DS38EP100 1 to 5 Gbps, Power-Saver Equalizer for Backplanes and Cables

Check for Samples: DS38EP100

FEATURES

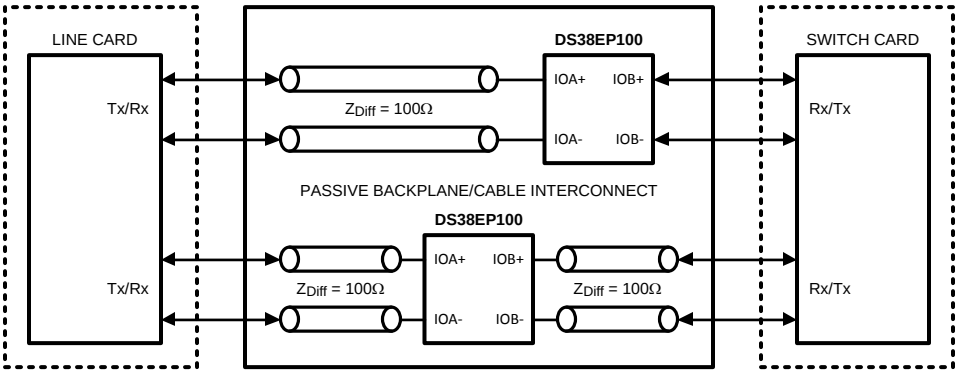
- **1 to 5 Gbps Operation**
- **No Power or Ground Required**
- **Equalization Effective Anywhere in Data Path**
- **Equalizes CML, LV-PECL, LVDS Signals**
- **Symmetric I/O Structures Provide Equal Boost for Bi-directional Operation**
- **7 dB Maximum Boost**
- **Code Independent, 8b/10b or Scrambled**
- **Supports Both Bi-level and Multi-level Signaling**
- **Extends Reach Over Backplanes and Cables**
- **Compatible with PCI-Express Gen1 and Gen2**
- **Compatible with XAUI**
- **Operates in Series with Existing Active Equalizer**
- **Easy to Handle 6 Pin WSON**

DESCRIPTION

TI's Power-saver equalizer compensates for transmission medium losses and minimizes medium-induced deterministic jitter. Performance is ensured over the full range of 1 to 5 Gbps. The DS38EP100 requires no power to operate. The equalizer operates anywhere in the data path to minimize media-induced deterministic jitter in both FR4 and cable applications. Symmetric I/O structures support full duplex or half duplex applications. Linear compensation is provided independent of line coding or protocol. The device is ideal for both bi-level and multi-level signaling.

The equalizer is available in a 6 pin leadless WSON package with a space saving 2.2 mm X 2.5 mm footprint. This tiny package provides maximum flexibility in placement and routing of the Power-saver equalizer.

Simplified Application Diagram



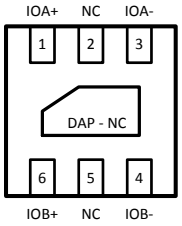
NOTE

The DS38EP100 provides the flexibility of passing the data from either side of the device. It can be placed anywhere in the data path..

PIN DESCRIPTIONS

Pin Name	Pin Number	I/O, Type	Description
High Speed Differential I/O			
IOA- IOA+	3 1	I/O	Symmetric differential I/O.
IOB- IOB+	4 6	I/O	Symmetric differential I/O.
NC Exposed Pad	2, 5 DAP	N/A	Reserved. Do not connect.

Pin Diagram



2.2mm × 2.5mm 6-Pin WSON Package
Bottom View

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)

INPUT/OUTPUT	
(IOA+ and IOB+) or (IOA- and IOB-)	+2V
(IOA+ and IOA-) or (IOB+ and IOB-)	+4V
(IOA+ and IOB-) or (IOA- and IOB+)	+4V
Junction Temperature	+150°C
Storage Temperature	−65°C to +150°C
Lead Temperature Soldering, 4 sec	+260°C
ESD Rating	
HBM, 1.5 kΩ, 100 pF	1.3kV

(1) "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.
(2) If Military/Aerospace specified devices are required, please contact the TI Sales Office/Distributors for availability and specifications.

Recommended Operating Conditions

	Min	Typ	Max	Units
Operating Temperature	−40	25	+85	°C
Bit Rate	1		5	Gbps

Electrical Characteristics (1)

Over recommended operating conditions unless other specified. All parameters are ensured by test, statistical analysis or design.

Symbol	Parameter	Conditions	Min	Typ (2)	Max	Units
V_{IN}	Input voltage swing	See (3)		1000	3600	mVp-p
	Equalization	2.5 GHz relative to 100MHz		6		dB
R_{LI}	Differential input return loss	100 MHz – 2.5 GHz, with fixture's effect de-embedded		15		dB
R_{LO}	Differential output return loss	100 MHz – 2.5 GHz, with fixture's effect de-embedded. IOA+,or IOB+ = static high.		15		dB
R_{IN}	Input Impedance	Differential across IOA+ and IOA-, or IOB+ and IOB-, ZLOAD = 100Ω		100		Ω
R_O	Output Impedance	Differential across IOA+ and IOA-, or IOB+ and IOB-, ZSOURCE = 100Ω		100		Ω
	Through Response	Relative to ideal load, see Figure 2 for setup	See Figure 3 and Table 1 for limits			
R1	Resistance IOA+ to IOA- and IOB+ to IOB-	No load, high impedance on all ports		150		Ω
R2	Resistance IOA+ to IOB+ and IOA- to IOB-	No load, high impedance on all ports		50		Ω
R3	Resistance IOA+ to IOB- and IOA- to IOB+	No load, high impedance on all ports		150		Ω
	DC Gain (IOA/IOB or IOB/IOA)	ZLOAD = 100Ω		0.4		
DJ1	Residual deterministic jitter	2.5 Gbps, 40 in of 6mil microstrip FR4 See (4)		0.1		UIp-p
DJ2	Residual deterministic jitter	3.125 Gbps, 40 in of 6mil microstrip FR4 See (4) (5)		0.1	0.15	UIp-p
DJ3	Residual deterministic jitter	3.8 Gbps, 40 in of 6mil microstrip FR4 See (4) (5)		0.1	0.15	UIp-p
DJ4	Residual deterministic jitter	5 Gbps, 30 in of 6mil microstrip FR4 See (4)		0.1		UIp-p

(1) The Electrical Characteristics tables list ensured 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 ensured.
(2) Typical values represent most likely parametric norms, TA = +25 degC, and at the Recommended Operating Conditions at the time of product characterization and are not ensured.
(3) Differential signal to Equalizer, measured at the input to a transmission line, see point A of Figure 1. The transmission line is Z_0 = 100Ω, 6-mil, microstrip in FR4 material.
(4) Deterministic jitter is measured at the differential outputs (point C of Figure 1), minus the deterministic jitter before the test channel (point A of Figure 1). Test pattern: PRBS- 7 .
(5) Specification is ensured by characterization and is not tested in production.

