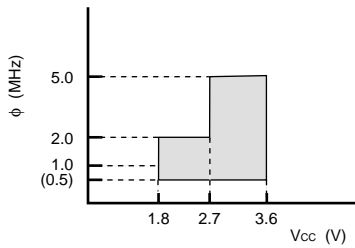
- Active (high-speed) mode
- Sleep (high-speed) mode



- All operating modes

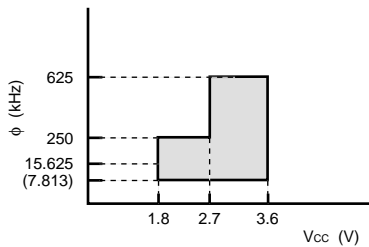
Note: fosc is the oscillator frequency. When external clocks are used, fosc=1MHz is the minimum.

2. Power supply voltage and operating frequency range



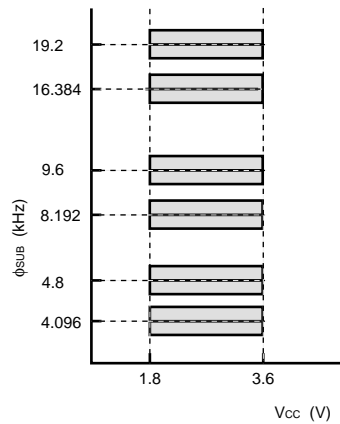
- Active (high-speed) mode
- Sleep (high-speed) mode (except CPU)

Note: Figures in parentheses are the minimum operating frequency of a case external clocks are used. When using an oscillator, the minimum operating frequency is $\phi=1\text{MHz}$.



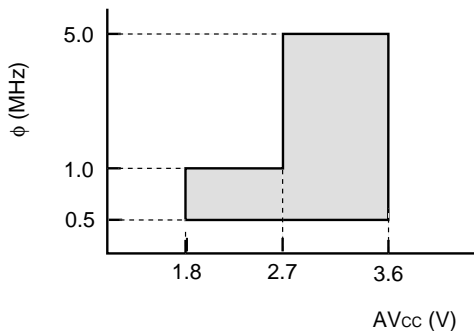
- Active (medium-speed) mode (except A/D converter)
- Sleep (medium-speed) mode (except A/D converter)

Note: Figures in parentheses are the minimum operating frequency of a case external clocks are used. When using an oscillator, the minimum operating frequency is $\phi=15.625\text{kHz}$.

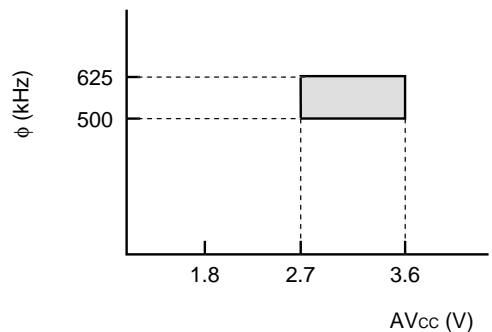


- Subactive mode
- Subsleep mode (except CPU)
- Watch mode (except CPU)

3. Analog power supply voltage and A/D converter operating range



- Active (high-speed) mode
- Sleep (high-speed) mode



- Active (medium-speed) mode
- Sleep (medium-speed) mode

15.6.2 DC Characteristics

Table 15.18 lists the DC characteristics.

Table 15.18 DC Characteristics

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Notes
			Min	Typ	Max			
Input high voltage	V_{IH}	\overline{RES} , \overline{WKP}_0 to \overline{WKP}_7 , \overline{IRQ}_0 to \overline{IRQ}_4 , \overline{AEVL} , \overline{AEVH} , \overline{TMIC} , \overline{TMIF} , \overline{TMIG} , \overline{SCK}_1 , \overline{SCK}_{31} , \overline{SCK}_{32} , \overline{ADTRG}	$0.9 V_{CC}$	—	$V_{CC} + 0.3$	V		
		SI_1 , RXD_{31} , RXD_{32} , UD	$0.8 V_{CC}$	—	$V_{CC} + 0.3$	V		
		OSC_1	$0.9 V_{CC}$	—	$V_{CC} + 0.3$	V		
		X_1	$0.9 V_{CC}$	—	$V_{CC} + 0.3$	V		
		$P1_0$ to $P1_7$, $P2_0$ to $P2_7$, $P3_0$ to $P3_7$, $P4_0$ to $P4_3$, $P5_0$ to $P5_7$, $P6_0$ to $P6_7$, $P7_0$ to $P7_7$, $P8_0$ to $P8_7$, $P9_0$ to $P9_7$, PA_0 to PA_3	$0.8 V_{CC}$	—	$V_{CC} + 0.3$	V		
Input low voltage	V_{IL}	\overline{RES} , \overline{WKP}_0 to \overline{WKP}_7 , \overline{IRQ}_0 to \overline{IRQ}_4 , \overline{AEVL} , \overline{AEVH} , \overline{TMIC} , \overline{TMIF} , \overline{TMIG} , \overline{SCK}_1 , \overline{SCK}_{31} , \overline{SCK}_{32} , \overline{ADTRG}	-0.3	—	$0.1 V_{CC}$	V		
		SI_1 , RXD_{31} , RXD_{32} , UD	-0.3	—	$0.2 V_{CC}$	V		
		OSC_1	-0.3	—	$0.1 V_{CC}$	V		
		$X1$	-0.3	—	$0.1 V_{CC}$	V		
		$P1_0$ to $P1_7$, $P2_0$ to $P2_7$, $P3_0$ to $P3_7$, $P4_0$ to $P4_3$, $P5_0$ to $P5_7$, $P6_0$ to $P6_7$, $P7_0$ to $P7_7$, $P8_0$ to $P8_7$, $P9_0$ to $P9_7$, PA_0 to PA_3 , PB_0 to PB_7 , PC_0 to PC_3	-0.3	—	$0.2 V_{CC}$	V		
Output high voltage	V_{OH}	$P1_0$ to $P1_7$, $P2_0$ to $P2_7$, $P3_0$ to $P3_7$, $P4_0$ to $P4_2$, $P5_0$ to $P5_7$, $P6_0$ to $P6_7$, $P7_0$ to $P7_7$, $P8_0$ to $P8_7$, $P9_0$ to $P9_7$, PA_0 to PA_3	$V_{CC} - 0.3$	—	—	V	$-I_{OH} = 0.1 \text{ mA}$	

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Notes
			Min	Typ	Max			
Output low voltage	V_{OL}	P1 ₀ to P1 ₇ , P4 ₀ to P4 ₂	—	—	0.5	V	$I_{OL} = 0.4 \text{ mA}$	
		P5 ₀ to P5 ₇ , P6 ₀ to P6 ₇ , P7 ₀ to P7 ₇ , P8 ₀ to P8 ₇ , P9 ₀ to P9 ₇ , PA ₀ to PA ₃	—	—	0.5		$I_{OL} = 0.4 \text{ mA}$	
		P2 ₀ to P2 ₇ , P3 ₀ to P3 ₇	—	—	0.5		$I_{OL} = 0.4 \text{ mA}$	
output leakage current	$ I_{IL} $	RES, OSC ₁ , X ₁ , P1 ₀ to P1 ₇ , P2 ₀ to P2 ₇ , P3 ₀ to P3 ₇ , P4 ₀ to P4 ₃ , P5 ₀ to P5 ₇ , P6 ₀ to P6 ₇ , P7 ₀ to P7 ₇ , P8 ₀ to P8 ₇ , P9 ₀ to P9 ₇ , PA ₀ to PA ₃	—	—	1.0	μA	$V_{IN} = 0.5 \text{ V}$ to $V_{CC} - 0.5 \text{ V}$	
		PB ₀ to PB ₇ , PC ₀ to PC ₃	—	—	1.0		$V_{IN} = 0.5 \text{ V}$ to $AV_{CC} - 0.5 \text{ V}$	
Pull-up MOS current	-I _p	P1 ₀ to P1 ₇ , P3 ₀ to P3 ₇ , P5 ₀ to P5 ₇ , P6 ₀ to P6 ₇	10.0	—	300.0	μA	$V_{CC} = 3 \text{ V}$, $V_{IN} = 0 \text{ V}$	
Input capacitance	C _{IN}	All input pins except power supply	—	—	15.0	pF	f = 1 MHz, $V_{IN} = 0 \text{ V}$, Ta = 25°C	
Active mode current dissipation	I _{OPe1}	V _{CC}	—	0.4	*3	mA	Active (high-speed) mode $V_{CC} = 1.8 \text{ V}$, $f_{OSC} = 2 \text{ MHz}$	*1 *2
			—	1.4	*3		Active (high-speed) mode $V_{CC} = 3 \text{ V}$, $f_{OSC} = 4 \text{ MHz}$	
			—	3.5	5.5		Active (high-speed) mode $V_{CC} = 3 \text{ V}$, $f_{OSC} = 10 \text{ MHz}$	

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Notes
			Min	Typ	Max			
Active mode current dissipation	I _{OPE2}	V _{CC}	—	0.1	*3		Active (medium-speed) mode V _{CC} = 1.8 V, f _{OSC} = 2 MHz φ _{OSC} /128	*1 *2
			—	0.3	*3			
			—	0.7	1.6			
Sleep mode current dissipation	I _{SLEEP}	V _{CC}	—	0.2	*3	mA	V _{CC} = 1.8 V, f _{OSC} = 2 MHz	*1 *2
			—	0.6	*3			
			—	1.4	2.9			
Sub-active mode current dissipation	I _{SUB}	V _{CC}	—	8	*3	μA	V _{CC} = 1.8 V, LCD on 32 kHz crystal oscillator (φ _{SUB} = φ _W /2)	*1 *2
			—	4	*3			
			—	14	*3			
Sub-sleep mode current dissipation	I _{SUBSP}	V _{CC}	—	5.0	12	μA	V _{CC} = 2.7 V, LCD on 32 kHz crystal oscillator (φ _{SUB} = φ _W /2)	*1 *2

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Notes	
			Min	Typ	Max				
Watch mode current dissipation	I_{WATCH}	V_{CC}	—	1.4	*3	μA	$V_{CC} = 1.8 V$, $T_a = 25^\circ C$ 32 kHz crystal oscillator LCD not used	*1 *2	
			—	2.2	*3				$V_{CC} = 2.7 V$, $T_a = 25^\circ C$ 32 kHz crystal oscillator LCD not used
			—	2.8	6				
Stand-by mode current dissipation	I_{STBY}	V_{CC}	—	0.3	*3	μA	32 kHz crystal oscillator not used $V_{CC} = 1.8 V$, $T_a = 25^\circ C$	*1 *2	
			—	0.5	*3				32 kHz crystal oscillator not used $V_{CC} = 2.7 V$, $T_a = 25^\circ C$
			—	1	5				
RAM data retaining voltage	V_{RAM}	V_{CC}	1.5	—	—	V			
Allowable output low current (per pin)	I_{OL}	All output pins	—	—	0.5	mA			
Allowable output low current (total)	$\sum I_{OL}$	All output pins	—	—	20.0	mA			
Allowable output high current (per pin)	$-I_{OH}$	All output pins	—	—	0.2	mA			

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Notes
			Min	Typ	Max			
Allowable output high current (total)	$\sum - I_{OH}$	All output pins	—	—	10.0	mA		

Notes: Connect the TEST pin to V_{SS} .

1. Pin States during Current Dissipation Measurement.

Mode	\overline{RES} Pin	Internal State	Other Pins	Constant-Voltage	Oscillator Pins
Active (high-speed) mode	V_{CC}	Only CPU Operates	V_{CC}	Halted	System clock oscillator: Crystal
Active (medium-speed) mode					Subclock oscillator: Pin $X_1 = GND$
Sleep mode	V_{CC}	Only timers operate	V_{CC}		
Subactive mode	V_{CC}	Only CPU Operates	V_{CC}	Halted	System clock oscillator: crystal
Subsleep mode	V_{CC}	Only timers operate, CPU stops	V_{CC}	Halted	Subclock oscillator: crystal
Watch mode	V_{CC}	Only time base operates, CPU stops	V_{CC}	Halted	
Standby mode	V_{CC}	CPU and timers both stop	V_{CC}	Halted	System clock oscillator: crystal Subclock oscillator: Pin $X_1 = GND$

2. Excludes current in pull-up MOS transistors and output buffers.

3. The maximum current consumption value (standard) is $1.1 \times \text{typ}$.

15.6.3 AC Characteristics

Table 15.19 lists the control signal timing, and tables 15.20 and 15.21 list the serial interface timing.

Table 15.19 Control Signal Timing

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Reference Figure
			Min	Typ	Max			
System clock oscillation frequency	f_{OSC}	OSC ₁ , OSC ₂	2	—	10	MHz	$V_{CC} = 2.7\text{ V to }3.6\text{ V}$	
			2	—	4		$V_{CC} = 1.8\text{ V to }3.6\text{ V}$	
OSC clock (ϕ_{OSC}) cycle time	t_{OSC}	OSC ₁ , OSC ₂	100	—	500 (1000)	ns	$V_{CC} = 2.7\text{ V to }3.6\text{ V}$	Figure 15.1 *2
			250	—	500 (1000)		$V_{CC} = 1.8\text{ V to }3.6\text{ V}$	
System clock (ϕ) cycle time	t_{cyc}		2	—	128	t_{OSC}		
			—	—	128	μs		
Subclock oscillation frequency	f_W	X ₁ , X ₂	—	32.768 or 38.4	—	kHz		
Watch clock (ϕ_W) cycle time	t_W	X ₁ , X ₂	—	30.5 or 26.0	—	μs		Figure 15.1
Subclock (ϕ_{SUB}) cycle time	t_{subcyc}		2	—	8	t_W		*1
Instruction cycle time			2	—	—	t_{cyc} t_{subcyc}		
Oscillation stabilization time	t_{rc}	OSC ₁ , OSC ₂	—	20	45	μs	Ceramic Oscillator Parameters $V_{CC} = 2.2\text{ V to }3.6\text{ V}$	Figure 15.10
			—	80	—		Ceramic Oscillator Parameters Except the above	
			—	0.8	2	ms	Crystal Oscillator Parameters $V_{CC} = 2.7\text{ V to }3.6\text{ V}$	
			—	1.2	3		Crystal Oscillator Parameters $V_{CC} = 2.2\text{ V to }3.6\text{ V}$	

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Reference Figure
			Min	Typ	Max			
Oscillation stabilization time	t_{rc}	OSC ₁ , OSC ₂	—	4.0	—		Crystal Oscillator Parameters Except the above	Figure 15.10
			—	—	50		Except the above	
		X1, X2	—	—	2	s	V _{CC} = 2.2 V to 3.6 V	
			—	4	—		Except the above	
External clock high width	t_{CPH}	OSC ₁	40	—	—	ns	V _{CC} = 2.7 V to 3.6 V	Figure 15.1
			100	—	—		V _{CC} = 1.8 V to 3.6 V	
		X ₁	—	15.26 or 13.02	—	μs		
External clock low width	t_{CPL}	OSC ₁	40	—	—	ns	V _{CC} = 2.7 V to 3.6 V	Figure 15.1
			100	—	—		V _{CC} = 1.8 V to 3.6 V	
		X ₁	—	15.26 or 13.02	—	μs		
External clock rise time	t_{CPr}	OSC ₁	—	—	10	ns	V _{CC} = 2.7 V to 3.6 V	Figure 15.1
			—	—	25		V _{CC} = 1.8 V to 3.6 V	
		X ₁	—	—	55.0	ns	Figure 15.1	
External clock fall time	t_{CPf}	OSC ₁	—	—	10	ns	V _{CC} = 2.7 V to 3.6 V	Figure 15.1
			—	—	25		V _{CC} = 1.8 V to 3.6 V	
		X ₁	—	—	55.0	ns	Figure 15.1	
Pin \overline{RES} low width	t_{REL}	\overline{RES}	10	—	—	t_{cyc}		Figure 15.2
Input pin high width	t_{IH}	$\overline{IRQ_0}$ to $\overline{IRQ_4}$, 2 $\overline{WKP_0}$ to $\overline{WKP_7}$, \overline{ADTRG} , TMIC TMIF, TMIG, AEVL, AEVH	—	—	—	t_{cyc} t_{subcyc}		Figure 15.3
Input pin low width	t_{IL}	$\overline{IRQ_0}$ to $\overline{IRQ_4}$, 2 $\overline{WKP_0}$ to $\overline{WKP_7}$, \overline{ADTRG} , TMIC, TMIF, TMIG, AEVL, AEVH	—	—	—	t_{cyc} t_{subcyc}		Figure 15.3

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Reference Figure
			Min	Typ	Max			
UD pin minimum modulation width	t_{UDH} t_{UDL}	UD	4	—	—	t_{cyc} t_{subcyc}		Figure 15.4

- Notes: 1. Selected with SA1 and SA0 of system clock control register 2 (SYSCR2).
 2. Figures in parentheses are the maximum t_{OSC} rate with external clock input.

Table 15.20 Serial Interface (SCI1) Timing

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Reference Figure
			Min	Typ	Max			
Input clock cycle	$t_{S_{cyc}}$	SCK ₁	4	—	—	t_{cyc}		Figure 15.5
Input clock high width	$t_{S_{CKH}}$	SCK ₁	0.4	—	—	$t_{S_{cyc}}$		Figure 15.5
Input clock low width	$t_{S_{CKL}}$	SCK ₁	0.4	—	—	$t_{S_{cyc}}$		Figure 15.5
Input clock rise time	$t_{S_{CKr}}$	SCK ₁	—	—	80.0	ns		Figure 15.5
Input clock fall time	$t_{S_{CKf}}$	SCK ₁	—	—	80.0	ns		Figure 15.5
Serial output data delay time	$t_{S_{OD}}$	SO ₁	—	—	350.0	ns		Figure 15.5
Serial input data setup time	$t_{S_{IS}}$	SI ₁	400.0	—	—	ns		Figure 15.5
Serial input data hold time	$t_{S_{IH}}$	SI ₁	400.0	—	—	ns		Figure 15.5

Table 15.21 Serial Interface (SCI3-1, SCI3-2) Timing

Item	Symbol	Values			Unit	Test Conditions	Reference Figure
		Min	Typ	Max			
Input clock cycle	Asynchronous	t_{Scyc}	4	—	—	t_{cyc} Or	Figure 15.6
	Synchronous		6	—	—	t_{subcyc}	
Input clock pulse width		t_{SCKW}	0.4	—	0.6	t_{Scyc}	Figure 15.6
Transmit data delay time (synchronous)		t_{TXD}	—	—	1	t_{cyc} Or t_{subcyc}	Figure 15.7
Receive data setup time (synchronous)		t_{RXS}	400.0	—	—	ns	Figure 15.7
Receive data hold time (synchronous)		t_{RXH}	400.0	—	—	ns	Figure 15.7

15.6.4 A/D Converter Characteristics

Table 15.22 shows the A/D converter characteristics.

Table 15.22 A/D Converter Characteristics

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Notes
			Min	Typ	Max			
Analog power supply voltage	AV _{CC}	AV _{CC}	1.8	—	3.6	V		*1
Analog input voltage	AV _{IN}	AN ₀ to AN ₁₁	-0.3	—	AV _{CC} + 0.3	V		
Analog power supply current	AI _{OPE}	AV _{CC}	—	—	1.2	mA	AV _{CC} = 3.0 V	
	AI _{STOP1}	AV _{CC}	—	600	—	μA		*2 Reference value
	AI _{STOP2}	AV _{CC}	—	—	5	μA		*3
Analog input capacitance	C _{AIN}	AN ₀ to AN ₁₁	—	—	15.0	pF		
Allowable signal source impedance	R _{AIN}		—	—	10.0	kΩ		
Resolution (data length)			—	—	10	bit		
Nonlinearity error			—	—	±3.5	LSB	AV _{CC} = 2.7 V to 3.6 V V _{CC} = 2.7 V to 3.6 V	
			—	—	±5.5		AV _{CC} = 2.0 V to 3.6 V V _{CC} = 2.0 V to 3.6 V	
			—	—	±7.5		Except the above	*4
			—	—	±0.5	LSB		
Absolute accuracy			—	±2	±4	LSB	AV _{CC} = 2.7 V to 3.6 V V _{CC} = 2.7 V to 3.6 V	
			—	±2.5	±6		AV _{CC} = 2.0 V to 3.6 V V _{CC} = 2.0 V to 3.6 V	
			—	±3	±8		Except the above	*4
			12.4	—	124	μs	AV _{CC} = 2.7 V to 3.6 V V _{CC} = 2.7 V to 3.6 V	
Conversion time			62	—	124		Except the above	

Notes: 1. Set AV_{CC} = V_{CC} when the A/D converter is not used.

2. AI_{STOP1} is the current in active and sleep modes while the A/D converter is idle.

3. AI_{STOP2} is the current at reset and in standby, watch, subactive, and subsleep modes while the A/D converter is idle.

4. Conversion time: 62 μs

15.6.5 LCD Characteristics

Table 15.23 shows the LCD characteristics.

Table 15.23 LCD Characteristics

Item	Symbol	Applicable Pins	Values			Unit	Test Conditions	Notes
			Min	Typ	Max			
Segment driver drop voltage	V_{DS}	SEG ₁ to SEG ₄₀	—	—	0.6	V	$I_D = 2 \mu A$ $V_1 = 2.7 V$ to $3.6 V$	*1
Common driver drop voltage	V_{DC}	COM ₁ to COM ₄	—	—	0.3	V	$I_D = 2 \mu A$ $V_1 = 2.7 V$ to $3.6 V$	*1
LCD power supply split-resistance	R_{LCD}		1.5	3.5	7	M Ω	Between V_1 and V_{SS}	
Liquid crystal display voltage	V_{LCD}	V_1	2.2	—	3.6	V		*2

- Notes: 1. The voltage drop from power supply pins V_1 , V_2 , V_3 , and V_{SS} to each segment pin or common pin.
2. When the liquid crystal display voltage is supplied from an external power source, ensure that the following relationship is maintained: $V_1 \geq V_2 \geq V_3 \geq V_{SS}$.

Table 15.24 Segment External Expansion AC Characteristics

Item	Symbol	Applicable Pins	Values			Test Unit	Test Conditions	Reference Figure
			Min	Typ	Max			
Clock high width	t_{CWH}	CL ₁ , CL ₂	800.0	—	—	ns	*	Figure 15.8
Clock low width	t_{CWL}	CL ₂	800.0	—	—	ns	*	Figure 15.8
Clock setup time	t_{CSU}	CL ₁ , CL ₂	500.0	—	—	ns	*	Figure 15.8
Data setup time	t_{SU}	DO	300.0	—	—	ns	*	Figure 15.8
Data retaining time	t_{DH}	DO	300.0	—	—	ns	*	Figure 15.8
M delay time	t_{DM}	M	-1000.0	—	1000.0	ns	*	Figure 15.8
Clock rise/fall time	t_{CT}	CL ₁ , CL ₂	—	—	170.0	ns		Figure 15.8

Note: * When the frame frequency is set at 488 Hz to 30.5 Hz.

15.7 Absolute Maximum Ratings of H8/38347 Group and H8/38447 Group

Table 15.25 lists the absolute maximum ratings.

Table 15.25 Absolute Maximum Ratings

Item	Symbol	Value	Unit	Note
Power supply voltage	V_{CC}	-0.3 to +7.0	V	*1
	CV_{CC}	-0.3 to +4.3	V	
Analog power supply voltage	AV_{CC}	-0.3 to +7.0	V	
Input voltage	Other than ports B, C V_{in}	-0.3 to $V_{CC} + 0.3$	V	
	Ports B, C AV_{in}	-0.3 to $AV_{CC} + 0.3$	V	
Operating temperature	T_{opr}	-20 to +75* ² (regular specifications)	°C	
		-40 to +85* ² (wide-range temperature specifications)		
		+75* ³ (chip shipment specifications)		
Storage temperature	T_{stg}	-55 to +125	°C	

- Notes:
1. Permanent damage may result if maximum ratings are exceeded. Normal operation should be under the conditions specified in Electrical Characteristics. Exceeding these values can result in incorrect operation and reduced reliability.
 2. The operating temperature ranges from -20°C to +75°C when programming or erasing the flash memory.
 3. The temperature range in which power may be applied to the device is -20 to +75°C.

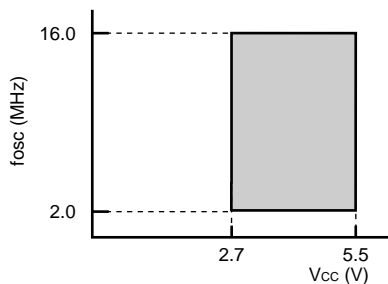
15.8 Electrical Characteristics of H8/38347 Group and H8/38447 Group

15.8.1 Power Supply Voltage and Operating Ranges

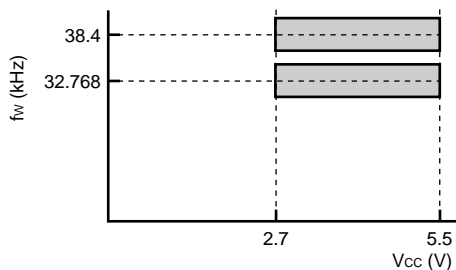
The power supply voltage and operating ranges (shaded portions) are shown below.

1. Power Supply Voltage and Oscillation Frequency Range

- H8/38347 Group

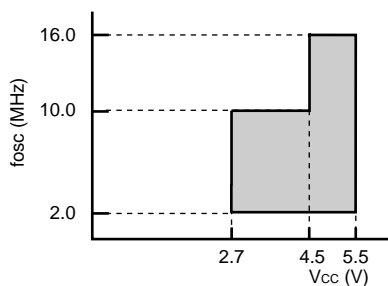


- Active (high-speed) mode
- Sleep (high-speed) mode

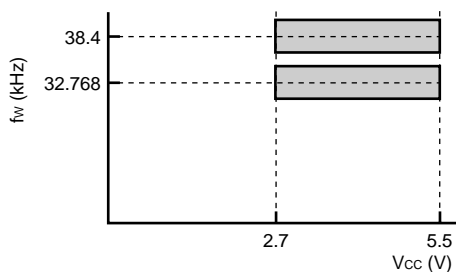


- All operating modes

- H8/38447 Group



- Active (high-speed) mode
- Sleep (high-speed) mode

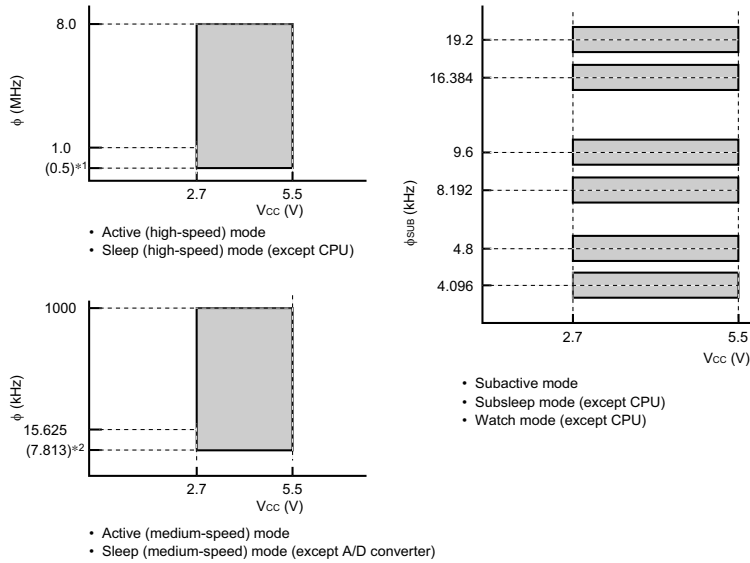


- All operating modes

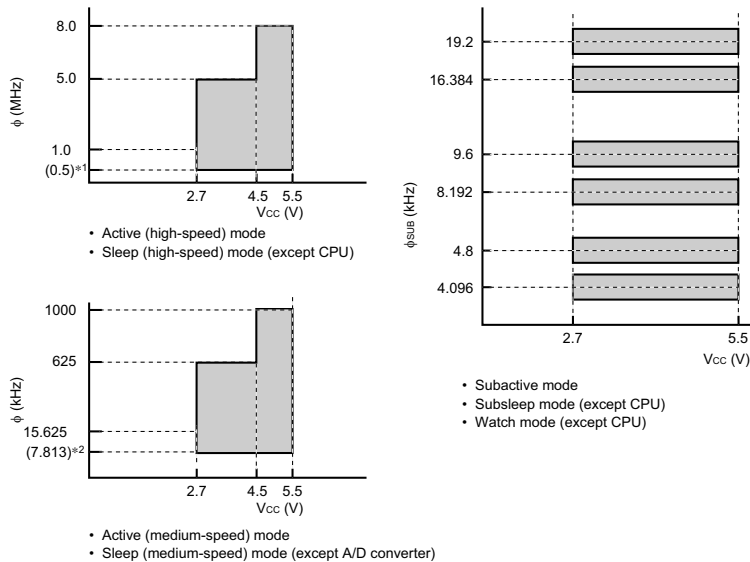
Note: f_{osc} is the oscillator frequency. When an external clock is used 1 MHz is the minimum f_{osc} value.

2. Power Supply Voltage and Operating Frequency Range

• H8/38347 Group



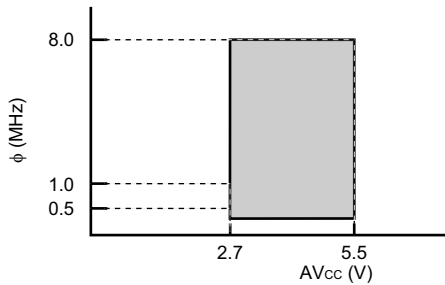
• H8/38447 Group



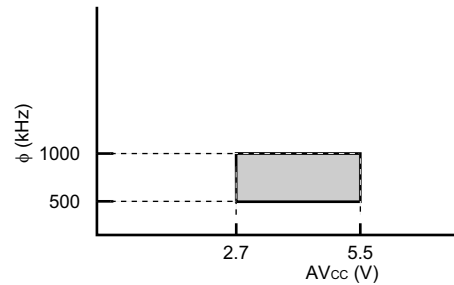
- Notes
1. The figure in parentheses () indicates the minimum operating frequency when an external clock is used. When the resonator is used the minimum operating frequency (ϕ) is 1 MHz.
 2. The figure in parentheses () indicates the minimum operating frequency when an external clock is used. When the resonator is used the minimum operating frequency (ϕ) is 15.625 kHz.

3. Analog Power Supply Voltage and A/D Converter Operating Range

- H8/38347 Group

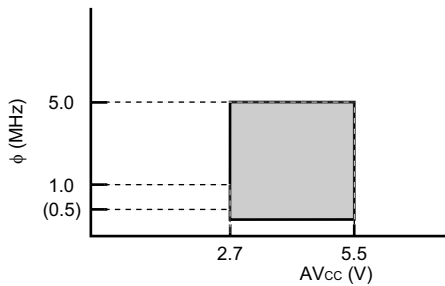


- Active (high-speed) mode
- Sleep (high-speed) mode

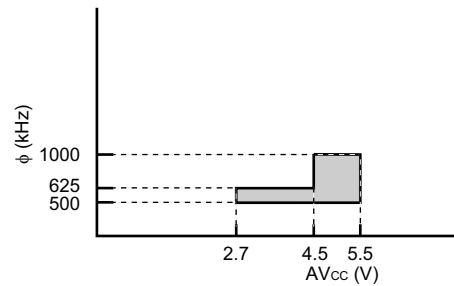


- Active (medium-speed) mode
- Sleep (medium-speed) mode

- H8/38447 Group



- Active (high-speed) mode
- Sleep (high-speed) mode



- Active (medium-speed) mode
- Sleep (medium-speed) mode

15.8.2 DC Characteristics

Table 15.26 lists the DC characteristics.

Table 15.26 DC Characteristics

$V_{CC} = 2.7\text{ V to }5.5\text{ V}$, $AV_{CC} = 2.7\text{ V to }5.5\text{ V}$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, unless otherwise specified

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Notes
			Min	Typ	Max			
Input high voltage	V_{IH}	RES, WKP ₀ to WKP ₇ , IRQ ₀ , to IRQ ₄ , AEVL, AEVH, TMIC, TMIF, TMIG, ADTRG, SCK ₁ , SCK ₃₂ , SCK ₃₁	$V_{CC} \times 0.8$	—	$V_{CC} + 0.3$	V	$V_{CC} = 4.0\text{ V to }5.5\text{ V}$	
			$V_{CC} \times 0.9$	—	$V_{CC} + 0.3$		Other than above	
		RXD ₃₂ , UD, RXD ₃₁ , SI ₁	$V_{CC} \times 0.7$	—	$V_{CC} + 0.3$	V	$V_{CC} = 4.0\text{ V to }5.5\text{ V}$	
			$V_{CC} \times 0.8$	—	$V_{CC} + 0.3$		Other than above	
		OSC ₁	$V_{CC} \times 0.8$	—	$V_{CC} + 0.3$	V	$V_{CC} = 4.0\text{ V to }5.5\text{ V}$	
			$V_{CC} \times 0.9$	—	$V_{CC} + 0.3$		Other than above	
		P1 ₀ to P1 ₇ , P2 ₀ to P2 ₇ , P3 ₀ to P3 ₇ , P4 ₀ to P4 ₃ , P5 ₀ to P5 ₇ , P6 ₀ to P6 ₇ , P7 ₀ to P7 ₇ , P8 ₀ to P8 ₇ , P9 ₀ to P9 ₇ , PA ₀ to PA ₃	$V_{CC} \times 0.7$	—	$V_{CC} + 0.3$	V	$V_{CC} = 4.0\text{ V to }5.5\text{ V}$	
			$V_{CC} \times 0.8$	—	$V_{CC} + 0.3$		Other than above	
	PB ₀ to PB ₇ , PC ₀ to PC ₃	$V_{CC} \times 0.7$	—	$AV_{CC} + 0.3$	V	$V_{CC} = 4.0\text{ V to }5.5\text{ V}$		
		$V_{CC} \times 0.8$	—	$AV_{CC} + 0.3$		Other than above		
	EXCL	$V_{CC} \times 0.9$	—	$V_{CC} + 0.3$	V			

Note: Connect the TEST pin to V_{SS} .

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Notes
			Min	Typ	Max			
Input low voltage	V _{IL}	RES, WKP ₀ to WKP ₇ , IRQ ₀ , to IRQ ₄ , AEVL, AEVH, TMIC, TMIF, TMIG, ADTRG, SCK ₁ , SCK ₃₂ , SCK ₃₁	-0.3	—	V _{CC} × 0.2	V	V _{CC} = 4.0 V to 5.5 V	
			-0.3	—	V _{CC} × 0.1		Other than above	
		RXD ₃₂ , UD, RXD ₃₁ , SI ₁	-0.3	—	V _{CC} × 0.3	V	V _{CC} = 4.0 V to 5.5 V	
			-0.3	—	V _{CC} × 0.2		Other than above	
		OSC ₁	-0.3	—	V _{CC} × 0.2	V	V _{CC} = 4.0 V to 5.5 V	
			-0.3	—	V _{CC} × 0.1		Other than above	
		EXCL	-0.3	—	V _{CC} × 0.1	V		
		P1 ₀ to P1 ₇ , P2 ₀ to P2 ₇ , P3 ₀ to P3 ₇ , P4 ₀ to P4 ₃ , P5 ₀ to P5 ₇ , P6 ₀ to P6 ₇ , P7 ₀ to P7 ₇ , P8 ₀ to P8 ₇ , P9 ₀ to P9 ₇ , PA ₀ to PA ₃ , PB ₀ to PB ₇ , PC ₀ to PC ₃	-0.3	—	V _{CC} × 0.3	V	V _{CC} = 4.0 V to 5.5 V	
			-0.3	—	V _{CC} × 0.2		Other than above	
Output high voltage	V _{OH}	P1 ₀ , to P1 ₇ , P2 ₀ to P2 ₇ , P3 ₀ to P3 ₇ ,	V _{CC} - 1.0	—	—	V	V _{CC} = 4.0 V to 5.5 V	
		P4 ₀ to P4 ₂ , P5 ₀ to P5 ₇ , P6 ₀ to P6 ₇ ,	V _{CC} - 0.5	—	—		-I _{OH} = 1.0 mA	
		P7 ₀ to P7 ₇ , P8 ₀ to P8 ₇ , P9 ₀ to P9 ₇ , PA ₀ to PA ₃	V _{CC} - 0.3	—	—		-I _{OH} = 0.5 mA	
							-I _{OH} = 0.1 mA	

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Notes
			Min	Typ	Max			
Output low voltage	V_{OL}	P1 ₀ to P1 ₇ , P4 ₀ to P4 ₂ , P5 ₀ to P5 ₇ , P6 ₀ to P6 ₇ , P7 ₀ to P7 ₇ , P8 ₀ to P8 ₇ , P9 ₀ to P9 ₇ , PA ₀ to PA ₃	—	—	0.6	V	$V_{CC} = 4.0\text{ V to }5.5\text{ V}$ $I_{OL} = 1.6\text{ mA}$	
			—	—	0.5		$I_{OL} = 0.4\text{ mA}$	
		P2 ₀ to P2 ₇ , P3 ₀ to P3 ₇	—	—	1.0	V	$V_{CC} = 4.0\text{ V to }5.5\text{ V}$ $I_{OL} = 10\text{ mA}$	
			—	—	0.6		$V_{CC} = 4.0\text{ V to }5.5\text{ V}$ $I_{OL} = 1.6\text{ mA}$	
			—	—	0.5		$I_{OL} = 0.4\text{ mA}$	
Input/output leakage current	$ I_{IL} $	RES, P4 ₃ , OSC ₁ , X ₁ , P1 ₀ to P1 ₇ , P2 ₀ to P2 ₇ , P3 ₀ to P3 ₇ , P4 ₀ to P4 ₂ , P5 ₀ to P5 ₇ , P6 ₀ to P6 ₇ , P7 ₀ to P7 ₇ , P8 ₀ to P8 ₇ , P9 ₀ to P9 ₇ , PA ₀ to PA ₃	—	—	1.0	μA	$V_{IN} = 0.5\text{ V to }V_{CC} - 0.5\text{ V}$	
			PB ₀ to PB ₇ , PC ₀ to PC ₃	—	—		1.0	$V_{IN} = 0.5\text{ V to }AV_{CC} - 0.5\text{ V}$
Pull-up MOS current	$-I_p$	P1 ₀ to P1 ₇ , P2 ₄ ^{*6} , P3 ₀ to P3 ₇ , P5 ₀ to P5 ₇ , P6 ₀ to P6 ₇	20	—	200	μA	$V_{CC} = 5.0\text{ V},$ $V_{IN} = 0.0\text{ V}$	
			—	40	—		$V_{CC} = 2.7\text{ V},$ $V_{IN} = 0.0\text{ V}$	Reference value
Input capacitance	C_{in}	All input pins except power supply pin	—	—	15.0	pF	$f = 1\text{ MHz},$ $V_{IN} = 0.0\text{ V},$ $T_a = 25^\circ\text{C}$	

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Notes
			Min	Typ	Max			
Active mode current consumption	I _{OP1}	V _{CC}	—	0.8	—	mA	Active (high-speed) mode V _{CC} = 2.7 V, f _{OSC} = 2 MHz	*1 *3 *4 Approx. max. value = 1.1 × Typ.
			—	1.2	—			*2 *3 *4 Approx. max. value = 1.1 × Typ.
			—	1.0	—		Active (high-speed) mode V _{CC} = 5 V, f _{OSC} = 2 MHz	*1 *3 *4 Approx. max. value = 1.1 × Typ.
			—	1.5	—			*2 *3 *4 Approx. max. value = 1.1 × Typ.
			—	2.0	—		Active (high-speed) mode V _{CC} = 5 V, f _{OSC} = 4 MHz	*1 *3 *4 Approx. max. value = 1.1 × Typ.
			—	2.4	—			*2 *3 *4 Approx. max. value = 1.1 × Typ.
			—	4.0	7.0		Active (high-speed) mode V _{CC} = 5 V, f _{OSC} = 10 MHz	*1 *3 *4
			—	4.9	7.0			*2 *3 *4

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Notes	
			Min	Typ	Max				
Active mode current consumption	IOPE2	V _{CC}	—	0.4	—	mA	Active (medium-speed) mode V _{CC} = 2.7 V, f _{OSC} = 2 MHz, φ _{OSC} /128	*1 *3 *4 Approx. max. value = 1.1 × Typ.	
			—	0.7	—			*2 *3 *4 Approx. max. value = 1.1 × Typ.	
			—	0.5	—			*1 *3 *4 Approx. max. value = 1.1 × Typ.	
			—	1.0	—			*2 *3 *4 Approx. max. value = 1.1 × Typ.	
			—	0.8	—			*1 *3 *4 Approx. max. value = 1.1 × Typ.	
			—	1.2	—			*2 *3 *4 Approx. max. value = 1.1 × Typ.	
			—	1.2	3.0			Active (medium-speed) mode V _{CC} = 5 V, f _{OSC} = 10 MHz, φ _{OSC} /128	*1 *3 *4
			—	1.7	3.0				*2 *3 *4

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Notes				
			Min	Typ	Max							
Sleep mode current consumption	I _{SLEEP}	V _{CC}	—	0.5	—	mA	V _{CC} = 2.7 V, f _{OSC} = 2 MHz	*1 *3 *4 Approx. max. value = 1.1 × Typ.				
			—	0.8	—			*2 *3 *4 Approx. max. value = 1.1 × Typ.				
			—	0.7	—		V _{CC} = 5 V, f _{OSC} = 2 MHz	*1 *3 *4 Approx. max. value = 1.1 × Typ.				
			—	1.2	—			*2 *3 *4 Approx. max. value = 1.1 × Typ.				
			—	1.1	—		V _{CC} = 5 V, f _{OSC} = 4 MHz	*1 *3 *4 Approx. max. value = 1.1 × Typ.				
			—	1.6	—			*2 *3 *4 Approx. max. value = 1.1 × Typ.				
			—	1.9	5.0		V _{CC} = 5 V, f _{OSC} = 10 MHz	*1 *3 *4				
			—	2.6	5.0			*2 *3 *4				
			Subactive mode current consumption	I _{SUB}	V _{CC}		—	12	—	μA	V _{CC} = 2.7 V, LCD on, 32-kHz crystal resonator used ($\phi_{SUB} = \phi_W/8$)	*1 *3 *4 Reference value
							—	15	—			*2 *3 *4 Reference value
—	18	50				V _{CC} = 2.7 V, LCD on, 32-kHz crystal resonator used ($\phi_{SUB} = \phi_W/2$)	*1 *3 *4					
—	30	50					*2 *3 *4					

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Notes
			Min	Typ	Max			
Subsleep mode current consumption	ISUBSP	V _{CC}	—	3.8	16	μA	V _{CC} = 2.7 V, LCD on, 32-kHz crystal resonator used ($\phi_{SUB} = \phi_{W/2}$)	*3 *4
Watch mode current consumption	IWATCH	V _{CC}	—	1.8	—	μA	V _{CC} = 2.7 V, T _a = 25°C, 32-kHz crystal resonator used, LCD not used	*1 *3 *4 Reference value
			—	1.8	—			*2 *3 *4 Reference value
			—	3.0	6.0			V _{CC} = 2.7 V, 32-kHz crystal resonator used, LCD not used *3 *4
Standby mode current consumption	ISTBY	V _{CC}	—	0.3	—	μA	V _{CC} = 2.7 V, T _a = 25°C, 32-kHz crystal resonator not used	*1 *3 *4 Reference value
			—	0.3	—			*2 *3 *4 Reference value
			—	0.4	—			V _{CC} = 5.0 V, T _a = 25°C, 32-kHz crystal resonator not used *1 *3 *4 Reference value
			—	0.5	—			*2 *3 *4 Reference value
			—	1.0	5.0			32-kHz crystal resonator not used *3 *4
RAM data retaining voltage	V _{RAM}	V _{CC}	2.0	—	—	V		*5

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Notes
			Min	Typ	Max			
Allowable output low current (per pin)	I _{OL}	Output pins except ports 2 and 3	—	—	2.0	mA	V _{CC} = 4.0 V to 5.5 V	
		Ports 2 and 3	—	—	10.0		V _{CC} = 4.0 V to 5.5 V	
		All pins	—	—	0.5			
Allowable output low current (total)	ΣI _{OL}	Output pins except ports 2 and 3	—	—	40.0	mA	V _{CC} = 4.0 V to 5.5 V	
		Ports 2 and 3	—	—	80.0		V _{CC} = 4.0 V to 5.5 V	
		All pins	—	—	20.0			
Allowable output high current (per pin)	-I _{OH}	All output pins	—	—	2.0	mA	V _{CC} = 4.0 V to 5.5 V	
			—	—	0.2		Other than above	
Allowable output high current (total)	Σ-I _{OH}	All output pins	—	—	15.0	mA	V _{CC} = 4.0 V to 5.5 V	
			—	—	10.0		Other than above	

Notes: Connect the TEST pin to V_{SS}.

