3 Gbps HD/SD SDI Adaptive Cable Equalizer

Check for Samples: LMH0344

FEATURES

- **SMPTE 424M, SMPTE 292M, SMPTE 344M, and SMPTE 259M Compliant**
- **Supports DVB-ASI at 270 Mbps**
- **Wide Range of Data Rates: 125 Mbps to 2.97 Gbps**
- **Equalizes up to 120 Meters of Belden 1694A at 2.97 Gbps, up to 140 Meters of Belden 1694A at 1.485 Gbps, or up to 400 Meters of Belden 1694A at 270 Mbps**
- **Equalizes 0-120m of Belden 1694A at 2.97 Gbps With 0.3 UI Maximum Output Jitter**
- **Manual Bypass and Output Mute With a Programmable Threshold**
- **Single-Ended or Differential Input**
- **50Ω Differential Outputs (Internal 50Ω Pullups)**
- **Single 3.3V Supply Operation**
- **280 mW Typical Power Consumption**
- **16-Pin WQFN or 25-Ball CS-BGA Package**
- **Industrial Temperature Range: −40°C to +85°C**
- **HBM ESD Rating: 8 kV**
- **WQFN Version Footprint Compatible With the LMH0044 and LMH0074**
- **Replaces the Gennum GS2974A or GS2974B**

APPLICATIONS

- **SMPTE 424M, SMPTE 292M, SMPTE 344M, and SMPTE 259M Serial Digital Interfaces**
- **Serial Digital Data Equalization and Reception**
- **Data Recovery Equalization**

DESCRIPTION

The LMH0344 3 Gbps HD/SD SDI Adaptive Cable Equalizer is designed to equalize data transmitted over cable (or any media with similar dispersive loss characteristics). The equalizer operates over a wide range of data rates from 125 Mbps to 2.97 Gbps and supports SMPTE 424M, SMPTE 292M, SMPTE 344M, and SMPTE 259M.

The LMH0344 implements DC restoration to correctly handle pathological data conditions. The equalizer may be driven in either a single ended or differential configuration.

Additional features include separate carrier detect and output mute pins which may be tied together to mute the output when no signal is present. A programmable mute reference is provided to mute the output at a selectable level of signal degradation.

For applications which use the RGBα data patterns, the LMH0394 cable equalizer will provide better performance.

The device is available in two space–saving packages: a 4 X 4 mm 16-pin WQFN and even more space-efficient 3 x 3 mm 25-ball CS-BGA package.

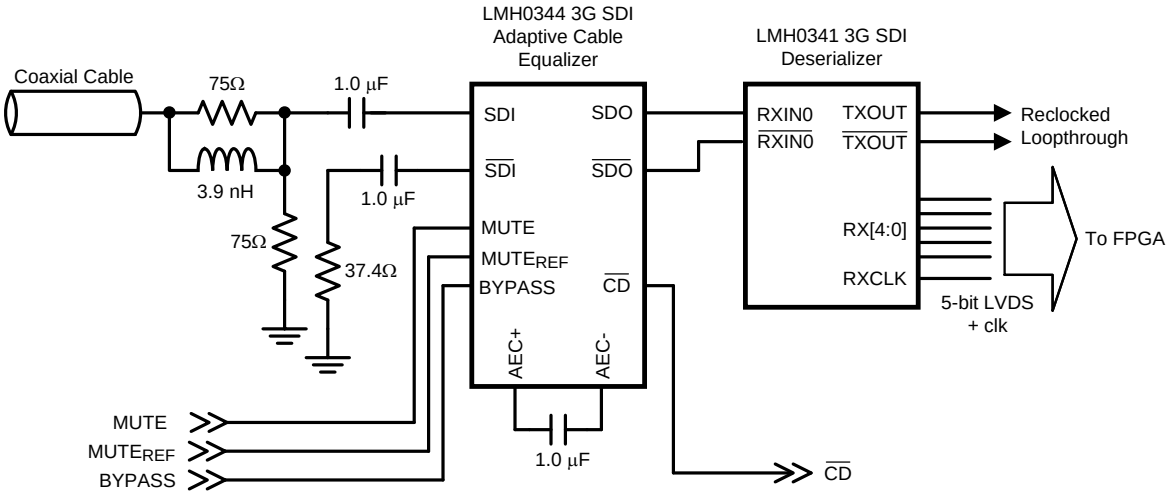
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Typical Application



