

Low-Cost, CMOS, Rail-to-Rail, I/O OPERATIONAL AMPLIFIERS

FEATURES

- RAIL-TO-RAIL INPUT AND OUTPUT
- WIDE SUPPLY RANGE:
Single Supply: 4V to 12V
Dual Supplies: ± 2 to ± 6
- LOW QUIESCENT CURRENT: 160 μ A
- LIMITED RANGE CMRR: 96dB
- LOW OFFSET: 0.5mV
- HIGH SPEED: 1MHz, 0.6V/ μ s
- *Micro*SIZE PACKAGES:
SOT23-5, MSOP-8, TSSOP-14
- LOW INPUT BIAS CURRENT: 1pA

APPLICATIONS

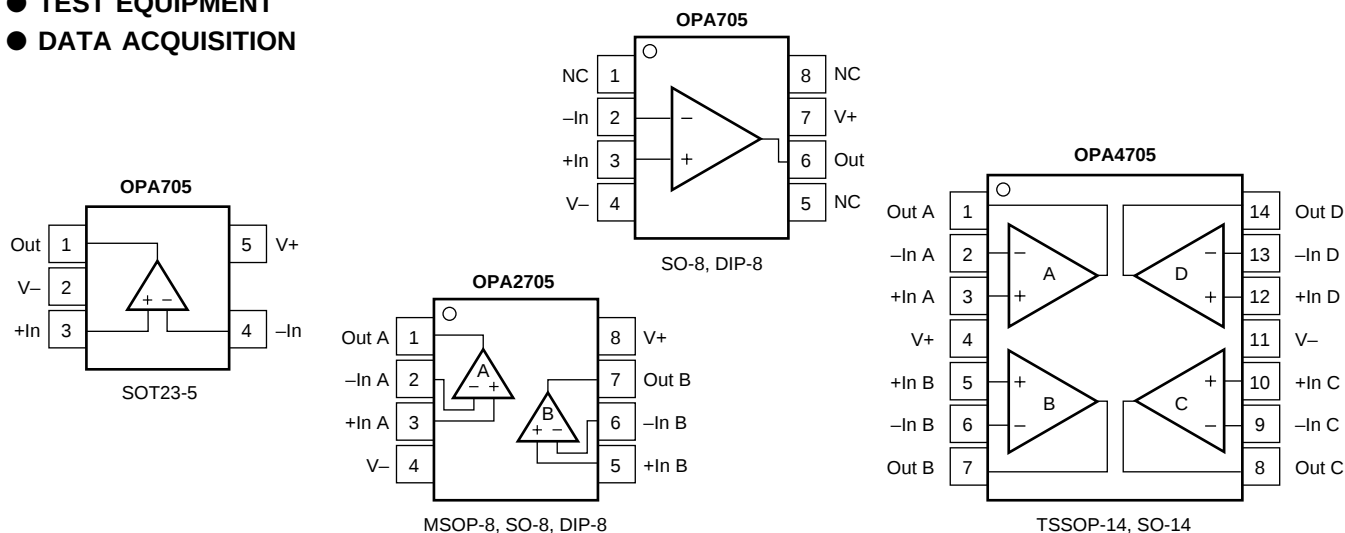
- AUTOMOTIVE APPLICATIONS:
Audio, Sensor Applications, Security Systems
- PORTABLE EQUIPMENT
- ACTIVE FILTERS
- TRANSDUCER AMPLIFIER
- TEST EQUIPMENT
- DATA ACQUISITION

DESCRIPTION

The OPA705 series low-cost op amps are optimized for applications requiring rail-to-rail input and output swing. Single, dual, and quad versions are offered in a variety of packages. While the quiescent current is less than 200 μ A per amplifier, the OPA705 still offers excellent dynamic performance (1MHz GBW and 0.6V/ μ s SR) and unity-gain stability.

The OPA705 series is fully specified and guaranteed over the supply range of ± 2 V to ± 6 V. Input swing extends 300mV beyond the rail and the output swings to within 40mV of the rail.

The single version (OPA705) is available in the *Micro*SIZE SOT23-5 and in the standard SO-8 surface-mount packages. The dual version (OPA2705) is available in the MSOP-8, SO-8, and DIP-8 packages. The quad OPA4705 is available in the TSSOP-14 and SO-14 packages. All are specified for operation from -40° C to $+85^{\circ}$ C.



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-.....	13.2V
Signal Input Terminals, Voltage ⁽²⁾ (V-) -0.3V to (V+) +0.3V	
Current ⁽²⁾	10mA
Output Short-Circuit ⁽³⁾	Continuous
Operating Temperature	-55°C to +125°C
Storage Temperature	-65°C to +150°C
Junction Temperature.....	+150°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. (2) Input terminals are diode-clamped to the power supply rails. Input signals that can swing more than 0.3V 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	DESCRIPTION	MINIMUM RECOMMENDED GAIN	PACKAGE	PACKAGE DRAWING NUMBER	PACKAGE MARKING	ORDERING NUMBER ⁽¹⁾	TRANSPORT MEDIA
OPA705NA "	Single, GBW = 1MHz "	1 "	SOT23-5 "	331 "	A05 "	OPA705NA/250 OPA705NA/3K	Tape and Reel
OPA705UA "	Single, GBW = 1MHz "	1 "	SO-8 "	182 "	OPA705UA "	OPA705UA OPA705UA/2K5	Tape and Reel Rails
OPA705PA "	Single, GBW = 1MHz "	1 "	DIP-8 "	006 "	OPA705PA "	OPA705PA "	Tape and Reel Rails
OPA2705EA "	Dual, GBW = 1MHz "	1 "	MSOP-8 "	337 "	B05 "	OPA2705EA/250 OPA2705EA/2K5	Tape and Reel
OPA2705UA "	Dual, GBW = 1MHz "	1 "	SO-8 "	182 "	OPA2705UA "	OPA2705UA OPA2705UA/2K5	Tape and Reel Rails
OPA2705PA "	Dual, GBW = 1MHz "	1 "	DIP-8 "	006 "	OPA2705PA "	OPA2705PA "	Tape and Reel Rails
OPA4705EA "	Quad, GBW = 1MHz "	1 "	TSSOP-14 "	357 "	OPA4705EA "	OPA4705EA/250 OPA4705EA/2K5	Tape and Reel
OPA4705UA "	Quad, GBW = 1MHz "	1 "	SO-14 "	235 "	OPA4705UA "	OPA4705UA OPA4705UA/2K5	Tape and Reel Rails

NOTE: (1) Models with a slash (/) are available only in Tape and Reel in the quantities indicated (e.g., /3K indicates 3000 devices per reel). Ordering 3000 pieces of "OPA705NA/3K" will get a single 3000-piece Tape and Reel.

