

## DC TO 4-GBPS DUAL 1:2 MULTIPLEXER/REPEATER/EQUALIZER

### FEATURES

- Receiver Equalization and Selectable Driver Preemphasis to Counteract High-Frequency Transmission Line Losses
- Integration of Two-Serial Port
- Selectable Loopback
- Typical Power Consumption 650 mW
- 30-ps Deterministic Jitter
- On-Chip 100- $\Omega$  Receiver and Driver Differential Termination Resistors Eliminate External Components and Reflection from Stubs
- 3.3-V Nominal Power Supply

- 48-Terminal QFN (Quad Flatpack No-lead)  
7 mm  $\times$  7 mm  $\times$  1 mm, 0.5-mm Terminal Pitch

### APPLICATIONS

- Bidirectional Link Replicator
- Signal Conditioner
- XAUI 802.3ae Protocol Backplane Redundancy
- Host Adapter (Applications With Internal and External Connection to SERDES)
- Signaling Rates DC to 4 Gbps Including XAUI, GbE, FC, HDTV

### DESCRIPTION

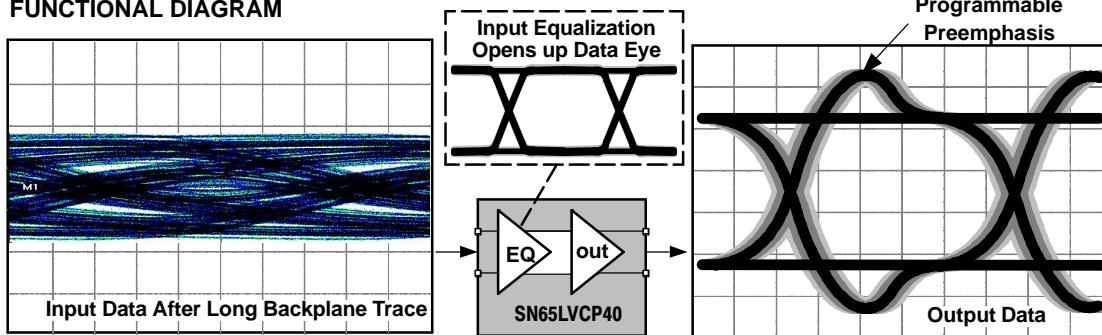
The SN65LVCP40 is a signal conditioner and data multiplexer optimized for backplanes. Input equalization and programmable output preemphasis support data rates up to 4 Gbps. Common applications are redundancy switching, signal buffering, or performance improvements on legacy backplane hardware.

The SN65LVCP40 combines a pair of 1:2 buffers with a pair of 2:1 multiplexers (mux). Selectable switch-side loopback supports system testing. System interconnects and serial backplane applications of up to 4 Gbps are supported. Each of the two independent channels consists of a transmitter with a fan-out of two, and a receiver with a 2:1 input multiplexer.

The drivers provide four selectable levels of preemphasis to compensate for transmission line losses. The receivers incorporate receive equalization and compensates for input transmission line loss. This minimizes deterministic jitter in the link. The equalization is optimized to compensate for a FR-4 backplane trace with 5-dB, high-frequency loss between 375 MHz and 1.875 MHz. This corresponds to a 24-inch long FR-4 trace with 6-mil trace width.

This device operates from a single 3.3-V supply. The device has integrated 100- $\Omega$  line termination and provides self-biasing. The input tolerates most differential signaling levels such as LVDS, LVPECL or CML. The output impedance matches 100- $\Omega$  line impedance. The inputs and outputs may be ac coupled for best interconnectivity with other devices such as SERDES I/O or additional XAUI multiplexer buffer. With ac coupling, jitter is the lowest.

**FUNCTIONAL DIAGRAM**



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.



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.

The SN65LVCP40 is packaged in a 7 mm × 7 mm × 1 mm QFN (quad flatpack no-lead) lead-free package, and is characterized for operation from 0°C to 85°C.

### AVAILABLE OPTIONS

T <sub>A</sub>	DESCRIPTION	PACKAGED DEVICE <sup>(1)</sup>
		RGZ (48 pin)
0°C to 85°C	Serial multiplexer	SN65LVCP40

(1) The package is available taped and reeled. Add an R suffix to device types (e.g., SN65LVCP40RGZR).

### ABSOLUTE MAXIMUM RATINGS

over operating free-air temperature range (unless otherwise noted)<sup>(1)</sup>

		UNIT
V <sub>CC</sub>	Supply voltage range <sup>(2)</sup>	–0.5 V to 6 V
Voltage range	Control inputs, all outputs	–0.5 V to (V <sub>CC</sub> + 0.5 V)
	Receiver inputs	–0.5 V to 4 V
ESD	Human Body Model <sup>(3)</sup>	All pins 4 kV
	Charged-Device Model <sup>(4)</sup>	All pins 500 V
Continuous power dissipation		See Dissipation Rating Table
Moisture sensitivity level		2
Reflow temperature package soldering, 4 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, except differential I/O bus voltages, are with respect to network ground terminal.

(3) Tested in accordance with JEDEC Standard 22, Test Method A114-A.

(4) Tested in accordance with JEDEC Standard 22, Test Method C101.

### POWER DISSIPATION RATINGS

PACKAGE THERMAL CHARACTERISTICS <sup>(1)</sup>		NOM	UNIT
θ <sub>JA</sub> (junction-to-ambient)	4-layer JEDEC Board (JESD51-7) using eight GND-vias Ø-0.2 on the center pad as shown in the section: <i>Recommended pcb footprint</i> with boundary and environment conditions of JEDEC Board (JESD51-2)	33.0	°C/W
θ <sub>JB</sub> (junction-to-board)		20.0	°C/W
θ <sub>JC</sub> (junction-to-case)		23.6	°C/W
PSI-jt (junction-to-top pseudo)		0.6	°C/W
PSI-jb (junction-to-board pseudo)		19.4	°C/W
θ <sub>JP</sub> (junction-to-pad)		5.4	°C/W

(1) See application note [SPRA953](http://www-s.ti.com/sc/psheets/spra953/spra953.pdf) for a detailed explanation of thermal parameters (<http://www-s.ti.com/sc/psheets/spra953/spra953.pdf>).

**RECOMMENDED OPERATING CONDITIONS**

		MIN	NOM	MAX	UNIT	
dR	Operating data rate			4.0	Gbps	
V <sub>CC</sub>	Supply voltage	3.135	3.3	3.465	V	
V <sub>CC(N)</sub>	Supply voltage noise amplitude	10 Hz to 2 GHz		20	mV	
T <sub>J</sub>	Junction temperature			125	°C	
T <sub>A</sub>	Operating free-air temperature <sup>(1)</sup>	0		85	°C	
<b>DIFFERENTIAL INPUTS</b>						
V <sub>ID</sub>	Receiver peak-to-peak differential input voltage <sup>(2)</sup>	dR <sub>(in)</sub> ≤ 1.25 Gbps		100	1750	mVpp
		1.25 Gbps < dR <sub>(in)</sub> ≤ 3.125 Gbps		100	1560	mVpp
		dR <sub>(in)</sub> > 3.125 Gbps		100	1000	mVpp
V <sub>ICM</sub>	Receiver common-mode input voltage	Note: for best jitter performance ac coupling is recommended.		1.5	1.6 V <sub>CC</sub> - $\frac{ V_{ID} }{2}$	V
<b>CONTROL INPUTS</b>						
V <sub>IH</sub>	High-level input voltage	2.0		V <sub>CC</sub> + 0.3	V	
V <sub>IL</sub>	Low-level input voltage	-0.3		0.8	V	
<b>DIFFERENTIAL OUTPUTS</b>						
R <sub>L</sub>	Differential load resistance	80	100	120	Ω	

(1) Maximum free-air temperature operation is allowed as long as the device maximum junction temperature is not exceeded.

(2) Differential input voltage V<sub>ID</sub> is defined as |IN+ – IN–|.

