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ON Semiconductor®

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# FPF2895

## 28 V / 5 A Rated Current Limit Switch with OVP and TRCB

### Features

- 28 V / 5 A Capability
- Wide Input Voltage Range: 4 V ~ 22 V
- Ultra Low On-Resistance
  - Typ. 27 mΩ at 5 V and 25 °C
- Adjustable Current Limit with external RSET
  - 500 mA ~ 5 A
- Selectable OVLO with OV1 and OV2 Logic Input
  - 5.95 V ± 50 mV
  - 10 V ± 100 mV
  - 14 V ± 280 mV
  - 23 V ± 460 mV
- Selectable ON Polarity
- Selectable Over-Current Behavior
  - Auto-Restart Mode
  - Current Source Mode
- True Reverse Current Block
- Thermal Shutdown
- Open Drain Fault FLAGB Output
- UL60950-1 & IEC 60950-1 Certification 5 A Max Loading
- Robust ESD Capability
  - 2 kV HBM & 1 kV CDM
  - 15 kV Air Discharge & 8 kV Contact Discharge under IEC 61000-4-2

### Description

The FPF2895 features a 28 V and 5 A rated current limit power switch, which offers Over-Current Protection (OCP), Over-Voltage Protection (OVP), and True Reverse Current Block (TRCB) to protect system. It has low On-resistance of typical 27 mΩ with WL-CSP can operate over an input voltage range of 4 V to 22 V.

The FPF2895 supports ±10% of current limit accuracy, over-current range of 500 mA to 5 A, flexible operations such as selectable OVP, selectable ON polarity and selectable OCP behavior, which can be optimized according to system requirements.

The FPF2895 is available in a 24-bump, 1.67 mm x 2.60 mm Wafer-Level Chip-Scale Package (WL-CSP) with 0.4 mm pitch.

### Applications

- Laptop, Desktop Computing and Monitor
- Power Accessories

### Related Resources

[www.fairchildsemi.com](http://www.fairchildsemi.com)

### Ordering Information

| Part Number | Operating Temperature Range | Top Mark | Package                     | Packing Method |
|-------------|-----------------------------|----------|-----------------------------|----------------|
| FPF2895UCX  | -40°C – +85°C               | T9       | 24-Ball, 0.4 mm Pitch WLCSP | Tape & Reel    |

