



# DS90LV028AH 高温用 3V LVDS デュアル差動ライン・レシーバ

## 1 特長

- $-40^{\circ}\text{C} \sim +125^{\circ}\text{C}$  の動作温度範囲
- 400Mbps (200MHz) を超えるスイッチング速度
- 差動スキュー: 50ps (標準値)
- チャネル間スキュー: 0.1ns (標準値)
- 最大伝搬遅延: 2.5ns
- 3.3V電源の設計
- フロースルーのピン配置
- パワーダウン時高インピーダンスのLVDS入力
- 低消費電力の設計: 18 mW (3.3V 固定)
- LVDS 入力は LVDS/CML/LVPECL 信号に対応
- ANSI/TIA/EIA-644 規格に準拠
- SOIC パッケージで供給

## 2 アプリケーション

- 基板間通信
- 試験/測定機器
- LED ビデオ・ウォール
- モータ駆動
- ワイヤレス・インフラ
- 通信インフラ
- 多機能プリンタ
- NIC カード
- ラック・サーバー
- 超音波スキャナ

## 3 概要

DS90LV028AH はデュアル CMOS 差動ライン・レシーバで、超低消費電力、低ノイズ、高いデータ速度を必要とするアプリケーション用に設計されています。このデバイスは、低電圧差動信号 (LVDS) テクノロジーを活用し、400Mbps (200MHz) を超えるデータ速度をサポートするように設計されています。

DS90LV028AH は低電圧 (標準値 350mV) の差動入力信号を受信し、3V CMOS 出力レベルへ変換します。

DS90LV028AH にはフロースルー設計が採用されているため、PCB レイアウトが容易です。

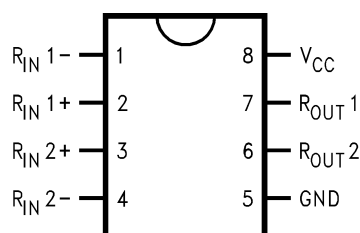
DS90LV028AH と、対になる LVDS ライン・ドライバ DS90LV027AH は、消費電力の大きい PECL/ECL デバイスの新しい代替品として、高速のポイント・ツー・ポイント・インターフェイス・アプリケーションに使用できます。

### 製品情報<sup>(1)</sup>

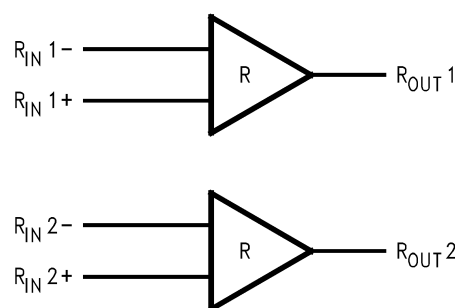
| 型番          | パッケージ    | 本体サイズ (公称)    |
|-------------|----------|---------------|
| DS90LV028AH | SOIC (8) | 4.90mm×3.91mm |

(1) 提供されているすべてのパッケージについては、巻末の注文情報を参照してください。

接続図



機能図



## 目次

|     |                                                |   |      |                                             |    |
|-----|------------------------------------------------|---|------|---------------------------------------------|----|
| 1   | 特長 .....                                       | 1 | 8.3  | Feature Description .....                   | 9  |
| 2   | アプリケーション .....                                 | 1 | 8.4  | Device Functional Modes .....               | 10 |
| 3   | 概要 .....                                       | 1 | 9    | <b>Application and Implementation</b> ..... | 11 |
| 4   | 改訂履歴 .....                                     | 2 | 9.1  | Application Information .....               | 11 |
| 5   | <b>Pin Configuration and Functions</b> .....   | 3 | 9.2  | Typical Application .....                   | 11 |
| 6   | <b>Specifications</b> .....                    | 4 | 10   | <b>Power Supply Recommendations</b> .....   | 14 |
| 6.1 | Absolute Maximum Ratings .....                 | 4 | 11   | <b>Layout</b> .....                         | 14 |
| 6.2 | ESD Ratings .....                              | 4 | 11.1 | Layout Guidelines .....                     | 14 |
| 6.3 | Recommended Operating Conditions .....         | 4 | 11.2 | Layout Example .....                        | 18 |
| 6.4 | Thermal Information .....                      | 4 | 12   | <b>デバイスおよびドキュメントのサポート</b> .....             | 19 |
| 6.5 | Electrical Characteristics .....               | 5 | 12.1 | 関連資料 .....                                  | 19 |
| 6.6 | Switching Characteristics .....                | 5 | 12.2 | ドキュメントの更新通知を受け取る方法 .....                    | 19 |
| 6.7 | Typical Characteristics .....                  | 6 | 12.3 | コミュニティ・リソース .....                           | 19 |
| 7   | <b>Parameter Measurement Information</b> ..... | 8 | 12.4 | 商標 .....                                    | 19 |
| 8   | <b>Detailed Description</b> .....              | 9 | 12.5 | 静電気放電に関する注意事項 .....                         | 19 |
| 8.1 | Overview .....                                 | 9 | 12.6 | Glossary .....                              | 19 |
| 8.2 | Functional Block Diagram .....                 | 9 | 13   | <b>メカニカル、パッケージ、および注文情報</b> .....            | 19 |

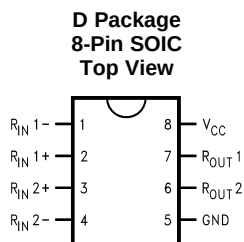
## 4 改訂履歴

資料番号末尾の英字は改訂を表しています。その改訂履歴は英語版に準じています。

| Revision A (April 2013) から Revision B に変更                                                                                                                                                                                 | Page |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| <ul style="list-style-type: none"> <li>「製品情報」表、「製品比較」表、「ESD 定格」表、「機能説明」セクション、「デバイスの機能モード」セクション、「アプリケーションと実装」セクション、「電源に関する推奨事項」セクション、「レイアウト」セクション、「デバイスおよびドキュメントのサポート」セクション、「メカニカル、パッケージ、および注文情報」セクションを追加 .....</li> </ul> | 1    |
| <ul style="list-style-type: none"> <li>データシートのページの上端にナビゲーション・リンクを追加し、NRND バナーを削除 .....</li> </ul>                                                                                                                         | 1    |
| <ul style="list-style-type: none"> <li>Moved the thermal resistance (<math>\theta_{JA}</math>) parameter in the <i>Absolute Maximum Ratings</i> table to the <i>Thermal Information</i> table .....</li> </ul>            | 4    |

| 2013年4月発行のものから更新                                                                                           | Page |
|------------------------------------------------------------------------------------------------------------|------|
| <ul style="list-style-type: none"> <li>Changed layout of National Data Sheet to TI format .....</li> </ul> | 7    |

## 5 Pin Configuration and Functions



**Pin Functions**

| PIN       |      | I/O | DESCRIPTION                          |
|-----------|------|-----|--------------------------------------|
| NAME      | NO.  |     |                                      |
| $R_{IN-}$ | 1, 4 | I   | Inverting receiver input pin         |
| $R_{IN+}$ | 2, 3 | I   | Noninverting receiver input pin      |
| $R_{OUT}$ | 6, 7 | O   | Receiver output pin                  |
| $V_{CC}$  | 8    | I   | Power supply pin, +3.3 V $\pm$ 0.3 V |
| GND       | 5    | I   | Ground pin                           |

## 6 Specifications

### 6.1 Absolute Maximum Ratings<sup>(1)(2)</sup>

|                                            |                                | MIN  | MAX            | UNIT  |
|--------------------------------------------|--------------------------------|------|----------------|-------|
| Supply Voltage ( $V_{CC}$ )                |                                | -0.3 | 4              | V     |
| Input Voltage ( $R_{IN+}$ , $R_{IN-}$ )    |                                | -0.3 | 3.9            | V     |
| Output Voltage ( $R_{OUT}$ )               |                                | -0.3 | $V_{CC} + 0.3$ | V     |
| Maximum Package Power Dissipation at +25°C | D Package                      |      | 1025           | mW    |
|                                            | Derate D Package (above +25°C) |      | 8.2            | mW/°C |
| Lead Temperature Range Soldering           | (4 sec.)                       |      | 260            | °C    |
| Maximum Junction Temperature               |                                |      | 150            | °C    |
| Storage Temperature, $T_{stg}$             |                                | -65  | 150            | °C    |

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.

### 6.2 ESD Ratings

|                                     |                                                                                                | VALUE | UNIT |
|-------------------------------------|------------------------------------------------------------------------------------------------|-------|------|
| $V_{(ESD)}$ Electrostatic discharge | Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)(2)</sup> (1.5 k $\Omega$ , 100 pF) | 7000  | V    |
|                                     | EIAJ (0 $\Omega$ , 200 pF)                                                                     | 500   |      |

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process. Pins listed as  $\pm 7000$  V may actually have higher performance.
- (2) ESD Rating:  
HBM (1.5 k $\Omega$ , 100 pF)  $\geq 7$  kV  
EIAJ (0 $\Omega$ , 200 pF)  $\geq 500$ V

### 6.3 Recommended Operating Conditions

|                                | MIN | NOM  | MAX  | UNIT |
|--------------------------------|-----|------|------|------|
| Supply Voltage ( $V_{CC}$ )    | +3  | +3.3 | +3.6 | V    |
| Receiver Input Voltage         | GND |      | 3    | V    |
| Ambient Temperature ( $T_A$ )  | -40 | 25   | +125 | °C   |
| Junction Temperature ( $T_J$ ) |     |      | +130 | °C   |

### 6.4 Thermal Information

| THERMAL METRIC <sup>(1)</sup> |                                              | DS90LV028AH | UNIT |
|-------------------------------|----------------------------------------------|-------------|------|
|                               |                                              | D (SOIC)    |      |
|                               |                                              | 8 PINS      |      |
| $R_{\theta JA}$               | Junction-to-ambient thermal resistance       | 119.6       | °C/W |
| $R_{\theta JC(top)}$          | Junction-to-case (top) thermal resistance    | 59.3        | °C/W |
| $R_{\theta JB}$               | Junction-to-board thermal resistance         | 62.2        | °C/W |
| $\Psi_{JT}$                   | Junction-to-top characterization parameter   | 10.9        | °C/W |
| $\Psi_{JB}$                   | Junction-to-board characterization parameter | 61.6        | °C/W |

- (1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.

