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# FPF2488 Dual Channel Over-Voltage Protection Load Switch

## Features

- Dual Channel Power Switch ( $V_{BUS}$  and  $V_{IF}$ )
- Surge Protection under IEC 61000-4-5
  - $V_{BUS}$ :  $\pm 100$  V
  - $V_{IF}$ :  $\pm 40$  V
- Input Voltage Range
  - $V_{BUS}$ : 2.5 V ~ 23 V
  - $V_{IF}$ : 3.1 V ~ 5.5 V
- Max Continuous Current Capability
  - $V_{BUS}$ : 2.5 A
  - $V_{IF}$ : 6 A
- Ultra Low On-Resistance
  - $V_{BUS}$ : Typ. 33 m $\Omega$
  - $V_{IF}$ : Typ. 10 m $\Omega$
- Over Voltage Protection
  - $V_{BUS}$ : 10 V  $\pm$  100 mV
  - $V_{IF}$ : 5.25 V  $\pm$  250 mV
- LDO Output based  $V_{BUS\_DET}$  for  $V_{BUS}$  Detection
- Active Low Control for  $V_{BUS}$  Path
- OTG Functionality on  $V_{BUS}$  Path
- Conditional Active High Control for  $V_{IF}$  Path
- Reverse-Current Blocking for  $V_{IF}$  Path

## Applications

- Mobile Handsets and Tablets
- Wearable Devices

## Description

The FPF2488 features a 2-channel power switch, which offers surge protection and Over-Voltage Protection (OVP), to protect downstream components and enhancing overall system robustness.

Channel one ( $V_{BUS}$ ) is an active-low, 28 V/2.5 A rated, power MOSFET switch with an internal clamp supporting  $\pm 100$  V surge protection, highly accurate fixed OVP at 10.0 V ( $\pm 100$  mV), and OTG functionality. Channel two ( $V_{IF}$ ) is a conditional active-high, 6 V/6 A rated, power MOSFET switch with an integrated TVS supporting  $\pm 40$  V surge protection and fixed OVP at 5.25 V ( $\pm 250$  mV).  $V_{IF}$  also provides Reverse Current Blocking (RCB) during its OFF state to minimize leakage current.

$V_{BUS\_DET}$  is paired with always ON LDO to power downstream devices even with  $V_{BUS}$  is greater than 2.5 V, even when disabled through the ONB pin. This provides power sequence control or a host controlled configuration in system.

The FPF2488 is available in a 15-bump, 1.6 mm x 2.2 mm Wafer-Level Chip-Scale Package (WLCSP) with 0.4 mm pitch.

## Related Resources

- <http://www.fairchildsemi.com/>

## Ordering Information

| Part Number | Operating Temperature Range | Top Mark | Package                     | Packing Method |
|-------------|-----------------------------|----------|-----------------------------|----------------|
| FPF2488UCX  | -40°C – +85°C               | GW       | 15-Ball, 0.4 mm Pitch WLCSP | Tape & Reel    |

