

# 200MHz, CMOS OPERATIONAL AMPLIFIER WITH SHUTDOWN

## FEATURES

- **UNITY-GAIN BANDWIDTH: 450MHz**
- **WIDE BANDWIDTH: 200MHz GBW**
- **HIGH SLEW RATE: 360V/ $\mu$ 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 $\mu$ 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

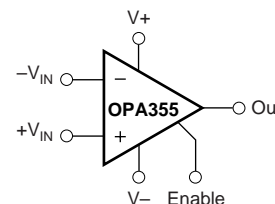
The OPA355 series high-speed, voltage-feedback CMOS operational amplifiers are designed for video and other applications requiring wide bandwidth. The OPA355 is unity-gain stable and can drive large output currents. In addition, the OPA355 has a digital shutdown (Enable) function. This feature provides 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  $-40^{\circ}\text{C}$  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.

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## ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

Supply Voltage, V+ to V- .....	7.5V
Signal Input Terminals, Voltage <sup>(2)</sup> .....	(V-) - 0.5V to (V+) + 0.5V
Current <sup>(2)</sup> .....	10mA
Enable Input .....	(V-) - 0.5V to (V+) + 0.5V
Output Short-Circuit <sup>(3)</sup> .....	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.

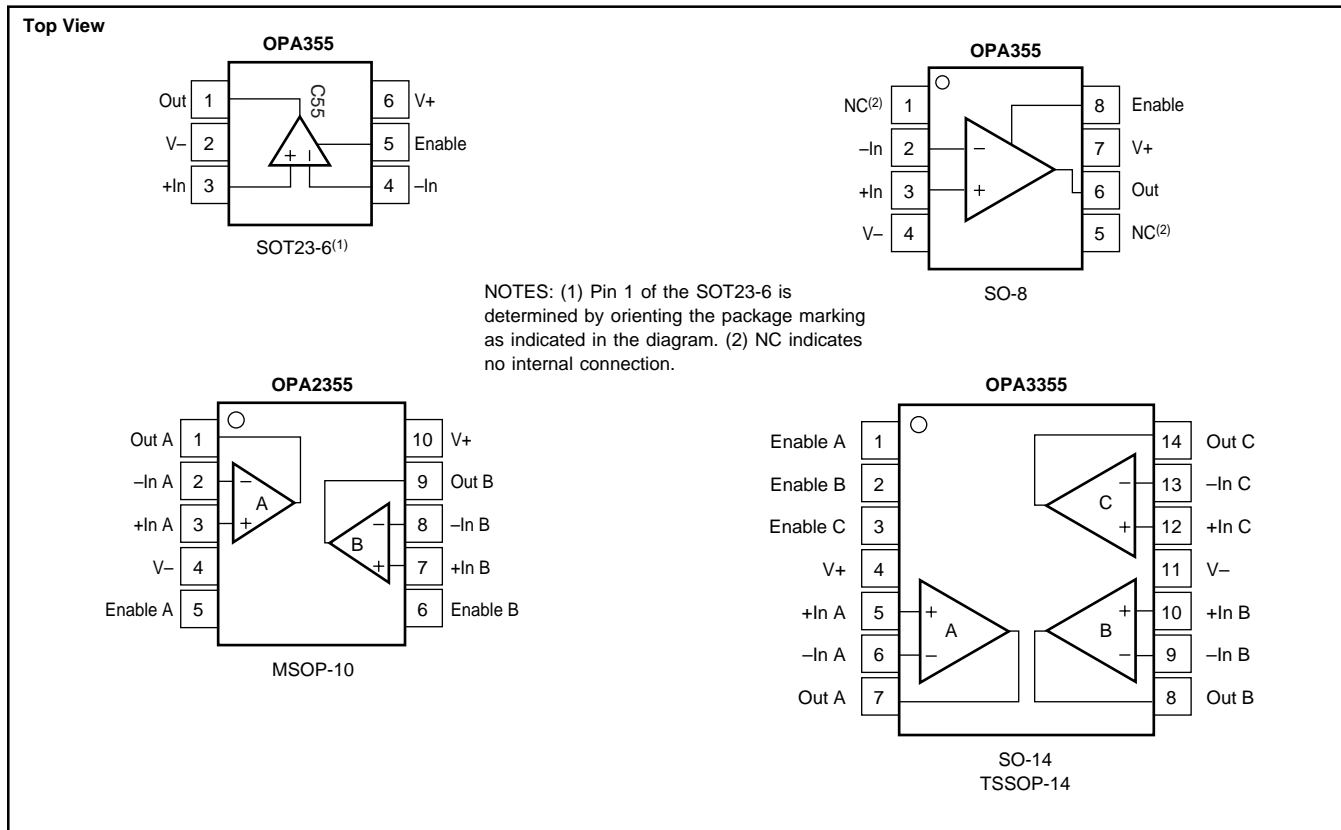
ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

## PACKAGE/ORDERING INFORMATION<sup>(1)</sup>

PRODUCT	PACKAGE-LEAD	PACKAGE MARKING
OPA355	SOT23-6	C55
"	"	"
OPA355	SO-8	OPA355UA
"	"	"
OPA2355	MSOP-10	D55
"	"	"
OPA3355	TSSOP-14	OPA3355EA
"	"	"
OPA3355	SO-14	OPA3355UA
"	"	"

NOTE: (1) For the most current package and ordering information, see the Package Option Addendum located at the end of this data sheet.

## PIN CONFIGURATIONS



# 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	OPA355 OPA2355 OPA3355			UNITS
		MIN	TYP	MAX	
<b>OFFSET VOLTAGE</b>					
Input Offset Voltage $V_{OS}$	$V_S = +5V$		$\pm 2$	$\pm 9$	mV
<b>vs Temperature</b>	<b>Specified Temperature Range</b>		$\pm 7$	$\pm 15$	mV
<b>vs Power Supply</b>	<b>Specified Temperature Range</b> $V_S = +2.7V$ to $+5.5V$ , $V_{CM} = V_S/2 - 0.15V$		$\pm 80$	$\pm 350$	$\mu V/^\circ C$ $\mu V/V$
<b>INPUT BIAS CURRENT</b>					
Input Bias Current $I_B$			3	$\pm 50$	pA
Input Offset Current $I_{OS}$			$\pm 1$	$\pm 50$	pA
<b>NOISE</b>					
Input Noise Voltage Density $e_n$	$f = 1MHz$		5.8		$nV/\sqrt{Hz}$
Current Noise Density $i_n$	$f = 1MHz$		50		$fA/\sqrt{Hz}$
<b>INPUT VOLTAGE RANGE</b>					
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
	<b>Specified Temperature Range</b>	<b>66</b>			<b>dB</b>
<b>INPUT IMPEDANCE</b>					
Differential			$10^{13} \parallel 1.5$		$\Omega \parallel pF$
Common-Mode			$10^{13} \parallel 1.5$		$\Omega \parallel pF$
<b>OPEN-LOOP GAIN</b>					
	$V_S = +5V$ , $0.3V < V_O < 4.7V$	84	92		dB
<b>OPA355</b>	<b><math>V_S = +5V</math>, <math>0.3V &lt; V_O &lt; 4.7V</math></b>	<b>80</b>			<b>dB</b>
<b>OPA2355, OPA3355</b>	<b><math>V_S = +5V</math>, <math>0.4V &lt; V_O &lt; 4.6V</math></b>	<b>80</b>			<b>dB</b>
<b>FREQUENCY RESPONSE</b>					
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/ $\mu s$
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	$V_{IN} \cdot Gain = V_S$		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	$f = 5MHz$		–90		dB
	$f = 5MHz$		–70		dB
<b>OUTPUT</b>					
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 <sup>(1)</sup> $I_O$			$\pm 60$		mA
Output Current, Peak <sup>(1)</sup> $I_O$	$V_S = +5V$		$\pm 100$		mA
Output Current, Peak <sup>(1)</sup> $I_O$	$V_S = +3V$		$\pm 80$		mA
Closed-Loop Output Impedance	$f < 100kHz$		0.02		$\Omega$
<b>POWER SUPPLY</b>					
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
	<b>Specified Temperature Range</b>			<b>14</b>	<b>mA</b>

