

- **Members of the Texas Instruments Widebus™ Family**
- **State-of-the-Art Advanced BiCMOS Technology (ABT) Design for 3.3-V Operation and Low Static-Power Dissipation**
- **Support Mixed-Mode Signal Operation (5-V Input and Output Voltages With 3.3-V V<sub>CC</sub>)**
- **Support Unregulated Battery Operation Down to 2.7 V**
- **UBT™ (Universal Bus Transceiver) Combines D-Type Latches and D-Type Flip-Flops for Operation in Transparent, Latched, or Clocked Mode**
- **Typical V<sub>OLP</sub> (Output Ground Bounce) < 0.8 V at V<sub>CC</sub> = 3.3 V, T<sub>A</sub> = 25°C**
- **I<sub>off</sub> and Power-Up 3-State Support Hot Insertion**
- **Bus Hold on Data Inputs Eliminates the Need for External Pullup/Pulldown Resistors**
- **Distributed V<sub>CC</sub> and GND Pin Configuration Minimizes High-Speed Switching Noise**
- **Flow-Through Architecture Optimizes PCB Layout**
- **Latch-Up Performance Exceeds 500 mA Per JESD 17**
- **ESD Protection Exceeds 2000 V Per MIL-STD-883, Method 3015; Exceeds 200 V Using Machine Model (C = 200 pF, R = 0)**
- **Package Options Include Plastic Shrink Small-Outline (DL) and Thin Shrink Small-Outline (DGG) Packages and 380-mil Fine-Pitch Ceramic Flat (WD) Package Using 25-mil Center-to-Center Spacings**

SN54LVTH16501 . . . WD PACKAGE  
 SN74LVTH16501 . . . DGG OR DL PACKAGE  
 (TOP VIEW)

OEAB	1	56	GND
LEAB	2	55	CLKAB
A1	3	54	B1
GND	4	53	GND
A2	5	52	B2
A3	6	51	B3
V <sub>CC</sub>	7	50	V <sub>CC</sub>
A4	8	49	B4
A5	9	48	B5
A6	10	47	B6
GND	11	46	GND
A7	12	45	B7
A8	13	44	B8
A9	14	43	B9
A10	15	42	B10
A11	16	41	B11
A12	17	40	B12
GND	18	39	GND
A13	19	38	B13
A14	20	37	B14
A15	21	36	B15
V <sub>CC</sub>	22	35	V <sub>CC</sub>
A16	23	34	B16
A17	24	33	B17
GND	25	32	GND
A18	26	31	B18
OEBA	27	30	CLKBA
LEBA	28	29	GND

## description

The 'LVTH16501 devices are 18-bit universal bus transceivers designed for low-voltage (3.3-V) V<sub>CC</sub> operation, but with the capability to provide a TTL interface to a 5-V system environment.

Data flow in each direction is controlled by output-enable (OEAB and OEBA), latch-enable (LEAB and LEBA), and clock (CLKAB and CLKBA) inputs. For A-to-B data flow, the devices operate in the transparent mode when LEAB is high. When LEAB is low, the A data is latched if CLKAB is held at a high or low logic level. If LEAB is low, the A data is stored in the latch/flip-flop on the low-to-high transition of CLKAB. When OEAB is high, the outputs are active. When OEAB is low, the outputs are in the high-impedance state.



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**SN54LVTH16501, SN74LVTH16501  
3.3-V ABT 18-BIT UNIVERSAL BUS TRANSCEIVERS  
WITH 3-STATE OUTPUTS**

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**description (continued)**

Data flow for B to A is similar to that of A to B but uses  $\overline{OEBA}$ , LEBA, and CLKBA. The output enables are complementary (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.

When  $V_{CC}$  is between 0 and 1.5 V, the devices are in the high-impedance state during power up or power down. However, to ensure the high-impedance state above 1.5 V,  $\overline{OE}$  should be tied to  $V_{CC}$  through a pullup resistor and OE should be tied to GND through a pulldown resistor; the minimum value of the resistor is determined by the current-sinking/current-sourcing capability of the driver.