Test Setup Diagrams

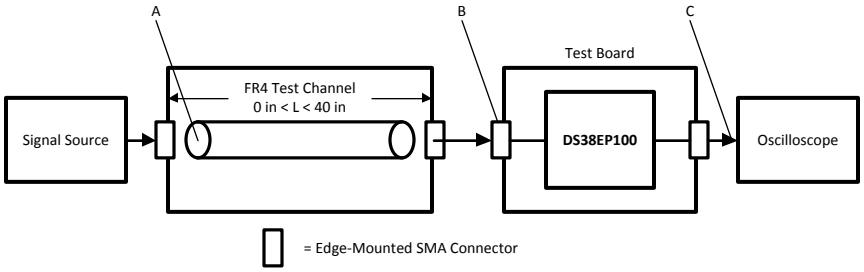


Figure 1. Transient Test Setup Diagram

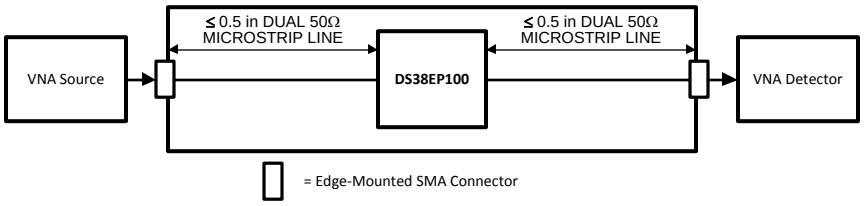


Figure 2. Frequency Response Test Circuit

Typical Equalizer Transfer Function

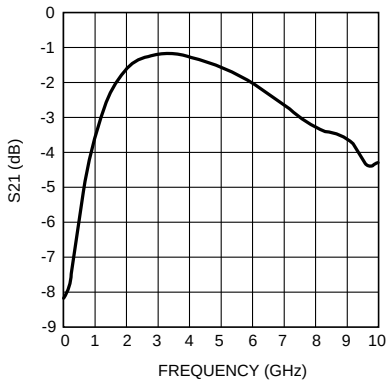


Figure 3. Typical Equalizer Transfer Function

Table 1. Typical Through Response

Frequency (GHz)	DS38EP100 Attenuation Typ (dB)
0.1	-7.98
0.5	-5.93
1	-3.53
1.5	-2.25
2	-1.58
3	-1.14
4	-1.26
5	-1.54
6	-1.99
7	-2.62
8	-3.26
9	-3.61
10	-4.26

Block Diagram

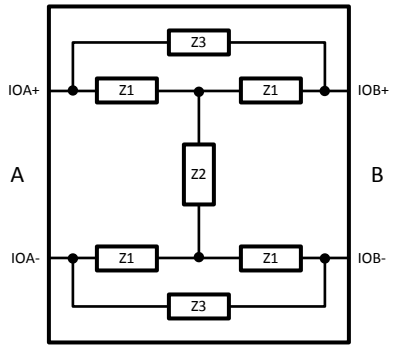


Figure 4. Simplified Block Diagram

APPLICATION INFORMATION

DS38EP100 DEVICE DESCRIPTION

The DS38EP100 Power-Saver equalizer is a passive network circuit composed of resistive, capacitive, and inductive components (See Figure 4). A differential bridged T-network compensates for the transmission medium losses and minimizes medium-induced deterministic jitter with FR4 and cables. The equalizer attenuates low frequency signals and is a bandpass filter at the resonant frequency. The response is linear and symmetric.

I/O TERMINATIONS

The DS38EP100 I/O impedance is 100Ω differential. The equalizer is designed for 100Ω-balanced differential signals and is not intended for single-ended transmission.

LINEAR COMPENSATION

The unique linear compensation feature of the DS38EP100 combined with the tiny package allows maximum flexibility in placement. The equalizer can be placed anywhere in the data path and will provide the same compensation at the receiving circuit. (See Simplified Application Diagram)

SYMMETRIC I/O STRUCTURES

The symmetry of the passive equalization network allows bi-directional operation. Signals receive equal compensation regardless of the direction of data flow. (See Figure 4).

PCB LAYOUT CONSIDERATIONS FOR DIFFERENTIAL PAIRS AND NO CONNECT PADS

The differential I/Os must have a controlled differential impedance of 100Ω. It is preferable to route all differential lines exclusively on one layer of the board. The use of vias should be avoided if possible. If vias must be used, they should be used sparingly and must be placed symmetrically for each side of a given differential pair. Differential signals should be routed away from other signals and noise sources on the printed circuit board. Pin 2, Pin 5, and the center DAP have to be left as a no connect. Therefore, do not connect the landing pads of these pins to the power or ground plane. See AN-1187 (SNOA401) for additional information on the WSON package.

