OPAx363, OPAx364 1.8-V, 7-MHz, 90-dB CMRR, Single-Supply, Rail-to-Rail I/O Operational Amplifier

1 Features

- 1.8-V Operation
- *Micro*SIZE Packages
- Bandwidth: 7 MHz
- CMRR: 90 dB (Typical)
- Slew Rate: 5 V/µs
- Low Offset: 500 µV (Maximum)
- Quiescent Current: 750 µA/Channel (Maximum)
- Shutdown Mode: Less Than 1 µA/Channel

2 Applications

- Signal Conditioning
- Data Acquisition
- Process Control
- Active Filters
- Test Equipment

3 Description

The OPA363 and OPA364 families are high-performance, CMOS operational amplifiers optimized for very low voltage, single-supply operation. These miniature, low-cost amplifiers are designed to operate on single supplies from 1.8 V (±0.9 V) to 5.5 V (±2.75 V). Applications include sensor amplification and signal conditioning in battery-powered systems.

The OPA363 and OPA364 families offer excellent CMRR without the crossover associated with traditional complimentary input stages. This feature results in excellent performance for driving analog-to-digital (A/D) converters without degradation of differential linearity and THD. The input common-mode range includes both the negative and positive supplies. The output voltage swing is within 10 mV of the rails.

The OPA363 family includes a shutdown mode. Under logic control, the amplifiers can be switched from normal operation to a standby current that is less than 1 µA.

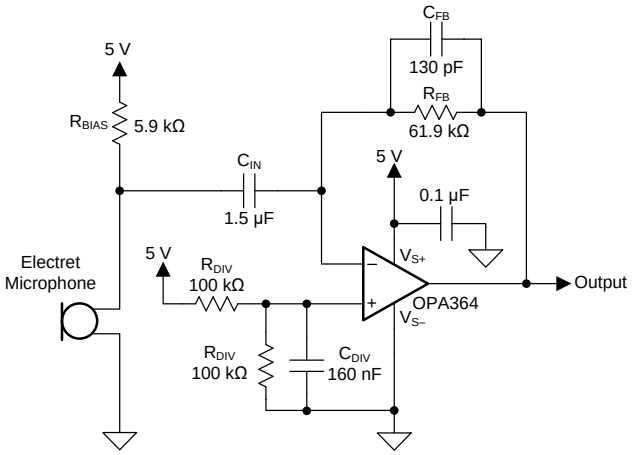
The single version is available in the *Micro*Size 5-pin SOT-23 (6-pin SOT-23 for shutdown) and 8-pin SOIC. The dual version is available in 8-pin VSSOP, 10-pin VSSOP, 16-pin UQFN, and 8-pin SOIC packages. Quad packages are available in 14-pin TSSOP and 14-pin SOIC packages. All versions are specified for operation from –40°C to +125°C.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
OPA363	SOT-23 (6)	2.60 mm × 1.60 mm
	SOIC (8)	4.90 mm × 3.91 mm
OPA364	SOT-23 (5)	2.60 mm × 1.60 mm
	SOIC (8)	4.90 mm × 3.91 mm
OPA2363	VSSOP (10)	3.00 mm × 3.00 mm
	UQFN (16)	2.60 mm × 1.80 mm
OPA2364	SOIC (8)	4.90 mm × 3.91 mm
	VSSOP (8)	3.00 mm × 3.00 mm
OPA4364	SOIC (14)	8.65 mm × 3.91 mm
	TSSOP (14)	5.00 mm × 4.40 mm

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

Single-Supply Microphone Preamplifier



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4 Revision History

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

Changes from Revision E (January 2018) to Revision F **Page**

- Changed OPA363 SOT-23 (5) to SOT-23 (6) in *Device Information* table ... 1
- Added OPA363 SOIC (8) package to *Device Information* table ... 1
- Changed OPA364 SOT-23 (6) to SOT-23 (5) in *Device Information* table ... 1
- Deleted OPA2364 VSSOP (10) and UQFN (16) packages from *Device Information table* ... 1
- Deleted OPA2363 SOIC (8) and VSSOP (8) packages from *Device Information* table ... 1

Changes from Revision D (September 2016) to Revision E **Page**

- Changed OPA36x and OPA236x part numbers to OPA364 and OPA2363 in *Device Information* table ... 1
- Added OPA2364 device to *Device Information* table ... 1
- Corrected formatting of pinout drawings in *Pin Configuration and Functions* section ... 4
- Corrected formatting of pinout tables in *Pin Configuration and Functions* section ... 4
- Added a minimum value of 0 V to supply voltage parameter in *Absolute Maximum Ratings* table ... 8
- Added "([V+] – [V–])" to supply voltage parameter in *Absolute Maximum Ratings* table ... 8
- Deleted operating temperature range from *Absolute Maximum Ratings* table ... 8
- Added the word "temperature" to junction and storage temperature ranges in *Absolute Maximum Ratings* table ... 8
- Added "([V+] – [V–])" to supply voltage parameter in *Recommended Operating Conditions* table ... 8
- Changed output voltage swing parameter units from V to mV ... 11
- Deleted temperature range section of *Electrical Characteristics* table ... 11
- Changed PSRR test condition from V_{CM} = 0 to V_{CM} = (V–) in *Electrical Characteristics* table ... 11
- Deleted *Buffered Reference Voltage* subsection in *Application Information* section ... 20
- Changed Figure 33 ... 26
- Added Figure 34 ... 27

- Changed "IC" to "device" throughout data sheet 28

Changes from Revision C (May 2013) to Revision D **Page**

- Added *ESD Ratings* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section 1
- Deleted *Package and Ordering Information* section, see POA at the end of the datasheet. 1

Changes from Revision B (February 2003) to Revision C **Page**

- Converted data sheet to current format 1
- Added RSV package (UQFN-16) to data sheet 1
- Added text to last bullet of *Layout Guidelines* section 26

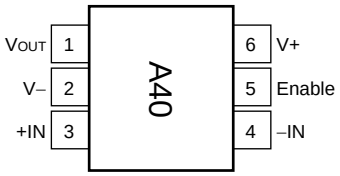
5 Device Comparison Table

5.1 Device Comparison Table

	OPA363	OPA364	OPA2363	OPA2364	OPA4364
SOT-23-5		X			
SOT-23-6 (shutdown)	X				
MSOP-8				X	
MSOP-10			X		
SO-8	X	X		X	
TSSOP-14					X
SO-14					X
UQFN-16			X		

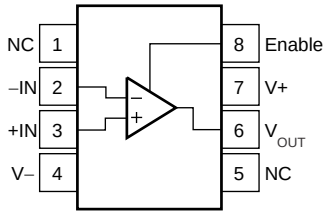
6 Pin Configuration and Functions

OPA363: DBV Package
6-Pin SOT-23
Top View



(1) Orient according to marking.

OPA363: D Package
8-Pin SOIC
Top View

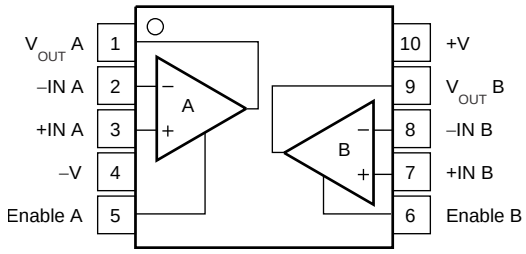


NC- no internal connection

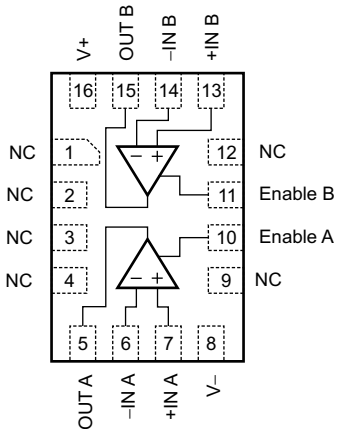
Pin Functions: OPA363

PIN			I/O	DESCRIPTION
NAME	SOIC	SOT-23		
Enable	8	5	I	Enable
–IN	2	4	I	Negative (inverting) input
+IN	3	3	I	Positive (noninverting) input
NC	1, 5	—	—	No internal connection (can be left floating)
V_{OUT}	6	1	O	Output
V–	4	2	—	Negative (lowest) power supply
V+	7	6	—	Positive (highest) power supply

OPA2363: DGS Package
10-Pin MSOP
Top View



OPA2363: RSV Package
16-Pin UQFN
Top View

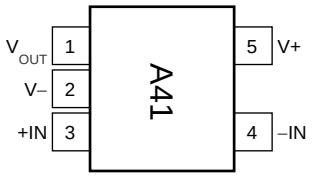


NC- no internal connection

Pin Functions: OPA2363

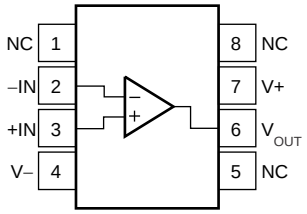
PIN			I/O	DESCRIPTION
NAME	MSOP	UQFN		
Enable A	5	10	I	Enable A amplifier
Enable B	6	11	I	Enable B amplifier
–IN A	2	6	I	Inverting input, channel A
+IN A	3	7	I	Noninverting input, channel A
–IN B	8	14	I	Inverting input, channel B
+IN B	7	13	I	Noninverting input, channel B
NC	—	1, 2, 3, 4, 9, 12	—	No internal connection (can be left floating)
OUT A	—	5	O	Output, channel A
OUT B	—	15	O	Output, channel B
V_{OUT} A	1	—	O	Output, channel A
V_{OUT} B	9	—	O	Output, channel B
–V, V–	4	8	—	Negative (lowest) power supply
+V, V+	10	16	—	Positive (highest) power supply

OPA364: DBV Package
5-Pin SOT-23
Top View



(1) Orient according to marking.

OPA364: D Package
8-Pin SOIC
Top View

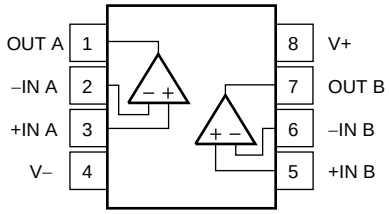


NC - no internal connection

Pin Functions: OPA364

PIN			I/O	DESCRIPTION
NAME	SOIC	SOT-23		
–IN	2	4	I	Negative (inverting) input
+IN	3	3	I	Positive (noninverting) input
NC	1, 5, 8	—	—	No internal connection (can be left floating)
V_{OUT}	6	1	O	Output
V–	4	2	—	Negative (lowest) power supply
V+	7	5	—	Positive (highest) power supply

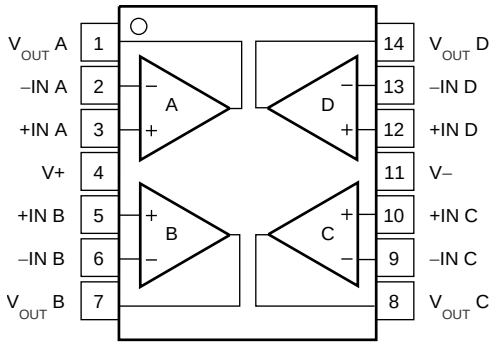
OPA2364: DGK and D Packages
8-Pin MSOP and SOIC
Top View



Pin Functions: OPA2364

PIN		I/O	DESCRIPTION
NAME	NO.		
–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

OPA4364: D and PW Packages
14-Pin SOIC and TSSOP
Top View



NC- no internal connection.

Pin Functions: OPA4364

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

7 Specifications

7.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
Voltage	Supply ([V+] – [V–])	0	5.5	V
	Signal input pin(2)	−0.5	(V+) + 0.5	
Current	Signal input pin(2)	–10	10	mA
	Output short-circuit(3)	Continuous		mA
Junction temperature, T_J			150	°C
Storage temperature, 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 terminals are diode-clamped to the power-supply rails. Input signals that can swing more than 0.5 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)	±2000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101(2)	±750	

(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
	Supply voltage ([V+] – [V–])	1.8		5.5	V
T_A	Operating temperature	–40		125	°C

7.4 Thermal Information: OPA363

THERMAL METRIC[1]		OPA363 DBV (SOT-23) 5 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	211.4	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	137	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	39.8	°C/W
ψ_{JT}	Junction-to-top characterization parameter	20.6	°C/W
ψ_{JB}	Junction-to-board characterization parameter	38.9	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	—	°C/W

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

7.5 Thermal Information: OPA364

THERMAL METRIC[1]		OPA364 DBV (SOT-23) 6 PINS	OPA364 D (SOIC) 8 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	182.7	125.3	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	130.7	73.7	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	34.1	65.7	°C/W
ψ_{JT}	Junction-to-top characterization parameter	24.8	25.4	°C/W
ψ_{JB}	Junction-to-board characterization parameter	33.5	65.2	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	—	—	°C/W

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

7.6 Thermal Information: OPA2363

THERMAL METRIC(1)		OPA2363				UNIT
		D (SOIC)	DGK (VSSOP)	DGS (VSSOP)	UQFN (RSV)	
		8 PINS	8 PINS	10 PINS	16 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	125.3	171.8	166.4	112.4	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	73.7	63.2	55.9	44	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	65.7	92.4	86.6	41.2	°C/W
ψ_{JT}	Junction-to-top characterization parameter	25.4	9.5	6.8	0.8	°C/W
ψ_{JB}	Junction-to-board characterization parameter	65.2	91	85.2	41.2	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	—	—	—	—	°C/W

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

7.7 Thermal Information: OPA2364

THERMAL METRIC(1)		OPA2364				UNIT
		D (SOIC)	DGK (VSSOP)	DGS (VSSOP)	UQFN (RSV)	
		8 PINS	8 PINS	10 PINS	16 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	125.3	171.8	166.4	112.4	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	73.7	63.2	55.9	44	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	65.7	92.4	86.6	41.2	°C/W
ψ_{JT}	Junction-to-top characterization parameter	25.4	9.5	6.8	0.8	°C/W
ψ_{JB}	Junction-to-board characterization parameter	65.2	91	85.2	41.2	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	—	—	—	—	°C/W

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

7.8 Thermal Information: OPA4364

THERMAL METRIC(1)		OPA4364		UNIT
		D (SOIC)	PW (TSSOP)	
		14 PINS	14 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	82.6	107.5	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	41.1	31.9	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	37.1	50.6	°C/W
ψ_{JT}	Junction-to-top characterization parameter	9.4	1.9	°C/W
ψ_{JB}	Junction-to-board characterization parameter	36.8	49.9	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	—	—	°C/W

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

7.9 Electrical Characteristics

at T_A = 25°C, R_L = 10 kΩ connected to V_S / 2, V_{OUT} = V_S / 2, and V_{CM} = V_S / 2, V_S = 1.8 V to 5.5 V, (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
OFFSET VOLTAGE							
V_{OS}	Input offset voltage	V_S = 5 V (OPA363I, OPA364I)				500	µV
		OPA2363I, OPA2364I				900	µV
		OPA363AI, OPA364AI, OPA2363AI, OPA2364AI, OPA4364AI			1	2.5	mV
dV_{OS}/dT	Drift	T_A = –40°C to +125°C			3		µV/°C
PSRR	Input offset voltage vs power supply	V_S = 1.8 V to 5.5 V V_{CM} = (V–) T_A = –40°C to +125°C			80	330	µV/V
	Channel separation, DC				1		µV/V
INPUT BIAS CURRENT							
I_B	Input bias current	T_A = 25°C			±1	±10	pA
		T_A = –40°C to +125°C		See *Typical Characteristics*			
I_{OS}	Input offset current				±1	±10	pA
NOISE							
e_n	Input voltage noise,	f = 0.1 Hz to 10 Hz			10		$µV_{PP}$
e_n	Input voltage noise density	f = 10 kHz			17		$nV/\sqrt{Hz}$
i_n	Input current noise density	f = 10 kHz			0.6		$fA/\sqrt{Hz}$
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 T_A = –40°C to +125°C		74	90		dB
INPUT CAPACITANCE							
	Differential				2		pF
	Common-mode				3		pF
OPEN-LOOP GAIN							
A_{OL}	Open-loop voltage gain	R_L = 10 kΩ 100 mV < V_O < (V+) – 100 mV	T_A = 25°C	94	100		dB
			T_A = 25°C (OPA4364)	90			dB
		R_L = 10 kΩ 100 mV < V_O < (V+) – 100 mV	V_S = 1.8 V to 5.5 V T_A = –40°C to +125°C	86			dB
FREQUENCY RESPONSE							
GBW	Gain-bandwidth product	C_L = 100 pF			7		MHz
SR	Slew rate	C_L = 100 pF, G = 1			5		V/µs
t_S	Settling time	0.1%, C_L = 100 pF, V_S = 5 V, 4-V step, G = 1			1		µs
		0.01%, C_L = 100 pF, V_S = 5 V, 4-V step, G = 1			1.5		µs
	Overload recovery time	C_L = 100 pF V_{IN} × Gain > V_S			0.8		µs
THD+N	Total harmonic distortion + noise	C_L = 100 pF, V_S = 5 V, G = 1, f = 20 Hz to 20 kHz			0.002%		
OUTPUT							
	Voltage output swing	R_L = 10 kΩ, T_A = 25°C			10	20	mV
		R_L = 10 kΩ T_A = –40°C to +125°C				20	mV
I_{SC}	Short-circuit current			See *Typical Characteristics*			
C_{LOAD}	Capacitive load drive			See *Typical Characteristics*			
SHUTDOWN (OPA363)							
t_{OFF}	Turnoff time				1		µs
t_{ON}	Turnon time (1)				20		µs
V_L	Logic low threshold	Shutdown				(V–) + 0.8	V
V_H	Logic high threshold	Amplifier is active		0.75 (V+)		5.5	V
$I_{Q(sd)}$	Quiescent current at shutdown (per amplifier)					0.9	µA

(1) Part is considered enabled when input offset voltage returns to specified range.

