National Semiconductor

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DS25BR100 / DS25BR101

3.125 Gbps LVDS Buffer with Transmit Pre-Emphasis and Receive Equalization

General Description

The DS25BR100 and DS25BR101 are single channel 3.125 Gbps LVDS buffers optimized for high-speed signal transmission over lossy FR-4 printed circuit board backplanes and balanced metallic cables. Fully differential signal paths ensure exceptional signal integrity and noise immunity.

The DS25BR100 and DS25BR101 feature transmit pre-emphasis (PE) and receive equalization (EQ), making them ideal for use as a repeater device. Other LVDS devices with similar IO characteristics include the following products. The DS25BR120 features four levels of pre-emphasis for use as an optimized driver device, while the DS25BR110 features four levels of equalization for use as an optimized receiver device. The DS25BR150 is a buffer/repeater with the lowest power consumption and does not feature transmit pre-emphasis nor receive equalization.

Wide input common mode range allows the receiver to accept signals with LVDS, CML and LVPECL levels; the output levels are LVDS. A very small package footprint requires minimal space on the board while the flow-through pinout allows easy board layout. On the DS25BR100 the differential input and output is internally terminated with a 100Ω resistor to lower return losses, reduce component count and further minimize board space. For added design flexibility the 100Ω input terminations on the DS25BR101 have been eliminated. This enables a designer to adjust the termination for custom interconnect topologies and layout.

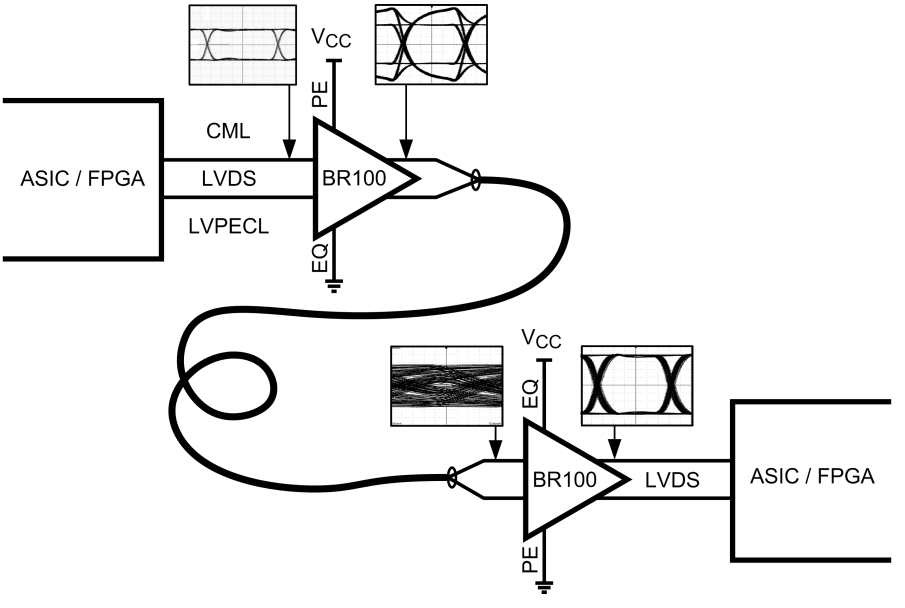
Features

- DC - 3.125 Gbps low jitter, high noise immunity, low power operation
- Receive equalization reduces ISI jitter due to media loss
- Transmit pre-emphasis drives lossy backplanes and cables
- On-chip 100Ω input and output termination minimizes insertion and return losses, reduces component count and minimizes board space. The DS25BR101 eliminates the on-chip input termination for added design flexibility.
- 7 kV ESD on LVDS I/O pins protects adjoining components
- Small 3 mm x 3 mm LLP-8 space saving package

Applications

- Clock and data buffering
- Metallic cable driving and equalization
- FR-4 equalization

Typical Application



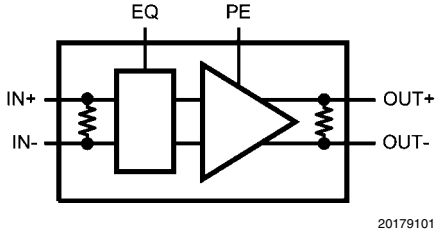
Device Information

Device	Function	Termination Option	Available Signal Conditioning
DS25BR100	Buffer / Repeater	Internal 100Ω for LVDS inputs	2 Levels: PE and EQ
DS25BR101	Buffer / Repeater	External termination required	2 Levels: PE and EQ
DS25BR110	Receiver	Internal 100Ω for LVDS inputs	4 Levels: EQ
DS25BR120	Driver	Internal 100Ω for LVDS inputs	4 Levels: PE
DS25BR150	Buffer / Repeater	Internal 100Ω for LVDS inputs	None

Ordering Information

NSID	Package	Tape & Reel QTY	Package Number
DS25BR100TSD	8 Lead LLP Package	1000	SDA08A
DS25BR100TSDX	8 Lead LLP Package	4500	SDA08A
DS25BR101TSD	8 Lead LLP Package	1000	SDA08A
DS25BR101TSDX	8 Lead LLP Package	4500	SDA08A

Block Diagram



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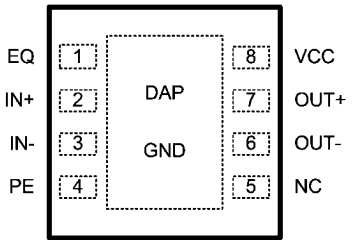
Note: DS25BR101 eliminates 100Ω input termination.

