# Advanced Load Management Switch

# FPF1504 / FPF1504L

### Description

The FPF1504/FPF1504L are low−$R_{DS}$ P−channel MOSFET load switches of the IntelliMAX™ family. Integrated slew−rate control prevents excessive inrush current from the supply rails with capacitive loads common in power applications. In addition, the FPF1504/FPF1504L feature output discharge capability.

The input voltage range operates from 1.0 V to 3.6 V to fulfill today's mobile device supply requirements. Switch control is by a logic input (ON pin) capable of interfacing directly with low−voltage CMOS control signals and GPIOs in embedded processors.

### Features

- 1.0 V to 3.6 V Input Voltage Operating Range
- Typical $R_{DS(ON)}$:
  - 15 mΩ at $V_{IN}$ = 3.3 V
  - 20 mΩ at $V_{IN}$ = 1.8 V
  - 40 mΩ at $V_{IN}$ = 1.0 V
- Slew Rate Control
- Output Discharge Function
- Low <1 μA Quiescent Current at $V_{ON}$ = $V_{IN}$
- ESD Protected: 4000 V HBM, 2000 V CDM
- GPIO/CMOS−Compatible Enable Circuitry
- Active HIGH and active LOW versions

### Applications

- Mobile Devices and Smart Phones
- Portable Media Devices
- Digital Cameras
- Advanced Notebook, UMPC, and MID
- Portable Medical Devices
- GPS and Navigation Equipment

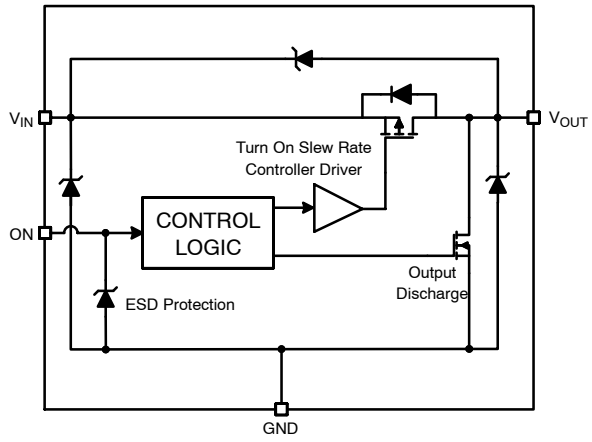



**Figure 1. Block Diagram**

**ON Semiconductor®**

www.onsemi.com

**WLCSP4**
**CASE 567RH**

### MARKING DIAGRAM


| | |
|---|---|
| G | = 1st Digit of 2 Digit Device ID Mark |
| &K | = 2−Digits Lot Run Traceability Code |
| 4 | = 2nd Digit of 2 Digit Device ID Mark |
| &2 | = 2−digit Date Code Format |
| &. | = Pin 1 Identifier |
| &E | = Space Designator |
| &Z | = Assembly Plant Code |

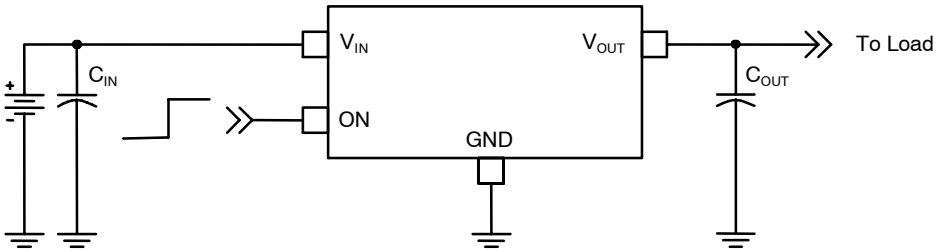
### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 2 of this data sheet.

## ORDERING INFORMATION

| Part Number | Top Mark | Switch (Typical) At 1.8 $V_{IN}$ | Input Buffer | Output Discharge | ON Pin Activity | Package |
|---|---|---|---|---|---|---|
| FPF1504UCX | G4 | 20 mΩ | CMOS | YES | Active HIGH | 4−Ball, WLCSP, 0.5 mm Pitch |
| FPF1504BUCX | G4 | 20 mΩ | CMOS | YES | Active HIGH | 4−Ball, WLCSP with Backside Laminate, 0.5 mm Pitch |
| FPF1504LUCX | GZ | 20 mΩ | CMOS | YES | Active LOW | 4−Ball, WLCSP, 0.5 mm Pitch |
| FPF1504LBUCX | GZ | 20 mΩ | CMOS | YES | Active LOW | 4−Ball, WLCSP with Backside Laminate, 0.5 mm Pitch |

## Application Diagram




NOTES: 1. $C_{IN}$ =1 μF, X5R, 0603, for example Murata GRM185R60J105KE26.
2. $C_{OUT}$ = 1 μF, X5R, 0805, for example Murata GRM216R61A105KA01.

