

High Output-Drive, 10MHz, 10V/μs, Rail-to-Rail I/O Op Amps with Shutdown in SC70

General Description

The MAX4230–MAX4234 single/dual/quad, high-output-drive CMOS op amps feature 200mA of peak output current, rail-to-rail input, and output capability from a single 2.7V to 5.5V supply. These amplifiers exhibit a high slew rate of 10V/μs and a gain-bandwidth product (GBWP) of 10MHz. The MAX4230–MAX4234 can drive typical headset levels (32Ω), as well as bias an RF power amplifier (PA) in wireless handset applications.

The MAX4230 comes in a tiny 5-pin SC70 package and the MAX4231, single with shutdown, is offered in a 6-pin SC70 package and in 1.5mm x 1.0mm UCSP and thin μDFN packages. The dual op-amp MAX4233 is offered in the space-saving 10-bump chip-scale package (UCSP™), providing the smallest footprint area for a dual op amp with shutdown.

These op amps are designed to be part of the PA control circuitry, biasing RF PAs in wireless headsets. The MAX4231/MAX4233 offer a $\overline{\text{SHDN}}$ feature that drives the output low. This ensures that the RF PA is fully disabled when needed, preventing unconverted signals to the RF antenna.

The MAX4230 family offers low offsets, wide bandwidth, and high-output drive in a tiny 2.1mm x 2.0mm space-saving SC70 package. These parts are offered over the automotive temperature range (-40°C to +125°C).

Applications

- RF PA Biasing Controls in Handset Applications
- Portable/Battery-Powered Audio Applications
- Portable Headphone Speaker Drivers (32Ω)
- Audio Hands-Free Car Phones (Kits)
- Laptop/Notebook Computers/TFT Panels
- Sound Ports/Cards
- Set-Top Boxes
- Digital-to-Analog Converter Buffers
- Transformer/Line Drivers
- Motor Drivers

Selector Guide appears at end of data sheet.
Pin Configurations appear at end of data sheet.

UCSP is a trademark of Maxim Integrated Products, Inc.

Features

- ◆ 200mA Output Drive Capability
- ◆ Rail-to-Rail Input and Output
- ◆ 1.1mA Supply Current per Amplifier
- ◆ 2.7V to 5.5V Single-Supply Operation
- ◆ 10MHz Gain-Bandwidth Product
- ◆ High Slew Rate: 10V/μs
- ◆ 100dB Voltage Gain ($R_L = 100k\Omega$)
- ◆ 85dB Power-Supply Rejection Ratio
- ◆ No Phase Reversal for Overdriven Inputs
- ◆ Unity-Gain Stable for Capacitive Loads to 780pF
- ◆ Low-Power Shutdown Mode Reduces Supply Current to < 1μA
- ◆ Available in 5-Pin SC70 Package (MAX4230) and 6-Bump, UCSP and 6-Pin Thin μDFN Packages (MAX4231)
- ◆ Available in 10-Bump UCSP Package (MAX4233)

Ordering Information

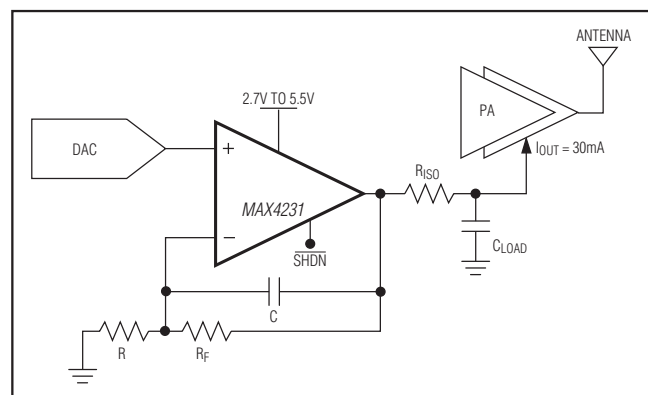
| PART | TEMP RANGE | PIN-PACKAGE | TOP MARK |
|----------------|-----------------|-------------|----------|
| MAX4230AXK+T | -40°C to +125°C | 5 SC70 | ACS |
| MAX4230AXK/V+T | -40°C to +125°C | 5 SC70 | +AUU |
| MAX4230AUK+T | -40°C to +125°C | 5 SOT23 | ABZZ |
| MAX4231AXT+T | -40°C to +125°C | 6 SC70 | ABA |
| MAX4231AUT+T | -40°C to +125°C | 6 SOT23 | ABNF |
| MAX4231ART+T | -40°C to +125°C | 6 UCSP | AAM |
| MAX4231AYT+T | -40°C to +125°C | 6 Thin μDFN | +AH |

+ Denotes a lead-free(Pb)/RoHS-compliant package.

T = Tape and reel.

Ordering Information continued at end of data sheet.

Typical Operating Circuit



For pricing, delivery, and ordering information, please contact Maxim Direct at 1-888-629-4642, or visit Maxim's website at www.maximintegrated.com.

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ABSOLUTE MAXIMUM RATINGS

| | |
|--|------------------------------|
| Supply Voltage (VDD to VSS)..... | 6V |
| All Other Pins | (VSS - 0.3V) to (VDD + 0.3V) |
| Output Short-Circuit Duration to VDD or VSS (Note 1) | 10s |
| Continuous Power Dissipation (Multilayer, TA = +70°C) | |
| 5-Pin SC70 (derate 3.1mW/°C above +70°C)..... | 247mW |
| 5-Pin SOT23 (derate 3.9mW/°C above +70°C)..... | 313mW |
| 6-Pin SC70 (derate 3.1mW/°C above +70°C)..... | 245mW |
| 6-Pin SOT23 (derate 13.4mW/°C above +70°C)..... | 1072mW |
| 6-Pin Thin μ DFN (derate 2.1mW/°C above +70°C)... | 170.2mW |
| 6-Bump UCSP (derate 3.9mW/°C above +70°C) | 308.3mW |
| 8-Pin SOT23 (derate 5.1mW/°C above +70°C)..... | 408.2mW |

| | |
|--|-----------------|
| 8-Pin μ MAX® (derate 4.8mW/°C above +70°C) | 387.8mW |
| 10-Pin μ MAX (derate 8.8mW/°C above +70°C) | 707.3mW |
| 10-Bump UCSP (derate 5.6mW/°C above +70°C) | 448.7mW |
| 14-Pin SO (derate 11.9mW/°C above +70°C) | 952.4mW |
| 14-Pin TSSOP (derate 10mW/°C above +70°C) | 796.8mW |
| Operating Temperature Range | -40°C to +125°C |
| Junction Temperature | +150°C |
| Storage Temperature Range | -65°C to +150°C |
| Lead Temperature | |
| (excluding 6 and 10 UCSP, soldering, 10s) | +300°C |
| Soldering Temperature (reflow) | +260°C |

Note 1: Package power dissipation should also be observed.

μ MAX is a registered trademark of Maxim Integrated Products, Inc.

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

(VDD = 2.7V, VSS = 0V, VCM = VDD/2, VOUT = (VDD/2), RL = ∞ connected to (VDD/2), VSHDN = VDD, TA = +25°C, unless otherwise noted.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS | |
|---------------------------------|------------|--|--------------------|-----------|---------|------------|----|
| Operating Supply Voltage Range | VDD | Inferred from PSRR test | 2.7 | | 5.5 | V | |
| Input Offset Voltage | VOS | | | 0.85 | ± 6 | mV | |
| Input Bias Current (Note 4) | IB | VCM = VSS to VDD | | | 1 | pA | |
| Input Offset Current | IOS | VCM = VSS to VDD | | 50 | | pA | |
| Input Resistance | RIN | | | 1000 | | M Ω | |
| Common-Mode Input Voltage Range | VCM | Inferred from CMRR test | VSS | | VDD | V | |
| Common-Mode Rejection Ratio | CMRR | VSS < VCM < VDD | 52 | 70 | | dB | |
| Power-Supply Rejection Ratio | PSRR | VDD = 2.7V to 5.5V | 73 | 85 | | dB | |
| Shutdown Output Impedance | ROUT | VSHDN = 0V (Note 3) | | 10 | | Ω | |
| Output Voltage in Shutdown | VOUT(SHDN) | VSHDN = 0V, RL = 200 Ω (Note 3) | | 68 | 120 | mV | |
| Large-Signal Voltage Gain | AVOL | VSS + 0.20V < VOUT < VDD - 0.20V | RL = 100k Ω | | 100 | dB | |
| | | | RL = 2k Ω | 85 | 98 | | |
| | | | RL = 200 Ω | 74 | 80 | | |
| Output Voltage Swing | VOUT | RL = 32 Ω | VDD - VOH | 400 | 500 | mV | |
| | | | VOL - VSS | 360 | 500 | | |
| | | RL = 200 Ω | VDD - VOH | 80 | 120 | | |
| | | | VOL - VSS | 70 | 120 | | |
| | | RL = 2k Ω | VDD - VOH | 8 | 14 | | |
| | | | VOL - VSS | 7 | 14 | | |
| Output Source/Sink Current | IOUT | VDD = 2.7V, VIN = ± 100 mV | | 70 | | mA | |
| | | VDD = 5V, VIN = ± 100 mV | | 200 | | | |
| Output Voltage | | IL = 10mA | VDD = 2.7V | VDD - VOH | 128 | 200 | mV |
| | | | | VOL - VSS | 112 | 175 | |
| | | IL = 30mA | VDD = 5V | VDD - VOH | 240 | 320 | |
| | | | | VOL - VSS | 224 | 300 | |

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DC ELECTRICAL CHARACTERISTICS (continued)

($V_{DD} = 2.7V$, $V_{SS} = 0V$, $V_{CM} = V_{DD}/2$, $V_{OUT} = (V_{DD}/2)$, $R_L = \infty$ connected to $(V_{DD}/2)$, $V_{\overline{SHDN}} = V_{DD}$, $T_A = +25^\circ C$, unless otherwise noted.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|--|---------------------------|--|----------------------|-----|-----|---------|
| Quiescent Supply Current (per Amplifier) | I_{DD} | $V_{DD} = 5.5V$, $V_{CM} = V_{DD}/2$ | | 1.2 | 2.3 | mA |
| | | $V_{DD} = 2.7V$, $V_{CM} = V_{DD}/2$ | | 1.1 | 2.0 | |
| Shutdown Supply Current (per Amplifier) (Note 3) | $I_{DD(\overline{SHDN})}$ | $V_{\overline{SHDN}} = 0V$, $R_L = \infty$ | $V_{DD} = 5.5V$ | 0.5 | 1 | μA |
| | | | $V_{DD} = 2.7V$ | 0.1 | 1 | |
| \overline{SHDN} Logic Threshold (Note 3) | V_{IL} | Shutdown mode | | | 0.8 | V |
| | V_{IH} | Normal mode | $V_{DD} \times 0.57$ | | | |
| \overline{SHDN} Input Bias Current | | $V_{SS} < V_{\overline{SHDN}} < V_{DD}$ (Note 3) | | 50 | | pA |

DC ELECTRICAL CHARACTERISTICS

($V_{DD} = 2.7V$, $V_{SS} = 0V$, $V_{CM} = V_{DD}/2$, $V_{OUT} = (V_{DD}/2)$, $R_L = \infty$ connected to $(V_{DD}/2)$, $V_{\overline{SHDN}} = V_{DD}$, $T_A = -40$ to $+125^\circ C$, unless otherwise noted.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---------------------------------|----------------------------|---|-------------------|-------------------|----------|------------------|
| Operating Supply Voltage Range | V_{DD} | Inferred from PSRR test | 2.7 | | 5.5 | V |
| Input Offset Voltage | V_{OS} | | | | ± 8 | mV |
| Offset-Voltage Tempco | $\Delta V_{OS}/\Delta T$ | | | ± 3 | | $\mu V/^\circ C$ |
| Input Bias Current (Note 4) | I_B | $T_A = -40^\circ C$ to $+85^\circ C$ | | | 17 | pA |
| | | $T_A = -40^\circ C$ to $+125^\circ C$ | | | 550 | |
| Common-Mode Input Voltage Range | V_{CM} | Inferred from CMRR test | V_{SS} | | V_{DD} | V |
| Common-Mode Rejection Ratio | CMRR | $V_{SS} < V_{CM} < V_{DD}$ | 46 | | | dB |
| Power-Supply Rejection Ratio | PSRR | $V_{DD} = 2.7V$ to $5.5V$ | 70 | | | dB |
| Output Voltage in Shutdown | $V_{OUT(\overline{SHDN})}$ | $V_{\overline{SHDN}} < 0V$, $R_L = 200\Omega$ (Note 3) | | | 150 | mV |
| Large-Signal Voltage Gain | A_{VOL} | $V_{SS} + 0.2V < V_{DD} - 0.2V$ | $R_L = 2k\Omega$ | 76 | | dB |
| | | | $R_L = 200\Omega$ | 67 | | |
| Output Voltage Swing | V_{OUT} | $R_L = 32\Omega$, $T_A = +85^\circ C$ | $V_{DD} - V_{OH}$ | | 650 | mV |
| | | | $V_{OL} - V_{SS}$ | | 650 | |
| | | $R_L = 200\Omega$ | $V_{DD} - V_{OH}$ | | 150 | |
| | | | $V_{OL} - V_{SS}$ | | 150 | |
| | | $R_L = 2k\Omega$ | $V_{DD} - V_{OH}$ | | 20 | |
| | | | $V_{OL} - V_{SS}$ | | 20 | |
| Output Voltage | | $I_L = 10mA$ | $V_{DD} = 2.7V$ | $V_{DD} - V_{OH}$ | | 250 |
| | | | | $V_{OL} - V_{SS}$ | | 230 |
| | | $I_L = 30mA$, $T_A = -40^\circ C$ to $+85^\circ C$ | $V_{DD} = 5V$ | $V_{DD} - V_{OH}$ | | 400 |
| | | | | $V_{OL} - V_{SS}$ | | 370 |

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DC ELECTRICAL CHARACTERISTICS (continued)

