19-1146; Rev 2; 11/98

1A, Current-Limited, High-Side P-Channel Switch with Thermal Shutdown

General Description

The MAX890L smart, low-voltage, P-channel, MOSFET power switch is intended for high-side load-switching applications. This switch operates with inputs from 2.7V to 5.5V, making it 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 MAX890L's maximum current limit is 1A. The current limit through the switch is programmed with a resistor from SET to ground. The quiescent supply current is a low 10µA. When the switch is off, the supply current decreases to 0.1µA.

The MAX890L is available in an 8-pin SO package.

Features

- **2.7V to 5.5V Input Range**
- **Programmable Current Limit**
- **Low Quiescent Current**
  - **10µA (typ) at V_{IN} = 3.3V**
  - **0.1µA (typ) with Switch Off**
- **Thermal Shutdown**
- **$\overline{\text{FAULT}}$ Indicator Output**
- **0.09Ω (typ) On-Resistance**

Applications

PCMCIA Slots

Access Bus Slots

Portable Equipment

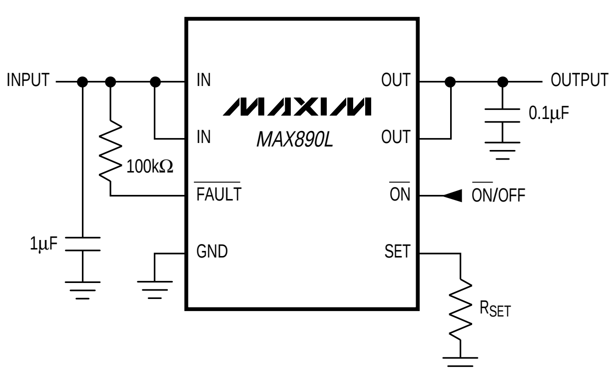
Ordering Information

PART*	TEMP. RANGE	PIN-PACKAGE	CURRENT LIMIT
MAX890LC/D	0°C to +70°C	Dice**	1A
MAX890LESA	-40°C to +85°C	8 SO	1A

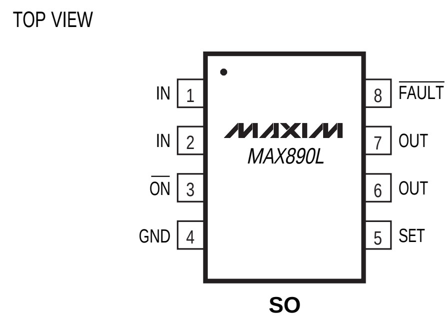
** To order this unit in tape and reel, add (-T) to the end of the part number.*

*** Dice are tested at T_A = +25°C.*

Typical Operating Circuit



Pin Configuration



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ABSOLUTE MAXIMUM RATINGS

IN to GND ....-0.3V to 6V
$\overline{ON}$, $\overline{FAULT}$ to GND ....-0.3V to 6V
SET, OUT to GND .... -0.3V to (V_{IN} + 0.3V)
Maximum Continuous Switch Current 1.5A
Continuous Power Dissipation (T_A = +70°C)
SO (derate 5.88mW/°C above +70°C) 471mW