1. Applies to the mask-ROM version.
2. Applies to the F-ZTAT version.

3. Pin states when current consumption is measured

Mode	$\overline{\text{RES}}$ Pin	Internal State	Other Pins	LCD Power Supply	Oscillator Pins
Active (high-speed) mode (I_{OPE1})	V_{CC}	Only CPU operates	V_{CC}	Stops	System clock: crystal resonator
Active (medium-speed) mode (I_{OPE2})					Subclock: Pin X_1 = GND
Sleep mode	V_{CC}	Only all on-chip timers operate	V_{CC}	Stops	
Subactive mode	V_{CC}	Only CPU operates	V_{CC}	Stops	System clock: crystal resonator
Subsleep mode	V_{CC}	Only all on-chip timers operate CPU stops	V_{CC}	Stops	Subclock: crystal resonator
Watch mode	V_{CC}	Only clock time base operates CPU stops	V_{CC}	Stops	
Standby mode	V_{CC}	CPU and timers both stop	V_{CC}	Stops	System clock: crystal resonator Subclock: Pin X_1 = GND

4. Except current which flows to the pull-up MOS or output buffer

5. Voltage maintained in standby mode

6. Applies to the F-ZTAT version. The specified values for this pin in reference values.

15.8.3 AC Characteristics

Table 15.27 lists the control signal timing and table 15.28 and 15.29 list the serial interface timing.

Table 15.27 Control Signal Timing

$V_{CC} = 2.7\text{ V to }5.5\text{ V}$, $AV_{CC} = 2.7\text{ V to }5.5\text{ V}$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, unless otherwise specified

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Reference Figure	
			Min	Typ	Max				
System clock oscillation frequency	f_{OSC}	OSC ₁ , OSC ₂	2.0	—	16.0	MHz		*3	
			2.0	—	16.0		$V_{CC} = 4.5\text{ to }5.5\text{ V}$	*4	
			2.0	—	10.0		$V_{CC} = 2.7\text{ to }5.5\text{ V}$		
OSC clock (ϕ_{OSC}) cycle time	t_{OSC}	OSC ₁ , OSC ₂	62.5	—	500 (1000)	ns		Figure 15.1 *2 *3	
			62.5	—	500 (1000)		$V_{CC} = 4.5\text{ to }5.5\text{ V}$	Figure 15.1 *2 *4	
			100	—	500 (1000)		$V_{CC} = 2.7\text{ to }5.5\text{ V}$		
System clock (ϕ) cycle time	t_{cyc}		2	—	128	t_{osc}			
			—	—	128		μs		
Subclock oscillation frequency	f_W	X ₁ , X ₂ , EXCL	—	32.768 or 38.4	—	kHz			
Watch clock (ϕ_W) cycle time	t_W	X ₁ , X ₂ , EXCL	—	30.5 or 26.0	—	μs		Figure 15.1	
Subclock (ϕ_{SUB}) cycle time	t_{subcyc}		2	—	4	t_W		*1	
Instruction cycle time			2	—	—	t_{cyc} t_{subcyc}			
Oscillation stabilization time	t_{rc}	OSC ₁ , OSC ₂	—	20	45	μs	Ceramic resonator ($V_{CC} = 3.0\text{ to }5.5\text{ V}$)	Figure 15.11	
			—	80	—				Ceramic resonator other than above
			—	0.8	2		ms		
			—	—	50				Other than above
	t_{rc}	X ₁ , X ₂	—	—	2.0	s			

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Reference Figure		
			Min	Typ	Max					
External clock high width	t_{CPH}	OSC ₁	25	—	—	ns		Figure 15.1* ³		
			25	—	—				$V_{CC} = 4.5$ to 5.5 V	Figure 15.1* ⁴
			40	—	—				$V_{CC} = 2.7$ to 5.5 V	
		EXCL	—	15.26 or 13.02	—	μ s	Figure 15.1			
External clock low width	t_{CPL}	OSC ₁	25	—	—	ns		Figure 15.1* ³		
			25	—	—				$V_{CC} = 4.5$ to 5.5 V	Figure 15.1* ⁴
			40	—	—				$V_{CC} = 2.7$ to 5.5 V	
		EXCL	—	15.26 or 13.02	—	μ s	Figure 15.1			
External clock rise time	t_{CPr}	OSC ₁	—	—	6	ns		Figure 15.1* ³		
			—	—	6				$V_{CC} = 4.5$ to 5.5 V	Figure 15.1* ⁴
			—	—	10				$V_{CC} = 2.7$ to 5.5 V	
		EXCL	—	—	55.0	Figure 15.1				
External clock fall time	t_{CPf}	OSC ₁	—	—	6	ns		Figure 15.1* ³		
			—	—	6				$V_{CC} = 4.5$ to 5.5 V	Figure 15.1* ⁴
			—	—	10				$V_{CC} = 2.7$ to 5.5 V	
		EXCL	—	—	55.0	Figure 15.1				
\overline{RES} pin low width	t_{REL}	\overline{RES}	10	—	—	t_{cyc}		Figure 15.2		
Input pin high width	t_{IH}	$\overline{IRQ0_0}$ to $\overline{IRQ0_4}$, $\overline{WKP0_0}$ to $\overline{WKP7_7}$, \overline{ADTRG} , TMIC, TMIF, TMIG, AEVL, AEVH	2	—	—	t_{cyc} t_{subcyc}		Figure 15.3		

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Reference Figure
			Min	Typ	Max			
Input pin low width	t_{IL}	$\overline{IRQ0_0}$ to $\overline{IRQ0_4}$, $\overline{WKP0_0}$ to $\overline{WKP0_7}$, \overline{ADTRG} , TMIC, TMIF, TMIG, AEVL, AEVH	2	—	—	t_{cyc} t_{subcyc}		Figure 15.3
UD pin minimum transition width	t_{UDH} t_{UDL}	UD	4	—	—	t_{cyc} t_{subcyc}		Figure 15.4

- Notes: 1. Determined by the SA1 and SA0 bits in the system control register 2 (SYSCR2).
 2. The figure in parentheses () indicates the maximum fosc value when an external clock is used.
 3. Also applies to H8/38347 Group.
 4. Also applies to H8/38447 Group.

Table 15.28 Serial Interface (SCI1) Timing

$V_{CC} = 2.7\text{ V to }5.5\text{ V}$, $AV_{CC} = 2.7\text{ V to }5.5\text{ V}$, $V_{SS} = AV_{SS} = 0.0\text{ V}$ unless otherwise indicated

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Reference Figure
			Min	Typ	Max			
Input clock cycle	t_{Syc}	SCK ₁	4	—	—	t_{cyc}		Figure 15.5
Input clock high width	t_{SCKH}	SCK ₁	0.4	—	—	t_{Syc}		Figure 15.5
Input clock low width	t_{SCKL}	SCK ₁	0.4	—	—	t_{Syc}		Figure 15.5
Input clock rise time	t_{SCKr}	SCK ₁	—	—	60.0	ns		Figure 15.5*
Input clock fall time	t_{SCKf}	SCK ₁	—	—	60.0	ns		Figure 15.5*
Serial output data delay time	t_{SOD}	SO ₁	—	—	200.0	ns		Figure 15.5*
Serial input data setup time	t_{SIS}	SI ₁	200.0	—	—	ns		Figure 15.5*
Serial input data hold time	t_{SIH}	SI ₁	200.0	—	—	ns		Figure 15.5*

Table 15.29 Serial Interface (SCI3) Timing

$V_{CC} = 2.7\text{ V to }5.5\text{ V}$, $AV_{CC} = 2.7\text{ V to }5.5\text{ V}$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, unless otherwise specified

Item	Symbol	Values			Unit	Test Condition	Reference Figure
		Min	Typ	Max			
Input clock cycle	Asynchronous	t_{SCYC}	4	—	—	t_{cyc} or t_{subcyc}	Figure 15.6
	Clocked synchronous		6	—	—		
Input clock pulse width	t_{SCKW}	0.4	—	0.6	t_{SCYC}	Figure 15.6	
Transmit data delay time (clocked synchronous)	t_{TXD}	—	—	1	t_{cyc} or t_{subcyc}	Figure 15.7	
Receive data setup time (clocked synchronous)	t_{RXS}	200	—	—	ns	Figure 15.7	
Receive data hold time (clocked synchronous)	t_{RXH}	200	—	—	ns	Figure 15.7	

15.8.4 A/D Converter Characteristics

Table 15.30 shows the A/D converter characteristics.

Table 15.30 A/D Converter Characteristics

$V_{CC} = 2.7\text{ V to }5.5\text{ V}$, $AV_{CC} = 2.7\text{ V to }5.5\text{ V}$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, unless otherwise specified

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Reference Figure
			Min	Typ	Max			
Analog power supply voltage	AV_{CC}	AV_{CC}	2.7	—	5.5	V		*1
Analog input voltage	AV_{IN}	AN_0 to AN_{11}	-0.3	—	$AV_{CC} + 0.3$	V		
Analog power supply current	AI_{OPE}	AV_{CC}	—	—	1.5	mA	$AV_{CC} = 5.0\text{ V}$	
	AI_{STOP1}	AV_{CC}	—	600	—	μA		*2 Reference value
	AI_{STOP2}	AV_{CC}	—	—	5.0	μA		*3
Analog input capacitance	C_{AIN}	AN_0 to AN_{11}	—	—	15.0	pF		
Allowable signal source impedance	R_{AIN}		—	—	10.0	k Ω		
Resolution (data length)			—	—	10	bit		
Nonlinearity error			—	—	± 3.5	LSB	$AV_{CC} = 4.0\text{ V to }5.5\text{ V}$	
			—	—	± 7.5		$AV_{CC} = 2.7\text{ V to }5.5\text{ V}$	
Quantization error			—	—	± 0.5	LSB		
Absolute accuracy			—	± 2.0	± 4.0	LSB	$AV_{CC} = 4.0\text{ V to }5.5\text{ V}$	
			—	± 2.0	± 8.0		$AV_{CC} = 2.7\text{ V to }5.5\text{ V}$	
Conversion time			7.8	—	124	μs		*4
			12.4	—	124			*5

Notes: 1. Set $AV_{CC} = V_{CC}$ when the A/D converter is not used.

2. AI_{STOP1} is the current in active and sleep modes while the A/D converter is idle.

3. AI_{STOP2} is the current at reset and in standby, watch, subactive, and subsleep modes while the A/D converter is idle.

4. Also applies to H8/38347 Group.

5. Also applies to H8/38447 Group.

15.8.5 LCD Characteristics

Table 15.31 shows the LCD characteristics.

Table 15.31 LCD Characteristics

$V_{CC} = 2.7\text{ V to }5.5\text{ V}$, $AV_{CC} = 2.7\text{ V to }5.5\text{ V}$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, unless otherwise specified

Item	Symbol	Applicable Pins	Values			Unit	Test Condition	Reference Figure
			Min	Typ	Max			
Segment driver step-down voltage	V_{DS}	SEG ₁ to SEG ₄₀	—	—	0.6	V	$I_D = 2\ \mu\text{A}$ V1 = 2.7 V to 5.5 V	*1
Common driver step-down voltage	V_{DC}	COM ₁ to COM ₄	—	—	0.3	V	$I_D = 2\ \mu\text{A}$ V1 = 2.7 V to 5.5 V	*1
LCD power supply split-resistance	R_{LCD}		1.5	3.0	7.0	M Ω	Between V1 and V _{SS}	
Liquid crystal display voltage	V_{LCD}	V ₁	2.7	—	5.5	V		*2

- Notes:
1. The voltage step-down from power supply pins V1, V2, V3, and V_{SS} to each segment pin or common pin.
 2. When the liquid crystal display voltage is supplied from an external power supply, ensure that the following relationship is maintained: $V1 \geq V2 \geq V3 \geq V_{SS}$.

15.8.6 Flash Memory Characteristics

Table 15.32 Flash Memory Characteristics

Condition: $AV_{CC} = 2.7\text{ V to }5.5\text{ V}$, $V_{SS} = AV_{SS} = 0.0\text{ V}$, $V_{CC} = 2.7\text{ V to }5.5\text{ V}$ (range of operating voltage when reading), $V_{CC} = 3.0\text{ V to }5.5\text{ V}$ (range of operating voltage when programming/erasing), $T_a = -20^\circ\text{C to }+75^\circ\text{C}$ (range of operating temperature when programming/erasing: product with regular specifications, product with wide-range temperature specifications)

Item	Symbol	Values			Unit	Test Conditions	
		Min	Typ	Max			
Programming time ^{*1*2*4}	t_P	—	7	200	ms/128 bytes		
Erase time ^{*1*3*5}	t_E	—	100	1200	ms/block		
Reprogramming count	N_{WEC}	1000 ^{*8}	10000 ^{*9}	—	times		
Data retain period	t_{DRP}	10 ^{*10}	—	—	year		
Programming	Wait time after SWE-bit setting ^{*1}	x	1	—	—	μs	
	Wait time after PSU-bit setting ^{*1}	y	50	—	—	μs	
	Wait time after P-bit setting ^{*1*4}	z1	28	30	32	μs	$1 \leq n \leq 6$
		z2	198	200	202	μs	$7 \leq n \leq 1000$
		z3	8	10	12	μs	Additional programming
	Wait time after P-bit clear ^{*1}	α	5	—	—	μs	
	Wait time after PSU-bit clear ^{*1}	β	5	—	—	μs	
	Wait time after PV-bit setting ^{*1}	γ	4	—	—	μs	
	Wait time after dummy write ^{*1}	ϵ	2	—	—	μs	
	Wait time after PV-bit clear ^{*1}	η	2	—	—	μs	
Wait time after SWE-bit clear ^{*1}	θ	100	—	—	μs		
Maximum programming count ^{*1*4*5}	N	—	—	1000	times		

Item	Symbol	Values			Unit	Test Conditions
		Min	Typ	Max		
Erase	Wait time after SWE-bit setting*1	x	1	—	—	μs
	Wait time after ESU-bit setting*1	y	100	—	—	μs
	Wait time after E-bit setting*1*6	z	10	—	100	ms
	Wait time after E-bit clear*1	α	10	—	—	μs
	Wait time after ESU-bit clear*1	β	10	—	—	μs
	Wait time after EV-bit setting*1	γ	20	—	—	μs
	Wait time after dummy write*1	ε	2	—	—	μs
	Wait time after EV-bit clear*1	η	4	—	—	μs
	Wait time after SWE-bit clear*1	θ	100	—	—	μs
	Maximum erase count*1*6*7	N	—	—	120	times

- Notes:
- Set the times according to the program/erase algorithms.
 - Programming time per 128 bytes (Shows the total period for which the P bit in FLMCR1 is set. It does not include the programming verification time.)
 - Block erase time (Shows the total period for which the E bit in FLMCR1 is set. It does not include the erase verification time.)
 - Maximum programming time (t_P (max))
 t_P (max) = Wait time after P-bit setting (z) × maximum number of writes (N)
 - The maximum number of writes (N) should be set according to the actual set value of z1, z2, and z3 to allow programming within the maximum programming time (t_P (max)).
 The wait time after P-bit setting (z1 and z2) should be alternated according to the number of writes (n) as follows:
 $1 \leq n \leq 6$ z1 = 30 μs
 $7 \leq n \leq 1000$ z2 = 200 μs
 - Maximum erase time (t_E (max))
 t_E (max) = Wait time after E-bit setting (z) × maximum erase count (N)
 - The maximum number of erases (N) should be set according to the actual set value of z to allow erasing within the maximum erase time (t_E (max)).
 - This minimum value guarantees all characteristics after reprogramming (the guaranteed range is from 1 to the minimum value).
 - Reference value when the temperature is 25°C (normally reprogramming will be performed by this count).

10. This is a data retain characteristic when reprogramming is performed within the specification range including this minimum value.

15.9 Operation Timing

Figures 15.1 to 15.8 show timing diagrams.

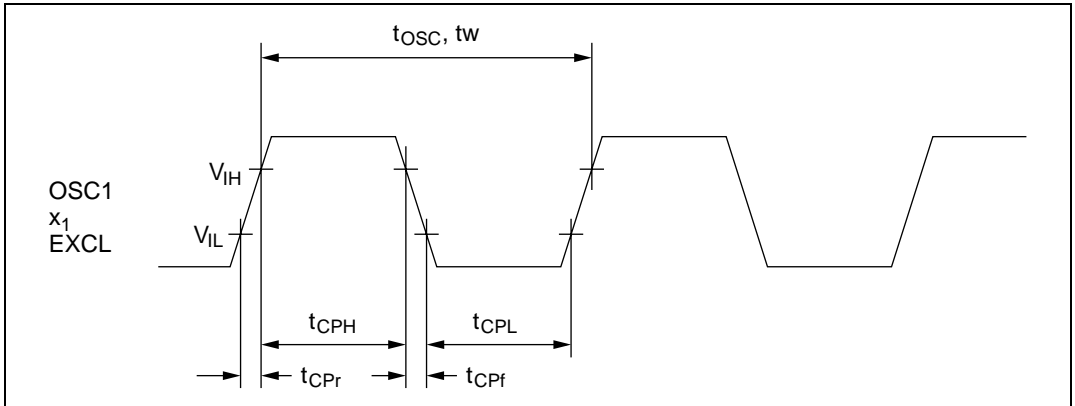


Figure 15.1 Clock Input Timing

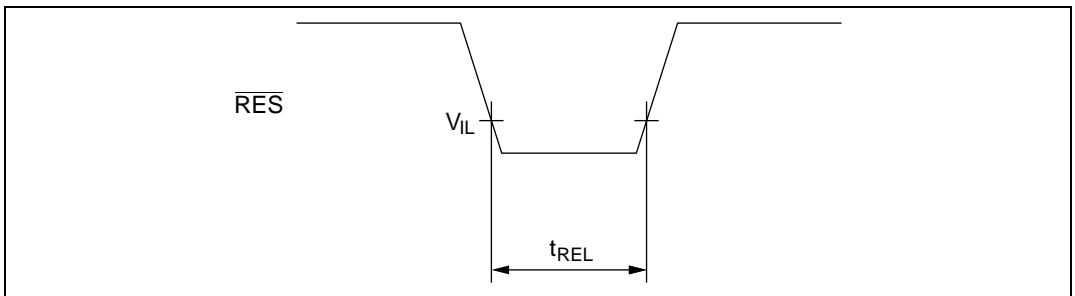


Figure 15.2 \overline{RES} Low Width

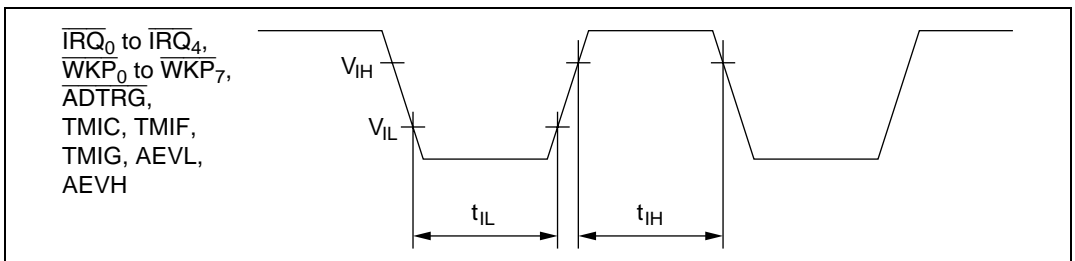


Figure 15.3 Input Timing

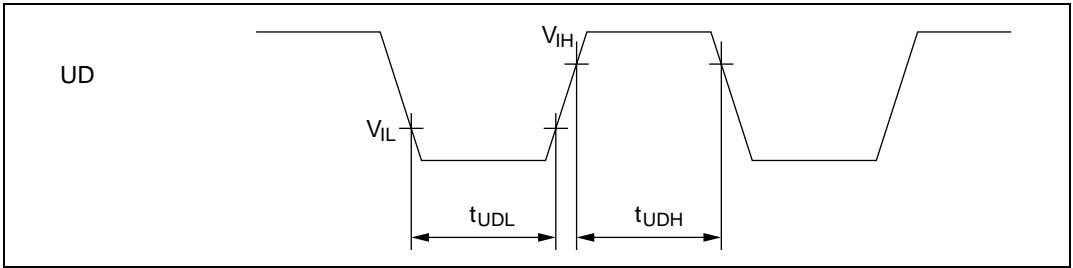


Figure 15.4 UD Pin Minimum Modulation Width Timing

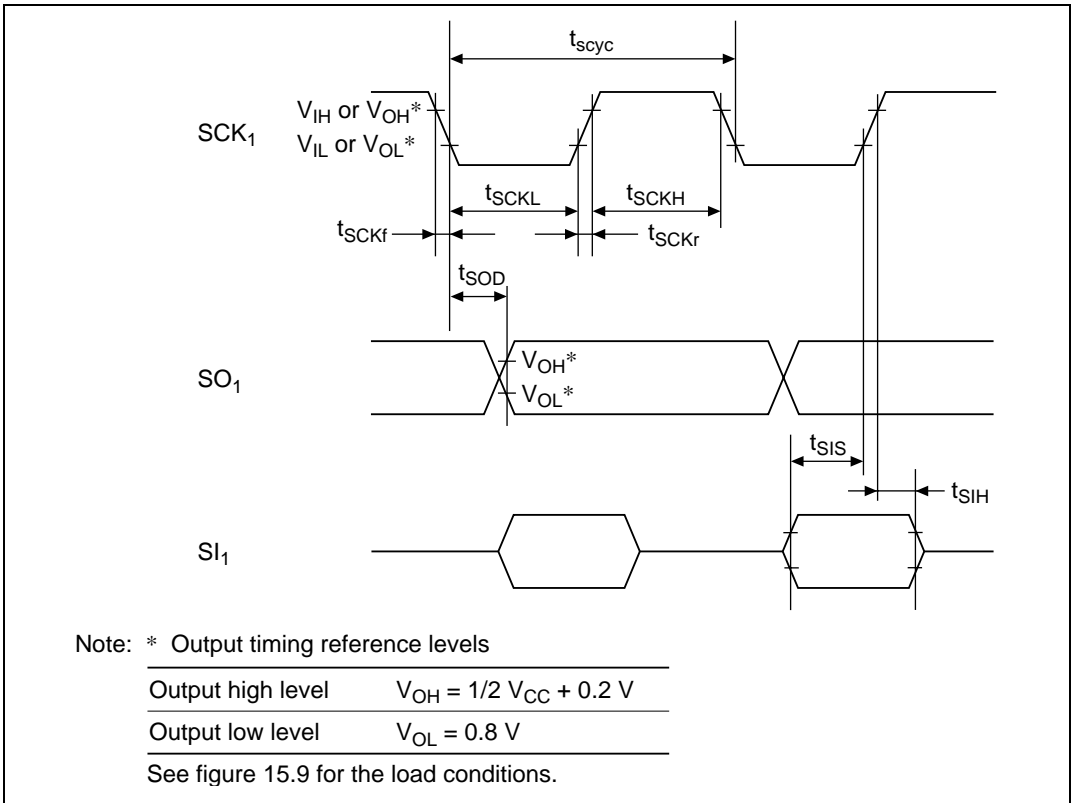


Figure 15.5 SC11 Input/Output Timing

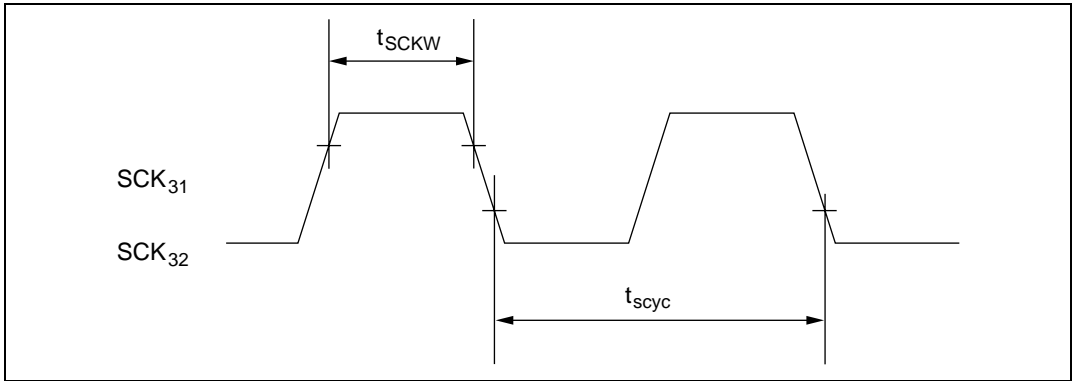


Figure 15.6 SCK3 Input Clock Timing

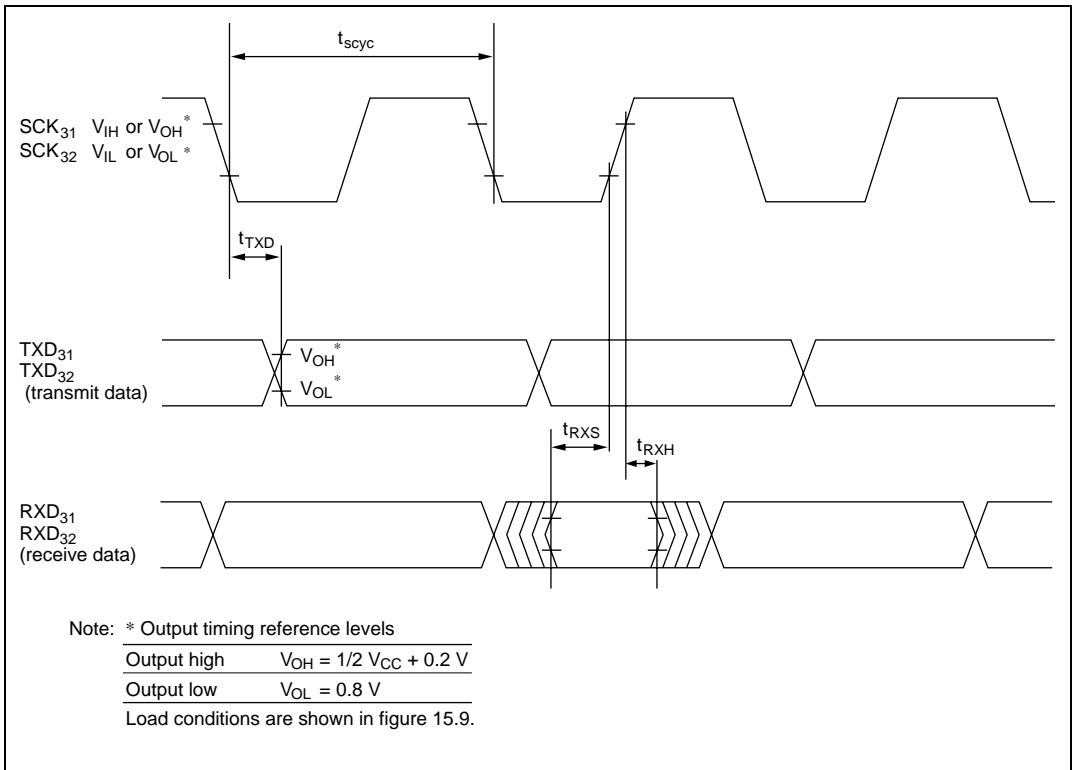


Figure 15.7 SCI3 Synchronous Mode Input/Output Timing

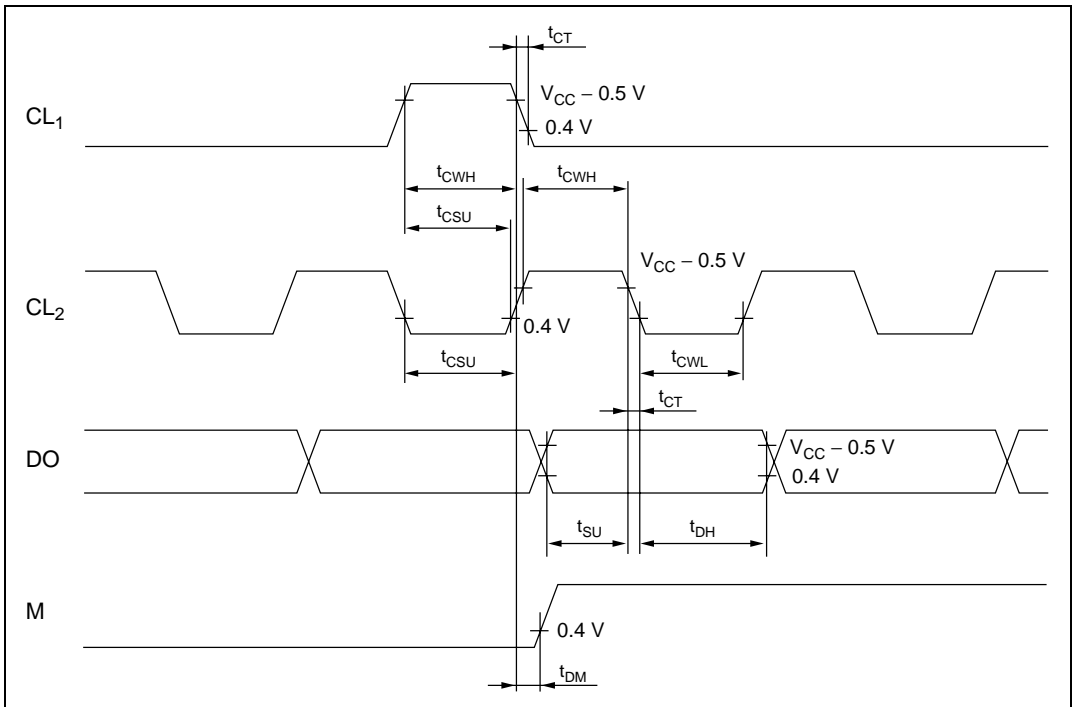


Figure 15.8 Segment Expansion Signal Timing

15.10 Output Load Circuit

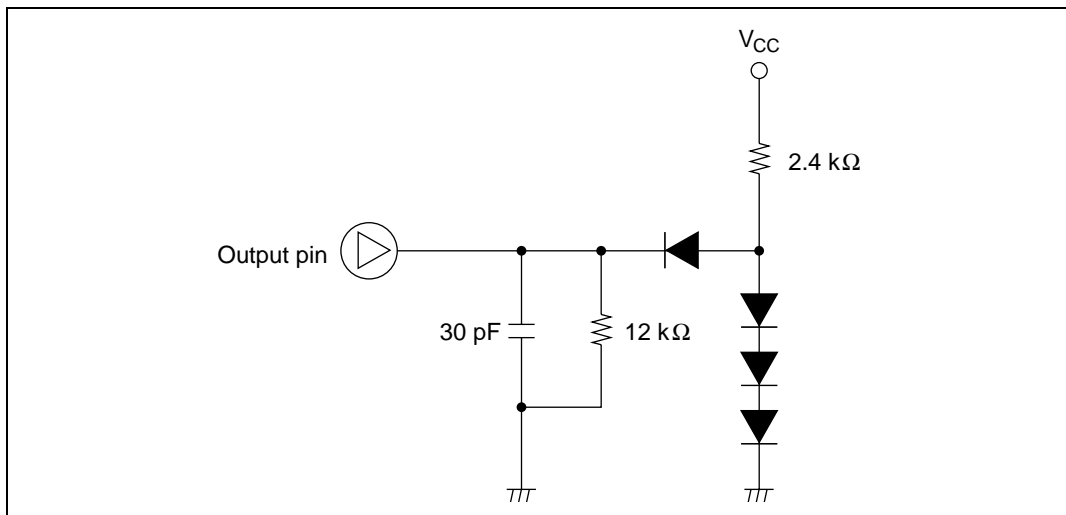
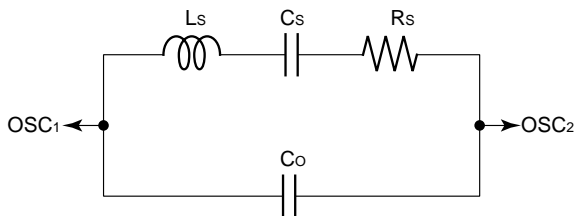


Figure 15.9 Output Load Condition

15.11 Resonator



Ceramic Oscillator Parameters

Frequency	4 MHz	Manufacturer	Products Name
R_s	Manufacturer's Publicly Released Values Max. 8.8 $\frac{1}{2}$	MURATA	CSTLS 4M00G 53/56
C_o	Max. 36 pF		

Crystal Oscillator Parameters

Frequency	4.193 MHz	Manufacturer	Products Name
R_s	Manufacturer's Publicly Released Values Max. 100 $\frac{1}{2}$	Nihon Denpa Kogyo	NR-18
C_o	Max. 16 pF		

Figure 15.10 Resonator Equivalent Circuit

Crystal resonator

Resonating Frequency	Manufacturer	Model	C_1, C_2
4 MHz	Nihon Denpa Kogyo	NR-18	12pF \pm 20%
10 MHz			

Ceramic resonator

Resonating Frequency	Manufacturer	Model	C_1, C_2
2 MHz	MURATA	CSTCC2M00G53-B0	15pF \pm 20%
		CSTCC2M00G56-B0	47pF \pm 20%
4 MHz		CSTLS4M00G53-B0	15pF \pm 20%
		CSTLS4M00G56-B0	47pF \pm 20%
10 MHz		CSTLS10M0G53-B0	15pF \pm 20%
		CSTLS10M0G56-B0	47pF \pm 20%

Figure 15.11 Recommended Resonators

15.12 Usage Note

Each of the products covered in this manual satisfy the electrical characteristics indicated. However, the actual electrical characteristics, operating margin and noise margin may differ from the indicated values due to differences in the manufacturing process, built-in ROM, layout pattern and other factors.

If a system evaluation test is conducted with the ZTAT or F-ZTAT version, when switching to a mask ROM version, perform the same evaluation test with the mask ROM version.

Appendix A CPU Instruction Set

A.1 Instructions

Operation Notation

Rd8/16	General register (destination) (8 or 16 bits)
Rs8/16	General register (source) (8 or 16 bits)
Rn8/16	General register (8 or 16 bits)
CCR	Condition code register
N	N (negative) flag in CCR
Z	Z (zero) flag in CCR
V	V (overflow) flag in CCR
C	C (carry) flag in CCR
PC	Program counter
SP	Stack pointer
#xx: 3/8/16	Immediate data (3, 8, or 16 bits)
d: 8/16	Displacement (8 or 16 bits)
@aa: 8/16	Absolute address (8 or 16 bits)
+	Addition
−	Subtraction
×	Multiplication
÷	Division
^	Logical AND
∨	Logical OR
⊕	Exclusive logical OR
→	Move
—	Logical complement

Condition Code Notation

Symbol

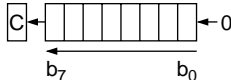
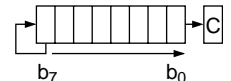
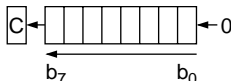
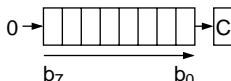
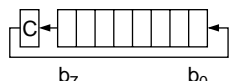
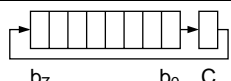
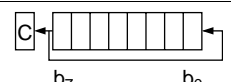
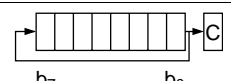
↓	Modified according to the instruction result
*	Not fixed (value not guaranteed)
0	Always cleared to 0
—	Not affected by the instruction execution result

Table A.1 lists the H8/300L CPU instruction set.

Table A.1 Instruction Set

Mnemonic	Operand Size	Operation	Addressing Mode/ Instruction Length (bytes)								Condition Code						No. of States	
			#xx: 8/16	Rn	@Rn	@(d:16, Rn)	@-Rn/@Rn+	@aa: 8/16	@(d:8, PC)	@@aa	Implied	I	H	N	Z	V		C
MOV.B #xx:8, Rd	B	#xx:8 → Rd8	2									—	—	⇕	⇕	0	—	2
MOV.B Rs, Rd	B	Rs8 → Rd8		2								—	—	⇕	⇕	0	—	2
MOV.B @Rs, Rd	B	@Rs16 → Rd8			2							—	—	⇕	⇕	0	—	4
MOV.B @(d:16, Rs), Rd	B	@(d:16, Rs16) → Rd8				4						—	—	⇕	⇕	0	—	6
MOV.B @Rs+, Rd	B	@Rs16 → Rd8 Rs16+1 → Rs16					2					—	—	⇕	⇕	0	—	6
MOV.B @aa:8, Rd	B	@aa:8 → Rd8						2				—	—	⇕	⇕	0	—	4
MOV.B @aa:16, Rd	B	@aa:16 → Rd8							4			—	—	⇕	⇕	0	—	6
MOV.B Rs, @Rd	B	Rs8 → @Rd16			2							—	—	⇕	⇕	0	—	4
MOV.B Rs, @(d:16, Rd)	B	Rs8 → @(d:16, Rd16)				4						—	—	⇕	⇕	0	—	6
MOV.B Rs, @-Rd	B	Rd16-1 → Rd16 Rs8 → @Rd16					2					—	—	⇕	⇕	0	—	6
MOV.B Rs, @aa:8	B	Rs8 → @aa:8							2			—	—	⇕	⇕	0	—	4
MOV.B Rs, @aa:16	B	Rs8 → @aa:16								4		—	—	⇕	⇕	0	—	6
MOV.W #xx:16, Rd	W	#xx:16 → Rd	4									—	—	⇕	⇕	0	—	4
MOV.W Rs, Rd	W	Rs16 → Rd16		2								—	—	⇕	⇕	0	—	2
MOV.W @Rs, Rd	W	@Rs16 → Rd16			2							—	—	⇕	⇕	0	—	4
MOV.W @(d:16, Rs), Rd	W	@(d:16, Rs16) → Rd16				4						—	—	⇕	⇕	0	—	6
MOV.W @Rs+, Rd	W	@Rs16 → Rd16 Rs16+2 → Rs16					2					—	—	⇕	⇕	0	—	6
MOV.W @aa:16, Rd	W	@aa:16 → Rd16								4		—	—	⇕	⇕	0	—	6
MOV.W Rs, @Rd	W	Rs16 → @Rd16			2							—	—	⇕	⇕	0	—	4
MOV.W Rs, @(d:16, Rd)	W	Rs16 → @(d:16, Rd16)				4						—	—	⇕	⇕	0	—	6
MOV.W Rs, @-Rd	W	Rd16-2 → Rd16 Rs16 → @Rd16					2					—	—	⇕	⇕	0	—	6
MOV.W Rs, @aa:16	W	Rs16 → @aa:16									4	—	—	⇕	⇕	0	—	6
POP Rd	W	@SP → Rd16 SP+2 → SP						2				—	—	⇕	⇕	0	—	6
PUSH Rs	W	SP-2 → SP Rs16 → @SP							2			—	—	⇕	⇕	0	—	6

Mnemonic	Operand Size	Operation	Addressing Mode/ Instruction Length (bytes)								Condition Code					No. of States					
			#xx: 8/16	Rn	@Rn	@(d:16, Rn)	@-Rn/@Rn+	@aa: 8/16	@(d8, PC)	@@aa	Implied	I	H	N	Z		V	C			
ADD.B #xx:8, Rd	B	Rd8+#xx:8 → Rd8	2										—	↓	↓	↓	↓	↓	↓	2	
ADD.B Rs, Rd	B	Rd8+Rs8 → Rd8		2										—	↓	↓	↓	↓	↓	↓	2
ADD.W Rs, Rd	W	Rd16+Rs16 → Rd16		2										—	(1)	↓	↓	↓	↓	↓	2
ADDX.B #xx:8, Rd	B	Rd8+#xx:8 +C → Rd8	2											—	↓	↓	(2)	↓	↓	↓	2
ADDX.B Rs, Rd	B	Rd8+Rs8 +C → Rd8		2										—	↓	↓	(2)	↓	↓	↓	2
ADDS.W #1, Rd	W	Rd16+1 → Rd16		2										—	—	—	—	—	—	—	2
ADDS.W #2, Rd	W	Rd16+2 → Rd16		2										—	—	—	—	—	—	—	2
INC.B Rd	B	Rd8+1 → Rd8		2										—	—	↓	↓	↓	↓	—	2
DAA.B Rd	B	Rd8 decimal adjust → Rd8		2										—	*	↓	↓	*	(3)	—	2
SUB.B Rs, Rd	B	Rd8-Rs8 → Rd8		2										—	↓	↓	↓	↓	↓	↓	2
SUB.W Rs, Rd	W	Rd16-Rs16 → Rd16		2										—	(1)	↓	↓	↓	↓	↓	2
SUBX.B #xx:8, Rd	B	Rd8-#xx:8 -C → Rd8	2											—	↓	↓	(2)	↓	↓	↓	2
SUBX.B Rs, Rd	B	Rd8-Rs8 -C → Rd8		2										—	↓	↓	(2)	↓	↓	↓	2
SUBS.W #1, Rd	W	Rd16-1 → Rd16		2										—	—	—	—	—	—	—	2
SUBS.W #2, Rd	W	Rd16-2 → Rd16		2										—	—	—	—	—	—	—	2
DEC.B Rd	B	Rd8-1 → Rd8		2										—	—	↓	↓	↓	↓	—	2
DAS.B Rd	B	Rd8 decimal adjust → Rd8		2										—	*	↓	↓	*	—	—	2
NEG.B Rd	B	0-Rd → Rd		2										—	↓	↓	↓	↓	↓	↓	2
CMP.B #xx:8, Rd	B	Rd8-#xx:8	2											—	↓	↓	↓	↓	↓	↓	2
CMP.B Rs, Rd	B	Rd8-Rs8		2										—	↓	↓	↓	↓	↓	↓	2
CMP.W Rs, Rd	W	Rd16-Rs16		2										—	(1)	↓	↓	↓	↓	↓	2
MULXU.B Rs, Rd	B	Rd8 × Rs8 → Rd16		2										—	—	—	—	—	—	—	14
DIVXU.B Rs, Rd	B	Rd16÷Rs8 → Rd16 (RdH: remainder, RdL: quotient)		2										—	—	(5)	(6)	—	—	—	14
AND.B #xx:8, Rd	B	Rd8^#xx:8 → Rd8	2											—	—	↓	↓	0	—	—	2
AND.B Rs, Rd	B	Rd8^Rs8 → Rd8		2										—	—	↓	↓	0	—	—	2
OR.B #xx:8, Rd	B	Rd8∨#xx:8 → Rd8	2											—	—	↓	↓	0	—	—	2
OR.B Rs, Rd	B	Rd8∨Rs8 → Rd8		2										—	—	↓	↓	0	—	—	2
XOR.B #xx:8, Rd	B	Rd8⊕#xx:8 → Rd8	2											—	—	↓	↓	0	—	—	2
XOR.B Rs, Rd	B	Rd8⊕Rs8 → Rd8		2										—	—	↓	↓	0	—	—	2
NOT.B Rd	B	Rd̄ → Rd		2										—	—	↓	↓	0	—	—	2

Mnemonic	Operand Size	Operation	Addressing Mode/ Instruction Length (bytes)								Condition Code						No. of States
			#xx: 8/16	Rn	@Rn	@(d:16, Rn)	@-Rn/@Rn+	@aa: 8/16	@(d:8, PC)	@@aa	Implied	I	H	N	Z	V	
SHAL.B Rd	B		2								—	—	↓	↓	↓	↓	2
SHAR.B Rd	B		2								—	—	↓	↓	0	↓	2
SHLL.B Rd	B		2								—	—	↓	↓	0	↓	2
SHLR.B Rd	B		2								—	—	0	↓	0	↓	2
ROTXL.B Rd	B		2								—	—	↓	↓	0	↓	2
ROTXR.B Rd	B		2								—	—	↓	↓	0	↓	2
ROTL.B Rd	B		2								—	—	↓	↓	0	↓	2
ROTR.B Rd	B		2								—	—	↓	↓	0	↓	2
BSET #xx:3, Rd	B	(#xx:3 of Rd8) ← 1	2								—	—	—	—	—	—	2
BSET #xx:3, @Rd	B	(#xx:3 of @Rd16) ← 1		4							—	—	—	—	—	—	8
BSET #xx:3, @aa:8	B	(#xx:3 of @aa:8) ← 1				4					—	—	—	—	—	—	8
BSET Rn, Rd	B	(Rn8 of Rd8) ← 1	2								—	—	—	—	—	—	2
BSET Rn, @Rd	B	(Rn8 of @Rd16) ← 1		4							—	—	—	—	—	—	8
BSET Rn, @aa:8	B	(Rn8 of @aa:8) ← 1				4					—	—	—	—	—	—	8
BCLR #xx:3, Rd	B	(#xx:3 of Rd8) ← 0	2								—	—	—	—	—	—	2
BCLR #xx:3, @Rd	B	(#xx:3 of @Rd16) ← 0		4							—	—	—	—	—	—	8
BCLR #xx:3, @aa:8	B	(#xx:3 of @aa:8) ← 0				4					—	—	—	—	—	—	8
BCLR Rn, Rd	B	(Rn8 of Rd8) ← 0	2								—	—	—	—	—	—	2

