200-MHz CMOS OPERATIONAL AMPLIFIER

FEATURES

- **Qualified For Automotive Applications**
- **Unity-Gain Bandwidth: 450 MHz**
- **Wide Bandwidth: 200 MHz GBW**
- **High Slew Rate: 360 V/s**
- **Low Noise: 5.8 nV/√Hz**
- **Excellent Video Performance**
  - **Differential Gain: 0.02%**
  - **Differential Phase: 0.05°**
  - **0.1-dB Gain Flatness: 75 MHz**
- **Input Range Includes Ground**
- **Rail-To-Rail Output (Within 100 mV)**
- **Low Input Bias Current: 3 pA**
- **Thermal Shutdown**
- **Single-Supply Operating Range: 2.5 V To 5.5 V**

APPLICATIONS

- **Video Processing**
- **Ultrasound**
- **Optical Networking, Tunable Lasers**
- **Photodiode Transimpedance Amplifiers**
- **Active Filters**
- **High-Speed Integrators**
- **Analog-To-Digital (A/D) Converter Input Buffers**
- **Digital-To-Analog (D/A) Converter Output Amplifiers**
- **Barcode Scanners**
- **Communications**

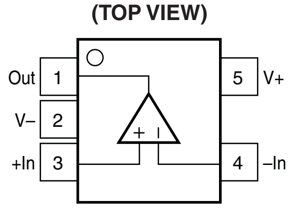
DESCRIPTION

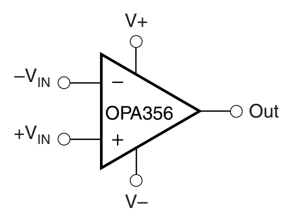
The OPA356 is a high-speed voltage-feedback CMOS operational amplifier designed for video and other applications requiring wide bandwidth. The OPA356 is unity gain stable and can drive large output currents. Differential gain is 0.02% and differential phase is 0.05°. Quiescent current is only 8.3 mA.

OPA356 is optimized for operation on single or dual supplies as low as 2.5 V (±1.25 V) and up to 5.5 V (±2.75 V). Common-mode input range for the OPA356 extends 100 mV below ground and up to 1.5 V from V+. The output swing is within 100 mV of the rails, supporting wide dynamic range.

The OPA356 is available in the SOT23-5 package and is specified over the –40°C to 125°C range.

DBV PACKAGE (TOP VIEW)





ORDERING INFORMATION(1)

T_A	PACKAGE(2)		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 125°C	SOT-23 – DBV	Reel of 3000	OPA356AQDBVRQ1	OOVQ

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at www.ti.com.
(2) Package drawings, thermal data, and symbolization are available at www.ti.com/packaging.

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.

ABSOLUTE MAXIMUM RATINGS[1]

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

V_S	Supply voltage, V+ to V–	7.5 V
V_{IN}	Signal input terminals voltage range[2]	–0.5 V to (V+ + 0.5 V)
	V– current[2]	10 mA
	Output short-circuit duration[3]	Continuous
θ_{JA}	Thermal impedance, junction to free air[4]	150°C/W
T_A	Operating free-air temperature range	–40°C to 125°C
T_{STG}	Storage temperature range	–65°C to 150°C
T_J	Junction temperature	160°C
T_{LEAD}	Lead temperature (soldering, 10 s)	300°C

(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) Input terminals are diode-clamped to the power-supply rails. Input signals that can swing more than 0.5 V beyond the supply rails should be current limited to 10 mA or less.
(3) Short-circuit to ground one amplifier per package.
(4) The package thermal impedance is calculated in accordance with JESD 51-5.

RECOMMENDED OPERATING CONDITIONS

		MIN	MAX	UNIT
V_S	Supply voltage, V– to V+	2.7	5.5	V
T_A	Operating free-air temperature	–40	125	°C

ELECTRICAL CHARACTERISTICS

V_S = 2.7 V to 5.5 V, R_F = 604 Ω, R_L = 150 Ω connected to V_S/2 (unless otherwise noted)

PARAMETER			TEST CONDITIONS	T_A (1)	MIN	TYP	MAX	UNIT
V_{OS}	Input offset voltage		V_S = 5 V, V_{CM} = V– + 0.8 V	25°C		±2	±9	mV
				Full range			±15	
$\Delta V_{OS}/\Delta T$	Offset voltage drift over temperature			Full range		±7		µV/°C
PSRR	Offset voltage drift vs power supply		V_S = 2.7 V to 5.5 V, V_{CM} = V_S/2 – 0.15 V	25°C		±80	±350	µV/V
I_B	Input bias current			25°C		3	±50	pA
I_{OS}	Input offset current			25°C		±1	±50	pA
V_n	Input voltage noise density		f = 1 MHz	25°C		5.8		nV/√Hz
I_n	Input current noise density		f = 1 MHz	25°C		50		fA/√Hz
V_{CM}	Input common-mode voltage range			25°C	V– – 0.1		V+ – 1.5	V
CMRR	Input common-mode rejection ratio		V_S = 5.5 V, –0.1 V < V_{CM} < 4 V	25°C	66	80		dB
				Full range	66			
Z_{ID}	Differential input impedance			25°C		10^{13} || 1.5		Ω || pF
Z_{ICM}	Common-mode input impedance			25°C		10^{13} || 1.5		Ω || pF
A_{OL}	Open-loop gain		V_S = 5 V, 0.3 V < V_O < 4.7 V	25°C	84	92		dB
				Full range	80			
f_{-3dB}	Small-signal bandwidth		G = +1, V_O = 100 mVp-p, R_F = 0 Ω	25°C		450		MHz
			G = +2, V_O = 100 mVp-p, R_L = 50 Ω			100		
			G = +2, V_O = 100 mVp-p, R_L = 150 Ω			170		
			G = +2, V_O = 100 mVp-p, R_L = 1 kΩ			200		
GBW	Gain-bandwidth product		G = +10, R_L = 1 kΩ	25°C		200		MHz
$f_{0.1dB}$	Bandwidth for 0.1-dB gain flatness		G = +2, V_O = 100 mVp-p, R_F = 560 Ω	25°C		75		MHz
SR	Slew rate		V_S = 5 V, G = +2, 4-V output step	25°C		+300 –360		V/µs
t_{rf}	Rise-and-fall time		G = +2, V_O = 200 mVp-p, 10% to 90%	25°C		2.4		ns
			G = +2, V_O = 2 Vp-p, 10% to 90%			8		
t_{settle}	Settling time	0.1%	V_S = 5 V, G = +2, 2-V output step	25°C		30		ns
		0.01%		25°C		120		
	Overload recovery time		V_{IN} × Gain = V_S	25°C		8		ns
	Harmonic distortion	Second harmonic	G = +2, f = 1 MHz, VO = 2 Vp-p, R_L = 200 Ω	25°C		–81		dBc
		Third harmonic		25°C		–93		
	Differential gain error		NTSC, R_L = 150 Ω	25°C		0.02		%
	Differential phase error		NTSC, R_L = 150 Ω	25°C		0.05		°
	Voltage output swing from rail		V_S = 5 V, R_L = 150 Ω, A_{OL} > 84 dB	25°C		0.2	0.3	V
			V_S = 5 V, R_L = 1 kΩ			0.1		
			V_S = 5 V, R_L = 50 Ω			0.4	0.6	
I_O	Output current (2)	Continuous		25°C	±60			mA
		Peak	V_S = 5 V		±100			
			V_S = 3 V			±80		

