MAX14575A/MAX14575AL/ MAX14575B/MAX14575C

250mA to 2.5A Adjustable Current-Limit Switches

General Description

The MAX14575A/MAX14575AL/MAX14575B/MAX14575C programmable current-limit switches feature internal current limiting to prevent damage to host devices due to faulty load conditions. These current-limit switches feature a low 32mΩ (typ) on-resistance and operate from a +2.3V to +5.5V input voltage range. The current limit is adjustable from 250mA to 2.5A, making these devices ideal for charging a large load capacitor as well as for high-current load switching applications.

Each device in the family handles an overcurrent event differently depending on the option selected. The MAX14575A/MAX14575AL feature an autoretry mode, the MAX14575A has active high, and the MAX14575AL has active-low EN polarity. The MAX14575B has latch-off mode, and the MAX14575C features a continuous current-limit mode. Additional safety features include thermal shutdown protection to prevent overheating and reverse current blocking to prevent current from being driven back into the source (see the *Selector Guide*).

The MAX14575A/MAX14575AL/MAX14575B/MAX14575C are available in a small 8-pin, 2mm x 2mm TDFN package and operate over the -40°C to +85°C extended temperature range.

Features

- **Adjustable Current Limit (250mA to 2500mA)**
- **Accurate ±10% Overload Current Limit (500mA to 2.5A)**
- **32mΩ (typ) Low R_{ON}**
- **+2.3V to +5.5V Supply Voltage Range**
- **Reverse Current Protection**
- **Short-Circuit Protection**
- **Thermal Shutdown Protection**
- **130µA (typ) Low Supply Current**
- **1µA (max) Shutdown Reverse Current**
- **Small, 8-Pin, 2mm x 2mm TDFN Package**

Applications

RF Power Amplifier in Cell Phones

USB Ports

Data Modem Cards

Portable Media Players

UTCA/ATCA Platforms

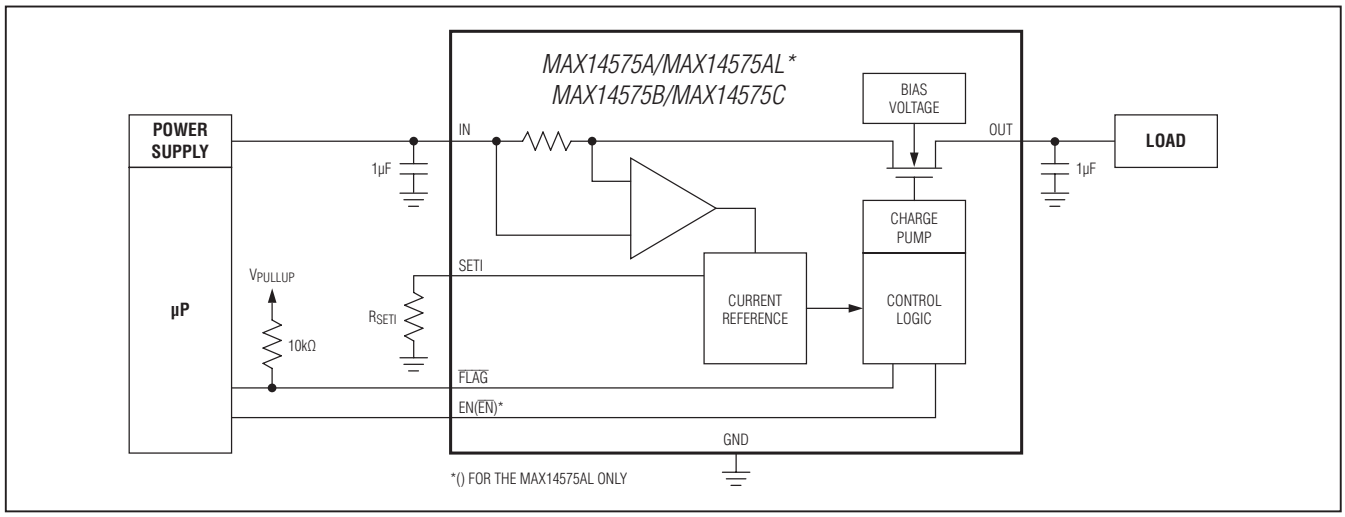
SDXC Card Power-Supply Protection

Ordering Information/Selector Guide

PART	PIN-PACKAGE	TEMP RANGE	EN POLARITY	OVERCURRENT RESPONSE	TOP MARK
MAX14575AETA+T	8 TDFN-EP*	-40°C to +85°C	Active-High	Autoretry	BMV
MAX14575ALETA+T	8 TDFN-EP*	-40°C to +85°C	Active-Low	Autoretry	BMW
MAX14575BETA+T	8 TDFN-EP*	-40°C to +85°C	Active-High	Latch-off	BMX
MAX14575CETA+T	8 TDFN-EP*	-40°C to +85°C	Active-High	Continuous	BMY

+Denotes a lead(Pb)-free/RoHS-compliant package.
T = Tape and reel.
**EP = Exposed pad.*

Typical Operating Circuit



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

19-6458; Rev 0; 9/12

ABSOLUTE MAXIMUM RATINGS

(Voltages referenced to GND.)
IN, EN, $\overline{EN}$, $\overline{FLAG}$, OUT, and SETI to GND .....-0.3V to +6V
Current into Any Pin (Except IN, OUT) ..... ±20mA
OUT Short Circuit to GND.....Internally Limited
Continuous Power Dissipation (T_A = +70°C)
TDFN (derate 11.9mW/°C above +70°C) 954mW

