

200MHz, CMOS OPERATIONAL AMPLIFIER WITH SHUTDOWN

FEATURES

- **UNITY-GAIN BANDWIDTH: 450MHz**
- **WIDE BANDWIDTH: 200MHz GBW**
- **HIGH SLEW RATE: 360V/ μ s**
- **LOW NOISE: 5.8nV/ $\sqrt{\text{Hz}}$**
- **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**
- **LOW SHUTDOWN CURRENT: 3.4 μ A**
- **ENABLE/DISABLE TIME: 100ns/30ns**
- **THERMAL SHUTDOWN**
- **SINGLE-SUPPLY OPERATING RANGE: 2.5V to 5.5V**
- **MicroSIZE 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

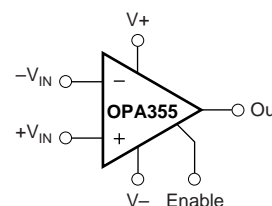
The OPA355 series high-speed, voltage-feedback CMOS operational amplifiers are designed for video and other applications requiring wide bandwidth. The OPA355 is unity-gain stable and can drive large output currents. In addition, the OPA355 has a digital shutdown (Enable) function. This feature provides power savings during idle periods and places the output in a high-impedance state to support output multiplexing. Differential gain is 0.02% and differential phase is 0.05°. Quiescent current is only 8.3mA per channel.

The OPA355 is optimized for operation on single or dual supplies as low as 2.5V ($\pm 1.25\text{V}$) and up to 5.5V ($\pm 2.75\text{V}$). Common-mode input range for the OPA355 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 OPA355 series is available in single (SOT23-6 and SO-8), dual (MSOP-10), and triple (TSSOP-14 and SO-14) versions. Multichannel versions feature completely independent circuitry for lowest crosstalk and freedom from interaction. All are specified over the extended -40°C to $+125^{\circ}\text{C}$ range.

OPA355 RELATED PRODUCTS

FEATURES	PRODUCT
200MHz, Rail-to-Rail Output, CMOS, No Shutdown	OPA356
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



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

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
Enable Input	(V-) - 0.5V to (V+) + 0.5V
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

NOTES: (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.

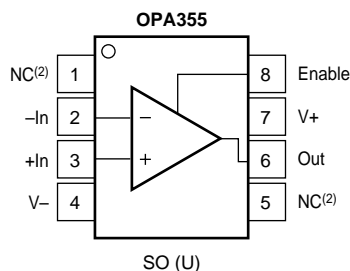
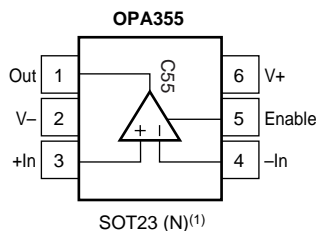
PACKAGE/ORDERING INFORMATION

PRODUCT	PACKAGE-LEAD	PACKAGE DESIGNATOR ⁽¹⁾	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER	TRANSPORT MEDIA, QUANTITY
OPA355	SOT23-6	DBV	-40°C to +125°C	C55	OPA355NA/250 OPA355NA/3K	Tape and Reel, 250 Tape and Reel, 3000
OPA355	SO-8	D	-40°C to +125°C	OPA355UA	OPA355UA OPA355UA/2K5	Rails, 100 Tape and Reel, 2500
OPA2355	MSOP-10	DGS	-40°C to +125°C	D55	OPA2355DGSA/250 OPA2355DGSA/2K5	Tape and Reel, 250 Tape and Reel, 2500
OPA3355	TSSOP-14	PW	-40°C to +125°C	OPA3355EA	OPA3355EA/250 OPA3355EA/2K5	Tape and Reel, 250 Tape and Reel, 2500
OPA3355	SO-14	D	-40°C to +125°C	OPA3355UA	OPA3355UA OPA3355UA/2K5	Rails, 58 Tape and Reel, 2500

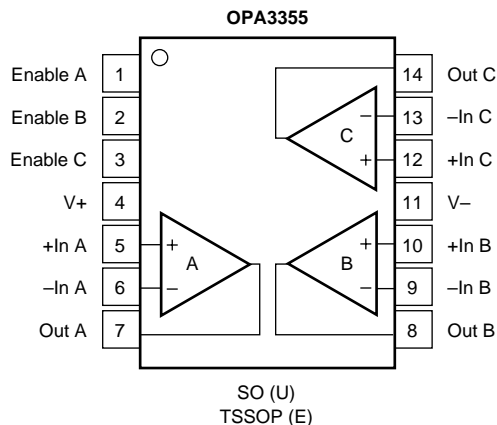
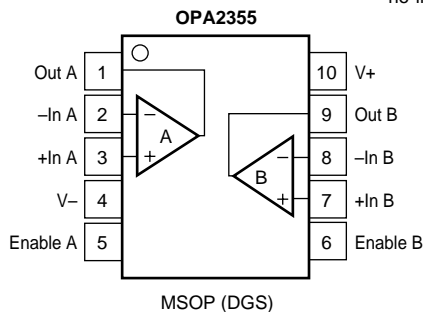
NOTE: (1) For the most current specifications and package information, refer to our web site at www.ti.com.

PIN CONFIGURATIONS

Top View



NOTES: (1) Pin 1 of the SOT23-6 is determined by orienting the package marking as indicated in the diagram. (2) NC indicates no internal connection.



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

Boldface limits apply over the specified temperature range, $T_A = -40^{\circ}C$ to $+125^{\circ}C$.

At $T_A = +25^{\circ}C$, $R_F = 604\Omega$, $R_L = 150\Omega$, and connected to $V_S/2$, unless otherwise noted.

PARAMETER	CONDITION	OPA355NA, UA, OPA2355DGSA OPA3355EA, UA			UNITS
		MIN	TYP	MAX	
OFFSET VOLTAGE					
Input Offset Voltage V_{OS}	$V_S = +5V$		± 2	± 9	mV
vs Temperature dV_{OS}/dT	Specified Temperature Range		± 7	± 15	mV/ $^{\circ}C$
vs Power Supply PSRR	$V_S = +2.7V$ to $+5.5V$, $V_{CM} = V_S/2 - 0.15V$		± 80	± 350	$\mu V/V$
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}	$V_S = +5.5V$, $-0.1V < V_{CM} < +4.0V$	$(V-) - 0.1$		$(V+) - 1.5$	V
Common-Mode Rejection Ratio CMRR	Specified Temperature Range	66	80		dB
		66			dB
INPUT IMPEDANCE					
Differential			$10^{13} \parallel 1.5$		$\Omega \parallel pF$
Common-Mode			$10^{13} \parallel 1.5$		$\Omega \parallel pF$
OPEN-LOOP GAIN					
	$V_S = +5V$, $0.3V < V_O < 4.7V$	84	92		dB
OPA355	$V_S = +5V$, $0.3V < V_O < 4.7V$	80			dB
OPA2355, OPA3355	$V_S = +5V$, $0.4V < V_O < 4.6V$	80			dB
FREQUENCY RESPONSE					
Small-Signal Bandwidth f_{-3dB}	$G = +1$, $V_O = 100mVp-p$, $R_F = 0\Omega$		450		MHz
f_{-3dB}	$G = +2$, $V_O = 100mVp-p$, $R_L = 50\Omega$		100		MHz
f_{-3dB}	$G = +2$, $V_O = 100mVp-p$, $R_L = 150\Omega$		170		MHz
f_{-3dB}	$G = +2$, $V_O = 100mVp-p$, $R_L = 1k\Omega$		200		MHz
Gain-Bandwidth Product GBW	$G = +10$, $R_L = 1k\Omega$		200		MHz
Bandwidth for 0.1dB Gain Flatness $f_{0.1dB}$	$G = +2$, $V_O = 100mVp-p$, $R_F = 560\Omega$		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	$V_{IN} \bullet \text{Gain} = V_S$		8		ns
Harmonic Distortion					
2nd-Harmonic	$G = +2$, $f = 1MHz$, $V_O = 2Vp-p$, $R_L = 200\Omega$		–81		dBc
3rd-Harmonic	$G = +2$, $f = 1MHz$, $V_O = 2Vp-p$, $R_L = 200\Omega$		–93		dBc
Differential Gain Error	NTSC, $R_L = 150\Omega$		0.02		%
Differential Phase Error	NTSC, $R_L = 150\Omega$		0.05		degrees
Channel-to-Channel Crosstalk OPA2355	$f = 5MHz$		–90		dB
OPA3355	$f = 5MHz$		–70		dB
OUTPUT					
Voltage Output Swing from Rail	$V_S = +5V$, $R_L = 150\Omega$, $A_{OL} > 84dB$		0.2	0.3	V
Voltage Output Swing from Rail	$V_S = +5V$, $R_L = 1k\Omega$		0.1		V
Output Current, Continuous ⁽¹⁾ I_O			± 60		mA
Output Current, Peak ⁽¹⁾ I_O	$V_S = +5V$		± 100		mA
Output Current, Peak ⁽¹⁾ I_O	$V_S = +3V$		± 80		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	$V_S = +5V$, Enabled, $I_O = 0$		8.3	11	mA
	Specified Temperature Range			14	mA

