MIC2544/2548

Programmable Current Limit High-Side Switch

General Description

The MIC2544 and MIC2548 are integrated, high-side power switches optimized for low loss DC power switching and other power management applications, including Advanced Configuration and Power Interface (ACPI). The MIC2544/48 is a cost-effective, highly integrated solution that requires few external components to satisfy USB and ACPI requirements.

Load current management features include a precision resistor-programmable output current-limit and a soft-start circuit which minimizes inrush current when the switch is enabled. Thermal shutdown, along with current-limit, protects the switch and the attached device.

The MIC2544/48's open-drain flag output is used to indicate current-limiting or thermal shutdown to a local controller. The MIC2548 has an additional internal latch which turns the output off upon thermal shutdown providing robust fault control. The enable signal is compatible with both 3V and 5V logic, and is also used as the thermal shutdown latch reset for the MIC2548.

The MIC2544 and MIC2548 are available in active-high and active-low enable versions in the 8-pin SOIC (small-outline integrated circuit) and 8-pin MSOP (micro-small-outline package).

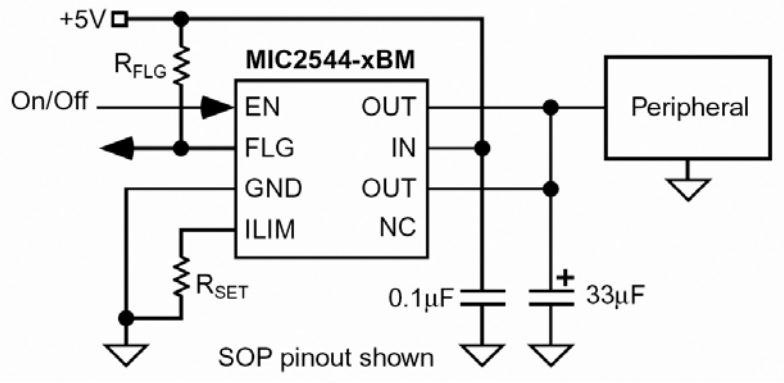
Features

- 2.7V to 5.5V input
- Adjustable current-limit up to 1.5A
- Reverse current flow blocking (no "body diode")
- 75μA typical on-state supply current
- 1μA typical off-state supply current
- 120mΩ maximum on-resistance
- Open-drain fault flag
- Thermal shutdown
- Thermal shutdown output latch (MIC2548)
- 2ms (slow) turn-on and fast turnoff
- Available with active-high or active-low enable

Applications

- USB power distribution
- PCI bus power switching
- Notebook PC
- ACPI power distribution
- PC card hot swap applications
- Inrush current-limiting

