National Semiconductor

January 17, 2008

DS25CP102
3.125 Gbps 2X2 LVDS Crosspoint Switch with Transmit Pre-Emphasis and Receive Equalization

General Description

The DS25CP102 is a 3.125 Gbps 2x2 LVDS crosspoint switch optimized for high-speed signal routing and switching over lossy FR-4 printed circuit board backplanes and balanced cables. Fully differential signal paths ensure exceptional signal integrity and noise immunity. The non-blocking architecture allows connections of any input to any output or outputs.

The DS25CP102 features two levels (Off and On) of transmit pre-emphasis (PE) and two levels (Off and On) of receive equalization (EQ).

Wide input common mode range allows the switch to accept signals with LVDS, CML and LVPECL levels; the output levels are LVDS. A very small package footprint requires a minimal space on the board while the flow-through pinout allows easy board layout. Each differential input and output is internally terminated with a 100Ω resistor to lower device insertion and return losses, reduce component count and further minimize board space.

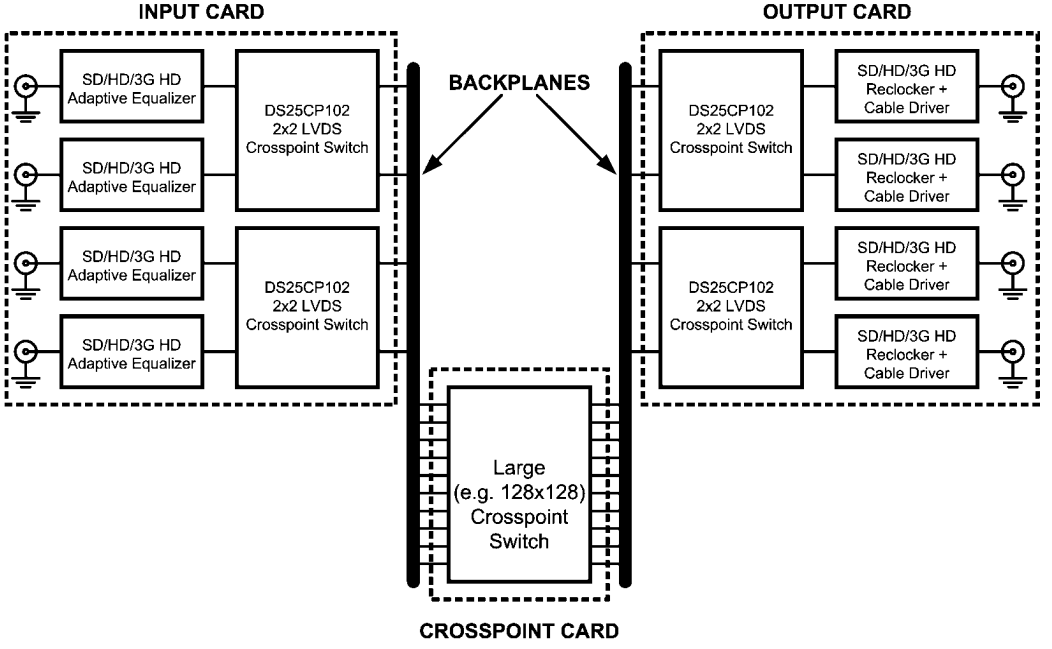
Features

- DC - 3.125 Gbps low jitter, low skew, low power operation
- Pin configurable, fully differential, non-blocking architecture
- Pin selectable transmit pre-emphasis and receive equalization eliminate data dependant jitter
- Wide Input Common Mode Voltage Range allows DC-coupled interface to CML and LVPECL drivers
- On-chip 100Ω input and output termination minimizes insertion and return losses, reduces component count and minimizes board space
- 8 kV ESD on LVDS I/O pins protects adjoining components
- Small 4 mm x 4 mm LLP-16 space saving package

Applications

- High-speed channel select applications
- Clock and data buffering and muxing
- OC-48 / STM-16
- SD/HD/3GHD SDI Routers

Typical Application



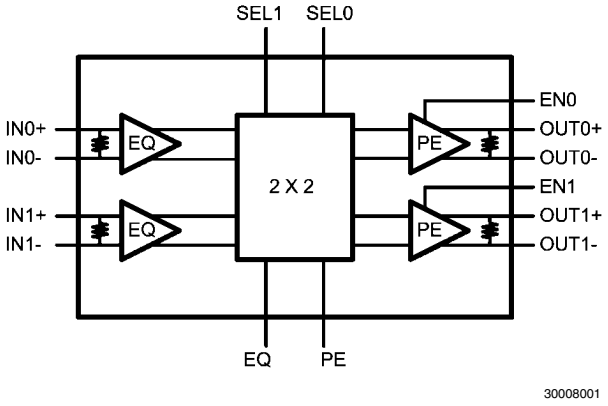
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Ordering Code

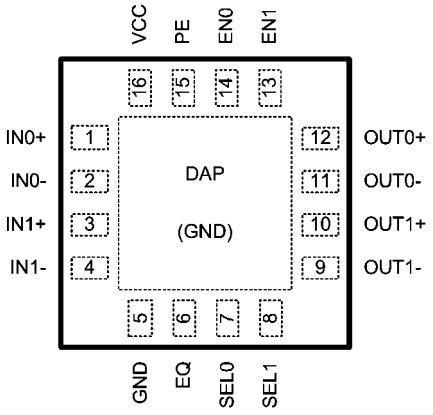
NSID	Function	Available Equalization Levels	Available Pre-Emphasis Levels
DS25CP102TSQ	Crosspoint Switch	Off / On	Off / On

