DS90LT012AH High Temperature 3V LVDS Differential Line Receiver

Check for Samples: DS90LT012AH

FEATURES

- **-40 to +125°C temperature range operation**
- **Compatible with ANSI TIA/EIA-644-A Standard**
- **>400 Mbps (200 MHz) switching rates**
- **100 ps differential skew (typical)**
- **3.5 ns maximum propagation delay**
- **Integrated line termination resistor (100Ω typical)**
- **Single 3.3V power supply design (2.7V to 3.6V range)**
- **Power down high impedance on LVDS inputs**
- **LVDS inputs accept LVDS/CML/LVPECL signals**
- **Pinout simplifies PCB layout**
- **Low Power Dissipation (10mW typical@ 3.3V static)**
- **SOT-23 5-lead package**

DESCRIPTION

The DS90LT012AH is a single CMOS differential line receiver designed for applications requiring ultra low power dissipation, low noise, and high data rates. The devices are designed to support data rates in excess of 400 Mbps (200 MHz) utilizing Low Voltage Differential Swing (LVDS) technology

The DS90LT012AH accepts low voltage (350 mV typical) differential input signals and translates them to 3V CMOS output levels. The DS90LT012AH includes an input line termination resistor for point-to-point applications.

The DS90LT012AH and companion LVDS line driver DS90LV011AH provide a new alternative to high power PECL/ECL devices for high speed interface applications.

Connection Diagram

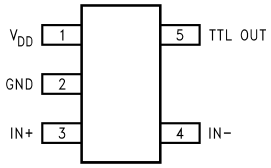


Figure 1. Top View
See Package Number DBV (R-PDSO-G5)

Functional Diagram

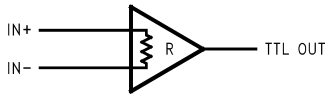


Figure 2. DS90LT012AH

Truth Table

INPUTS	OUTPUT
[IN+] − [IN−]	**TTL OUT**
$V_{ID} \geq 0V$	H
$V_{ID} \leq -0.1V$	L
Full Fail-safe OPEN/SHORT or Terminated	H

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 (V_{DD})	−0.3V to +4V
Input Voltage (IN+, IN−)	−0.3V to +3.9V
Output Voltage (TTL OUT)	−0.3V to (V_{DD} + 0.3V)
Output Short Circuit Current	−100mA
Maximum Package Power Dissipation @ +25°C	
DBV Package	902mW
Derate DBV Package	7.22 mW/°C above +25°C
Thermal resistance (θ_{JA})	138.5°C/W
Storage Temperature Range	−65°C to +150°C
Lead Temperature Range Soldering	
(4 sec.)	+260°C
Maximum Junction Temperature	+150°C
ESD Ratings (2)	

(1) "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. They are not meant to imply that the devices should be operated at these limits. Electrical Characteristics specifies conditions of device operation.

(2) ESD Ratings:
DS90LT012AH:
(a) HBM (1.5 kΩ, 100 pF) ≥ 2kV
(b) EIAJ (0Ω, 200 pF) ≥ 700V
(c) CDM ≥ 2000V
(d) IEC direct (330Ω, 150 pF) ≥ 7kV

Recommended Operating Conditions

	Min	Typ	Max	Units
Supply Voltage (V_{DD})	+2.7	+3.3	+3.6	V
Operating Free Air				
Temperature (T_A)	−40	25	+125	°C

