Micropower, Single-Supply, Rail-to-Rail Precision Differential Amplifiers

ABSOLUTE MAXIMUM RATINGS

Supply Voltage (V_{CC} to V_{EE}).....+8V
All Other Pins to GND .....(V_{EE} - 0.3V) to (V_{CC} + 0.3V)
Output Short-Circuit Duration (to V_{CC} or V_{EE}).....Continuous
Continuous Power Dissipation (T_A = +70°C)
8-Pin SO (derate 9.09mW/°C above +70°C).....471mW
8-Pin µMAX (derate 4.1mW/°C above +70°C) 330mW

Operating Temperature Range .....-40°C to +85°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—MAX4198 (+5V Supply)

(V_{CC} = +5V, V_{EE} = 0V, R_L = 25kΩ tied to V_{CC} / 2, V_{REF} = V_{CC} / 2, $V_{\overline{SHDN}}$ = V_{CC} - 1.5V, typical values are at T_A = +25°C, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Supply Voltage Range (Note 2)	V_{CC}	Single supply		2.7		7.5	V
		Dual supply		±1.35		±3.75	
Input Offset Voltage	V_{OS}	T_A = +25°C, V_{CM} = V_{CC} / 2	MAX4198ESA		±30	±500	µV
			MAX4198EUA		±100	±1000	
		T_A = T_{MIN} to T_{MAX}, V_{CM} = V_{CC} / 2	MAX4198ESA			±750	
			MAX4198EUA			±2300	
Input Offset Voltage Drift	TCO	MAX4198ESA			±0.5	±5	µV/°C
		MAX4198EUA			±1	±20	
Input Resistance	R_{IN}	IN+ differential-mode			50		kΩ
		IN- differential-mode			25		
		Common-mode			50		
Input Voltage Range	V_{IN}	Guaranteed by CMR test		V_{EE} - 0.1		V_{CC} + 0.1	V
DC Common-Mode Rejection	CMR_{DC}	V_{CM} = V_{EE} - 0.1V to V_{CC} + 0.1V	MAX4198ESA	74	90		dB
			MAX4198EUA	70	90		
AC Common-Mode Rejection	CMR_{AC}	V_{CM} = V_{EE} - 0.1 to V_{CC} + 0.1V, f = 60Hz, f = 120Hz			90		dB
Power-Supply Rejection	PSR	+2.7V ≤ V_{CC} ≤ +7.5V, V_{CM} = +1.5V, V_{REF} = +1.5V, R_L = 25kΩ to +1.5V		90	115		dB
Input Noise Voltage		f = 10Hz			120		$nV/\sqrt{Hz}$
		f = 100Hz			60		
		f = 10kHz			58		
		f = 0.1Hz to 10Hz			7.8		μV_{RMS}
Output Voltage Swing		R_L = 25kΩ, ±10mV input overdrive		V_{EE} + 0.1 to V_{CC} - 0.1	V_{EE} + 0.03 to V_{CC} - 0.03		V
		R_L = 5kΩ, ±10mV input overdrive		V_{EE} + 0.2 to V_{CC} - 0.2	V_{EE} + 0.1 to V_{CC} - 0.1		
Short-Circuit Current		Sink/source			±5.5		mA
Gain Error		V_{CM} = V_{CC} / 2, T_A = +25°C	R_L = 25kΩ, V_{EE} + 0.1V ≤ V_{OUT} ≤ V_{CC} - 0.1V		±0.01	±0.1	%
			R_L = 5kΩ, V_{EE} + 0.2V ≤ V_{OUT} ≤ V_{CC} - 0.2V		±0.01	±0.1	
Gain Temperature Coefficient		V_{EE} + 0.1V ≤ V_{OUT} ≤ V_{CC} - 0.1V	MAX4198ESA		±0.2	±3	ppm/°C
			MAX4198EUA		±0.65	±6	
Nonlinearity		V_{EE} + 0.1V ≤ V_{OUT} ≤ V_{CC} - 0.1V			±0.0003		%

ELECTRICAL CHARACTERISTICS—MAX4198 (+5V Supply) (continued)

(V_{CC} = +5V, V_{EE} = 0V, R_L = 25kΩ tied to V_{CC} / 2, V_{REF} = V_{CC} / 2, $V_{\overline{SHDN}}$ = V_{CC} - 1.5V, typical values are at T_A = +25°C, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Capacitive-Load Stability	C_L			690		pF
-3dB Bandwidth	BW_{-3dB}	V_{OUT} ≤ 0.1V_{P-P}, V_{CM} = V_{CC} / 2		175		kHz
Slew Rate	SR	V_{OUT} = 2V_{P-P} step		0.07		V/µs
Settling Time to 0.1%	t_S	V_{OUT} = 2V_{P-P} step		34		µs
Total Harmonic Distortion	THD	V_{OUT} = 2V_{P-P}, f = 1kHz		0.001		%
Supply Current	I_{CC}	V_{CM} = V_{CC} / 2, V_{IN+} = V_{IN-}		45	55	µA
Shutdown Supply Current	$I_{\overline{SHDN}}$	$V_{\overline{SHDN}}$ = V_{IL}		6.5	12	µA
Input Logic Voltage High (Note 3)	V_{IH}		V_{CC} - 1.5			V
Input Logic Voltage Low (Note 3)	V_{IL}				V_{CC} - 2.5	V
$\overline{SHDN}$ Input Bias Current		$V_{\overline{SHDN}}$ = V_{CC} - 1.5V or $V_{\overline{SHDN}}$ = V_{EE}	-0.1		0.1	µA
Enable/Disable Settling Time	$t_{ON/OFF}$	$V_{\overline{SHDN}}$ = V_{CC} - 2.5V to V_{CC} - 1.5V, V_{OUT} = 3.5V, settled to within 0.1%		28		µs
Power-Up Delay		V_{OUT} = 3.5V, settled to within 0.1%		800		µs

ELECTRICAL CHARACTERISTICS—MAX4198 (+3V Supply)