Typical Application



Typical Advanced Configuration and Power Interface (ACPI) Application

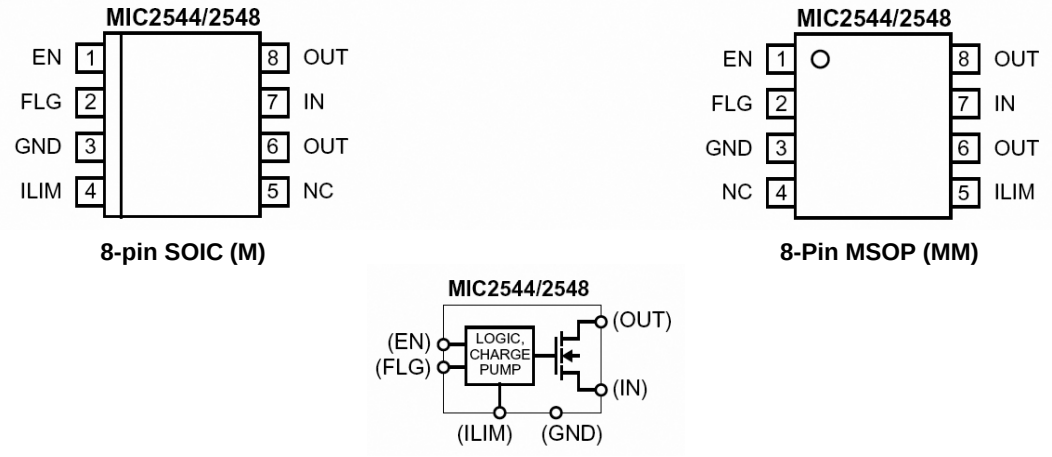
UL Recognized Component

Ordering Information*

Part Number	Enable	Latch*	Temperature Range	Package	Pb-Free
MIC2544-1BM	Active High		-40°C to +85°C	8-pin SOIC	
MIC2544-1BMM	Active High		-40°C to +85°C	8-pin MSOP	
MIC2544-2BM	Active Low		-40°C to +85°C	8-pin SOIC	
MIC2544-2BM	Active Low		-40°C to +85°C	8-pin MSOP	
MIC2544-1YM	Active High		-40°C to +85°C	8-pin SOIC	■
MIC2544-1YMM	Active High		-40°C to +85°C	8-pin MSOP	■
MIC2544-2YM	Active Low		-40°C to +85°C	8-pin SOIC	■
MIC2544-2YMM	Active Low		-40°C to +85°C	8-pin MSOP	■
MIC2548-1BM	Active High	■	-40°C to +85°C	8-pin SOIC	
MIC2548-1BMM	Active High	■	-40°C to +85°C	8-pin MSOP	
MIC2548-2BM	Active Low	■	-40°C to +85°C	8-pin SOIC	
MIC2548-2BMM	Active Low	■	-40°C to +85°C	8-pin MSOP	
MIC2548-1YM	Active High	■	-40°C to +85°C	8-pin SOIC	■
MIC2548-1YMM	Active High	■	-40°C to +85°C	8-pin MSOP	■
MIC2548-2YM	Active Low	■	-40°C to +85°C	8-pin SOIC	■
MIC2548-2YMM	Active Low	■	-40°C to +85°C	8-pin MSOP	■

***Thermal Shutdown Latch**

Pin Configuration



8-pin SOIC (M) **8-Pin MSOP (MM)**

Note: Pins 4 and 5 for SOIC and MSOP are different.

Pin Description

Pin Number MSOP-8	Pin Number SOIC-9	Pin Name	Pin Function
1	1	EN	Enable (Input): Logic-compatible enable input. Active-high (-1) or active-low (-2). High input >1.7V typical; low input <1.5V typical. Do not float. MIC2548 only: Also resets thermal shutdown latch.
2	2	FLG	Fault Flag (Output): Active-low, open-drain output. Indicates overcurrent or thermal shutdown conditions. MIC2548 only: latched low on thermal shutdown.
3	3	GND	Ground.
5	4	ILIM	Current Limit: Sets current-limit threshold using an external resistor, R_{SET}[1] connected to ground. 154Ω < R_{SET} < 2.29kΩ.
7	7	IN	Input: Output MOSFET drain. Also powers internal circuitry.
6,8	6,8	OUT	Switch (Output): Output MOSFET source. Pins 6 and 8 must be externally connected.
4	5	NC	Not internally connected.

Absolute Maximum Ratings[1]

Supply Voltage (V_{IN}) ..... +7.0V
Output Voltage (V_{OUT}) ..... +7.0V
Output Current (I_{OUT}) ..... Internally Limited
Enable Input (V_{EN}) ..... –0.3V to VIN+0.3V
Fault Flag Voltage (V_{FLG}) ..... +7.0V
Fault Flag Current (I_{FLG}) 50mA
Storage Temperature (T_s) ..... –65°C to +150°C
Junction Temperature (T_J) ..... Internally Limited
Lead Temperature (soldering, 5 sec.) ..... 260°C
ESD Rating[3] 2kV

Operating Ratings[2]

Supply Voltage (V_{IN}) ..... +2.7V to +5.5V
Current Limit Set Range ..... 0.1A to 1.5A
Ambient Temperature (T_A) ..... –40°C to +85°C
Package Thermal Resistance
SOIC (θ_{JA}) ..... 160°C/W
MSOP (θ_{JA}) ..... 206°C/W

Electrical Characteristics

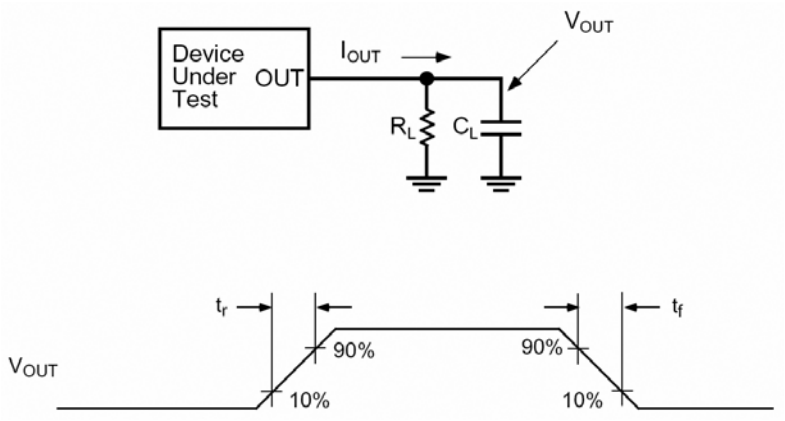
V_{IN} = +5V; T_A = 25°C, bold values indicate –40°C to +85°C, unless noted.