ELECTRICAL CHARACTERISTICS: $V_S = 4V$ to $12V$

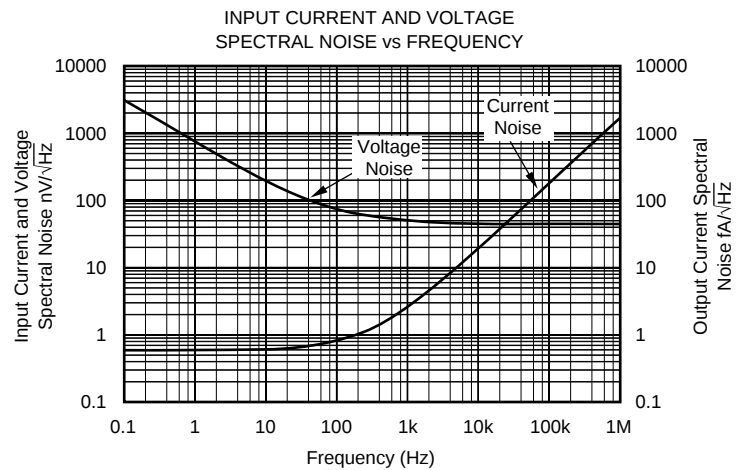
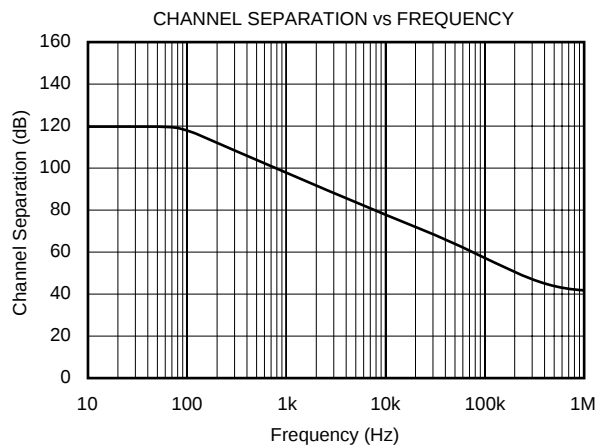
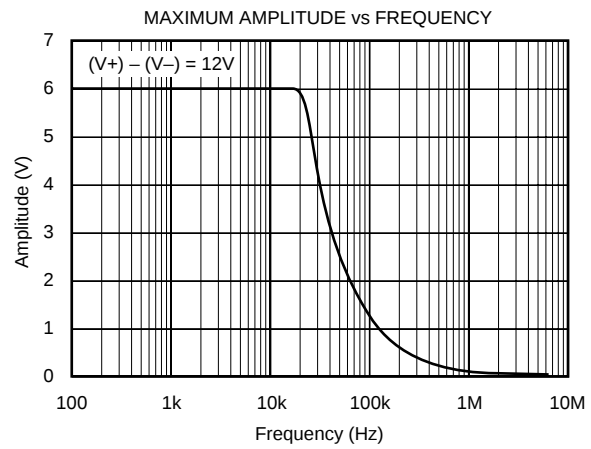
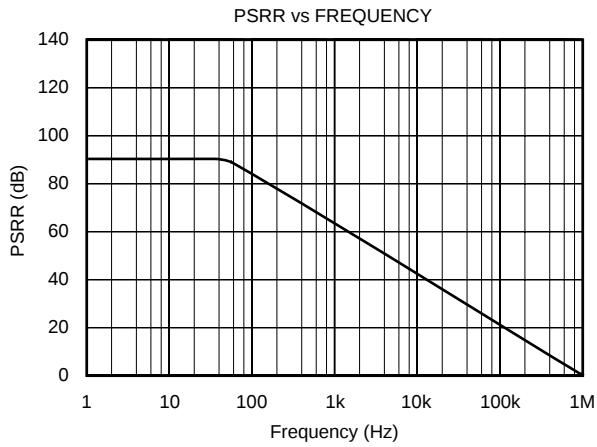
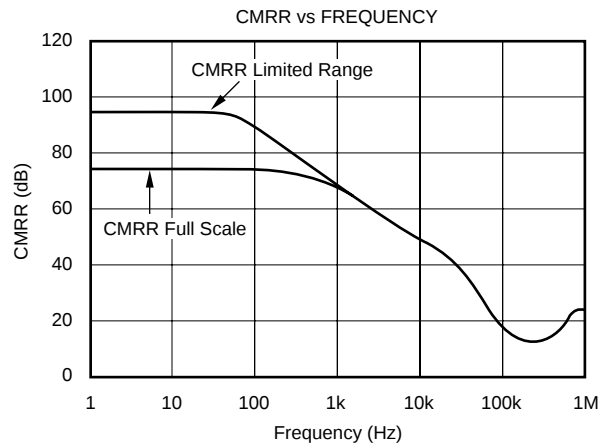
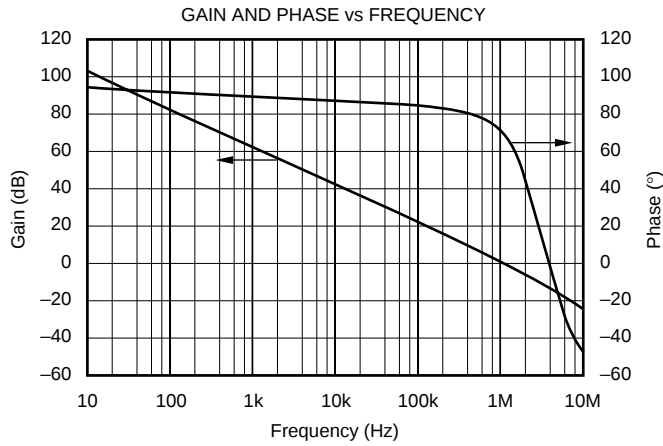
Boldface limits apply over the specified temperature range, $T_A = -40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$

At $T_A = +25^{\circ}\text{C}$, $R_L = 20\text{k}\Omega$ connected to $V_S/2$ and $V_{OUT} = V_S/2$, unless otherwise noted.

