



Current-Limited, High-Side P-Channel Switches with Thermal Shutdown

General Description

The MAX891L/MAX892L smart, low-voltage, P-channel, MOSFET power switches are intended for high-side load-switching applications. These switches operate with inputs from 2.7V to 5.5V, making them ideal for both 3V and 5V systems. Internal current-limiting circuitry protects the input supply against overload. Thermal-overload protection limits power dissipation and junction temperatures.

The MAX891L/MAX892L's maximum current limits are 500mA and 250mA, respectively. The current limit through the switch is programmed with a resistor from SET to ground. When the switch is on, the quiescent supply current is a low 13 μ A. When the switch is off, the quiescent current decreases to 0.1 μ A.

The MAX891L/MAX892L are available in 8-pin μ MAX packages.

Applications

PCMCIA Slots
Access Bus Slots
Portable Equipment

Features

- ♦ **Ultra-Small μ MAX Package—Only 1.11mm High**
- ♦ **2.7V to 5.5V Input Range**
- ♦ **Programmable Current Limit**
- ♦ **Low 13 μ A Quiescent Current at $V_{IN} = 3.3V$, 0.1 μ A Switch Off**
- ♦ **Thermal Shutdown**
- ♦ **FAULT Indicator Output**
- ♦ **On-Resistances:**
0.12 Ω (MAX891L)
0.25 Ω (MAX892L)

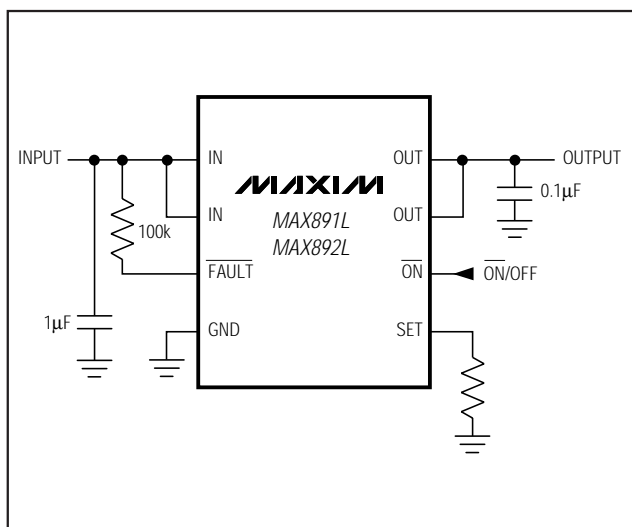
Ordering Information

| PART | TEMP. RANGE | PIN-PACKAGE | CURRENT LIMIT |
|-------------|----------------|-------------|---------------|
| MAX891LC/D | 0°C to +70°C | Dice** | 500mA |
| MAX891LEUA* | -40°C to +85°C | 8 μ MAX | 500mA |
| MAX892LC/D | 0°C to +70°C | Dice** | 250mA |
| MAX892LEUA* | -40°C to +85°C | 8 μ MAX | 250mA |

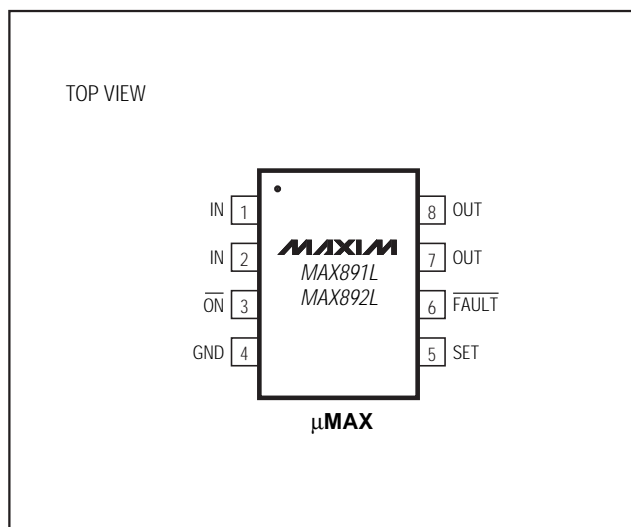
* To order these units in tape and reel, add (-T) to the end of the part number.

