

## 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

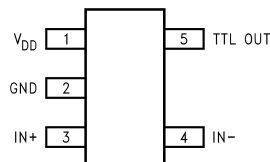
### DESCRIPTION

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.

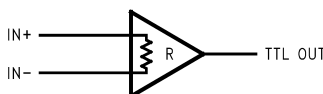
The DS90LT012AH and companion LVDS line driver DS90LV011AH provide a new alternative to high power PECL/ECL devices for high speed interface applications.

### 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



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

All trademarks are the property of their respective owners.



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 <sup>(1)</sup>

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 ( $\theta_{JA}$ )	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 <sup>(2)</sup>	

(1) "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be verified. 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 k $\Omega$ , 100 pF)  $\geq$  2kV  
 (b) EIAJ (0 $\Omega$ , 200 pF)  $\geq$  700V  
 (c) CDM  $\geq$  2000V  
 (d) IEC direct (330 $\Omega$ , 150 pF)  $\geq$  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. <sup>(1)</sup> <sup>(2)</sup>

Symbol	Parameter	Conditions		Pin	Min	Typ	Max	Units
V <sub>TH</sub>	Differential Input High Threshold	V <sub>CM</sub> dependant on V <sub>DD</sub> <sup>(3)</sup>		IN+, IN–		–30	0	mV
V <sub>TL</sub>	Differential Input Low Threshold				–100	–30		mV
V <sub>CM</sub>	Common-Mode Voltage				0.05		2.35	V
		0.05			V <sub>DD</sub> - 0.3V	V		
		0.10			2.35	V		
I <sub>IN</sub>	Input Current (DS90LV012A)	V <sub>IN</sub> = +2.8V	V <sub>DD</sub> = 3.6V or 0V		–10	±1	+10	µA
		V <sub>IN</sub> = 0V			–10	±1	+10	µA
		V <sub>IN</sub> = +3.6V	V <sub>DD</sub> = 0V		–20		+20	µA
ΔI <sub>IN</sub>	Change in Magnitude of I <sub>IN</sub>	V <sub>IN</sub> = +2.8V	V <sub>DD</sub> = 3.6V or 0V			4		µA
		V <sub>IN</sub> = 0V				4		µA
		V <sub>IN</sub> = +3.6V	V <sub>DD</sub> = 0V			4		µA
I <sub>IND</sub>	Differential Input Current	V <sub>IN+</sub> = +0.4V, V <sub>IN–</sub> = +0V		TTL OUT	3	3.9	4.4	mA
		V <sub>IN+</sub> = +2.4V, V <sub>IN–</sub> = +2.0V						
R <sub>T</sub>	Integrated Termination Resistor					100		Ω
C <sub>IN</sub>	Input Capacitance	IN+ = IN– = GND				3		pF
V <sub>OH</sub>	Output High Voltage	I <sub>OH</sub> = –0.4 mA, V <sub>ID</sub> = +200 mV			2.4	3.1		V
		I <sub>OH</sub> = –0.4 mA, Inputs terminated			2.4	3.1		V
		I <sub>OH</sub> = –0.4 mA, Inputs shorted			2.4	3.1		V
V <sub>OL</sub>	Output Low Voltage	I <sub>OL</sub> = 2 mA, V <sub>ID</sub> = –200 mV				0.3	0.5	V
I <sub>OS</sub>	Output Short Circuit Current	V <sub>OUT</sub> = 0V <sup>(4)</sup>			–15	–50	–100	mA
V <sub>CL</sub>	Input Clamp Voltage	I <sub>CL</sub> = –18 mA			–1.5	–0.7		V
I <sub>DD</sub>	No Load Supply Current	Inputs Open		V <sub>DD</sub>		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<sub>ID</sub>).
- (2) All typicals are given for: V<sub>DD</sub> = +3.3V and T<sub>A</sub> = +25°C.
- (3) V<sub>DD</sub> is always higher than IN+ and IN– voltage. IN+ and IN– are allowed to have voltage range –0.05V to +2.35V when V<sub>DD</sub> = 2.7V and |V<sub>ID</sub>| / 2 to V<sub>DD</sub> – 0.3V when V<sub>DD</sub> = 3.0V to 3.6V. V<sub>ID</sub> is not allowed to be greater than 100 mV when V<sub>CM</sub> = 0.05V to 2.35V when V<sub>DD</sub> = 2.7V or when V<sub>CM</sub> = |V<sub>ID</sub>| / 2 to V<sub>DD</sub> – 0.3V when V<sub>DD</sub> = 3.0V to 3.6V.
- (4) Output short circuit current (I<sub>OS</sub>) 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. <sup>(1)</sup> <sup>(2)</sup>

