National Semiconductor

December 2006

DS25BR400
Quad Transceiver with Input Equalization and Output De-Emphasis

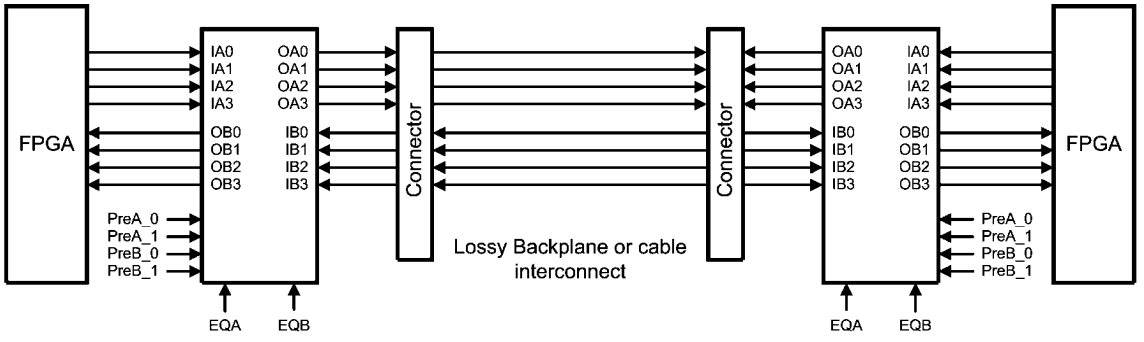
General Description

The DS25BR400 is a quad 250 Mbps – 2.5 Gbps CML transceiver, or 8-channel buffer, for use in PCI Express, SATA, SAS, Fibre Channel backplane and cable applications. With operation down to 250 Mbps, the DS25BR400 can be used in applications requiring both low and high frequency data rates. Each input stage has a fixed equalizer to reduce ISI distortion from board traces. The equalizers are grouped in fours and are enabled through two control pins. These control pins provide customers flexibility in PCI Express applications where ISI distortion may vary from one direction to another. All output drivers have four selectable steps of de-emphasis to compensate against transmission loss across long FR4 backplanes. The de-emphasis blocks are also grouped in fours. In addition, the DS25BR400 also has loopback control capability on four channels. All CML drivers and receivers are internally terminated with 50Ω pull-up resistors.