(V_{CC} = +3V, V_{EE} = 0V, R_L = 25kΩ tied to V_{CC} / 2, V_{REF} = V_{CC} / 2, $V_{\overline{SHDN}}$ = V_{CC} - 1.5V, typical values are at T_A = +25°C, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Input Offset Voltage	V_{OS}	T_A = +25°C, V_{CM} = V_{CC} / 2	MAX4198ESA		±35	±600	µV
			MAX4198EUA		±100	±1100	
		T_A = T_{MIN} to T_{MAX}, V_{CM} = V_{CC} / 2	MAX4198ESA			±850	
			MAX4198EUA			±2400	
Input Offset Voltage Drift	TCO	MAX4198ESA			±0.5	±5.0	µV/°C
		MAX4198EUA			±1.0	±20	
Input Voltage Range	V_{IN}	Guaranteed by CMR test		V_{EE} - 0.1		V_{CC} + 0.1	V
DC Common-Mode Rejection	CMR_{DC}	V_{CM} = V_{EE} - 0.1 to V_{CC} + 0.1	MAX4198ESA	74	90		dB
			MAX4198EUA	70	90		
Output Voltage Swing		R_L = 25kΩ, ±10mV input overdrive		V_{EE} + 0.1 to V_{CC} - 0.1	V_{EE} + 0.03 to V_{CC} - 0.03		V
		R_L = 5kΩ, ±10mV input overdrive		V_{EE} + 0.2 to V_{CC} - 0.2	V_{EE} + 0.1 to V_{CC} - 0.1		
Short-Circuit Current		Sink/source			±4.5		mA
Gain Error		V_{CM} = V_{CC} / 2, T_A = +25°C	R_L = 25kΩ, V_{EE} + 0.1V ≤ V_{OUT} ≤ V_{CC} - 0.1V		±0.01	±0.1	%
			R_L = 5kΩ, V_{EE} + 0.2V ≤ V_{OUT} ≤ V_{CC} - 0.2V		±0.01	±0.1	
Gain Temperature Coefficient		V_{EE} + 0.1V ≤ V_{OUT} ≤ V_{CC} - 0.1V	MAX4198ESA		±0.2	±3	ppm/°C
			MAX4198EUA		±0.65	±6	
Supply Current	I_{CC}	V_{CM} = V_{CC} / 2, V_{DIFF} = 0V			42		µA
Shutdown Supply Current	$I_{\overline{SHDN}}$				6.5		µA
Input Logic High Voltage (Note 3)	V_{IH}			V_{CC} - 1.5			V
Input Logic Low Voltage (Note 3)	V_{IL}					V_{CC} - 2.5	V

Micropower, Single-Supply, Rail-to-Rail Precision Differential Amplifiers

ELECTRICAL CHARACTERISTICS—MAX4199 (+5V Supply)

(V_{CC} = +5V, V_{EE} = 0V, R_L = 25kΩ tied to V_{CC} / 2, V_{REF} = V_{CC} / 2, $V_{\overline{SHDN}}$ = V_{CC} - 1.5V, typical values are at T_A = +25°C, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Supply Voltage Range (Note 2)	V_{CC}	Single supply		2.7		7.5	V
		Dual supply		±1.35		±3.75	
Input Offset Voltage	V_{OS}	T_A = +25°C, V_{CM} = V_{CC} / 2	MAX4199ESA		±10	±300	µV
			MAX4199EUA		±100	±600	
		T_A = T_{MIN} to T_{MAX}, V_{CM} = V_{CC} / 2	MAX4199ESA			±500	
			MAX4199EUA			±1475	
Input Offset Voltage Drift	TCO	MAX4199ESA			±0.25	±3	µV/°C
		MAX4199EUA			±0.75	±15	
Input Resistance	R_{IN}	IN+ differential mode			275		kΩ
		IN- differential mode			25		
		Common-mode			275		
Input Voltage Range (Note 2)	V_{IN}	Guaranteed by CMR test		V_{EE} - 0.1		V_{CC} - 1.0	V
DC Common-Mode Rejection	CMR_{DC}	V_{CM} = V_{EE} - 0.1V to V_{CC} - 1.0V	MAX4199ESA	76	110		dB
			MAX4199EUA	76	110		
AC Common-Mode Rejection	CMR_{AC}	V_{CM} = V_{EE} - 0.1V to V_{CC} - 1.0V, f = 60Hz			110		dB
Power-Supply Rejection	PSR	+2.7V ≤ V_{CC} ≤ +7.5V, V_{CM} = +1.5V, V_{REF} = +1.5V, R_L = 25kΩ to +1.5V		90	120		dB
Input Noise Voltage		f = 10Hz			60		$nV/\sqrt{Hz}$
		f = 100Hz			40		
		f = 10kHz			38		
		f = 0.1Hz to 10Hz			6.6		μV_{RMS}
Output Voltage Swing		R_L = 25kΩ, ±10mV input overdrive		V_{EE} + 0.1 to V_{CC} - 0.1	V_{EE} + 0.02 to V_{CC} - 0.02		V
		R_L = 5kΩ, ±10mV input overdrive		V_{EE} + 0.2 to V_{CC} - 0.2	V_{EE} + 0.1 to V_{CC} - 0.1		
Short-Circuit Current		Sink/source			±5.5		mA
Gain Error		V_{CM} = V_{CC} / 2, T_A = +25°C	R_L = 25kΩ, V_{EE} + 0.1V ≤ V_{OUT} ≤ V_{CC} - 0.1V		±0.01	±0.3	%
			R_L = 5kΩ, V_{EE} + 0.2V ≤ V_{OUT} ≤ V_{CC} - 0.2V		±0.01	±0.3	
Gain Temperature Coefficient		V_{EE} + 0.1V ≤ V_{OUT} ≤ V_{CC} - 0.1V	MAX4199ESA		±1	±5	ppm/°C
			MAX4199EUA		±2	±10	
Nonlinearity		V_{EE} + 0.1V ≤ V_{OUT} ≤ V_{CC} - 0.1V			±0.0003		%
Capacitive-Load Stability	C_L				600		pF
-3dB Bandwidth	BW_{-3dB}	V_{OUT} ≤ $0.1V_{P-P}$, V_{CM} = V_{CC} / 2			45		kHz
Slew Rate	SR	V_{OUT} = $2V_{P-P}$			0.1		V/µs
Settling Time to 0.1%	t_S	V_{OUT} = $2V_{P-P}$ step			37		µs
Total Harmonic Distortion	THD	V_{OUT} = $2V_{P-P}$, f = 1kHz			0.001		%
Supply Current	I_{CC}	V_{CM} = V_{CC} / 2, V_{IN+} = V_{IN-}			45	55	µA
Shutdown Supply Current	$I_{\overline{SHDN}}$	$V_{\overline{SHDN}}$ = V_{IL}			6.5	12	µA

ELECTRICAL CHARACTERISTICS—MAX4199 (+5V Supply) (continued)

(V_{CC} = +5V, V_{EE} = 0V, R_L = 25kΩ tied to V_{CC} / 2, V_{REF} = V_{CC} / 2, $V_{\overline{SHDN}}$ = V_{CC} - 1.5V, typical values are at T_A = +25°C, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Logic Voltage High (Note 3)	V_{IH}		V_{CC} - 1.5			V
Input Logic Voltage Low (Note 3)	V_{IL}				V_{CC} - 2.5	V
$\overline{SHDN}$ Input Bias Current		$V_{\overline{SHDN}}$ = V_{CC} - 1.5V or $V_{\overline{SHDN}}$ = V_{EE}	-0.1		+0.1	µA
Enable/Disable Settling Time	$t_{ON/OFF}$	$V_{\overline{SHDN}}$ = V_{CC} - 2.5V to V_{CC} - 1.5V, V_{OUT} = 3.5V, settled to within 0.1%		35		µs
Power-Up Delay		V_{OUT} = 3.5V, settled to within 0.1%		800		µs

