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19-1525; Rev 2; 4/01

Low-Cost, High-Slew-Rate, Rail-to-Rail I/O Op Amps in SC70

General Description

The MAX4490/MAX4491/MAX4492 single/dual/quad, low-cost CMOS op amps feature Rail-to-Rail® input and output capability from either a single 2.7V to 5.5V supply or dual ±1.35V to ±2.75V supplies. These amplifiers exhibit a high slew rate of 10V/µs and a gain-bandwidth product of 10MHz. They can drive 2kΩ resistive loads to within 55mV of either supply rail and remain unity-gain stable with capacitive loads up to 300pF.

The MAX4490 is offered in the ultra-small, 5-pin SC70 package, which is 50% smaller than the standard 5-pin SOT23 package. Specifications for all parts are guaranteed over the automotive (-40°C to +125°C) temperature range.

Applications

Battery-Powered Instruments
Portable Equipment
Audio Signal Conditioning
Low-Power/Low-Voltage Applications
Sensor Amplifiers
RF Power Amplifier Control
High-Side/Low-Side Current Sensors

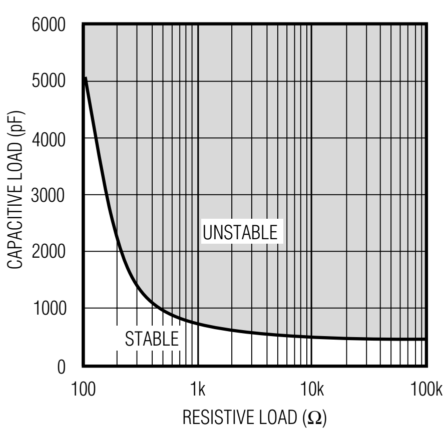
Features

- ♦ **2.7V to 5.5V Single-Supply Operation**
- ♦ **10V/µs Slew Rate**
- ♦ **Rail-to-Rail Input Common-Mode Voltage Range**
- ♦ **Rail-to-Rail Output Voltage Swing**
- ♦ **10MHz Gain-Bandwidth Product**
- ♦ **Unity-Gain Stable with Capacitive Loads Up to 300pF**
- ♦ **50pA Input Bias Current**
- ♦ **Ultra-Small, 5-Pin SC70 Package (MAX4490)**

Ordering Information

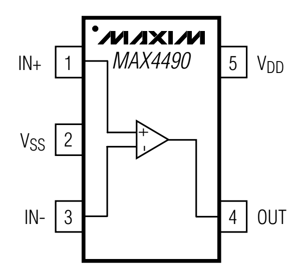
PART	TEMP RANGE	PIN-PACKAGE	TOP MARK
MAX4490AXK-T	-40°C to +125°C	5 SC70-5	AAB
MAX4490AUK-T	-40°C to +125°C	5 SOT23-5	ADKQ
MAX4491AKA-T	-40°C to +125°C	8 SOT23-5	AADB
MAX4491AUA	-40°C to +125°C	8 µMAX	—
MAX4492AUD	-40°C to +125°C	14 TSSOP	—
MAX4492ASD	-40°C to +125°C	14 SO	—

Capacitive-Load Stability



Pin Configurations/ Functional Diagrams

TOP VIEW



SOT23-5/SC70-5

Pin Configurations continued at end of data sheet.

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

ABSOLUTE MAXIMUM RATINGS

Supply Voltage (V_{DD} to V_{SS})..6V
All Other Pins ....(V_{SS} - 0.3V) to (V_{DD} + 0.3V)
Output Short-Circuit Duration 10s
Continuous Power Dissipation (T_A = +70°C)
5-Pin SC70 (derate 2.5mW/°C above +70°C)............ 200mW
5-Pin SOT23 (derate 7.1mW/°C above +70°C).......... 571mW
8-Pin SOT23 (derate 5.26mW/°C above +70°C)........421 mW
8-Pin µMAX (derate 4.1mW/°C above +70°C)........... 330mW
14-Pin TSSOP (derate 8.3mW/°C above +70°C) 667mW
14-Pin SO (derate 8.3mW/°C above +70°C)............. 667mW
Operating Temperature Range .... -40°C to +125°C
Junction Temperature .... +150°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.

