

DATA SHEET

74LVC16373A; 74LVCH16373A
16-bit D-type transparent latch with
5 V tolerant inputs/outputs; 3-state

Product specification
Supersedes data of 2002 Oct 02

2003 Dec 08

16-bit D-type transparent latch with 5 V tolerant inputs/outputs; 3-state

74LVC16373A; 74LVCH16373A

FEATURES

- 5 V tolerant inputs/outputs for interfacing with 5 V logic
- Wide supply voltage range from 1.2 to 3.6 V
- CMOS low power consumption
- MULTIBYTE flow-through standard pin-out architecture
- Low inductance multiple power and ground pins for minimum noise and ground bounce
- Direct interface with TTL levels
- All data inputs have bushold (74LVCH16373A only)
- High-impedance when $V_{CC} = 0$ V.
- Complies with JEDEC standard no. 8-1A
- ESD protection:
HBM EIA/JESD22-A114-A exceeds 2000 V
MM EIA/JESD22-A115-A exceeds 200 V.
- Specified from -40 to $+85$ °C and -40 to $+125$ °C.

DESCRIPTION

The 74LVC(H)16373A is a 16-bit D-type transparent latch featuring separate D-type inputs for each latch and 3-state outputs for bus oriented applications. One Latch Enable (LE) input and one Output Enable (\overline{OE}) are provided for each octal. Inputs can be driven from either 3.3 or 5 V devices. In 3-state operation, outputs can handle 5 V. These features allow the use of these devices in a mixed 3.3 and 5 V environment.

The 74LVC(H)16373A consists of 2 sections of eight D-type transparent latches with 3-state true outputs. When LE is HIGH, data at the Dn inputs enter the latches. In this condition the latches are transparent, i.e., a latch output will change each time its corresponding D-input changes.

When LE is LOW the latches store the information that was present at the D-inputs a set-up time preceding the HIGH-to-LOW transition of LE. When \overline{OE} is LOW, the contents of the eight latches are available at the outputs. When \overline{OE} is HIGH, the outputs go to the high impedance OFF-state. Operation of the \overline{OE} input does not affect the state of the latches.

The 74LVCH16373A bushold data inputs eliminates the need for external pull up resistors to hold unused inputs.

FUNCTION TABLE

Per section of eight bits; note 1

OPERATING MODES	INPUT			INTERNAL LATSHE	OUTPUT nQ0 to nQ7
	n \overline{OE}	nLE	nDn		
Enable and read register (transparent mode)	L	H	L	L	L
	L	H	H	H	H
Latch and read register	L	L	l	L	L
	L	L	h	H	H
Latch register and disable outputs	H	L	l	L	Z
	H	L	h	H	Z

Note

1. H = HIGH voltage level;
h = HIGH voltage level one set-up time prior to the HIGH-to-LOW LE transition;
L = LOW voltage level;
l = LOW voltage level one set-up time prior to the HIGH-to-LOW LE transition;
Z = high-impedance OFF-state.

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QUICK REFERENCE DATA

GND = 0 V; $T_{amb} = 25\text{ °C}$; $t_r = t_f \leq 2.5\text{ ns}$

SYMBOL	PARAMETER	CONDITIONS	TYPICAL	UNIT
t_{PHL}/t_{PLH}	propagation delay Dn to Qn	$C_L = 50\text{ pF}$; $V_{CC} = 3.3\text{ V}$	3.0	ns
	propagation delay LE to Qn	$C_L = 50\text{ pF}$; $V_{CC} = 3.3\text{ V}$	3.4	ns
t_{PZH}/t_{PZL}	3-state output enable time \overline{OE} to Qn	$C_L = 50\text{ pF}$; $V_{CC} = 3.3\text{ V}$	3.5	ns
t_{PHZ}/t_{PLZ}	3-state output disable time \overline{OE} to Qn	$C_L = 50\text{ pF}$; $V_{CC} = 3.3\text{ V}$	3.9	ns
C_I	input capacitance		5.0	pF
C_{PD}	power dissipation per latch	$V_{CC} = 3.3\text{ V}$; notes 1 and 2 outputs enabled	15	pF
		outputs disabled	11	pF

Note

1. C_{PD} is used to determine the dynamic power dissipation (P_D in μW).

a) $P_D = C_{PD} \times V_{CC}^2 \times f_i \times N + \Sigma(C_L \times V_{CC}^2 \times f_o)$ where:

f_i = input frequency in MHz;

f_o = output frequency in MHz;

C_L = output load capacity in pF;

V_{CC} = supply voltage in Volts;

N = total load switching outputs;

$\Sigma(C_L \times V_{CC}^2 \times f_o)$ = sum of the outputs.

