**FAIRCHILD**

**SEMICONDUCTOR®**

# FPF1038
## Low On-Resistance, Slew-Rate-Controlled Load Switch

## Features

- 1.2 V to 5.5 V Input Voltage Operating Range
- Typical $R_{ON}$:
    - 20 mΩ at $V_{IN}$=5.5 V
    - 21 mΩ at $V_{IN}$=4.5 V
    - 37 mΩ at $V_{IN}$=1.8 V
    - 75 mΩ at $V_{IN}$=1.2 V
- Slew Rate / Inrush Control with $t_R$: 2.7 ms (Typical)
- 3.5 A Maximum Continuous Current Capability
- Low <1 µA Shutdown Current
- ESD Protected: Above 8 kV HBM, 1.5 kV 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 advanced load-management switch target applications requiring a highly integrated solution for disconnecting loads powered from DC power rail (<6 V) with stringent shutdown current targets and high load capacitances (up to 200 µF). The FPF1038 consists of slew-rate controlled low-impedance MOSFET switch (21 mΩ 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 (<1 µA maximum) that facilitates compliance in low standby power applications. The input voltage range operates from 1.2 V to 5.5 V 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 x1.5 mm 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 4.5 $V_{IN}$ | Input Buffer | Output Discharge | ON Pin Activity | $t_R$ | Package |
|---|---|---|---|---|---|---|---|
| FPF1038UCX | QE | 21 mΩ | CMOS | NA | Active HIGH | 2.7 ms | 6-Bump, WLCSP, 1.0 mm x 1.5 mm, 0.5 mm Pitch |

