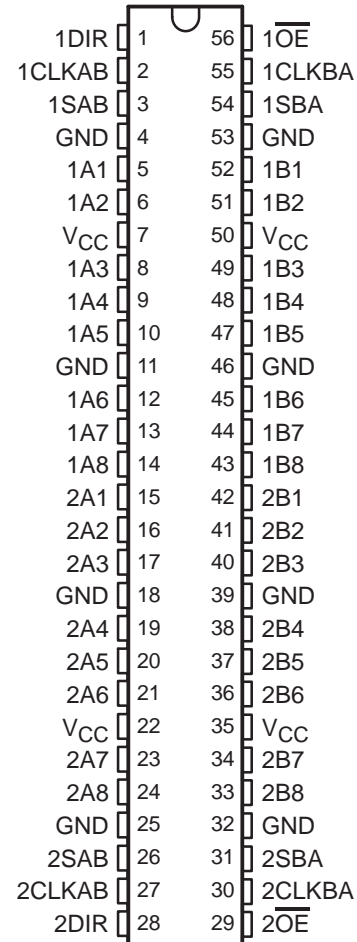


# SN54ABT16646, SN74ABT16646 16-BIT BUS TRANSCEIVERS AND REGISTERS WITH 3-STATE OUTPUTS

SCBS212D – JUNE 1992 – REVISED JULY 1999

- **Members of the Texas Instruments Widebus™ Family**
- **State-of-the-Art EPIC-IIB™ BiCMOS Design Significantly Reduces Power Dissipation**
- **Latch-Up Performance Exceeds 500 mA Per JESD 17**
- **Typical  $V_{OLP}$  (Output Ground Bounce) < 1 V at  $V_{CC} = 5 V$ ,  $T_A = 25^\circ C$**
- **Distributed  $V_{CC}$  and GND Pin Configuration Minimizes High-Speed Switching Noise**
- **Flow-Through Architecture Optimizes PCB Layout**
- **High-Drive Outputs ( $-32\text{-mA } I_{OH}$ ,  $64\text{-mA } I_{OL}$ )**
- **Package Options Include Plastic Shrink Small-Outline (DL), Thin Shrink Small-Outline (DGG) Packages and 380-mil Fine-Pitch Ceramic Flat (WD) Package Using 25-mil Center-to-Center Spacings**

SN54ABT16646 . . . WD PACKAGE  
SN74ABT16646 . . . DGG OR DL PACKAGE  
(TOP VIEW)



## description

The 'ABT16646 devices consist of bus-transceiver circuits, D-type flip-flops, and control circuitry arranged for multiplexed transmission of data directly from the input bus or from the internal registers.

These devices can be used as two 8-bit transceivers or one 16-bit transceiver. Data on the A or B bus is clocked into the registers on the low-to-high transition of the appropriate clock (CLKAB or CLKBA) input. Figure 1 illustrates the four fundamental bus-management functions that can be performed with the 'ABT16646 devices.

Output-enable ( $\overline{OE}$ ) and direction-control (DIR) inputs are provided to control the transceiver functions. In the transceiver mode, data present at the high-impedance port may be stored in either register or in both. The select-control (SAB and SBA) inputs can multiplex stored and real-time (transparent mode) 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. The direction control (DIR) determines which bus receives data when  $\overline{OE}$  is low. In the isolation mode ( $\overline{OE}$  high), A data can be stored in one register and/or B data can be stored in the other register.

When an output function is disabled, the input function is still enabled and can be used to store and transmit data. Only one of the two buses, A or B, can be driven at a time.

To ensure the high-impedance state during power up or power down,  $\overline{OE}$  should be tied to  $V_{CC}$  through a pullup resistor; the minimum value of the resistor is determined by the current-sinking capability of the driver.



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PRODUCTION DATA information is 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**

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On products compliant to MIL-PRF-38535, all parameters are tested unless otherwise noted. On all other products, production processing does not necessarily include testing of all parameters.

**SN54ABT16646, SN74ABT16646**  
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**description (continued)**

The SN54ABT16646 is characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ .  
 The SN74ABT16646 is characterized for operation from  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ .

**FUNCTION TABLE**

INPUTS						DATA I/O†		OPERATION OR FUNCTION
$\overline{\text{OE}}$	DIR	CLKAB	CLKBA	SAB	SBA	A1–A8	B1–B8	
X	X	↑	X	X	X	Input	Unspecified	Store A, B unspecified†
X	X	X	↑	X	X	Unspecified	Input	Store B, A unspecified†
H	X	↑	↑	X	X	Input	Input	Store A and B data
H	X	H or L	H or L	X	X	Input disabled	Input disabled	Isolation, hold storage
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
L	H	X	X	L	X	Input	Output	Real-time A data to B Bus
L	H	H or L	X	H	X	Input	Output	Stored A data to bus

† The data-output functions can be enabled or disabled by various signals at  $\overline{\text{OE}}$  or DIR. 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.



