FAIRCHILD SEMICONDUCTOR®

March 2012

FPF1038/FPF1039 — IntelliMAX™ Advanced Slew Rate Controlled Load Switch

FPF1038 / FPF1039
Low On-Resistance, Slew-Rate-Controlled Load Switch

Features

- 1.2V to 5.5V Input Voltage Operating Range
- Typical R_{ON}:
  - 20mΩ at V_{IN}=5.5V
  - 21mΩ at V_{IN}=4.5V
  - 37mΩ at V_{IN}=1.8V
  - 75mΩ at V_{IN}=1.2V
- Slew Rate / Inrush Control with t_R: 2.7ms (Typical)
- 3A Maximum Continuous Current Capability
- Output Capacitor Discharge Function on FPF1039
- Low <1µA Shutdown Current
- ESD Protected: Above 8kV HBM, 1.5kV CDM
- GPIO / CMOS-Compatible Enable Circuitry

Applications

- HDD, Storage, and Solid-State Memory Devices
- Portable Media Devices, UMPC, Tablets, MIDs
- Wireless LAN Cards and Modules
- SLR Digital Cameras
- Portable Medical Devices
- GPS and Navigation Equipment
- Industrial Handheld and Enterprise Equipment

Description

The FPF1038/39 advanced load-management switches target applications requiring a highly integrated solution for disconnecting loads powered from DC power rail (<6V) with stringent shutdown current targets and high load capacitances (up to 200µF). The FPF1038/39 consists of slew-rate controlled low-impedance MOSFET switch (21mΩ typical) and other integrated analog features. The slew-rate controlled turn-on characteristic prevents inrush current and the resulting excessive voltage droop on power rails.

These devices have exceptionally low shutdown current drain (<1µA maximum) that facilitates compliance in low standby power applications. The input voltage range operates from 1.2V to 5.5V DC to support a wide range of applications in consumer, optical, medical, storage, portable, and industrial device power management.

Switch control is managed by a logic input (active HIGH) capable of interfacing directly with low-voltage control signal / GPIO with no external pull-up required. The device is packaged in advanced fully "green" 1mm x1.5mm Wafer-Level Chip-Scale Packaging (WLCSP); providing excellent thermal conductivity, small footprint, and low electrical resistance for wider application usage.

Ordering Information

Part Number	Top Mark	Switch R_{ON} (Typical) at $4.5V_{IN}$	Input Buffer	Output Discharge	ON Pin Activity	t_R	Package
FPF1038UCX	QE	21mΩ	CMOS	NA	Active HIGH	2.7ms	6-Bump, WLCSP, 1.0mm x 1.5mm, 0.5mm Pitch
FPF1039UCX	QF	21mΩ	CMOS	65Ω	Active HIGH	2.7ms	

Application Diagram

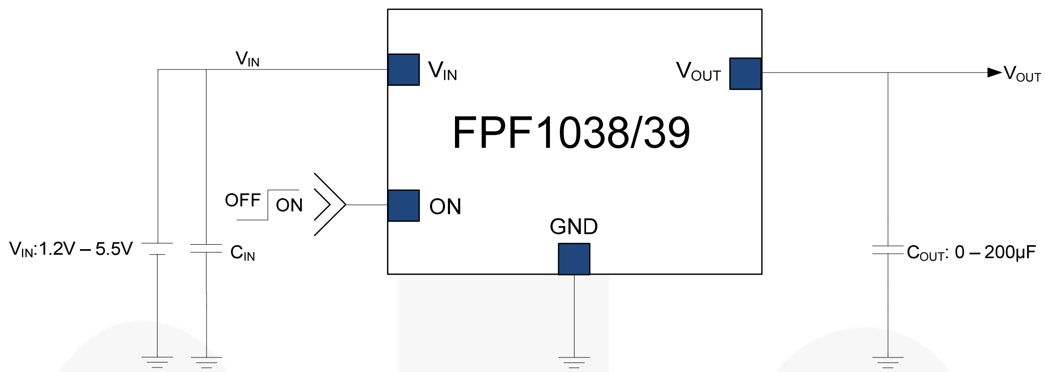

Figure 1. Typical Application

Functional Block Diagram

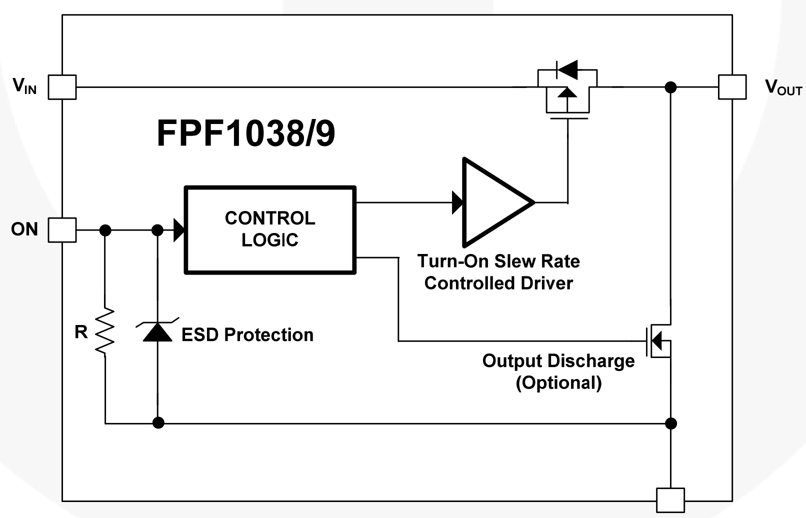

Figure 2. Functional Block Diagram (Output Discharge for FPF1039 Only)

