19-2023; Rev 0; 1/02

1.0V Micropower, SOT23, Operational Amplifier

MAX4289

General Description

The MAX4289 micropower, operational amplifier is optimized for ultra-low supply voltage operation. The amplifier consumes only 9µA of quiescent supply current and is fully specified for operation from a single 1.0V to 5.5V power supply. This ultra-low voltage operation together with the low quiescent current consumption make the MAX4289 ideal for use in battery-powered systems operated from as little as a single alkaline cell. The MAX4289 also features a wide input common-mode range that includes the ground, and an output voltage swing that is virtually Rail-to-Rail®, allowing almost all of the power supply to be used for signal voltage.

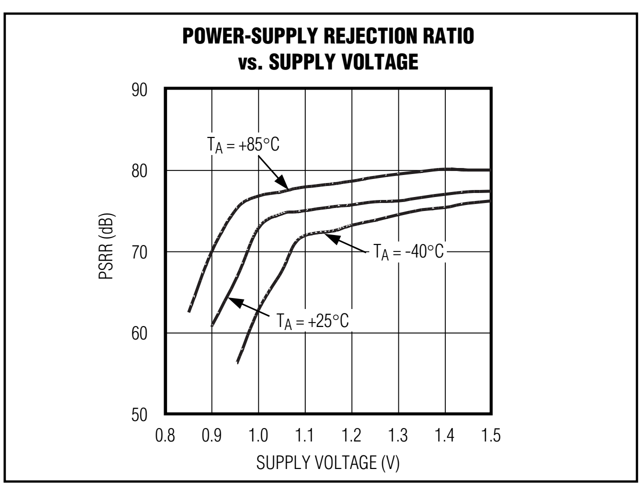
The low input offset voltage and low input bias current specifications along with the high open-loop gain make the MAX4289 well-suited to applications requiring a high degree of precision.

The MAX4289 is available in a tiny 6-pin SOT23 package. All specifications are guaranteed over the extended temperature range of -40°C to +85°C.

Applications

- Single-Cell Systems
- Portable Electronic Equipment
- Battery-Powered Instrumentation
- Hearing Aids Using Zinc Air Battery
- Strain Gauges
- Cellular Phones
- Notebook Computers
- Sensor Amplifiers
- Portable Communication Devices

Typical Operating Characteristic



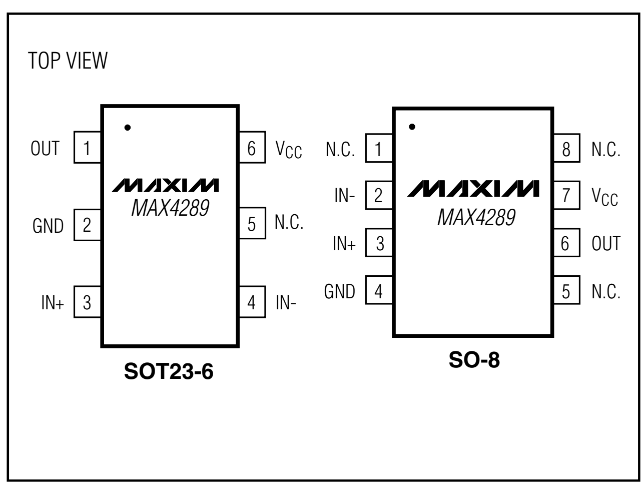
Features

- ♦ **Ultra-Low Voltage Operation: Guaranteed Specifications from 1.0V to 5.5V**
- ♦ **Input Common-Mode Range: 0 to (V_{CC} - 0.2V)**
- ♦ **Ultra-Low Power Consumption: 9µA Supply Current (typ)**
- ♦ **Optimized for Operation from Single-Cell Battery-Powered Systems**
- ♦ **Compatible with 3.0V and 5.0V Single-Supply Systems**
- ♦ **Low Offset Voltage: 0.2mV**
- ♦ **Low Input Bias Current: 5nA**
- ♦ **High Open-Loop Voltage Gain: 90dB**
- ♦ **Rail-to-Rail Output Stage Drives 5kΩ Load**
- ♦ **No Output Phase Reversal for Overdriven Inputs**
- ♦ **Available in a Tiny 6-Pin SOT23 (3mm × 3mm)**

