## Absolute Maximum Ratings

$V_{CC}$, SIGN to GND ................................................-0.3V to +6V
RS+, RS- to GND .................................................-0.3V to +30V
OUT to GND ........................................... -0.3V to ($V_{CC}$ + 0.3V)
Differential Input Voltage ($V_{RS+}$ - $V_{RS-}$)............................±30V
OUT, SIGN Short Circuit to $V_{CC}$ or GND .................Continuous
Current into Any Pin ........................................................±20mA
Continuous Power Dissipation ($T_A$ = +70°C)
6-Bump 1mm x 1.5mm UCSP
(derate 3.9mW/°C above +70°C)..........................308.3mW
8-Pin μMAX (derate 4.8mW/°C above +70°C)...........388mW
Operating Temperature Range........................ -40°C to +125°C
Storage Temperature Range........................... -65°C to +150°C
Junction Temperature ....................................................+150°C
Lead Temperature (soldering, 10s) ................................+300°C
Soldering Temperature (reflow)......................................+260°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

($V_{RS+}$ = -0.1V to +28V, $V_{CC}$ = 3.3V, $V_{SENSE}$ = ($V_{RS+}$ - $V_{RS-}$) = 0V, $R_{OUT}$ = 10kΩ for MAX9928F, $T_A$ = -40°C to +125°C, unless otherwise noted. Typical values are at $T_A$ = +25°C.) (Note 1)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| **AMPLIFIER DC ELECTRICAL CHARACTERISTICS** | | | | | | | |
| Input Offset Voltage (Note 2) | $V_{OS}$ | $V_{RS+}$ = 3.6V | $T_A$ = +25°C | | ±0.1 | ±0.4 | mV |
| | | | $T_A$ = -40°C to +125°C | | | ±0.8 | |
| | | $V_{RS+}$ = -0.1V | $T_A$ = +25°C | | ±0.6 | ±1.0 | |
| | | | $T_A$ = -40°C to +125°C | | | ±3.0 | |
| Common-Mode Input Range | $V_{CMR}$ | (Note 3) | | -0.1 | | +28 | V |
| Common-Mode Rejection Ratio | CMRR | 2V ≤ $V_{RS+}$ ≤ 28V | $T_A$ = +25°C | 93 | 104 | | dB |
| | | | $T_A$ = -40°C to +125°C | 87 | | | |
| | | -0.1V ≤ $V_{RS+}$ ≤ +2V | $T_A$ = +25°C | 60 | 72 | | |
| | | | $T_A$ = -40°C to +125°C | 54 | | | |
| Full-Scale Sense Voltage (Note 2) | $V_{SENSE}$ | MAX992_F | | | ±50 | | mV |
| Gain (Note 2) | $A_V$ | MAX9929F | | | 50 | | V/V |
| Gain Accuracy (Notes 2, 6) | | MAX9929F, $V_{RS+}$ = 3.6V | $T_A$ = +25°C | | ±0.3 | ±1.0 | % |
| | | | $T_A$ = -40°C to +125°C | | | ±2.5 | |
| | | MAX9929F, $V_{RS+}$ = -0.1V | $T_A$ = +25°C | | ±0.3 | ±1.0 | |
| | | | $T_A$ = -40°C to +125°C | | | ±2.8 | |
| Transconductance (Note 2) | $G_M$ | MAX9928F | | | 5 | | μA/mV |
| Transconductance Accuracy (Note 2) | | MAX9928F, $V_{RS+}$ = 3.6V | $T_A$ = +25°C | | ±0.3 | ±1.0 | % |
| | | | $T_A$ = -40°C to +125°C | | | ±2.5 | |
| | | MAX9928F, $V_{RS+}$ = -0.1V | $T_A$ = +25°C | | ±0.3 | ±1.0 | |
| | | | $T_A$ = -40°C to +125°C | | | ±2.8 | |
| Input Bias Current (Note 4) | $I_{RS+}$, $I_{RS-}$ | 2V ≤ $V_{RS+}$ ≤ 28V | | 0 | 1.6 | 6 | μA |
| | | -0.1V ≤ $V_{RS+}$ ≤ +2V | | -80 | | +6 | |
| Input Offset Bias Current (Note 4) | $I_{OS}$ | 2V ≤ $V_{RS+}$ ≤ 28V | | | ±0.05 | ±1 | μA |
| | | -0.1V ≤ $V_{RS+}$ ≤ +2V | | | ±0.2 | ±2 | |
| Input Leakage Current | $I_{RS+}$, $I_{RS-}$ | $V_{CC}$ = 0V, $V_{RS+}$ = $V_{RS-}$ = 28V (Note 5) | | | 0.05 | 1.0 | μA |