ELECTRICAL CHARACTERISTICS

(V_{DD} = 5V, V_{SS} = 0, V_{CM} = 0, V_{OUT} = V_{DD}/2, R_L = 100kΩ connected to V_{DD}/2, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 1)

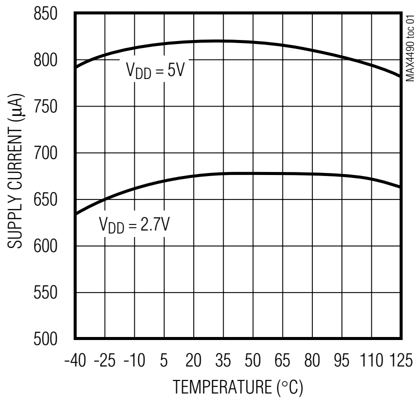
PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Supply Voltage Range	V_{DD}	(Note 2)		2.7		5.5	V
Supply Current (per amplifier)	I_S				0.8	2	mA
Input Offset Voltage	V_{OS}	(Note 3)	T_A = +25°C		±1.5	±10	mV
			T_A = T_{MIN} to T_{MAX}			16	
Input Bias Current	I_B	(Note 3)			±0.05	±2.5	nA
Input Offset Current	I_{OS}	(Note 3)			±0.05	±2.5	nA
Input Resistance	R_{IN}				1000		MΩ
Input Common-Mode Range	V_{CM}	Inferred from CMRR test		V_{SS}		V_{DD}	V
Common-Mode Rejection Ratio	CMRR	$V_{SS} \le V_{CM} \le V_{DD}$		54	75		dB
Power-Supply Rejection Ratio	PSRR	$2.7V \le V_{DD} \le 5.5V$		65	100		dB
Large-Signal Voltage Gain	A_V	(V_{SS} + 0.25V) ≤ V_{OUT} ≤ (V_{DD} - 0.25V)	R_L = 100kΩ		110		dB
			R_L = 2kΩ	65	85		
Output-Voltage Swing High	V_{OH}	Specified as V_{DD} - V_{OH}	R_L = 100kΩ		1.5		mV
			R_L = 2kΩ		55	200	
Output-Voltage Swing Low	V_{OL}	Specified as V_{OL} - V_{SS}	R_L = 100kΩ		1.5		mV
			R_L = 2kΩ		35	150	
Output Short-Circuit Current	$I_{OUT(SC)}$	Sourcing or sinking			±50		mA
Gain-Bandwidth Product	GBWP	C_L = 10pF			10		MHz
Input Capacitance	C_{IN}				5		pF
Phase Margin		C_L = 10pF			60		degrees
Gain Margin		C_L = 10pF			10		dB
Slew Rate	SR	Measured from 10% to 90% of $4V_{P-P}$ step			10		V/µs
Voltage-Noise Density	e_n	f = 10kHz			12		$nV/\sqrt{Hz}$
Current-Noise Density	i_n	f = 10kHz			1		$fA\sqrt{Hz}$
Capacitive-Load Drive		$A_{V(CL)}$ = 1, no sustained oscillations			300		pF

Note 1: All units production tested at T_A = +25°C. Limits over temperature guaranteed by design.
Note 2: Guaranteed by the Power-Supply Rejection Ratio (PSRR) test.
Note 3: Input Offset Voltage, Input Bias Current, and Input Offset Current are all tested and guaranteed at both ends of the common-mode range.

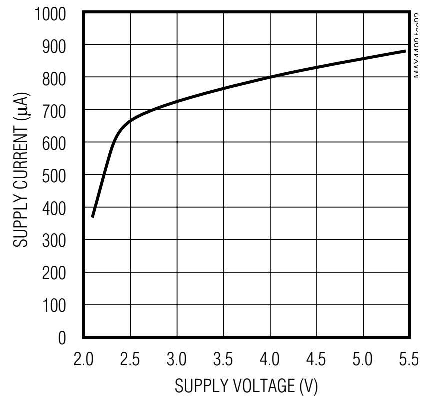
Typical Operating Characteristics

(V_{DD} = 5V, V_{SS} = 0, V_{CM} = V_{DD}/2, R_L = 100kΩ to V_{DD}/2, T_A = +25°C, unless otherwise noted.)

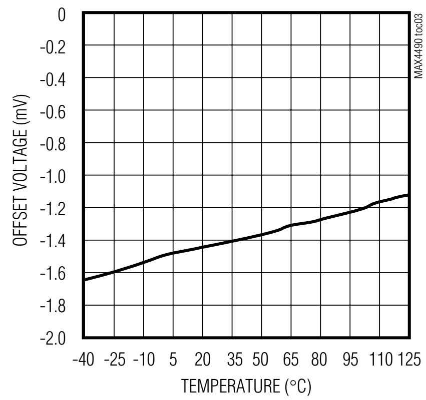
SUPPLY CURRENT PER AMPLIFIER vs. TEMPERATURE



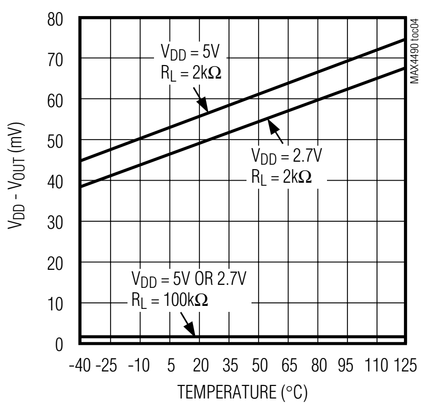
SUPPLY CURRENT PER AMPLIFIER vs. SUPPLY VOLTAGE



