

# DATA SHEET

## **74ALVT16245**

**2.5V/3.3V ALVT 16-bit transceiver  
(3-State)**

Product specification  
Supersedes data of 1995 Nov 01  
IC23 Data Handbook

1998 Feb 13

# 2.5V/3.3V 16-bit transceiver (3-State)

# 74ALVT16245

## FEATURES

- 16-bit bidirectional bus interface
- 5V I/O Compatible
- 3-State buffers
- Output capability: +64mA/-32mA
- TTL input and output switching levels
- Bus-hold data inputs eliminate the need for external pull-up resistors to hold unused inputs
- Live insertion/extraction permitted
- Power-up 3-State
- No bus current loading when output is tied to 5V bus
- Latch-up protection exceeds 500mA per JEDEC Std 17
- ESD protection exceeds 2000V per MIL STD 883 Method 3015 and 400V per Machine Model

## DESCRIPTION

The 74ALVT16245 is a high-performance BiCMOS product designed for  $V_{CC}$  operation at 2.5V or 3.3V with I/O compatibility up to 5V.

This device is a 16-bit transceiver featuring non-inverting 3-State bus compatible outputs in both send and receive directions. The control function implementation minimizes external timing requirements. The device features an Output Enable ( $\overline{OE}$ ) input for easy cascading and a Direction (DIR) input for direction control.

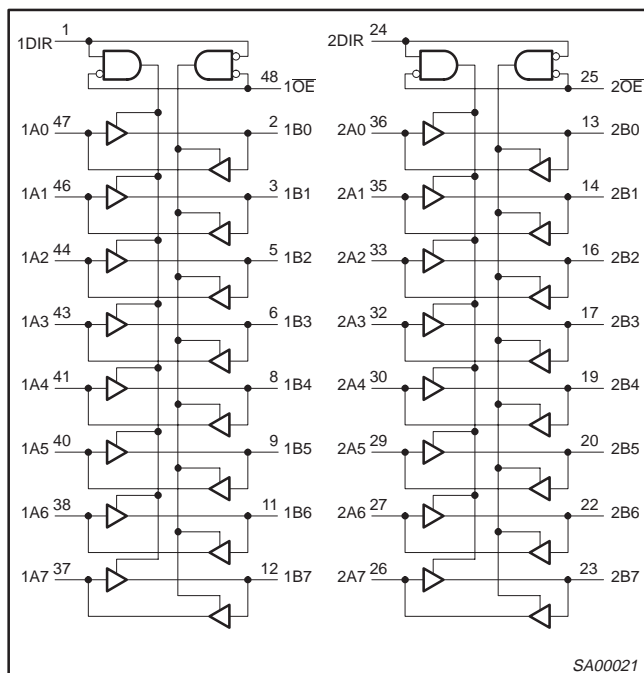
## QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS $T_{amb} = 25^{\circ}C$	TYPICAL		UNIT
			2.5V	3.3V	
$t_{PLH}$ $t_{PHL}$	Propagation delay nAx to nBx or nBx to nAx	$C_L = 50pF$	1.7 1.9	1.5 1.5	ns
$C_{IN}$	Input capacitance DIR, $\overline{OE}$	$V_I = 0V$ or $V_{CC}$	3	3	pF
$C_{I/O}$	I/O pin capacitance	$V_{I/O} = 0V$ or $V_{CC}$	9	9	pF
$I_{CCZ}$	Total supply current	Outputs disabled	40	70	$\mu A$

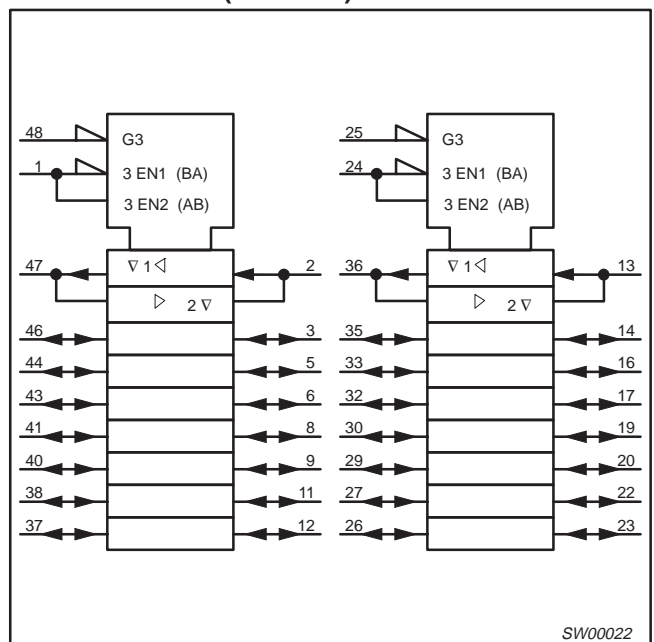
## ORDERING INFORMATION

PACKAGES	TEMPERATURE RANGE	OUTSIDE NORTH AMERICA	NORTH AMERICA	DWG NUMBER
48-Pin Plastic SSOP Type III	-40°C to +85°C	74ALVT16245 DL	AV16245 DL	SOT370-1
48-Pin Plastic TSSOP Type II	-40°C to +85°C	74ALVT16245 DGG	AV16245 DGG	SOT362-1

## LOGIC SYMBOL



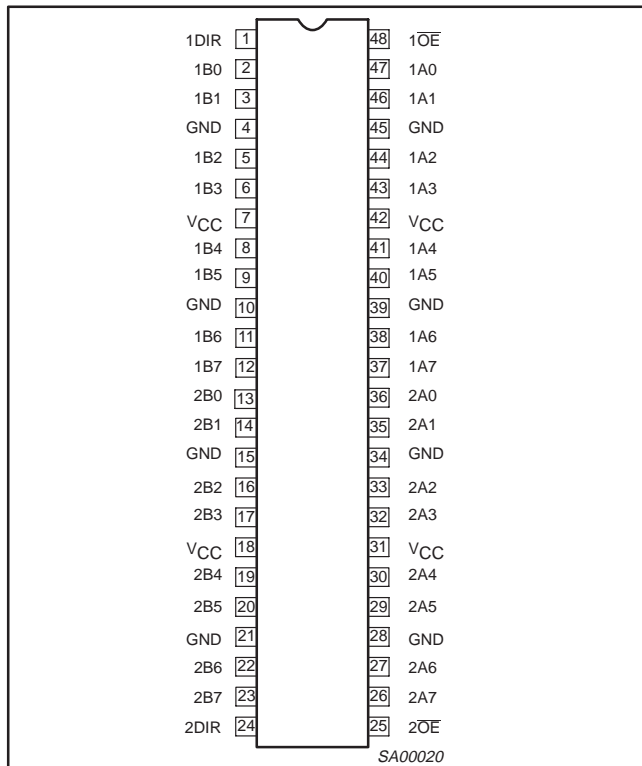
## LOGIC SYMBOL (IEEE/IEC)