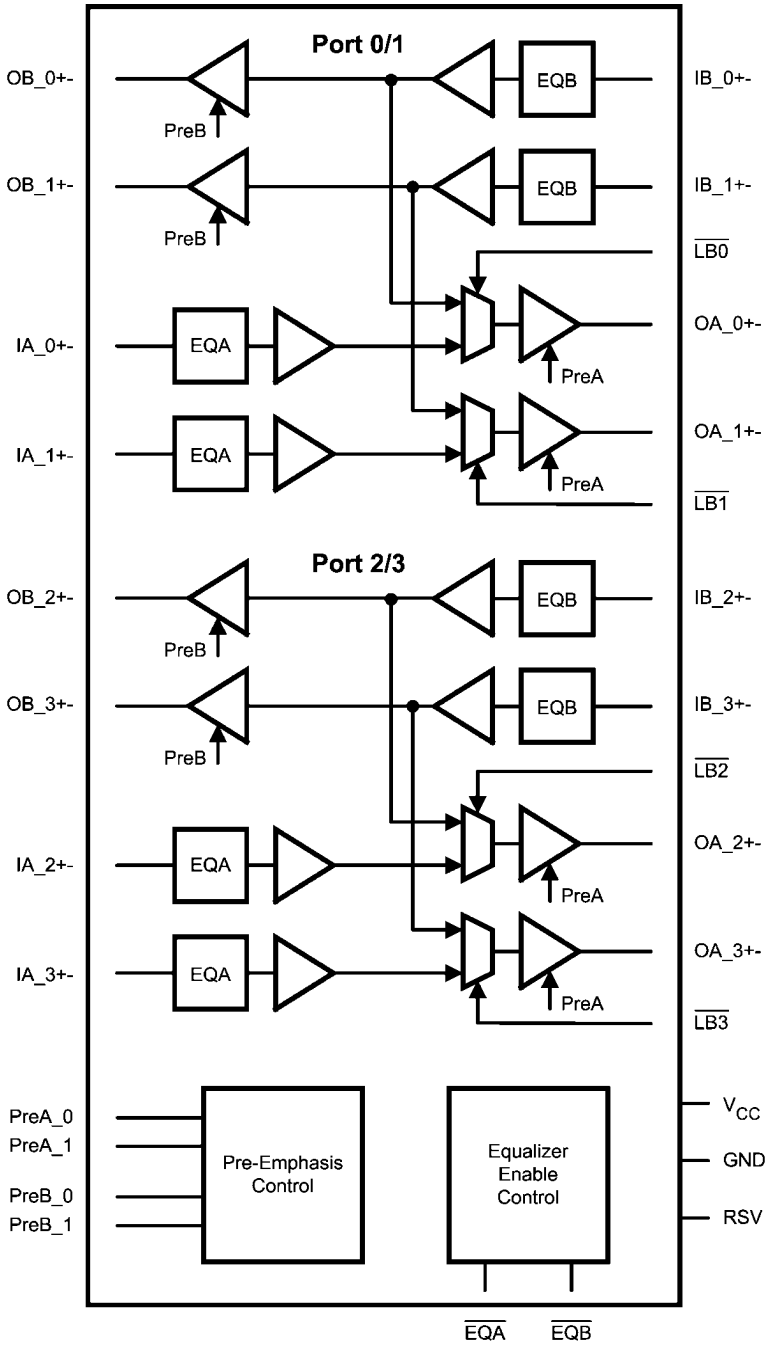
Features

- Quad 2.5 Gbps Transceiver or 8-Channel CML Serial Buffer
- 250 Mbps – 2.5 Gbps Fully Differential Data Paths
- Optional Fixed Input Equalization
- Selectable Output De-emphasis
- Individual Loopback Controls
- On-chip Termination
- +3.3V supply
- Low Power, 1.3 Watts MAX
- Lead-less eLLP-60 pin package (9mmx9mmx0.8mm, 0.5mm pitch)
- –40°C to +85°C Industrial Temperature Range
- 6 kV ESD Rating, HBM

