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19-2944; Rev 0; 8/03

MAXIM

450mA/500mA Current-Limit Switches

General Description

The MAX4795–MAX4798 family of switches feature internal current limiting to prevent damage to host devices due to faulty load conditions. These analog switches have a low 0.2Ω on-resistance and operate from a 2.0V to 4.5V input voltage range. They are available with guaranteed 450mA and 500mA current limits, making them ideal for SDIO and other load-switching applications.

When the switch is on and a load is connected to the port, a guaranteed blanking time of 14ms ensures the transient voltages settle down. If after this blanking time, the load current is greater than the current limit, the MAX4795 and MAX4797 switches are turned off and $\overline{FLAG}$ is issued to the microprocessor. The switch can be turned on again by cycling the power or the ON input.

The MAX4796 and MAX4798 have an autoretry feature where the switch turns off and issues a $\overline{FLAG}$ to the microprocessor after the blanking time and then continuously checks to see if the overload condition is present. The switch remains on after the overload condition disappears and $\overline{FLAG}$ deasserts.

The MAX4795–MAX4798 are available in tiny, space-saving, 5-pin SOT23 and 6-pin TDFN (3mm x 3mm) packages.

Applications

SDIO

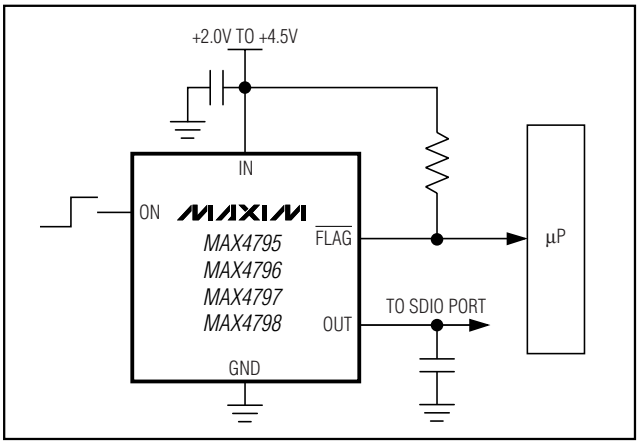
PDAs and Palmtop Devices

Cell Phones

GPS Systems

Hand-Held Devices

Typical Operating Circuit



Features

- ♦ **Guaranteed Current Limit: 450mA and 500mA**
- ♦ **Thermal-Shutdown Protection**
- ♦ **Reverse-Current Protection**
- ♦ **0.2Ω On-Resistance**
- ♦ **14ms Guaranteed Blanking Time**
- ♦ **$\overline{FLAG}$ Function**
- ♦ **Autoretry (MAX4796/MAX4798)**
- ♦ **80µA Supply Current**
- ♦ **6µA Latchoff Current (MAX4795/MAX4797)**
- ♦ **0.01µA Shutdown Current**
- ♦ **+2V to +4.5V Supply Range**
- ♦ **Fast Current-Limit Response Time**
- ♦ **Tiny SOT23 and TDFN Packages**
- ♦ **UL Certification Pending**

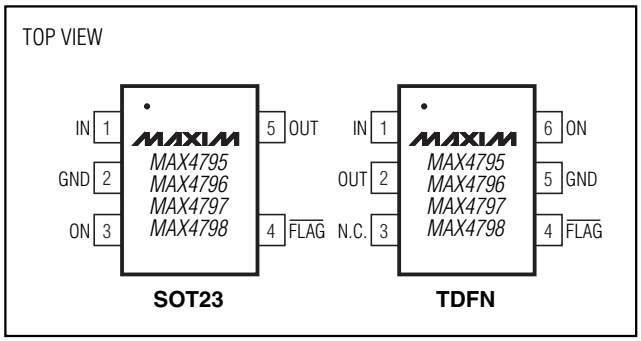
Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	TOP MARK
MAX4795EUK-T	-40°C to +85°C	5 SOT23-5	AEDI
MAX4795ETT*	40°C to +85°C	6 TDFN-EP**	—
MAX4796EUK-T	-40°C to +85°C	5 SOT23-5	AEDJ
MAX4796ETT*	-40°C to +85°C	6 TDFN-EP**	—
MAX4797EUK-T	-40°C to +85°C	5 SOT23-5	AEDK
MAX4797ETT*	-40°C to +85°C	6 TDFN-EP**	—
MAX4798EUK-T	-40°C to +85°C	5 SOT23-5	AEDL
MAX4798ETT*	-40°C to +85°C	6 TDFN-EP**	—

*Future product—contact factory for availability.
**EP = Exposed pad.

Selector Guide appears at end of data sheet.

Pin Configurations



For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at 1-888-629-4642, or visit Maxim's website at www.maxim-ic.com.

