



# SC70, Low-Power, General-Purpose, Dual-Supply, Rail-to-Rail Op Amps

## General Description

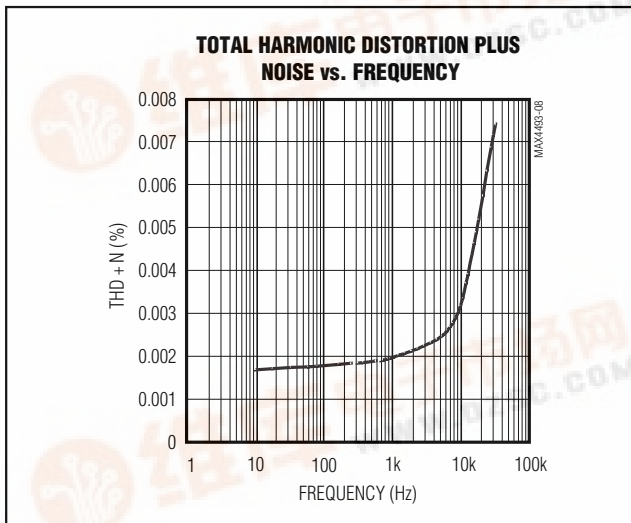
The MAX4493/MAX4494/MAX4495 single/dual/quad general-purpose operational amplifiers are designed for use in systems powered with dual supplies from  $\pm 2.25\text{V}$  to  $\pm 5.5\text{V}$ . These op amps provide a unity-gain bandwidth of 5MHz with only 770 $\mu\text{A}$  of quiescent current per amplifier. The wide input common-mode range extends from 200mV beyond the negative rail to within 1.5V of the positive supply rail while the output swings within 10mV ( $R_L = 100\text{k}\Omega$ ) of either rail.

These amplifiers have excellent (110dB) open-loop gain with very low THD+N of 0.002% ( $f = 1\text{kHz}$ ). The single MAX4493 is available in a tiny 5-pin SC70 package and the dual MAX4494 is available in the space-saving 8-pin SOT23. The quad MAX4495 is available in both 14-pin TSSOP and 14-pin SO packages. All products are rated at the automotive temperature range of  $-40^\circ\text{C}$  to  $+125^\circ\text{C}$ .

## Applications

- Battery-Powered Systems
- DAC Output Amplifiers
- Industrial Control Systems
- Voltage Reference Generators
- Signal Conditioning

## Typical Operating Characteristic



Typical Operating Circuit appears at end of data sheet.

Rail-to-Rail is a registered trademark of Nippon Motorola, Ltd.

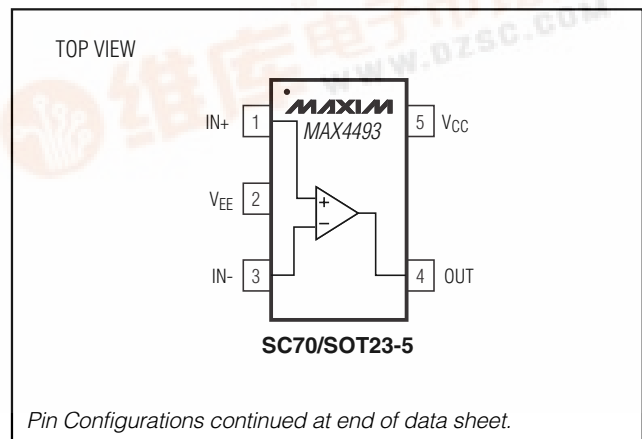
## Features

- 770 $\mu\text{A}$  Supply Current per Amplifier
- Operates from Dual  $\pm 2.25\text{V}$  to  $\pm 5.5\text{V}$  Supplies
- 5MHz Gain-Bandwidth Product
- Rail-to-Rail<sup>®</sup> Output Swing
- Input Voltage Range Extends 200mV Below the Negative Rail
- 110dB Open-Loop Gain ( $R_L = 100\text{k}\Omega$ )
- Low THD+N of 0.002% ( $f = 1\text{kHz}$ )
- No Phase Reversal for Overdriven Inputs
- Unity-Gain Stable
- Available in Space-Saving Packages
  - 5-Pin SC70 (MAX4493)
  - 8-Pin SOT23 (MAX4494)
  - 14-Pin TSSOP (MAX4495)

## Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE	TOP MARK
MAX4493AXK-T	$-40^\circ\text{C}$ to $+125^\circ\text{C}$	5 SC70-5	ABR
MAX4493AUK-T	$-40^\circ\text{C}$ to $+125^\circ\text{C}$	5 SOT23-5	ADPG
MAX4494AKA-T	$-40^\circ\text{C}$ to $+125^\circ\text{C}$	8 SOT23-8	AAEM
MAX4494AUA	$-40^\circ\text{C}$ to $+125^\circ\text{C}$	8 $\mu\text{MAX}$	—
MAX4494ASA	$-40^\circ\text{C}$ to $+125^\circ\text{C}$	8 SO	—
MAX4495AUD	$-40^\circ\text{C}$ to $+125^\circ\text{C}$	14 TSSOP	—
MAX4495ASD	$-40^\circ\text{C}$ to $+125^\circ\text{C}$	14 SO	—

## Pin Configurations



MAX4493/MAX4494/MAX4495

# SC70, Low-Power, General-Purpose, Dual-Supply, Rail-to-Rail Op Amps

## ABSOLUTE MAXIMUM RATINGS

Supply Voltage ( $V_{CC}$ to $V_{EE}$ ).....	+12V	8-Pin SOT23 (derate 9.1mW/°C above +70°C).....	727mW
Voltage from Any Pin to Ground or Any Other Pin.....	( $V_{EE} - 0.3V$ ) to ( $V_{CC} + 0.3V$ )	8-Pin $\mu$ MAX (derate 4.5mW/°C above +70°C).....	362mW
Output Short-Circuit Duration to $V_{CC}$ , $V_{EE}$ , or Ground .....	Continuous	8-Pin SO (derate 5.9mW/°C above +70°C).....	471mW
Continuous Power Dissipation ( $T_A = +70^\circ\text{C}$ )		14-Pin TSSOP (derate 9.1mW/°C above +70°C).....	727mW
5-Pin SC70 (derate 3.1mW/°C above +70°C).....	247mW	14-Pin SO (derate 8.3mW/°C above +70°C).....	667mW
5-Pin SOT23 (derate 7.1mW/°C above +70°C).....	571mW	Operating Temperature Range .....	-40°C to +125°C
		Storage Temperature Range .....	-65°C to +150°C
		Lead Temperature (soldering, 10s) .....	+300°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## DC ELECTRICAL CHARACTERISTICS

