FAIRCHILD SEMICONDUCTOR®

April 2009

FPF2165R
Full Function Load Switch with Adjustable Current Limit

Features

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

Applications

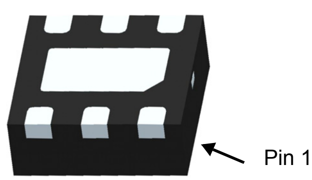
- PDAs
- Cell Phones
- GPS Devices
- MP3 Players
- Digital Cameras
- Peripheral Ports
- Hot Swap Supplies

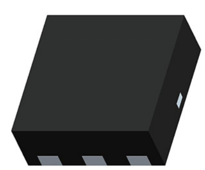
General Description

The FPF2165R is a load switch which provides full protection to systems and loads which may encounter large current conditions. These devices contain a 0.12Ω current-limited P-channel MOSFET which can operate over an input voltage range of 1.8-5.5V. 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. Each part 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 parts operate in a constant-current mode to prohibit excessive currents from causing damage. The FPF2165R will not turn off after a current limit fault, but will rather remain in the constant current mode indefinitely. The minimum current limit is 150mA.

These parts are available in a space-saving 6 pin 2X2 MLP package.

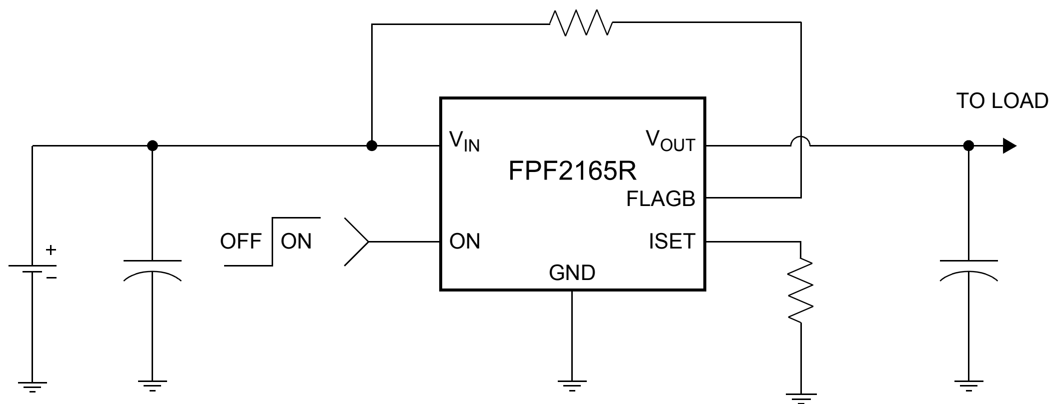




