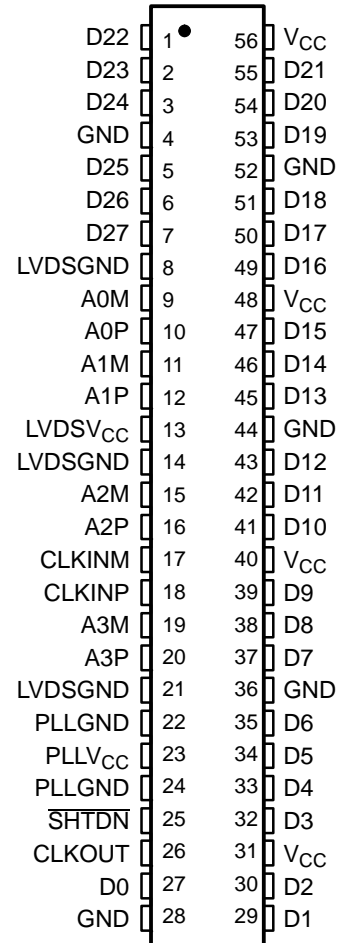


LVDS SERDES RECEIVER

FEATURES

- 4:28 Data Channel Expansion at up to 1.904 Gigabits per Second Throughput
- Suited for Point-to-Point Subsystem Communication With Very Low EMI
- 4 Data Channels and Clock Low-Voltage Differential Channels in and 28 Data and Clock Out Low-Voltage TTL Channels Out
- Operates From a Single 3.3-V Supply and 250 mW (Typ)
- 5-V Tolerant $\overline{\text{SHTDN}}$ Input
- Rising Clock Edge Triggered Outputs
- Bus Pins Tolerate 4-kV HBM ESD
- Packaged in Thin Shrink Small-Outline Package With 20 Mil Terminal Pitch
- Consumes <1 mW When Disabled
- Wide Phase-Lock Input Frequency Range 20 MHz to 68 MHz
- No External Components Required for PLL
- Meets or Exceeds the Requirements of ANSI EIA/TIA-644 Standard
- Industrial Temperature Qualified
 $T_A = -40^\circ\text{C}$ to 85°C
- Replacement for the DS90CR286

**DGG PACKAGE
(TOP VIEW)**



DESCRIPTION

The SN65LVDS94 LVDS serdes (serializer/deserializer) receiver contains four serial-in 7-bit parallel-out shift registers, a 7x clock synthesizer, and five low-voltage differential signaling (LVDS) line receivers in a single integrated circuit. These functions allow receipt of synchronous data from a compatible transmitter, such as the SN65LVDS93 and SN65LVDS95, over five balanced-pair conductors and expansion to 28 bits of single-ended LVTTTL synchronous data at a lower transfer rate.

When receiving, the high-speed LVDS data is received and loaded into registers at the rate seven times the LVDS input clock (CLKIN). The data is then unloaded to a 28-bit wide LVTTTL parallel bus at the CLKIN rate. A phase-locked loop clock synthesizer circuit generates a 7x clock for internal clocking and an output clock for the expanded data. The SN65LVDS94 presents valid data on the rising edge of the output clock (CLKOUT).



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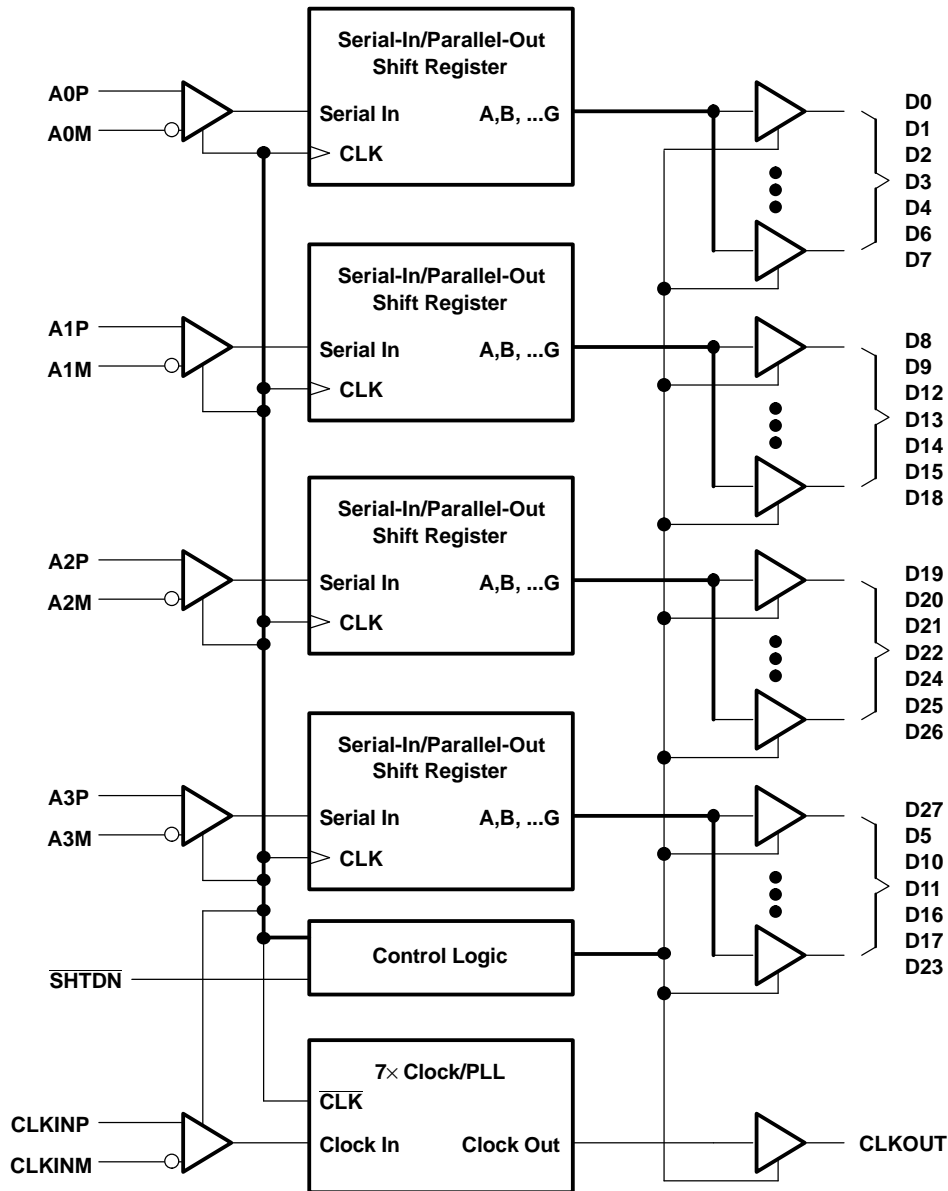
These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