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)

Supply Voltage		4.0V
Input Voltage (all inputs)		−0.3V to V_{CC}+0.3V
Storage Temperature Range		−65°C to +150°C
Junction Temperature		+125°C
Lead Temperature (Soldering 4 Sec)		+260°C
Package Thermal Resistance	θ_{JA} 16-pin WQFN	+40°C/W
	θ_{JC} 16-pin WQFN	+4.5°C/W
	θ_{JA} 25-ball CS-BGA	+58.1°C/W
ESD Rating	HBM	8 kV
	MM	400V
	CDM	2 kV

(1) Absolute Maximum Ratings are those parameter values beyond which the life and operation of the device cannot be ensured. The stating herein of these maximums shall not be construed to imply that the device can or should be operated at or beyond these values. The table of Electrical Characteristics specifies acceptable device operating conditions.

Recommended Operating Conditions

Supply Voltage (V_{CC} – V_{EE})	3.3V ±5%
Input Coupling Capacitance	1.0 µF
AEC Capacitor (Connected between AEC+ and AEC-)	1.0 µF
Operating Free Air Temperature (T_A)	−40°C to +85°C

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DC Electrical Characteristics

Over Supply Voltage and Operating Temperature ranges, unless otherwise specified (1) (2).

Symbol	Parameter	Conditions	Reference	Min	Typ	Max	Units
V_{CMIN}	Input Common Mode Voltage		SDI, $\overline{SDI}$		1.9		V
V_{SDI}	Input Voltage Swing	At LMH0344 input (3) (4)		720	800	950	mV_{P-P}
V_{CMOUT}	Output Common Mode Voltage		SDO, $\overline{SDO}$		$V_{CC} - V_{SDO}/2$		V
V_{SDO}	Output Voltage Swing	100Ω load, differential			750		mV_{P-P}
	$MUTE_{REF}$ DC Voltage (floating)		$MUTE_{REF}$		1.3		V
	$MUTE_{REF}$ Range				0.6		V
	$\overline{CD}$ Output Voltage	Carrier not present	$\overline{CD}$	2.4			V
		Carrier present				0.4	V
	MUTE Input Voltage	Min to mute outputs	MUTE	2.0			V
		Max to force outputs active				0.8	V
I_{CC}	Supply Current				85	100	mA

(1) Current flow into device pins is defined as positive. Current flow out of device pins is defined as negative. All voltages are stated referenced to V_{EE} = 0 Volts.
(2) Typical values are stated for V_{CC} = +3.3V and T_A = +25°C.
(3) Specification is ensured by characterization.
(4) This specification is for 0m cable only.

AC Electrical Characteristics

Over Supply Voltage and Operating Temperature ranges, unless otherwise specified (1).

Symbol	Parameter	Conditions	Reference	Min	Typ	Max	Units
BR_{MIN}	Minimum Input Data Rate		SDI, $\overline{SDI}$		125		Mbps
BR_{Max}	Maximum Input Data Rate					2970	Mbps
	Jitter for Various Cable Lengths	270 Mbps, Belden 1694A, 0-400 meters (2)				0.2	UI
		270 Mbps, Belden 1694A, 0-400 meters (3)			0.07		UI
		1.485 Gbps, Belden 1694A, 0-140 meters (2)				0.25	UI
		1.485 Gbps, Belden 1694A, 0-140 meters (3)			0.08		UI
		2.97 Gbps, Belden 1694A, 0-120 meters (2)				0.3	UI
		2.97 Gbps, Belden 1694A, 0-120 meters (3)			0.18		UI
t_r,t_f	Output Rise Time, Fall Time	20% – 80% (4)	SDO, $\overline{SDO}$		60	130	ps
	Mismatch in Rise/Fall Time	(4)			2	15	ps
t_{OS}	Output Overshoot	(4)			1	5	%
R_{OUT}	Output Resistance	single-ended			50		Ω
RL_{IN}	Input Return Loss	5 MHz - 1.5 GHz (5)	SDI, $\overline{SDI}$	15			dB
		1.5 GHz - 3.0 GHz (5)		10			dB
R_{IN}	Input Resistance	single-ended			1.3		kΩ
C_{IN}	Input Capacitance	single-ended			1		pF