Block Diagram



30008001

Connection Diagram



30008002

Pin Descriptions

Pin Name	Pin Number	I/O, Type	Pin Description
IN0+, IN0- , IN1+, IN1-	1, 2, 3, 4	I, LVDS	Inverting and non-inverting high speed LVDS input pins.
OUT0+, OUT0-, OUT1+, OUT1-	12, 11, 10, 9	O, LVDS	Inverting and non-inverting high speed LVDS output pins.
SEL0, SEL1	7, 8	I, LVCMOS	Switch configuration pins. There is a 20k pulldown resistor on this pin.
EN0, EN1	14, 13	I, LVCMOS	Output enable pins. There is a 20k pulldown resistor on this pin.
PE	15	I, LVCMOS	Transmit Pre-Emphasis select pin. There is a 20k pulldown resistor on this pin.
EQ	6	I, LVCMOS	Receive Equalizaton select pin. There is a 20k pulldown resistor on this pin.
VDD	16	Power	Power supply pin.
GND	5, DAP	Power	Ground pin and Device Attach Pad (DAP) ground.

Absolute Maximum Ratings (Note 4)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Supply Voltage	−0.3V to +4V
LVCMOS Input Voltage	−0.3V to (V_{CC} + 0.3V)
LVDS Input Voltage	−0.3V to +4V
LVDS Differential Input Voltage	0V to 1.0V
LVDS Output Voltage	−0.3V to (V_{CC} + 0.3V)
LVDS Differential Output Voltage	0V to 1.0V
LVDS Output Short Circuit Current Duration	5 ms
Junction Temperature	+150°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature Range	
Soldering (4 sec.)	+260°C
Maximum Package Power Dissipation at 25°C	
SQA Package	2.99W
Derate SQA Package	23.9 mW/°C above +25°C
Package Thermal Resistance	
θ_{JA}	+41.8°C/W
θ_{JC}	+6.9°C/W
ESD Susceptibility	
HBM (Note 1)	≥8 kV
MM (Note 2)	≥250V
CDM (Note 3)	≥1250V

Note 1: Human Body Model, applicable std. JESD22-A114C

Note 2: Machine Model, applicable std. JESD22-A115-A

Note 3: Field Induced Charge Device Model, applicable std. JESD22-C101-C

Recommended Operating Conditions

	Min	Typ	Max	Units
Supply Voltage (V_{CC})	3.0	3.3	3.6	V
Receiver Differential Input Voltage (V_{ID})	0		1	V
Operating Free Air Temperature (T_A)	−40	+25	+85	°C

DC Electrical Characteristics (Notes 5, 6, 7)

Over recommended operating supply and temperature ranges unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
LVCMOS DC SPECIFICATIONS						
V_{IH}	High Level Input Voltage		2.0		V_{CC}	V
V_{IL}	Low Level Input Voltage		GND		0.8	V
I_{IH}	High Level Input Current	V_{IN} = 3.6V V_{CC} = 3.6V	40	175	250	µA
I_{IL}	Low Level Input Current	V_{IN} = GND V_{CC} = 3.6V		0	±10	µA
V_{CL}	Input Clamp Voltage	I_{CL} = −18 mA, V_{CC} = 0V		−0.9	−1.5	V
LVDS INPUT DC SPECIFICATIONS						
V_{ID}	Input Differential Voltage	V_{CM} = +0.05V or V_{CC}-0.05V	0		1	V
V_{TH}	Differential Input High Threshold			0	+100	mV
V_{TL}	Differential Input Low Threshold		−100	0		mV
V_{CMR}	Common Mode Voltage Range	V_{ID} = 100 mV	0.05		V_{CC} - 0.05	V
I_{IN}	Input Current	V_{IN} = +3.6V or 0V V_{CC} = 3.6V or 0V		±1	±10	µA
C_{IN}	Input Capacitance	Any LVDS Input Pin to GND		1.7		pF
R_{IN}	Input Termination Resistor	Between IN+ and IN-		100		Ω

Symbol	Parameter	Conditions	Min	Typ	Max	Units
LVDS OUTPUT DC SPECIFICATIONS						
V_{OD}	Differential Output Voltage	R_L = 100Ω	250	350	450	mV
ΔV_{OD}	Change in Magnitude of V_{OD} for Complimentary Output States		-35		35	mV
V_{OS}	Offset Voltage	R_L = 100Ω	1.05	1.2	1.375	V
ΔV_{OS}	Change in Magnitude of V_{OS} for Complimentary Output States		-35		35	mV
I_{OS}	Output Short Circuit Current (Note 8)	OUT to GND		-35	-55	mA
		OUT to V_{CC}		7	55	mA
C_{OUT}	Output Capacitance	Any LVDS Output Pin to GND		1.2		pF
R_{OUT}	Output Termination Resistor	Between OUT+ and OUT-		100		Ω
SUPPLY CURRENT						
I_{CC}	Supply Current	PE = OFF, EQ = OFF		77	90	mA
I_{CCZ}	Supply Current with Outputs Disabled	EN0 = EN1 = 0		23	29	mA

Note 4: "Absolute Maximum Ratings" indicate limits beyond which damage to the device may occur, including inoperability and degradation of device reliability and/or performance. Functional operation of the device and/or non-degradation at the Absolute Maximum Ratings or other conditions beyond those indicated in the Recommended Operating Conditions is not implied. The Recommended Operating Conditions indicate conditions at which the device is functional and the device should not be operated beyond such conditions.

Note 5: The Electrical Characteristics tables list guaranteed specifications under the listed Recommended Operating Conditions except as otherwise modified or specified by the Electrical Characteristics Conditions and/or Notes. Typical specifications are estimations only and are not guaranteed.

Note 6: Current into device pins is defined as positive. Current out of device pins is defined as negative. All voltages are referenced to ground except V_{OD} and ΔV_{OD}.

