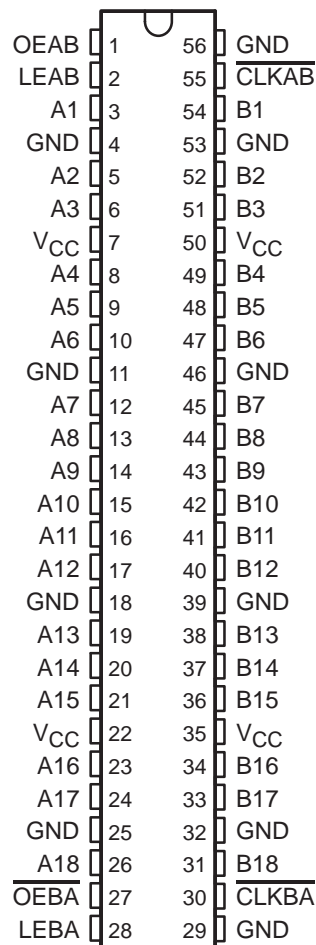


SN54LVTH16500, SN74LVTH16500 3.3-V ABT 18-BIT UNIVERSAL BUS TRANSCEIVERS WITH 3-STATE OUTPUTS

SCBS701D – JULY 1997 – REVISED APRIL 1999

- **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**
- **UBT™ (Universal Bus Transceiver) Combines D-Type Latches and D-Type Flip-Flops for Operation in Transparent, Latched, or Clocked Mode**
- **Support Mixed-Mode Signal Operation (5-V Input and Output Voltages With 3.3-V V_{CC})**
- **Support Unregulated Battery Operation Down to 2.7 V**
- **Typical V_{OLP} (Output Ground Bounce) < 0.8 V at V_{CC} = 3.3 V, T_A = 25°C**
- **I_{off} and Power-Up 3-State Support Hot Insertion**
- **Bus Hold on Data Inputs Eliminates the Need for External Pullup/Pulldown Resistors**
- **Distributed V_{CC} 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**

SN54LVTH16500 . . . WD PACKAGE
SN74LVTH16500 . . . DGG OR DL PACKAGE
(TOP VIEW)



description

The 'LVTH16500 devices are 18-bit universal bus transceivers designed for low-voltage (3.3-V) V_{CC} 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 \overline{OEBA}), latch-enable (LEAB and LEBA), and clock (\overline{CLKAB} and \overline{CLKBA}) inputs. For A-to-B data flow, the device operates in the transparent mode when LEAB is high. When LEAB is low, the A data is latched if \overline{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 high-to-low transition of \overline{CLKAB} . Output-enable OEAB is active high. When OEAB is high, the B-port outputs are active. When OEAB is low, the B-port outputs are in the high-impedance state.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

Widebus and UBT are trademarks of Texas Instruments Incorporated.

UNLESS OTHERWISE NOTED this document contains PRODUCTION DATA information current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

 **TEXAS
INSTRUMENTS**

POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

Copyright © 1999, Texas Instruments Incorporated

SN54LVTH16500, SN74LVTH16500

3.3-V ABT 18-BIT UNIVERSAL BUS TRANSCEIVERS

WITH 3-STATE OUTPUTS

SCBS701D – JULY 1997 – REVISED APRIL 1999

description (continued)

Data flow for B to A is similar to that of A to B but uses \overline{OEBA} , LEBA, and \overline{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 SN54LVTH16500 is characterized for operation over the full military temperature range of -55°C to 125°C . The SN74LVTH16500 is characterized for operation from -40°C to 85°C .