Pin Diagram



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Pin Descriptions

Pin Name	Pin Name	Pin Type	Pin Description
EQ	1	Input	Equalizer select pin.
IN+	2	Input	Non-inverting LVDS input pin.
IN-	3	Input	Inverting LVDS input pin.
PE	4	Input	Pre-emphasis select pin.
NC	5	NA	"NO CONNECT" pin.
OUT-	6	Output	Inverting LVDS output pin.
OUT+	7	Output	Non-inverting LVDS Output pin.
VCC	8	Power	Power supply pin.
GND	DAP	Power	Ground pad (DAP - die attach pad).

Control Pins (PE and EQ) Truth Table

EQ	PE	Equalization Level	Pre-emphasis Level
0	0	Low (Approx. 4 dB at 1.56 GHz)	Off
0	1	Low (Approx. 4 dB at 1.56 GHz)	Medium (Approx. 6 dB at 1.56 GHz)
1	0	Medium (Approx. 8 dB at 1.56 GHz)	Off
1	1	Medium (Approx. 8 dB at 1.56 GHz)	Medium (Approx. 6 dB at 1.56 GHz)

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 (V_{CC})	−0.3V to +4V
LVCMOS Input Voltage (EQ, PE)	−0.3V to (V_{CC} + 0.3V)
LVDS Input Voltage (IN+, IN−)	−0.3V to +4V
LVDS Differential Input Voltage (DS25BR100)	0V to 1V
LVDS Differential Input Voltage (DS25BR101)	V_{CC} + 0.6V
LVDS Output Voltage (OUT+, OUT−)	−0.3V to (V_{CC} + 0.3V)
LVDS Differential Output Voltage ((OUT+) - (OUT−))	0V to 1V
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	
SDA Package	2.08W
Derate SDA Package	16.7 mW/°C above +25°C
Package Thermal Resistance	
θ_{JA}	+60.0°C/W
θ_{JC}	+12.3°C/W
ESD Susceptibility	
HBM (Note 1)	≥7 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}) (DS25BR100 only)			1.0	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
LVCMOS INPUT DC SPECIFICATIONS (EQ, PE)						
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		0	±10	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 OUTPUT DC SPECIFICATIONS (OUT+, OUT-)						
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 10)	OUT to GND, PE = 0		-35	-55	mA
		OUT to V_{CC}, PE = 0		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

Symbol	Parameter	Conditions	Min	Typ	Max	Units
LVDS INPUT DC SPECIFICATIONS (IN+, IN-)						
V_{ID}	Input Differential Voltage (Note 8)	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} = GND or 3.6V V_{CC} = 3.6V or 0.0V		±1	±10	µA
C_{IN}	Input Capacitance	Any LVDS Input Pin to GND		1.7		pF
R_{IN}	Input Termination Resistor (Note 9)	Between IN+ and IN-		100		Ω
SUPPLY CURRENT						
I_{CC}	Supply Current	EQ = 0, PE = 0		35	43	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: Input Differential Voltage (V_{ID}) The DS25BR100 limits input amplitude to 1 volt. The DS25BR101 supports any V_{ID} within the supply voltage to GND range.

Note 9: Input Termination Resistor (R_{IN}) The DS25BR100 provides an integrated 100 ohm input termination for the high speed LVDS pair. The DS25BR101 eliminates this internal termination.

Note 10: Output short circuit current (I_{OS}) is specified as magnitude only, minus sign indicates direction only.

AC Electrical Characteristics (Note 13)

Over recommended operating supply and temperature ranges unless otherwise specified. (Notes 11, 12)

