

## 6 A, 33 mΩ, 2.8 V to 23 V, eFuse With Programmable Current Limit and OVP

### DESCRIPTION

The SIP32434A and SIP32434B are single-channel eFuses that integrate multiple control and protection features, which provide increased controllability and reliability, with simplified designs and minimal external components.

The SIP32434A and SIP32434B protect both power sources and downstream circuitry connected to the switch from overloads, short circuits, voltage surges, and excessive inrush currents.

The output current limit can be set by a single external resistor.  $V_{IN}$  overvoltage protection and undervoltage lockout threshold levels can be set with an external resistor network.  $V_{IN}$  inrush current requirements can be set with a single external soft start capacitor.

Upon switch-off due to latchable faults, the SIP32434A will latch the power switch off and the PGD will remain low. The switch can restart by resetting the EN or  $V_{IN}$ . The SIP32434B will auto retry if there is no OTP or OVP fault. The retry delay time is 32 times the soft start time set by the CSS.

The switch is characterized for operation over a junction temperature range of -40 °C to +125 °C.

### APPLICATIONS

- Industrial
- IoT and smart home
- Medical and healthcare equipment
- Network and telecom equipment
- Data storage, solid state drives
- Computing
- PLC
- Lighting
- Gaming consoles

### FEATURES

- 2.8 V to 23 V operation voltage
- 28 V max. voltage rating with 24 V internal OVP
- 33 mΩ typical switch resistance
- 0.5 A to 6 A current limit setting range
- Current limit accuracy of  $\pm 7\%$
- Fast short circuit protection response
- OCP triggering without overhead current
- Programmable turn-on slew rate
- Turn-on delay: 190  $\mu$ s
- Adjustable OVP (and fixed 24 V OVP at  $V_{IN}$ )
- Adjustable UVLO
- Over-temperature protection
- ESD / HBM: > 2 kV
- ESD / CDM: > 750 V
- PGD: power good indicator output
- Compact TDFN10 3 mm x 3 mm package (for AEC-Q100 qualified automotive applications, please refer to SIPQ32434)
- Active reverse blocking feature available with [SIP32433](#)
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)

### TYPICAL APPLICATION CIRCUIT

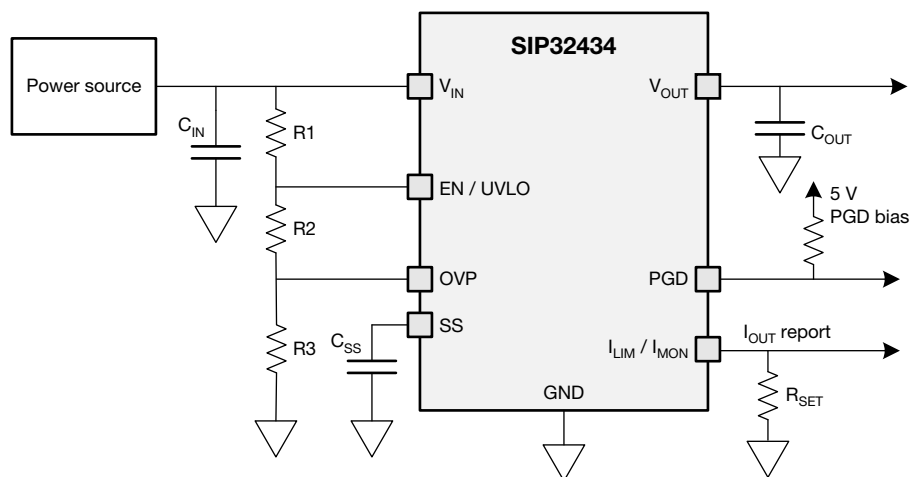


Fig. 1 - Application Circuit

**ORDERING INFORMATION**

| PART NUMBER      | OCP RESPONSE     | $R_{DS(on)}$<br>(m $\Omega$ ) | TRUE REVERSE<br>CURRENT BLOCKING | REPORT | MARKING<br>CODE | PACKAGE           |
|------------------|------------------|-------------------------------|----------------------------------|--------|-----------------|-------------------|
| SIP32434ADN-T1E4 | Latch            | 33                            | No                               | PG     | 2434A           | DFN10 3 mm x 3 mm |
| SIP32434BDN-T1E4 | Auto-retry       | 33                            | No                               | PG     | 2434B           | DFN10 3 mm x 3 mm |
| SIP32434AEVB     | Evaluation board |                               |                                  |        |                 |                   |
| SIP32434BEVB     | Evaluation board |                               |                                  |        |                 |                   |

**Note**

- For AEC-Q100 qualified automotive applications, please refer to SIPQ32434ADN-T1E4 and SIPQ32434BDN-T1E4

