THE DATASHEET OF

74LVT16501ADGG,112

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74LVT16501A

3.3 V LVT 18-bit universal bus transceiver; 3-state

Rev. 04 — 19 May 2006 Product data sheet

1. General description

The 74LVT16501A is a high-performance BiCMOS product designed for V_{CC} operation at 3.3 V. This device is an 18-bit universal transceiver featuring non-inverting 3-state bus compatible outputs in both send and receive directions.

Data flow in each direction is controlled by output enable (OEAB and $\overline{OEBA}$), latch enable (LEAB and LEBA), and clock (CPAB and CPBA) inputs.

For A-to-B data flow, the device operates in the transparent mode when LEAB is HIGH. When LEAB is LOW, the A-bus data is latched if CPAB is held at a HIGH or LOW level. If LEAB is LOW, the A-bus data is stored in the latch/flip-flop on the LOW-to-HIGH transition of CPAB. When OEAB is HIGH, the outputs are active. When OEAB is LOW, the outputs are in the high-impedance state.

Data flow for B-to-A is similar to that of A-to-B but uses $\overline{OEBA}$, LEBA and CPBA. The output enables are complimentary (OEAB is active HIGH and $\overline{OEBA}$ is active LOW).

Active bus hold circuitry is provided to hold unused or floating data inputs at a valid logic level.

2. Features

- 18-bit bidirectional bus interface
- 3-state buffers
- Output capability: +64 mA to –32 mA
- TTL input and output switching levels
- Input and output interface capability to systems at 5 V supply
- Bus hold data inputs eliminate need for external pull-up resistors to hold unused inputs
- Live insertion and extraction permitted
- Power-up reset
- Power-up 3-state
- No bus current loading when output is tied to 5 V bus
- Positive-edge triggered clock inputs
- Latch-up protection:
  - JESD78: exceeds 500 mA
- ESD protection:
  - MIL STD 883, method 3015: exceeds 2000 V
  - Machine model: exceeds 200 V

PHILIPS

3. Quick reference data

Table 1. Quick reference data

GND = 0 V; T_{amb} = 25 °C.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
t_{PLH}	propagation delay An to Bn or Bn to An	C_L = 50 pF; V_{CC} = 3.3 V	-	1.9	-	ns
t_{PHL}	propagation delay An to Bn or Bn to An	C_L = 50 pF; V_{CC} = 3.3 V	-	1.9	-	ns
C_i	input capacitance (control pins)	V_I = 0 V or 3.0 V	-	3	-	pF
C_{io}	input/output capacitance (I/O pins)	outputs disabled; $V_{I/O}$ = 0 V or 3.0 V	-	9	-	pF
I_{CC}	quiescent supply current	outputs disabled; V_{CC} = 3.6 V	-	70	-	µA

4. Ordering information

Table 2. Ordering information

Type number	Package			
	Temperature range	Name	Description	Version
74LVT16501ADL	–40 °C to +85 °C	SSOP56	plastic shrink small outline package; 56 leads; body width 7.5 mm	SOT371-1
74LVT16501ADGG	–40 °C to +85 °C	TSSOP56	plastic thin shrink small outline package; 56 leads; body width 6.1 mm	SOT364-1