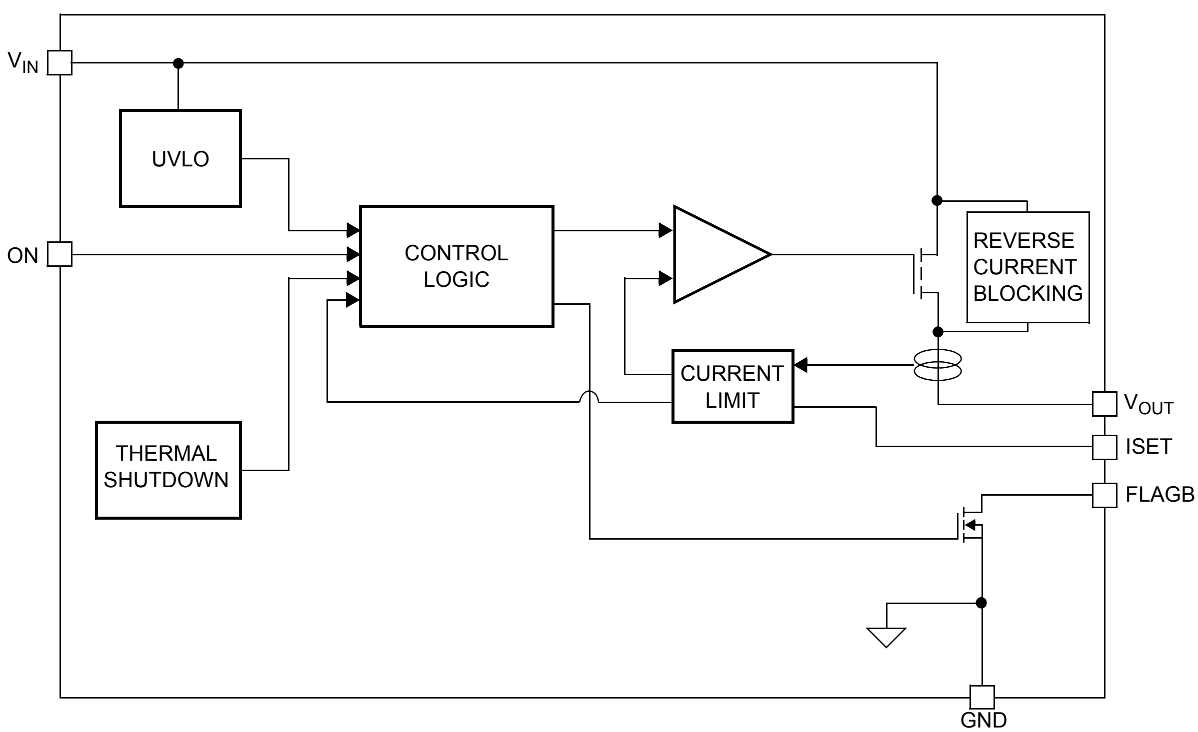
Ordering Information

Part	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

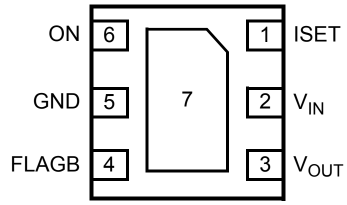
Typical Application Circuit



Functional Block Diagram



Pin Configuration



2X2 MicroFET-6

Pin Description

Pin	Name	Function
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

Parameter			Min.	Max.	Unit
V_{IN}, V_{OUT}, ON, FLAGB, ISET to GND			-0.3	6	V
Power Dissipation				1.2	W
Operating and Storage Junction Temperature			-65	150	°C
Thermal Resistance, Junction to Ambient				86	°C/W
Electrostatic Discharge Protection	Jedec A114A	HBM	4000		V
	Jedec C101C	CDM	2000		V
	Jedec A115	MM	400		V
	IEC 61000-4-2	Air Discharge	15000		V
		Contact Discharge	8000		V

Recommended Operating Range

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

Electrical Characteristics

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

Parameter	Symbol	Conditions		Min	Typ	Max	Units
Basic Operation							
Operating Voltage	V_{IN}			1.8		5.5	V
Quiescent Current	I_Q	I_{OUT} = 0mA	V_{IN} = 1.8V		63	100	µA
			V_{IN} = 3.3V		68		
			V_{IN} = 5.5V		77	120	

Electrical Characteristics Cont.