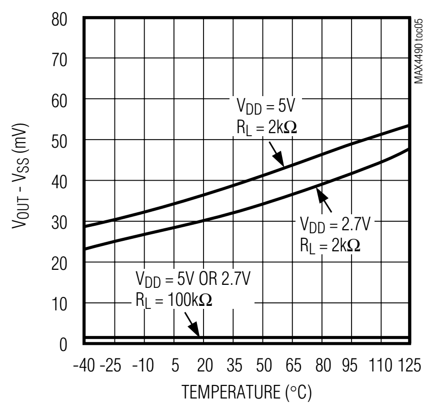
INPUT OFFSET VOLTAGE vs. TEMPERATURE



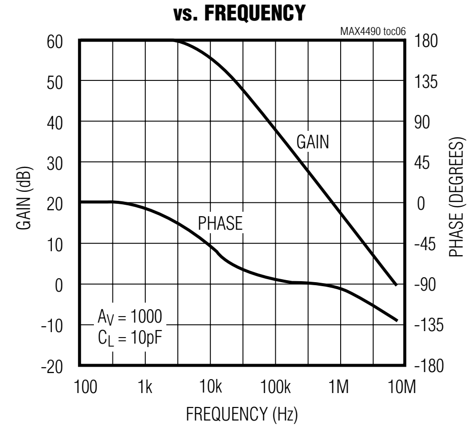
OUTPUT SWING HIGH vs. TEMPERATURE



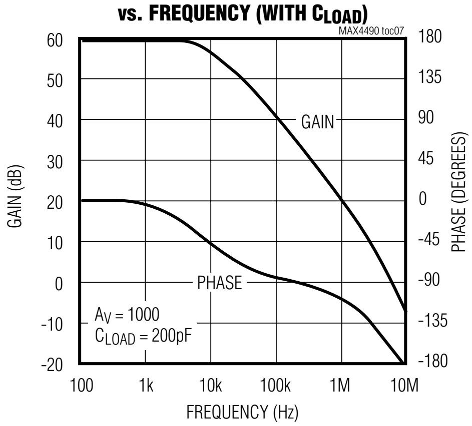
OUTPUT SWING LOW vs. TEMPERATURE



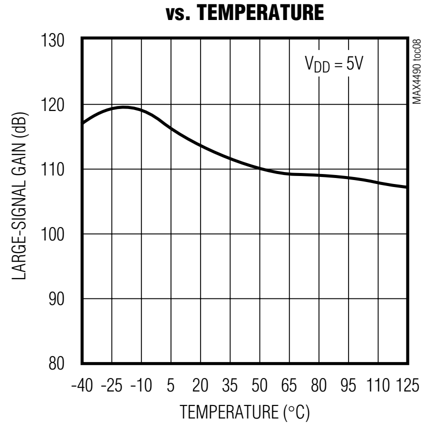
OP AMP GAIN AND PHASE vs. FREQUENCY



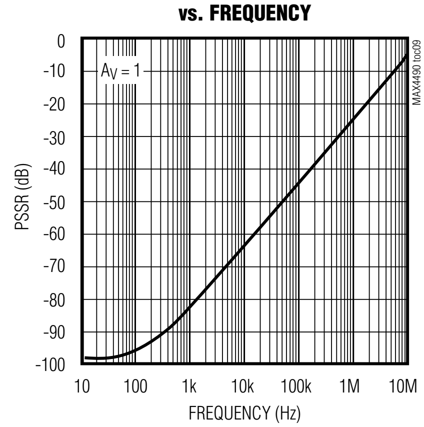
GAIN AND PHASE vs. FREQUENCY (WITH C_{LOAD})



LARGE-SIGNAL GAIN vs. TEMPERATURE



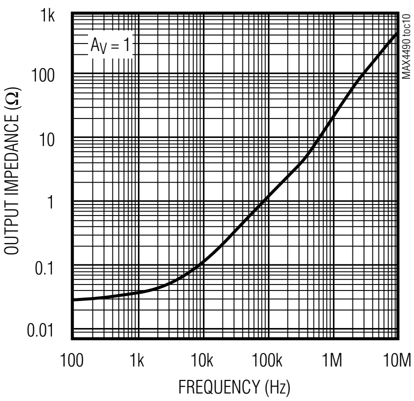
POWER-SUPPLY REJECTION RATIO vs. FREQUENCY



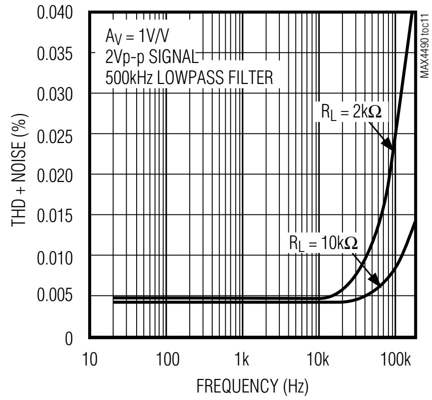
Typical Operating Characteristics (continued)

(V_{DD} = 5V, V_{SS} = 0, V_{CM} = V_{DD}/2, R_L = 100kΩ to V_{DD}/2, T_A = +25°C, unless otherwise noted.)

