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May 2015

FPF2165R
Full Function Load Switch with Adjustable Current Limit

Features

- 1.8 to 5.5 V Input Voltage Range
- Controlled Turn-On
- 0.15-1.5 A Adjustable Current Limit
- ±10% Current Limit Accuracy vs. Temperature
- Under-Voltage Lockout (UVLO)
- Thermal Shutdown
- < 2 µA Shutdown Current
- Fast Current limit Response Time
  - 5 µs to Moderate Over Currents
  - 30 ns to Hard Shorts
- Reverse Current Blocking
- RoHS Compliant

Applications

- PDAs
- Cell Phones
- GPS Devices
- MP3 Players
- Digital Cameras
- Peripheral Ports
- Hot Swap Supplies

Related Resources

- *FPF2165R Product Information*

Description

The FPF2165R is a load switch which provides full protection to systems and loads which may encounter large current conditions. The device contains a 0.12 Ω current-limited Pchannel MOSFET which can operate over an input voltage range of 1.8-5.5 V. Internally, current is prevented from flowing when the MOSFET is off and the output voltage is higher than the input voltage. Switch control is by a logic input (ON) capable of interfacing directly with low-voltage control signals. The FPF2165R contains thermal shutdown protection, which shuts off the switch to prevent damage to the part when a continuous over-current condition causes excessive heating.

When the switch current reaches the current limit, the part operates in a Constant-Current (CC) mode to prohibit excessive currents from causing damage. The FPF2165R does not turn off after a current limit fault; it remains in the constant current mode indefinitely. The minimum current limit is 150 mA.

The FPF2165R is available in a space-saving 6-pin 2 mm x 2 mm Molded Leadless Package (MLP).

Figure 1. 2 mm x 2 mm Molded Leadless Package (MLP)

Ordering Information

Part Number	Current Limit [mA]	Current Limit Blanking Time [ms]	Auto Restart Time [ms]	On Pin Activity	Top Mark
FPF2165R	150-1500	0	NA	Active HI	65R