2. The condition is $V_I = \text{GND}$ to V_{CC} .

ORDERING INFORMATION

TYPE NUMBER	TEMPERATURE RANGE	PACKAGE			
		PINS	PACKAGE	MATERIAL	CODE
74LVC16373ADGG	-40 to +125 °C	48	TSSOP48	plastic	SOT362-1
74LVCH16373ADGG	-40 to +125 °C	48	TSSOP48	plastic	SOT362-1
74LVC16373ADL	-40 to +125 °C	48	SSOP48	plastic	SOT370-1
74LVCH16373ADL	-40 to +125 °C	48	SSOP48	plastic	SOT370-1

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PINNING

SYMBOL	PIN	DESCRIPTION
1OE	1	output enable input (active LOW)
1Q0	2	data output
1Q1	3	data output
GND	4, 10, 15, 21, 28, 34, 39, 45	ground (0 V)
1Q2	5	data output
1Q3	6	data output
V _{CC}	7, 18, 31, 42	supply voltage
1Q4	8	data output
1Q5	9	data output
1Q6	11	data output
1Q7	12	data output
2Q0	13	data output
2Q1	14	data output
2Q2	16	data output
2Q3	17	data output
2Q4	19	data output
2Q5	20	data output
2Q6	22	data output
2Q7	23	data output
2OE	24	output enable input (active LOW)
2LE	25	latch enable input (active HIGH)
2D7	26	data input
2D6	27	data input
2D5	29	data input
2D4	30	data input
2D3	32	data input
2D2	33	data input
2D1	35	data input
2D0	36	data input
1D7	37	data input
1D6	38	data input
1D5	40	data input
1D4	41	data input
1D3	43	data input
1D2	44	data input

SYMBOL	PIN	DESCRIPTION
1D1	46	data input
1D0	47	data input
1LE	48	latch enable input (active HIGH)

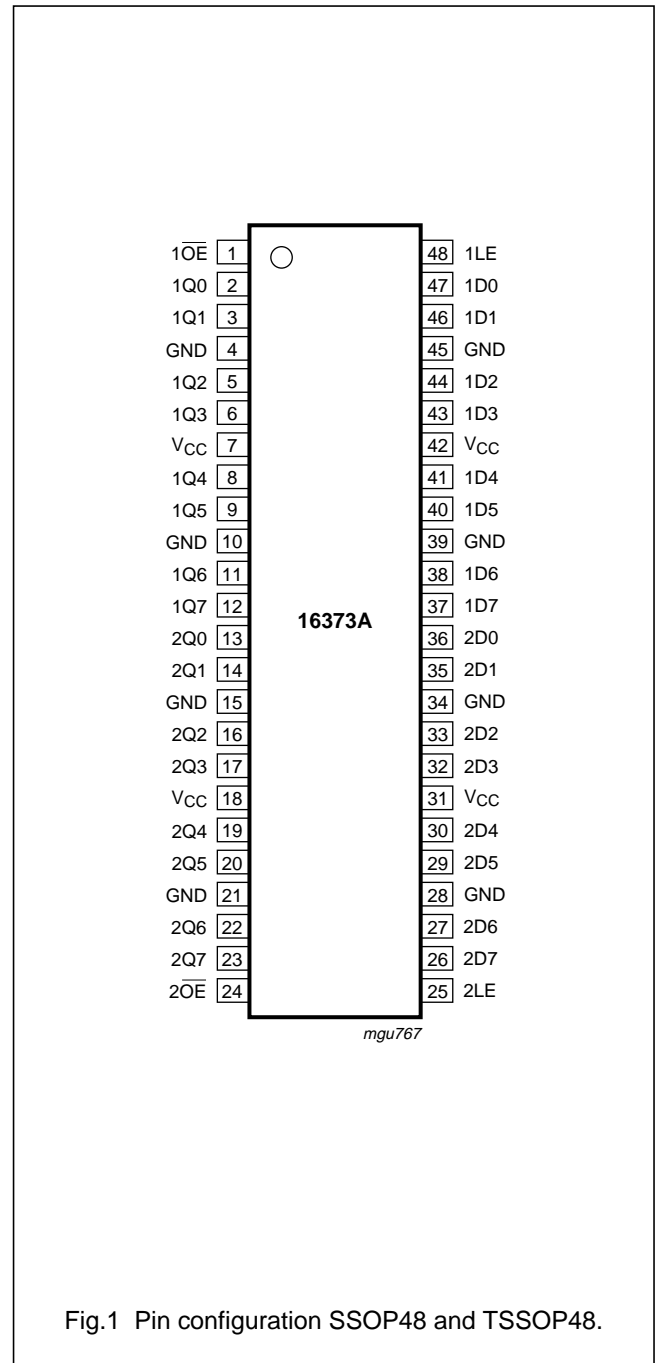


Fig.1 Pin configuration SSOP48 and TSSOP48.

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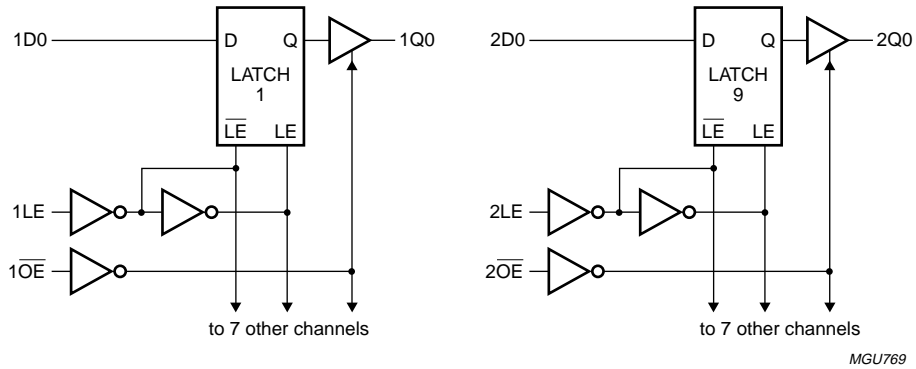


Fig.2 Logic diagram.