## 6.5 Electrical Characteristics

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

| PARAMETER                                         | TEST CONDITIONS                                      | PIN                                 | MIN  | TYP  | MAX  | UNIT |
|---------------------------------------------------|------------------------------------------------------|-------------------------------------|------|------|------|------|
| V <sub>TH</sub> Differential Input High Threshold | V <sub>CM</sub> = +1.2 V, 0 V, 3 V <sup>(3)</sup>    | R <sub>IN+</sub> , R <sub>IN-</sub> |      |      | +100 | mV   |
| V <sub>TL</sub> Differential Input Low Threshold  |                                                      |                                     | -100 |      |      | mV   |
| I <sub>IN</sub> Input Current                     | V <sub>IN</sub> = +2.8 V                             |                                     | -10  | ±1   | +10  | μA   |
|                                                   | V <sub>IN</sub> = 0 V                                |                                     | -10  | ±1   | +10  | μA   |
|                                                   | V <sub>IN</sub> = +3.6 V                             |                                     | -20  |      | +20  | μA   |
| V <sub>OH</sub> Output High Voltage               | I <sub>OH</sub> = -0.4 mA, V <sub>ID</sub> = +200 mV | R <sub>OUT</sub>                    | 2.7  | 3.1  |      | V    |
|                                                   | I <sub>OH</sub> = -0.4 mA, Inputs terminated         |                                     | 2.7  | 3.1  |      | V    |
|                                                   | I <sub>OH</sub> = -0.4 mA, Inputs shorted            |                                     | 2.7  | 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> = 0 V <sup>(4)</sup>                |                                     | -15  | -50  | -100 | mA   |
| V <sub>CL</sub> Input Clamp Voltage               | I <sub>CL</sub> = -18 mA                             |                                     | -1.5 | -0.8 |      | V    |
| I <sub>CC</sub> No Load Supply Current            | Inputs Open                                          | V <sub>CC</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>CC</sub> = +3.3 V and T<sub>A</sub> = +25°C.
- (3) V<sub>CC</sub> is always higher than R<sub>IN+</sub> and R<sub>IN-</sub> voltage. R<sub>IN+</sub> and R<sub>IN-</sub> are allowed to have voltage range -0.05 V to +3.05 V. V<sub>ID</sub> is not allowed to be greater than 100 mV when V<sub>CM</sub> = 0 V or 3 V.
- (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.

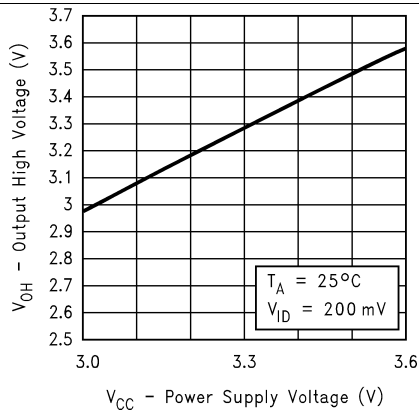
## 6.6 Switching Characteristics

V<sub>CC</sub> = +3.3 V ± 10%, T<sub>A</sub> = -40°C to +125°C <sup>(1)(2)</sup>

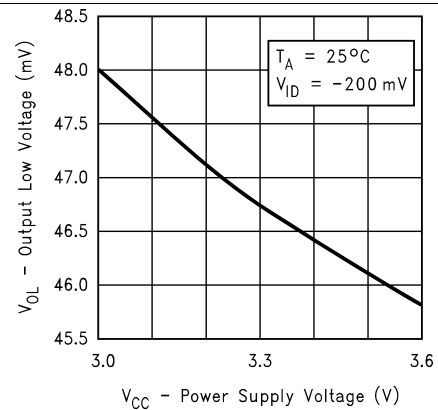
| PARAMETER                                                                                         |                                                                                 | MIN | TYP | MAX | UNIT |
|---------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|-----|-----|-----|------|
| t <sub>PHLD</sub> Differential Propagation Delay High to Low                                      | C <sub>L</sub> = 15 pF<br>V <sub>ID</sub> = 200 mV<br>(Figure 14 and Figure 15) | 1   | 1.6 | 2.5 | ns   |
| t <sub>PLHD</sub> Differential Propagation Delay Low to High                                      |                                                                                 | 1   | 1.7 | 2.5 | ns   |
| t <sub>SKD1</sub> Differential Pulse Skew  t <sub>PHLD</sub> - t <sub>PLHD</sub>   <sup>(3)</sup> |                                                                                 | 0   | 50  | 650 | ps   |
| t <sub>SKD2</sub> Differential Channel-to-Channel Skew-same device <sup>(4)</sup>                 |                                                                                 | 0   | 0.1 | 0.5 | ns   |
| t <sub>SKD3</sub> Differential Part to Part Skew <sup>(5)</sup>                                   |                                                                                 | 0   |     | 1   | ns   |
| t <sub>SKD4</sub> Differential Part to Part Skew <sup>(6)</sup>                                   |                                                                                 | 0   |     | 1.5 | ns   |
| t <sub>TLH</sub> Rise Time                                                                        |                                                                                 |     | 325 | 800 | ps   |
| t <sub>THL</sub> Fall Time                                                                        |                                                                                 |     | 225 | 800 | ps   |
| f <sub>MAX</sub> Maximum Operating Frequency <sup>(7)</sup>                                       |                                                                                 | 200 | 250 |     | MHz  |

- (1) C<sub>L</sub> includes probe and jig capacitance.
- (2) Generator waveform for all tests unless otherwise specified: f = 1 MHz, Z<sub>O</sub> = 50 Ω, t<sub>r</sub> and t<sub>f</sub> (0% to 100%) ≤ 3 ns for R<sub>IN-</sub>.
- (3) t<sub>SKD1</sub> 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<sub>SKD2</sub> is the differential channel-to-channel skew of any event on the same device. This specification applies to devices having multiple receivers within the integrated circuit.
- (5) t<sub>SKD3</sub>, 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<sub>CC</sub> and within 5°C of each other within the operating temperature range.
- (6) t<sub>SKD4</sub>, 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<sub>SKD4</sub> is defined as |Max - Min| differential propagation delay.
- (7) f<sub>MAX</sub> generator input conditions: t<sub>r</sub> = t<sub>f</sub> < 1 ns (0% to 100%), 50% duty cycle, differential (1.05 V to 1.35 V peak-to-peak). Output criteria: 60%/40% duty cycle, V<sub>OL</sub> (max 0.4 V), V<sub>OH</sub> (min 2.7 V), load = 15 pF (stray plus probes).

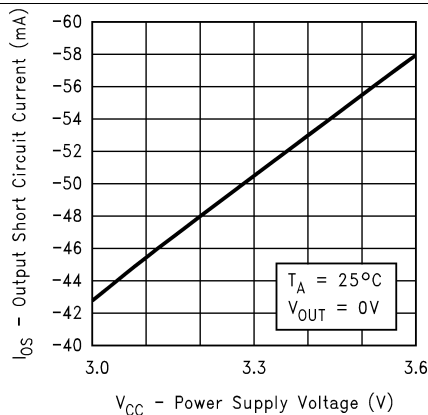
## 6.7 Typical Characteristics



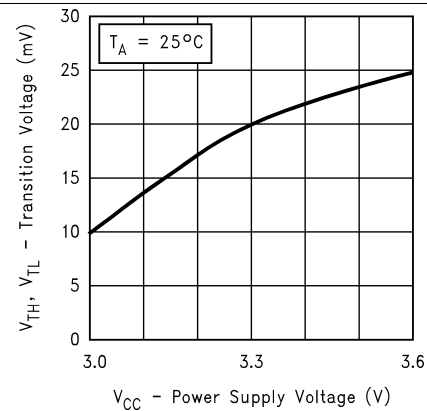
**Figure 1. Output High Voltage vs Power Supply Voltage**



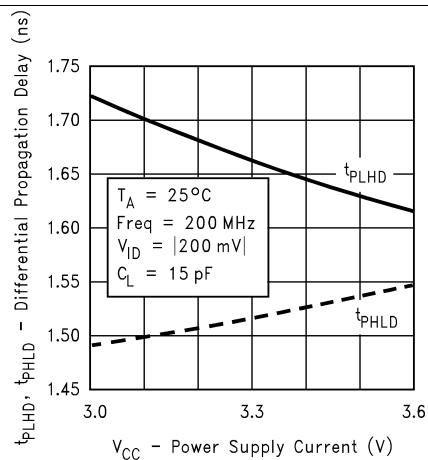
**Figure 2. Output Low Voltage vs Power Supply Voltage**



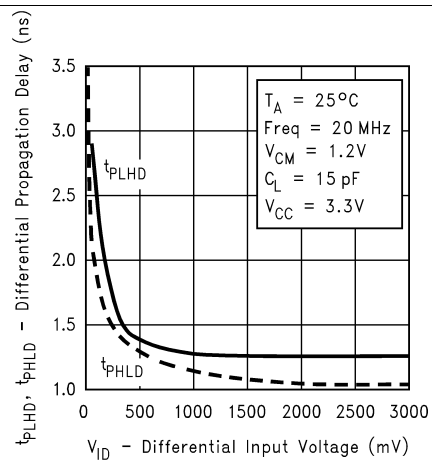
**Figure 3. Output Short-Circuit Current vs Power Supply Voltage**