TYPICAL PERFORMANCE CHARACTERISTICS

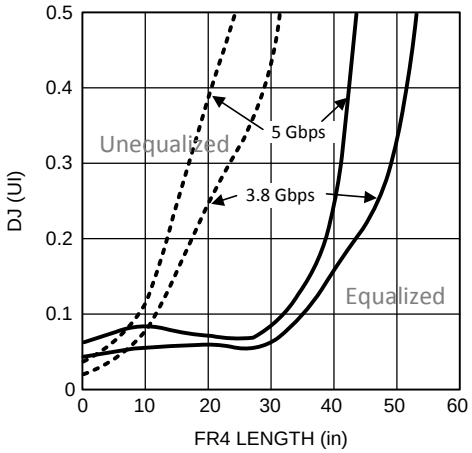


Figure 5. Residual Deterministic Jitter vs. FR4 Length

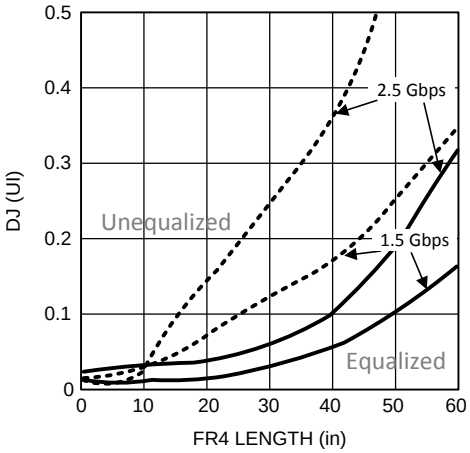


Figure 6. Residual Deterministic Jitter vs. FR4 Length

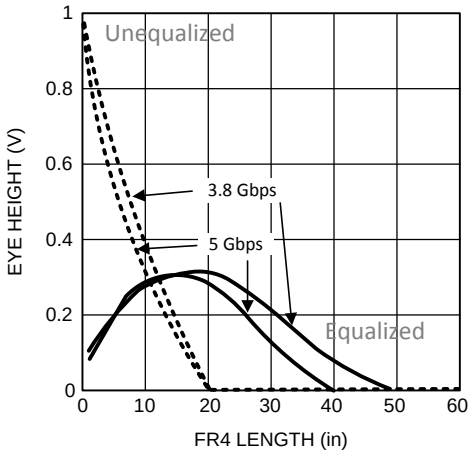


Figure 7. Eye Height vs. FR4 Length

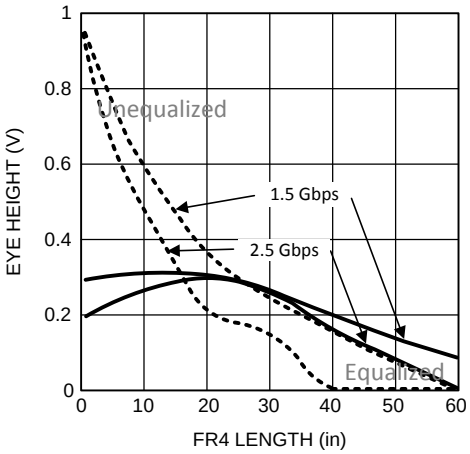


Figure 8. Eye Height vs. FR4 Length

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Typical Eye Diagrams — Includes Transmitter Setup, Interconnect, and Device Total Jitter

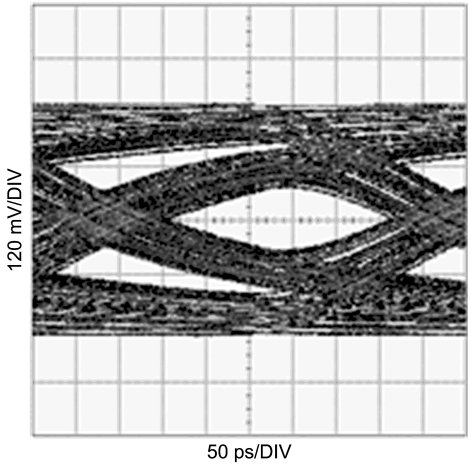


Figure 9. Unequalized Signal (40in FR4, 2.5Gbps, PRBS7)

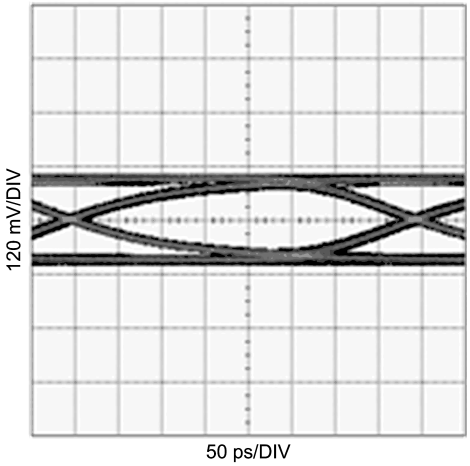


Figure 10. Equalized Signal (40in FR4, 2.5Gbps, PRBS7)

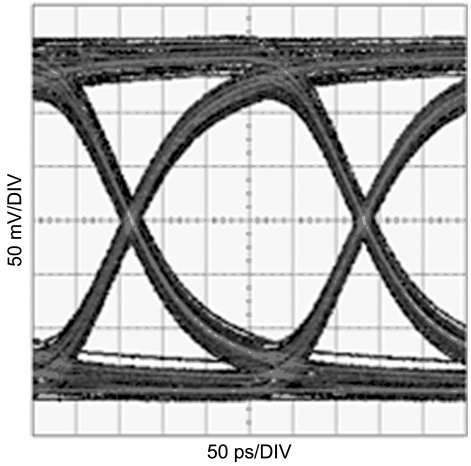


Figure 11. Equalized Signal (Zoom) (40in FR4, 2.5Gbps, PRBS7)

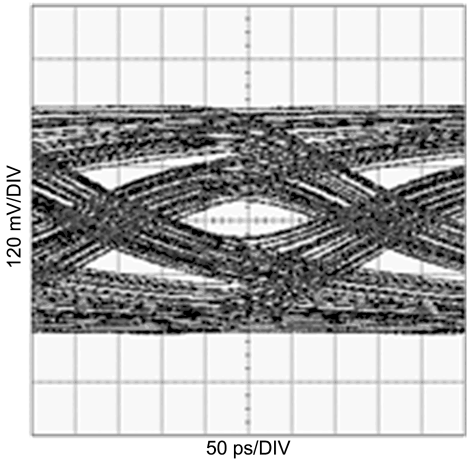


Figure 12. Unequalized Signal (40in FR4, 3.125Gbps, PRBS7)