5. Functional diagram

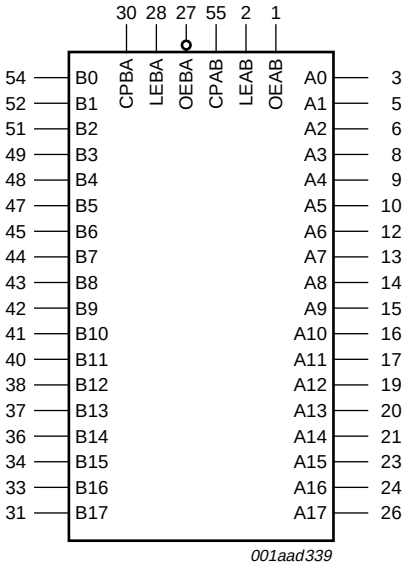


Fig 1. Logic symbol

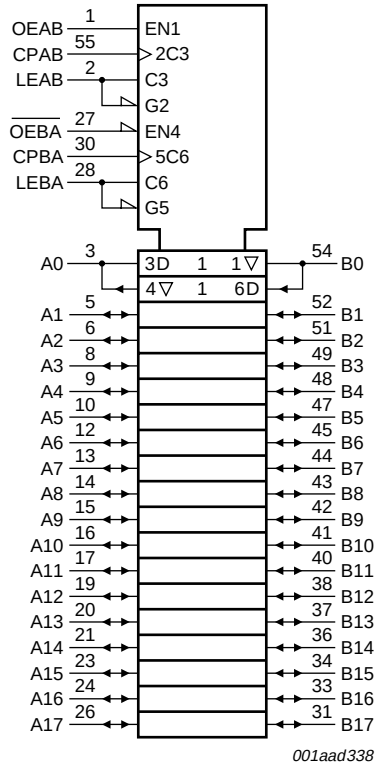


Fig 2. IEC logic symbol

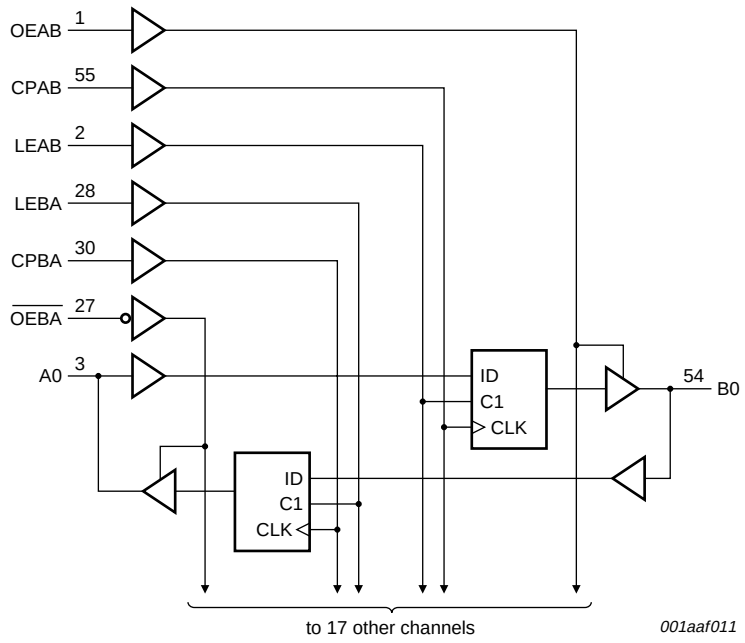


Fig 3. Logic diagram

6. Pinning information

6.1 Pinning

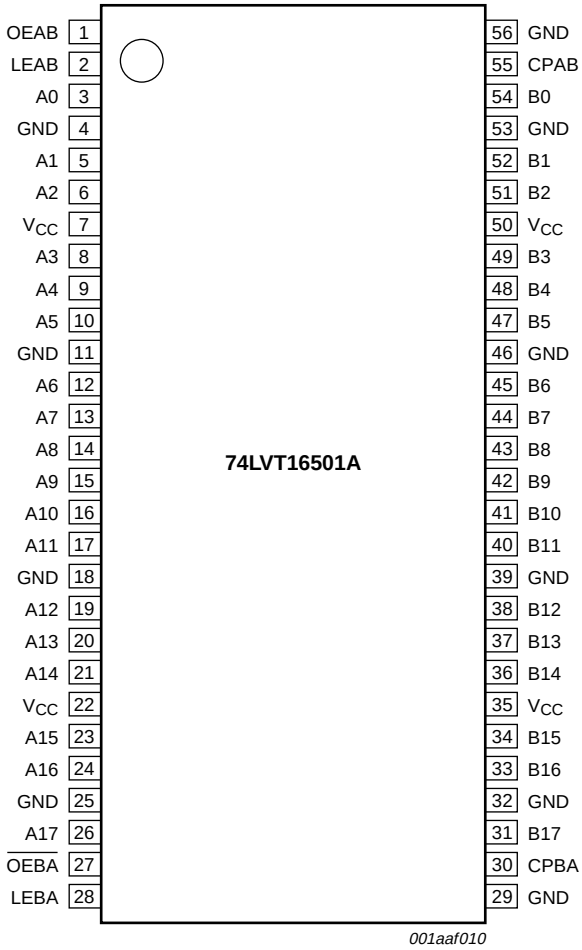


Fig 4. Pin configuration

6.2 Pin description

Table 3. Pin description

Symbol	Pin	Description
OEAB	1	A-to-B output enable input
LEAB	2	A-to-B latch enable input
A0	3	data input or output A0
GND	4	ground (0 V)
A1	5	data input or output A1
A2	6	data input or output A2
V_{CC}	7	voltage supply
A3	8	data input or output A3

Table 3. Pin description *…continued*

Symbol	Pin	Description
A4	9	data input or output A4
A5	10	data input or output A5
GND	11	ground (0 V)
A6	12	data input or output A6
A7	13	data input or output A7
A8	14	data input or output A8
A9	15	data input or output A9
A10	16	data input or output A10
A11	17	data input or output A11
GND	18	ground (0 V)
A12	19	data input or output A12
A13	20	data input or output A13
A14	21	data input or output A14
V_{CC}	22	voltage supply
A15	23	data input or output A15
A16	24	data input or output A16
GND	25	ground (0 V)
A17	26	data input or output A17
$\overline{OEBA}$	27	B-to-A output enable input (active LOW)
LEBA	28	B-to-A latch enable input
GND	29	ground (0 V)
CPBA	30	B-to-A clock input (active rising edge)
B17	31	data input or output B17
GND	32	ground (0 V)
B16	33	data input or output B16
B15	34	data input or output B15
V_{CC}	35	voltage supply
B14	36	data input or output B14
B13	37	data input or output B13
B12	38	data input or output B12
GND	39	ground (0 V)
B11	40	data input or output B11
B10	41	data input or output B10
B9	42	data input or output B9
B8	43	data input or output B8
B7	44	data input or output B7
B6	45	data input or output B6
GND	46	ground (0 V)
B5	47	data input or output B5
B4	48	data input or output B4
B3	49	data input or output B3

