

## DS25CP102Q

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

### General Description

The DS25CP102Q 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 DS25CP102Q 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.

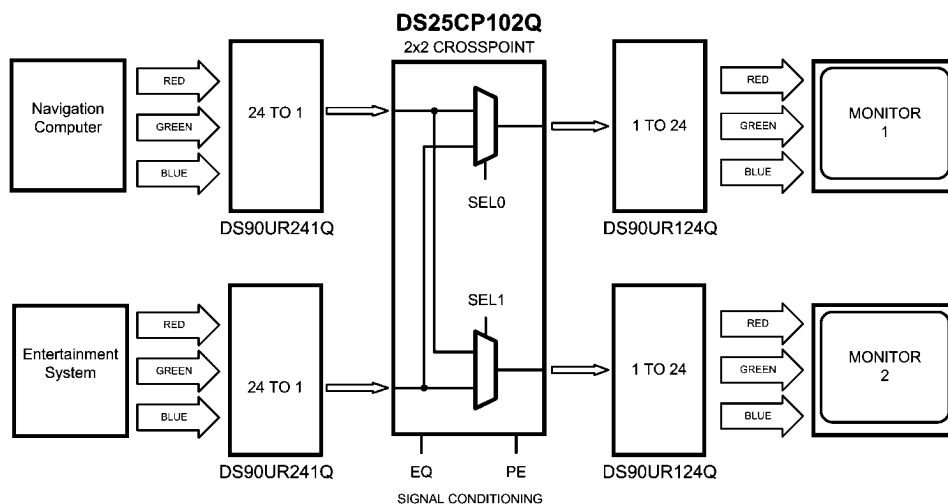
### Features

- AECQ-100 Grade 3
- 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

- Automotive display applications
- Clock and data buffering and muxing
- OC-48 / STM-16
- SD/HD/3GHD SDI Routers

### Typical Application

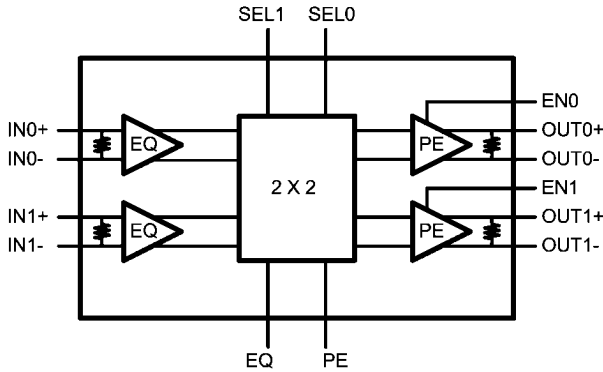


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## Ordering Code

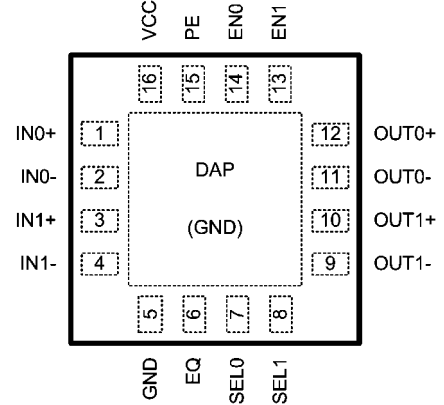
NSID	Function	Available Equalization Levels	Available Pre-Emphasis Levels
DS25CP102QSQ	Crosspoint Switch	Off / On	Off / On

## Block Diagram



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## Connection Diagram



30063302

## 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 Equalization 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
LVC MOS 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	+105°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	1.91W
Derate SQA Package	23.9 mW/°C above +25°C

Package Thermal Resistance

 $\theta_{JA}$  +41.8°C/W $\theta_{JC}$  +6.9°C/W

ESD Susceptibility

HBM (Note 1)  $\geq 8$  kVMM (Note 2)  $\geq 250V$ CDM (Note 3)  $\geq 1250V$ **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
<b>LVC MOS DC SPECIFICATIONS</b>						
$V_{IH}$	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	$\mu A$
$I_{IL}$	Low Level Input Current	$V_{IN} = GND$ $V_{CC} = 3.6V$		0	$\pm 10$	$\mu A$
$V_{CL}$	Input Clamp Voltage	$I_{CL} = -18$ mA, $V_{CC} = 0V$		-0.9	-1.5	V
<b>LVDS INPUT DC SPECIFICATIONS</b>						
$V_{ID}$	Input Differential Voltage		0		1	V
$V_{TH}$	Differential Input High Threshold	$V_{CM} = +0.05V$ or $V_{CC} - 0.05V$		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 $0V$		$\pm 1$	$\pm 10$	$\mu A$
$C_{IN}$	Input Capacitance	Any LVDS Input Pin to GND		1.7		pF
$R_{IN}$	Input Termination Resistor	Between IN+ and IN-		100		$\Omega$