Typical Application

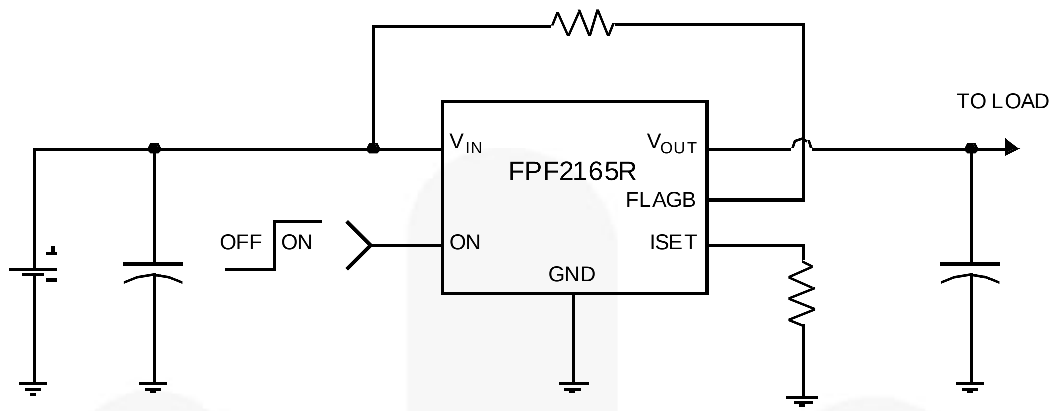


Figure 2. Typical Application

Block Diagram

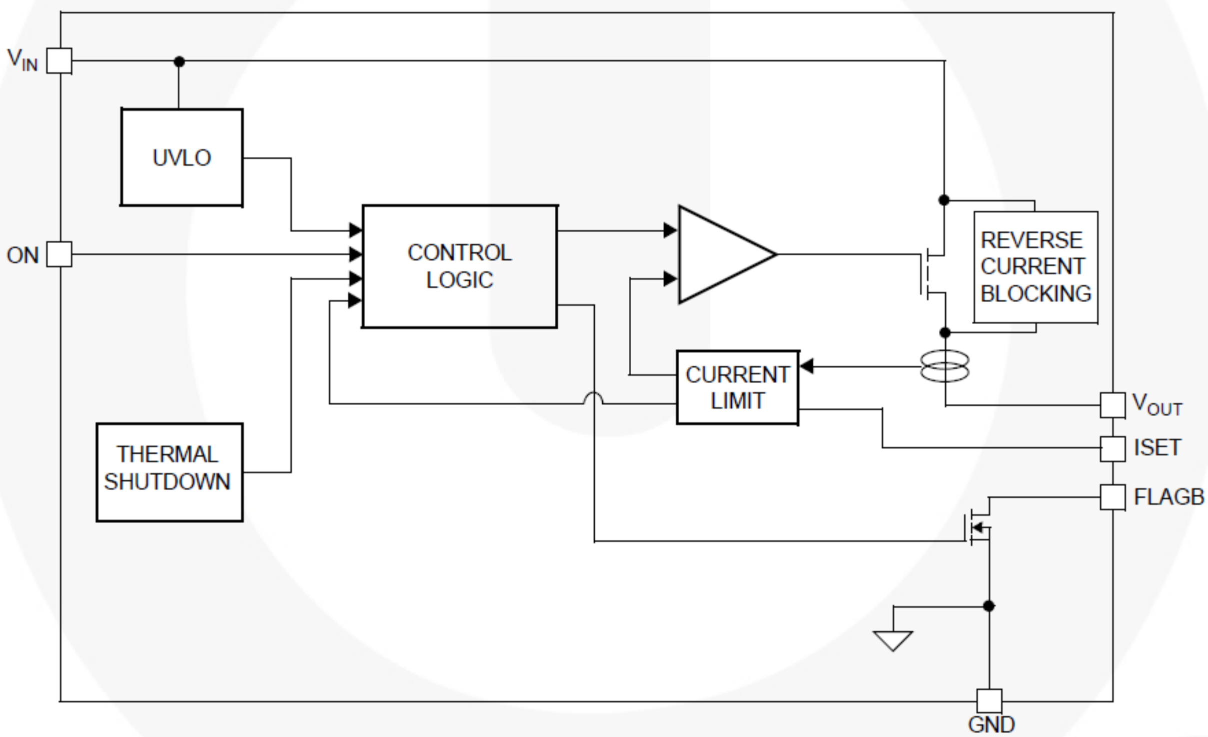


Figure 3. Block Diagram

Pin Configuration

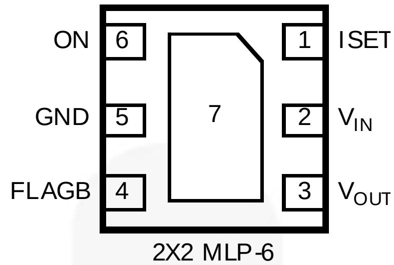


Figure 4. Pin Assignment (Top Through View)

Pin Descriptions

Name	Type	Description
1	ISET	Current Limit Set Input: A resistor from ISET to ground sets the current limit for the switch.
2	V_{IN}	Supply Input: Input to the power switch and the supply voltage For the IC
3	V_{OUT}	Switch Output: Output of the power switch
4	FLAGB	Fault Output: Active LO, open drain output which indicates an over-current supply under-voltage or over-temperature state.
5, 7	GND	Ground
6	ON	ON Control Input

Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

<table>
<tr><th>Symbol</th><th colspan="3">Parameter</th><th>Min.</th><th>Max.</th><th>Unit</th></tr>
<tr><td>V_{IN}</td><td colspan="3">V_{IN}, V_{OUT}, ON, FLAGB, ISET to GND</td><td>-0.3</td><td>6.0</td><td>V</td></tr>
<tr><td>P_D</td><td colspan="3">Power Dissipation</td><td></td><td>1.2</td><td>W</td></tr>
<tr><td>T_{STG}</td><td colspan="3">Operating and Storage Junction Temperature</td><td>-65</td><td>150</td><td>°C</td></tr>
<tr><td>Θ_{JA}</td><td colspan="3">Thermal Resistance, Junction to Ambient</td><td></td><td>86</td><td>°C/W</td></tr>
<tr><td rowspan="5">ESD</td><td rowspan="5">Electrostatic Discharge Capability</td><td colspan="2">Human Body Model; JEDEC A1141</td><td>4000</td><td></td><td rowspan="5">V</td></tr>
<tr><td colspan="2">Charged Device Model; JEDEC C101C</td><td>2000</td><td></td></tr>
<tr><td colspan="2">Machine Model; JEDEC A115</td><td>400</td><td></td></tr>
<tr><td rowspan="2">IEC 61000-4-2</td><td>Air Discharge</td><td>15000</td><td></td></tr>
<tr><td>Contact Discharge</td><td>8000</td><td></td></tr>
</table>

Recommended Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance. Fairchild does not recommend exceeding them or designing to Absolute Maximum Ratings.