### Application Diagram

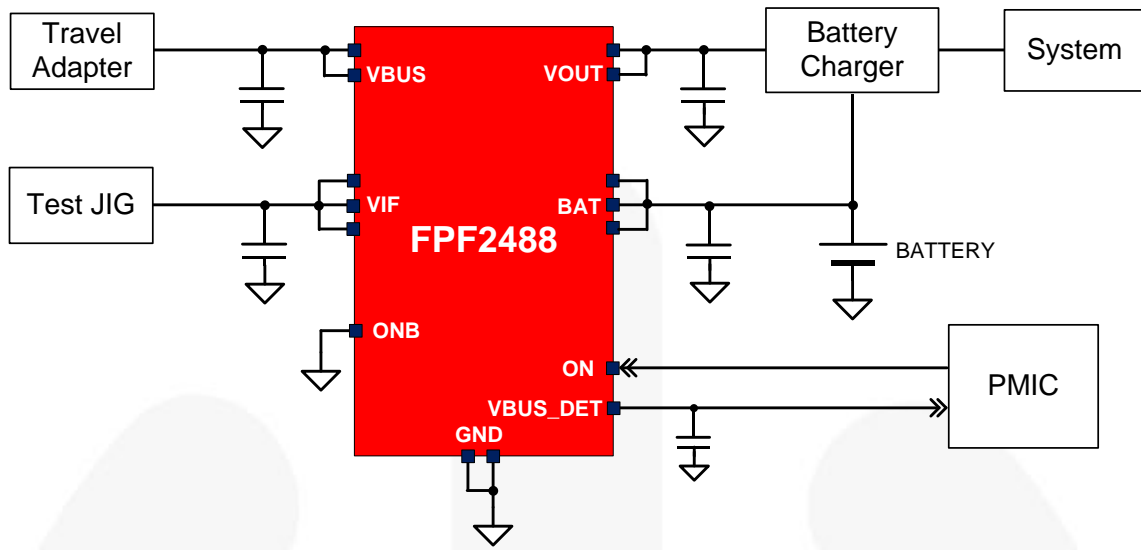


Figure 1. Typical Application

### Block Diagram

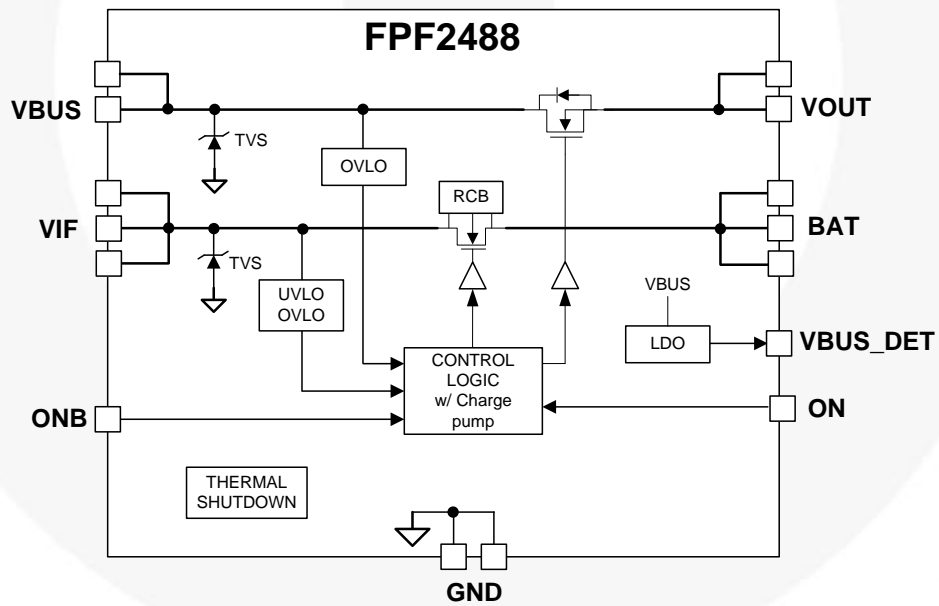


Figure 2. Functional Block Diagram

## Pin Configuration

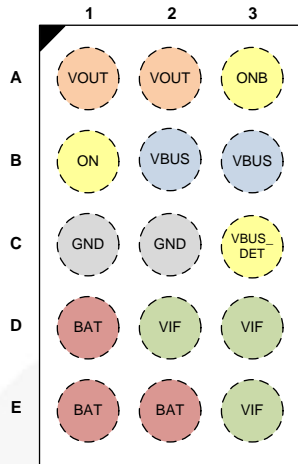


Figure 3. Pin Configuration (Top View)

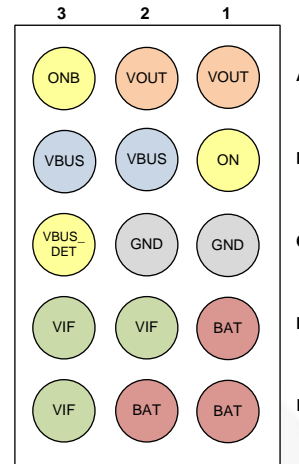


Figure 4. Pin Configuration (Bottom View)

## Pin Definitions

| Name           | Bump       | Type         | Description   |
|----------------|------------|--------------|---|
| $V_{BUS}$      | B2, B3     | Input/Supply | Switch Input and Device Supply  |
| VOUT           | A1, A2     | Output       | Switch Output to Load   |
| $V_{IF}$       | D2, D3, E3 | Input/Supply | Switch Input and Device Supply  |
| BAT            | D1, E1, E2 | Output       | Switch Output to Battery  |
| $V_{BUS\_DET}$ | C3         | Output       | Regulated Output according to $V_{BUS}$                                 |
| ON             | B1         | Input        | Active HIGH: $V_{IF}$ path only and when BAT is valid prior to $V_{IF}$ |
| ONB            | A3         | Input        | Active LOW: $V_{BUS}$ path only   |
| GND            | C1, C2     | GND          | Ground  |