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	TOP MARK
MAX4289EUT-T	-40°C to +85°C	6 SOT23-6	AARX
MAX4289ESA	-40°C to +85°C	8 SO	—

Pin Configurations



ABSOLUTE MAXIMUM RATINGS

Power-Supply Voltage (V_{CC} to GND)......................................6V
Input Voltage (IN+ or IN-)..........................(V_{CC} + 0.3V) to -0.3V
Input Current (IN+ or IN-)...20mA
Output Short-Circuit Duration to V_{CC} or GND............Continuous
Continuous Power Dissipation (T_A = +70°C)
6-Pin SOT23 (derate 8.7mW/°C above +70°C)............696mW
8-Pin SO (derate 5.88mW/°C above +70°C)................471mW

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

(V_{CC} = 3V, V_{CM} = 0, V_{OUT} = V_{CC}/2, R_L tied to V_{CC}/2, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Supply Voltage Range	V_{CC}	Inferred from the PSRR tests	T_A = +25°C	1.0		5.5	V
			T_A = -40°C to +85°C	1.2		5.5	
Quiescent Supply Current	I_{CC}	V_{CC} = 1.0V, T_A = +25°C			9	14	µA
		V_{CC} = 3.0V			12	25	
		V_{CC} = 5.5V			18	40	
Input Offset Voltage	V_{OS}	T_A = +25°C			±0.2	±2.0	mV
		T_A = T_{MIN} to T_{MAX}				±6.0	
Input Bias Current	I_B				±5	±15	nA
Input Offset Current	I_{OS}				±0.5	±2.0	nA
Differential Input Resistance	R_{IN}				50		MΩ
Input Common-Mode Voltage Range	V_{CM}	Inferred from CMRR test	V_{CC} = 1.2V	0		V_{CC} - 0.2	V
			V_{CC} = 3.0V	0		V_{CC} - 0.8	
Common-Mode Rejection Ratio	CMRR	V_{CC} = 1.2V, 0 ≤ V_{CC} - 0.2V			57		dB
		V_{CC} = 1.2V, 0 ≤ V_{CM} ≤ V_{CC} - 0.8V		57	85		
		V_{CC} = 3.0V, 0 ≤ V_{CM} ≤ V_{CC} - 0.8V		57	110		
Power-Supply Rejection Ratio	PSRR	1.0V ≤ V_{CC} ≤ 5.5V, T_A = +25°C		54	75		dB
		1.2V ≤ V_{CC} ≤ 5.5V, T_A = -40°C to +85°C		58	75		
Large-Signal Voltage Gain	A_{VOL}	R_L = 100kΩ (50mV ≤ V_{OUT} ≤ V_{CC} - 50mV)			110		dB
		R_L = 5kΩ (100mV ≤ V_{OUT} ≤ V_{CC} - 100mV)		80	90		
Output Voltage Swing High	V_{OH}	Specified as |V_{CC} - V_{OH}|	R_L = 100kΩ		0.2	10	mV
			R_L = 5kΩ		7	40	
Output Voltage Swing Low	V_{OL}	Specified as V_{OL}	R_L = 100kΩ		0.4	10	mV
			R_L = 5kΩ		7	40	

ELECTRICAL CHARACTERISTICS (continued)

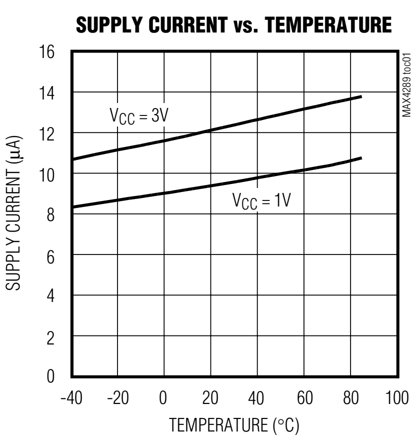
(V_{CC} = 3V, V_{CM} = 0, V_{OUT} = V_{CC}/2, R_L tied to V_{CC}/2, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.) (Note 1)

