FAIRCHILD SEMICONDUCTOR®

December 2004

FPF2000-FPF2007
IntelliMAX™ Advanced Load Management Products

Features

- 1.8 to 5.5V Input Voltage Range
- Controlled Turn-On
- 50mA and 100mA Current Limit Options
- Under voltage Lockout
- Thermal Shutdown
- <1uA Shutdown Current
- Auto Restart
- Fast Current limit Response Time
  - 3us to Moderate Over Currents
  - 20ns to Hard Shorts
- Fault Blanking

Applications

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

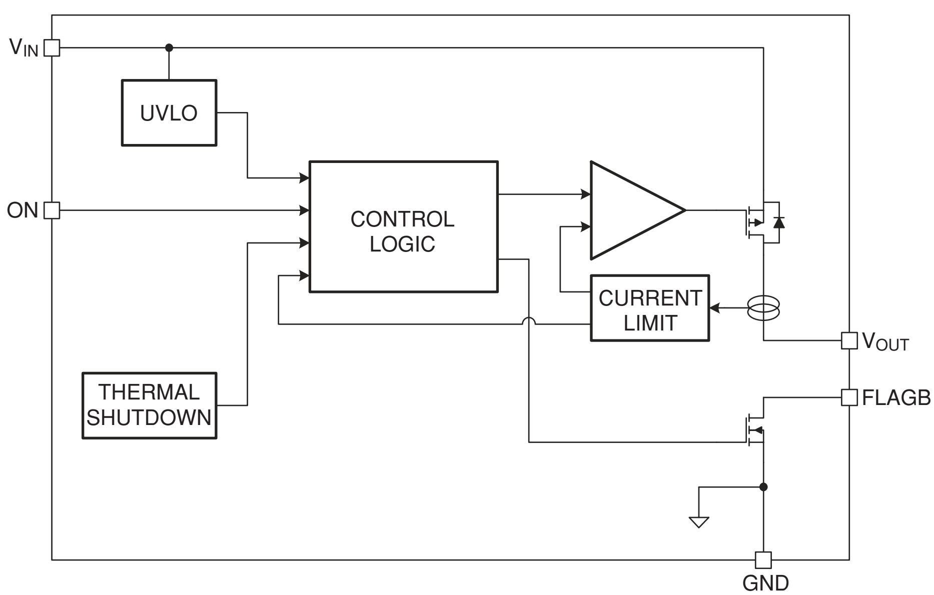
General Description

The FPF2000 through FPF2007 is a family of load switches which provide full protection to systems and loads which may encounter large current conditions. These devices contain a 0.7Ω current-limited P-channel MOSFET which can operate over an input voltage range of 1.8-5.5V. 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.

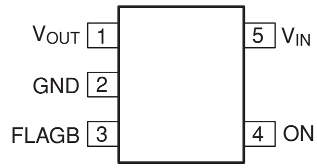
When the switch current reaches the current limit, the part operates in a constant-current mode to prohibit excessive currents from causing damage. For the FPF2000-FPF2002 and FPF2004-FPF2006, if the constant current condition still persists after 10ms, these parts will shut off the switch and pull the fault signal pin (FLAGB) low. The FPF2000, FPF2001, FPF2004 and FPF2005, have an auto-restart feature which will turn the switch on again after 80ms if the ON pin is still active. The FPF2002 and FPF2006 do not have this auto-restart feature so the switch will remain off until the ON pin is cycled. For the FPF2003 and FPF2007, a current limit condition will immediately pull the fault signal pin low and the part will remain in the constant-current mode until the switch current falls below the current limit. For the FPF2000 through FPF2003, the minimum current limit is 50mA while that for the FPF2004 through FPF2007 is 100mA.

These parts are available in a space-saving 5 pin SC-70 package.