($V_{DD} = 2.7V$, $V_{SS} = 0V$, $V_{CM} = V_{DD}/2$, $V_{OUT} = (V_{DD}/2)$, $R_L = \infty$ connected to $(V_{DD}/2)$, $V_{\overline{SHDN}} = V_{DD}$, $T_A = -40$ to $+125^\circ C$, unless otherwise noted.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|----------------|---|----------------------|-----|-----|-------|
| Quiescent Supply Current (per Amplifier) | I_{DD} | $V_{DD} = 5.5V$, $V_{CM} = V_{DD}/2$ | | | 2.8 | mA |
| | | $V_{DD} = 2.7V$, $V_{CM} = V_{DD}/2$ | | | 2.5 | |
| Shutdown Supply Current (per Amplifier) (Note 3) | $I_{DD(SHDN)}$ | $V_{\overline{SHDN}} < 0V$, $R_L = \infty$ | $V_{DD} = 5.5V$ | | 2.0 | μA |
| | | | $V_{DD} = 2.7V$ | | 2.0 | |
| \overline{SHDN} Logic Threshold (Note 3) | V_{IL} | Shutdown mode | | | 0.8 | V |
| | V_{IH} | Normal mode | $V_{DD} \times 0.61$ | | | |

AC ELECTRICAL CHARACTERISTICS

($V_{DD} = 2.7V$, $V_{SS} = 0V$, $V_{CM} = V_{DD}/2$, $V_{OUT} = (V_{DD}/2)$, $R_L = \infty$ connected to $(V_{DD}/2)$, $V_{\overline{SHDN}} = V_{DD}$, $T_A = +25^\circ C$, unless otherwise noted.) (Note 2)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|--------------------------------------|-----------------------|---|-----|--------|-----|----------------|
| Gain-Bandwidth Product | GBWP | $V_{CM} = V_{DD}/2$ | | 10 | | MHz |
| Full-Power Bandwidth | FPBW | $V_{OUT} = 2V_{P-P}$, $V_{DD} = 5V$ | | 0.8 | | MHz |
| Slew Rate | SR | | | 10 | | V/μs |
| Phase Margin | PM | | | 70 | | Degrees |
| Gain Margin | GM | | | 15 | | dB |
| Total Harmonic Distortion Plus Noise | THD+N | $f = 10kHz$, $V_{OUT} = 2V_{P-P}$, $A_{VCL} = 1V/V$ | | 0.0005 | | % |
| Input Capacitance | C_{IN} | | | 8 | | pF |
| Voltage-Noise Density | e_n | $f = 1kHz$ | | 15 | | nV/\sqrt{Hz} |
| | | $f = 10kHz$ | | 12 | | |
| Channel-to-Channel Isolation | | $f = 1kHz$, $R_L = 100k\Omega$ | | 125 | | dB |
| Capacitive-Load Stability | | $A_{VCL} = 1V/V$, no sustained oscillations | | 780 | | pF |
| Shutdown Time | $t_{\overline{SHDN}}$ | (Note 3) | | 1 | | μs |
| Enable Time from Shutdown | t_{ENABLE} | (Note 3) | | 1 | | μs |
| Power-Up Time | t_{ON} | | | 5 | | μs |

Note 2: All units 100% tested at $+25^\circ C$. All temperature limits are guaranteed by design.

Note 3: \overline{SHDN} logic parameters are for the MAX4231/MAX4233 only.

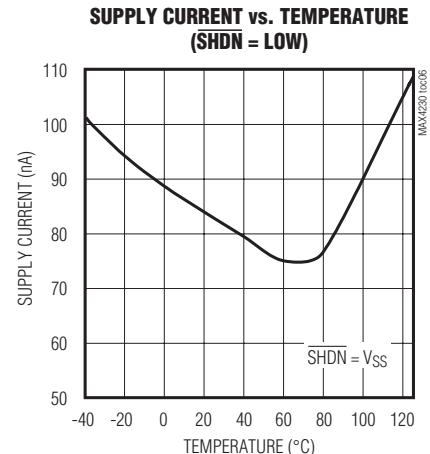
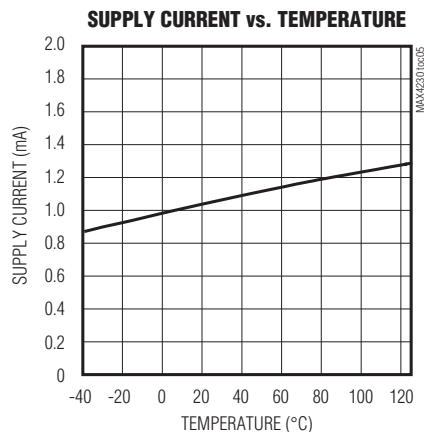
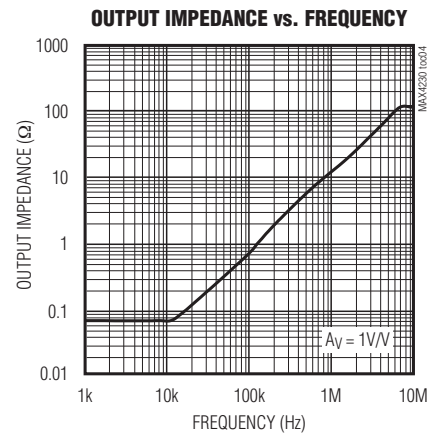
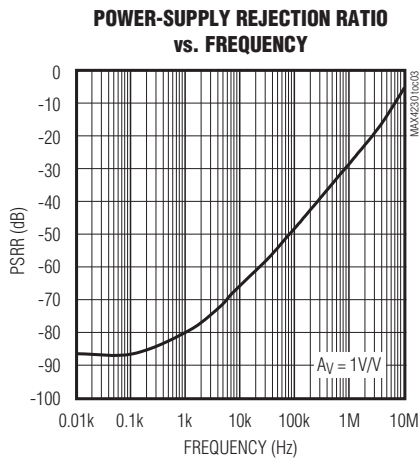
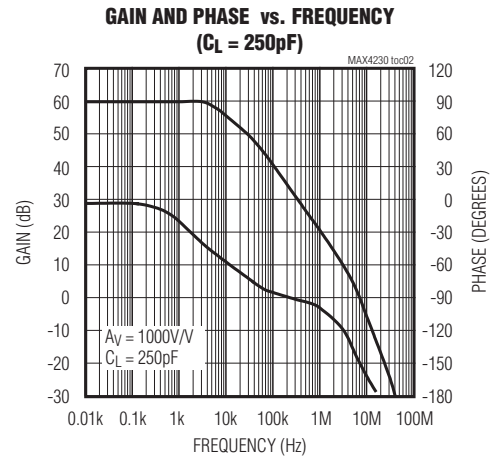
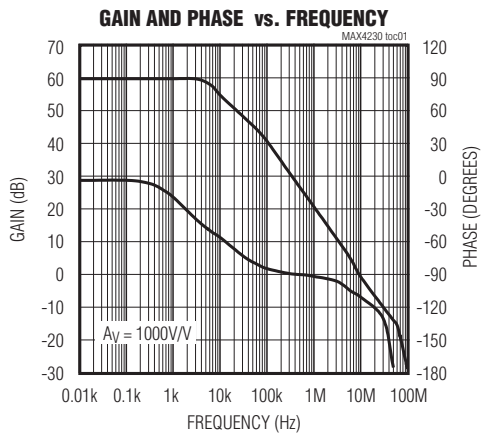
Note 4: Guaranteed by design.

MAX4230–MAX4234

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Typical Operating Characteristics

($V_{DD} = 2.7V$, $V_{SS} = 0V$, $V_{CM} = V_{DD}/2$, $V_{OUT} = V_{DD}/2$, $R_L = \infty$, connected to $V_{DD}/2$, $V_{SHDN} = V_{DD}$, $T_A = +25^\circ C$, unless otherwise noted.)

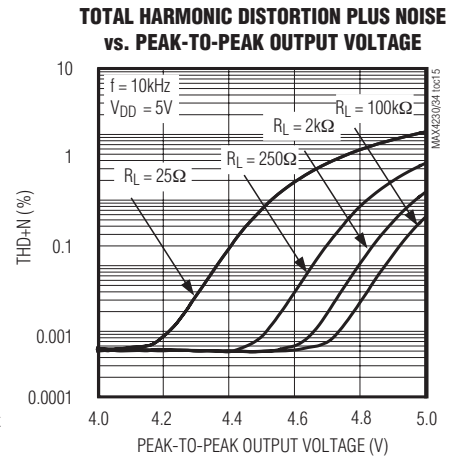
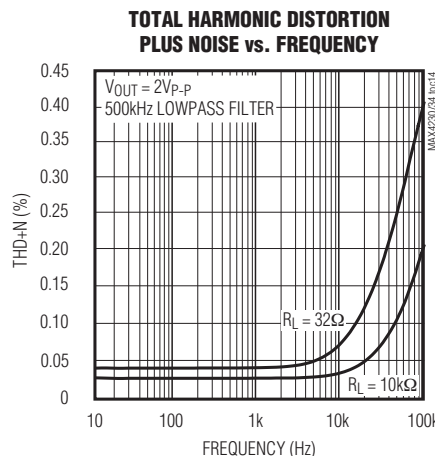
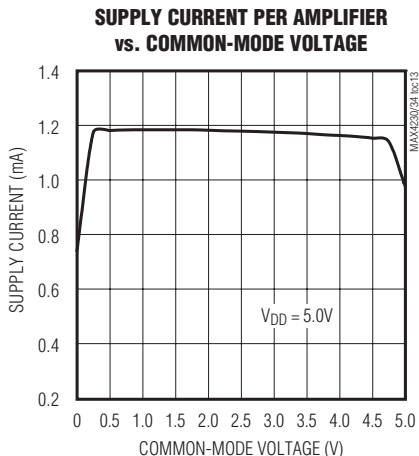
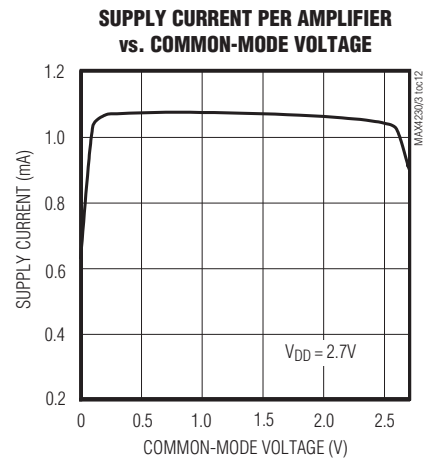
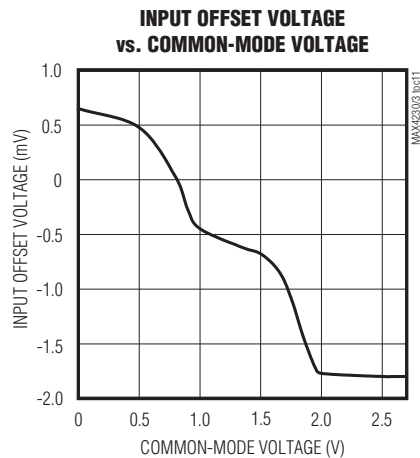
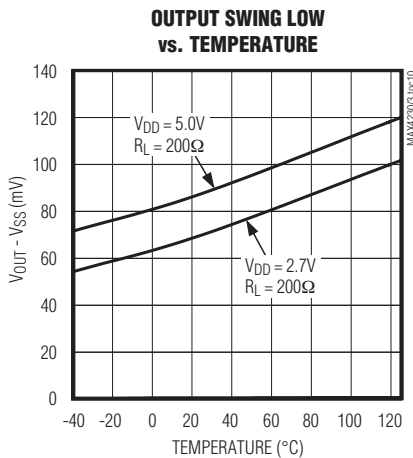
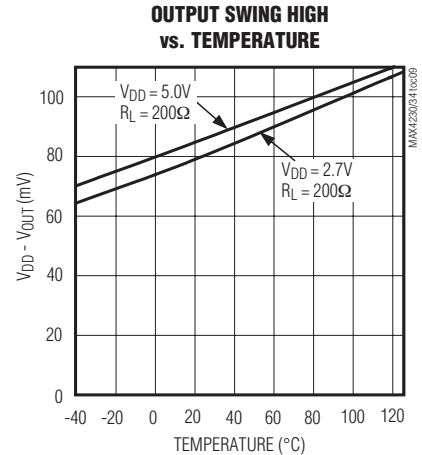
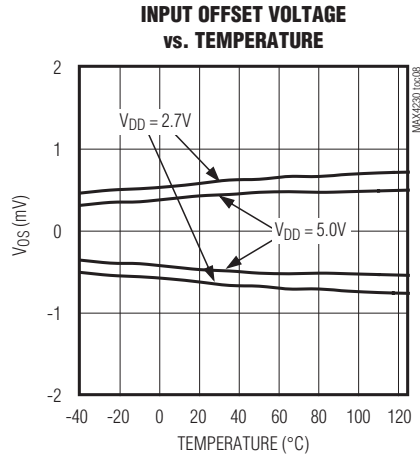
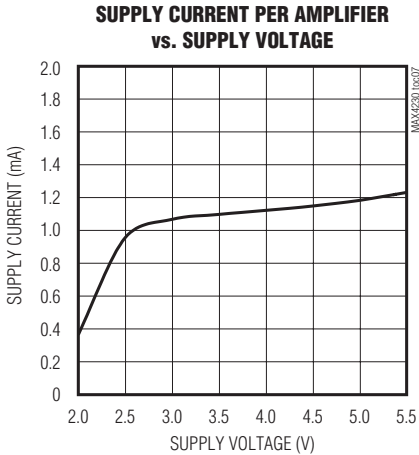


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High-Output-Drive, 10MHz, 10V/ μ s, Rail-to-Rail I/O Op Amps with Shutdown in SC70

Typical Operating Characteristics (continued)

($V_{DD} = 2.7V$, $V_{SS} = 0V$, $V_{CM} = V_{DD}/2$, $V_{OUT} = V_{DD}/2$, $R_L = \infty$, connected to $V_{DD}/2$, $V_{SHDN} = V_{DD}$, $T_A = +25^\circ C$, unless otherwise noted.)