Electrical Characteristics

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

Symbol	Parameter	Conditions		Pin	Min	Typ	Max	Units
V_{TH}	Differential Input High Threshold	V_{CM} dependant on V_{DD} (3)		IN+, IN−		−30	0	mV
V_{TL}	Differential Input Low Threshold				−100	−30		mV
V_{CM}	Common-Mode Voltage	V_{DD} = 2.7V, V_{ID} = 100mV			0.05		2.35	V
		V_{DD} = 3.0V to 3.6V, V_{ID} = 100mV			0.05		V_{DD} - 0.3V	V
		T_A = 125°C			0.10		2.35	V
I_{IN}	Input Current (DS90LV012A)	V_{IN} = +2.8V	V_{DD} = 3.6V or 0V		−10	±1	+10	µA
		V_{IN} = 0V			−10	±1	+10	µA
		V_{IN} = +3.6V	V_{DD} = 0V		−20		+20	µA
ΔI_{IN}	Change in Magnitude of I_{IN}	V_{IN} = +2.8V	V_{DD} = 3.6V or 0V			4		µA
		V_{IN} = 0V				4		µA
		V_{IN} = +3.6V	V_{DD} = 0V			4		µA
I_{IND}	Differential Input Current	V_{IN+} = +0.4V, V_{IN-} = +0V			3	3.9	4.4	mA
		V_{IN+} = +2.4V, V_{IN-} = +2.0V						
R_T	Integrated Termination Resistor					100		Ω
C_{IN}	Input Capacitance	IN+ = IN− = GND				3		pF
V_{OH}	Output High Voltage	I_{OH} = −0.4 mA, V_{ID} = +200 mV		TTL OUT	2.4	3.1		V
		I_{OH} = −0.4 mA, Inputs terminated			2.4	3.1		V
		I_{OH} = −0.4 mA, Inputs shorted			2.4	3.1		V
V_{OL}	Output Low Voltage	I_{OL} = 2 mA, V_{ID} = −200 mV				0.3	0.5	V
I_{OS}	Output Short Circuit Current	V_{OUT} = 0V (4)			−15	−50	−100	mA
V_{CL}	Input Clamp Voltage	I_{CL} = −18 mA			−1.5	−0.7		V
I_{DD}	No Load Supply Current	Inputs Open		V_{DD}		5.4	9	mA

(1) Current into device pins is defined as positive. Current out of device pins is defined as negative. All voltages are referenced to ground unless otherwise specified (such as V_{ID}).
(2) All typicals are given for: V_{DD} = +3.3V and T_A = +25°C.
(3) V_{DD} is always higher than IN+ and IN− voltage. IN+ and IN− are allowed to have voltage range −0.05V to +2.35V when V_{DD} = 2.7V and $|V_{ID}|$ / 2 to V_{DD} − 0.3V when V_{DD} = 3.0V to 3.6V. V_{ID} is not allowed to be greater than 100 mV when V_{CM} = 0.05V to 2.35V when V_{DD} = 2.7V or when V_{CM} = $|V_{ID}|$ / 2 to V_{DD} − 0.3V when V_{DD} = 3.0V to 3.6V.
(4) Output short circuit current (I_{OS}) is specified as magnitude only, minus sign indicates direction only. Only one output should be shorted at a time, do not exceed maximum junction temperature specification.

Switching Characteristics

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

Symbol	Parameter	Conditions	Min	Typ	Max	Units
t_{PHLD}	Differential Propagation Delay High to Low	C_L = 15 pF V_{ID} = 200 mV (Figure 3 and Figure 4)	1.0	1.8	3.5	ns
t_{PLHD}	Differential Propagation Delay Low to High		1.0	1.7	3.5	ns
t_{SKD1}	Differential Pulse Skew $\|t_{PHLD} - t_{PLHD}\|$ (3)		0	100	400	ps
t_{SKD3}	Differential Part to Part Skew (4)		0	0.3	1.0	ns
t_{SKD4}	Differential Part to Part Skew (5)		0	0.4	1.5	ns
t_{TLH}	Rise Time			350	800	ps
t_{THL}	Fall Time			175	800	ps
f_{MAX}	Maximum Operating Frequency (6)		200	250		MHz

(1) C_L includes probe and jig capacitance.
(2) Generator waveform for all tests unless otherwise specified: f = 1 MHz, Z_O = 50Ω, t_r and t_f (0% to 100%) ≤ 3 ns for IN±.
(3) t_{SKD1} is the magnitude difference in differential propagation delay time between the positive-going-edge and the negative-going-edge of the same channel.
(4) t_{SKD3}, part to part skew, is the differential channel-to-channel skew of any event between devices. This specification applies to devices at the same V_{DD} and within 5°C of each other within the operating temperature range.
(5) t_{SKD4}, part to part skew, is the differential channel-to-channel skew of any event between devices. This specification applies to devices over the recommended operating temperature and voltage ranges, and across process distribution. t_{SKD4} is defined as |Max − Min| differential propagation delay.
(6) f_{MAX} generator input conditions: $t_r = t_f < 1$ ns (0% to 100%), 50% duty cycle, differential (1.05V to 1.35 peak to peak). Output criteria: 60%/40% duty cycle, V_{OL} (max 0.4V), V_{OH} (min 2.4V), load = 15 pF (stray plus probes). The parameter is guaranteed by design. The limit is based on the statistical analysis of the device over the PVT range by the transition times (t_{TLH} and t_{THL}).