Functional Block Diagram



Pin Configuration



SC70-5

Pin Description

Pin	Name	Function
1	V_{OUT}	Switch Output: Output of the power switch
2	GND	Ground
3	FLAGB	Fault Output: Active LO, open drain output which indicates an over current, supply under voltage or over temperature state.
4	ON	On Control Input
5	V_{IN}	Supply Input: Input to the power switch and the supply voltage for the IC

Absolute Maximum Ratings

Parameter		Min.	Max.	Units
V_{IN}		-0.3	6	V
DC Input Voltage		-0.7	6	V
Power Dissipation for Single Operation @ 85°C			250	mW
Operating Junction Temperature		-40	85	°C
Storage Temperature		-65	150	°C
Thermal Resistance, Junction to Ambient			400	°C/W
Electrostatic Discharge Protection	HBM	4000		V
	MM	400		V

Recommended Operating Range

Parameter	Min.	Max.	Units
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} = 1.8 to 3.3V		60		μA
			V_{IN} = 3.3 to 5.5V			100	
Latch-Off Current	I_{LATCH}	FPF2002, FPF2006			40		μA
Shutdown Current	I_{SHDN}					1	μA
On-Resistance	R_{ON}	T_A = 25°C, I_{OUT} = 20mA			0.7	1	Ω
		T_A = -40 to +85°C, I_{OUT} = 20mA			0.85		
ON Input Logic High Voltage	V_{IH}	V_{IN} = 1.8V		0.5	0.66		V
		V_{IN} = 5.5V		0.9	1.22		
ON Input Logic Low Voltage	V_{IL}	V_{IN} = 1.8V			0.64	0.8	V
		V_{IN} = 5.5V			1.17	1.5	
ON Input Leakage		V_{ON} = V_{IN} or GND				1	μA
Off Switch Leakage	I_{SWOFF}	V_{ON} = 0V, V_{OUT} = 0V				1	μA
FLAGB Output Logic Low Voltage		V_{IN} = 5V, I_{SINK} = 10mA			0.1	0.2	V
		V_{IN} = 1.8V, I_{SINK} = 10mA			0.1	0.3	
FLAGB Output High Leakage Current		V_{IN} = 5V, Switch on				1	μA
Protections							
Current Limit	I_{LIM}	V_{IN} = 3.3V, V_{OUT} = 0V	FPF2000, FPF2001, FPF2002, FPF2003	50	75	100	mA
		V_{IN} = 3.3V, V_{OUT} = 0V	FPF2004, FPF2005, FPF2006, FPF2007	100	150	200	
Thermal Shutdown		T_J Increasing			140		°C
		T_J Decreasing			130		°C
Under Voltage Shutdown	UVLO	V_{IN} Increasing		1.5	1.6	1.7	V
Under Voltage Shutdown Hysteresis					50		mV
Dynamic							
Turn on time	t_{ON}	Ω, CL=0.1μF			50		μs
Turn off time	t_{OFF}	Ω, CL=0.1μF			0.5		μs
Rise Time	t_{RISE}	Ω, CL=0.1μF			10		μs
Fall Time	t_{FALL}	Ω, CL=0.1μF			0.1		μs
OVER Current Blanking Time	t_{BLANK}	FPF2000, FPF2001, FPF2002, FPF2004, FPF2005, FPF2006		5	10	20	ms
Auto-Restart Time	$t_{RESTART}$	FPF2000, FPF2001, FPF2004, FPF2005		40	80	160	ms
Short Circuit Response Time		Vin = Von = 3.3V. Moderate Over-current condition.			3		μs
		Vin = Von = 3.3V. Hard Shorts.			20		nS