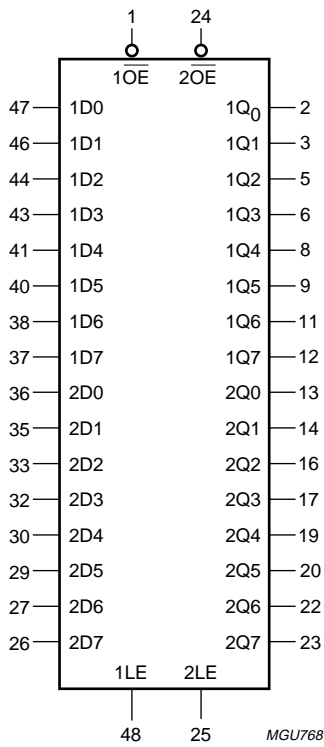


Fig.3 Logic symbol.

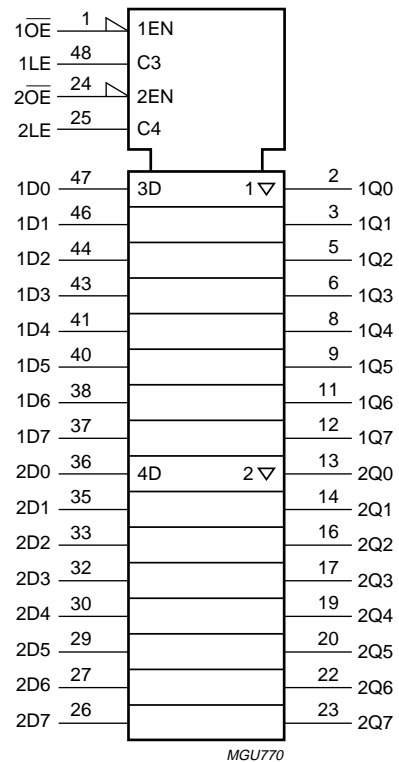


Fig.4 Logic symbol (IEEE/IEC).

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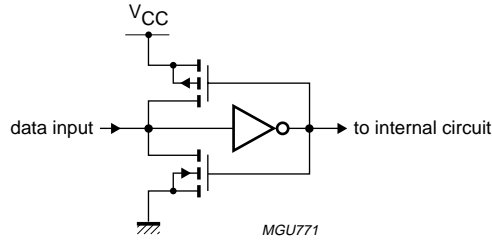


Fig.5 Bushhold circuit.

RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V _{CC}	supply voltage	for maximum speed performance	2.7	3.6	V
		for low voltage applications	1.2	3.6	V
V _I	input voltage		0	5.5	V
V _O	output voltage	output HIGH or LOW state	0	V _{CC}	V
		output 3-state	0	5.5	V
T _{amb}	operating ambient temperature	in free-air	-40	+125	°C
t _r , t _f	input rise and fall times	V _{CC} = 1.2 to 2.7 V	0	20	ns/V
		V _{CC} = 2.7 to 3.6 V	0	10	ns/V

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 60134); voltages are referenced to GND (ground = 0 V).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V _{CC}	supply voltage		-0.5	+6.5	V
I _{IK}	input diode current	V _I < 0	-	-50	mA
V _I	input voltage	note 1	-0.5	+6.5	V
I _{OK}	output diode current	V _O > V _{CC} or V _O < 0	-	±50	mA
V _O	output voltage	output HIGH or LOW state; note 1	-0.5	V _{CC} + 0.5	V
		output 3-state; note 1	-0.5	+6.5	V
I _O	output source or sink current	V _O = 0 to V _{CC}	-	±50	mA
I _{CC} , I _{GND}	V _{CC} or GND current		-	±100	mA
T _{stg}	storage temperature		-65	+150	°C
P _{tot}	power dissipation	T _{amb} = -40 to +125 °C; note 2	-	500	mW

Notes

1. The input and output voltage ratings may be exceeded if the input and output current ratings are observed.
2. Above 60 °C the value of P_{tot} derate linearly with 5.5 mW/K.

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DC CHARACTERISTICS

All recommended operating conditions; voltages are referenced to GND (ground = 0 V).