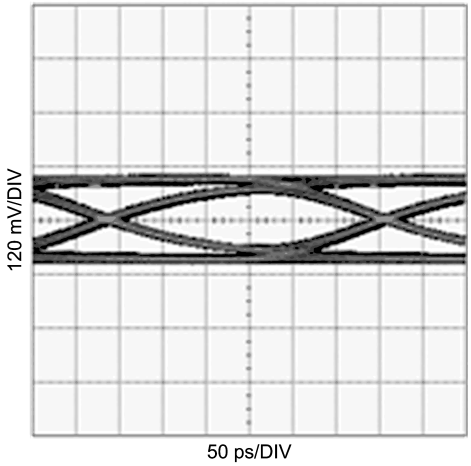


Figure 13. Equalized Signal (40in FR4, 3.125Gbps, PRBS7)

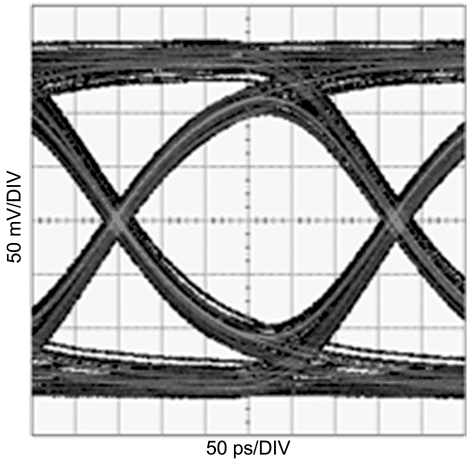


Figure 14. Equalized Signal (Zoom) (40in FR4, 3.125Gbps, PRBS7)

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

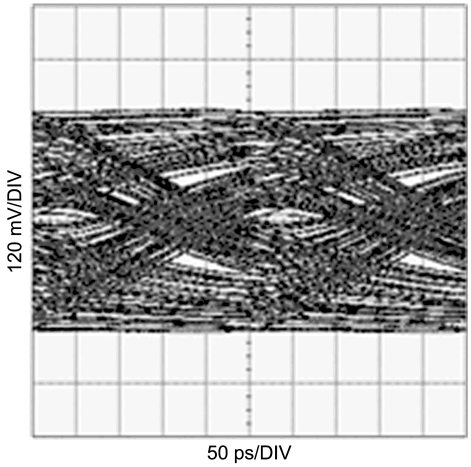


Figure 15. Unequalized Signal (40in FR4, 3.8Gbps, PRBS7)

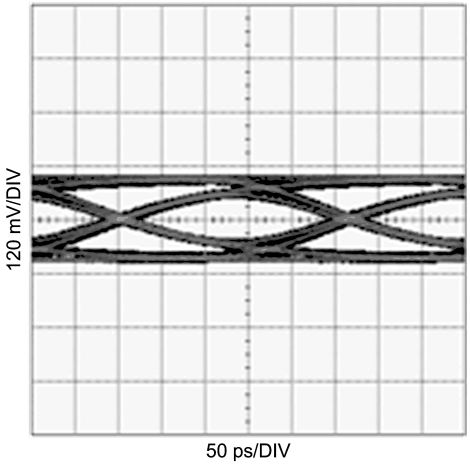


Figure 16. Equalized Signal (40in FR4, 3.8Gbps, PRBS7)

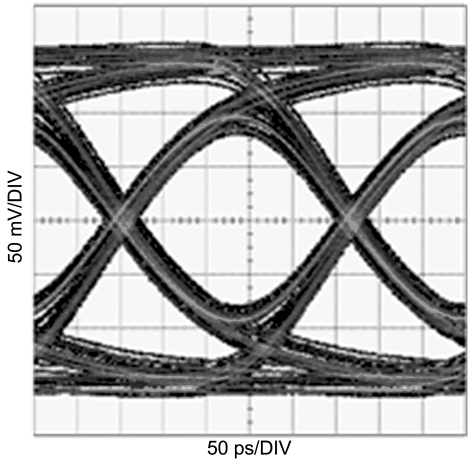


Figure 17. Equalized Signal (Zoom) (40in FR4, 3.8Gbps, PRBS7)

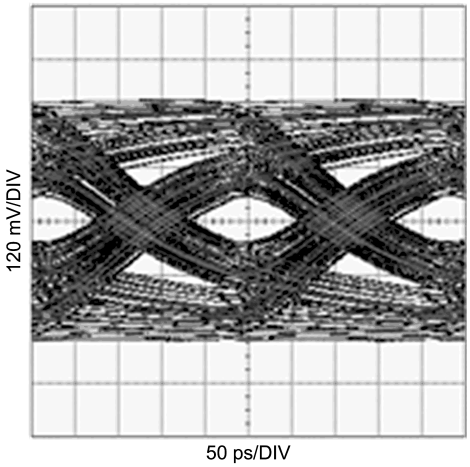


Figure 18. Unequalized Signal (30in FR4, 4.25Gbps, PRBS7)

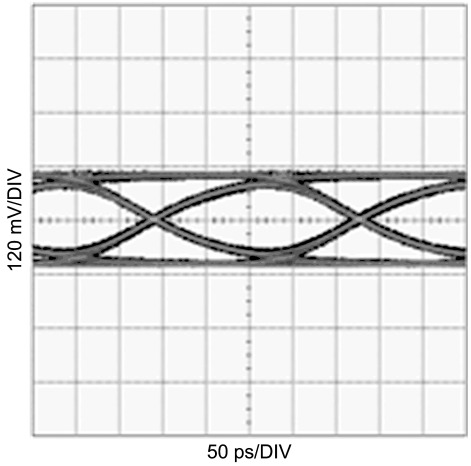


Figure 19. Equalized Signal (30in FR4, 4.25Gbps, PRBS7)

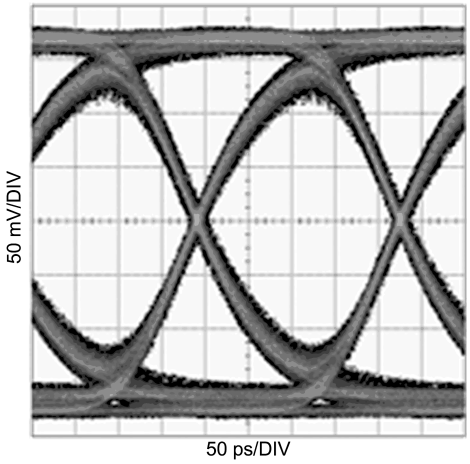


Figure 20. Equalized Signal (Zoom) (30in FR4, 4.25Gbps, PRBS7)