(1) Full range T_A = –40°C to 125°C
(2) See typical characteristic graph *Output Voltage Swing vs Output Current*.

ELECTRICAL CHARACTERISTICS (continued)

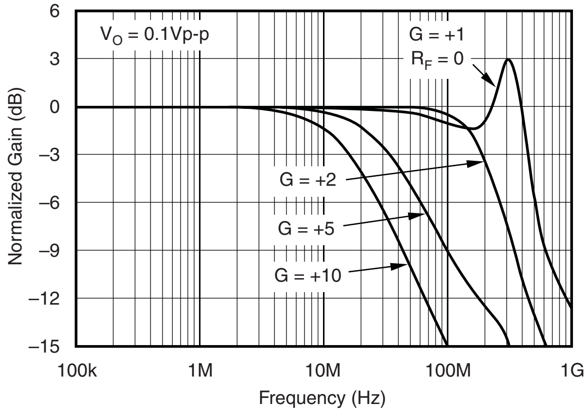
V_S = 2.7 V to 5.5 V, R_F = 604 Ω, R_L = 150 Ω connected to V_S/2 (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A (1)	MIN	TYP	MAX	UNIT
	Short-circuit current		25°C		+250 –200		mA
	Closed-loop output impedance		25°C		0.02		Ω
I_Q	Quiescent current	V_S = 5 V, I_O = 0	25°C		8.3	11	mA
			Full range			14	
	Thermal shutdown junction temperature	Shutdown	25°C		160		°C
		Reset from shutdown			140		

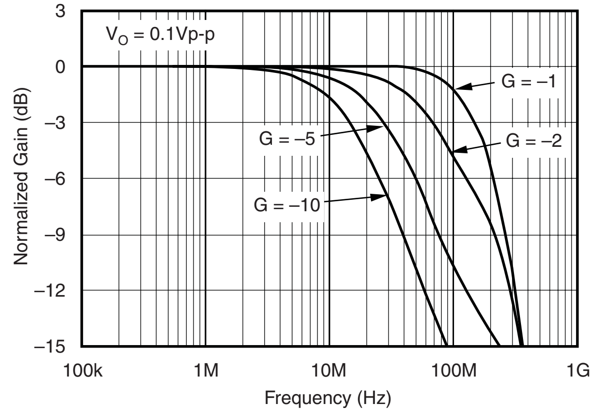
TYPICAL CHARACTERISTICS

T_A = 25°C, V_S = 5 V, G = +2, R_F = 604 Ω, R_L = 150 Ω connected to V_S/2 (unless otherwise noted)

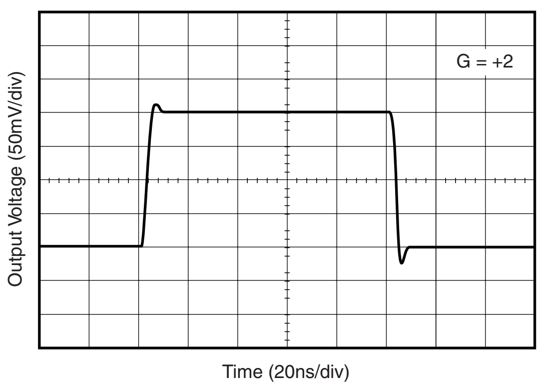
NON-INVERTING SMALL-SIGNAL FREQUENCY RESPONSE



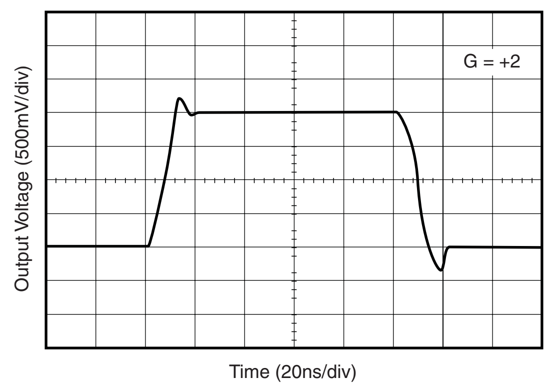
INVERTING SMALL-SIGNAL FREQUENCY RESPONSE



