## ON Semiconductor ${ }^{\text {® }}$

## FPF2193 / FPF2194 / FPF2195 <br> Full-Function Load Switch with Adjustable Current Limit

## Features

- <1.8 to 5.5 V Input Voltage Range
- Controlled Turn-On
- 0.1 to 1.5 A Adjustable Current Limit
- Under-Voltage Lockout
- Thermal Shutdown
- $\quad<2 \mu \mathrm{~A}$ Shutdow $n$ Current
- Auto Restart
- Fast Current Limit Response Time
- $5 \mu \mathrm{~s}$ to Moderate Over Currents
- 30 ns to Hard Shorts
- Fault Blanking
- Reverse Current Blocking


## Applications

- PDAs
- Cell Phones
- Handheld GPS Devices
- Portable Enterprise / Industrial Devices
- Digital Cameras
- Peripheral Ports and Accessories
- Portable Medical Equipment
- Hot Sw ap Supplies


## Description

The FPF2193, FPF2194, and FPF2195 form a series of load switches that provides full protection to systems and loads that may encounter large current conditions. These devices contain a $55 \mathrm{~m} \Omega$ current-limited $P$ channel MOSFET that can operate over an input voltage range of 1.8 to 5.5 V . Internally, current is prevented from flow ing when the MOSFET is off and the output voltage is higher than the input voltage. Switch control is by a logic input (ON) capable of interfacing directly with low-voltage control signals. Each part contains thermal shutdown protection that shuts off the sw itch to prevent damage to the part when a continuous over-current condition causes excessive heating.

When the switch current reaches the current limit, the parts operate in a constant-current mode to prohibit excessive currents from causing damage. For the FPF2193 and FPF2194, if the constant current condition still persists after 30 ms , the parts shut off the switch and pull the fault signal pin (FLAGB) LOW. The FPF2193 has an auto-restart feature that turns the sw itch on again after 450 ms if the ON pin is still active. The FPF2194 does not have this auto-restart feature, so the switch remains off until the ON pin is cycled. The FPF2195 does not turn off after a current limit fault, but remains in the constant-current mode indefinitely. The minimum current limit can be set as low as 45 mA .
These parts are available in a space-saving six ball advanced $0.98 \times 1.48 \mathrm{~mm}$ WLCSP package.

## Ordering Information

| Part Number | Current <br> Limit [mA] | Current Limit Blanking Time [ms] | Auto-Restart Time [ms] | ON Pin Activity | Top Mark |
| :---: | :---: | :---: | :---: | :---: | :---: |
| FPF2193 | 100-1500 | 15/30/60 | 225/450/900 | Active HIGH | S6 |
| FPF2194 |  | 15/30/60 | NA |  | S7 |
| FPF2195 |  | 0 | NA |  | S9 |
| FPF2195BUCX | 45-1500 | 0 | NA |  | SY |

## Application Diagram



Figure 1. Typical Application

## Block Diagram



Figure 2. Functional Block Diagram

## Pin Configuration

Pin 1


BOTTOM


TOP

Figure 3. $1.0 \times 1.5 \mathrm{~mm}$ Chip-Scale Package


Figure 4. Pin Configuration (Bottom View)

## Pin Definitions

| Pin \# | Name | Description |
| :---: | :---: | :--- |
| C1 | ISET | Current Limit Set Input. A resistor from Iset to ground sets the current limit for the sw itch. |
| B2 | VIN $^{\prime}$ | Supply Input. Input to the pow er sw itch and the supply voltage for the IC. |
| B1 | Vout | Sw itch Output. Output of the pow er sw itch. |
| A1 | FLAGB | Fault Output. Active LOW, open-drain output that indicates an over-current supply, under- <br> voltage, or over-temperature state. |
| C2 | GND | Ground. |
| A2 | ON | ON control input, active HIGH. |

