

## Low-Power, High-Speed Buffer for CCD Sensor

Check for Samples: [VSP1000](#)

### FEATURES

- **High Speed:**
  - **210 MHz, 3-dB Bandwidth**
- **Fast Settling Time**
- **Adjustable Active Load Current**
- **Adjustable Drive Strength**
- **Low Power: 20 mW**
- **Ultra-Small Package:**
  - **1-mm × 1-mm Ultra-Thin 0.35-mm QFN**

### DESCRIPTION

The VSP1000 is a high-speed, low-noise, low-power, fast-settling, unity-gain buffer. It is specially designed for use between charge-coupled device (CCD) sensors and analog front-ends (AFE). The device has an adjustable active load current that can load the CCD sensor output appropriately. The VSP1000 also features an adjustable output drive strength that can be set in accordance with the bandwidth requirements. At a 2-mA drive current, the device provides a bandwidth of 210 MHz, which allows for very low power operation with good performance. An ultra-small package of 1 mm × 1 mm and 0.35-mm height helps in saving printed circuit board (PCB) space and achieving a very low profile.

The VSP1000 is ideal for driving Texas Instruments AFEs for CCD sensors and, in general, any analog-to-digital converter (ADC) inputs. The adjustable load current allows for easy interfacing with a variety of CCD sensors from various manufacturers.



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This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

### PACKAGE/ORDERING INFORMATION<sup>(1)</sup>

| PRODUCT | PACKAGE-LEAD | PACKAGE DESIGNATOR | SPECIFIED TEMPERATURE RANGE | PACKAGE MARKING | ORDERING NUMBER | TRANSPORT MEDIA, QUANTITY |
|---------|--------------|--------------------|-----------------------------|-----------------|-----------------|---------------------------|
| VSP1000 | QFN-6        | DSF                | 0°C to +85°C                | VSP1000DSF      | VSP1000DSFT     | Tape and Reel, 250        |
|         |              |                    |                             |                 | VSP1000DSFR     | Tape and Reel, 5000       |

- (1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or visit the device product folder at [www.ti.com](http://www.ti.com).

### ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

Over free-air temperature range, unless otherwise noted.

|                                       |                         | VSP1000           | UNIT |
|---------------------------------------|-------------------------|-------------------|------|
| Supply voltage                        | VCC                     | 20.0              | V    |
| Input voltage                         |                         | -0.3 to VCC + 0.3 | V    |
| Input current                         | Any pin except supplies | ±10               | mA   |
| Ambient temperature under bias        |                         | -25 to +85        | °C   |
| Storage temperature                   |                         | -55 to +125       | °C   |
| Junction temperature                  |                         | +150              | °C   |
| Package temperature (IR reflow, peak) |                         | +250              | °C   |

- (1) Stresses beyond those listed under *absolute maximum ratings* may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under *recommended operating conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

## ELECTRICAL CHARACTERISTICS

All specifications at  $T_A = +25^\circ\text{C}$ ,  $V_{CC} = 13\text{ V}$ ,  $R_{IDRV} = 90\text{ k}\Omega$ , and  $C_{LOAD} = 22\text{ pF}$ , unless otherwise noted.

| PARAMETER                  | TEST CONDITIONS                         | VSP1000 |       |      | UNIT |
|----------------------------|---|---------|-------|------|------|
|                            |   | MIN     | TYP   | MAX  |      |
| <b>POWER SUPPLY</b>        |   |         |       |      |      |
| $V_{CC}$                   | Supply voltage                          | 10      | 13    | 16   | V    |
| $I_{CC}$                   | Supply current                          |         | 2     |      | mA   |
| <b>DYNAMIC PERFORMANCE</b> |   |         |       |      |      |
| Gain                       | 1-MHz, 200-mV <sub>PP</sub> input       |         | 0.999 |      | ns   |
| Rise time                  | $V_{IN} = 7.5\text{ V to }8.5\text{ V}$ |         | 5     |      | ns   |
| Fall time                  | $V_{IN} = 8.5\text{ V to }7.5\text{ V}$ |         | 6     |      | ns   |
| I/O delay time             | $V_{IN} = 7.5\text{ V to }8.5\text{ V}$ |         | 1.28  |      | ns   |
| –3-dB bandwidth            | 100-mV <sub>PP</sub> input              |         | 210   |      | MHz  |
| $V_{IN}$                   | Input voltage range                     | 1.5     |       | 10.5 | V    |
| $T_A$                      | Operating free-air temperature          | 0       |       | +85  | °C   |