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

Parameter	Symbol	Conditions	Min	Typ	Max	Units
On-Resistance	R_{ON}	V_{IN} = 3.3V, I_{OUT} = 200mA, T_A = 25°C		120	160	mΩ
		V_{IN} = 3.3V, I_{OUT} = 200mA, T_A = 85°C		135	180	
		V_{IN} = 3.3V, I_{OUT} = 200mA, T_A = -40°C to +85°C	65		180	
		V_{IN} = 5V, I_{OUT} = 200mA, T_A = 25°C		95	124	
		V_{IN} = 5V, I_{OUT} = 200mA, T_A = 85°C		110	143	
		V_{IN} = 5V, I_{OUT} = 200mA, T_A = -40°C to +85°C	58		143	
ON Input Logic High Voltage (ON)	V_{IH}	V_{IN} = 1.8V	0.8			V
		V_{IN} = 5.5V	1.4			
ON Input Logic Low Voltage	V_{IL}	V_{IN} = 1.8V			0.5	V
		V_{IN} = 5.5V			1	
ON Input Leakage		V_{ON} = V_{IN} or GND	-1		1	µA
V_{IN} Shutdown Current		V_{ON} = 0V, V_{IN} = 5.5V, V_{OUT} = short to GND	-2		2	µA
FLAGB Output Logic Low Voltage		V_{IN} = 5V, I_{SINK} = 10mA		0.05	0.2	V
		V_{IN} = 1.8V, I_{SINK} = 10mA		0.12	0.3	
FLAGB Output High Leakage Current		V_{IN} = 5V, Switch on			1	µA
Reverse Block						
V_{OUT} Shutdown Current		V_{ON} = 0V, V_{OUT} = 5.5V, V_{IN} = short to GND	-2		2	µA
Protections						
Current Limit	I_{LIM}	V_{IN} = 3.3V, V_{OUT} = 3.0V, R_{SET} = 1840Ω	135	150	165	mA
		V_{IN} = 3.3V, V_{OUT} = 3.0V, R_{SET} = 361Ω	720	800	880	mA
		V_{IN} = 3.3V, V_{OUT} = 3.0V, R_{SET} = 196Ω	1350	1500	1650	mA
Thermal Shutdown		Shutdown Threshold		140		°C
		Return from Shutdown		130		
		Hysteresis		10		
Under Voltage Shutdown	UVLO	V_{IN} Increasing	1.55	1.65	1.75	V
Under Voltage Shutdown Hysteresis				50		mV
Dynamic						
Delay On Time	td_{ON}	R_L = 500Ω, C_L = 0.1µF		25		µs
Delay Off Time	td_{OFF}	R_L = 500Ω, C_L = 0.1µF		45		µs
V_{OUT} Rise Time	t_{RISE}	R_L = 500Ω, C_L = 0.1µF		10		µs
V_{OUT} Fall Time	t_{FALL}	R_L = 500Ω, C_L = 0.1µF		110		µs
Short Circuit Response Time		V_{IN} = V_{OUT} = 3.3V. Moderate Over-Current Condition.		5		µs
		V_{IN} = V_{OUT} = 3.3V. Hard Short.		30		ns