# 2.5V/3.3V 16-bit transceiver (3-State)

# 74ALVT16245

## PIN CONFIGURATION



## PIN DESCRIPTION

PIN NUMBER	SYMBOL	NAME AND FUNCTION
1, 24	nDIR	Direction control input
47, 46, 44, 43, 41, 40, 38, 37, 36, 35, 33, 32, 30, 29, 27, 26	nA0 – nA7	Data inputs/outputs (A side)
2, 3, 5, 6, 8, 9, 11, 12, 13, 14, 16, 17, 19, 20, 22, 23	nB0 – nB7	Data inputs/outputs (B side)
25, 48	nOE	Output enable input (active-Low)
4, 10, 15, 21, 28, 34, 39, 45	GND	Ground (0V)
7, 18, 31, 42	V <sub>CC</sub>	Positive supply voltage

## FUNCTION TABLE

INPUTS		INPUTS/OUTPUTS	
nOE	nDIR	nAx	nBx
L	L	nAx = nBx	Inputs
L	H	Inputs	nBx = nAx
H	X	Z	Z

- H = High voltage level
- L = Low voltage level
- X = Don't care
- Z = High Impedance "off" state

## ABSOLUTE MAXIMUM RATINGS<sup>1, 2</sup>

SYMBOL	PARAMETER	CONDITIONS	RATING	UNIT
V <sub>CC</sub>	DC supply voltage		-0.5 to +4.6	V
I <sub>IK</sub>	DC input diode current	V <sub>I</sub> < 0	-50	mA
V <sub>I</sub>	DC input voltage <sup>3</sup>		-0.5 to +7.0	V
I <sub>OK</sub>	DC output diode current	V <sub>O</sub> < 0	-50	mA
V <sub>OUT</sub>	DC output voltage <sup>3</sup>	Output in Off or High state	-0.5 to +7.0	V
I <sub>OUT</sub>	DC output current	Output in Low state	128	mA
		Output in High state	-64	
T <sub>stg</sub>	Storage temperature range		-65 to +150	°C

### NOTES:

- Stresses beyond those listed may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- The performance capability of a high-performance integrated circuit in conjunction with its thermal environment can create junction temperatures which are detrimental to reliability. The maximum junction temperature of this integrated circuit should not exceed 150°C.
- The input and output negative voltage ratings may be exceeded if the input and output clamp current ratings are observed.

## 2.5V/3.3V 16-bit transceiver (3-State)

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## RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	2.5V RANGE LIMITS		3.3V RANGE LIMITS		UNIT
		MIN	MAX	MIN	MAX	
$V_{CC}$	DC supply voltage	2.3	2.7	3.0	3.6	V
$V_I$	Input voltage	0	5.5	0	5.5	V
$V_{IH}$	High-level input voltage	1.7		2.0		V
$V_{IL}$	Input voltage		0.7		0.8	V
$I_{OH}$	High-level output current		-8		-32	mA
$I_{OL}$	Low-level output current		8		32	mA
	Low-level output current; current duty cycle $\leq 50\%$ ; $f \geq 1$ kHz		24		64	
$\Delta t/\Delta v$	Input transition rise or fall rate; Outputs enabled		10		10	ns/V
$T_{amb}$	Operating free-air temperature range	-40	+85	-40	+85	$^{\circ}\text{C}$

DC ELECTRICAL CHARACTERISTICS (3.3V  $\pm$  0.3V RANGE)

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS			UNIT
			Temp = -40 $^{\circ}\text{C}$ to +85 $^{\circ}\text{C}$			
			MIN	TYP <sup>1</sup>	MAX	
$V_{IK}$	Input clamp voltage	$V_{CC} = 3.0\text{V}$ ; $I_{IK} = -18\text{mA}$		-0.85	-1.2	V
$V_{OH}$	High-level output voltage	$V_{CC} = 3.0$ to $3.6\text{V}$ ; $I_{OH} = -100\mu\text{A}$	$V_{CC}-0.2$	$V_{CC}$		V
		$V_{CC} = 3.0\text{V}$ ; $I_{OH} = -32\text{mA}$	2.0	2.3		
$V_{OL}$	Low-level output voltage	$V_{CC} = 3.0\text{V}$ ; $I_{OL} = 100\mu\text{A}$		0.07	0.2	V
		$V_{CC} = 3.0\text{V}$ ; $I_{OL} = 16\text{mA}$		0.25	0.4	
		$V_{CC} = 3.0\text{V}$ ; $I_{OL} = 32\text{mA}$		0.3	0.5	
		$V_{CC} = 3.0\text{V}$ ; $I_{OL} = 64\text{mA}$		0.4	0.55	
$I_I$	Input leakage current	$V_{CC} = 3.6\text{V}$ ; $V_I = V_{CC}$ or GND	Control pins	0.1	$\pm 1$	$\mu\text{A}$
		$V_{CC} = 0$ or $3.6\text{V}$ ; $V_I = 5.5\text{V}$		0.1	10	
		$V_{CC} = 3.6\text{V}$ ; $V_I = 5.5\text{V}$	Data pins <sup>4</sup>	0.1	20	
		$V_{CC} = 3.6\text{V}$ ; $V_I = V_{CC}$		0.5	10	
		$V_{CC} = 3.6\text{V}$ ; $V_I = 0$		0.1	-5	
$I_{OFF}$	Off current	$V_{CC} = 0\text{V}$ ; $V_I$ or $V_O = 0$ to $4.5\text{V}$		0.1	$\pm 100$	$\mu\text{A}$
$I_{HOLD}$	Bus Hold current A or B ports <sup>6</sup>	$V_{CC} = 3\text{V}$ ; $V_I = 0.8\text{V}$		75	130	$\mu\text{A}$
		$V_{CC} = 3\text{V}$ ; $V_I = 2.0\text{V}$		-75	-140	
		$V_{CC} = 0\text{V}$ to $3.6\text{V}$ ; $V_{CC} = 3.6\text{V}$		$\pm 500$		
$I_{EX}$	Current into an output in the High state when $V_O > V_{CC}$	$V_O = 5.5\text{V}$ ; $V_{CC} = 3.0\text{V}$		50	125	$\mu\text{A}$
$I_{PU/PD}$	Power up/down 3-State output current <sup>3</sup>	$V_{CC} \leq 1.2\text{V}$ ; $V_O = 0.5\text{V}$ to $V_{CC}$ ; $V_I = \text{GND}$ or $V_{CC}$ ; OE/OE = Don't care		40	$\pm 100$	$\mu\text{A}$
$I_{CCH}$	Quiescent supply current	$V_{CC} = 3.6\text{V}$ ; Outputs High, $V_I = \text{GND}$ or $V_{CC}$ , $I_O = 0$		0.07	0.1	mA
$I_{CCL}$		$V_{CC} = 3.6\text{V}$ ; Outputs Low, $V_I = \text{GND}$ or $V_{CC}$ , $I_O = 0$		3.2	5	
$I_{CCZ}$		$V_{CC} = 3.6\text{V}$ ; Outputs Disabled; $V_I = \text{GND}$ or $V_{CC}$ , $I_O = 0^5$		0.07	0.1	
$\Delta I_{CC}$	Additional supply current per input pin <sup>2</sup>	$V_{CC} = 3\text{V}$ to $3.6\text{V}$ ; One input at $V_{CC}-0.6\text{V}$ , Other inputs at $V_{CC}$ or GND		0.2	0.4	mA