## 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 |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\mathrm{V}_{\text {IN }}$, $\mathrm{V}_{\text {out, }}$ ON, FLAGB, ISET to GND |  | -0.3 | 6.0 | V |
| PD | Pow er Dissipation at $\mathrm{TA}^{\prime}=25^{\circ} \mathrm{C}{ }^{(1)}$ |  |  | 1.2 | W |
| TJ | Operating Temperature Range |  | -40 | +125 | ${ }^{\circ} \mathrm{C}$ |
| Tsta | Storage Temperature |  | -65 | +150 | ${ }^{\circ} \mathrm{C}$ |
| $\Theta_{\mathrm{JA}}$ | Thermal Resistance, Junction to Ambient |  |  | 85 | ${ }^{\circ} \mathrm{C} / \mathrm{W}$ |
| ESD | Electrostatic Discharge Capability | Human Body Model, JESD22-A114 | 8000 |  |  |
|  |  | Machine Model, JESD22-A115 | 400 |  |  |

## Note:

1. Package pow er dissipation on one-square inch pad, tw o-ounce copper board.

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

| Symbol | Parameter | Min. | Max. | Unit |
| :---: | :--- | :---: | :---: | :---: |
| $\mathrm{V}_{\text {IN }}$ | Input Voltage | 1.8 | 5.5 | V |
| $\mathrm{~T}_{\mathrm{A}}$ | Ambient Operating Temperature | -40 | +85 | ${ }^{\circ} \mathrm{C}$ |

## Electrical Characteristics

$\mathrm{V}_{\mathbb{N}}=1.8$ to $5.5 \mathrm{~V}, \mathrm{~T}_{\mathrm{A}}=-40$ to $+85^{\circ} \mathrm{C}$ unless otherw ise noted. Typical values are at $\mathrm{V}_{\mathbb{N}}=3.3 \mathrm{~V}$ and $\mathrm{T}_{\mathrm{A}}=25^{\circ} \mathrm{C}$.