## Electrical Characteristics (continued)

($V_{RS+}$ = -0.1V to +28V, $V_{CC}$ = 3.3V, $V_{SENSE}$ = ($V_{RS+}$ - $V_{RS-}$) = 0V, $R_{OUT}$ = 10kΩ for MAX9928F, $T_A$ = -40°C to +125°C, unless otherwise noted. Typical values are at $T_A$ = +25°C.) (Note 1)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| Output Resistance | $R_{OUT}$ | MAX9928F | | | 5 | | MΩ |
| | | MAX9929F | | 6.4 | 10 | 13.6 | kΩ |
| Output High Voltage (Note 6) | $V_{OH}$ | MAX9928F, $R_{OUT}$ = 10kΩ | | | ($V_{CC}$ - 0.1) | ($V_{CC}$ - 0.45) | V |
| | | MAX9929F | | | ($V_{CC}$ - 0.1) | ($V_{CC}$ - 0.45) | |
| Minimum Output Voltage (Note 7) | $V_{OL}$ | MAX9929F | $T_A$ = +25°C | | 0.25 | 2.0 | mV |
| | | | $T_A$ = -40°C to +125°C | | | 15 | |
| Minimum Output Current (Note 7) | $I_{OL}$ | MAX9928F | $T_A$ = +25°C | | 0.025 | 0.2 | µA |
| | | | $T_A$ = -40°C to +125°C | | | 1.5 | |
| **SIGN COMPARATOR DC ELECTRICAL CHARACTERISTICS** | | | | | | | |
| Discharge to Charge Trip Point (Note 8) | $V_{TDC}$ | $V_{RS+}$ = 3.6V | $T_A$ = +25°C | -1.6 | -1.2 | -0.5 | mV |
| | | | $T_A$ = -40°C to +125°C | -2.15 | | -0.15 | |
| | | $V_{RS+}$ = -0.1V | $T_A$ = +25°C | -2.5 | -1.2 | +0.25 | |
| | | | $T_A$ = -40°C to +125°C | -4.6 | | +2.3 | |
| Charge to Discharge Trip Point (Note 8) | $V_{TCD}$ | $V_{RS+}$ = 3.6V | $T_A$ = +25°C | | -1.8 | | mV |
| | | $V_{RS+}$ = -0.1V | $T_A$ = +25°C | | -1.8 | | |
| Hysteresis Width | $V_{HYS}$ | $V_{RS+}$ = 3.6V, -0.1V | $T_A$ = +25°C | | 0.6 | | mV |
| Common-Mode Input Range (Note 9) | $V_{CMR}$ | | | -0.1 | | +28 | V |
| Common-Mode Rejection Ratio (Note 9) | CMRR | 2V ≤ $V_{RS+}$ ≤ 28V | | | 102 | | dB |
| | | -0.1V ≤ $V_{RS+}$ ≤ +2V | | | 74 | | |
| Output Low Voltage | $V_{OL}$ | $I_{SINK}$ = 100µA | | | 0.03 | 0.1 | V |
| Output High Voltage | $V_{OH}$ | | | | ($V_{CC}$ - 0.01) | ($V_{CC}$ - 0.04) | V |
| Internal Pullup Resistor | $R_{PULL-UP}$ | | | | 1 | | MΩ |
| **POWER SUPPLY** | | | | | | | |
| Supply Voltage Range (Note 10) | $V_{CC}$ | $T_A$ = +25°C | | 2.5 | | 5.5 | V |
| | | $T_A$ = -40°C to +125°C | | 2.8 | | 5.5 | |
| Amplifier Power-Supply Rejection Ratio (Note 10) | $PSRR_A$ | $V_{RS+}$ = 3.6V | | 72 | 90 | | dB |
| | | $V_{RS+}$ = -0.1V | | 66 | 86 | | |
| Comparator Power-Supply Rejection Ratio | $PSRR_C$ | $V_{RS+}$ = 3.6V | | | 90 | | dB |
| | | $V_{RS+}$ = -0.1V | | | 86 | | |
| Quiescent Supply Current | $I_{CC}$ | 2V ≤ $V_{RS+}$ ≤ 28V | | | 20 | 30 | µA |
| | | -0.1V ≤ $V_{RS+}$ < +2V | | | 115 | 200 | |

## Electrical Characteristics (continued)

($V_{RS+}$ = -0.1V to +28V, $V_{CC}$ = 3.3V, $V_{SENSE}$ = ($V_{RS+}$ - $V_{RS-}$) = 0V, $R_{OUT}$ = 10kΩ for MAX9928F, $T_A$ = -40°C to +125°C, unless otherwise noted. Typical values are at $T_A$ = +25°C.) (Note 1)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| **AC ELECTRICAL CHARACTERISTICS** | | | | | | | |
| -3dB Bandwidth | BW | MAX992_F, $V_{SENSE}$ = 50mV | | | 150 | | kHz |
| OUT Settling to 1% of Final Value | $t_{SET}$ | $V_{RS+}$ = 3.6V, $C_{LOAD}$ = 10pF, $R_{OUT}$ = 10kΩ for MAX9928F | MAX992_F, $V_{SENSE}$ = 5mV to 50mV step | | 6 | | µs |
| | | | MAX992_F, $V_{SENSE}$ = 50mV to 5mV step | | 15 | | |
| SIGN Comparator Propagation Delay (Low to High) | $t_{PROP\_LH}$ | Overdrive = 1mV | | | 80 | | µs |
| | | Overdrive = 5mV | | | 30 | | |
| SIGN Comparator Propagation Delay (High to Low) | $t_{PROP\_HL}$ | Overdrive = 1mV | | | 50 | | µs |
| | | Overdrive = 5mV | | | 13 | | |
| Power-Up Time to 1% of Final Value | | $V_{SENSE}$ = 50mV for MAX992_F, $V_{RS+}$ = 3.6V, $C_{LOAD}$ = 10pF | | | 50 | | µs |
| Saturation Recovery Time | | 100mV ≤ $V_{SENSE}$ P 50mV for MAX992_F, $V_{RS+}$ = 3.6V, $C_{LOAD}$ = 10pF | | | 4 | | ms |

**Note 1:** All devices are 100% production tested at $T_A$ = +25°C. All temperature limits are guaranteed by design.

**Note 2:** $V_{OS}$ is extrapolated from two point transconductance and gain accuracy tests. Measurements are made at $V_{SENSE}$ = +5mV and $V_{SENSE}$ = +50mV for MAX992_F. These measurements are also used to test the full-scale sense voltage, transconductance, and gain. These $V_{OS}$ specifications are for the trimmed direction only ($V_{RS+}$ > $V_{RS-}$). For current flowing in the opposite direction ($V_{RS-}$ > $V_{RS+}$), $V_{OS}$ is ±1mV (max) at +25°C and ±1.8mV (max) over temperature, when $V_{RS+}$ is at 3.6V. See the *Detailed Description* for more information.

**Note 3:** Guaranteed by common-mode rejection ratio. Extrapolated $V_{OS}$ as described in Note 2 is used to calculate common-mode rejection ratio.