Operating Temperature Range
MAX890LESA ....-40°C to +85°C
Storage Temperature Range .... -65°C to +150°C
Lead Temperature (soldering, 10sec) . ...+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_{IN} = 3V, **T_A = 0°C to +85°C,** unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Operating Voltage		2.7		5.5	V
Quiescent Current	V_{IN} = 5V, $\overline{ON}$ = GND, I_{OUT} = 0		13	20	µA
Off-Supply Current	$\overline{ON}$ = IN, V_{IN} = V_{OUT} = 5.5V		0.03	1	µA
Off-Switch Current	$\overline{ON}$ = IN, V_{IN} = 5.5V, V_{OUT} = 0		0.04	15	µA
Undervoltage Lockout	Rising edge, 1% hysteresis	2.0	2.4	2.6	V
On-Resistance	V_{IN} = 4.5V		75	130	mΩ
	V_{IN} = 3.0V		90	150	
Current-Limit-Amplifier Threshold	V_{SET} required to turn the switch off (Note 1)	1.178	1.240	1.302	V
Maximum Output Current Limit			1		A
I_{OUT} to I_{SET} Current Ratio	I_{OUT} = 500mA, V_{OUT} > 1.6V	970	1110	1300	A/A
$\overline{ON}$ Input Low Voltage	V_{IN} = 2.7V to 5.5V			0.8	V
$\overline{ON}$ Input High Voltage	V_{IN} = 2.7V to 3.6V	2.0			V
	V_{IN} = 4.5V to 5.5V	2.4			
$\overline{ON}$ Input Leakage	$V_{\overline{ON}}$ = 5.5V		0.01	1	µA
I_{SET} Bias Current	V_{SET} = 1.24V, I_{OUT} = 0; V_{IN} = V_{OUT}		0.5	3	µA
$\overline{FAULT}$ Logic Output Low Voltage	I_{SINK} = 1mA, V_{SET} = 1.4V			0.4	V
$\overline{FAULT}$ Logic Output High Leakage Current	$V_{\overline{FAULT}}$ = 5.5V, V_{SET} = 1V		0.05	1	µA
Slow-Current-Loop Response Time	20% current overdrive, V_{CC} = 5V		5		µs
Fast-Current-Loop Response Time			2		µs
Turn-On Time	V_{IN} = 5V, I_{OUT} = 500mA		120	200	µs
	V_{IN} = 3V, I_{OUT} = 500mA		185		
Turn-Off Time	V_{IN} = 5V	2	5		µs

Note 1: Tested with I_{OUT} = 100mA and V_{SET} raised until V_{IN} - V_{OUT} ≥ 0.8V.

ELECTRICAL CHARACTERISTICS

(V_{IN} = 3V, **T_A = -40°C to +85°C,** unless otherwise noted.) (Note 2)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Operating Voltage		2.9		5.5	V
Quiescent Current	V_{IN} = 5V, $\overline{ON}$ = GND, I_{OUT} = 0			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} = 0			15	µA
Undervoltage Lockout	Rising edge, 1% hysteresis	2.0		2.9	V
On-Resistance	V_{IN} = 4.5V			130	mΩ
	V_{IN} = 3.0V			150	
Current-Limit-Amplifier Threshold	V_{SET} required to turn the switch off (Note 1)	1.14		1.34	V
I_{OUT} to I_{SET} Current Ratio	I_{OUT} = 500mA, V_{OUT} > 1.6V	925		1390	A/A
$\overline{FAULT}$ Logic Output Low Voltage	I_{SINK} = 1mA, V_{SET} = 1V			0.4	V
Turn-On Time	V_{IN} = 5V			200	µs
Turn-Off Time	V_{IN} = 5V	1		20	µs

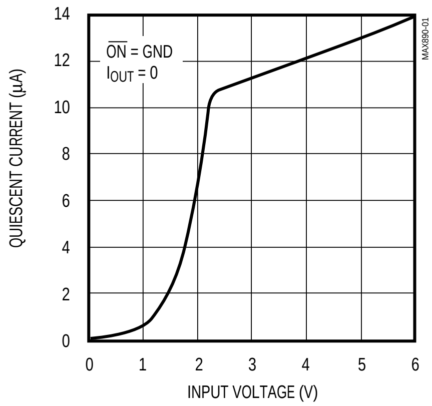
Note 2: Specifications to -40°C are guaranteed by design, not production tested.

1A, Current-Limited, High-Side P-Channel Switch with Thermal Shutdown

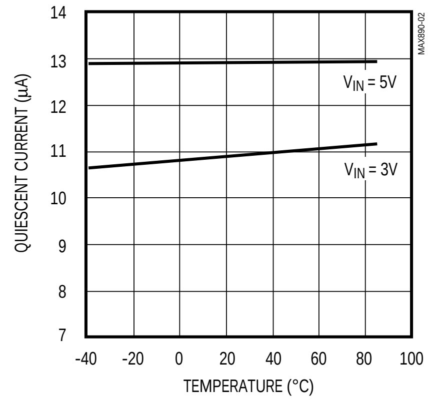
Typical Operating Characteristics

(T_A = +25°C, unless otherwise noted.)