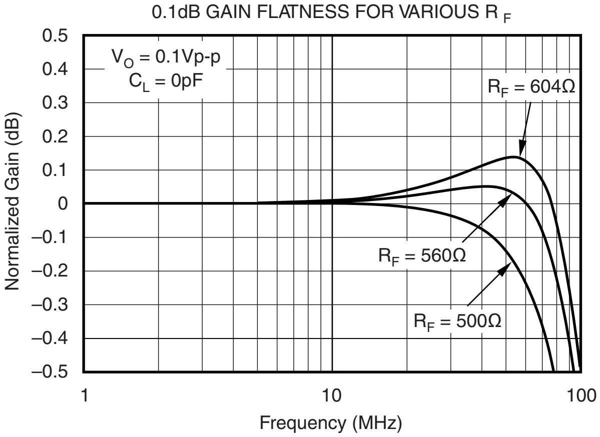
NON-INVERTING SMALL-SIGNAL STEP RESPONSE



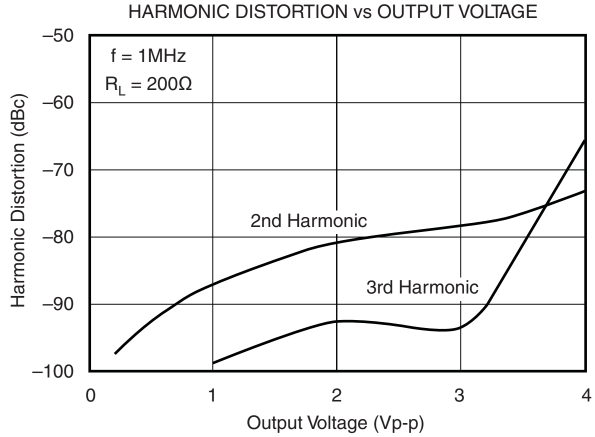
NON-INVERTING LARGE-SIGNAL STEP RESPONSE



0.1dB GAIN FLATNESS FOR VARIOUS R_F



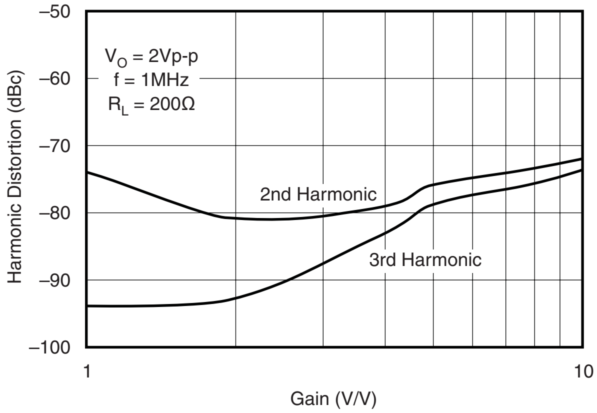
HARMONIC DISTORTION vs OUTPUT VOLTAGE



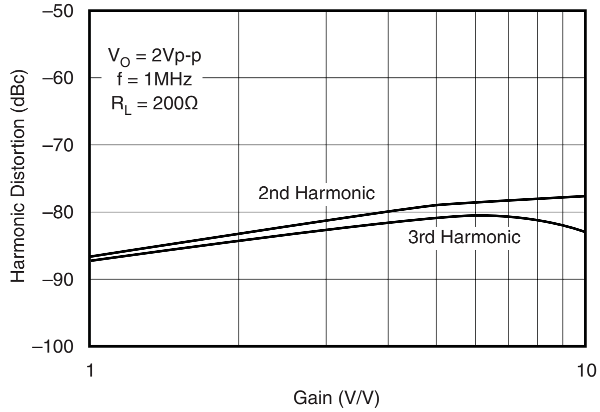
TYPICAL CHARACTERISTICS (continued)

T_A = 25°C, V_S = 5 V, G = +2, R_F = 604 Ω, R_L = 150 Ω connected to V_S/2 (unless otherwise noted)

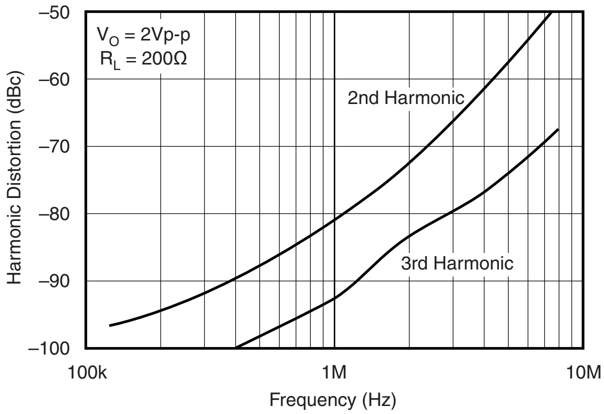
HARMONIC DISTORTION vs NON-INVERTING GAIN



