



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

General Description

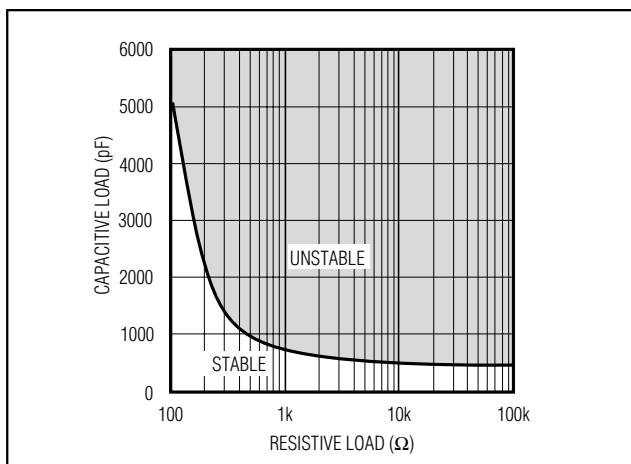
The MAX4490/MAX4491/MAX4492 single/dual/quad, low-cost CMOS op amps feature Rail-to-Rail® input and output capability from either a single 2.7V to 5.5V supply or dual $\pm 1.35V$ to $\pm 2.75V$ supplies. These amplifiers exhibit a high slew rate of $10V/\mu s$ and a gain-bandwidth product of 10MHz. They can drive $2k\Omega$ 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 ($-40^{\circ}C$ to $+125^{\circ}C$) 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

Capacitive-Load Stability



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

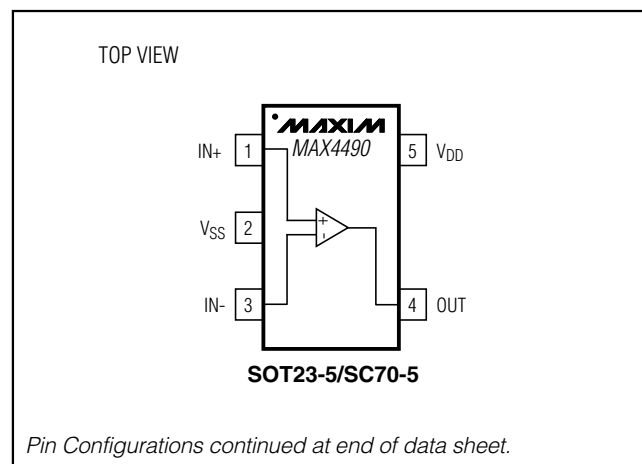
Features

- ◆ 2.7V to 5.5V Single-Supply Operation
- ◆ $10V/\mu s$ 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 | $-40^{\circ}C$ to $+125^{\circ}C$ | 5 SC70-5 | AAB |
| MAX4490AUK-T | $-40^{\circ}C$ to $+125^{\circ}C$ | 5 SOT23-5 | ADKQ |
| MAX4491AKA-T | $-40^{\circ}C$ to $+125^{\circ}C$ | 8 SOT23-5 | AADB |
| MAX4491AUA | $-40^{\circ}C$ to $+125^{\circ}C$ | 8 μ MAX | — |
| MAX4492AUD | $-40^{\circ}C$ to $+125^{\circ}C$ | 14 TSSOP | — |
| MAX4492ASD | $-40^{\circ}C$ to $+125^{\circ}C$ | 14 SO | — |

Pin Configurations/ Functional Diagrams



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ABSOLUTE MAXIMUM RATINGS

| | | | |
|--|--|--|-----------------|
| Supply Voltage (V_{DD} to V_{SS})..... | 6V | 8-Pin μ MAX (derate 4.1mW/°C above +70°C)..... | 330mW |
| All Other Pins..... | ($V_{SS} - 0.3V$) to ($V_{DD} + 0.3V$) | 14-Pin TSSOP (derate 8.3mW/°C above +70°C)..... | 667mW |
| Output Short-Circuit Duration..... | 10s | 14-Pin SO (derate 8.3mW/°C above +70°C)..... | 667mW |
| Continuous Power Dissipation ($T_A = +70^\circ\text{C}$) | | Operating Temperature Range..... | -40°C to +125°C |
| 5-Pin SC70 (derate 2.5mW/°C above +70°C)..... | 200mW | Junction Temperature..... | +150°C |
| 5-Pin SOT23 (derate 7.1mW/°C above +70°C)..... | 571mW | Storage Temperature Range..... | -65°C to +150°C |
| 8-Pin SOT23 (derate 5.26mW/°C above +70°C)..... | 421 mW | 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