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$t_{PHLD}$	Differential Propagation Delay High to Low	$C_L = 15 \text{ pF}$ $V_{ID} = 200 \text{ mV}$ (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} $ <sup>(3)</sup>		0	100	400	ps
$t_{SKD3}$	Differential Part to Part Skew <sup>(4)</sup>		0	0.3	1.0	ns
$t_{SKD4}$	Differential Part to Part Skew <sup>(5)</sup>		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 <sup>(6)</sup>		200	250		MHz

(1)  $C_L$  includes probe and jig capacitance.

(2) Generator waveform for all tests unless otherwise specified:  $f = 1 \text{ MHz}$ ,  $Z_O = 50\Omega$ ,  $t_r$  and  $t_f$  (0% to 100%)  $\leq 3 \text{ ns}$  for  $IN_{\pm}$ .

(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  $5^\circ\text{C}$  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:  $t_r = t_f < 1 \text{ ns}$  (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 specified 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

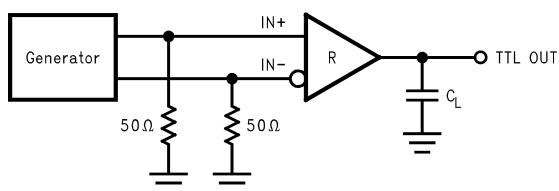


Figure 3. Receiver Propagation Delay and Transition Time Test Circuit

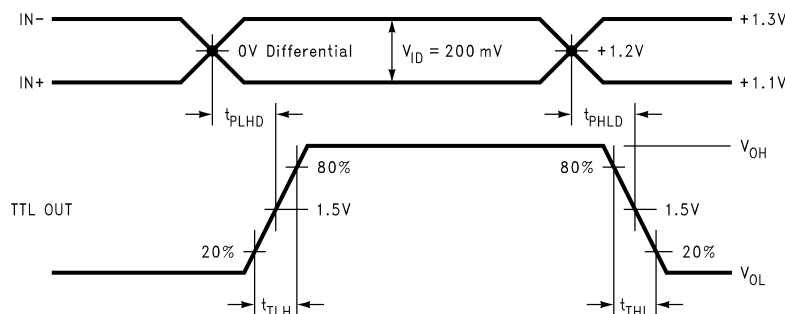


Figure 4. Receiver Propagation Delay and Transition Time Waveforms

## TYPICAL APPLICATIONS

### Balanced System

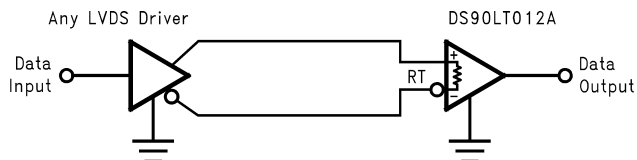


Figure 5. Point-to-Point Application (DS90LT012AH)

## APPLICATION INFORMATION

General application guidelines and hints for LVDS drivers and receivers may be found in the following application notes: LVDS Owner's Manual([SNLA187](#)), AN-808([SNLA028](#)), AN-977([SNLA166](#)), AN-971([SNLA165](#)), AN-916([SNLA219](#)), AN-805([SNOA233](#)), AN-903([SNLA034](#)).

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  $\pm 1V$  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  $\pm 1V$  around this center point. The  $\pm 1V$  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,  $v = c/E$ , 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.

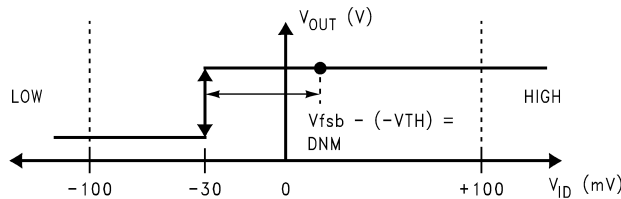
Within a pair of traces, the distance between the two traces should be minimized to maintain common-mode rejection of the receivers. On the printed circuit board, this distance should remain constant to avoid discontinuities in differential impedance. Minor violations at connection points are allowable.