Note 7: Typical values represent most likely parametric norms for V_{CC} = +3.3V and T_A = +25°C, and at the Recommended Operation Conditions at the time of product characterization and are not guaranteed.

Note 8: Output short circuit current (I_{OS}) is specified as magnitude only, minus sign indicates direction only.

AC Electrical Characteristics (Note 11)

Over recommended operating supply and temperature ranges unless otherwise specified. (Notes 9, 10)

Symbol	Parameter	Conditions		Min	Typ	Max	Units
LVDS OUTPUT AC SPECIFICATIONS							
t_{PLHD}	Differential Propagation Delay Low to High	R_L = 100Ω			365	500	ps
t_{PHLD}	Differential Propagation Delay High to Low				345	500	ps
t_{SKD1}	Pulse Skew $\|t_{PLHD} - t_{PHLD}\|$ (Note 12)				20	55	ps
t_{SKD2}	Channel to Channel Skew (Note 13)				12	25	ps
t_{SKD3}	Part to Part Skew , (Note 14)				50	150	ps
t_{LHT}	Rise Time	R_L = 100Ω			65	120	ps
t_{HLT}	Fall Time				65	120	ps
t_{ON}	Output Enable Time	ENn = LH to output active			7	20	µs
t_{OFF}	Output Disable Time	ENn = HL to output inactive			5	12	ns
t_{SEL}	Select Time	SELn LH or HL to output			3.5	12	ns
JITTER PERFORMANCE WITH EQ = Off, PE = Off (*Figure 5*)							
t_{RJ1}	Random Jitter (RMS Value) No Test Channels (Note 15)	V_{ID} = 350 mV V_{CM} = 1.2V Clock (RZ)	2.5 Gbps		0.5	1	ps
t_{RJ2}			3.125 Gbps		0.5	1	ps
t_{DJ1}	Deterministic Jitter (Peak to Peak) No Test Channels (Note 16)	V_{ID} = 350 mV V_{CM} = 1.2V K28.5 (NRZ)	2.5 Gbps		6	22	ps
t_{DJ2}			3.125 Gbps		6	22	ps
t_{TJ1}	Total Jitter (Peak to Peak) No Test Channels (Note 17)	V_{ID} = 350 mV V_{CM} = 1.2V PRBS-23 (NRZ)	2.5 Gbps		0.03	0.08	UI_{P-P}
t_{TJ2}			3.125 Gbps		0.05	0.11	UI_{P-P}
JITTER PERFORMANCE WITH EQ = Off, PE = On (*Figures 6*, *9*)							
t_{RJ1B}	Random Jitter (RMS Value) Test Channel B (Note 15)	V_{ID} = 350 mV V_{CM} = 1.2V Clock (RZ)	2.5 Gbps		0.5	1	ps
t_{RJ2B}			3.125 Gbps		0.5	1	ps
t_{DJ1B}	Deterministic Jitter (Peak to Peak) Test Channel B (Note 16)	V_{ID} = 350 mV V_{CM} = 1.2V K28.5 (NRZ)	2.5 Gbps		3	12	ps
t_{DJ2B}			3.125 Gbps		3	12	ps
t_{TJ1B}	Total Jitter (Peak to Peak) Test Channel B (Note 17)	V_{ID} = 350 mV V_{CM} = 1.2V PRBS-23 (NRZ)	2.5 Gbps		0.03	0.06	UI_{P-P}
t_{TJ2B}			3.125 Gbps		0.04	0.09	UI_{P-P}
JITTER PERFORMANCE WITH EQ = On, PE = Off (*Figures 7*, *9*)							
t_{RJ1D}	Random Jitter (RMS Value) Test Channel D (Note 15)	V_{ID} = 350 mV V_{CM} = 1.2V Clock (RZ)	2.5 Gbps		0.5	1	ps
t_{RJ2D}			3.125 Gbps		0.5	1	ps
t_{DJ1D}	Deterministic Jitter (Peak to Peak) Test Channel D (Note 16)	V_{ID} = 350 mV V_{CM} = 1.2V K28.5 (NRZ)	2.5 Gbps		16	24	ps
t_{DJ2D}			3.125 Gbps		12	24	ps
t_{TJ1D}	Total Jitter (Peak to Peak) Test Channel D (Note 17)	V_{ID} = 350 mV V_{CM} = 1.2V PRBS-23 (NRZ)	2.5 Gbps		0.07	0.11	UI_{P-P}
t_{TJ2D}			3.125 Gbps		0.07	0.11	UI_{P-P}

Symbol	Parameter	Conditions		Min	Typ	Max	Units
JITTER PERFORMANCE WITH EQ = On, PE = On (*Figures 8*, *9*)							
t_{RJ1BD}	Random Jitter (RMS Value)	V_{ID} = 350 mV	2.5 Gbps		0.5	1	ps
t_{RJ2BD}	Input Test Channel D Output Test Channel B (Note 15)	V_{CM} = 1.2V Clock (RZ)	3.125 Gbps		0.5	1	ps
t_{DJ1BD}	Deterministic Jitter (Peak to Peak)	V_{ID} = 350 mV	2.5 Gbps		14	31	ps
t_{DJ2BD}	Input Test Channel D Output Test Channel B (Note 16)	V_{CM} = 1.2V K28.5 (NRZ)	3.125 Gbps		6	21	ps
t_{TJ1BD}	Total Jitter (Peak to Peak)	V_{ID} = 350 mV	2.5 Gbps		0.08	0.15	UI_{P-P}
t_{TJ2BD}	Input Test Channel D Output Test Channel B (Note 17)	V_{CM} = 1.2V PRBS-23 (NRZ)	3.125 Gbps		0.10	0.16	UI_{P-P}

Note 9: The Electrical Characteristics tables list guaranteed specifications under the listed Recommended Operating Conditions except as otherwise modified or specified by the Electrical Characteristics Conditions and/or Notes. Typical specifications are estimations only and are not guaranteed.

