

# DATA SHEET

For a complete data sheet, please also download:

- The IC04 LOCMOS HE4000B Logic Family Specifications HEF, HEC
- The IC04 LOCMOS HE4000B Logic Package Outlines/Information HEF, HEC

## **HEF40193B**

### **MSI**

## **4-bit up/down binary counter**

Product specification  
File under Integrated Circuits, IC04

January 1995

# 4-bit up/down binary counter

# HEF40193B MSI

### DESCRIPTION

The HEF40193B is a 4-bit synchronous up/down binary counter. The counter has a count-up clock input (CP<sub>U</sub>), a count-down clock input (CP<sub>D</sub>), an asynchronous parallel load input ( $\overline{PL}$ ), four parallel data inputs (P<sub>0</sub> to P<sub>3</sub>), an asynchronous master reset input (MR), four counter outputs (O<sub>0</sub> to O<sub>3</sub>), an active LOW terminal count-up (carry) output ( $\overline{TC}_U$ ) and an active LOW terminal count-down (borrow) output ( $\overline{TC}_D$ ).

The counter outputs change state on the LOW to HIGH transition of either clock input. However, for correct counting, both clock inputs cannot be LOW simultaneously. The outputs  $\overline{TC}_U$  and  $\overline{TC}_D$  are normally HIGH. When the circuit has reached the maximum count state of '15', the next HIGH to LOW transition of CP<sub>U</sub> will cause  $\overline{TC}_U$  to go LOW.  $\overline{TC}_U$  will stay LOW until CP<sub>U</sub> goes HIGH again. Likewise, output  $\overline{TC}_D$  will go LOW when the circuit is in the zero state and CP<sub>D</sub> goes LOW. When  $\overline{PL}$  is LOW, the information on P<sub>0</sub> to P<sub>3</sub> is asynchronously loaded into the counter. A HIGH on MR resets the counter independent of all other input conditions. The counter stages are of a static toggle type flip-flop.

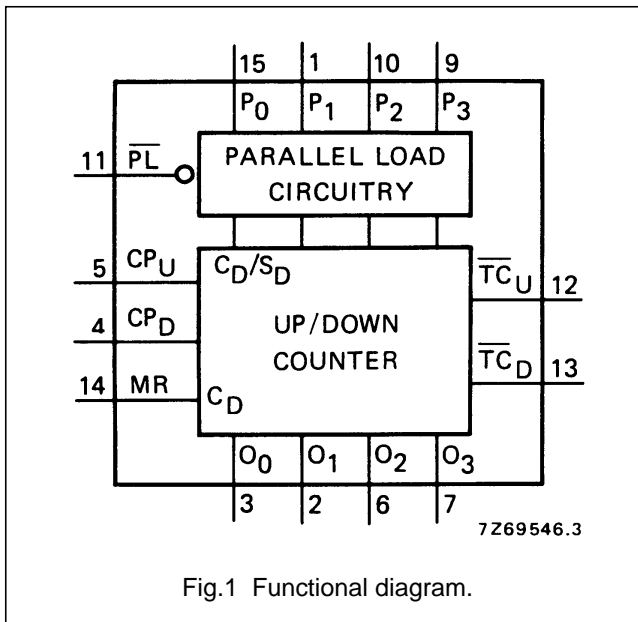


Fig.1 Functional diagram.

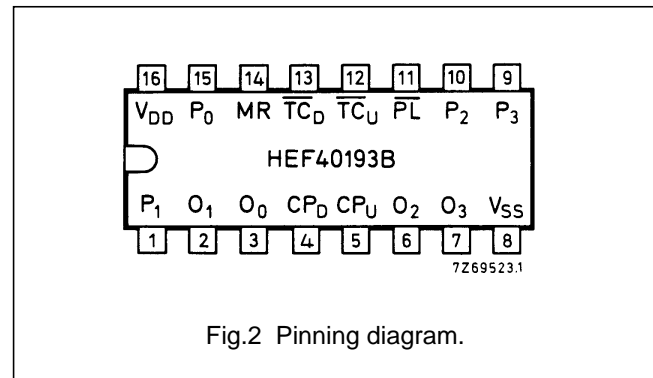


Fig.2 Pinning diagram.

