**FAIRCHILD**

**SEMICONDUCTOR®**

October 2013

# FPF1504 / FPF1504L
# Advanced Load Management Switch

## 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
  - 55 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

## 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.
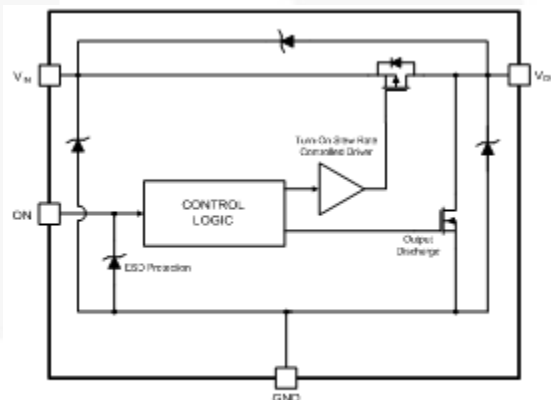


**Figure 1.    Block Diagram**

## Ordering Information

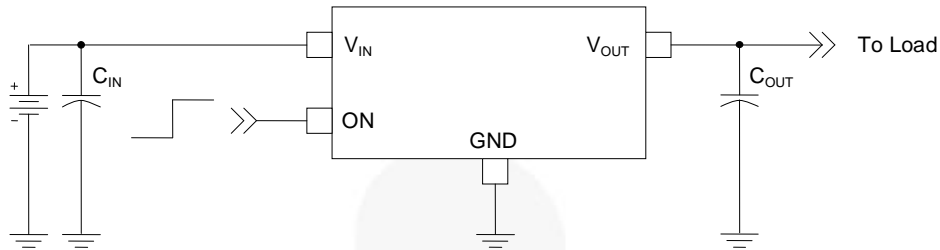| Part Number | Top Mark | Switch (Typical) At 1.8 $V_{IN}$ | Input Buffer | Output Discharge | ON Pin Activity | Package |
|---|---|---|---|---|---|---|
| FPF1504UCX | G4 | 20 mΩ | CMOS | YES | Active HIGH | 4-Ball, WLCSP, 0.5 mm Pitch |
| FPF1504BUCX | G4 | 20 mΩ | CMOS | YES | Active HIGH | 4-Ball,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

## Application Diagram



**Figure 2.    Typical Application**

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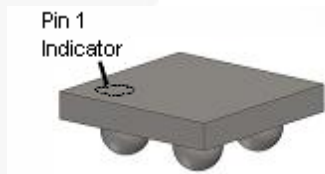2.  $C_{OUT}$=1 μF, X5R, 0805, for example Murata GRM216R61A105KA01.

## Pin Configurations
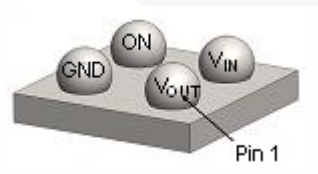


**Figure 3.    1 x 1 mm WLCSP Bumps Facing Down**



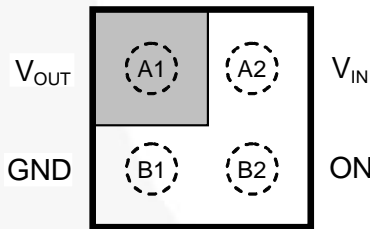**Figure 4.    1 x 1 mm WLCSP Bumps Facing Up**



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



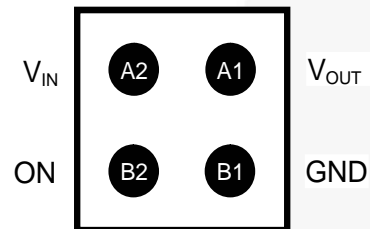**Figure 6.    Pin Assignments (Bottom View)**

## 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

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 | 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 | | |

## 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 | 1.0 | 3.6 | V |
| $T_A$ | Ambient Operating Temperature | -40 | +85 | °C |

## 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[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[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[4] | FPF1504 | | | 130 | | |
| $t_{ON}$ | Turn-On Time[4] | FPF1504 | | | 210 | | |
| $t_{DON}$ | Turn-On Delay[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[4] | FPF1504 | | | 110 | 150 | |
| | | FPF1504L | | | 115 | | |
| $t_{ON}$ | Turn-On Time[4] | FPF1504 | | | 180 | 250 | |
| | | FPF1504L | | | 210 | | |