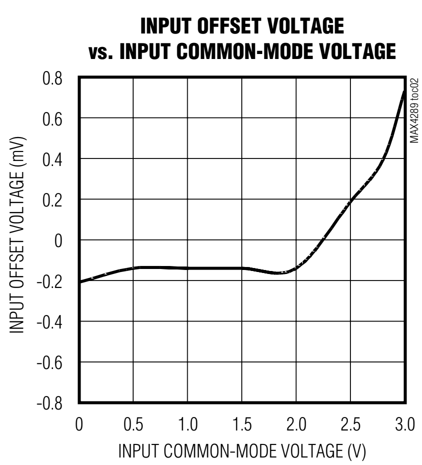
PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Output Short-Circuit Current	I_{OUT}	Sourcing/sinking current	V_{CC} = 1.0V		0.6		mA
			V_{CC} = 3.0V		19		
Power-Up Time	t_{PU}				300		µs
Input Capacitance	C_{IN}				3.0		pF
Gain-Bandwidth Product	GBW				17		kHz
Phase Margin	θM				80		degrees
Gain Margin	GM				10		dB
Slew Rate	SR				6		V/ms
Capacitive-Load Stability		A_{VCL} = +1V/V, no sustained oscillations			200		pF
Settling Time to 0.1%	t_S	A_{VCL} = +1V/V, no sustained oscillations			75		µs

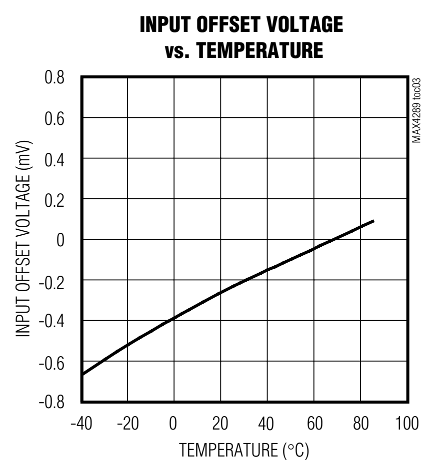
Note 1: All specifications are 100% production tested at T_A = +25°C. Temperature specification limits are guaranteed by design.

Typical Operating Characteristics

(V_{CC} = 3V, V_{CM} = 0, R_L to V_{CC}/2, T_A = +25°C, unless otherwise noted.)





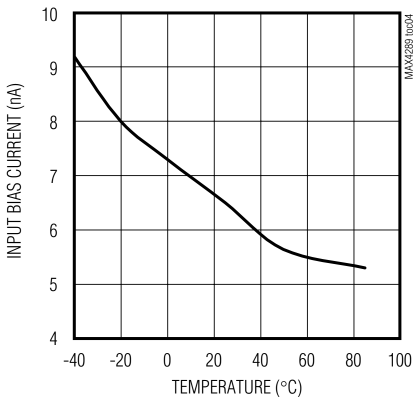


1.0V Micropower, SOT23, Operational Amplifier

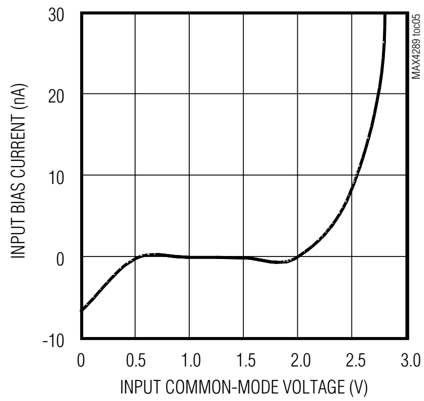
Typical Operating Characteristics (continued)

(V_{CC} = 3V, V_{CM} = 0, R_L to $V_{CC}/2$, T_A = +25°C, unless otherwise noted.)