PARAMETER MEASUREMENT INFORMATION

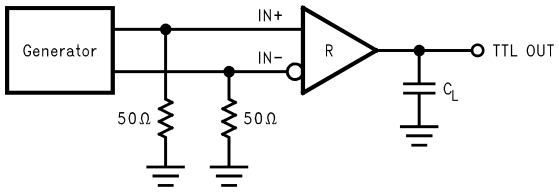


Figure 3. Receiver Propagation Delay and Transition Time Test Circuit

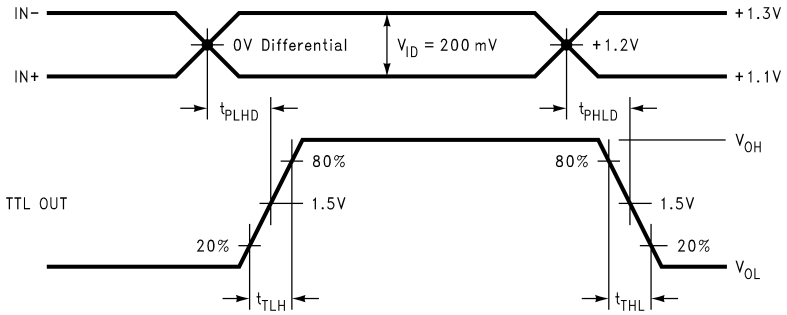


Figure 4. Receiver Propagation Delay and Transition Time Waveforms

TYPICAL APPLICATIONS

Balanced System

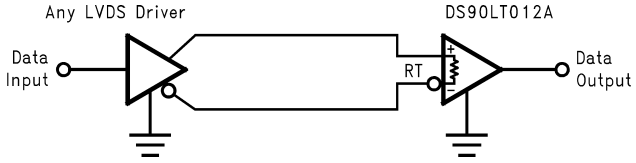


Figure 5. Point-to-Point Application (DS90LT012AH)

APPLICATION INFORMATION

General application guidelines and hints for LVDS drivers and receivers may be found in the following application notes: LVDS Owner's Manual (lit #550062-003), AN-808, AN-977, AN-971, AN-916, AN-805, AN-903.

LVDS drivers and receivers are intended to be primarily used in an uncomplicated point-to-point configuration as is shown in Figure 5. This configuration provides a clean signaling environment for the fast edge rates of the drivers. The receiver is connected to the driver through a balanced media which may be a standard twisted pair cable, a parallel pair cable, or simply PCB traces. Typically the characteristic impedance of the media is in the range of 100Ω. The internal termination resistor converts the driver output (current mode) into a voltage that is detected by the receiver. Other configurations are possible such as a multi-receiver configuration, but the effects of a mid-stream connector(s), cable stub(s), and other impedance discontinuities as well as ground shifting, noise margin limits, and total termination loading must be taken into account.

The DS90LT012AH differential line receiver is capable of detecting signals as low as 100 mV, over a ±1V common-mode range centered around +1.2V. This is related to the driver offset voltage which is typically +1.2V. The driven signal is centered around this voltage and may shift ±1V around this center point. The ±1V shifting may be the result of a ground potential difference between the driver's ground reference and the receiver's ground reference, the common-mode effects of coupled noise, or a combination of the two. The AC parameters of both receiver input pins are optimized for a recommended operating input voltage range of 0V to +2.4V (measured from each pin to ground). The device will operate for receiver input voltages up to V_{DD}, but exceeding V_{DD} will turn on the ESD protection circuitry which will clamp the bus voltages.

POWER DECOUPLING RECOMMENDATIONS

Bypass capacitors must be used on power pins. Use high frequency ceramic (surface mount is recommended) 0.1µF and 0.001µF capacitors in parallel at the power supply pin with the smallest value capacitor closest to the device supply pin. Additional scattered capacitors over the printed circuit board will improve decoupling. Multiple vias should be used to connect the decoupling capacitors to the power planes. A 10µF (35V) or greater solid tantalum capacitor should be connected at the power entry point on the printed circuit board between the supply and ground.

PC BOARD CONSIDERATIONS

Use at least 4 PCB board layers (top to bottom): LVDS signals, ground, power, TTL signals.