NOTES: (1) See typical characteristic *Output Voltage Swing vs Output Current*. (2) Logic LOW and HIGH levels are CMOS logic compatible. They are referenced to  $V_-$ .

# 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  $+125^\circ C$ .

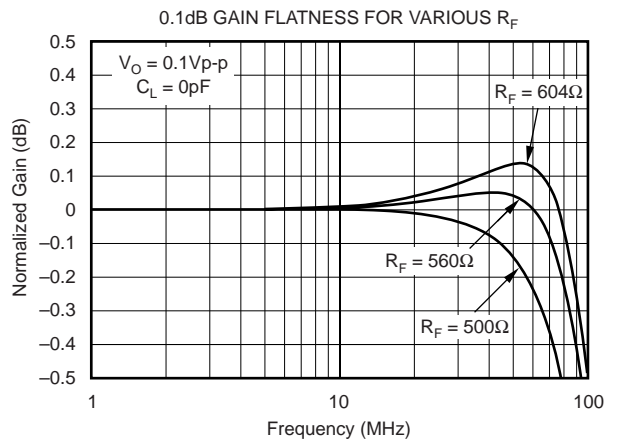
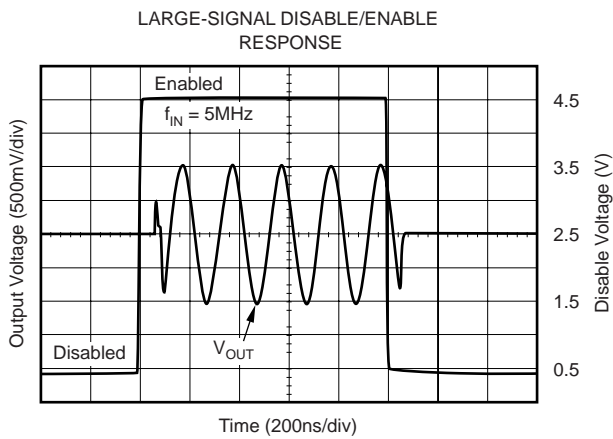
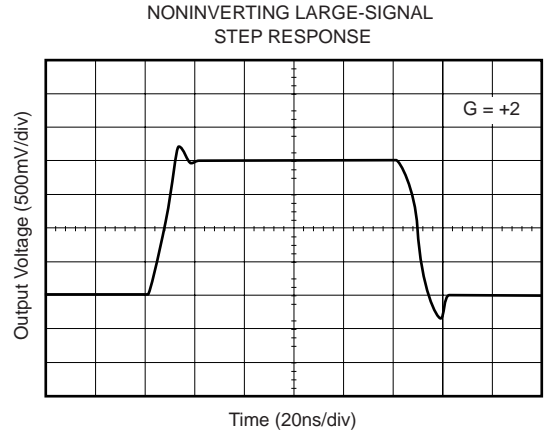
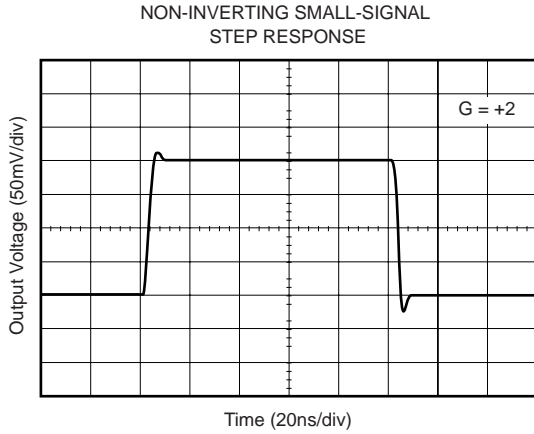
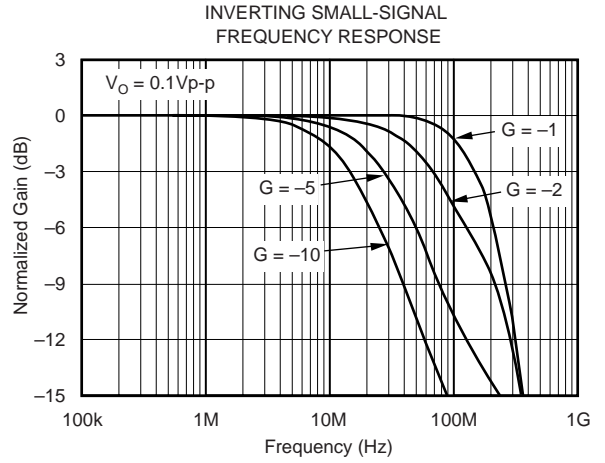
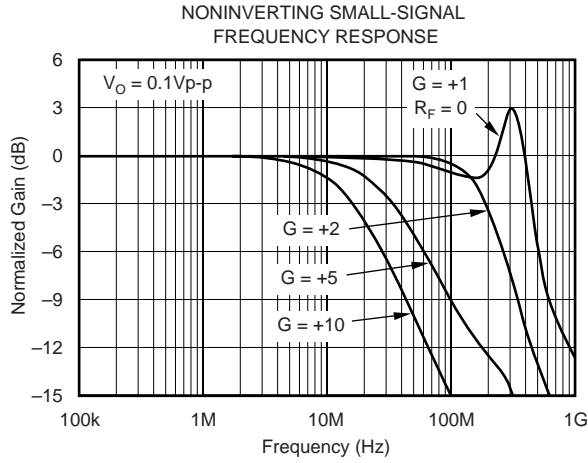
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PARAMETER	CONDITION	OPA355 OPA2355 OPA3355			UNITS
		MIN	TYP	MAX	
<b>SHUTDOWN</b>					
Disabled (Logic-LOW Threshold) <sup>(2)</sup>				0.8	V
Enabled (Logic-HIGH Threshold) <sup>(2)</sup>		2			V
Enable Time			100		ns
Disable Time			30		ns
Shutdown Current (per amplifier)	$V_S = +5V$ , Disabled		3.4	6	$\mu A$
<b>THERMAL SHUTDOWN</b>					
Junction Temperature					
Shutdown			160		$^\circ C$
Reset from Shutdown			140		$^\circ C$
<b>TEMPERATURE RANGE</b>					
Specified Range		-40		125	$^\circ C$
Operating Range		-55		150	$^\circ C$
Storage Range		-65		150	$^\circ C$
Thermal Resistance	$\theta_{JA}$				$^\circ C/W$
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 characteristic *Output Voltage Swing vs Output Current*. (2) Logic LOW and HIGH levels are CMOS logic compatible. They are referenced to  $V_-$ .