Electrical Characteristics (continued)

at T_A = 25°C, R_L = 10 kΩ connected to V_S / 2, V_{OUT} = V_S / 2, and V_{CM} = V_S / 2, V_S = 1.8 V to 5.5 V, (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
POWER SUPPLY						
V_S	Specified voltage range		1.8		5.5	V
I_Q	Quiescent current (per amplifier)	V_S = 1.8 V T_A = –40°C to +125°C		650	750	µA
		V_S = 3.6 V T_A = –40°C to +125°C		850	1000	µA
		V_S = 5.5 V T_A = –40°C to +125°C		1.1	1.4	mA

7.10 Typical Characteristics

at T_A = 25°C, R_L = 10 kΩ connected to V_S / 2, V_{OUT} = V_S / 2, and V_{CM} = V_S / 2, (unless otherwise noted)

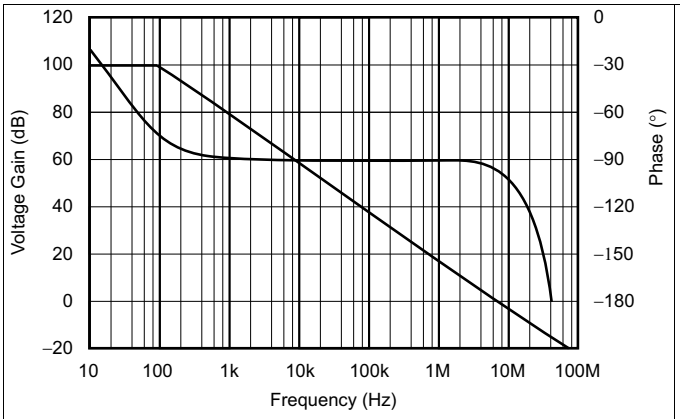


Figure 1. Open-Loop Gain and Phase vs Frequency

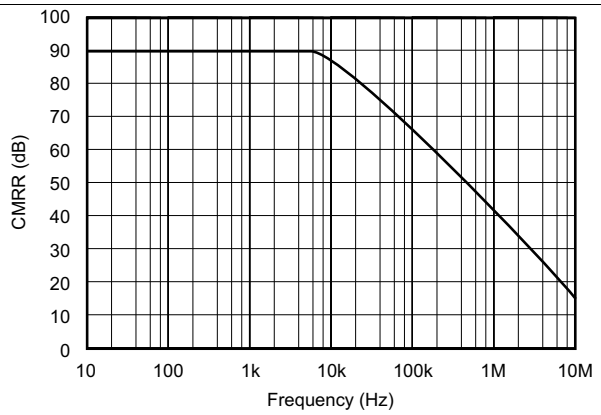


Figure 2. Common-Mode Rejection Ratio vs Frequency

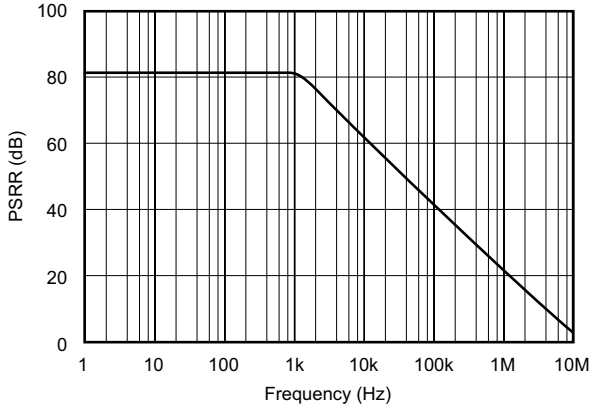


Figure 3. Power-Supply Rejection Ratio vs Frequency

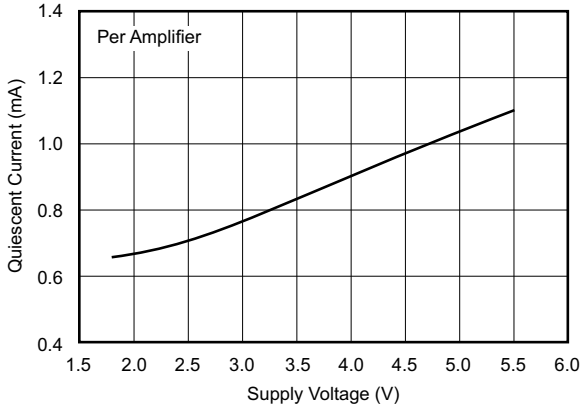


Figure 4. Quiescent Current vs Supply Voltage

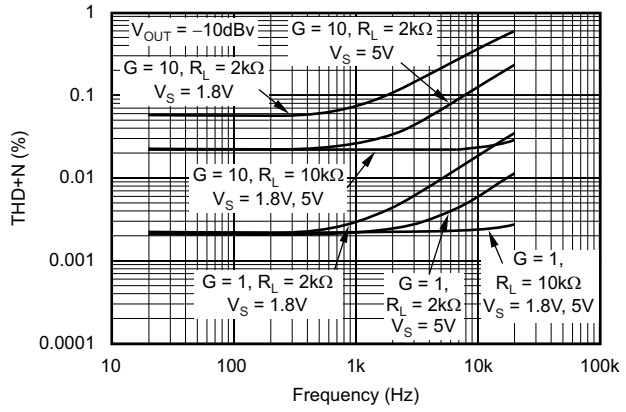


Figure 5. Total Harmonic Distortion + Noise Ratio vs Frequency

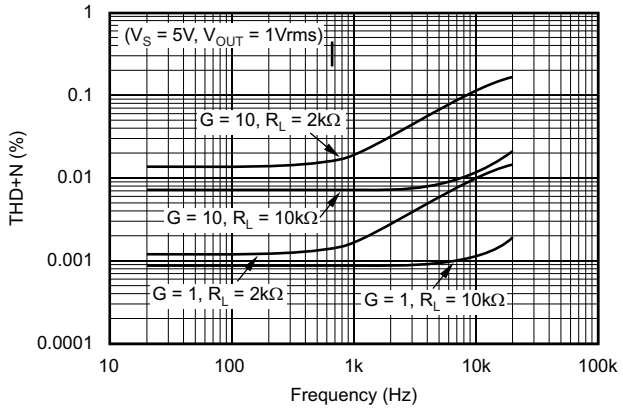


Figure 6. Total Harmonic Distortion + Noise Ratio vs Frequency

Typical Characteristics (continued)

at T_A = 25°C, R_L = 10 kΩ connected to V_S / 2, V_{OUT} = V_S / 2, and V_{CM} = V_S / 2, (unless otherwise noted)

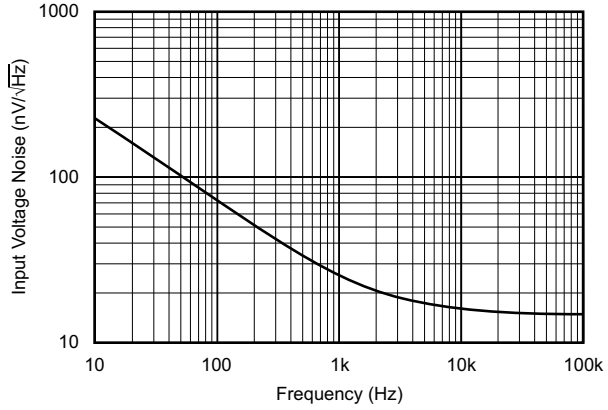


Figure 7. Input Voltage Noise Spectral Density vs Frequency

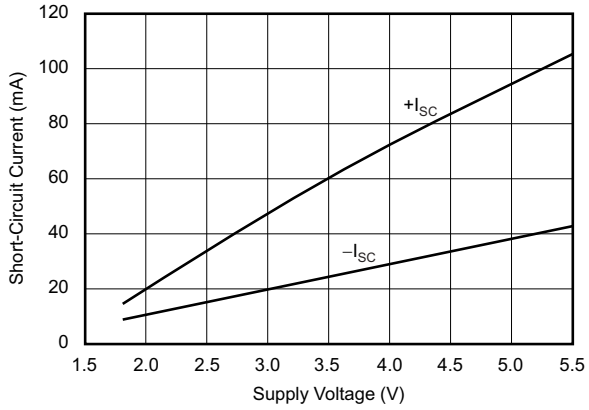


Figure 8. Short-Circuit Current vs Supply Voltage

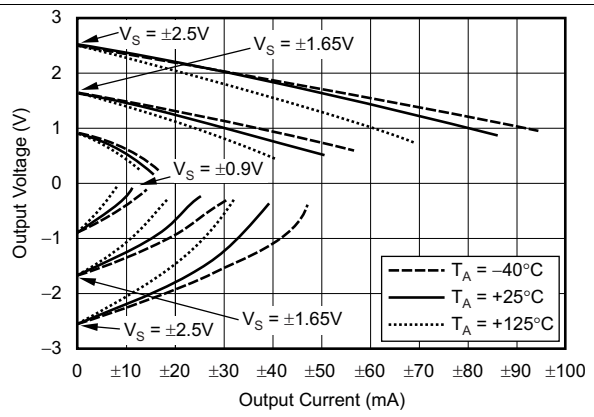


Figure 9. Output Voltage Swing vs Output Current

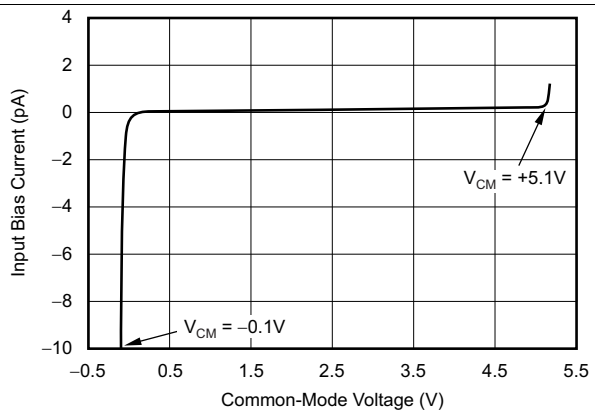


Figure 10. Input Bias Current vs Input Common-Mode Voltage

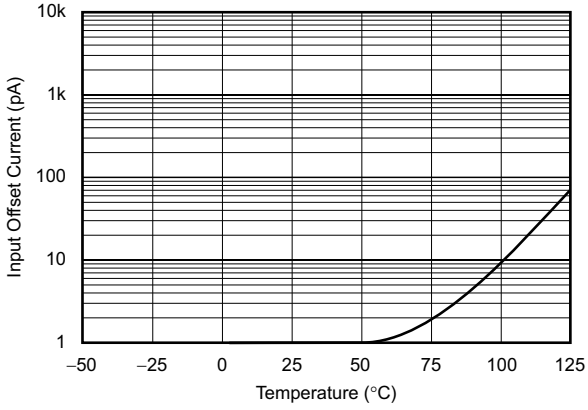


Figure 11. Input Offset Current vs Temperature

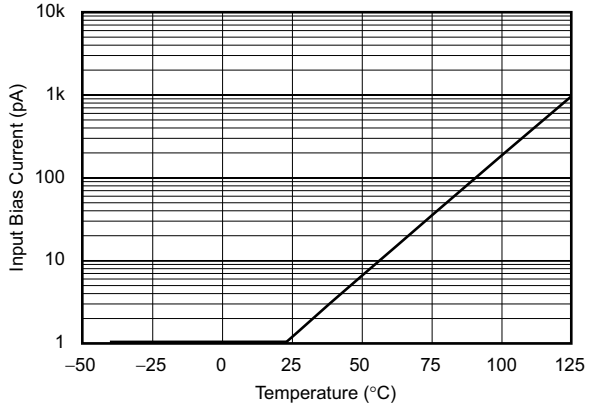


Figure 12. Input Bias Current vs Temperature

Typical Characteristics (continued)

at T_A = 25°C, R_L = 10 kΩ connected to V_S / 2, V_{OUT} = V_S / 2, and V_{CM} = V_S / 2, (unless otherwise noted)

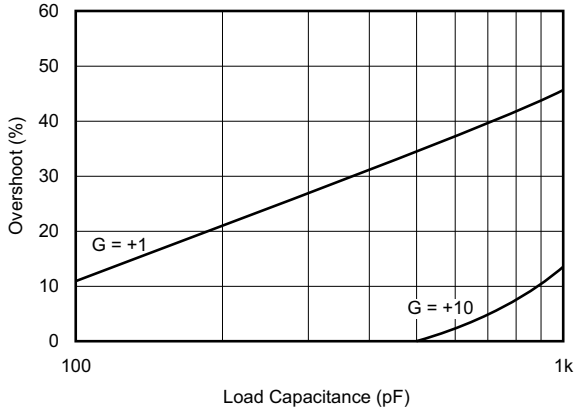


Figure 13. Small-Signal Overshoot vs Load Capacitance

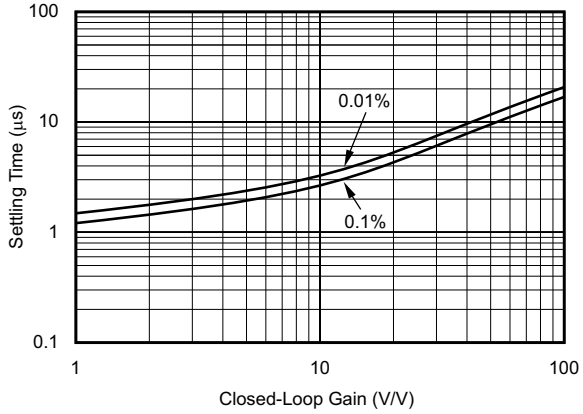


Figure 14. Settling Time vs Closed-Loop Gain

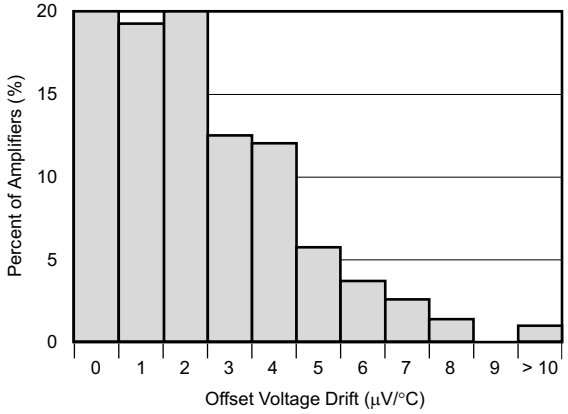


Figure 15. Offset Drift Distribution

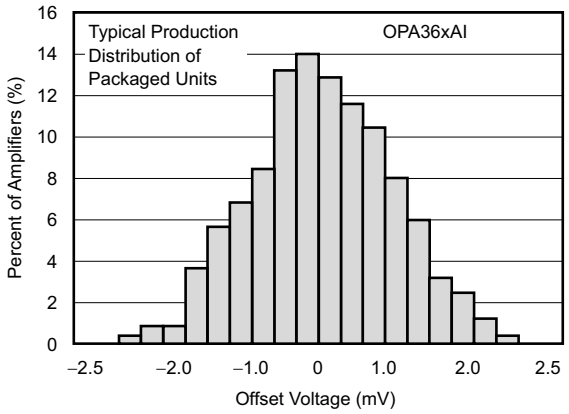


Figure 16. Offset Voltage Production Distribution

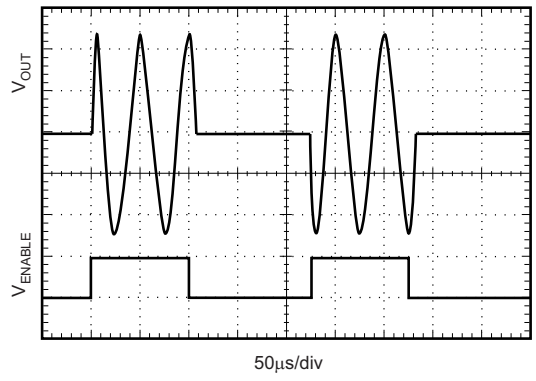


Figure 17. Output Enable Characteristic (V_S = 5 V, V_{OUT} = 20-kHz Sinusoid)

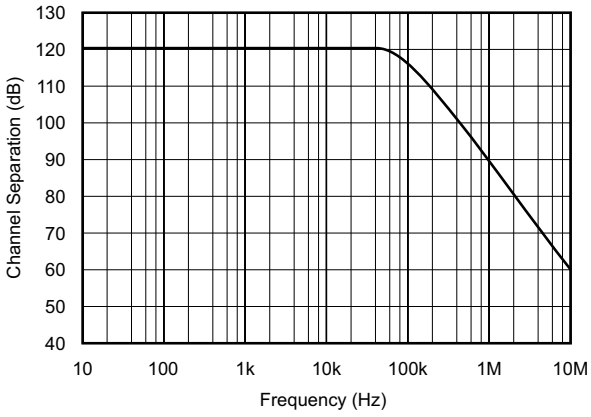


Figure 18. Channel Separation vs Frequency

Typical Characteristics (continued)

at T_A = 25°C, R_L = 10 kΩ connected to V_S / 2, V_{OUT} = V_S / 2, and V_{CM} = V_S / 2, (unless otherwise noted)