Isolate TTL signals from LVDS signals, otherwise the TTL signals may couple onto the LVDS lines. It is best to put TTL and LVDS signals on different layers which are isolated by a power/ground plane(s).

Keep drivers and receivers as close to the (LVDS port side) connectors as possible.

DIFFERENTIAL TRACES

Use controlled impedance traces which match the differential impedance of your transmission medium (ie. cable) and termination resistor. Run the differential pair trace lines as close together as possible as soon as they leave the IC (stubs should be < 10mm long). This will help eliminate reflections and ensure noise is coupled as common-mode. In fact, we have seen that differential signals which are 1mm apart radiate far less noise than traces 3mm apart since magnetic field cancellation is much better with the closer traces. In addition, noise induced on the differential lines is much more likely to appear as common-mode which is rejected by the receiver.

Match electrical lengths between traces to reduce skew. Skew between the signals of a pair means a phase difference between signals which destroys the magnetic field cancellation benefits of differential signals and EMI will result! (Note that the velocity of propagation, $v = c/E_r$ where c (the speed of light) = 0.2997mm/ps or 0.0118 in/ps). Do not rely solely on the autoroute function for differential traces. Carefully review dimensions to match differential impedance and provide isolation for the differential lines. Minimize the number of vias and other discontinuities on the line.

Avoid 90° turns (these cause impedance discontinuities). Use arcs or 45° bevels.

Within a pair of traces, the distance between the two traces should be minimized to maintain common-mode rejection of the receivers. On the printed circuit board, this distance should remain constant to avoid discontinuities in differential impedance. Minor violations at connection points are allowable.

TERMINATION

The DS90LT012AH integrates the terminating resistor for point-to-point applications. The resistor value will be between 90Ω and 133Ω.

THRESHOLD

The LVDS Standard (ANSI/TIA/EIA-644-A) specifies a maximum threshold of ±100mV for the LVDS receiver. The DS90LV012A and DS90LT012A support an enhanced threshold region of −100mV to 0V. This is useful for fail-safe biasing. The threshold region is shown in the Voltage Transfer Curve (VTC) in Figure 6. The typical DS90LT012AH LVDS receiver switches at about −30mV. Note that with V_{ID} = 0V, the output will be in a HIGH state. With an external fail-safe bias of +25mV applied, the typical differential noise margin is now the difference from the switch point to the bias point. In the example below, this would be 55mV of Differential Noise Margin (+25mV − (−30mV)). With the enhanced threshold region of −100mV to 0V, this small external fail-safe biasing of +25mV (with respect to 0V) gives a DNM of a comfortable 55mV. With the standard threshold region of ±100mV, the external fail-safe biasing would need to be +25mV with respect to +100mV or +125mV, giving a DNM of 155mV which is stronger fail-safe biasing than is necessary for the DS90LT012AH. If more DNM is required, then a stronger fail-safe bias point can be set by changing resistor values.

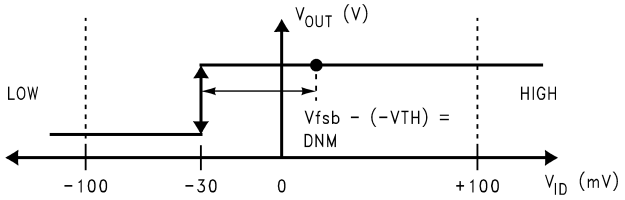


Figure 6. VTC of the DS90LT012AH LVDS Receiver

FAIL SAFE BIASING

External pull up and pull down resistors may be used to provide enough of an offset to enable an input failsafe under open-circuit conditions. This configuration ties the positive LVDS input pin to VDD thru a pull up resistor and the negative LVDS input pin is tied to GND by a pull down resistor. The pull up and pull down resistors should be in the 5kΩ to 15kΩ range to minimize loading and waveform distortion to the driver. The common-mode bias point ideally should be set to approximately 1.2V (less than 1.75V) to be compatible with the internal circuitry. Please refer to application note AN-1194, “Failsafe Biasing of LVDS Interfaces” for more information.

PROBING LVDS TRANSMISSION LINES

Always use high impedance (> 100kΩ), low capacitance (< 2 pF) scope probes with a wide bandwidth (1 GHz) scope. Improper probing will give deceiving results.