Pin Configuration

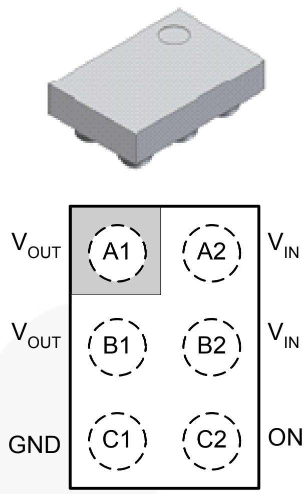

Figure 3. Top View

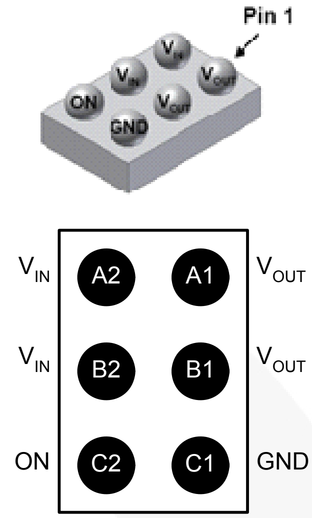

Figure 4. Bottom View

Pin Definitions

Pin #	Name	Description
A1, B1	V_{OUT}	Switch Output
A2, B2	V_{IN}	Supply Input: Input to the Power Switch
C1	GND	Ground
C2	ON	ON/OFF Control, Active High - GPIO Compatible

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="2">Parameters</th><th>Min.</th><th>Max.</th><th>Unit</th></tr>
<tr><td>V_{IN}</td><td colspan="2">V_{IN}, V_{OUT}, V_{ON} to GND</td><td>-0.3</td><td>6.0</td><td>V</td></tr>
<tr><td>I_{SW}</td><td colspan="2">Maximum Continuous Switch Current</td><td></td><td>3</td><td>A</td></tr>
<tr><td>P_D</td><td colspan="2">Power Dissipation at T_A=25°C</td><td></td><td>1.2</td><td>W</td></tr>
<tr><td>T_{STG}</td><td colspan="2">Storage Junction Temperature</td><td>-65</td><td>+150</td><td>°C</td></tr>
<tr><td>T_A</td><td colspan="2">Operating Temperature Range</td><td>-40</td><td>+85</td><td>°C</td></tr>
<tr><td rowspan="2">Θ_{JA}</td><td colspan="2" rowspan="2">Thermal Resistance, Junction-to-Ambient</td><td></td><td>85(1)</td><td rowspan="2">°C/W</td></tr>
<tr><td></td><td>110(2)</td></tr>
<tr><td rowspan="2">ESD</td><td rowspan="2">Electrostatic Discharge Capability</td><td>Human Body Model, JESD22-A114</td><td>8.0</td><td></td><td rowspan="2">kV</td></tr>
<tr><td>Charged Device Model, JESD22-C101</td><td>1.5</td><td></td></tr>
</table>

Notes:
1. Measured using 2S2P JEDEC std. PCB.
2. Measured using 2S2P JEDEC PCB COLD PLATE method.

Recommended Operating Conditions

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

Symbol	Parameters	Min.	Max.	Unit
V_{IN}	Input Voltage	1.2	5.5	V
T_A	Ambient Operating Temperature	-40	+85	°C

Electrical Characteristics

Unless otherwise noted, V_{IN}=1.2 to 5.5V and T_A=-40 to +85°C; typical values are at V_{IN}=4.5V and T_A=25°C.

Symbol	Parameters	Conditions	Min.	Typ.	Max.	Units
Basic Operation						
V_{IN}	Input Voltage		1.2		5.5	V
$I_{Q(OFF)}$	Off Supply Current	V_{ON}=GND, V_{OUT}=Open			1.0	µA
I_{SD}	Shutdown Current	V_{ON}=GND, V_{OUT}=GND		0.2	1.0	µA
I_Q	Quiescent Current	I_{OUT}=0mA		5.5	8.0	µA
R_{ON}	On Resistance	V_{IN}=5.5V, I_{OUT}=1A(3)		20	24	mΩ
		V_{IN}=4.5V, I_{OUT}=1A, T_A=25°C		21	25	
		V_{IN}=3.3V, I_{OUT}=500mA(3)		24	29	
		V_{IN}=2.5V, I_{OUT}=500mA(3)		28	35	
		V_{IN}=1.8V, I_{OUT}=250mA(3)		37	45	
		V_{IN}=1.2V, I_{OUT}=250mA, T_A=25°C		75	100	
R_{PD}	Output Discharge $R_{PULL\ DOWN}$	V_{IN}=4.5V, V_{ON}=0V, I_{FORCE}=20mA, T_A=25°C, FPF1039 Only		65	85	Ω
V_{IH}	On Input Logic HIGH Voltage		1.0			V
V_{IL}	On Input Logic LOW Voltage				0.4	V
I_{ON}	On Input Leakage	FPF1038			1.0	µA
		FPF1039			1.5	
Dynamic Characteristics						
t_{DON}	Turn-On Delay(4)	V_{IN}=4.5V, R_L=5Ω, C_L=100µF, T_A=25°C		1.7		ms
t_R	V_{OUT} Rise Time(4)			2.7		ms
t_{ON}	Turn-On Time(6)			4.4		ms
t_{DOFF}	Turn-Off Delay(4)	V_{IN}=4.5V, R_L=150Ω, C_L=100µF, T_A=25°C, FPF1038 (No Load Discharge)		2.0		ms
t_F	V_{OUT} Fall Time(4)			30.0		ms
t_{OFF}	Turn-Off(7)			32.0		ms
t_{DOFF}	Turn-Off Delay(4,5)	V_{IN}=4.5V, R_L=150Ω, C_L=100µF, T_A=25°C; FPF1039(5)		0.5		ms
t_F	V_{OUT} Fall Time(4,5)			10.0		ms
t_{OFF}	Turn-Off (5,7)			10.5		ms

Notes:
3. This parameter is guaranteed by design and characterization; not production tested.
4. $t_{DON}/t_{DOFF}/t_R/t_F$ are defined in Figure 36.
5. Output discharge enabled during off-state.
6. $t_{ON}=t_R + t_{DON}$
7. $t_{OFF}=t_F + t_{DOFF}$