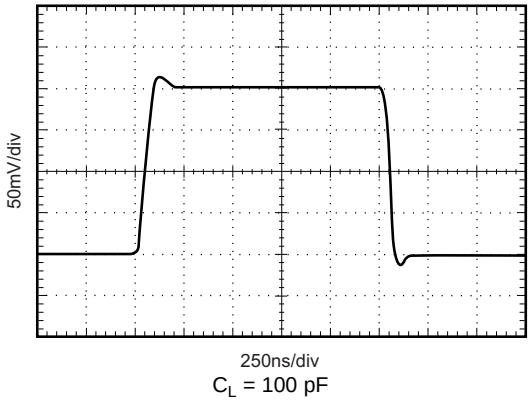


Figure 19. Small-Signal Step Response

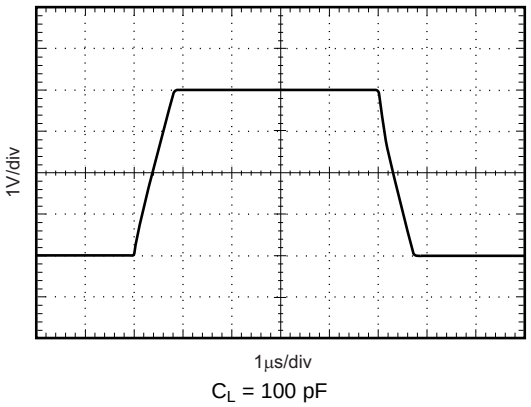


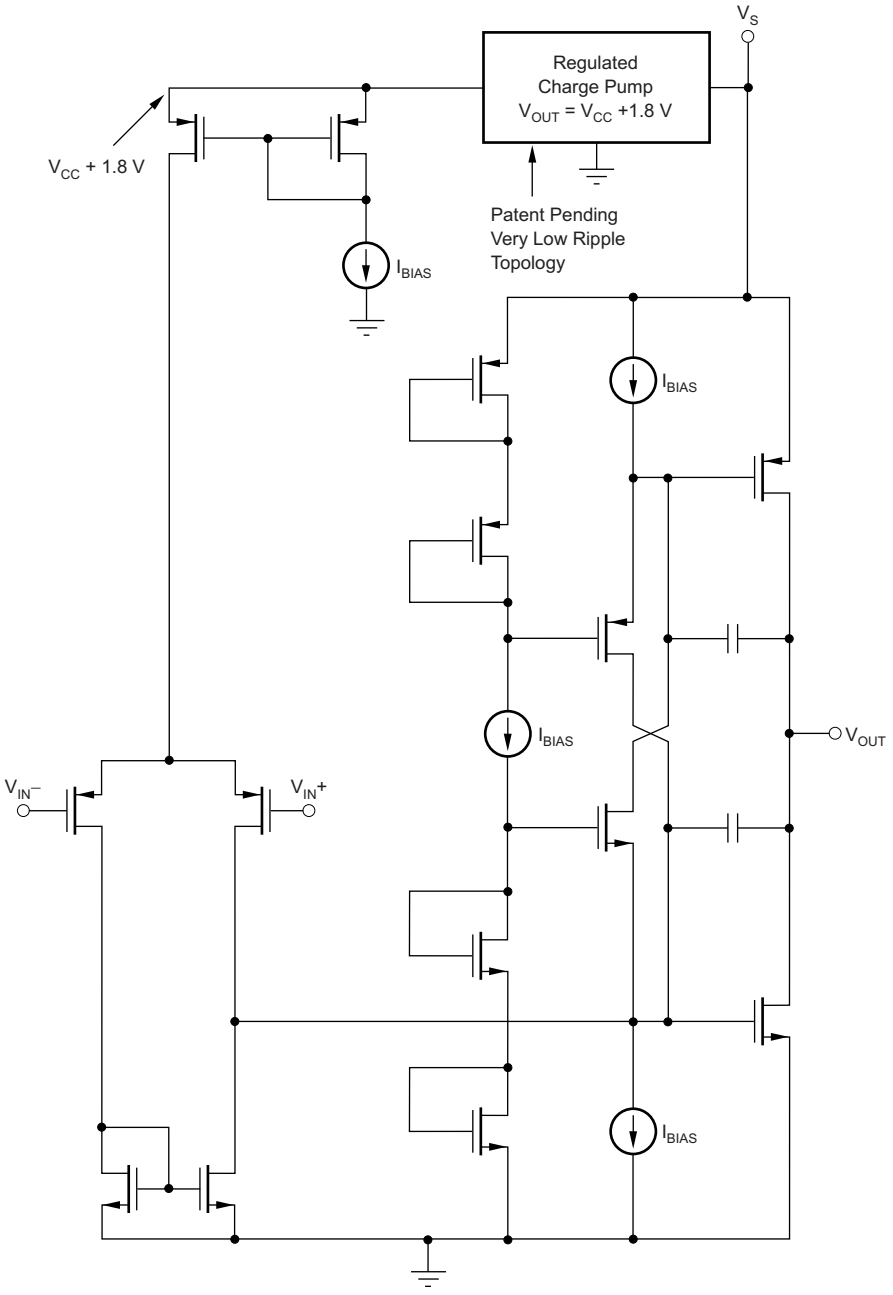
Figure 20. Large-Signal Step Response

8 Detailed Description

8.1 Overview

The OPA363 and OPA364 series op amps are rail-to-rail operational amplifiers with excellent CMRR, low noise, low offset, and wide bandwidth on supply voltages as low as ±0.9 V. The OPA363 features an additional pin for a shutdown and enable function. These families do not exhibit phase reversal and are unity-gain stable. Specified over the industrial temperature range of –40°C to +125°C, the OPA363 and OPA364 families offer precision performance for a wide range of applications.

8.2 Functional Block Diagram



8.3 Feature Description

8.3.1 Rail-to-Rail Input

The OPA363 and OPA364 feature excellent rail-to-rail operation, with supply voltages as low as ±0.9 V. The input common-mode voltage range of the OPA363 and OPA364 family extends 100 mV beyond supply rails. The unique input topology of the OPA363 and OPA364 eliminates the input offset transition region typical of most rail-to-rail, complementary stage operational amplifiers, allowing the OPA363 and OPA364 to provide superior common-mode performance over the entire common-mode input range, as seen in Figure 21. This feature prevents degradation of the differential linearity error and THD when driving A/D converters. A simplified schematic of the OPA363 and OPA364 is shown in the *Functional Block Diagram*.

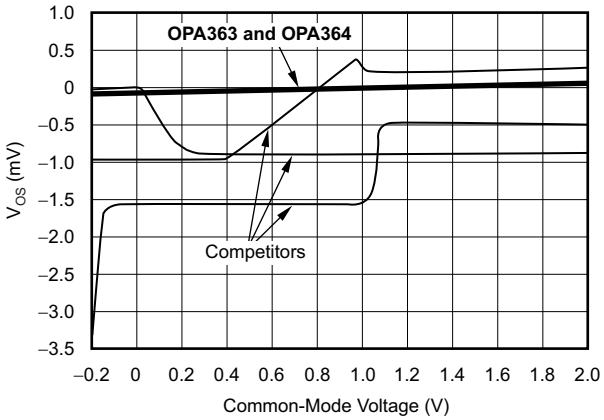


Figure 21. OPA363 and OPA364 Have Linear Offset Over Entire Common-Mode Range

8.3.2 Operating Voltage

The OPA363 and OPA364 series op amp parameters are fully specified from 1.8 V to 5.5 V. Single 0.1-µF bypass capacitors must be placed across supply pins and as close to the part as possible. Supply voltages higher than 5.5 V (absolute maximum) may cause permanent damage to the amplifier. Many specifications apply from –40°C to +125°C. Parameters that vary significantly with operating voltages or temperature are shown in the *Typical Characteristics*.

8.3.3 Capacitive Load

The OPAx363 and OPAx364 series op amps can drive a wide range of capacitive loads. However, all op amps under certain conditions may become unstable. Op amp configuration, gain, and load value are a few of the factors to consider when determining stability. An op amp in unity-gain configuration is the most susceptible to the effects of capacitive load. The capacitive load reacts with the output resistance of the op amp to create a pole in the small-signal response, which degrades the phase margin.

In unity gain, the OPAx363 and OPAx364 series op amps perform well with a pure capacitive load up to approximately 1000 pF. The equivalent series resistance (ESR) of the loading capacitor may be sufficient to allow the OPA363 and OPA364 to directly drive very large capacitive loads (greater than 1 µF). Increasing gain enhances the ability of the amplifier to drive more capacitance; see Figure 13.

One method of improving capacitive load drive in the unity-gain configuration is to insert a 10-Ω to 20-Ω resistor in series with the output, as shown in Figure 22. This resistor significantly reduces ringing with large capacitive loads. However, if there is a resistive load in parallel with the capacitive load, the load creates a voltage divider, introduces a DC error at the output, and slightly reduces output swing. This error may be insignificant. For example, with R_L = 10 kΩ and R_S = 20 Ω, there is an approximate 0.2% error at the output.

Feature Description (continued)

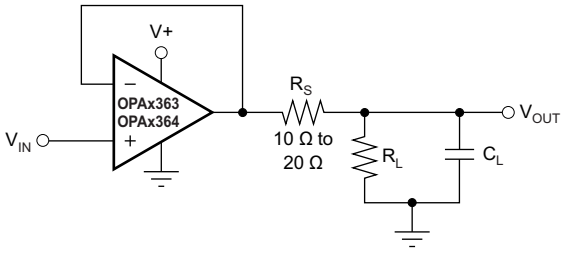


Figure 22. Improving Capacitive Load Drive

8.3.4 Input and ESD Protection

All OPAx363 and OPAx364 pins are static-protected with internal ESD protection diodes tied to the supplies. These diodes provide overdrive protection if the current is externally limited to 10 mA, as shown in the *Absolute Maximum Ratings* and shown in Figure 23.

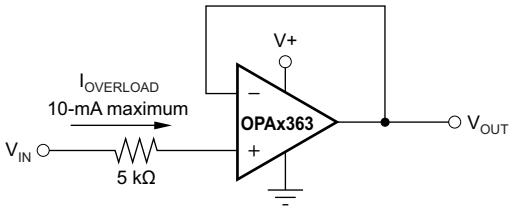


Figure 23. Input Current Protection

8.4 Device Functional Modes

8.4.1 Enable Function

The shutdown (enable) function of the OPAx363 is referenced to the negative supply voltage of the operational amplifier. A logic level HIGH enables the op amp. A valid logic HIGH is defined as voltage greater than 75% of the positive supply applied to the enable pin. The valid logic HIGH signal can be as much as 5.5 V above the negative supply, independent of the positive supply voltage. A valid logic LOW is defined as less than 0.8 V above the negative supply pin. If dual or split power supplies are used, take care to ensure that logic input signals are properly referred to the negative supply voltage. This pin must be connected to a valid high or low voltage or driven, not left open-circuit.

The logic input is a high-impedance CMOS input. Dual op amps are provided separate logic inputs. For battery-operated applications, this feature reduces the average current and extend battery life. The enable time is 20 μs; disable time is 1 μs. When disabled, the output assumes a high-impedance state. This configuration allows the OPAx363 to operate as a *gated* amplifier, or to have the output multiplexed onto a common analog output bus.

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

9.1.1 Achieving Output Swing to the Op Amp Negative Rail

Some applications require an accurate output voltage swing from 0 V to a positive full-scale voltage. A good single-supply op amp may be able to swing within a few millivolts of single-supply ground, but as the output is driven toward 0 V, the output stage of the amplifier prevents the output from reaching the negative supply rail of the amplifier.

The output of the OPAx363 or OPAx364 can be made to swing to ground, or slightly below, on a single-supply power source. To do so requires use of another resistor and an additional, more negative power supply than the op amp negative supply. A pulldown resistor may be connected between the output and the additional negative supply to pull the output down below the value that the output would otherwise achieve, as shown in Figure 24.

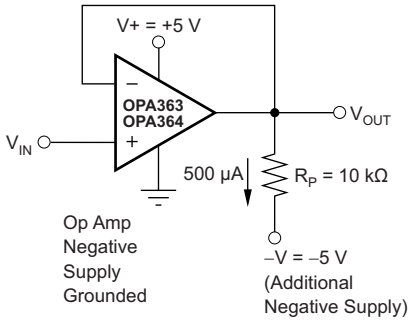


Figure 24. OPA363 and OPA364 Swing to Ground

This technique does not work with all op amps. The output stage of the OPAx363 and OPA3x64 allows the output voltage to be pulled below that of most op amps, if approximately 500 µA is maintained through the output stage. To calculate the appropriate value load resistor and negative supply, R_L = –V / 500 µA. The OPAx363 and OPAx364 are characterized to perform well under the described conditions, maintaining excellent accuracy down to 0 V and as low as –10 mV. Limiting and nonlinearity occur below –10 mV, with linearity returning as the output is again driven above –10 mV.

9.1.2 Directly Driving the ADS8324 and the MSP430

The OPAx363 and OPAx364 series op amps are optimized for driving medium speed (up to 100-kHz) sampling A/D converters. However, they also offer excellent performance for higher speed converters. The no-crossover input stage of the OPAx363 and OPAx364 directly drive A/D converters without degradation of differential linearity and THD. They provide an effective means of buffering the A/D converter input capacitance and resulting charge injection while providing signal gain. Figure 25 and Figure 26 show the OPAx363 and OPAx364 configured to drive the ADS8324 and the 12-bit A/D converter on the MSP430.

Application Information (continued)

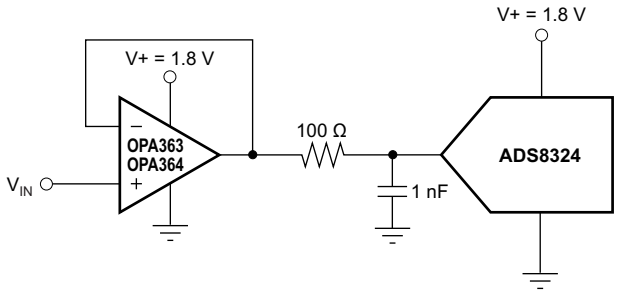


Figure 25. OPAx363 and OPAx364 Directly Drive the ADS8324

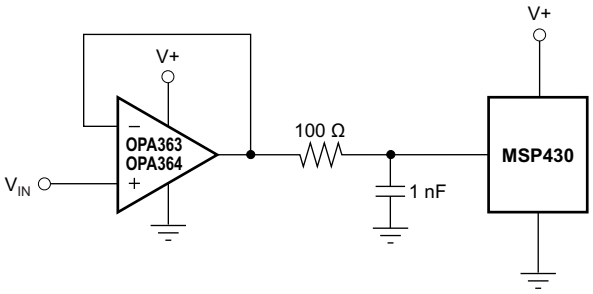


Figure 26. Driving the 12-Bit A/D Converter on the MSP430

9.1.3 Audio Applications

The OPAx363 and OPAx364 op amp family has linear offset voltage over the entire input common-mode range. Combined with low noise, this feature makes the OPAx363 and OPAx364 suitable for audio applications. Single-supply, 1.8-V operation allows the OPA2363 and OPA2364 to be optimal candidates for dual stereo-headphone drivers and microphone preamplifiers in portable stereo equipment; see Figure 27 and Figure 28.

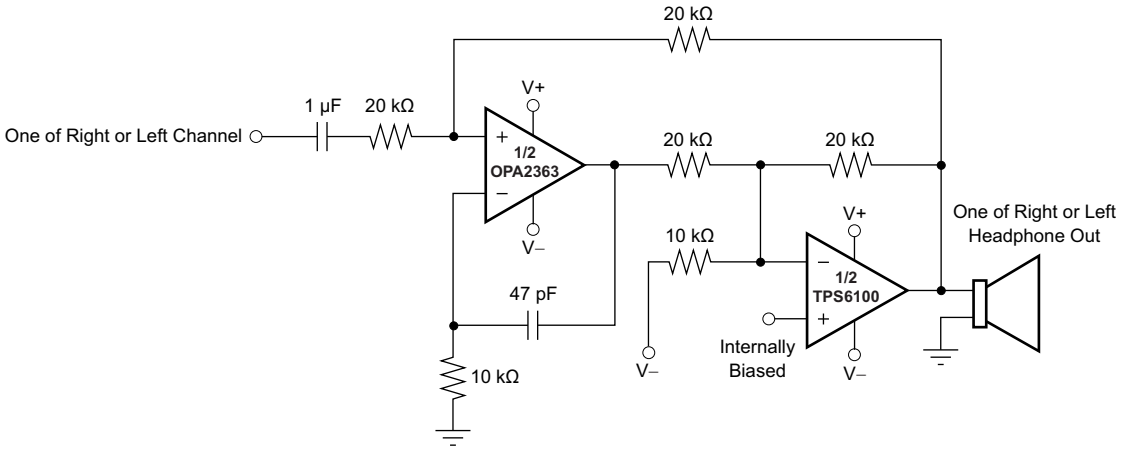


Figure 27. OPA2363 Configured as Half of a Dual Stereo-Headphone Driver

Application Information (continued)

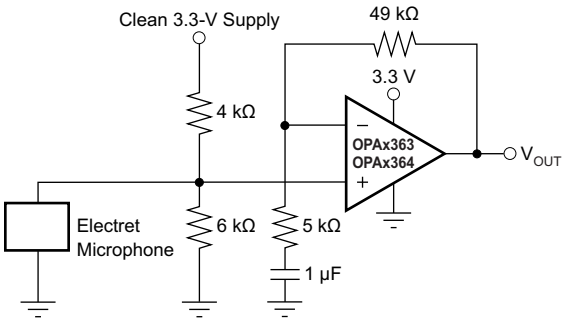


Figure 28. Microphone Preamplifier

9.1.4 Active Filtering

Low harmonic distortion and noise specifications plus high gain and slew rate make the OPAx363 and OPAx364 optimal candidates for active filtering. Figure 29 shows the OPA2363 configured as a low-distortion, third-order general immittance converter (GIC) filter. Figure 30 shows the implementation of a Sallen-Key, 3-pole, low-pass Bessel filter.

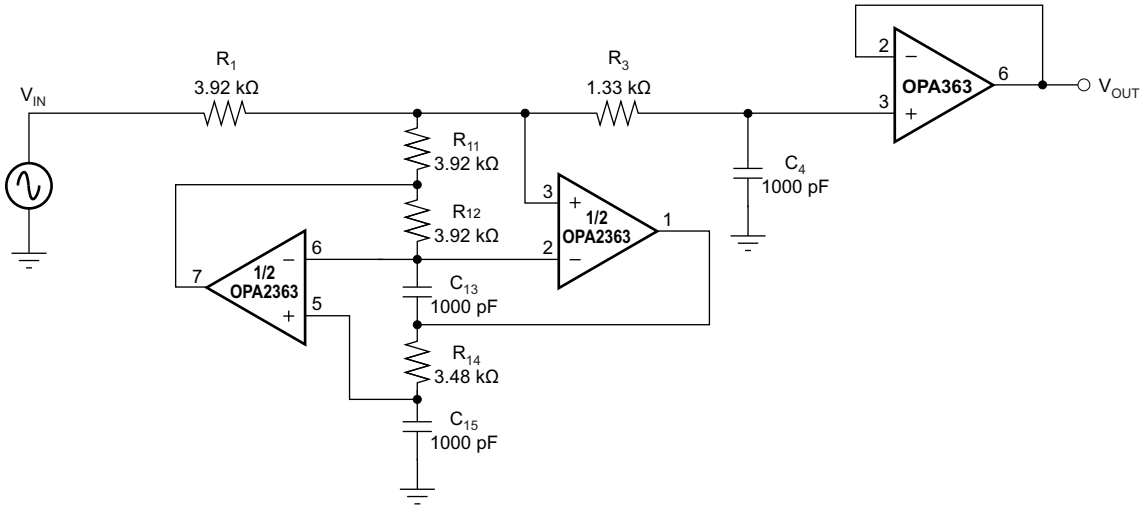


Figure 29. OPA2363 as a Third-Order, 40-kHz, Low-Pass GIC Filter

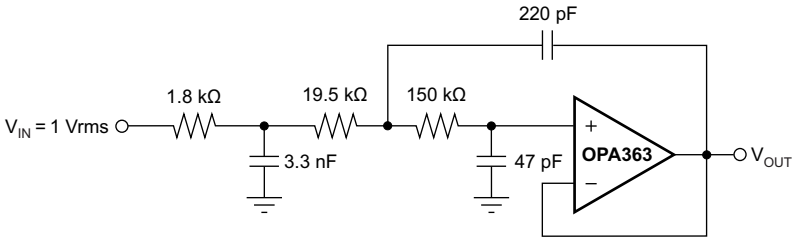


Figure 30. OPAx363 or OPAx364 Configured as a 3-Pole, 20-kHz, Sallen-Key Filter

9.2 Typical Application

9.2.1 Single-Supply Electret Microphone Preamplifier

Electret microphones are commonly used in portable electronics because of their small size, low cost, and relatively good signal-to-noise ratio (SNR). The small package size and excellent AC performance of the OPA364 make it an excellent choice for preamplifier circuits for electret microphones. The circuit shown in Figure 31 is a single-supply preamplifier circuit for electret microphones.