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

Typical Characteristics

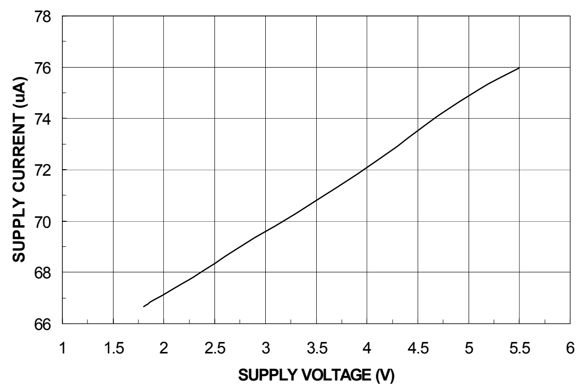


Figure 1. Quiescent Current vs. Input Voltage

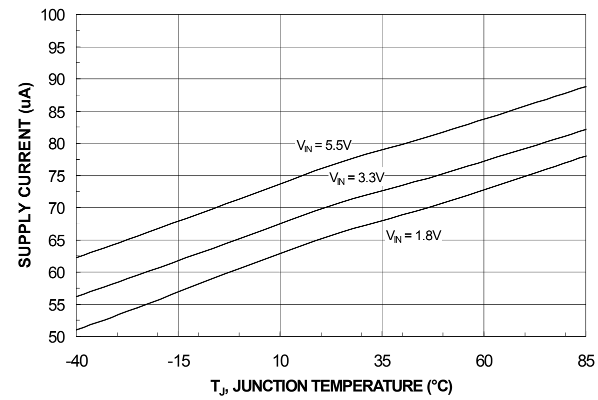


Figure 2. Quiescent Current vs. Temperature

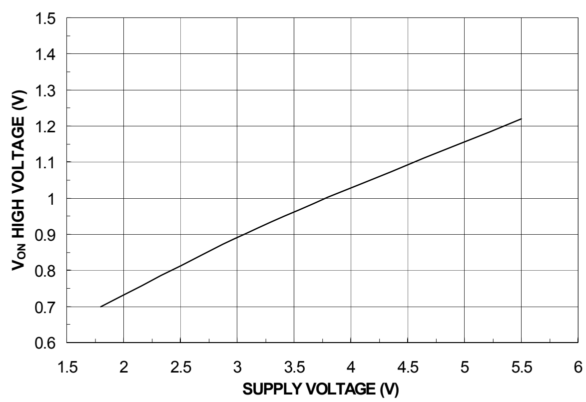


Figure 3. V_{ON} High Voltage vs. Input Voltage

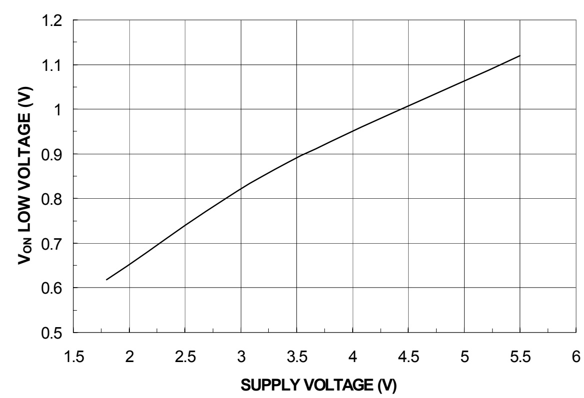


Figure 4. V_{ON} Low Voltage vs. Input Voltage

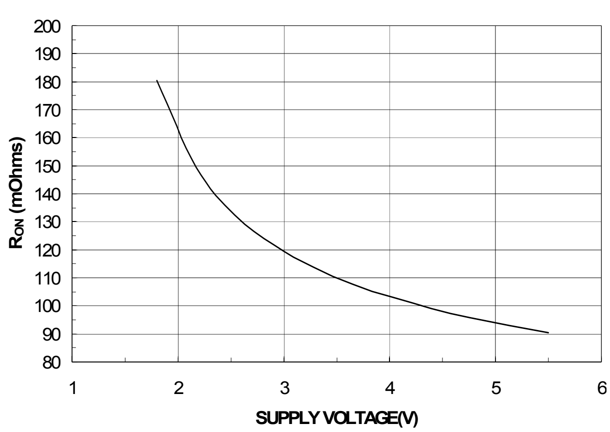


Figure 5. R_{ON} vs. V_{IN}

