# High-Side Power and Current Monitors

## ABSOLUTE MAXIMUM RATINGS

$V_{CC}$, IN, CIN1, CIN2 to GND .....-0.3V to +6V
RS+, RS-, INHIBIT, LE, COUT1, COUT2 to GND ...-0.3V to +30V
IOUT, POUT, REF to GND .....-0.3V to ($V_{CC}$ + 0.3V)
Differential Input Voltage ($V_{RS+}$ - $V_{RS-}$) .....±5V
Maximum Current into Any Pin.....±10mA
Output Short-Circuit Duration to $V_{CC}$ or GND .....10s
Continuous Power Dissipation ($T_A$ = +70°C)
6-Pin TDFN (derate 24.4mW/°C above +70°C) .....1951mW
8-Pin µMAX (derate 4.5mW/°C above +70°C) .....362mW
16-Pin TSSOP (derate 9.4mW/°C above +70°C) .....754mW
16-Pin Thin QFN (derate 25mW/°C above +70°C) .....2000mW
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

($V_{CC}$ = 5.0V, $V_{RS+}$ = 25V, $V_{SENSE}$ = 5mV, $V_{IN}$ = 1.0V, $V_{LE}$ = 0V, $R_{IOUT}$ = $R_{POUT}$ = 1MΩ, $V_{CIN1+}$ = $V_{CIN2+}$ = $V_{REF}$, $V_{CIN1-}$ = $V_{CIN2-}$ = GND, $V_{INHIBIT}$ = 0V, $R_{COUT1}$ = $R_{COUT2}$ = 5kΩ connected to $V_{CC}$, $T_A$ = -40°C to +85°C, unless otherwise noted. Typical values are at $T_A$ = +25°C, unless otherwise noted.) (Note 1)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| Operating Voltage Range (Note 2) | $V_{CC}$ | | | 2.7 | | 5.5 | V |
| Common-Mode Input Range (Note 3) | $V_{CMR}$ | Measured at RS+ | | 4 | | 28 | V |
| Supply Current | $I_{CC}$ | $T_A$ = +25°C, $V_{CC}$ = +5.5V | MAX4210 | | 380 | 570 | µA |
| | | | MAX4211 | | 670 | 960 | |
| | | $V_{CC}$ = +5.5V | MAX4210 | | | 670 | |
| | | | MAX4211 | | | 1100 | |
| Input Bias Current | $I_{RS+}$ | $V_{SENSE}$ = 0mV | MAX421_A/B/C | | 14 | 25 | µA |
| | | | MAX421_D/E/F | | 3 | 8 | |
| | $I_{RS-}$ | $V_{SENSE}$ = 0mV | | | 3 | 8 | |
| IN Input Bias Current | $I_{IN}$ | MAX421_D/E/F | | | -0.1 | -1 | µA |
| Leakage Current | $I_{RS+}$, $I_{RS-}$ | $V_{CC}$ = 0V | | | 0.1 | 1 | µA |
| $V_{SENSE}$ Full-Scale Voltage (Note 4) | $V_{SENSE\_FS}$ | MAX421_A/B/D/E | | 150 | | | mV |
| | | MAX421_C/F | | 100 | | | |
| IN Full-Scale Voltage (Note 4) | $V_{IN\_FS}$ | MAX421_D/E/F, $V_{SENSE}$ = 10mV to 100mV | | 1 | | | V |
| IN Input Voltage Range (Note 5) | $V_{IN}$ | MAX421_D/E/F, $V_{SENSE}$ = 10mV to 100mV | | 0.16 | | 1.10 | V |
| $V_{RS+}$ Full-Scale Voltage (Note 4) | | MAX421_A/B/C, $V_{SENSE}$ = 10mV to 100mV | | 25 | | | V |
| $V_{RS+}$ Input Voltage Range (Note 5) | $V_{RS+}$ | MAX421_A/B/C, $V_{SENSE}$ = 10mV to 100mV | | 4 | | 28 | V |
| Minimum IOUT/POUT Voltage | $V_{OUT\_MIN}$ | $V_{SENSE}$ = 0V, $V_{RS+}$ = 25V | Current into IOUT = 10µA | | 1.5 | | mV |
| | | | Current into IOUT = 100µA | | 2.5 | 80 | |
| | | | Current into POUT = 10µA | | 1.5 | | |
| | | | Current into POUT = 100µA | | 2.5 | 80 | |
| Maximum IOUT/POUT Voltage (Note 6) | $V_{OUT\_MAX}$ | $V_{SENSE}$ = 300mV, $V_{RS+}$ = 25V | Current out of IOUT = 500µA | | | $V_{CC}$ - 0.25 | V |
| | | | Current out of POUT = 500µA | | | $V_{CC}$ - 0.25 | |

## ELECTRICAL CHARACTERISTICS (continued)

($V_{CC}$ = 5.0V, $V_{RS+}$ = 25V, $V_{SENSE}$ = 5mV, $V_{IN}$ = 1.0V, $V_{LE}$ = 0V, $R_{IOUT}$ = $R_{POUT}$ = 1MΩ, $V_{CIN1+}$ = $V_{CIN2+}$ = $V_{REF}$, $V_{CIN1-}$ = $V_{CIN2-}$ = GND, $V_{INHIBIT}$ = 0V, $R_{COUT1}$ = $R_{COUT2}$ = 5kΩ connected to $V_{CC}$, $T_A$ = -40°C to +85°C, unless otherwise noted. Typical values are at $T_A$ = +25°C, unless otherwise noted.) (Note 1)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| Current-Sense Amplifier Gain | $V_{IOUT}$/ $V_{SENSE}$ | MAX4211A/D | | | 16.67 | | V/V |
| | | MAX4211B/E | | | 25.00 | | |
| | | MAX4211C/F | | | 40.96 | | |
| Power-Sense Amplifier Gain | $V_{POUT}$/ ($V_{SENSE}$ x $V_{RS+}$) | MAX421_A | | | 0.667 | | 1/V |
| | | MAX421_B | | | 1.00 | | |
| | | MAX421_C | | | 1.64 | | |
| | $V_{POUT}$/ ($V_{SENSE}$ x $V_{IN}$) | MAX421_D | | | 16.67 | | |
| | | MAX421_E | | | 25.00 | | |
| | | MAX421_F | | | 40.96 | | |
| IOUT Common-Mode Rejection | CMRI | MAX4211, $V_{RS+}$ = 4V to 28V | | 60 | 80 | | dB |
| POUT Common-Mode Rejection | CMRP | MAX421_D/E/F, $V_{RS+}$ = 4V to 28V | | 60 | 80 | | dB |
| IOUT Power-Supply Rejection | PSRI | $V_{CC}$ = 2.7V to 5.5V | | 52 | 80 | | dB |
| POUT Power-Supply Rejection | PSRP | $V_{CC}$ = 2.7V to 5.5V | | 52 | 70 | | dB |
| Output Resistance for POUT, IOUT, REF | $R_{OUT}$ | | | | 0.5 | | Ω |
| IOUT -3dB Bandwidth | $BW_{IOUT/SENSE}$ | $V_{SENSE}$ = 100mV, $V_{SENSE}$ AC source | | | 220 | | kHz |
| POUT -3dB Bandwidth | $BW_{POUT/SENSE}$ | $V_{SENSE}$ = 100mV, $V_{SENSE}$ AC source | | | 220 | | kHz |
| | $BW_{POUT/VIN}$ | $V_{SENSE}$ = 100mV, $V_{IN}$ AC source, MAX421_D/E/F | | | 500 | | |
| | $BW_{POUT/RS+}$ | $V_{SENSE}$ = 100mV, $V_{RS+}$ AC source, MAX421_A/B/C | | | 250 | | |
| Capacitive-Load Stability (POUT, IOUT, REF) | $C_{LOAD}$ | No sustained oscillations | | | 450 | | pF |
| Current Output (IOUT) Settling Time to 1% of Final Value | | MAX4211 | $V_{SENSE}$ = 10mV to 100mV | | 15 | | µs |
| | | | $V_{SENSE}$ = 100mV to 10mV | | 15 | | |
| Power Output (POUT) Settling Time to 1% of Final Value | | MAX421_A/B/C | $V_{SENSE}$ = 10mV to 100mV | | 10 | | µs |
| | | | $V_{SENSE}$ = 100mV to 10mV | | 10 | | |
| | | | $V_{RS+}$ = 4V to 25V, $V_{SENSE}$ = 100mV | | 15 | | |
| | | | $V_{RS+}$ = 25V to 4V, $V_{SENSE}$ = 100mV | | 15 | | |
| | | MAX421_D/E/F | $V_{SENSE}$ = 10mV to 100mV | | 10 | | |
| | | | $V_{SENSE}$ = 100mV to 10mV | | 10 | | |
| | | | $V_{IN}$ = 160mV to 1V, $V_{SENSE}$ = 100mV | | 10 | | |
| | | | $V_{IN}$ = 1V to 160mV, $V_{SENSE}$ = 100mV | | 10 | | |

## ELECTRICAL CHARACTERISTICS (continued)

($V_{CC}$ = 5.0V, $V_{RS+}$ = 25V, $V_{SENSE}$ = 5mV, $V_{IN}$ = 1.0V, $V_{LE}$ = 0V, $R_{IOUT}$ = $R_{POUT}$ = 1MΩ, $V_{CIN1+}$ = $V_{CIN2+}$ = $V_{REF}$, $V_{CIN1-}$ = $V_{CIN2-}$ = GND, $V_{INHIBIT}$ = 0V, $R_{COUT1}$ = $R_{COUT2}$ = 5kΩ connected to $V_{CC}$, $T_A$ = -40°C to +85°C, unless otherwise noted. Typical values are at $T_A$ = +25°C, unless otherwise noted.) (Note 1)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Power-Up Time to 1% of Current Output Final Value | | $V_{SENSE}$ = 100mV, $C_{LOAD}$ = 10pF, MAX4211 | | 100 | | µs |
| Power-Up Time to 1% of Power Output Final Value | | $V_{SENSE}$ = 100mV, $C_{LOAD}$ = 10pF | | 100 | | µs |
| Saturation Recovery Time for Current Out (Note 7) | | $C_{LOAD}$ = 10pF, $V_{SENSE}$ = -100mV to +100mV | | 35 | | µs |
| | | $C_{LOAD}$ = 10pF, $V_{SENSE}$ = 1.5V to 100mV | | 35 | | |
| Saturation Recovery Time for Power Out (Note 7) | | $V_{CC}$ = 5V, $V_{RS+}$ = 10V, $C_{LOAD}$ = 10pF, $V_{SENSE}$ = -100mV to +100mV | | 25 | | µs |
| | | $V_{CC}$ = 5V, $V_{RS+}$ = 10V, $C_{LOAD}$ = 10pF, $V_{SENSE}$ = 1.5V to 100mV | | 25 | | |
| Reference Voltage | $V_{REF}$ | $I_{REF}$ = 0 to 100µA, $T_A$ = +25°C | 1.20 | 1.21 | 1.22 | V |
| | | $I_{REF}$ = 0 to 100µA, $T_A$ = -40°C to +85°C | 1.19 | | 1.23 | |
| Comparator Input Offset | | Common-mode voltage = REF | | ±0.5 | ±5 | mV |
| Comparator Hysteresis | | | | 5 | | mV |
| Comparator Common-Mode Low | | Functional test | | 0.1 | | V |
| Comparator Common-Mode High | | Functional test | | $V_{CC}$ - 1.15 | | V |
| Comparator Input Bias Current | $I_{BIAS}$ | | | -2 | | nA |
| Comparator Output Low Voltage | $V_{OL}$ | $I_{SINK}$ = 1mA | | 0.2 | 0.6 | V |
| Comparator Output-High Leakage Current (Note 8) | | $V_{PULLUP}$ = 28V | | | 1 | µA |
| LE Logic Input-High Voltage Threshold | $V_{IH}$ | | 0.67 x $V_{CC}$ | | | V |
| LE Logic Input-Low Voltage Threshold | $V_{IL}$ | | | | 0.33 x $V_{CC}$ | V |
| LE Logic Input Internal Pulldown Current | | | 0.68 | 1 | 2.20 | µA |
| INHIBIT Logic Input-High Voltage Threshold | | | 1.3 | | | V |
| INHIBIT Logic Input-Low Voltage Threshold | | | | | 0.5 | V |
| INHIBIT Logic Input Hysteresis | | | | 0.6 | | V |
| INHIBIT Logic Input Internal Pulldown Current | | | 0.68 | 1 | 2.20 | µA |

## ELECTRICAL CHARACTERISTICS (continued)

($V_{CC}$ = 5.0V, $V_{RS+}$ = 25V, $V_{SENSE}$ = 5mV, $V_{IN}$ = 1.0V, $V_{LE}$ = 0V, $R_{IOUT}$ = $R_{POUT}$ = 1MΩ, $V_{CIN1+}$ = $V_{CIN2+}$ = $V_{REF}$, $V_{CIN1-}$ = $V_{CIN2-}$ = GND, $V_{INHIBIT}$ = 0V, $R_{COUT1}$ = $R_{COUT2}$ = 5kΩ connected to $V_{CC}$, $T_A$ = -40°C to +85°C, unless otherwise noted. Typical values are at $T_A$ = +25°C, unless otherwise noted.) (Note 1)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| Comparator Propagation Delay | $t_{PD+}$, $t_{PD-}$ | $C_{LOAD}$ = 10pF, $R_{LOAD}$ = 10kΩ pullup to $V_{CC}$, 5mV overdrive | | | 4 | | µs |
| Minimum INHIBIT Pulse Width | | | | | 1 | | µs |
| Minimum LE Pulse Width | | | | | 1 | | µs |
| Comparator Power-Up Blanking Time From $V_{CC}$ | $t_{ON}$ | $V_{CC}$ from 0 to (2.7V to 5.5V) | | | 300 | | µs |
| LATCH Setup Time | $t_{SETUP}$ | | | | 3 | | µs |
| **MAX4210A/MAX4211A (power gain = 0.667)** | | | | | | | |
| POUT Gain Accuracy (Note 9) | $\Delta V_{POUT}$/ $\Delta V_{SENSE}$ | $V_{SENSE}$ = 10mV to 100mV, $V_{RS+}$ = 25V | $T_A$ = +25°C | | ±0.5 | ±1.5 | % |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |
| | $\Delta V_{POUT}$/ $\Delta V_{RS+}$ | $V_{SENSE}$ = 100mV, $V_{RS+}$ = 5V to 25V | $T_A$ = +25°C | | ±0.5 | ±1.5 | |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |
| Total POUT Output Error (Note 10) | $\Delta V_{POUT\_MAX}$/ FSO | $V_{SENSE}$ = 5mV to 100mV, $V_{RS+}$ = 5V to 25V | $T_A$ = +25°C | | ±0.15 | ±1.5 | % FSO* |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |
| | $\Delta V_{POUT\_MAX}$/ $V_{POUT}$ | $V_{SENSE}$ = 150mV, $V_{RS+}$ ≥ 15V | $T_A$ = +25°C | | ±0.2 | ±1.5 | % |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |
| | | $V_{SENSE}$ = 100mV, $V_{RS+}$ ≥ 4V | | | ±2.5 | | |
| | | $V_{SENSE}$ = 100mV, $V_{RS+}$ ≥ 9V | | | ±1.2 | | |
| | | $V_{SENSE}$ = 50mV, $V_{RS+}$ ≥ 6V | | | ±1.8 | | |
| | | $V_{SENSE}$ = 25mV, $V_{RS+}$ ≥ 15V | | | ±1.8 | | |
| POUT Output Offset Voltage (Note 11) | | $V_{SENSE}$ = 0V, $V_{RS+}$ = 25V | $T_A$ = +25°C | | 1.5 | 5 | mV |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | 15 | |
| **MAX4210B/MAX4211B (power gain = 1.00)** | | | | | | | |
| POUT Gain Accuracy (Note 9) | $\Delta V_{POUT}$/ $\Delta V_{SENSE}$ | $V_{SENSE}$ = 10mV to 100mV, $V_{RS+}$ = 25V | $T_A$ = +25°C | | ±0.5 | ±1.5 | % |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |
| | $\Delta V_{POUT}$/ $\Delta V_{RS+}$ | $V_{SENSE}$ = 100mV, $V_{RS+}$ = 5V to 25V | $T_A$ = +25°C | | ±0.5 | ±1.5 | |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |

**FSO refers to full-scale output under the conditions: $V_{SENSE}$ = 100mV, $V_{RS+}$ = +25V, or $V_{IN}$ = 1V.*

## ELECTRICAL CHARACTERISTICS (continued)

($V_{CC}$ = 5.0V, $V_{RS+}$ = 25V, $V_{SENSE}$ = 5mV, $V_{IN}$ = 1.0V, $V_{LE}$ = 0V, $R_{IOUT}$ = $R_{POUT}$ = 1MΩ, $V_{CIN1+}$ = $V_{CIN2+}$ = $V_{REF}$, $V_{CIN1-}$ = $V_{CIN2-}$ = GND, $V_{INHIBIT}$ = 0V, $R_{COUT1}$ = $R_{COUT2}$ = 5kΩ connected to $V_{CC}$, $T_A$ = -40°C to +85°C, unless otherwise noted. Typical values are at $T_A$ = +25°C, unless otherwise noted.) (Note 1)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| Total POUT Output Error (Note 10) | $\Delta V_{POUT\_MAX}$/FSO | $V_{SENSE}$ = 5mV to 100mV, $V_{RS+}$ = 5V to 25V | $T_A$ = +25°C | | ±0.15 | ±1.5 | % FSO* |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |
| | $\Delta V_{POUT\_MAX}$/$V_{POUT}$ | $V_{SENSE}$ = 150mV, $V_{RS+}$ > 15V | $T_A$ = +25°C | | ±0.2 | ±1.5 | % |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |
| | | $V_{SENSE}$ = 100mV, $V_{RS+}$ > 4V | | | ±2.5 | | |
| | | $V_{SENSE}$ = 100mV, $V_{RS+}$ > 9V | | | ±1.2 | | |
| | | $V_{SENSE}$ = 50mV, $V_{RS+}$ > 6V | | | ±1.8 | | |
| | | $V_{SENSE}$ = 25mV, $V_{RS+}$ > 15V | | | ±1.8 | | |
| POUT Output Offset Voltage (Note 11) | | $V_{SENSE}$ = 0V, $V_{RS+}$ = 25V | $T_A$ = +25°C | | 2 | 6.5 | mV |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | 20 | |
| **MAX4210C/MAX4211C (power gain = 1.64)** | | | | | | | |
| POUT Gain Accuracy (Note 9) | $\Delta V_{POUT}$/$\Delta V_{SENSE}$ | $V_{SENSE}$ = 10mV to 100mV, $V_{RS+}$ = 25V | $T_A$ = +25°C | | ±0.5 | ±1.5 | % |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |
| | $\Delta V_{POUT}$/$\Delta V_{RS+}$ | $V_{SENSE}$ = 100mV, $V_{RS+}$ = 5V to 25V | $T_A$ = +25°C | | ±0.5 | ±1.5 | |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |
| Total POUT Output Error (Note 10) | $\Delta V_{POUT\_MAX}$/FSO | $V_{SENSE}$ = 5mV to 100mV, $V_{RS+}$ = 5V to 25V | $T_A$ = +25°C | | ±0.15 | ±1.5 | % FSO* |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |
| | $\Delta V_{POUT\_MAX}$/$V_{POUT}$ | $V_{SENSE}$ = 100mV, $V_{RS+}$ ≥ 4V | | | ±2.5 | | % |
| | | $V_{SENSE}$ = 100mV, $V_{RS+}$ ≥ 9V | | | ±1.2 | | |
| | | $V_{SENSE}$ = 50mV, $V_{RS+}$ ≥ 6V | | | ±1.8 | | |
| | | $V_{SENSE}$ = 25mV, $V_{RS+}$ ≥ 15V | | | ±1.8 | | |
| POUT Output Offset Voltage (Note 11) | | $V_{SENSE}$ = 0V, $V_{RS+}$ = 25V | $T_A$ = +25°C | | 3 | 10 | mV |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | 30 | |
| **MAX4210D/MAX4211D (power gain = 16.67)** | | | | | | | |
| POUT Gain Accuracy (Note 9) | $\Delta V_{POUT}$/$\Delta V_{SENSE}$ | $V_{SENSE}$ = 10mV to 100mV, $V_{IN}$ = 1V | $T_A$ = +25°C | | ±0.5 | ±1.5 | % |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |
| | $\Delta V_{POUT}$/$\Delta V_{IN}$ | $V_{SENSE}$ = 100mV, $V_{IN}$ = 0.2V to 1V | $T_A$ = +25°C | | ±0.5 | ±1.5 | |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |

**FSO refers to full-scale output under the conditions: $V_{SENSE}$ = 100mV, $V_{RS+}$ = +25V, or $V_{IN}$ = 1V.*

## ELECTRICAL CHARACTERISTICS (continued)

($V_{CC}$ = 5.0V, $V_{RS+}$ = 25V, $V_{SENSE}$ = 5mV, $V_{IN}$ = 1.0V, $V_{LE}$ = 0V, $R_{IOUT}$ = $R_{POUT}$ = 1MΩ, $V_{CIN1+}$ = $V_{CIN2+}$ = $V_{REF}$, $V_{CIN1-}$ = $V_{CIN2-}$ = GND, $V_{INHIBIT}$ = 0V, $R_{COUT1}$ = $R_{COUT2}$ = 5kΩ connected to $V_{CC}$, $T_A$ = -40°C to +85°C, unless otherwise noted. Typical values are at $T_A$ = +25°C, unless otherwise noted.) (Note 1)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| Total POUT Output Error (Note 10) | $\Delta V_{POUT\_MAX}$/FSO | $V_{SENSE}$ = 5mV to 100mV, $V_{RS+}$ = 25V, $V_{IN}$ = 0.2V to 1V | $T_A$ = +25°C | | ±0.15 | ±1.5 | % FSO* |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |
| | $\Delta V_{POUT\_MAX}$/$V_{POUT}$ | $V_{SENSE}$ = 150mV, $V_{RS+}$ = 25V, $V_{IN}$ = 600mV | $T_A$ = +25°C | | ±0.2 | ±1.5 | % |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |
| | | $V_{SENSE}$ = 100mV, $V_{RS+}$ = 15V, $V_{IN}$ ≥ 160mV | | | ±2.5 | | |
| | | $V_{SENSE}$ = 100mV, $V_{RS+}$ = 15V, $V_{IN}$ ≥ 360mV | | | ±1.2 | | |
| | | $V_{SENSE}$ = 50mV, $V_{RS+}$ = 15V, $V_{IN}$ ≥ 240mV | | | ±1.8 | | |
| | | $V_{SENSE}$ = 25mV, $V_{RS+}$ = 15V, $V_{IN}$ ≥ 600mV | | | ±1.8 | | |
| POUT Output Offset Voltage (Note 11) | | $V_{SENSE}$ = 0V, $V_{RS+}$ = 25V, $V_{IN}$ = 1V | $T_A$ = +25°C | | 1.5 | 5 | mV |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | 15 | |
| **MAX4210E/MAX4211E (power gain = 25.00)** | | | | | | | |
| POUT Gain Accuracy (Note 9) | $\Delta V_{POUT}$/$\Delta V_{SENSE}$ | $V_{SENSE}$ = 10mV to 100mV, $V_{IN}$ = 1V | $T_A$ = +25°C | | ±0.5 | ±1.5 | % |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |
| | $\Delta V_{POUT}$/$\Delta V_{IN}$ | $V_{SENSE}$ = 100mV, $V_{IN}$ = 0.2V to 1V | $T_A$ = +25°C | | ±0.5 | ±1.5 | |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |
| Total POUT Output Error (Note 10) | $\Delta V_{POUT\_MAX}$/FSO | $V_{SENSE}$ = 5mV to 100mV, $V_{RS+}$ = 25V, $V_{IN}$ = 0.2V to 1V | $T_A$ = +25°C | | ±0.15 | ±1.5 | % FSO* |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |
| | $\Delta V_{POUT\_MAX}$/$V_{POUT}$ | $V_{SENSE}$ = 150mV, $V_{RS+}$ =25V, $V_{IN}$ = 600mV | $T_A$ = +25°C | | ±0.2 | ±1.5 | % |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |
| | | $V_{SENSE}$ = 100mV, $V_{RS+}$ = 15V, $V_{IN}$ ≥ 160mV | | | ±2.5 | | |
| | | $V_{SENSE}$ = 100mV, $V_{RS+}$ = 15V, $V_{IN}$ ≥ 360mV | | | ±1.2 | | |
| | | $V_{SENSE}$ = 50mV, $V_{RS+}$ = 15V, $V_{IN}$ ≥ 240mV | | | ±1.8 | | |
| | | $V_{SENSE}$ = 25mV, $V_{RS+}$ = 15V, $V_{IN}$ ≥ 600mV | | | ±1.8 | | |
| POUT Output Offset Voltage (Note 11) | | $V_{SENSE}$ = 0V, $V_{RS+}$ = 25V, $V_{IN}$ = 1V | $T_A$ = +25°C | | 2 | 6.5 | mV |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | 20 | |

**FSO refers to full-scale output under the conditions: $V_{SENSE}$ = 100mV, $V_{RS+}$ = +25V, or $V_{IN}$ = 1V.*

## ELECTRICAL CHARACTERISTICS (continued)

($V_{CC}$ = 5.0V, $V_{RS+}$ = 25V, $V_{SENSE}$ = 5mV, $V_{IN}$ = 1.0V, $V_{LE}$ = 0V, $R_{IOUT}$ = $R_{POUT}$ = 1MΩ, $V_{CIN1+}$ = $V_{CIN2+}$ = $V_{REF}$, $V_{CIN1-}$ = $V_{CIN2-}$ = GND, $V_{INHIBIT}$ = 0V, $R_{COUT1}$ = $R_{COUT2}$ = 5kΩ connected to $V_{CC}$, $T_A$ = -40°C to +85°C, unless otherwise noted. Typical values are at $T_A$ = +25°C, unless otherwise noted.) (Note 1)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| **MAX4210F/MAX4211F (power gain = 40.96)** | | | | | | | |
| POUT Gain Accuracy (Note 9) | $\Delta V_{POUT}/\Delta V_{SENSE}$ | $V_{SENSE}$ = 10mV to 100mV, $V_{IN}$ = 1V | $T_A$ = +25°C | | ±0.5 | ±1.5 | % |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |
| | $\Delta V_{POUT}/\Delta V_{IN}$ | $V_{SENSE}$ = 100mV, $V_{IN}$ = 0.2V to 1V | $T_A$ = +25°C | | ±0.5 | ±1.5 | |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |
| Total POUT Output Error (Note 10) | $\Delta V_{POUT\_MAX}$/FSO | $V_{SENSE}$ = 5mV to 100mV, $V_{RS+}$ = 25V, $V_{IN}$ = 0.2V to 1V | $T_A$ = +25°C | | ±0.15 | ±1.5 | % FSO* |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |
| | $\Delta V_{POUT\_MAX}/V_{POUT}$ | $V_{SENSE}$ = 100mV, $V_{RS+}$ = 15V, $V_{IN}$ ≥ 160mV | | | ±2.5 | | % |
| | | $V_{SENSE}$ = 100mV, $V_{RS+}$ = 15V, $V_{IN}$ ≥ 360mV | | | ±1.2 | | |
| | | $V_{SENSE}$ = 50mV, $V_{RS+}$ = 15V, $V_{IN}$ ≥ 240mV | | | ±1.8 | | |
| | | $V_{SENSE}$ = 25mV, $V_{RS+}$ = 15V, $V_{IN}$ ≥ 600mV | | | ±1.8 | | |
| POUT Output Offset Voltage (Note 11) | | $V_{SENSE}$ = 0V, $V_{RS+}$ = 25V, $V_{IN}$ = 1V | $T_A$ = +25°C | | 3 | 10 | mV |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | 30 | |
| **MAX4211A/MAX4211D (current gain = 16.67)** | | | | | | | |
| IOUT Gain Accuracy | $\Delta V_{IOUT}/\Delta V_{SENSE}$ | $V_{SENSE}$ = 20mV to 100mV, $V_{RS+}$ = 25V | $T_A$ = +25°C | | ±0.5 | ±1.5 | % |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |
| Total IOUT Output Error (Note 10) | $\Delta V_{IOUT\_MAX}$/FSO | $V_{SENSE}$ = 5mV to 100mV | $T_A$ = +25°C | | ±0.15 | ±1.5 | % FSO* |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |
| | $\Delta V_{IOUT\_MAX}/V_{IOUT}$ | $V_{SENSE}$ = 150mV | $T_A$ = +25°C | | ±0.2 | ±1.5 | % |
| | | | $T_A$= $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |
| | | $V_{SENSE}$ = 50mV | | | ±1.2 | | |
| | | $V_{SENSE}$ = 25mV | | | ±1.8 | | |
| | | $V_{SENSE}$ = 5mV | | | ±20 | | |

**FSO refers to full-scale output under the conditions: $V_{SENSE}$ = 100mV, $V_{RS+}$ = +25V, or $V_{IN}$ = 1V.*

## ELECTRICAL CHARACTERISTICS (continued)

($V_{CC}$ = 5.0V, $V_{RS+}$ = 25V, $V_{SENSE}$ = 5mV, $V_{IN}$ = 1.0V, $V_{LE}$ = 0V, $R_{IOUT}$ = $R_{POUT}$ = 1MΩ, $V_{CIN1+}$ = $V_{CIN2+}$ = $V_{REF}$, $V_{CIN1-}$ = $V_{CIN2-}$ = GND, $V_{INHIBIT}$ = 0V, $R_{COUT1}$ = $R_{COUT2}$ = 5kΩ connected to $V_{CC}$, $T_A$ = -40°C to +85°C, unless otherwise noted. Typical values are at $T_A$ = +25°C, unless otherwise noted.) (Note 1)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| **MAX4211B/MAX4211E (current gain = 25.00)** | | | | | | | |
| IOUT Gain Accuracy | $\Delta V_{IOUT}/\Delta V_{SENSE}$ | $V_{SENSE}$ = 20mV to 100mV, $V_{RS+}$ = 25V | $T_A$ = +25°C | | ±0.5 | ±1.5 | % |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |
| Total IOUT Output Error (Note 10) | $\Delta V_{IOUT\_MAX}$/FSO | $V_{SENSE}$ = 5mV to 100mV | $T_A$ = +25°C | | ±0.15 | ±1.5 | % FSO* |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |
| | $\Delta V_{IOUT\_MAX}/V_{IOUT}$ | $V_{SENSE}$ = 150mV | $T_A$ = +25°C | | ±0.2 | ±1.5 | % |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |
| | | $V_{SENSE}$ = 50mV | | | ±1.2 | | |
| | | $V_{SENSE}$ = 25mV | | | ±1.8 | | |
| | | $V_{SENSE}$ = 5mV | | | ±20 | | |
| **MAX4211C/MAX4211F (current gain = 40.96)** | | | | | | | |
| IOUT Gain Accuracy | $\Delta V_{IOUT}/\Delta V_{SENSE}$ | $V_{SENSE}$ = 20mV to 100mV, $V_{RS+}$ =25V | $T_A$ = +25°C | | ±0.5 | ±1.5 | % |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |
| Total IOUT Output Error (Note 10) | $\Delta V_{IOUT\_MAX}$/FSO | $V_{SENSE}$ = 5mV to 100mV | $T_A$ = +25°C | | ±0.15 | ±1.5 | % FSO* |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |
| | $\Delta V_{IOUT\_MAX}/V_{IOUT}$ | $V_{SENSE}$ = 100mV | $T_A$ = +25°C | | ±0.2 | ±1.5 | % |
| | | | $T_A$ = $T_{MIN}$ to $T_{MAX}$ | | | ±3.0 | |
| | | $V_{SENSE}$ = 50mV | | | ±1.2 | | |
| | | $V_{SENSE}$ = 25mV | | | ±1.8 | | |
| | | $V_{SENSE}$ = 5mV | | | ±20 | | |

**FSO refers to full-scale output under the conditions: $V_{SENSE}$ = 100mV, $V_{RS+}$ = +25V, or $V_{IN}$ = 1V.*

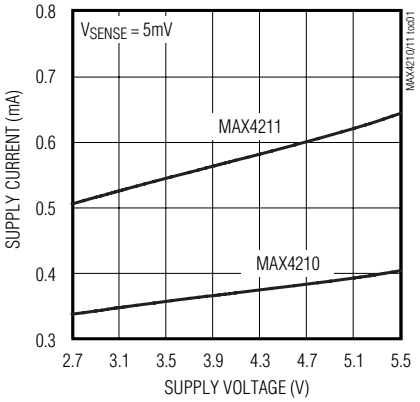
**Note 1:** All devices are 100% production tested at $T_A$ = +25°C. All temperature limits are guaranteed by design.
**Note 2:** Guaranteed by power-supply rejection test.
**Note 3:** Guaranteed by output voltage error tests (IOUT).
**Note 4:** Guaranteed by output voltage error tests (IOUT or POUT, or both).
**Note 5:** IN Input Voltage Range (MAX421_D/E/F) and $V_{RS+}$ Input Voltage Range (MAX421_A/B/C) are guaranteed by design (GBD) and not production tested. See Multiplier Transfer Characteristics graphs in the *Typical Operating Characteristics*.
**Note 6:** This test does not apply to the low gain options, MAX421_A/D, because OUT is clamped at approximately 4V.
**Note 7:** The device does not experience phase reversal when overdriven.
**Note 8:** $V_{PULLUP}$ is defined as an externally applied voltage through a resistor, $R_{PULLUP}$, to pull up the comparator output.
**Note 9:** POUT gain accuracy is the sum of gain error and multiplier nonlinearity.
**Note 10:** Total output voltage error is the sum of gain and offset voltage errors.
**Note 11:** POUT Output Offset Voltage is the sum of offset and multiplier feedthrough.

