

- 4:28 Data Channel Expansion at up to 1.820 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 65 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  $85^\circ\text{C}$
- Replacement for the DS90CR286

## description

The SN65LVDS94 LVDS serdes (serializer/deserializer) receiver contains four serial-in 7-bit parallel-out shift registers, a  $7\times$  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  $7\times$  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).

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 ( $\overline{\text{SHTDN}}$ ) 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  $-40^\circ\text{C}$  to  $85^\circ\text{C}$ .

## DGG PACKAGE (TOP VIEW)

|                               |    |    |                 |
|-------------------------------|----|----|-----------------|
| D22                           | 1  | 56 | V <sub>CC</sub> |
| D23                           | 2  | 55 | D21             |
| D24                           | 3  | 54 | D20             |
| GND                           | 4  | 53 | D19             |
| D25                           | 5  | 52 | GND             |
| D26                           | 6  | 51 | D18             |
| D27                           | 7  | 50 | D17             |
| LVDSGND                       | 8  | 49 | D16             |
| A0M                           | 9  | 48 | V <sub>CC</sub> |
| A0P                           | 10 | 47 | D15             |
| A1M                           | 11 | 46 | D14             |
| A1P                           | 12 | 45 | D13             |
| LVDSV <sub>CC</sub>           | 13 | 44 | GND             |
| LVDSGND                       | 14 | 43 | D12             |
| A2M                           | 15 | 42 | D11             |
| A2P                           | 16 | 41 | D10             |
| CLKINM                        | 17 | 40 | V <sub>CC</sub> |
| CLKINP                        | 18 | 39 | D9              |
| A3M                           | 19 | 38 | D8              |
| A3P                           | 20 | 37 | D7              |
| LVDSGND                       | 21 | 36 | GND             |
| PLL <sub>GND</sub>            | 22 | 35 | D6              |
| PLL <sub>V<sub>CC</sub></sub> | 23 | 34 | D5              |
| PLL <sub>GND</sub>            | 24 | 33 | D4              |
| $\overline{\text{SHTDN}}$     | 25 | 32 | D3              |
| CLKOUT                        | 26 | 31 | V <sub>CC</sub> |
| D0                            | 27 | 30 | D2              |
| GND                           | 28 | 29 | D1              |



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**TEXAS  
INSTRUMENTS**

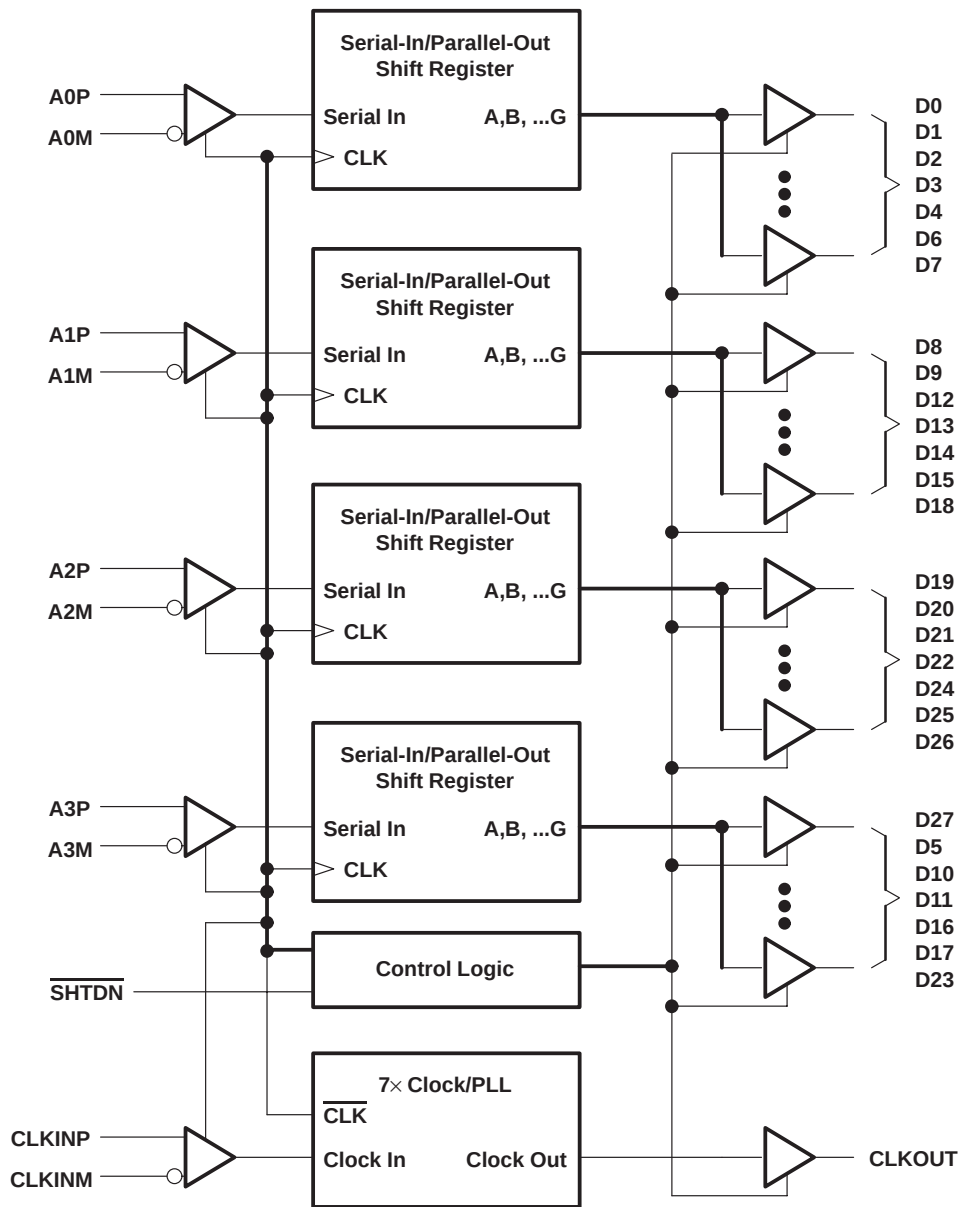
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SN65LVDS94  
LVDS SERDES RECEIVER

