

# SN74LVTH16652-EP

## 3.3-V ABT 16-BIT BUS TRANSCEIVER AND REGISTER WITH 3-STATE OUTPUTS

SCBS787 – NOVEMBER 2003

- **Controlled Baseline**
  - One Assembly/Test Site, One Fabrication Site
- **Enhanced Diminishing Manufacturing Sources (DMS) Support**
- **Enhanced Product-Change Notification**
- **Qualification Pedigree†**
- **Member 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**
- **Supports Mixed-Mode Signal Operation (5-V Input and Output Voltages With 3.3-V  $V_{CC}$ )**
- **Supports Unregulated Battery Operation Down To 2.7 V**
- **Typical  $V_{OLP}$  (Output Ground Bounce) <0.8 V at  $V_{CC} = 3.3$  V,  $T_A = 25^\circ\text{C}$**
- **$I_{off}$  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 Pins Minimize 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,  $R = 0$ )**
- **Thin Shrink Small-Outline (DGG) Package**

DGG PACKAGE  
(TOP VIEW)

1OEAB	1	56	1OEBA
1CLKAB	2	55	1CLKBA
1SAB	3	54	1SBA
GND	4	53	GND
1A1	5	52	1B1
1A2	6	51	1B2
$V_{CC}$	7	50	$V_{CC}$
1A3	8	49	1B3
1A4	9	48	1B4
1A5	10	47	1B5
GND	11	46	GND
1A6	12	45	1B6
1A7	13	44	1B7
1A8	14	43	1B8
2A1	15	42	2B1
2A2	16	41	2B2
2A3	17	40	2B3
GND	18	39	GND
2A4	19	38	2B4
2A5	20	37	2B5
2A6	21	36	2B6
$V_{CC}$	22	35	$V_{CC}$
2A7	23	34	2B7
2A8	24	33	2B8
GND	25	32	GND
2SAB	26	31	2SBA
2CLKAB	27	30	2CLKBA
2OEAB	28	29	2OEBA

† Component qualification in accordance with JEDEC and industry standards to ensure reliable operation over an extended temperature range. This includes, but is not limited to, Highly Accelerated Stress Test (HAST) or biased 85/85, temperature cycle, autoclave or unbiased HAST, electromigration, bond intermetallic life, and mold compound life. Such qualification testing should not be viewed as justifying use of this component beyond specified performance and environmental limits.

### description/ordering information

The SN74LVTH16652 is a 16-bit bus transceiver 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. These devices can be used as two 8-bit transceivers or one 16-bit transceiver.



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**description/ordering information (continued)**

Output-enable ( $\overline{OEAB}$  and  $\overline{OEBA}$ ) inputs are provided to control the transceiver functions. Select-control (SAB and SBA) inputs are provided to select whether real-time or stored data is transferred. A low input level selects real-time data, and a high input level selects stored data. The circuitry used for select control eliminates the typical decoding glitch that occurs in a multiplexer during the transition between stored and real-time data. Figure 1 illustrates the four fundamental bus-management functions that can be performed with the SN74LVTH16652.

Data on the A or B bus, or both, can be stored in the internal D flip-flops by low-to-high transitions at the appropriate clock (CLKAB or CLKBA) inputs, regardless of the levels on the select-control or output-enable inputs. When SAB and SBA are in the real-time transfer mode, it also is possible to store data without using the internal D-type flip-flops by simultaneously enabling  $\overline{OEAB}$  and  $\overline{OEBA}$ . In this configuration, each output reinforces its input. When all other data sources to the two sets of bus lines are at high impedance, each set of bus lines remains at its last level configuration.

When  $V_{CC}$  is between 0 and 1.5 V, the device is 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.

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

This device is 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 device when it is 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.

**ORDERING INFORMATION**

TA	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
-40°C to 85°C	TSSOP – DGG	Tape and reel	CLVTH16652IDGGREP	LH16652EP

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at [www.ti.com/sc/package](http://www.ti.com/sc/package).