450mA/500mA Current-Limit Switches

ABSOLUTE MAXIMUM RATINGS

IN, ON, $\overline{FLAG}$, OUT to GND .....-0.3V to +6V
OUT Short Circuit to GND .....Internally Limited
Continuous Power Dissipation (T_A = +70°C)
5-Pin SOT23 (derate 7.1mW/°C above +70°C).....571mW
6-Pin TDFN (derate 24.4mW/°C above +70°C) 1951mW
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_{IN} = +2.0V to +4.5V, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at V_{IN} = 3.3V, T_A = +25°C.) (Note 1)

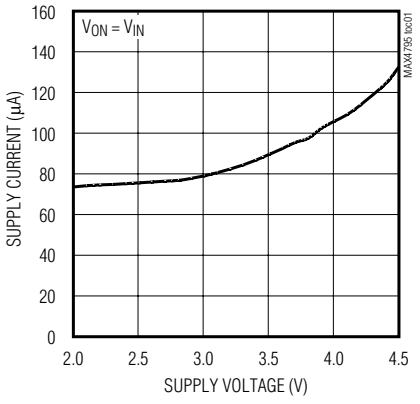
PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Operating Voltage	V_{IN}			2.0		4.5	V
Quiescent Current	I_Q	V_{ON} = V_{IN}, I_{OUT} = 0, switch on	V_{IN} = +3.3V		80	125	µA
Latch-Off Current	I_{LATCH}	V_{ON} = V_{IN}, after an overcurrent fault (MAX4795/MAX4797) (Note 2)	V_{IN} = +3.3V		6	10	µA
Shutdown Current	I_{SHDN}	V_{ON} = 0V			0.03	1	µA
Forward Current Limit		MAX4795/MAX4796, V_{IN} = 3.3V, V_{OUT} = GND		450		720	mA
		MAX4797/MAX4798, V_{IN} = 3.3V, V_{OUT} = GND		500		800	
Reverse Current Limit		MAX4795/MAX4796				720	mA
		MAX4797/MAX4798				800	
ON Input Leakage				-1		+1	µA
Shutdown Forward Leakage		V_{ON} = 0V, V_{OUT} = 0V			0.01	1	µA
Shutdown Reverse Leakage		V_{ON} = 0V, V_{IN} = 2V, V_{OUT} = 4.5V				1	µA
On-Resistance (Note 3)	R_{ON}	MAX4795/MAX4796, I_{LOAD} = 100mA			0.2	0.4	Ω
		MAX4797/MAX4798, I_{LOAD} = 100mA			0.18	0.36	
ON Input Logic High Voltage	V_{IH}	V_{IN} = +2V to +3.6V		1.4			V
		V_{IN} > 3.6V		2			
ON Input Logic Low Voltage	V_{IL}					0.5	V
$\overline{FLAG}$ Output Logic Low Voltage		I_{SINK} = 1mA				0.4	V
$\overline{FLAG}$ Output High Leakage Current		V_{IN} = $V_{\overline{FLAG}}$ = V_{ON} = 4.5V				1	µA
Thermal Shutdown					150		°C
Thermal-Shutdown Hysteresis					15		°C
DYNAMIC							
Turn-On Time		V_{ON} from low to high; I_{OUT} = 10mA, C_L = 0.1µF (Note 4)			120		µs
Turn-Off Time		V_{ON} from high to low; I_{OUT} = 10mA, C_L = 0.1µF (Note 4)			100		ns
Blanking Time	t_{BLANK}	Overcurrent fault; Figures 2, 3		14		60	ms
Short-Circuit Current-Limit Response Time		V_{ON} = V_{IN}, short circuit applied to OUT			5		µs
Retry Time	t_{RETRY}	MAX4796/MAX4798, Figure 2 (Note 5)		210		900	ms

Note 1: All parts are 100% tested at +25°C. Electrical limits across the full temperature range are guaranteed by design and correlation.
Note 2: Latch-off current does not include the current flowing into $\overline{FLAG}$.
Note 3: TDFN packages are guaranteed by design.
Note 4: The on-time is defined as the time taken for the current through the switch to go from 0mA to full load. The off-time is defined as the time taken for the current through the switch to go from full load to 0mA.
Note 5: Retry time is typically 15 times the blanking time.

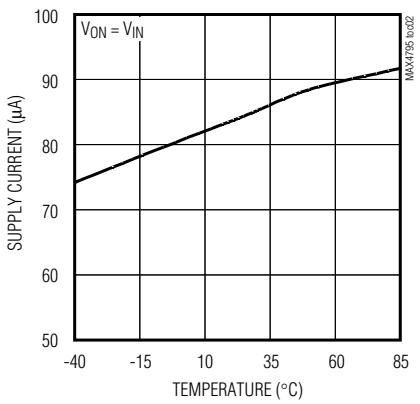
Typical Operating Characteristics

(V_{IN} = 3.3V, T_A = +25°C, unless otherwise noted.)