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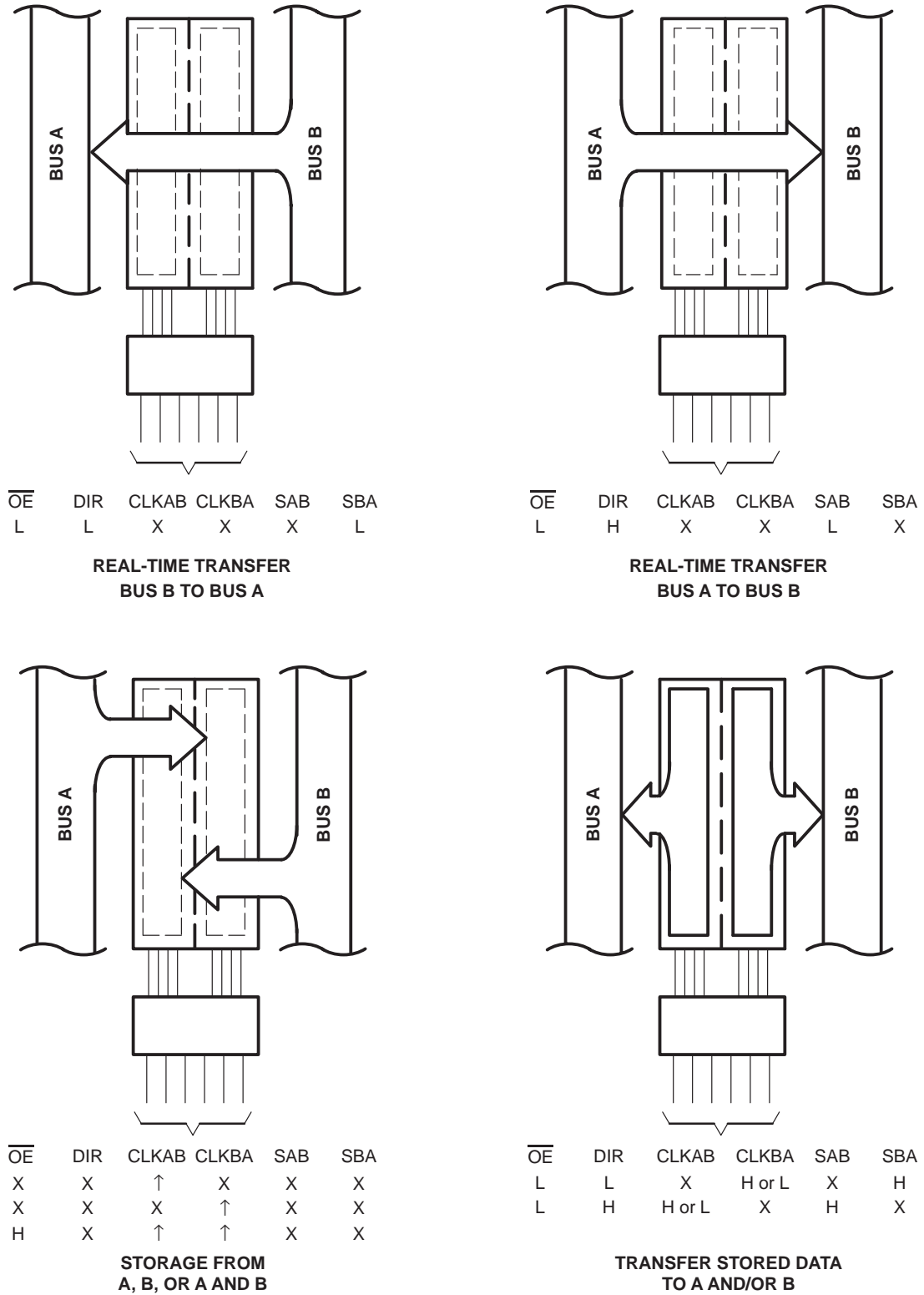
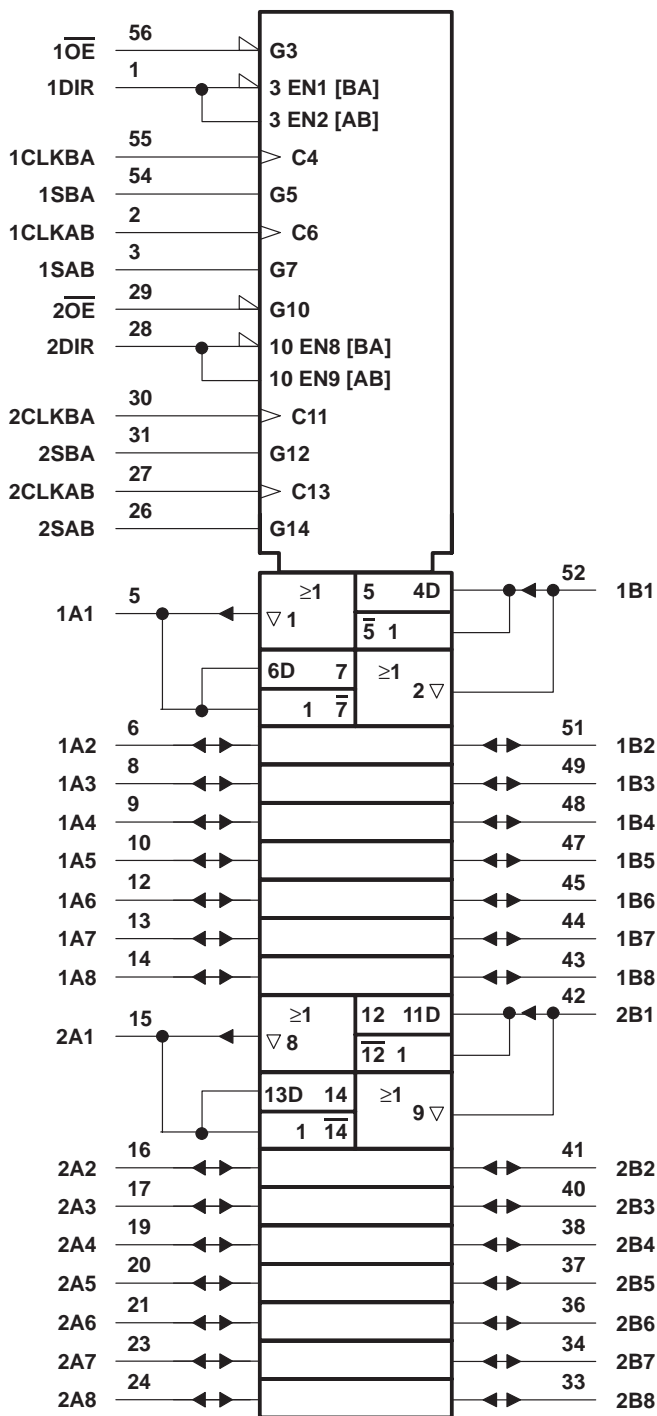