Symbol	Parameter	Condition	Min	Typ	Max	Units
	Supply Current	Switch off, OUT = open[4]	#	0.75	5	µA
		Switch on, OUT = open[4]		75	160	µA
V_{EN}	Enable Input Voltage	Enable high[4]	2.4	1.7		V
		Enable low[1]		1.5	0.8	V
	Enable Input Capacitance	Note 5		1		pF
$R_{DS(on)}$	Switch Resistance	I_{OUT} = 500mA		80	120	mΩ
	Current Limit Factor	I_{OUT} = 100mA to 1A, V_{OUT}=1V to 4V[6]	184	230	276	V
		I_{OUT} = 500mA to 1.5A, V_{OUT}=1V to 4V[6]	161	230	299	V
	Output Leakage Current	Switch off		1	10	µA
t_{ON}	Output Turn-On Delay	R_L = 10Ω, C_L = 1µF, Figures 1a, 1b	1	2	5	ms
T_R	Output Turn-On Rise Time	R_L = 10Ω, C_L = 1µF, Figures 1a, 1b	1	2	5	ms
T_{OFF}	Output Turn-Off Delay	R_L = 10Ω, C_L = 1µF, Figures 1a, 1b		22		µs
T_F	Output Turn-Off Fall Time	R_L = 10Ω, C_L = 1µF, Figures 1a, 1b		21		µs
	Overtemperature Threshold Shutdown	T_J increasing		140		°C
		T_J decreasing		130		°C
	Error Flag Output Resistance	V_{IN} = 5V, I_L = 10µA		4	15	Ω
		V_{IN} = 3.3V, I_L = 10µA		5	20	Ω
	Error Flag Off Current	V_{FLG} = 5V		0.01	1	µA
	EN Pulse Reset Width	MIC2548 thermal shutdown latch	5			µs
	V_{IN} to EN Set-Up	MIC2548[6]	0			µs
	Current-Limit Response Time	V_{OUT} = 0V[6]		25		µs
	Overcurrent Flag Response Time	V_{OUT} = V_{IN}/2 to FLG low		5		µs

Notes:

1. Exceeding the absolute maximum rating may damage the device.
2. The device is not guaranteed to function outside its operating rating.
3. Devices are ESD sensitive. Handling precautions recommended. Human body model, 1.5k in series with 100pF.
4. Off is ≤0.8V and on is ≥2.4V for the MIC2544-1 and MIC2548-1. Off is ≥2.4V and on is ≤0.8V for the MIC2544-2 and MIC2548-2. The enable input has about 200mV of hysteresis.
5. Guaranteed by design but not production tested.
6. Current limit threshold is determined by $I_{LIMIT} = \frac{230V}{R_{SET}}$, where R_{SET} is in ohms.

