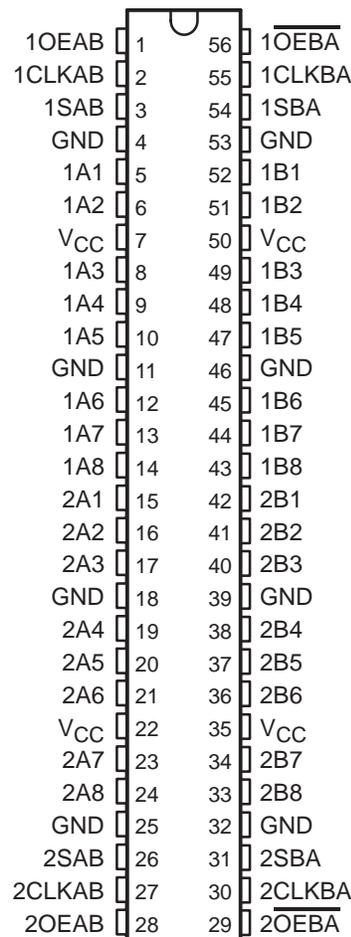


# SN54LVTH16652, SN74LVTH16652 3.3-V ABT 16-BIT BUS TRANSCEIVERS AND REGISTERS WITH 3-STATE OUTPUTS

SCBS150K – JULY 1994 – 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**
- **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,  $T_A = 25^\circ\text{C}$**
- **$I_{off}$  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 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**

**SN54LVTH16652 . . . WD PACKAGE  
SN74LVTH16652 . . . DGG OR DL PACKAGE  
(TOP VIEW)**



## description

The 'LVTH16652 devices are 16-bit 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. These devices can be used as two 8-bit transceivers or one 16-bit transceiver.

Output-enable (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 'LVTH16652 devices.



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# SN54LVTH16652, SN74LVTH16652

## 3.3-V ABT 16-BIT BUS TRANSCEIVERS AND REGISTERS

### WITH 3-STATE OUTPUTS

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#### description (continued)

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 OEAB and 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 devices are in the high-impedance state during power up or power down. However, to ensure the high-impedance state above 1.5 V, 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.

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 SN54LVTH16652 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74LVTH16652 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

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

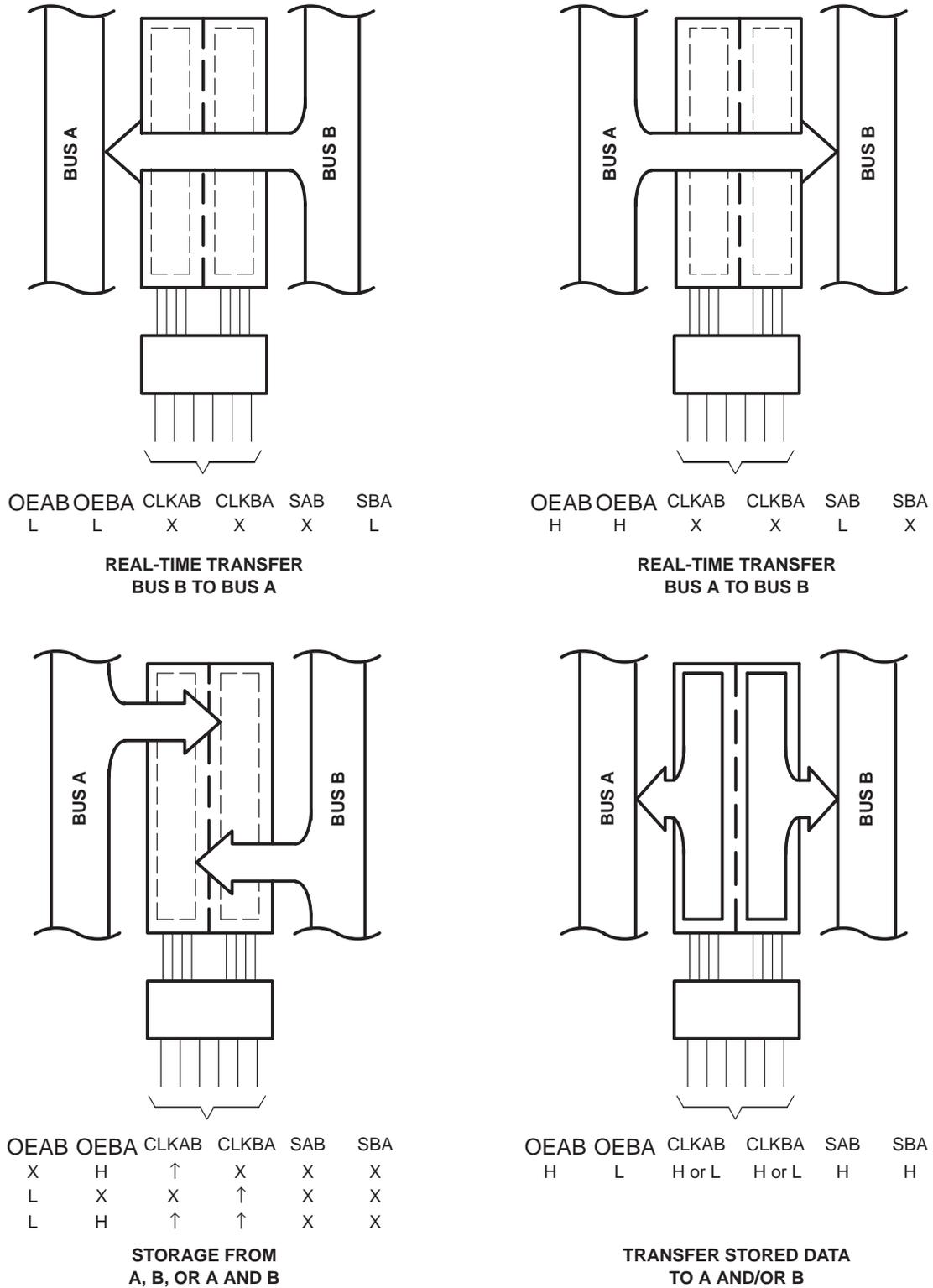
† The data-output functions may be enabled or disabled by a variety of level combinations at OEAB or OEBA. Data-input functions always are enabled; i.e., data at the bus terminals is stored on every low-to-high transition of the clock inputs.