($V_{DD} = 5V$, $V_{SS} = 0$, $V_{CM} = 0$, $V_{OUT} = V_{DD}/2$, $R_L = 100k\Omega$ connected to $V_{DD}/2$, $T_A = T_{MIN}$ to T_{MAX} , unless otherwise noted. Typical values are at $T_A = +25^\circ\text{C}$.) (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) | $T_A = +25^\circ\text{C}$ | | ±10 | mV |
| | | | $T_A = T_{MIN}$ to T_{MAX} | | | |
| 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 | | M Ω |
| Input Common-Mode Range | V_{CM} | Inferred from CMRR test | V_{SS} | | V_{DD} | V |
| Common-Mode Rejection Ratio | CMRR | $V_{SS} \leq V_{CM} \leq V_{DD}$ | 54 | 75 | | dB |
| Power-Supply Rejection Ratio | PSRR | $2.7V \leq V_{DD} \leq 5.5V$ | 65 | 100 | | dB |
| Large-Signal Voltage Gain | A_V | $(V_{SS} + 0.25V) \leq V_{OUT} \leq (V_{DD} - 0.25V)$ | $R_L = 100k\Omega$ | | 110 | dB |
| | | | $R_L = 2k\Omega$ | | | |
| Output-Voltage Swing High | V_{OH} | Specified as $V_{DD} - V_{OH}$ | $R_L = 100k\Omega$ | | 1.5 | mV |
| | | | $R_L = 2k\Omega$ | | | |
| Output-Voltage Swing Low | V_{OL} | Specified as $V_{OL} - V_{SS}$ | $R_L = 100k\Omega$ | | 1.5 | mV |
| | | | $R_L = 2k\Omega$ | | | |
| 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/ μ s |
| 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 | | $A_V(C_L) = 1$, no sustained oscillations | | 300 | | pF |

Note 1: All units production tested at $T_A = +25^\circ\text{C}$. Limits over temperature guaranteed by design.

Note 2: Guaranteed by the Power-Supply Rejection Ratio (PSRR) test.