**ABSOLUTE MAXIMUM RATINGS**

| PARAMETER                                   | CONDITION        | LIMIT                                                   | UNIT           |
|---------------------------------------------|------------------|---------------------------------------------------------|----------------|
| Input voltage ( $V_{IN}$ )                  | Reference to GND | -0.3 to +28                                             | V              |
| Output voltage ( $V_{OUT}$ )                | Reference to GND | -0.3 to ( $V_{IN} + 0.3$ ) or 28, whichever comes first |                |
|                                             |                  | -5 V for +5 $\mu$ s                                     |                |
| EN voltage                                  | Reference to GND | -0.3 to +28                                             |                |
| OVP                                         | Reference to GND | -0.3 to +6.0                                            |                |
| SS                                          | Reference to GND | -0.3 to +6.0                                            |                |
| $I_{LIM}$                                   |                  | -0.3 to +6.0                                            |                |
| PGD                                         |                  | -0.3 to +6.0                                            | A              |
| Maximum continuous switch current           | SIP32434         | 6                                                       |                |
| Thermal resistance ( $\theta_{thJA}$ )      |                  | 44.8                                                    | $^{\circ}$ C/W |
| ESD rating                                  | HBM              | $\pm 2$                                                 | kV             |
| ESD rating                                  | CDM              | $\pm 0.75$                                              |                |
| Latch up current ( $V_{IN}$ and $V_{OUT}$ ) |                  | 200                                                     | mA             |
| <b>Temperature</b>                          |                  |                                                         |                |
| Operating junction temperature              |                  | -40 to 150                                              | $^{\circ}$ C   |
| Maximum operating junction temperature      |                  | +150                                                    |                |
| Storage temperature                         |                  | -65 to +150                                             |                |

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

**RECOMMENDED OPERATING RANGE**

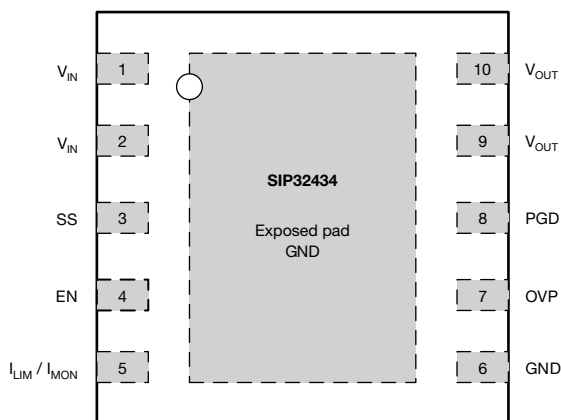
| ELECTRICAL                     | LIMIT       | UNIT         |
|--------------------------------|-------------|--------------|
| Input voltage ( $V_{IN}$ )     | 3 to 23     | V            |
| Operating junction temperature | -40 to +125 | $^{\circ}$ C |