(1) Typical values are stated for V_{CC} = +3.3V and T_A = +25°C.
(2) Based on characterization data over the full range of recommended operating conditions of the device. Jitter is measured in accordance with SMPTE RP 184, SMPTE RP 192, and the applicable serial data transmission standard: SMPTE 424M, SMPTE 292M, or SMPTE 259M.
(3) Measured with Pseudo Matrix Pathological test signal.
(4) Specification is ensured by characterization.
(5) Input return loss is dependent on board design. The LMH0344 exceeds this specification on the SD344 evaluation board with a return loss network consisting of an 8.2 nH inductor in parallel with a 0.5 pF capacitor in parallel with the 75Ω series resistor on the input.

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Typical Performance Characteristics

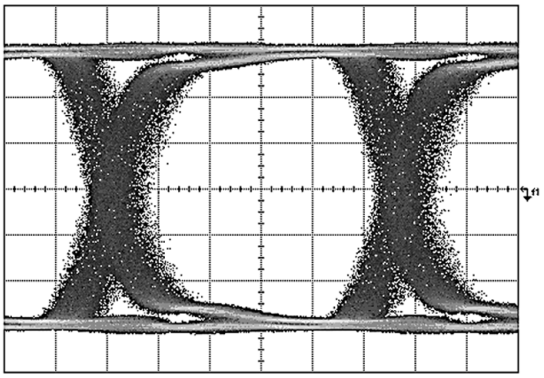


Figure 1. After Equalization: 120m of Belden 1694A with 2.97 Gbps PRBS

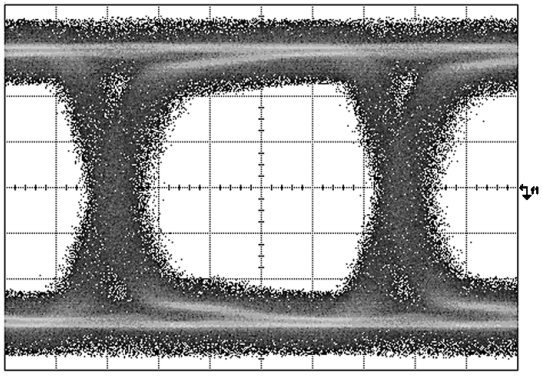
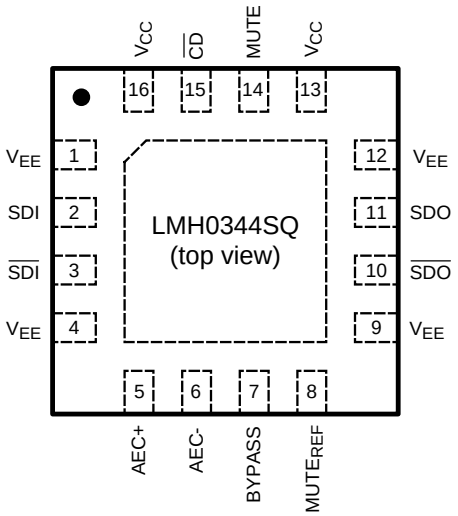


Figure 2. After Equalization: 120m of Belden 1694A with 2.97 Gbps Pseudo Matrix Pathological