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functional block diagram



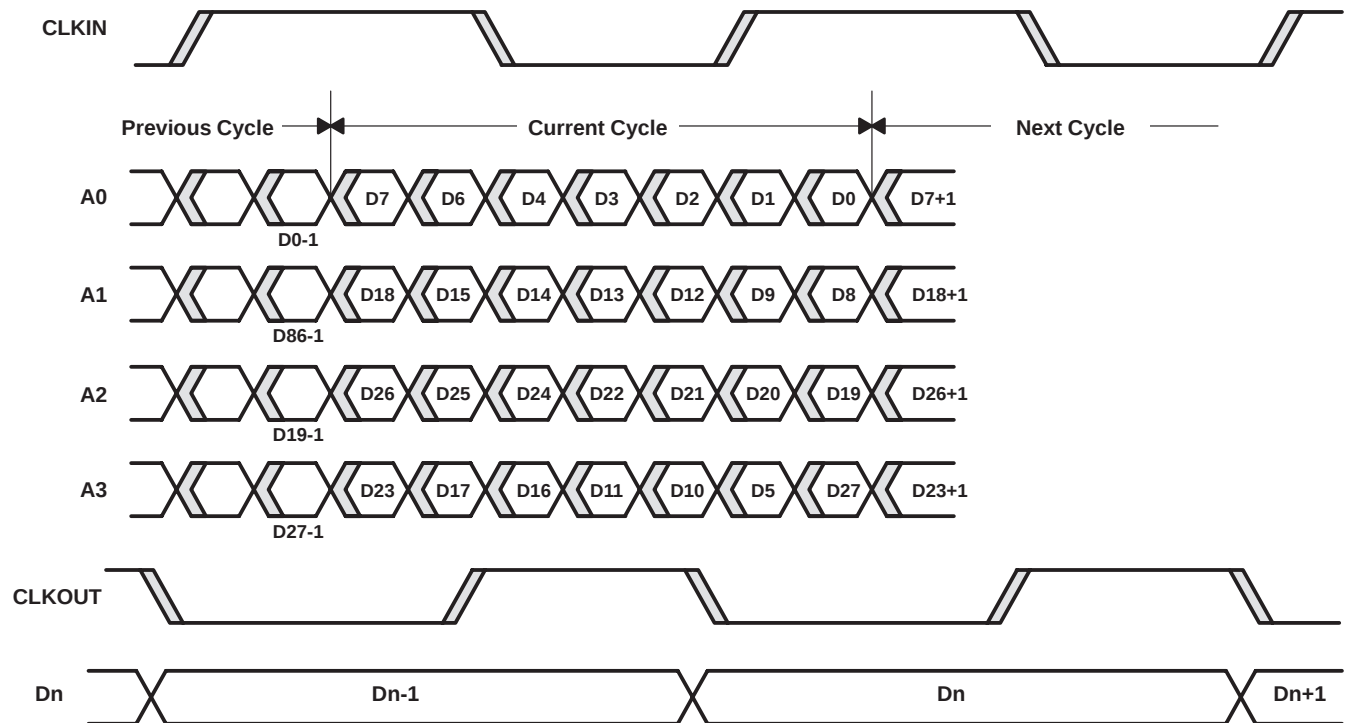
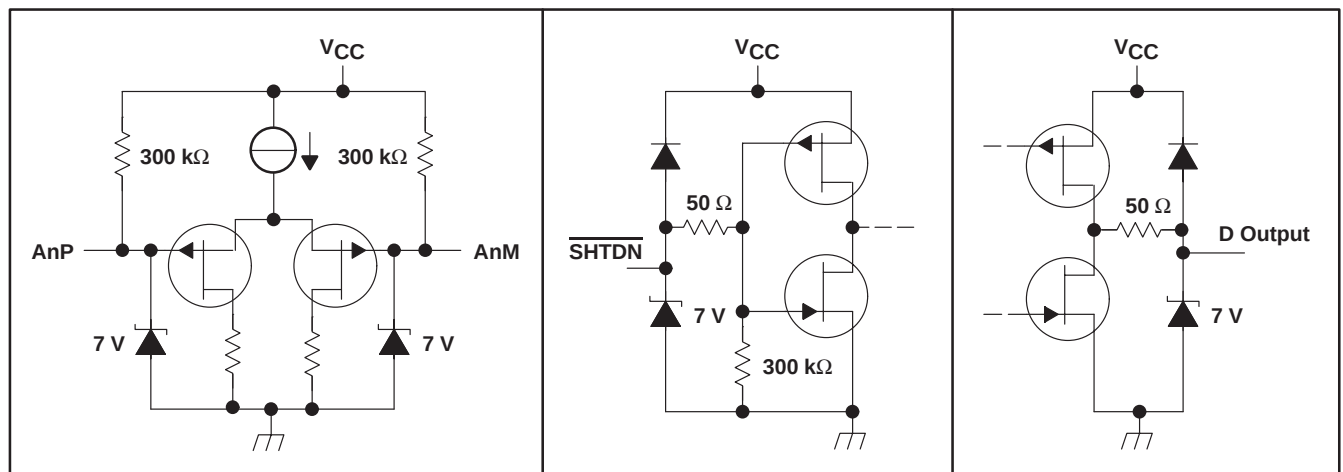