Symbol	Parameter	Conditions	Min	Typ	Max	Units
<b>LVDS OUTPUT DC SPECIFICATIONS</b>						
$V_{OD}$	Differential Output Voltage	$R_L = 100\Omega$	250	350	450	mV
$\Delta V_{OD}$	Change in Magnitude of $V_{OD}$ for Complimentary Output States		-35		35	mV
$V_{OS}$	Offset Voltage	$R_L = 100\Omega$	1.05	1.2	1.375	V
$\Delta V_{OS}$	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		$\Omega$
<b>SUPPLY CURRENT</b>						
$I_{CC}$	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  $\Delta V_{OD}$ .

**Note 7:** Typical values represent most likely parametric norms for  $V_{CC} = +3.3V$  and  $T_A = +25^\circ C$ , 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	
<b>LVDS OUTPUT AC SPECIFICATIONS</b>							
$t_{PLHD}$	Differential Propagation Delay Low to High	$R_L = 100\Omega$		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	$R_L = 100\Omega$		65	120	ps	
$t_{HLT}$	Fall Time			65	120	ps	
$t_{ON}$	Output Enable Time	ENn = LH to output active		7	20	$\mu$ s	
$t_{OFF}$	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	
<b>JITTER PERFORMANCE WITH EQ = Off, PE = Off (Figure 5)</b>							
$t_{RJ1}$	Random Jitter (RMS Value)	$V_{ID} = 350\text{ mV}$ $V_{CM} = 1.2\text{V}$ Clock (RZ)	2.5 Gbps		0.5	1	ps
$t_{RJ2}$	No Test Channels (Note 15)		3.125 Gbps		0.5	1	ps
$t_{DJ1}$	Deterministic Jitter (Peak to Peak)	$V_{ID} = 350\text{ mV}$ $V_{CM} = 1.2\text{V}$ K28.5 (NRZ)	2.5 Gbps		6	22	ps
$t_{DJ2}$	No Test Channels (Note 16)		3.125 Gbps		6	22	ps
$t_{TJ1}$	Total Jitter (Peak to Peak)	$V_{ID} = 350\text{ mV}$ $V_{CM} = 1.2\text{V}$ PRBS-23 (NRZ)	2.5 Gbps		0.03	0.08	UI <sub>P-P</sub>
$t_{TJ2}$	No Test Channels (Note 17)		3.125 Gbps		0.05	0.11	UI <sub>P-P</sub>
<b>JITTER PERFORMANCE WITH EQ = Off, PE = On (Figure 6 Figure 9)</b>							
$t_{RJ1B}$	Random Jitter (RMS Value)	$V_{ID} = 350\text{ mV}$ $V_{CM} = 1.2\text{V}$ Clock (RZ)	2.5 Gbps		0.5	1	ps
$t_{RJ2B}$	Test Channel B (Note 15)		3.125 Gbps		0.5	1	ps
$t_{DJ1B}$	Deterministic Jitter (Peak to Peak)	$V_{ID} = 350\text{ mV}$ $V_{CM} = 1.2\text{V}$ K28.5 (NRZ)	2.5 Gbps		3	12	ps
$t_{DJ2B}$	Test Channel B (Note 16)		3.125 Gbps		3	12	ps
$t_{TJ1B}$	Total Jitter (Peak to Peak)	$V_{ID} = 350\text{ mV}$ $V_{CM} = 1.2\text{V}$ PRBS-23 (NRZ)	2.5 Gbps		0.03	0.06	UI <sub>P-P</sub>
$t_{TJ2B}$	Test Channel B (Note 17)		3.125 Gbps		0.04	0.09	UI <sub>P-P</sub>
<b>JITTER PERFORMANCE WITH EQ = On, PE = Off (Figure 7 Figure 9)</b>							
$t_{RJ1D}$	Random Jitter (RMS Value)	$V_{ID} = 350\text{ mV}$ $V_{CM} = 1.2\text{V}$ Clock (RZ)	2.5 Gbps		0.5	1	ps
$t_{RJ2D}$	Test Channel D (Note 15)		3.125 Gbps		0.5	1	ps
$t_{DJ1D}$	Deterministic Jitter (Peak to Peak)	$V_{ID} = 350\text{ mV}$ $V_{CM} = 1.2\text{V}$ K28.5 (NRZ)	2.5 Gbps		16	24	ps
$t_{DJ2D}$	Test Channel D (Note 16)		3.125 Gbps		12	24	ps
$t_{TJ1D}$	Total Jitter (Peak to Peak)	$V_{ID} = 350\text{ mV}$ $V_{CM} = 1.2\text{V}$ PRBS-23 (NRZ)	2.5 Gbps		0.07	0.11	UI <sub>P-P</sub>
$t_{TJ2D}$	Test Channel D (Note 17)		3.125 Gbps		0.07	0.11	UI <sub>P-P</sub>