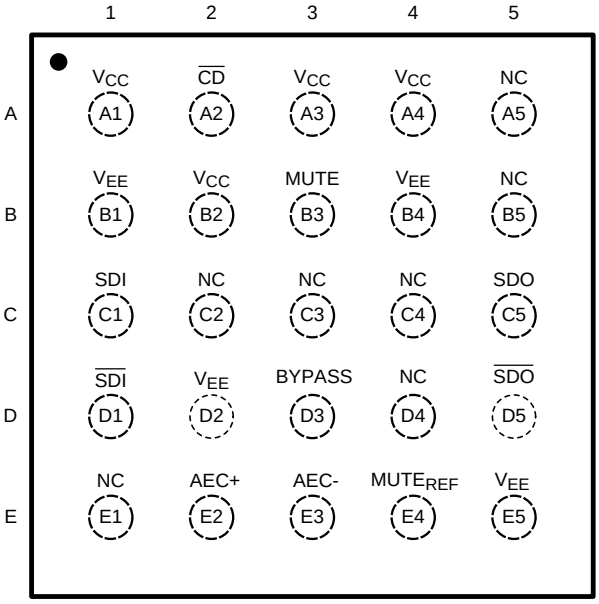
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CONNECTION DIAGRAM



The exposed die attach pad is a negative electrical terminal for this device. It should be connected to the negative power supply voltage.

Figure 3. 16-Pin WQFN
See Package Number RUM



LMH0344GR
(top view)

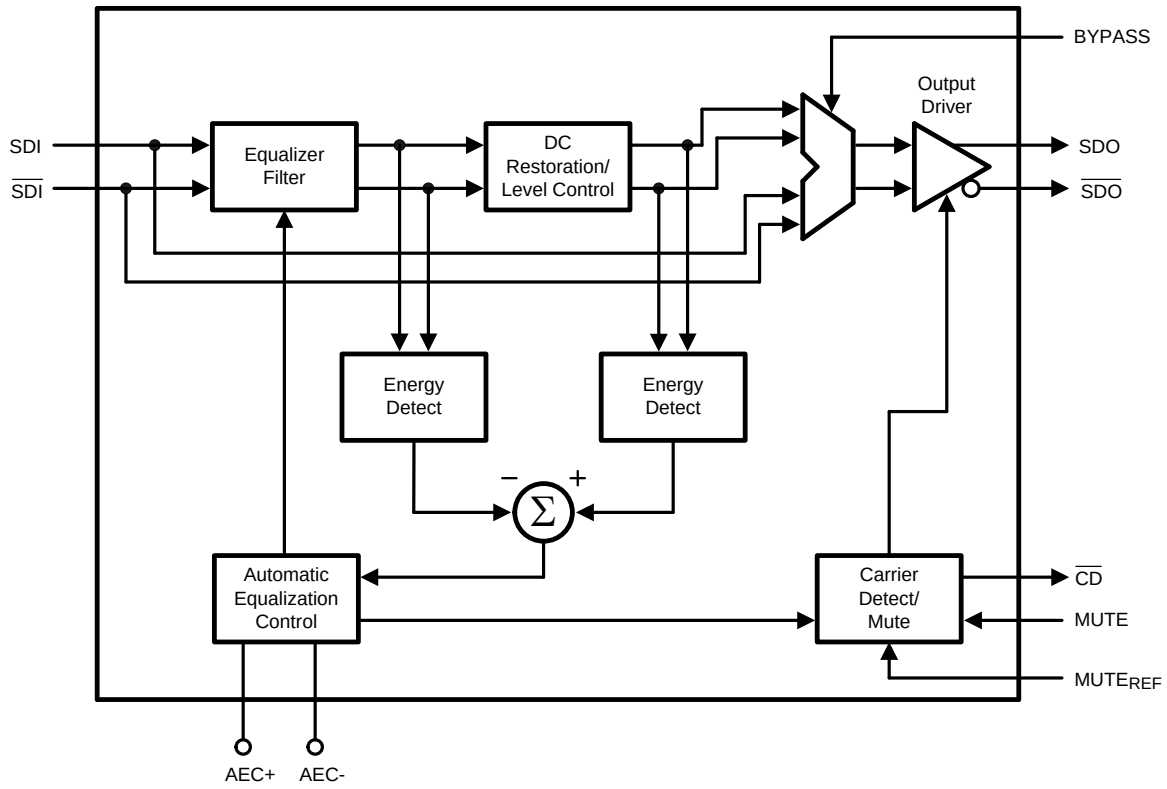
Figure 4. 25-Ball CS-BGA
See Package Number NYA