Operating Temperature Range ..... -40°C to +85°C
Storage Temperature Range..... -65°C to +150°C
Junction Temperature .....+150°C
Lead Temperature (soldering, 10s) .....+300°C
Soldering Temperature (reflow) .....+260°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

PACKAGE THERMAL CHARACTERISTICS (Note 1)

TDFN
Junction-to-Ambient Thermal Resistance (θ_{JA})..... +83.9°C/W
Junction-to-Case Thermal Resistance (θ_{JC})..... +37°C/W

Note 1: Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to **www.maximintegrated.com/thermal-tutorial**.

ELECTRICAL CHARACTERISTICS

(V_{IN} = +2.3V to +5.5V and T_A = -40°C to +85°C, unless otherwise noted. Typical values are at V_{IN} = +3.3V, C_{IN} = 1µF, C_{OUT} = 1µF, R_{SETI} = 100kΩ., T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
SUPPLY OPERATION						
Operating Voltage	V_{IN}		2.3		5.5	V
Quiescent Current	I_Q	I_{OUT} = 0A, switch on, V_{IN} = 3.3V, R_{SETI} = 560kΩ		130	275	µA
Latchoff Current	I_{LATCH}	I_{OUT} = 0A , after an overcurrent fault (MAX14575B)		6	20	µA
Shutdown Forward Current	I_{SHDN}	V_{EN} = 0V, $V_{\overline{EN}}$ = 5.5V, V_{IN} = 5.5V, V_{OUT} = 0V		0.1	3.5	µA
Shutdown Reverse Current	I_{RSHDN}	V_{EN} = 0V, $V_{\overline{EN}}$ = 5.5V, V_{IN} = 0V, V_{OUT} = 5.5V (current into OUT)		0.07	1	µA
INTERNAL FET						
Switch On-Resistance	R_{ON}	V_{IN} = 5.5V, T_A = +25°C, I_{OUT} = 100mA, I_{OUT} < I_{LIM}		32	50	mΩ
Forward Current Limit	I_{LIM}	R_{SETI} = 52.65kΩ	2250	2500	2750	mA
		R_{SETI} = 268.7kΩ	450	500	550	
		R_{SETI} = 538.7kΩ	200	250	300	
R_{SETI} Coefficient	P	I_{LIM} = 0.5A to 2.5A		135		kV
R_{SETI} Constant	C	I_{LIM} = 0.5A to 2.5A		1.35		kΩ
R_{SETI} x I_{LIM} Product		I_{LIM} = 250mA to 2500mA, V_{IN} - V_{OUT} = 1V	172	215	258	kV
Reverse Blocking Current		V_{OUT} > V_{IN} + 145mV, after reverse current-limit shutdown			2	µA
Reverse Blocking Threshold	V_{OUT} - V_{IN}	V_{OUT} - V_{IN} = 300mV, OUT falling until switch turns on, while measuring V_{OUT} - V_{IN}	25	100	145	mV
$\overline{FLAG}$ Assertion Drop Voltage Threshold	V_{FA}	Increase (V_{IN} - V_{OUT}) drop until $\overline{FLAG}$ asserts, in current-limit mode, V_{IN} = 3.3V, R_{SETI} = unconnected		345		mV

ELECTRICAL CHARACTERISTICS (continued)

(V_{IN} = +2.3V to +5.5V and T_A = -40°C to +85°C, unless otherwise noted. Typical values are at V_{IN} = +3.3V, C_{IN} = 1µF, C_{OUT} = 1µF, R_{SETI} = 100kΩ, T_A = +25°C.) (Note 2)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
EN, $\overline{EN}$ INPUT						
EN, $\overline{EN}$ Input Leakage	I_{LEAK}	EN, $\overline{EN}$ = IN or GND	-1		+1	µA
EN, $\overline{EN}$ Input Logic-High Voltage	V_{IH}		1.6			V
EN, $\overline{EN}$ Input Logic-Low Voltage	V_{IL}				0.4	V
$\overline{FLAG}$ OUTPUT						
$\overline{FLAG}$ Output Logic-Low Voltage		I_{SINK} = 1mA			0.4	V
$\overline{FLAG}$ Output Leakage Current		V_{IN} = $V_{\overline{FLAG}}$ = 5.5V, $\overline{FLAG}$ deasserted			1	µA
TIMING CHARACTERISTICS						
Turn-On Time	t_{SS}	Time from ENABLE signal to V_{OUT} = 90% of V_{IN}, Figure 1		600		µs
Turn-Off Time	t_{OFF}	Time from DISABLE signal to V_{OUT} = 10% of V_{IN}, R_L = 1kΩ, C_{OUT} = 0, Figure 1		100		µs
Current-Limit Reaction Time	t_{LIM}	Output high and then short circuit applied		3		µs
Blanking Time	t_{BLANK}	Figures 2 and 3 (Note 3)	10	15	25	ms
Retry Time	t_{RETRY}	MAX14575A/MAX14575AL Figure 2 (Note 3)	320	500	875	ms
THERMAL PROTECTION						
Thermal Shutdown				+160		°C
Thermal Shutdown Hysteresis				20		°C

Note 2: All devices are 100% production tested at T_A = +25°C. Limits over the operating temperature range are guaranteed by design; not production tested.