*Continued on the following page…*

## 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** (Continued) | | | | | | | |
| $t_{DOFF}$ | Turn-Off Delay[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[4] | FPF1504 | | | 2 | | |
| $t_{OFF}$ | Turn-Off Time[4] | FPF1504 | | | 27 | | |
| $t_{DOFF}$ | Turn-Off Delay[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[4] | FPF1504 | | | 12 | | |
| | | FPF1504L | | | 14 | | |
| $t_{OFF}$ | Turn-Off Time[4] | FPF1504 | | | 37 | | |
| | | FPF1504L | | | 16 | | |

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

## Timing Diagram – FPF1504
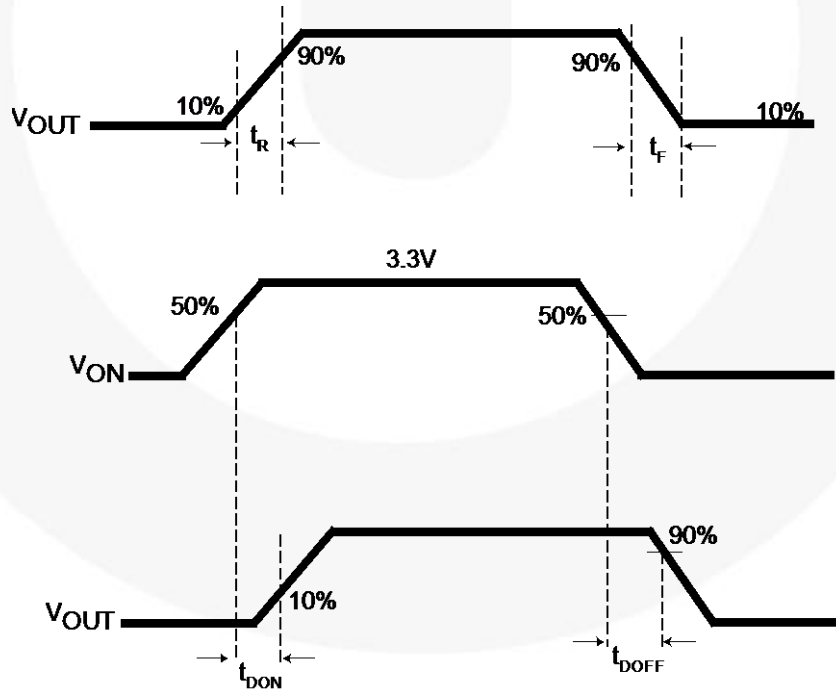


**Notes:**
6. $t_{ON}$=$t_R$ + $t_{DON}$.
7. $t_{OFF}$=$t_F$ + $t_{DOFF}$.

**Figure 7.    Timing Diagram for FPF1504**

## Typical Performance Characteristics for FPF1504
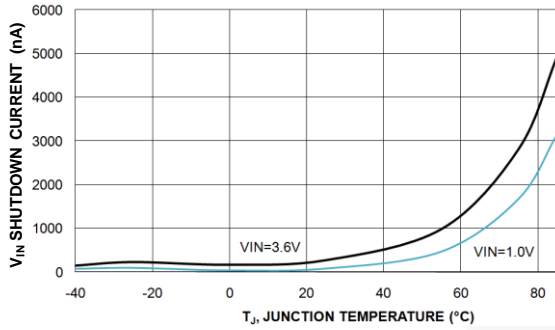
Applicable to active high version only.



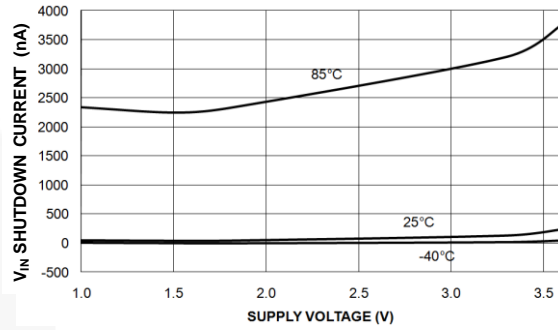Figure 8.    Shutdown Current vs. Temperature



Figure 9.    Shutdown Current vs. Supply Voltage
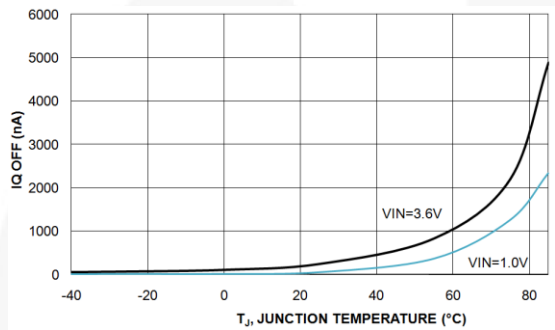