## Application Diagram

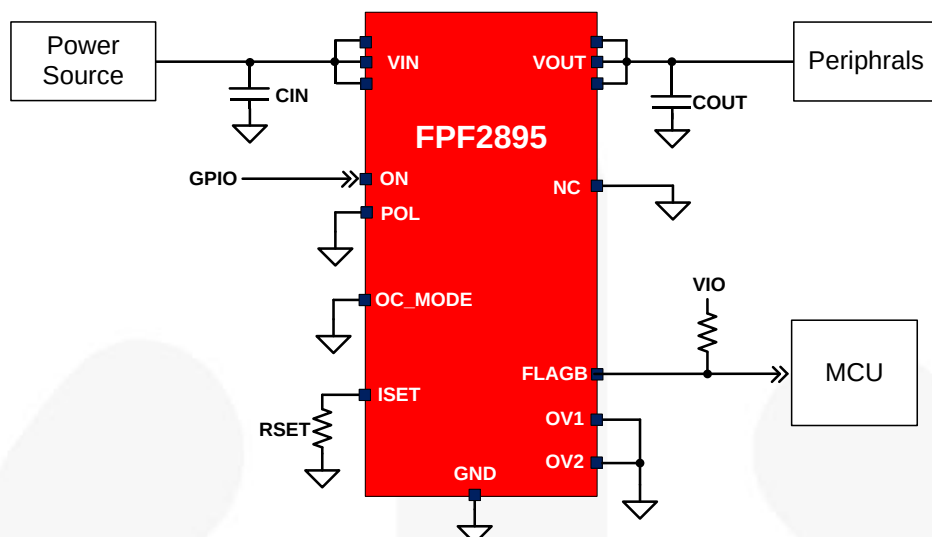


Figure 1. Typical Application

## Block Diagram

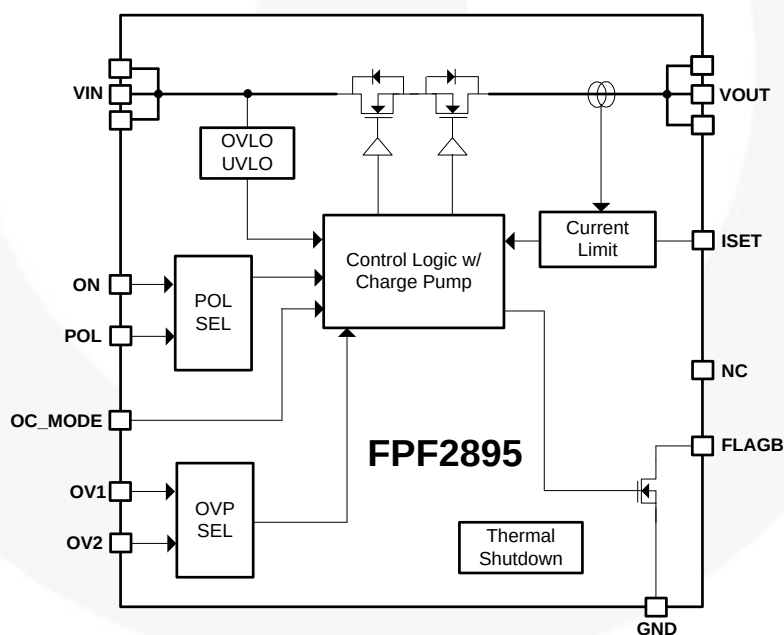


Figure 2. Functional Block Diagram

## Pin Configuration

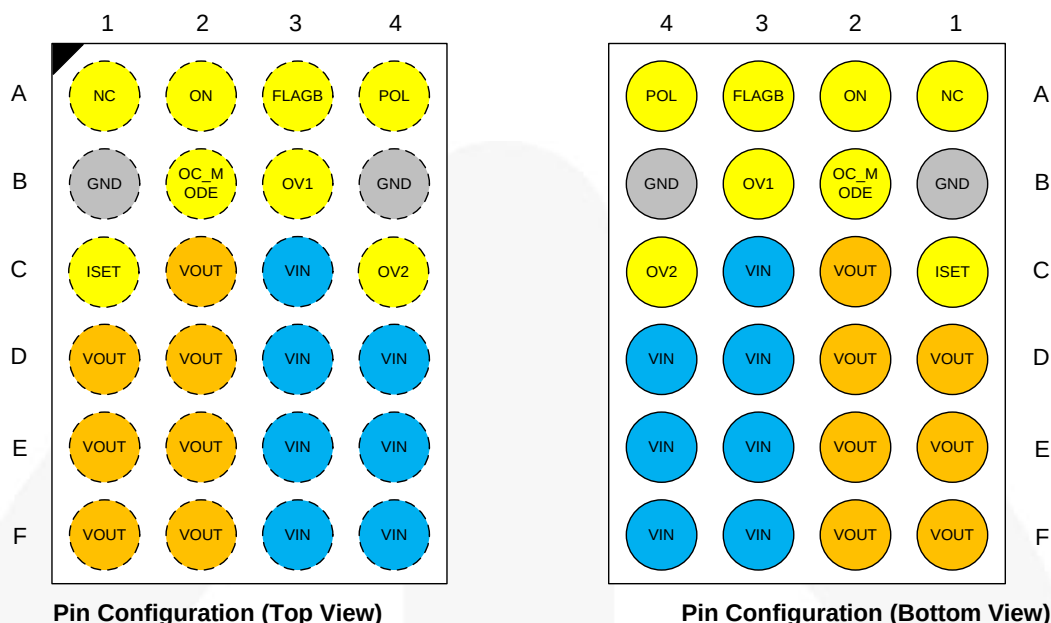


Figure 3. 24 Ball WL\_CSP, 4 x 6 Array, 0.4 mm Pitch, 250  $\mu$ m Ball

## Pin Definitions

| Name    | Bump                       | Type         | Description                                                                                                                                                                                                                |
|---------|----------------------------|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| VIN     | C3, D3, D4, E3, E4, F3, F4 | Input/Supply | Switch Input and Device Supply                                                                                                                                                                                             |
| VOUT    | C2, D1, D2, E1, E2, F1, F2 | Output       | Switch Output to Load                                                                                                                                                                                                      |
| NC      | A1                         | Dummy        | Recommended to connect to GND                                                                                                                                                                                              |
| ON      | A2                         | Input        | Internal pull-down resistor of 5 M $\Omega$ is included. Active polarity is depending on POL state. <sup>(1)</sup>                                                                                                         |
| POL     | A4                         | Input        | Enable Polarity Selection. Internal pull-up of 5 M $\Omega$ is included. HIGH (or Floating): Active LOW<br>LOW: Active HIGH <sup>(1)</sup>                                                                                 |
| FLAGB   | A3                         | Output       | Active LOW, open drain output indicates an over-current, under-voltage, over-voltage, or over-temperature state.                                                                                                           |
| ISET    | C1                         | Input        | A resistor from ISET to ground set the current limit for the switch. See below selection table 1.                                                                                                                          |
| OC_MODE | B2                         | Input        | OCP behavior can be selected. Internal pull-up of 5 M $\Omega$ is included. HIGH (or Floating): Auto-restart mode during over-current condition.<br>LOW: Current source mode during over-current condition. <sup>(1)</sup> |
| OV1     | B3                         | Input        | Over-Voltage Selection Input 1. Internal pull-up of 5 M $\Omega$ is included and see below selection table 2. <sup>(1)</sup>                                                                                               |
| OV2     | C4                         | Input        | Over-Voltage Selection Input 2. Internal pull-up of 5 M $\Omega$ is included and see Table 2. <sup>(1)</sup>                                                                                                               |
| GND     | B1, B4                     | GND          | Device Ground                                                                                                                                                                                                              |