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FUNCTION TABLE

INPUTS						DATA I/O†		OPERATION OR FUNCTION
OEAB	OEBA	CLKAB	CLKBA	SAB	SBA	A1–A8	B1–B8	
L	H	H or L	H or L	X	X	Input	Input	Isolation
L	H	↑	↑	X	X	Input	Input	Store A and B data
X	H	↑	H or L	X	X	Input	Unspecified‡	Store A, hold B
H	H	↑	↑	X‡	X	Input	Output	Store A in both registers
L	X	H or L	↑	X	X	Unspecified‡	Input	Hold A, store B
L	L	↑	↑	X	X‡	Output	Input	Store B in both registers
L	L	X	X	X	L	Output	Input	Real-time B data to A bus
L	L	X	H or L	X	H	Output	Input	Stored B data to A bus
H	H	X	X	L	X	Input	Output	Real-time A data to B bus
H	H	H or L	X	H	X	Input	Output	Stored A data to B bus
H	L	H or L	H or L	H	H	Output	Output	Stored A data to B bus and stored B data to A bus

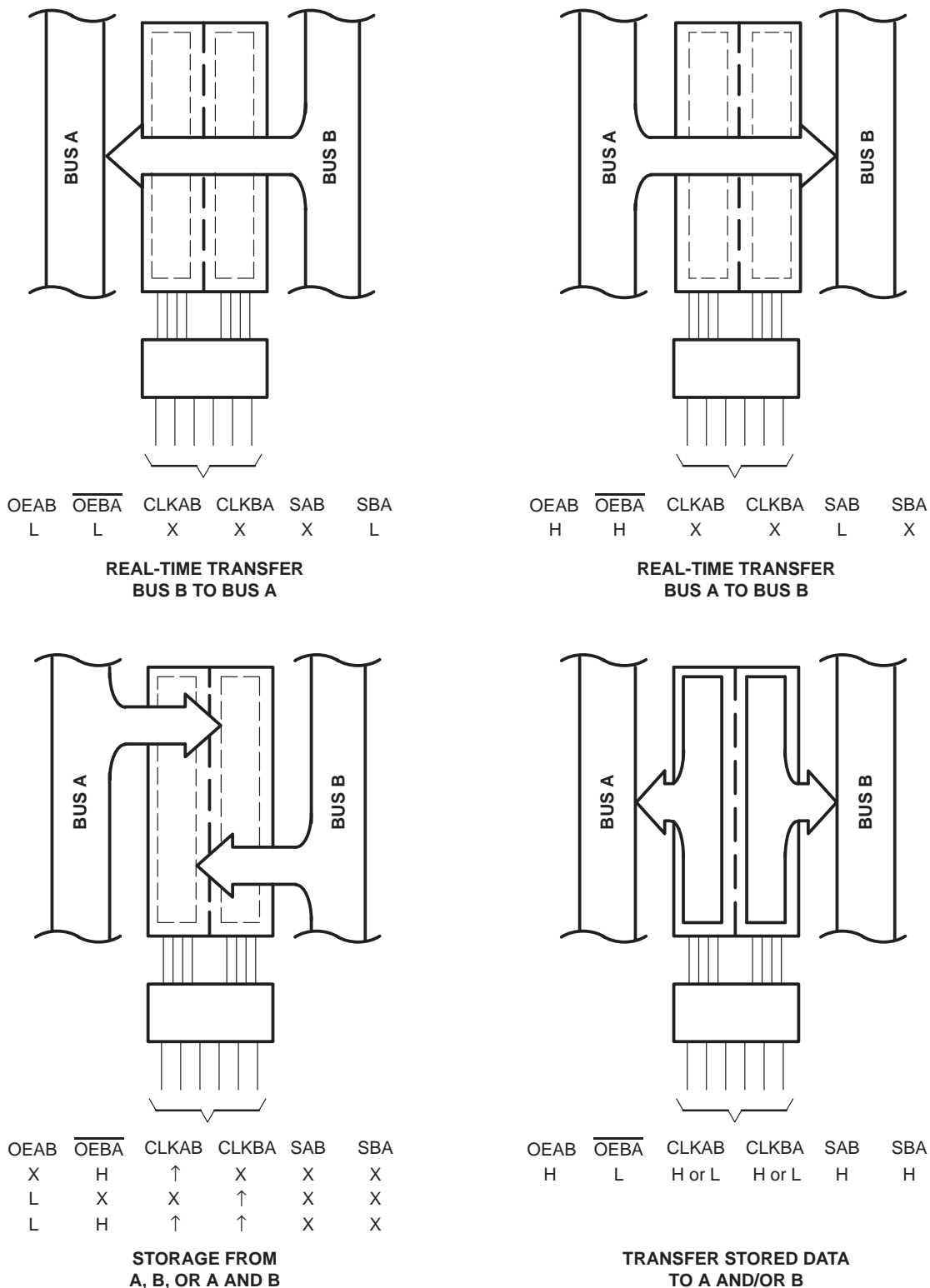
† The data-output functions may be enabled or disabled by a variety of level combinations at OEAB or OEBA. Data-input functions always are enabled; i.e., data at the bus terminals is stored on every low-to-high transition of the clock inputs.