Mnemonic	Operand Size	Operation	Addressing Mode/ Instruction Length (bytes)								Condition Code					No. of States	
			#xx: 8/16	Rn	@Rn	@(d:16, Rn)	@-Rn/@Rn+	@aa: 8/16	@(d:8, PC)	@@aa	Implied	I	H	N	Z		V
BCLR Rn, @Rd	B	(Rn8 of @Rd16) ← 0		4													8
BCLR Rn, @aa:8	B	(Rn8 of @aa:8) ← 0					4										8
BNOT #xx:3, Rd	B	(#xx:3 of Rd8) ← (#xx:3 of Rd8)	2														2
BNOT #xx:3, @Rd	B	(#xx:3 of @Rd16) ← (#xx:3 of @Rd16)		4													8
BNOT #xx:3, @aa:8	B	(#xx:3 of @aa:8) ← (#xx:3 of @aa:8)					4										8
BNOT Rn, Rd	B	(Rn8 of Rd8) ← (Rn8 of Rd8)	2														2
BNOT Rn, @Rd	B	(Rn8 of @Rd16) ← (Rn8 of @Rd16)		4													8
BNOT Rn, @aa:8	B	(Rn8 of @aa:8) ← (Rn8 of @aa:8)					4										8
BTST #xx:3, Rd	B	(#xx:3 of Rd8) → Z	2												↓		2
BTST #xx:3, @Rd	B	(#xx:3 of @Rd16) → Z		4											↓		6
BTST #xx:3, @aa:8	B	(#xx:3 of @aa:8) → Z					4								↓		6
BTST Rn, Rd	B	(Rn8 of Rd8) → Z	2												↓		2
BTST Rn, @Rd	B	(Rn8 of @Rd16) → Z		4											↓		6
BTST Rn, @aa:8	B	(Rn8 of @aa:8) → Z					4								↓		6
BLD #xx:3, Rd	B	(#xx:3 of Rd8) → C	2													↓	2
BLD #xx:3, @Rd	B	(#xx:3 of @Rd16) → C		4												↓	6
BLD #xx:3, @aa:8	B	(#xx:3 of @aa:8) → C					4									↓	6
BILD #xx:3, Rd	B	(#xx:3 of Rd8) → C	2													↓	2
BILD #xx:3, @Rd	B	(#xx:3 of @Rd16) → C		4												↓	6
BILD #xx:3, @aa:8	B	(#xx:3 of @aa:8) → C					4									↓	6
BST #xx:3, Rd	B	C → (#xx:3 of Rd8)	2														2
BST #xx:3, @Rd	B	C → (#xx:3 of @Rd16)		4													8
BST #xx:3, @aa:8	B	C → (#xx:3 of @aa:8)					4										8
BIST #xx:3, Rd	B	C → (#xx:3 of Rd8)	2														2
BIST #xx:3, @Rd	B	C → (#xx:3 of @Rd16)		4													8
BIST #xx:3, @aa:8	B	C → (#xx:3 of @aa:8)					4										8
BAND #xx:3, Rd	B	C ∧ (#xx:3 of Rd8) → C	2													↓	2
BAND #xx:3, @Rd	B	C ∧ (#xx:3 of @Rd16) → C		4												↓	6
BAND #xx:3, @aa:8	B	C ∧ (#xx:3 of @aa:8) → C					4									↓	6

Mnemonic	Operand Size	Operation	Addressing Mode/ Instruction Length (bytes)							Condition Code					No. of States		
			#xx: 8/16	Rn	@Rn	@(d:16, Rn)	@-Rn/@Rn+	@aa: 8/16	@(d:8, PC)	@@aa	Implied	I	H	N		Z	V
BIAND #xx:3, Rd	B	$C \wedge (\#xx:3 \text{ of } \overline{Rd8}) \rightarrow C$		2												↑	2
BIAND #xx:3, @Rd	B	$C \wedge (\#xx:3 \text{ of } \overline{@Rd16}) \rightarrow C$			4											↑	6
BIAND #xx:3, @aa:8	B	$C \wedge (\#xx:3 \text{ of } \overline{@aa:8}) \rightarrow C$						4								↑	6
BOR #xx:3, Rd	B	$C \vee (\#xx:3 \text{ of } Rd8) \rightarrow C$		2												↑	2
BOR #xx:3, @Rd	B	$C \vee (\#xx:3 \text{ of } @Rd16) \rightarrow C$			4											↑	6
BOR #xx:3, @aa:8	B	$C \vee (\#xx:3 \text{ of } @aa:8) \rightarrow C$						4								↑	6
BIOR #xx:3, Rd	B	$C \vee (\#xx:3 \text{ of } \overline{Rd8}) \rightarrow C$		2												↑	2
BIOR #xx:3, @Rd	B	$C \vee (\#xx:3 \text{ of } \overline{@Rd16}) \rightarrow C$			4											↑	6
BIOR #xx:3, @aa:8	B	$C \vee (\#xx:3 \text{ of } \overline{@aa:8}) \rightarrow C$						4								↑	6
BXOR #xx:3, Rd	B	$C \oplus (\#xx:3 \text{ of } Rd8) \rightarrow C$		2												↑	2
BXOR #xx:3, @Rd	B	$C \oplus (\#xx:3 \text{ of } @Rd16) \rightarrow C$			4											↑	6
BXOR #xx:3, @aa:8	B	$C \oplus (\#xx:3 \text{ of } @aa:8) \rightarrow C$						4								↑	6
BIXOR #xx:3, Rd	B	$C \oplus (\#xx:3 \text{ of } \overline{Rd8}) \rightarrow C$		2												↑	2
BIXOR #xx:3, @Rd	B	$C \oplus (\#xx:3 \text{ of } \overline{@Rd16}) \rightarrow C$			4											↑	6
BIXOR #xx:3, @aa:8	B	$C \oplus (\#xx:3 \text{ of } \overline{@aa:8}) \rightarrow C$						4								↑	6
BRA d:8 (BT d:8)	—	$PC \leftarrow PC+d:8$						2									4
BRN d:8 (BF d:8)	—	$PC \leftarrow PC+2$						2									4
BHI d:8	—	If condition	$C \vee Z = 0$					2									4
BLS d:8	—	is true then	$C \vee Z = 1$					2									4
BCC d:8 (BHS d:8)	—	$PC \leftarrow PC+d:8$	$C = 0$					2									4
BCS d:8 (BLO d:8)	—	else next;	$C = 1$					2									4
BNE d:8	—		$Z = 0$					2									4
BEQ d:8	—		$Z = 1$					2									4
BVC d:8	—		$V = 0$					2									4
BVS d:8	—		$V = 1$					2									4
BPL d:8	—		$N = 0$					2									4
BMI d:8	—		$N = 1$					2									4
BGE d:8	—		$N \oplus V = 0$					2									4
BLT d:8	—		$N \oplus V = 1$					2									4
BGT d:8	—		$Z \vee (N \oplus V) = 0$					2									4
BLE d:8	—		$Z \vee (N \oplus V) = 1$					2									4

Mnemonic	Operand Size	Operation	Addressing Mode/ Instruction Length (bytes)							Condition Code					No. of States	
			#xx: 8/16	Rn	@Rn	@(d:16, Rn)	@-Rn/@Rn+	@aa: 8/16	@(d:8, PC)	@@aa	Implied	I	H	N		Z
JMP @Rn	—	PC ← Rn16		2							—	—	—	—	—	4
JMP @aa:16	—	PC ← aa:16					4				—	—	—	—	—	6
JMP @@aa:8	—	PC ← @aa:8						2			—	—	—	—	—	8
BSR d:8	—	SP-2 → SP PC → @SP PC ← PC+d:8						2			—	—	—	—	—	6
JSR @Rn	—	SP-2 → SP PC → @SP PC ← Rn16		2							—	—	—	—	—	6
JSR @aa:16	—	SP-2 → SP PC → @SP PC ← aa:16					4				—	—	—	—	—	8
JSR @@aa:8		SP-2 → SP PC → @SP PC ← @aa:8						2			—	—	—	—	—	8
RTS	—	PC ← @SP SP+2 → SP							2		—	—	—	—	—	8
RTE	—	CCR ← @SP SP+2 → SP PC ← @SP SP+2 → SP							2		↕	↕	↕	↕	↕	1 0
SLEEP	—	Transit to sleep mode.							2		—	—	—	—	—	2
LDC #xx:8, CCR	B	#xx:8 → CCR	2								↕	↕	↕	↕	↕	2
LDC Rs, CCR	B	Rs8 → CCR		2							↕	↕	↕	↕	↕	2
STC CCR, Rd	B	CCR → Rd8		2							—	—	—	—	—	2
ANDC #xx:8, CCR	B	CCR ∧ #xx:8 → CCR	2								↕	↕	↕	↕	↕	2
ORC #xx:8, CCR	B	CCR ∨ #xx:8 → CCR	2								↕	↕	↕	↕	↕	2
XORC #xx:8, CCR	B	CCR ⊕ #xx:8 → CCR	2								↕	↕	↕	↕	↕	2
NOP	—	PC ← PC+2							2		—	—	—	—	—	2
EEPMOV	—	if R4L≠0 Repeat @R5 → @R6 R5+1 → R5 R6+1 → R6 R4L-1 → R4L Until R4L=0 else next;							4		—	—	—	—	—	(4)

Notes: (1) Set to 1 when there is a carry or borrow from bit 11; otherwise cleared to 0.

(2) If the result is zero, the previous value of the flag is retained; otherwise the flag is cleared to 0.

- (3) Set to 1 if decimal adjustment produces a carry; otherwise retains value prior to arithmetic operation.
- (4) The number of states required for execution is $4n + 9$ in the H8/3847R Group and $4n + 8$ in the H8/3847S Group, H8/38347 Group and H8/38447 Group ($n =$ value of R4L).
- (5) Set to 1 if the divisor is negative; otherwise cleared to 0.
- (6) Set to 1 if the divisor is zero; otherwise cleared to 0.

A.2 Operation Code Map

Table A.2 is an operation code map. It shows the operation codes contained in the first byte of the instruction code (bits 15 to 8 of the first instruction word).

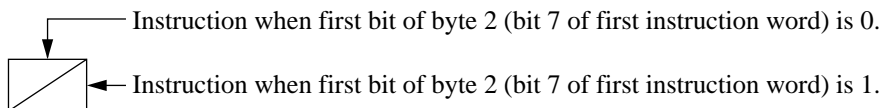


Table A.2 Operation Code Map

Low High	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	NOP	SLEEP	STC	LDC	ORC	XORC	ANDC	LDC	ADD	INC	ADDS	MOV	ADDX	DAA		
1	SHLL SHAL	SHLR SHAR	ROTXL ROTL	ROTXR ROTR	OR	XOR	AND	NOT NEG	SUB	DEC	SUBS	CMP	SUBX	DAS		
2	MOV															
3	MOV															
4	BRA	BRN	BHI	BLS	BCC	BCS	BNE	BEQ	BVC	BVS	BPL	BMI	BGE	BLT	BGT	BLE
5	MULXU	DIVXU			RTS	BSR	RTE				JMP					JSR
6	BSET	BNOT	BCLR	BTST				BST								
7					BOR	BXOR	BAND	BBLD								
					BIOR	BIXOR	BIAND	BILD		MOV		EEMOV		Bit-manipulation instructions		
8	ADD															
9	ADDX															
A	CMP															
B	SUBX															
C	OR															
D	XOR															
E	AND															
F	MOV															

Note: * The PUSH and POP instructions are identical in machine language to MOV instructions.

A.3 Number of Execution States

The tables here can be used to calculate the number of states required for instruction execution. Table A.4 indicates the number of states required for each cycle (instruction fetch, read/write, etc.), and table A.3 indicates the number of cycles of each type occurring in each instruction. The total number of states required for execution of an instruction can be calculated from these two tables as follows:

$$\text{Execution states} = I \times S_I + J \times S_J + K \times S_K + L \times S_L + M \times S_M + N \times S_N$$

Examples: When instruction is fetched from on-chip ROM, and an on-chip RAM is accessed.

BSET #0, @FF00

From table A.4:

$$I = L = 2, \quad J = K = M = N = 0$$

From table A.3:

$$S_I = 2, \quad S_L = 2$$

$$\text{Number of states required for execution} = 2 \times 2 + 2 \times 2 = 8$$

When instruction is fetched from on-chip ROM, branch address is read from on-chip ROM, and on-chip RAM is used for stack area.

JSR @@ 30

From table A.4:

$$I = 2, \quad J = K = 1, \quad L = M = N = 0$$

From table A.3:

$$S_I = S_J = S_K = 2$$

$$\text{Number of states required for execution} = 2 \times 2 + 1 \times 2 + 1 \times 2 = 8$$

Table A.3 Number of Cycles in Each Instruction

Execution Status (instruction cycle)		Access Location	
		On-Chip Memory	On-Chip Peripheral Module
Instruction fetch	S _I	2	—
Branch address read	S _J		
Stack operation	S _K		
Byte data access	S _L		2 or 3*
Word data access	S _M		—
Internal operation	S _N	1	

Note: * Depends on which on-chip module is accessed. See section 2.9.1, Notes on Data Access for details.

Table A.4 Number of Cycles in Each Instruction

Instruc- tion	Mnemonic	Instruction	Branch	Stack	Byte Data	Word Data	Internal
		Fetch I	Addr. Read J	Operation K	Access L	Access M	Operation N
ADD	ADD.B #xx:8, Rd	1					
	ADD.B Rs, Rd	1					
	ADD.W Rs, Rd	1					
ADDS	ADDS.W #1, Rd	1					
	ADDS.W #2, Rd	1					
ADDX	ADDX.B #xx:8, Rd	1					
	ADDX.B Rs, Rd	1					
AND	AND.B #xx:8, Rd	1					
	AND.B Rs, Rd	1					
ANDC	ANDC #xx:8, CCR	1					
BAND	BAND #xx:3, Rd	1					
	BAND #xx:3, @Rd	2			1		
	BAND #xx:3, @aa:8	2			1		
Bcc	BRA d:8 (BT d:8)	2					
	BRN d:8 (BF d:8)	2					
	BHI d:8	2					
	BLS d:8	2					
	BCC d:8 (BHS d:8)	2					
	BCS d:8 (BLO d:8)	2					
	BNE d:8	2					
	BEQ d:8	2					
	BVC d:8	2					
	BVS d:8	2					
	BPL d:8	2					
	BMI d:8	2					
	BGE d:8	2					
	BLT d:8	2					
	BGT d:8	2					
	BLE d:8	2					
BCLR	BCLR #xx:3, Rd	1					
	BCLR #xx:3, @Rd	2			2		
	BCLR #xx:3, @aa:8	2			2		
	BCLR Rn, Rd	1					
	BCLR Rn, @Rd	2			2		
	BCLR Rn, @aa:8	2			2		

Instruction	Mnemonic	Instruction Fetch I	Branch Addr. Read J	Stack Operation K	Byte Data Access L	Word Data Access M	Internal Operation N
BIAND	BIAND #xx:3, Rd	1					
	BIAND #xx:3, @Rd	2			1		
	BIAND #xx:3, @aa:8	2			1		
BILD	BILD #xx:3, Rd	1					
	BILD #xx:3, @Rd	2			1		
	BILD #xx:3, @aa:8	2			1		
BIOR	BIOR #xx:3, Rd	1					
	BIOR #xx:3, @Rd	2			1		
	BIOR #xx:3, @aa:8	2			1		
BIST	BIST #xx:3, Rd	1					
	BIST #xx:3, @Rd	2			2		
	BIST #xx:3, @aa:8	2			2		
BIXOR	BIXOR #xx:3, Rd	1					
	BIXOR #xx:3, @Rd	2			1		
	BIXOR #xx:3, @aa:8	2			1		
BLD	BLD #xx:3, Rd	1					
	BLD #xx:3, @Rd	2			1		
	BLD #xx:3, @aa:8	2			1		
BNOT	BNOT #xx:3, Rd	1					
	BNOT #xx:3, @Rd	2			2		
	BNOT #xx:3, @aa:8	2			2		
	BNOT Rn, Rd	1					
	BNOT Rn, @Rd	2			2		
	BNOT Rn, @aa:8	2			2		
BOR	BOR #xx:3, Rd	1					
	BOR #xx:3, @Rd	2			1		
	BOR #xx:3, @aa:8	2			1		
BSET	BSET #xx:3, Rd	1					
	BSET #xx:3, @Rd	2			2		
	BSET #xx:3, @aa:8	2			2		
	BSET Rn, Rd	1					
	BSET Rn, @Rd	2			2		
	BSET Rn, @aa:8	2			2		
BSR	BSR d:8	2		1			
BST	BST #xx:3, Rd	1					
	BST #xx:3, @Rd	2			2		
	BST #xx:3, @aa:8	2			2		

Instruction	Mnemonic	Instruction Fetch I	Branch Addr. Read J	Stack Operation K	Byte Data Access L	Word Data Access M	Internal Operation N
BTST	BTST #xx:3, Rd	1					
	BTST #xx:3, @Rd	2			1		
	BTST #xx:3, @aa:8	2			1		
	BTST Rn, Rd	1					
	BTST Rn, @Rd	2			1		
	BTST Rn, @aa:8	2			1		
BXOR	BXOR #xx:3, Rd	1					
	BXOR #xx:3, @Rd	2			1		
	BXOR #xx:3, @aa:8	2			1		
CMP	CMP.B #xx:8, Rd	1					
	CMP.B Rs, Rd	1					
	CMP.W Rs, Rd	1					
DAA	DAA.B Rd	1					
DAS	DAS.B Rd	1					
DEC	DEC.B Rd	1					
DIVXU	DIVXU.B Rs, Rd	1					12
EEMOV	EEMOV	2			$2n+2^{*1}$		1^{*2}
INC	INC.B Rd	1					
JMP	JMP @Rn	2					
	JMP @aa:16	2					2
	JMP @@aa:8	2	1				2
JSR	JSR @Rn	2		1			
	JSR @aa:16	2		1			2
	JSR @@aa:8	2	1	1			
LDC	LDC #xx:8, CCR	1					
	LDC Rs, CCR	1					
MOV	MOV.B #xx:8, Rd	1					
	MOV.B Rs, Rd	1					
	MOV.B @Rs, Rd	1			1		
	MOV.B @(d:16, Rs), Rd	2			1		
	MOV.B @Rs+, Rd	1			1		2
	MOV.B @aa:8, Rd	1			1		
	MOV.B @aa:16, Rd	2			1		
	MOV.B Rs, @Rd	1			1		

Instruction	Mnemonic	Instruction Fetch I	Branch Addr. Read J	Stack Operation K	Byte Data Access L	Word Data Access M	Internal Operation N
MOV	MOV.B Rs, @(d:16, Rd)	2			1		
	MOV.B Rs, @-Rd	1			1		2
	MOV.B Rs, @aa:8	1			1		
	MOV.B Rs, @aa:16	2			1		
	MOV.W #xx:16, Rd	2					
	MOV.W Rs, Rd	1					
	MOV.W @Rs, Rd	1				1	
	MOV.W @(d:16, Rs), Rd	2				1	
	MOV.W @Rs+, Rd	1				1	2
	MOV.W @aa:16, Rd	2				1	
	MOV.W Rs, @Rd	1				1	
	MOV.W Rs, @(d:16, Rd)	2				1	
	MOV.W Rs, @-Rd	1				1	2
	MOV.W Rs, @aa:16	2				1	
MULXU	MULXU.B Rs, Rd	1					12
NEG	NEG.B Rd	1					
NOP	NOP	1					
NOT	NOT.B Rd	1					
OR	OR.B #xx:8, Rd	1					
	OR.B Rs, Rd	1					
ORC	ORC #xx:8, CCR	1					
ROTL	ROTL.B Rd	1					
ROTR	ROTR.B Rd	1					
ROTXL	ROTXL.B Rd	1					
ROTXR	ROTXR.B Rd	1					
RTE	RTE	2		2			2
RTS	RTS	2		1			2
SHAL	SHAL.B Rd	1					
SHAR	SHAR.B Rd	1					
SHLL	SHLL.B Rd	1					
SHLR	SHLR.B Rd	1					
SLEEP	SLEEP	1					
STC	STC CCR, Rd	1					

Instruction	Mnemonic	Instruction Fetch I	Branch Addr. Read J	Stack Operation K	Byte Data Access L	Word Data Access M	Internal Operation N
SUB	SUB.B Rs, Rd	1					
	SUB.W Rs, Rd	1					
SUBS	SUBS.W #1, Rd	1					
	SUBS.W #2, Rd	1					
POP	POP Rd	1		1			2
PUSH	PUSH Rs	1		1			2
SUBX	SUBX.B #xx:8, Rd	1					
	SUBX.B Rs, Rd	1					
XOR	XOR.B #xx:8, Rd	1					
	XOR.B Rs, Rd	1					
XORC	XORC #xx:8, CCR	1					

- Notes:
1. n: Initial value in R4L. The source and destination operands are accessed n + 1 times each.
 2. 1 in the H8/3847R Group and 0 in the H8/3847S Group, H8/38347 Group, and H8/38447 Group.

Appendix B Internal I/O Registers

B.1 Addresses

Upper Address: H'F0

Lower Address	Register Name	Bit Names								Module Name
		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
H'20	FLMCR1	—	SWE	ESU	PSU	EV	PV	E	P	ROM
H'21	FLMCR2	FLER	—	—	—	—	—	—	—	
H'22	FLPWCR	PDWND	—	—	—	—	—	—	—	
H'23	EBR	EB7	EB6	EB5	EB4	EB3	EB2	EB1	EB0	
H'24										
H'25										
H'26										
H'27										
H'28										
H'29										
H'2A										
H'2B	FENR	FLSHE	—	—	—	—	—	—	—	
H'2C										
H'2D										
H'2E										
H'2F										

Upper Address: H'FF

Lower Address	Register Name	Bit Names								Module Name
		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
H'90	WEGR	WKEGS7	WKEGS6	WKEGS5	WKEGS4	WKEGS3	WKEGS2	WKEGS1	WKEGS0	System control
H'91	SPCR	—	—	SPC32	SPC31	SCINV3	SCINV2	SCINV1	SCINV0	SCI
H'92	CWOSR	—	—	—	—	—	—	—	CWOS	Timer A
H'93										
H'94										
H'95	ECCSR	OVH	OVL	—	CH2	CUEH	CUEL	CRCH	CRCL	Asynchronous event counter
H'96	ECH	ECH7	ECH6	ECH5	ECH4	ECH3	ECH2	ECH1	ECH0	
H'97	ECL	ECL7	ECL6	ECL5	ECL4	ECL3	ECL2	ECL1	ECL0	
H'98	SMR31	COM31	CHR31	PE31	PM31	STOP31	MP31	CKS311	CKS310	SCI31
H'99	BRR31	BRR317	BRR316	BRR315	BRR314	BRR313	BRR312	BRR311	BRR310	
H'9A	SCR31	TIE31	RIE31	TE31	RE31	MPIE31	TEIE31	CKE31	CKE310	
H'9B	TDR31	TDR317	TDR316	TDR315	TDR314	TDR313	TDR312	TDR311	TDR310	
H'9C	SSR31	TDRE31	RDRF31	OER31	FER31	PER31	TEND31	MPBR31	MPBT31	
H'9D	RDR31	RDR317	RDR316	RDR315	RDR314	RDR313	RDR312	RDR311	RDR310	
H'9E										
H'9F										
H'A0	SCR1	SNC1	SNC0	MRKON	LTCH	CKS3	CKS2	CKS1	CKS0	SCI1
H'A1	SCSR1	—	SOL	ORER	—	—	—	MTRF	STF	
H'A2	SDRU	SDRU7	SDRU6	SDRU5	SDRU4	SDRU3	SDRU2	SDRU1	SDRU0	
H'A3	SDRL	SDRL7	SDRL6	SDRL5	SDRL4	SDRL3	SDRL2	SDRL1	SDRL0	
H'A4										
H'A5										
H'A6										
H'A7										
H'A8	SMR32	COM32	CHR32	PE32	PM32	STOP32	MP32	CKS321	CKS320	SCI32
H'A9	BRR32	BRR327	BRR326	BRR325	BRR324	BR323	BRR322	BRR321	BRR320	
H'AA	SCR32	TIE32	RIE32	TE32	RE32	MPIE32	TEIE32	CKE321	CKE320	
H'AB	TDR32	TDR327	TDR326	TDR325	TDR324	TDR323	TDR322	TDR321	TDR320	
H'AC	SSR32	TDRE32	RDRF32	OER32	FER32	PER32	TEND32	MPBR32	MPBT32	
H'AD	RDR32	RDR327	RDR326	RDR325	RDR324	RDR323	RDR322	RDR321	RDR320	
H'AE										
H'AF										
H'B0	TMA	TMA7	TMA6	TMA5	—	TMA3	TMA2	TMA1	TMA0	Timer A
H'B1	TCA	TCA7	TCA6	TCA5	TCA4	TCA3	TCA2	TCA1	TCA0	

Appendix B Internal I/O Registers

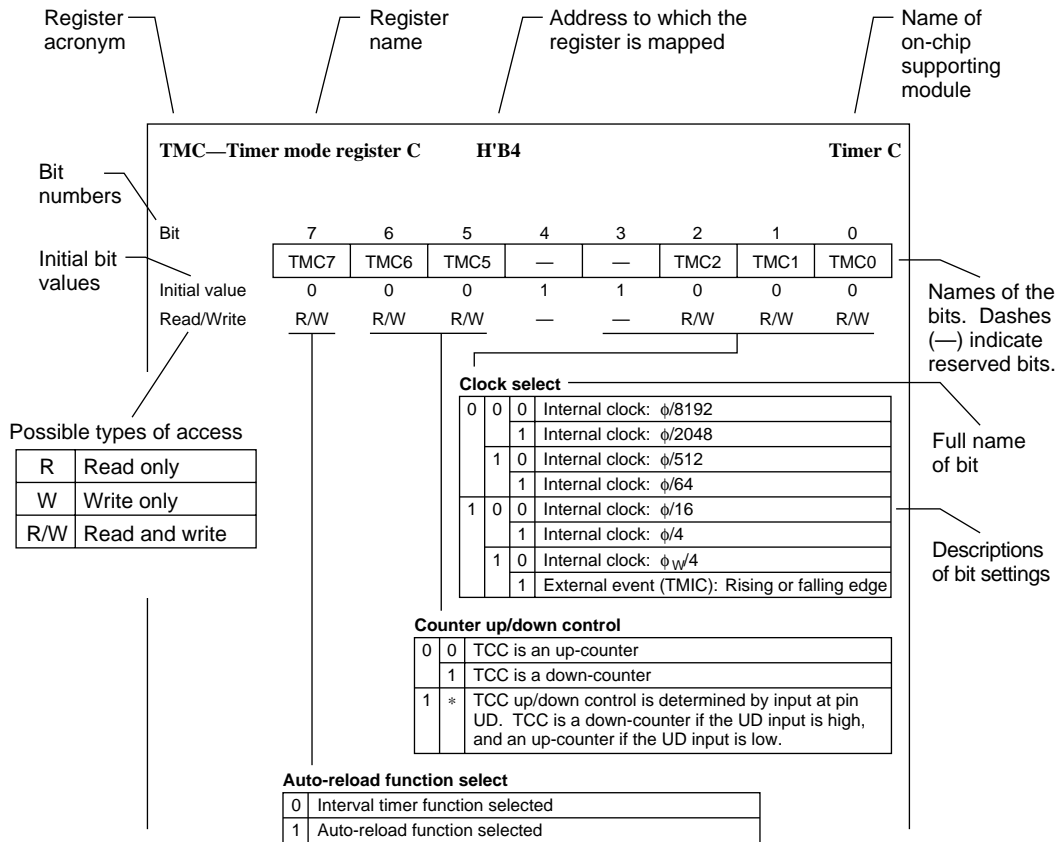
Lower Address	Register Name	Bit Names								Module Name
		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
H'B2	TCSRW	B6W1	TCWE	B4W1	TCSRWE	B2W1	WDON	BOW1	WRST	Watchdog timer
H'B3	TCW	TCW7	TCW6	TCW5	TCW4	TCW3	TCW2	TCW1	TCWO	
H'B4	TMC	TMC7	TMC6	TMC5	—	—	TMC2	TMC1	TMC0	Timer C
H'B5	TCC/ TLC	TCC/ TLC7	TCC6/ TLC6	TCC5/ TLC5	TCC4/ TLC4	TCC3/ TLC3	TCC2/ TLC2	TCC1/ TLC1	TCC0/ TLC0	Timer F
H'B6	TCRF	TOLH	CKSH2	CKSH1	CKSH0	TOLL	CKSL2	CKSL1	CKSL0	
H'B7	TCSRFB	OVFH	CMFH	OVIEH	CCLRFB	OVFL	CMFL	OVIEL	CCLRFB	Timer G
H'B8	TCFH	TCFH7	TCFH6	TCFH5	TCFH4	TCFH3	TCFH2	TCFH1	TCFH0	
H'B9	TCFL	TCFL7	TCFL6	TCFL5	TCFL4	TCFL3	TCFL2	TCFL1	TCFL0	Timer G
H'BA	OCRFB	OCRFB7	OCRFB6	OCRFB5	OCRFB4	OCRFB3	OCRFB2	OCRFB1	OCRFB0	
H'BB	OCRFL	OCRFL7	OCRFL6	OCRFL5	OCRFL4	OCRFL3	OCRFL2	OCRFL1	OCRFL0	Timer G
H'BC	TMG	OVFH	OVFL	OVIE	IIEGS	CCLR1	CCLR0	CKS1	CKS0	
H'BD	ICRGF	ICRGF7	ICRGF6	ICRGF5	ICRGF4	ICRGF3	ICRGF2	ICRGF1	ICRGF0	LCD controller/ driver
H'BE	ICRGR	ICRGR7	ICRGR6	ICRGR5	ICRGR4	ICRGR3	ICRGR2	ICRGR1	ICRGR0	
H'BF										LCD controller/ driver
H'C0	LPCR	DTS1	DTS0	CMX	SGX	SGS3	SGS2	SGS1	SGS0	
H'C1	LCR	—	PSW	ACT	DISP	CKS3	CKS2	CKS1	CKS0	LCD controller/ driver
H'C2	LCR2	LCDAB	—	—	—	CDS3	CDS2	CDS1	CDS0	
H'C3										A/D converter
H'C4	ADRRH	ADR9	ADR8	ADR7	ADR6	ADR5	ADR4	ADR3	ADR2	
H'C5	ADRRL	ADR1	ADR0	—	—	—	—	—	—	A/D converter
H'C6	AMR	CKS	TRGE	—	—	CH3	CH2	CH1	CH0	
H'C7	ADSR	ADSF	—	—	—	—	—	—	—	I/O port
H'C8	PMR1	IRQ3	IRQ2	IRQ1	IRQ4	TMIG	TMOFH	TMOFL	TMOW	
H'C9	PMR2	EXCL	—	POF1	—	—	SO1	SI1	SCK1	I/O port
H'CA	PMR3	AEVL	AEVH	WDCKS	NCS	IRQ0	RESO	UD	PWM	
H'CB	PMR4	NMOD7	NMOD6	NMOD5	NMOD4	NMOD3	NMOD2	NMOD1	NMOD0	I/O port
H'CC	PMR5	WKP7	WKP6	WKP5	WKP4	WKP3	WKP2	WKP1	WKP0	
H'CD										I/O Port
H'CE										
H'CF										Bit 14
H'D0	PWCR	—	—	—	—	—	—	PWCR1	PWCR0	
H'D1	PWDRU	—	—	PWDRU5	PWDRU4	PWDRU3	PWDRU2	PWDRU1	PWDRU0	PWM
H'D2	PWDRL	PWDRL7	PWDRL6	PWDRL5	PWDRL4	PWDRL3	PWDRL2	PWDRL1	PWDRL0	I/O Port
H'D3										
H'D4	PDR1	P1 ₇	P1 ₆	P1 ₅	P1 ₄	P1 ₃	P1 ₂	P1 ₁	P1 ₀	I/O Port
H'D5	PDR2	P2 ₇	P2 ₆	P2 ₅	P2 ₄	P2 ₃	P2 ₂	P2 ₁	P2 ₀	
H'D6	PDR3	P3 ₇	P3 ₆	P3 ₅	P3 ₄	P3 ₃	P3 ₂	P3 ₁	P3 ₀	I/O Port
H'D7	PDR4	—	—	—	—	P4 ₃	P4 ₂	P4 ₁	P4 ₀	
H'D8	PDR5	P5 ₇	P5 ₆	P5 ₅	P5 ₄	P5 ₃	P5 ₂	P5 ₁	P5 ₀	I/O Port

Lower Address	Register Name	Bit Names								Module Name
		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
H'D9	PDR6	P6 ₇	P6 ₆	P6 ₅	P6 ₄	P6 ₃	P6 ₂	P6 ₁	P6 ₀	I/O Port
H'DA	PDR7	P7 ₇	P7 ₆	P7 ₅	P7 ₄	P7 ₃	P7 ₂	P7 ₁	P7 ₀	
H'DB	PDR8	P8 ₇	P8 ₆	P8 ₅	P8 ₄	P8 ₃	P8 ₂	P8 ₁	P8 ₀	
H'DC	PDR9	P9 ₇	P9 ₆	P9 ₅	P9 ₄	P9 ₃	P9 ₂	P9 ₁	P9 ₀	
H'DD	PDRA	—	—	—	—	PA ₃	PA ₂	PA ₁	PA ₀	
H'DE	PDRB	PB ₇	PB ₆	PB ₅	PB ₄	PB ₃	PB ₂	PB ₁	PB ₀	
H'DF	PDRC	—	—	—	—	PC ₃	PC ₂	PC ₁	PC ₀	
H'E0	PUCR1	PUCR1 ₇	PUCR1 ₆	PUCR1 ₅	PUCR1 ₄	PUCR1 ₃	PUCR1 ₂	PUCR1 ₁	PUCR1 ₀	I/O Port
H'E1	PUCR3	PUCR3 ₇	PUCR3 ₆	PUCR3 ₅	PUCR3 ₄	PUCR3 ₃	PUCR3 ₂	PUCR3 ₁	PUCR3 ₀	
H'E2	PUCR5	PUCR5 ₇	PUCR5 ₆	PUCR5 ₅	PUCR5 ₄	PUCR5 ₃	PUCR5 ₂	PUCR5 ₁	PUCR5 ₀	
H'E3	PUCR6	PUCR6 ₇	PUCR6 ₆	PUCR6 ₅	PUCR6 ₄	PUCR6 ₃	PUCR6 ₂	PUCR6 ₁	PUCR6 ₀	
H'E4	PCR1	PCR1 ₇	PCR1 ₆	PCR1 ₅	PCR1 ₄	PCR1 ₃	PCR1 ₂	PCR1 ₁	PCR1 ₀	
H'E5	PCR2	PCR2 ₇	PCR2 ₆	PCR2 ₅	PCR2 ₄	PCR2 ₃	PCR2 ₂	PCR2 ₁	PCR2 ₀	
H'E6	PCR3	PCR3 ₇	PCR3 ₆	PCR3 ₅	PCR3 ₄	PCR3 ₃	PCR3 ₂	PCR3 ₁	PCR3 ₀	
H'E7	PCR4	—	—	—	—	—	PCR4 ₂	PCR4 ₁	PCR4 ₀	
H'E8	PCR5	PCR5 ₇	PCR5 ₆	PCR5 ₅	PCR5 ₄	PCR5 ₃	PCR5 ₂	PCR5 ₁	PCR5 ₀	
H'E9	PCR6	PCR6 ₇	PCR6 ₆	PCR6 ₅	PCR6 ₄	PCR6 ₃	PCR6 ₂	PCR6 ₁	PCR6 ₀	
H'EA	PCR7	PCR7 ₇	PCR7 ₆	PCR7 ₅	PCR7 ₄	PCR7 ₃	PCR7 ₂	PCR7 ₁	PCR7 ₀	
H'EB	PCR8	PCR8 ₇	PCR8 ₆	PCR8 ₅	PCR8 ₄	PCR8 ₃	PCR8 ₂	PCR8 ₁	PCR8 ₀	
H'EC	PCR9	PCR9 ₇	PCR9 ₆	PCR9 ₅	PCR9 ₄	PCR9 ₃	PCR9 ₂	PCR9 ₁	PCR9 ₀	
H'ED	PCRA	—	—	—	—	PCRA ₃	PCRA ₂	PCRA ₁	PCRA ₀	
H'EE										
H'EF										
H'F0	SYSCR1	SSBY	STS2	STS1	STS0	LSON	—	MA1	MA0	System control
H'F1	SYSCR2	—	—	—	NESEL	DTON	MSON	SA1	SA0	
H'F2	IEGR	—	—	—	IEG4	IEG3	IEG2	IEG1	IEG0	
H'F3	IENR1	IENTA	IENS1	IENWP	IEN4	IEN3	IEN2	IEN1	IEN0	
H'F4	IENR2	IENDT	IENAD	—	IENTG	IENTFH	IENTFL	IENTC	IENEC	
H'F5										
H'F6	IRR1	IRRTA	IRRS1	—	IRRI4	IRRI3	IRRI2	IRRI1	IRRI0	
H'F7	IRRI2	IRRTD	IRRAD	—	IRRTG	IRRTFH	IRRTFL	IRRTC	IRREC	
H'F8										
H'F9	IWPR	IWPF7	IWPF6	IWPF5	IWPF4	IWPF3	IWPF2	IWPF1	IWPF0	
H'FA	CKSTPR1	S1CKSTP	S31CKSTP	S32CKSTP	ADCKSTP	TGCKSTP	TFCKSTP	TCCKSTP	TACKSTP	
H'FB	CKSTPR2	—	—	—	—	AECKSTP	WDCKSTP	PWCKSTP	LDCKSTP	
H'FC										
H'FD										
H'FE										
H'FF										

Legend

SCI: Serial Communication Interface

B.2 Functions



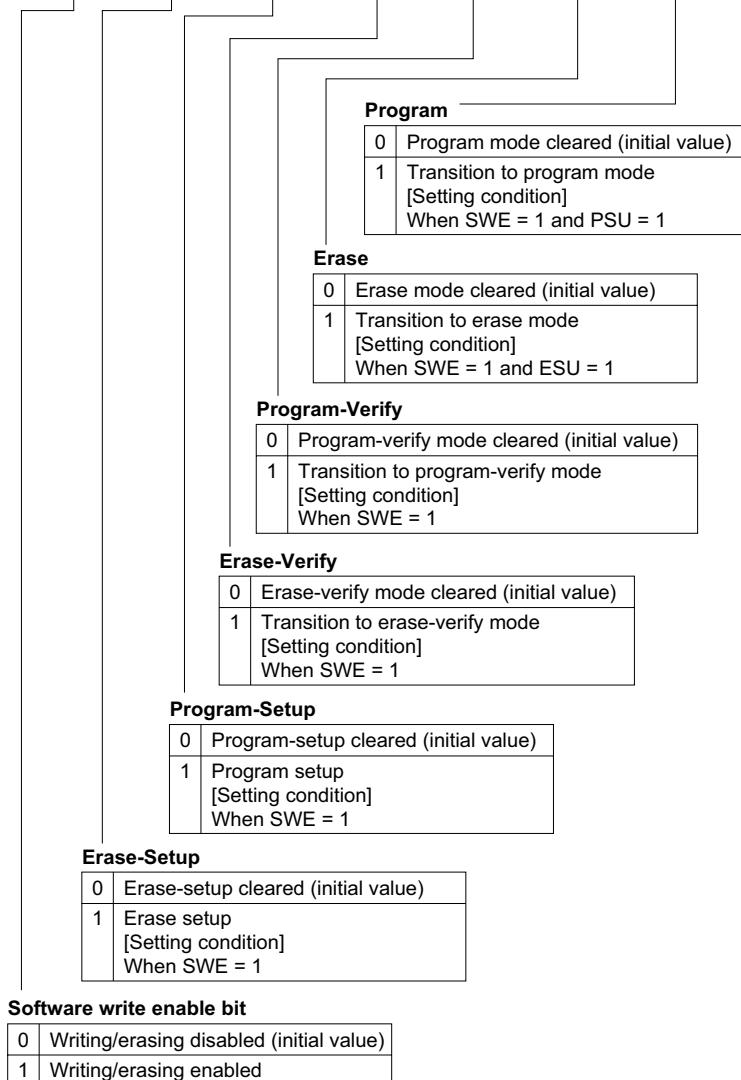
*: Don't care

FLMCR1—Flash Memory Control Register 1

H'F020

Flash Memory

Bit	7	6	5	4	3	2	1	0
	—	SWE	ESU	PSU	EV	PV	E	P
Initial value	0	0	0	0	0	0	0	0
Read/Write	—	R/W	R/W	R/W	R/W	R/W	R/W	R/W



FLMCR2—Flash Memory Control Register 2**H'F021****Flash Memory**

Bit	7	6	5	4	3	2	1	0
	FLER	—	—	—	—	—	—	—
Initial value	0	0	0	0	0	0	0	0
Read/Write	R	—	—	—	—	—	—	—

|
Flash memory error

Note: A write to FLMCR2 is prohibited.

FLPWCR—Flash Memory Power Control Register**H'F022****Flash Memory**

Bit	7	6	5	4	3	2	1	0
	PDWND	—	—	—	—	—	—	—
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	—	—	—	—	—	—	—

|
Power-down Disable

0	When the system transits to sub-active mode, the flash memory changes to low-power mode
1	When the system transits to sub-active mode, the flash memory changes to normal mode

EBR—Erase Block Register**H'F023****Flash Memory**

Bit	7	6	5	4	3	2	1	0
	EB7	EB6	EB5	EB4	EB3	EB2	EB1	EB0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Blocks 7 to 0

0	When a block of EB7 to EB0 is not selected (initial value)
1	When a block of EB7 to EB0 is selected

Note: Set the bit of EBR to H'00 when erasing.