These devices are fully specified for hot-insertion applications using  $I_{off}$  and power-up 3-state. The  $I_{off}$  circuitry disables the outputs, preventing damaging current backflow through the devices when they are powered down. The power-up 3-state circuitry places the outputs in the high-impedance state during power up and power down, which prevents driver conflict.

The SN54LVTH16501 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74LVTH16501 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

**FUNCTION TABLE†**

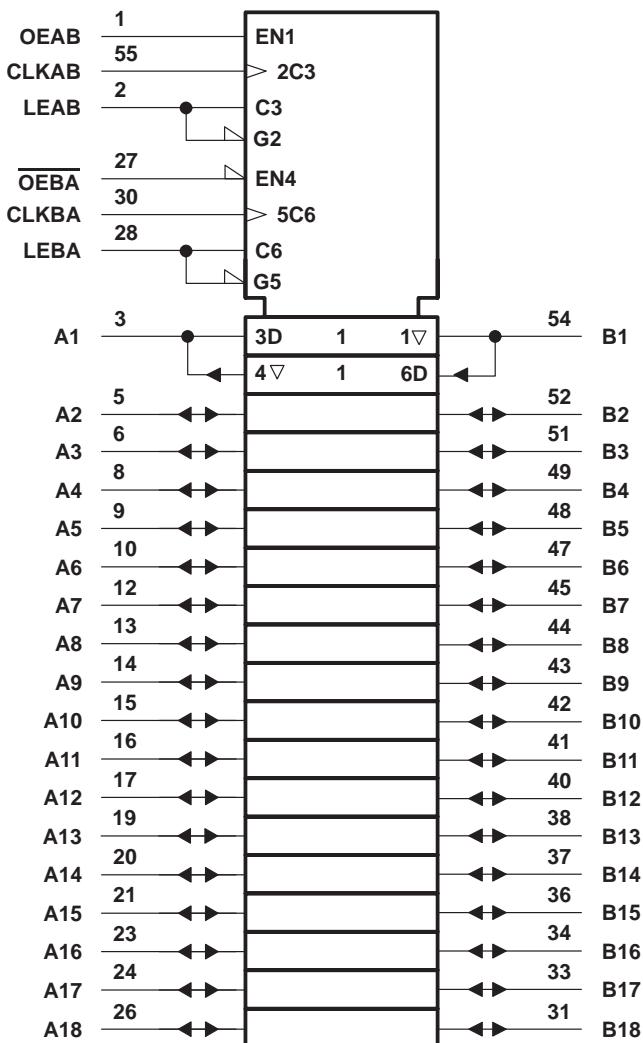
INPUTS				OUTPUT B
OEAB	LEAB	CLKAB	A	
L	X	X	X	Z
H	H	X	L	L
H	H	X	H	H
H	L	=	L	L
H	L	↑	H	H
H	L	H	X	$B_0^{\ddagger}$
H	L	L	X	$B_0^{\$}$

† A-to-B data flow is shown: B-to-A flow is similar but uses  $\overline{OEBA}$ , LEBA, and CLKBA.

‡ Output level before the indicated steady-state input conditions were established, provided that CLKAB was high before LEAB went low

§ Output level before the indicated steady-state input conditions were established

