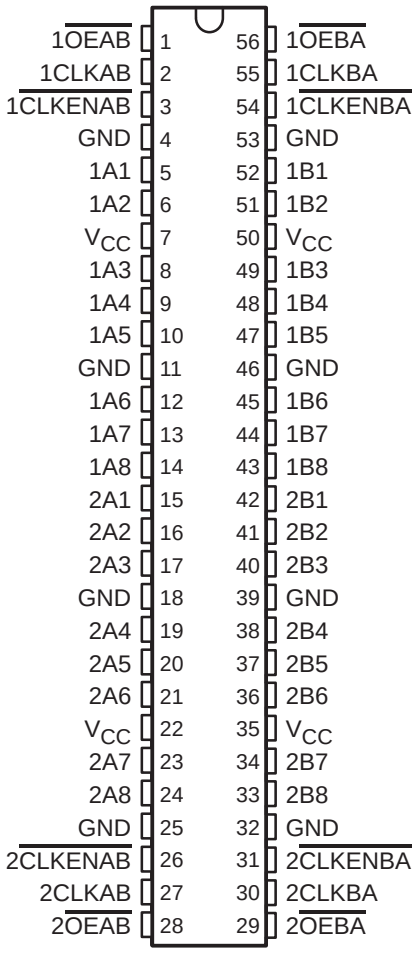
THE DATASHEET OF

SN74LVTH16952DGGR

- **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°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)**
- **Package Options Include Plastic Shrink Small-Outline (DL) and Thin Shrink Small-Outline (DGG) Packages and 380-mil Fine-Pitch Ceramic Flat (WD) Package**

SN54LVTH16952 . . . WD PACKAGE
SN74LVTH16952 . . . DGG OR DL PACKAGE
(TOP VIEW)



description

The 'LVTH16952 devices are 16-bit registered 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. Data on the A or B bus is stored in the registers on the low-to-high transition of the clock (CLKAB or CLKBA) input, provided that the clock-enable ($\overline{\text{CLKENAB}}$ or $\overline{\text{CLKENBA}}$) input is low. Taking the output-enable ($\overline{\text{OEAB}}$ or $\overline{\text{OEBA}}$) input low accesses the data on either port.

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, $\overline{\text{OE}}$ 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.

description (continued)

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 SN54LVTH16952 is characterized for operation over the full military temperature range of –55°C to 125°C. The SN74LVTH16952 is characterized for operation from –40°C to 85°C.