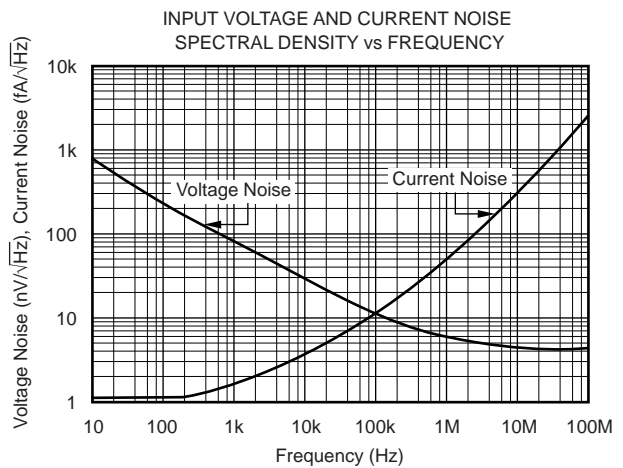
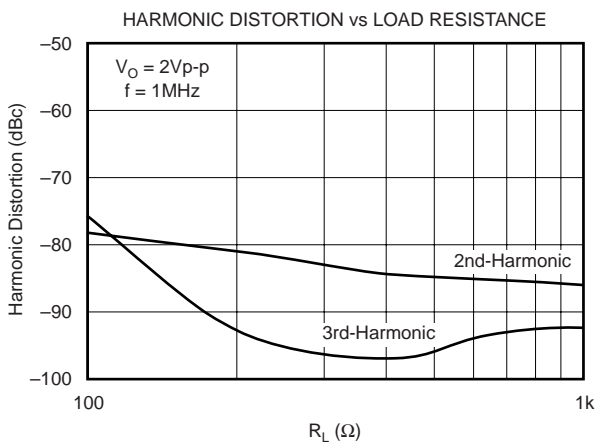
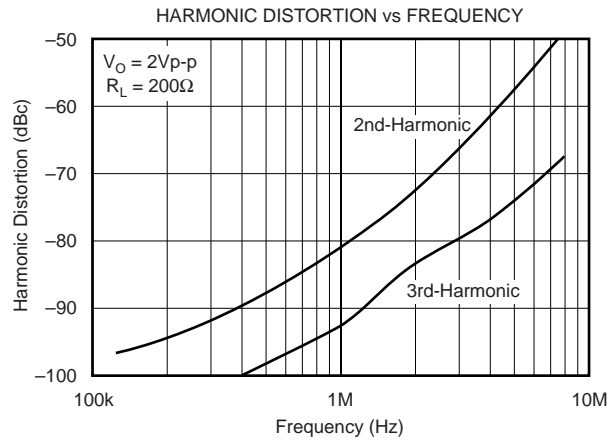
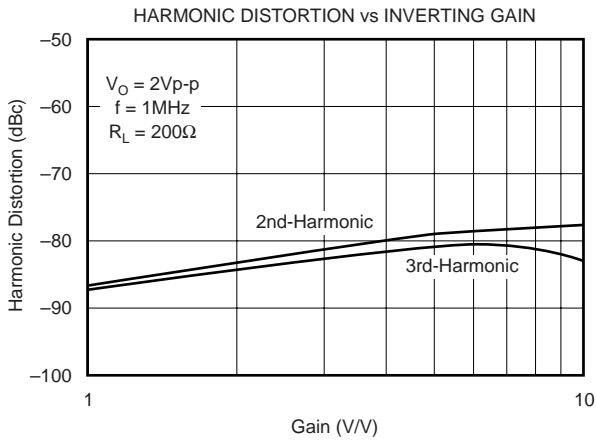
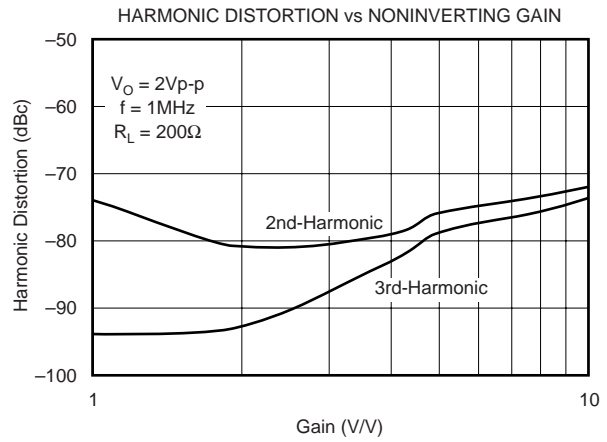
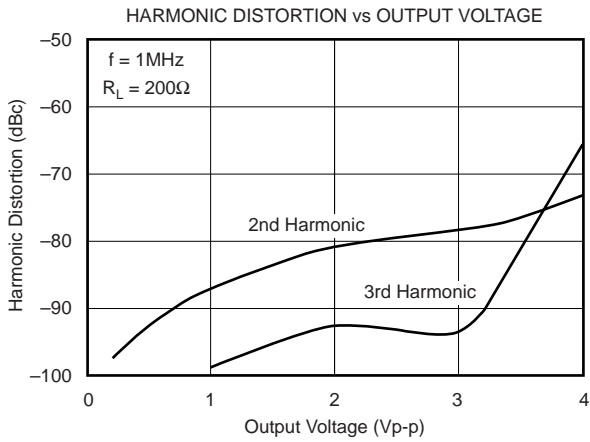
# TYPICAL CHARACTERISTICS

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.