** Dice are tested at $T_A = +25^\circ\text{C}$.

Typical Operating Circuit



Pin Configuration



Maxim Integrated Products 1

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MAX891L/MAX892L

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ABSOLUTE MAXIMUM RATINGS

| | | | |
|---------------------------------------|--|---|---|
| IN to GND | -0.3V to 6V | Continuous Power Dissipation ($T_A = +70^\circ\text{C}$) | |
| $\overline{\text{ON}}$, FAULT to GND | -0.3V to 6V | μMAX (derate 4.1mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$) | 330mW |
| SET, OUT to GND | -0.3V to ($V_{\text{IN}} + 0.3\text{V}$) | Operating Temperature Range | |
| Maximum Continuous Switch Current | | MAX891LEUA/MAX892LEUA | -40 $^\circ\text{C}$ to +85 $^\circ\text{C}$ |
| MAX891L | 0.75A | Storage Temperature Range | -65 $^\circ\text{C}$ to +150 $^\circ\text{C}$ |
| MAX892L | 0.375A | Lead Temperature (soldering, 10sec) | +300 $^\circ\text{C}$ |

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

($V_{\text{IN}} = 3\text{V}$, $T_A = 0^\circ\text{C}$ to +85 $^\circ\text{C}$, unless otherwise noted. Typical values are at $T_A = +25^\circ\text{C}$.)

| PARAMETER | CONDITIONS | | MIN | TYP | MAX | UNITS |
|--|---|--|-------|-------|-------|------------------|
| Operating Voltage | | | 2.7 | | 5.5 | V |
| Quiescent Current | $V_{\text{IN}} = 5\text{V}$, $\overline{\text{ON}} = \text{GND}$, $I_{\text{OUT}} = 0\text{mA}$ | | | 13 | 20 | μA |
| Off-Supply Current | $\overline{\text{ON}} = \text{IN}$, $V_{\text{IN}} = V_{\text{OUT}} = 5.5\text{V}$ | | | 0.02 | 1 | μA |
| Off-Switch Current | $\overline{\text{ON}} = \text{IN}$, $V_{\text{IN}} = 5.5\text{V}$, $V_{\text{OUT}} = 0\text{V}$ | | | 0.02 | 3 | μA |
| Undervoltage Lockout | Rising edge, 1% hysteresis | | 2.0 | 2.3 | 2.6 | V |
| On-Resistance | $V_{\text{IN}} = 4.5\text{V}$ | MAX891L | | 120 | 225 | $\text{m}\Omega$ |
| | | MAX892L | | 250 | 420 | |
| | $V_{\text{IN}} = 3.0\text{V}$ | MAX891L | | 150 | 300 | $\text{m}\Omega$ |
| | | MAX892L | | 300 | 500 | |
| Current-Limit-Amplifier Accuracy | V_{SET} required to turn the switch off (Note 1) | | 1.178 | 1.240 | 1.302 | V |
| Maximum Output Current | MAX891L | | | 500 | | mA |
| | MAX892L | | | 250 | | |
| I_{OUT} to I_{SET} Current Ratio | $V_{\text{OUT}} = 1.6\text{V}$ to 2.8V | MAX891L, $I_{\text{OUT}} = 250\text{mA}$ | 840 | 965 | 1130 | A/A |
| | | MAX892L, $I_{\text{OUT}} = 125\text{mA}$ | 840 | 965 | 1130 | |
| $\overline{\text{ON}}$ Input Low Voltage | $V_{\text{IN}} = 2.7\text{V}$ to 5.5V | | | | 0.8 | V |
| $\overline{\text{ON}}$ Input High Voltage | $V_{\text{IN}} = 2.7\text{V}$ to 3.6V | | 2.0 | | | V |
| | $V_{\text{IN}} = 4.5\text{V}$ to 5.5V | | 2.4 | | | |
| $\overline{\text{ON}}$ Input Leakage | $V_{\overline{\text{ON}}} = 5.5\text{V}$ | | -1 | 0.01 | 1 | μA |
| I_{SET} Bias Current | $V_{\text{SET}} = 1.24\text{V}$, $I_{\text{OUT}} = 0\text{mA}$ | | | 0.5 | 3 | μA |
| FAULT Logic Output Low Voltage | $I_{\text{SINK}} = 1\text{mA}$, $V_{\text{SET}} = 1.4\text{V}$ | | | | 0.4 | V |
| FAULT Logic Output High Leakage | $V_{\text{FAULT}} = 5.5\text{V}$, $V_{\text{SET}} = 1\text{V}$ | | | 0.05 | 1 | μA |
| Slow-Current-Loop Response Time | 20% current overdrive, $V_{\text{IN}} = 5\text{V}$ | | | 5 | | μs |
| Fast-Current-Loop Response Time | | | | 2 | | μs |
| Turn-On Time | $I_{\text{OUT}} = 250\text{mA}$ (MAX891L), or 125mA (MAX892L) | $V_{\text{IN}} = 5\text{V}$ | | 100 | 200 | μs |
| | | $V_{\text{IN}} = 3\text{V}$ | | 150 | | |
| Turn-Off Time | $V_{\text{IN}} = 5\text{V}$ | | 0.8 | 2 | 20 | μs |