Note 10: Typical values represent most likely parametric norms for V_{CC} = +3.3V and T_A = +25°C, and at the Recommended Operation Conditions at the time of product characterization and are not guaranteed.

Note 11: Specification is guaranteed by characterization and is not tested in production.

Note 12: t_{SKD1}, $|t_{PLHD} - t_{PHLD}|$, Pulse Skew, is the magnitude difference in differential propagation delay time between the positive going edge and the negative going edge of the same channel.

Note 13: t_{SKD2}, Channel to Channel Skew, is the difference in propagation delay (t_{PLHD} or t_{PHLD}) among all output channels in Broadcast mode (any one input to all outputs).

Note 14: t_{SKD3}, Part to Part Skew, is defined as the difference between the minimum and maximum differential propagation delays. This specification applies to devices at the same V_{CC} and within 5°C of each other within the operating temperature range.

Note 15: Measured on a clock edge with a histogram and an acummulation of 1500 histogram hits. Input stimulus jitter is subtracted geometrically.

Note 16: Tested with a combination of the 1100000101 (K28.5+ character) and 0011111010 (K28.5- character) patterns. Input stimulus jitter is subtracted algebraically.

Note 17: Measured on an eye diagram with a histogram and an acummulation of 3500 histogram hits. Input stimulus jitter is subtracted.