### PINNING

- $\overline{PL}$  parallel load input (active LOW)
- P<sub>0</sub> to P<sub>3</sub> parallel data inputs
- CP<sub>U</sub> count-up clock pulse input (LOW to HIGH, edge-triggered)
- CP<sub>D</sub> count-down clock pulse input (LOW to HIGH, edge-triggered)
- MR master reset input (asynchronous)
- $\overline{TC}_U$  buffered terminal count-up (carry) output (active LOW)
- $\overline{TC}_D$  buffered terminal count-down (borrow) output (active LOW)
- O<sub>0</sub> to O<sub>3</sub> buffered counter outputs

- HEF40193BP(N): 16-lead DIL; plastic (SOT38-1)
- HEF40193BD(F): 16-lead DIL; ceramic (cerdip) (SOT74)
- HEF40193BT(D): 16-lead SO; plastic (SOT109-1)
- ( ): Package Designator North America

### FAMILY DATA, I<sub>DD</sub> LIMITS category MSI

See Family Specification

4-bit up/down binary counter

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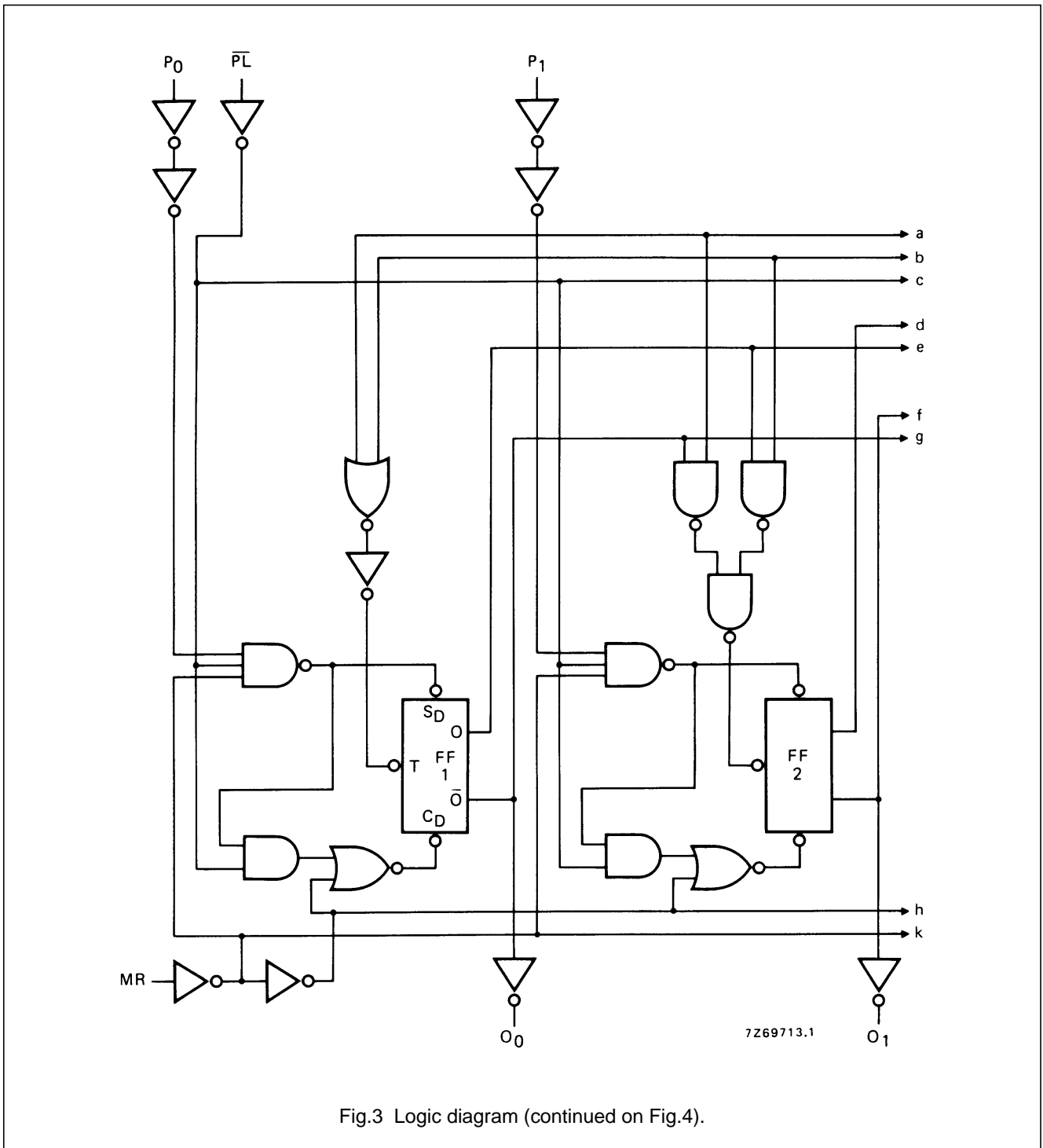