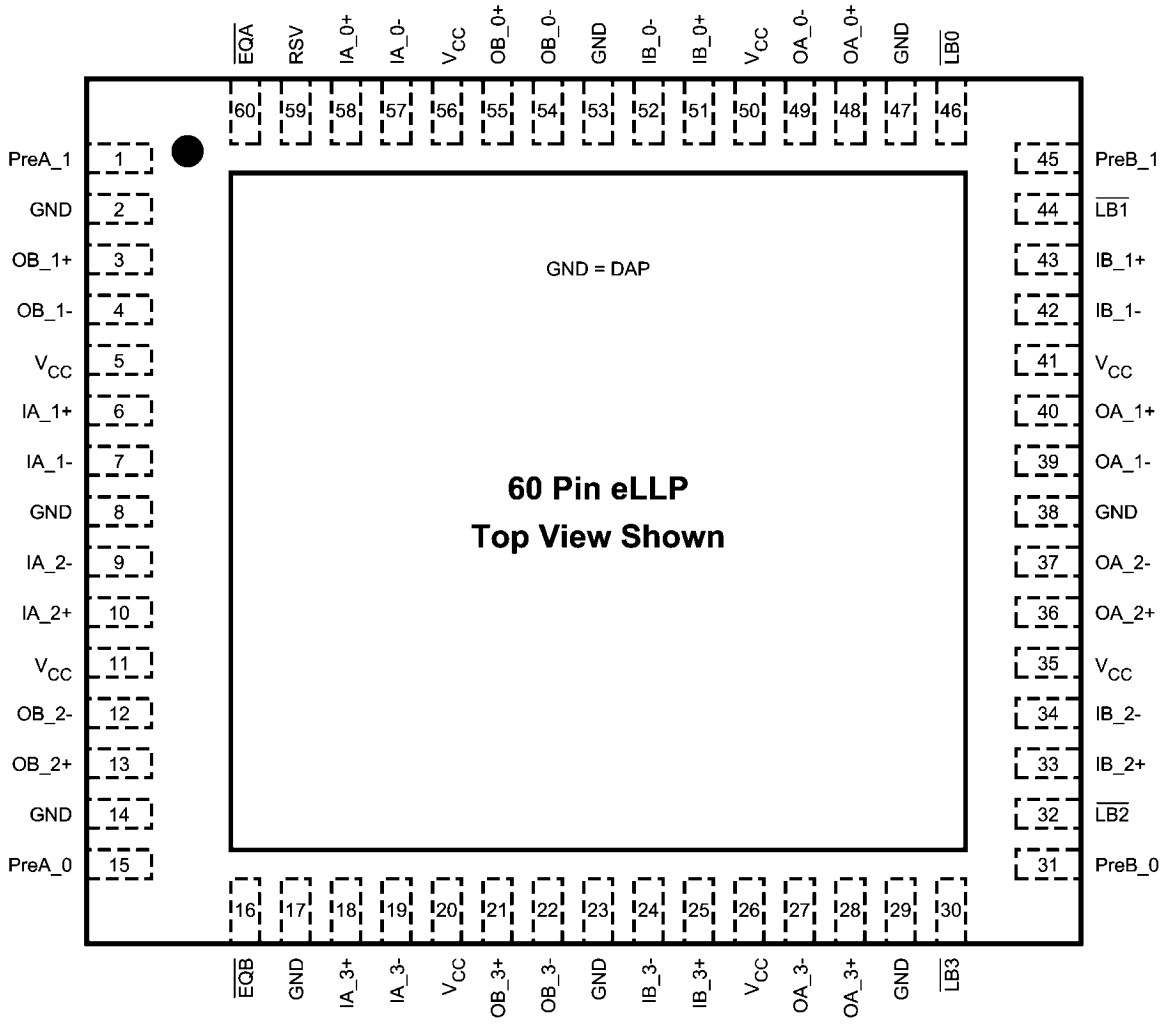
Block Diagram



Functional Block Diagram



Connection Diagram



20194202

Leadless eLLP-60 Pin Package
(9mmx9mmx0.8mm, 0.4mm pitch)
Order number DS25BR400TSQ
See NS Package Number SQA060

Pin Descriptions

Pin Name	Pin Number	I/O	Description
DIFFERENTIAL I/O			
IB_0+ IB_0−	51 52	I	Inverting and non-inverting differential inputs of port_0. IB_0+ and IB_0− are internally connected to a reference voltage through a 50Ω resistor.
OA_0+ OA_0−	48 49	O	Inverting and non-inverting differential outputs of port_0. OA_0+ and OA_0− are connected to V_{CC} through a 50Ω resistor.
IB_1+ IB_1−	43 42	I	Inverting and non-inverting differential inputs of port_1. IB_1+ and IB_1− are internally connected to a reference through a 50Ω resistor.
OA_1+ OA_1−	40 39	O	Inverting and non-inverting differential outputs of port_1. OA_1+ and OA_1− are connected to V_{CC} through a 50Ω resistor.
IB_2+ IB_2−	33 34	I	Inverting and non-inverting differential inputs of port_2. IB_2+ and IB_2− are internally connected to a reference voltage through a 50Ω resistor.
OA_2+ OA_2−	36 37	O	Inverting and non-inverting differential outputs of port_2. OA_2+ and OA_2− are connected to V_{CC} through a 50Ω resistor.
IB_3+ IB_3−	25 24	I	Inverting and non-inverting differential inputs of port_3. IB_3+ and IB_3− are internally connected to a reference voltage through a 50Ω resistor.
OA_3+ OA_3−	28 27	O	Inverting and non-inverting differential outputs of port_3. OA_3+ and OA_3− are connected to V_{CC} through a 50Ω resistor.
IA_0+ IA_0−	58 57	I	Inverting and non-inverting differential inputs of port_0. IA_0+ and IA_0− are internally connected to a reference voltage through a 50Ω resistor.
OB_0+ OB_0−	55 54	O	Inverting and non-inverting differential outputs of port_0. OB_0+ and OB_0− are connected to V_{CC} through a 50Ω resistor.
IA_1+ IA_1−	6 7	I	Inverting and non-inverting differential inputs of port_1. IA_1+ and IA_1− are internally connected to a reference through a 50Ω resistor.
OB_1+ OB_1−	3 4	O	Inverting and non-inverting differential outputs of port_1. OB_1+ and OB_1− are connected to V_{CC} through a 50Ω resistor.
IA_2+ IA_2−	10 9	I	Inverting and non-inverting differential inputs of port_2. IA_2+ and IA_2− are internally connected to a reference voltage through a 50Ω resistor.
OB_2+ OB_2−	13 12	O	Inverting and non-inverting differential outputs of port_2. OB_2+ and OB_2− are connected to V_{CC} through a 50Ω resistor.
IA_3+ IA_3−	18 19	I	Inverting and non-inverting differential inputs of port_3. IA_3+ and IA_3− are internally connected to a reference voltage through a 50Ω resistor.
OB_3+ OB_3−	21 22	O	Inverting and non-inverting differential outputs of port_3. OB_3+ and OB_3− are connected to V_{CC} through a 50Ω resistor.
CONTROL (3.3V LVCMOS)			
$\overline{EQA}$	60	I	This pin is active LOW. A logic LOW at $\overline{EQA}$ enables equalization for input channels IA_0±, IA_1±, IA_2±, and IA_3±. By default, this pin is internally pulled high and equalization is disabled.
$\overline{EQB}$	16	I	This pin is active LOW. A logic LOW at $\overline{EQB}$ enables equalization for input channels IB_0±, IB_1±, IB_2±, and IB_3±. By default, this pin is internally pulled high and equalization is disabled.
PreA_0 PreA_1	15 1	I	PreA_0 and PreA_1 select the output de-emphasis levels (OA_0±, OA_1±, OA_2±, and OA_3±). PreA_0 and PreA_1 are internally pulled high. Please see *Table 2* for de-emphasis levels.
PreB_0 PreB_1	31 45	I	PreB_0 and PreB_1 select the output de-emphasis levels (OB_0±, OB_1±, OB_2±, and OB_3±). PreB_0 and PreB_1 are internally pulled high. Please see *Table 2* for de-emphasis levels.
$\overline{LB0}$	46	I	This pin is active LOW. A logic LOW at $\overline{LB0}$ enables the internal loopback path from IB_0± to OA_0±. $\overline{LB0}$ is internally pulled high. Please see *Table 1* for more information.
$\overline{LB1}$	44	I	This pin is active LOW. A logic LOW at $\overline{LB1}$ enables the internal loopback path from IB_1± to OA_1±. $\overline{LB1}$ is internally pulled high. Please see *Table 1* for more information.
$\overline{LB2}$	32	I	This pin is active LOW. A logic LOW at $\overline{LB2}$ enables the internal loopback path from IB_2± to OA_2±. $\overline{LB2}$ is internally pulled high. Please see *Table 1* for more information.
$\overline{LB3}$	30	I	This pin is active LOW. A logic LOW at $\overline{LB3}$ enables the internal loopback path from IB_3± to OA_3±. $\overline{LB3}$ is internally pulled high. Please see *Table 1* for more information.