Note 3: Blanking time and retry time are generated by the same internal oscillator. The ratio of $\frac{t_{RETRY}}{t_{BLANK}}$ is a constant value of 32.

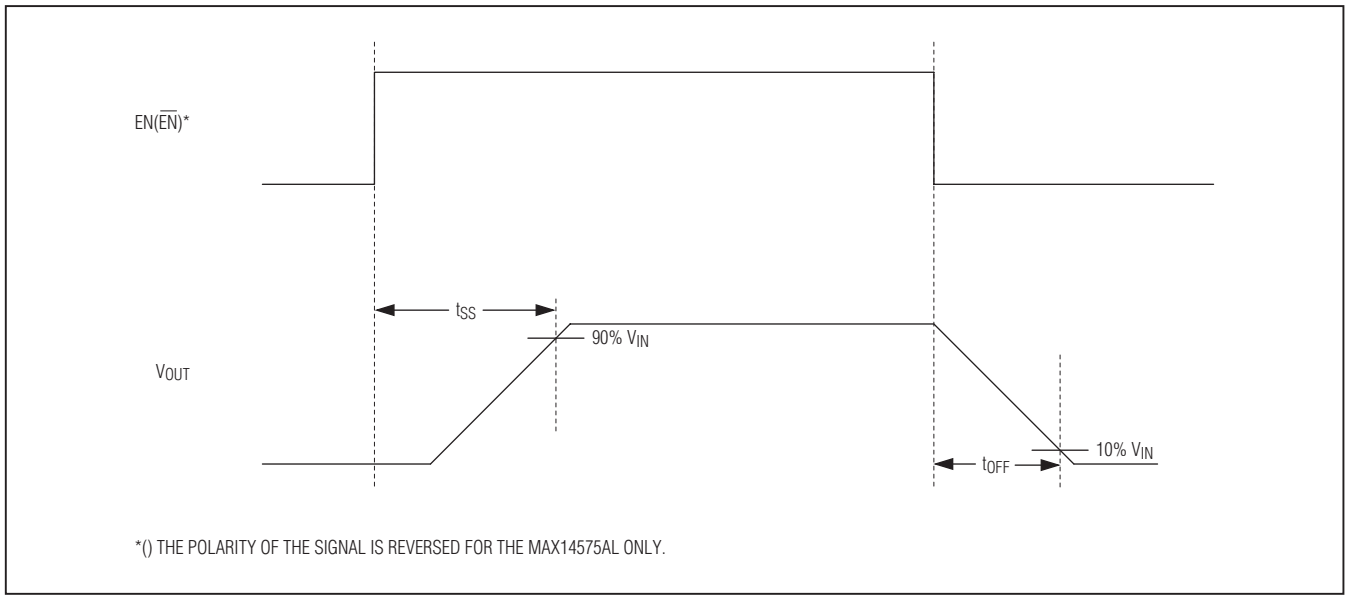


Figure 1. Timing Diagram for Measuring Turn-On Time (t_{SS}) and Turn-Off Time (t_{OFF}).