‡ Select control = L; clocks can occur simultaneously.

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

SN54LVTH16652, SN74LVTH16652  
**3.3-V ABT 16-BIT BUS TRANSCEIVERS AND REGISTERS  
 WITH 3-STATE OUTPUTS**

SCBS150K – JULY 1994 – REVISED APRIL 1999



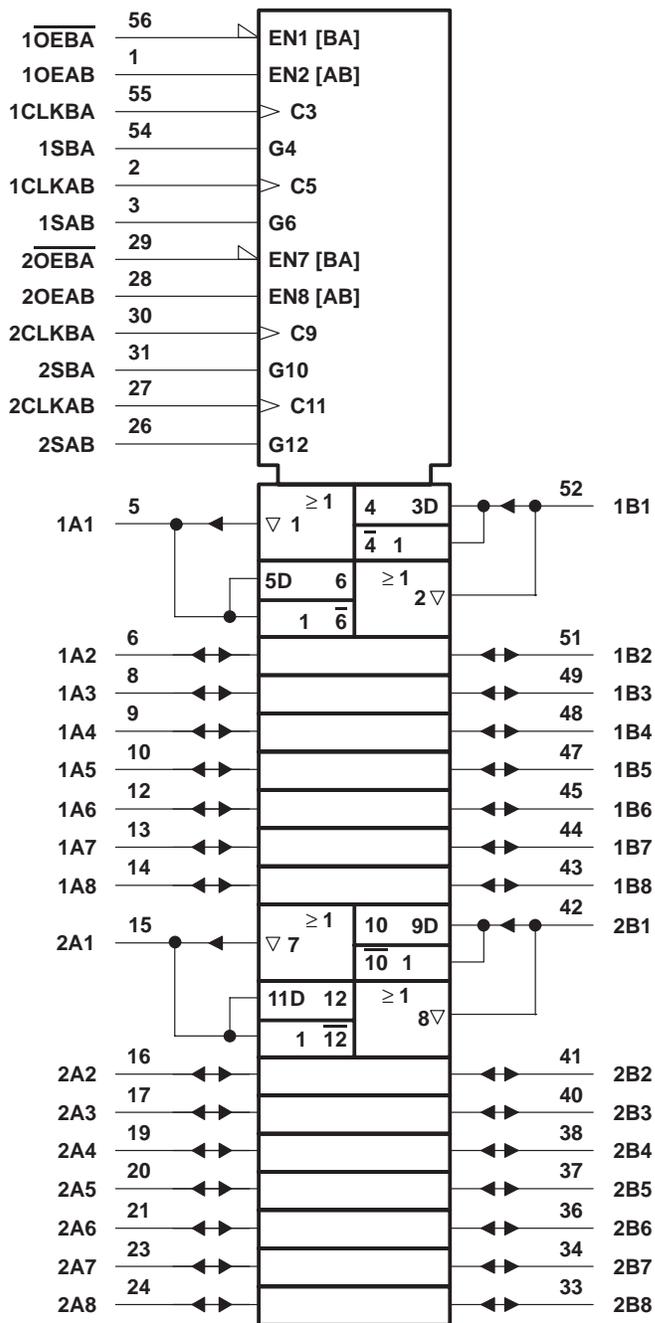