## NOTES:

- All typical values are at  $V_{CC} = 3.3\text{V}$  and  $T_{amb} = 25^{\circ}\text{C}$ .
- This is the increase in supply current for each input at the specified voltage level other than  $V_{CC}$  or GND
- This parameter is valid for any  $V_{CC}$  between  $0\text{V}$  and  $1.2\text{V}$  with a transition time of up to  $10\text{msec}$ . From  $V_{CC} = 1.2\text{V}$  to  $V_{CC} = 3.3\text{V} \pm 0.3\text{V}$  a transition time of  $100\mu\text{sec}$  is permitted. This parameter is valid for  $T_{amb} = 25^{\circ}\text{C}$  only.
- Unused pins at  $V_{CC}$  or GND.
- $I_{CCZ}$  is measured with outputs pulled up to  $V_{CC}$  or pulled down to ground.
- This is the bus hold overdrive current required to force the input to the opposite logic state.

## 2.5V/3.3V 16-bit transceiver (3-State)

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**AC CHARACTERISTICS (3.3V ± 0.3V RANGE)**GND = 0V;  $t_R = t_F = 2.5\text{ns}$ ;  $C_L = 50\text{pF}$ ;  $R_L = 500\Omega$ ;  $T_{\text{amb}} = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ .

SYMBOL	PARAMETER	WAVEFORM	LIMITS			UNIT
			$V_{CC} = 3.3V \pm 0.3V$			
			MIN	TYP <sup>1</sup>	MAX	
$t_{PLH}$ $t_{PHL}$	Propagation delay nAx to nBx or nBx to nAx	1	0.5 0.5	1.5 1.5	2.4 2.4	ns
$t_{PZH}$ $t_{PZL}$	Output enable time to High and Low level	2	1.0 1.0	2.1 1.7	3.5 2.9	ns
$t_{PHZ}$ $t_{PLZ}$	Output disable time from High and Low Level	2	1.5 1.5	3.4 2.8	4.5 3.7	ns

**NOTE:**1. All typical values are at  $V_{CC} = 3.3V$  and  $T_{\text{amb}} = 25^\circ\text{C}$ .**DC ELECTRICAL CHARACTERISTICS (2.5V ± 0.2V RANGE)**

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS			UNIT
			Temp = $-40^\circ\text{C}$ to $+85^\circ\text{C}$			
			MIN	TYP <sup>1</sup>	MAX	
$V_{IK}$	Input clamp voltage	$V_{CC} = 2.3V$ ; $I_{IK} = -18\text{mA}$		-0.85	-1.2	V
$V_{OH}$	High-level output voltage	$V_{CC} = 2.3$ to $3.6V$ ; $I_{OH} = -100\mu\text{A}$ $V_{CC} = 2.3V$ ; $I_{OH} = -8\text{mA}$	$V_{CC}-0.2$ 1.8			V
$V_{OL}$	Low-level output voltage	$V_{CC} = 2.3V$ ; $I_{OL} = 100\mu\text{A}$ $V_{CC} = 2.3V$ ; $I_{OL} = 24\text{mA}$ $V_{CC} = 2.3V$ ; $I_{OL} = 8\text{mA}$		0.07 0.3	0.2 0.5	V
$I_I$	Input leakage current	$V_{CC} = 2.7V$ ; $V_I = V_{CC}$ or GND	Control pins	0.1	$\pm 1$	$\mu\text{A}$
		$V_{CC} = 0$ or $2.7V$ ; $V_I = 5.5V$		0.1	10	
		$V_{CC} = 2.7V$ ; $V_I = 5.5V$	Data pins <sup>4</sup>	0.1	20	
		$V_{CC} = 2.7V$ ; $V_I = V_{CC}$		0.1	10	
		$V_{CC} = 2.7V$ ; $V_I = 0$		0.1	-5	
$I_{OFF}$	Off current	$V_{CC} = 0V$ ; $V_I$ or $V_O = 0$ to $4.5V$		0.1	$\pm 100$	$\mu\text{A}$
$I_{HOLD}$	Bus Hold current	$V_{CC} = 2.3V$ ; $V_I = 0.7V$		90		$\mu\text{A}$
	Data inputs <sup>6</sup>	$V_{CC} = 2.3V$ ; $V_I = 1.7V$		-10		
$I_{EX}$	Current into an output in the High state when $V_O > V_{CC}$	$V_O = 5.5V$ ; $V_{CC} = 2.3V$		50	125	$\mu\text{A}$
$I_{PU/PD}$	Power up/down 3-State output current <sup>3</sup>	$V_{CC} \leq 1.2V$ ; $V_O = 0.5V$ to $V_{CC}$ ; $V_I = \text{GND}$ or $V_{CC}$ ; OE/OE = Don't care		40	100	$\mu\text{A}$
$I_{CCH}$	Quiescent supply current	$V_{CC} = 2.7V$ ; Outputs High, $V_I = \text{GND}$ or $V_{CC}$ , $I_O = 0$		0.04	0.1	mA
$I_{CCL}$		$V_{CC} = 2.7V$ ; Outputs Low, $V_I = \text{GND}$ or $V_{CC}$ , $I_O = 0$		2.3	45	
$I_{CCZ}$		$V_{CC} = 2.7V$ ; Outputs Disabled; $V_I = \text{GND}$ or $V_{CC}$ , $I_O = 0^5$		0.04	0.1	
$\Delta I_{CC}$	Additional supply current per input pin <sup>2</sup>	$V_{CC} = 2.3V$ to $2.7V$ ; One input at $V_{CC}-0.6V$ , Other inputs at $V_{CC}$ or GND		0.1	0.4	mA