Table 3. Pin description *…continued*

Symbol	Pin	Description
V_{CC}	50	voltage supply
B2	51	data input or output B2
B1	52	data input or output B1
GND	53	ground (0 V)
B0	54	data input or output B0
CPAB	55	A-to-B clock input (active rising edge)
GND	56	ground (0 V)

7. Functional description

7.1 Function table

Table 4. Function table[1]

Operating mode	Control			Input	Internal register	Output
	OEAB	LEAB	CPAB	An		Bn
	$\overline{OEBA}$	LEBA	CPBA	Bn		An
Disabled	L	H	X	X	X	Z
Disabled, latch data	L	↓	X	h	H	Z
				l	L	Z
Disabled, hold data	L	L	H or L	X	NC	Z
Disabled, clock data	L	L	↑	h	H	Z
				l	L	Z
Transparent	H	H	X	H	H	H
				L	L	L
Latch data and display	H	↓	X	h	H	H
				l	L	L
Clock data and display	H	L	↑	h	H	H
				l	L	L
Hold data and display	H	L	H or L	X	H	H
				X	L	L

[1] H = HIGH voltage level;
h = HIGH voltage level one setup time prior to the enable or clock transition;
L = LOW voltage level;
l = LOW voltage level one setup time prior to the enable or clock transition;
NC = no change;
X = don't care;
Z = high-impedance OFF-state;
↓ = HIGH-to-LOW enable transition;
↑ = LOW-to-HIGH clock transition.

8. Limiting values

Table 5. 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	+4.6	V
V_I	input voltage		[1]	–0.5	+7.0	V
V_O	output voltage	output in OFF-state or HIGH-state	[1]	–0.5	+7.0	V
I_{IK}	input clamping current	$V_I < 0$ V		-	–50	mA
I_{OK}	output clamping current	$V_O < 0$ V		-	–50	mA
I_O	output current	output in LOW-state		-	128	mA
		output in HIGH-state		-	–64	mA
T_{stg}	storage temperature			–65	+150	°C
T_j	junction temperature		[2]	-	150	°C

[1] The input and output negative voltage ratings may be exceeded if the input and output clamp current ratings are observed.

[2] The performance capability of a high-performance integrated circuit in conjunction with its thermal environment can create junction temperatures which are detrimental to reliability.

9. Recommended operating conditions

Table 6. Recommended operating conditions

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{CC}	supply voltage		2.7	-	3.6	V
V_I	input voltage		0	-	5.5	V
V_{IH}	HIGH-state input voltage		2.0	-	-	V
V_{IL}	LOW-state input voltage		-	-	0.8	V
I_{OH}	HIGH-state output current		-	-	–32	mA
I_{OL}	LOW-state output current	none	-	-	32	mA
		current duty cycle ≤ 50 %; f ≥ 1 kHz	-	-	64	mA
$\Delta t/\Delta V$	input transition rise and fall rate	outputs enabled	-	-	10	ns/V
T_{amb}	ambient temperature	free air	–40	-	+85	°C

10. Static characteristics

Table 7. Static characteristics

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

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
T_{amb} = −40 °C to +85 °C [1]							
V_{IK}	input clamping voltage	V_{CC} = 2.7 V; I_{IK} = −18 mA		-	−0.85	−1.2	V
V_{OH}	HIGH-state output voltage	V_{CC} = 2.7 V to 3.6 V; I_{OH} = −100 µA		V_{CC} − 0.2	V_{CC}	-	V
		V_{CC} = 2.7 V; I_{OH} = −8 mA		2.4	2.55	-	V
		V_{CC} = 3.0 V; I_{OH} = −32 mA		2.0	2.3	-	V
V_{OL}	LOW-state output voltage	V_{CC} = 2.7 V					
		I_{OL} = 100 µA		-	0.07	0.2	V
		I_{OL} = 24 mA		-	0.3	0.5	V
		V_{CC} = 3.0 V					
		I_{OL} = 16 mA		-	0.25	0.4	V
		I_{OL} = 32 mA		-	0.3	0.5	V
		I_{OL} = 64 mA		-	0.36	0.55	V
V_{RST}	power-up output low voltage	V_{CC} = 3.6 V; I_O = 1 mA; V_I = V_{CC} or GND	[2]	-	0.1	0.55	V
I_{LI}	input leakage current						
	control pins	V_{CC} = 3.6 V; V_I = V_{CC} or GND		-	0.1	±1	µA
		V_{CC} = 0 V or 3.6 V; V_I = 5.5 V		-	0.1	10	µA
	I/O data pins	V_{CC} = 3.6 V	[3]				
		V_I = 5.5 V		-	1.0	20	µA
		V_I = V_{CC}		-	0.1	10	µA
		V_I = 0 V		-	+0.1	−5	µA
I_{OFF}	power-off leakage current	V_{CC} = 0 V; V_I or V_O = 0 V to 4.5 V		-	1.0	±100	µA
I_{HOLD}	bus hold current data input	V_{CC} = 3.0 V	[4]				
		V_I = 0.8 V		75	130	-	µA
		V_I = 2.0 V		−75	−130	-	µA
		V_{CC} = 3.6 V	[4]				
		V_I = 0 V to 3.6 V		±500	-	-	µA
I_{EX}	external current into output	output in HIGH-state when V_O > V_{CC}; V_O = 5.5 V; V_{CC} = 3.0 V		-	50	125	µA
$I_{O(pu/pd)}$	power-up/power-down output current	V_{CC} ≤ 1.2 V; V_O = 0.5 V to V_{CC}; V_I = GND or V_{CC}; OEAB or $\overline{OEBA}$ don't care	[5]	-	40	±100	µA
I_{CC}	quiescent supply current	V_{CC} = 3.6 V; V_I = GND or V_{CC}; I_O = 0 A					
		outputs HIGH-state		-	0.07	0.12	mA
		outputs LOW-state		-	4	5	mA
		outputs disabled	[6]	-	0.07	0.12	mA