### Note:

1. To avoid external noise influence when floating, recommend to connect these pins to a certain level.

## 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 <sub>IN</sub> , V <sub>OUT</sub> | V <sub>IN</sub> , V <sub>OUT</sub> to GND                                       | -0.3                                     | 28.0              | V    |
| V <sub>PIN</sub>                   | ON, POL, OC_MODE, ISET, FLAGB and OVn to GND                                    | -0.3                                     | 6.0               | V    |
| I <sub>SW</sub>                    | Continuous Switch Current                                                       |                                          | 5.5               | A    |
| t <sub>PD</sub>                    | Total Power Dissipation at T <sub>A</sub> =25°C                                 |                                          | 2.08              | W    |
| T <sub>STG</sub>                   | Storage Junction Temperature                                                    | -65                                      | +150              | °C   |
| T <sub>J</sub>                     | Operating Junction Temperature                                                  |                                          | +150              | °C   |
| T <sub>L</sub>                     | Lead Temperature (Soldering, 10 Seconds)                                        |                                          | +260              | °C   |
| Θ <sub>JA</sub>                    | Thermal Resistance, Junction-to-Ambient (1in. <sup>2</sup> pad of 2 oz. copper) |                                          | 60 <sup>(2)</sup> | °C/W |
| ESD                                | Electrostatic Discharge Capability                                              | Human Body Model, ANSI/ESDA/JEDEC JS-001 | 2                 | kV   |
|                                    |                                                                                 | Charged Device Model, JESD22-C101        | 1                 |      |
|                                    | IEC61000-4-2 System Level                                                       | Air Discharge                            | 15                |      |
|                                    |                                                                                 | Contact Discharge                        | 8                 |      |

**Note:**

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. ON does not recommend exceeding them or designing to Absolute Maximum Ratings.

| Symbol                             | Parameter                     | Min. | Max. | Unit |
|------------------------------------|-------------------------------|------|------|------|
| V <sub>IN</sub>                    | Supply Voltage                | 4.0  | 22.0 | V    |
| C <sub>IN</sub> / C <sub>OUT</sub> | Input and Output Capacitance  | 1.0  |      | μF   |
| T <sub>A</sub>                     | Ambient Operating Temperature | -40  | +85  | °C   |

## Electrical Characteristics

Unless otherwise noted,  $V_{IN}=4$  to 22 V,  $T_A=-40$  to 85°C; typical values are at  $V_{IN}=5$  V,  $C_{IN}=C_{OUT}=1$   $\mu$ F, ON=HIGH, POL=OV1=OV2=OC\_MODE=GND and  $T_A = 25^\circ\text{C}$ .