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

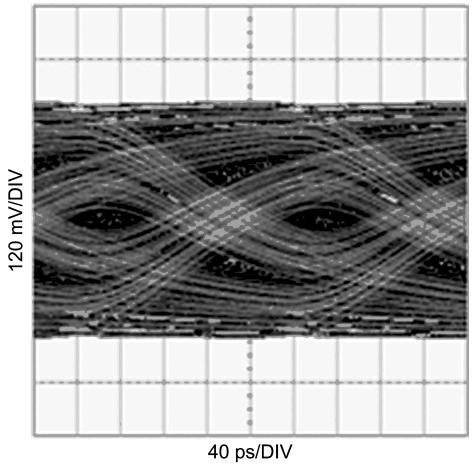


Figure 21. Unequalized Signal (30in FR4, 5Gbps, PRBS7)

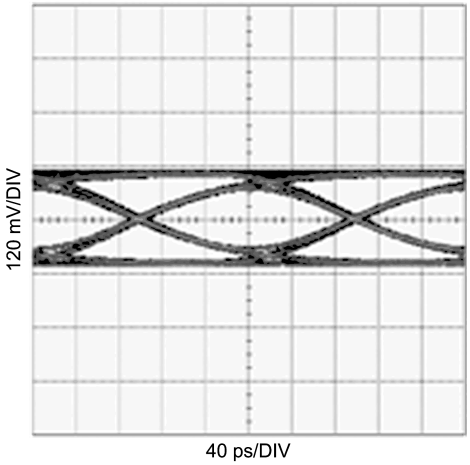


Figure 22. Equalized Signal (30in FR4, 5Gbps, PRBS7)

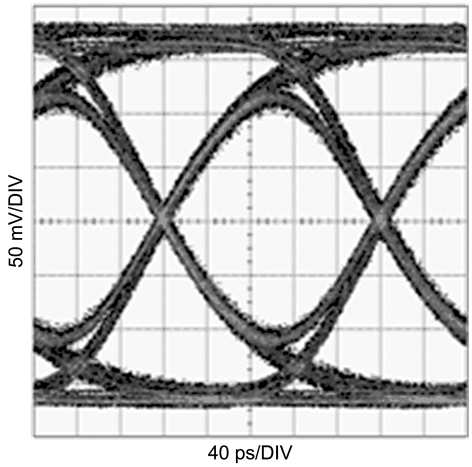


Figure 23. Equalized Signal (Zoom) (30in FR4, 5Gbps, PRBS7)

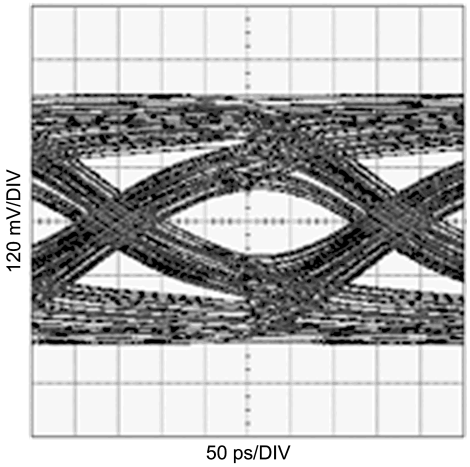


Figure 24. Unequalized Signal (34in Tyco XAUI Backplane, 3.125Gbps, PRBS7)

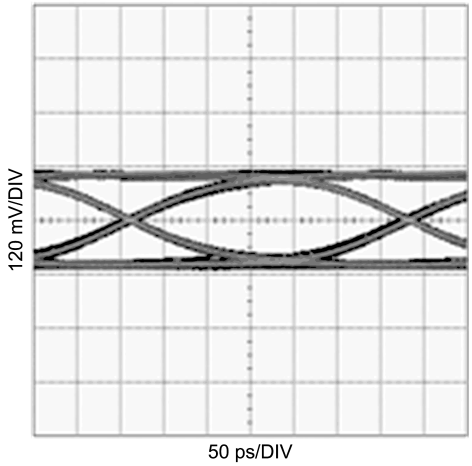


Figure 25. Equalized Signal (34in Tyco XAUI Backplane, 3.125Gbps, PRBS7)

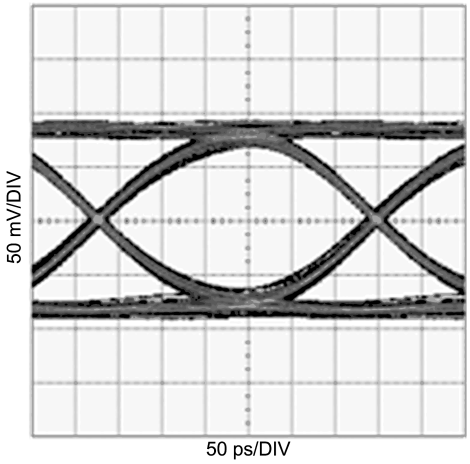


Figure 26. Equalized Signal (Zoom) (34in Tyco XAUI Backplane, 3.125Gbps, PRBS7)

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

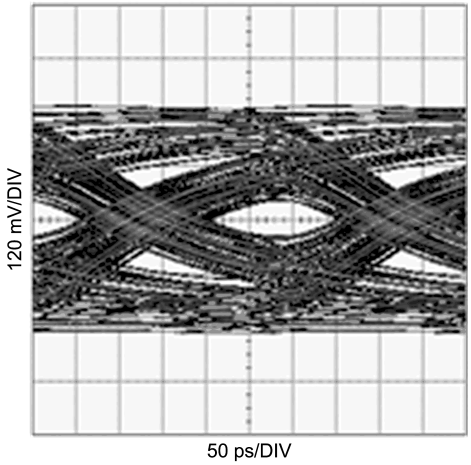


Figure 27. Unequalized Signal (5m 28AWG HDMI Cable, 3.4Gbps, PRBS7)