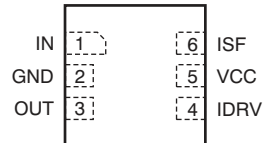
## THERMAL INFORMATION

| THERMAL METRIC <sup>(1)</sup> |  | VSP1000 | UNITS |
|-------------------------------|--|---------|-------|
|                               |  | DSF     |       |
|                               |  | 6 PINS  |       |
| $\theta_{JA}$                 | Junction-to-ambient thermal resistance       | 333.2   | °C/W  |
| $\theta_{JCTop}$              | Junction-to-case (top) thermal resistance    | 56.9    |       |
| $\theta_{JB}$                 | Junction-to-board thermal resistance         | 239     |       |
| $\Psi_{JT}$                   | Junction-to-top characterization parameter   | 13.9    |       |
| $\Psi_{JB}$                   | Junction-to-board characterization parameter | 236     |       |
| $\theta_{JCbott}$             | Junction-to-case (bottom) thermal resistance | 202     |       |

(1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, [SPRA953](#).

## PIN CONFIGURATION

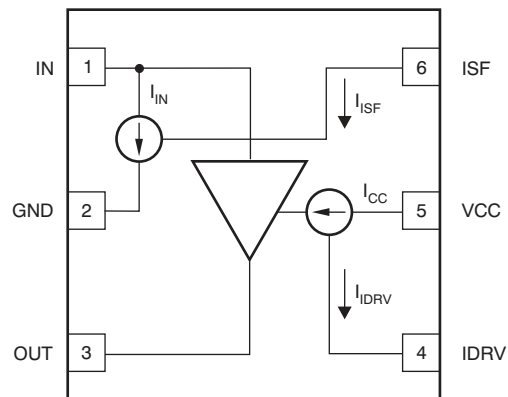
**DSF PACKAGE**  
**1-mm × 1-mm × 0.35-mm QFN-6**  
**(TOP VIEW)**



## PIN ASSIGNMENTS

| PIN NAME | PIN NUMBER | TYPE          | DESCRIPTION   |
|----------|------------|---------------|---|
| IN       | 1          | Analog input  | Input terminal; connect this pin to the sensor output   |
| VEE      | 2          | Ground        | Negative supply terminal; must be connected to ground   |
| OUT      | 3          | Analog output | Output terminal; connect this pin to the AFE input  |
| IDRV     | 4          | Analog input  | Drive current adjustment; refer to the application diagram for further details                |
| VCC      | 5          | Power         | Positive supply terminal; must be decoupled to the VEE terminal with a 0.1- $\mu$ F capacitor |
| ISF      | 6          | Analog input  | Sink current adjustment; refer to the application diagram for further details                 |