NOTES: (1) See typical performance characteristic "Output Voltage Swing vs Output Current." (2) Logic LOW and HIGH levels are CMOS logic compatible.

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

Boldface limits apply over the specified temperature range, $T_A = -40^{\circ}C$ to $+125^{\circ}C$.

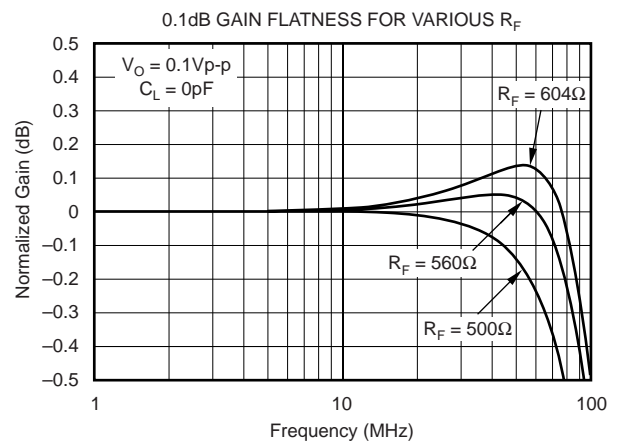
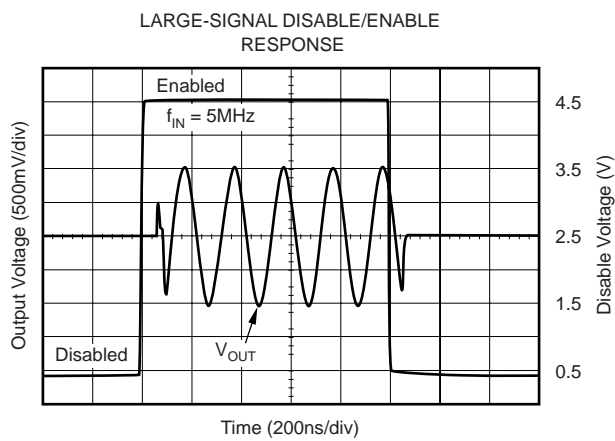
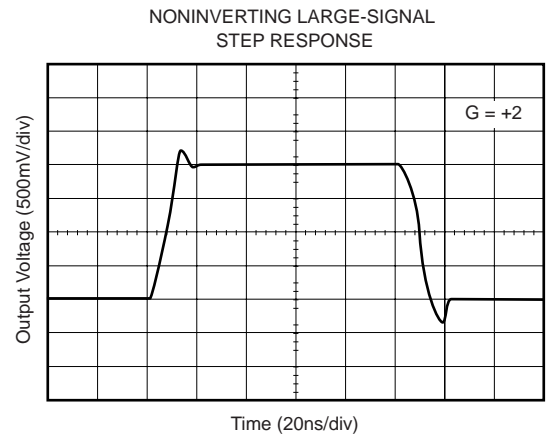
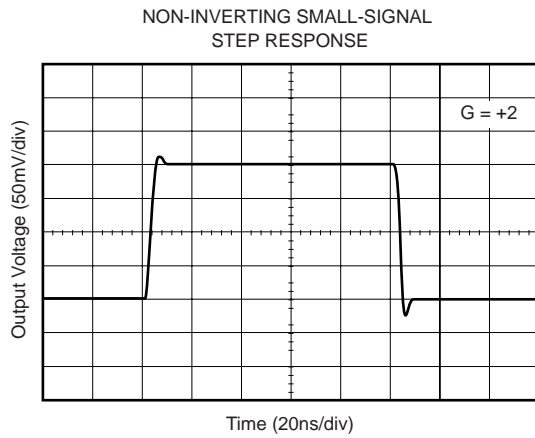
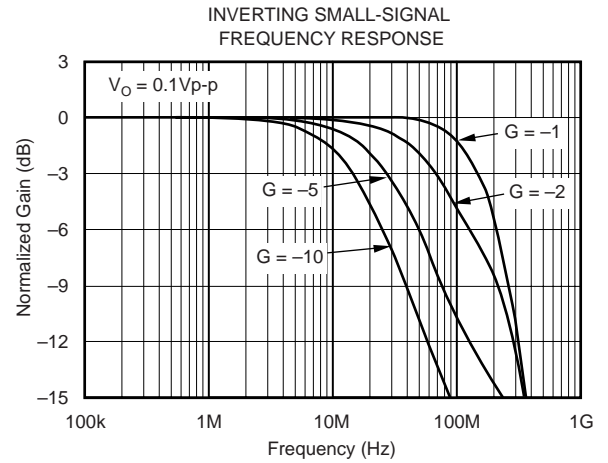
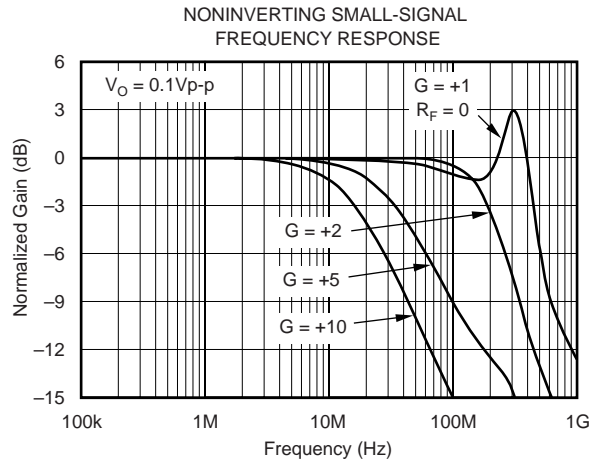
At $T_A = +25^{\circ}C$, $R_F = 604\Omega$, $R_L = 150\Omega$, and connected to $V_S/2$, unless otherwise noted.

PARAMETER	CONDITION	OPA355NA, UA, OPA2355DGSA OPA3355EA, UA			UNITS
		MIN	TYP	MAX	
SHUTDOWN					
Disabled (Logic-LOW Threshold) ⁽²⁾				0.8	V
Enabled (Logic-HIGH Threshold) ⁽²⁾		2			V
Enable Time			100		ns
Disable Time			30		ns
Shutdown Current (per amplifier)	$V_S = +5V$, Disabled		3.4	6	μA
THERMAL SHUTDOWN					
Junction Temperature					
Shutdown			160		$^{\circ}C$
Reset from Shutdown			140		$^{\circ}C$
TEMPERATURE RANGE					
Specified Range		-40		125	$^{\circ}C$
Operating Range		-55		150	$^{\circ}C$
Storage Range		-65		150	$^{\circ}C$
Thermal Resistance	θ_{JA}				$^{\circ}C/W$
SOT-23-6, MSOP-10			150		$^{\circ}C/W$
SO-8			125		$^{\circ}C/W$
SO-14, TSSOP-14			100		$^{\circ}C/W$

NOTES: (1) See typical performance characteristic "Output Voltage Swing vs Output Current." (2) Logic LOW and HIGH levels are CMOS logic compatible.

