DS42BR400 Quad 4.25 Gbps CML Transceiver with Transmit De-Emphasis and Receive Equalization

Check for Samples: DS42BR400

FEATURES

- **250 Mbps – 4.25 Gbps Fully Differential Data Paths**
- **Optional Fixed Input Equalization**
- **Selectable Output De-emphasis**
- **Individual Loopback Controls**
- **On-Chip Termination**
- **Lead-less WQFN-60 Pin Package (9 mm x 9 mm x 0.8 mm, 0.5 mm Pitch)**
- **−40°C to +85°C Industrial Temperature Range**
- **6 kV ESD Rating, HBM**

APPLICATIONS

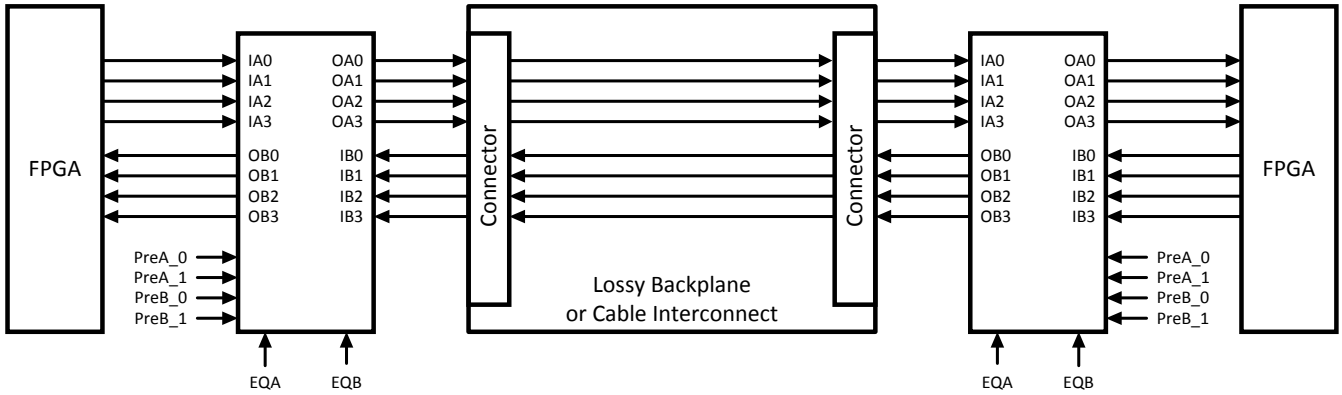
- **Backplane Driver or Cable Driver**
- **Signal Repeating, Buffering and Conditioning Applications**