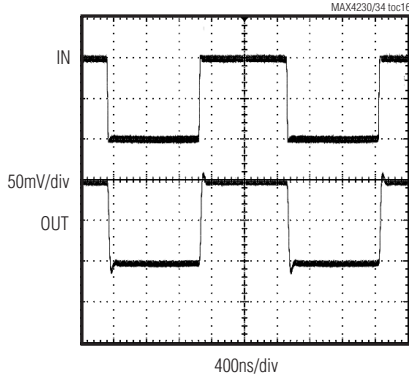
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High Output-Drive, 10MHz, 10V/ μ s, Rail-to-Rail I/O Op Amps with Shutdown in SC70

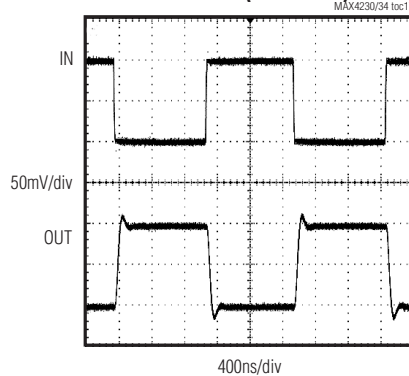
Typical Operating Characteristics (continued)

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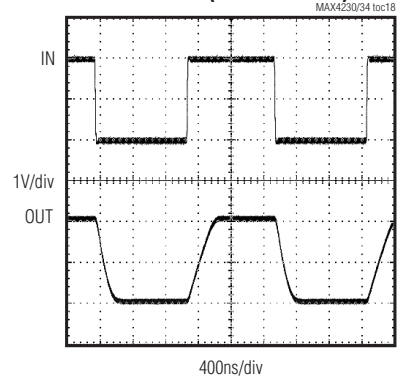
SMALL-SIGNAL TRANSIENT RESPONSE (NONINVERTING)



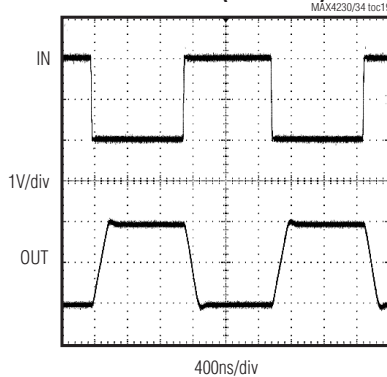
SMALL-SIGNAL TRANSIENT RESPONSE (INVERTING)



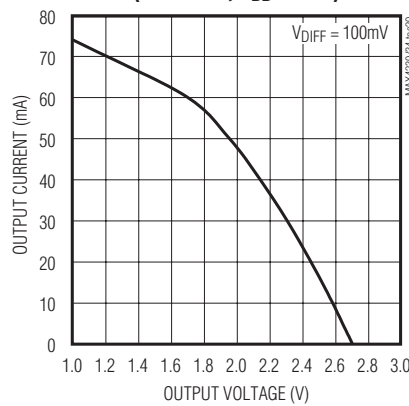
LARGE-SIGNAL TRANSIENT RESPONSE (NONINVERTING)



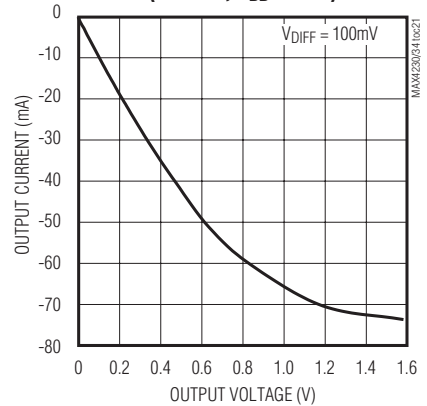
LARGE-SIGNAL TRANSIENT RESPONSE (INVERTING)



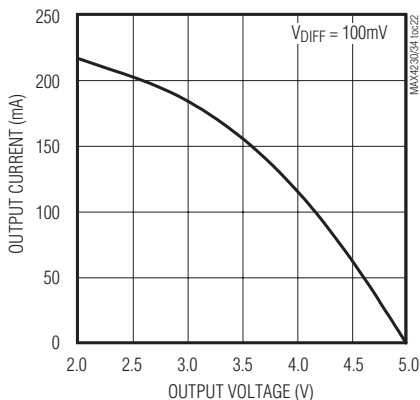
OUTPUT CURRENT vs. OUTPUT VOLTAGE (SOURCING, $V_{DD} = 2.7V$)



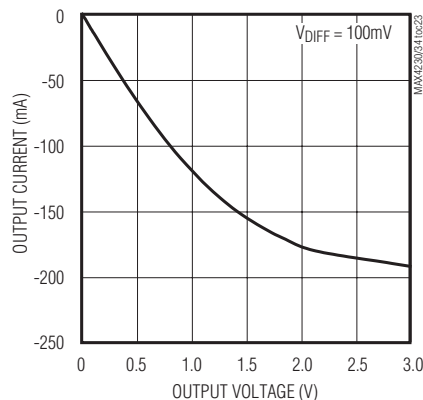
OUTPUT CURRENT vs. OUTPUT VOLTAGE (SINKING, $V_{DD} = 2.7V$)



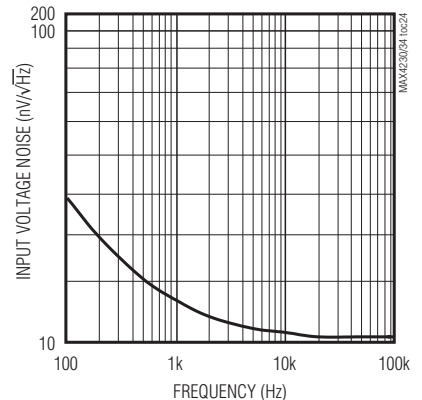
OUTPUT CURRENT vs. OUTPUT VOLTAGE (SOURCING, $V_{DD} = 5.0V$)



OUTPUT CURRENT vs. OUTPUT VOLTAGE (SINKING, $V_{DD} = 5.0V$)



INPUT VOLTAGE NOISE vs. FREQUENCY



MAX4230–MAX4234

High-Output-Drive, 10MHz, 10V/μs, Rail-to-Rail I/O Op Amps with Shutdown in SC70

Pin Description

| PIN | | | | | BUMP | | NAME | FUNCTION |
|---------------------------|--|---------------------------|-----------------|-------------------------|-----------------|-----------------|--------------------|---|
| MAX4230 SOT23/ SC70 | MAX4231 SOT23/ SC70/Thin μDFN | MAX4232 SOT23/ μMAX | MAX4233 μMAX | MAX4234 TSSOP/ SO | MAX4231 UCSP | MAX4233 UCSP | | |
| 1 | 1 | — | — | — | B1 | — | IN+ | Noninverting Input |
| 2 | 2 | 4 | 4 | 11 | A1 | B4 | V _{SS} | Negative Supply Input. Connect to ground for single-supply operation. |
| 3 | 3 | — | — | — | B2 | — | IN- | Inverting Input |
| 4 | 4 | — | — | — | A2 | — | OUT | Amplifier Output |
| 5 | 6 | 8 | 10 | 4 | A3 | B1 | V _{DD} | Positive Supply Input |
| — | 5 | — | 5, 6 | — | B3 | C4, A4 | SHDN, SHDN1, SHDN2 | Shutdown Control. Tie to high for normal operation. |
| — | — | 3 | 3 | 3 | — | C3 | IN1+ | Noninverting Input to Amplifier 1 |
| — | — | 2 | 2 | 2 | — | C2 | IN1- | Inverting Input to Amplifier 1 |
| — | — | 1 | 1 | 1 | — | C1 | OUT1 | Amplifier 1 Output |
| — | — | 5 | 7 | 5 | — | A3 | IN2+ | Noninverting Input to Amplifier 2 |
| — | — | 6 | 8 | 6 | — | A2 | IN2- | Inverting Input to Amplifier 2 |
| — | — | 7 | 9 | 7 | — | A1 | OUT2 | Amplifier 2 Output |
| — | — | — | — | 10, 12 | — | — | IN3+, IN4+ | Noninverting Input to Amplifiers 3 |
| — | — | — | — | 9, 13 | — | — | IN3-, IN4- | Inverting Input to Amplifiers 3 and |
| — | — | — | — | 8, 14 | — | — | OUT3, OUT4 | Amplifiers 3 and 4 Outputs |

Detailed Description

Rail-to-Rail Input Stage

The MAX4230–MAX4234 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).

Applications Information

Package Power Dissipation

Warning: Due to the high output current drive, this op amp can exceed the absolute maximum power-dissipation rating. As a general rule, as long as the peak current is less than or equal to 40mA, the maximum package power dissipation is not exceeded for any of the package

types offered. There are some exceptions to this rule, however. The absolute maximum power-dissipation rating of each package should always be verified using the following equations. The equation below gives an approximation of the package power dissipation:

$$P_{C(DISS)} \cong V_{RMS} I_{RMS} \cos \theta$$

where:

V_{RMS} = RMS voltage from V_{DD} to V_{OUT} when sourcing current and RMS voltage from V_{OUT} to V_{SS} when sinking current.

I_{RMS} = RMS current flowing out of or into the op amp and the load.

θ = phase difference between the voltage and the current. For resistive loads, COS θ = 1.

MAX4230-MAX4234

High Output-Drive, 10MHz, 10V/ μ s, Rail-to-Rail I/O Op Amps with Shutdown in SC70

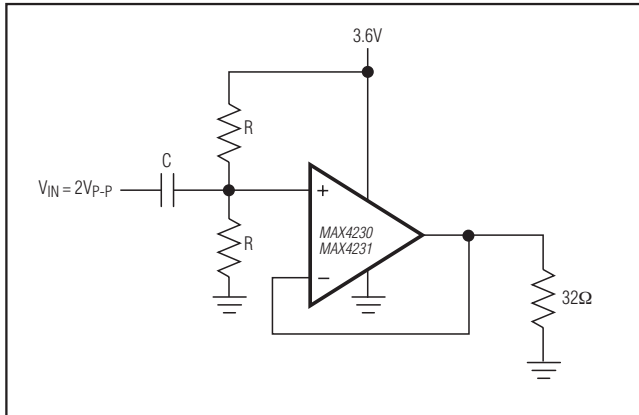


Figure 1. MAX4230/MAX4231 Used in Single-Supply Operation Circuit Example

For example, the circuit in Figure 1 has a package power dissipation of 196mW:

$$\begin{aligned} \text{RMS} &\cong (V_{\text{DD}} - V_{\text{DC}}) + \frac{V_{\text{PEAK}}}{\sqrt{2}} \\ &= 3.6\text{V} - 1.8\text{V} + \frac{1.0\text{V}}{\sqrt{2}} = 2.507V_{\text{RMS}} \\ I_{\text{RMS}} &\cong I_{\text{DC}} + \frac{I_{\text{PEAK}}}{\sqrt{2}} = \frac{1.8\text{V}}{32\Omega} + \frac{1.0\text{V}/32\Omega}{\sqrt{2}} \\ &= 78.4\text{mA}_{\text{RMS}} \end{aligned}$$

where:

V_{DC} = the DC component of the output voltage.

I_{DC} = the DC component of the output current.

V_{PEAK} = the highest positive excursion of the AC component of the output voltage.

I_{PEAK} = the highest positive excursion of the AC component of the output current.

Therefore:

$$\begin{aligned} \text{PIC(DISS)} &= V_{\text{RMS}} I_{\text{RMS}} \cos \theta \\ &= 196\text{mW} \end{aligned}$$

Adding a coupling capacitor improves the package power dissipation because there is no DC current to the load, as shown in Figure 2:

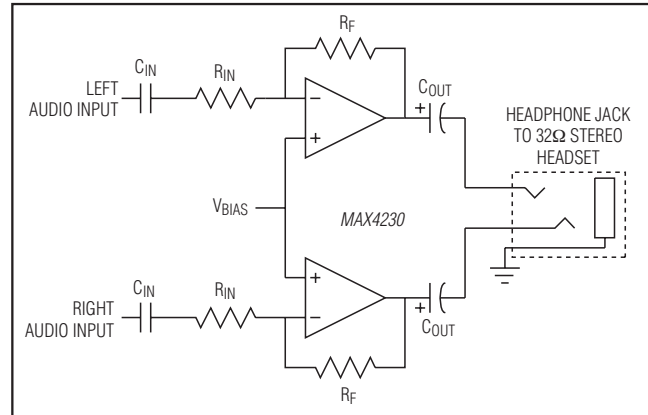


Figure 2. Circuit Example: Adding a Coupling Capacitor Greatly Reduces Power Dissipation of its Package

$$\begin{aligned} V_{\text{RMS}} &\cong \frac{V_{\text{PEAK}}}{\sqrt{2}} \\ &= \frac{1.0\text{V}}{\sqrt{2}} = 0.707V_{\text{RMS}} \\ I_{\text{RMS}} &\cong I_{\text{DC}} + \frac{I_{\text{PEAK}}}{\sqrt{2}} = 0\text{A} + \frac{1.0\text{V}/32\Omega}{\sqrt{2}} \\ &= 22.1\text{mA}_{\text{RMS}} \end{aligned}$$

Therefore:

$$\begin{aligned} \text{PIC(DISS)} &= V_{\text{RMS}} I_{\text{RMS}} \cos \theta \\ &= 15.6\text{mW} \end{aligned}$$

If the configuration in Figure 1 were used with all four of the MAX4234 amplifiers, the absolute maximum power-dissipation rating of this package would be exceeded (see the *Absolute Maximum Ratings* section).

60mW Single-Supply Stereo Headphone Driver

Two MAX4230/MAX4231s can be used as a single-supply, stereo headphone driver. The circuit shown in Figure 2 can deliver 60mW per channel with 1% distortion from a single 5V supply.

The input capacitor (C_{IN}), in conjunction with R_{IN} , forms a highpass filter that removes the DC bias from the incoming signal. The -3dB point of the highpass filter is given by:

$$f_{-3\text{dB}} = \frac{1}{2\pi R_{\text{IN}} C_{\text{IN}}}$$

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High-Output-Drive, 10MHz, 10V/μs, Rail-to-Rail I/O Op Amps with Shutdown in SC70

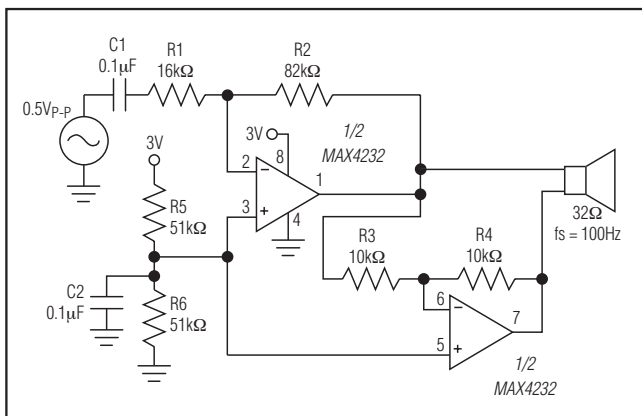


Figure 3. Dual MAX4230/MAX4231 Bridge Amplifier for 200mW at 3V

Choose gain-setting resistors R_{IN} and R_F according to the amount of desired gain, keeping in mind the maximum output amplitude. The output coupling capacitor, C_{OUT} , blocks the DC component of the amplifier output, preventing DC current flowing to the load. The output capacitor and the load impedance form a highpass filter with the -3dB point determined by:

$$f_{-3dB} = \frac{1}{2\pi R_L C_{OUT}}$$

For a 32Ω load, a 100μF aluminum electrolytic capacitor gives a low-frequency pole at 50Hz.

