OPA356
OPA2356

SBOS212A – NOVEMBER, 2001

200MHz, CMOS OPERATIONAL AMPLIFIER

FEATURES

- **UNITY-GAIN BANDWIDTH: 450MHz**
- **WIDE BANDWIDTH: 200MHz GBW**
- **HIGH SLEW RATE: 360V/μs**
- **LOW NOISE: 5.8nV/√Hz**
- **EXCELLENT VIDEO PERFORMANCE: DIFF GAIN: 0.02%, DIFF PHASE: 0.05° 0.1dB GAIN FLATNESS: 75MHz**
- **INPUT RANGE INCLUDES GROUND**
- **RAIL-TO-RAIL OUTPUT (within 100mV)**
- **LOW INPUT BIAS CURRENT: 3pA**
- **THERMAL SHUTDOWN**
- **SINGLE-SUPPLY OPERATING RANGE: 2.5V to 5.5V**
- ***Micro*SIZE PACKAGES**

APPLICATIONS

- **VIDEO PROCESSING**
- **ULTRASOUND**
- **OPTICAL NETWORKING, TUNABLE LASERS**
- **PHOTODIODE TRANSIMPEDANCE AMPS**
- **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

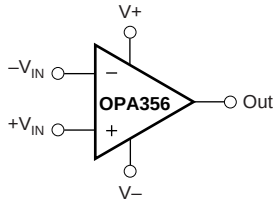
The OPAx356 series high-speed, voltage-feedback CMOS operational amplifiers are designed for video and other applications requiring wide bandwidth. The OPAx356 is unity gain stable and can drive large output currents. Differential gain is 0.02% and differential phase is 0.05°. Quiescent current is only 8.3mA per channel.

OPAx356 is optimized for operation on single or dual supplies as low as 2.5V (±1.25V) and up to 5.5V (±2.75V). Common-mode input range for the OPAx356 extends 100mV below ground and up to 1.5V from V+. The output swing is within 100mV of the rails, supporting wide dynamic range.

The OPAx356 series is available in single (SOT23-5 and SO-8), and dual (MSOP-8 and SO-8) versions. Multichannel versions feature completely independent circuitry for lowest crosstalk and freedom from interaction. All are specified over the extended –40°C to +125°C range.

OPAx356 RELATED PRODUCTS

FEATURES	PRODUCT
200MHz, Rail-to-Rail Output, CMOS, Shutdown	OPAx355
38MHz, Rail-to-Rail Input/Output, CMOS	OPAx350
75MHz, Rail-to-Rail Output	OPAx631
150MHz, Rail-to-Rail Output	OPAx634
Differential Input/Output, 3.3V Supply	THS412x



ABSOLUTE MAXIMUM RATINGS(1)

Supply Voltage, V+ to V–	7.5V
Signal Input Terminals, Voltage(2)	(V–) – 0.5V to (V+) + 0.5V
Current(2)	10mA
Output Short-Circuit(3)	Continuous
Operating Temperature	–55°C to +150°C
Storage Temperature	–65°C to +150°C
Junction Temperature	+160°C
Lead Temperature (soldering, 10s)	+300°C

NOTE: (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 0.5V beyond the supply rails should be current limited to 10mA or less. (3) Short-circuit to ground one amplifier per package.

ELECTROSTATIC DISCHARGE SENSITIVITY

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.

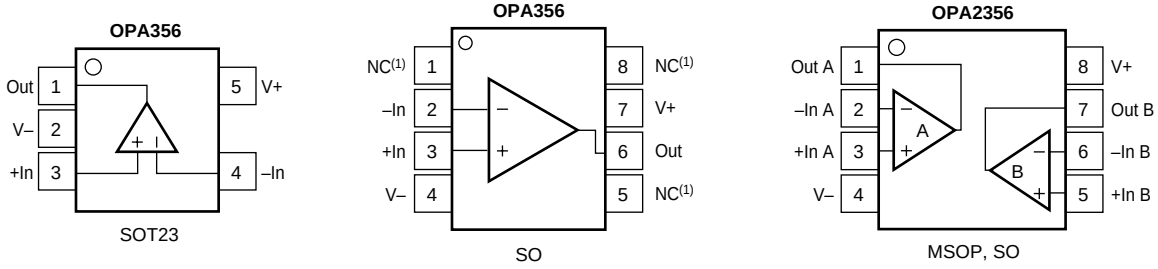
PACKAGE/ORDERING INFORMATION

PRODUCT	PACKAGE-LEAD	PACKAGE DESIGNATOR(1)	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER(2)	TRANSPORT MEDIA, QUANTITY
OPA356AIDBV	SOT23-5	DBV	–40°C to +125°C	OAAI	OPA356AIDBVT	Tape and Reel, 250
"	"	"	"	"	OPA356AIDBVR	Tape and Reel, 3000
OPA356AID	SO-8	D	–40°C to +125°C	OPA356A	OPA356AID	Rails, 100
"	"	"	"	"	OPA356AIDR	Tape and Reel, 2500
OPA2356AIDGK	MSOP-8	DGK	–40°C to +125°C	AYI	OPA2356AIDGKT	Tape and Reel, 250
"	"	"	"	"	OPA2356AIDGKR	Tape and Reel, 2500
OPA2356AID	SO-8	D	–40°C to +125°C	OPA2356A	OPA2356AID	Rails, 100
"	"	"	"	"	OPA2356AIDR	Tape and Reel, 2500

NOTES: (1) For the most current specifications and package information, refer to our web site at www.ti.com. (2) Models labeled with "T" indicate smaller quantity tape and reel, "R" indicates large quantity tape and reel and "D" indicates rails of specified quantity.

PIN CONFIGURATIONS

Top View



NOTE: (1) NC means no internal connection.

ELECTRICAL CHARACTERISTICS: V_S = +2.7V to +5.5V Single Supply

Boldface limits apply over the specified temperature range, T_A = –40°C to +125°C.

At T_A = +25°C, R_F = 604Ω, R_L = 150Ω, Connected to V_S/2, unless otherwise noted.