DESCRIPTION

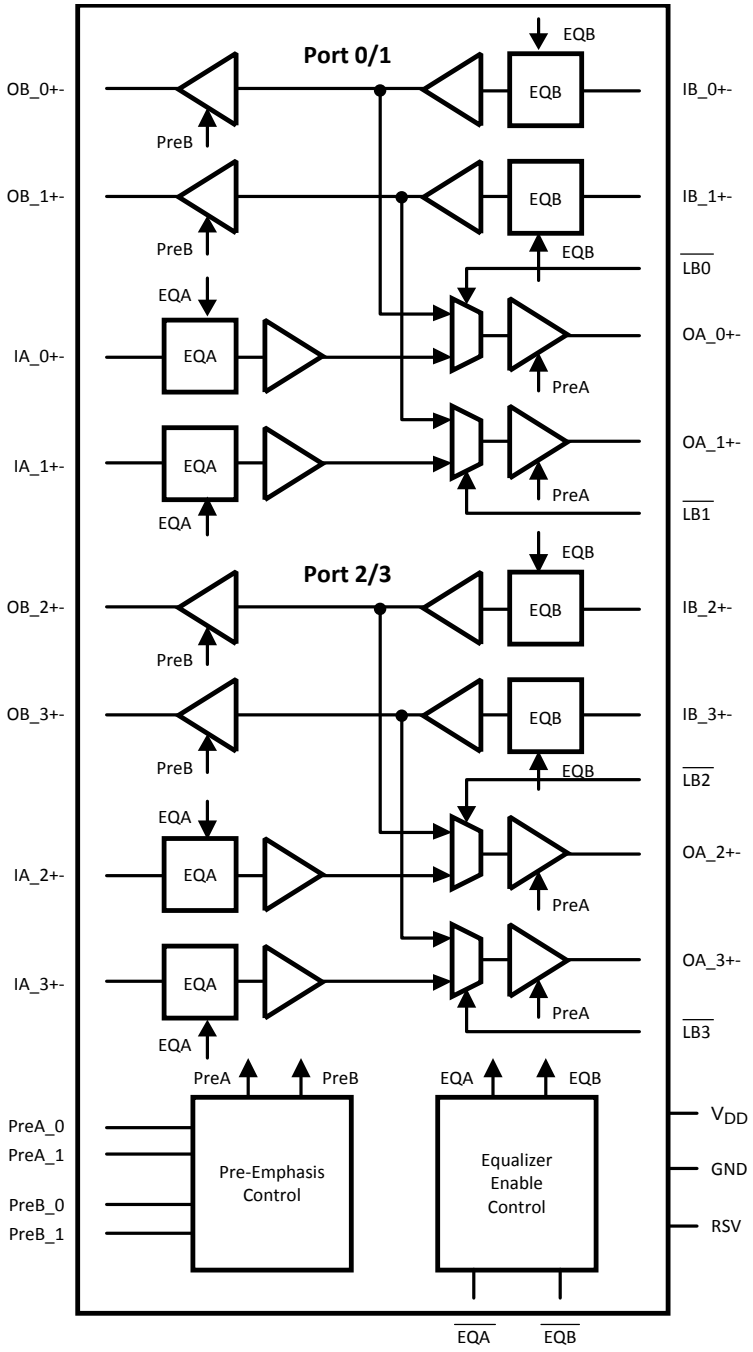
The DS42BR400 is a quad 250 Mbps – 4.25 Gbps CML transceiver, or 8-channel buffer, for use in backplane and cable applications. With operation down to 250 Mbps, the DS42BR400 can be used in applications requiring both low and high frequency data rates. Each input stage has a fixed equalizer to reduce ISI distortion from board traces. The equalizers are grouped in fours and are enabled through two control pins. These control pins provide customers flexibility 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 DS42BR400 also has loopback control capability on four channels. All CML drivers have 50Ω termination to V_{CC}. All receivers are internally terminated with differential 100Ω.