logic symbol†

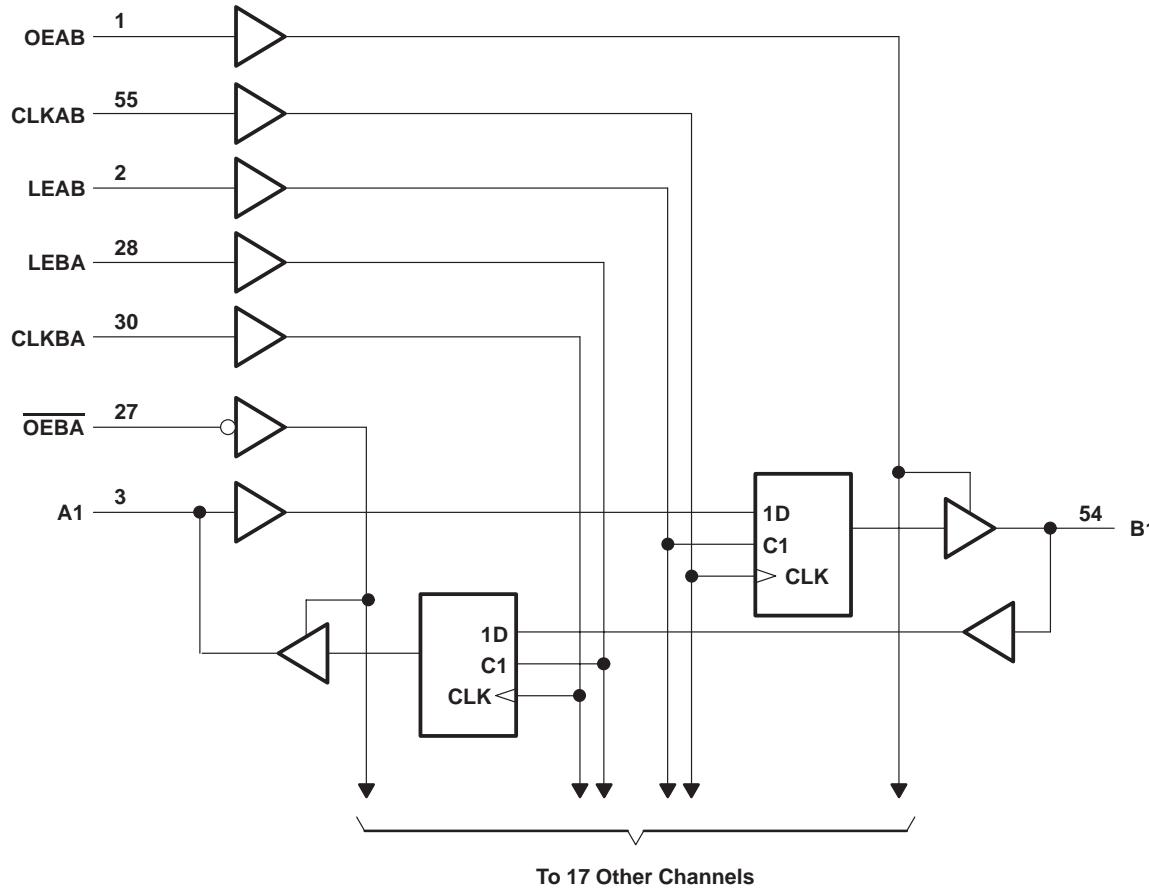


† This symbol is in accordance with ANSI/IEEE Std 91-1984 and IEC Publication 617-12.

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## logic diagram (positive logic)



**absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†**

† Stresses beyond those listed under "absolute maximum ratings" 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.

NOTES: 1. The input and output negative-voltage ratings may be exceeded if the input and output clamp-current ratings are observed.  
 2. This current flows only when the output is in the high state and  $V_O > V_{CC}$ .  
 3. The package thermal impedance is calculated in accordance with JEDEC 51.

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**recommended operating conditions (see Note 4)**

		SN54LVTH16501		SN74LVTH16501		UNIT
		MIN	MAX	MIN	MAX	
V <sub>CC</sub>	Supply voltage	2.7	3.6	2.7	3.6	V
V <sub>IH</sub>	High-level input voltage	2		2		V
V <sub>IL</sub>	Low-level input voltage		0.8		0.8	V
V <sub>I</sub>	Input voltage		5.5		5.5	V
I <sub>OH</sub>	High-level output current		-24		-32	mA
I <sub>OL</sub>	Low-level output current		48		64	mA
Δt/Δv	Input transition rise or fall rate	Outputs enabled		10	10	ns/V
Δt/ΔV <sub>CC</sub>	Power-up ramp rate	200		200		μs/V
T <sub>A</sub>	Operating free-air temperature	-55	125	-40	85	°C

NOTE 4: All unused control inputs of the device must be held at V<sub>CC</sub> or GND to ensure proper device operation. Refer to the TI application report, *Implications of Slow or Floating CMOS Inputs*, literature number SCBA004.

