36V, Single-Supply, SOT553, Low-Power OPERATIONAL AMPLIFIERS

Check for Samples: OPA170, OPA2170, OPA4170

FEATURES

- **Supply Range: +2.7V to +36V, ±1.35V to ±18V**
- **Low Noise: 19nV/√Hz**
- **RFI Filtered Inputs**
- **Input Range Includes the Negative Supply**
- **Input Range Operates to Positive Supply**
- **Rail-to-Rail Output**
- **Gain Bandwidth: 1.2MHz**
- **Low Quiescent Current: 110μA per Amplifier**
- **High Common-Mode Rejection: 120dB**
- **Low Bias Current: 15pA (max)**
- **Industry-Standard Packages:**
  - **8-Pin SOIC**
  - **8-Pin MSOP**
  - **14-Pin TSSOP**
- ***micro*Packages:**
  - **Single in 5-Pin SOT553**
  - **Dual in 8-Pin VSSOP**

APPLICATIONS

- **Tracking Amplifier in Power Modules**
- **Merchant Power Supplies**
- **Transducer Amplifiers**
- **Bridge Amplifiers**
- **Temperature Measurements**
- **Strain Gauge Amplifiers**
- **Precision Integrators**
- **Battery-Powered Instruments**
- **Test Equipment**

Product Family

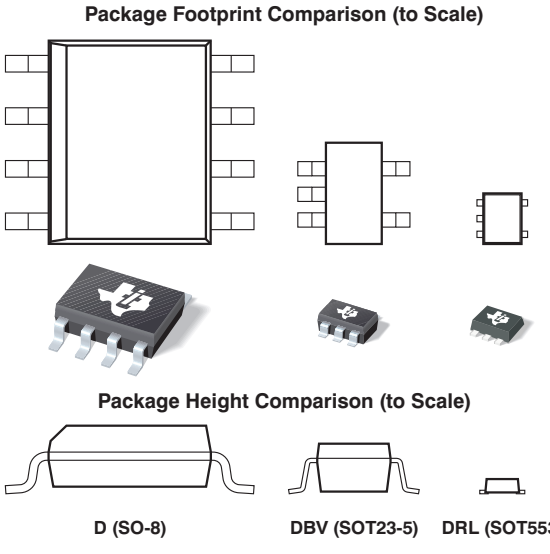
DEVICE	PACKAGE
OPA170 (single)	SOT553, SOT23-5, SO-8
OPA2170 (dual)	VSSOP-8, MSOP-8, SO-8
OPA4170 (quad)	TSSOP-14, SO-14

DESCRIPTION

The OPA170, OPA2170 and OPA4170 (OPAx170) are a family of 36V, single-supply, low-noise operational amplifiers that feature micro packages with the ability to operate on supplies ranging from +2.7V (±1.35V) to +36V (±18V). They offer good offset, drift, and bandwidth with low quiescent current. The single, dual, and quad versions all have identical specifications for maximum design flexibility.

Unlike most op amps, which are specified at only one supply voltage, the OPAx170 family of op amps is specified from +2.7V to +36V. Input signals beyond the supply rails do not cause phase reversal. The OPAx170 family is stable with capacitive loads up to 300pF. The input can operate 100mV below the negative rail and within 2V of the positive rail for normal operation. Note that these devices can operate with full rail-to-rail input 100mV beyond the positive rail, but with reduced performance within 2V of the positive rail.

The OPA170 is available in SOT553, SOT23-5, and SO-8 packages. The dual OPA2170 comes in VSSOP-8, MSOP-8, and SO-8 packages. The quad OPA4170 is offered in TSSOP-14 and SO-14 packages. The OPAx170 op amps are specified from –40°C to +125°C.



Smallest Packaging for 36V Op Amps

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

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

PACKAGE/ORDERING INFORMATION(1)

PRODUCT	PACKAGE-LEAD	PACKAGE DESIGNATOR	PACKAGE MARKING	ORDERING NUMBER	TRANSPORT MEDIA, QUANTITY
OPA170	SOT553-5	DRL	DAQ	OPA170AIDRLT	Tape and Reel, 250
				OPA170AIDRLR	Tape and Reel, 4000
	SOT23-5	DBV	OSVI	OPA170AIDBVT	Tape and Reel, 250
				OPA170AIDBVR	Tape and Reel, 3000
	SO-8	D	O170A	OPA170AID	Rail, 75
				OPA170AIDR	Tape and Reel, 2500
OPA2170	MSOP-8	DGK	OPNI	OPA2170AIDGK	Rail, 80
				OPA2170AIDGKR	Tape and Reel, 2500
	VSSOP-8	DCU	OPQC	OPA2170AIDCUT	Tape and Reel, 250
				OPA2170AIDCUR	Tape and Reel, 3000
	SO-8	D	2170A	OPA2170AID	Rail, 75
				OPA2170AIDR	Tape and Reel, 2500
OPA4170	SO-14	D	OPA4170	OPA4170AID	Rail, 50
				OPA4170AIDR	Tape and Reel, 2500
	TSSOP-14	PW	OPA4170	OPA4170AIPW	Rail, 90
				OPA4170AIPWR	Tape and Reel, 2000

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

ABSOLUTE MAXIMUM RATINGS(1)

Over operating free-air temperature range, unless otherwise noted.

		OPA170, OPA2170, OPA4170	UNIT
Supply voltage		±20, +40 (single supply)	V
Signal input terminals	Voltage	(V–) – 0.5 to (V+) + 0.5	V
	Current	±10	mA
Output short circuit(2)		Continuous	
Operating temperature		–55 to +150	°C
Storage temperature		–65 to +150	°C
Junction temperature		+150	°C
ESD ratings	Human body model (HBM)	4	kV
	Charged device model (CDM)	750	V

(1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not implied.
(2) Short-circuit to ground, one amplifier per package.

ELECTRICAL CHARACTERISTICS

Boldface limits apply over the specified temperature range, **T_A = –40°C to +125°C.**
At T_A = +25°C, V_{CM} = V_{OUT} = V_S/2, and R_L = 10kΩ connected to V_S/2, unless otherwise noted.

PARAMETER		TEST CONDITIONS	OPA170, OPA2170, OPA4170 MIN	TYP	MAX	UNIT
OFFSET VOLTAGE						
Input offset voltage	V_{OS}			0.25	±1.8	mV
Over temperature					**±2**	**mV**
Drift	**dV_{OS}/dT**			**±0.3**	**±2**	**µV/°C**
vs power supply	**PSRR**	**V_S = +4V to +36V**		**1**	**±5**	**µV/V**
Channel separation, dc		dc		5		µV/V
INPUT BIAS CURRENT						
Input bias current	I_B			±8	±15	pA
Over temperature					**±3.5**	**nA**
Input offset current	I_{OS}			±4	±15	pA
Over temperature					**±3.5**	**nA**
NOISE						
Input voltage noise		f = 0.1Hz to 10Hz		2		μV_{PP}
Input voltage noise density	e_n	f = 100Hz		22		nV/√Hz
		f = 1kHz		19		nV/√Hz
INPUT VOLTAGE						
Common-mode voltage range(1)	V_{CM}		(V–) – 0.1V		(V+) – 2V	V
Common-mode rejection ratio	**CMRR**	**V_S = ±2V, (V–) – 0.1V < V_{CM} < (V+) – 2V**	**90**	**104**		**dB**
		V_S = ±18V, (V–) – 0.1V < V_{CM} < (V+) – 2V	**104**	**120**		**dB**
INPUT IMPEDANCE						
Differential				100 || 3		MΩ || pF
Common-mode				6 || 3		10^{12} Ω || pF
OPEN-LOOP GAIN						
Open-loop voltage gain	**A_{OL}**	**V_S = +4V to +36V, (V–) + 0.35V < V_O < (V+) – 0.35V**	**110**	**130**		**dB**
FREQUENCY RESPONSE						
Gain bandwidth product	GBP			1.2		MHz
Slew rate	SR	G = +1		0.4		V/µs
Settling time	t_S	To 0.1%, V_S = ±18V, G = +1, 10V step		20		µs
		To 0.01% (12 bit), V_S = ±18V, G = +1, 10V step		28		µs
Overload recovery time		V_{IN} × Gain > V_S		2		µs
Total harmonic distortion + noise	THD+N	G = +1, f = 1kHz, V_O = $3V_{RMS}$		0.0002		%
OUTPUT						
Voltage output swing from rail	**V_O**					
Positive rail		I_L = 0mA, V_S = +4V to +36V	10			mV
		I_L sourcing 1mA, V_S = +4V to +36V	115			mV
Negative Rail		I_L = 0mA, V_S = +4V to +36V			8	mV
		I_L sinking 1mA, V_S = +4V to +36V			70	mV
Over temperature		**V_S = 5V, R_L = 10kΩ**	**(V–) + 0.03**		**(V+) – 0.05**	**V**
		R_L = 10kΩ, A_{OL} ≥ 110dB	**(V–) + 0.35**		**(V+) – 0.35**	**V**
Short-circuit current	I_{SC}			+17/–20		mA
Capacitive load drive	C_{LOAD}			See Typical Characteristics		pF
Open-loop output resistance	R_O	f = 1MHz, I_O = 0A		900		Ω
POWER SUPPLY						
Specified voltage range	V_S		+2.7		+36	V
Quiescent current per amplifier	I_Q	I_O = 0A		110	145	µA
Over temperature		**I_O = 0A**			**155**	**µA**

(1) The input range can be extended beyond (V+) – 2V up to V+. See the *Typical Characteristics* and *Application Information* sections for additional information.

ELECTRICAL CHARACTERISTICS (continued)

Boldface limits apply over the specified temperature range, $\mathbf{T_A}$ **= –40°C to +125°C.**
At T_A = +25°C, V_{CM} = V_{OUT} = V_S/2, and R_L = 10kΩ connected to V_S/2, unless otherwise noted.

PARAMETER	TEST CONDITIONS	OPA170, OPA2170, OPA4170			UNIT
		MIN	TYP	MAX	
TEMPERATURE					
Specified range		–40		+125	°C
Operating range		–55		+150	°C

THERMAL INFORMATION: OPA170

THERMAL METRIC(1)		OPA170			UNITS
		D (SO)	DBV (SOT23)	DRL (SOT553)	
		8 PINS	5 PINS	5 PINS	
θ_{JA}	Junction-to-ambient thermal resistance	149.5	245.8	208.1	°C/W
$\theta_{JC(top)}$	Junction-to-case(top) thermal resistance	97.9	133.9	0.1	
θ_{JB}	Junction-to-board thermal resistance	87.7	83.6	42.4	
ψ_{JT}	Junction-to-top characterization parameter	35.5	18.2	0.5	
ψ_{JB}	Junction-to-board characterization parameter	89.5	83.1	42.2	
$\theta_{JC(bottom)}$	Junction-to-case(bottom) thermal resistance	N/A	N/A	N/A	

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

THERMAL INFORMATION: OPA2170

THERMAL METRIC(1)		OPA2170			UNITS
		D (SO)	DCU (VSSOP)	DGK (MSOP)	
		8 PINS	8 PINS	8 PINS	
θ_{JA}	Junction-to-ambient thermal resistance	134.3	175.2	180	°C/W
$\theta_{JC(top)}$	Junction-to-case(top) thermal resistance	72.1	74.9	55	
θ_{JB}	Junction-to-board thermal resistance	60.6	22.2	130	
ψ_{JT}	Junction-to-top characterization parameter	18.2	1.6	5.3	
ψ_{JB}	Junction-to-board characterization parameter	53.8	22.8	120	
$\theta_{JC(bottom)}$	Junction-to-case(bottom) thermal resistance	N/A	N/A	N/A	

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

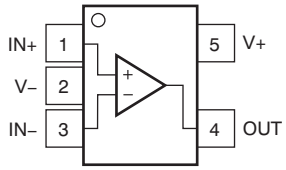
THERMAL INFORMATION: OPA4170

THERMAL METRIC(1)		OPA4170		UNITS
		D (SO)	PW (TSSOP)	
		14 PINS	14 PINS	
θ_{JA}	Junction-to-ambient thermal resistance	93.2	106.9	°C/W
$\theta_{JC(top)}$	Junction-to-case(top) thermal resistance	51.8	24.4	
θ_{JB}	Junction-to-board thermal resistance	49.4	59.3	
ψ_{JT}	Junction-to-top characterization parameter	13.5	0.6	
ψ_{JB}	Junction-to-board characterization parameter	42.2	54.3	
$\theta_{JC(bottom)}$	Junction-to-case(bottom) thermal resistance	N/A	N/A	

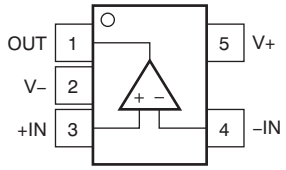
(1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, SPRA953.