Typical Characteristics

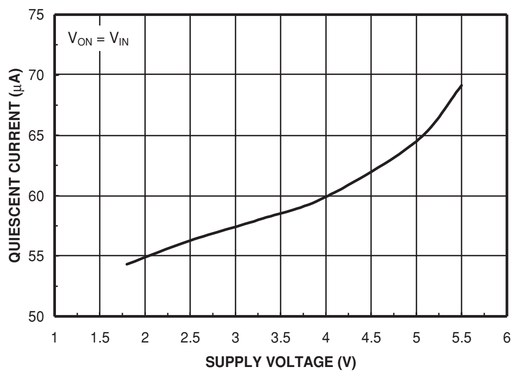


Figure 1. Quiescent Current vs. Input Voltage

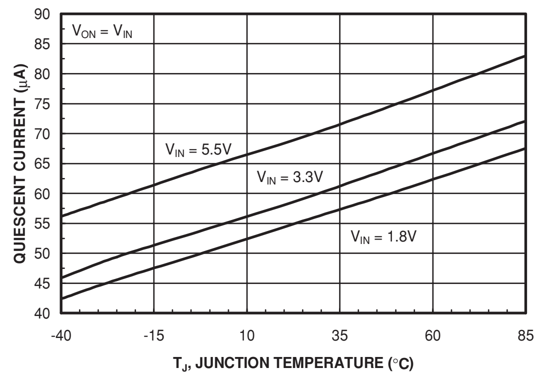


Figure 2. Quiescent Current vs. Temperature

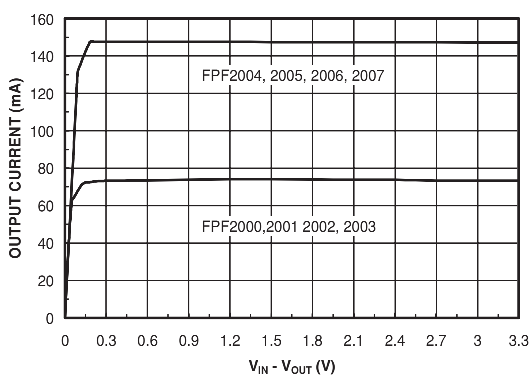


Figure 3. Current Limit vs. Output Voltage

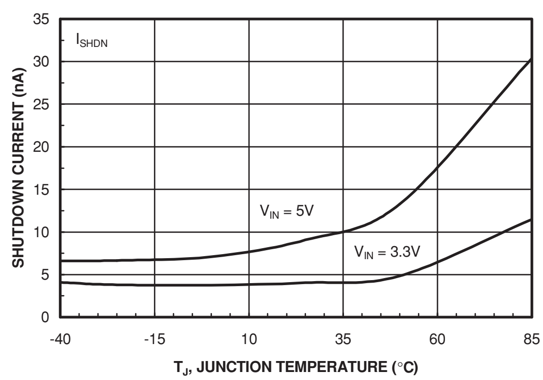


Figure 4. Shutdown Supply Current vs. Temperature

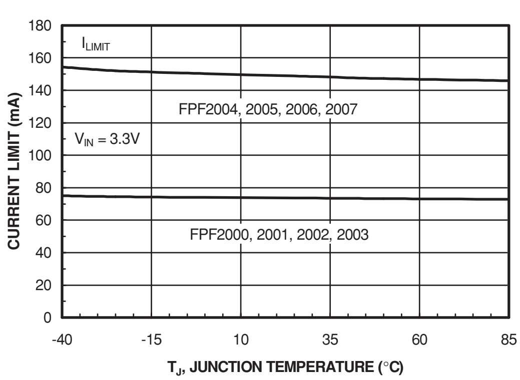


Figure 5. Current Limit vs. Temperature