( $V_{CC} = +5V$ ,  $V_{EE} = -5V$ ,  $R_L = 100k\Omega$  to ground,  $T_A = -40^\circ\text{C}$  to  $+125^\circ\text{C}$ . Typical values are at  $T_A = +25^\circ\text{C}$ , unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Operating Supply Voltage Range	$V_S$	Guaranteed by PSRR test	$\pm 2.25$		$\pm 5.5$	V
Quiescent Supply Current per Amplifier	$I_S$			770	1100	$\mu\text{A}$
Input Offset Voltage	$V_{OS}$	$T_A = +25^\circ\text{C}$ $T_A = T_{MIN}$ to $T_{MAX}$		0.3	5	mV
Input Offset Voltage Drift	$TCV_{OS}$			3		$\mu\text{V}/^\circ\text{C}$
Input Offset Voltage Channel Matching		MAX4494 and MAX4495		1		mV
Input Bias Current	$I_B$			0.2	1	$\mu\text{A}$
Input Offset Current	$I_{OS}$			5	300	nA
Input Resistance	$R_{IN}$	Differential mode ( $-1V \leq V_{IN} \leq +1V$ ) Common mode ( $V_{EE} - 0.2V \leq V_{CM} \leq V_{CC} - 1.5V$ )		250		$k\Omega$ $M\Omega$
Common-Mode Input Voltage Range	$V_{CM}$	Guaranteed by CMRR test	$V_{EE} - 0.2V$		$V_{CC} - 1.5V$	V
Common-Mode Rejection Ratio	CMRR	$V_{EE} - 0.2V \leq V_{CM} \leq V_{CC} - 1.5V$	65	90		dB
Power-Supply Rejection Ratio	PSRR	$V_S = \pm 2.25V$ to $\pm 5.5V$	65	80		dB
Large-Signal Voltage Gain	$A_{VOL}$	$R_L = 100k\Omega$ , $V_{EE} + 0.25V \leq V_{OUT} \leq V_{CC} - 0.25V$ $R_L = 1k\Omega$ , $V_{EE} + 0.5V \leq V_{OUT} \leq V_{CC} - 0.5V$	85	110		dB
Output Voltage Swing	$V_{OUT}$	$R_L = 100k\Omega$ , $V_{CC} - V_{OH}$ and $V_{OL} - V_{EE}$ $R_L = 1k\Omega$ , $V_{CC} - V_{OH}$ and $V_{OL} - V_{EE}$		10	150	mV
Output Short-Circuit Current	$I_{SC}$	Sourcing or sinking		15		mA

**Note 1:** All devices are 100% production tested at  $T_A = +25^\circ\text{C}$ . Limits over the operating temperature range are guaranteed by design and not production tested.

# SC70, Low-Power, General-Purpose, Dual-Supply, Rail-to-Rail Op Amps

MAX4493/MAX4494/MAX4495

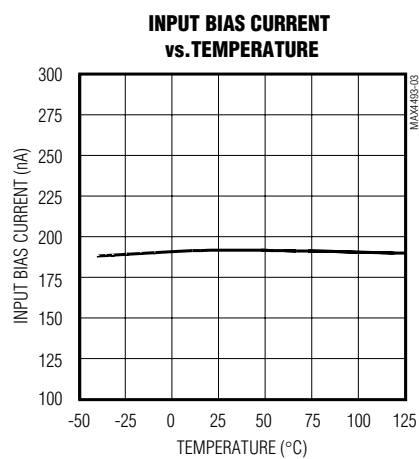
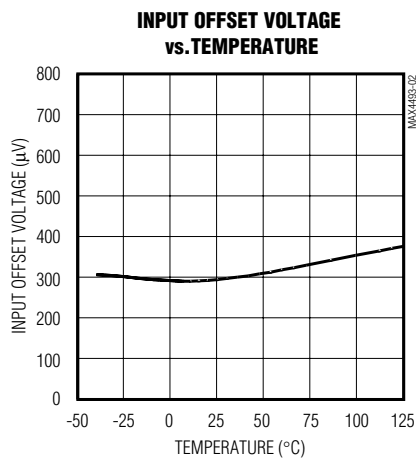
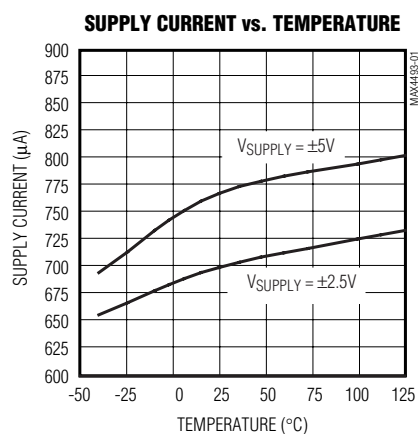
## AC ELECTRICAL CHARACTERISTICS