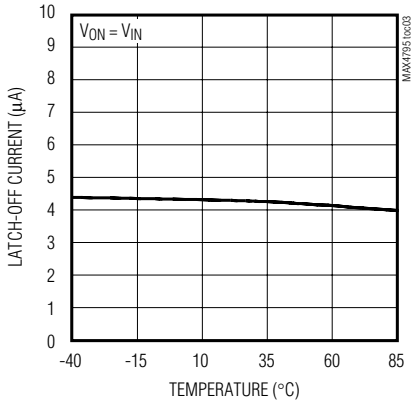
QUIESCENT SUPPLY CURRENT vs. SUPPLY VOLTAGE



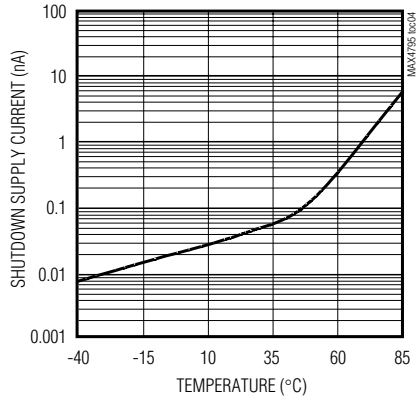
SUPPLY CURRENT vs. TEMPERATURE



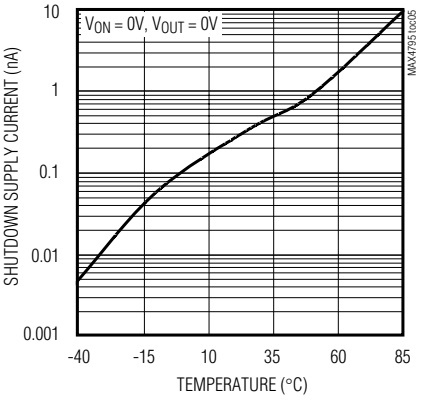
LATCH-OFF CURRENT vs. TEMPERATURE



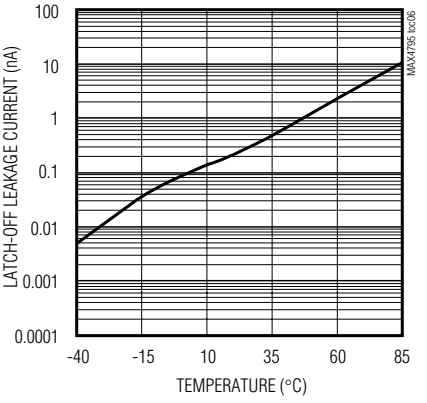
SHUTDOWN SUPPLY CURRENT vs. TEMPERATURE



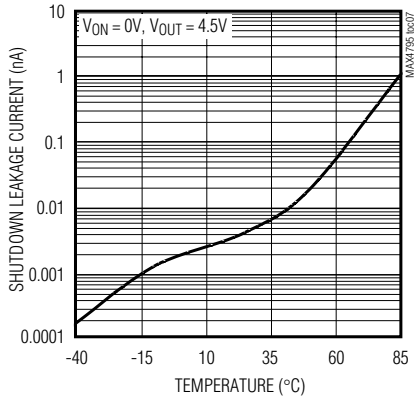
SHUTDOWN LEAKAGE CURRENT vs. TEMPERATURE



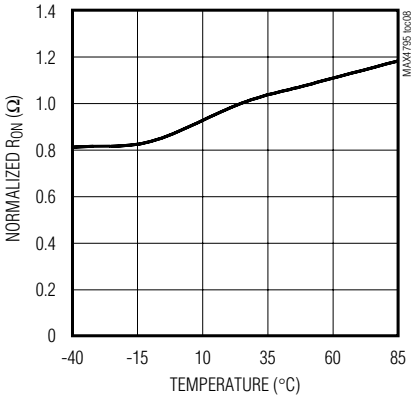
LATCH-OFF LEAKAGE CURRENT vs. TEMPERATURE



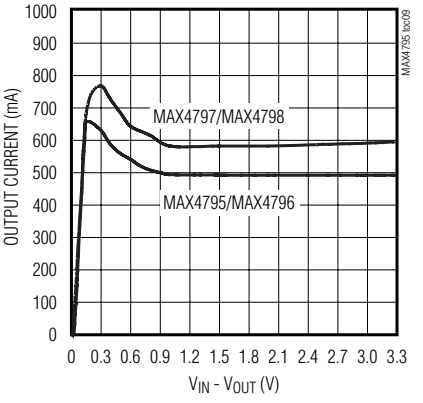
SHUTDOWN REVERSE LEAKAGE CURRENT vs. TEMPERATURE