Symbol	Parameter	Min.	Max.	Unit
V_{IN}	Input Voltage	1.8	5.5	V
T_A	Ambient Operating Temperature	-40	85	°C

Electrical Characteristics

V_{IN} = 1.8 to 5.5 V, T_A = -40 to +85°C unless otherwise noted. Typical values are at V_{IN} = 3.3 V and T_A = 25°C.

Symbol	Parameter	Conditions		Min.	Typ.	Max.	Unit
Basic Operation							
V_{IN}	Operating Voltage			1.8		5.5	V
I_Q	Quiescent Current	I_{OUT} = 1 mA	V_{IN} = 1.8 V		63	100	µA
			V_{IN} = 3.3 V		68		
			V_{IN} = 5.5 V		77	120	
R_{ON}	On Resistance	V_{IN} = 3.3 V, I_{OUT} = 200 mA, T_A = 25°C			120	160	mΩ
		V_{IN} = 3.3 V, I_{OUT} = 200 mA, T_A = 85°C			135	180	
		V_{IN} = 3.3 V, I_{OUT} = 200 mA, T_A = -40°C to +85°C		65		180	
		V_{IN} = 5 V, I_{OUT} = 200 mA, T_A = 25°C			95	124	
		V_{IN} = 5 V, I_{OUT} = 200 mA, T_A = 85°C			110	143	
		V_{IN} = 5 V, I_{OUT} = 200 mA, T_A = -40°C to +85°C		58		143	
V_{IH}	ON Input Logic High Voltage (ON)	V_{IN} = 1.8 V		0.8			V
		V_{IN} = 5.5 V		1.4			
V_{IL}	ON Input Logic Low Voltage	V_{IN} = 1.8 V				0.5	V
		V_{IN} = 5.5 V				1	
	ON Input Leakage	V_{ON} = V_{IN} or GND		-1		1	µA
	V_{IN} Shutdown Current	V_{ON} = 0 V, V_{IN} = 5.5 V, V_{OUT} = Short to GND		-2		2	µA
	FLAGB Output Logic Low Voltage	V_{IN} = 5 V, I_{SINK} = 10 mA			0.05	0.20	V
		V_{IN} = 1.8 V, I_{SINK} = 10 mA			0.12	0.30	
	FLAGB Output High Leakage Current	V_{IN} = 5 V, Switch On				1	µA
Reverse Block							
	V_{OUT} Shutdown Current	V_{ON} = 0 V, V_{OUT} = 5.5 V, V_{IN} = Short to GND		-2		2	µA
Protections							
I_{LIM}	Current Limit	V_{IN} = 3.3 V, V_{OUT} = 3.0 V, R_{SET} = 1840Ù		135	150	165	mA
		V_{IN} = 3.3 V, V_{OUT} = 3.0 V, R_{SET} = 361Ù		720	800	880	
		V_{IN} = 3.3 V, V_{OUT} = 3.0 V, R_{SET} = 196Ù		1350	1500	1650	
	Thermal Shutdown	Shutdown Threshold			140		°C
		Return from Shutdown			130		
		Hysteresis			10		
UVLO	Under-Voltage Shutdown	V_{IN} Increasing		1.55	1.65	1.75	V
	Under-Voltage Shutdown Hysteresis				50		mV
Dynamic							
td_{ON}	Delay On Time	R_L = 500 Ω, C_L = 0.1 µF			25		µs
td_{OFF}	Delay Off Time	R_L = 500 Ω, C_L = 0.1 µF			45		µs
t_{RISE}	V_{OUT} Rise Time	R_L = 500 Ω, C_L = 0.1 µF			10		µs
t_{FALL}	V_{OUT} Fall Time	R_L = 500 Ω, C_L = 0.1 µF			110		µs
	Short-Circuit Response Time	V_{IN} = V_{OUT} = 3.3 V, Moderate Over-Current Condition			5		µs
		V_{IN} = V_{OUT} = 3.3 V, Hard Short			30		ns

Note:
1. Package power dissipation on 1square inch pad, 2 oz copper board.

