FAIRCHILD SEMICONDUCTOR®

April 2010



# 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)
- Output Capacitor Discharge Function on FPF1039
- Low <1µA Shutdown Current at $V_{ON}$=GND
- ESD Protected: Above 8000V HBM, 1500V CDM
- GPIO/CMOS-Compatible Enable Circuitry

## Applications

- HDD, Storage, and Solid State Memory Devices
- Portable Media Devices, UMPC, Tablets & MID's
- 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 off-state 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 off-state current drain (<1uA max) which facilitate compliance in very low stand-by power applications. The input voltage range operates from 1.2V to 5.5V DC to fulfill 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 full-Green compliant 1x1.5 mm WLCSP (Wafer-Level-Chip-Scale Packaging) device 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-Ball, Wafer-Level Chip-Scale Package (WLCSP), 1.0 x 1.5mm, 0.5mm Pitch |
| FPF1039UCX | QF | 21mΩ | CMOS | 65Ω | Active HIGH | 2.7ms | |

## Application Diagram

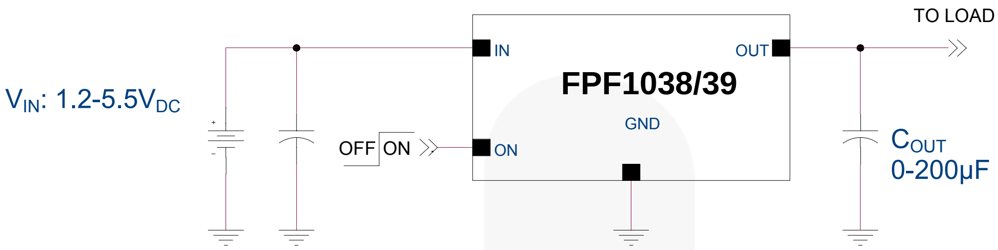



**Figure 1. Typical Application**

**Note:**
1. $C_{IN}$=1µF, X5R, 0603, such as Murata GRM185R60J105KE26.

## Block Diagram

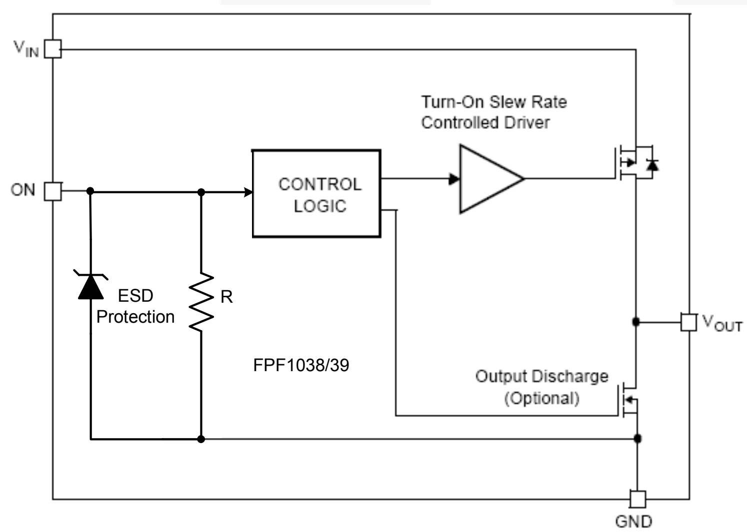



**Figure 2. Block Diagram (Output Discharge for FPF1039 Only)**

## Pin Configurations

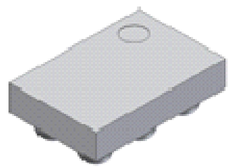


**Figure 3. Bumps Facing Down**

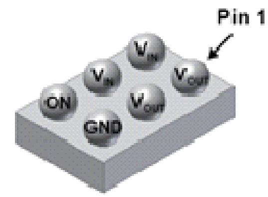



**Figure 4. Bumps Facing Up**

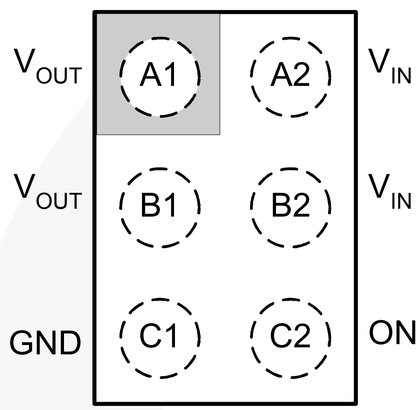



**Figure 5. Top View**

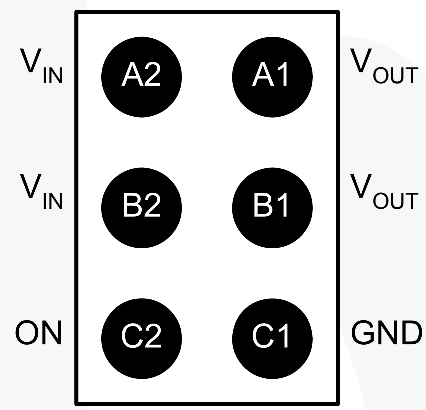



**Figure 6. Bottom View**

## 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.

| Symbol | Parameter | | Min. | Max. | Unit |
|---|---|---|---|---|---|
| $V_{IN}$ | $V_{IN}$, $V_{OUT}$, $V_{ON}$ to GND | | -0.3 | 6.0 | V |
| $I_{SW}$ | Maximum Continuous Switch Current | | | 2 | A |
| $P_D$ | Power Dissipation at $T_A$=25°C | | | 1.2 | W |
| $T_{STG}$ | Storage Junction Temperature | | -65 | +150 | °C |