**Figure 2. Typical Application**

## Pin Configurations

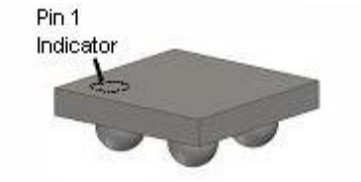



**Figure 3. 1 x 1 mm WLCSP Bumps Facing Down**

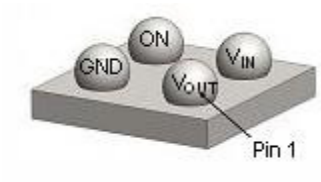



**Figure 4. 1 x 1 mm WLCSP Bumps Facing Up**

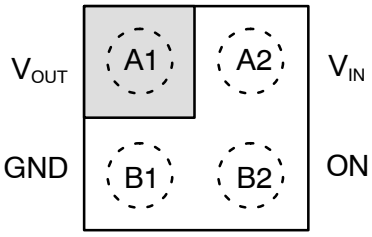



**Figure 5. Pin Assignments (Top View)**

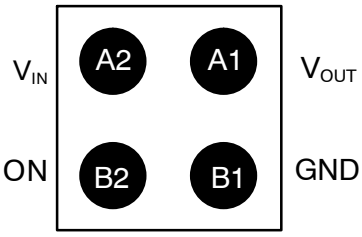



**Figure 6. Pin Assignments (Bottom View)**

## PIN DEFINITIONS

| Pin # | Name | Description |
|---|---|---|
| A1 | $V_{OUT}$ | Switch Output |
| A2 | $V_{IN}$ | Supply Input; Input to the Power Switch |
| B1 | GND | Ground |
| B2 | ON | ON/OFF Control |

## ABSOLUTE MAXIMUM RATINGS

| Symbol | Parameter | | Min. | Max. | Unit |
|---|---|---|---|---|---|
| $V_{IN}$ | $V_{IN}$, $V_{OUT}$, $V_{ON}$ to GND | | −0.3 | 4.0 | V |
| $I_{SW}$ | Maximum Continuous Switch Current | | | 1.5 | A |
| $P_D$ | Power Dissipation at $T_A$ = 25°C | | | 1.0 | W |
| $T_{STG}$ | Storage Junction Temperature | | −65 | +150 | °C |
| $T_A$ | Operating Temperature Range | | −40 | +85 | °C |
| $\theta_{JA}$ | Thermal Resistance, Junction−to−Ambient | 1S2P with 1 Thermal Via | | 95 | °C/W |
| | | 1S2P without Thermal Via | | 187 | |
| ESD | Electrostatic Discharge Capability | Human Body Model, JESD22−A114 | 4 | | kV |
| | | Charged Device Model, JESD22−C101 | 2 | | |

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.

## RECOMMENDED OPERATING CONDITIONS

| Symbol | Parameter | Min. | Max. | Unit |
|---|---|---|---|---|
| $V_{IN}$ | Supply Voltage | 1.0 | 3.6 | V |
| $T_A$ | Ambient Operating Temperature | −40 | +85 | °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.

## ELECTRICAL CHARACTERISTICS

Unless otherwise noted, $V_{IN}$ = 1.0 to 3.6 V, $T_A$ = −40 to +85°C; Typical Values are at $V_{IN}$ = 3.3 V and $T_A$ = 25°C.