DESCRIPTION (CONTINUED)

The SN65LVDS94 requires only five line termination resistors for the differential inputs and little or no control. The data bus appears the same at the input to the transmitter and output of the receiver with the data transmission transparent to the user(s). The only user intervention is the possible use of the shutdown/clear (SHTDN) active-low input to inhibit the clock and shut off the LVDS receivers for lower power consumption. A low level on this signal clears all internal registers to a low level.

The SN65LVDS94 is characterized for operation over ambient air temperatures of -40°C to 85°C.

FUNCTIONAL BLOCK DIAGRAM



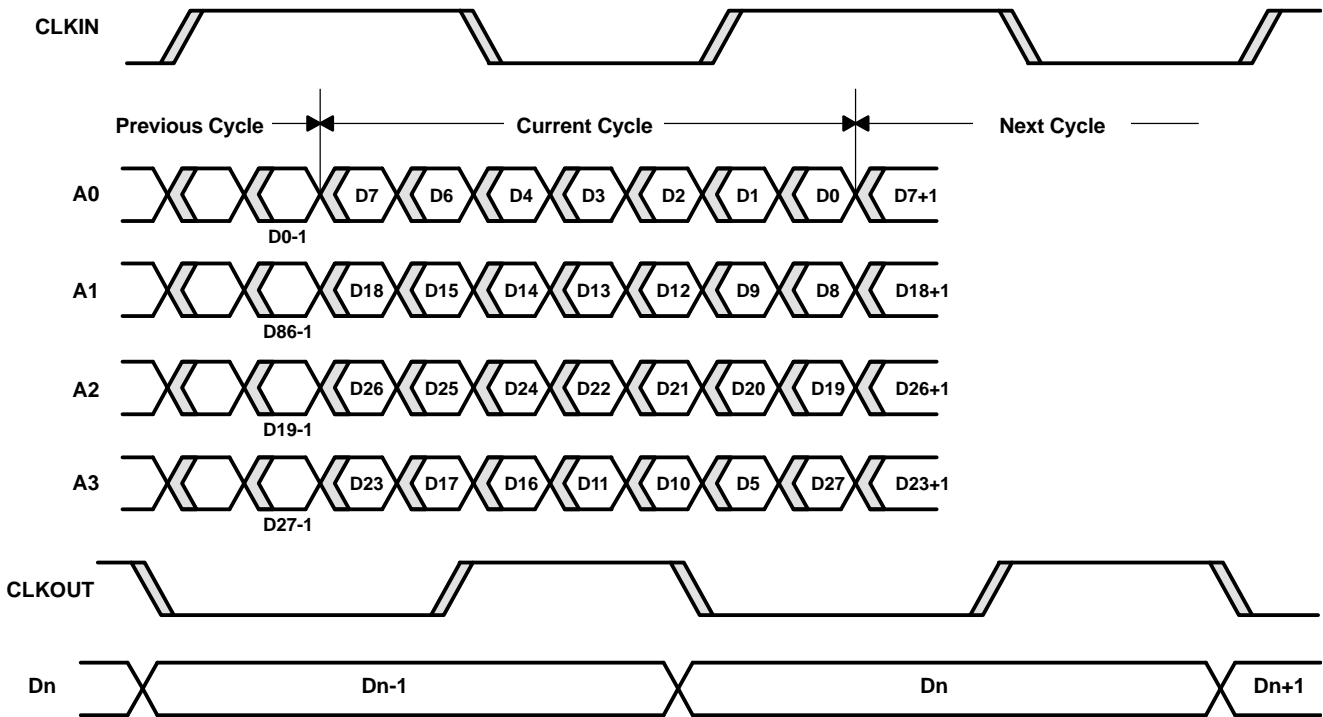
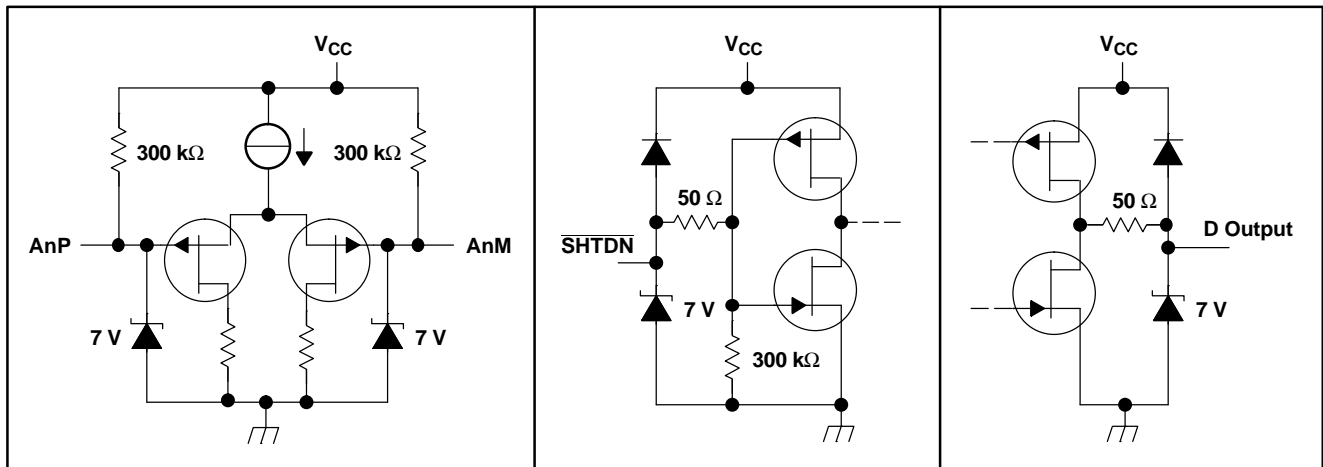


