MIC2505/2506

Single 2A / Dual 1A / High-Side Switches

General Description

The MIC2505 and MIC2506 are single and dual integrated high-side power switches that consist of TTL compatible inputs, a charge pump, and protected N-channel MOSFETs. The MIC2505/6 can be used instead of separate high-side drivers and MOSFETs in many low-voltage applications.

The MIC2505 switches voltages ranging from 2.7V to 7.5V and can deliver at least 2A continuous current. An MIC2506 can deliver at least 1A continuous current from each output. A slow turn on feature prevents high inrush current when switching capacitive loads. The internal control circuitry is powered from the same 2.7V to 7.5V. An MIC2505/6 output can be forced higher than the input voltage safely while in the off mode.

Multipurpose open-drain fault flag outputs indicate overcurrent limiting, open-load detection, thermal shutdown, or undervoltage lockout for each channel.

Overcurrent limiting is internally fixed and requires no external components.

Open-load detection is active when the switch is off. When off, a normal load pulls the output pin low. If the load is open, an optional, external, high-value resistor pulls the output pin high, triggering the fault flag.

Thermal shutdown turns off the output if the die temperature exceeds approximately 135°C. The switch automatically restarts when the temperature falls 10°C.

Undervoltage lockout (UVLO) shuts off the output if the supply drops below 2.3V typical and reenables the output when the supply exceeds 2.5V typical.

The MIC2505/6 is available in the 8-pin SOIC and DIP packages with a temperature range of –40°C to +85°C.

Features

- Low MOSFET on resistance to 2.7V
  - 30mΩ typical at 5V (MIC2505)
  - 35mΩ typical at 3.3V (MIC2505)
  - 75mΩ typical at 5V (each MIC2506 output)
  - 80mΩ typical at 3.3V (each MIC2506 output)
- 2.7V to 7.5V input
- 110µA typical on-state supply current
- 1µA typical off-state supply current
- Output can be forced higher than input (off-state)
- Current limit
- Thermal shutdown
- 2.5V undervoltage lockout (UVLO)
- Open-load detection
- Open-drain fault flag
- 5ms (slow) turn-on and fast turnoff

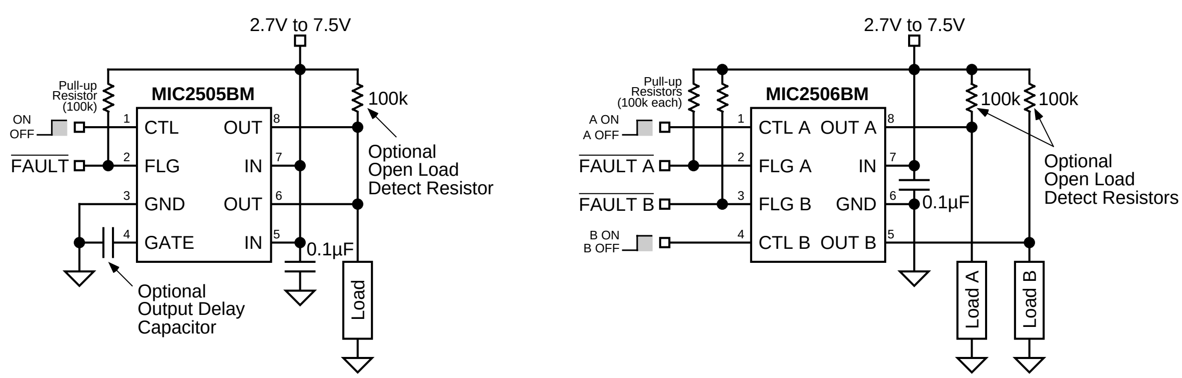
Applications

- 3.3V and 5V power management
- PC Card card inrush limiting switch
- Hot plug-in power supplies
- Battery-charger circuits

Ordering Information

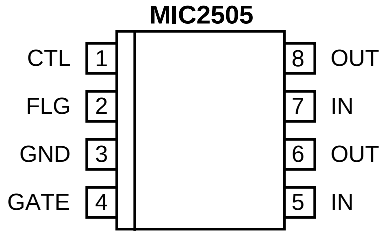
Part Number	Temperature Range	Package
Single Switch		
MIC2505BM	–40°C to +85°C	8-pin SOIC
MIC2505BN	–40°C to +85°C	8-pin DIP
Dual Switch		
MIC2506BM	–40°C to +85°C	8-pin SOIC
MIC2506BN	–40°C to +85°C	8-pin DIP