Figure 1. SN65LVDS94 Load and Shift Sequences

## equivalent input and output schematic diagrams



# SN65LVDS94

## LVDS SERDES RECEIVER

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### absolute maximum ratings over operating free-air temperature (unless otherwise noted)<sup>†</sup>

|                                                                   |                                |
|-------------------------------------------------------------------|--------------------------------|
| Supply voltage range, $V_{CC}$ (see Note 1)                       | –0.3 V to 4 V                  |
| Voltage range at any terminal (except $\overline{\text{SHTDN}}$ ) | –0.5 V to $V_{CC} + 0.5$ V     |
| Voltage range at $\overline{\text{SHTDN}}$ terminal               | –0.5 V to $V_{CC} + 3$ V       |
| Electrostatic discharge (see Note 2): Bus pins (Class 3A)         | 4 kV                           |
| Bus pins (Class 2B)                                               | 200 V                          |
| All pins (Class 3A)                                               | 3 kV                           |
| All pins (Class 2B)                                               | 200 V                          |
| Continuous total power dissipation                                | (see Dissipation Rating Table) |
| Operating free-air temperature range, $T_A$                       | –40°C to 85°C                  |
| Storage temperature range, $T_{stg}$                              | –65°C to 150°C                 |
| Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds      | 260°C                          |

<sup>†</sup> 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. All voltage values are with respect to the GND terminals unless otherwise noted.  
2. This rating is measured using MIL-STD-883C Method, 3015.7.

DISSIPATION RATING TABLE

| PACKAGE | $T_A \leq 25^\circ\text{C}$<br>POWER RATING | DERATING FACTOR <sup>‡</sup><br>ABOVE $T_A = 25^\circ\text{C}$ | $T_A = 70^\circ\text{C}$<br>POWER RATING | $T_A = 85^\circ\text{C}$<br>POWER RATING |
|---------|---------------------------------------------|----------------------------------------------------------------|------------------------------------------|------------------------------------------|
| DGG     | 1377 mW                                     | 11 mW/°C                                                       | 882 mW                                   | 717 mW                                   |

<sup>‡</sup> 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 |
|------------------------------------------------------------------|----------------------|---------------------------------|-----|------|
| Supply voltage, $V_{CC}$                                         | 3                    | 3.3                             | 3.6 | V    |
| High-level input voltage ( $\overline{\text{SHTDN}}$ ), $V_{IH}$ | 2                    |                                 |     | V    |
| Low-level input voltage ( $\overline{\text{SHTDN}}$ ), $V_{IL}$  |                      |                                 | 0.8 | V    |
| Magnitude of differential input voltage, $ V_{ID} $              | 0.1                  |                                 | 0.6 | V    |
| Common-mode input voltage, $V_{IC}$ (see Figures 2 and 3)        | $\frac{ V_{ID} }{2}$ | $2.4 \times \frac{ V_{ID} }{2}$ |     | V    |
|                                                                  |                      | $V_{CC}-0.8$                    |     |      |
| Operating free-air temperature, $T_A$                            | –40                  |                                 | 85  | °C   |

### timing requirements

|                            | MIN  | NOM   | MAX | UNIT |
|----------------------------|------|-------|-----|------|
| $t_c^S$ Input clock period | 15.4 | $t_c$ | 50  | Vns  |

<sup>S</sup>  $t_c$  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 <sup>†</sup> | MAX | UNIT |
|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|------|------------------|-----|------|
| V <sub>IT+</sub> Positive-going differential input voltage threshold              |                                                                                                         |      |                  | 100 | mV   |
| V <sub>IT-</sub> Negative-going differential input voltage threshold <sup>‡</sup> |                                                                                                         | -100 |                  |     |      |
| V <sub>OH</sub> High-level output voltage                                         | I <sub>OH</sub> = -4 mA                                                                                 | 2.4  |                  |     | V    |
| V <sub>OL</sub> Low-level output voltage                                          | I <sub>OL</sub> = 4 mA                                                                                  |      |                  | 0.4 | V    |
| I <sub>CC</sub> Quiescent current (average)                                       | Disabled, all inputs open                                                                               |      |                  | 280 | μA   |
|                                                                                   | Enabled, AnP at 1 V and AnM at 1.4 V, t <sub>c</sub> = 15.38 ns                                         |      | 62               | 84  | mA   |
|                                                                                   | Enabled, C <sub>L</sub> = 8 pF (5 places), Worst-case pattern (see Figure 4), t <sub>c</sub> = 15.38 ns |      | 107              |     | mA   |
| I <sub>IH</sub> High-level input current (SHTDN)                                  | V <sub>IH</sub> = V <sub>CC</sub>                                                                       |      |                  | ±20 | μA   |
| I <sub>IL</sub> Low-level input current (SHTDN)                                   | V <sub>IL</sub> = 0 V                                                                                   |      |                  | ±20 | μA   |
| I <sub>IN</sub> Input current (A inputs)                                          | 0 V ≤ V <sub>I</sub> ≤ 2.4 V                                                                            |      |                  | ±20 | μA   |
| I <sub>OZ</sub> High-impedance output current                                     | V <sub>O</sub> = 0 V or V <sub>CC</sub>                                                                 |      |                  | ±10 | μA   |

<sup>†</sup> All typical values are V<sub>CC</sub> = 3.3 V, T<sub>A</sub> = 25°C.