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**electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)**

PARAMETER	TEST CONDITIONS	SN54LVTH16501			SN74LVTH16501			UNIT
		MIN	TYP†	MAX	MIN	TYP†	MAX	
$V_{IK}$	$V_{CC} = 2.7 \text{ V}$ , $I_I = -18 \text{ mA}$			-1.2			-1.2	V
$V_{OH}$	$V_{CC} = 2.7 \text{ V to } 3.6 \text{ V}$ , $I_{OH} = -100 \mu\text{A}$	$V_{CC} - 0.2$			$V_{CC} - 0.2$			V
	$V_{CC} = 2.7 \text{ V}$ , $I_{OH} = -8 \text{ mA}$	2.4			2.4			
	$V_{CC} = 3 \text{ V}$	$I_{OH} = -24 \text{ mA}$	2				2	
		$I_{OH} = -32 \text{ mA}$						
$V_{OL}$	$V_{CC} = 2.7 \text{ V}$	$I_{OL} = 100 \mu\text{A}$		0.2			0.2	V
		$I_{OL} = 24 \text{ mA}$		0.5			0.5	
	$V_{CC} = 3 \text{ V}$	$I_{OL} = 16 \text{ mA}$		0.4			0.4	
		$I_{OL} = 32 \text{ mA}$		0.5			0.5	
		$I_{OL} = 48 \text{ mA}$		0.55				
		$I_{OL} = 64 \text{ mA}$					0.55	
$I_I$	Control inputs	$V_{CC} = 3.6 \text{ V}$ , $V_I = V_{CC}$ or GND		$\pm 1$			$\pm 1$	$\mu\text{A}$
		$V_{CC} = 0$ or $3.6 \text{ V}$ , $V_I = 5.5 \text{ V}$		10			10	
	A or B ports‡	$V_I = 5.5 \text{ V}$		20			20	
		$V_I = V_{CC}$		1			1	
		$V_I = 0$		-5			-5	
$I_{off}$	$V_{CC} = 0$ , $V_I$ or $V_O = 0$ to $4.5 \text{ V}$						$\pm 100$	$\mu\text{A}$
$I_I$ (hold)	A or B ports	$V_{CC} = 3 \text{ V}$	$V_I = 0.8 \text{ V}$	75		75		$\mu\text{A}$
			$V_I = 2 \text{ V}$	-75		-75		
		$V_{CC} = 3.6 \text{ V}^{\$}$	$V_I = 0$ to $3.6 \text{ V}$				$\pm 500$	
$I_{OZPU}$	$V_{CC} = 0$ to $1.5 \text{ V}$ , $V_O = 0.5 \text{ V}$ to $3 \text{ V}$ , OE/OE = don't care			$\pm 100^*$			$\pm 100$	$\mu\text{A}$
$I_{OZPD}$	$V_{CC} = 1.5 \text{ V}$ to $0$ , $V_O = 0.5 \text{ V}$ to $3 \text{ V}$ , OE/OE = don't care			$\pm 100^*$			$\pm 100$	$\mu\text{A}$
$I_{CC}$	$V_{CC} = 3.6 \text{ V}$ , $I_O = 0$ , $V_I = V_{CC}$ or GND	Outputs high		0.19			0.19	$\text{mA}$
		Outputs low		5			5	
		Outputs disabled		0.19			0.19	
$\Delta I_{CC}^{\parallel}$	$V_{CC} = 3 \text{ V}$ to $3.6 \text{ V}$ , One input at $V_{CC} - 0.6 \text{ V}$ , Other inputs at $V_{CC}$ or GND			0.2			0.2	$\text{mA}$
$C_I$	$V_I = 3 \text{ V}$ or $0$			4			4	$\text{pF}$
$C_{IO}$	$V_O = 3 \text{ V}$ or $0$			10			10	$\text{pF}$

\* On products compliant to MIL-PRF-38535, this parameter is not production tested.