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MAX891L/MAX892L

ELECTRICAL CHARACTERISTICS

($V_{IN} = 3V$, $T_A = -40^{\circ}C$ to $+85^{\circ}C$, unless otherwise noted.) (Note 2)

| PARAMETER | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|----------------------------|-----|------|-----------|
| Operating Voltage | | 3.0 | | 5.5 | V |
| Quiescent Current | $V_{IN} = 5V$, $\overline{ON} = GND$, $I_{OUT} = 0mA$ | | | 50 | μA |
| Off-Supply Current | $\overline{ON} = IN$, $V_{IN} = V_{OUT} = 5.5V$ | | | 2.2 | μA |
| Off-Switch Current | $\overline{ON} = IN$, $V_{IN} = 5.5V$, $V_{OUT} = 0V$ | | | 8 | μA |
| Undervoltage Lockout | Rising edge, 1% hysteresis | 2.0 | | 2.9 | V |
| On-Resistance | $V_{IN} = 4.5V$ | MAX891L | | 225 | $m\Omega$ |
| | | MAX892L | | 420 | |
| | $V_{IN} = 3.0V$ | MAX891L | | 300 | $m\Omega$ |
| | | MAX892L | | 500 | |
| Current-Limit-Amplifier Accuracy | V_{SET} required to turn the switch off (Note 1) | 1.14 | | 1.34 | V |
| I_{OUT} to I_{SET} Current Ratio | $V_{OUT} = 1.6V$ to $2.8V$ | MAX891L, $I_{OUT} = 250mA$ | | 805 | A/A |
| | | MAX892L, $I_{OUT} = 125mA$ | | 805 | |
| \overline{FAULT} Logic Output Low Voltage | $I_{SINK} = 1mA$, $V_{SET} = 1.4V$ | | | 0.4 | V |
| Turn-On Time | $V_{IN} = 5V$ | | | 200 | μs |
| Turn-Off Time | $V_{IN} = 5V$ | 0.25 | | 20 | μs |