SYMBOL	PARAMETER	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
		OTHER	V _{CC} (V)				
T_{amb} = -40 to +85 °C; note 1							
V _{IH}	HIGH-level input voltage		1.2	V _{CC}	-	-	V
			2.7 to 3.6	2.0	-	-	V
V _{IL}	LOW-level input voltage		1.2	-	-	GND	V
			2.7 to 3.6	-	-	0.8	V
V _{OH}	HIGH-level output voltage	V _I = V _{IH} or V _{IL} : I _O = -100 μA I _O = -12 mA I _O = -18 mA I _O = -24 mA	2.7 to 3.6	V _{CC} - 0.2	-	-	V
			2.7	V _{CC} - 0.5	-	-	V
			3.0	V _{CC} - 0.6	-	-	V
			3.0	V _{CC} - 0.8	-	-	V
V _{OL}	LOW-level output voltage	V _I = V _{IH} or V _{IL} : I _O = 100 μA I _O = 12 mA I _O = 24 mA	2.7 to 3.6	-	-	0.20	V
			2.7	-	-	0.40	V
			3.0	-	-	0.55	V
I _{LI}	input leakage current	V _I = 5.5 V or GND; note 3	3.6	-	±0.1	±5	μA
I _{OZ}	3-state output OFF-state current	V _I = V _{IH} or V _{IL} ; V _O = 5.5 V or GND; note 3	3.6	-	±0.1	±5	μA
I _{off}	power off leakage current	V _I or V _O = 5.5 V	0	-	±0.1	±10	μA
I _{CC}	quiescent supply current	V _I = V _{CC} or GND; I _O = 0	3.6	-	0.1	20	μA
ΔI _{CC}	additional quiescent supply current per input pin	V _I = V _{CC} - 0.6 V; I _O = 0	2.7 to 3.6	-	5 ⁽²⁾	500	μA
I _{BHL}	bushold LOW sustaining current	V _I = 0.8 V; notes 4 and 5	3.0	75	-	-	μA
I _{BHH}	bushold HIGH sustaining current	V _I = 2.0 V; notes 4 and 5	3.0	-75	-	-	μA
I _{BHLO}	bushold LOW overdrive current	notes 4 and 6	3.6	500	-	-	μA
I _{BHHO}	bushold HIGH overdrive current	notes 4 and 6	3.6	-500	-	-	μA

**16-bit D-type transparent latch with 5 V
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**74LVC16373A;
74LVCH16373A**

SYMBOL	PARAMETER	TEST CONDITIONS		MIN.	TYP.	MAX.	UNIT
		OTHER	V _{CC} (V)				
T_{amb} = -40 to +125 °C							
V _{IH}	HIGH-level input voltage		1.2	V _{CC}	-	-	V
			2.7 to 3.6	2.0	-	-	V
V _{IL}	LOW-level input voltage		1.2	-	-	GND	V
			2.7 to 3.6	-	-	0.8	V
V _{OH}	HIGH-level output voltage	V _I = V _{IH} or V _{IL} : I _O = -100 µA I _O = -12 mA I _O = -18 mA I _O = -24 mA	2.7 to 3.6	V _{CC} - 0.3	-	-	V
			2.7	V _{CC} - 0.65	-	-	V
			3.0	V _{CC} - 0.75	-	-	V
			3.0	V _{CC} - 1	-	-	V
V _{OL}	LOW-level output voltage	V _I = V _{IH} or V _{IL} : I _O = 100 µA I _O = 12 mA I _O = 24 mA	2.7 to 3.6	-	-	0.3	V
			2.7	-	-	0.6	V
			3.0	-	-	0.8	V
I _{LI}	input leakage current	V _I = 5.5 V or GND; note 3	3.6	-	-	±20	µA
I _{OZ}	3-state output OFF-state current	V _I = V _{IH} or V _{IL} ; V _O = 5.5 V or GND; note 3	3.6	-	-	±20	µA
I _{off}	power off leakage current	V _I or V _O = 5.5 V	0	-	-	±20	µA
I _{CC}	quiescent supply current	V _I = V _{CC} or GND; I _O = 0	3.6	-	-	80	µA
ΔI _{CC}	additional quiescent supply current per input pin	V _I = V _{CC} - 0.6 V; I _O = 0	2.7 to 3.6	-	-	5000	µA
I _{BHL}	bushold LOW sustaining current	V _I = 0.8 V; notes 4 and 5	3.0	60	-	-	µA
I _{BHH}	bushold HIGH sustaining current	V _I = 2.0 V; notes 4 and 5	3.0	-60	-	-	µA
I _{BHLO}	bushold LOW overdrive current	notes 4 and 6	3.6	500	-	-	µA
I _{BHHO}	bushold HIGH overdrive current	notes 4 and 6	3.6	-500	-	-	µA

Notes

- All typical values are measured at T_{amb} = 25 °C.
- Measured at V_{CC} = 3.3 V.
- For bushold parts, the bushold circuit is switched off when V_I > V_{CC} allowing 5.5 V on the input pin.
- Valid for data inputs of bushold parts (LVCH16373A) only. For data inputs only; control inputs do not have a bushold circuit.
- The specified sustaining current at the data inputs holds the input below the specified V_I level.
- The specified overdrive current at the data input forces the data input to the opposite logic input state.

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AC CHARACTERISTICS

GND = 0 V; $t_r = t_f \leq 2.5$ ns; $C_L = 50$ pF; $R_L = 500$ Ω .