Fig.3 Logic diagram (continued on Fig.4).

4-bit up/down binary counter

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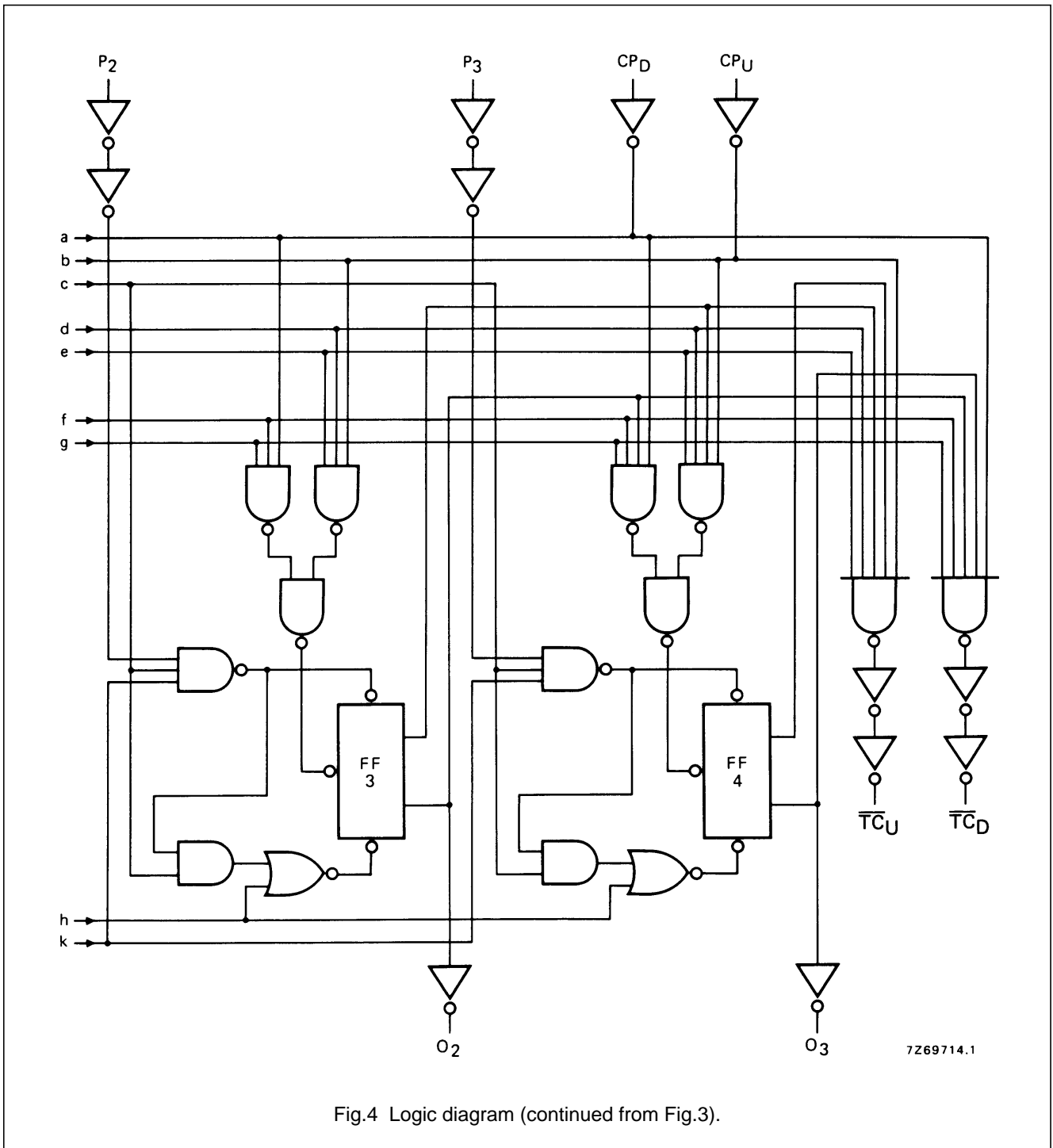




