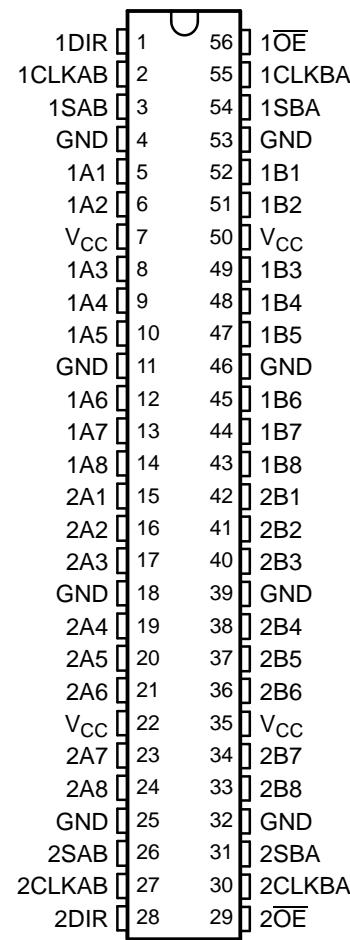


FEATURES

- Member of the Texas Instruments Widebus™ Family
- Operates From 1.65 V to 3.6 V
- Inputs Accept Voltages to 5.5 V
- In Transparent Mode, Max t_{pd} of 5.2 ns at 3.3 V
- Typical V_{OLP} (Output Ground Bounce) < 0.8 V at $V_{CC} = 3.3$ V, $T_A = 25^\circ\text{C}$
- Typical V_{OHV} (Output V_{OH} Undershoot) > 2 V at $V_{CC} = 3.3$ V, $T_A = 25^\circ\text{C}$
- Supports Mixed-Mode Signal Operation on All Ports (5-V Input/Output Voltage With 3.3-V V_{CC})
- I_{off} Supports Partial-Power-Down Mode Operation
- Latch-Up Performance Exceeds 250 mA Per JESD 17
- ESD Protection Exceeds JESD 22
 - 2000-V Human-Body Model (A114-A)
 - 1000-V Charged-Device Model (C101)

**DGG, DGV, OR DL PACKAGE
(TOP VIEW)**



DESCRIPTION/ORDERING INFORMATION

This 16-bit bus transceiver and register is designed for 1.65-V to 3.6-V V_{CC} operation.

The SN74LVC16646A can be used as two 8-bit transceivers or one 16-bit transceiver. The device consists 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.

ORDERING INFORMATION

T_A	PACKAGE ⁽¹⁾		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 85°C	SSOP – DL	Tube	SN74LVC16646ADL	LVC16646A
		Tape and reel	SN74LVC16646ADLR	
	TSSOP – DGG	Tape and reel	SN74LVC16646ADGGR	LVC16646A
	TVSOP – DGV	Tape and reel	SN74LVC16646ADGVR	LD646A

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



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 is a trademark of Texas Instruments.

DESCRIPTION/ORDERING INFORMATION (CONTINUED)

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 SN74LVC1664A.

Output-enable (\overline{OE}) and direction-control (DIR) inputs control the transceiver functions. In the transceiver mode, data present at the high-impedance port can 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. 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.

This device is fully specified for partial-power-down applications using I_{off} . The I_{off} circuitry disables the outputs, preventing damaging current backflow through the device when it is powered down.

When an output function is disabled, the input function still is 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.

Inputs can be driven from either 3.3-V or 5-V devices. This feature allows the use of these devices as translators in a mixed 3.3-V/5-V system environment.

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.

FUNCTION TABLE

INPUTS						DATA I/O ⁽¹⁾		OPERATION OR FUNCTION
\overline{OE}	DIR	CLKAB	CLKBA	SAB	SBA	A1-A8	B1-B8	
X	X	↑	X	X	X	Input	Unspecified	Store A, B unspecified ⁽¹⁾
X	X	X	↑	X	X	Unspecified	Input	Store B, A unspecified ⁽¹⁾
H	X	↑	↑	X	X	Input	Input	Store A and B data
H	X	H or L	H or L	X	X	Input	Input	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

(1) The data-output functions can be enabled or disabled by various signals at \overline{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.