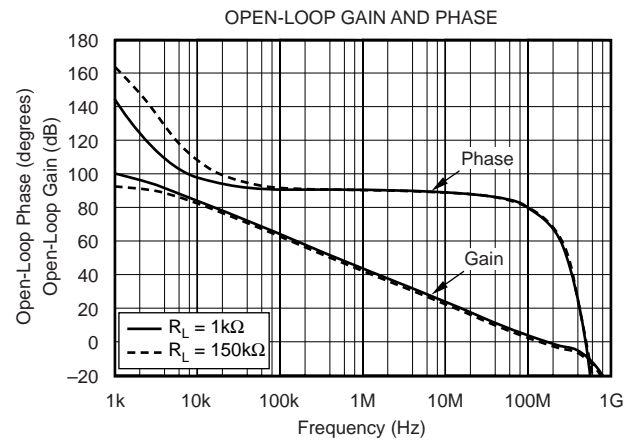
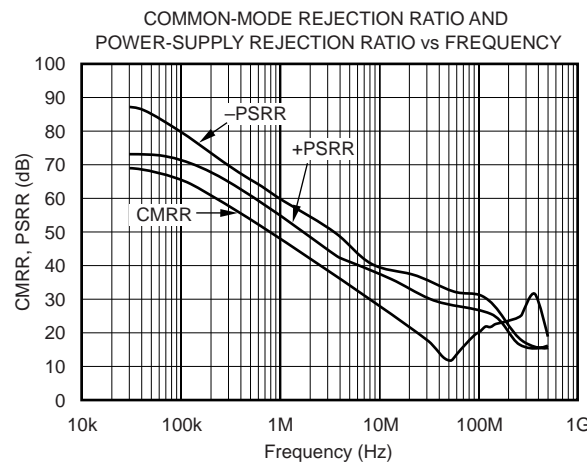
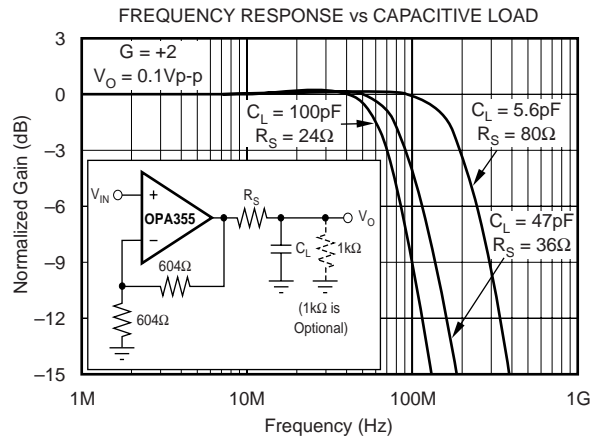
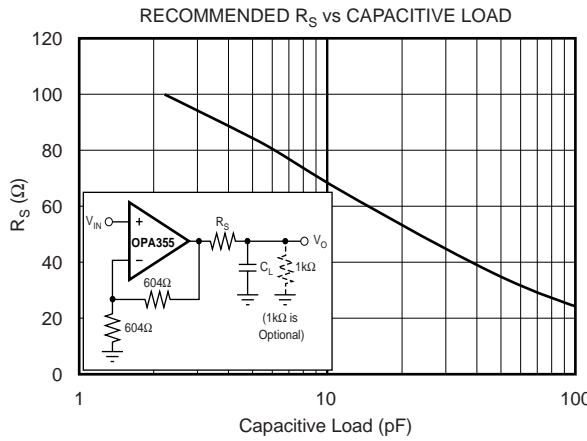
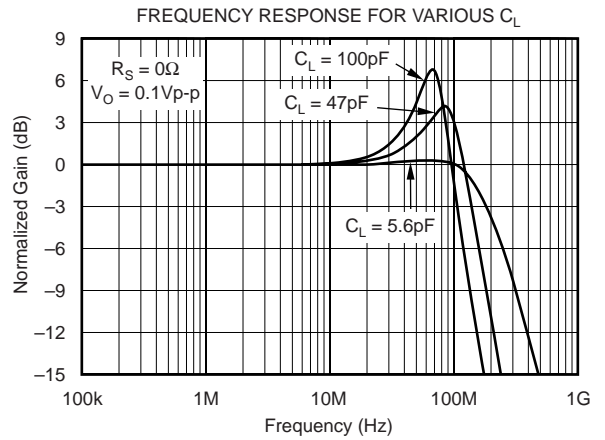
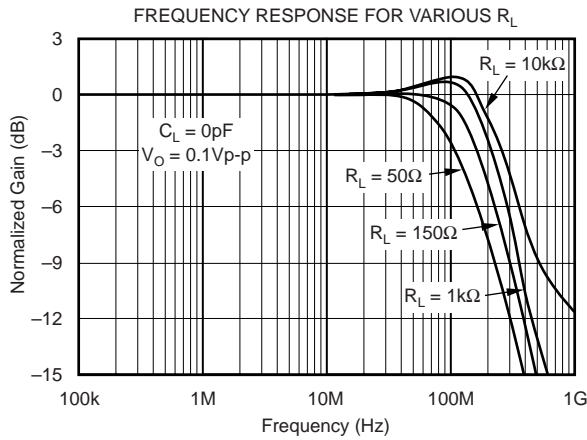
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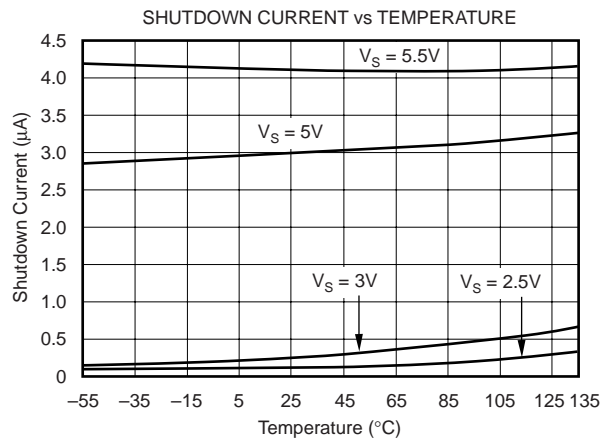
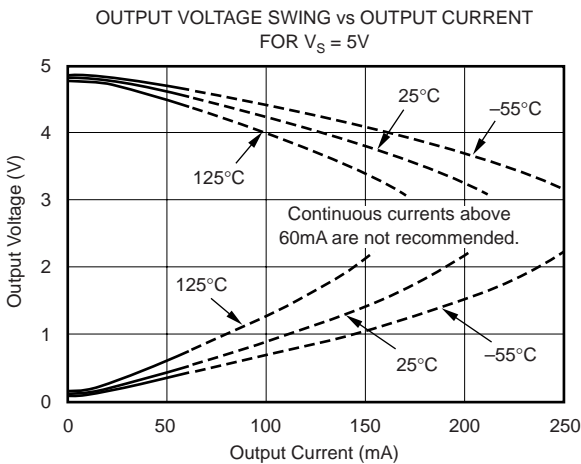
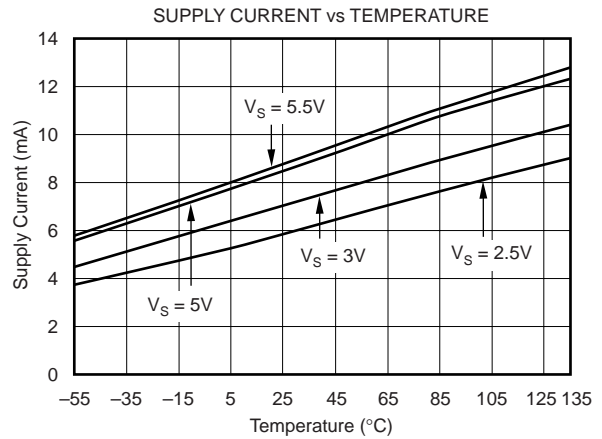
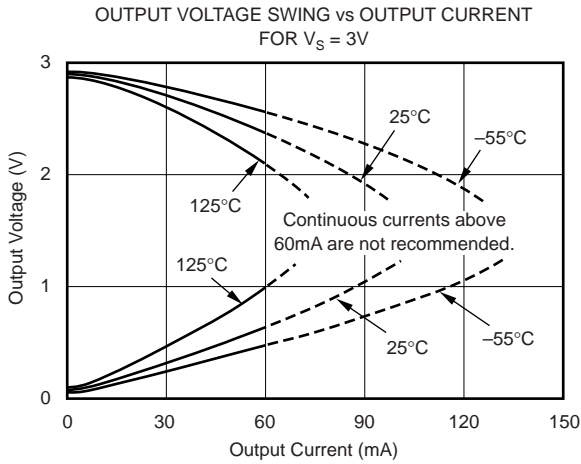
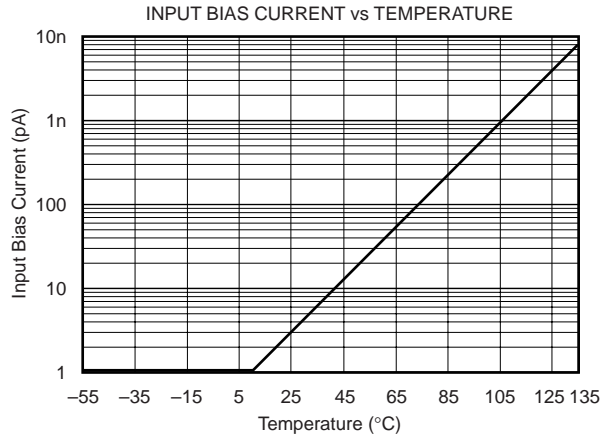