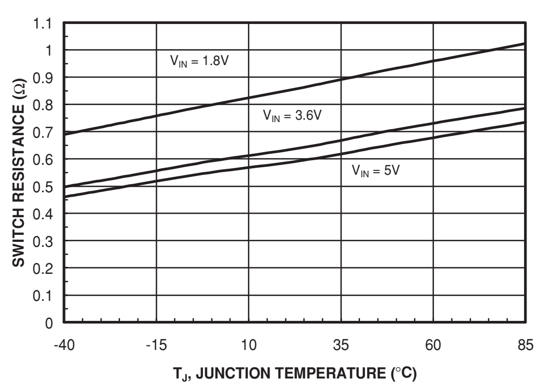


Figure 6. Switch Resistance vs. Temperature

Typical Characteristics

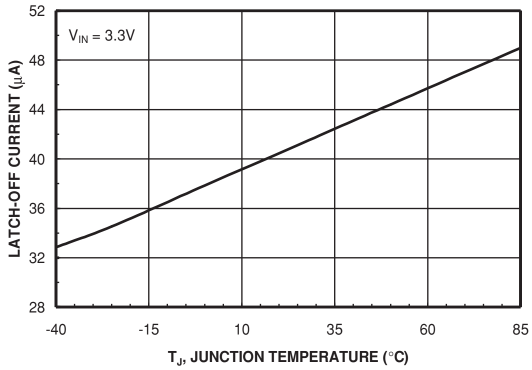


Figure 7. Latch-Off Current vs. Temperature

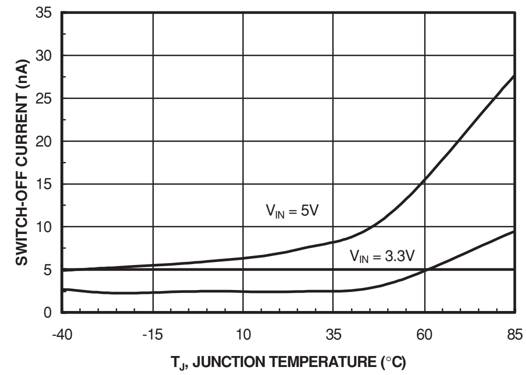


Figure 8. Switch-Off Current vs. Temperature

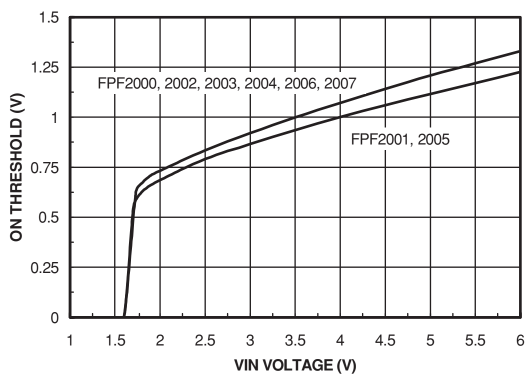


Figure 9. ON Threshold vs. V_{IN}

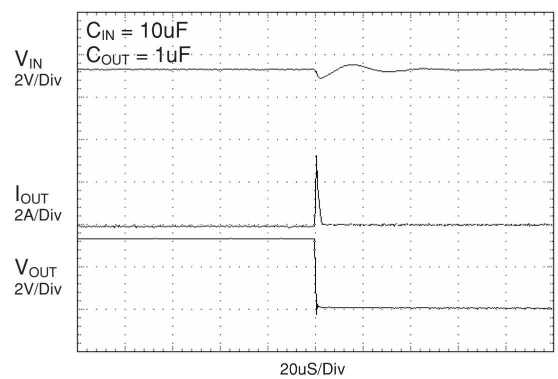


Figure 10. Short Circuit Response Time (Output to GND)

