

**MAXIM**

# Dual-Supply, 180MHz, 16-Bit Accurate, Ultra-Low Distortion Op Amps

## General Description

The MAX4430/MAX4431 single and MAX4432/MAX4433 dual operational amplifiers feature wide bandwidth, 16-bit settling times in 37ns, and low-noise/low-distortion operation. The MAX4430/MAX4432 are compensated for unity gain stability and have a small signal -3dB bandwidth of 180MHz. The MAX4431/MAX4433 are compensated for closed-loop gains of +2 or greater and have a small-signal -3dB bandwidth of 215MHz.

The MAX4430–MAX4433 op amps require only 11mA of supply current per amplifier while achieving 125dB open-loop gain. Voltage noise density is a low  $2.8\text{nV}/\sqrt{\text{Hz}}$ , and provides 100dB spurious-free dynamic range (SFDR) at 1MHz. These characteristics make these op amps ideal for driving modern high-speed 14- and 16-bit analog-to-digital converters (ADCs).

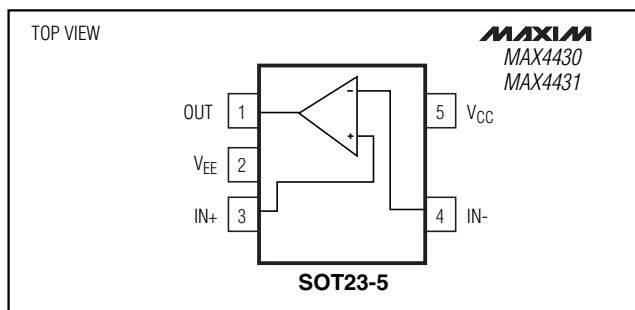
These high-speed op amps feature wide output voltage swings capable of driving ADCs with  $\geq 4\text{V}$  input dynamic range and a high current output drive up to 60mA. Using a voltage feedback architecture, the MAX4430–MAX4433 meet the requirements of many applications that previously depended on current feedback amplifiers.

The MAX4430/MAX4431 are available in a space-saving 5-pin SOT23 package, and the MAX4432/MAX4433 are available in an 8-pin  $\mu\text{MAX}$  package.

## Applications

High-Speed 14- and 16-Bit ADC Preamplifiers  
 Low-Noise Preamplifiers  
 IF/RF Amplifiers  
 Low-Distortion Active Filters  
 High-Performance Receivers  
 Precision Instrumentation

## Pin Configurations



Pin Configurations continued at end of data sheet.

## Features

- ◆ 16-Bit Accurate Settling in 37ns (MAX4430/MAX4432)
- ◆ 100dB SFDR at 1MHz, 4Vp-p Output
- ◆  $2.8\text{nV}/\sqrt{\text{Hz}}$  Input Voltage Noise Density
- ◆ 110dB (min) Open-Loop Gain
- ◆  $145\text{V}/\mu\text{s}$  Slew Rate (MAX4431/MAX4433)
- ◆ 60mA High Output Drive
- ◆ Wide Voltage Swing Capable of Driving ADC Inputs with  $\geq 4\text{Vp-p}$  Input Dynamic Range
- ◆ Available in Space-Saving Packages
  - 5-pin SOT23 (MAX4430/MAX4431)
  - 8-pin  $\mu\text{MAX}$  (MAX4432/MAX4433)

## Ordering Information

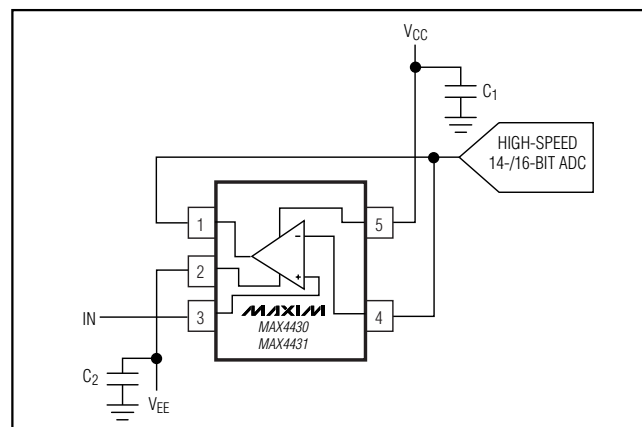
PART	TEMP. RANGE	PIN-PACKAGE
MAX4430EUK-T	-40°C to +85°C	5 SOT23-5
MAX4430ESA	-40°C to +85°C	8 SO

Ordering Information continued at end of data sheet.

## Selector Guide

PART	AMPS	MIN GAIN STABLE (V/V)	BW (MHz)	SETTLING TIME TO 0.0015% (ns)
MAX4430	1	+1	180	37
MAX4431	1	+2	215	63
MAX4432	2	+1	180	37
MAX4433	2	+2	215	63

## Typical Operating Circuit

**MAXIM**

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 For small orders, phone 1-800-835-8769.

**MAX4430–MAX4433**

# Dual-Supply, 180MHz, 16-Bit Accurate, Ultra-Low Distortion Op Amps

## ABSOLUTE MAXIMUM RATINGS

Supply Voltage ( $V_{CC}$ to $V_{EE}$ ).....	+12V	Operating Temperature Range .....	-40°C to +85°C
Differential Input Voltage .....	+2V	Junction Temperature .....	+150°C
Input Voltage Range .....	( $V_{CC} + 0.3V$ ) to ( $V_{EE} - 0.3V$ )	Storage Temperature Range .....	-65°C to +150°C
Output Short-Circuit Duration to $V_{CC}$ or $V_{EE}$ .....	(Note 1)	Lead Temperature (soldering, 10s) .....	+300°C
Current Into Any Input Pin .....	±25mA		
Continuous Power Dissipation ( $T_A = +70^\circ\text{C}$ )			
5-Pin SOT23 (derate 7.1mW/°C above +70°C).....	571mW		
8-Pin $\mu\text{MAX}$ (derate 4.5mW/°C above +70°C).....	330mW		
8-Pin SO (derate 5.88mW/°C above +70°C).....	471mW		