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

**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  $V_{CC} = +3.3\text{V}$  and  $T_A = +25^\circ\text{C}$ , 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  $5^\circ\text{C}$  of each other within the operating temperature range.

**Note 15:** Measured on a clock edge with a histogram and an accumulation 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 accumulation of 3500 histogram hits. Input stimulus jitter is subtracted.

## DC Test Circuits

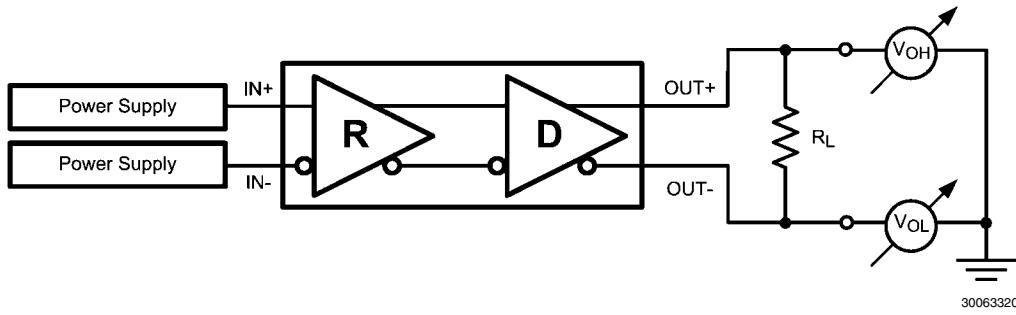


FIGURE 1. Differential Driver DC Test Circuit