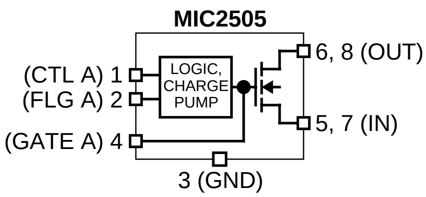
Typical Applications



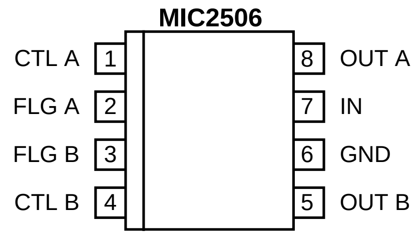
Single and Dual Switch/Circuit Breakers with Open-Load Detection and Fault Output

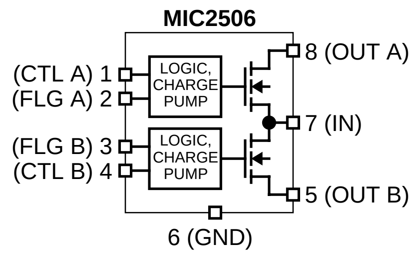
Pin Configuration





8-Pin SOIC (M)
8-Pin DIP (N)





8-Pin SOIC (M)
8-Pin DIP (N)

Pin Description

Pin Number MIC2505	Pin Number MIC2506	Pin Name	Pin Function
1	1 / 4	CTL (A/B)	Control (Input): Noninverting TTL compatible control input. High (> 1.8V typical) = on, low (< 1.6V typical) = off.
2	2 / 3	FLG (A/B)	Fault Flag (Output): Active-low, open-drain output. If CTL is low, indicates open load. If CTL is high, indicates current limit, thermal shutdown, or UVLO.
3	6	GND	Ground: Return.
4	—	GATE	Output MOSFET Gate: Open for fastest rise and fall times. Connect capacitor to ground to slow rise and fall times.
5, 7	7	IN	Supply Input: Output MOSFET drain. Also supplies IC's internal circuitry. Connect to supply. *MIC2505 only:* pins 5 and 7 must be externally connected.
6, 8	8 / 5	OUT (A/B)	Switch Output: Output MOSFET source. Typically connect to switched side of load. Output voltage can be pulled above input voltage in off mode. *MIC2505 only:* pins 6 and 8 must be externally connected.

Absolute Maximum Ratings

Supply Voltage (V_{IN}) 8.0V
Fault Flag Voltage (V_{FLG}) 7.5V
Fault Flag Current (I_{FLG}) 50mA
Output Voltage (V_{OUT}) 7.5V
Output Current (I_{OUT}) .... Internally Limited
Gate Voltage (V_{GATE}) .... V_{IN} + 15V
Control Input (V_{CTL}) .... –0.3V to 15V
Storage Temperature (T_A) .... –65°C to +150°C
Lead Temperature (Soldering 5 sec.) .... 260°C

Operating Ratings

Supply Voltage (V_{IN}) .... +2.7V to +7.5V
Ambient Operating Temperature (T_A) .... –40°C to +85°C
Thermal Resistance
  SOIC (θ_{JA}) .... 160°C/W
  DIP (θ_{JA}) .... 160°C/W

Electrical Characteristics

V_{IN} = +5V; GATE = open; T_A = 25°C, **bold** indicates –40°C ≤ T_A ≤ +85°C; unless noted