PARAMETER	CONDITION	OPA705NA, UA, PA OPA2705EA, UA, PA OPA4705EA, UA			UNITS
		MIN	TYP	MAX	
OFFSET VOLTAGE Input Offset Voltage Drift vs Power Supply Over Temperature Channel Separation, dc $f = 1\text{kHz}$	V_{OS} dV_{OS}/dT PSRR $V_S = \pm 5V$, $V_{CM} = 0V$ $T_A = -40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$ $V_S = \pm 2V$ to $\pm 6V$, $V_{CM} = 0V$ $V_S = \pm 2V$ to $\pm 6V$, $V_{CM} = 0V$ $R_L = 20\text{k}\Omega$		± 0.5 ± 4 20 100 1 98	± 5 100	mV $\mu\text{V}/^{\circ}\text{C}$ $\mu\text{V}/V$ $\mu\text{V}/V$ $\mu\text{V}/V$ dB
INPUT VOLTAGE RANGE Common-Mode Voltage Range Common-Mode Rejection Ratio over Temperature over Temperature	V_{CM} CMRR $V_S = \pm 5V$, $(V-) - 0.3V < V_{CM} < (V+) + 0.3V$ $V_S = \pm 5V$, $(V-) < V_{CM} < (V+)$ $V_S = \pm 5V$, $(V-) - 0.3V < V_{CM} < (V+) - 2V$ $V_S = \pm 5V$, $(V-) < V_{CM} < (V+) - 2V$	$(V-) - 0.3$ 66 66	 77 74 96 93	$(V+) + 0.3$	V dB dB dB dB
INPUT BIAS CURRENT Input Bias Current Input Offset Current	I_B I_{OS} $V_S = \pm 5V$, $V_{CM} = 0V$ $V_S = \pm 5V$, $V_{CM} = 0V$		± 1 ± 0.5	± 10 ± 10	pA pA
INPUT IMPEDANCE Differential Common-Mode			$4 \cdot 10^9 \parallel 4$ $5 \cdot 10^{12} \parallel 4$		$\Omega \parallel \text{pF}$ $\Omega \parallel \text{pF}$
NOISE Input Voltage Noise, $f = 0.1\text{Hz}$ to 10Hz Input Voltage Noise Density, $f = 1\text{kHz}$ Current Noise Density, $f = 1\text{kHz}$	e_n i_n $V_S = \pm 5V$, $V_{CM} = 0V$ $V_S = \pm 5V$, $V_{CM} = 0V$ $V_S = \pm 5V$, $V_{CM} = 0V$		6 45 2.5		$\mu\text{Vp-p}$ $\text{nV}/\sqrt{\text{Hz}}$ $\text{fA}/\sqrt{\text{Hz}}$
OPEN-LOOP GAIN Open-Loop Voltage Gain over Temperature over Temperature	A_{OL} $R_L = 100\text{k}\Omega$, $(V-)+0.1V < V_O < (V+)-0.1V$ $R_L = 20\text{k}\Omega$, $(V-)+0.075V < V_O < (V+)-0.075V$ $R_L = 20\text{k}\Omega$, $(V-)+0.075V < V_O < (V+)-0.075V$ $R_L = 5\text{k}\Omega$, $(V-)+0.15V < V_O < (V+)-0.15V$ $R_L = 5\text{k}\Omega$, $(V-)+0.15V < V_O < (V+)-0.15V$	100 100	120 110 106 110 106		dB dB dB dB dB
OUTPUT Voltage Output Swing from Rail Output Current Short-Circuit Current Capacitive Load Drive	I_{OUT} I_{SC} C_{LOAD} $R_L = 100\text{k}\Omega$, $A_{OL} > 80\text{dB}$ $R_L = 20\text{k}\Omega$, $A_{OL} > 100\text{dB}$ $R_L = 5\text{k}\Omega$, $A_{OL} > 100\text{dB}$ $ V_S - V_{OUT} < 1V$		40 ± 10 ± 40	75 150	mV mV mV mA mA
FREQUENCY RESPONSE Gain-Bandwidth Product Slew Rate Settling Time, 0.1% 0.01% Overload Recovery Time Total Harmonic Distortion + Noise	GBW SR t_S $t_{IN} \cdot \text{Gain} = V_S$ THD+N $C_L = 100\text{pF}$ $G = +1$ $V_S = \pm 5V$, $G = +1$ $V_S = \pm 5V$, 5V Step, $G = +1$ $V_S = \pm 5V$, 5V Step, $G = +1$ $V_S = \pm 5V$, $V_O = 3V_{p-p}$, $G = +1$, $f = 1\text{kHz}$		1 0.6 15 20 3 0.02		MHz $V/\mu\text{s}$ μs μs μs %
POWER SUPPLY Specified Voltage Range, Single Supply Specified Voltage Range, Dual Supplies Operating Voltage Range Quiescent Current (per amplifier) over Temperature	V_S V_S I_Q $I_O = 0$	4 ± 2	3.6 to 12 160 200	12 ± 6 250	V V V μA μA
TEMPERATURE RANGE Specified Range Operating Range Storage Range Thermal Resistance SOT23-5 Surface-Mount MSOP-8 Surface-Mount TSSOP-14 Surface-Mount SO-8 Surface Mount SO-14 Surface Mount DIP-8	θ_{JA}	-40 -55 -65		85 125 150	$^{\circ}\text{C}$ $^{\circ}\text{C}$ $^{\circ}\text{C}$ $^{\circ}\text{C}/W$ $^{\circ}\text{C}/W$ $^{\circ}\text{C}/W$ $^{\circ}\text{C}/W$ $^{\circ}\text{C}/W$ $^{\circ}\text{C}/W$