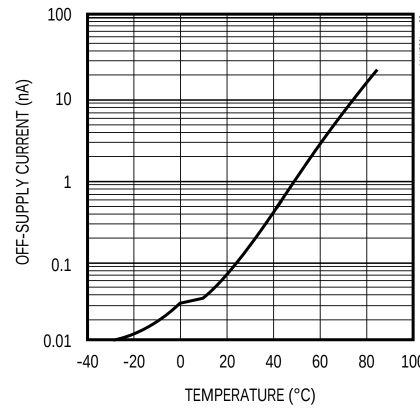
QUIESCENT CURRENT vs. INPUT VOLTAGE



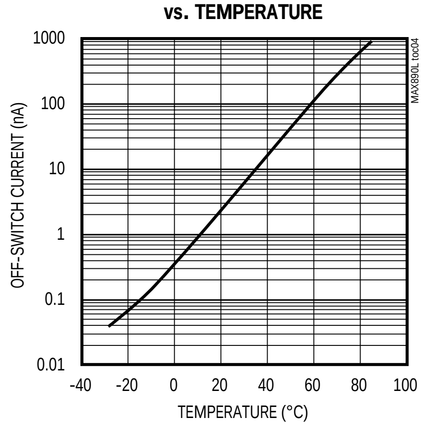
QUIESCENT CURRENT vs. TEMPERATURE



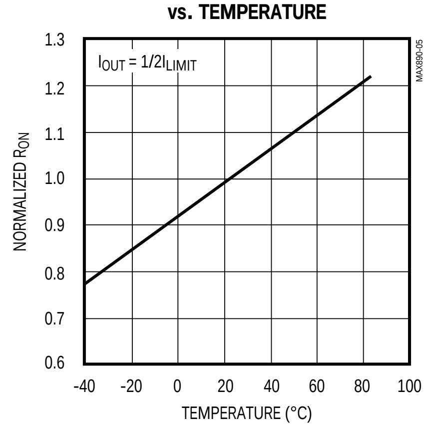
OFF-SUPPLY CURRENT vs. TEMPERATURE



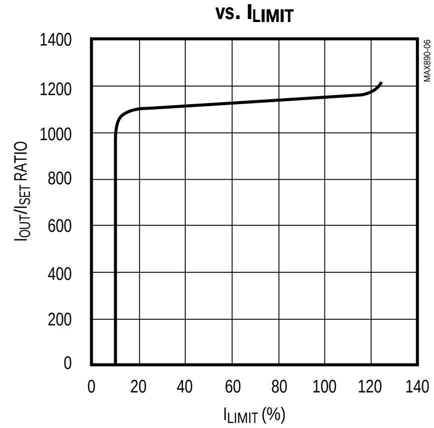
OFF-SWITCH CURRENT vs. TEMPERATURE



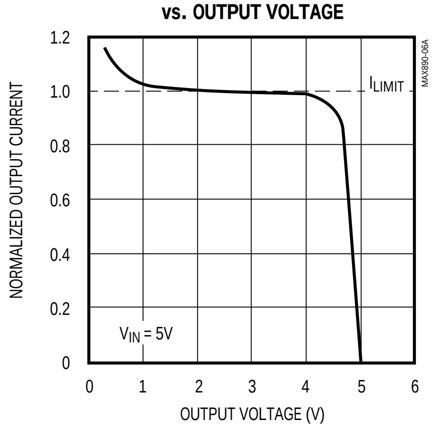
NORMALIZED ON-RESISTANCE vs. TEMPERATURE