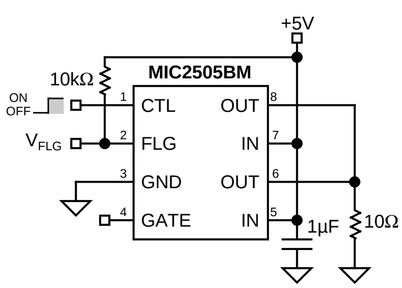
Parameter	Condition		Min	Typ	Max	Units
Supply Current	MIC2505	V_{CTL} = logic 0, OUT = open V_{CTL} = logic 1, OUT = open		.75 110	**5** **160**	µA µA
	MIC2506	V_{CTL} = logic 0, OUT = open V_{CTL} = logic 1, OUT = open		.75 110	**5** **160**	µA µA
Control Input Voltage		V_{CTL} = logic 0 → logic 1 transition V_{CTL} = logic 1 → logic 0 transition	 **0.8**	2.1 1.9	**2.4** 	V V
Control Input Current		V_{CTL} = logic 0 V_{CTL} = logic 1		0.01 0.01	**1** **1**	µA µA
Control Input Capacitance				1		pF
Output MOSFET Resistance	MIC2505	V_{IN} = 5V, T_A = 25°C V_{IN} = 5V, –40°C < T_A < +85°C V_{IN} = 3.3V, T_A = 25°C V_{IN} = 3.3V, –40°C < T_A < +85°C		30 35 	**50** **60** **60** **75**	mΩ mΩ mΩ mΩ
	MIC2506	V_{IN} = 5V, T_A = 25°C V_{IN} = 5V, –40°C < T_A < +85°C V_{IN} = 3.3V, T_A = 25°C V_{IN} = 3.3V, –40°C < T_A < +85°C		75 80 	**125** **150** **135** **165**	mΩ mΩ mΩ mΩ
Output Turn-On Delay	MIC2505	R_L = 10Ω	**200**	850	**2000**	µs
	MIC2506	R_L = 10Ω each output	**100**	700	**2000**	µs
Output Turn-On Rise Time	MIC2505	R_L = 10Ω	**500**	3000	**7500**	µs
	MIC2506	R_L = 10Ω each output	**200**	2000	**6000**	µs
Output Turn-Off Delay	MIC2505	R_L = 10Ω		0.7	**20**	µs
	MIC2506	R_L = 10Ω each output		0.8	**20**	µs
Output Turn-Off Fall Time	MIC2505	R_L = 10Ω		1.5	**20**	µs
	MIC2506	R_L = 10Ω each output		0.7	**20**	µs
Output Leakage Current					**10**	µA
Current Limit Threshold	MIC2505		**2**	4		A
	MIC2506		**1**	2	3	A
Open Load Threshold		V_{CTL} = logic low, **Note 1**	**0.5**	1	**1.5**	V
Overtemperature Shutdown Threshold		T_J increasing T_J decreasing		135 125		°C °C
Error Flag Output Resistance		V_{IN} = 5V, I_L = 10mA V_{IN} = 3.3V, I_L = 10mA		10 15	**25** **40**	Ω Ω
Error Flag Off Current		V_{FLAG} = 5V		0.01	**1**	µA
UVLO Threshold		V_{IN} = increasing V_{IN} = decreasing	**2.2** **2.0**	2.5 2.3	**2.7** **2.5**	V V

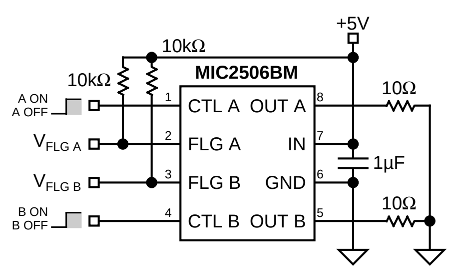
General Note: Devices are ESD protected, however, handling precautions recommended.

General Note: All limits guaranteed by testing or statistical analysis.

Note 1: Open load threshold is the OUT voltage where FLG becomes active (low). OUT driven high externally.