| ELECTRICAL SPECIFICATIONS       |                 |                                                                                                                                                                                                                                          |        |      |       |               |
|---------------------------------|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------|-------|---------------|
| PARAMETER                       | SYMBOL          | TEST CONDITIONS UNLESS SPECIFIED<br>$V_{IN} = 12\text{ V}$ , $T_J = -40\text{ }^{\circ}\text{C}$ to $+125\text{ }^{\circ}\text{C}$ ,<br>$V_{EN(H)} = 2.4\text{ V}$ , $C_{OUT} = 0.1\text{ }\mu\text{F}$ , $R_{LIM} = 4.1\text{ k}\Omega$ | LIMITS |      |       | UNIT          |
|                                 |                 |                                                                                                                                                                                                                                          | MIN.   | TYP. | MAX.  |               |
| Power Supply                    |                 |                                                                                                                                                                                                                                          |        |      |       |               |
| Power input voltage             | $V_{IN}$        | Operating input voltage range                                                                                                                                                                                                            | 2.8    | -    | 28    | V             |
| Quiescent current               | $I_{Q(ON)}$     | $EN = 1.8\text{ V}$ , $V_{IN} = 2.8\text{ V}$ to $28\text{ V}$ , $V_{OUT}$ open                                                                                                                                                          | -      | 230  | 340   | $\mu\text{A}$ |
| Shutdown current                | $I_{Q(SD)}$     | $V_{IN} = 2.8\text{ V}$ to $28\text{ V}$ , $EN = 0\text{ V}$ , $T_A = 25\text{ }^{\circ}\text{C}$                                                                                                                                        | -      | 0.8  | 5     |               |
| OVP switch-off current          | $I_{Q(OVP)}$    | $V_{IN} = 2.8\text{ V}$ to $28\text{ V}$ , $EN = 2.4\text{ V}$ , $OVP = 1.4\text{ V}$                                                                                                                                                    | -      | 1    | -     |               |
| $V_{IN}$ ULVO                   |                 |                                                                                                                                                                                                                                          |        |      |       |               |
| Switch $V_{OUT}$ leakage        | $I_{UVLO\_OUT}$ |                                                                                                                                                                                                                                          | -500   | -    | +500  | nA            |
| Switch $V_{IN}$ leakage         | $I_{UVLO\_IN}$  | $V_{IN} = 2.3\text{ V}$                                                                                                                                                                                                                  | -      | 27   | 50    | $\mu\text{A}$ |
| Overvoltage Protection          |                 |                                                                                                                                                                                                                                          |        |      |       |               |
| OVP threshold                   | $V_{OVP}$       | $V_{IN} = 12\text{ V}$ , OVP rising, $T_A = 25\text{ }^{\circ}\text{C}$                                                                                                                                                                  | 1.14   | 1.2  | 1.26  | V             |
| OVP hysteresis                  | $OVP_{HST}$     | $T_A = 25\text{ }^{\circ}\text{C}$                                                                                                                                                                                                       | 60     | 105  | 140   | mV            |
| OVP leakage                     | $I_{OVP}$       | $V_{OVP} = 1.2\text{ V}$ on the pin, $T_A = 25\text{ }^{\circ}\text{C}$                                                                                                                                                                  | -      | 40   | 100   | nA            |
| IN pin internal fixed OVP       | $IN_{OVP}$      | $T_A = 25\text{ }^{\circ}\text{C}$                                                                                                                                                                                                       | 23     | 24   | 25.6  | V             |
| EN / UVLO                       |                 |                                                                                                                                                                                                                                          |        |      |       |               |
| EN on threshold                 | $V_{UVPR}$      | $V_{EN}$ rising                                                                                                                                                                                                                          | -      | 1.25 | -     | V             |
| EN off threshold                | $V_{UVPF}$      | $V_{EN}$ falling                                                                                                                                                                                                                         | -      | 1.05 | -     |               |
| EN / UVLO leakage               |                 | $V_{EN} = 1.2\text{ V}$                                                                                                                                                                                                                  | -0.25  | -    | +0.25 | $\mu\text{A}$ |
| Overcurrent Protection          |                 |                                                                                                                                                                                                                                          |        |      |       |               |
| Current limit voltage threshold | $V_{OCP}$       | Voltage that triggers the OCP shown on $I_{LIM}$ pin                                                                                                                                                                                     | -      | 0.6  | -     | VCu           |
| Current limit accuracy          | $I_{OCP}$       | $V_{IN} - V_{OUT} = 1\text{ V}$ , $R_{SET} = 2.06\text{ k}\Omega$                                                                                                                                                                        | 5.58   | 6    | 6.42  | A             |
|                                 |                 |                                                                                                                                                                                                                                          | 3.22   | 3.5  | 3.78  |               |
|                                 |                 |                                                                                                                                                                                                                                          | 1.32   | 1.5  | 1.68  |               |
|                                 |                 |                                                                                                                                                                                                                                          | 0.43   | 0.5  | 0.58  |               |
| Current limit setting range     |                 | Minimum $R_{SET} = 2\text{ k}\Omega$                                                                                                                                                                                                     | 0.5    | -    | 6     |               |
| Current limit hold-up time      | $t_{ILIM}$      | Current limiting timeout, if no OTP                                                                                                                                                                                                      | 3      | 6    | 9     | ms            |
| Power Switch                    |                 |                                                                                                                                                                                                                                          |        |      |       |               |
| ON resistance                   | $R_{DS(ON)}$    | $V_{IN} = 5\text{ V}$ to $22\text{ V}$ , $I_{OUT} = 1\text{ A}$ , $T_J = 25\text{ }^{\circ}\text{C}$                                                                                                                                     | -      | 33   | 41    | m $\Omega$    |
|                                 |                 | $V_{IN} = 5\text{ V}$ to $22\text{ V}$ , $I_{OUT} = 1\text{ A}$ , $T_J = 85\text{ }^{\circ}\text{C}$                                                                                                                                     | -      | -    | 48    |               |
| PGD, Power Good                 |                 |                                                                                                                                                                                                                                          |        |      |       |               |
| PGD pull-down resistance        | $R_{PG}$        | $V_{IN} = 5\text{ V}$ , output pin = $0.1\text{ V}$                                                                                                                                                                                      | -      | 5.2  | 10    | $\Omega$      |
| PGD oII leakage                 | $I_{PG}$        | Biased with $5\text{ V}_{DC}$                                                                                                                                                                                                            | -      | 0.01 | 1     | $\mu\text{A}$ |
| Switching Characteristics       |                 |                                                                                                                                                                                                                                          |        |      |       |               |
| EN / UVLO                       |                 |                                                                                                                                                                                                                                          |        |      |       |               |
| Switch turn-on delay time       | $T_{ON\_DLY}$   | From EN / UVLO voltage, $V_{UVPR}$ to $V_{OUT}$ reaches 10 % $V_{IN}$ , $R_L = 10\text{ }\Omega$ , $C_L = 10\text{ }\mu\text{F}$ , $C_{SS}$ open                                                                                         | -      | 220  | -     | $\mu\text{s}$ |
| Shutdown delay                  | $T_{OFF\_DLY}$  | From EN / UVLO low to $V_{OUT} = 0.9 \times V_{IN}$ , $R_L = 10\text{ }\Omega$ , $C_L = 10\text{ }\mu\text{F}$ , $C_{SS}$ open                                                                                                           | -      | 10   | -     |               |
| OVP Timing                      |                 |                                                                                                                                                                                                                                          |        |      |       |               |
| OVP off time                    | $t_{OVP}$       | $R_L = 100\text{ }\Omega$ , $C_L = 0\text{ }\mu\text{F}$ , OVP steps from $1\text{ V}$ to $1.4\text{ V}$ ; measured from OVP pin voltage crossing $1.2\text{ V}$ threshold to $V_{OUT} = 0.9 \times V_{IN}$                              | -      | 0.3  | 1     | $\mu\text{s}$ |
| Internal OVP off time           | $t_{OVP\_INT}$  | $R_L = 100\text{ }\Omega$ , $C_L = 0\text{ }\mu\text{F}$ , $V_{IN}$ steps from $22\text{ V}$ to $26\text{ V}$ ; measured from $V_{IN}$ pin voltage crossing $24\text{ V}$ threshold to $V_{OUT} = 0.9 \times V_{IN}$                     | -      | 1.5  | -     |               |
| Flag reporting delay            |                 | PGD pull up to $5\text{ V}$ through a $100\text{ k}\Omega$ ; delay time from OVP pin voltage step to PGD is below $0.5\text{ V}$                                                                                                         | -      | -    | 2     |               |
| Overcurrent protection          |                 |                                                                                                                                                                                                                                          |        |      |       |               |
| Moderate overcurrent protection | $t_{OCP}$       | Load current is 120 % of current limit threshold                                                                                                                                                                                         | -      | 1.1  | -     | $\mu\text{s}$ |