Test Circuit



Functional Characteristics Test Circuit

Timing Diagrams

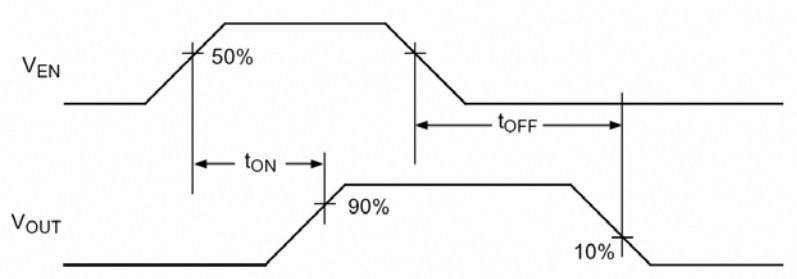


Figure 1a. MIC2544/48-1

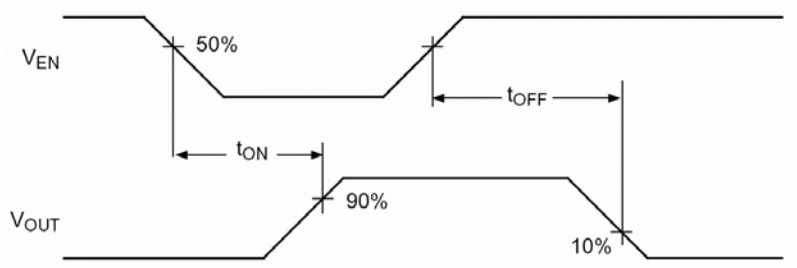


Figure 1b. MIC2544/48-2

Timing Diagrams continued

