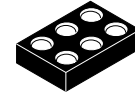


# Low On-Resistance, Slew-Rate-Controlled Load Switch

## FPF1038



WLCSP6 1.5x1.0x0.582  
CASE 567RL

### 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  $\mu$ F). The FPF1038 consists of slew-rate controlled low-impedance MOSFET switch (21 m $\Omega$  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  $\mu$ A 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” 1 mm x 1.5 mm Wafer-Level Chip-Scale Packaging (WLCSP); providing excellent thermal conductivity, small footprint, and low electrical resistance for wider application usage.

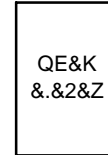
### Features

- 1.2 V to 5.5 V Input Voltage Operating Range
- Typical  $R_{ON}$ :
  - ◆ 20 m $\Omega$  at  $V_{IN} = 5.5$  V
  - ◆ 21 m $\Omega$  at  $V_{IN} = 4.5$  V
  - ◆ 37 m $\Omega$  at  $V_{IN} = 1.8$  V
  - ◆ 75 m $\Omega$  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  $\mu$ A Shutdown Current
- ESD Protected: Above 8 kV HBM, 1.5 kV CDM
- GPIO / CMOS-Compatible Enable Circuitry
- This Device is Pb-Free, Halide Free and is RoHS Compliant

### 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

### MARKING DIAGRAM



- QE = Specific Device Code
- &K = 2-Digits Lot Run Traceability Code
- &. = Pin One Dot
- &2 = 2-Digit Date Code
- &Z = Assembly Plant Code

### ORDERING INFORMATION

See detailed ordering and shipping information on page 11 of this data sheet.