( $V_{CC} = +5V$ ,  $V_{EE} = -5V$ ,  $R_L = 100k\Omega$  to ground,  $C_L = 15pF$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Gain-Bandwidth Product	GBWP			5		MHz
Full-Power Bandwidth	FPBW	$V_{OUT} = 5Vp-p$		190		kHz
Slew Rate	SR	$V_{OUT} = 5Vp-p$		3		V/ $\mu s$
Phase Margin				75		degrees
Gain Margin				15		dB
Total Harmonic Distortion Plus Noise	THD+N	$f = 1kHz$ , $V_{OUT} = 5Vp-p$ , $A_V = +1V/V$		0.002		%
Settling Time to 0.01%	$t_S$	$A_V = +1V/V$ , $V_{OUT} = 5V$ step		4		$\mu s$
Input Capacitance	$C_{IN}$			2		pF
Input Noise Voltage Density	$e_{IN}$	$f = 1kHz$		8		nV/ $\sqrt{Hz}$
Input Noise Current Density	$i_{IN}$	$f = 1kHz$		0.2		pA/ $\sqrt{Hz}$
All-Hostile Crosstalk		$f = 1kHz$ , MAX4494 and MAX4495		-100		dB
Capacitive-Load Stability		$A_V = +1V/V$ , no sustained oscillations		300		pF
Power-Up Time	$t_{ON}$	$V_{OUT} = 1V$ , $1\mu s$ power supply rise-time		3		$\mu s$

## Typical Operating Characteristics

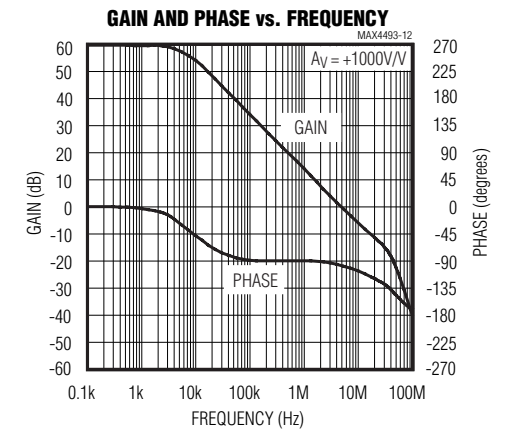
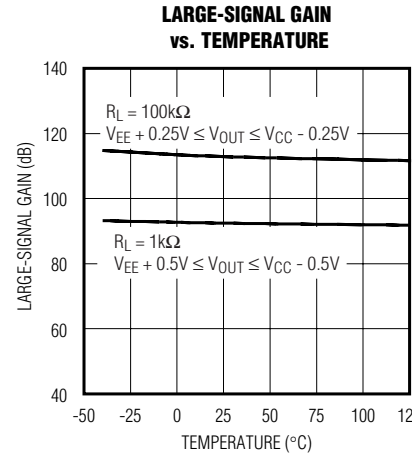
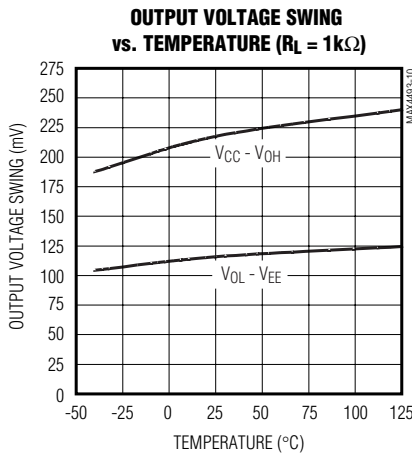
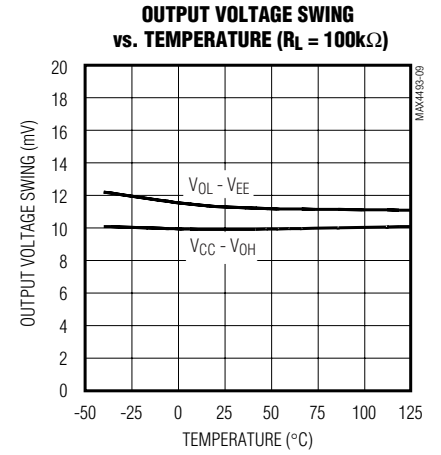
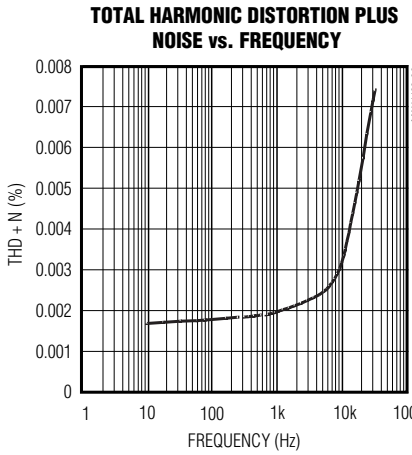
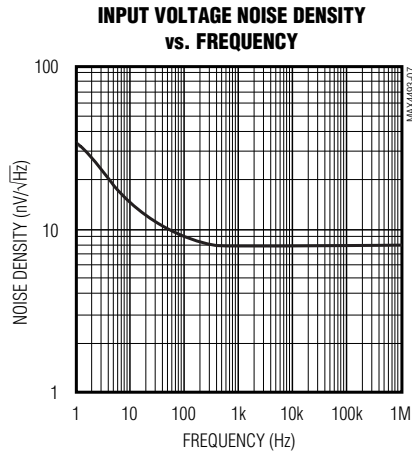
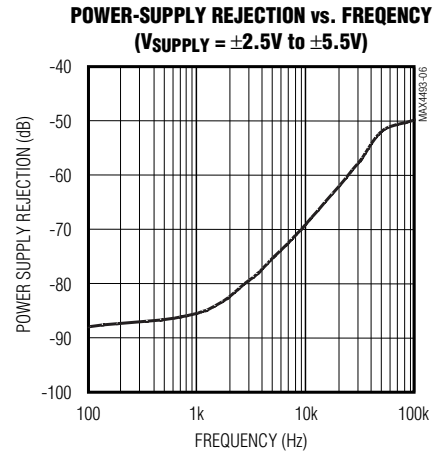
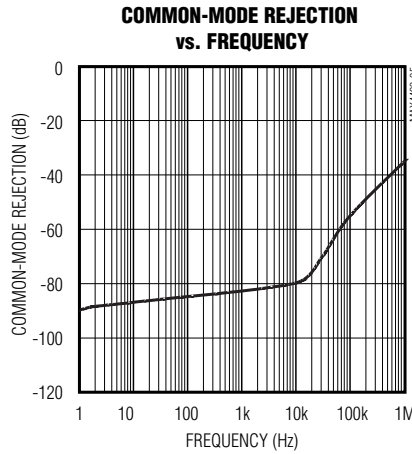
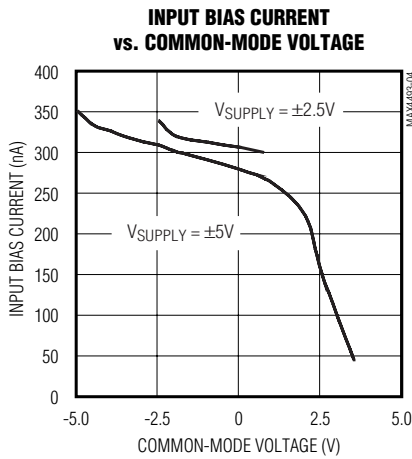
( $V_{CC} = +5V$ ,  $V_{EE} = -5V$ ,  $V_{CM} = 0$ ,  $R_L = 100k\Omega$  to ground,  $C_L = 15pF$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