# High-Side Power and Current Monitors

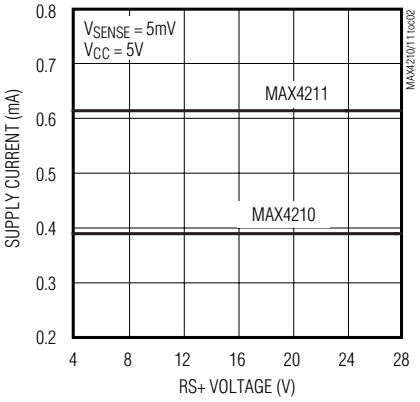
## Typical Operating Characteristics

($V_{CC}$ = 5.0V, $V_{RS+}$ = 25V, $V_{SENSE}$ = 100mV, $V_{IN}$ = 1V, $V_{LE}$ = 0V, $R_{IOUT}$ = $R_{POUT}$ = 1MΩ, $V_{CIN1+}$ = $V_{CIN2+}$ = $V_{REF}$, $V_{CIN1-}$ = $V_{CIN2-}$ = 0V, $V_{INHIBIT}$ = 0V, $R_{COUT1}$ = $R_{COUT2}$ = 5kΩ connected to $V_{CC}$, $T_A$ = +25°C, unless otherwise noted.)

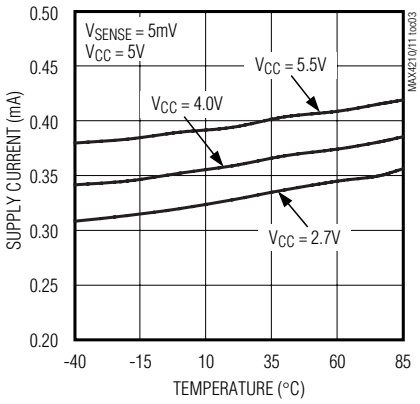
**SUPPLY CURRENT vs. SUPPLY VOLTAGE**



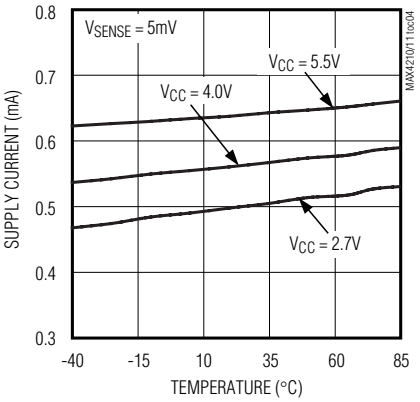

**SUPPLY CURRENT vs. COMMON-MODE VOLTAGE**



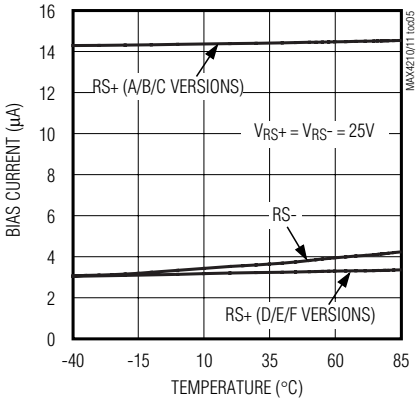

**MAX4210 SUPPLY CURRENT vs. TEMPERATURE**



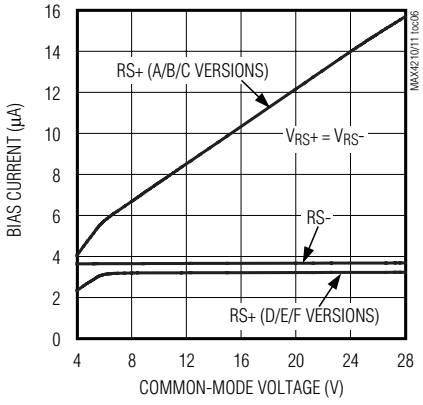

**MAX4211 SUPPLY CURRENT vs. TEMPERATURE**



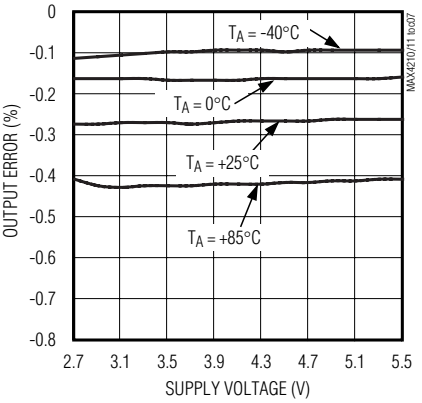

**RS+/RS- BIAS CURRENT vs. TEMPERATURE**



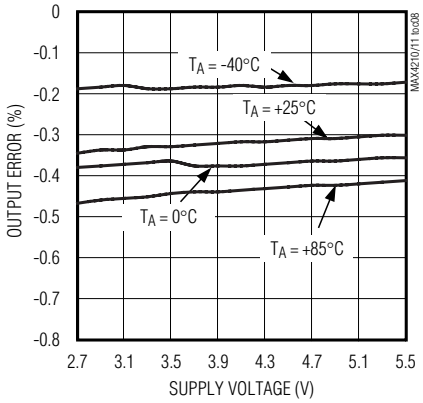

**RS+/RS- BIAS CURRENT vs. COMMON-MODE VOLTAGE**



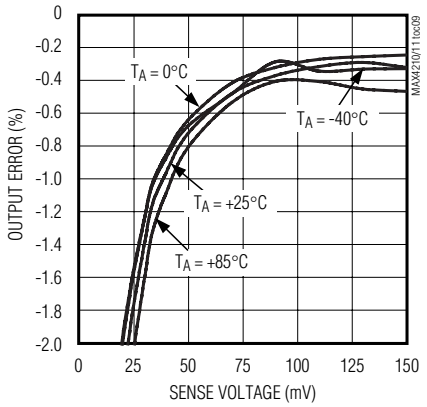

**POWER OUTPUT ERROR vs. SUPPLY VOLTAGE**




**CURRENT OUTPUT ERROR vs. SUPPLY VOLTAGE**



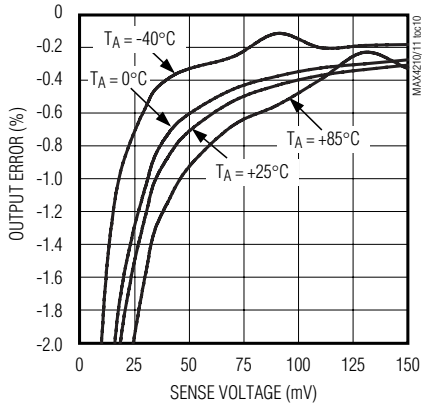

**POWER OUTPUT ERROR vs. SENSE VOLTAGE**



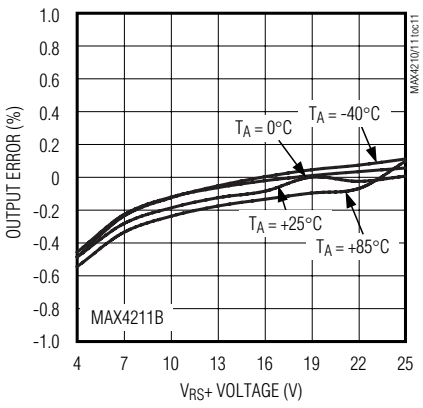
## Typical Operating Characteristics (continued)

($V_{CC}$ = 5.0V, $V_{RS+}$ = 25V, $V_{SENSE}$ = 100mV, $V_{IN}$ = 1V, $V_{LE}$ = 0V, $R_{IOUT}$ = $R_{POUT}$ = 1MΩ, $V_{CIN1+}$ = $V_{CIN2+}$ = $V_{REF}$, $V_{CIN1-}$ = $V_{CIN2-}$ = 0V, $V_{INHIBIT}$ = 0V, $R_{COUT1}$ = $R_{COUT2}$ = 5kΩ connected to $V_{CC}$, $T_A$ = +25°C, unless otherwise noted.)

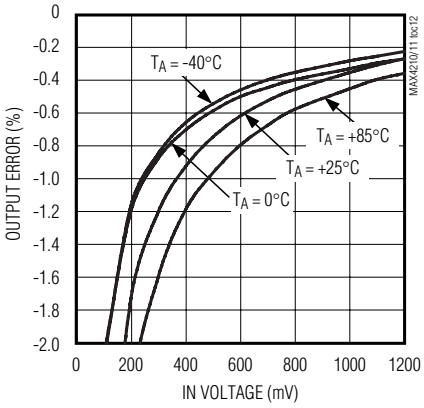
**CURRENT OUTPUT ERROR vs. SENSE VOLTAGE**



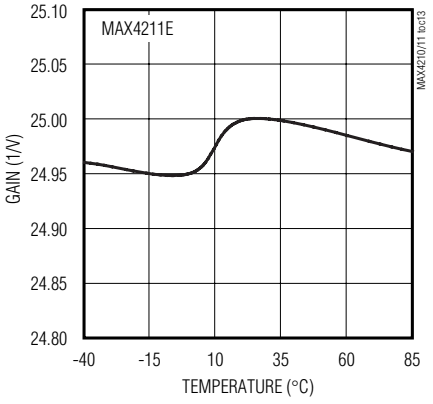

**POWER OUTPUT ERROR vs. $V_{RS+}$**



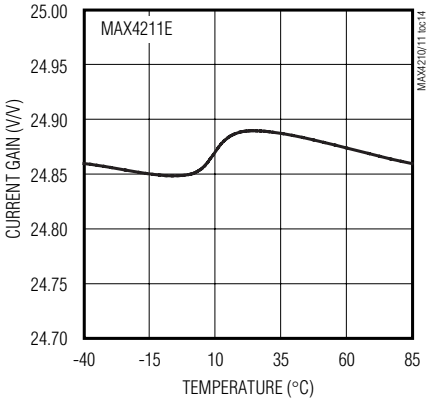

**POWER OUTPUT ERROR vs. IN VOLTAGE**



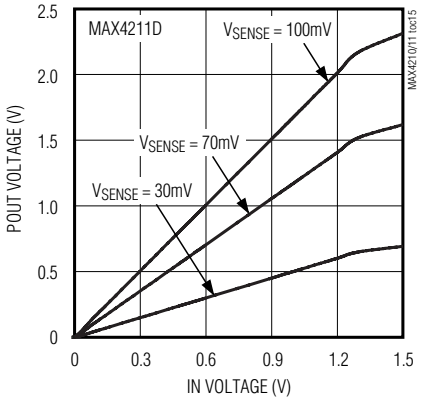

**POWER GAIN vs. TEMPERATURE**



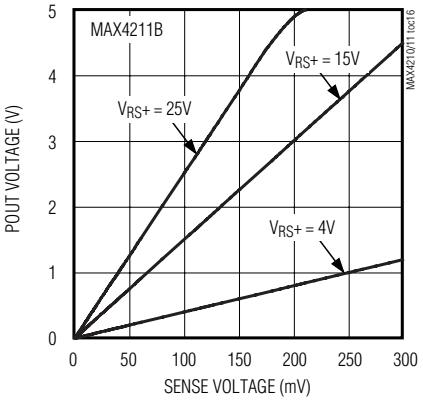

**CURRENT GAIN vs. TEMPERATURE**



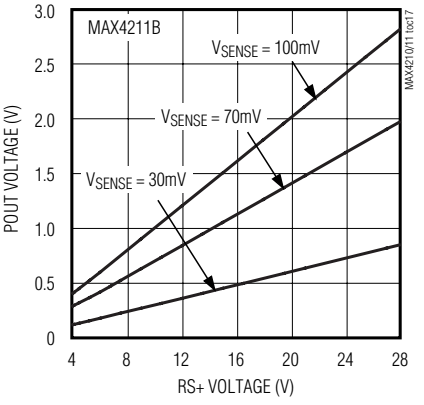

**MULTIPLIER TRANSFER CHARACTERISTICS**



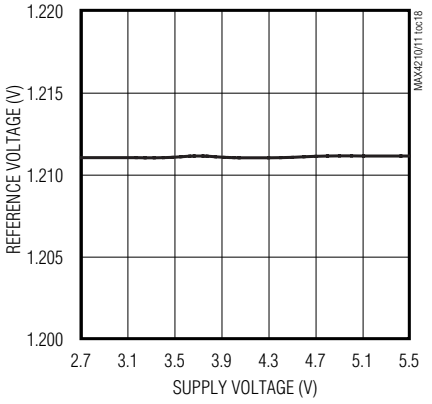

**MULTIPLIER TRANSFER CHARACTERISTICS**




**MULTIPLIER TRANSFER CHARACTERISTICS**




**REFERENCE VOLTAGE vs. SUPPLY VOLTAGE**

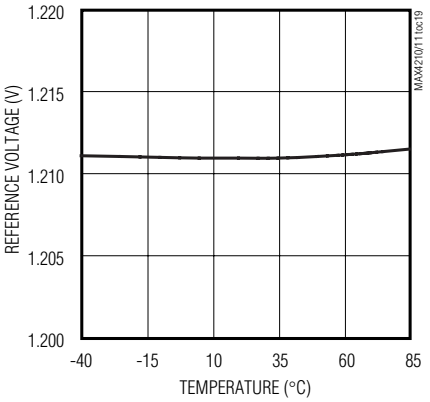


# High-Side Power and Current Monitors

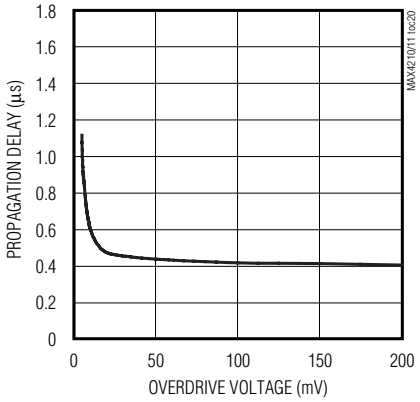
## Typical Operating Characteristics (continued)

($V_{CC}$ = 5.0V, $V_{RS+}$ = 25V, $V_{SENSE}$ = 100mV, $V_{IN}$ = 1V, $V_{LE}$ = 0V, $R_{IOUT}$ = $R_{POUT}$ = 1MΩ, $V_{CIN1+}$ = $V_{CIN2+}$ = $V_{REF}$, $V_{CIN1-}$ = $V_{CIN2-}$ = 0V, $V_{INHIBIT}$ = 0V, $R_{COUT1}$ = $R_{COUT2}$ = 5kΩ connected to $V_{CC}$, $T_A$ = +25°C, unless otherwise noted.)