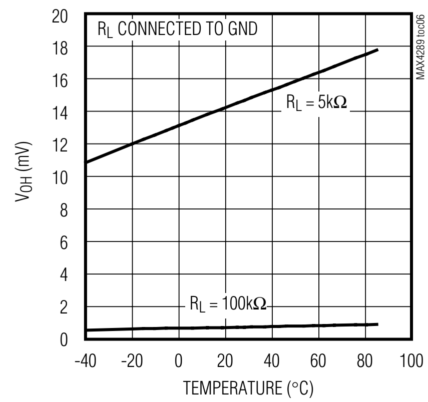
INPUT BIAS CURENT vs. TEMPERATURE



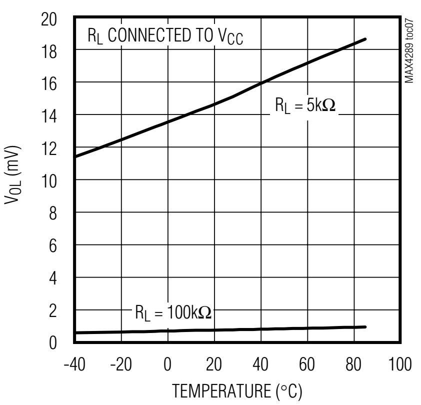
INPUT BIAS CURRENT vs. INPUT COMMON-MODE VOLTAGE