ELECTRICAL CHARACTERISTICS—MAX4199 (+3V Supply)

(V_{CC} = +3V, V_{EE} = 0V, R_L = 25kΩ tied to V_{CC} / 2, V_{REF} = V_{CC} / 2, $V_{\overline{SHDN}}$ = V_{CC} - 1.5V, values are at T_A = +25°C, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Input Offset Voltage	V_{OS}	T_A = +25°C, V_{CM} = V_{CC} / 2	MAX4199ESA		±15	±400	µV
			MAX4199EUA		±100	±700	
		T_A = T_{MIN} to T_{MAX}, V_{CM} = V_{CC} / 2	MAX4199ESA			±600	
			MAX4199EUA			±1675	
Input Offset Voltage Drift	TCO	MAX4199ESA			±0.25	±5	µV/°C
		MAX4199EUA			±0.75	±15	
Input Voltage Range	V_{IN}	Guaranteed by CMR test		V_{EE} - 0.1		V_{CC} - 1.1	V
DC Common-Mode Rejection	CMR_{DC}	V_{CM} = V_{EE} - 0.1 to V_{CC} - 1.1	MAX4199ESA	76	110		dB
			MAX4199EUA	76	110		
Output Voltage Swing		R_L = 25kΩ, ±10mV input overdrive		V_{EE} + 0.1 to V_{CC} - 0.1	V_{EE} + 0.02 to V_{CC} - 0.02		V
		R_L = 5kΩ, ±10mV input overdrive		V_{EE} + 0.2 to V_{CC} - 0.2	V_{EE} + 0.1 to V_{CC} - 0.1		
Short-Circuit Current		Sink/source			±4.5		mA
Gain Error		V_{CM} = V_{CC} / 2, T_A = +25°C	R_L = 25kΩ, V_{EE} + 0.1V ≤ V_{OUT} ≤ V_{CC} - 0.1V		±0.01	±0.3	%
			R_L = 5kΩ, V_{EE} + 0.2V ≤ V_{OUT} ≤ V_{CC} - 0.2V		±0.01	±0.3	
Gain Temperature Coefficient		V_{EE} + 0.1V ≤ V_{OUT} ≤ V_{CC} - 0.1V	MAX4199ESA		±1	±5	ppm/°C
			MAX4199EUA		±2	±10	
Supply Current	I_{CC}	V_{CM} = V_{CC} / 2, V_{DIFF} = 0V			42		µA
Shutdown Supply Current	$I_{\overline{SHDN}}$				6.5		µA
Input Logic High Voltage (Note 3)	V_{IH}			V_{CC} - 1.5			V
Input Logic Low Voltage (Note 3)	V_{IL}					V_{CC} - 2.5	V

Note 1: The MAX4198EUA and the MAX4199EUA are 100% production tested at +25°C. All temperature limits are guaranteed by design.

Note 2: Guaranteed by PSR test.

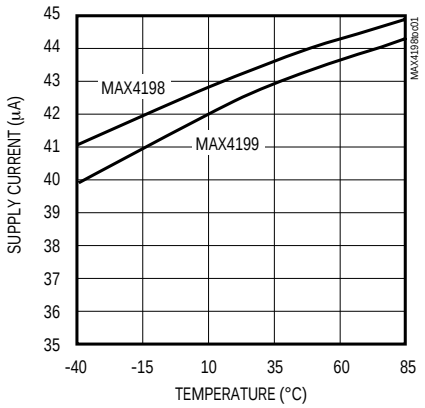
Note 3: When shutdown input is at logic high, the part is active; when at logic low, the part is in shutdown.

Micropower, Single-Supply, Rail-to-Rail Precision Differential Amplifiers

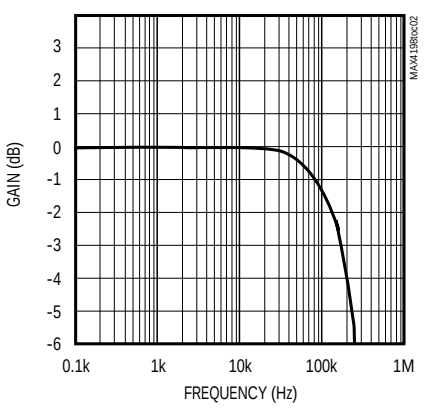
Typical Operating Characteristics

(V_{CC} = +5V, V_{EE} = 0V, R_L = 25kΩ to V_{CC} / 2, $V_{\overline{SHDN}}$ = V_{CC} - 1.5V, small-signal V_{OUT} = 100mV_{P-P}, large-signal V_{OUT} = 1V_{P-P}, T_A = +25°C, unless otherwise noted.)

