TLVx333 2-µV V_{OS}, 0.02-µV/°C, 17-µA, CMOS Operational Amplifiers Zero-Drift Series

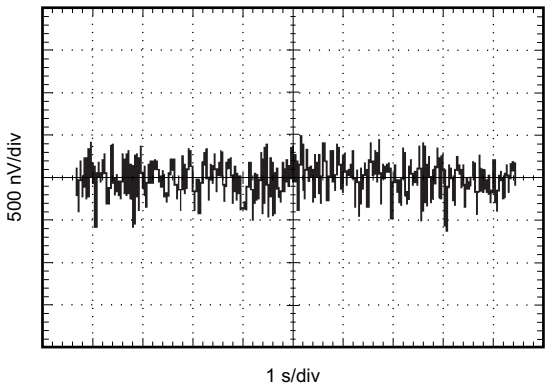
1 Features

- Unmatched Price Performance
- Low Offset Voltage: 2 µV
- Zero Drift: 0.02 µV/°C
- Low Noise: 1.1 μV_{PP}, 0.1 Hz to 10 Hz
- Quiescent Current: 17 µA
- Supply Voltage: 1.8 V to 5.5 V
- Rail-to-Rail Input/Output
- Internal EMI Filtering
- *micro*Size Packages: SOT23, SC70

2 Applications

- Battery-Powered Instruments
- Temperature Measurements
- Transducer Applications
- Electronic Scales
- Medical Instrumentation
- Handheld Test Equipment
- Current Sense

0.1-Hz to 10-Hz Noise



3 Description

The TLVx333 series of CMOS operational amplifiers offer precision performance at a very competitive price. These devices are members of the *zero-drift* family of amplifiers that uses a proprietary auto-calibration technique to simultaneously provide low offset voltage (15 µV, max) and near-zero drift over time and temperature at only 28 µA (max) of quiescent current. The TLVx333 family features rail-to-rail input and output in addition to near-flat 1/f noise, making this amplifier ideal for many applications and much easier to design into a system. These devices are optimized for low-voltage operation as low as 1.8 V (±0.9 V) and up to 5.5 V (±2.75 V).

The TLV333 (single version) is available in the SC70-5, SOT23-5, and SOIC-8 packages. The TLV2333 (dual version) is offered in VSSOP-8 and SOIC-8 packages. The TLV4333 is offered in the standard SOIC-14 and TSSOP-14 packages. All versions are specified for operation from –40°C to +125°C.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
TLV333	SOIC (8)	4.90 mm × 3.91 mm
	SOT-23 (5)	2.90 mm × 1.60 mm
	SC70 (5)	2.00 mm × 1.25 mm
TLV2333	SOIC (8)	4.90 mm × 3.91 mm
	VSSOP (8)	3.00 mm × 3.00 mm
TLV4333	SOIC (14)	8.65 mm × 3.91
	TSSOP (14)	5.00 mm × 4.40 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. PRODUCTION DATA.

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4 Revision History

DATE	REVISION	NOTES
December 2015	*	Initial release.

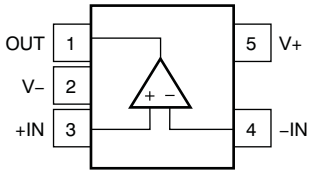
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5 Device Comparison Table

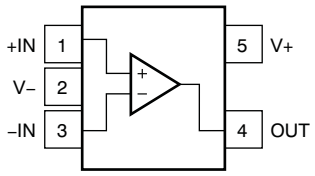
DEVICE	NO. OF CHANNELS	PACKAGE-LEADS				
		SOIC	SOT23	SC70	VSSOP	TSSOP
TLV333	1	8	5	5	—	—
TLV2333	2	8	—	—	8	—
TLV4333	4	14	—	—	—	14

6 Pin Configuration and Functions

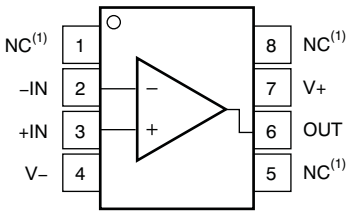
DBV Package: TLV333
5-Pin SOT23
Top View



DCK Package: TLV333
5-Pin SC70
Top View



D Package: TLV333
8-Pin SOIC
Top View



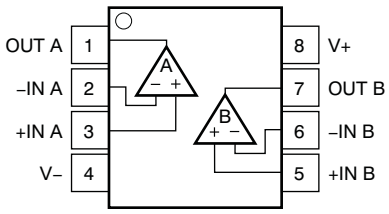
(1) NC denotes no internal connection.

Pin Functions: TLV333

NAME	PIN NO.			I/O	DESCRIPTION
	DBV (SOT23)	DCK (SC70)	D (SOIC)		
–IN	4	3	2	I	Inverting input
+IN	3	1	3	I	Noninverting input
NC	—	—	1, 5, 8	—	No internal connection (can be left floating)
OUT	1	4	6	O	Output
V–	2	2	4	—	Negative (lowest) power supply
V+	5	5	7	—	Positive (highest) power supply

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D Package: TLV2333
8-Pin SOIC, VSSOP
Top View

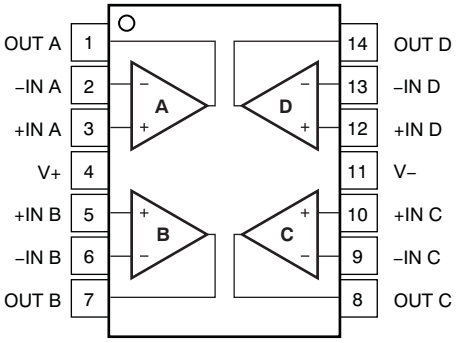


Pin Functions: TLV2333

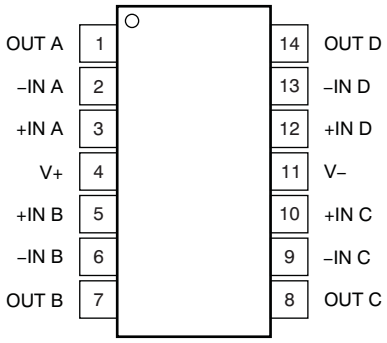
PIN		I/O	DESCRIPTION
NAME	NO. D (SOIC, VSSOP)		
–IN A	2	I	Inverting input, channel A
+IN A	3	I	Noninverting input, channel A
–IN B	6	I	Inverting input, channel B
+IN B	5	I	Noninverting input, channel B
OUT A	1	O	Output, channel A
OUT B	7	O	Output, channel B
V–	4	—	Negative (lowest) power supply
V+	8	—	Positive (highest) power supply

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D Package: TLV4333
14-Pin SOIC
Top View



PW Package: TLV4333
14-Pin TSSOP
Top View



Pin Functions: TLV4333

PIN			I/O	DESCRIPTION
NAME	NO.			
	D (SOIC)	PW (TSSOP)		
–IN A	2	2	I	Inverting input, channel A
+IN A	3	3	I	Noninverting input, channel A
–IN B	6	6	I	Inverting input, channel B
+IN B	5	5	I	Noninverting input, channel B
–IN C	9	9	I	Inverting input, channel C
+IN C	10	10	I	Noninverting input, channel C
–IN D	13	13	I	Inverting input, channel D
+IN D	12	12	I	Noninverting input, channel D
OUT A	1	1	O	Output, channel A
OUT B	7	7	O	Output, channel B
OUT C	8	8	O	Output, channel C
OUT D	14	14	O	Output, channel D
V–	11	11	—	Negative (lowest) power supply
V+	4	4	—	Positive (highest) power supply

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7 Specifications

7.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)

		MIN	MAX	UNIT
Supply voltage	V_S = (V+) – (V–)		7	V
Signal input pins(2)	Voltage	(V–) –0.3	(V+) + 0.3	V
	Current	–10	10	mA
Output short-circuit(3)		Continuous		
Temperature	Operating	–40	150	°C
	Junction		150	
	Storage, T_{stg}	–65	150	

(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) Input pins are diode-clamped to the power-supply rails. Input signals that can swing more than 0.3 V beyond the supply rails must be current limited to 10 mA or less.
(3) Short-circuit to ground, one amplifier per package.

7.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(1)	±4000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101(2)	±1000	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

7.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
V_S	Supply voltage	1.8		5.5	V
	Specified temperature range	–40		125	°C

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7.4 Thermal Information: TLV333

THERMAL METRIC(1)		TLV333			UNIT
		D (SOIC)	DBV (SOT23)	DCK (SC70)	
		8 PINS	5 PINS	5 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	140.1	220.8	298.4	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	89.8	97.5	65.4	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	80.6	61.7	97.1	°C/W
ψ_{JT}	Junction-to-top characterization parameter	28.7	7.6	0.8	°C/W
ψ_{JB}	Junction-to-board characterization parameter	80.1	61.1	95.5	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	n/a	n/a	n/a	°C/W

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

7.5 Thermal Information: TLV2333

THERMAL METRIC(1)		TLV2333		UNIT
		D (SOIC)	DGK (VSSOP)	
		8 PINS	8 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	124.0	180.3	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	73.7	48.1	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	64.4	100.9	°C/W
ψ_{JT}	Junction-to-top characterization parameter	18.0	2.4	°C/W
ψ_{JB}	Junction-to-board characterization parameter	63.9	99.3	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	n/a	n/a	°C/W

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

7.6 Thermal Information: TLV4333

THERMAL METRIC(1)		TLV4333		UNIT
		D (SOIC)	PW (TSSOP)	
		14 PINS	14 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	83.8	120.8	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	70.7	34.3	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	59.5	62.8	°C/W
ψ_{JT}	Junction-to-top characterization parameter	11.6	1.0	°C/W
ψ_{JB}	Junction-to-board characterization parameter	37.7	56.5	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	n/a	n/a	°C/W

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

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7.7 Electrical Characteristics: V_S = 1.8 V to 5.5 V

at T_A = 25°C, R_L = 10 kΩ connected to mid-supply, and V_{CM} = V_{OUT} = mid-supply (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
OFFSET VOLTAGE						
V_{OS}	Input offset voltage (1)	V_S = 5 V		2	15	µV
dV_{OS}/dT	V_{OS} vs temperature	T_A = –40°C to +125°C		0.02		µV/°C
PSRR	V_{OS} vs power supply	V_S = 1.8 V to 5.5 V		1	8	µV/V
	Long-term stability (2)			1 (2)		µV
	Channel separation, dc			0.1		µV/V
INPUT BIAS CURRENT						
I_B	Input bias current			±70		pA
	Input bias current over temperature	T_A = –40°C to +125°C		±150		pA
I_{OS}	Input offset current			±140		pA
NOISE						
e_n	Input voltage noise density	f = 1 kHz		55		nV/√Hz
	Input voltage noise	f = 0.01 Hz to 1 Hz		0.3		$µV_{PP}$
		f = 0.1 Hz to 10 Hz		1.1		
i_n	Input current noise	f = 10 Hz		100		fA/√Hz
INPUT VOLTAGE RANGE						
V_{CM}	Common-mode voltage range		(V–) – 0.1		(V+) + 0.1	V
CMRR	Common-mode rejection ratio	(V–) – 0.1 V < V_{CM} < (V+) + 0.1 V	102	115		dB
INPUT CAPACITANCE						
	Differential			2		pF
	Common-mode			4		
OPEN-LOOP GAIN						
A_{OL}	Open-loop voltage gain	(V–) + 0.1 V< V_O < (V+) – 0.1 V	102	130		dB
FREQUENCY RESPONSE						
GBW	Gain-bandwidth product	C_L = 100 pF		350		kHz
SR	Slew rate	G = 1		0.16		V/µs
OUTPUT						
	Voltage output swing from rail	T_A = –40°C to +125°C		30	70	mV
I_{SC}	Short-circuit current			±5		mA
C_L	Capacitive load drive		See *Typical Characteristics*			
Z_O	Open-loop output impedance	f = 350 kHz, I_O = 0 mA		2		kΩ
POWER SUPPLY						
V_S	Specified voltage range		1.8		5.5	V
I_Q	Quiescent current per amplifier	I_O = 0 mA, T_A = –40°C to +125°C		17	28	µA
	Turn-on time	V_S = 5 V		100		µs
TEMPERATURE RANGE						
	Specified range		–40		125	°C
	Operating range		–40		150	°C
	Storage range		–65		150	°C

(1) Specified by design and characterization. Amplifiers are 100% production screened at 25°C to reduce defective units.
(2) 300-hour life test at 150°C demonstrated randomly distributed variation of approximately 1 µV.