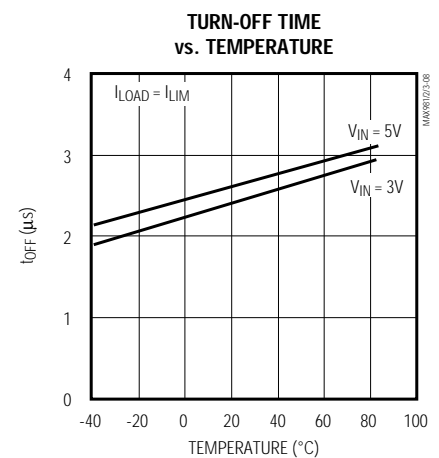
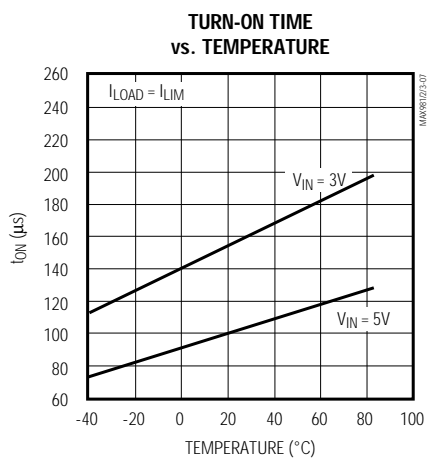
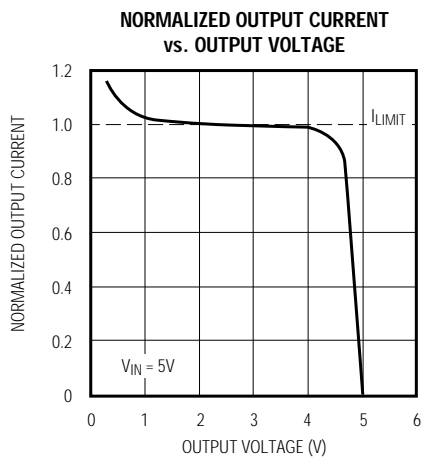
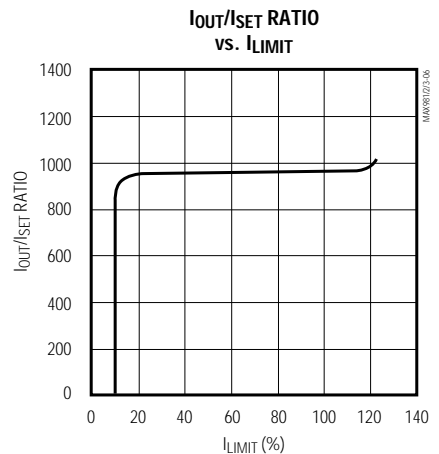
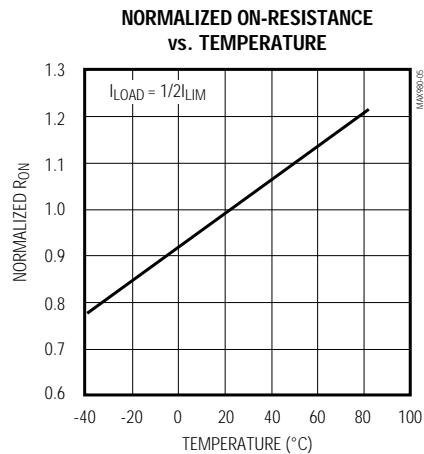
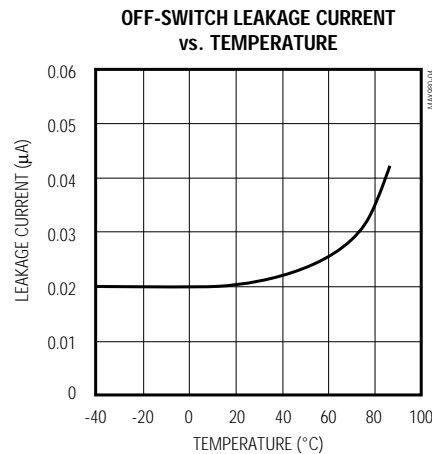
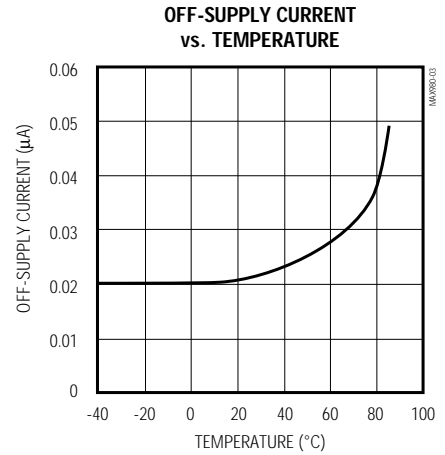
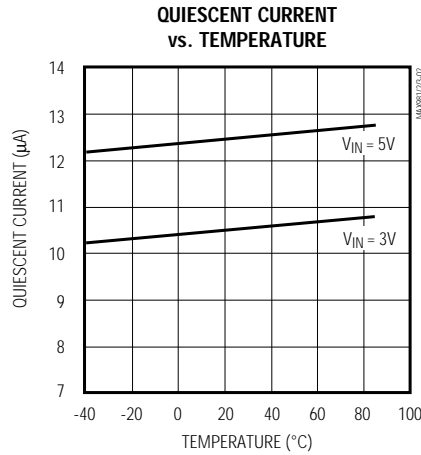
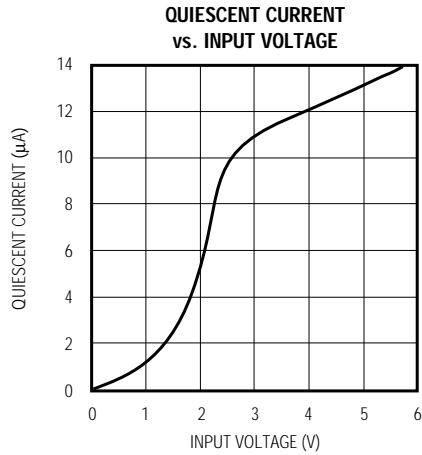
Note 1: Tested with $I_{OUT} = 50mA$ for the MAX891L, 25mA for the MAX892L, and V_{SET} raised until $V_{IN} - V_{OUT} \geq 0.8V$.