**Figure 4. Differential Transition Voltage vs Power Supply Voltage**

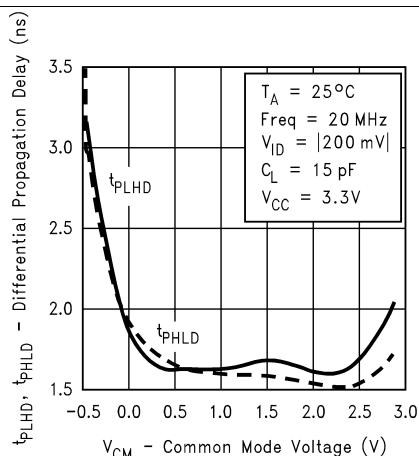


**Figure 5. Differential Propagation Delay vs Power Supply Voltage**

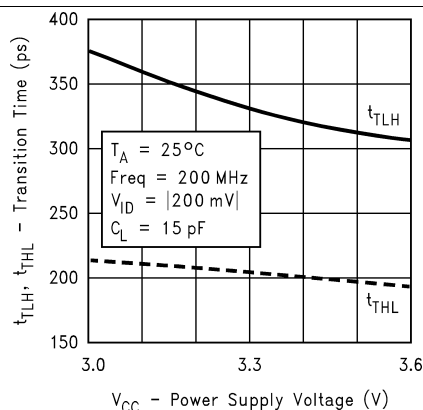


**Figure 6. Differential Propagation Delay vs Differential Input Voltage**

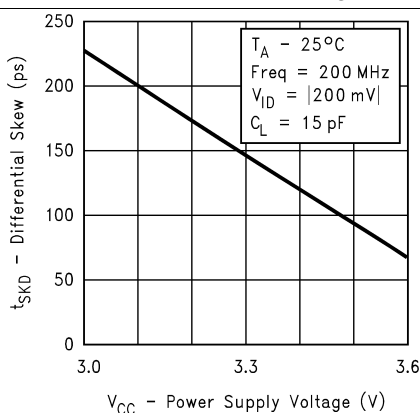
## Typical Characteristics (continued)



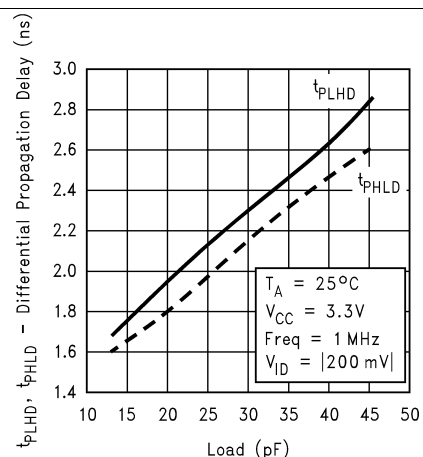
**Figure 7. Differential Propagation Delay vs Common-Mode Voltage**



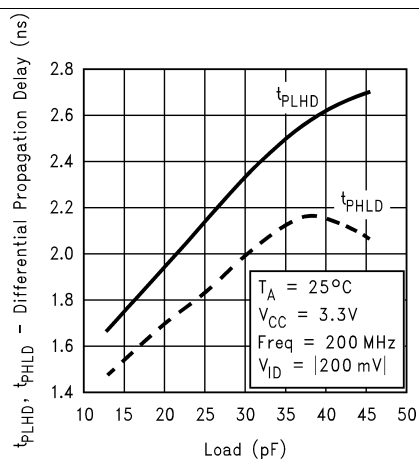
**Figure 8. Transition Time vs Power Supply Voltage**



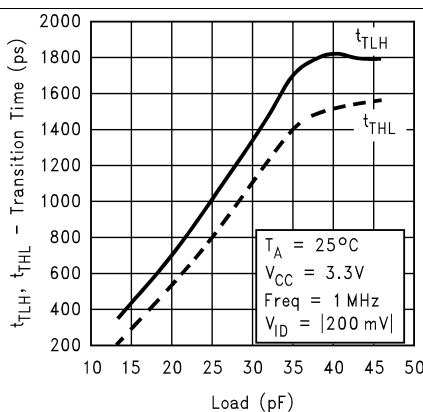
**Figure 9. Differential Skew vs Power Supply Voltage**



**Figure 10. Differential Propagation Delay vs Load**



**Figure 11. Differential Propagation Delay vs Load**



**Figure 12. Transition Time vs Load**

## Typical Characteristics (continued)

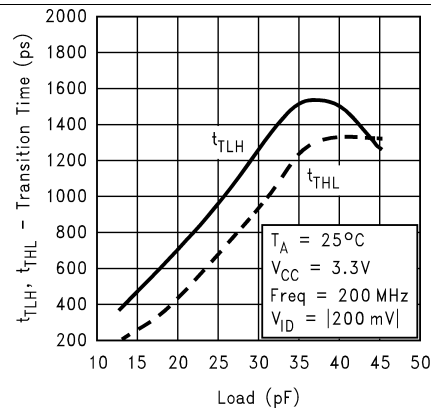


Figure 13. Transition Time vs Load

## 7 Parameter Measurement Information

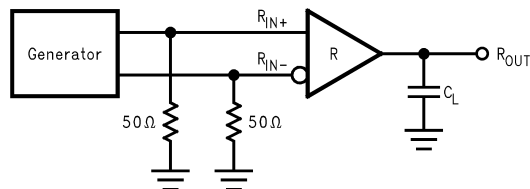


Figure 14. Receiver Propagation Delay and Transition Time Test Circuit

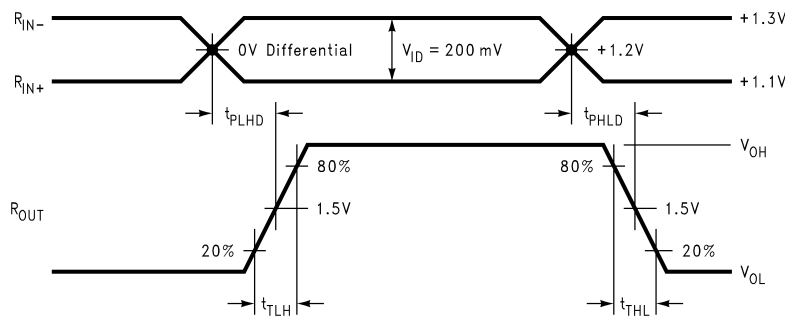


Figure 15. Receiver Propagation Delay and Transition Time Waveforms



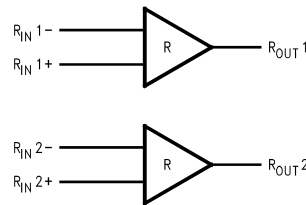
## 8 Detailed Description

### 8.1 Overview

The DS90LV028AH is a dual-channel, low-voltage differential signaling (LVDS) line receiver. It operates from a single power supply that is nominally 3.3 V, but the supply can be as low as 3 V and as high as 3.6 V. The input to the DS90LV028AH is a differential signal that complies with the LVDS Standard (TIA/EIA-644), and the output is a 3.3-V LVCMOS/LVTTL signal. The differential input signal operates with a signal level of 350 mV (nominally) at a common-mode voltage of 1.2 V. The differential nature of the inputs provides immunity to common-mode coupled signals that the driven signal may experience. A termination resistor of 100  $\Omega$  should be used with DS90LV028AH.

LVDS receivers are intended to be used primarily in point-to-point configurations. This type of 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 that 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 100  $\Omega$ . The integrated termination resistor converts the driver output (current mode) into a voltage without the need for external termination and 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.

### 8.2 Functional Block Diagram



### 8.3 Feature Description

The DS90LV028AH is capable of detecting signals as low as 100 mV, over a  $\pm 1$ -V common-mode range centered around 1.2 V. The AC parameters of the input pins are optimized for a recommended operating input voltage range of 0 V to 2.4 V (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.

**Table 1. DS90LV028AH Receiver Function**

| INPUTS                  | OUTPUT    |
|-------------------------|-----------|
| $[R_{IN+}] - [R_{IN-}]$ | $R_{OUT}$ |
| $V_{ID} \geq 0.1$ V     | H         |
| $V_{ID} \leq -0.1$ V    | L         |

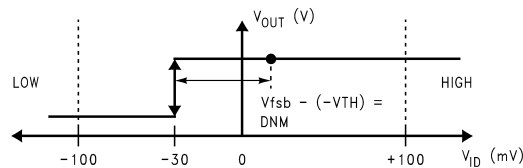
#### 8.3.1 Termination

Use a termination resistor which best matches the differential impedance or your transmission line. The resistor should be between 90  $\Omega$  and 130  $\Omega$ . Remember that the current mode outputs need the termination resistor to generate the differential voltage. LVDS will not work correctly without resistor termination. Typically, connecting a single resistor across the pair at the receiver end will suffice.

Surface mount 1% to 2% resistors are the best. PCB stubs, component lead, and the distance from the termination to the receiver inputs should be minimized. The distance between the termination resistor and the receiver should be < 10 mm (12 mm MAX).

### 8.3.2 Threshold

The LVDS Standard (ANSI/TIA/EIA-644-A) specifies a maximum threshold of  $\pm 100$  mV for the LVDS receiver. The DS90LV028AH supports an enhanced threshold region of  $-100$  mV to  $0$  V. This is useful for fail-safe biasing. The threshold region is shown in the Voltage Transfer Curve (VTC) in Figure 16. The typical DS90LV028AH LVDS receiver switches at about  $-30$  mV. Note that with  $V_{ID} = 0$  V, the output will be in a HIGH state. With an external fail-safe bias of  $+25$  mV applied, the typical differential noise margin is now the difference from the switch point to the bias point. In the example shown in Figure 16, this would be  $55$  mV of Differential Noise Margin (DNM) ( $+25$  mV  $- (-30$  mV)). With the enhanced threshold region of  $-100$  mV to  $0$  V, this small external fail-safe biasing of  $+25$  mV (with respect to  $0$  V) gives a DNM of a comfortable  $55$  mV. With the standard threshold region of  $\pm 100$  mV, the external fail-safe biasing must be  $+25$  mV with respect to  $+100$  mV or  $+125$  mV, giving a DNM of  $155$  mV that is a stronger fail-safe biasing than necessary for the DS90LV028AH. If more DNM is required, then a stronger fail-safe bias point can be set by changing resistor values.