**NOTES:**

- All typical values are at  $V_{CC} = 2.5V$  and  $T_{\text{amb}} = 25^\circ\text{C}$ .
- This is the increase in supply current for each input at the specified voltage level other than  $V_{CC}$  or GND
- This parameter is valid for any  $V_{CC}$  between 0V and 1.2V with a transition time of up to 10msec. From  $V_{CC} = 1.2V$  to  $V_{CC} = 2.5V \pm 0.3V$  a transition time of 100 $\mu\text{sec}$  is permitted. This parameter is valid for  $T_{\text{amb}} = 25^\circ\text{C}$  only.
- Unused pins at  $V_{CC}$  or GND.
- $I_{CCZ}$  is measured with outputs pulled up to  $V_{CC}$  or pulled down to ground.
- Not guaranteed.

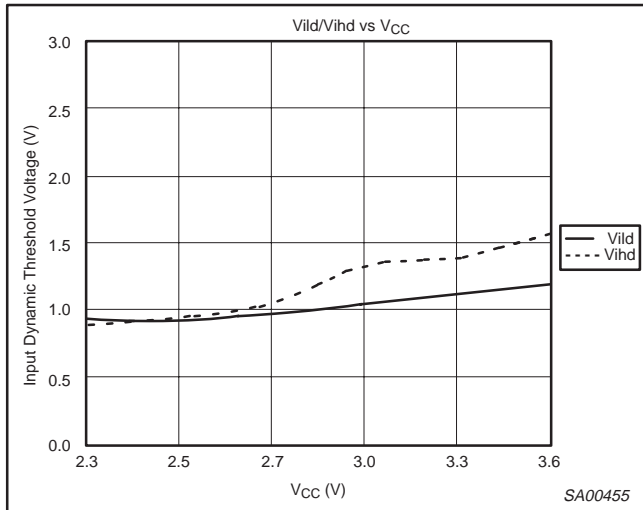
# 2.5V/3.3V 16-bit transceiver (3-State)

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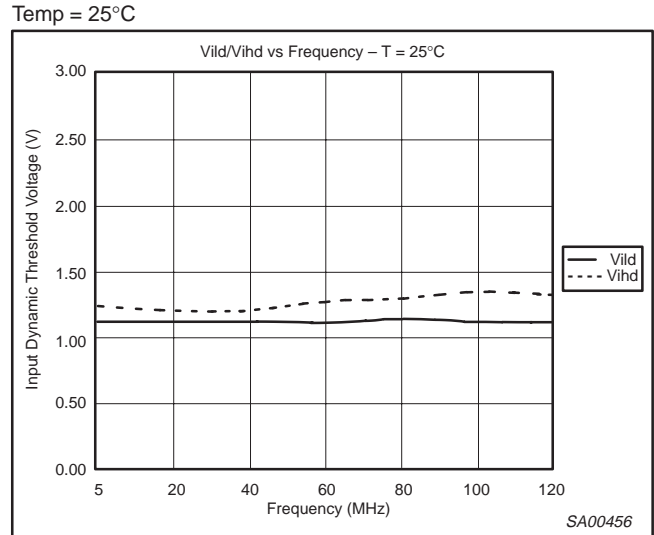
## DYNAMIC SWITCHING THRESHOLD

Dynamic switching threshold is the change in  $V_{IH}$  and  $V_{IL}$  when the device is operated in various switching and output loading conditions. The cause of this variation is due to extra load placed on internal circuit structures.  $V_{IHD}$  and  $V_{ILD}$  are measures of the dynamic switching threshold.  $V_{IHD}$  is the input high switching level when the device is heavily loaded.  $V_{ILD}$  is the input low switching level when the device is heavily loaded.