| $T_A$ | Operating Temperature Range | | -40 | +85 | °C |
| $\Theta_{JA}$ | Thermal Resistance, Junction-to-Ambient | | | 85 | °C/W |
| ESD | Electrostatic Discharge Capability | Human Body Model, JESD22-A114 | 8.0 | | kV |
| | | Charged Device Model, JESD22-C101 | 1.5 | | |

## 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 | Parameter | Min. | Max. | Unit |
|---|---|---|---|---|
| $V_{IN}$ | Supply Voltage | 1.2 | 5.5 | V |
| $T_A$ | Ambient Operating Temperature | -40 | +85 | °C |

## Electrical Characteristics

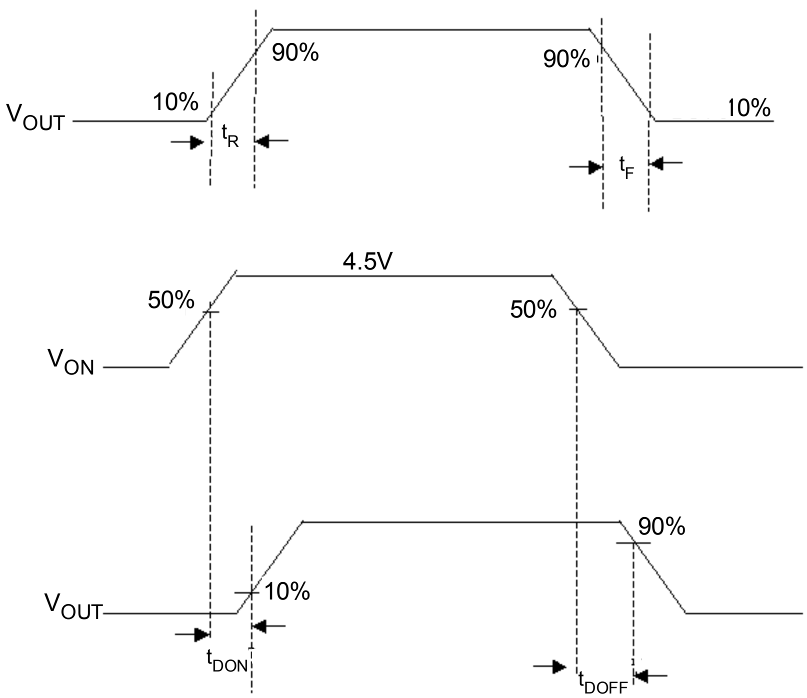
Unless otherwise noted, $V_{IN}$=1.2 to 5.5V and $T_A$=-40 to +85°C; typical values are at $V_{IN}$=4.5V and $T_A$=25°C.

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| **Basic Operation** | | | | | | |
| $V_{IN}$ | Supply Voltage | | 1.2 | | 5.5 | V |
| $I_{Q(OFF)}$ | Off Supply Current | $V_{ON}$=GND, $V_{OUT}$=Open | | | 1 | µA |
| $I_{SD(OFF)}$ | Off Switch 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(2) | | 20 | | mΩ |
| | | $V_{IN}$=4.5V, $I_{OUT}$=1A, $T_A$=25°C | | 21 | 25 | |
| | | $V_{IN}$=3.3V, $I_{OUT}$=500mA(2) | | 24 | | |
| | | $V_{IN}$=2.5V, $I_{OUT}$=500mA(2) | | 28 | | |
| | | $V_{IN}$=1.8V, $I_{OUT}$=250mA(2) | | 37 | | |
| | | $V_{IN}$=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: See Definitions Below** | | | | | | |
| $t_{DON}$ | Turn-On Delay(3) | $V_{IN}$=4.5V, $R_L$=5Ω, $C_L$=100µF, $T_A$=25°C | | 1.7 | | ms |
| $t_R$ | $V_{OUT}$ Rise Time(3) | | | 2.7 | | ms |
| $t_{ON}$ | Turn-On Time(3,5) | | | 4.4 | | ms |
| $t_{DOFF}$ | Turn-Off Delay(3) | $V_{IN}$=4.5V, $R_L$=150Ω, $C_L$=100µF, $T_A$=25°C FPF1038 (No Load Discharge) | | 2 | | ms |
| $t_F$ | $V_{OUT}$ Fall Time(3) | | | 30 | | ms |
| $t_{OFF}$ | Turn-Off(3,6) | | | 32 | | ms |
| $t_{DOFF}$ | Turn-Off Delay(3) | $V_{IN}$=4.5V, $R_L$=150Ω, $C_L$=100µF, $T_A$=25°C; FPF1039(4) | | 0.5 | | ms |
| $t_F$ | $V_{OUT}$ Fall Time(3) | | | 10 | | ms |
| $t_{OFF}$ | Turn-Off(3,6) | | | 10.5 | | ms |