Simplified Application Diagram



Functional Block Diagram



Connection Diagram

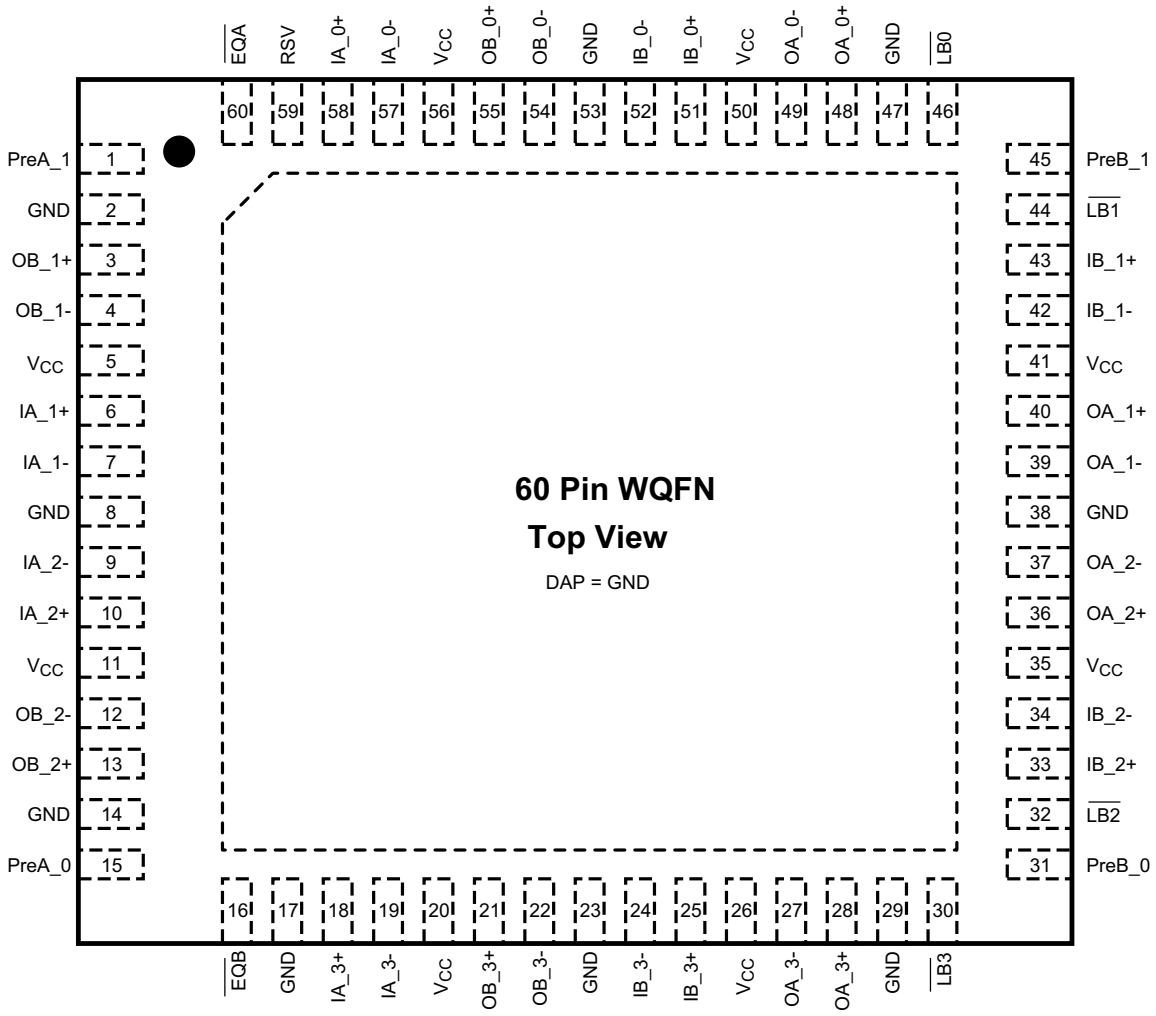


Figure 1. Leadless WQFN-60 Pin Package
(9 mm x 9 mm x 0.8 mm, 0.5 mm pitch)
See Package Number NKA0060A

PIN DESCRIPTIONS

Pin Name	Pin Number	I/O[1]	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. Refer to Figure 8.
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 voltage through a 50Ω resistor. Refer to Figure 8.
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. Refer to Figure 8.
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. Refer to Figure 8.
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. Refer to Figure 8.
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 voltage through a 50Ω resistor. Refer to Figure 8.
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. Refer to Figure 8.
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. Refer to Figure 8.
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.
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.

(1) **Note:** I = Input, O = Output, P = Power

PIN DESCRIPTIONS (continued)

Pin Name	Pin Number	I/O[1]	Description
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 WQFN-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.

Functional Description

Table 1. Logic Table for Loopback Controls

$\overline{LB0}$	**Loopback Function**
0	Enable loopback from IB_0± to OA_0±.
1 (default)	Normal mode. Loopback disabled.
$\overline{LB1}$	**Loopback Function**
0	Enable loopback from IB_1± to OA_1±.
1 (default)	Normal mode. Loopback disabled.
$\overline{LB2}$	**Loopback Function**
0	Enable loopback from IB_2± to OA_2±.
1 (default)	Normal mode. Loopback disabled.
$\overline{LB3}$	**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 DS42BR400 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 2 shows a driver de-emphasis waveform. The de-emphasis duration is nominal 200 ps, corresponding to 85% bit-width at 4.25 Gbps.

The high speed inputs are self-biased to about 1.3V and are designed for AC coupling allowing the DS42BR400 to be directly inserted into the datapath without any limitation. The ideal AC coupling capacitor value is often based on the lowest frequency component embedded within the serial link. A typical AC coupling capacitor value rages between 100 and 1000nF, some specifications with scrambled data may require a larger coupling capacitor for optimal performance. To reduce unwanted parasitics around and within the AC coupling capacitor, a body size of 0402 is recommended. *Figure 7* shows the AC coupling capacitor placement in an AC test circuit.

Input Equalization

Each differential input of the DS42BR400 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 $\overline{\text{EQA}}$ and $\overline{\text{EQB}}$, respectively. By default, the equalizers are internally pulled high and disabled. Therefore, $\overline{\text{EQA}}$ and $\overline{\text{EQB}}$ must be asserted LOW to enable equalization.