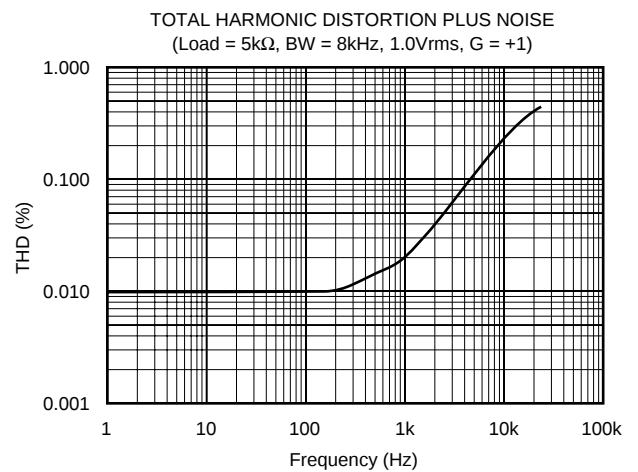
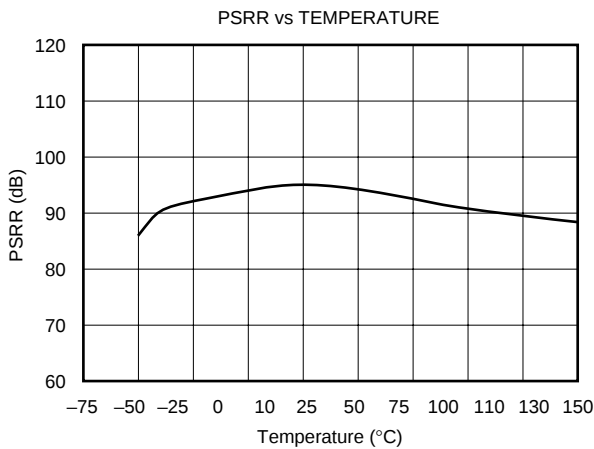
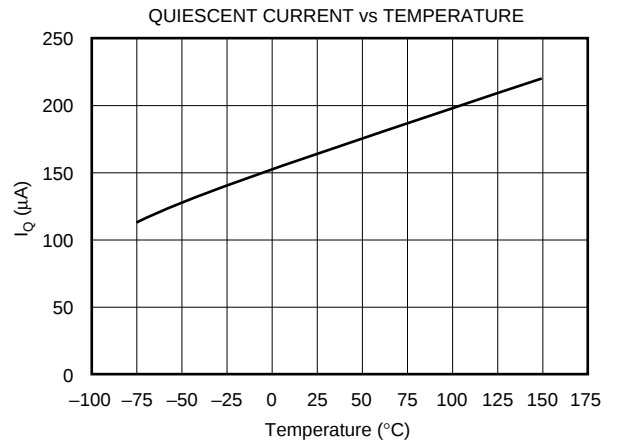
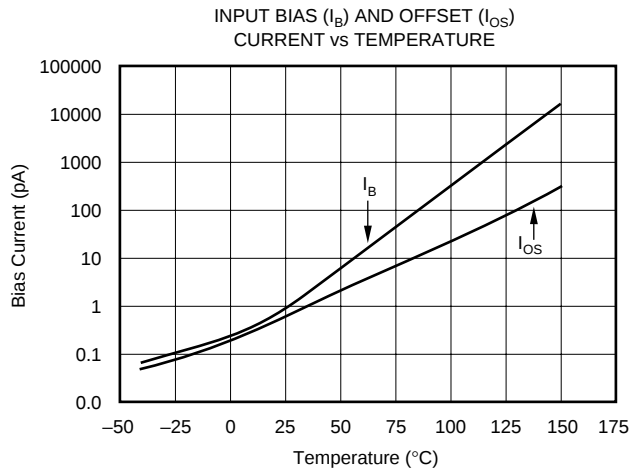
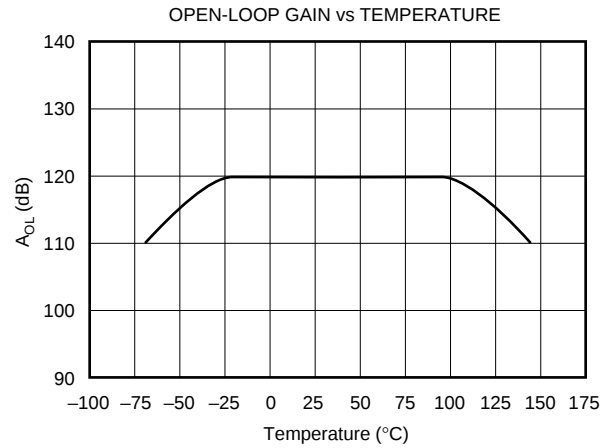
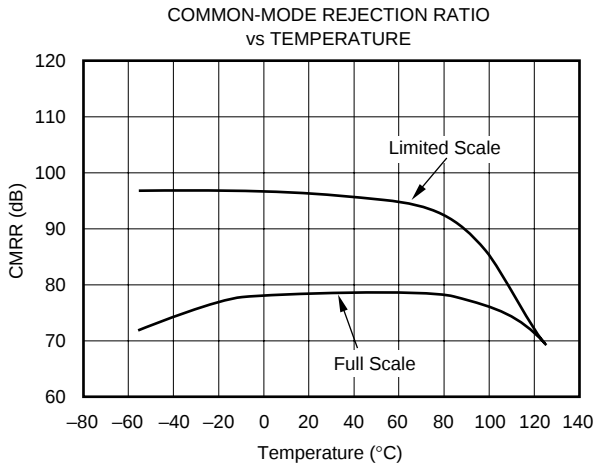
TYPICAL CHARACTERISTICS

At $T_A = +25^\circ\text{C}$, $V_S = \pm 5\text{V}$, and $R_L = 20\text{k}\Omega$, unless otherwise noted.