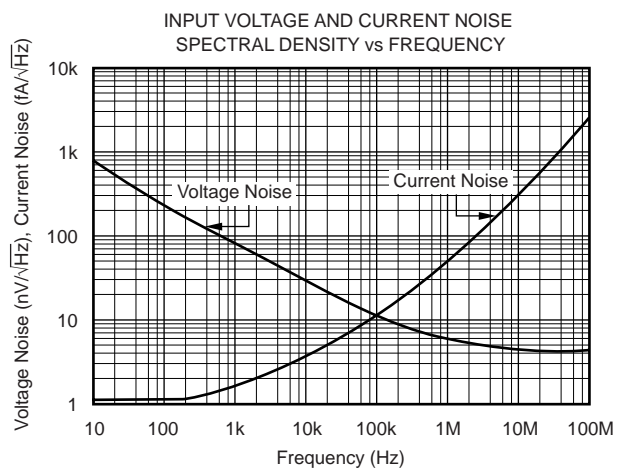
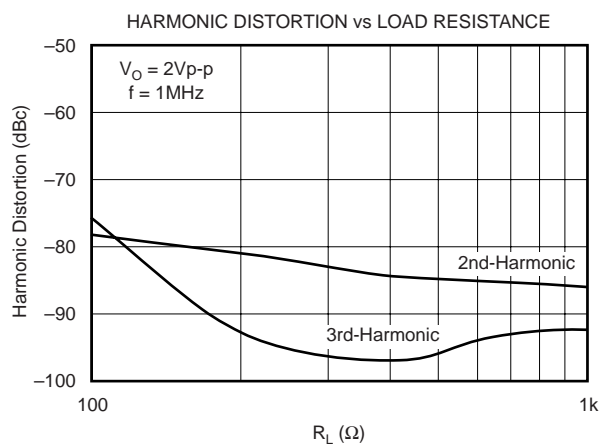
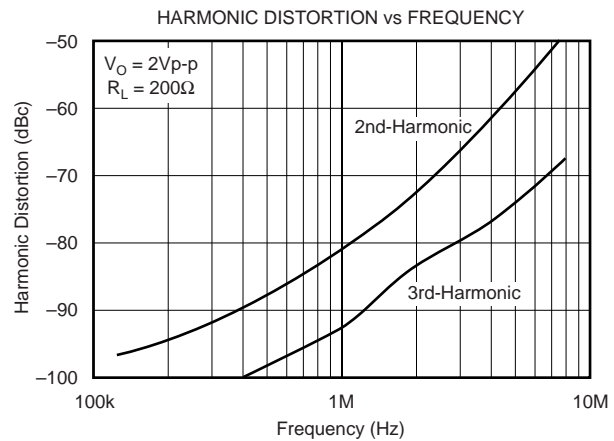
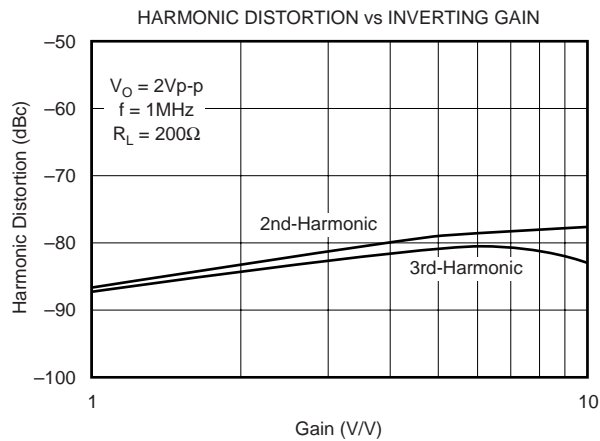
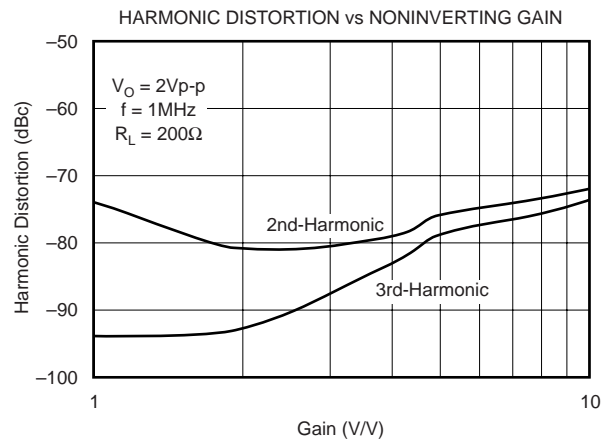
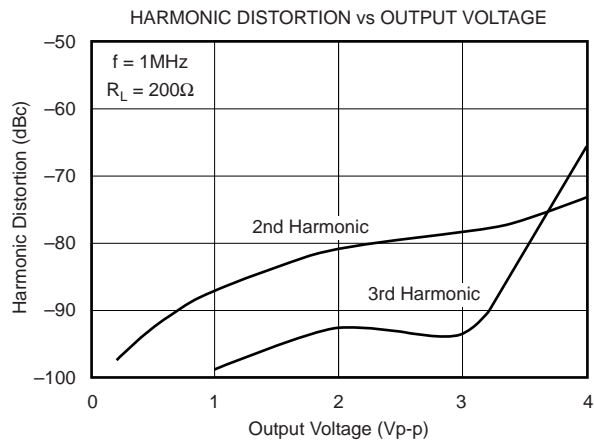
TYPICAL CHARACTERISTICS

At $T_A = +25^\circ\text{C}$, $V_S = 5\text{V}$, $G = +2$, $R_F = 604\Omega$, and $R_L = 150\Omega$ connected to $V_S/2$, unless otherwise noted.