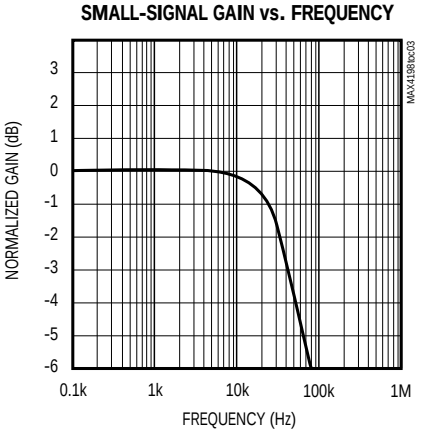
SUPPLY CURRENT vs. TEMPERATURE



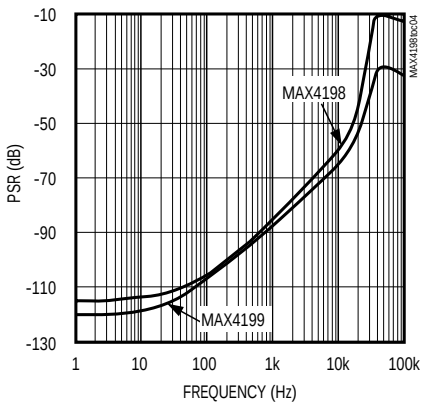
MAX4198
SMALL-SIGNAL GAIN vs. FREQUENCY



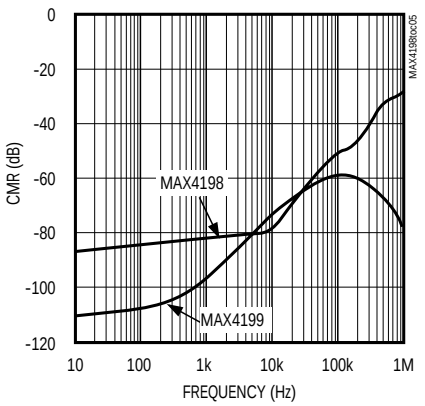
MAX4199
SMALL-SIGNAL GAIN vs. FREQUENCY



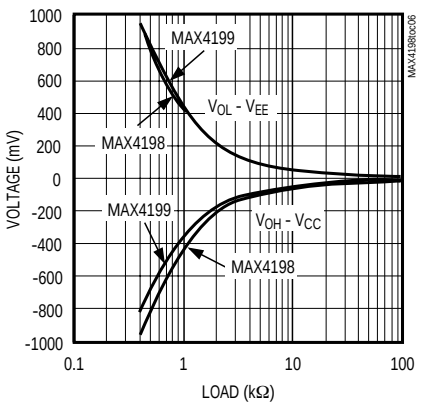
POWER-SUPPLY REJECTION vs. FREQUENCY



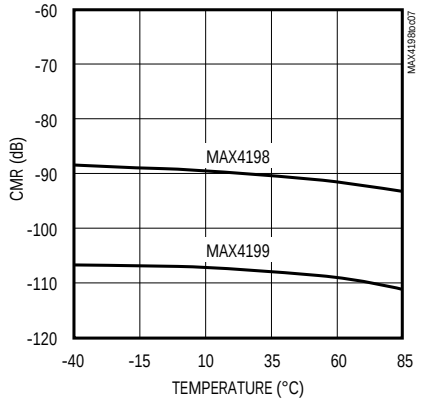
COMMON-MODE REJECTION vs. FREQUENCY



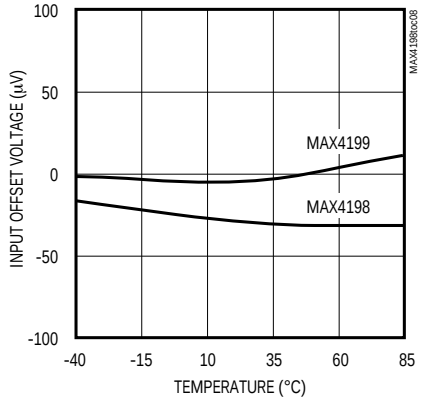
OUTPUT VOLTAGE HIGH AND LOW vs. LOAD RESISTANCE



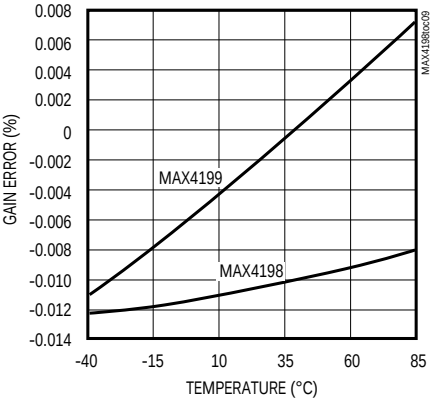
COMMON-MODE REJECTION vs. TEMPERATURE



INPUT OFFSET VOLTAGE vs. TEMPERATURE



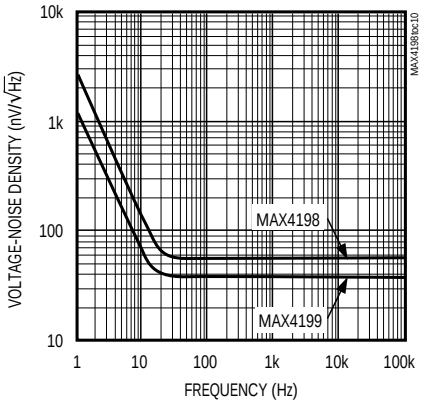
GAIN ERROR vs. TEMPERATURE



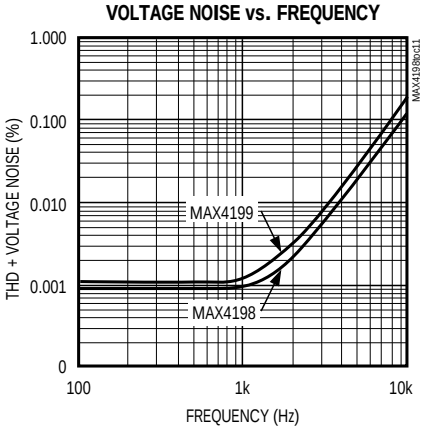
Typical Operating Characteristics (continued)

(V_{CC} = +5V, V_{EE} = 0V, R_L = 25kΩ to V_{CC} / 2, $V_{\overline{SHDN}}$ = V_{CC} - 1.5V, small-signal V_{OUT} = 100mV$_{P-P}$, large-signal V_{OUT} = 1V$_{P-P}$, T_A = +25°C, unless otherwise noted.)

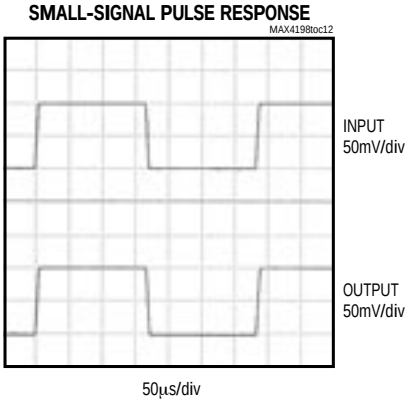
VOLTAGE-NOISE DENSITY vs. FREQUENCY



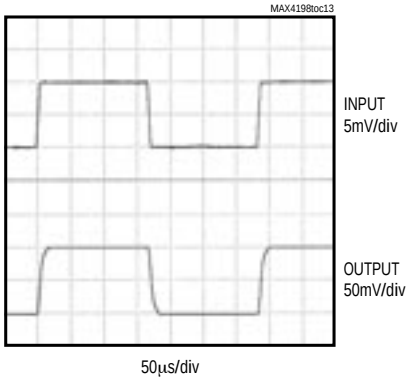
TOTAL HARMONIC DISTORTION VOLTAGE NOISE vs. FREQUENCY