PIN CONFIGURATIONS

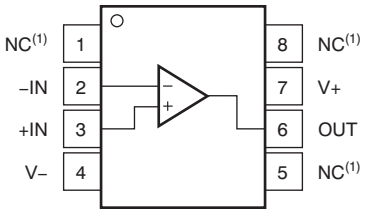
DRL PACKAGE: OPA170
SOT-553
(TOP VIEW)



DBV PACKAGE: OPA170
SOT23-5
(TOP VIEW)

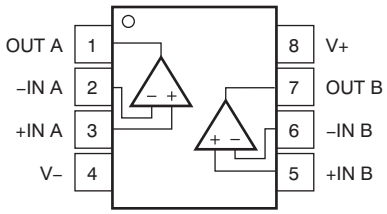


D PACKAGE: OPA170
SO-8
(TOP VIEW)

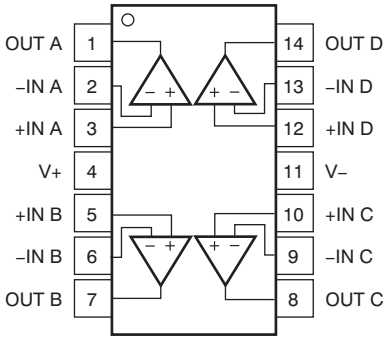


(1) No internal connection.

D, DGK, AND DCU PACKAGES: OPA2170
MSOP-8, SO-8, AND VSSOP-8
(TOP VIEW)



D AND PW PACKAGES: OPA4170
SO-14 AND TSSOP-14
(TOP VIEW)



TYPICAL CHARACTERISTICS

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TYPICAL CHARACTERISTICS

V_S = ±18V, V_{CM} = V_S/2, R_{LOAD} = 10kΩ connected to V_S/2, and C_L = 100pF, unless otherwise noted.

OFFSET VOLTAGE PRODUCTION DISTRIBUTION

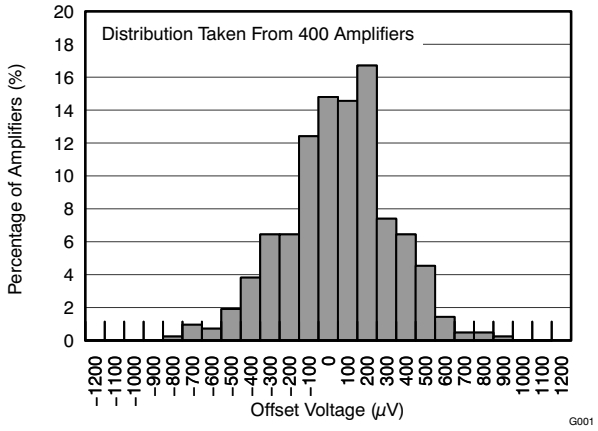

Figure 1.

OFFSET VOLTAGE DRIFT DISTRIBUTION

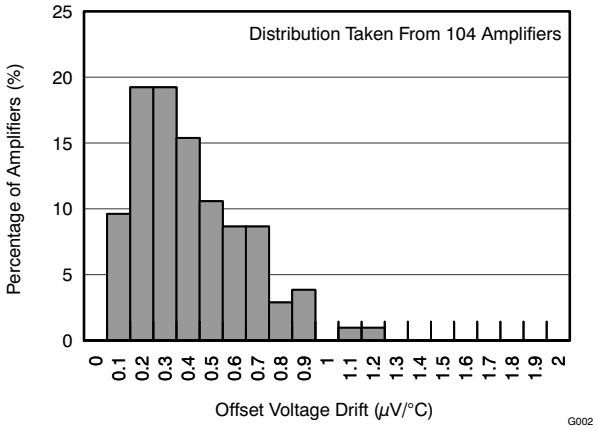

Figure 2.

OFFSET VOLTAGE vs TEMPERATURE

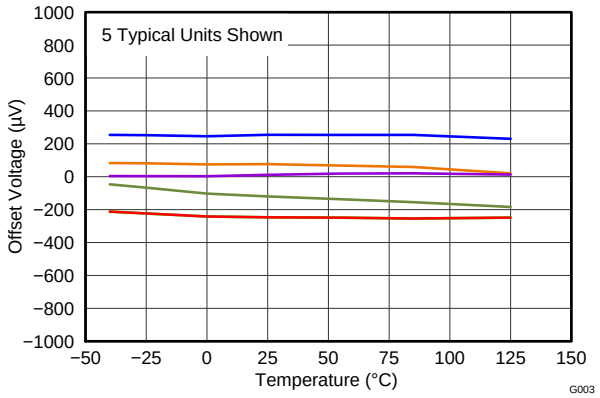

Figure 3.

OFFSET VOLTAGE vs COMMON-MODE VOLTAGE

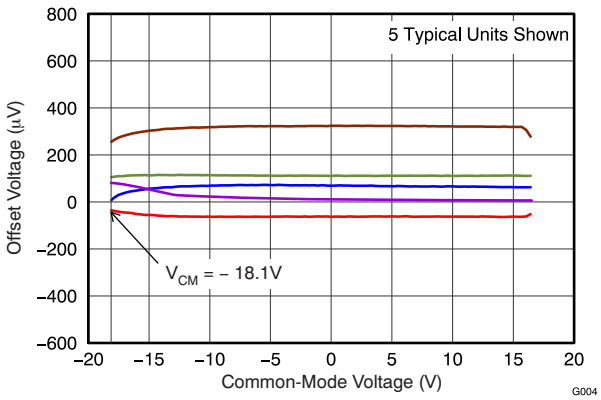

Figure 4.

OFFSET VOLTAGE vs COMMON-MODE VOLTAGE (Upper Stage)

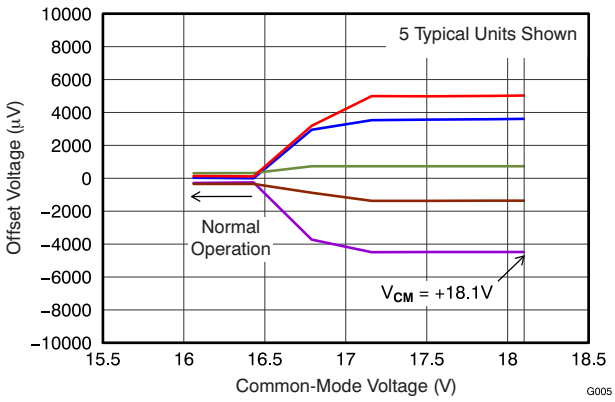

Figure 5.

OFFSET VOLTAGE vs POWER SUPPLY

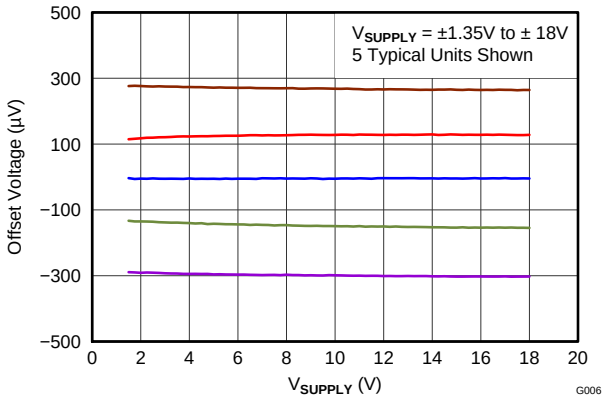

Figure 6.

TYPICAL CHARACTERISTICS (continued)

V_S = ±18V, V_{CM} = V_S/2, R_{LOAD} = 10kΩ connected to V_S/2, and C_L = 100pF, unless otherwise noted.

I_B AND I_{OS} vs COMMON-MODE VOLTAGE

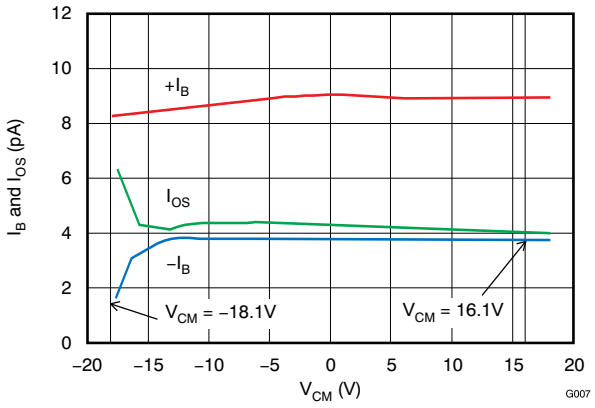

Figure 7.

INPUT BIAS CURRENT vs TEMPERATURE

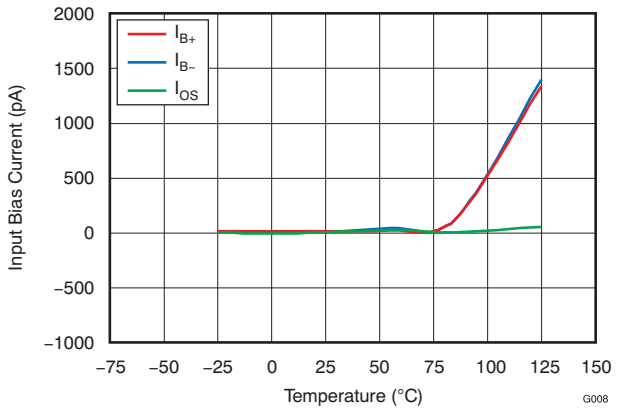

Figure 8.

OUTPUT VOLTAGE SWING vs OUTPUT CURRENT (Maximum Supply)

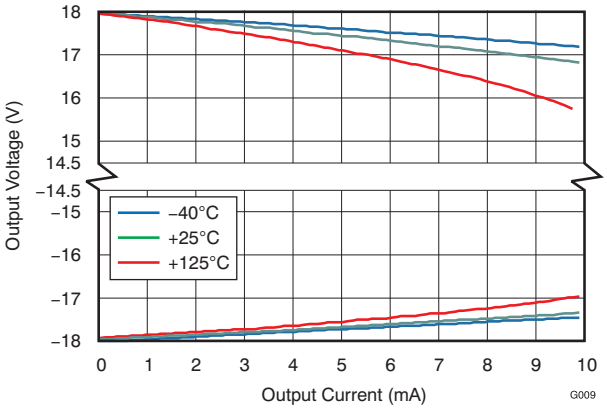

Figure 9.