| Symbol | Parameter | Conditions |  | Min. | Typ. | Max. | Units |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Basic Operation |  |  |  |  |  |  |  |
| $\mathrm{V}_{\text {IN }}$ | Operating Voltage |  |  | 1.8 |  | 5.5 | V |
| lQ | Quiescent Current | lout $=0 \mathrm{~mA}, \mathrm{~V}_{\text {ON }}=\mathrm{V}_{\text {IN }}$ | $\mathrm{V}_{\mathrm{IN}}=1.8 \mathrm{~V}$ |  | 70 |  | $\mu \mathrm{A}$ |
|  |  |  | $\mathrm{V}_{\mathrm{IN}}=3.3 \mathrm{~V}$ |  | 75 |  |  |
|  |  |  | $\mathrm{V}_{\mathrm{IN}=}=5.5 \mathrm{~V}$ |  | 80 |  |  |
| Ron | On Resistance | $\mathrm{T}_{\mathrm{A}}=25^{\circ} \mathrm{C}$, lout $=200 \mathrm{~mA}$ |  |  | 55 | 80 | $\mathrm{m} \Omega$ |
|  |  | $\mathrm{T}_{\mathrm{A}=-40}$ to $85^{\circ} \mathrm{C}$, lout $=200 \mathrm{~mA}$ |  |  |  | 135 |  |
| $\mathrm{V}_{\text {IH }}$ | On Input Logic High Voltage ON | $\mathrm{V}_{\mathrm{IN}}=1.8 \mathrm{~V}$ |  | 0.8 |  |  | V |
|  |  | $\mathrm{V}_{\mathrm{IN}}=5.5 \mathrm{~V}$ |  | 1.4 |  |  |  |
| VIL | On Input Logic Low Voltage | $\mathrm{V}_{\mathrm{IN}}=1.8 \mathrm{~V}$ |  |  |  | 0.5 | V |
|  |  | $\mathrm{V}_{\mathrm{IN}}=5.5 \mathrm{~V}$ |  |  |  | 1.0 |  |
| 1 N | On Input Leakage | $\mathrm{V}_{\text {ON }}=\mathrm{V}_{\text {IN }}$ or GND |  | -1 | 0 | 1 | $\mu \mathrm{A}$ |
| VIN_SD | VIN Shutdown Current | $\begin{aligned} & \mathrm{V}_{\text {ON }}=0 \mathrm{~V}, \mathrm{~V}_{\text {IN }}=5.5 \mathrm{~V}, \\ & \mathrm{~V}_{\text {OUT }}=\text { Short to } \end{aligned}$ |  | -2 |  | 2 | $\mu \mathrm{A}$ |
| $V_{\text {FLB_L }}$ | FLAGB Output Logic Low Voltage | $\mathrm{V}_{\text {IN }}=5 \mathrm{~V}, \mathrm{ISINK}=10 \mathrm{~mA}$ |  |  | 0.05 | 0.20 | V |
|  |  | $\mathrm{V}_{\text {IN }}=1.8 \mathrm{~V}, \mathrm{ISINK}=10 \mathrm{~mA}$ |  |  | 0.12 | 0.30 |  |
| IFLB_H | FLAGB Output Logic High Leakage Current | $\mathrm{V}_{\text {IN }}=5 \mathrm{~V}$, Sw itch ON |  |  |  | 1 | $\mu \mathrm{A}$ |
| Reverse Block |  |  |  |  |  |  |  |
| ISDT | Vout Shutdow n Current | $\begin{aligned} & \hline \mathrm{V}_{\text {ON }}=0 \mathrm{~V}, \mathrm{~V}_{\text {OUT }}=5.5 \mathrm{~V}, \\ & \mathrm{~V}_{\text {IN }}=\text { Short-to-GND } \end{aligned}$ |  | -2 |  | 2 | $\mu \mathrm{A}$ |
| V breakcown | Reverse Breakdow n Voltage | $\mathrm{V}_{\text {IN }}=\mathrm{V}_{\text {ON }}=0 \mathrm{~V}$, lout $=200 \mu \mathrm{~A}$ |  |  | 9 |  | V |
| Protections |  |  |  |  |  |  |  |
| lıIM | Current Limit | $\mathrm{V}_{\text {IN }}=3.3 \mathrm{~V}, \mathrm{~V}_{\text {OUT }}=3.0 \mathrm{~V}, \mathrm{R}_{\text {SET }}=690 \Omega$ |  | 600 | 800 | 1000 | mA |
|  | Current Limit for FPF2195BUCX | $\begin{aligned} & \hline \mathrm{V}_{\text {IN }}=4.5 \mathrm{~V}, \mathrm{~V}_{\text {OUT }}=4.2 \mathrm{~V}, \\ & \mathrm{R}_{\mathrm{SET}}=15.8 \mathrm{~K} \Omega \\ & \hline \end{aligned}$ |  | 35 | 45 | 60 | mA |
| LIIM(MIN) | Minimum Current Limit | $\begin{aligned} & \hline \mathrm{V}_{\text {IN }}=3.3 \mathrm{~V}, \mathrm{~V}_{\text {OUT }}=3.0 \mathrm{~V}, \\ & \mathrm{R}_{\mathrm{SET}}=5516 \Omega \\ & \hline \end{aligned}$ |  |  | 100 |  | ma |
| TSD | Thermal Shutdown | Shutdow n Threshold |  |  | 140 |  | ${ }^{\circ} \mathrm{C}$ |
|  |  | Return from Shutdow n |  |  | 130 |  |  |
|  |  | Hysteresis |  |  | 10 |  |  |
| Vuvio | Under-Voltage Lockout | VIN Increasing |  | 1.55 | 1.65 | 1.75 | V |
| VuvLo_hYst | Under-Voltage Lockout Hysteresis |  |  |  | 50 |  | mV |
| Dynamic |  |  |  |  |  |  |  |
| tdon | Delay On Time | $\mathrm{R}_{L}=500 \Omega, \mathrm{C}_{L}=0.1 \mu \mathrm{~F}$ |  |  | 20 |  | $\mu \mathrm{s}$ |
| $\mathrm{t}_{\mathrm{R}}$ | Vout Rise Time | $\mathrm{R}_{\mathrm{L}}=500 \Omega, \mathrm{C}_{L}=0.1 \mu \mathrm{~F}$ |  |  | 20 |  | $\mu \mathrm{s}$ |
| ton | Turn-On Time | $\mathrm{R}_{L}=500 \Omega, \mathrm{C}_{L}=0.1 \mu \mathrm{~F}$ |  |  | 40 |  | $\mu \mathrm{s}$ |
| tdoff | Delay Off Time | $\mathrm{R}_{L}=500 \Omega, \mathrm{C}_{L}=0.1 \mu \mathrm{~F}$ |  |  | 15 |  | $\mu \mathrm{s}$ |
| $\mathrm{t}_{\mathrm{F}}$ | Vout Fall Time | $\mathrm{R}_{\mathrm{L}}=500 \Omega, \mathrm{C}_{L}=0.1 \mu \mathrm{~F}$ |  |  | 110 |  | $\mu \mathrm{s}$ |
| toff | Turn-Off Time | $\mathrm{R}_{\mathrm{L}}=500 \Omega, \mathrm{C}_{\mathrm{L}}=0.1 \mu \mathrm{~F}$ |  |  | 125 |  | $\mu \mathrm{s}$ |
| tblank | Over-Current Blanking Time | FPF2193, FPF2194 |  | 15 | 30 | 60 | ms |
| trstri | Auto-Restart | FPF2193 Only |  | 225 | 450 | 900 | ms |
| tsc | Short-Circuit Response Time | $\mathrm{V}_{\text {IN }}=\mathrm{V}_{\text {out }}=3.3 \mathrm{~V}$, Moderate OverCurrent Condition |  |  | 5 |  | $\mu \mathrm{s}$ |
|  |  | $\mathrm{V}_{\text {IN }}=\mathrm{V}_{\text {OUT }}=3.3 \mathrm{~V}$, Hard | d Short |  | 30 |  | ns |