Typical Characteristics

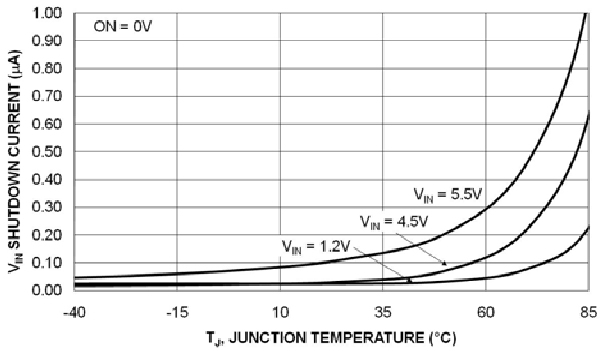

Figure 5. Shutdown Current vs. Temperature

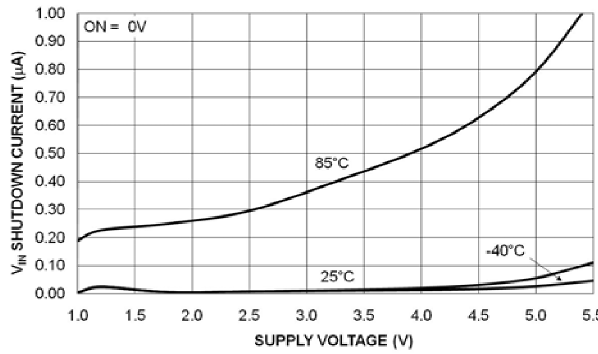

Figure 6. Shutdown Current vs. Supply Voltage

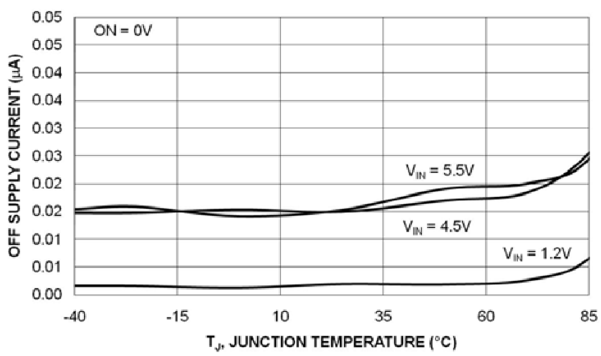

Figure 7. Off Supply Current vs. Temperature (FPF1038, V_{OUT} Floating)

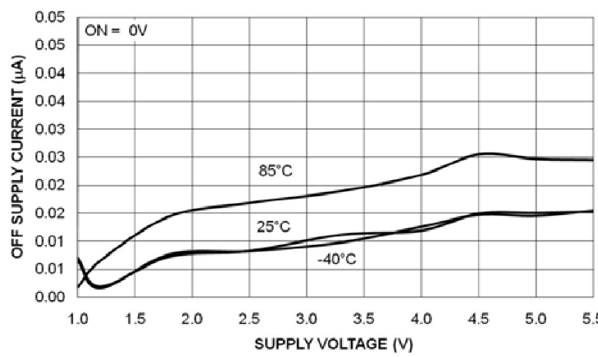

Figure 8. Off Supply Current vs. Supply Voltage (FPF1038, V_{OUT} Floating)

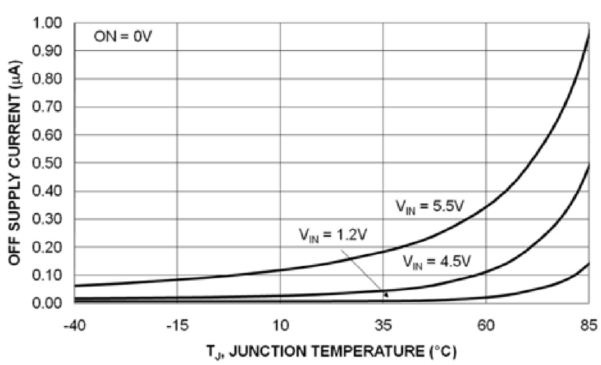

Figure 9. Off Supply Current vs. Temperature (FPF1039, V_{OUT} = 0V)

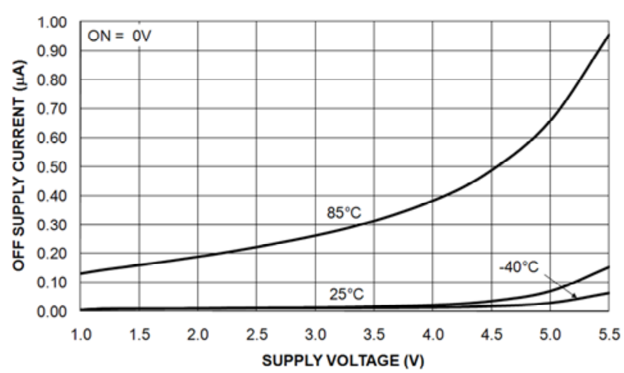

Figure 10. Off Supply Current vs. Supply Voltage (FPF1039, V_{OUT} = 0V)

Typical Characteristics (Continued)

