

## DS10CP152Q

# Automotive 1.5 Gbps 2X2 LVDS Crosspoint Switch

## General Description

The DS10CP152Q is a 1.5 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.

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 return losses, reduce component count and further minimize board space.

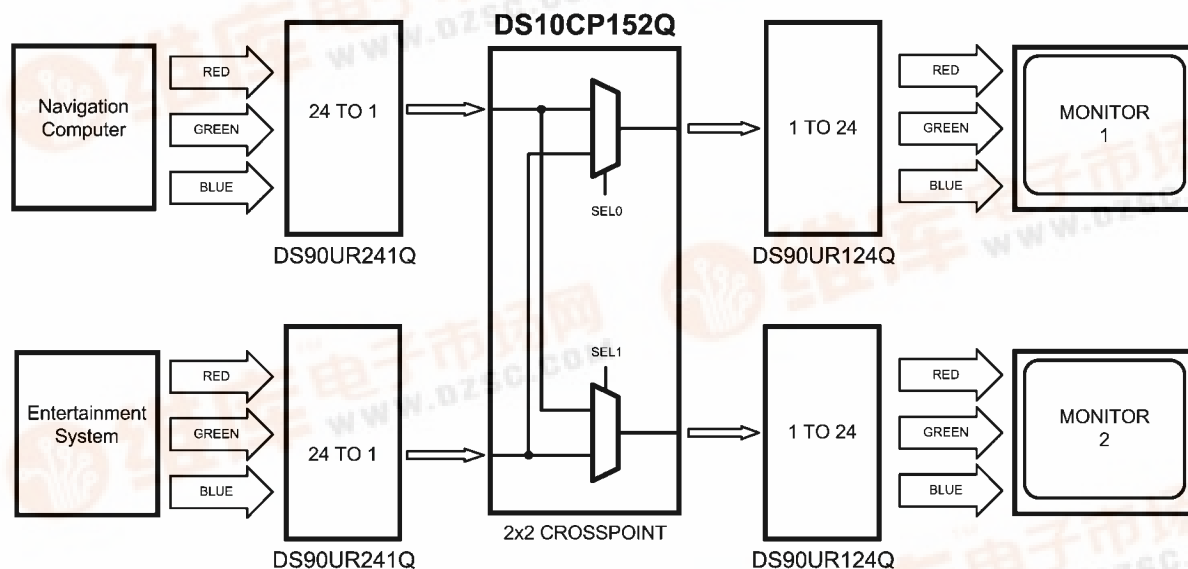
## Features

- AECQ-100 Grade 3
- DC - 1.5 Gbps low jitter, low skew, low power operation
- Pin configurable, fully differential, non-blocking architecture
- Wide Input Common Mode Voltage Range allows DC-coupled interface to LVDS, 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 SOIC-16 space saving package

## Applications

- Automotive display applications
- Clock and data buffering and muxing
- SD/HD SDI Routers

## Typical Application



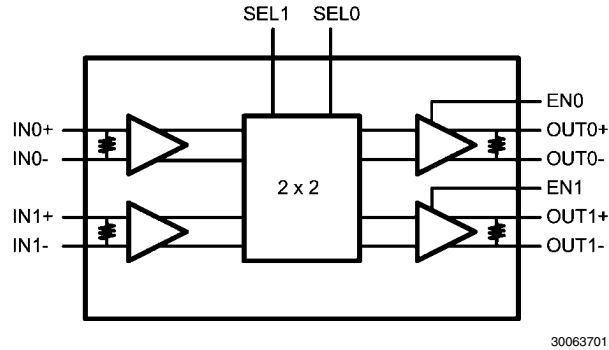
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## Ordering Code

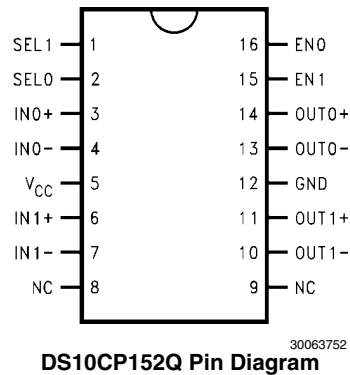
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NSID	Function
DS10CP152QMA	2x2 Crosspoint Switch

