

MIC2545/2549

Programmable Current Limit High-Side Switch

Advance Information

General Description

The MIC2545 and MIC2549 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 MIC2545/9 is a cost-effective, highly integrated solution that requires few external components to satisfy USB and ACPI requirements.

The MIC2545/2549's low switch on-resistance meets USB voltage regulation requirements of many high current peripherals.

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. A thermal shutdown, along with current-limit, protects the switch and the attached device.

The MIC2545/9's open-drain flag output is used to indicate undervoltage, current limiting, or thermal shutdown to a local controller. The MIC2549 has an additional internal latch which turns the output off upon thermal shutdown. The enable signal is compatible with both 3V and 5V logic and is also used as the thermal shutdown latch reset for the MIC2549. Undervoltage lockout (UVLO) ensures that the device remains off unless there is a valid input voltage present.

The MIC2545 and MIC2549 are available in active-high and active-low enable versions in 8-pin DIP and SOIC packages.

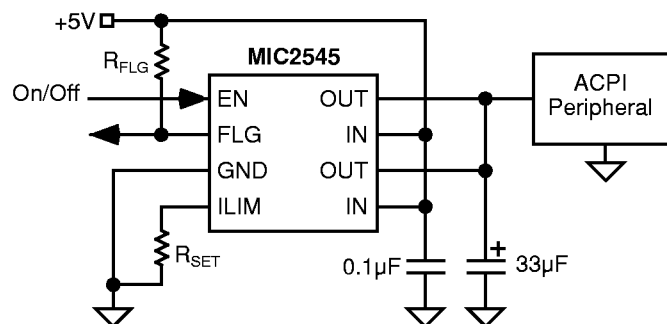
Features

- Compliant to USB specifications
- 2.7V to 5.5V input
- Adjustable current limit
- 75 μ A typical on-state supply current
- 1 μ A typical off-state supply current
- 50m Ω maximum on-resistance
- Open-drain fault flag
- Thermal shutdown
- Thermal shutdown output latch (MIC2549)
- 1 ms (slow) turn-on and fast turnoff
- 2.4V typical undervoltage lockout (UVLO)
- Available with active-high or active-low enable

Applications

- USB self-powered hubs
- USB monitors
- USB printers
- USB personal computers
- ACPI-compliant peripherals
- PCI Bus Power Switching

Typical Application



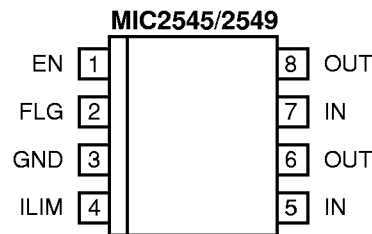
Typical Advanced Configuration and Power Interface (ACPI) Application

Ordering Information

Part Number	Enable	Latch*	Temperature Range	Package
MIC2545-1BM	Active High		-40°C to +85°C	8-pin SOIC
MIC2545-1BN	Active High		-40°C to +85°C	8-pin DIP
MIC2545-2BM	Active Low		-40°C to +85°C	8-pin SOIC
MIC2545-2BN	Active Low		-40°C to +85°C	8-pin DIP
MIC2549-1BM	Active High	•	-40°C to +85°C	8-pin SOIC
MIC2549-1BN	Active High	•	-40°C to +85°C	8-pin DIP
MIC2549-2BM	Active Low	•	-40°C to +85°C	8-pin SOIC
MIC2549-2BN	Active Low	•	-40°C to +85°C	8-pin DIP

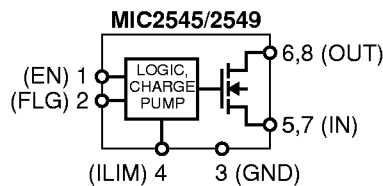
* Thermal Shutdown Latch

Pin Configuration



8-Pin SOIC (M)

8-Pin DIP (N)



Pin Description

Pin Number	Pin Name	Pin Function
1	EN	Enable (Input): Logic-compatible enable input (-1 version is active high, -2 version is active low). High input >1.8V typical; low input <1.4V typical. Do not float. MIC2549 only: Also resets thermal shutdown latch.
2	FLG	Fault Flag (Output): Active-low, open-drain output. Indicates overcurrent, UVLO, or thermal shutdown. MIC2549 only: latched low on threshold shutdown.
3	GND	Ground: Supply return.
4	ILIM	Current Limit: Sets current limit threshold using an external resistor connected to ground.
5, 7	IN	Supply Input: Output MOSFET drain. Also powers internal circuitry. Pins 5 and 7 must be externally connected.
6, 8	OUT	Switch Output: Output MOSFET source. Pins 6 and 8 must be externally connected.