CABLES AND CONNECTORS, GENERAL COMMENTS

When choosing cable and connectors for LVDS it is important to remember:

Use controlled impedance media. The cables and connectors you use should have a matched differential impedance of about 100Ω. They should not introduce major impedance discontinuities.

Balanced cables (e.g. twisted pair) are usually better than unbalanced cables (ribbon cable, simple coax) for noise reduction and signal quality. Balanced cables tend to generate less EMI due to field canceling effects and also tend to pick up electromagnetic radiation a common-mode (not differential mode) noise which is rejected by the receiver.

For cable distances < 0.5M, most cables can be made to work effectively. For distances 0.5M ≤ d ≤ 10M, CAT 3 (category 3) twisted pair cable works well, is readily available and relatively inexpensive.

Pin Descriptions

Package Pin Number SOT-23	Pin Name	Description
4	IN−	Inverting receiver input pin
3	IN+	Non-inverting receiver input pin
5	TTL OUT	Receiver output pin
1	V_{DD}	Power supply pin, +3.3V ± 0.3V
2	GND	Ground pin
	NC	No connect

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
DS90LT012AHMF	NRND	SOT-23	DBV	5	1000	TBD	Call TI	Call TI		N05	
DS90LT012AHMF/NOPB	NRND	SOT-23	DBV	5	1000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM		N05	
DS90LT012AHMFX	NRND	SOT-23	DBV	5	3000	TBD	Call TI	Call TI		N05	
DS90LT012AHMFX/NOPB	NRND	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM		N05	

(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.

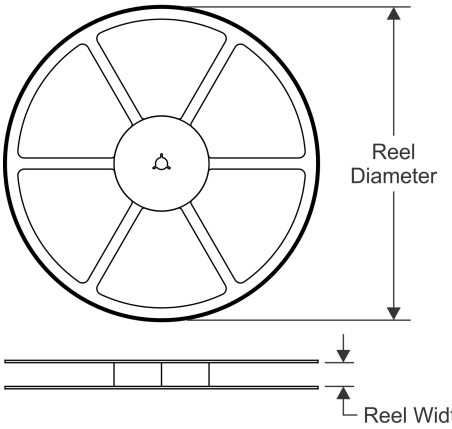
(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been 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.

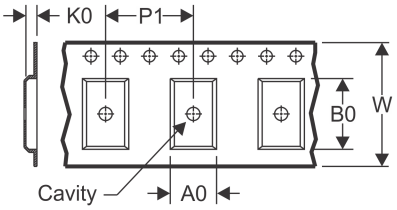
(4) Only one of markings shown within the brackets will appear on the physical device.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

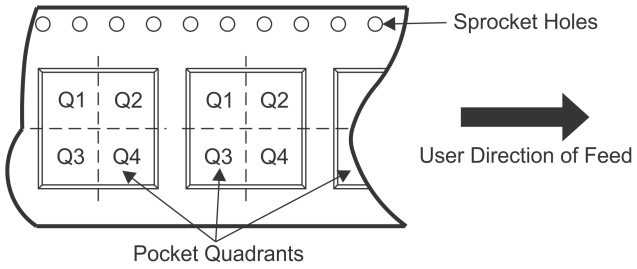


TAPE DIMENSIONS



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

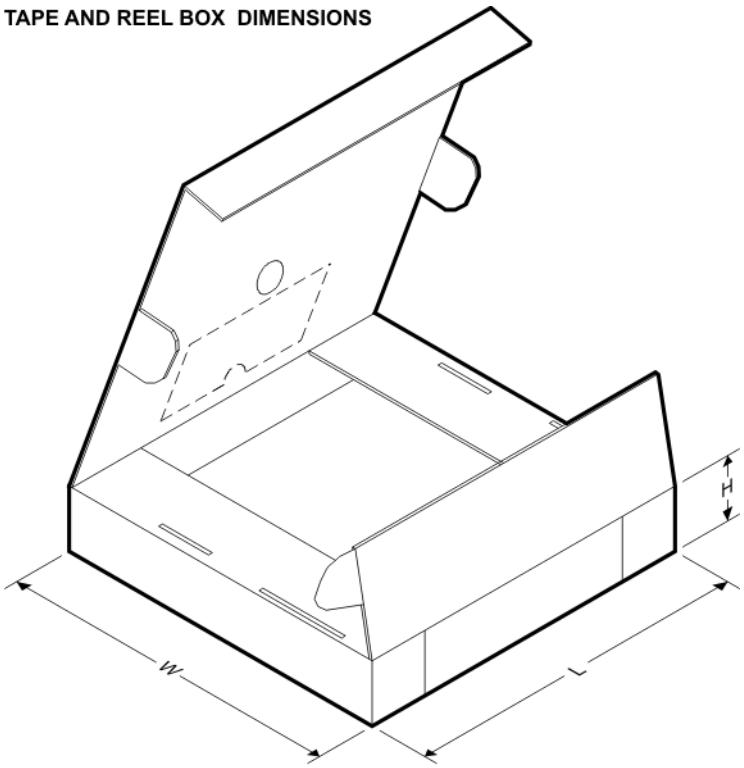
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
DS90LT012AHMF	SOT-23	DBV	5	1000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
DS90LT012AHMF/NOPB	SOT-23	DBV	5	1000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
DS90LT012AHMFX	SOT-23	DBV	5	3000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
DS90LT012AHMFX/NOPB	SOT-23	DBV	5	3000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3

