

Gigabit 2 × 2 CROSSPOINT SWITCH

FEATURES

- Up to 2.5-Gbps Operation
- Nonblocking Architecture Allows Each Output to Be Connected to Any Input
- 30 ps of Deterministic Jitter
- Selectable Transmit Preemphasis Per Lane
- Receive Equalization
- Available Packaging: 24-Pin QFN
- Propagation Delay Times: 500 ps Typical
- Inputs Electrically Compatible With CML Signal Levels
- Operates From a Single 3.3-V Supply
- Outputs Can Be Driven to Hi-Z State
- Low Power: 290 mW (typ)
- Integrated Termination Resistors

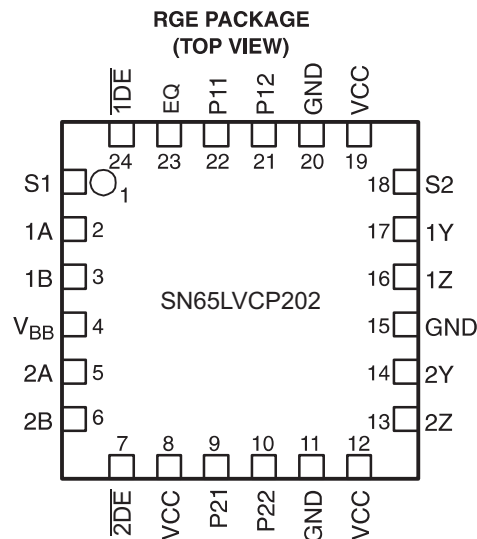
APPLICATIONS

- Clock Buffering/Clock MUXing
- Wireless Base Stations
- High-Speed Network Routing
- Telecom/Datacom

DESCRIPTION

The SN65LVCP202 is a 2 × 2 nonblocking crosspoint switch in a flow-through pinout allowing for ease in PCB layout. VML signaling is used to achieve a high-speed data throughput while using low power. Each of the output drivers includes a 2:1 multiplexer to allow any input to be routed to any output. Internal signal paths are fully differential to achieve high signaling speeds while maintaining low signal skews. The SN65LVCP202 incorporates 100-Ω termination resistors for those applications where board space is at a premium. Transmit preemphasis and receive equalization are built in for superior signal integrity performance.

The SN65LVCP202 is characterized for operation from –40°C to 85°C.

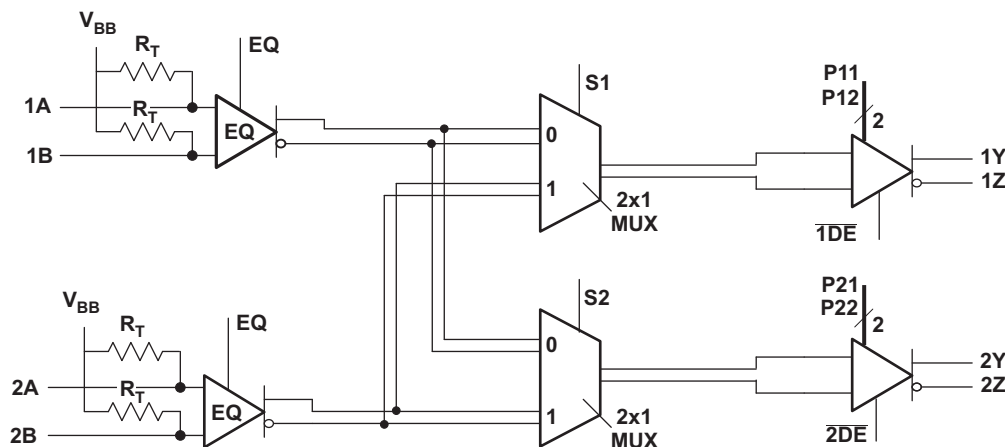


Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.



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.

LOGIC DIAGRAM



- Note:**
- V_{BB}:** Receiver input internal biasing voltage (allows ac coupling)
 - EQ:** Input equalizer (compensates for frequency dependent transmission line loss of backplanes)
 - R_T:** Internal 50-Ω receiver termination (100-Ω differential)
 - Preemphasis:** Output precompensation for transmission line losses

TERMINAL FUNCTIONS

TERMINAL		TYPE	DESCRIPTION
NAME	NO.		
High Speed I/O			
xA xB	2, 5 3, 6	Differential Inputs (with 50-Ω termination to V _{BB}) xA = P; xB = N	Line-side differential inputs, CML compatible
xY xZ	17, 14 16, 13	Differential output xY = P; xZ = N	Switch-side differential outputs, VML
Control Signals			
\overline{xDE}	24, 7	Input	Data enable; active-low; LVTTTL; when not enabled, the output is in high-impedance state for power savings.
S1, S2	1, 18	Input; S1 = channel 1	Switching selection; LVTTTL
P11–P22	22, 21, 9, 10	Input; P11 = channel 1 bit 1	Output preemphasis control; LVTTTL
EQ	23	Input: Selection for receive equalization setting	EQ = 1 (default) is for the 5-dB setting; EQ = 0 is for the 12-dB setting.
Power Supply			
VCC	8, 12, 19	Power	Power supply, 3.3 V ±5%
GND	11, 15, 20		Ground
Thermal pad	Thermal pad		The ground center pad of the package must be connected to GND plane with thermal vias.
V _{BB}	4	Input	Receiver input biasing voltage