## 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 <sub>BUS</sub>         | V <sub>BUS</sub> to GND & V <sub>BUS</sub> to V <sub>OUT</sub> =GND or Float                    |   | -0.3                              | 29.0                  | V    |    |
| V <sub>IF</sub>          | V <sub>IF</sub> to GND  |   | -2 <sup>(1)</sup>                 | 6                     | V    |    |
| V <sub>OUT</sub>         | V <sub>OUT</sub> to GND   |   | -0.3                              | V <sub>IN</sub> + 0.3 | V    |    |
| BAT                      | BAT to GND  |   | -0.3                              | V <sub>IF</sub> + 0.3 | V    |    |
| V <sub>BUS_DET</sub>     | V <sub>BUS_DET</sub> to GND   |   |                                   | 8                     | V    |    |
| V <sub>ON(B)</sub>       | ONB or ON to GND  |   |                                   | 6                     | V    |    |
| I <sub>IN_VBUS</sub>     | Continuous V <sub>BUS</sub> Current   |   |                                   | 2.5                   | A    |    |
|                          | Peak V <sub>BUS</sub> Current (5 ms)  |   |                                   | 5                     | A    |    |
| I <sub>IN_VIF</sub>      | Continuous V <sub>IF</sub> Current  |   |                                   | 6                     | A    |    |
|                          | Peak V <sub>IF</sub> Current (5 ms)   |   |                                   | 12                    | A    |    |
| I <sub>IN_VBUS_DET</sub> | Continuous V <sub>BUS_DET</sub> Current   |   |                                   | 1                     | mA   |    |
| t <sub>PD</sub>          | Total Power Dissipation at T <sub>A</sub> =25°C   |   |                                   | 1.54                  | W    |    |
| T <sub>STG</sub>         | Storage Temperature Range   |   | -65                               | +150                  | °C   |    |
| T <sub>J</sub>           | Maximum Junction Temperature  |   |                                   | +150                  | °C   |    |
| T <sub>L</sub>           | Lead Temperature (Soldering, 10 Seconds)  |   |                                   | +260                  | °C   |    |
| θ <sub>JA</sub>          | Thermal Resistance, Junction-to-Ambient <sup>(2)</sup> (1-in. <sup>2</sup> Pad of 2-oz. Copper) |   |                                   | 81 <sup>(2)</sup>     | °C/W |    |
| ESD                      | Electrostatic Discharge Capability  | IEC 61000-4-2 System Level ESD                | Air Discharge                     | 15.0                  |      | kV |
|                          |   |   | Contact Discharge                 | 8.0                   |      |    |
|                          |   | Human Body Model, ANSI/ESDA/JEDEC JS-001-2012 | All Pins                          | 2                     |      |    |
|                          |   |   | Charged Device Model, JESD22-C101 | All Pins              | 1    |    |
| Surge                    |   | IEC 61000-4-5, Surge Protection               | V <sub>BUS</sub>                  | ±100                  |      | V  |
|                          |   |   | V <sub>IF</sub>                   | ±40                   |      |    |

### Notes:

1. Pulsed, 50 ms maximum non-repetitive.
2. Measured using 2S2P JEDEC std. PCB.

## 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 <sub>BUS</sub>                   | Supply Voltage, V <sub>BUS</sub> | 2.5  | 23.0 | V    |
| V <sub>IF</sub>                    | Supply Voltage, V <sub>IF</sub>  | 3.1  | 5.5  | V    |
| C <sub>IN</sub> / C <sub>OUT</sub> | Input and Output Capacitance     | 0.1  |      | μF   |
| C <sub>VBUS_DET</sub>              | Output Capacitance               | 0.47 |      | μF   |
| T <sub>A</sub>                     | Operating Temperature            | -40  | +85  | °C   |

## Electrical Characteristics

Unless otherwise noted,  $V_{BUS}=2.5$  to  $23$  V,  $V_{IF}=3.1$  to  $5.5$  V,  $T_A=-40$  to  $85^\circ\text{C}$ ; Typical values are at  $V_{BUS}=5$  V,  $I_{IN} \leq 2$  A,  $V_{IF}=4$  V,  $C_{IN}=0.1$   $\mu\text{F}$  and  $T_A=25^\circ\text{C}$ .