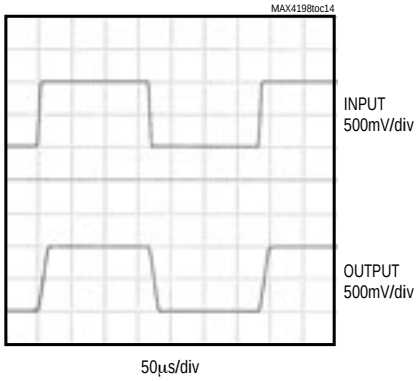
SMALL-SIGNAL PULSE RESPONSE



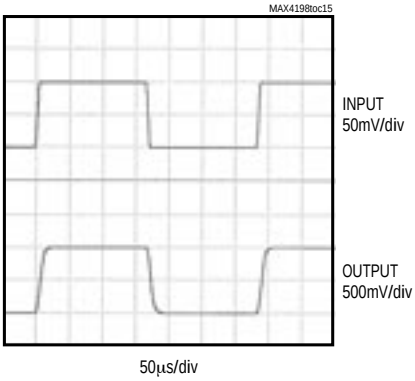
MAX4199 SMALL-SIGNAL PULSE RESPONSE



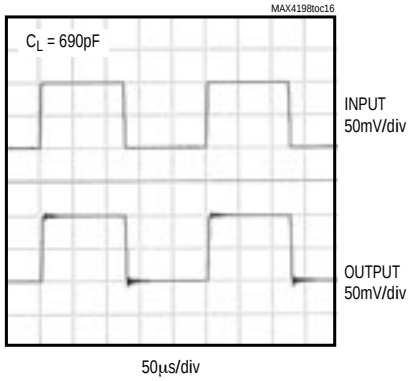
MAX4198 LARGE-SIGNAL PULSE RESPONSE



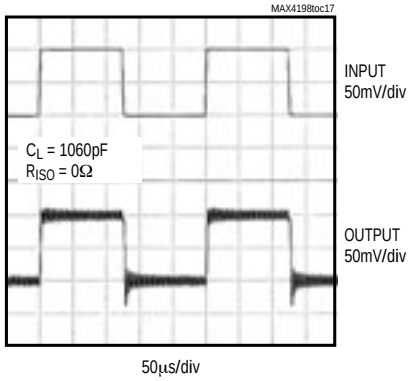
MAX4199 LARGE-SIGNAL PULSE RESPONSE



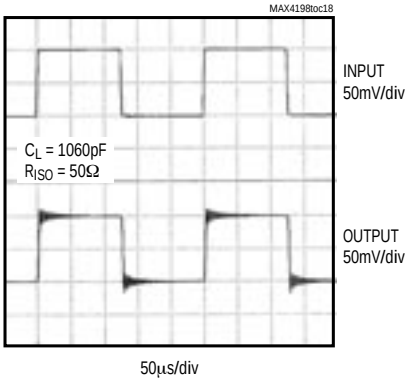
MAX4198 SMALL-SIGNAL PULSE RESPONSE WITH CAPACITIVE LOAD



MAX4198 SMALL-SIGNAL PULSE RESPONSE WITH EXCESSIVE CAPACITIVE LOAD



MAX4198 SMALL-SIGNAL PULSE RESPONSE WITH EXCESSIVE CAPACITIVE LOAD AND ISOLATION RESISTOR

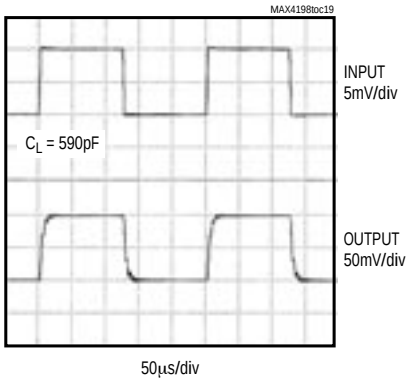


Micropower, Single-Supply, Rail-to-Rail Precision Differential Amplifiers

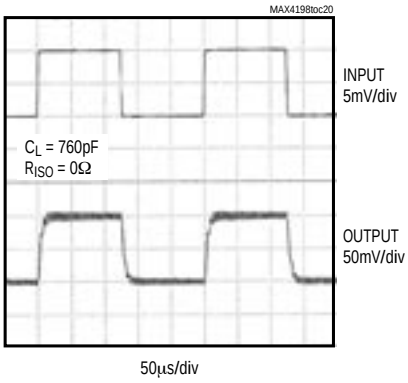
Typical Operating Characteristics (continued)

(V_{CC} = +5V, V_{EE} = 0V, R_L = 25kΩ to V_{CC} / 2, $V_{\overline{SHDN}}$ = V_{CC} - 1.5V, small-signal V_{OUT} = 100mV$_{P-P}$, large-signal V_{OUT} = 1V$_{P-P}$, T_A = +25°C, unless otherwise noted.)

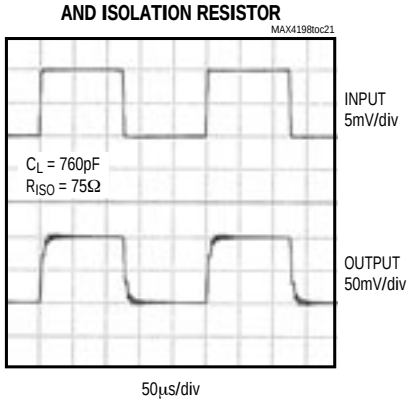
MAX4199
SMALL-SIGNAL PULSE RESPONSE WITH CAPACITIVE LOAD



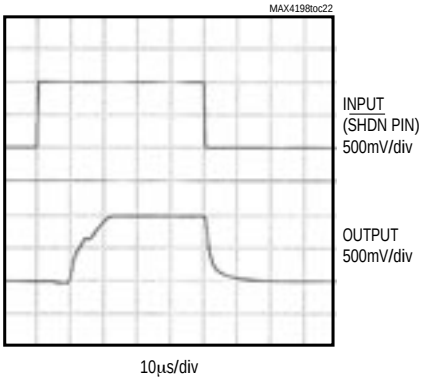
MAX4199
SMALL-SIGNAL PULSE RESPONSE WITH EXCESSIVE CAPACITIVE LOAD



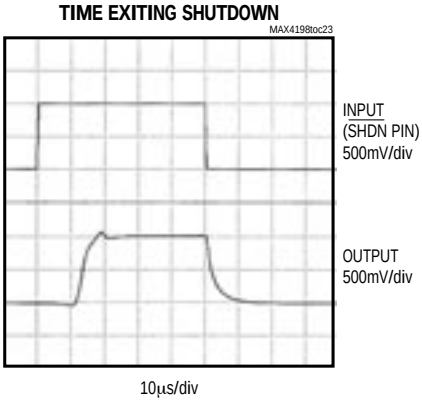
MAX4199
SMALL-SIGNAL PULSE RESPONSE WITH EXCESSIVE CAPACITIVE LOAD AND ISOLATION RESISTOR