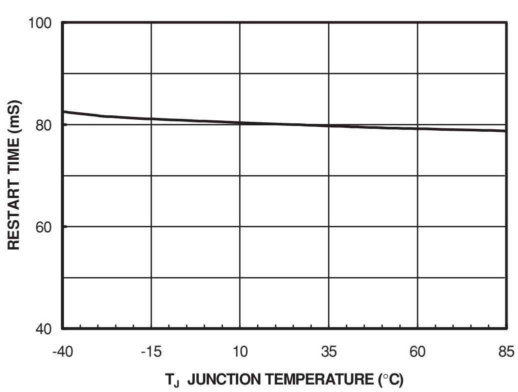


Figure 11. Auto-Restart Time vs. Temperature

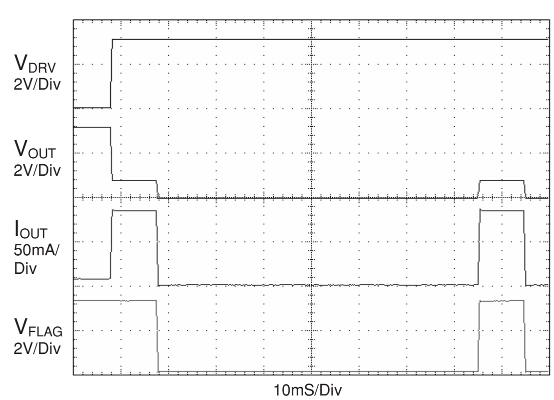


Figure 12. Auto-Restart Time Response

Typical Characteristics

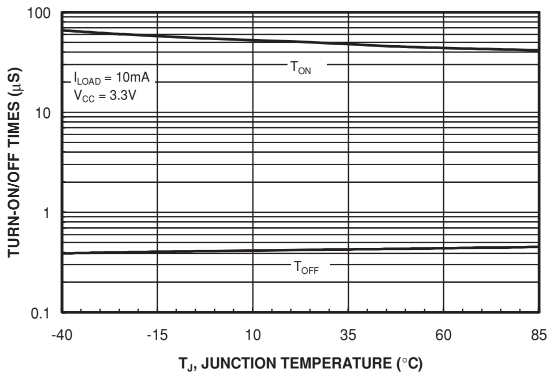


Figure 13. Ton/Toff vs. Temperature

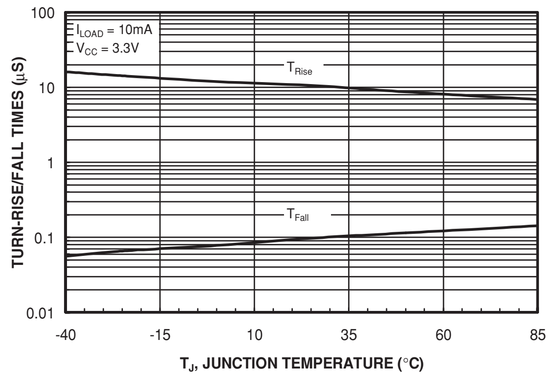


Figure 14. Trise/Tfall vs. Temperature

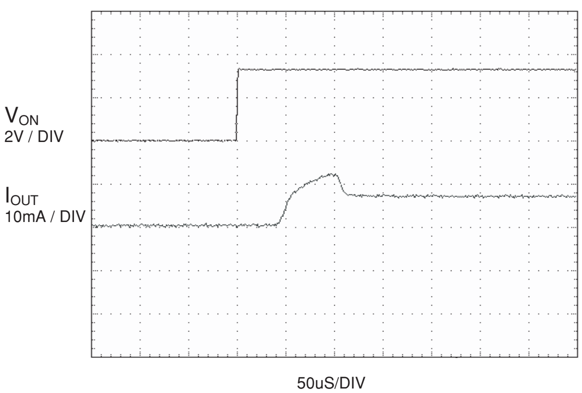


Figure 15. Turn-On Response

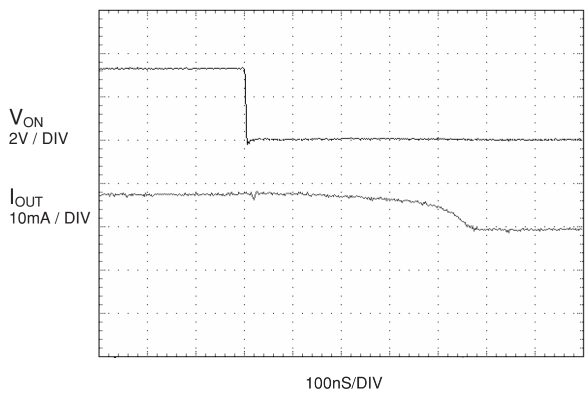


Figure 16. Turn-Off Response

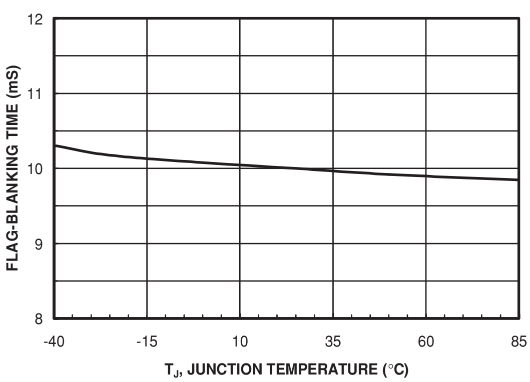


Figure 17. Blank Time vs. Temperature

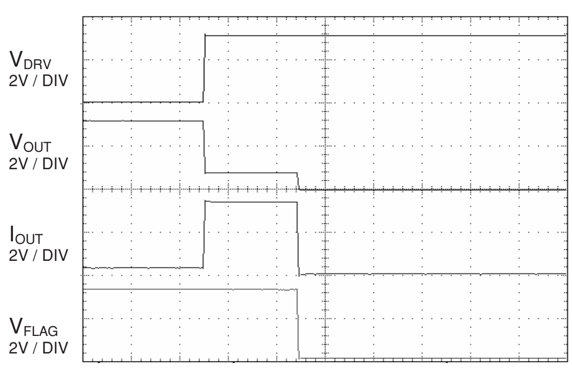


Figure 18. Fault Blanking Response

Typical Characteristics

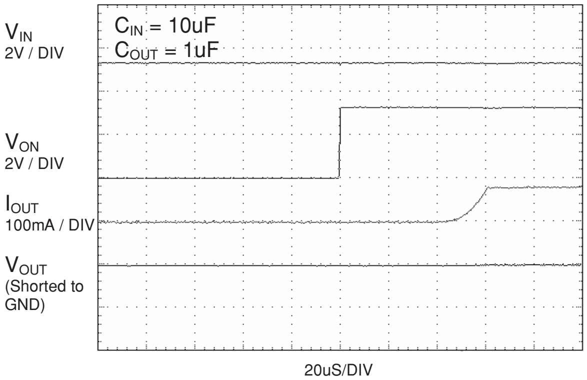


Figure 19. Current-Limit Response Time (Output to GND)

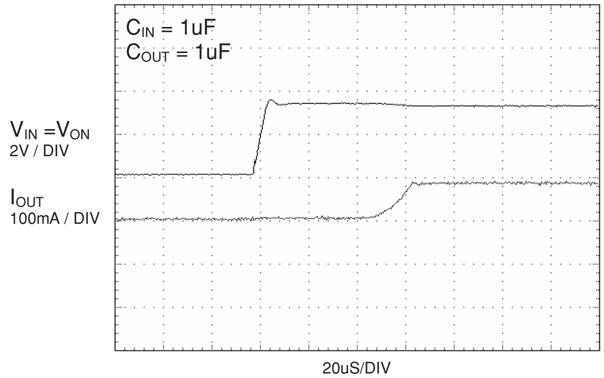


Figure 20. Current-Limit Response

Description of Operation

The FPF2000-FPF2007 are current limited switches that protect systems and loads which can be damaged or disrupted by the application of high currents. The core of each device is a 0.7Ω 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, under-voltage lockout and thermal shutdown. The current limit is preset for either 50mA or 100mA.

On/Off Control

The ON pin controls the state of the switch. Active HI and LO versions are available. Refer to the Ordering Information for details. Activating ON continuously holds the switch in the on state so long as there is no fault. For all versions, an under-voltage on VIN or a junction temperature in excess of 150°C overrides the ON control to turn off the switch. In addition, excessive currents will cause the switch to turn off in FPF2000-FPF2002 and FPF2004-FPF2007. The