**ELECTRICAL CHARACTERISTICS**

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

PARAMETER	TEST CONDITIONS	MIN	TYP <sup>(1)</sup>	MAX	UNIT
<b>DIFFERENTIAL INPUTS</b>					
V <sub>IT+</sub>	Positive going differential input high threshold			50	mV
V <sub>IT-</sub>	Negative going differential input low threshold	-50			mV
A <sub>(EQ)</sub>	Equalizer gain	From 375 MHz to 1.875 GHz		5	dB
R <sub>T(D)</sub>	Termination resistance, differential	80	100	120	Ω
V <sub>BB</sub>	Open-circuit Input voltage (input self-bias voltage)	AC-coupled inputs		1.6	V
R <sub>(BBDC)</sub>	Biassing network dc impedance		30		kΩ
R <sub>(BBAC)</sub>	Biassing network ac impedance	375 MHz		42	Ω
		1.875 GHz		8.4	
<b>DIFFERENTIAL OUTPUTS</b>					
V <sub>OH</sub>	High-level output voltage	R <sub>L</sub> = 100 Ω±1%, PRES_1 = PRES_0=0; PREL_1 = PREL_0=0; 4 Gbps alternating 1010-pattern; Figure 1		650	mVpp
V <sub>OL</sub>	Low-level output voltage			-650	mVpp
V <sub>ODB(PP)</sub>	Output differential voltage without preemphasis <sup>(2)</sup>	1000	1300	1500	mVpp
V <sub>OCM</sub>	Output common mode voltage			1.65	V
ΔV <sub>OC(SS)</sub>	Change in steady-state common-mode output voltage between logic states	See Figure 6		1	mV

(1) All typical values are at T<sub>A</sub> = 25°C and V<sub>CC</sub> = 3.3 V supply unless otherwise noted. They are for reference purposes and are not production tested.

(2) Differential output voltage V<sub>(ODB)</sub> is defined as |OUT+ – OUT–|.

**ELECTRICAL CHARACTERISTICS (continued)**

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

PARAMETER		TEST CONDITIONS		MIN	TYP <sup>(1)</sup>	MAX	UNIT
$V_{(PE)}$	Output preemphasis voltage ratio, $\frac{V_{ODB(PP)}}{V_{ODPE(PP)}}$	$R_L = 100 \Omega \pm 1\%$ ; $x = L$ or $S$ ; See <a href="#">Figure 1</a>	PREx_1:PREx_0 = 00		0		dB
			PREx_1:PREx_0 = 01		3		
			PREx_1:PREx_0 = 10		6		
			PREx_1:PREx_0 = 11		9		
$t_{(PRE)}$	Preemphasis duration measurement	Output preemphasis is set to 9 dB during test PREx_x = 1; Measured with a 100-MHz clock signal; $R_L = 100 \Omega, \pm 1\%$ , See <a href="#">Figure 2</a>			175		ps
$r_o$	Output resistance	Differential on-chip termination between OUT+ and OUT–			100		$\Omega$
<b>CONTROL INPUTS</b>							
$I_{IH}$	High-level Input current	$V_{IN} = V_{CC}$				5	$\mu A$
$I_{IL}$	Low-level Input current	$V_{IN} = GND$			90	125	$\mu A$
$R_{(PU)}$	Pullup resistance				35		k $\Omega$
<b>POWER CONSUMPTION</b>							
$P_D$	Device power dissipation	All outputs terminated 100 $\Omega$			650	880	mW
$I_{CC}$	Device current consumption	All outputs terminated 100 $\Omega$	PRBS 2 <sup>7-1</sup> pattern at 4 Gbps			254	mA

**SWITCHING CHARACTERISTICS**

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

PARAMETER		TEST CONDITIONS		MIN	TYP <sup>(1)</sup>	MAX	UNIT
<b>MULTIPLEXER</b>							
$t_{(SM)}$	Multiplexer switch time	Multiplexer or loopback control to valid output			3	6	ns
<b>DIFFERENTIAL OUTPUTS</b>							
$t_{PLH}$	Low-to-high propagation delay	Propagation delay input to output See <a href="#">Figure 4</a>			0.5	1	ns
$t_{PHL}$	High-to-low propagation delay				0.5	1	ns
$t_r$	Rise time	20% to 80% of $V_{O(DB)}$ ; Test Pattern: 100-MHz clock signal; See <a href="#">Figure 3</a> and <a href="#">Figure 7</a>			80		ps
$t_f$	Fall time				80		ps
$t_{sk(p)}$	Pulse skew, $ t_{PHL} - t_{PLH} ^{(2)}$					20	ps
$t_{sk(o)}$	Output skew <sup>(3)</sup>	All outputs terminated with 100 $\Omega$			25	200	ps
$t_{sk(pp)}$	Part-to-part skew <sup>(4)</sup>					500	ps
RJ	Device random jitter, rms	See <a href="#">Figure 7</a> for test circuit. BERT setting 10 <sup>-15</sup> Alternating 10-pattern.			0.8	2	ps-rms

(1) All typical values are at 25°C and with 3.3 V supply unless otherwise noted.

(2)  $t_{sk(p)}$  is the magnitude of the time difference between the  $t_{PLH}$  and  $t_{PHL}$  of any output of a single device.(3)  $t_{sk(o)}$  is the magnitude of the time difference between the  $t_{PLH}$  and  $t_{PHL}$  of any two outputs of a single device.(4)  $t_{sk(pp)}$  is the magnitude of the difference in propagation delay times between any specified terminals of two devices when both devices operate with the same supply voltages, at the same temperature, and have identical packages and test circuits.

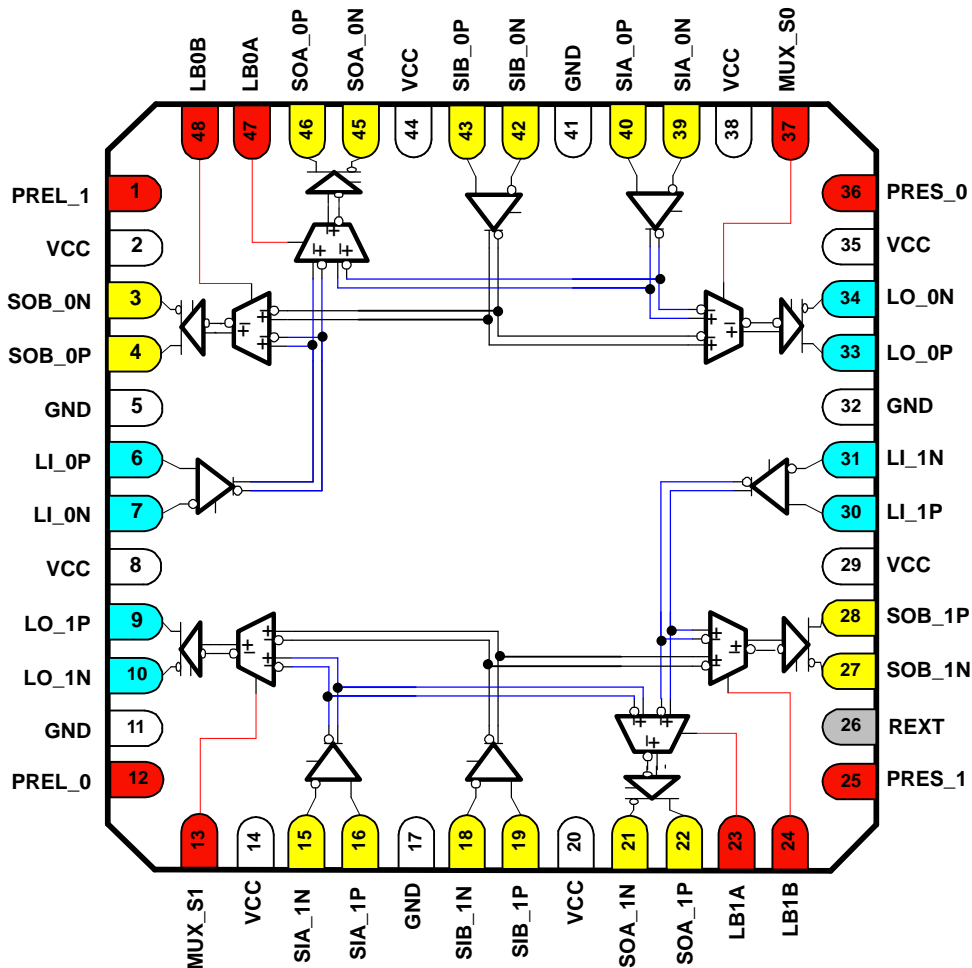
## SWITCHING CHARACTERISTICS (continued)