Symbol	Parameter	Conditions		Min	Typ	Max	Units
LVDS OUTPUT AC SPECIFICATIONS (OUT+, OUT-)							
t_{PHLD}	Differential Propagation Delay High to Low	R_L = 100Ω			350	465	ps
t_{PLHD}	Differential Propagation Delay Low to High				350	465	ps
t_{SKD1}	Pulse Skew $\lvert t_{PLHD} - t_{PHLD} \rvert$ (Note 14)				45	100	ps
t_{SKD2}	Part to Part Skew (Note 15)				45	150	ps
t_{LHT}	Rise Time	R_L = 100Ω			80	150	ps
t_{HLT}	Fall Time				80	150	ps
JITTER PERFORMANCE WITH PE = OFF AND EQ = LOW (*Figures 6, 7*)							
t_{RJ1A}	Random Jitter (RMS Value) Input Test Channel D (Note 16)	V_{ID} = 350 mV, V_{CM} = 1.2V, Clock (RZ), PE = 0, EQ = 0	2.5 Gbps		0.5	1	ps
t_{RJ2A}			3.125 Gbps		0.5	1	ps
t_{DJ1A}	Deterministic Jitter (Peak to Peak) Input Test Channel D (Note 17)	V_{ID} = 350 mV, V_{CM} = 1.2V, K28.5 (NRZ), PE = 0, EQ = 0	2.5 Gbps		1	16	ps
t_{DJ2A}			3.125 Gbps		11	31	ps
t_{TJ1A}	Total Jitter (Peak to Peak) Input Test Channel D (Note 18)	V_{ID} = 350 mV, V_{CM} = 1.2V, PRBS-23 (NRZ), PE = 0, EQ = 0	2.5 Gbps		0.03	0.09	UI_{P-P}
t_{TJ2A}			3.125 Gbps		0.06	0.14	UI_{P-P}
JITTER PERFORMANCE WITH PE = OFF AND EQ = MEDIUM (*Figures 6, 7*)							
t_{RJ1B}	Random Jitter (RMS Value) Input Test Channel E (Note 16)	V_{ID} = 350 mV, V_{CM} = 1.2V, Clock (RZ), PE = 0, EQ = 1	2.5 Gbps		0.5	1	ps
t_{RJ2B}			3.125 Gbps		0.5	1	ps
t_{DJ1B}	Deterministic Jitter (Peak to Peak) Input Test Channel E (Note 17)	V_{ID} = 350 mV, V_{CM} = 1.2V, K28.5 (NRZ), PE = 0, EQ = 1	2.5 Gbps		10	29	ps
t_{DJ2B}			3.125 Gbps		27	43	ps
t_{TJ1B}	Total Jitter (Peak to Peak) Input Test Channel E (Note 18)	V_{ID} = 350 mV, V_{CM} = 1.2V, PRBS-23 (NRZ), PE = 0, EQ = 1	2.5 Gbps		0.07	0.12	UI_{P-P}
t_{TJ2B}			3.125 Gbps		0.12	0.17	UI_{P-P}
JITTER PERFORMANCE WITH PE = MEDIUM AND EQ = LOW (*Figures 5, 7*)							
t_{RJ1C}	Random Jitter (RMS Value) Input Test Channel D Output Test Channel B (Note 16)	V_{ID} = 350 mV, V_{CM} = 1.2V, Clock (RZ), PE = 1, EQ = 0	2.5 Gbps		0.5	1	ps
t_{RJ2C}			3.125 Gbps		0.5	1	ps
t_{DJ1C}	Deterministic Jitter (Peak to Peak) Input Test Channel D Output Test Channel B (Note 17)	V_{ID} = 350 mV, V_{CM} = 1.2V, K28.5 (NRZ), PE = 1, EQ = 0	2.5 Gbps		29	57	ps
t_{DJ2C}			3.125 Gbps		29	51	ps
t_{TJ1C}	Total Jitter (Peak to Peak) Input Test Channel D Output Test Channel B (Note 18)	V_{ID} = 350 mV, V_{CM} = 1.2V, PRBS-23 (NRZ), PE = 1, EQ = 0	2.5 Gbps		0.10	0.19	UI_{P-P}
t_{TJ2C}			3.125 Gbps		0.13	0.22	UI_{P-P}

Symbol	Parameter	Conditions		Min	Typ	Max	Units
JITTER PERFORMANCE WITH PE = MEDIUM AND EQ = MEDIUM (*Figures 5, 7*)							
t_{RJ1D}	Random Jitter (RMS Value)	V_{ID} = 350 mV	2.5 Gbps		0.5	1.1	ps
t_{RJ2D}	Input Test Channel E Output Test Channel B (Note 16)	V_{CM} = 1.2V Clock (RZ) PE = 1, EQ = 1	3.125 Gbps		0.5	1	ps
t_{DJ1D}	Deterministic Jitter (Peak to Peak)	V_{ID} = 350 mV	2.5 Gbps		41	77	ps
t_{DJ2D}	Input Test Channel E Output Test Channel B (Note 17)	V_{CM} = 1.2V K28.5 (NRZ) PE = 1, EQ = 1	3.125 Gbps		46	98	ps
t_{TJ1D}	Total Jitter (Peak to Peak)	V_{ID} = 350 mV	2.5 Gbps		0.13	0.20	UI_{P-P}
t_{TJ2D}	Input Test Channel E Output Test Channel B (Note 18)	V_{CM} = 1.2V PRBS-23 (NRZ) PE = 1, EQ = 1	3.125 Gbps		0.19	0.30	UI_{P-P}

Note 11: 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 12: 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 13: Specification is guaranteed by characterization and is not tested in production.

Note 14: t_{SKD1}, $|t_{PLHD} - t_{PHLD}|$, is the magnitude difference in differential propagation delay time between the positive going edge and the negative going edge of the same channel.