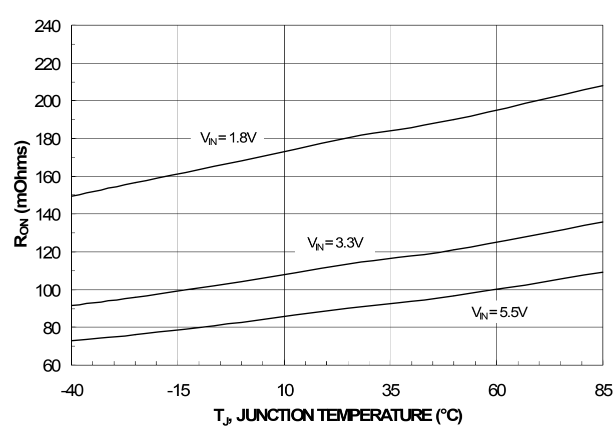


Figure 6. R_{ON} vs. Temperature

Typical Characteristics

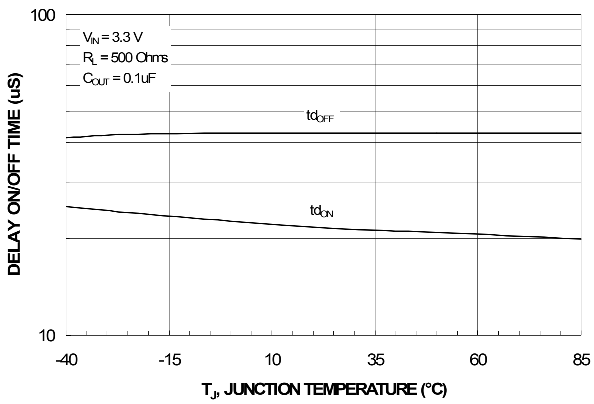


Figure 7. td_{ON} / td_{OFF} vs. Temperature

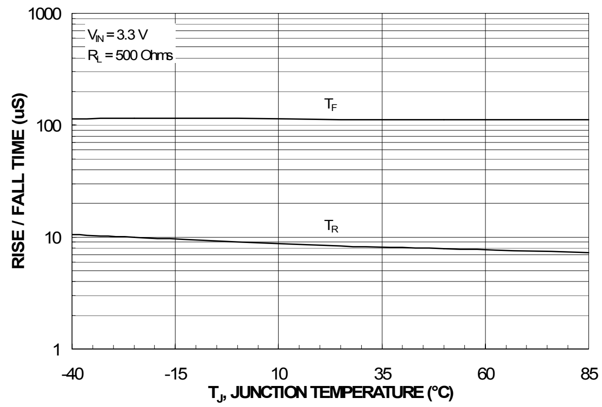


Figure 8. T_{RISE} / T_{FALL} vs. Temperature

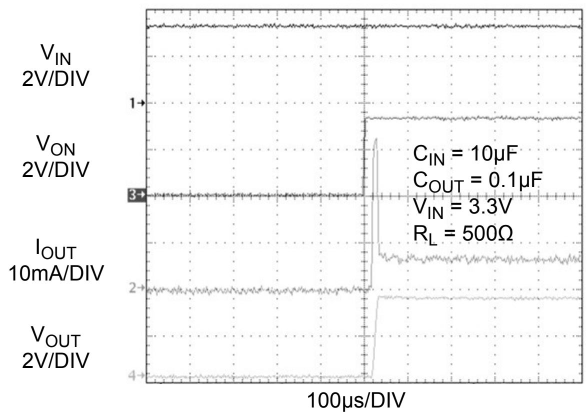


Figure 9. td_{ON} Response

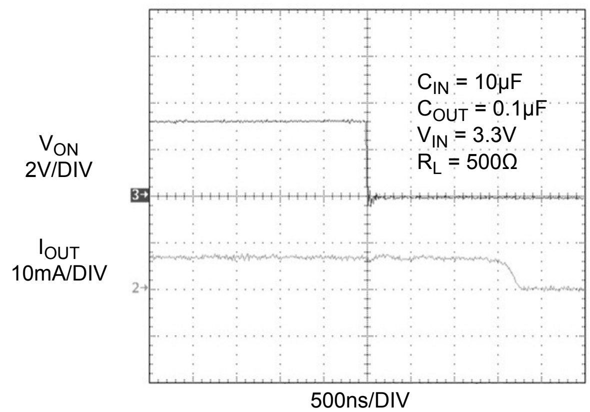


Figure 10. td_{OFF} Response

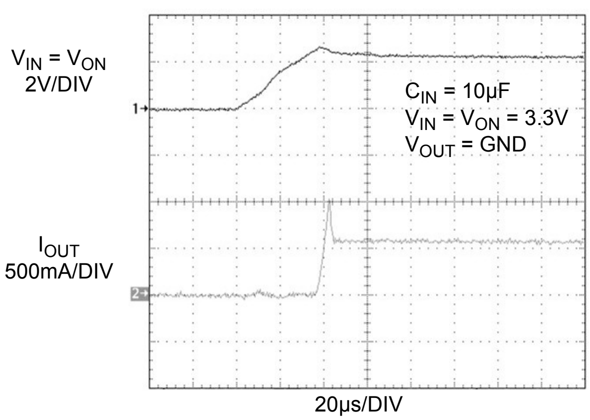


Figure 11. Current Limit Response Time
(Switch is powered into a short)