**Note 1:** The MAX4430-MAX4433 are not protected for output short-circuit conditions.

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

( $V_{CC} = +5V$ ,  $V_{EE} = -5V$ ,  $R_L = \infty$ ,  $V_{CM} = 0$ , and  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $T_A = +25^\circ\text{C}$ .) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Common-Mode Voltage Range	$V_{CM}$	Guaranteed by CMRR test	$V_{EE} + 2.5$		$V_{CC} - 0.9$	V
Input Offset Voltage	$V_{OS}$			±1.25	±5	mV
Input Offset Voltage Temperature Coefficient	$TC_{VOS}$			7		$\mu\text{V}/^\circ\text{C}$
Input Offset Voltage Matching		MAX4432/MAX4433		±0.25		mV
Input Bias Current	$I_B$			11	30	$\mu\text{A}$
Input Offset Current	$I_{OS}$			0.35	5	$\mu\text{A}$
Input Resistance	$R_{IN}$	Differential ( $-10\text{mV} \leq V_{IN} \leq +10\text{mV}$ )		12k		$\Omega$
		Common mode ( $V_{EE} + 2.5V \leq V_{CM} \leq V_{CC} - 0.9V$ )		1M		
Common-Mode Rejection Ratio	CMRR	$V_{EE} + 2.5V \leq V_{CM} \leq V_{CC} - 0.9V$	100	120		dB
Open-Loop Gain	$A_{VOL}$	$V_{EE} + 2.5 \leq V_{OUT} \leq V_{CC} - 0.9V$ ; $R_L = 10\text{k}\Omega$ to ground	115	125		dB
		$V_{EE} + 2.5 \leq V_{OUT} \leq V_{CC} - 0.9V$ ; $R_L = 500\Omega$ to ground	110	125		
Output Voltage Swing	$V_{OUT}$	$R_L = 10\text{k}\Omega$ to ground	$V_{EE} + 2.5$		$V_{CC} - 0.25$	V
		$R_L = 500\Omega$ to ground	$V_{EE} + 2.6$		$V_{CC} - 0.6$	
Output Current	$I_{OUT}$	$R_L = 20\Omega$ to ground	±30	±60		mA
Output Short-Circuit Current	$I_{SC}$	Sinking or sourcing		±100		mA
Power-Supply Rejection Ratio	PSRR-	$V_{EE} = -5.5V$ to $-4.5V$	75	95		dB
	PSRR+	$V_{CC} = +4.5V$ to $+5.5V$				
Operating Supply Voltage Range	$V_S$	Guaranteed by PSRR test	±4.5		±5.5	V
Quiescent Supply Current (per amplifier)	$I_S$			11	13.5	mA

# Dual-Supply, 180MHz, 16-Bit Accurate, Ultra-Low Distortion Op Amps

**MAX4430-MAX4433**

## AC ELECTRICAL CHARACTERISTICS

( $V_{CC} = +5V$ ,  $V_{EE} = -5V$ ,  $R_L = 500\Omega$ ,  $V_{CM} = 0$ ,  $A_{VCL} = +1$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Small-Signal -3dB Bandwidth	BW <sub>SS</sub>	V <sub>OUT</sub> = 100mVp-p, MAX4430/MAX4432		180		MHz
		V <sub>OUT</sub> = 100mVp-p, MAX4431/MAX4433 (A <sub>VCL</sub> = +2)		215		
Large-Signal -3dB Bandwidth	BW <sub>LS</sub>	V <sub>OUT</sub> = 1Vp-p, MAX4430/MAX4432		45		MHz
		V <sub>OUT</sub> = 2Vp-p, MAX4430/MAX4432		32		
		V <sub>OUT</sub> = 2Vp-p, MAX4431/MAX4433 (A <sub>VCL</sub> = +2)		40		
		V <sub>OUT</sub> = 4Vp-p, MAX4431/MAX4433 (A <sub>VCL</sub> = +2)		20		
Bandwidth for 0.1dB Flatness	BW <sub>0.1dB</sub>	V <sub>OUT</sub> = 100mVp-p, MAX4430/MAX4432		12		MHz
		V <sub>OUT</sub> = 100mVp-p, MAX4431/MAX4433 (A <sub>VCL</sub> = +2)		80		
Slew Rate	SR	V <sub>OUT</sub> = 2V step, MAX4430/MAX4432		100		V/ $\mu$ s
		V <sub>OUT</sub> = 2V step, MAX4431/MAX4433 (A <sub>VCL</sub> = +2)		145		
Rise/Fall Time	t <sub>R</sub> , t <sub>F</sub>	V <sub>OUT</sub> = 2V step		20		ns
		V <sub>OUT</sub> = 4V step		40		
Settling Time to 16 Bit (0.0015%)	t <sub>s</sub>	V <sub>OUT</sub> = 0 to 2V step, MAX4430/MAX4432		37		ns
		V <sub>OUT</sub> = 0 to 2V step, MAX4431/MAX4433 (A <sub>VCL</sub> = +2)		63		
		V <sub>OUT</sub> = 0 to 4V step, MAX4430/MAX4432		56		
		V <sub>OUT</sub> = 0 to 4V step, MAX4431/MAX4433 (A <sub>VCL</sub> = +2)		140		

# Dual-Supply, 180MHz, 16-Bit Accurate, Ultra-Low Distortion Op Amps

## AC ELECTRICAL CHARACTERISTICS (continued)

( $V_{CC} = +5V$ ,  $V_{EE} = -5V$ ,  $R_L = 500\Omega$ ,  $V_{CM} = 0$ ,  $A_{VCL} = +1$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Output "Glitch" Settling to 16-Bit (0.0015%)		5pF load; $C_L$ charged from 0 to 4V		24		ns
Output Overload Recovery Time		50% overdrive, settling to 10% accuracy		95		ns
AC Common-Mode Rejection Ratio		$f = 100kHz$		-84		dB
AC Power-Supply Rejection Ratio		$f = 100kHz$		-77		dB
Spurious-Free Dynamic Range	SFDR	$V_{OUT} = 2Vp-p$ centered at 0V, $f_C = 100kHz$		-110		dBc
		$V_{OUT} = 2Vp-p$ centered at 0V, $f_C = 1MHz$		-105		
		$V_{OUT} = 4Vp-p$ centered at 0V, $f_C = 100kHz$		-105		
		$V_{OUT} = 4Vp-p$ centered at 0V, $f_C = 1MHz$		-103		
		$V_{OUT} = 2Vp-p$ centered at 1V, $f_C = 100kHz$		-112		
		$V_{OUT} = 2Vp-p$ centered at 1V, $f_C = 1MHz$		-107		
		$V_{OUT} = 4Vp-p$ centered at 2V, $f_C = 100kHz$		-106		
		$V_{OUT} = 4Vp-p$ centered at 2V, $f_C = 1MHz$		-100		
		$V_{OUT} = 4Vp-p$ centered at 2V, $f_C = 1MHz$ ( $R_L = 1k\Omega$ )		-99		
		$V_{OUT} = 4Vp-p$ centered at 2V, $f_C = 1MHz$ ( $R_L = 10k\Omega$ )		-100		
Input Noise Voltage Density	$e_n$	$f = 100kHz$		2.8		$nV/\sqrt{Hz}$
Input Noise Current Density	$i_n$	$f = 100kHz$		1.8		$pA/\sqrt{Hz}$
Input Capacitance	$C_{IN}$			2.5		pF
Maximum Capacitive Load Without Sustained Oscillations				47		pF
Output Impedance	$Z_{OUT}$	$f = 1MHz$		0.2		$\Omega$
Crosstalk		MAX4432/MAX4433 $f_C = 1MHz$		-125		dB

**Note 2:** All devices are 100% production tested at  $T_A = +25^\circ C$ . All temperature limits are guaranteed by design.