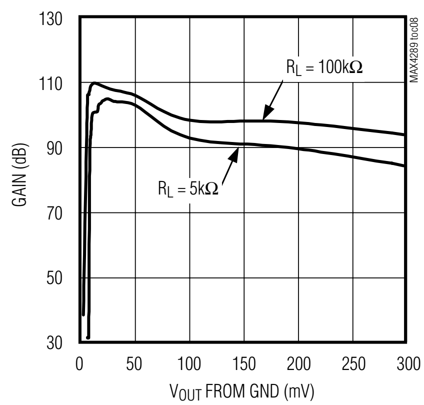
OUTPUT SWING HIGH vs. TEMPERATURE



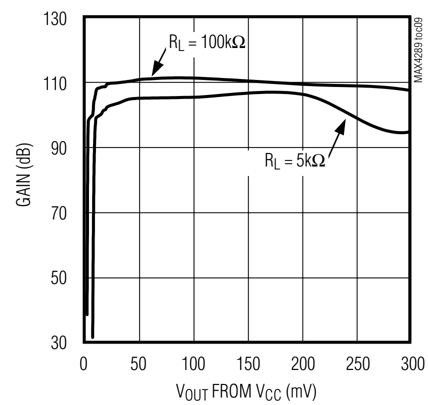
OUTPUT SWING LOW vs. TEMPERATURE



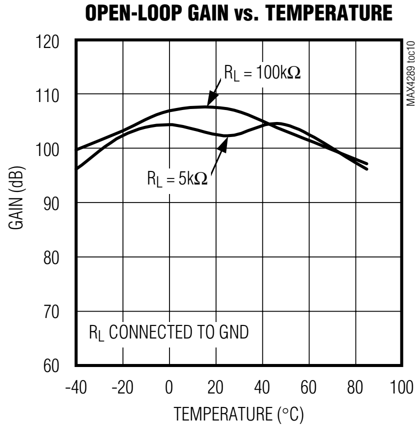
OPEN-LOOP GAIN vs. OUTPUT SWING LOW



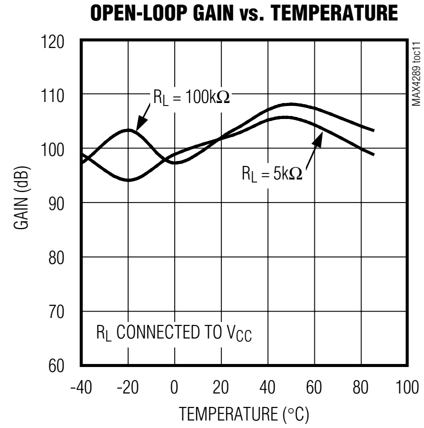
OPEN-LOOP GAIN vs. OUTPUT SWING HIGH



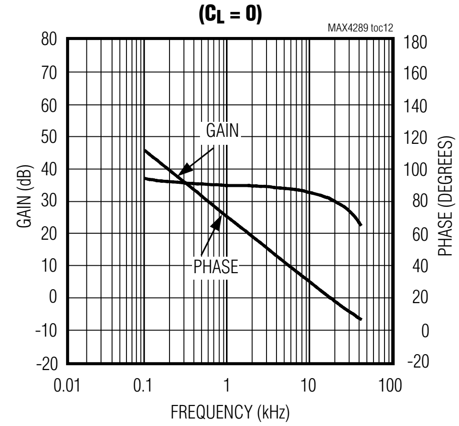
OPEN-LOOP GAIN vs. TEMPERATURE



OPEN-LOOP GAIN vs. TEMPERATURE

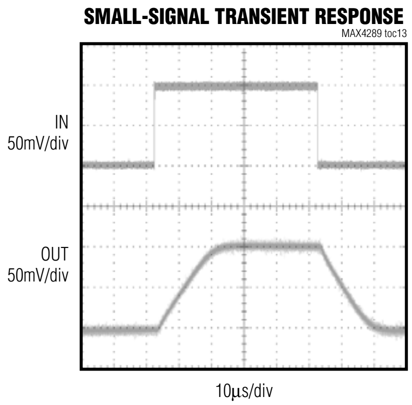


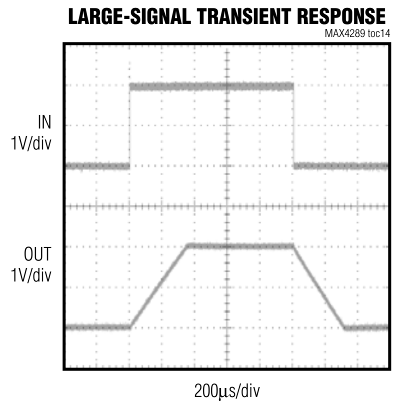
GAIN AND PHASE vs. FREQUENCY (C_L = 0)

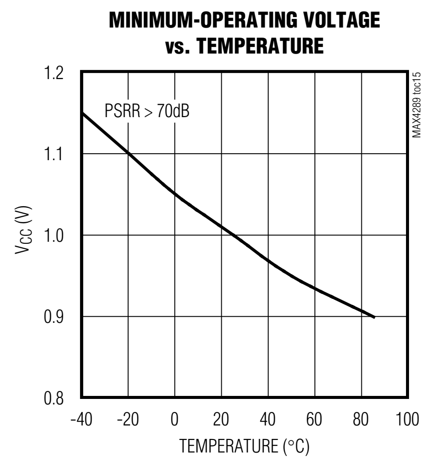


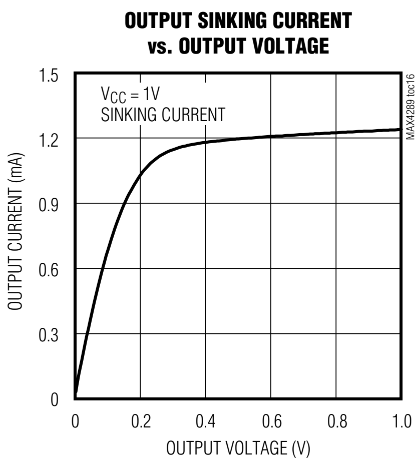
Typical Operating Characteristics (continued)

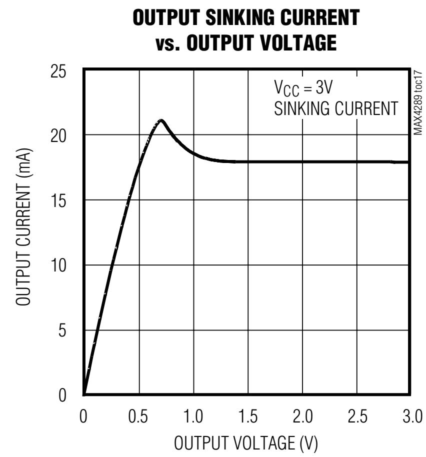
(V_{CC} = 3V, V_{CM} = 0, R_L to $V_{CC}/2$, T_A = +25°C, unless otherwise noted.)