| Symbol   | Parameter                                  | Conditions  | Min. | Typ. | Max. | Unit             |
|--|--|---|------|------|------|------------------|
| <b>Basic Operation</b>                                     |  |   |      |      |      |                  |
| $I_Q$  | Input Quiescent Current                    | $V_{BUS}=5$ V, $ONB=0$ V, $V_{BUS\_DET}$ =Floating  |      | 160  | 250  | $\mu\text{A}$    |
|  |  | $V_{IF}=4$ V  |      | 100  | 150  | $\mu\text{A}$    |
| $I_{IN\_Q}$  | OVLO Supply Current                        | $V_{BUS}=12$ V, $V_{OUT}=0$ V, $V_{BUS\_DET}$ =Floating   |      | 150  | 205  | $\mu\text{A}$    |
|  |  | $V_{IF}=5.5$ V, $BAT=0$ V   |      | 100  | 180  | $\mu\text{A}$    |
| $T_{SDN}$  | Thermal Shutdown <sup>(3)</sup>            |   |      | 140  |      | $^\circ\text{C}$ |
| $T_{SDN\_HYS}$   | Thermal Shutdown Hysteresis <sup>(3)</sup> |   |      | 20   |      | $^\circ\text{C}$ |
| <b><math>V_{BUS}</math> to <math>V_{OUT}</math> Switch</b> |  |   |      |      |      |                  |
| $V_{BUS\_CLAMP}$   | Input Clamping Voltage                     | $I_{IN}=10$ mA  |      | 35   |      | V                |
| $V_{BUS\_OVLO}$  | Over-Voltage Trip Level                    | $V_{BUS}$ Rising, $T_A=-40$ to $85^\circ\text{C}$   | 9.9  | 10.0 | 10.1 | V                |
|  |  | $V_{BUS}$ Falling, $T_A=-40$ to $85^\circ\text{C}$  | 9.8  |      |      | V                |
| $R_{ON\_VBUS}$   | On-Resistance                              | $V_{BUS}=5$ V, $I_{OUT}=1$ A, $T_A=25^\circ\text{C}$  |      | 33   | 39   | $\text{m}\Omega$ |
|  |  | $V_{BUS}=9$ V, $I_{OUT}=1$ A, $T_A=25^\circ\text{C}$  |      | 33   | 39   | $\text{m}\Omega$ |
| $t_{DEB\_VBUS}$  | Debounce Time                              | Time from $V_{BUS\_MIN} < V_{BUS} < V_{BUS\_OVLO}$ to $V_{OUT}=0.1 \times V_{BUS}$                        |      | 15   |      | ms               |
| $t_{START\_VBUS}$  | Soft-Start Time                            | Time from $V_{BUS}=V_{BUS\_MIN}$ to $0.1 \times V_{BUS\_DET}$   |      | 30   |      | ms               |
| $t_{ON\_VBUS}$   | Switch Turn-On Time                        | $R_L=100$ $\Omega$ , $C_L=22$ $\mu\text{F}$ , $V_{OUT}$ from $0.1 \times V_{BUS}$ to $0.9 \times V_{BUS}$ |      | 3    |      | ms               |
| $t_{OFF\_VBUS}$  | Switch Turn-Off Time                       | $R_L=100$ $\Omega$ , No $C_L$ , $V_{BUS} > V_{BUS\_OVLO}$ to $V_{OUT}=0.8 \times V_{BUS}$                 |      |      | 150  | ns               |
| <b><math>V_{IF}</math> to <math>BAT</math> Switch</b>      |  |   |      |      |      |                  |
| $V_{IF\_CLAMP}$  | Input Clamping Voltage                     | $I_{IN}=10$ mA  |      | 6.4  |      | V                |
| $V_{IF\_UVLO}$   | Under-Voltage Trip Level                   | $V_{IF}$ Rising, $T_A=-40$ to $85^\circ\text{C}$  |      | 2.85 | 3.05 | V                |
|  |  | $V_{IF}$ Falling, $T_A=-40$ to $85^\circ\text{C}$   |      | 2.7  |      | V                |
| $V_{IF\_OVLO}$   | Over-Voltage Trip Level                    | $V_{IF}$ Rising, $T_A=-40$ to $85^\circ\text{C}$  | 5.00 | 5.25 | 5.50 | V                |
|  |  | $V_{IF}$ Falling, $T_A=-40$ to $85^\circ\text{C}$   | 4.8  |      |      | V                |
| $R_{ON\_VIF}$  | On-Resistance                              | $V_{IF}=3.1$ V, $I_{OUT}=1$ A, $T_A=25^\circ\text{C}$   |      | 10   | 15   | $\text{m}\Omega$ |
| $I_{RCB}$  | Reverse Current                            | $V_{IF}=0$ V, $BAT=4.4$ V   |      | 3    | 7    | $\mu\text{A}$    |
| $t_{DEB\_VIF}$   | Debounce Time                              | Time from $V_{IF\_UVLO} < V_{IF} < V_{IF\_OVLO}$ to $BAT=0.1 \times V_{IF}$                               |      | 15   |      | ms               |
| $t_{QUAL\_VIF}$  | Qualification Time                         | $BAT > V_{IH\_BAT}$ First, Time from $ON > V_{IH\_ON(B)}$ to $BAT$ Voltage Increase                       |      | 30   |      | ms               |
| $t_{ON\_VIF}$  | Switch Turn-On Time                        | $R_L=100$ $\Omega$ , $C_L=22$ $\mu\text{F}$ , $V_{OUT}$ from $0.1 \times V_{IF}$ to $0.9 \times V_{IF}$   |      | 3    |      | ms               |
| $t_{OFF\_VIF}$   | Switch Turn-Off Time                       | $R_L=100$ $\Omega$ , No $C_L$ , $V_{IN} > V_{OVLO}$ to $V_{OUT}=0.8 \times V_{IF}$                        |      |      | 150  | ns               |

### Note:

- Guaranteed by characterization and design.

Continued on the following page...