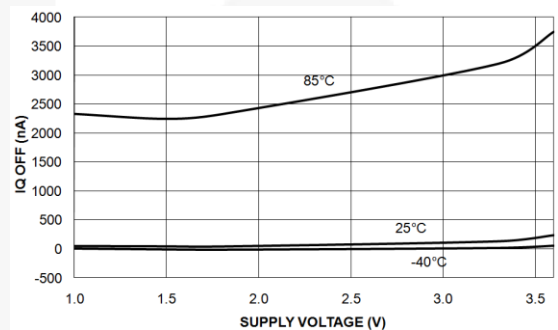Figure 10.   Off Supply Current vs. Temperature



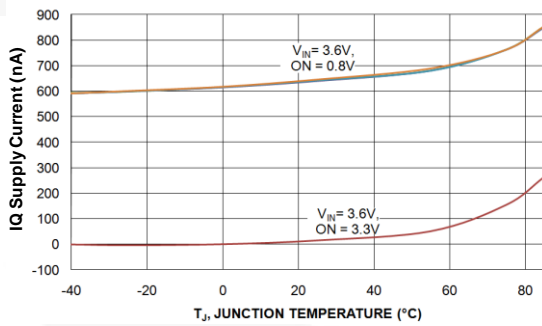Figure 11.   Off Supply Current vs. Supply Voltage
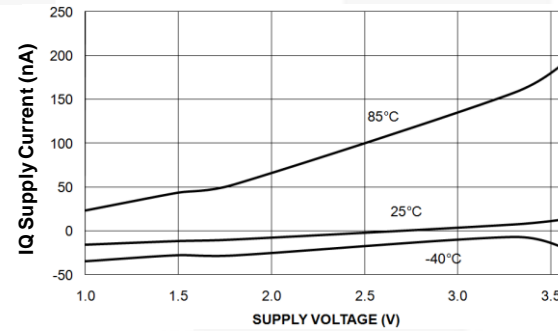


Figure 12.   Quiescent Current vs. Temperature



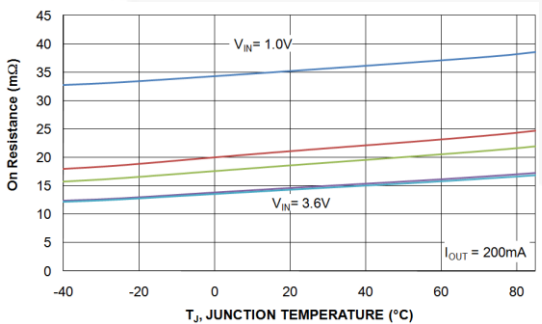Figure 13.   Quiescent Current vs. Supply Voltage ($V_{ON}=V_{IN}$)
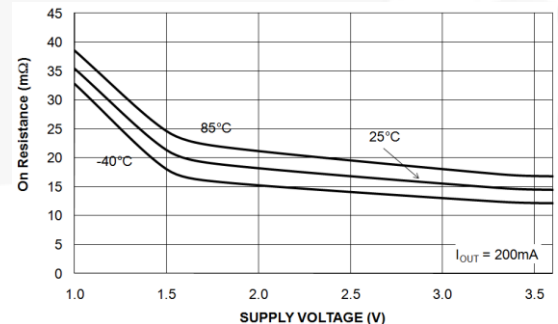


Figure 14.   $R_{ON}$ vs. Temperature



Figure 15.   $R_{ON}$ vs. Supply Voltage

## Typical Performance Characteristics for FPF1504

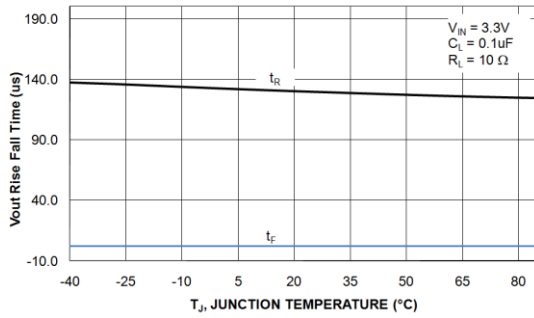Applicable to active high version only.