## Block Diagram



## Connection Diagram



DS10CP152Q Pin Diagram

## Pin Descriptions

Pin Name	Pin Number	I/O, Type	Pin Description
IN0+, IN0- , IN1+, IN1-	3, 4, 6, 7	I, LVDS	Inverting and non-inverting high speed LVDS input pins.
OUT0+, OUT0- , OUT1+, OUT1-	14, 13, 11, 10	O, LVDS	Inverting and non-inverting high speed LVDS output pins.
SEL1, SEL0	1, 2	I, LVCMOS	Switch configuration pins.
EN0, EN1	16, 15	I, LVCMOS	Output enable pins.
NC	8, 9	NC	"NO CONNECT" pins.
VDD	5	Power	Power supply pin.
GND	12	Power	Ground pin.

## Absolute Maximum Ratings (Note 4)

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

Package Thermal Resistance

$\theta_{JA}$  +72.7°C/W

$\theta_{JC}$  +41.2°C/W

ESD Susceptibility

HBM (Note 1)  $\geq 8$  kV

MM (Note 2)  $\geq 250$  V

CDM (Note 3)  $\geq 1250$  V

**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

Over recommended operating supply and temperature ranges unless otherwise specified. (Notes 5, 6, 7)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
<b>LVCMOS DC SPECIFICATIONS</b>						
$V_{IH}$	High Level Input Voltage		2.0		$V_{DD}$	V
$V_{IL}$	Low Level Input Voltage		GND		0.8	V
$I_{IH}$	High Level Input Current	$V_{IN} = 3.6$ V $V_{CC} = 3.6$ V	40	175	250	$\mu$ A
$I_{IL}$	Low Level Input Current	$V_{IN} = \text{GND}$ $V_{CC} = 3.6$ V		$\pm 1$	$\pm 10$	$\mu$ A
$V_{CL}$	Input Clamp Voltage	$I_{CL} = -18$ mA, $V_{CC} = 0$ V		-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	$V_{CM} = +0.05$ V or $V_{CC} - 0.05$ V		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	$V_{IN} = 3.6$ V or 0 V $V_{CC} = 3.6$ V or 0 V		$\pm 1$	$\pm 10$	$\mu$ 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		-23	-55	mA
		OUT to $V_{CC}$		8	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	EN0 = EN1 = H		58	70	mA
$I_{CCZ}$	Outputs Powered Down Supply Current	EN0 = EN1 = L		25	30	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

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Over recommended operating supply and temperature ranges unless otherwise specified. (Notes 9, 10, 11)

Symbol	Parameter	Conditions	Min	Typ	Max	Units	
LVDS OUTPUT AC SPECIFICATIONS							
t <sub>PLHD</sub>	Differential Propagation Delay Low to High	R <sub>L</sub> = 100Ω		440	650	ps	
t <sub>PHLD</sub>	Differential Propagation Delay High to Low			400	650	ps	
t <sub>SKD1</sub>	Pulse Skew  t <sub>PLHD</sub> – t <sub>PHLD</sub>   (Note 12)			40	120	ps	
t <sub>SKD2</sub>	Channel to Channel Skew (Note 13)			25	60	ps	
t <sub>SKD3</sub>	Part to Part Skew (Note 14)			45	190	ps	
t <sub>LHT</sub>	Rise Time	R <sub>L</sub> = 100Ω		170	350	ps	
t <sub>HLT</sub>	Fall Time			170	350	ps	
t <sub>ON</sub>	Output Enable Time			5	20	μs	
t <sub>OFF</sub>	Output Disable Time			3	12	ns	
t <sub>SEL</sub>	Select Time			3	12	ns	
JITTER PERFORMANCE (Note 11)							
t <sub>RJ1</sub>	Random Jitter (RMS Value)	V <sub>ID</sub> = 350 mV V <sub>CM</sub> = 1.2V Clock (RZ)	135 MHz		0.5	1.2	ps
t <sub>RJ2</sub>			311 MHz		0.5	1.2	ps
t <sub>RJ3</sub>			503 MHz		0.5	1.2	ps
t <sub>RJ4</sub>			750 MHz		0.5	1.2	ps
t <sub>DJ1</sub>	Deterministic Jitter (Peak-to-Peak Value )	V <sub>ID</sub> = 350 mV V <sub>CM</sub> = 1.2V Clock (RZ)	270 Mbps		9	38	ps
t <sub>DJ2</sub>			622 Mbps		7	36	ps
t <sub>DJ3</sub>			1.06 Gbps		7	34	ps
t <sub>DJ4</sub>			1.5 Gbps		9	35	ps
t <sub>TJ1</sub>	Total Jitter (Peak to Peak Value)	V <sub>ID</sub> = 350 mV V <sub>CM</sub> = 1.2V PRBS-23 (NRZ)	270 Mbps		0.01	0.03	UI <sub>P-P</sub>
t <sub>TJ2</sub>			622 Mbps		0.01	0.04	UI <sub>P-P</sub>
t <sub>TJ3</sub>			1.06 Gbps		0.01	0.05	UI <sub>P-P</sub>
t <sub>TJ4</sub>			1.5 Gbps		0.01	0.07	UI <sub>P-P</sub>