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

PARAMETER		TEST CONDITIONS		MIN	TYP <sup>(1)</sup>	MAX	UNIT
DJ	Intrinsic deterministic device jitter <sup>(5)(6)</sup> , peak-to-peak	0 dB preemphasis (PRE <sub>x</sub> = 0); See Figure 7 for the test circuit.	PRBS 2 <sup>7</sup> -1 pattern			30	ps
	Absolute deterministic output jitter <sup>(7)</sup> , peak-to-peak	0 dB preemphasis (PRE <sub>x</sub> = 0); See Figure 7 for the test circuit.	PRBS 2 <sup>7</sup> -1 pattern		7		ps
					20		ps

- (5) Intrinsic deterministic device jitter is a measurement of the deterministic jitter contribution from the device. It is derived by the equation  $(DJ_{(OUT)} - DJ_{(IN)})$ , where  $DJ_{(OUT)}$  is the total peak-to-peak deterministic jitter measured at the output of the device in pspp.  $DJ_{(IN)}$  is the peak-to-peak deterministic jitter of the pattern generator driving the device.
- (6) The SN65LVCP40 built-in passive input equalizer compensates for ISI. For a 20-inch FR4 transmission line with 8-mil trace width, the LVCP40 typically reduces jitter by 60 ps from the device input to the device output.
- (7) Absolute deterministic output jitter reflects the deterministic jitter measured at the SN65LVCP40 output. The value is a real measured value with a Bit error tester as described in Figure 7. The absolute DJ reflects the sum of all deterministic jitter components accumulated over the link:  $DJ_{(absolute)} = DJ_{(Signal\ generator)} + DJ_{(transmission\ line)} + DJ_{(intrinsic(LVCP40))}$ .

## PIN ASSIGNMENTS

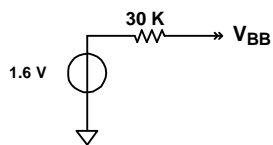
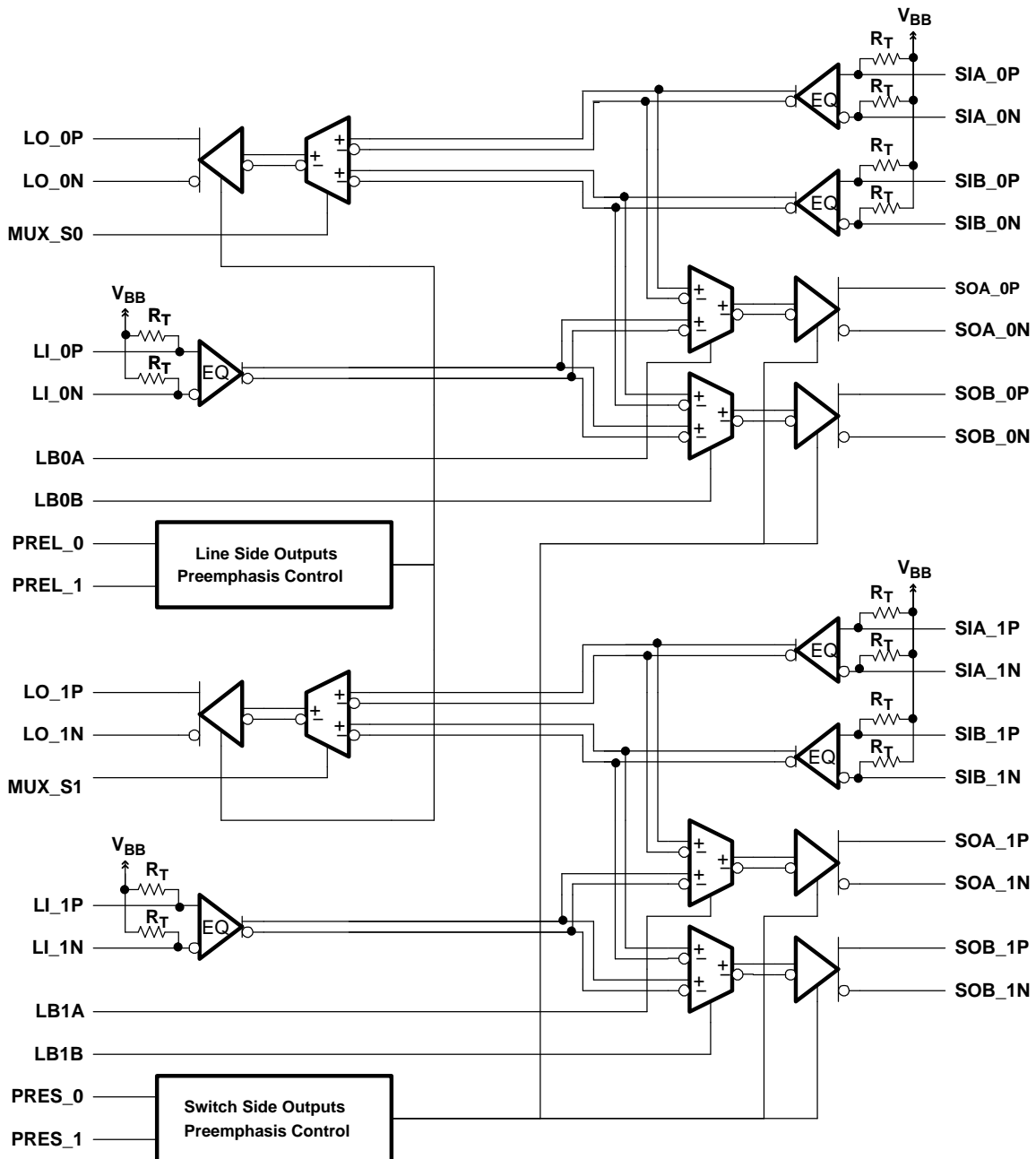