CMRR AND PSRR vs FREQUENCY (Referred-to Input)

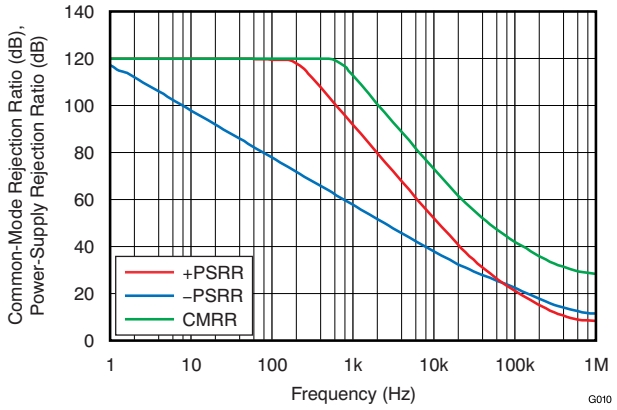

Figure 10.

CMRR vs TEMPERATURE

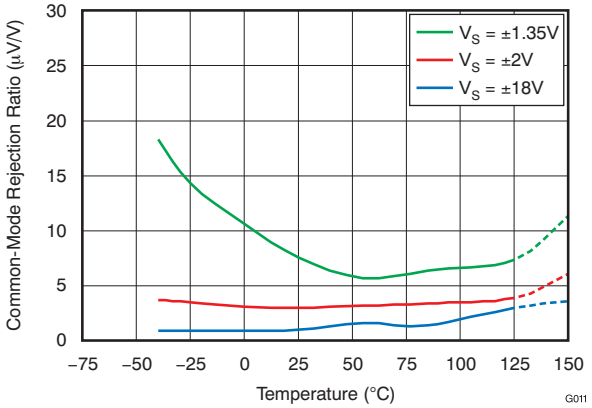

Figure 11.

PSRR vs TEMPERATURE

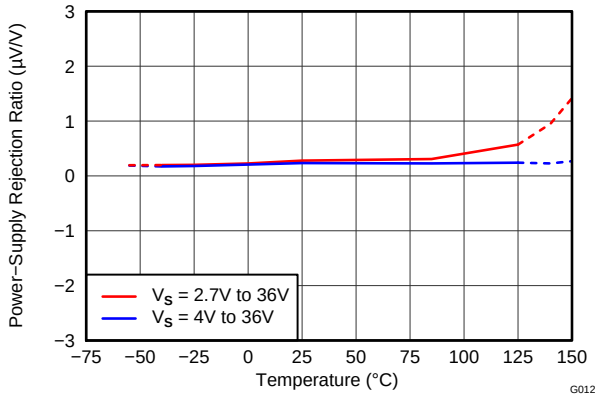

Figure 12.

TYPICAL CHARACTERISTICS (continued)

V_S = ±18V, V_{CM} = V_S/2, R_{LOAD} = 10kΩ connected to V_S/2, and C_L = 100pF, unless otherwise noted.

0.1Hz TO 10Hz NOISE

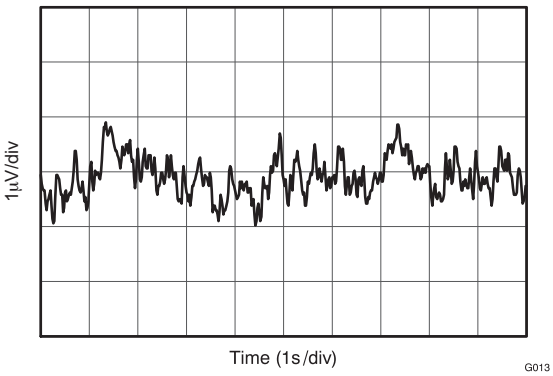

Figure 13.

INPUT VOLTAGE NOISE SPECTRAL DENSITY vs FREQUENCY

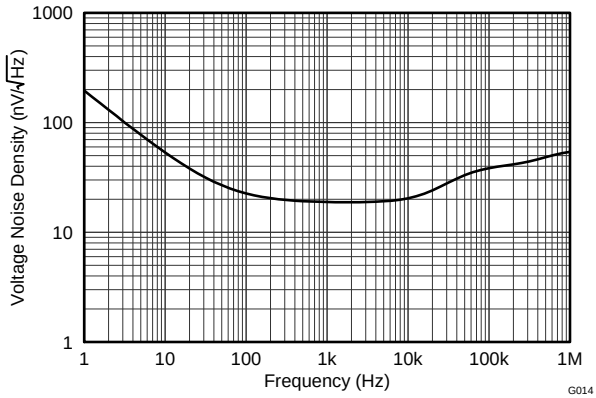

Figure 14.

THD+N RATIO vs FREQUENCY

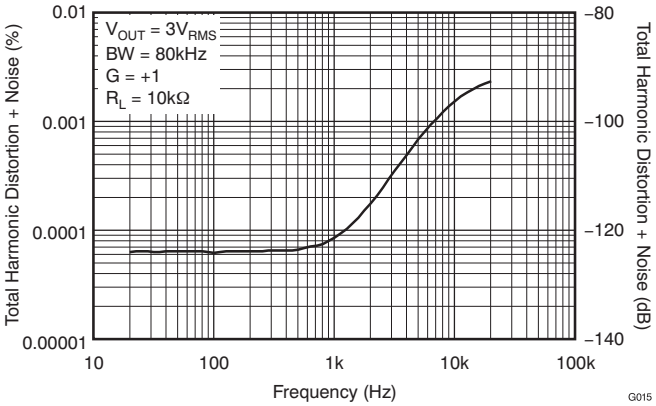

Figure 15.

THD+N vs OUTPUT AMPLITUDE

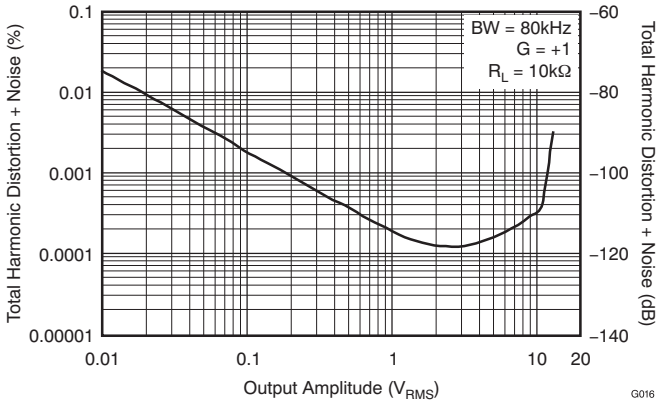

Figure 16.

QUIESCENT CURRENT vs TEMPERATURE

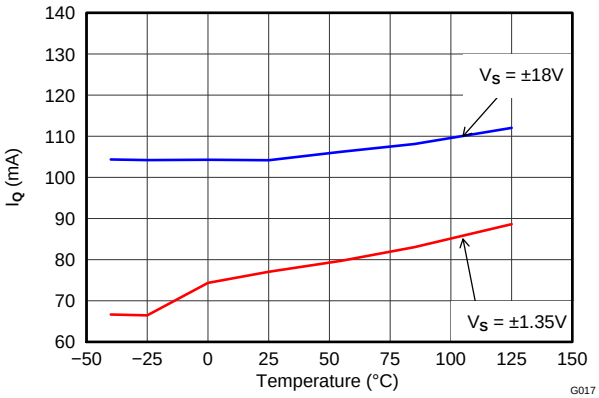

Figure 17.

QUIESCENT CURRENT vs SUPPLY VOLTAGE

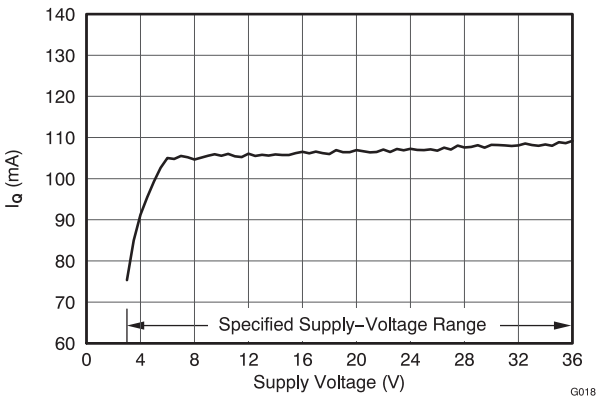

Figure 18.

TYPICAL CHARACTERISTICS (continued)

V_S = ±18V, V_{CM} = V_S/2, R_{LOAD} = 10kΩ connected to V_S/2, and C_L = 100pF, unless otherwise noted.

OPEN-LOOP GAIN AND PHASE vs FREQUENCY

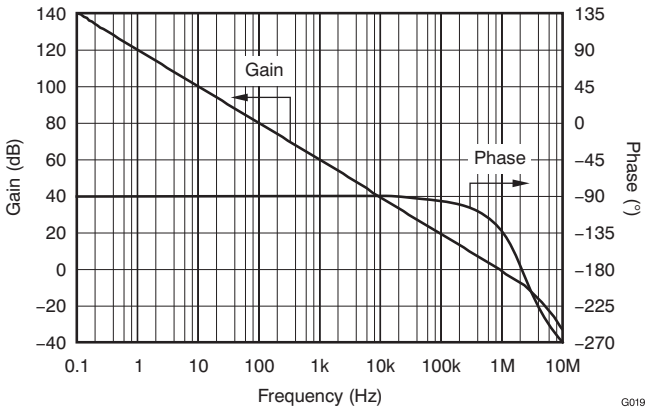

Figure 19.

CLOSED-LOOP GAIN vs FREQUENCY

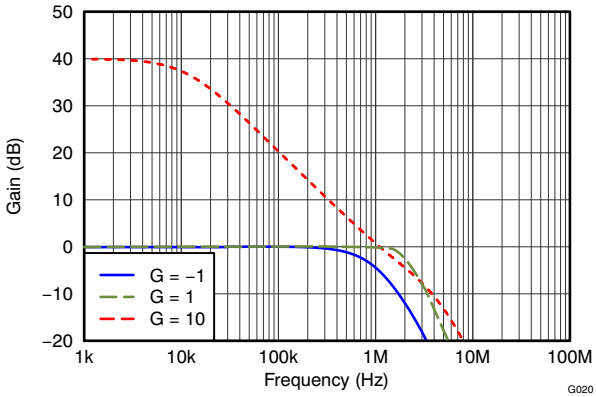

Figure 20.

OPEN-LOOP GAIN vs TEMPERATURE

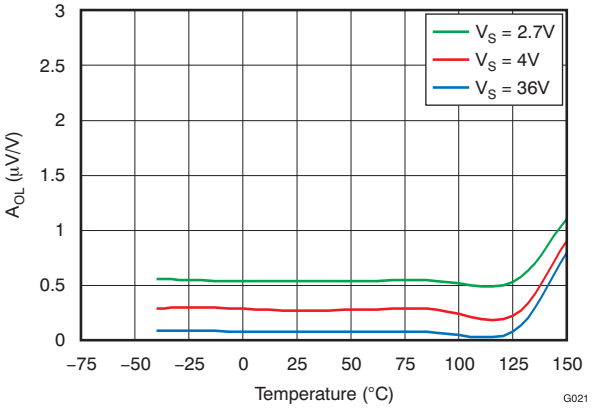

Figure 21.

OPEN-LOOP OUTPUT IMPEDANCE vs FREQUENCY

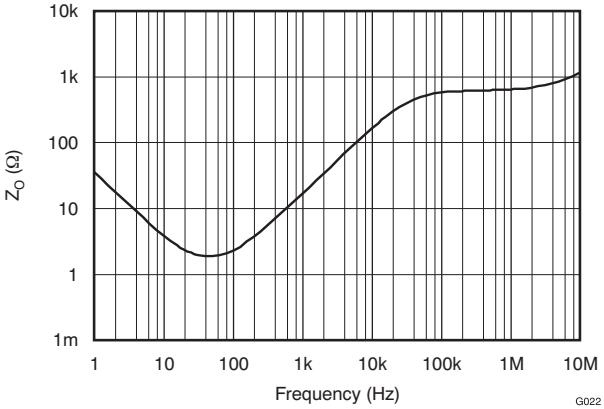

Figure 22.