Table 7. Static characteristics *…continued*

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

Symbol	Parameter	Conditions		Min	Typ	Max	Unit
ΔI_{CC}	additional quiescent supply current	per input pin; V_{CC} = 3.0 V to 3.6 V; one input at V_{CC} – 0.6 V, other inputs at V_{CC} or GND	[7]	-	0.1	0.2	mA
C_i	input capacitance (control pins)	V_I = 0 V or 3.0 V		-	3	-	pF
C_{io}	input/output capacitance (I/O pins)	outputs disabled; $V_{I/O}$ = 0 V or 3.0 V		-	9	-	pF

[1] Typical values are at V_{CC} = 3.3 V and T_{amb} = 25 °C.

[2] For valid test results, data must not be loaded into the flip-flops (or latches) after applying power.

[3] Unused pins at V_{CC} or GND.

[4] This is the bus hold overdrive current required to force the input to the opposite logic state.

[5] This parameter is valid for any V_{CC} between 0 V and 1.2 V with a transition time of up to 10 ms. From V_{CC} = 1.2 V to V_{CC} = 3.3 V ± 0.3 V a transition time of 100 µs is permitted. This parameter is valid for T_{amb} = 25 °C only.

[6] I_{CC} is measured with outputs pulled to V_{CC} or GND.

[7] This is the increase in supply current for each input at the specified voltage level other than V_{CC} or GND.

11. Dynamic characteristics

Table 8. Dynamic characteristics

Voltages are referenced to GND (ground = 0 V); for test circuit see Figure 11.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{CC} = 2.7 V; T_{amb} = −40 °C to +85 °C						
t_{PLH}	propagation delay					
	An to Bn or Bn to An	see Figure 5	-	-	5.4	ns
	CPAB to Bn or CPBA to An	see Figure 6	-	-	6.4	ns
	LEAB to Bn or LEBA to An	see Figure 7	-	-	6.4	ns
t_{PHL}	propagation delay		-	-		
	An to Bn or Bn to An	see Figure 5	-	-	5.4	ns
	CPAB to Bn or CPBA to An	see Figure 6	-	-	6.4	ns
	LEAB to Bn or LEBA to An	see Figure 7	-	-	6.4	ns
t_{PZH}	output enable time to HIGH-state	see Figure 8	-	-	5.5	ns
t_{PZL}	output enable time to LOW-state	see Figure 9	-	-	5.2	ns
t_{PHZ}	output disable time from HIGH-state	see Figure 8	-	-	6.3	ns
t_{PLZ}	output disable time from LOW-state	see Figure 9	-	-	5.6	ns
$t_{su(H)}$	setup time HIGH	see Figure 10				
	An to CPAB or Bn to CPBA		2.4	-	-	ns
	An to LEAB with CPAB LOW or Bn to LEBA with CPBA LOW		2.0	-	-	ns
	An to LEAB with CPAB HIGH or Bn to LEBA with CPBA HIGH		1.5	-	-	ns