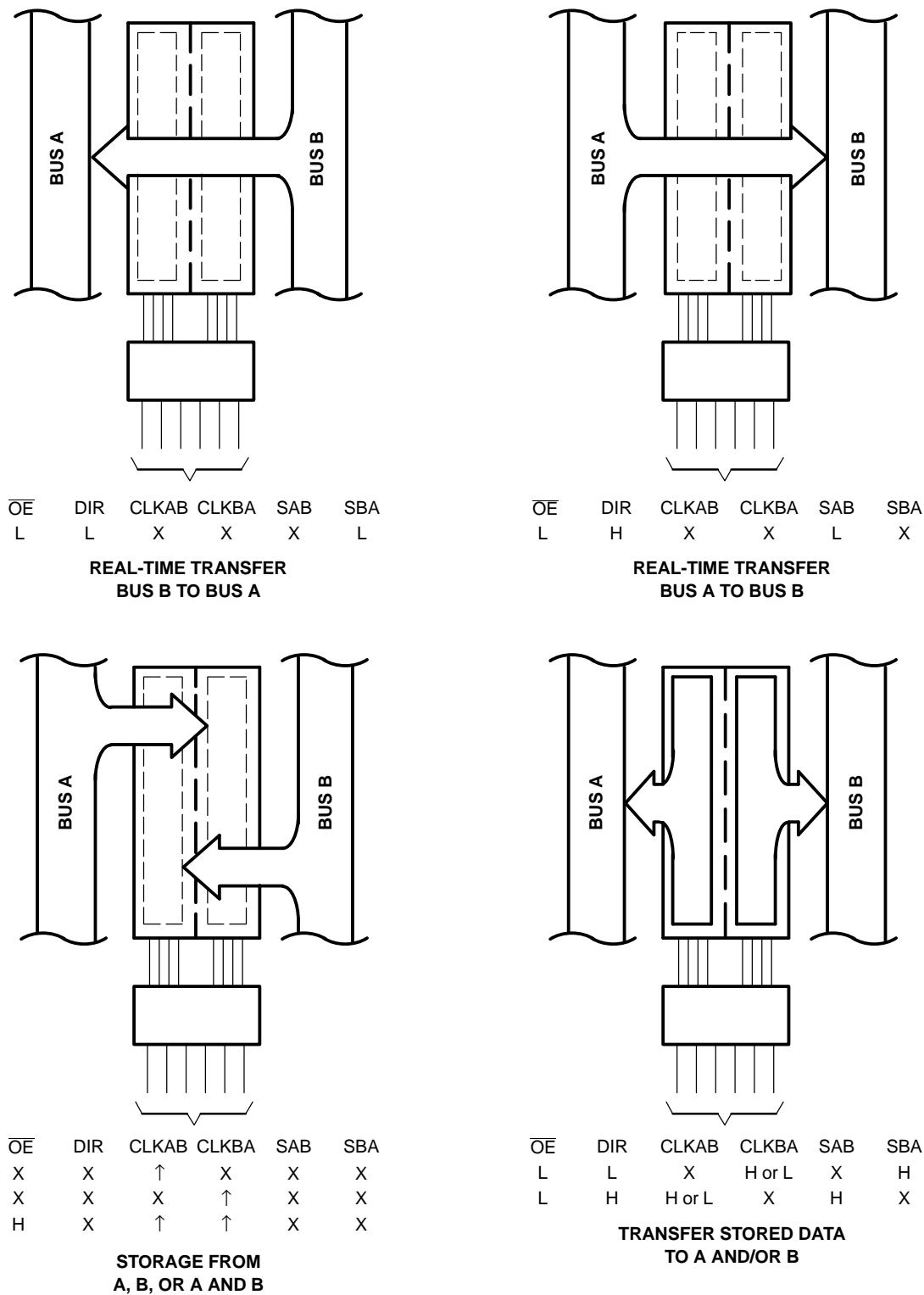


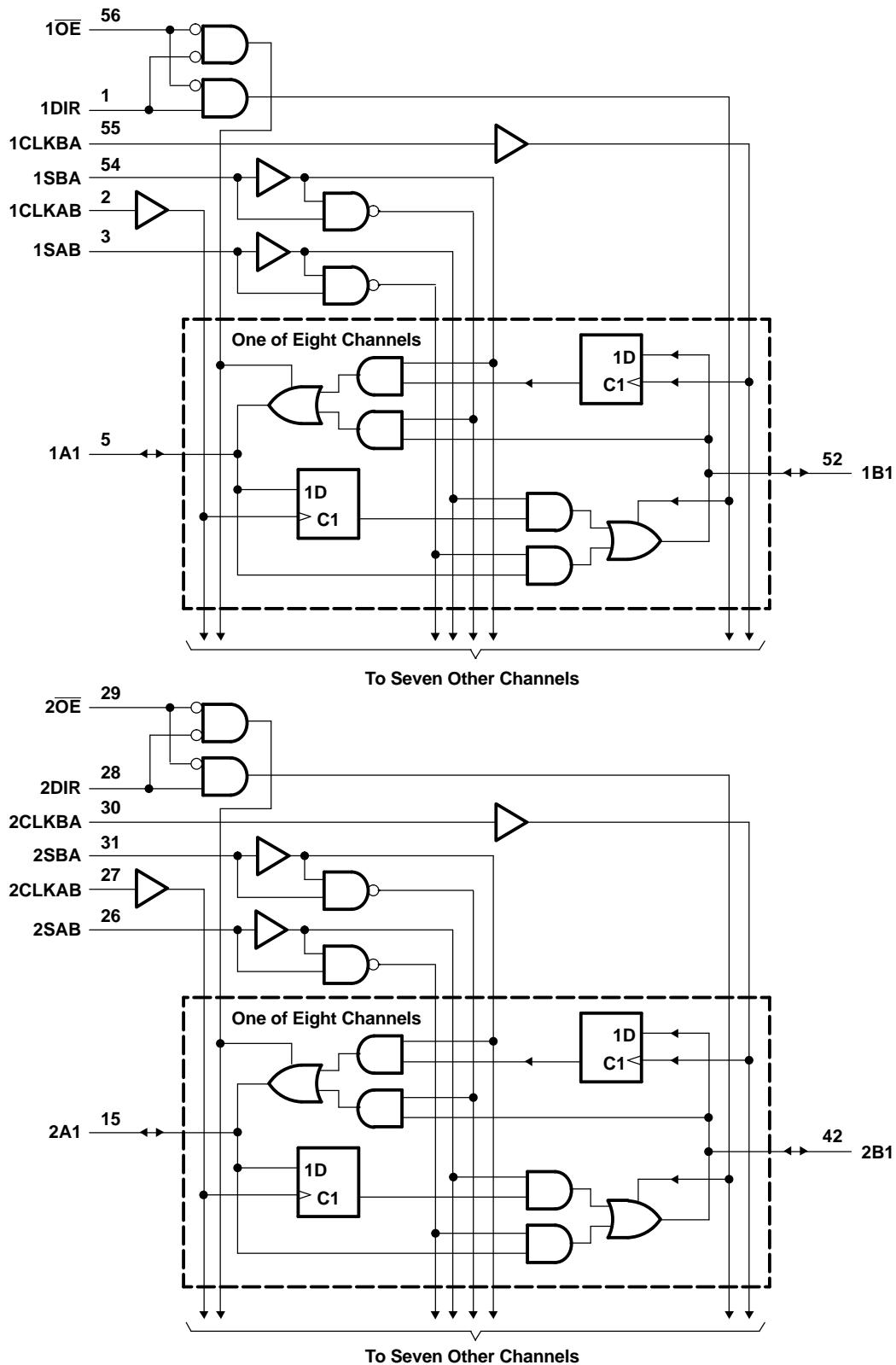
Figure 1. Bus-Management Functions

SN74LVC16646A
16-BIT BUS TRANSCEIVER AND REGISTER
WITH 3-STATE OUTPUTS

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LOGIC DIAGRAM (POSITIVE LOGIC)



Absolute Maximum Ratings⁽¹⁾

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

		MIN	MAX	UNIT
V_{CC}	Supply voltage range	-0.5	6.5	V
V_I	Input voltage range ⁽²⁾	-0.5	6.5	V
V_O	Voltage range applied to any output in the high-impedance or power-off state ⁽²⁾	-0.5	6.5	V
V_O	Voltage range applied to any output in the high or low state ⁽²⁾⁽³⁾	-0.5	$V_{CC} + 0.5$	V
I_{IK}	Input clamp current	$V_I < 0$	-50	mA
I_{OK}	Output clamp current	$V_O < 0$	-50	mA
I_O	Continuous output current		± 50	mA
	Continuous current through each V_{CC} or GND		± 100	mA
θ_{JA}	Package thermal impedance ⁽⁴⁾	DGG package	64	°C/W
		DGV package	48	
		DL package	56	
T_{stg}	Storage temperature range	-65	150	°C

- (1) 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.
- (2) The input negative-voltage and output voltage ratings may be exceeded if the input and output current ratings are observed.