Pin Name	Pin Number	I/O	Description
RSV	59	I	Reserve pin to support factory testing. This pin can be left open, tied to GND, or tied to GND through an external pull-down resistor.
POWER			
V_{CC}	5, 11, 20, 26, 35, 41, 50, 56	P	V_{CC} = 3.3V ± 5%. Each V_{CC} pin should be connected to the V_{CC} plane through a low inductance path, typically with a via located as close as possible to the landing pad of the V_{CC} pin. It is recommended to have a 0.01 µF or 0.1 µF, X7R, size-0402 bypass capacitor from each V_{CC} pin to ground plane.
GND	2, 8, 14, 17, 23, 29, 38, 47, 53	P	Ground reference. Each ground pin should be connected to the ground plane through a low inductance path, typically with a via located as close as possible to the landing pad of the GND pin.
GND	DAP	P	DAP is the metal contact at the bottom side, located at the center of the eLLP-60 pin package. It should be connected to the GND plane with at least 4 via to lower the ground impedance and improve the thermal performance of the package.

Note: I = Input, O = Output, P = Power

Functional Description

TABLE 1. Logic Table for Loopback Controls

$\overline{\text{LB0}}$	Loopback Function
0	Enable loopback from IB_0± to OA_0±.
1 (default)	Normal mode. Loopback disabled.
$\overline{\text{LB1}}$	Loopback Function
0	Enable loopback from IB_1± to OA_1±.
1 (default)	Normal mode. Loopback disabled.
$\overline{\text{LB2}}$	Loopback Function
0	Enable loopback from IB_2± to OA_2±.
1 (default)	Normal mode. Loopback disabled.
$\overline{\text{LB3}}$	Loopback Function
0	Enable loopback from IB_3± to OA_3±.
1 (default)	Normal mode. Loopback disabled.

TABLE 2. De-Emphasis Controls

PreA_[1:0]	Default VOD Level in mV_{PP} (VODB)	De-Emphasis Level in mV_{PP} (VODPE)	De-Emphasis in dB (VODPE/VODB)
0 0	1200	1200	0
0 1	1200	850	–3
1 0	1200	600	–6
1 1 (Default)	1200	426	–9
PreB_[1:0]	**Default VOD Level in mV_{PP} (VODB)**	**De-Emphasis Level in mV_{PP} (VODPE)**	**De-Emphasis in dB (VODPE/VODB)**
0 0	1200	1200	0
0 1	1200	850	–3
1 0	1200	600	–6
1 1 (Default)	1200	426	–9

De-emphasis is the primary signal conditioning function for use in compensating against backplane transmission loss. The DS25BR400 provides four steps of de-emphasis ranging from 0, –3, –6 and –9 dB, user-selectable dependent on the loss profile of the backplane. *Figure 1* shows a driver de-emphasis waveform. The de-emphasis duration is nominal 188 ps, corresponding to 0.75 bit-width at 2.5 Gbps. The de-emphasis levels of switch-side and line-side can be individually programmed.

Input Equalization

Each differential input of the DS25BR400 has a fixed equalizer front-end stage. It is designed to provide fixed equalization for short board traces with transmission losses of approximately 5 dB between 375 MHz to 1.875 GHz. Programmable de-emphasis together with input equalization ensures an acceptable eye opening for a 40-inch FR-4 backplane.

The differential input equalizer for inputs on Channel A and inputs on Channel B can be bypassed by using $\overline{EQA}$ and $\overline{EQB}$, respectively. By default, the equalizers are internally pulled high and disabled. Therefore, $\overline{EQA}$ and $\overline{EQB}$ must be asserted LOW to enable equalization.