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7.8 Typical Characteristics

at T_A = 25°C, C_L = 0 pF, R_L = 10 kΩ connected to mid-supply, V_{CM} = V_{OUT} = mid-supply (unless otherwise noted)

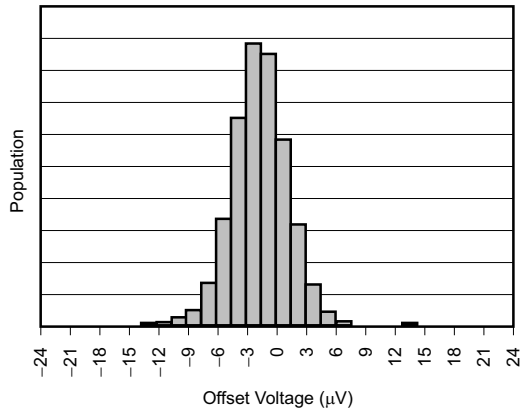


Figure 1. Offset Voltage Production Distribution

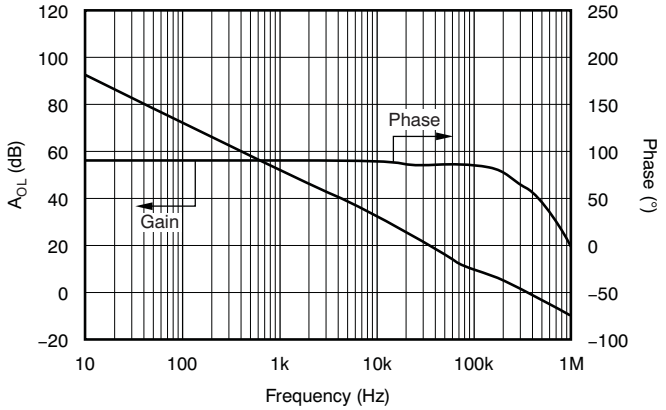


Figure 2. Open-Loop Gain vs Frequency

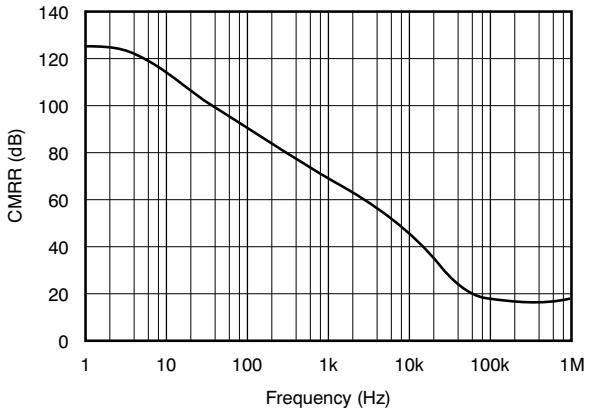


Figure 3. Common-Mode Rejection Ratio vs Frequency

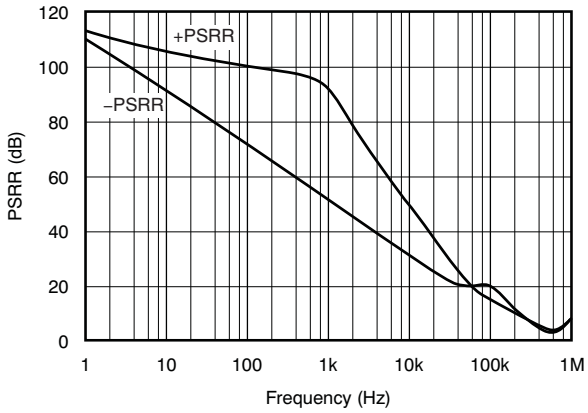


Figure 4. Power-Supply Rejection Ratio vs Frequency

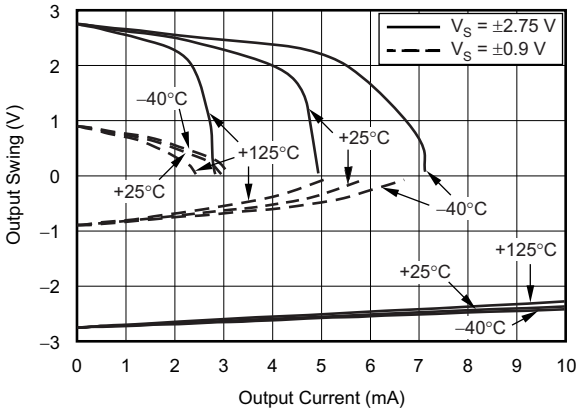


Figure 5. Output Voltage Swing vs Output Current

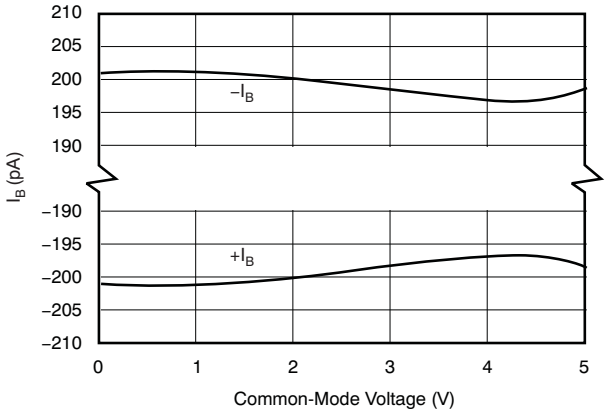


Figure 6. Input Bias Current vs Common-Mode Voltage

Typical Characteristics (continued)

at T_A = 25°C, C_L = 0 pF, R_L = 10 kΩ connected to mid-supply, V_{CM} = V_{OUT} = mid-supply (unless otherwise noted)

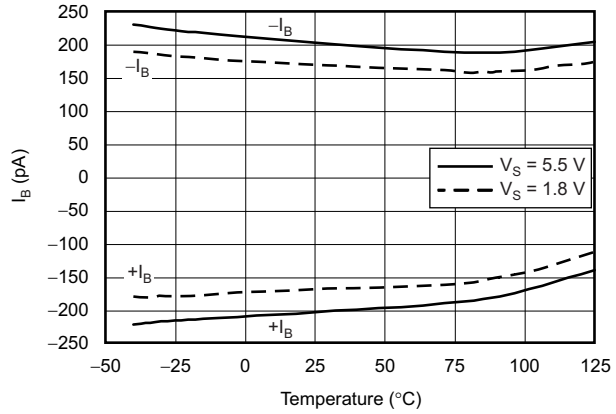


Figure 7. Input Bias Current vs Temperature

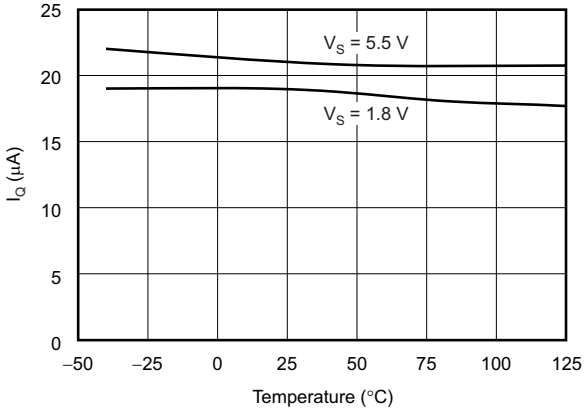


Figure 8. Quiescent Current vs Temperature

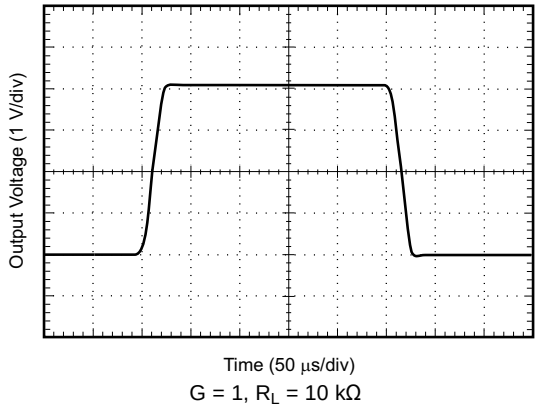


Figure 9. Large-Signal Step Response

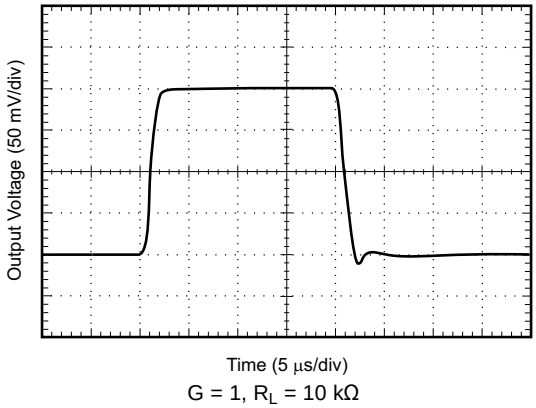


Figure 10. Small-Signal Step Response

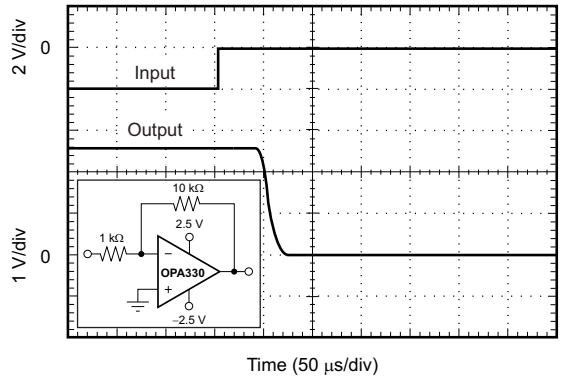


Figure 11. Positive Overvoltage Recovery

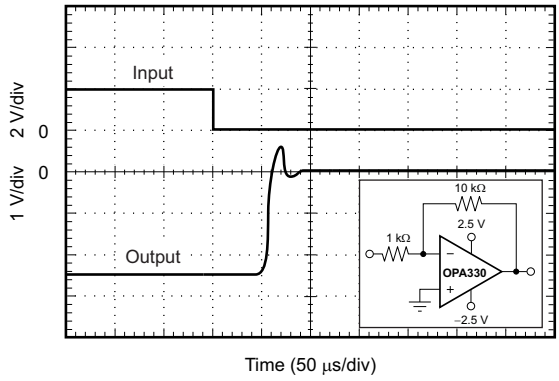


Figure 12. Negative Overvoltage Recovery

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Typical Characteristics (continued)

at T_A = 25°C, C_L = 0 pF, R_L = 10 kΩ connected to mid-supply, V_{CM} = V_{OUT} = mid-supply (unless otherwise noted)