FUNCTION TABLE†

INPUTS				OUTPUT
OEAB	LEAB	\overline{CLKAB}	A	B
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^{\S}

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

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

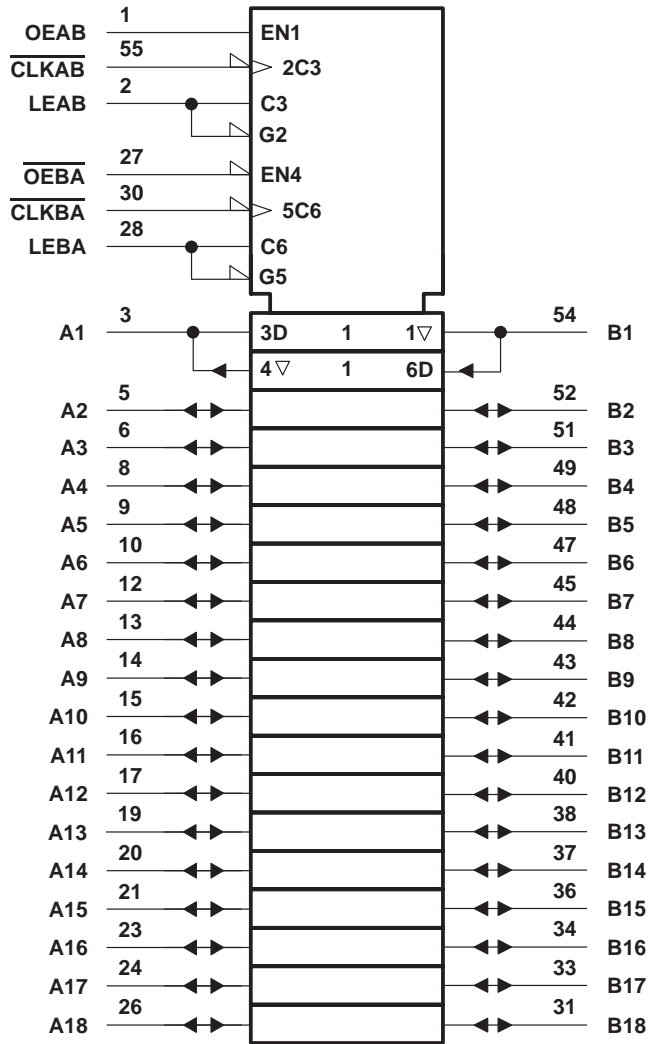
§ Output level before the indicated steady-state input conditions were established, provided that \overline{CLKAB} was low before LEAB went low