## Typical Performance Characteristics



Figure 5. Quiescent Current vs. Input Voltage


Figure 7. Quiescent Current vs. Temperature


Figure 9. Von Low Voltage vs. Input Voltage


Figure 6. Quiescent Current vs. Input Voltage


Figure 8. Von High Voltage vs. Input Voltage


Figure 10. Current Limit vs. Output Voltage

Typical Performance Characteristics (Continued)


Figure 11. Current Limit vs. Temperature


Figure 13. Ron vs. Temperature


Figure 15. $t_{\text {RISE }} / t_{\text {FALL }}$ vs. Temperature


Figure 12. Ron vs. Vin


Figure 14. ton / toff vs. Temperature


Figure 16. $t_{\text {RStRT }}$ vs. Temperature

Typical Performance Characteristics (Continued)


Figure 17. tblank vs.Temperature


Figure 19. toff Response

Figure 21. Current Limit Response Time (Switch is Powered into a Short)


Figure 18. ton Response


Figure 20. Short-Circuit Response Time (Output Shorted to GND)

Figure 22. Current Limit Response Time (Output is Loaded by $2.2 \Omega$, Cout=0.1 $\mu \mathrm{F}$ )

Typical Performance Characteristics (Continued)


Figure 23. Current Limit Response Time (Output is Loaded by $2.2 \Omega$, Cout=10 $\mu \mathrm{F}$ )


Figure 24. Short-Circuit Detection Function ${ }^{(4)}$


Figure 25. tblank vs. Response ${ }^{(0)}$

## Notes:

2. When the output voltage is below $\mathrm{V}_{\mathrm{SCTH}}=1.1 \mathrm{~V}$, the current limit value is set at $62.5 \%$ of the current limit value.
3. VDRVsignal forces the device to go into over-current condition by loading.