PARAMETER		CONDITION	OPA356AIDBV, AID, OPA2356AIDGK, AID MIN	TYP	MAX	UNITS
OFFSET VOLTAGE						
Input Offset Voltage	V_{OS}	V_S = +5V		±2	±9	mV
		Specified Temperature Range			**±15**	**mV**
vs Temperature	**dV_{OS}/dT**	**Specified Temperature Range**		**±7**		**µV/°C**
vs Power Supply	PSRR	V_S = +2.7V to +5.5V, V_{CM} = V_S/2 – 0.15V		±80	±350	µV/V
INPUT BIAS CURRENT						
Input Bias Current	I_B			3	±50	pA
Input Offset Current	I_{OS}			±1	±50	pA
NOISE						
Input Noise Voltage Density	e_n	f = 1MHz		5.8		$nV/\sqrt{Hz}$
Current Noise Density	i_n	f = 1MHz		50		$fA/\sqrt{Hz}$
INPUT VOLTAGE RANGE						
Common-Mode Voltage Range	V_{CM}		(V–) – 0.1		(V+) – 1.5	V
Common-Mode Rejection Ratio	CMRR	V_S = +5.5V, –0.1V < V_{CM} < +4.0V	66	80		dB
		Specified Temperature Range	**66**			**dB**
INPUT IMPEDANCE						
Differential				10^{13} || 1.5		Ω || pF
Common-Mode				10^{13} || 1.5		Ω || pF
OPEN-LOOP GAIN		V_S = +5V, 0.3V < V_O < 4.7V	84	92		dB
	OPA356	**V_S = +5V, 0.3V < V_O < 4.7V**	**80**			**dB**
	OPA2356	**V_S = +5V, 0.4V < V_O < 4.6V**	**80**			**dB**
FREQUENCY RESPONSE						
Small-Signal Bandwidth	f_{-3dB}	G = +1, V_O = 100mVp-p, R_F = 0Ω		450		MHz
	f_{-3dB}	G = +2, V_O = 100mVp-p, R_L = 50Ω		100		MHz
	f_{-3dB}	G = +2, V_O = 100mVp-p, R_L = 150Ω		170		MHz
	f_{-3dB}	G = +2, V_O = 100mVp-p, R_L = 1kΩ		200		MHz
Gain-Bandwidth Product	GBW	G = +10, R_L = 1kΩ		200		MHz
Bandwidth for 0.1dB Gain Flatness	$f_{0.1dB}$	G = +2, V_O = 100mVp-p, R_F = 560Ω		75		MHz
Slew Rate	SR	V_S = +5V, G = +2, 4V Output Step		300/–360		V/µs
Rise-and-Fall Time		G = +2, V_O = 200mVp-p, 10% to 90%		2.4		ns
		G = +2, V_O = 2Vp-p, 10% to 90%		8		ns
Settling Time, 0.1%		V_S = +5V, G = +2, 2V Output Step		30		ns
0.01%		V_S = +5V, G = +2, 2V Output Step		120		ns
Overload Recovery Time		V_{IN} • Gain = V_S		8		ns
Harmonic Distortion						
2nd Harmonic		G = +2, f = 1MHz, V_O = 2Vp-p, R_L = 200Ω		–81		dBc
3rd Harmonic		G = +2, f = 1MHz, V_O = 2Vp-p, R_L = 200Ω		–93		dBc
Differential Gain Error		NTSC, R_L = 150Ω		0.02		%
Differential Phase Error		NTSC, R_L = 150Ω		0.05		degrees
Channel-to-Channel Crosstalk	OPA2356	f = 5MHz		–90		dB
OUTPUT						
Voltage Output Swing from Rail		V_S = +5V, R_L = 150Ω, A_{OL} > 84dB		0.2	0.3	V
Voltage Output Swing from Rail		V_S = +5V, R_L = 1kΩ		0.1		V
Voltage Output Swing from Rail		I_O = ±100mA		0.8	1	V
Ouput Current, Continuous[1]	I_O		±60			mA
Maximum Output Current, Peak[1]	I_O	V_S = +5V	±100			mA
Maximum Output Current, Peak[1]	I_O	V_S = +3V		±80		mA
Short Circuit Current				+250/–200		mA
Closed-Loop Output Impedance		f < 100kHz		0.02		Ω
POWER SUPPLY						
Specified Voltage Range	V_S		2.7		5.5	V
Operating Voltage Range				2.5 to 5.5		V
Quiescent Current (per amplifier)	I_Q	V_S = +5V, I_O = 0		8.3	11	mA
		Specified Temperature Range			**14**	**mA**

ELECTRICAL CHARACTERISTICS: V_S = +2.7V to +5.5V Single Supply (Cont.)

Boldface limits apply over the specified temperature range, **T_A = –40°C to +125°C.**

At T_A = +25°C, R_F = 604Ω, R_L = 150Ω, Connected to V_S/2, unless otherwise noted.

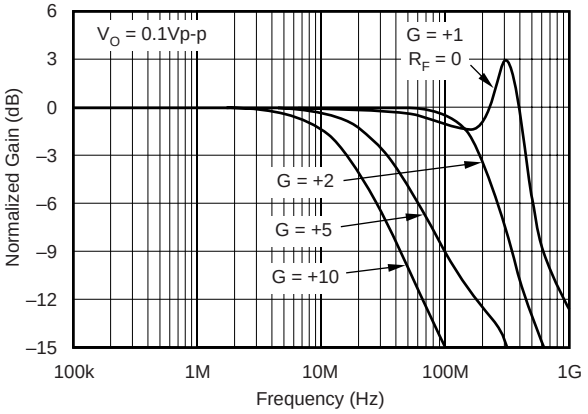
PARAMETER	CONDITION	OPA356AIDBV, AID, OPA2356AIDGK, AID			UNITS
		MIN	TYP	MAX	
THERMAL SHUTDOWN					
Junction Temperature					
Shutdown			160		°C
Reset from Shutdown			140		°C
TEMPERATURE RANGE					
Specified Range		–40		125	°C
Operating Range		–55		150	°C
Storage Range		–65		150	°C
Thermal Resistance θ_{JA}					°C/W
SOT23-5, MSOP-8			150		°C/W
SO-8			125		°C/W

NOTES: (1) See typical characteristic “Output Voltage Swing vs Output Current”.

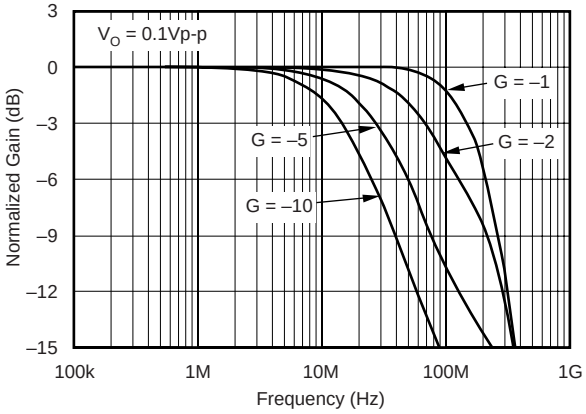
TYPICAL CHARACTERISTICS

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

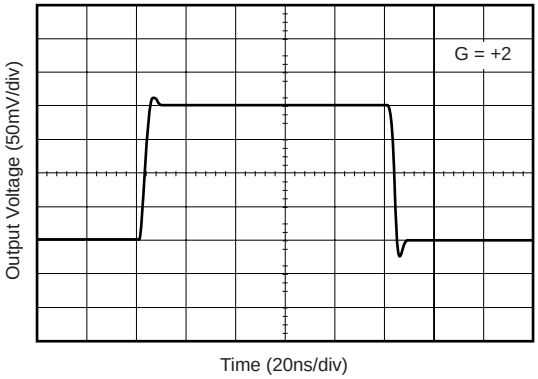
NON-INVERTING SMALL-SIGNAL FREQUENCY RESPONSE



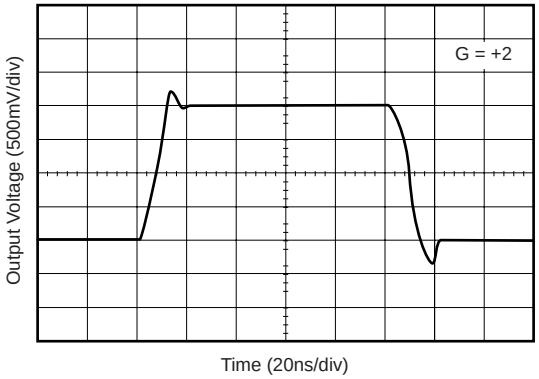
INVERTING SMALL-SIGNAL FREQUENCY RESPONSE



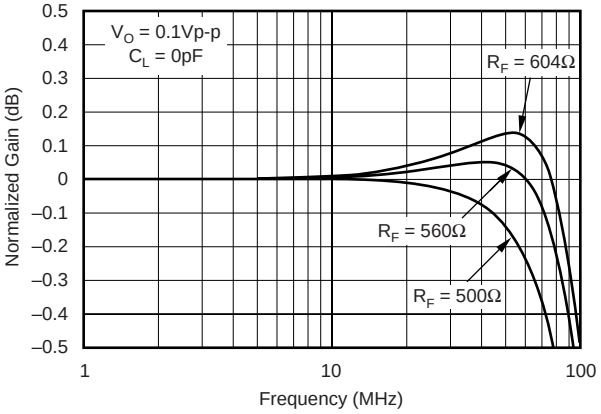
NON-INVERTING SMALL-SIGNAL STEP RESPONSE