**Notes:**

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

## Timing Diagram




**Notes:**
7. $t_{ON} = t_R + t_{DON}$.
8. $t_{OFF} = t_F + t_{DOFF}$.

**Figure 7. Timing Diagram**

## Typical Characteristics

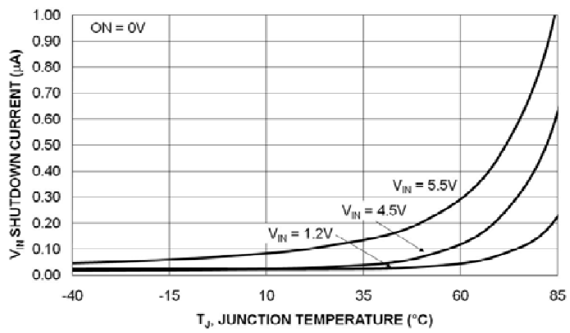



**Figure 8. Shutdown Current vs. Temperature**

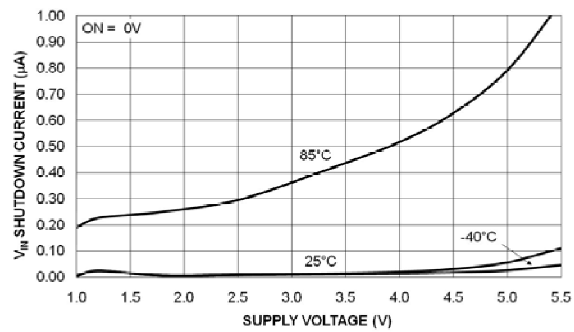



**Figure 9. Shutdown Current vs. Supply Voltage**

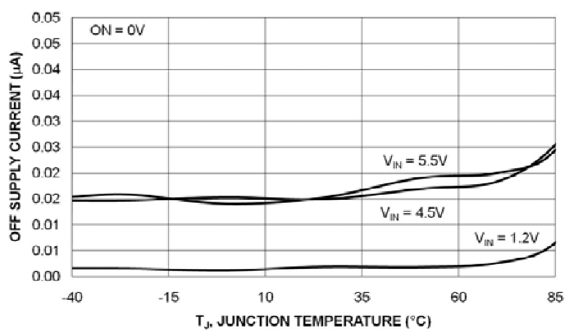



**Figure 10. Off Supply Current vs. Temperature (FPF1038, $V_{OUT}$ Floating)**

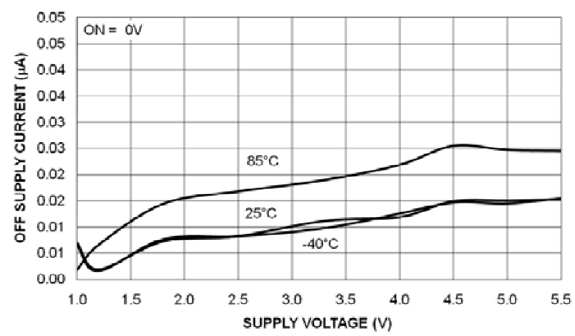



**Figure 11. Off Supply Current vs. Supply Voltage (FPF1038, $V_{OUT}$ Floating)**

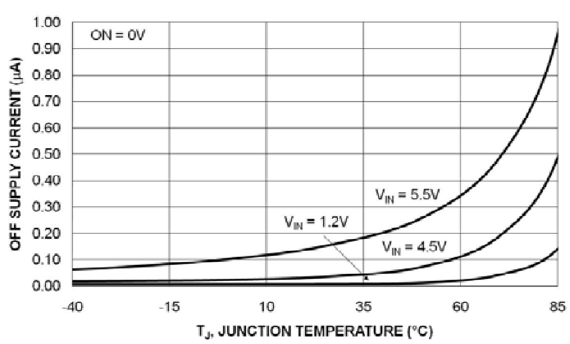



**Figure 12. Off Supply Current vs. Temperature (FPF1039, $V_{OUT}$ = 0V)**

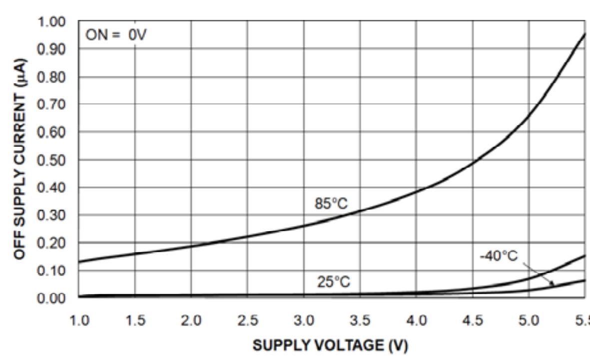



**Figure 13. Off Supply Current vs. Supply Voltage (FPF1039, $V_{OUT}$ = 0V)**

## Typical Characteristics (Continued)

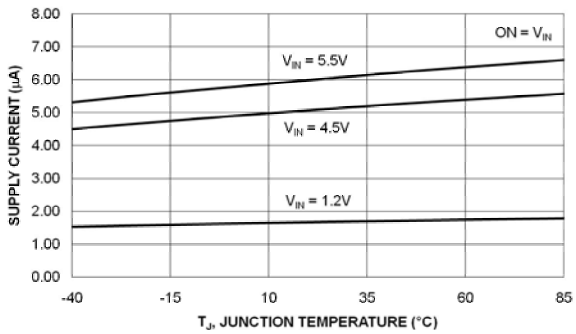