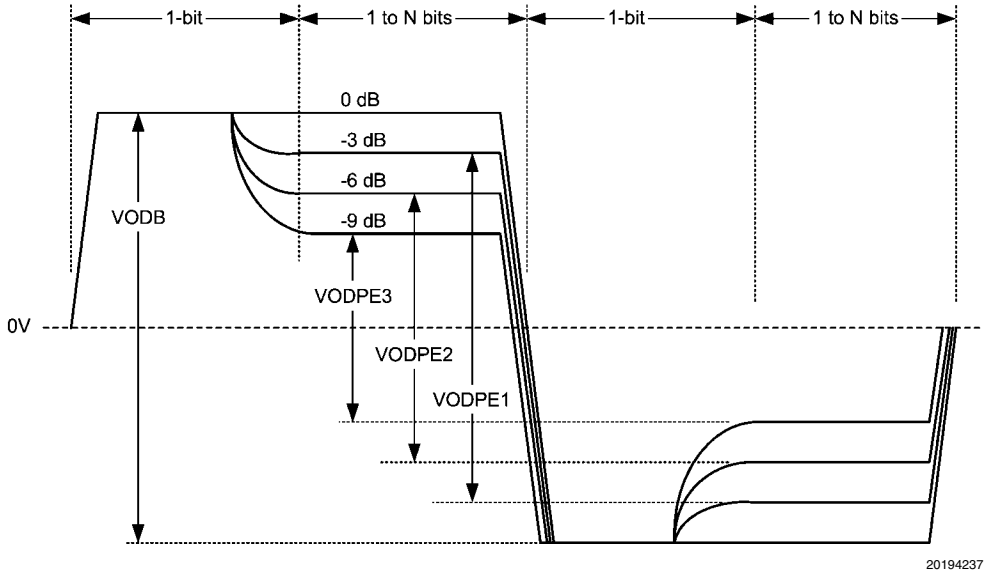


FIGURE 1. Driver De-Emphasis Differential Waveform (showing all 4 de-emphasis steps)

Absolute Maximum Ratings (Note 1)

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
CMOS/TTL Input Voltage	−0.3V to (V_{CC} +0.3V)
CML Input/Output Voltage	−0.3V to (V_{CC} +0.3V)
Junction Temperature	+150°C
Storage Temperature	−65°C to +150°C
Lead Temperature Soldering, 4 sec	+260°C
Thermal Resistance, θ_{JA}	22.3°C/W
Thermal Resistance, θ_{JC}	3.2°C/W
Thermal Resistance, Φ_{JB}	10.3°C/W

(Note: assumes 26 thermal vias)

ESD Ratings ((Note 9))

HBM	6kV
CDM	1kV
MM	350V

Recommended Operating Ratings

	Min	Typ	Max	Units
Supply Voltage (V_{CC}-GND)	3.135	3.3	3.465	V
Supply Noise Amplitude 10 Hz to 2 GHz			100	mV_{PP}
Ambient Temperature	−40		+85	°C
Case Temperature			100	°C

Electrical Characteristics

Over recommended operating supply and temperature ranges unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ (Note 2)	Max	Units
LVCMOS DC SPECIFICATIONS						
V_{IH}	High Level Input Voltage		2.0		V_{CC} +0.3	V
V_{IL}	Low Level Input Voltage		−0.3		0.8	V
I_{IH}	High Level Input Current	$V_{IN} = V_{CC}$	−10		10	µA
I_{IL}	Low Level Input Current	V_{IN} = GND	75	94	124	µA
R_{PU}	Pull-High Resistance			35		kΩ
RECEIVER SPECIFICATIONS						
V_{ID}	Differential Input Voltage Range	AC Coupled Differential Signal. Below 1.25 Gb/s At 1.25 Gbps–3.125 Gbps Above 3.125 Gbps This parameter is not production tested.	 100 100 100		 1750 1560 1200	 mV_{P-P} mV_{P-P} mV_{P-P}
V_{ICM}	Common Mode Voltage at Receiver Inputs	Measured at receiver inputs reference to ground.		1.3		V
R_{ITD}	Input Differential Termination	On-chip differential termination between IN+ or IN−.	84	100	116	Ω
R_{ITSE}	Input Termination (single-end)	On-chip termination IN+ or IN− to GND for frequency > 100 MHz.		50		Ω
DRIVER SPECIFICATIONS						
VODB	Output Differential Voltage Swing without De-Emphasis	R_L = 100Ω ±1% PreA_1 = 0; PreA_0 = 0 PreB_1 = 0; PreB_0 = 0 Driver de-emphasis disabled. Running K28.7 pattern at 2.5 Gbps. *(Figure 6)*	1000	1200	1400	mV_{P-P}