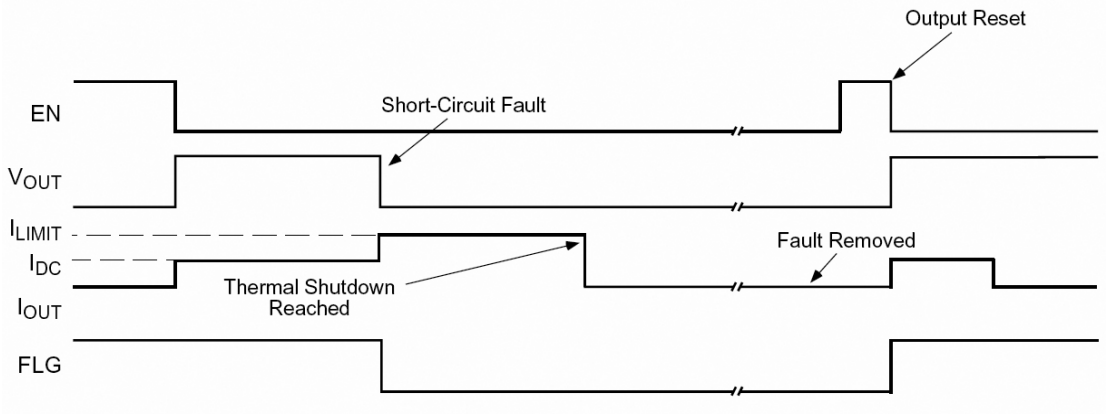


Figure 2a. MIC2548-2 Timing: Output is reset by toggling EN

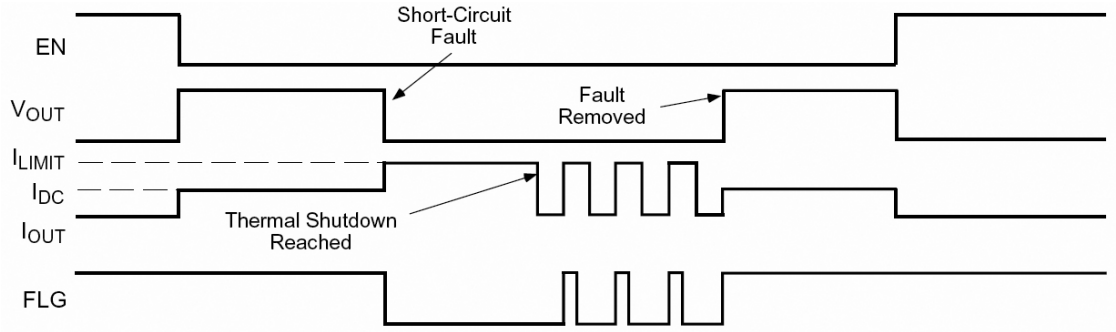
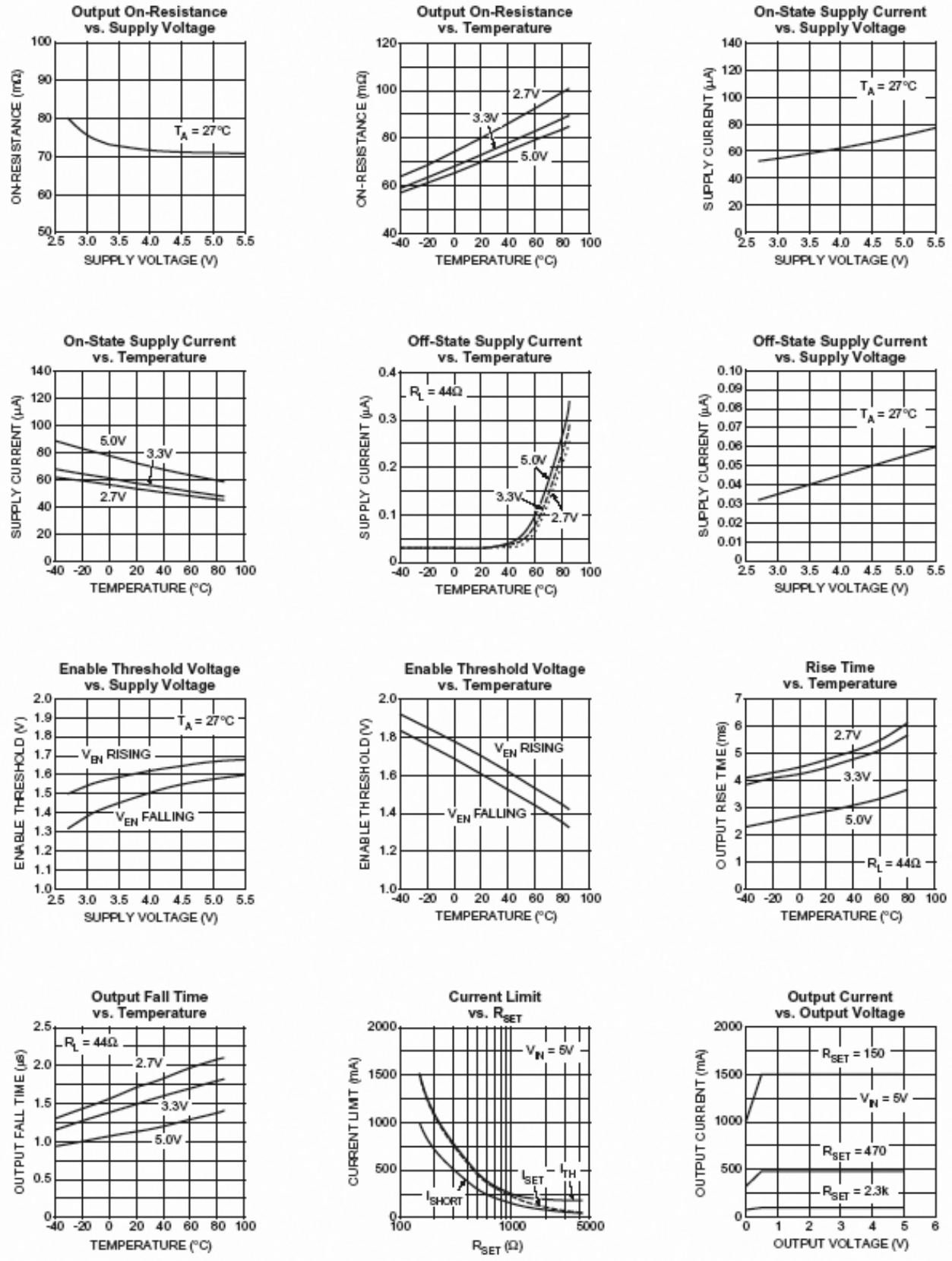
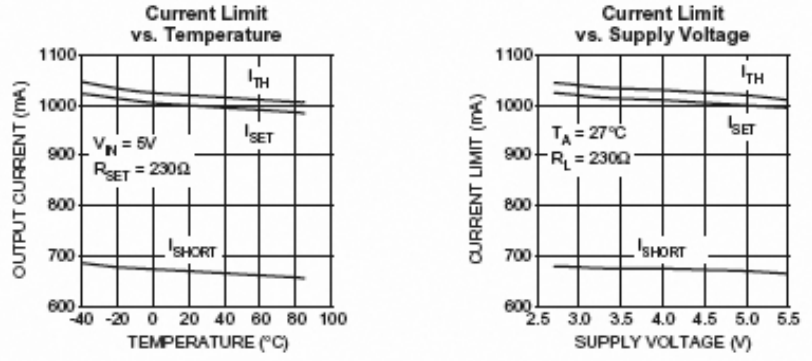