NORMALIZED ON-RESISTANCE vs. TEMPERATURE



OUTPUT CURRENT vs. OUTPUT VOLTAGE

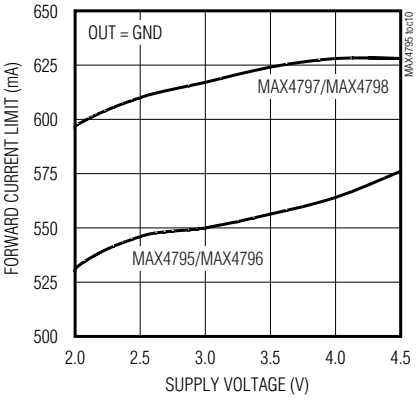


450mA/500mA Current-Limit Switches

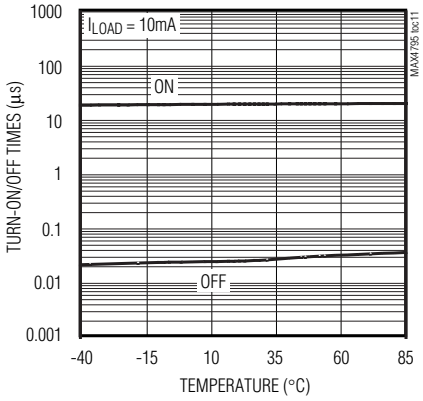
Typical Operating Characteristics (continued)

(V_{IN} = 3.3V, T_A = +25°C, unless otherwise noted.)

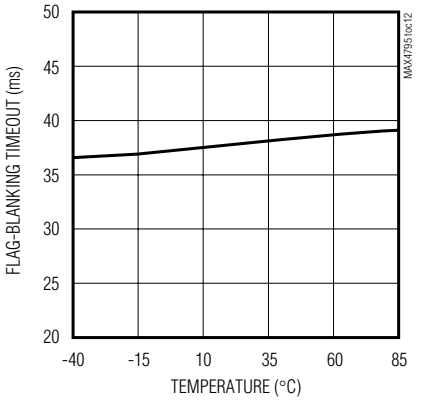
FORWARD CURRENT LIMIT vs. SUPPLY VOLTAGE



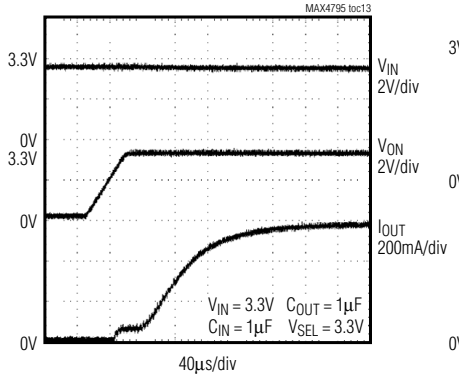
SWITCH TURN-ON/OFF TIMES vs. TEMPERATURE



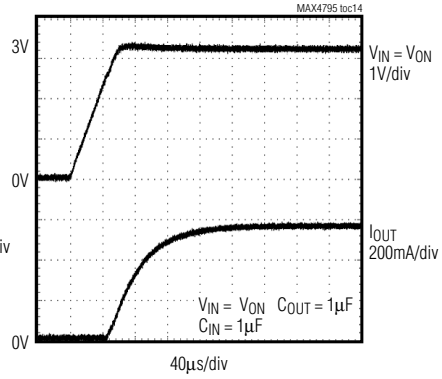
FLAG-BLANKING TIMEOUT vs. TEMPERATURE



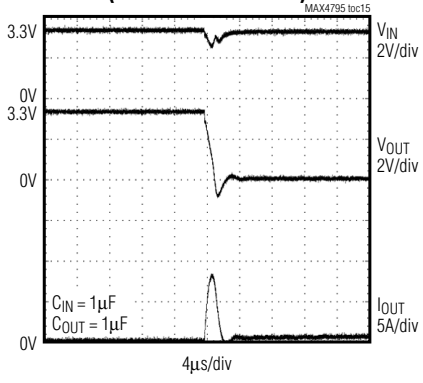
MAX4797/MAX4798 CURRENT-LIMIT RESPONSE



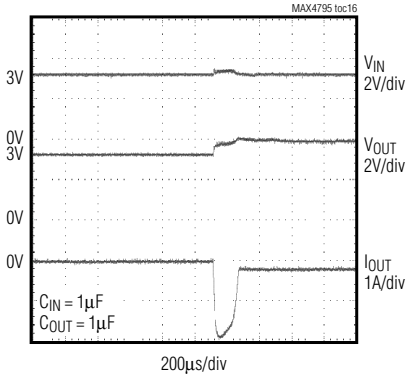
MAX4797/MAX4798 CURRENT-LIMIT RESPONSE



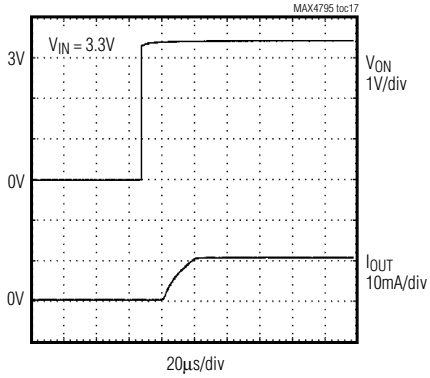
CURRENT-LIMIT RESPONSE (OUT SHORTED TO GND)