Note 15: t_{SKD2}, 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 16: Measured on a clock edge with a histogram and an acummulation of 1500 histogram hits. Input stimulus jitter is subtracted geometrically.

Note 17: Tested with a combination of the 1100000101 (K28.5+ character) and 0011111010 (K28.5- character) patterns. Input stimulus jitter is subtracted algebraically.

Note 18: Measured on an eye diagram with a histogram and an acummulation of 3500 histogram hits. Input stimulus jitter is subtracted.

DC Test Circuits

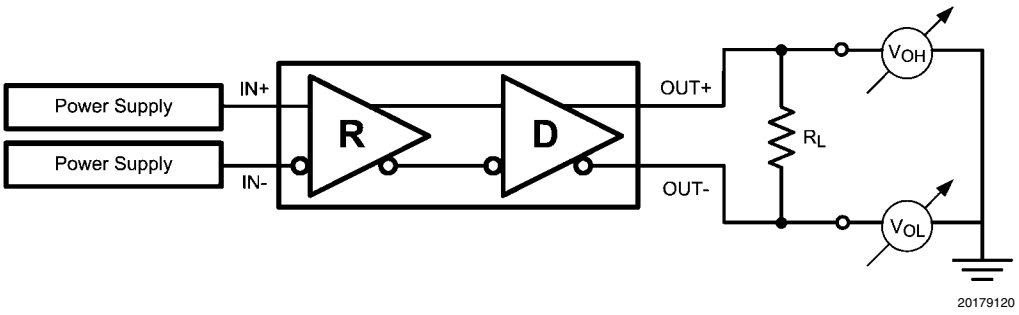


FIGURE 1. Differential Driver DC Test Circuit

AC Test Circuits and Timing Diagrams

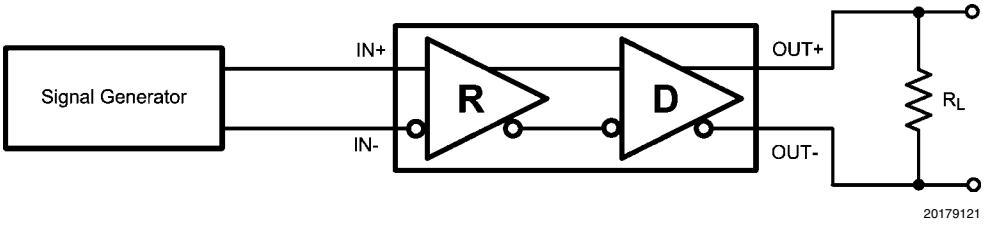


FIGURE 2. Differential Driver AC Test Circuit

Note: DS25BR101 requires external 100Ω input termination.

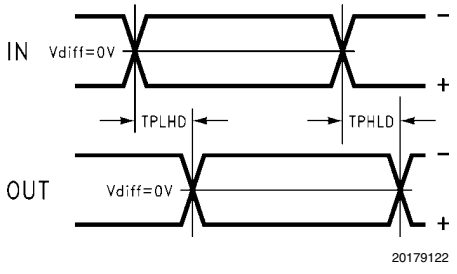


FIGURE 3. Propagation Delay Timing Diagram

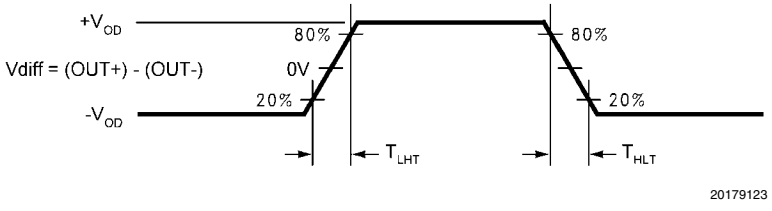


FIGURE 4. LVDS Output Transition Times

Pre-Emphasis and Equalization Test Circuits

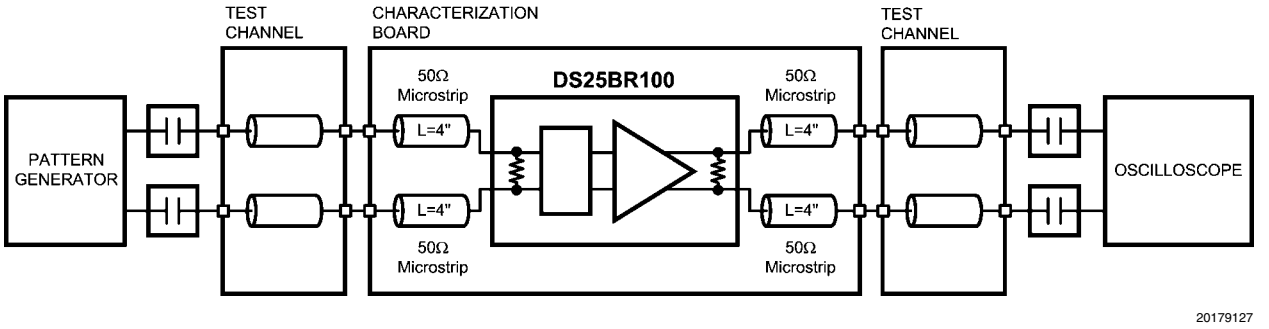


FIGURE 5. Pre-emphasis and Equalization Performance Test Circuit

Note: DS25BR101 requires external 100Ω input termination.