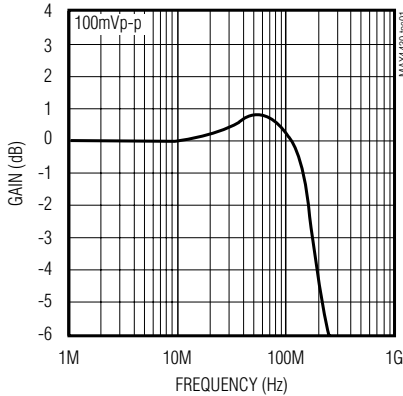
# Dual-Supply, 180MHz, 16-Bit Accurate, Ultra-Low Distortion Op Amps

## Typical Operating Characteristics

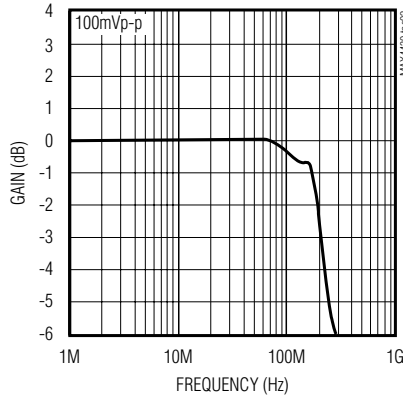
( $V_{CC} = +5V$ ,  $V_{EE} = -5V$ ,  $R_L = 500\Omega$ ,  $C_L = 0pF$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

**MAX4430-MAX4433**

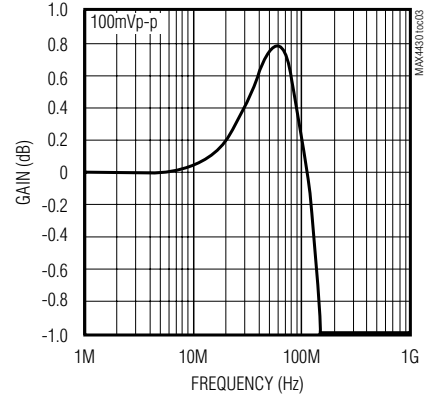
**MAX4430/MAX4432**  
SMALL-SIGNAL GAIN vs. FREQUENCY  
( $A_{VCL} = +1V/V$ )



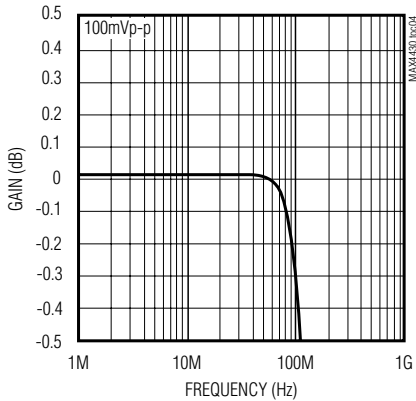
**MAX4431/MAX4433**  
SMALL-SIGNAL GAIN vs. FREQUENCY  
( $A_{VCL} = +2V/V$ )



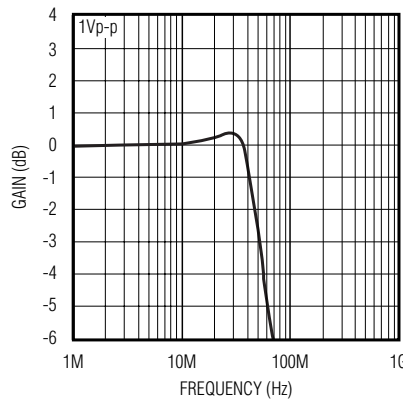
**MAX4430/MAX4432**  
GAIN FLATNESS vs. FREQUENCY  
( $A_{VCL} = +1V/V$ )



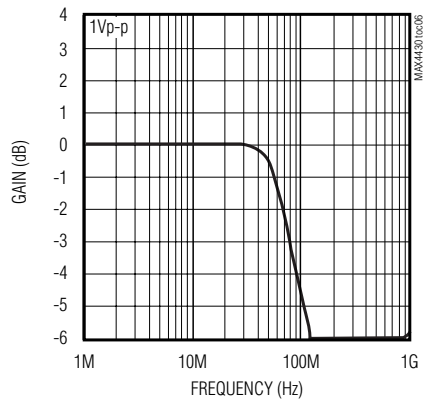
**MAX4431/MAX4433**  
GAIN FLATNESS vs. FREQUENCY  
( $A_{VCL} = +2V/V$ )



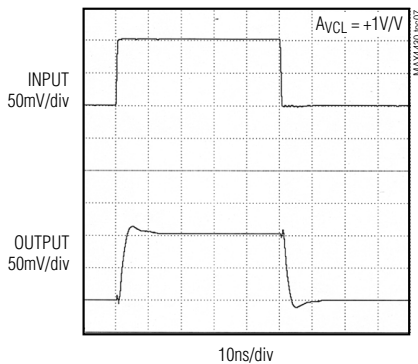
**MAX4430/MAX4432**  
LARGE-SIGNAL GAIN vs. FREQUENCY  
( $A_{VCL} = +1V/V$ )



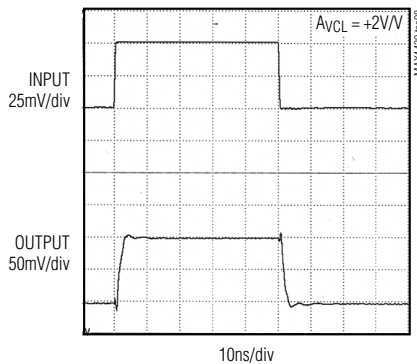
**MAX4431/MAX4433**  
LARGE-SIGNAL GAIN vs. FREQUENCY  
( $A_{VCL} = +2V/V$ )