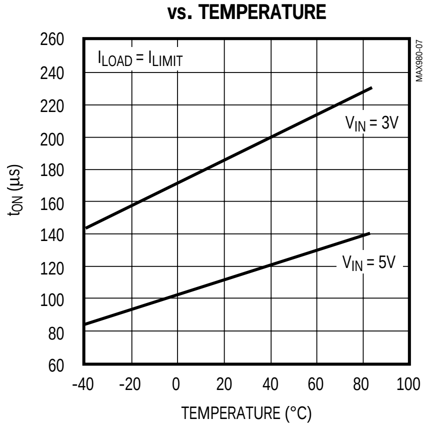
I_{OUT}/I_{SET} RATIO vs. I_{LIMIT}



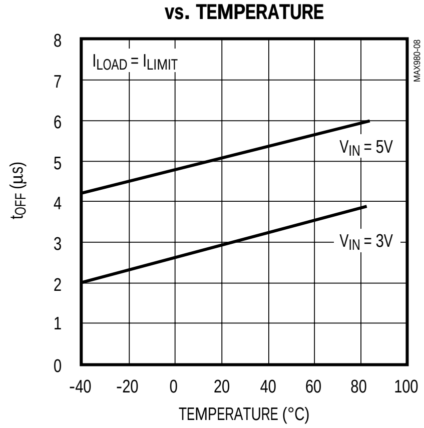
NORMALIZED OUTPUT CURRENT vs. OUTPUT VOLTAGE



TURN-ON TIME vs. TEMPERATURE



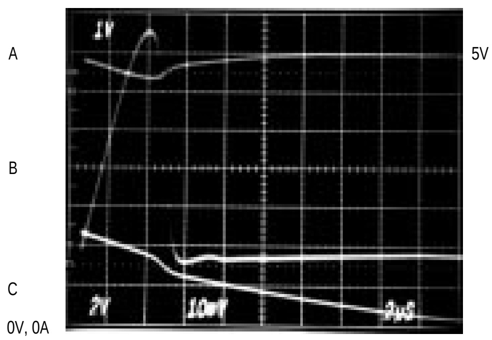
TURN-OFF TIME vs. TEMPERATURE



Typical Operating Characteristics (continued)

(T_A = +25°C, unless otherwise noted.)

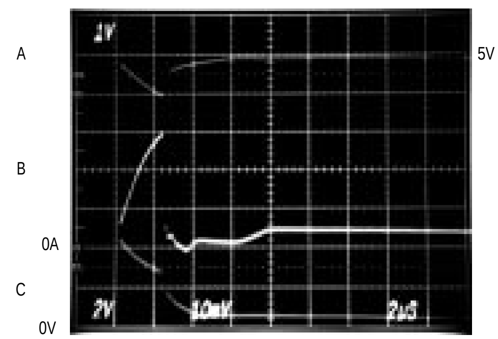
CURRENT-LIMIT RESPONSE (R_L = 0.6Ω)



2µs/div

C_{IN} = 100µF, C_{OUT} = 0.1µF
A: V_{IN}, 1V/div, AC COUPLED
B: I_{OUT}, 1A/div
C: V_{OUT}, 2V/div

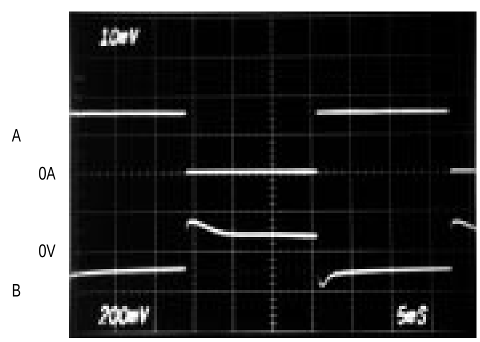
CURRENT-LIMIT RESPONSE (R_L = 0.3Ω)



2µs/div

C_{IN} = 100µF, C_{OUT} = 0.1µF
A: V_{IN}, 1V/div, AC COUPLED
B: I_{OUT}, 5A/div
C: V_{OUT}, 2V/div

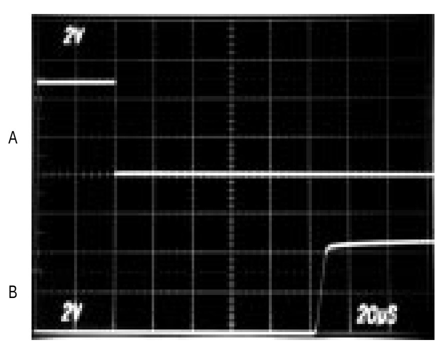
LOAD-TRANSIENT RESPONSE



5ms/div

V_{IN} = 5V
A: I_{OUT} = 0mA TO 750mA, 0.5A/div
B: V_{OUT} RIPPLE, 200mV/div, AC COUPLED