## 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  $\pm 100\text{mV}$  for the LVDS receiver. The DS90LV012A and DS90LT012A support an enhanced threshold region of  $-100\text{mV}$  to  $0\text{V}$ . 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  $-30\text{mV}$ . Note that with  $V_{ID} = 0\text{V}$ , the output will be in a HIGH state. With an external fail-safe bias of  $+25\text{mV}$  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  $55\text{mV}$  of Differential Noise Margin ( $+25\text{mV} - (-30\text{mV})$ ). With the enhanced threshold region of  $-100\text{mV}$  to  $0\text{V}$ , this small external fail-safe biasing of  $+25\text{mV}$  (with respect to  $0\text{V}$ ) gives a DNM of a comfortable  $55\text{mV}$ . With the standard threshold region of  $\pm 100\text{mV}$ , the external fail-safe biasing would need to be  $+25\text{mV}$  with respect to  $+100\text{mV}$  or  $+125\text{mV}$ , giving a DNM of  $155\text{mV}$  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"(SNLA051) for more information.

## PROBING LVDS TRANSMISSION LINES

Always use high impedance ( $> 100\text{k}\Omega$ ), low capacitance ( $< 2\text{ pF}$ ) 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  $< 0.5\text{M}$ , most cables can be made to work effectively. For distances  $0.5\text{M} \leq d \leq 10\text{M}$ , CAT 3 (category 3) twisted pair cable works well, is readily available and relatively inexpensive.

**Pin Descriptions**

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



## REVISION HISTORY

### Changes from Original (April 2013) to Revision A

### Page

- Changed layout of National Data Sheet to TI format ..... [8](#)

## 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
DS90LT012AHMF	NRND	SOT-23	DBV	5	1000	TBD	Call TI	Call TI	-40 to 125	N05	
DS90LT012AHMF/NOPB	ACTIVE	SOT-23	DBV	5	1000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 125	N05	<a href="#">Samples</a>

(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.

**Important Information and Disclaimer:** The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

**TAPE AND REEL INFORMATION**


\*All dimensions are nominal

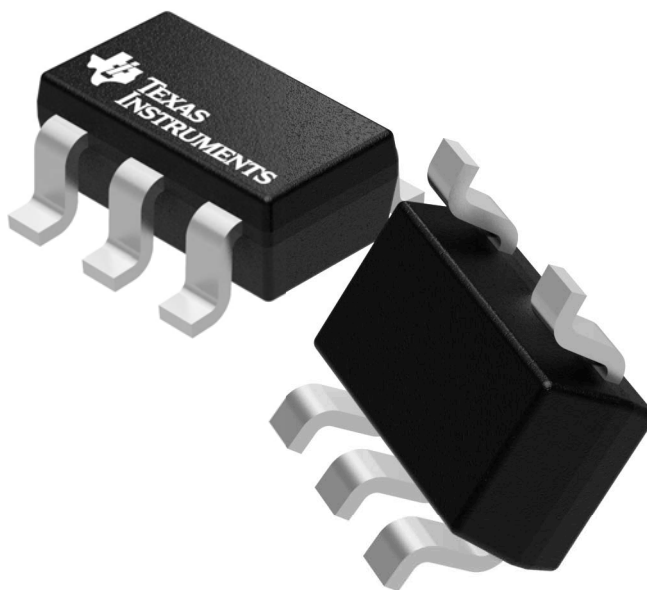
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
DS90LT012AHMF	SOT-23	DBV	5	1000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
DS90LT012AHMF/NOPB	SOT-23	DBV	5	1000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3

## 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



Images above are just a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.