**Table 1. Signal Descriptions**

SIGNAL	PIN(S)	TYPE	SIGNAL TYPE	DESCRIPTION
<b>LINE SIDE HIGH-SPEED I/O</b>				
LI_0P LI_0N	6 7	I (w/ 50-Ω termination to VBB)	PECL/CML compatible	Differential input, port_0 line side
LI_1P LI_1N	30 31	I (w/ 50-Ω termination to VBB)	PECL/CML compatible	Differential input, port_1 line side
LO_0P LO_0N	33 34	O	VML <sup>(1)</sup>	Differential output, port_0 line side
LO_1P LO_1N	9 10	O	VML <sup>(1)</sup>	Differential output, port_1 line side
<b>SWITCH SIDE HIGH-SPEED I/O</b>				
SIA_0P SIA_0N	40 39	I (w/ 50-Ω termination to VBB)	CML/PECL compatible	Differential input, mux_0 switch_A_side
SIB_0P SIB_0N	43 42	I (w/ 50-Ω termination to VBB)	CML/PECL compatible	Differential input, mux_0 switch_B_side
SIA_1P SIA_1N	16 15	I (w/ 50-Ω termination to VBB)	CML/PECL compatible	Differential input, mux_1 switch_A_side
SIB_1P SIB_1N	19 18	I (w/ 50-Ω termination to VBB)	CML/PECL compatible	Differential input, mux_1 switch_B_side
SOA_0P SOA_0N	46 45	O	VML <sup>(1)</sup>	Differential output, mux_0 switch_A_side
SOB_0P SOB_0N	4 3	O	VML <sup>(1)</sup>	Differential output, mux_0 switch_B_side
SOA_1P SOA_1N	22 21	O	VML <sup>(1)</sup>	Differential output, mux_1 switch_A_side
SOB_1P SOB_1N	28 27	O	VML <sup>(1)</sup>	Differential output, mux_1 switch_B_side
<b>CONTROL SIGNALS</b>				
PREL_0 PREL_1	12 1	I (w/ 35-kΩ pullup)	LVTTTL	Output preemphasis control, line side port_0 and port_1. Has internal pull-up. See <b>Preemphasis Controls PREL_0, PREL_1, PRES_0 and PRES</b> for function definition.
PRES_0 PRES_1	36 25	I (w/ 35-kΩ pullup)	LVTTTL	Output preemphasis control, switch side port_0 and port_1. See <b>Preemphasis Controls PREL_0, PREL_1, PRES_0 and PRES</b> for function definition.
LB0A LB0B	47 48	I (w/ 35-kΩ pullup)	LVTTTL	Loopback control for mux_0 switch side. See <b>Loopback Controls LB0A, LB0B, LB1A and LB1B</b> for function definition.
LB1A LB1B	23 24	I (w/ 35-kΩ pullup)	LVTTTL	Loopback control for mux_1 switch side. See <b>Loopback Controls LB0A, LB0B, LB1A and LB1B</b> for function definition.
MUX_S0 MUX_S1	37 13	I (w/ 35-kΩ pullup)	LVTTTL	Port A and B multiplex control of mux_0 and mux_1. See <b>Multiplex Controls MUX_S0 and MUX_S1</b> for function definition.
REXT	26		N/A	No connect. This pin is unused and can be left open or tied to GND with any resistor.
<b>POWER SUPPLY</b>				
VCC	2, 8, 14, 20, 29, 35, 38, 44	PWR		Power supply 3.3 V ±5%
GND	5, 11, 17, 32, 41	PWR		Power supply return
GND Center Pad		PWR		The ground center pad is the metal contact at the bottom of the 48-pin package. It must be connected to the GND plane. At least 4 vias are recommended to minimize inductance and provide a solid ground. See the package drawing for the via placement.

(1) VML stands for Voltage Mode logic; VML provides a differential output impedance of 100-Ω. VML offers the benefits of CML and consumes less power.

**FUNCTIONAL BLOCK DIAGRAM**



- Note:**
- V<sub>BB</sub>:** Receiver input internal biasing voltage (allows ac coupling)
  - EQ:** Input Equalizer (compensates for frequency dependent transmission line loss of backplanes)
  - R<sub>T</sub>:** Internal 50-Ohm receiver termination (100-Ohm differential)
- Preemphasis:** Output precompensation for transmission line losses

## FUNCTIONAL DEFINITIONS

**Table 2. Multiplex Controls MUX\_S0 and MUX\_S1**

MUX_Sn <sup>(1)</sup>	MUX FUNCTION
0	MUX_n select input B
1	MUX_n select input A

(1) n = 0 or 1

**Table 3. Loopback Controls LB0A, LB0B, LB1A and LB1B**

LBnx <sup>(1)</sup>	LOOPBACK FUNCTION
0	Enable loopback of S <sub>lx</sub> input to S <sub>Ox</sub> output
1	Disable loopback of S <sub>lx</sub> input to S <sub>Ox</sub> output

(1) n = 0 or 1, x = A or B

**Table 4. Multiplexer and Loopback Controls**

INPUTS / OUTPUTS	SOA_0	SOB_0	SOA_1	SOB_1	LO_0	LO_1
SIA_0	LB0A = 0	x	x	x	MUX_S0 = 1	x
SIB_0	x	LB0B = 0	x	x	MUX_S0 = 0	x
SIA_1	x	x	LB1A = 0	x	x	MUX_S1 = 1
SIB_1	x	x	x	LB1B = 0	x	MUX_S1 = 0
LI_0	LB0A = 1	LB0B = 1	x	x	x	x
LI_1	x	x	LB1A = 1	LB1B = 1	x	x

**Table 5. Preemphasis Controls PREL\_0, PREL\_1, PRES\_0, and PRES\_1**

PREx_1 <sup>(1)</sup>	PREx_0 <sup>(1)</sup>	OUTPUT PREEMPHASIS LEVEL IN dB	OUTPUT LEVEL IN mVpp		TYPICAL FR4 TRACE LENGTH
			DEEMPHASIZED	PREEMPHASIZED	
0	0	0 dB	1200	1200	10 inches of FR4 trace
0	1	3 dB	850	1200	20 inches of FR4 trace
1	0	6 dB	600	1200	30 inches of FR4 trace
1	1	9 dB	425	1200	40 inches of FR4 trace

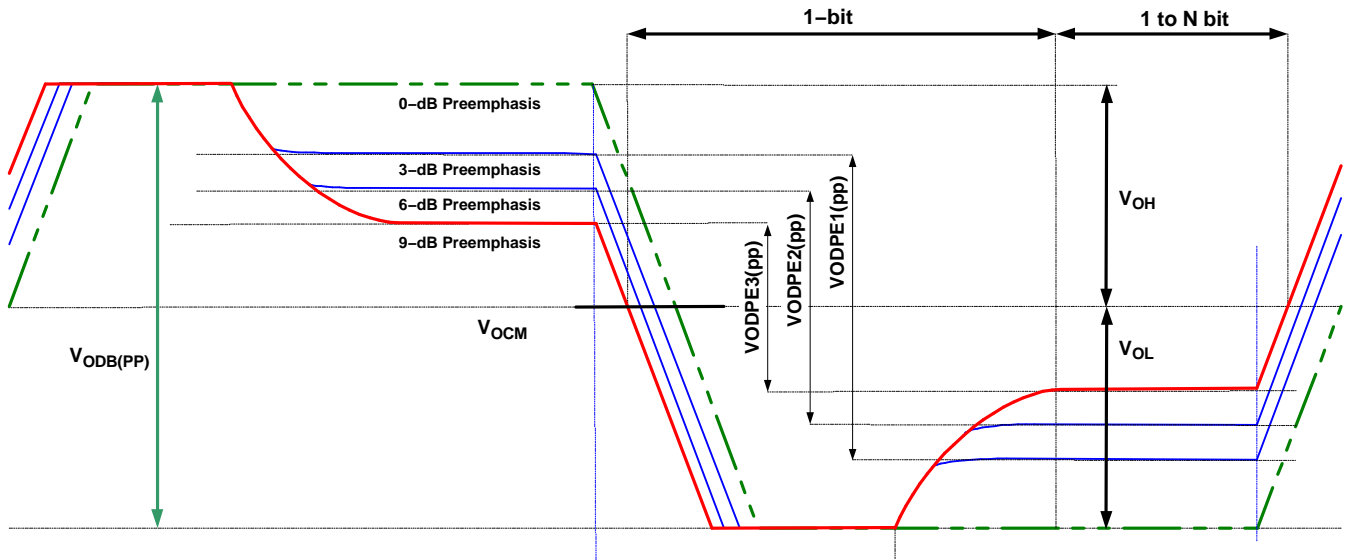
(1) x = L or S

Preemphasis is the primary signal conditioning mechanism. See [Figure 1](#) and [Figure 2](#) for further definition.