Figure 1. Bus-Management Functions

# SN54ABT16646, SN74ABT16646 16-BIT BUS TRANSCEIVERS AND REGISTERS WITH 3-STATE OUTPUTS

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## logic symbol†

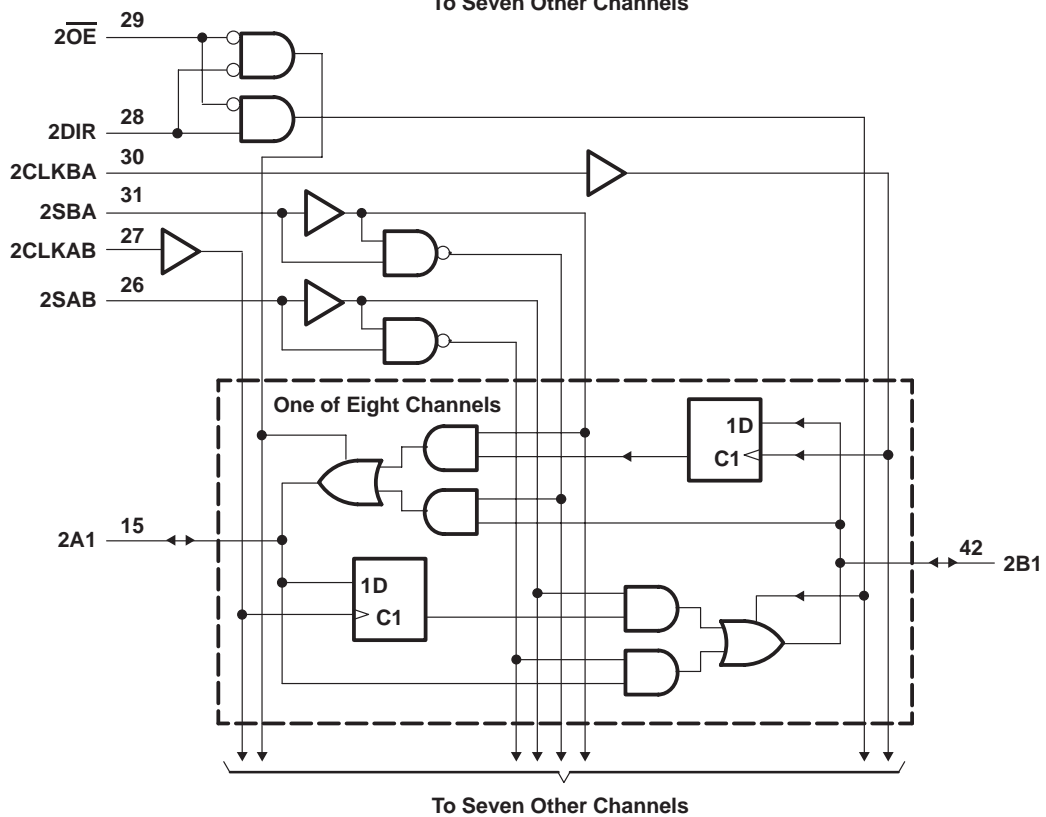
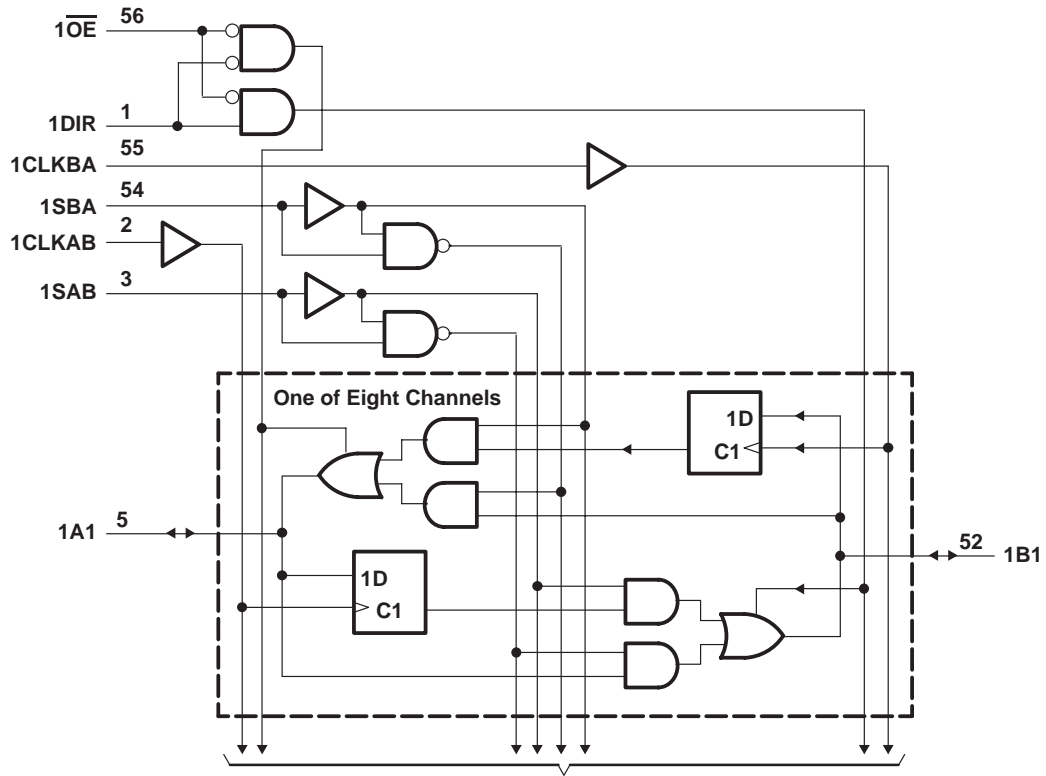


† This symbol is in accordance with ANSI/IEEE Std 91-1984 and IEC Publication 617-12.