**Note 4:** Includes input bias current of SIGN comparator.

**Note 5:** Leakage in to RS+ or RS- when $V_{CC}$ = 0V. Includes input leakage current of SIGN comparator. This specification does not add to the bias current.

**Note 6:** Output voltage should be 650mV below $V_{CC}$ to achieve full accuracy.

**Note 7:** $I_{OL}$ is the minimum output current in the $V_{SENSE}$ - $I_{OUT}$ transfer characteristics. $V_{OL}$ is the minimum output voltage in the $V_{SENSE}$ - $V_{OUT}$ transfer characteristic.

**Note 8:** $V_{SENSE}$ voltage required to switch comparator.

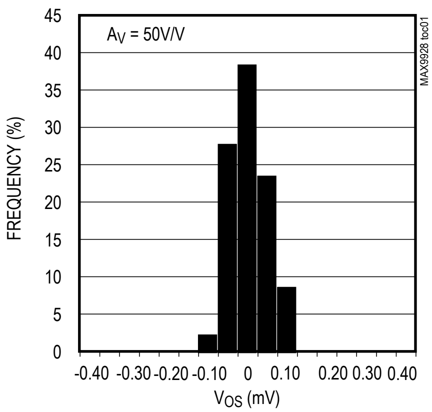
**Note 9:** Discharge to charge trip point is functionally tested at $V_{CM}$ = -0.1V, +3.6V, and +28V.

**Note 10:** Guaranteed by PSRR test. Extrapolated $V_{OS}$ as described in Note 2 is used to calculate the power-supply rejection ratio. $V_{SENSE}$ has to be such that the output voltage is 650mV below $V_{CC}$ to achieve full accuracy.

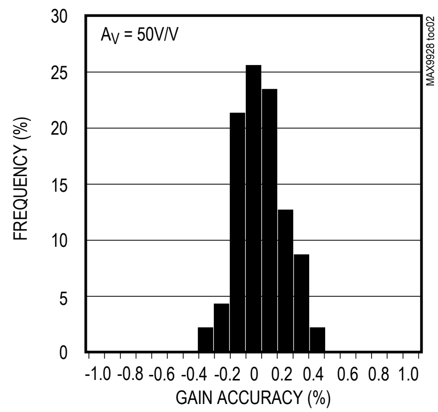
## Typical Operating Characteristics

($V_{CC}$ = 3.3V, $V_{RS+}$ = 12V, $T_A$ = +25°C, unless otherwise noted.)