Typical Performance Characteristics

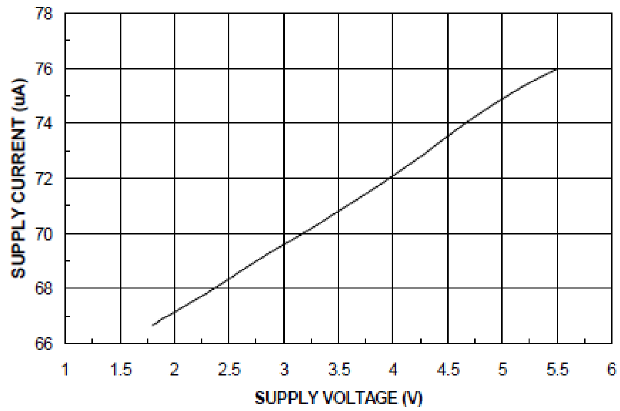


Figure 5. Quiescent Current vs. Input Voltage

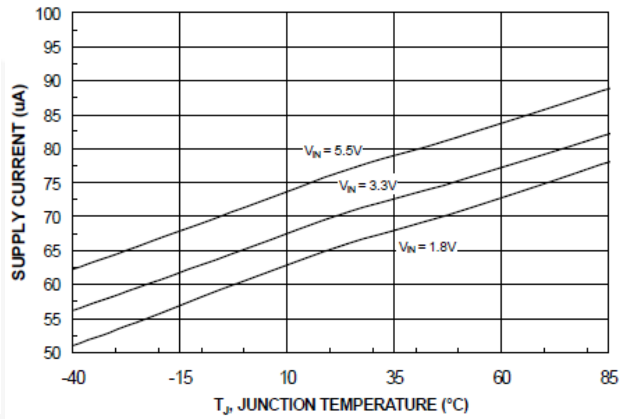


Figure 6. Quiescent Current vs. Temperature

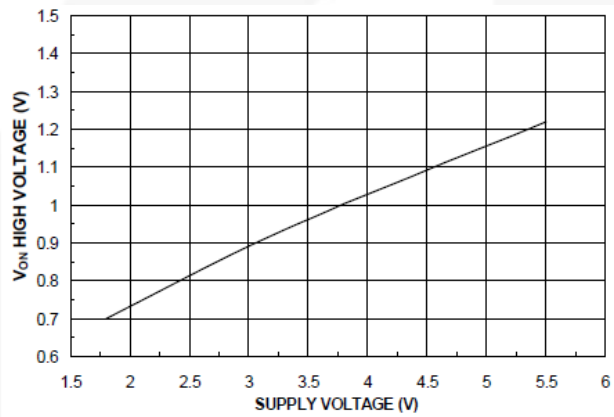


Figure 7. V_{ON} High Voltage vs. Input Voltage

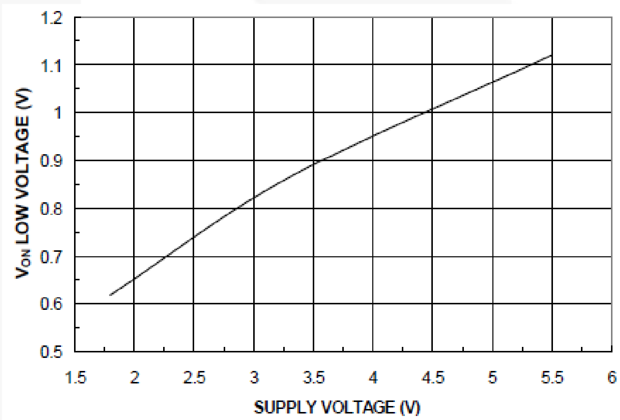


Figure 8. V_{ON} Low Voltage vs. Input Voltage

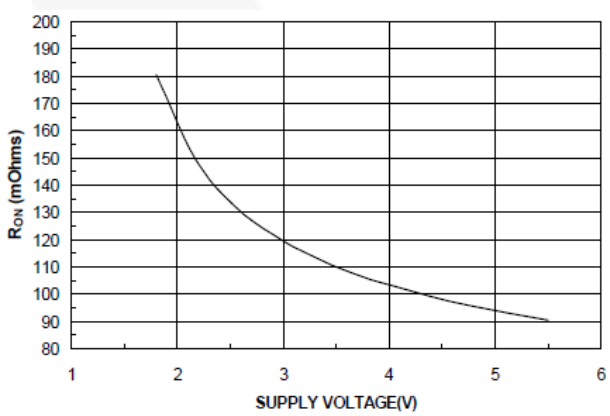


Figure 9. R_{ON} vs. V_{IN}

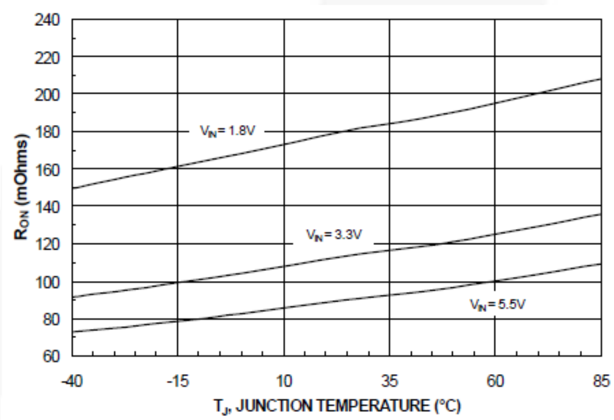