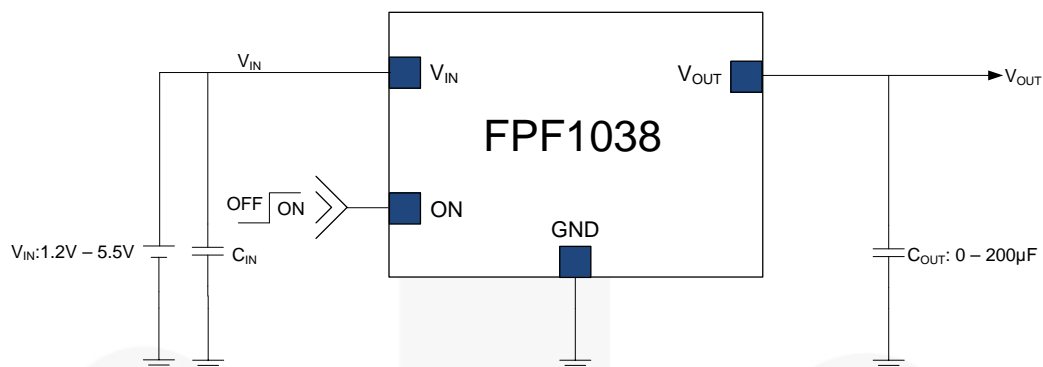## Application Diagram



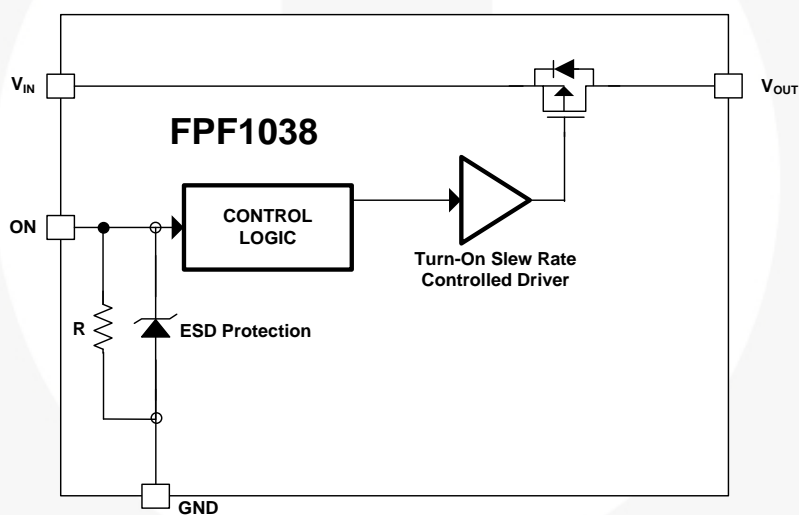**Figure 1.   Typical Application**

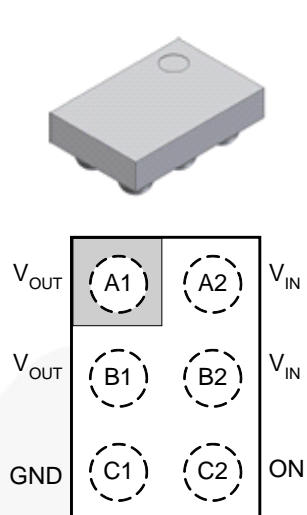## Functional Block Diagram



**Figure 2.   Functional Block Diagram**
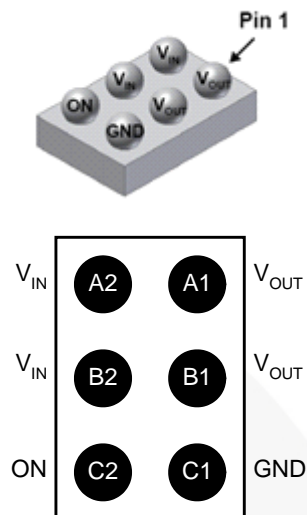
## Pin Configuration



**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 |

FPF1038 • Rev. 1.0.6

www.fairchildsemi.com

## 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 | Parameters | | Min. | Max. | Unit |
|---|---|---|---|---|---|
| $V_{IN}$ | $V_{IN}$, $V_{OUT}$, $V_{ON}$ to GND | | -0.3 | 6.0 | V |
| $I_{SW}$ | Maximum Continuous Switch Current | | | 3.5 | 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[1] | °C/W |
| | | | | 110[2] | |
| ESD | Electrostatic Discharge Capability | Human Body Model, JESD22-A114 | 8.0 | | kV |
| | | Charged Device Model, JESD22-C101 | 1.5 | | |

**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 5.5 V and $T_A$=-40 to +85°C; typical values are at $V_{IN}$=4.5 V 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 | $I_{OUT}$=0 mA | | 5.5 | 8.0 | µA |
| $R_{ON}$ | On Resistance | $V_{IN}$=5.5 V, $I_{OUT}$=1 A[3] | | 20 | 24 | mΩ |
| | | $V_{IN}$=4.5 V, $I_{OUT}$=1 A, $T_A$=25°C | | 21 | 25 | |
| | | $V_{IN}$=3.3 V, $I_{OUT}$=500 mA[3] | | 24 | 29 | |
| | | $V_{IN}$=2.5 V, $I_{OUT}$=500 mA[3] | | 28 | 35 | |
| | | $V_{IN}$=1.8 V, $I_{OUT}$=250 mA[3] | | 37 | 45 | |
| | | $V_{IN}$=1.2 V, $I_{OUT}$=250 mA, $T_A$=25°C | | 75 | 100 | |
| $V_{IH}$ | On Input Logic HIGH Voltage | | 1.0 | | | V |
| $V_{IL}$ | On Input Logic LOW Voltage | | | | 0.4 | V |
| $I_{ON}$ | On Input Leakage | | | | 1.0 | µA |
| **Dynamic Characteristics** | | | | | | |
| $t_{DON}$ | Turn-On Delay[4] | $V_{IN}$=4.5 V, $R_L$=5 Ω, $C_L$=100 µF, $T_A$=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] | $V_{IN}$=4.5 V, $R_L$=150 Ω, $C_L$=100 µF, $T_A$=25°C, No Load Discharge | | 2.0 | | ms |
| $t_F$ | $V_{OUT}$ Fall Time[4] | | | 30.0 | | ms |
| $t_{OFF}$ | Turn-Off[7] | | | 32.0 | | 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 27.
5. Output discharge enabled during off-state.
6. $t_{ON}$=$t_R$ + $t_{DON}$
7. $t_{OFF}$=$t_F$ + $t_{DOFF}$
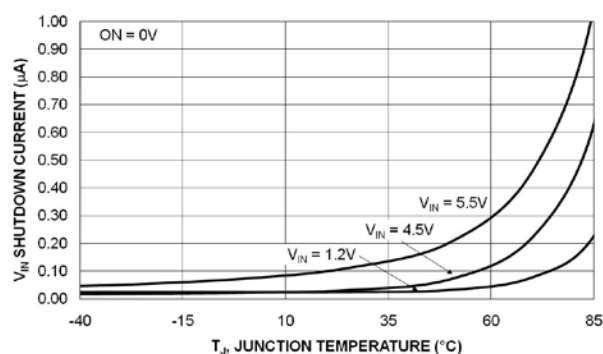
## Typical Characteristics