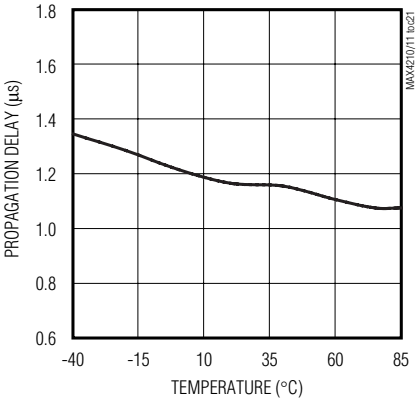
**REFERENCE VOLTAGE vs. TEMPERATURE**



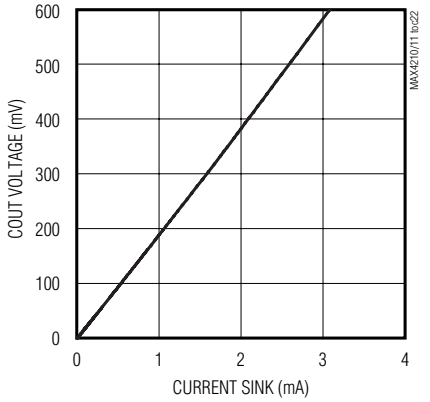

**COMPARATOR PROPAGATION DELAY vs. OVERDRIVE VOLTAGE**



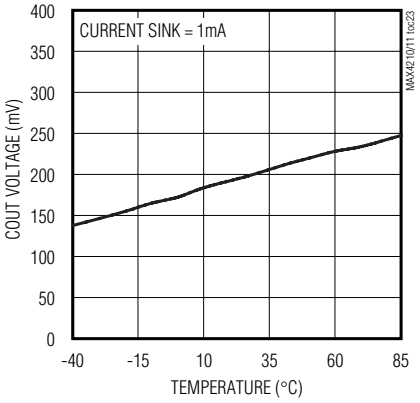

**COMPARATOR PROPAGATION DELAY vs. TEMPERATURE**



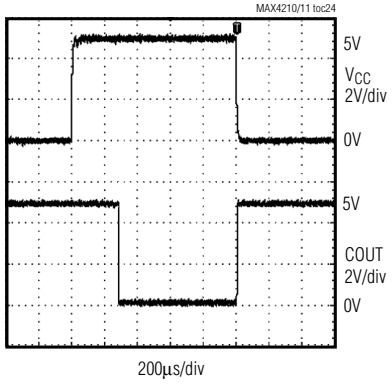

**COMPARATOR OUTPUT VOLTAGE ($V_{OL}$) vs. CURRENT SINK**



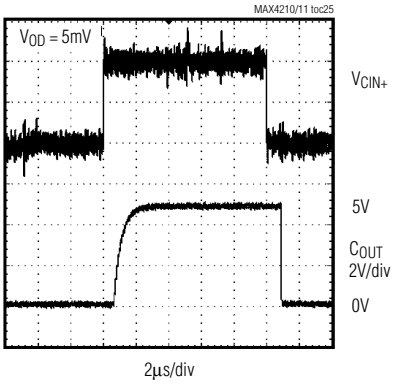

**COMPARATOR OUTPUT VOLTAGE ($V_{OL}$) vs. TEMPERATURE**



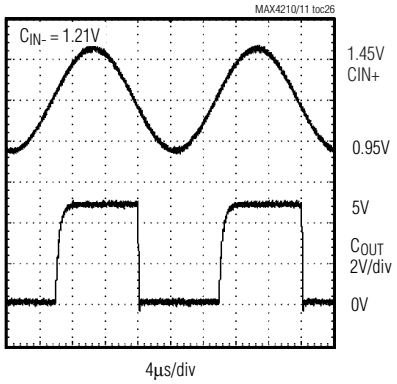

**COMPARATOR POWER-UP DELAY**



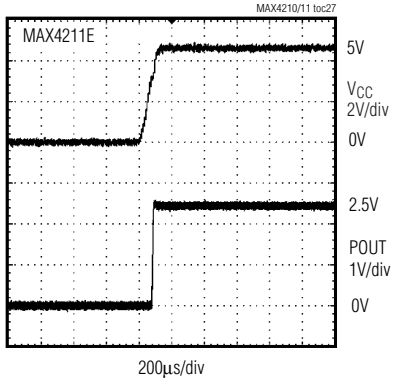

**COMPARATOR PROPAGATION DELAY**




**COMPARATOR AC RESPONSE**



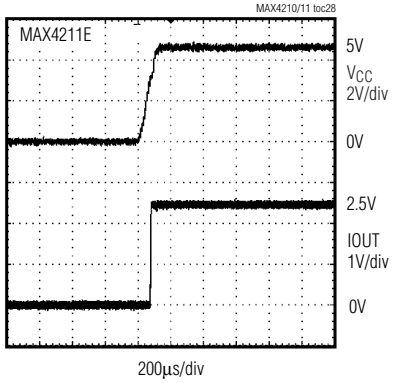

**POUT POWER-UP DELAY**



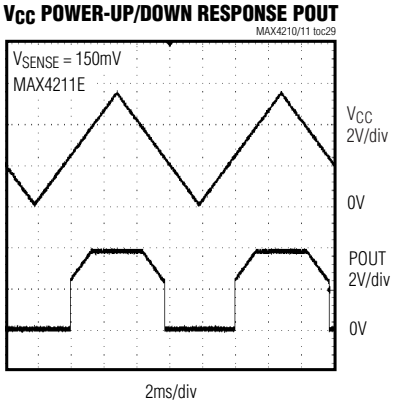
## Typical Operating Characteristics (continued)

($V_{CC}$ = 5.0V, $V_{RS+}$ = 25V, $V_{SENSE}$ = 100mV, $V_{IN}$ = 1V, $V_{LE}$ = 0V, $R_{IOUT}$ = $R_{POUT}$ = 1MΩ, $V_{CIN1+}$ = $V_{CIN2+}$ = $V_{REF}$, $V_{CIN1-}$ = $V_{CIN2-}$ = 0V, $V_{INHIBIT}$ = 0V, $R_{COUT1}$ = $R_{COUT2}$ = 5kΩ connected to $V_{CC}$, $T_A$ = +25°C, unless otherwise noted.)

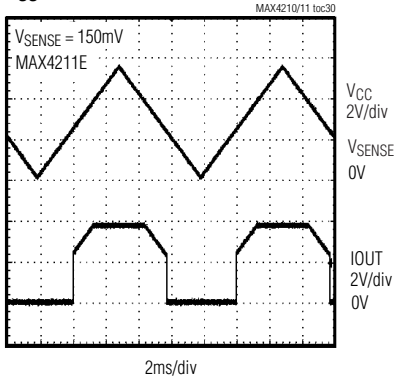
**IOUT POWER-UP DELAY**



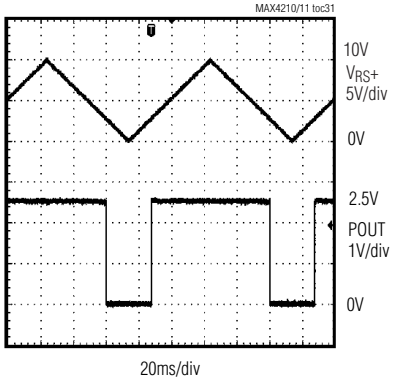

**$V_{CC}$ POWER-UP/DOWN RESPONSE POUT**



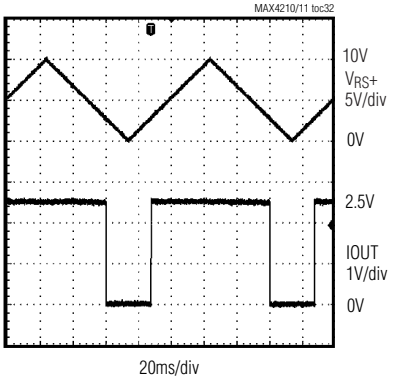

**$V_{CC}$ POWER-UP/DOWN RESPONSE IOUT**



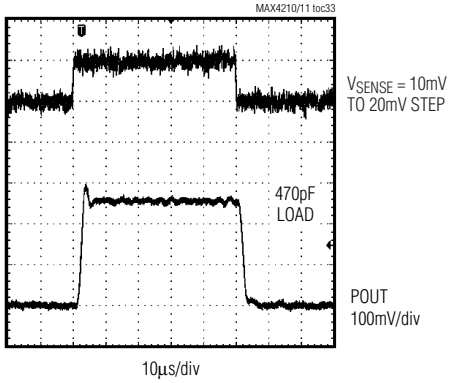

**RS POWER-UP/DOWN RESPONSE POUT**




**RS POWER-UP/DOWN RESPONSE IOUT**




**POUT SMALL-SIGNAL PULSE RESPONSE**

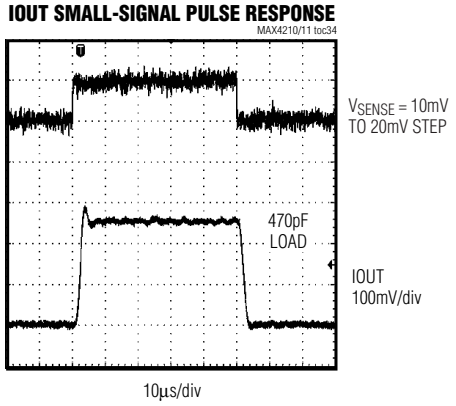


# High-Side Power and Current Monitors

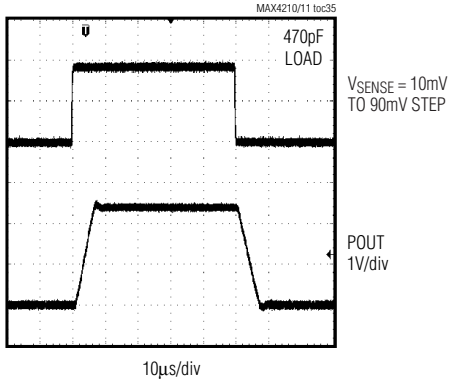
## Typical Operating Characteristics (continued)

($V_{CC}$ = 5.0V, $V_{RS+}$ = 25V, $V_{SENSE}$ = 100mV, $V_{IN}$ = 1V, $V_{LE}$ = 0V, $R_{IOUT}$ = $R_{POUT}$ = 1MΩ, $V_{CIN1+}$ = $V_{CIN2+}$ = $V_{REF}$, $V_{CIN1-}$ = $V_{CIN2-}$ = 0V, $V_{INHIBIT}$ = 0V, $R_{COUT1}$ = $R_{COUT2}$ = 5kΩ connected to $V_{CC}$, $T_A$ = +25°C, unless otherwise noted.)

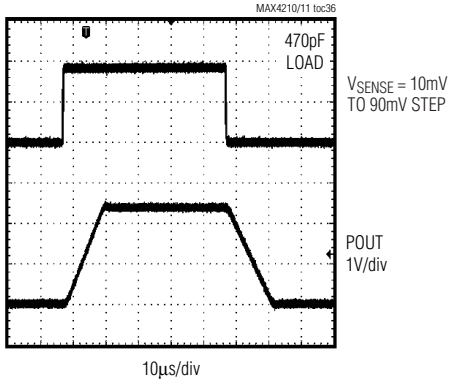
**IOUT SMALL-SIGNAL PULSE RESPONSE**



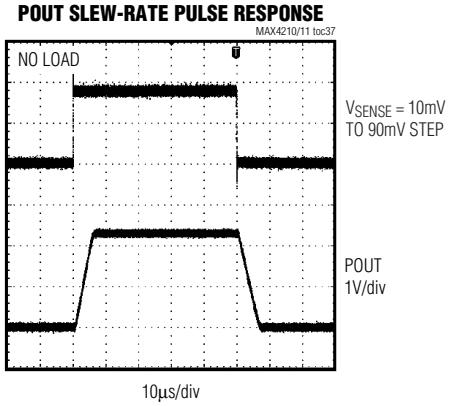

**POUT LARGE-SIGNAL PULSE RESPONSE**



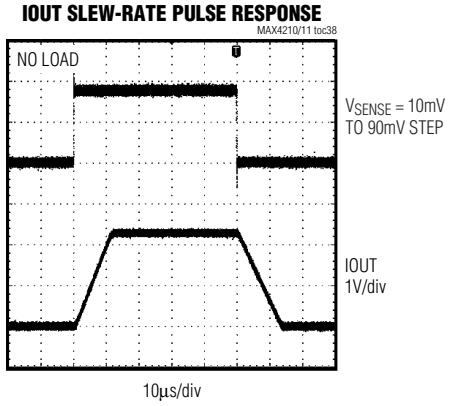

**IOUT LARGE-SIGNAL PULSE RESPONSE**



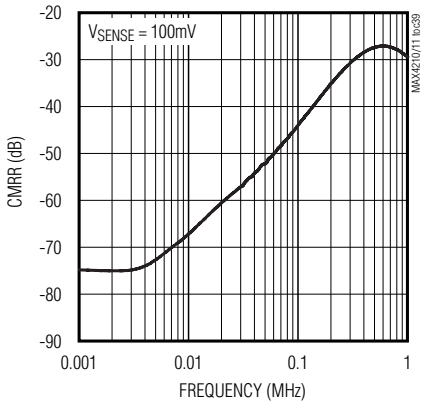

**POUT SLEW-RATE PULSE RESPONSE**




**IOUT SLEW-RATE PULSE RESPONSE**



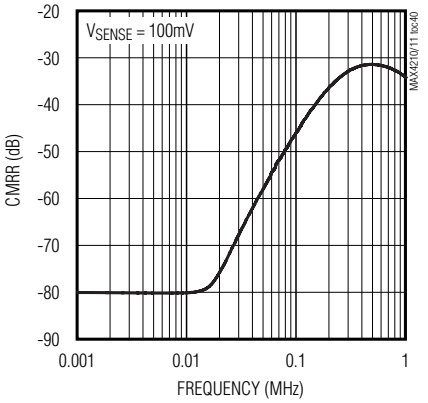

**POUT COMMON-MODE REJECTION RATIO vs. FREQUENCY**



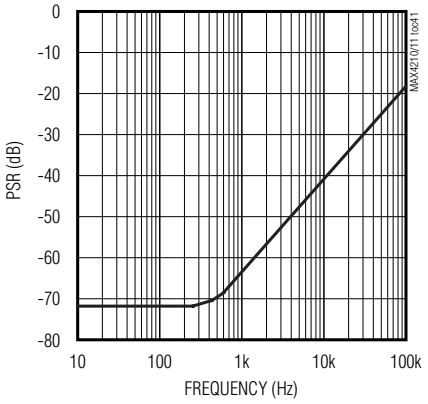
## Typical Operating Characteristics (continued)

($V_{CC}$ = 5.0V, $V_{RS+}$ = 25V, $V_{SENSE}$ = 100mV, $V_{IN}$ = 1V, $V_{LE}$ = 0V, $R_{IOUT}$ = $R_{POUT}$ = 1MΩ, $V_{CIN1+}$ = $V_{CIN2+}$ = $V_{REF}$, $V_{CIN1-}$ = $V_{CIN2-}$ = 0V, $V_{INHIBIT}$ = 0V, $R_{COUT1}$ = $R_{COUT2}$ = 5kΩ connected to $V_{CC}$, $T_A$ = +25°C, unless otherwise noted.)

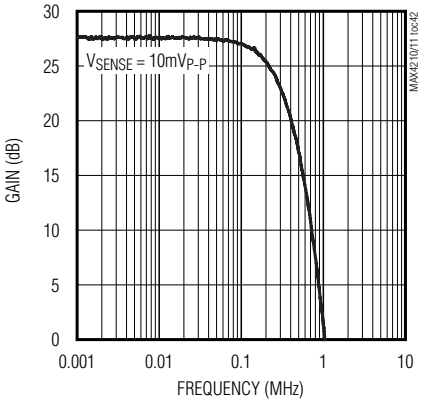
**IOUT COMMON-MODE REJECTION RATIO vs. FREQUENCY**



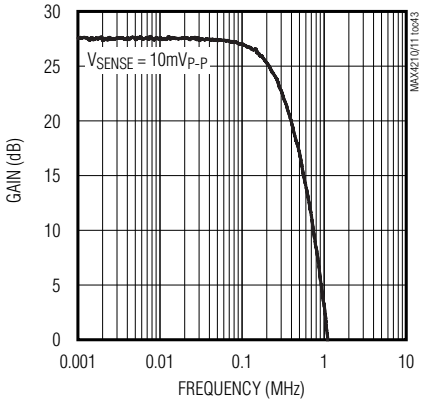

**POWER-SUPPLY REJECTION vs. FREQUENCY**



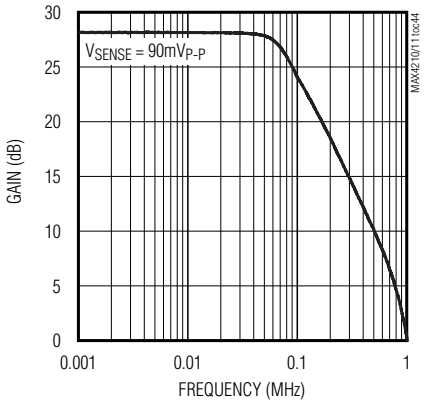

**POUT SMALL-SIGNAL GAIN vs. FREQUENCY**



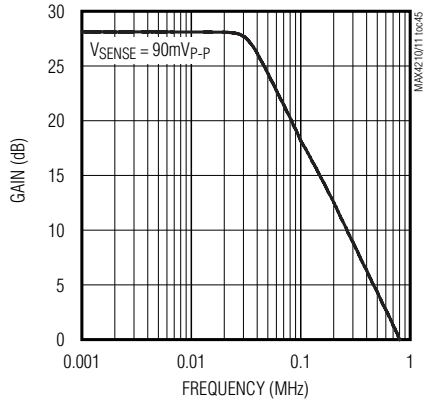

**IOUT SMALL-SIGNAL GAIN vs. FREQUENCY**



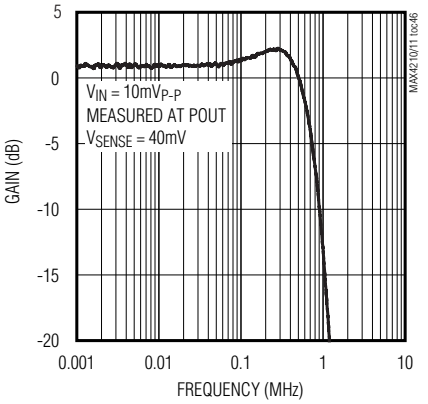

**POUT LARGE-SIGNAL GAIN vs. FREQUENCY**




**IOUT LARGE-SIGNAL GAIN vs. FREQUENCY**




**IN SMALL-SIGNAL GAIN vs. FREQUENCY**



## MAX4210A/B/C Pin Description

| PIN | | NAME | FUNCTION |
|---|---|---|---|
| 6 TDFN | 8 µMAX | | |
| 1 | 1 | GND | Ground |
| 2 | 2, 3, 6 | N.C. | No Connection. Not internally connected. |
| 3 | 4 | $V_{CC}$ | Power-Supply Voltage. Connect a 0.1µF bypass capacitor from $V_{CC}$ to GND. |
| 4 | 5 | RS+ | Power Connection to External-Sense Resistor and Internal Resistor-Divider |
| 5 | 7 | RS- | Load-Side Connection for External-Sense Resistor |
| 6 | 8 | POUT | Power Output Voltage. Voltage output proportional to source power (input voltage multiplied by load current). |
| EP | — | EP* | Exposed Paddle. EP is internally connected to GND. |