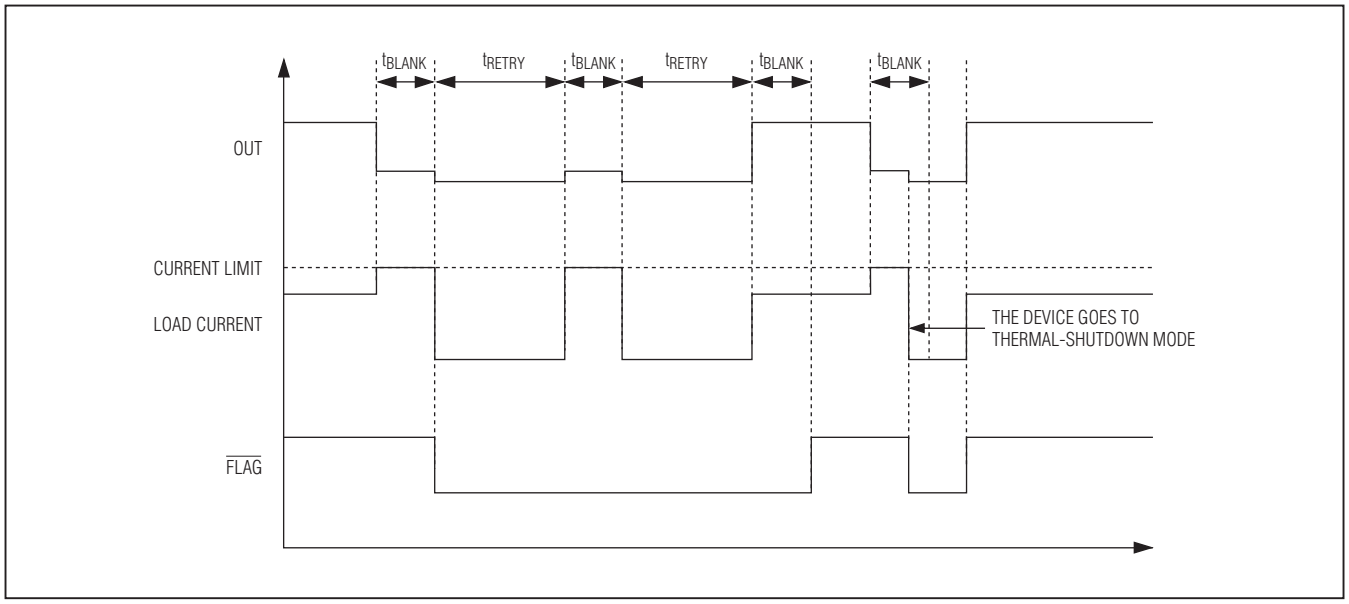


Figure 2. Autoretry Fault Diagram

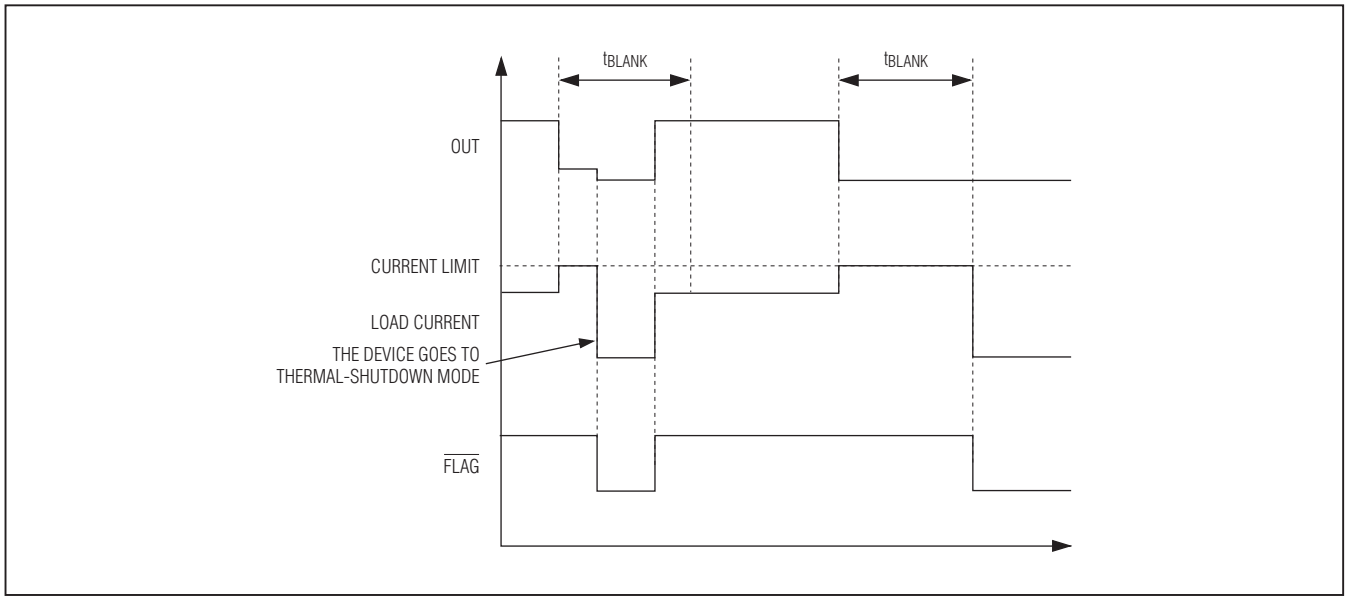
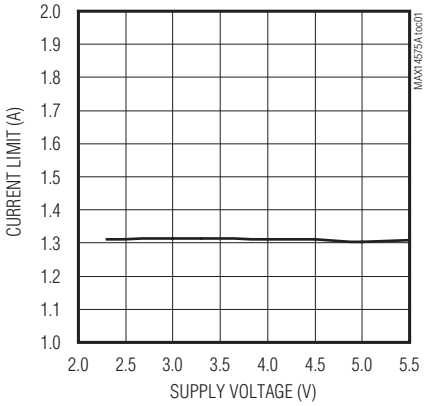


Figure 3. Latchoff Fault Diagram

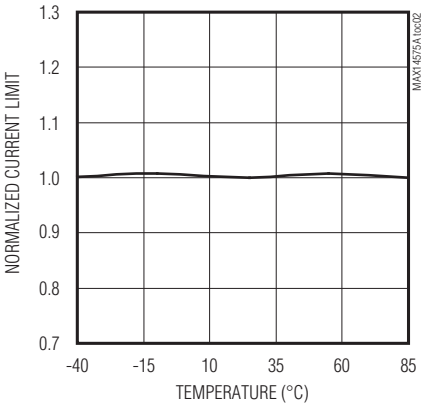
Typical Operating Characteristics

(V_{IN} = +3.3V, C_{IN} = 1µF, C_{OUT} = 1µF, R_{SETI} = 94.2kΩ, T_A = +25°C, unless otherwise noted.)