**$V_{ILD}/V_{IHD}$  vs  $V_{CC}$**

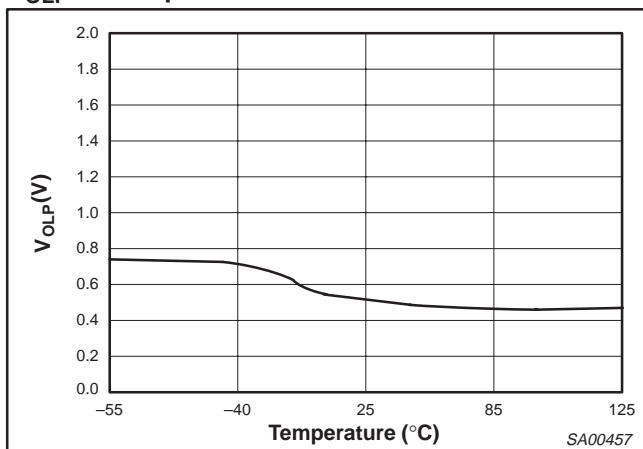


**$V_{ILD}/V_{IHD}$  vs Frequency**

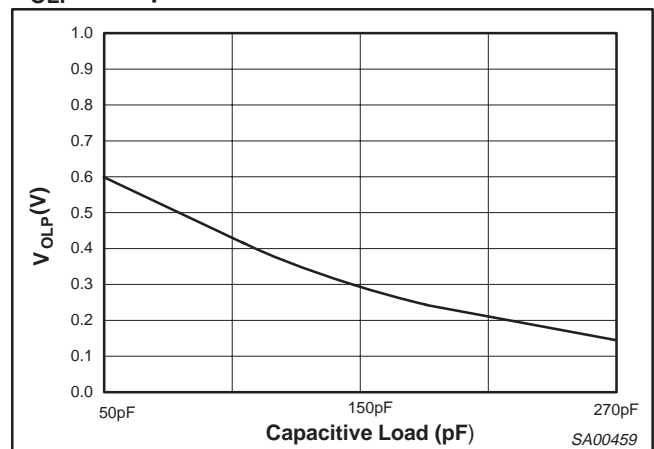


## GROUND/ $V_{CC}$ BOUNCE

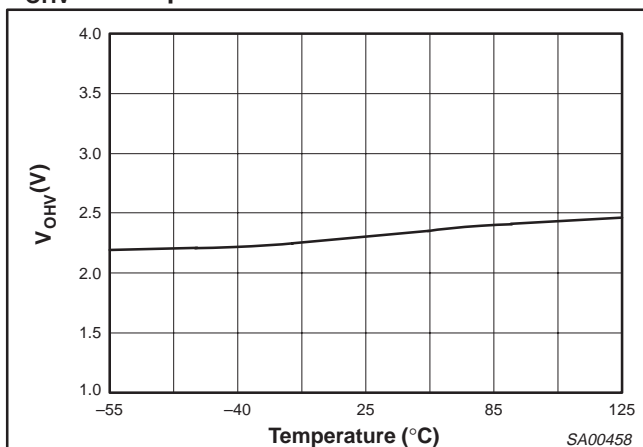
**$V_{OLP}$  vs Temperature**



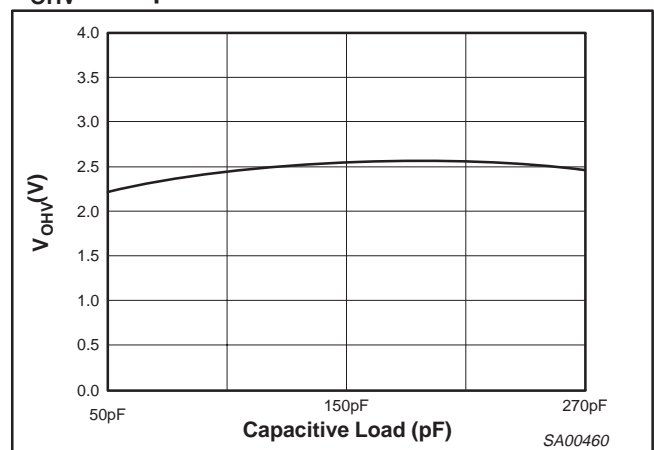
**$V_{OLP}$  vs Capacitive Load**



**$V_{OHV}$  vs Temperature**



**$V_{OHV}$  vs Capacitive Load**



## 2.5V/3.3V 16-bit transceiver (3-State)

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**AC CHARACTERISTICS (2.5V ± 0.2V RANGE)**GND = 0V;  $t_R = t_F = 2.5\text{ns}$ ;  $C_L = 50\text{pF}$ ;  $R_L = 500\Omega$ ;  $T_{\text{amb}} = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ .

SYMBOL	PARAMETER	WAVEFORM	LIMITS			UNIT
			$V_{CC} = 2.5V \pm 0.2V$			
			MIN	TYP <sup>1</sup>	MAX	
$t_{PLH}$ $t_{PHL}$	Propagation delay nAx to nBx or nBx to nAx	1	0.5 0.5	1.7 1.9	2.8 2.8	ns
$t_{PZH}$ $t_{PZL}$	Output enable time to High and Low level	2	1.5 1.0	3.0 2.3	4.5 3.5	ns
$t_{PHZ}$ $t_{PLZ}$	Output disable time from High and Low Level	2	1.5 1.0	3.0 2.3	4.6 3.5	ns

**NOTE:**1. All typical values are at  $V_{CC} = 2.5V$  and  $T_{\text{amb}} = 25^\circ\text{C}$ .**SKEW DATA** $t_{ps}$  (Pin Skew or Transition Skew)

$$t_{PS} = |t_{PHL} - t_{PLH}|$$

$t_{PS} \text{ Max}$	$V_{CC} = 2.3$	$V_{CC} = 2.5$	$V_{CC} = 2.7$	$V_{CC} = 3.0$	$V_{CC} = 3.3$	$V_{CC} = 3.6$	UNITS
		429	469	430	426	267	336

$$t_{OST} = |t_{P\Phi m} - t_{P\Phi n}|$$

Where  $\Phi$  is any edge transition (high-to-low or low-to-high)  
measured between any two outputs (m or n) within any given  
device.

$t_{OST} \text{ nAn-nBn}$	$V_{CC} = 2.3$	$V_{CC} = 2.5$	$V_{CC} = 2.7$	$V_{CC} = 3.0$	$V_{CC} = 3.3$	$V_{CC} = 3.6$	UNITS
		546	625	586	546	427	397
$\text{nBn-nAn}$	508	547	586	506	427	417	

**NOTE:**One output switching, Temp =  $25^\circ\text{C}$ . $t_{OSHL}$ ,  $t_{OSLH}$ , (Common Edge Skew)

$$t_{OSHL} = |t_{PHL \text{ max}} - t_{PHL \text{ min}}| \text{ (Output Skew for Low-to-High Transitions)}$$

$$t_{OSLH} = |t_{PLH \text{ max}} - t_{PLH \text{ min}}| \text{ (Output Skew for High-to-Low Transitions)}$$

$t_{OSLH} \text{ nAn-nBn}$	$V_{CC} = 2.3$	$V_{CC} = 2.5$	$V_{CC} = 2.7$	$V_{CC} = 3.0$	$V_{CC} = 3.3$	$V_{CC} = 3.6$	UNITS
		312	312	313	276	267	257
$t_{OSHL} \text{ nAn-nBn}$	312	352	352	297	289	267	
$t_{OSLH} \text{ nBn-nAn}$	235	273	312	274	296	326	
$t_{OSHL} \text{ nBn-nAn}$	234	235	274	248	287	267	