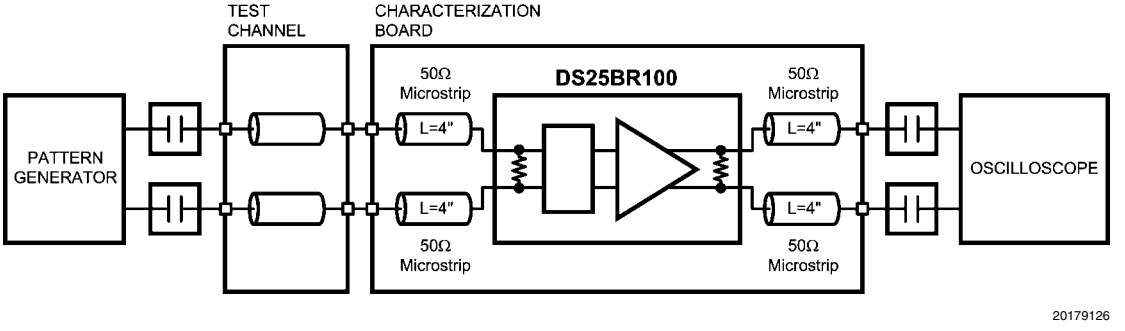


FIGURE 6. Equalization Performance Test Circuit

Note: DS25BR101 requires external 100Ω input termination.

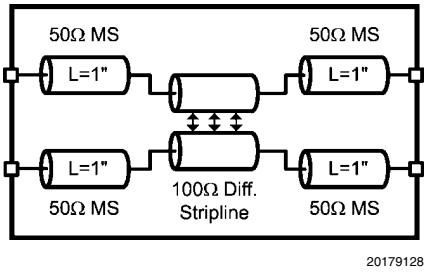


FIGURE 7. Test Channel Description

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

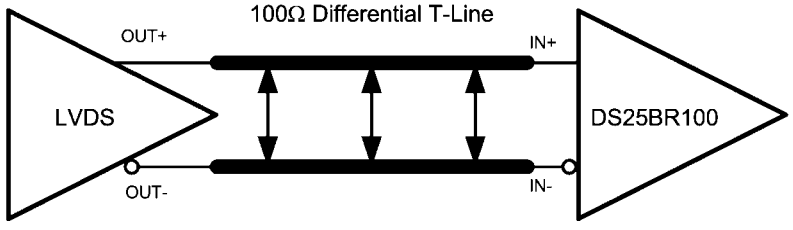
Device Operation

INPUT INTERFACING

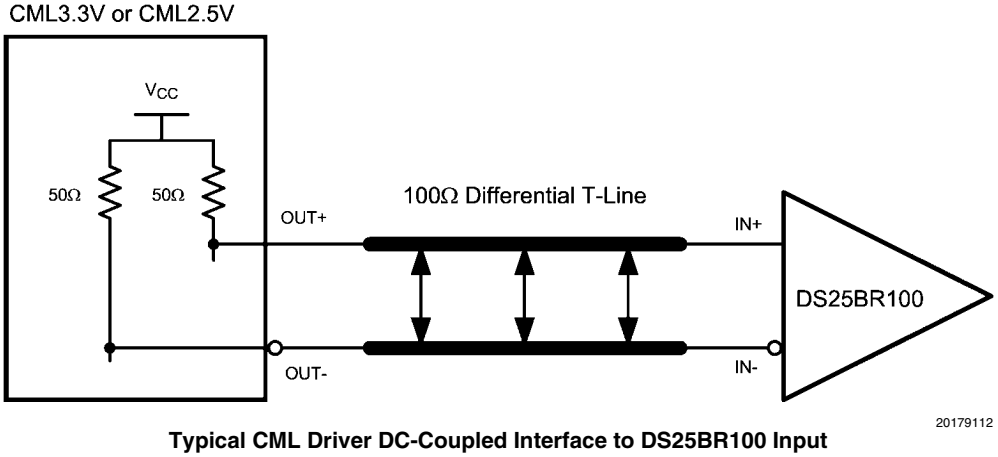
The DS25BR100/101 accepts differential signals and allows simple AC or DC coupling. With a wide common mode range, the DS25BR100/101 can be DC-coupled with all common differential drivers (i.e. LVPECL, LVDS, CML). The following three figures illustrate typical DC-coupled interface to common differential drivers.

The DS25BR100 inputs are internally terminated with a 100Ω resistor for optimal device performance, reduced component count, and minimum board space. External input terminations on the DS25BR101 need to be placed as close as possible to the device inputs to achieve equivalent AC performance. It is recommended that SMT resistors sized 0402 or smaller be used and the mounting distance to the DS25BR101 pins kept under 200 mils.