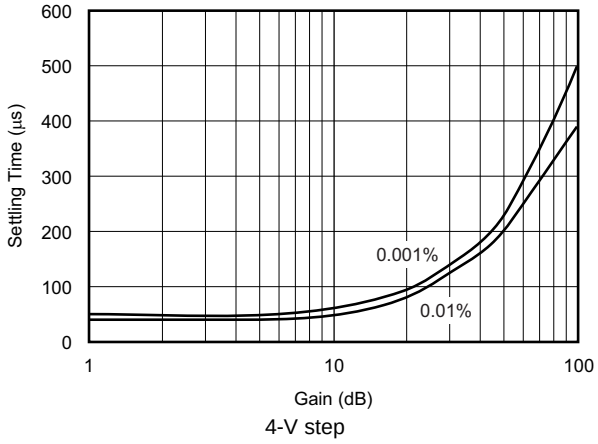


Figure 13. Settling Time vs Closed-Loop Gain

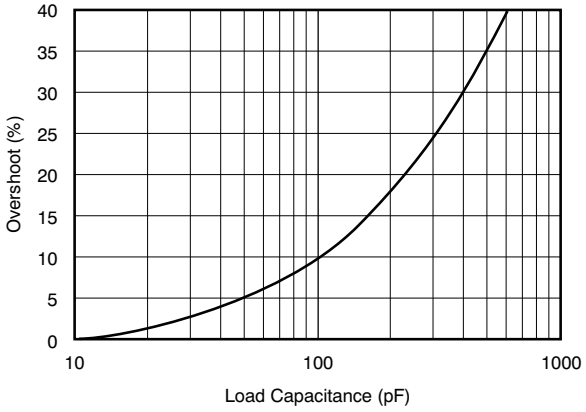


Figure 14. Small-Signal Overshoot vs Load Capacitance

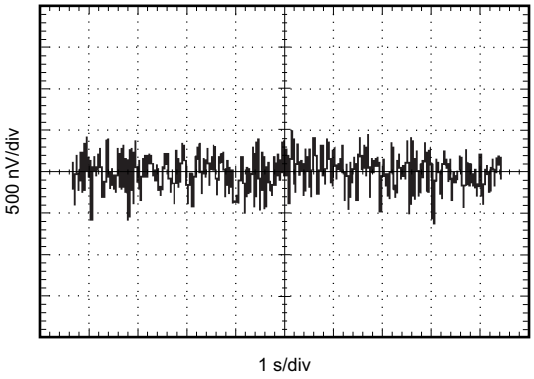


Figure 15. 0.1-Hz to 10-Hz Noise

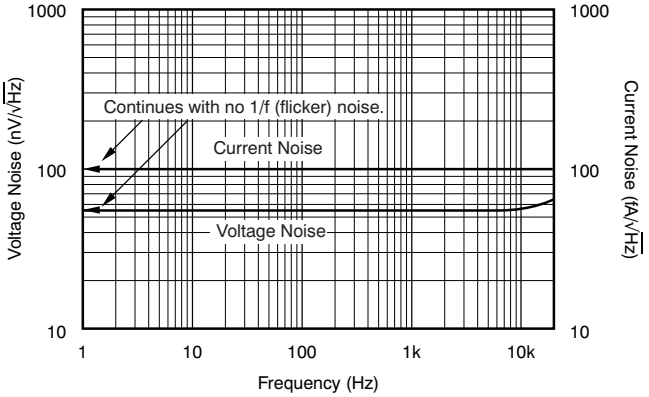


Figure 16. Current and Voltage Noise Spectral Density vs Frequency

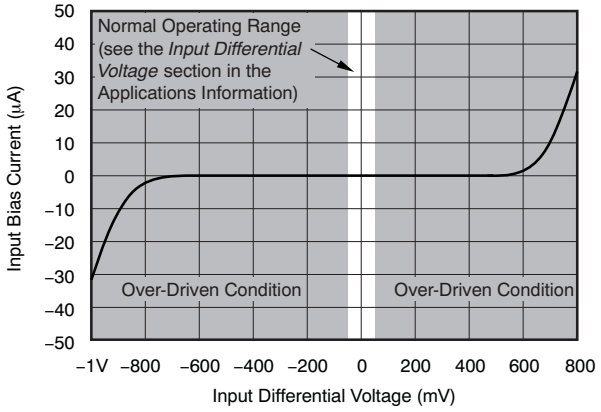


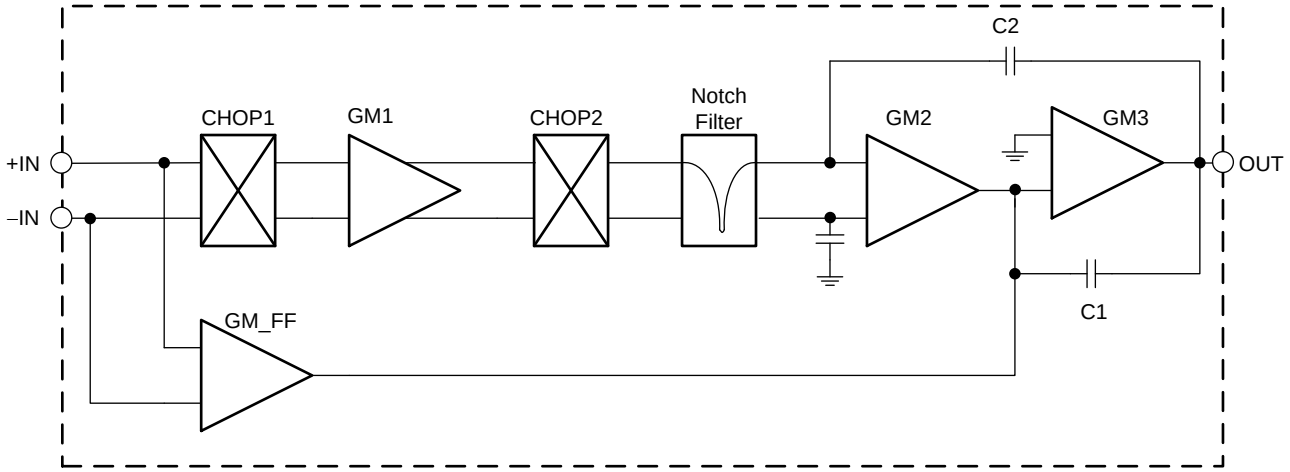
Figure 17. Input Bias Current vs Input Differential Voltage

8 Detailed Description

8.1 Overview

The TLVx333 series of low-cost operational amplifiers are unity-gain stable and free from unexpected output phase reversal. These devices use a proprietary auto-calibration technique to provide low offset voltage and very low drift over time and temperature. The TLVx333 family also offers rail-to-rail input and output and near-flat 1/f noise. These features make this series of op amps ideal for many applications and much easier to design into a wide variety of systems.

8.2 Functional Block Diagram



8.3 Feature Description

The TLV333, TLV2333, and TLV4333 are unity-gain stable, precision operational amplifiers free from unexpected output phase reversal. The use of proprietary zero-drift circuitry gives the benefit of low input offset voltage over time and temperature, as well as lowering the 1/f noise component. As a result of the high PSRR, these devices work well in applications that run directly from battery power without regulation. The TLV333 family is optimized for low-voltage, single-supply operation. These miniature, high-precision, low quiescent current amplifiers offer high-impedance inputs that have a common-mode range 100 mV beyond the supplies and a rail-to-rail output that swings within 100 mV of the supplies under normal test conditions. The TLV333 series are precision amplifiers for cost-sensitive applications.

8.3.1 Operating Voltage

The TLV333 series op amps can be used with single or dual supplies from an operating range of V_S = 1.8 V (±0.9 V) up to 5.5 V (±2.75 V). Supply voltages greater than 7 V can permanently damage the device; see the *Absolute Maximum Ratings* table. Key parameters that vary over the supply voltage or temperature range are listed in the *Typical Characteristics* section.

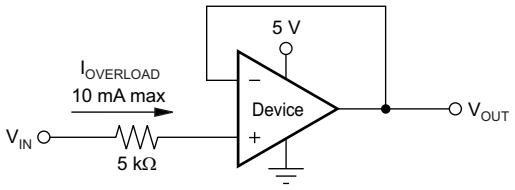
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Feature Description (continued)

8.3.2 Input Voltage

The TLV333, TLV2333, and TLV4333 input common-mode voltage range extends 0.1 V beyond the supply rails. The TLV333 is designed to cover the full range without the troublesome transition region found in some other rail-to-rail amplifiers.

Typically, input bias current is approximately 200 pA; however, input voltages that exceed the power supplies can cause excessive current to flow into or out of the input pins. Momentary voltages greater than the power supply can be tolerated if the input current is limited to 10 mA. This limitation is easily accomplished with an input resistor, as shown in Figure 18.



NOTE: A current-limiting resistor required if the input voltage exceeds the supply rails by ≥ 0.3 V.

Figure 18. Input Current Protection

8.3.3 Internal Offset Correction

The TLV333, TLV2333, and TLV4333 op amps use an auto-calibration technique with a time-continuous, 125-kHz op amp in the signal path. This amplifier is zero-corrected every 8 µs using a proprietary technique. Upon power-up, the amplifier requires approximately 100 µs to achieve specified V_{OS} accuracy. This design has no aliasing or flicker noise.

8.3.4 Achieving Output Swing to the Op Amp Negative Rail

Some applications require output voltage swings from 0 V to a positive full-scale voltage (such as 2.5 V) with excellent accuracy. With most single-supply op amps, problems arise when the output signal approaches 0 V, near the lower output swing limit of a single-supply op amp. A good single-supply op amp can swing close to single-supply ground, but does not reach ground. The output of the TLV333, TLV2333, and TLV4333 can be made to swing to ground, or slightly below, on a single-supply power source. This swing to ground requires the use of another resistor and an additional, more negative, power supply than the op amp negative supply. Connect a pull-down resistor between the output and the additional negative supply to pull the output down below the value that the output can otherwise achieve, as shown in Figure 19.

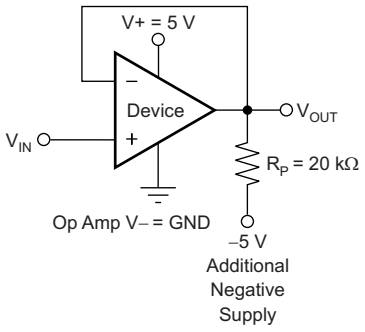


Figure 19. For V_{OUT} Range to Ground

Feature Description (continued)

The TLV333, TLV2333, and TLV4333 have an output stage that allows the output voltage to be pulled to its negative supply rail, or slightly below, using the technique previously described. This technique only works with some types of output stages. The TLV333, TLV2333, and TLV4333 are characterized to perform with this technique; the recommended resistor value is approximately 20 kΩ. Note that this configuration increases the current consumption by several hundreds of microamps. Accuracy is excellent down to 0 V and as low as –2 mV. Limiting and nonlinearity occur below –2 mV, but excellent accuracy returns when the output is again driven above –2 mV. Lowering the resistance of the pull-down resistor allows the op amp to swing even further below the negative rail. Resistances as low as 10 kΩ can be used to achieve excellent accuracy down to –10 mV.

8.3.5 Input Differential Voltage

The typical input bias current of the TLV333 during normal operation is approximately 200 pA. In overdriven conditions, the bias current can increase significantly (see Figure 17).The most common cause of an overdriven condition occurs when the op amp is outside of the linear range of operation. When the output of the op amp is driven to one of the supply rails, the feedback loop requirements cannot be satisfied and a differential input voltage develops across the input pins. This differential input voltage results in activation of parasitic diodes inside the front-end input chopping switches that combine with 10-kΩ electromagnetic interference (EMI) filter resistors to create the equivalent circuit shown in Figure 20. Notice that the input bias current remains within specification within the linear region.

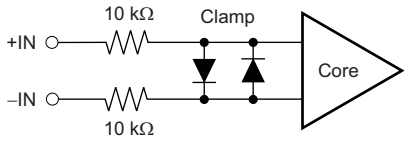


Figure 20. Equivalent Input Circuit

8.3.6 EMI Susceptibility and Input Filtering

Operational amplifiers vary in their susceptibility to EMI. If conducted EMI enters the operational amplifier, the dc offset observed at the amplifier output may shift from its nominal value when EMI is present. This shift is a result of signal rectification associated with the internal semiconductor junctions. Although all operational amplifier pin functions can be affected by EMI, the input pins are likely to be the most susceptible. The TLV333 operational amplifier family incorporates an internal input low-pass filter that reduces the amplifier response to EMI. Both common-mode and differential mode filtering are provided by the input filter. The filter is designed for a cutoff frequency of approximately 8 MHz (–3 dB), with a roll-off of 20 dB per decade.