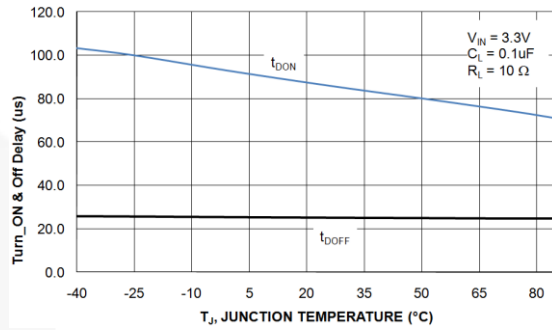**Figure 16.  V$_{OUT}$ Rise/Fall Times vs. Temperature (R$_L$=10 Ω)**



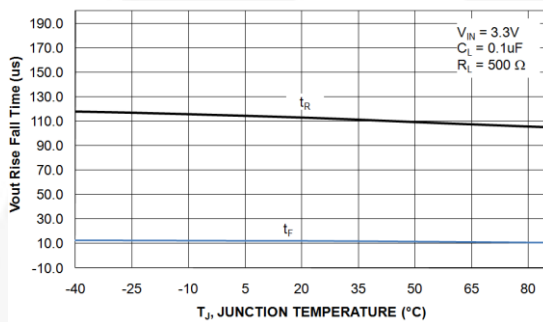**Figure 17.  V$_{OUT}$ Turn-On/Turn-Off Delays vs. Temperature (R$_L$=10 Ω)**



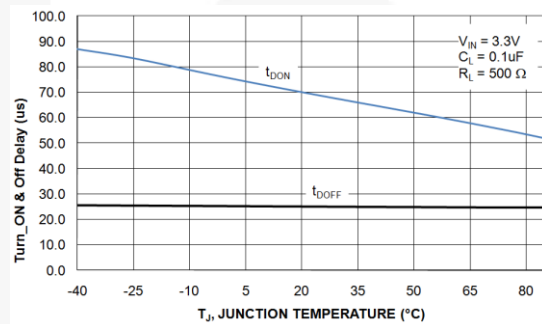**Figure 18.  V$_{OUT}$ Rise/Fall Time vs. Temperature (R$_L$=500 Ω)**



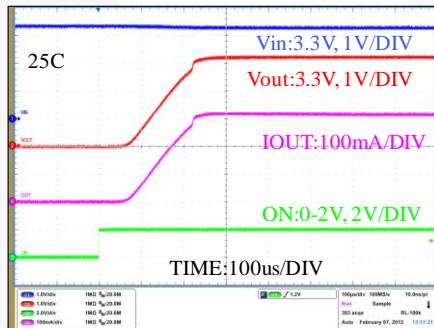**Figure 19.  V$_{OUT}$ Turn-On/Turn-Off Delays vs. Temperature (R$_L$=500 Ω)**



**Figure 20.  Turn-On Response (V$_{IN}$=3.3 V, C$_{OUT}$=0.1 µF, R$_L$=10 Ω)**
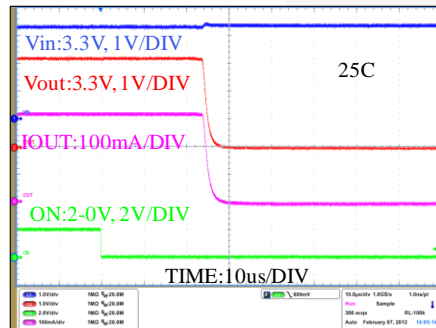


**Figure 21.  Turn-Off Response (V$_{IN}$=3.3 V, C$_{OUT}$=0.1 µF, R$_L$=10 Ω)**
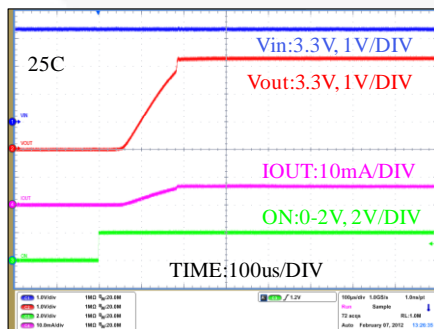