EQUIVALENT INPUT AND OUTPUT SCHEMATIC DIAGRAMS

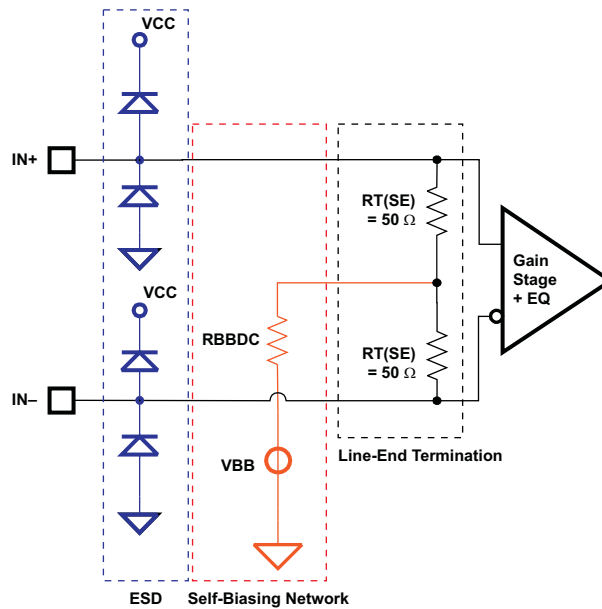


Figure 1. Equivalent Input Circuit Design

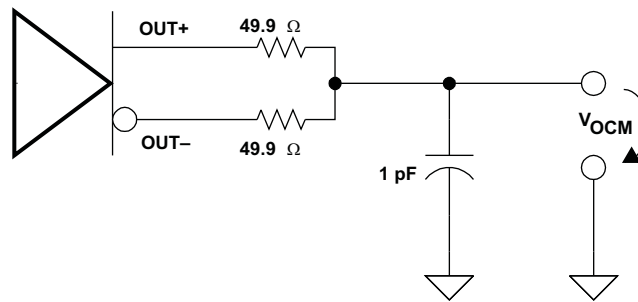


Figure 2. Common-Mode Output Voltage Test Circuit

Table 1. CROSSPOINT LOGIC TABLE

OUTPUT CHANNEL 1 (1Y/1Z)		OUTPUT CHANNEL 2 (2Y/2Z)	
CONTROL PINS, S1x	INPUT SELECTED	CONTROL PINS, S2x	INPUT SELECTED
0	1A/1B	0	1A/1B
1	2A/2B	1	2A/2B

AVAILABLE OPTIONS

T _A	DESCRIPTION	PACKAGED DEVICE ⁽¹⁾⁽²⁾
		RGE (24-Pin) (Orderable)
-40°C to 85°C	Serial multiplexer	SN65LVCP202RGE

- (1) The package is available taped and reeled. Add an R suffix to device types (e.g., SN65LVCP202RGER).
- (2) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at www.ti.com.

DISSIPATION RATINGS

PACKAGE THERMAL CHARACTERISTICS ⁽¹⁾		
Parameter	Conditions	NOM
θ_{JA} (junction-to-ambient)	Four-layer JEDEC board (JESD51-7) using four thermal vias of 0,3-mm diameter each, airflow = 0 ft/min (0 m/s)	55.4 C/W

(1) See the *IC Package Thermal Metrics* application report ([SPRA953](#)) for a detailed explanation of thermal parameters.

ABSOLUTE MAXIMUM RATINGS

over operating free-air temperature range (unless otherwise noted)⁽¹⁾

		UNIT	
V_{CC}	Supply voltage range ⁽²⁾	–0.5 V to 6 V	
V_I	Voltage range	Control inputs, all outputs	–0.5 V to ($V_{CC} + 0.5$ V)
		Receiver inputs	–0.5 V to 4 V
ESD	Human-body model ⁽³⁾	All pins	4 kV
	Charged-device model ⁽⁴⁾	All pins	500 V
T_J	Maximum junction temperature	See <i>Package Thermal Characteristics</i> 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 the ground terminals.
- (3) Tested in accordance with JEDEC Standard 22, Test Method A114-A.
- (4) Tested in accordance with JEDEC Standard 22, Test Method C101.