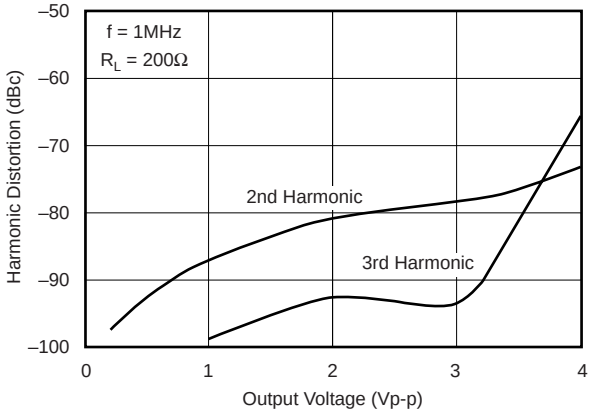
NON-INVERTING LARGE-SIGNAL STEP RESPONSE



0.1dB GAIN FLATNESS FOR VARIOUS R_F



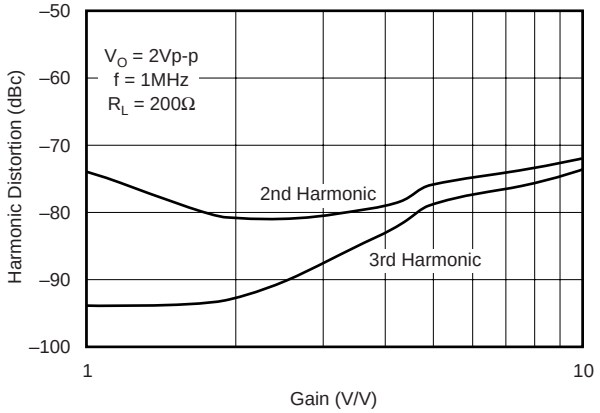
HARMONIC DISTORTION vs OUTPUT VOLTAGE



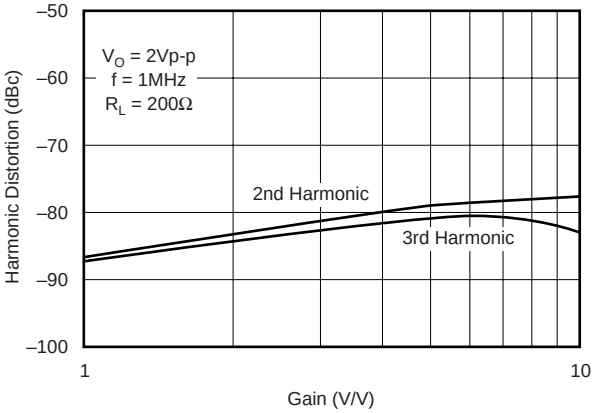
TYPICAL CHARACTERISTICS (Cont.)

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

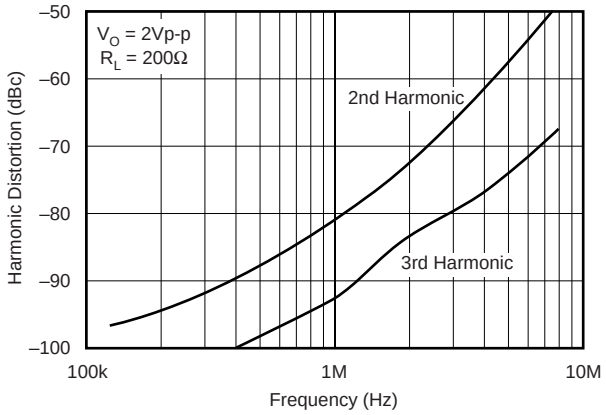
HARMONIC DISTORTION vs NON-INVERTING GAIN



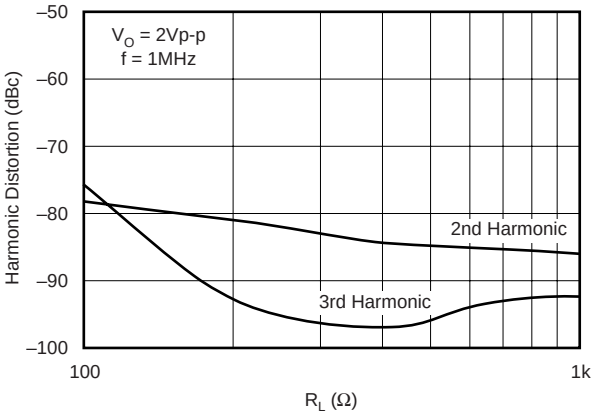
HARMONIC DISTORTION vs INVERTING GAIN



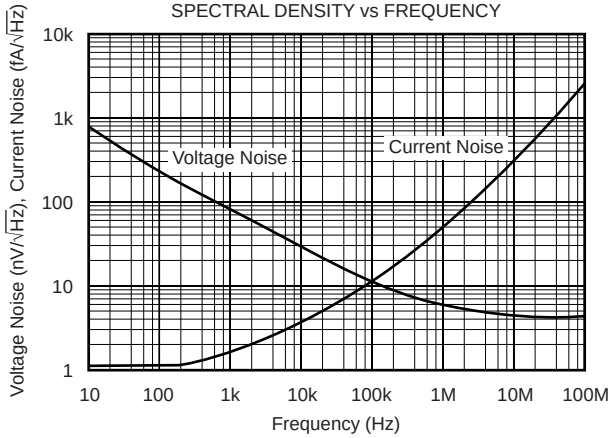
HARMONIC DISTORTION vs FREQUENCY



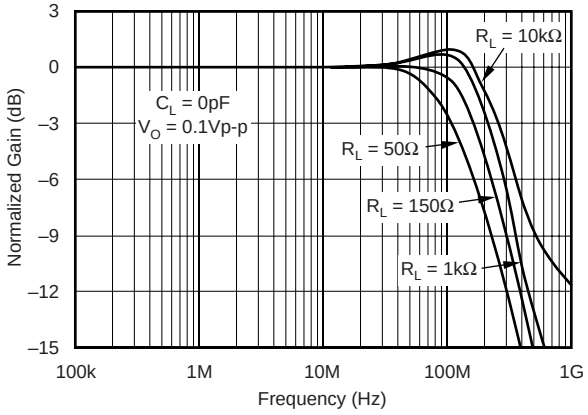
HARMONIC DISTORTION vs LOAD RESISTANCE



INPUT VOLTAGE AND CURRENT NOISE SPECTRAL DENSITY vs FREQUENCY



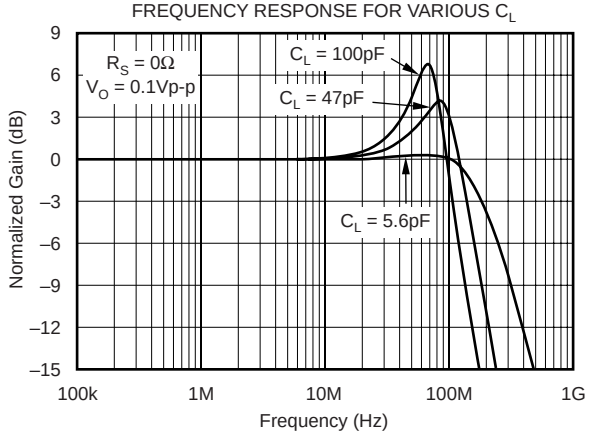
FREQUENCY RESPONSE FOR VARIOUS R_L



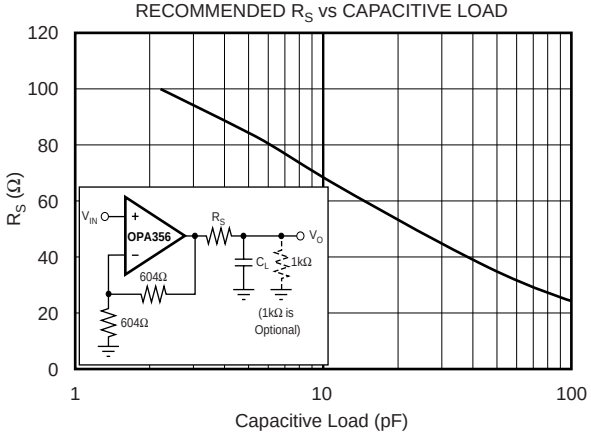
TYPICAL CHARACTERISTICS (Cont.)