**Figure 14. Quiescent Current vs. Temperature**

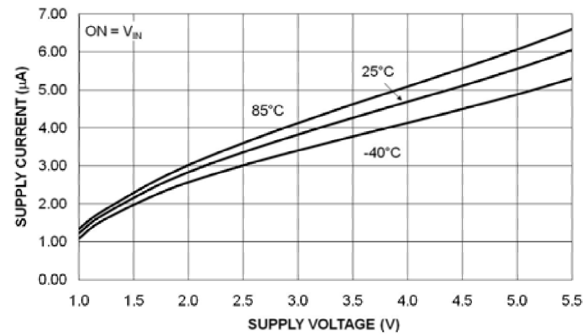



**Figure 15. Quiescent Current vs. Supply Voltage**

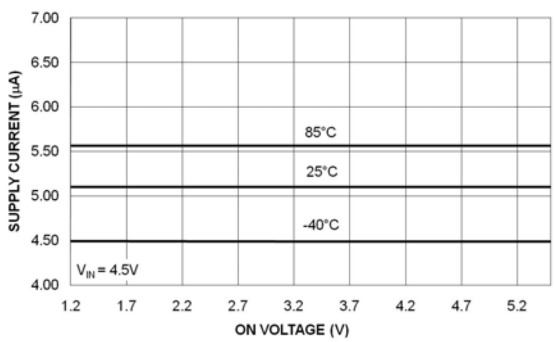



**Figure 16. Quiescent Current vs. On Voltage ($V_{IN}$ = 4.5V)**

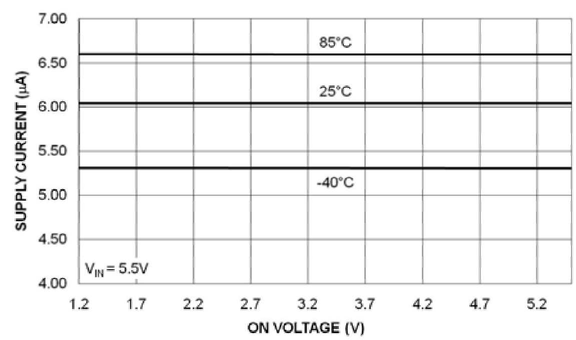



**Figure 17. Quiescent Current vs. On Voltage ($V_{IN}$ = 5.5V)**

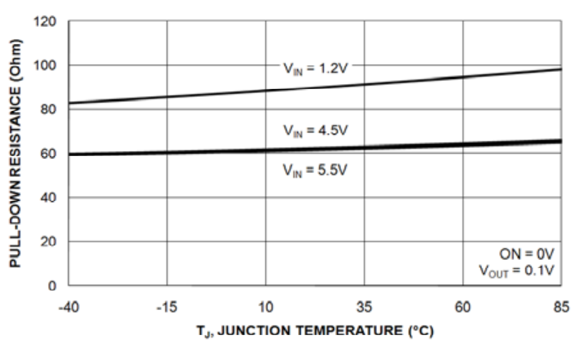



**Figure 18. Output Discharge Resistor RPD vs. Temperature (FPF1039 Only)**

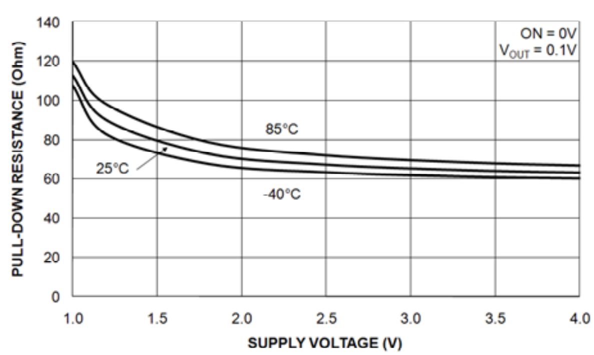



**Figure 19. Output Discharge Resistor RPD vs. Supply Voltage (FPF1039 Only)**

## Typical Characteristics (Continued)

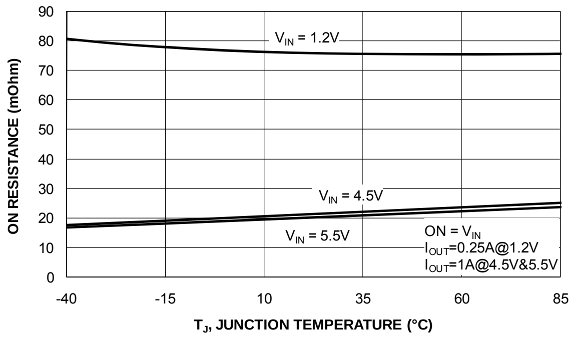



Figure 20. $R_{ON}$ vs. Temperature

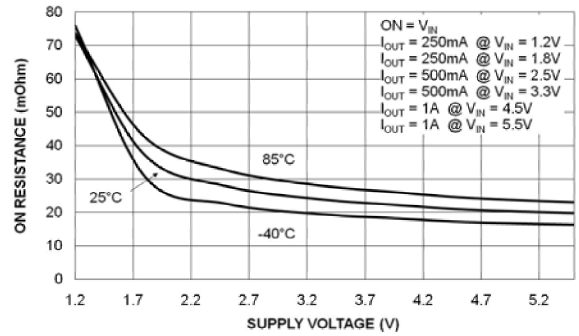



Figure 21. $R_{ON}$ vs. Supply Voltage

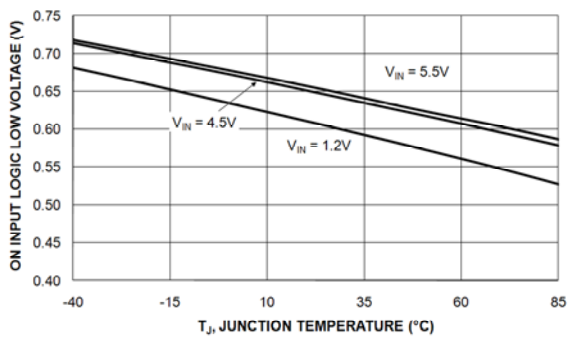