Absolute Maximum Ratings

Supply Voltage (V_{IN})	+8.0V
Output Voltage (V_{OUT})	+7.5V
Output Current (I_{OUT})	Internally Limited
Enable Input (V_{EN})	-0.3V to 12V
Fault Flag Voltage (V_{FLG})	+8.0V
Fault Flag Current (I_{FLG})	50mA
Power Dissipation (P_{DISS})	250mW
Storage Temperature (T_S)	-65°C to +150°C
Junction Temperature (T_J)	Internally Limited
Lead Temperature (soldering 5 sec.)	260°C

Operating Ratings

Supply Voltage (V_{IN})	+2.7V to +5.5V
Ambient Temperature Range (T_A)	-40°C to +85°C
Package Thermal Resistance	
PDIP (θ_{JA})	160°C/W
SOIC (θ_{JA})	160°C/W

Electrical Characteristics

$V_{IN} = +5V$; $R_{SET} = 240\Omega$, $T_A = 25^\circ C$, **bold** indicates -40°C to +85°C; unless noted

Parameter	Condition	Min	Typ	Max	Units
Supply Current	switch off, OUT = open, Note 1		0.75		μA
	switch on, OUT = open, Note 1		75		μA
Enable Input Threshold	low-to-high transition		1.7	2.4	V
	high-to-low transition, Note 1	0.8	1.5		V
Enable Input Current	$V_{EN} = V_{OH(min)} = 2.4V$.01		μA
	$V_{EN} = V_{OL(max)} = 0.8V$.01		μA
Enable Input Capacitance			1		pF
Switch Resistance			35		m Ω
Output Leakage Current			1		μA
Output Turn-On Delay	$R_L = 10\Omega$, Note 2		0.7		ms
Output Turn-On Rise Time	$R_L = 10\Omega$, Note 3		4		ms
Output Turnoff Delay	$R_L = 10\Omega$, Note 4		1		μs
Output Turnoff Fall Time	$R_L = 10\Omega$, Note 5		10		μs
Current Limit Range	$R_{SET} 2k\Omega$ to 80Ω , Note 6	0.1		3	A
Current Limit Setpoint Accuracy					%
Overtemperature Threshold Shutdown	T_J increasing		135		$^\circ C$
	T_J decreasing		125		$^\circ C$
Error Flag Output Resistance	$V_{IN} = 5V$, $I_L = 10\mu A$		10		Ω
	$V_{IN} = 3.3V$, $I_L = 10\mu A$		15		Ω
Error Flag Off Current	$V_{FLG} = 5V$		0.01		μA
UVLO Threshold	V_{IN} increasing	2.2	2.5	2.7	V
	V_{IN} decreasing		2.3		V

Note 1. Off is $\leq 0.8V$ and on is $\geq 2.4V$ for the MIC2545-1 and MIC2549-1. Off is $\geq 2.4V$ and on is $\leq 0.8V$ for the MIC2545-2 and MIC2549-2. The enable input has about 200mV of hysteresis.

Note 2. Output turn-on delay is the time from switch activation at the enable input until $V_{OUT} = 10\%$ of 5V.

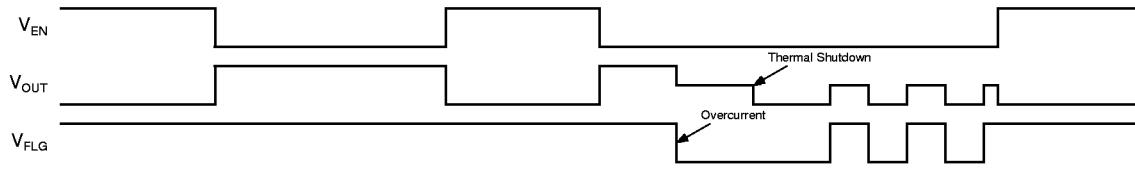
Note 3. Output turn-on rise time is the time from $V_{OUT} = 10\%$ to $V_{OUT} = 90\%$ of 5V.

Note 4. Output turnoff delay is the time from switch deactivation at the enable input until $V_{OUT} = 90\%$ of 5V.

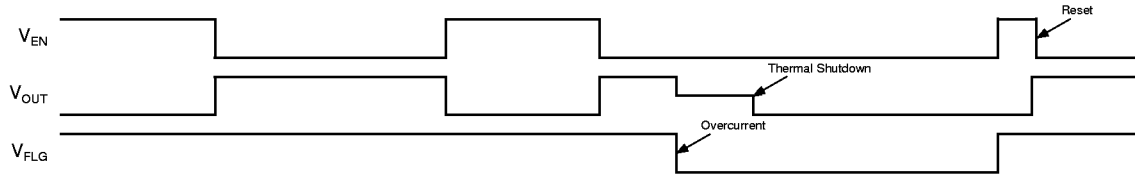
Note 5. Output turnoff fall time is the time from $V_{OUT} = 90\%$ to $V_{OUT} = 10\%$ of 5V.