Bridge Amplifier

The circuit shown in Figure 3 uses a dual MAX4230 to implement a 3V, 200mW amplifier suitable for use in size-constrained applications. This configuration eliminates the need for the large coupling capacitor required by the single op-amp speaker driver when single-supply operation is necessary. Voltage gain is set to 10V/V; however, it can be changed by adjusting the 82kΩ resistor value.

Rail-to-Rail Input Stage

The MAX4230–MAX4234 CMOS op amps 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 ($V_{DD} - 1.2V$).

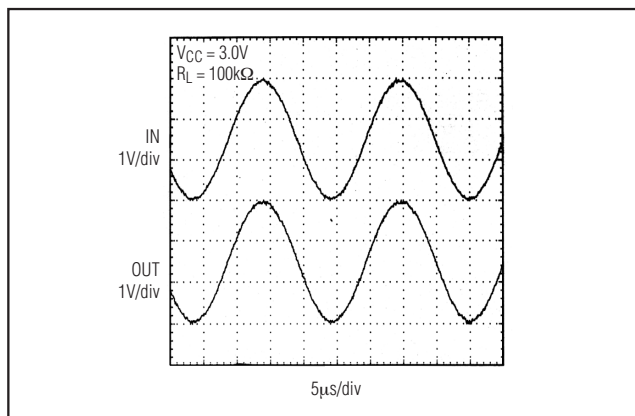


Figure 4. Rail-to-Rail Input/Output Range

Rail-to-Rail Output Stage

The minimum output is within millivolts of ground for single-supply operation, where the load is referenced to ground (V_{SS}). Figure 4 shows the input voltage range and the output voltage swing of a MAX4230 connected as a voltage follower. The maximum output voltage swing is load dependent; however, it is guaranteed to be within 500mV of the positive rail ($V_{DD} = 2.7V$) even with maximum load (32Ω to ground).

Observe the *Absolute Maximum Ratings* for power dissipation and output short-circuit duration (10s, max) because the output current can exceed 200mA (see the *Typical Operating Characteristics*.)

Input Capacitance

One consequence of the parallel-connected differential input stages for rail-to-rail operation is a relatively large input capacitance C_{IN} (5pF typ). This introduces a 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 5). If the pole frequency is less than or comparable to the unity-gain bandwidth (10MHz), the phase margin is reduced, and the amplifier exhibits degraded AC performance through either ringing in the step response or sustained oscillations. The pole frequency is 10MHz when $R' = 2k\Omega$. To maximize stability, $R' \ll 2k\Omega$ is recommended.

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High Output-Drive, 10MHz, 10V/μs, Rail-to-Rail I/O Op Amps with Shutdown in SC70

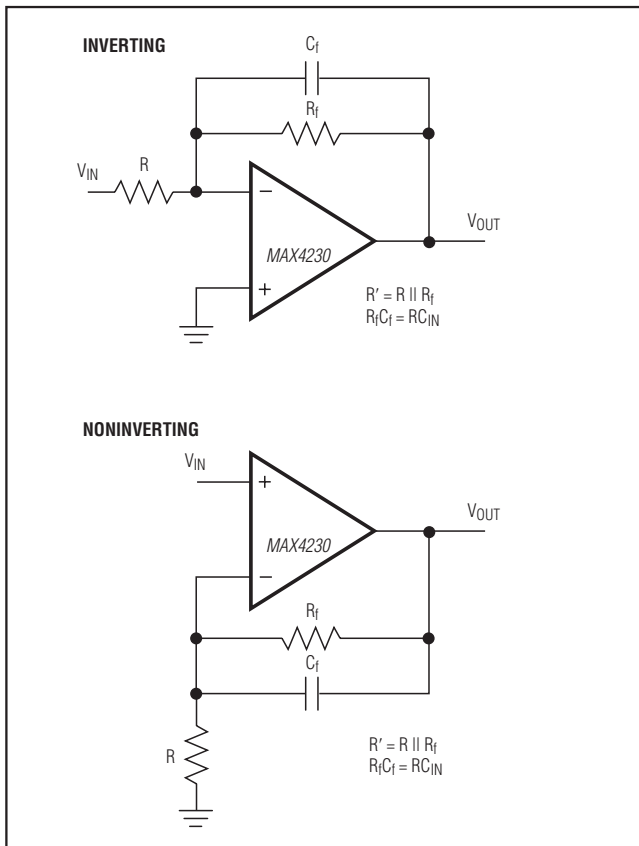


Figure 5. Inverting and Noninverting Amplifiers with Feedback Compensation

To improve step response when $R' > 2k\Omega$, connect small capacitor C_f between the inverting input and output. Choose C_f as follows:

$$C_f = 8(R / R_f) \text{ [pf]}$$

where R_f is the feedback resistor and R is the gain-setting resistor (Figure 5).

Driving Capacitive Loads

The MAX4230–MAX4234 have a high tolerance for capacitive loads. They are stable with capacitive loads up to 780pF. Figure 6 is a graph of the stable operating region for various capacitive loads vs. resistive loads. Figures 7 and 8 show the transient response with excessive capacitive loads (1500pF), with and without the addition of an isolation resistor in series with the output. Figure 9 shows a typical noninverting capacitive-load-driving circuit in the unity-gain configuration.

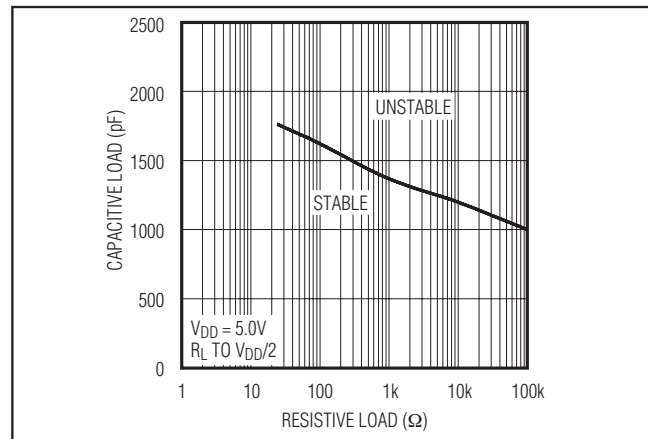


Figure 6. Capacitive-Load Stability

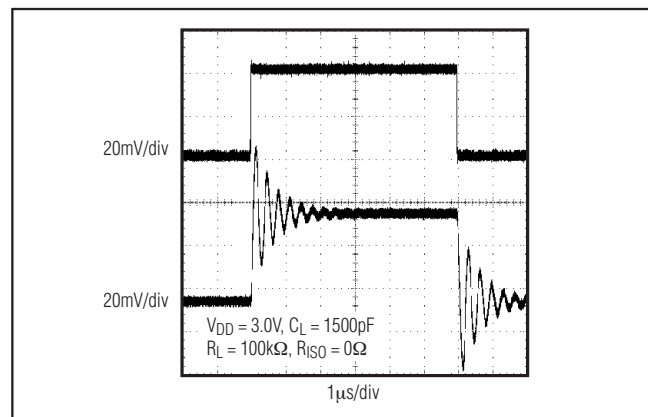


Figure 7. Small-Signal Transient Response with Excessive Capacitive Load

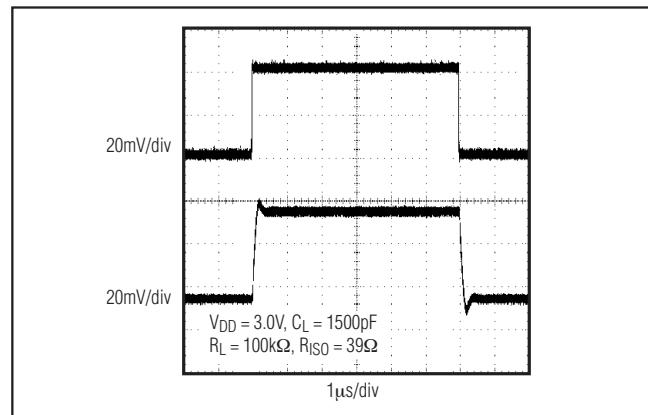


Figure 8. Small-Signal Transient Response with Excessive Capacitive Load with Isolation Resistor

MAX4230–MAX4234

High-Output-Drive, 10MHz, 10V/ μ s, Rail-to-Rail I/O Op Amps with Shutdown in SC70

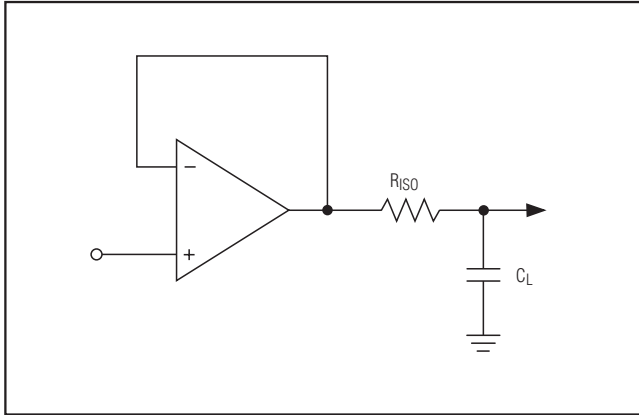


Figure 9. Capacitive-Load-Driving Circuit

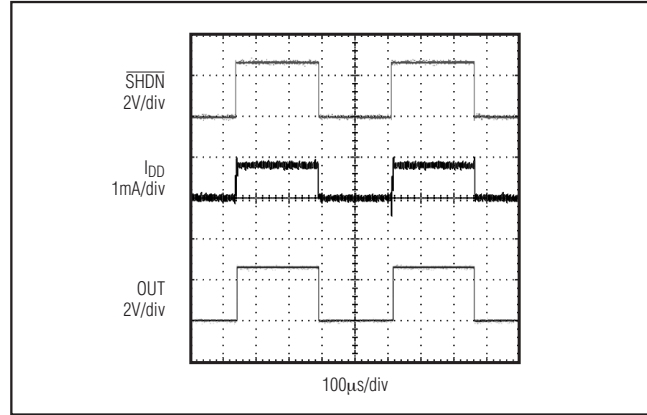


Figure 11. Shutdown Enable/Disable Supply Current

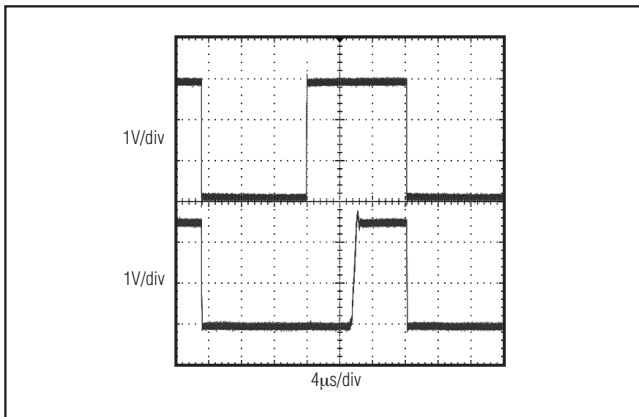


Figure 10. Shutdown Output Voltage Enable/Disable

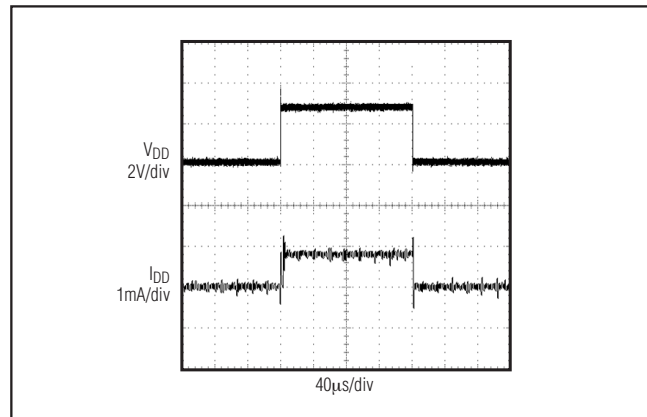


Figure 12. Power-Up/Down Supply Current

The resistor improves the circuit's phase margin by isolating the load capacitor from the op amp's output.

Power-Up and Shutdown Modes

The MAX4231/MAX4233 have a shutdown option. When the shutdown pin (SHDN) is pulled low, supply current drops to 0.5 μ A per amplifier ($V_{DD} = 2.7V$), the amplifiers are disabled, and their outputs are driven to V_{SS} . Since the outputs are actively driven to V_{SS} in shutdown, any pullup resistor on the output causes a current drain from the supply. Pulling SHDN high enables the amplifier. In the dual MAX4233, the two amplifiers shut down independently. Figure 10 shows the MAX4231's output voltage to a shutdown pulse. The MAX4231–MAX4234 typically settle within 5 μ s after power-up. Figures 11 and 12 show I_{DD} to a shutdown plus and voltage power-up cycle.