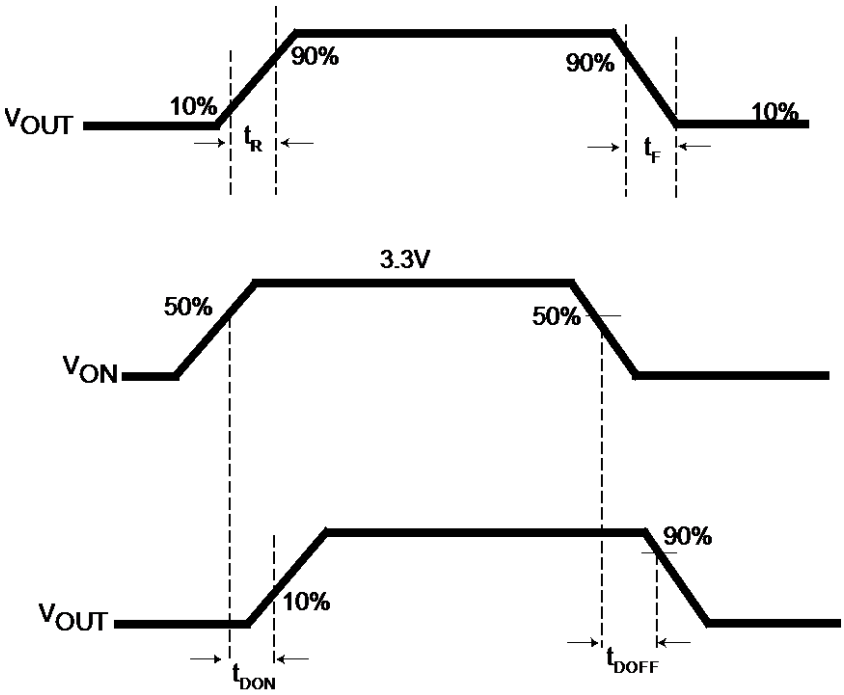
| Symbol | Parameter | | Conditions | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|---|
| **BASIC OPERATION** | | | | | | | |
| $V_{IN}$ | Supply Voltage | | | 1.0 | | 3.6 | V |
| $I_{Q(OFF)}$ | Off Supply Current | FPF1504 | $V_{ON}$ = GND, $V_{OUT}$ = Open | | 0.25 | | μA |
| | | FPF1504L | $V_{ON}$ = $V_{IN}$, $V_{OUT}$ = Open | | 0.3 | | |
| $I_{SD(OFF)}$ | Off Switch Current | FPF1504 | $V_{ON}$ = GND, $V_{OUT}$ = GND | | 0.25 | | |
| | | FPF1504L | $V_{ON}$ = $V_{IN}$, $V_{OUT}$ = GND | | 0.3 | | |
| $I_Q$ | Quiescent Current | FPF1504 | $I_{OUT}$ = 0 mA, $V_{IN}$ = 3.6 V, $V_{ON}$ = $V_{IN}$ | | 0.08 | | |
| | | | $I_{OUT}$ = 0 mA, $V_{ON}$ = $V_{IH(MIN)}$ | | 0.75 | | |
| | | FPF1504L | $I_{OUT}$ = 0 mA, $V_{IN}$ = 3.6 V, $V_{ON}$ = GND | | 0.08 | | |
| | | | $I_{OUT}$ = 0 mA, $V_{ON}$ = $V_{IL(MAX)}$ | | 0.95 | | |
| $R_{ON}$ | On Resistance | | $V_{IN}$ = 3.3 V, $I_{OUT}$ = 200 mA, $T_A$ = 25°C | | 15 | 30 | mΩ |
| | | | $V_{IN}$ = 1.8 V, $I_{OUT}$ = 200 mA, $T_A$ = 25°C | | 20 | 40 | |
| | | | $V_{IN}$ = 1.5 V, $I_{OUT}$ = 200 mA, $T_A$ = 25°C | | 30 | | |
| | | | $V_{IN}$ = 1.0 V, $I_{OUT}$ = 200 mA, $T_A$ = 25°C | | 40 | 80 | |
| | | | $V_{IN}$ = 1.8 V, $I_{OUT}$ = 200 mA, $T_A$ = 85°C (Note 3) | | 35 | 50 | |
| $R_{PD}$ | Output Discharge Pull−Down Resistance | | $V_{ON}$ = 0 V or $V_{IN}$, $I_{OUT}$ = −20 mA | | 65 | 95 | Ω |
| $V_{IH}$ | On Input Logic High Voltage | FPF1504 | | 0.8 | | | V |
| $V_{IL}$ | On Input Logic Low Voltage | FPF1504 | | | | 0.3 | |
| $I_{ON}$ | On Input Leakage | | $V_{ON}$ = $V_{IN}$ or GND | | | 1 | μA |
| **DYNAMIC CHARACTERISTICS** | | | | | | | |
| $t_{DON}$ | Turn−On Delay (Note 4) | FPF1504 | $R_L$ = 10 Ω, $C_L$ = 0.1 μF, $V_{IN}$ = 3.3 V, $T_A$ = 25°C | | 80 | | μs |
| $t_R$ | $V_{OUT}$ Rise Time (Note 4) | FPF1504 | | | 130 | | |
| $t_{ON}$ | Turn−On Time (Note 4) | FPF1504 | | | 210 | | |
| $t_{DON}$ | Turn−On Delay (Note 4) | FPF1504 | $R_L$ = 500 Ω, $C_L$ = 0.1 μF, $V_{IN}$ = 3.3 V, $T_A$ = 25°C | | 70 | 100 | μs |
| | | FPF1504L | | | 95 | | |
| $t_R$ | $V_{OUT}$ Rise Time (Note 4) | FPF1504 | | | 110 | 150 | |
| | | FPF1504L | | | 115 | | |
| $t_{ON}$ | Turn−On Time (Note 4) | FPF1504 | | | 180 | 250 | |
| | | FPF1504L | | | 210 | | |
| $t_{DOFF}$ | Turn−Off Delay (Note 4) | FPF1504 | $R_L$=10 Ω, $C_L$ = 0.1 μF, $V_{IN}$ = 3.3 V, $T_A$ = 25°C | | 25 | 30 | μs |
| $t_F$ | $V_{OUT}$ Fall Time (Note 4) | FPF1504 | | | 2 | | |
| $t_{OFF}$ | Turn−Off Time (Note 4) | FPF1504 | | | 27 | | |