Note 6. Current limit threshold is determined by: Threshold = $1200(0.2 + R_{SET})$, where R_{SET} is in ohms.

Timing Diagram

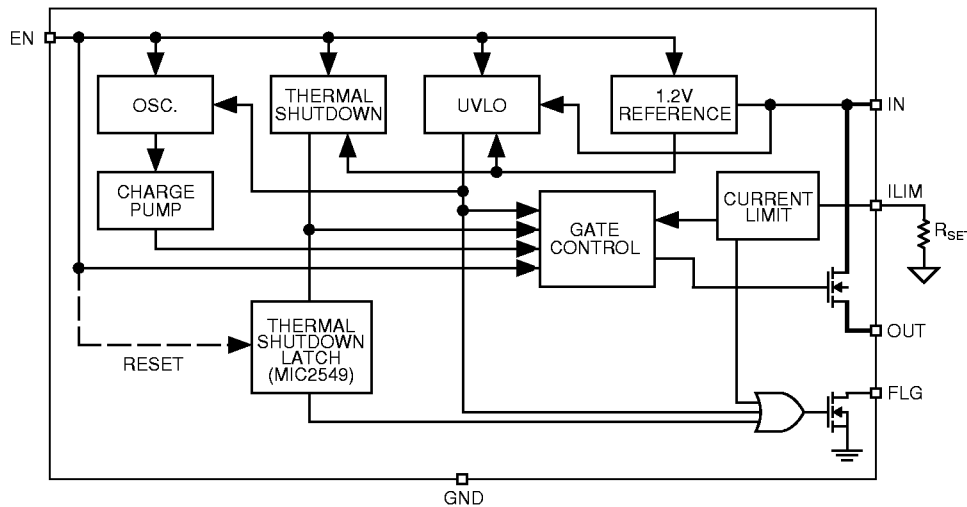


MIC2545-2 Timing



MIC2549-2 Latch-Mode Timing

Block Diagram



Functional Description

The MIC2545 and MIC2549 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 (input) is the power supply connection to the logic circuitry and the drain of the output MOSFET. OUT (output) is the source of the output MOSFET. In a typical circuit, current flows through the switch from IN to OUT toward the load. Both OUT pins must be connected to the load.

Reverse Flow Protection

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 output is off. In this situation, the MIC2545/49 avoids undesirable drain-to-body diode current flow when the switch is off. If $V_{OUT} > V_{IN}$ when switch is disabled, current will flow from V_{OUT} to V_{IN} when the switch is enabled. If $V_{IN} < 2.3V$, reverse current may flow from V_{OUT} to V_{IN} regardless of enable state.

Thermal Shutdown

Thermal shutdown shuts off the output MOSFET and signals the fault flag if the die temperature exceeds 135°C. 10°C of hysteresis prevents the switch from turning on until the die temperature drops to 125°C. Overtemperature detection functions only when the switch is enabled.

The MIC2549 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.

Undervoltage Lockout

UVLO (undervoltage lockout) prevents the output MOSFET from turning on until V_{IN} (input voltage) exceeds 2.5V. After

the switch turns on, if the voltage drops below 2.3V, UVLO shuts off the output MOSFET and signals the fault flag. Undervoltage detection functions only when the switch is enabled.

Adjustable Current Limit

The short-circuit current limit is user-adjustable with an external set resistor. Current limit in the range of 100mA to 3A is available with a set point accuracy of better than $\pm 20\%$. 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 pin 4 (ILIM) and pin 3 (GND). For a desired current limit, the value of the external set resistor is given by:

$$R_{SET} = 1200 \left(\frac{0.2}{I_{LIM}} \right)$$

where:

$$80\Omega < R_{SET} < 2.4k\Omega$$

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

$$1200 \left(\frac{0.2}{1.0} \right) = 1200 \times 0.2 = 240\Omega$$

Short-Circuit Protection

In the event of a short-circuit, the output current will be limited to a value of $1.6 \times I_{SET}$.

Fault Flag

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

Applications Information

Supply Filtering

A 0.1µF to 1µF bypass capacitor from IN to GND, located near the MIC2545 and MIC2549, 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 ($V_{IN\ max} = 8V$) even for a short duration.