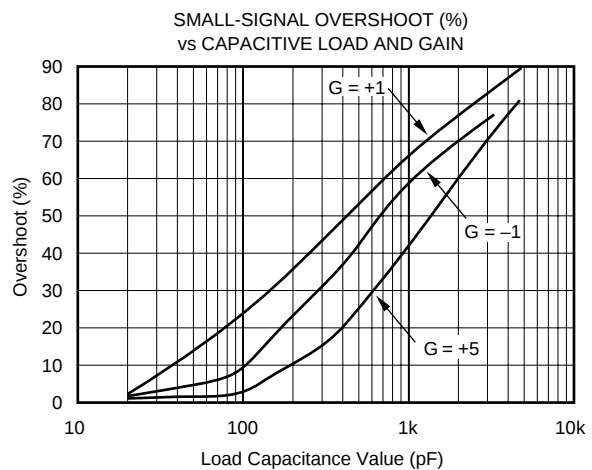
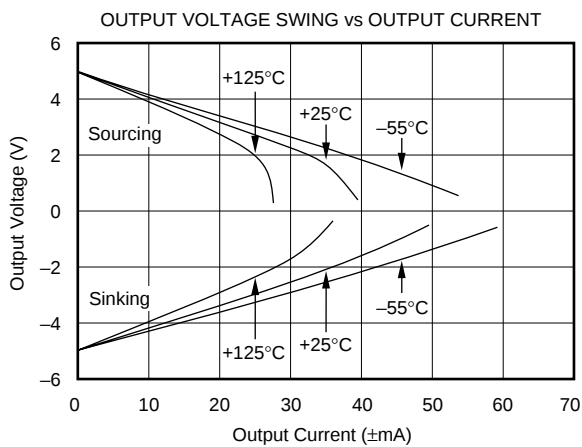
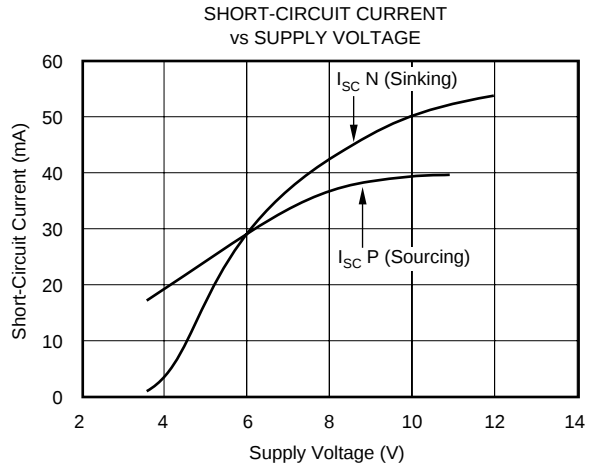
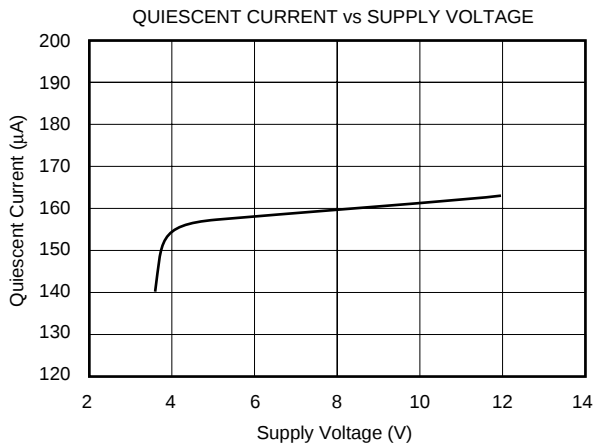
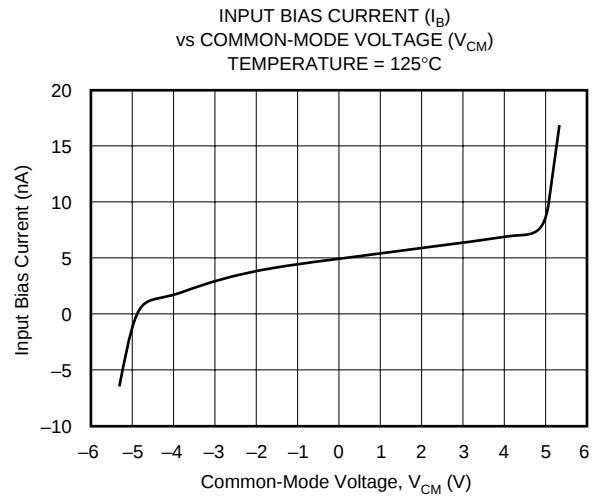
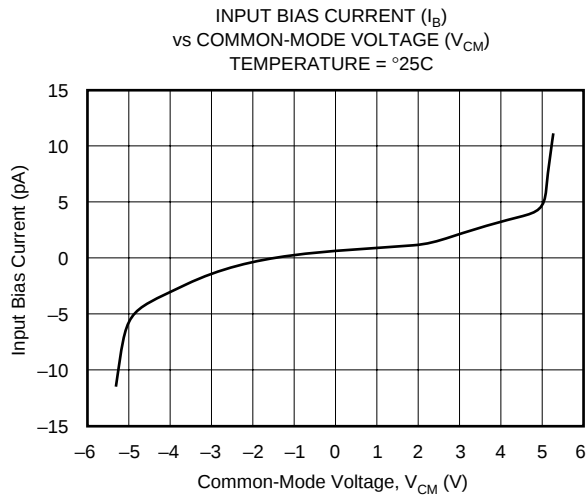
TYPICAL CHARACTERISTICS (Cont.)

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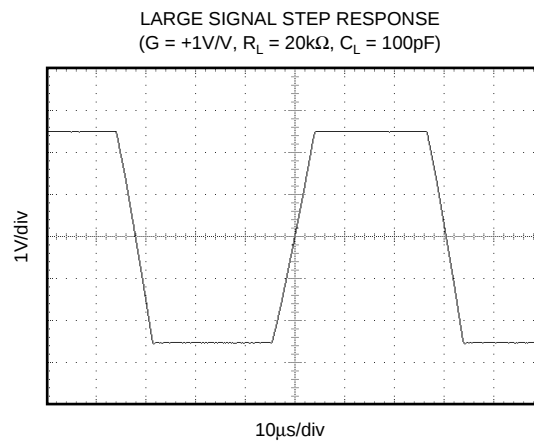
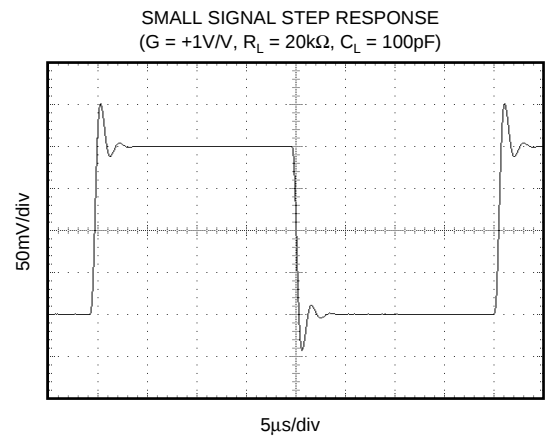
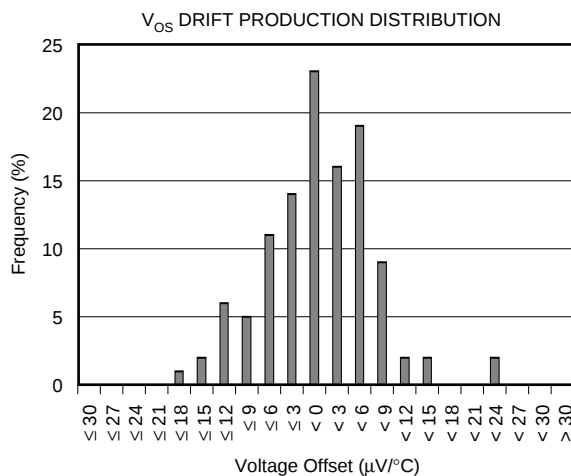
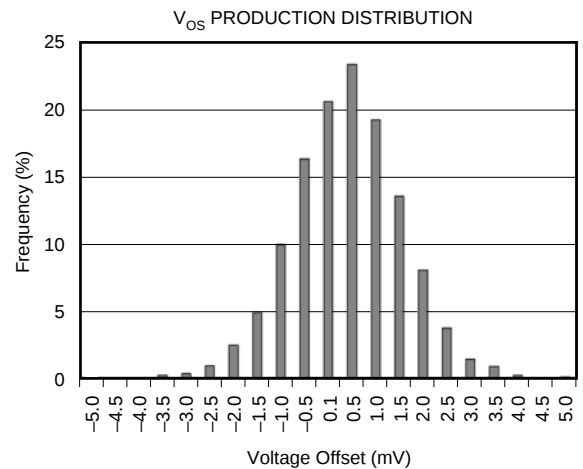
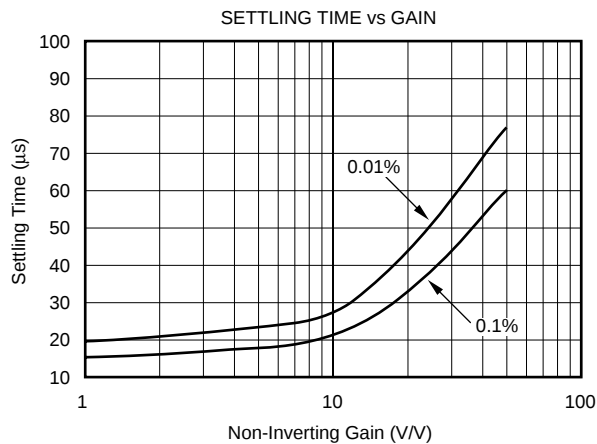
TYPICAL CHARACTERISTICS (Cont.)