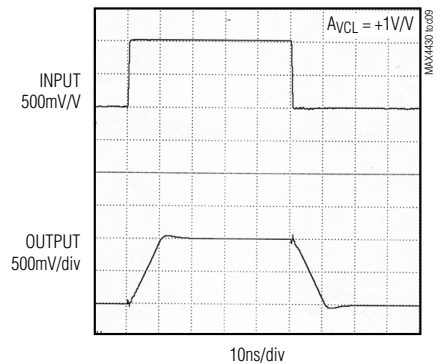
**MAX4430/MAX4432**  
SMALL-SIGNAL PULSE RESPONSE  
( $A_{VCL} = +1V/V$ )



**MAX4431/MAX4433**  
SMALL-SIGNAL PULSE RESPONSE  
( $A_{VCL} = +2V/V$ )



**MAX4430/MAX4432**  
LARGE-SIGNAL PULSE RESPONSE  
( $A_{VCL} = +1V/V$ )

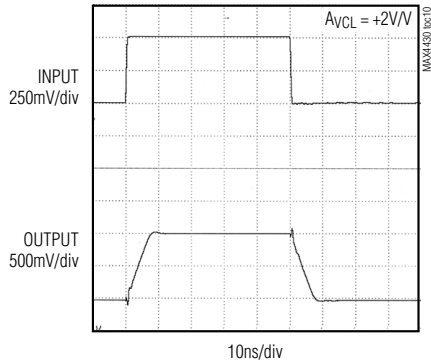


# Dual-Supply, 180MHz, 16-Bit Accurate, Ultra-Low Distortion Op Amps

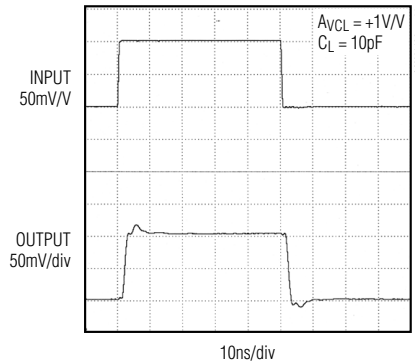
## Typical Operating Characteristics (continued)

( $V_{CC} = +5V$ ,  $V_{EE} = -5V$ ,  $R_L = 500\Omega$ ,  $C_L = 0pF$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

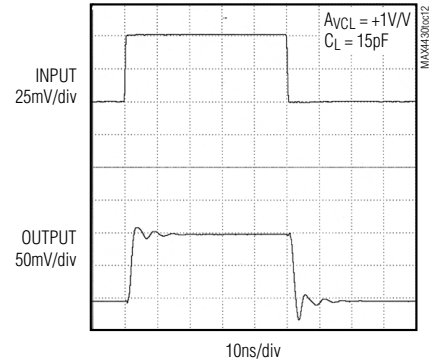
**MAX4431/MAX4433  
LARGE-SIGNAL PULSE RESPONSE**



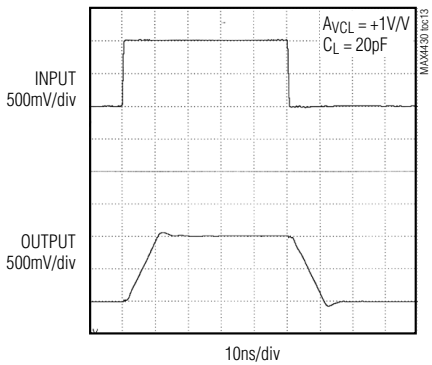
**MAX4430/MAX4432  
SMALL-SIGNAL PULSE RESPONSE**



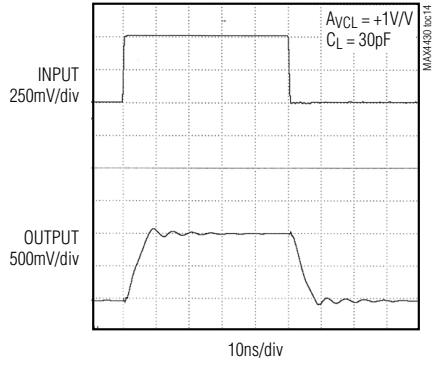
**MAX4431/MAX4433  
SMALL-SIGNAL PULSE RESPONSE**



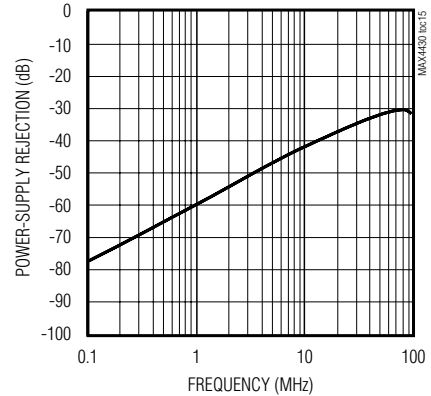
**MAX4430/MAX4432  
LARGE-SIGNAL PULSE RESPONSE**



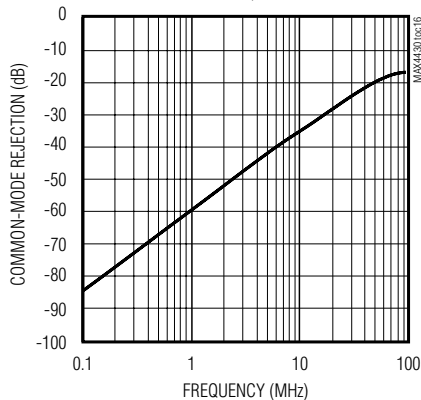
**MAX4431/MAX4433  
LARGE-SIGNAL PULSE RESPONSE**



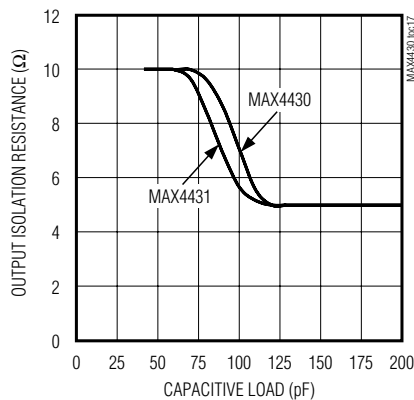
**POWER-SUPPLY REJECTION RATIO  
vs. FREQUENCY**