Figure 1. SN65LVDS94 Load and Shift Sequences

EQUIVALENT INPUT AND OUTPUT SCHEMATIC DIAGRAMS



ABSOLUTE MAXIMUM RATINGSover operating free-air temperature (unless otherwise noted) ⁽¹⁾

		UNIT
$V_{CC}^{(2)}$	Supply voltage range	-0.3 V to 4 V
	Voltage range at any terminal (except \overline{SHTDN})	-0.5 V to $V_{CC} + 0.5$ V
	Voltage range at \overline{SHTDN} terminal	-0.5 V to $V_{CC} + 3$ V
	Electrostatic discharge ⁽³⁾	Bus pins (Class 3A)
		Bus pins (Class 2B)
		All pins (Class 3A)
		All pins (Class 2B)
	Continuous total power dissipation	(see Dissipation Rating Table)
T_A	Operating free-air temperature range	-40°C to 85°C
T_{stg}	Storage temperature range	-65°C to 150°C
	Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260°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) All voltage values are with respect to the GND terminals unless otherwise noted.
- (3) This rating is measured using MIL-STD-883C Method, 3015.7.

DISSIPATION RATING TABLE

PACKAGE	$T_A \leq 25^\circ\text{C}$ POWER RATING	DERATING FACTOR ⁽¹⁾ ABOVE $T_A = 25^\circ\text{C}$	$T_A = 70^\circ\text{C}$ POWER RATING	$T_A = 85^\circ\text{C}$ POWER RATING
DGG	1377 mW	11 mW/°C	882 mW	717 mW

- (1) This is the inverse of the junction-to-ambient thermal resistance when board-mounted and with no air flow.

RECOMMENDED OPERATING CONDITIONS

		MIN	NOM	MAX	UNIT
V_{CC}	Supply voltage	3	3.3	3.6	V
V_{IH}	High-level input voltage (\overline{SHTDN})	2			
V_{IL}	Low-level input voltage (\overline{SHTDN})			0.8	
$ V_{ID} $	Magnitude of differential input voltage	0.1		0.6	
V_{IC} , see Figure 2 and Figure 3	Common-mode input voltage	$\frac{ V_{ID} }{2}$	$2.4 - \frac{ V_{ID} }{2}$	$V_{CC}-0.8$	
T_A	Operating free-air temperature	-40		85	°C

TIMING REQUIREMENTS

		MIN	NOM	MAX	UNIT
$t_c^{(1)}$	Input clock period	14.7	t_c	50	ns

- (1) t_c is defined as the mean duration of a minimum of 32,000 clock periods.

ELECTRICAL CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP ⁽¹⁾	MAX	UNIT
V _{IT+}	Positive-going differential input voltage threshold				100	mV
V _{IT-}	Negative-going differential input voltage threshold ⁽²⁾		-100			
V _{OH}	High-level output voltage	I _{OH} = -4 mA	2.4			V
V _{OL}	Low-level output voltage	I _{OL} = 4 mA			0.4	V
I _{CC}	Quiescent current (average)	Disabled, all inputs open			280	μA
		Enabled, AnP at 1 V and AnM at 1.4 V, t _c = 15.38 ns		62	84	mA
		Enabled, C _L = 8 pF (5 places), Worst-case pattern, see Figure 4, t _c = 15.38 ns		107		mA
I _{IH}	High-level input current ($\overline{\text{SHTDN}}$)	V _{IH} = V _{CC}			±20	μA
I _{IL}	Low-level input current ($\overline{\text{SHTDN}}$)	V _{IL} = 0 V			±20	μA
I _{IN}	Input current (A and CLKIN inputs)	0 V ≤ V _I ≤ 2.4 V			±20	μA
I _{OZ}	High-impedance output current	V _O = 0 V or V _{CC}			±10	μA

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

(2) The algebraic convention, in which the less-positive (more-negative) limit is designated minimum, is used in this data sheet for the negative-going input voltage threshold only.

SWITCHING CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP ⁽¹⁾	MAX	UNIT
t _{su}	Data setup time, D0 through D27 to CLKOUT	C _L = 8 pF See Figure 5	4	6		ns
t _h	Data hold time, CLKOUT to D0 through D27		4	6		
t _{RSKM}	Receiver input skew margin ⁽¹⁾ , see Figure 6	t _c = 15.38 ns (±0.2%), Input clock jitter < 50 ps ⁽²⁾	T _A = 0°C to 85°C T _A = -40°C to 0°C		490 800	ps
t _d	Delay time, input clock to output clock, see Figure 6	t _c = 15.38 ns (±0.2%)		3.7		ns
Δt _{C(O)}	Change in output clock period from cycle to cycle ⁽³⁾	t _c = 15.38 + 0.75 sin(2π500E3t) ± 0.05 ns, See Figure 7		±80		ps
		t _c = 15.38 + 0.75 sin(2π3E6t) ± 0.05 ns, See Figure 7		±300		
t _{en}	Enable time, $\overline{\text{SHTDN}}$ to phase lock	See Figure 8		1		ms
t _{dis}	Disable time, $\overline{\text{SHTDN}}$ to Off state	See Figure 9		400		ns
t _t	Output transition time (t _r or t _f)	C _L = 8 pF		3		ns
t _w	Output clock pulse duration			0.43 t _c		ns

(1) t_{RSKM} is the timing margin available to allocate to the transmitter and interconnection skews and clock jitter. It is defined by $\frac{t_c}{14} - t_s/h$.

(2) |Input clock jitter| is the magnitude of the change in the input clock period.

(3) Δt_{C(O)} is the change in the output clock period from one cycle to the next cycle observed over 15,000 cycles.