SN54LVTH16500, SN74LVTH16500
**3.3-V ABT 18-BIT UNIVERSAL BUS TRANSCEIVERS
 WITH 3-STATE OUTPUTS**

SCBS701D – JULY 1997 – REVISED APRIL 1999

logic symbol†

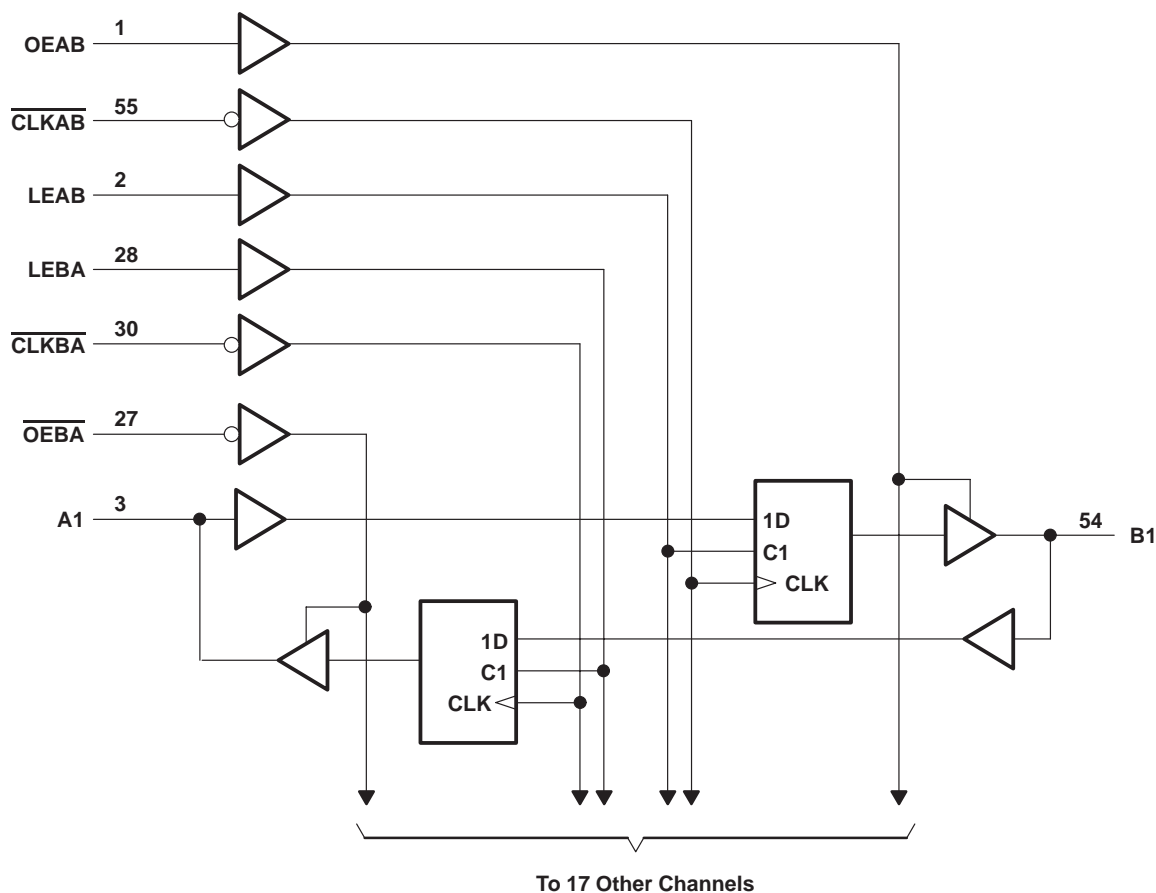


† This symbol is in accordance with ANSI/IEEE Std 91-1984 and IEC Publication 617-12.

SN54LVTH16500, SN74LVTH16500 3.3-V ABT 18-BIT UNIVERSAL BUS TRANSCEIVERS WITH 3-STATE OUTPUTS

SCBS701D – JULY 1997 – REVISED APRIL 1999

logic diagram (positive logic)



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

Supply voltage range, V_{CC}	-0.5 V to 4.6 V
Input voltage range, V_I (see Note 1)	-0.5 V to 7 V
Voltage range applied to any output in the high-impedance or power-off state, V_O (see Note 1)	-0.5 V to 7 V
Voltage range applied to any output in the high state, V_O (see Note 1)	-0.5 V to $V_{CC} + 0.5$ V
Current into any output in the low state, I_O : SN54LVTH16500	96 mA
SN74LVTH16500	128 mA
Current into any output in the high state, I_O (see Note 2): SN54LVTH16500	48 mA
SN74LVTH16500	64 mA
Input clamp current, I_{IK} ($V_I < 0$)	-50 mA
Output clamp current, I_{OK} ($V_O < 0$)	-50 mA
Package thermal impedance, θ_{JA} (see Note 3): DGG package	81°C/W
DL package	74°C/W
Storage temperature range, T_{stg}	-65°C to 150°C

† 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 JESD 51.



POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

SN54LVTH16500, SN74LVTH16500 3.3-V ABT 18-BIT UNIVERSAL BUS TRANSCEIVERS WITH 3-STATE OUTPUTS

SCBS701D – JULY 1997 – REVISED APRIL 1999

recommended operating conditions (see Note 4)

		SN54LVTH16500		SN74LVTH16500		UNIT
		MIN	MAX	MIN	MAX	
V _{CC}	Supply voltage	2.7	3.6	2.7	3.6	V
V _{IH}	High-level input voltage	2		2		V
V _{IL}	Low-level input voltage		0.8		0.8	V
V _I	Input voltage		5.5		5.5	V
I _{OH}	High-level output current		-24		-32	mA
I _{OL}	Low-level output current		48		64	mA
Δt/Δv	Input transition rise or fall rate	Outputs enabled		10	10	ns/V
Δt/ΔV _{CC}	Power-up ramp rate	200		200		μs/V
T _A	Operating free-air temperature	-55	125	-40	85	°C