Figure 5.   Shutdown Current vs. Temperature
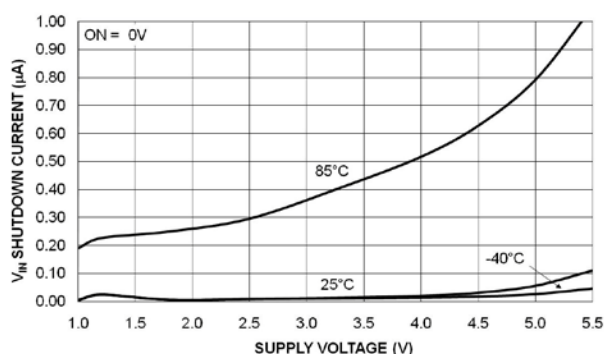
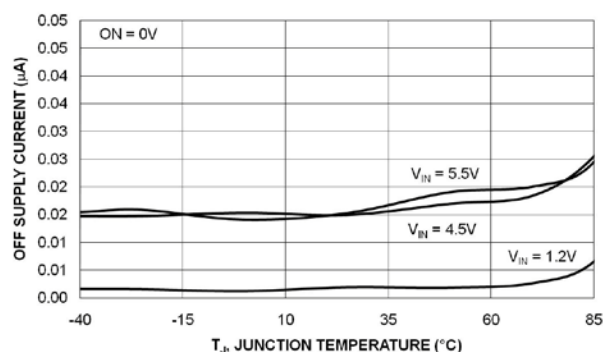Figure 6.   Shutdown Current vs. Supply Voltage

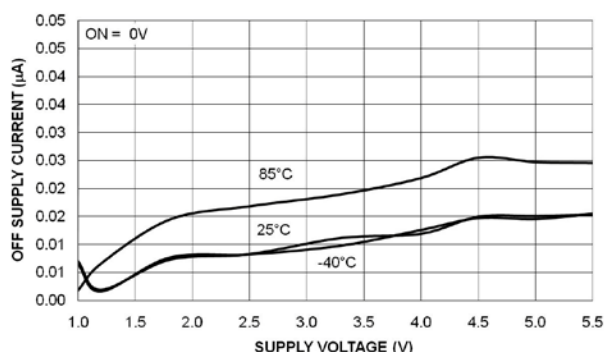Figure 7.   Off Supply Current vs. Temperature
(V$_{OUT}$ Floating)