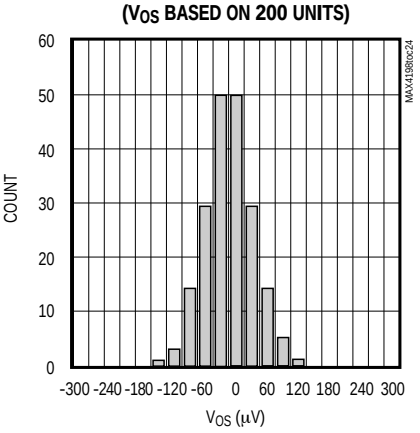
MAX4198
TIME EXITING SHUTDOWN



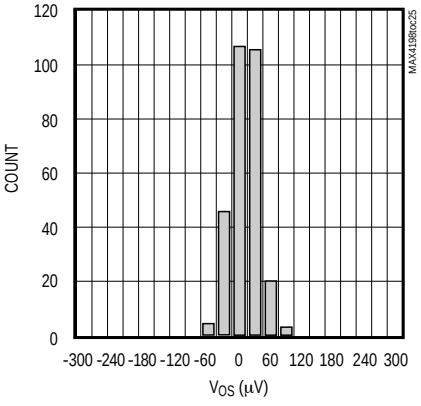
MAX4199
TIME EXITING SHUTDOWN



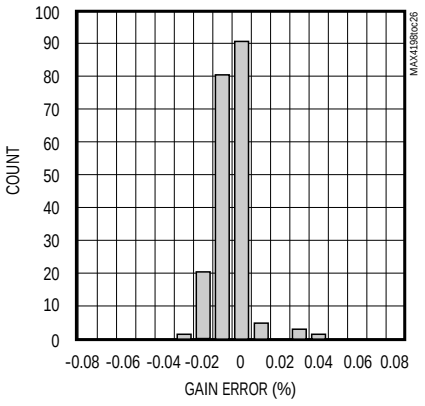
MAX4198 HISTOGRAM
(V_{OS} BASED ON 200 UNITS)



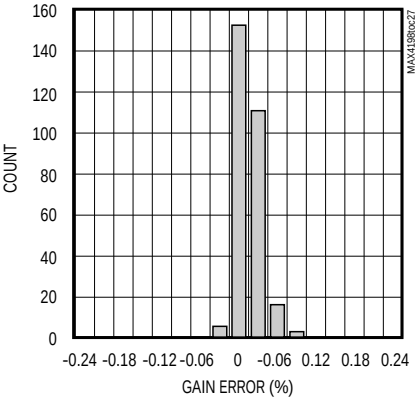
MAX4199 HISTOGRAM
(V_{OS} BASED ON 280 UNITS)



MAX4198 HISTOGRAM
(GAIN ACCURACY BASED ON 200 UNITS)



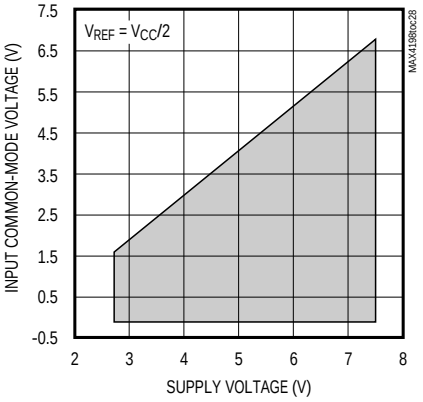
MAX4199 HISTOGRAM
(GAIN ACCURACY BASED ON 280 UNITS)



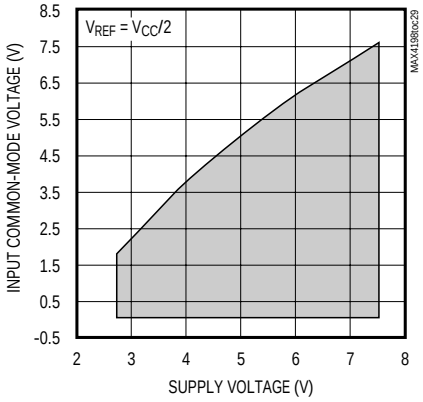
Typical Operating Characteristics (continued)

(V_{CC} = +5V, V_{EE} = 0V, R_L = 25kΩ to V_{CC} / 2, $V_{\overline{SHDN}}$ = V_{CC} - 1.5V, small-signal V_{OUT} = 100mV$_{P-P}$, large-signal V_{OUT} = 1V$_{P-P}$, T_A = +25°C, unless otherwise noted.)

MAX4199
INPUT COMMON-MODE RANGE vs. SUPPLY VOLTAGE



MAX4198
INPUT COMMON-MODE RANGE vs. SUPPLY VOLTAGE



Pin Description

PIN	NAME	FUNCTION
1	REF	Reference Voltage Input. Offsets output voltage.
2	IN-	Inverting Input
3	IN+	Noninverting Input
4	V_{EE}	Negative Supply Voltage
5	FB	Feedback Resistor. Can be used as a sense input.
6	OUT	Amplifier Output
7	V_{CC}	Positive Supply Voltage
8	$\overline{SHDN}$	Shutdown Control. Shutdown threshold is referenced to V_{CC}. When pulled 2.5V below V_{CC}, part is in shutdown.

Detailed Description

The MAX4198/MAX4199 are precision low-power differential amplifiers with factory-trimmed internal gain-setting resistors. The MAX4198 is trimmed to a gain of +1V/V and the MAX4199 is trimmed to a gain of +10V/V.

Input Stage

The *Functional Diagram* shows the internal structure of the MAX4198/MAX4199. Although the resistors are precision matched, their absolute value varies by ±25%. The typical input impedance for the MAX4198 is 50kΩ for the noninverting input and 25kΩ for the inverting input. The typical input impedance for the MAX4199 is 275kΩ for the noninverting input and 25kΩ for the inverting input.

The common-mode inputs of the internal op amp can range from V_{EE} to (V_{CC} - 1.1V). Although the inputs to the internal op amp are not rail-to-rail, the internal resistors form a voltage divider that extends the input common-mode range beyond-the-rails for the MAX4198. The overall input range of the MAX4198 extends 100mV beyond-the-rails without adversely affecting common-mode rejection or undergoing phase reversal (V_{CC} = 5V). The MAX4199 input common-mode range extends from 100mV below the negative rail to (V_{CC} - 1V) (see the Input Common-Mode Voltage Range vs. Supply Voltage graph in the *Typical Operating Characteristics*).

Micropower, Single-Supply, Rail-to-Rail Precision Differential Amplifiers

Rail-to-Rail Output Stage

The MAX4198/MAX4199 output stage incorporates a common-source rail-to-rail structure which maximizes the dynamic range of the differential amplifier. The output can swing to within 100mV from each rail with a 5kΩ load to V_{CC} / 2 (see the *Typical Operating Characteristics*).

Shutdown Mode

The MAX4198/MAX4199 have an active-low shutdown input. $\overline{SHDN}$ input logic thresholds are referenced to V_{CC}, not to GND. Pulling $\overline{SHDN}$ 2.5V below the positive rail places the amplifiers in a 12µA (max) shutdown mode. The MAX4198/MAX4199 exit or enter shutdown in 35µs. In shutdown, the OUT pin is high-impedance.