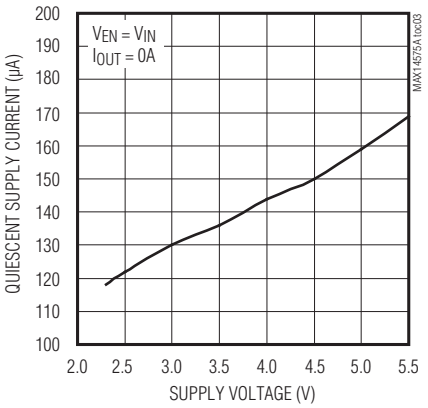
CURRENT LIMIT vs. SUPPLY VOLTAGE



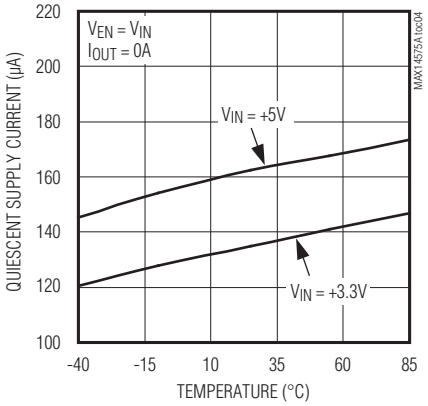
NORMALIZED CURRENT LIMIT vs. TEMPERATURE



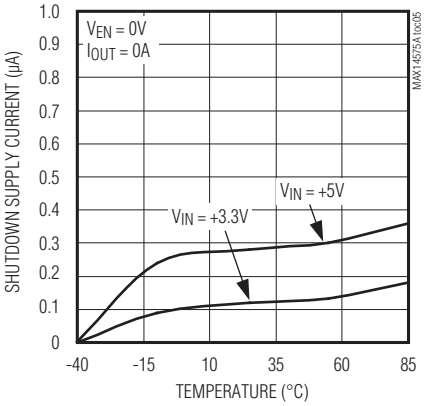
QUIESCENT SUPPLY CURRENT vs. SUPPLY VOLTAGE



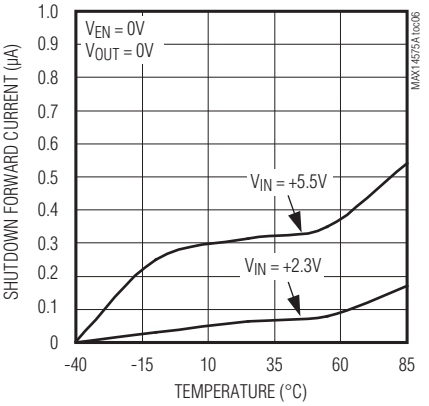
QUIESCENT SUPPLY CURRENT vs. TEMPERATURE



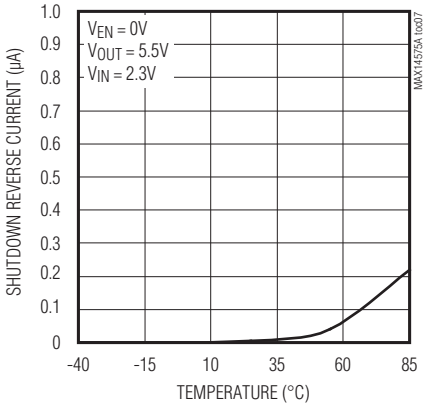
SHUTDOWN SUPPLY CURRENT vs. TEMPERATURE



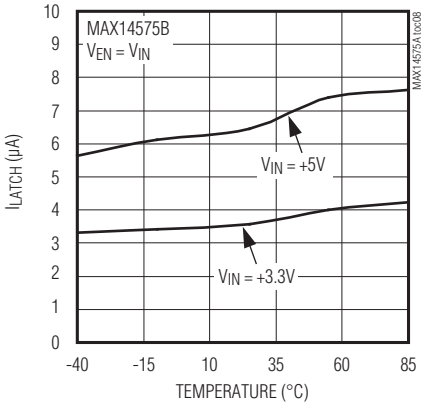
SHUTDOWN FORWARD CURRENT vs. TEMPERATURE



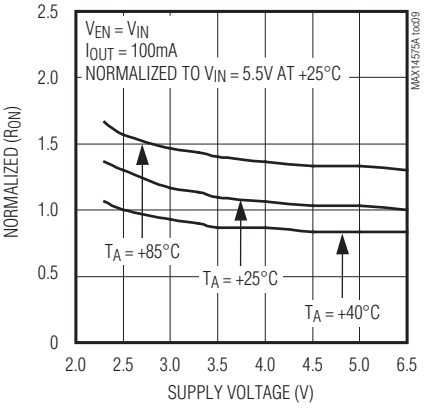
SHUTDOWN REVERSE CURRENT vs. TEMPERATURE



LATCHOFF CURRENT vs. TEMPERATURE



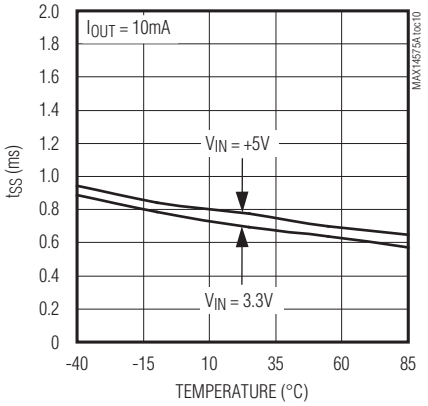
NORMALIZED ON-RESISTANCE vs. SUPPLY VOLTAGE



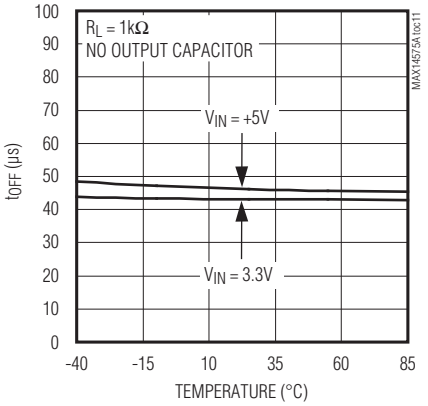
Typical Operating Characteristics (continued)

(V_{IN} = +3.3V, C_{IN} = 1µF, C_{OUT} = 1µF, R_{SETI} = 94.2kΩ, T_A = +25°C, unless otherwise noted.)