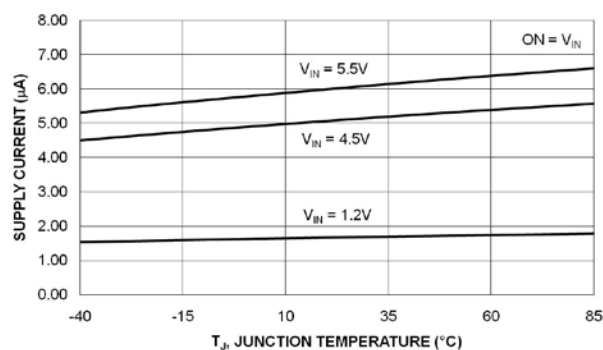Figure 8.   Off Supply Current vs. Supply Voltage
(V$_{OUT}$ Floating)
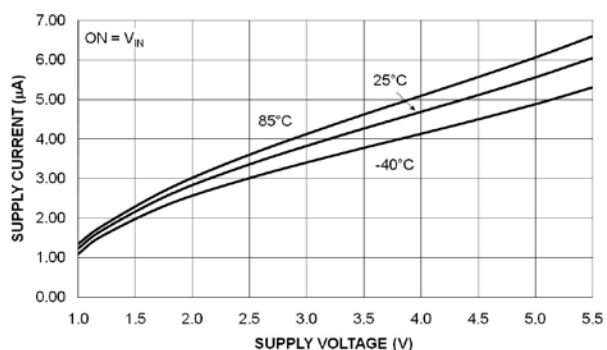
Figure 9.   Quiescent Current vs. Temperature

Figure 10.  Quiescent Current vs. Supply Voltage
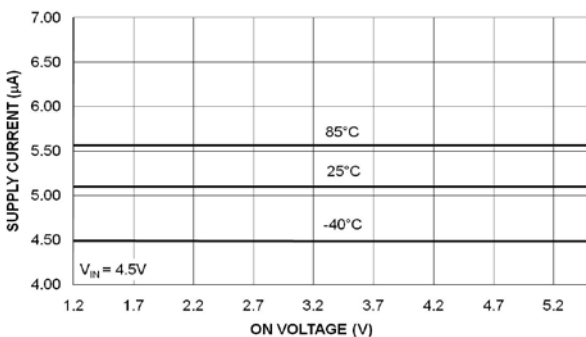
## Typical Characteristics (Continued)



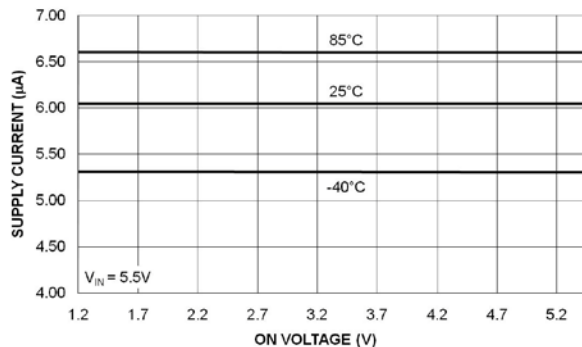**Figure 11.   Quiescent Current vs. On Voltage ($V_{IN}$ = 4.5V)**



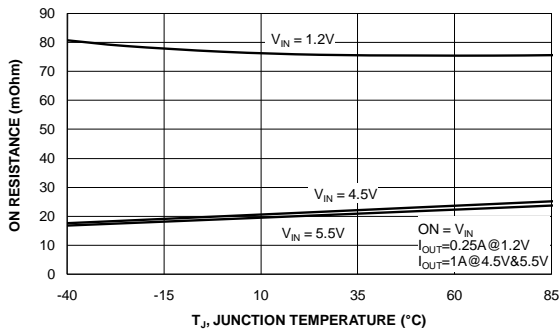**Figure 12.   Quiescent Current vs. On Voltage ($V_{IN}$ = 5.5V)**
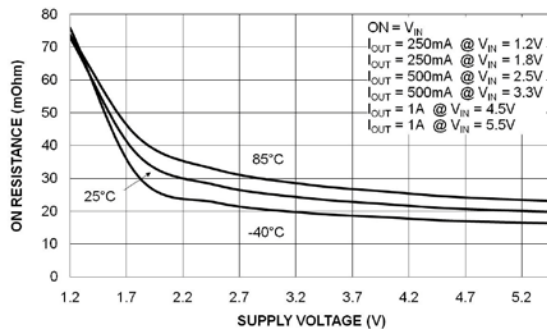