FPF2000, FPF2001, FPF2004 and FPF2005 have an Auto-Restart feature which will automatically turn the switch on again after 80ms. For the FPF2002 and FPF2006, the ON pin must be toggled to turn-on the switch again. The FPF2003 and FPF2007 do not turn off in response to a over current condition but instead remain operating in a constant current mode so long as ON is active and the thermal shutdown or under-voltage lockout have not activated.

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 LO. For the FPF2000-FPF2002 and FPF2004-FPF2006, the FLAGB goes LO at the end of the blanking time while FLAGB goes LO immediately for the FPF2003 and FPF2007. FLAGB remains LO through the Auto-Restart Time for the FPF2000, FPF2001 FPF2004 and FPF2005. For the FPF2002 and FPF2006, FLAGB is latched LO and ON must be toggled to release it. With the FPF2003 and FPF2007, 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 V_{IN} 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. For the FPF2000-FPF2003 the minimum current is 50mA and the maximum current is 100mA and for the FPF2004-FPF2007 the minimum current is 100mA and the maximum current is 200mA. The FPF2000-FPF2002 and the FPF2004-FPF2006, have a blanking time of 10ms, nominally, during which the switch will act as a constant current source. At the end of the blanking time, the switch will be turned-off and the FLAGB pin will activate to indicate that current limiting has occurred. The FPF2003 and FPF2007 have no current limit blanking period so immediately upon a current limit condition FLAGB is activated. These parts will remain in a constant current state until the ON pin is deactivated or the thermal shutdown turns-off the switch.