PARAMETER MEASUREMENT INFORMATION

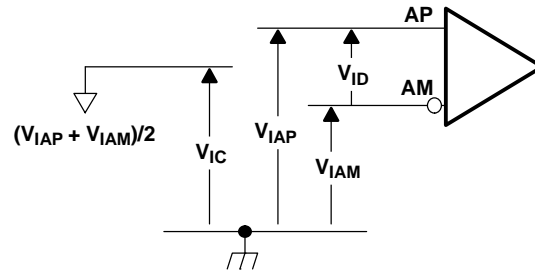


Figure 2. Voltage Definitions

COMMON-MODE INPUT VOLTAGE
vs
DIFFERENTIAL INPUT VOLTAGE AND V_{CC}

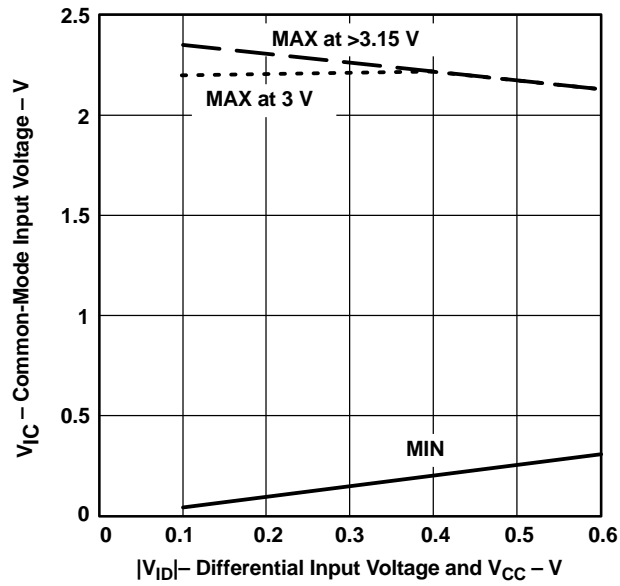


Figure 3. Recommended V_{IC} Versus V_{ID} and V_{CC}

PARAMETER MEASUREMENT INFORMATION (continued)

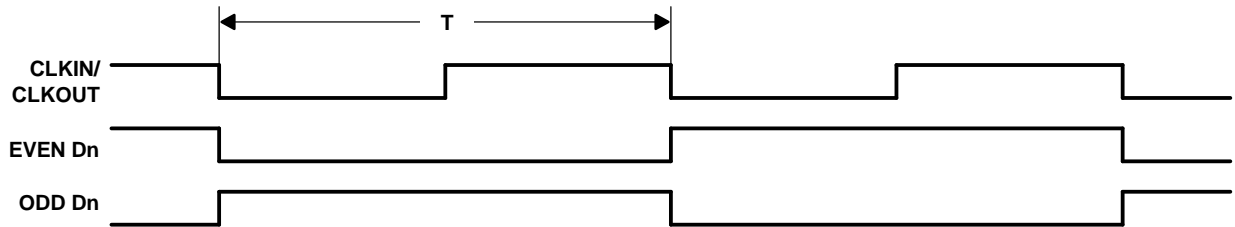


Figure 4. Worst-Case Power Test Pattern

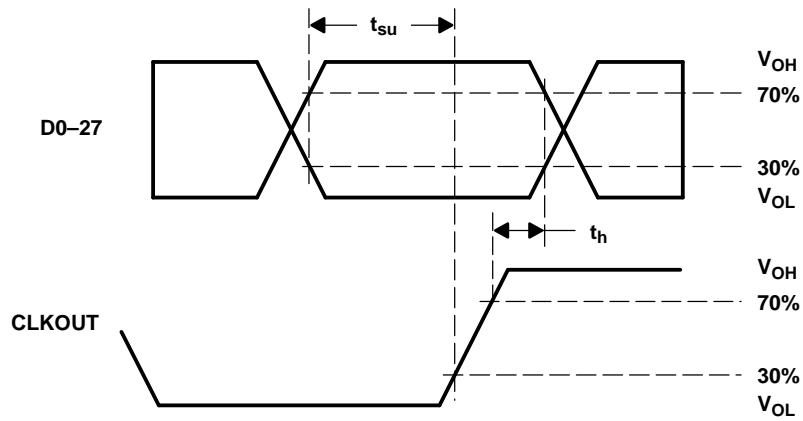
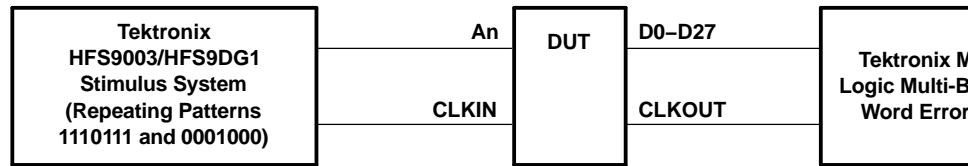


Figure 5. Setup and Hold Time Measurements

PARAMETER MEASUREMENT INFORMATION (continued)



CLKIN is advanced or delayed with respect to data until errors are observed at the receiver output. The magnitude of the advance or delay is t_{RSKM} .