**Figure 1. Bus-Management Functions**

# SN54LVTH16652, SN74LVTH16652

## 3.3-V ABT 16-BIT BUS TRANSCEIVERS AND REGISTERS WITH 3-STATE OUTPUTS

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### logic symbol†

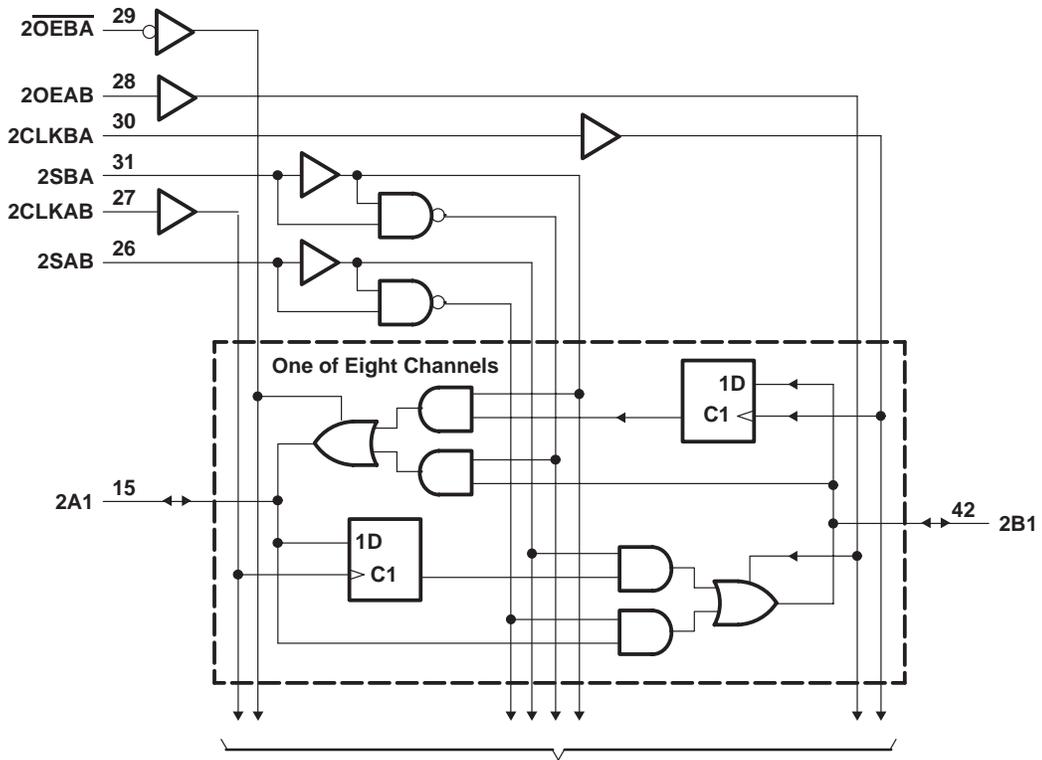
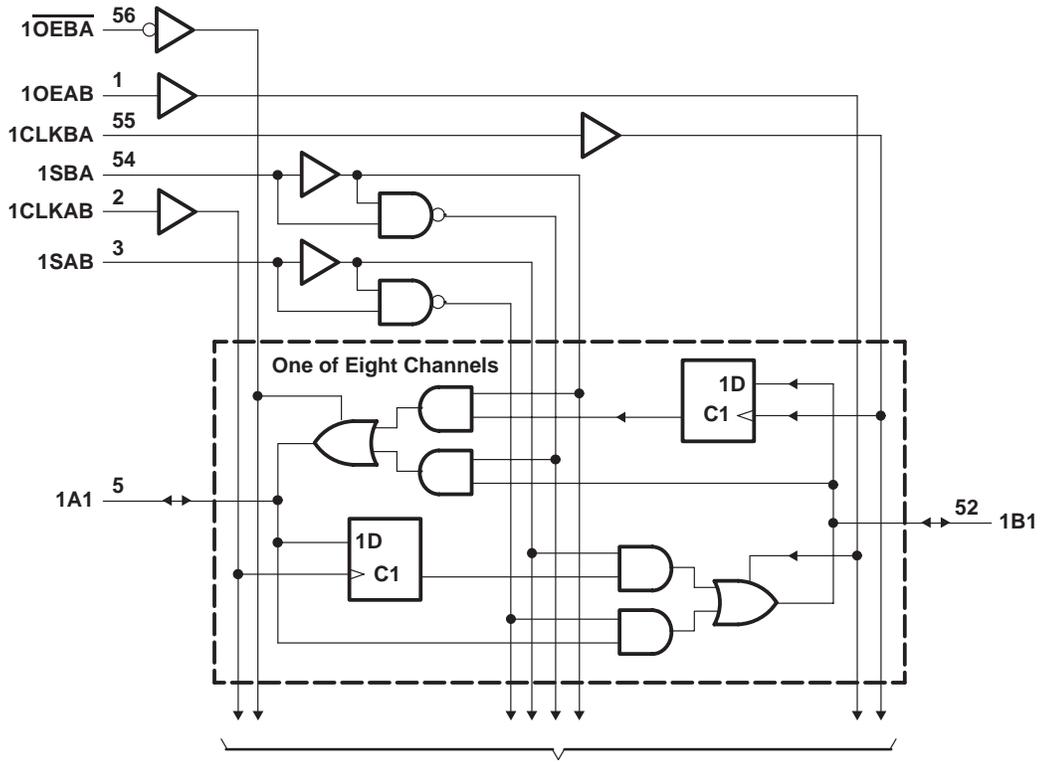