Note 2: Parameters to $-40^{\circ}C$ are guaranteed by design, not production tested.

Current-Limited, High-Side P-Channel Switches with Thermal Shutdown

Typical Operating Characteristics

(Typical Operating Circuit, $T_A = +25^\circ\text{C}$, unless otherwise noted.)

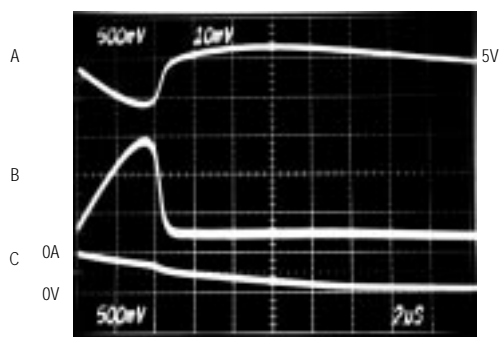


Current-Limited, High-Side P-Channel Switches with Thermal Shutdown

Typical Operating Characteristics (continued)

(Typical Operating Circuit, $T_A = +25^\circ\text{C}$, unless otherwise noted.)

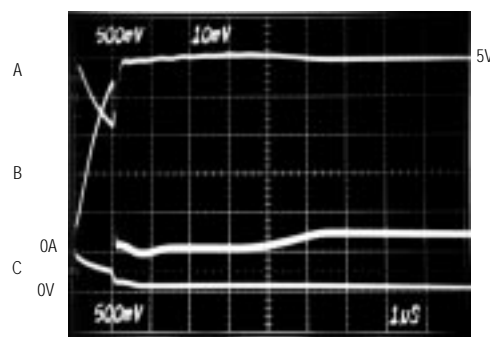
CURRENT-LIMIT RESPONSE
(MAX891L, $R_L = 0.8\Omega$)



$C_{IN} = 47\mu\text{F}$, $C_{OUT} = 0.1\mu\text{F}$
A: V_{IN} , 500mV/div, AC COUPLED

B: I_{OUT} , 2A/div
C: V_{OUT} , 5V/div

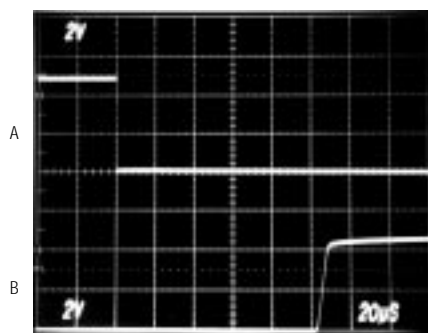
CURRENT-LIMIT RESPONSE
(MAX891L, $R_L = 0.5\Omega$)



$C_{IN} = 47\mu\text{F}$, $C_{OUT} = 0.1\mu\text{F}$
A: V_{IN} , 500mV/div, AC COUPLED

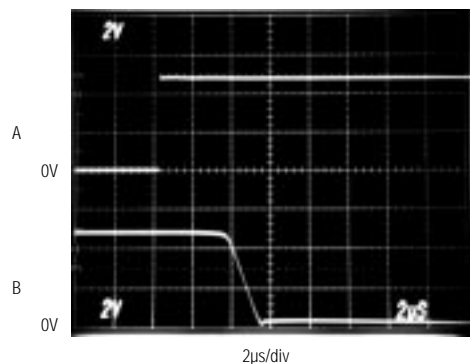
B: I_{OUT} , 2A/div
C: V_{OUT} , 5V/div

SWITCH TURN-ON TIME



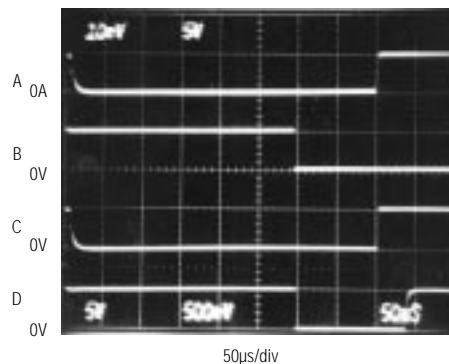
$V_{IN} = 5\text{V}$, $I_{OUT} = I_{LIM}$
A: V_{ON} , 2V/div
B: V_{OUT} , 2V/div