Table 8. Dynamic characteristics *…continued*

Voltages are referenced to GND (ground = 0 V); for test circuit see Figure 11.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$t_{su(L)}$	setup time LOW	see Figure 10				
	An to CPAB or Bn to CPBA		2.4	-	-	ns
	An to LEAB with CPAB LOW or Bn to LEBA with CPBA LOW		2.0	-	-	ns
	An to LEAB with CPAB HIGH or Bn to LEBA with CPBA HIGH		1.5	-	-	ns
$t_{h(H)}$	hold time HIGH	see Figure 10				
	An to CPAB or Bn to CPBA		0	-	-	ns
	An to LEAB or Bn to LEAB		0.4	-	-	ns
$t_{h(L)}$	hold time LOW	see Figure 10		-		
	An to CPAB or Bn to CPBA		0	-	-	ns
	An to LEAB or Bn to LEAB		0.4	-	-	ns
t_{WH}	pulse width HIGH			-		
	CPAB or CPBA	see Figure 6	1.5	-	-	ns
	LEAB or LEBA	see Figure 7	1.5	-	-	ns
t_{WL}	pulse width LOW			-		
	CPAB or CPBA	see Figure 6	1.5	-	-	ns
V_{CC} = 3.3 V ± 0.3 V; T_{amb} = −40 °C to +85 °C[1]						
t_{PLH}	propagation delay					
	An to Bn or Bn to An	see Figure 5	0.5	1.9	4.2	ns
	CPAB to Bn or CPBA to An	see Figure 6	1.0	3.2	5.4	ns
	LEAB to Bn or LEBA to An	see Figure 7	1.0	2.4	5.4	ns
t_{PHL}	propagation delay					
	An to Bn or Bn to An	see Figure 5	0.5	1.9	4.2	ns
	CPAB to Bn or CPBA to An	see Figure 6	1.0	3.2	5.4	ns
	LEAB to Bn or LEBA to An	see Figure 7	1.0	2.9	5.4	ns
t_{PZH}	output enable time to HIGH-state	see Figure 8	1.0	2.4	4.8	ns
t_{PZL}	output enable time to LOW-state	see Figure 9	1.0	2.2	4.8	ns
t_{PHZ}	output disable time from HIGH-state	see Figure 8	1.0	2.8	5.8	ns
t_{PLZ}	output disable time from LOW-state	see Figure 9	1.0	3.2	5.2	ns
$t_{su(H)}$	setup time HIGH	see Figure 10				
	An to CPAB or Bn to CPBA		2.1	1.0	-	ns
	An to LEAB with CPAB LOW or Bn to LEBA with CPBA LOW		1.8	1.6	-	ns
	An to LEAB with CPAB HIGH or Bn to LEBA with CPBA HIGH		2.0	1.6	-	ns
$t_{su(L)}$	setup time LOW	see Figure 10				
	An to CPAB or Bn to CPBA		2.1	0.7	-	ns
	An to LEAB with CPAB LOW or Bn to LEBA with CPBA LOW		1.8	1.6	-	ns
	An to LEAB with CPAB HIGH or Bn to LEBA with CPBA HIGH		2.0	1.6	-	ns

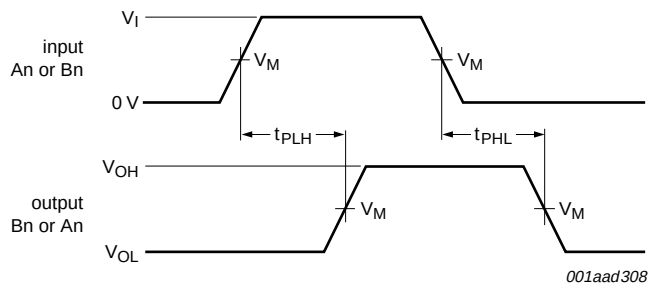
Table 8. Dynamic characteristics *…continued*

Voltages are referenced to GND (ground = 0 V); for test circuit see Figure 11.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$t_{h(H)}$	hold time HIGH	see Figure 10				
	An to CPAB or Bn to CPBA		0.3	0	-	ns
	An to LEAB or Bn to LEAB		0.2	0	-	ns
$t_{h(L)}$	hold time LOW	see Figure 10				
	An to CPAB or Bn to CPBA		0.3	0	-	ns
	An to LEAB or Bn to LEAB		0.2	0	-	ns
t_{WH}	pulse width HIGH					
	CPAB or CPBA	see Figure 6	1.2	0.8	-	ns
	LEAB or LEBA	see Figure 7	1.2	0.8	-	ns
t_{WL}	pulse width LOW					
	CPAB or CPBA	see Figure 6	1.2	0.8	-	ns
f_{max}	maximum input clock frequency	see Figure 6	150	-	-	MHz

[1] All typical values are measured at V_{CC} = 3.3 V and T_{amb} = 25 °C.

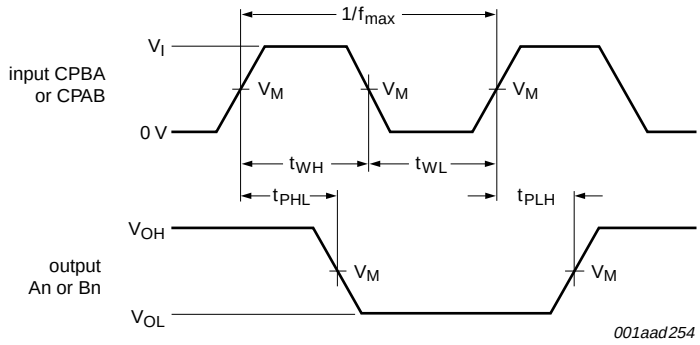
12. Waveforms



Measurement points are given in Table 9.