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

SN54LVTH16500, SN74LVTH16500

3.3-V ABT 18-BIT UNIVERSAL BUS TRANSCEIVERS

WITH 3-STATE OUTPUTS

SCBS701D – JULY 1997 – REVISED APRIL 1999

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

PARAMETER		TEST CONDITIONS	SN54LVTH16500			SN74LVTH16500			UNIT
			MIN	TYP†	MAX	MIN	TYP†	MAX	
V _{IK}		V _{CC} = 2.7 V, I _I = -18 mA	-1.2			-1.2			V
V _{OH}		V _{CC} = 2.7 V to 3.6 V, I _{OH} = -100 μA	V _{CC} -0.2			V _{CC} -0.2			V
		V _{CC} = 2.7 V, I _{OH} = -8 mA	2.4			2.4			
		V _{CC} = 3 V	2			2			
V _{OL}		V _{CC} = 2.7 V	I _{OL} = 100 μA		0.2		0.2		V
			I _{OL} = 24 mA		0.5		0.5		
		V _{CC} = 3 V	I _{OL} = 16 mA		0.4		0.4		
			I _{OL} = 32 mA		0.5		0.5		
			I _{OL} = 48 mA		0.55		0.55		
			I _{OL} = 64 mA				0.55		
I _I		Control inputs	V _{CC} = 3.6 V, V _I = V _{CC} or GND		±1		±1		μA
			V _{CC} = 0 or 3.6 V, V _I = 5.5 V		10		10		
		A or B ports‡	V _{CC} = 3.6 V, V _I = 5.5 V		20		20		
			V _{CC} = 3.6 V, V _I = V _{CC}		1		1		
		V _{CC} = 3.6 V, V _I = 0		-5		-5			
I _{off}		V _{CC} = 0, V _I or V _O = 0 to 4.5 V				±100		μA	
I _I (hold)		A or B ports	V _{CC} = 3 V, V _I = 0.8 V		75		75		μA
			V _{CC} = 3 V, V _I = 2 V		-75		-75		
		V _{CC} = 3.6 V§, V _I = 0 to 3.6 V						±500	
I _{OZPU}		V _{CC} = 0 to 1.5 V, V _O = 0.5 V to 3 V, OE/OE = don't care		±100*		±100		μA	
I _{OZPD}		V _{CC} = 1.5 V to 0, V _O = 0.5 V to 3 V, OE/OE = don't care		±100*		±100		μA	
I _{CC}		V _{CC} = 3.6 V, I _O = 0, V _I = V _{CC} or GND	Outputs high		0.19		0.19		mA
			Outputs low		5		5		
			Outputs disabled		0.19		0.19		
ΔI _{CC} ¶		V _{CC} = 3 V to 3.6 V, One input at V _{CC} - 0.6 V, Other inputs at V _{CC} or GND		0.2		0.2		mA	
C _i		V _I = 3 V or 0		4		4		pF	
C _{io}		V _O = 3 V or 0		10		10		pF	

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

† All typical values are at V_{CC} = 3.3 V, T_A = 25°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.

PRODUCT PREVIEW information concerns products in the formative or design phase of development. Characteristic data and other specifications are design goals. Texas Instruments reserves the right to change or discontinue these products without notice.



POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

SN54LVTH16500, SN74LVTH16500
3.3-V ABT 18-BIT UNIVERSAL BUS TRANSCEIVERS
WITH 3-STATE OUTPUTS

SCBS701D – JULY 1997 – REVISED APRIL 1999

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

		SN54LVTH16500				SN74LVTH16500				UNIT	
		$V_{CC} = 3.3\text{ V} \pm 0.3\text{ V}$		$V_{CC} = 2.7\text{ V}$		$V_{CC} = 3.3\text{ V} \pm 0.3\text{ V}$		$V_{CC} = 2.7\text{ V}$			
		MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX		
f_{clock}	Clock frequency	150		150		150		150		MHz	
t_w	Pulse duration	LE high		3.3		3.3		3.3		ns	
		$\overline{\text{CLK}}$ high or low		3.3		3.3		3.3			
t_{su}	Setup time	A before $\overline{\text{CLKAB}}\downarrow$		3.1		3.1		2.9		ns	
		B before $\overline{\text{CLKBA}}\downarrow$		3.1		3.1		2.9			
		A or B before $\text{LE}\downarrow$	$\overline{\text{CLK}}$ high		1.5		0.6		1.4		
			$\overline{\text{CLK}}$ low		3.1		2.5		2.9		
t_h	Hold time	A or B after $\overline{\text{CLK}}\downarrow$		0.4		0.4		0.4		ns	
		A or B after $\text{LE}\downarrow$		1.7		1.7		1.6			

switching characteristics over recommended operating free-air temperature range, $C_L = 50\text{ pF}$ (unless otherwise noted) (see Figure 1)