## Functional Description

The FPF2193, FPF2194, and FPF2195 are currentlimited switches that protect systems and loads that can be damaged or disrupted by the application of high currents. The core of each device is a $55 \mathrm{~m} \Omega \mathrm{P}$-channel MOSFET and a controller capable of functioning over the $w$ ide input operating range of $1.8-5.5 \mathrm{~V}$. The controller protects against system malfunctions through current limiting, under-voltage lockout, and thermal shutdow n . The current limit is adjustable from $100 \mathrm{~mA}(45 \mathrm{~mA}$ for FPF2195BUCX) to 1.5 A through the selection of an external resistor.

## On/Off Control

The ON pin controls the state of the switch. When ON is HIGH, the switch is in ON state. Activating ON continuously holds the sw itch in the ON state so long as there is no fault. For all versions, an under-voltage on Vin or a junction temperature in excess of $140^{\circ} \mathrm{C}$ overrides the ON control to turn off the switch. In addition, excessive currents cause the switch to turn off in the FPF2193 and FPF2194. The FPF2193 has an autorestartfeature that automatically turns the sw itch on again after 450 ms . For the FPF2194, the ON pin must be toggled to turn the switch on again. The FPF2195 does not turn off in response to an over-current condition, but remains operating in constant-current mode as long as ON is active and the thermal shutdow n or under-voltage lockout have not activated.

## Fault Reporting

Upon the detection of an over-current, input undervoltage, or over-temperature condition, FLAGB signals the fault mode by activating LOW. For the FPF2193 and FPF2194, the FLAGB goes LOW at the end of the blanking time, while FLAGB goes LOW immediately for the FPF2195. FLAGB remains LOW through the autorestart time for the FPF2195. For the FPF2194, FLAGB is latched LOW and ON must be toggled to release it. With the FPF2195, FLAGB is LOW during the faults and immediately returns HIGH at the end of the fault condition. FLAGB is an open-drain MOSFET that requires a pull-up resistor between $V_{\mathbb{N}}$ and FLAGB. During shutdow n , the pull-dow n on FLAGB is disabled to reduce current draw from the supply.

## Current Limiting

The current limit ensures that the current through the switch doesn't exceed a maximum value, while not limiting at less than a minimum value. The current at which the parts limit is adjustable through the selection of an external resistor connected to Iset. Information for selecting the resistor is found in the Application Information section. The FPF2193 and FPF2194 have a blanking time of 30 ms , nominally, during which the sw itch acts as a constant current source. At the end of the blanking time, the switch is turned off. The FPF2195 has no current limit blanking period, so it remains in a constant current state until the ON pin is deactivated or the thermal shutdow $n$ turns off the switch.
For preventing the switch from large pow er dissipation during heavy load, a short-circuit detection feature is introduced. Short-circuit condition is detected by, observing the output voltage. The switch is put into shortcircuit current-limiting mode if the switch is loaded with a
heavy load. When the output voltage drops below $\mathrm{V}_{\text {scth }}$, the short-circuit detection threshold voltage, the current limit value is re-conditioned and the short-circuit currentlimit value is decreased to $62.5 \%$ of the current limit value. This keeps the pow er dissipation of the part below a certain limit even at dead-short conditions at 5.5 V input voltage. The $\mathrm{V}_{\text {scth }}$ value is set to be 1 V . At around 1.1 V of output voltage, the sw itch is removed from short-circuit current-limiting mode and the current limit is set to the current limit value.

## Under-Voltage Lockout (UVLO)

The under-voltage lockout turns the sw itch off if the input voltage drops below the under-voltage lockout threshold. With the ON pin active, the input voltage rising above the under-voltage lockout threshold causes a controlled turnon of the sw itch, which limits current over shoot.

## Thermal Shutdown

The thermal shutdow $n$ protects the die from internally or externally generated excessive temperatures. During an over-temperature condition, FLAGB is activated and the switch is turned off. The sw itch automatically turns on again if temperature of the die drops below the threshold temperature.