RECOMMENDED OPERATING CONDITIONS

			MIN	NOM	MAX	UNIT
dR	Operating data rate				2.5	Gbps
V _{CC}	Supply voltage		3.135	3.3	3.465	V
V _{CC(N)}	Supply-voltage noise amplitude	10 Hz to 1.25 GHz			20	mV
T _J	Junction temperature				125	°C
T _A	Operating free-air temperature ⁽¹⁾		–40		85	°C
DIFFERENTIAL INPUTS						
V _{ID}	Receiver peak-to-peak differential input voltage ⁽²⁾	dR _(in) ≤ 1.25 Gbps	100		1750	mV _{PP}
V _{ICM}	Receiver common-mode input voltage	Note: for best jitter performance, ac coupling is recommended.	1.5	1.6	V _{CC} – $\frac{ V_{ID} }{2}$	V
CONTROL INPUTS						
V _{IH}	High-level input voltage		2		V _{CC} + 0.3	V
V _{IL}	Low-level input voltage		–0.3		0.8	V
DIFFERENTIAL OUTPUTS						
R _L	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_{ID} is defined as |IN+ – IN–|.

ELECTRICAL CHARACTERISTICS

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

PARAMETER	TEST CONDITIONS	MIN	TYP ⁽¹⁾	MAX	UNIT		
DIFFERENTIAL INPUTS							
V _{IT+}	Positive-going differential input high threshold			50	mV		
V _{IT–}	Negative-going differential input low threshold	–50			mV		
A _(EQ)	Equalizer gain	at 1.25 GHz (EQ = 0)		12	dB		
R _{T(D)}	Termination resistance, differential	80	100	120	Ω		
V _{BB}	Open-circuit input voltage (input self-bias voltage)	AC-coupled inputs		1.6	V		
R _(BBDC)	Biasing network dc impedance		30		kΩ		
R _(BBAC)	Biasing network ac impedance	375 MHz		42	Ω		
DIFFERENTIAL OUTPUTS							
V _{ODH}	High-level output voltage	R _L = 100 Ω ±1%, Px2 = Px1 = 0; 2.5-Gbps alternating 1010-pattern; Figure 3		650	mV _{PP}		
V _{ODL}	Low-level output voltage			–650	mV _{PP}		
V _{ODB(PP)}	Output differential voltage without preemphasis ⁽²⁾			1000	1300	1500	mV _{PP}
V _{OCM}	Output common-mode voltage			1.65		V	
ΔV _{OC(SS)}	Change in steady-state common-mode output voltage between logic states			See Figure 2		1	mV

(1) All typical values are at T_A = 25°C and V_{CC} = 3.3 V supply unless otherwise noted. They are for reference purposes and are not production tested.

(2) Differential output voltage V_{ODB} is defined as |OUT+ – OUT–|.

ELECTRICAL CHARACTERISTICS (continued)

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

PARAMETER		TEST CONDITIONS	MIN	TYP ⁽¹⁾	MAX	UNIT
V _(PE)	Output preemphasis voltage ratio, $\frac{V_{ODB(PP)}}{V_{ODPE(PP)}}$	Px2:Px1 = 00		0		dB
		Px2:Px1 = 01		3		
		Px2:Px1 = 10		6		
		Px2:Px1 = 11		9		
t _(PRE)	Preemphasis duration measurement	Output preemphasis is set to 9 dB during test; Pxx = 1; Measured with a 100-MHz clock signal; R _L = 100 Ω ±1%, See Figure 4		175		ps
R _O	Output resistance	Differential on-chip termination between OUT+ and OUT–		100		Ω
CONTROL INPUTS						
I _{IH}	High-level input current	V _{IN} = VCC			5	μA
I _{IL}	Low-level input current	V _{IN} = GND	–125	–90		μA
R _(PU)	Pullup resistance			35		kΩ
POWER CONSUMPTION						
P _D	Device power dissipation	All outputs terminated 100 Ω		290	414	mW
P _Z	Device power dissipation in high-impedance state	All outputs in high-impedance state			331	mW
I _{CC}	Device current consumption	All outputs terminated 100 Ω; PRBS 2 ⁷ – 1 pattern at 2.5 Gbps			115	mA