# SC70, Low-Power, General-Purpose, Dual-Supply, Rail-to-Rail Op Amps

## Typical Operating Characteristics (continued)

( $V_{CC} = +5V$ ,  $V_{EE} = -5V$ ,  $V_{CM} = 0$ ,  $R_L = 100k\Omega$  to ground,  $C_L = 15pF$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

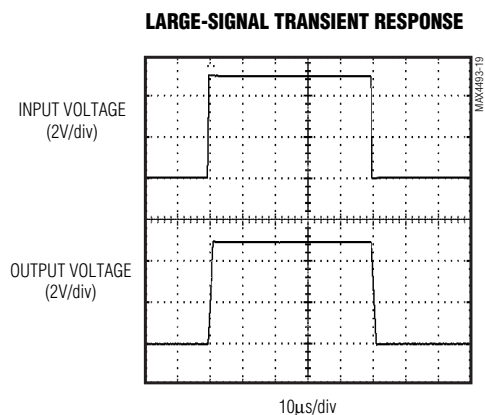
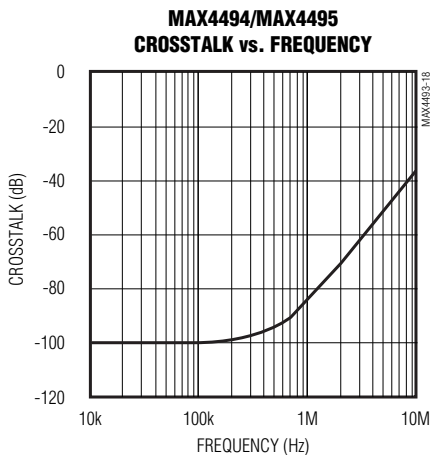
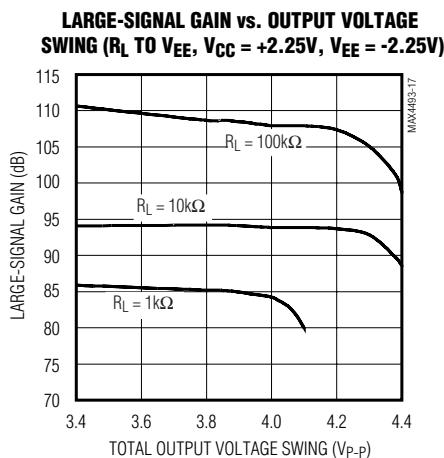
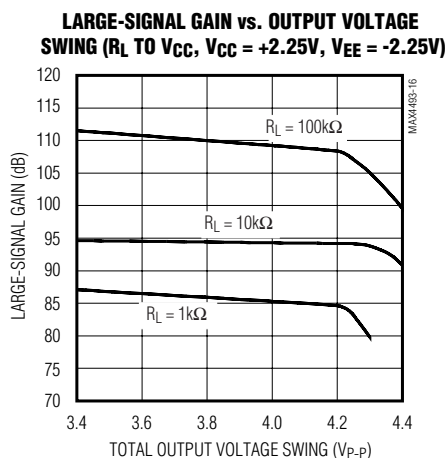
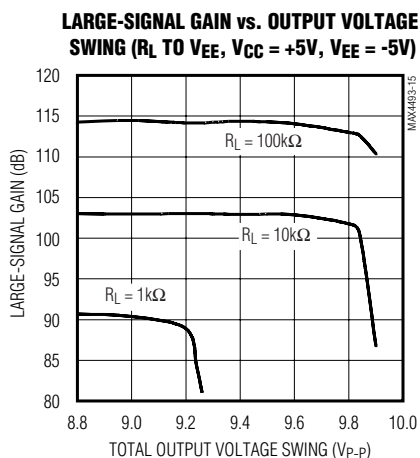
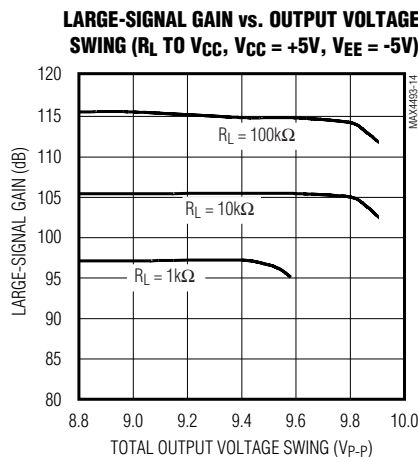
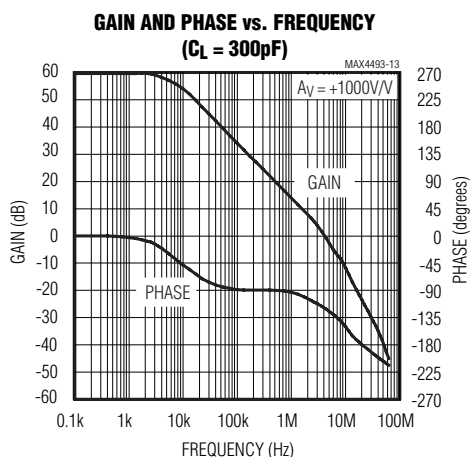