**Figure 13.   $R_{ON}$ vs. Temperature**



**Figure 14.   $R_{ON}$ vs. Supply Voltage**
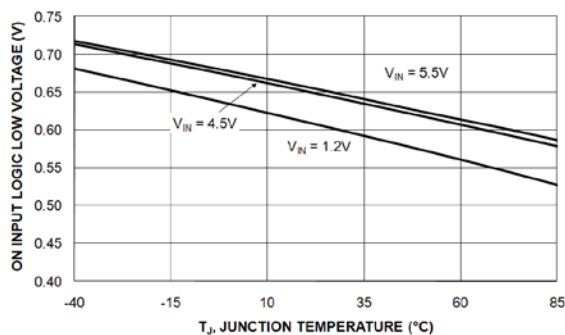


**Figure 15.    On Pin Threshold Low vs. Temperature**



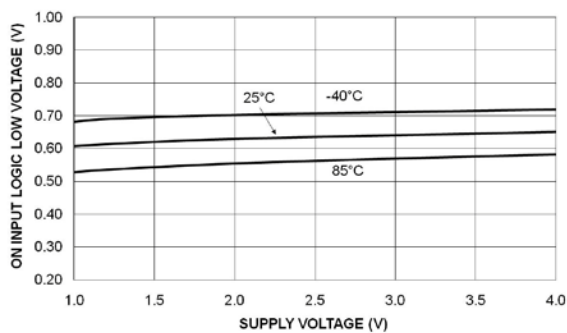**Figure 16.    On Pin Threshold Low vs. $V_{IN}$**

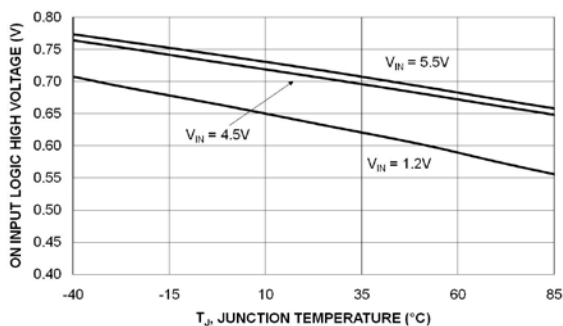## Typical Characteristics (Continued)