DC Test Circuits

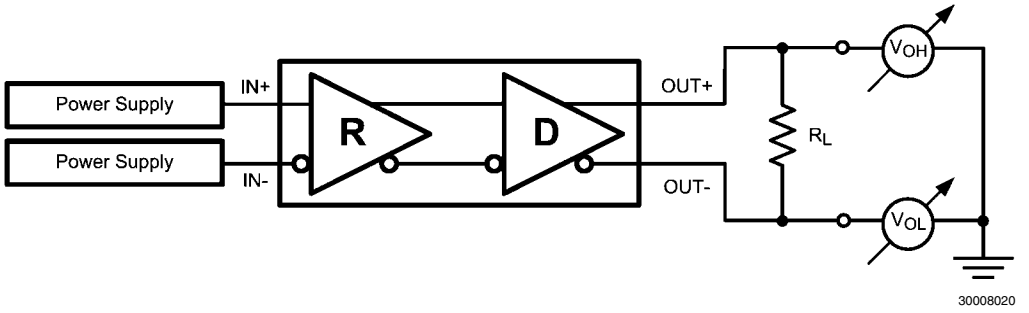


FIGURE 1. Differential Driver DC Test Circuit

AC Test Circuits and Timing Diagrams

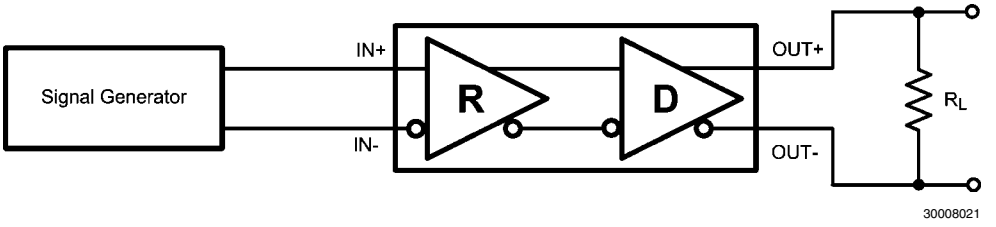


FIGURE 2. Differential Driver AC Test Circuit

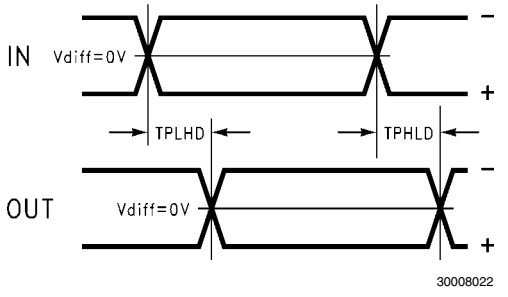


FIGURE 3. Propagation Delay Timing Diagram

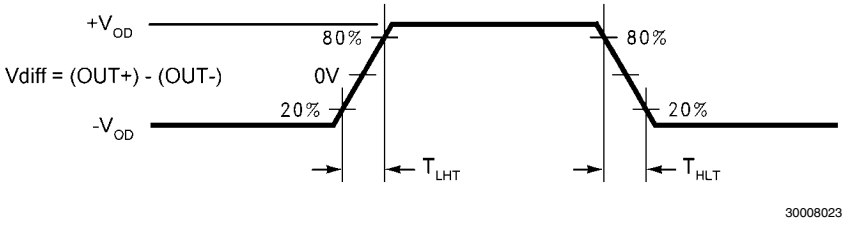


FIGURE 4. LVDS Output Transition Times

Pre-Emphasis and Equalization Test Circuits

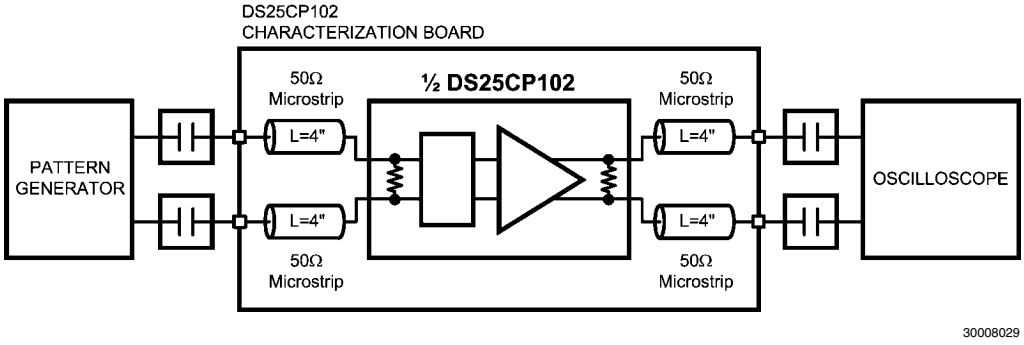


FIGURE 5. Jitter Performance Test Circuit

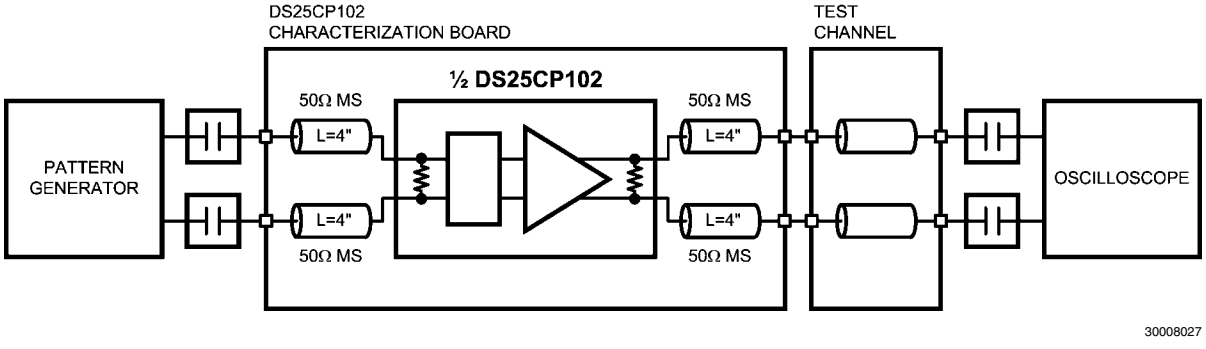


FIGURE 6. Pre-Emphasis Performance Test Circuit

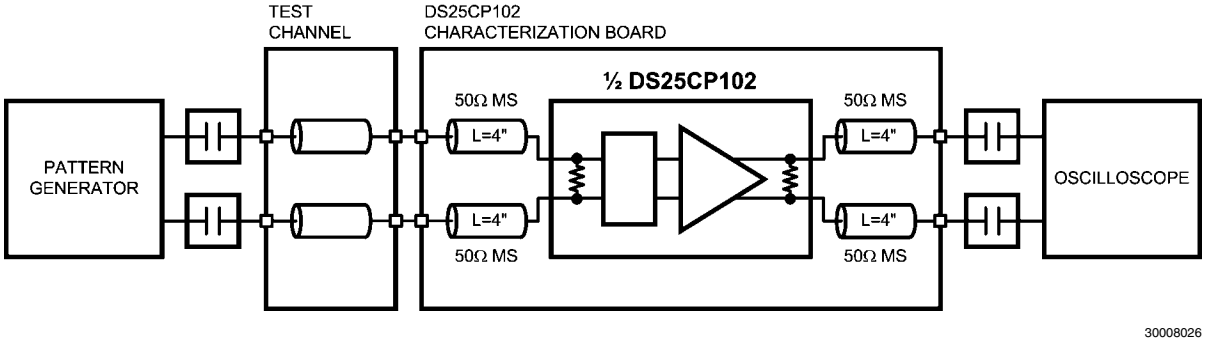


FIGURE 7. Equalization Performance Test Circuit

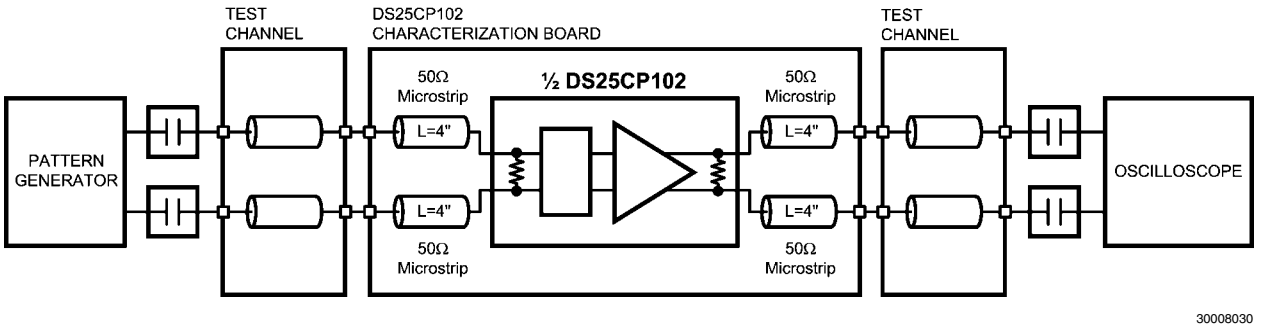


FIGURE 8. Pre-Emphasis and Equalization Performance Test Circuit

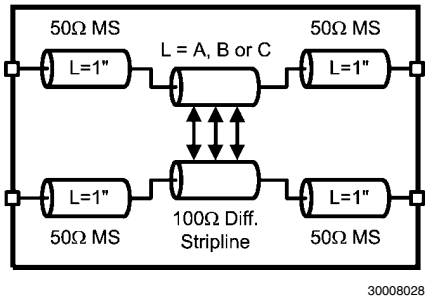


FIGURE 9. Test Channel Block Diagram

Test Channel Loss Characteristics

The test channel was fabricated with Polyclad PCL-FR-370-Laminate/PCL-FRP-370 Prepreg materials (Dielectric constant of 3.7 and Loss Tangent of 0.02). The edge coupled differential striplines have the following geometries: Trace Width (W) = 5 mils, Gap (S) = 5 mils, Height (B) = 16 mils.