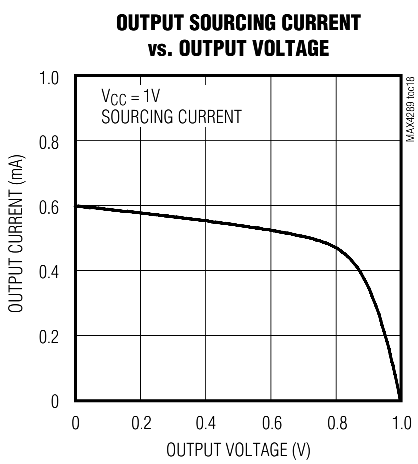


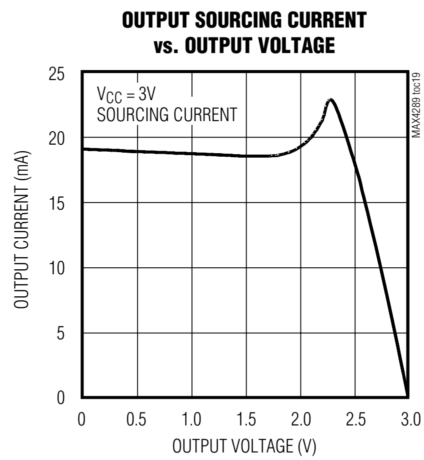












1.0V Micropower, SOT23, Operational Amplifier

Pin Description

PIN		NAME	FUNCTION
SO	SOT23		
1, 5, 8	5	N.C.	No Connection. Not internally connected.
2	4	IN-	Inverting Input
3	3	IN+	Noninverting Input
4	2	GND	Ground
6	1	OUT	Amplifier Output
7	6	V_{CC}	Positive Supply. Bypass with a 0.1µF capacitor to GND.

Detailed Description

The MAX4289 consumes ultra-low power (9µA supply current typically) and has a rail-to-rail output stage that is specifically designed for low-voltage operation. The input common-mode voltage range extends from V_{CC} - 0.2V to ground, although full rail-to-rail input range is possible with degraded performance. The input offset voltage is typically 200µV. Low-operating supply voltage, low supply current, and rail-to-rail outputs make this operational amplifier an excellent choice for precision or general-purpose, low-voltage, battery-powered systems.

Rail-to-Rail Output Stage

The MAX4289 output stage can drive a 5kΩ load and still swing to within 7mV of the rails. Figure 1 shows the output voltage swing of the MAX4289 configured as a unity-gain buffer, powered from a single 2V supply voltage. The output for this setup typically swings from +0.4mV to (V_{CC} - 0.2mV) with a 100kΩ load.

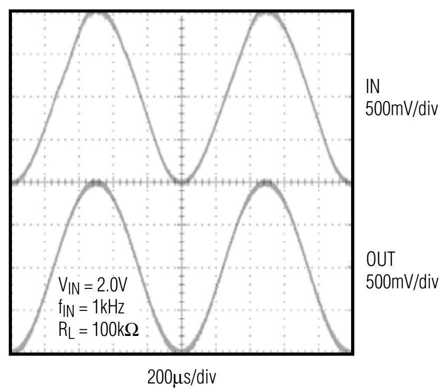


Figure 1. Rail-to-Rail Input/Output Voltage Range

Applications Information

Power-Supply Considerations

The MAX4289 operates from a single 1.0V to 5.5V supply and consumes only 9µA of supply current. A high power-supply rejection ratio of 75dB allows the amplifier to be powered directly off a decaying battery voltage, simplifying design and extending battery life. The MAX4289 is ideally suited for single-cell battery-powered systems. Figures 2 and 3 show the supply current and PSRR as a function of supply voltage and temperature.