# FPF1038

## APPLICATION DIAGRAM

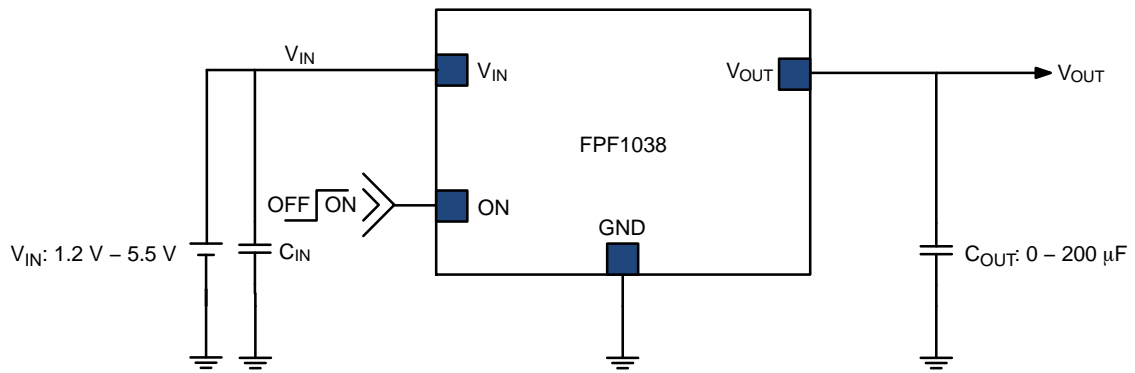


Figure 1. Typical Application

## FUNCTIONAL BLOCK DIAGRAM

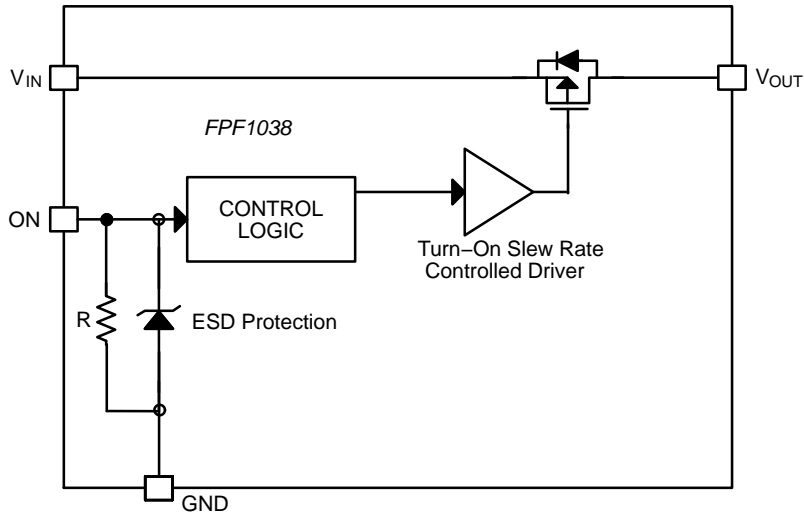


Figure 2. Functional Block Diagram

# FPF1038

## PIN CONFIGURATION

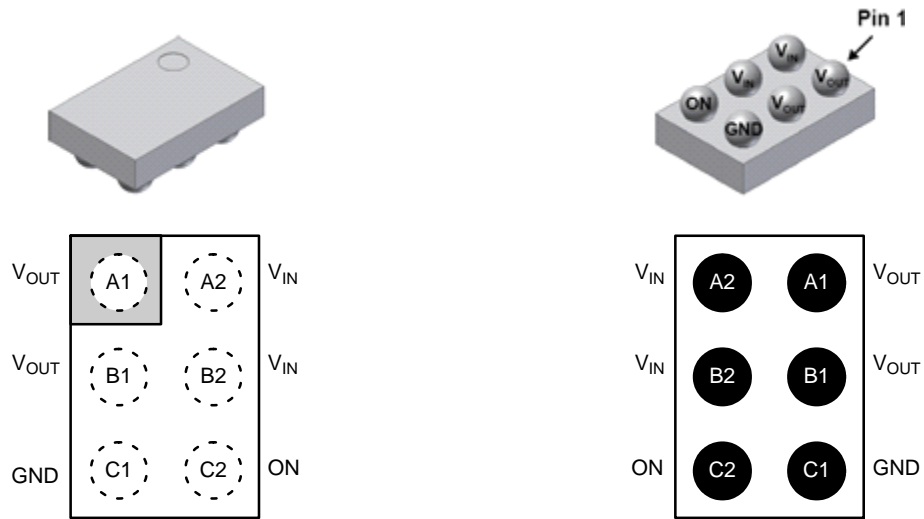


Figure 3. Top View

Figure 4. Bottom View

### PIN DEFINITIONS

Pin No.	Name	Description
A1, B1	V <sub>OUT</sub>	Switch Output
A2, B2	V <sub>IN</sub>	Supply Input: Input to the Power Switch
C1	GND	Ground
C2	ON	ON/OFF Control, Active High – GPIO Compatible

# FPF1038

## ABSOLUTE MAXIMUM RATINGS

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 $T_A = 25^\circ\text{C}$	-	1.2	W	
$T_{STG}$	Storage Junction Temperature	-65	+150	$^\circ\text{C}$	
$T_A$	Operating Temperature Range	-40	+85	$^\circ\text{C}$	
$\theta_{JA}$	Thermal Resistance, Junction-to-Ambient	-	85 (Note 1)	$^\circ\text{C/W}$	
		-	110 (Note 2)		
ESD	Electrostatic Discharge Capability	Human Body Model, JESD22-A114	8.0	-	kV
		Charged Device Model, JESD22-C101	1.5	-	

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

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

## RECOMMENDED OPERATING CONDITIONS

Symbol	Parameters	Min	Max	Unit
$V_{IN}$	Input Voltage	1.2	5.5	V
$T_A$	Ambient Operating Temperature	-40	+85	$^\circ\text{C}$

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

# FPF1038

**ELECTRICAL CHARACTERISTICS** (Unless otherwise noted,  $V_{IN} = 1.2$  to  $5.5$  V and  $T_A = -40$  to  $+85^\circ\text{C}$ ; typical values are at  $V_{IN} = 4.5$  V and  $T_A = 25^\circ\text{C}$ .)

Symbol	Parameter	Test Condition	Min	Typ	Max	Unit
<b>BASIC OPERATION</b>						
$V_{IN}$	Input Voltage		1.2	–	5.5	V
$I_{Q(OFF)}$	Off Supply Current	$V_{ON} = \text{GND}, V_{OUT} = \text{Open}$	–	–	1.0	$\mu\text{A}$
$I_{SD}$	Shutdown Current	$V_{ON} = \text{GND}, V_{OUT} = \text{GND}$	–	0.2	1.0	$\mu\text{A}$
$I_Q$	Quiescent Current	$I_{OUT} = 0$ mA	–	5.5	8.0	$\mu\text{A}$
$R_{ON}$	On Resistance	$V_{IN} = 5.5$ V, $I_{OUT} = 1$ A (Note 3)	–	20	24	m $\Omega$
		$V_{IN} = 4.5$ V, $I_{OUT} = 1$ A, $T_A = 25^\circ\text{C}$	–	21	25	
		$V_{IN} = 3.3$ V, $I_{OUT} = 500$ mA (Note 3)	–	24	29	
		$V_{IN} = 2.5$ V, $I_{OUT} = 500$ mA (Note 3)	–	28	35	
		$V_{IN} = 1.8$ V, $I_{OUT} = 250$ mA (Note 3)	–	37	45	
		$V_{IN} = 1.2$ V, $I_{OUT} = 250$ mA, $T_A = 25^\circ\text{C}$	–	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	$\mu\text{A}$