Selector Guide

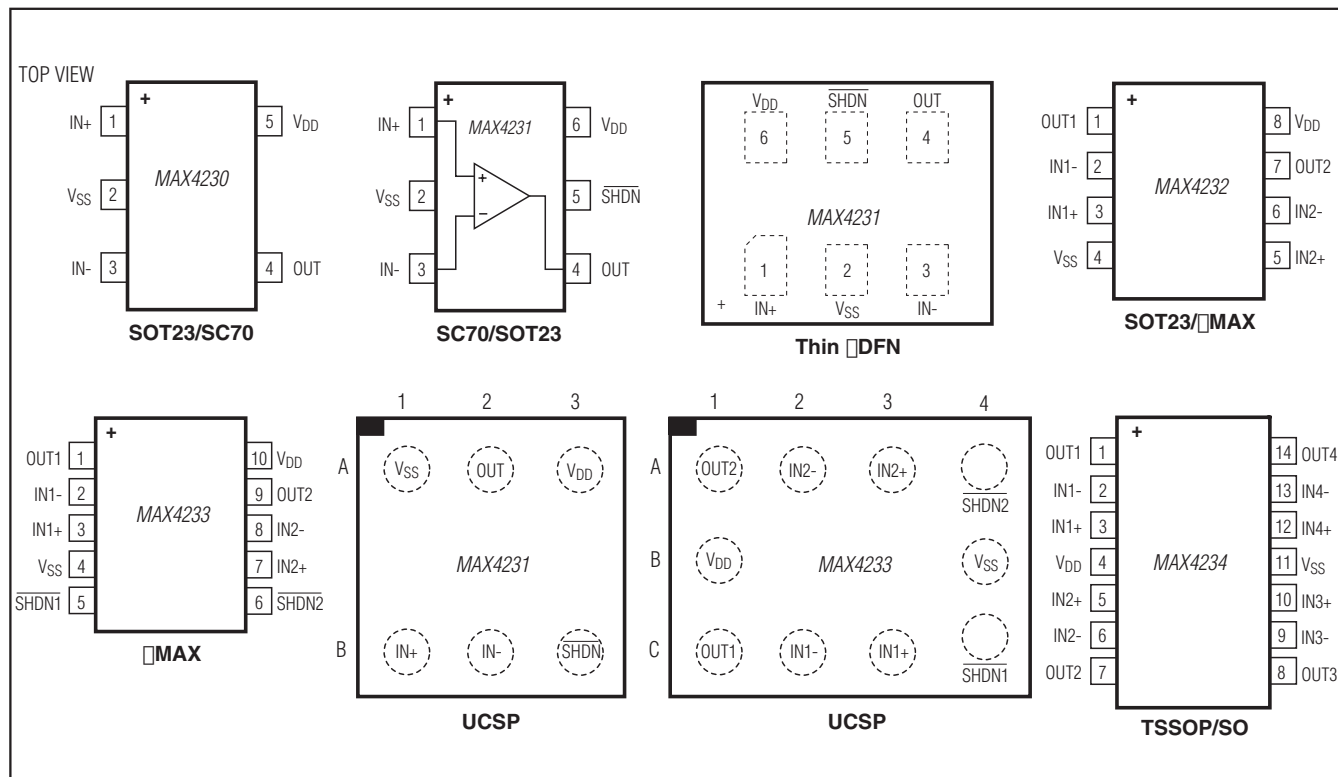
| PART | AMPS PER PACKAGE | SHUTDOWN MODE |
|---------|------------------|---------------|
| MAX4230 | Single | — |
| MAX4231 | Single | Yes |
| MAX4232 | Dual | — |
| MAX4233 | Dual | Yes |
| MAX4234 | Quad | — |

When exiting shutdown, there is a 6 μ s delay before the amplifier's output becomes active (Figure 10).

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High Output-Drive, 10MHz, 10V/ μ s, Rail-to-Rail I/O Op Amps with Shutdown in SC70

Pin/Bump Configurations



Power Supplies and Layout

The MAX4230–MAX4234 can operate from a single 2.7V to 5.5V supply, or from dual ± 1.35 V to ± 2.5 V supplies. For single-supply operation, bypass the power supply with a 0.1 μ F ceramic capacitor. For dual-supply operation, bypass each supply to ground. Good layout improves performance by decreasing the amount of stray capacitance at the op amps' inputs and outputs. Decrease stray capacitance by placing external components close to the op amps' pins, minimizing trace and lead lengths.

Ordering Information (continued)

| PART | TEMP RANGE | PIN-PACKAGE | TOP MARK |
|---------------|-----------------|--------------|----------|
| MAX4232AKA+T | -40°C to +125°C | 8 SOT23 | AAKW |
| MAX4232AUA+T | -40°C to +125°C | 8 μ MAX | — |
| MAX4233AUB+T | -40°C to +125°C | 10 μ MAX | — |
| MAX4233ABC+T | -40°C to +125°C | 10 UCSP | ABF |
| MAX4234AUD | -40°C to +125°C | 14 TSSOP | — |
| MAX4234AUD/V+ | -40°C to +125°C | 14 TSSOP | +YWD |
| MAX4234ASD | -40°C to +125°C | 14 SO | — |

+ Denotes a lead-free(Pb)/RoHS-compliant package.

T = Tape and reel.

*EP = Exposed pad.

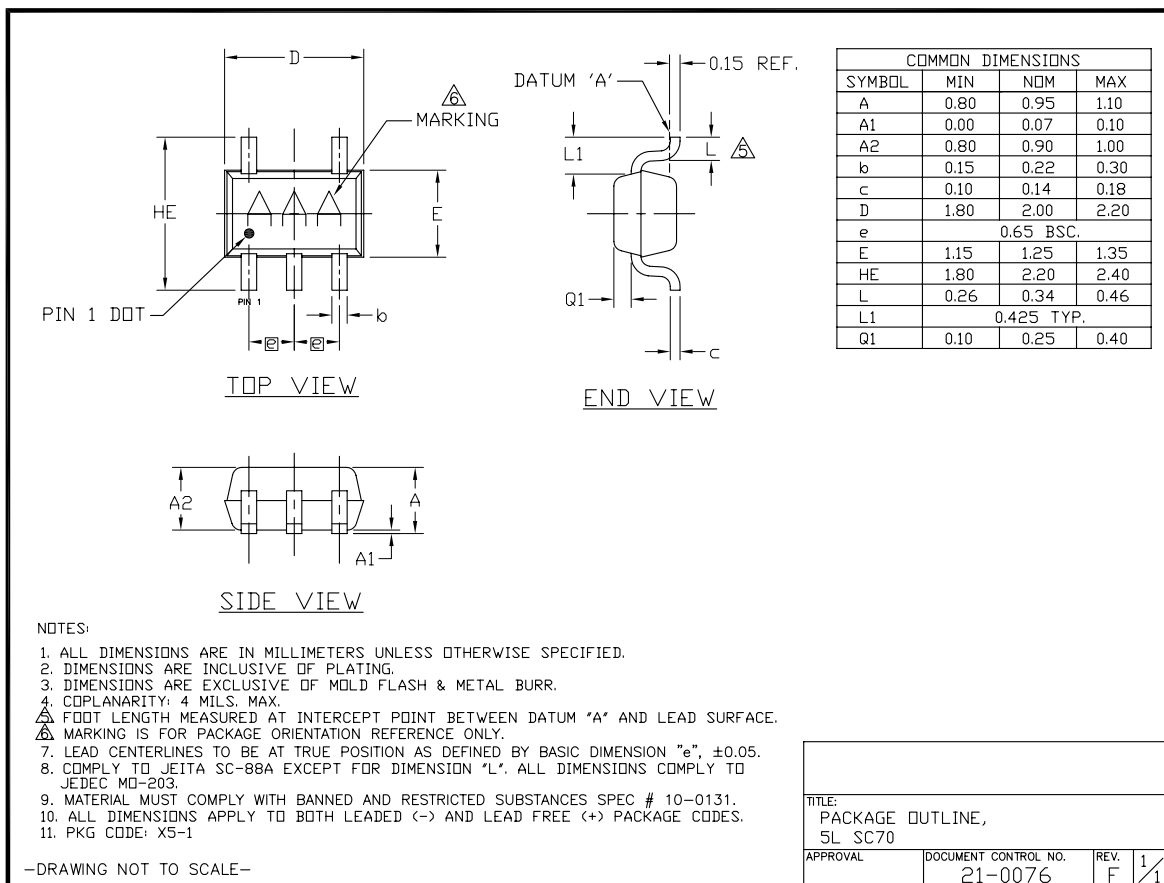
MAX4230-MAX4234

High-Output-Drive, 10MHz, 10V/ μ s, Rail-to-Rail I/O Op Amps with Shutdown in SC70

Package Information

For the latest package outline information and land patterns, go to www.maximintegrated.com/packages. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

| PACKAGE TYPE | PACKAGE CODE | OUTLINE NO. | LAND PATTERN NO. |
|------------------|--------------|-------------------------|-------------------------|
| 5 SC70 | X5+1 | 21-0076 | 90-0188 |
| 6 SC70 | X6SN+1 | 21-0077 | 90-0189 |
| 5 SOT23 | U5+1 | 21-0057 | 90-0174 |
| 6 SOT23 | U6SN+1 | 21-0058 | 90-0175 |
| 8 μ MAX | U8+1 | 21-0036 | 90-0092 |
| 8 SOT23 | K8+5 | 21-0078 | 90-0176 |
| 10 μ MAX | U10+2 | 21-0061 | 90-0330 |
| 10 UCSP | B12+4 | 21-0104 | — |
| 6 UCSP | R61A1+1 | 21-0228 | — |
| 6 Thin μ DFN | Y61A1+1 | 21-0190 | 90-0233 |
| 14 TSSOP | U14+1 | 21-0066 | 90-0113 |
| 14 SO | S14+1 | 21-0041 | 90-0112 |

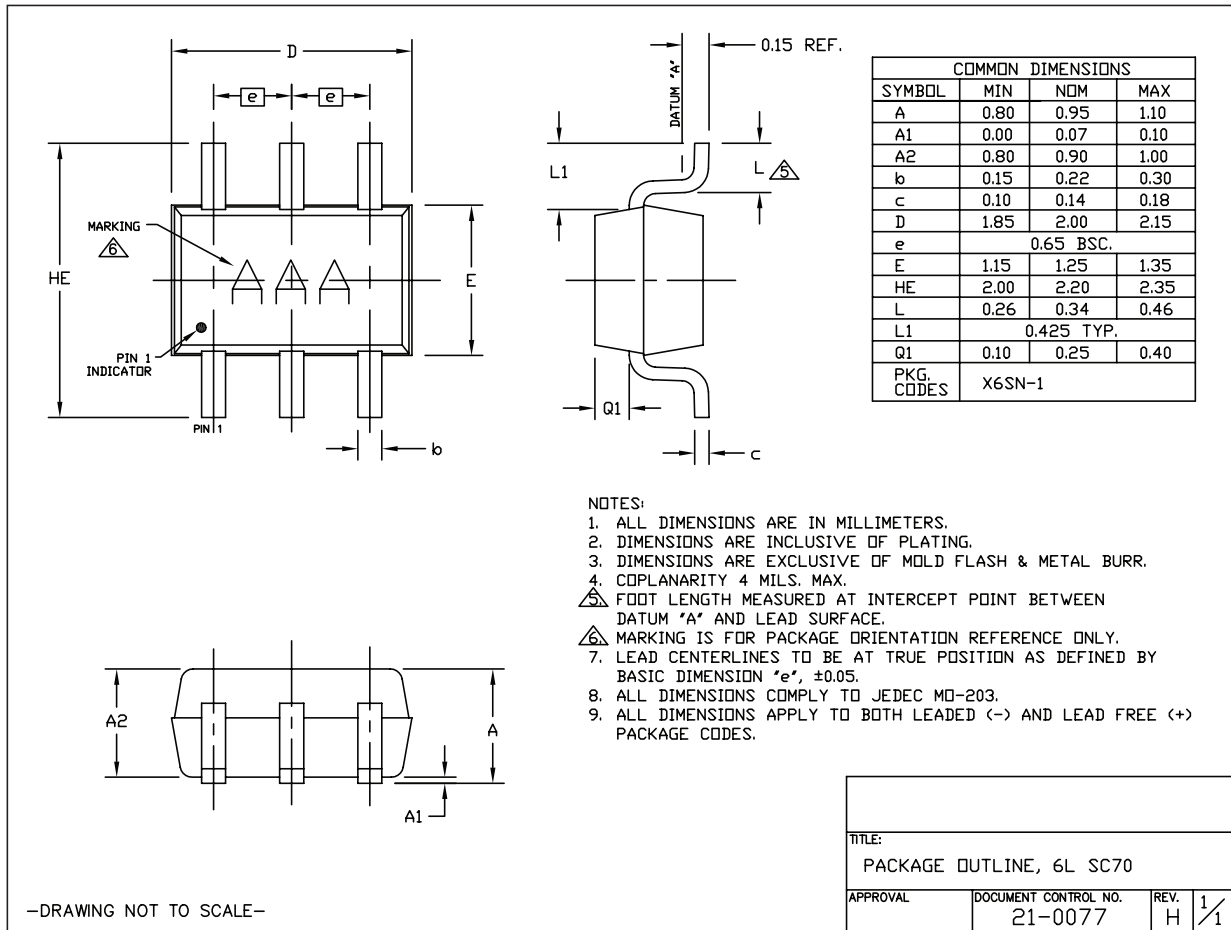


MAX4230-MAX4234

High Output-Drive, 10MHz, 10V/ μ s, Rail-to-Rail I/O Op Amps with Shutdown in SC70

Package Information (continued)