‡ Select control = L; clocks can occur simultaneously.

Select control = H; clocks must be staggered to load both registers.

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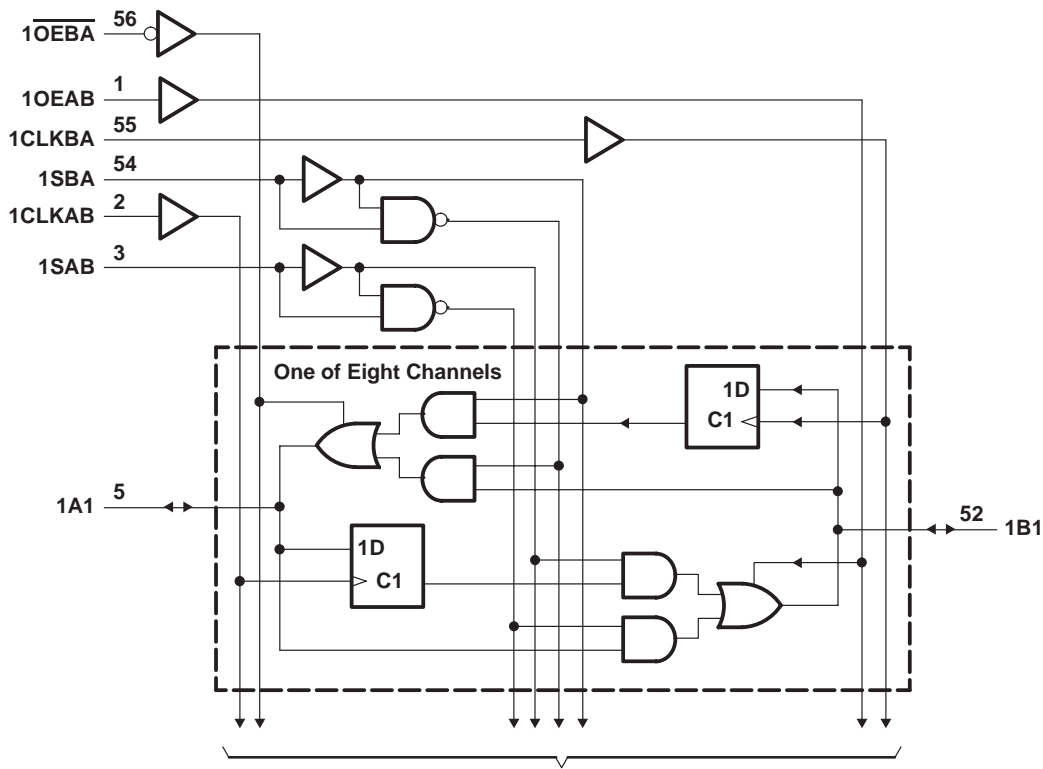