SYMBOL	PARAMETER	CONDITIONS		MIN.	TYP.	MAX.	UNIT
		WAVEFORMS	V _{CC} (V)				
T_{amb} = -40 to +85 °C; note1							
t _{PHL} /t _{PLH}	propagation delay Dn to Qn	see Fig 6 and 10	1.2	–	12	–	ns
			2.7	1.5	–	4.9	ns
			3.0 to 3.6	1.0	3.0 ⁽²⁾	4.4	ns
	propagation delay LE to Qn	see Fig 7 and 10	1.2	–	14	–	ns
			2.7	1.5	–	5.3	ns
			3.0 to 3.6	1.5	3.4 ⁽²⁾	4.8	ns
t _{PZH} /t _{PZL}	3-state output enable time \overline{OE} to Qn	see Fig 8 and 10	1.2	–	18	–	ns
			2.7	1.5	–	5.7	ns
			3.0 to 3.6	1.0	3.5 ⁽²⁾	4.9	ns
t _{PHZ} /t _{PLZ}	3-state output disable time \overline{OE} to Qn	see Fig 8 and 10	1.2	–	11	–	ns
			2.7	1.5	–	6.3	ns
			3.0 to 3.6	1.5	3.9 ⁽²⁾	5.4	ns
t _w	LE pulse width HIGH	see Fig 7	1.2	–	–	–	ns
			2.7	3.0	–	–	ns
			3.0 to 3.6	3.0	2.0 ⁽²⁾	–	ns
t _{su}	set-up time Dn to LE	see Fig 9	1.2	–	–	–	ns
			2.7	2.0	–	–	ns
			3.0 to 3.6	2.0	1.0 ⁽²⁾	–	ns
t _h	hold time Dn to LE	see Fig 9	1.2	–	–	–	ns
			2.7	0.9	–	–	ns
			3.0 to 3.6	0.9	-1.0 ⁽²⁾	–	ns
t _{sk(0)}	skew	note 3	3.0 to 3.6	–	–	1.0	ns

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SYMBOL	PARAMETER	CONDITIONS		MIN.	TYP.	MAX.	UNIT
		WAVEFORMS	V _{CC} (V)				
T_{amb} = -40 to +125 °C							
t _{PHL} /t _{PLH}	propagation delay Dn to Qn	see Fig 6 and 10	1.2	–	–	–	ns
			2.7	1.5	–	6.5	ns
			3.0 to 3.6	1.0	–	5.5	ns
	propagation delay LE to Qn	see Fig 7 and 10	1.2	–	–	–	ns
			2.7	1.5	–	7.0	ns
			3.0 to 3.6	1.5	–	6.0	ns
t _{PZH} /t _{PZL}	3-state output enable time \overline{OE} to Qn	see Fig 8 and 10	1.2	–	–	–	ns
			2.7	1.5	–	7.5	ns
			3.0 to 3.6	1.0	–	6.5	ns
t _{PHZ} /t _{PLZ}	3-state output disable time \overline{OE} to Qn	see Fig 8 and 10	1.2	–	–	–	ns
			2.7	1.5	–	8.0	ns
			3.0 to 3.6	1.5	–	7.0	ns
t _w	LE pulse width HIGH	see Fig 7	1.2	–	–	–	ns
			2.7	3.0	–	–	ns
			3.0 to 3.6	3.0	–	–	ns
t _{su}	set-up time Dn to LE	see Fig 9	1.2	–	–	–	ns
			2.7	2.0	–	–	ns
			3.0 to 3.6	2.0	–	–	ns
t _h	hold time Dn to LE	see Fig 9	1.2	–	–	–	ns
			2.7	0.9	–	–	ns
			3.0 to 3.6	0.9	–	–	ns
t _{sk(0)}	skew	note 3	3.0 to 3.6	–	–	1.5	ns

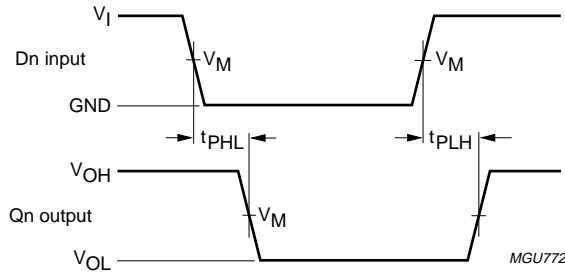
Notes

1. All typical values are measured at T_{amb} = 25 °C.
2. Measured at V_{CC} = 3.3 V.
3. Skew between any two outputs of the same package switching in the same direction.
This parameter is guaranteed by design.

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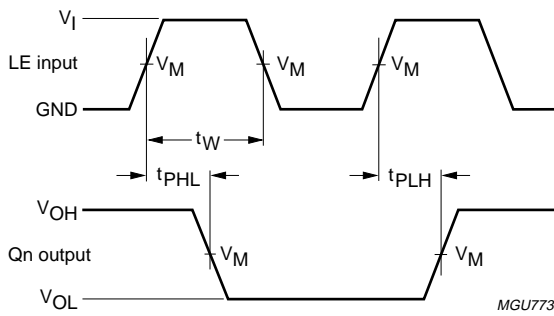
AC WAVEFORMS



V _{CC}	V _M	INPUT	
		V _I	t _r = t _f
1.2 V	0.5 × V _{CC}	V _{CC}	≤ 2.5 ns
2.7 V	1.5 V	2.7 V	≤ 2.5 ns
3.0 to 3.6 V	1.5 V	2.7 V	≤ 2.5 ns

V_{OL} and V_{OH} are the typical output voltage drop that occur with the output load.

Fig.6 Input (Dn) to output (Qn) propagation delays.