SWITCHING CHARACTERISTICS

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

PARAMETER		TEST CONDITIONS	MIN	TYP ⁽¹⁾	MAX	UNIT
MULTIPLEXER						
t _(SM)	Multiplexer switch time	Multiplexer to valid output		3	6	ns
DIFFERENTIAL OUTPUTS						
t _{PLH}	Low-to-high propagation delay	Propagation delay, input to output See Figure 6		0.5	0.7	ns
t _{PHL}	High-to-low propagation delay			0.5	0.7	ns
t _r	Rise time	20% to 80% of V _{O(DB)} ; test pattern: 100-MHz clock signal; See Figure 5 and Figure 8		110		ps
t _f	Fall time			110		ps
t _{sk(p)}	Pulse skew, t _{PHL} – t _{PLH} ⁽²⁾				20	ps
t _{sk(o)}	Output skew ⁽³⁾	All outputs terminated with 100 Ω		25	100	ps
t _{sk(pp)}	Part-to-part skew ⁽⁴⁾				300	ps
t _{zd}	Switching time, hi-Z to disable	Assumes 50 Ω to V _{cm} and 150-pF load on each output			20	ns
t _{ze}	Switching time, hi-Z to enable	Assumes 50 Ω to V _{cm} and 150-pF load on each output			10	ns
R _J	Device random jitter, rms	See Figure 8 for test circuit. BERT setting 10 ^{–15} 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 ⁽¹⁾	MAX	UNIT
DJ	Intrinsic deterministic device jitter ⁽⁵⁾⁽⁶⁾ , peak-to-peak	0-dB preemphasis (Pxx = 0); See Figure 8 for the test circuit.	PRBS 2 ⁷ – 1 pattern	2.5 Gbps			30	ps
	Absolute deterministic output jitter ⁽⁷⁾ , peak-to-peak	0-dB preemphasis (Pxx = 0); See Figure 8 for the test circuit.	PRBS 2 ⁷ – 1 pattern	1.25 Gbps Over 20-inch (50,8-cm) FR4 trace		7		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 SN65LVCP202 built-in passive input equalizer compensates for ISI. For a 20-inch (50,8-cm) FR4 transmission line with 8-mil (0,2-mm) trace width, the SN65LVCP202 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 SN65LVCP202 output. The value is a real value measured with a bit-error tester as described in [Figure 8](#). The absolute DJ reflects the sum of all deterministic jitter components accumulated over the link: $DJ_{(absolute)} = DJ_{(signal\ generator)} + DJ_{(transmission\ line)} + DJ_{[intrinsic(SN65LVCP202)]}$.

Table 2. Preemphasis Controls Settings

Px2 ⁽¹⁾	Px1 ⁽¹⁾	OUTPUT PREEMPHASIS LEVEL IN dB	OUTPUT LEVEL IN mV _{PP}		TYPICAL FR4 TRACE LENGTH
			DE-EMPHASIZED	PREEMPHASIZED	
0	0	0 dB	1200	1200	10 inches (25,4 cm)
0	1	3 dB	850	1200	20 inches (50,8 cm)
1	0	6 dB	600	1200	30 inches (76,2 cm)
1	1	9 dB	425	1200	40 inches (101,6 cm)

(1) x = 1 or 2

Table 2. Receive Equalization Settings

EQ	Equalization	Typical Line Trace
1	5 dB	25 inches (63,5 cm) of FR4
0	12 dB	43 inches (109,2 cm) of FR4