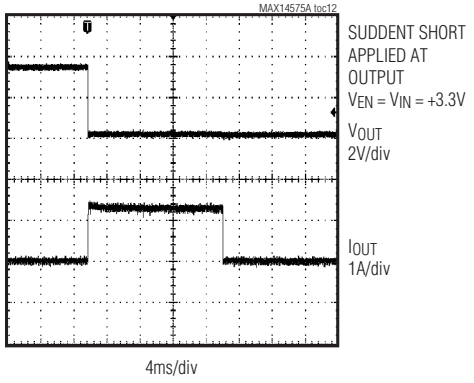
SWITCH TURN-ON TIME vs. TEMPERATURE



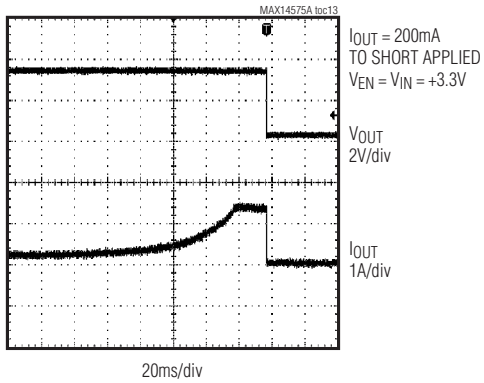
SWITCH TURN-OFF TIME vs. TEMPERATURE



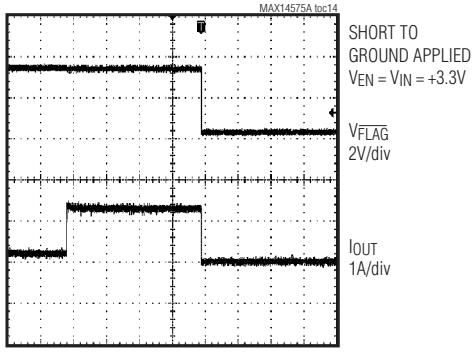
CURRENT-LIMIT RESPONSE



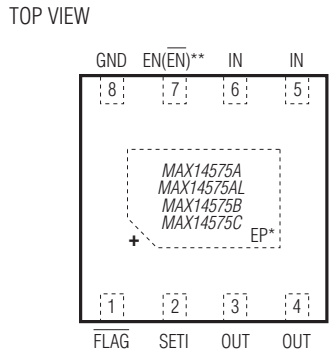
CURRENT-LIMIT RESPONSE



FLAG RESPONSE (OVERLOAD CONDITION)



Pin Configuration



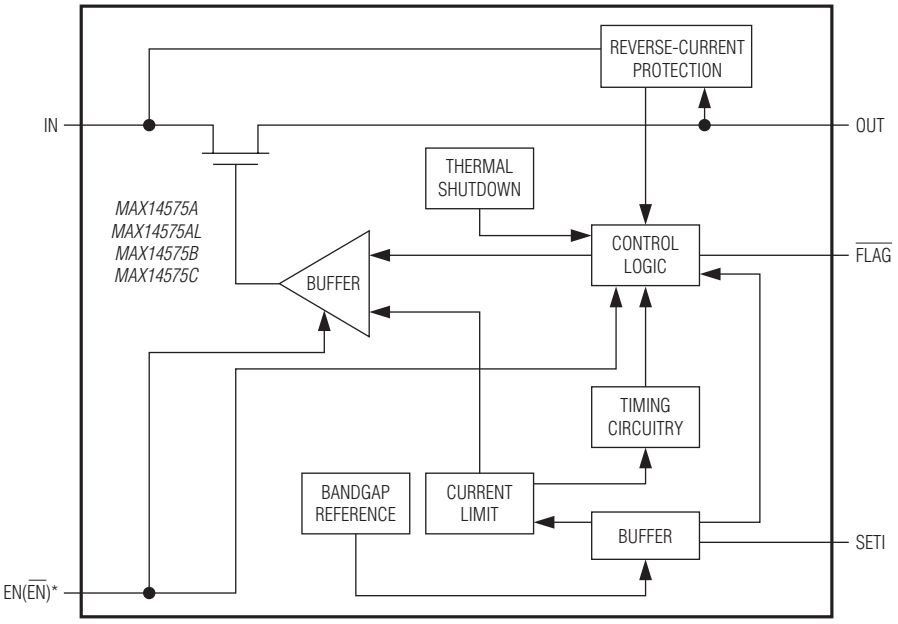
TDFN
(2mm × 2mm)