| ELECTRICAL SPECIFICATIONS   |             |                                                                                                                                                                                                                                          |        |      |      |                    |
|-----------------------------|-------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------|------|--------------------|
| PARAMETER                   | SYMBOL      | TEST CONDITIONS UNLESS SPECIFIED<br>$V_{IN} = 12\text{ V}$ , $T_J = -40\text{ }^{\circ}\text{C}$ to $+125\text{ }^{\circ}\text{C}$ ,<br>$V_{EN(H)} = 2.4\text{ V}$ , $C_{OUT} = 0.1\text{ }\mu\text{F}$ , $R_{LIM} = 4.1\text{ k}\Omega$ | LIMITS |      |      | UNIT               |
|                             |             |                                                                                                                                                                                                                                          | MIN.   | TYP. | MAX. |                    |
| Soft Start Control          |             |                                                                                                                                                                                                                                          |        |      |      |                    |
| Output rise up time         | $t_R$       | $V_{IN} = 12\text{ V}$ , $R_L = 10\text{ }\Omega$ , $C_L = 10\text{ }\mu\text{F}$ , $V_{OUT}$ from 10 % to 90 % $V_{IN}$ , $C_{SS}$ open                                                                                                 | -      | 560  | -    | $\mu\text{s}$      |
|                             |             | $V_{IN} = 12\text{ V}$ , $R_L = 10\text{ }\Omega$ , $C_L = 10\text{ }\mu\text{F}$ , $V_{OUT}$ from 10 % to 90 % $V_{IN}$ , $C_{SS} = 22\text{ nF}$                                                                                       | -      | 4.7  | -    | ms                 |
| SS charge current           |             |                                                                                                                                                                                                                                          | -      | 5    | -    | $\mu\text{A}$      |
| Auto Retry                  |             |                                                                                                                                                                                                                                          |        |      |      |                    |
| Auto retry cycle            | $RTY_{cnt}$ | Delay time of restart after all faults are removed; this is defined as the number of cycles of soft start time set by $C_{SS}$                                                                                                           | -      | 32   | -    |                    |
| Thermal Shutdown            |             |                                                                                                                                                                                                                                          |        |      |      |                    |
| Thermal shutdown            |             | Temperature increases                                                                                                                                                                                                                    | -      | 165  | -    | $^{\circ}\text{C}$ |
| Thermal shutdown hysteresis |             |                                                                                                                                                                                                                                          | -      | 45   | -    | $^{\circ}\text{C}$ |

## PACKAGE OUTLINE



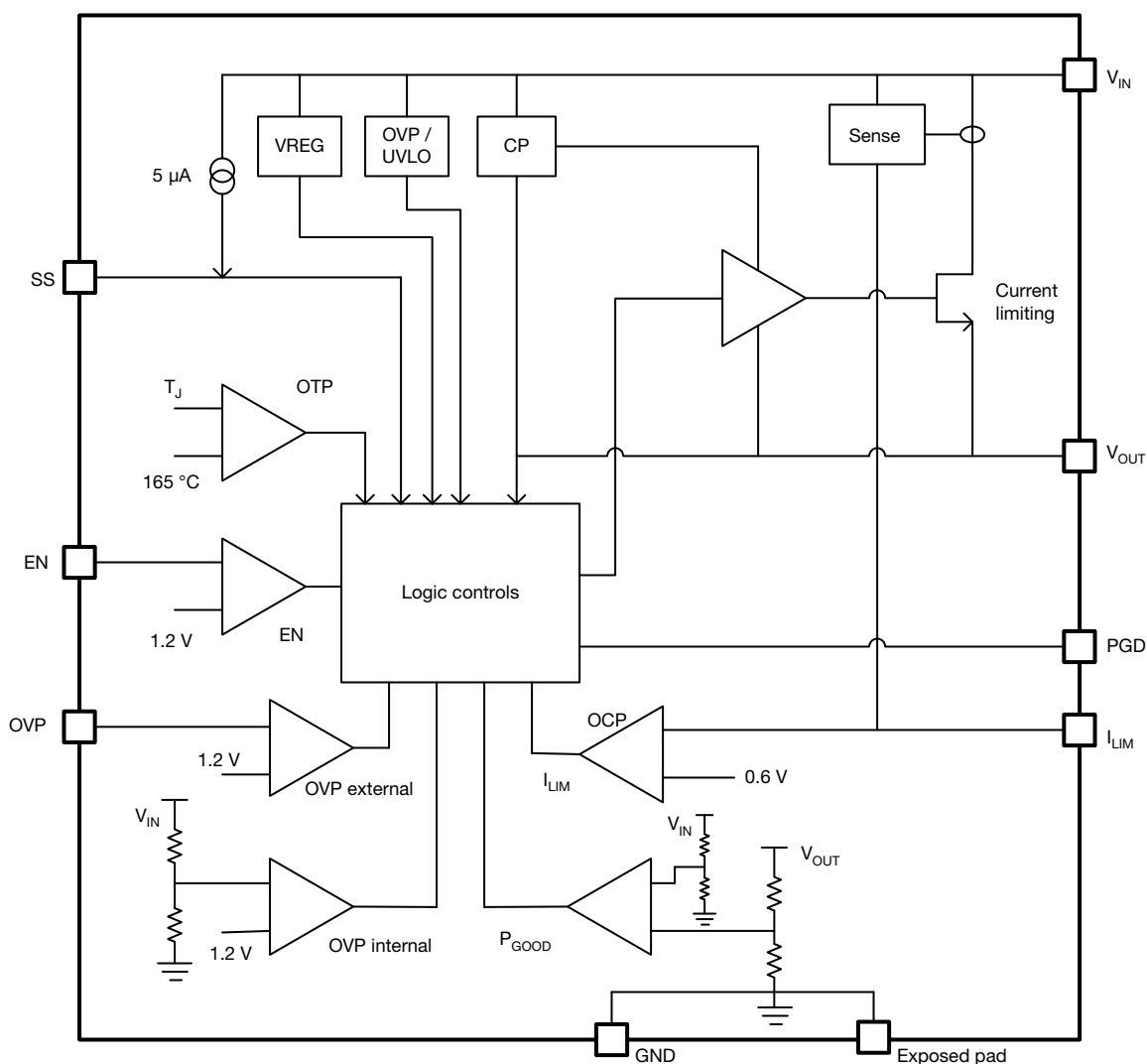
DFN10, pin 1 dot marking is on top of the device