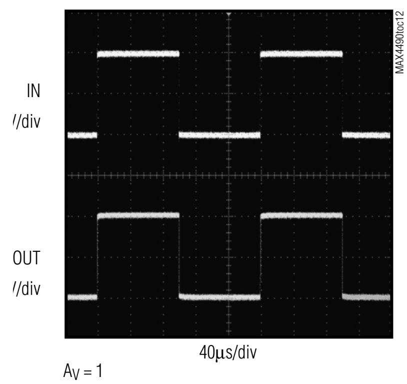
OUTPUT IMPEDANCE vs. FREQUENCY



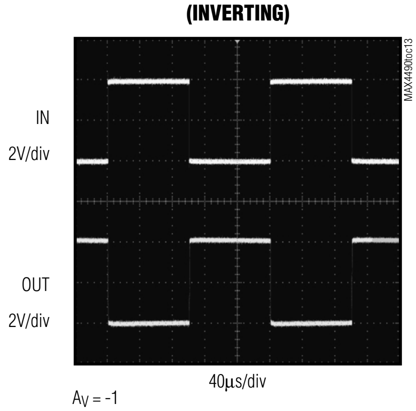
TOTAL HARMONIC DISTORTION PLUS NOISE vs. FREQUENCY



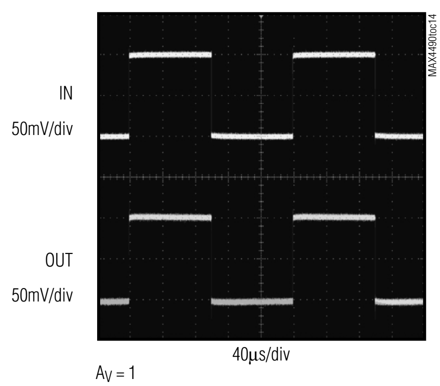
LARGE-SIGNAL TRANSIENT RESPONSE (NONINVERTING)



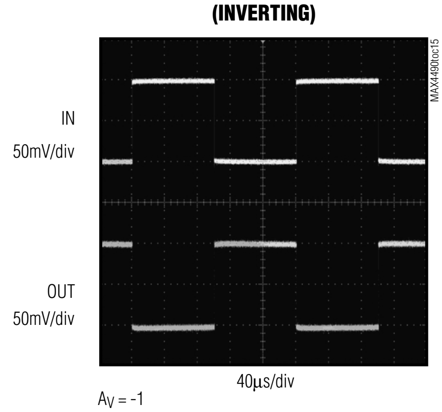
LARGE-SIGNAL TRANSIENT RESPONSE (INVERTING)



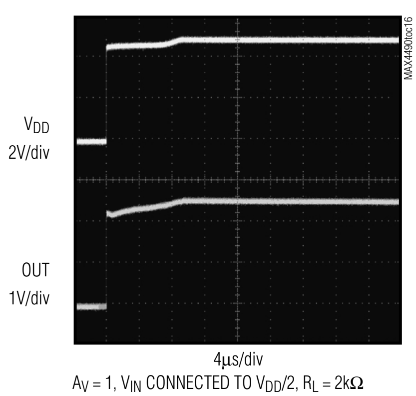
SMALL-SIGNAL TRANSIENT RESPONSE (NONINVERTING)



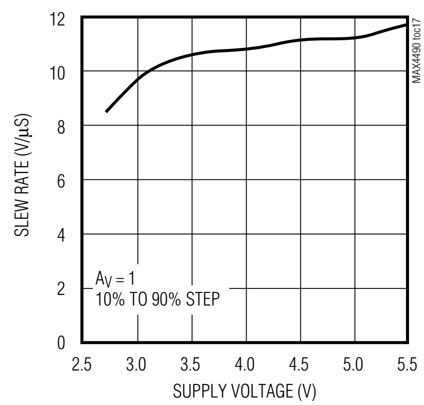
SMALL-SIGNAL TRANSIENT RESPONSE (INVERTING)