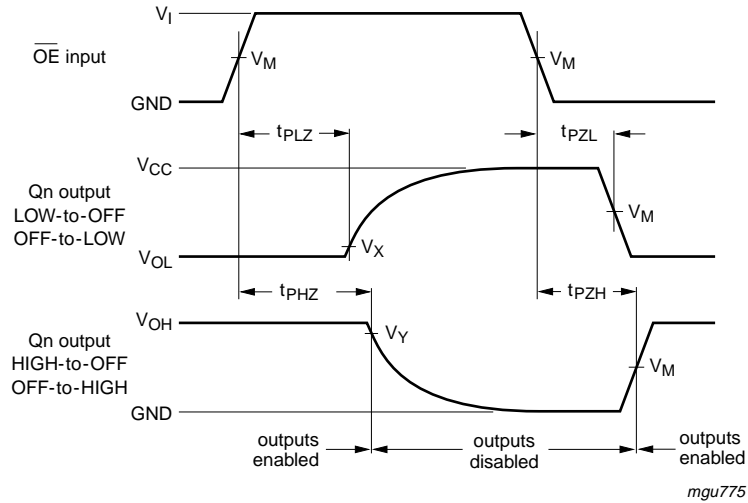
V _{CC}	V _M	INPUT	
		V _I	t _r = t _f
1.2 V	0.5 × V _{CC}	V _{CC}	≤ 2.5 ns
2.7 V	1.5 V	2.7 V	≤ 2.5 ns
3.0 to 3.6 V	1.5 V	2.7 V	≤ 2.5 ns

V_{OL} and V_{OH} are the typical output voltage drop that occur with the output load.

Fig.7 Latch enable input (LE) pulse width, and the latch enable input to output (Qn) propagation delays.

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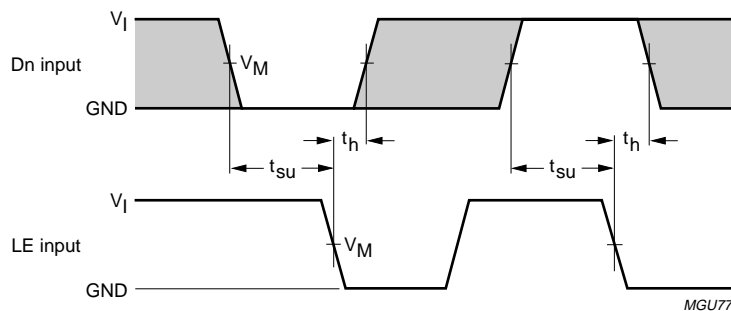
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V _{CC}	V _M	INPUT	
		V _I	t _r = t _f
1.2 V	0.5 × V _{CC}	V _{CC}	≤ 2.5 ns
2.7 V	1.5 V	2.7 V	≤ 2.5 ns
3.0 to 3.6 V	1.5 V	2.7 V	≤ 2.5 ns

V_X = V_{OL} + 0.3 V at V_{CC} ≥ 2.7 V.
 V_X = V_{OL} + 0.1V_{CC} at V_{CC} < 2.7 V.
 V_Y = V_{OH} - 0.3 V at V_{CC} ≥ 2.7 V.
 V_Y = V_{OH} - 0.1V_{CC} at V_{CC} < 2.7 V.

V_{OL} and V_{OH} are the typical output voltage drop that occur with the output load.

Fig.8 3-state enable and disable times.



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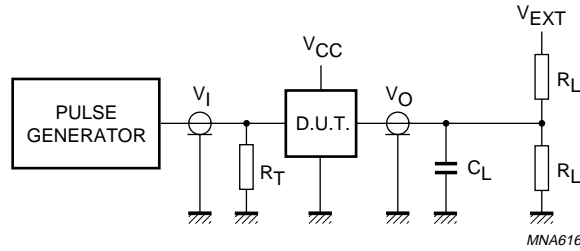
V _{CC}	V _M	INPUT	
		V _I	t _r = t _f
1.2 V	0.5 × V _{CC}	V _{CC}	≤ 2.5 ns
2.7 V	1.5 V	2.7 V	≤ 2.5 ns
3.0 to 3.6 V	1.5 V	2.7 V	≤ 2.5 ns

The shaded areas indicate when the input is permitted to change for predictable performance.

Fig.9 Data set-up and hold times for the Dn input to the LE input.

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V _{CC}	V _I	C _L	R _L	V _{EXT}		
				t _{PLH} /t _{PHL}	t _{PZH} /t _{PHZ}	t _{PZL} /t _{PLZ}
1.2 V	V _{CC}	50 pF	500 Ω ⁽¹⁾	open	GND	2 × V _{CC}
2.7 V	2.7 V	50 pF	500 Ω	open	GND	2 × V _{CC}
3.0 to 3.6 V	2.7 V	50 pF	500 Ω	open	GND	2 × V _{CC}

Note

1. The circuit performs better when R_L = 1000 Ω.

Definitions for test circuits:

R_L = Load resistor.

C_L = Load capacitance including jig and probe capacitance.

R_T = Termination resistance should be equal to the output impedance Z_o of the pulse generator.

Fig.10 Load circuitry for switching times.