Figure 10. R_{ON} vs. Temperature

Typical Performance Characteristics

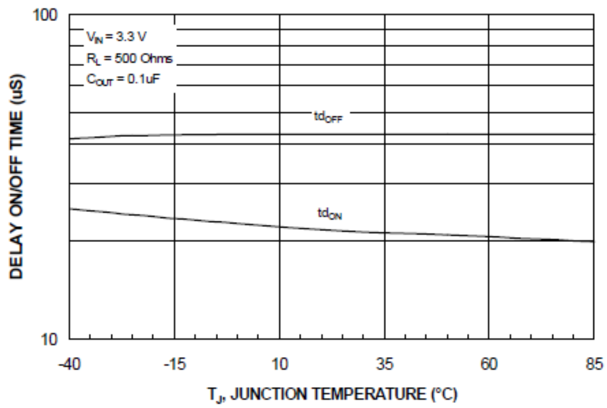


Figure 11. td_{ON} / td_{OFF} vs. Temperature

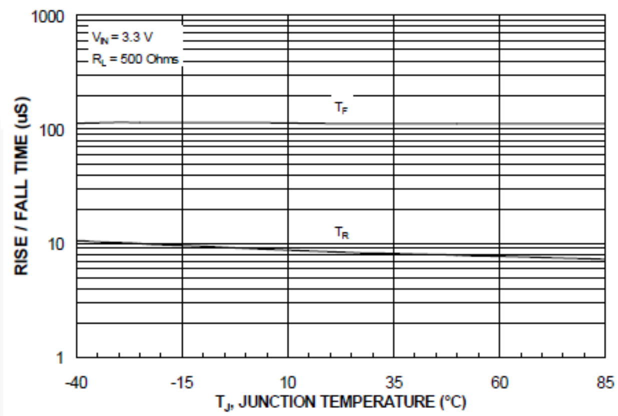


Figure 12. T_{RISE} / T_{FALL} vs. Temperature

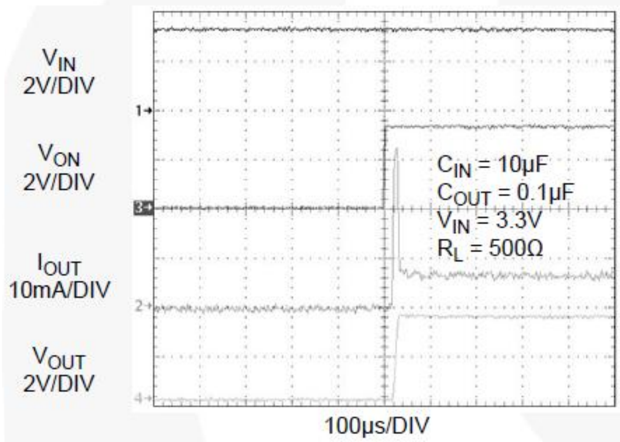


Figure 13. td_{ON} Response

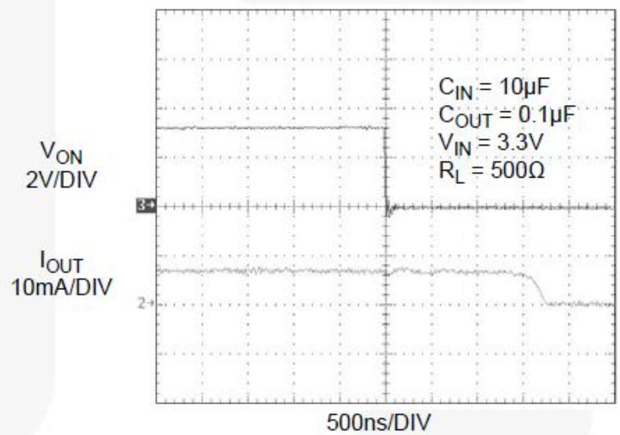


Figure 14. td_{OFF} Response

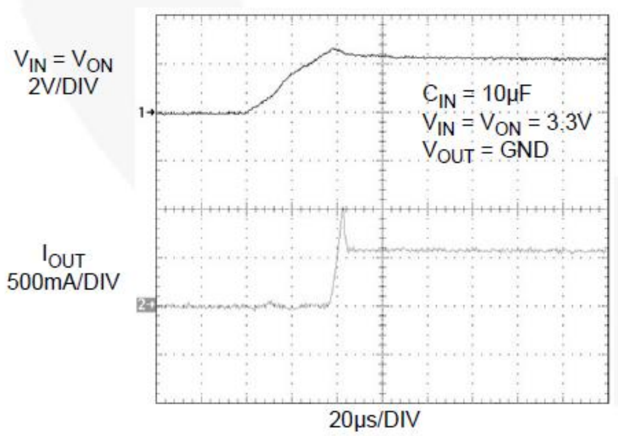


Figure 15. Current Limit Response Time (Switch Powered into Short)