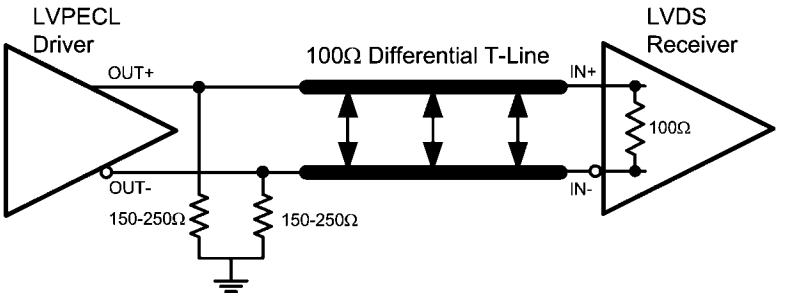
When using the DS25BR101 in a limited multi-drop topology, any transmission line stubs should be kept very short to minimize any negative effects on signal quality. A single termination resistor or resistor network that matches the differential line impedance should be used. If DS25BR101 input pairs from two separate devices are to be connected to a single differential output, it is recommended that the DS25BR101 devices are mounted directly opposite of each other. One on top of the PCB and the other directly under the first on the bottom of the PCB, this keeps the distance between inputs equal to the PCB thickness.



Typical LVDS Driver DC-Coupled Interface to DS25BR100 Input



Typical CML Driver DC-Coupled Interface to DS25BR100 Input



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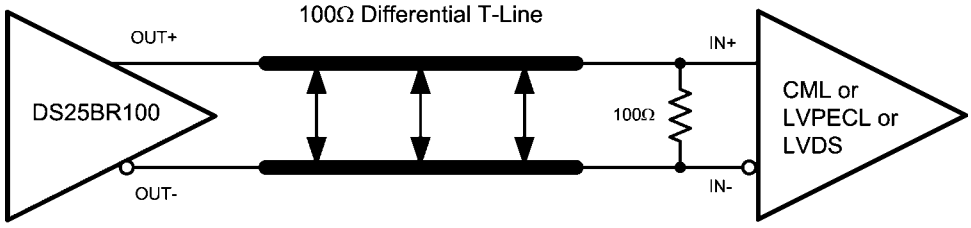
Typical LVPECL Driver DC-Coupled Interface to DS25BR100 Input

Note: DS25BR101 requires external 100Ω input termination.

OUTPUT INTERFACING

The DS25BR100/101 outputs signals compliant to the LVDS standard. It 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.



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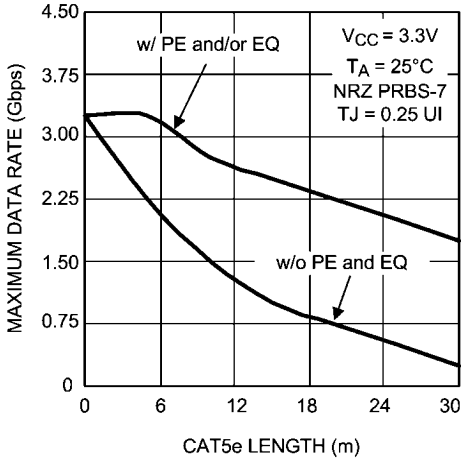
Typical Output DC-Coupled Interface to an LVDS, CML or LVPECL Receiver

Typical Performance



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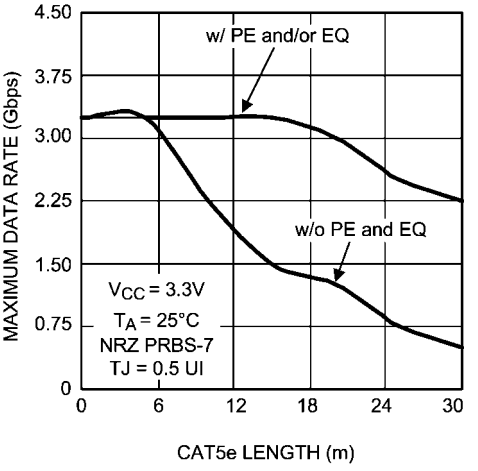
Maximum Data Rate as a Function of CAT5e (Belden 1700A) Length



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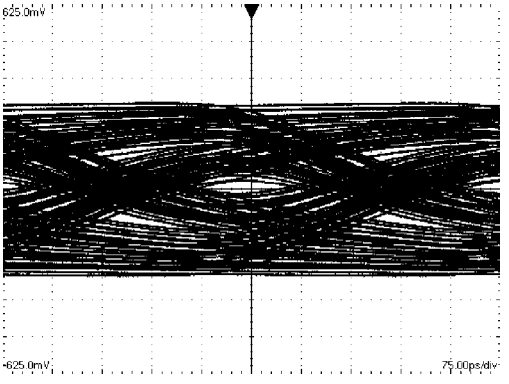
Maximum Data Rate as a Function of CAT5e (Belden 1700A) Length