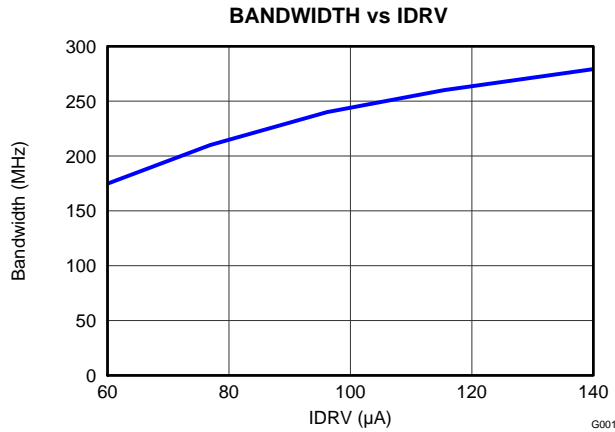
## FUNCTIONAL BLOCK DIAGRAM



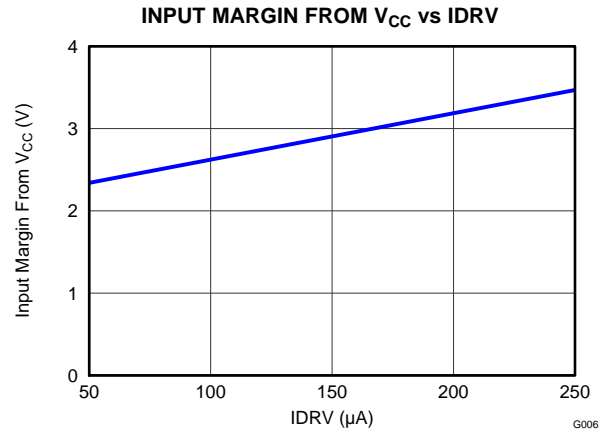
**Figure 1. Block Diagram**

**TYPICAL CHARACTERISTICS**

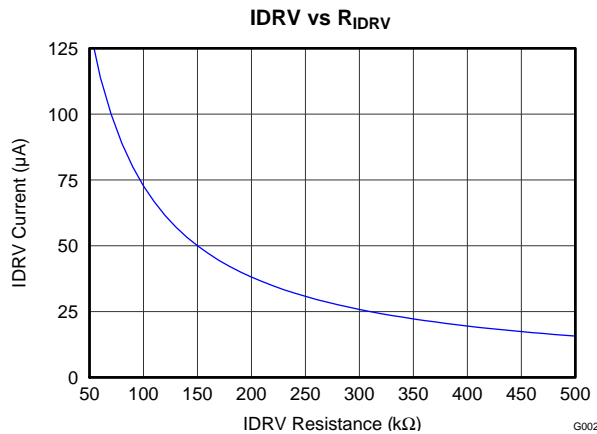
At  $T_A = +25^\circ\text{C}$ ,  $V_{CC} = 13\text{ V}$ ,  $R_{IDRV} = 90\text{ k}\Omega$ ,  $R_{ISF} = 300\text{ k}\Omega$ , and  $C_{LOAD} = 22\text{ pF}$ , unless otherwise noted.