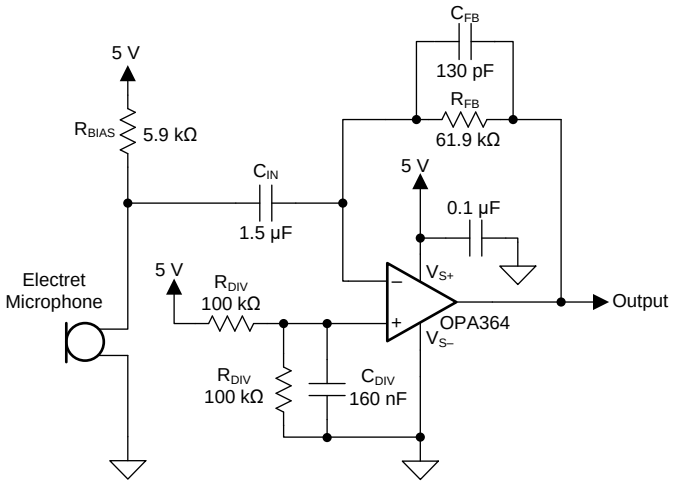


Figure 31. Preamplifier Circuit for Electret Microphones Using a Single-Supply Voltage

9.2.1.1 Design Requirements

- 5-V single supply
- 1-V_{RMS} output for 100-dB_{SPL} input
- 20-Hz to 20-kHz, –3-dB bandwidth
- Microphone sensitivity: 8 µA/Pa
- Microphone operating voltage: 2 V to 10 V
- Microphone bias current: 500 µA

9.2.1.2 Detailed Design Procedure

In this circuit, the op amp is configured as a transimpedance amplifier which converts the signal current of the microphone into an output voltage. The gain of the circuit is determined by the feedback resistor R_{FB}, which must be calculated according to the microphone sensitivity. For this design, a microphone output current of 8 µA per Pascal (Pa) of air pressure was chosen. Using this value, the output current for a sound pressure level of 100 dB_{SPL}, or 2 Pa air pressure, is calculated in Equation 1.

$$i_{mic} = \frac{8\ \mu A}{1\ Pa} \times 2\ Pa = 16\ \mu A \tag{1}$$

R_{FB} is then calculated from this current to produce 1-V_{RMS} output for a 100-dB_{SPL} input signal in Equation 2.

$$R_{FB} = \frac{V_O}{i_{mic}} = \frac{1\ V_{RMS}}{16\ \mu A} = 62500 \rightarrow 61.9\ k\Omega \tag{2}$$

The feedback capacitor (C_{FB}) is calculated to limit the bandwidth of the amplifier to 20 kHz in Equation 3.

$$C_{FB} = \frac{1}{2 \cdot \pi \cdot R_{FB} \cdot f_H} = \frac{1}{2 \cdot \pi \cdot (61.9\ k\Omega) \cdot (20\ kHz)} = 128.5 \times 10^{-12} \rightarrow 130\ pF \tag{3}$$

Typical Application (continued)

R_{BIAS} is required to divert the microphone signal current through capacitor C_{IN} rather than flowing from the power supply, V_{CC}. Larger values of R_{BIAS} allow for a smaller capacitor to be used for C_{IN} and reduce the overall noise of the circuit. However, the maximum value for R_{BIAS} is limited by the microphone bias current and minimum operating voltage.

The value of R_{BIAS} is calculated in Equation 4.

$$R_{BIAS} = \frac{V_{CC} - V_{MIC}}{I_{BIAS}} = \frac{5\ V - 2\ V}{500\ \mu A} = 6000 \rightarrow 5.9\ k\Omega \tag{4}$$

Input capacitor C_{IN} forms a high-pass filter in combination with resistor R_{BIAS}. The filter corner frequency calculation is shown in Equation 5 to place the high-pass corner frequency at 20 Hz.

$$C_{IN} = \frac{1}{2 \cdot \pi \cdot R_{BIAS} \cdot f_L} = \frac{1}{2 \cdot \pi \cdot (5.9\ k\Omega) \cdot (20\ Hz)} = 1.349 \times 10^{-6} \rightarrow 1.5\ \mu F \tag{5}$$

The voltage divider network at the op amp noninverting input is used to bias the op amp output to the mid-supply point (V_{CC} / 2) to maximize the output voltage range of the circuit. This result is easily achieved by selecting the same value for both resistors in the divider. The absolute value of those resistors is limited by the acceptable power-supply current drawn by the voltage divider. Selecting 25 µA as an acceptable limit of supply current gives a value of 100 kΩ for the resistors in the divider, as Equation 6 shows.

$$R_{DIV} = \frac{V_{CC}}{2 \cdot I_{DIV}} = \frac{5\ V}{2 \cdot 25\ \mu A} = 100\ k\Omega \tag{6}$$

Finally, to minimize the additional noise contribution from the voltage divider, a capacitor is placed at the op amp noninverting input. This capacitor forms a low-pass filter with the parallel combination of the voltage divider resistors. Selecting a filter corner frequency of 20 Hz minimizes the noise contribution of the voltage divider inside the amplifier passband; see Equation 7.

$$C_{DIV} = \frac{1}{2 \cdot \pi \cdot \left(\frac{R_{DIV}}{2}\right) \cdot f_L} = \frac{1}{2 \cdot \pi \cdot \left(\frac{100\ k\Omega}{2}\right) \cdot (20\ Hz)} = 1.592 \times 10^{-7} \rightarrow 160\ nF \tag{7}$$

9.2.1.3 Application Curve

The transfer function of the microphone preamplifier circuit is shown in Figure 32. The nominal gain of the circuit is 95.82 dB, or 61,800 V per amp of input current. The –3-dB bandwidth limits of the circuit are 17.99 Hz and 19.23 kHz.

Typical Application (continued)

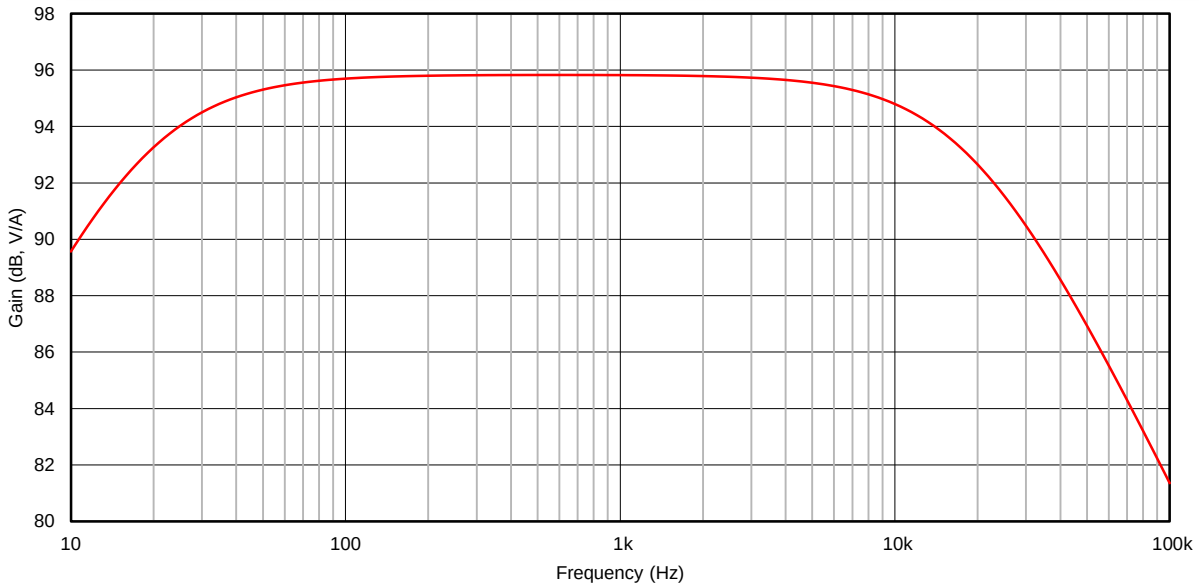


Figure 32. Microphone Preamplifier Transfer Function

10 Power Supply Recommendations

The OPAx363 and OPAx364 are specified for operation from 2.7 V to 5.5 V (±1.35 V to ±2.75 V). Parameters that can exhibit significant variance with regard to operating voltage are presented in the *Electrical Characteristics*.

11 Layout

11.1 Layout Guidelines

For best operational performance of the device, use good printed-circuit board (PCB) layout practices, including:

- Noise can propagate into analog circuitry through the power pins of the circuit as a whole and of op amp itself. Bypass capacitors reduce the coupled noise by providing low-impedance power sources local to the analog circuitry.
  - Connect low-ESR, 0.1-µF ceramic bypass capacitors between each supply pin and ground, placed as close to the device as possible. A single bypass capacitor from V+ to ground is applicable for single-supply applications.
- Separate grounding for analog and digital portions of circuitry is one of the simplest and most effective methods of noise suppression. One or more layers on multilayer PCBs are usually devoted to ground planes. A ground plane helps distribute heat and reduces EMI noise pickup. Make sure to physically separate digital and analog grounds, paying attention to the flow of the ground current.
- To reduce parasitic coupling, run the input traces as far away from the supply or output traces as possible. If these traces cannot be kept separate, crossing the sensitive trace perpendicular is much better as opposed to in parallel with the noisy trace.
- Place the external components as close to the device as possible. As shown in Figure 33, keeping R_F and R_G close to the inverting input minimizes parasitic capacitance.
- Keep the length of input traces as short as possible. Always remember that the input traces are the most sensitive part of the circuit.
- Consider a driven, low-impedance guard ring around the critical traces. A guard ring can significantly reduce leakage currents from nearby traces that are at different potentials.
- Cleaning the PCB following board assembly is recommended for best performance.
- Any precision integrated circuit can experience performance shifts resulting from moisture ingress into the plastic package. Following any aqueous PCB cleaning process, baking the PCB assembly is recommended to remove moisture introduced into the device packaging during the cleaning process. A low temperature, post-cleaning bake at 85°C for 30 minutes is sufficient for most circumstances.

11.2 Layout Example

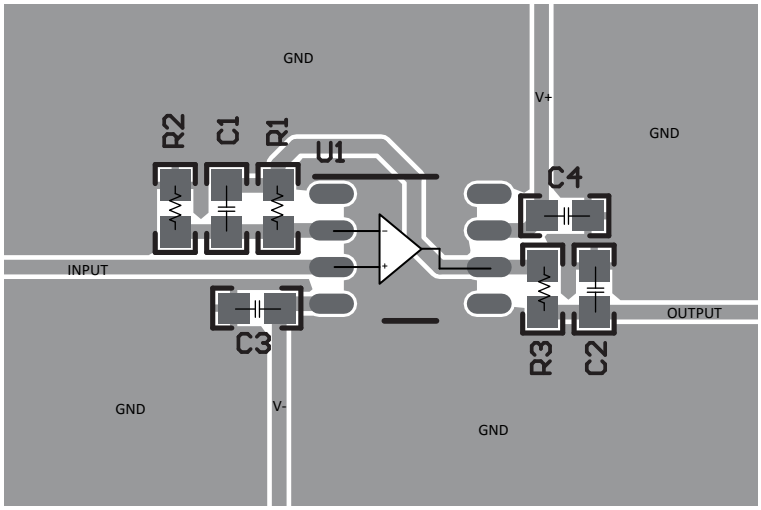


Figure 33. Operational Amplifier Board Layout for Noninverting Configuration

Layout Example (continued)

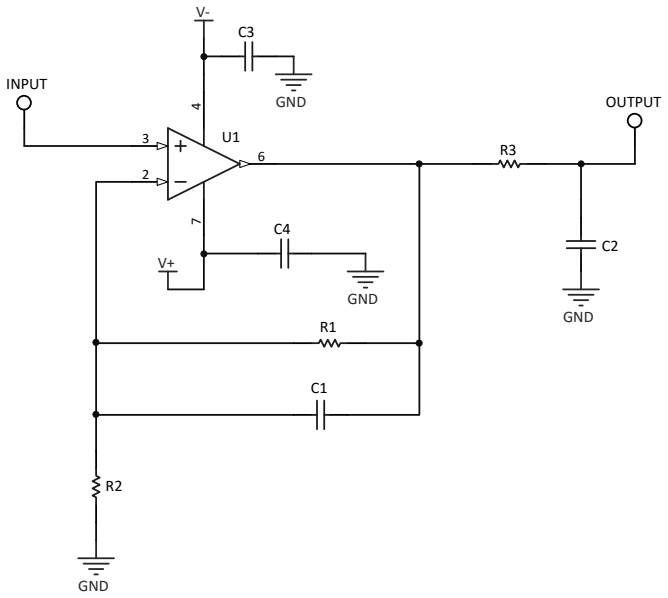


Figure 34. Layout Example Schematic

12 Device and Documentation Support

12.1 Device Support

12.1.1 Development Support

12.1.1.1 TINA-TI™ (Free Software Download)

TINA™ is a simple, powerful, and easy-to-use circuit simulation program based on a SPICE engine. TINA-TI™ is a free, fully-functional version of the TINA software, preloaded with a library of macro models in addition to a range of both passive and active models. TINA-TI provides all the conventional dc, transient, and frequency domain analysis of SPICE, as well as additional design capabilities.

Available as a free download from the Analog eLab Design Center, TINA-TI offers extensive post-processing capability that allows users to format results in a variety of ways. Virtual instruments offer the ability to select input waveforms and probe circuit nodes, voltages, and waveforms, creating a dynamic quick-start tool.

NOTE

These files require that either the TINA software (from DesignSoft™) or TINA-TI software be installed. Download the free TINA-TI software from the TINA-TI folder.

12.1.1.2 DIP Adapter EVM

The DIP Adapter EVM tool provides an easy, low-cost way to prototype small surface mount devices. The evaluation tool these TI packages: D or U (8-pin SOIC), PW (8-pin TSSOP), DGK (8-pin MSOP), DBV (6-pin SOT-23, 5-pin SOT-23, and 3-pin SOT-23), DCK (6-pin SC-70 and 5-pin SC-70), and DRL (6-pin SOT-563). The DIP Adapter EVM may also be used with terminal strips or may be wired directly to existing circuits.

12.1.1.3 Universal Op Amp EVM

The Universal Op Amp EVM is a series of general-purpose, blank circuit boards that simplify prototyping circuits for a variety of device package types. The evaluation module board design allows many different circuits to be constructed easily and quickly. Five models are offered, with each model intended for a specific package type. PDIP, SOIC, MSOP, TSSOP and SOT-23 packages are all supported.

NOTE

These boards are unpopulated, so users must provide their own devices. TI recommends requesting several op amp device samples when ordering the Universal Op Amp EVM.

12.1.1.4 TI Precision Designs

TI Precision Designs are analog solutions created by TI's precision analog applications experts and offer the theory of operation, component selection, simulation, complete PCB schematic and layout, bill of materials, and measured performance of many useful circuits. TI Precision Designs are available online at http://www.ti.com/ww/en/analog/precision-designs/.

12.1.1.5 WEBENCH® Filter Designer

WEBENCH® Filter Designer is a simple, powerful, and easy-to-use active filter design program. The WEBENCH Filter Designer allows the user to create optimized filter designs using a selection of TI operational amplifiers and passive components from TI's vendor partners.

Available as a web-based tool from the WEBENCH® Design Center, WEBENCH® Filter Designer allows the user to design, optimize, and simulate complete multistage active filter solutions within minutes.

12.2 Documentation Support

12.2.1 Related Documentation

The following documents are relevant to using the OPAx363 and OPAx364, and are recommended for reference. All are available for download at www.ti.com (unless otherwise noted):

- *AB-045 Op Amp Performance Analysis*
- *AB-067 Single-Supply Operation of Operational Amplifiers*
- *AB-105 Tuning in Amplifiers*
- *QFN/SON PCB Attachment*
- *Quad Flatpack No-Lead Logic Packages*

12.3 Related Links

The table below 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	ORDER NOW	TECHNICAL DOCUMENTS	TOOLS & SOFTWARE	SUPPORT & COMMUNITY
OPA363	Click here	Click here	Click here	Click here	Click here
OPA2363	Click here	Click here	Click here	Click here	Click here
OPA364	Click here	Click here	Click here	Click here	Click here
OPA2364	Click here	Click here	Click here	Click here	Click here
OPA4364	Click here	Click here	Click here	Click here	Click here

12.4 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

12.5 Community Resource

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.

12.6 Trademarks

TINA-TI, E2E are trademarks of Texas Instruments.
WEBENCH is a registered trademark of Texas Instruments.
TINA, DesignSoft are trademarks of DesignSoft, Inc.
All other trademarks are the property of their respective owners.

12.7 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.

12.8 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.