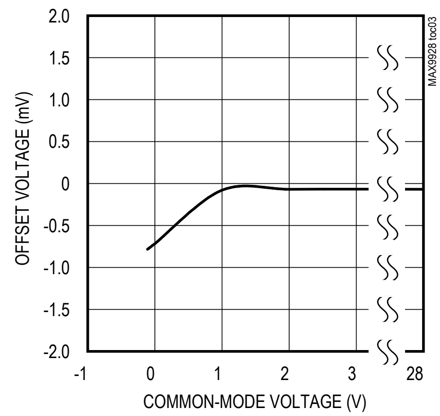
**$V_{OS}$ HISTOGRAM**



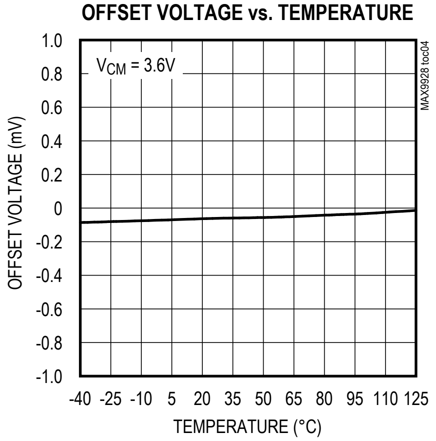

**GAIN ACCURACY HISTOGRAM**



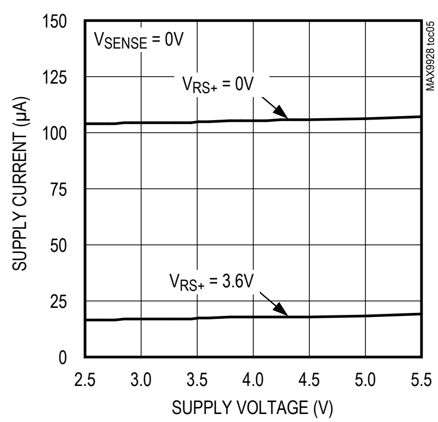

**OFFSET VOLTAGE vs. COMMON-MODE VOLTAGE**



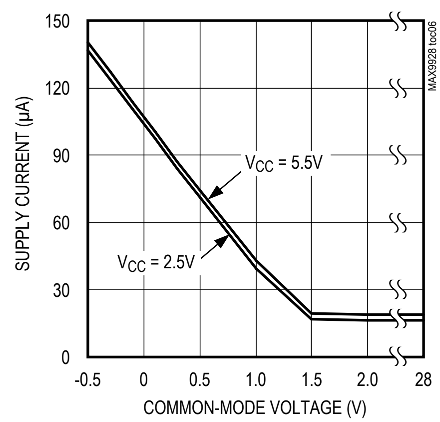

**OFFSET VOLTAGE vs. TEMPERATURE**



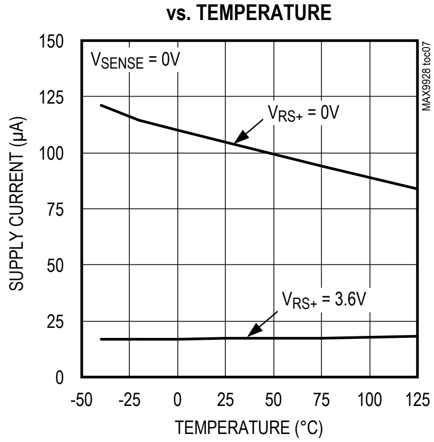

**SUPPLY CURRENT vs. SUPPLY VOLTAGE**



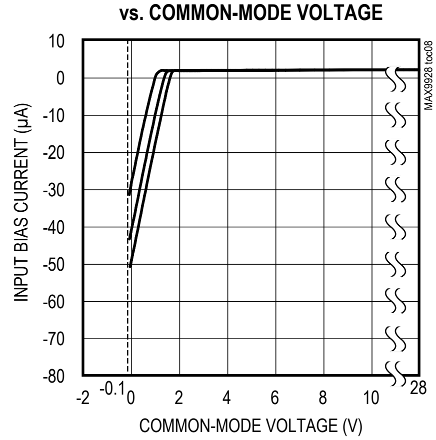

**SUPPLY CURRENT vs. COMMON-MODE VOLTAGE**




**SUPPLY CURRENT vs. TEMPERATURE**



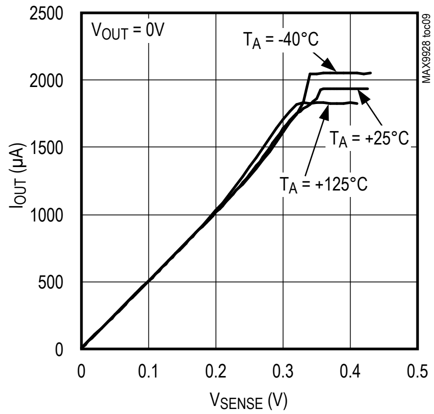

**INPUT BIAS CURRENT vs. COMMON-MODE VOLTAGE**



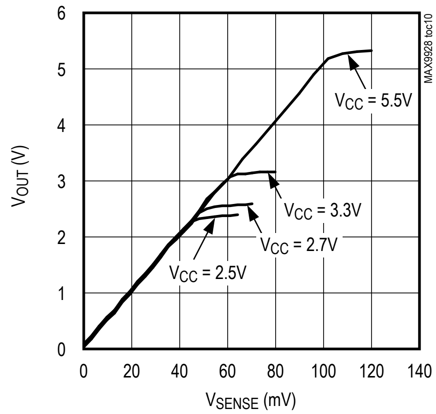
## Typical Operating Characteristics (continued)

($V_{CC}$ = 3.3V, $V_{RS+}$ = 12V, $T_A$ = +25°C, unless otherwise noted.)

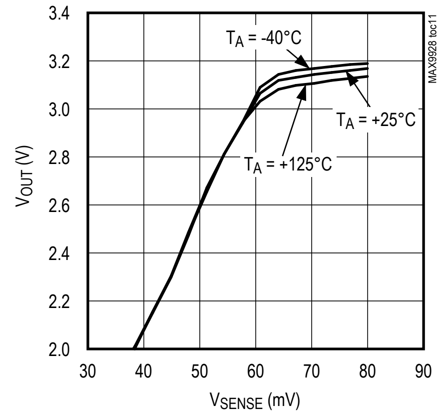
**MAX9928F**
**$I_{OUT}$ vs. $V_{SENSE}$**