*CONNECT EXPOSED PAD TO GND
**PARENTHESES ARE FOR THE MAX14575AL ONLY

Pin Description

PIN		NAME	FUNCTION
MAX14575AL	MAX14575_		
1	1	$\overline{FLAG}$	Open-Drain Overcurrent Indicator Output. $\overline{FLAG}$ goes low when the overload fault duration exceeds the blanking time, reverse current is detected, thermal shutdown mode is active, or SETI is connected to ground.
2	2	SETI	Forward Current-Limit Adjust Input. Connect a resistor from SETI to GND to program the overcurrent limit. If SETI is connected to GND, the switch turns off and $\overline{FLAG}$ is asserted. Do not leave SETI unconnected or connect any capacitor larger than 20pF to SETI.
3, 4	3, 4	OUT	Switch Output. Connect OUT pins 3 and 4 together and bypass OUT to GND with a 1µF ceramic capacitor as close to the device as possible.
5, 6	5, 6	IN	Power Input. Connect IN pins 5 and 6 together and bypass IN to GND with a 1µF ceramic capacitor as close to the device as possible. If necessary, use higher capacitance to prevent large load transients from pulling down the supply voltage.
7	—	$\overline{EN}$	Active-Low Enable Input. Drive $\overline{EN}$ low to turn on the switch. Drive $\overline{EN}$ high to turn off the switch.
—	7	EN	Active-High Enable Input. Drive EN high to turn on the switch. Drive EN low to turn off the switch.
8	8	GND	Ground
—	—	EP	Exposed Pad. Internally connected to GND. Connect to a large ground plane to maximize thermal performance. Not intended as an electrical connection point.

Functional Diagram



*PARENTHESES ARE FOR THE MAX14575AL ONLY

Detailed Description

The MAX14575A/MAX14575AL/MAX14575B/MAX14575C programmable current-limit switches operate from +2.3V to +5.5V and provide internal current limiting adjustable from 250mA to 2.5A. These devices feature a fixed blanking time and a $\overline{FLAG}$ output that notifies the processor when a fault condition is present.

Programmable Current-Limit Threshold

A resistor from SETI to GND sets the current-limit threshold for the switch (see the *Setting the Current-Limit Threshold* section). If the output current is limited at the current threshold value for a time equal to or longer than t_{BLANK} with V_{IN} - V_{OUT} higher than the $\overline{FLAG}$ assertion drop voltage threshold ($V_{FA.}$), then the $\overline{FLAG}$ asserts, and the MAX14575A/MAX14575AL enter the autoretry mode, the MAX14575B latches off the switch, and the MAX14575C enters the continuous current-limit mode.

Autoretry (MAX14575A/MAX14575AL)

When the forward current reaches the current threshold, the t_{BLANK} timer begins counting (Figure 2). $\overline{FLAG}$ asserts if the overcurrent condition is present for t_{BLANK}. The timer resets if the overcurrent condition disappears before the blanking time (t_{BLANK}) has elapsed. A retry time delay (t_{RETRY}) starts immediately after the blanking time has elapsed and during that time, the switch latches off. At the end of t_{RETRY}, the switch turns on again. If the fault still exists, the cycle repeats. If the fault has been removed, the switch stays on. During this cycle, $\overline{FLAG}$ stays low. In autoretry, if the die temperature exceeds +160°C (typ) due to self-heating, the MAX14575A/MAX14575AL go into thermal-shutdown mode until the die temperature drops by approximately 20°C.

The autoretry feature saves system power in case of an overcurrent or short-circuit condition. During t_{BLANK} time, when the switch is on, the supply current is held at the current limit. During time t_{RETRY}, when the switch is off, the current through the switch is zero. Thus, the average output current is much less than the programmed current limit. Calculate the average output current using the following equation:

$$I_{LOAD} = I_{LIM} \times \frac{t_{BLANK}}{t_{BLANK} + t_{RETRY}}$$

For example, if t_{BLANK} = 15ms and t_{RETRY} = 500ms, the duty cycle is 3%, resulting in a 97% power savings over the switch being on the entire time.

Latchoff (MAX14575B)

When the forward current reaches the current threshold, the t_{BLANK} timer begins counting (Figure 3). $\overline{FLAG}$ asserts if an overcurrent condition is present for greater than t_{BLANK} time. The timer resets if the overcurrent condition disappears before t_{BLANK} has elapsed. The switch turns off if the overcurrent condition continues beyond the blanking time. Reset the switch by either toggling the control logic (EN) or cycling the input voltage. If the die temperature exceeds +160°C (typ) due to self-heating, the MAX14575B goes into thermal-shutdown mode until the die temperature drops by approximately 20°C.

Continuous Current Limit (MAX14575C)

When the forward current reaches the forward-current threshold, the MAX14575C limits the output current to the programmed current limit. $\overline{FLAG}$ asserts if the current limit is present for t_{BLANK} and deasserts when the overload condition is removed. In this mode, if the die temperature exceeds +160°C (typ) due to self-heating, the MAX14575C goes into thermal-shutdown mode until the die temperature drops by approximately 20°C.

Switch Enable Control (EN/$\overline{EN}$)

The EN input for the MAX14575A/B/C and $\overline{EN}$ input for the MAX14575AL control the internal switch. See Table 1.

Reverse Current Protection

The MAX14575A/MAX14575AL/MAX14575B/MAX14575C feature a reverse current protection circuit that limits the backflow current to 2µA when the reverse current protection circuitry has tripped. The switch turns off and $\overline{FLAG}$ asserts without waiting for t_{BLANK} to elapse. The switch turns back on and $\overline{FLAG}$ deasserts when V_{OUT} - V_{IN} drops below the reverse blocking threshold.