<sup>‡</sup> 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 <sup>†</sup>    | MAX | UNIT |
|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------------|-------------------------------|---------------------|-----|------|
| t <sub>su</sub> Data setup time, D0 through D27 to CLKOUT                         | C <sub>L</sub> = 8 pF See Figure 5                                              | 4                             | 6                   |     | ns   |
| t <sub>h</sub> Data hold time, CLKOUT to D0 through D27                           |                                                                                 | 4                             | 6                   |     |      |
| t <sub>RSKM</sub> Receiver input skew margin <sup>§</sup> (see Figure 7)          | t <sub>c</sub> = 15.38 ns (±0.2%),<br> Input clock jitter  < 50 ps <sup>¶</sup> | T <sub>A</sub> = 0°C to 85°C  |                     | 490 | ps   |
|                                                                                   |                                                                                 | T <sub>A</sub> = -40°C to 0°C |                     | 390 |      |
| t <sub>d</sub> Delay time, input clock to output clock (see Figure 7)             | t <sub>c</sub> = 15.38 ns (±0.2%)                                               |                               | 3.7                 |     | ns   |
| Δt <sub>C(O)</sub> Change in output clock period from cycle to cycle <sup>#</sup> | t <sub>c</sub> = 15.38 + 0.75 sin (2π500E3t) ± 0.05 ns, See Figure 7            |                               | ±80                 |     | ps   |
|                                                                                   | t <sub>c</sub> = 15.38 + 0.75 sin (2π3E6t) ± 0.05 ns, See Figure 7              |                               | ±300                |     |      |
| t <sub>en</sub> Enable time, SHTDN to phase lock                                  | See Figure 8                                                                    |                               | 1                   |     | ms   |
| t <sub>dis</sub> Disable time, SHTDN to Off state                                 | See Figure 9                                                                    |                               | 400                 |     | ns   |
| t <sub>t</sub> Output transition time (t <sub>r</sub> or t <sub>f</sub> )         | C <sub>L</sub> = 8 pF                                                           |                               | 3                   |     | ns   |
| t <sub>w</sub> Output clock pulse duration                                        |                                                                                 |                               | 0.43 t <sub>c</sub> |     | ns   |

<sup>§</sup> t<sub>RSKM</sub> is the timing margin available to allocate to the transmitter and interconnection skews and clock jitter. It is defined by

$$\frac{t_c}{14} - t_{s/h}.$$

<sup>¶</sup> |Input clock jitter| is the magnitude of the change in the input clock period.

<sup>#</sup> Δt<sub>C(O)</sub> is the change in the output clock period from one cycle to the next cycle observed over 15,000 cycles.

PARAMETER MEASUREMENT INFORMATION

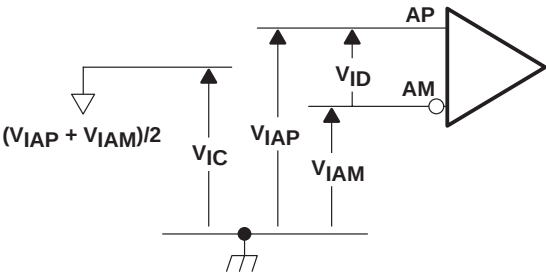


Figure 2. Voltage Definitions

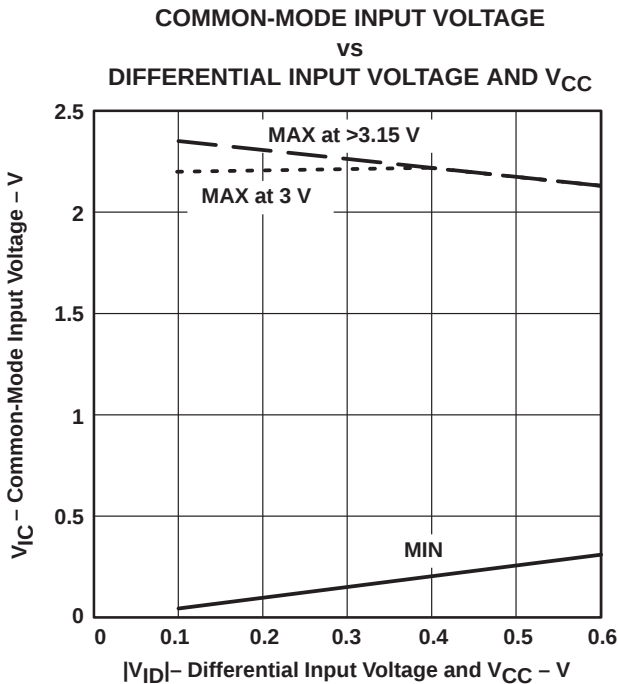
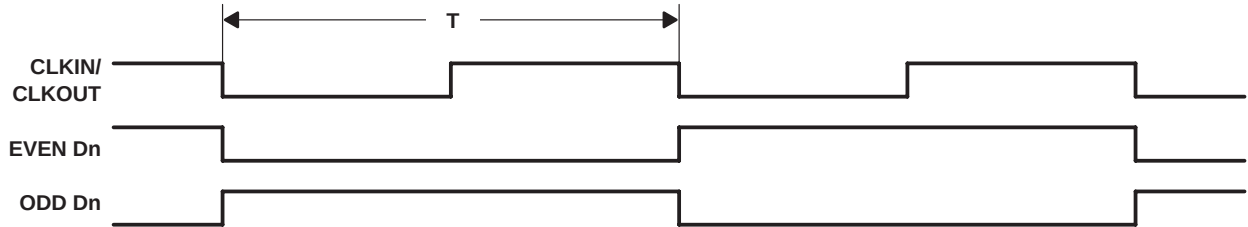