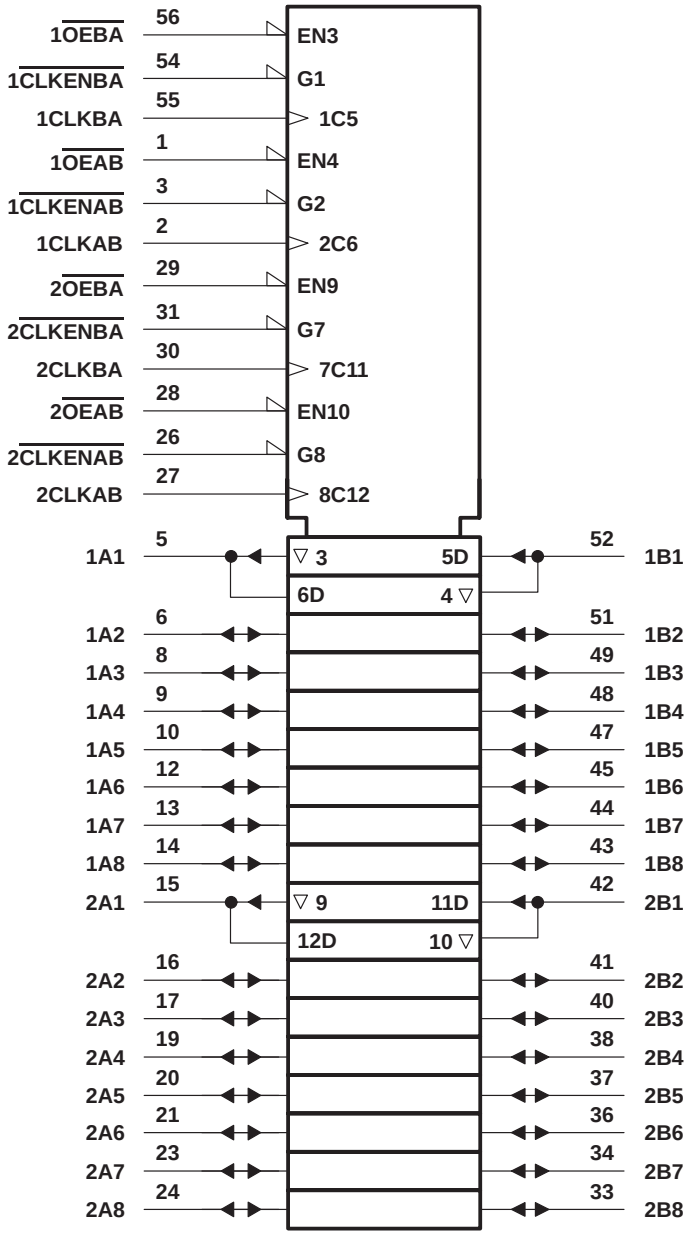
FUNCTION TABLE†

INPUTS				OUTPUT
$\overline{\text{CLKENAB}}$	CLKAB	$\overline{\text{OEAB}}$	A	B
H	X	L	X	B_0‡
X	L	L	X	B_0‡
L	↑	L	L	L
L	↑	L	H	H
X	X	H	X	Z

† A-to-B data flow is shown; B-to-A data flow is similar, but uses $\overline{\text{CLKENBA}}$, CLKBA, and $\overline{\text{OEBA}}$.

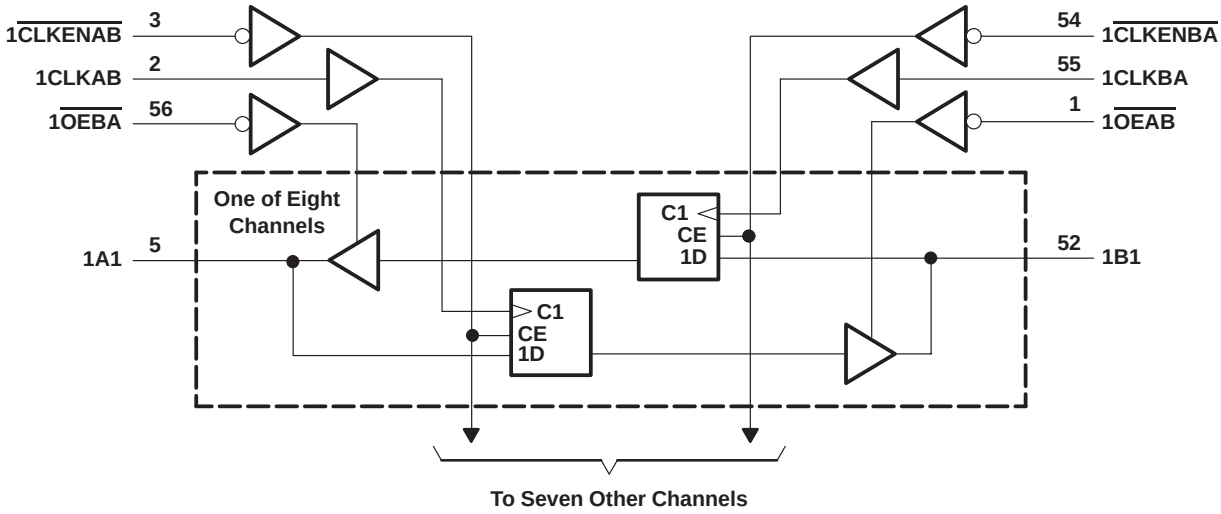
‡ Level of B before the indicated steady-state input conditions were established

