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Simplifying Portable Power Management and Protection Circuit Design Using the FPF200X Integrated Switch Product Family

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Introduction

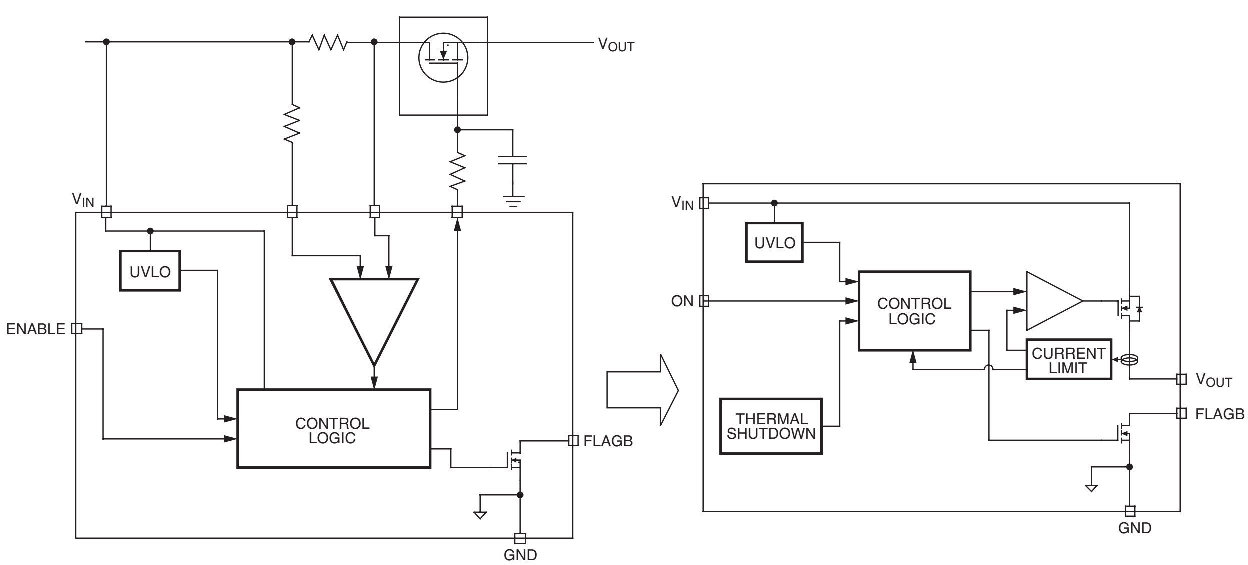
The load management portion of power management for portable devices is becoming increasingly more important in the system designer's drive for better end-unit performance. The FPF200X family of eight advanced load management products offers designers a new choice in simplifying power management designs requiring load protection, control, and fault management. All of these features have been combined with a low-loss PMOS switch and enough options to rapidly expedite time-to-market in a high-volume, small SMD SC70-5 (Pb-Free Capable) package. Features such as current limiting (with range options), under voltage lockout, inrush current limiting, fast short-circuit protection, and thermal shutdown provide protection while fault conditions are managed by the internal hardware with combinations of options for auto-restart, fault blanking, and fault status flag.

With a small footprint SMD package, the FPF200X family of devices is targeted at the latest generation of portable battery-powered devices, such as, Cell Phone Handsets, MP3 players, Digital Still Cameras, Video Cameras, Palm Computers, and Notebook computers where board space and power management performance are equally critical to power designs.

These products extend Fairchild's portfolio of power management solutions by integrating a PMOS switch with several critical protection and control features, reducing board space, parts count, time-to-market and complexity in power management designs for the latest generation of battery powered devices.

These devices can operate over a wide input voltage range of 1.8-5.5V, allowing for compatibility with a variety of portable battery technologies and also with low voltage bus applications. This low-voltage operation also allows the devices to be easily interfaced with the latest generation of portable micro-processors and applications processors.

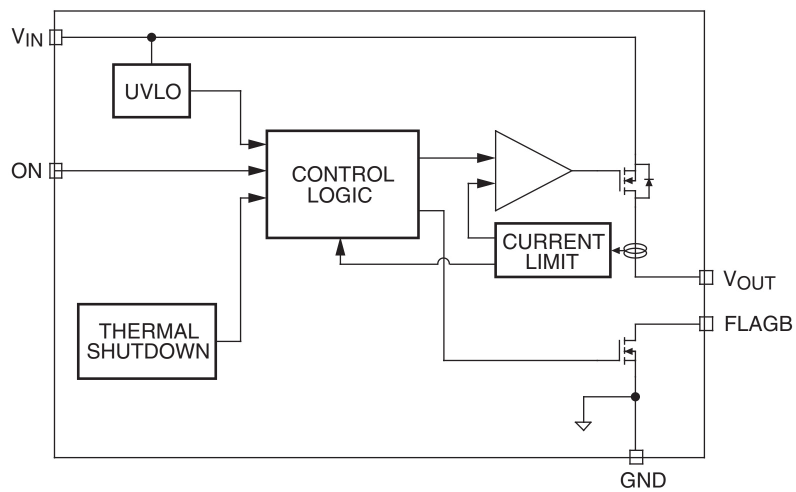
This application note focuses on selecting a device from the FPF200X product family based upon the system hardware and software design approach. The device has options for current-limiting, fault handling (restart, blanking time, flag state), and for all of the fault conditions (current limit, thermal shutdown, UVLO).