SMALL-SIGNAL OVERSHOOT vs CAPACITIVE LOAD (100mV Output Step)

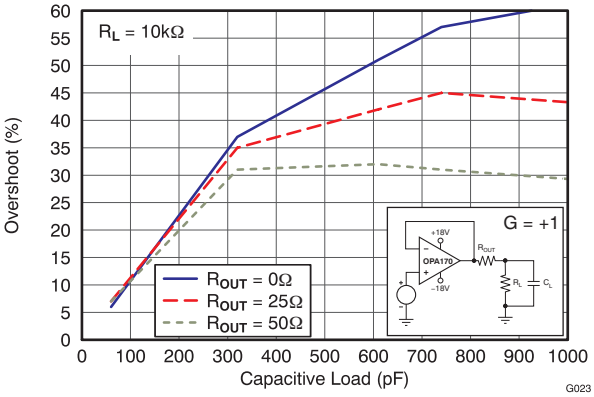

Figure 23.

SMALL-SIGNAL OVERSHOOT vs CAPACITIVE LOAD (100mV Output Step)

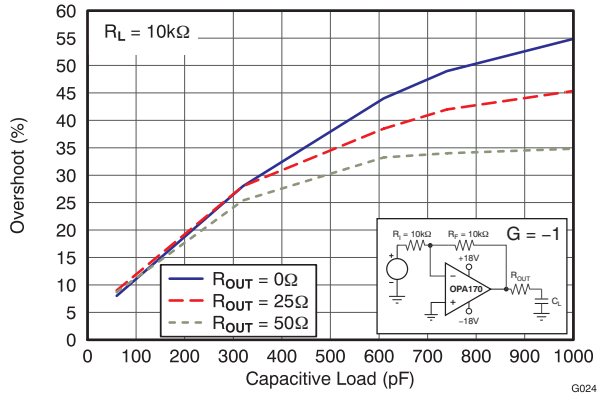

Figure 24.

TYPICAL CHARACTERISTICS (continued)

V_S = ±18V, V_{CM} = V_S/2, R_{LOAD} = 10kΩ connected to V_S/2, and C_L = 100pF, unless otherwise noted.

NO PHASE REVERSAL

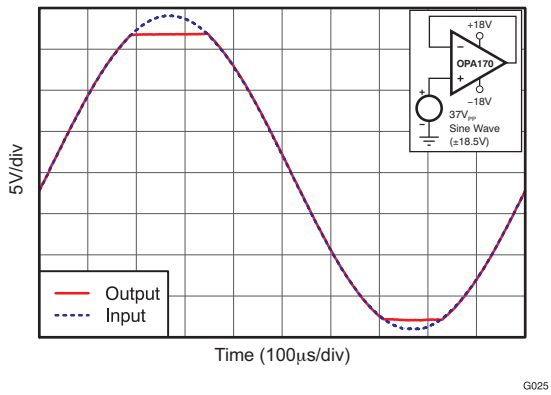

Figure 25.

POSITIVE OVERLOAD RECOVERY

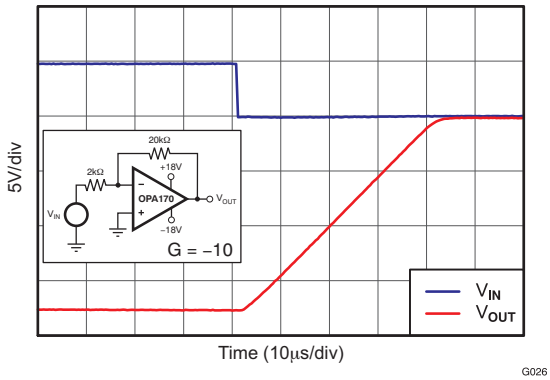

Figure 26.

NEGATIVE OVERLOAD RECOVERY

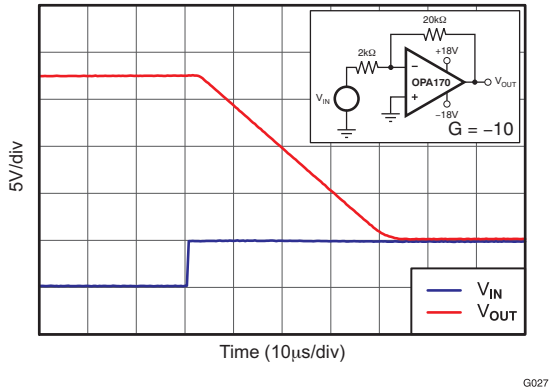

Figure 27.

SMALL-SIGNAL STEP RESPONSE (100mV)

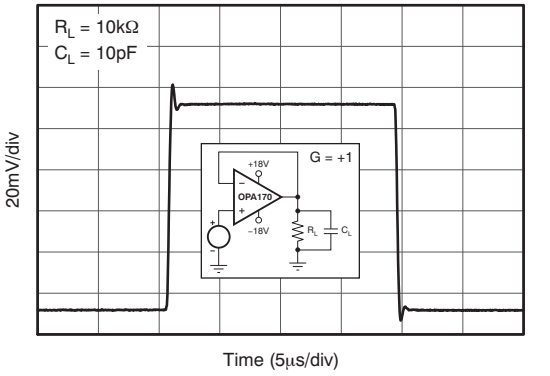

Figure 28.

SMALL-SIGNAL STEP RESPONSE (100mV)

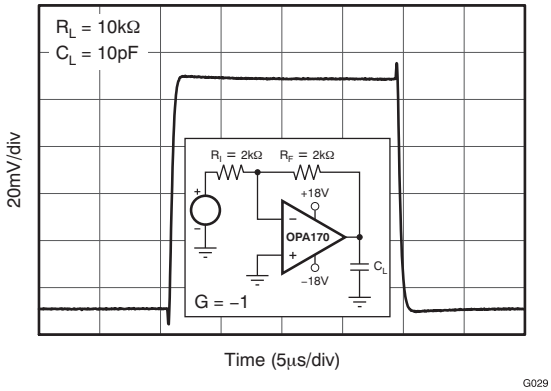

Figure 29.

LARGE-SIGNAL STEP RESPONSE

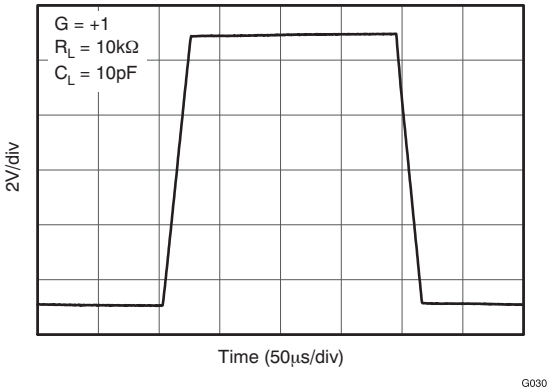

Figure 30.

TYPICAL CHARACTERISTICS (continued)

V_S = ±18V, V_{CM} = V_S/2, R_{LOAD} = 10kΩ connected to V_S/2, and C_L = 100pF, unless otherwise noted.

LARGE-SIGNAL STEP RESPONSE

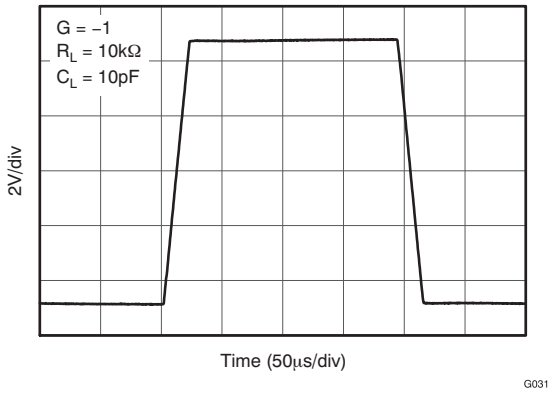

Figure 31.

LARGE-SIGNAL SETTLING TIME (10V Positive Step)

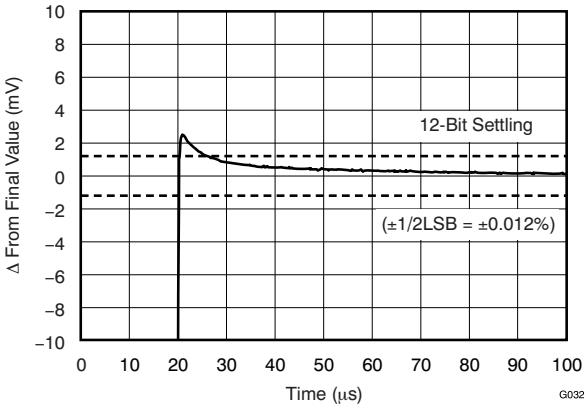

Figure 32.

LARGE-SIGNAL SETTLING TIME (10V Negative Step)

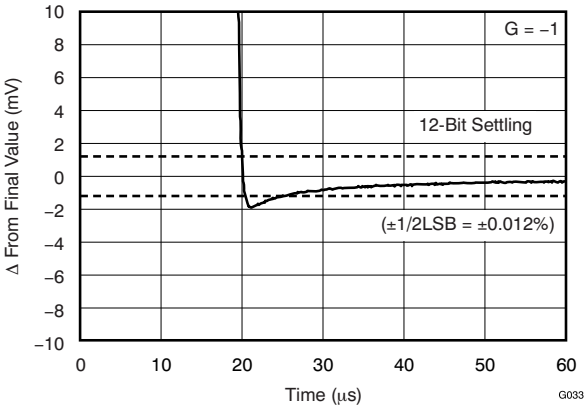

Figure 33.

SHORT-CIRCUIT CURRENT vs TEMPERATURE

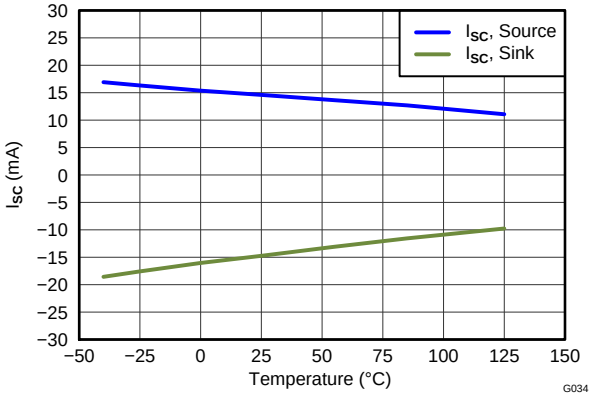

Figure 34.

MAXIMUM OUTPUT VOLTAGE vs FREQUENCY

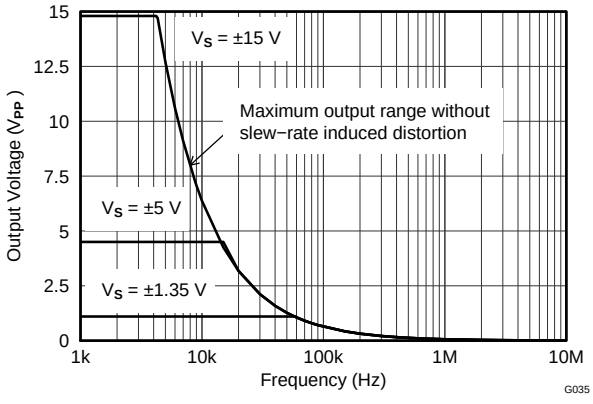

Figure 35.