**Figure 22.  Turn-On Response (V$_{IN}$=3.3 V, C$_{OUT}$=0.1 µF, R$_L$=500 Ω)**
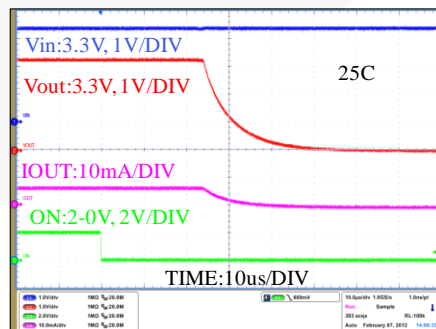


**Figure 23.  Turn-Off Response (V$_{IN}$=3.3 V, C$_{OUT}$=0.1 µF, R$_L$=500 Ω)**

## 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:

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

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:

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

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.
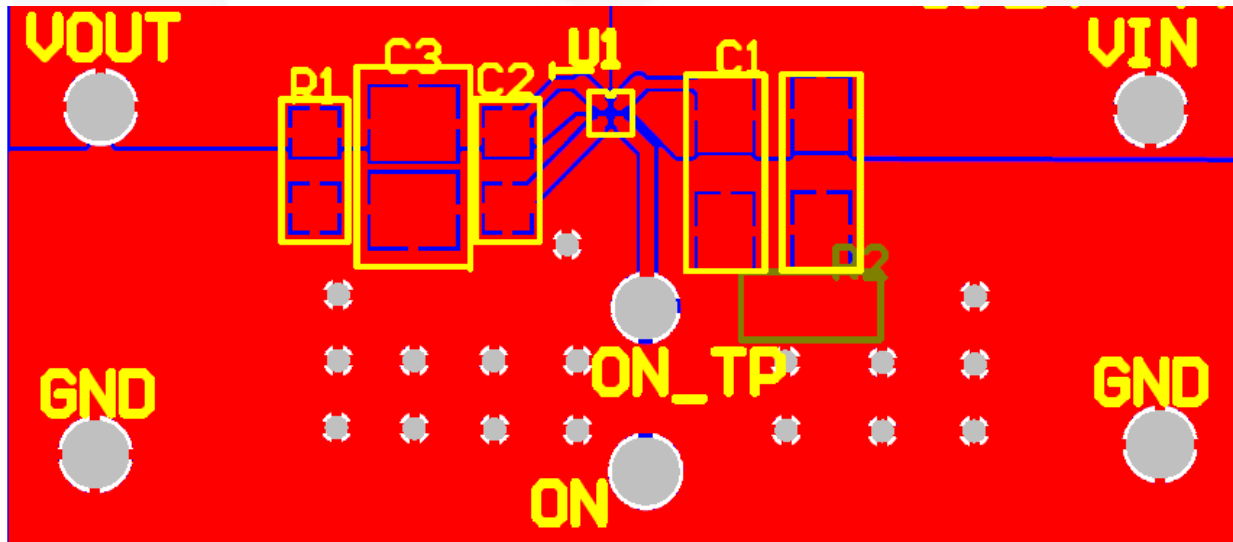