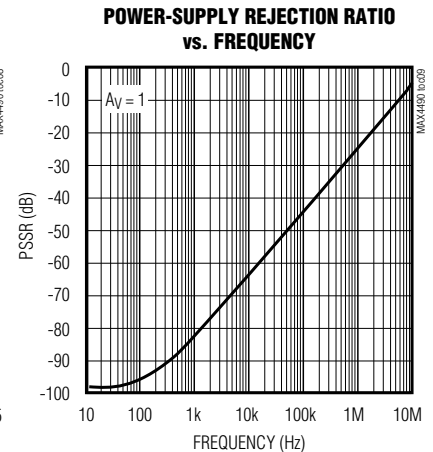
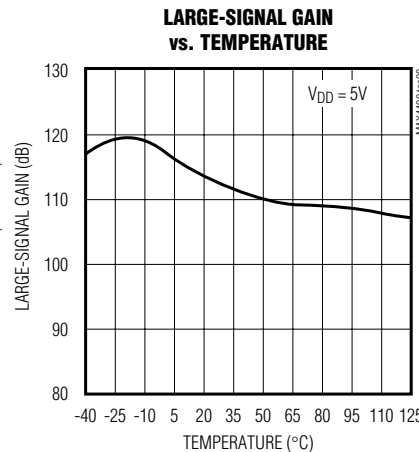
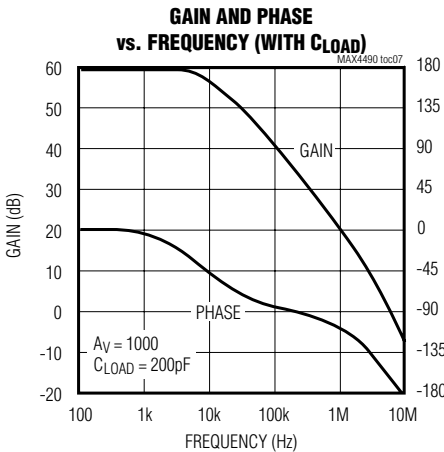
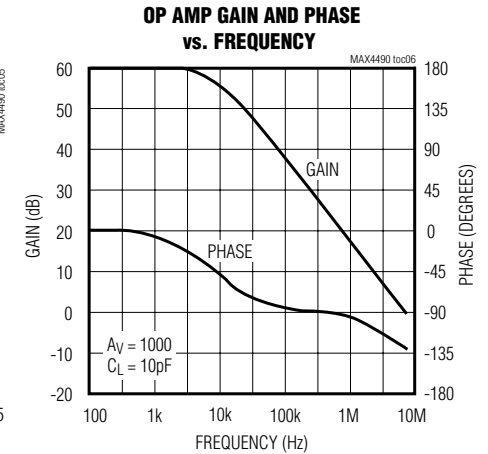
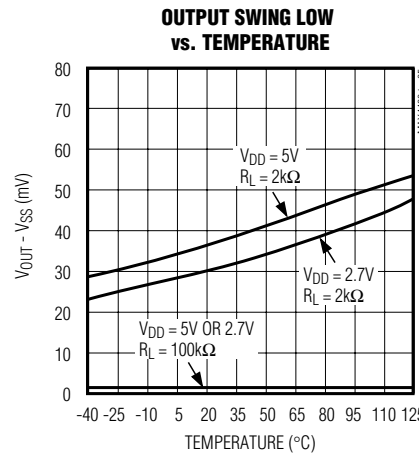
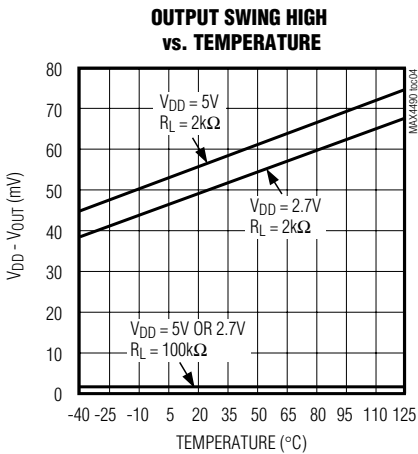
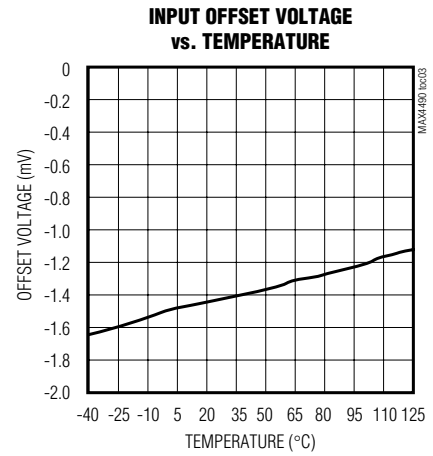
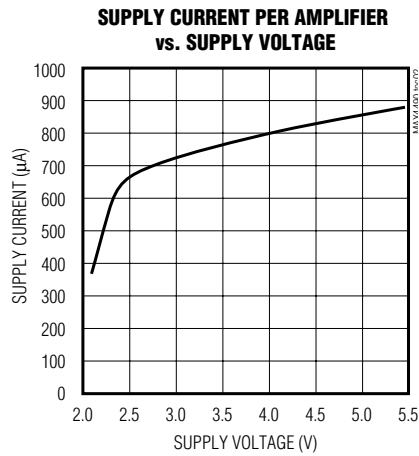
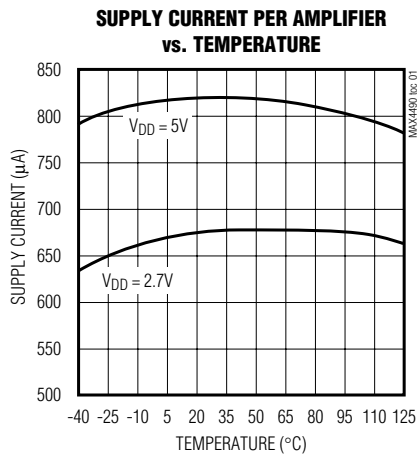
Note 3: Input Offset Voltage, Input Bias Current, and Input Offset Current are all tested and guaranteed at both ends of the common-mode range.