- (3) The value of V_{CC} is provided in the recommended operating conditions table.
- (4) The package thermal impedance is calculated in accordance with JESD 51-7.

Recommended Operating Conditions⁽¹⁾

		MIN	MAX	UNIT
V_{CC}	Supply voltage	Operating	1.65	V
		Data retention only	1.5	
V_{IH}	High-level input voltage	$V_{CC} = 1.65 \text{ V to } 1.95 \text{ V}$	$0.65 \times V_{CC}$	V
		$V_{CC} = 2.3 \text{ V to } 2.7 \text{ V}$	1.7	
		$V_{CC} = 2.7 \text{ V to } 3.6 \text{ V}$	2	
V_{IL}	Low-level input voltage	$V_{CC} = 1.65 \text{ V to } 1.95 \text{ V}$	$0.35 \times V_{CC}$	V
		$V_{CC} = 2.3 \text{ V to } 2.7 \text{ V}$	0.7	
		$V_{CC} = 2.7 \text{ V to } 3.6 \text{ V}$	0.8	
V_I	Input voltage	0	5.5	V
V_O	Output voltage	High or low state	0	V
		3-state	0	
I_{OH}	High-level output current	$V_{CC} = 1.65 \text{ V}$	-4	mA
		$V_{CC} = 2.3 \text{ V}$	-8	
		$V_{CC} = 2.7 \text{ V}$	-12	
		$V_{CC} = 3 \text{ V}$	-24	
I_{OL}	Low-level output current	$V_{CC} = 1.65 \text{ V}$	4	mA
		$V_{CC} = 2.3 \text{ V}$	8	
		$V_{CC} = 2.7 \text{ V}$	12	
		$V_{CC} = 3 \text{ V}$	24	
$\Delta t/\Delta V$	Input transition rise or fall rate		10	ns/V
T_A	Operating free-air temperature	-40	85	°C

- (1) 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.