| Symbol                   | Parameter                                 | Conditions                                                                                                                  |                         | Min.  | Typ.  | Max.  | Unit |
|--------------------------|-------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|-------------------------|-------|-------|-------|------|
| Basic Operation          |                                           |                                                                                                                             |                         |       |       |       |      |
| V <sub>IN</sub>          | Input Voltage                             |                                                                                                                             |                         | 4     |       | 22    | V    |
| I <sub>SD_IN</sub>       | V <sub>IN</sub> Shutdown Current          | V <sub>ON</sub> =OFF, V <sub>IN</sub> =5.5 V, V <sub>OUT</sub> =Short to GND                                                |                         |       | 75    | 100   | μA   |
| I <sub>Q</sub>           | Quiescent Current                         | I <sub>OUT</sub> =0 mA, V <sub>ON</sub> =ON                                                                                 | V <sub>IN</sub> =5 V    |       | 270   | 330   | μA   |
|                          |                                           |                                                                                                                             | V <sub>IN</sub> =12 V   |       | 300   | 400   |      |
|                          |                                           |                                                                                                                             | V <sub>IN</sub> =20 V   |       | 350   | 450   |      |
| R <sub>ON</sub>          | On Resistance                             | T <sub>A</sub> =25°C, I <sub>OUT</sub> =1 A                                                                                 | V <sub>IN</sub> =5 V    |       | 27    | 39    | mΩ   |
|                          |                                           |                                                                                                                             | V <sub>IN</sub> =12 V   |       | 27    | 39    |      |
|                          |                                           |                                                                                                                             | V <sub>IN</sub> =20 V   |       | 27    | 39    |      |
| I <sub>ON</sub>          | ON Input Leakage                          | V <sub>ON</sub> =V <sub>IN</sub> or GND                                                                                     |                         |       |       | 2     | μA   |
| V <sub>IH</sub>          | ON Input Logic High Voltage               | V <sub>IN</sub> =3 V~23 V                                                                                                   |                         | 1.2   |       |       | V    |
| V <sub>IL</sub>          | ON Input Logic Low Voltage                | V <sub>IN</sub> =3 V~23 V                                                                                                   |                         |       |       | 0.4   | V    |
| V <sub>P_LOW</sub>       | FLAGB Output Logic Low Voltage            | V <sub>IN</sub> =5 V, I <sub>SINK</sub> =5 mA                                                                               |                         |       | 0.1   | 0.2   | V    |
| I <sub>LKG</sub>         | FLAGB Output High, Leakage Current        | V <sub>IN</sub> =5 V, Switch ON                                                                                             |                         |       |       | 1     | μA   |
| Protections              |                                           |                                                                                                                             |                         |       |       |       |      |
| I <sub>LIM</sub>         | Current Limit <sup>(3)</sup>              | V <sub>IN</sub> =5 V, V <sub>OUT</sub> =4 V, R <sub>SET</sub> =2.96 kΩ, T <sub>A</sub> = -40 to 85°C                        |                         | 1.35  | 1.50  | 1.65  | A    |
|                          |                                           | V <sub>IN</sub> =5 V, V <sub>OUT</sub> =4 V, R <sub>SET</sub> =1.48 kΩ, T <sub>A</sub> = -40 to 85°C                        |                         | 2.7   | 3.0   | 3.3   |      |
| V <sub>FOLD</sub>        | ILIM Foldback Trip Voltage <sup>(3)</sup> | V <sub>OUT</sub> under ILIM Mode                                                                                            |                         |       | 2     |       | V    |
| I <sub>FOLD</sub>        | ILIM Foldback Gain <sup>(3)</sup>         | V <sub>IN</sub> =5 V, V <sub>OUT</sub> < V <sub>FOLD</sub> , T <sub>A</sub> =25°C, OC_MODE=HIGH                             |                         |       | 500   |       | mA   |
|                          |                                           | V <sub>IN</sub> =5 V, V <sub>OUT</sub> < V <sub>FOLD</sub> , T <sub>A</sub> =25°C, OC_MODE=LOW                              |                         |       | 250   |       | mA   |
| V <sub>UVLO</sub>        | Under-Voltage Lockout                     | V <sub>IN</sub> Increasing                                                                                                  |                         |       | 2.70  | 2.95  | V    |
|                          |                                           | V <sub>IN</sub> Decreasing                                                                                                  |                         |       | 2.5   |       |      |
|                          | UVLO Hysteresis                           |                                                                                                                             |                         |       | 200   |       | mV   |
| V <sub>OVLO</sub>        | Over-Voltage Lockout                      | OV1=LOW, OV2=LOW                                                                                                            | V <sub>IN</sub> Rising  | 22.54 | 23.00 | 23.46 | V    |
|                          |                                           |                                                                                                                             | V <sub>IN</sub> Falling | 22.34 |       |       |      |
|                          |                                           | OV1=LOW, OV2=HIGH                                                                                                           | V <sub>IN</sub> Rising  | 9.90  | 10.00 | 10.10 |      |
|                          |                                           |                                                                                                                             | V <sub>IN</sub> Falling | 9.85  |       |       |      |
|                          |                                           | OV1=HIGH, OV2=LOW                                                                                                           | V <sub>IN</sub> Rising  | 13.72 | 14.00 | 14.28 |      |
|                          |                                           |                                                                                                                             | V <sub>IN</sub> Falling | 13.52 |       |       |      |
|                          |                                           | OV1=HIGH, OV2=HIGH                                                                                                          | V <sub>IN</sub> Rising  | 5.90  | 5.95  | 6.00  |      |
|                          |                                           |                                                                                                                             | V <sub>IN</sub> Falling | 5.85  |       |       |      |
| t <sub>OVP</sub>         | OVP Response Time <sup>(3)</sup>          | R <sub>L</sub> =100 Ω, C <sub>L</sub> =0 μF, V <sub>IN</sub> > V <sub>OVLO</sub> to V <sub>OUT</sub> =0.9 × V <sub>IN</sub> |                         |       |       | 150   | ns   |
| V <sub>T_RCB</sub>       | TRCB Protection Trip Point                | V <sub>OUT</sub> - V <sub>IN</sub>                                                                                          |                         |       | 25    | 40    | mV   |
| V <sub>R_RCB</sub>       | TRCB Protection, Release Point            | V <sub>IN</sub> - V <sub>OUT</sub>                                                                                          |                         |       | 25    | 40    | mV   |
| t <sub>RCB</sub>         | TRCB Response Time <sup>(3)</sup>         | V <sub>IN</sub> =5 V, V <sub>ON</sub> =HIGH/LOW                                                                             |                         |       | 5     |       | μs   |
| t <sub>RCB_Release</sub> | TRCB Release Time <sup>(3)</sup>          | V <sub>IN</sub> =5 V, Enabled                                                                                               |                         |       | 1     |       | μs   |
| t <sub>OC</sub>          | Over Current Response Time <sup>(3)</sup> | V <sub>IN</sub> =5 V, Moderate OC                                                                                           |                         |       | 20    |       | μs   |
|                          |                                           | V <sub>IN</sub> =5 V, Hard Short                                                                                            |                         |       | 5     |       |      |