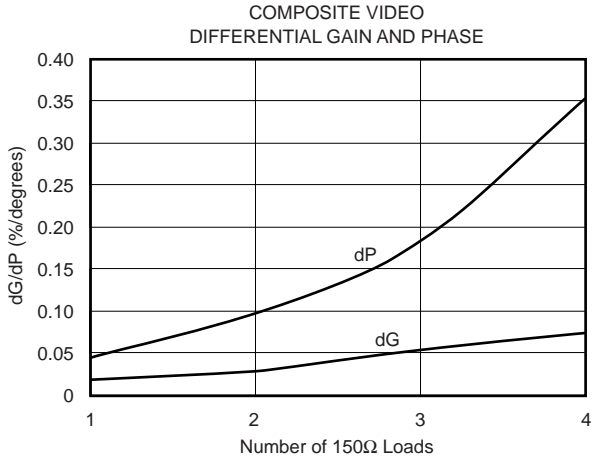
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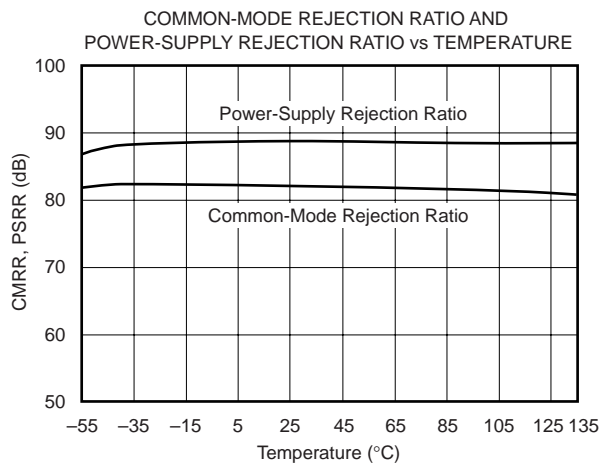
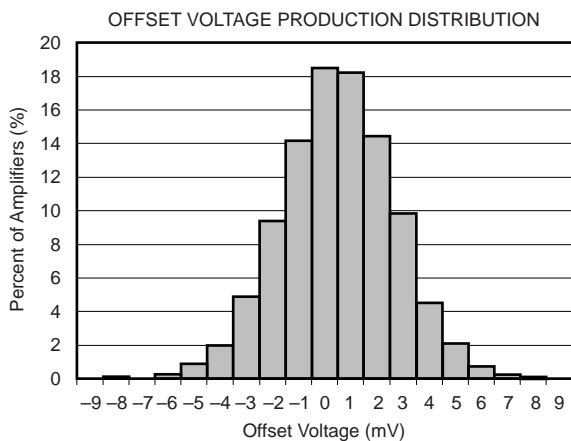
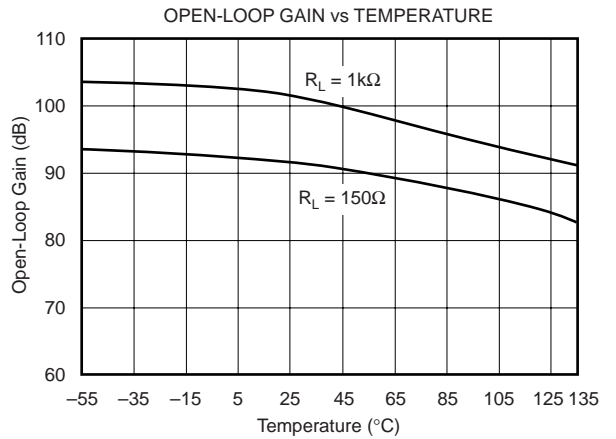
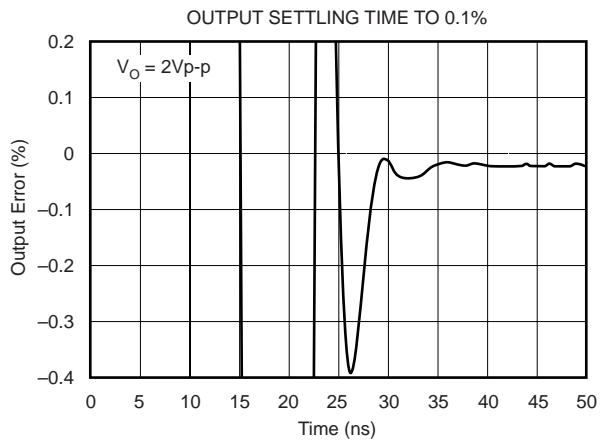
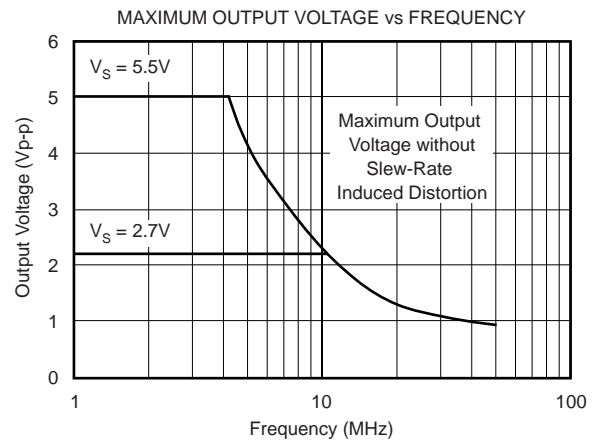
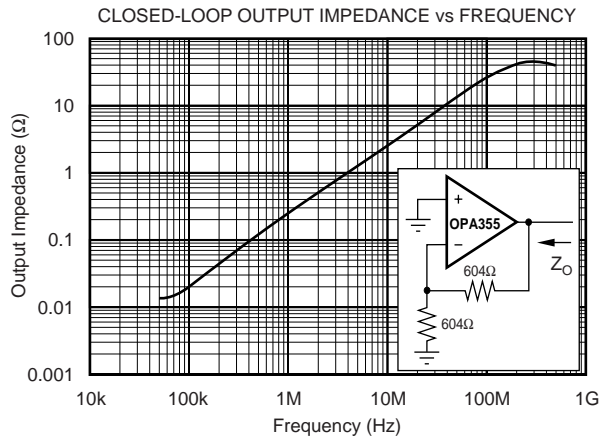
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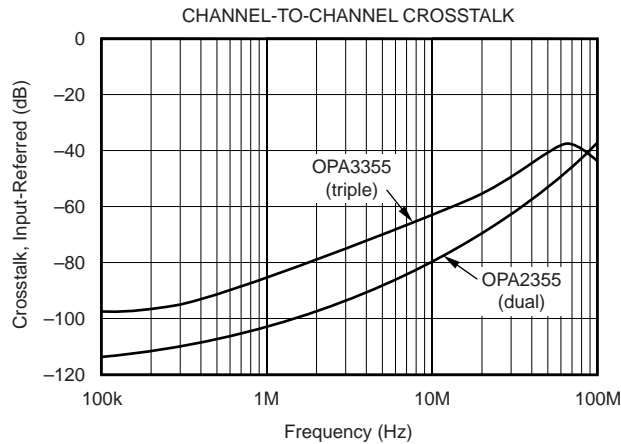
# TYPICAL CHARACTERISTICS (Cont.)