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PIN DESCRIPTIONS

WQFN Pin	CS-BGA Ball	Name	Description
2	C1	SDI	Serial data true input.
3	D1	$\overline{SDI}$	Serial data complement input.
5	E2	AEC+	AEC loop filter external capacitor (1µF) positive connection.
6	E3	AEC-	AEC loop filter external capacitor (1µF) negative connection.
7	D3	BYPASS	Bypasses equalization and DC restoration when high. No equalization occurs in this mode.
8	E4	$MUTE_{REF}$	Mute reference. Sets the threshold for $\overline{CD}$ and (with $\overline{CD}$ tied to MUTE) determines the maximum cable to be equalized before muting. $MUTE_{REF}$ may be either unconnected or connected to ground for maximum equalization.
10	D5	$\overline{SDO}$	Serial data complement output.
11	C5	SDO	Serial data true output.
14	B3	MUTE	Output mute. To disable the mute function and enable the output, MUTE must be tied to GND or a low level signal. To force the outputs to a muted state, tie to V_{CC}. $\overline{CD}$ may be tied to this pin to inhibit the output when no input signal is present. MUTE has no function in BYPASS mode.
15	A2	$\overline{CD}$	Carrier detect. $\overline{CD}$ is high when no signal is present. $\overline{CD}$ has no function in BYPASS mode.
13, 16	A1, A3, A4, B2	V_{CC}	Positive power supply (+3.3V).
DAP, 1, 4, 9, 12	B1, B4, D2, E5	V_{EE}	Negative power supply (ground).
—	A5, B5, C2, C3, C4, D4, E1	NC	No connect.

BLOCK DIAGRAM



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DEVICE OPERATION

BLOCK DESCRIPTION

The **Equalizer Filter** block is a multi-stage adaptive filter. If Bypass is high, the equalizer filter is disabled.

The **DC Restoration / Level Control** block receives the differential signals from the equalizer filter block. This block incorporates a self-biasing DC restoration circuit to fully DC restore the signals. If Bypass is high, this function is disabled.

The signals before and after the DC Restoration / Level Control block are used to generate the **Automatic Equalization Control (AEC)** signal. This control signal sets the gain and bandwidth of the equalizer filter. The loop response in the AEC block is controlled by an external 1µF capacitor placed across the AEC+ and AEC- pins.

The **Carrier Detect / Mute** block generates the carrier detect signal and controls the mute function of the output. This block utilizes the $\overline{\textbf{CD}}$ and **MUTE** signals along with **Mute Reference ($\textbf{MUTE}_{\textbf{REF}}$)**.

The **Output Driver** produces SDO and $\overline{\text{SDO}}$.

MUTE REFERENCE (MUTE_{REF})

The mute reference sets the threshold for $\overline{\text{CD}}$ and (with $\overline{\text{CD}}$ tied to MUTE) determines the amount of cable to equalize before automatically muting the outputs. This is set by applying a voltage inversely proportional to the length of cable to equalize. The applied voltage must be greater than the MUTE_{REF} floating voltage (typically 1.3V) in order to change the $\overline{\text{CD}}$ threshold. As the applied MUTE_{REF} voltage is increased, the amount of cable that can be equalized before carrier detect is de-asserted and the outputs are muted is decreased. MUTE_{REF} may be left unconnected or connected to ground for maximum equalization before muting.

CARRIER DETECT ($\overline{\text{CD}}$) AND MUTE

Carrier detect $\overline{\text{CD}}$ indicates if a valid signal is present at the LMH0344 input. If MUTE_{REF} is used, the carrier detect threshold will be altered accordingly. $\overline{\text{CD}}$ provides a high voltage when no signal is present at the LMH0344 input. $\overline{\text{CD}}$ is low when a valid input signal is detected.

MUTE can be used to manually mute or enable SDO and $\overline{\text{SDO}}$. Applying a high input to MUTE will mute the LMH0344 outputs by forcing the output to a logic zero. Applying a low input will force the outputs to be active.