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Typical Operating Characteristics

($V_{DD} = 5V$, $V_{SS} = 0$, $V_{CM} = V_{DD}/2$, $R_L = 100k\Omega$ to $V_{DD}/2$, $T_A = +25^\circ C$, unless otherwise noted.)

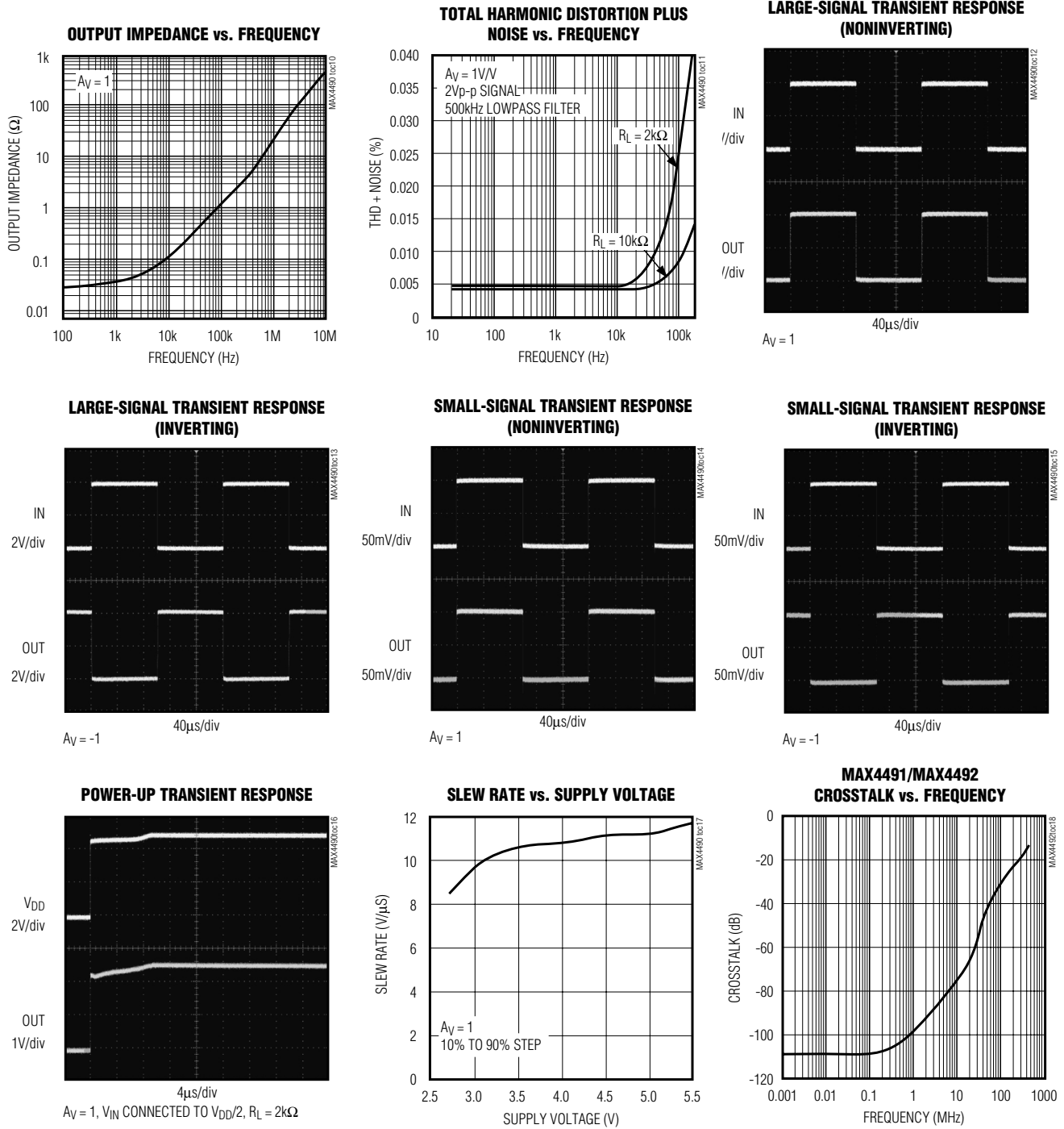
MAX4490/MAX4491/MAX4492



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

Typical Operating Characteristics (continued)

($V_{DD} = 5V$, $V_{SS} = 0$, $V_{CM} = V_{DD}/2$, $R_L = 100k\Omega$ to $V_{DD}/2$, $T_A = +25^\circ C$, unless otherwise noted.)



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Pin Description

MAX4490/MAX4491/MAX4492

| 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

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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 $R' = 3.2k\Omega$. To maximize stability, $R' < 3k\Omega$ 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 $> 3k\Omega$. To improve step response under these conditions, connect a small

capacitor C_f between the inverting input and output. Choose C_f as follows:

$$C_f = 5(R / R_f) \text{ [pF]}$$

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 $R' = 4k\Omega$ with and without the C_f feedback capacitor.