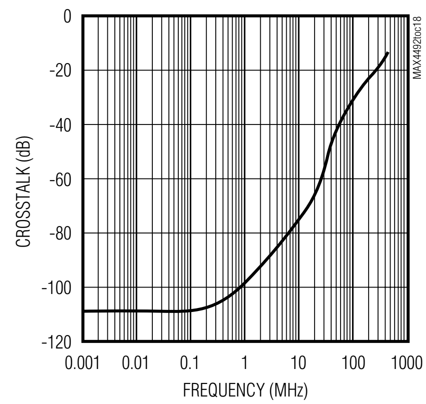
POWER-UP TRANSIENT RESPONSE



SLEW RATE vs. SUPPLY VOLTAGE



MAX4491/MAX4492 CROSSTALK vs. FREQUENCY



Pin Description

PIN			NAME	FUNCTION
MAX4490	MAX4491	MAX4492		
1	—	—	IN+	Noninverting Input
2	4	11	V_{SS}	Negative Supply Input. Connect to ground for single-supply operation.
3	—	—	IN-	Inverting Input
4	—	—	OUT	Amplifier Output
5	8	4	V_{DD}	Positive Supply Input
—	3	3	INA+	Noninverting Input to Amplifier A
—	2	2	INA-	Inverting Input to Amplifier A
—	1	1	OUTA	Amplifier A Output
—	5	5	INB+	Noninverting Input to Amplifier B
—	6	6	INB-	Inverting Input to Amplifier B
—	7	7	OUTB	Amplifier B Output
—	—	10, 12	INC+, IND+	Noninverting Inputs to Amplifiers C and D
—	—	9, 13	INC-, IND-	Inverting Inputs to Amplifiers C and D
—	—	8, 14	OUTC, OUTD	Amplifiers C and D Outputs

Detailed Description

Rail-to-Rail Input Stage

The MAX4490/MAX4491/MAX4492 CMOS operational amplifiers have parallel-connected N- and P-channel differential input stages that combine to accept a common-mode range extending to both supply rails. The N-channel stage is active for common-mode input voltages typically greater than (V_{SS} + 1.2V), and the P-channel stage is active for common-mode input voltages typically less than (V_{DD} - 1.2V).

Rail-to-Rail Output Stage

The MAX4490/MAX4491/MAX4492 CMOS operational amplifiers feature class-AB push-pull output stages that can drive a 100kΩ load to within 1.5mV of either supply rail. Short-circuit output current is typically ±50mA.

Figures 1a and 1b show the typical temperature dependence of output source and sink currents, respectively, for three fixed values of (V_{DD} - V_{OH}) and (V_{OL} - V_{SS}). For example, at V_{DD} = 5.0V, the load currents that maintain (V_{DD} - V_{OH}) = 100mV and (V_{OL} - V_{SS}) = 100mV at T_A = +25°C are 2.2mA and 3.3mA, respectively, when the load is connected to V_{DD}/2. Consistent resistive-drive capability is (2.5 - 0.1) / 2.2 = 1.1kΩ. For the same application, resistive-drive capability is 2.2kΩ when the load is connected to V_{DD} or V_{SS}.

Applications Information

Power-Supply Considerations

The MAX4490/MAX4491/MAX4492 operate from a single 2.7V to 5.5V supply or from dual ±1.35V to ±2.75V supplies with typically 800µA supply current per amplifier. A high power-supply rejection ratio of 100dB allows for extended operation from a decaying battery voltage, thereby simplifying designs for portable applications. For single-supply operation, bypass the power supply with a 0.1µF ceramic capacitor placed close to the V_{DD} pin. For dual-supply operation, bypass each supply to ground.

Input Capacitance

One consequence of the parallel-connected differential input stages for rail-to-rail operation is a relatively large input capacitance C_{IN} (typically 5pF). This introduces a

Low-Cost, High-Slew-Rate, Rail-to-Rail I/O Op Amps in SC70

pole at frequency $(2\pi R'C_{IN})^{-1}$, where R′ is the parallel combination of the gain-setting resistors for the inverting or noninverting amplifier configuration (Figure 2). If the pole frequency is less than or comparable to the unity-gain bandwidth (10MHz), the phase margin will be reduced, and the amplifier will exhibit degraded AC performance through either ringing in the step response or sustained oscillations. The pole frequency is 10MHz when R′ = 3.2kΩ. To maximize stability, R′ <3kΩ is recommended.

Applications that require rail-to-rail operation with minimal loading (for small V_{DD} - V_{OH} and V_{OL} - V_{SS}) will typically require R′ values >3kΩ. To improve step response under these conditions, connect a small capacitor C_f between the inverting input and output. Choose C_f as follows:

$$C_f = 5(R / R_f)\ [pf]$$

where R_f is the feedback resistor and R is the gain-setting resistor (Figure 2).

Figure 3 shows the step response for a noninverting amplifier subject to R′ = 4kΩ with and without the C_f feedback capacitor.