**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

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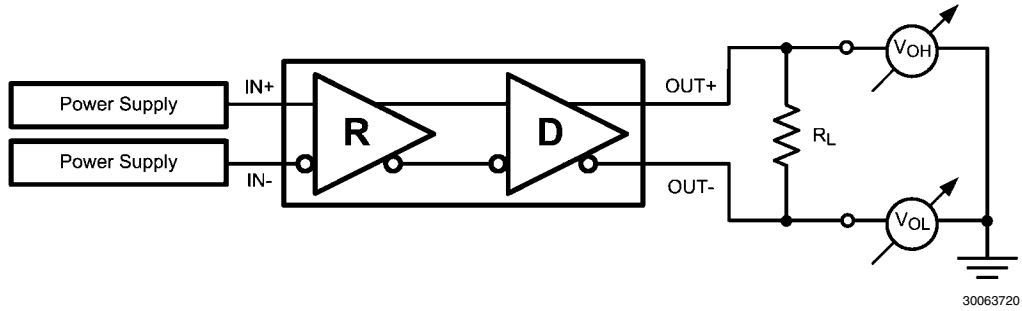


FIGURE 1. Differential Driver DC Test Circuit

## AC Test Circuits and Timing Diagrams

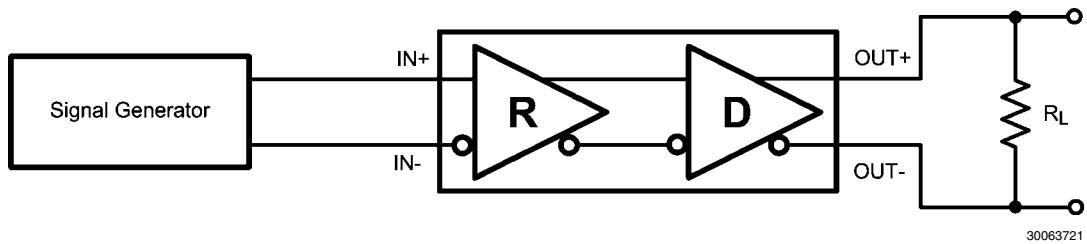


FIGURE 2. Differential Driver AC Test Circuit

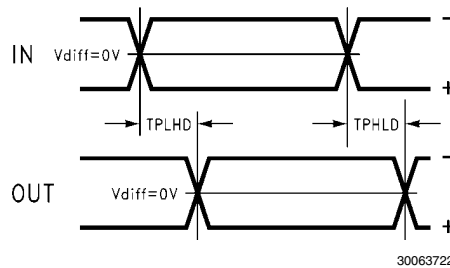


FIGURE 3. Propagation Delay Timing Diagram

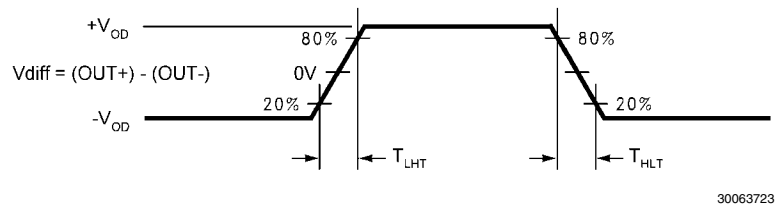


FIGURE 4. LVDS Output Transition Times

## Functional Description

The DS10CP152Q is a 1.5 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**

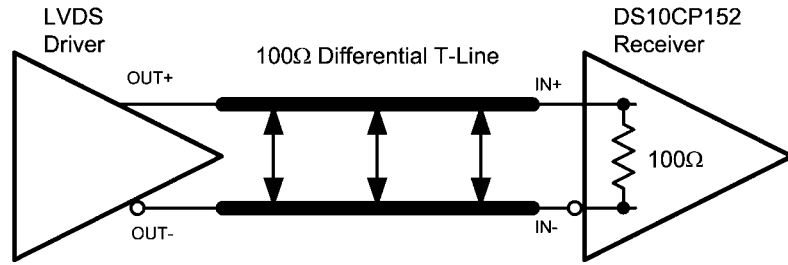
EN1	EN0	OUT1	OUT0
0	0	Disabled	Disabled
0	1	Disabled	Enabled
1	0	Enabled	Disabled
1	1	Enabled	Enabled