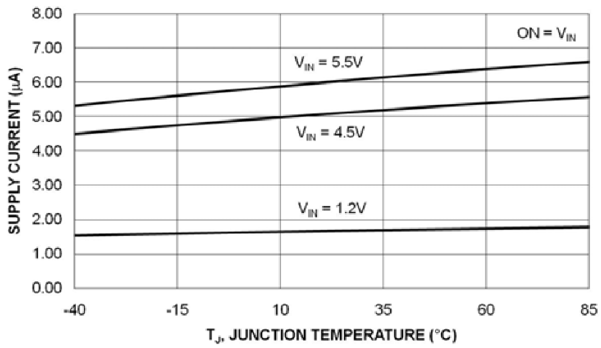

Figure 11. Quiescent Current vs. Temperature

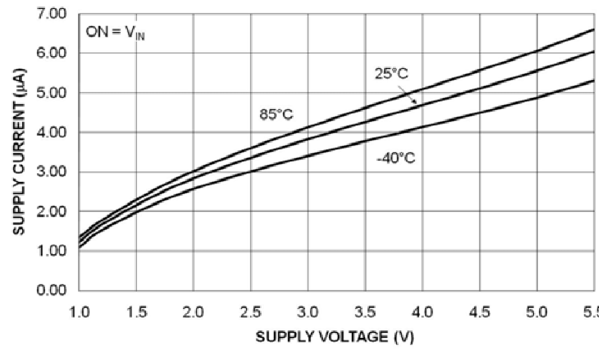

Figure 12. Quiescent Current vs. Supply Voltage

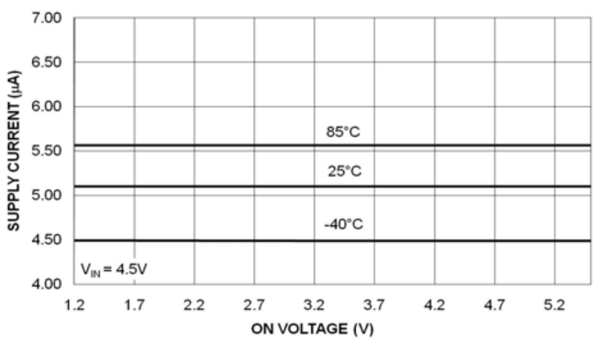

Figure 13. Quiescent Current vs. On Voltage (V_{IN} = 4.5V)

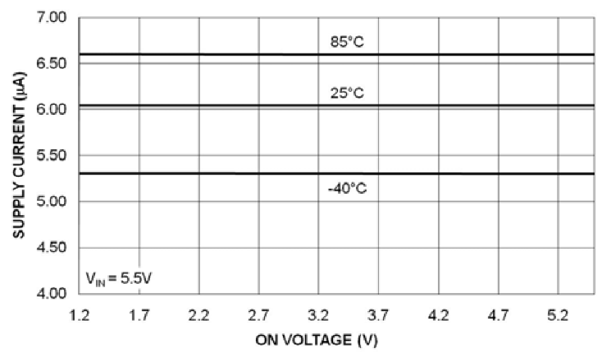

Figure 14. Quiescent Current vs. On Voltage (V_{IN} = 5.5V)

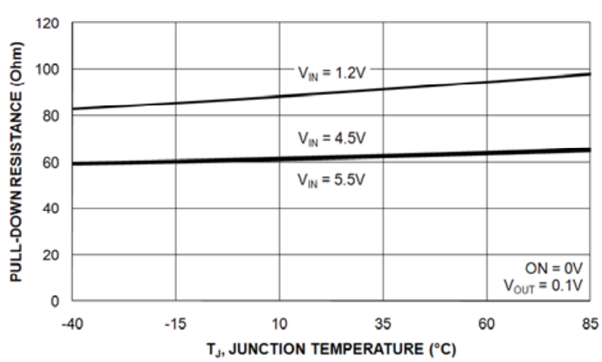

Figure 15. Output Discharge Resistor RPD vs. Temperature (FPF1039 Only)

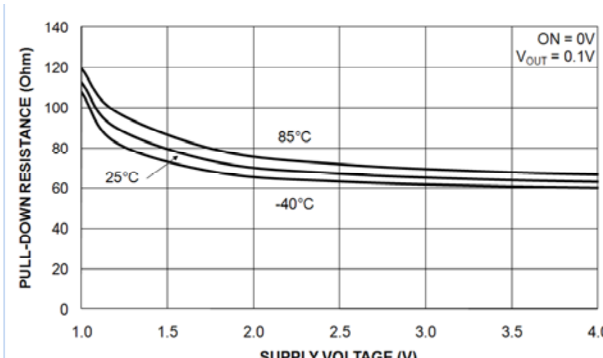

Figure 16. Output Discharge Resistor RPD vs. Supply Voltage (FPF1039 Only)

Typical Characteristics (Continued)