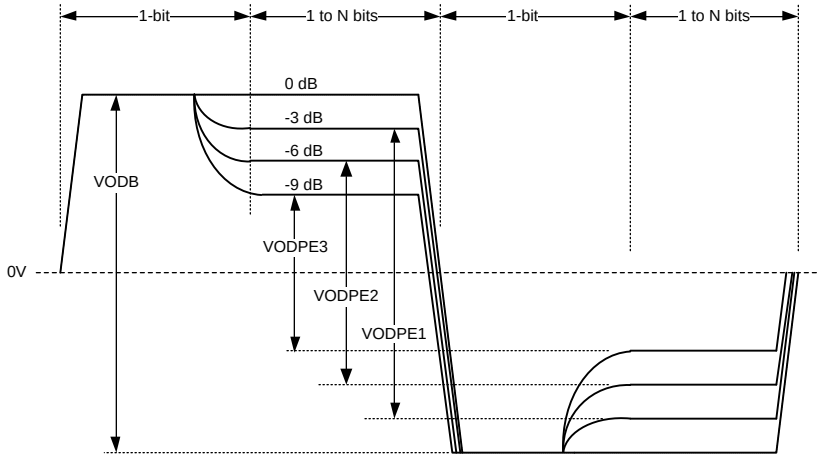


Figure 2. Driver De-Emphasis Differential Waveform (showing all 4 de-emphasis steps)

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

Absolute Maximum Ratings[1][2]

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
ESD Ratings[3]	HBM	6kV
	CDM	1kV
	MM	350V

(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 ensured specifications and the test conditions, see the Electrical Characteristics Tables. Operation of the device beyond the maximum Operating Ratings is not recommended.
(2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/ Distributors for availability and specifications.
(3) ESD tests conform to the following standards:Human Body Model (HBM) applicable standard: MIL-STD-883, Method 3015.7Machine 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)

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 (1) (2)

Over recommended operating supply and temperature ranges unless otherwise specified.

Parameter		Test Conditions	Min	Typ (3)	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−.SeeFigure 8	84	100	116	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 4 Gbps. *See(Figure 7)*	1000	1200	1400	mV_{P-P}
V_{PE}	Output De-Emphasis Voltage Ratio 20*log(VODPE/VODB)	R_L = 100Ω ±1% Running K28.7 pattern at 4.25 Gbps PreX_[1:0] = 00 PreX_[1:0] = 01 PreX_[1:0] = 10 PreX_[1:0] = 11 X = A/B channel de-emphasis drivers See(Figure 2/ Figure 7)		 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 6 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 4.25 Gbps			1.3	W

(1) IN+ and IN− are generic names that refer to one of the many pairs of complementary inputs of the DS42BR400. OUT+ and OUT− are generic names that refer to one of the many pairs of the complementary outputs of the DS42BR400. Differential input voltage V_{ID} is defined as |IN+ – IN−|. Differential output voltage V_{OD} is defined as |OUT+ – OUT−|.

(2) 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}

(3) Typical specifications are at TA=25 C, and represent most likely parametric norms at the time of product characterization. The typical specifications are not ensured.

Electrical Characteristics[1][2] (continued)

Over recommended operating supply and temperature ranges unless otherwise specified.

Parameter		Test Conditions	Min	Typ [3]	Max	Units
AC CHARACTERISTICS						
t_R	Differential Low to High Transition Time	Measured with a clock-like pattern at 4.25 Gbps, between 20% and 80% of the differential output voltage. De-emphasis disabled. Transition time is measured with the fixture shown in Figure 7 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[4]	Difference in propagation delay between channels on the same part (Channel-to-Channel Skew)[4]			100	ps
t_{SKPP}	Part-to-Part Skew[4]	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 SeeFigure 5			4	ns
RJ	Device Random Jitter[5]	At 0.25 Gbps At 1.5 Gbps At 4.25 Gbps Alternating-10 pattern. De-emphasis disabled. See(*Figure 7*)			2 2 2	ps rms ps rms ps rms
DJ	Device Deterministic Jitter[6]	At 0.25 Mbps, PRBS7 pattern At 1.5 Gbps, K28.5 pattern At 4.25 Gbps, K28.5 pattern At 4.25 Gbps, PRBS7 pattern De-emphasis disabled. *See(Figure 7)*			25 25 25 25	ps pp ps pp ps pp ps pp
DR	Data Rate[7]	Alternating-10 pattern	0.25		4.25	Gbps

(4) 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.