**Figure 1. Bus-Management Functions**

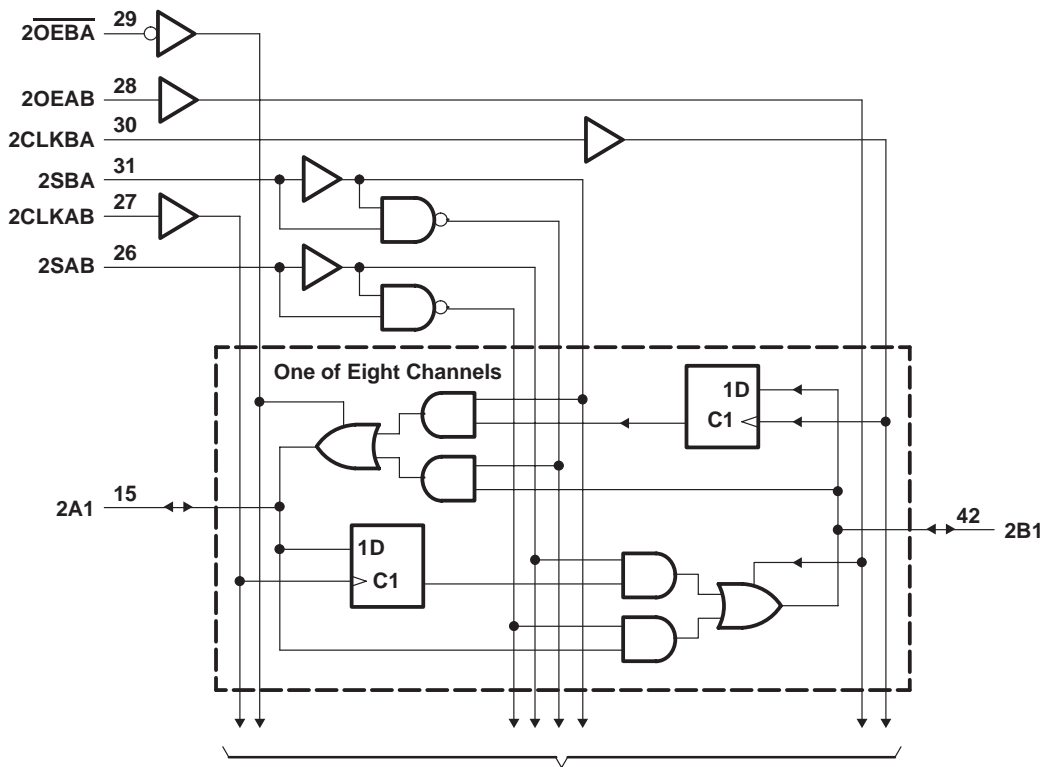
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logic diagram (positive logic)



To Seven Other Channels



To Seven Other Channels

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**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, $I_O$	128 mA
Current into any output in the high state, $I_O$ (see Note 2)	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, $\theta_{JA}$ (see Note 3)	81°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.

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

		MIN	MAX	UNIT
$V_{CC}$	Supply voltage	2.7	3.6	V
$V_{IH}$	High-level input voltage	2		V
$V_{IL}$	Low-level input voltage		0.8	V
$V_I$	Input voltage		5.5	V
$I_{OH}$	High-level output current		–32	mA
$I_{OL}$	Low-level output current		64	mA
$\Delta t/\Delta v$	Input transition rise or fall rate		10	ns/V
				Outputs enabled
$\Delta t/\Delta V_{CC}$	Power-up ramp rate	200		µs/V
$T_A$	Operating free-air temperature	–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.



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## 3.3-V ABT 16-BIT BUS TRANSCEIVER AND REGISTER WITH 3-STATE OUTPUTS

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

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

† 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.

timing requirements over recommended operating free-air temperature range (unless otherwise noted) (see Figure 2)

		$V_{CC} = 3.3 \pm 0.3\text{ V}$		$V_{CC} = 2.7\text{ V}$		UNIT
		MIN	MAX	MIN	MAX	
$f_{\text{clock}}$	Clock frequency	150		150		MHz
$t_w$	Pulse duration, CLK high or low	3.3		3.3		ns
$t_{su}$	Setup time, A or B before CLKAB↑ or CLKBA↑	Data high	1.2	1.5		ns
		Data low	2	2.8		
$t_h$	Hold time, A or B after CLKAB↑ or CLKBA↑	Data high	0.5	0		ns
		Data low	0.5	0.5		



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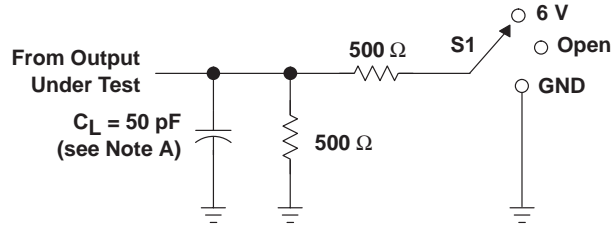
switching characteristics over recommended operating free-air temperature range,  $C_L = 50$  pF (unless otherwise noted) (see Figure 2)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC} = 3.3\text{ V} \pm 0.3\text{ V}$			$V_{CC} = 2.7\text{ V}$		UNIT
			MIN	TYP†	MAX	MIN	MAX	
$f_{max}$			150			150		MHz
$t_{PLH}$	CLK	B or A	1.3	2.7	4.2	4.7		ns
$t_{PHL}$			1.3	2.8	4.2	4.7		
$t_{PLH}$	A or B	B or A	1	2.4	3.4	3.9		ns
$t_{PHL}$			1	2.1	3.4	3.9		
$t_{PLH}$	SAB or SBA	B or A	1	2.7	4.5	5.4		ns
$t_{PHL}$			1	3	4.5	5.4		
$t_{PZH}$	$\overline{OEBA}$	A	1	2.4	4.3	5.2		ns
$t_{PZL}$			1	2.3	4.3	5.2		
$t_{PHZ}$	$\overline{OEBA}$	A	2	3.9	5.6	6.1		ns
$t_{PLZ}$			2	3.4	5.4	6.1		
$t_{PZH}$	OEAB	B	1.3	2.7	4.2	4.9		ns
$t_{PZL}$			1.3	2.6	4.2	4.9		
$t_{PHZ}$	OEAB	B	1.3	3.5	5.5	6.2		ns
$t_{PLZ}$			1.3	3.2	5.5	6.2		