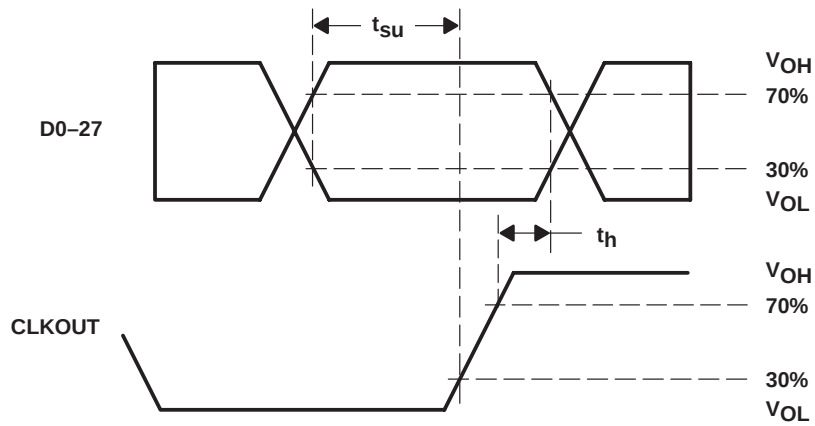
Figure 3. Recommended  $V_{IC}$  Versus  $V_{ID}$  and  $V_{CC}$

## PARAMETER MEASUREMENT INFORMATION



**Figure 4. Worst-Case Power Test Pattern**

‡ The worst-case test pattern produces nearly the maximum switching frequency for all of the LV-TTL outputs.



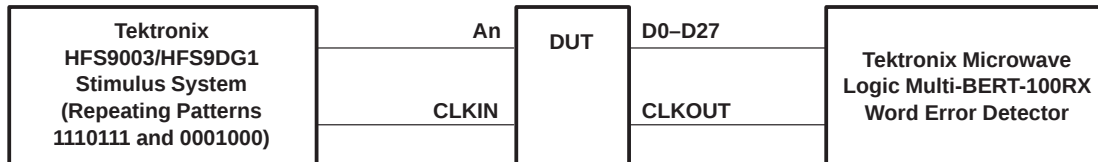
**Figure 5. Setup and Hold Time Measurements**

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### PARAMETER MEASUREMENT INFORMATION