PARAMETER MEASUREMENT INFORMATION

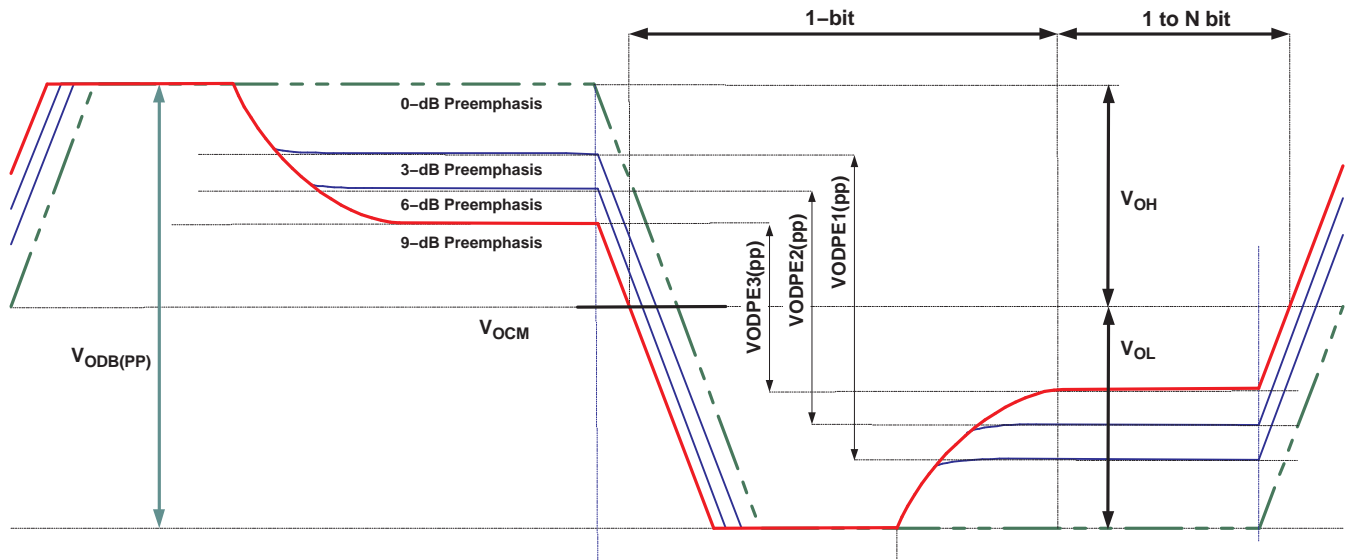


Figure 3. Preemphasis and Output Voltage Waveforms and Definitions

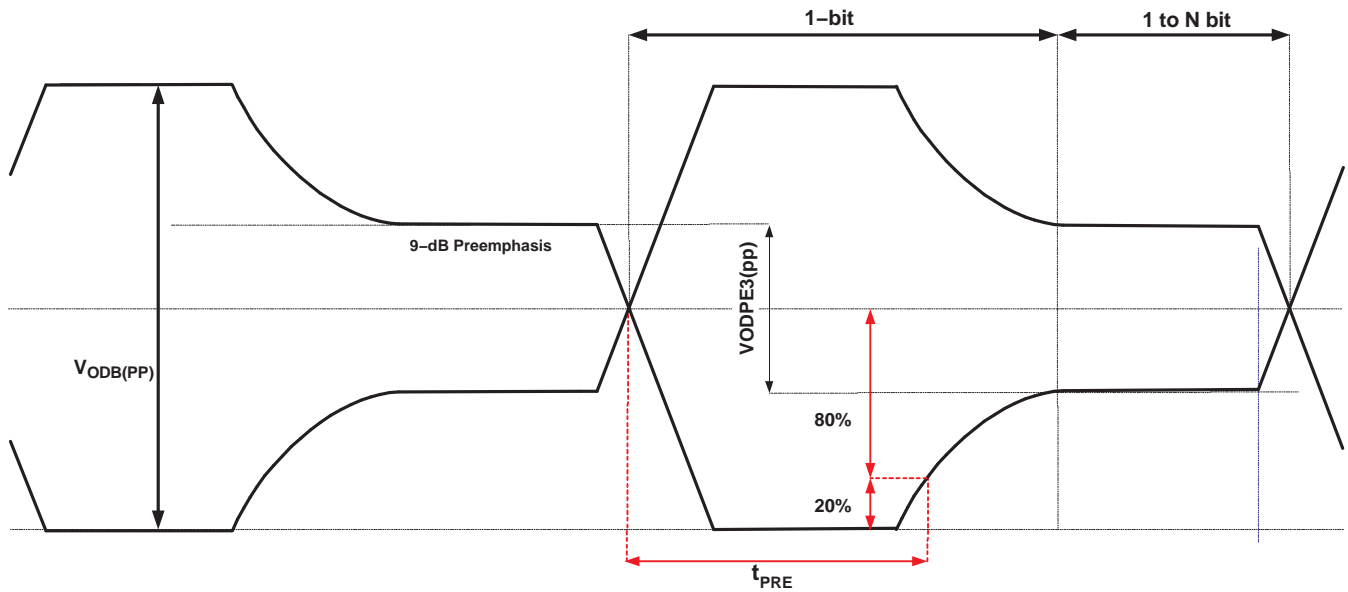


Figure 4. t_{PRE} Preemphasis Duration Measurement

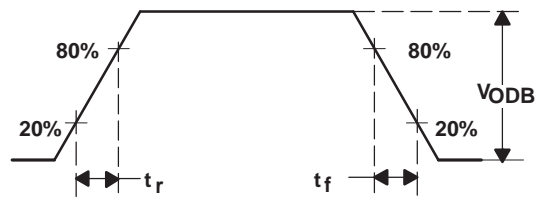


Figure 5. Driver Output Transition Time

PARAMETER MEASUREMENT INFORMATION (continued)

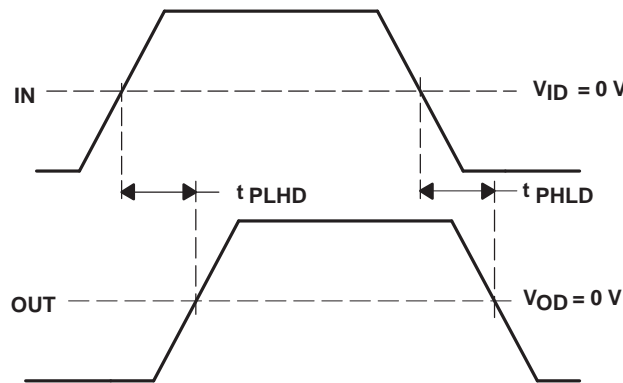
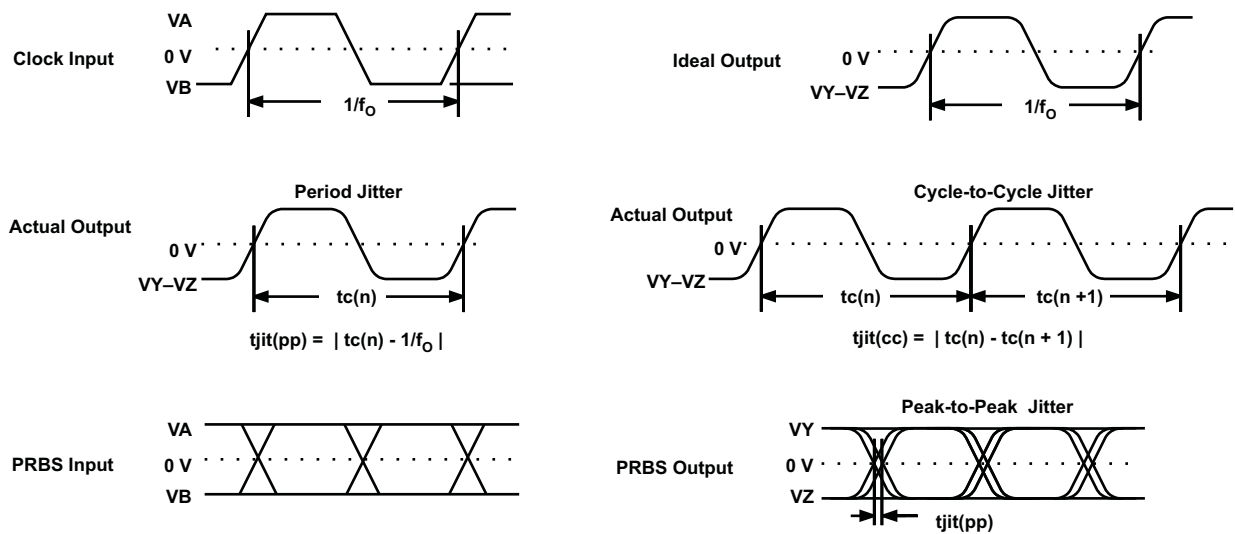