† All typical values are at  $V_{CC} = 3.3 \text{ V}$ ,  $T_A = 25^\circ\text{C}$ .

‡ Unused pins at  $V_{CC}$  or GND

§ This is the bus-hold maximum dynamic current. It is the minimum overdrive current required to switch the input from one state to another.

¶ This is the increase in supply current for each input that is at the specified TTL voltage level rather than  $V_{CC}$  or GND.

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**timing requirements over recommended operating free-air temperature range (unless otherwise noted) (see Figure 1)**

			SN54LVTH16501		SN74LVTH16501		UNIT	
			V <sub>CC</sub> = 3.3 V ± 0.3 V		V <sub>CC</sub> = 2.7 V			
			MIN	MAX	MIN	MAX		
f <sub>clock</sub>	Clock frequency			150	150	150	150	MHz
t <sub>w</sub>	Pulse duration	LE high	3.3	3.3	3.3	3.3	ns	
		CLK high or low	3.3	3.3	3.3	3.3		
t <sub>su</sub>	Setup time	A before CLKAB↑	2.3	2.6	2.1	2.4	ns	
		B before CLKBA↑	2.3	2.6	2.1	2.4		
		A or B before LE↓	2.6	1.8	2.4	1.6		
			1.6	0.7	1.4	0.5		
t <sub>h</sub>	Hold time	A or B after CLK↑	1.1	0	1	0	ns	
		A or B after LE↓	1.8	1.8	1.7	1.7		

**switching characteristics over recommended operating free-air temperature range, C<sub>L</sub> = 50 pF (unless otherwise noted) (see Figure 1)**

PARAMETER	FROM (INPUT)	TO (OUTPUT)	SN54LVTH16501		SN74LVTH16501		UNIT	
			V <sub>CC</sub> = 3.3 V ± 0.3 V		V <sub>CC</sub> = 2.7 V			
			MIN	MAX	MIN	MAX		
f <sub>max</sub>			150	150	150	150	MHz	
t <sub>PLH</sub>	B or A	A or B	1.2	3.9	4.3	1.3	2.7	3.7
			1.2	3.9	4.3	1.3	2.4	3.7
t <sub>PLH</sub>	LEBA or LEAB	A or B	1.4	5.5	5.9	1.5	3.4	5.1
			1.4	5.5	5.9	1.5	3.5	5.1
t <sub>PLH</sub>	CLKBA or CLKAB	A or B	1.2	5.4	6	1.3	3.5	5.1
			1.2	5.4	6	1.3	3.4	5.1
t <sub>PZH</sub>	OEBA or OEAB	A or B	1.2	5.1	5.8	1.3	3.4	4.8
			1.2	5.1	5.8	1.3	3.4	4.8
t <sub>PZL</sub>	OEBA or OEAB	A or B	1.6	6.1	6.6	1.7	4.2	5.8
			1.6	6.1	6.6	1.7	3.8	5.8
t <sub>PLZ</sub>	OEBA or OEAB	A or B	1.6	6.1	6.6	1.7	3.8	5.8
			1.6	6.1	6.6	1.7	3.8	5.8

† All typical values are at V<sub>CC</sub> = 3.3 V, T<sub>A</sub> = 25°C.