# SC70, Low-Power, General-Purpose, Dual-Supply, Rail-to-Rail Op Amps

## Typical Operating Characteristics (continued)

( $V_{CC} = +5V$ ,  $V_{EE} = -5V$ ,  $V_{CM} = 0$ ,  $R_L = 100k\Omega$  to ground,  $C_L = 15pF$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

MAX4493/MAX4494/MAX4495

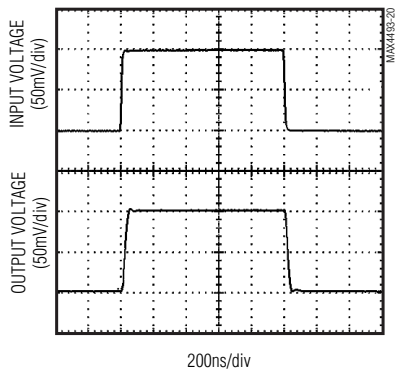


# SC70, Low-Power, General-Purpose, Dual-Supply, Rail-to-Rail Op Amps

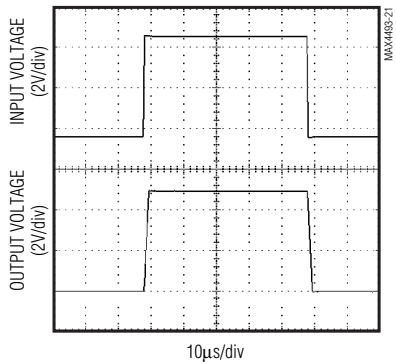
## Typical Operating Characteristics (continued)

( $V_{CC} = +5V$ ,  $V_{EE} = -5V$ ,  $V_{CM} = 0$ ,  $R_L = 100k\Omega$  to ground,  $C_L = 15pF$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

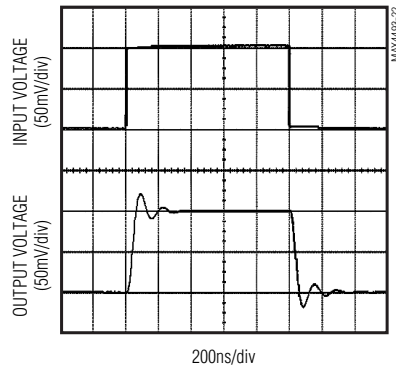
**SMALL-SIGNAL TRANSIENT RESPONSE**



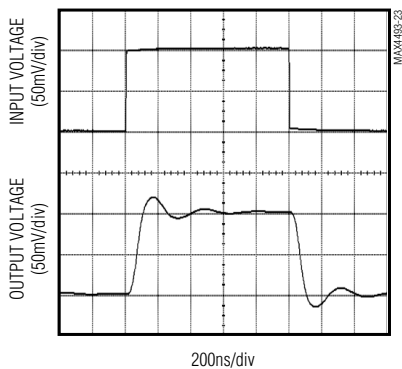
**LARGE-SIGNAL CAPACITIVE-LOAD STABILITY ( $C_L = 1200pF$ )**



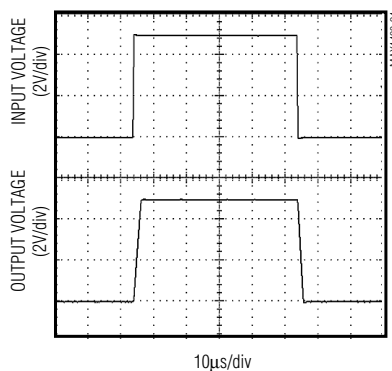
**SMALL-SIGNAL CAPACITIVE-LOAD STABILITY ( $C_L = 300pF$ )**



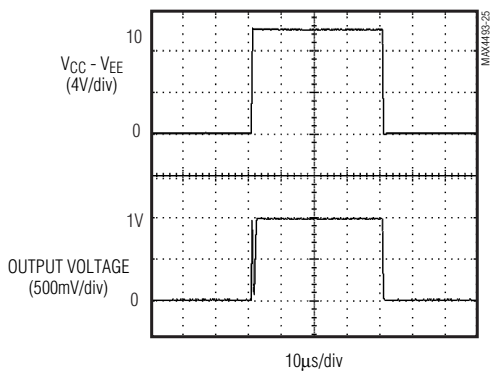
**SMALL-SIGNAL TRANSIENT RESPONSE ( $R_{ISO} = 15\Omega$ ,  $C_L = 1000pF$ )**



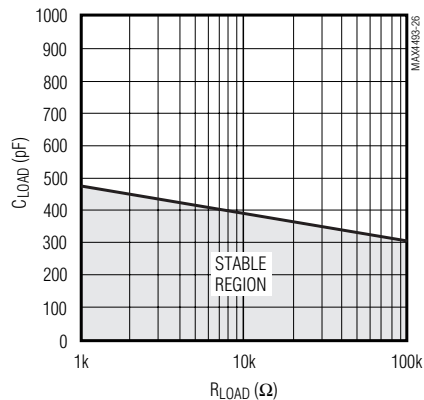
**LARGE-SIGNAL TRANSIENT RESPONSE ( $R_{ISO} = 15\Omega$ ,  $C_L = 0.01\mu F$ )**



**POWER-UP TIME ( $V_{IN} = +1V$ )**



**STABILITY vs. CAPACITIVE AND RESISTIVE LOADS**



# SC70, Low-Power, General-Purpose, Dual-Supply, Rail-to-Rail Op Amps

MAX4493/MAX4494/MAX4495

## Pin Description

PIN			NAME	FUNCTION
MAX4493	MAX4494	MAX4495		
—	1	1	OUTA	Channel A Output
—	2	2	INA-	Channel A Inverting Input
—	3	3	INA+	Channel A Noninverting Input
—	7	7	OUTB	Channel B Output
—	6	6	INB-	Channel B Inverting Input
—	5	5	INB+	Channel B Noninverting Input
—	—	8	OUTC	Channel C Output
—	—	9	INC-	Channel C Inverting Input
—	—	10	INC+	Channel C Noninverting Input
—	—	14	OUTD	Channel D Output
—	—	13	IND-	Channel D Inverting Input
—	—	12	IND+	Channel D Noninverting Input
4	—	—	OUT	Output
1	—	—	IN+	Noninverting Input
3	—	—	IN-	Inverting Input
5	8	4	VCC	Positive Supply
2	4	11	VEE	Negative Supply

## Applications Information

### Rail-to-Rail Output Stage

The MAX4493/MAX4494/MAX4495 output stage can drive up to 1kΩ and still swing within 200mV of the rails.