Description of Operation

The FPF2165R is a current limited switch that protects systems and loads which can be damaged or disrupted by the application of high currents. The core of each device is a 0.12 Ω P-channel MOSFET and a controller capable of functioning over a wide input operating range of 1.8-5.5 V. The controller protects against system malfunctions through current limiting, under-voltage lockout and thermal shutdown. The current limit is adjustable from 0.15 A to 1.5 A through the selection of an external resistor.

On/Off Control

The ON pin controls the state of the switch. When ON is high, the switch is in the On state. Activating ON continuously holds the switch in the On state so long as there is no fault. An under-voltage on V_{IN} or a junction temperature in excess of 140°C overrides the ON control to turn off the switch. The FPF2165R does not turn off in response to an over-current condition but instead remains operating in a constant current mode so long as ON is active and the thermal shutdown or under-voltage lockout have not activated.

The ON pin control voltage and V_{IN} pin have independent recommended operating ranges. The ON pin voltage can be driven by a voltage level higher than the input voltage.

Fault Reporting

Upon the detection of an over-current, an input under-voltage, or an over-temperature condition, the FLAGB signals the fault mode by activating LOW. With the FPF2165R, FLAGB is LOW during the faults and immediately returns HI at the end of the fault condition. FLAGB is an open-drain MOSFET which requires a pull-up resistor between VIN and FLAGB. During shutdown, the pull-down on FLAGB is disabled to reduce current draw from the supply.

Current Limiting

The current limit ensures that the current through the switch doesn't exceed a maximum value while not limiting at less than a minimum value. The current at which the parts will limit is adjustable through the selection of an external resistor connected to ISET. Information for selecting the resistor is found in the Application Info section. The FPF2165R has no current limit blanking period so it remains in a constant-current state until the ON pin is deactivated or the thermal shutdown turns-off the switch.

For preventing the switch from large power dissipation during heavy load a short circuit detection feature is introduced. Short circuit condition is detected by observing the output voltage. The switch is put into short circuit current limiting mode if the switch is loaded with a heavy load. When the output voltage drops below V_{SCTH}, short circuit detection threshold voltage, the current limit value re-conditioned and short circuit current limit value is decreased to 62.5% of the current limit value. This keeps the power dissipation of the part below a certain limit even at dead short conditions at 5.5 V input voltage. The VSCTH value is set to be 1 V. At around 1.1 V of output voltage the switch is removed from short circuit current limiting mode and the current limit is set to the current limit value.

Under-Voltage Lockout

The under-voltage lockout turns-off the switch if the input voltage drops below the under-voltage lockout threshold. With the ON pin active the input voltage rising above the under-voltage lockout threshold causes a controlled turn-on of the switch which limits current over-shoots.

Reverse Current Blocking

The FPF2165R family has a Reverse Current Blocking feature that protects input source against current flow from output to input. For a standard USB power design, this is an important feature that protects the USB host from being damaged due to reverse current flow on V_{BUS}. The reverse-current blocking feature is active when the load switch is turned off.

If ON pin is LOW and output voltage becomes greater than input voltage, no current can flow from the output to the input. FLAGB operation is independent of the reverse current blocking and does not report a fault condition if this feature is activated.

Thermal Shutdown

The thermal shutdown protects the die from internally or externally generated excessive temperatures. During an over-temperature condition the FLAGB is activated and the switch is turned-off. The switch automatically turns-on again if temperature of the die drops below the threshold temperature.