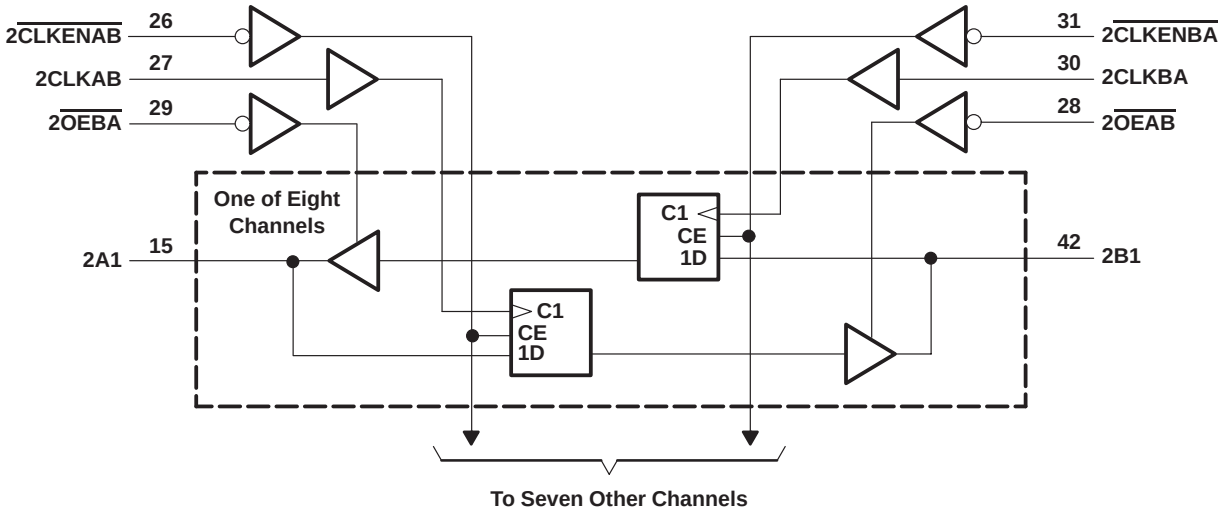
logic symbol†



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

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: SN54LVTH16952 . . . . . 96 mA
SN74LVTH16952 . . . . . 128 mA
Current into any output in the high state, I_O (see Note 2): SN54LVTH16952 . . . . . 48 mA
SN74LVTH16952 . . . . . 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 . . . . . 64°C/W
DL package . . . . . 56°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)

			SN54LVTH16952		SN74LVTH16952		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		10	ns/V
$\Delta t/\Delta V_{CC}$	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.

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

PARAMETER		TEST CONDITIONS		SN54LVTH16952			SN74LVTH16952			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	I_{OH} = –24 mA	2						
			I_{OH} = –32 mA				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				
			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_I = V_{CC}			1			1	
			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_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, $\overline{OE}$ = don't care				±100			±100	μA
I_{OZPD}		V_{CC} = 1.5 V to 0, V_O = 0.5 V to 3 V, $\overline{OE}$ = 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

† 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.

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

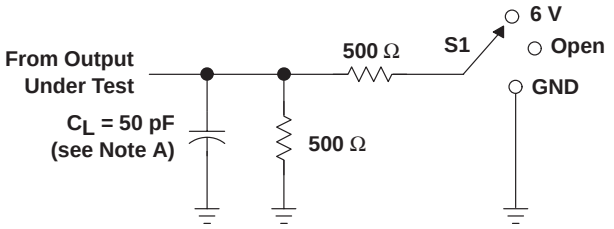
			SN54LVTH16952				SN74LVTH16952				UNIT
			V_{CC} = 3.3 V ± 0.3 V		V_{CC} = 2.7 V		V_{CC} = 3.3 V ± 0.3 V		V_{CC} = 2.7 V		
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
f_{clock}	Clock frequency			150		150		150		150	MHz
t_w	Pulse duration	CLK high or low	3.3		3.3		3.3		3.3		ns
t_{su}	Setup time	A or B before CLK	2.6		3.3		1.7		2.5		ns
		$\overline{CLKEN}$ before CLK	2.2		2.8		2		2.8		
t_h	Hold time	A or B after CLK	1		1		0.8		0		ns
		$\overline{CLKEN}$ after CLK	1.4		1.5		0.4		0		

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

PARAMETER	FROM (INPUT)	TO (OUTPUT)	SN54LVTH16952				SN74LVTH16952					UNIT
			V_{CC} = 3.3 V ± 0.3 V		V_{CC} = 2.7 V		V_{CC} = 3.3 V ± 0.3 V			V_{CC} = 2.7 V		
			MIN	MAX	MIN	MAX	MIN	TYP†	MAX	MIN	MAX	
f_{max}			150		150		150			150		MHz
t_{PLH}	CLKBA or CLKAB	A or B	1.6	5.7		7.4	1.3	2.7	4		4.4	ns
t_{PHL}			1.7	6		7	1.3	2.7	4		4.4	
t_{PZH}	$\overline{OEBA}$ or $\overline{OEAB}$	A or B	0.9	5		7.3	1	2.3	4		4.9	ns
t_{PZL}			1.1	5.2		5.9	1	2.4	4		4.9	
t_{PHZ}	$\overline{OEBA}$ or $\overline{OEAB}$	A or B	1.7	6.7		7.3	2.1	3.9	5.7		6.2	ns
t_{PLZ}			1.1	5.8		6	2.1	3.5	5.1		5.3	

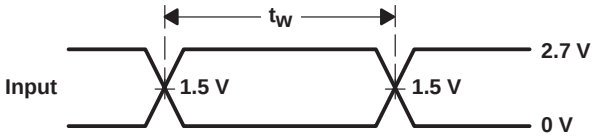
† All typical values are at V_{CC} = 3.3 V, T_A = 25°C.