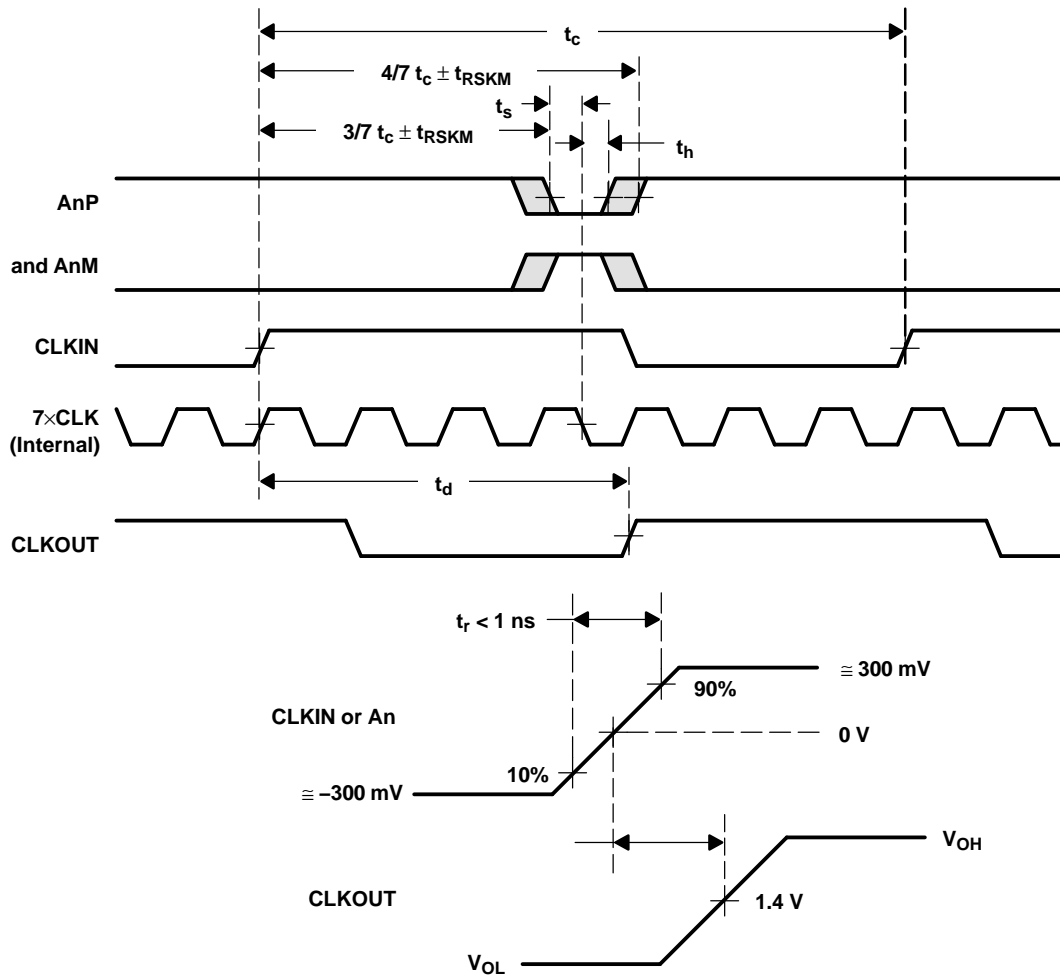


Figure 6. Receiver Input Skew Margin and t_d Definitions

PARAMETER MEASUREMENT INFORMATION (continued)