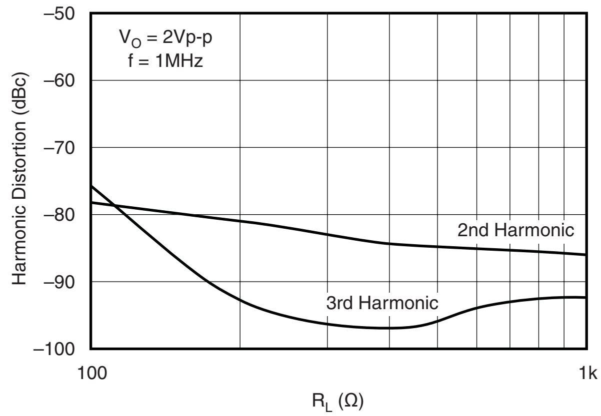
HARMONIC DISTORTION vs INVERTING GAIN



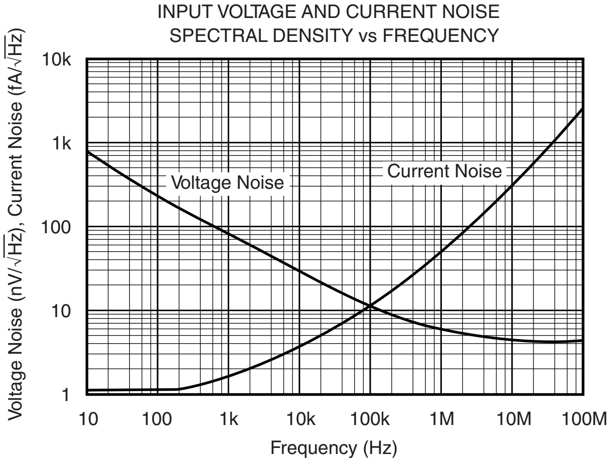
HARMONIC DISTORTION vs FREQUENCY



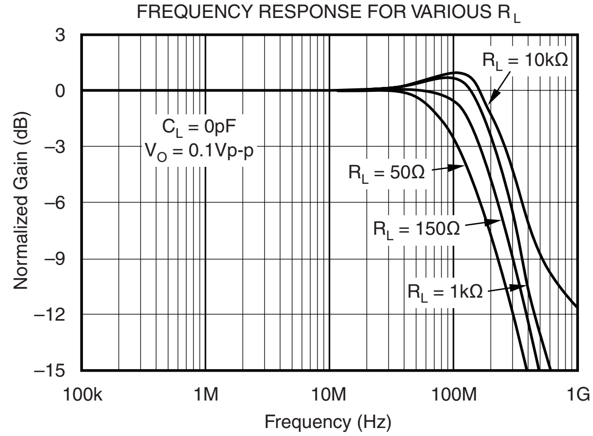
HARMONIC DISTORTION vs LOAD RESISTANCE



INPUT VOLTAGE AND CURRENT NOISE SPECTRAL DENSITY vs FREQUENCY



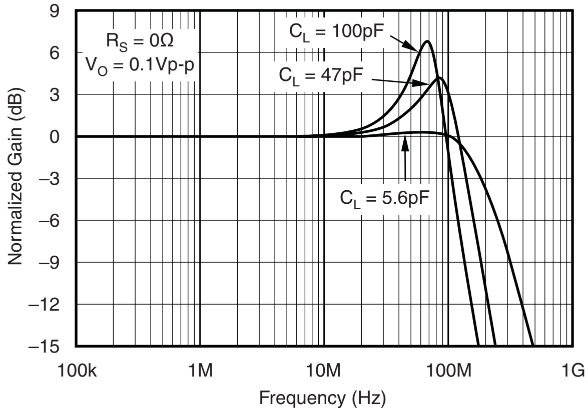
FREQUENCY RESPONSE FOR VARIOUS R_L



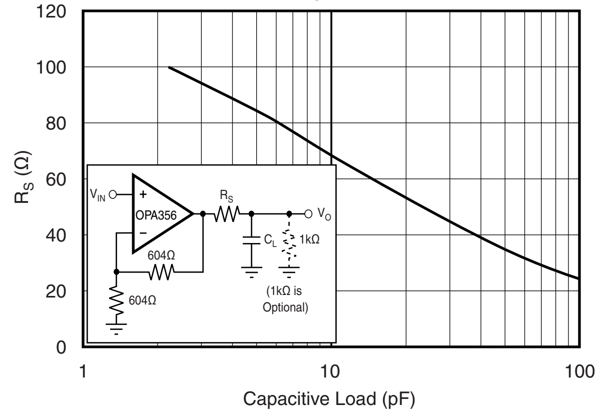
TYPICAL CHARACTERISTICS (continued)

T_A = 25°C, V_S = 5 V, G = +2, R_F = 604 Ω, R_L = 150 Ω connected to V_S/2 (unless otherwise noted)