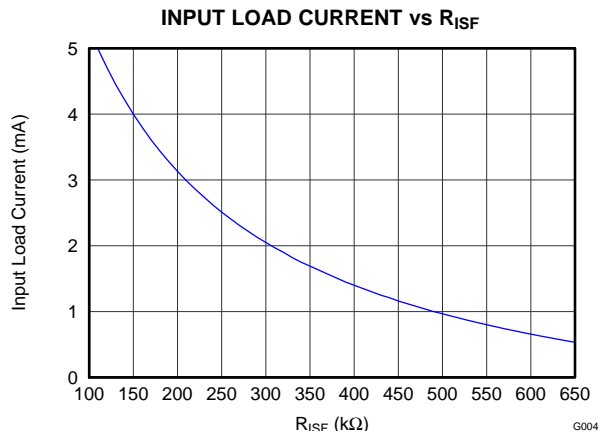
**Figure 2.**



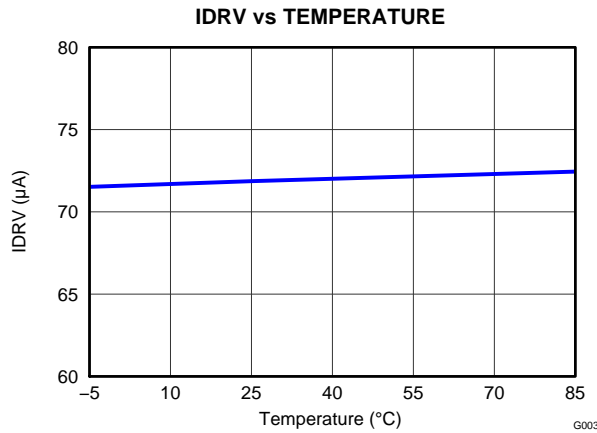
**Figure 3.**



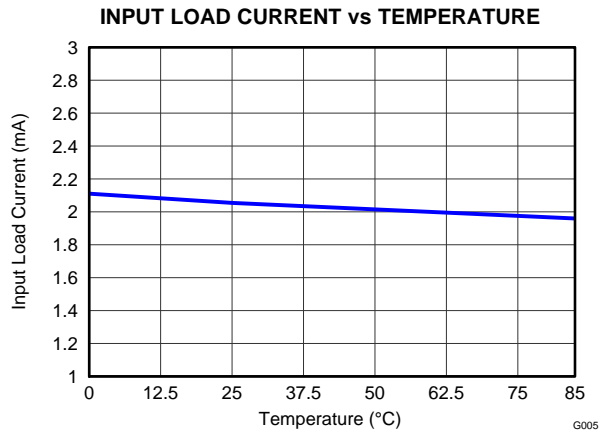
**Figure 4.**



**Figure 5.**



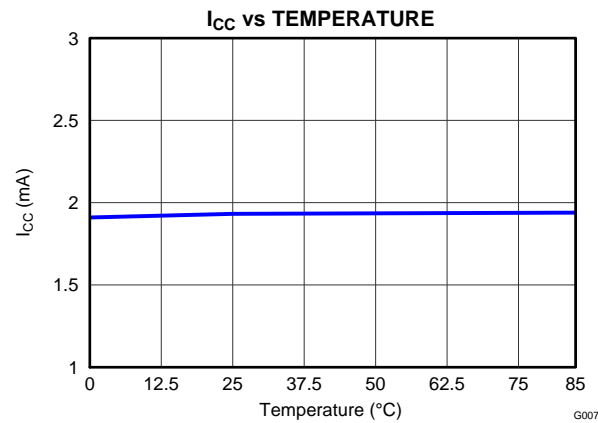
**Figure 6.**



**Figure 7.**

### TYPICAL CHARACTERISTICS (continued)

At  $T_A = +25^\circ\text{C}$ ,  $V_{CC} = 13\text{ V}$ ,  $R_{IDRV} = 90\text{ k}\Omega$ ,  $R_{ISF} = 300\text{ k}\Omega$ , and  $C_{LOAD} = 22\text{ pF}$ , unless otherwise noted.



## OVERVIEW

### TYPICAL APPLICATION CIRCUIT

Figure 9 shows a typical application circuit for the VSP1000.

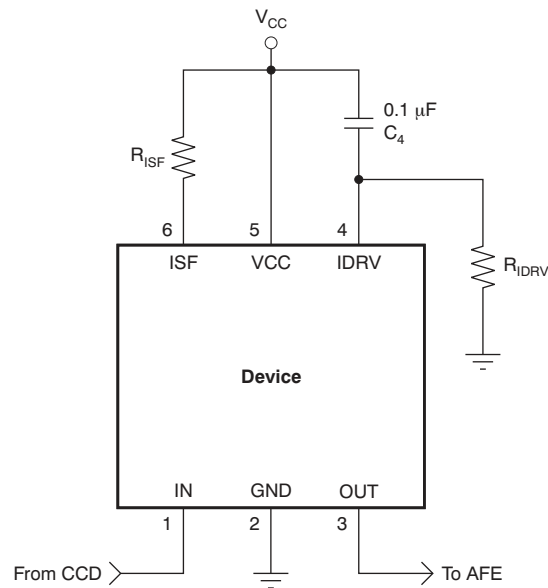


Figure 9. Typical Application Circuit

## DESIGN EQUATIONS

The CCD outputs must be loaded with current for proper operation. The VSP1000 provides the ability to draw adjustable current through the IN pin. The value of the input load current can be set by choosing an appropriate value of  $R_{ISF}$  connected to the ISF pin, as per [Equation 1](#).