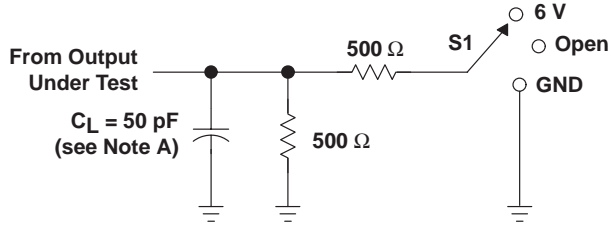
PARAMETER	FROM (INPUT)	TO (OUTPUT)	SN54LVTH16500				SN74LVTH16500				UNIT	
			$V_{CC} = 3.3\text{ V} \pm 0.3\text{ V}$		$V_{CC} = 2.7\text{ V}$		$V_{CC} = 3.3\text{ V} \pm 0.3\text{ V}$			$V_{CC} = 2.7\text{ V}$		
			MIN	MAX	MIN	MAX	MIN	TYP†	MAX	MIN		MAX
f_{max}			150		150		150			150		MHz
t_{PLH}	B or A	A or B	1.2 3.9		4.1		1.3 2.8 3.7			4		ns
t_{PHL}			1.2 3.9		4.1		1.3 2.6 3.7			4		
t_{PLH}	$\overline{\text{LEBA}}$ or $\overline{\text{LEAB}}$	A or B	1.4 5.5		5.9		1.5 3.8 5.1			5.7		ns
t_{PHL}			1.4 5.5		5.9		1.5 3.8 5.1			5.7		
t_{PLH}	$\overline{\text{CLKBA}}$ or $\overline{\text{CLKAB}}$	A or B	1.2 5.3		6.1		1.3 3.6 5			5.9		ns
t_{PHL}			1.2 5.3		6.1		1.3 3.5 5			5.9		
t_{PZH}	$\overline{\text{OEBA}}$ or $\overline{\text{OEAB}}$	A or B	1.2 5.1		5.8		1.3 3.6 4.8			5.5		ns
t_{PZL}			1.2 5.1		5.8		1.3 3.6 4.8			5.5		
t_{PHZ}	$\overline{\text{OEBA}}$ or $\overline{\text{OEAB}}$	A or B	1.6 6.1		6.6		1.7 4.5 5.8			6.3		ns
t_{PLZ}			1.6 6.1		6.6		1.7 4.1 5.8			6.3		

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

SN54LVTH16500, SN74LVTH16500
3.3-V ABT 18-BIT UNIVERSAL BUS TRANSCEIVERS
WITH 3-STATE OUTPUTS

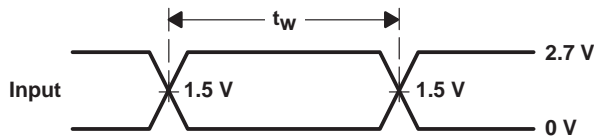
SCBS701D – JULY 1997 – REVISED APRIL 1999