Fig.4 Logic diagram (continued from Fig.3).

4-bit up/down binary counter


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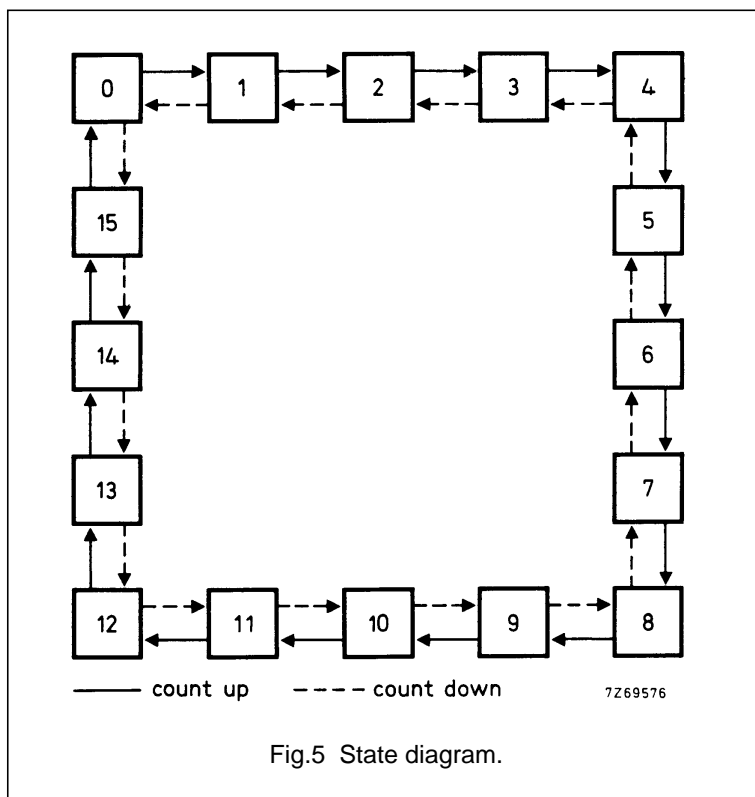
FUNCTION TABLE

MR	$\overline{PL}$	$CP_U$	$CP_D$	MODE
H	X	X	X	reset (asyn.)
L	L	X	X	parallel load
L	H		H	count-up
L	H	H		count-down

Notes

- H = HIGH state (the more positive voltage)  
L = LOW state (the less positive voltage)  
X = state is immaterial

 = positive-going transition



Logic equations for terminal count:

$$\overline{TC}_U = \overline{O_0 \cdot O_1 \cdot O_2 \cdot O_3} \cdot \overline{CP_U}$$

$$\overline{TC}_D = \overline{\overline{O_0} \cdot \overline{O_1} \cdot \overline{O_2} \cdot \overline{O_3}} \cdot \overline{CP_D}$$

AC CHARACTERISTICS

$V_{SS} = 0\text{ V}$ ;  $T_{amb} = 25\text{ }^\circ\text{C}$ ; input transition times  $\leq 20\text{ ns}$