**ELECTRICAL CHARACTERISTICS** (continued)
Unless otherwise noted, $V_{IN}$ = 1.0 to 3.6 V, $T_A$ = −40 to +85°C; Typical Values are at $V_{IN}$ = 3.3 V and $T_A$ = 25°C.

| Symbol | Parameter | | Conditions | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|---|
| **DYNAMIC CHARACTERISTICS** | | | | | | | |
| $t_{DOFF}$ | Turn−Off Delay (Note 4) | FPF1504 | $R_L$ = 500 Ω, $C_L$ = 0.1 μF, $V_{IN}$ = 3.3 V, $T_A$ = 25°C | | 25 | | μs |
| | | FPF1504L | | | 2 | | |
| $t_F$ | $V_{OUT}$ Fall Time (Note 4) | FPF1504 | | | 12 | | |
| | | FPF1504L | | | 14 | | |
| $t_{OFF}$ | Turn−Off Time (Note 4) | FPF1504 | | | 37 | | |
| | | FPF1504L | | | 16 | | |

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 7.
5. Output discharge path is enabled during off.

### Timing Diagram – FPF1504




NOTES: 6. $t_{ON} = t_R + t_{DON}$.
7. $t_{OFF} = t_F + t_{DOFF}$.

**Figure 7. Timing Diagram for FPF1504**

## TYPICAL PERFORMANCE CHARACTERISTICS FOR FPF1504

Applicable to active high version only.