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

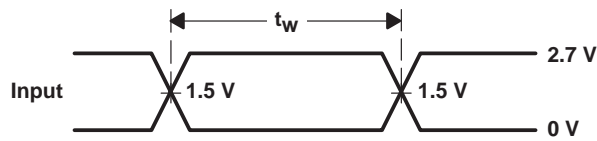


**PARAMETER MEASUREMENT INFORMATION**

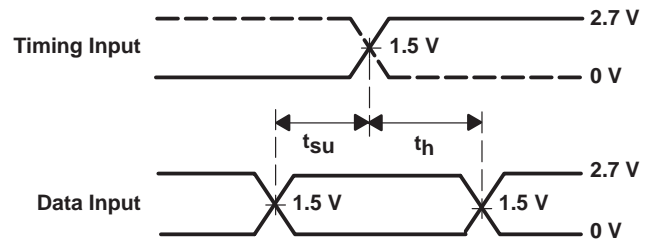


**LOAD CIRCUIT**

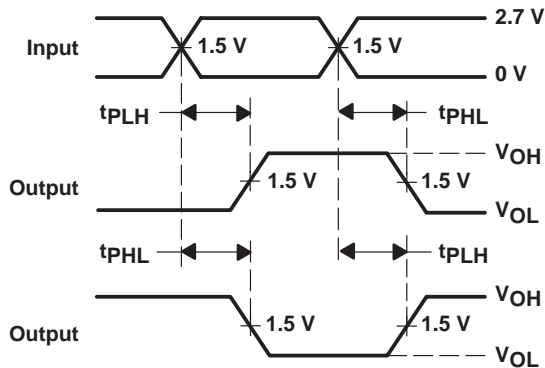
TEST	S1
$t_{PLH}/t_{PHL}$	Open
$t_{PLZ}/t_{PZL}$	6 V
$t_{PHZ}/t_{PZH}$	GND



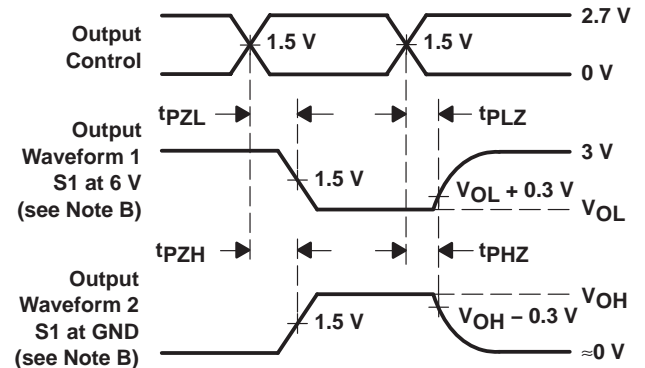
**VOLTAGE WAVEFORMS  
PULSE DURATION**



**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 2. Load Circuit and Voltage Waveforms**

**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
CLVTH16652IDGGREP	ACTIVE	TSSOP	DGG	56	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
V62/04717-01XE	ACTIVE	TSSOP	DGG	56	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

<sup>(1)</sup> The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBsolete:** TI has discontinued the production of the device.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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**OTHER QUALIFIED VERSIONS OF SN74LVTH16652-EP :**

- Catalog: [SN74LVTH16652](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

**TAPE AND REEL INFORMATION**



**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
CLVTH16652IDGGREP	TSSOP	DGG	56	2000	330.0	24.4	8.6	15.6	1.8	12.0	24.0	Q1

**TAPE AND REEL BOX DIMENSIONS**



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
CLVTH16652IDGGREP	TSSOP	DGG	56	2000	346.0	346.0	41.0

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