## Electrical Characteristics

Unless otherwise noted,  $V_{IN}=4$  to 22 V,  $T_A=-40$  to 85°C; typical values are at  $V_{IN}=5$  V,  $C_{IN}=C_{OUT}=1$   $\mu$ F, ON=HIGH, POL=OV1=OV2=OC\_MODE=GND and  $T_A = 25^\circ\text{C}$ .

| Symbol              | Parameter                                      | Conditions                                                                 | Min. | Typ. | Max. | Unit |
|---------------------|------------------------------------------------|----------------------------------------------------------------------------|------|------|------|------|
| I <sub>SD_OUT</sub> | V <sub>OUT</sub> Shutdown Current              | V <sub>ON</sub> =OFF, V <sub>OUT</sub> =5 V, V <sub>IN</sub> =Short to GND |      |      | 2    | μA   |
| TSD                 | Thermal Shutdown <sup>(3)</sup>                | Shutdown Threshold                                                         |      | 150  |      | °C   |
|                     |                                                | Hysteresis                                                                 |      | 20   |      |      |
| Dynamic Behavior    |                                                |                                                                            |      |      |      |      |
| t <sub>DON</sub>    | Delay On Time                                  | R <sub>L</sub> =100 Ω, C <sub>L</sub> =1 μF                                |      | 1    |      | ms   |
| t <sub>R</sub>      | V <sub>OUT</sub> Rise Time                     | R <sub>L</sub> =100 Ω, C <sub>L</sub> =1 μF                                |      | 1    |      | ms   |
| t <sub>ON</sub>     | Turn-On Time                                   | R <sub>L</sub> =100 Ω, C <sub>L</sub> =1 μF                                |      | 2    |      | ms   |
| t <sub>DOFF</sub>   | Delay Off Time                                 | R <sub>L</sub> =100 Ω, C <sub>L</sub> =1 μF                                |      | 10   |      | μs   |
| t <sub>F</sub>      | V <sub>OUT</sub> Fall Time                     | R <sub>L</sub> =100 Ω, C <sub>L</sub> =1 μF                                |      | 200  |      | μs   |
| t <sub>OFF</sub>    | Turn-Off Time                                  | R <sub>L</sub> =100 Ω, C <sub>L</sub> =1 μF                                |      | 210  |      | μs   |
| t <sub>BLANK</sub>  | Over-Current Blanking Time <sup>(3)</sup>      | OC_MODE=HIGH                                                               |      | 5    |      | ms   |
| t <sub>RSTRT</sub>  | Auto-Restart Time <sup>(3)</sup>               | OC_MODE=HIGH                                                               |      | 200  |      | ms   |
| t <sub>QUAL</sub>   | Over-Current Qualification Time <sup>(3)</sup> | OC_MODE=LOW                                                                |      | 5    |      | ms   |
| t <sub>DEB</sub>    | FLAGB Debounce Time <sup>(3)</sup>             | Restart-up during or after OC                                              |      | 3    |      | ms   |
|                     |                                                | Restart-up during or after Thermal shutdown                                |      | 15   |      |      |
|                     |                                                | Restart-up during or after UVLO                                            |      | 1    |      |      |

### Note:

- Guaranteed by characterization and design, not production test.

## Setting Current Limit

FPF2895 current limit is set with an external resistor connected between I<sub>SET</sub> and GND. This resistor is selected using the following equation:

$$R_{SET} [k\Omega] = 4448.6 / I_{LIM} [mA] \quad (1)$$

The resistor can be selected using 0. Resistor tolerance of 1% or less is recommended