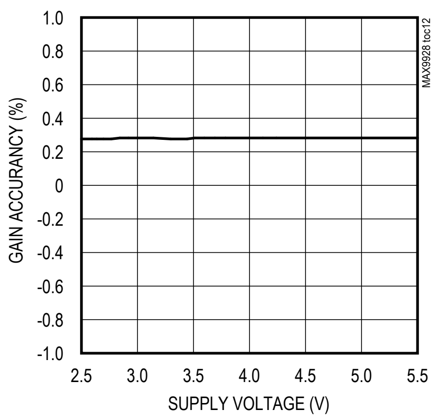

**MAX9929F**
**$V_{OUT}$ vs. $V_{SENSE}$**



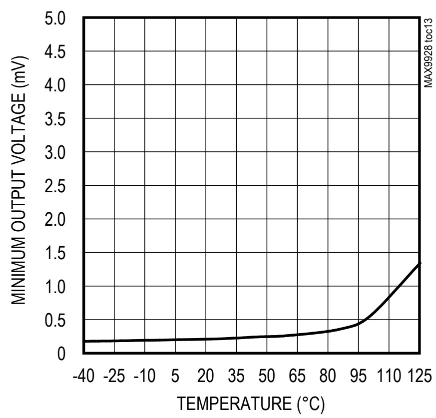

**MAX9929F**
**$V_{OUT}$ vs. $V_{SENSE}$**



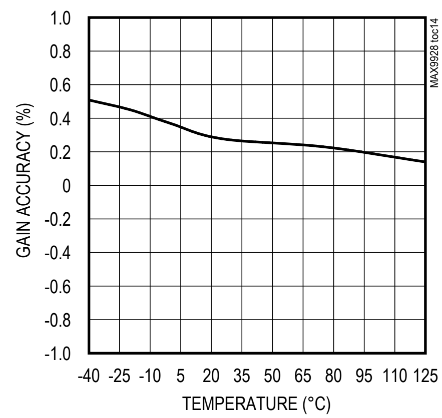

**GAIN ACCURACY vs. SUPPLY VOLTAGE**



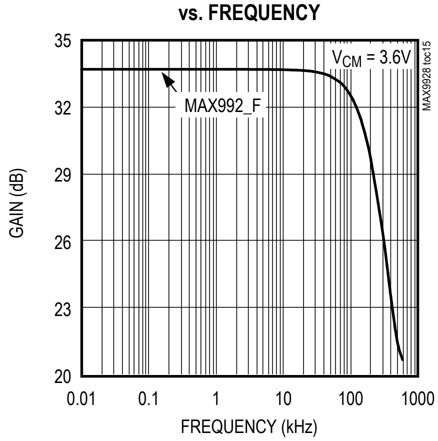

**MINIMUM OUTPUT VOLTAGE vs. TEMPERATURE**



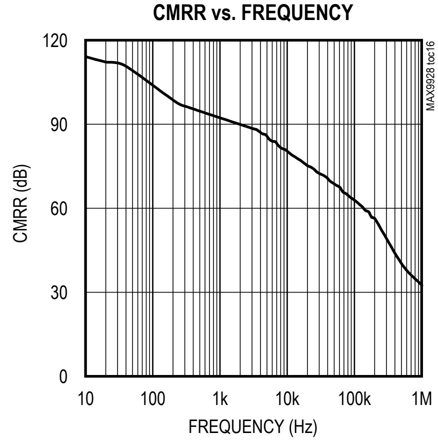

**GAIN ACCURACY vs. TEMPERATURE**




**SMALL-SIGNAL GAIN vs. FREQUENCY**



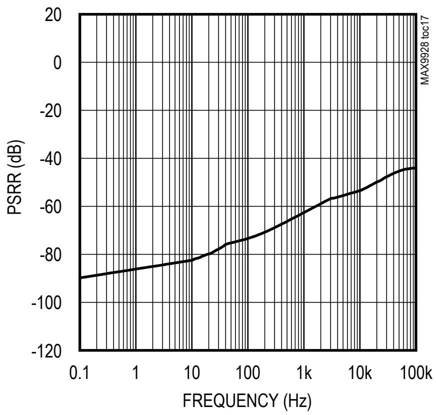

**CMRR vs. FREQUENCY**



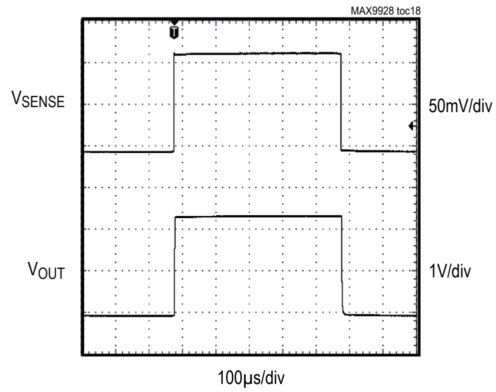
## Typical Operating Characteristics (continued)

($V_{CC}$ = 3.3V, $V_{RS+}$ = 12V, $T_A$ = +25°C, unless otherwise noted.)

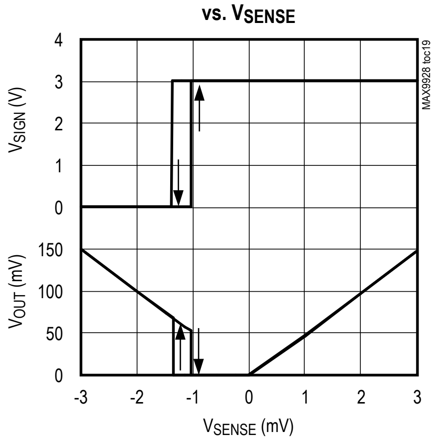
**PSRR vs. FREQUENCY**



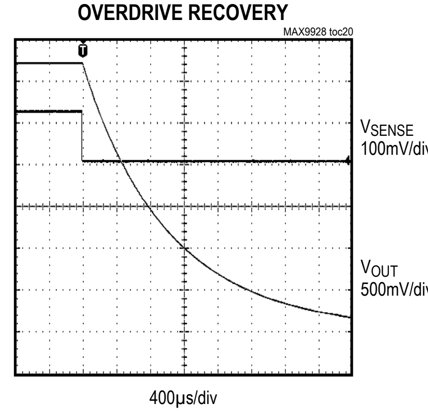

**MAX9929F LARGE-SIGNAL TRANSIENT RESPONSE**



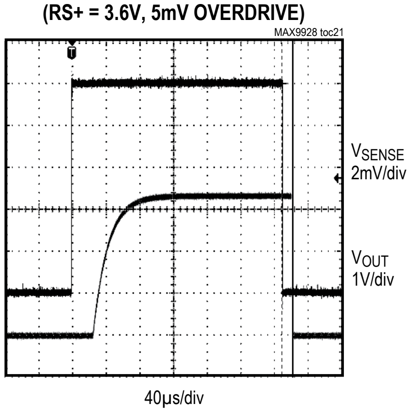

**VSIGN AND VOUT vs. VSENSE**



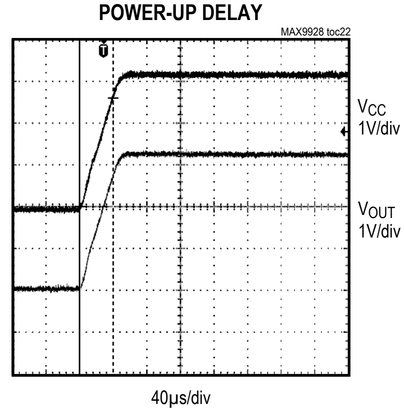

**OVERDRIVE RECOVERY**




**COMPARATOR PROPAGATION DELAY (RS+ = 3.6V, 5mV OVERDRIVE)**




**POWER-UP DELAY**



## Pin Configuration

| PIN µMAX | BUMP UCSP | NAME | FUNCTION |
|---|---|---|---|
| 1 | B3 | RS- | Negative Current-Sense Input. Load-side connection for the external sense resistor. |
| 2 | B2 | SIGN | SIGN Output. Indicates polarity of $V_{SENSE}$.<br>SIGN = H indicates $V_{RS+} > V_{RS-}$<br>SIGN = L indicates $V_{RS+} < V_{RS-}$ |
| 3 | B1 | RS+ | Positive Current-Sense Input. Power-side connection to the external sense resistor. |
| 4, 5 | — | N.C. | No Connection. Not internally connected. |
| 6 | A1 | $V_{CC}$ | Supply Voltage Input. Bypass to GND with a 0.1µF capacitor. |
| 7 | A2 | GND | Circuit Ground |
| 8 | A3 | OUT | Current-Sense Output. MAX9928: Current output ($I_{OUT}$ is proportional to $\|V_{SENSE}\|$). MAX9929: Voltage output ($V_{OUT}$ is proportional to $\|V_{SENSE}\|$). |

## Detailed Description

The MAX9928F/MAX9929F micropower uni-/bidirectional, current-sense amplifiers feature -0.1V to +28V input common-mode range that is independent of the supply voltage. This wide input voltage range feature allows the monitoring of the current flow out of a power supply during short-circuit/fault conditions, and also enables highside current sensing at voltages far in excess of the supply voltage ($V_{CC}$). The MAX9928F/MAX9929F operate from a 2.5V to 5.5V single supply and draw a low 20µA quiescent supply current.