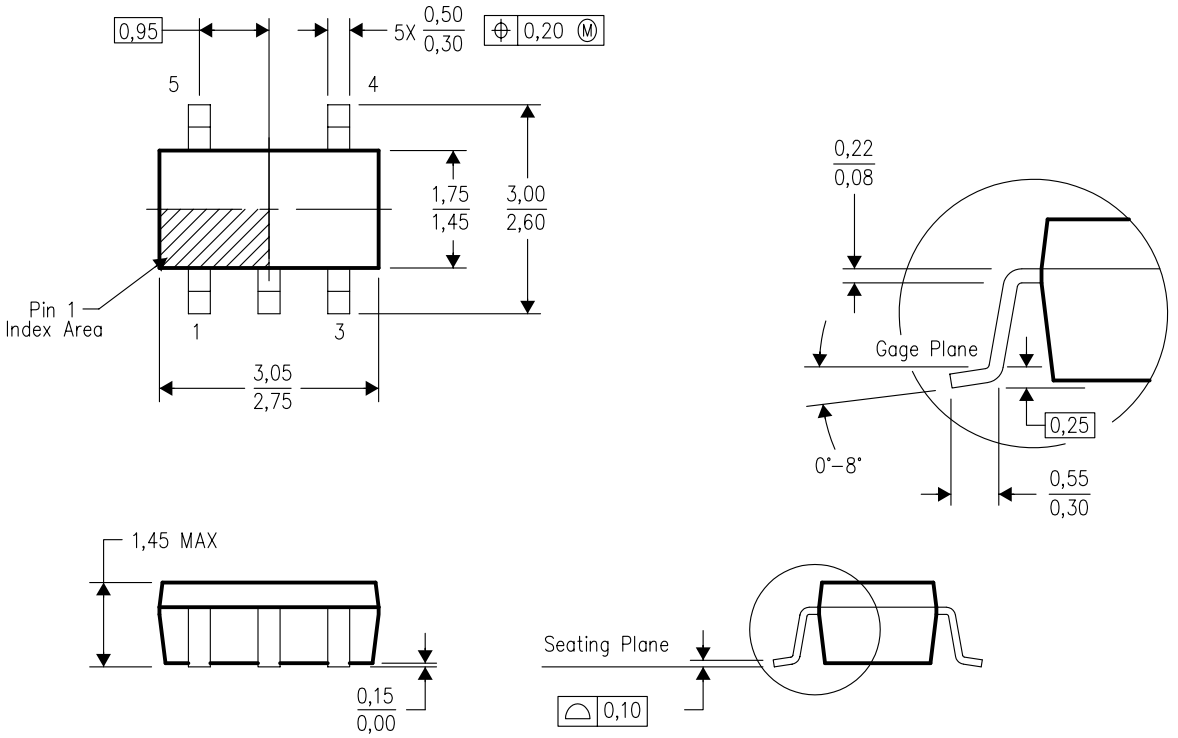
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
DS90LT012AHMF	SOT-23	DBV	5	1000	210.0	185.0	35.0
DS90LT012AHMF/NOPB	SOT-23	DBV	5	1000	210.0	185.0	35.0
DS90LT012AHMFX	SOT-23	DBV	5	3000	210.0	185.0	35.0
DS90LT012AHMFX/NOPB	SOT-23	DBV	5	3000	206.0	191.0	90.0