PARAMETER MEASUREMENT INFORMATION

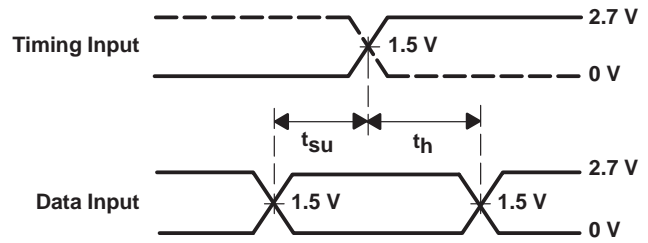


LOAD CIRCUIT

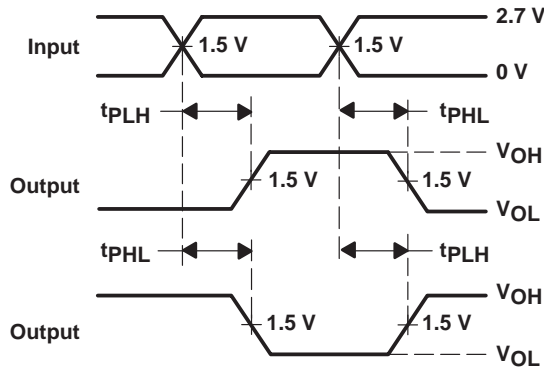
TEST	S1
t_{PHL}/t_{PLH}	Open
t_{PLZ}/t_{PZL}	6 V
t_{PHZ}/t_{PZH}	GND



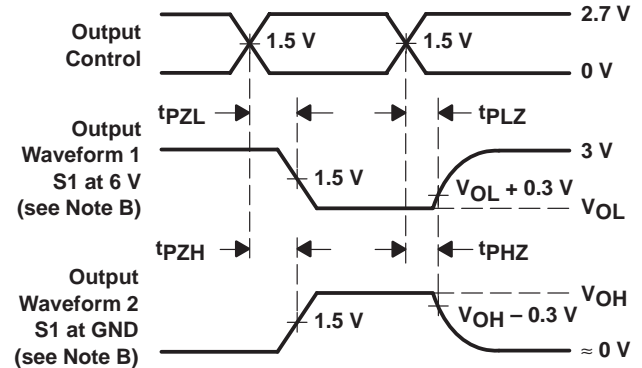
VOLTAGE WAVEFORMS
PULSE DURATION



VOLTAGE WAVEFORMS
SETUP AND HOLD TIMES



VOLTAGE WAVEFORMS
PROPAGATION DELAY TIMES
INVERTING AND NONINVERTING OUTPUTS



VOLTAGE WAVEFORMS
ENABLE AND DISABLE TIMES
LOW- AND HIGH-LEVEL ENABLING

- NOTES: A. C_L includes probe and jig capacitance.
 B. 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.
 C. All input pulses are supplied by generators having the following characteristics: $PRR \leq 10 \text{ MHz}$, $Z_O = 50 \Omega$, $t_r \leq 2.5 \text{ ns}$, $t_f \leq 2.5 \text{ ns}$.
 D. The outputs are measured one at a time with one transition per measurement.

Figure 1. Load Circuit and Voltage Waveforms

IMPORTANT NOTICE

Texas Instruments and its subsidiaries (TI) reserve the right to make changes to their products or to discontinue any product or service without notice, and advise customers to obtain the latest version of relevant information to verify, before placing orders, that information being relied on is current and complete. All products are sold subject to the terms and conditions of sale supplied at the time of order acknowledgement, including those pertaining to warranty, patent infringement, and limitation of liability.

TI warrants performance of its semiconductor products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are utilized to the extent TI deems necessary to support this warranty. Specific testing of all parameters of each device is not necessarily performed, except those mandated by government requirements.

CERTAIN APPLICATIONS USING SEMICONDUCTOR PRODUCTS MAY INVOLVE POTENTIAL RISKS OF DEATH, PERSONAL INJURY, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE ("CRITICAL APPLICATIONS"). TI SEMICONDUCTOR PRODUCTS ARE NOT DESIGNED, AUTHORIZED, OR WARRANTED TO BE SUITABLE FOR USE IN LIFE-SUPPORT DEVICES OR SYSTEMS OR OTHER CRITICAL APPLICATIONS. INCLUSION OF TI PRODUCTS IN SUCH APPLICATIONS IS UNDERSTOOD TO BE FULLY AT THE CUSTOMER'S RISK.

In order to minimize risks associated with the customer's applications, adequate design and operating safeguards must be provided by the customer to minimize inherent or procedural hazards.

TI assumes no liability for applications assistance or customer product design. TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right of TI covering or relating to any combination, machine, or process in which such semiconductor products or services might be or are used. TI's publication of information regarding any third party's products or services does not constitute TI's approval, warranty or endorsement thereof.