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

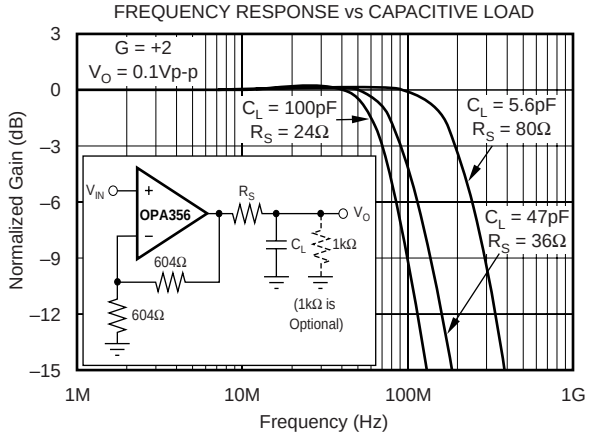
FREQUENCY RESPONSE FOR VARIOUS C_L



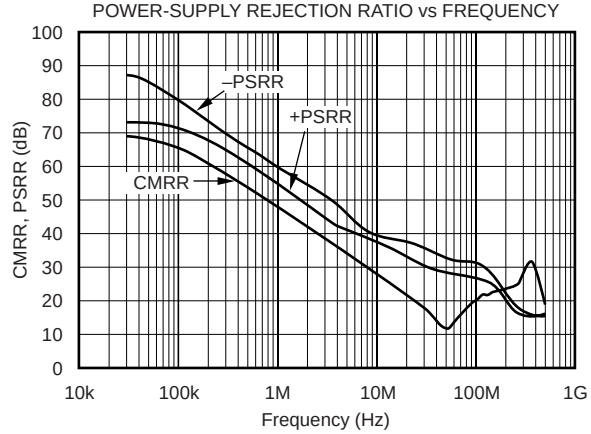
RECOMMENDED R_S vs CAPACITIVE LOAD



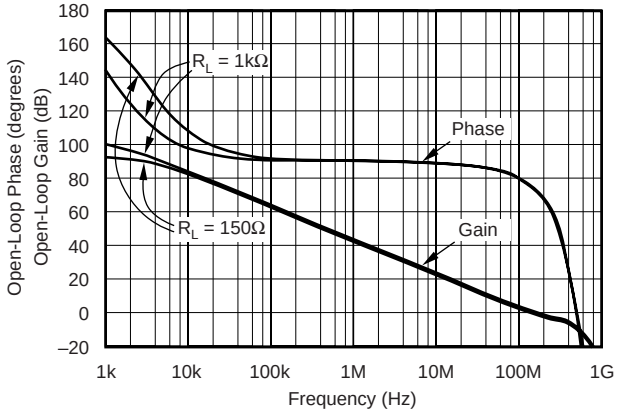
FREQUENCY RESPONSE vs CAPACITIVE LOAD



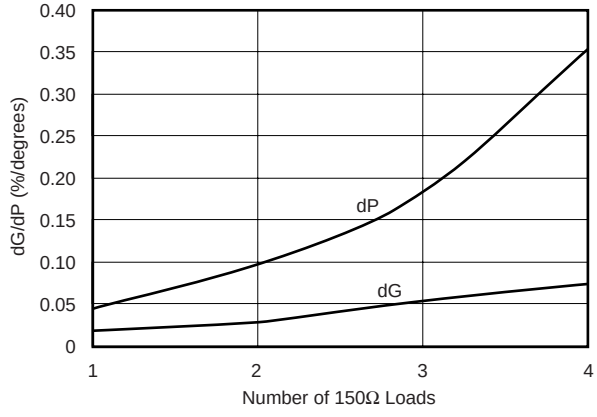
COMMON-MODE REJECTION RATIO AND POWER-SUPPLY REJECTION RATIO vs FREQUENCY



OPEN-LOOP GAIN AND PHASE



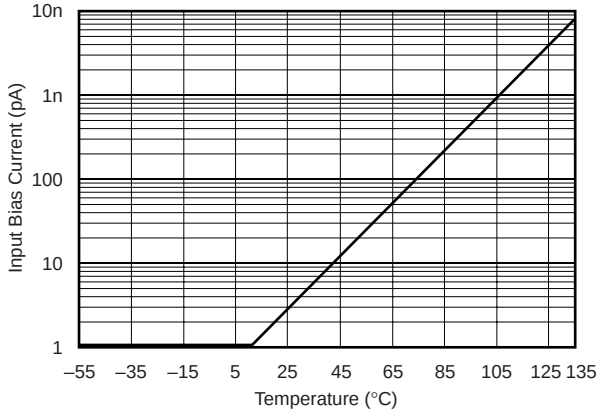
COMPOSITE VIDEO DIFFERENTIAL GAIN AND PHASE



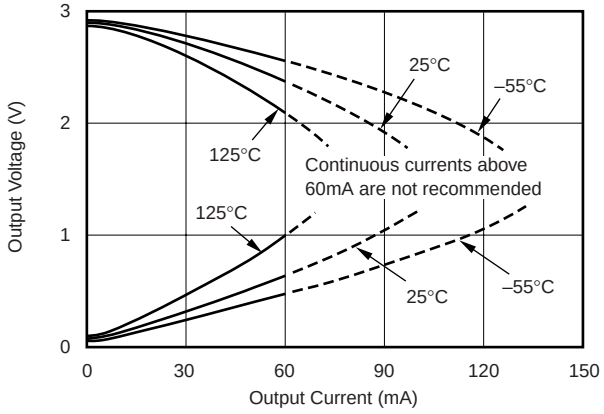
TYPICAL CHARACTERISTICS (Cont.)

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

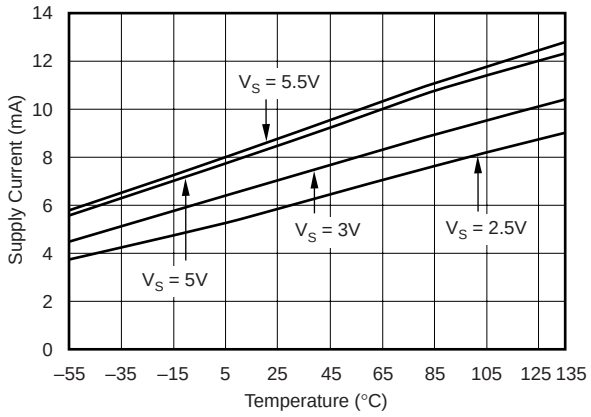
INPUT BIAS CURRENT vs TEMPERATURE



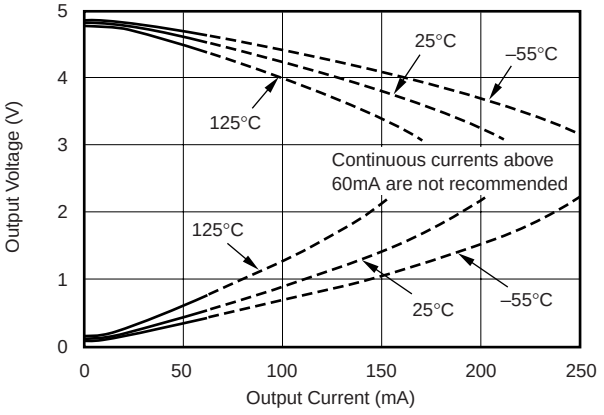
OUTPUT VOLTAGE SWING vs OUTPUT CURRENT FOR V_S = 3V