## AC Test Circuits and Timing Diagrams

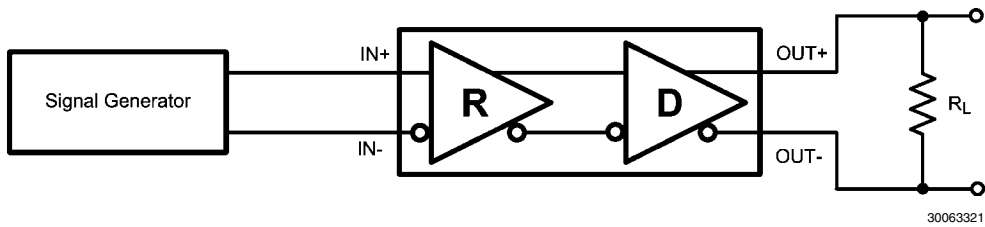


FIGURE 2. Differential Driver AC Test Circuit

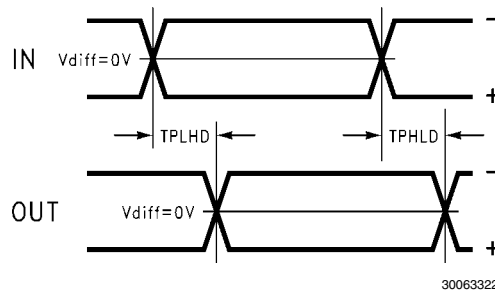


FIGURE 3. Propagation Delay Timing Diagram

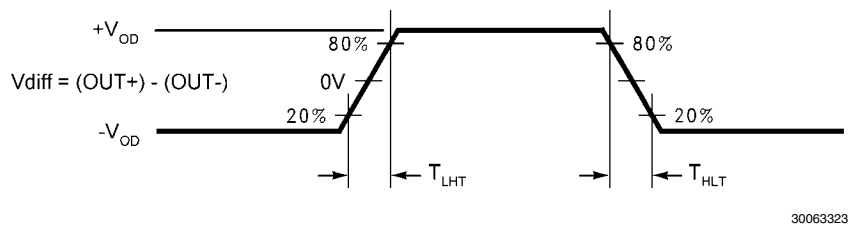
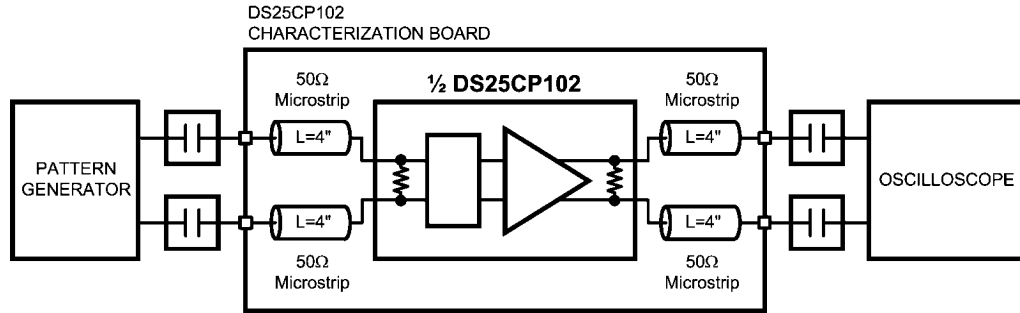


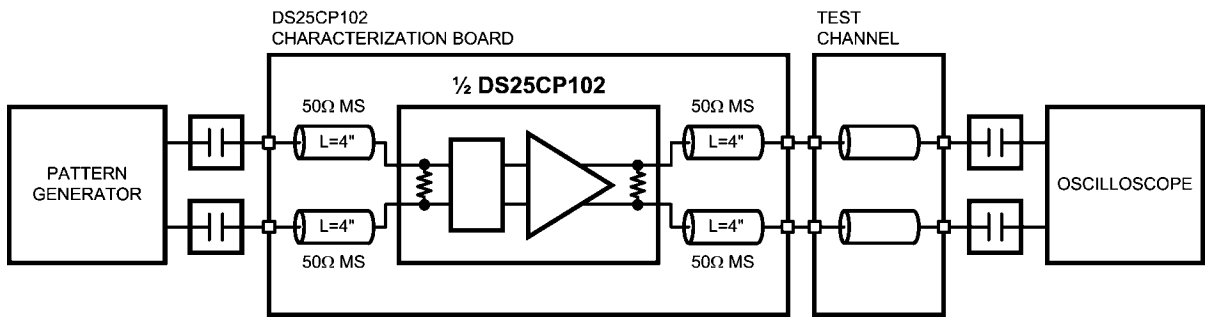
FIGURE 4. LVDS Output Transition Times

# Pre-Emphasis and Equalization Test Circuits



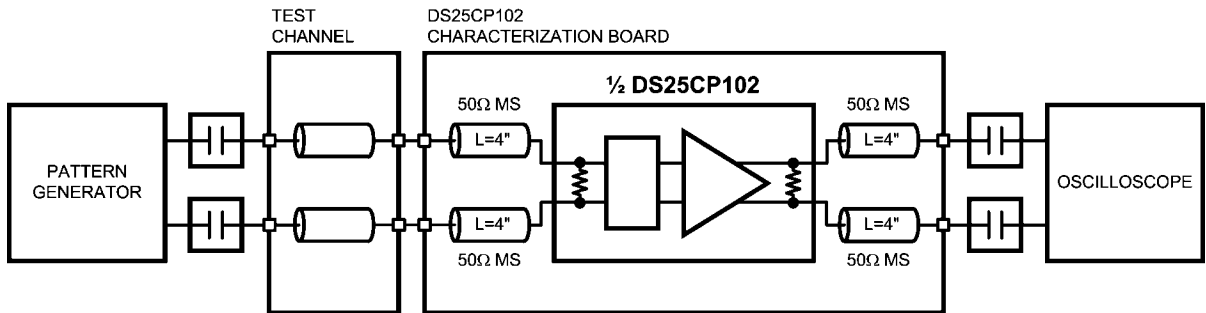
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FIGURE 5. Jitter Performance Test Circuit