PARAMETER MEASUREMENT INFORMATION

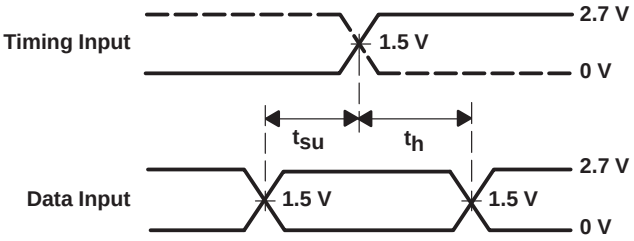


LOAD CIRCUIT

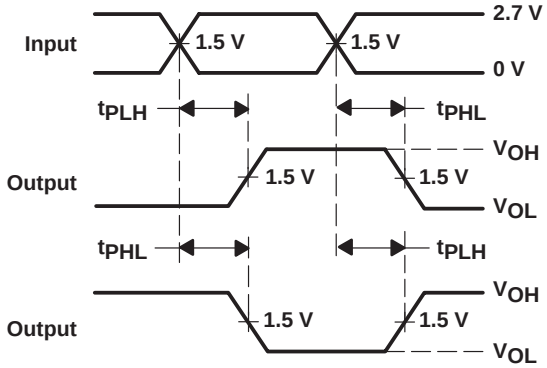
TEST	S1
t_{PLH}/t_{PHL}	Open
t_{PLZ}/t_{PZL}	6 V
t_{PHZ}/t_{PZH}	GND



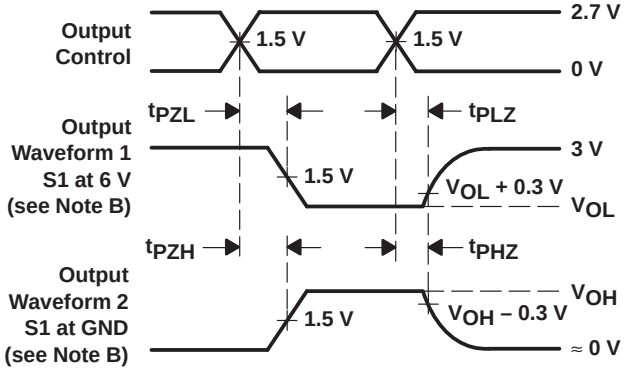
VOLTAGE WAVEFORMS
PULSE DURATION



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 ≤ 10 MHz, Z_O = 50 Ω, t_r ≤ 2.5 ns, t_f ≤ 2.5 ns.
D. The outputs are measured one at a time with one transition per measurement.

Figure 1. 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
SN74LVTH16952DGGR	ACTIVE	TSSOP	DGG	56	2000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	LVTH16952	Samples
SN74LVTH16952DL	ACTIVE	SSOP	DL	56	20	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	LVTH16952	Samples
SN74LVTH16952DLR	ACTIVE	SSOP	DL	56	1000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	LVTH16952	Samples

(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.
OBSOLETE: 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.

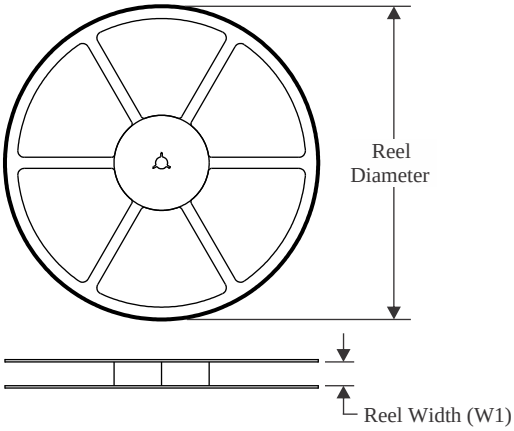
(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(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.