**Figure 16. VTC of the DS90LV028AH LVDS Receiver**

### 8.3.3 Fail-Safe Feature

The LVDS receiver is a high-gain, high-speed device that amplifies a small differential signal ( $20$  mV) to LVCMOS/LVTTL logic levels. Due to the high gain and tight threshold of the receiver, take care to prevent noise from appearing as a valid signal.

The receiver's internal fail-safe circuitry is designed to source/sink a small amount of current, providing fail-safe protection (a stable known state of HIGH output voltage) for floating, terminated, or shorted receiver inputs.

1. **Open Input Pins:** It is not required to tie the receiver inputs to ground or any supply voltage. Internal fail-safe circuitry will ensure a HIGH, stable output state for open inputs.
2. **Terminated Input:** If the driver is disconnected (cable unplugged), or if the driver is in a power-off condition, the receiver output will again be in a HIGH state, even with the end cable  $100\text{-}\Omega$  termination resistor across the input pins. The unplugged cable can become a floating antenna which can pick up noise. If the cable picks up more than  $10$  mV of differential noise, the receiver may see the noise as a valid signal and switch. To insure that any noise is seen as common-mode and not differential, a balanced interconnect should be used. A twisted-pair cable will offer better balance than flat ribbon cable.
3. **Shorted Inputs:** If a fault condition occurs that shorts the receiver inputs together, thus resulting in a  $0$ -V differential input voltage, the receiver output will remain in a HIGH state. Shorted input fail-safe is not supported across the common-mode range of the device (GND to  $2.4$  V). It is only supported with inputs shorted and no external common-mode voltage applied.

External lower value pullup and pulldown resistors (for a stronger bias) may be used to boost fail-safe in the presence of higher noise levels. The pullup and pulldown resistors should be in the  $5\text{-k}\Omega$  to  $15\text{-k}\Omega$  range to minimize loading and waveform distortion to the receiver. The common-mode bias point should be set to approximately  $1.2$  V (less than  $1.75$  V) to be compatible with the internal circuitry.

The DS90LV028AH is compliant to the original ANSI EIA/TIA-644 specification and is also compliant to the new ANSI EIA/TIA-644-A specification with the exception of the newly added  $\Delta I_{IN}$  specification. Due to the internal fail-safe circuitry,  $\Delta I_{IN}$  cannot meet the  $6\text{-}\mu\text{A}$  maximum specified. This exception will not be relevant unless more than  $10$  receivers are used.

Additional information on the fail-safe biasing of LVDS devices may be found in [AN-1194 Fail-Safe Biasing of LVDS Interfaces](#) (SNLA051).

## 8.4 Device Functional Modes

The device has one mode of operation that applies when operated within the [Recommended Operating Conditions](#).

## 9 Application and Implementation

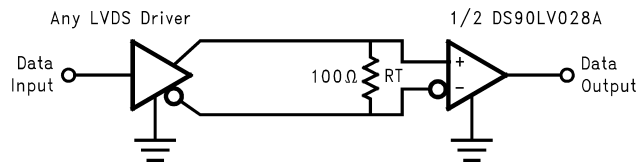
### NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

### 9.1 Application Information

The DS90LV028AH device is a dual-channel LVDS receiver. The functionality of this device is simple, yet extremely flexible, leading to its use in designs ranging from wireless base stations to desktop computers. The DS90LV027AH has a flow-through pinout that allows for easy PCB layout. The LVDS signals on one side of the device allow for easy matching of the electrical lengths for the differential pair trace lines between the driver and the receiver, and the signal placement allows the trace lines to be close together to couple noise as common-mode. Noise isolation is achieved with the LVDS signals on one side of the device and the TTL signals on the other side.

### 9.2 Typical Application



**Figure 17. Balanced System Point-to-Point Application**

#### 9.2.1 Design Requirements

Table 2 lists the design parameters for this example.

**Table 2. Design Parameters**

| DESIGN PARAMETERS                        | EXAMPLE VALUE |
|------------------------------------------|---------------|
| Receiver Supply Voltage ( $V_{CC}$ )     | 3 to 3.6 V    |
| Receiver Output Voltage                  | 0 to 3.6 V    |
| Signaling Rate                           | 0 to 400 Mbps |
| Interconnect Characteristic Impedance    | 100 $\Omega$  |
| Termination Resistance                   | 100 $\Omega$  |
| Number of Driver Nodes                   | 2             |
| Ground shift between driver and receiver | $\pm 1$ V     |

#### 9.2.2 Detailed Design Procedure

##### 9.2.2.1 Receiver Bypass Capacitance

Bypass capacitors play a key role in power distribution circuitry. Specifically, they create low-impedance paths between power and ground. At low frequencies, a good digital power supply offers very low-impedance paths between its terminals. However, as higher frequency currents propagate through power traces, the source is quite often incapable of maintaining a low-impedance path to ground. Bypass capacitors are used to address this shortcoming. Usually, large bypass capacitors (10  $\mu$ F to 1000  $\mu$ F) at the board-level do a good job up into the kHz range. Due to their size and length of their leads, they tend to have large inductance values at the switching frequencies of modern digital circuitry. To solve this problem, one must resort to the use of smaller capacitors (nF to  $\mu$ F range) installed locally next to the integrated circuit.

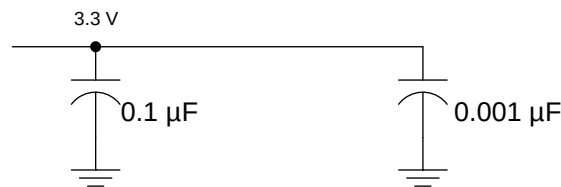
Multilayer ceramic chip or surface-mount capacitors (size 0603 or 0805) minimize lead inductances of bypass capacitors in high-speed environments, because their lead inductance is about 1 nH. For comparison purposes, a typical capacitor with leads has a lead inductance around 5 nH.

The value of the bypass capacitors used locally with LVDS chips can be determined by [Equation 1](#) and [Equation 2](#) according to Johnson<sup>(1)</sup> equations 8.18 to 8.21. A conservative rise time of 200 ps and a worst-case change in supply current of 1 A covers the whole range of LVDS devices offered by Texas Instruments. In this example, the maximum power supply noise tolerated is 200 mV. However, this figure varies depending on the noise budget available in the design. <sup>(1)</sup>

$$C_{\text{chip}} = \left( \frac{\Delta I_{\text{Maximum Step Change Supply Current}}}{\Delta V_{\text{Maximum Power Supply Noise}}} \right) \times T_{\text{Rise Time}} \quad (1)$$

$$C_{\text{LVDS}} = \left( \frac{1\text{A}}{0.2\text{V}} \right) \times 200 \text{ ps} = 0.001 \mu\text{F} \quad (2)$$

[Figure 18](#) lowers lead inductance and covers intermediate frequencies between the board-level capacitor (>10  $\mu\text{F}$ ) and the value of capacitance found above (0.001  $\mu\text{F}$ ). TI recommends that the user place the smallest value of capacitance as close to the chip as possible.



**Figure 18. Recommended LVDS Bypass Capacitor Layout**

### 9.2.2.2 Interconnecting Media

The physical communication channel between the driver and the receiver may be any balanced and paired metal conductors meeting the requirements of the LVDS standard, the key points of which are included here. This media may be twisted-pair, twinax cables, flat ribbon cables, or PCB traces.

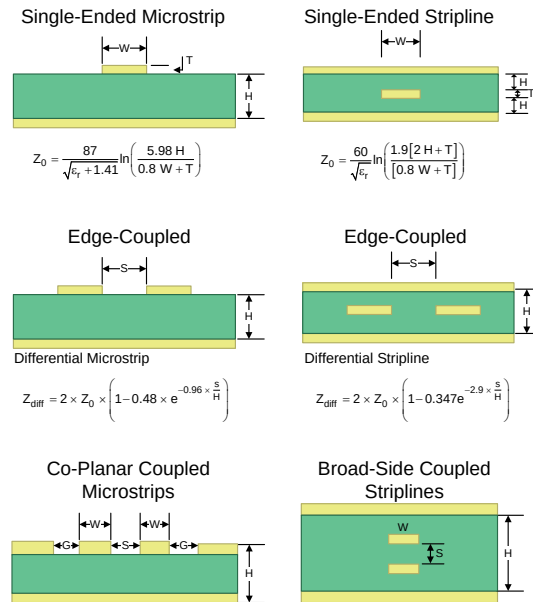
The nominal characteristic impedance of the interconnect should be between 100  $\Omega$  and 120  $\Omega$  with a variation of no more than 10% (90  $\Omega$  to 132  $\Omega$ ).

### 9.2.2.3 PCB Transmission Lines

As per the [LVDS Owner's Manual Design Guide, 4th Edition](#) (SNLA187), [Figure 19](#) depicts several transmission line structures commonly used in printed-circuit boards (PCBs). Each structure consists of a signal line and return path with a uniform cross section along its length. A microstrip is a signal trace on the top (or bottom) layer, separated by a dielectric layer from its return path in a ground or power plane. A stripline is a signal trace in the inner layer, with a dielectric layer in between a ground plane above and below the signal trace. The dimensions of the structure along with the dielectric material properties determine the characteristic impedance of the transmission line (also called controlled-impedance transmission line).