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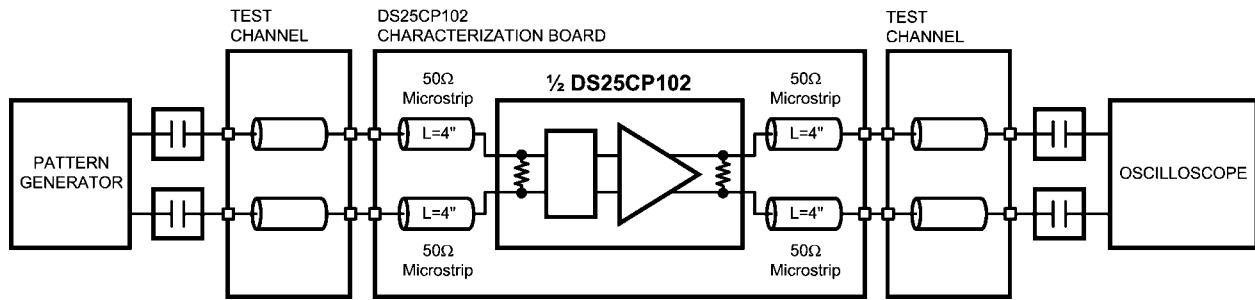
FIGURE 6. Pre-Emphasis Performance Test Circuit



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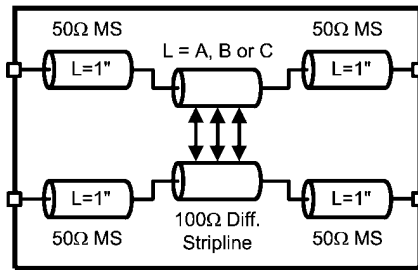
FIGURE 7. Equalization Performance Test Circuit





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FIGURE 8. Pre-Emphasis and Equalization Performance Test Circuit



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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 con-

stant 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 DS25CP102Q is a 3.125 Gbps 2x2 LVDS digital cross-point 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 DS25CP102Q 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

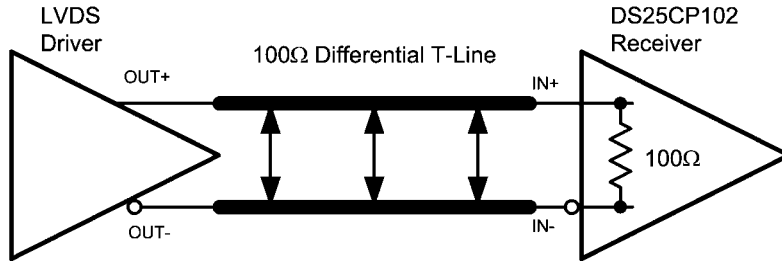
INPUTS IN0 and IN1	
CONTROL Pin (EQ) State	Equalization Level
0	OFF
1	ON

Receive Equalization Level Selection

## Input Interfacing

The DS25CP102Q accepts differential signals and allows simple AC or DC coupling. With a wide common mode range, the DS25CP102Q can be DC-coupled with all common dif-

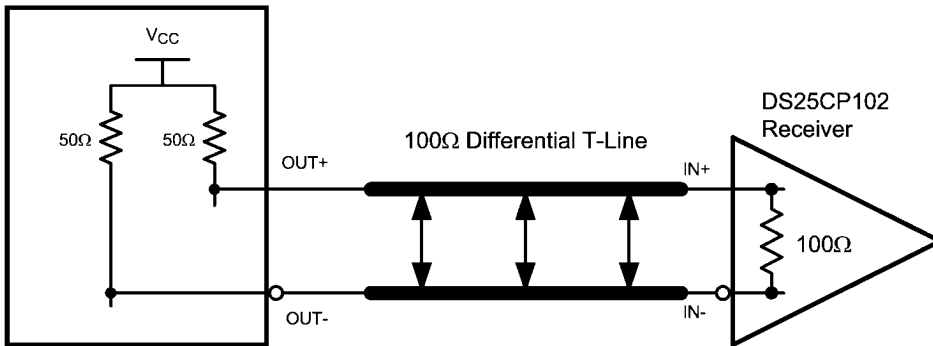
ferential drivers (i.e. LVPECL, LVDS, CML). The following three figures illustrate typical DC-coupled interface to common differential drivers. Note that the DS25CP102Q inputs are internally terminated with a 100Ω resistor.