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

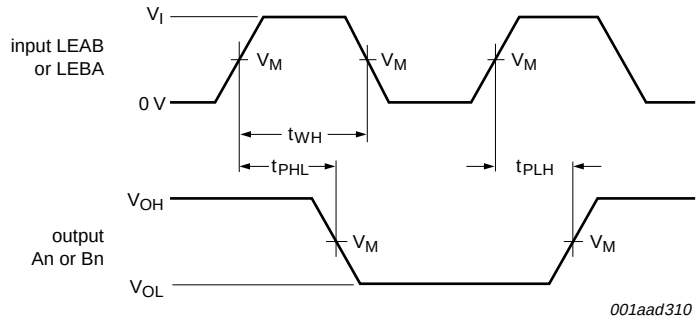
Fig 5. Propagation delay input (An, Bn) to output (Bn, An) in transparent mode



Measurement points are given in Table 9.

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

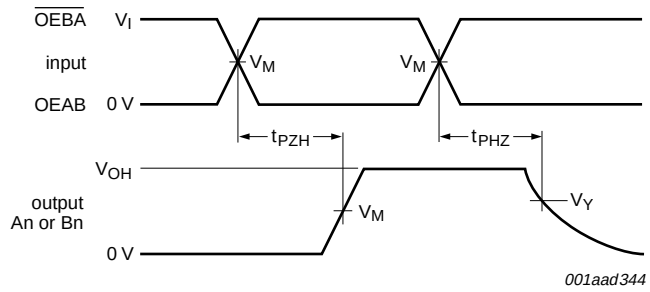
Fig 6. Propagation delay clock (CPAB, CPBA) to output (An, Bn), clock (CPAB, CPBA) pulse width and maximum clock frequency (CPAB, CPBA)



Measurement points are given in Table 9.

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

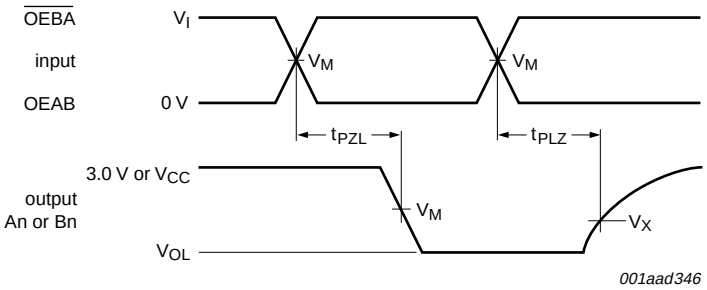
Fig 7. Propagation delay latch enable (LEAB, LEBA) to output (An, Bn) and latch enable (LEAB, LEBA) pulse width



Measurement points are given in Table 9.

V_{OH} is typical voltage output drop that occur with the output load.

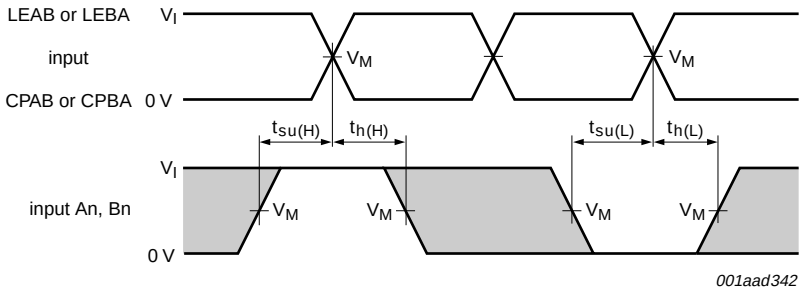
Fig 8. 3-state output enable time to HIGH-state and output disable time from HIGH-state



Measurement points are given in Table 9.

V_{OL} is typical voltage output drop that occur with the output load.

Fig 9. 3-state output enable time to LOW-state and output disable time from LOW-state



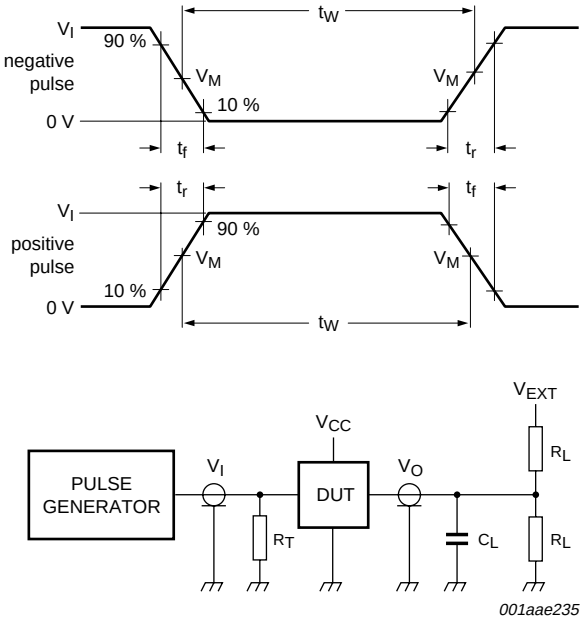
Measurement points are given in Table 9.