**TDFN package only.*

## MAX4210D/E/F Pin Description

| PIN | | NAME | FUNCTION |
|---|---|---|---|
| 6 TDFN | 8 µMAX | | |
| 1 | 1 | GND | Ground |
| 2 | 2 | IN | Multiplier Input Voltage. Voltage input for internal multiplier. |
| 3 | 4 | $V_{CC}$ | Power-Supply Voltage. Connect a 0.1µF bypass capacitor from $V_{CC}$ to GND. |
| 4 | 5 | RS+ | Power Connection to External-Sense Resistor |
| 5 | 7 | RS- | Load-Side Connection for External-Sense Resistor |
| 6 | 8 | POUT | Power Output Voltage. Voltage output proportional to source power (input voltage multiplied by load current). |
| EP | — | EP* | Exposed Paddle. EP is internally connected to GND. |
| — | 3, 6 | N.C. | No Connection. Not internally connected. |

**TDFN package only.*

## MAX4211A/B/C Pin Description

| PIN | | NAME | FUNCTION |
|---|---|---|---|
| 16 THIN QFN | 16 TSSOP | | |
| 1 | 3 | $V_{CC}$ | Power-Supply Voltage. Connect a 0.1µF bypass capacitor from $V_{CC}$ to GND. |
| 2 | 4 | N.C. | No Connection. Not internally connected. |
| 3 | 5 | LE | Latch Enable for Comparator 1. Driving logic low makes the comparator transparent (regular comparator). Driving logic high latches the output. |
| 4 | 6 | COUT1 | Open-Drain Comparator 1 Output. LE and INHIBIT control the comparator 1 output. |
| 5 | 7 | INHIBIT | INHIBIT for Comparator 1 Output. Driving logic high inhibits the comparator operation. Drive logic low for normal operation. |
| 6 | 8 | COUT2 | Open-Drain Comparator 2 Output |
| 7 | 9 | GND | Ground |
| 8 | 10 | CIN2+ | Comparator 2 Positive Input |
| 9 | 11 | CIN2- | Comparator 2 Negative Input |
| 10 | 12 | CIN1+ | Comparator 1 Positive Input |
| 11 | 13 | CIN1- | Comparator 1 Negative Input |
| 12 | 14 | REF | 1.21V Internal Reference Output |
| 13 | 15 | POUT | Power Output Voltage. Voltage output proportional to source power (input voltage multiplied by load current). |
| 14 | 16 | IOUT | Current Output Voltage. Voltage output proportional to $V_{SENSE}$ ($V_{RS+}$ - $V_{RS-}$) load current. |
| 15 | 1 | RS- | Load-Side Connection for External-Sense Resistor |
| 16 | 2 | RS+ | Power Connection to External-Sense Resistor and Internal Resistor-Divider |
| EP | — | EP* | Exposed Paddle. EP is internally connected to GND. |

**Thin QFN package only.*

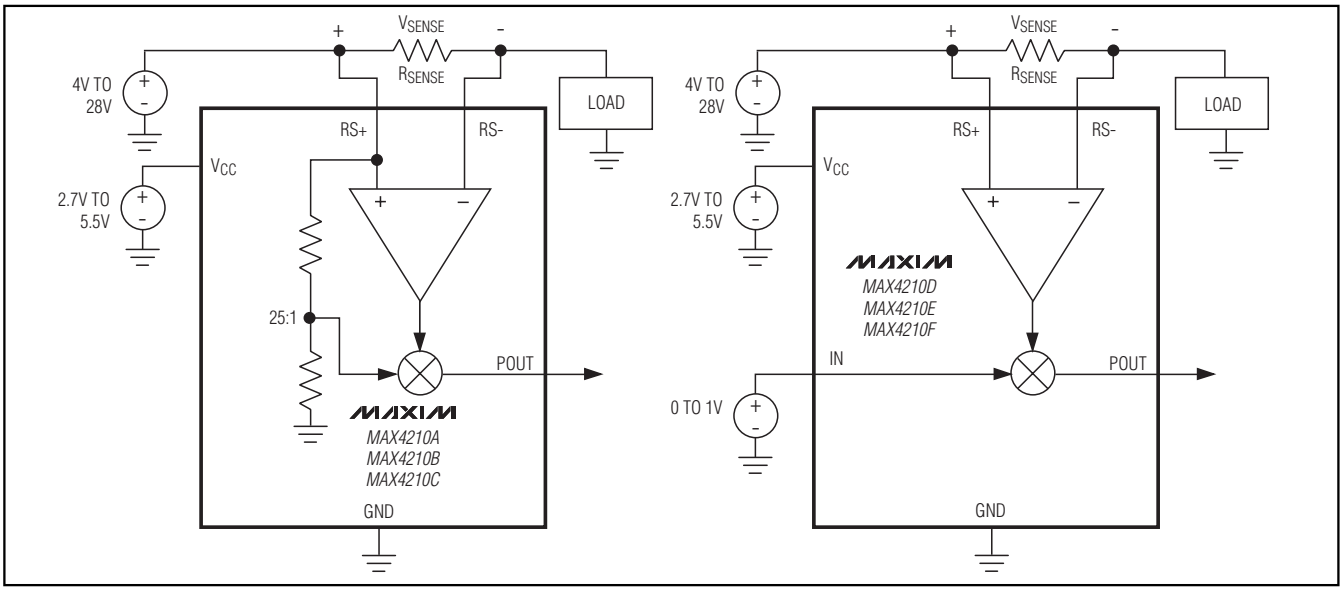
# High-Side Power and Current Monitors

## MAX4211D/E/F Pin Description

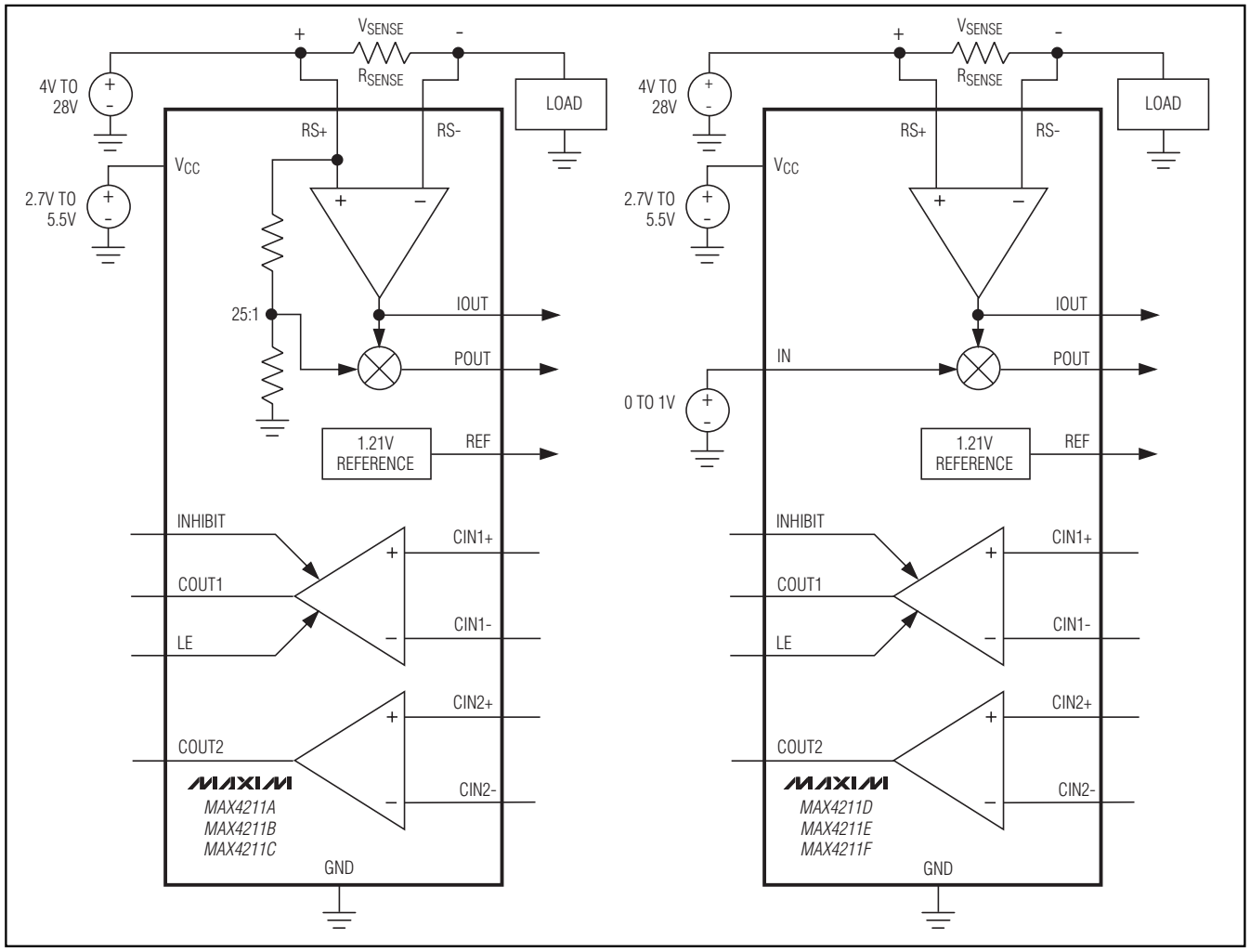
| PIN | | NAME | FUNCTION |
|---|---|---|---|
| 16 THIN QFN | 16 TSSOP | | |
| 1 | 3 | $V_{CC}$ | Power-Supply Voltage. Connect a 0.1µF bypass capacitor from $V_{CC}$ to GND. |
| 2 | 4 | IN | Multiplier Input Voltage. Voltage input for internal multiplier. |
| 3 | 5 | LE | Latch Enable for Comparator 1. Driving logic low makes the comparator transparent (regular comparator). Driving logic high latches the output. |
| 4 | 6 | COUT1 | Open-Drain Comparator 1 Output. Output controlled by LE and INHIBIT. |
| 5 | 7 | INHIBIT | INHIBIT for Comparator 1 Output. Driving logic high inhibits the comparator operation. Drive logic low for normal operation. |
| 6 | 8 | COUT2 | Open-Drain Comparator 2 Output |
| 7 | 9 | GND | Ground |
| 8 | 10 | CIN2+ | Comparator 2 Positive Input |
| 9 | 11 | CIN2- | Comparator 2 Negative Input |
| 10 | 12 | CIN1+ | Comparator 1 Positive Input |
| 11 | 13 | CIN1- | Comparator 1 Negative Input |
| 12 | 14 | REF | 1.21V Internal Reference Output |
| 13 | 15 | POUT | Power Output Voltage. Voltage output proportional source power (input voltage multiplied by load current). |
| 14 | 16 | IOUT | Current Output Voltage. Voltage output proportional $V_{SENSE}$ ($V_{RS+}$ - $V_{RS-}$) load current. |
| 15 | 1 | RS- | Load-Side Connection for External-Sense Resistor |
| 16 | 2 | RS+ | Power Connection to External-Sense Resistor |
| EP | — | EP* | Exposed Paddle. EP is internally connected to GND. |

**Thin QFN package only.*

## Functional Diagrams



## Functional Diagrams (continued)




## Detailed Description

The MAX4210/MAX4211 families of current- and power-monitoring ICs integrate a precision current-sense amplifier and an analog multiplier for a variety of current and power measurements. The MAX4211 integrates an additional uncommitted 1.21V reference and two comparators with open-drain outputs. These features enable the design of detector circuits for overpower, overcurrent, overvoltage, or any combination of fault conditions. The MAX4210/MAX4211 offer various gains, packages, and configurations allowing for greater design flexibility and lower overall cost.

These devices monitor the load current with their high-side current-sense amplifiers and provide an analog output voltage proportional to that current at IOUT (MAX4211). This voltage is fed to the analog multiplier for multiplying the load current with a source voltage to obtain a voltage proportional to load power at POUT.

### Current-Sense Amplifier

The integrated current-sense amplifier is a differential amplifier that amplifies the voltage across RS+ and RS-. A sense resistor, $R_{SENSE}$, is connected across RS+ and RS-. A voltage drop across $R_{SENSE}$ is developed when a load current is passed through it. This voltage is amplified and is proportional to the load current. This voltage is also fed to the analog multiplier for power-sensing applications (see the *Analog Multiplier* section). The current-sense amplifiers feature three gain options: 16.67V/V, 25.0V/V, and 40.96V/V (see Table 1).

# High-Side Power and Current Monitors

The common-mode voltage range is +4V to +28V and independent of the supply voltage. With this feature, the device can monitor the output current of a high-voltage source while running at a lower system voltage typically between 2.7V and 5.5V.

The MAX4211 has a current-sense amplifier output. The voltage at IOUT is proportional to the voltage across $V_{SENSE}$:

$$V_{IOUT} = A_{VIOUT} \times V_{SENSE}$$

where $V_{SENSE}$ is the voltage across RS+ and RS-, and $A_{VIOUT}$ is the amplifier gain of the device given in Table 1.

### Analog Multiplier

The MAX4210/MAX4211 integrate an analog multiplier that enables real-time monitoring of power delivered to a load. The voltage proportional to the load current is fed to one input of the multiplier and a voltage proportional to the source voltage is fed to the other. The analog multiplier multiplies these two voltages to obtain an output voltage proportional to the load power. The analog multiplier is designed only to operate in the positive quadrant, that is, the inputs and outputs are always positive voltages.

For the MAX4210D/E/F and MAX4211D/E/F, the analog multiplier full-scale input at IN is approximately 1V. This independent multiplier input allows greater design flexibility when using an external voltage-divider. For the MAX4210A/B/C and MAX4211A/B/C, an integrated voltage-divider divides the source voltage at the RS+ pin by a nominal value of 25 and passes this voltage to the multiplier. Thus, the full-scale input voltage at RS+ is 25V. The integrated, trimmed resistor-dividers reduce external component count and cost.

The voltage output at POUT is proportional to the output power:

For the MAX4210A/B/C and MAX4211A/B/C:

$$V_{POUT} = A_{VPOUT} \times V_{SENSE} \times V_{RS+}$$

For the MAX4210D/E/F and MAX4211D/E/F:

$$V_{POUT} = A_{VPOUT} \times V_{SENSE} \times V_{IN}$$

## Table 1. MAX4211 Current-Sense Amplifier Gain and Full-Scale Sense Voltage

| PART | CURRENT-SENSE AMPLIFIER GAIN ($A_{VIOUT}$, V/V) | FULL-SCALE SENSE VOLTAGE (mV) |
|---|---|---|
| MAX4211A/D | 16.67 | 150 |
| MAX4211B/E | 25.00 | 150 |
| MAX4211C/F | 40.96 | 100 |

where $V_{SENSE}$ is the voltage across RS+ and RS- and $A_{VPOUT}$ is the amplifier gain of the device given in Table 2.

### Internal Comparators (MAX4211)

The MAX4211 features two uncommitted open-drain output comparators. These comparators can be configured to trip when load current or power reaches a set limit. They can also be configured as a window comparator with wire-OR output. Comparator 1 (COUT1) features latch-enable (LE) and inhibit (INHIBIT) inputs. When LE is low, the comparator is transparent (it functions as a regular unlatched comparator). When LE is high, the comparator output (COUT1) is latched. When high, the INHIBIT input suspends the comparator operation and latches the output to the current state. The operation of INHIBIT is similar to LE, except it has a different input threshold and wider hysteresis. The INHIBIT logic-high threshold is 1.21V and logic-low threshold is 0.6V with 0.6V hysteresis. INHIBIT is useful in preventing the comparator from giving false output during fast RS+ transients. INHIBIT is generally triggered by an RC network connected to RS+ (see the *Applications Information*). Both comparators have a built-in 300µs blanking period at power-up to prevent false outputs. The comparator outputs are open drain and they can be pulled up to $V_{CC}$, RS+, or any voltage less than +28V. LE and INHIBIT are internally pulled down by a 1µA source.