Figure 2b. MIC2544-2 Timing

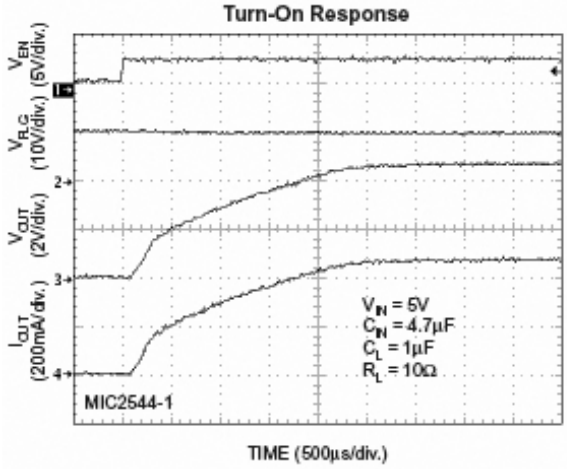
Typical Characteristics

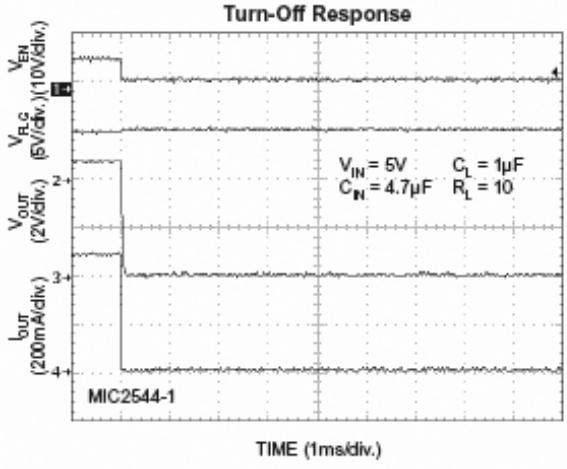


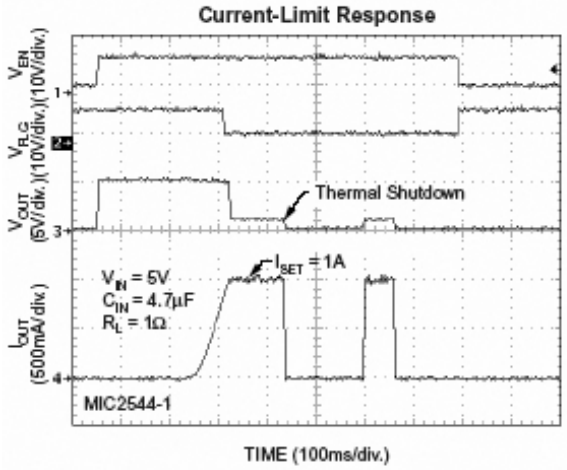
Typical Characteristics continued

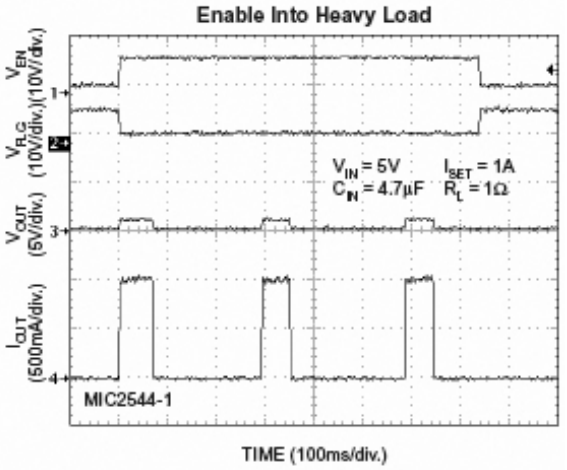


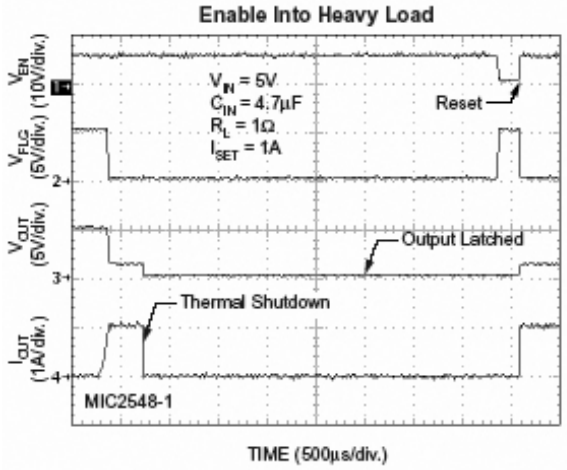
Functional Characteristics

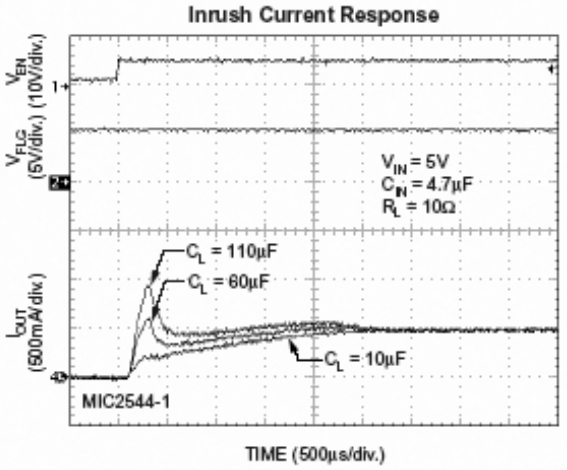




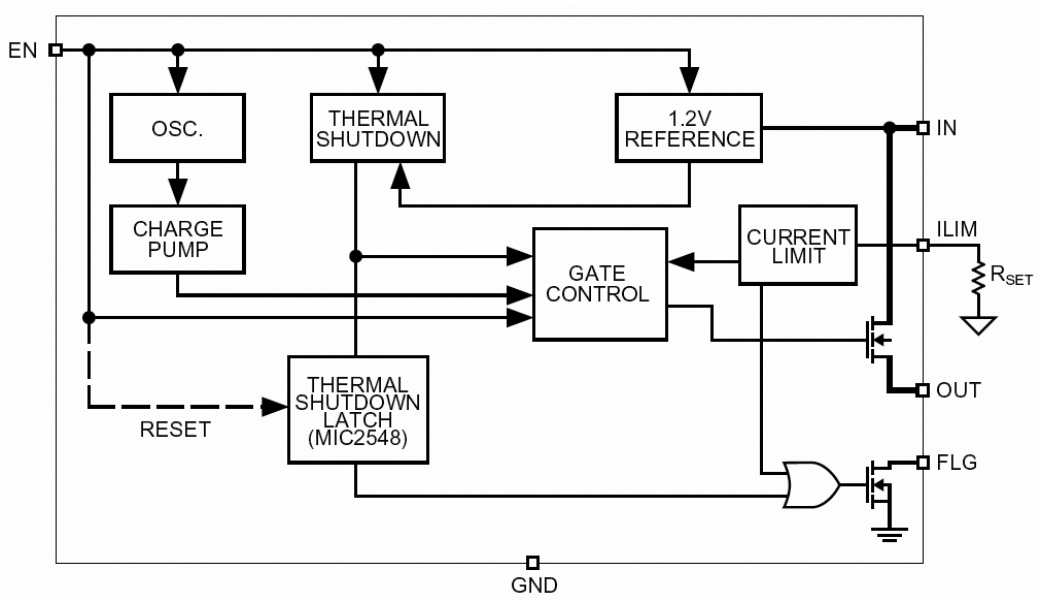








Block Diagram



Functional Description

The MIC2544 and MIC2548 are high-side N-channel switches available with active-high or active-low enable inputs. Fault conditions turn-off or inhibit turn-on of the output transistor and activate the open-drain error flag transistor making it sink current to ground.

Input and Output

IN is the power supply connection to the logic circuitry and the drain of the output MOSFET. OUT is the source of the output MOSFET. In a typical circuit, current flows from IN to OUT toward the load. If VOUT is greater than VIN, current will flow from OUT to IN since the switch is bidirectional when enabled.

The output MOSFET and driver circuitry are also designed to allow the MOSFET source to be externally forced to a higher voltage than the drain (V_{OUT} > V_{IN}) when the switch is disabled. In this situation, the MIC2544/48 avoids undesirable current flow from OUT to IN. Both OUT pins must be connected together.

Thermal Shutdown

Thermal shutdown shuts off the output MOSFET and signals the fault flag if the die temperature exceeds 140°C. 10°C of hysteresis prevents the switch from turning on until the die temperature drops to 130°C. Overtemperature detection functions only when the switch is enabled.

The MIC2548 features an internal latch which causes the part to remain off after thermal shutdown until a reset pulse is provided via the enable pin (pin 1). While in current-limit, the thermal shutdown latch prevents on/off cycling of the output.