Current flows through the sense resistor, generating a sense voltage $V_{SENSE}$ (Figure 1). The comparator senses the direction of the sense voltage and configures the amplifier for either positive or negative sense voltages by controlling the S1 and S2 switches.

For positive $V_{SENSE}$ voltage, the amplifier's inverting input is high impedance and equals $V_{IN}$ - $V_{SENSE}$. The amplifier's output drives the base of Q1, forcing its noninverting input terminal to ($V_{IN}$ - $V_{SENSE}$); this causes a current to flow through RG1 equal to $|V_{SENSE}|/R_{G1}$. Transistor Q2 and the current mirror amplify the current by a factor of M.

For negative $V_{SENSE}$ voltage, the amplifier's noninverting input is high impedance and the voltage on RS- terminal equals $V_{IN}$ + $V_{SENSE}$. The amplifier's output drives the base of Q1 forcing its inverting input terminal to match the voltage at the noninverting input terminal; this causes a current to flow through $R_{G2}$ equal to $|V_{SENSE}|/R_{G2}$. Again, transistor Q2 and the current mirror amplify the current by a factor of M.

### +$V_{SENSE}$ vs. -$V_{SENSE}$

The amplifier is configured for either positive $V_{SENSE}$ or negative $V_{SENSE}$ by the SIGN comparator. The comparator has a built-in offset skew of -1.2mV so that random offsets in the comparator do not affect the precision of $I_{OUT}$ ($V_{OUT}$) with positive $V_{SENSE}$. The comparator has a small amount of hysteresis (typically 0.6mV) to prevent its output from oscillating at the crossover sense voltage. The ideal transfer characteristic of $I_{OUT}$ ($V_{OUT}$) and the output of the comparator (SIGN) is shown in Figure 2.

The amplifier $V_{OS}$ is only trimmed for the positive $V_{SENSE}$ voltages ($V_{RS+} > V_{RS-}$). The SIGN comparator reconfigures the internal structure of the amplifier to work with negative $V_{SENSE}$ voltages ($V_{RS-} > V_{RS+}$) and the precision $V_{OS}$ trim is no longer effective and the resulting $V_{OS}$ is slightly impacted. See details in the *Electrical Characteristics* Note 2. The user can choose the direction that needs the best precision to be the direction where $V_{RS+} > V_{RS-}$. For example, when monitoring Li+ battery currents, the discharge current should be $V_{RS+} > V_{RS-}$ to give the best accuracy over the largest dynamic range. When the battery charger is plugged in, the charge current flows in the opposite direction and is usually much larger, and a higher $V_{OS}$ error can be tolerated. See the *Typical Operating Circuit*.

For applications with unidirectional currents (e.g., battery discharge only), the SIGN output can be ignored.

Note that as $V_{SENSE}$ increases, the output current ($I_{OUT}$ for the MAX9928 or $V_{OUT}$/10kΩ for the MAX9929) also increases. This additional current is supplied from $V_{CC}$.