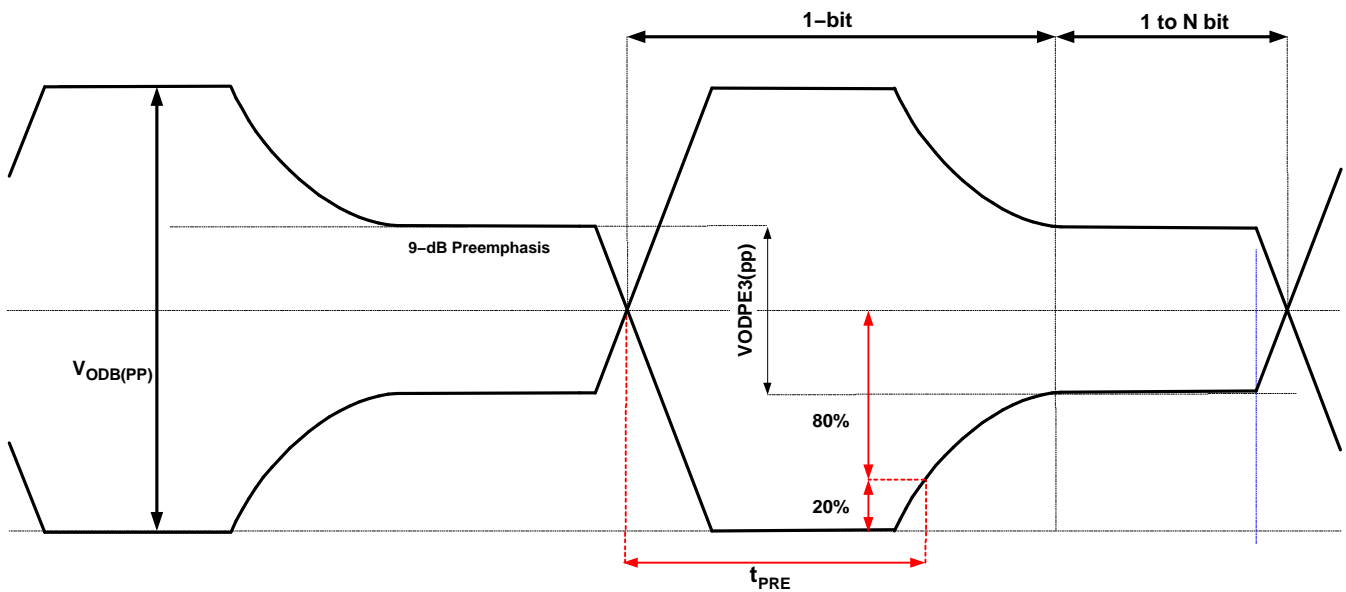
Equalization is secondary signal conditioning mechanism. The input stage provides 5-dB of fixed equalization gain from 375 MHz to 1.875 GHz (optimized for 3.75-Gbps 8B10B coded data).



**PARAMETER MEASUREMENT INFORMATION**



**Figure 1. Preemphasis and Output Voltage Waveforms and Definitions**



**Figure 2.  $t_{PRE}$  Preemphasis Duration Measurement**

PARAMETER MEASUREMENT INFORMATION (continued)

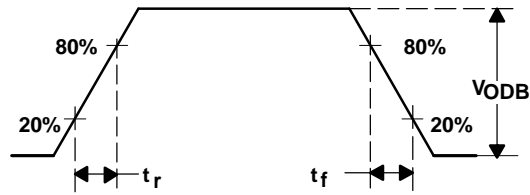


Figure 3. Driver Output Transition Time

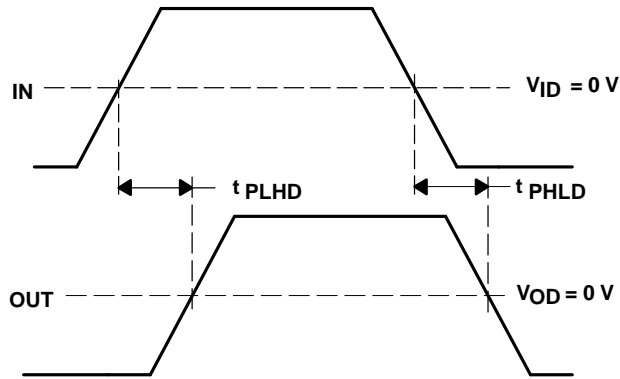


Figure 4. Propagation Delay Input to Output

CIRCUIT DIAGRAMS

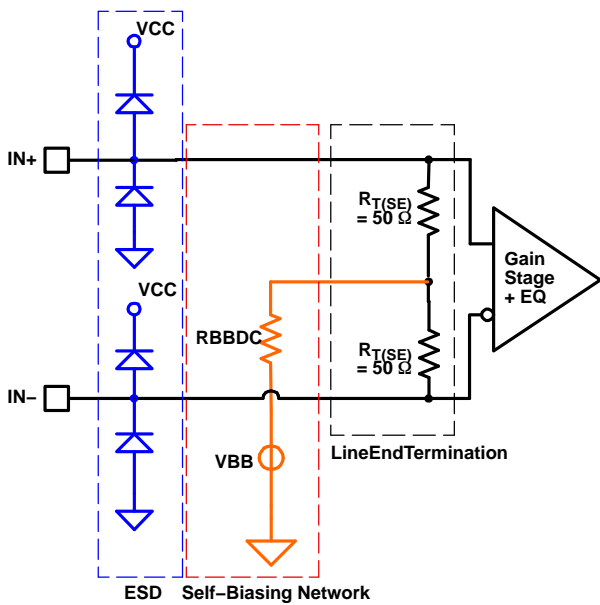


Figure 5. Equivalent Input Circuit Design

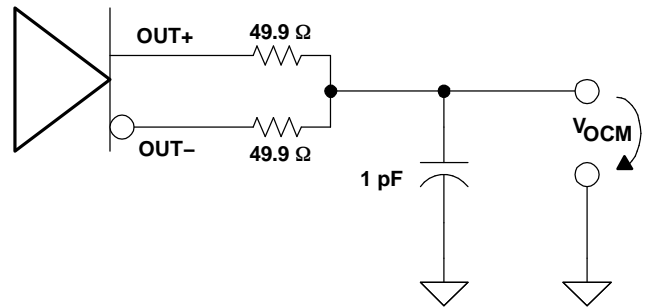
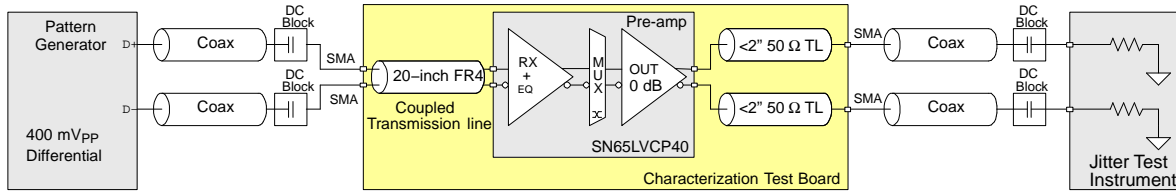


Figure 6. Common-Mode Output Voltage Test Circuit

**JITTER TEST CIRCUIT**

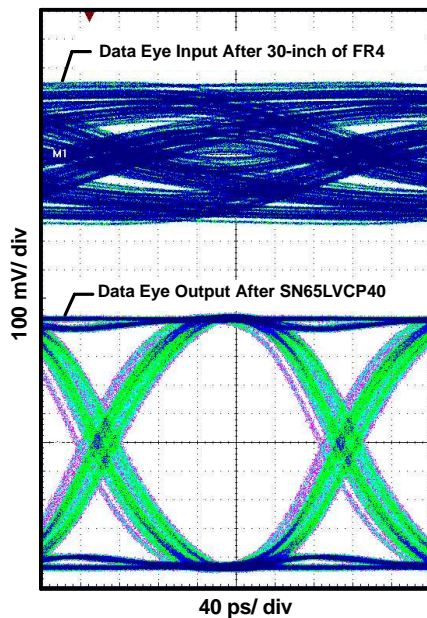


NOTE: For the Jitter Test, the preemphasis level of the output is set to 0 dB (PREx\_x=0)

**Figure 7. AC Test Circuit – Jitter and Output Rise Time Test Circuit**

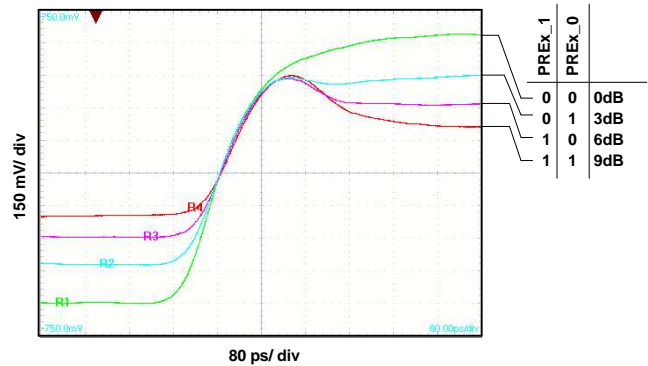
The SN65LVCP40 input equalizer provides 5-dB frequency gain to compensate for frequency loss of a shorter backplane transmission line. For characterization purposes, a 24-inch FR-4 coupled transmission line is used in place of the backplane trace. The 24-inch trace provides roughly 5 dB of attenuation between 375 MHz and 1.875 GHz, representing closely the characteristics of a short backplane trace. The loss tangent of the FR4 in the test board is 0.018 with an effective  $\epsilon(r)$  of 3.1.