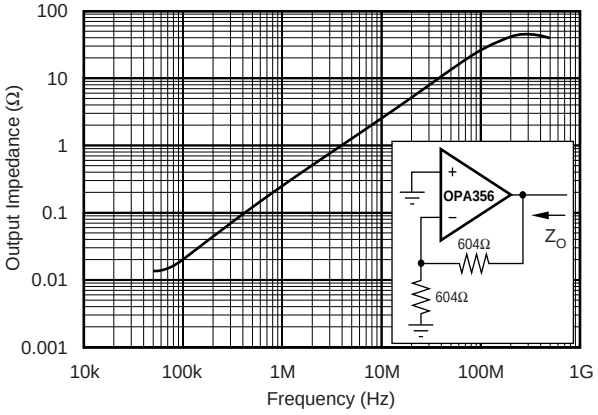
SUPPLY CURRENT vs TEMPERATURE



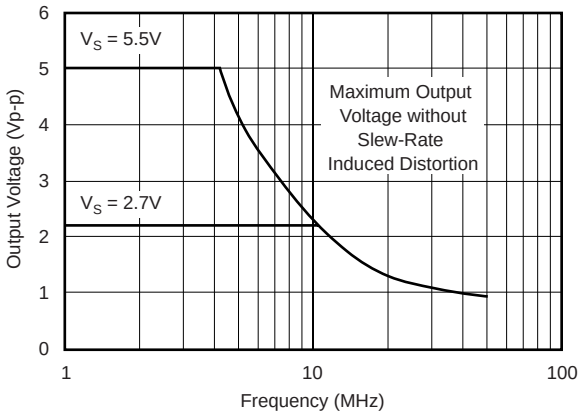
OUTPUT VOLTAGE SWING vs OUTPUT CURRENT FOR V_S = 5V



CLOSED-LOOP OUTPUT IMPEDANCE vs FREQUENCY



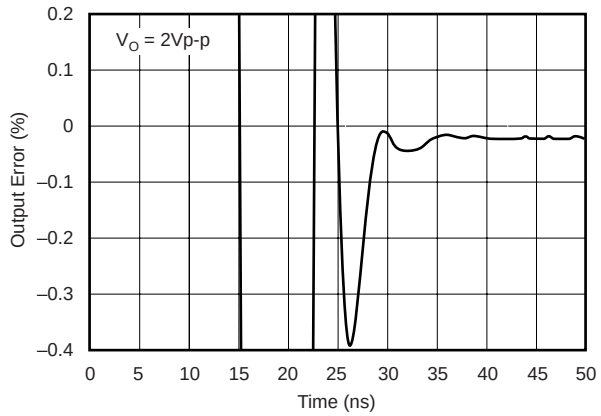
MAXIMUM OUTPUT VOLTAGE vs FREQUENCY



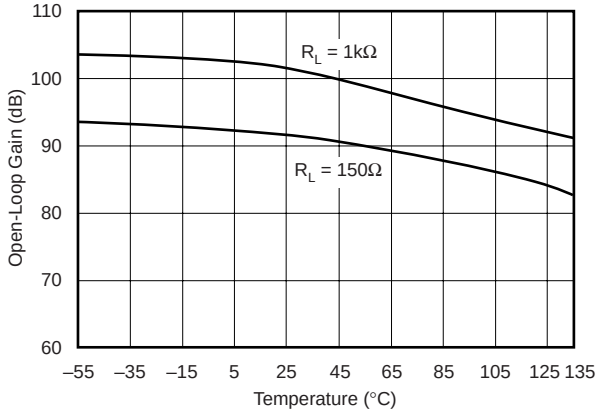
TYPICAL CHARACTERISTICS (Cont.)

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

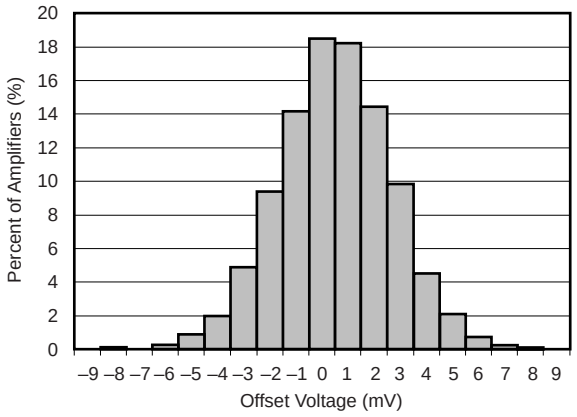
OUTPUT SETTLING TIME TO 0.1%



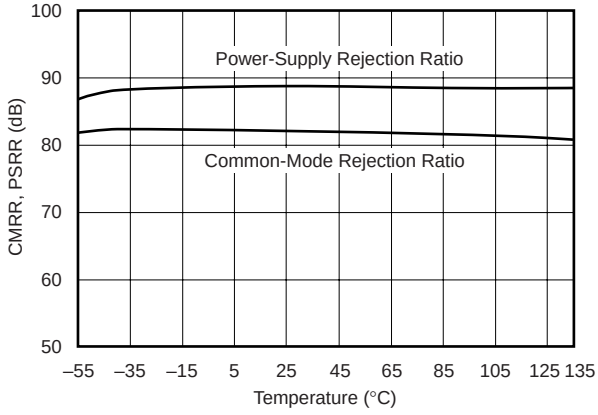
OPEN-LOOP GAIN vs TEMPERATURE



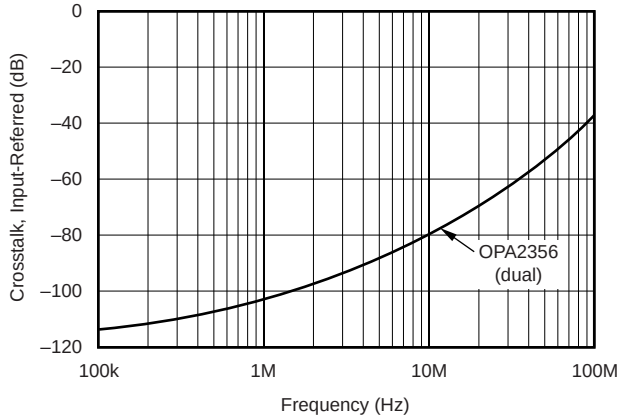
OFFSET VOLTAGE PRODUCTION DISTRIBUTION



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



CHANNEL-TO-CHANNEL CROSSTALK



APPLICATIONS INFORMATION

The OPAx356 series is a CMOS, high-speed, voltage feedback, operational amplifier designed for video and other general-purpose applications. It is available as a single or dual op amp.

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

Its input common-mode voltage range includes ground, allowing the OPAx356 to be used in virtually any single-supply application up to a supply voltage of +5.5V.

PCB LAYOUT

Good high-frequency PC board layout techniques should be employed for the OPAx356. Generous use of ground planes, short direct signal traces, and a suitable bypass capacitor located at the V+ pin will 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 10µF ceramic bypass capacitor is the minimum recommended value; adding a 1µF 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 OPAx356 is specified over a power-supply range of +2.7V to +5.5V (±1.35 to ±2.75V). However, the supply voltage may range from +2.5V to +5.5V (±1.25V to ±2.75V). Supply voltages higher than 7.5V (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 OPAx356 output stage is capable of driving a standard back-terminated 75Ω video cable. By back-terminating a transmission line, it does not exhibit a capacitive load to its driver. A properly back-terminated 75Ω cable does not appear as capacitance; it presents only a 150Ω resistive load to the OPAx356 output.

The output stage can supply high short-circuit current (typically over 200mA). Therefore, an on-chip thermal shutdown circuit is provided to protect the OPAx356 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 ±60mA. Refer to the graph of “Output Voltage Swing vs Output Current”, shown in the “Typical Characteristics” section of this data sheet.