SN74LVC16646A
16-BIT BUS TRANSCEIVER AND REGISTER
WITH 3-STATE OUTPUTS

SCES408B—AUGUST 2002—REVISED APRIL 2005

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Electrical Characteristics

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

PARAMETER		TEST CONDITIONS	V _{CC}	MIN	TYP ⁽¹⁾	MAX	UNIT
V _{OH}	I _{OH} = -100 µA		1.65 V to 3.6 V	V _{CC} - 0.2			V
	I _{OH} = -4 mA		1.65 V	1.2			
	I _{OH} = -8 mA		2.3 V	1.7			
	I _{OH} = -12 mA		2.7 V	2.2			
	I _{OH} = -24 mA		3 V	2.4			
V _{OL}	I _{OL} = 100 µA		1.65 V to 3.6 V		0.2		V
	I _{OL} = 4 mA		1.65 V		0.45		
	I _{OL} = 8 mA		2.3 V		0.7		
	I _{OL} = 12 mA		2.7 V		0.4		
	I _{OL} = 24 mA		3 V		0.55		
I _I	Control inputs	V _I = 0 to 5.5 V	3.6 V		±5	µA	
I _{off}		V _I or V _O = 5.5 V	0		±10	µA	
I _{OZ} ⁽²⁾		V _O = 0 to 5.5 V	3.6 V		±10	µA	
I _{CC}	V _I = V _{CC} or GND 3.6 V ≤ V _I ≤ 5.5 V ⁽³⁾	I _O = 0	3.6 V		20 20	µA	
ΔI _{CC}	One input at V _{CC} - 0.6 V, Other inputs at V _{CC} or GND		2.7 V to 3.6 V		500	µA	
C _i	Control inputs	V _I = V _{CC} or GND	3.3 V		5	pF	
C _{io}	A or B ports	V _O = V _{CC} or GND	3.3 V		8.5	pF	

(1) All typical values are at V_{CC} = 3.3 V, T_A = 25°C.

(2) For I/O ports, the parameter I_{OZ} includes the input leakage current, but not I_{I(hold)}.

(3) This applies in the disabled state only.

Timing Requirements

over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted) (see [Figure 2](#))

		V _{CC} = 1.8 V ± 0.15 V	V _{CC} = 2.5 V ± 0.2 V	V _{CC} = 2.7 V	V _{CC} = 3.3 V ± 0.3 V	UNIT		
		MIN	MAX	MIN	MAX	MIN	MAX	
f _{clock}	Clock frequency	85		125		150	150	MHz
t _w	Pulse duration, CLK high or low	5		4		3.3	3.3	ns
t _{su}	Setup time, A or B before CLKAB↑ or CLKBA↑	6.5		3.5		3	2.7	ns
t _h	Hold time, A or B after CLKAB↑ or CLKBA↑	0		0		0	0.3	ns

Switching Characteristics

over recommended operating free-air temperature range (unless otherwise noted) (see [Figure 2](#))

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC} = 1.8 \text{ V} \pm 0.15 \text{ V}$		$V_{CC} = 2.5 \text{ V} \pm 0.2 \text{ V}$		$V_{CC} = 2.7 \text{ V}$		$V_{CC} = 3.3 \text{ V} \pm 0.3 \text{ V}$	
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX
f_{max}			85		125		150		150	
t_{pd}	A or B	B or A	11.3		6.2		6	0.5	5.2	ns
	CLKAB or CLKBA	A or B	12.4		7.2		7	1.8	6	
	SAB or SBA		13.5		7.3		7	1.7	6.1	
t_{en}	\overline{OE}	A or B	13		9.5		8.5	1.3	6.9	ns
t_{dis}			12		8.5		7.7	2.1	6.9	
t_{en}	DIR	A or B	13		9.5		8.5	1.4	7.2	ns
t_{dis}			12		8.5		7.8	2	7	
$t_{sk(o)}$					1		1		1	ns

Operating Characteristics

$T_A = 25^\circ\text{C}$

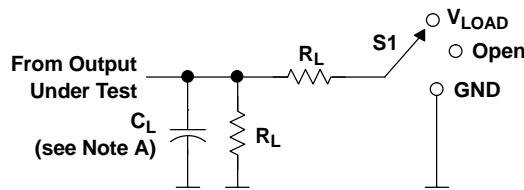
PARAMETER	TEST CONDITIONS	$V_{CC} = 1.8 \text{ V}$	$V_{CC} = 2.5 \text{ V}$	$V_{CC} = 3.3 \text{ V}$	UNIT
		TYP	TYP	TYP	
C_{pd} Power dissipation capacitance per transceiver	Outputs enabled	53	55	60	pF
	Outputs disabled	9	10	12	

SN74LVC16646A 16-BIT BUS TRANSCEIVER AND REGISTER WITH 3-STATE OUTPUTS

SCES408B—AUGUST 2002—REVISED APRIL 2005

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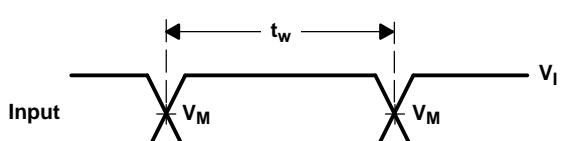
PARAMETER MEASUREMENT INFORMATION



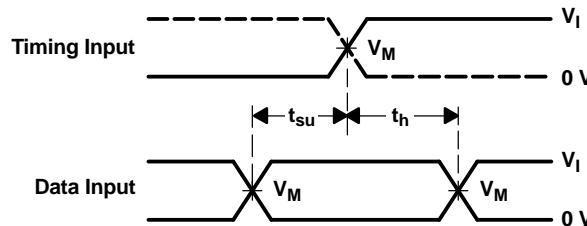
TEST	S1
t_{PLH}/t_{PHL}	Open
t_{PLZ}/t_{PZL}	V_{LOAD}
t_{PHZ}/t_{PZH}	GND