Figure 22. On Pin Threshold Low vs. Temperature

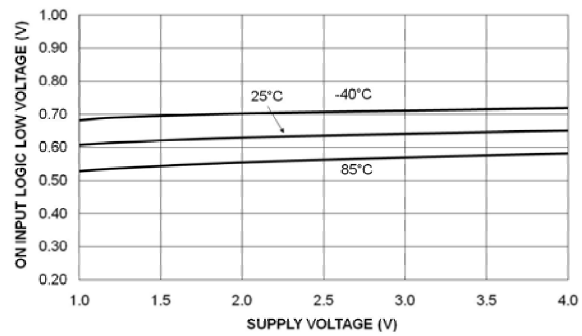



Figure 23. On Pin Threshold Low vs. $V_{IN}$

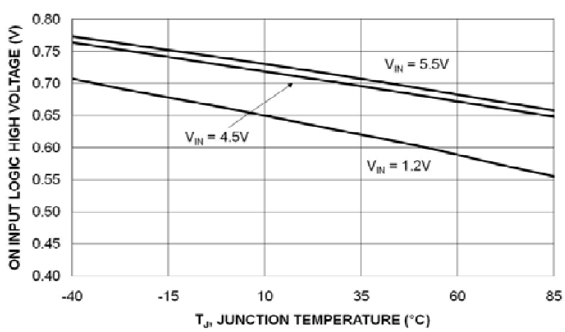



Figure 24. On Pin Threshold High vs. Temperature

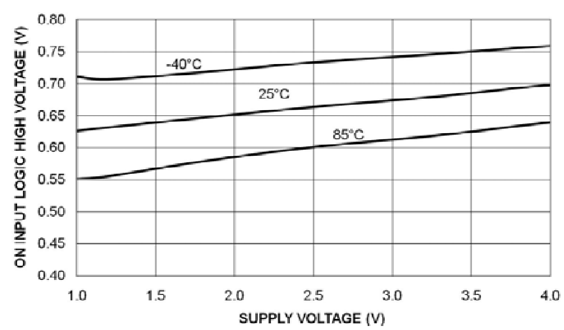



Figure 25. On Pin Threshold High vs. $V_{IN}$

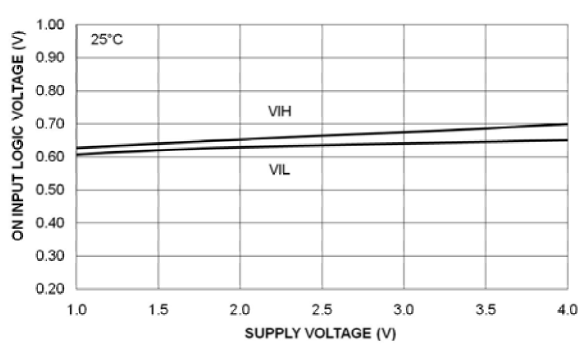



Figure 26. On Pin Threshold vs. Supply Voltage

## Typical Characteristics (Continued)

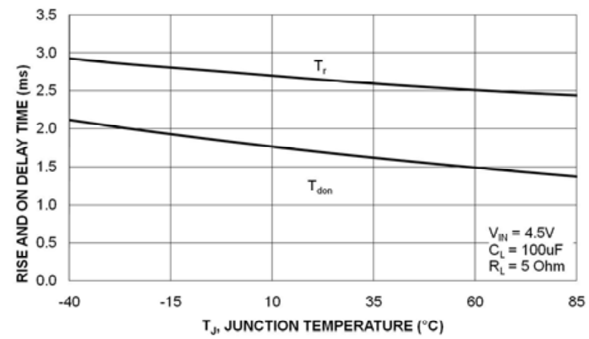



**Figure 27.** $t_{RISE}/t_{DON}$ **vs. Temperature (FPF1038)**

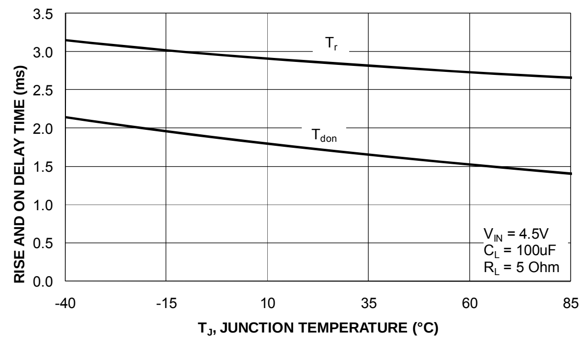



**Figure 28.** $t_{RISE}/t_{DON}$ **vs. Temperature (FPF1039)**

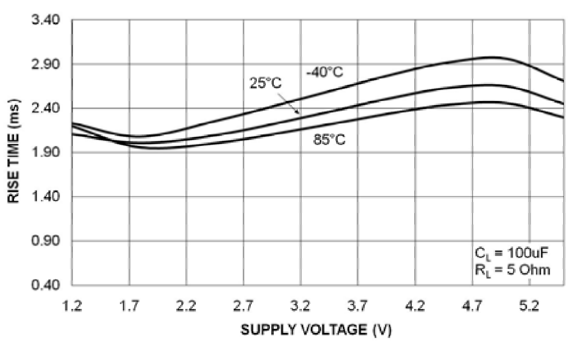



**Figure 29.** $t_{RISE}$ **vs. Supply Voltage**

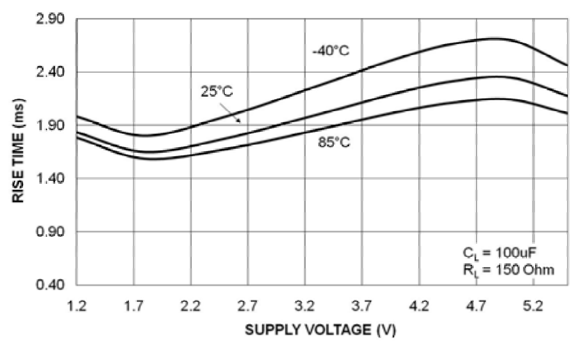



**Figure 30.** $t_{RISE}$ **vs. Supply Voltage**

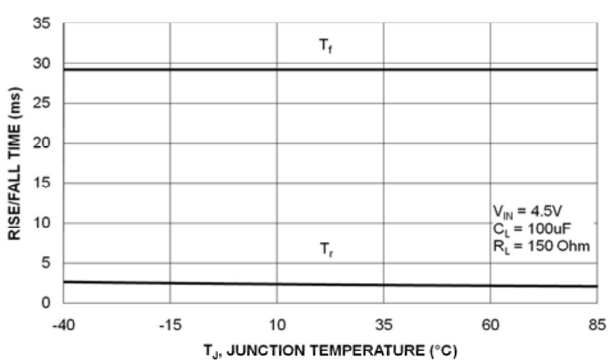