When two signal lines are placed close by, they form a pair of coupled transmission lines. [Figure 19](#) shows examples of edge-coupled microstrip lines, and edge-coupled or broad-side-coupled striplines. When excited by differential signals, the coupled transmission line is referred to as a differential pair. The characteristic impedance of each line is called odd-mode impedance. The sum of the odd-mode impedances of each line is the differential impedance of the differential pair. In addition to the trace dimensions and dielectric material properties, the spacing between the two traces determines the mutual coupling and impacts the differential impedance. When the two lines are immediately adjacent (like if  $S$  is less than  $2W$ , for example), the differential pair is called a tightly-coupled differential pair. To maintain constant differential impedance along the length, it is important to keep the trace width and spacing uniform along the length, as well as maintain good symmetry between the two lines.

(1) Howard Johnson & Martin Graham.1993. High Speed Digital Design – A Handbook of Black Magic. Prentice Hall PRT. ISBN number 013395724.



**Figure 19. Controlled-Impedance Transmission Lines**

#### 9.2.2.4 Input Fail-Safe Biasing

External pullup and pulldown resistors may be used to provide enough of an offset to enable an input fail-safe under open-circuit conditions. This configuration ties the positive LVDS input pin to VDD through a pullup resistor, and the negative LVDS input pin is tied to GND by a pulldown resistor. The pullup and pulldown resistors should be in the 5 kΩ to 15 kΩ range to minimize loading and waveform distortion to the driver. The common-mode bias point should ideally be set to approximately 1.2 V (less than 1.75 V) to be compatible with the internal circuitry. Refer to application note [AN-1194 Fail-Safe Biasing of LVDS Interfaces](#) (SNLA051) for more information.

#### 9.2.2.5 Probing LVDS Transmission Lines on PCB

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

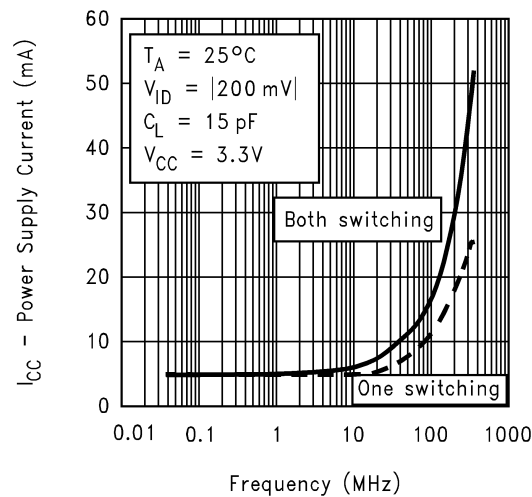
#### 9.2.2.6 Cables and Connectors, General Comments

When choosing cable and connectors for LVDS, it is important to use controlled impedance media. The cables and connectors used should have a matched differential impedance of about 100 Ω. They should not introduce major impedance discontinuities.

Balanced cables (like twisted-pair cables, for example) are usually better than unbalanced cables (like ribbon cables, 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 and common-mode (not differential mode) noise, which the receiver will reject.

For cable distances < 0.5M, most cables can work effectively. For distances 0.5M ≤ d ≤ 10M, TI recommends using CAT 3 (category 3) twisted-pair cables which are readily available and relatively inexpensive.

### 9.2.3 Application Curve



**Figure 20. Power Supply Current vs Frequency**

## 10 Power Supply Recommendations

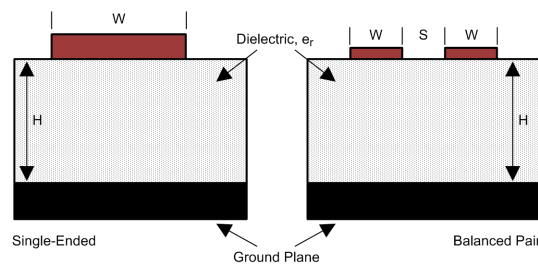
The DS90LV028AH receiver is designed to operate from a single power supply with supply voltage in the range of 3.0 V to 3.6 V. In a typical application, a driver and a receiver may be on separate boards, or even separate equipment. In these cases, separate supplies would be used at each location. The expected ground potential difference between the driver power supply and the receiver power supply would be less than  $\pm 1$  V. Board level and local device level bypass capacitance should be used.

## 11 Layout

### 11.1 Layout Guidelines

#### 11.1.1 Microstrip vs. Stripline Topologies

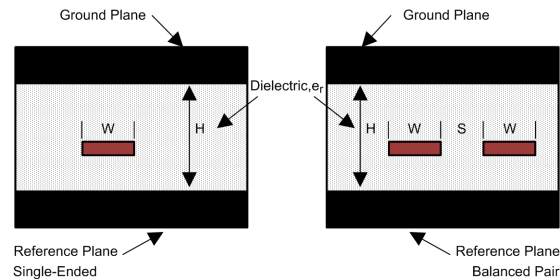
As per the [LVDS Application and Data Handbook](#) (SLLD009), printed-circuit boards usually offer designers two transmission line options: microstrip and stripline. Microstrips are traces on the outer layer of a PCB, as shown in [Figure 21](#).



**Figure 21. Microstrip Topology**

## Layout Guidelines (continued)

On the other hand, striplines are traces between two ground planes. Striplines are less prone to emissions and susceptibility problems because the reference planes effectively shield the embedded traces. However, from the standpoint of high-speed transmission, juxtaposing two planes creates additional capacitance. TI recommends routing LVDS signals on microstrip transmission lines when possible. The PCB traces allow designers to specify the necessary tolerances for  $Z_0$  based on the overall noise budget and reflection allowances. Footnotes 1<sup>(2)</sup>, 2<sup>(3)</sup>, and 3<sup>(4)</sup> provide formulas for  $Z_0$  and  $t_{PD}$  for differential and single-ended traces. <sup>(2)</sup> <sup>(3)</sup> <sup>(4)</sup>



**Figure 22. Stripline Topology**

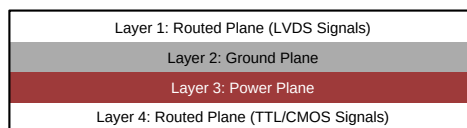
### 11.1.2 Dielectric Type and Board Construction

The speeds at which signals travel across the board dictates the choice of dielectric. FR-4, or an equivalent, usually provides adequate performance for use with LVDS signals. If rise or fall times of LVCMOS/LVTTL signals are less than 500 ps, empirical results indicate that a material with a dielectric constant near 3.4, such as Rogers™ 4350 or Nelco N4000-13 may be desired. When the designer chooses the dielectric, there are several parameters pertaining to the board construction that can affect performance. The following set of guidelines were developed experimentally through several designs involving LVDS devices:

- Copper weight: 15 g or 1/2 oz start, plated to 30 g or 1 oz
- All exposed circuitry should be solder-plated (60/40) to 7.62  $\mu\text{m}$  or 0.0003 in (minimum).
- Copper plating should be 25.4  $\mu\text{m}$  or 0.001 in (minimum) in plated-through-holes.
- Solder mask over bare copper with solder hot-air leveling

### 11.1.3 Recommended Stack Layout

Following the choice of dielectrics and design specifications, the designer must decide how many levels to use in the stack. To reduce the LVCMOS/LVTTL to LVDS crosstalk, it is good practice to have at least two separate signal planes as shown in Figure 23.



**Figure 23. Four-Layer PCB Board**

#### NOTE

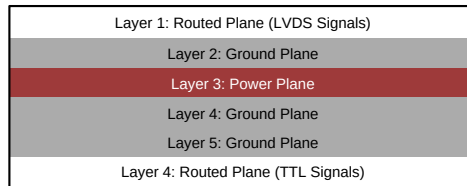
The separation between layers 2 and 3 should be 127  $\mu\text{m}$  (0.005 in). By keeping the power and ground planes tightly coupled, the increased capacitance acts as a bypass for transients.

- (2) Howard Johnson & Martin Graham.1993. High Speed Digital Design – A Handbook of Black Magic. Prentice Hall PRT. ISBN number 013395724.
- (3) Mark I. Montrose. 1996. Printed Circuit Board Design Techniques for EMC Compliance. IEEE Press. ISBN number 0780311310.
- (4) Clyde F. Coombs, Jr. Ed, Printed Circuits Handbook, McGraw Hill, ISBN number 0070127549.



## Layout Guidelines (continued)

One of the most common stack configurations is the six-layer board, as shown in Figure 24.



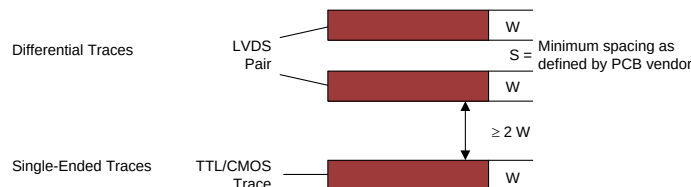
**Figure 24. Six-Layer PCB Board**

In this particular configuration, it is possible to isolate each signal layer from the power plane by at least one ground plane. The result is improved signal integrity, but fabrication is more expensive. Using the 6-layer board is preferable, because it offers the layout designer more flexibility in varying the distance between signal layers and referenced planes in addition to ensuring reference to a ground plane for signal layers 1 and 6.

### 11.1.4 Separation Between Traces

The separation between traces depends on several factors, but the amount of coupling that can be tolerated usually dictates the actual separation. Low-noise coupling requires close coupling between the differential pair of an LVDS link to benefit from the electromagnetic field cancellation. The traces should be 100-Ω differential and thus coupled in the manner that best fits this requirement. In addition, differential pairs should have the same electrical length to ensure that they are balanced, thus minimizing problems with skew and signal reflection.