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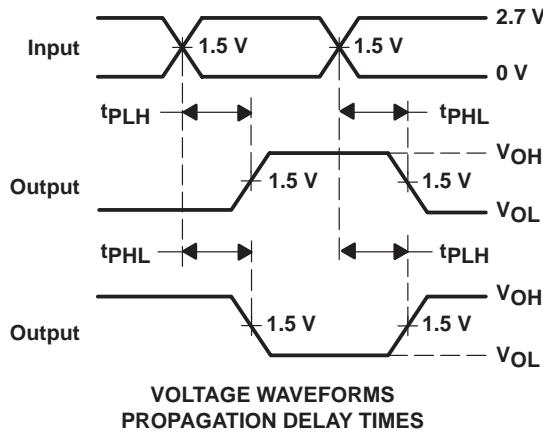
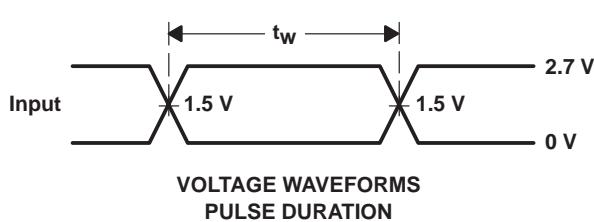
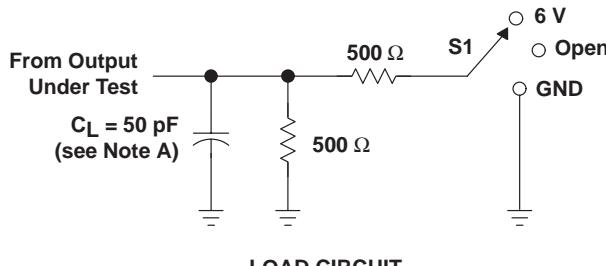


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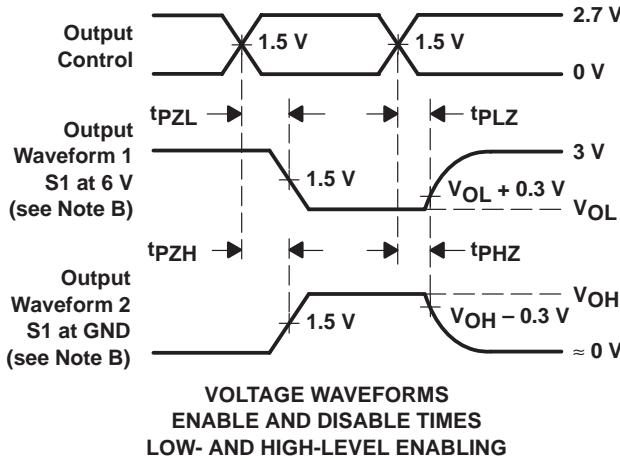
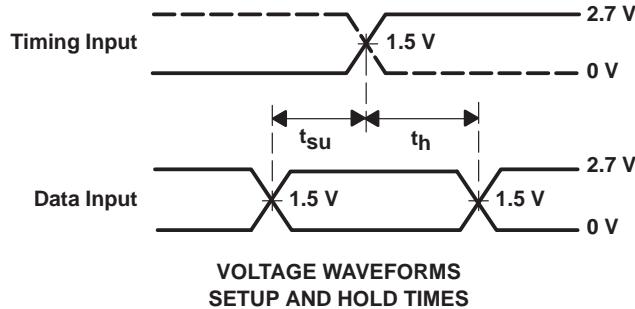
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**PARAMETER MEASUREMENT INFORMATION**



TEST	S1
$t_{PLH}/t_{PHL}$	Open
$t_{PLZ}/t_{PZL}$	6 V
$t_{PHZ}/t_{PZH}$	GND



NOTES:

- $C_L$  includes probe and jig capacitance.
- Waveform 1 is for an output with internal conditions such that the output is low except when disabled by the output control. Waveform 2 is for an output with internal conditions such that the output is high except when disabled by the output control.
- All input pulses are supplied by generators having the following characteristics: PRR  $\leq 10$  MHz,  $Z_O = 50 \Omega$ ,  $t_r \leq 2.5$  ns,  $t_f \leq 2.5$  ns.
- The outputs are measured one at a time with one transition per measurement.

**Figure 1. Load Circuit and Voltage Waveforms**

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