DBV (R–PDSO–G5) PLASTIC SMALL–OUTLINE PACKAGE



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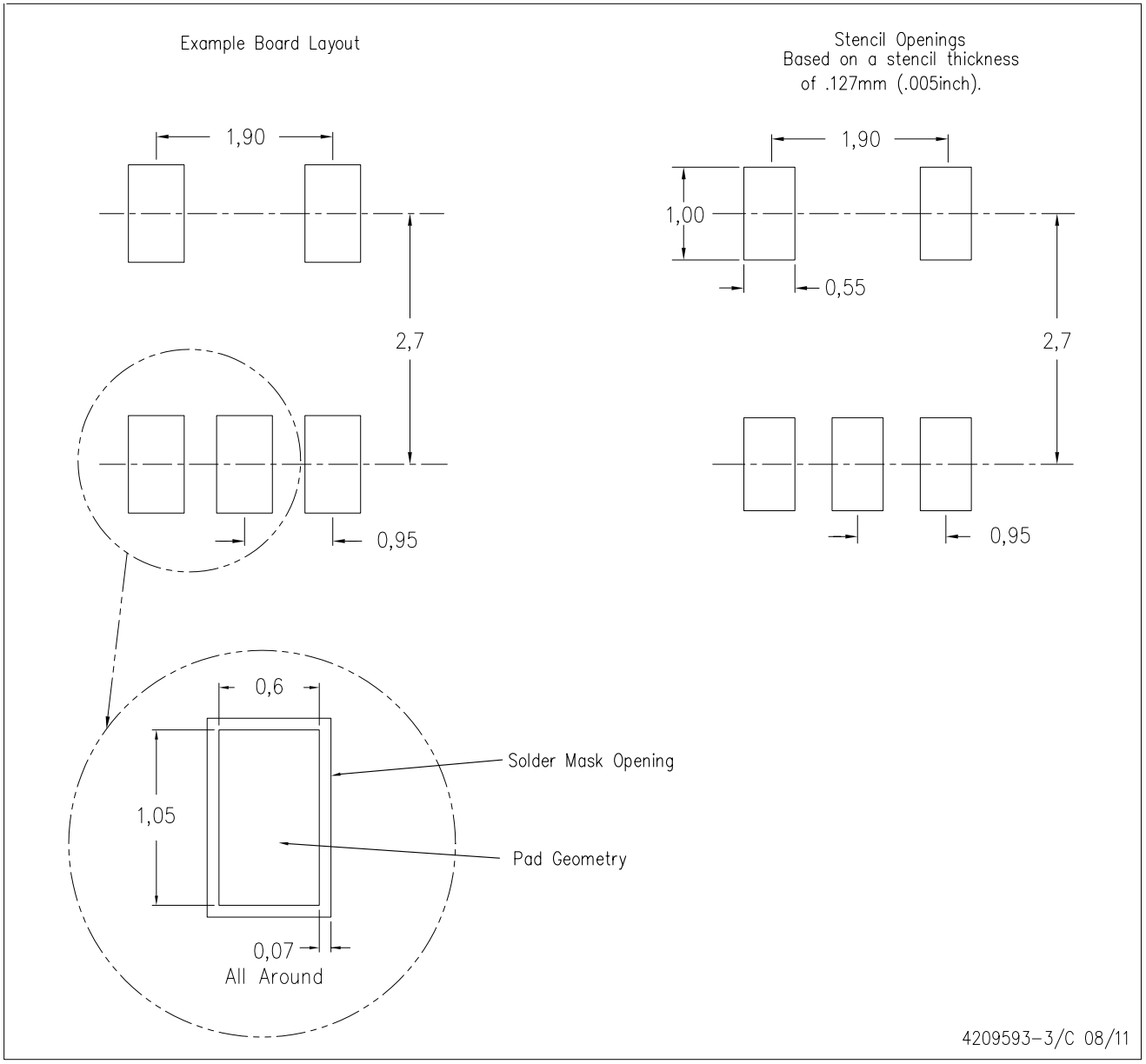
NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
D. Falls within JEDEC MO–178 Variation AA.

DBV (R–PDSO–G5) PLASTIC SMALL OUTLINE



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
D. Publication IPC–7351 is recommended for alternate designs.
E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC–7525 for other stencil recommendations.

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