**Figure 17.   On Pin Threshold High vs. Temperature**

**Figure 18.   On Pin Threshold High vs. V$_{IN}$**

**Figure 19.   On Pin Threshold vs. Supply Voltage**

**Figure 20.   I$_{SW}$ vs. (V$_{IN}$-V$_{OUT}$) — SOA**

**Figure 21.   t$_R$/t$_{DON}$ vs. Temperature**

**Figure 22.   t$_R$/t$_F$ vs. Temperature**

## Typical Characteristics (Continued)



**Figure 23.   t$_R$ vs. Supply Voltage**



**Figure 24.   t$_R$ vs. Supply Voltage**



**Figure 25.   Turn-On Response (V$_{IN}$=4.5 V, C$_{IN}$=10 µF, C$_L$=1 µF, R$_L$=50 Ω)**



**Figure 26.   Turn-On Response (V$_{IN}$=4.5 V, C$_{IN}$=10 µF, C$_L$=100 µF, R$_L$=5 Ω)**



**Figure 27.    Timing Diagram**

## Application Information

### Input Capacitor

This IntelliMAX™ switch doesn't require an input capacitor. To reduce device inrush current, a 0.1 µF 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 0.1 µF capacitor, $C_{OUT}$, should be placed between $V_{OUT}$ and GND.
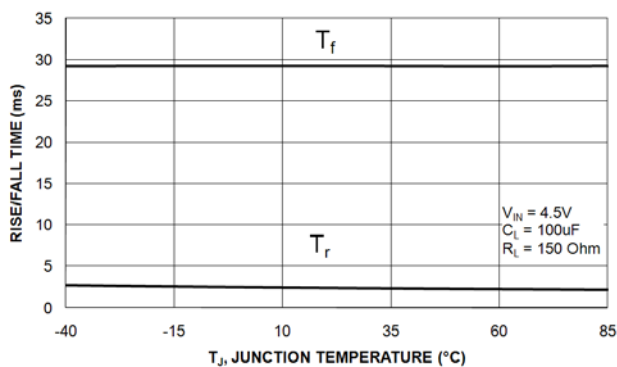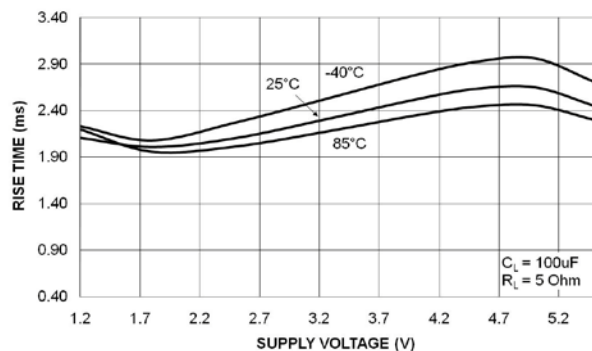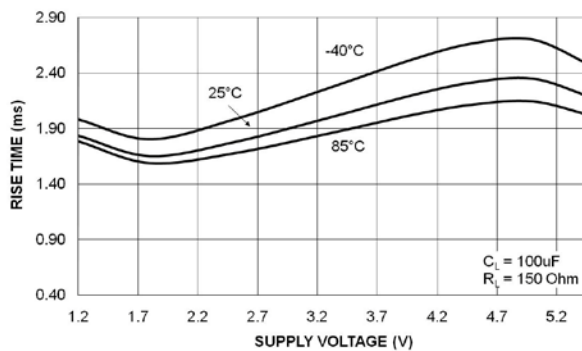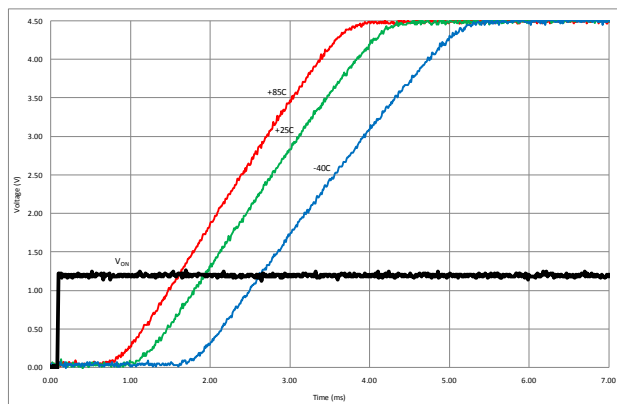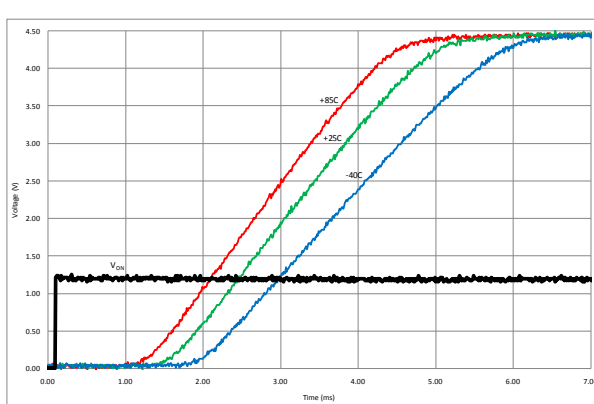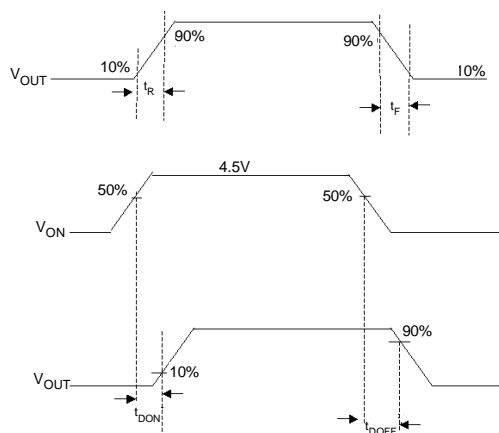
### Fall Time

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

$$t_F = R_L \times C_L \times 2.2 \tag{1}$$

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:

$$t_F = \frac{R_L \times R_{PD}}{R_L + R_{PD}} \times C_L \times 2.2 \tag{2}$$

where $t_F$ is 90% to 10% fall time, $R_L$ is output load, $R_{PD}=65\ \Omega$ 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 28.    Device Setup**

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

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

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:

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

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

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

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

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

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

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

### 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 29 is a recommended layout for this device to achieve optimum performance.