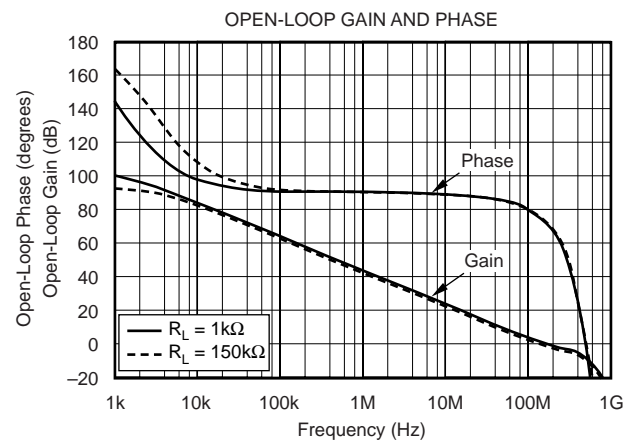
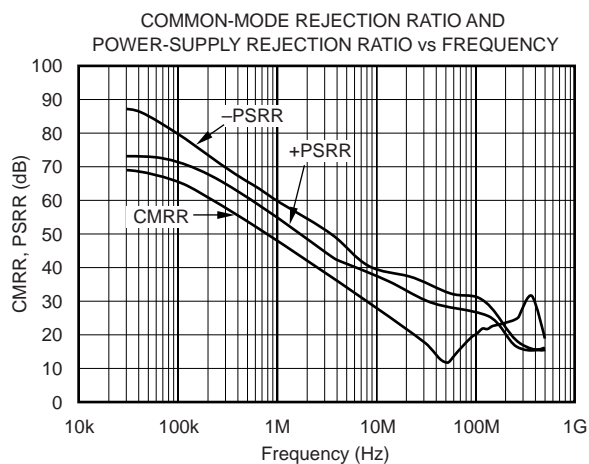
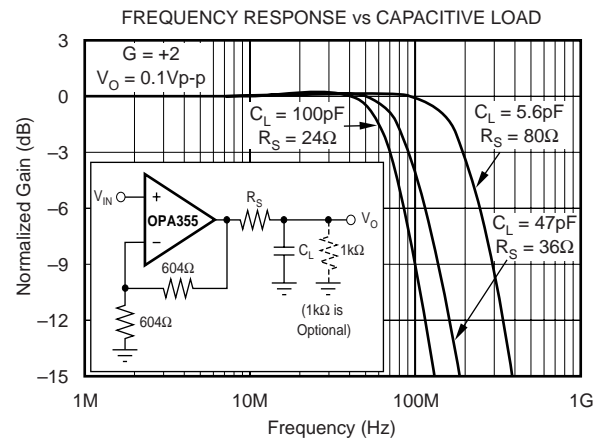
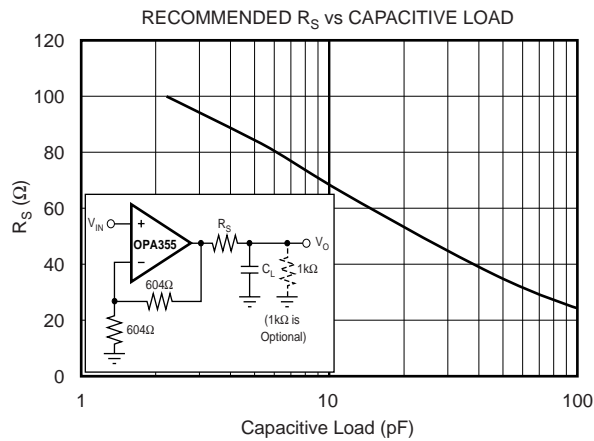
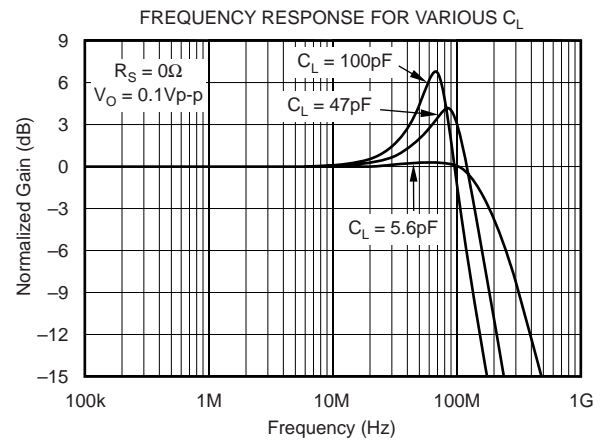
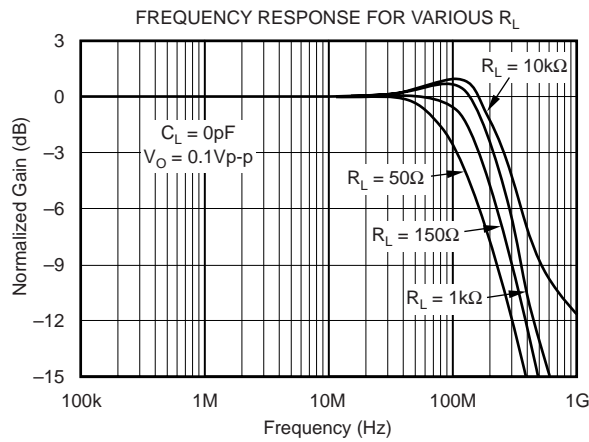
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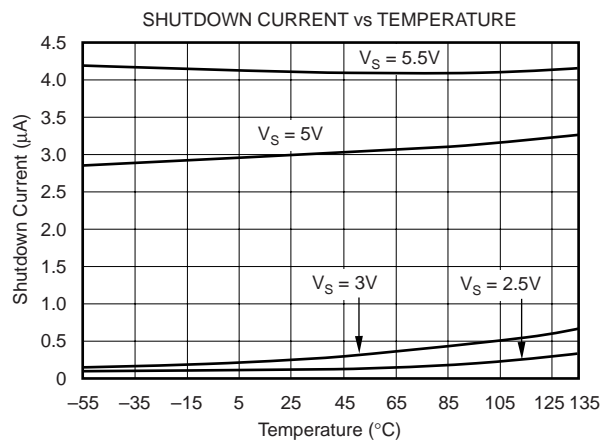
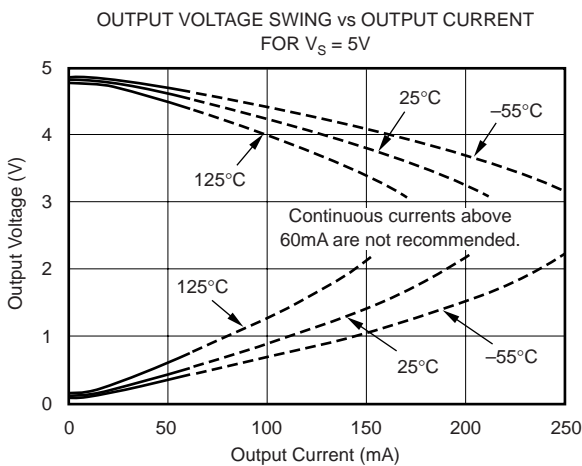
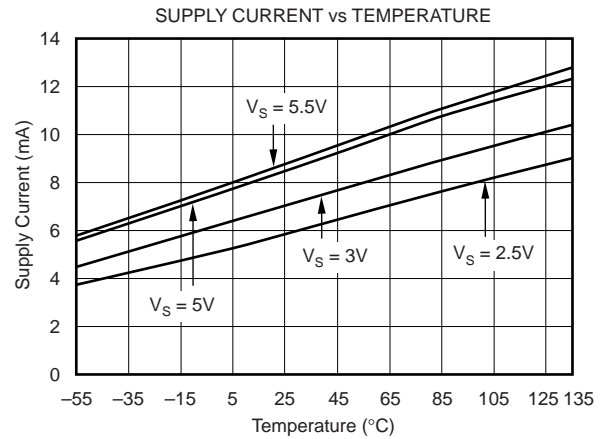
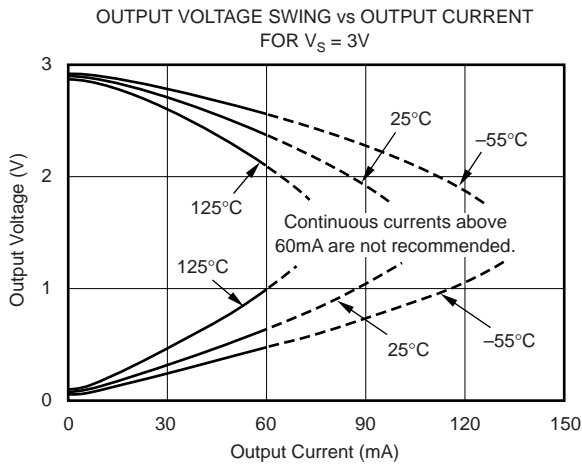
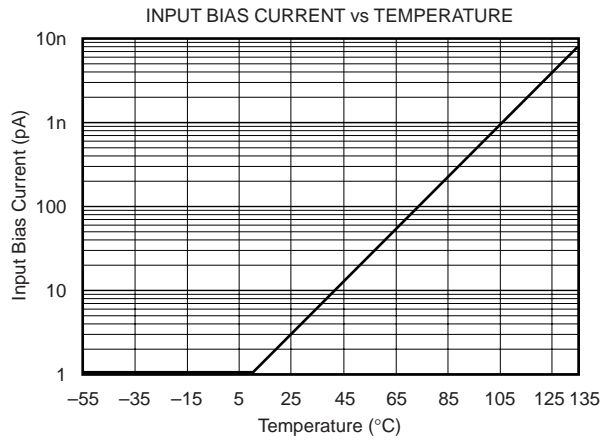