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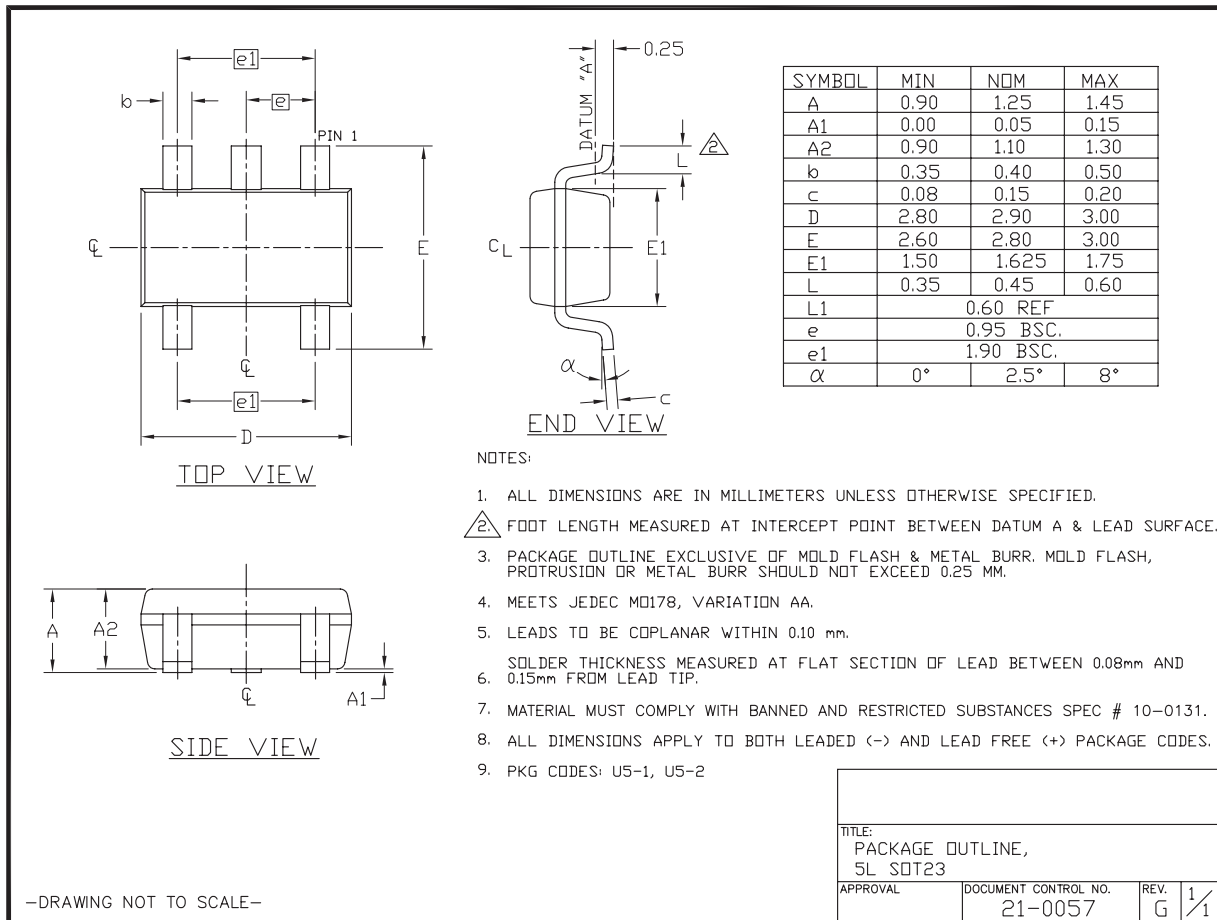


MAX4230-MAX4234

High-Output-Drive, 10MHz, 10V/ μ s, Rail-to-Rail I/O Op Amps with Shutdown in SC70

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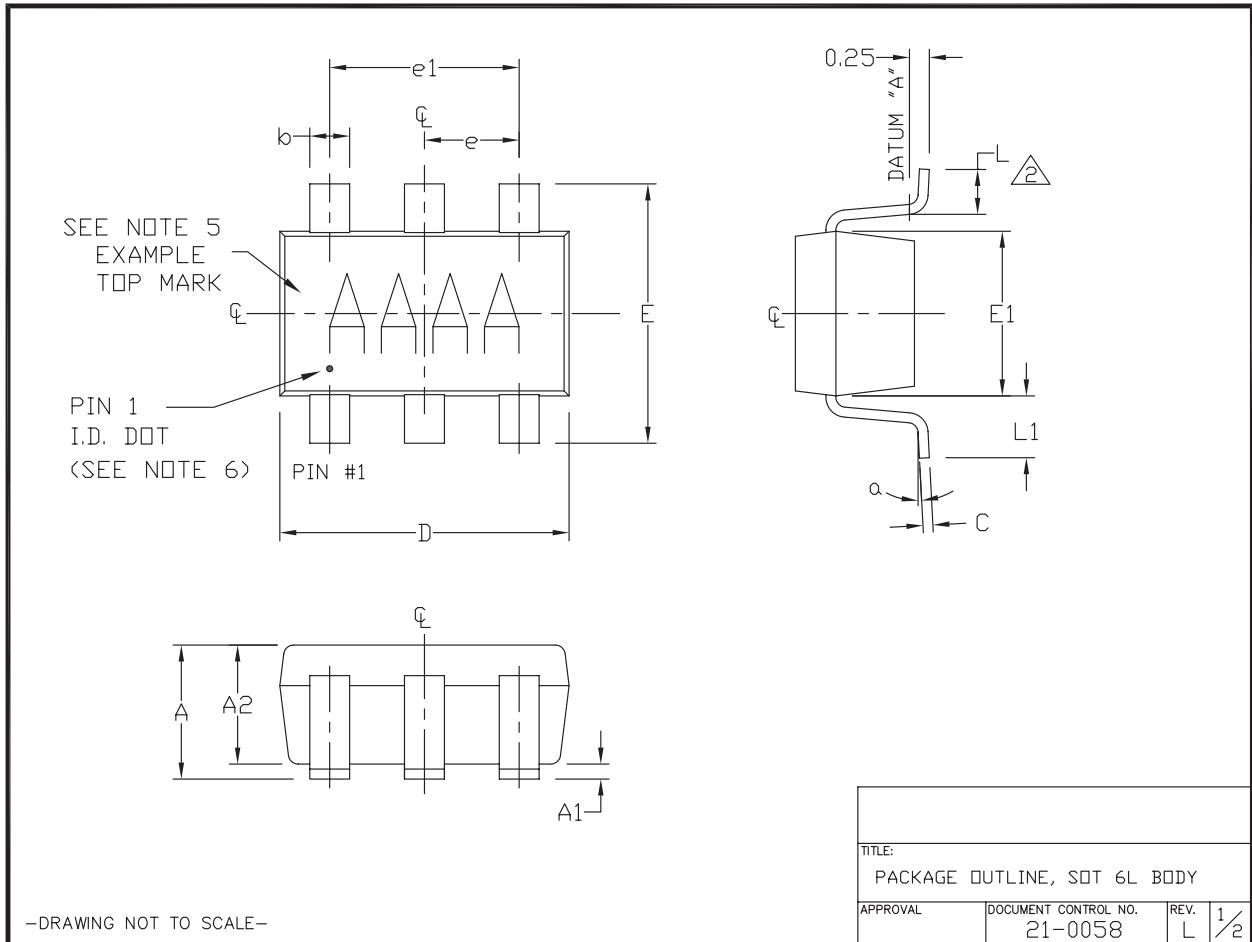


MAX4230-MAX4234

High Output-Drive, 10MHz, 10V/ μ s, Rail-to-Rail I/O Op Amps with Shutdown in SC70

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High-Output-Drive, 10MHz, 10V/ μ s, Rail-to-Rail I/O Op Amps with Shutdown in SC70

Package Information (continued)

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NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. FOOT LENGTH MEASURED AT INTERCEPT POINT BETWEEN DATUM A & LEAD SURFACE.
3. PACKAGE OUTLINE EXCLUSIVE OF MOLD FLASH & METAL BURR. MOLD FLASH, PROTRUSION OR METAL BURR SHOULD NOT EXCEED 0.25mm.
4. PACKAGE OUTLINE INCLUSIVE OF SOLDER PLATING.
5. PIN 1 IS LOWER LEFT PIN WHEN READING TOP MARK FROM LEFT TO RIGHT. (SEE EXAMPLE TOP MARK)
6. PIN 1 I.D. DOT IS 0.3mm ϕ MIN. LOCATED ABOVE PIN 1.
7. MEETS JEDEC MO178, VARIATION AB.
8. SOLDER THICKNESS MEASURED AT FLAT SECTION OF LEAD BETWEEN 0.08mm AND 0.15mm FROM LEAD TIP.
9. LEAD TO BE COPLANAR WITHIN 0.1mm.
10. NUMBER OF LEADS SHOWN ARE FOR REFERENCE ONLY.
11. MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY.
12. ALL DIMENSIONS APPLY TO BOTH LEADED (-) AND PbFREE (+) PKG. CODES.

| SYMBOL | MIN | NOMINAL | MAX |
|--------|-----------|---------|------|
| A | 0.90 | 1.25 | 1.45 |
| A1 | 0.00 | 0.05 | 0.15 |
| A2 | 0.90 | 1.10 | 1.30 |
| b | 0.35 | 0.40 | 0.50 |
| C | 0.08 | 0.15 | 0.20 |
| D | 2.80 | 2.90 | 3.00 |
| E | 2.60 | 2.80 | 3.00 |
| E1 | 1.50 | 1.625 | 1.75 |
| L | 0.35 | 0.45 | 0.60 |
| L1 | 0.60 REF. | | |
| e1 | 1.90 BSC. | | |
| e | 0.95 BSC. | | |
| a | 0° | 2.5° | 10° |

PKG CODES:
U6-1, U6-2, U6-4, U6CN-2,
U6SN-1, U6F-6, U6FH-6; U6FH-7

** U6FH-7 TO BE USED FOR NP42 PARTS ONLY.

-DRAWING NOT TO SCALE-

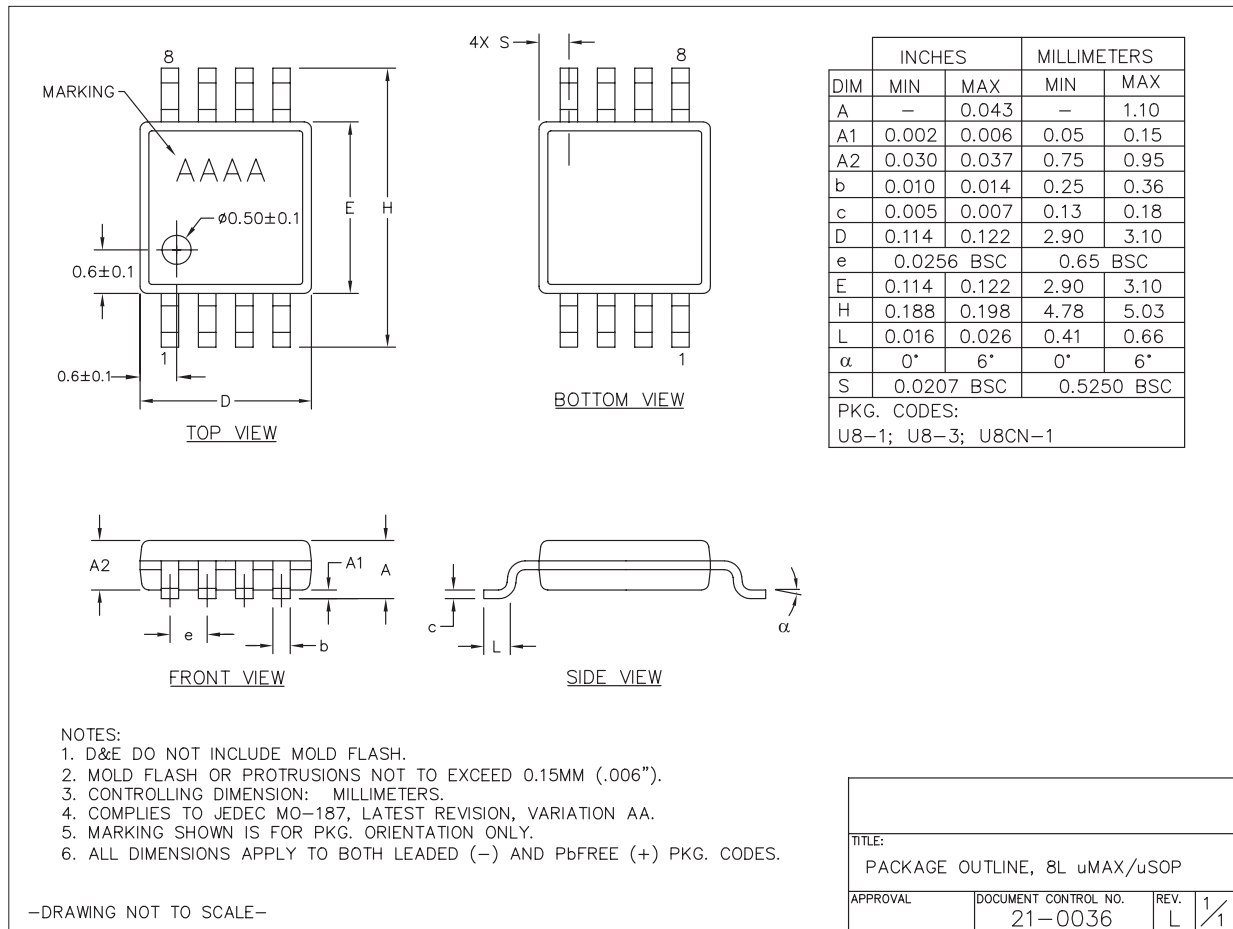
| | | | |
|--|---------------------------------|-----------|-----|
| TITLE: PACKAGE OUTLINE, SOT 6L BODY | | | |
| APPROVAL | DOCUMENT CONTROL NO. 21-0058 | REV. L | 2/2 |

MAX4230-MAX4234

High Output-Drive, 10MHz, 10V/ μ s, Rail-to-Rail I/O Op Amps with Shutdown in SC70

Package Information (continued)