Refer to Figures 2a and 2b for timing diagram. The flag remains low until reset.

Enable Input

EN must be driven logic high or logic low, or be pulled high or low for a clearly defined input. Floating the input may cause unpredictable operation. EN should not be allowed to go negative with respect to GND, and V_{EN} should be less than or equal to V_{IN}.

Adjustable Current-Limit

The short-circuit current-limit is user-adjustable with an external set resistor. Current-limit in the range of 100mA to 1.5A is available with a set point accuracy of better than ±20%. The current-limit circuit prevents damage to the output MOSFET and external load.

The nominal current-limit value is set with an external resistor between ILIM and GND. For a desired current-limit, the value of the external set resistor is given by:

$$R_{SET} = \left(\frac{230V}{I_{LIMIT}}\right)$$

where:

$$154\Omega < R_{SET} < 2.29k\Omega$$

For example, to set a 1A nominal current-limit, R_{SET} is calculated as:

$$\left(\frac{230V}{1A}\right) = 230\Omega$$

Current through R_{SET} increases with OUT current. The voltage across R_{SET} could be monitored with a high impedance comparator to provide an indication of output current. R_{SET} should be between 154Ω ±0.5% and 2.29kΩ ±0.5%.

Short-Circuit Protection

In the event of a short circuit, the output current will fold back to approximately 80% of the short-circuit current-limit.

Fault Flag

FLG is an N-channel, open-drain MOSFET output. The faultflag is active (low) for current-limit or thermal shutdown conditions. The flag output MOSFET is capable of sinking a 10mA load to typically 100mV above ground.

Application Information

Supply Filtering

A 0.1µF to 1µF bypass capacitor from IN to GND, located near the MIC2544 and MIC2548, is strongly recommended to control supply transients. Without a bypass capacitor, an output short may cause sufficient ringing on the input (from supply lead inductance) to damage internal control circuitry.

Input transients must not exceed the absolute maximum supply voltage ($V_{IN\ max}$ = 6V) even for a short duration.

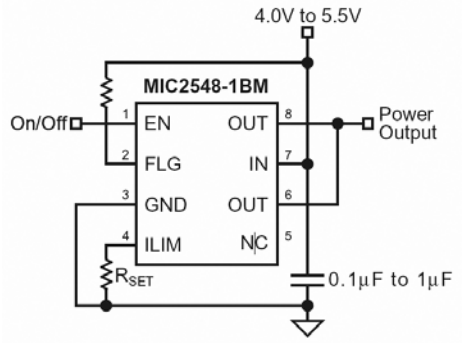


Figure 3. Supply Bypassing

Power Dissipation

The device's junction temperature depends on several factors such as the load, PCB layout, ambient temperature, and package type. Equations that can be used to calculate power dissipation and junction temperature are found below.

Calculation of power dissipation can be accomplished by the following equation:

$$PD = R_{DS(on)} \times (I_{OUT})^2$$

To relate this to junction temperature, the following equation can be used:

$$T_j = P_D \times \theta_{JA} + T_A$$

where:

T_j = junction temperature

T_A = ambient temperature

θ_{JA} = is the thermal resistance of the package

Transient Overcurrent Filter

The inrush current from the connection of a heavy capacitive load may cause the fault flag to fall for 10µs to 200µs while the switch is in a constant-current mode, charging the capacitance.

Adding an optional series resistor-capacitor (R_{SET2}) in parallel with R_{SET}, as shown in Figure 4, allows the transient current-limit to be set to a different value than steady state. A typical USB hot-plug inrush is 2A to 3A for 10µs to 20µs. If R_{SET} is 435Ω (510mA), an R_{SET2} of 88Ω (2.5A) and C_{SET} of 1µF (RC = 100µs) allows transient surge of 3A to pass for 100µs without tripping the overcurrent flag (FLG).

USB Power Distribution

The MIC2544 is ideal for meeting USB power distribution requirements. Figure 4 depicts a USB Host application. RSET should be set to a value providing a current-limit >500mA.

The accurate current-limit of the MIC2544 will reduce power supply current requirements. Also, fast reaction to short circuit faults prevent voltage droop in mobile PC applications.

Printed Circuit Board Hot-Plug

The MIC2544/48 are ideal inrush current-limiters suitable for hot-plug applications. Due to the integrated charge pump, the MIC2544/48 presents a high impedance when off and slowly becomes a low impedance as it turns on. This “softstart” feature effectively isolates power supplies from highly capacitive loads by reducing inrush current during hot-plug events. Figure 5 shows how the MIC2544 may be used in a hot-plug application.