(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 7 for the AC test circuit.

(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 7 for the AC test circuit.

(7) This parameter is specified by design and/or characterization and is not tested in production.

TIMING DIAGRAMS

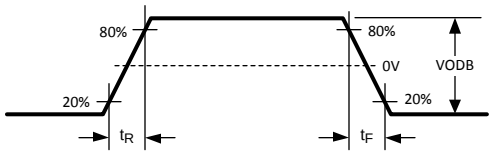


Figure 3. Driver Output Transition Time

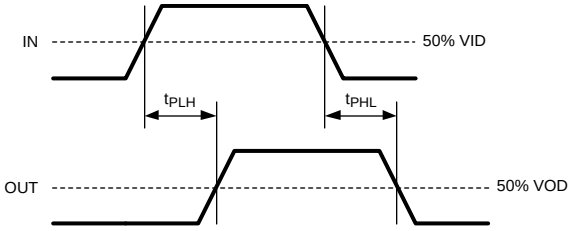


Figure 4. Propagation Delay

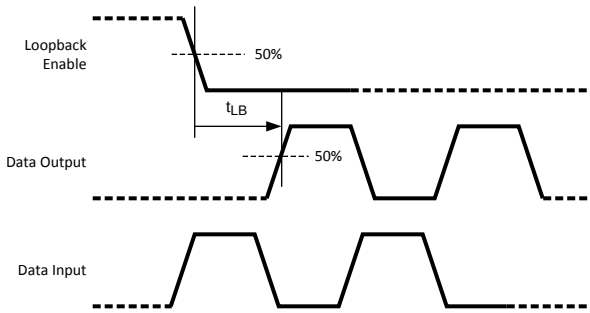


Figure 5. Loopback Delay Timing

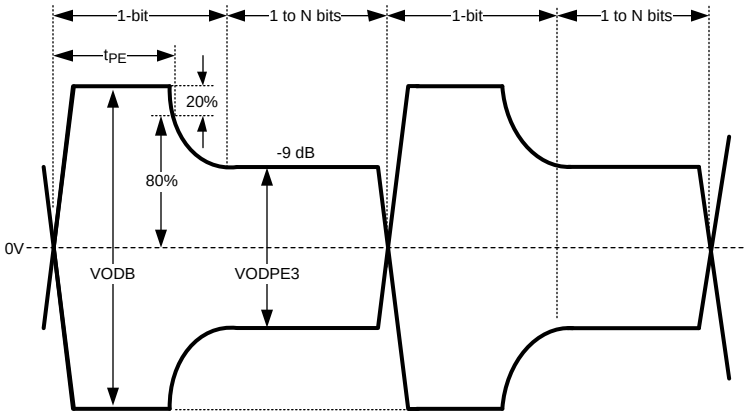


Figure 6. Output De-Emphasis Duration

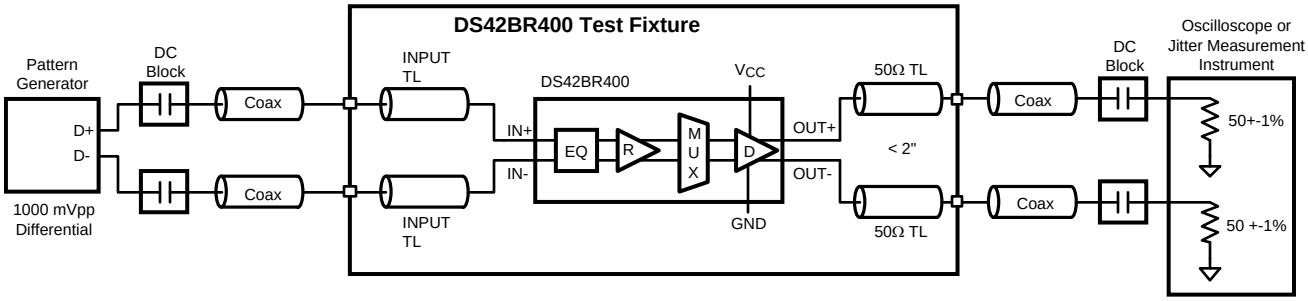


Figure 7. AC Test Circuit

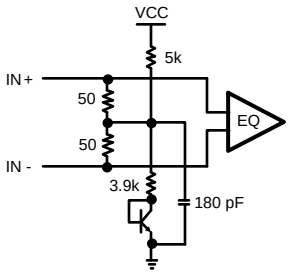


Figure 8. Receiver Input Termination

REVISION HISTORY

Changes from Revision I (April 2013) to Revision J	Page
• Changed layout of National Data Sheet to TI format	11