Description of Operation

The FPF2165R is a current limited switch that protect systems and loads which can be damaged or disrupted by the application of high currents. The core of each device is a 0.12Ω P-channel MOSFET and a controller capable of functioning over a wide input operating range of 1.8-5.5V. The controller protects against system malfunctions through current limiting, undervoltage lockout and thermal shutdown. The current limit is adjustable from 0.15A to 1.5A 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 undervoltage 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 undervoltage 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 undervoltage, or an over-temperature condition, the FLAGB signals the fault mode by activating LO. With the FPF2165R, FLAGB is LO 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 will remain 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 VSCTH, 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 5.5V input voltage. The VSCTH value is set to be 1V. At around 1.1V of output voltage the switch is removed from short circuit current limiting mode and the current limit is set to the current limit value.

Undervoltage Lockout

The undervoltage lockout turns-off the switch if the input voltage drops below the undervoltage lockout threshold. With the ON pin active the input voltage rising above the undervoltage lockout threshold will cause 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 which 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.

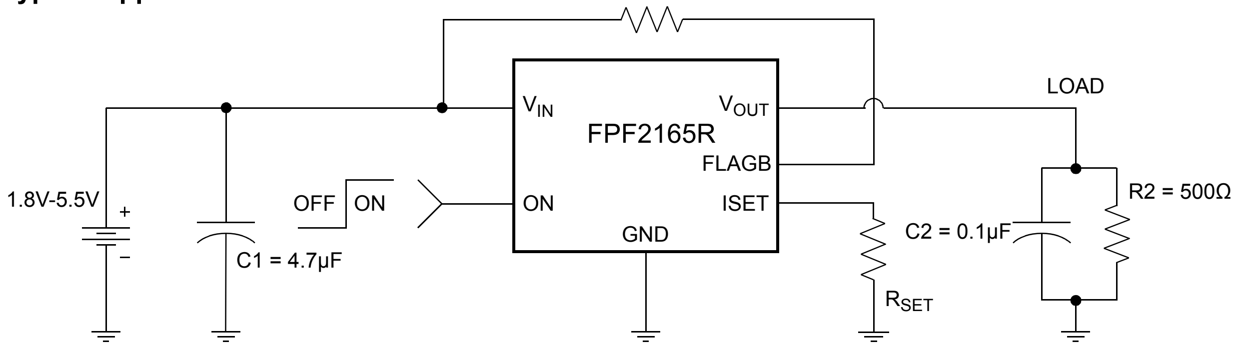
If ON pin is LO and output voltage become greater than input voltage, no current can flow from the output to the input. The FLAGB operation is independent of the Reverse Current blocking feature and will not report a fault condition if this feature is activated.

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.

Application Information

Typical Application



Setting Current Limit

The FPF2165R have a current limit which is set with an external resistor connected between ISET and GND. This resistor is selected by using the following equation,

$$I_{LIM} = 340.1 \times R_{SET}^{-1.0278} \quad (1)$$

The table below can be used to select RSET. A typical application would be the 500mA current that is required by a single USB port. Using the table below an appropriate selection for the RSET resistor would be 570Ω.

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 4.7μF 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 0.1uF capacitor C_{OUT}, should be placed between V_{OUT} and GND. This capacitor will prevent 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 will depend upon the level at which the current limit is set. The maximum allowed setting for the current limit is 0.77A and this will result in a power dissipation of,