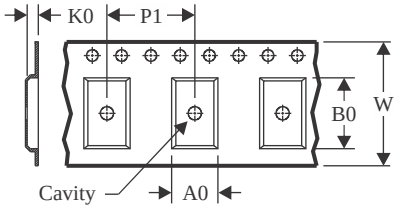
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

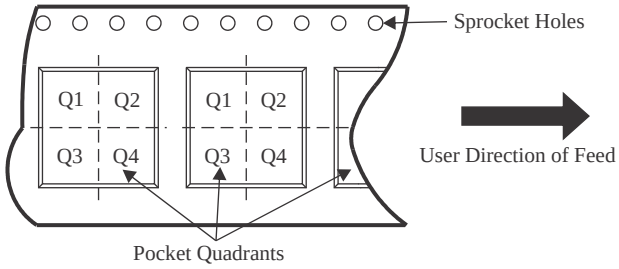


TAPE DIMENSIONS



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

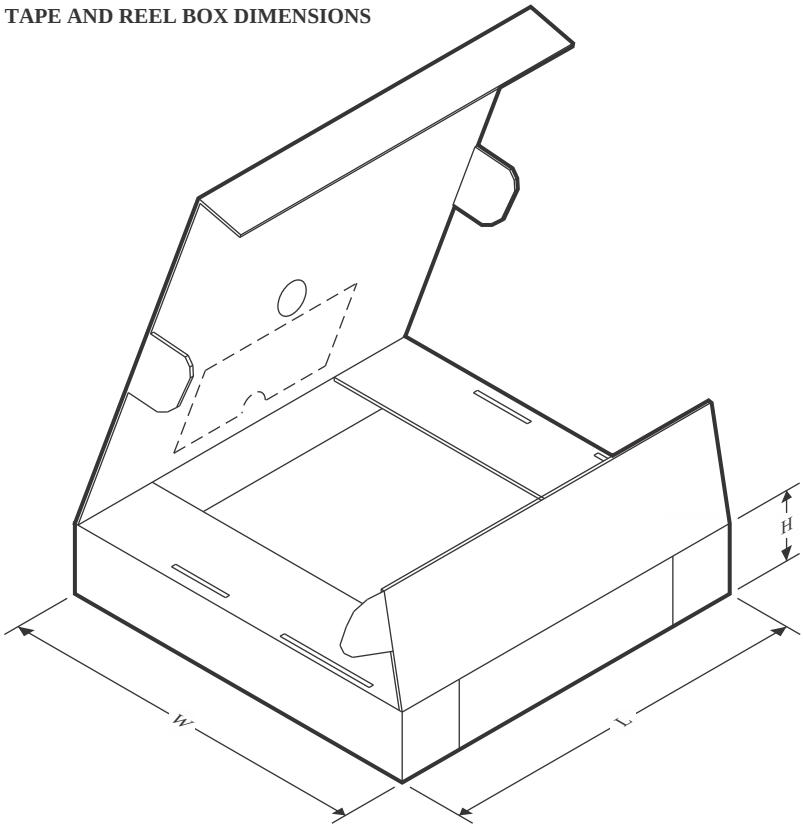
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
SN74LVTH16952DGGR	TSSOP	DGG	56	2000	330.0	24.4	8.6	15.6	1.8	12.0	24.0	Q1
SN74LVTH16952DLR	SSOP	DL	56	1000	330.0	32.4	11.35	18.67	3.1	16.0	32.0	Q1

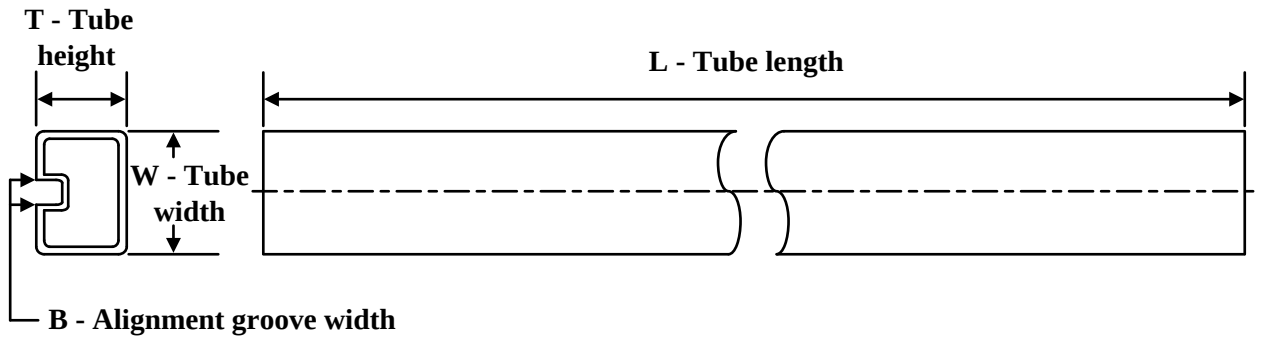
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN74LVTH16952DGGR	TSSOP	DGG	56	2000	367.0	367.0	45.0
SN74LVTH16952DLR	SSOP	DL	56	1000	367.0	367.0	55.0