At $T_A = +25^\circ\text{C}$, $V_S = \pm 5\text{V}$, and $R_L = 20\text{k}\Omega$, unless otherwise noted.



TYPICAL CHARACTERISTICS (Cont.)

At $T_A = +25^\circ\text{C}$, $V_S = \pm 5\text{V}$, and $R_L = 20\text{k}\Omega$, unless otherwise noted.



APPLICATIONS INFORMATION

OPA705 series op amps can operate on 160μA quiescent current from a single (or split) supply in the range of 4V to 12V ($\pm 2V$ to $\pm 6V$), making them highly versatile and easy to use. The OPA705 is unity-gain stable and offers 1MHz bandwidth and 0.6V/μs slew rate.

Rail-to-rail input and output swing helps maintain dynamic range, especially in low supply applications. Figure 1 shows the input and output waveforms for the OPA705 in unity-gain configuration. Operation is from a $\pm 5V$ supply with a 100kΩ load connected to $V_S/2$. The input is a 10Vp-p sinusoid. Output voltage is approximately 10Vp-p.

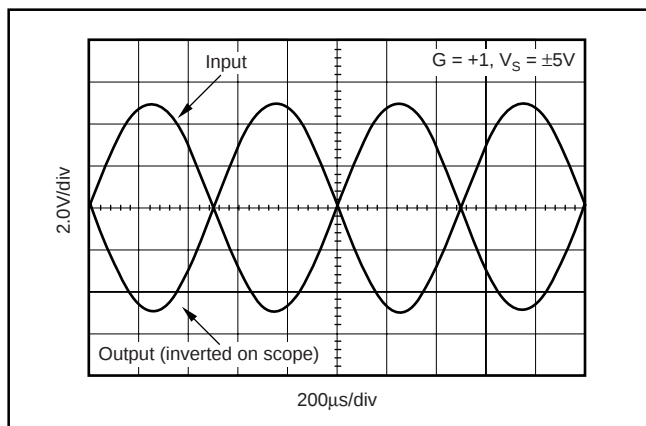


FIGURE 1. Rail-to-Rail Input and Output.

Power-supply pins should be bypassed with 1000pF ceramic capacitors in parallel with 1μF tantalum capacitors.

OPERATING VOLTAGE

OPA705 series op amps are fully specified and guaranteed from +4V to +12V over a temperature range of $-40^{\circ}C$ to $+85^{\circ}C$. Parameters that vary significantly with operating voltages or temperature are shown in the Typical Characteristics.

RAIL-TO-RAIL INPUT

The input common-mode voltage range of the OPA705 series extends 300mV beyond the supply rails at room temperature. This is achieved with a complementary input stage—an N-channel input differential pair in parallel with a P-channel differential pair, as shown in Figure 2. The N-channel pair is active for input voltages close to the positive rail, typically $(V+) - 2.0V$ to 300mV above the positive supply, while the P-channel pair is on for inputs from 300mV below the negative supply to approximately $(V+) - 1.5V$. There is a small transition region, typically $(V+) - 2.0V$ to $(V+) - 1.5V$, in which both pairs are on. This 500mV transition region can vary $\pm 100mV$ with process variation. Thus, the transition region (both stages on) can range from $(V+) - 2.1V$ to $(V+) - 1.4V$ on the low end, up to $(V+) - 1.9V$ to $(V+) - 1.6V$ on the high end. Within the 500mV transition region PSRR, CMRR, offset voltage, and offset drift, and THD may vary compared to operation outside this region.