**NOTE:**One output switching, Temp =  $25^\circ\text{C}$ .

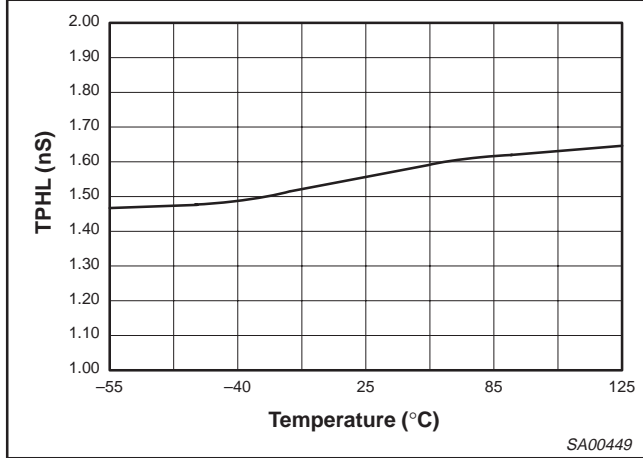
# 2.5V/3.3V 16-bit transceiver (3-State)

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## EXTENDED DATA

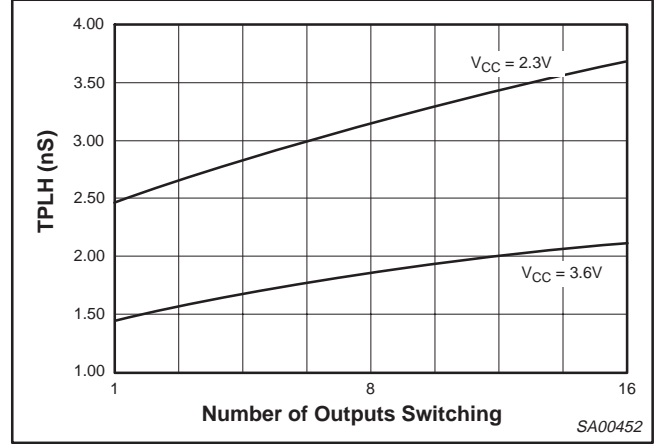
### TPHL vs TEMP

$V_{CC} = 3.3V$ , one output switching



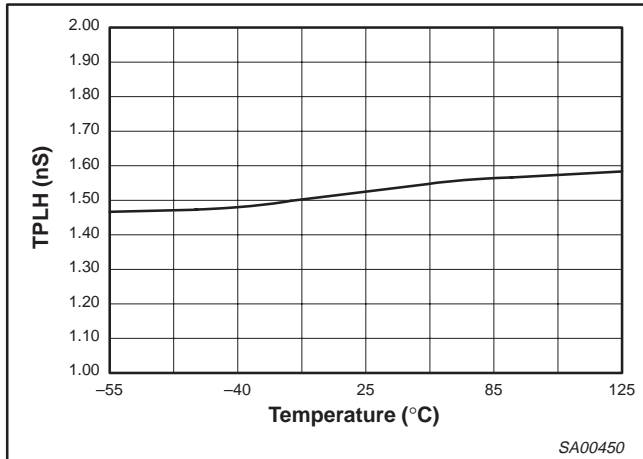
### TPLH vs NUMBER of OUTPUTS SWITCHING

$T = 25^{\circ}C$ , 50pF/500 ohm load



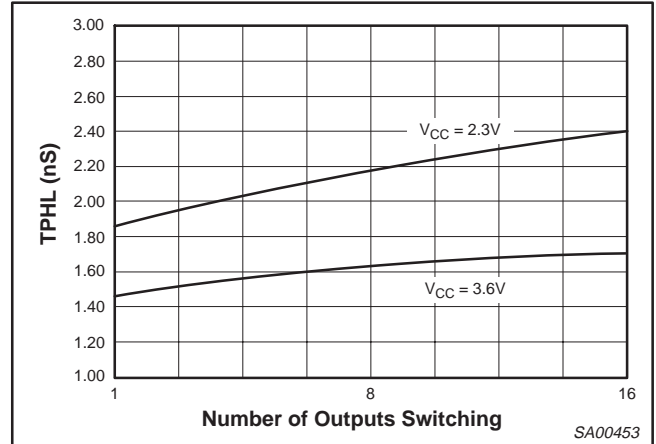
### TPHL vs TEMP

$V_{CC} = 3.3V$ , one output switching



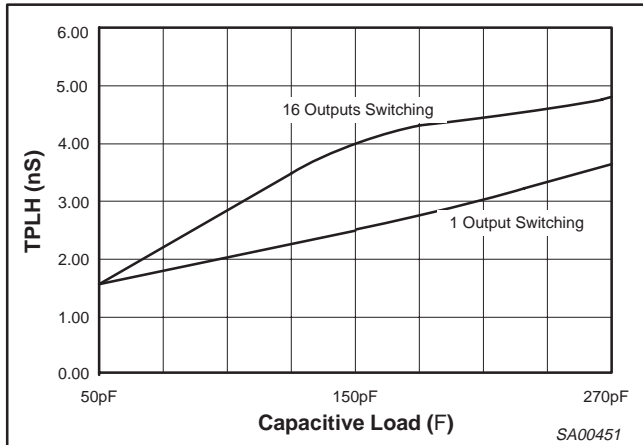
### TPHL vs NUMBER of OUTPUTS SWITCHING

$T = 25^{\circ}C$ , 50pF/500 ohm load



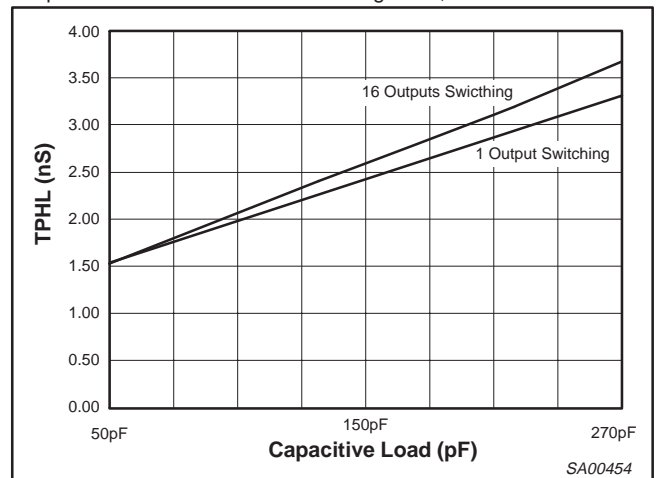
### TPHL vs OUTPUT LOAD

Outputs also loaded with 500 ohms to ground,  $T = 25^{\circ}C$



### TPHL vs OUTPUT LOAD

Outputs also loaded with 500 ohms to ground,  $T = 25^{\circ}C$



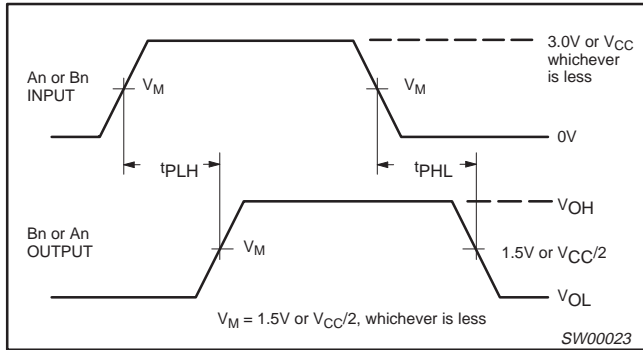


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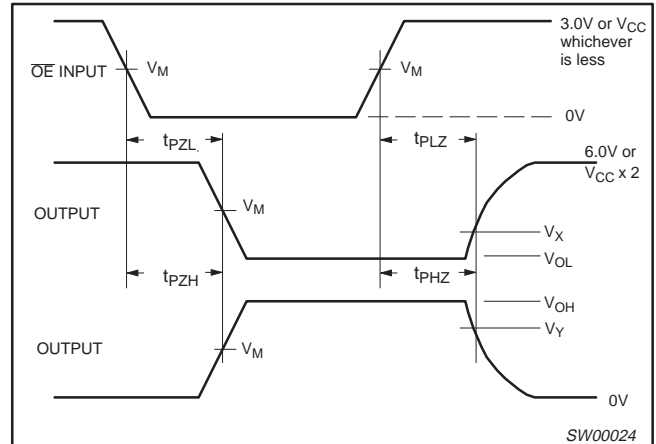