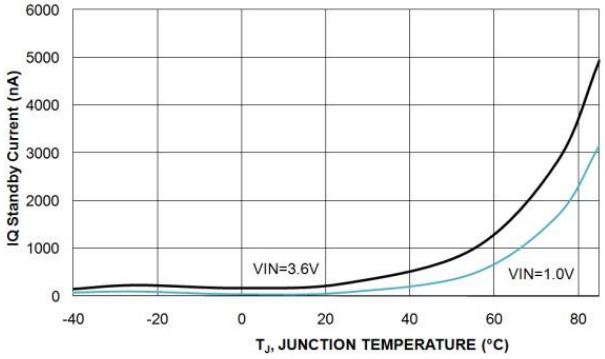



**Figure 1. Shutdown Current vs. Temperature**

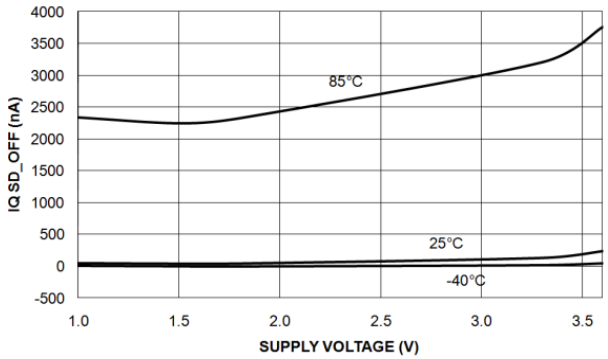



**Figure 2. Shutdown Current vs. Supply Voltage**

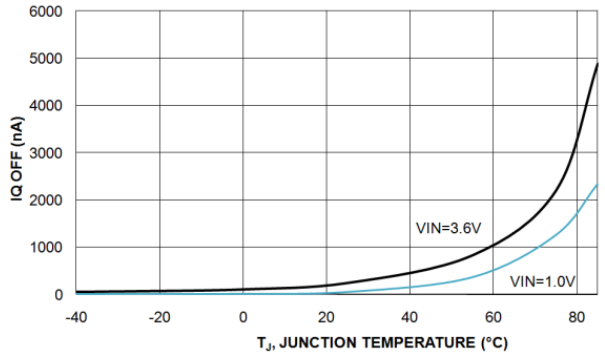



**Figure 3. Off Supply Current vs. Temperature**

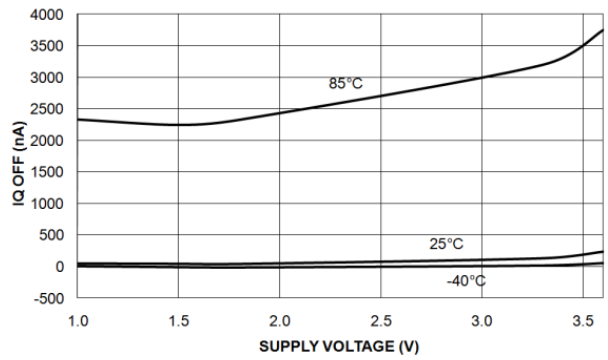



**Figure 4. Off Supply Current vs. Supply Voltage**

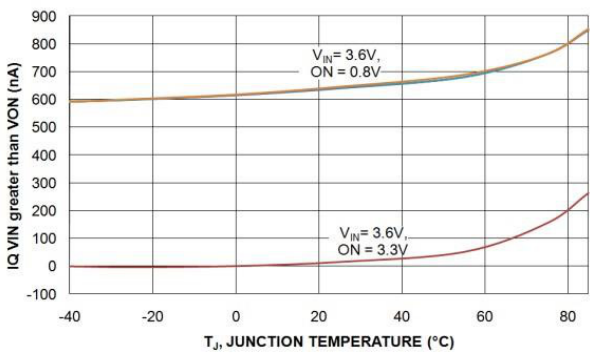



**Figure 5. Quiescent Current vs. Temperature**

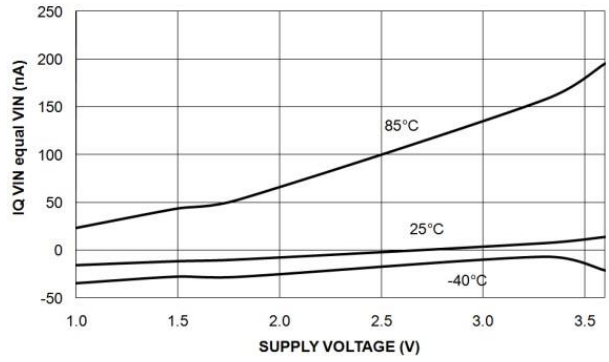



**Figure 6. Quiescent Current vs. Supply Voltage ($V_{ON}$ = $V_{IN}$)**

## TYPICAL PERFORMANCE CHARACTERISTICS FOR FPF1504

Applicable to active high version only.