$$I_{IN} = \frac{\left( \frac{V_{CC} \times 100 \text{ k}\Omega}{R_{ISF} + 100 \text{ k}\Omega} \right) - 1.2}{1 \text{ k}\Omega} \quad (1)$$

The bandwidth of the VSP1000 can be adjusted using the IDRV pin. The resistor connected at IDRV determines the drive strength of the output buffer as well as the total quiescent current of the VSP1000. [Equation 2](#) and [Equation 3](#) describe the relationship between  $R_{IDRV}$  and the drive strength.  $C_{IDRV}$  is used to increase the power-supply rejection ratio of the device. A value of 0.1  $\mu\text{F}$  for  $C_{IDRV}$  is recommended.

$$I_{DRV} = \frac{(V_{CC} - 5)}{(R_{IDRV} + 10 \text{ k}\Omega)} \quad (2)$$

$$I_{CC} = 26 \times I_{DRV} \quad (3)$$

## EXAMPLE CONFIGURATIONS

[Table 1](#) details several example configurations for the VSP1000. All examples are with  $V_{CC} = 13 \text{ V}$ .

**Table 1. Example Configurations**

| CONFIGURATION                                 | $I_{CC}$ (mA) | $R_{ISF}$ (k $\Omega$ ) | $R_{IDRV}$ (k $\Omega$ ) |
|---|---------------|-------------------------|--------------------------|
| Bandwidth = 170 MHz , $I_{IN} = 2 \text{ mA}$ | 1.5           | 300                     | 133                      |
| Bandwidth = 170 MHz , $I_{IN} = 4 \text{ mA}$ | 1.5           | 150                     | 133                      |
| Bandwidth = 210 MHz , $I_{IN} = 2 \text{ mA}$ | 2             | 300                     | 91                       |
| Bandwidth = 210 MHz , $I_{IN} = 4 \text{ mA}$ | 2             | 150                     | 91                       |
| Bandwidth = 260 MHz , $I_{IN} = 2 \text{ mA}$ | 3             | 300                     | 62                       |
| Bandwidth = 260 MHz , $I_{IN} = 4 \text{ mA}$ | 3             | 150                     | 62                       |

## LAYOUT GUIDELINES

The decoupling capacitors  $C_{IDRV}$ ,  $R_{IDRV}$ , and  $R_{ISF}$  should be placed as close as possible to the VSP1000.

### REVISION HISTORY

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| Changes from Original (September 2011) to Revision A | Page |
|--|------|
| • Updated <a href="#">Figure 4</a> .....             | 5    |
| • Updated <a href="#">Figure 5</a> .....             | 5    |



**PACKAGING INFORMATION**

| Orderable Device | Status<br>(1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan<br>(2) | Lead finish/<br>Ball material<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|-----------------|------|-------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| VSP1000DSFR      | ACTIVE        | SON          | DSF             | 6    | 5000        | RoHS & Green    | NIPDAU   NIPDAUAG                    | Level-1-260C-UNLIM   | 0 to 85      | VK                      | <a href="#">Samples</a> |
| VSP1000DSFT      | ACTIVE        | SON          | DSF             | 6    | 250         | RoHS & Green    | NIPDAU   NIPDAUAG                    | Level-1-260C-UNLIM   | 0 to 85      | VK                      | <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 finish/Ball material - Orderable Devices 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.

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**TAPE AND REEL INFORMATION**

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**


\*All dimensions are nominal

| Device      | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|-------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| VSP1000DSFR | SON          | DSF             | 6    | 5000 | 180.0              | 9.5                | 1.16    | 1.16    | 0.63    | 4.0     | 8.0    | Q2            |
| VSP1000DSFT | SON          | DSF             | 6    | 250  | 180.0              | 9.5                | 1.16    | 1.16    | 0.63    | 4.0     | 8.0    | Q2            |

**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

| Device      | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|-------------|--------------|-----------------|------|------|-------------|------------|-------------|
| VSP1000DSFR | SON          | DSF             | 6    | 5000 | 184.0       | 184.0      | 19.0        |
| VSP1000DSFT | SON          | DSF             | 6    | 250  | 184.0       | 184.0      | 19.0        |