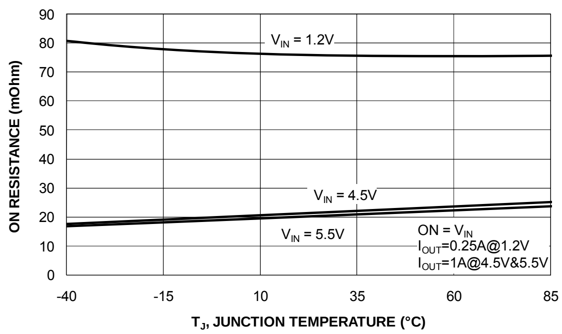

Figure 17. R_{ON} vs. Temperature

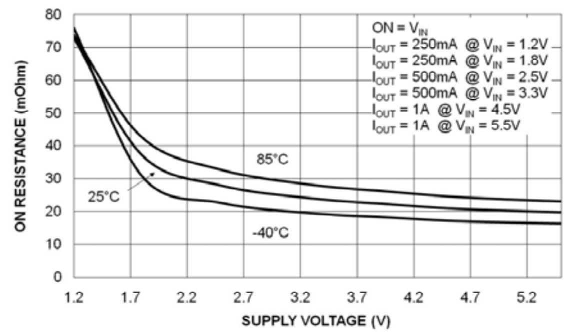

Figure 18. R_{ON} vs. Supply Voltage

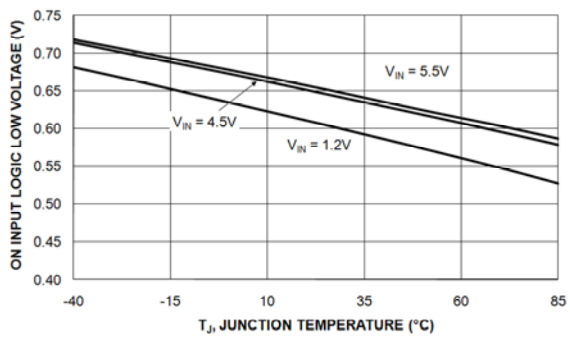

Figure 19. On Pin Threshold Low vs. Temperature

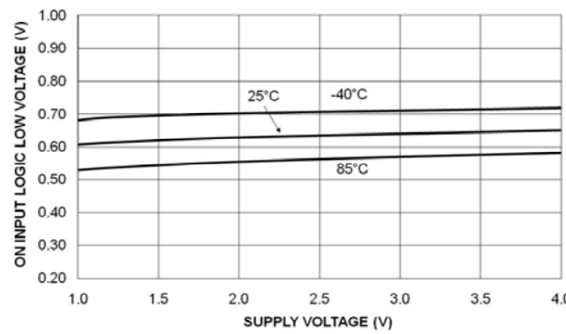

Figure 20. On Pin Threshold Low vs. V_{IN}

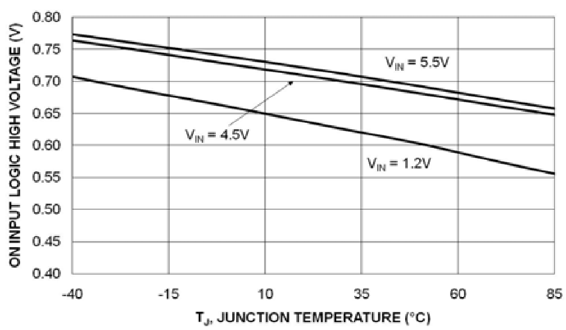

Figure 21. On Pin Threshold High vs. Temperature

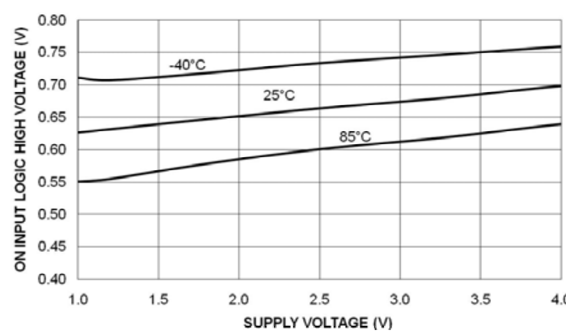

Figure 22. On Pin Threshold High vs. V_{IN}

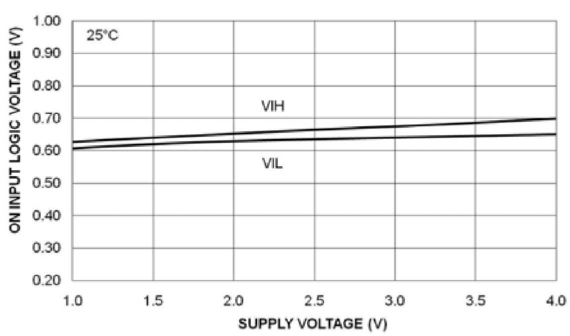

Figure 23. On Pin Threshold vs. Supply Voltage

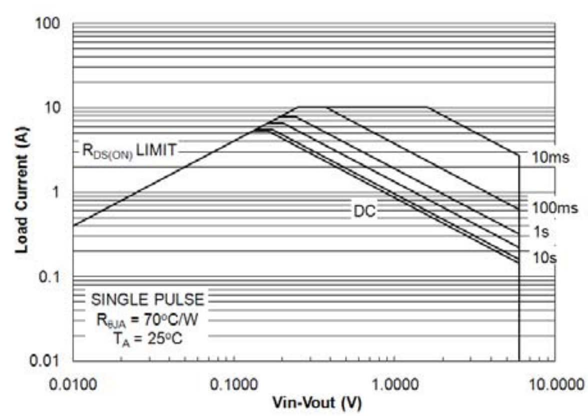

Figure 24. I_{SW} vs. (V_{IN}-V_{OUT}) — SOA

Typical Characteristics (Continued)

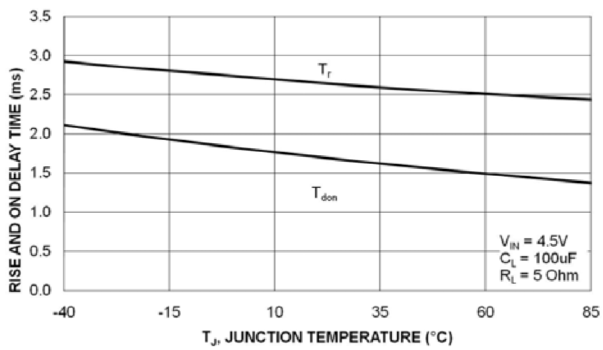

Figure 25. t_R/t_{DON} vs. Temperature (FPF1038)

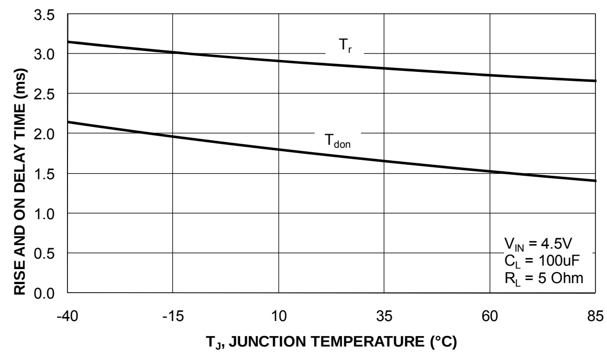

Figure 26. t_R/t_{DON} vs. Temperature (FPF1039)