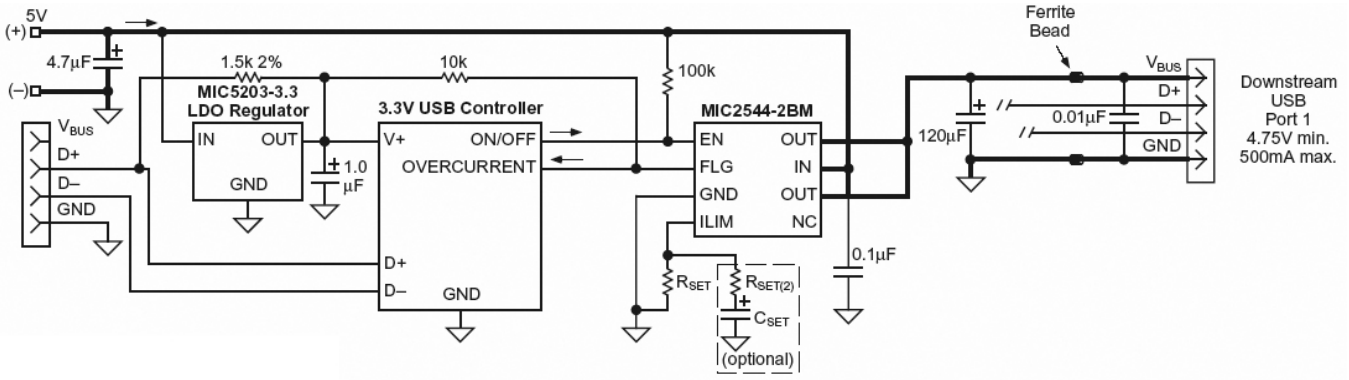


Figure 4. USB Host Application

Note: MSOP package option uses pin 5 for ILIM. Pin 4 is not connected (NC). **Bold** lines indicate 0.1” wide, 1-oz. copper high-current traces.

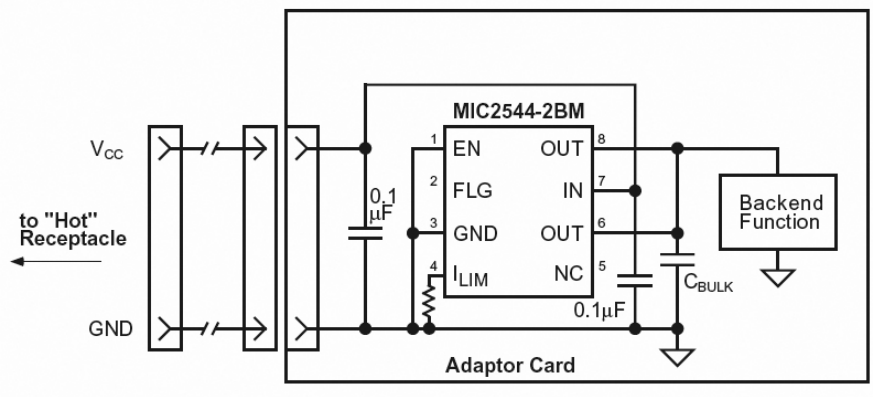
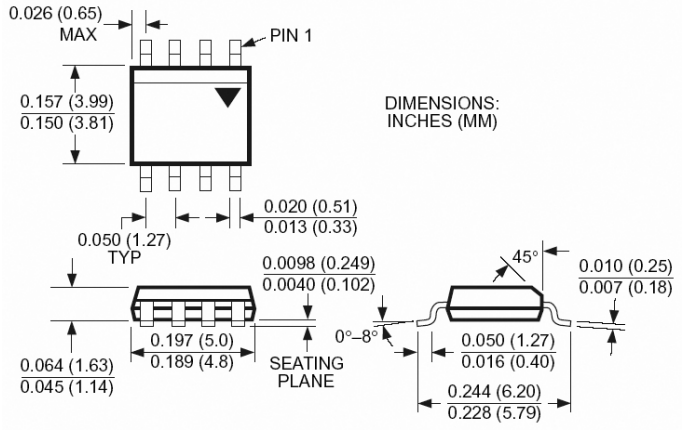
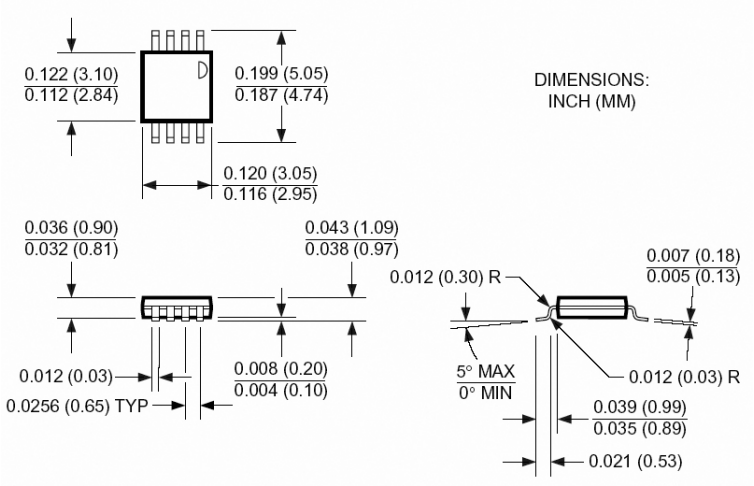


Figure 5. Hot Plug Application

Package Information



8-pin SOIC (M)



8-Pin MSOP (MM)

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