$\overline{\text{CD}}$ and MUTE may be tied together to automatically mute the output when no input signal is present.

INPUT INTERFACING

The LMH0344 accepts either differential or single-ended input. The input must be AC coupled. Transformer coupling is not supported.

The LMH0344 correctly handles equalizer pathological signals for standard definition and high definition serial digital video, as described in SMPTE RP 178 and RP 198, respectively.

OUTPUT INTERFACING

The SDO and $\overline{\text{SDO}}$ outputs are internally loaded with 50Ω. They produce a 750 $\text{mV}_{\text{P-P}}$ differential output, or a 375 $\text{mV}_{\text{P-P}}$ single-ended output.

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REVISION HISTORY

Changes from Revision K (April 2013) to Revision L	Page
• Changed layout of National Data Sheet to TI format	7

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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
LMH0344GR/NOPB	ACTIVE	csBGA	NYA	25	1000	Green (RoHS & no Sb/Br)	CU SNAGCU	Level-1-260C-UNLIM	-40 to 85	344G	Samples
LMH0344GRE/NOPB	ACTIVE	csBGA	NYA	25	250	Green (RoHS & no Sb/Br)	CU SNAGCU	Level-1-260C-UNLIM	-40 to 85	344G	Samples
LMH0344GRX/NOPB	ACTIVE	csBGA	NYA	25	3500	Green (RoHS & no Sb/Br)	CU SNAGCU	Level-1-260C-UNLIM	-40 to 85	344G	Samples
LMH0344SQ/NOPB	ACTIVE	WQFN	RUM	16	1000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	L0344	Samples
LMH0344SQE/NOPB	ACTIVE	WQFN	RUM	16	250	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	L0344	Samples
LMH0344SQX/NOPB	ACTIVE	WQFN	RUM	16	4500	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 85	L0344	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.

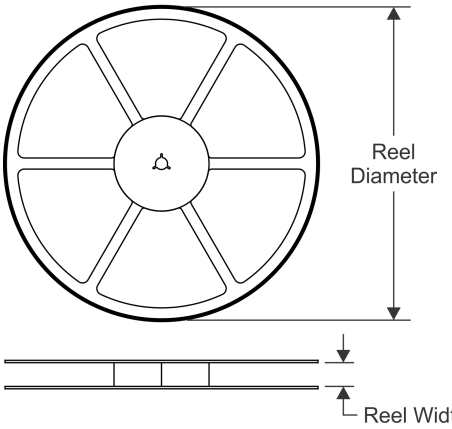
(4) Multiple Top-Side Markings will be inside parentheses. Only one Top-Side Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Top-Side Marking for that device.

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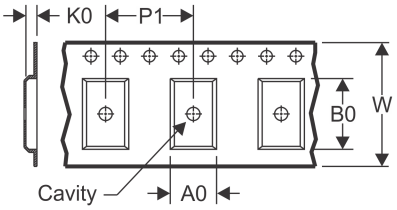
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TAPE AND REEL INFORMATION