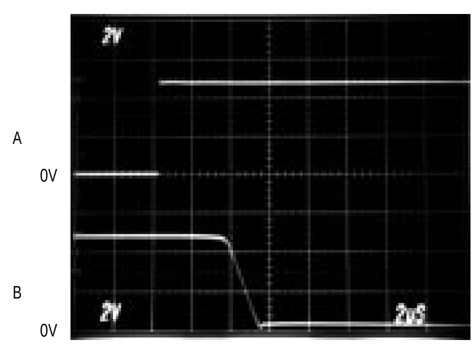
SWITCH TURN-ON TIME



20µs/div

V_{IN} = 5V, I_{OUT} = I_{LIMIT}
A: V_{ON}, 2V/div
B: V_{OUT}, 2V/div

SWITCH TURN-OFF TIME



2µs/div

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

1A, Current-Limited, High-Side P-Channel Switch 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. $R_{SET} = 1.38 \times 10^3 / I_{LIMIT}$, where I_{LIMIT} is the desired current limit in amperes.
6, 7	OUT	Switch Output. P-channel MOSFET drain. Bypass OUT with a 0.1µF capacitor to ground.
8	$\overline{\text{FAULT}}$	Fault-Indicator Output. This open-drain output goes low when in current limit or when the die temperature exceeds +135°C.

Detailed Description

The MAX890L P-channel MOSFET power switch limits output current to a programmed level. When the output current is increased beyond the programmed current limit, or 1A (I_{MAX}), the current also increases through the replica switch (I_{OUT}/1110) 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 limit (I_{LIMIT}) or 1A.

This switch is not bidirectional; therefore, the input voltage must be higher than the output voltage.

Setting the Current Limit

The MAX890L features internal current-limiting circuitry with a maximum programmable value (I_{MAX}) of 1A. For best performance, set the current limit (I_{LIMIT}) between $0.2\ I_{MAX} \le I_{LIMIT} \le I_{MAX}$. 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:

$$I_{SET} = I_{LIMIT} / 1110$$

$$R_{SET} = 1.24V / I_8 = 1.38 \times 10^3 / I_{LIMIT}$$

where I_{LIMIT} is the desired current limit.

Short-Circuit Protection

The MAX890L is a short-circuit-protected switch. 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 $1.5 \times I_{LIMIT}$. When the fault condition is removed, the replica error amplifier will set the current limit back to I_{LIMIT}.

For a high dV_{DS}/dt 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 $1.5 \times I_{LIMIT}$. When the fault condition is removed, the current limit is set back to I_{LIMIT}. Refer to Output Short-Circuit Fast-Loop Response and Output Short-Circuit Slow-Loop Response in the *Typical Operating Characteristics*.