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

Fig 10. Data setup and hold times

Table 9. Measurement points

Supply voltage	Input	Output		
	V_M	V_M	V_X	V_Y
2.7 V	1.5 V	1.5 V	V_{OL} + 0.3 V	V_{OH} − 0.3 V
3.3 V	1.5 V	1.5 V	V_{OL} + 0.3 V	V_{OH} − 0.3 V



Test data is given in Table 10.

Definitions test circuit:

R_L = Load resistor.

C_L = Load capacitance including jig and probe capacitance.

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

V_{EXT} = Test voltage for switching times.

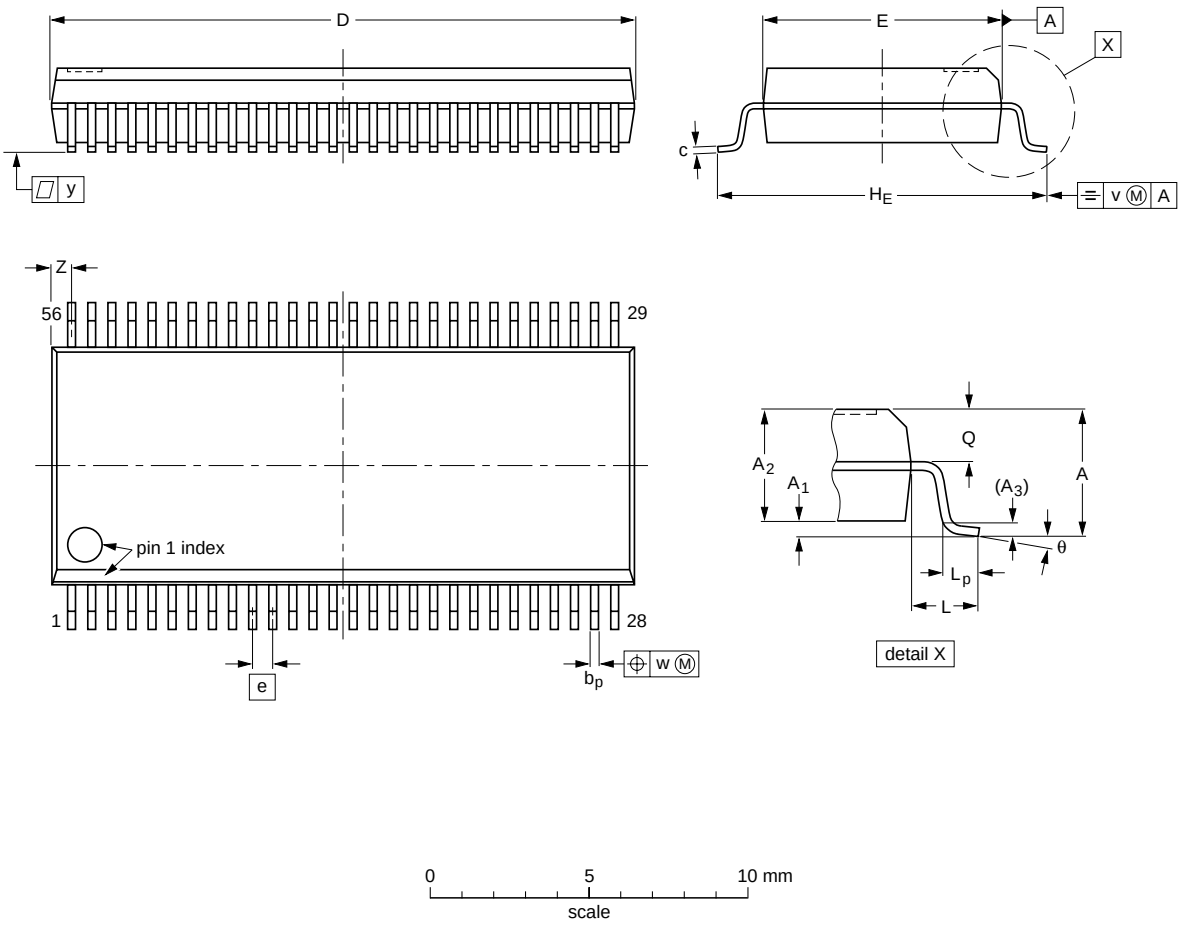
Fig 11. Load circuitry for switching times

Table 10. Test data

Input				Load		V_{EXT}		
V_I	f_i	t_W	t_r, t_f	C_L	R_L	t_{PHZ}, t_{PZH}	t_{PLZ}, t_{PZL}	t_{PLH}, t_{PHL}
2.7 V	≤ 10 MHz	500 ns	≤ 2.5 ns	50 pF	500 Ω	GND	6 V	open

13. Package outline

SSOP56: plastic shrink small outline package; 56 leads; body width 7.5 mm **SOT371-1**



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	18.55 18.30	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^o 0^o