	$V_{DD}$ V	TYPICAL FORMULA FOR P ( $\mu\text{W}$ )	
Dynamic power dissipation per package (P)	5	$600 f_i + \sum(f_o C_L) \times V_{DD}^2$	where $f_i$ = input freq. (MHz) $f_o$ = output freq. (MHz) $C_L$ = load capacitance (pF) $\sum(f_o C_L)$ = sum of outputs $V_{DD}$ = supply voltage (V)
	10	$2700 f_i + \sum(f_o C_L) \times V_{DD}^2$	
	15	$7500 f_i + \sum(f_o C_L) \times V_{DD}^2$	

## 4-bit up/down binary counter

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## AC CHARACTERISTICS

 $V_{SS} = 0\text{ V}$ ;  $T_{amb} = 25\text{ }^{\circ}\text{C}$ ;  $C_L = 50\text{ pF}$ ; input transition times  $\leq 20\text{ ns}$ 

	$V_{DD}$ V	SYMBOL	MIN.	TYP.	MAX.	TYPICAL EXTRAPOLATION FORMULA	
Propagation delays $CP_U \rightarrow O_n$ HIGH to LOW	5	$t_{PHL}$	210	415	ns	$183\text{ ns} + (0,55\text{ ns/pF}) C_L$	
	10		85	165	ns	$74\text{ ns} + (0,23\text{ ns/pF}) C_L$	
	15		60	120	ns	$52\text{ ns} + (0,16\text{ ns/pF}) C_L$	
	LOW to HIGH	5	$t_{PLH}$	170	340	ns	$143\text{ ns} + (0,55\text{ ns/pF}) C_L$
		10		70	140	ns	$59\text{ ns} + (0,23\text{ ns/pF}) C_L$
		15		50	100	ns	$42\text{ ns} + (0,16\text{ ns/pF}) C_L$
$CP_D \rightarrow O_n$ HIGH to LOW	5	$t_{PHL}$	210	425	ns	$183\text{ ns} + (0,55\text{ ns/pF}) C_L$	
	10		85	170	ns	$74\text{ ns} + (0,23\text{ ns/pF}) C_L$	
	15		60	125	ns	$57\text{ ns} + (0,16\text{ ns/pF}) C_L$	
	LOW to HIGH	5	$t_{PLH}$	170	340	ns	$143\text{ ns} + (0,55\text{ ns/pF}) C_L$
		10		70	140	ns	$59\text{ ns} + (0,23\text{ ns/pF}) C_L$
		15		50	100	ns	$42\text{ ns} + (0,16\text{ ns/pF}) C_L$
$CP_U \rightarrow \overline{TC}_U$ HIGH to LOW	5	$t_{PHL}$	125	250	ns	$98\text{ ns} + (0,55\text{ ns/pF}) C_L$	
	10		50	100	ns	$39\text{ ns} + (0,23\text{ ns/pF}) C_L$	
	15		35	70	ns	$27\text{ ns} + (0,16\text{ ns/pF}) C_L$	
	LOW to HIGH	5	$t_{PLH}$	95	185	ns	$68\text{ ns} + (0,55\text{ ns/pF}) C_L$
		10		40	80	ns	$29\text{ ns} + (0,23\text{ ns/pF}) C_L$
		15		30	60	ns	$22\text{ ns} + (0,16\text{ ns/pF}) C_L$
$CP_D \rightarrow \overline{TC}_D$ HIGH to LOW	5	$t_{PHL}$	140	280	ns	$113\text{ ns} + (0,55\text{ ns/pF}) C_L$	
	10		55	110	ns	$44\text{ ns} + (0,23\text{ ns/pF}) C_L$	
	15		40	80	ns	$32\text{ ns} + (0,16\text{ ns/pF}) C_L$	
	LOW to HIGH	5	$t_{PLH}$	100	195	ns	$73\text{ ns} + (0,55\text{ ns/pF}) C_L$
		10		40	85	ns	$29\text{ ns} + (0,23\text{ ns/pF}) C_L$
		15		30	65	ns	$22\text{ ns} + (0,16\text{ ns/pF}) C_L$
$MR \rightarrow O_n$ HIGH to LOW	5	$t_{PHL}$	195	390	ns	$168\text{ ns} + (0,55\text{ ns/pF}) C_L$	
	10		80	160	ns	$69\text{ ns} + (0,23\text{ ns/pF}) C_L$	
	15		60	120	ns	$52\text{ ns} + (0,16\text{ ns/pF}) C_L$	
$MR \rightarrow \overline{TC}_U$ LOW to HIGH	5	$t_{PLH}$	145	285	ns	$118\text{ ns} + (0,55\text{ ns/pF}) C_L$	
	10		60	115	ns	$49\text{ ns} + (0,23\text{ ns/pF}) C_L$	
	15		45	90	ns	$37\text{ ns} + (0,16\text{ ns/pF}) C_L$	
$MR \rightarrow \overline{TC}_D$ HIGH to LOW	5	$t_{PHL}$	365	730	ns	$338\text{ ns} + (0,55\text{ ns/pF}) C_L$	
	10		130	265	ns	$119\text{ ns} + (0,23\text{ ns/pF}) C_L$	
	15		100	205	ns	$92\text{ ns} + (0,16\text{ ns/pF}) C_L$	
$\overline{PL} \rightarrow O_n$ HIGH to LOW	5	$t_{PHL}$	185	360	ns	$158\text{ ns} + (0,55\text{ ns/pF}) C_L$	
	10		75	150	ns	$64\text{ ns} + (0,23\text{ ns/pF}) C_L$	
	15		55	110	ns	$47\text{ ns} + (0,16\text{ ns/pF}) C_L$	