Under-Voltage Lockout

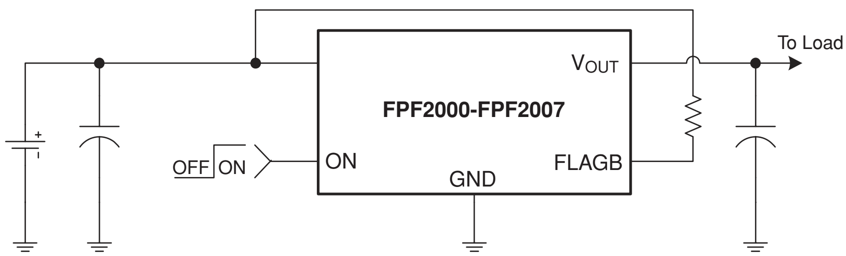
The under-voltage lockout turns-off the switch if the input voltage drops below the under-voltage lockout threshold. With the ON pin active the input voltage rising above the under-voltage lockout threshold will cause a controlled turn-on of the switch which limits current over-shoots.

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



Input Capacitor

To limit the voltage drop on the input supply caused by transient in-rush currents when the switch turns-on into a discharged load capacitor or a short-circuit, a capacitor needs to be placed between V_{IN} and GND. A 0.1µF ceramic capacitor, C_{IN}, placed close to the pins is usually sufficient. Higher values of C_{IN} can be used to further reduce the voltage drop.

Output Capacitor

A 0.1µF capacitor COUT, 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. For the FPF2000-FPF2002 and the FPF2004-FPF2006, the total output capacitance needs to be kept below a maximum value, COUT(max), to prevent the part from registering an over-current condition and turning-off the switch. The maximum output capacitance can be determined from the following formula,

$$C_{OUT} = \frac{I_{LIM}(max) \times t_{BLANK}(min)}{V_{IN}} \qquad (1)$$

Due to the integral body diode in the PMOS switch, a C_{IN} greater than C_{OUT} is highly recommended. A C_{OUT} greater than C_{IN} can cause V_{OUT} to exceed V_{IN} when the system supply is removed. This could result in current flow through the body diode from V_{OUT} to V_{IN}.

Power Dissipation

During normal operation as a switch, the power dissipation is small and has little effect on the operating temperature of the part. The parts with the higher current limits will dissipate the most power and that will only be,

$$P = (I_{LIM})^2 \times R_{DS} = (0.2)^2 \times 0.7 = 28mW \qquad (2)$$

If the part goes into current limit the maximum power dissipation will occur when the output is shorted to ground. For the FPF2000, FPF2001, FPF2004 and FPF2005, the power dissipation will scale by the Auto-Restart Time, $t_{RESTART}$, and the Over Current Blanking Time, t_{BLANK}, so that the maximum power dissipated is,

$$P(max) = \frac{t_{BLANK}}{t_{RESTART} + t_{BLANK}} \times V_{IN(max)} \times I_{LIM(max)}$$