† This symbol is in accordance with ANSI/IEEE Std 91-1984 and IEC Publication 617-12.

**SN54LVTH16652, SN74LVTH16652**  
**3.3-V ABT 16-BIT BUS TRANSCEIVERS AND REGISTERS**  
**WITH 3-STATE OUTPUTS**

SCBS150K – JULY 1994 – REVISED APRIL 1999

**logic diagram (positive logic)**



# SN54LVTH16652, SN74LVTH16652

## 3.3-V ABT 16-BIT BUS TRANSCEIVERS AND REGISTERS WITH 3-STATE OUTPUTS

SCBS150K – JULY 1994 – REVISED APRIL 1999

### 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, $I_O$ : SN54LVTH16652 .....	96 mA
SN74LVTH16652 .....	128 mA
Current into any output in the high state, $I_O$ (see Note 2): SN54LVTH16652 .....	48 mA
SN74LVTH16652 .....	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): 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.

### recommended operating conditions (see Note 4)

		SN54LVTH16652		SN74LVTH16652		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
$\Delta t/\Delta v$	Input transition rise or fall rate	Outputs enabled			10	ns/V
$\Delta t/\Delta V_{CC}$	Power-up ramp rate	200		200		$\mu$ s/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.

# SN54LVTH16652, SN74LVTH16652 3.3-V ABT 16-BIT BUS TRANSCEIVERS AND REGISTERS WITH 3-STATE OUTPUTS

SCBS150K – JULY 1994 – REVISED APRIL 1999

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

PARAMETER		TEST CONDITIONS	SN54LVTH16652		SN74LVTH16652		UNIT
			MIN	TYP†	MAX	MIN	
$V_{IK}$		$V_{CC} = 2.7\text{ V}$ , $I_I = -18\text{ mA}$	-1.2		-1.2		V
$V_{OH}$		$V_{CC} = 2.7\text{ V to }3.6\text{ V}$ , $I_{OH} = -100\text{ }\mu\text{A}$	$V_{CC}-0.2$		$V_{CC}-0.2$		V
		$V_{CC} = 2.7\text{ V}$ , $I_{OH} = -8\text{ mA}$	2.4		2.4		
		$V_{CC} = 3\text{ V}$	2		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		
			$I_{OL} = 48\text{ mA}$		0.55		
			$I_{OL} = 64\text{ mA}$		0.55		
$I_I$		Control inputs $V_{CC} = 0\text{ or }3.6\text{ V}$ , $V_I = 5.5\text{ V}$	10		10		$\mu\text{A}$
			$\pm 1$		$\pm 1$		
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		
$I_{off}$		$V_{CC} = 0$ , $V_I\text{ or }V_O = 0\text{ to }4.5\text{ V}$			$\pm 100$		
$I_I(\text{hold})$		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		
		$V_{CC} = 3.6\text{ V}\S$ , $V_I = 0\text{ to }3.6\text{ V}$			$\pm 500$		
$I_{OZPU}$		$V_{CC} = 0\text{ to }1.5\text{ V}$ , $V_O = 0.5\text{ V to }3\text{ V}$ , 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	$\pm 100^*$		$\pm 100$		$\mu\text{A}$
$I_{CC}$		$V_{CC} = 3.6\text{ V}$ , $I_O = 0$ , $V_I = V_{CC}\text{ or GND}$	Outputs high		0.19		mA
			Outputs low		5		
			Outputs disabled		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 $V_{CC}\text{ or GND}$	0.2		0.2		mA
$C_i$		$V_I = 3\text{ V or }0$	4		4		pF
$C_{io}$		$V_O = 3\text{ V or }0$	10		10		pF

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

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

‡ Unused pins at  $V_{CC}\text{ or GND}$

§ 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  $V_{CC}\text{ or GND}$ .