EMIRR IN+ vs FREQUENCY

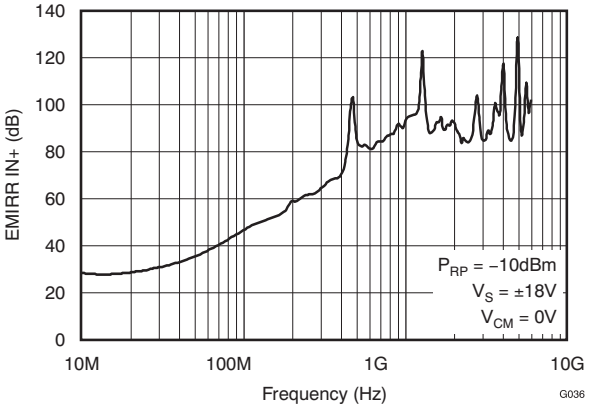

Figure 36.

APPLICATION INFORMATION

The OPAx170 family of operational amplifiers provides high overall performance. These devices are ideal for many general-purpose applications. The excellent offset drift of only 2µV/°C provides excellent stability over the entire temperature range. In addition, the device offers very good overall performance with high CMRR, PSRR, and A_{OL}. As with all amplifiers, applications with noisy or high-impedance power supplies require decoupling capacitors placed close to the device pins. In most cases, 0.1µF capacitors are adequate.

OPERATING CHARACTERISTICS

The OPAx170 family of amplifiers is specified for operation from 2.7V to 36V (±1.35V to ±18V). Many of the specifications apply from –40°C to +125°C. Parameters that can exhibit significant variance with regard to operating voltage or temperature are presented in the Typical Characteristics.

GENERAL LAYOUT GUIDELINES

For best operational performance of the device, good printed circuit board (PCB) layout practices are recommended. Low-loss, 0.1µF bypass capacitors should be connected between each supply pin and ground, placed as close to the device as possible. A single bypass capacitor from V+ to ground is applicable to single-supply applications.

COMMON-MODE VOLTAGE RANGE

The input common-mode voltage range of the OPAx170 series extends 100mV below the negative rail and within 2V of the positive rail for normal operation.

This device can operate with full rail-to-rail input 100mV beyond the positive rail, but with reduced performance within 2V of the positive rail. The typical performance in this range is summarized in Table 2.

PHASE-REVERSAL PROTECTION

The OPAx170 family has an internal phase-reversal protection. Many op amps exhibit a phase reversal when the input is driven beyond its linear common-mode range. This condition is most often encountered in noninverting circuits when the input is driven beyond the specified common-mode voltage range, causing the output to reverse into the opposite rail. The input of the OPAx170 prevents phase reversal with excessive common-mode voltage. Instead, the output limits into the appropriate rail. This performance is shown in Figure 37.

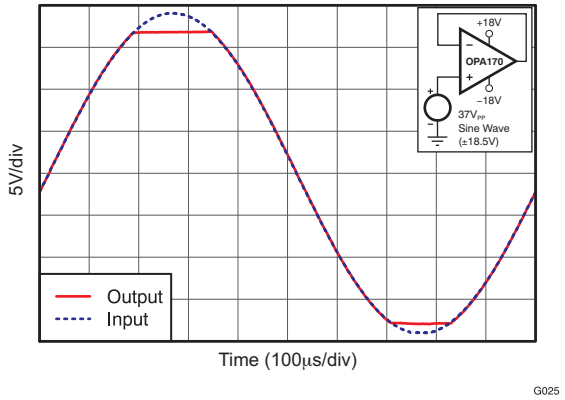

Figure 37. No Phase Reversal

Table 2. Typical Performance Range

PARAMETER	MIN	TYP	MAX	UNIT
Input Common-Mode Voltage	**(V+) – 2**		**(V+) + 0.1**	**V**
Offset voltage		7		mV
vs Temperature		**12**		**µV/°C**
Common-mode rejection		65		dB
Open-loop gain		60		dB
Gain-bandwidth product		0.3		MHz
Slew rate		0.3		V/µs

CAPACITIVE LOAD AND STABILITY

The dynamic characteristics of the OPAx170 have been optimized for common operating conditions. The combination of low closed-loop gain and high capacitive loads decreases the phase margin of the amplifier and can lead to gain peaking or oscillations. As a result, heavier capacitive loads must be isolated from the output. The simplest way to achieve this isolation is to add a small resistor (for example, R_{OUT} equal to 50Ω) in series with the output. Figure 38 and Figure 39 illustrate graphs of small-signal overshoot versus capacitive load for several values of R_{OUT}. Also, refer to Applications Bulletin AB-028, *Feedback Plots Define Op Amp AC Performance* (literature number SBOA015, available for download from the TI website), for details of analysis techniques and application circuits.

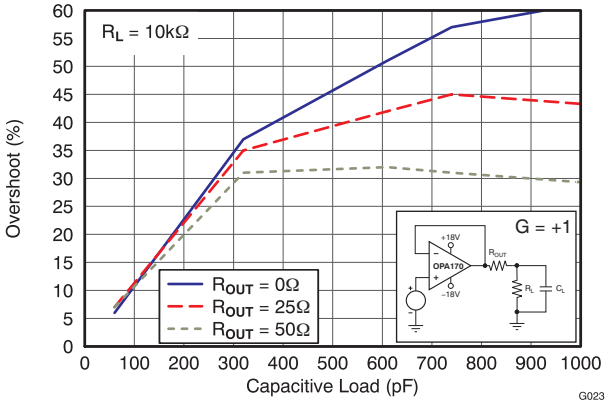

Figure 38. Small-Signal Overshoot versus Capacitive Load (100mV Output Step, G = +1)

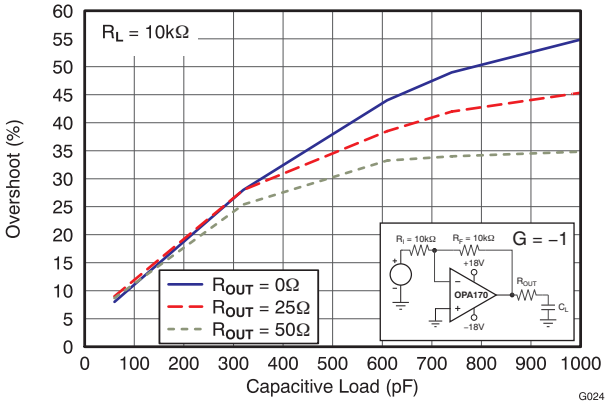

Figure 39. Small-Signal Overshoot versus Capacitive Load (100mV Output Step, G = –1)

ELECTRICAL OVERSTRESS

Designers often ask questions about the capability of an operational amplifier to withstand electrical overstress. These questions tend to focus on the device inputs, but may involve the supply voltage pins or even the output pin. Each of these different pin functions have electrical stress limits determined by the voltage breakdown characteristics of the particular semiconductor fabrication process and specific circuits connected to the pin. Additionally, internal electrostatic discharge (ESD) protection is built into these circuits to protect them from accidental ESD events both before and during product assembly.

These ESD protection diodes also provide in-circuit, input overdrive protection, as long as the current is limited to 10mA as stated in the Absolute Maximum Ratings. Figure 40 shows how a series input resistor may be added to the driven input to limit the input current. The added resistor contributes thermal noise at the amplifier input and its value should be kept to a minimum in noise-sensitive applications.

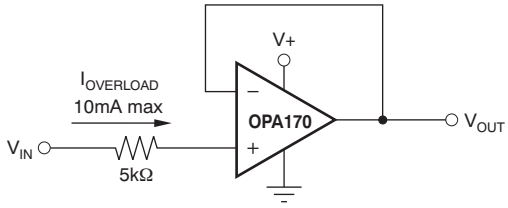

Figure 40. Input Current Protection

An ESD event produces a short duration, high-voltage pulse that is transformed into a short duration, high-current pulse as it discharges through a semiconductor device. The ESD protection circuits are designed to provide a current path around the operational amplifier core to prevent it from being damaged. The energy absorbed by the protection circuitry is then dissipated as heat.

When the operational amplifier connects into a circuit, the ESD protection components are intended to remain inactive and not become involved in the application circuit operation. However, circumstances may arise where an applied voltage exceeds the operating voltage range of a given pin. Should this condition occur, there is a risk that some of the internal ESD protection circuits may be biased on, and conduct current. Any such current flow occurs through ESD cells and rarely involves the absorption device.

If there is an uncertainty about the ability of the supply to absorb this current, external zener diodes may be added to the supply pins. The zener voltage must be selected such that the diode does not turn on during normal operation. However, its zener voltage should be low enough so that the zener diode conducts if the supply pin begins to rise above the safe operating supply voltage level.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/ Ball Finish	MSL Peak Temp (3)	Samples (Requires Login)
OPA170AID	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	
OPA170AIDBVR	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	
OPA170AIDBVT	ACTIVE	SOT-23	DBV	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	
OPA170AIDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	
OPA170AIDRLR	PREVIEW	SOT	DRL	5	4000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
OPA170AIDRLT	PREVIEW	SOT	DRL	5	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
OPA2170AIDGK	PREVIEW	MSOP	DGK	8	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	
OPA2170AIDGKR	PREVIEW	MSOP	DGK	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	
OPA4170AID	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	
OPA4170AIDR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	
OPA4170AIPW	PREVIEW	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	
OPA4170AIPWR	PREVIEW	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	

(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) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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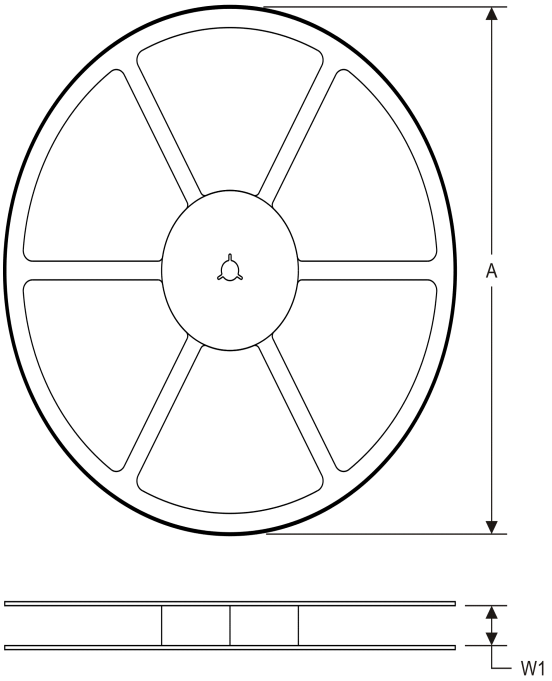
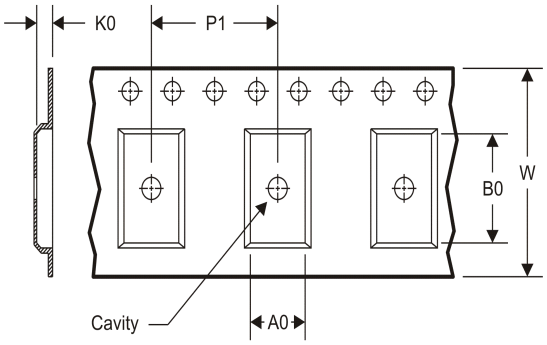
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