## Electrical Characteristics

Unless otherwise noted,  $V_{BUS}=2.5$  to  $23$  V,  $V_{IF}=3.1$  to  $5.5$  V,  $T_A=-40$  to  $85^{\circ}\text{C}$ ; Typical values are at  $V_{BUS}=5$  V,  $I_{IN} \leq 2$  A,  $V_{IF}=4$  V,  $C_{IN}=0.1$   $\mu\text{F}$  and  $T_A=25^{\circ}\text{C}$ .

| Symbol                           | Parameter                      | Conditions   | Min. | Typ. | Max. | Unit          |
|----------------------------------|--------------------------------|--|------|------|------|---------------|
| <b><math>V_{BUS\_DET}</math></b> |                                |  |      |      |      |               |
| $V_{BUS\_DET}$                   | $V_{BUS\_DET}$ Output Voltage  | $V_{BUS}=6.5$ V, $I_{BUS\_DET}=0$ mA, $T_A=25^{\circ}\text{C}$ | 6.0  |      | 6.5  | V             |
|                                  |                                | $V_{BUS}=15$ V, $I_{BUS\_DET}=0$ mA, $T_A=25^{\circ}\text{C}$  | 6.0  | 7.0  | 7.9  | V             |
|                                  |                                | $V_{BUS}=6.5$ V, $I_{BUS\_DET}=1$ mA, $T_A=25^{\circ}\text{C}$ | 6.0  | 6.3  | 6.5  | V             |
|                                  |                                | $V_{BUS}=15$ V, $I_{BUS\_DET}=1$ mA, $T_A=25^{\circ}\text{C}$  | 6.0  | 7.0  | 7.9  | V             |
| <b>Digital Signals</b>           |                                |  |      |      |      |               |
| $V_{IH\_ON(B)}$                  | Enable HIGH Voltage            | $V_{BUS}$ , $V_{IF}$ Operating Range                           | 1.2  |      |      | V             |
| $V_{IL\_ON(B)}$                  | Enable LOW Voltage             | $V_{BUS}$ , $V_{IF}$ Operating Range                           |      |      | 0.5  | V             |
| $V_{IH\_BAT}$                    | BAT Presence HIGH Voltage      | BAT Rising   | 2.6  |      |      | V             |
| $V_{IL\_BAT}$                    | BAT Presence Low Voltage       | BAT Falling  |      |      | 1.7  | V             |
| $I_{VBUS\_DET\_LEAK}$            | $V_{BUS\_DET}$ Leakage Current | $V_{VBUS\_DET}=5$ V, $V_{BUS}=0$ V                             |      |      | 1    | $\mu\text{A}$ |
| $O_{NB\_Leak}$                   | ONB Leakage Current            | $V_{BUS}=5$ V, $V_{OUT}=\text{Float}$                          |      |      | 1    | $\mu\text{A}$ |