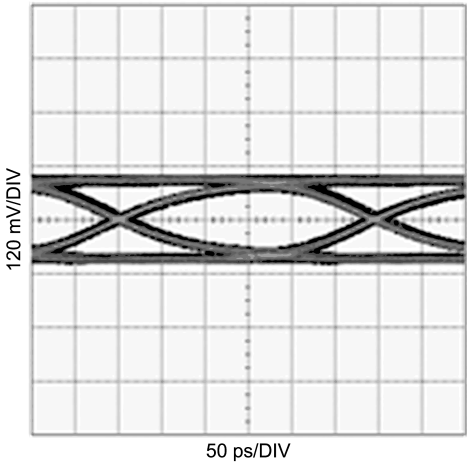


Figure 28. Equalized Signal (5m 28AWG HDMI Cable, 3.4Gbps, PRBS7)

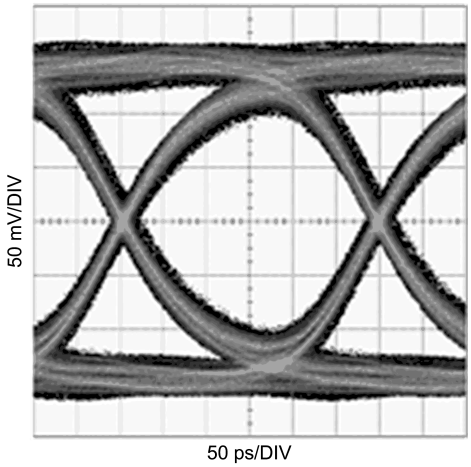


Figure 29. Equalized Signal (Zoom) (5m 28AWG HDMI Cable, 3.4Gbps, PRBS7)

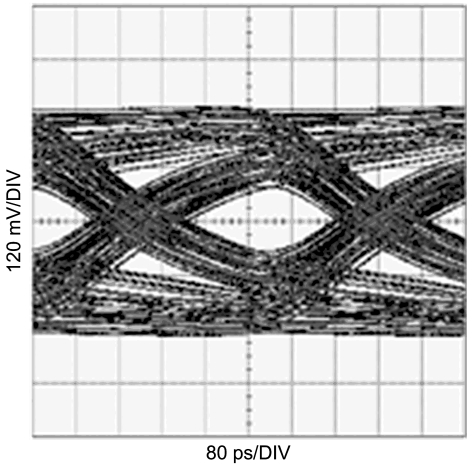


Figure 30. Unequalized Signal (10m 26AWG HDMI Cable, 2.25Gbps, PRBS7)

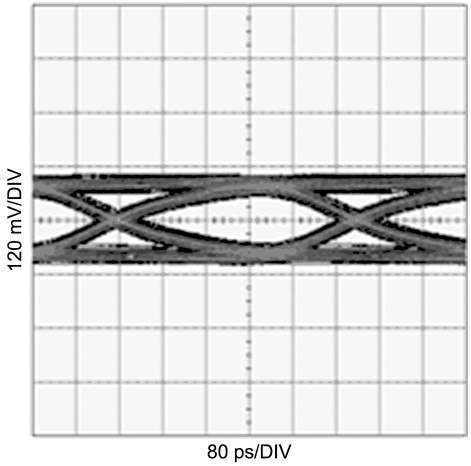


Figure 31. Equalized Signal (10m 26AWG HDMI Cable, 2.25Gbps, PRBS7)

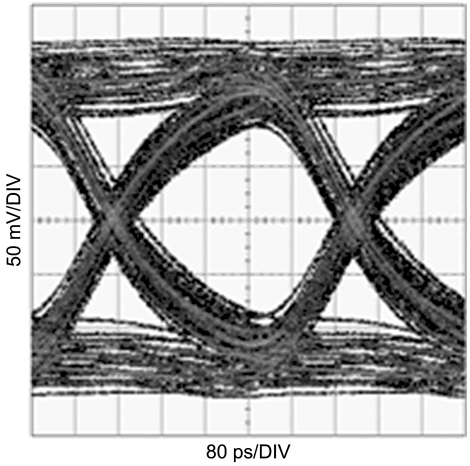


Figure 32. Equalized Signal (Zoom) (10m 26AWG HDMI Cable, 2.25Gbps, PRBS7)

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

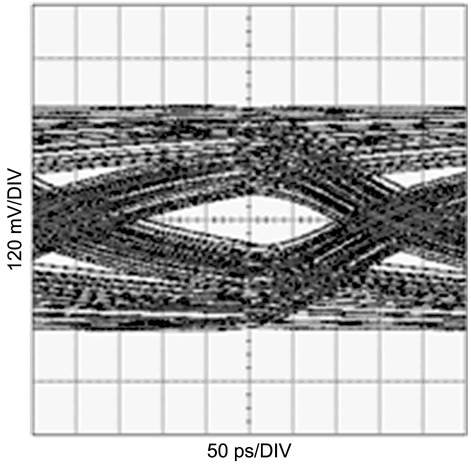


Figure 33. Unequalized Signal (10m 24AWG PCIe Cable, 2.5Gbps, PRBS7)

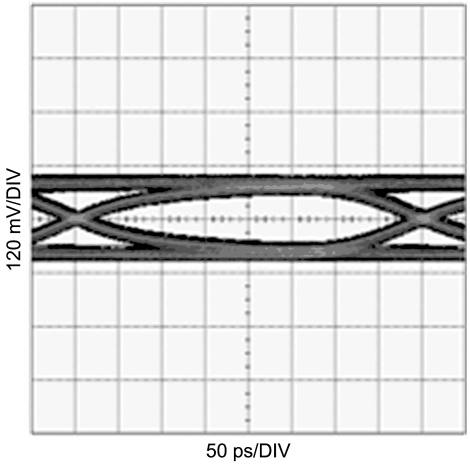


Figure 34. Equalized Signal (10m 24AWG PCIe Cable, 2.5Gbps, PRBS7)