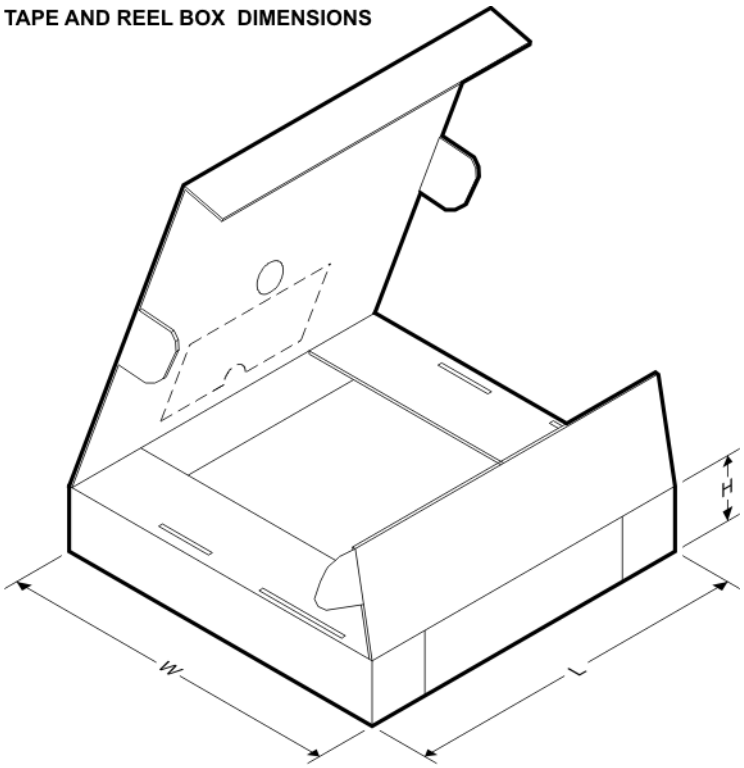
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

TAPE AND REEL INFORMATION

*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
OPA170AIDBVR	SOT-23	DBV	5	3000	180.0	8.4	3.23	3.17	1.37	4.0	8.0	Q3
OPA170AIDBVT	SOT-23	DBV	5	250	180.0	8.4	3.23	3.17	1.37	4.0	8.0	Q3
OPA170AIDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
OPA4170AIDR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1

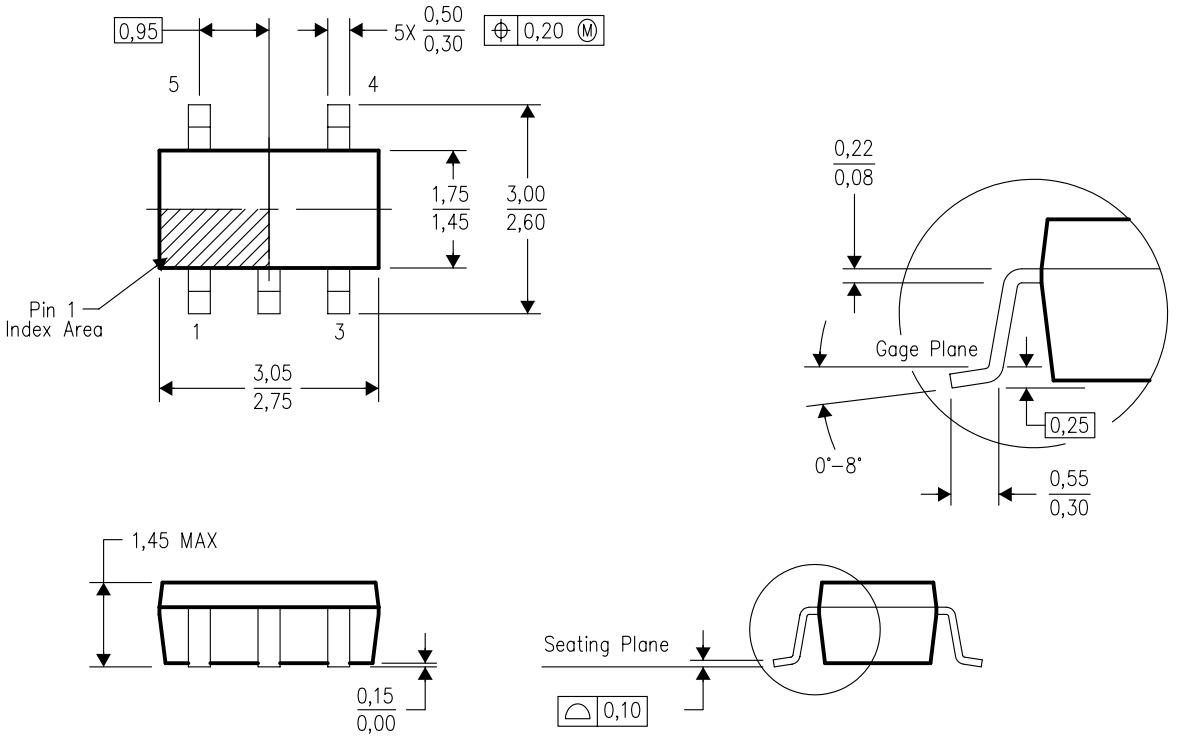
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
OPA170AIDBVR	SOT-23	DBV	5	3000	202.0	201.0	28.0
OPA170AIDBVT	SOT-23	DBV	5	250	202.0	201.0	28.0
OPA170AIDR	SOIC	D	8	2500	346.0	346.0	29.0
OPA4170AIDR	SOIC	D	14	2500	346.0	346.0	33.0

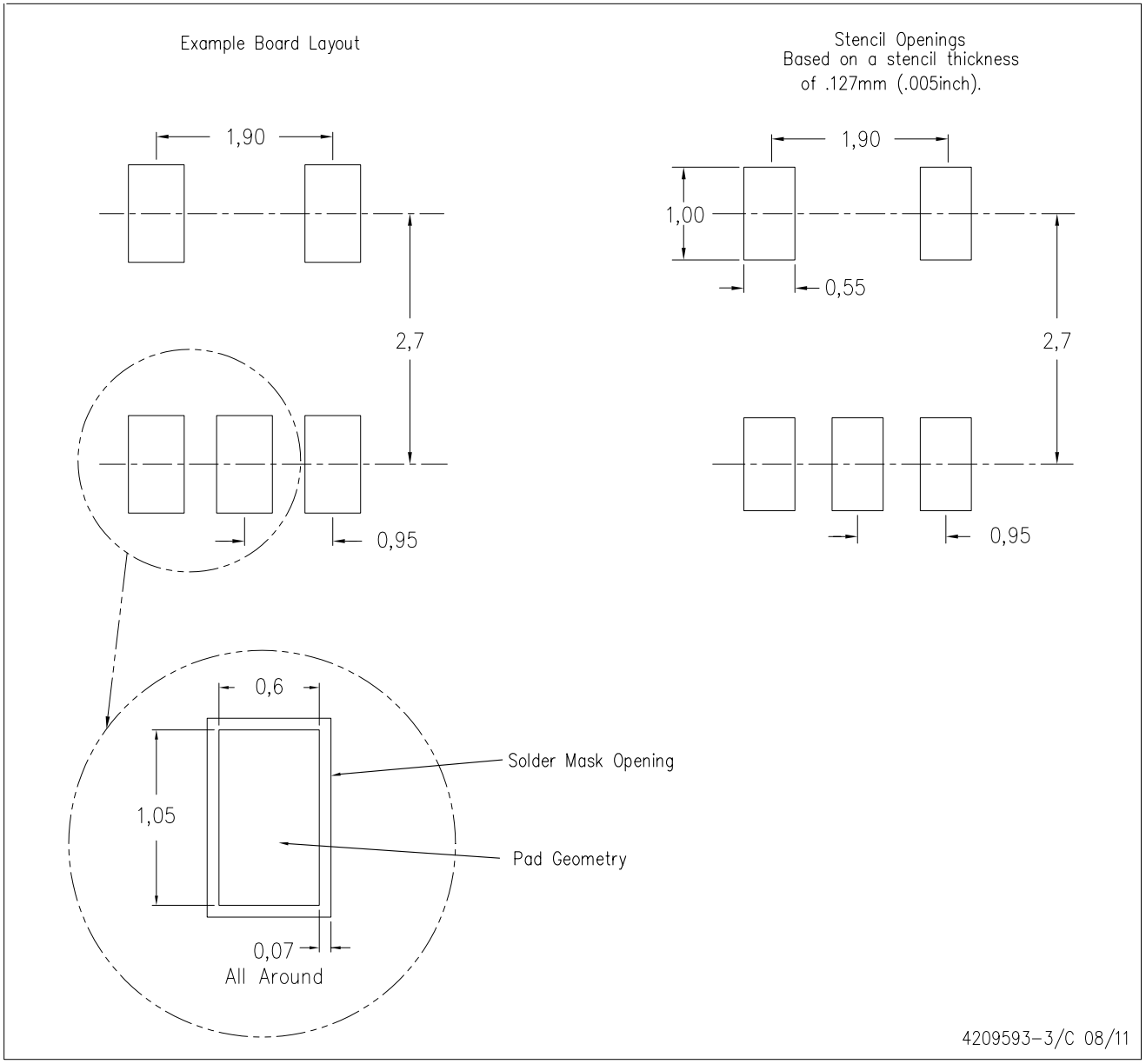
DBV (R–PDSO–G5) PLASTIC SMALL–OUTLINE PACKAGE



4073253–4/K 03/2006

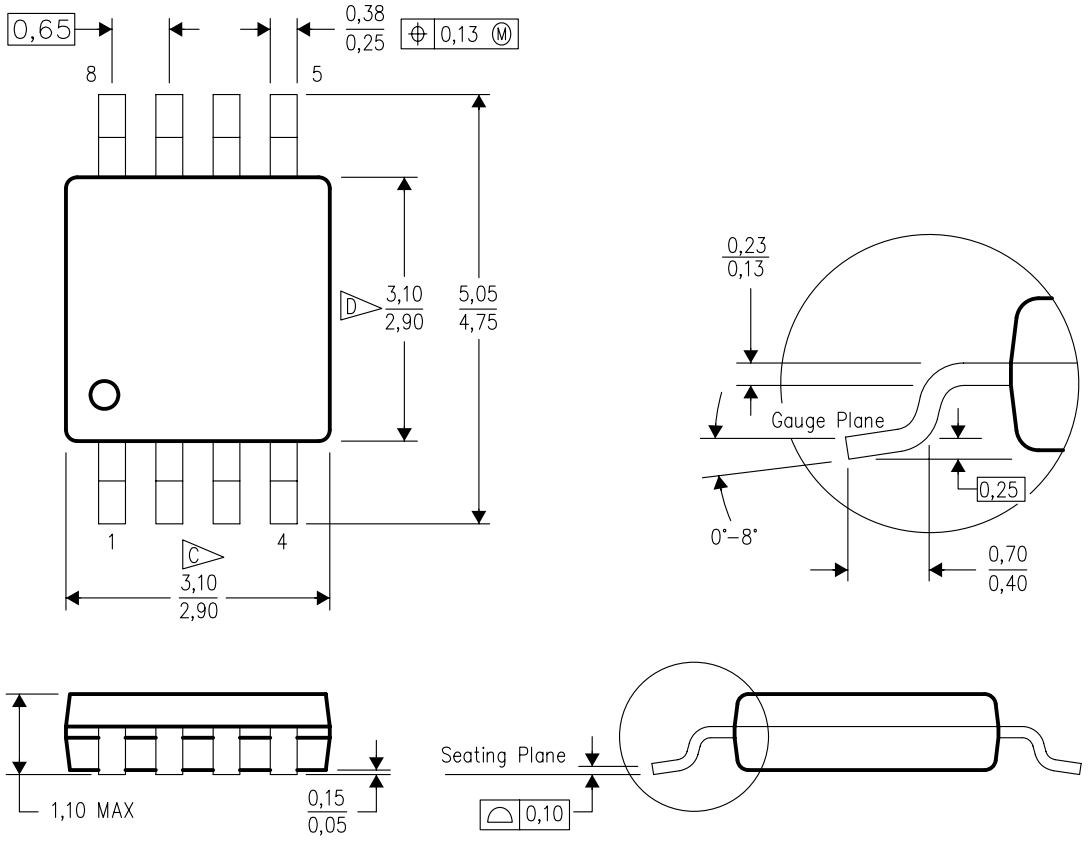
NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
D. Falls within JEDEC MO–178 Variation AA.