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.



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# SN54LVTH16652, SN74LVTH16652

## 3.3-V ABT 16-BIT BUS TRANSCEIVERS AND REGISTERS

### WITH 3-STATE OUTPUTS

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

		SN54LVTH16652				SN74LVTH16652				UNIT
		$V_{CC} = 3.3 V \pm 0.3 V$		$V_{CC} = 2.7 V$		$V_{CC} = 3.3 V \pm 0.3 V$		$V_{CC} = 2.7 V$		
		MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
$f_{clock}$	Clock frequency	150		150		150		150		MHz
$t_w$	Pulse duration, CLK high or low	3.3		3.3		3.3		3.3		ns
$t_{su}$	Setup time, A or B before CLKAB $\uparrow$ or CLKBA $\uparrow$	Data high	1.2	1.5	1.2	1.5			ns	
		Data low	2	2.8	2	2.8				
$t_h$	Hold time, A or B after CLKAB $\uparrow$ or CLKBA $\uparrow$	Data high	0.5	0	0.5	0			ns	
		Data low	0.5	0.5	0.5	0.5				

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

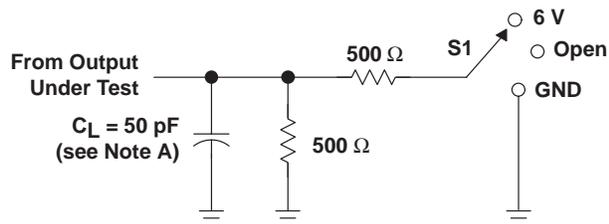
PARAMETER	FROM (INPUT)	TO (OUTPUT)	SN54LVTH16652				SN74LVTH16652				UNIT	
			$V_{CC} = 3.3 V \pm 0.3 V$		$V_{CC} = 2.7 V$		$V_{CC} = 3.3 V \pm 0.3 V$			$V_{CC} = 2.7 V$		
			MIN	MAX	MIN	MAX	MIN	TYP $\dagger$	MAX	MIN		MAX
$f_{max}$			150		150		150			150		MHz
$t_{PLH}$	CLK	B or A	1.3	4.5	5		1.3	2.7	4.2	4.7		ns
$t_{PHL}$			1.3	4.5	5		1.3	2.8	4.2	4.7		
$t_{PLH}$	A or B	B or A	1	3.6	4.1		1	2.4	3.4	3.9		ns
$t_{PHL}$			1	3.6	4.1		1	2.1	3.4	3.9		
$t_{PLH}$	SAB or SBA	B or A	1	4.7	5.6		1	2.7	4.5	5.4		ns
$t_{PHL}$			1	4.7	5.6		1	3	4.5	5.4		
$t_{PZH}$	$\overline{OEBA}$	A	1	4.5	5.4		1	2.4	4.3	5.2		ns
$t_{PZL}$			1	4.5	5.4		1	2.3	4.3	5.2		
$t_{PHZ}$	$\overline{OEBA}$	A	2	5.8	6.3		2	3.9	5.6	6.1		ns
$t_{PLZ}$			2	5.6	6.3		2	3.4	5.4	6.1		
$t_{PZH}$	OEAB	B	1.3	4.4	5.1		1.3	2.7	4.2	4.9		ns
$t_{PZL}$			1.3	4.4	5.1		1.3	2.6	4.2	4.9		
$t_{PHZ}$	OEAB	B	1.6	5.8	6.5		1.3	3.5	5.5	6.2		ns
$t_{PLZ}$			1.6	5.8	6.5		1.3	3.2	5.5	6.2		

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

# SN54LVTH16652, SN74LVTH16652 3.3-V ABT 16-BIT BUS TRANSCEIVERS AND REGISTERS WITH 3-STATE OUTPUTS

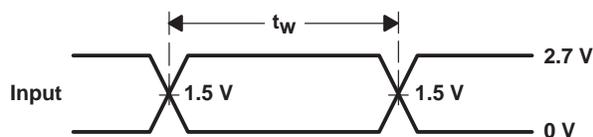
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## PARAMETER MEASUREMENT INFORMATION