MAX4797/MAX4798 REVERSE CURRENT LIMIT



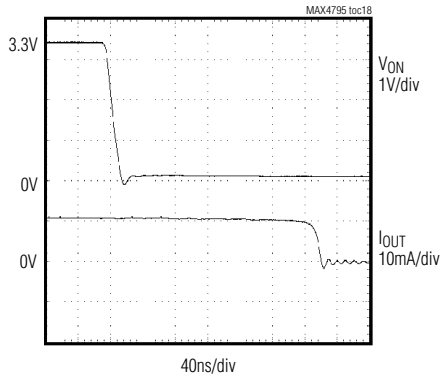
SWITCH TURN-ON TIME RESPONSE



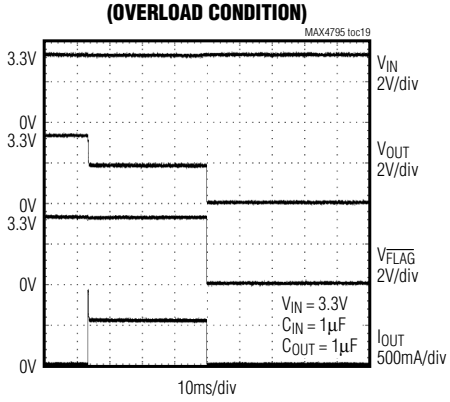
Typical Operating Characteristics (continued)

(V_{IN} = 3.3V, T_A = +25°C, unless otherwise noted.)

SWITCH TURN-OFF TIME RESPONSE



MAX4797/MAX4798
FLAG-BLANKING RESPONSE
(OVERLOAD CONDITION)



Pin Description

PIN		NAME	FUNCTION
SOT23	TDFN		
1	1	IN	Input. Bypass with a 0.1µF ceramic capacitor to ground.
2	5	GND	Ground
3	6	ON	Active-High Switch On Input. A logic high turns the switch on.
4	4	$\overline{FLAG}$	Fault Output. This open-drain output goes low when the device stays in forward or reverse current limit for more than the blanking time period. $\overline{FLAG}$ is high impedance when a fault is not present or when ON is low.
5	2	OUT	Switch Output. Bypass with a 0.1µF ceramic capacitor to ground.
—	3	N.C.	No Connection. Not internally connected.

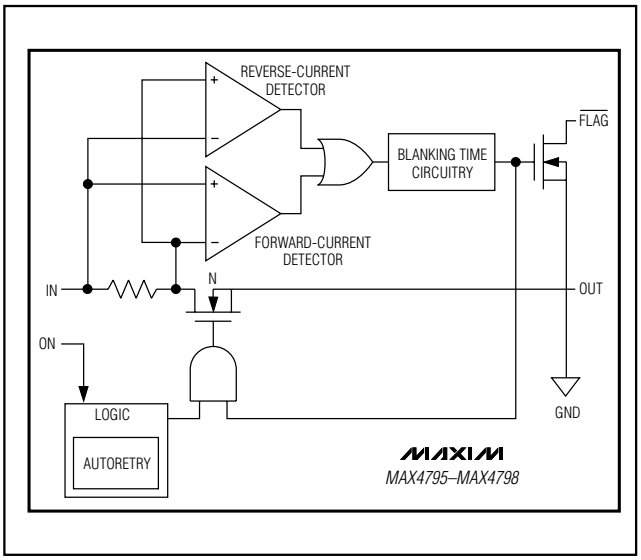


Figure 1. Functional Diagram

450mA/500mA Current-Limit Switches

Detailed Description

The MAX4795–MAX4798 are forward/reverse current-limited switches that operate from a 2V to 4.5V input voltage range and guarantee a 450mA and 500mA minimum current-limit threshold for different options. The voltage drop across an internal sense resistor is compared to two reference voltages to indicate a forward or reverse current-limit fault. When the load current exceeds the preset current limit for greater than the fault-blanking time, the switch opens.

The MAX4796 and MAX4798 have an autoretry function that turns on the switch again after an internal retry time expires. If the faulty load condition is still present after the blanking time, the switch turns off again and the cycle is repeated. If the faulty load condition is not present, the switch remains on.

The MAX4795 and MAX4797 do not have the autoretry option and the switch remains in latch-off mode until the ON pin or the input power is cycled from high to low and then high again.