DBV (R–PDSO–G5) PLASTIC SMALL OUTLINE



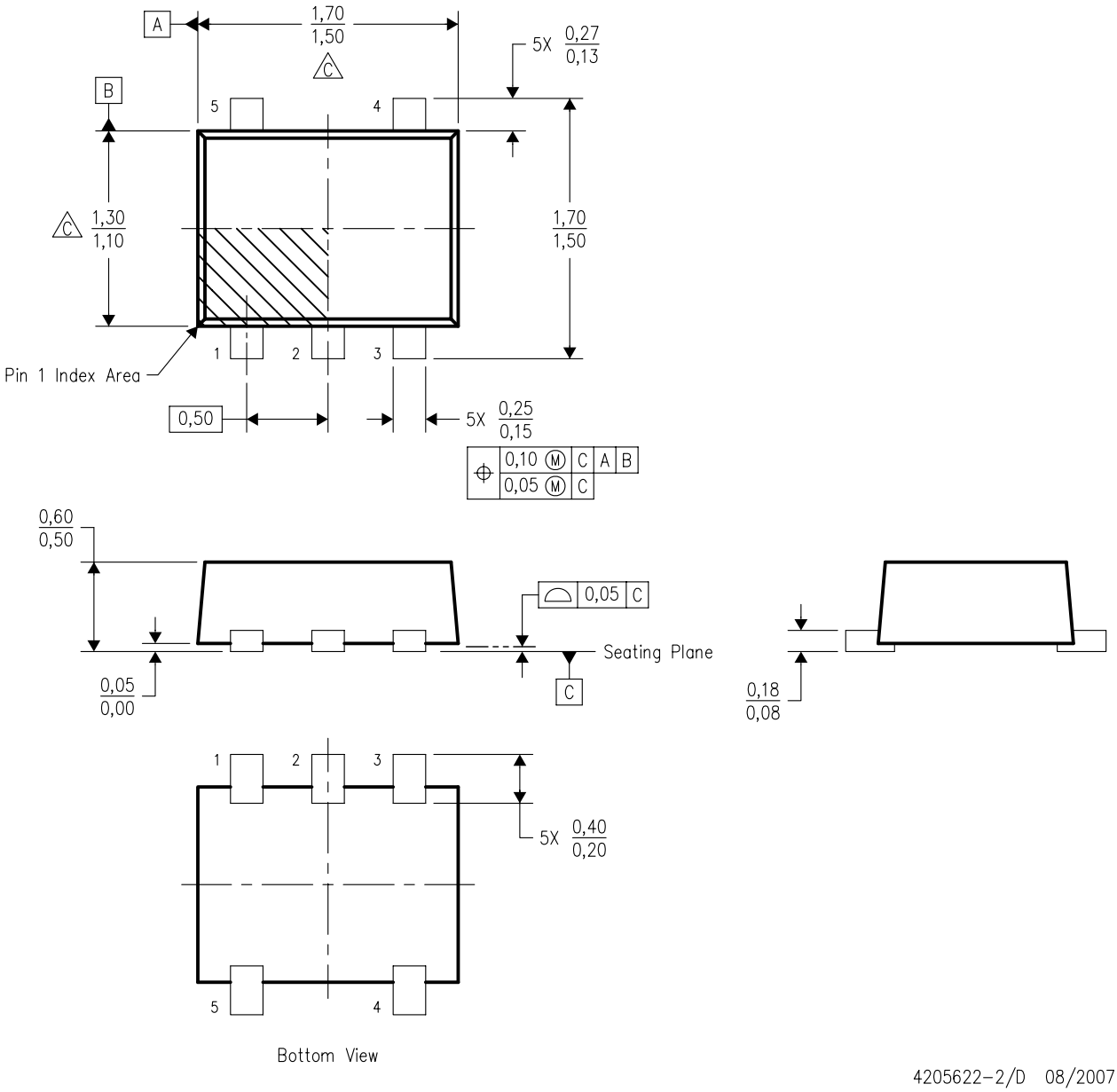
NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
D. Publication IPC–7351 is recommended for alternate designs.
E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC–7525 for other stencil recommendations.

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



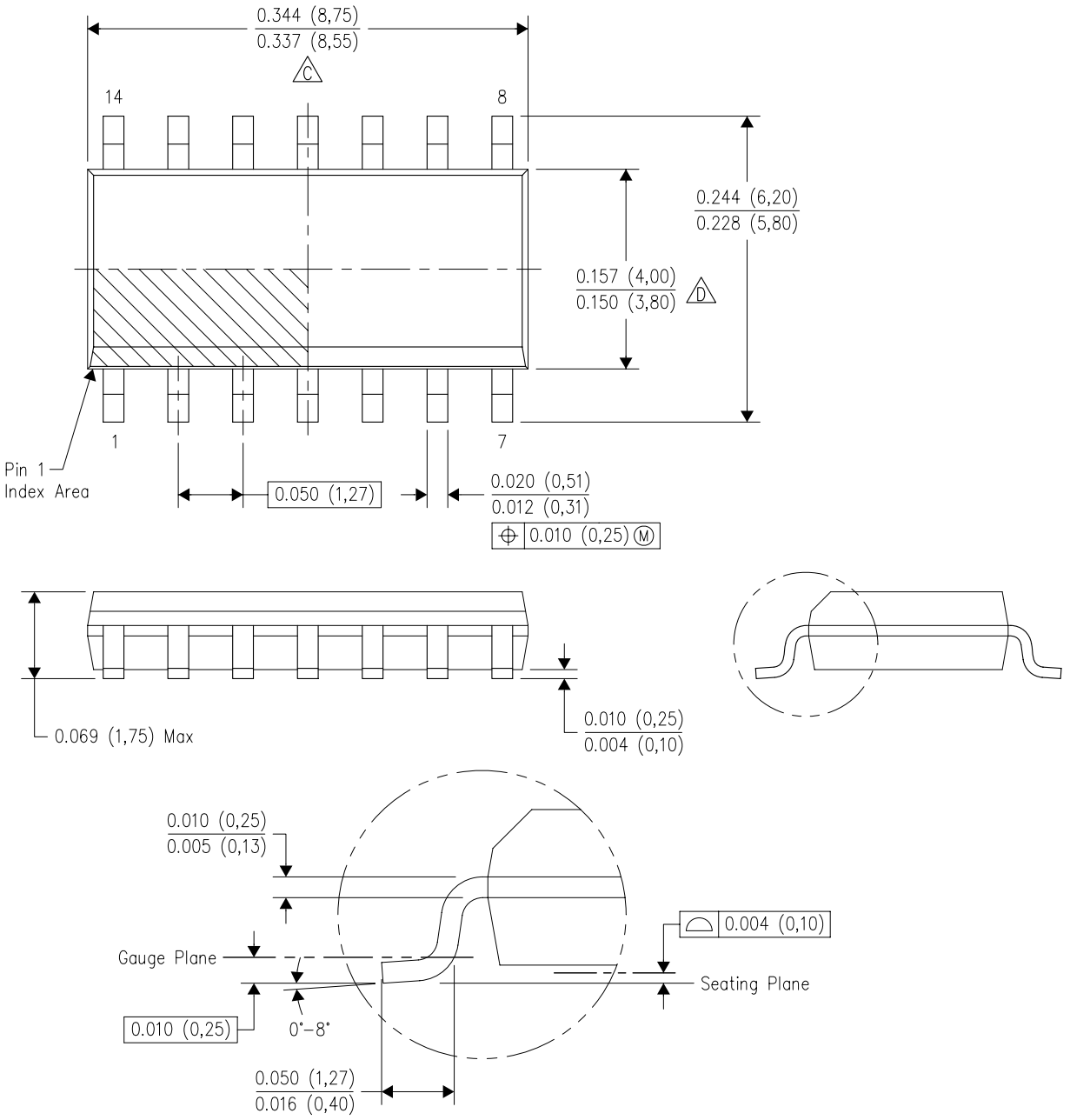
4073329/E 05/06

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.



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 dimensions do not include mold flash, interlead flash, protrusions, or gate burrs. Mold flash, interlead flash, protrusions, or gate burrs shall not exceed 0,15 per end or side.
D. JEDEC package registration is pending.