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
OPA2363AIDGSR	ACTIVE	VSSOP	DGS	10	2500	RoHS & Green	Call TI	Call TI	-40 to 125	BHK	Samples
OPA2363AIDGST	ACTIVE	VSSOP	DGS	10	250	RoHS & Green	Call TI	Call TI	-40 to 125	BHK	Samples
OPA2363AIDGSTG4	ACTIVE	VSSOP	DGS	10	250	RoHS & Green	Call TI	Call TI	-40 to 125	BHK	Samples
OPA2363AIRSVR	ACTIVE	UQFN	RSV	16	3000	RoHS & Green	NIPDAUAG	Level-2-260C-1 YEAR	-40 to 125	SIN	Samples
OPA2363IDGSR	ACTIVE	VSSOP	DGS	10	2500	RoHS & Green	Call TI	Call TI	-40 to 125	BHK	Samples
OPA2363IDGST	ACTIVE	VSSOP	DGS	10	250	RoHS & Green	Call TI	Call TI	-40 to 125	BHK	Samples
OPA2364AID	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 2364 A	Samples
OPA2364AIDG4	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 2364 A	Samples
OPA2364AIDGKR	ACTIVE	VSSOP	DGK	8	2500	RoHS & Green	NIPDAUAG	Level-2-260C-1 YEAR	-40 to 125	BHL	Samples
OPA2364AIDGKRG4	ACTIVE	VSSOP	DGK	8	2500	RoHS & Green	NIPDAUAG	Level-2-260C-1 YEAR	-40 to 125	BHL	Samples
OPA2364AIDGKT	ACTIVE	VSSOP	DGK	8	250	RoHS & Green	NIPDAUAG	Level-2-260C-1 YEAR	-40 to 125	BHL	Samples
OPA2364AIDGKTG4	ACTIVE	VSSOP	DGK	8	250	RoHS & Green	NIPDAUAG	Level-2-260C-1 YEAR	-40 to 125	BHL	Samples
OPA2364AIDR	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 2364 A	Samples
OPA2364AIDRG4	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 2364 A	Samples
OPA2364ID	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 2364	Samples
OPA2364IDGKR	ACTIVE	VSSOP	DGK	8	2500	RoHS & Green	NIPDAUAG	Level-2-260C-1 YEAR	-40 to 125	BHL	Samples
OPA2364IDGKT	ACTIVE	VSSOP	DGK	8	250	RoHS & Green	NIPDAUAG	Level-2-260C-1 YEAR	-40 to 125	BHL	Samples

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
OPA2364IDGKTG4	ACTIVE	VSSOP	DGK	8	250	RoHS & Green	NIPDAUAG	Level-2-260C-1 YEAR	-40 to 125	BHL	Samples
OPA2364IDR	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 2364	Samples
OPA2364IDRG4	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 2364	Samples
OPA363AID	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 363 A	Samples
OPA363AIDBVR	ACTIVE	SOT-23	DBV	6	3000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	A40	Samples
OPA363AIDBVT	ACTIVE	SOT-23	DBV	6	250	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	A40	Samples
OPA363AIDBVTG4	ACTIVE	SOT-23	DBV	6	250	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	A40	Samples
OPA363ID	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 363	Samples
OPA363IDBVR	ACTIVE	SOT-23	DBV	6	3000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	A40	Samples
OPA363IDBVT	ACTIVE	SOT-23	DBV	6	250	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	A40	Samples
OPA363IDBVTG4	ACTIVE	SOT-23	DBV	6	250	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	A40	Samples
OPA364AID	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 364 A	Samples
OPA364AIDBVR	ACTIVE	SOT-23	DBV	5	3000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	A41	Samples
OPA364AIDBVT	ACTIVE	SOT-23	DBV	5	250	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	A41	Samples
OPA364AIDBVTG4	ACTIVE	SOT-23	DBV	5	250	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	A41	Samples
OPA364AIDR	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 364 A	Samples
OPA364ID	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 364	Samples
OPA364IDBVR	ACTIVE	SOT-23	DBV	5	3000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	A41	Samples

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
OPA364IDBVRG4	ACTIVE	SOT-23	DBV	5	3000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	A41	Samples
OPA364IDBVT	ACTIVE	SOT-23	DBV	5	250	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	A41	Samples
OPA364IDBVTG4	ACTIVE	SOT-23	DBV	5	250	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	A41	Samples
OPA364IDG4	ACTIVE	SOIC	D	8	75	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 364	Samples
OPA364IDR	ACTIVE	SOIC	D	8	2500	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 364	Samples
OPA4364AID	ACTIVE	SOIC	D	14	50	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA4364A	Samples
OPA4364AIDR	ACTIVE	SOIC	D	14	2500	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA4364A	Samples
OPA4364AIDRG4	ACTIVE	SOIC	D	14	2500	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA4364A	Samples
OPA4364AIPWR	ACTIVE	TSSOP	PW	14	2500	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 4364A	Samples
OPA4364AIPWT	ACTIVE	TSSOP	PW	14	250	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 4364A	Samples
OPA4364AIPWTG4	ACTIVE	TSSOP	PW	14	250	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 4364A	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.

OTHER QUALIFIED VERSIONS OF OPA4364 :

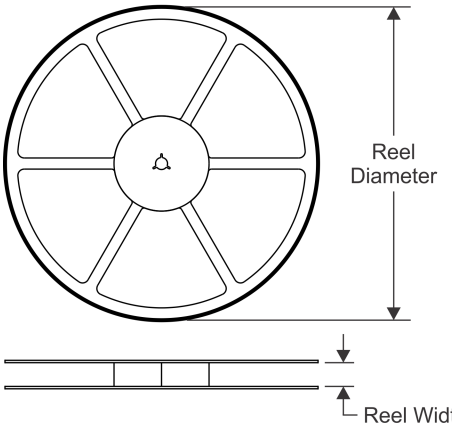
- Automotive: OPA4364-Q1

NOTE: Qualified Version Definitions:

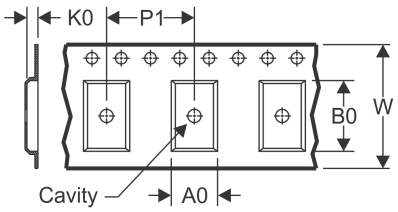
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

TAPE AND REEL INFORMATION

REEL DIMENSIONS

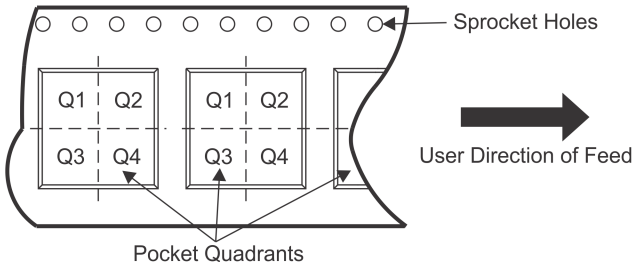


TAPE DIMENSIONS



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

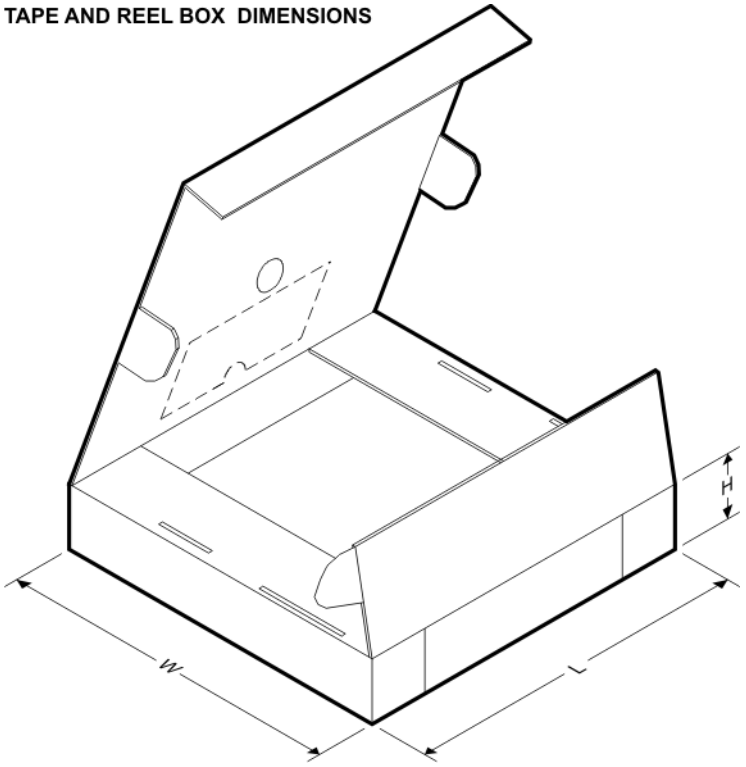


*All dimensions are nominal

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
OPA2363AIDGSR	VSSOP	DGS	10	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
OPA2363AIDGST	VSSOP	DGS	10	250	180.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
OPA2363AIRSVR	UQFN	RSV	16	3000	177.8	12.4	2.0	2.8	0.7	4.0	12.0	Q1
OPA2363IDGSR	VSSOP	DGS	10	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
OPA2363IDGST	VSSOP	DGS	10	250	180.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
OPA2364AIDGKR	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
OPA2364AIDGKT	VSSOP	DGK	8	250	180.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
OPA2364AIDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
OPA2364IDGKR	VSSOP	DGK	8	2500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
OPA2364IDGKT	VSSOP	DGK	8	250	180.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
OPA2364IDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
OPA363AIDBVR	SOT-23	DBV	6	3000	178.0	9.0	3.23	3.17	1.37	4.0	8.0	Q3
OPA363AIDBVT	SOT-23	DBV	6	250	178.0	9.0	3.23	3.17	1.37	4.0	8.0	Q3
OPA363IDBVR	SOT-23	DBV	6	3000	178.0	9.0	3.23	3.17	1.37	4.0	8.0	Q3
OPA363IDBVT	SOT-23	DBV	6	250	178.0	9.0	3.23	3.17	1.37	4.0	8.0	Q3
OPA364AIDBVR	SOT-23	DBV	5	3000	180.0	8.4	3.15	3.1	1.55	4.0	8.0	Q3
OPA364AIDBVT	SOT-23	DBV	5	250	180.0	8.4	3.15	3.1	1.55	4.0	8.0	Q3
OPA364AIDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1

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
OPA364IDBVR	SOT-23	DBV	5	3000	180.0	8.4	3.15	3.1	1.55	4.0	8.0	Q3
OPA364IDBVT	SOT-23	DBV	5	250	180.0	8.4	3.15	3.1	1.55	4.0	8.0	Q3
OPA364IDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
OPA4364AIDR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
OPA4364AIPWR	TSSOP	PW	14	2500	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
OPA4364AIPWT	TSSOP	PW	14	250	180.0	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)
OPA2363AIDGSR	VSSOP	DGS	10	2500	853.0	449.0	35.0
OPA2363AIDGST	VSSOP	DGS	10	250	210.0	185.0	35.0
OPA2363AIRSVR	UQFN	RSV	16	3000	223.0	270.0	35.0
OPA2363IDGSR	VSSOP	DGS	10	2500	853.0	449.0	35.0
OPA2363IDGST	VSSOP	DGS	10	250	210.0	185.0	35.0
OPA2364AIDGKR	VSSOP	DGK	8	2500	853.0	449.0	35.0
OPA2364AIDGKT	VSSOP	DGK	8	250	210.0	185.0	35.0
OPA2364AIDR	SOIC	D	8	2500	853.0	449.0	35.0
OPA2364IDGKR	VSSOP	DGK	8	2500	853.0	449.0	35.0
OPA2364IDGKT	VSSOP	DGK	8	250	210.0	185.0	35.0
OPA2364IDR	SOIC	D	8	2500	853.0	449.0	35.0

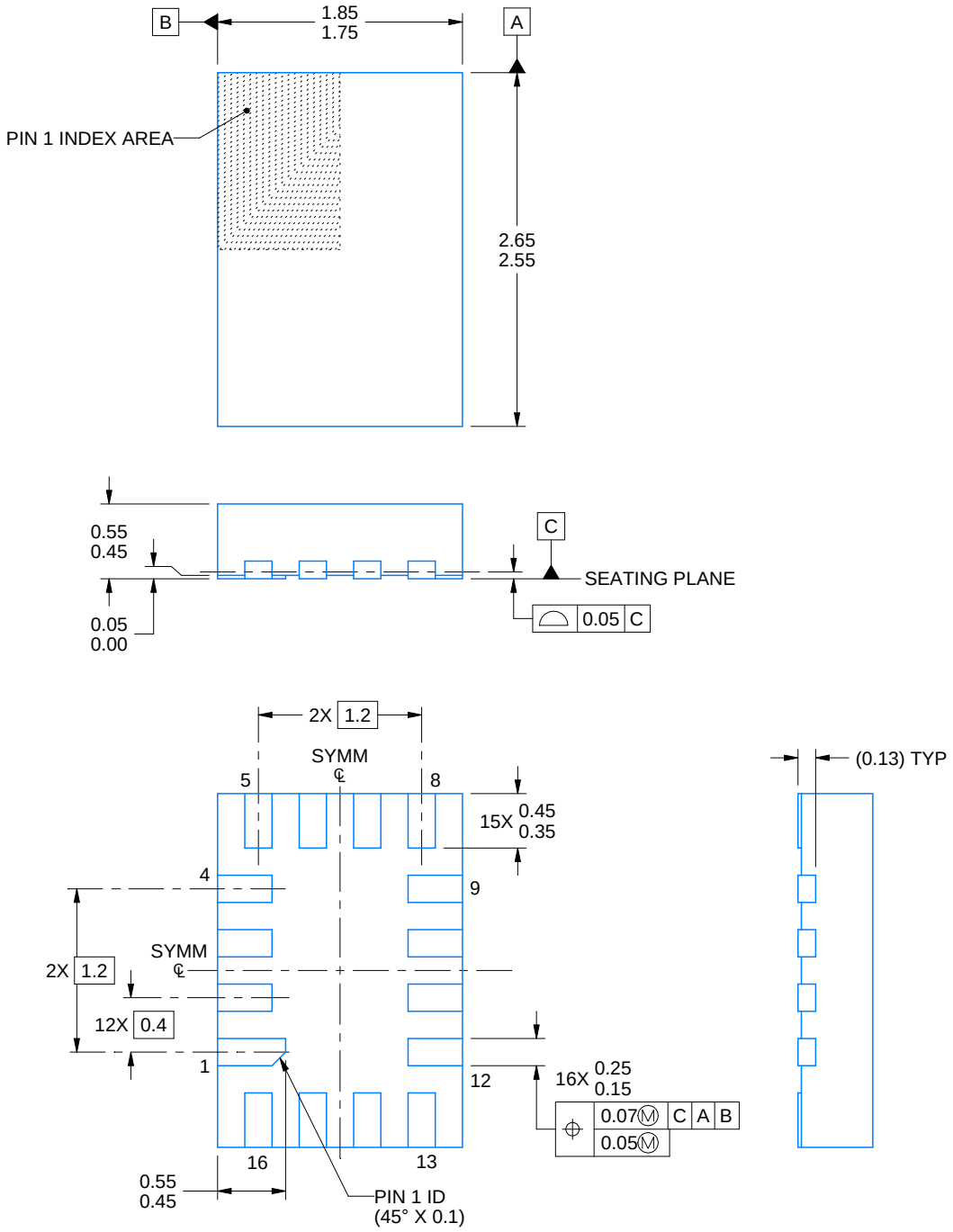
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
OPA363AIDBVR	SOT-23	DBV	6	3000	565.0	140.0	75.0
OPA363AIDBVT	SOT-23	DBV	6	250	565.0	140.0	75.0
OPA363IDBVR	SOT-23	DBV	6	3000	565.0	140.0	75.0
OPA363IDBVT	SOT-23	DBV	6	250	565.0	140.0	75.0
OPA364AIDBVR	SOT-23	DBV	5	3000	210.0	185.0	35.0
OPA364AIDBVT	SOT-23	DBV	5	250	210.0	185.0	35.0
OPA364AIDR	SOIC	D	8	2500	853.0	449.0	35.0
OPA364IDBVR	SOT-23	DBV	5	3000	210.0	185.0	35.0
OPA364IDBVT	SOT-23	DBV	5	250	210.0	185.0	35.0
OPA364IDR	SOIC	D	8	2500	853.0	449.0	35.0
OPA4364AIDR	SOIC	D	14	2500	853.0	449.0	35.0
OPA4364AIPWR	TSSOP	PW	14	2500	853.0	449.0	35.0
OPA4364AIPWT	TSSOP	PW	14	250	210.0	185.0	35.0

RSV0016A

PACKAGE OUTLINE

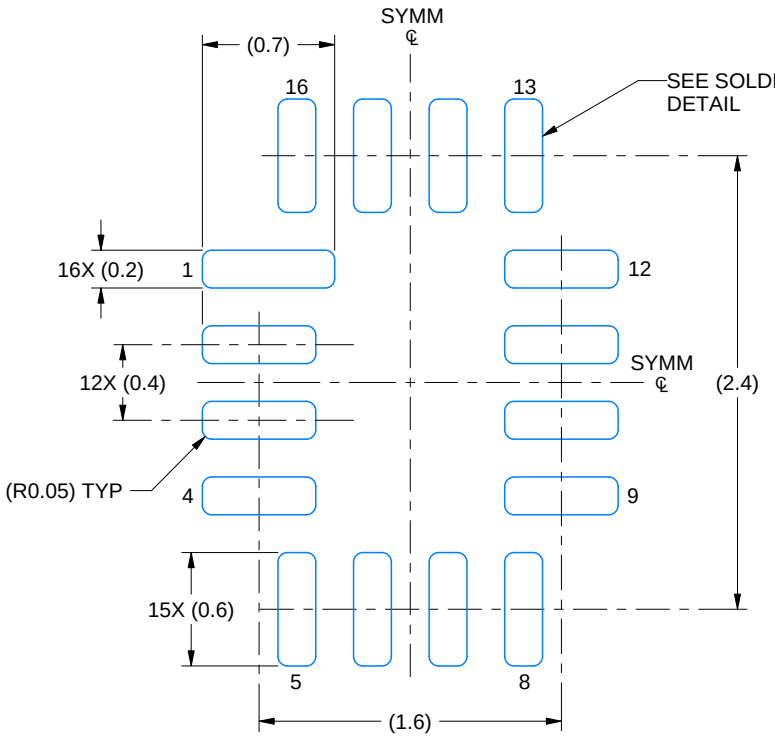
UQFN - 0.55 mm max height

ULTRA THIN QUAD FLATPACK - NO LEAD

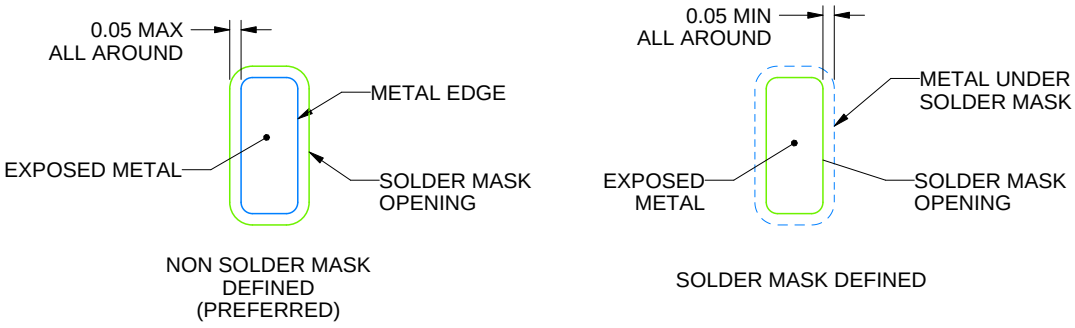


NOTES:

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.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 25X

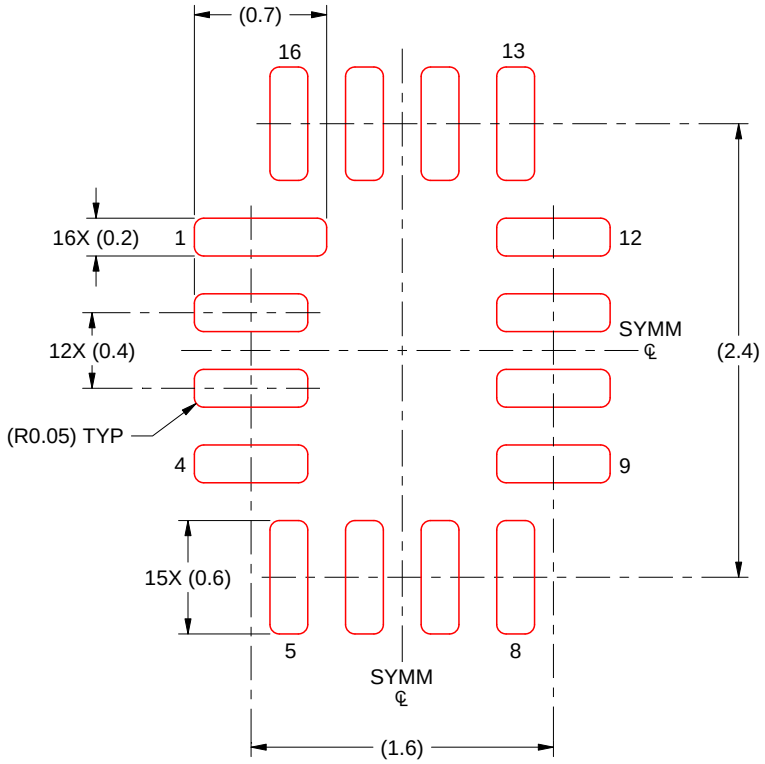


SOLDER MASK DETAILS

4220314/C 02/2020

NOTES: (continued)

3. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).



SOLDER PASTE EXAMPLE
BASED ON 0.125 MM THICK STENCIL
SCALE: 25X

4220314/C 02/2020

NOTES: (continued)

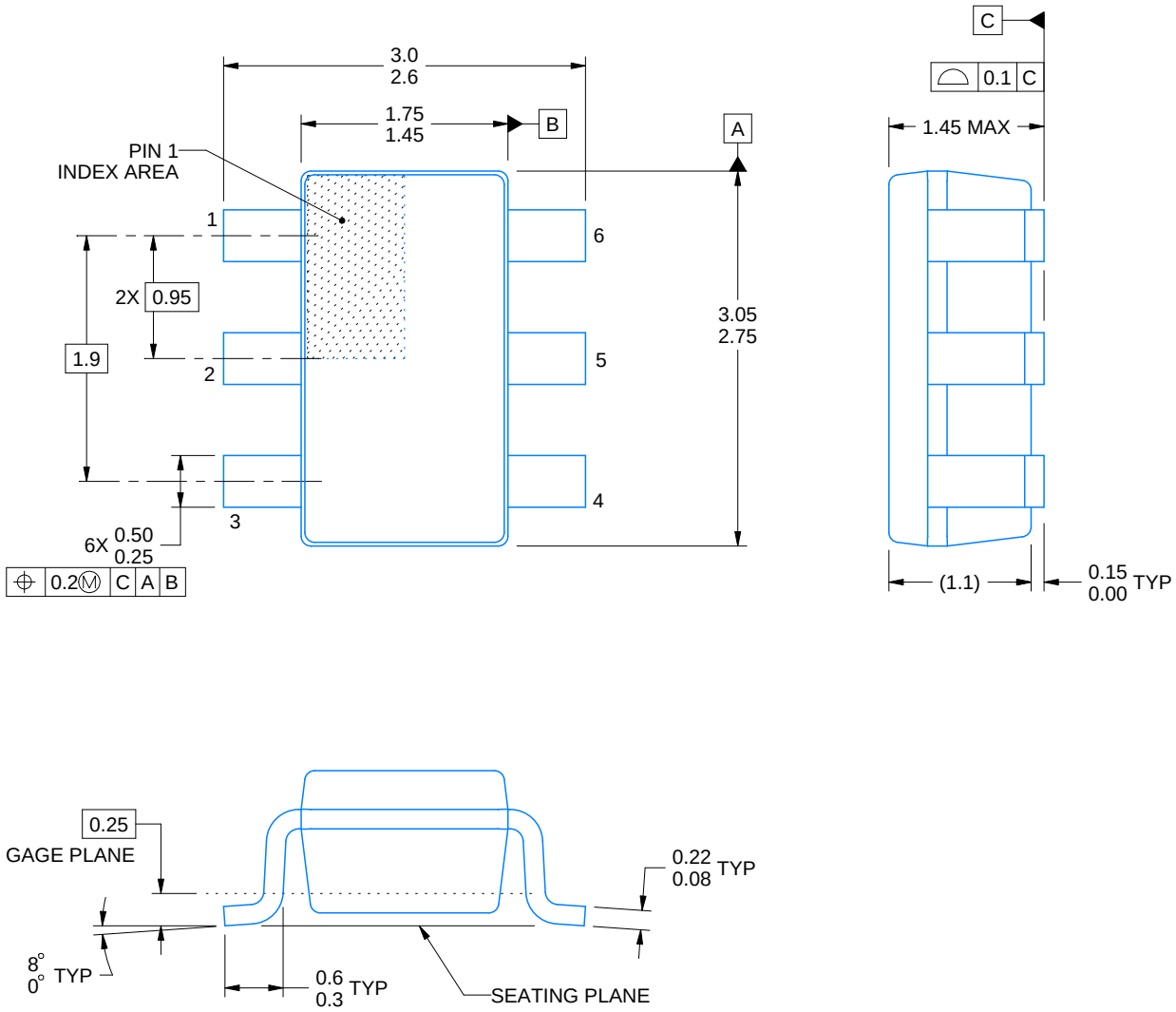
4. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

PACKAGE OUTLINE

DBV0006A

SOT-23 - 1.45 mm max height

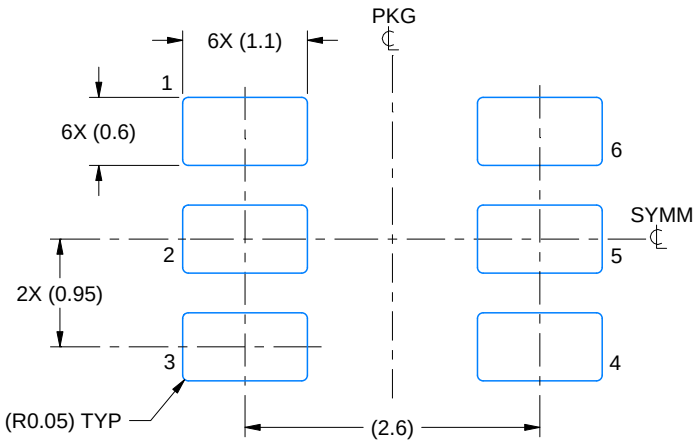
SMALL OUTLINE TRANSISTOR



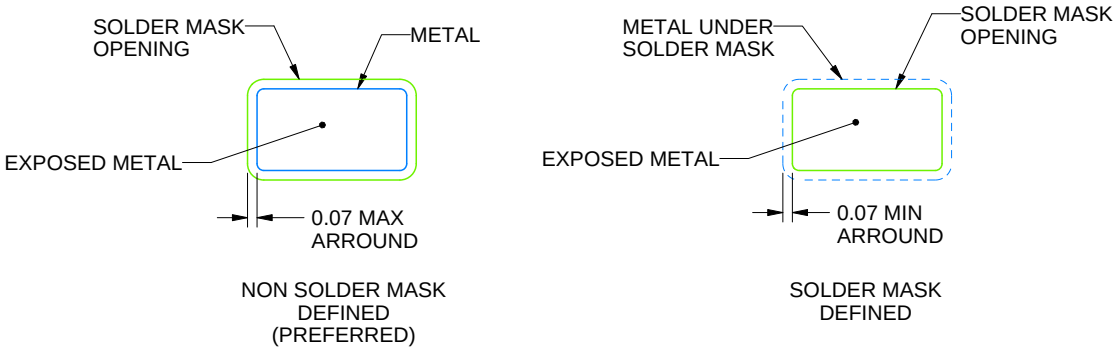
4214840/B 03/2018

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. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
4. Leads 1,2,3 may be wider than leads 4,5,6 for package orientation.
5. Refernce JEDEC MO-178.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:15X

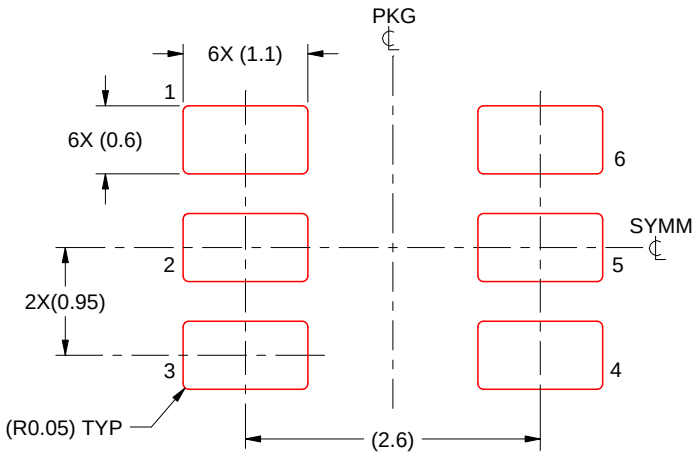


SOLDER MASK DETAILS

4214840/B 03/2018

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

4214840/B 03/2018

NOTES: (continued)

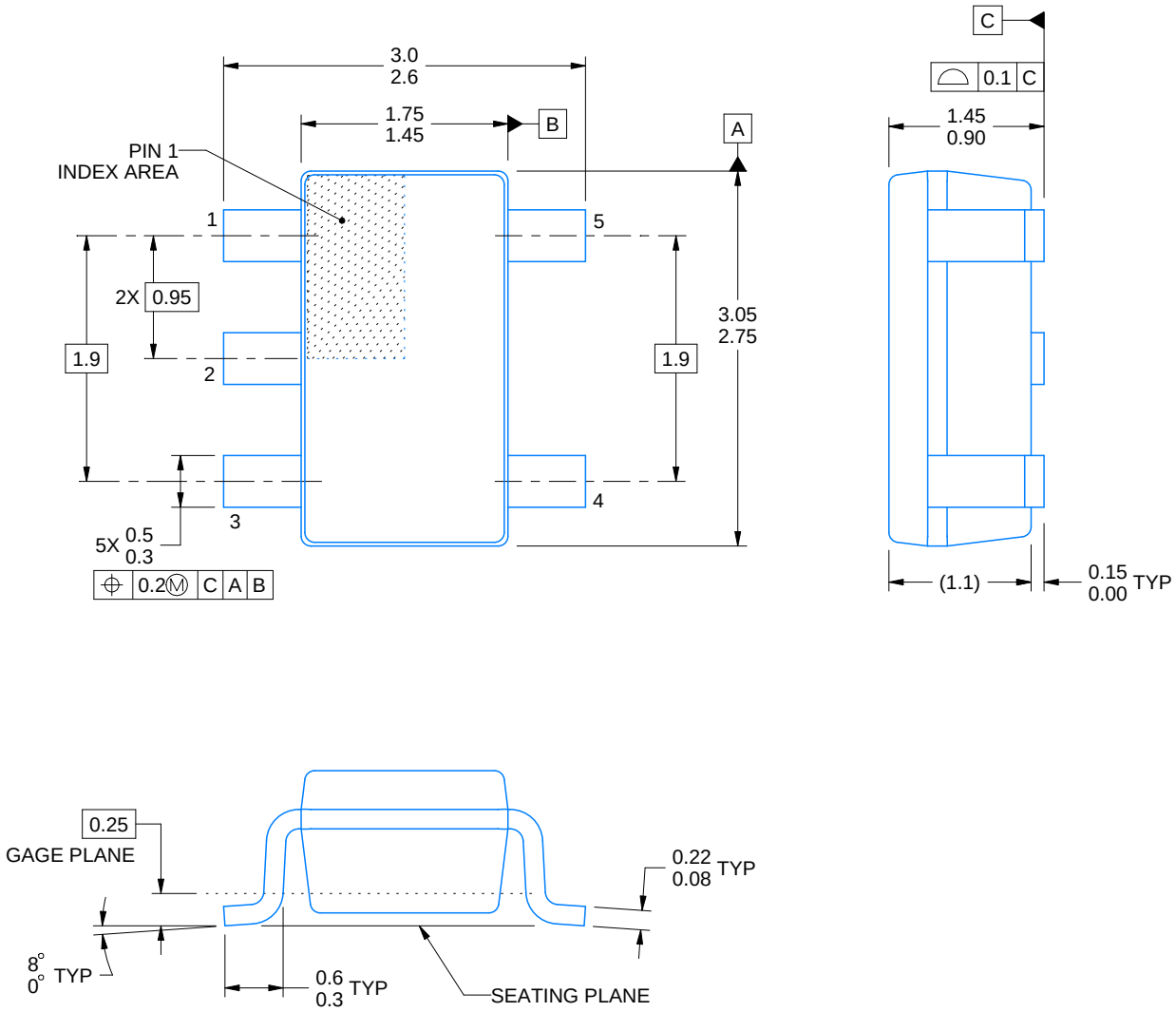
8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

PACKAGE OUTLINE

DBV0005A

SOT-23 - 1.45 mm max height

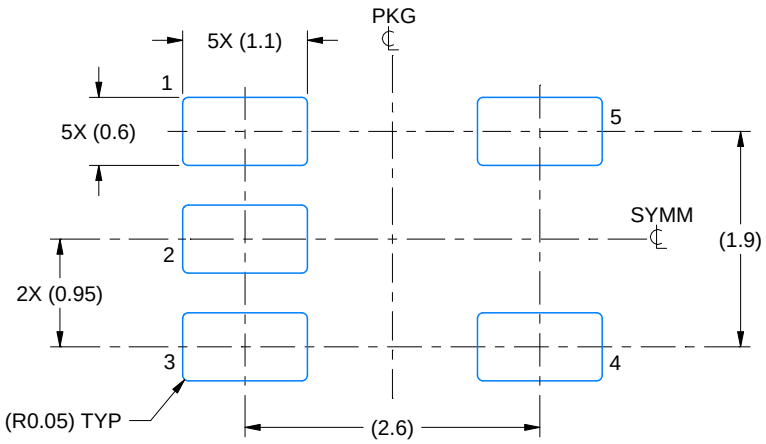
SMALL OUTLINE TRANSISTOR



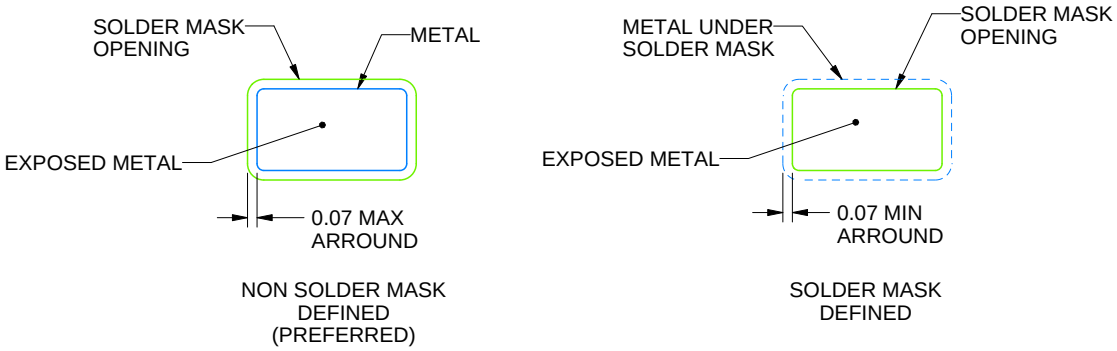
4214839/E 09/2019

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 0.15 mm per side.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:15X

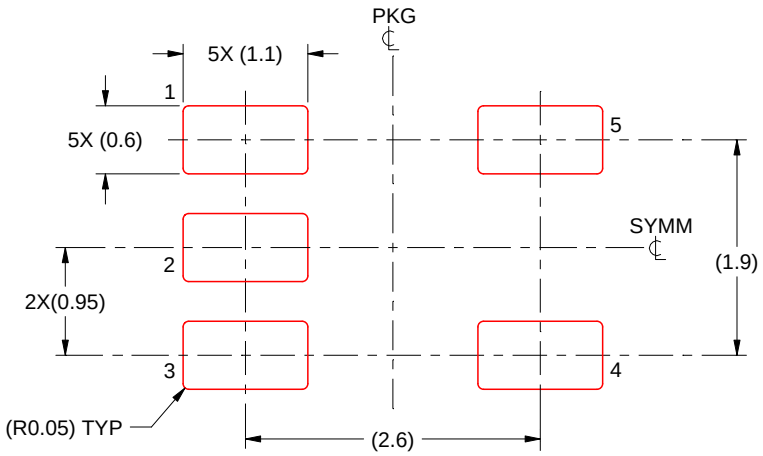


SOLDER MASK DETAILS

4214839/E 09/2019

NOTES: (continued)