FENR—Flash Memory Enable Register**H'F02B****Flash Memory**

Bit	7	6	5	4	3	2	1	0
	FLSHE	—	—	—	—	—	—	—
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	—	—	—	—	—	—	—

Flash Memory Control Register Enable

0	The flash memory control register cannot be accessed
1	The flash memory control register can be accessed

WEGR—Wakeup Edge Select Register**H'90****System control**

Bit	7	6	5	4	3	2	1	0
	WKEGS7	WKEGS6	WKEGS5	WKEGS4	WKEGS3	WKEGS2	WKEGS1	WKEGS0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

WKPn edge selected

0	WKPn pin falling edge detected
1	WKPn pin rising edge detected

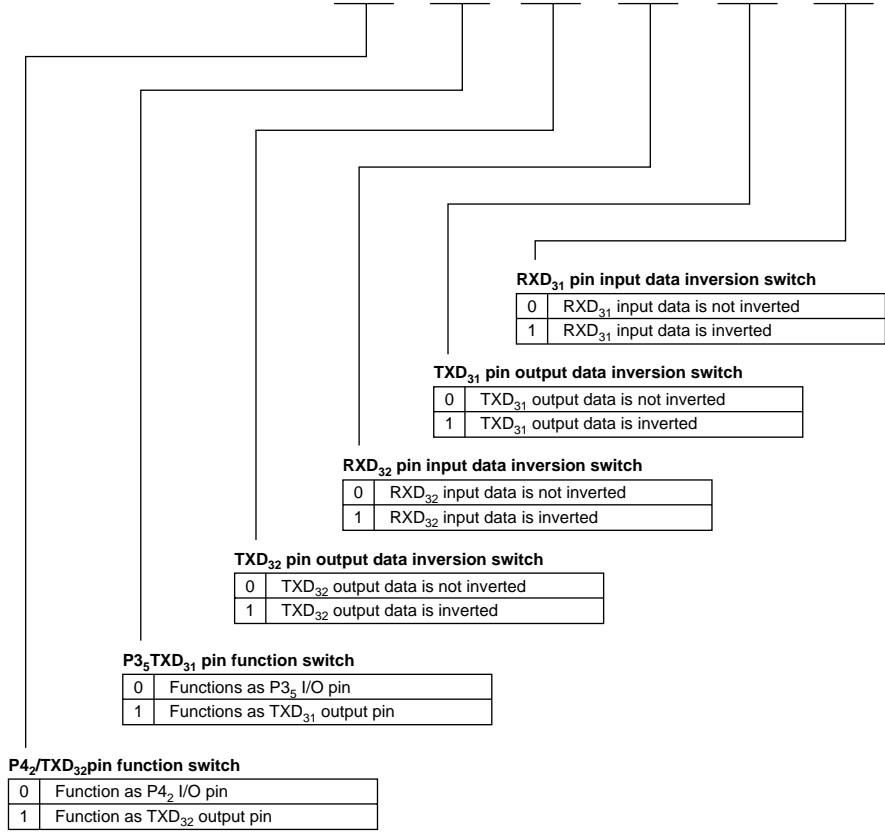
(n = 0 to 7)

SPCR—Serial Port Control Register

H'91

SCI

Bit	7	6	5	4	3	2	1	0
	—	—	SPC32	SPC31	SCINV3	SCINV2	SCINV1	SCINV0
Initial value	1	1	0	0	0	0	0	0
Read/Write	—	—	R/W	R/W	R/W	R/W	R/W	R/W



CWOSR—Subclock Output Select Register

H'92

Timer A

Bit	7	6	5	4	3	2	1	0
	—	—	—	—	—	—	—	CWOS
Initial value	1	1	1	1	1	1	1	0
Read/Write	R	R	R	R	R	R	R	R/W


TMOW pin clock select

0	Clock output from TMA is output
1	ϕ_W is output

ECCSR—Event Counter Control/Status Register

H'95

AEC

Bit	7	6	5	4	3	2	1	0
	OVH	OVL	—	CH2	CUEH	CUEL	CRCH	CRCL
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/(W)*	R/(W)*	R/W	R/W	R/W	R/W	R/W	R/W

Counter reset control L

0	ECL is reset
1	ECL reset is cleared and count-up function is enabled

Counter reset control H

0	ECH is reset
1	ECH reset is cleared and count-up function is enabled

Count-up enable L

0	ECL event clock input is disabled. ECL value is held
1	ECL event clock input is enabled

Count-up enable H

0	ECH event clock input is disabled. ECH value is held
1	ECH event clock input is enabled

Channel select

0	ECH and ECL are used together as a single-channel 16-bit event counter
1	ECH and ECL are used as two independent 8-bit event counter channels

Counter overflow L

0	ECL has not overflowed Clearing condition: After reading OVL = 1, cleared by writing 0 to OVL
1	ECL has overflowed Setting condition: Set when ECL overflows from H'FF to H'00 while CH2 is set to 1

Counter overflow H

0	ECH has not overflowed Clearing condition: After reading OVH = 1, cleared by writing 0 to OVH
1	ECH has overflowed Setting condition: Set when ECH overflows from H'FF to H'00

Note: * Only a write of 0 for clearing is possible.

ECH—Event Counter H**H'96****AEC**

Bit	7	6	5	4	3	2	1	0
	ECH7	ECH6	ECH5	ECH4	ECH3	ECH2	ECH1	ECH0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R	R	R	R	R	R	R	R

|
Count value

Note: * ECH and ECL can also be used as the upper and lower halves, respectively, of a 16-bit event counter (EC).

ECL—Event Counter L**H'97****AEC**

Bit	7	6	5	4	3	2	1	0
	ECL7	ECL6	ECL5	ECL4	ECL3	ECL2	ECL1	ECL0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R	R	R	R	R	R	R	R

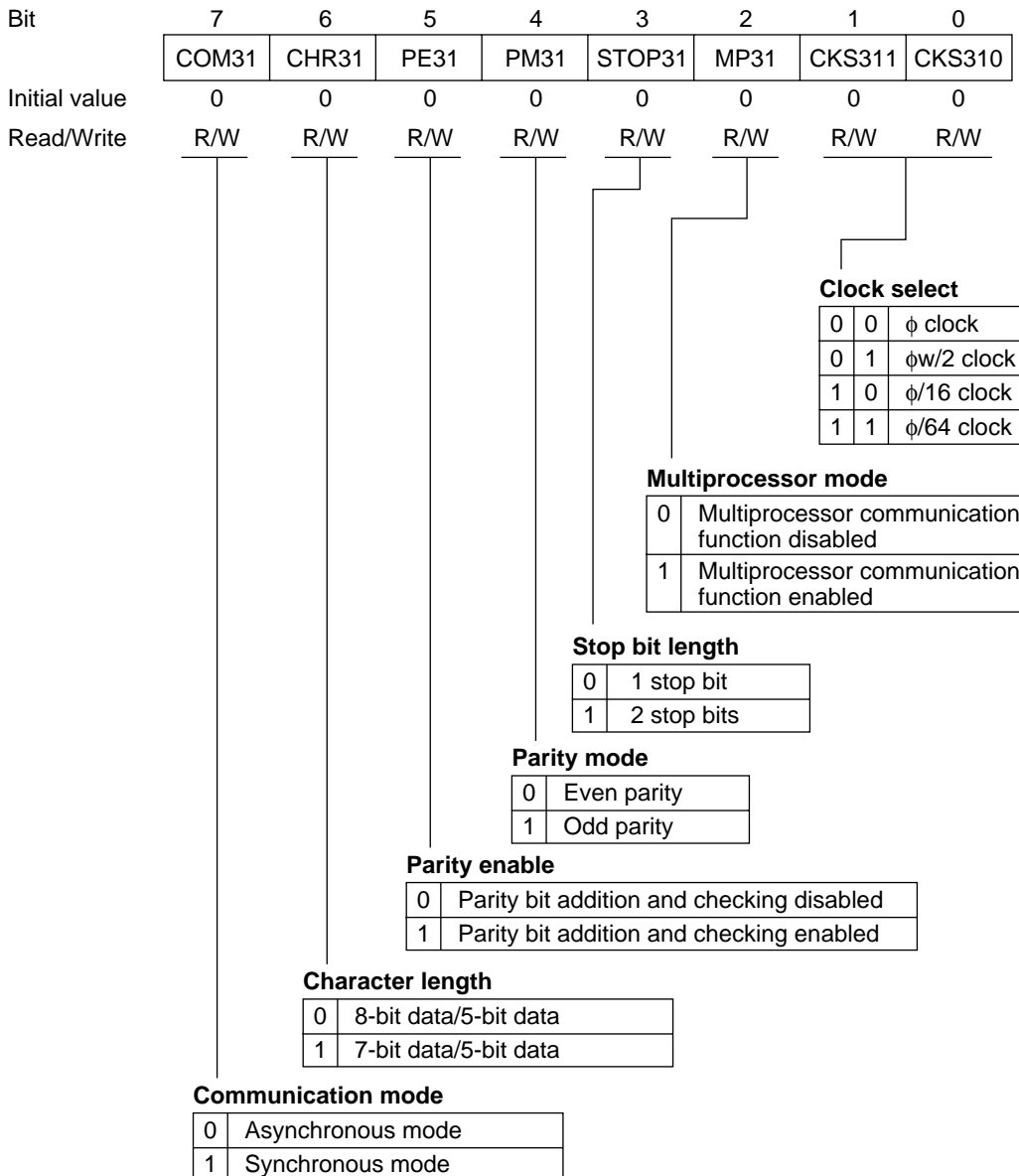
|
Count value

Note: * ECH and ECL can also be used as the upper and lower halves, respectively, of a 16-bit event counter (EC).

SMR31—Serial Mode Register 31

H'98

SCI31



BRR31—Bit Rate Register 31**H'99****SCI31**

Bit	7	6	5	4	3	2	1	0
	BRR317	BRR316	BRR315	BRR314	BRR313	BRR312	BRR311	BRR310
Initial value	1	1	1	1	1	1	1	1
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Serial transmit/receive bit rate

SCR31—Serial Control Register 31

H'9A

SCI31

Bit	7	6	5	4	3	2	1	0
	TIE31	RIE31	TE31	RE31	MPIE31	TEIE31	CKE311	CKE310
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Clock enable

Bit 1	Bit 0	Description		
CKE311	CKE310	Communication Mode	Clock Source	SCK ₃ Pin Function
		Asynchronous	Internal clock	I/O port
0	0	Synchronous	Internal clock	Serial clock output
		Asynchronous	Internal clock	Clock output
0	1	Synchronous	Reserved (Do not specify this combination)	
		Asynchronous	External clock	Clock input
1	0	Synchronous	External clock	Serial clock input
		Asynchronous	Reserved (Do not specify this combination)	
1	1	Asynchronous	Reserved (Do not specify this combination)	
		Synchronous	Reserved (Do not specify this combination)	

Transmit end interrupt enable

0	Transmit end interrupt request (TEI) disabled
1	Transmit end interrupt request (TEI) enabled

Multiprocessor interrupt enable

0	Multiprocessor interrupt request disabled (normal receive operation) [Clearing condition] When data is received in which the multiprocessor bit is set to 1
1	Multiprocessor interrupt request enabled The receive interrupt request (RXI), receive error interrupt request (ERI), and setting of the RDRF, FER, and OER flags in the serial status register (SSR), are disabled until data with the multiprocessor bit set to 1 is received.

Receive enable

0	Receive operation disabled (RXD pin is I/O port)
1	Receive operation enabled (RXD pin is receive data pin)

Transmit enable

0	Transmit operation disabled (TXD pin is transmit data pin)
1	Transmit operation enabled (TXD pin is transmit data pin)

Receive interrupt enable

0	Receive data full interrupt request (RXI) and receive error interrupt request (ERI) disabled
1	Receive data full interrupt request (RXI) and receive error interrupt request (ERI) enabled

Transmit interrupt enable

0	Transmit data empty interrupt request (TXI) disabled
1	Transmit data empty interrupt request (TXI) enabled

TDR31—Transmit Data Register 31**H'9B****SCI31**

Bit	7	6	5	4	3	2	1	0
	TDR317	TDR316	TDR315	TDR314	TDR313	TDR312	TDR311	TDR310
Initial value	1	1	1	1	1	1	1	1
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

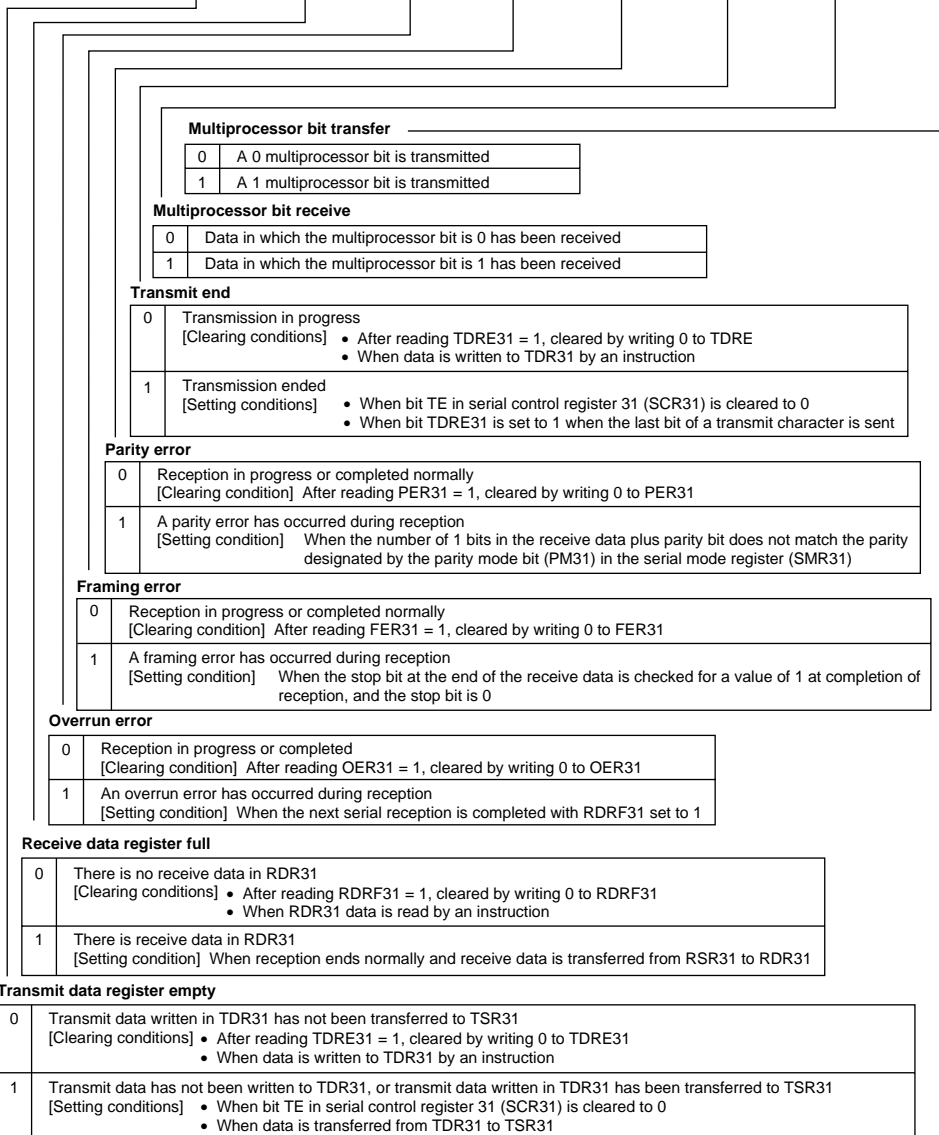
Data for transfer to TSR

SSR31—Serial Status Register31

H'9C

SCI3

Bit	7	6	5	4	3	2	1	0
	TDRE31	RDRF31	OER31	FER31	PER31	TEND31	MPBR31	MPBT31
Initial value	1	0	0	0	0	1	0	0
Read/Write	R/(W)*	R/(W)*	R/(W)*	R/(W)*	R/(W)*	R	R	R/W



Note: * Only a write of 0 for flag clearing is possible.

RDR31—Receive Data Register 31**H'9D****SCI31**

Bit	7	6	5	4	3	2	1	0
	RDR317	RDR316	RDR315	RDR314	RDR313	RDR312	RDR311	RDR310
Initial value	0	0	0	0	0	0	0	0
Read/Write	R	R	R	R	R	R	R	R

Serial receiving data are stored

SCR1—Serial Control Register 1

H'A0

SCI1

Bit	7	6	5	4	3	2	1	0
	SNC1	SNC0	MRKON	LTCH	CKS3	CKS2	CKS1	CKS0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Clock select 2 to 0

Bit 2	Bit 1	Bit 0	Prescaler Division Ratio	Serial Clock Cycle Clock Cycle $\phi = 2.5$ MHz
CKS2	CKS1	CKS0		
0	0	0	$\phi/1024$	409.6 μ s
0	0	1	$\phi/256$	102.4 μ s
0	1	0	$\phi/64$	25.6 μ s
0	1	1	$\phi/32$	12.8 μ s
1	0	0	$\phi/16$	6.4 μ s
1	0	1	$\phi/8$	3.2 μ s
1	1	0	$\phi/4$	1.6 μ s
1	1	1	$\phi_W/4$	122 μ s

Clock source select

0	Clock source is prescaler S, SCK ₁ is output pin
1	Clock source is external clock, SCK ₁ is input pin

LATCH TAIL select

0	HOLD TAIL is output
1	LATCH TAIL is output

Tail mark control

0	Tail mark is not output (synchronous mode)
1	Tail mark is output (SSB mode)

Operating mode select

0	0	8-bit synchronous mode
	1	16-bit synchronous mode
1	0	Continuous clock output mode
	1	Reserved

SCSR1—Serial Control Status Register 1

H'A1

SCI1

Bit	7	6	5	4	3	2	1	0
	—	SOL	ORER	—	—	—	MTRF	STF
Initial value	1	0	0	1	1	1	0	0
Read/Write	—	R/W	R/(W)*	—	—	—	R	R/W

Start flag

0	Read	Transfer operation stopped
	Write	Invalid
1	Read	Transfer operation in progress
	Write	Starts transfer operation

Tail mark transmission flag

0	Idle state, or 8-bit/16-bit data transfer in progress
1	Tail mark transmission in progress

Overrun error flag

0	[Clearing condition] After reading ORER = 1, cleared by writing 0 to ORER
1	[Setting condition] When an external clock is used and the clock is input after transfer is completed

Extension data bit

0	Read	SO ₁ pin output level is low
	Write	Changes SO ₁ pin output to low level
1	Read	SO ₁ pin output level is high
	Write	Changes SO ₁ pin output to high level

Note: * Only a write of 0 for flag clearing is possible.

SDRU—Serial Data Register U**H'A2****SCI1**

Bit	7	6	5	4	3	2	1	0
	SDRU7	SDRU6	SDRU5	SDRU4	SDRU3	SDRU2	SDRU1	SDRU0
Initial value	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Used for transmit data setting and receive data storage

8-bit transfer mode: Not used

16-bit transfer mode: Upper 8 bits of data register

SDRL—Serial Data Register L**H'A3****SCI1**

Bit	7	6	5	4	3	2	1	0
	SDRL7	SDRL6	SDRL5	SDRL4	SDRL3	SDRL2	SDRL1	SDRL0
Initial value	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Used for transmit data setting and receive data storage

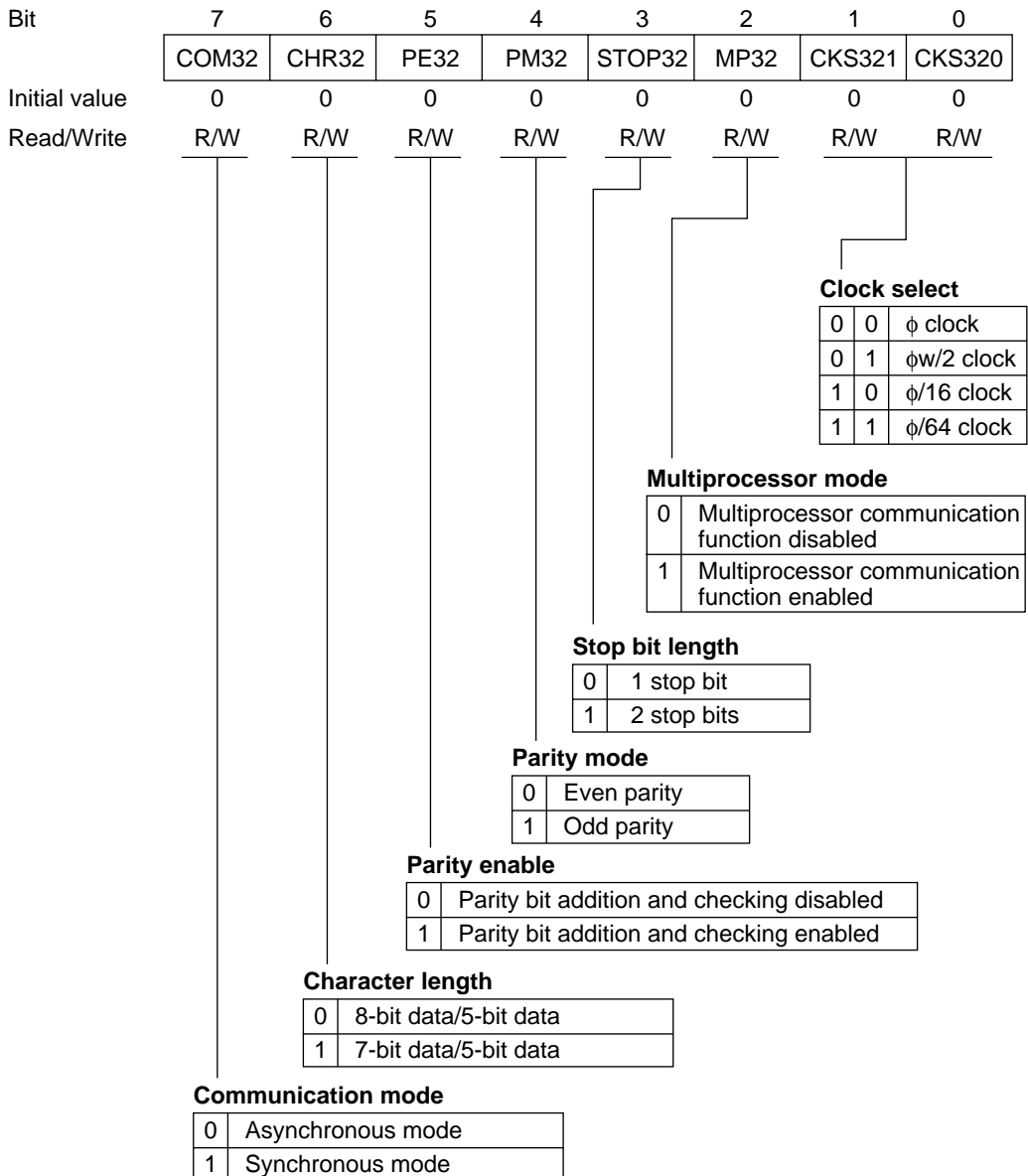
8-bit transfer mode: Data register

16-bit transfer mode: Lower 8 bits of data register

SMR32—Serial Mode Register 32

H'A8

SCI32



BRR32—Bit Rate Register 32**H'A9****SCI32**

Bit	7	6	5	4	3	2	1	0
	BRR327	BRR326	BRR325	BRR324	BRR323	BRR322	BRR321	BRR3120
Initial value	1	1	1	1	1	1	1	1
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Serial transmit/receive bit rate

SCR32—Serial Control Register 32

H'AA

SCI32

Bit	7	6	5	4	3	2	1	0
	TIE32	RIE32	TE32	RE32	MPIE32	TEIE32	CKE321	CKE320
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Clock enable

Bit 1	Bit 0	Description		
CKE321	CKE320	Communication Mode	Clock Source	SCK ₃ Pin Function
0	0	Asynchronous	Internal clock	I/O port
		Synchronous	Internal clock	Serial clock output
0	1	Asynchronous	Internal clock	Clock output
		Synchronous	Reserved (Do not specify this combination)	
1	0	Asynchronous	External clock	Clock input
		Synchronous	External clock	Serial clock input
1	1	Asynchronous	Reserved (Do not specify this combination)	
		Synchronous	Reserved (Do not specify this combination)	

Transmit end interrupt enable

0	Transmit end interrupt request (TEI) disabled
1	Transmit end interrupt request (TEI) enabled

Multiprocessor interrupt enable

0	Multiprocessor interrupt request disabled (normal receive operation) [Clearing condition] When data is received in which the multiprocessor bit is set to 1
1	Multiprocessor interrupt request enabled The receive interrupt request (RXI), receive error interrupt request (ERI), and setting of the RDRF, FER, and OER flags in the serial status register (SSR), are disabled until data with the multiprocessor bit set to 1 is received.

Receive enable

0	Receive operation disabled (RXD pin is I/O port)
1	Receive operation enabled (RXD pin is receive data pin)

Transmit enable

0	Transmit operation disabled (TXD pin is transmit data pin)
1	Transmit operation enabled (TXD pin is transmit data pin)

Receive interrupt enable

0	Receive data full interrupt request (RXI) and receive error interrupt request (ERI) disabled
1	Receive data full interrupt request (RXI) and receive error interrupt request (ERI) enabled

Transmit interrupt enable

0	Transmit data empty interrupt request (TXI) disabled
1	Transmit data empty interrupt request (TXI) enabled

TDR32—Transmit Data Register 32**H'AB****SCI32**

Bit	7	6	5	4	3	2	1	0
	TDR327	TDR326	TDR325	TDR324	TDR323	TDR322	TDR321	TDR320
Initial value	1	1	1	1	1	1	1	1
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Data for transfer to TSR

SSR32—Serial Status Register 32

H'AC

SCI32

Bit	7	6	5	4	3	2	1	0
	TDRE32	RDRF32	OER32	FER32	PER32	TEND32	MPBR32	MPBT32
Initial value	1	0	0	0	0	1	0	0
Read/Write	R/(W)*	R/(W)*	R/(W)*	R/(W)*	R/(W)*	R	R	R/W

Multiprocessor bit transfer	
0	A 0 multiprocessor bit is transmitted
1	A 1 multiprocessor bit is transmitted
Multiprocessor bit receive	
0	Data in which the multiprocessor bit is 0 has been received
1	Data in which the multiprocessor bit is 1 has been received
Transmit end	
0	Transmission in progress [Clearing conditions] <ul style="list-style-type: none"> After reading TDRE32 = 1, cleared by writing 0 to TDRE32 When data is written to TDR32 by an instruction
1	Transmission ended [Setting conditions] <ul style="list-style-type: none"> When bit TE in serial control register 32 (SCR32) is cleared to 0 When bit TDRE32 is set to 1 when the last bit of a transmit character is sent
Parity error	
0	Reception in progress or completed normally [Clearing condition] After reading PER32 = 1, cleared by writing 0 to PER32
1	A parity error has occurred during reception [Setting condition] When the number of 1 bits in the receive data plus parity bit does not match the parity designated by the parity mode bit (PM32) in the serial mode register (SMR32)
Framing error	
0	Reception in progress or completed normally [Clearing condition] After reading FER32 = 1, cleared by writing 0 to FER32
1	A framing error has occurred during reception [Setting condition] When the stop bit at the end of the receive data is checked for a value of 1 at completion of reception, and the stop bit is 0
Overrun error	
0	Reception in progress or completed [Clearing condition] After reading OER32 = 1, cleared by writing 0 to OER32
1	An overrun error has occurred during reception [Setting condition] When the next serial reception is completed with RDRF32 set to 1
Receive data register full	
0	There is no receive data in RDR32 [Clearing conditions] <ul style="list-style-type: none"> After reading RDRF32 = 1, cleared by writing 0 to RDRF32 When RDR32 data is read by an instruction
1	There is receive data in RDR32 [Setting condition] When reception ends normally and receive data is transferred from RSR32 to RDR32
Transmit data register empty	
0	Transmit data written in TDR32 has not been transferred to TSR32 [Clearing conditions] <ul style="list-style-type: none"> After reading TDRE32 = 1, cleared by writing 0 to TDRE32 When data is written to TDR32 by an instruction
1	Transmit data has not been written to TDR32, or transmit data written in TDR32 has been transferred to TSR32 [Setting conditions] <ul style="list-style-type: none"> When bit TE32 in serial control register 32 (SCR32) is cleared to 0 When data is transferred from TDR32 to TSR32

Note: * Only a write of 0 for flag clearing is possible.

RDR32—Receive Data Register 32**H'AD****SCI32**

Bit	7	6	5	4	3	2	1	0
	RDR327	RDR326	RDR325	RDR324	RDR323	RDR322	RDR321	RDR320
Initial value	0	0	0	0	0	0	0	0
Read/Write	R	R	R	R	R	R	R	R

Serial receiving data are stored

TMA—Timer Mode Register A

H'B0

Timer A

Bit	7	6	5	4	3	2	1	0
	TMA7	TMA6	TMA5	—	TMA3	TMA2	TMA1	TMA0
Initial value	0	0	0	1	0	0	0	0
Read/Write	R/W	R/W	R/W	—	R/W	R/W	R/W	R/W

Clock output select*

0	0	0	$\phi/32$
0	0	1	$\phi/16$
0	1	0	$\phi/8$
0	1	1	$\phi/4$
1	0	0	$\phi_W/32$
1	0	1	$\phi_W/16$
1	1	0	$\phi_W/8$
1	1	1	$\phi_W/4$

Internal clock select

TMA3	TMA2	TMA1	TMA0	Prescaler and Divider Ratio or Overflow Period	Function
0	0	0	0	PSS $\phi/8192$	Interval timer
0	0	0	1	PSS $\phi/4096$	
0	0	1	0	PSS $\phi/2048$	
0	0	1	1	PSS $\phi/512$	
0	1	0	0	PSS $\phi/256$	
0	1	0	1	PSS $\phi/128$	
0	1	1	0	PSS $\phi/32$	
0	1	1	1	PSS $\phi/8$	
1	0	0	0	PSW 1 s	Time base (when using 32.768 kHz)
1	0	0	1	PSW 0.5 s	
1	0	1	0	PSW 0.25 s	
1	0	1	1	PSW 0.03125 s	
1	1	0	0	PSW and TCA are reset	
1	1	0	1		
1	1	1	0		
1	1	1	1		

Note * Values when the CWOS bit in CWOSR is cleared to 0. When the CWOS bit is set to 1, ϕ_w is output regardless of the value of bits TMA7 to TMA5.

TCA—Timer Counter A

H'B1

Timer A

Bit	7	6	5	4	3	2	1	0
	TCA7	TCA6	TCA5	TCA4	TCA3	TCA2	TCA1	TCA0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R	R	R	R	R	R	R	R

|
Count value

TCSRW—Timer Control/Status Register W

H'B2

Watchdog timer

Bit	7	6	5	4	3	2	1	0
	B6WI	TCWE	B4WI	TCSRWE	B2WI	WDON	B0WI	WRST
Initial value	1	0	1	0	1	0	1	0
Read/Write	R	R/(W)*	R	R/(W)*	R	R/(W)*	R	R/(W)*

Watchdog timer reset

0	[Clearing conditions]
	<ul style="list-style-type: none"> Reset by RES pin When TCSRWE = 1, and 0 is written in both B0WI and WRST
1	[Setting condition]
	When TCW overflows and a reset signal is generated

Bit 0 write inhibit

0	Bit 0 is write-enabled
1	Bit 0 is write-protected

Watchdog timer on

0	Watchdog timer operation is disabled
1	Watchdog timer operation is enabled

Bit 2 write inhibit

0	Bit 2 is write-enabled
1	Bit 2 is write-protected

Timer control/status register W write enable

0	Data cannot be written to bits 2 and 0
1	Data can be written to bits 2 and 0

Bit 4 write inhibit

0	Bit 4 is write-enabled
1	Bit 4 is write-protected

Timer counter W write enable

0	Data cannot be written to TCW
1	Data can be written to TCW

Bit 6 write inhibit

0	Bit 6 is write-enabled
1	Bit 6 is write-protected

Note: * Write is permitted only under certain conditions.

TCW—Timer Counter W**H'B3****Watchdog timer**

Bit	7	6	5	4	3	2	1	0
	TCW7	TCW6	TCW5	TCW4	TCW3	TCW2	TCW1	TCW0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Count value

TMC—Timer Mode Register C**H'B4****Timer C**

Bit	7	6	5	4	3	2	1	0
	TMC7	TMC6	TMC5	—	—	TMC2	TMC1	TMC0
Initial value	0	0	0	1	1	0	0	0
Read/Write	R/W	R/W	R/W	—	—	R/W	R/W	R/W

Clock select

0	0	0	Internal clock: $\phi/8192$
0	0	1	Internal clock: $\phi/2048$
0	1	0	Internal clock: $\phi/512$
0	1	1	Internal clock: $\phi/64$
1	0	0	Internal clock: $\phi/16$
1	0	1	Internal clock: $\phi/4$
1	1	0	Internal clock: $\phi_w/4$
1	1	1	External event (TMIC): Counting on rising or falling edge

Counter up/down control

0	0	TCC is an up-counter
0	1	TCC is a down-counter
1	*	Hardware control of TCC up/down operation by UD pin input UD pin input high: Down-counter UD pin input low: Up-counter

Auto-reload function select

* Don't care

0	Interval timer function selected
1	Auto-reload function selected

TCC—Timer Counter C **H'B5** **Timer C**

Bit	7	6	5	4	3	2	1	0
	TCC7	TCC6	TCC5	TCC4	TCC3	TCC2	TCC1	TCC0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R	R	R	R	R	R	R	R

|
Count value

Note: TCC is assigned to the same address as TLC. In a read, the TCC value is read.

TLC—Timer Load Register C **H'B5** **Timer C**

Bit	7	6	5	4	3	2	1	0
	TLC7	TLC6	TLC5	TLC4	TLC3	TLC2	TLC1	TLC0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

|
Reload value

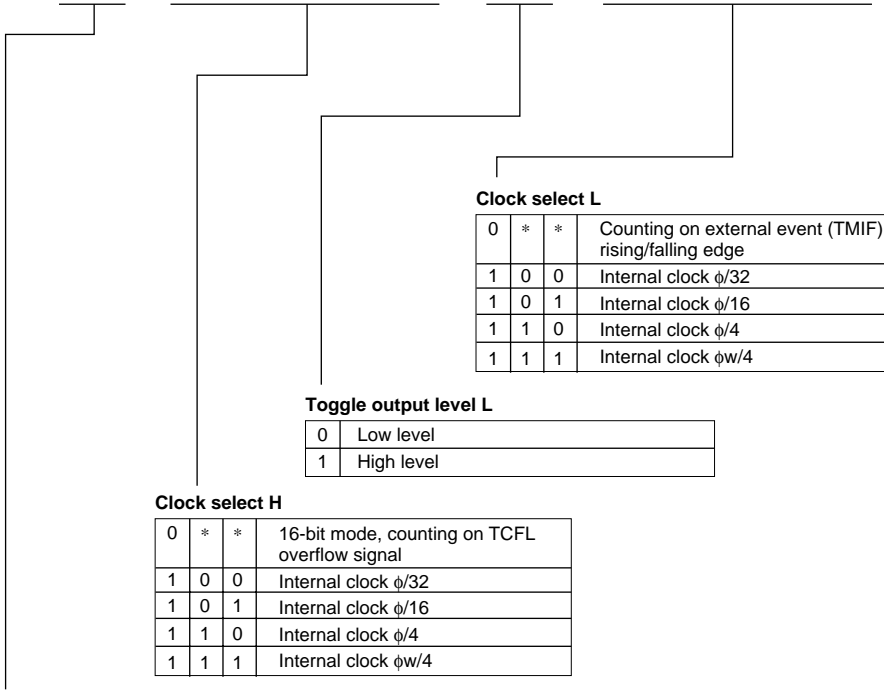
Note: TLC is assigned to the same address as TCC. In a write, the TLC value is written.

TCRF—Timer Control Register F

H'B6

Timer F

Bit	7	6	5	4	3	2	1	0
	TOLH	CKSH2	CKSH1	CKSH0	TOLL	CKSL2	CKSL1	CKSL0
Initial value	0	0	0	0	0	0	0	0
Read/Write	W	W	W	W	W	W	W	W



Clock select L

0	*	*	Counting on external event (TMIF) rising/falling edge
1	0	0	Internal clock $\phi/32$
1	0	1	Internal clock $\phi/16$
1	1	0	Internal clock $\phi/4$
1	1	1	Internal clock $\phi w/4$

Toggle output level L

0	Low level
1	High level

Clock select H

0	*	*	16-bit mode, counting on TCFL overflow signal
1	0	0	Internal clock $\phi/32$
1	0	1	Internal clock $\phi/16$
1	1	0	Internal clock $\phi/4$
1	1	1	Internal clock $\phi w/4$

Toggle output level H

0	Low level
1	High level

* Don't care



TCSRFB—Timer Control/Status Register F

H'B7

Timer F

Bit	7	6	5	4	3	2	1	0
	OVFH	CMFH	OVIEH	CCLRH	OVFL	CMFL	OVIEL	CCLRL
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/(W)*	R/(W)*	R/W	R/W	R/(W)*	R/(W)*	R/W	R/W

Counter clear L

0	TCFL clearing by compare match is disabled
1	TCFL clearing by compare match is enabled

Timer overflow interrupt enable L

0	TCFL overflow interrupt request is disabled
1	TCFL overflow interrupt request is enabled

Compare match flag L

0	[Clearing condition] After reading CMFL = 1, cleared by writing 0 to CMFL
1	[Setting condition] Set when the TCFL value matches the OCRFL value

Timer overflow flag L

0	[Clearing condition] After reading OVFL = 1, cleared by writing 0 to OVFL
1	[Setting condition] Set when TCFL overflows from H'FF to H'00

Counter clear H

0	16-bit mode: TCF clearing by compare match is disabled 8-bit mode: TCFH clearing by compare match is disabled
1	16-bit mode: TCF clearing by compare match is enabled 8-bit mode: TCFH clearing by compare match is enabled

Timer overflow interrupt enable H

0	TCFH overflow interrupt request is disabled
1	TCFH overflow interrupt request is enabled

Compare match flag H

0	[Clearing condition] After reading CMFH = 1, cleared by writing 0 to CMFH
1	[Setting condition] Set when the TCFH value matches the OCRFH value

Timer overflow flag H

0	[Clearing condition] After reading OVFH = 1, cleared by writing 0 to OVFH
1	[Setting condition] Set when TCFH overflows from H'FF to H'00

Note: * Bits 7, 6, 3, and 2 can only be written with 0, for flag clearing.

TCFH—8-Bit Timer Counter FH**H'B8****Timer F**

Bit	7	6	5	4	3	2	1	0
	TCFH7	TCFH6	TCFH5	TCFH4	TCFH3	TCFH2	TCFH1	TCFH0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Count value

Note: TCFH and TCFL can also be used as the upper and lower halves, respectively, of a 16-bit timer counter (TCF).

TCFL—8-Bit Timer Counter FL**H'B9****Timer F**

Bit	7	6	5	4	3	2	1	0
	TCFL7	TCFL6	TCFL5	TCFL4	TCFL3	TCFL2	TCFL1	TCFL0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Count value

Note: TCFH and TCFL can also be used as the upper and lower halves, respectively, of a 16-bit timer counter (TCF).

OCRFH—Output Compare Register FH**H'BA****Timer F**

Bit	7	6	5	4	3	2	1	0
	OCRFH7	OCRFH6	OCRFH5	OCRFH4	OCRFH3	OCRFH2	OCRFH1	OCRFH0
Initial value	1	1	1	1	1	1	1	1
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Note: OCRFH and OCRFL can also be used as the upper and lower halves, respectively, of a 16-bit output compare register (OCRF).

OCRFL—Output Compare Register FL**H'BB****Timer F**

Bit	7	6	5	4	3	2	1	0
	OCRFL7	OCRFL6	OCRFL5	OCRFL4	OCRFL3	OCRFL2	OCRFL1	OCRFL0
Initial value	1	1	1	1	1	1	1	1
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Note: OCRFH and OCRFL can also be used as the upper and lower halves, respectively, of a 16-bit output compare register (OCRF).

TMG—Timer Mode Register G

H'BC

Timer G

Bit	7	6	5	4	3	2	1	0
	OVFH	OVFL	OVIE	IIEGS	CCLR1	CCLR0	CKS1	CKS0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/(W)*	R/(W)*	W	W	W	W	W	W

Clock select		
0	0	Internal clock: counting on $\phi/64$
0	1	Internal clock: counting on $\phi/32$
1	0	Internal clock: counting on $\phi/2$
1	1	Internal clock: counting on $\phi w/4$

Counter clear		
0	0	TCG clearing is disabled
0	1	TCG cleared by falling edge of input capture input signal
1	0	TCG cleared by rising edge of input capture input signal
1	1	TCG cleared by both edges of input capture input signal

Input capture interrupt edge select	
0	Interrupt generated on rising edge of input capture input signal
1	Interrupt generated on falling edge of input capture input signal

Timer overflow interrupt enable	
0	TCG overflow interrupt request is disabled
1	TCG overflow interrupt request is enabled

Timer overflow flag L	
0	[Clearing condition] After reading OVFL = 1, cleared by writing 0 to OVFL
1	[Setting condition] Set when TCG overflows from H'FF to H'00

Timer overflow flag H	
0	[Clearing condition] After reading OVFH = 1, cleared by writing 0 to OVFH
1	[Setting condition] Set when TCG overflows from H'FF to H'00

Note: * Bits 7 and 6 can only be written with 0, for flag clearing.

ICRGF—Input Capture Register GF**H'BD****Timer G**

Bit	7	6	5	4	3	2	1	0
	ICRGF7	ICRGF6	ICRGF5	ICRGF4	ICRGF3	ICRGF2	ICRGF1	ICRGF0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R	R	R	R	R	R	R	R

Stores TCG value at falling edge of input capture signal

ICRGR—Input Capture Register GR**H'BE****Timer G**

Bit	7	6	5	4	3	2	1	0
	ICRGR7	ICRGR6	ICRGR5	ICRGR4	ICRGR3	ICRGR2	ICRGR1	ICRGR0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R	R	R	R	R	R	R	R

Stores TCG value at rising edge of input capture signal

LPCR—LCD Port Control Register

H'C0 LCD controller/driver

Bit	7	6	5	4	3	2	1	0
	DTS1	DTS0	CMX	SGX	SGS3	SGS2	SGS1	SGS0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Segment driver select

Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Function of Pins SEG ₃₂ to SEG ₁					Notes
SGX	SGS3	SGS2	SGS1	SGS0	SEG ₄₀ to SEG ₃₃	SEG ₃₂ to SEG ₂₅	SEG ₂₄ to SEG ₁₇	SEG ₁₆ to SEG ₉	SEG ₈ to SEG ₁	
0	0	0	0	0	Port	Port	Port	Port	Port	(Initial value)
0	0	0	0	1	SEG	Port	Port	Port	Port	
0	0	0	1	*	SEG	SEG	Port	Port	Port	
0	0	1	0	*	SEG	SEG	SEG	Port	Port	
0	0	1	1	*	SEG	SEG	SEG	SEG	Port	
0	1	*	*	*	SEG	SEG	SEG	SEG	SEG	
1	0	0	0	0	Port* ¹	Port	Port	Port	Port	
1	0	0	0	1	Do not use					
1	0	0	1	*						
1	0	1	*	*						
1	1	*	*	*						

Note: 1. SEG₄₀ to SEG₃₇ are external expansion pins.

*: Don't care

Expansion signal select

0	SEG ₄₀ to SEG ₃₇ pin* (Initial value)
1	CL ₁ , CL ₂ , DO and M pin

Note: * Functions as ports when SGS3 to SGS0 are set at "0000".

In the case of the H8/38347 Group and H8/38447 Group the initial values of these bits must not be changed.