## 4-bit up/down binary counter

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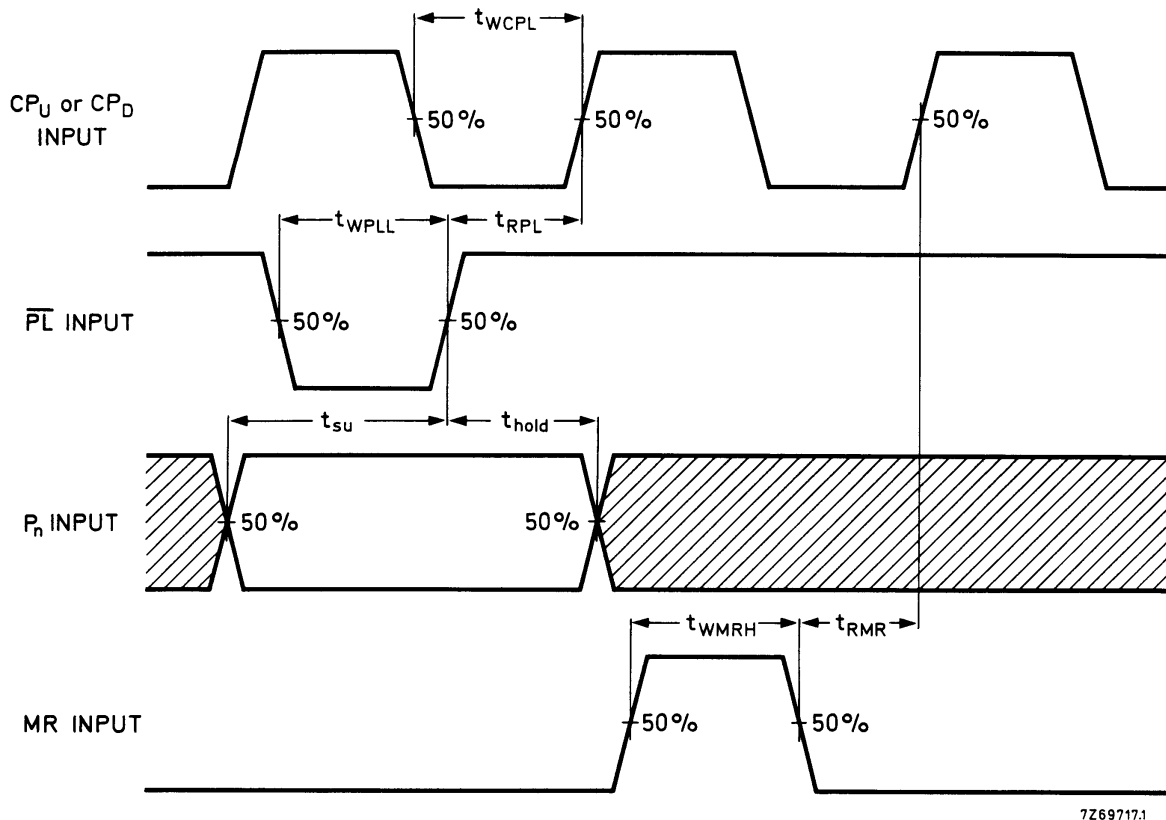
	V <sub>DD</sub> V	SYMBOL	MIN.	TYP.	MAX.	TYPICAL EXTRAPOLATION FORMULA
LOW to HIGH	5	t <sub>PLH</sub>	145	290	ns	118 ns + (0,55 ns/pF) C <sub>L</sub>
	10		60	120	ns	49 ns + (0,23 ns/pF) C <sub>L</sub>
	15		45	90	ns	37 ns + (0,16 ns/pF) C <sub>L</sub>