Applications Information

Driving Capacitive Loads

The MAX4198/MAX4199 are relatively immune to oscillations caused when driving large capacitive loads. Although heavy load capacitance increases transient ringing, sustained oscillations typically do not occur for loads under 600pF (see Pulse Response with Capacitive Load in the *Typical Operating Characteristics*). Applications that require driving higher capacitive loads can isolate the output capacitance using a 15Ω to 100Ω resistor between the amplifier output and the load (Figure 1). Although adding an isolation resistor dampens the response enough to prevent oscillations, it does so at the expense of bandwidth and DC accuracy.

Power Supply Considerations

The MAX4198/MAX4199 operate from single +2.7V to +7.5V supplies or from dual ±1.35V to ±3.75V supplies, and they consume only 45µA of supply current. Excellent power-supply rejection permits the amplifiers to be operated directly from a decaying 3V cell without excessive error. To maximize AC performance, the supply must be bypassed with a 0.1µF ceramic capacitor to ground that must be as close as possible to the pin. If dual supplies are used, bypass both supply pins with 0.1µF to ground.

Application Circuits

Differential amplifiers can be used in single-ended and other amplifier applications. Figures 2 through 6 show the MAX4198/MAX4199 in different configurations. The internally trimmed and matched resistors offer convenience and have a distinct advantage over external resistors. These amplifiers are not compensated for single-ended unity gain; therefore, IN- should not be connected to OUT or left unconnected.

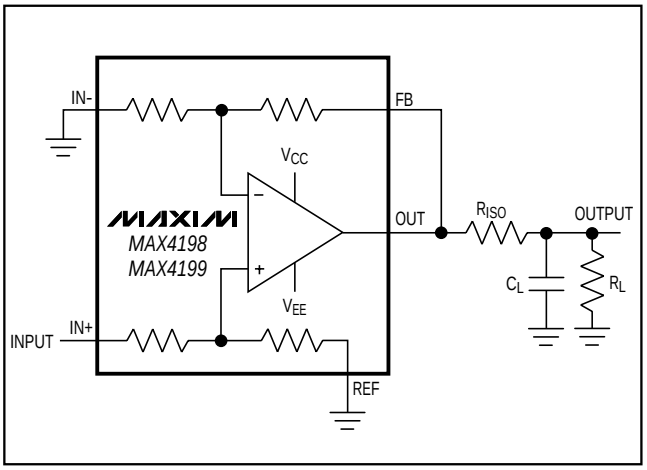


Figure 1. Dual-Supply, Capacitive-Load Driving Circuit

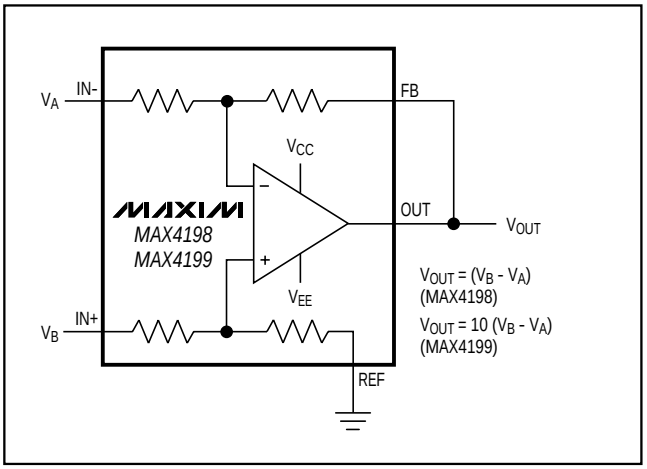


Figure 2. Standard Difference Amplifier

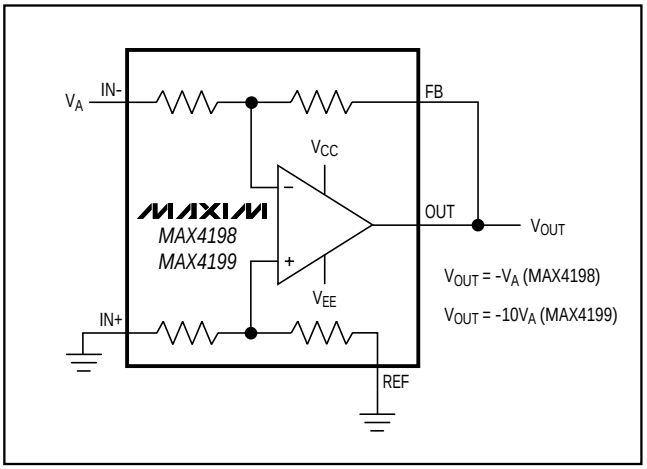


Figure 3. Precision Inverting Buffer

Instrumentation Amplifier Applications

For applications that require a complete low-power instrumentation amplifier, refer to the MAX4194–MAX4197 data sheet. Some differential to single-ended voltage amplifier applications that do not require a high input impedance can use the MAX4198/MAX4199 for gains of +1V/V or +10V/V. The MAX4198/MAX4199 can also be used as an instrumentation amplifier building block. The circuit of Figure 7 takes advantage of the 10pA (max), 0.1pA (typ) bias current of the MAX406A to form an instrumentation amplifier similar to the MAX4194 family, except with lower input bias currents. The MAX406A's low 1.2µA supply current maintains a low overall supply current.