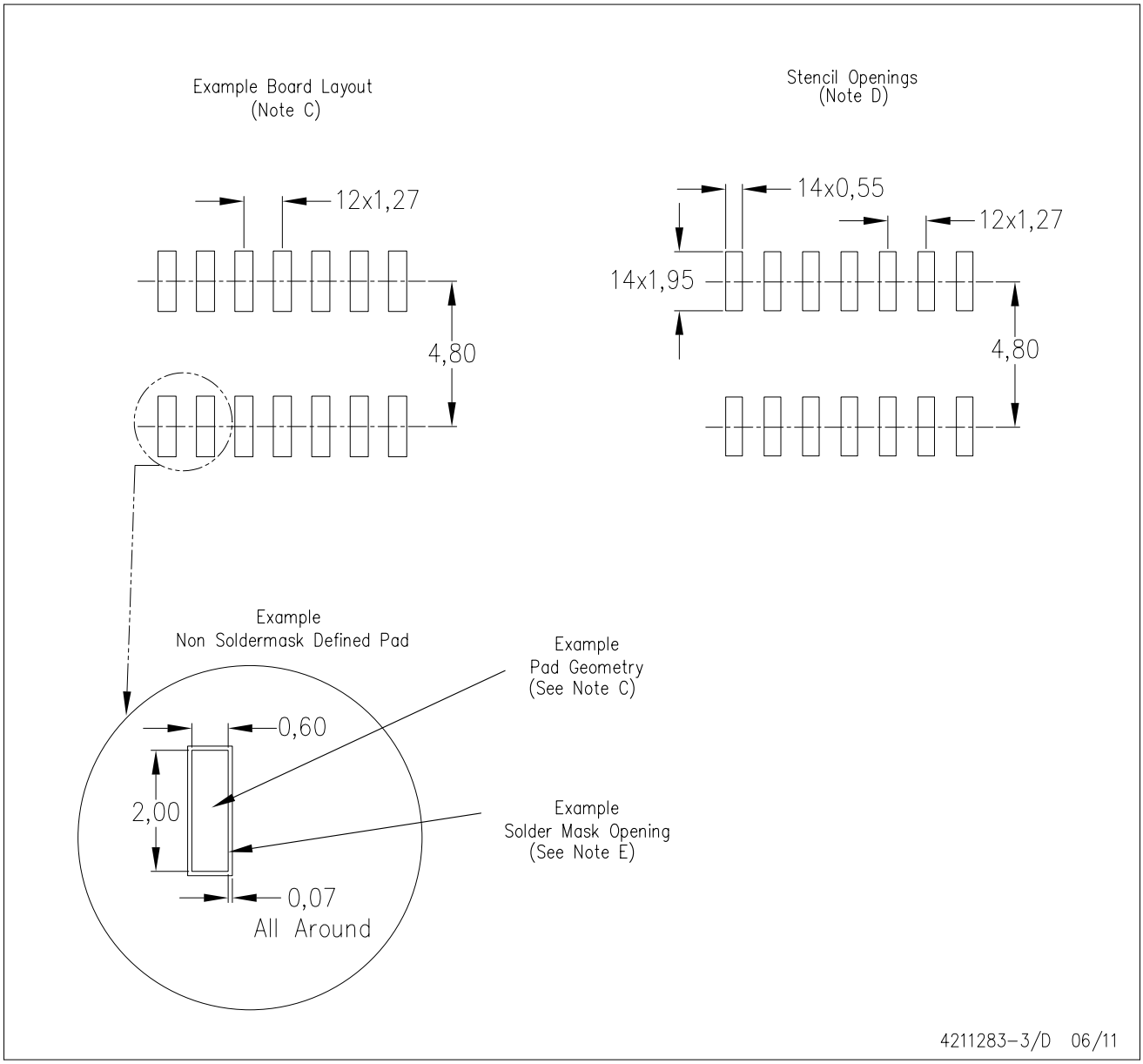
D (R–PDSO–G14) PLASTIC SMALL OUTLINE



4040047–5/M 06/11

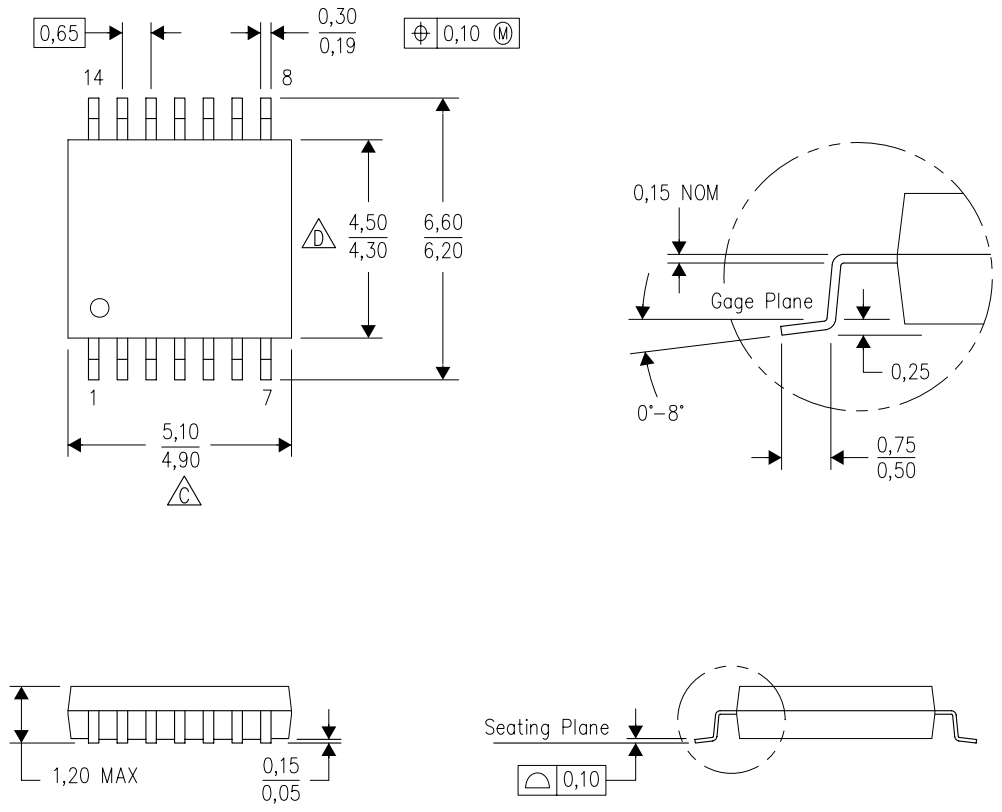
NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
D. Body width does not include interlead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

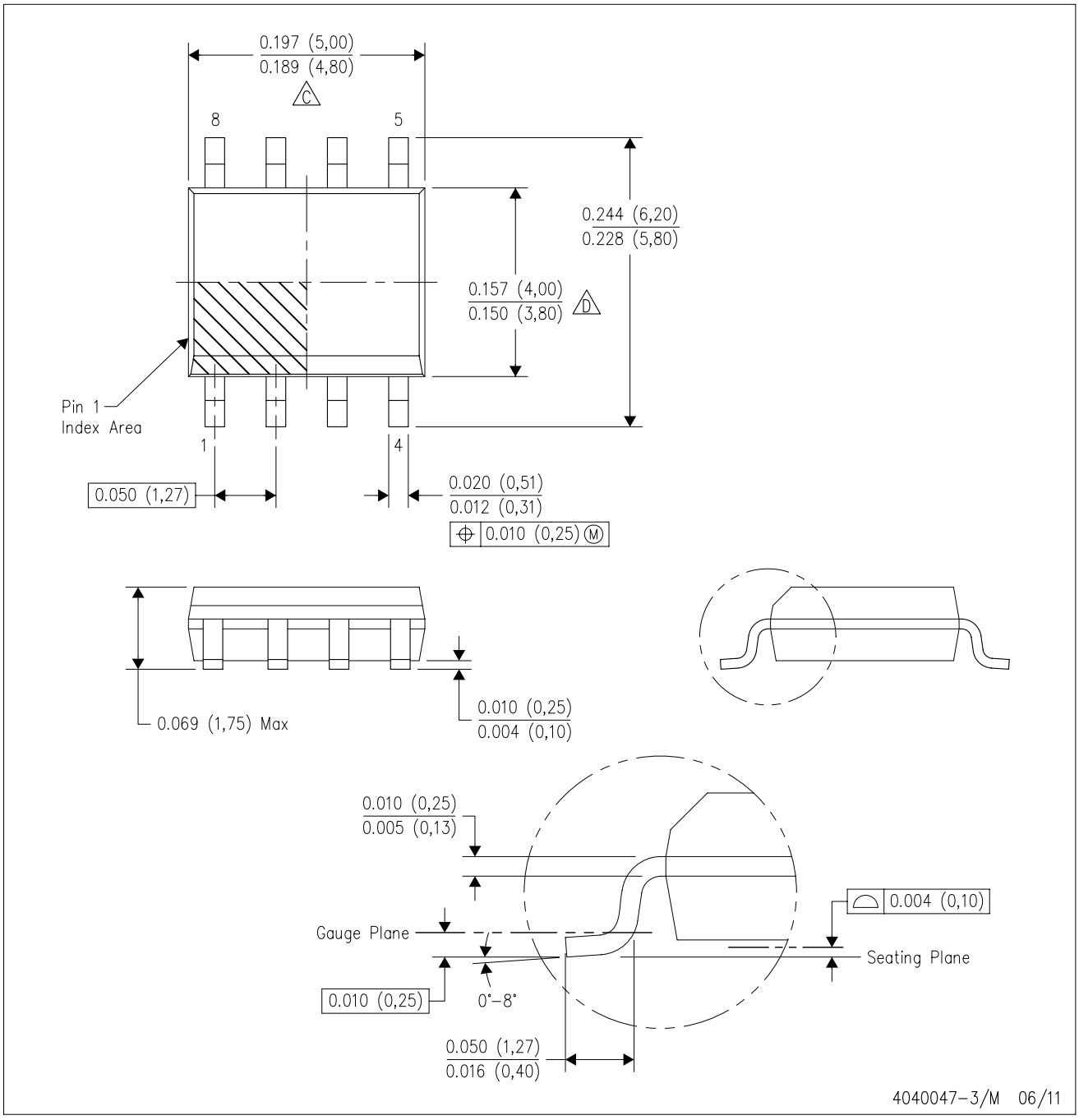
PW (R–PDSO–G14) PLASTIC SMALL OUTLINE



4040064–3/G 02/11

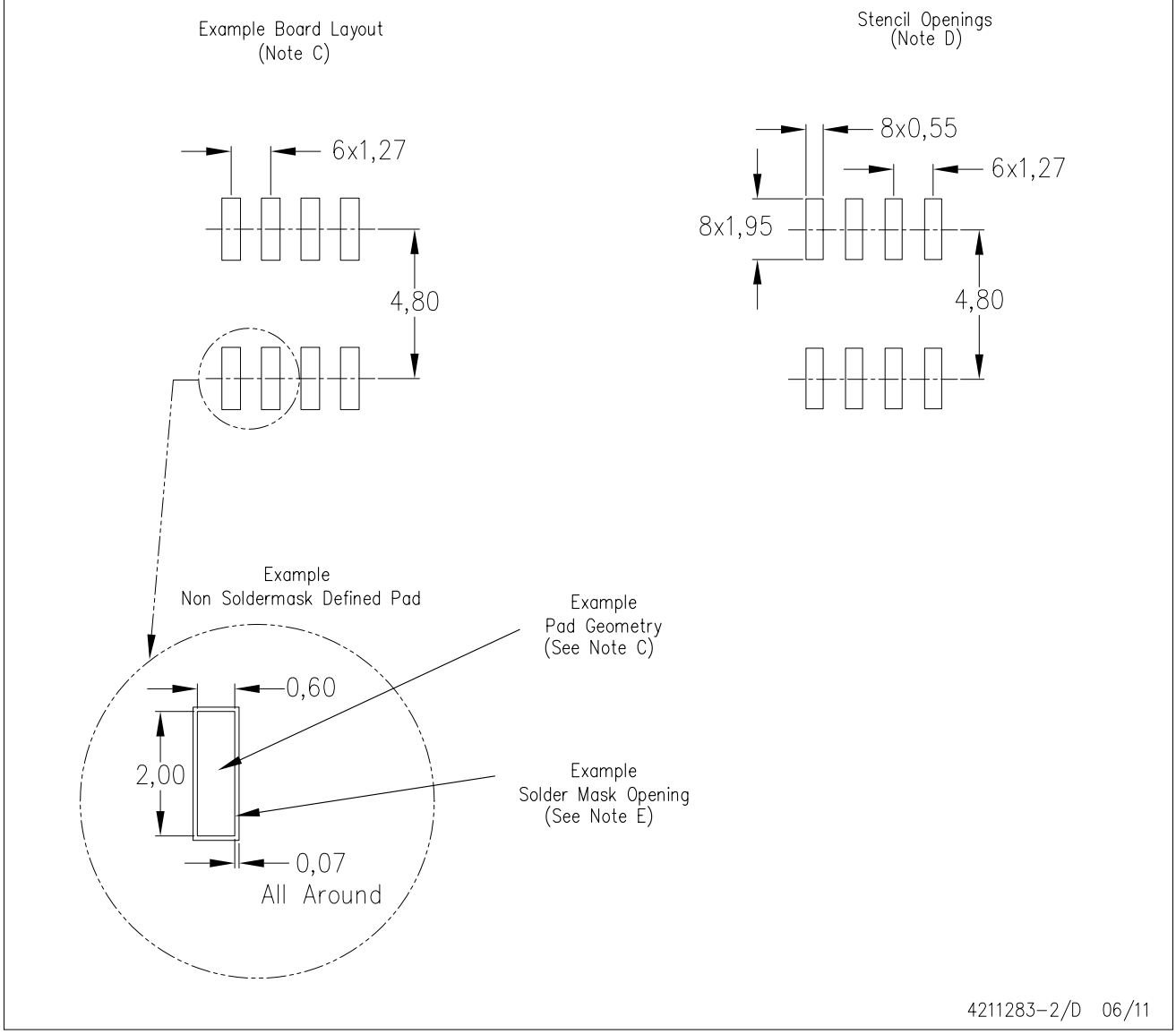
NOTES:
A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M–1994.
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0,15 each side.
D.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

D (R–PDSO–G8) PLASTIC SMALL OUTLINE



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 AA.

D (R–PDSO–G8) 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.

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