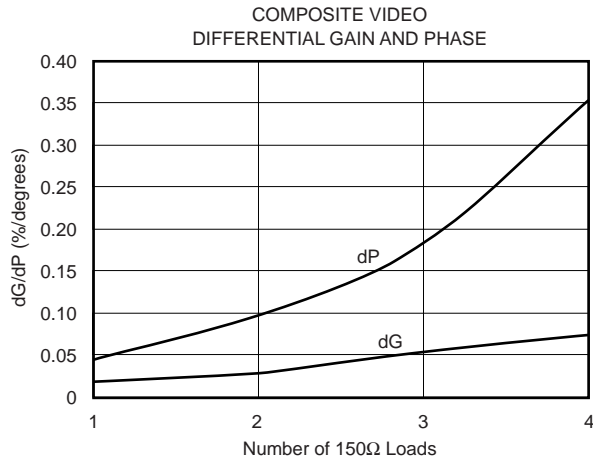
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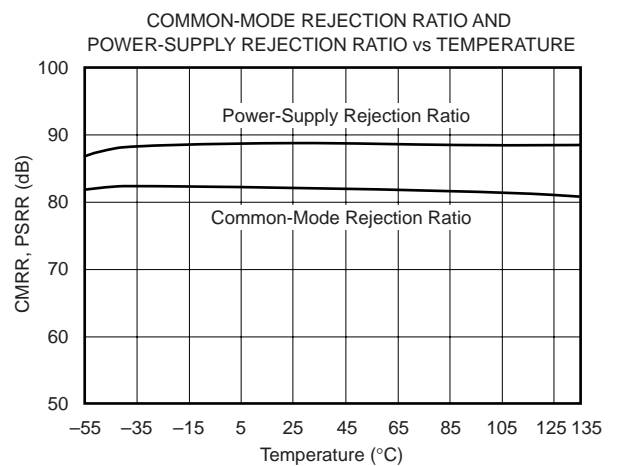
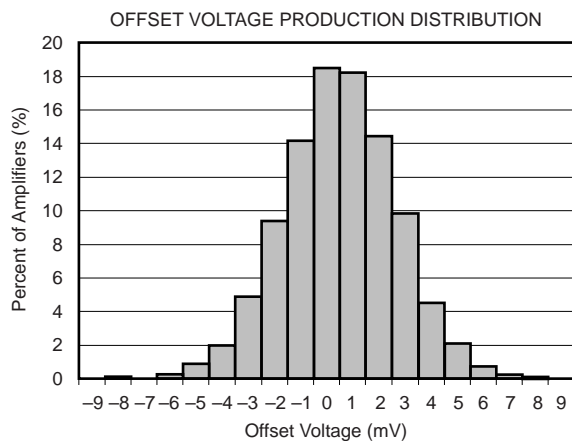
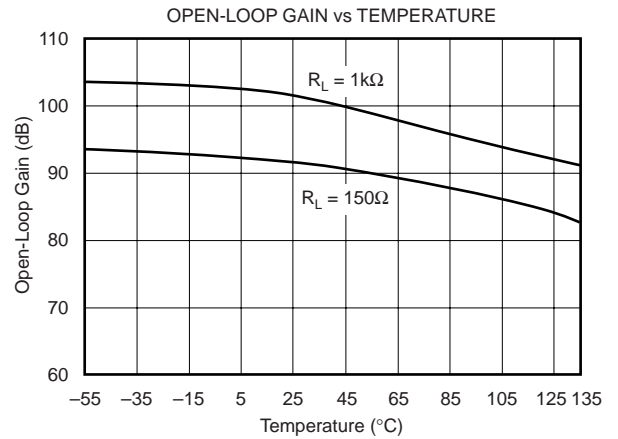
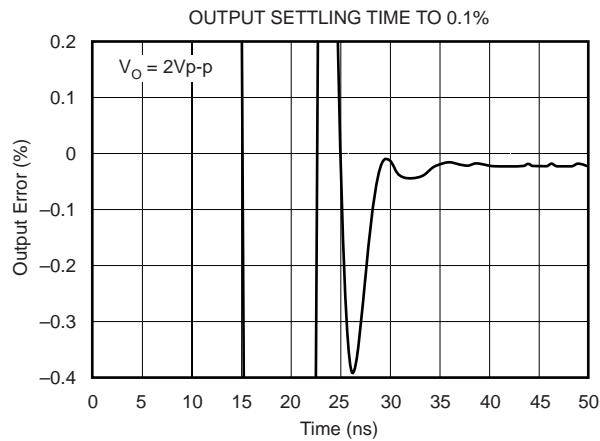
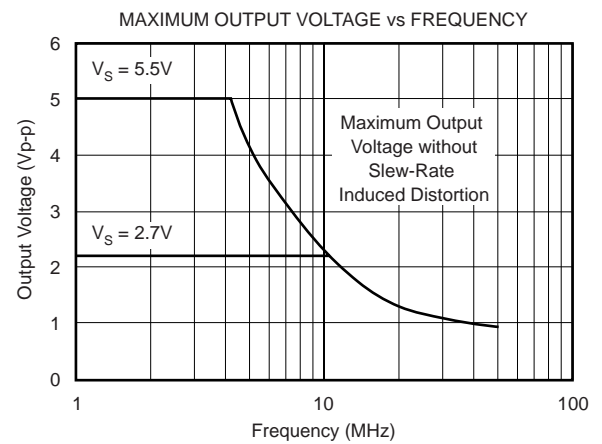
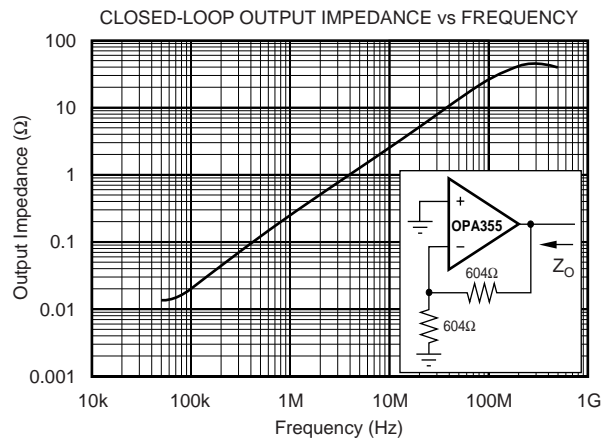
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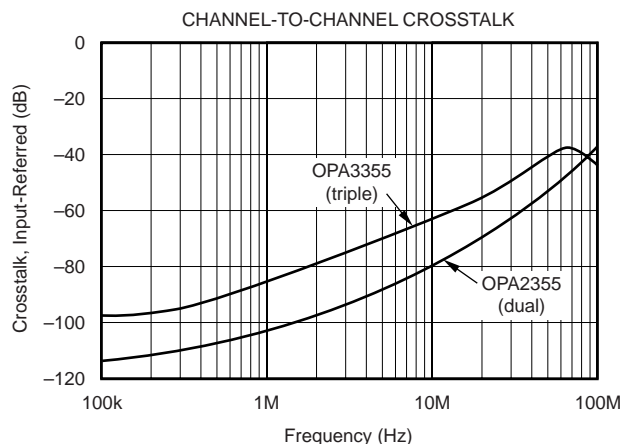
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TYPICAL CHARACTERISTICS (Cont.)