# 74ALVT16245

## AC WAVEFORMS

$V_M = 1.5V$  at  $V_{CC} \geq 3.0V$ ,  $V_M = V_{CC}/2$  at  $V_{CC} \leq 2.7V$   
 $V_X = V_{OL} + 0.3V$  at  $V_{CC} \geq 3.0V$ ,  $V_X = V_{OL} + 0.15V$  at  $V_{CC} \leq 2.7V$   
 $V_Y = V_{OH} - 0.3V$  at  $V_{CC} \geq 3.0V$ ,  $V_Y = V_{OH} - 0.15V$  at  $V_{CC} \leq 2.7V$



Waveform 1. Input to Output Propagation Delays



Waveform 2. 3-State Output Enable and Disable Times

## TEST CIRCUIT AND WAVEFORMS

**Test Circuit for 3-State Outputs**

SWITCH POSITION	
TEST	SWITCH
$t_{PLZ}/t_{PZL}$	6V or $V_{CC} \times 2$
$t_{PLH}/t_{PHL}$	Open
$t_{PHZ}/t_{PZH}$	GND

**DEFINITIONS**

$R_L$  = Load resistor; see AC CHARACTERISTICS for value.

$C_L$  = Load capacitance includes jig and probe capacitance: See AC CHARACTERISTICS for value.

$R_T$  = Termination resistance should be equal to  $Z_{OUT}$  of pulse generators.

FAMILY	INPUT PULSE REQUIREMENTS				
	Amplitude	Rep. Rate	$t_W$	$t_R$	$t_F$
74ALVT16	3.0V or $V_{CC}$ whichever is less	$\leq 10\text{MHz}$	500ns	$\leq 2.5\text{ns}$	$\leq 2.5\text{ns}$