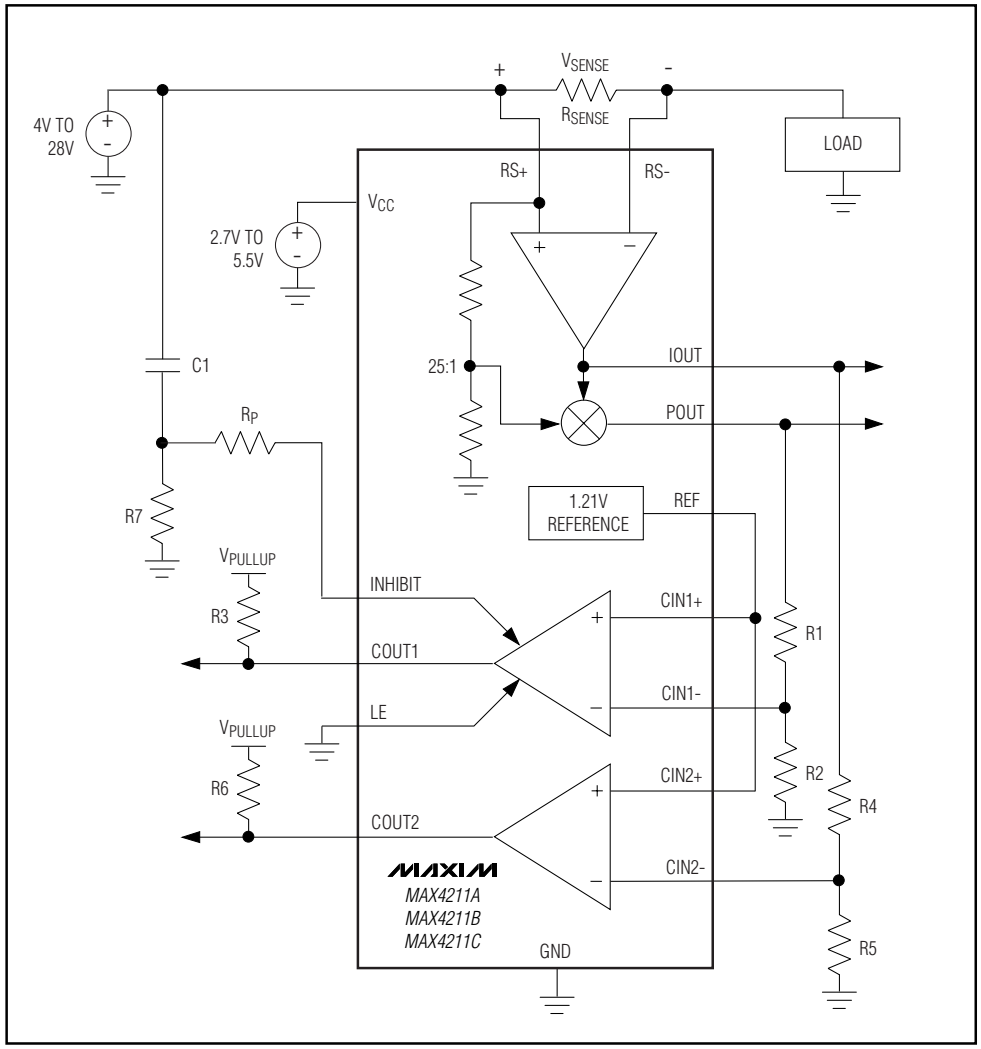
## Table 2. MAX4210/MAX4211 Power-Sense Amplifier Gain and Full-Scale Sense Voltage

| PART | POWER-SENSE AMPLIFIER GAIN ($A_{VPOUT}$, 1/V) | FULL-SCALE SENSE VOLTAGE (mV) |
|---|---|---|
| MAX4210A | 0.667 | 150 |
| MAX4210B | 1.000 | 150 |
| MAX4210C | 1.640 | 100 |
| MAX4210D | 16.670 | 150 |
| MAX4210E | 25.000 | 150 |
| MAX4210F | 40.960 | 100 |
| MAX4211A | 0.667 | 150 |
| MAX4211B | 1.000 | 150 |
| MAX4211C | 1.640 | 100 |
| MAX4211D | 16.670 | 150 |
| MAX4211E | 25.000 | 150 |
| MAX4211F | 40.960 | 100 |

### Internal Reference (MAX4211)

The MAX4211 features a 1.21V bandgap reference output, stable over supply voltage and temperature. Typically, the reference output is connected to one of the comparators' inputs. This is the comparison reference voltage. If a lower reference voltage is needed, use an external voltage-divider. The reference can source or sink a load current up to 100µA.

## Typical Operating Circuit



# High-Side Power and Current Monitors

## Applications Information

### Recommended Component Values

Ideally, the maximum load current develops the full-scale sense voltage across the current-sense resistor. Choose the gain version needed to yield the maximum current-sense amplifier output voltage without saturating it. The typical high-side saturation voltage is about $V_{CC}$ - 0.25V. The current-sense amplifier output voltage is given by:

$$V_{IOUT} = V_{SENSE} \times A_{VIOUT}$$

where $V_{IOUT}$ is the voltage fed to the analog multiplier or at IOUT. $V_{SENSE}$ is the sense voltage. $A_{VIOUT}$ is the current-sense amplifier gain of the device specified in Table 1. Calculate the maximum value for $R_{SENSE}$ so the differential voltage across RS+ and RS- does not exceed the full-scale sense voltage:

$$R_{SENSE} = \frac{V_{SENSE(FULL-SCALE)}}{I_{LOAD(FULL-SCALE)}}$$

Choose the highest value resistance possible to maximize $V_{SENSE}$ and thus minimize total output error. In applications monitoring high current, ensure that $R_{SENSE}$ is able to dissipate its own $I^2R$ power dissipation. If the resistor's power dissipation is exceeded, its value can drift or it can fail altogether, causing a differential voltage across the terminals in excess of the absolute maximum ratings. Use resistors specified for current-sensing applications.

### Window Comparator

In some applications where undercurrent or underpower (open-circuit fault) and overcurrent or overpower (short-circuit fault) needs to be monitored, a window comparator is desirable. Figure 1 shows a simple circuit suitable for window detection. Let $P_{OVER}$ be the minimum load power required to cause a low state at COUT2, and let $P_{UNDER}$ be the maximum load current required to cause a high state at COUT1:

$$P_{UNDER}(WATTS) = \frac{V_{REF}}{A_{VPOUT} \times R_{SENSE}} \left(\frac{R1 + R_2}{R_2}\right)$$

$$P_{OVER}(WATTS) = \frac{V_{REF}}{A_{VPOUT} \times R_{SENSE}} \left(\frac{R4 + R_5}{R_5}\right)$$

where $A_{VPOUT}$ is the power-sense amplifier gain given in Table 2, and $V_{REF}$ is the internal reference voltage (1.2V, typ). The resulting comparator output is high when the current is inside the current window and low when the current is outside the window. Note that COUT1 and COUT2 are wire-ORed together.

### Overpower Circuit Breaker

Figure 2 shows a circuit breaker that shuts off current to the load when an overpower fault is detected (the same circuit can be used to detect overcurrent conditions by connecting the R1-R2 resistor-divider to IOUT, instead of POUT). This circuit is useful for protecting the battery from short-circuit or overpower conditions. When a power fault is detected, the P-MOSFET, M1, is turned off and stays off until the manual reset button is pressed. Also, cycling the input power causes the LE pin to go low, which unlatches the comparator output OUT1 and resets the circuit breaker.

During power-up or when the characteristics of the load change, there can be an inrush current into the load. The temporary inrush current results in a higher voltage at POUT. This can bring the voltage at CIN+ above the reference voltage at CIN-, and, as a result, COUT1 goes high triggering the circuit-breaker function. This unwanted behavior can be disabled by bringing comparator 1's INHIBIT input high. An RC network connected to INHIBIT (R4 and C1) can be incorporated to suspend comparator 1's operation for a brief period. In this way, short surges in load power can be made invisible to the circuit-breaker function, while longer term overpower load demands (or a load short circuit) still "trip the breaker."

The logic-high threshold for INHIBIT is typically 1.2V, and the logic-low threshold is 0.6V. During power-up, INHIBIT quickly exceeds 1.2V through C1 and inhibits COUT1 from changing state. The comparator inputs are "inhibited" until the INHIBIT voltage is discharged to 0.6V. R3 is a current-limiting resistor, typically 10kΩ, which protects the INHIBIT input. Since INHIBIT is a high-impedance input, R3 has no effect on the R4-C1 charge/discharge time. The time during which the comparator is suspended is approximated by:

$$t_{INHIBIT} = R_4 \times C1 \ln\left(\frac{\Delta V}{0.6V}\right)$$

where ΔV is the voltage change at the load. For improved transient immunity, $t_{INHIBIT}$ can be increased as required, with the understanding that the breaker function will be suspended for this period.

If any comparator is not used, its input must be biased to a known state. For example, connect CIN+ to $V_{CC}$ and CIN- to GND.

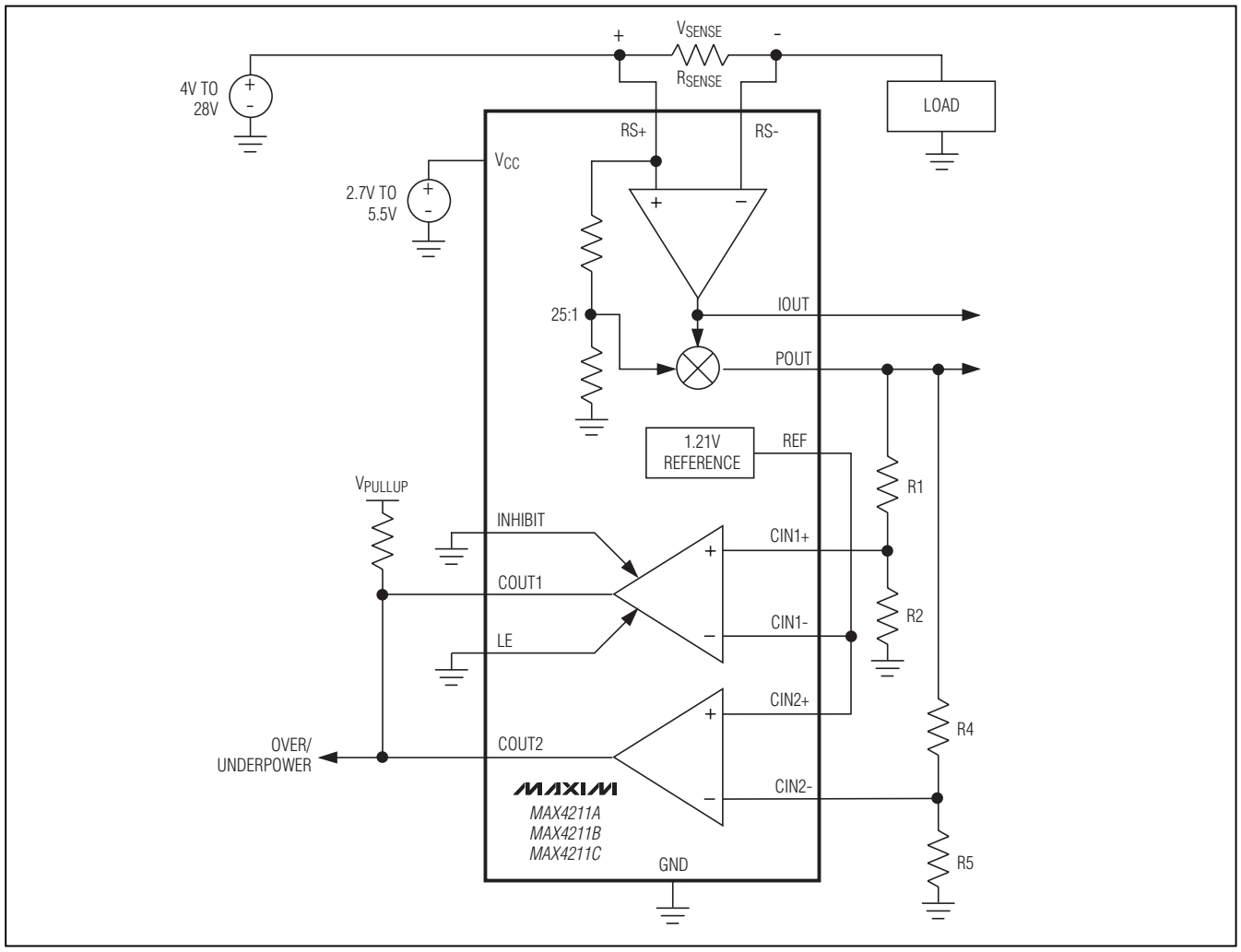



*Figure 1. Window Comparator for Detecting Underpower and Overpower Faults (Also Detects Undercurrent and Overcurrent Faults by R1 and R4 to IOUT Instead of POUT)*

### Variable-Gain Amplifier

Figure 3 shows single-ended input, variable-gain amplifiers (VGA). This VGA features more than 200kHz bandwidth and is useful in automatic gain-control circuits commonly found in baseband processors. The gain is controlled by applying 0 to 1V to IN ($V_{GC}$) of the MAX4210D/E/F; 0V corresponds to minimum gain and 1V corresponds to maximum gain.

### Measure Load Power

The MAX4210A/B/C and MAX4211A/B/C have internal voltage-divider resistors connected to RS+ and the analog multiplier input. This configuration measures source power accurately and provides protection to the power source such as a battery. To measure the load power accurately, choose the MAX4210D/E/F and MAX4211D/E/F with an external resistor-divider connected directly to the load as shown in Figure 4. This configuration improves the load-power measurement accuracy by excluding the additional power dissipated by $R_{SENSE}$.

### Power-Supply Bypassing

Bypass $V_{CC}$ to GND with a 0.1µF ceramic capacitor to isolate the IC from supply-voltage transients. To prevent high-frequency coupling, bypass RS+ or RS- with a 0.1µF capacitor. On the TDFN and thin QFN packages, there is an exposed paddle that does not carry any current, but should also be connected to the ground plane for rated power dissipation.

# High-Side Power and Current Monitors

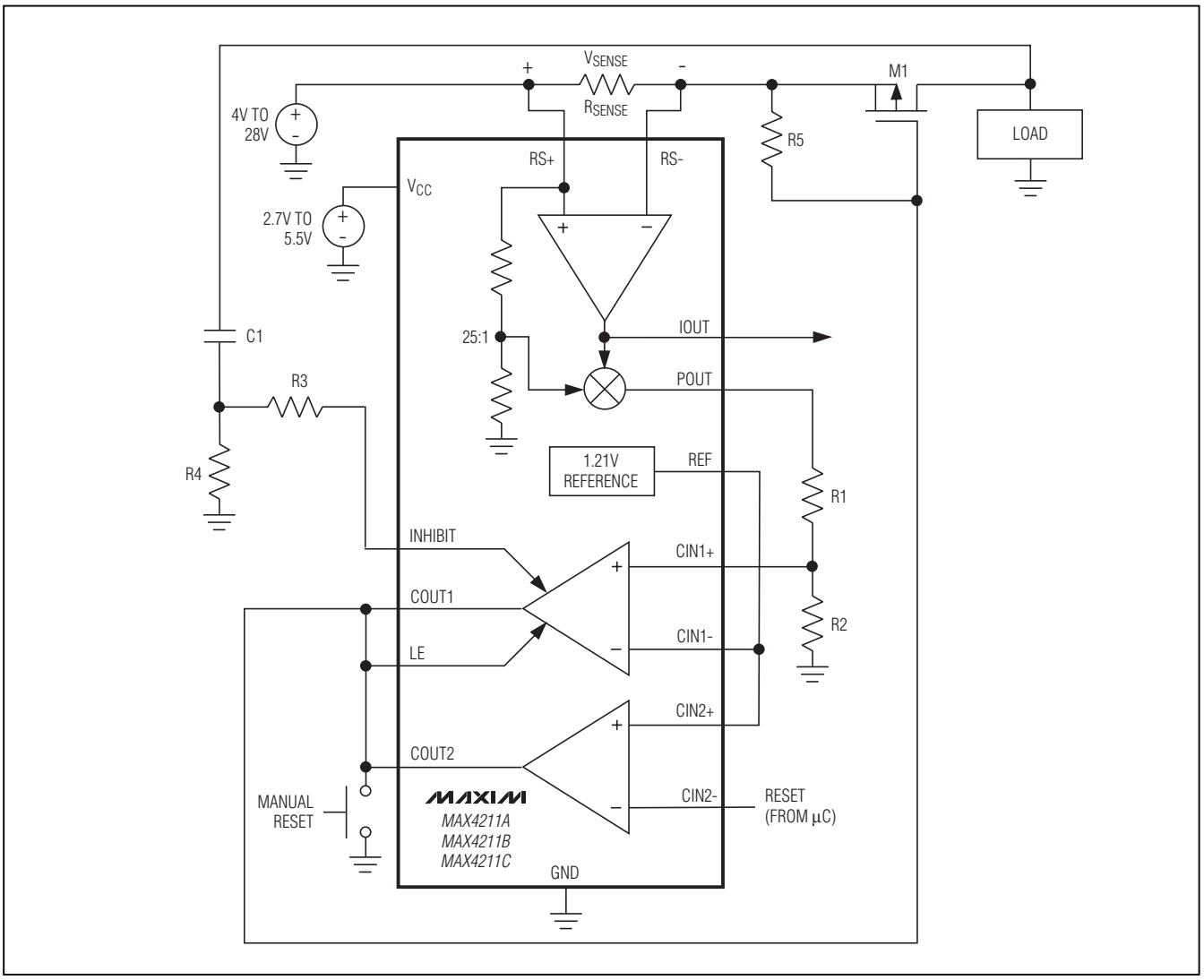



*Figure 2. Overpower Circuit Breaker (For a Detailed Example, Refer to the MAX4211E EV Kit)*