**TYPICAL DEVICE BEHAVIOR**



NOTE: 30 Inch Input Trace, dR = 4 Gbps;  $2^{7-1}$  PRBS

**Figure 8. Data Input and Output Pattern**



**Figure 9. Preemphasis Signal Shape**

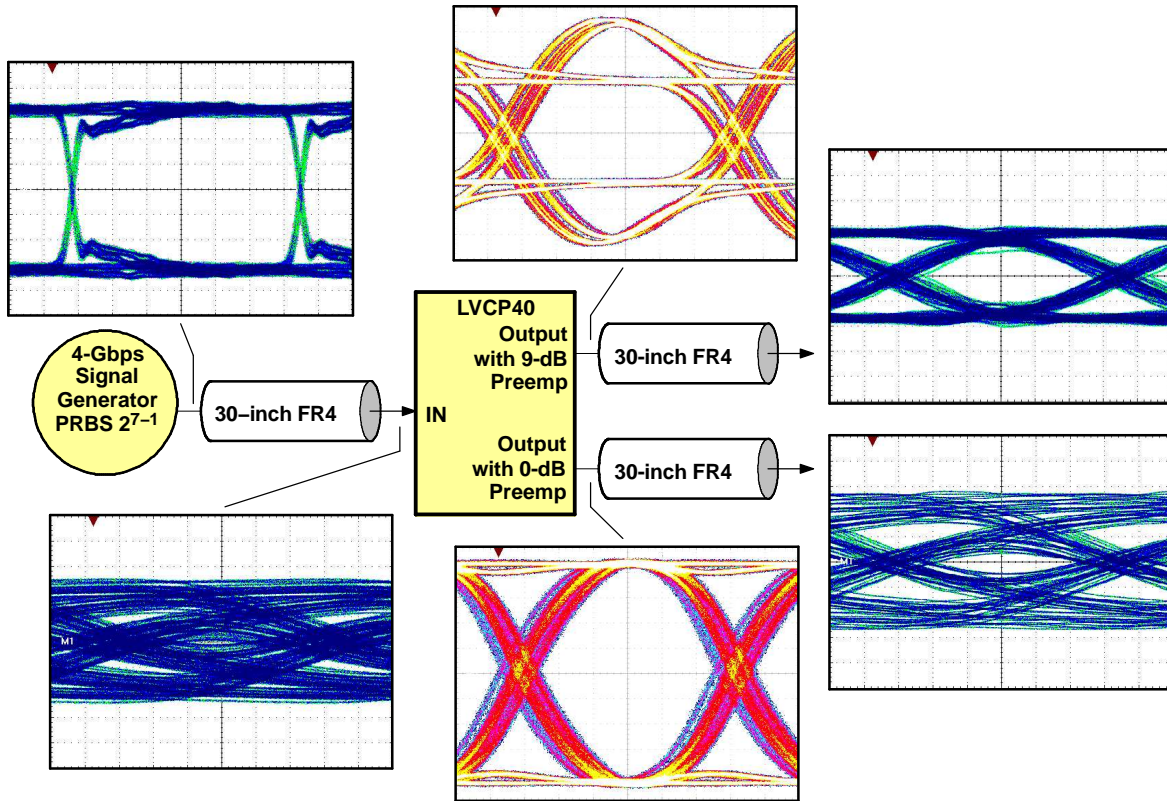


Figure 10. Data Output Pattern

TYPICAL CHARACTERISTICS

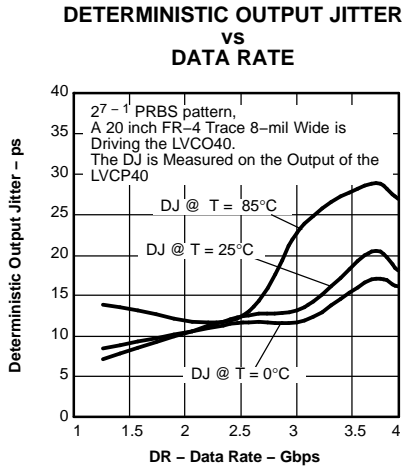


Figure 11.

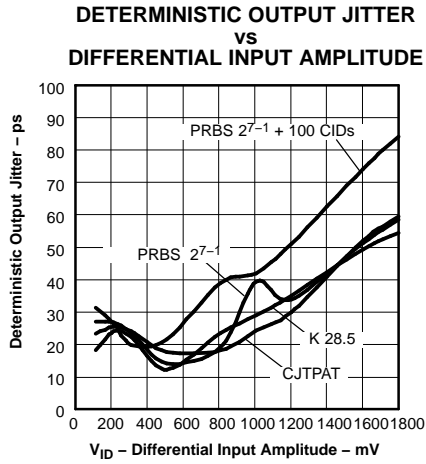


Figure 12.

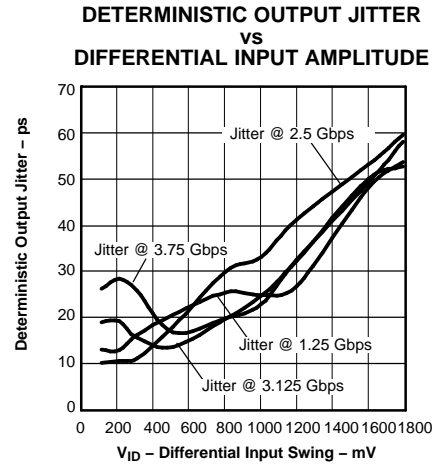


Figure 13.

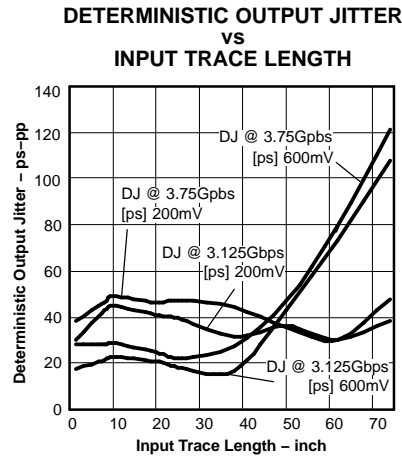


Figure 14.

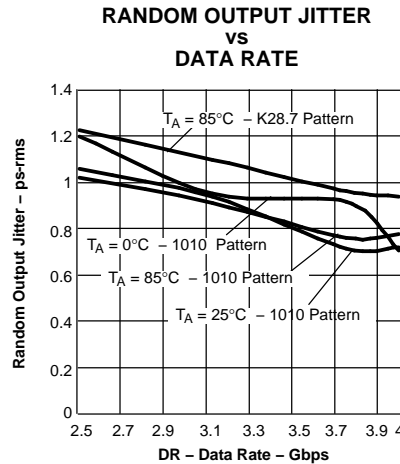


Figure 15.

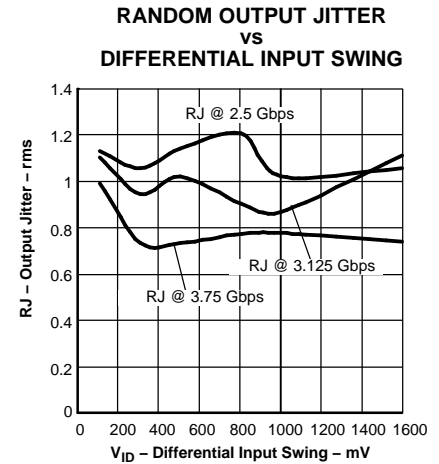


Figure 16.