REEL DIMENSIONS

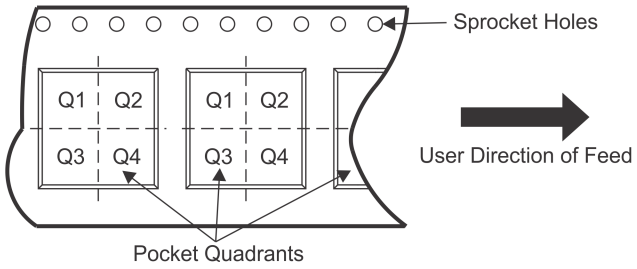


TAPE DIMENSIONS



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

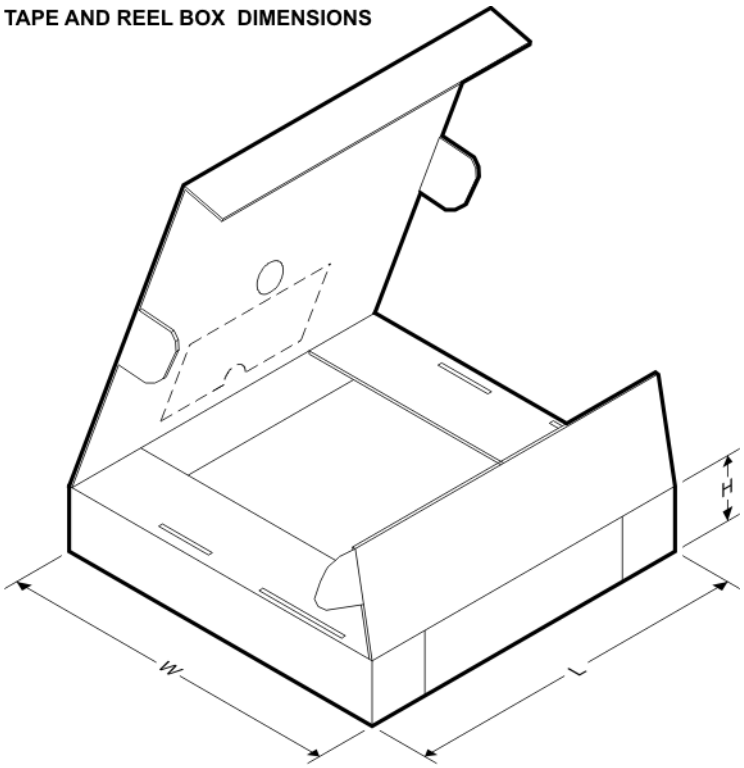
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
LMH0344GR/NOPB	csBGA	NYA	25	1000	178.0	12.4	3.3	3.3	1.6	8.0	12.0	Q1
LMH0344GRE/NOPB	csBGA	NYA	25	250	178.0	12.4	3.3	3.3	1.6	8.0	12.0	Q1
LMH0344GRX/NOPB	csBGA	NYA	25	3500	330.0	12.4	3.3	3.3	1.6	8.0	12.0	Q1
LMH0344SQ/NOPB	WQFN	RUM	16	1000	178.0	12.4	4.3	4.3	1.3	8.0	12.0	Q1
LMH0344SQE/NOPB	WQFN	RUM	16	250	178.0	12.4	4.3	4.3	1.3	8.0	12.0	Q1
LMH0344SQX/NOPB	WQFN	RUM	16	4500	330.0	12.4	4.3	4.3	1.3	8.0	12.0	Q1

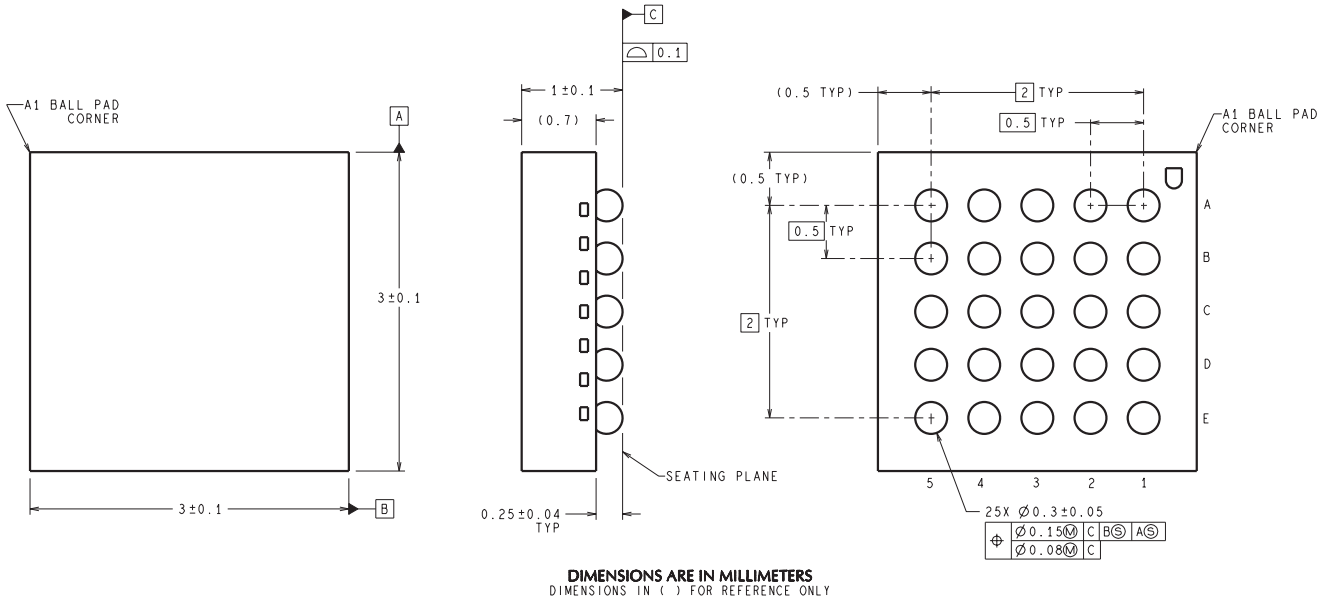
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LMH0344GR/NOPB	csBGA	NYA	25	1000	210.0	185.0	35.0
LMH0344GRE/NOPB	csBGA	NYA	25	250	210.0	185.0	35.0
LMH0344GRX/NOPB	csBGA	NYA	25	3500	367.0	367.0	35.0
LMH0344SQ/NOPB	WQFN	RUM	16	1000	210.0	185.0	35.0
LMH0344SQE/NOPB	WQFN	RUM	16	250	210.0	185.0	35.0
LMH0344SQX/NOPB	WQFN	RUM	16	4500	367.0	367.0	35.0