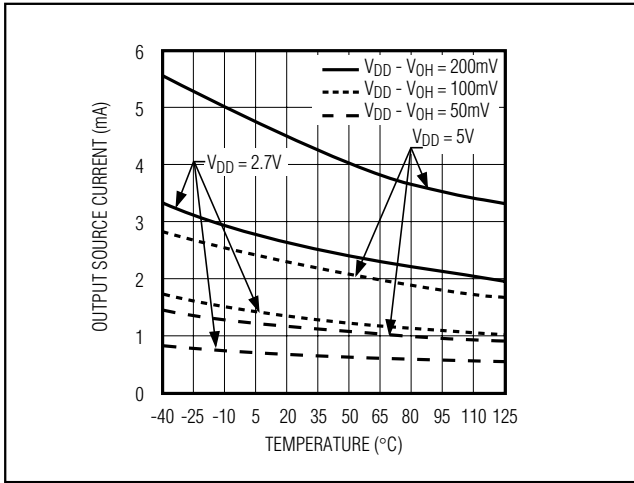


Figure 1a. Output Source Current vs. Temperature

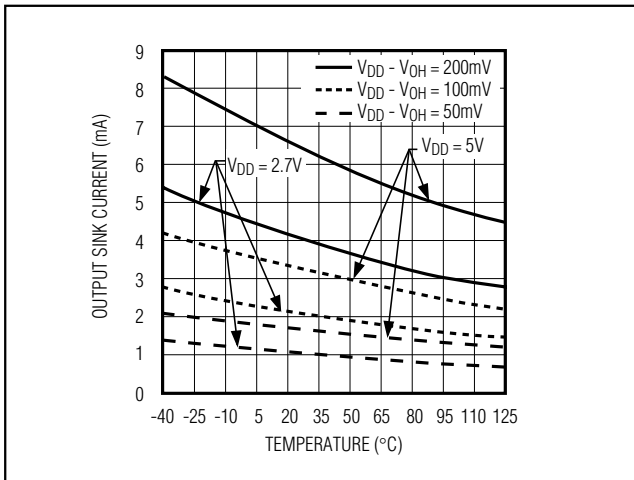


Figure 1b. Output Sink Current vs. Temperature

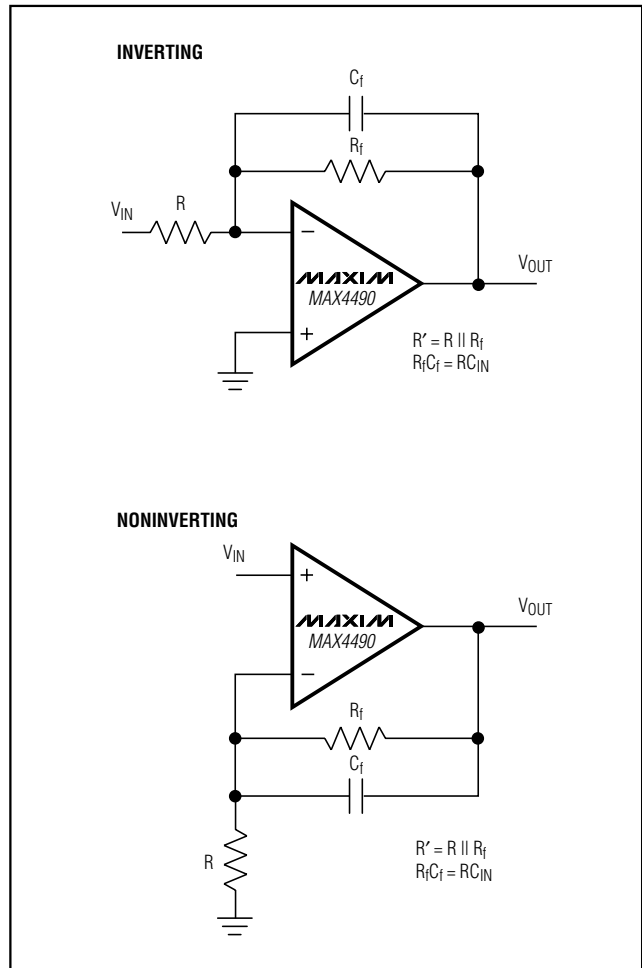


Figure 2. Inverting and Noninverting Amplifier with Feedback Compensation

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MAX4490/MAX4491/MAX4492