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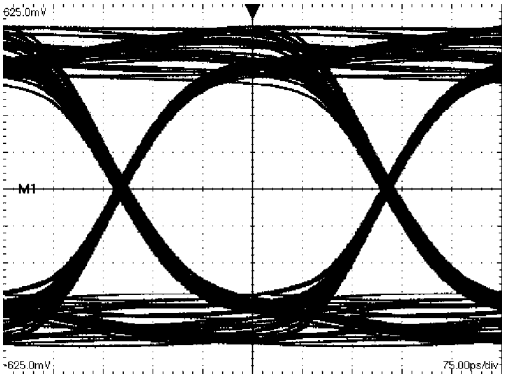
A 2.5 Gbps NRZ PRBS-7 After 60" Differential FR-4 Stripline
V:125 mV / DIV, H:75 ps / DIV



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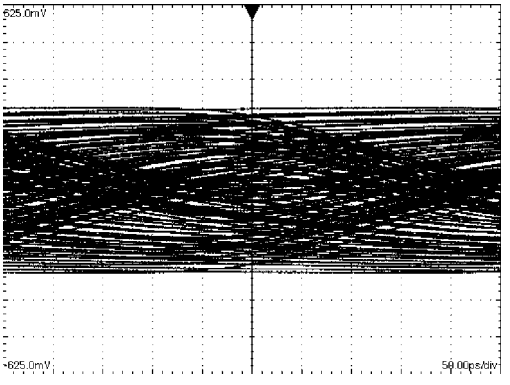
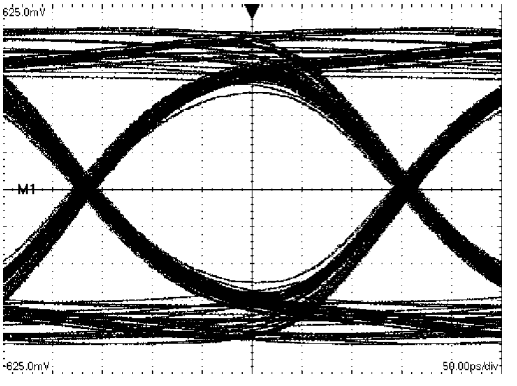
An Equalized (with PE and EQ) 2.5 Gbps NRZ PRBS-7 After The 40" Input and 20" Output Differential Stripline (*Figure 5*)
V:125 mV / DIV, H:75 ps / DIV



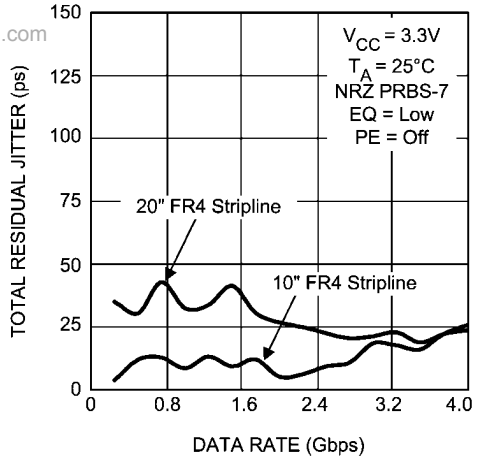
20179132

A 3.125 Gbps NRZ PRBS-7 After 60" Differential FR-4 Stripline
V:125 mV / DIV, H:50 ps / DIV



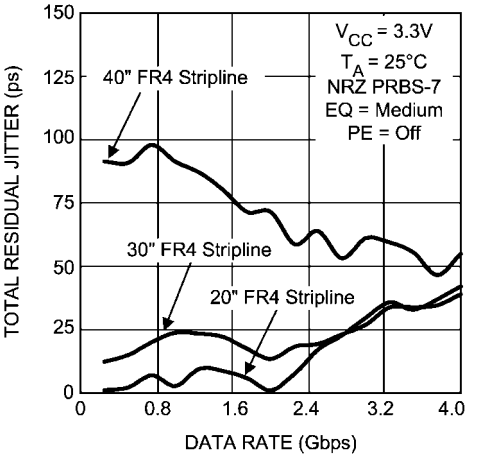
20179133

An Equalized (with PE and EQ) 3.125 Gbps NRZ PRBS-7 After The 40" Input and 20" Output Differential Stripline (*Figure 5*)
V:125 mV / DIV, H:50 ps / DIV