5. Publication IPC-7351 may have alternate designs.
6. 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/E 09/2019

NOTES: (continued)

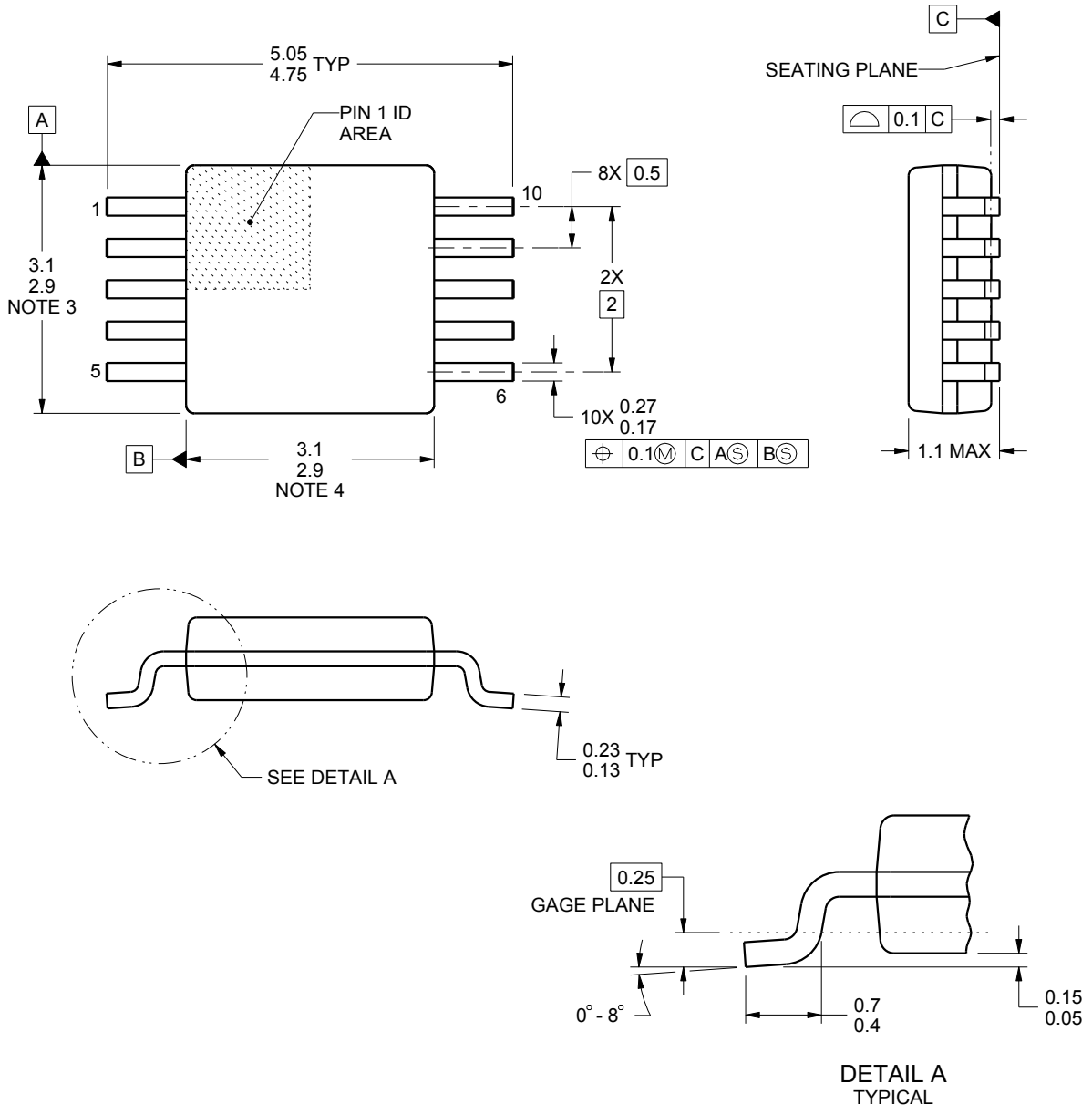
7. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
8. Board assembly site may have different recommendations for stencil design.

PACKAGE OUTLINE

DGS0010A

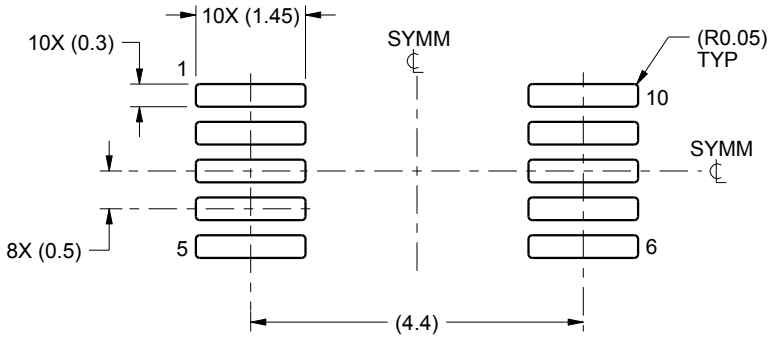
VSSOP - 1.1 mm max height

SMALL OUTLINE PACKAGE

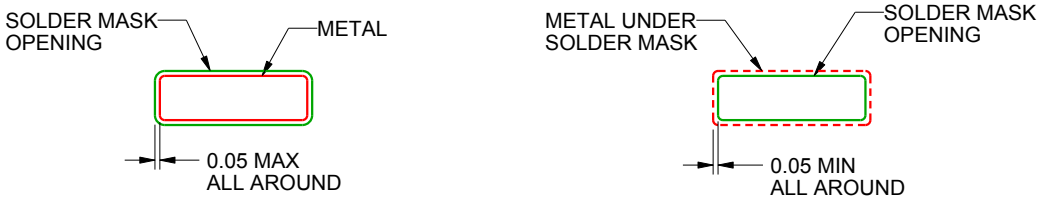


NOTES:

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, variation BA.



LAND PATTERN EXAMPLE
SCALE:10X

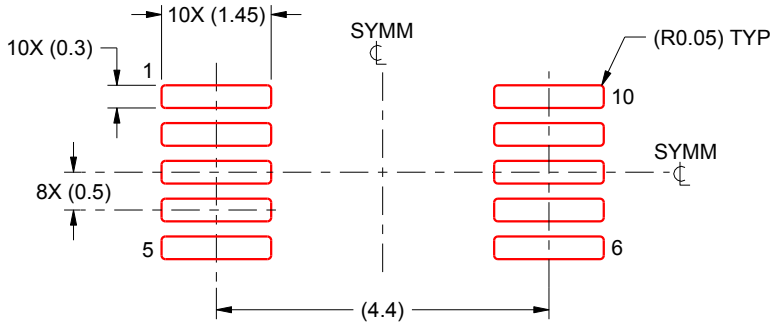


SOLDER MASK DETAILS
NOT TO SCALE

4221984/A 05/2015

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.



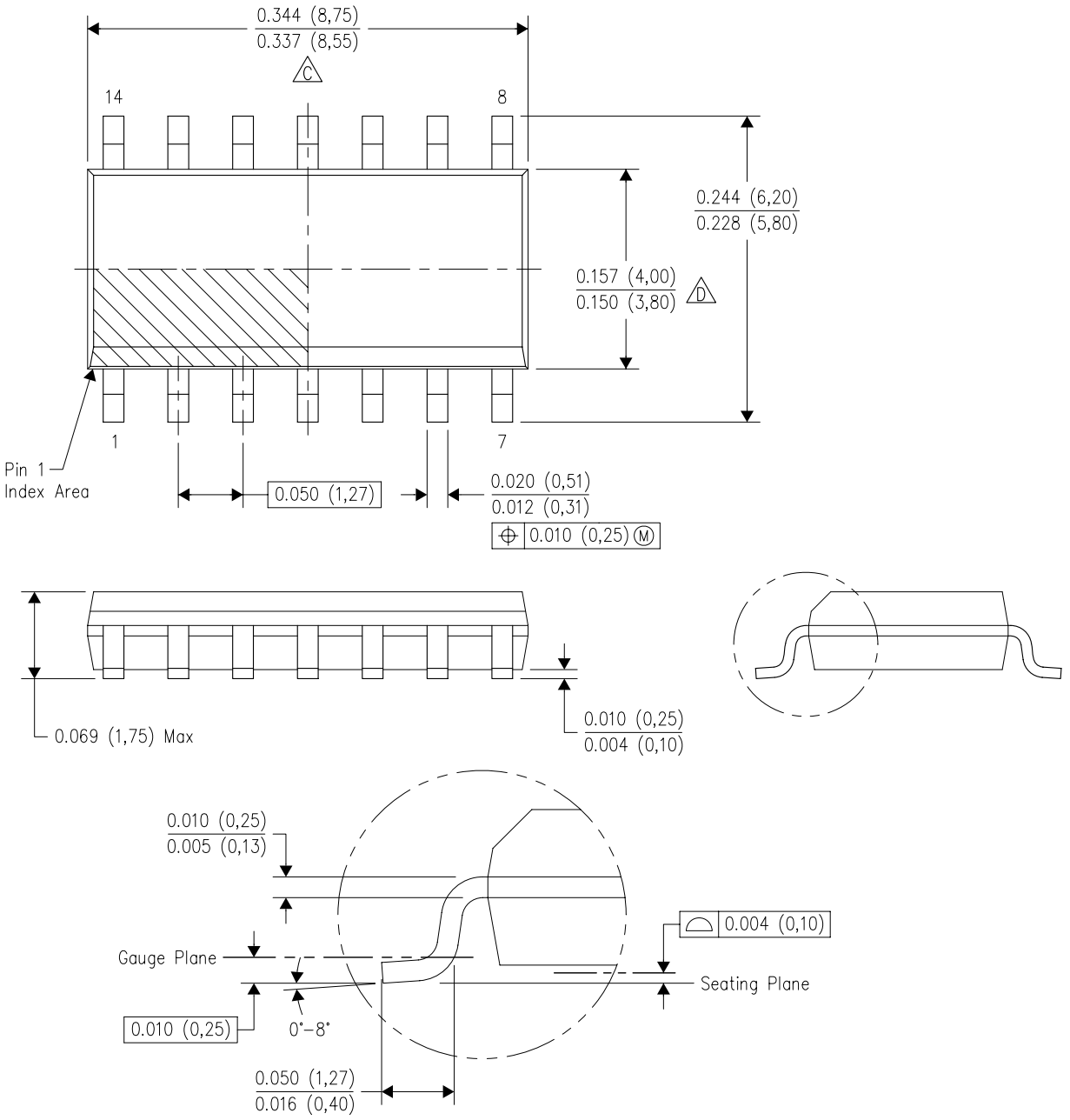
SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:10X

4221984/A 05/2015

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.

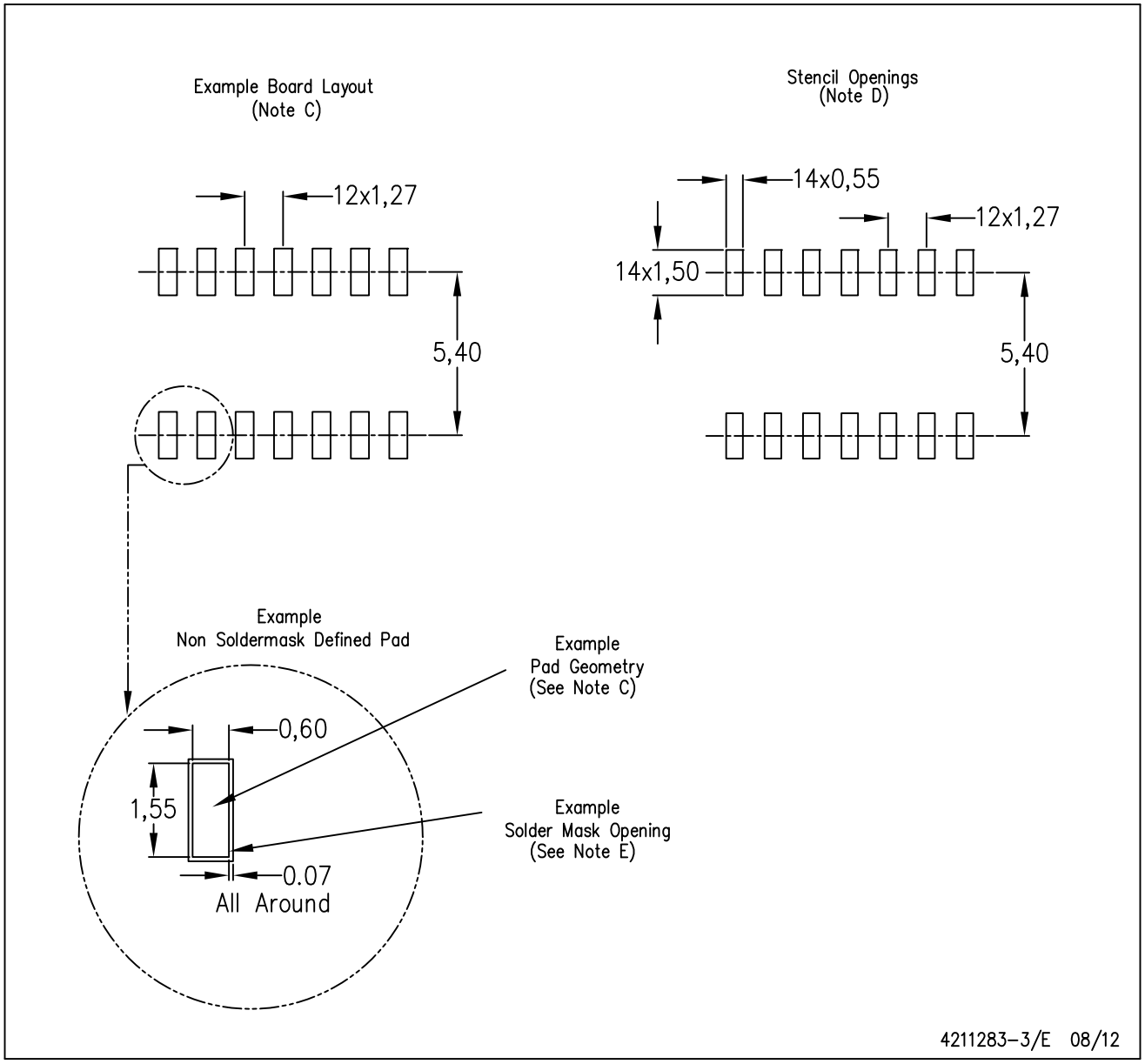
D (R–PDSO–G14) PLASTIC SMALL OUTLINE



4040047–5/M 06/11

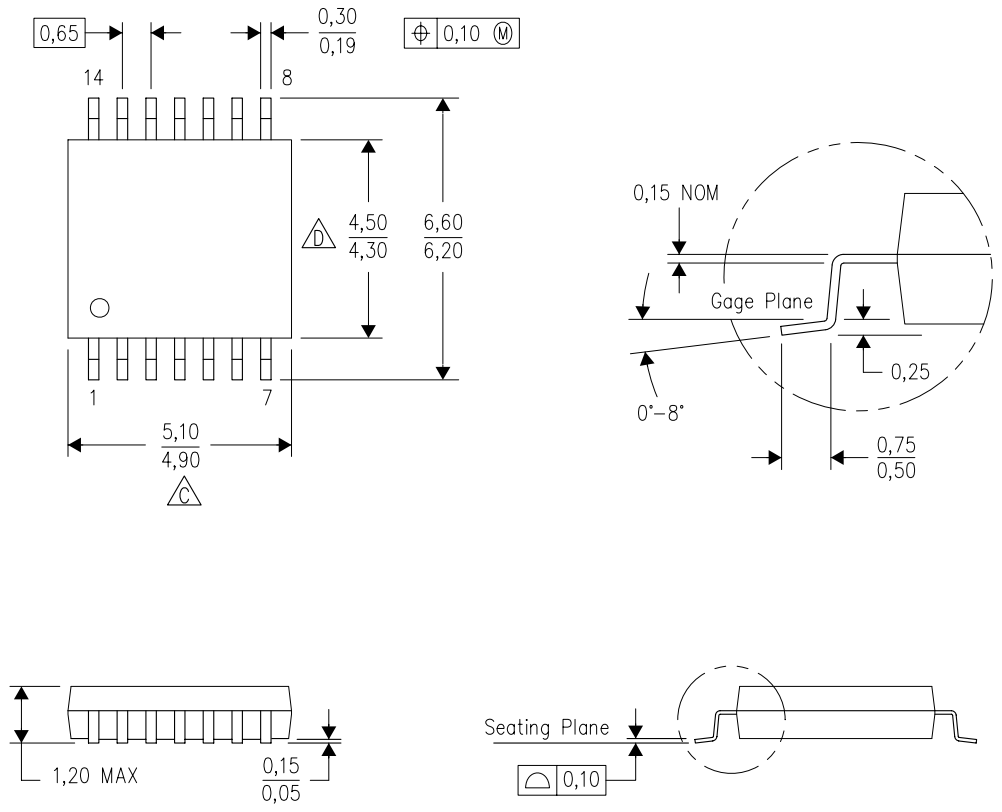
NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
D. Body width does not include interlead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