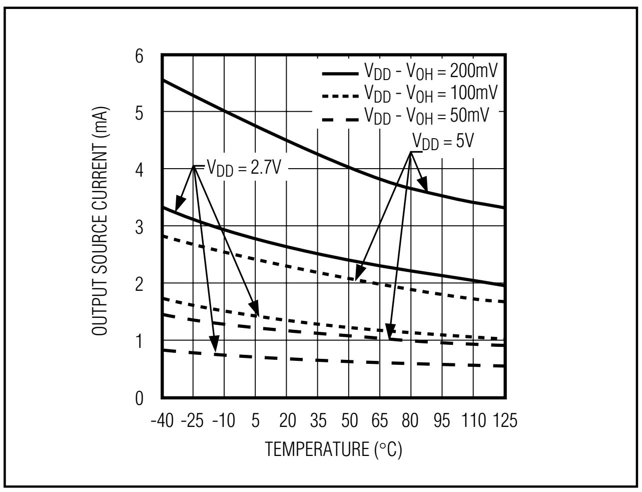


Figure 1a. Output Source Current vs. Temperature

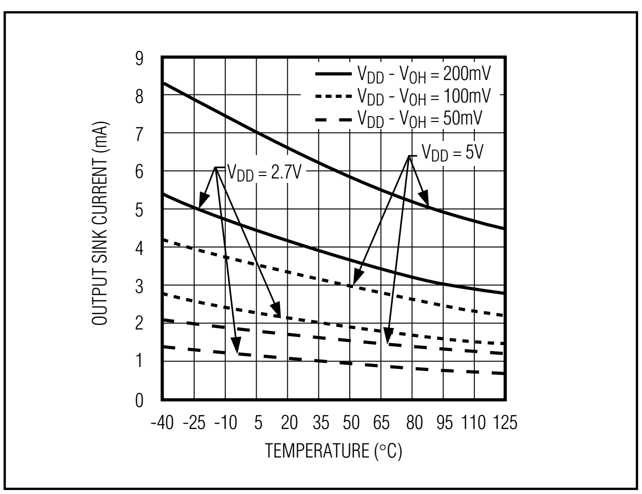


Figure 1b. Output Sink Current vs. Temperature

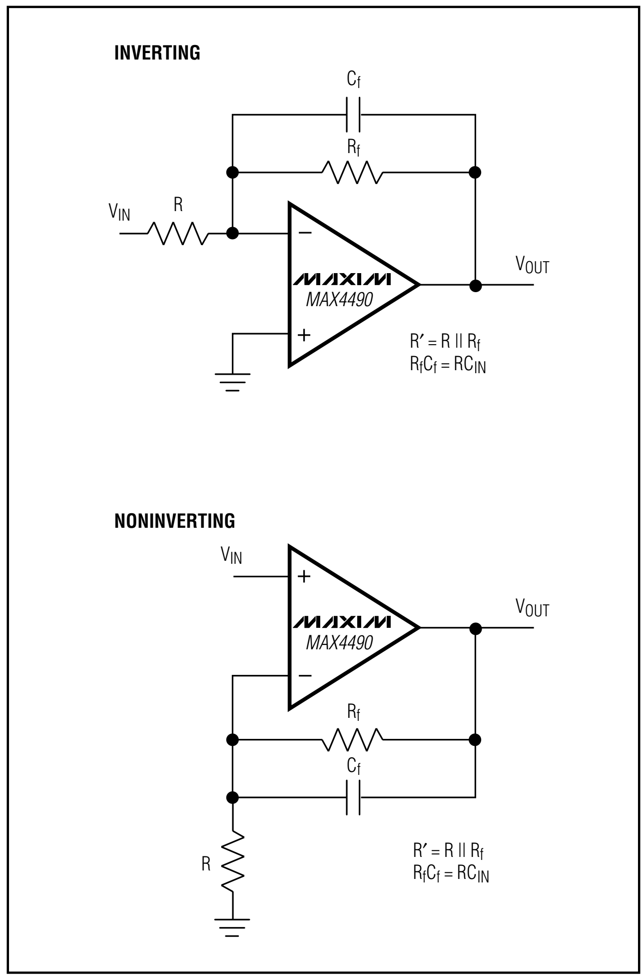


Figure 2. Inverting and Noninverting Amplifier with Feedback Compensation

Driving Capacitive Loads

In conjunction with op amp output resistance, capacitive loads introduce a pole frequency that can reduce phase margin and lead to unstable operation. The MAX4490/MAX4491/MAX4492 drive capacitive loads up to 300pF without significant degradation of step response and slew rate (Figure 4). *Capacitive-Load Stability* (page 1) shows regions of stable and marginally stable (step overshoot <10%) operation for different combinations of capacitive and resistive loads.

Improve stability for large capacitive loads by adding an isolation resistor (typically 10Ω) in series with the output (Figure 5). Note that the isolation resistor forms a voltage divider with potential for gain error.