## DYNAMIC CHARACTERISTICS

$t_{DON}$	Turn-On Delay (Note 4)	$V_{IN} = 4.5$ V, $R_L = 5$ $\Omega$ , $C_L = 100$ $\mu\text{F}$ , $T_A = 25^\circ\text{C}$		1.7	–	ms
$t_R$	$V_{OUT}$ Rise Time (Note 4)		–	2.7	–	ms
$t_{ON}$	Turn-On Time (Note 6)		–	4.4	–	ms
$t_{DOFF}$	Turn-Off Delay (Note 4)	$V_{IN} = 4.5$ V, $R_L = 150$ $\Omega$ , $C_L = 100$ $\mu\text{F}$ , $T_A = 25^\circ\text{C}$ , No Load Discharge	–	2.0	–	ms
$t_F$	$V_{OUT}$ Fall Time (Note 4)		–	30.0	–	ms
$t_{OFF}$	Turn-Off (Note 7)		–	32.0	–	ms

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

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

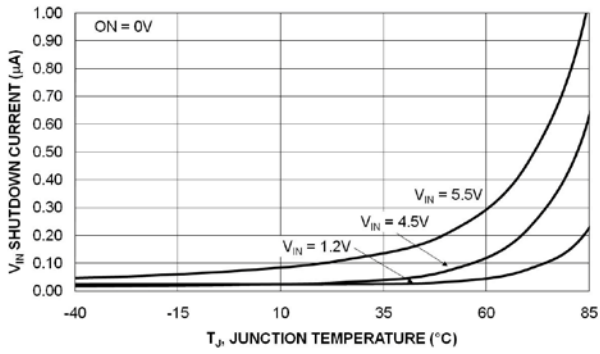


Figure 5. Shutdown Current vs. Temperature

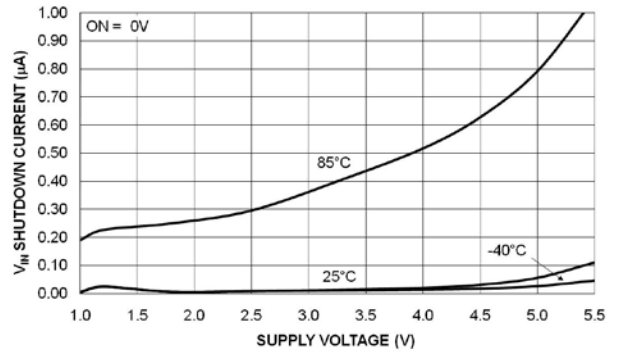


Figure 6. Shutdown Current vs. Supply Voltage

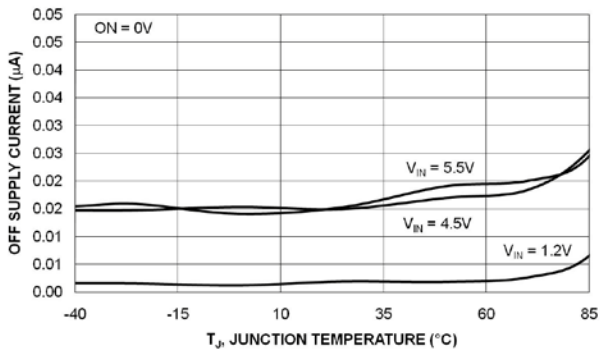


Figure 7. Off Supply Current vs. Temperature  
(V<sub>OUT</sub> Floating)

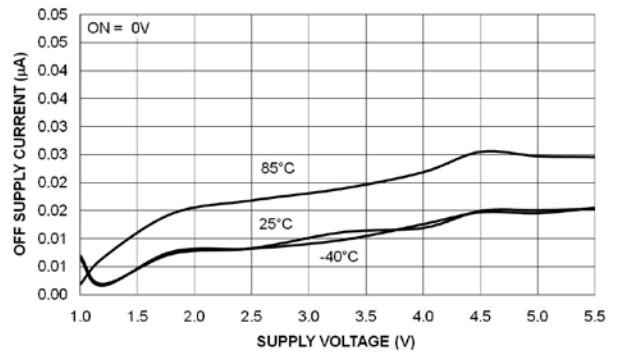


Figure 8. Off Supply Current vs. Supply Voltage  
(V<sub>OUT</sub> Floating)