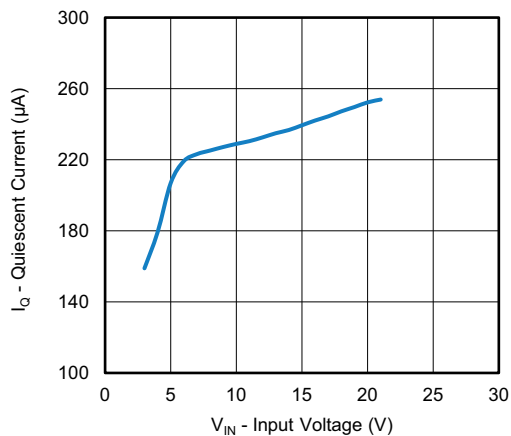
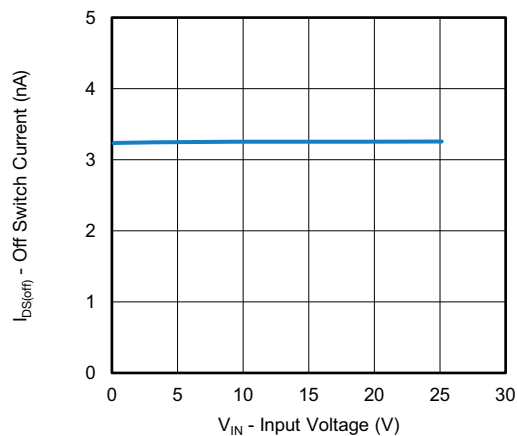
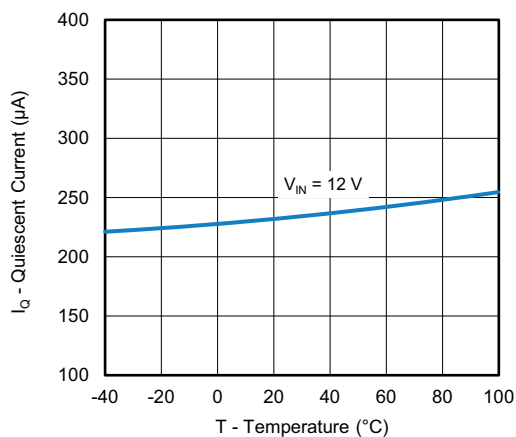
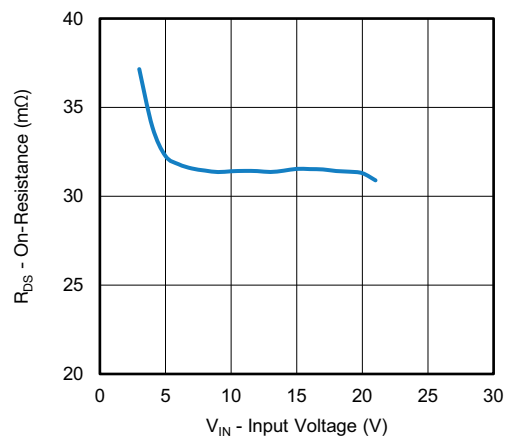
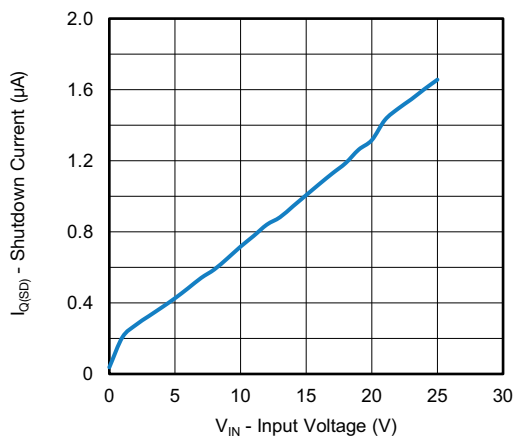
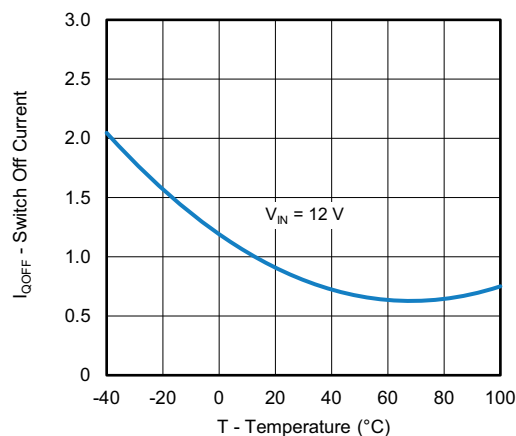
**Fig. 2 - Pin Out Drawing (top view)**