## INPUT INTERFACING

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The DS10CP152Q accepts differential signals and allows simple AC or DC coupling. With a wide common mode range, the DS10CP152Q can be DC-coupled with all common dif-

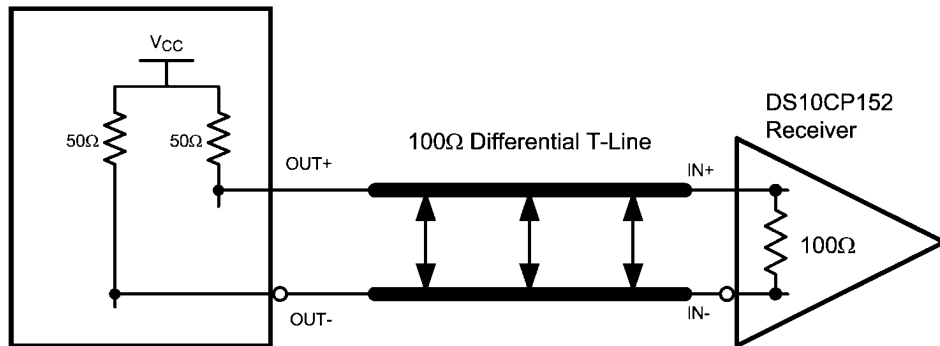
ferential drivers (i.e. LVPECL, LVDS, CML). The following three figures illustrate typical DC-coupled interface to common differential drivers. Note that the DS10CP152Q inputs are internally terminated with a  $100\Omega$  resistor.



Typical LVDS Driver DC-Coupled Interface to an DS10CP152Q Input

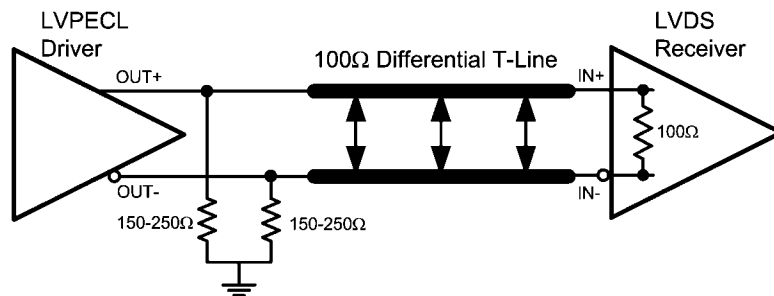
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CML3.3V or CML2.5V  
Driver



Typical CML Driver DC-Coupled Interface to an DS10CP152Q Input

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Typical LVPECL Driver DC-Coupled Interface to an DS10CP152Q Input