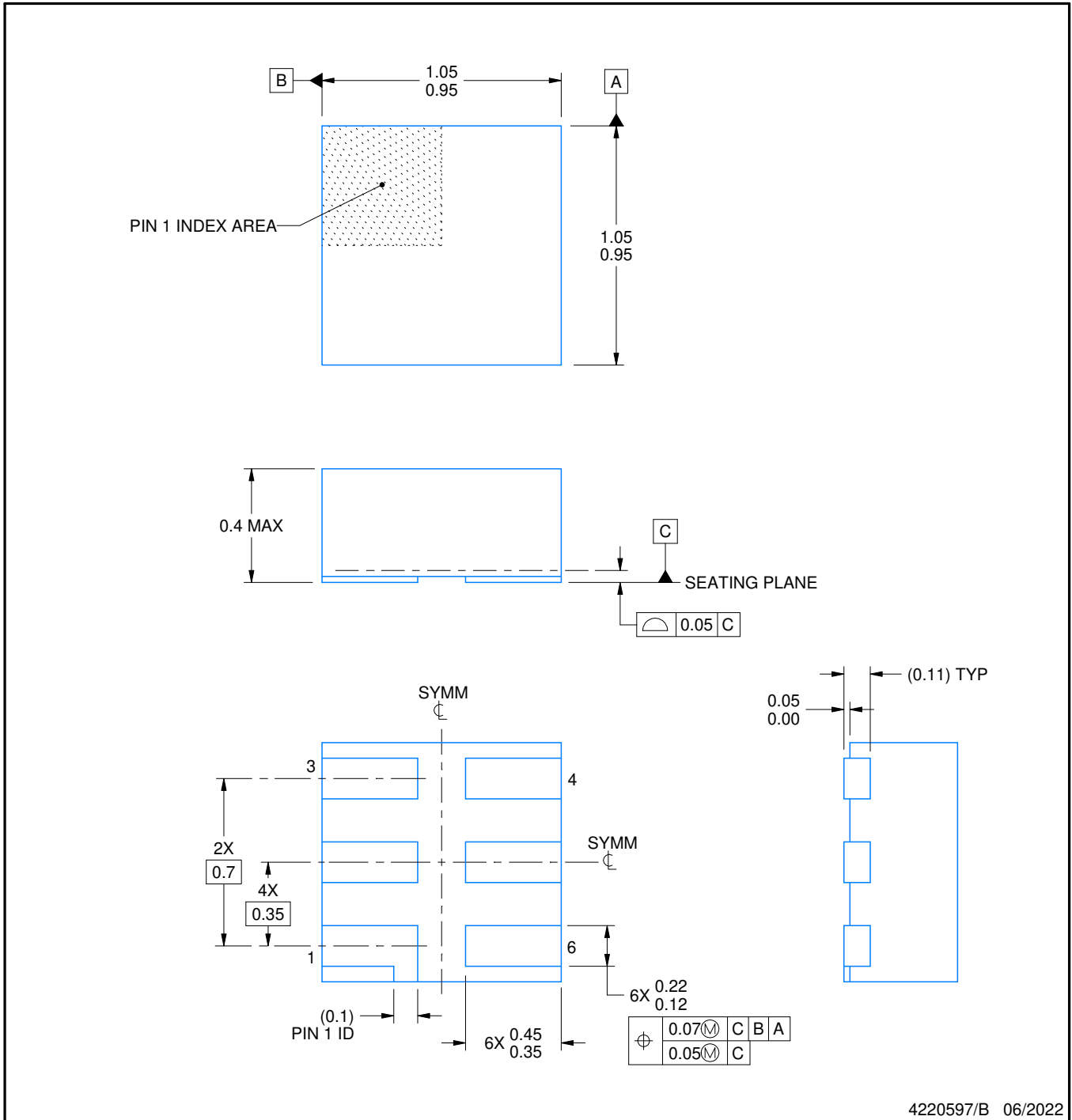


# DSF0006A

# PACKAGE OUTLINE

## X2SON - 0.4 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



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### NOTES:

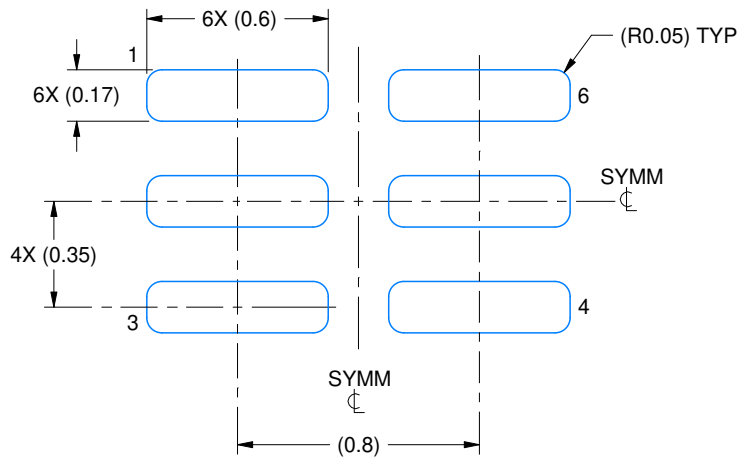
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Reference JEDEC registration MO-287, variation X2AAF.

# EXAMPLE BOARD LAYOUT

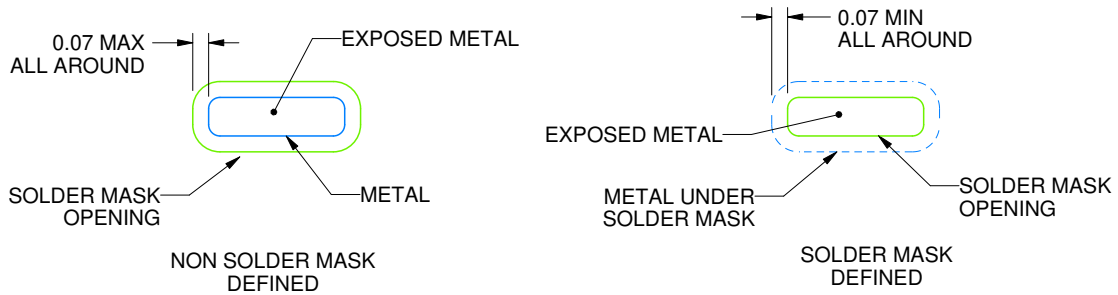
DSF0006A

X2SON - 0.4 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:40X



SOLDER MASK DETAILS

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NOTES: (continued)

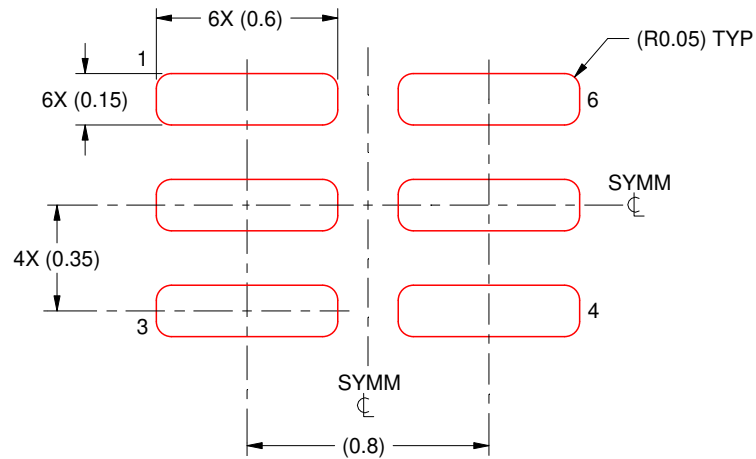
4. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/slua271](http://www.ti.com/lit/slua271)).

# EXAMPLE STENCIL DESIGN

DSF0006A

X2SON - 0.4 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



SOLDER PASTE EXAMPLE  
BASED ON 0.09 mm THICK STENCIL

PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE  
SCALE:40X

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4. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

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