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
DS42BR400TSQ/NOPB	ACTIVE	WQFN	NKA	60	250	Green (RoHS & no Sb/Br)	CU SN	Level-3-260C-168 HR	-40 to 85	DS42BR400 TSQ	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

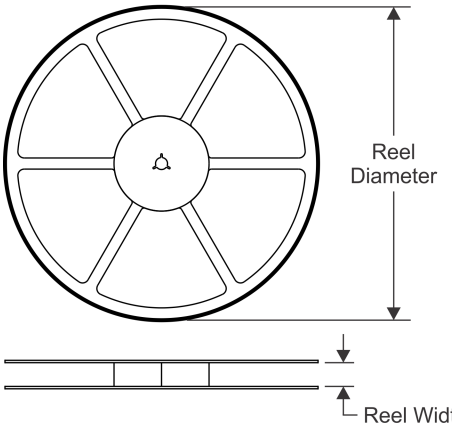
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

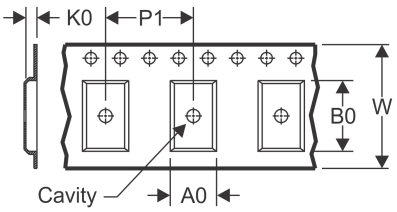
(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

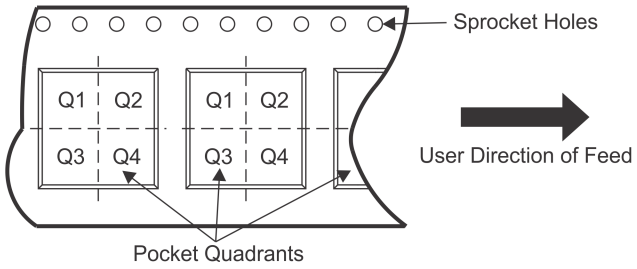


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

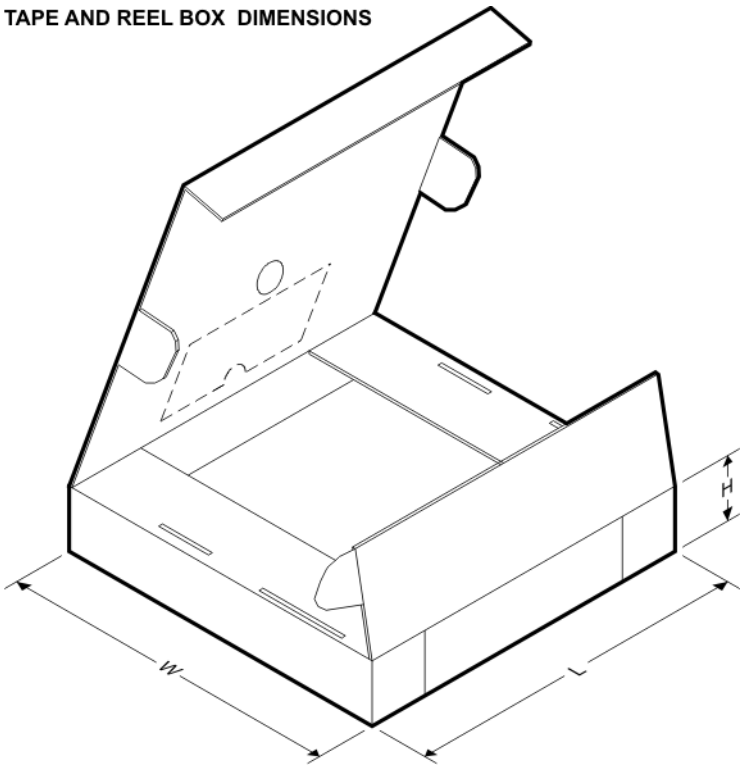
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
DS42BR400TSQ/NOPB	WQFN	NKA	60	250	178.0	16.4	9.3	9.3	1.3	12.0	16.0	Q1