8.4 Device Functional Modes

The TLV333 devices have a single functional mode. These devices are powered on as long as the power-supply voltage is between 1.8 V (±0.9 V) and 5.5 V (±2.75 V).

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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 System Examples

Figure 21 shows the basic configuration for a bridge amplifier.

A low-side current shunt monitor is shown in Figure 22.

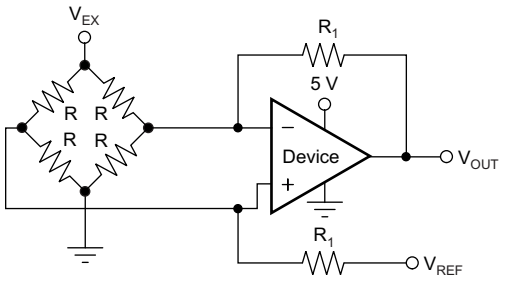
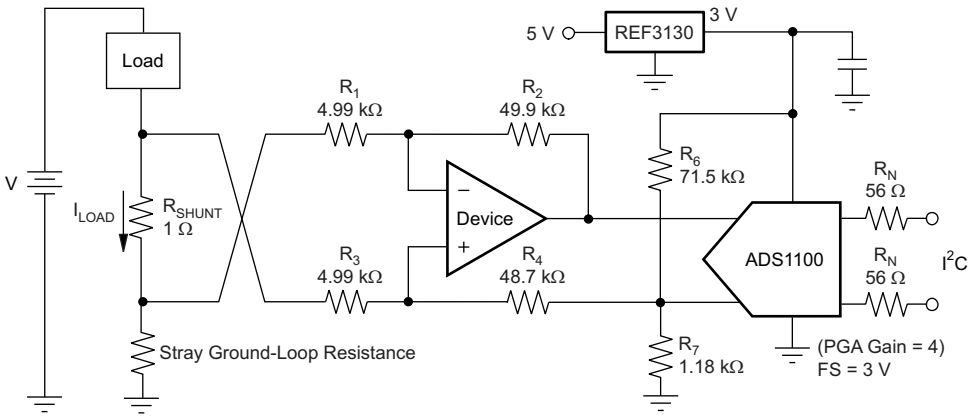


Figure 21. Single Op Amp Bridge Amplifier



NOTE: 1% resistors provide adequate common-mode rejection at small ground-loop errors.

Figure 22. Low-Side Current Monitor

R_N are operational resistors used to isolate the ADS1100 from the noise of the digital I^2C bus. Because the ADS1100 is a 16-bit converter, a precise reference is essential for maximum accuracy. If absolute accuracy is not required, and the 5-V power supply is sufficiently stable, the REF3130 can be omitted.

Figure 23 shows the TLV333 in a typical thermistor circuit.

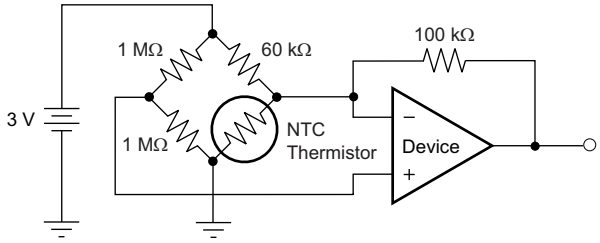


Figure 23. Thermistor Measurement

10 Power Supply Recommendations

The TLV333 is specified for operation from 1.8 V to 5.5 V (±0.9 V to ±2.75 V); many specifications apply from –40°C to +125°C. The *Typical Characteristics* section presents parameters that can exhibit significant variance with regard to operating voltage or temperature.

CAUTION

Supply voltages larger than 7 V can permanently damage the device (see the *Absolute Maximum Ratings* table).

Place 0.1-µF bypass capacitors close to the power-supply pins to reduce errors coupling in from noisy or high-impedance power supplies. For more detailed information on bypass capacitor placement, see the *Layout* section.

11 Layout

11.1 Layout Guidelines

11.1.1 General Layout Guidelines

Attention to good layout practice is always recommended. Keep traces short and, when possible, use a printed circuit board (PCB) ground plane with surface-mount components placed as close to the device pins as possible. Place a 0.1-µF capacitor closely across the supply pins. Apply these guidelines throughout the analog circuit to improve performance and to provide benefits such as reducing the electromagnetic interference (EMI) susceptibility.

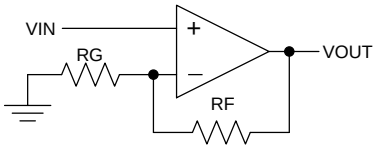
For lowest offset voltage and precision performance, circuit layout and mechanical conditions must be optimized. Avoid temperature gradients that create thermoelectric (Seebeck) effects in the thermocouple junctions formed from connecting dissimilar conductors. These thermally-generated potentials can be made to cancel by assuring they are equal on both input terminals. Other layout and design considerations include:

- Use low thermoelectric-coefficient conditions (avoid dissimilar metals).
- Thermally isolate components from power supplies or other heat sources.
- Shield op amp and input circuitry from air currents, such as cooling fans.

Following these guidelines reduces the likelihood of junctions being at different temperatures, which can cause thermoelectric voltages of 0.1 µV/°C or higher, depending on materials used.

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11.2 Layout Example



(Schematic Representation)

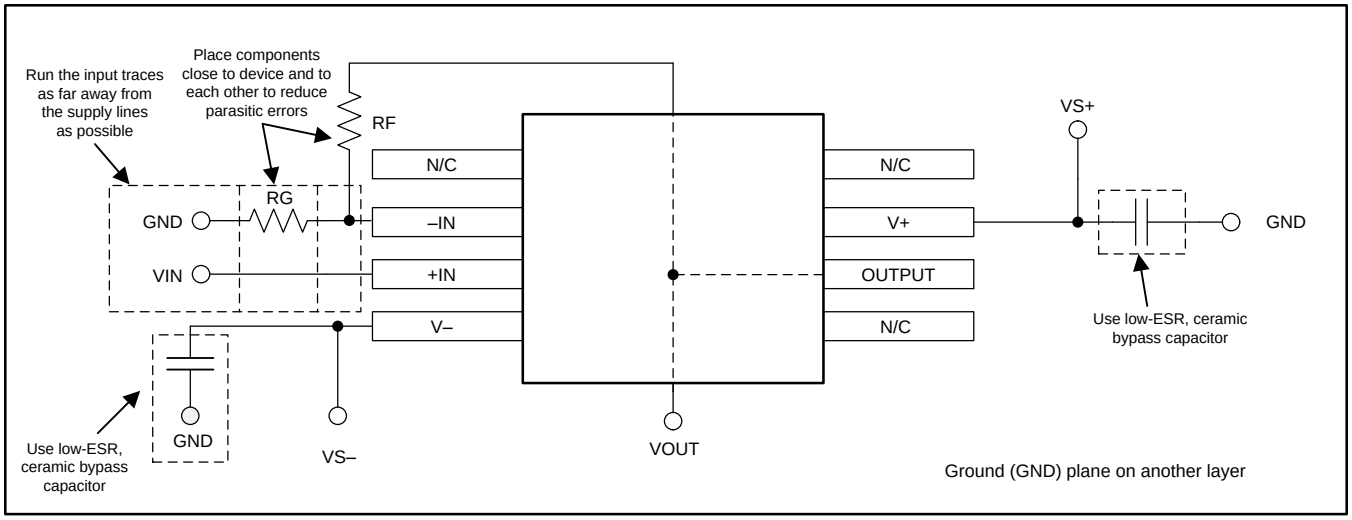


Figure 24. Layout Example

12 Device and Documentation Support

12.1 Device Support

12.1.1 Development Support

For development support on this product, see the following:

- High-Side V-I Converter, 0 V to 2 V to 0 mA to 100 mA, 1% Full-Scale Error, TIPD102
- Low-Level V-to-I Converter Reference Design, 0-V to 5-V Input to 0-µA to 5-µA Output, TIPD107
- 18-Bit, 1-MSPS, Serial Interface, microPower, Truly-Differential Input, SAR ADC, ADS8881
- Very Low-Power, High-Speed, Rail-To-Rail Input/Output, Voltage Feedback Operational Amplifier, THS4281
- Data Acquisition Optimized for Lowest Distortion, Lowest Noise, 18-bit, 1-MSPS Reference Design, TIPD115
- Self-Calibrating, 16-Bit Analog-to-Digital Converter, ADS1100
- 20-ppm/Degrees C Max, 100-µA, SOT23-3 Series Voltage Reference, REF3130

12.2 Documentation Support

12.2.1 Related Documentation

For related documentation, see the following:

- *QFN/SON PCB Attachment*, SLUA271
- *Quad Flatpack No-Lead Logic Packages*, SCBA017

12.3 Related Links

Table 1 lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to sample or buy.

Table 1. Related Links

PARTS	PRODUCT FOLDER	SAMPLE & BUY	TECHNICAL DOCUMENTS	TOOLS & SOFTWARE	SUPPORT & COMMUNITY
TLV333	Click here	Click here	Click here	Click here	Click here
TLV2333	Click here	Click here	Click here	Click here	Click here
TLV4333	Click here	Click here	Click here	Click here	Click here

12.4 Community Resources

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™ Online Community ***TI's Engineer-to-Engineer (E2E) Community.*** Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support ***TI's Design Support*** Quickly find helpful E2E forums along with design support tools and contact information for technical support.

12.5 Trademarks

E2E is a trademark of Texas Instruments.
All other trademarks are the property of their respective owners.

12.6 Electrostatic Discharge Caution



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.

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12.7 Glossary

SLYZ022 — *TI Glossary*.

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

13 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

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PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TLV2333IDGKR	ACTIVE	VSSOP	DGK	8	2500	RoHS & Green	NIPDAU | SN | NIPDAUAG	Level-1-260C-UNLIM	-40 to 125	12Z6	Samples
TLV2333IDGKT	ACTIVE	VSSOP	DGK	8	250	RoHS & Green	NIPDAU | SN | NIPDAUAG	Level-1-260C-UNLIM	-40 to 125	12Z6	Samples
TLV2333IDR	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TLV233	Samples
TLV333IDBVR	ACTIVE	SOT-23	DBV	5	3000	RoHS & Green	NIPDAU | SN	Level-1-260C-UNLIM	-40 to 125	12YD	Samples
TLV333IDBVT	ACTIVE	SOT-23	DBV	5	250	RoHS & Green	NIPDAU | SN	Level-1-260C-UNLIM	-40 to 125	12YD	Samples
TLV333IDCKR	ACTIVE	SC70	DCK	5	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	12B	Samples
TLV333IDCKT	ACTIVE	SC70	DCK	5	250	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	12B	Samples
TLV333IDR	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	TLV333	Samples
TLV4333IDR	ACTIVE	SOIC	D	14	2500	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	TLV4333	Samples
TLV4333IPWR	ACTIVE	TSSOP	PW	14	2000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	TLV4333	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **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.

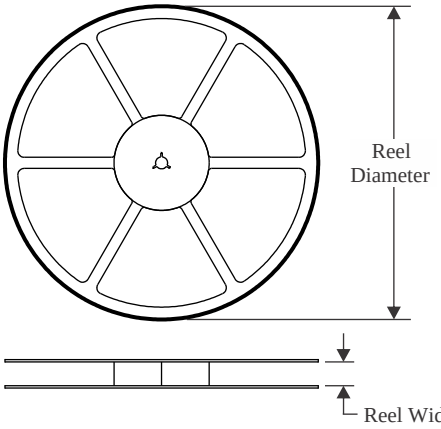
(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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.