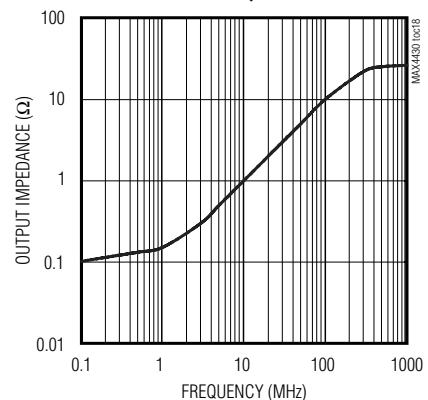
**COMMON-MODE REJECTION RATIO  
vs. FREQUENCY**



**OUTPUT ISOLATION RESISTANCE  
vs. CAPACITIVE LOAD**



**CLOSED-LOOP OUTPUT IMPEDANCE  
vs. FREQUENCY**

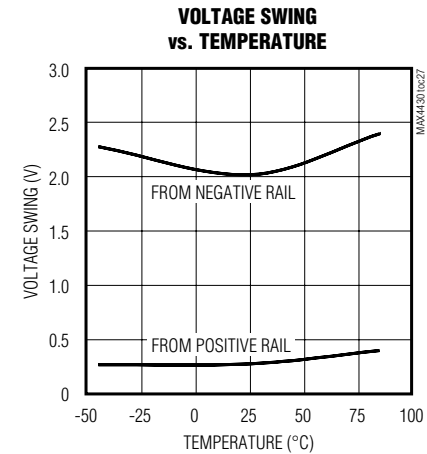
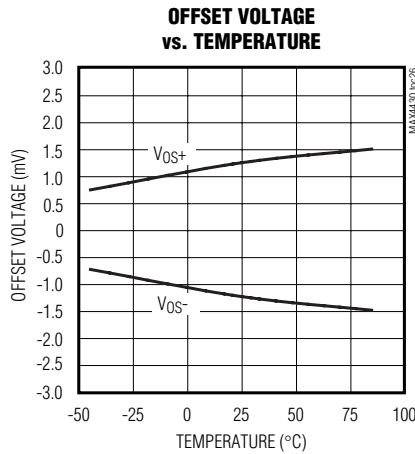
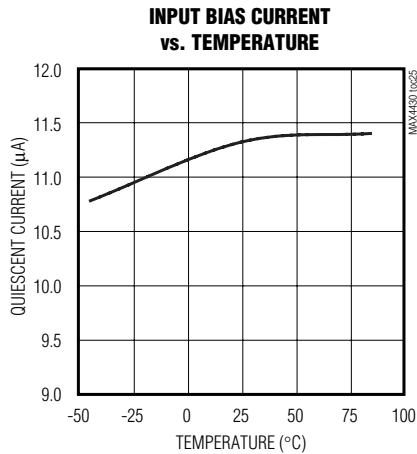
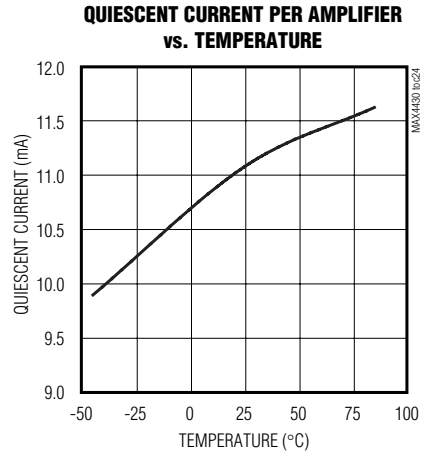
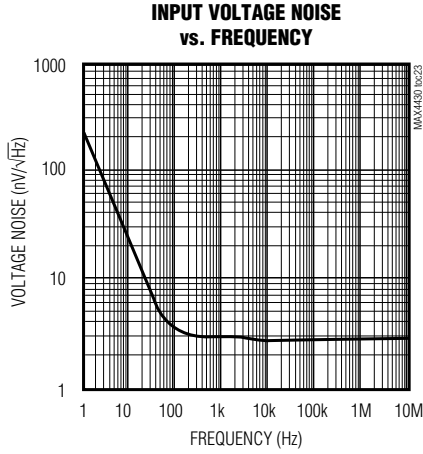
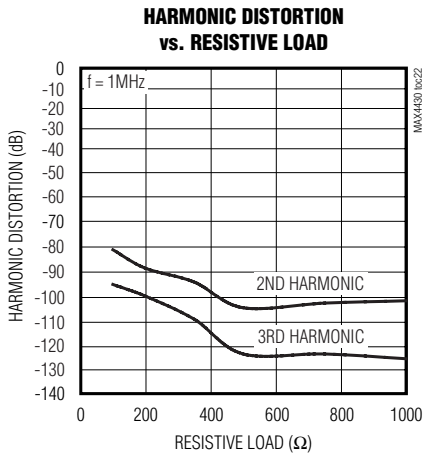
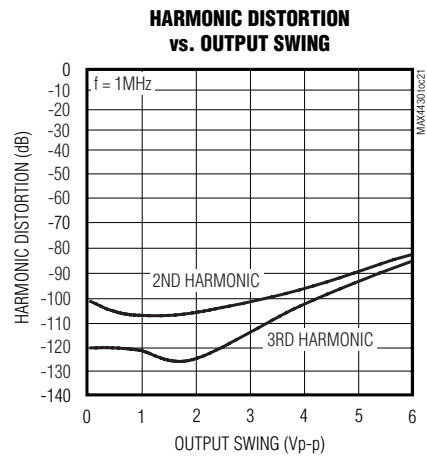
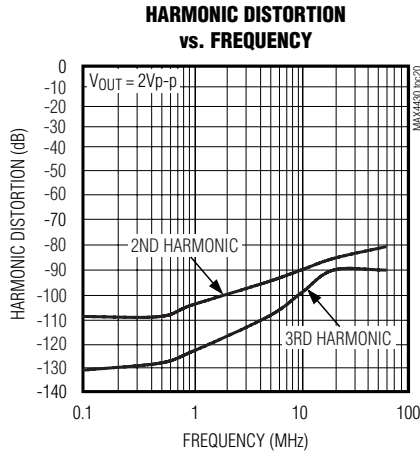
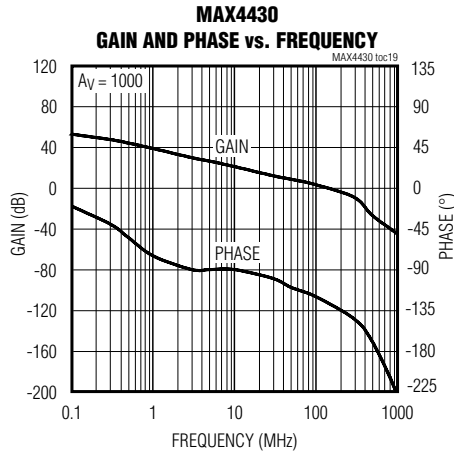