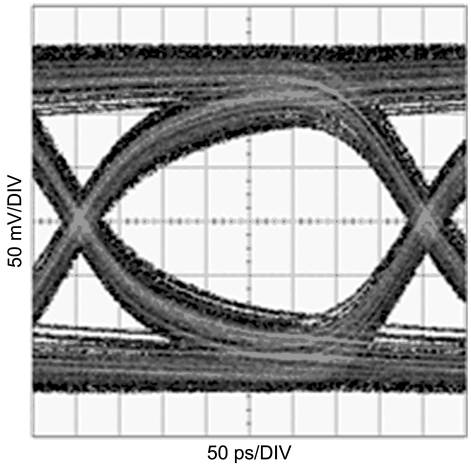


Figure 35. Equalized Signal (Zoom) (10m 24AWG PCIe Cable, 2.5Gbps, PRBS7)

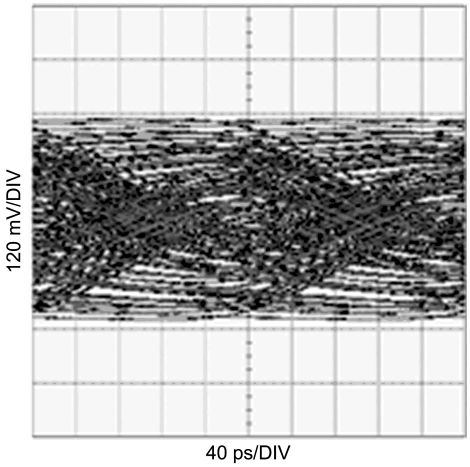


Figure 36. Unequalized Signal (10m 24AWG PCIe Cable, 5Gbps, PRBS7)

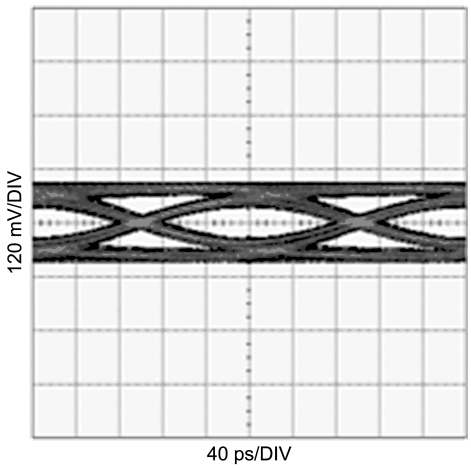


Figure 37. Equalized Signal (10m 24AWG PCIe Cable, 5Gbps, PRBS7)

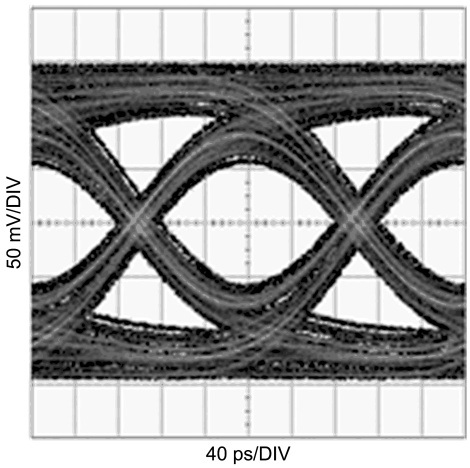


Figure 38. Equalized Signal (Zoom) (10m 24AWG PCIe Cable, 5Gbps, PRBS7)

REVISION HISTORY

Changes from Revision B (April 2013) to Revision C	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	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
DS38EP100SD/NOPB	ACTIVE	WSON	NGF	6	1000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	38S	Samples
DS38EP100SDX/NOPB	ACTIVE	WSON	NGF	6	4500	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	38S	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.

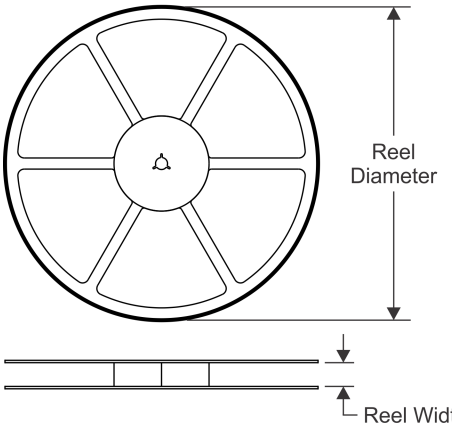
(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

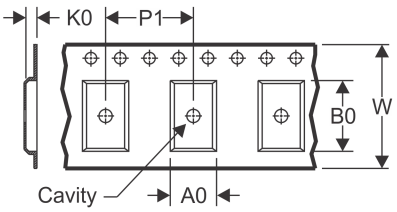
(4) Multiple Top-Side Markings will be inside parentheses. Only one Top-Side Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Top-Side Marking for that device.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