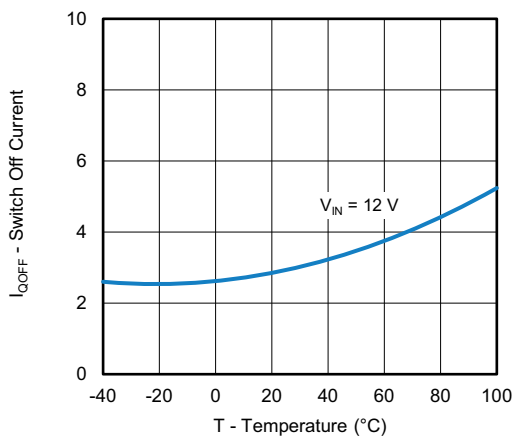
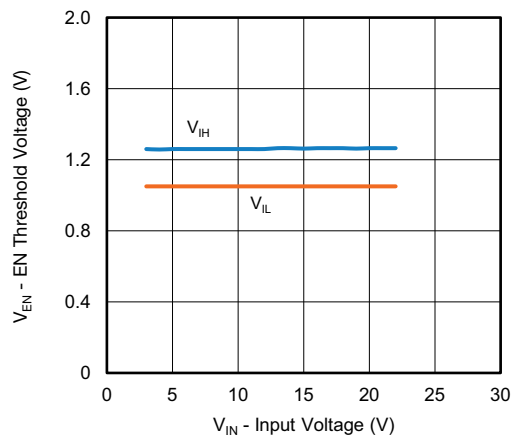
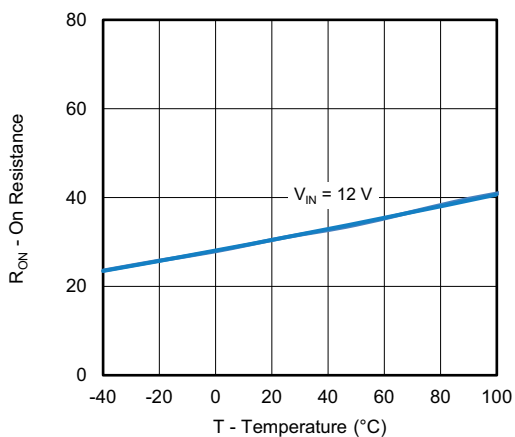
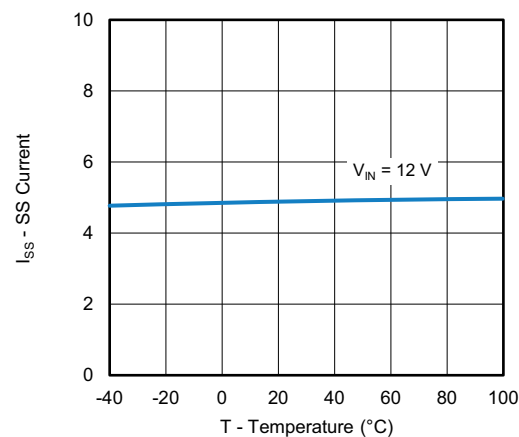
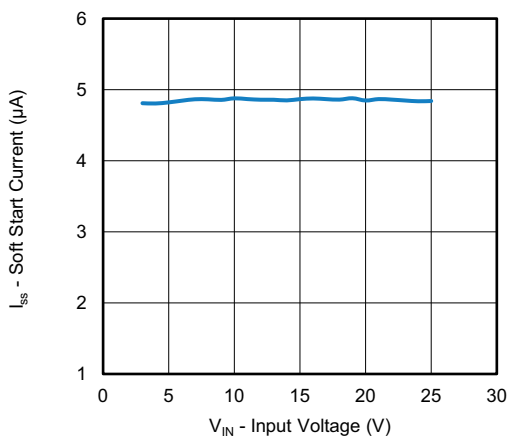
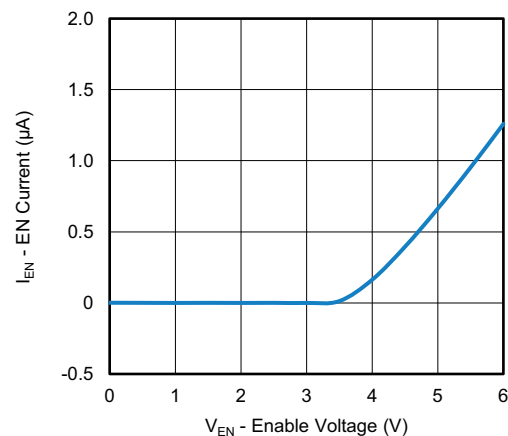
| PIN DESCRIPTION |                     |                                                                                                                                                                                                          |
|-----------------|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| PIN #           | NAME                | FUNCTION                                                                                                                                                                                                 |
| 1, 2            | $V_{IN}$            | Power switch input pins; two pins are fused inside the package                                                                                                                                           |
| 3               | SS                  | A capacitor from this pin to GND sets output voltage slew rate                                                                                                                                           |
| 4               | EN / UVLO           | Active high switch control input; $V_{THL} < 0.3\text{ V}$ , $V_{THH} > 1.4\text{ V}$                                                                                                                    |
| 5               | $I_{LIM} / I_{MON}$ | A resistor from this pin to GND sets the overload and short-circuit current limit; the pin can be used for current reporting, referring to the voltage developed over the current limit setting resistor |
| 6               | GND                 | Ground                                                                                                                                                                                                   |
| 7               | OVP                 | Input for setting the programmable overvoltage protection threshold. An overvoltage event turns-off the internal FET and asserts FLT to indicate the overvoltage fault                                   |
| 8               | PGD                 | Open drain output, when $V_{OUT} \geq 95\text{ \% } V_{IN}$ , and none of the following faults are triggered: OT, OC, OV                                                                                 |
| 9, 10           | $V_{OUT}$           | Power switch output pins; two pins are fused inside the package                                                                                                                                          |
| Exposed pad     | GND                 | The package's central exposed pad must be connected to the ground plane; optimal PCB thermal design will enhance device performance                                                                      |