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APPLICATIONS INFORMATION

The OPA355 series is a CMOS, high-speed, voltage-feed-back, operational amplifier designed for video and other general-purpose applications. It is available as a single, dual, or triple 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 OPA355 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 OPA355. 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 10nF 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 OPA355 is specified over a power-supply range of +2.7V to +5.5V ($\pm 1.35\text{V}$ to $\pm 2.75\text{V}$). However, the supply voltage may range from +2.5V to +5.5V ($\pm 1.25\text{V}$ to $\pm 2.75\text{V}$). 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.

ENABLE FUNCTION

The OPA355 can be enabled by applying a TTL HIGH voltage level to the Enable pin. Conversely, a TTL LOW voltage level will disable the amplifier, reducing its supply current from 8.3mA to only 3.4 μA per amplifier. Independent Enable pins are available for each channel, providing maximum design flexibility. For portable battery-operated applications, this feature can be used to greatly reduce the average current and thereby extend battery life.

The Enable input can be modeled as a CMOS input gate with a 100k Ω pull-up resistor to V+. Left open, the Enable pin will assume a logic HIGH, and the amplifier will be on.

The Enable time is 100ns and the disable time is only 30ns. This allows the OPA355 to be operated as a “gated” amplifier, or to have its output multiplexed onto a common output bus. When disabled, the output assumes a high-impedance state.

OUTPUT DRIVE

The output stage can supply high short-circuit current (typically over 200mA). Therefore, an on-chip thermal shutdown circuit is provided to protect the OPA355 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 $\pm 60\text{mA}$. Refer to the Typical Characteristics “Output Voltage Swing vs Output Current.”

VIDEO

The OPA355 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 OPA355 output.

The OPA355's rail-to-rail input and output capabilities make possible its use as an amplifier for RGB graphic signals, which have a voltage of zero at the video black level, as shown in Figure 1.

WIDEBAND VIDEO MULTIPLEXING

One common application for video speed amplifiers which include an enable pin is to wire multiple amplifier outputs together, then select which one of several possible video inputs to source onto a single line. This simple “Wired-OR Video Multiplexer” can be easily implemented using the OPA357, see Figure 2.

INPUT AND ESD PROTECTION

All OPA355 pins are static protected with internal ESD protection diodes tied to the supplies, see Figure 3.

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

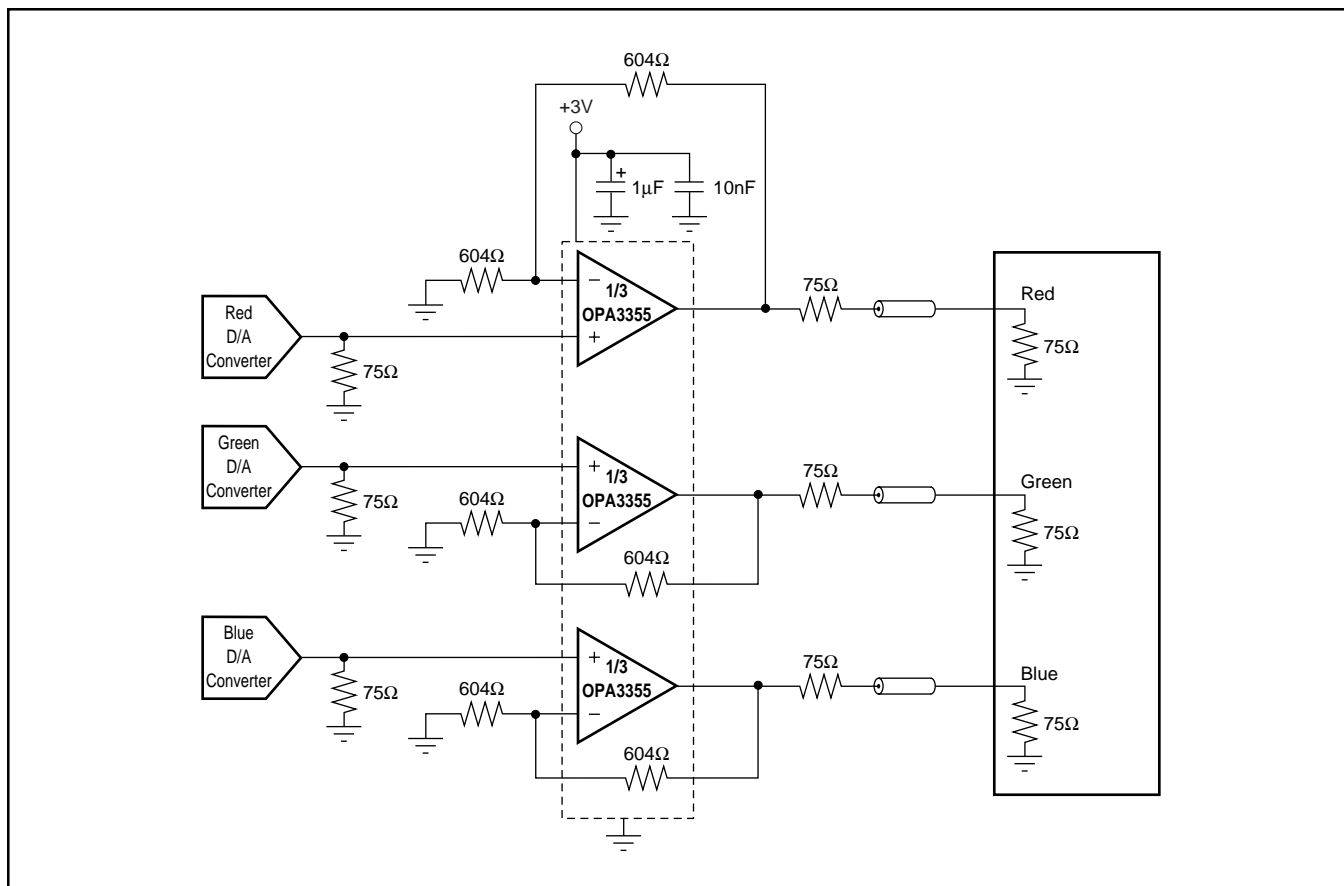


FIGURE 1. RGB Cable Driver.

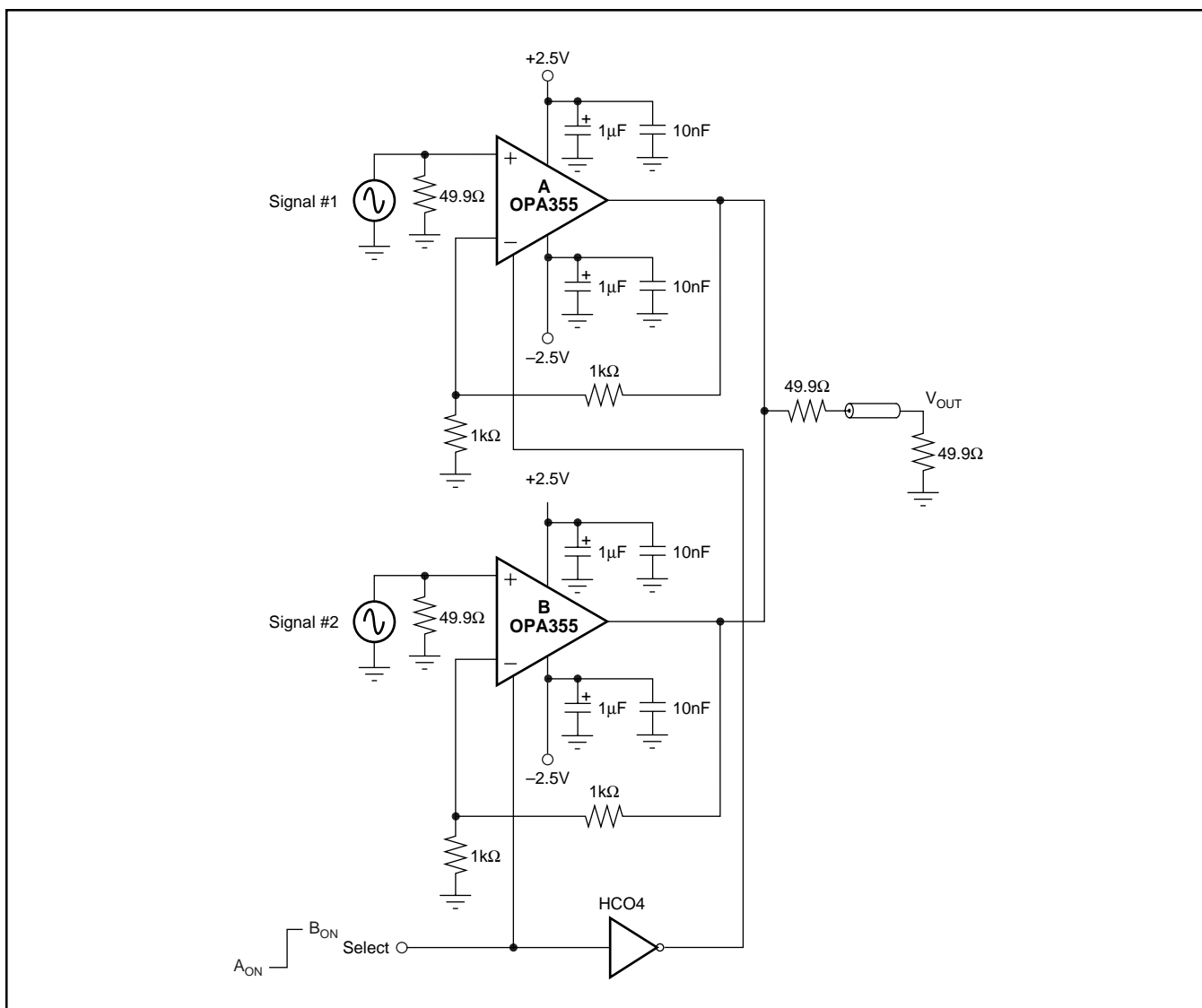


FIGURE 2. Multiplexed Output.