$\overline{FLAG}$ Indicator

$\overline{FLAG}$ is an open-drain fault indicator output and requires an external pullup resistor to a DC supply. $\overline{FLAG}$ goes low when any of the following conditions occur:

- An overcurrent condition after the blanking time has elapsed and V_{IN} - V_{OUT} > V_{FA}
- The reverse current protection has tripped
- The die temperature exceeds +160°C
- SETI is connected to ground

Thermal Shutdown

Thermal shutdown circuitry protects the devices from overheating. The switch turns off and $\overline{FLAG}$ goes low immediately when the junction temperature exceeds +160°C (typ). The MAX14575A/AL/C switches turn on again after the device temperature drops by approximately 20°C (typ).

Table 1. Switch Truth Table

MAX14575A/B/C	MAX14575AL	SWITCH STATUS
EN	$\overline{EN}$	
0	1	OFF
1	0	ON

Applications Information

Setting the Current-Limit Threshold

Connect a resistor between SETI and ground to program the current-limit threshold value for the MAX14575A/MAX14575AL/MAX14575B/MAX14575C. Table 2 shows current-limit thresholds for different resistor values at SETI. Connecting SETI to ground asserts $\overline{FLAG}$.

Use the following formula to calculate the current limit:

$$R_{SETI(k\Omega)} = \frac{P(kV)}{I_{LIM}(mA)} - C(k\Omega)$$

Do not use an R_{SETI} value smaller than 40kΩ.

Note: Connecting any capacitor larger than 20pF to SETI can cause instability.

Table 2. Current-Limit Threshold vs. Resistor Values

R_{SETI} (kΩ)	CURRENT LIMIT (A)
510	0.26
470	0.28
402	0.33
301	0.45
261	0.51
200	0.625
150	0.86
100	1.32
90	1.45
85	1.55
75	1.75
64	2.02
57.6	2.26
53	2.5

IN Bypass Capacitor

Connect a minimum 1µF capacitor from IN to GND to limit the input-voltage drop during momentary output short-circuit conditions. If the power supply cannot support the required short-circuit current, then a larger capacitor should be used to maintain the input voltage above 2.3V.

If the supply is not strong enough and the user does not want to use a larger capacitor at the input, then the following circuitry can be used (Figure 4.)

OUT Bypass Capacitor

For stable operation over the full temperature range and over the full programmable current-limit range, use a 1µF ceramic capacitor from OUT to ground.

Excessive output capacitance can cause a false overcurrent condition due to decreased dV/dt across the capacitor. Use the following formula to calculate the maximum capacitive load (C_{MAX}) on OUT:

$$C_{MAX}(\mu F) = \frac{I_{LIM}(mA) \times t_{BLANK(MIN)}(ms)}{V_{IN}(V)}$$

For example, for V_{IN} = 5.0V, t_{BLANK} = 10ms, and I_{LIM} = 1000mA, C_{MAX} equals 2000µF.

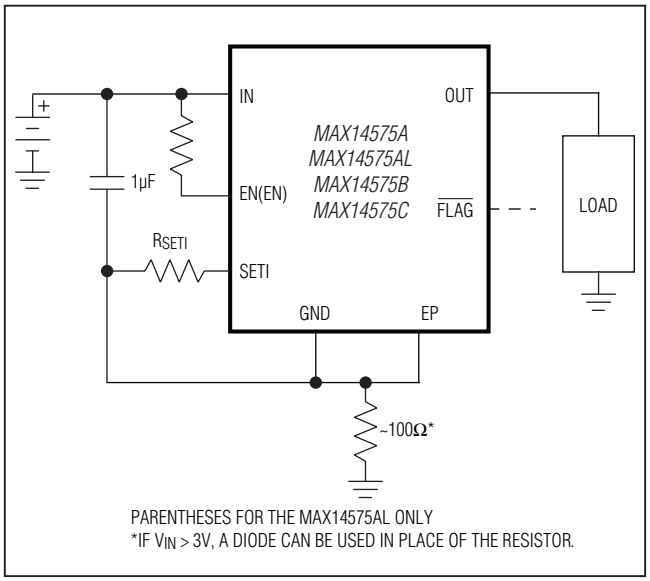


Figure 4. Optional Protection for Weak Supply

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 (should be no more than 5mm). IN and OUT must be connected with wide short traces to the power bus. 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:

$$P_{(MAX)} = \frac{V_{IN(MAX)} \times I_{OUT(MAX)} \times t_{BLANK}}{t_{RETRY} + t_{BLANK}}$$

Attention must be given to the MAX14575C continuous current-limit version when the power dissipation during a fault condition causes the device to reach the thermal-shutdown threshold.

Chip Information

PROCESS: BiCMOS

Package Information

For the latest package outline information and land patterns (footprints), go to **www.maximintegrated.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

PACKAGE TYPE	PACKAGE CODE	OUTLINE NO.	LAND PATTERN NO.
8 TDFN-EP	T822+2	21-0168	90-0065

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	9/12	Initial release	—

maxim integrated™

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. The parametric values (min and max limits) shown in the Electrical Characteristics table are guaranteed. Other parametric values quoted in this data sheet are provided for guidance.

© 2012 Maxim Integrated Products, Inc. Maxim Integrated and the Maxim Integrated logo are trademarks of Maxim Integrated Products, Inc.