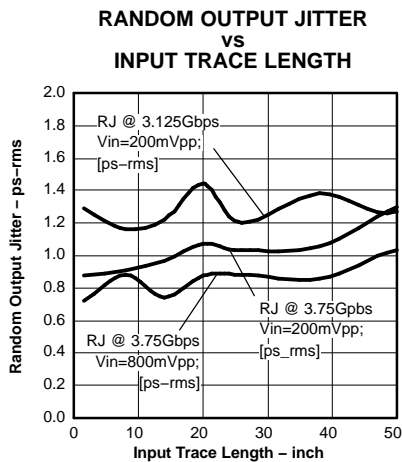


Figure 17.

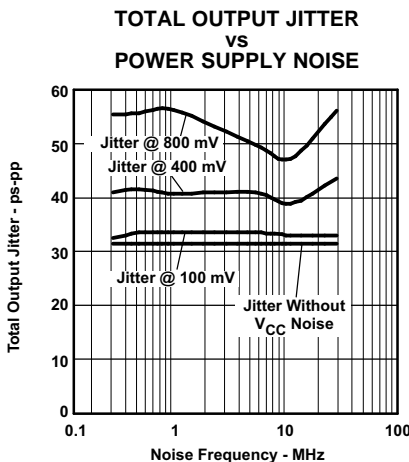


Figure 18.

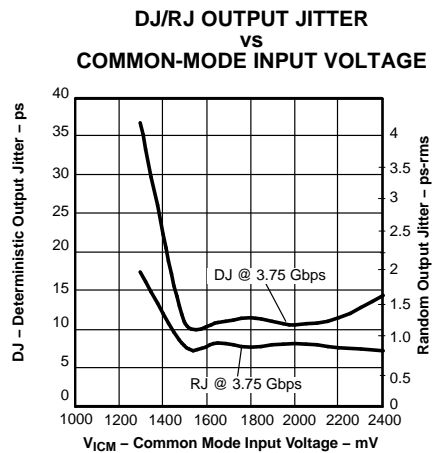


Figure 19.

TYPICAL CHARACTERISTICS (continued)

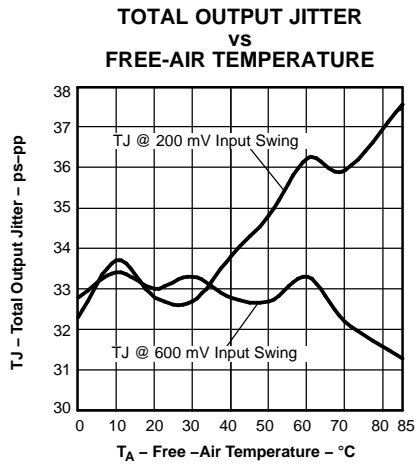


Figure 20.

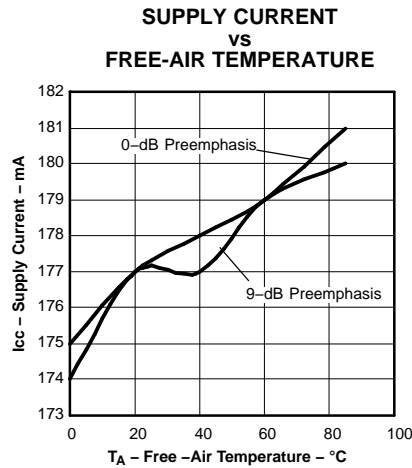


Figure 21.

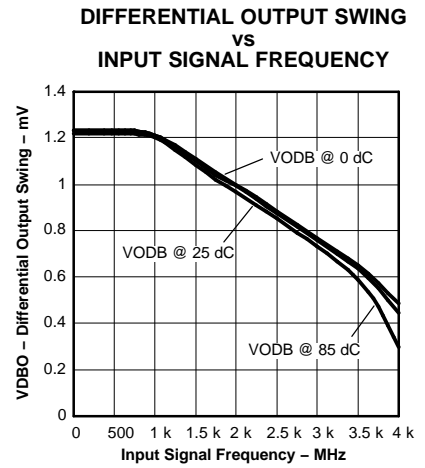


Figure 22.

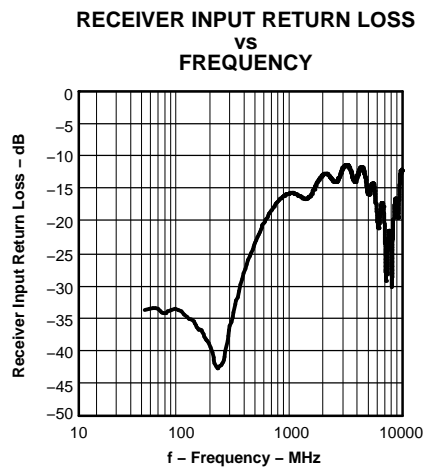
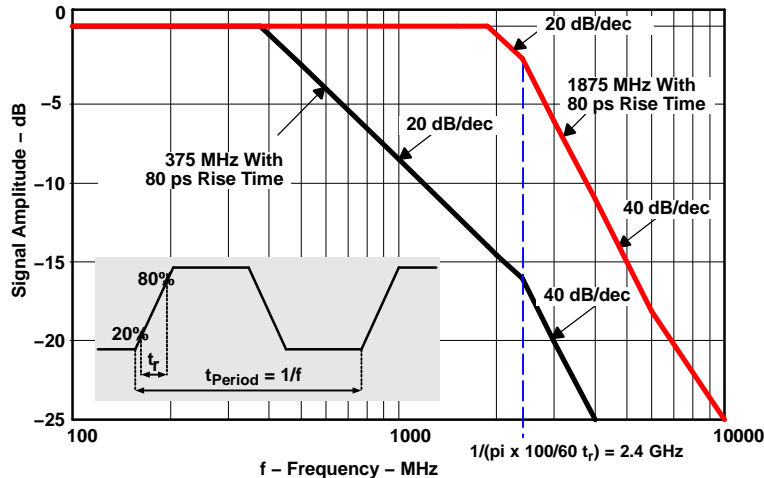


Figure 23.

## APPLICATION INFORMATION

### BANDWIDTH REQUIREMENTS

Error free transmission of data over a transmission line has specific bandwidth demands. It is helpful to analyze the frequency spectrum of the transmit data first. For an 8B10B coded data stream at 3.75 Gbps of random data, the highest bit transition density occurs with a 1010 pattern (1.875 GHz). The least transition density in 8B10B allows for five consecutive ones or zeros. Hence, the lowest frequency of interest is  $1.875 \text{ GHz}/5 = 375 \text{ MHz}$ . Real data signals consist of higher frequency components than sine waves due to the fast rise time. The faster the rise time, the more bandwidth becomes required. For 80-ps rise time, the highest important frequency component is at least  $0.6/(\pi \times 80 \text{ ps}) = 2.4 \text{ GHz}$ . Figure 24 shows the Fourier transformation of the 375-MHz and 1.875-GHz trapezoidal signal.



**Figure 24. Approximate Frequency Spectrum of the Transmit Output Signal With 80 ps Rise Time**

The spectrum analysis of the data signal suggests building a backplane with little frequency attenuation up to 2 GHz. Practically, this is achievable only with expensive, specialized PCB material. To support material like FR4, a compensation technique is necessary to compensate for backplane imperfections.