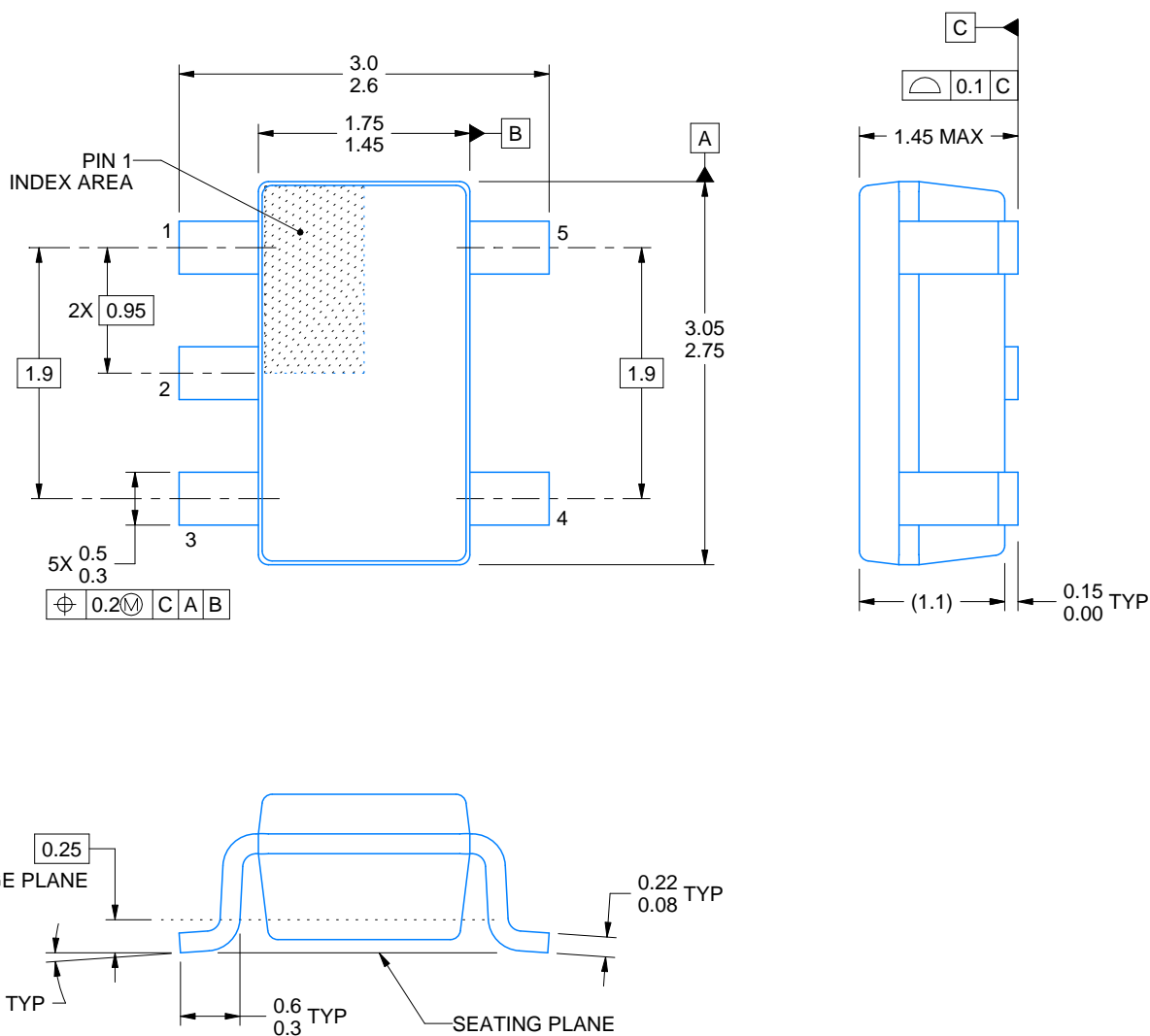


**DBV0005A**

# PACKAGE OUTLINE

**SOT-23 - 1.45 mm max height**

SMALL OUTLINE TRANSISTOR



4214839/C 04/2017

## NOTES:

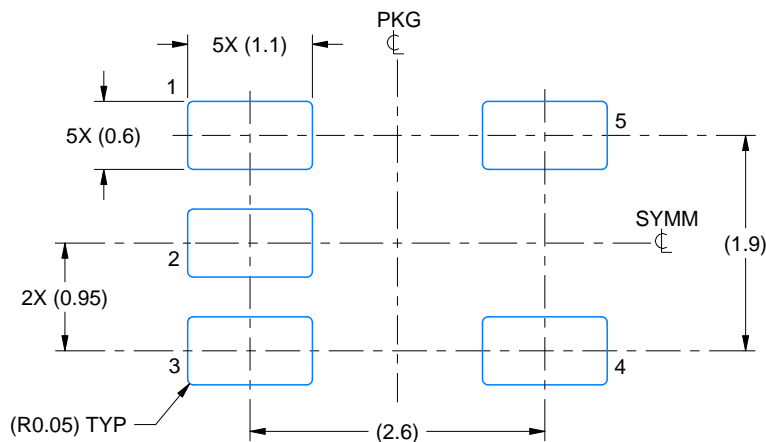
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Reference JEDEC MO-178.