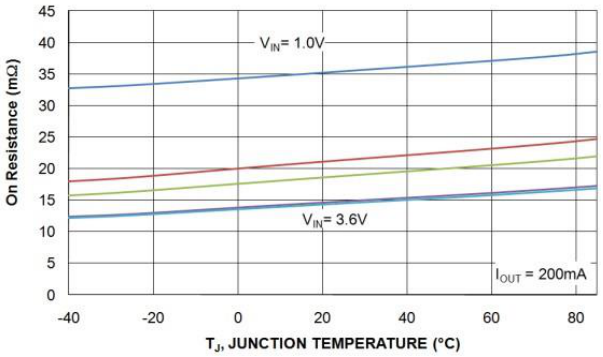



**Figure 7. $R_{ON}$ vs. Temperature**

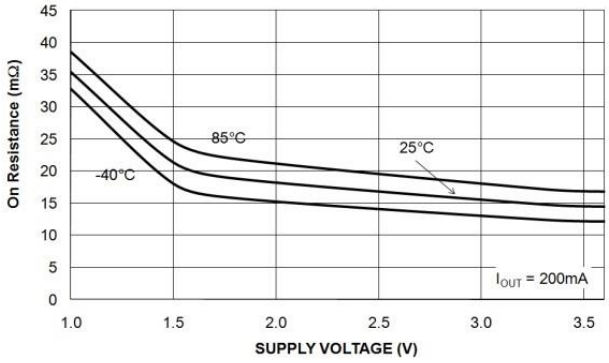



**Figure 8. $R_{ON}$ vs. Temperature**

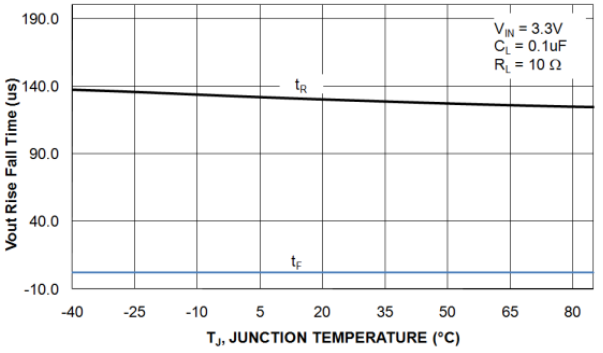



**Figure 9. $V_{OUT}$ Rise/Fall Times vs. Temperature ($R_L$ = 10 Ω)**

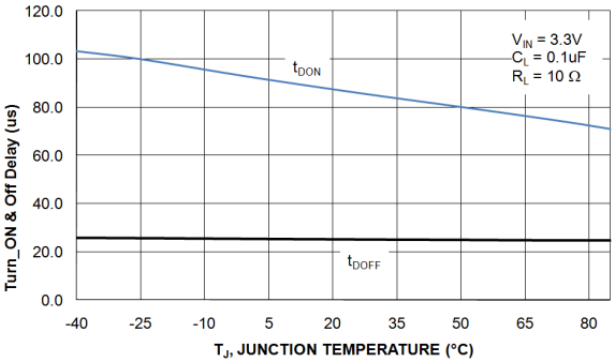



**Figure 10. $V_{OUT}$ Turn−On/Turn−Off Delays vs. Temperature ($R_L$ = 10 Ω)**

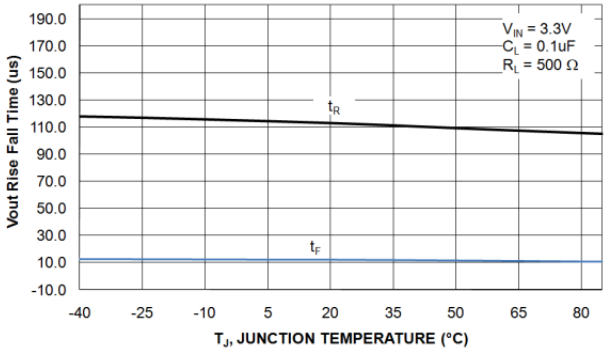



**Figure 11. $V_{OUT}$ Rise/Fall Time vs. Temperature ($R_L$ = 500 Ω)**

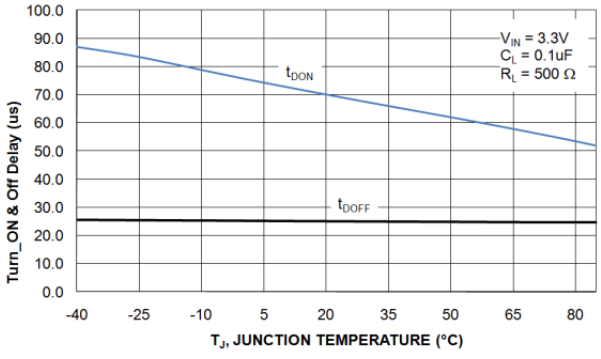



**Figure 12. $V_{OUT}$ Turn−On/Turn−Off Delays vs. Temperature ($R_L$ = 500 Ω)**

## TYPICAL PERFORMANCE CHARACTERISTICS FOR FPF1504

Applicable to active high version only.