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

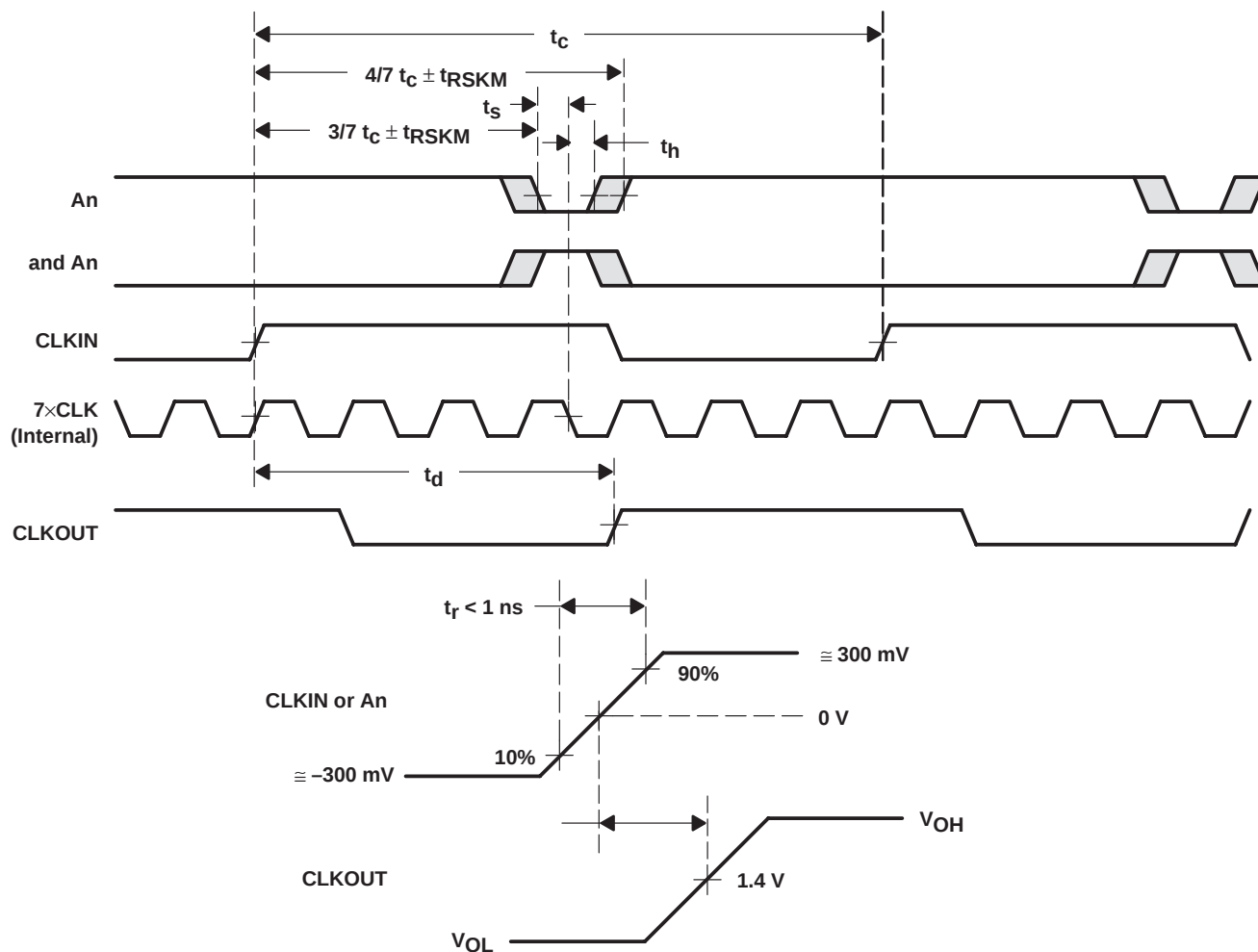


Figure 6. Receiver Input Skew Margin and  $t_d$  Definitions

## PARAMETER MEASUREMENT INFORMATION

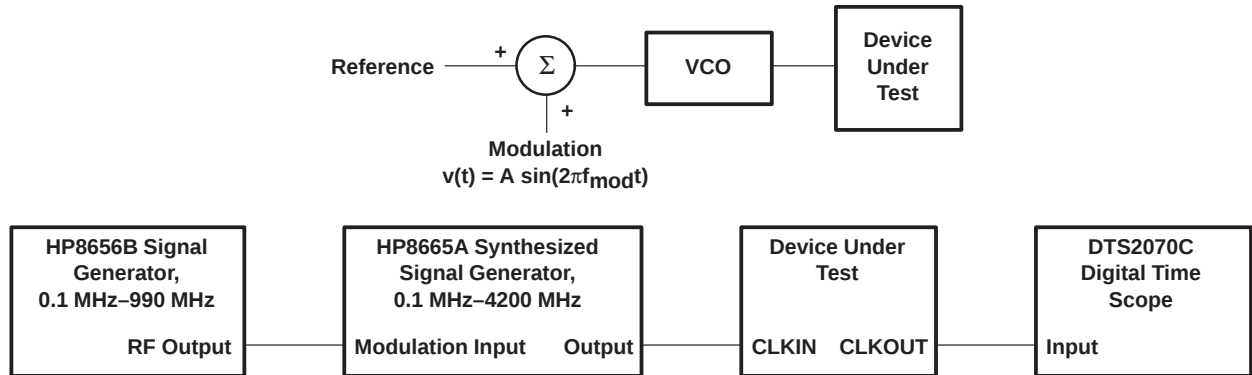


Figure 7. Output Clock Jitter Test Setup

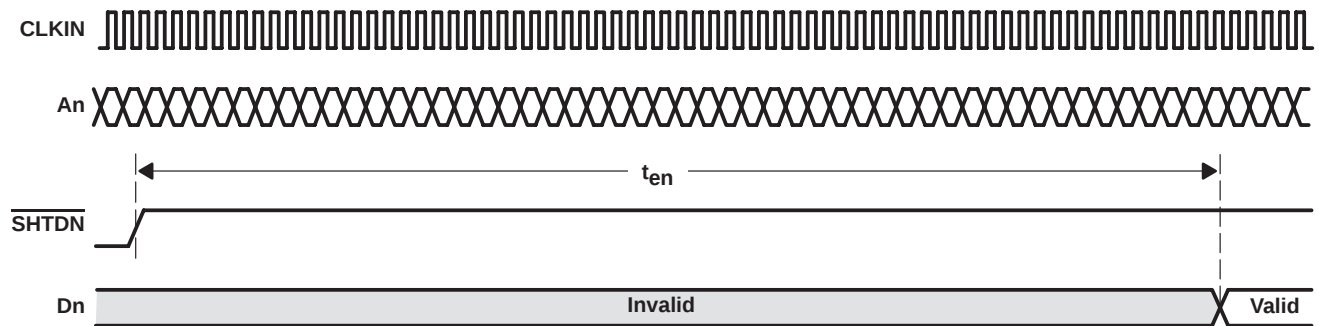


Figure 8. Enable Time Waveforms

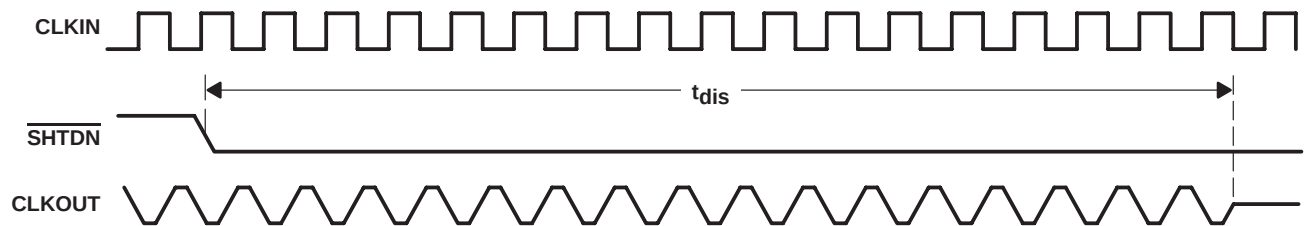


Figure 9. Disable Time Waveforms

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TYPICAL CHARACTERISTICS