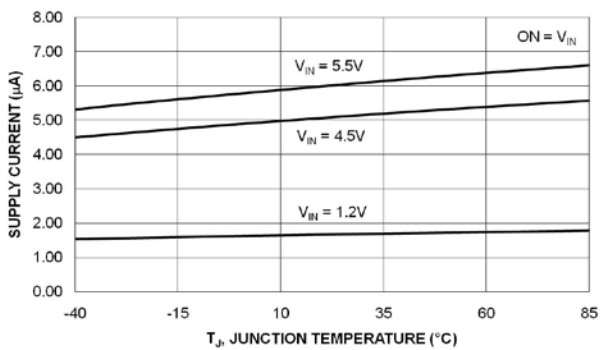


Figure 9. Quiescent Current vs. Temperature

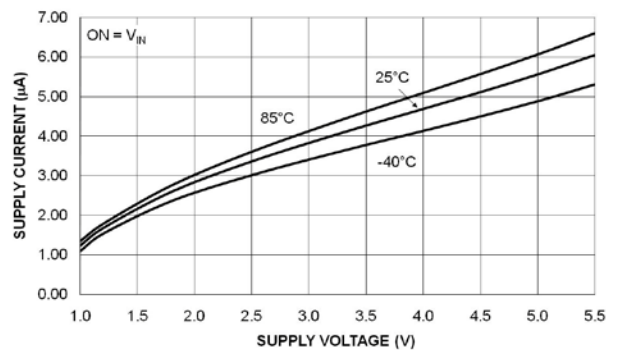


Figure 10. Quiescent Current vs. Supply Voltage

TYPICAL CHARACTERISTICS (continued)

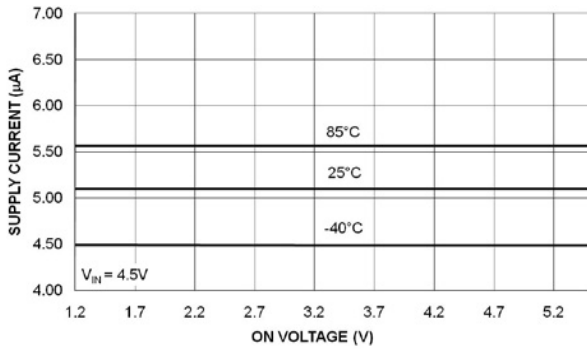


Figure 11. Quiescent Current vs. On Voltage ( $V_{IN} = 4.5\text{ V}$ )

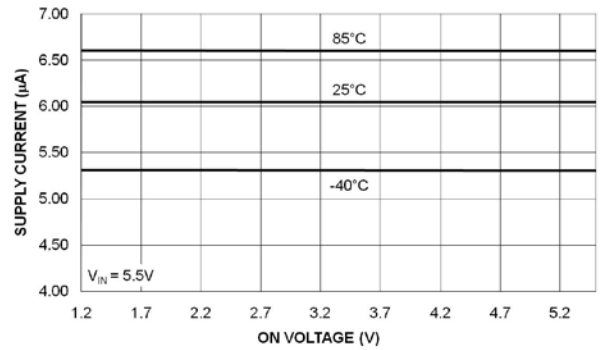


Figure 12. Quiescent Current vs. On Voltage ( $V_{IN} = 5.5\text{ V}$ )