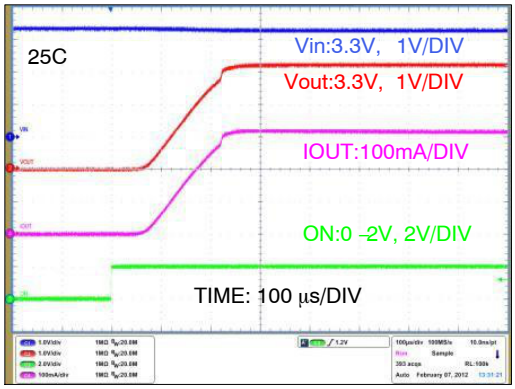



**Figure 13. Turn−On Response**
**($V_{IN}$ = 3.3 V, $C_{OUT}$ = 0.1 μF, $R_L$ = 10 Ω)**

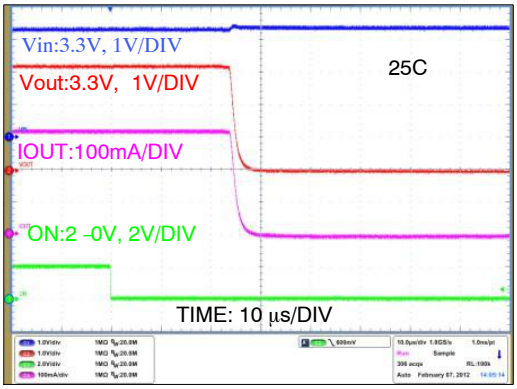



**Figure 14. Turn−Off Response**
**($V_{IN}$ = 3.3 V, $C_{OUT}$ = 0.1 μF, $R_L$ = 10 Ω)**

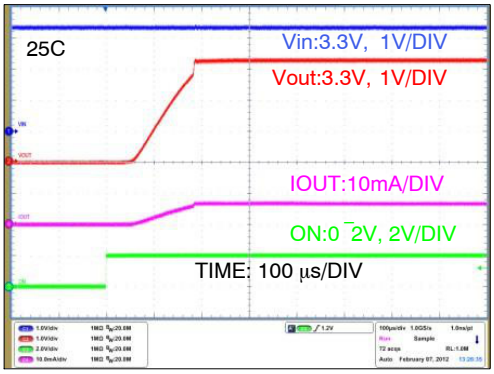



**Figure 15. Turn−On Response**
**($V_{IN}$ = 3.3 V, $C_{OUT}$ = 0.1 μF, $R_L$ = 500 Ω)**

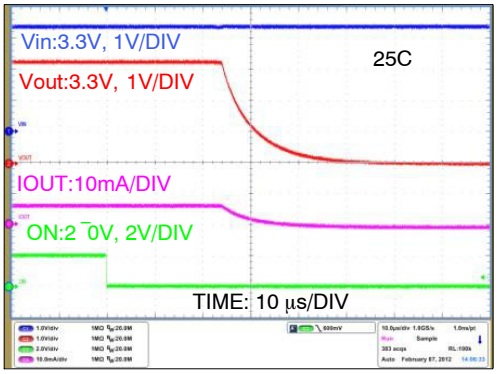



**Figure 16. Turn−Off Response**
**($V_{IN}$ = 3.3 V, $C_{OUT}$ = 0.1 μF, $R_L$ = 500 Ω)**

## APPLICATION INFORMATION

### Input Capacitor

IntelliMAX switches don'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 further reduce the voltage drop experienced as the switch is turned on into a large capacitive load.

### Output Capacitor

IntelliMAX switches work without an output capacitor. If the applications 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 external components as follows:

$$t_F = R_L \times C_L \times 2.2 \quad \text{(eq. 1)}$$

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, then $R_L$ is replaced by a parallel connected pull−down and external output resistor combination, as follows:

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

where $t_F$ is 90% to 10% fall time, $R_L$ is output load, $R_{PD}$ is output pull−down resistor (65 Ω typical), and $C_L$ is the output capacitor.

## 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 the capacitors as close to the device as possible. Below is a recommended layout for this device to achieve optimum performance.