# EXAMPLE BOARD LAYOUT

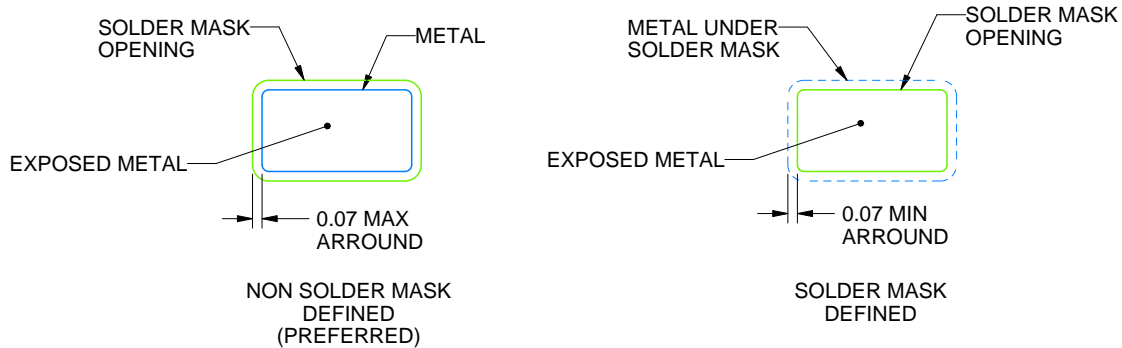
DBV0005A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:15X



SOLDER MASK DETAILS

4214839/C 04/2017

NOTES: (continued)

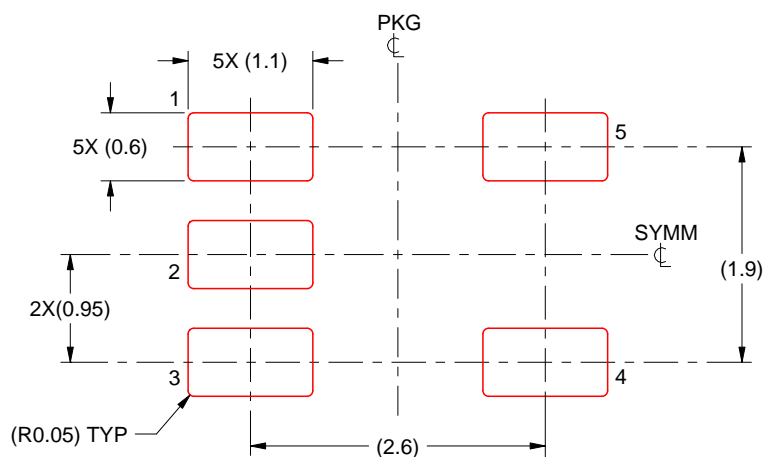
4. Publication IPC-7351 may have alternate designs.
5. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

## EXAMPLE STENCIL DESIGN

DBV0005A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE:15X

4214839/C 04/2017

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
7. Board assembly site may have different recommendations for stencil design.



## IMPORTANT NOTICE

Texas Instruments Incorporated (TI) reserves 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.

TI's published terms of sale for semiconductor products (<http://www.ti.com/sc/docs/stdterms.htm>) apply to the sale of packaged integrated circuit products that TI has qualified and released to market. Additional terms may apply to the use or sale of other types of TI products and services.

Reproduction of significant portions of TI information in TI 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 reproduced documentation. Information of third parties may be subject to additional restrictions. Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyers and others who are developing systems that incorporate TI products (collectively, "Designers") understand and agree that Designers remain responsible for using their independent analysis, evaluation and judgment in designing their applications and that Designers have full and exclusive responsibility to assure the safety of Designers' applications and compliance of their applications (and of all TI products used in or for Designers' applications) with all applicable regulations, laws and other applicable requirements. Designer represents that, with respect to their applications, Designer has all the necessary expertise to create and implement safeguards that (1) anticipate dangerous consequences of failures, (2) monitor failures and their consequences, and (3) lessen the likelihood of failures that might cause harm and take appropriate actions. Designer agrees that prior to using or distributing any applications that include TI products, Designer will thoroughly test such applications and the functionality of such TI products as used in such applications.