## Reverse-Current Blocking

The entire FPF2193/94/95 family has a reverse current blocking feature that protects the input source against current flow from output to input. For a standard USB pow er design, this is an important feature to protect the USB host from being damaged due to reverse current flow on $V_{\text {bus. }}$
When the load sw itch is OFF, no current flow s from the output to the input. If the switch is turned on and the output voltage is greater than input voltage, this feature is activated and turns off the switch. This prevents any current flow from output to input. The reverse-current blocking feature is deactivated if the $\mathrm{V}_{\text {OUT }}-\mathrm{V}_{\text {IN }}$ is smaller than a typically 50 mV threshold. During this time, some current ( $50 \mathrm{mV} /$ Ron) flow s from the output to input until input voltage becomes greater than output voltage. FLAGB operation is independent of the reverse-current blocking and does not report a fault condition if this feature is activated.


Figure 27. Timing Diagram
where:
tdon = Delay On Time
$\mathrm{t}_{\mathrm{R}}=\mathrm{V}_{\text {OUt }}$ Rise Time
ton $=$ Turn-On Time
tdoff = Delay Off Time
$\mathrm{t}_{\mathrm{F}}=$ Vout Fall Time
toff $=$ Turn-Off Time

## Application Information



Figure 28. Typical Application

## Setting Current Limit

The FPF2193, FPF2194, and FPF2195 current limit is set with an external resistor connected betw een ISET and GND. This resistor is selected using the following equation:

$$
\begin{equation*}
\mathrm{R}_{\mathrm{SET}}=\frac{551.6}{\mathrm{I}_{\mathrm{LIM}}} \tag{1}
\end{equation*}
$$

Rset is in $\Omega$ and Iset is in Amps.
Table 1 can also be used to select RSET. A typical application would be the 500 mA current required by a single USB port. Using Table 1, an appropriate selection for the RSET resistor would be $788 \Omega$. This ensures that the port load could draw 525 mA , but not more than 875 mA . Likew ise for a dual-port system; an RSET of $368 \Omega$ alw ays delivers at least 1125 mA and never more than 1875 mA .

Table 1. Current Limit Various Rset Values

| RSET $^{(\Omega)}$ ) | Min. Current <br> Limit (m A) | Typ. Current <br> Lim it (m A) | Max. Current <br> Limit (m A) |
| :---: | :---: | :---: | :---: |
| 368 | 1125 | 1500 | 1875 |
| 441 | 928 | 1250 | 1562 |
| 552 | 750 | 1000 | 1250 |
| 613 | 675 | 900 | 1125 |
| 690 | 600 | 800 | 1000 |
| 788 | 525 | 700 | 875 |
| 919 | 450 | 600 | 750 |
| 1103 | 375 | 500 | 625 |
| 1226 | 338 | 450 | 563 |
| 1379 | 300 | 400 | 500 |
| 1576 | 263 | 350 | 438 |
| 1839 | 225 | 300 | 375 |
| 2206 | 188 | 250 | 313 |
| 2758 | 150 | 200 | 250 |
| 3677 | 113 | 150 | 188 |
| 5516 | 75 | 100 | 125 |
| $15800^{(4)}$ | 35 | 45 | 60 |

## Note:

4. FPF2195BUCX only.

## Input Capacitor

To limit the voltage drop on the input supply caused by transient inrush currents when the switch is turned on into a discharged load capacitor or a short-circuit, a capacitor needs to be placed betw een $\mathrm{V}_{\mathbb{I}}$ and GND. A $0.1 \mu \mathrm{~F}$ ceramic capacitor, $\mathrm{C}_{\mathrm{I}}$, placed close to the pins is usually sufficient. Higher values of $\mathrm{ClN}_{\mathrm{IN}}$ can be used to further reduce the voltage drop.