Figure 6. Propagation Delay Input to Output



- A. All input pulses are supplied by an Agilent 81250 Stimulus System.
- B. The measurement is made on a TEK TDS6604 running TDSJIT3 application software.

Figure 7. Driver Jitter Measurement Waveforms

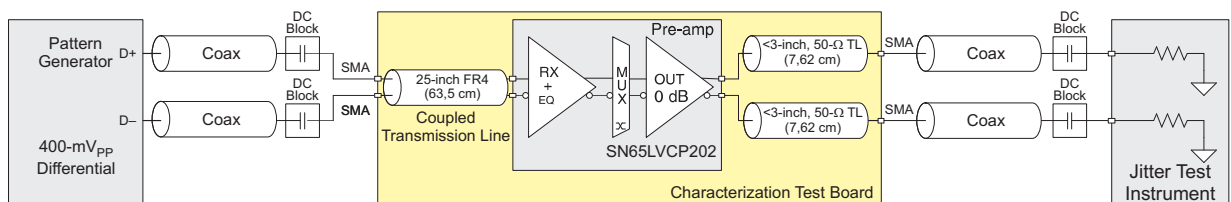
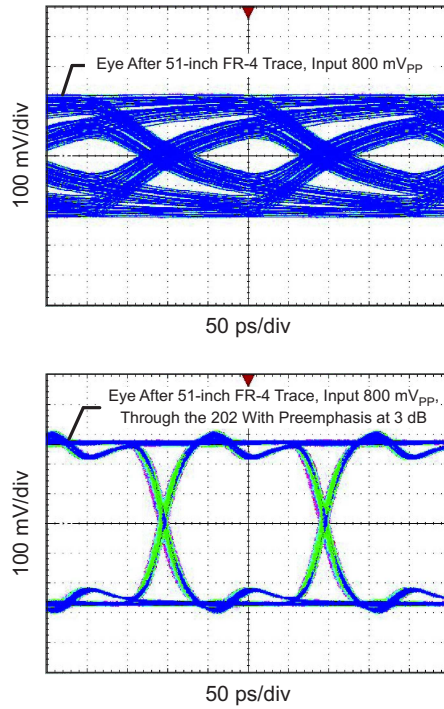


Figure 8. AC Test Circuit — Jitter and Output Rise Time Test Circuit

The SN65LVCP202 input equalizer provides 5-dB frequency gain to compensate for the frequency loss of a shorter backplane transmission line. For characterization purposes, a 24-inch (61-cm) FR-4 coupled transmission line is used in place of the backplane trace. The 24-inch (61-cm) 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 4.1.