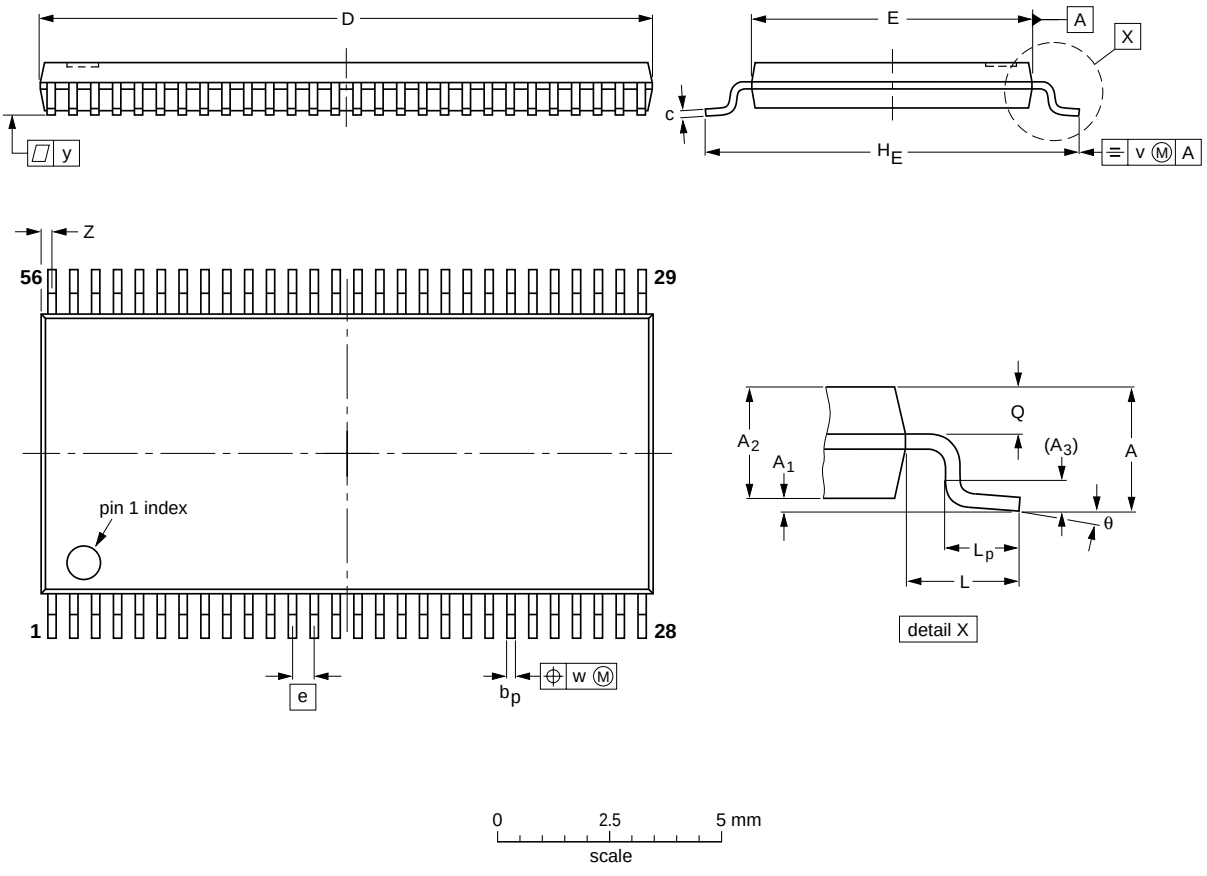
Note

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			
SOT371-1		MO-118				~~99-12-27~~ 03-02-18

Fig 12. Package outline SOT371-1 (SSOP56)

TSSOP56: plastic thin shrink small outline package; 56 leads; body width 6.1 mm **SOT364-1**



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**	14.1 13.9	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	0.5 0.1	8^o 0^o

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			
SOT364-1		MO-153				~~99-12-27~~ 03-02-19

Fig 13. Package outline SOT364-1 (TSSOP56)

14. Abbreviations

Table 11. Abbreviations

Acronym	Description
BiCMOS	Bipolar Complementary Metal Oxide Semiconductor
DUT	Device Under Test
ESD	ElectroStatic Discharge
TTL	Transistor-Transistor Logic

15. Revision history

Table 12. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
74LVT16501A_4	20060519	Product data sheet	-	74LVT16501A_3
Modifications:	• The format of this data sheet has been redesigned to comply with the new presentation and information standard of Philips Semiconductors. • Section 2: replaced JESD17 with JESD78. • Figure 3: corrected clock names. • Table 7: changed I_{HOLD} conditions V_{CC} = 0 V to 3.6 V into V_I = 0 V to 3.6 V. • Table 8: – Changed values for output enable and output disable times. – Added new parameters and changed values for setup and hold times.			
74LVT16501A_3	19980219	Product specification	-	74LVT16501A_2
74LVT16501A_2	19970612	Product specification	-	74LVT16501A_1
74LVT16501A_1	-	-	-	-

16. Legal information

16.1 Data sheet status

Document status[1][2]	Product status[3]	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
Product [short] data sheet	Production	This document contains the product specification.

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL http://www.semiconductors.philips.com.

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