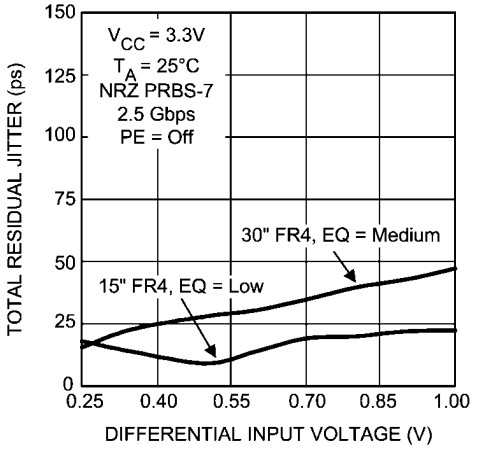
20179137

Total Jitter as a Function of Data Rate



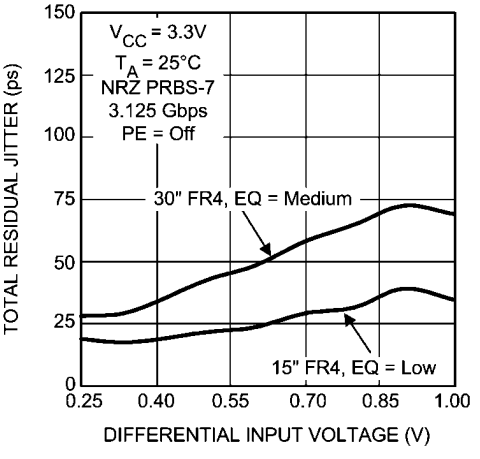
20179138

Total Jitter as a Function of Data Rate



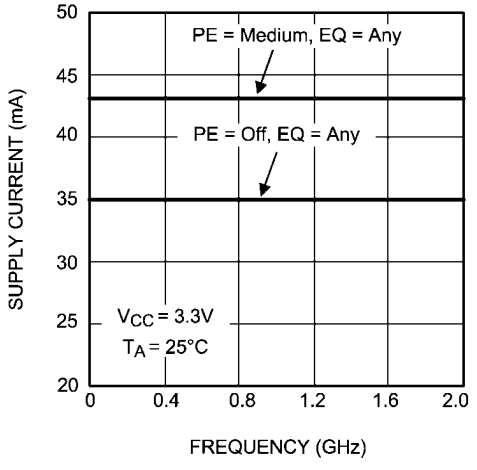
20179139

Total Jitter as a Function of Input Amplitude



20179140

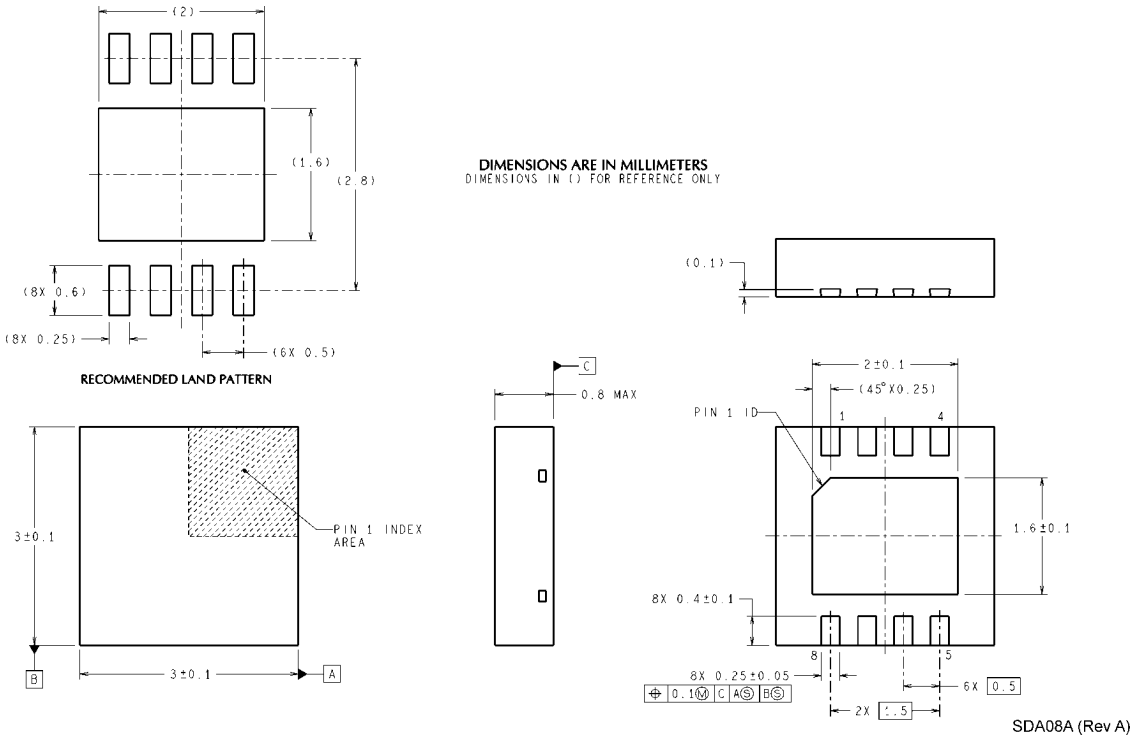
Total Jitter as a Function of Input Amplitude



20179136

Power Supply Current as a Function of Frequency

Physical Dimensions inches (millimeters) unless otherwise noted



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Order Number DS25BR101TSD
NS Package Number SDA08A
(See AN-1187 for PCB Design and Assembly Recommendations)

Notes

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