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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/ $\mu\text{s}$  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 $\mu\text{F}$  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 $\mu\text{A}$  per amplifier. This pin voltage is referenced to single-supply ground. When using a split-supply, such as  $\pm 2.5\text{V}$ , the enable/disable voltage levels will be referenced to  $V_-$ . 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 100kΩ 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 ±60mA. Refer to the Typical Characteristics, *Output Voltage Swing vs Output Current*.

## VIDEO

The OPA355 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 OPA355 output.

The OPA355 can be used as an amplifier for RGB graphic signals, which have a voltage of zero at the video black level, by offsetting and AC-coupling the signal, 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.

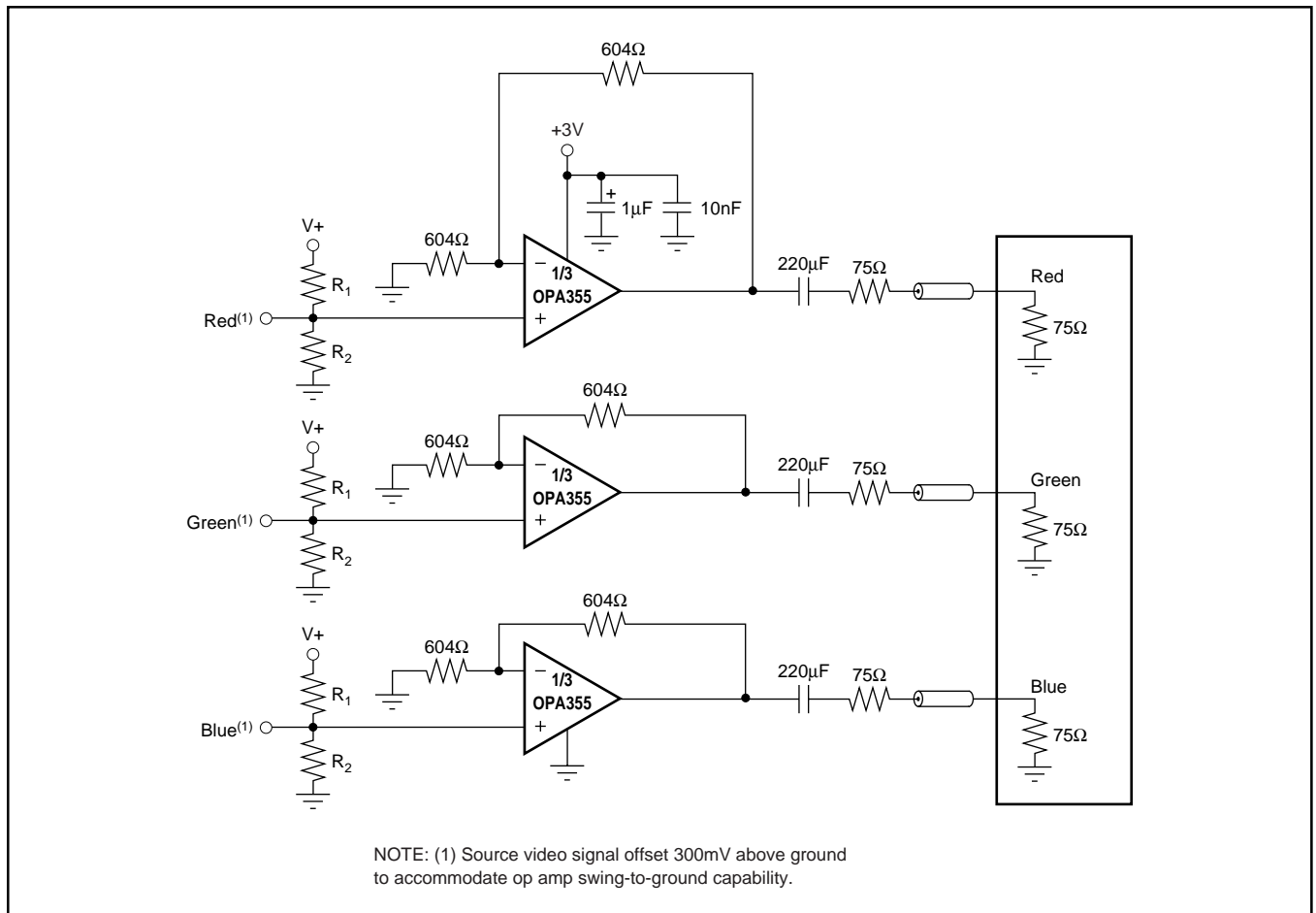


FIGURE 1. RGB Cable Driver.