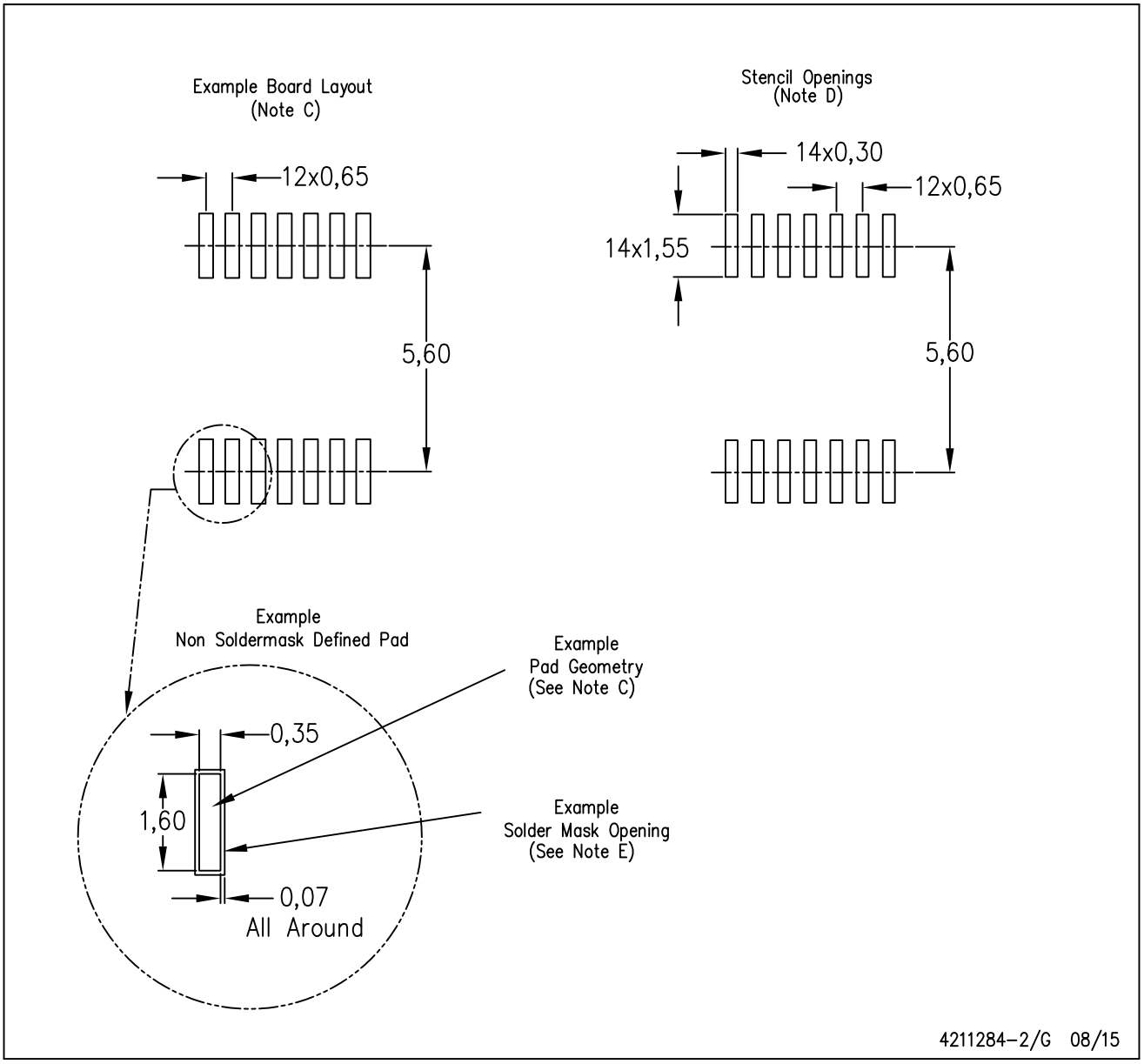
PW (R–PDSO–G14) PLASTIC SMALL OUTLINE



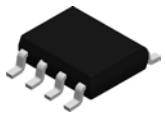
4040064–3/G 02/11

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

PW (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.

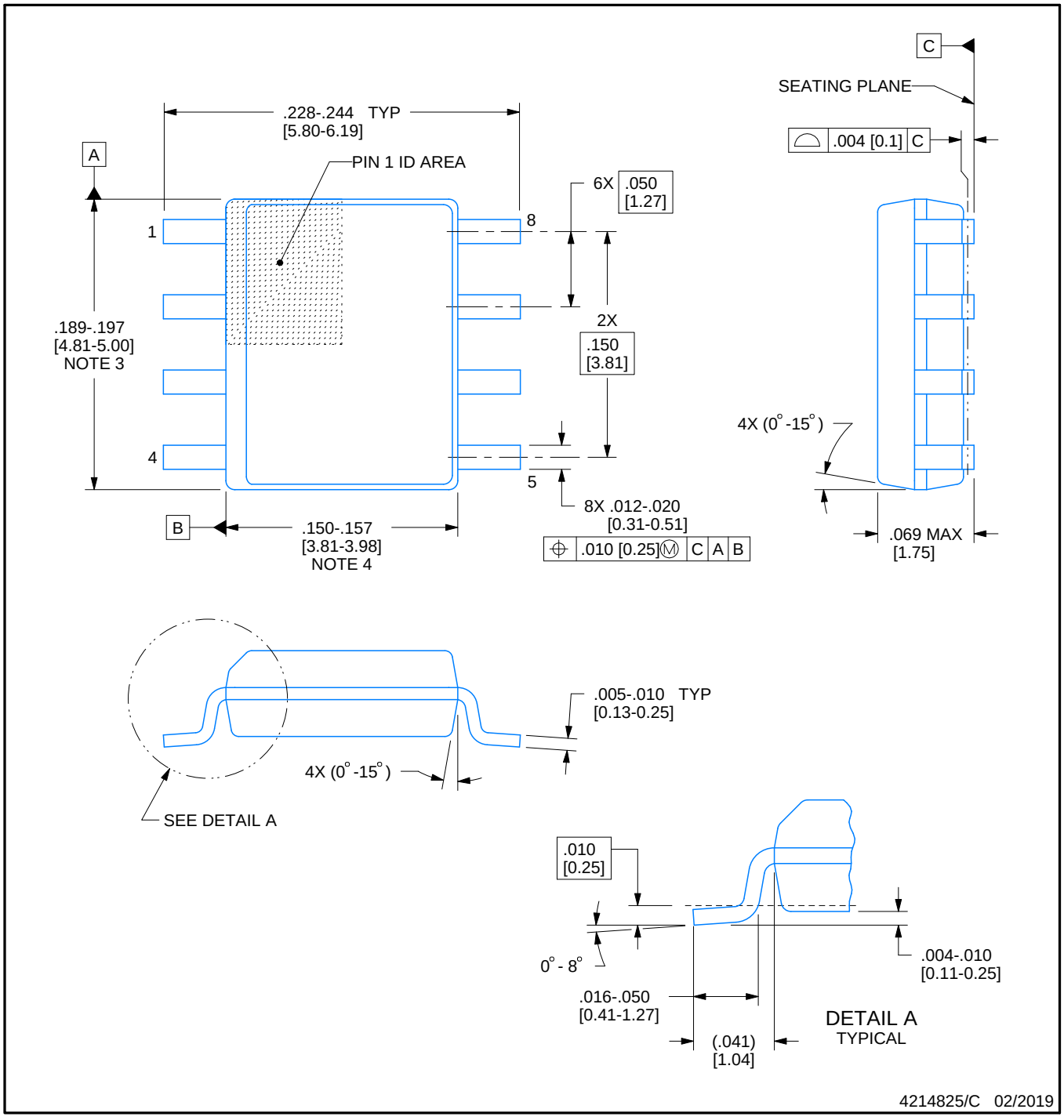


PACKAGE OUTLINE

D0008A

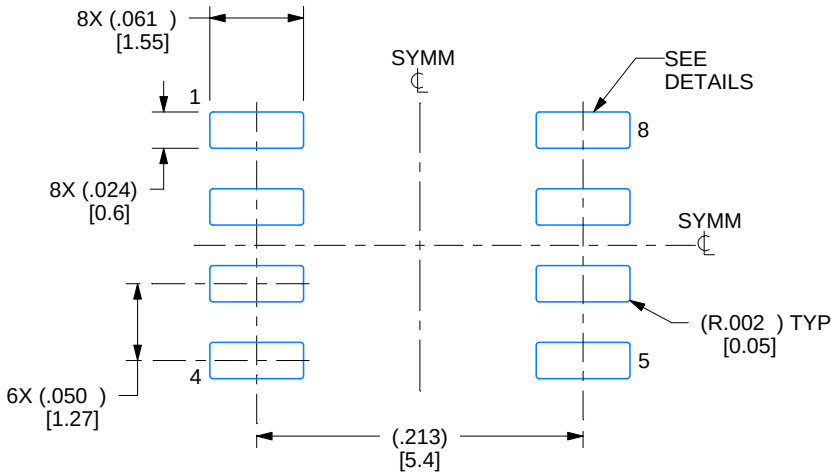
SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT

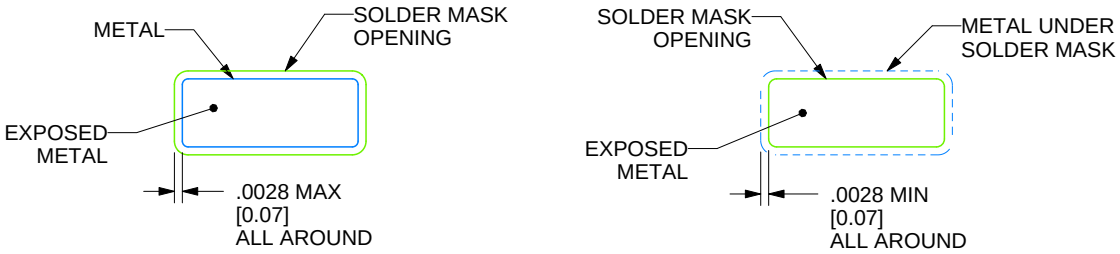


NOTES:

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)

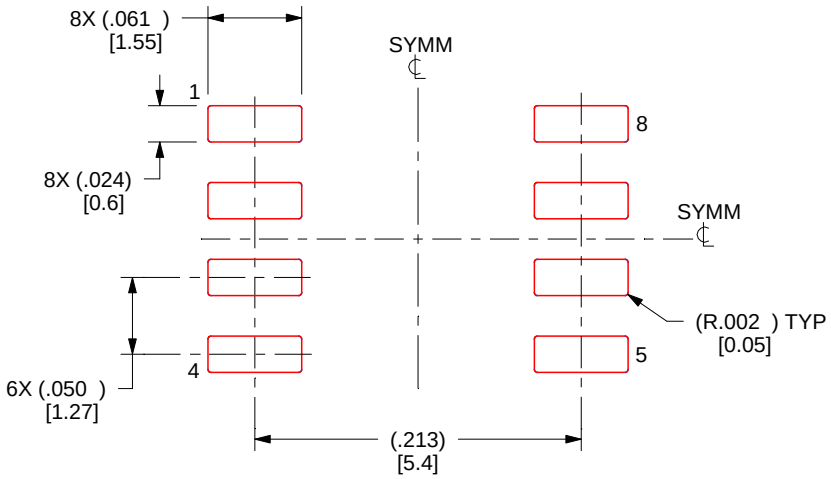
6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



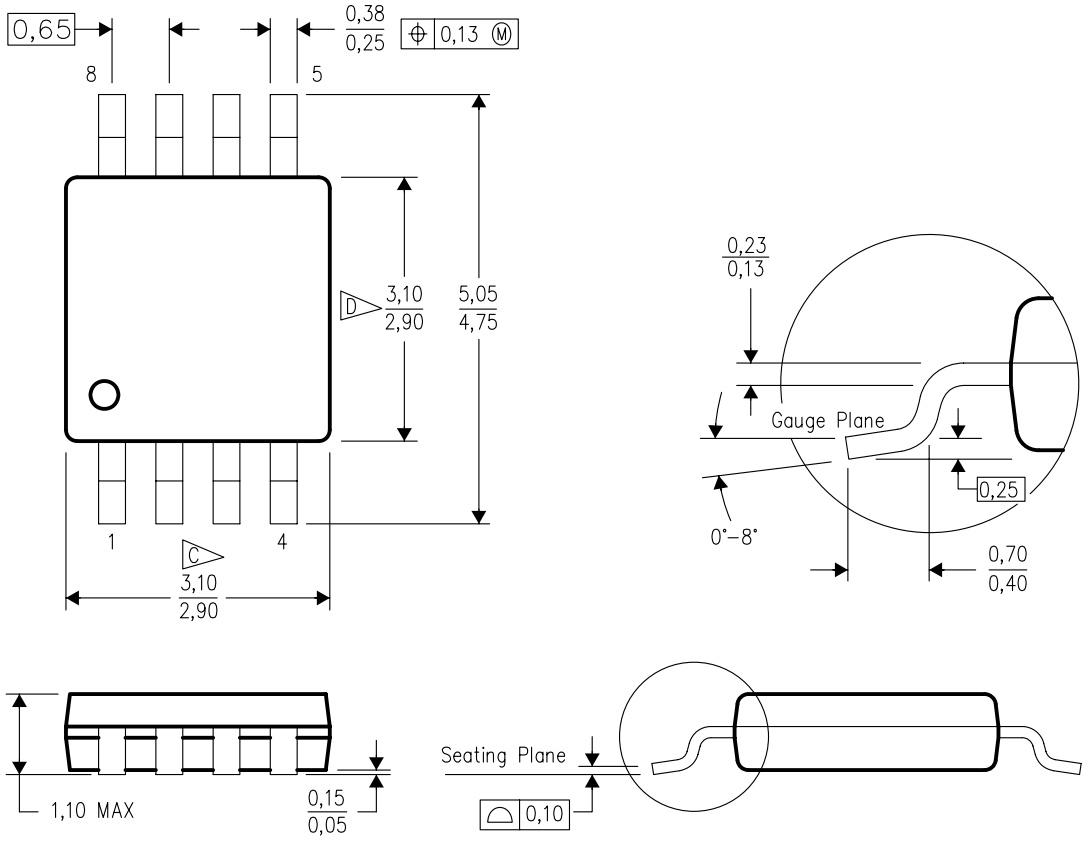
SOLDER PASTE EXAMPLE
BASED ON .005 INCH [0.125 MM] THICK STENCIL
SCALE:8X

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.

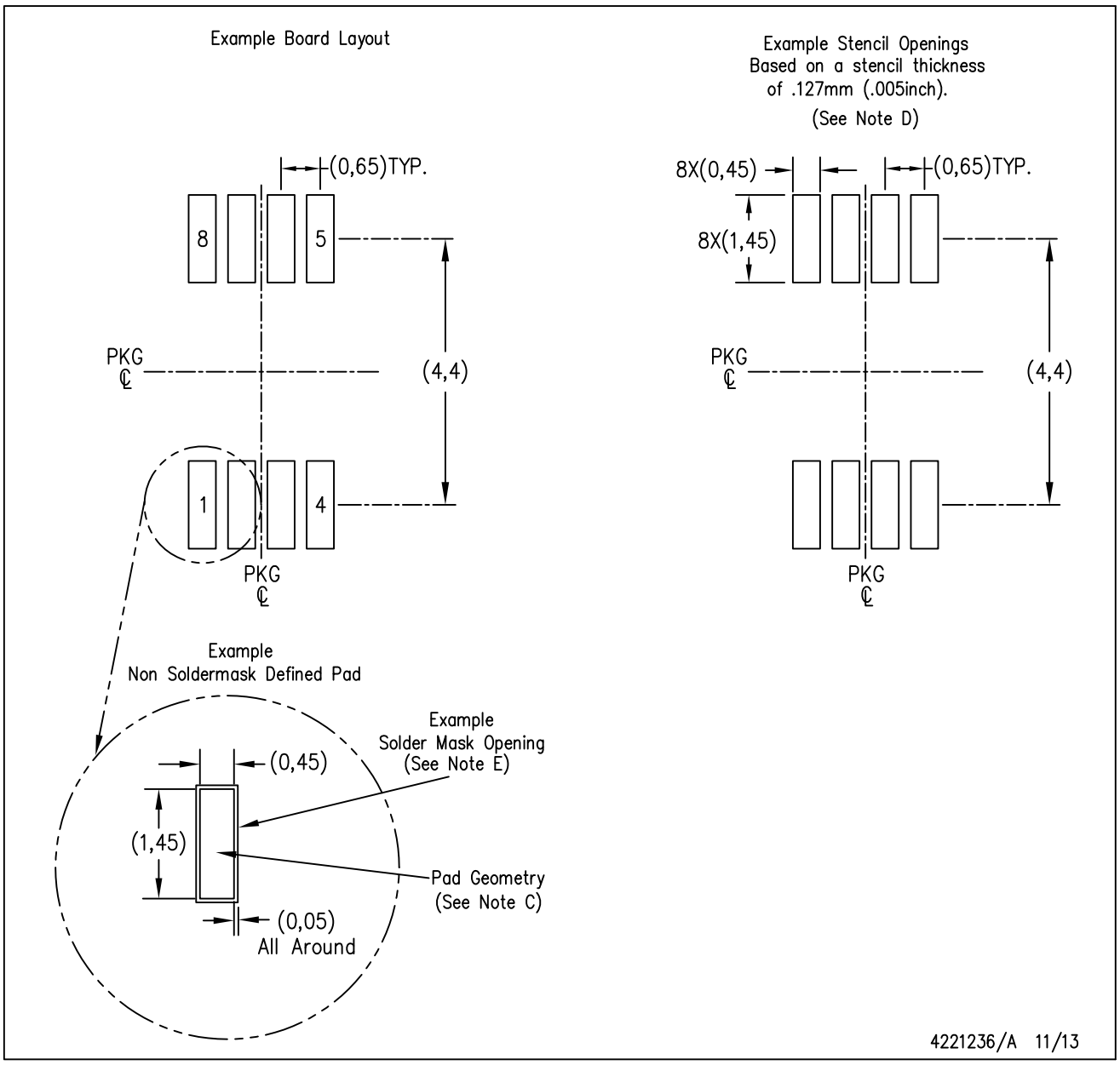
DGK (S–PDSO–G8) PLASTIC SMALL–OUTLINE PACKAGE



4073329/E 05/06

NOTES:
A. All linear dimensions are in 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 0.15 per end.
D. Body width does not include interlead flash. Interlead flash shall not exceed 0.50 per side.
E. Falls within JEDEC MO–187 variation AA, except interlead flash.

DGK (S–PDSO–G8) PLASTIC SMALL OUTLINE PACKAGE



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.

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