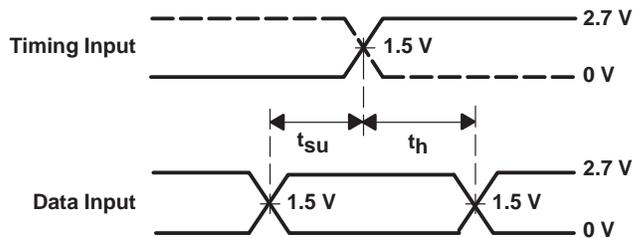


LOAD CIRCUIT

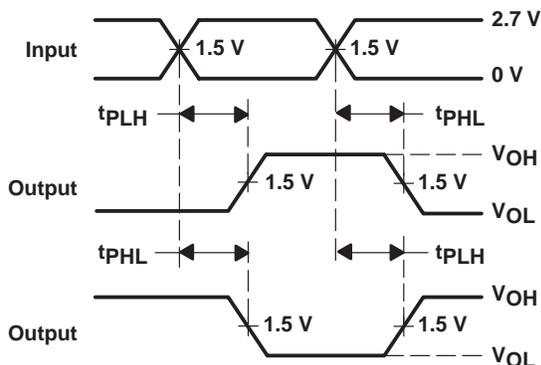
TEST	S1
$t_{PLH}/t_{PHL}$	Open
$t_{PLZ}/t_{PZL}$	6 V
$t_{PHZ}/t_{PZH}$	GND



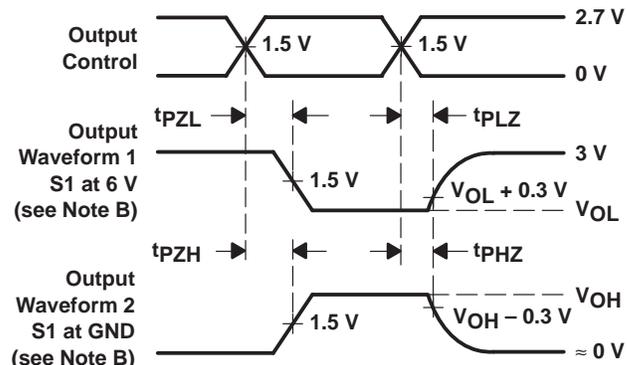
VOLTAGE WAVEFORMS  
PULSE DURATION



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 (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
SN74LVTH16652DGGR	ACTIVE	TSSOP	DGG	56	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	LVTH16652	<a href="#">Samples</a>
SN74LVTH16652DL	ACTIVE	SSOP	DL	56	20	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	LVTH16652	<a href="#">Samples</a>

(1) 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.

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

(2) 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)

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

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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**OTHER QUALIFIED VERSIONS OF SN74LVTH16652 :**

- Enhanced Product: [SN74LVTH16652-EP](#)

**NOTE: Qualified Version Definitions:**

- Enhanced Product - Supports Defense, Aerospace and Medical Applications

## TAPE AND REEL INFORMATION



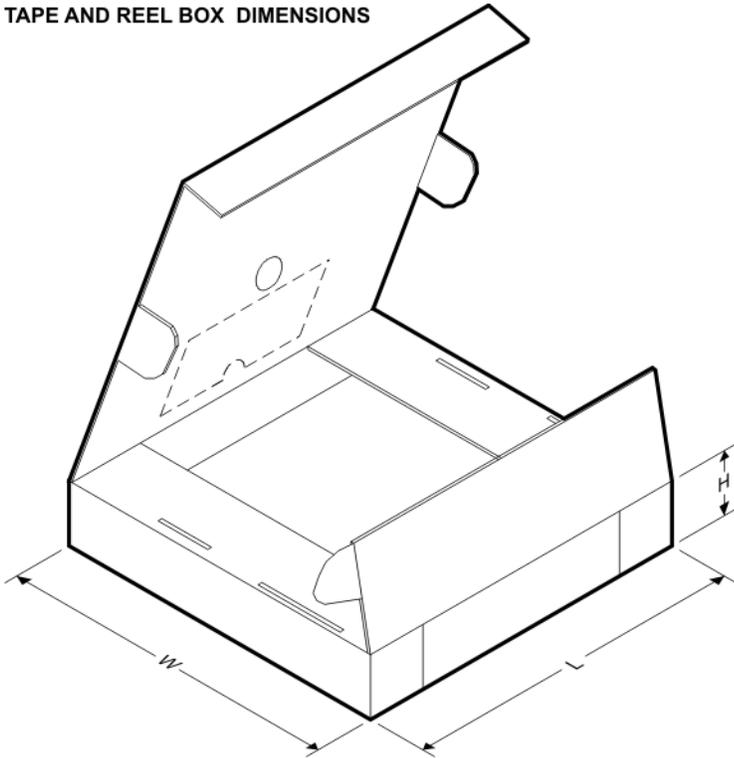
### QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