LOAD CIRCUIT

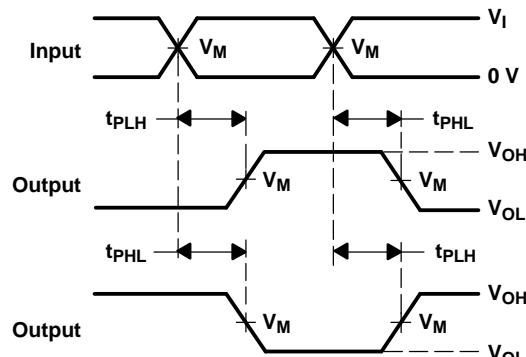
V_{CC}	INPUTS		V_M	V_{LOAD}	C_L	R_L	V_Δ
	V_I	t_r/t_f					
$1.8 \text{ V} \pm 0.15 \text{ V}$	V_{CC}	$\leq 2 \text{ ns}$	$V_{CC}/2$	$2 \times V_{CC}$	30 pF	1 k Ω	0.15 V
$2.5 \text{ V} \pm 0.2 \text{ V}$	V_{CC}	$\leq 2 \text{ ns}$	$V_{CC}/2$	$2 \times V_{CC}$	30 pF	500 Ω	0.15 V
2.7 V	2.7 V	$\leq 2.5 \text{ ns}$	1.5 V	6 V	50 pF	500 Ω	0.3 V
$3.3 \text{ V} \pm 0.3 \text{ V}$	2.7 V	$\leq 2.5 \text{ ns}$	1.5 V	6 V	50 pF	500 Ω	0.3 V



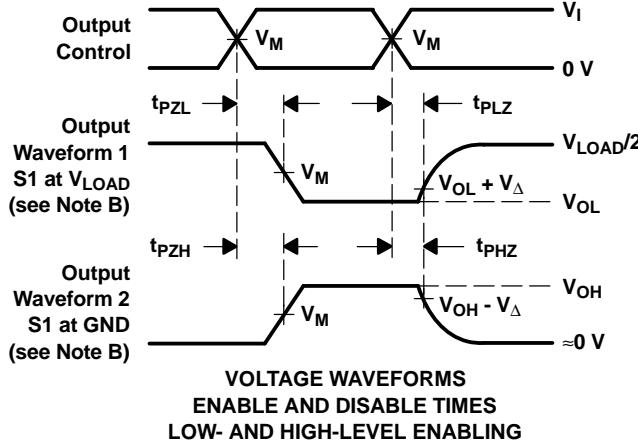
VOLTAGE WAVEFORMS
PULSE DURATION



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 $\leq 10 \text{ MHz}$, $Z_O = 50 \Omega$.

D. The outputs are measured one at a time, with one transition per measurement.

E. t_{PLZ} and t_{PHZ} are the same as t_{dis} .

F. t_{PZL} and t_{PZH} are the same as t_{en} .

G. t_{PLH} and t_{PHL} are the same as t_{pd} .

H. All parameters and waveforms are not applicable to all devices.

Figure 2. Load Circuit and Voltage Waveforms

PACKAGING INFORMATION

Orderable part number	Status	Material type	Package Pins	Package qty Carrier	RoHS	Lead finish/ Ball material	MSL rating/ Peak reflow	Op temp (°C)	Part marking
	(1)	(2)			(3)	(4)	(5)		(6)
SN74LVC16646ADGGR	Active	Production	TSSOP (DGG) 56	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	LVC16646A
SN74LVC16646ADL	Active	Production	SSOP (DL) 56	20 TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	LVC16646A
SN74LVC16646ADLR	Active	Production	SSOP (DL) 56	1000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	LVC16646A

(1) **Status:** For more details on status, see our [product life cycle](#).

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

(4) **Lead finish/Ball material:** Parts 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.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

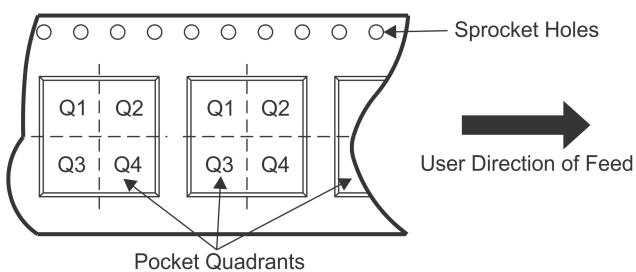
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TAPE AND REEL INFORMATION
REEL DIMENSIONS