## Timing Diagrams

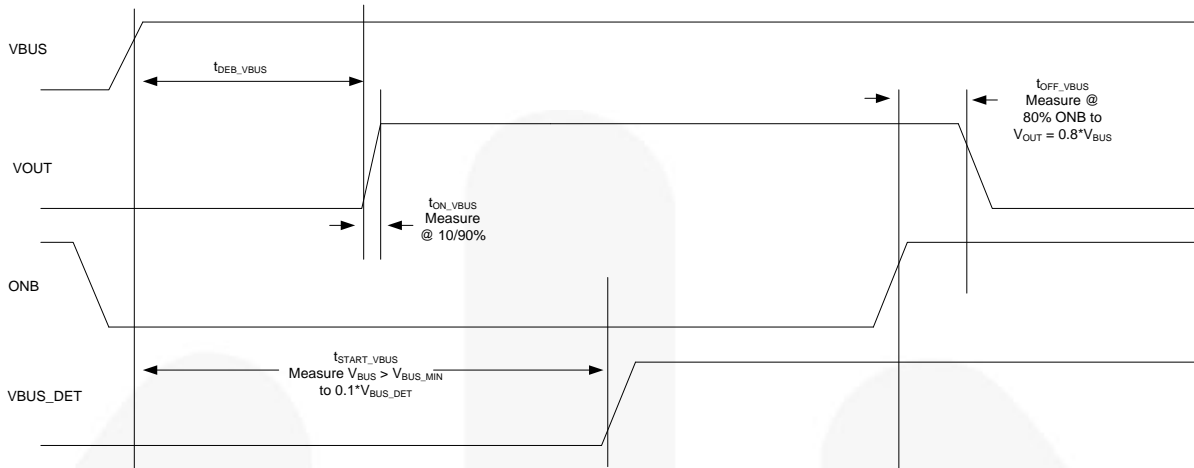


Figure 5. Timing for  $V_{BUS}$  Power Up/Down and Normal Operation

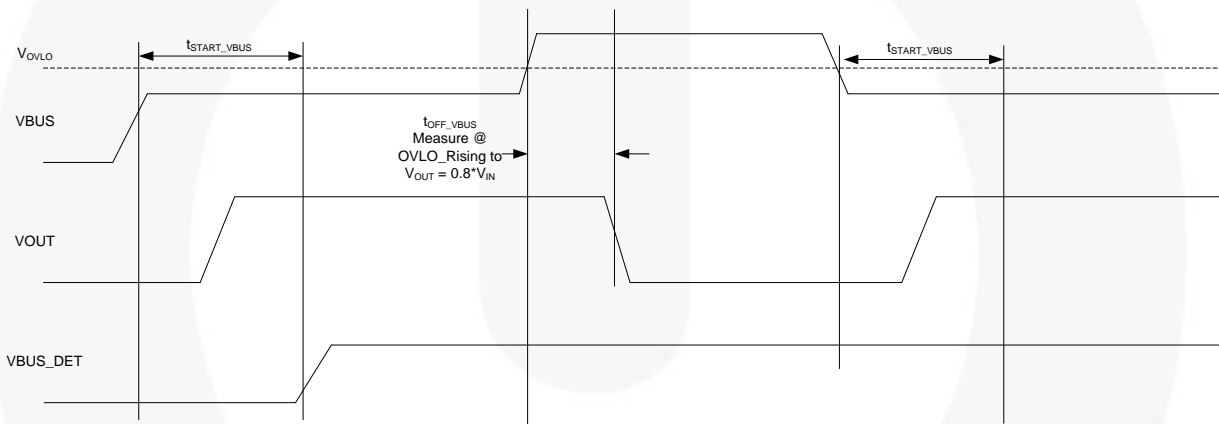


Figure 6. Timing for  $V_{BUS}$  OVLO Operation (ONB=LOW)

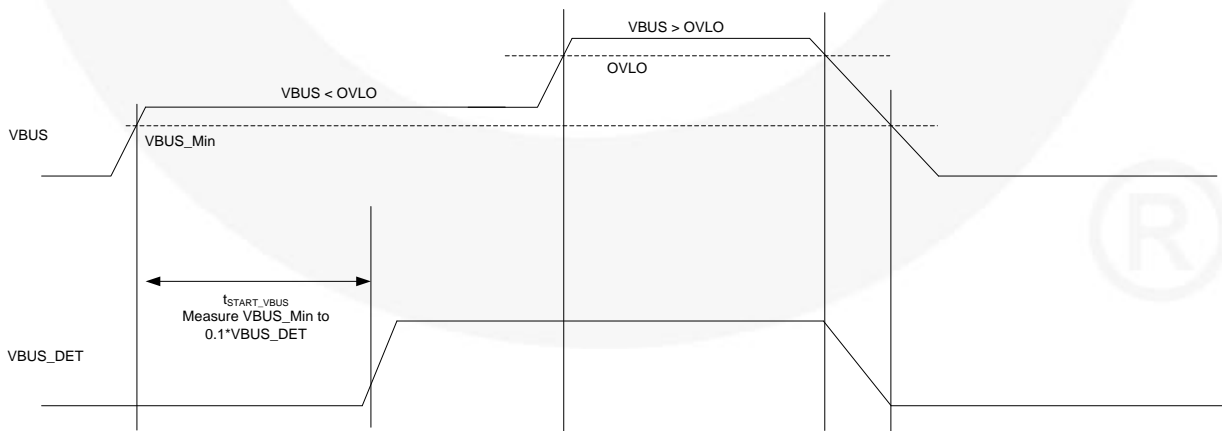


Figure 7. Always ON  $V_{BUS\_DET}$  Operation (ONB=HIGH)



Timing Diagrams (Continued)

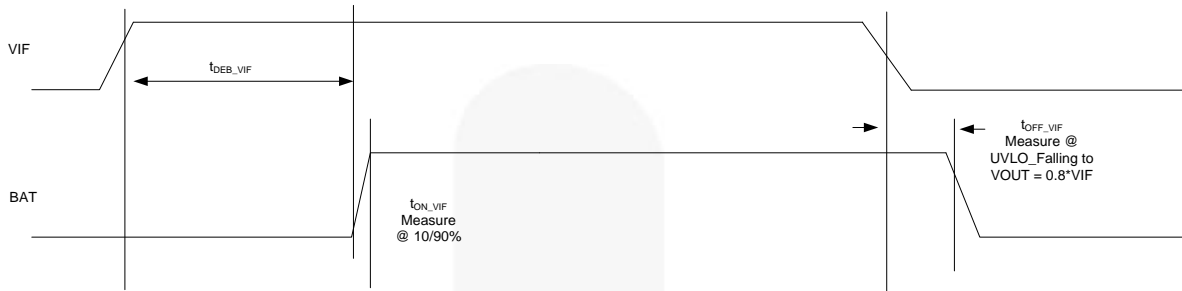


Figure 8. Timing for  $V_{IF}$  Power Up/Down and Normal Operation (ON=Don't Care)