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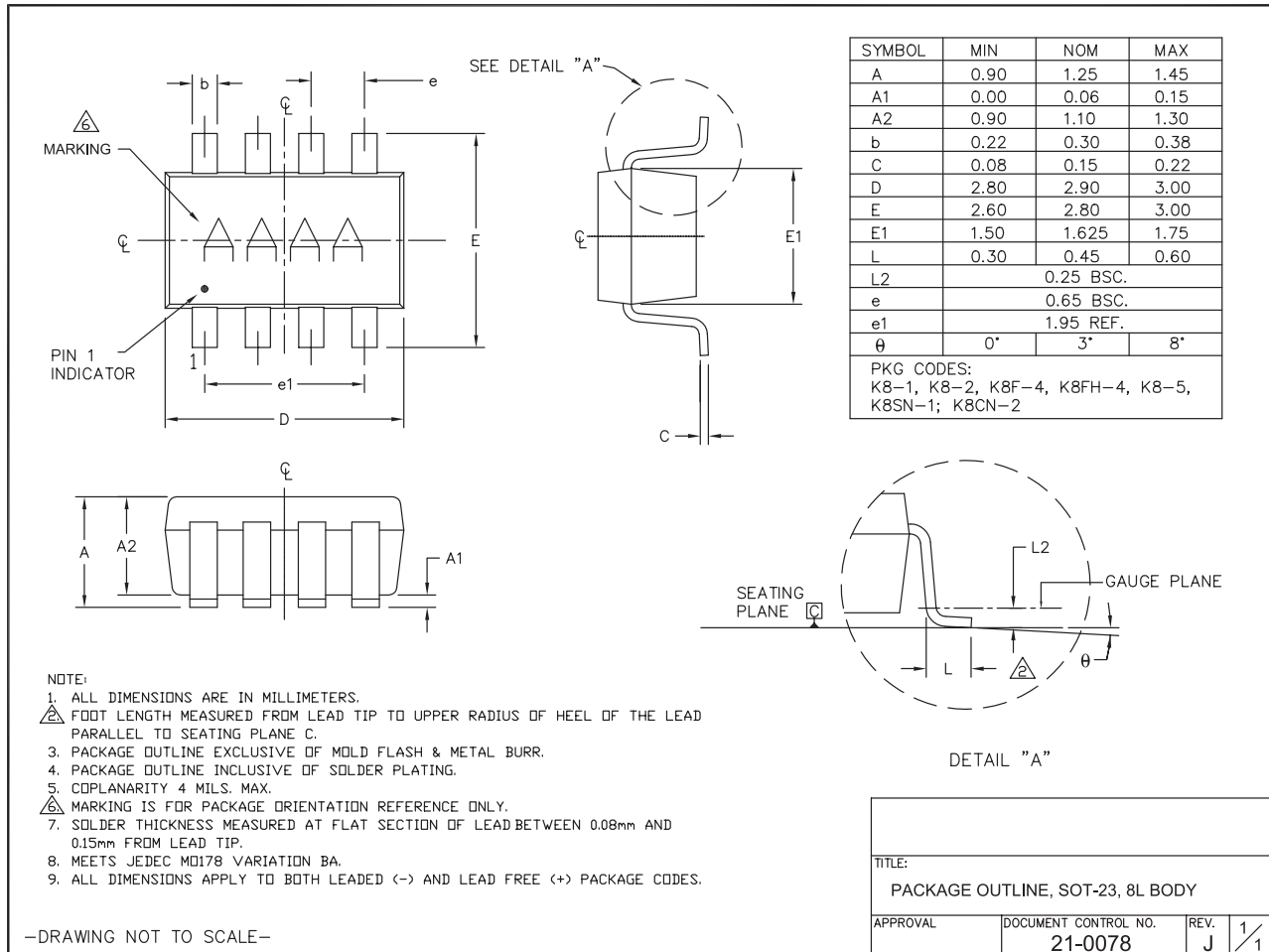


MAX4230-MAX4234

High-Output-Drive, 10MHz, 10V/ μ s, Rail-to-Rail I/O Op Amps with Shutdown in SC70

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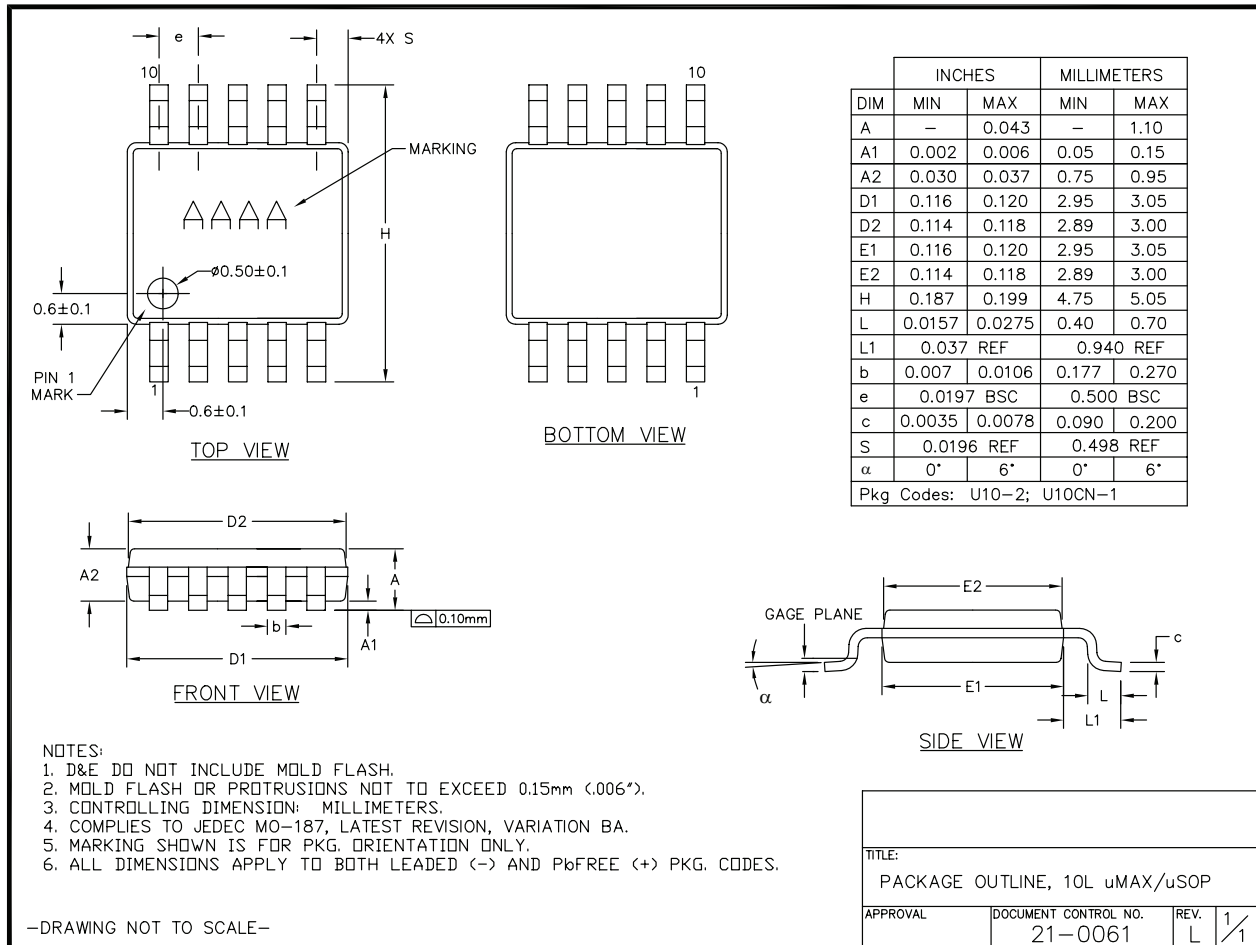


MAX4230-MAX4234

High Output-Drive, 10MHz, 10V/ μ s, Rail-to-Rail I/O Op Amps with Shutdown in SC70

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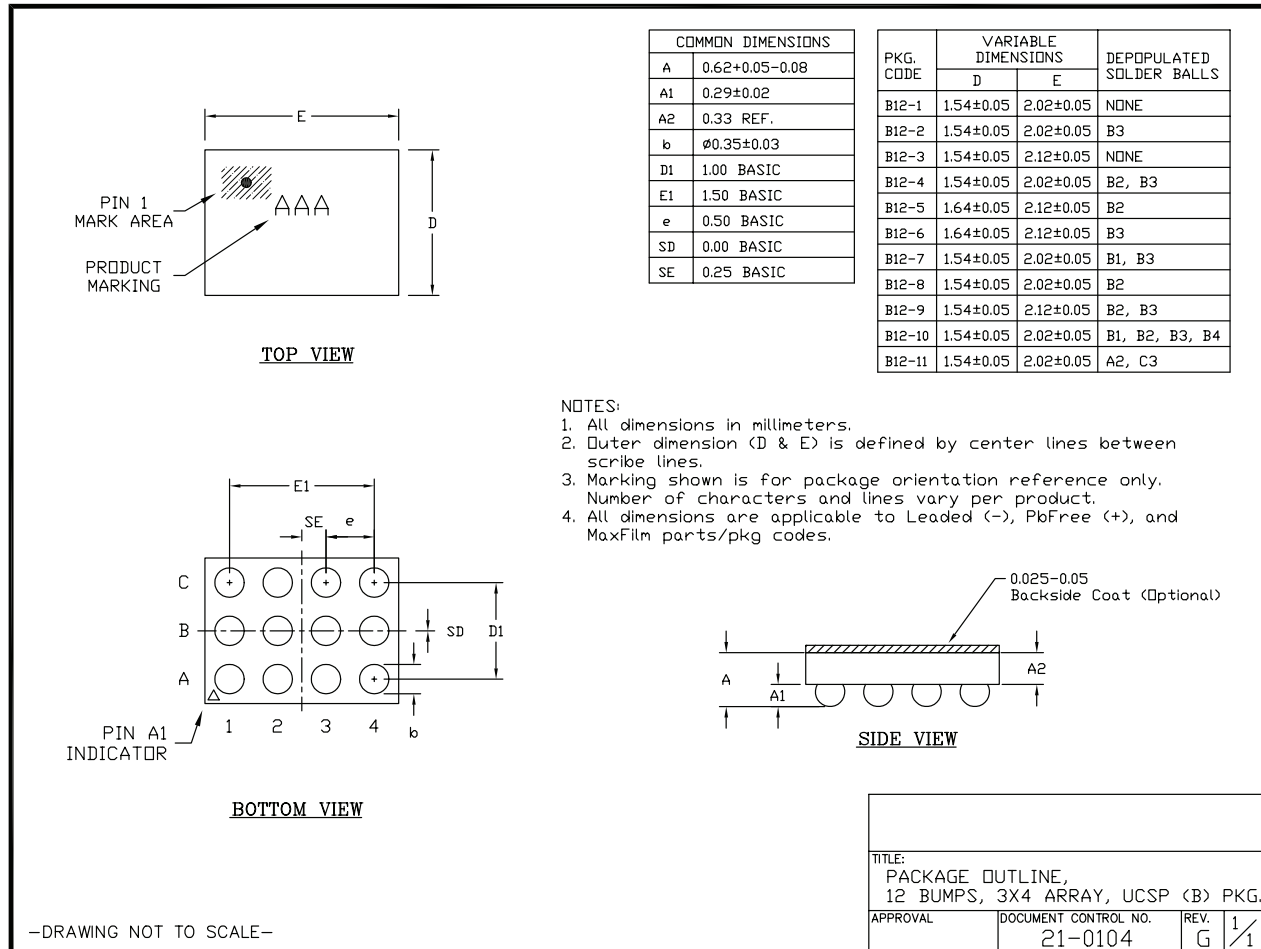


MAX4230-MAX4234

High-Output-Drive, 10MHz, 10V/ μ s, Rail-to-Rail I/O Op Amps with Shutdown in SC70

Package Information (continued)

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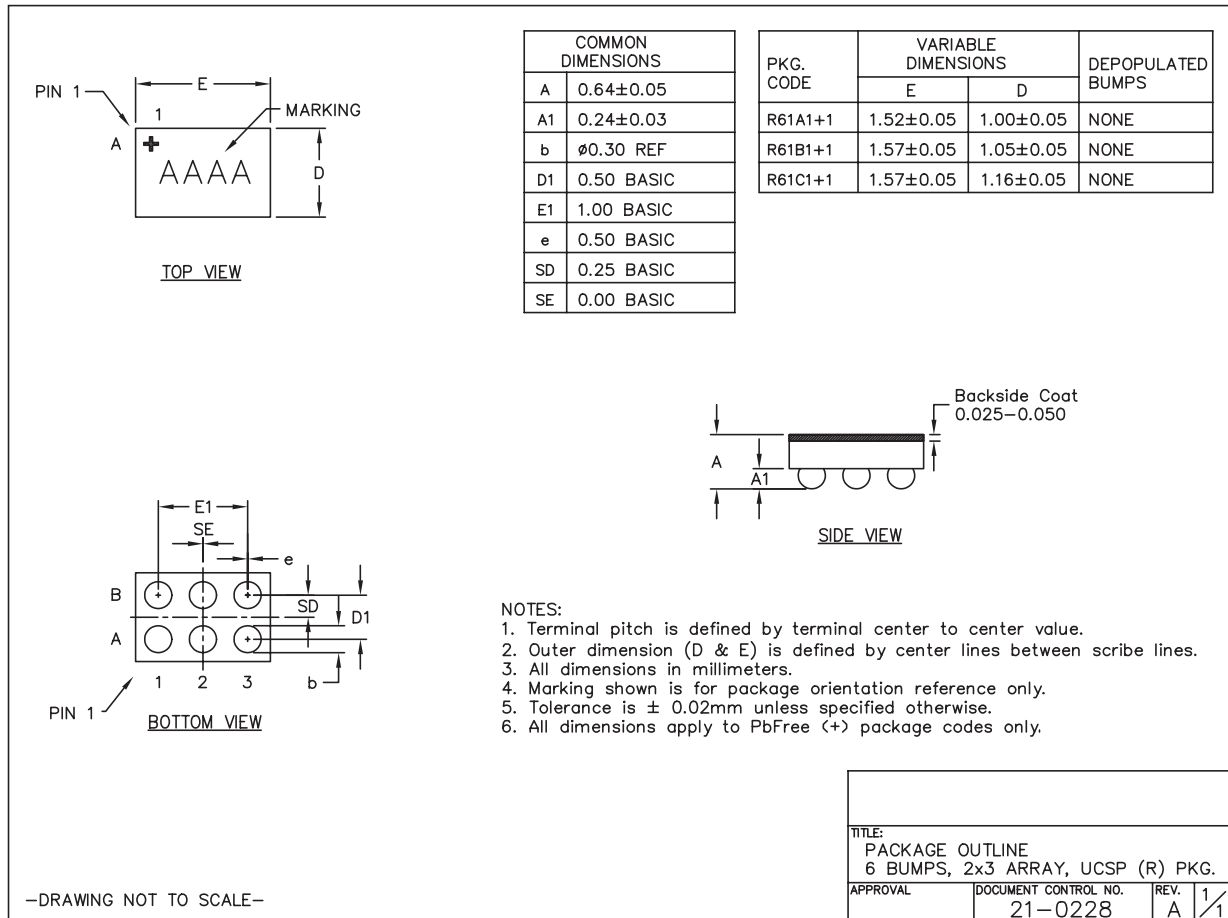


MAX4230–MAX4234

High Output-Drive, 10MHz, 10V/ μ s, Rail-to-Rail I/O Op Amps with Shutdown in SC70

Package Information (continued)