Duty select, common function select

Bit 7	Bit 6	Bit 5	Duty Cycle	Common Drivers	Notes
DTS1	DTS0	CMX			
0	0	0	Static	COM ₁	Do not use COM ₄ , COM ₃ , and COM ₂
0	0	1		COM ₄ to COM ₁	COM ₄ to COM ₂ output the same waveform as COM ₁
0	1	0	1/2 duty	COM ₂ to COM ₁	Do not use COM ₄ and COM ₃
0	1	1		COM ₄ to COM ₁	COM ₄ outputs the same waveform as COM ₃ and COM ₂ outputs the same waveform as COM ₁
1	0	0	1/3 duty	COM ₃ to COM ₁	Do not use COM ₄
1	0	1		COM ₄ to COM ₁	Do not use COM ₄
1	1	0	1/4 duty	COM ₄ to COM ₁	—
1	1	1			

LCR—LCD Control Register

H'C1 LCD controller/driver

Bit	7	6	5	4	3	2	1	0
	—	PSW	ACT	DISP	CKS3	CKS2	CKS1	CKS0
Initial value	1	0	0	0	0	0	0	0
Read/Write	—	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Frame frequency select

Bit 3	Bit 2	Bit 1	Bit 1	Operating Clock
CKS3	CKS2	CKS1	CKS0	
0	*	0	0	ϕ_w
0	*	0	1	$\phi_w/2$
0	*	1	*	$\phi_w/4$
1	0	0	0	$\phi/2$
1	0	0	1	$\phi/4$
1	0	1	0	$\phi/8$
1	0	1	1	$\phi/16$
1	1	0	0	$\phi/32$
1	1	0	1	$\phi/64$
1	1	1	0	$\phi/128$
1	1	1	1	$\phi/256$

* Don't care

Display data control

0	Blank data is displayed
1	LCD RAM data is displayed

Display function activate

0	LCD controller/driver operation halted
1	LCD controller/driver operates

LCD drive power supply on/off control

0	LCD drive power supply off
1	LCD drive power supply on

LCR2—LCD Control Register 2

H'C2

LCD

Bit	7	6	5	4	3	2	1	0
	LCDAB	\bar{N}	\bar{N}	\bar{N}	CDS3	CDS2	CDS1	CDS0
Initial value	0	1	1	0	0	0	0	0
Read/Write	R/W	\bar{N}	\bar{N}	R/W	R/W	R/W	R/W	R/W

Charge/discharge pulse duty cycle select

Bit 3	Bit 2	Bit 1	Bit 0	Duty Cycle
CDS3	CDS2	CDS1	CDS0	
0	0	0	0	1
0	0	0	1	1/8
0	0	1	0	2/8
0	0	1	1	3/8
0	1	0	0	4/8
0	1	0	1	5/8
0	1	1	0	6/8
0	1	1	1	0
1	0	*	*	1/16
1	1	*	*	1/32

* Don't care

A waveform/B waveform switching control

0	Drive using A waveform
1	Drive using B waveform

ADRRH—A/D Result Register H**H'C4****A/D converter****ADRRL—A/D Result Register L****H'C5**

ADRRH

Bit	7	6	5	4	3	2	1	0
	ADR9	ADR8	ADR7	ADR6	ADR5	ADR4	ADR3	ADR2
Initial value	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined	Undefined
Read/Write	R	R	R	R	R	R	R	R

A/D conversion result

ADRRL

Bit	7	6	5	4	3	2	1	0
	ADR1	ADR0	—	—	—	—	—	—
Initial value	Undefined	Undefined	—	—	—	—	—	—
Read/Write	R	R	—	—	—	—	—	—

A/D conversion result

AMR—A/D Mode Register

H'C6

A/D converter

Bit	7	6	5	4	3	2	1	0
	CKS	TRGE	—	—	CH3	CH2	CH1	CH0
Initial value	0	0	1	1	0	0	0	0
Read/Write	R/W	R/W	—	—	R/W	R/W	R/W	R/W

Channel select

Bit 3	Bit 2	Bit 1	Bit 0	Analog Input Channel
CH3	CH2	CH1	CH0	
0	0	*	*	No channel selected
0	1	0	0	AN ₀
0	1	0	1	AN ₁
0	1	1	0	AN ₂
0	1	1	1	AN ₃
1	0	0	0	AN ₄
1	0	0	1	AN ₅
1	0	1	0	AN ₆
1	0	1	1	AN ₇
1	1	0	0	AN ₈
1	1	0	1	AN ₉
1	1	1	0	AN ₁₀
1	1	1	1	AN ₁₁

* Don't care

External trigger select

0	Disables start of A/D conversion by external trigger
1	Enables start of A/D conversion by rising or falling edge of external trigger at pin ADTRG

Clock select

Bit 7	Conversion Period	Conversion Time	
CKS		$\phi = 1$ MHz	$\phi = 5$ MHz
0	$62/\phi$	62 μ s	12.4 μ s
1	$31/\phi$	31 μ s	—

ADSR—A/D Start Register

H'C7

A/D converter

Bit	7	6	5	4	3	2	1	0
ADSF	—	—	—	—	—	—	—	—
Initial value	0	1	1	1	1	1	1	1
Read/Write	R/W	—	—	—	—	—	—	—

A/D status flag

0	Read	Indicates completion of A/D conversion
	Write	Stops A/D conversion
1	Read	Indicates A/D conversion in progress
	Write	Starts A/D conversion

PMR1—Port Mode Register 1

H'C8

I/O port

Bit	7	6	5	4	3	2	1	0
	IRQ3	IRQ2	IRQ1	IRQ4	TMIG	TMOFH	TMOFL	TMOW
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

P1₇/IRQ₃/TMIF pin function switch

0	Functions as P1 ₇ I/O pin
1	Functions as IRQ ₃ /TMIF input pin

P1₆/IRQ₂ pin function switch

0	Functions as P1 ₆ I/O pin
1	Functions as IRQ ₂ input pin

P1₅/IRQ₁/TMIC pin function switch

0	Functions as P1 ₅ I/O pin
1	Functions as IRQ ₁ /TMIC input pin

P1₄/IRQ₄/ADTRG pin function switch

0	Functions as P1 ₄ I/O pin
1	Functions as IRQ ₄ /ADTRG input pin

P1₃/TMIG pin function switch

0	Functions as P1 ₃ I/O pin
1	Functions as TMIG input pin

P1₂/TMOFH pin function switch

0	Functions as P1 ₂ I/O pin
1	Functions as TMOFH output pin

P1₁/TMOFL pin function switch

0	Functions as P1 ₁ I/O pin
1	Functions as TMOFL output pin

P1₀/TMOW pin function switch

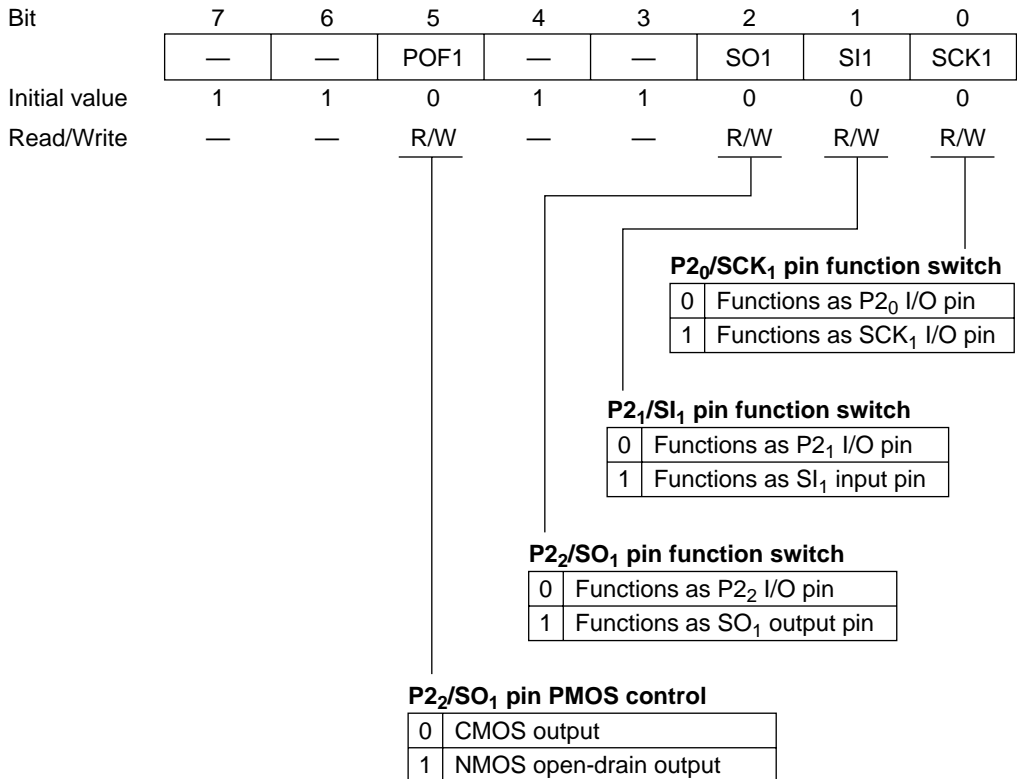
0	Functions as P1 ₀ I/O pin
1	Functions as TMOW output pin

PMR2—Port Mode Register 2

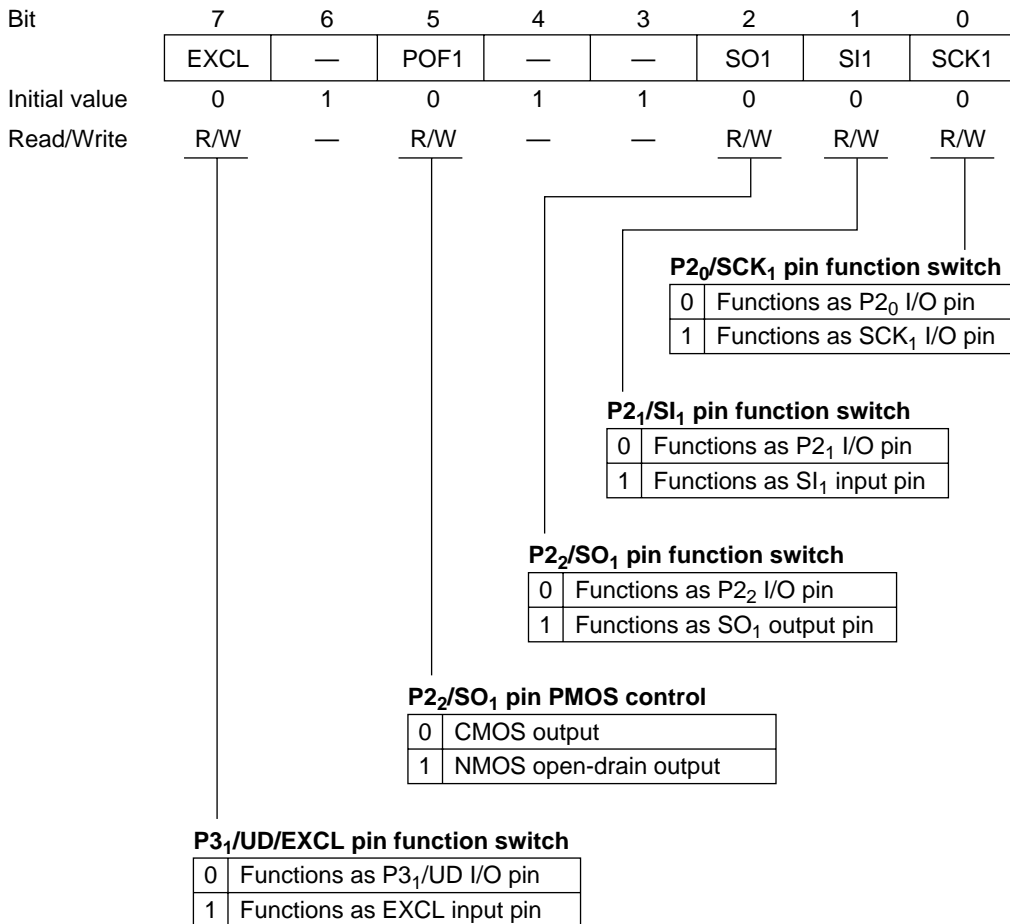
H'C9

I/O port

- H8/3847R Group and H8/3847S Group



• H8/38347 Group and H8/38447 Group



PMR3—Port Mode Register 3

H'CA

I/O port

Bit	7	6	5	4	3	2	1	0
	AEVL	AEVH	WDCKS	NCS	IRQ0	RESO*	UD	PWM
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

P3₀/PWM pin function switch

0	Functions as P3 ₀ I/O pin
1	Functions as PWM output pin

P3₁/UD pin function switch

0	Functions as P3 ₁ I/O pin
1	Functions as UD input pin

P3₂/RESO pin function switch

0	Functions as P3 ₂ I/O pin
1	Functions as RESO I/O pin

P4₃/IRQ0 pin function switch

0	Functions as P4 ₃ I/O pin
1	Functions as $\overline{\text{IRQ}}_0$ input pin

TMIG noise canceler select

0	Noise cancellation function not used
1	Noise cancellation function used

Watchdog timer switch

0	ϕ 8192
1	ϕ w/4

P3₆/AEVH pin function switch

0	Functions as P3 ₆ I/O pin
1	Functions as AEVH input pin

P3₇/AEVL pin function switch

0	Functions as P3 ₇ I/O pin
1	Functions as AEVL input pin

Vertical lines connect the bit labels in the table above to their respective function switch tables.

Note: * In the H8/38347 Group and H8/38447 Group this bit is reserved and cannot be written to.

PMR4—Port Mode Register 4

H'CB

I/O port

Bit	7	6	5	4	3	2	1	0
	NMOD7	NMOD6	NMOD5	NMOD4	NMOD3	NMOD2	NMOD1	NMOD0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

0	P2 _n is CMOS output
1	P2 _n is NMOS open-drain output

(n = 7 to 0)

PMR5—Port Mode Register 5

H'CC

I/O port

Bit	7	6	5	4	3	2	1	0
	WKP ₇	WKP ₆	WKP ₅	WKP ₄	WKP ₃	WKP ₂	WKP ₁	WKP ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

P5_n/WKP_n/SEG_{n+1} pin function switch

0	Functions as P5 _n I/O pin
1	Functions as WKP _n input pin

(n = 7 to 0)

PWCR—PWM Control Register**H'D0****14-bit PWM**

Bit	7	6	5	4	3	2	1	0
	—	—	—	—	—	—	PWCR1	PWCR0
Initial value	1	1	1	1	1	1	0	0
Read/Write	—	—	—	—	—	—	W	W

Clock select

0	The input clock is $\phi/2$ ($t\phi^* = 2/\phi$) The conversion period is $16,384/\phi$, with a minimum modulation width of $1/\phi$
	The input clock is $\phi/4$ ($t\phi^* = 4/\phi$) The conversion period is $32,768/\phi$, with a minimum modulation width of $2/\phi$
1	The input clock is $\phi/8$ ($t\phi^* = 8/\phi$) The conversion period is $65,536/\phi$, with a minimum modulation width of $4/\phi$
	The input clock is $\phi/16$ ($t\phi^* = 16/\phi$) The conversion period is $131,072/\phi$, with a minimum modulation width of $8/\phi$

Note: * $t\phi$: Period of PWM input clock**PWDRU—PWM Data Register U****H'D1****14-bit PWM**

Bit	7	6	5	4	3	2	1	0
	—	—	PWDRU5	PWDRU4	PWDRU3	PWDRU2	PWDRU1	PWDRU0
Initial value	1	1	0	0	0	0	0	0
Read/Write	—	—	W	W	W	W	W	W

Upper 6 bits of data for generating PWM waveform

PWDRL—PWM Data Register L**H'D2****14-bit PWM**

Bit	7	6	5	4	3	2	1	0
	PWDRL7	PWDRL6	PWDRL5	PWDRL4	PWDRL3	PWDRL2	PWDRL1	PWDRL0
Initial value	0	0	0	0	0	0	0	0
Read/Write	W	W	W	W	W	W	W	W

Lower 8 bits of data for generating PWM waveform

PDR1—Port Data Register 1**H'D4****I/O ports**

Bit	7	6	5	4	3	2	1	0
	P1 ₇	P1 ₆	P1 ₅	P1 ₄	P1 ₃	P1 ₂	P1 ₁	P1 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Data for port 1 pins

PDR2—Port Data Register 2**H'D5****I/O ports**

Bit	7	6	5	4	3	2	1	0
	P2 ₇	P2 ₆	P2 ₅	P2 ₄	P2 ₃	P2 ₂	P2 ₁	P2 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Data for port 2 pins

PDR3—Port Data Register 3**H'D6****I/O ports**

Bit	7	6	5	4	3	2	1	0
	P3 ₇	P3 ₆	P3 ₅	P3 ₄	P3 ₃	P3 ₂	P3 ₁	P3 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Data for port 3 pins

PDR4—Port Data Register 4**H'D7****I/O ports**

Bit	7	6	5	4	3	2	1	0
	—	—	—	—	P4 ₃	P4 ₂	P4 ₁	P4 ₀
Initial value	1	1	1	1	1	0	0	0
Read/Write	—	—	—	—	R	R/W	R/W	R/W

Pin P4₃ state is read

Data for port pins P4₂ to P4₀

PDR5—Port Data Register 5**H'D8****I/O ports**

Bit	7	6	5	4	3	2	1	0
	P5 ₇	P5 ₆	P5 ₅	P5 ₄	P5 ₃	P5 ₂	P5 ₁	P5 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Data for port 5 pins

PDR6—Port Data Register 6**H'D9****I/O ports**

Bit	7	6	5	4	3	2	1	0
	P6 ₇	P6 ₆	P6 ₅	P6 ₄	P6 ₃	P6 ₂	P6 ₁	P6 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Data for port 6 pins

PDR7—Port Data Register 7**H'DA****I/O ports**

Bit	7	6	5	4	3	2	1	0
	P7 ₇	P7 ₆	P7 ₅	P7 ₄	P7 ₃	P7 ₂	P7 ₁	P7 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Data for port 7 pins

PDR8—Port Data Register 8**H'DB****I/O ports**

Bit	7	6	5	4	3	2	1	0
	P8 ₇	P8 ₆	P8 ₅	P8 ₄	P8 ₃	P8 ₂	P8 ₁	P8 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Data for port 8 pins

PDR9—Port Data Register 9**H'DC****I/O ports**

Bit	7	6	5	4	3	2	1	0
	P9 ₇	P9 ₆	P9 ₅	P9 ₄	P9 ₃	P9 ₂	P9 ₁	P9 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Data for port 9 pins

PDRA—Port Data Register A**H'DD****I/O ports**

Bit	7	6	5	4	3	2	1	0
	—	—	—	—	PA ₃	PA ₂	PA ₁	PA ₀
Initial value	1	1	1	1	0	0	0	0
Read/Write	—	—	—	—	R/W	R/W	R/W	R/W

Data for port A pins

PDRB—Port Data Register B**H'DE****I/O ports**

Bit	7	6	5	4	3	2	1	0
	PB ₇	PB ₆	PB ₅	PB ₄	PB ₃	PB ₂	PB ₁	PB ₀
Read/Write	R	R	R	R	R	R	R	R

Data for port B pins

PDRC—Port Data Register C**H'DF****I/O ports**

Bit	7	6	5	4	3	2	1	0
	—	—	—	—	PC ₃	PC ₂	PC ₁	PC ₀
Read/Write	—	—	—	—	R	R	R	R

Data for port C pins

PUCR1—Port Pull-Up Control Register 1**H'E0****I/O ports**

Bit	7	6	5	4	3	2	1	0
	PUCR1 ₇	PUCR1 ₆	PUCR1 ₅	PUCR1 ₄	PUCR1 ₃	PUCR1 ₂	PUCR1 ₁	PUCR1 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Port 1 input pull-up MOS control

0	Input pull-up MOS is off
1	Input pull-up MOS is on

Note: When the PCR1 specification is 0.
(Input port specification)

PUCR3—Port Pull-Up Control Register 3**H'E1****I/O ports**

Bit	7	6	5	4	3	2	1	0
	PUCR3 ₇	PUCR3 ₆	PUCR3 ₅	PUCR3 ₄	PUCR3 ₃	PUCR3 ₂	PUCR3 ₁	PUCR3 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Port 3 input pull-up MOS control

0	Input pull-up MOS is off
1	Input pull-up MOS is on

Note: When the PCR3 specification is 0.
(Input port specification)

PUCR5—Port Pull-Up Control Register 5**H'E2****I/O ports**

Bit	7	6	5	4	3	2	1	0
	PUCR5 ₇	PUCR5 ₆	PUCR5 ₅	PUCR5 ₄	PUCR5 ₃	PUCR5 ₂	PUCR5 ₁	PUCR5 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Port 5 input pull-up MOS control

0	Input pull-up MOS is off
1	Input pull-up MOS is on

Note: When the PCR5 specification is 0.
(Input port specification)

PUCR6—Port Pull-Up Control Register 6**H'E3****I/O ports**

Bit	7	6	5	4	3	2	1	0
	PUCR6 ₇	PUCR6 ₆	PUCR6 ₅	PUCR6 ₄	PUCR6 ₃	PUCR6 ₂	PUCR6 ₁	PUCR6 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Port 6 input pull-up MOS control

0	Input pull-up MOS is off
1	Input pull-up MOS is on

Note: When the PCR6 specification is 0.
(Input port specification)

PCR1—Port Control Register 1**H'E4****I/O ports**

Bit	7	6	5	4	3	2	1	0
	PCR1 ₇	PCR1 ₆	PCR1 ₅	PCR1 ₄	PCR1 ₃	PCR1 ₂	PCR1 ₁	PCR1 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	W	W	W	W	W	W	W	W

Port 1 input/output select

0	Input pin
1	Output pin

PCR2—Port Control Register 2**H'E5****I/O ports**

Bit	7	6	5	4	3	2	1	0
	PCR2 ₇	PCR2 ₆	PCR2 ₅	PCR2 ₄	PCR2 ₃	PCR2 ₂	PCR2 ₁	PCR2 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	W	W	W	W	W	W	W	W

Port 2 input/output select

0	Input pin
1	Output pin

PCR3—Port Control Register 3**H'E6****I/O ports**

Bit	7	6	5	4	3	2	1	0
	PCR3 ₇	PCR3 ₆	PCR3 ₅	PCR3 ₄	PCR3 ₃	PCR3 ₂	PCR3 ₁	PCR3 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	W	W	W	W	W	W	W	W

Port 3 input/output select

0	Input pin
1	Output pin

PCR4—Port Control Register 4**H'E7****I/O ports**

Bit	7	6	5	4	3	2	1	0
	—	—	—	—	—	PCR4 ₂	PCR4 ₁	PCR4 ₀
Initial value	1	1	1	1	1	0	0	0
Read/Write	—	—	—	—	—	W	W	W

Port 4 input/output select

0	Input pin
1	Output pin

PCR5—Port Control Register 5**H'E8****I/O ports**

Bit	7	6	5	4	3	2	1	0
	PCR5 ₇	PCR5 ₆	PCR5 ₅	PCR5 ₄	PCR5 ₃	PCR5 ₂	PCR5 ₁	PCR5 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	W	W	W	W	W	W	W	W

Port 5 input/output select

0	Input pin
1	Output pin

PCR6—Port Control Register 6**H'E9****I/O ports**

Bit	7	6	5	4	3	2	1	0
	PCR6 ₇	PCR6 ₆	PCR6 ₅	PCR6 ₄	PCR6 ₃	PCR6 ₂	PCR6 ₁	PCR6 ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	W	W	W	W	W	W	W	W

Port 6 input/output select

0	Input pin
1	Output pin

PCR7—Port Control Register 7**H'EA****I/O ports**

Bit	7	6	5	4	3	2	1	0
	PCR ₇ ₇	PCR ₇ ₆	PCR ₇ ₅	PCR ₇ ₄	PCR ₇ ₃	PCR ₇ ₂	PCR ₇ ₁	PCR ₇ ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	W	W	W	W	W	W	W	W

Port 7 input/output select

0	Input pin
1	Output pin

PCR8—Port Control Register 8**H'EB****I/O ports**

Bit	7	6	5	4	3	2	1	0
	PCR ₈ ₇	PCR ₈ ₆	PCR ₈ ₅	PCR ₈ ₄	PCR ₈ ₃	PCR ₈ ₂	PCR ₈ ₁	PCR ₈ ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	W	W	W	W	W	W	W	W

Port 8 input/output select

0	Input pin
1	Output pin

PCR9—Port Control Register 9**H'EC****I/O ports**

Bit	7	6	5	4	3	2	1	0
	PCR ₉ ₇	PCR ₉ ₆	PCR ₉ ₅	PCR ₉ ₄	PCR ₉ ₃	PCR ₉ ₂	PCR ₉ ₁	PCR ₉ ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	W	W	W	W	W	W	W	W

Port 9 input/output select

0	Input pin
1	Output pin

PCRA—Port Control Register A

H'ED

I/O ports

Bit	7	6	5	4	3	2	1	0
	—	—	—	—	PCRA ₃	PCRA ₂	PCRA ₁	PCRA ₀
Initial value	0	0	0	0	0	0	0	0
Read/Write	—	—	—	—	W	W	W	W

|

Port A input/output select

0	Input pin
1	Output pin

SYSCR1—System Control Register 1

H'F0

System control

Bit	7	6	5	4	3	2	1	0
	SSBY	STS2	STS1	STS0	LSON	—	MA1	MA0
Initial value	0	0	0	0	0	1	1	1
Read/Write	R/W	R/W	R/W	R/W	R/W	—	R/W	R/W

Active (medium-speed) mode clock select

0	0	$\phi_{osc}/16$
	1	$\phi_{osc}/32$
1	0	$\phi_{osc}/64$
	1	$\phi_{osc}/128$

Low speed on flag

0	The CPU operates on the system clock (ϕ)
1	The CPU operates on the subclock (ϕ_{SUB})

Standby timer select 2 to 0

0	0	0	Wait time = 8,192 states
		1	Wait time = 16,384 states
	1	0	Wait time = 32,768 states
		1	Wait time = 65,536 states
1	0	0	Wait time = 131,072 states
		1	Wait time = 2 states
	1	0	Wait time = 8 states
		1	Wait time = 16 states

Software standby

0	<ul style="list-style-type: none"> When a SLEEP instruction is executed in active mode, a transition is made to sleep mode When a SLEEP instruction is executed in subactive mode, a transition is made to subsleep mode
1	<ul style="list-style-type: none"> When a SLEEP instruction is executed in active mode, a transition is made to standby mode or watch mode When a SLEEP instruction is executed in subactive mode, a transition is made to watch mode

SYSCR2—System Control Register 2

H'F1

System control

Bit	7	6	5	4	3	2	1	0
	—	—	—	NESEL	DTON	MSON	SA1	SA0
Initial value	1	1	1	1	0	0	0	0
Read/Write	—	—	—	R/W	R/W	R/W	R/W	R/W

Subactive mode clock select

0	0	$\phi_{VV}/8$
	1	$\phi_{VV}/4$
1	*	$\phi_{VV}/2$

Medium speed on flag

0	Operates in active (high-speed) mode
1	Operates in active (medium-speed) mode

*: Don't care

Direct transfer on flag

0	<ul style="list-style-type: none"> When a SLEEP instruction is executed in active mode, a transition is made to standby mode, watch mode, or sleep mode When a SLEEP instruction is executed in subactive mode, a transition is made to watch mode or subsleep mode
1	<ul style="list-style-type: none"> When a SLEEP instruction is executed in active (high-speed) mode, a direct transition is made to active (medium-speed) mode if SSBY = 0, MSON = 1, and LSON = 0, or to subactive mode if SSBY = 1, TMA3 = 1, and LSON = 1 When a SLEEP instruction is executed in active (medium-speed) mode, a direct transition is made to active (high-speed) mode if SSBY = 0, MSON = 0, and LSON = 0, or to subactive mode if SSBY = 1, TMA3 = 1, and LSON = 1 When a SLEEP instruction is executed in subactive mode, a direct transition is made to active (high-speed) mode if SSBY = 1, TMA3 = 1, LSON = 0, and MSON = 0, or to active (medium-speed) mode if SSBY = 1, TMA3 = 1, LSON = 0, and MSON = 1

Noise elimination sampling frequency select

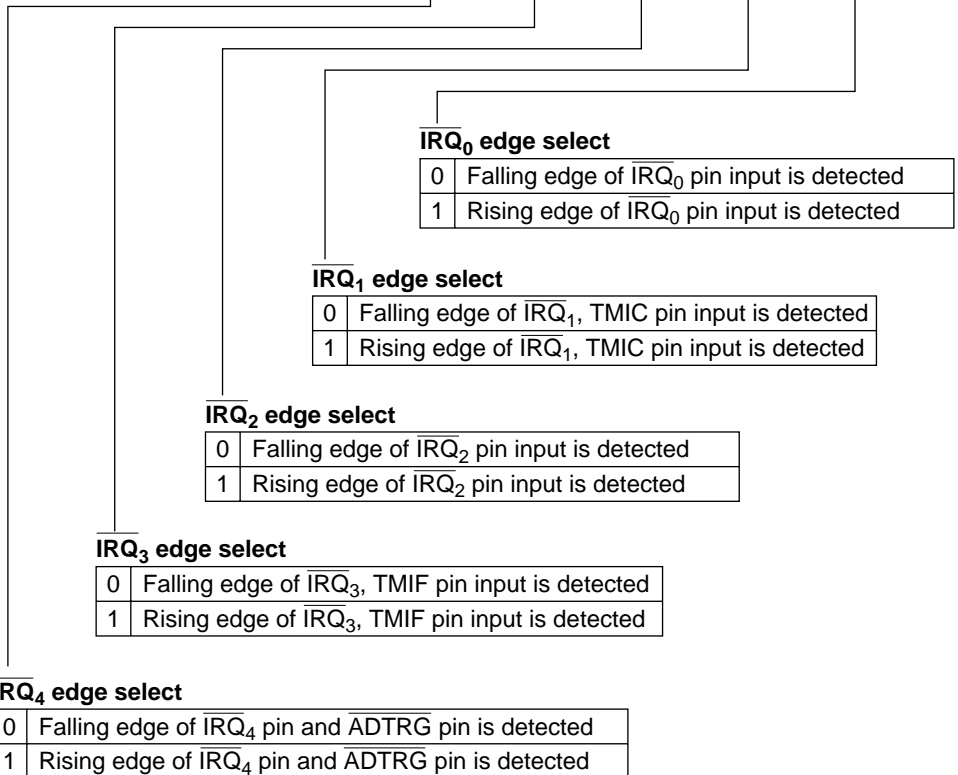
0	Sampling rate is $\phi_{OSC}/16$
1	Sampling rate is $\phi_{OSC}/4$

IEGR—IRQ Edge Select Register

H'F2

System control

Bit	7	6	5	4	3	2	1	0
	—	—	—	IEG4	IEG3	IEG2	IEG1	IEG0
Initial value	0	1	1	0	0	0	0	0
Read/Write	—	—	—	R/W	R/W	R/W	R/W	R/W



IENR1—Interrupt Enable Register 1**H'F3****System control**

Bit	7	6	5	4	3	2	1	0
	IENTA	IENS1	IENWP	IEN4	IEN3	IEN2	IEN1	IEN0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

IRQ₄ to IRQ₀ interrupt enable	
0	Disables $\overline{\text{IRQ}}_4$ to $\overline{\text{IRQ}}_0$ interrupt requests
1	Enables $\overline{\text{IRQ}}_4$ to $\overline{\text{IRQ}}_0$ interrupt requests

Wakeup interrupt enable	
0	Disables $\overline{\text{WKP}}_7$ to $\overline{\text{WKP}}_0$ interrupt requests
1	Enables $\overline{\text{WKP}}_7$ to $\overline{\text{WKP}}_0$ interrupt requests

SCI1 interrupt enable	
0	Disables SCI1 interrupt requests
1	Enables SCI1 interrupt requests

Timer A interrupt enable	
0	Disables timer A interrupt requests
1	Enables timer A interrupt requests

IENR2—Interrupt Enable Register 2

H'F4

System control

Bit	7	6	5	4	3	2	1	0
	IENDT	IENAD	—	IENTG	IENTFH	IENTFL	IENTC	IENEC
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

Asynchronous event counter interrupt enable	
0	Disables asynchronous event counter interrupt requests
1	Enables asynchronous event counter interrupt requests

Timer C interrupt enable	
0	Disables timer C interrupt requests
1	Enables timer C interrupt requests

Timer FL interrupt enable	
0	Disables timer FL interrupt requests
1	Enables timer FL interrupt requests

Timer FH interrupt enable	
0	Disables timer FH interrupt requests
1	Enables timer FH interrupt requests

Timer G interrupt enable	
0	Disables timer G interrupt requests
1	Enables timer G interrupt requests

A/D converter interrupt enable	
0	Disables A/D converter interrupt requests
1	Enables A/D converter interrupt requests

Direct transition interrupt enable	
0	Disables direct transition interrupt requests
1	Enables direct transition interrupt requests

IRR1—Interrupt Request Register 1

H'F6

System control

Bit	7	6	5	4	3	2	1	0
	IRRTA	IRRS1	—	IRRI4	IRRI3	IRRI2	IRRI1	IRRI0
Initial value	0	0	1	0	0	0	0	0
Read/Write	R/(W)*	R/(W)*	—	R/(W)*	R/(W)*	R/(W)*	R/(W)*	R/(W)*

IRQ4 to IRQ0 interrupt request flags

0	[Clearing condition] When IRRIn = 1, it is cleared by writing 0
1	[Setting condition] When pin \overline{IRQn} is designated for interrupt input and the designated signal edge is input

(n = 4 to 0)

SCI1 interrupt request flag

0	[Clearing condition] When IRRS1 = 1, it is cleared by writing 0
1	[Setting condition] When SCI1 completes transfer

Timer A interrupt request flag

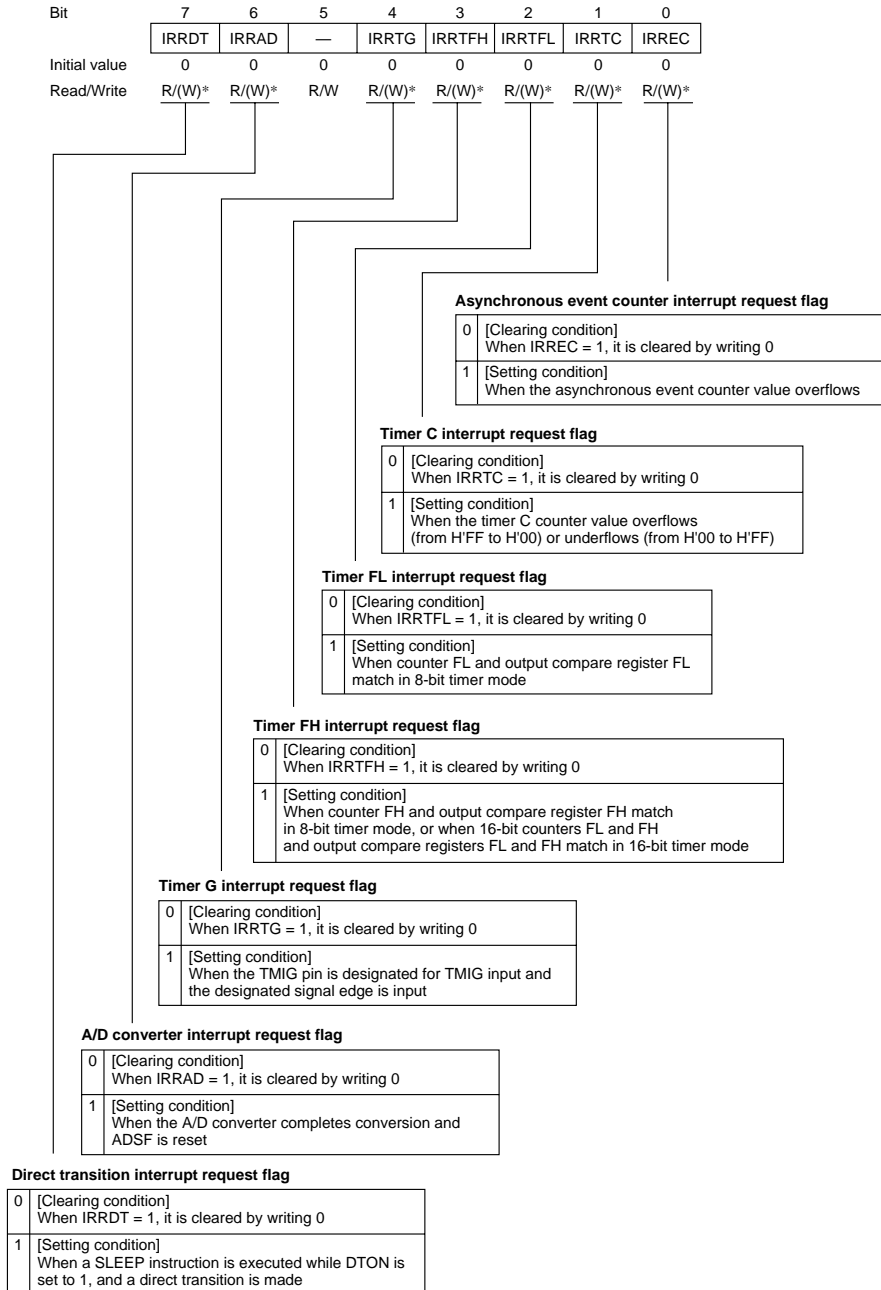
0	[Clearing condition] When IRRTA = 1, it is cleared by writing 0
1	[Setting condition] When the timer A counter value overflows (from H'FF to H'00)

Note: * Bits 7, 6, and 4 to 0 can only be written with 0, for flag clearing.

IRR2—Interrupt Request Register 2

H'F7

System control



Note: * Bits 7, 6 and 4 to 0 can only be written with 0, for flag clearing.

WPR—Wakeup Interrupt Request Register**H'F9****System control**

Bit	7	6	5	4	3	2	1	0
	IWPF7	IWPF6	IWPF5	IWPF4	IWPF3	IWPF2	IWPF1	IWPF0
Initial value	0	0	0	0	0	0	0	0
Read/Write	R/(W)*	R/(W)*	R/(W)*	R/(W)*	R/(W)*	R/(W)*	R/(W)*	R/(W)*

Wakeup interrupt request register

0	[Clearing condition] When IWPF _n = 1, it is cleared by writing 0
1	[Setting condition] When pin WKPN is designated for wakeup input and a falling edge is input at that pin

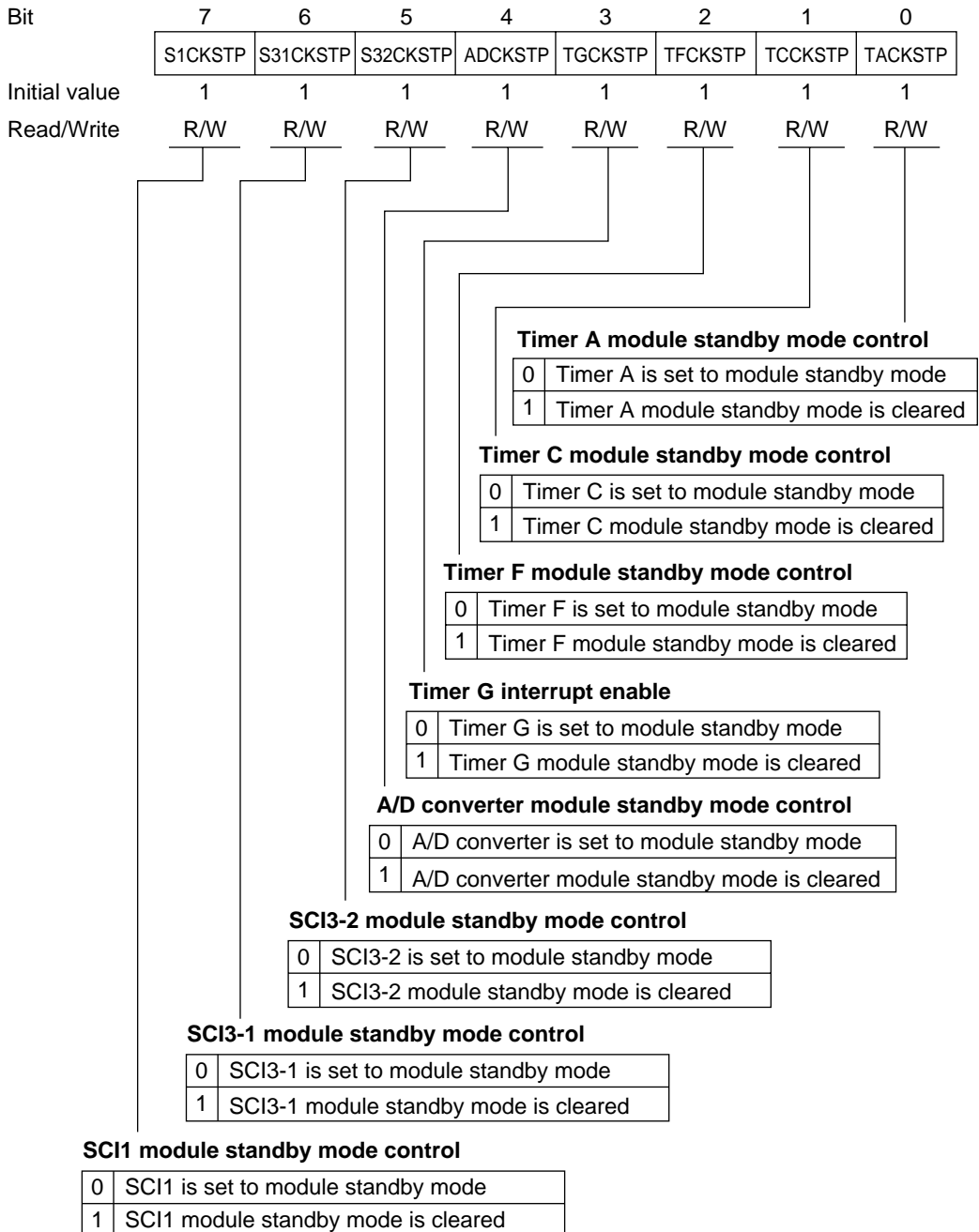
(n = 7 to 0)

Note: * All bits can only be written with 0, for flag clearing.