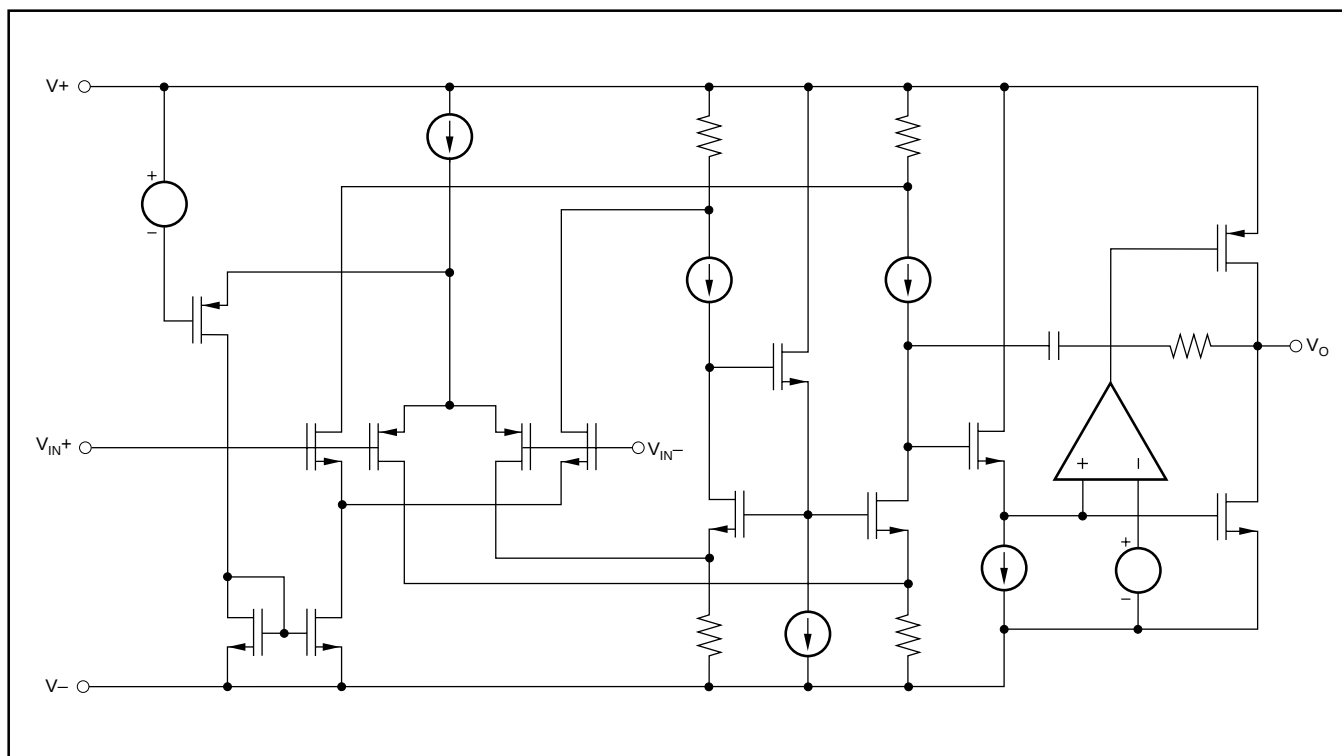


FIGURE 2. Simplified Schematic.

INPUT VOLTAGE

Device inputs are protected by ESD diodes that will conduct if the input voltages exceed the power supplies by more than approximately 300mV. Momentary voltages greater than 300mV beyond the power supply can be tolerated if the current is limited to 10mA. This is easily accomplished with an input resistor, as shown in Figure 3. Many input signals are inherently current-limited to less than 10mA; therefore, a limiting resistor is not always required. The OPA705 features no phase inversion when the inputs extend beyond supplies if the input current is limited, as seen in Figure 4.

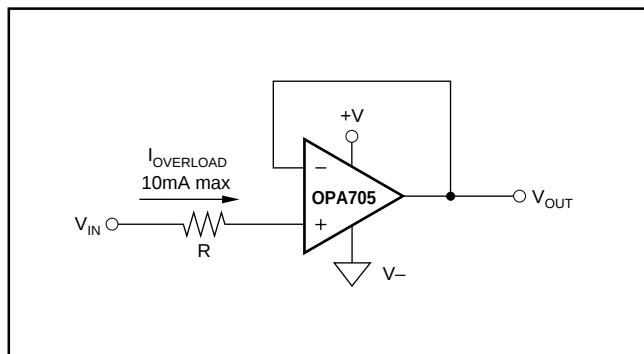


FIGURE 3. Input Current Protection for Voltages Exceeding the Supply Voltage.

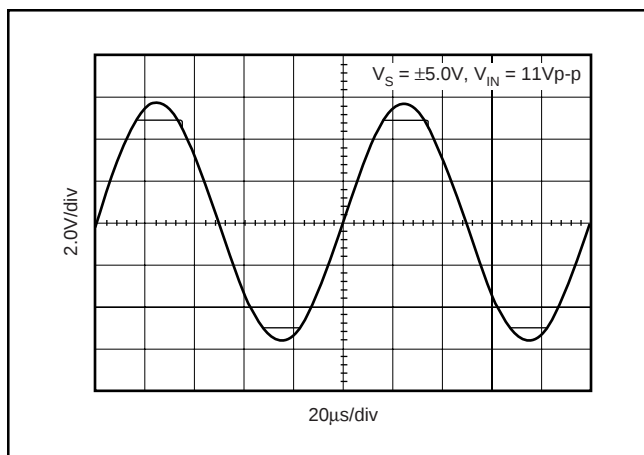


FIGURE 4. OPA705—No Phase Inversion with Inputs Greater than the Power-Supply Voltage.

RAIL-TO-RAIL OUTPUT

A class AB output stage with common-source transistors is used to achieve rail-to-rail output. This output stage is capable of driving 1kΩ loads connected to any point between V+ and ground. For light resistive loads (> 100kΩ), the output voltage can swing to 40mV from the supply rail. With moderate resistive loads (20kΩ), the output can swing to within 75mV from the supply rails while maintaining high open-loop gain (see the typical performance curve “Output Voltage Swing vs Output Current”).

CAPACITIVE LOAD AND STABILITY

The OPA705 series op amps can drive up to 1000pF pure capacitive load. Increasing the gain enhances the amplifier’s ability to drive greater capacitive loads (see the typical performance curve “Small Signal Overshoot vs Capacitive Load”).

One method of improving capacitive load drive in the unity-gain configuration is to insert a 10Ω to 20Ω resistor inside the feedback loop, as shown in Figure 5. This reduces ringing with large capacitive loads while maintaining DC accuracy.

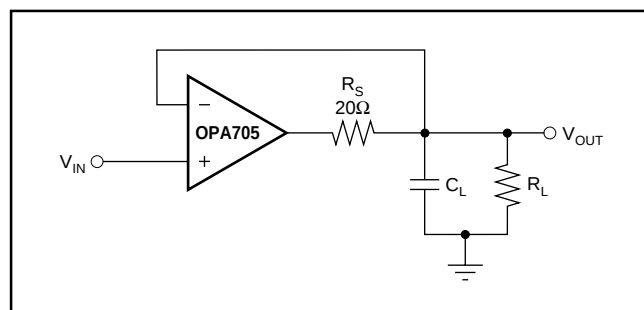


FIGURE 5. Series Resistor in Unity-Gain Buffer Configuration Improves Capacitive Load Drive.