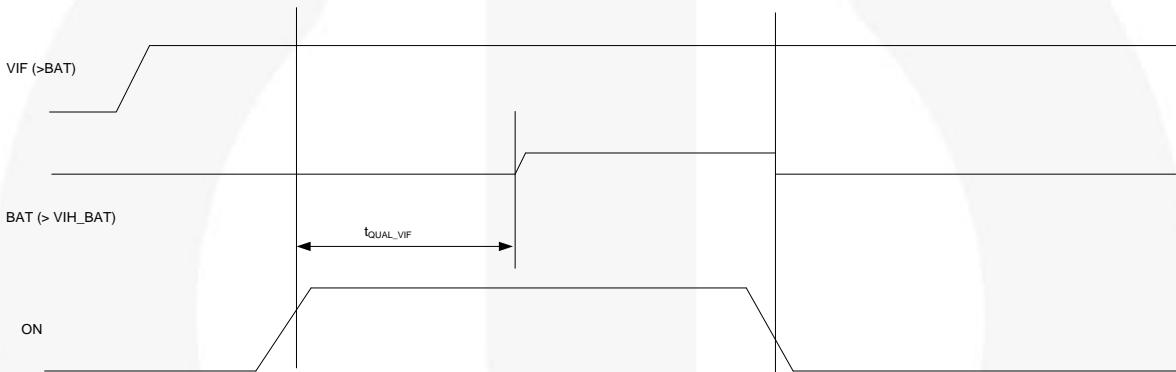


Figure 9. Timing for  $V_{IF}$  Power Up/Down and Normal Operation with ON Pin

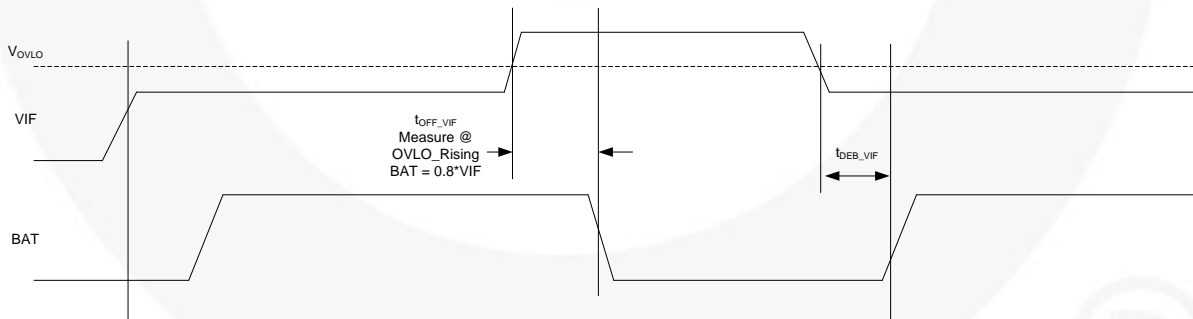


Figure 10. Timing for  $V_{IF}$  OVLO Operation (ON=Don't Care)