WORST-CASE SUPPLY CURRENT  
VS  
FREQUENCY

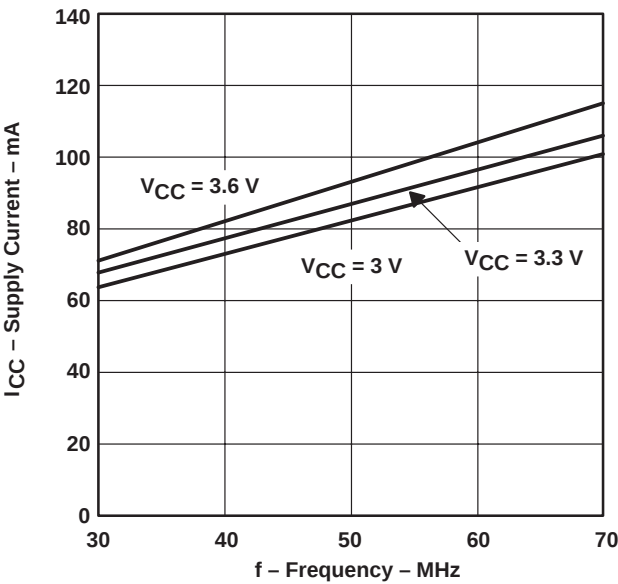


Figure 10

## 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.

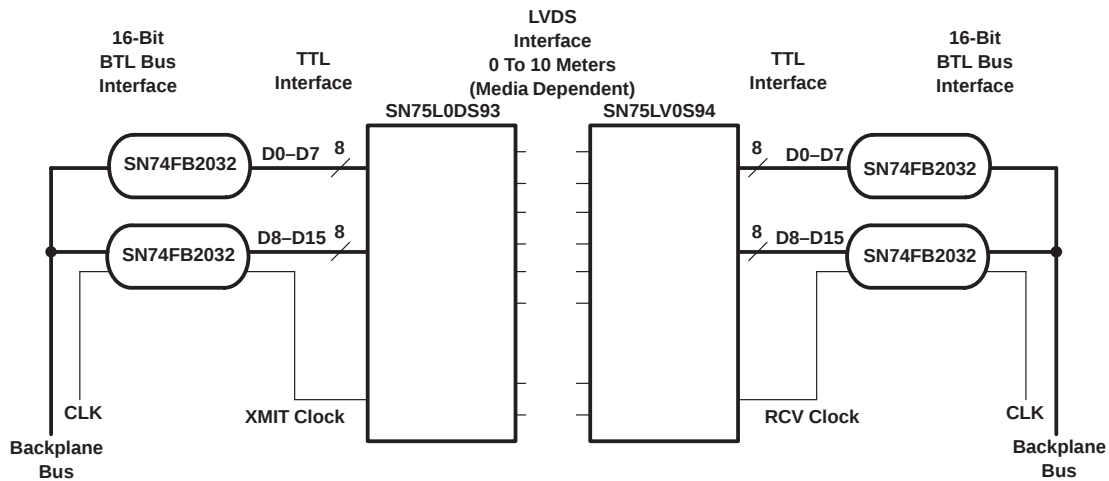


Figure 11. 16-Bit Bus Extension

### 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.

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## APPLICATION INFORMATION

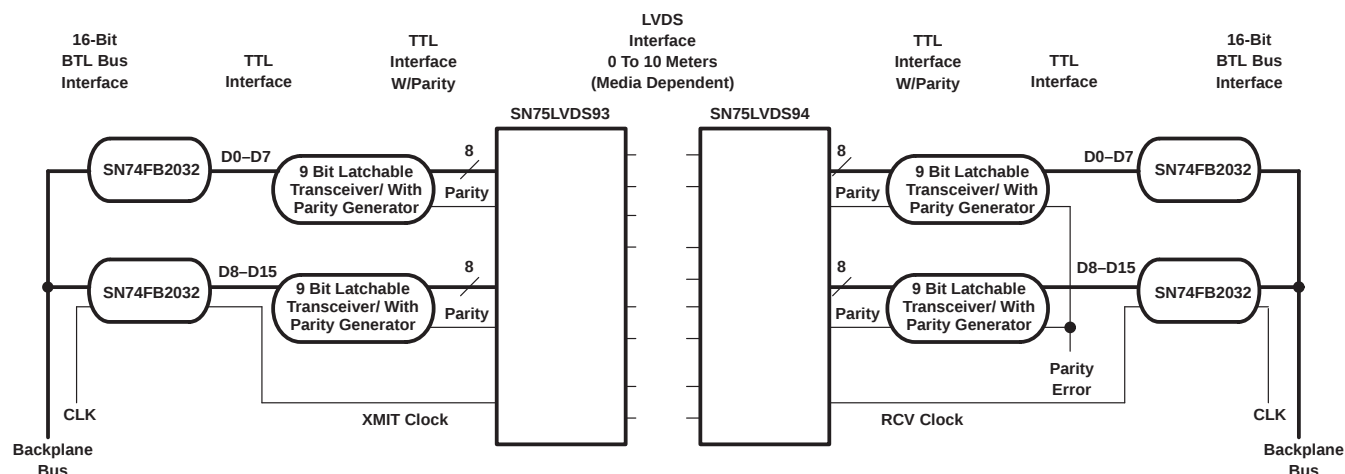


Figure 12. 16-Bit Bus Extension With Parity