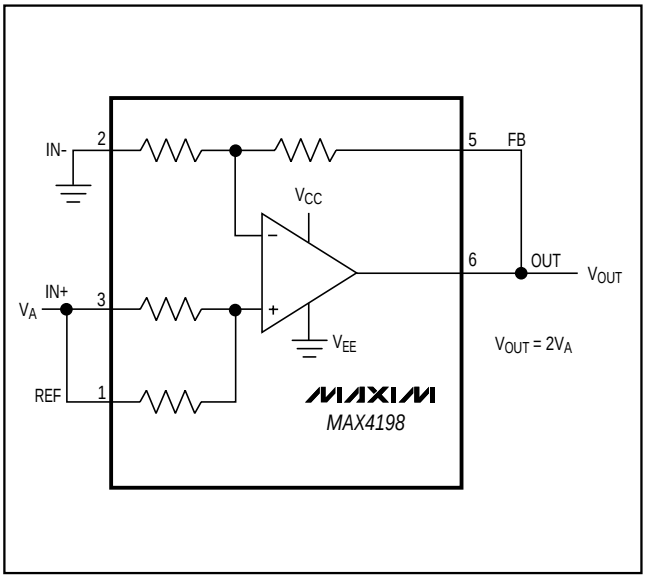


Figure 4. Precision Gain of Two Amplifiers

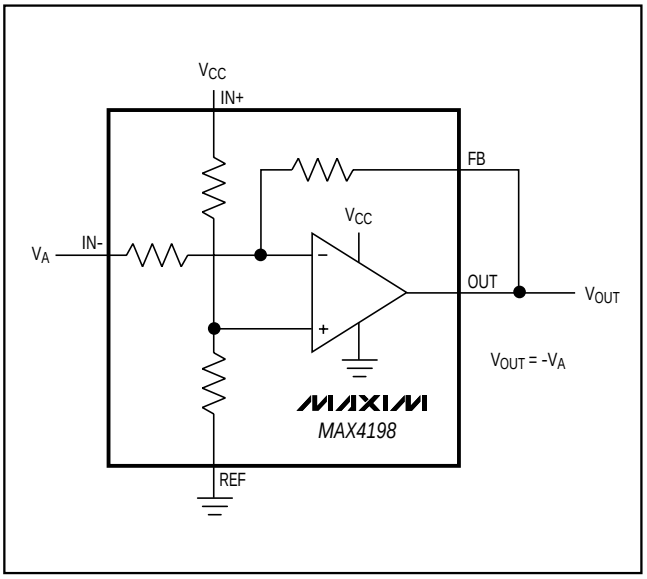


Figure 5. Single-Supply Inverting Amplifier Biased at V_{CC} / 2

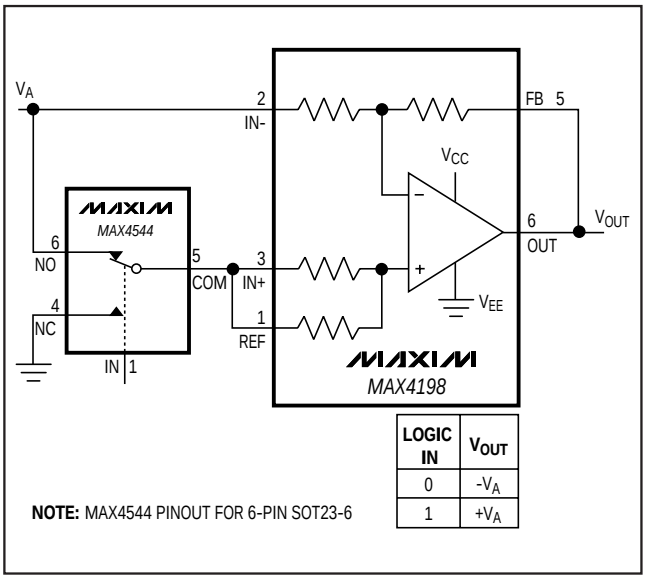


Figure 6. Digitally Controlled Precision Gain of ±1 Amplifier

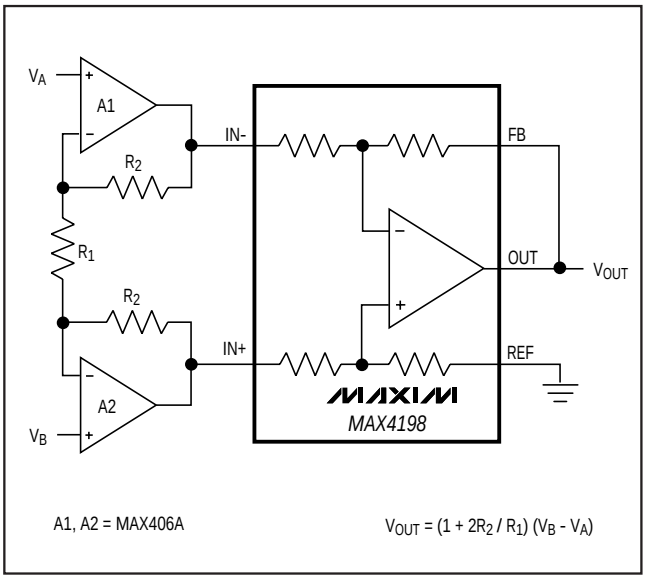


Figure 7. Ultra-Low Input Bias Current (0.1pA) Instrumentation Amplifiers with 47µA Supply-Current Consumption

Micropower, Single-Supply, Rail-to-Rail Precision Differential Amplifiers

Chip Information

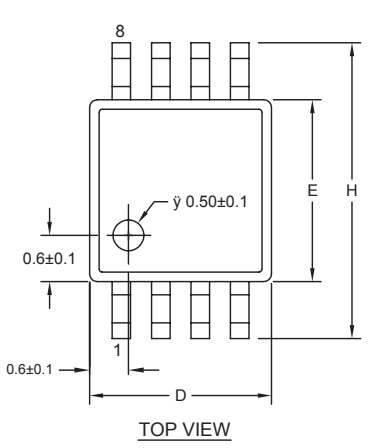
TRANSISTOR COUNT: 250

SUBSTRATE CONNECTED TO V_{EE}

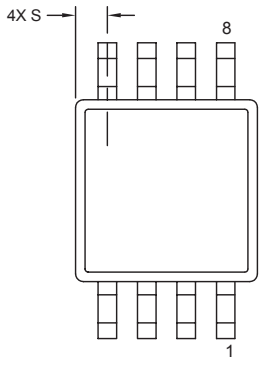
Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to **www.maxim-ic.com/packages**.)

8LUMAXD.EPS

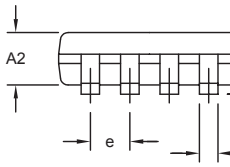


TOP VIEW

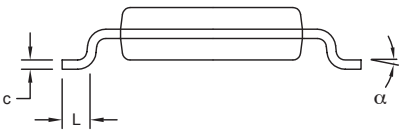


BOTTOM VIEW

DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	-	0.043	-	1.10
A1	0.002	0.006	0.05	0.15
A2	0.030	0.037	0.75	0.95
b	0.010	0.014	0.25	0.36
c	0.005	0.007	0.13	0.18
D	0.116	0.120	2.95	3.05
e	0.0256 BSC		0.65 BSC	
E	0.116	0.120	2.95	3.05
H	0.188	0.198	4.78	5.03
L	0.016	0.026	0.41	0.66
α	0∞	6∞	0∞	6∞
S	0.0207 BSC		0.5250 BSC	



FRONT VIEW



SIDE VIEW

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15MM (.006").
3. CONTROLLING DIMENSION: MILLIMETERS.
4. MEETS JEDEC MO-187C-AA.

DALLAS SEMICONDUCTOR MAXIM

PROPRIETARY INFORMATION

TITLE: PACKAGE OUTLINE, 8L uMAX/uSOP

APPROVAL	DOCUMENT CONTROL NO.	REV.	
	21-0036	J	1/1