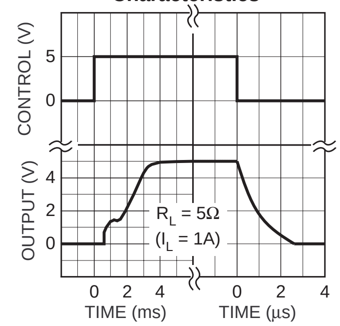
Test Circuits



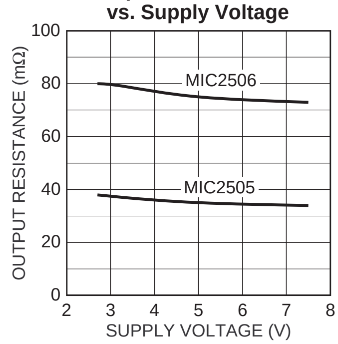


Typical Characteristics Note 2

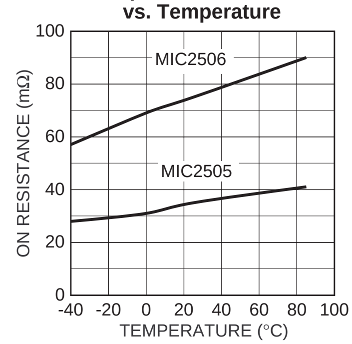
MIC2505 Turn-On, Turn-Off Characteristics



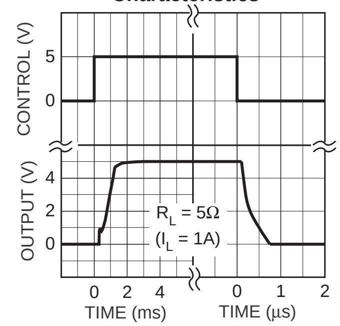
Output On Resistance vs. Supply Voltage



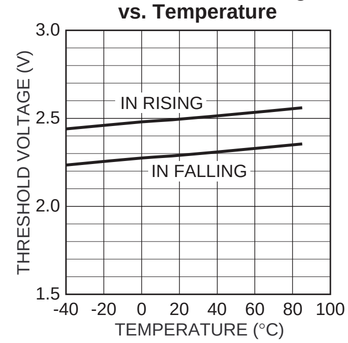
Output On Resistance vs. Temperature



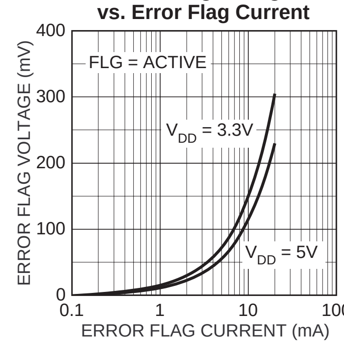
MIC2506 Turn-On, Turn-Off Characteristics



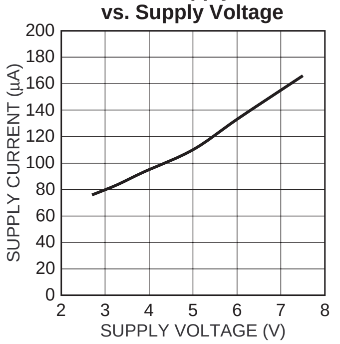
UVLO Threshold Voltage vs. Temperature



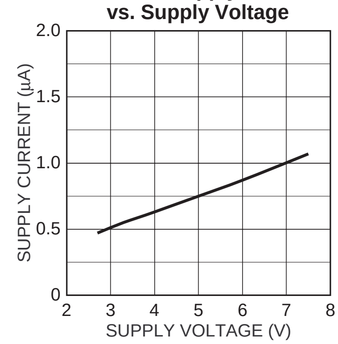
Error Flag Voltage vs. Error Flag Current



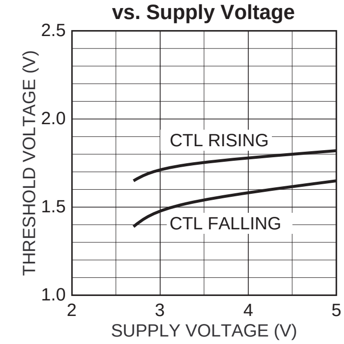
On-State Supply Current vs. Supply Voltage



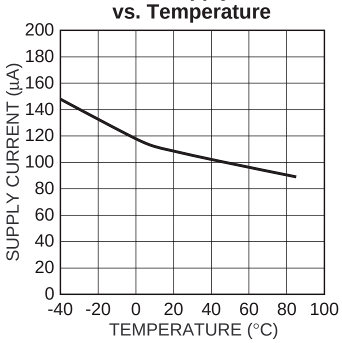
Off-State Supply Current vs. Supply Voltage