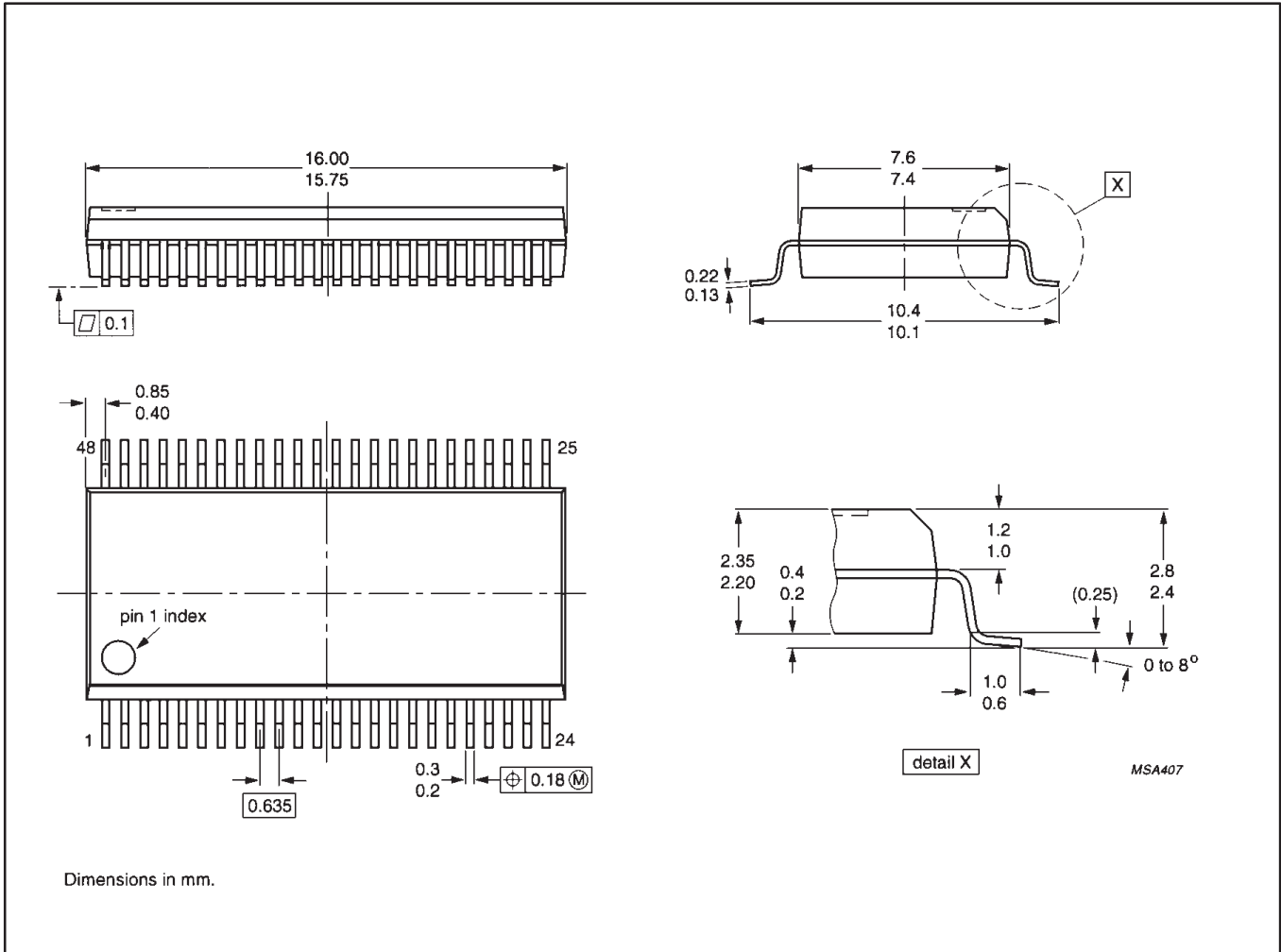
SW00025

# 2.5V/3.3V ALVT 16-bit transceiver (3-State)

# 74ALVT16245

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

**SOT370-1**

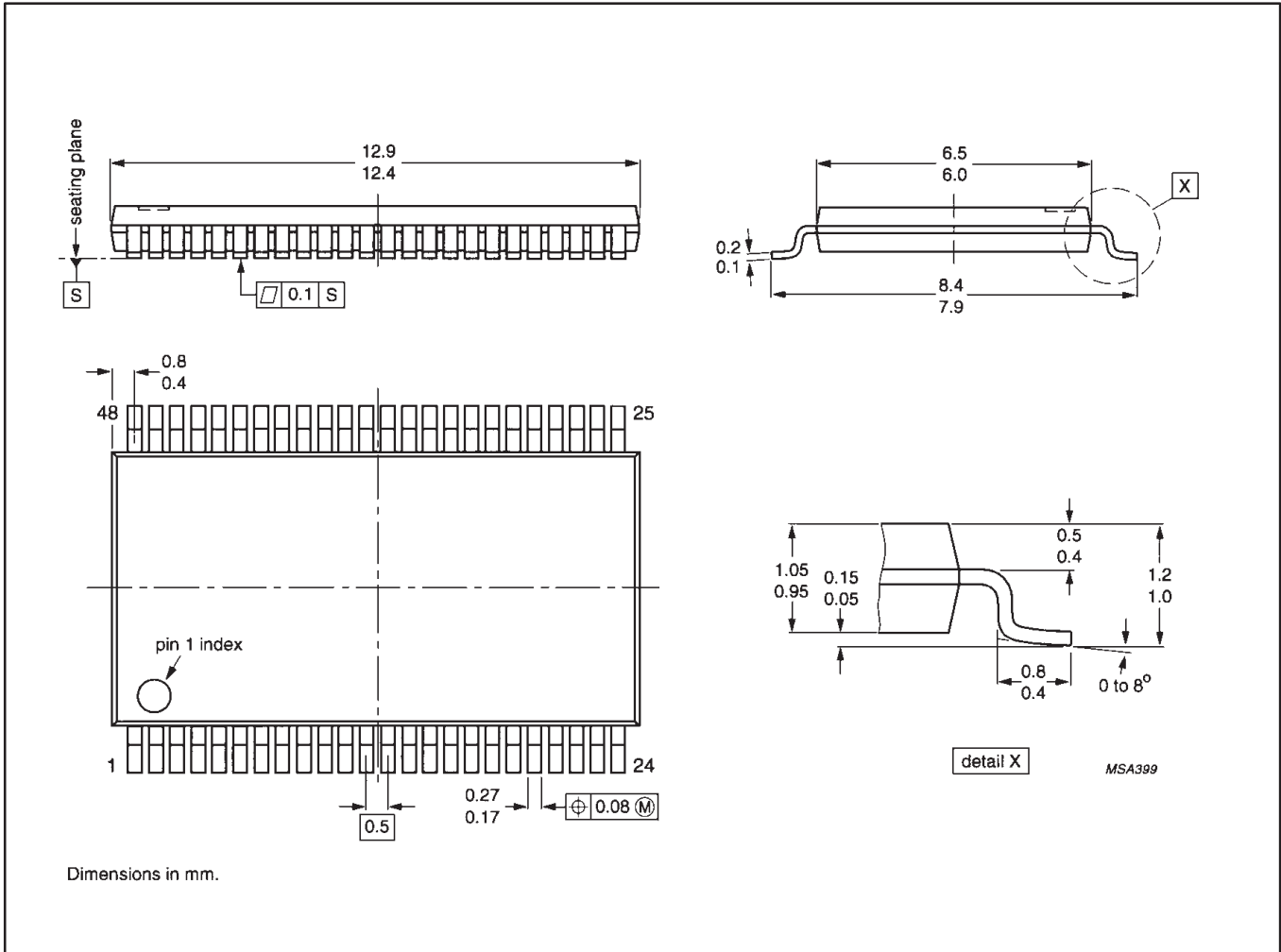


# 2.5V/3.3V ALVT 16-bit transceiver (3-State)

# 74ALVT16245

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

**SOT362-1**



## 2.5V/3.3V ALVT 16-bit transceiver (3-State)

74ALVT16245

**Data sheet status**

Data sheet status	Product status	Definition [1]
Objective specification	Development	This data sheet contains the design target or goal specifications for product development. Specification may change in any manner without notice.
Preliminary specification	Qualification	This data sheet contains preliminary data, and supplementary data will be published at a later date. Philips Semiconductors reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.
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[1] Please consult the most recently issued datasheet before initiating or completing a design.

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**Philips Semiconductors**  
 811 East Arques Avenue  
 P.O. Box 3409  
 Sunnyvale, California 94088-3409  
 Telephone 800-234-7381

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