Reverse-Current Protection

The MAX4795–MAX4798 limit the reverse current (V_{OUT} to V_{IN}) from exceeding the maximum I_{REV} value. The switch is shut off and $\overline{FLAG}$ is asserted if the reverse current-limit condition persists for more than the blanking time. This feature prevents excessive reverse currents from flowing through the device.

Switch-On/Off Control

Toggle ON high to enable the current-limited switches. The switches are continuously on if there is no fault. When a forward/reverse current fault is present or the die exceeds the thermal-shutdown temperature of +150°C, OUT is internally disconnected from IN and the supply current decreases to 8µA (latch off). The switch is now operating in one of its off states. The switch-off state also occurs when driving ON low, thus reducing the supply current (shutdown) to 0.01µA. Table 1 illustrates the ON/OFF state of the MAX4795–MAX4798 current-limit switches.

$\overline{FLAG}$ Indicator

The MAX4795–MAX4798 feature a latched output ($\overline{FLAG}$). Whenever an overcurrent condition is encountered, the MAX4795/MAX4797 latch $\overline{FLAG}$ low and turn the switch off. The MAX4796/MAX4798 latch $\overline{FLAG}$ low and keep it low until the overcurrent condition is removed. During this time, the switch cycles on and off in the autoretry mode. When the overcurrent condition is removed, $\overline{FLAG}$ deasserts and the switch turns on (Figure 2). $\overline{FLAG}$ is an open-drain output transistor and requires an external pullup resistor from $\overline{FLAG}$ to IN. During shutdown (ON is low), the pulldown on $\overline{FLAG}$ output is released to limit power dissipation. $\overline{FLAG}$ goes low when any of the following conditions occur:

- The die temperature exceeds the thermal-shutdown temperature limit of +150°C.
- The device is in current limit for more than the fault-blanking period.
- The switch is in autoretry.

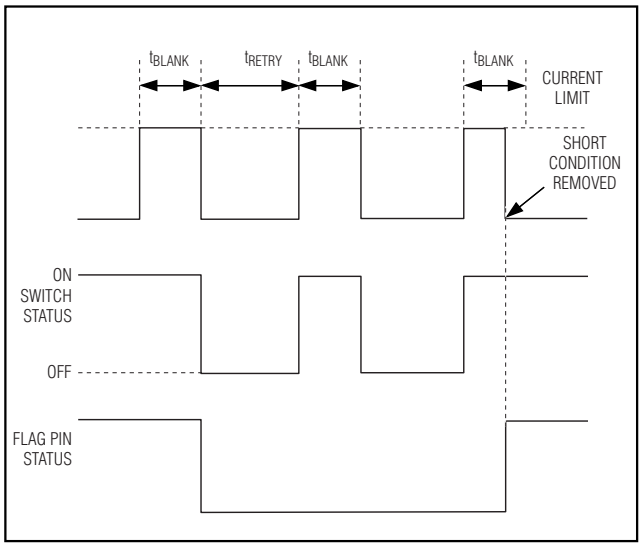


Figure 2. MAX4796/MAX4798 Autoretry Fault-Blanking Diagram

Table 1. MAX4795–MAX4798 Switch Truth Table

ON	FAULT	SWITCH ON/OFF	SUPPLY CURRENT MODE
Low	X	OFF	Shutdown
High	Thermal	OFF immediately (t_{BLANK} period does not apply)	Latchoff
High	Current limit	OFF after t_{BLANK} period has elapsed	Latchoff
		ON during t_{BLANK} period, OFF during t_{RETRY} period for the MAX4796 and MAX4798; cycle repeats until fault is removed	See the *Autoretry* section

Autoretry (MAX4796/MAX4798)

When the forward or reverse current-limit threshold is exceeded, t_{BLANK} timer begins counting (Figure 2). The timer resets if the overcurrent condition disappears before t_{BLANK} has elapsed. A retry time delay, t_{RETRY}, is started immediately after t_{BLANK} has elapsed and during that time, the switch is latched off and $\overline{FLAG}$ asserts. At the end of t_{RETRY}, the switch is turned on again. If the fault still exists, the cycle is repeated. If the fault has been removed, the switch stays on and $\overline{FLAG}$ deasserts.

The autoretry feature saves system power in the case of an overcurrent or short-circuit condition. During t_{BLANK}, when the switch is on, the supply current is at the current limit. During t_{RETRY}, when the switch is off, the current through the switch is zero. Instead of observing the full load current, the switch sees the equivalent load current times duty cycle or $I_{SUPPLY} = I_{LOAD} \times t_{BLANK}/(t_{BLANK} + t_{RETRY})$. With a typical t_{BLANK} = 37ms and typical t_{RETRY} = 555ms, the duty cycle is 6%, which results in a 94% power savings over the switch being on the entire time. The duty cycle is consistent across the process and devices.