TYPICAL DEVICE BEHAVIOR



NOTE: 51-Inch (129,54-cm) input trace, dR = 2.5 Gbps; $2^7 - 1$ PRBS

Figure 9. Data Input and Output Pattern

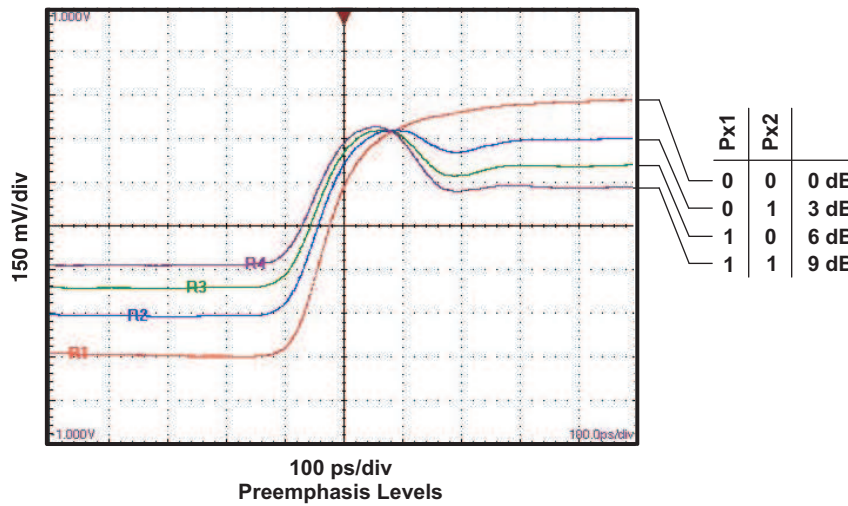


Figure 10. Preemphasis Signal Shape

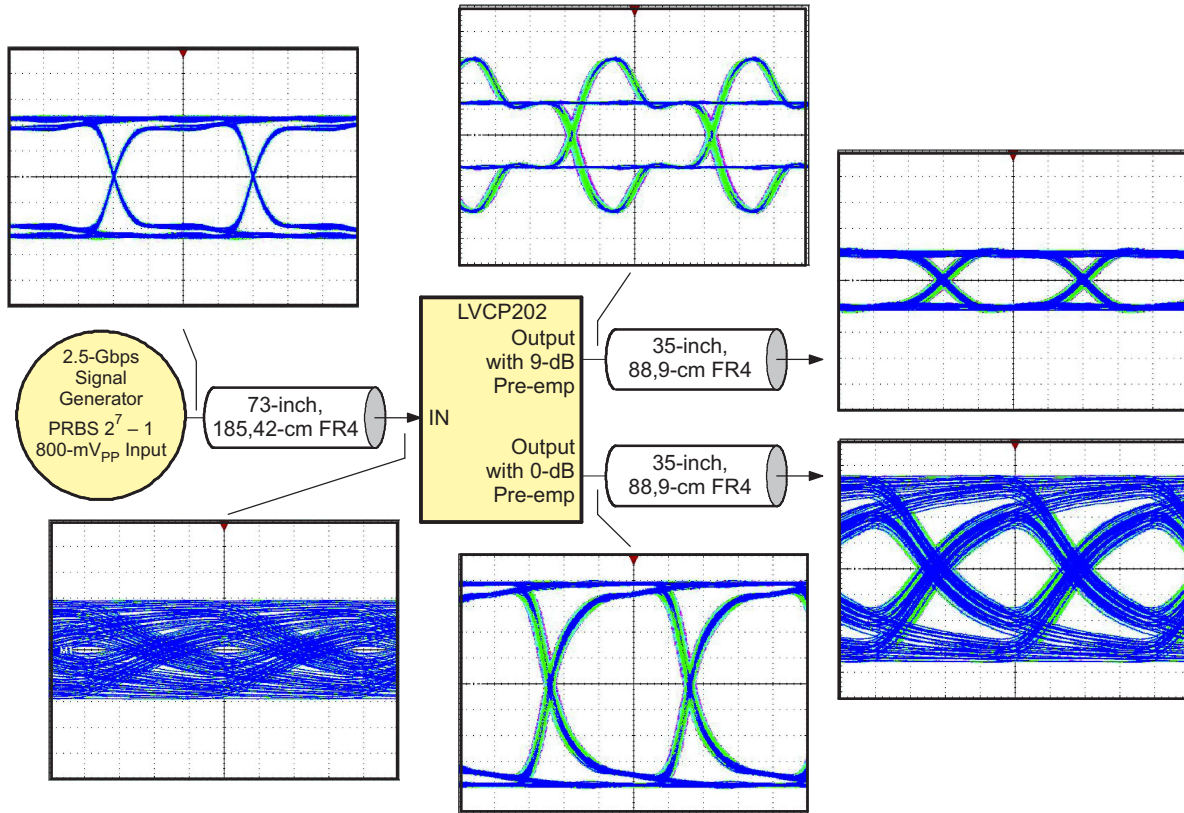


Figure 11. Data Output Pattern

TYPICAL CHARACTERISTICS

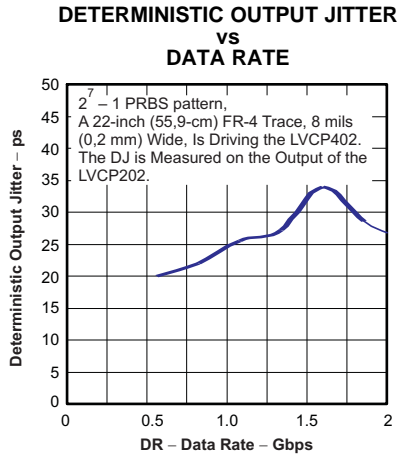


Figure 12.