CKSTPR1—Clock Stop Register 1

H'FA

System control

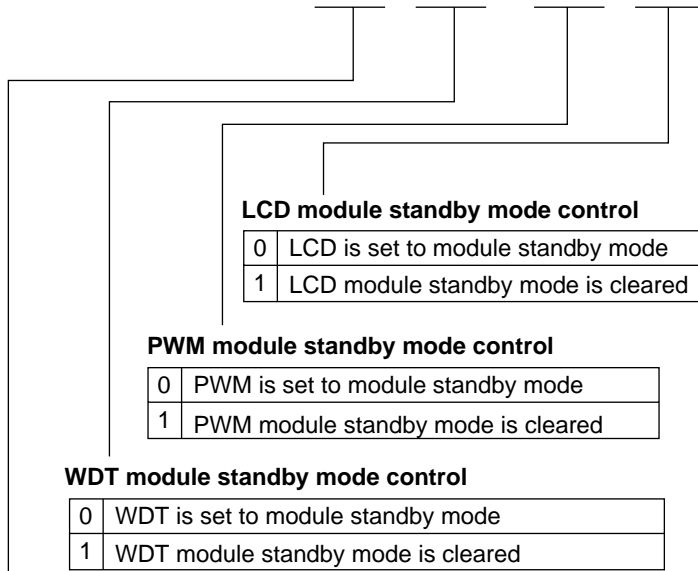


CKSTPR2—Clock Stop Register 2

H'FB

System control

Bit	7	6	5	4	3	2	1	0
	—	—	—	—	AECKSTP	WDCKSTP	PWCKSTP	LDCKSTP
Initial value	1	1	1	1	1	1	1	1
Read/Write	—	—	—	—	R/W	R/W	R/W	R/W

**Asynchronous event counter module standby mode control**

0	Asynchronous event counter is set to module standby mode
1	Asynchronous event counter module standby mode is cleared

Appendix C I/O Port Block Diagrams

C.1 Block Diagrams of Port 1

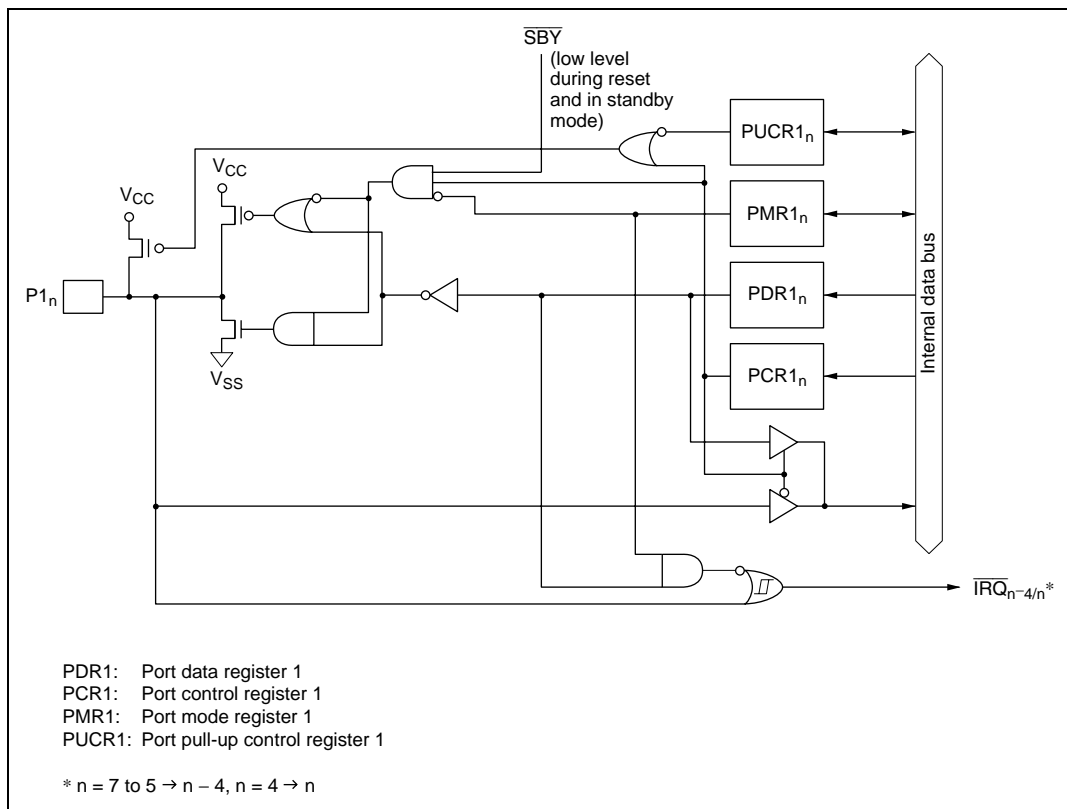


Figure C.1 (a) Port 1 Block Diagram (Pins $P1_7$ to $P1_4$)

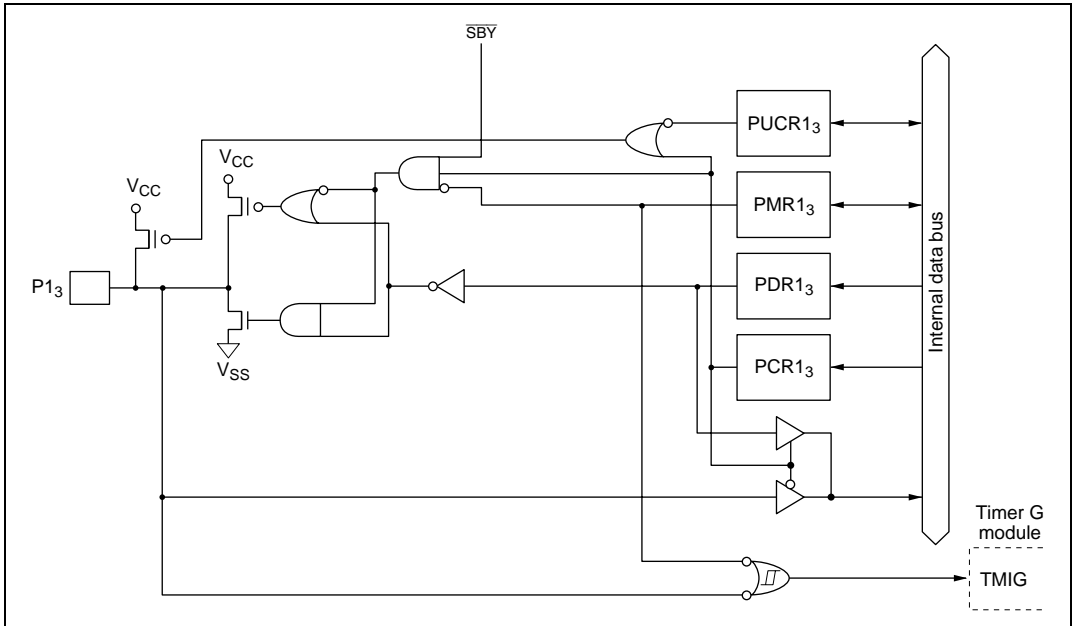


Figure C.1 (b) Port 1 Block Diagram (Pin P1₃)

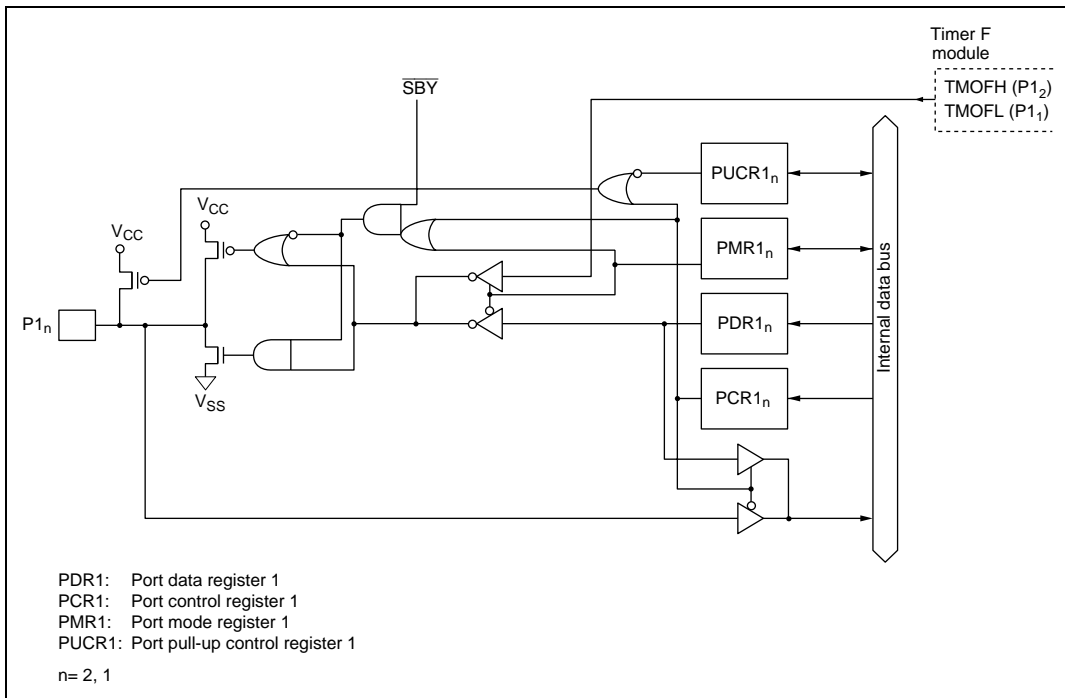


Figure C.1 (c) Port 1 Block Diagram (Pin $P1_2$, $P1_1$)

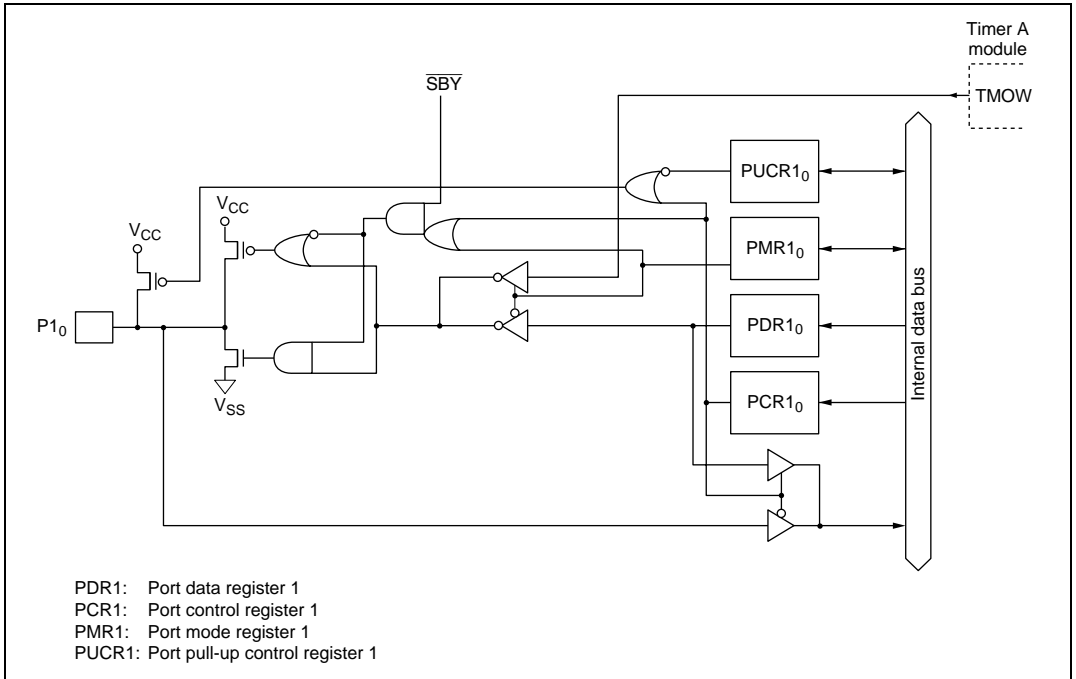


Figure C.1 (d) Port 1 Block Diagram (Pin P1₀)

C.2 Block Diagrams of Port 2

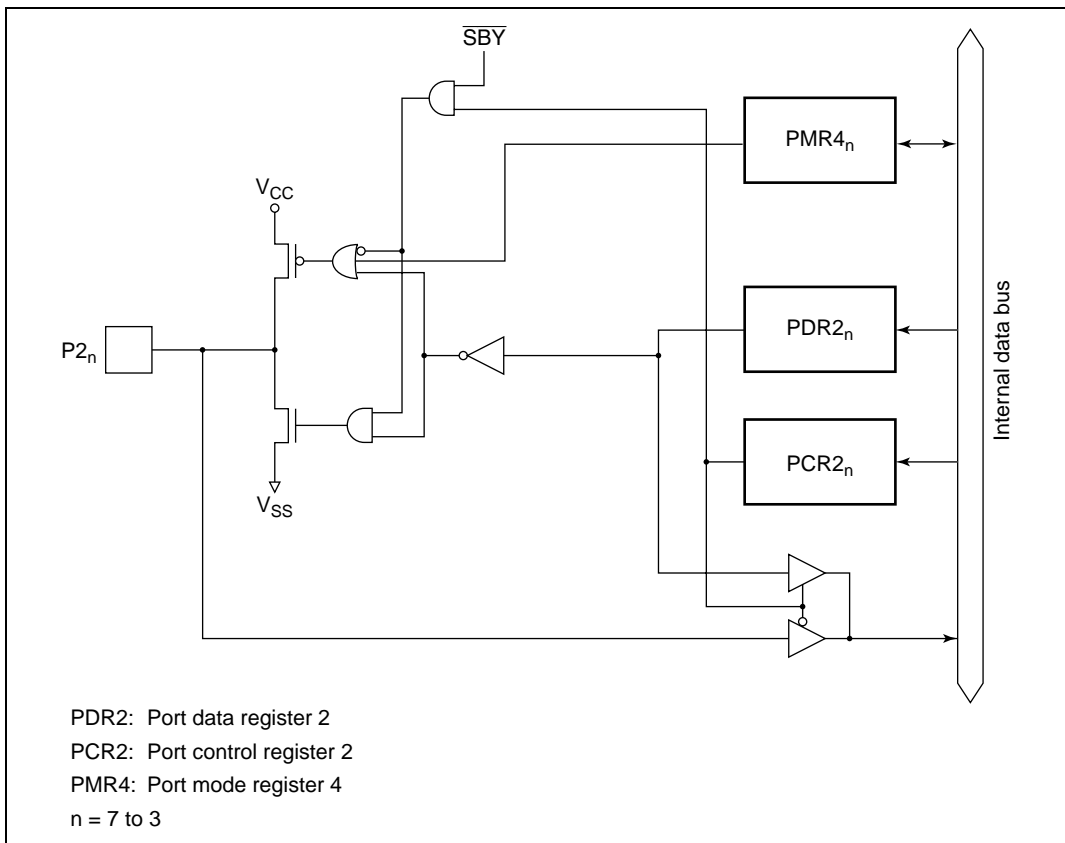


Figure C.2 (a-1) Port 2 Block Diagram (Pins P2₇ to P2₃, Not Including P2₄ in the F-ZTAT Version of the H8/38347 Group and H8/38447 Group)

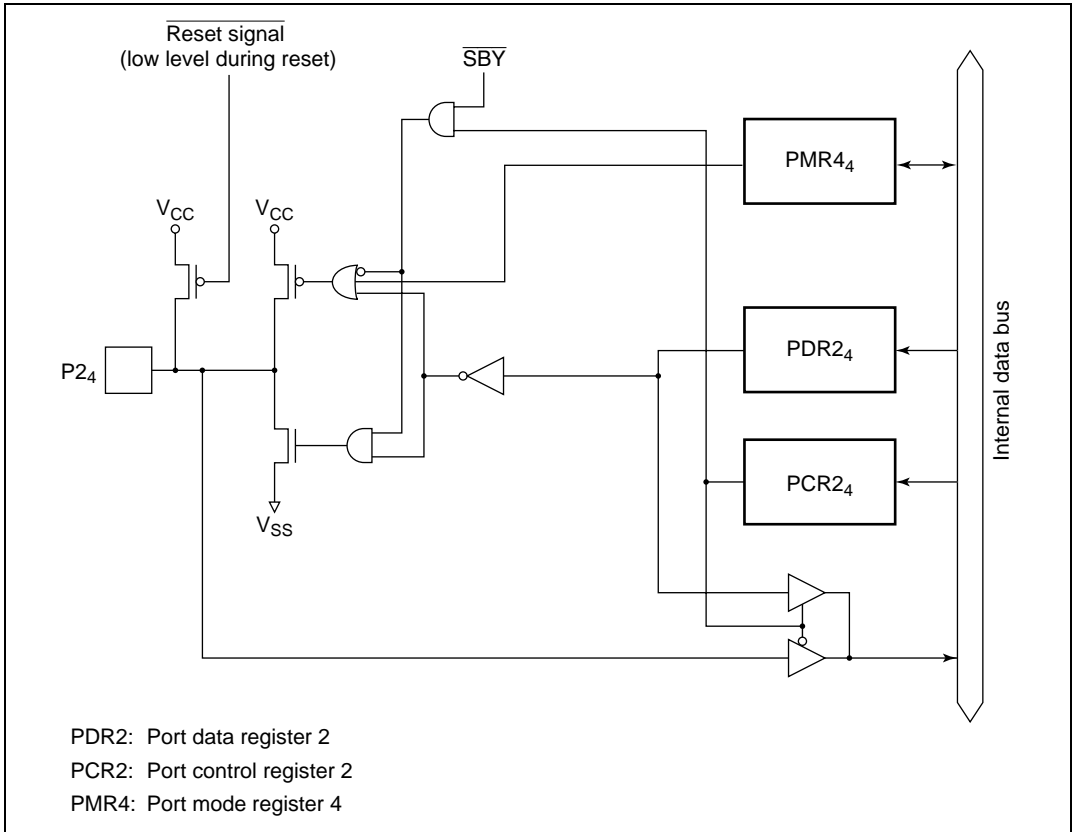


Figure C.2 (a-2) Port 2 Block Diagram (Pin P2₄ in the F-ZTAT Version of the H8/38347 Group and H8/38447 Group)

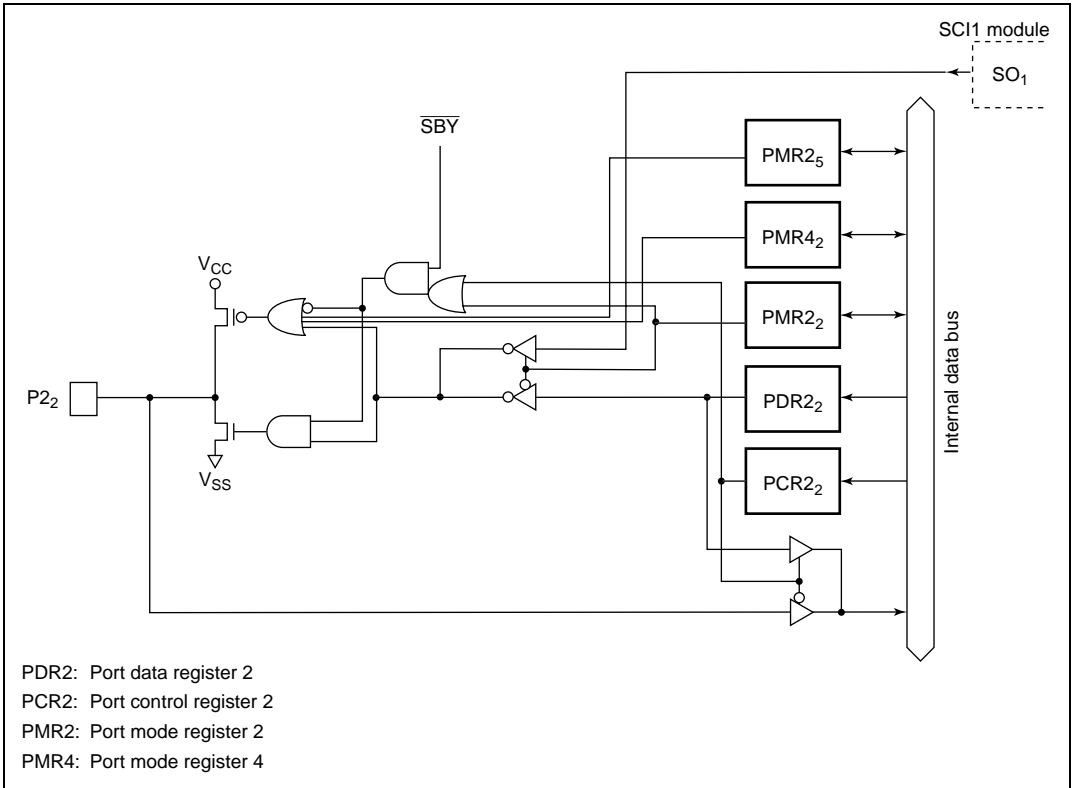


Figure C.2 (b) Port 2 Block Diagram (Pin P2₂)

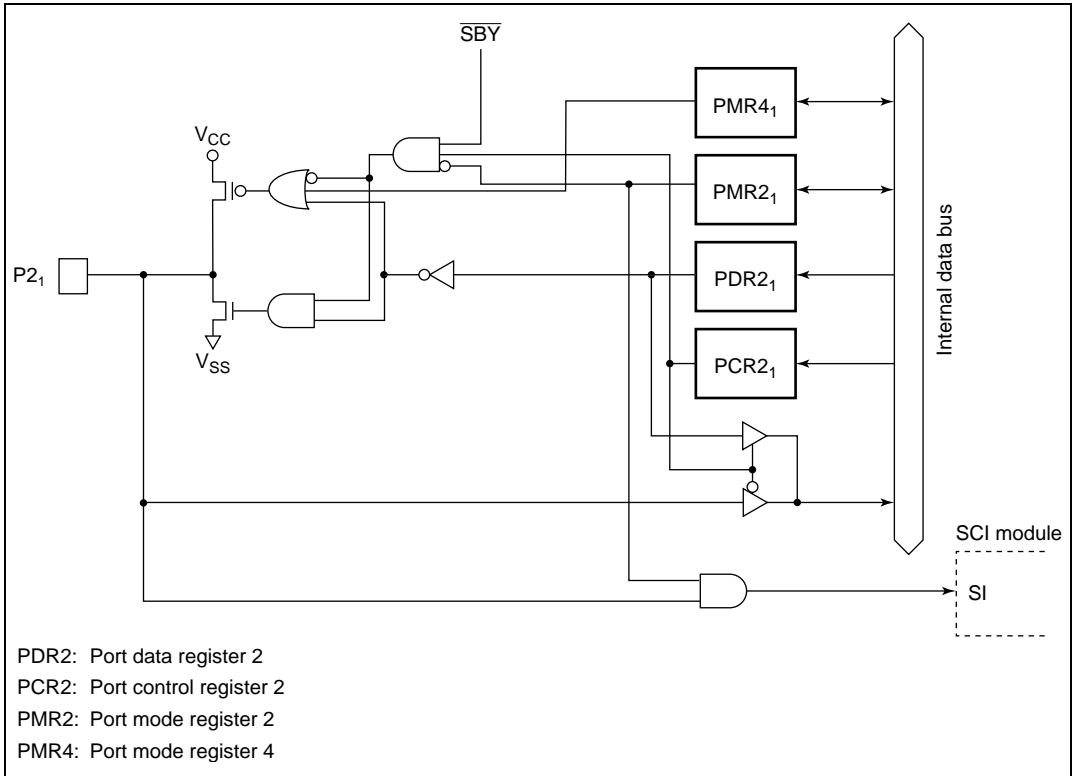


Figure C.2 (c) Port 2 Block Diagram (Pin P2₁)

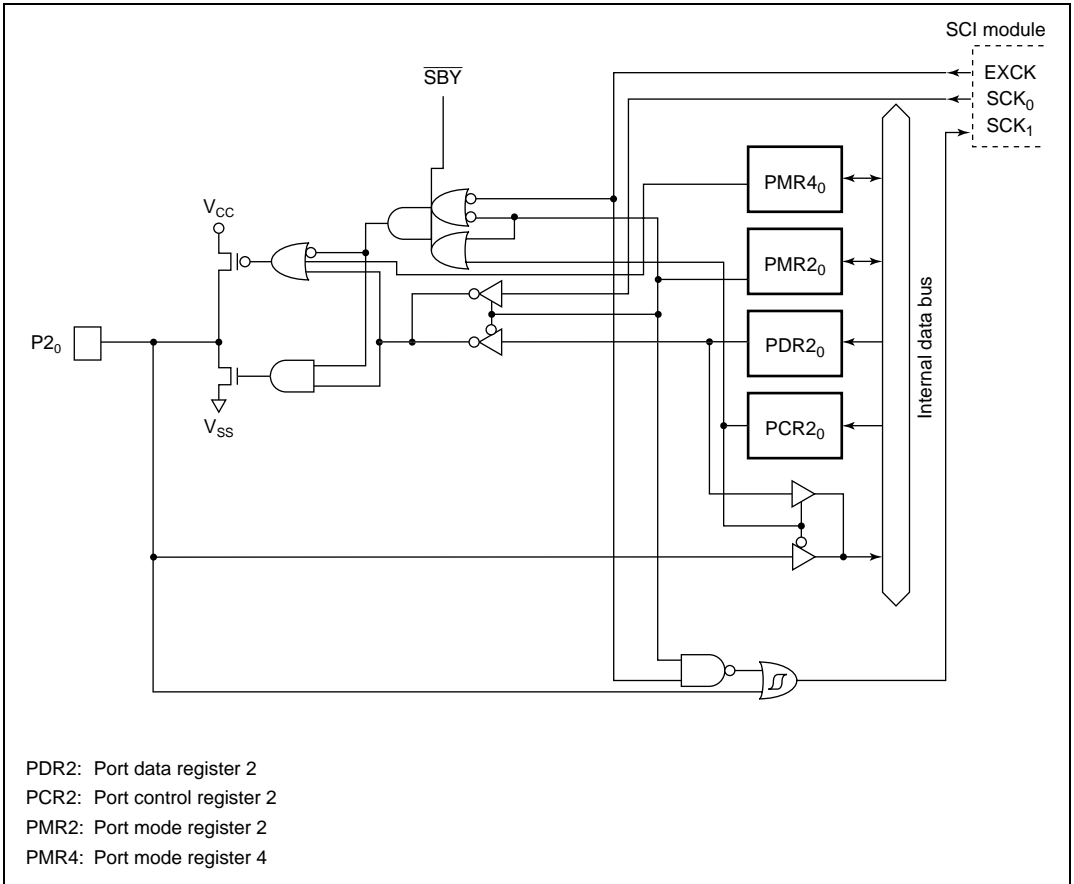


Figure C.2 (d) Port 2 Block Diagram (Pin P2₀)

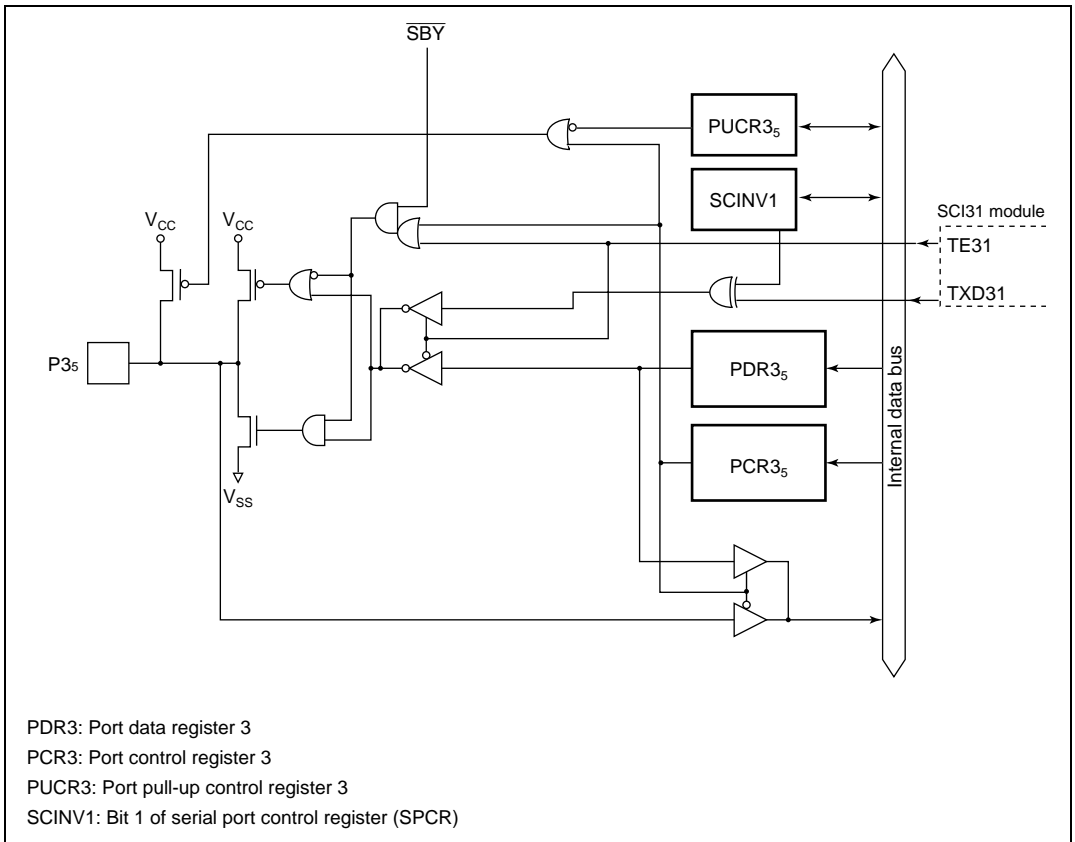


Figure C.3 (b) Port 3 Block Diagram (Pin P3₅)

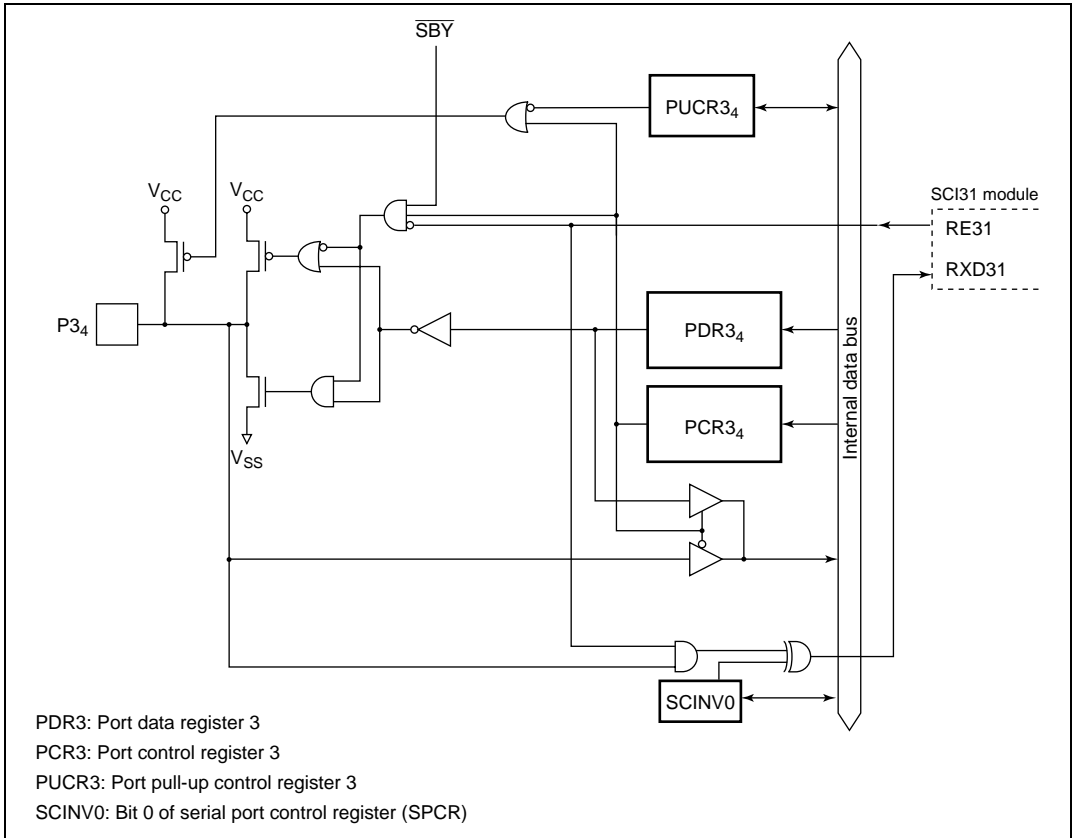


Figure C.3 (c) Port 3 Block Diagram (Pin P3₄)

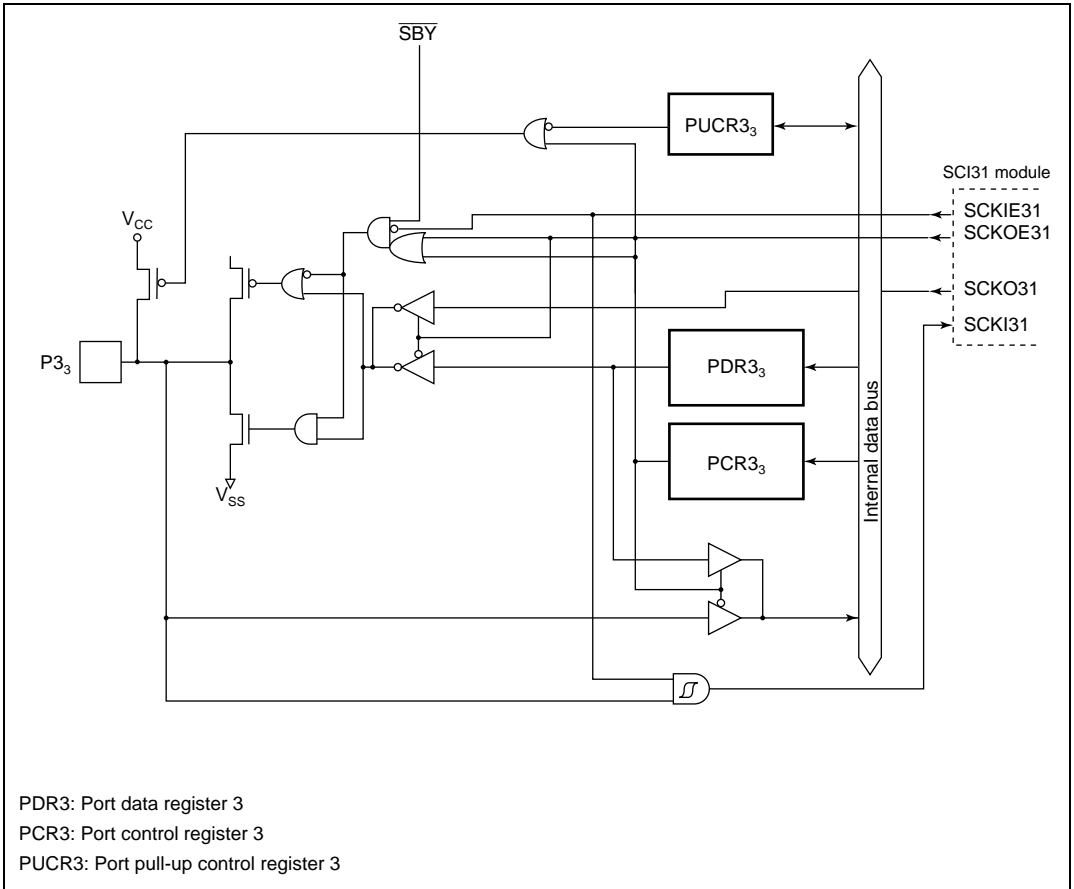


Figure C.3 (d) Port 3 Block Diagram (Pin P3₃)

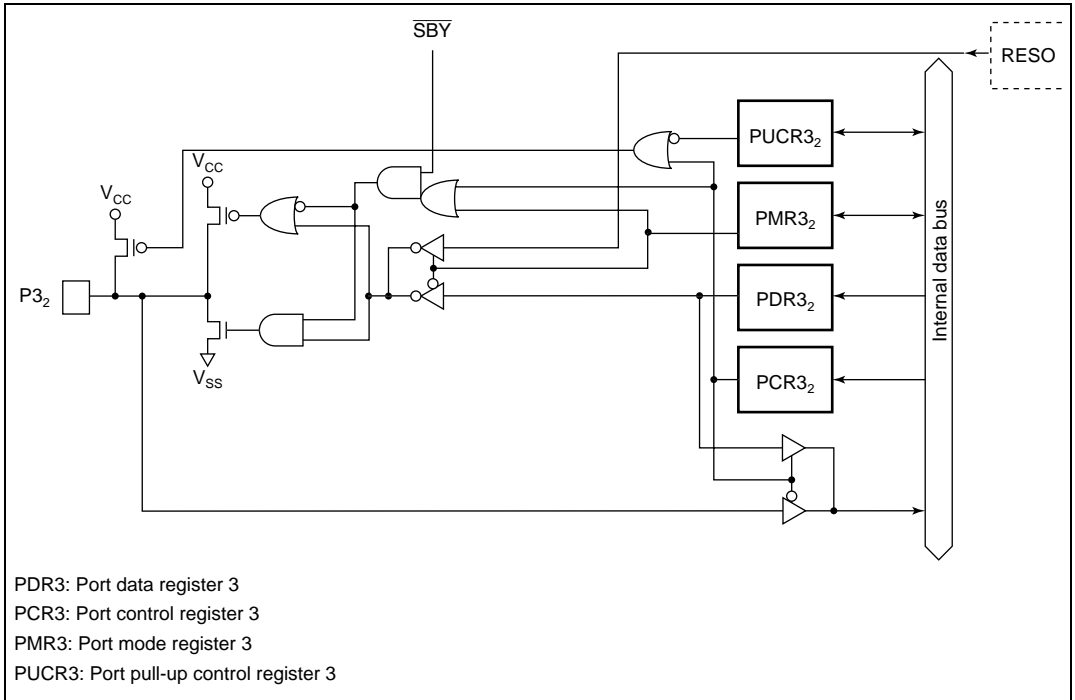


Figure C.3 (e-1) Port 3 Block Diagram (Pin P3₂, H8/3847R Group and H8/3847S Group)

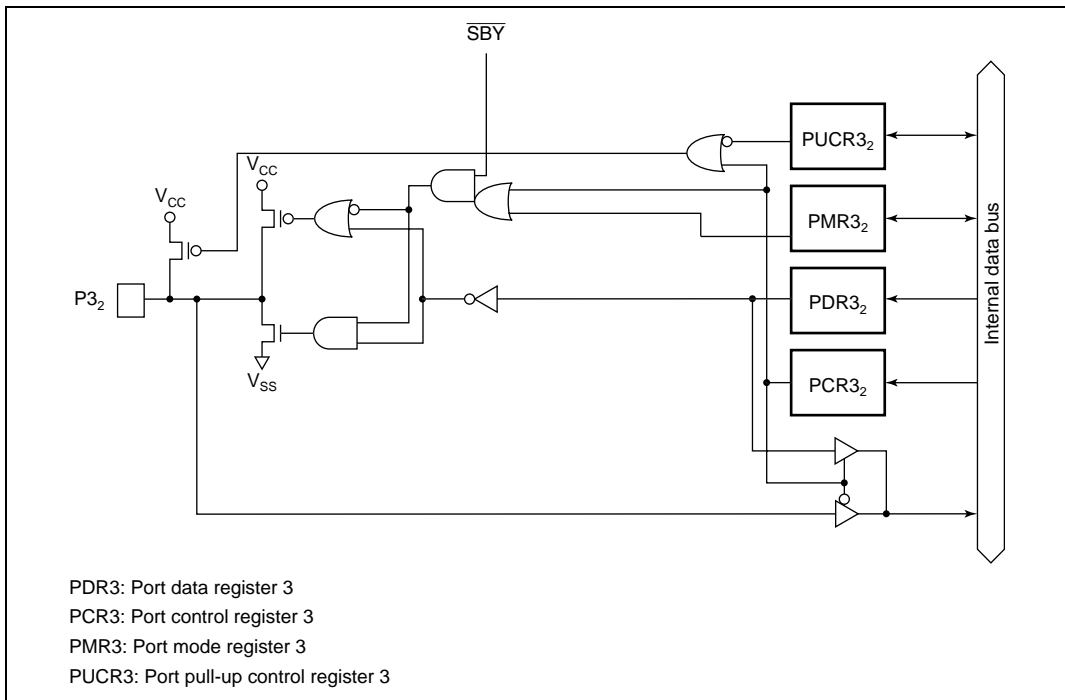


Figure C.3 (e-2) Port 3 Block Diagram (Pin P3₂, H8/38347 Group and H8/38447 Group)

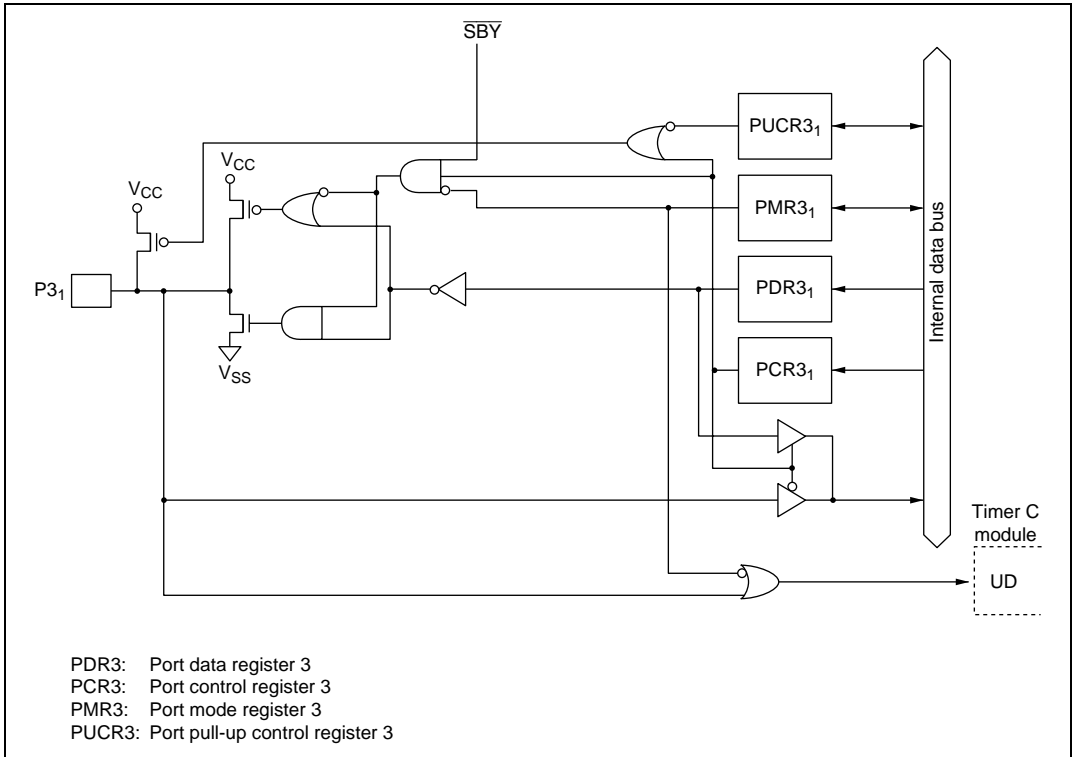


Figure C.3 (f-1) Port 3 Block Diagram (Pin P3₁, H8/3847R Group and H8/3847S Group)

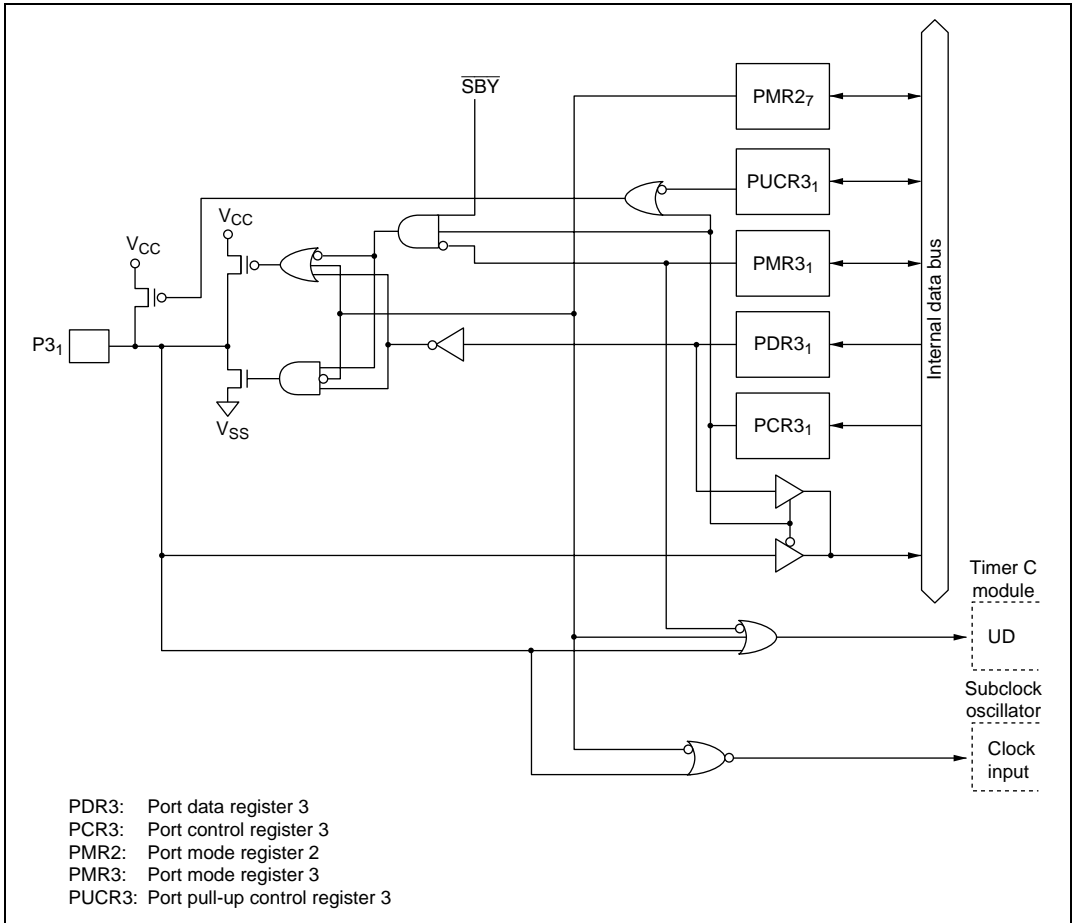


Figure C.3 (f-2) Port 3 Block Diagram (Pin P3₁, H8/38347 Group and H8/38447 Group)

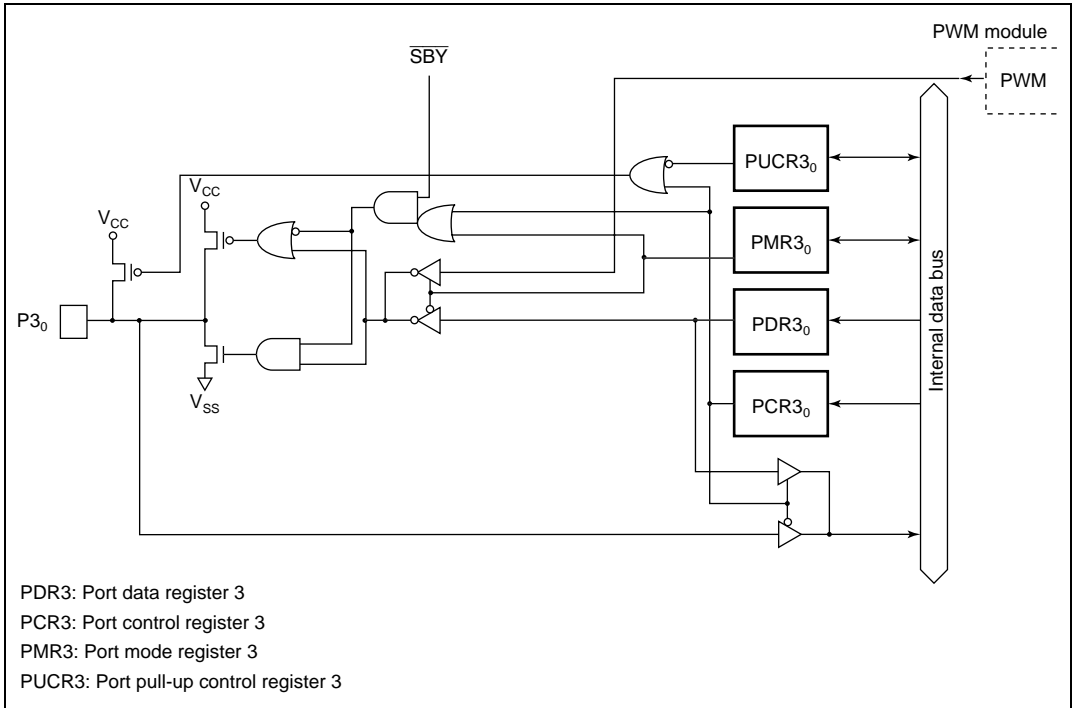


Figure C.3 (g) Port 3 Block Diagram (Pin P3₀)