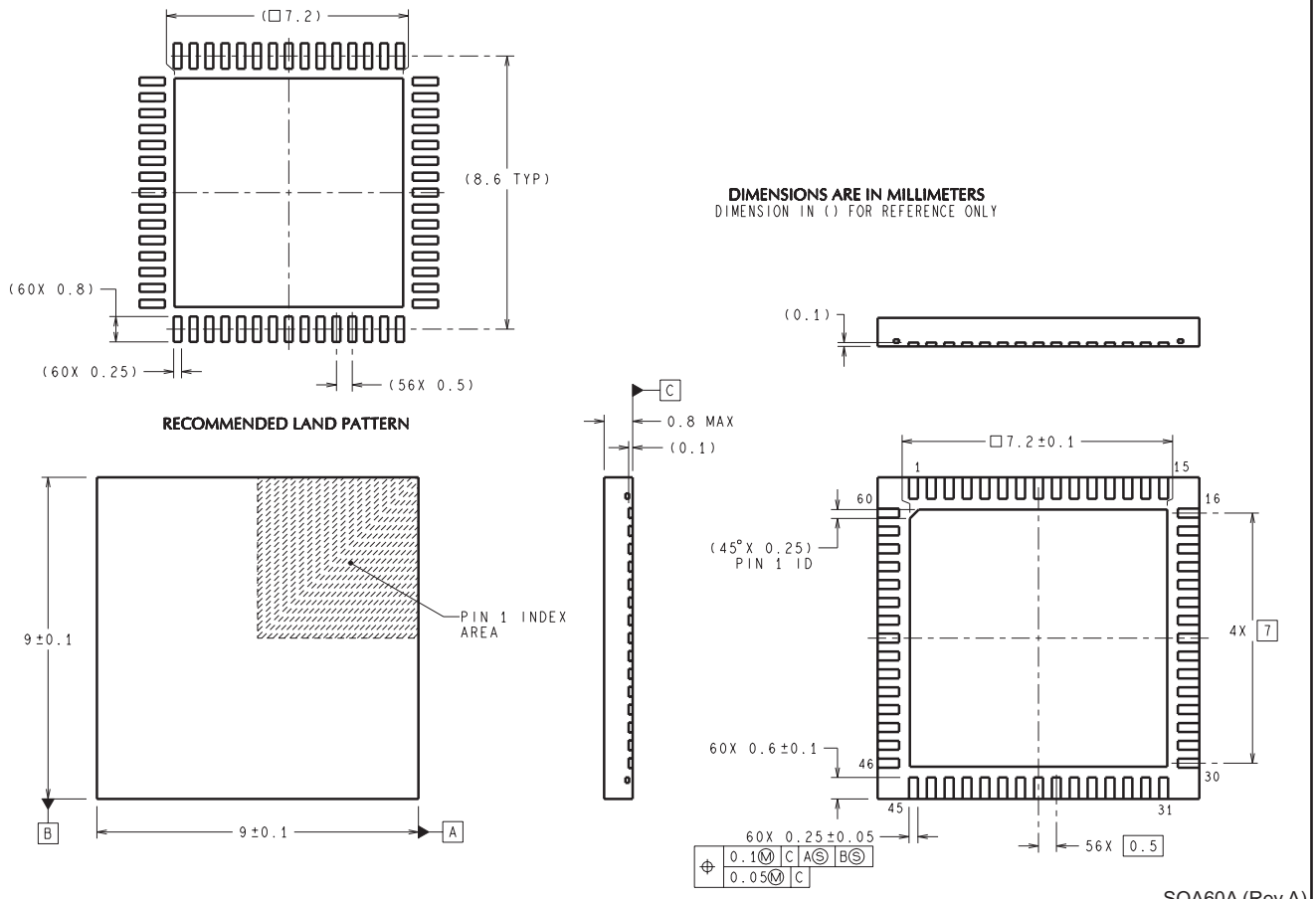
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
DS42BR400TSQ/NOPB	WQFN	NKA	60	250	210.0	185.0	35.0

NKA0060A



SQA60A (Rev A)

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