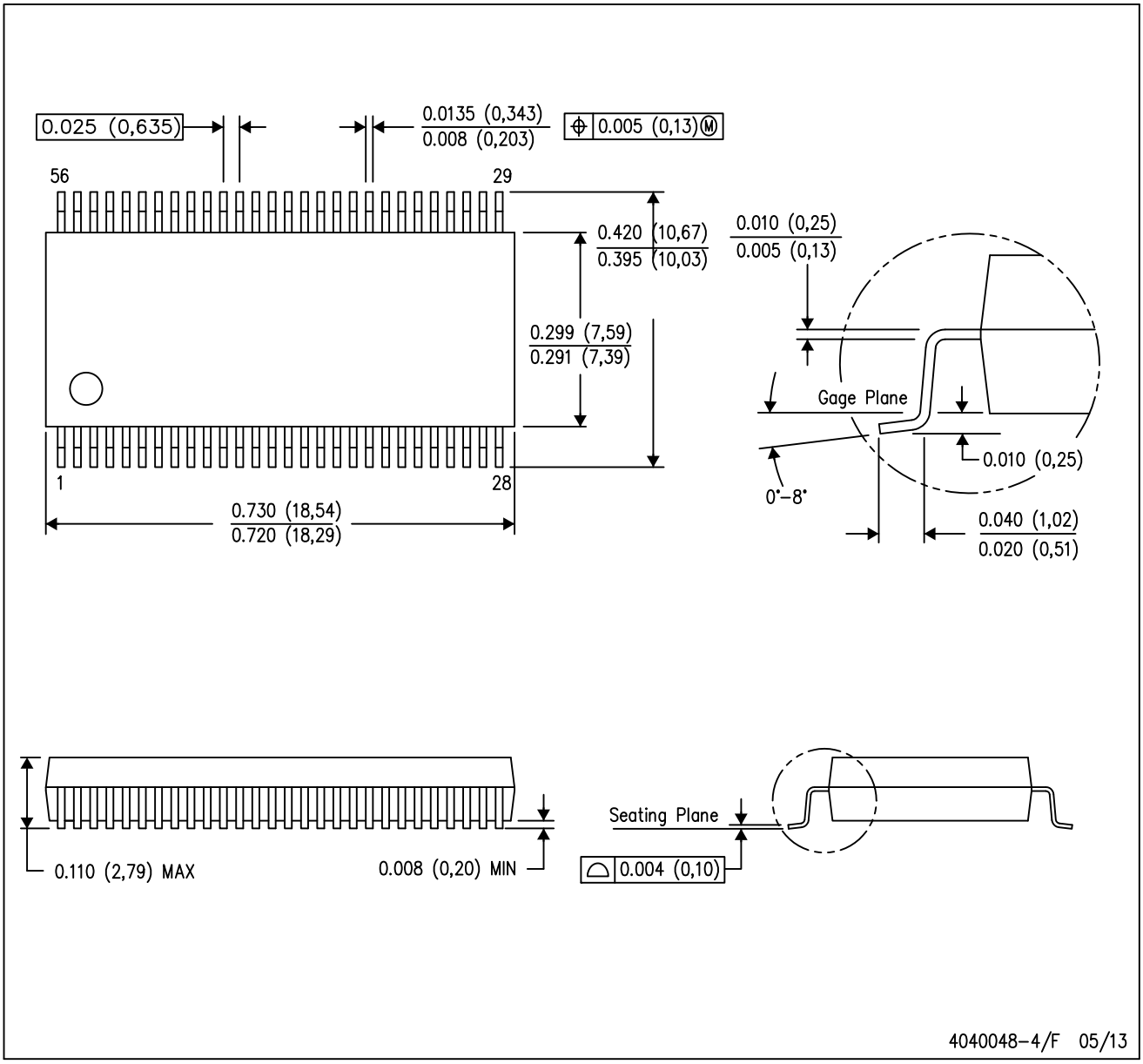
TUBE



*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
SN74LVTH16952DL	DL	SSOP	56	20	473.7	14.24	5110	7.87