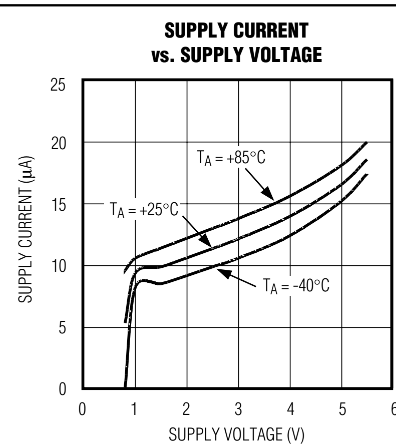


Figure 2. I_{CC} vs. V_{CC} Over the Temperature Range

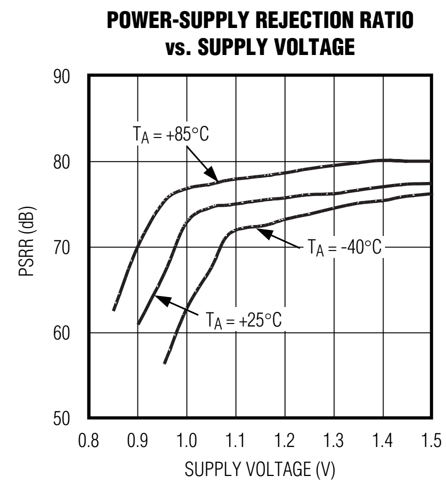


Figure 3. PSRR vs. V_{CC} Over the Temperature Range

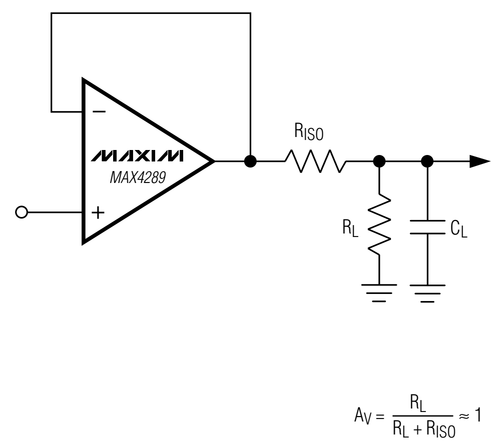


Figure 4. Using a Resistor to Isolate a Capacitive Load from the Op Amp

Power-Up Settling Time

The MAX4289 typically requires 300µs to power-up after V_{CC} is stable. During this startup time, the output is indeterminate. The application circuit should allow for this initial delay.

Driving Capacitive Loads

The MAX4289 is unity-gain stable for loads up to 200pF. Applications that require greater capacitive-drive capability should use an isolation resistor between the output and the capacitive load (Figure 4). Note that this solution results in a loss of gain accuracy because R_{ISO} forms a voltage-divider with the load resistor.

Using the MAX4289 as a Comparator

Although optimized for use as an operational amplifier, the MAX4289 can also be used as a rail-to-rail I/O comparator (Figure 5). External hysteresis can be used to minimize the risk of output oscillation. The positive feedback circuit, shown in Figure 5, causes the input threshold to change when the output voltage changes state.

Power Supplies and Layout

The MAX4289 operates from a single 1V to 5.5V power supply. Bypass the power with a 0.1µF capacitor to ground.

Good layout techniques optimize performance by decreasing the amount of stray capacitance at the op amp's inputs and outputs. To decrease stray capacitance, minimize trace lengths by placing external components close to the op amp's pins.