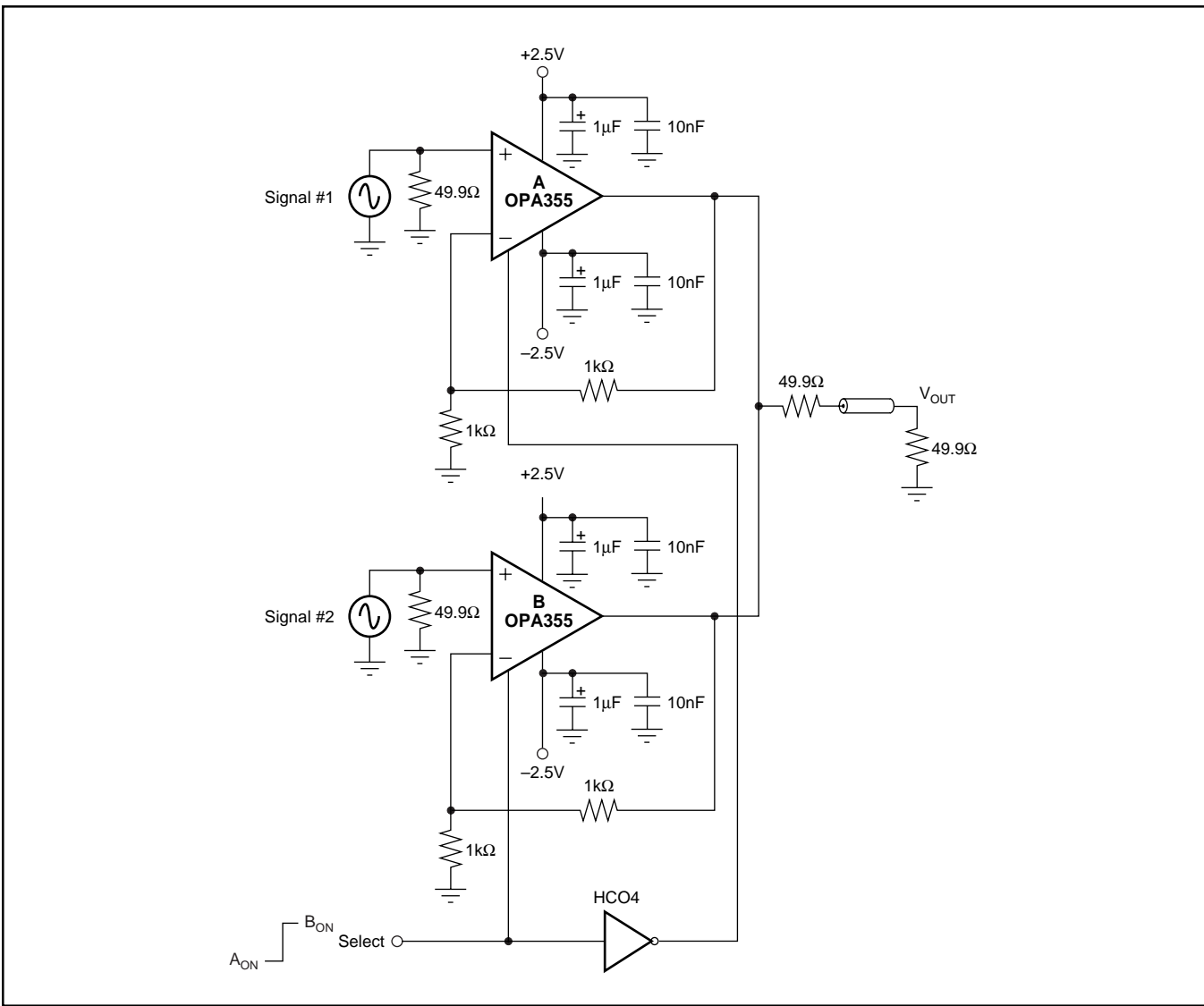


FIGURE 2. Multiplexed Output.