DL (R–PDSO–G56) PLASTIC SMALL–OUTLINE PACKAGE



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

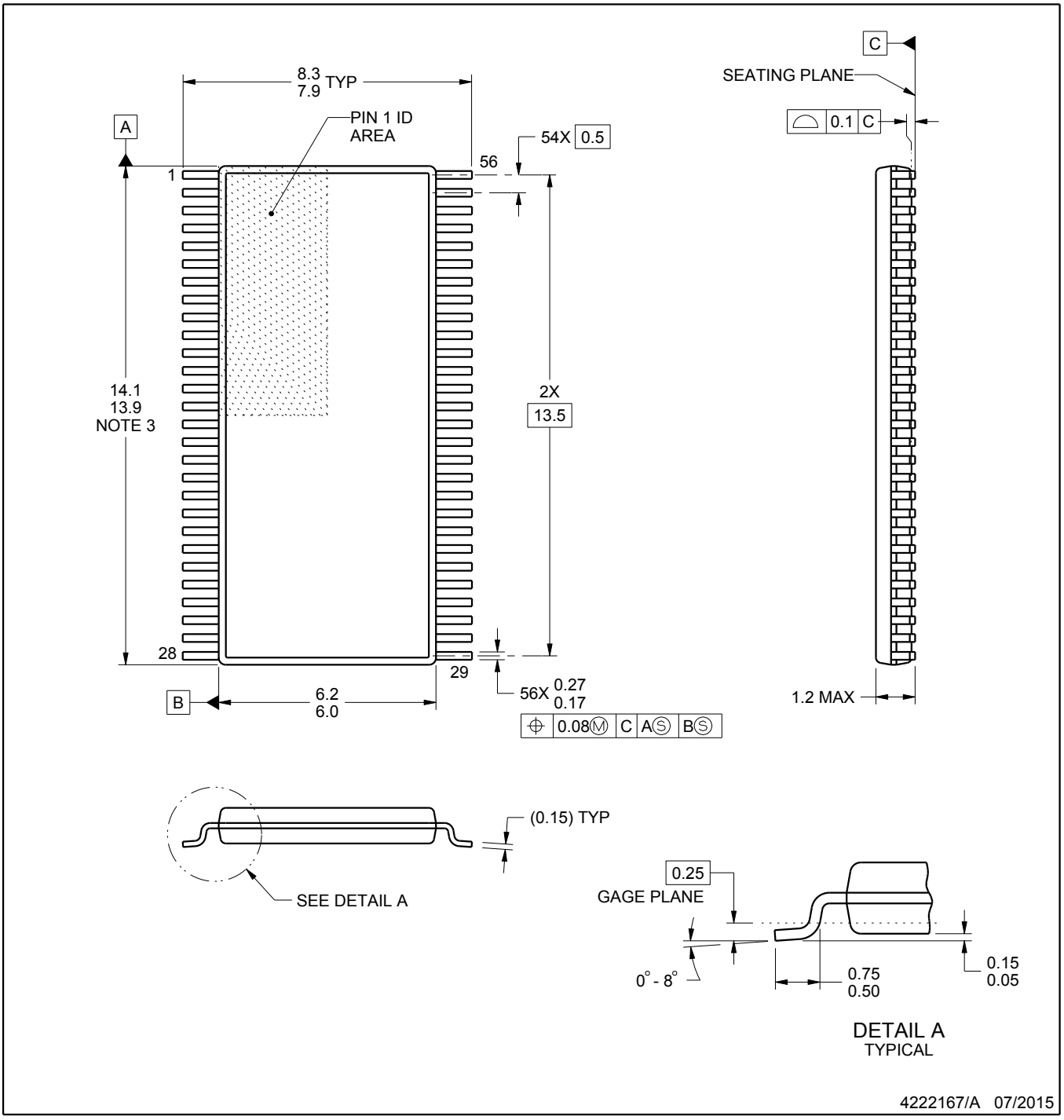
PowerPAD is a trademark of Texas Instruments.