Symbol	Parameter	Conditions	Min	Typ (Note 2)	Max	Units
V_{PE}	Output De-Emphasis Voltage Ratio 20*log(VODPE/VODB)	R_L = 100Ω ±1% Running K28.7 pattern at 2.5 Gbps PreX_[1:0] = 00 PreX_[1:0] = 01 PreX_[1:0] = 10 PreX_[1:0] = 11 X = A/B channel de-emphasis drivers *(Figure 1 / Figure 6)*		 0 –3 –6 –9		 dB dB dB dB
t_{PE}	De-Emphasis Width	Tested at –9 dB de-emphasis level, PreX[1:0] = 11 X = A/B channel de-emphasis drivers See *Figure 5* on measurement condition.	125	200	250	ps
R_{OTSE}	Output Termination	On-chip termination from OUT+ or OUT– to V_{CC}	42	50	58	Ω
R_{OTD}	Output Differential Termination	On-chip differential termination between OUT+ and OUT–		100		Ω
ΔR_{OTSE}	Mis-Match in Output Termination Resistors	Mis-match in output termination resistors			5	%
V_{OCM}	Output Common Mode Voltage			2.7		V
POWER DISSIPATION						
P_D	Power Dissipation	V_{DD} = 3.465V All outputs terminated by 100Ω ±1%. PreB_[1:0] = 0, PreA_[1:0] = 0 Running PRBS 2^7-1 pattern at 2.5 Gbps			1.3	W
AC CHARACTERISTICS						
t_R	Differential Low to High Transition Time	Measured with a clock-like pattern at 2.5 Gbps, between 20% and 80% of the differential output voltage. De-emphasis disabled. Transition time is measured with the fixture shown in *Figure 6* adjusted to reflect the transition time at the output pins.		80		ps
t_F	Differential High to Low Transition Time			80		ps
t_{PLH}	Differential Low to High Propagation Delay	Measured at 50% differential voltage from input to output.			1	ns
t_{PHL}	Differential High to Low Propagation Delay				1	ns
t_{SKP}	Pulse Skew	$\lvert t_{PHL} – t_{PLH} \rvert$			20	ps
t_{SKO}	Output Skew (Note 7)	Difference in propagation delay between channels on the same part (Channel-to-Channel Skew)			100	ps
t_{SKPP}	Part-to-Part Skew (Note 7)	Difference in propagation delay between devices across all channels operating under identical conditions			165	ps
t_{LB}	Loopback Delay Time	Delay from enabling loopback mode to signals appearing at the differential outputs *Figure 4*			4	ns
RJ	Device Random Jitter (Note 5)	At 0.25 Gbps At 1.5 Gbps At 2.5 Gbps Alternating-10 pattern. De-emphasis disabled. *(Figure 6)*			2 2 2	ps rms ps rms ps rms

Symbol	Parameter	Conditions	Min	Typ (Note 2)	Max	Units
DJ	Device Deterministic Jitter (Note 6)	At 0.25 Mbps, PRBS7 pattern At 1.5 Gbps, K28.5 pattern At 2.5 Gbps, K28.5 pattern At 2.5 Gbps, PRBS7 pattern De-emphasis disabled. *(Figure 6)*			25 25 25 25	ps pp ps pp ps pp ps pp
DR	Data Rate (Note 8)	Alternating-10 pattern	0.25		2.5	Gbps

Note 1: "Absolute Maximum Ratings" indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional. For guaranteed specifications and the test conditions, see the Electrical Characteristics Tables. Operation of the device beyond the maximum Operating Ratings is not recommended.

Note 2: Typical specifications are at TA=25 C, and represent most likely parametric norms at the time of product characterization. The typical specifications are not guaranteed.

Note 3: IN+ and IN– are generic names that refer to one of the many pairs of complementary inputs of the DS25BR400. OUT+ and OUT– are generic names that refer to one of the many pairs of the complementary outputs of the DS25BR400. Differential input voltage V_{ID} is defined as |IN+ – IN–|. Differential output voltage V_{OD} is defined as |OUT+ – OUT–|.

Note 4: K28.7 pattern is a 10-bit repeating pattern of K28.7 code group {001111 1000}

K28.5 pattern is a 20-bit repeating pattern of +K28.5 and –K28.5 code groups {110000 0101 001111 1010}

Note 5: Device output random jitter is a measurement of random jitter contributed by the device. It is derived by the equation $SQRT[(RJ_{OUT})^2 – (RJ_{IN})^2]$, where RJ_{OUT} is the total random jitter measured at the output of the device in ps(rms), RJ_{IN} is the random jitter of the pattern generator driving the device. Below 400 Mbps, system jitter and device jitter could not be separated. The 250 Mbps specification includes system random jitter. Please see *Figure 6* for the AC test circuit.

Note 6: Device output deterministic jitter is a measurement of the deterministic jitter contribution from the device. It is derived by the equation (DJ_{OUT} - DJ_{IN}), where DJ_{OUT} is the total peak-to-peak deterministic jitter measured at the output of the device in ps(p-p). DJ_{IN} is the peak-to-peak deterministic jitter at the input of the test board. Please see *Figure 6* for the AC test circuit.