In the case of two adjacent single-ended traces, one should use the 3-W rule, which stipulates that the distance between two traces must be greater than two times the width of a single trace, or three times its width measured from trace center to trace center. This increased separation effectively reduces the potential for crosstalk. The same rule should be applied to the separation between adjacent LVDS differential pairs, whether the traces are edge-coupled or broad-side-coupled.



**Figure 25. 3-W Rule for Single-Ended and Differential Traces (Top View)**

Exercise caution when using autorouters, because they do not always account for all factors affecting crosstalk and signal reflection. For instance, it is best to avoid sharp 90° turns to prevent discontinuities in the signal path. Using successive 45° turns tends to minimize reflections.

### 11.1.5 Crosstalk and Ground Bounce Minimization

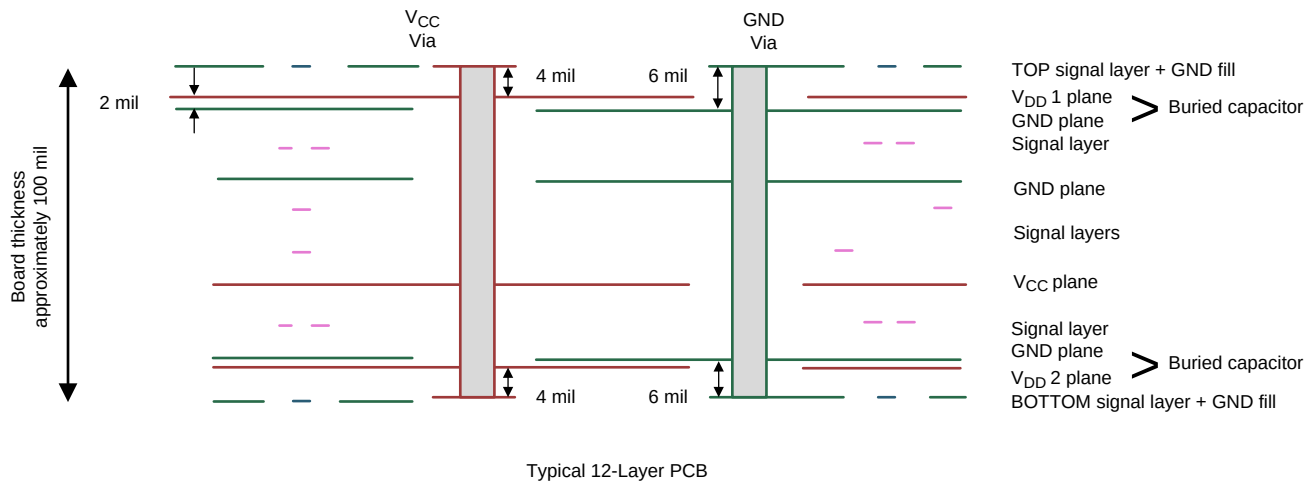
To reduce crosstalk, it is important to provide a return path to high-frequency currents that is as close to its originating trace as possible. A ground plane usually achieves this. Because the returning currents always choose the path of lowest inductance, they are most likely to return directly under the original trace, thus minimizing crosstalk. Lowering the area of the current loop lowers the potential for crosstalk. Traces kept as short as possible with an uninterrupted ground plane running beneath them emit the minimum amount of electromagnetic field strength. Discontinuities in the ground plane increase the return path inductance and should be avoided.

### 11.1.6 Decoupling

Each power or ground lead of a high-speed device should be connected to the PCB through a low inductance path. For best results, one or more vias are used to connect a power or ground pin to the nearby plane. TI recommends that the user place a via immediately adjacent to the pin to avoid adding trace inductance. Placing a power plane closer to the top of the board reduces the effective via length and its associated inductance.



## Layout Guidelines (continued)



**Figure 26. Low Inductance, High-Capacitance Power Connection**

Bypass capacitors should be placed close to  $V_{DD}$  pins. They can be placed conveniently near the corners or underneath the package to minimize the loop area. This extends the useful frequency range of the added capacitance. Small-physical-size capacitors, such as 0402 or even 0201, or X7R surface-mount capacitors should be used to minimize body inductance of capacitors. Each bypass capacitor is connected to the power and ground plane through vias tangent to the pads of the capacitor as shown in Figure 27(a).

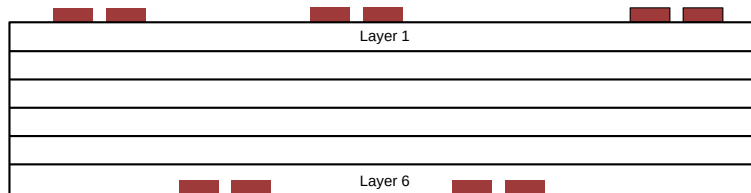
An X7R surface-mount capacitor of size 0402 has about 0.5 nH of body inductance. At frequencies above 30 MHz or so, X7R capacitors behave as low-impedance inductors. To extend the operating frequency range to a few hundred MHz, an array of different capacitor values like 100 pF, 1 nF, 0.03  $\mu$ F, and 0.1  $\mu$ F are commonly used in parallel. The most effective bypass capacitor can be built using sandwiched layers of power and ground at a separation of 2 to 3 mils. With a 2-mil FR4 dielectric, there is approximately 500 pF per square inch of PCB. Refer back to Figure 19 for some examples. Many high-speed devices provide a low-inductance GND connection on the backside of the package. This center dap must be connected to a ground plane through an array of vias. The via array reduces the effective inductance to ground and enhances the thermal performance of the small Surface Mount Technology (SMT) package. Placing vias around the perimeter of the dap connection ensures proper heat spreading and the lowest possible die temperature. Placing high-performance devices on opposing sides of the PCB using two GND planes (as shown in Figure 19) creates multiple paths for heat transfer. Often thermal PCB issues are the result of one device adding heat to another, resulting in a very high local temperature. Multiple paths for heat transfer minimize this possibility. In many cases the GND dap that is so important for heat dissipation makes the optimal decoupling layout impossible to achieve due to insufficient pad-to-dap spacing as shown in Figure 27(b). When this occurs, placing the decoupling capacitor on the backside of the board keeps the extra inductance to a minimum. It is important to place the  $V_{DD}$  via as close to the device pin as possible while still allowing for sufficient solder mask coverage. If the via is left open, solder may flow from the pad and into the via barrel. This will result in a poor solder connection.



**Figure 27. Typical Decoupling Capacitor Layouts**

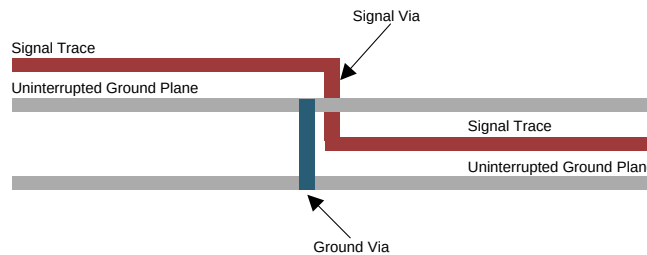
## Layout Guidelines (continued)

At least two or three times the width of an individual trace should separate single-ended traces and differential pairs to minimize the potential for crosstalk. Single-ended traces that run in parallel for less than the wavelength of the rise or fall times usually have negligible crosstalk. Increase the spacing between signal paths for long parallel runs to reduce crosstalk. Boards with limited real estate can benefit from the staggered trace layout, as shown in Figure 28.



**Figure 28. Staggered Trace Layout**

This configuration lays out alternating signal traces on different layers. Thus, the horizontal separation between traces can be less than 2 or 3 times the width of individual traces. To ensure continuity in the ground signal path, TI recommends having an adjacent ground via for every signal via, as shown in Figure 29. Note that vias create additional capacitance. For example, a typical via has a lumped capacitance effect of 1/2 pF to 1 pF in FR4.

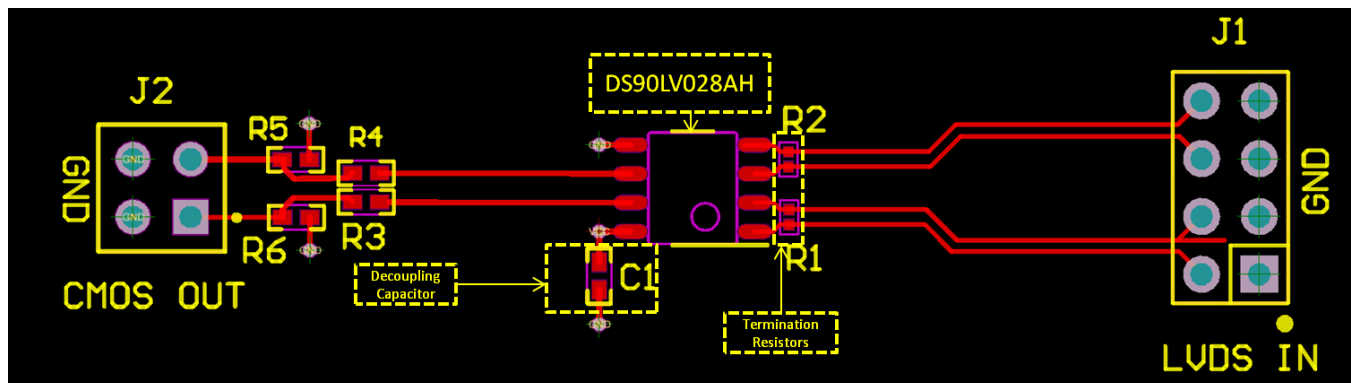


**Figure 29. Ground Via Location (Side View)**

Short and low-impedance connection of the device ground pins to the PCB ground plane reduces ground bounce. Holes and cutouts in the ground planes can adversely affect current return paths if they create discontinuities that increase returning current loop areas.