SWITCH TURN-OFF TIME



$V_{IN} = 5\text{V}$, $I_{OUT} = I_{LIM}$
A: V_{ON} , 2V/div
B: V_{OUT} , 2V/div

SWITCH TIMING CHARACTERISTICS



$V_{IN} = 5\text{V}$
A: I_{LOAD} , 0.1A/div
B: V_{ON} , 5V/div

C: V_{OUT} , 5V/div
D: V_{FAULT} , 5V/div

Current-Limited, High-Side P-Channel Switches with Thermal Shutdown

Pin Description

| PIN | NAME | FUNCTION |
|------|---------------------------|---|
| 1, 2 | IN | Input. P-channel MOSFET source. Bypass IN with a 1μF capacitor to ground. |
| 3 | $\overline{\text{ON}}$ | Active-Low Switch On Input. A logic low turns the switch on. |
| 4 | GND | Ground |
| 5 | SET | Set Current-Limit Input. A resistor from SET to ground sets the current limit for the switch. See <i>Setting the Current Limit</i> section. |
| 6 | $\overline{\text{FAULT}}$ | Fault-Indicator Output. This open-drain output goes low when in current limit or when the die temperature exceeds +135°C. |
| 7, 8 | OUT | Switch Output. P-channel MOSFET drain. Bypass OUT with a 0.1μF capacitor to ground. |

Detailed Description

The MAX891L/MAX892L P-channel MOSFET power switches limit output current to a user-programmed level. When the output current is increased beyond the set current level, the current is also increased through the replica switch ($I_{\text{OUT}}/965$) and through R_{SET} (Figure 1). The current-limit error amplifier compares the voltage across R_{SET} to the internal 1.24V reference and regulates the current back to the lesser of the programmed current limit (I_{LIMIT}) or the maximum current limit (I_{MAX}).

These switches are not bidirectional; therefore, the input voltage must be higher than the output voltage.

Setting the Current Limit

The MAX891L/MAX892L feature internal current-limiting circuitry with maximum programmable values (I_{MAX}) of 500mA and 250mA, respectively. For best performance, set the current limit (I_{LIMIT}) between $0.2I_{\text{MAX}} \leq I_{\text{LIMIT}} \leq I_{\text{MAX}}$. This current limit remains in effect throughout the input supply-voltage range.

Program the current limit with a resistor (R_{SET}) from SET to ground (Figure 2) as follows:

$$I_{\text{SET}} = I_{\text{LIMIT}} / I_{\text{RATIO}}$$

$$R_{\text{SET}} = 1.240 / I_{\text{SET}}$$

where I_{LIMIT} is the desired current limit, and I_{RATIO} is the I_{OUT} to I_{SET} current ratio (965).

Short-Circuit Protection

The MAX891L/MAX892L are short-circuit-protected switches. In the event of an output short circuit or current-overload condition, the current through the switch is limited by the internal current-limiting error amplifier to $1.5 \times I_{\text{LIMIT}}$. When the fault condition is removed, the replica error amplifier sets the current limit back to I_{LIMIT} .