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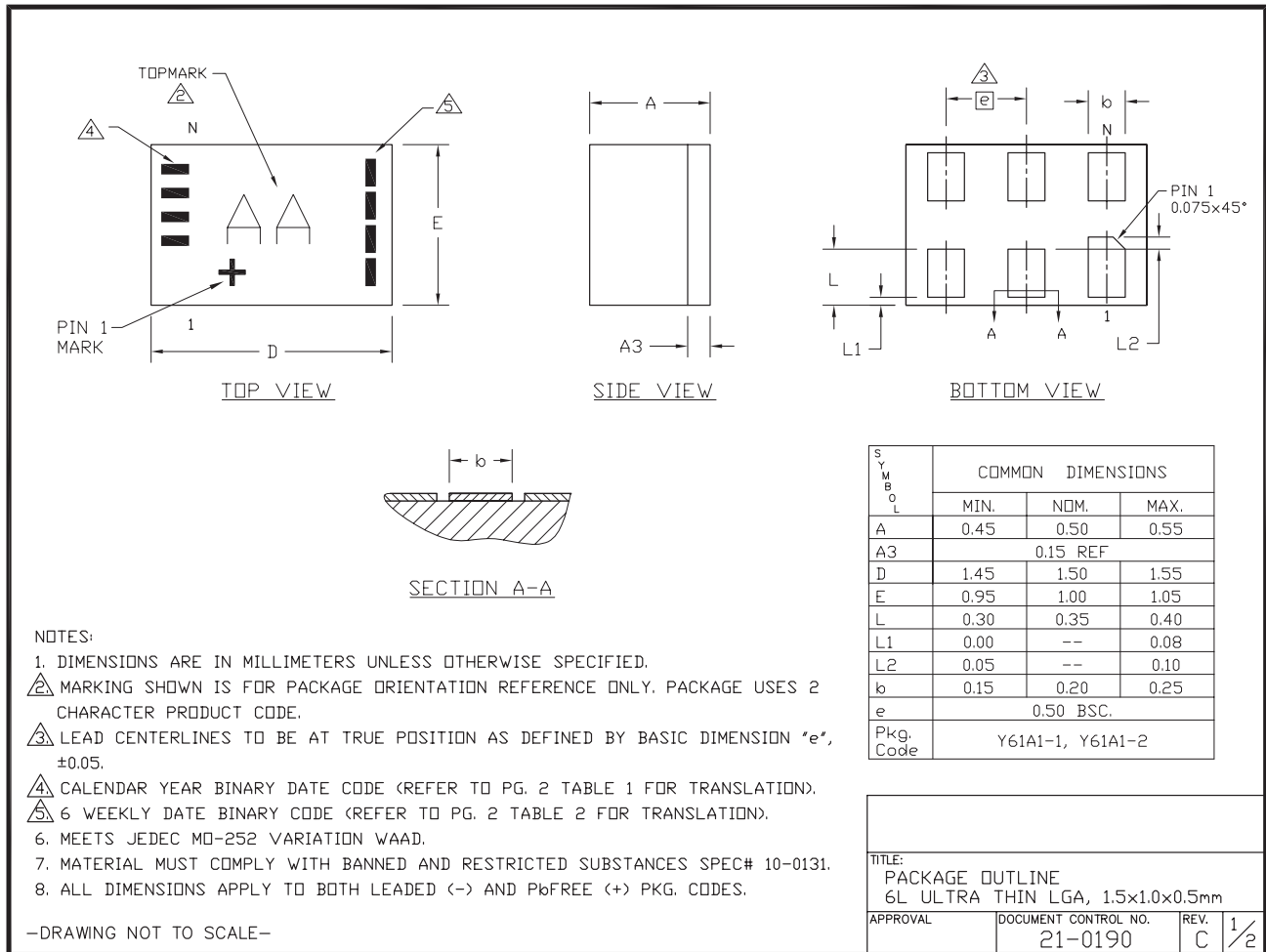


MAX4230-MAX4234

High-Output-Drive, 10MHz, 10V/ μ s, Rail-to-Rail I/O Op Amps with Shutdown in SC70

Package Information (continued)

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MAX4230–MAX4234

High Output-Drive, 10MHz, 10V/ μ s, Rail-to-Rail I/O Op Amps with Shutdown in SC70

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TABLE 1 Translation Table for Calendar Year Code

| Calendar Year | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---------------|------|------|------|------|------|------|------|------|------|------|
| | □ | □ | □ | ■ | □ | □ | ■ | □ | ■ | ■ |
| | □ | □ | ■ | □ | □ | ■ | □ | ■ | □ | □ |
| | □ | ■ | □ | □ | ■ | □ | □ | ■ | ■ | ■ |
| | ■ | □ | □ | □ | ■ | ■ | ■ | □ | □ | □ |

Legend: Marked with bar Blank space - no bar required

TABLE 2 Translation Table for Payweek Binary Coding

| Payweek | 06-11 | 12-17 | 18-23 | 24-29 | 30-35 | 36-41 | 42-47 | 48-51 | 52-05 |
|---------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| | □ | □ | □ | ■ | □ | □ | ■ | □ | ■ |
| | □ | □ | ■ | □ | □ | ■ | □ | ■ | □ |
| | □ | ■ | □ | □ | ■ | □ | □ | ■ | ■ |
| | ■ | □ | □ | □ | ■ | ■ | ■ | □ | □ |

Legend: Marked with bar Blank space - no bar required

–DRAWING NOT TO SCALE–

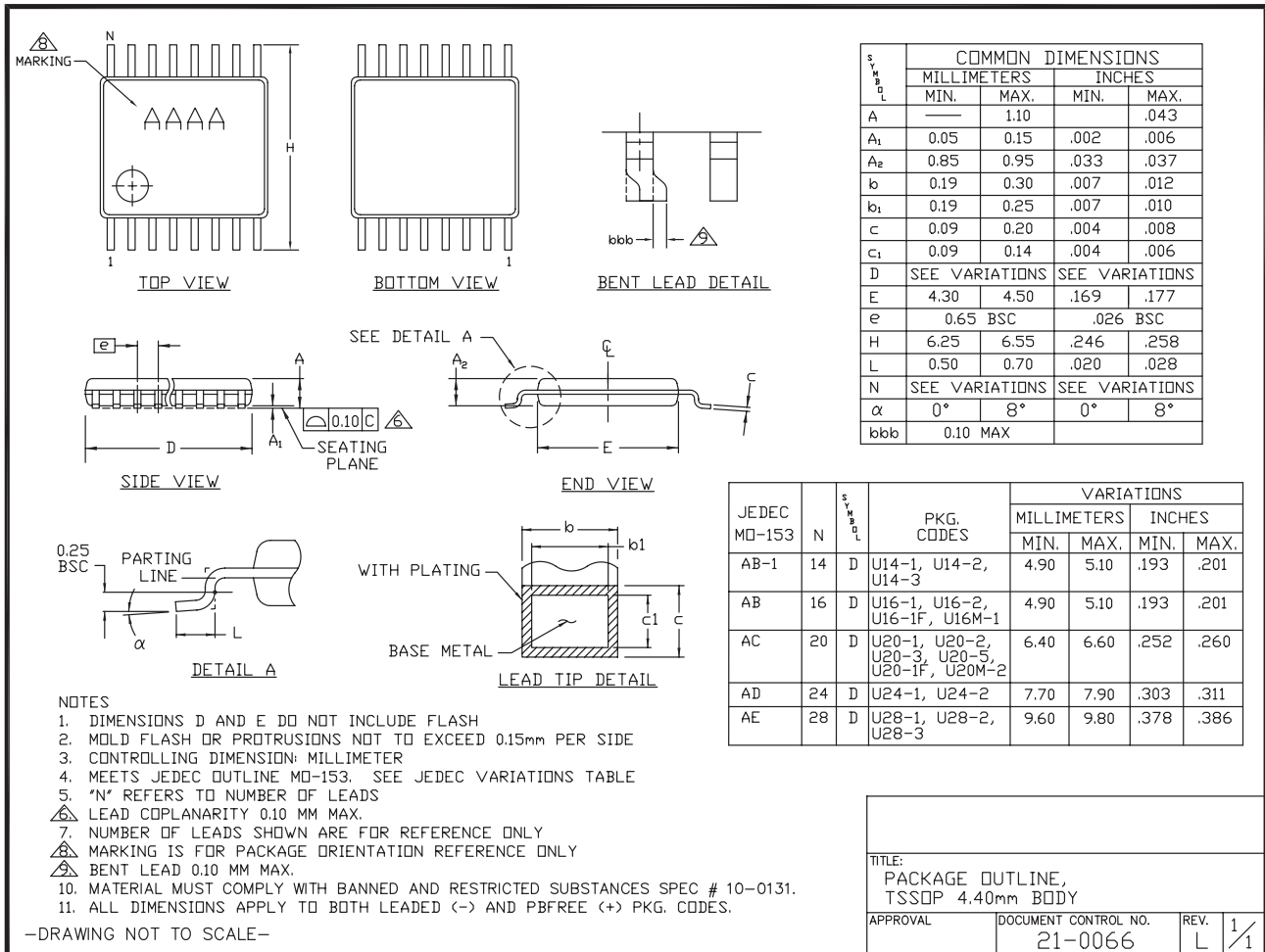
| | | | |
|---|---------------------------------|-----------|-----|
| TITLE: PACKAGE OUTLINE 6L ULTRA THIN LGA, 1.5x1.0x0.5mm | | | |
| APPROVAL | DOCUMENT CONTROL NO. 21-0190 | REV. C | 2/2 |

MAX4230-MAX4234

High-Output-Drive, 10MHz, 10V/ μ s, Rail-to-Rail I/O Op Amps with Shutdown in SC70

Package Information (continued)

For the latest package outline information and land patterns, go to www.maximintegrated.com/packages. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

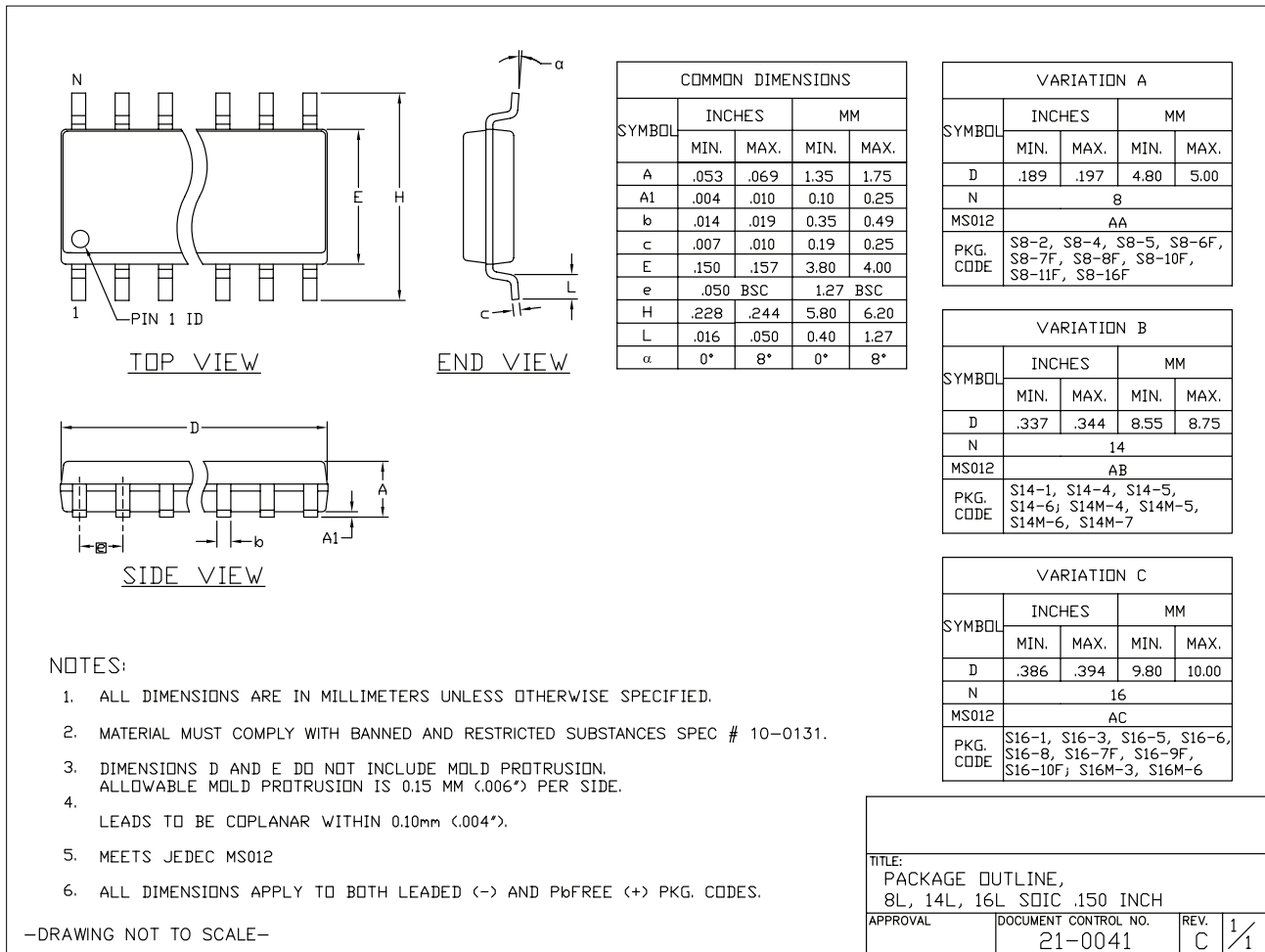


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MAX4230–MAX4234

High-Output-Drive, 10MHz, 10V/ μ s, Rail-to-Rail I/O Op Amps with Shutdown in SC70

Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION | PAGES CHANGED |
|-----------------|---------------|---|---------------|
| 7 | 7/08 | Added 6-pin μ DFN package for the MAX4231 | 1, 2, 8, 13 |
| 8 | 10/08 | Corrected top mark for MAX4321, 6 SOT23 package; changed MAX4320 and 4321 to lead-free packages | 1 |
| 9 | 10/08 | Added shutdown pin limits | 3, 4 |
| 10 | 12/08 | Added automotive part number | 13 |
| 11 | 9/09 | Corrected top mark designation and pin configuration, and added UCSP package | 1, 2, 8, 13 |
| 12 | 1/10 | Updated <i>Absolute Maximum Ratings</i> section | 2 |
| 13 | 1/11 | Added 10 μ MAX to <i>Package Information</i> section | 14 |
| 14 | 10/11 | Updated <i>Electrical Characteristics</i> table with specs for bias current at various temperatures | 1–4 |
| 15 | 3/12 | Updated thermal data in the <i>Absolute Maximum Ratings</i> . | 2 |
| 16 | 6/12 | Added automotive part number for MAX4230. | 1 |



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