Typical LVDS Driver DC-Coupled Interface to DS25CP102Q Input

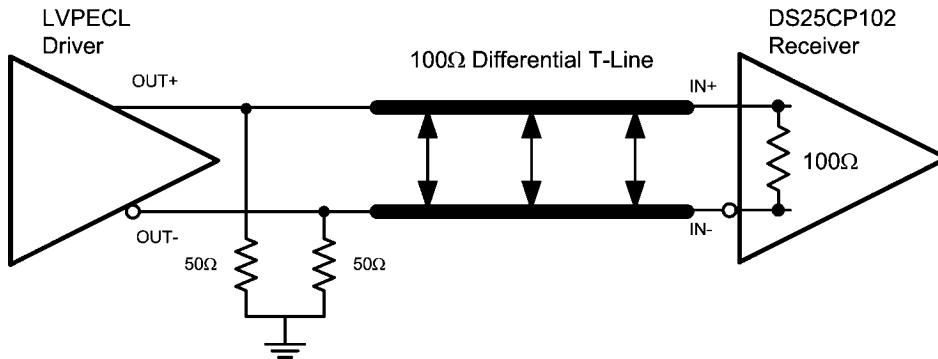
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CML3.3V or CML2.5V Driver



Typical CML Driver DC-Coupled Interface to DS25CP102Q Input

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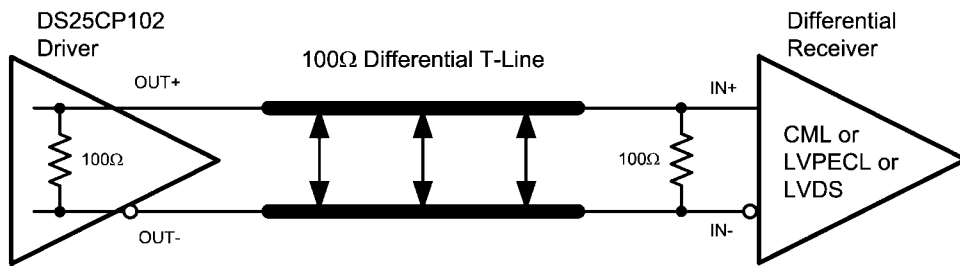
Typical LVPECL Driver DC-Coupled Interface to DS25CP102Q Input

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## Output Interfacing

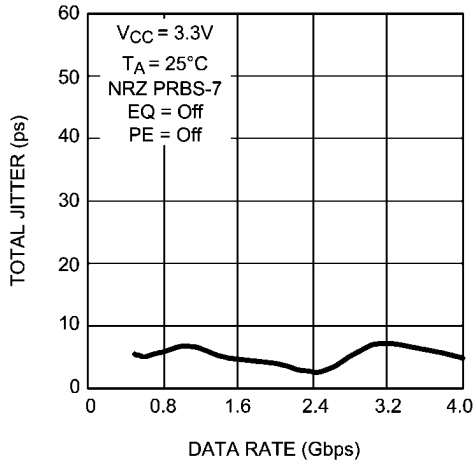
The DS25CP102Q outputs signals that are compliant to the LVDS standard. Its outputs can be DC-coupled to most common differential receivers. The following figure illustrates typical DC-coupled interface to common differential receivers

and assumes that the receivers have high impedance inputs. While most differential receivers have a common mode input range that can accommodate LVDS compliant signals, it is recommended to check respective receiver's data sheet prior to implementing the suggested interface implementation.

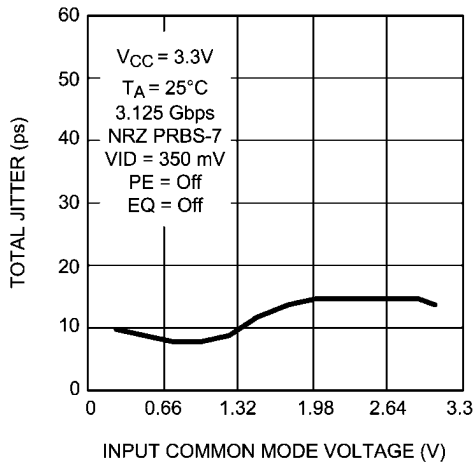


Typical DS25CP102Q Output DC-Coupled Interface to an LVDS, CML or LVPECL Receiver 30063334