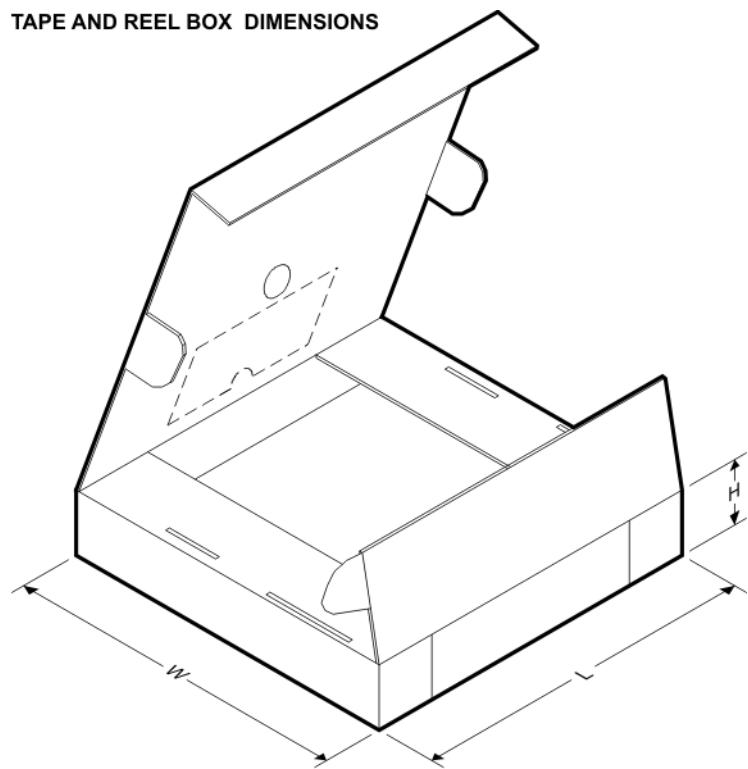
TAPE DIMENSIONS


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

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


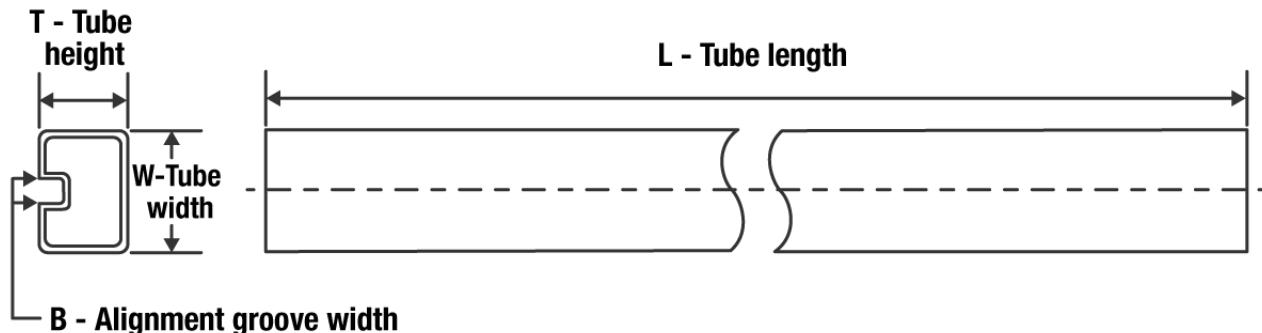
*All dimensions are nominal

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
SN74LVC16646ADGGR	TSSOP	DGG	56	2000	330.0	24.4	8.6	15.6	1.8	12.0	24.0	Q1
SN74LVC16646ADLR	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)
SN74LVC16646ADGGR	TSSOP	DGG	56	2000	367.0	367.0	45.0
SN74LVC16646ADLR	SSOP	DL	56	1000	367.0	367.0	55.0