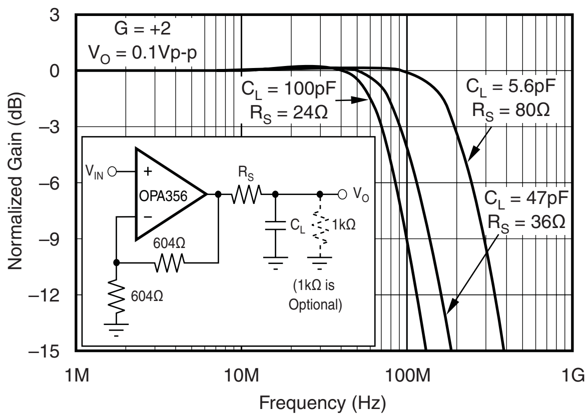
FREQUENCY RESPONSE FOR VARIOUS C_L



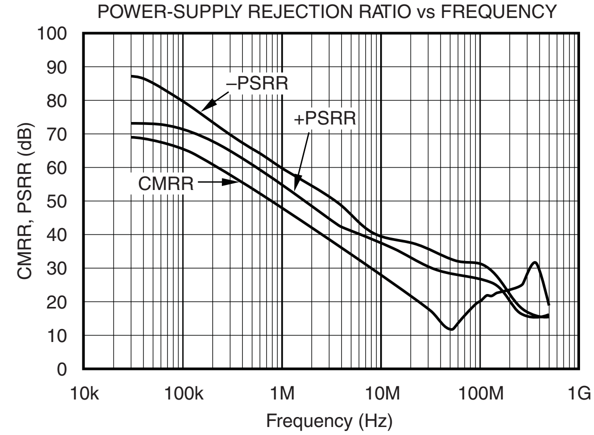
RECOMMENDED R_S vs CAPACITIVE LOAD



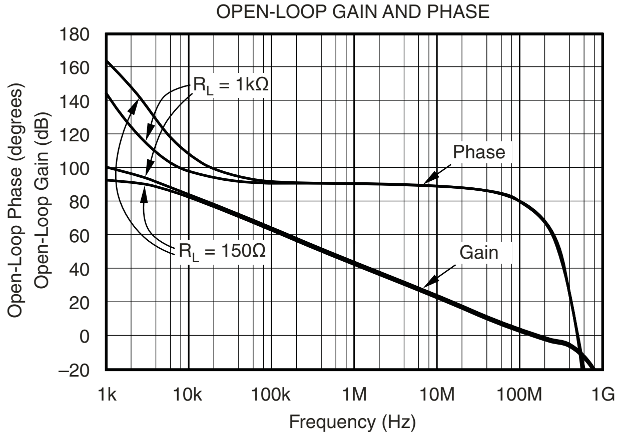
FREQUENCY RESPONSE vs CAPACITIVE LOAD



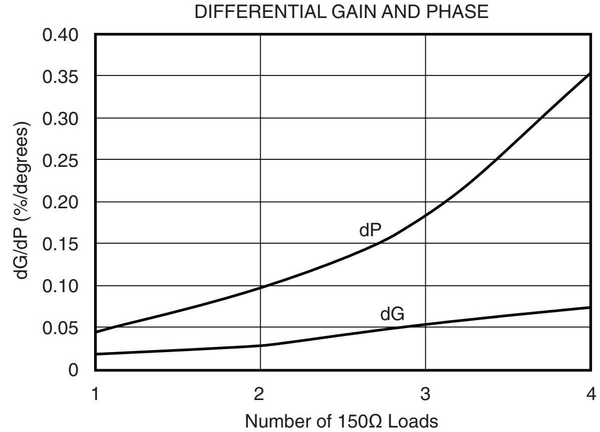
COMMON-MODE REJECTION RATIO AND POWER-SUPPLY REJECTION RATIO vs FREQUENCY



OPEN-LOOP GAIN AND PHASE



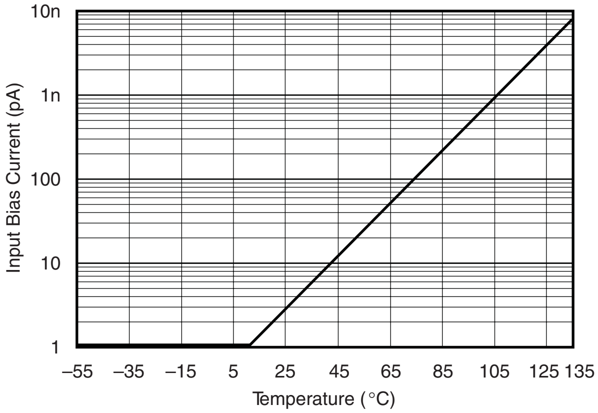
COMPOSITE VIDEO DIFFERENTIAL GAIN AND PHASE



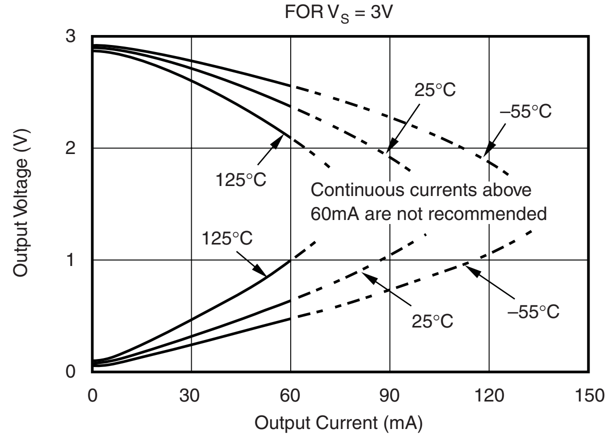
TYPICAL CHARACTERISTICS (continued)

T_A = 25°C, V_S = 5 V, G = +2, R_F = 604 Ω, R_L = 150 Ω connected to V_S/2 (unless otherwise noted)

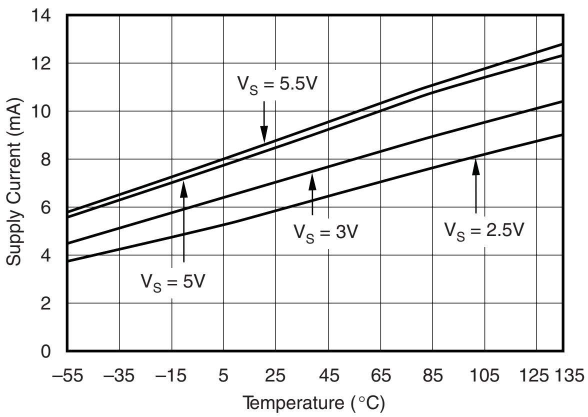
INPUT BIAS CURRENT vs TEMPERATURE



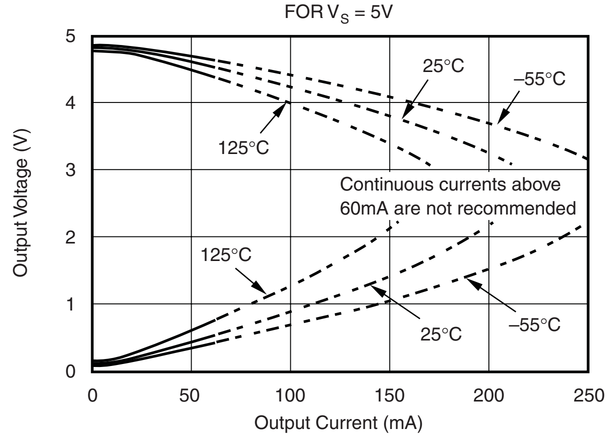
OUTPUT VOLTAGE SWING vs OUTPUT CURRENT FOR V_S = 3V