\*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
SN74LVTH16652DGGR	TSSOP	DGG	56	2000	330.0	24.4	8.6	15.6	1.8	12.0	24.0	Q1

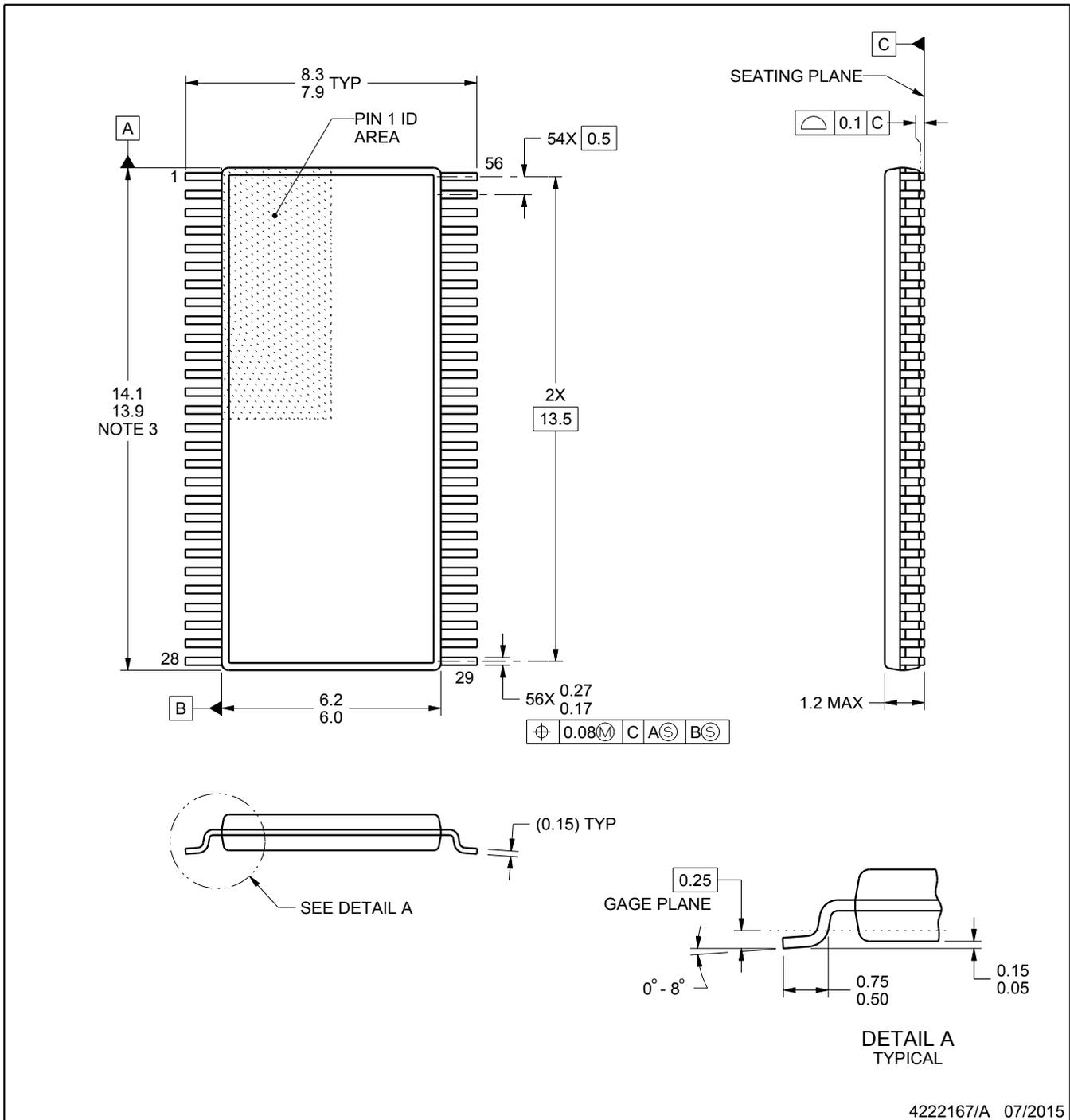
**TAPE AND REEL BOX DIMENSIONS**



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN74LVTH16652DGGR	TSSOP	DGG	56	2000	367.0	367.0	45.0





4222167/A 07/2015

NOTES:

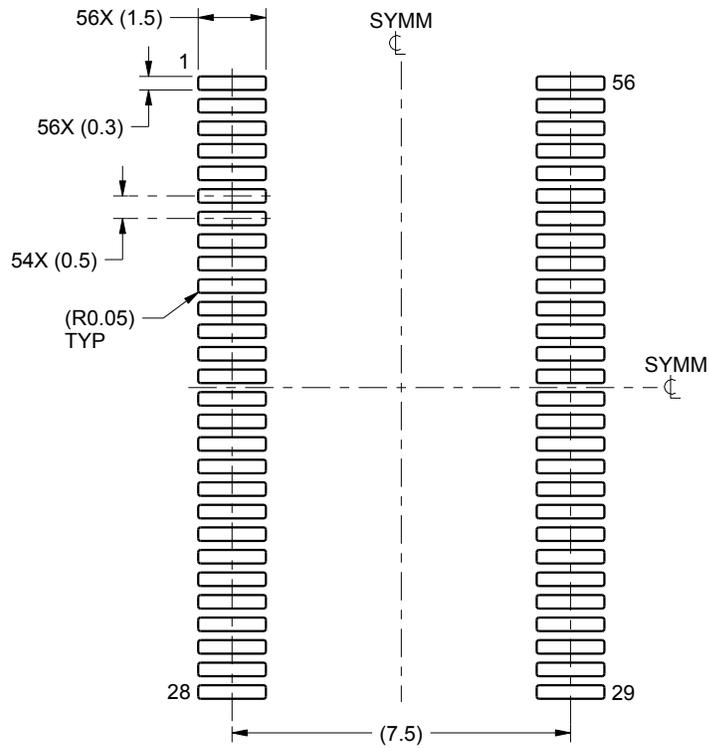
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. Reference JEDEC registration MO-153.

# EXAMPLE BOARD LAYOUT

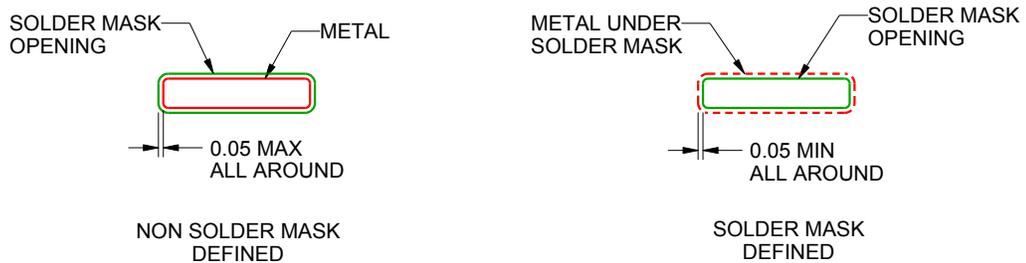
DGG0056A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE  
SCALE:6X



SOLDER MASK DETAILS

4222167/A 07/2015

NOTES: (continued)

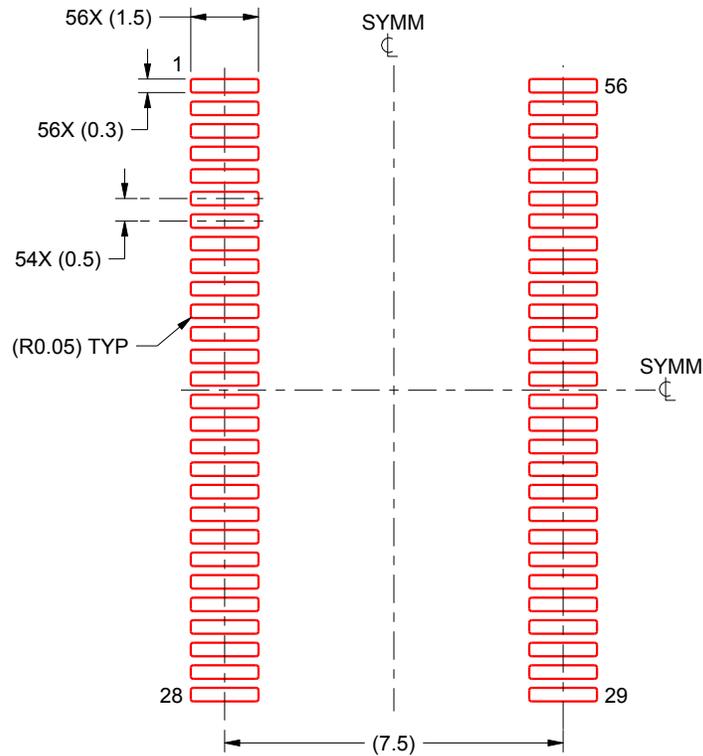
5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

DGG0056A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE:6X

4222167/A 07/2015

NOTES: (continued)

7. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
8. Board assembly site may have different recommendations for stencil design.

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