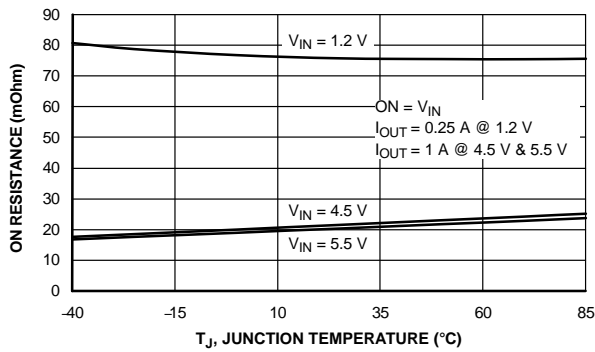


Figure 13.  $R_{ON}$  vs. Temperature

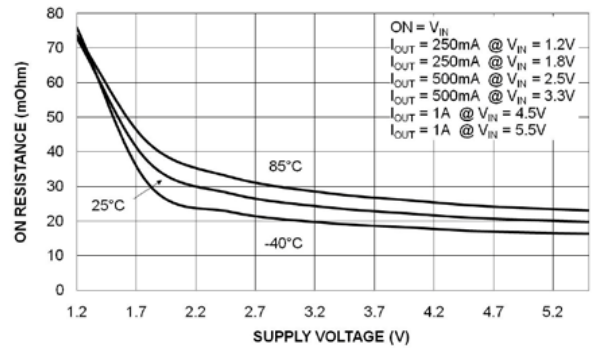


Figure 14.  $R_{ON}$  vs. Supply Voltage

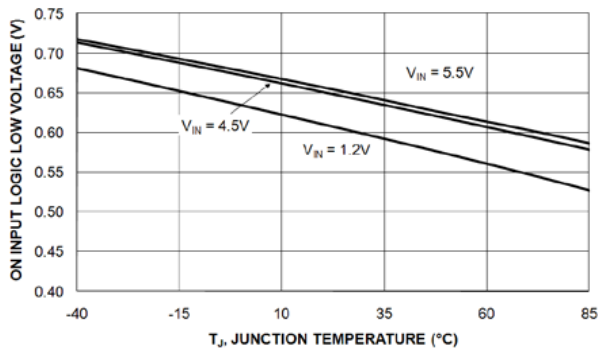


Figure 15. On Pin Threshold Low vs. Temperature

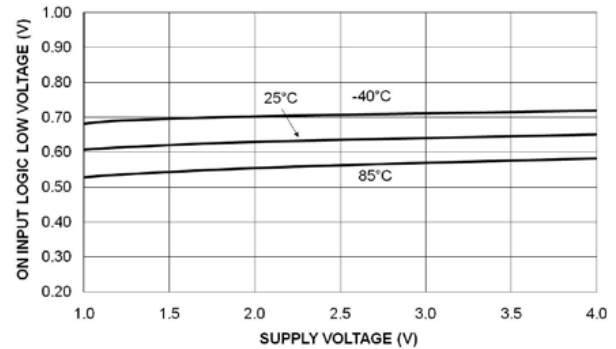


Figure 16. On Pin Threshold Low vs.  $V_{IN}$

TYPICAL CHARACTERISTICS (continued)