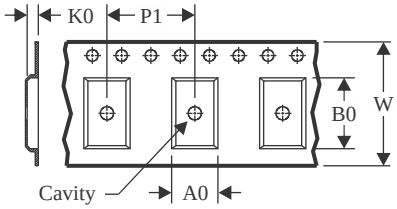
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

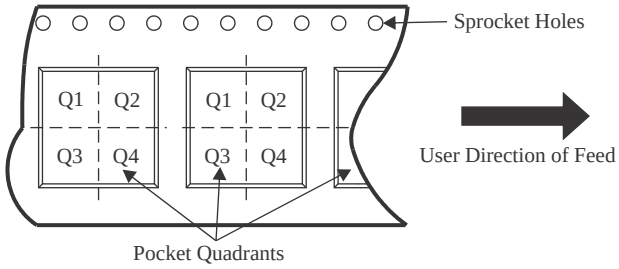


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

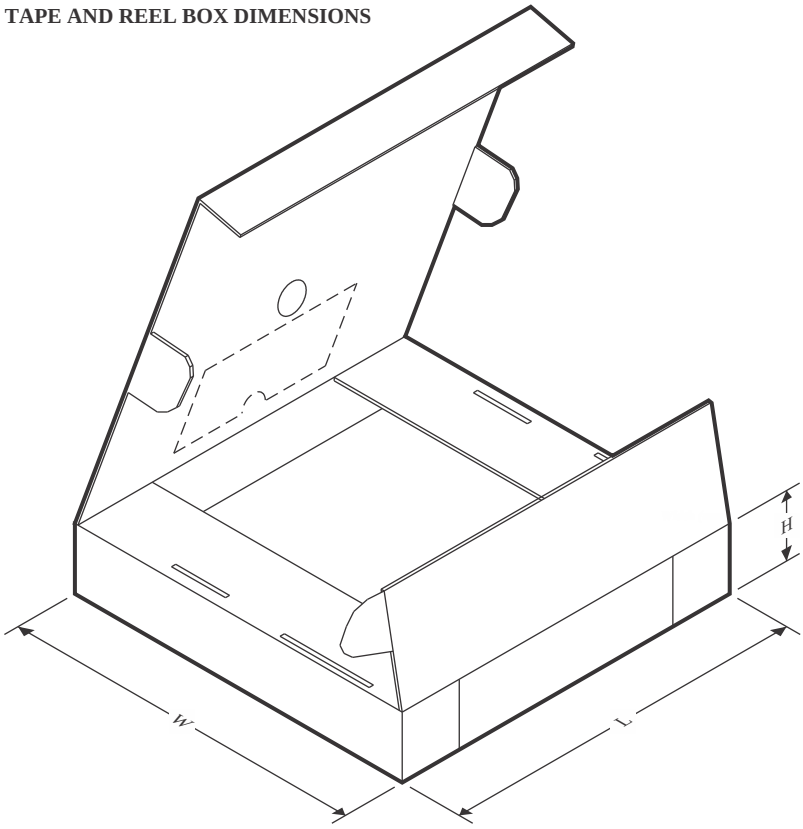
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TLV2333IDGKR	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
TLV2333IDGKT	VSSOP	DGK	8	250	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
TLV2333IDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
TLV333IDBVR	SOT-23	DBV	5	3000	180.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
TLV333IDBVT	SOT-23	DBV	5	250	180.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
TLV333IDCKR	SC70	DCK	5	3000	178.0	9.0	2.4	2.5	1.2	4.0	8.0	Q3
TLV333IDCKT	SC70	DCK	5	250	178.0	9.0	2.4	2.5	1.2	4.0	8.0	Q3
TLV333IDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
TLV4333IDR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
TLV4333IPWR	TSSOP	PW	14	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

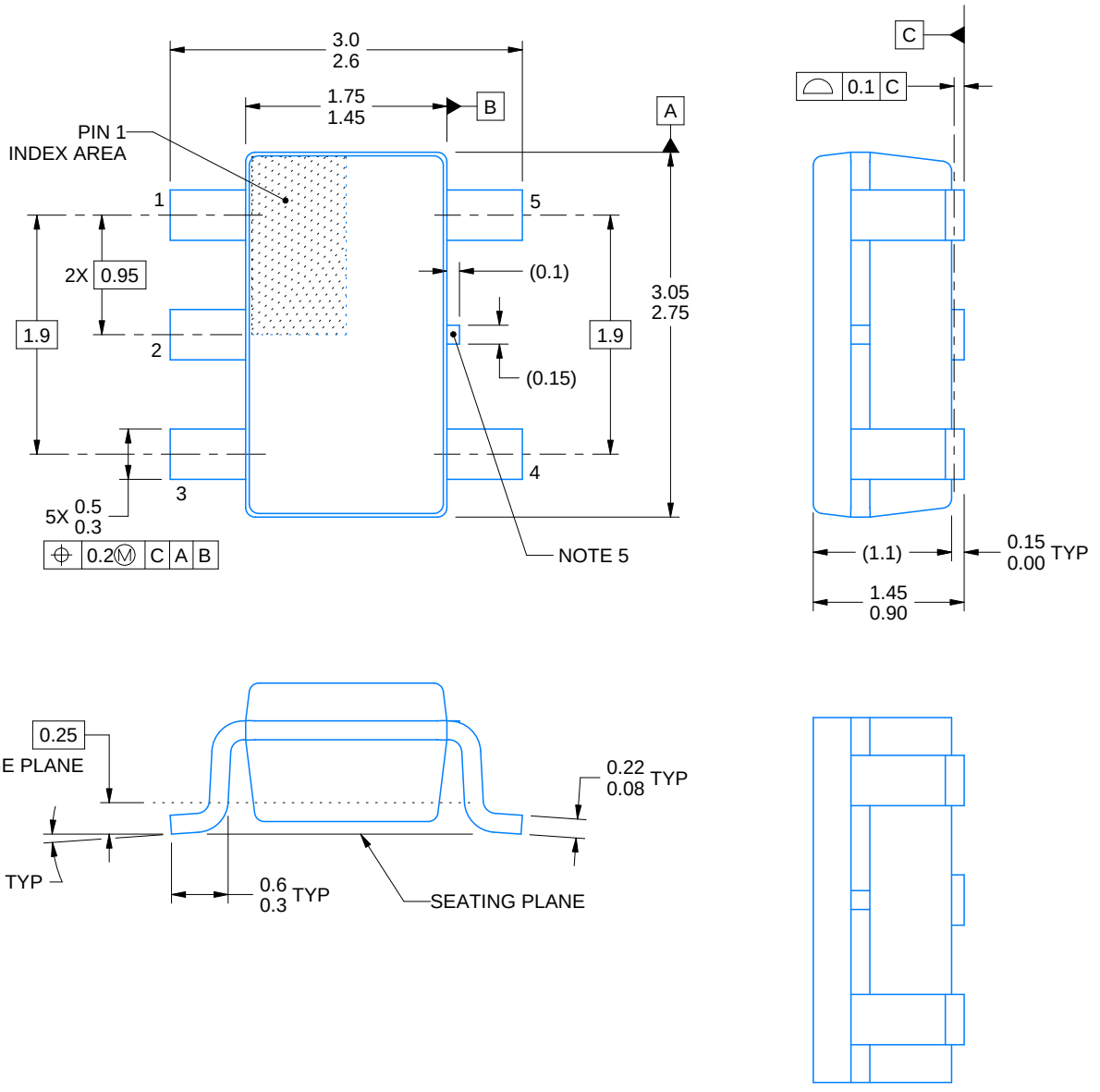
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TLV2333IDGKR	VSSOP	DGK	8	2500	353.0	353.0	32.0
TLV2333IDGKT	VSSOP	DGK	8	250	353.0	353.0	32.0
TLV2333IDR	SOIC	D	8	2500	356.0	356.0	35.0
TLV333IDBVR	SOT-23	DBV	5	3000	210.0	185.0	35.0
TLV333IDBVT	SOT-23	DBV	5	250	210.0	185.0	35.0
TLV333IDCKR	SC70	DCK	5	3000	180.0	180.0	18.0
TLV333IDCKT	SC70	DCK	5	250	180.0	180.0	18.0
TLV333IDR	SOIC	D	8	2500	356.0	356.0	35.0
TLV4333IDR	SOIC	D	14	2500	356.0	356.0	35.0
TLV4333IPWR	TSSOP	PW	14	2000	356.0	356.0	35.0

PACKAGE OUTLINE

DBV0005A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR

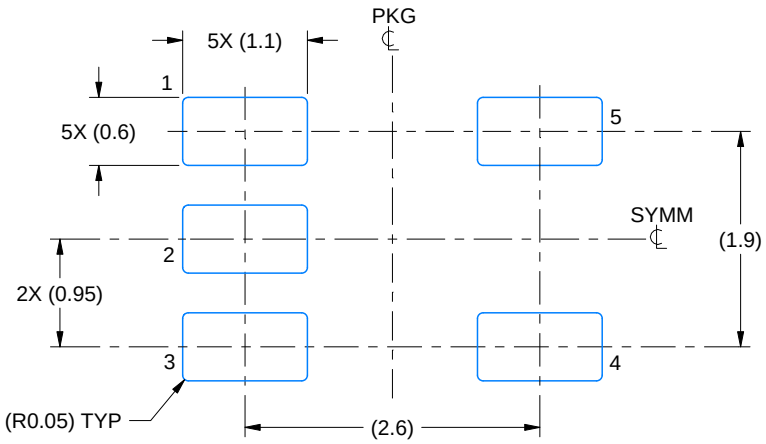


ALTERNATIVE PACKAGE SINGULATION VIEW

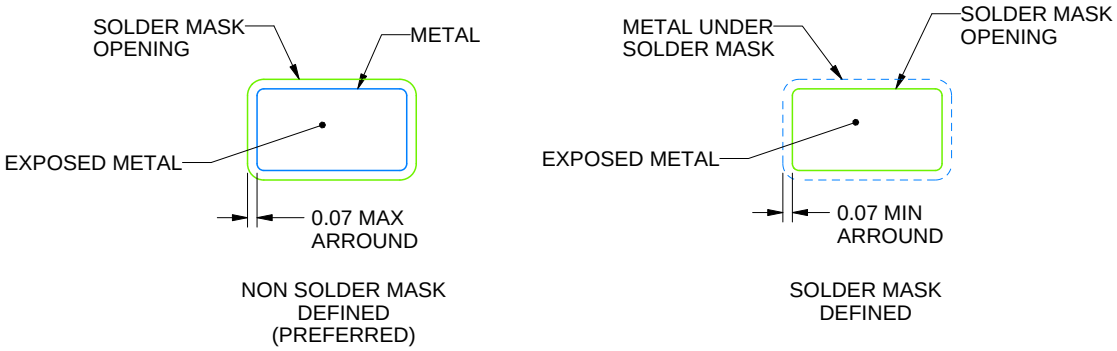
4214839/J 02/2024

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. Refernce JEDEC MO-178.
4. Body dimensions do not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.25 mm per side.
5. Support pin may differ or may not be present.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:15X

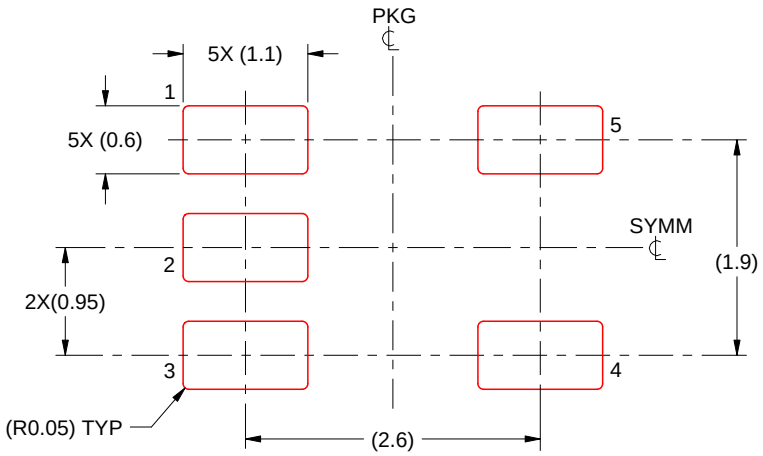


SOLDER MASK DETAILS

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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.