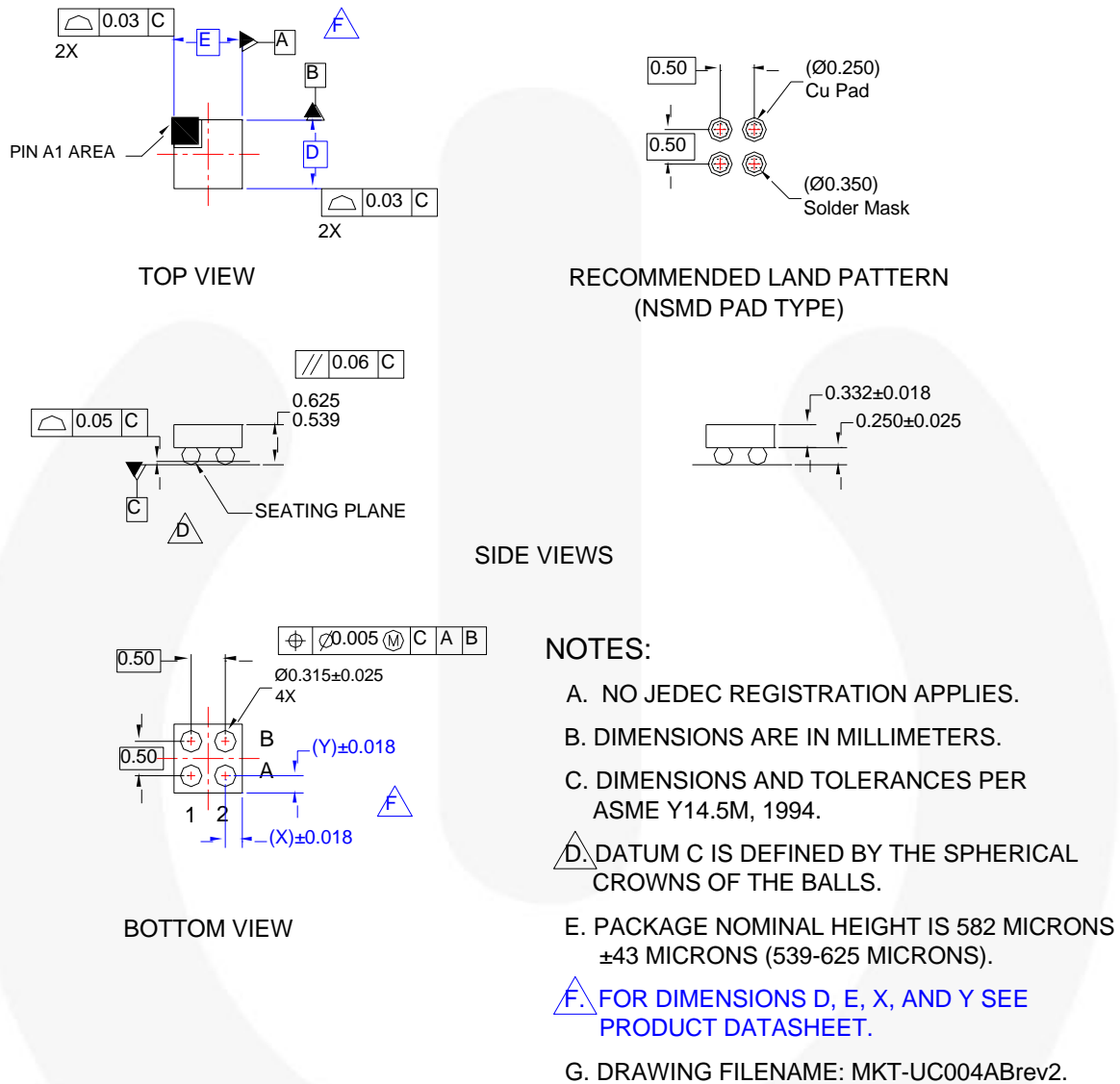**Figure 24.   Recommended Land Pattern and Layout**

## Physical Dimensions



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, 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-UC004ABrev2.

**Figure 25.   4-Ball, 1.0 x 1.0 mm Wafer-Level Chip Scale (WLCSP) Packaging**

## Product-Specific Dimensions

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

*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/dwg/UC/UC004AB.pdf.*

## 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™
AX-CAP®*
BitSiC™
Build it Now™
CorePLUS™
CorePOWER™
CROSSVOLT™
CTL™
Current Transfer Logic™
DEUXPEED®
Dual Cool™
EcoSPARK®
EfficientMax™
ESBC™
F®
Fairchild®
Fairchild Semiconductor®
FACT Quiet Series™
FACT®
FAST®
FastvCore™
FETBench™
FPS™

F-PFS™
FRFET®
Global Power Resource℠
GreenBridge™
Green FPS™
Green FPS™ e-Series™
Gmax™
GTO™
IntelliMAX™
ISOPLANAR™
Making Small Speakers Sound Louder and Better™
MegaBuck™
MICROCOUPLER™
MicroFET™
MicroPak™
MicroPak2™
MillerDrive™
MotionMax™
mWSaver®
OptoHiT™
OPTOLOGIC®
OPTOPLANAR®

®
PowerTrench®
PowerXS™
Programmable Active Droop™
QFET®
QS™
Quiet Series™
RapidConfigure™
™
Saving our world, 1mW/W/kW at a time™
SignalWise™
SmartMax™
SMART START™
Solutions for Your Success™
SPM®
STEALTH™
SuperFET®
SuperSOT™-3
SuperSOT™-6
SuperSOT™-8
SupreMOS®
SyncFET™

Sync-Lock™
SYSTEM GENERAL®*
TinyBoost®
TinyBuck®
TinyCalc™
TinyLogic®
TINYOPTO™
TinyPower™
TinyPWM™
TinyWire™
TranSiC™
TriFault Detect™
TRUECURRENT®*
μSerDes™
μSerDes™
UHC®
Ultra FRFET™
UniFET™
VCX™
VisualMax™
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