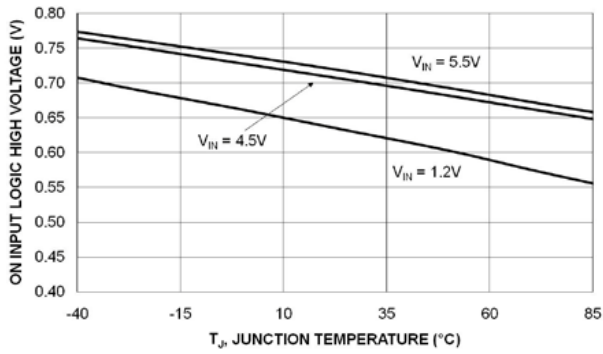


Figure 17. On Pin Threshold High vs. Temperature

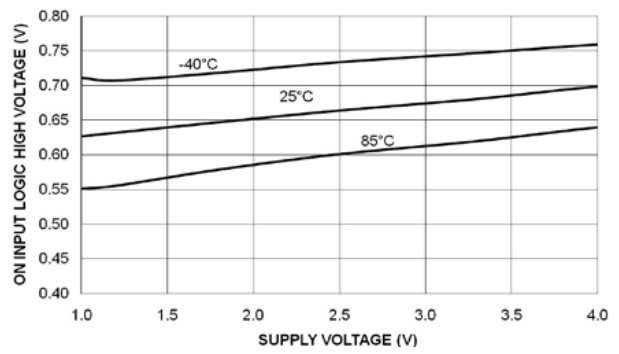


Figure 18. On Pin Threshold High vs.  $V_{IN}$

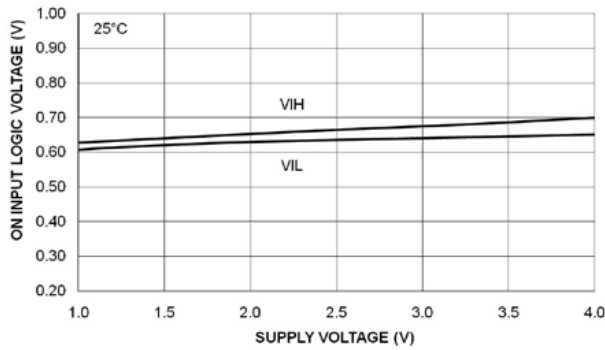


Figure 19. On Pin Threshold vs. Supply Voltage

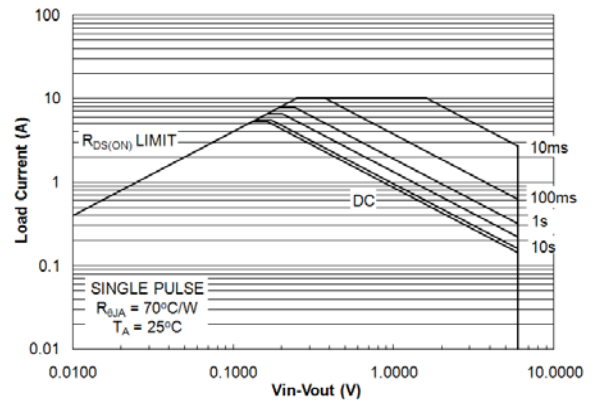


Figure 20.  $I_{SW}$  vs.  $(V_{IN}-V_{OUT})$  — SOA

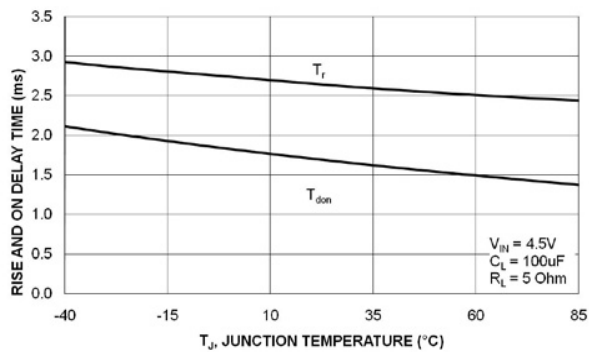


Figure 21.  $t_R/t_{DON}$  vs. Temperature

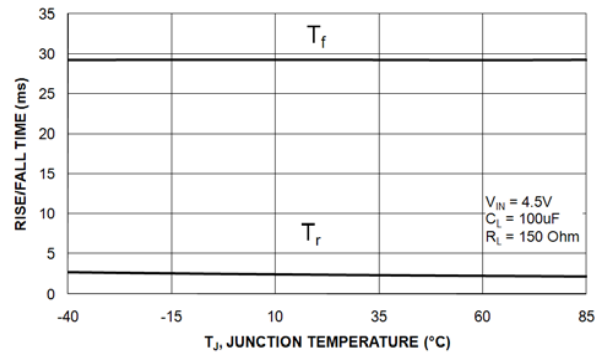


Figure 22.  $t_R/t_F$  vs. Temperature



TYPICAL CHARACTERISTICS (continued)

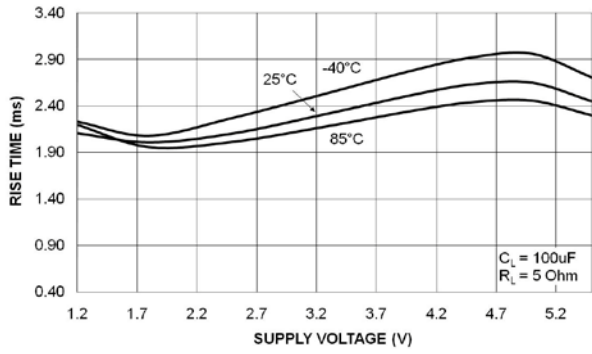


Figure 23.  $t_R$  vs. Supply Voltage

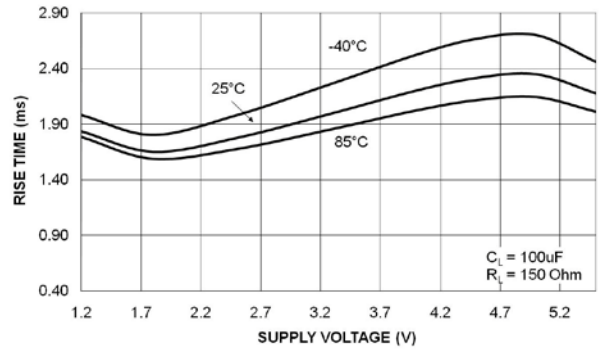


Figure 24.  $t_R$  vs. Supply Voltage

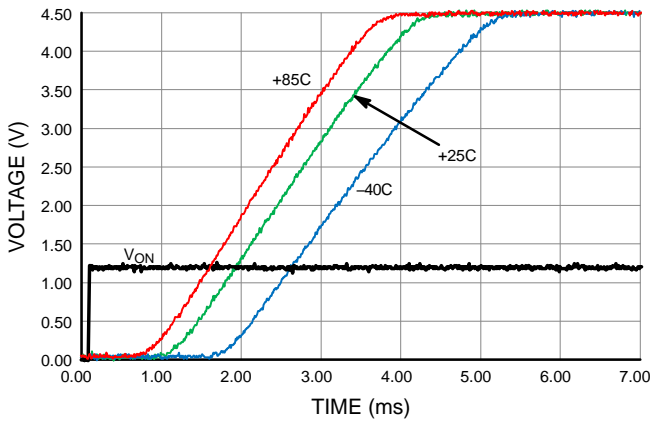


Figure 25. Turn-On Response ( $V_{IN} = 4.5\text{ V}$ ,  $C_{IN} = 10\ \mu\text{F}$ ,  $C_L = 1\ \mu\text{F}$ ,  $R_L = 50\ \Omega$ )