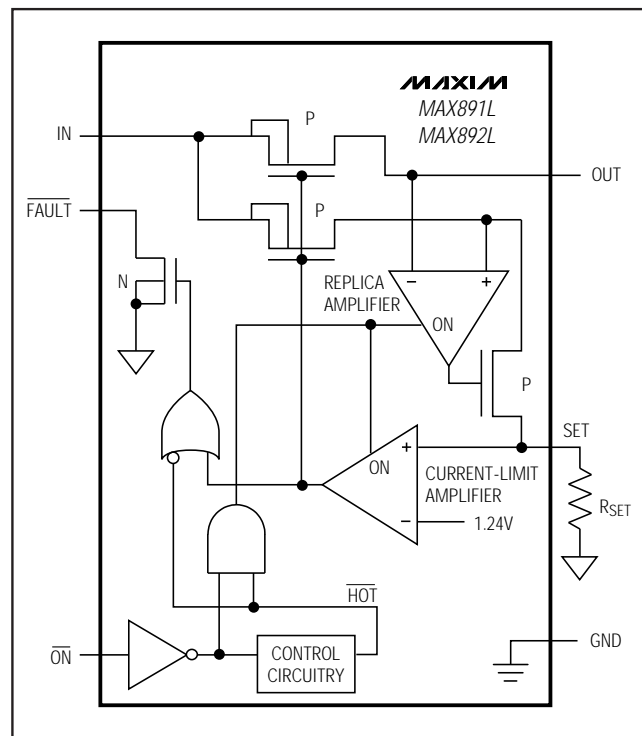


Figure 1. Functional Diagram

For a high $\Delta I_{\text{DS}}/\Delta$ during an output short-circuit condition, the switch turns off and disconnects the input supply from the output. The current-limiting amplifier then slowly turns the switch on with the output current limited to $1.5 \times I_{\text{LIMIT}}$. When the fault condition is removed, the current limit is set back to I_{LIMIT} . Refer to the Current-Limit Response graphs in the *Typical Operating Characteristics*.

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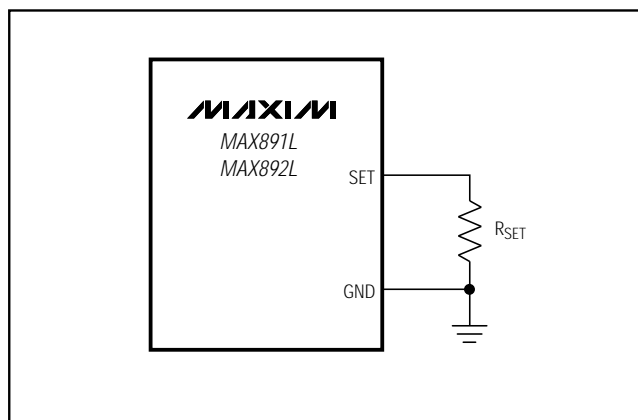


Figure 2. Setting the Current Limit

Thermal Shutdown

The MAX891L/MAX892L feature thermal shutdown. The switch turns off when the junction temperature exceeds +135°C. Once the device cools by 10°C, the switch turns back on. If the fault short-circuit condition is not removed, the switch will cycle on and off, resulting in a pulsed output.

Fault Indicator

The MAX891L/MAX892L provide a fault output ($\overline{\text{FAULT}}$). This open-drain output goes low when in current limit or when the die temperature exceeds +135°C. During start-up, $\overline{\text{FAULT}}$ is low until the switch is fully on and no over-current condition exists. A 100k Ω pull-up resistor from $\overline{\text{FAULT}}$ to IN provides a logic-control signal.

Applications Information

Input Capacitor

To limit input voltage drop during momentary output short-circuit conditions, connect a capacitor from IN to GND. A 1 μF ceramic capacitor is adequate for most applications; however, higher capacitor values further reduce voltage drop at the input.

Output Capacitor

Connect a 0.1 μF capacitor from OUT to GND. One function of this capacitor is to prevent inductive parasitics from pulling OUT negative during turn-off.

Layout and Thermal-Dissipation Consideration

To take full advantage of the switch-response time to output short-circuit conditions, it is very important to keep all traces as short as possible to reduce the effect of undesirable parasitic inductance. Place input and output capacitors as close as possible to the device (no more than 5mm).

Under normal operating conditions, the package dissipates and channels heat away. Calculate maximum power as follows:

$$P = I_{\text{LIM}}^2 \times R_{\text{ON}}$$

where R_{ON} is the on-resistance of the switch.

When the output is short circuited, voltage drop across the switch equals the input supply. Hence, the power dissipated across the switch increases, as does the die temperature. If the fault condition is not removed, the thermal-overload-protection circuitry turns the switch off until the die temperature falls by 10°C. A ground plane in contact with the device helps dissipate additional heat.