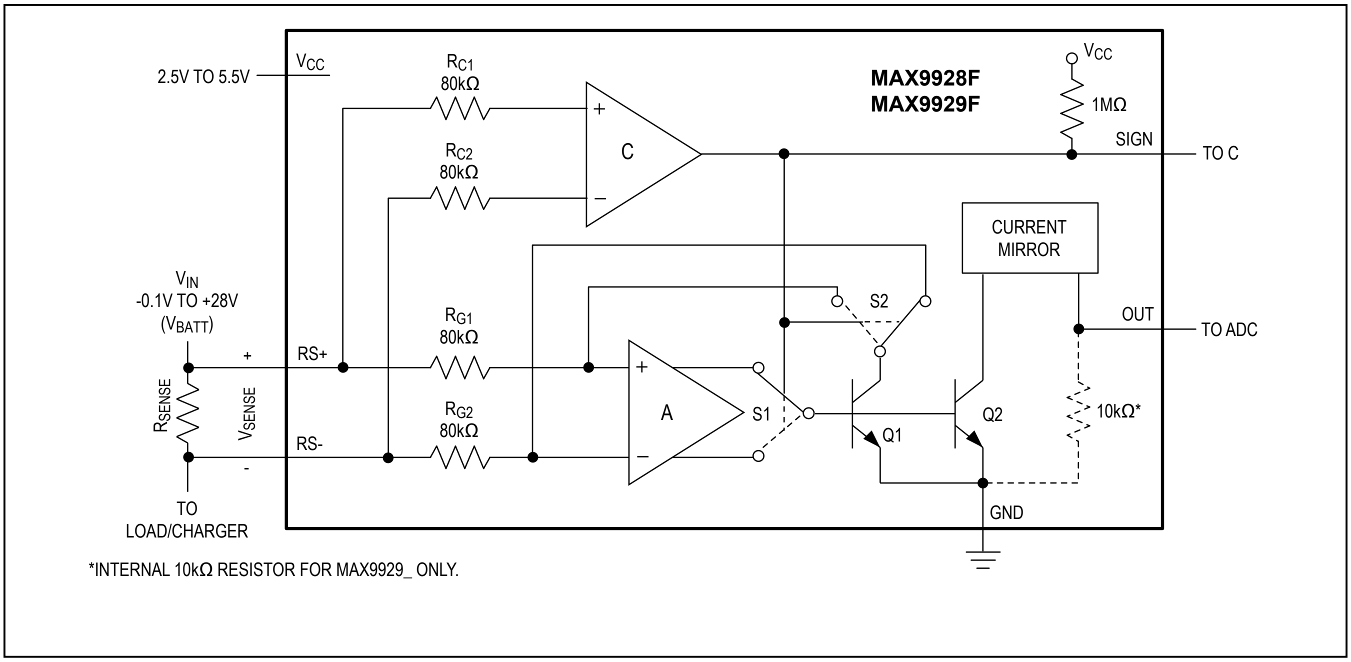



*Figure 1. Functional Diagram*

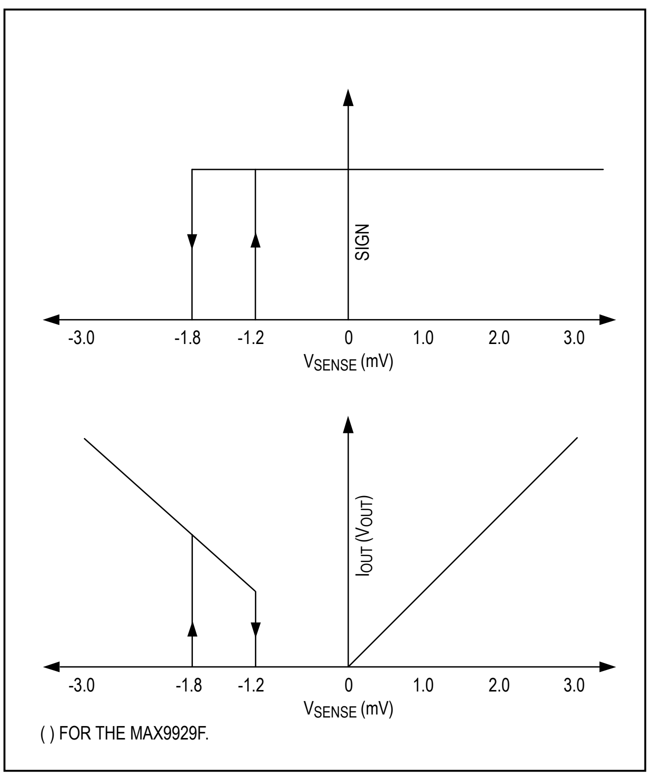



*Figure 2. Ideal Transfer Characteristics with 0mV Amplifier Input Offset Voltage and -1mV Comparator Input Offset Voltage*

For both positive and negative $V_{SENSE}$ voltages, the current flowing out of the current mirror is equal to:

$$I_{OUT} = M \times |V_{SENSE}|/R_{G1}$$

For the MAX9928F, the transconductance of the device is trimmed so that $I_{OUT}/|V_{SENSE}|$ = 5µA/mV. For the MAX9929F, the voltage gain of the device is trimmed so that $V_{OUT}/|V_{SENSE}|$ = 50V/V. The SIGN output from the comparator indicates the polarity of $V_{SENSE}$.

## Current Output (MAX9928F)

The output voltage equation for the MAX9928_ is given below:

$$V_{OUT} = (R_{SENSE} \times I_{LOAD}) \times (G_m \times R_{OUT})$$

where $V_{OUT}$ = the desired full-scale output voltage, $I_{LOAD}$ = the full-scale current being sensed, $R_{SENSE}$ = the current-sense resistor, $R_{OUT}$ = the voltage-setting resistor, and $G_m$ = MAX9928F transconductance (5µA/mV).

The full-scale output voltage range can be set by changing the $R_{OUT}$ resistor value. The above equation can be modified to determine the $R_{OUT}$ required for a particular full-scale range:

$$R_{OUT} = (V_{OUT})/(I_{LOAD} \times R_{SENSE} \times G_m)$$

OUT is a high-impedance current source and can drive an unlimited amount of capacitance.

### Voltage Output (MAX9929F)

The output voltage equation for the MAX9929_ is given below:

$$V_{OUT} = (R_{SENSE} \times I_{LOAD}) \times (A_V)$$

where $V_{OUT}$ = the desired full-scale output voltage, $I_{LOAD}$ = the full-scale current being sensed, $R_{SENSE}$ = the current-sense resistor, $A_V$ = MAX9929F voltage gain (50V/V).

### SIGN Output

The current/voltage at OUT indicates magnitude. The SIGN output indicates the current's direction. The SIGN comparator compares RS+ to RS-. The sign output is high when RS+ is greater than RS- indicating positive current flow. The sign output is low when RS- is greater than RS+ indicating negative current flow. In battery-operated systems, this is useful for determining whether the battery is charging or discharging. The SIGN output might not correctly indicate the direction of load current when $V_{SENSE}$ is between -1.8mV to -1.2mV (see Figure 2). Comparator hysteresis of 0.6mV prevents oscillation of SIGN output. If current direction is not needed, leave SIGN unconnected.

## Applications Information

### Choosing $R_{SENSE}$

The MAX9928F/MAX9929F operate over a wide variety of current ranges with different sense resistors. Adjust the $R_{SENSE}$ value to monitor higher or lower current levels. Select $R_{SENSE}$ using these guidelines:

- **Voltage Loss:** A high $R_{SENSE}$ value causes the power-source voltage to drop due to IR loss. For least voltage loss, use the lowest $R_{SENSE}$ value.
- **Accuracy:** A high $R_{SENSE}$ value allows lower currents to be measured more accurately. This is because offsets become less significant when the sense voltage is larger.
- **Efficiency and Power Dissipation:** At high current levels, the $I^2R$ losses in $R_{SENSE}$ might be significant. Take this into consideration when choosing the resistor value and power dissipation (wattage) rating. Also, if the sense resistor is allowed to heat up excessively, its value could drift.
- **Inductance:** If there is a large high-frequency component to $I_{SENSE}$, keep inductance low. Wire-wound resistors have the highest inductance, while metal film is somewhat better. Low-inductance metal-film resistors are available. Instead of being spiral wrapped around a core, as in metal film or wirewound resistors, these are a straight band of metal. They are made in values under 1Ω.