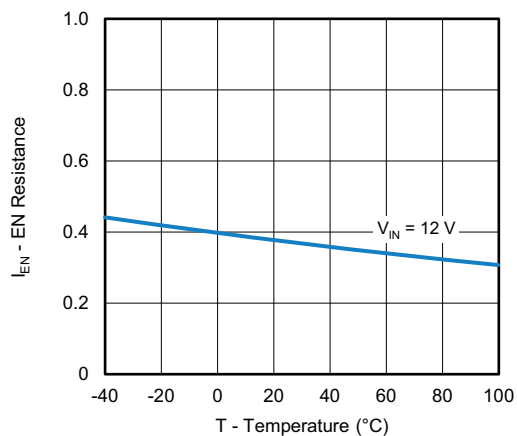
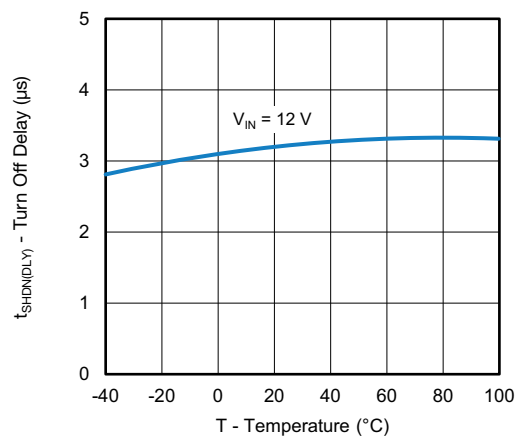
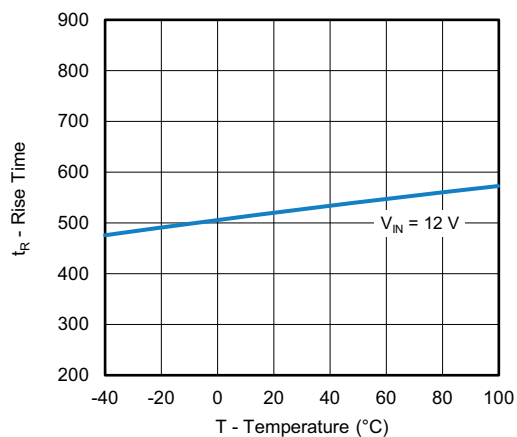
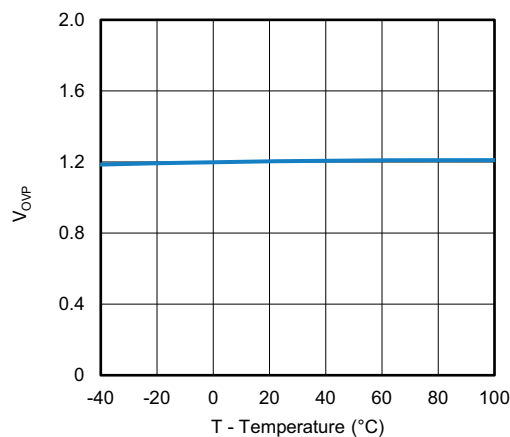
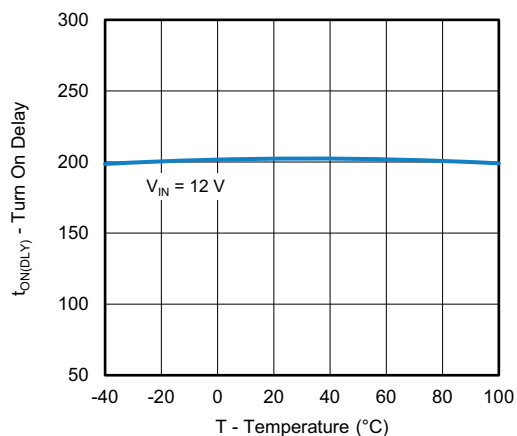
**FUNCTIONAL BLOCK DIAGRAM AND TRUTH TABLE**

| TRUTH TABLE |        |
|-------------|--------|
| EN          | SWITCH |
| 1           | ON     |
| 0           | OFF    |