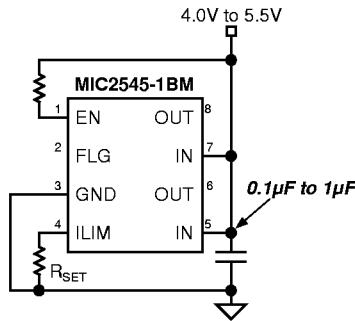


Figure 1. Supply Bypassing

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.

Soft Start

The MIC2545/9 switch is a high impedance when off and slowly becomes a low impedance as it turns on. This reduces inrush current and related voltage drop that results from charging a capacitive load, satisfying the USB voltage drop requirements.

The soft start circuit can be utilized to meet USB transient regulation specifications when the device has large load capacitance ($C_{BULK} > 10\mu F$). The MIC2545/49 will provide inrush current limiting for these applications.

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. If needed, a simple 1ms RC low-pass filter in series with the fault flag circuit will prevent erroneous overcurrent reporting. See *Application Note 17* for suggestions on layout and component selection to minimize transient effects.

Adding an optional series resistor-capacitor (R_{SET2}) in parallel with R_{SET} 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 470Ω (510mA), an R_{SET2} of 100Ω (2.5A) and C_{SET} of 100nF ($RC = 10\mu s$) allows transient surge of 3A to pass for 10µs without tripping the overcurrent flag (FLG).

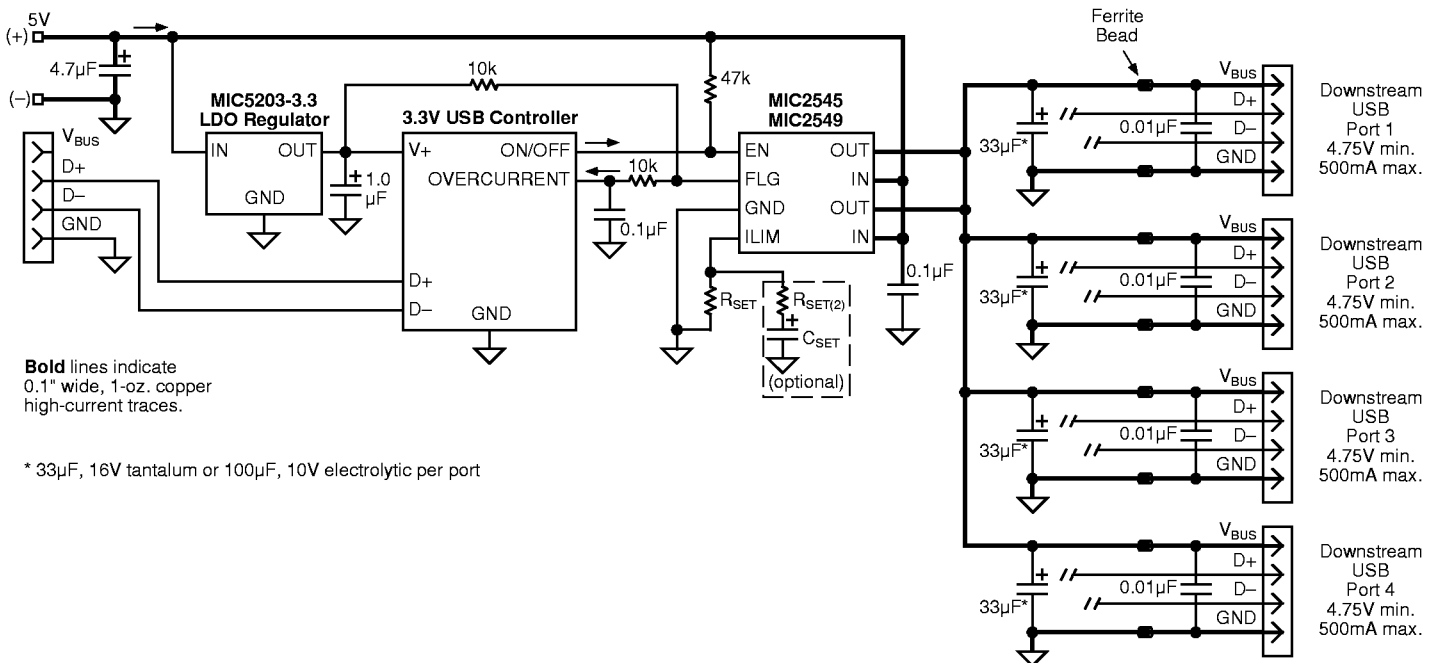


Figure 2. Four-Port Self-Powered USB Hub with Ganged Power Switching