### Use in Systems with Super Capacitors

Since the input common-mode voltage range of the MAX9928/MAX9929 extends all the way from -0.1V to 28V, they are ideal to use in applications that require use of super capacitors for temporary or emergency energy storage systems. Some modern industrial systems use multifarad (1F–50F) capacitor banks to supply enough energy to keep critical systems alive even if the primary power source is removed or temporarily disabled. Unlike batteries, these capacitors can discharge all the way down to 0V. The MAX9928/MAX9929 can continuously help monitor their health and state of charge/discharge.

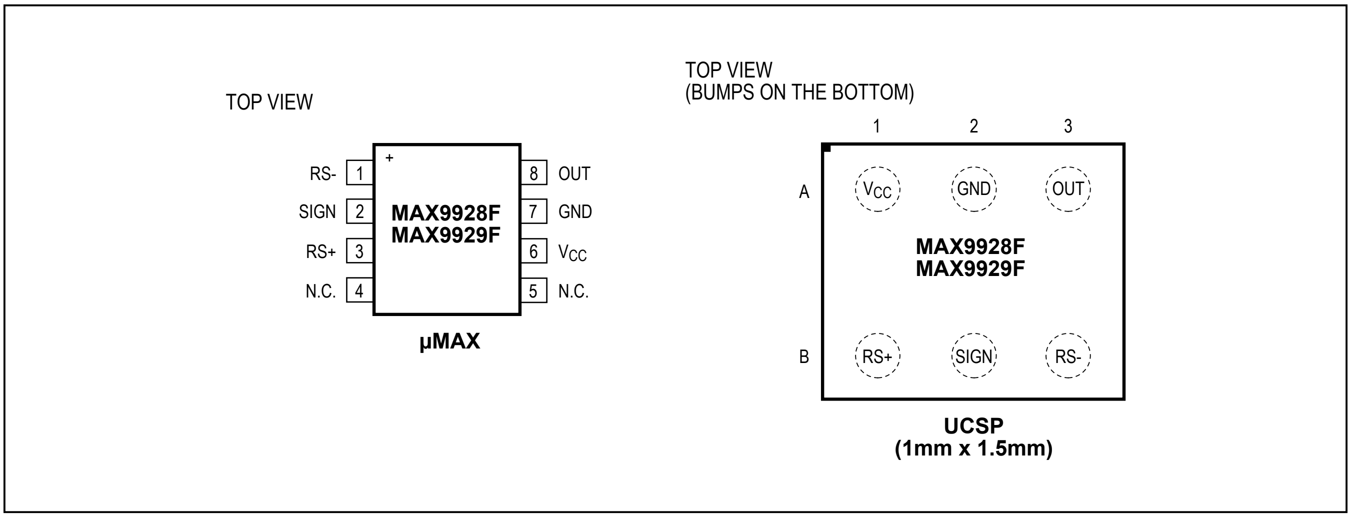
## UCSP Applications Information

For the latest application details on UCSP construction, dimensions, tape carrier information, PCB techniques, bump-pad layout, and recommended reflow temperature profile, as well as the latest information on reliability testing results, go to Maxim's website at **www.maximintegrated.com/ucsp** to find Application Note 1891: *Wafer-Level Packaging (WLP) and its Applications*.

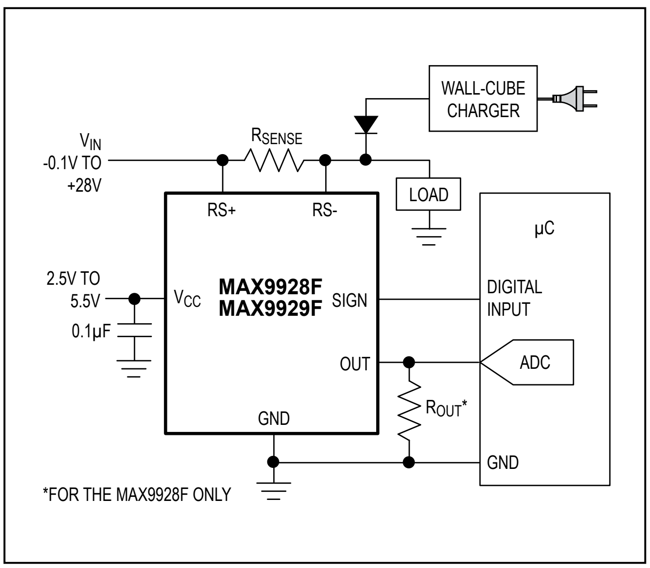
## Chip Information

PROCESS: BiCMOS

## Pin Configurations




## Typical Operating Circuit



## Package Information

For the latest package outline information and land patterns (footprints), 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. |
|---|---|---|---|
| 8 µMAX | U8+1 | 21-0036 | 90-0092 |
| 6 UCSP | B6+1 | 21-0097 | — |

## Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION | PAGES CHANGED |
|---|---|---|---|
| 0 | 12/08 | Initial release | — |
| 1 | 8/09 | Removed MAX9928T and MAX9929T from data sheet | 1–5, 7–12 |
| 2 | 4/11 | Updated top marks | 1 |
| 3 | 4/12 | Removed the R61A1+1 package code note and references | 1 |
| 4 | 9/14 | Removed automotive reference from data sheet. | 10 |

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