# Dual-Supply, 180MHz, 16-Bit Accurate, Ultra-Low Distortion Op Amps

## Typical Operating Characteristics (continued)

( $V_{CC} = +5V$ ,  $V_{EE} = -5V$ ,  $R_L = 500\Omega$ ,  $C_L = 0pF$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)

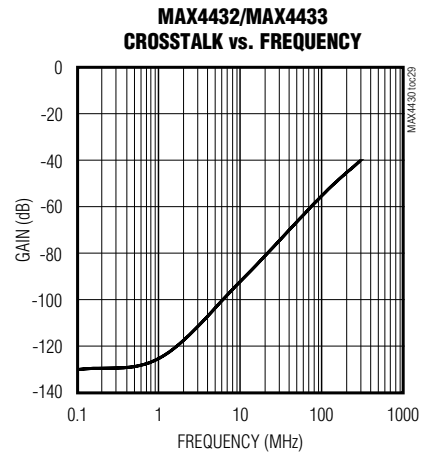
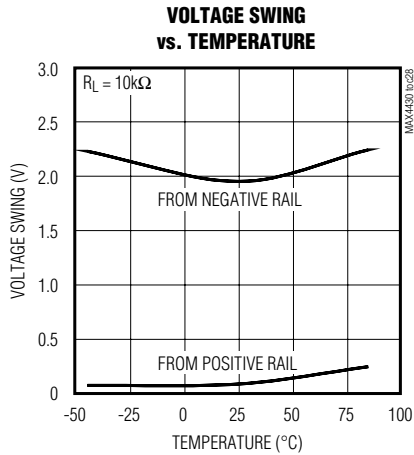
**MAX4430-MAX4433**



# Dual-Supply, 180MHz, 16-Bit Accurate, Ultra-Low Distortion Op Amps

## Typical Operating Characteristics (continued)

( $V_{CC} = +5V$ ,  $V_{EE} = -5V$ ,  $R_L = 500\Omega$ ,  $C_L = 0pF$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



## Pin Description

PIN		NAME	FUNCTION
MAX4430/MAX4431			
5 SOT23	8 SO		
1	6	OUT	Output
2	4	$V_{EE}$	Negative Power Supply
3	3	IN+	Noninverting Input
4	2	IN-	Inverting Input
5	7	$V_{CC}$	Positive Power Supply
—	1, 5, 8	N.C.	No Connection. Not internally connected.

PIN		NAME	FUNCTION
MAX4432/MAX4433			
8 SO/8 $\mu$ MAX			
1		OUTA	Amplifier A Output
2		INA-	Amplifier A Inverting Input
3		INA+	Amplifier A Noninverting Input
4		$V_{EE}$	Negative Power Supply
5		INB+	Amplifier B Noninverting Input
6		INB-	Amplifier B Inverting Input
7		OUTB	Amplifier B Output
8		$V_{CC}$	Positive Power Supply



# Dual-Supply, 180MHz, 16-Bit Accurate, Ultra-Low Distortion Op Amps

## Detailed Description

The MAX4430–MAX4433 are wide-bandwidth, ultra-low-distortion, voltage-feedback amplifiers. The MAX4430/MAX4432 are internally compensated for unity gain. The MAX4431/MAX4433 are internally compensated for gains of +2V/V or greater.

These amplifiers have ultra-fast 37ns (MAX4430/MAX4432) 16-bit settling times, 100dB SFDR at 1MHz, and 4Vp-p output swing with minimum 110dB open-loop gain.

### High-Speed ADC Input Driver Application

The MAX4430–MAX4433 op amps are ideal for driving high-speed 14- to 16-bit ADCs. In most cases, these ADCs operate with a charge balance scheme, with capacitive loads internally switched on and off from the input. The driver used must withstand these changing capacitive loads while holding the signal amplitude stability consistent with the ADC's resolution and, at the same time, have a frequency response compatible with the sampling speed of the ADC (Figure 1).

### Inverting and Noninverting Configurations

The circuits typically used for the inverting and non-inverting configurations of the MAX4430–MAX4433 are shown in Figures 2a and 2b. The minimum unconditionally stable gain values are 1 for the MAX4430/MAX4432

and 2 for the MAX4431/MAX4433. Use care in selecting the value for the resistor marked  $R_S$  in both circuits. From dynamic stability considerations (based on the part's frequency response and the input capacitance of the MAX4430–MAX4433), the maximum recommended value for  $R_S$  is 500Ω. In general, lower  $R_S$  values will yield a higher bandwidth and better dynamic stability, at the cost of higher power consumption, higher power dissipation in the IC, and reduced output drive availability. For a minimum  $R_S$  value, take into consideration that the current indicated as  $I_F$  is supplied by the output stage and must be discounted from the maximum output current to calculate the maximum current available to the load.  $I_F$  can be found using the following equation:

$$I_F = V_{IN(MAX)} / R_S$$

If DC thermal stability is an important design concern, the Thevenin resistance seen by both inputs at DC must be balanced. This includes the resistance of the signal source and termination resistors if the amplifier signal input is fed from a transmission line. The capacitance associated with the feedback resistors must also be considered as a possible limitation to the available bandwidth or to the dynamic stability. Only resistors with small parallel capacitance specifications should be considered.

## Applications Information

### Layout and Power-Supply Bypassing

The MAX4430–MAX4433 have wide bandwidth and consequently require careful board layout. To realize the full AC performance of these high-speed amplifiers, pay careful attention to power-supply bypassing and board layout. The PC board should have a large low-impedance ground plane that is as free of voids as possible. Do not use commercial breadboards. Keep signal lines as short and straight as possible. Observe high-frequency bypassing techniques to maintain the