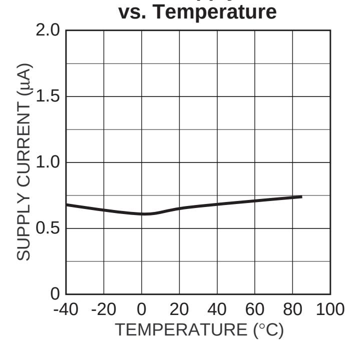
Control Threshold vs. Supply Voltage



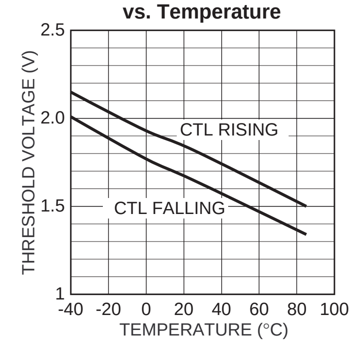
On-State Supply Current vs. Temperature



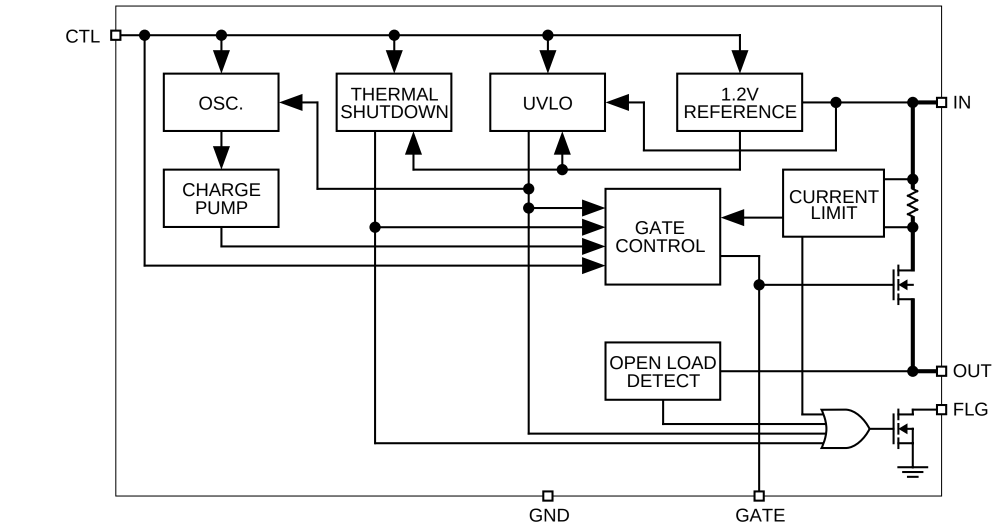
Off-State Supply Current vs. Temperature