INPUT AND ESD PROTECTION

All OPAx356 pins are static protected with internal ESD protection diodes tied to the supplies, as shown in Figure 1.

These diodes will provide overdrive protection if the current is externally limited to 10mA by the source or by a resistor.

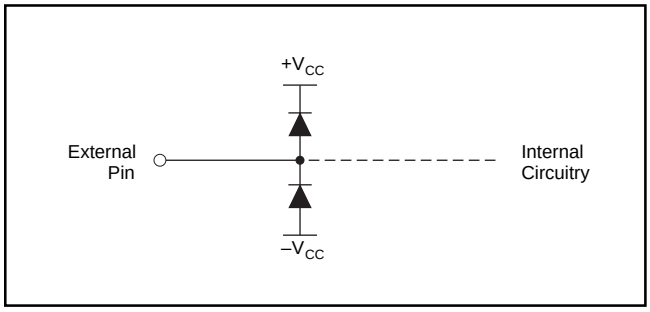
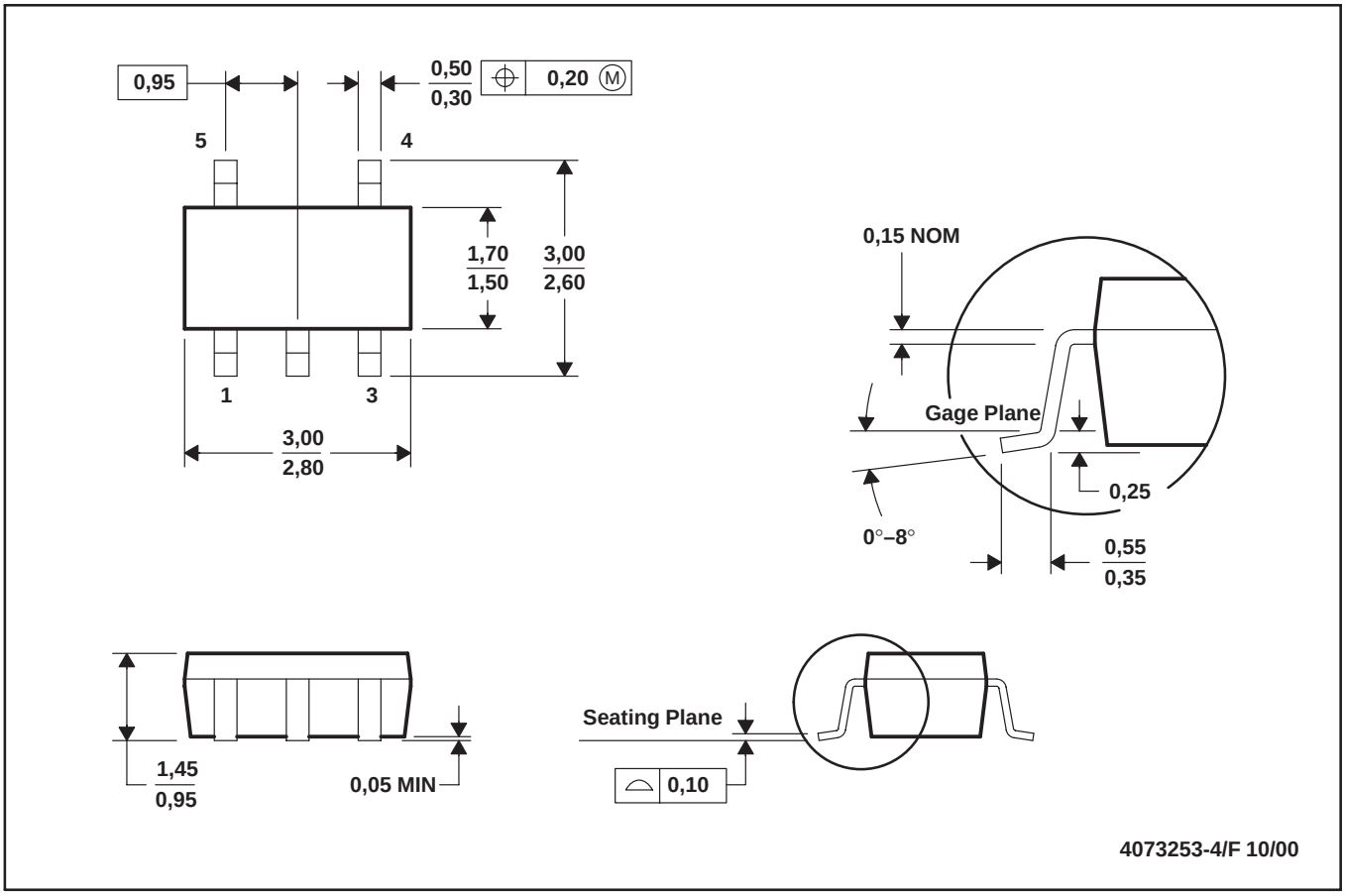


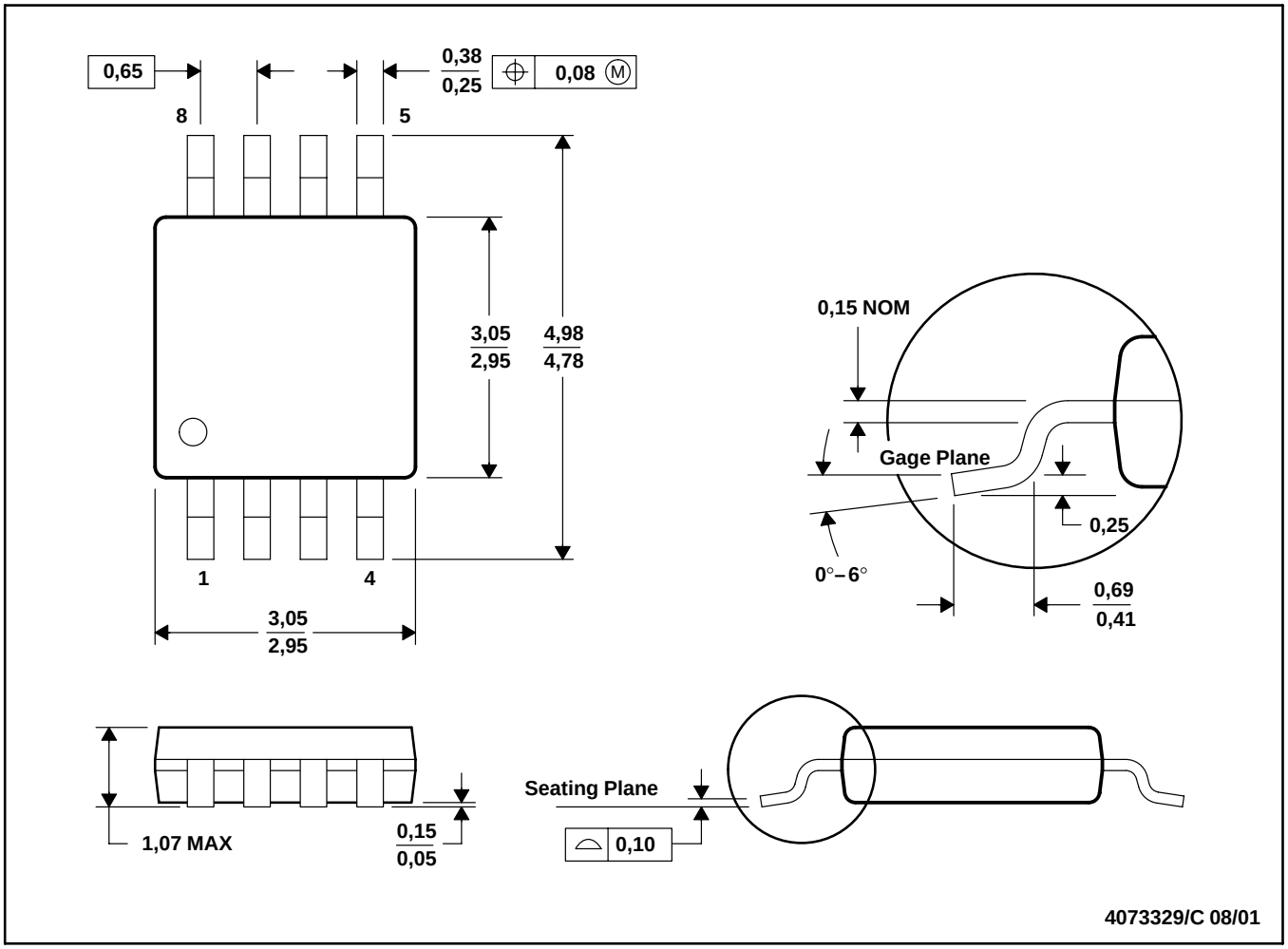
FIGURE 1. Internal ESD Protection.