SN54ABT16646, SN74ABT16646  
 16-BIT BUS TRANSCEIVERS AND REGISTERS  
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logic diagram (positive logic)



# SN54ABT16646, SN74ABT16646

## 16-BIT BUS TRANSCEIVERS AND REGISTERS

### WITH 3-STATE OUTPUTS

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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 7 V
Input voltage range, $V_I$ (except I/O ports) (see Note 1) .....	-0.5 V to 7 V
Voltage range applied to any output in the high or power-off state, $V_O$ .....	-0.5 V to 5.5 V
Current into any output in the low state, $I_O$ : SN54ABT16646 .....	96 mA
SN74ABT16646 .....	128 mA
Input clamp current, $I_{IK}$ ( $V_I < 0$ ) .....	-18 mA
Output clamp current, $I_{OK}$ ( $V_O < 0$ ) .....	-50 mA
Package thermal impedance, $\theta_{JA}$ (see Note 2): 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. The package thermal impedance is calculated in accordance with JESD 51.

#### recommended operating conditions (see Note 3)

		SN54ABT16646		SN74ABT16646		UNIT
		MIN	MAX	MIN	MAX	
$V_{CC}$	Supply voltage	4.5	5.5	4.5	5.5	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	0	$V_{CC}$	0	$V_{CC}$	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	10	ns/V
$T_A$	Operating free-air temperature	-55	125	-40	85	°C

NOTE 3: All unused 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.



# SN54ABT16646, SN74ABT16646 16-BIT BUS TRANSCEIVERS AND REGISTERS WITH 3-STATE OUTPUTS

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

PARAMETER	TEST CONDITIONS	T <sub>A</sub> = 25°C			SN54ABT16646		SN74ABT16646		UNIT	
		MIN	TYP†	MAX	MIN	MAX	MIN	MAX		
V <sub>IK</sub>	V <sub>CC</sub> = 4.5 V, I <sub>I</sub> = -18 mA			-1.2		-1.2		-1.2	V	
V <sub>OH</sub>	V <sub>CC</sub> = 4.5 V, I <sub>OH</sub> = -3 mA			2.5		2.5		2.5	V	
	V <sub>CC</sub> = 5 V, I <sub>OH</sub> = -3 mA			3		3		3		
	V <sub>CC</sub> = 4.5 V, I <sub>OH</sub> = -24 mA			2		2				
V <sub>OL</sub>	V <sub>CC</sub> = 4.5 V, I <sub>OL</sub> = 48 mA					0.55			V	
		I <sub>OL</sub> = 64 mA				0.55*		0.55		
V <sub>hys</sub>				100					mV	
I <sub>I</sub>	Control inputs A or B ports	V <sub>CC</sub> = 5.5 V, V <sub>I</sub> = V <sub>CC</sub> or GND			±1		±1		±1	μA
					±20		±20		±20	
I <sub>OZH</sub> ‡	V <sub>CC</sub> = 5.5 V, V <sub>O</sub> = 2.7 V			10		10		10	μA	
I <sub>OZL</sub> ‡	V <sub>CC</sub> = 5.5 V, V <sub>O</sub> = 0.5 V			-10		-10		-10	μA	
I <sub>off</sub>	V <sub>CC</sub> = 0, V <sub>I</sub> or V <sub>O</sub> ≤ 4.5 V			±100				±100	μA	
I <sub>CEX</sub>	V <sub>CC</sub> = 5.5 V, V <sub>O</sub> = 5.5 V	Outputs high		50		50		50	μA	
I <sub>O</sub> §	V <sub>CC</sub> = 5.5 V, V <sub>O</sub> = 2.5 V			-50	-100	-180		-50	-180	mA
I <sub>CC</sub>	A or B ports	V <sub>CC</sub> = 5.5 V, I <sub>O</sub> = 0, V <sub>I</sub> = V <sub>CC</sub> or GND	Outputs high		2		2		2	mA
			Outputs low		32		32		32	
			Outputs disabled		2		2		2	
ΔI <sub>CC</sub> ¶	Data inputs	V <sub>CC</sub> = 5.5 V, One input at 3.4 V, Other inputs at V <sub>CC</sub> or GND	Outputs enabled		50		50		50	μA
			Outputs disabled		50		50		50	
	Control inputs	V <sub>CC</sub> = 5.5 V, One input at 3.4 V, Other inputs at V <sub>CC</sub> or GND			50		50		50	
C <sub>i</sub>	Control inputs	V <sub>I</sub> = 2.5 V or 0.5 V			4				pF	
C <sub>io</sub>	A or B ports	V <sub>O</sub> = 2.5 V or 0.5 V			8				pF	

\* On products compliant to MIL-PRF-38535, this parameter does not apply.

† All typical values are at V<sub>CC</sub> = 5 V.

‡ The parameters I<sub>OZH</sub> and I<sub>OZL</sub> include the input leakage current.

§ Not more than one output should be tested at a time, and the duration of the test should not exceed one second.

¶ This is the increase in supply current for each input that is at the specified TTL voltage level rather than V<sub>CC</sub> or GND.