Latchoff (MAX4795/MAX4797)

When the forward or reverse current-limit threshold is exceeded, t_{BLANK} timer begins counting. The timer resets if the overcurrent condition disappears before t_{BLANK} has elapsed. The switch is shut off and $\overline{FLAG}$ asserts if the overcurrent condition continues up to the end of the blanking time. Reset the switch by either toggling ON (Figure 3) or cycling the input voltage.

Fault Blanking

The MAX4795–MAX4798 feature 14ms (min) fault blanking. Fault blanking allows current-limit faults, including momentary short-circuit faults that occur when hot swapping a capacitive load, and also ensures that no fault is issued during power-up. When a load transient causes the device to enter current limit, an internal counter starts. If the load-transient fault persists beyond the fault-blanking timeout, $\overline{FLAG}$ asserts low. Load-transient faults less than t_{BLANK} do not cause a $\overline{FLAG}$ output assertion. Only current-limit faults are blanked.

A thermal fault causes $\overline{FLAG}$ to assert immediately and does not wait for the blanking time.

Thermal Shutdown

The MAX4795–MAX4798 have a thermal-shutdown feature to protect the devices from overheating. The switch turns off and $\overline{FLAG}$ goes low immediately (no fault blanking) when the junction temperature exceeds +150°C. The switches with autoretry turn back on when the device temperature drops approximately 15°C. The switches with latchoff require ON cycling.

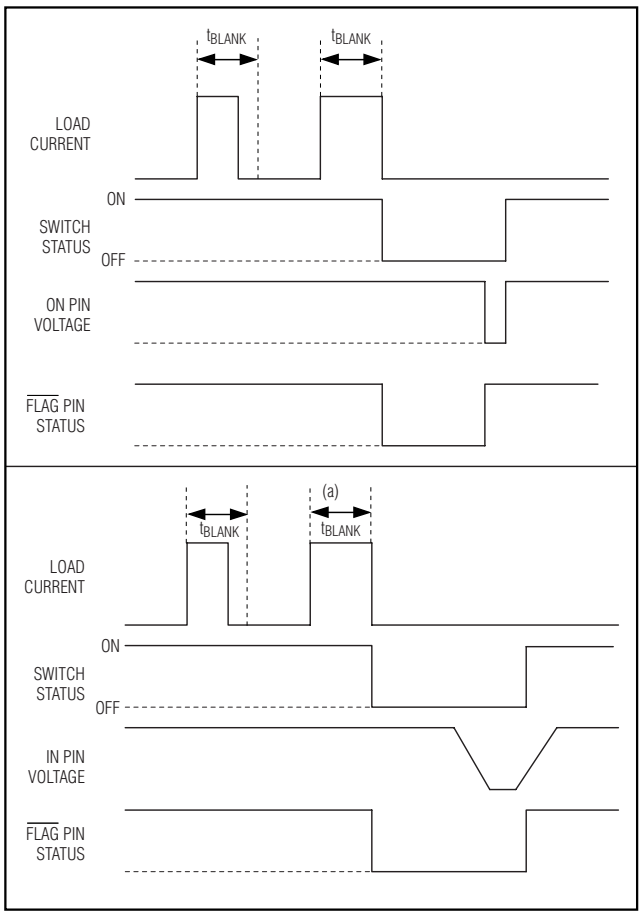


Figure 3. MAX4795/MAX4797 Latch-Off Fault Blanking

Applications Information

Input Capacitor

To limit the input voltage drop during momentary output short-circuit conditions, connect a capacitor from IN to GND. A 0.1µF ceramic capacitor is adequate for most applications; however, higher capacitor values further reduce the voltage drop at the input and are recommended for lower voltage applications.

Output Capacitance

Connect a 0.1µF capacitor from OUT to GND. This capacitor helps prevent inductive parasitics from pulling OUT negative during turn off, thus preventing the MAX4795–MAX4798 from tripping erroneously. If the load capacitance is too large, then current may not have enough time to charge the capacitor and the device assumes that there is a faulty load condition. The maximum capacitive load value that can be driven from OUT is obtained by the following formula:

$$C_{MAX} < \frac{I_{FWD_MIN} \times t_{BLANK_MIN}}{V_{IN}}$$

Layout and Thermal Dissipation

To optimize 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). IN and OUT pins must be connected with short traces to the power bus.

Selector Guide

PART	CURRENT LIMIT (mA)	AUTORETRY
MAX4795EUK-T	450	No
MAX4795ETT	450	No
MAX4796EUK-T	450	Yes
MAX4796ETT	450	Yes
MAX4797EUK-T	500	No
MAX4797ETT	500	No
MAX4798EUK-T	500	Yes
MAX4798ETT	500	Yes

During normal operation, the power dissipation is small and the package temperature change is minimal. If the output is continuously shorted to ground at the maximum supply voltage, the operation of the switches with the autoretry option does not cause problems because the total power dissipated during the short is scaled by the duty cycle:

$$P_{MAX} = \frac{V_{IN_MAX} \times I_{OUT_MAX} \times t_{BLANK}}{t_{RETRY} + t_{BLANK}} = 211mW$$

where V_{IN} = 4.5V, I_{OUT} = 750mA, t_{BLANK} = 14ms, and t_{RETRY} = 210ms.