To minimize EMI problems, TI recommends avoiding discontinuities below a trace (for example, holes, slits, and so on) and keeping traces as short as possible. Zoning the board wisely by placing all similar functions in the same area, as opposed to mixing them together, helps reduce susceptibility issues.

## 11.2 Layout Example



**Figure 30. Example DS90LV028AH Layout**

## 12 デバイスおよびドキュメントのサポート

### 12.1 関連資料

関連資料については、以下を参照してください。

- 『LVDSオーナー・マニュアル』(SNLA187)
- 『AN-808、長い伝送ラインとデータ信号の品質』(SNLA028)
- 『AN-977、LVDS信号の品質: アイ・パターンを使用したジッタ測定のテスト・レポート #1』(SNLA166)
- 『AN-971、LVDSテクノロジーの概要』(SNLA165)
- 『AN-916、ケーブル選択の実践的ガイド』(SNLA219)
- 『AN-805、差動ライン・ドライバの消費電力の計算』(SNOA233)
- 『AN-903、差動終端技法の比較』(SNLA034)
- 『AN-1194、LVDSインターフェイスのフェイルセーフ・バイアス法』(SNLA051)

### 12.2 ドキュメントの更新通知を受け取る方法

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### 12.3 コミュニティ・リソース

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

**TI E2E™ オンライン・コミュニティ** TIのE2E ( *Engineer-to-Engineer* ) コミュニティ。エンジニア間の共同作業を促進するために開設されたものです。e2e.ti.comでは、他のエンジニアに質問し、知識を共有し、アイデアを検討して、問題解決に役立てることができます。

**設計サポート** TIの設計サポート 役に立つE2Eフォーラムや、設計サポート・ツールをすばやく見つけることができます。技術サポート用の連絡先情報も参照できます。

### 12.4 商標

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Rogers is a trademark of Rogers Corporation.  
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### 12.5 静電気放電に関する注意事項



すべての集積回路は、適切なESD保護方法を用いて、取扱いと保存を行うようにして下さい。

静電気放電はわずかな性能の低下から完全なデバイスの故障に至るまで、様々な損傷を与えます。高精度の集積回路は、損傷に対して敏感であり、極めてわずかなパラメータの変化により、デバイスに規定された仕様に適合しなくなる場合があります。

### 12.6 Glossary

**SLYZ022** — TI Glossary.

This glossary lists and explains terms, acronyms, and definitions.

## 13 メカニカル、パッケージ、および注文情報

以降のページには、メカニカル、パッケージ、および注文に関する情報が記載されています。この情報は、そのデバイスについて利用可能な最新のデータです。このデータは予告なく変更されることがあり、ドキュメントが改訂される場合もあります。本データシートのブラウザ版を使用されている場合は、画面左側の説明をご覧ください。

## PACKAGING INFORMATION

| Orderable part number              | Status<br>(1) | Material type<br>(2) | Package   Pins | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|------------------------------------|---------------|----------------------|----------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| <a href="#">DS90LV028AHM/NOPB</a>  | Active        | Production           | SOIC (D)   8   | 95   TUBE             | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | 90LV0<br>28AHM      |
| DS90LV028AHM/NOPB.B                | Active        | Production           | SOIC (D)   8   | 95   TUBE             | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | 90LV0<br>28AHM      |
| <a href="#">DS90LV028AHMX/NOPB</a> | Active        | Production           | SOIC (D)   8   | 2500   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | 90LV0<br>28AHM      |
| DS90LV028AHMX/NOPB.B               | Active        | Production           | SOIC (D)   8   | 2500   LARGE T&R      | Yes         | SN                                   | Level-1-260C-UNLIM                | -40 to 125   | 90LV0<br>28AHM      |

<sup>(1)</sup> **Status:** For more details on status, see our [product life cycle](#).

<sup>(2)</sup> **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

<sup>(3)</sup> **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

<sup>(4)</sup> **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

<sup>(5)</sup> **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

<sup>(6)</sup> **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

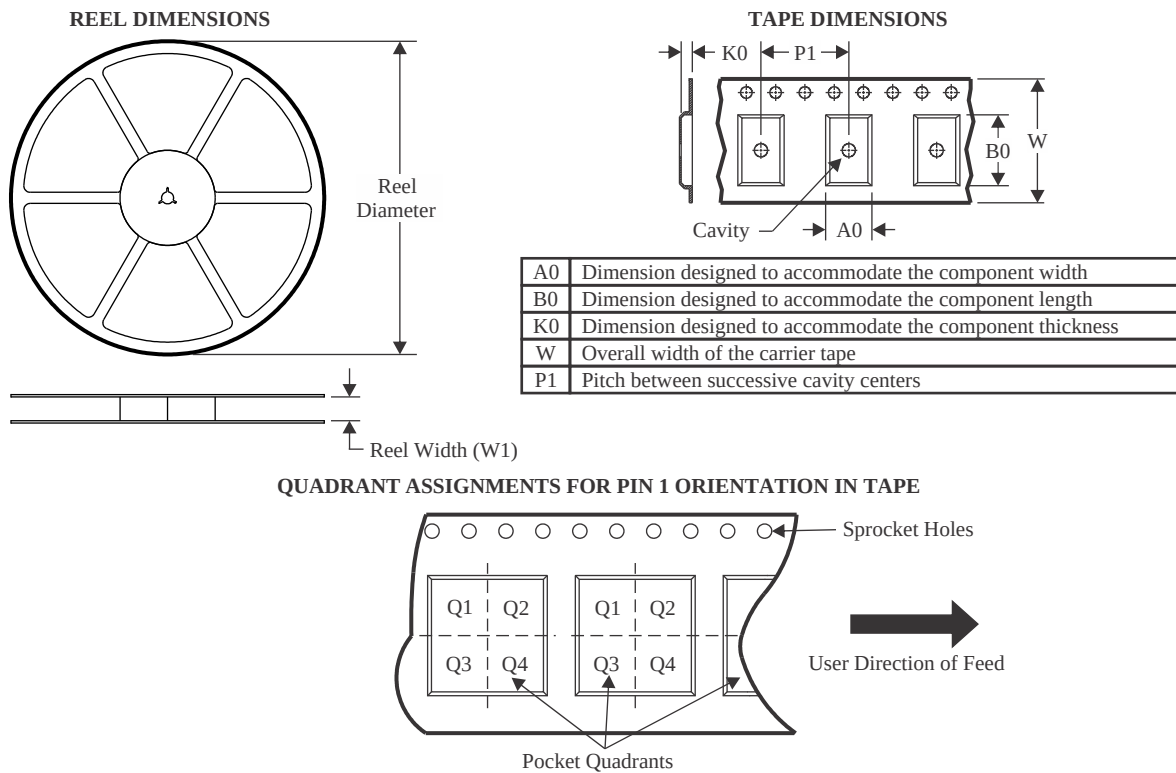
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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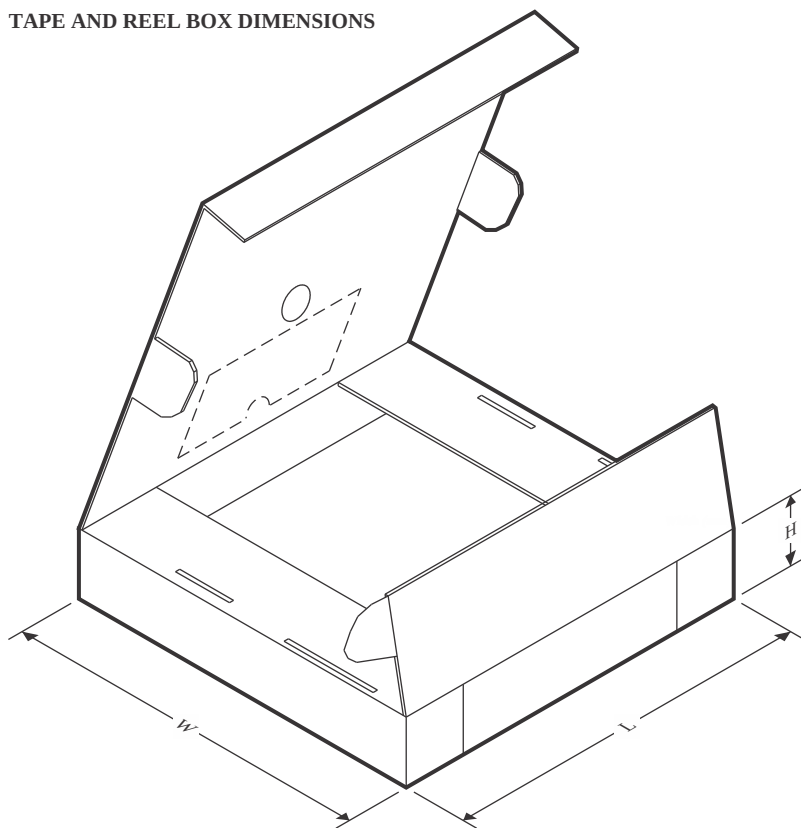
## TAPE AND REEL INFORMATION



\*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 |
|--------------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| DS90LV028AHMX/NOPB | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.5     | 5.4     | 2.0     | 8.0     | 12.0   | Q1            |