1.0V Micropower, SOT23, Operational Amplifier

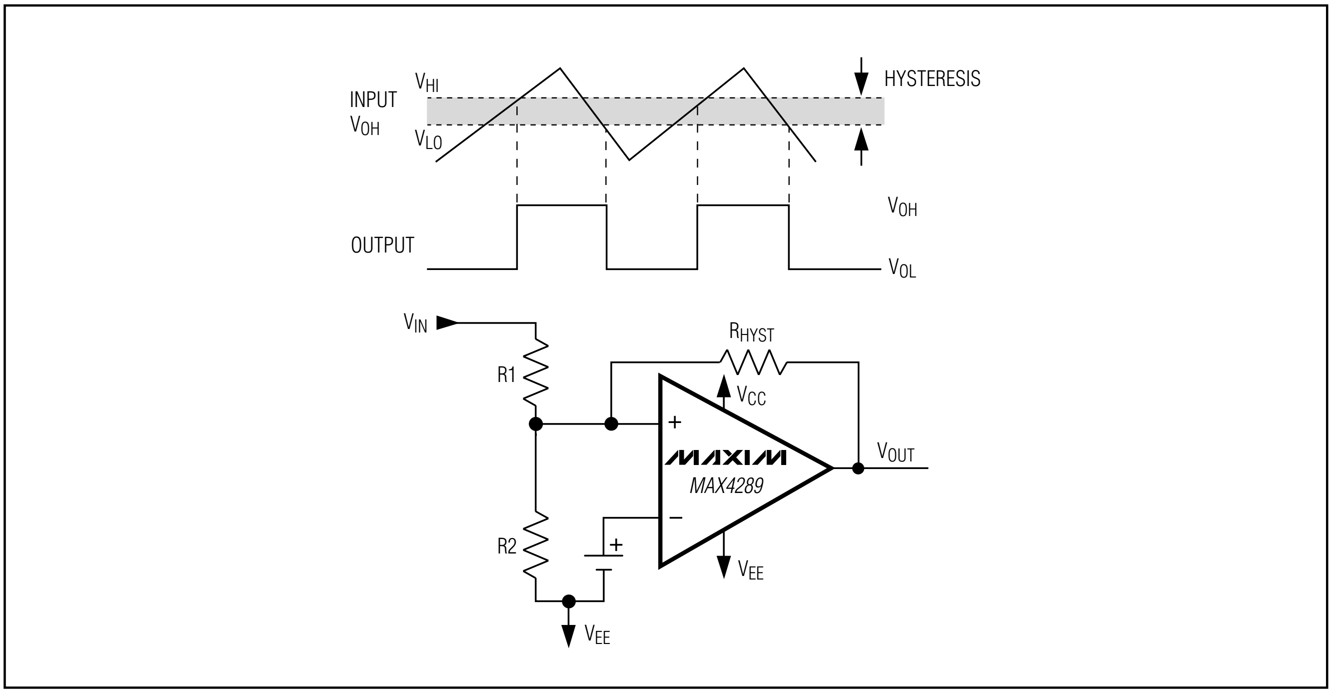


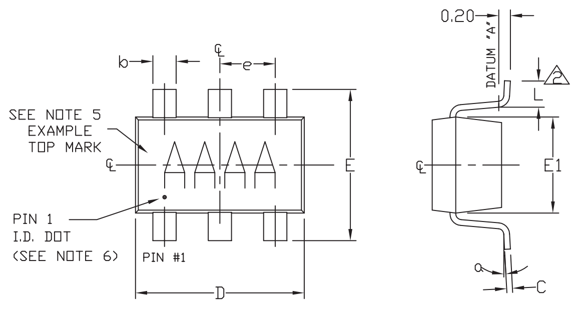
Figure 5. Hysteresis Comparator Circuit

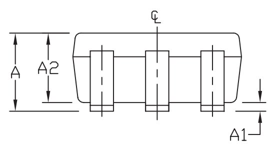
Chip Information

TRANSISTOR COUNT: 557

Package Information

6LSOT.EPS



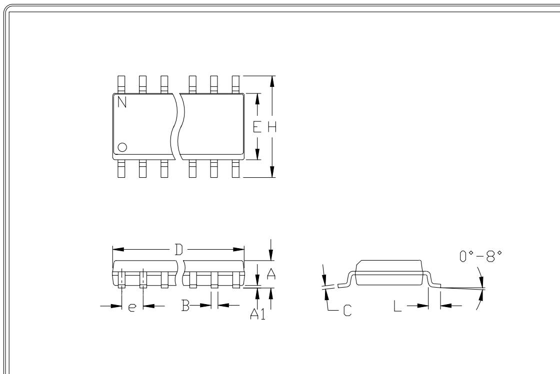


SYMBOL	MIN	MAX
A	0.90	1.45
A1	0.00	0.15
A2	0.90	1.30
b	0.35	0.50
C	0.08	0.20
D	2.80	3.00
E	2.60	3.00
E1	1.50	1.75
L	0.35	0.55
e	0.95 REF	
α	0°	10°

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.
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 0.3 MM ø MIN. LOCATED ABOVE PIN 1.
7. MEETS JEDEC MO178.

MAXIM
PROPRIETARY INFORMATION
TITLE: PACKAGE OUTLINE, SOT-23, 6L
APPROVAL | DOCUMENT CONTROL NO. 21-0058 | REV E | 1/1

SOICN.EPS



	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			
	MIN	MAX	MIN	MAX	N	MS012
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

MAXIM | PACKAGE FAMILY OUTLINE: SOIC .150" | 1/1 | 21-0041 A
120 SAN GABRIEL DR. SUNNYVALE CA 94086 FAX (408) 737 7194
PROPRIETARY INFORMATION | TITLE | DOCUMENT CONTROL NUMBER REV

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