Applications Information

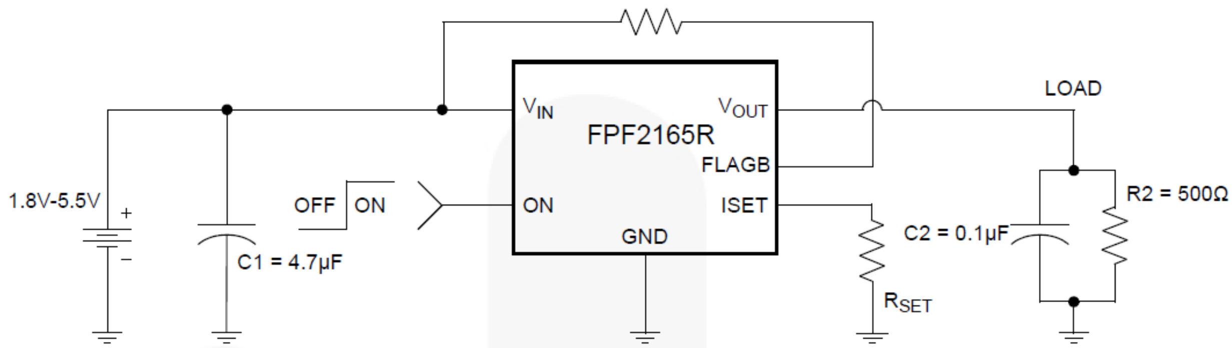


Figure 16. Typical Application

Setting Current Limit

The FPF2165R has a current limit which is set with an external resistor connected between ISET and GND. This resistor is selected by using equation (1),

$$I_{LIM} = 340.1 \times R_{SET} - 1.0278 \tag{1}$$

Table 1 can be used to select R_{SET}. A typical application would be the 500 mA current that is required by a single USB port. Using Table 1 an appropriate selection for the RSET resistor would be 570 Ω.

Table 1. Current Limit Various R_{SET} Values

R_{SET} [Ω]	Min. Current Limit [mA]	Typ. Current Limit [mA]	Max. Current Limit [mA]
1840	135	150	165
1391	180	200	220
937	270	300	330
708	360	400	440
632	405	450	495
570	450	500	550
478	540	600	660
411	630	700	770
361	720	800	880
322	810	900	990
290	900	1000	1100
265	990	1100	1210
243	1080	1200	1320
225	1170	1300	1430
209	1260	1400	1540
196	1350	1500	1650

Input Capacitor

To limit the voltage drop on the input supply caused by transient in-rush currents when the switch is turned on into a discharged load capacitor or a short-circuit; a capacitor needs to be placed between V_{IN} and GND. A 4.7 µF ceramic capacitor, C_{IN}, must be placed close to the V_{IN} pin. A higher value of C_{IN} can be used to further reduce the voltage drop experienced as the switch is turned on into a large capacitive load.

Output Capacitor

A 0.1 µF capacitor C_{OUT}, should be placed between V_{OUT} and GND. This capacitor prevents parasitic board inductances from forcing V_{OUT} below GND when the switch turns-off.

Power Dissipation

During normal operation as a switch, the power dissipated in the part depends upon the level at which the current limit is set. The maximum allowed setting for the current limit is 0.77 A and this results in a power dissipation of,

$$P = (I_{LIM})^2 \times R_{DS} = (0.77)^2 \times 0.12 = 71.148mW \tag{2}$$

If the part goes into current limit the maximum power dissipation occurs when the output is shorted to ground. This is more power than the package can dissipate, but the thermal shutdown of the part activates to protect the part from damage due to excessive heating. A short on the output causes the part to operate in a constant-current state dissipating a worst case power of,

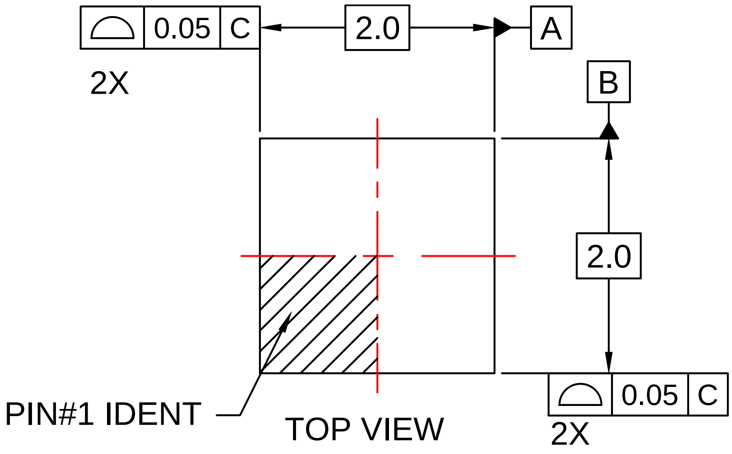
$$P(\max) = V_{IN}(\max) \times I_{LIM}(\max) = 5.5 \times 0.77 = 4.235\text{W} \tag{3}$$