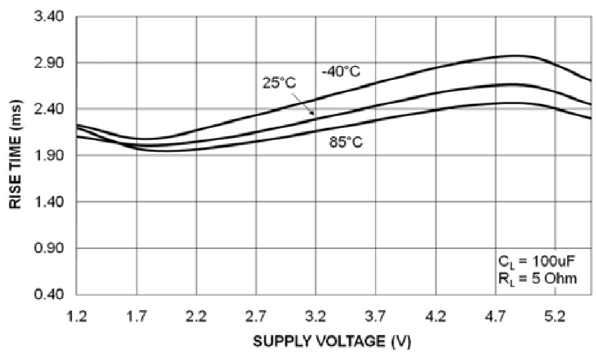

Figure 27. t_R vs. Supply Voltage

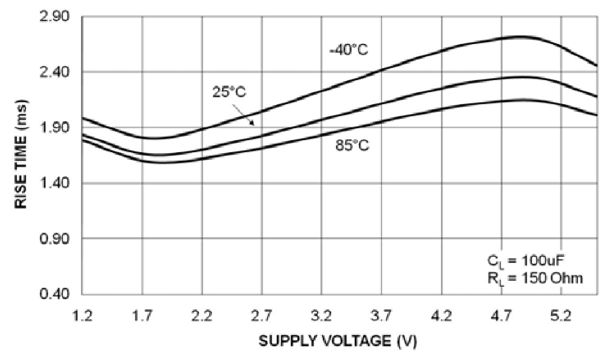

Figure 28. t_R vs. Supply Voltage

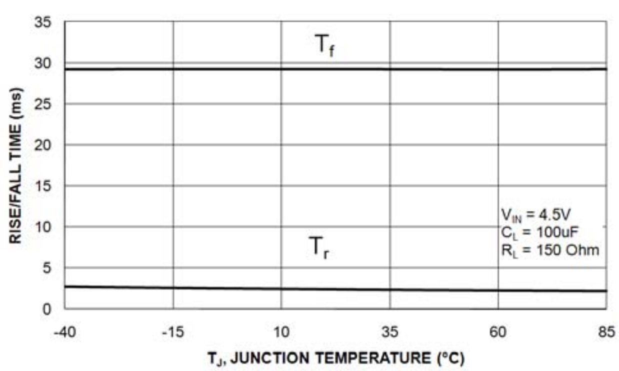

Figure 29. t_R/t_F vs. Temperature (FPF1038)

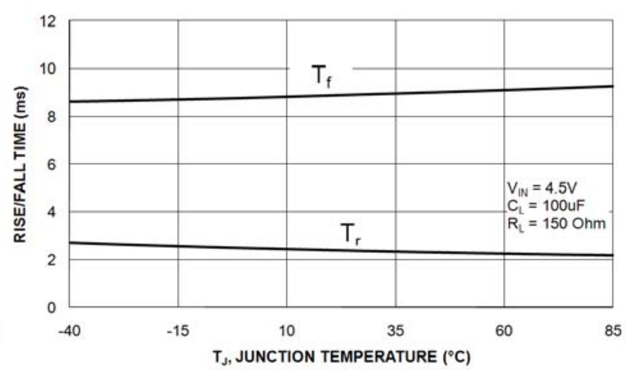

Figure 30. t_R/t_F vs. Temperature (FPF1039)

Typical Characteristics (Continued)

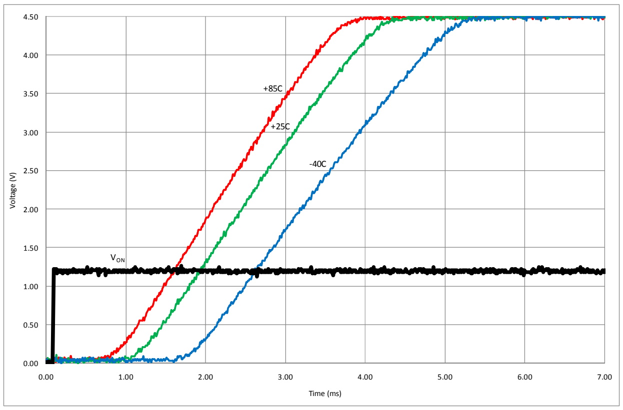

Figure 31. Turn-On Response (V_{IN}=4.5V, C_{IN}=10µF, C_L=1µF, R_L=50Ω)

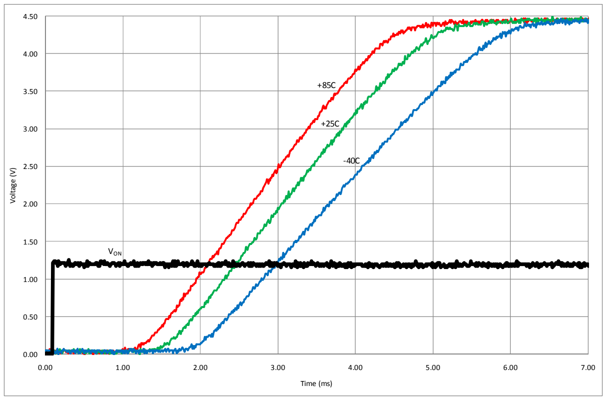

Figure 32. Turn-On Response (V_{IN}=4.5V, C_{IN}=10µF, C_L=100µF, R_L=5Ω)

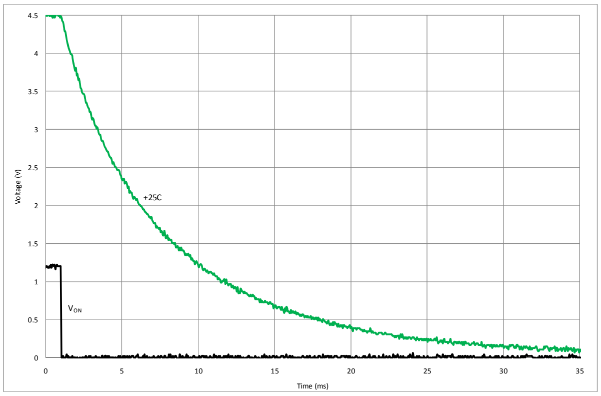

Figure 33. Turn-Off Response (V_{IN}=4.5V, C_{IN}=10µF, C_L=100µF, FPF1039 without External RL)