**SN54ABT16646, SN74ABT16646**  
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**timing requirements over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Figure 2)**

		SN54ABT16646				UNIT
		V <sub>CC</sub> = 5 V, T <sub>A</sub> = 25°C		MIN	MAX	
		MIN	MAX			
f <sub>clock</sub>	Clock frequency	125		125	MHz	
t <sub>w</sub>	Pulse duration, CLK high or low	4.3		4.3	ns	
t <sub>su</sub>	Setup time, A or B before CLKAB↑ or CLKBA↑	3.5		4	ns	
t <sub>h</sub>	Hold time, A or B after CLKAB↑ or CLKBA↑	0.5		0.5	ns	

**timing requirements over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see Figure 2)**

		SN74ABT16646				UNIT
		V <sub>CC</sub> = 5 V, T <sub>A</sub> = 25°C		MIN	MAX	
		MIN	MAX			
f <sub>clock</sub>	Clock frequency	125		125	MHz	
t <sub>w</sub>	Pulse duration, CLK high or low	4.3		4.3	ns	
t <sub>su</sub>	Setup time, A or B before CLKAB↑ or CLKBA↑	3		3	ns	
t <sub>h</sub>	Hold time, A or B after CLKAB↑ or CLKBA↑	0		0	ns	





**SN54ABT16646, SN74ABT16646**  
**16-BIT BUS TRANSCEIVERS AND REGISTERS**  
**WITH 3-STATE OUTPUTS**

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switching characteristics over recommended ranges of supply voltage and operating free-air temperature,  $C_L = 50$  pF (unless otherwise noted) (see Figure 2)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	SN54ABT16646					UNIT
			$V_{CC} = 5$ V, $T_A = 25^\circ\text{C}$			MIN	MAX	
			MIN	TYP	MAX			
$f_{max}$			125			125	MHz	
$t_{PLH}$	CLKBA or CLKAB	A or B	1.5	3.1	4	1	5	ns
$t_{PHL}$			1.5	3.2	4.1	1	5	
$t_{PLH}$	A or B	B or A	1	2.3	3.2	0.6	4	ns
$t_{PHL}$			1	3	4.1	0.6	4.9	
$t_{PLH}$	SAB or SBA†	B or A	1	2.9	4.3	0.6	5.3	ns
$t_{PHL}$			1	3.1	4.3	0.6	5.3	
$t_{PZH}$	$\overline{OE}$	A or B	1	3.4	4.6	0.6	5.9	ns
$t_{PZL}$			1.5	3.5	5.3	1	6	
$t_{PHZ}$	$\overline{OE}$	A or B	1.5	3.9	5.6	1	6.4	ns
$t_{PLZ}$			1.5	3.1	4.4	1	4.7	
$t_{PZH}$	DIR	A or B	1	3.2	4.5	0.6	5.8	ns
$t_{PZL}$			1.5	3.4	5.1	1	6.7	
$t_{PHZ}$	DIR	A or B	2	4.2	5.9	1.2	7.1	ns
$t_{PLZ}$			1.5	3.6	5.1	1	6.2	

† These parameters are measured with the internal output state of the storage register opposite that of the bus input.

switching characteristics over recommended ranges of supply voltage and operating free-air temperature,  $C_L = 50$  pF (unless otherwise noted) (see Figure 2)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	SN74ABT16646					UNIT
			$V_{CC} = 5$ V, $T_A = 25^\circ\text{C}$			MIN	MAX	
			MIN	TYP	MAX			
$f_{max}$			125			125	MHz	
$t_{PLH}$	CLKBA or CLKAB	A or B	1.5	3.1	4	1.5	4.9	ns
$t_{PHL}$			1.5	3.2	4.1	1.5	4.7	
$t_{PLH}$	A or B	B or A	1	2.3	3.2	1	3.9	ns
$t_{PHL}$			1	3	4.1	1	4.6	
$t_{PLH}$	SAB or SBA†	B or A	1	2.9	4.3	1	5	ns
$t_{PHL}$			1	3.1	4.3	1	5	
$t_{PZH}$	$\overline{OE}$	A or B	1	3.4	4.6	1	5.5	ns
$t_{PZL}$			1.5	3.5	4.9	1.5	5.7	
$t_{PHZ}$	$\overline{OE}$	A or B	1.5	3.9	4.9	1.5	5.4	ns
$t_{PLZ}$			1.5	3.1	4.1	1.5	4.5	
$t_{PZH}$	DIR	A or B	1	3.2	4.5	1	5.4	ns
$t_{PZL}$			1.5	3.4	4.8	1.5	5.6	
$t_{PHZ}$	DIR	A or B	2	4.2	5.7	2	6.7	ns
$t_{PLZ}$			1.5	3.6	5.1	1.5	5.9	

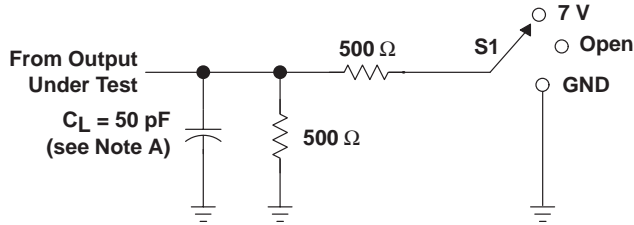
† These parameters are measured with the internal output state of the storage register opposite that of the bus input.