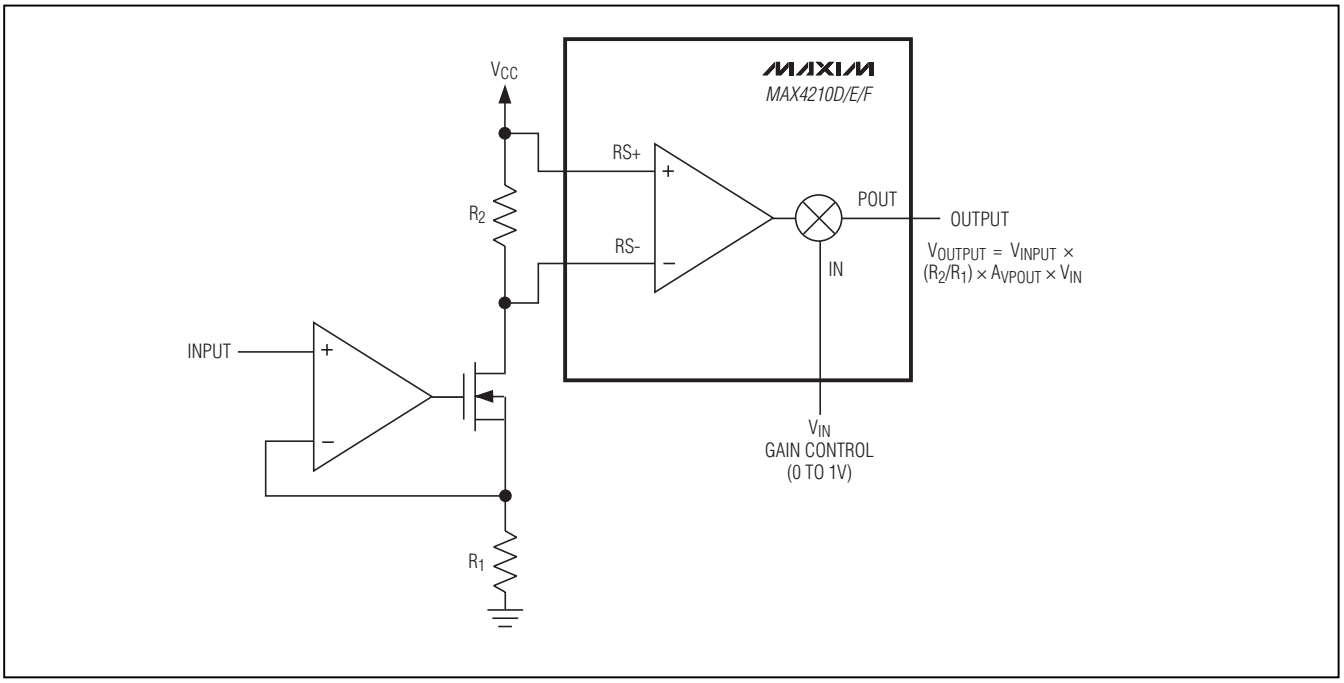



*Figure 3. Single-Ended-Input, Variable-Gain Amplifier*

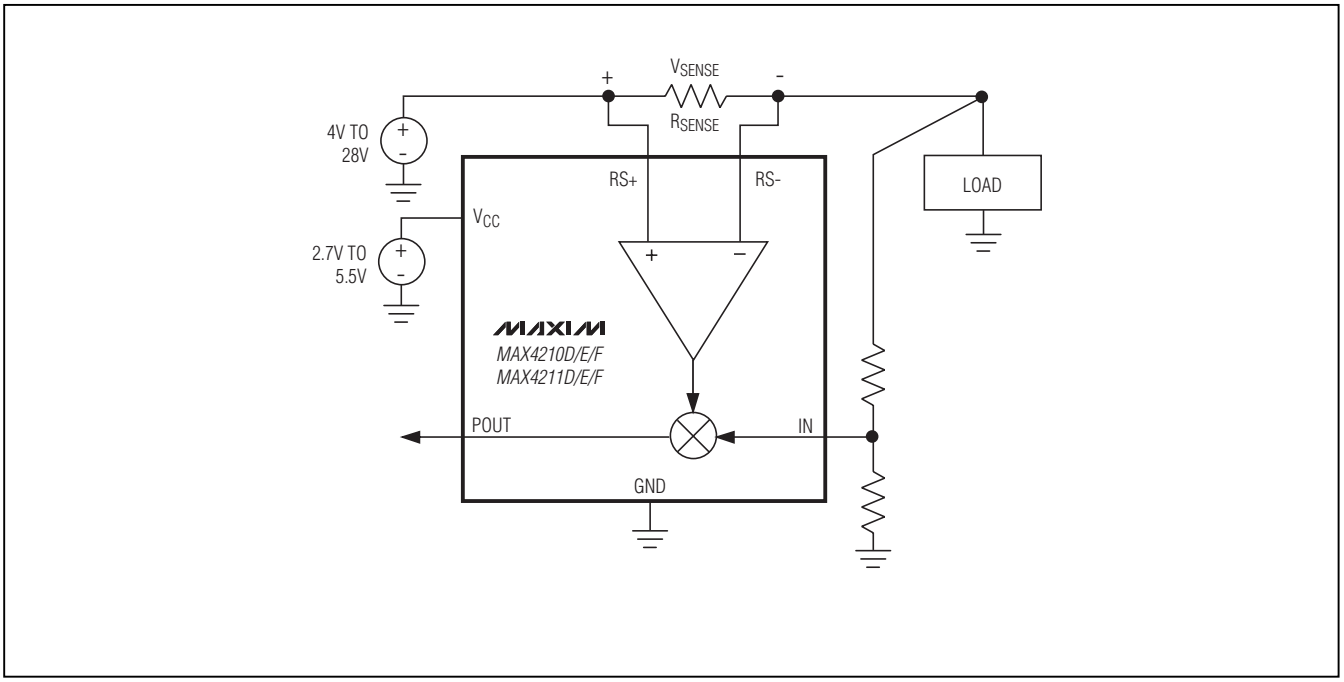



*Figure 4. Load-Power Measurement with External Voltage-Divider*

# High-Side Power and Current Monitors

## Selector Guide

| PART | PIN-PACKAGE | CURRENT GAIN (V/V) | POWER GAIN (1/V) | CURRENT/ POWER MEASUREMENT OUTPUT | NO. OF COMPARATORS | INTERNAL REFERENCE | VOLTAGE-MULTIPLIER INPUT (INTERNAL RESISTOR-DIVIDER/ EXTERNAL INPUT) | FULL-SCALE $V_{SENSE}$ VOLTAGE (mV) |
|---|---|---|---|---|---|---|---|---|
| MAX4210AETT | 6 TDFN | — | 0.667 | P | None | N | INT | 150 |
| MAX4210AEUA | 8 µMAX | — | 0.667 | P | None | N | INT | 150 |
| MAX4210BETT | 6 TDFN | — | 1.000 | P | None | N | INT | 150 |
| MAX4210BEUA | 8 µMAX | — | 1.000 | P | None | N | INT | 150 |
| MAX4210CETT | 6 TDFN | — | 1.640 | P | None | N | INT | 100 |
| MAX4210CEUA | 8 µMAX | — | 1.640 | P | None | N | INT | 100 |
| MAX4210DETT | 6 TDFN | — | 16.670 | P | None | N | EXT | 150 |
| MAX4210DEUA | 8 µMAX | — | 16.670 | P | None | N | EXT | 150 |
| MAX4210EETT | 6 TDFN | — | 25.000 | P | None | N | EXT | 150 |
| MAX4210EEUA | 8 µMAX | — | 25.000 | P | None | N | EXT | 150 |
| MAX4210FETT | 6 TDFN | — | 40.960 | P | None | N | EXT | 100 |
| MAX4210FEUA | 8 µMAX | — | 40.960 | P | None | N | EXT | 100 |
| MAX4211AETE | 16 Thin QFN | 16.67 | 0.667 | C/P | 2 | Y | INT | 150 |
| MAX4211AEUE | 16 TSSOP | 16.67 | 0.667 | C/P | 2 | Y | INT | 150 |
| MAX4211BETE | 16 Thin QFN | 25.00 | 1.000 | C/P | 2 | Y | INT | 150 |
| MAX4211BEUE | 16 TSSOP | 25.00 | 1.000 | C/P | 2 | Y | INT | 150 |
| MAX4211CETE | 16 Thin QFN | 40.96 | 1.640 | C/P | 2 | Y | INT | 100 |
| MAX4211CEUE | 16 TSSOP | 40.96 | 1.640 | C/P | 2 | Y | INT | 100 |
| MAX4211DETE | 16 Thin QFN | 16.67 | 16.670 | C/P | 2 | Y | EXT | 150 |
| MAX4211DEUE | 16 TSSOP | 16.67 | 16.670 | C/P | 2 | Y | EXT | 150 |
| MAX4211EETE | 16 Thin QFN | 25.00 | 25.000 | C/P | 2 | Y | EXT | 150 |
| MAX4211EEUE | 16 TSSOP | 25.00 | 25.000 | C/P | 2 | Y | EXT | 150 |
| MAX4211FETE | 16 Thin QFN | 40.96 | 40.960 | C/P | 2 | Y | EXT | 100 |
| MAX4211FEUE | 16 TSSOP | 40.96 | 40.960 | C/P | 2 | Y | EXT | 100 |

*C = Current Measurement Output Available (IOUT).*

*P = Power Measurement Output Available (POUT).*

*Y = Yes.*

*N = No.*

*INT = Internal Resistor-Divider.*

*EXT = External Input Pin.*

## Ordering Information (continued)

| PART | TEMP RANGE | PIN-PACKAGE | TOP MARK |
|---|---|---|---|
| MAX4210BETT | -40°C to +85°C | 6 TDFN-6-EP* (3mm x 3mm) | AHG |
| MAX4210BEUA | -40°C to +85°C | 8 µMAX | — |
| MAX4210CETT | -40°C to +85°C | 6 TDFN-6-EP* (3mm x 3mm) | AHH |
| MAX4210CEUA | -40°C to +85°C | 8 µMAX | — |
| MAX4210DETT | -40°C to +85°C | 6 TDFN-6-EP* (3mm x 3mm) | AHI |
| MAX4210DEUA | -40°C to +85°C | 8 µMAX | — |
| MAX4210EETT | -40°C to +85°C | 6 TDFN-6-EP* (3mm x 3mm) | AHJ |
| MAX4210EEUA | -40°C to +85°C | 8 µMAX | — |
| MAX4210FETT | -40°C to +85°C | 6 TDFN-6-EP* (3mm x 3mm) | AHK |
| MAX4210FEUA | -40°C to +85°C | 8 µMAX | — |
| **MAX4211**AETE | -40°C to +85°C | 16 Thin QFN-EP* (4mm x 4mm) | — |
| MAX4211AEUE | -40°C to +85°C | 16 TSSOP | — |
| MAX4211BETE | -40°C to +85°C | 16 Thin QFN-EP* (4mm x 4mm) | — |
| MAX4211BEUE | -40°C to +85°C | 16 TSSOP | — |
| MAX4211CETE | -40°C to +85°C | 16 Thin QFN-EP* (4mm x 4mm) | — |
| MAX4211CEUE | -40°C to +85°C | 16 TSSOP | — |
| MAX4211DETE | -40°C to +85°C | 16 Thin QFN-EP* (4mm x 4mm) | — |
| MAX4211DEUE | -40°C to +85°C | 16 TSSOP | — |
| MAX4211EETE | -40°C to +85°C | 16 Thin QFN-EP* (4mm x 4mm) | — |
| MAX4211EEUE | -40°C to +85°C | 16 TSSOP | — |
| MAX4211FETE | -40°C to +85°C | 16 Thin QFN-EP* (4mm x 4mm) | — |
| MAX4211FEUE | -40°C to +85°C | 16 TSSOP | — |

**EP = Exposed paddle.*

## Chip Information

MAX4210 TRANSISTOR COUNT: 515

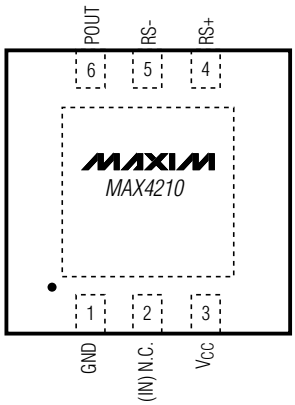
MAX4211 TRANSISTOR COUNT: 1032

PROCESS: BiCMOS

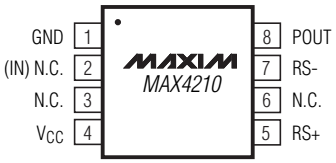
# High-Side Power and Current Monitors

## Pin Configurations

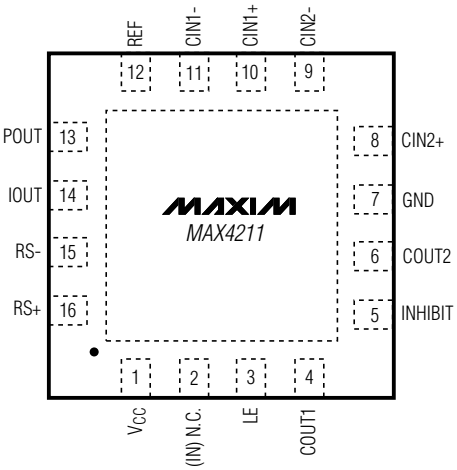
TOP VIEW



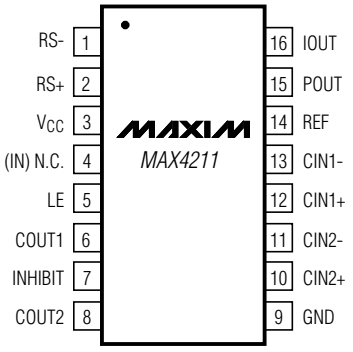

**3mm x 3mm TDFN**




**µMAX**




**4mm x 4mm THIN QFN**

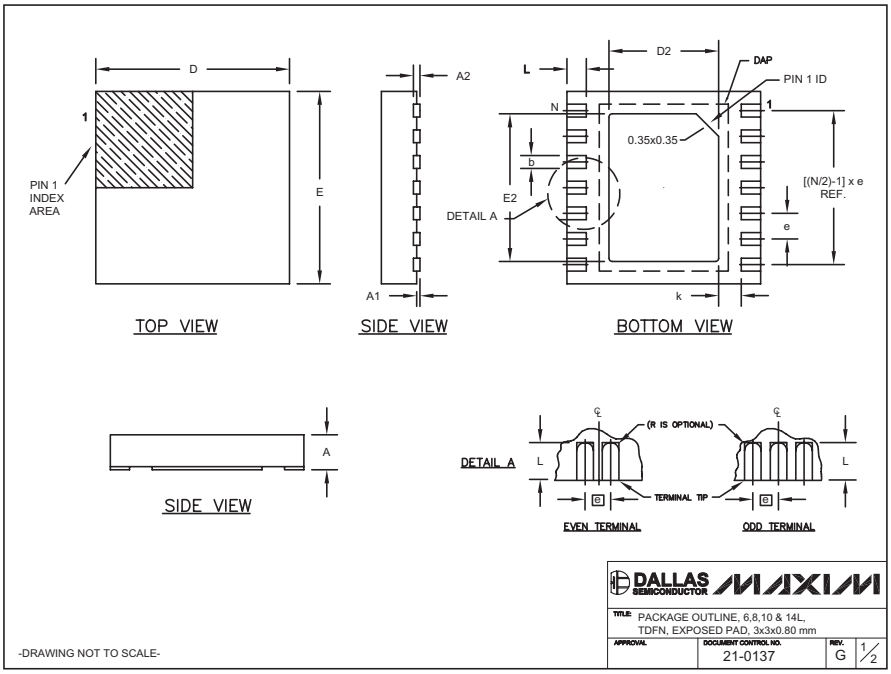



**TSSOP**

( ) ARE FOR MAX421_D/E/F.