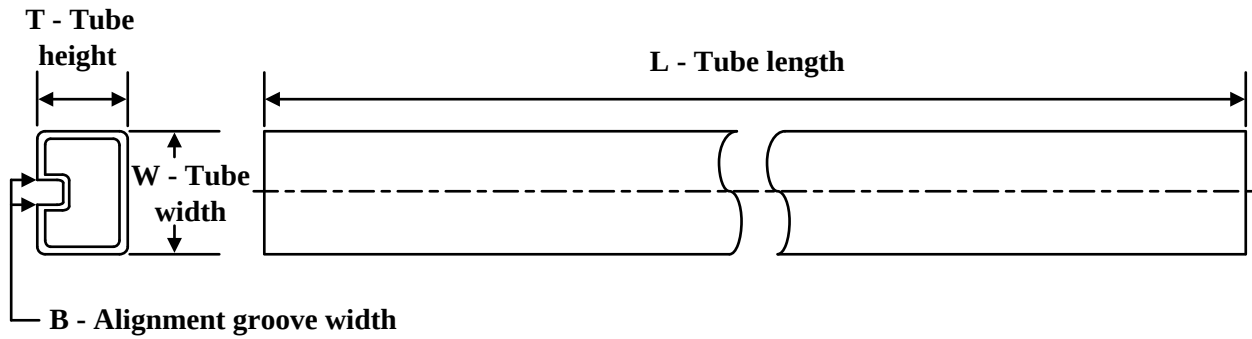
## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

| Device             | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|--------------------|--------------|-----------------|------|------|-------------|------------|-------------|
| DS90LV028AHMX/NOPB | SOIC         | D               | 8    | 2500 | 367.0       | 367.0      | 35.0        |

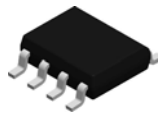
## TUBE



\*All dimensions are nominal

| Device              | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (μm) | B (mm) |
|---------------------|--------------|--------------|------|-----|--------|--------|--------|--------|
| DS90LV028AHM/NOPB   | D            | SOIC         | 8    | 95  | 495    | 8      | 4064   | 3.05   |
| DS90LV028AHM/NOPB.B | D            | SOIC         | 8    | 95  | 495    | 8      | 4064   | 3.05   |



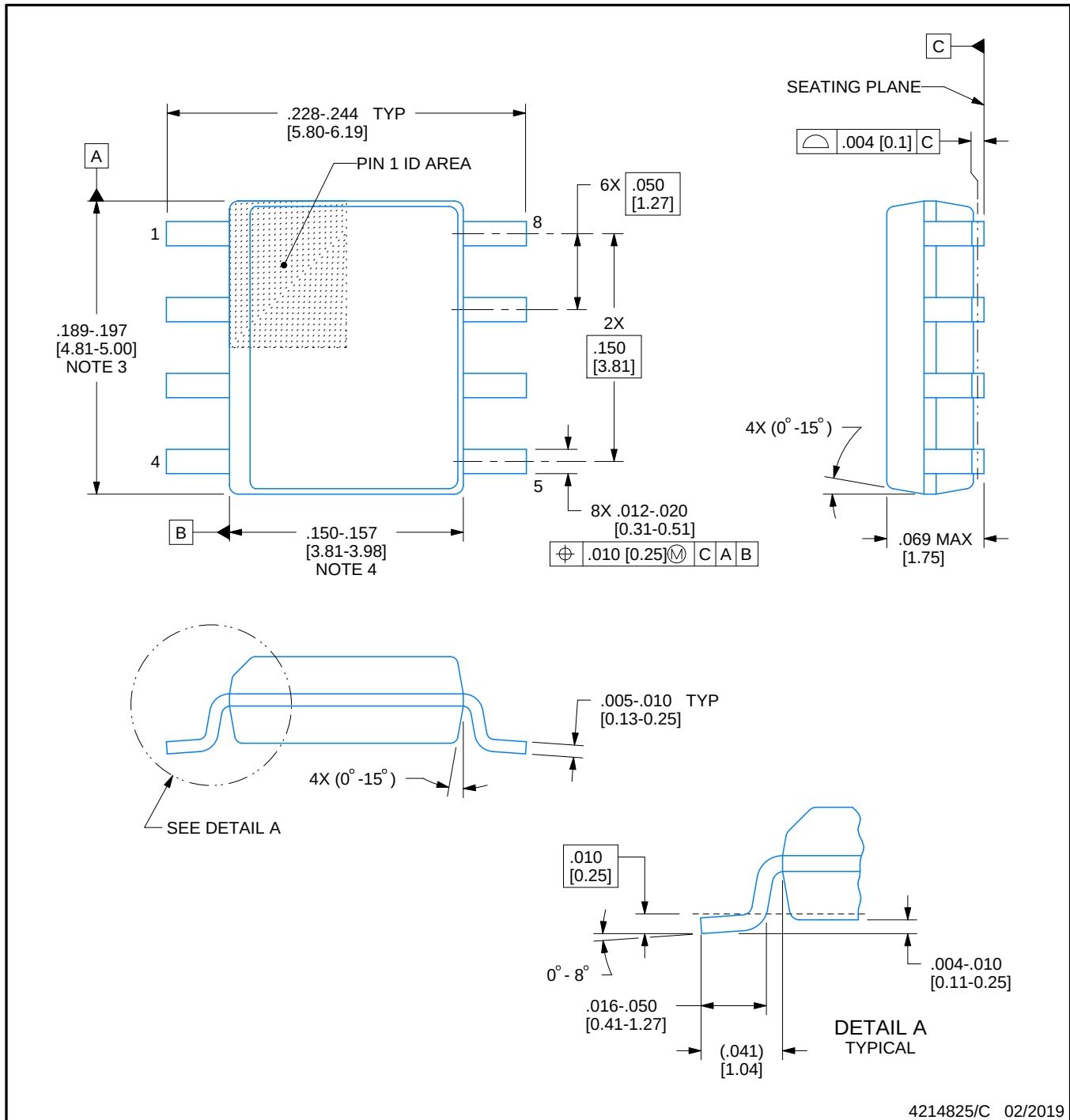


**D0008A**

# PACKAGE OUTLINE

**SOIC - 1.75 mm max height**

SMALL OUTLINE INTEGRATED CIRCUIT



4214825/C 02/2019

## NOTES:

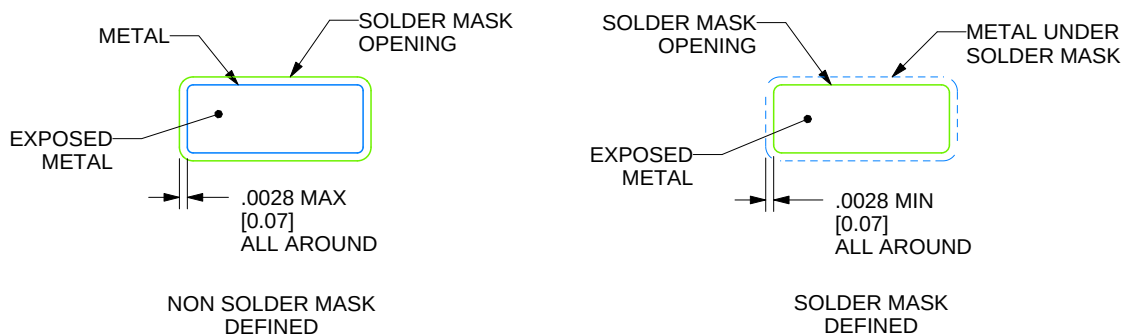
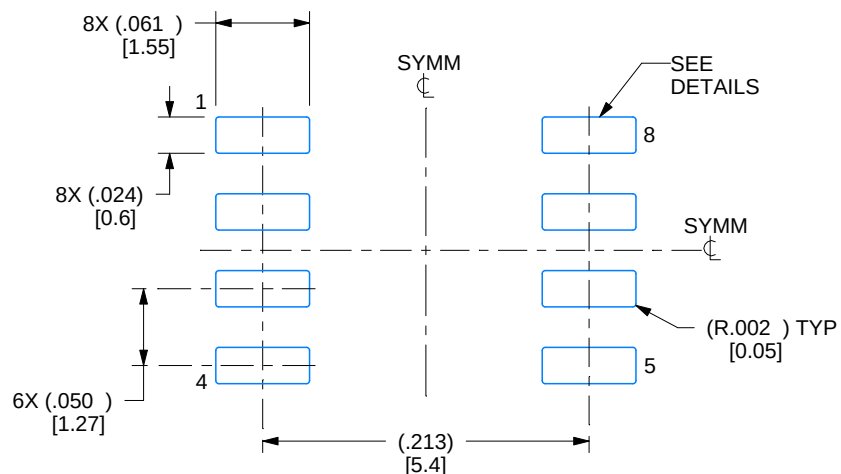
1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 [0.15] per side.
4. This dimension does not include interlead flash.
5. Reference JEDEC registration MS-012, variation AA.

# EXAMPLE BOARD LAYOUT

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



4214825/C 02/2019

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

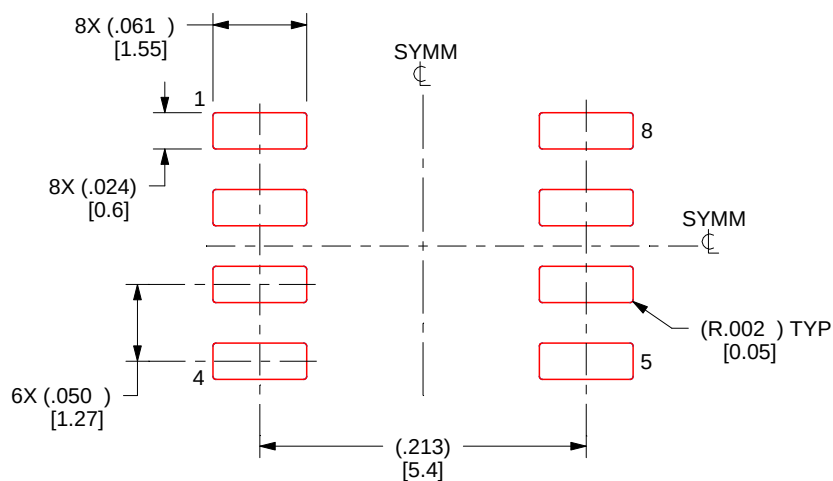
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

## EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE  
BASED ON .005 INCH [0.125 MM] THICK STENCIL  
SCALE:8X

4214825/C 02/2019

NOTES: (continued)

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

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