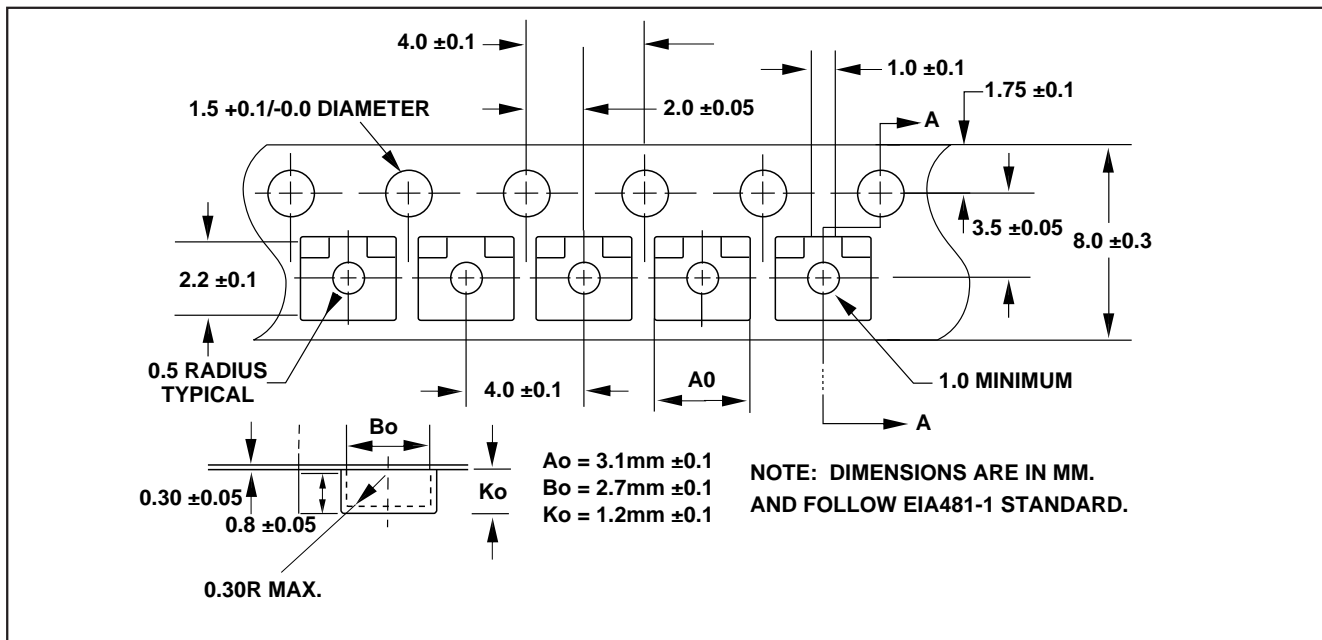
Chip Information

TRANSISTOR COUNT: 396

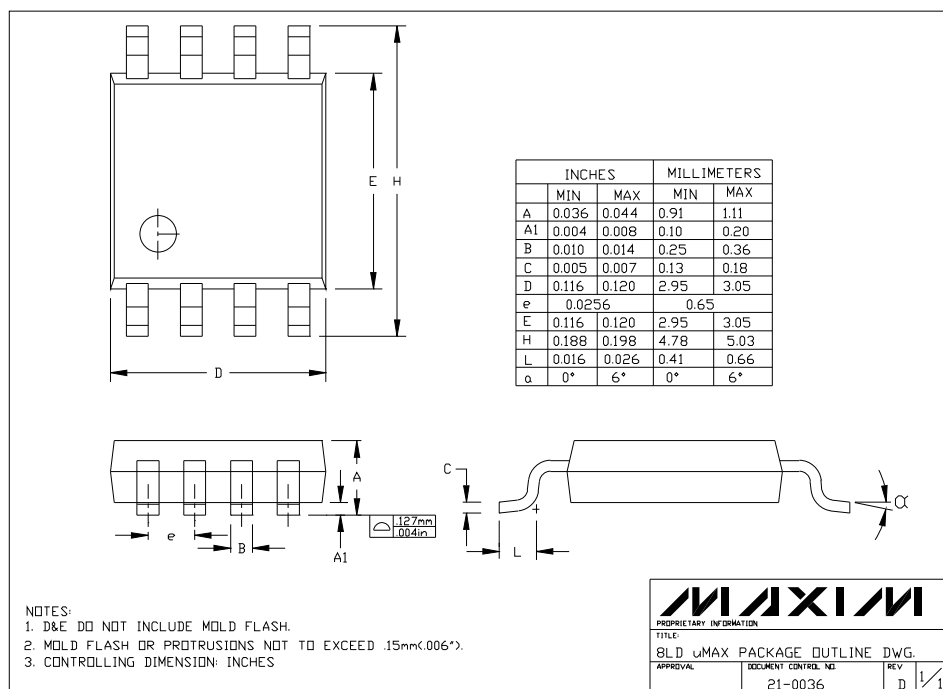
SUBSTRATE CONNECTED TO GND

Current-Limited, High-Side P-Channel Switches with Thermal Shutdown

Tape-and-Reel Information



Package Information



Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.

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