### 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.

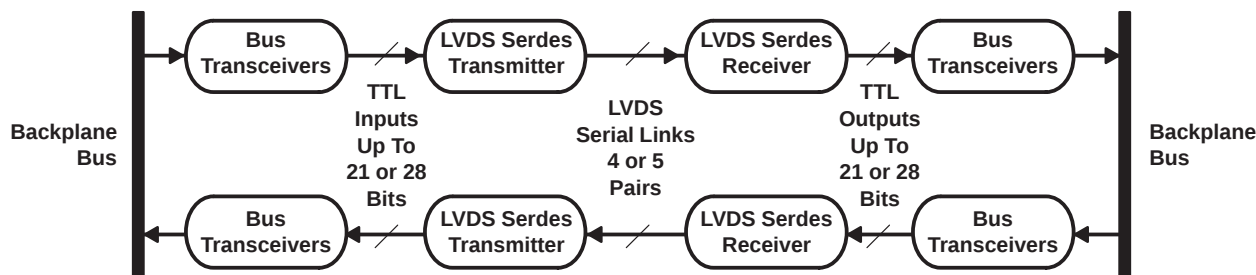


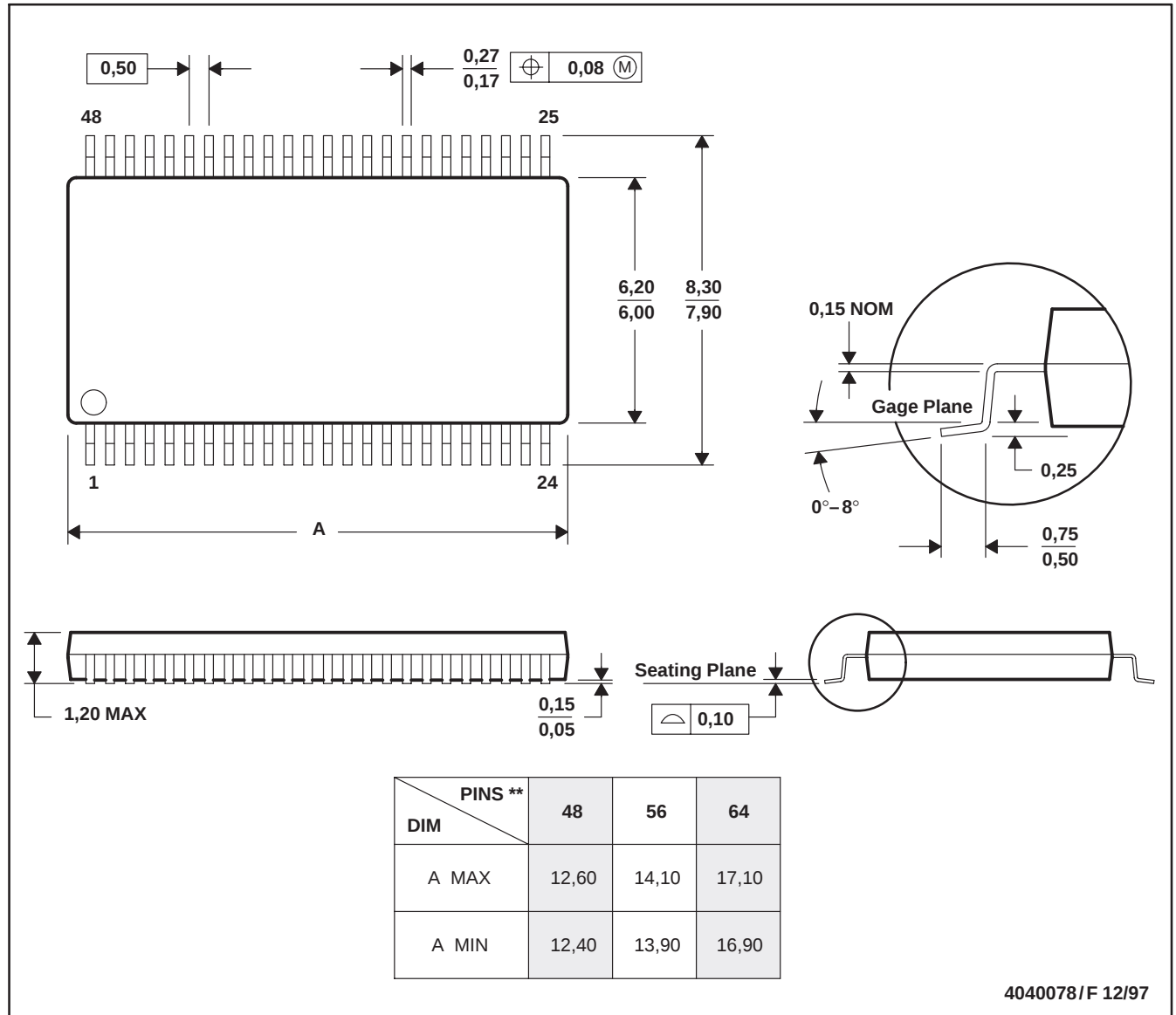
Figure 13. Virtual Backplane Transceiver

# MECHANICAL DATA

DGG (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE PACKAGE

48 PIN SHOWN



- NOTES: A. All linear dimensions are in millimeters.  
B. This drawing is subject to change without notice.  
C. Body dimensions do not include mold protrusion not to exceed 0,15.  
D. Falls within JEDEC MO-153

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