Chip Information

MAX4490 TRANSISTOR COUNT: 60
MAX4491 TRANSISTOR COUNT: 120
MAX4492 TRANSISTOR COUNT: 240
SUBSTRATE CONNECTED TO V_{SS}

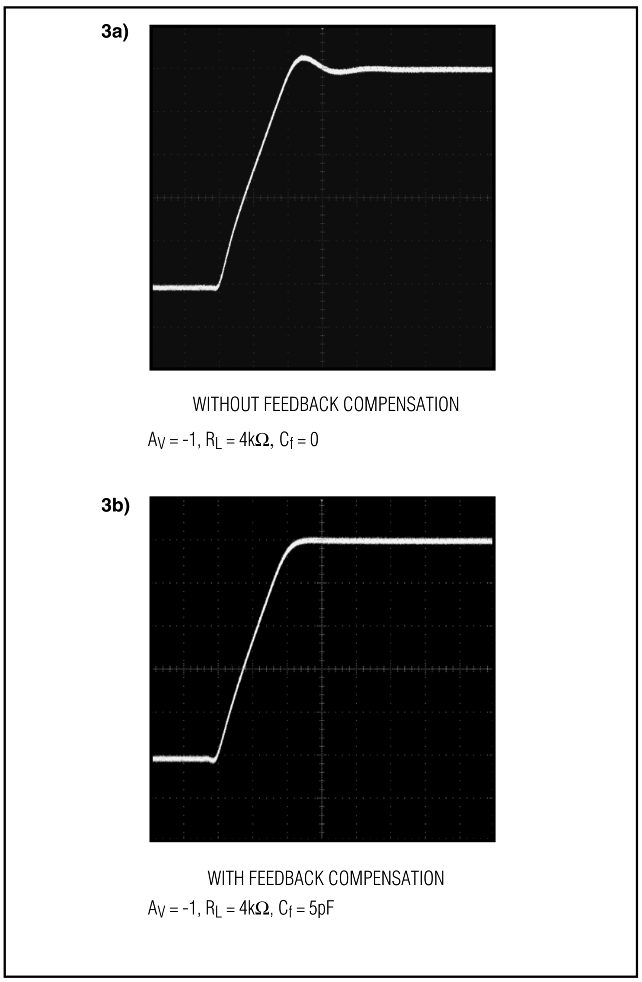


Figure 3. Step Response With and Without Feedback Compensation

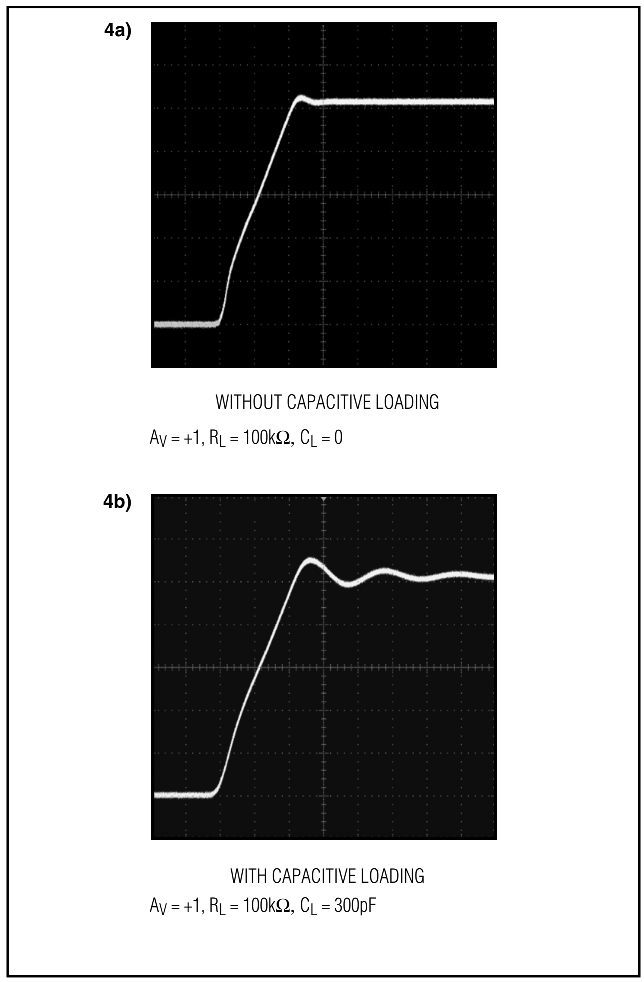


Figure 4. Step Response With and Without Capacitive Loading

Low-Cost, High-Slew-Rate, Rail-to-Rail I/O Op Amps in SC70

Pin Configurations/ Functional Diagrams (continued)