**Table 1. ILIM vs. RSET Look-up Table**

| RSET [kΩ] | ILIM [mA] |      |      |
|-----------|-----------|------|------|
|           | Min.      | Typ. | Max. |
| 8.89      | 450       | 500  | 550  |
| 7.41      | 540       | 600  | 660  |
| 6.35      | 630       | 700  | 770  |
| 5.56      | 720       | 800  | 880  |
| 4.94      | 810       | 900  | 990  |
| 4.45      | 900       | 1000 | 1100 |
| 4.04      | 990       | 1100 | 1210 |
| 3.71      | 1080      | 1200 | 1320 |
| 3.42      | 1170      | 1300 | 1430 |
| 3.18      | 1260      | 1400 | 1540 |
| 2.96      | 1350      | 1500 | 1650 |
| 2.78      | 1440      | 1600 | 1760 |
| 2.62      | 1530      | 1700 | 1870 |
| 2.47      | 1620      | 1800 | 1980 |
| 2.34      | 1710      | 1900 | 2090 |
| 2.22      | 1800      | 2000 | 2200 |
| 2.12      | 1890      | 2100 | 2310 |
| 2.02      | 1980      | 2200 | 2420 |
| 1.93      | 2070      | 2300 | 2530 |
| 1.85      | 2160      | 2400 | 2640 |
| 1.78      | 2250      | 2500 | 2750 |
| 1.71      | 2340      | 2600 | 2860 |
| 1.65      | 2430      | 2700 | 2970 |
| 1.59      | 2520      | 2800 | 3080 |
| 1.53      | 2610      | 2900 | 3190 |
| 1.48      | 2700      | 3000 | 3300 |
| 1.43      | 2790      | 3100 | 3410 |
| 1.39      | 2880      | 3200 | 3520 |
| 1.35      | 2970      | 3300 | 3630 |
| 1.31      | 3060      | 3400 | 3740 |
| 1.27      | 3150      | 3500 | 3850 |
| 1.24      | 3240      | 3600 | 3960 |
| 1.20      | 3330      | 3700 | 4070 |
| 1.17      | 3420      | 3800 | 4180 |
| 1.14      | 3510      | 3900 | 4290 |
| 1.11      | 3600      | 4000 | 4400 |
| 1.08      | 3690      | 4100 | 4510 |
| 1.06      | 3780      | 4200 | 4620 |
| 1.03      | 3870      | 4300 | 4730 |
| 1.01      | 3960      | 4400 | 4840 |



**Table 1. ILIM vs. RSET Look-up Table (Continued)**

| RSET [kΩ]           | ILIM [mA] |      |      |
|---------------------|-----------|------|------|
|                     | Min.      | Typ. | Max. |
| 0.99 <sup>(4)</sup> | 4050      | 4500 | 4950 |
| 0.97                | 4140      | 4600 | 5060 |
| 0.95                | 4230      | 4700 | 5170 |
| 0.93                | 4320      | 4800 | 5280 |
| 0.91                | 4410      | 4900 | 5390 |
| 0.89                | 4500      | 5000 | 5500 |

**Note:**

4. Passed UL&CB certification with max. 5 A output current.

**Table 2. OVLO Level Selection**

| OV1             | OV2             | OVLO          |
|-----------------|-----------------|---------------|
| LOW             | LOW             | 23 V ±460 mV  |
| LOW             | HIGH (Floating) | 10 V ±100 mV  |
| HIGH (Floating) | LOW             | 14 V ±280 mV  |
| HIGH (Floating) | HIGH (Floating) | 5.95 V ±50 mV |

**Table 3. Device Enable Polarity Selection**

| POL             | ON             | Device State | ON Polarity |
|-----------------|----------------|--------------|-------------|
| LOW             | LOW (Floating) | OFF          | Active HIGH |
| LOW             | HIGH           | ON           |             |
| HIGH (Floating) | LOW (Floating) | ON           | Active LOW  |
| HIGH (Floating) | HIGH           | OFF          |             |

## Timing Diagrams

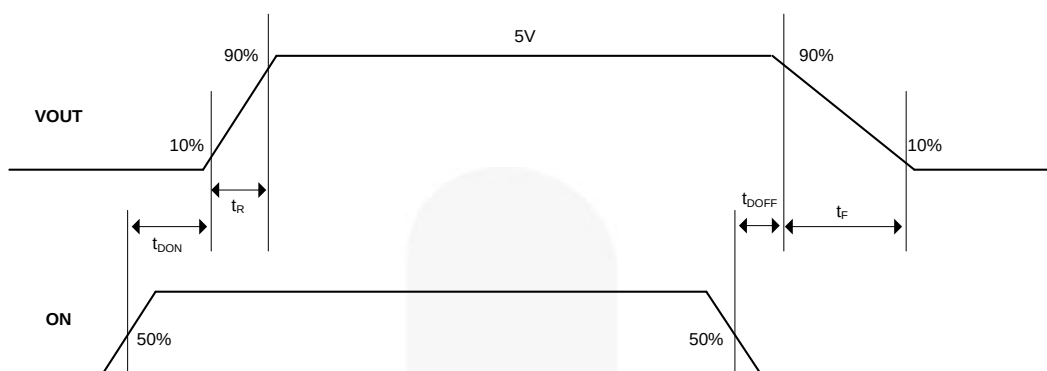


Figure 4. Normal ON/OFF Operation by ON (POL=GND)