# SN54ABT16646, SN74ABT16646 16-BIT BUS TRANSCEIVERS AND REGISTERS WITH 3-STATE OUTPUTS

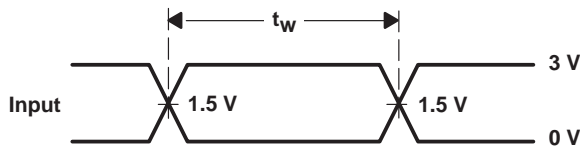
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## PARAMETER MEASUREMENT INFORMATION

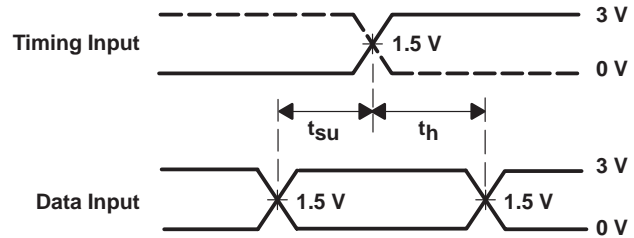


LOAD CIRCUIT

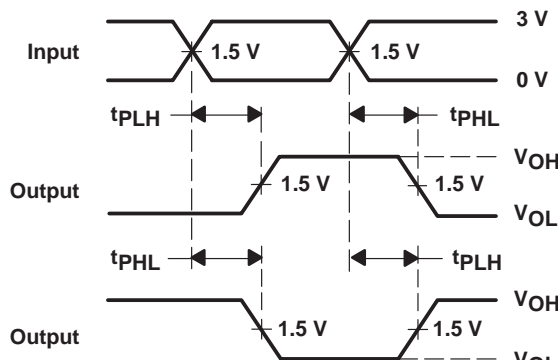
TEST	S1
$t_{PLH}/t_{PHL}$	Open
$t_{PLZ}/t_{PZL}$	7 V
$t_{PHZ}/t_{PZH}$	Open



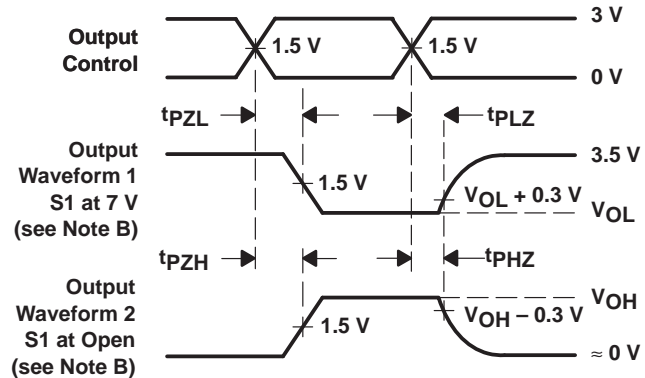
VOLTAGE WAVEFORMS  
PULSE DURATION



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:
- $C_L$  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:  $PRR \leq 10 \text{ MHz}$ ,  $Z_O = 50 \Omega$ ,  $t_r \leq 2.5 \text{ ns}$ ,  $t_f \leq 2.5 \text{ ns}$ .
  - 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 finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
SN74ABT16646DGGR	ACTIVE	TSSOP	DGG	56	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	ABT16646	<a href="#">Samples</a>
SN74ABT16646DL	ACTIVE	SSOP	DL	56	20	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	ABT16646	<a href="#">Samples</a>
SN74ABT16646DLR	ACTIVE	SSOP	DL	56	1000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	ABT16646	<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) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(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.

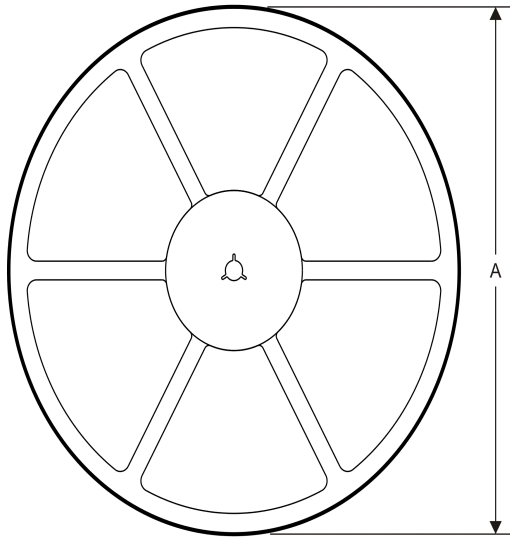
(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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**TAPE AND REEL INFORMATION**

**REEL DIMENSIONS**



**TAPE DIMENSIONS**



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

**TAPE AND REEL INFORMATION**

\*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
SN74ABT16646DGGR	TSSOP	DGG	56	2000	330.0	24.4	8.6	15.6	1.8	12.0	24.0	Q1
SN74ABT16646DLR	SSOP	DL	56	1000	330.0	32.4	11.35	18.67	3.1	16.0	32.0	Q1