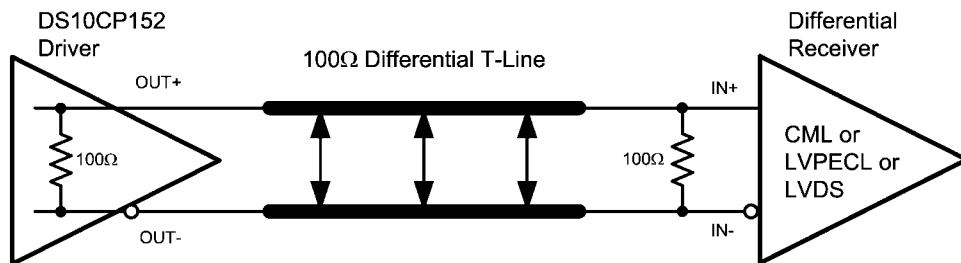
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## OUTPUT INTERFACING

The DS10CP152Q outputs are LVDS 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

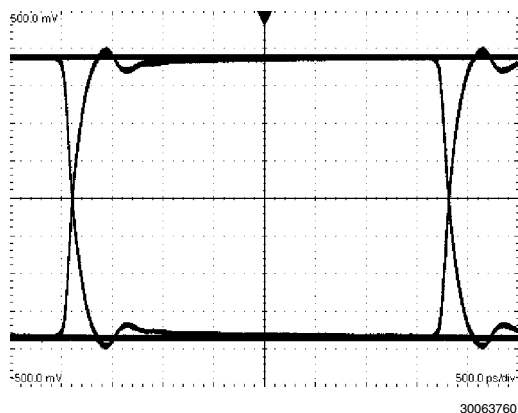
assumes that the receivers have high impedance inputs. While most differential receivers have a common mode input range that can accommodate LVDS compliant signals, it is recommended to check respective receiver's data sheet prior to implementing the suggested interface implementation.



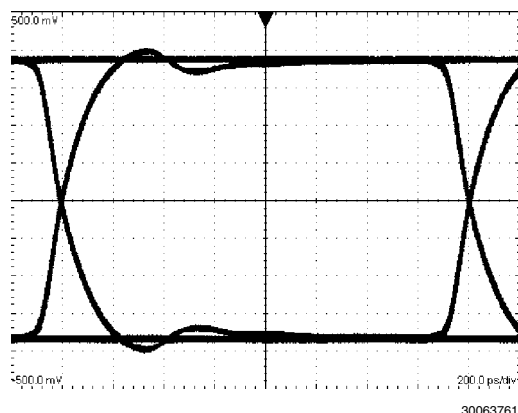
Typical DS10CP152Q Output DC-Coupled Interface to an LVDS, CML or LVPECL Receiver 30063734

# Typical Performance Characteristics

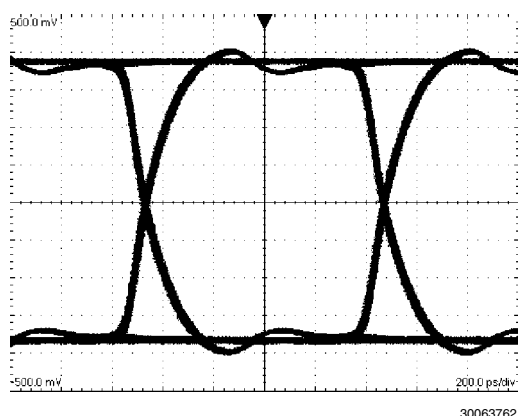
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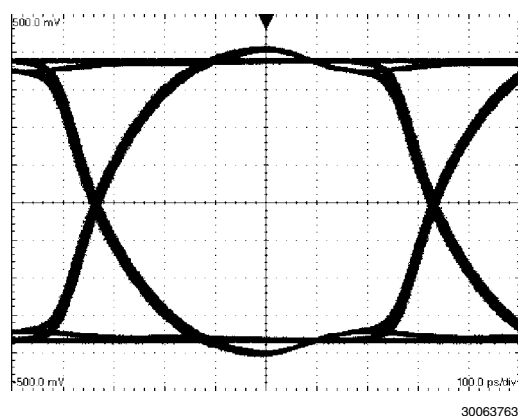
**A 270 Mbps NRZ PRBS-7 After 2"**  
Differential FR-4 Stripline  
V:100 mV / DIV, H:500 ps / DIV