$$= \frac{10}{80 + 10} \times 5.5 \times 0.2 = 1.22mW \qquad (3)$$

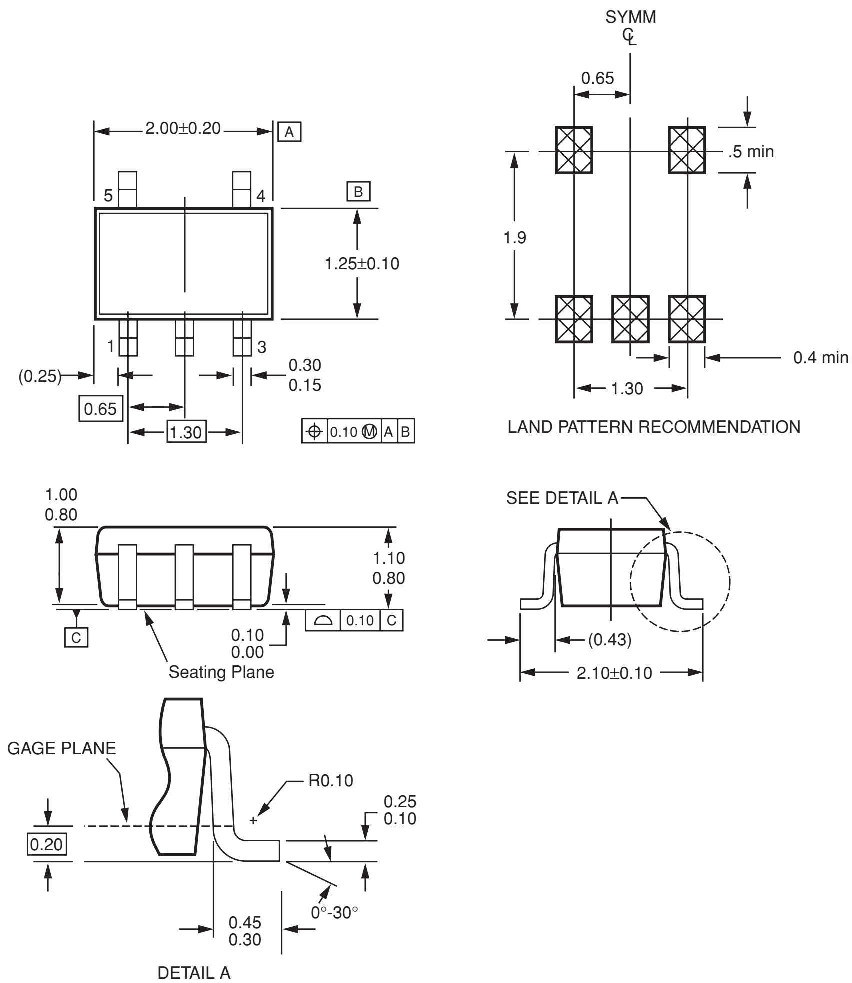
When using the FPF2002 and FPF2006 attention must be given to the manual resetting of the part. Continuously resetting the part at a high duty cycle when a short on the output is present can cause the temperature of the part to increase. The junction temperature will only be allowed to increase to the thermal shutdown threshold. Once this temperature has been reached, toggling ON will not turn-on the switch until the junction temperature drops. For the FPF2003 and FPF2007, a short on the output will cause the part to operate in a constant current state dissipating a worst case power as calculated in (3) until the thermal shutdown activates. It will then 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.

Dimensional Outline and Pad Layout

SC70-5



NOTES:

A. THIS PACKAGE CONFORMS TO EIAJ SC-88A, 1996.
B. DIMENSIONS ARE IN MILLIMETERS.
C. DIMENSIONS DO NOT INCLUDE BURRS OR MOLD FLASH.

Ordering Information

Part Number	Minimum Current Limit [mA]	Current Limit Blanking Time [ms]	Auto-Restart Time [ms]	ON Pin Activity	Top Mark
FPF2000	50	10	80	Active HI	200
FPF2001	50	10	80	Active LO	201
FPF2002	50	10	NA	Active HI	202
FPF2003	50	0	NA	Active HI	203
FPF2004	100	10	80	Active HI	204
FPF2005	100	10	80	Active LO	205
FPF2006	100	10	NA	Active HI	206
FPF2007	100	0	NA	Active HI	207

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Bottomless™	FPS™	LittleFET™	PowerEdge™	SuperFET™
CoolFET™	FRFET™	MICROCOUPLER™	PowerSaver™	SuperSOT™-3
CROSSVOLT™	GlobalOptoisolator™	MicroFET™	PowerTrench®	SuperSOT™-6
DOME™	GTO™	MicroPak™	QFET®	SuperSOT™-8
EcoSPARK™	HiSeC™	MICROWIRE™	QS™	SyncFET™
E^2CMOS™	I^2C™	MSX™	QT Optoelectronics™	TinyLogic®
EnSigna™	*i-Lo*™	MSXPro™	Quiet Series™	TINYOPTO™
FACT™	ImpliedDisconnect™	OCX™	RapidConfigure™	TruTranslation™
FACT Quiet Series™		OCXPro™	RapidConnect™	UHC™
Across the board. Around the world.™		OPTOLOGIC®	μSerDes™	UltraFET®
The Power Franchise®		OPTOPLANAR™	SILENT SWITCHER®	UniFET™
Programmable Active Droop™		PACMAN™	SMART START™	VCX™

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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

PRODUCT STATUS DEFINITIONS

Definition of Terms

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

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