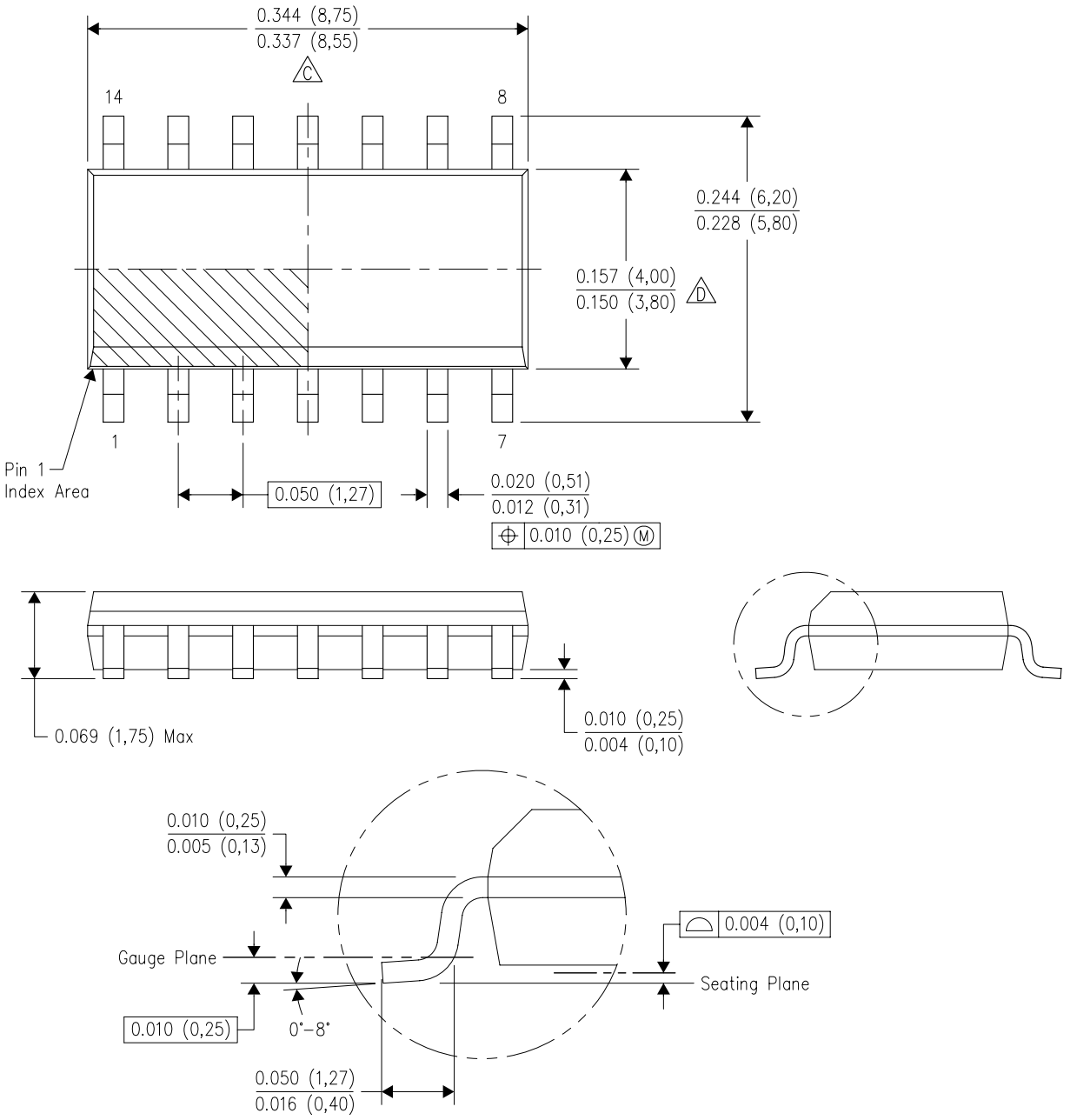
SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:15X

4214839/J 02/2024

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.

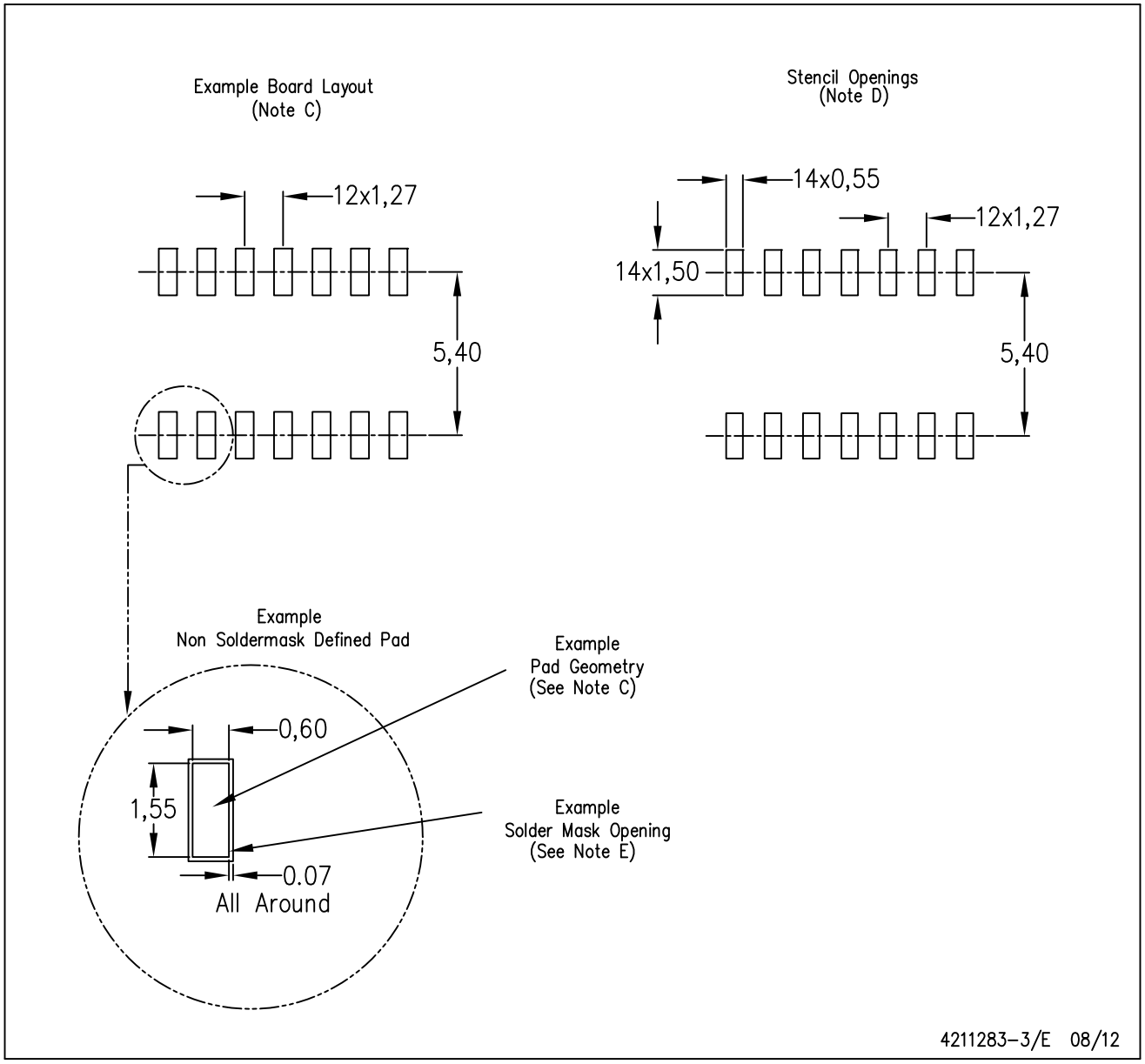
D (R–PDSO–G14) PLASTIC SMALL OUTLINE



4040047–5/M 06/11

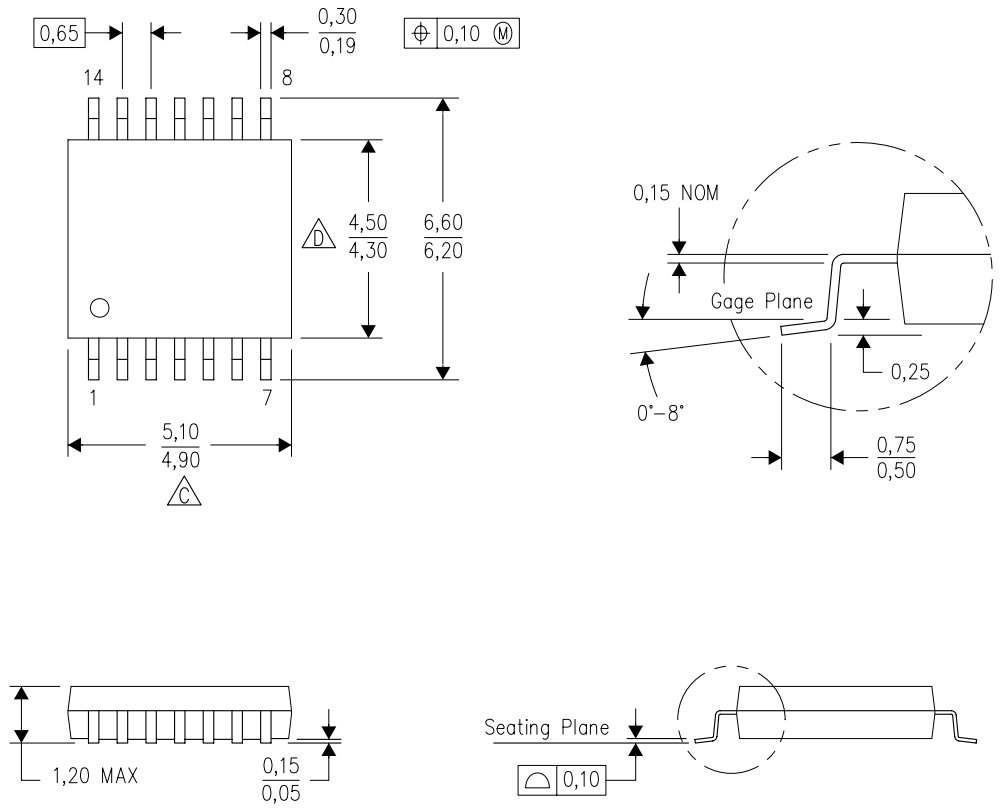
NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
E. Reference JEDEC MS–012 variation AB.