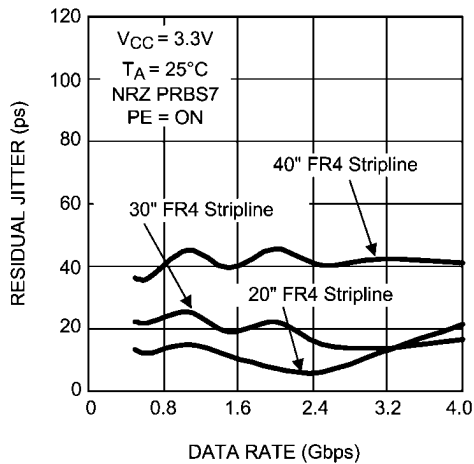
# Typical Performance



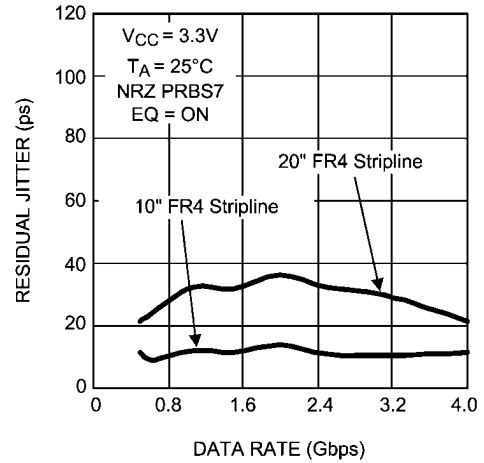
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**Total Jitter as a Function of Data Rate**



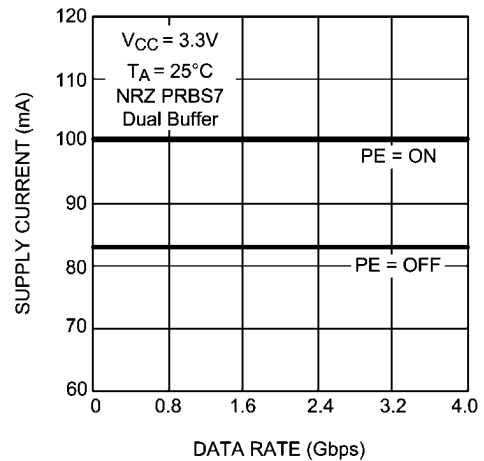
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**Total Jitter as a Function of Input Common Mode Voltage**



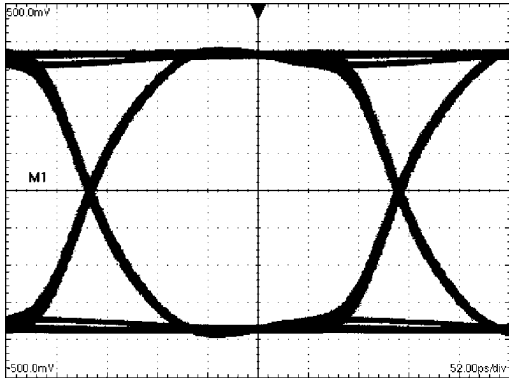
30063351  
**Residual Jitter as a Function of Data Rate, FR4 Stripline Length and PE Level**



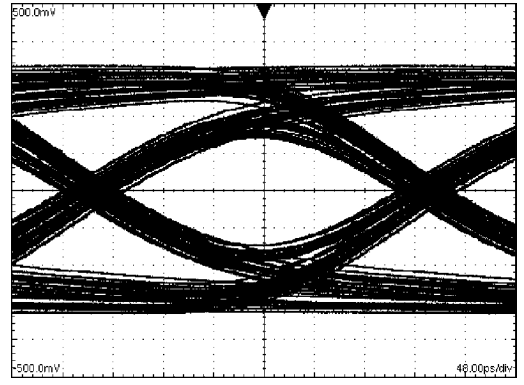
30063352  
**Residual Jitter as a Function of Data Rate, FR4 Stripline Length and EQ Level**



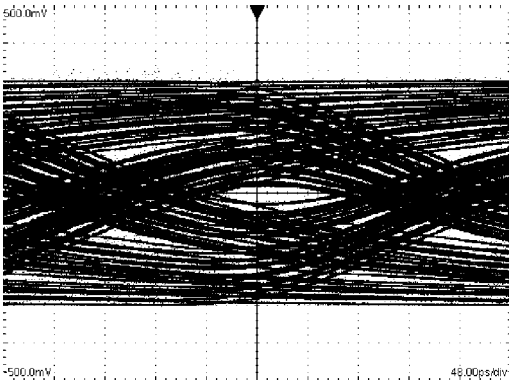
30063357  
**Supply Current as a Function of Data Rate and PE Level**