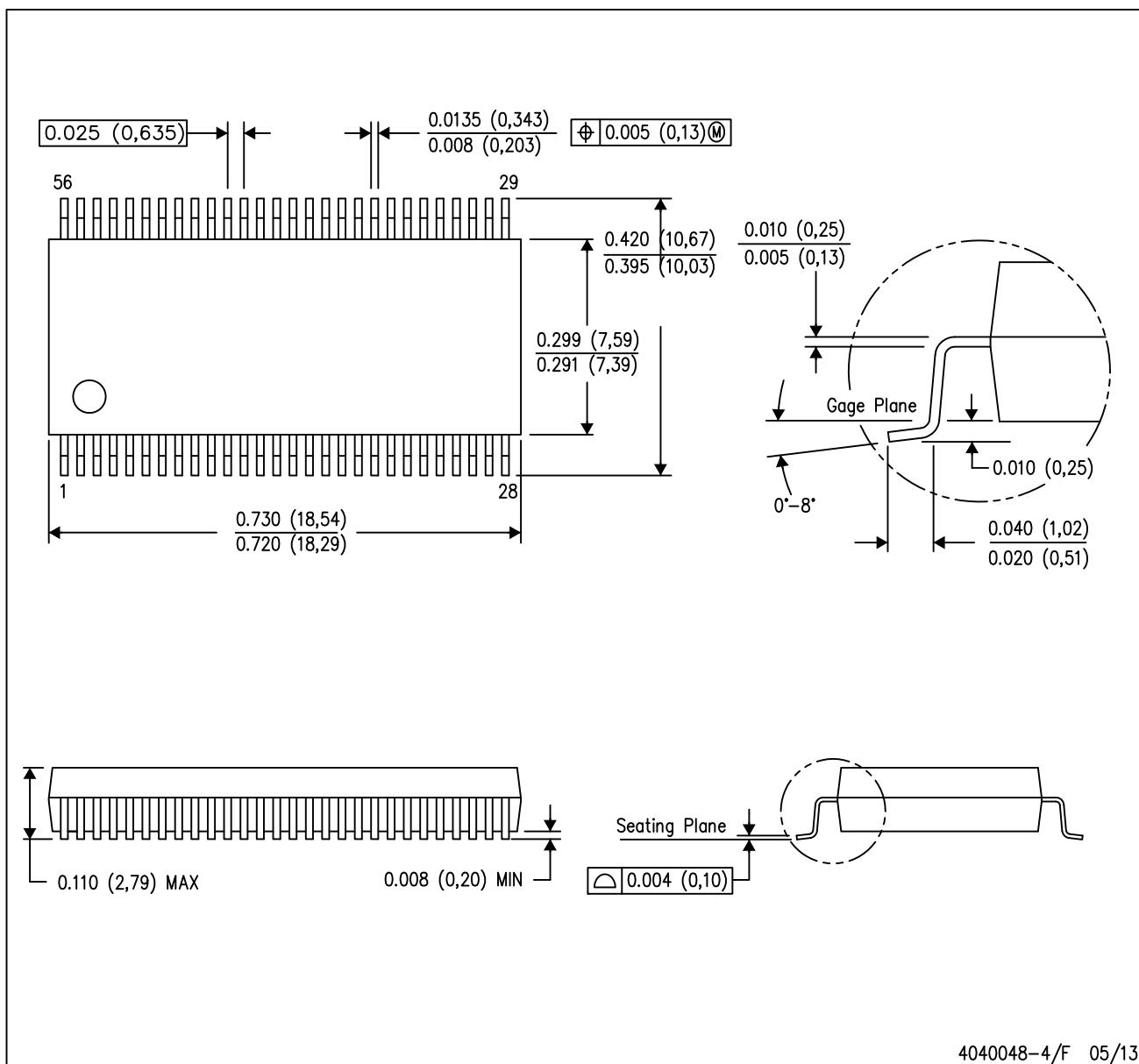
TUBE

*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (μm)	B (mm)
SN74LVC16646ADL	DL	SSOP	56	20	473.7	14.24	5110	7.87

DL (R-PDSO-G56)

PLASTIC SMALL-OUTLINE PACKAGE



4040048-4/F 05/13

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.

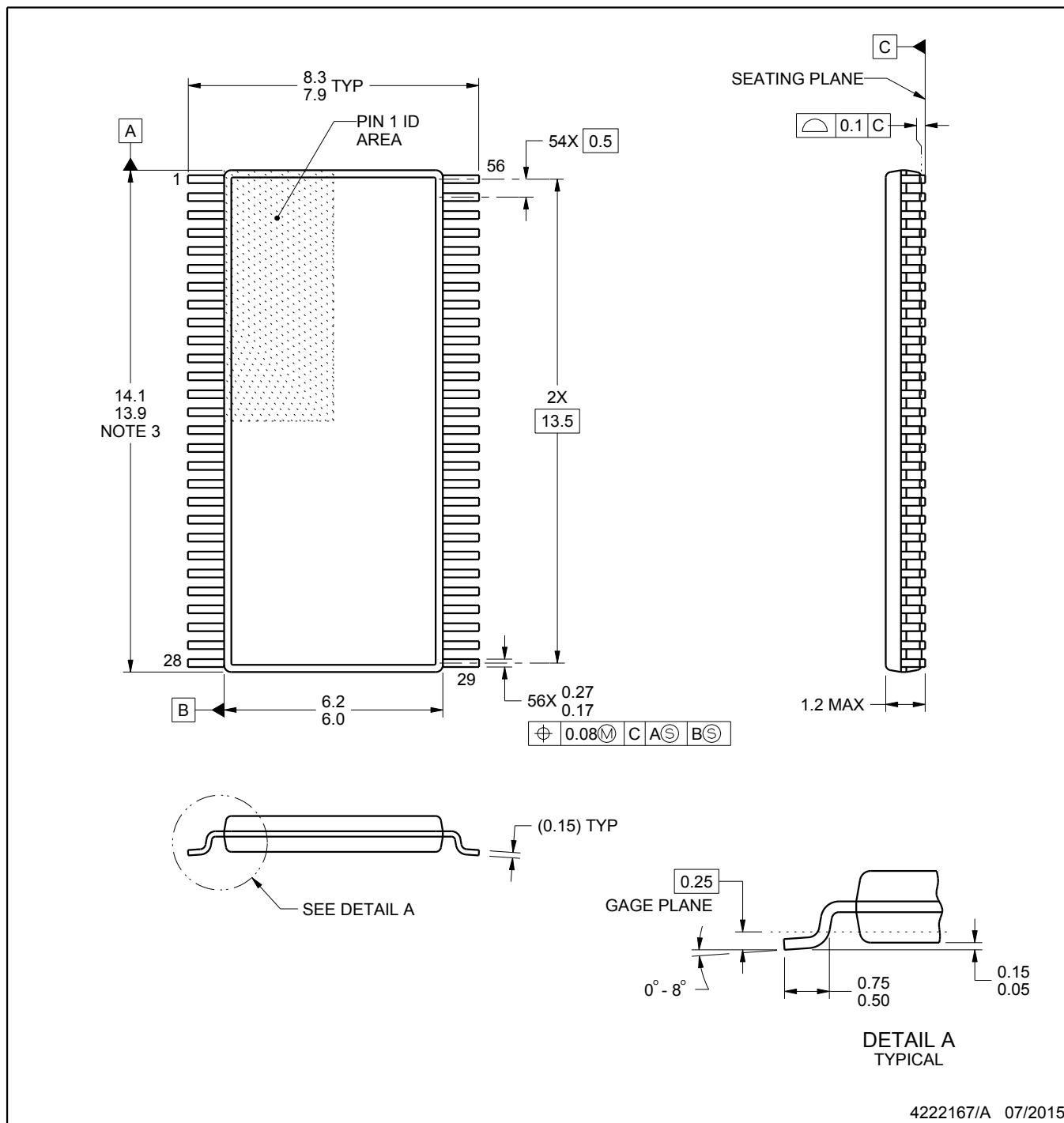
PACKAGE OUTLINE

DGG0056A



TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



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.