Note 7: t_{SKO} is the magnitude difference in propagation delays between all data paths on one device. This is channel-to-channel skew. t_{SKPP} is the worst case difference in propagation delay across multiple devices on all channels and operating under identical conditions. For example, for two devices operating under the same conditions, t_{SKPP} is the magnitude difference between the shortest propagation delay measurement on one device to the longest propagation delay measurement on another device.

Note 8: This parameter is guaranteed by design and/or characterization and is not tested in production.

Note 9: ESD tests conform to the following standards:

Human Body Model (HBM) applicable standard: MIL-STD-883, Method 3015.7

Machine Model (MM) applicable standard: JESD22-A115-A (ESD MM std. of JEDEC)

Field -Induced Charge Device Model (CDM) applicable standard: JESD22-C101-C (ESD FICDM std. of JEDEC)

Timing Diagrams

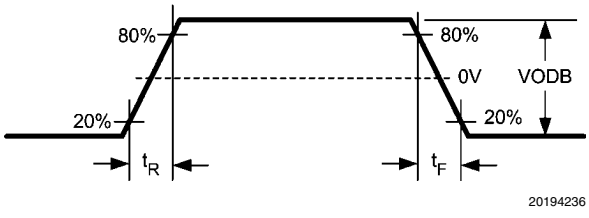


FIGURE 2. Driver Output Transition Time

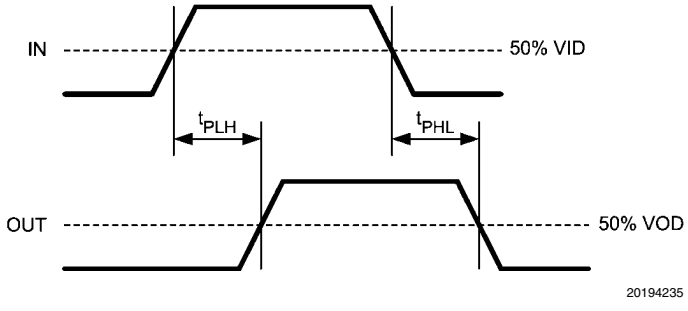


FIGURE 3. Propagation Delay

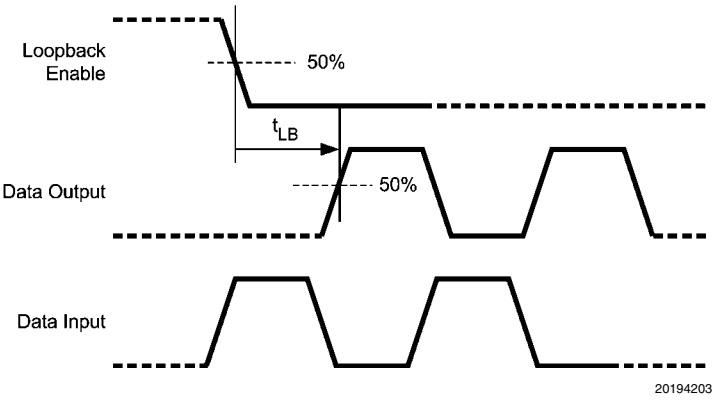


FIGURE 4. Loopback Delay Timing

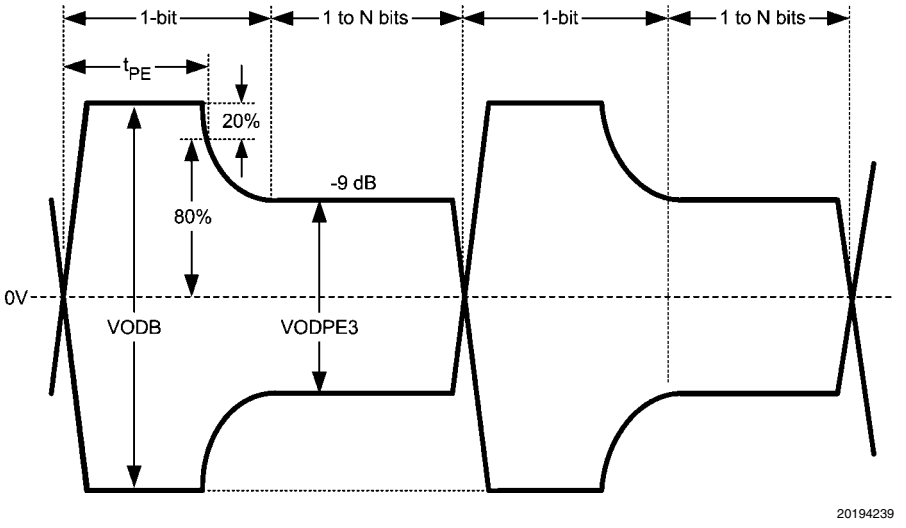


FIGURE 5. Output De-Emphasis Duration

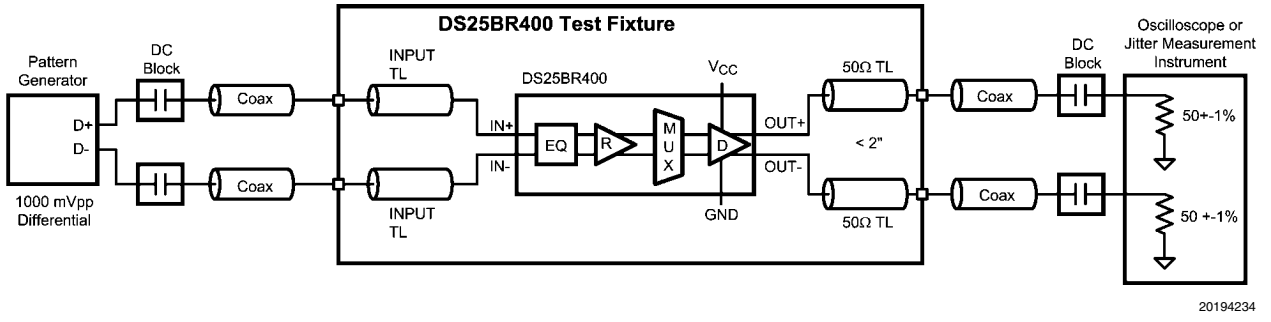


FIGURE 6. AC Test Circuit

Applications

PCI EXPRESS CABLE EXTENSION

DVI CABLE EXTENDER

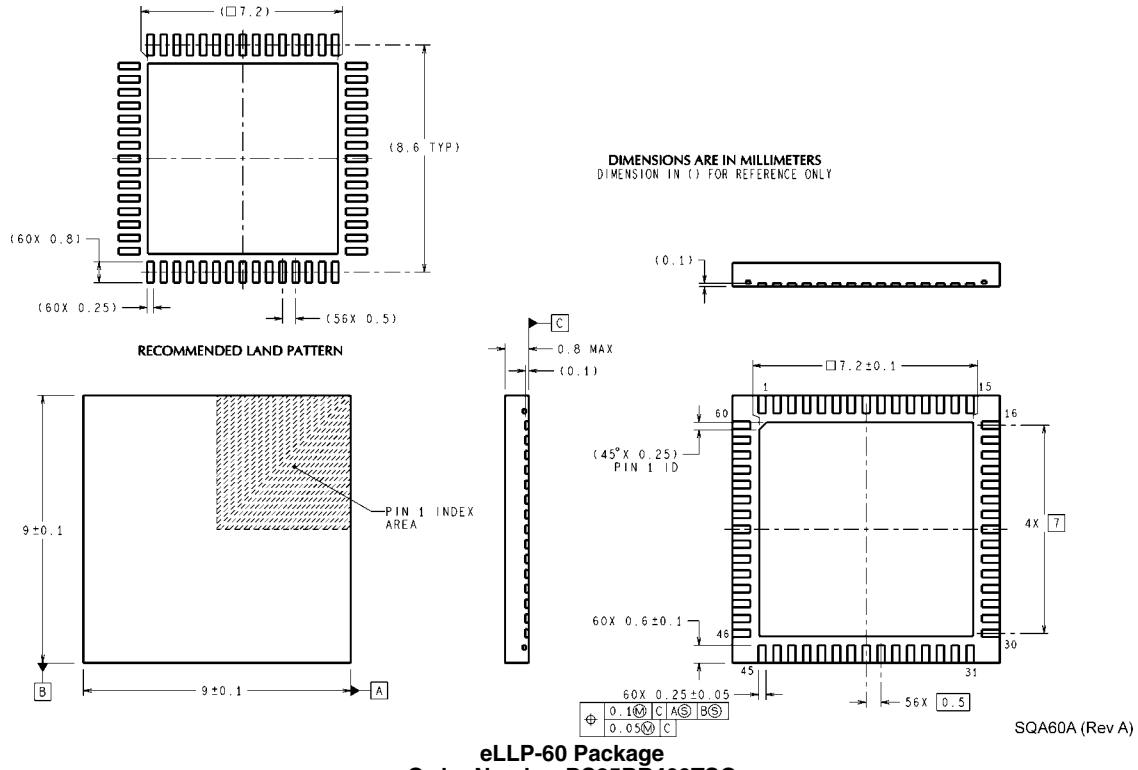
CAT6/CAT 7 CABLE TRANSMISSION

BACKPLANES AND CABLE

MEDICAL IMAGING

TEST AND MEASUREMENT

Physical Dimensions inches (millimeters) unless otherwise noted



eLLP-60 Package
Order Number DS25BR400TSQ
NS Package Number SQA060

Notes

Notes

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