### EXPLANATION OF EQUALIZATION

Backplane designs differ widely in size, layer stack-up, and connector placement. In addition, the performance is impacted by trace architecture (trace width, coupling method) and isolation from adjacent signals. Common to most commercial backplanes is the use of FR4 as board material and its related high-frequency signal attenuation. Within a backplane, the shortest to longest trace lengths differ substantially – often ranging from 8 inches up to 40 inches. Increased loss is associated with longer signal traces. In addition, the backplane connector often contributes a good amount of signal attenuation. As a result, the frequency signal attenuation for a 300-MHz signal might range from 1 dB to 4 dB while the corresponding attenuation for a 2-GHz signal might span 6 dB to 24 dB. This frequency dependent loss causes distortion jitter on the transmitted signal. Each LVCP40 receiver input incorporates an equalizer and compensates for such frequency loss. The SN65LVCP40 equalizer provides 5 dB of frequency gain between 375 MHz and 1.875 GHz, compensating roughly for 20 inches of FR4 material with 8-mil trace width. Distortion jitter improvement is substantial, often providing more than 30-ps jitter reduction. The 5-dB compensation is sufficient for most short backplane traces. For longer trace lengths, it is recommended to enable transmit preemphasis in addition.

### SETTING THE PREEMPHASIS LEVEL

The receive equalization compensates for ISI. This reduces jitter and opens the data eye. In order to find the best preemphasis setting for each link, calibration of every link is recommended. Assuming each link consists of a transmitter (with adjustable pre-emphasis such as LVCP40) and the LVCP40 receiver, the following steps are necessary:

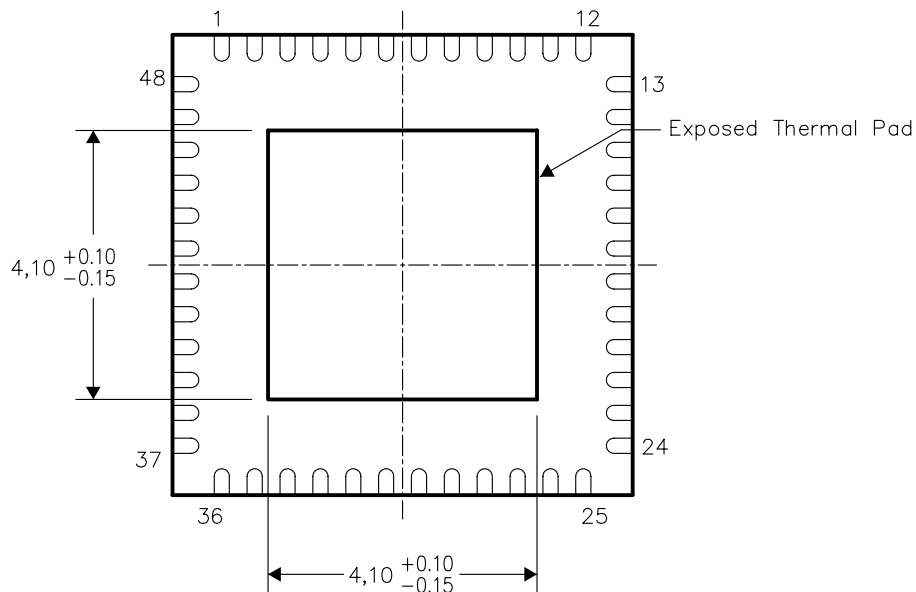
1. Set the transmitter and receiver to 0-dB preemphasis; record the data eye on the LVCP40 receiver output.
2. Increase the transmitter preemphasis until the data eye on the LVCP40 receiver output looks the cleanest.

THERMAL INFORMATION

This package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (PCB), the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to a ground plane or special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For information on the Quad Flatpack No-Lead (QFN) package and its advantages, refer to Application Report, Quad Flatpack No-Lead Logic Packages, Texas Instruments Literature No. SCBA017. This document is available at [www.ti.com](http://www.ti.com).

The exposed thermal pad dimensions for this package are shown in the following illustration.



Bottom View

NOTE: All linear dimensions are in millimeters

Exposed Thermal Pad Dimensions



**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
SN65LVCP40RGZ	ACTIVE	QFN	RGZ	48	52	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
SN65LVCP40RGZR	ACTIVE	QFN	RGZ	48	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR

<sup>(1)</sup> 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.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS) 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.

**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)

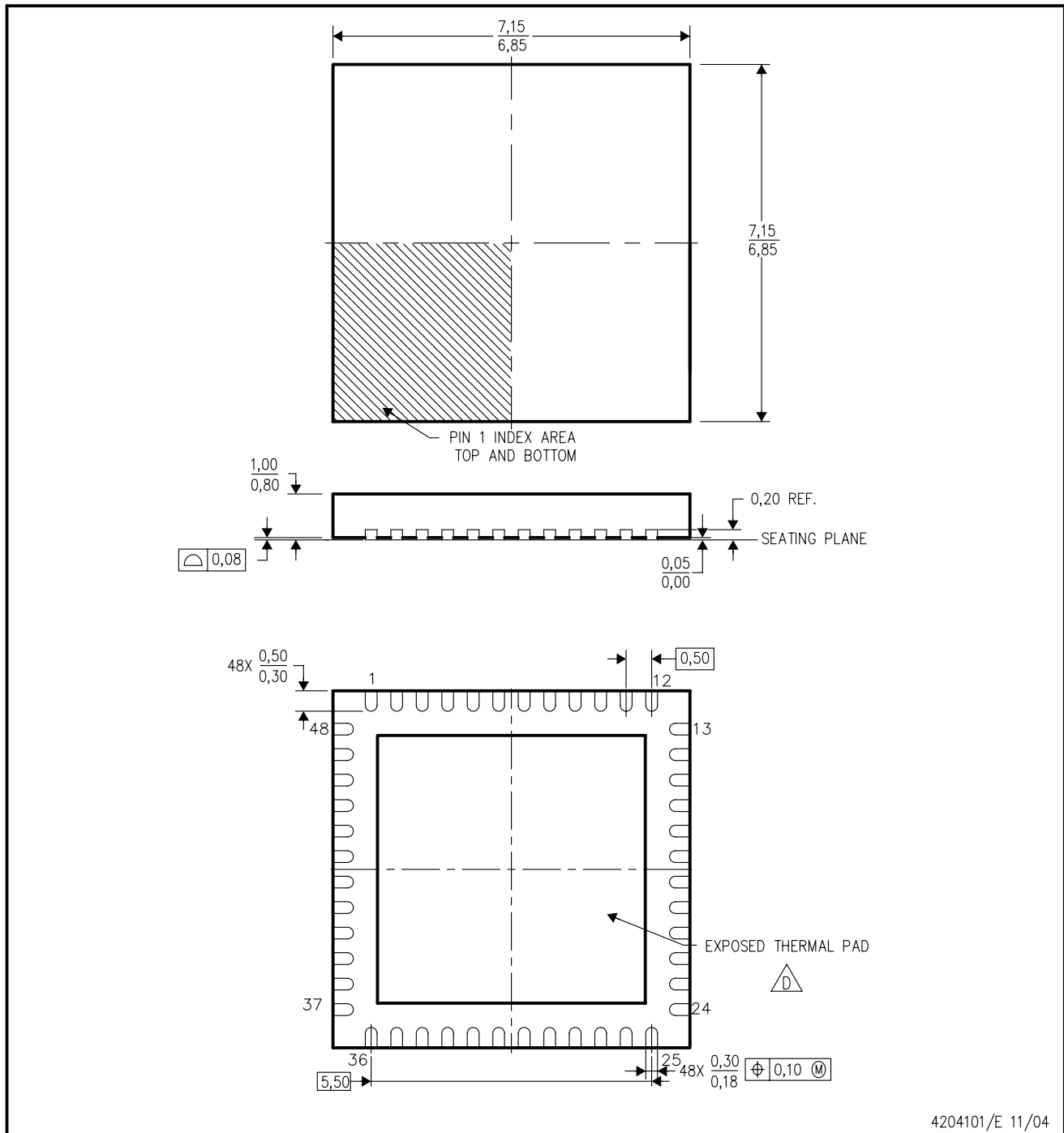
<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.


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RGZ (S-PQFP-N48)

PLASTIC QUAD FLATPACK



- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - B. This drawing is subject to change without notice.
  - C. Quad Flatpack, No-leads (QFN) package configuration.
  -  The package thermal pad must be soldered to the board for thermal and mechanical performance. See the Product Data Sheet for details regarding the exposed thermal pad dimensions.
  - E. Falls within JEDEC MO-220.

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