### Capacitive-Load Stability

Driving large capacitive loads can cause instability in many op amps. The MAX4493/MAX4494/MAX4495 are stable with capacitive loads up to 300pF. The

Capacitive-Load Stability graph in the *Typical Operating Characteristics* gives the stable operation region for capacitive versus resistive load. Stability with higher capacitive loads can be improved by adding an isolation resistor in series with the op-amp output, as shown in Figure 1. This resistor improves the circuit's phase margin by isolating the load capacitor from the amplifier's output. As seen in the *Typical Operating Characteristics*, driving capacitive loads with an isolation resistor exhibits some overshoot, but no oscillation.

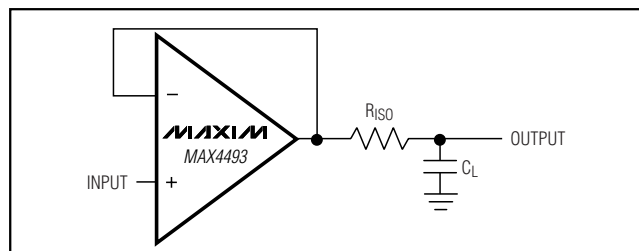


Figure 1. Capacitive Load Driving Circuit

### Full-Power Bandwidth

The FPBW is given by:

$$FPBW(\text{Hz}) = \frac{SR}{\pi [V_{OUTp-p(\text{max})}]}$$

# SC70, Low-Power, General-Purpose, Dual-Supply, Rail-to-Rail Op Amps

where the slew rate (SR) is  $3\text{V}/\mu\text{s}$ . Figure 2 shows the full-power bandwidth as a function of the peak-to-peak AC output voltage.

### Power-Up Conditions

The MAX4493/MAX4494/MAX4495 typically settle within  $3\mu\text{s}$  after power-up. See Power-Up Time in *Typical Operating Characteristics*.

### Power Supplies and Layout

The MAX4493/MAX4494/MAX4495 operate with dual supplies from  $\pm 2.25\text{V}$  to  $\pm 5.5\text{V}$ . Bypass both  $V_{CC}$  and  $V_{EE}$  with their own  $0.1\mu\text{F}$  capacitor to ground.

Good layout technique helps optimize performance by decreasing the amount of stray capacitance at the op amp's inputs and outputs. To decrease stray capacitance, minimize trace lengths by placing external components close to the op amp's pins.

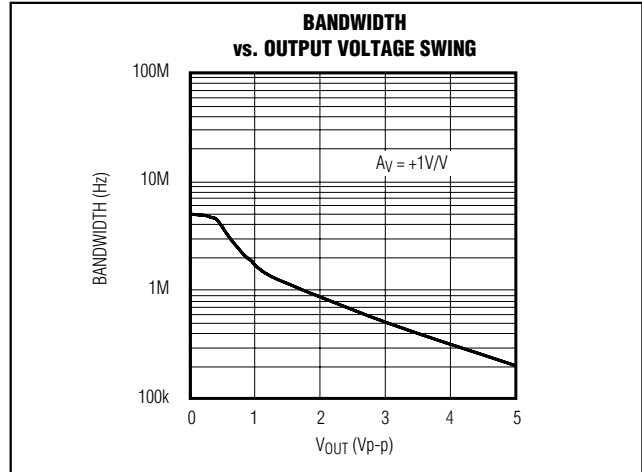
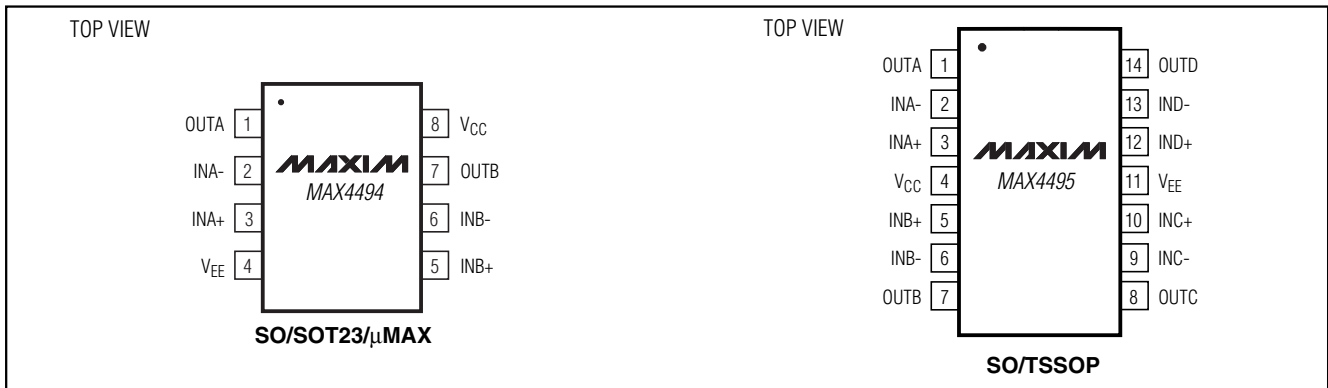
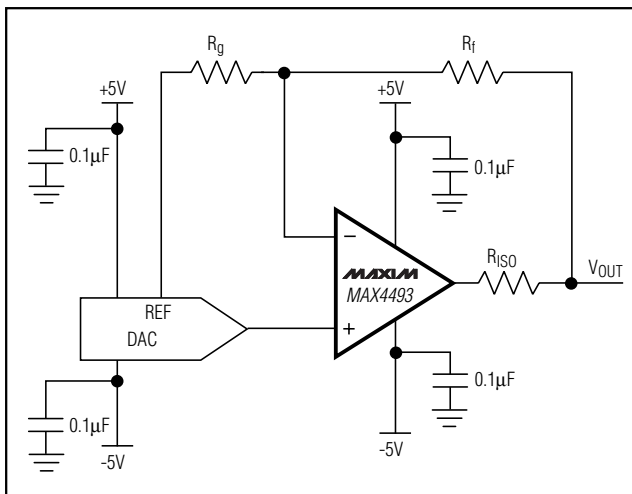