**TAPE AND REEL BOX DIMENSIONS**



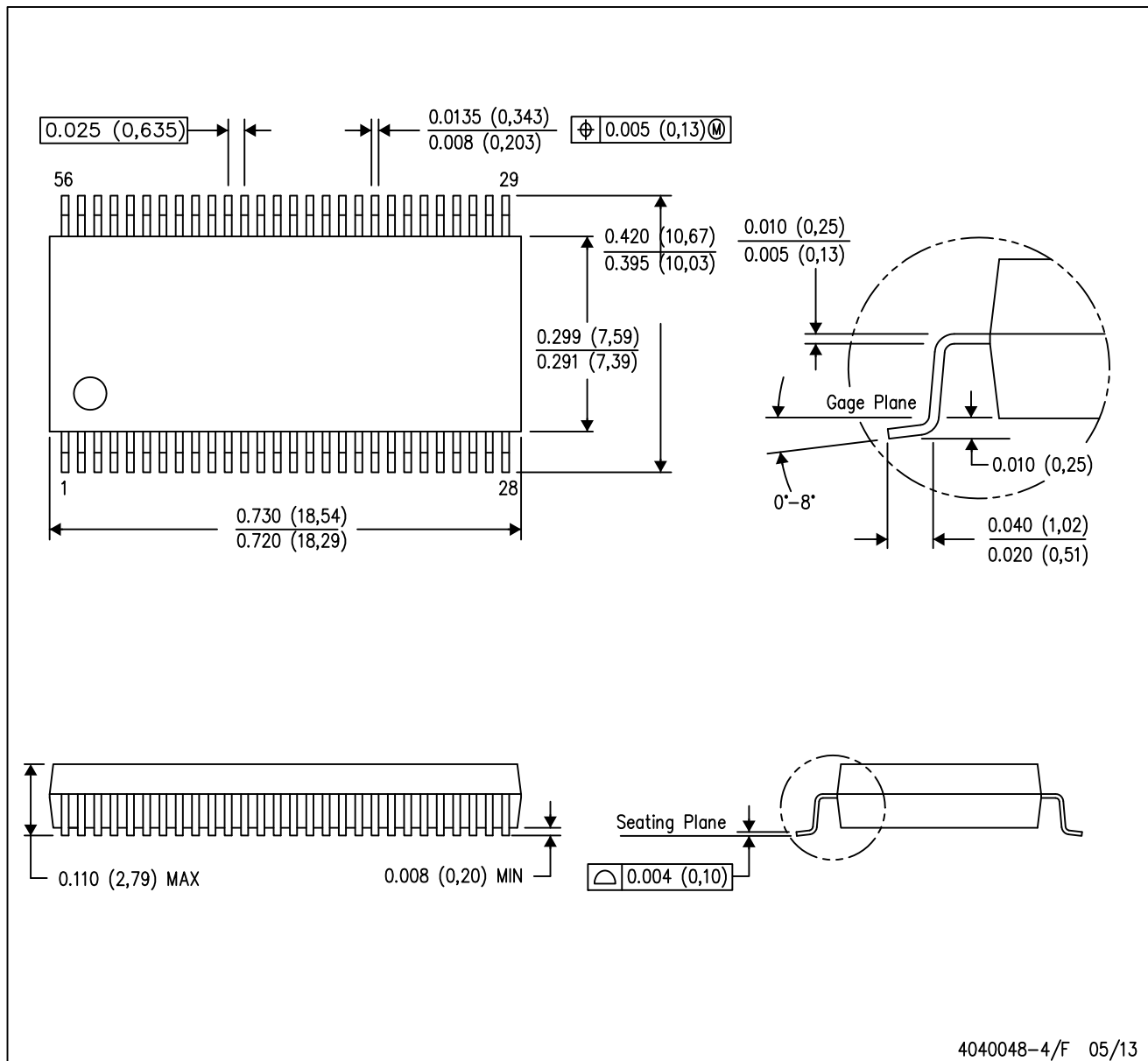
\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN74ABT16646DGGR	TSSOP	DGG	56	2000	367.0	367.0	45.0
SN74ABT16646DLR	SSOP	DL	56	1000	367.0	367.0	55.0

# MECHANICAL DATA

DL (R-PDSO-G56)

PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- All linear dimensions are in inches (millimeters).
  - This drawing is subject to change without notice.
  - Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
  - Falls within JEDEC MO-118

PowerPAD is a trademark of Texas Instruments.