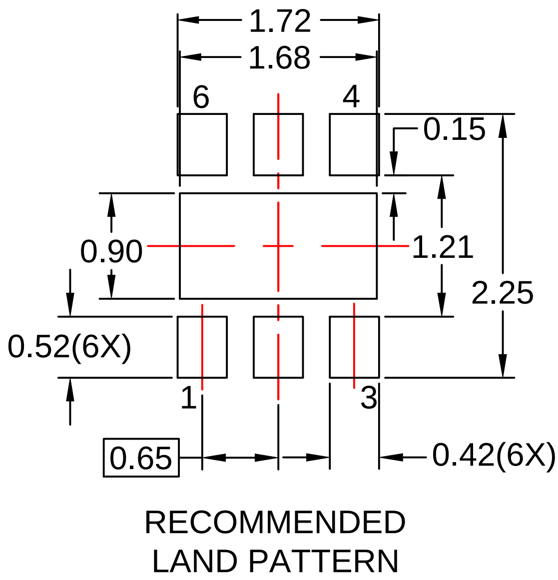
This large amount of power activates the thermal shutdown and the part cycles in and out of thermal shutdown so long as the ON pin is active and the short is present.

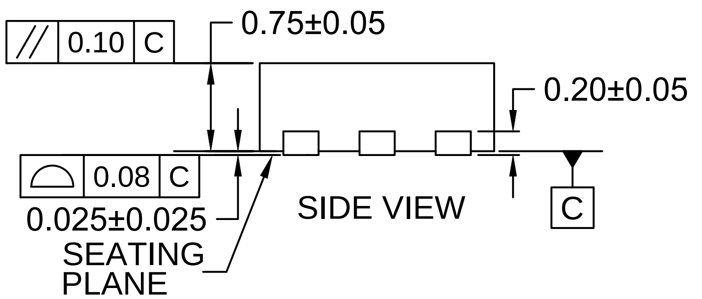
Board Layout

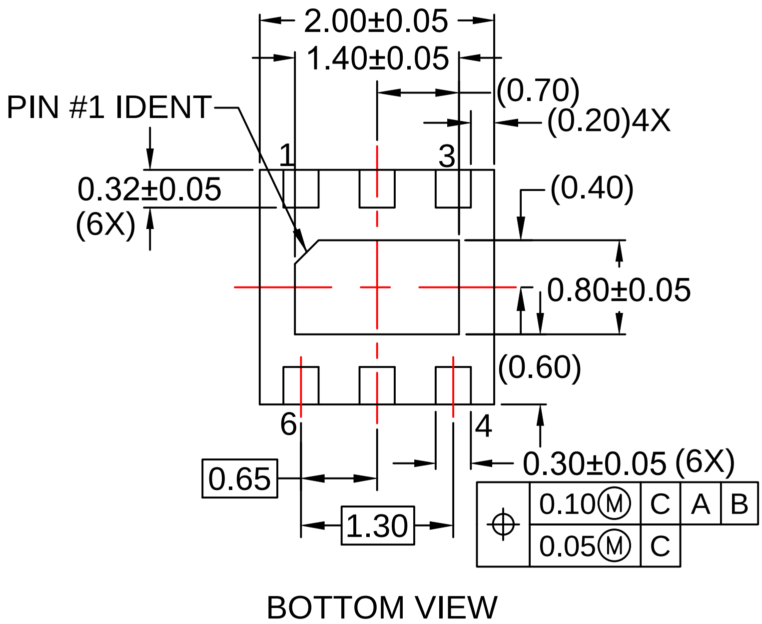
For best performance, all traces should be as short as possible. To be most effective, the input and output capacitors should be placed close to the device to minimize the effects that parasitic trace inductances may have on normal and short-circuit operation. Using wide traces for V_{IN}, V_{OUT} and GND helps minimize parasitic electrical effects along with minimizing the case-to-ambient thermal impedance.

The middle pad (pin 7) should be connected to the GND plate of PCB for improving thermal performance of the load switch. An improper layout could result higher junction temperature and triggering the thermal shutdown protection feature. This concern applies when the switch is set at higher current limit value and an over-current condition occurs. In this case power dissipation of the switch ($P_D = (V_{IN} - V_{OUT}) \times I_{LIM}(max)$) could exceed the maximum absolute power dissipation of 1.2 W.









NOTES:

A. PACKAGE DOES NOT FULLY CONFORM TO JEDEC MO-229 REGISTRATION

B. DIMENSIONS ARE IN MILLIMETERS.

C. DIMENSIONS AND TOLERANCES PER ASME Y14.5M, 2009.

D. LAND PATTERN RECOMMENDATION IS EXISTING INDUSTRY LAND PATTERN.

E. DRAWING FILENAME: MKT-MLP06Krev5.

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