PACKAGE OUTLINE

DGG0056A

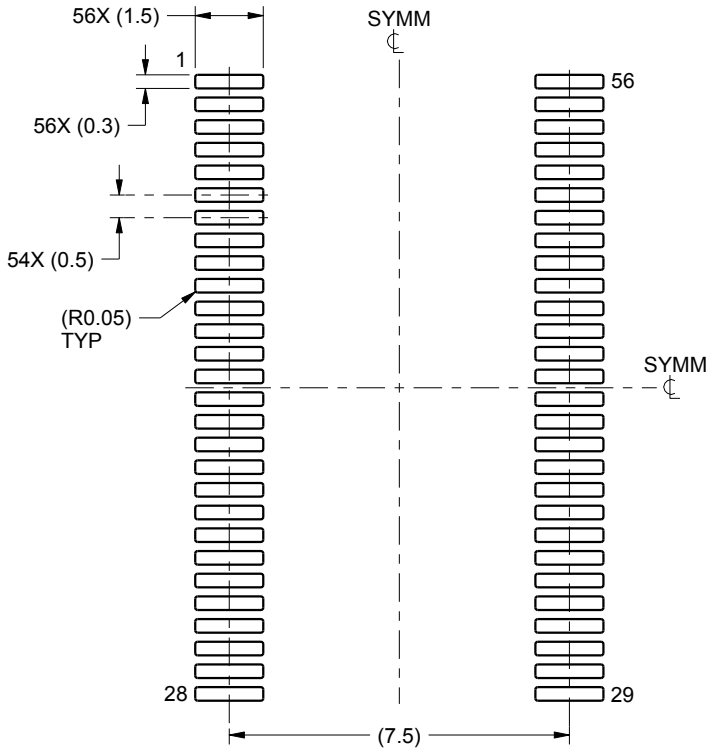
TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE

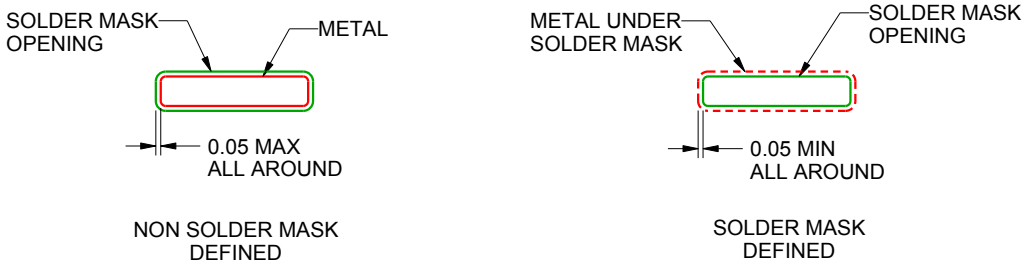


NOTES:

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.



LAND PATTERN EXAMPLE
SCALE:6X

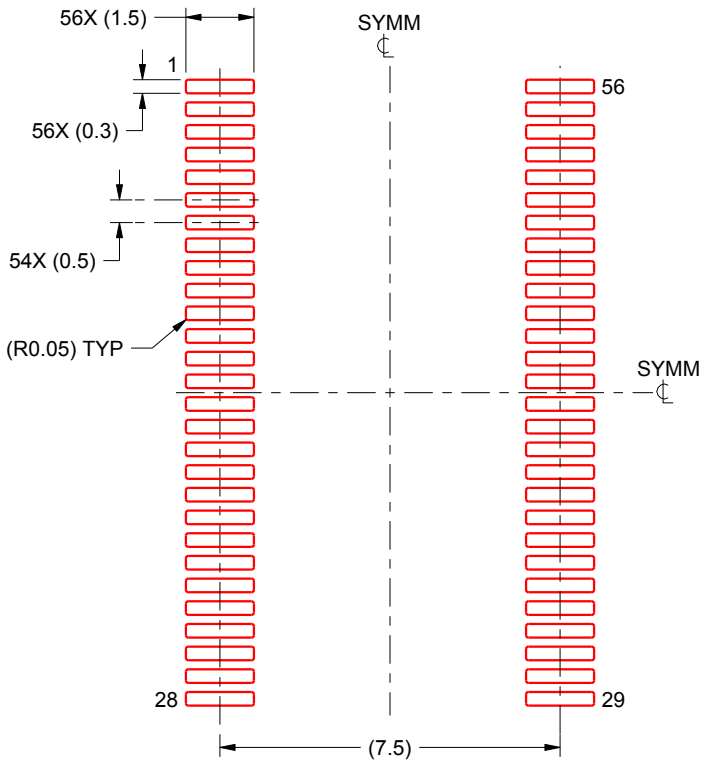


SOLDER MASK DETAILS

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.



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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