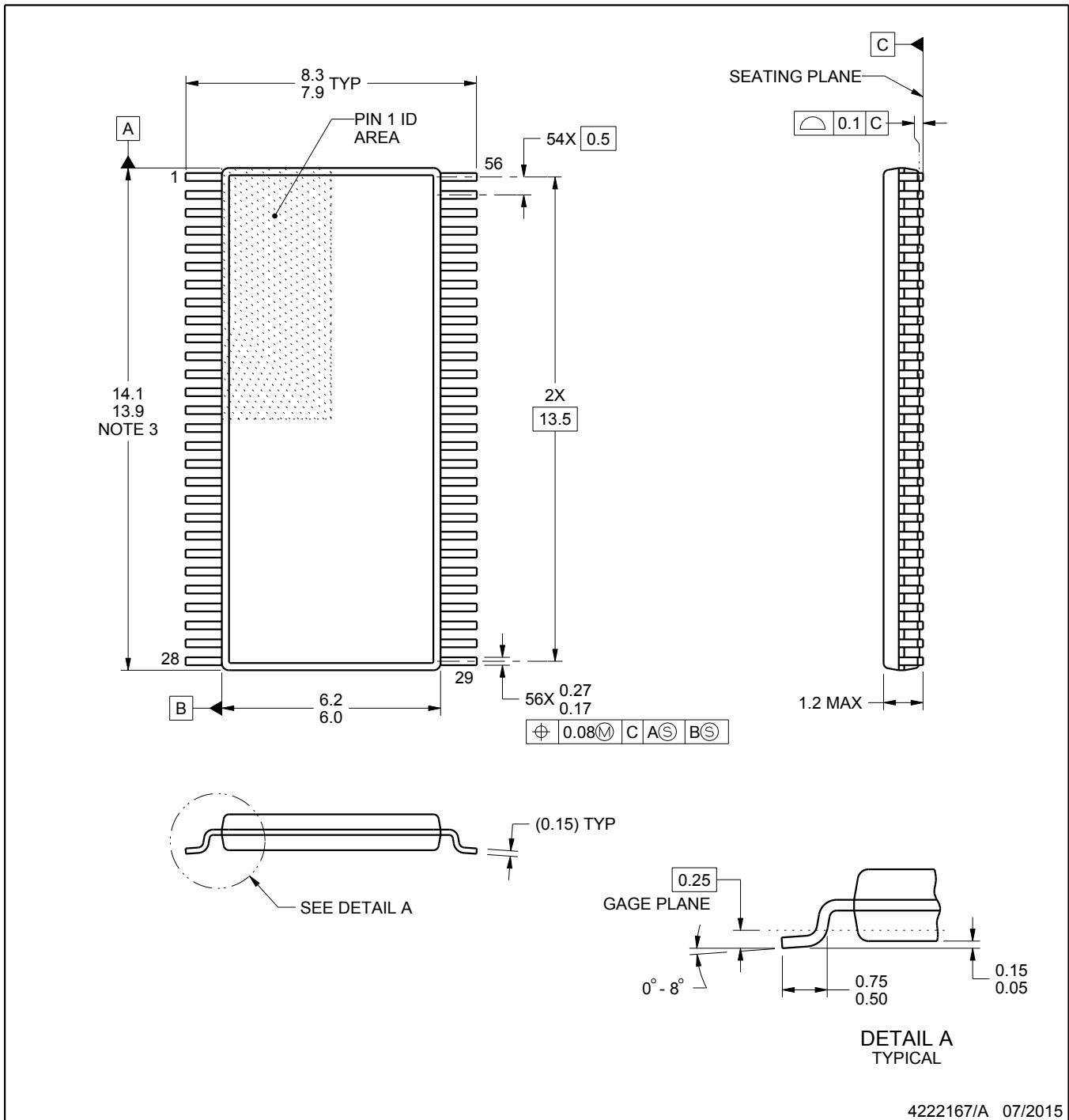
# DGG0056A



# PACKAGE OUTLINE

## TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



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### NOTES:

- All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
- This drawing is subject to change without notice.
- 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.
- Reference JEDEC registration MO-153.

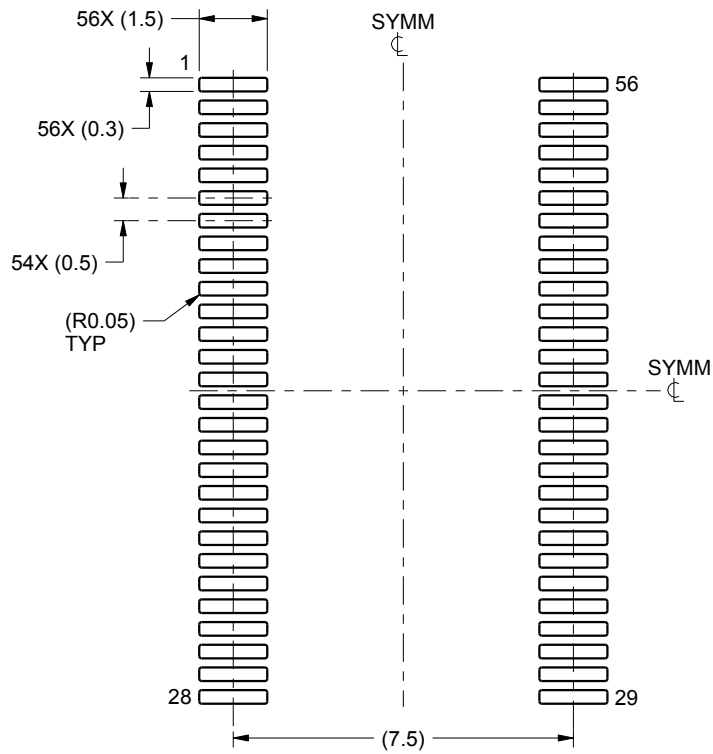


# EXAMPLE BOARD LAYOUT

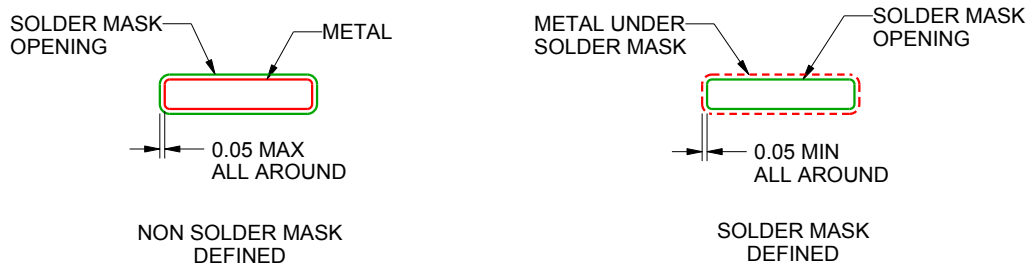
DGG0056A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE  
SCALE:6X



SOLDER MASK DETAILS

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NOTES: (continued)

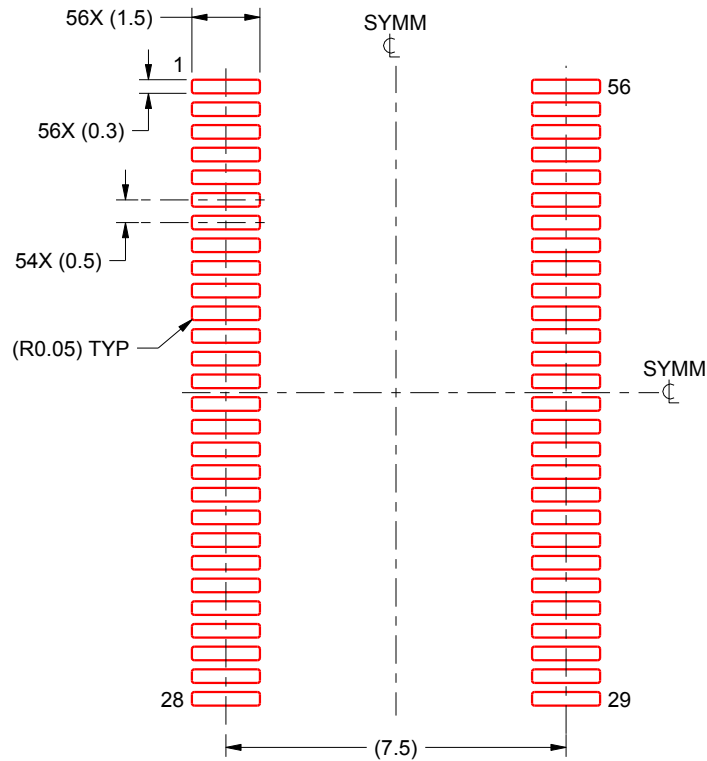
5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# 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

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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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