**Figure 29.    Recommended Land Pattern, Layout**

## Physical Dimensions

TOP VIEW

2X   0.03 C

E  A  F

B

BALL A1
INDEX AREA

D

0.03 C
2X

RECOMMENDED LAND PATTERN
(NSMD PAD TYPE)

(Ø0.350)
SOLDER MASK
OPENING

A1

(Ø0.250)
Cu Pad

(1.00)

(0.50)

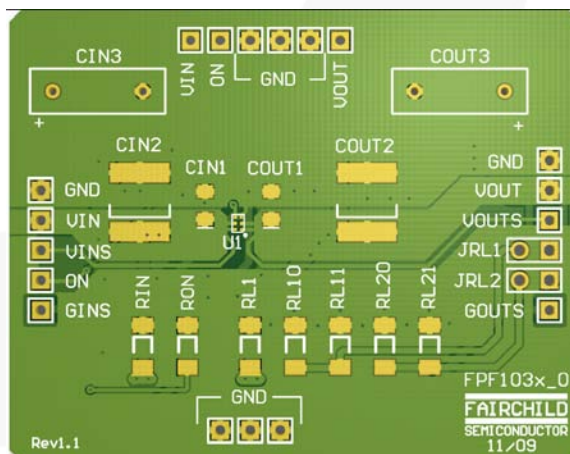SIDE VIEWS

0.06 C

0.05 C

0.625
0.539  E

C

SEATING PLANE  D

0.332±0.018
0.250±0.025

BOTTOM VIEW

Ø0.005 M C A B

Ø0.315 +/- .025
6X

0.50

1.00

0.50

C
B
A

1  2

(Y) ±0.018

(X) ±0.018

F

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 FILENAME: MKT-UC006AFrev2.

**Figure 30.    6 Ball, 1.0 x 1.5 mm Wafer-Level Chip-Scale Packaging (WLCSP)**

### Nominal Values

| Bump Pitch | Overall Package Height | Silicon Thickness | Solder Bump Height | Solder Bump Diameter |
|---|---|---|---|---|
| 0.5 mm | 0.582 mm | 0.332 mm | 0.250 mm | 0.315 mm |

### Product-Specific Dimensions

| Product | D | E | X | Y |
|---|---|---|---|---|
| FPF1038UCX | 1.5 mm ±0.03 | 1.0 mm ±0.03 | 0.240 mm | 0.240 mm |

*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.*

*Always visit Fairchild Semiconductor's online packaging area for the most recent package drawings:*
*http://www.fairchildsemi.com/packaging/.*

**FAIRCHILD**
**SEMICONDUCTOR®**

## TRADEMARKS

The following includes registered and unregistered trademarks and service marks, owned by Fairchild Semiconductor and/or its global subsidiaries, and is not intended to be an exhaustive list of all such trademarks.