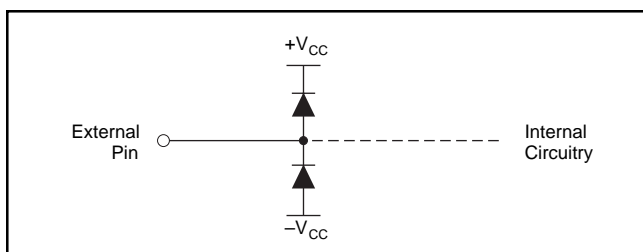
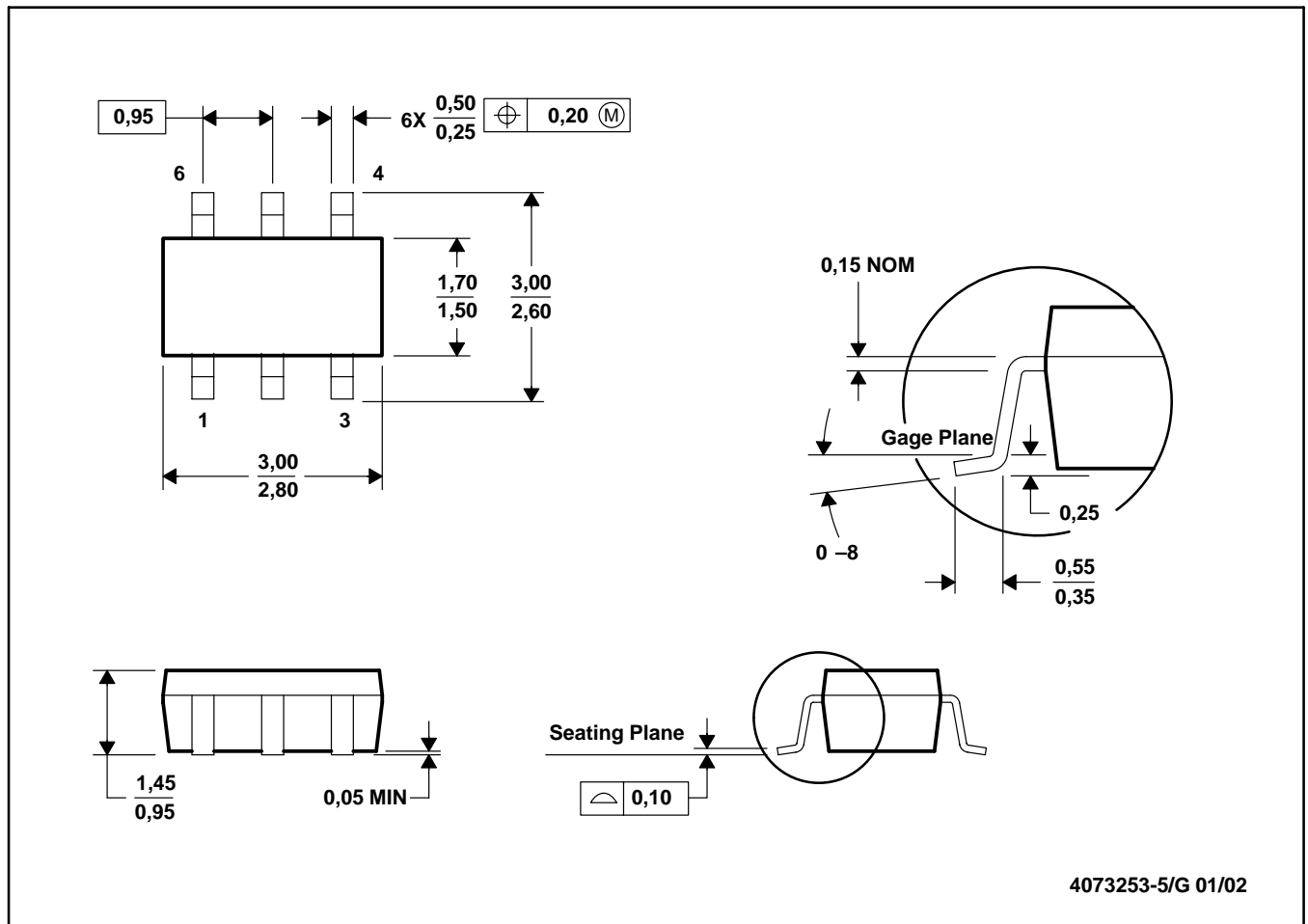


FIGURE 3. Internal ESD Protection.