D (R–PDSO–G14) PLASTIC SMALL OUTLINE



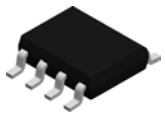
NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC–7351 is recommended for alternate designs.
D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC–7525 for other stencil recommendations.
E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

PW (R–PDSO–G14) PLASTIC SMALL OUTLINE



4040064–3/G 02/11

NOTES:
A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M–1994.
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0,15 each side.
D. Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.
E. Falls within JEDEC MO–153

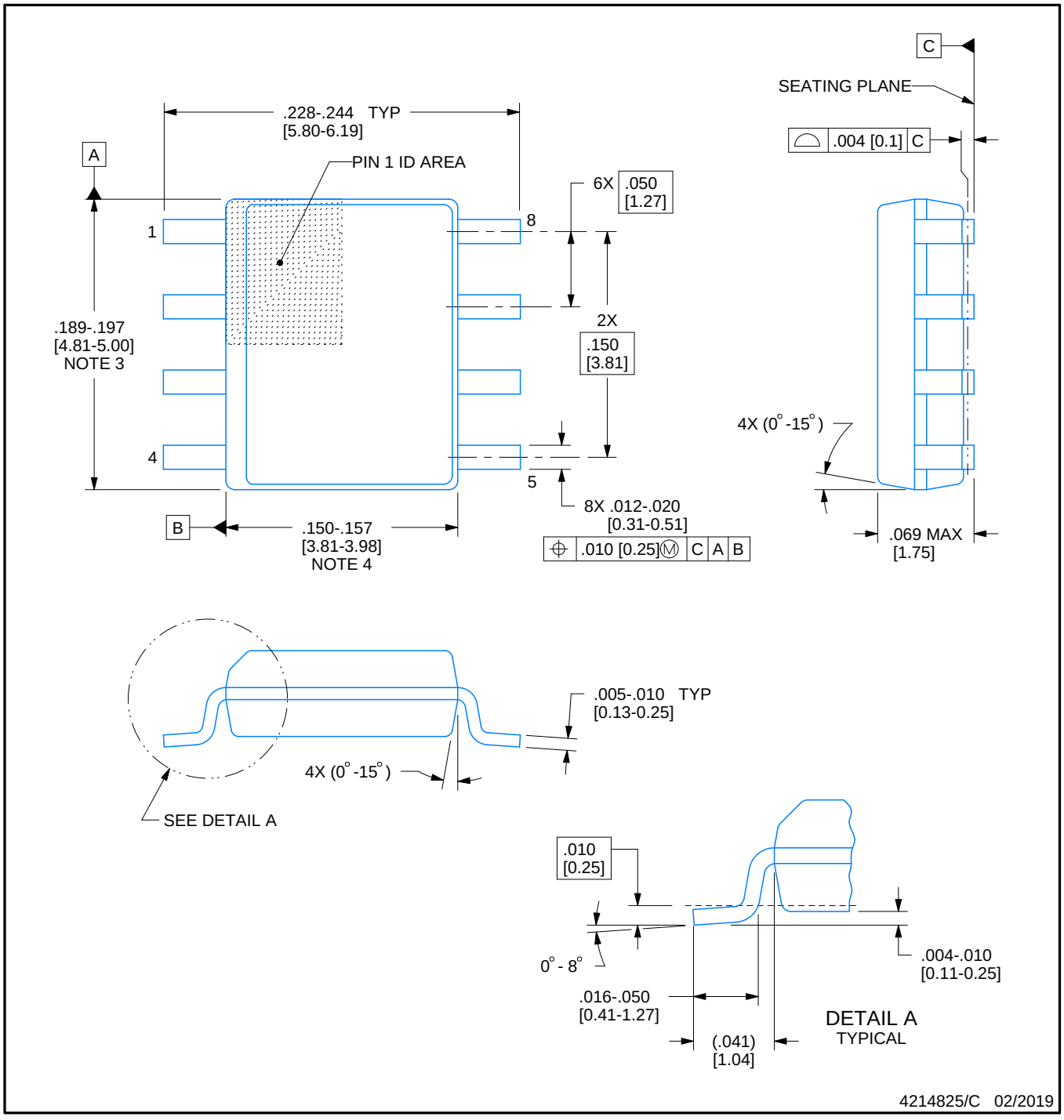


PACKAGE OUTLINE

D0008A

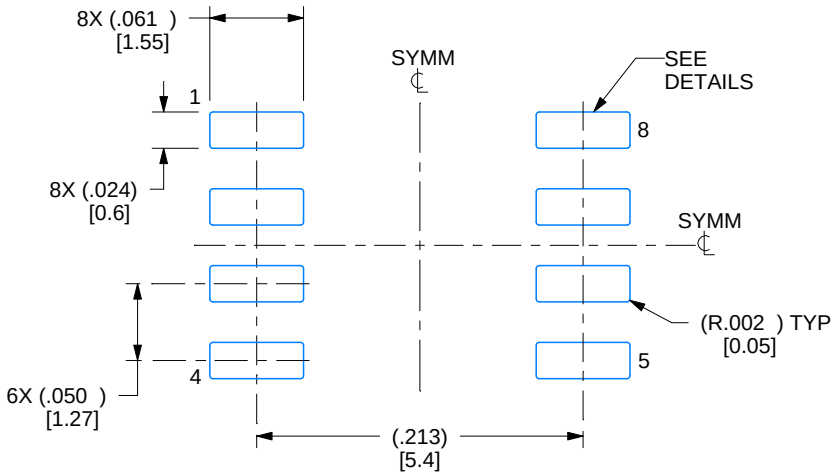
SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT

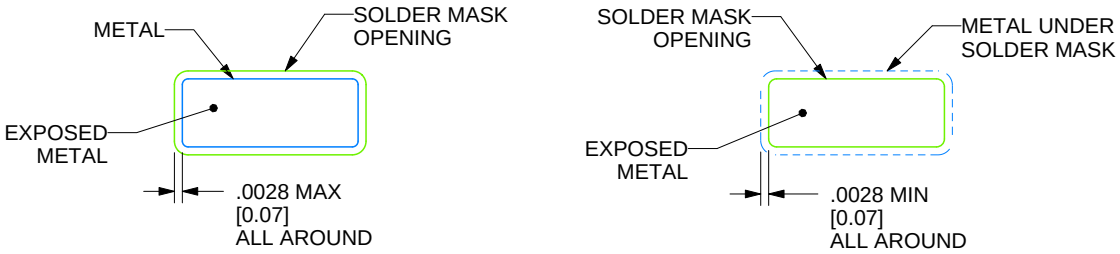


NOTES:

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.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:8X



SOLDER MASK DETAILS

4214825/C 02/2019

NOTES: (continued)

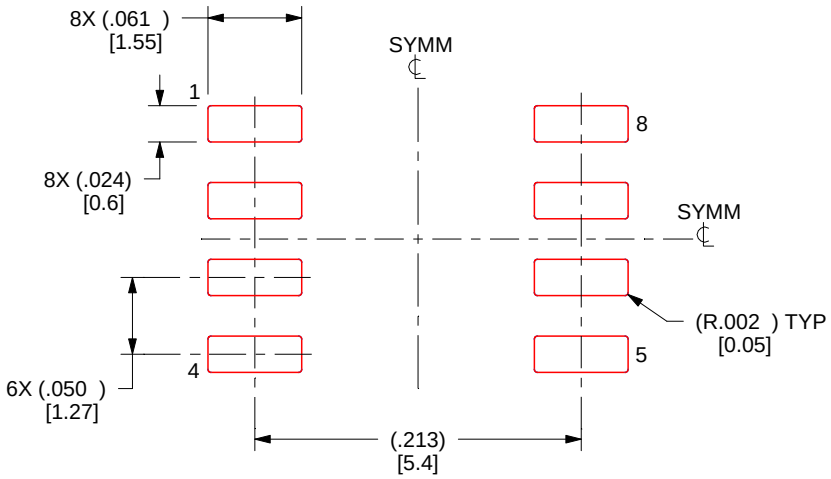
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

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)

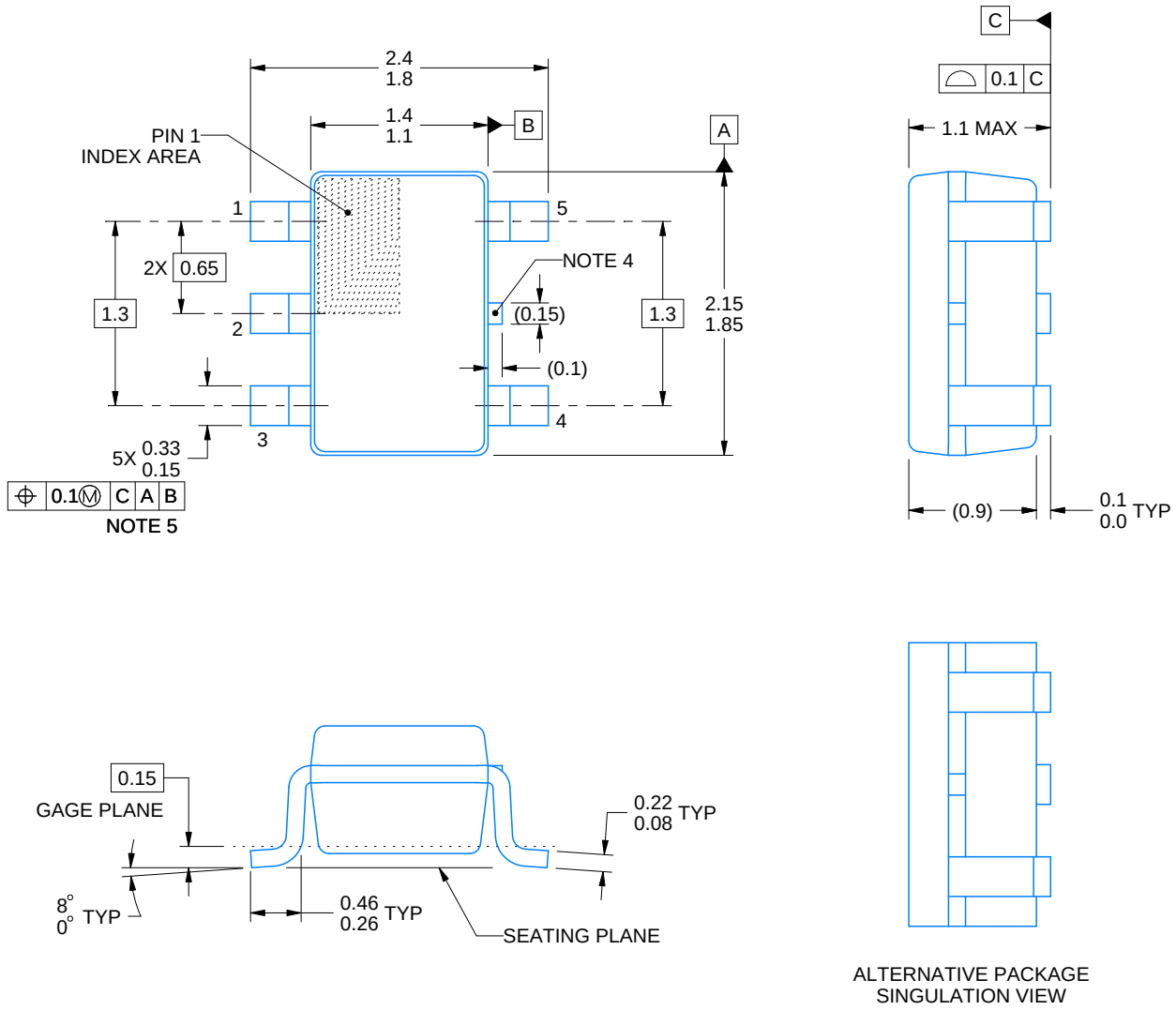
8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