APPLICATION CIRCUITS

The OPA705 series op amps are optimized for driving medium-speed sampling data converters. Figure 6 shows the OPA2705 in a dual-supply buffered reference configuration for the DAC7644. The DAC7644 is a 16-bit, low-power, quad-voltage output converter. Small size makes the combination ideal for automatic test equipment, data acquisition systems, and other low-power space-limited applications.

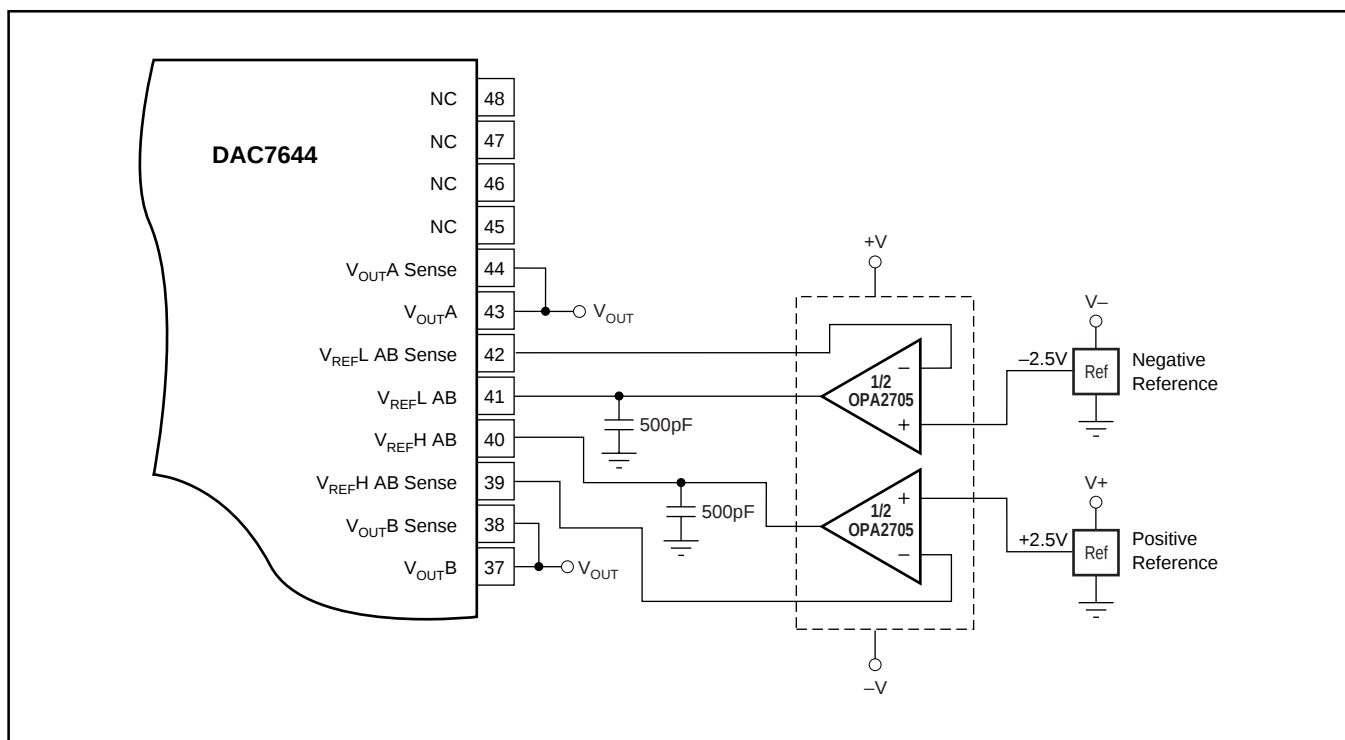


FIGURE 6. OPA705 as Dual Supply Configuration-Buffered References for the DAC7644.

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)
OPA2705EA/250	Active	Production	VSSOP (DGK) 8	250 SMALL T&R	Yes	Call TI Nipdauag	Level-2-260C-1 YEAR	-40 to 85	B05
OPA2705EA/250G4	Active	Production	VSSOP (DGK) 8	250 SMALL T&R	Yes	Call TI	Level-2-260C-1 YEAR	-40 to 85	B05
OPA2705PA	Active	Production	PDIP (P) 8	50 TUBE	Yes	NIPDAU	N/A for Pkg Type	-40 to 85	OPA2705PA
OPA2705UA	Active	Production	SOIC (D) 8	75 TUBE	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	OPA 2705UA
OPA2705UAG4	Active	Production	SOIC (D) 8	75 TUBE	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	OPA 2705UA
OPA4705EA/250	Active	Production	TSSOP (PW) 14	250 SMALL T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	OPA 4705EA
OPA4705EA/2K5	Active	Production	TSSOP (PW) 14	2500 LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	OPA 4705EA
OPA705NA/250	Active	Production	SOT-23 (DBV) 5	250 SMALL T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	A05
OPA705NA/3K	Active	Production	SOT-23 (DBV) 5	3000 LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	A05
OPA705PA	Active	Production	PDIP (P) 8	50 TUBE	Yes	NIPDAU	N/A for Pkg Type	-40 to 85	OPA705PA
OPA705UA	Active	Production	SOIC (D) 8	75 TUBE	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	OPA 705UA

⁽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.

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TAPE AND REEL INFORMATION



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
OPA4705EA/250	TSSOP	PW	14	250	180.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
OPA4705EA/2K5	TSSOP	PW	14	2500	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
OPA705NA/250	SOT-23	DBV	5	250	178.0	9.0	3.3	3.2	1.4	4.0	8.0	Q3
OPA705NA/3K	SOT-23	DBV	5	3000	178.0	9.0	3.23	3.17	1.37	4.0	8.0	Q3

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
OPA4705EA/250	TSSOP	PW	14	250	210.0	185.0	35.0
OPA4705EA/2K5	TSSOP	PW	14	2500	356.0	356.0	35.0
OPA705NA/250	SOT-23	DBV	5	250	180.0	180.0	18.0
OPA705NA/3K	SOT-23	DBV	5	3000	180.0	180.0	18.0

TUBE


*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (μm)	B (mm)
OPA2705PA	P	PDIP	8	50	506	13.97	11230	4.32
OPA2705UA	D	SOIC	8	75	506.6	8	3940	4.32
OPA2705UAG4	D	SOIC	8	75	506.6	8	3940	4.32
OPA705PA	P	PDIP	8	50	506	13.97	11230	4.32
OPA705UA	D	SOIC	8	75	506.6	8	3940	4.32

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