**Figure 31.** $t_{RISE}/t_{FALL}$ **vs. Temperature (FPF1038)**

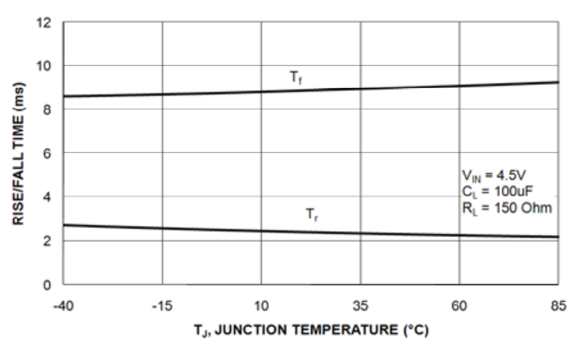



**Figure 32.** $t_{RISE}/t_{FALL}$ **vs. Temperature (FPF1039)**

## Typical Characteristics (Continued)

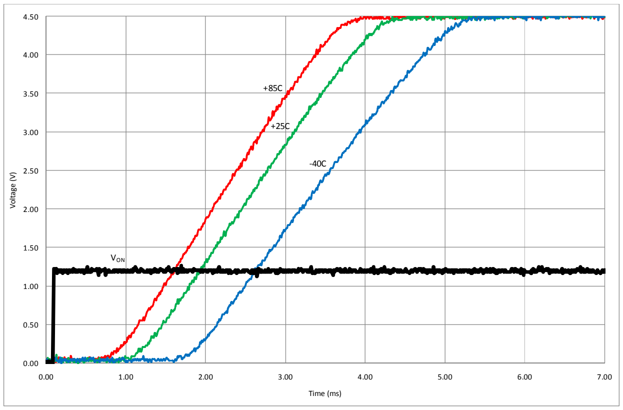



**Figure 33. Turn-On Response ($V_{IN}$=4.5V, $C_{IN}$=10µF, $C_L$=1µF, $R_L$=50Ω)**

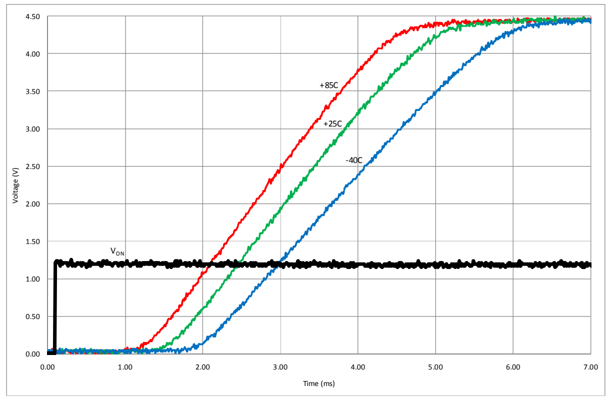



**Figure 34. Turn-On Response ($V_{IN}$=4.5V, $C_{IN}$=10µF, $C_L$=100µF, $R_L$=5Ω)**

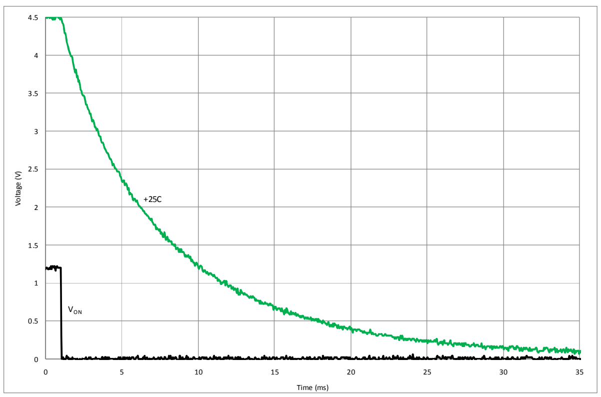



**Figure 35. Turn-Off Response ($V_{IN}$=4.5V, $C_{IN}$=10µF, $C_L$=100µF, FPF1039 without External $R_L$)**

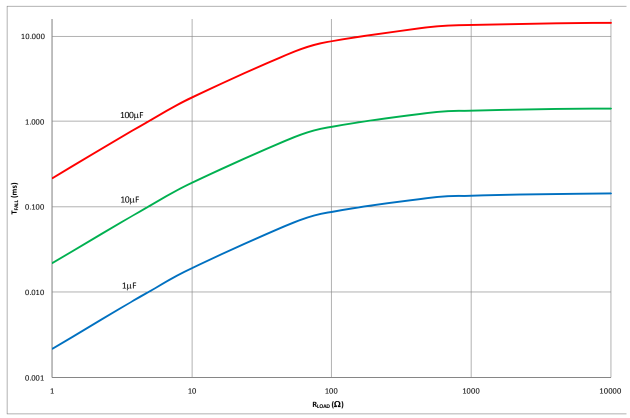



**Figure 36. Fall Time as a Function of External Resistive Load ($C_L$=1µF, 10µF and 100µF)**

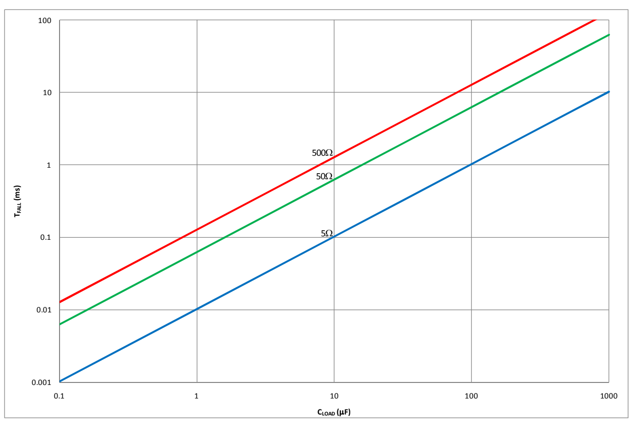



**Figure 37. Fall Time as a Function of External Capacitive Load ($R_L$=5Ω, 50Ω and 500Ω)**

# Application Information

## Input Capacitor

This IntelliMAX™ switch doesn't require an input capacitor. To reduce device inrush current effect, 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

This IntelliMAX™ switch works without an output capacitor. However, 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

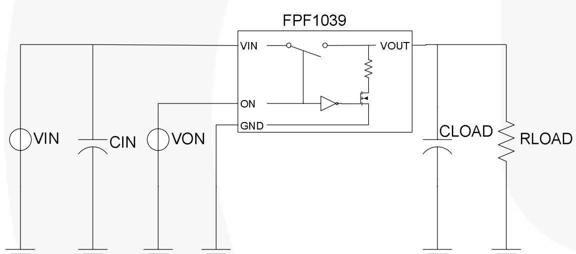



**Figure 38. Device Setup**

At maximum operational voltage ($V_{IN}$=5.5V) device in-rush 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

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

Where supply voltage VIN is in volts, capacitances are in micro farads and resistance 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:

$$I_{IN}(t) \approx \frac{V_{OUT}(t)}{R_{LOAD}} + (C_{LOAD} - C_{IN})\frac{dV_{IN}(t)}{dt} \quad (6)$$

$$\approx 2.75/50 + 100^*0.0022 = 0.275A$$

## Recommended Land Pattern and 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 39 is a recommended layout for this device to achieve optimum performance.