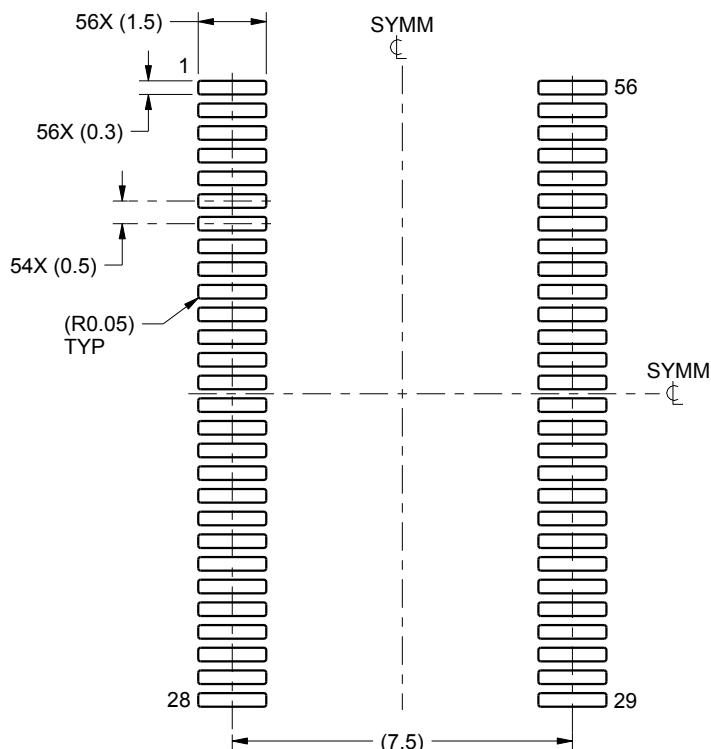


EXAMPLE BOARD LAYOUT

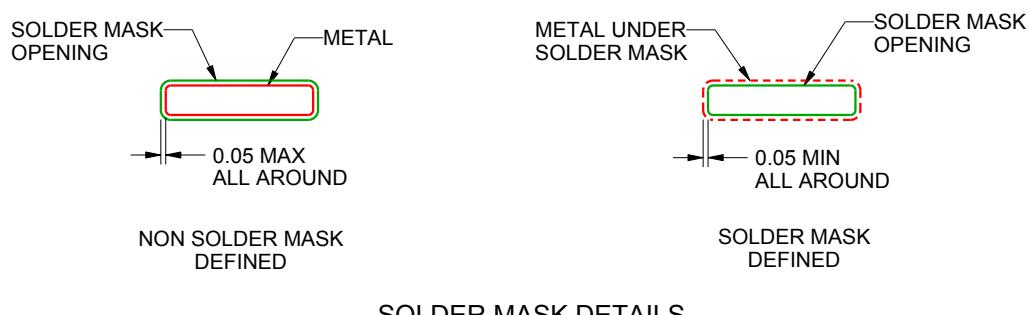
DGG0056A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE
SCALE:6X



SOLDER MASK DETAILS

4222167/A 07/2015

NOTES: (continued)

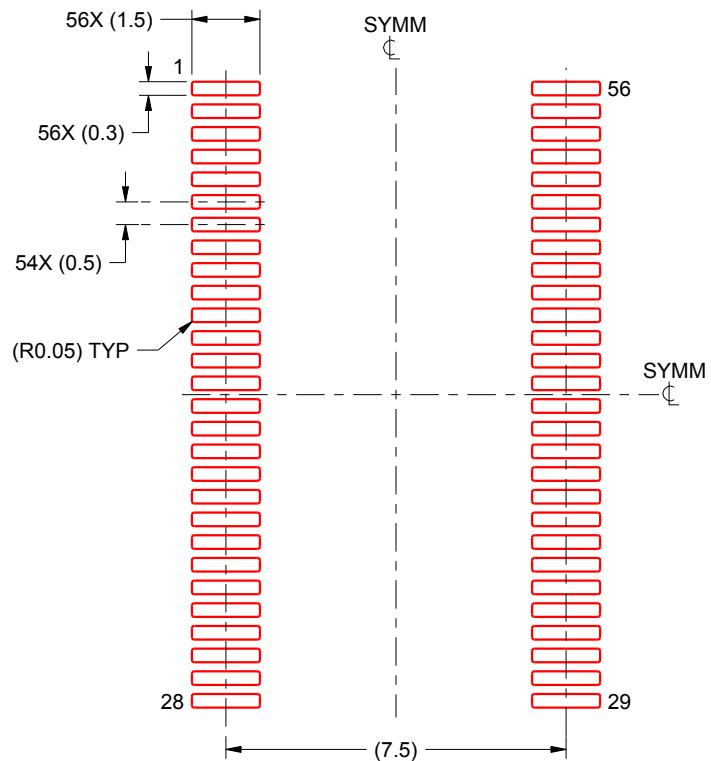
5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

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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