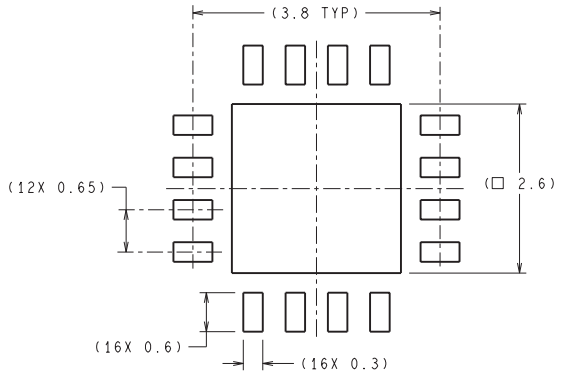
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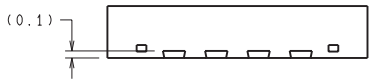
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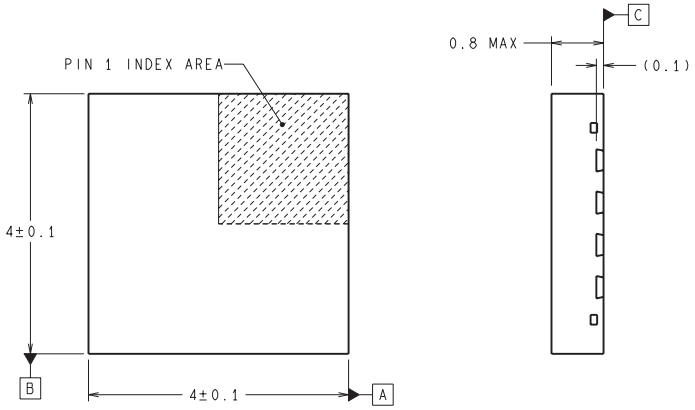
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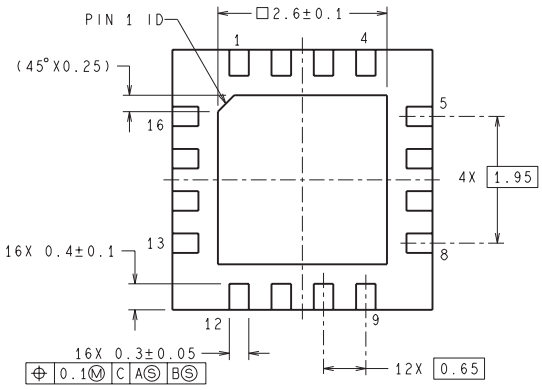


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