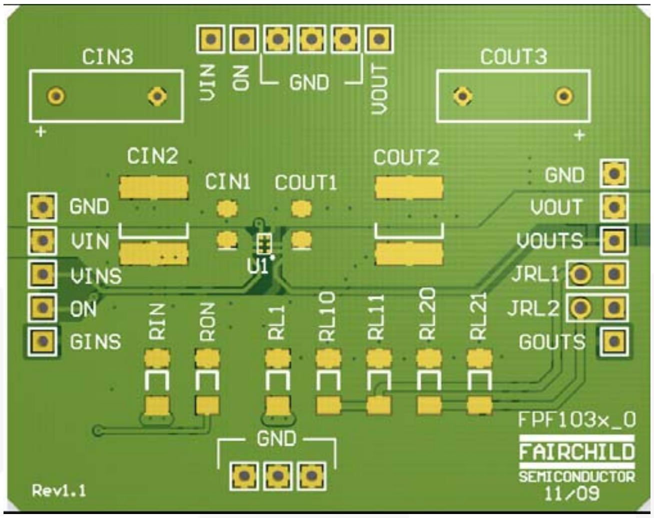
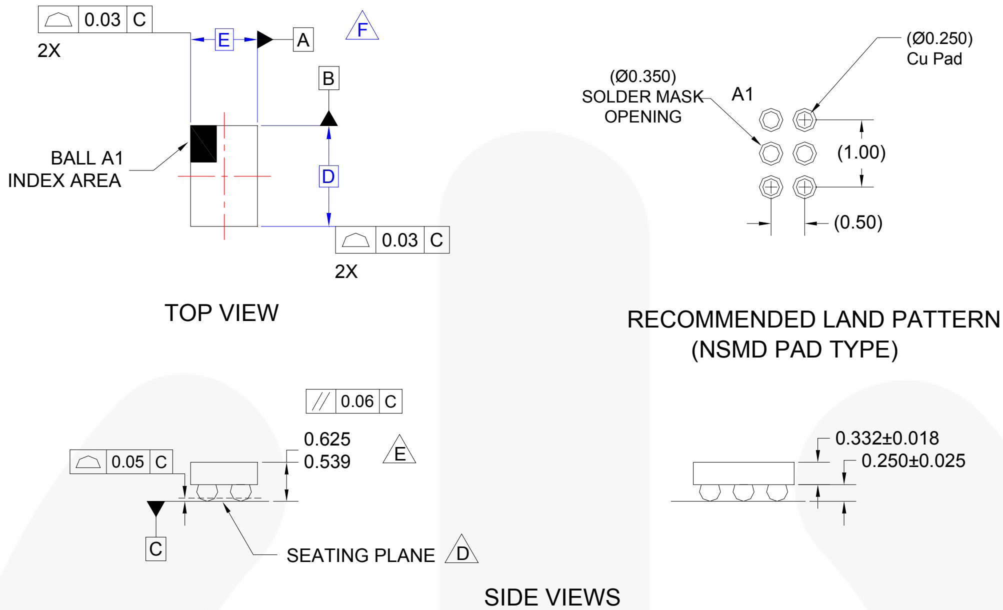
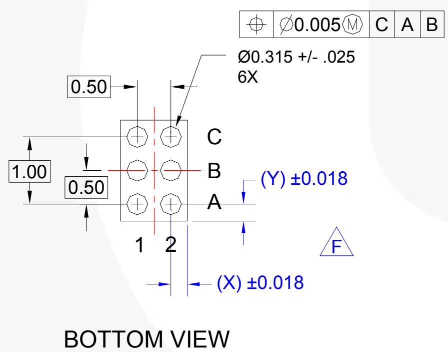



Figure 39. **Recommended Land Pattern and Layout**

## Physical Dimensions




NOTES:

A. NO JEDEC REGISTRATION APPLIES.

B. DIMENSIONS ARE IN MILLIMETERS.

C. DIMENSIONS AND TOLERANCE PER ASMEY14.5M, 1994.

D. DATUM C IS DEFINED BY THE SPHERICAL CROWNS OF THE BALLS.

E. PACKAGE NOMINAL HEIGHT IS 582 MICRONS ±43 MICRONS (539-625 MICRONS).

F. FOR DIMENSIONS D, E, X, AND Y SEE PRODUCT DATASHEET.

G. DRAWING FILNAME: MKT-UC006AFrev2.

**Figure 40. 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 | | | | |

*Package drawings are provided as a service to customers considering Fairchild components. Drawings may change in any manner without notice. Please note the revision and/or date on the drawing and contact a Fairchild Semiconductor representative to verify or obtain the most recent revision. Package specifications do not expand the terms of Fairchild's worldwide terms and conditions, specifically the warranty therein, which covers Fairchild products.*

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|---|---|---|
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