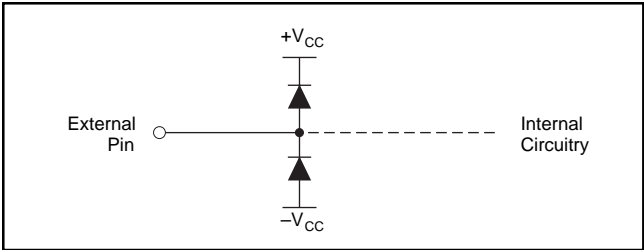
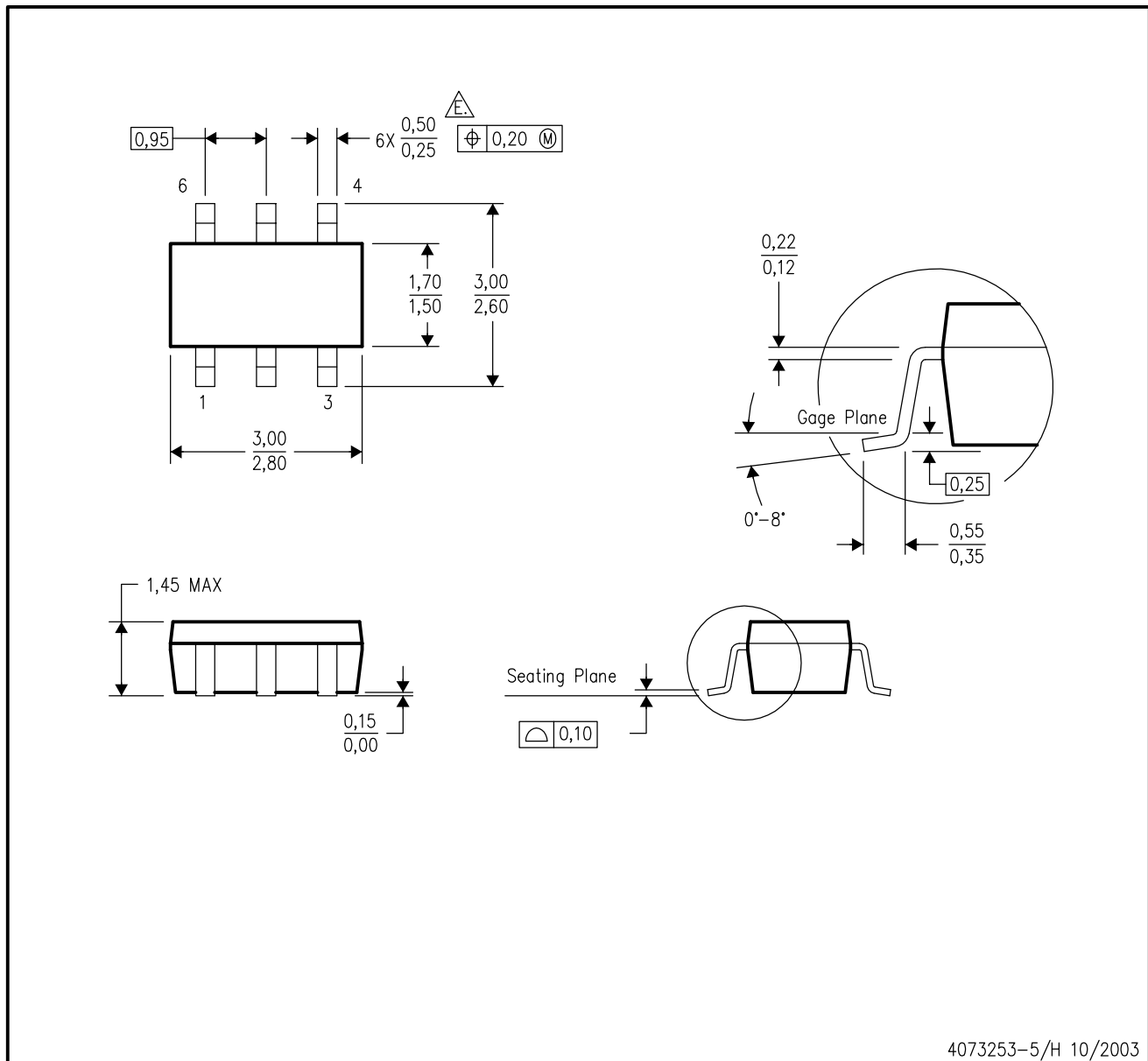


FIGURE 3. Internal ESD Protection.

DBV (R-PDSO-G6)

PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Body dimensions do not include mold flash or protrusion.
  - Leads 1,2,3 may be wider than leads 4,5,6 for package orientation.
- $\triangle A$  Falls within JEDEC MO-178 Variation AB, except minimum lead width.

DGS (S-PDSO-G10)

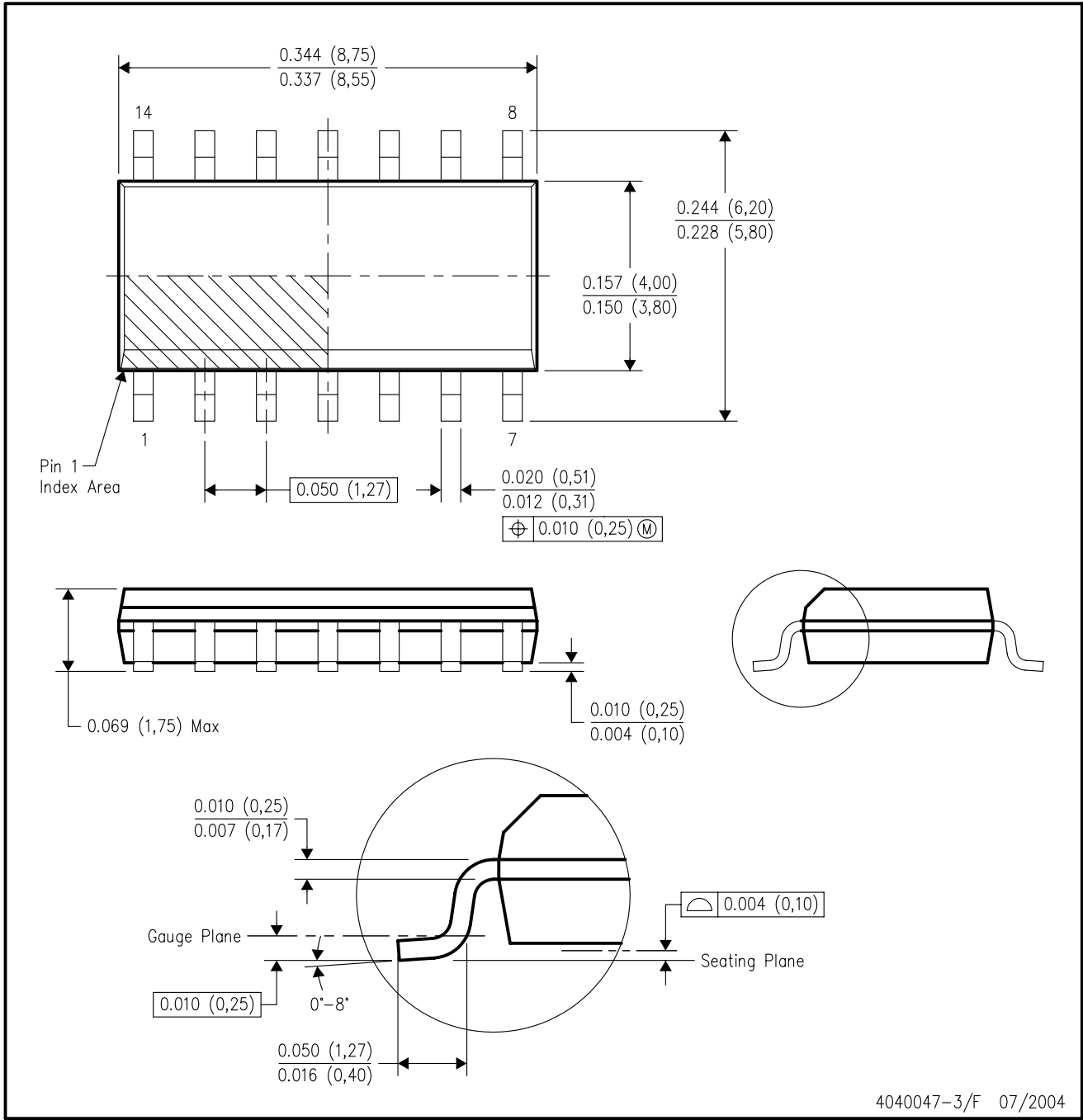
PLASTIC SMALL-OUTLINE PACKAGE



- 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 variation BA.

D (R-PDSO-G14)

PLASTIC SMALL-OUTLINE PACKAGE



4040047-3/F 07/2004

- 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 variation AB.

D (R-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



- 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 variation AA.



PW (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN



4040064/F 01/97

- 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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