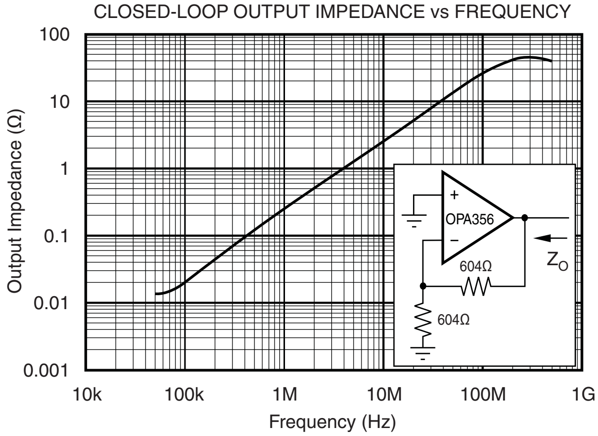
SUPPLY CURRENT vs TEMPERATURE



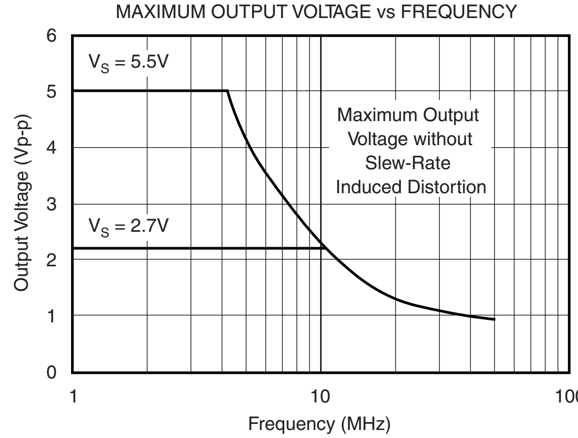
OUTPUT VOLTAGE SWING vs OUTPUT CURRENT FOR V_S = 5V



CLOSED-LOOP OUTPUT IMPEDANCE vs FREQUENCY



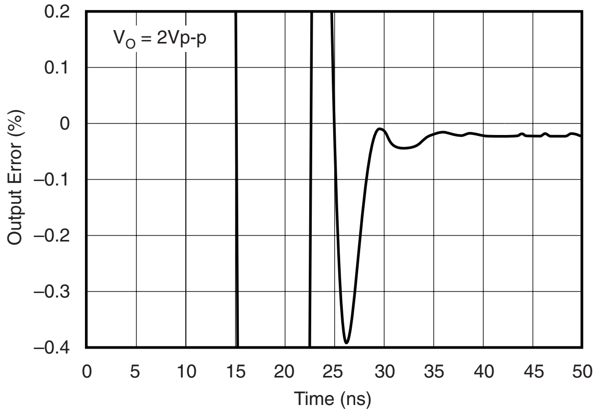
MAXIMUM OUTPUT VOLTAGE vs FREQUENCY



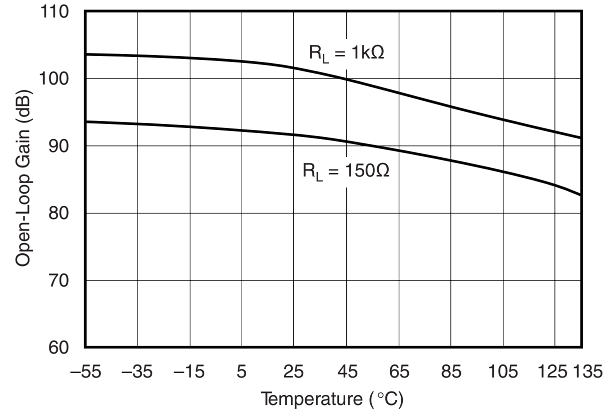
TYPICAL CHARACTERISTICS (continued)

T_A = 25°C, V_S = 5 V, G = +2, R_F = 604 Ω, R_L = 150 Ω connected to V_S/2 (unless otherwise noted)

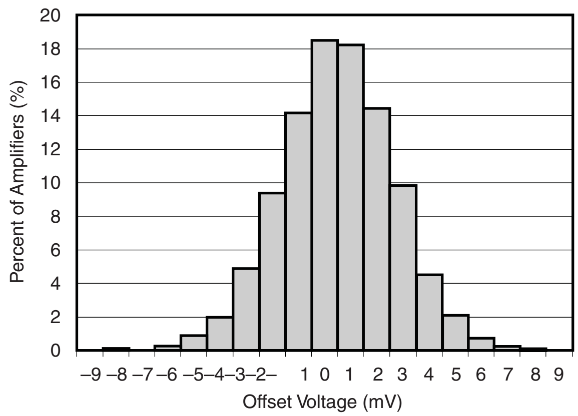
OUTPUT SETTLING TIME TO 0.1%



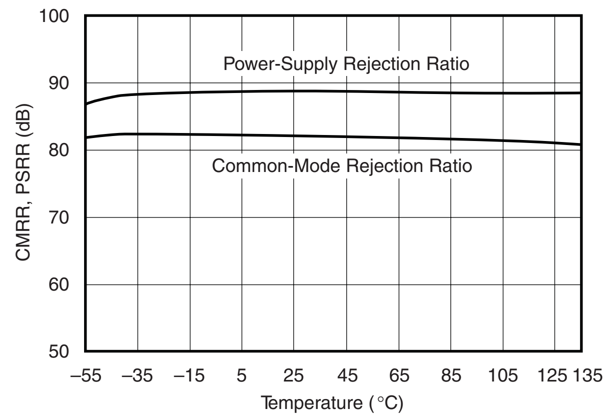
OPEN-LOOP GAIN vs TEMPERATURE



OFFSET VOLTAGE PRODUCTION DISTRIBUTION



COMMON-MODE REJECTION RATIO AND POWER-SUPPLY REJECTION RATIO vs TEMPERATURE



APPLICATION INFORMATION

The OPA356 is a CMOS high-speed voltage-feedback operational amplifier designed for video and other general-purpose applications.