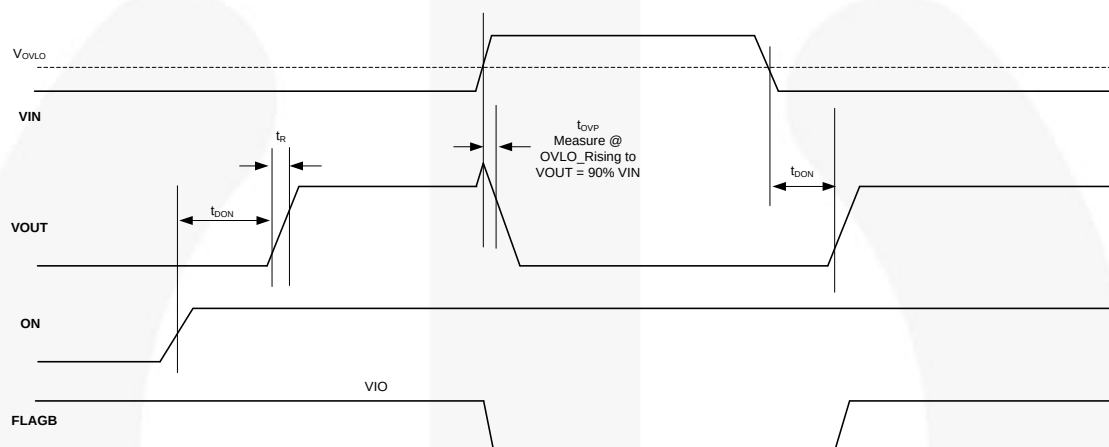


Figure 5. OVLO Operation (POL=GND & FLAGB is pulled up with an external VIO)

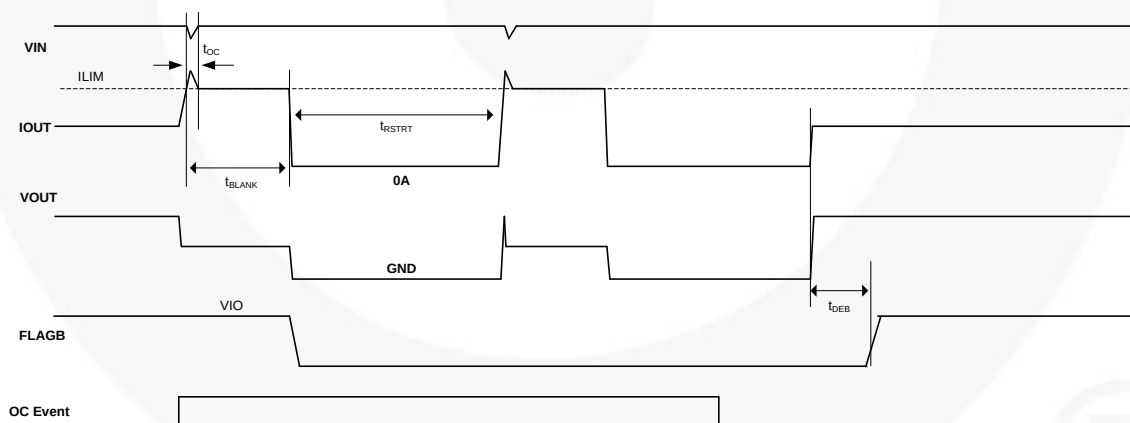


Figure 6. Current Limit Operation (OC\_MODE=HIGH & FLAGB is pulled up with an external VIO)

## Timing Diagrams (Continued)

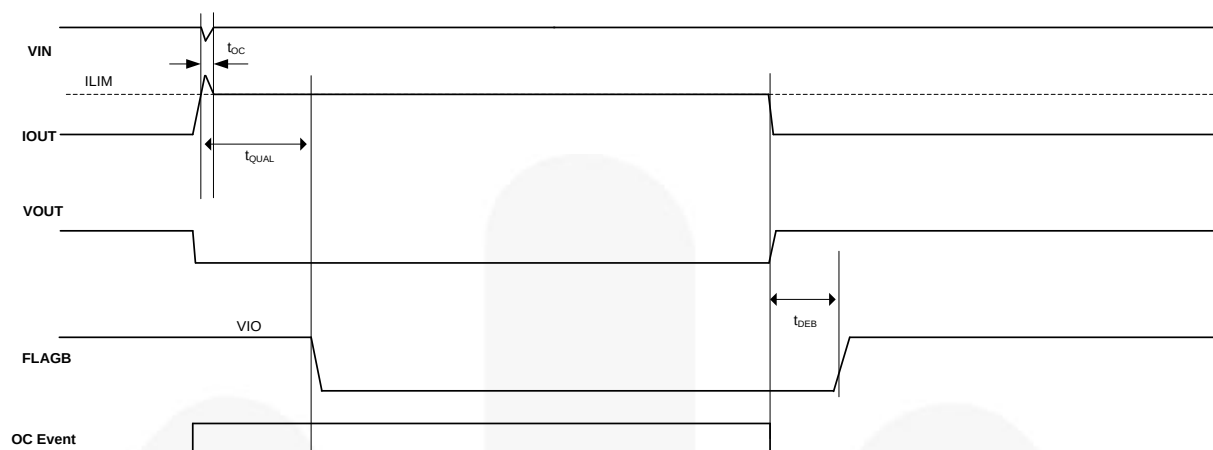


Figure 7. Current Limit Operation (OC\_MODE=LOW & FLAGB is pulled up with an external VIO)