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. Body dimensions do not include mold flash or protrusion.
D. Falls within JEDEC MO-178

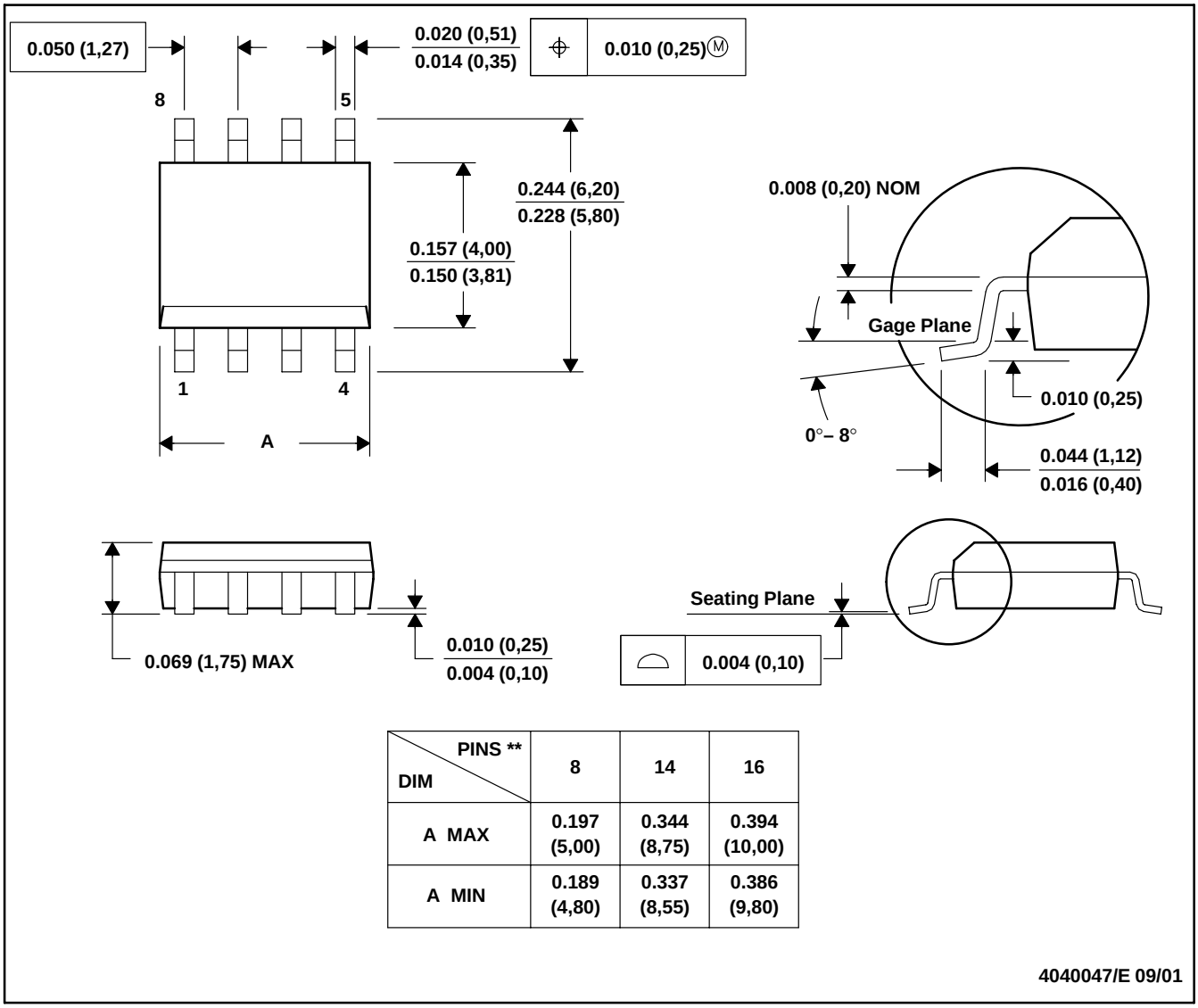
DGK (R-PDSO-G8) **PLASTIC SMALL-OUTLINE PACKAGE**



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.
D. Falls within JEDEC MO-187

D (R-PDSO-G)** **PLASTIC SMALL-OUTLINE PACKAGE**

8 PINS SHOWN



DIM \ PINS **	8	14	16
A MAX	0.197 (5,00)	0.344 (8,75)	0.394 (10,00)
A MIN	0.189 (4,80)	0.337 (8,55)	0.386 (9,80)

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NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion, not to exceed 0.006 (0,15).
D. Falls within JEDEC MS-012

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
OPA2356AID	Active	Production	SOIC (D) | 8	75 | TUBE	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 2356A
OPA2356AID.B	Active	Production	SOIC (D) | 8	75 | TUBE	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 2356A
OPA2356AIDG4	Active	Production	SOIC (D) | 8	75 | TUBE	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 2356A
OPA2356AIDGKR	Active	Production	VSSOP (DGK) | 8	2500 | LARGE T&R	Yes	Call TI | Nipdauag	Level-2-260C-1 YEAR	-40 to 125	AYI
OPA2356AIDGKR.B	Active	Production	VSSOP (DGK) | 8	2500 | LARGE T&R	Yes	Call TI	Level-2-260C-1 YEAR	-40 to 125	AYI
OPA2356AIDGKT	Active	Production	VSSOP (DGK) | 8	250 | SMALL T&R	Yes	Call TI | Nipdauag	Level-2-260C-1 YEAR	-40 to 125	AYI
OPA2356AIDGKT.B	Active	Production	VSSOP (DGK) | 8	250 | SMALL T&R	Yes	Call TI	Level-2-260C-1 YEAR	-40 to 125	AYI
OPA2356AIDGKTG4	Active	Production	VSSOP (DGK) | 8	250 | SMALL T&R	Yes	Call TI	Level-2-260C-1 YEAR	-40 to 125	AYI
OPA2356AIDR	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 2356A
OPA2356AIDR.B	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 2356A
OPA2356AIDRG4	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 2356A
OPA2356AIDRG4.B	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 2356A
OPA356AID	Active	Production	SOIC (D) | 8	75 | TUBE	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 356A
OPA356AID.B	Active	Production	SOIC (D) | 8	75 | TUBE	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 356A
OPA356AIDBVR	Active	Production	SOT-23 (DBV) | 5	3000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OAAI
OPA356AIDBVR.B	Active	Production	SOT-23 (DBV) | 5	3000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OAAI
OPA356AIDBVRG4	Active	Production	SOT-23 (DBV) | 5	3000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OAAI
OPA356AIDBVRG4.B	Active	Production	SOT-23 (DBV) | 5	3000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OAAI
OPA356AIDBVT	Active	Production	SOT-23 (DBV) | 5	250 | SMALL T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OAAI
OPA356AIDBVT.B	Active	Production	SOT-23 (DBV) | 5	250 | SMALL T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OAAI
OPA356AIDBVTG4	Active	Production	SOT-23 (DBV) | 5	250 | SMALL T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OAAI
OPA356AIDG4	Active	Production	SOIC (D) | 8	75 | TUBE	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 356A