## Output Capacitor

A $0.1 \mu \mathrm{~F}$ capacitor, Cout, should be placed between Vout and GND. This capacitor prevents parasitic board inductances from forcing Vout below GND when the sw itch turns off. For the FPF2193 and FPF2194, the total output capacitance needs to be kept below a maximum value, Cout(max), to prevent the part from registering an over-current condition and turning off the switch. The maximum output capacitance can be determined from the follow ing formula:

$$
\begin{equation*}
\mathrm{C}_{\text {OUT }}(\max )=\frac{\mathrm{I}_{\mathrm{LIM}}(\max ) \times \mathrm{t}_{\text {BLANK }}(\min )}{\mathrm{V}_{\mathrm{IN}}} \tag{2}
\end{equation*}
$$

## Power Dissipation

During normal operation as a switch, the power dissipated depends upon the level at which the current limit is set. The maximum allow ed setting for the current limit is 1.5 A and results in a pow er dissipation of:
$P=\left(l_{\text {LIM }}\right)^{2} \times R_{O N}=(1.5)^{2} \times 0.055=123.75 \mathrm{~mW}$
If the part goes into current limit, the maximum power dissipation occurs when the output is shorted to ground. For the FPF2193, the power dissipation scales by the auto-restart time, tretrt, and the over-current blanking time, tblank, so that the maximum pow er dissipated is:

$$
\begin{align*}
& \mathrm{P}(\max )=\frac{\mathrm{t}_{\text {BLANK }}}{\mathrm{t}_{\text {BLANK }}+\mathrm{t}_{\text {RSTRT }}} \times \mathrm{V}_{\text {IN }}(\max ) \times \mathrm{I}_{\mathrm{LIM}}(\max )  \tag{4}\\
& =\frac{30}{30+450} \times 5.5 \times 1.5=515.6 \mathrm{~mW}
\end{align*}
$$

This is more power than the package can dissipate, but the thermal shutdow $n$ of the part activates to protect the part from damage due to excessive heating. When using the FPF2194, attention must be given to the manual resetting of the part. The junction temperature is only able to increase to the thermal shutdow n threshold. Once this temperature has been reached, toggling ON does not turn the switch on until the junction temperature drops. For the FPF2195, a short on the output causes the part to operate in a constant-current state, dissipating a w orst-case pow er of:
$\mathrm{P}($ max $)=\mathrm{V}_{\text {IN }}($ max $) \times \mathrm{I}_{\text {LIM }}($ max $)$
$=5.5 \times 1.5=8.25 \mathrm{~W}$
This large amount of power activates the thermal shutdown and the part cycles in and out of thermal shutdow n as long as the ON pin is active and the short is present.

## Board Layout

For best performance, all traces should be as short as possible. To be most effective, the input and output capacitors should be placed close to the device to minimize the effects that parasitic trace inductances may have on normal and short-circuit operation. Using wide traces for $\mathrm{V}_{\text {IN }}$, Vout, and GND help to minimize parasitic electrical effects along with minimizing the case-to-ambient thermal impedance.

## Physical Dimensions



RECOMMENDED LAND PATTERN (NSMD PAD TYPE)

SIDE VIEWS


NOTES:
A. NO JEDEC REGISTRATION APPLIES.
B. DIMENSIONS ARE IN MILLIMETERS.
C. DIMENSIONS AND TOLERANCE PER ASMEY14.5M, 1994.
D. DATUM C IS DEFINED BY THE SPHERICAL CROWNS OF THE BALLS.
E. PACKAGE NOMINAL HEIGHT IS 582 MICRONS $\pm 43$ MICRONS (539-625 MICRONS).
f. FOR DIMENSIONS D, E, X, AND Y SEE PRODUCT DATASHEET.
G. DRAWING FILNAME: MKT-UC006AFrev2.

Figure 29. 6-Ball, Wafer-Level Chip-Scale Package (WLCSP)

| $\mathbf{D}$ | $\mathbf{E}$ | $\mathbf{X}$ | $\mathbf{Y}$ |
| :---: | :---: | :---: | :---: |
| $1.480 \pm 0.030$ | $0.980 \pm 0.030$ | 0.240 | 0.240 |

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