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}

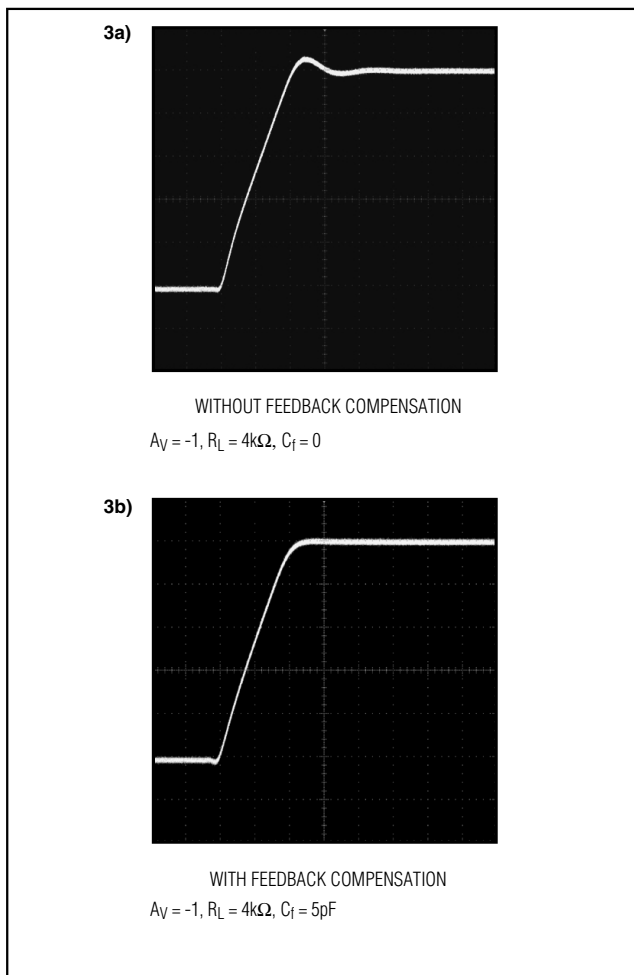


Figure 3. Step Response With and Without Feedback Compensation

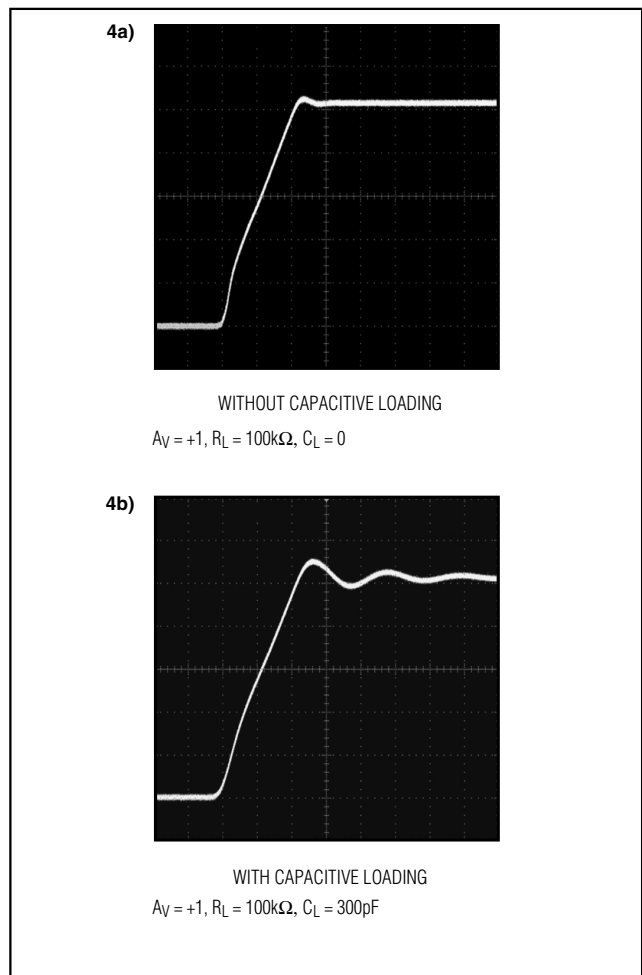


Figure 4. Step Response With and Without Capacitive Loading

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Pin Configurations/ Functional Diagrams (continued)

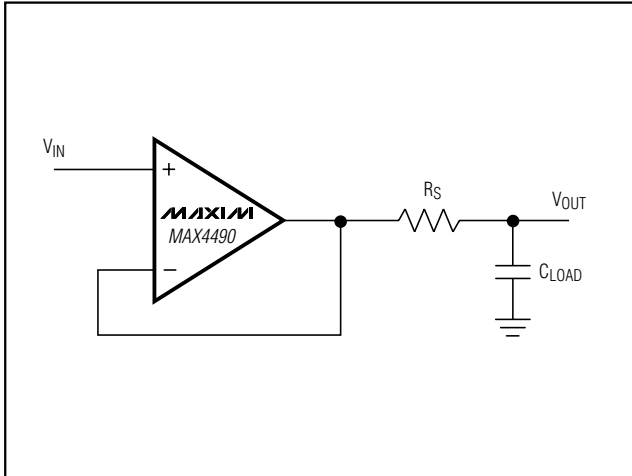