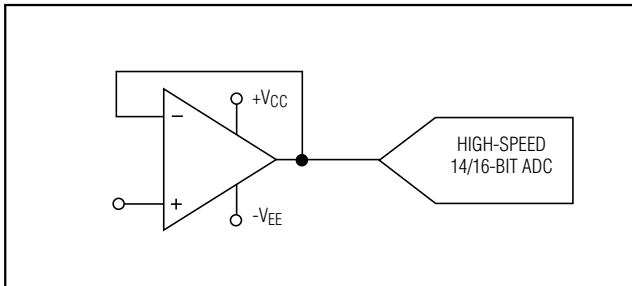


Figure 1. Typical Application Circuit

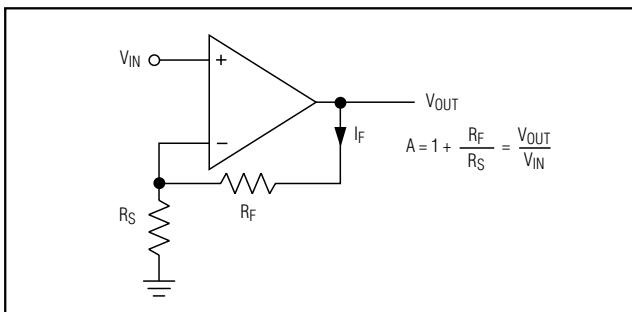


Figure 2a. Noninverting Configuration

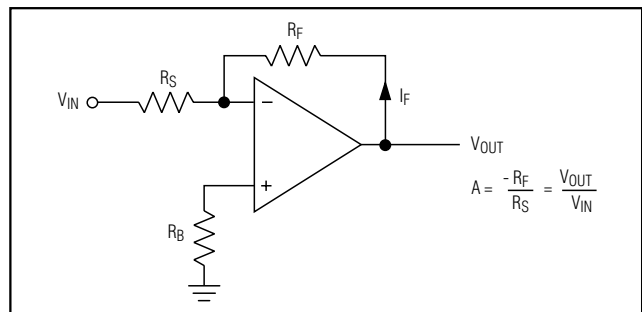


Figure 2b. Inverting Configuration

# Dual-Supply, 180MHz, 16-Bit Accurate, Ultra-Low Distortion Op Amps

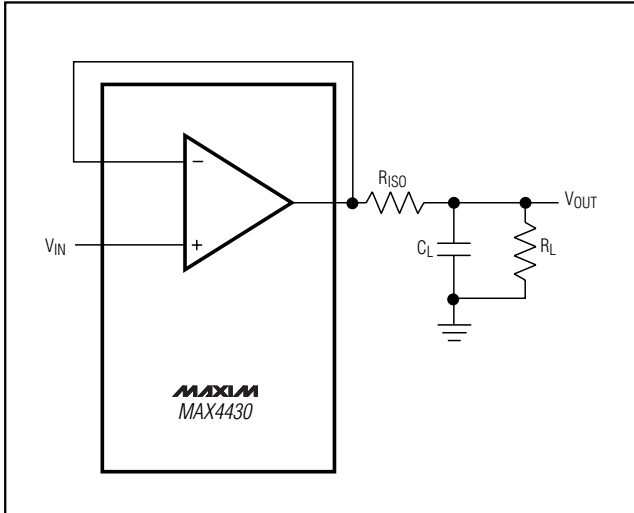


Figure 3. Capacitive-Load Driving Circuit

amplifier's accuracy and stability. In general, use surface-mount components since they have shorter bodies and lower parasitic reactance. This will result in improved performance over through-hole components. The bypass capacitors should include 1nF and/or 0.1μF surface-mount ceramic capacitors between each supply pin and the ground plane, located as close to the package as possible. Place a 10μF tantalum capacitor at the power supply's point of entry to the PC board to ensure the integrity of the incoming supplies. Input termination resistors and output back-termination resistors, if used, should be surface-mount types and should be placed as close to the IC pins as possible.

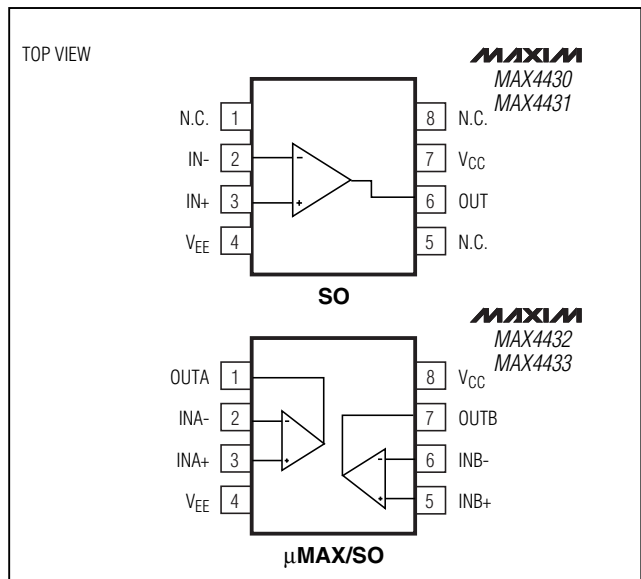
### Driving Capacitive Loads

MAX4430-MAX4433 can drive capacitive loads. However, excessive capacitive loads may cause ringing or instability at the output as phase margin is reduced. Adding a small isolation resistor in series with the output capacitive load helps reduce the ringing but slightly increases gain error (see *Typical Operating Characteristics* and Figure 3).

### Ordering Information (continued)

PART	TEMP. RANGE	PIN-PACKAGE
MAX4431EUK-T	-40°C to +85°C	5 SOT23-5
MAX4431ESA	-40°C to +85°C	8 SO
MAX4432EUA	-40°C to +85°C	8 μMAX
MAX4432ESA	-40°C to +85°C	8 SO
MAX4433EUA	-40°C to +85°C	8 μMAX
MAX4433ESA	-40°C to +85°C	8 SO