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

Functional Block Diagram



Current Limiting

The current limit protection 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 protection level is 50mA and the maximum current protection level is 100mA. The FPF2004-FPF2007 devices offer a minimum current protection of 100mA and the maximum current is 200mA. Therefore, the device should be chosen to ensure that maximum trip point for current handling is below the safe operating level in the design and also such that the minimum trip point is above the intended operating range in the design.

The FPF200X family also offers choices on the behavior of the device once an over-current condition occurs. 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. Alternatively, 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.

The devices were designed for typical fast current limit response time of 20ns for hard short conditions and 3µs for moderate over-current conditions.

Fault Reporting

In order to eliminate the need for additional supporting hardware to manage fault conditions, the FPF200X family of products includes options for the handling of fault conditions specifically: an over-current, an input under-voltage, or an over-temperature condition (resulting in thermal shutdown).

Upon the detection of the fault conditions above, 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. Also, the FLAGB will remain 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.

These options allow the designer's hardware/software interface to easily manage fault conditions at the product level without needing additional supporting circuitry or software/hardware modifications to the existing architecture. This can greatly improve time-to-market and reduction in component count, complexity.

On/Off Control

The ON pin controls the state of the switch. Active HI and LO versions are available as reflected in the FPF200X family datasheet. 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 thermal shutdown condition 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.

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.

Additional Application Info

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 0.1uF 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. For the FPF2000-FPF2002 and the FPF2004-FPF2006, the total output capacitance needs to be kept below a maximum value, C_{OUT}(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,

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

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}.

FLAGB Pull-Up Resistor

Fault reporting is performed through the FLAGB pin. Since it is an open-drain collector, a resistor needs to be connected between this pin and the input supply. The value of the resistor is non-critical, but should be in the 100-1000kΩ range. Current will flow through this resistor only during a fault condition and selecting a large value will reduce the magnitude of this current to levels which would be insignificant to the total system draw.

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,

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

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,

$$P(\max) = \frac{t_{BLANK}}{t_{RESTART} + t_{BLANK}} \times V_{IN(\max)} \times I_{LIM(\max)} = \frac{10}{80+10} \times 5.5 \times 0.2 = 122\text{mW} \qquad (3)$$

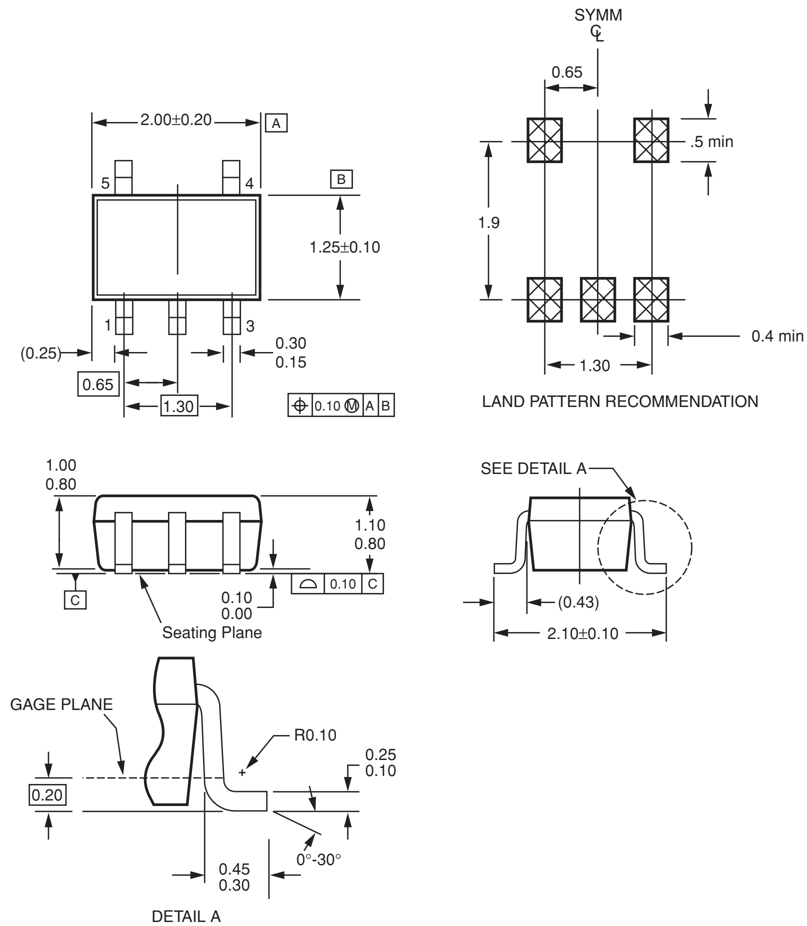
When using the FPF2002 and FPF2006 attention must be given to the manual resetting of the part. Continuously resetting the part at a high duty cycle when a short on the output is present can cause the temperature of the part to increase. The junction temperature will only be allowed to increase to the 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. The mechanical dimensions and recommended land pattern for SC70-5 package are included on the following page.

A Full datasheet of the device is available at www.fairchildsemi.com/fp/fpf2000.pdf.

Dimensional Outline and Pad Layout for SC70-5 Package



NOTES:

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

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