Test Channel	Length (inches)	Insertion Loss (dB)					
		500 MHz	750 MHz	1000 MHz	1250 MHz	1500 MHz	1560 MHz
A	10	-1.2	-1.7	-2.0	-2.4	-2.7	-2.8
B	20	-2.6	-3.5	-4.1	-4.8	-5.5	-5.6
C	30	-4.3	-5.7	-7.0	-8.2	-9.4	-9.7
D	15	-1.6	-2.2	-2.7	-3.2	-3.7	-3.8
E	30	-3.4	-4.5	-5.6	-6.6	-7.7	-7.9
F	60	-7.8	-10.3	-12.4	-14.5	-16.6	-17.0

Functional Description

The DS25CP102 is a 3.125 Gbps 2x2 LVDS digital crosspoint switch optimized for high-speed signal routing and switching over lossy FR-4 printed circuit board backplanes and balanced cables.

TABLE 1. Switch Configuration Truth Table

SEL1	SEL0	OUT1	OUT0
0	0	IN0	IN0
0	1	IN0	IN1
1	0	IN1	IN0
1	1	IN1	IN1

TABLE 2. Output Enable Truth Table

EN1	EN0	OUT1	OUT0
0	0	Disabled	Disabled
0	1	Disabled	Enabled
1	0	Enabled	Disabled
1	1	Enabled	Enabled

In addition, the DS25CP102 has a pre-emphasis control pin for switching the transmit pre-emphasis to ON and OFF setting and an equalization control pin for switching the receive equalization to ON and OFF setting. The following are the transmit pre-emphasis and receive equalization truth tables.

Transmit Pre-Emphasis Truth Table

OUTPUTS OUT0 and OUT1	
CONTROL Pin (PE) State	**Pre-Emphasis Level**
0	OFF
1	ON

Transmit Pre-Emphasis Level Selection

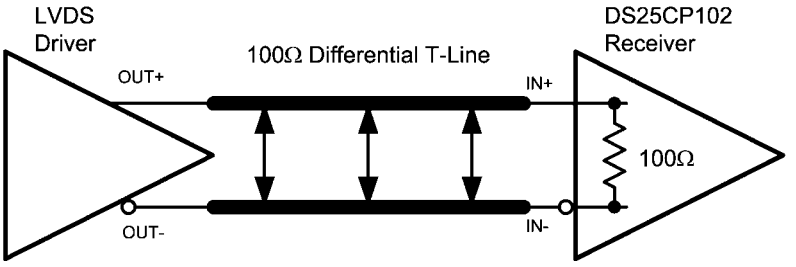
Receive Equalization Truth Table

INPUTS IN0 and IN1	
CONTROL Pin (EQ) State	**Equalization Level**
0	OFF
1	ON

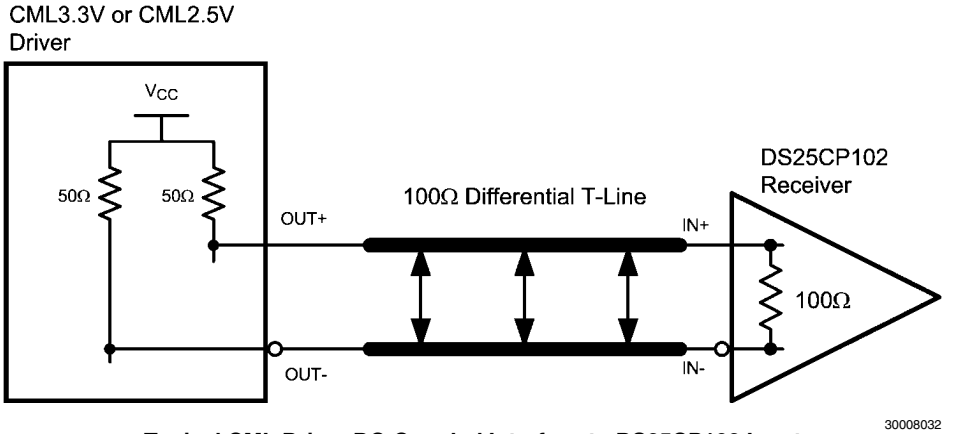
Receive Equalization Level Selection

Input Interfacing

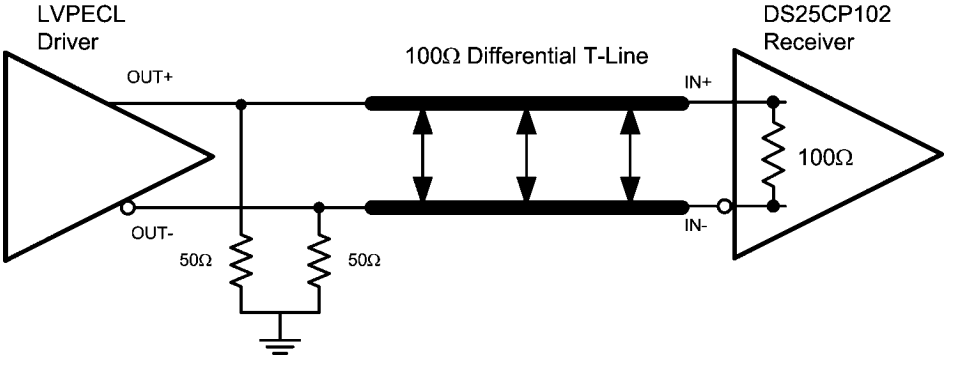
The DS25CP102 accepts differential signals and allows simple AC or DC coupling. With a wide common mode range, the DS25CP102 can be DC-coupled with all common differential drivers (i.e. LVPECL, LVDS, CML). The following three figures illustrate typical DC-coupled interface to common differential drivers. Note that the DS25CP102 inputs are internally terminated with a 100Ω resistor.