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
OPA356AIDR	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 356A
OPA356AIDR.B	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 356A
OPA356AIDRG4	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 356A
OPA356AIDRG4.B	Active	Production	SOIC (D) | 8	2500 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	OPA 356A

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts 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.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

OTHER QUALIFIED VERSIONS OF OPA2356, OPA356 :

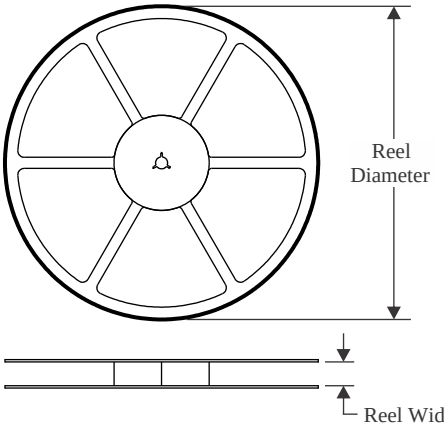
- Automotive : OPA356-Q1
- Enhanced Product : OPA2356-EP

NOTE: Qualified Version Definitions:

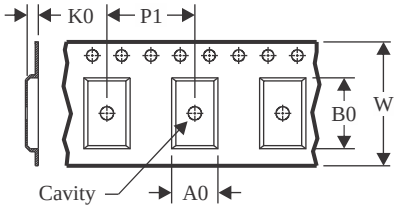
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects
- Enhanced Product - Supports Defense, Aerospace and Medical Applications

TAPE AND REEL INFORMATION

REEL DIMENSIONS

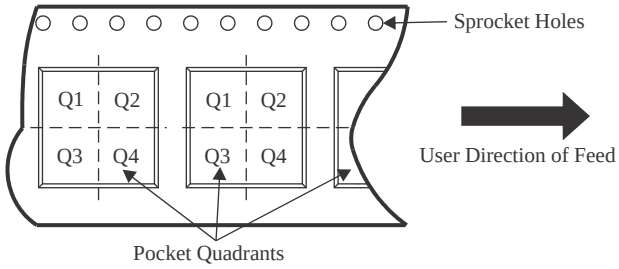


TAPE DIMENSIONS



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

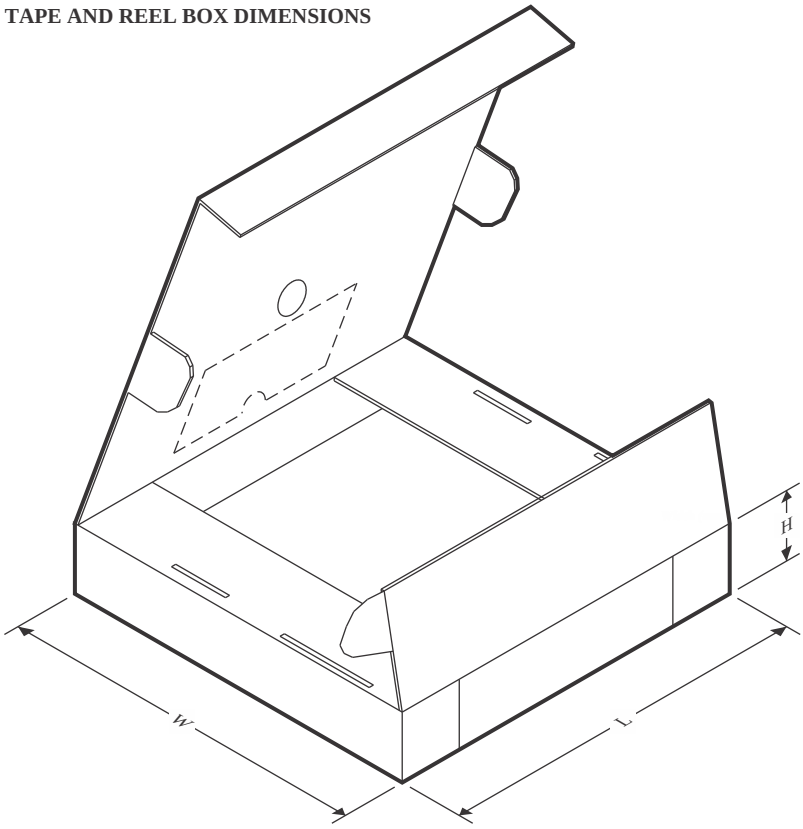
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
OPA2356AIDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
OPA2356AIDRG4	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
OPA356AIDBVR	SOT-23	DBV	5	3000	178.0	8.4	3.3	3.2	1.4	4.0	8.0	Q3
OPA356AIDBVRG4	SOT-23	DBV	5	3000	178.0	8.4	3.3	3.2	1.4	4.0	8.0	Q3
OPA356AIDBVT	SOT-23	DBV	5	250	178.0	8.4	3.3	3.2	1.4	4.0	8.0	Q3
OPA356AIDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
OPA356AIDRG4	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1

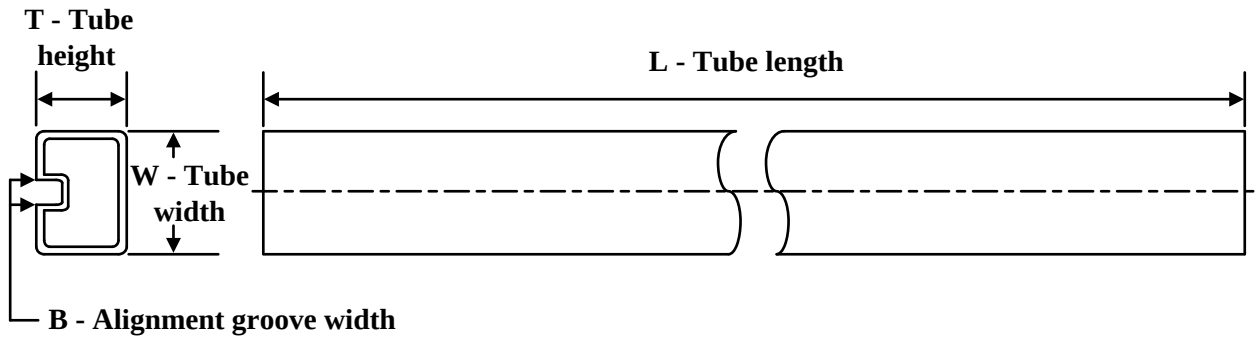
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
OPA2356AIDR	SOIC	D	8	2500	356.0	356.0	35.0
OPA2356AIDRG4	SOIC	D	8	2500	356.0	356.0	35.0
OPA356AIDBVR	SOT-23	DBV	5	3000	445.0	220.0	345.0
OPA356AIDBVRG4	SOT-23	DBV	5	3000	445.0	220.0	345.0
OPA356AIDBVT	SOT-23	DBV	5	250	445.0	220.0	345.0
OPA356AIDR	SOIC	D	8	2500	356.0	356.0	35.0
OPA356AIDRG4	SOIC	D	8	2500	356.0	356.0	35.0

TUBE



*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
OPA2356AID	D	SOIC	8	75	506.6	8	3940	4.32
OPA2356AID.B	D	SOIC	8	75	506.6	8	3940	4.32
OPA2356AIDG4	D	SOIC	8	75	506.6	8	3940	4.32
OPA356AID	D	SOIC	8	75	506.6	8	3940	4.32
OPA356AID.B	D	SOIC	8	75	506.6	8	3940	4.32
OPA356AIDG4	D	SOIC	8	75	506.6	8	3940	4.32

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