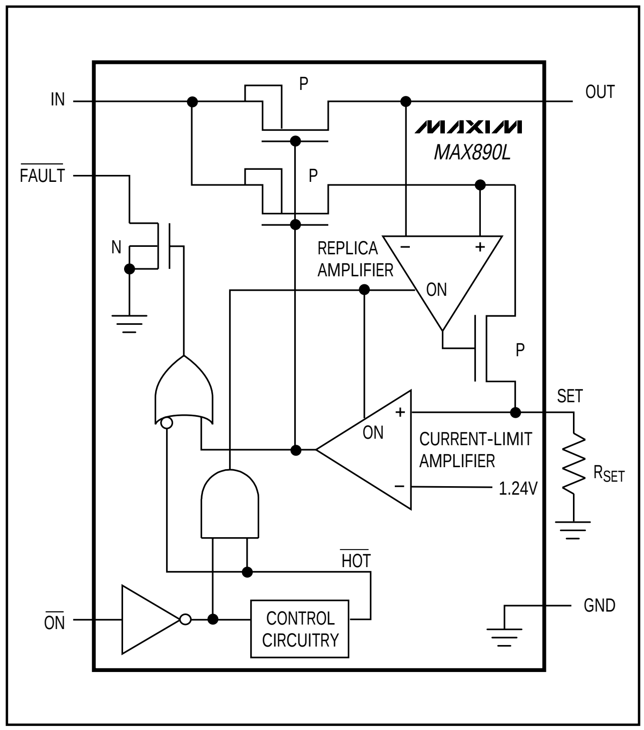


Figure 1. Functional Diagram

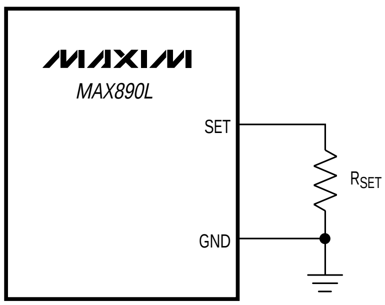


Figure 2. Setting the Current Limit

Thermal Shutdown

The MAX890L features 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 MAX890L provides a fault output ($\overline{FAULT}$). This open-drain output goes low when in current limit or when the die temperature exceeds +135°C. A 100kΩ pull-up resistor from $\overline{FAULT}$ to IN provides a logic-control signal.

Applications Information

Input Capacitor

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

Output Capacitor

Connect a 0.1µF 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 can dissipate and channel heat away. Calculate the maximum power as follows:

$$P = I^2_{LIMIT} \times R_{ON}$$

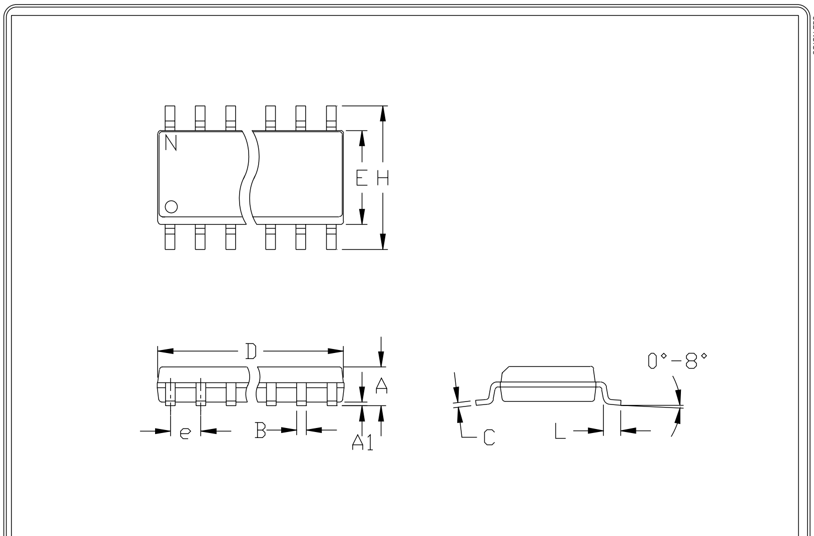
where R_{ON} is the on-resistance of the switch.

When the output is short circuited, the 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 will help dissipate additional heat.

Chip Information

TRANSISTOR COUNT: 396

Package Information



	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.053	0.069	1.35	1.75
A1	0.004	0.010	0.10	0.25
B	0.014	0.019	0.35	0.49
C	0.007	0.010	0.19	0.25
e	0.050		1.27	
E	0.150	0.157	3.80	4.00
H	0.228	0.244	5.80	6.20
h	0.010	0.020	0.25	0.50
L	0.016	0.050	0.40	1.27

	INCHES		MILLIMETERS			
	MIN	MAX	MIN	MAX	N	MS012
D	0.189	0.197	4.80	5.00	8	A
D	0.337	0.344	8.55	8.75	14	B
D	0.386	0.394	9.80	10.00	16	C

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15mm (.006")
3. LEADS TO BE COPLANAR WITHIN .102mm (.004")
4. CONTROLLING DIMENSION: MILLIMETER
5. MEETS JEDEC MS012-XX AS SHOWN IN ABOVE TABLE
6. N = NUMBER OF PINS

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