30063360  
**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

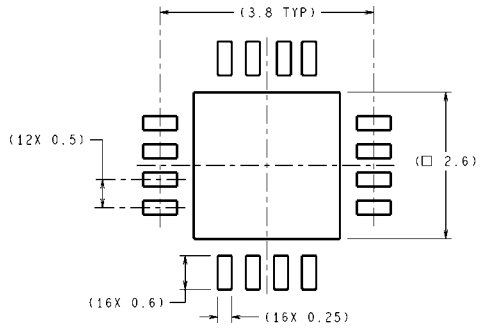


30063362  
**A 3.125 Gbps NRZ PRBS-7 with PE**  
**After 40" Differential FR-4 Stripline**  
H: 50 ps / DIV, V: 100 mV / DIV



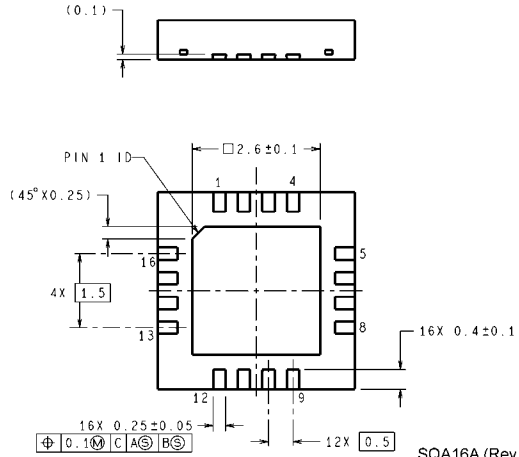
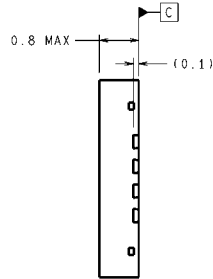
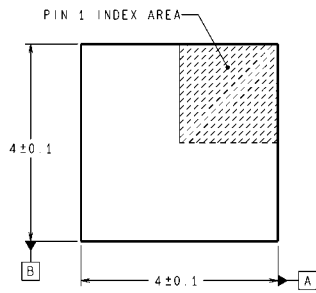
30063361  
**A 3.125 Gbps NRZ PRBS-7 without PE or EQ**  
**After 40" Differential FR-4 Stripline**  
H: 50 ps / DIV, V: 100 mV / DIV

# Physical Dimensions inches (millimeters) unless otherwise noted



DIMENSIONS ARE IN MILLIMETERS  
DIMENSIONS IN ( ) FOR REFERENCE ONLY

RECOMMENDED LAND PATTERN



SQA16A (Rev A)

Order Number DS25CP102QSQ  
NS Package Number SQA16A  
(See AN-1187 for PCB Design and Assembly Recommendations)

## Notes

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Clock Conditioners	<a href="http://www.national.com/timing">www.national.com/timing</a>	App Notes	<a href="http://www.national.com/appnotes">www.national.com/appnotes</a>
Data Converters	<a href="http://www.national.com/adc">www.national.com/adc</a>	Distributors	<a href="http://www.national.com/contacts">www.national.com/contacts</a>
Displays	<a href="http://www.national.com/displays">www.national.com/displays</a>	Green Compliance	<a href="http://www.national.com/quality/green">www.national.com/quality/green</a>
Ethernet	<a href="http://www.national.com/ethernet">www.national.com/ethernet</a>	Packaging	<a href="http://www.national.com/packaging">www.national.com/packaging</a>
Interface	<a href="http://www.national.com/interface">www.national.com/interface</a>	Quality and Reliability	<a href="http://www.national.com/quality">www.national.com/quality</a>
LVDS	<a href="http://www.national.com/lvds">www.national.com/lvds</a>	Reference Designs	<a href="http://www.national.com/refdesigns">www.national.com/refdesigns</a>
Power Management	<a href="http://www.national.com/power">www.national.com/power</a>	Feedback	<a href="http://www.national.com/feedback">www.national.com/feedback</a>
Switching Regulators	<a href="http://www.national.com/switchers">www.national.com/switchers</a>		
LDOs	<a href="http://www.national.com/lido">www.national.com/lido</a>		
LED Lighting	<a href="http://www.national.com/led">www.national.com/led</a>		
PowerWise	<a href="http://www.national.com/powerwise">www.national.com/powerwise</a>		
Serial Digital Interface (SDI)	<a href="http://www.national.com/sdi">www.national.com/sdi</a>		
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