| | | | |
|---|---|---|---|
| AccuPower™ | F-PFS™ | | Sync-Lock™ |
| AX-CAP®* | FRFET® | ® | **SYSTEM GENERAL**® |
| BitSiC™ | Global Power Resource℠ | PowerTrench® | |
| Build it Now™ | GreenBridge™ | PowerXS™ | TinyBoost® |
| CorePLUS™ | Green FPS™ | Programmable Active Droop™ | TinyBuck® |
| CorePOWER™ | Green FPS™ e-Series™ | QFET® | TinyCalc™ |
| CROSSVOLT™ | Gmax™ | QS™ | TinyLogic® |
| CTL™ | GTO™ | Quiet Series™ | TINYOPTO™ |
| Current Transfer Logic™ | IntelliMAX™ | RapidConfigure™ | TinyPower™ |
| DEUXPEED® | ISOPLANAR™ | ◯™ | TinyPWM™ |
| Dual Cool™ | Making Small Speakers Sound Louder | Saving our world, 1mW/W/kW at a time™ | TinyWire™ |
| EcoSPARK® | and Better™ | SignalWise™ | TranSiC™ |
| EfficientMax™ | MegaBuck™ | SmartMax™ | TriFault Detect™ |
| ESBC™ | MICROCOUPLER™ | SMART START™ | TRUECURRENT®* |
| **F**® | MicroFET™ | Solutions for Your Success™ | µSerDes™ |
| Fairchild® | MicroPak™ | SPM® | |
| Fairchild Semiconductor® | MicroPak2™ | STEALTH™ | µ SerDes™ |
| FACT Quiet Series™ | MillerDrive™ | SuperFET® | UHC® |
| FACT® | MotionMax™ | SuperSOT™-3 | Ultra FRFET™ |
| FAST® | mWSaver® | SuperSOT™-6 | UniFET™ |
| FastvCore™ | OptoHiT™ | SuperSOT™-8 | VCX™ |
| FETBench™ | OPTOLOGIC® | SupreMOS® | VisualMax™ |
| FPS™ | OPTOPLANAR® | SyncFET™ | VoltagePlus™ |
| | | | XS™ |

* Trademarks of System General Corporation, used under license by Fairchild Semiconductor.

## DISCLAIMER

FAIRCHILD SEMICONDUCTOR RESERVES THE RIGHT TO MAKE CHANGES WITHOUT FURTHER NOTICE TO ANY PRODUCTS HEREIN TO IMPROVE RELIABILITY, FUNCTION, OR DESIGN. FAIRCHILD DOES NOT ASSUME ANY LIABILITY ARISING OUT OF THE APPLICATION OR USE OF ANY PRODUCT OR CIRCUIT DESCRIBED HEREIN; NEITHER DOES IT CONVEY ANY LICENSE UNDER ITS PATENT RIGHTS, NOR THE RIGHTS OF OTHERS. THESE SPECIFICATIONS DO NOT EXPAND THE TERMS OF FAIRCHILD'S WORLDWIDE TERMS AND CONDITIONS, SPECIFICALLY THE WARRANTY THEREIN, WHICH COVERS THESE PRODUCTS.

## LIFE SUPPORT POLICY

FAIRCHILD'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF FAIRCHILD SEMICONDUCTOR CORPORATION.

As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body or (b) support or sustain life, and (c) whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury of the user.

2. A critical component in 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.

## ANTI-COUNTERFEITING POLICY

Fairchild Semiconductor Corporation's Anti-Counterfeiting Policy. Fairchild's Anti-Counterfeiting Policy is also stated on our external website, www.fairchildsemi.com, under Sales Support.

Counterfeiting of semiconductor parts is a growing problem in the industry. All manufacturers of semiconductor products are experiencing counterfeiting of their parts. Customers who inadvertently purchase counterfeit parts experience many problems such as loss of brand reputation, substandard performance, failed applications, and increased cost of production and manufacturing delays. Fairchild is taking strong measures to protect ourselves and our customers from the proliferation of counterfeit parts. Fairchild strongly encourages customers to purchase Fairchild parts either directly from Fairchild or from Authorized Fairchild Distributors who are listed by country on our web page cited above. Products customers buy either from Fairchild directly or from Authorized Fairchild Distributors are genuine parts, have full traceability, meet Fairchild's quality standards for handling and storage and provide access to Fairchild's full range of up-to-date technical and product information. Fairchild and our Authorized Distributors will stand behind all warranties and will appropriately address any warranty issues that may arise. Fairchild will not provide any warranty coverage or other assistance for parts bought from Unauthorized Sources. Fairchild is committed to combat this global problem and encourage our customers to do their part in stopping this practice by buying direct or from authorized distributors.

## PRODUCT STATUS DEFINITIONS

### Definition of Terms

| 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. |

Rev. I66