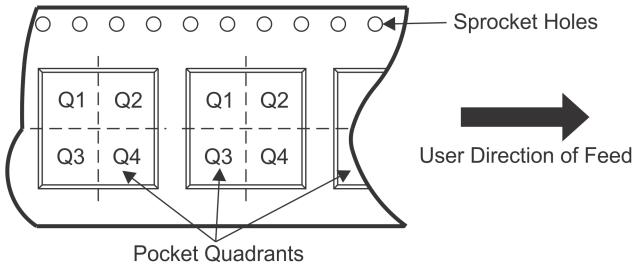


TAPE DIMENSIONS



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

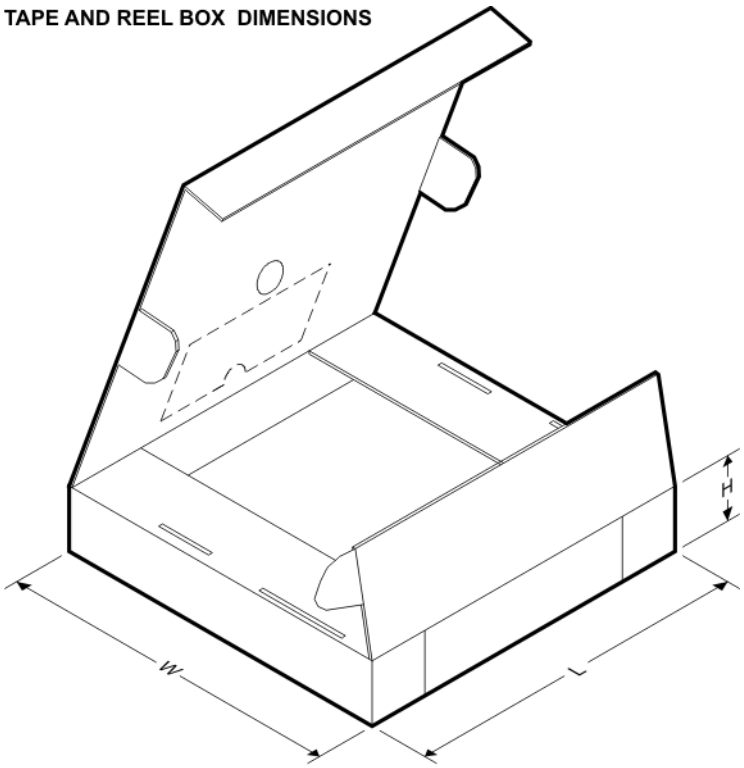
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
DS38EP100SD/NOPB	WSON	NGF	6	1000	178.0	12.4	2.8	2.5	1.0	8.0	12.0	Q1
DS38EP100SDX/NOPB	WSON	NGF	6	4500	330.0	12.4	2.8	2.5	1.0	8.0	12.0	Q1

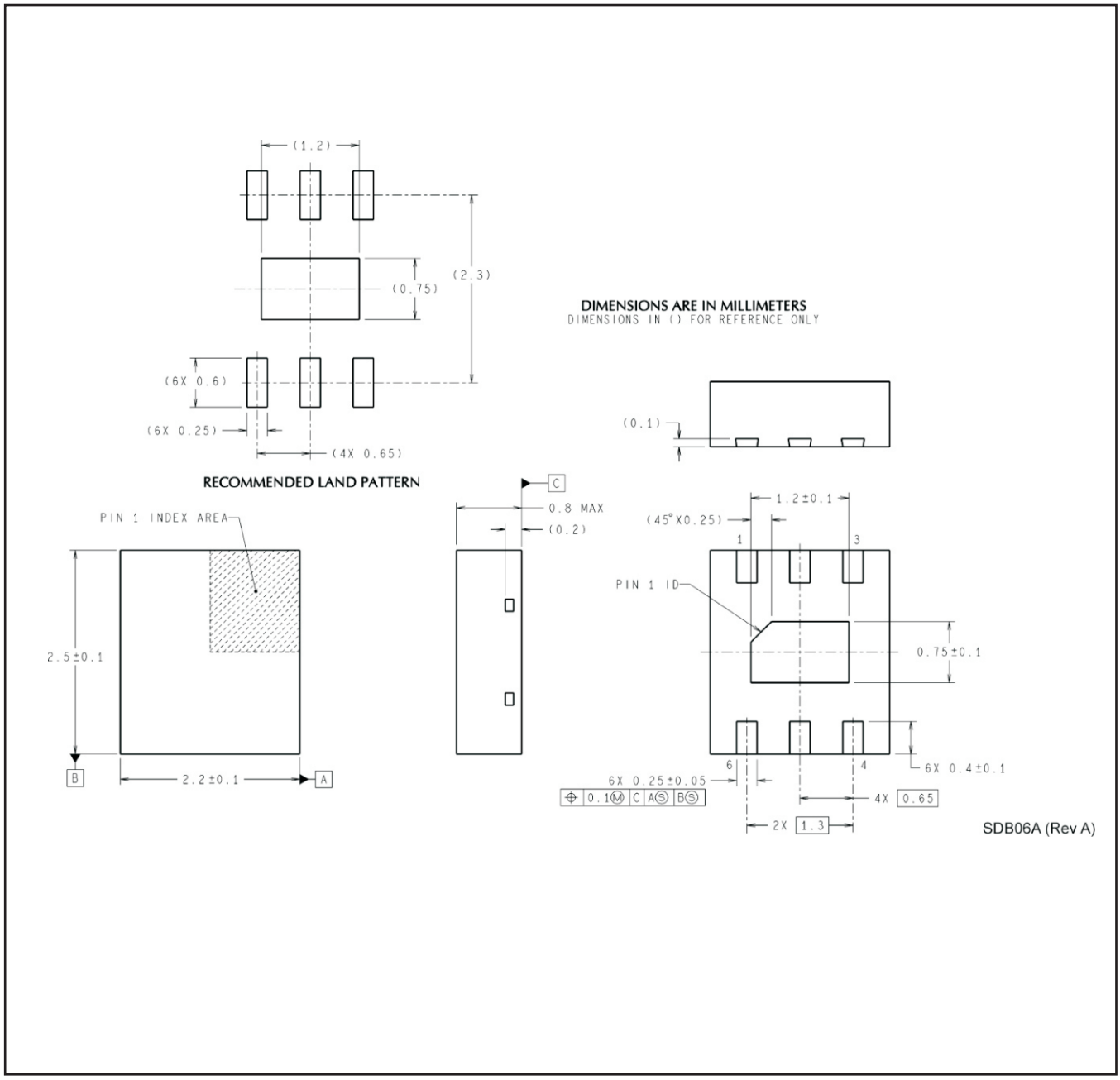
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
DS38EP100SD/NOPB	WSON	NGF	6	1000	210.0	185.0	35.0
DS38EP100SDX/NOPB	WSON	NGF	6	4500	367.0	367.0	35.0

NGF0006A


(1.2)
(2.3)
(0.75)
(6X 0.6)
(6X 0.25)
(4X 0.65)
RECOMMENDED LAND PATTERN
DIMENSIONS ARE IN MILLIMETERS
DIMENSIONS IN ( ) FOR REFERENCE ONLY
(0.1)
PIN 1 INDEX AREA
2.5±0.1
2.2±0.1
B
A
C
0.8 MAX
(0.2)
1.2±0.1
(45°X0.25)
1
3
PIN 1 ID
0.75±0.1
6
4
6X 0.4±0.1
6X 0.25±0.05
0.10 M C A S B S
4X 0.65
2X 1.3
SDB06A (Rev A)

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as “components”) are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers’ products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers’ products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have ***not*** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Applications Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265