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

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

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

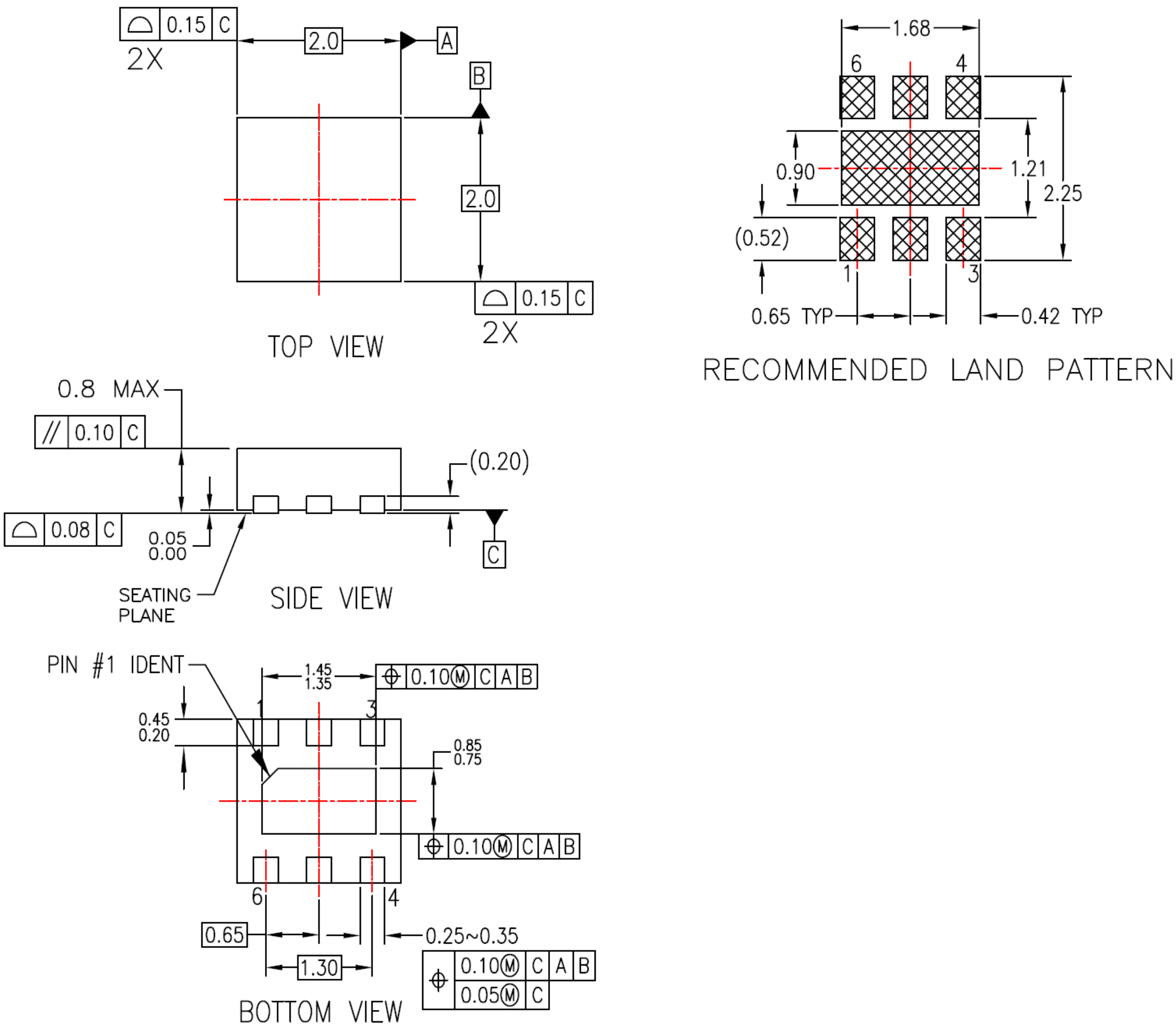
This large amount of power will activate the thermal shutdown and the part will cycle in and out of thermal shutdown so long as the ON pin is active and the short is present.

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 will help 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 overcurrent 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 1.2W.

Dimensional Outline and Pad Layout



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B. DIMENSIONS ARE IN MILLIMETERS.
C. DIMENSIONS AND TOLERANCES PER ASME Y14.5M, 1994

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Datasheet Identification	Product Status	Definition
Advance Information	Formative / In Design	Datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	Datasheet contains preliminary data; supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design.
No Identification Needed	Full Production	Datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve the design.
Obsolete	Not In Production	Datasheet contains specifications on a product that is discontinued by Fairchild Semiconductor. The datasheet is for reference information only.

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