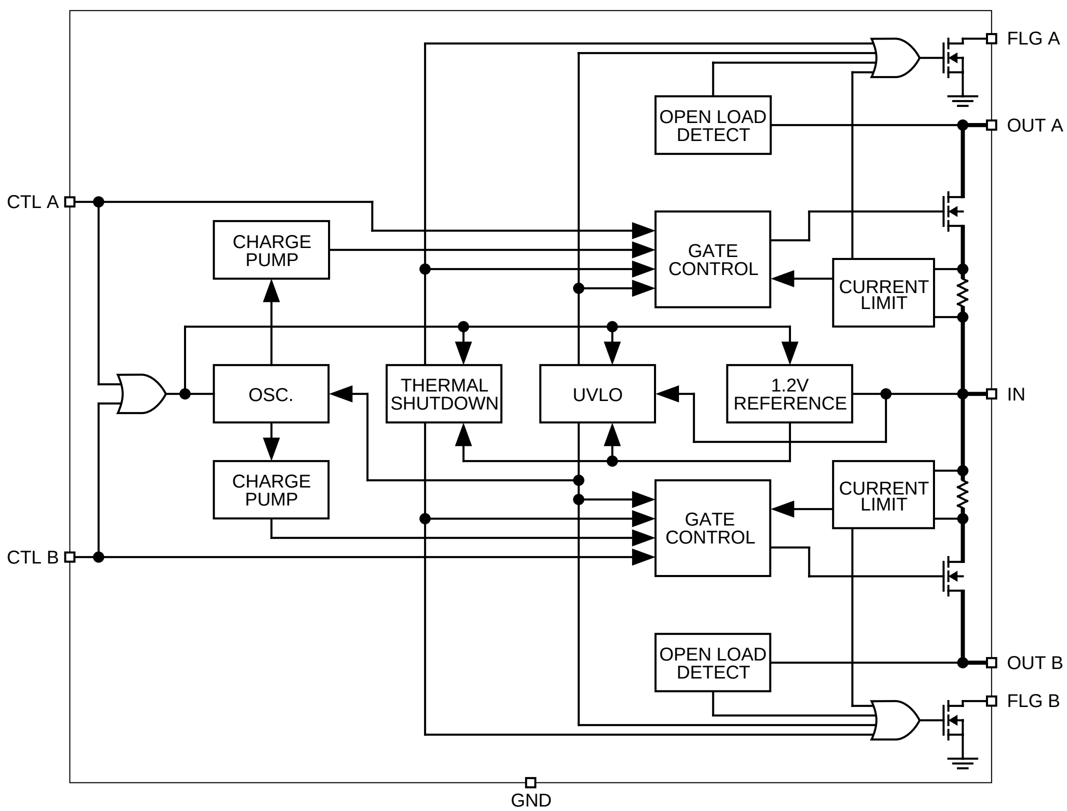
Control Threshold vs. Temperature



Block Diagrams



MIC2505 Block Diagram



MIC2506 Block Diagram

Functional Description

The MIC2505/6 is a noninverting high-side switch. A logic-high control input turns on the output transistor, and a logic-low turns off the output transistor. Fault conditions turn off or inhibit turn on of the output transistor.

Control Input

Applying a logic-high input to CTL (control input) activates the oscillator, thermal shutdown, UVLO, 1.2V reference, and gate control circuits. If there are no fault conditions, the output MOSFET turns on.

Reference

The 1.2V bandgap reference supplies a regulated voltage to the thermal shutdown and undervoltage lockout circuits. The reference is only active when CTL is high.

Oscillator/Charge Pump

The oscillator produces an 80kHz square wave output which drives the charge pump. The oscillator is disabled when CTL is low or during UVLO.

The charge pump is a voltage quintupler (5×). The charge pump capacitors are self contained.

Gate Control

The gate control circuit charges the output MOSFET gate from the charge pump output or discharges the MOSFET gate to ground as determined by CTL, thermal shutdown, or UVLO (undervoltage lockout).

An optional, external capacitor may be connected to the MIC2505 GATE to lengthen the rise and fall times. This slows the turn on and turn off of the MOSFET output switch.

Input and Output

IN (input) is the 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.

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 CTL is low (switch off). In this situation, the MIC2505/6 avoids undesirable drain to body diode current flow by grounding the body when the switch is off. (The conventional method for optimum turn on threshold has the source connected to the body. This would allow a large current to flow when $V_{source} > V_{drain} + 0.6V$.)

MIC2505 only

Duplicate IN and OUT leads are not internally connected and must be connected externally for proper operation.

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 control input is high (output MOSFET is on).

Undervoltage Lockout

UVLO (undervoltage lockout) prevents the output MOSFET from turning on until IN (input voltage) exceeds 2.5V typical. After the switch turns on, if the voltage drops below 2.3V typical, UVLO shuts off the output MOSFET and signals the fault flag.

Undervoltage detection functions only when the control input is high (output MOSFET is on).

Overcurrent Limit

The overcurrent limit is preset internally. The preset level prevents damage to the output MOSFET but allows a minimum current of 2A through the output MOSFET for the MIC2505 and 1A for each output MOSFET for the MIC2506. Output current is monitored by sensing the voltage drop across the output MOSFET drain metal resistance.

Overcurrent detection functions only when the control input is high (output MOSFET is on).

Open-Load Detection

Open-load detection indicates the absence of an output load by signaling the fault flag. Open-load detection is optional and is enabled by connecting a high-value pull-up resistor between IN and OUT. If there is no load, the circuit detects a high OUT (output) voltage (typically ≥1V) and signals the fault flag. Under normal conditions, the low resistance of a typical load pulls OUT low.

Open-load detection functions only when the control input is low (output MOSFET is off).