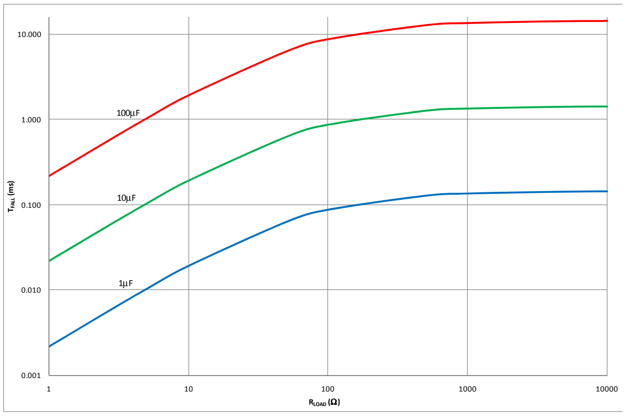

Figure 34. Fall Time as a Function of External Resistive Load (C_L=1µF, 10µF, and 100µF) (FPF1039)

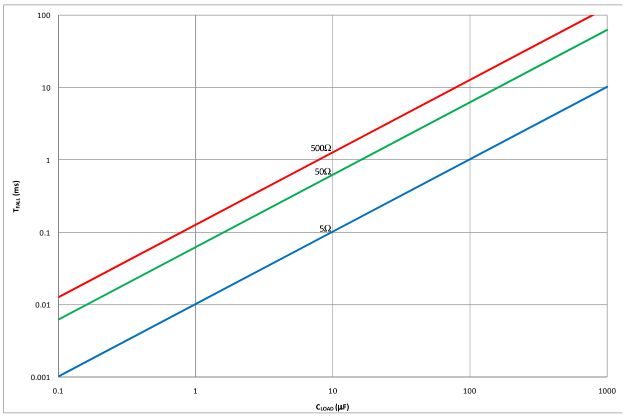

Figure 35. Fall Time as a Function of External Capacitive Load (RL=5Ω, 50Ω, and 500Ω)(FPF1039)

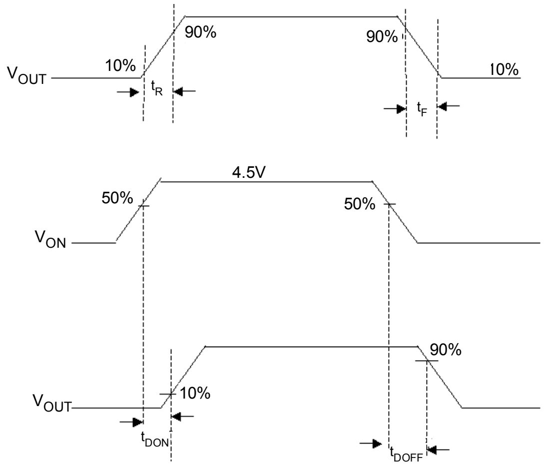

Figure 36. Timing Diagram

Application Information

Input Capacitor

This IntelliMAX™ switch doesn't require an input capacitor. To reduce device inrush current, a 0.1µF ceramic capacitor, C_{IN}, is recommended close to the VIN pin. A higher value of C_{IN} can be used to reduce the voltage drop experienced as the switch is turned on into a large capacitive load.

Output Capacitor

While this switch works without an output capacitor: if parasitic board inductance forces V_{OUT} below GND when switching off; a 0.1µF capacitor, C_{OUT}, should be placed between V_{OUT} and GND.

Fall Time

Device output fall time can be calculated based on RC constant of the external components as follows:

$$t_F = R_L \times C_L \times 2.2 \quad (1)$$

where t_F is 90% to 10% fall time, R_L is output load, and C_L is output capacitor.

The same equation works for a device with a pull-down output resistor. R_L is replaced by a parallel connected pull-down and an external output resistor combination as:

$$t_F = \frac{R_L \times R_{PD}}{R_L + R_{PD}} \times C_L \times 2.2 \quad (2)$$

where t_F is 90% to 10% fall time, R_L is output load, R_{PD}=65Ω is output pull-down resistor, and C_L is the output capacitor.

Resistive Output Load

If resistive output load is missing, the IntelliMAX switch without a pull-down output resistor does not discharge the output voltage. Output voltage drop depends, in that case, mainly on external device leaks.

Application Specifics

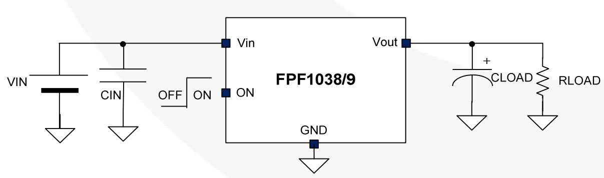

Figure 37. Device Setup

At maximum operational voltage (V_{IN}=5.5V), device inrush current might be higher than expected. Spike current should be taken into account if V_{IN}>5V and the output capacitor is much larger than the input capacitor. Input current can be calculated as:

$$I_{IN}(t) \approx \frac{V_{OUT}(t)}{R_{LOAD}} + (C_{LOAD} - C_{IN})\frac{dV_{OUT}(t)}{dt} \quad (3)$$

where switch and wire resistances are neglected and capacitors are assumed ideal.

Estimating $V_{OUT}(t)=V_{IN}/10$ and using experimental formula for slew rate ($dV_{OUT}(t)/dt$), spike current can be written as:

$$\max(I_{IN}) = \frac{V_{IN}}{10R_{LOAD}} + (C_{LOAD} - C_{IN})(0.05V_{IN} - 0.255) \quad (4)$$

where supply voltage V_{IN} is in volts, capacitances are in micro farads, and resistance is in ohms.