Typical LVDS Driver DC-Coupled Interface to DS25CP102 Input



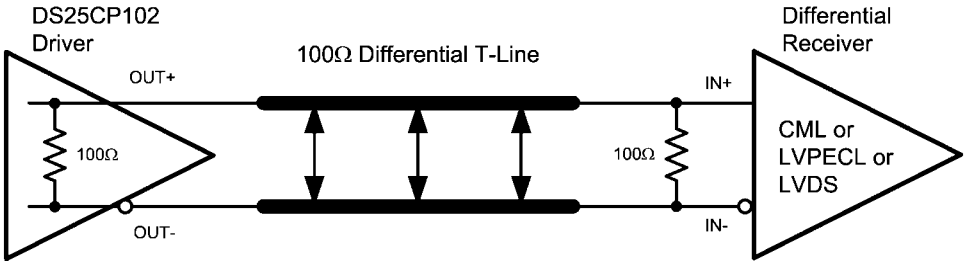
Typical CML Driver DC-Coupled Interface to DS25CP102 Input



Typical LVPECL Driver DC-Coupled Interface to DS25CP102 Input

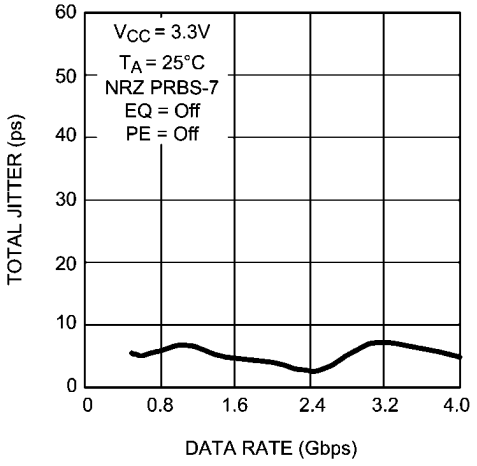
Output Interfacing

The DS25CP102 outputs signals that are compliant to the LVDS standard. Its outputs can be DC-coupled to most common differential receivers. The following figure illustrates typical DC-coupled interface to common differential receivers and assumes that the receivers have high impedance inputs. While most differential receivers have a common mode input range that can accomodate LVDS compliant signals, it is recommended to check respective receiver's data sheet prior to implementing the suggested interface implementation.



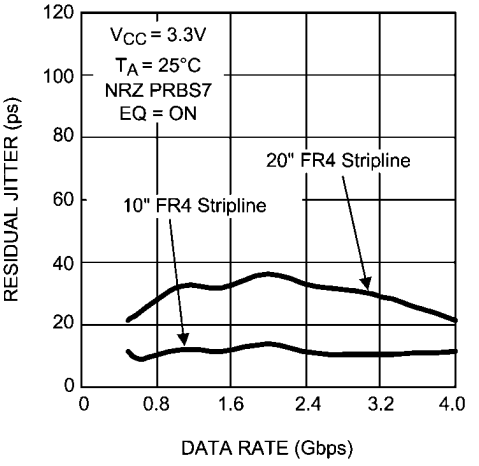
Typical DS25CP102 Output DC-Coupled Interface to an LVDS, CML or LVPECL Receiver

Typical Performance



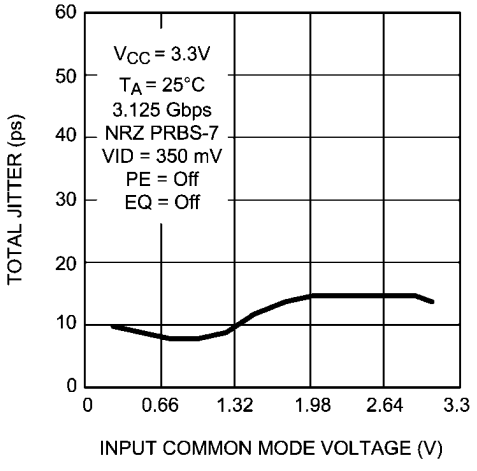
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Total Jitter as a Function of Data Rate



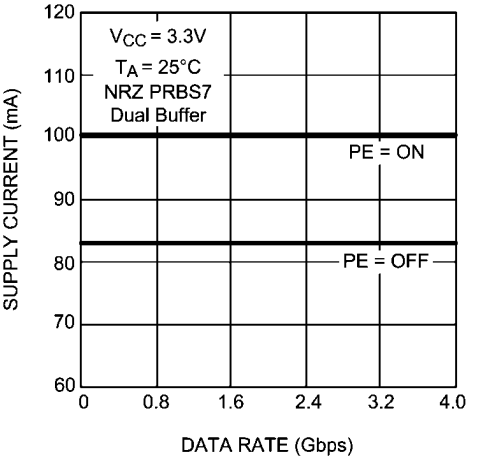
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Residual Jitter as a Function of Data Rate, FR4 Stripline Length and EQ Level



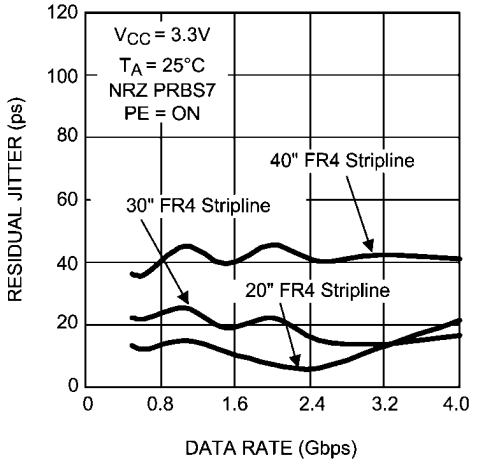
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Total Jitter as a Function of Input Common Mode Voltage