### V<sub>IF</sub> Turn-On Qualification State Diagram

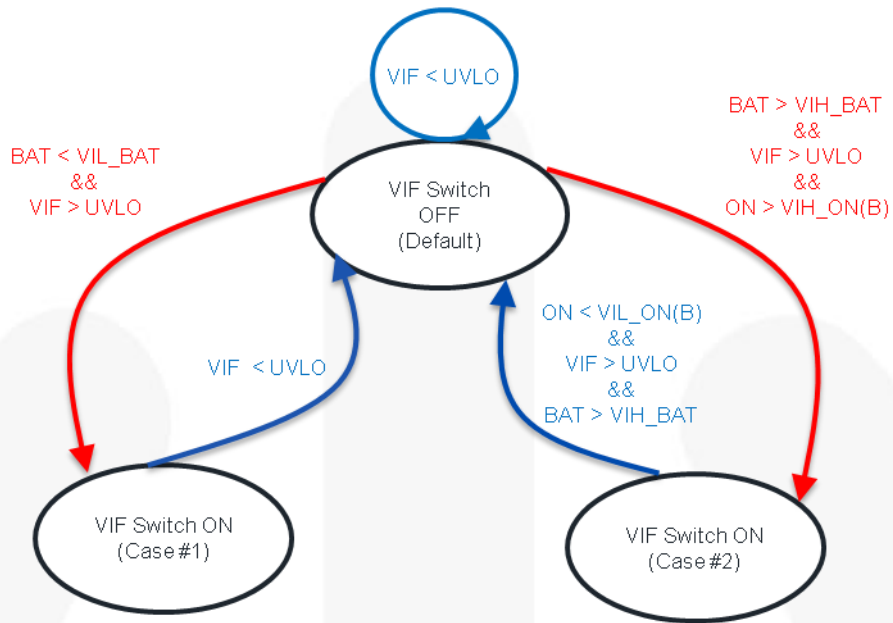


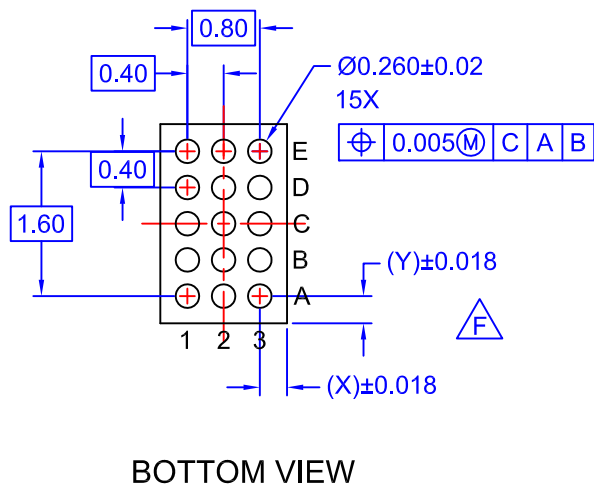
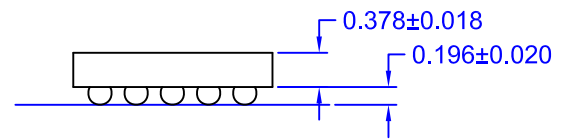
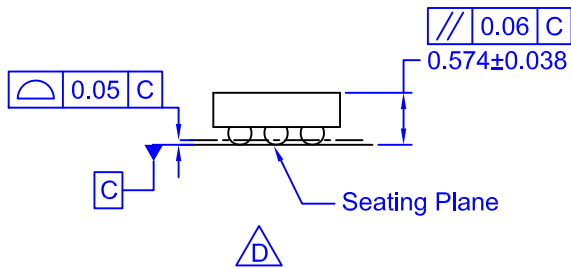
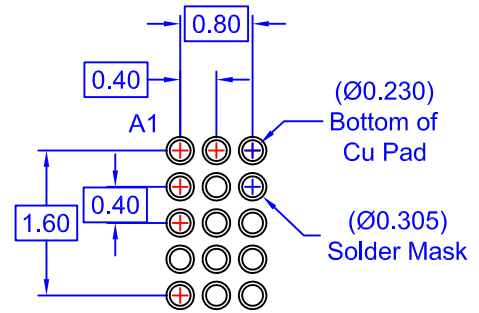
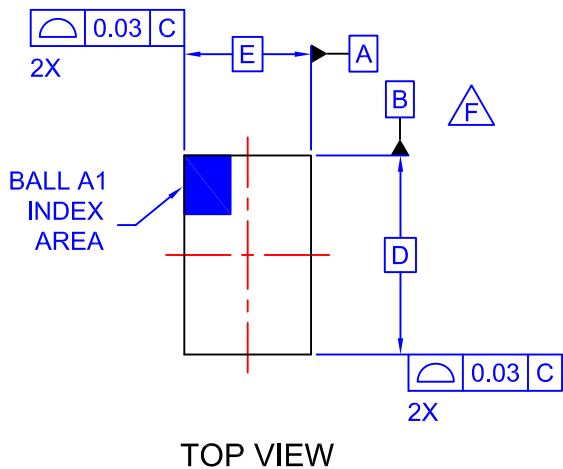
Figure 11. V<sub>IF</sub> Turn-On Qualification State Diagram

**Notes:**

- 4. Case #1 is reflecting removable battery system without ON signal.
- 5. Case #2 is reflecting embedded battery system with ON signal.

**Product-Specific Dimensions**

| D              | E              | X             | Y             |
|----------------|----------------|---------------|---------------|
| 2200 μm ±30 μm | 1600 μm ±30 μm | 400 μm ±18 μm | 300 μm ±18 μm |



#### NOTES

- A. NO JEDEC REGISTRATION APPLIES.
- B. DIMENSIONS ARE IN MILLIMETERS.
- C. DIMENSIONS AND TOLERANCE PER ASMEY14.5M, 2009.
- D.** DATUM C IS DEFINED BY THE SPHERICAL CROWNS OF THE BALLS.
- E.** PACKAGE NOMINAL HEIGHT IS  $574 \pm 38$  MICRONS (536-612 MICRONS).
- F.** FOR DIMENSIONS D, E, X, AND Y SEE PRODUCT DATASHEET.
- G. DRAWING FILNAME: MKT-UC015AC REV2.



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