Example: If V_{IN}=5.5V, C_{LOAD}=100µF, C_{IN}=10µF, and R_{LOAD}=50Ω; calculate the spike current by:

$$\max(I_{IN}) = \frac{5.5}{10^*50} + (100-10)(0.05^*5.5 - 0.255)A = 1.8A \quad (5)$$

Maximum spike current is 1.8A, while average ramp-up current is:

$$I_{IN}(t) \approx \frac{V_{OUT}(t)}{R_{LOAD}} + (C_{LOAD} - C_{IN})\frac{dV_{IN}(t)}{dt} \quad (6)$$
$$\approx 2.75/50 + 100^*0.0022 = 0.275A$$

Output Discharge

FPF1039 contains a 65Ω on-chip pull-down resistor for quick output discharge. The resistor is activated when the switch is turned off.

Recommended Layout

For best thermal performance and minimal inductance and parasitic effects, it is recommended to keep input and output traces short and capacitors as close to the device as possible. Figure 38 is a recommended layout for this device to achieve optimum performance.

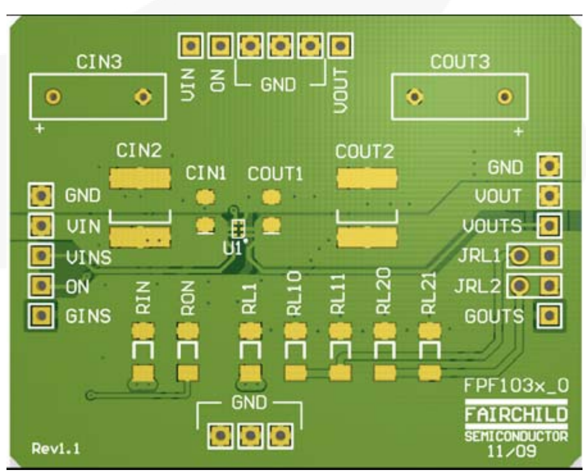

Figure 38. Recommended Land Pattern, Layout

Physical Dimensions

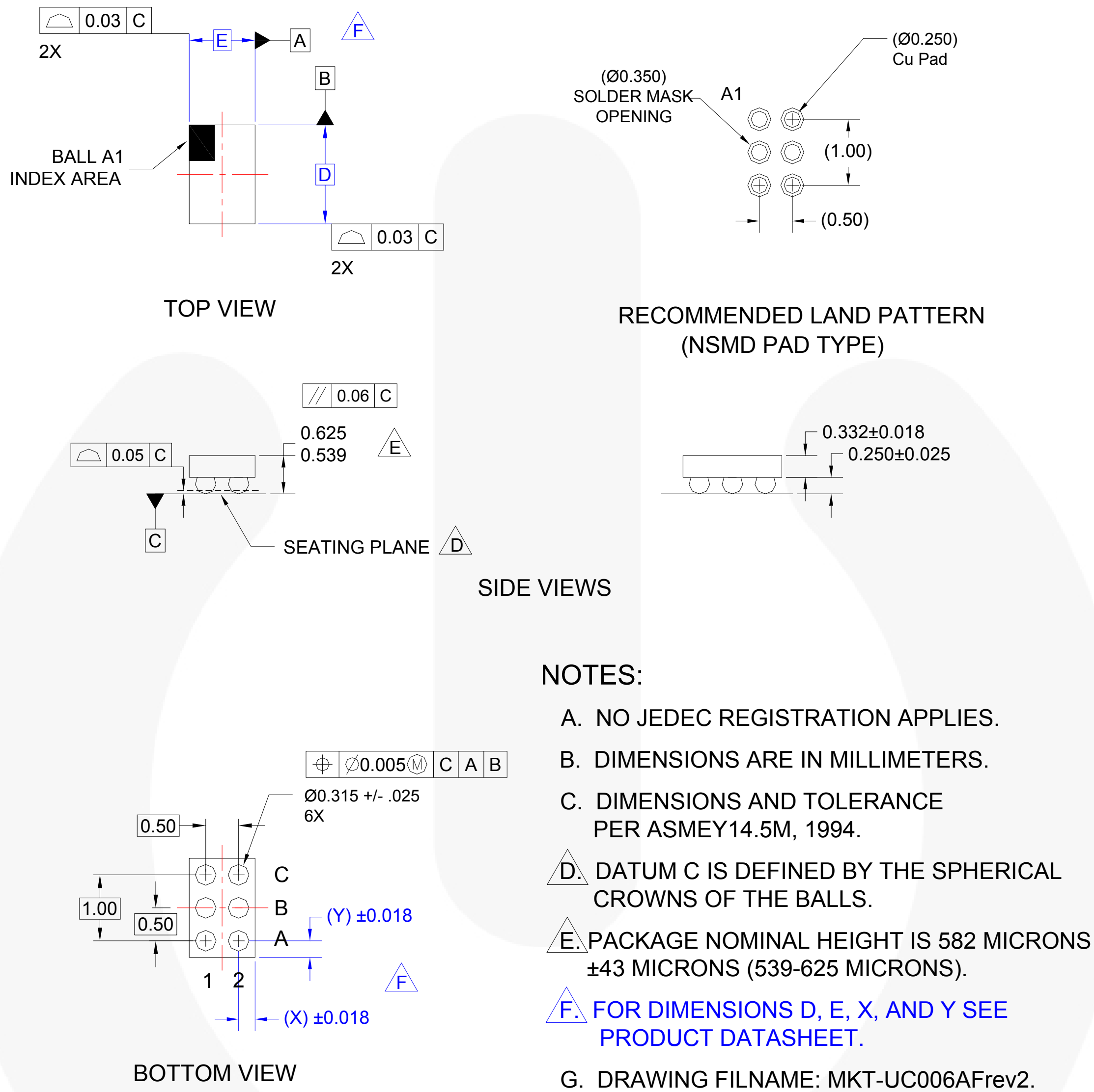

Figure 39. 6 Ball, 1.0 x 1.5mm Wafer-Level Chip-Scale Packaging (WLCSP)

Product-Specific Dimensions

Product	D	E	X	Y
FPF1038UCX	1.5mm+/-0.03	1.0mm+/-0.03	0.240mm	0.240mm
FPF1039UCX				

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