## 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**.)




| COMMON DIMENSIONS | | |
|---|---|---|
| SYMBOL | MIN. | MAX. |
| A | 0.70 | 0.80 |
| D | 2.90 | 3.10 |
| E | 2.90 | 3.10 |
| A1 | 0.00 | 0.05 |
| L | 0.20 | 0.40 |
| k | 0.25 MIN. | |
| A2 | 0.20 REF. | |

| PACKAGE VARIATIONS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| PKG. CODE | N | D2 | E2 | e | JEDEC SPEC | b | [(N/2)-1] x e | DOWNBONDS ALLOWED |
| T633-1 | 6 | 1.50–0.10 | 2.30–0.10 | 0.95 BSC | MO229 / WEEA | 0.40–0.05 | 1.90 REF | NO |
| T633-2 | 6 | 1.50–0.10 | 2.30–0.10 | 0.95 BSC | MO229 / WEEA | 0.40–0.05 | 1.90 REF | NO |
| T833-1 | 8 | 1.50–0.10 | 2.30–0.10 | 0.65 BSC | MO229 / WEEC | 0.30–0.05 | 1.95 REF | NO |
| T833-2 | 8 | 1.50–0.10 | 2.30–0.10 | 0.65 BSC | MO229 / WEEC | 0.30–0.05 | 1.95 REF | NO |
| T833-3 | 8 | 1.50–0.10 | 2.30–0.10 | 0.65 BSC | MO229 / WEEC | 0.30–0.05 | 1.95 REF | YES |
| T1033-1 | 10 | 1.50–0.10 | 2.30–0.10 | 0.50 BSC | MO229 / WEED-3 | 0.25–0.05 | 2.00 REF | NO |
| T1433-1 | 14 | 1.70–0.10 | 2.30–0.10 | 0.40 BSC | - - - - | 0.20–0.05 | 2.40 REF | YES |
| T1433-2 | 14 | 1.70–0.10 | 2.30–0.10 | 0.40 BSC | - - - - | 0.20–0.05 | 2.40 REF | NO |

NOTES:
1. ALL DIMENSIONS ARE IN mm. ANGLES IN DEGREES.
2. COPLANARITY SHALL NOT EXCEED 0.08 mm.
3. WARPAGE SHALL NOT EXCEED 0.10 mm.
4. PACKAGE LENGTH/PACKAGE WIDTH ARE CONSIDERED AS SPECIAL CHARACTERISTIC(S).
5. DRAWING CONFORMS TO JEDEC MO229, EXCEPT DIMENSIONS "D2" AND "E2", AND T1433-1 & T1433-2.
6. "N" IS THE TOTAL NUMBER OF LEADS.
7. NUMBER OF LEADS SHOWN ARE FOR REFERENCE ONLY.

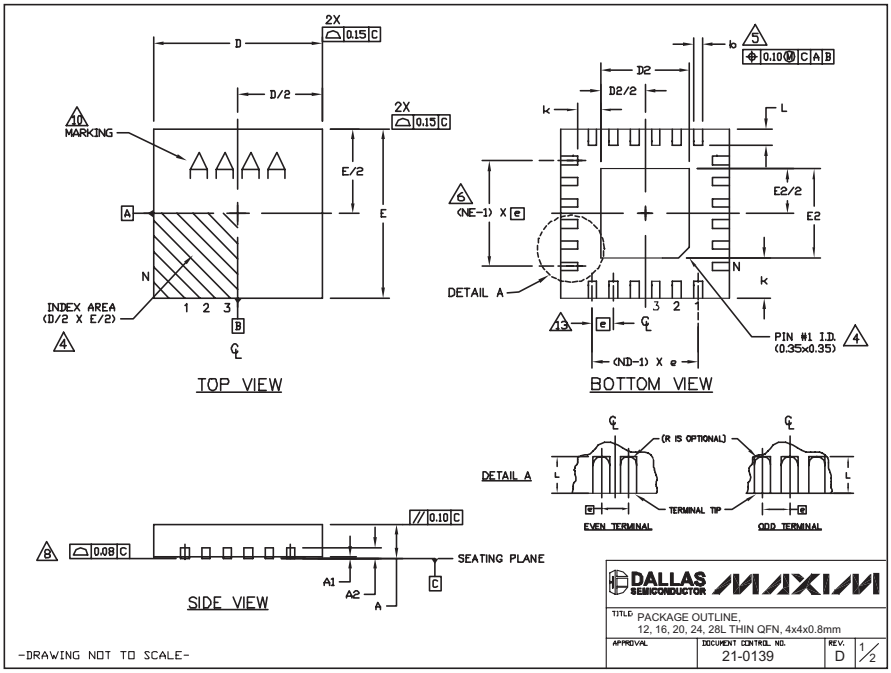
-DRAWING NOT TO SCALE-

DALLAS SEMICONDUCTOR MAXIM
TITLE: PACKAGE OUTLINE, 6,8,10 & 14L,
TDFN, EXPOSED PAD, 3x3x0.80 mm
APPROVAL
DOCUMENT CONTROL NO. 21-0137
REV. G
2/2

***NOTE:*** *THE TDFN EXPOSED PADDLE SIZE-VARIATION PACKAGE CODE: T633-1*

## Package Information (continued)

(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**.)




**COMMON DIMENSIONS**

| PKG | 12L 4x4 | | | 16L 4x4 | | | 20L 4x4 | | | 24L 4x4 | | | 28L 4x4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| REF. | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. |
| A | 0.70 | 0.75 | 0.80 | 0.70 | 0.75 | 0.80 | 0.70 | 0.75 | 0.80 | 0.70 | 0.75 | 0.80 | 0.70 | 0.75 | 0.80 |
| A1 | 0.0 | 0.02 | 0.05 | 0.0 | 0.02 | 0.05 | 0.0 | 0.02 | 0.05 | 0.0 | 0.02 | 0.05 | 0.0 | 0.02 | 0.05 |
| A2 | 0.20 REF | | | 0.20 REF | | | 0.20 REF | | | 0.20 REF | | | 0.20 REF | | |
| b | 0.25 | 0.30 | 0.35 | 0.25 | 0.30 | 0.35 | 0.20 | 0.25 | 0.30 | 0.18 | 0.23 | 0.30 | 0.15 | 0.20 | 0.25 |
| D | 3.90 | 4.00 | 4.10 | 3.90 | 4.00 | 4.10 | 3.90 | 4.00 | 4.10 | 3.90 | 4.00 | 4.10 | 3.90 | 4.00 | 4.10 |
| E | 3.90 | 4.00 | 4.10 | 3.90 | 4.00 | 4.10 | 3.90 | 4.00 | 4.10 | 3.90 | 4.00 | 4.10 | 3.90 | 4.00 | 4.10 |
| e | 0.80 BSC. | | | 0.65 BSC. | | | 0.50 BSC. | | | 0.50 BSC. | | | 0.40 BSC. | | |
| k | 0.25 | - | - | 0.25 | - | - | 0.25 | - | - | 0.25 | - | - | 0.25 | - | - |
| L | 0.45 | 0.55 | 0.65 | 0.45 | 0.55 | 0.65 | 0.45 | 0.55 | 0.65 | 0.30 | 0.40 | 0.50 | 0.30 | 0.40 | 0.50 |
| N | 12 | | | 16 | | | 20 | | | 24 | | | 28 | | |
| ND | 3 | | | 4 | | | 5 | | | 6 | | | 7 | | |
| NE | 3 | | | 4 | | | 5 | | | 6 | | | 7 | | |
| Jedec Var. | WGGB | | | WGGC | | | WGGD-1 | | | WGGD-2 | | | WGGE | | |

**EXPOSED PAD VARIATIONS**

| PKG. CODES | D2 | | | E2 | | | DOWN BONDS ALLOWED |
|---|---|---|---|---|---|---|---|
| | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. | |
| T1244-2 | 1.95 | 2.10 | 2.25 | 1.95 | 2.10 | 2.25 | NO |
| T1244-3 | 1.95 | 2.10 | 2.25 | 1.95 | 2.10 | 2.25 | YES |
| T1244-4 | 1.95 | 2.10 | 2.25 | 1.95 | 2.10 | 2.25 | NO |
| T1644-2 | 1.95 | 2.10 | 2.25 | 1.95 | 2.10 | 2.25 | NO |
| T1644-3 | 1.95 | 2.10 | 2.25 | 1.95 | 2.10 | 2.25 | YES |
| T1644-4 | 1.95 | 2.10 | 2.25 | 1.95 | 2.10 | 2.25 | NO |
| T2044-1 | 1.95 | 2.10 | 2.25 | 1.95 | 2.10 | 2.25 | NO |
| T2044-2 | 1.95 | 2.10 | 2.25 | 1.95 | 2.10 | 2.25 | YES |
| T2044-3 | 1.95 | 2.10 | 2.25 | 1.95 | 2.10 | 2.25 | NO |
| T2444-1 | 2.45 | 2.60 | 2.63 | 2.45 | 2.60 | 2.63 | NO |
| T2444-2 | 1.95 | 2.10 | 2.25 | 1.95 | 2.10 | 2.25 | YES |
| T2444-3 | 2.45 | 2.60 | 2.63 | 2.45 | 2.60 | 2.63 | YES |
| T2444-4 | 2.45 | 2.60 | 2.63 | 2.45 | 2.60 | 2.63 | NO |
| T2844-1 | 2.50 | 2.60 | 2.70 | 2.50 | 2.60 | 2.70 | NO |

NOTES:

1. DIMENSIONING & TOLERANCING CONFORM TO ASME Y14.5M-1994.
2. ALL DIMENSIONS ARE IN MILLIMETERS. ANGLES ARE IN DEGREES.
3. N IS THE TOTAL NUMBER OF TERMINALS.
4. THE TERMINAL #1 IDENTIFIER AND TERMINAL NUMBERING CONVENTION SHALL CONFORM TO JESD 95-1 SPP-012. DETAILS OF TERMINAL #1 IDENTIFIER ARE OPTIONAL, BUT MUST BE LOCATED WITHIN THE ZONE INDICATED. THE TERMINAL #1 IDENTIFIER MAY BE EITHER A MOLD OR MARKED FEATURE.
5. DIMENSION b APPLIES TO METALLIZED TERMINAL AND IS MEASURED BETWEEN 0.25 mm AND 0.30 mm FROM TERMINAL TIP.
6. ND AND NE REFER TO THE NUMBER OF TERMINALS ON EACH D AND E SIDE RESPECTIVELY.
7. DEPOPULATION IS POSSIBLE IN A SYMMETRICAL FASHION.
8. COPLANARITY APPLIES TO THE EXPOSED HEAT SINK SLUG AS WELL AS THE TERMINALS.
9. DRAWING CONFORMS TO JEDEC MO220, EXCEPT FOR T2444-1, T2444-3, T2444-4 AND T2844-1.
10. MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY.
11. COPLANARITY SHALL NOT EXCEED 0.08mm
12. WARPAGE SHALL NOT EXCEEND 0.10mm
13. LEAD CENTERLINES TO BE AT TRUE POSITION AS DEFINED BY BASIC DIMENSION "e", ±0.05.

-DRAWING NOT TO SCALE-

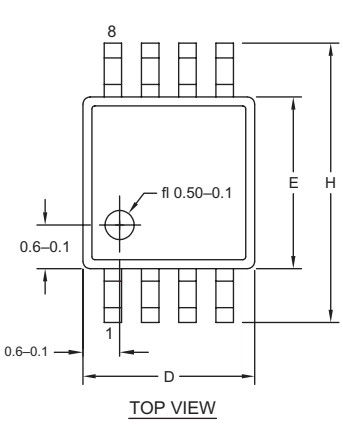
DALLAS SEMICONDUCTOR MAXIM
TITLE: PACKAGE OUTLINE, 12, 16, 20, 24, 28L THIN QFN, 4x4x0.8mm
APPROVAL
DOCUMENT CONTROL NO. 21-0139
REV. D
2/2

***NOTE:*** *THE THIN QFN EXPOSED PADDLE SIZE-VARIATION PACKAGE CODE: T1644-4*

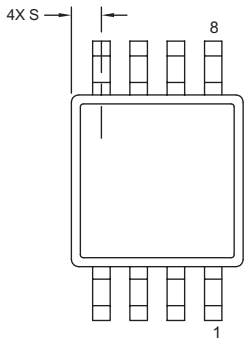
## Package Information (continued)

(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

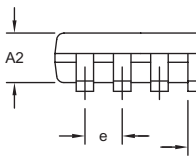



TOP VIEW

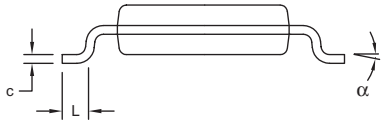



BOTTOM VIEW

| | INCHES | | MILLIMETERS | |
|---|---|---|---|---|
| DIM | MIN | MAX | MIN | 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

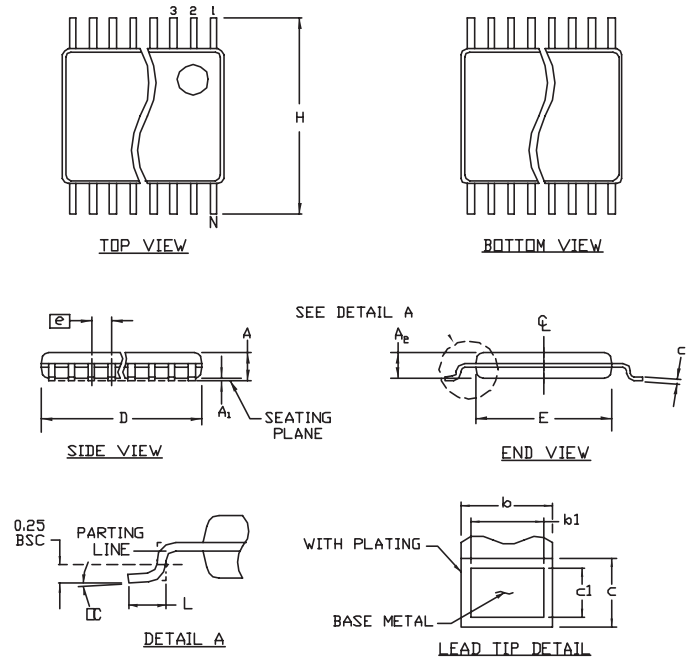
| APPROVAL | DOCUMENT CONTROL NO. | REV. | |
|---|---|---|---|
| | 21-0036 | J | 1/1 |

# High-Side Power and Current Monitors

## Package Information (continued)

(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**.)

TSSOP4.40mm.EPS




| SYMBOL | COMMON DIMENSIONS | | | |
|---|---|---|---|---|
| | MILLIMETERS | | INCHES | |
| | MIN. | MAX. | MIN. | MAX. |
| A | ——— | 1.10 | | .043 |
| $A_1$ | 0.05 | 0.15 | .002 | .006 |
| $A_e$ | 0.85 | 0.95 | .033 | .037 |
| b | 0.19 | 0.30 | .007 | .012 |
| | 0.19 | 0.25 | .007 | .010 |
| c | 0.09 | 0.20 | .004 | .008 |
| | 0.09 | 0.14 | .004 | .006 |
| D | SEE VARIATIONS | | SEE VARIATIONS | |
| E | 4.30 | 4.50 | .169 | .177 |
| e | 0.65 BSC | | .026 BSC | |
| H | 6.25 | 6.55 | .246 | .258 |
| L | 0.50 | 0.70 | .020 | .028 |
| N | SEE VARIATIONS | | SEE VARIATIONS | |
| α | 0° | 8° | 0° | 8° |

| JEDEC | | | VARIATIONS | | | |
|---|---|---|---|---|---|---|
| MO-153 | N | | MILLIMETERS | | INCHES | |
| | | | MIN. | MAX. | MIN. | MAX. |
| AB-1 | 14 | D | 4.90 | 5.10 | .193 | .201 |
| AB | 16 | D | 4.90 | 5.10 | .193 | .201 |
| AC | 20 | D | 6.40 | 6.60 | .252 | .260 |
| AD | 24 | D | 7.70 | 7.90 | .303 | .311 |
| AE | 28 | D | 9.60 | 9.80 | .378 | .386 |

NOTES:
1. DIMENSIONS D AND E DO NOT INCLUDE FLASH
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15mm PER SIDE
3. CONTROLLING DIMENSION: MILLIMETER
4. MEETS JEDEC OUTLINE MO-153. SEE JEDEC VARIATIONS TABLE
5. "N" REFERS TO NUMBER OF LEADS

# Mouser Electronics

Authorized Distributor

Click to View Pricing, Inventory, Delivery & Lifecycle Information:

Maxim Integrated:

MAX4210AETT+T MAX4210AEUA+T MAX4210BETT+T MAX4210BEUA+ MAX4210BEUA+T MAX4210CETT+T MAX4210CEUA+ MAX4210CEUA+T MAX4210DETT+T MAX4210DEUA+ MAX4210DEUA+T MAX4210EETT+T MAX4210EEUA+ MAX4210EEUA+T MAX4210FETT+T MAX4210FEUA+ MAX4210FEUA+T MAX4211AEUE+ MAX4211AEUE+T MAX4211BEUE+ MAX4211BEUE+T MAX4211DETE+ MAX4211DETE+T MAX4211EETE+ MAX4211EETE+T MAX4211EEUE+ MAX4211EEUE+T MAX4211FETE+ MAX4211FETE+T MAX4210AEUA+ MAX4211BETE+ MAX4211BETE+T MAX4211CEUE+ MAX4211FEUE MAX4211CEUE+T MAX4211FEUE-T MAX4210EEUA MAX4210EEUA-T MAX4211AEUE MAX4211AEUE-T MAX4211EEUE MAX4211EEUE-T MAX4211FEUE+T MAX4211FEUE+ MAX4211DEUE+ MAX4211DEUE+T MAX4211CETE+T MAX4211CETE+