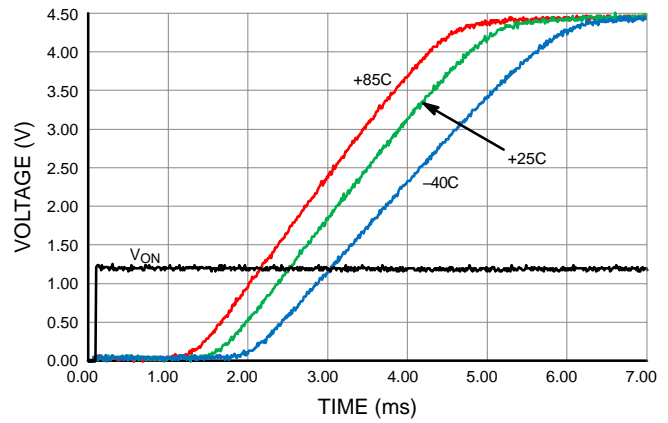


Figure 26. Turn-On Response ( $V_{IN} = 4.5\text{ V}$ ,  $C_{IN} = 10\ \mu\text{F}$ ,  $C_L = 100\ \mu\text{F}$ ,  $R_L = 5\ \Omega$ )

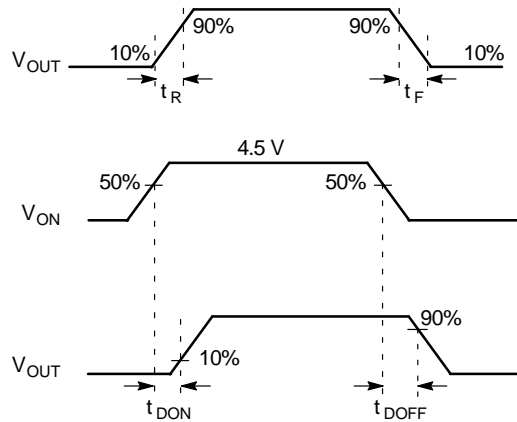


Figure 27. Timing Diagram

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<sub>IN</sub>, is recommended close to the V<sub>IN</sub> pin. A higher value of C<sub>IN</sub> 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<sub>OUT</sub> below GND when switching off; a 0.1 μF capacitor, C<sub>OUT</sub>, should be placed between V<sub>OUT</sub> and GND.

**Fall Time**

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

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

where t<sub>F</sub> is 90% to 10% fall time, R<sub>L</sub> is output load, and C<sub>L</sub> is output capacitor.

The same equation works for a device with a pull-down output resistor. R<sub>L</sub> is replaced by a parallel connected pull-down and an external output resistor combination as:

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

where t<sub>F</sub> is 90% to 10% fall time, R<sub>L</sub> is output load, R<sub>PD</sub> = 65 Ω is output pull-down resistor, and C<sub>L</sub> 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**

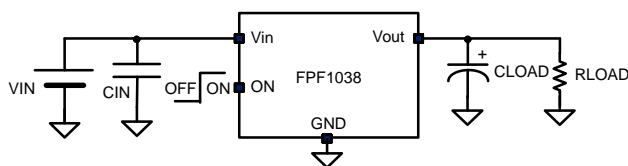


Figure 28. Device Setup

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

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

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

Estimating V<sub>OUT</sub>(t) = V<sub>IN</sub> / 10 and using experimental formula for slew rate (dV<sub>OUT</sub>(t) / dt), spike current can be written as:

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

where supply voltage V<sub>IN</sub> is in volts, capacitances are in micro farads, and resistance is in ohms.

Example: If V<sub>IN</sub> = 5.5 V, C<sub>LOAD</sub> = 100 μF, C<sub>IN</sub> = 10 μF, and R<sub>LOAD</sub> = 50 Ω; calculate the spike current by:

$$\begin{aligned} \max(I_{IN}) &= \frac{5.5}{10 \times 50} + (100 - 10)(0.05 \times 5.5 - 0.255) A = \\ &= 1.8 A \end{aligned} \tag{eq. 5}$$

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

$$\begin{aligned} I_{IN}(t) &\approx \frac{V_{OUT}(t)}{R_{LOAD}} + (C_{LOAD} - C_{IN}) \frac{dV_{IN}(t)}{dt} \\ &\approx 2.75 / 50 + 100 \times 0.0022 = 0.275 A \end{aligned} \tag{eq. 6}$$