The amplifier features a 200-MHz gain bandwidth and 360-V/µs slew rate, but it is unity-gain stable and can be operated as a 1-V/V voltage follower.

Its input common-mode voltage range includes ground, allowing the OPA356 to be used in virtually any single-supply application up to a supply voltage of 5.5 V.

PCB Layout

Good high-frequency PC board layout techniques should be employed for the OPA356. Generous use of ground planes, short direct signal traces, and a suitable bypass capacitor located at the V+ pin assure clean, stable operation. Large areas of copper also provide a means of dissipating heat that is generated within the amplifier in normal operation.

Sockets are definitely not recommended for use with any high-speed amplifier.

A 10-µF ceramic bypass capacitor is the minimum recommended value; adding a 1-µF or larger tantalum capacitor in parallel can be beneficial when driving a low-resistance load. Providing adequate bypass capacitance is essential to achieving very low harmonic and intermodulation distortion.

Operating Voltage

The OPA356 is specified over a power-supply range of 2.7 V to 5.5 V (±1.35 V to ±2.75 V). However, the supply voltage may range from 2.5 V to 5.5 V (±1.25 V to ±2.75 V). Supply voltages higher than 7.5 V (absolute maximum) can permanently damage the amplifier.

Parameters that vary significantly over supply voltage or temperature are shown in the *Typical Characteristics* section of this data sheet.

Output Drive

The OPA356 output stage is capable of driving a standard back-terminated 75-Ω video cable. By back-terminating a transmission line, it does not exhibit a capacitive load to its driver. A properly back-terminated 75-Ω cable does not appear as capacitance; it presents only a 150-Ω resistive load to the OPA356 output.

The output stage can supply high short-circuit current (typically over 200 mA). Therefore, an on-chip thermal shutdown circuit is provided to protect the OPA356 from dangerously high junction temperatures. At 160°C, the protection circuit will shut down the amplifier. Normal operation will resume when the junction temperature cools to below 140°C.

NOTE:

It is not recommended to run a continuous dc current in excess of ±60 mA. See the "Output Voltage Swing vs Output Current" graph in the *Typical Characteristics* section of this data sheet.

Input and ESD Protection

All OPA356 pins are static protected with internal ESD protection diodes tied to the supplies, as shown in Figure 1. These diodes provide overdrive protection if the current is externally limited to 10 mA by the source or by a resistor.

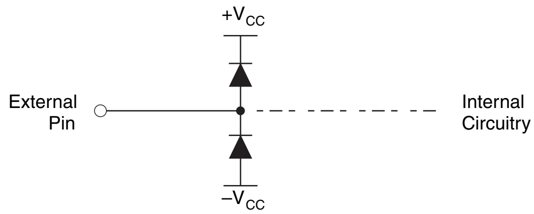


Figure 1. Internal ESD Protection

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
OPA356AQDBVRQ1	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR		OOVQ	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) 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.

(4) Only one of markings shown within the brackets will appear on the physical device.

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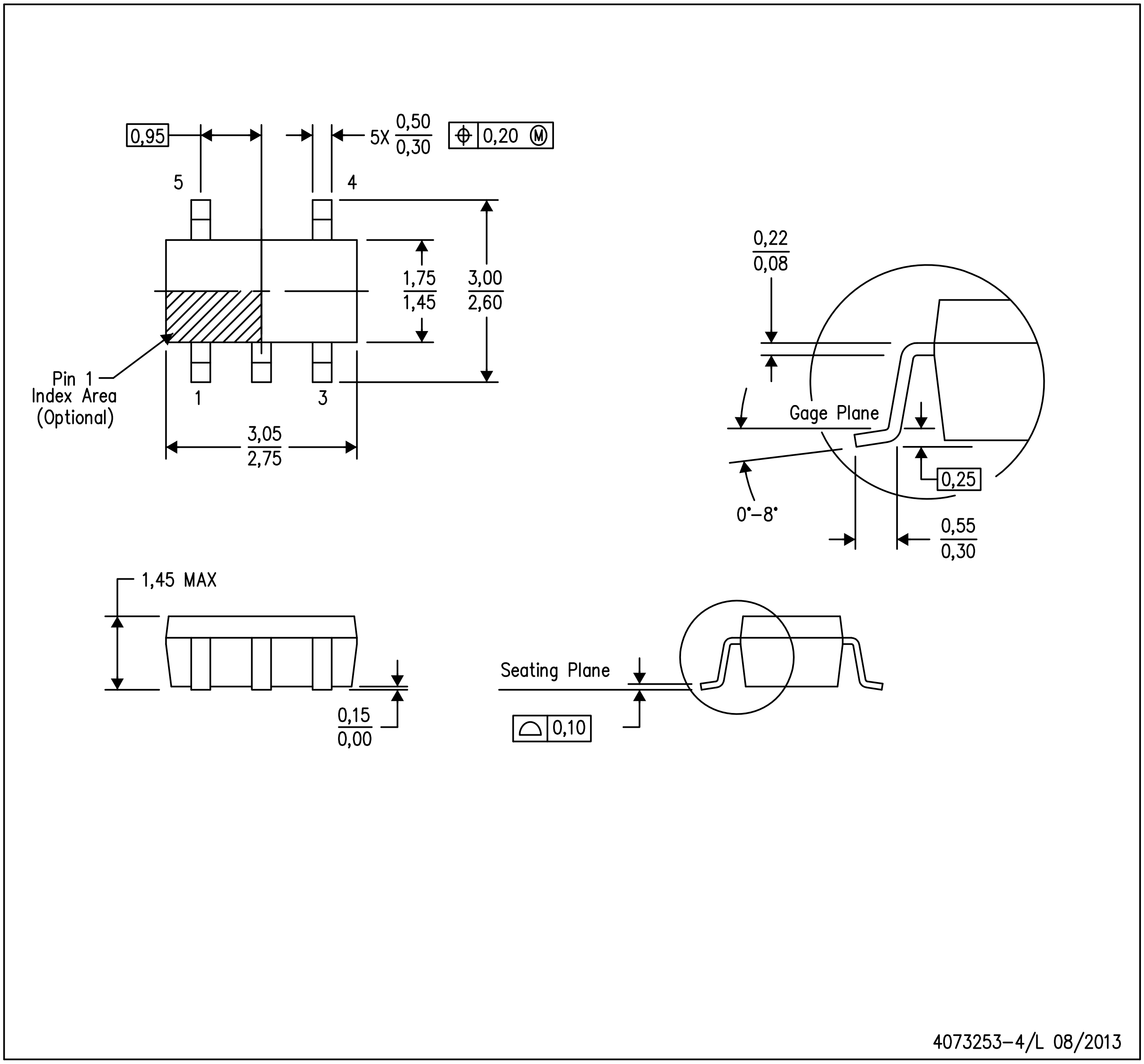
OTHER QUALIFIED VERSIONS OF OPA356-Q1 :