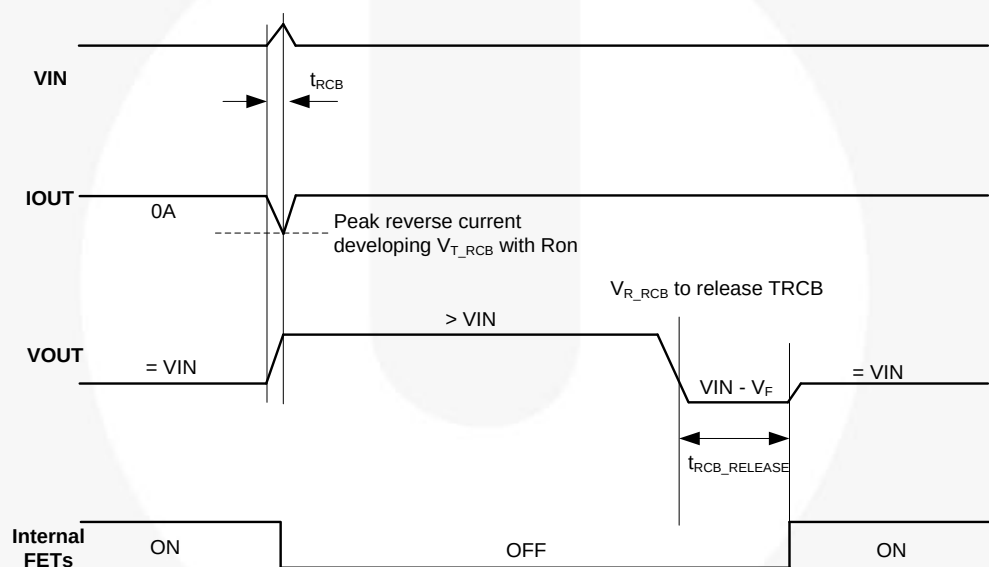
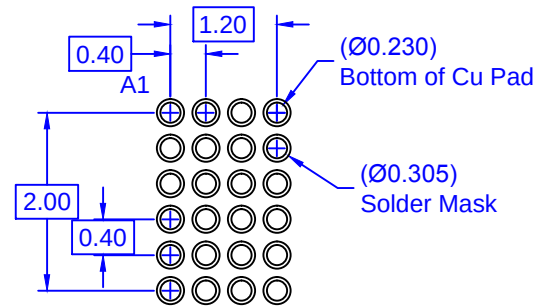


Figure 8. TRCB Operation (Device is Enabled)

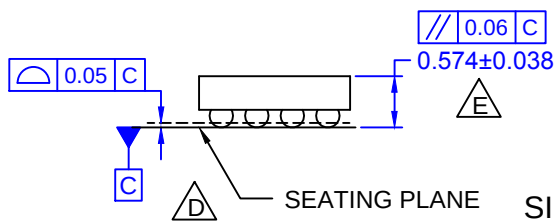
The table below pertains to the Marketing outline drawing on the following page.

## Product-Specific Dimensions

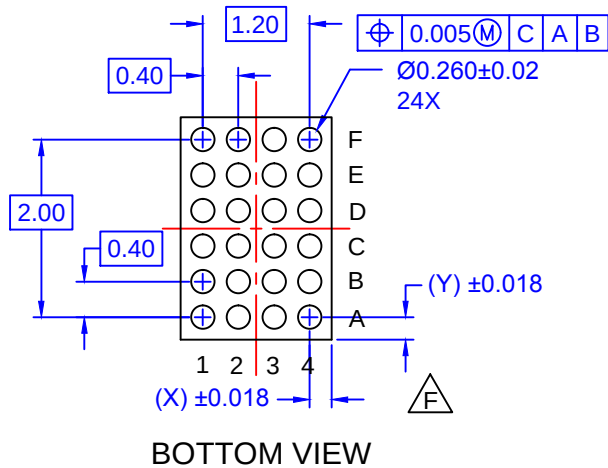
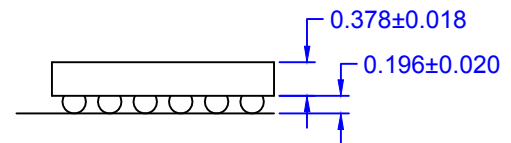
| D                                     | E                                     | X                                    | Y                                    |
|---------------------------------------|---------------------------------------|--------------------------------------|--------------------------------------|
| 2600 $\mu\text{m} \pm 30 \mu\text{m}$ | 1670 $\mu\text{m} \pm 30 \mu\text{m}$ | 235 $\mu\text{m} \pm 18 \mu\text{m}$ | 300 $\mu\text{m} \pm 18 \mu\text{m}$ |



### RECOMMENDED LAND PATTERN (NSMD PAD TYPE)



## SIDE VIEWS



- 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 FILENAME: MKT-UC024AA REV3



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