### Pin Configurations (continued)



### Chip Information

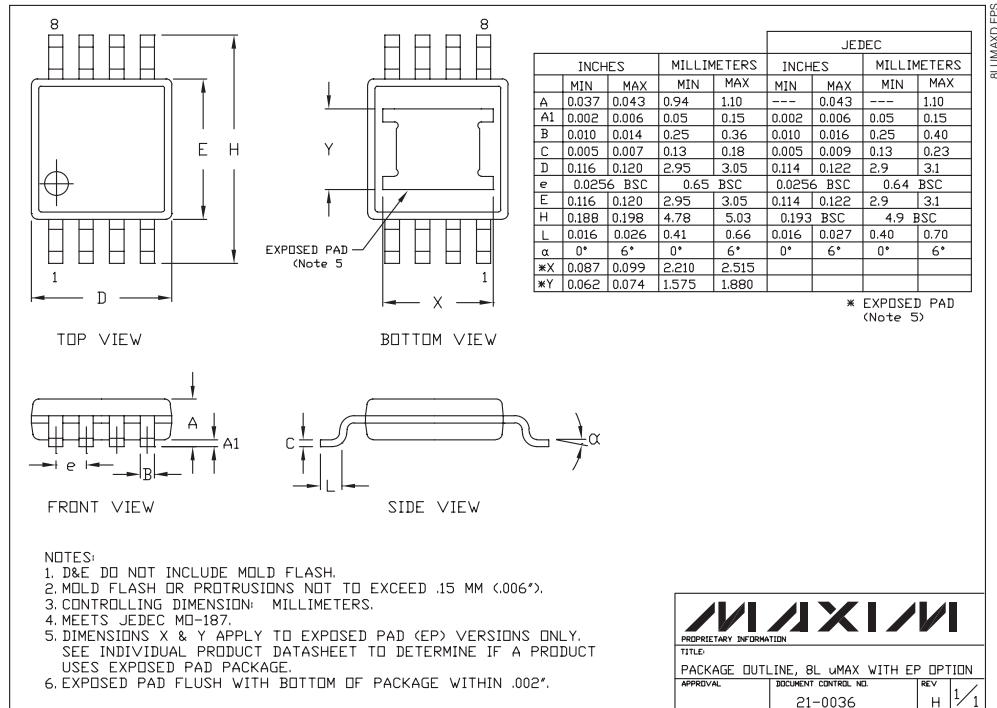
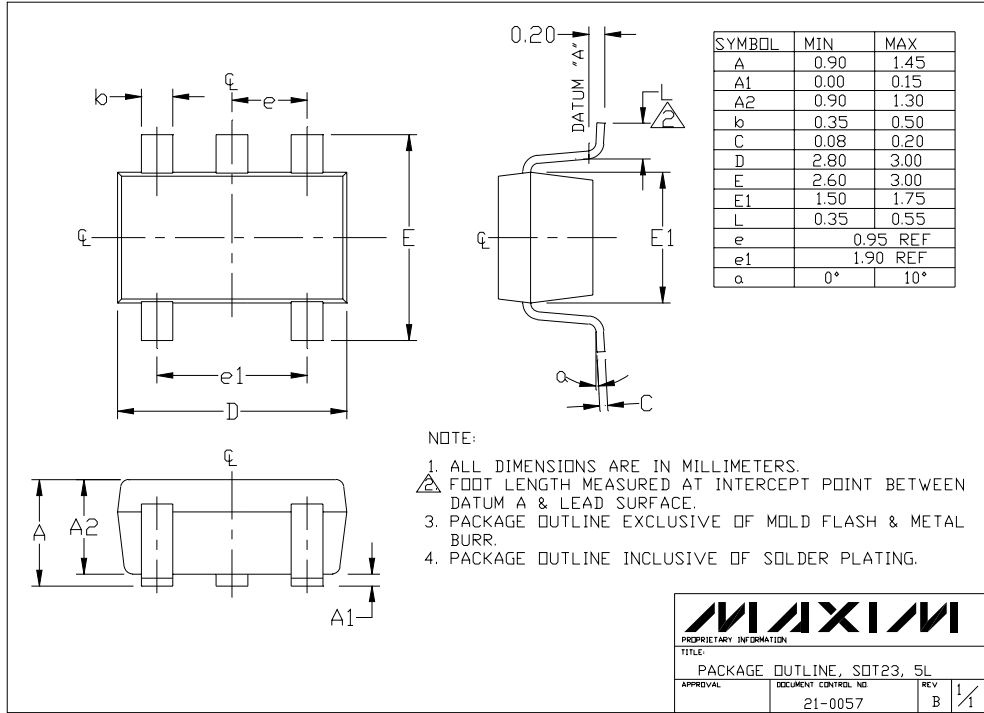
TRANSISTOR COUNT: MAX4430/MAX4431: 103

MAX4432/MAX4433: 248

# Dual-Supply, 180MHz, 16-Bit Accurate, Ultra-Low Distortion Op Amps

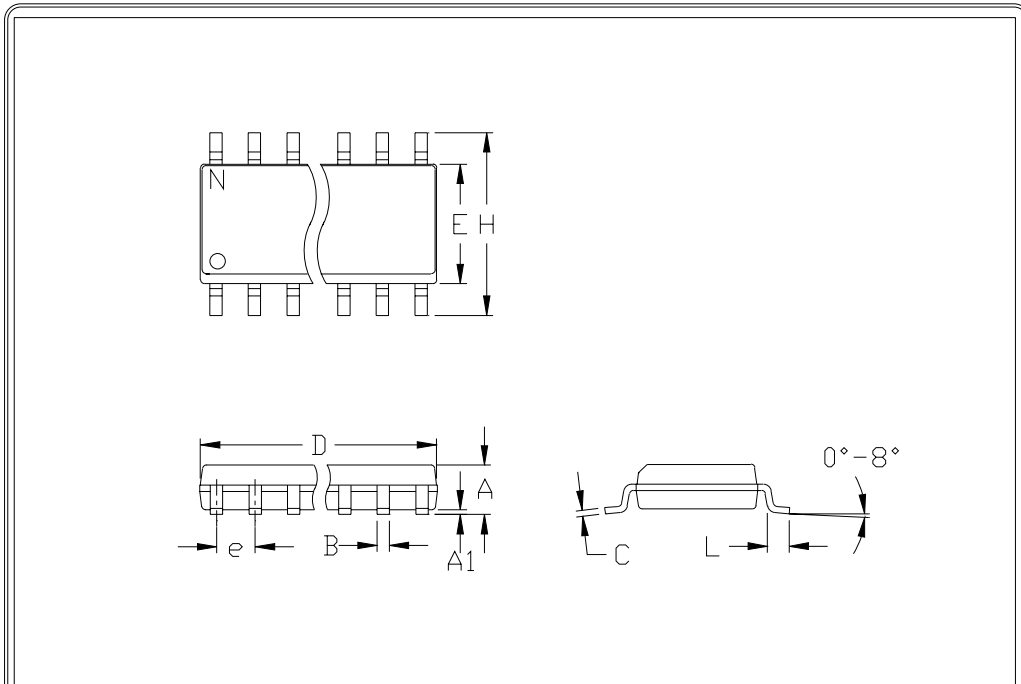
## Package Information

MAX4430-MAX4433



# Dual-Supply, 180MHz, 16-Bit Accurate, Ultra-Low Distortion Op Amps

## Package Information (continued)



	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

<p>120 SAN GABRIEL DR. SUNNYVALE, CA 94086 FAX (408) 737-7194 PROPRIETARY INFORMATION</p>	PACKAGE FAMILY OUTLINE: SOIC .150"	$\frac{1}{1}$	21-0041 A DOCUMENT CONTROL NUMBER REV
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- Подбор аналогов;
- Консультации по применению компонента;
- Поставка образцов и прототипов;
- Техническая поддержка проекта;
- Защита от снятия компонента с производства.



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