**AC CHARACTERISTICS**V<sub>SS</sub> = 0 V; T<sub>amb</sub> = 25 °C; C<sub>L</sub> = 50 pF; input transition times ≤ 20 ns

	V <sub>DD</sub> V	SYMBOL	MIN.	TYP.	MAX.	TYPICAL EXTRAPOLATION FORMULA	
Output transition times HIGH to LOW	5	t <sub>THL</sub>	60	120	ns	10 ns + (1,0 ns/pF) C <sub>L</sub>	
	10		30	60	ns	9 ns + (0,42 ns/pF) C <sub>L</sub>	
	15		20	40	ns	6 ns + (0,28 ns/pF) C <sub>L</sub>	
	LOW to HIGH	5	t <sub>TLH</sub>	60	120	ns	10 ns + (1,0 ns/pF) C <sub>L</sub>
		10		30	60	ns	9 ns + (0,42 ns/pF) C <sub>L</sub>
		15		20	40	ns	6 ns + (0,28 ns/pF) C <sub>L</sub>
Set-up time P <sub>n</sub> → $\overline{PL}$	5	t <sub>su</sub>	160	80	ns	see also waveforms Fig.6	
	10		60	30	ns		
	15		50	25	ns		
Hold time P <sub>n</sub> → $\overline{PL}$	5	t <sub>hold</sub>	10	-70	ns		
	10		5	-25	ns		
	15		5	-20	ns		
Minimum CP <sub>U</sub> or CP <sub>D</sub> pulse width; LOW	5	t <sub>WCPL</sub>	150	75	ns		
	10		50	25	ns		
	15		35	20	ns		
Minimum MR pulse width; HIGH	5	t <sub>WMRH</sub>	180	90	ns		
	10		70	35	ns		
	15		60	30	ns		
Minimum $\overline{PL}$ pulse width; LOW	5	t <sub>WPLL</sub>	120	60	ns		
	10		45	20	ns		
	15		30	15	ns		
Recovery time for MR	5	t <sub>RMR</sub>	125	65	ns		
	10		70	35	ns		
	15		50	25	ns		
Recovery time for $\overline{PL}$	5	t <sub>RPL</sub>	90	45	ns		
	10		35	15	ns		
	15		25	10	ns		
Maximum clock pulse frequency	5	f <sub>max</sub>	2,5	5	MHz		
	10		7	14	MHz		
	15		9	18	MHz		