**A 622 Mbps NRZ PRBS-7 After 2"**  
Differential FR-4 Stripline  
V:100 mV / DIV, H:200 ps / DIV

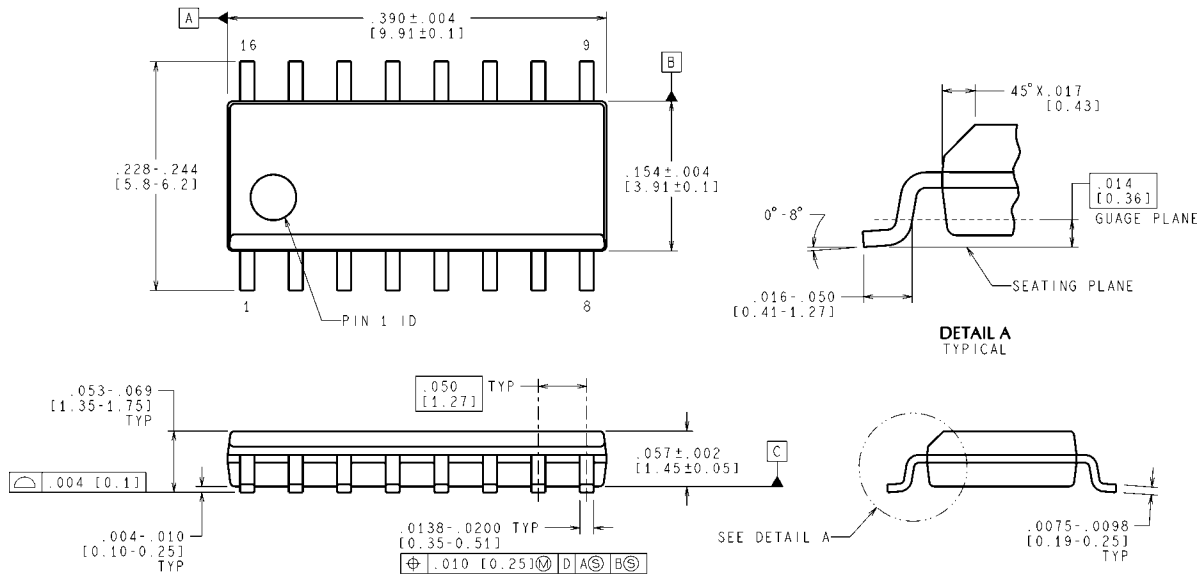


**A 1.06 Gbps NRZ PRBS-7 After 2"**  
Differential FR-4 Stripline  
V:100 mV / DIV, H:200 ps / DIV



**A 1.5 Gbps NRZ PRBS-7 After 2"**  
Differential FR-4 Stripline  
V:100 mV / DIV, H:100 ps / DIV

**Physical Dimensions** inches (millimeters) unless otherwise noted  
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Order Number DS10CP152QMA  
 NS Package Number M16A

M16A (Rev J)

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## Notes

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Interface	<a href="http://www.national.com/interface">www.national.com/interface</a>	Eval Boards	<a href="http://www.national.com/evalboards">www.national.com/evalboards</a>
LVDS	<a href="http://www.national.com/lvds">www.national.com/lvds</a>	Packaging	<a href="http://www.national.com/packaging">www.national.com/packaging</a>
Power Management	<a href="http://www.national.com/power">www.national.com/power</a>	Green Compliance	<a href="http://www.national.com/quality/green">www.national.com/quality/green</a>
Switching Regulators	<a href="http://www.national.com/switchers">www.national.com/switchers</a>	Distributors	<a href="http://www.national.com/contacts">www.national.com/contacts</a>
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LED Lighting	<a href="http://www.national.com/led">www.national.com/led</a>	Feedback/Support	<a href="http://www.national.com/feedback">www.national.com/feedback</a>
Voltage Reference	<a href="http://www.national.com/vref">www.national.com/vref</a>	Design Made Easy	<a href="http://www.national.com/easy">www.national.com/easy</a>
PowerWise® Solutions	<a href="http://www.national.com/powerwise">www.national.com/powerwise</a>	Solutions	<a href="http://www.national.com/solutions">www.national.com/solutions</a>
Serial Digital Interface (SDI)	<a href="http://www.national.com/sdi">www.national.com/sdi</a>	Mil/Aero	<a href="http://www.national.com/milaero">www.national.com/milaero</a>
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