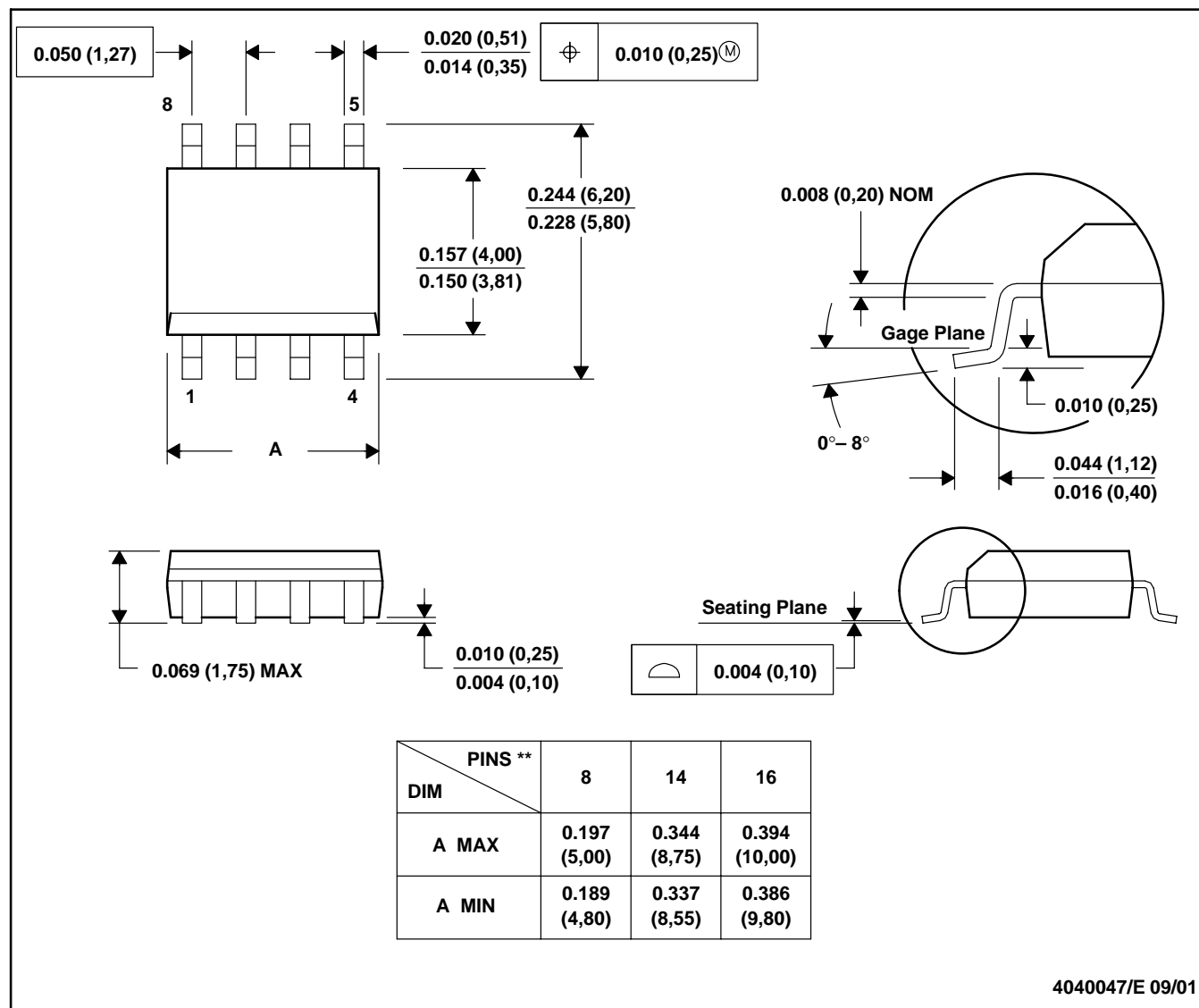


- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Body dimensions do not include mold flash or protrusion.
 - D. Leads 1, 2, 3 may be wider than leads 4, 5, 6 for package orientation.

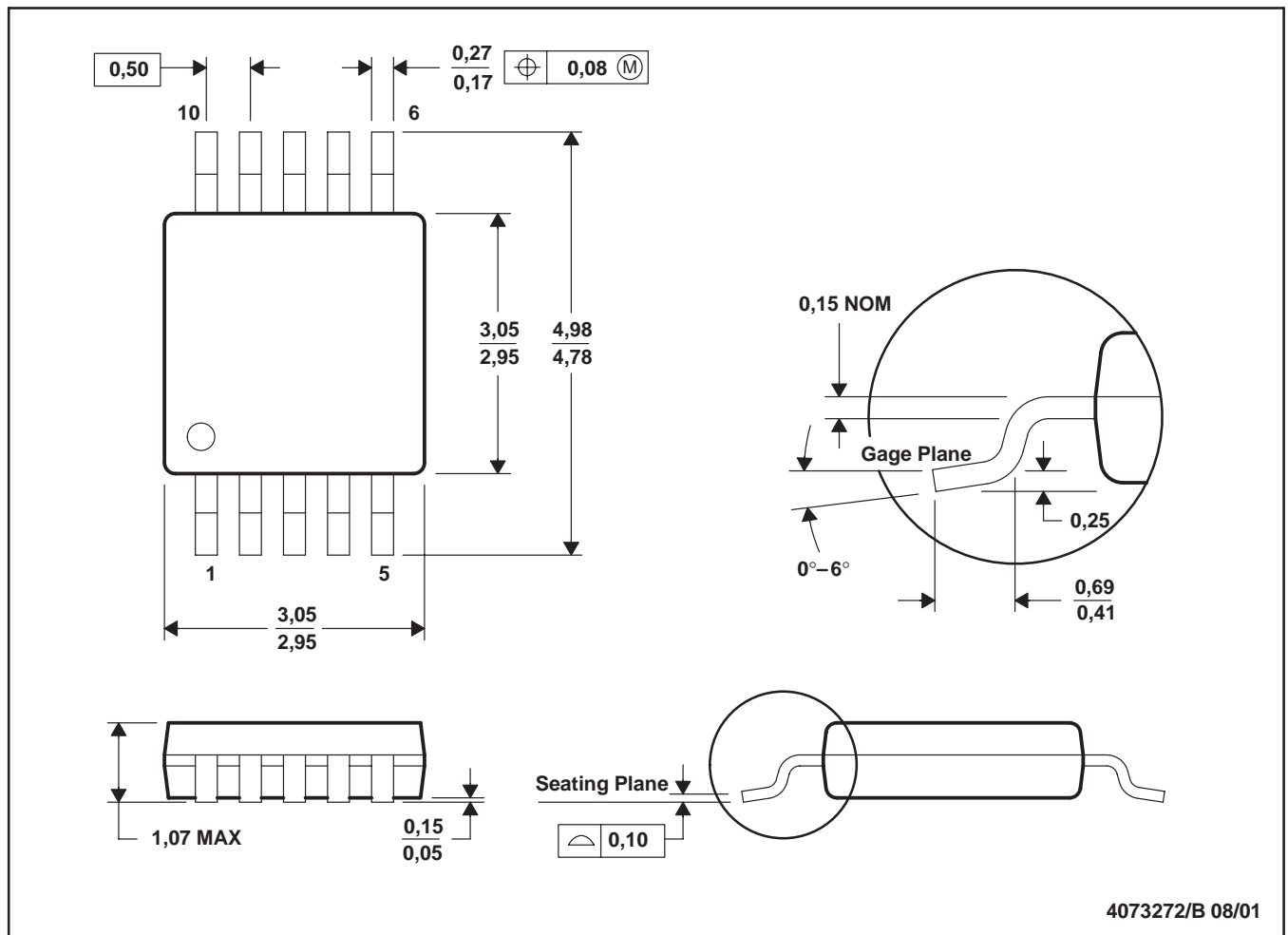
D (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

8 PINS SHOWN

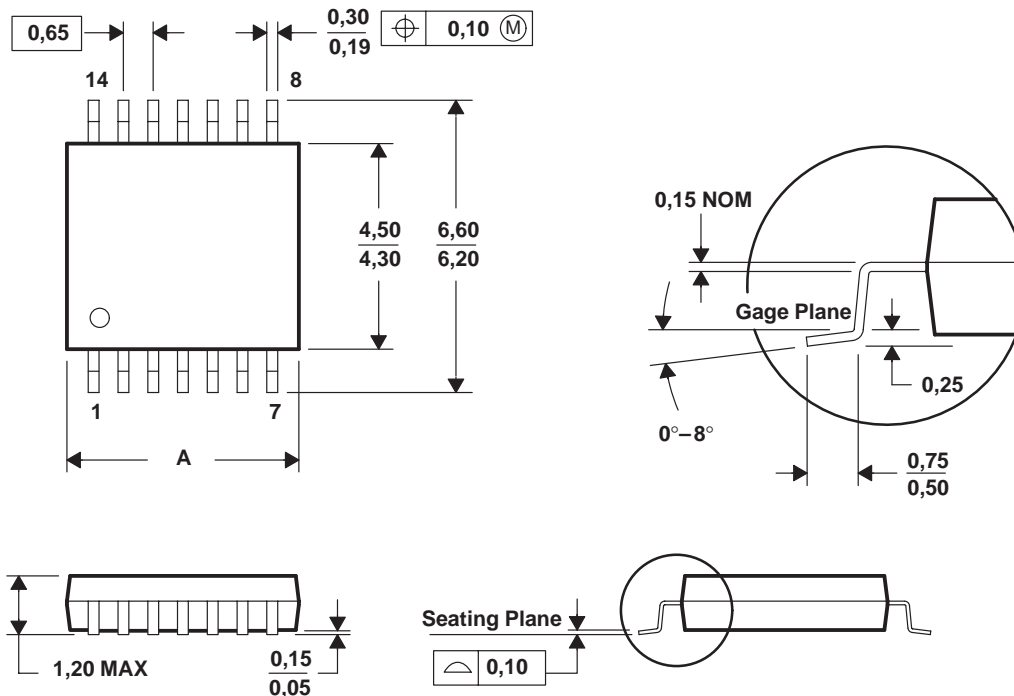


- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - C. Body dimensions do not include mold flash or protrusion, not to exceed 0.006 (0,15).
 - D. Falls within JEDEC MS-012



- 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.
 - A. Falls within JEDEC MO-187

14 PINS SHOWN



PINS ** DIM	8	14	16	20	24	28
A MAX	3,10	5,10	5,10	6,60	7,90	9,80
A MIN	2,90	4,90	4,90	6,40	7,70	9,60

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- 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 not to exceed 0,15.
 D. Falls within JEDEC MO-153

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