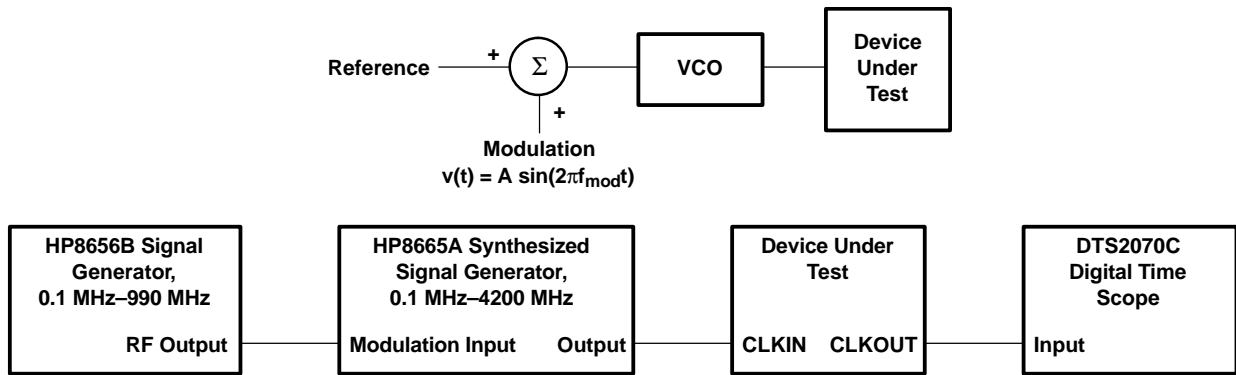


Figure 7. Output Clock Jitter Test Setup

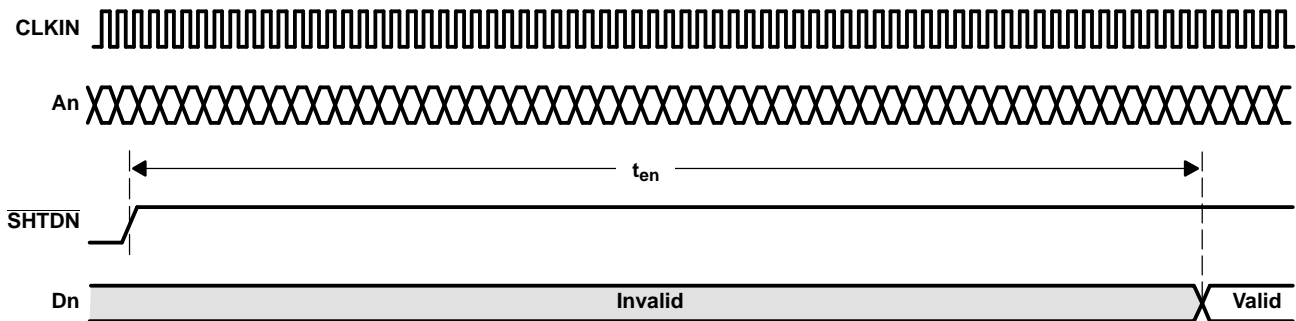


Figure 8. Enable Time Waveforms

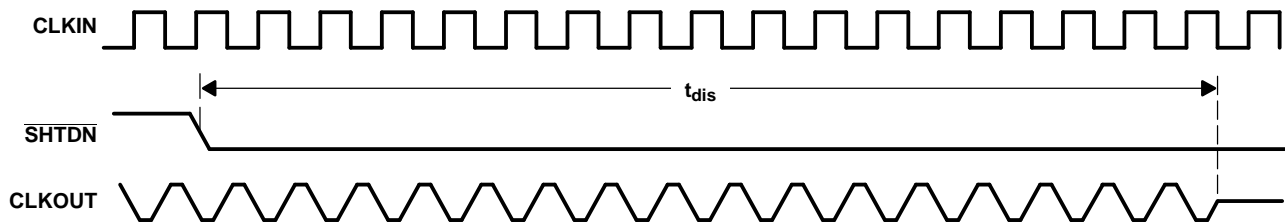


Figure 9. Disable Time Waveforms

TYPICAL CHARACTERISTICS
WORST-CASE SUPPLY CURRENT
vs
FREQUENCY

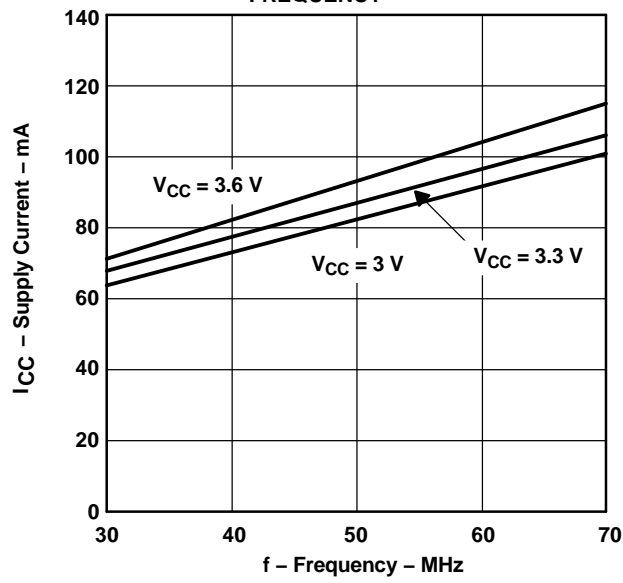


Figure 10.

APPLICATION INFORMATION

16-BIT BUS EXTENSION

In a 16-bit bus application (Figure 11), TTL data and clock coming from bus transceivers that interface the backplane bus arrive at the Tx parallel inputs of the LVDS serdes transmitter. The clock associated with the bus is also connected to the device. The on-chip PLL synchronizes this clock with the parallel data at the input. The data is then multiplexed into three different line drivers which perform the TTL to LVDS conversion. The clock is also converted to LVDS and presented to a separate driver. This synchronized LVDS data and clock at the receiver, which recovers the LVDS data and clock, performs a conversion back to TTL. Data is then demultiplexed into a parallel format. An on-chip PLL synchronizes the received clock with the parallel data, and then all are presented to the parallel output port of the receiver.

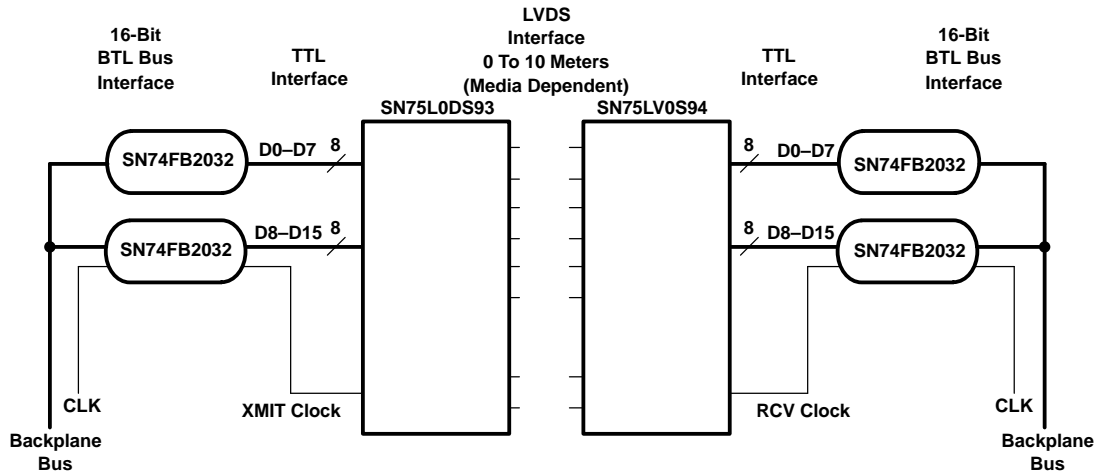


Figure 11. 16-Bit Bus Extension

16-BIT BUS EXTENSION WITH PARITY

In the previous application we did not have a checking bit that would provide assurance that the data crosses the link. If we add a parity bit to the previous example, we would have a diagram similar to the one in Figure 12. The device following the SN74FB2032 is a low cost parity generator. Each transmit-side transceiver/parity generator takes the LVTTTL data from the corresponding transceiver, performs a parity calculation over the byte, and then passes the bits with its calculated parity value on the parallel input of the LVDS serdes transmitter. Again, the on-chip PLL synchronizes this transmit clock with the eighteen parallel bits (16 data + 2 parity) at the input. The synchronized LVDS data/parity and clock arrive at the receiver.

The receiver performs the conversion from LVDS to LVTTTL and the transceiver/parity generator performs the parity calculations. These devices compare their corresponding input bytes with the value received on the parity bit. The transceiver/parity generator will assert its parity error output if a mismatch is detected.

APPLICATION INFORMATION (continued)