PACKAGE OUTLINE

DCK0005A

SOT - 1.1 max height

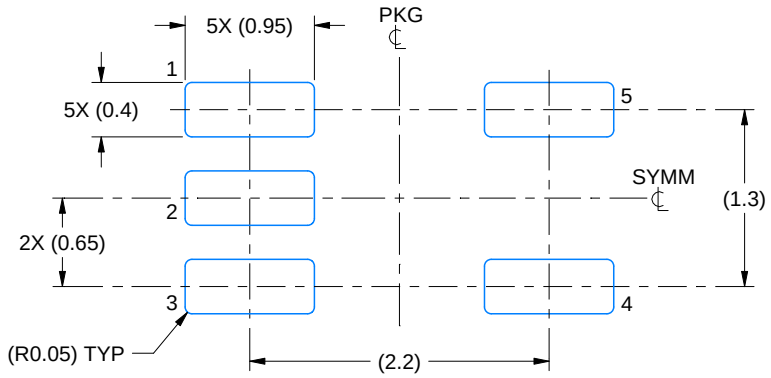
SMALL OUTLINE TRANSISTOR



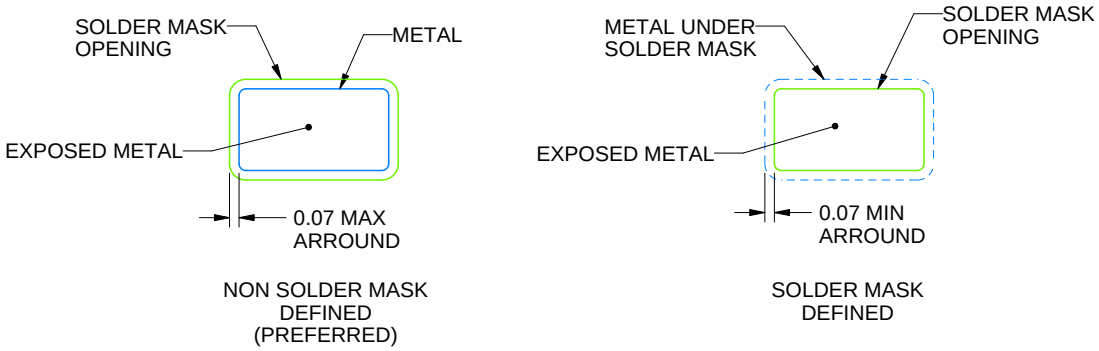
4214834/E 06/2024

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. Refernce JEDEC MO-203.
4. Support pin may differ or may not be present.
5. Lead width does not comply with JEDEC.
6. Body dimensions do not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.25mm per side



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:18X

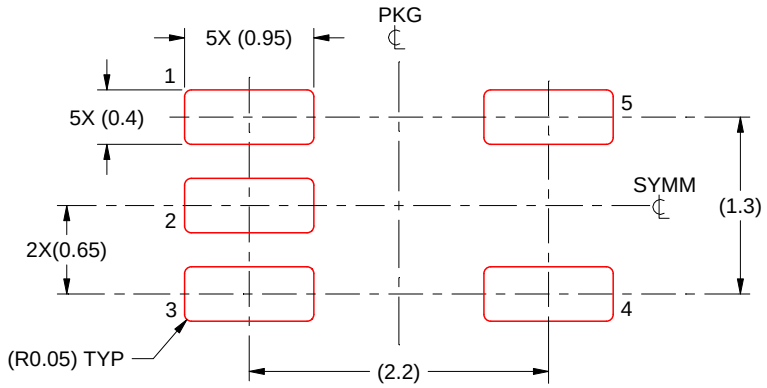


SOLDER MASK DETAILS

4214834/E 06/2024

NOTES: (continued)

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



SOLDER PASTE EXAMPLE
BASED ON 0.125 THICK STENCIL
SCALE:18X

4214834/E 06/2024

NOTES: (continued)

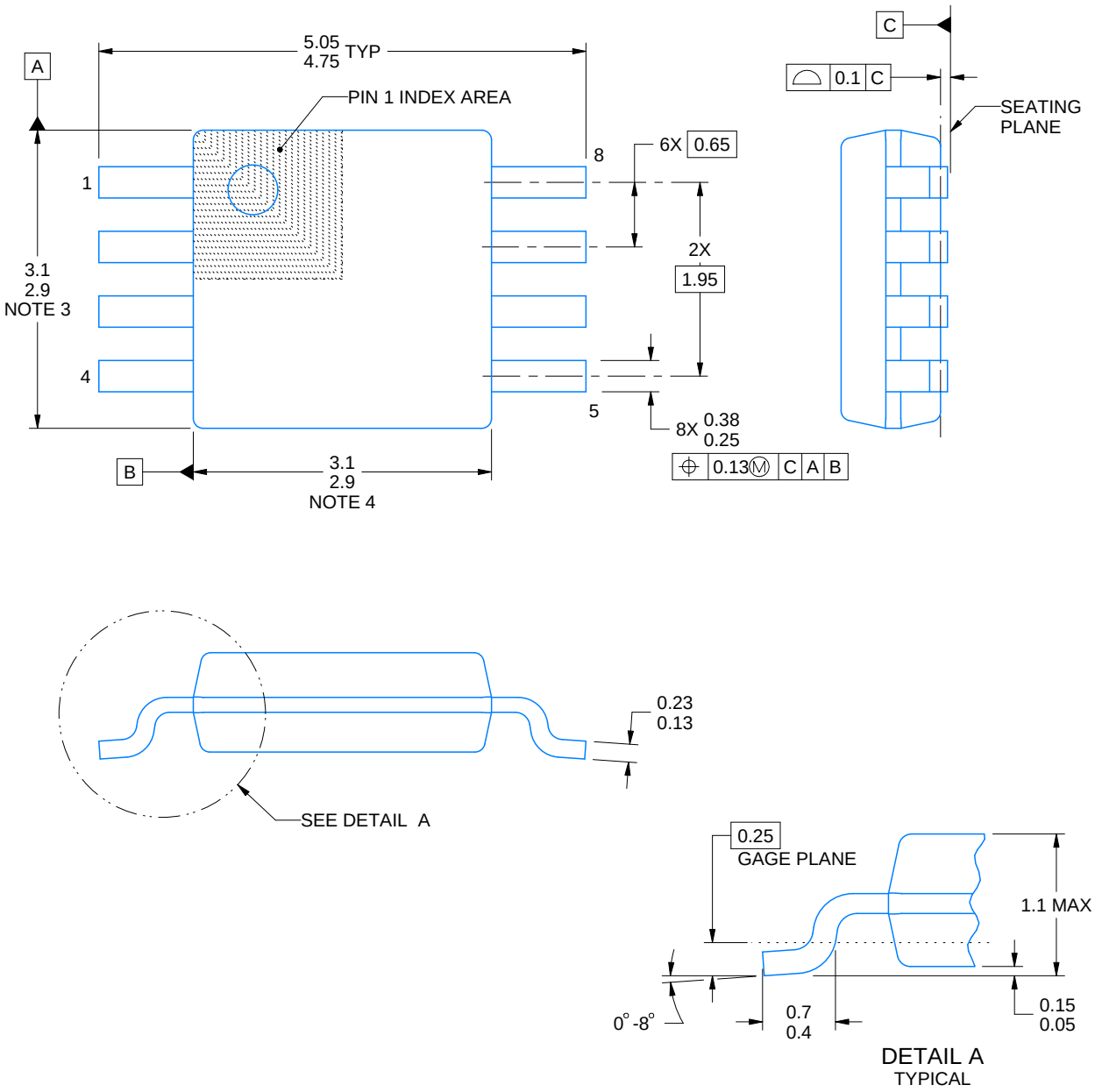
9. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
10. Board assembly site may have different recommendations for stencil design.

PACKAGE OUTLINE

DGK0008A

VSSOP - 1.1 mm max height

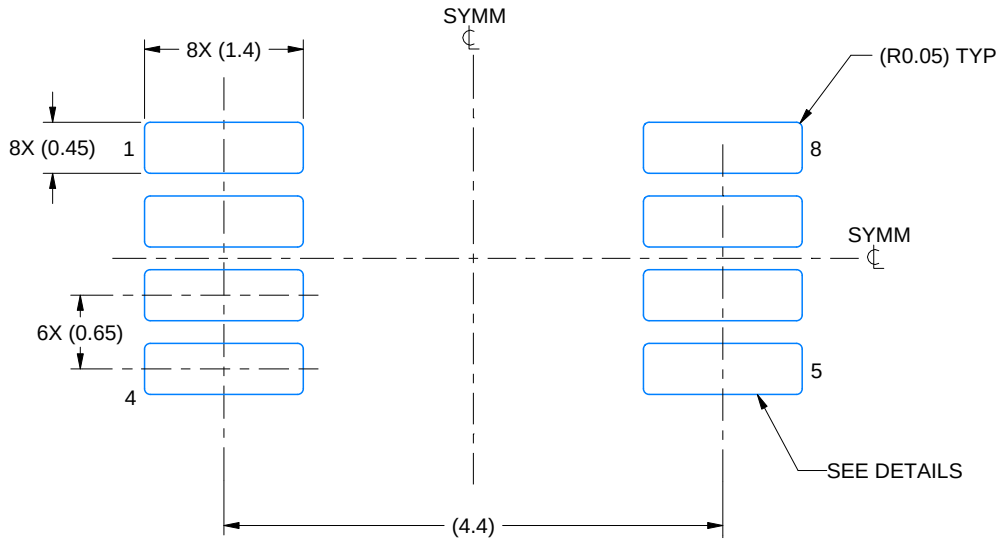
SMALL OUTLINE PACKAGE



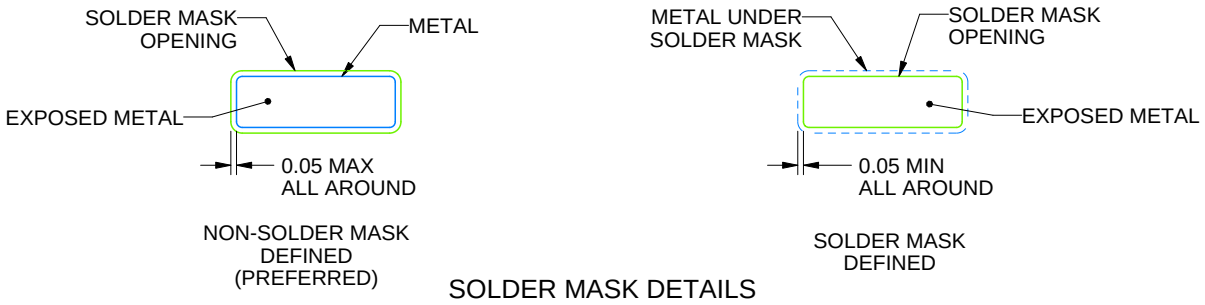
PowerPAD is a trademark of Texas Instruments.

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. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-187.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 15X

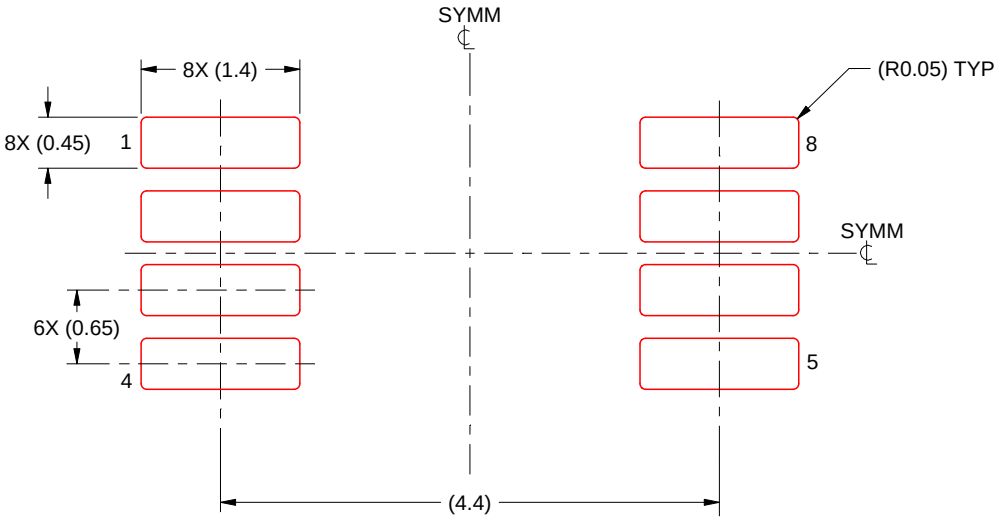


SOLDER MASK DETAILS

4214862/A 04/2023

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.
8. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.
9. Size of metal pad may vary due to creepage requirement.



SOLDER PASTE EXAMPLE
SCALE: 15X

4214862/A 04/2023

NOTES: (continued)

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

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