C.4 Block Diagrams of Port 4

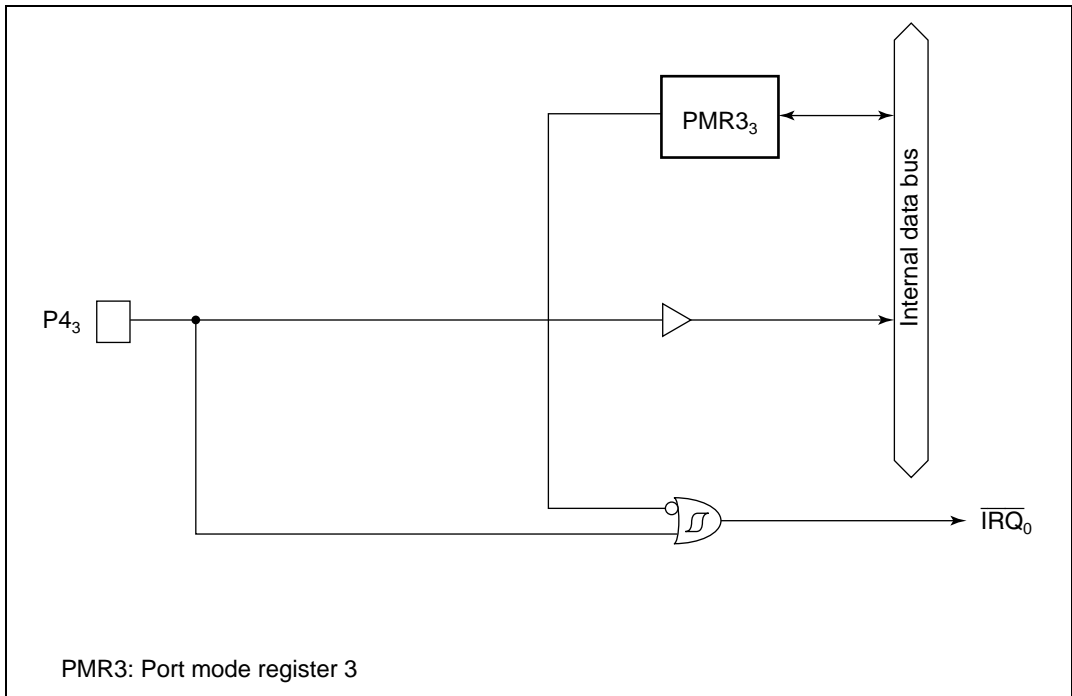


Figure C.4 (a) Port 4 Block Diagram (Pin P4₃)

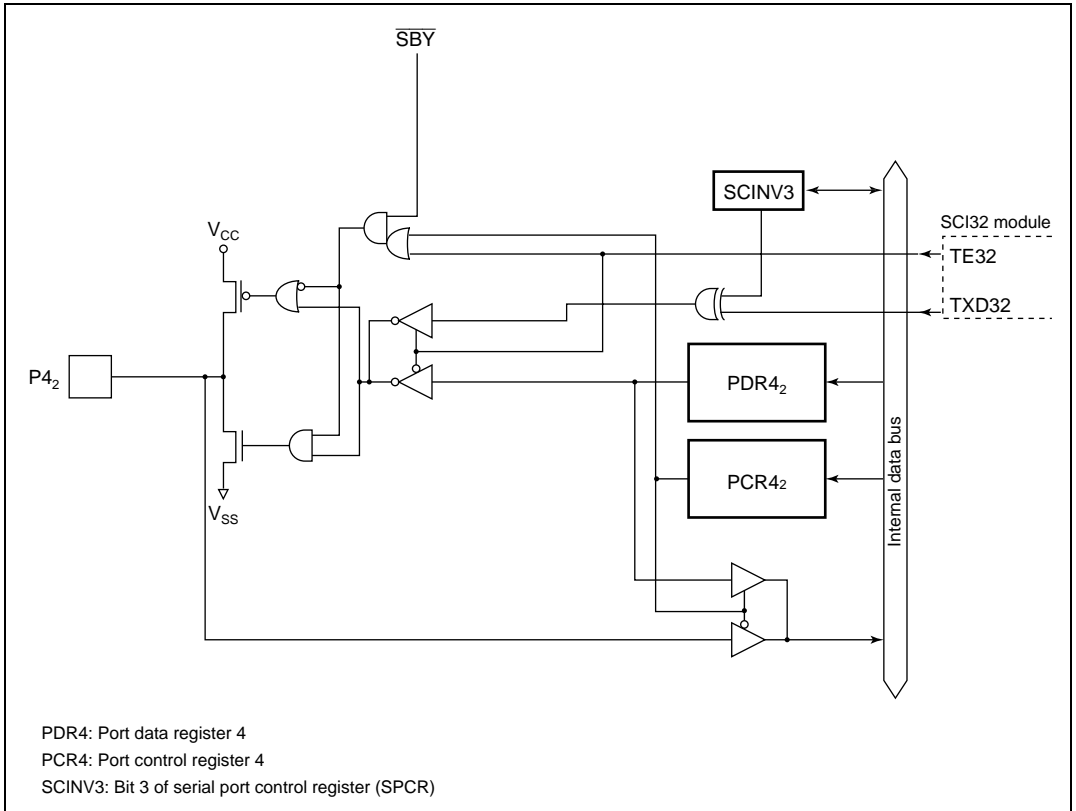


Figure C.4 (b) Port 4 Block Diagram (Pin P4₂)

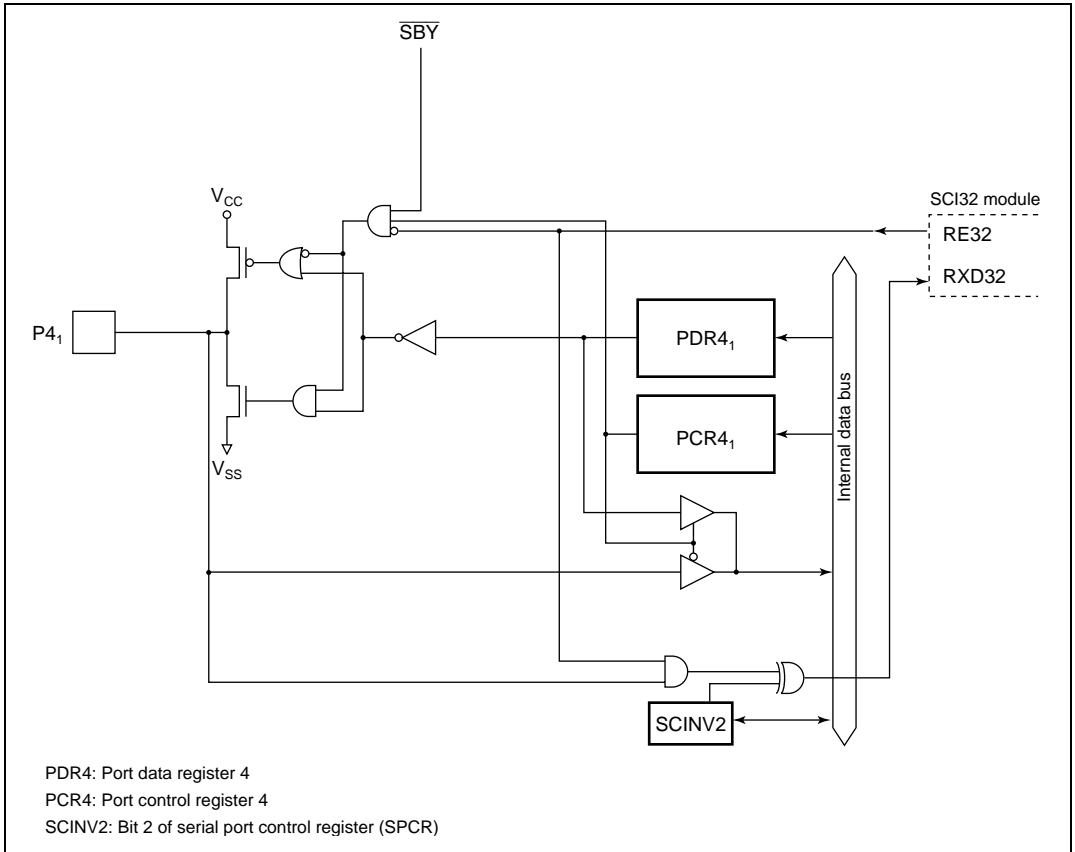


Figure C.4 (c) Port 4 Block Diagram (Pin P4₁)

C.5 Block Diagram of Port 5

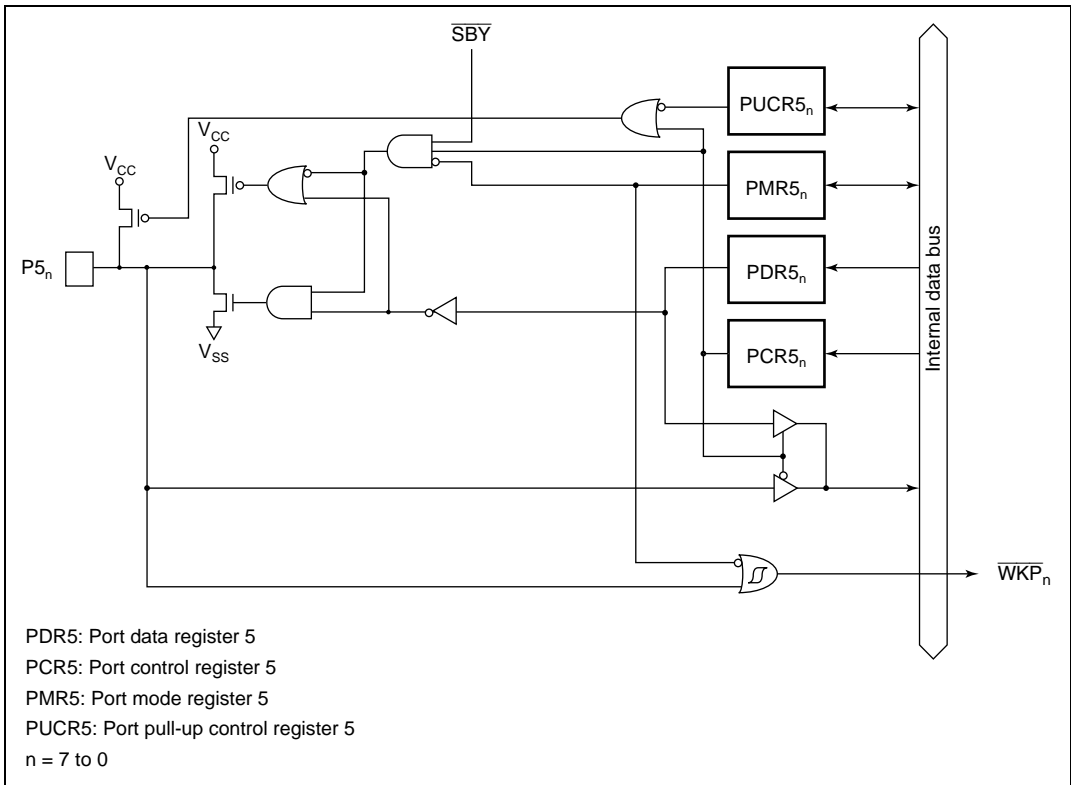


Figure C.5 Port 5 Block Diagram

C.6 Block Diagram of Port 6

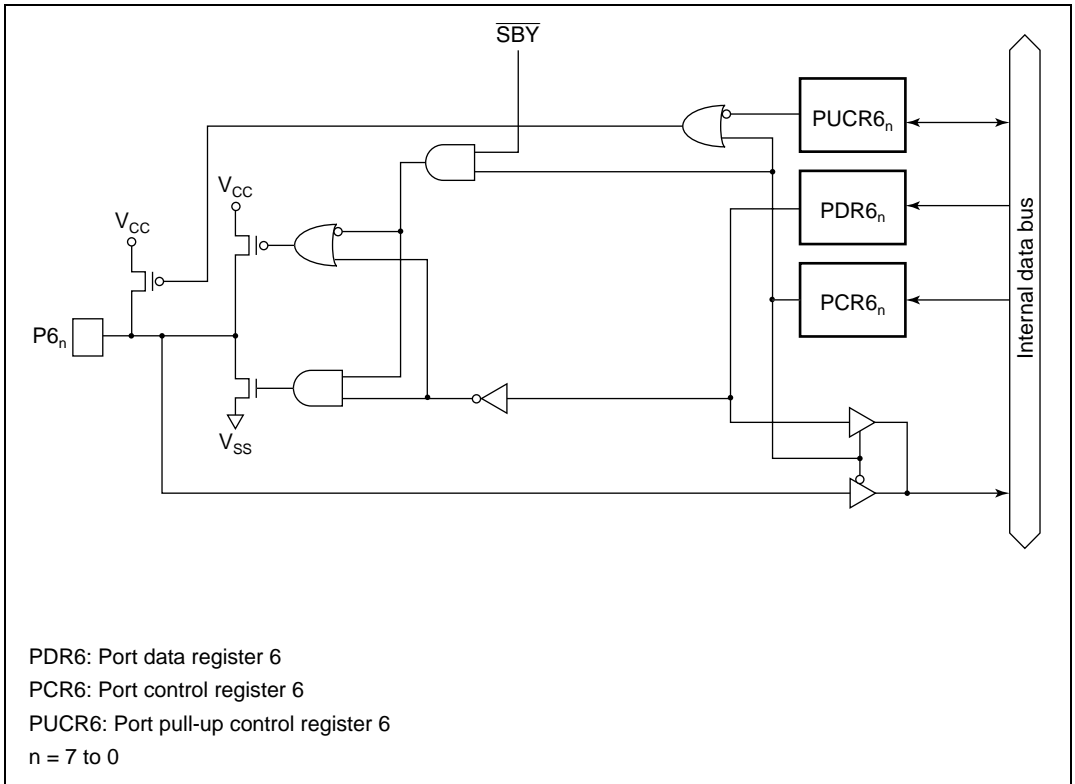


Figure C.6 Port 6 Block Diagram

C.7 Block Diagram of Port 7

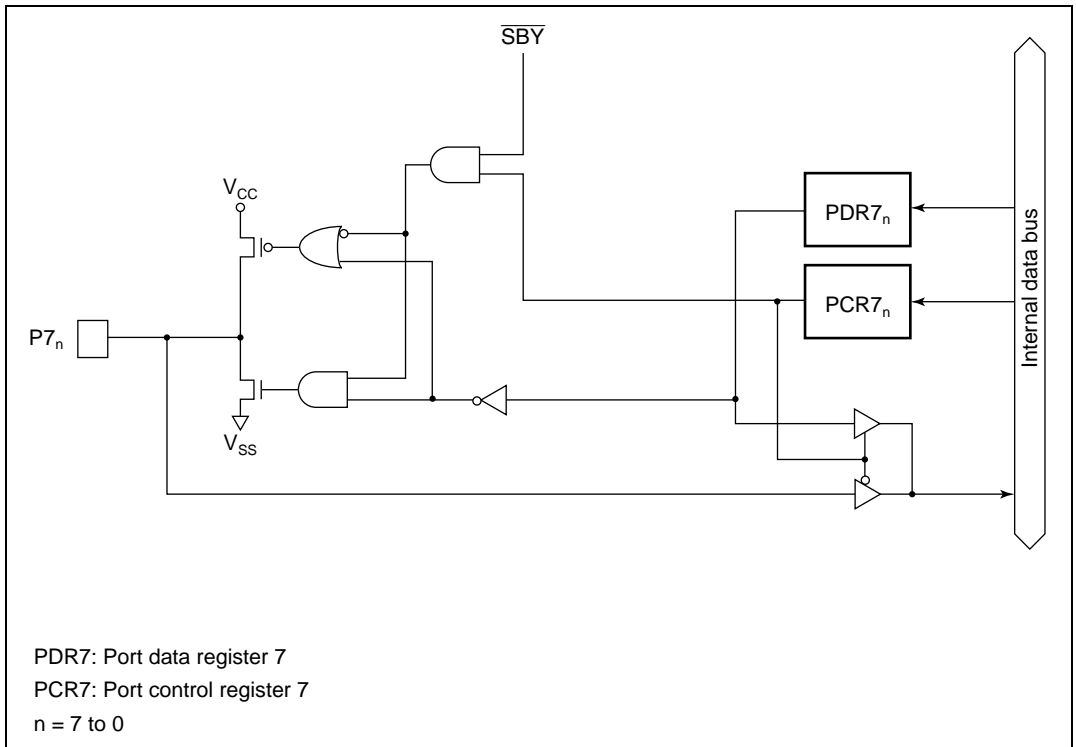


Figure C.7 Port 7 Block Diagram

C.8 Block Diagrams of Port 8

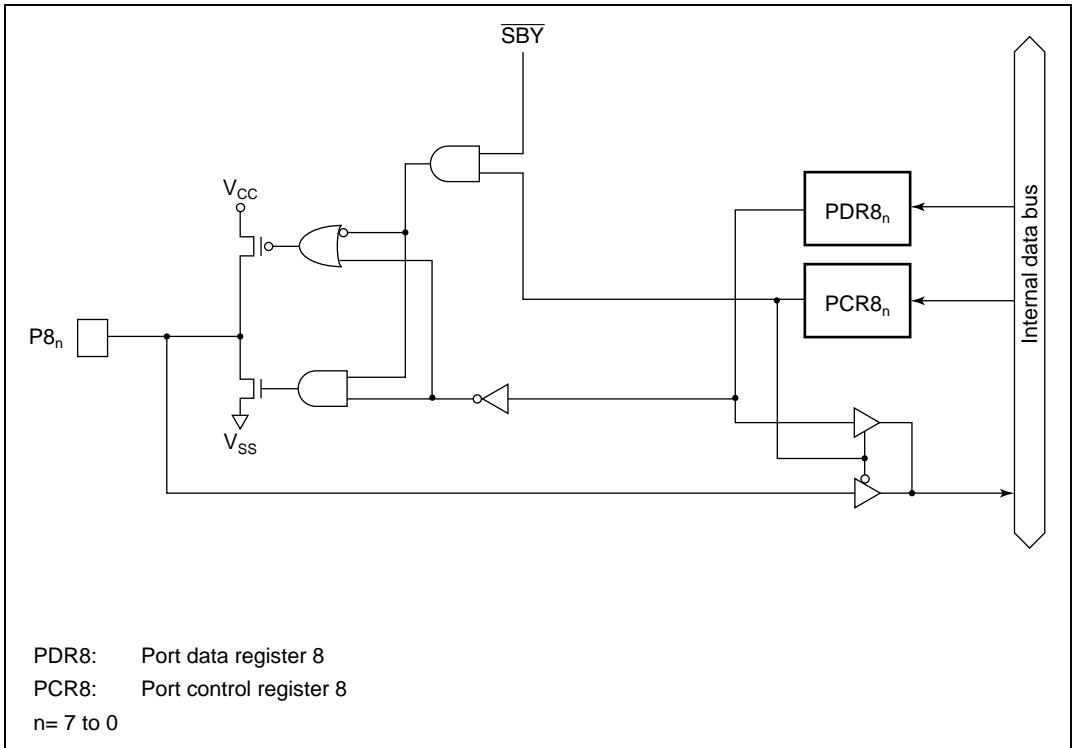


Figure C.8 Port 8 Block Diagram

C.9 Block Diagram of Port 9

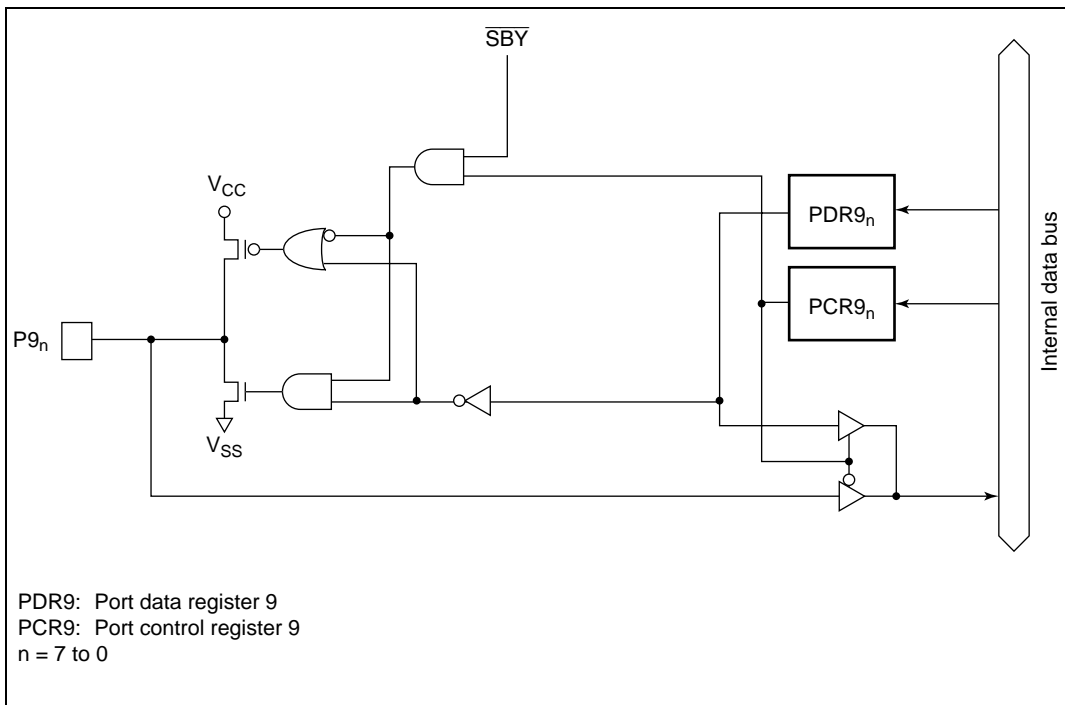


Figure C.9 Port 9 Block Diagram

C.10 Block Diagram of Port A

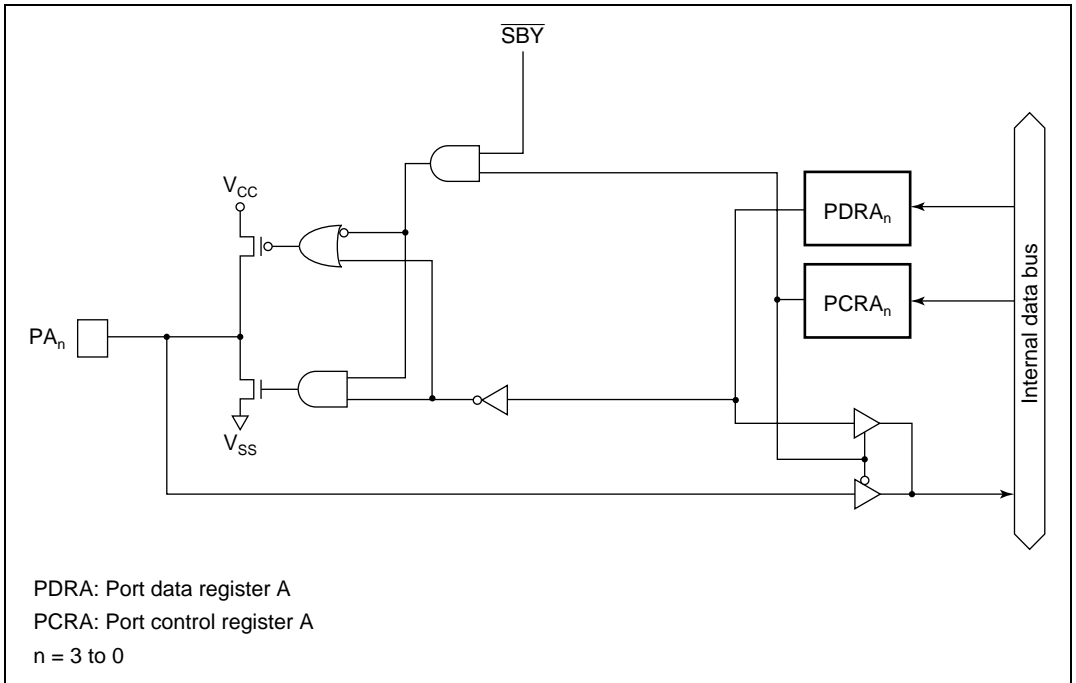


Figure C.10 Port A Block Diagram

C.11 Block Diagram of Port B

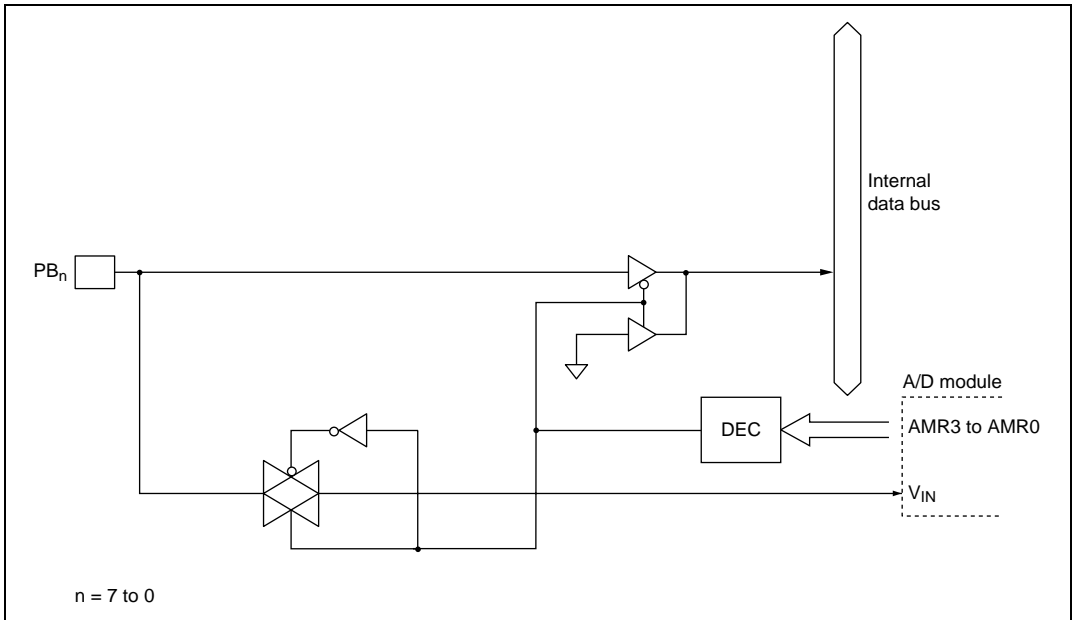


Figure C.11 Port B Block Diagram

C.12 Block Diagram of Port C

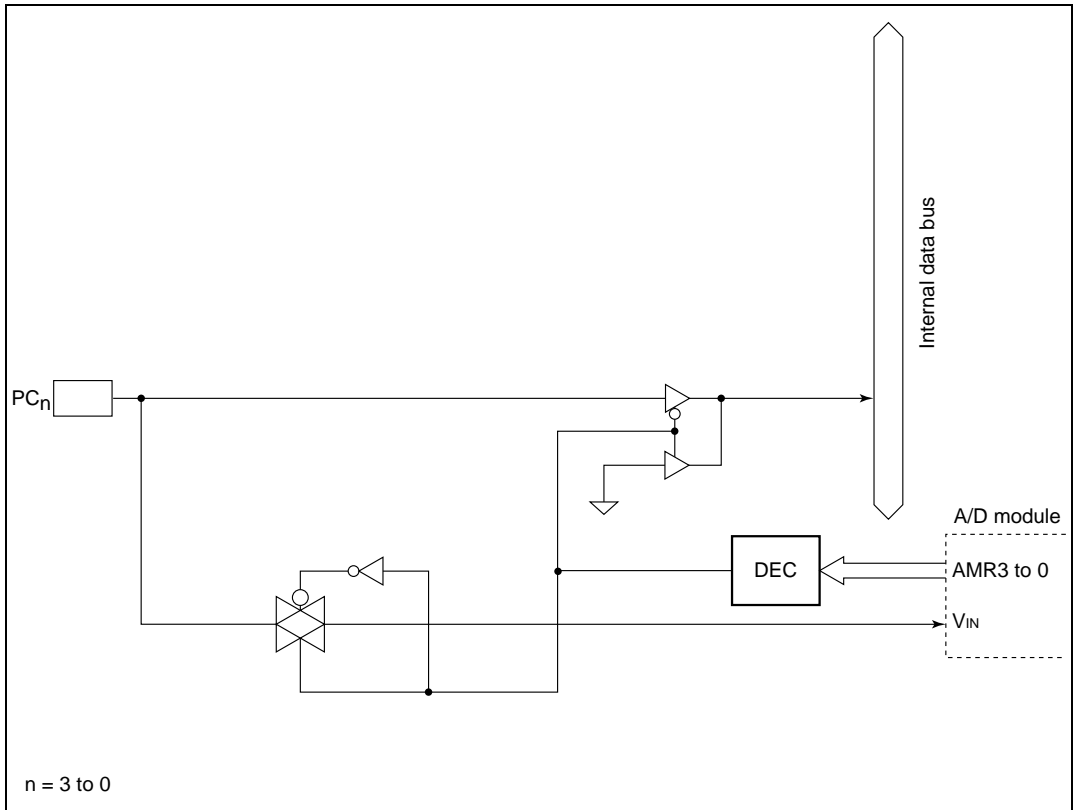


Figure C.12 Port C Block Diagram

Appendix D Port States in the Different Processing States

Table D.1 Port States Overview

Port	Reset	Sleep	Subsleep	Standby	Watch	Subactive	Active
P1 ₇ to P1 ₀	High-impedance	Retained	Retained	High-impedance* ¹	Retained	Functions	Functions
P2 ₇ to P2 ₀	High-impedance* ³	Retained	Retained	High-impedance	Retained	Functions	Functions
P3 ₇ to P3 ₀	High-impedance* ²	Retained	Retained	High-impedance* ¹	Retained	Functions	Functions
P4 ₃ to P4 ₀	High-impedance	Retained	Retained	High-impedance	Retained	Functions	Functions
P5 ₇ to P5 ₀	High-impedance	Retained	Retained	High-impedance* ¹	Retained	Functions	Functions
P6 ₇ to P6 ₀	High-impedance	Retained	Retained	High-impedance	Retained	Functions	Functions
P7 ₇ to P7 ₀	High-impedance	Retained	Retained	High-impedance	Retained	Functions	Functions
P8 ₇ to P8 ₀	High-impedance	Retained	Retained	High-impedance	Retained	Functions	Functions
P9 ₇ to P9 ₀	High-impedance	Retained	Retained	High-impedance	Retained	Functions	Functions
PA ₃ to PA ₀	High-impedance	Retained	Retained	High-impedance	Retained	Functions	Functions
PB ₇ to PB ₀	High-impedance	High-impedance	High-impedance	High-impedance	High-impedance	High-impedance	High-impedance
PC ₃ to PC ₀	High-impedance	High-impedance	High-impedance	High-impedance	High-impedance	High-impedance	High-impedance

- Notes:
1. High level output when MOS pull-up is in on state.
 2. Reset output from P3₂ pin only (H8/3847R Group and H8/3847S Group).
 3. On-chip pull-up MOS turns on for pin P2₄ only (F-ZTAT Version of the H8/38347 Group and H8/38447 Group).

Appendix E List of Product Codes

Table E.1 Product Code Lineup

Product Type				Product Code	Mark Code	Package (Package Code)
H8/3847R Group	H8/3842R Mask ROM versions	Regular products	HD6433842RH	HD6433842R(***)H	100-pin QFP (FP-100B)	
			HD6433842RF	HD6433842R(***)F	100-pin QFP (FP-100A)	
			HD6433842RX	HD6433842R(***)X	100-pin TQFP (TFP-100B)	
			HD6433842RW	HD6433842R(***)W	100-pin TQFP (TFP-100G)	
			HCD6433842R	—	Die	
	Wide- range specifi- cation products	HD6433842RD	HD6433842R(***)H	100-pin QFP (FP-100B)		
		HD6433842RE	HD6433842R(***)F	100-pin QFP (FP-100A)		
		HD6433842RL	HD6433842R(***)X	100-pin TQFP (TFP-100B)		
		HD6433842RWI	HD6433842R(***)W	100-pin TQFP (TFP-100G)		
	H8/3843R	Mask ROM versions	Regular products	HD6433843RH	HD6433843R(***)H	100-pin QFP (FP-100B)
				HD6433843RF	HD6433843R(***)F	100-pin QFP (FP-100A)
				HD6433843RX	HD6433843R(***)X	100-pin TQFP (TFP-100B)
				HD6433843RW	HD6433843R(***)W	100-pin TQFP (TFP-100G)
HCD6433843R				—	Die	
Wide- range specifi- cation products		HD6433843RD	HD6433843R(***)H	100-pin QFP (FP-100B)		
		HD6433843RE	HD6433843R(***)F	100-pin QFP (FP-100A)		
		HD6433843RL	HD6433843R(***)X	100-pin TQFP (TFP-100B)		
		HD6433843RWI	HD6433843R(***)W	100-pin TQFP (TFP-100G)		
H8/3844R		Mask ROM versions	Regular products	HD6433844RH	HD6433844R(***)H	100-pin QFP (FP-100B)
				HD6433844RF	HD6433844R(***)F	100-pin QFP (FP-100A)
				HD6433844RX	HD6433844R(***)X	100-pin TQFP (TFP-100B)
				HD6433844RW	HD6433844R(***)W	100-pin TQFP (TFP-100G)
	HCD6433844R			—	Die	
	Wide- range specifi- cation products	HD6433844RD	HD6433844R(***)H	100-pin QFP (FP-100B)		
		HD6433844RE	HD6433844R(***)F	100-pin QFP (FP-100A)		
		HD6433844RL	HD6433844R(***)X	100-pin TQFP (TFP-100B)		
		HD6433844RWI	HD6433844R(***)W	100-pin TQFP (TFP-100G)		

Product Type				Product Code	Mark Code	Package (Package Code)
H8/3847R Group	H8/3845R Mask ROM versions	Regular products	HD6433845RH	HD6433845R(***)H	100-pin QFP (FP-100B)	
			HD6433845RF	HD6433845R(***)F	100-pin QFP (FP-100A)	
			HD6433845RX	HD6433845R(***)X	100-pin TQFP (TFP-100B)	
			HD6433845RW	HD6433845R(***)W	100-pin TQFP (TFP-100G)	
			HCD6433845R	—	Die	
	Mask ROM versions	Wide- range specifi- cation products	HD6433845RD	HD6433845R(***)H	100-pin QFP (FP-100B)	
			HD6433845RE	HD6433845R(***)F	100-pin QFP (FP-100A)	
			HD6433845RL	HD6433845R(***)X	100-pin TQFP (TFP-100B)	
			HD6433845RWI	HD6433845R(***)W	100-pin TQFP (TFP-100G)	
	H8/3846R	Mask ROM versions	Regular products	HD6433846RH	HD6433846R(***)H	100-pin QFP (FP-100B)
				HD6433846RF	HD6433846R(***)F	100-pin QFP (FP-100A)
				HD6433846RX	HD6433846R(***)X	100-pin TQFP (TFP-100B)
				HD6433846RW	HD6433846R(***)W	100-pin TQFP (TFP-100G)
				HCD6433846R	—	Die
		Wide- range specifi- cation products	HD6433846RD	HD6433846R(***)H	100-pin QFP (FP-100B)	
			HD6433846RE	HD6433846R(***)F	100-pin QFP (FP-100A)	
HD6433846RL			HD6433846R(***)X	100-pin TQFP (TFP-100B)		
HD6433846RWI			HD6433846R(***)W	100-pin TQFP (TFP-100G)		
H8/3847R			Mask ROM versions	Regular products	HD6433847RH	HD6433847R(***)H
	HD6433847RF	HD6433847R(***)F			100-pin QFP (FP-100A)	
	HD6433847RX	HD6433847R(***)X			100-pin TQFP (TFP-100B)	
	HD6433847RW	HD6433847R(***)W			100-pin TQFP (TFP-100G)	
	HCD6433847R	—			Die	
	Wide- range specifi- cation products	HD6433847RD	HD6433847R(***)H	100-pin QFP (FP-100B)		
		HD6433847RE	HD6433847R(***)F	100-pin QFP (FP-100A)		
		HD6433847RL	HD6433847R(***)X	100-pin TQFP (TFP-100B)		
		HD6433847RWI	HD6433847R(***)W	100-pin TQFP (TFP-100G)		
		ZTAT versions	Regular products	HD6473847RH	HD6473847RH	100-pin QFP (FP-100B)
HD6473847RF	HD6473847RF			100-pin QFP (FP-100A)		
HD6473847RX	HD6473847RX			100-pin TQFP (TFP-100B)		
HD6473847RW	HD6473847RW			100-pin TQFP (TFP-100G)		
Wide- range specifi- cation products	HD6473847RD		HD6473847RH	100-pin QFP (FP-100B)		
	HD6473847RE		HD6473847RF	100-pin QFP (FP-100A)		
	HD6473847RL		HD6473847RX	100-pin TQFP (TFP-100B)		
	HD6473847RWI		HD6473847RW	100-pin TQFP (TFP-100G)		

Product Type				Product Code	Mark Code	Package (Package Code)
H8/3847S Group	H8/3844S Mask ROM versions	Regular products	HD6433844SH	HD6433844S(***)H	100-pin QFP (FP-100B)	
			HD6433844SX	HD6433844S(***)X	100-pin TQFP (TFP-100B)	
			HD6433844SW	HD6433844S(***)W	100-pin TQFP (TFP-100G)	
		HCD6433844S	—	Die		
		Wide- range specifi- cation products	HD6433844SD	HD6433844S(***)H	100-pin QFP (FP-100B)	
			HD6433844SL	HD6433844S(***)X	100-pin TQFP (TFP-100B)	
	HD6433844SWI		HD6433844S(***)W	100-pin TQFP (TFP-100G)		
	H8/3845S	Mask ROM versions	Regular products	HD6433845SH	HD6433845S(***)H	100-pin QFP (FP-100B)
				HD6433845SX	HD6433845S(***)X	100-pin TQFP (TFP-100B)
				HD6433845SW	HD6433845S(***)W	100-pin TQFP (TFP-100G)
			HCD6433845S	—	Die	
			Wide- range specifi- cation products	HD6433845SD	HD6433845S(***)H	100-pin QFP (FP-100B)
HD6433845SL				HD6433845S(***)X	100-pin TQFP (TFP-100B)	
HD6433845SWI		HD6433845S(***)W		100-pin TQFP (TFP-100G)		
H8/3846S		Mask ROM versions	Regular products	HD6433846SH	HD6433846S(***)H	100-pin QFP (FP-100B)
				HD6433846RX	HD6433846S(***)X	100-pin TQFP (TFP-100B)
				HD6433846SW	HD6433846S(***)W	100-pin TQFP (TFP-100G)
			HCD6333846S	—	Die	
			Wide- range specifi- cation products	HD6433846SD	HD6433846S(***)H	100-pin QFP (FP-100B)
	HD6433846SL			HD6433846S(***)X	100-pin TQFP (TFP-100B)	
	HD6433846SWI	HD6433846S(***)W		100-pin TQFP (TFP-100G)		
	H8/3847S	Mask ROM versions	Regular products	HD6433847SH	HD6433847S(***)H	100-pin QFP (FP-100B)
				HD6433847SX	HD6433847S(***)X	100-pin TQFP (TFP-100B)
				HD6433847SW	HD6433847S(***)W	100-pin TQFP (TFP-100G)
			HCD6433847S	—	Die	
			Wide- range specifi- cation products	HD6433847SD	HD6433847S(***)H	100-pin QFP (FP-100B)
HD6433847SL				HD6433847S(***)X	100-pin TQFP (TFP-100B)	
HD6433847SWI		HD6433847S(***)W		100-pin TQFP (TFP-100G)		

Appendix E List of Product Codes

Product Type				Product Code	Mark Code	Package (Package Code)
H8/38347 Group	H8/38342	Mask ROM versions	Regular products	HD64338342H	38342H	100-pin QFP (FP-100B)
				HD64338342W	38342W	100-pin TQFP (TFP-100G)
				HD64338342X	38342X	100-pin TQFP (TFP-100B)
				HCD64338342	—	Die
	Wide- range specifi- cation products	HD64338342HW	38342H	100-pin QFP (FP-100B)		
		HD64338342WW	38342W	100-pin TQFP (TFP-100G)		
		HD64338342XW	38342X	100-pin TQFP (TFP-100B)		
	H8/38343	Mask ROM versions	Regular products	HD64338343H	38343H	100-pin QFP (FP-100B)
				HD64338343W	38343W	100-pin TQFP (TFP-100G)
				HD64338343X	38343X	100-pin TQFP (TFP-100B)
				HCD64338343	—	Die
Wide- range specifi- cation products		HD64338343HW	38343H	100-pin QFP (FP-100B)		
		HD64338343WW	38343W	100-pin TQFP (TFP-100G)		
		HD64338343XW	38343X	100-pin TQFP (TFP-100B)		
H8/38344		Mask ROM versions	Regular products	HD64338344H	38344H	100-pin QFP (FP-100B)
				HD64338344W	38344W	100-pin TQFP (TFP-100G)
				HD64338344X	38344X	100-pin TQFP (TFP-100B)
				HCD64338344	—	Die
	Wide- range specifi- cation products	HD64338344HW	38344H	100-pin QFP (FP-100B)		
		HD64338344WW	38344W	100-pin TQFP (TFP-100G)		
		HD64338344XW	38344X	100-pin TQFP (TFP-100B)		
	F-ZTAT versions	Regular products	HD64F38344H	F38344H	100-pin QFP (FP-100B)	
			HD64F38344W	F38344W	100-pin TQFP (TFP-100G)	
			HD64F38344X	F38344X	100-pin TQFP (TFP-100B)	
Wide- range specifi- cation products	HD64F38344HW	F38344H	100-pin QFP (FP-100B)			
	HD64F38344W W	F38344W	100-pin TQFP (TFP-100G)			
	HD64F38344XW	F38344X	100-pin TQFP (TFP-100B)			

Product Type				Product Code	Mark Code	Package (Package Code)		
H8/38347 Group	H8/38345	Mask ROM versions	Regular products	HD64338345H	38345H	100-pin QFP (FP-100B)		
				HD64338345W	38345W	100-pin TQFP (TFP-100G)		
				HD64338345X	38345X	100-pin TQFP (TFP-100B)		
				HCD64338345	—	Die		
		Mask ROM versions	Wide- range specifi- cation products	HD64338345HW	38345H	100-pin QFP (FP-100B)		
				HD64338345WW	38345W	100-pin TQFP (TFP-100G)		
				HD64338345XW	38345X	100-pin TQFP (TFP-100B)		
H8/38346	Mask ROM versions	Regular products		HD64338346H	38346H	100-pin QFP (FP-100B)		
				HD64338346W	38346W	100-pin TQFP (TFP-100G)		
				HD64338346X	38346X	100-pin TQFP (TFP-100B)		
				HCD64338346	—	Die		
		Wide- range specifi- cation products				HD64338346HW	38346H	100-pin QFP (FP-100B)
						HD64338346WW	38346W	100-pin TQFP (TFP-100G)
						HD64338346XW	38346X	100-pin TQFP (TFP-100B)
		H8/38347	Mask ROM versions	Regular products		HD64338347H	38347H	100-pin QFP (FP-100B)
						HD64338347W	38347W	100-pin TQFP (TFP-100G)
						HD64338347X	38347X	100-pin TQFP (TFP-100B)
						HCD64338347	—	Die
Wide- range specifi- cation products						HD64338347HW	38347H	100-pin QFP (FP-100B)
						HD64338347WW	38347W	100-pin TQFP (TFP-100G)
						HD64338347XW	38347X	100-pin TQFP (TFP-100B)
F-ZTAT versions				Regular products		HD64F38347H	F38347H	100-pin QFP (FP-100B)
						HD64F38347W	F38347W	100-pin TQFP (TFP-100G)
						HD64F38347X	F38347X	100-pin TQFP (TFP-100B)
						HCD64F38347	—	Die
Wide- range specifi- cation products				HD64F38347HW	F38347H	100-pin QFP (FP-100B)		
				HD64F38347W	F38347W	100-pin TQFP (TFP-100G)		
				HD64F38347XW	F38347X	100-pin TQFP (TFP-100B)		

Appendix E List of Product Codes

Product Type				Product Code	Mark Code	Package (Package Code)
H8/38447 Group	H8/38442	Mask ROM versions	Regular products	HD64338442H	38442H	100-pin QFP (FP-100B)
				HD64338442W	38442W	100-pin TQFP (TFP-100G)
				HD64338442X	38442X	100-pin TQFP (TFP-100B)
				HCD64338442	—	Die
	Wide- range specifi- cation products	HD64338442HW	38442H	100-pin QFP (FP-100B)		
		HD64338442WW	38442W	100-pin TQFP (TFP-100G)		
		HD64338442XW	38442X	100-pin TQFP (TFP-100B)		
	H8/38443	Mask ROM versions	Regular products	HD64338443H	38443H	100-pin QFP (FP-100B)
				HD64338443W	38443W	100-pin TQFP (TFP-100G)
				HD64338443X	38443X	100-pin TQFP (TFP-100B)
				HCD64338443	—	Die
Wide- range specifi- cation products		HD64338443HW	38443H	100-pin QFP (FP-100B)		
		HD64338443WW	38443W	100-pin TQFP (TFP-100G)		
		HD64338443XW	38443X	100-pin TQFP (TFP-100B)		
H8/38444		Mask ROM versions	Regular products	HD64338444H	38444H	100-pin QFP (FP-100B)
				HD64338444W	38444W	100-pin TQFP (TFP-100G)
				HD64338444X	38444X	100-pin TQFP (TFP-100B)
				HCD64338444	—	Die
	Wide- range specifi- cation products	HD64338444HW	38444H	100-pin QFP (FP-100B)		
		HD64338444WW	38444W	100-pin TQFP (TFP-100G)		
		HD64338444XW	38444X	100-pin TQFP (TFP-100B)		
	F-ZTAT versions	Regular products	HD64F38444H	F38444H	100-pin QFP (FP-100B)	
			HD64F38444W	F38444W	100-pin TQFP (TFP-100G)	
			HD64F38444X	F38444X	100-pin TQFP (TFP-100B)	
Wide- range specifi- cation products	HD64F38444HW	F38444H	100-pin QFP (FP-100B)			
	HD64F38444W W	F38444W	100-pin TQFP (TFP-100G)			
	HD64F38444XW	F38444X	100-pin TQFP (TFP-100B)			

Product Type				Product Code	Mark Code	Package (Package Code)	
H8/38447 Group	H8/38445	Mask ROM versions	Regular products	HD64338445H	38445H	100-pin QFP (FP-100B)	
				HD64338445W	38445W	100-pin TQFP (TFP-100G)	
				HD64338445X	38445X	100-pin TQFP (TFP-100B)	
				HCD64338445	—	Die	
	Mask ROM versions	Wide- range specifi- cation products	Regular products	HD64338445HW	38445H	100-pin QFP (FP-100B)	
				HD64338445WW	38445W	100-pin TQFP (TFP-100G)	
				HD64338445XW	38445X	100-pin TQFP (TFP-100B)	
				HD64338446H	38446H	100-pin QFP (FP-100B)	
	H8/38446	Mask ROM versions	Regular products	HD64338446W	38446W	100-pin TQFP (TFP-100G)	
				HD64338446X	38446X	100-pin TQFP (TFP-100B)	
				HCD64338446	—	Die	
				Wide- range specifi- cation products	HD64338446HW	38446H	100-pin QFP (FP-100B)
		HD64338446WW	38446W	100-pin TQFP (TFP-100G)			
		HD64338446XW	38446X	100-pin TQFP (TFP-100B)			
		H8/38447	Mask ROM versions	Regular products	HD64338447H	38447H	100-pin QFP (FP-100B)
					HD64338447W	38447W	100-pin TQFP (TFP-100G)
HD64338447X	38447X				100-pin TQFP (TFP-100B)		
HCD64338447	—				Die		
Wide- range specifi- cation products	HD64338447HW				38447H	100-pin QFP (FP-100B)	
HD64338447WW	38447W				100-pin TQFP (TFP-100G)		
F-ZTAT versions	Regular products		Regular products	HD64F38447H	F38447H	100-pin QFP (FP-100B)	
				HD64F38447W	F38447W	100-pin TQFP (TFP-100G)	
				HD64F38447X	F38447X	100-pin TQFP (TFP-100B)	
				HCD64F38447	—	Die	
				Wide- range specifi- cation products	HD64F38447HW	F38447H	100-pin QFP (FP-100B)
				HD64F38447W	F38447W	100-pin TQFP (TFP-100G)	
HD64F38447XW	F38447X	100-pin TQFP (TFP-100B)					

Note: For mask ROM versions, (***) is the ROM code.