Figure 2. Bandwidth vs. Peak-to-Peak AC Voltage Plot

## Pin Configurations (continued)



## Typical Operating Circuit



## Chip Information

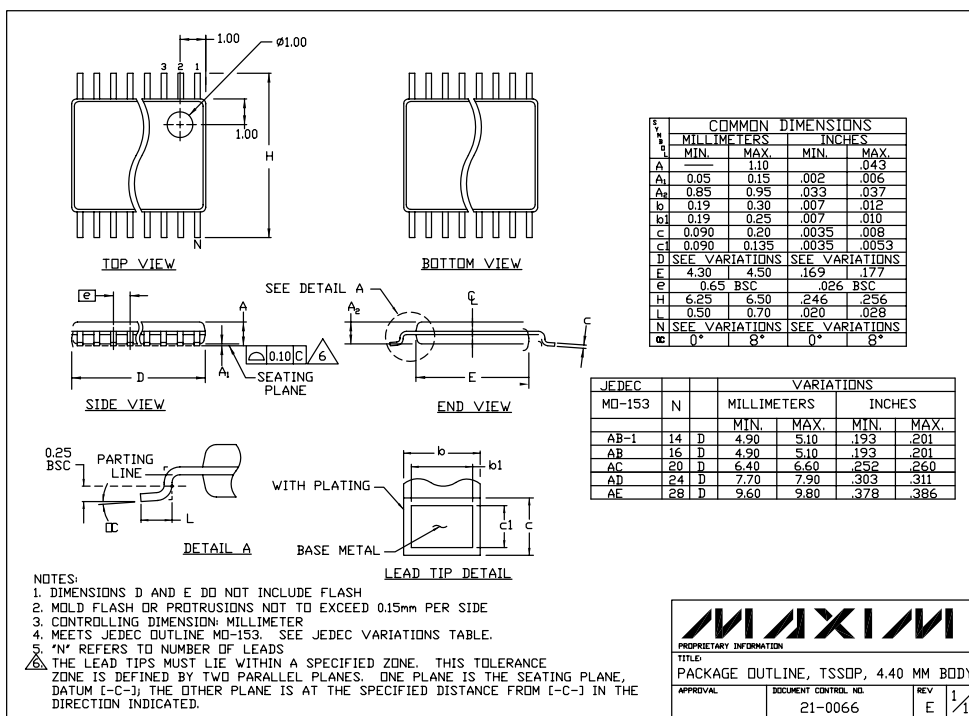
MAX4493 TRANSISTOR COUNT: 81  
 MAX4494 TRANSISTOR COUNT: 159  
 MAX4495 TRANSISTOR COUNT: 318  
 PROCESS: Bipolar



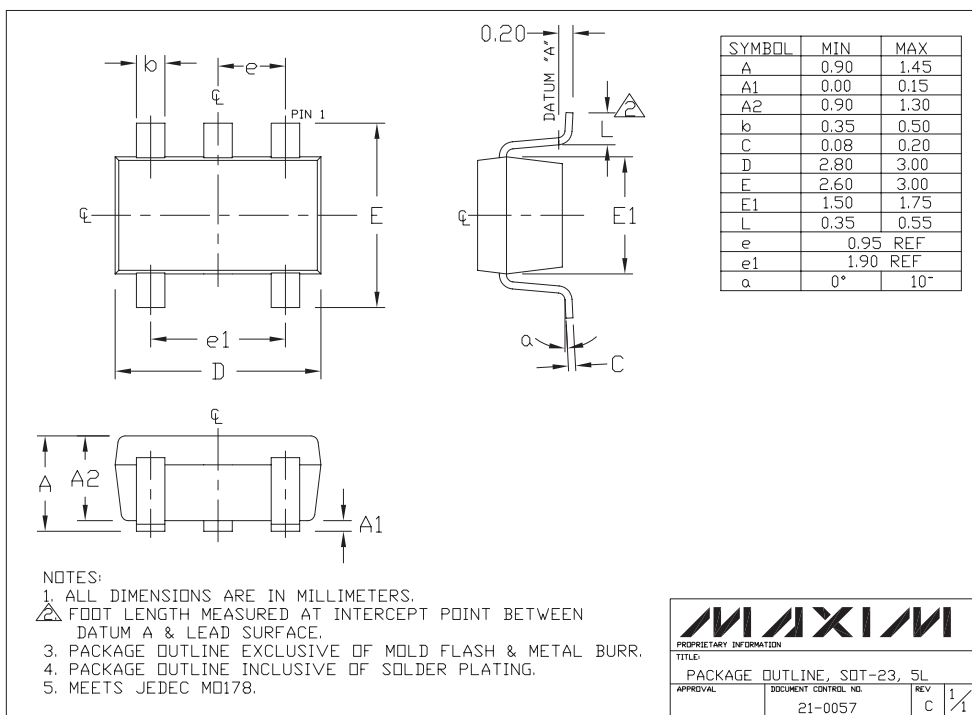
# SC70, Low-Power, General-Purpose, Dual-Supply, Rail-to-Rail Op Amps

## Package Information

MAX4493/MAX4494/MAX4495



TSSOP, NO PADS, EPS



SOT-23, 5L

# SC70, Low-Power, General-Purpose, Dual-Supply, Rail-to-Rail Op Amps

## Package Information (continued)

SYMBOL	MIN	MAX
e	0.65	BSC
D	1.80	2.20
b	0.15	0.30
E	1.15	1.35
HE	1.80	2.40
Q1	0.10	0.40
A2	0.80	1.00
A1	0.00	0.10
A	0.80	1.10
c	0.10	0.18
L	0.10	0.30
L1	0.425 TYP.	