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: open load, 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 at the MIC2505/6, 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 destroy the internal control circuitry.

Input transients must not exceed the absolute maximum supply voltage ($V_{IN\ max}$ = 7.5V) even for a short duration.

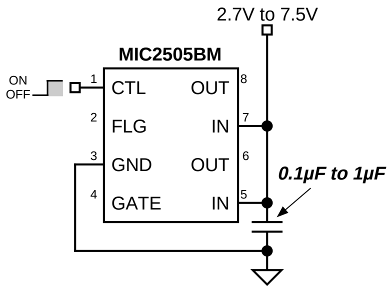


Figure 1. Supply Bypassing

The bypass capacitor may be omitted only if board design precautions are followed, such as using extremely short supply leads or power and ground planes.

Control Input

CTL 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.

Open-Load Detection

Refer to Typical Applications (first page).

The optional open-load detection resistor supplies a small current to the load when the MIC2505/6 is off. (A 100k resistor will draw 50µA from a 5V supply.) Normally, the load dominates, pulling OUT low. If the load is absent, the optional resistor pulls OUT high, activating the fault flag.

Open-load detection will not function with a pure capacitive load.

Omit the resistor when open load detection is not required and for the minimum off-state supply current.

Power Bus Switch

The MIC2505/6 features a MOSFET switch circuit that prevents current from flowing backwards (from OUT to IN) when CTL is low (switch off). In figure 2, when U1 is on and U2 is off, this feature prevents current flow from the load (5V) backward through U2 to the 3.3V supply. (If a discrete MOSFET and driver were used, the MOSFET's internal body diode would short the 5V load to the 3.3V supply.)

In a bus switch circuit, FLG will be active (low) on any switch that is off, whenever the load voltage is greater than the open load threshold (approximately 1V).

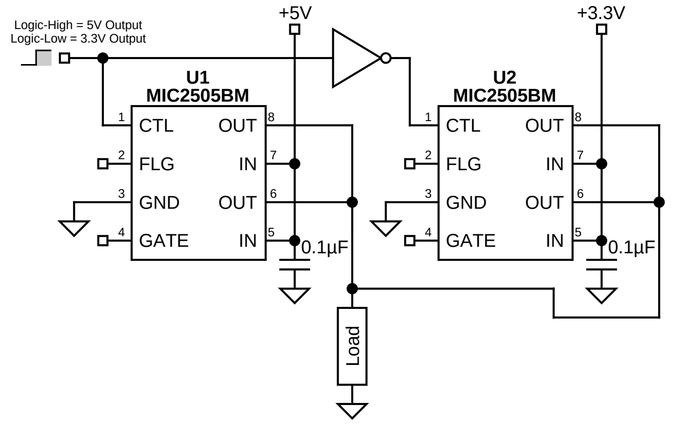


Figure 2. 5V/3.3V Switch Concept

This circuit's function would otherwise require a dual driver, two MOSFETs, plus two diodes (or a dual driver plus four MOSFETs).

Hot Plug-In Applications

The MIC2505/6 can be used to protect the socket-side and card-side of a supply circuit from transients caused when a capacitive load is connected to an active supply.

The switch presents a high impedance when off, and slowly becomes a low impedance as it turns on. This reduces the inrush current and related voltage drop that result from charging a capacitive load.

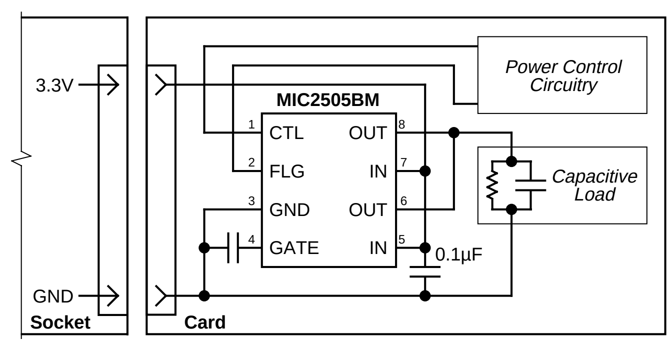


Figure 3. Hot Plug-In Concept

The gate capacitor slows the turn on time even more, reducing the inrush.