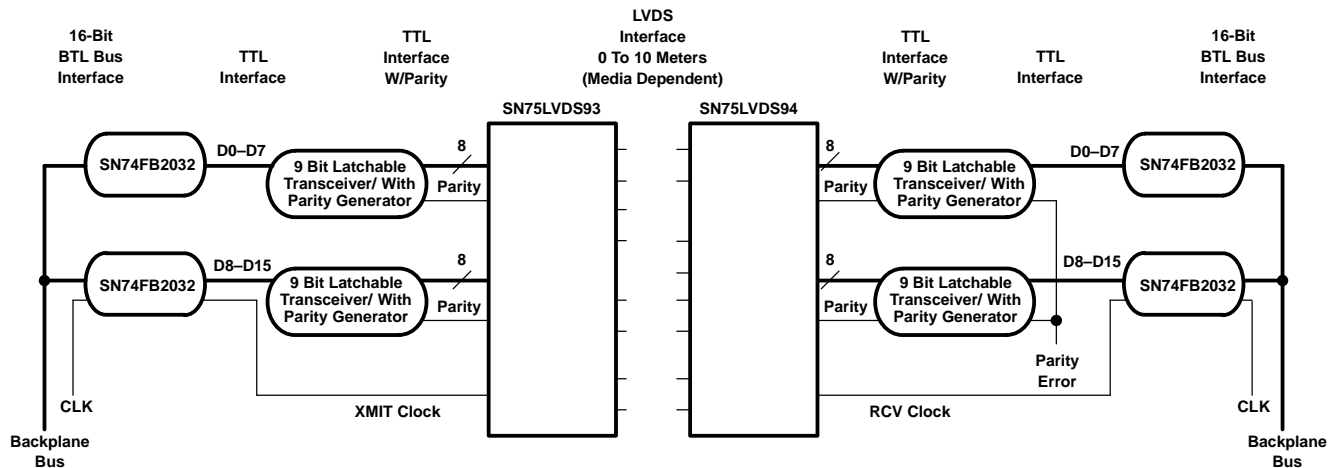


Figure 12. 16-Bit Bus Extension With Parity

LOW COST VIRTUAL BACKPLANE TRANSCEIVER

Figure 13 represents LVDS serdes in an application as a virtual backplane transceiver (VBT). The concept of a VBT can be achieved by implementing individual LVDS serdes chipsets in both directions of subsystem serialized links.

Depending on the application, the designer will face varying choices when implementing a VBT. In addition to the devices shown in Figure 13, functions such as parity and delay lines for control signals could be included. Using additional circuitry, half-duplex or full-duplex operation can be achieved by configuring the clock and control lines properly.

The designer may choose to implement an independent clock oscillator at each end of the link and then use a PLL to synchronize LVDS serdes's parallel I/O to the backplane bus. Resynchronizing FIFOs may also be required.

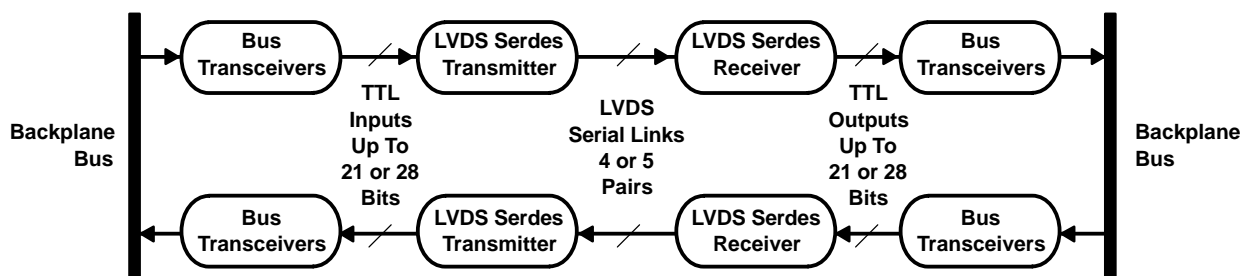


Figure 13. Virtual Backplane Transceiver

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
SN65LVDS94DGG	ACTIVE	TSSOP	DGG	56	35	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR		SN65LVDS94	Samples
SN65LVDS94DGGG4	ACTIVE	TSSOP	DGG	56	35	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR		SN65LVDS94	Samples
SN65LVDS94DGGR	ACTIVE	TSSOP	DGG	56	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	SN65LVDS94	Samples
SN65LVDS94DGGRG4	ACTIVE	TSSOP	DGG	56	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	-40 to 85	SN65LVDS94	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) 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) Multiple Top-Side Markings will be inside parentheses. Only one Top-Side 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 Top-Side 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

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
SN65LVDS94DGGR	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)
SN65LVDS94DGGR	TSSOP	DGG	56	2000	367.0	367.0	45.0