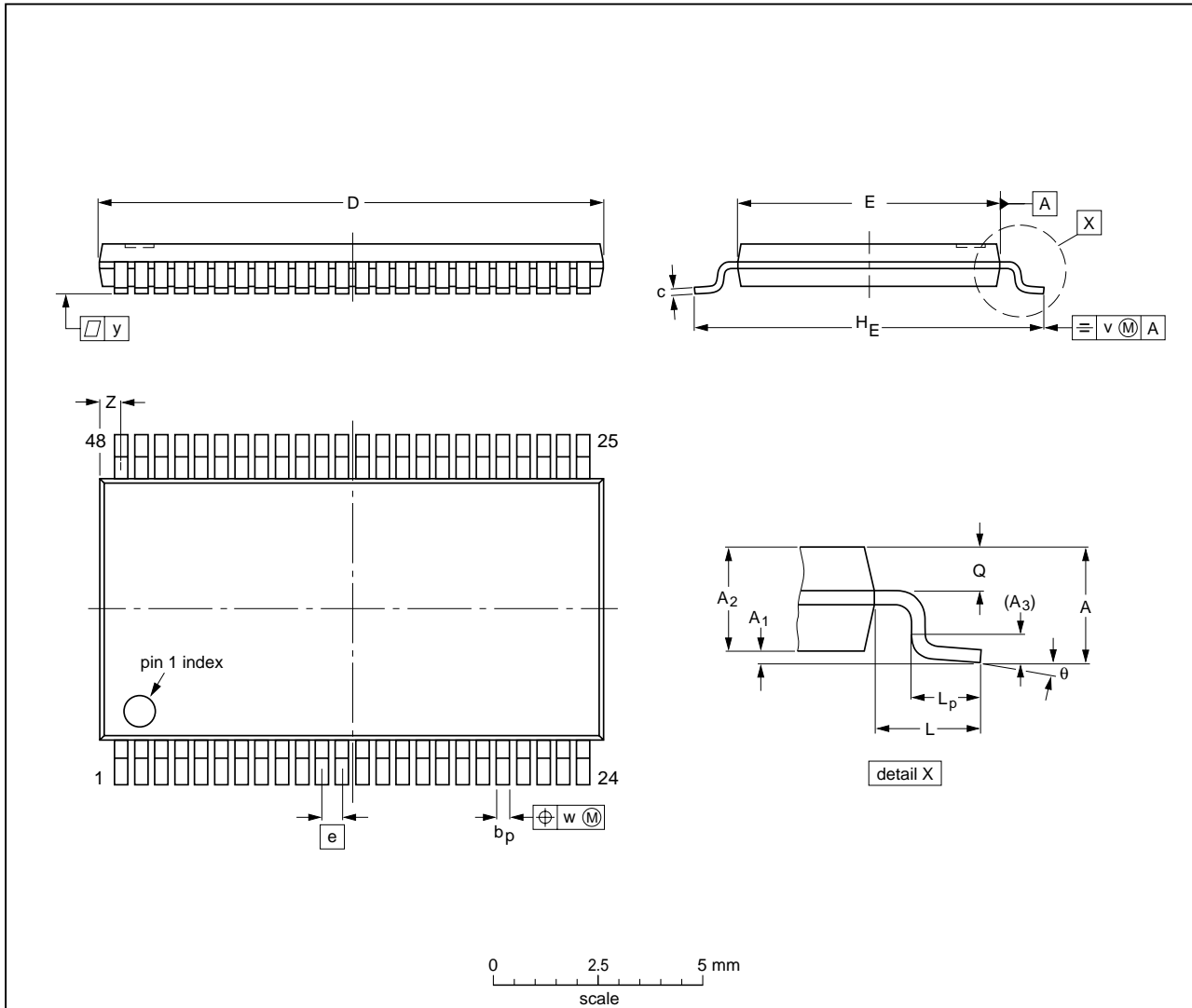
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74LVCH16373A

PACKAGE OUTLINES

TSSOP48: plastic thin shrink small outline package; 48 leads; body width 6.1 mm

SOT362-1



DIMENSIONS (mm are the original dimensions).

UNIT	A max.	A ₁	A ₂	A ₃	b _p	c	D ⁽¹⁾	E ⁽²⁾	e	H _E	L	L _p	Q	v	w	y	Z	θ
mm	1.2	0.15 0.05	1.05 0.85	0.25	0.28 0.17	0.2 0.1	12.6 12.4	6.2 6.0	0.5	8.3 7.9	1	0.8 0.4	0.50 0.35	0.25	0.08	0.1	0.8 0.4	8° 0°

Notes

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.
2. Plastic interlead protrusions of 0.25 mm maximum per side are not included.