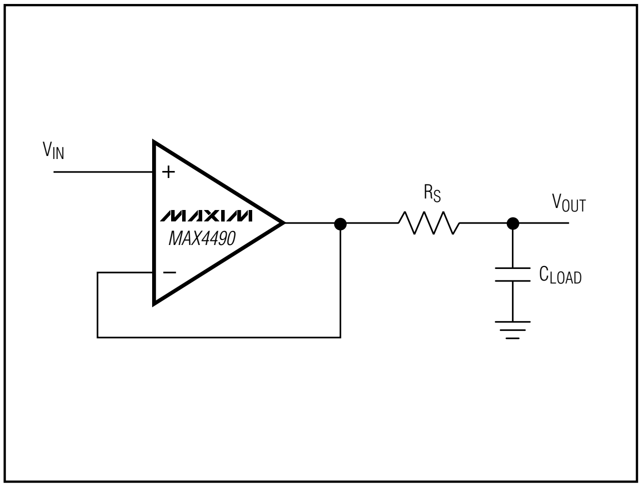
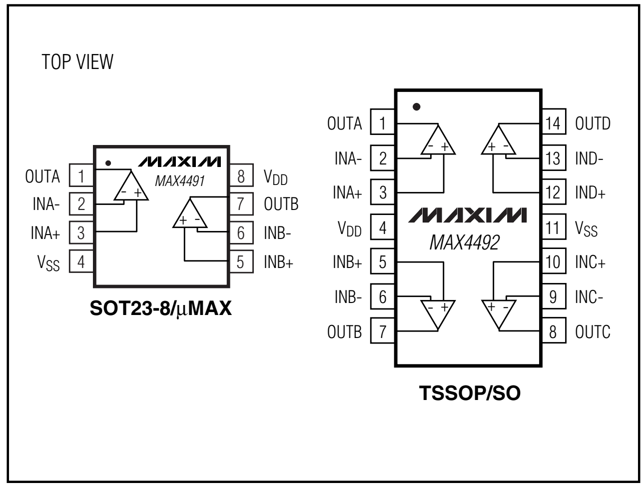
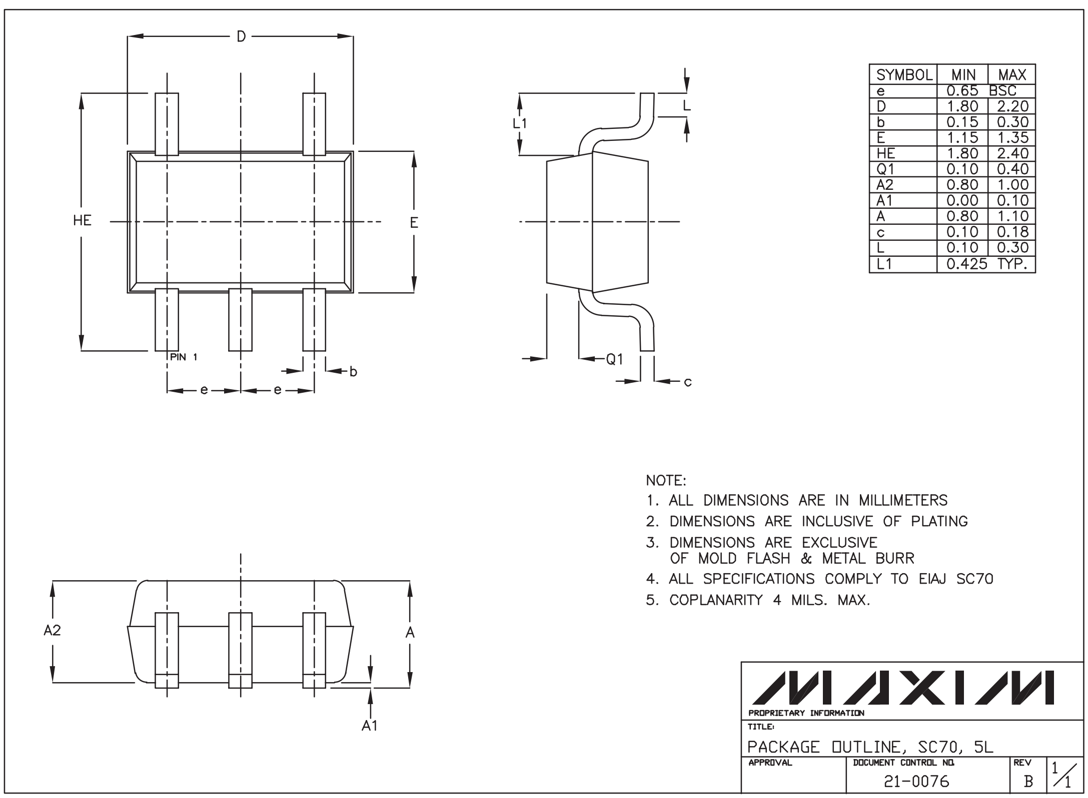


Figure 5. Isolation Resistor for Large Capacitive Loads



Package Information



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.	