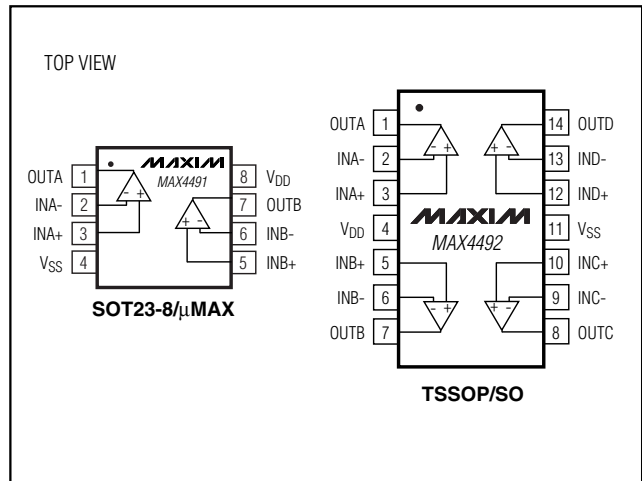


Figure 5. Isolation Resistor for Large Capacitive Loads



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. |

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.

SC70, 5L EPS

MAXIM
 PROPRIETARY INFORMATION
 TITLE:
 PACKAGE OUTLINE, SC70, 5L
 APPROVAL _____ DOCUMENT CONTROL NO. 21-0076 REV. B 1/1

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