Appendix F Package Dimensions

Dimensional drawings of H8/3847R Group, H8/3847S Group, H8/38347 Group, and H8/38447 Group packages FP-100A (only H8/3847R Group), FP-100B, TFP-100B and TFP-100G are shown in following figures F.1, F.2, F.3, and F.4, respectively.

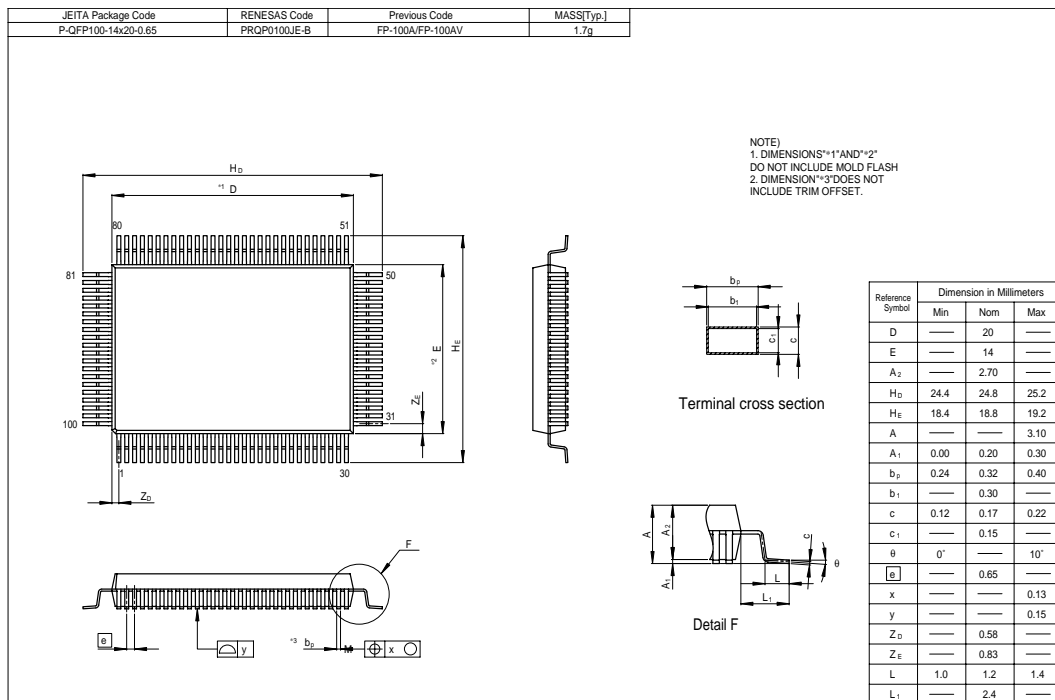
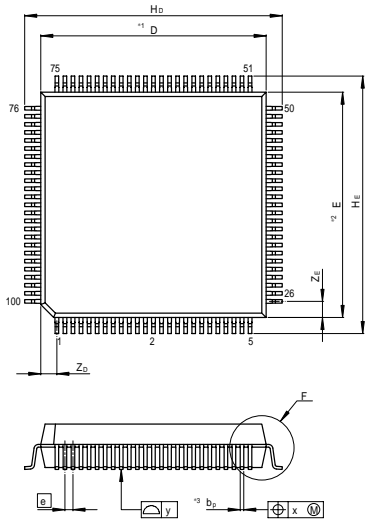
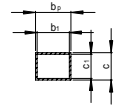


Figure F.1 FP-100A Package Dimensions

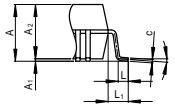
JEITA Package Code P-QFP100-14x14-0.50	RENESAS Code PRQP0100KA-A	Previous Code FP-100B/FP-100BV	MASS[Typ.] 1.2g
---	------------------------------	-----------------------------------	--------------------



NOTE)
1. DIMENSIONS *1 AND *2
DO NOT INCLUDE MOLD FLASH
2. DIMENSION *3 DOES NOT
INCLUDE TRIM OFFSET.



Terminal cross section



Detail F

Reference Symbol	Dimension in Millimeters		
	Min	Nom	Max
D	—	14	—
E	—	14	—
A ₂	—	2.70	—
H _D	15.7	16.0	16.3
H _E	15.7	16.0	16.3
A	—	—	3.05
A ₁	0.00	0.12	0.25
b _p	0.17	0.22	0.27
b ₁	—	0.20	—
c	0.12	0.17	0.22
c ₁	—	0.15	—
theta	0°	—	8°
a	—	0.5	—
x	—	—	0.08
y	—	—	0.10
Z ₀	—	1.0	—
Z _E	—	1.0	—
L	0.3	0.5	0.7
L ₁	—	1.0	—

Figure F.2 FP-100B Package Dimensions

Appendix F Package Dimensions

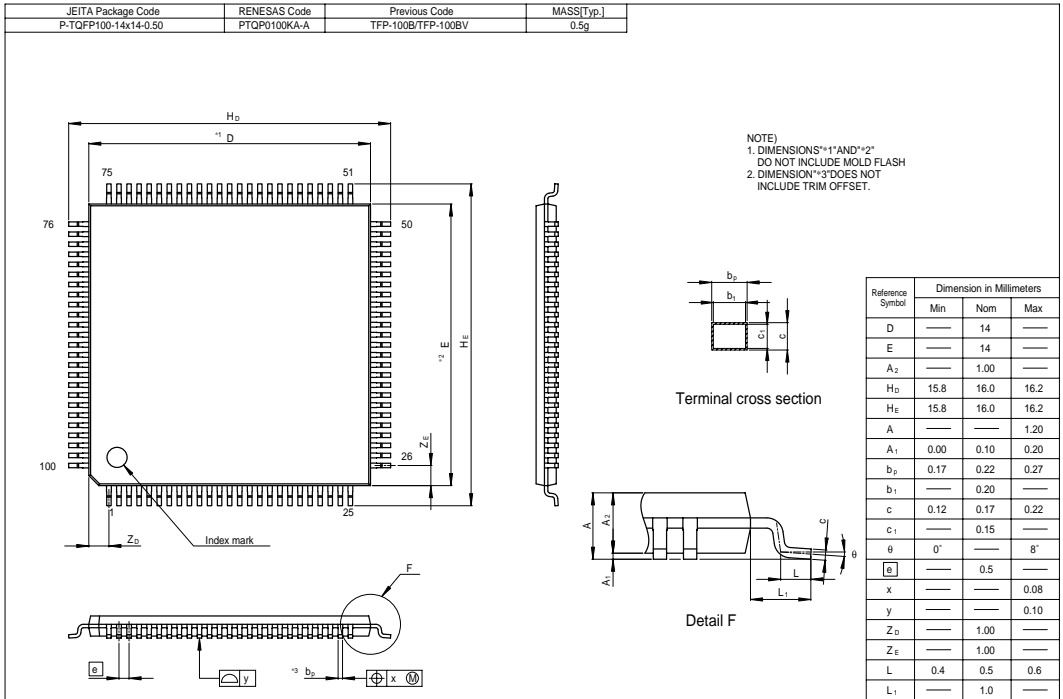
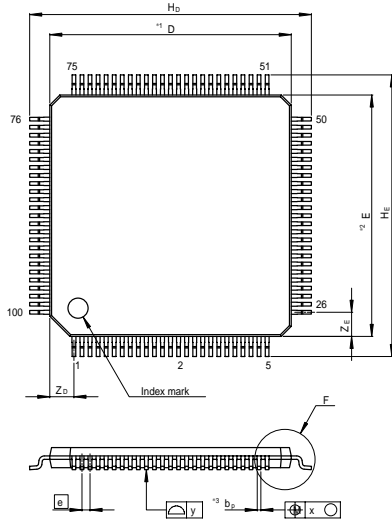
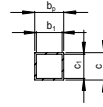


Figure F.3 TFP-100B Package Dimensions

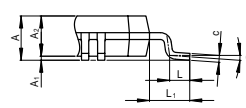
JEITA Package Code P-TQFP100-12x12-0.40	RENESAS Code PTQP0100LC-A	Previous Code TFP-100G/TFP-100GV	MASS[Typ.] 0.4g
--	------------------------------	-------------------------------------	--------------------



NOTE)
1. DIMENSIONS *1 AND *2
DO NOT INCLUDE MOLD FLASH
2. DIMENSION *3 DOES NOT
INCLUDE TRIM OFFSET.



Terminal cross section



Detail F

Reference Symbol	Dimension in Millimeters		
	Min	Nom	Max
D	—	12	—
E	—	12	—
A ₂	—	1.00	—
H _D	13.8	14.0	14.2
H _E	13.8	14.0	14.2
A	—	—	1.20
A ₁	0.00	0.10	0.20
b _p	0.13	0.18	0.23
b ₁	—	0.16	—
c	0.12	0.17	0.22
c ₁	—	0.15	—
θ	0°	—	8°
a	—	0.4	—
x	—	—	0.07
y	—	—	0.10
Z _D	—	1.2	—
Z _E	—	1.2	—
L	0.4	0.5	0.6
L ₁	—	1.0	—

Figure F.4 TFP-100G Package Dimension

Appendix G Specifications of Chip Form

The specifications of the chip form of the HCD6433847R, HCD6433846R, HCD6433845R, HCD6433844R, HCD6433843R, and HCD6433842R are shown in figure G.1.

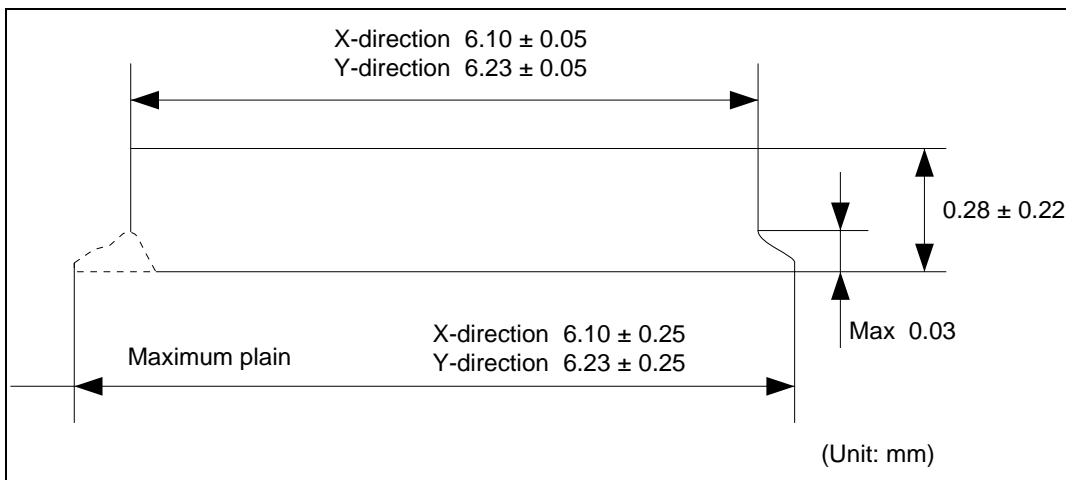


Figure G.1 Chip Sectional Figure

The specifications of the chip form of the HCD6433847S, HCD6433846S, HCD6433845S, and HCD6433844S are shown in figure G.2.

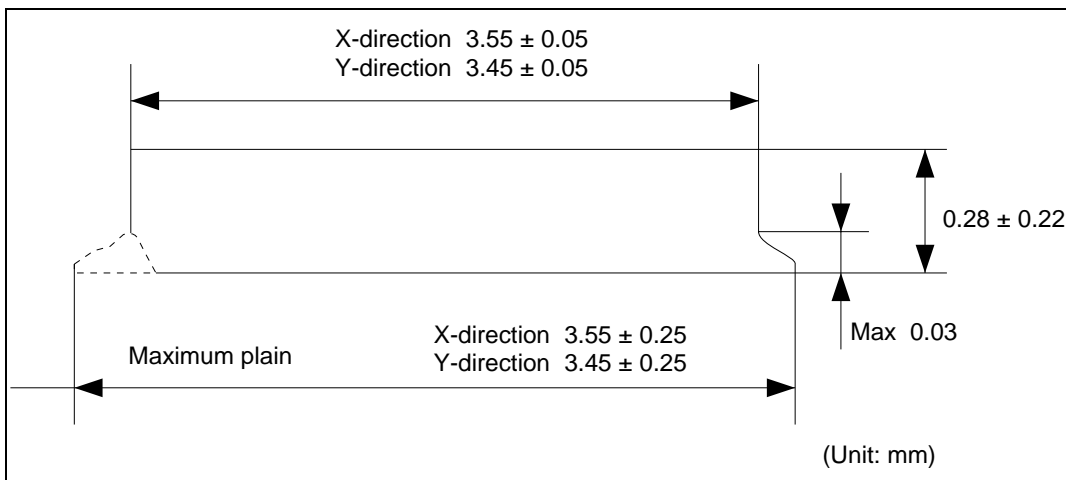


Figure G.2 Chip Sectional Figure

The specifications of the chip form of the HCD64F38347 and HCD64F38447 are shown in figure G.3.

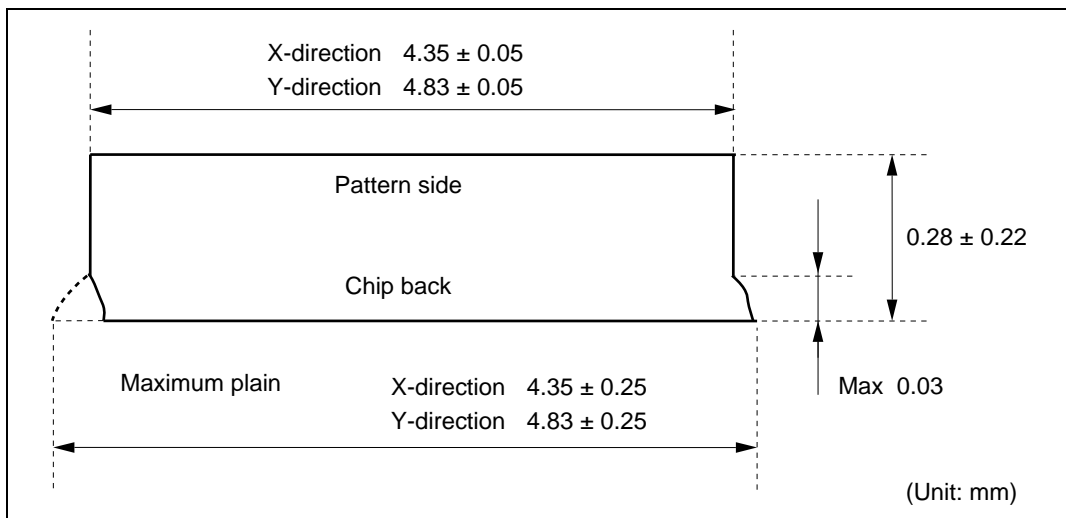


Figure G.3 Chip Sectional Figure

The specifications of the chip form of the H8/38347 Group (Mask ROM version) and H8/38447 Group (Mask ROM Version) are shown in figure G.4.

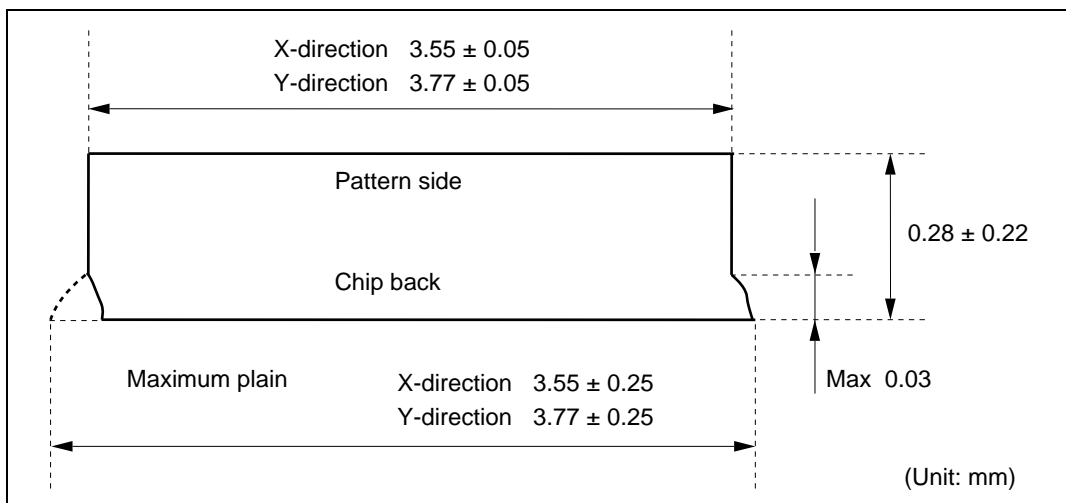


Figure G.4 Chip Sectional Figure

Appendix H Form of Bonding Pads

The form of the bonding pads for the HCD6433847R, HCD6433846R, HCD6433845R, HCD6433844R, HCD6433843R, and HCD6433842R is shown in figure H.1.

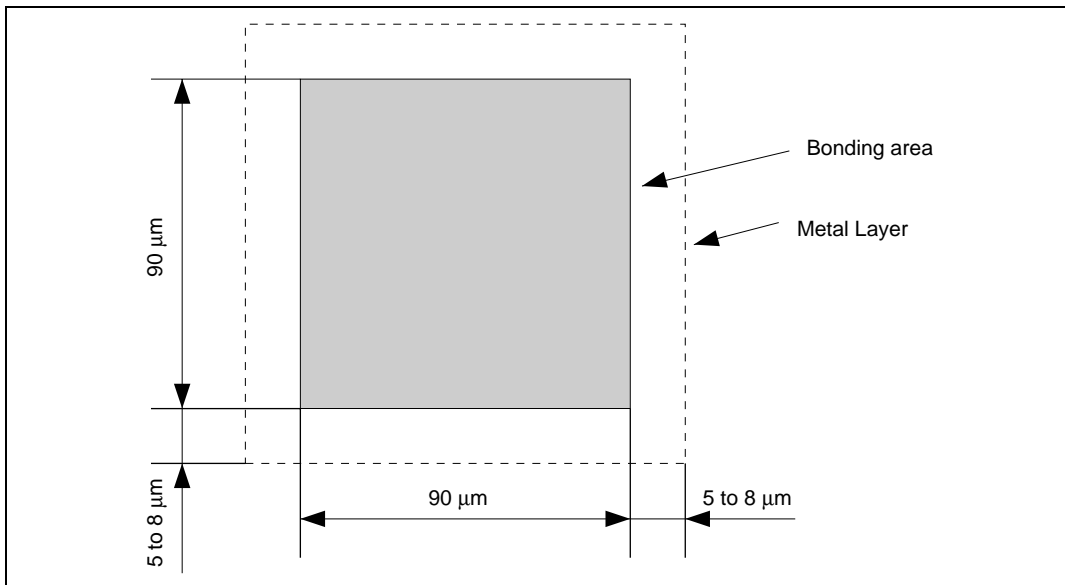


Figure H.1 Bonding Pad Form

The form of the bonding pads for the HCD6433847S, HCD6433846S, HCD6433845S, and HCD6433844S is shown in figure H.2.

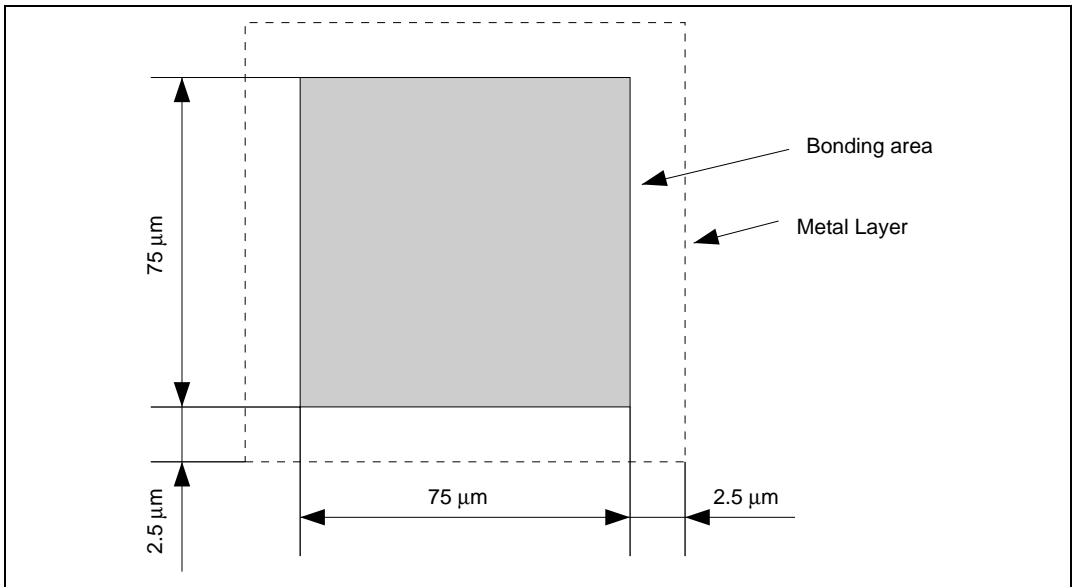


Figure H.2 Bonding Pad Form

The form of the bonding pads for the HCD64F38347, HCD64F38447, H8/38347 Group (Mask ROM version), and H8/38447 Group (Mask ROM version) is shown in figure H.3.

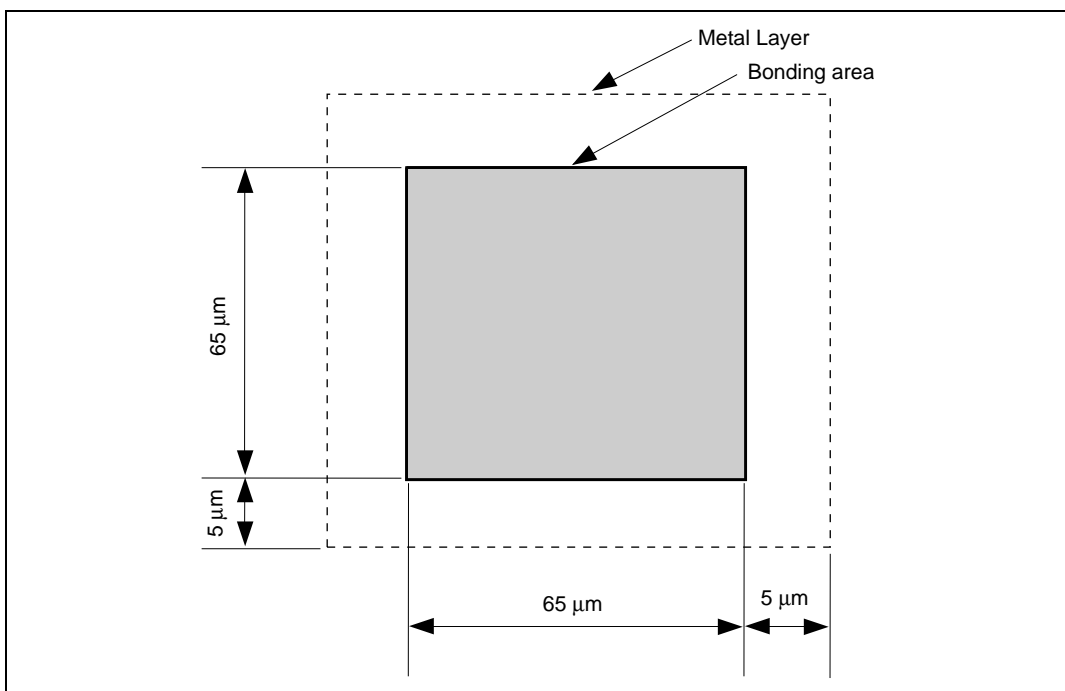


Figure H.3 Bonding Pad Form

Appendix I Specifications of Chip Tray

The specifications of the chip tray for the HCD6433847R, HCD6433846R, HCD6433845R, HCD6433844R, HCD6433843R, and HCD6433842R are shown in figure I.1.

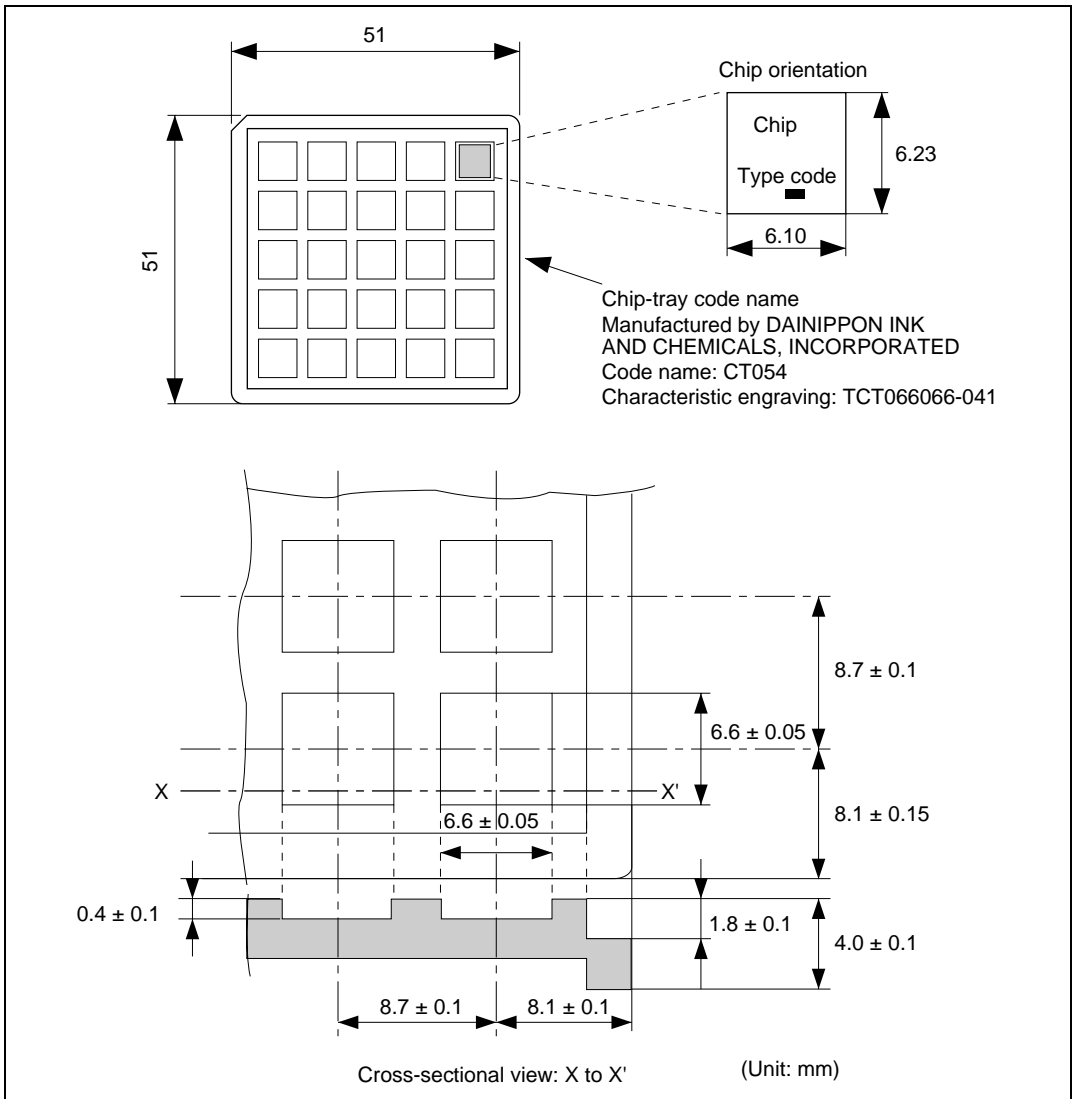


Figure I.1 Specifications of Chip Tray

The specifications of the chip tray for the HCD6433847S, HCD6433846S, HCD6433845S, and HCD6433844S are shown in figure I.2.

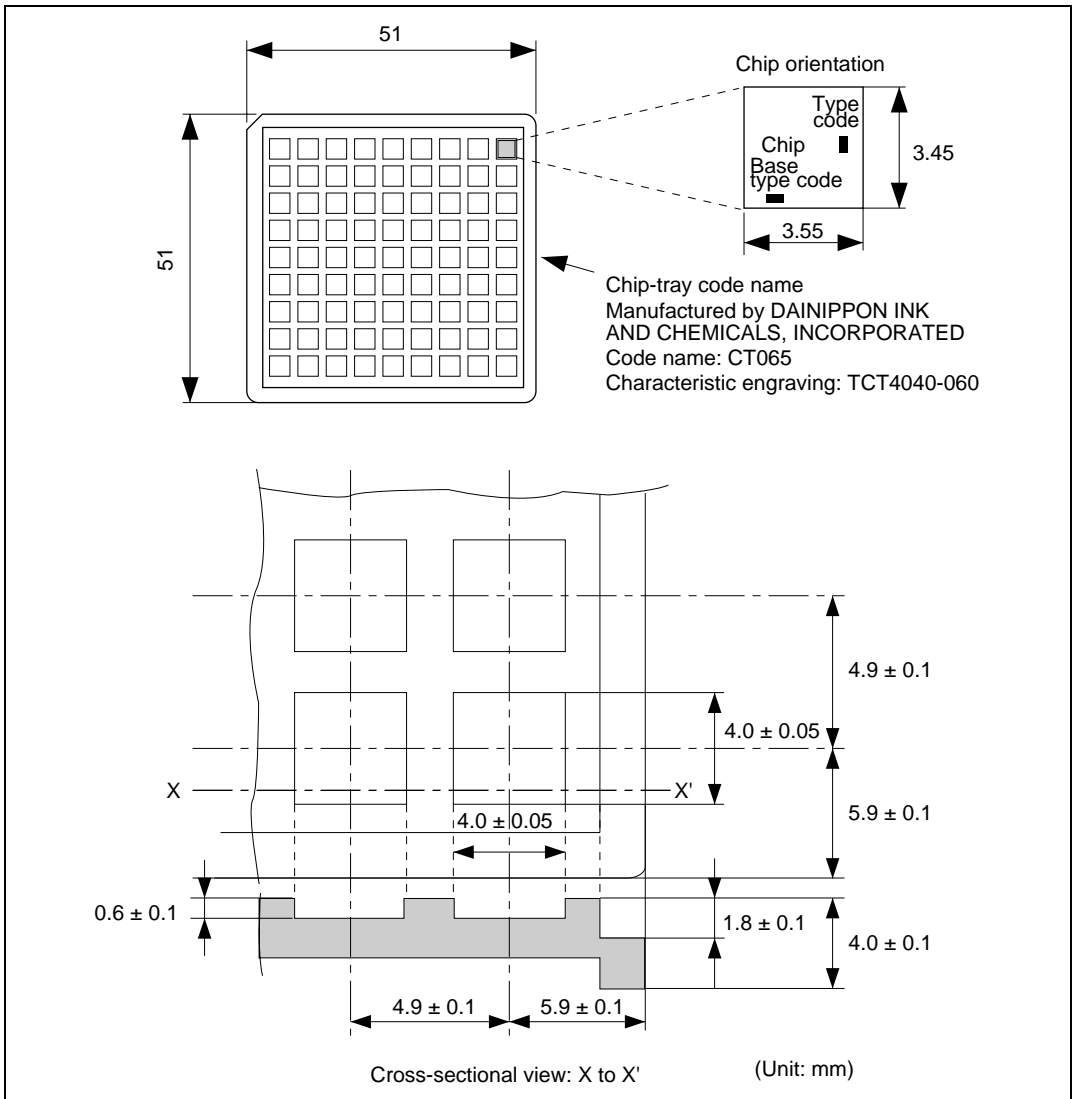


Figure I.2 Specifications of Chip Tray

The specifications of the chip tray for the HCD64F38347 and HCD64F38447 are shown in figure I.3.

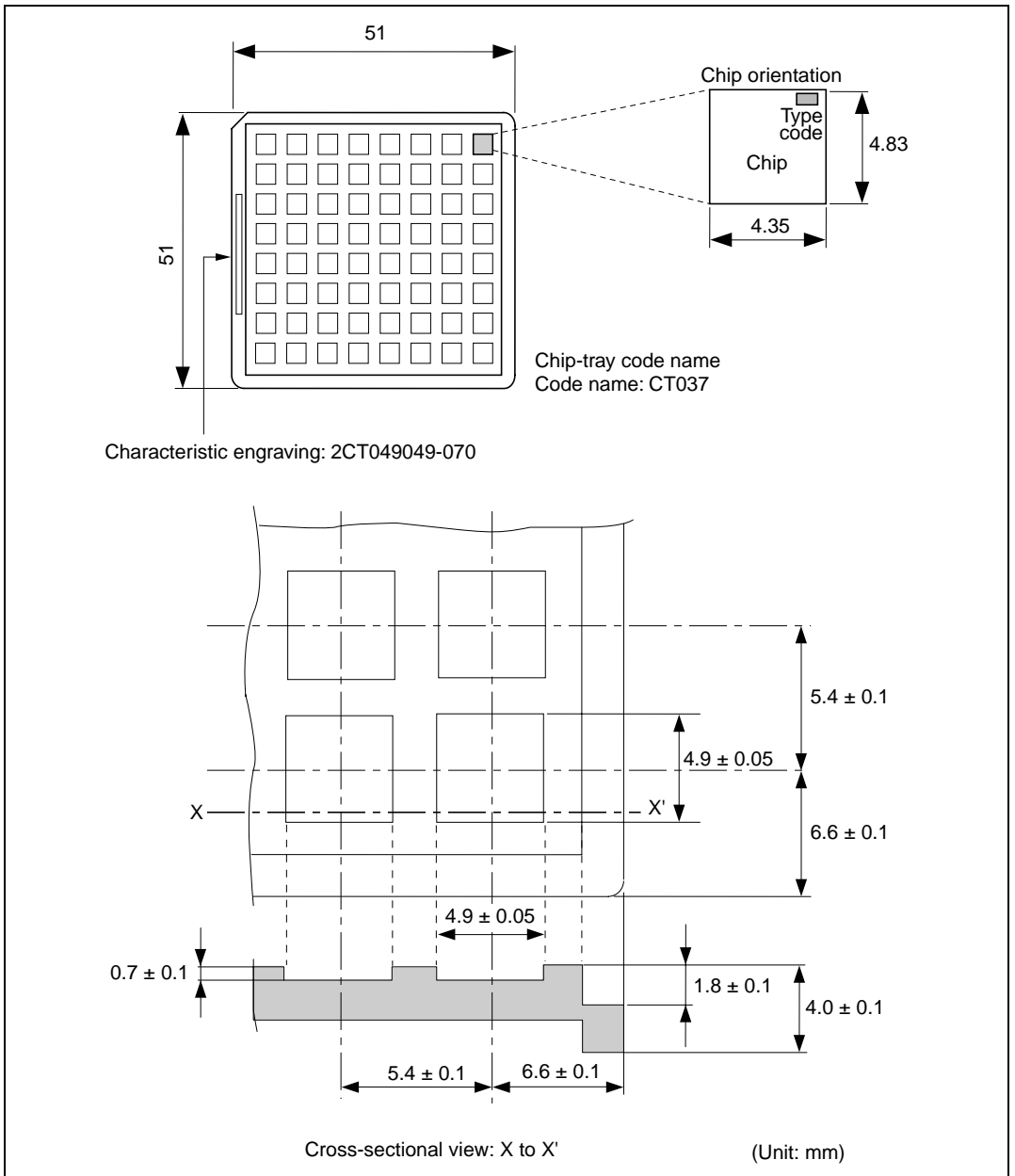


Figure I.3 Specifications of Chip Tray

The specifications of the chip tray for the H8/38347 Group (Mask ROM version) and H8/38447 Group (Mask ROM version) are shown in figure I.4.

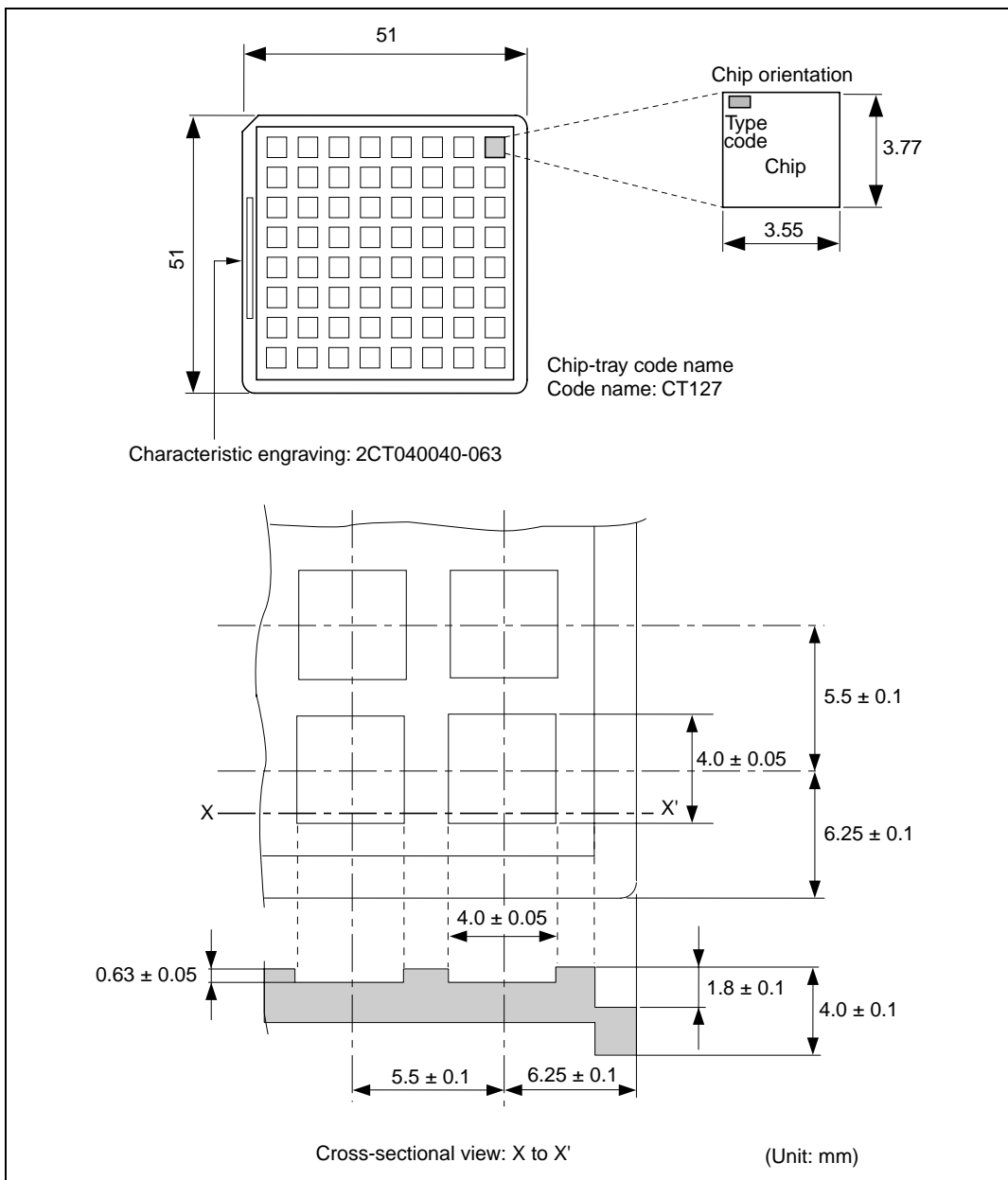


Figure I.4 Specifications of Chip Tray

**Renesas 8-Bit Single-Chip Microcomputer
Hardware Manual
H8/3847R Group, H8/3847S Group, H8/38347 Group,
H8/38447 Group**

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H8/38347 Group, H8/38447 Group
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