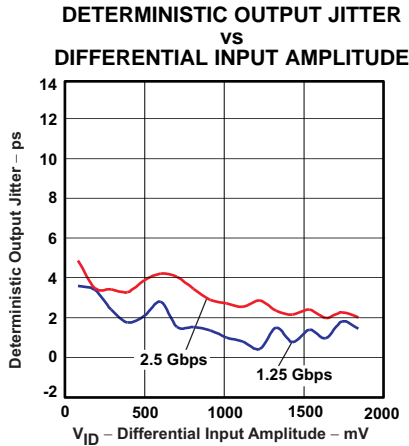


Figure 13.

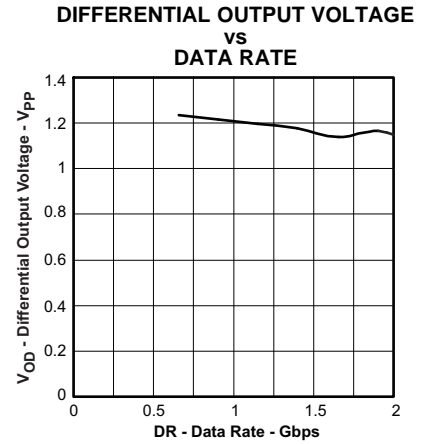


Figure 14.

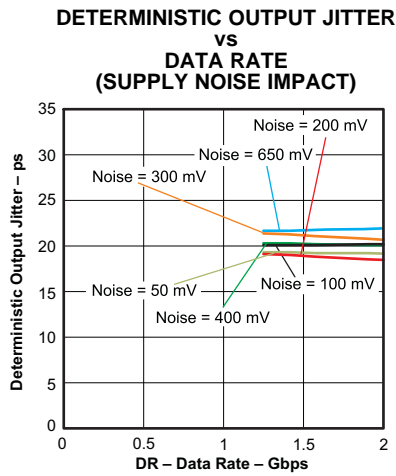


Figure 15.

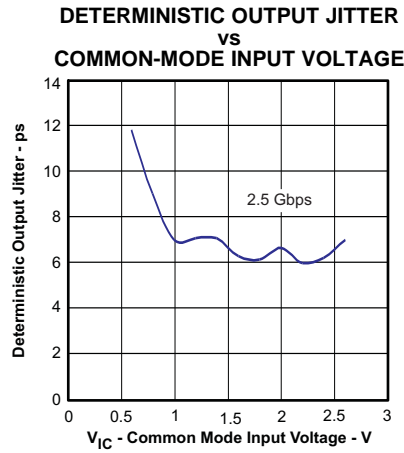


Figure 16.

APPLICATION INFORMATION

EXPLANATION OF EQUALIZATION

Backplane designs differ widely in size, layer stackup, 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, with its related high-frequency signal attenuation. Within a backplane, the shortest to longest trace lengths differ substantially – often ranging from 8 inches (20.3 cm) up to 40 inches (101.6 cm). 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 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 SN65LVCP202 receiver input incorporates an equalizer and compensates for such frequency loss. The SN65LVCP202 equalizer provides 5 dB or 12 dB of frequency gain between 375 MHz and 1.875 GHz, compensating roughly for 20 inches of FR4 material with 8-mil (0,2-cm) 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 preemphasis, such as the SN65LVCP202) and the SN65LVCP202 receiver, the following steps are necessary:

1. Set the transmitter and receiver to 0-dB preemphasis; record the data eye on the SN65LVCP202 receiver output.
2. Increase the transmitter preemphasis until the data eye on the SN65LVCP202 receiver output looks the cleanest.

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package Pins	Package qty Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
SN65LVCP202RGER	Active	Production	VQFN (RGE) 24	3000 LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 85	LVCP202
SN65LVCP202RGER.B	Active	Production	VQFN (RGE) 24	3000 LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 85	LVCP202
SN65LVCP202RGET	Active	Production	VQFN (RGE) 24	250 SMALL T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 85	LVCP202
SN65LVCP202RGET.B	Active	Production	VQFN (RGE) 24	250 SMALL T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 85	LVCP202

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

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

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

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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

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

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

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TAPE AND REEL INFORMATION

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
SN65LVCP202RGER	VQFN	RGE	24	3000	330.0	12.4	4.25	4.25	1.15	8.0	12.0	Q2
SN65LVCP202RGET	VQFN	RGE	24	250	180.0	12.4	4.25	4.25	1.15	8.0	12.0	Q2

TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN65LVCP202RGER	VQFN	RGE	24	3000	353.0	353.0	32.0
SN65LVCP202RGET	VQFN	RGE	24	250	213.0	191.0	35.0

RGE 24

GENERIC PACKAGE VIEW

VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

4204104/H

RGE0024B



PACKAGE OUTLINE

VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



4219013/A 05/2017

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. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

EXAMPLE BOARD LAYOUT

RGE0024B

VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:15X



SOLDER MASK DETAILS

4219013/A 05/2017

NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

EXAMPLE STENCIL DESIGN

RGE0024B

VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 25
78% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE
SCALE:20X

4219013/A 05/2017

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

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