Attention must be given to the MAX4795 and MAX4797 where the latchoff condition must be manually reset by toggling ON from high to low. If the latchoff time duration is not sufficiently high, it is possible for the device to reach the thermal-shutdown threshold and never be able to turn the device on until it cools down.

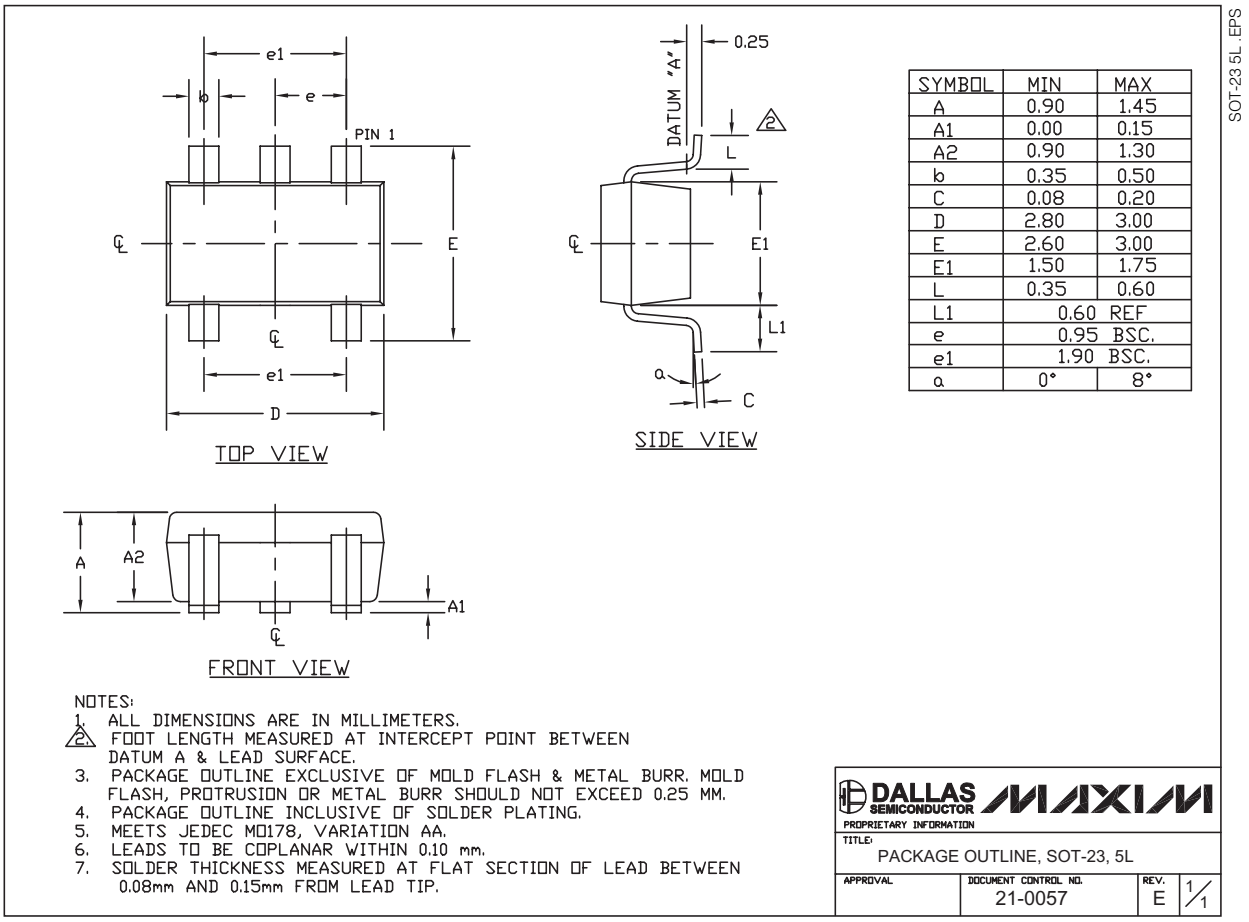
Chip Information

TRANSISTOR COUNT: 2539

PROCESS: BiCMOS

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**.)



SYMBOL	MIN	MAX
A	0.90	1.45
A1	0.00	0.15
A2	0.90	1.30
b	0.35	0.50
C	0.08	0.20
D	2.80	3.00
E	2.60	3.00
E1	1.50	1.75
L	0.35	0.60
L1	0.60 REF	
e	0.95 BSC.	
e1	1.90 BSC.	
a	0°	8°

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