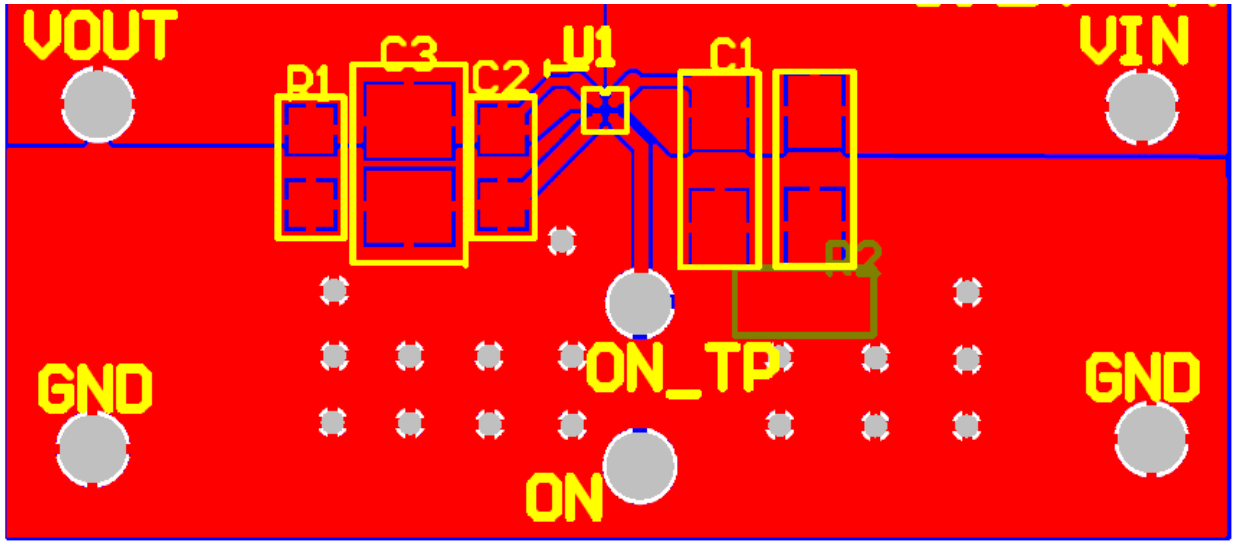



**Figure 17. Recommended Land Pattern and Layout**

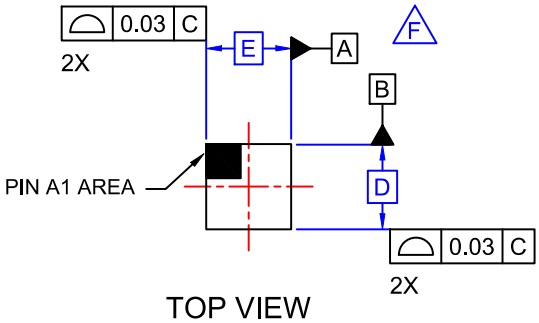
The following information applies to the WLCSP package dimensions on the next page:

### PRODUCT−SPECIFIC DIMENSIONS

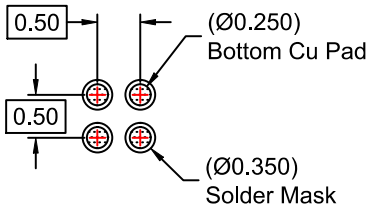
| Product | D | E | X | Y |
|---|---|---|---|---|
| FPF1504UCX | 960 μm ±30 μm | 960 μm ±30 μm | 0.230 mm | 0.230 mm |
| FPF1504BUCX | | | | |
| FPF1504LUCX | | | | |
| FPF1504LBUCX | | | | |

**WLCSP4 0.96x0.96x0.582**
CASE 567RH
ISSUE O

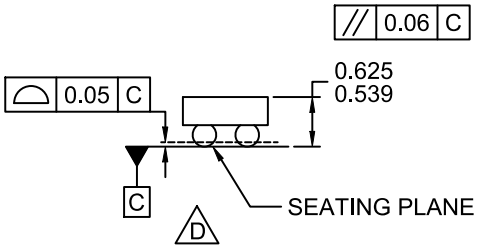
DATE 30 NOV 2016

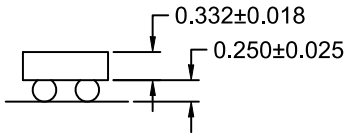



TOP VIEW

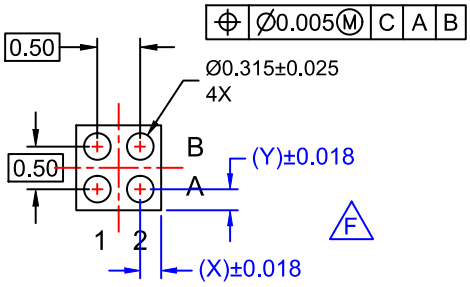



RECOMMENDED LAND PATTERN
(NSMD PAD TYPE)




SIDE VIEWS




BOTTOM VIEW

NOTES:

A. NO JEDEC REGISTRATION APPLIES.
B. DIMENSIONS ARE IN MILLIMETERS.
C. DIMENSIONS AND TOLERANCES PER ASME Y14.5M, 2009.
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.

| | | |
|---|---|---|
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| **DESCRIPTION:** | **WLCSP4 0.96x0.96x0.582** | **PAGE 1 OF 1** |

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