4-bit up/down binary counter

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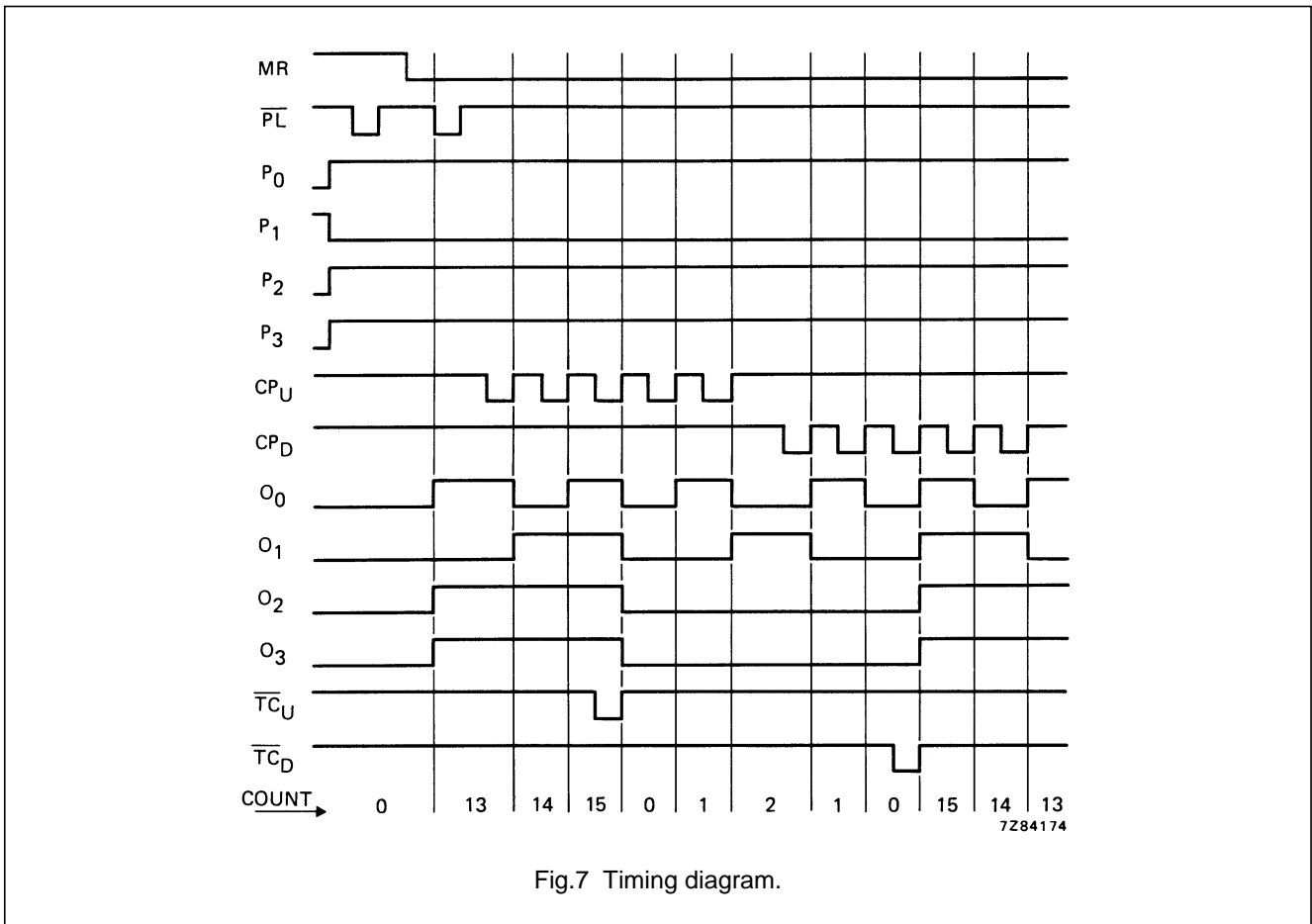
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Fig.6 Waveforms showing recovery times for  $\overline{P_L}$  and MR, minimum pulse widths for CP<sub>U</sub>, CP<sub>D</sub>,  $\overline{P_L}$  and MR, and set-up and hold times for P to  $\overline{P_L}$ . Set-up times and hold times are shown as positive values but may be specified as negative values.



4-bit up/down binary counter

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APPLICATION INFORMATION

Some examples of applications for the HEF40193B are:

- Up/down difference counting
- Multistage ripple counting
- Multistage synchronous counting