- Catalog: OPA356

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

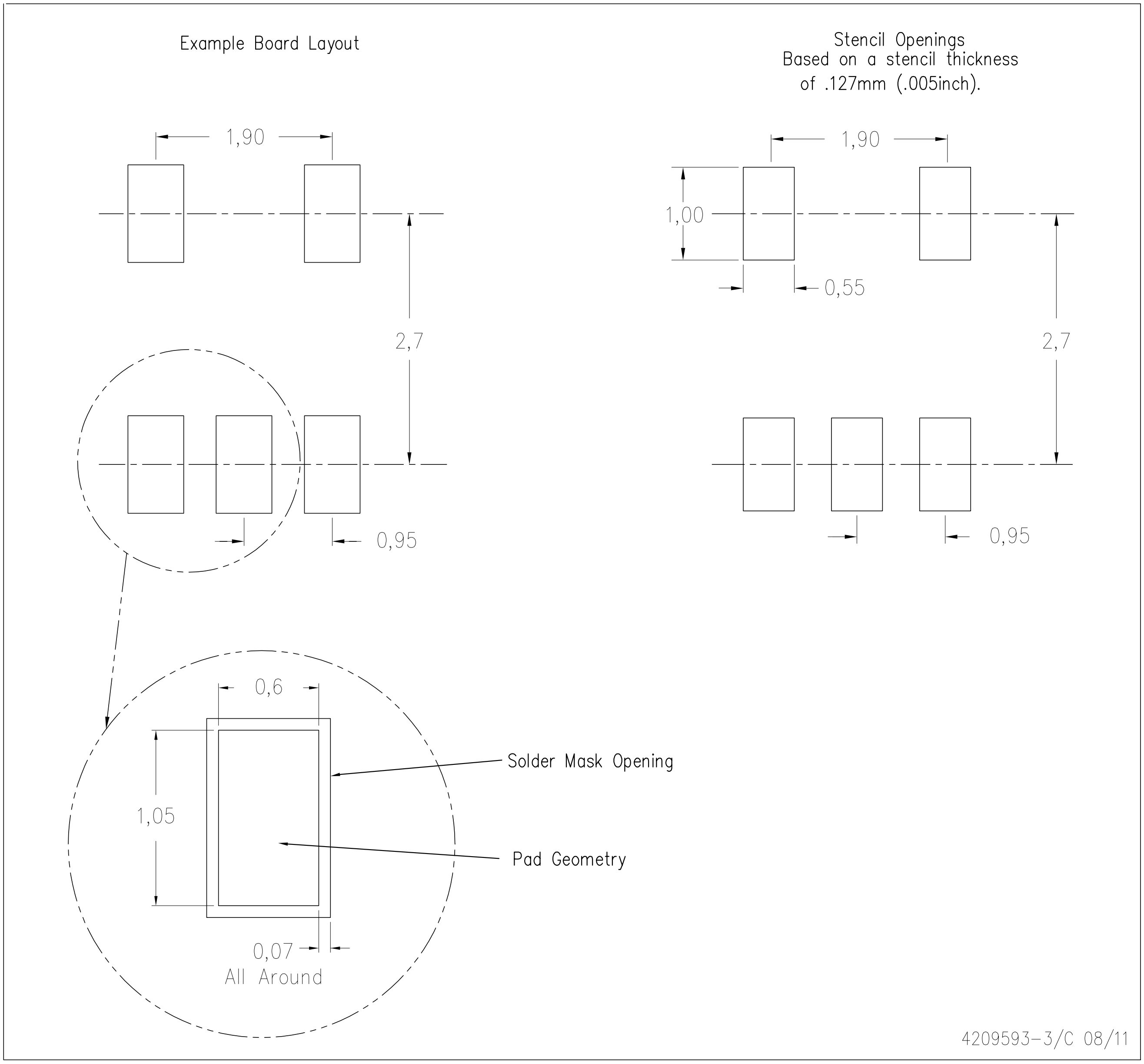
DBV (R-PDSO-G5) PLASTIC SMALL-OUTLINE PACKAGE



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.

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