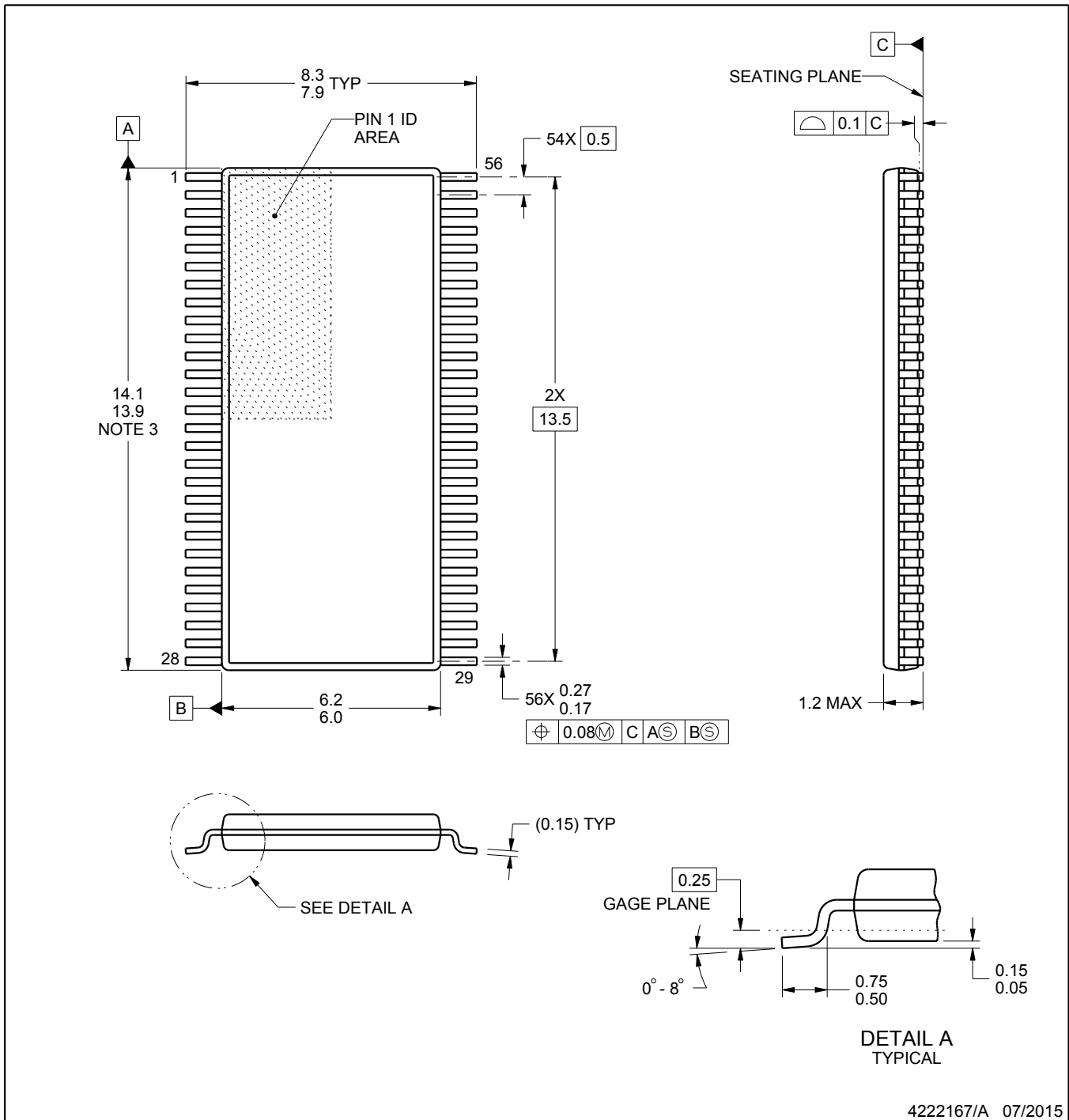
DGG0056A



PACKAGE OUTLINE

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



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NOTES:

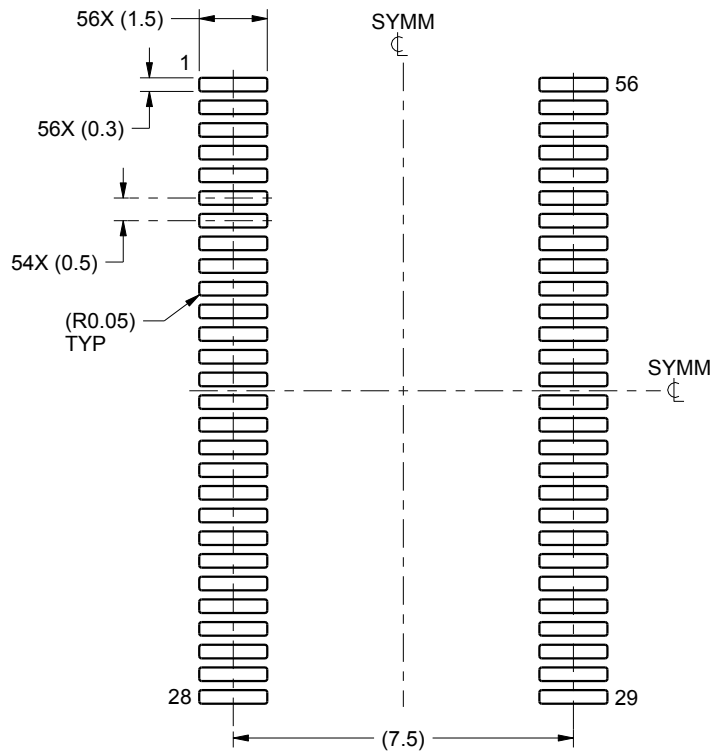
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or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

EXAMPLE BOARD LAYOUT

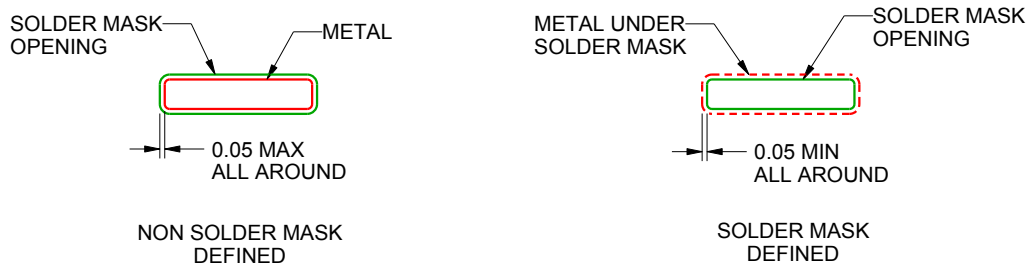
DGG0056A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE
SCALE:6X



SOLDER MASK DETAILS

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NOTES: (continued)

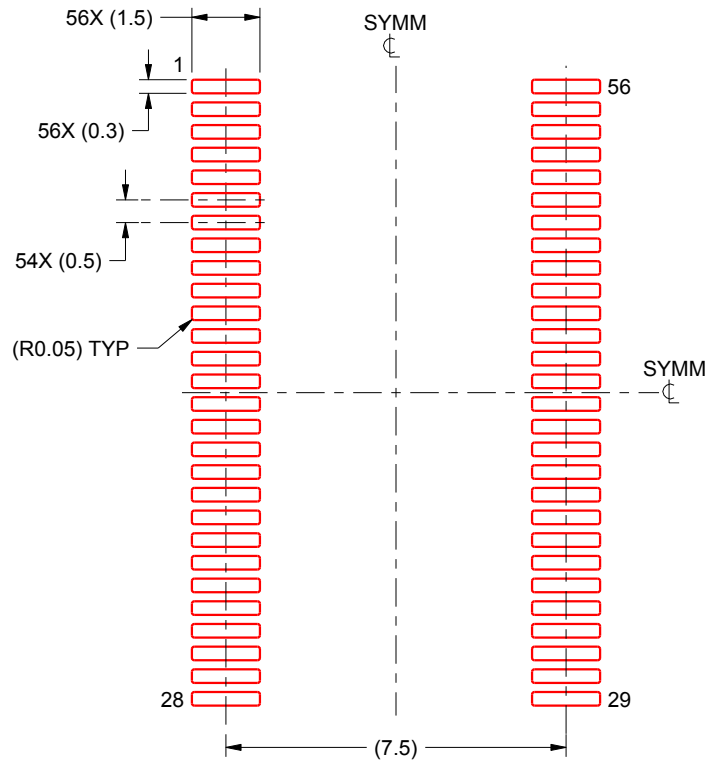
5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

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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