**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.

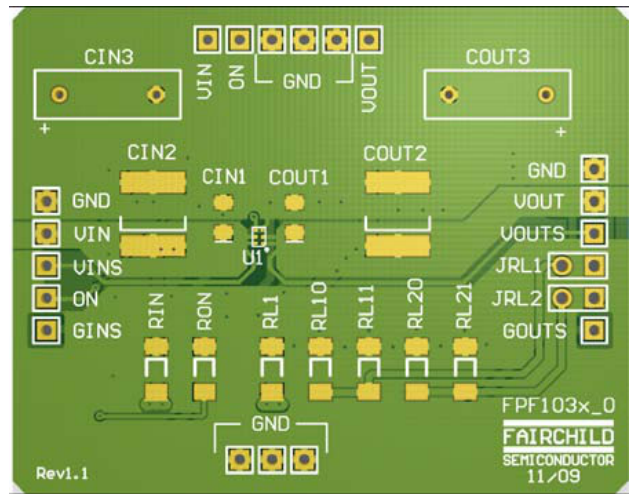


Figure 29. Recommended Land Pattern, Layout

# FPF1038

## 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	Shipping†
FPF1038UCX	QE	21 m $\Omega$	CMOS	NA	Active HIGH	2.7 ms	6-Bump, WLCSP, 1.0 mm x 1.5 mm, 0.5 mm Pitch (Pb-Free)	3000 / Tape & Reel

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

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# MECHANICAL CASE OUTLINE

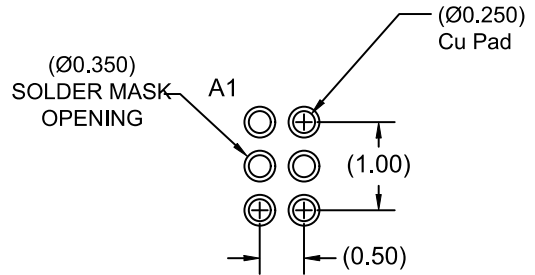
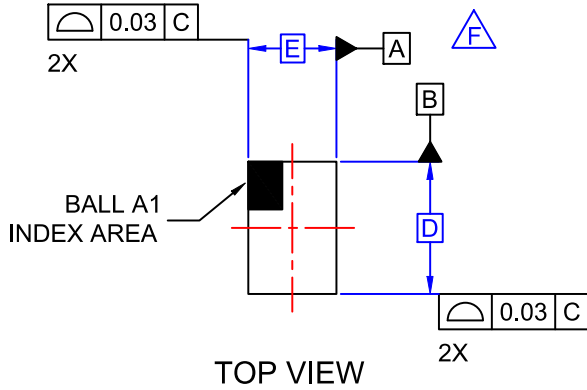
## PACKAGE DIMENSIONS

ON Semiconductor®

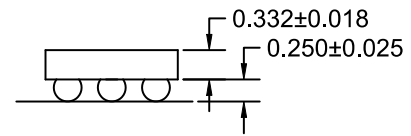
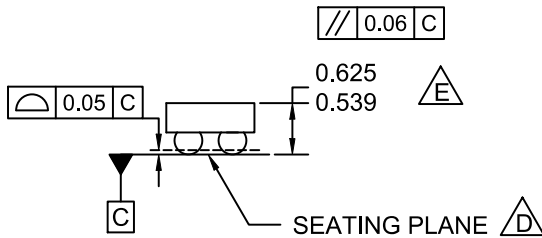


WLCSP6 1.5x1.0x0.582  
CASE 567RL  
ISSUE O

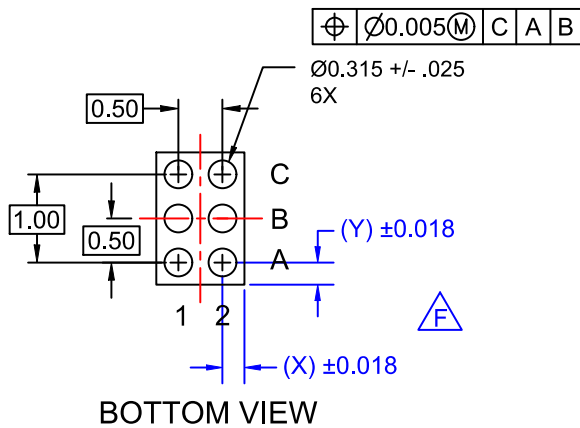
DATE 30 NOV 2016



RECOMMENDED LAND PATTERN  
(NSMD PAD TYPE)



SIDE VIEWS



BOTTOM VIEW

### 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.

<b>DOCUMENT NUMBER:</b>	<b>98AON16578G</b>	Electronic versions are uncontrolled except when accessed directly from the Document Repository. Printed versions are uncontrolled except when stamped "CONTROLLED COPY" in red.
<b>DESCRIPTION:</b>	<b>WLCSP6 1.5x1.0x0.582</b>	<b>PAGE 1 OF 1</b>

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