TI's provision of technical, application or other design advice, quality characterization, reliability data or other services or information, including, but not limited to, reference designs and materials relating to evaluation modules, (collectively, "TI Resources") are intended to assist designers who are developing applications that incorporate TI products; by downloading, accessing or using TI Resources in any way, Designer (individually or, if Designer is acting on behalf of a company, Designer's company) agrees to use any particular TI Resource solely for this purpose and subject to the terms of this Notice.

TI's provision of TI Resources does not expand or otherwise alter TI's applicable published warranties or warranty disclaimers for TI products, and no additional obligations or liabilities arise from TI providing such TI Resources. TI reserves the right to make corrections, enhancements, improvements and other changes to its TI Resources. TI has not conducted any testing other than that specifically described in the published documentation for a particular TI Resource.

Designer is authorized to use, copy and modify any individual TI Resource only in connection with the development of applications that include the TI product(s) identified in such TI Resource. NO OTHER LICENSE, EXPRESS OR IMPLIED, BY ESTOPPEL OR OTHERWISE TO ANY OTHER TI INTELLECTUAL PROPERTY RIGHT, AND NO LICENSE TO ANY TECHNOLOGY OR INTELLECTUAL PROPERTY RIGHT OF TI OR ANY THIRD PARTY IS GRANTED HEREIN, including but not limited to any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information regarding or referencing third-party products or services does not constitute a license to use such products or services, or a warranty or endorsement thereof. Use of TI Resources 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.

TI RESOURCES ARE PROVIDED "AS IS" AND WITH ALL FAULTS. TI DISCLAIMS ALL OTHER WARRANTIES OR REPRESENTATIONS, EXPRESS OR IMPLIED, REGARDING RESOURCES OR USE THEREOF, INCLUDING BUT NOT LIMITED TO ACCURACY OR COMPLETENESS, TITLE, ANY EPIDEMIC FAILURE WARRANTY AND ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS. TI SHALL NOT BE LIABLE FOR AND SHALL NOT DEFEND OR INDEMNIFY DESIGNER AGAINST ANY CLAIM, INCLUDING BUT NOT LIMITED TO ANY INFRINGEMENT CLAIM THAT RELATES TO OR IS BASED ON ANY COMBINATION OF PRODUCTS EVEN IF DESCRIBED IN TI RESOURCES OR OTHERWISE. IN NO EVENT SHALL TI BE LIABLE FOR ANY ACTUAL, DIRECT, SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF TI RESOURCES OR USE THEREOF, AND REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

Unless TI has explicitly designated an individual product as meeting the requirements of a particular industry standard (e.g., ISO/TS 16949 and ISO 26262), TI is not responsible for any failure to meet such industry standard requirements.

Where TI specifically promotes products as facilitating functional safety or as compliant with industry functional safety standards, such products are intended to help enable customers to design and create their own applications that meet applicable functional safety standards and requirements. Using products in an application does not by itself establish any safety features in the application. Designers must ensure compliance with safety-related requirements and standards applicable to their applications. Designer may not use any TI products in life-critical medical equipment unless authorized officers of the parties have executed a special contract specifically governing such use. Life-critical medical equipment is medical equipment where failure of such equipment would cause serious bodily injury or death (e.g., life support, pacemakers, defibrillators, heart pumps, neurostimulators, and implantables). Such equipment includes, without limitation, all medical devices identified by the U.S. Food and Drug Administration as Class III devices and equivalent classifications outside the U.S.

TI may expressly designate certain products as completing a particular qualification (e.g., Q100, Military Grade, or Enhanced Product). Designers agree that it has the necessary expertise to select the product with the appropriate qualification designation for their applications and that proper product selection is at Designers' own risk. Designers are solely responsible for compliance with all legal and regulatory requirements in connection with such selection.

Designer will fully indemnify TI and its representatives against any damages, costs, losses, and/or liabilities arising out of Designer's non-compliance with the terms and provisions of this Notice.