NOTE:  
 1. ALL DIMENSIONS ARE IN MILLIMETERS  
 2. DIMENSIONS ARE INCLUSIVE OF PLATING  
 3. DIMENSIONS ARE EXCLUSIVE OF MOLD FLASH & METAL BURR  
 4. ALL SPECIFICATIONS COMPLY TO EIAJ SC70  
 5. COPLANARITY 4 MILS. MAX.

**MAXIM**  
 PROPRIETARY INFORMATION  
 TITLE: PACKAGE OUTLINE, SC70, 5L  
 APPROVAL: DOCUMENT CONTROL: NS  
 21-0076 REV B 1/1

SC70, 5L EPS

INCHES		MILLIMETERS		
MIN	MAX	MIN	MAX	
A	0.053	0.069	1.35	1.75
A1	0.004	0.010	0.10	0.25
B	0.014	0.019	0.35	0.49
C	0.007	0.010	0.19	0.25
e	0.050		1.27	
E	0.150	0.157	3.80	4.00
H	0.228	0.244	5.80	6.20
h	0.010	0.020	0.25	0.50
L	0.016	0.050	0.40	1.27

INCHES		MILLIMETERS		N	MS012
MIN	MAX	MIN	MAX		
D	0.189	0.197	4.80	5.00	8 A
D	0.337	0.344	8.55	8.75	14 B
D	0.386	0.394	9.80	10.00	16 C

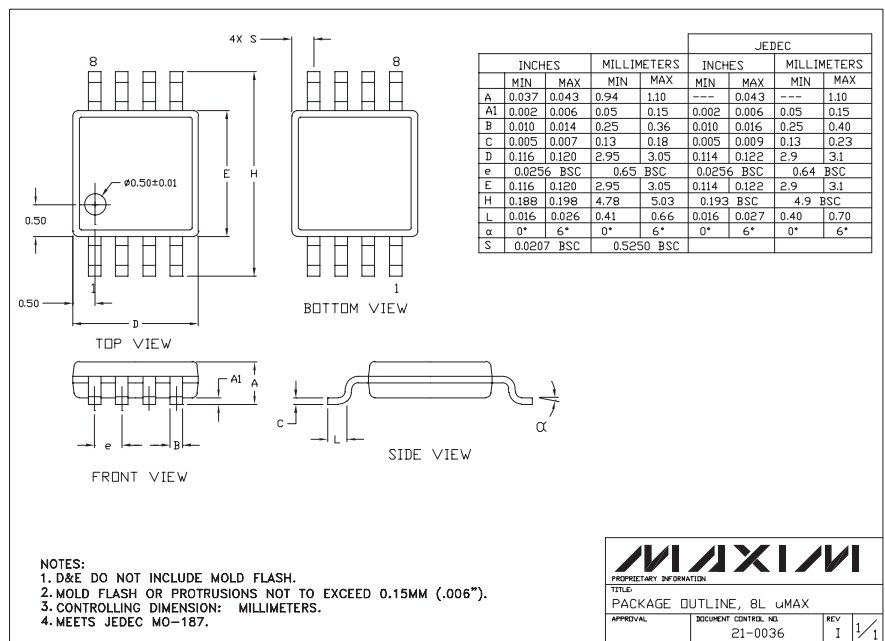
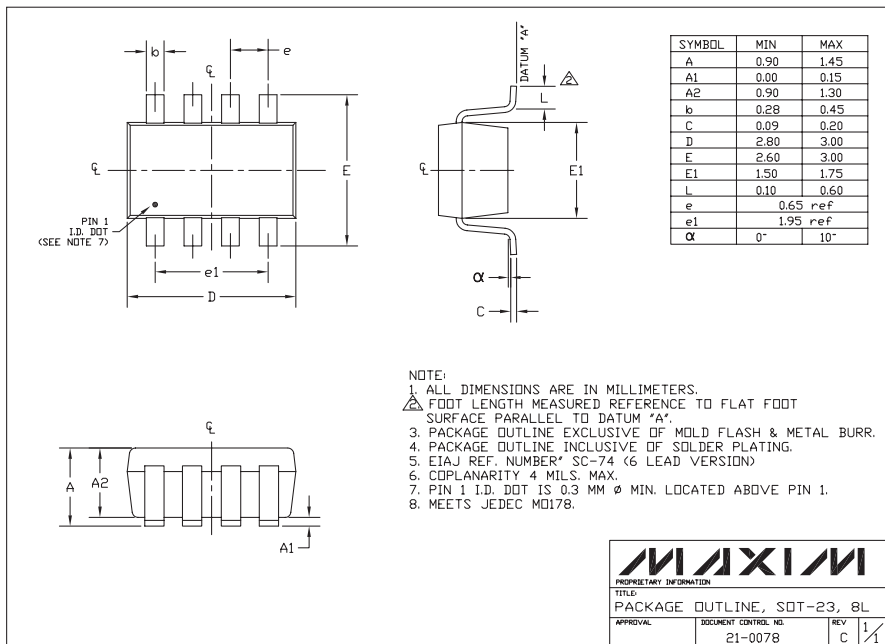
NOTES:  
 1. D&E DO NOT INCLUDE MOLD FLASH  
 2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15mm (.006")  
 3. LEADS TO BE COPLANAR WITHIN .102mm (.004")  
 4. CONTROLLING DIMENSION: MILLIMETER  
 5. MEETS JEDEC MS012-XX AS SHOWN IN ABOVE TABLE  
 6. N = NUMBER OF PINS

**MAXIM**  
 PROPRIETARY INFORMATION  
 TITLE: PACKAGE FAMILY OUTLINE: SOIC .150°  
 21-0041 A  
 APPROVAL: DOCUMENT CONTROL: NS

# SC70, Low-Power, General-Purpose, Dual-Supply, Rail-to-Rail Op Amps

## Package Information (continued)

MAX4493/MAX4494/MAX4495



Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.

Maxim Integrated Products, 120 San Gabriel Drive, Sunnyvale, CA 94086 408-737-7600 11