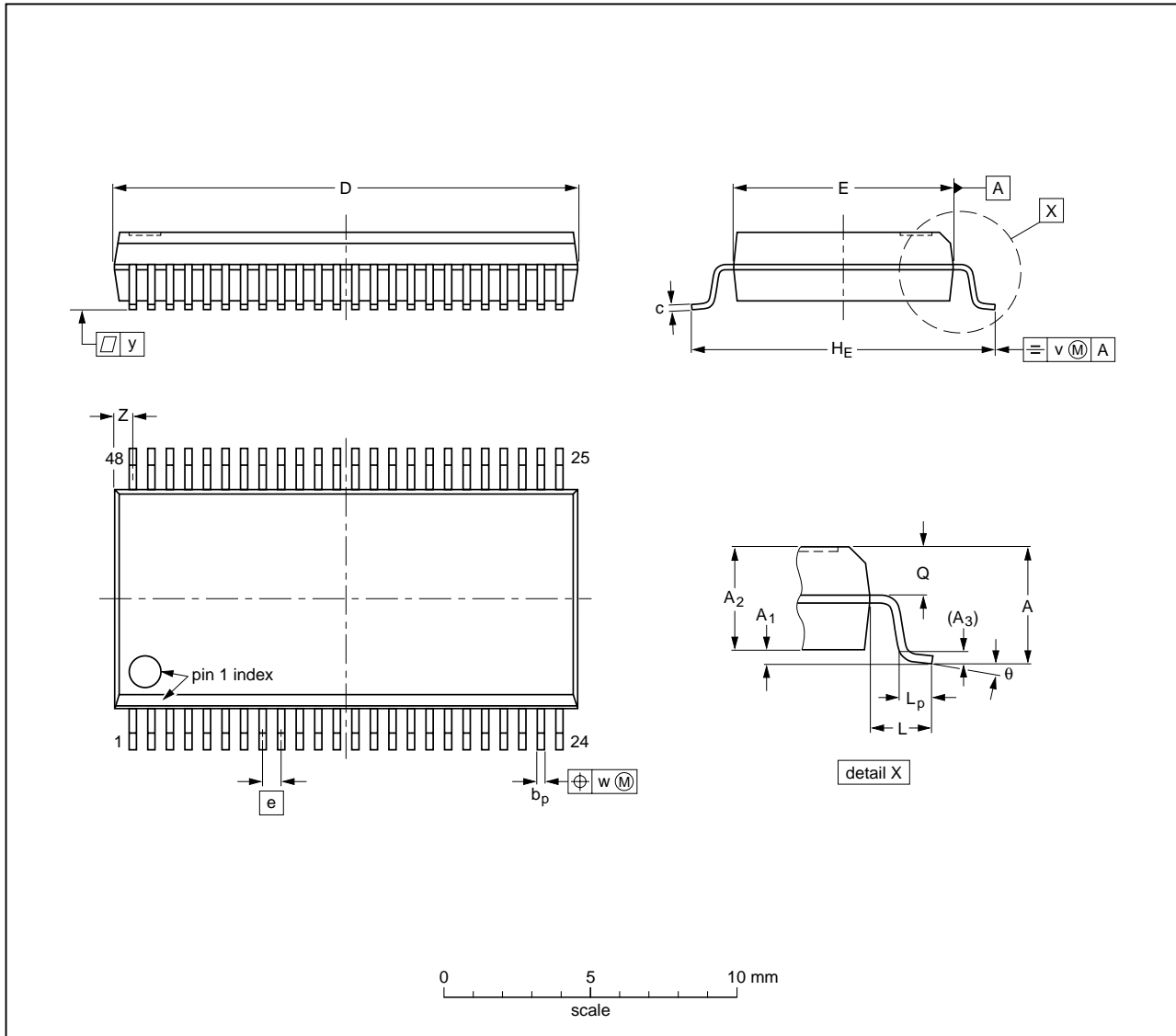
OUTLINE VERSION	REFERENCES			EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA		
SOT362-1		MO-153			99-12-27 03-02-19

16-bit D-type transparent latch with 5 V tolerant inputs/outputs; 3-state

74LVC16373A;
74LVCH16373A

SSOP48: plastic shrink small outline package; 48 leads; body width 7.5 mm

SOT370-1



DIMENSIONS (mm are the original dimensions)

UNIT	A max.	A ₁	A ₂	A ₃	b _p	c	D ⁽¹⁾	E ⁽¹⁾	e	H _E	L	L _p	Q	v	w	y	z ⁽¹⁾	θ
mm	2.8	0.4 0.2	2.35 2.20	0.25	0.3 0.2	0.22 0.13	16.00 15.75	7.6 7.4	0.635	10.4 10.1	1.4	1.0 0.6	1.2 1.0	0.25	0.18	0.1	0.85 0.40	8° 0°

Note

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES			EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA		
SOT370-1		MO-118			99-12-27 03-02-19

16-bit D-type transparent latch with 5 V
tolerant inputs/outputs; 3-state

74LVC16373A;
74LVCH16373A

DATA SHEET STATUS

LEVEL	DATA SHEET STATUS ⁽¹⁾	PRODUCT STATUS ⁽²⁾⁽³⁾	DEFINITION
I	Objective data	Development	This data sheet contains data from the objective specification for product development. Philips Semiconductors reserves the right to change the specification in any manner without notice.
II	Preliminary data	Qualification	This data sheet contains data from the preliminary specification. Supplementary data will be published at a later date. Philips Semiconductors reserves the right to change the specification without notice, in order to improve the design and supply the best possible product.
III	Product data	Production	This data sheet contains data from the product specification. Philips Semiconductors reserves the right to make changes at any time in order to improve the design, manufacturing and supply. Relevant changes will be communicated via a Customer Product/Process Change Notification (CPCN).

Notes

1. Please consult the most recently issued data sheet before initiating or completing a design.
2. The product status of the device(s) described in this data sheet may have changed since this data sheet was published. The latest information is available on the Internet at URL <http://www.semiconductors.philips.com>.
3. For data sheets describing multiple type numbers, the highest-level product status determines the data sheet status.

DEFINITIONS

Short-form specification — The data in a short-form specification is extracted from a full data sheet with the same type number and title. For detailed information see the relevant data sheet or data handbook.

Limiting values definition — Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 60134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.

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