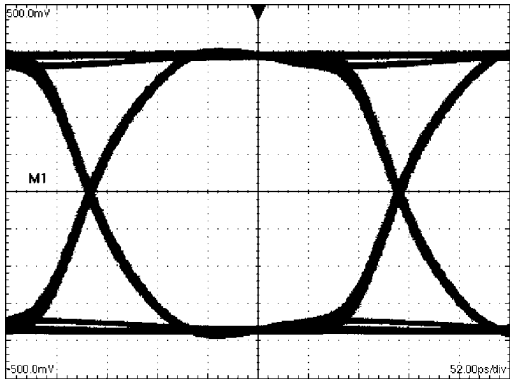
30008057

Supply Current as a Function of Data Rate and PE Level



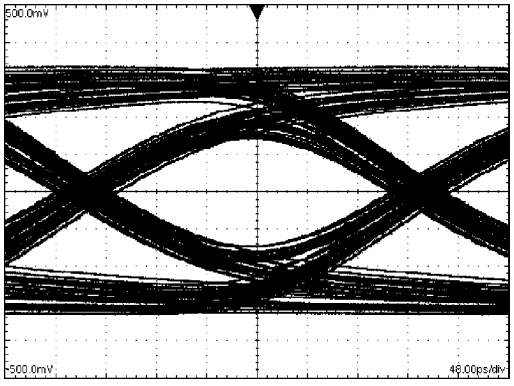
30008051

Residual Jitter as a Function of Data Rate, FR4 Stripline Length and PE Level



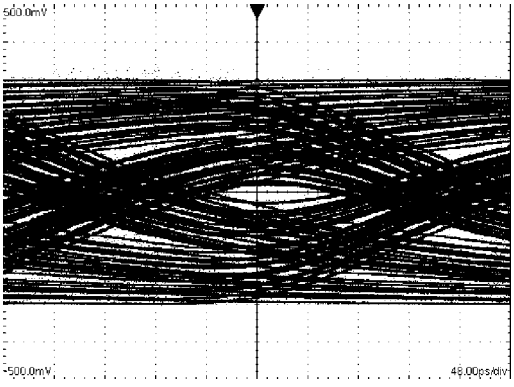
30008060

A 3.125 Gbps NRZ PRBS-7 without PE or EQ
After 2" Differential FR-4 Stripline
H: 50 ps / DIV, V: 100 mV / DIV



30008062

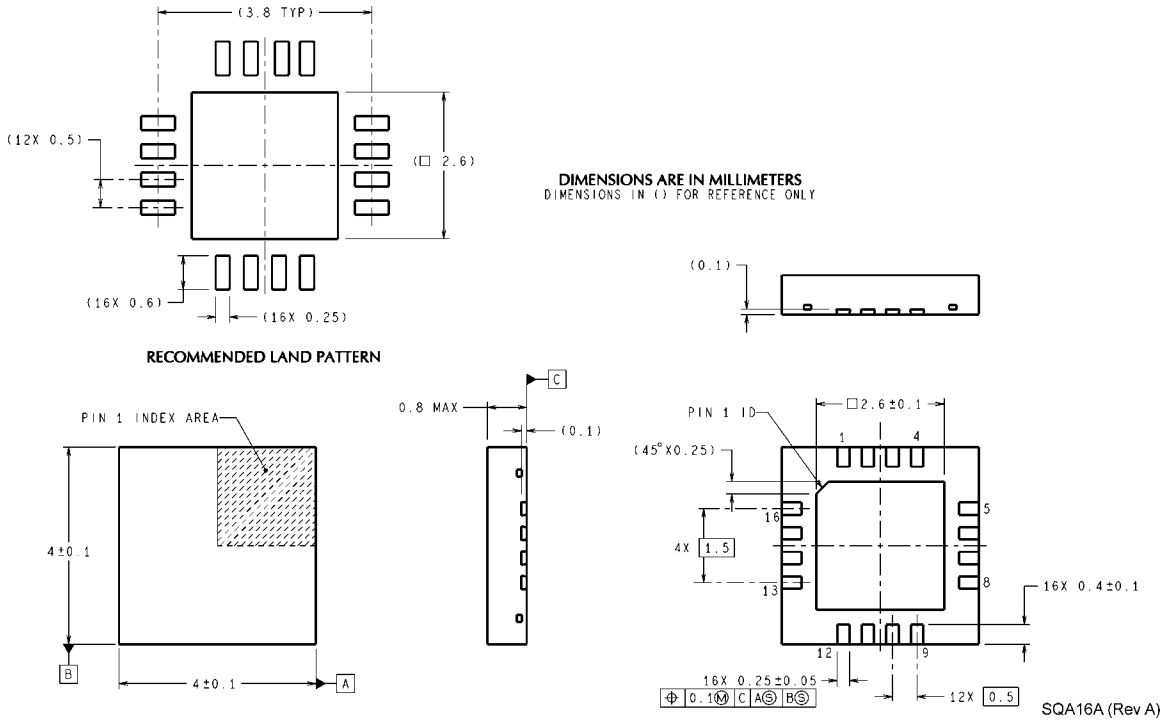
A 3.125 Gbps NRZ PRBS-7 with PE
After 40" Differential FR-4 Stripline
H: 50 ps / DIV, V: 100 mV / DIV



30008061

A 3.125 Gbps NRZ PRBS-7 without PE or EQ
After 40" Differential FR-4 Stripline
H: 50 ps / DIV, V: 100 mV / DIV

Physical Dimensions inches (millimeters) unless otherwise noted



Order Number DS25CP102TSQ
NS Package Number SQA16A
(See AN-1187 for PCB Design and Assembly Recommendations)

Notes

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