**Fig. 3 - Device Block Diagram**


**Fig. 4 - Quiescent Current vs. Input**

**Fig. 7 - Switch Off Current vs. Input**

**Fig. 5 - Quiescent Current vs. Temperature**

**Fig. 8 - On Resistance vs. Input**

**Fig. 6 - Shutdown Current vs. Input**

**Fig. 9 - Shutdown Current vs. Temperature**

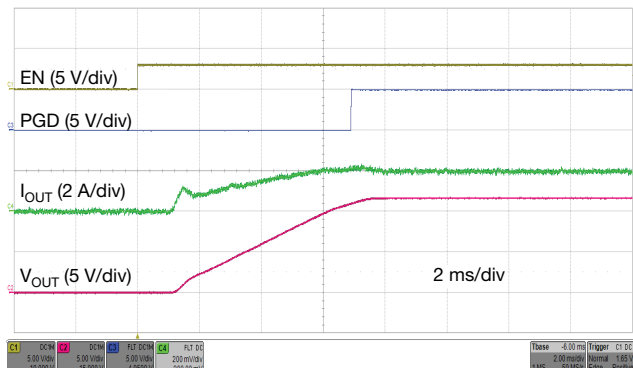

**Fig. 10 - Switch Off Current vs. Temperature**

**Fig. 13 - Threshold Voltage vs. Input Voltage  $V_{IN}$** 

**Fig. 11 - On Resistance vs. Temperature**

**Fig. 14 - Soft Start Current vs. Temperature**

**Fig. 12 - Soft Start Current vs. Input Voltage  $V_{IN}$** 

**Fig. 15 - EN Current vs. EN Voltage**


**Fig. 16 - Enable Resistance vs. Temperature**

**Fig. 19 - Turn Off Delay Time vs. Temperature**

**Fig. 17 - Rise Time vs. Temperature**

**Fig. 20 - OVP Voltage vs. Temperature**

**Fig. 18 - Turn On Delay Time vs. Temperature**

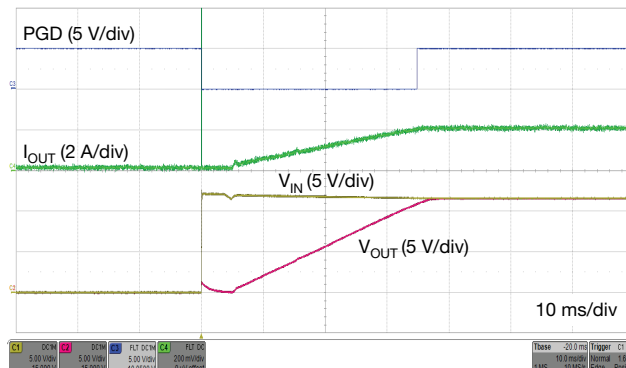




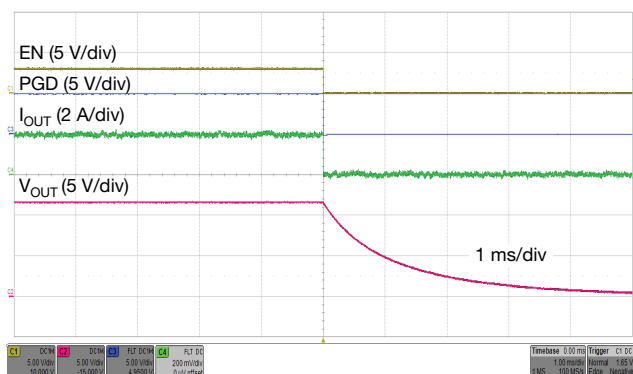
## TYPICAL CHARACTERISTICS



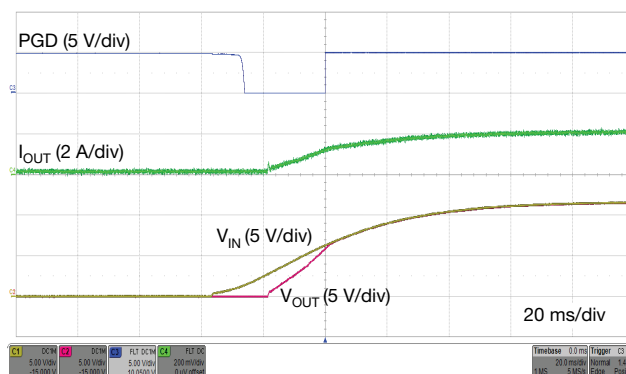
**Fig. 21 - Turn On by EN**  
 $V_{IN} = 12\text{ V}$ ,  $R_L = 6\ \Omega$ ,  $C_L = 220\ \mu\text{F}$ ,  $C_{SS} = 22\text{ nF}$ ,  $R_{LIM} = 1.74\text{ k}\Omega$



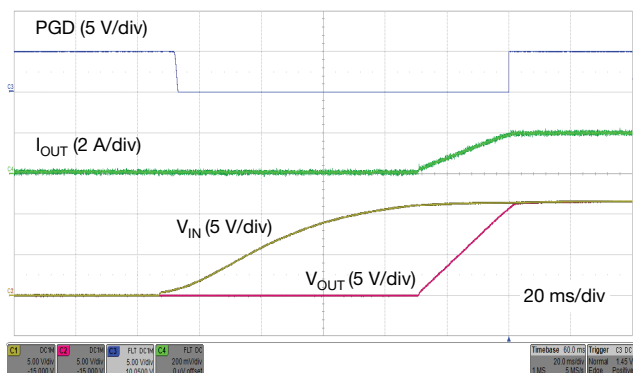
**Fig. 24 - Turn On by Hot-Plug of  $V_{IN}$**   
 $V_{IN} = 12\text{ V}$ ,  $R_L = 6\ \Omega$ ,  $C_L = 220\ \mu\text{F}$ ,  $C_{SS} = 133\text{ nF}$ ,  $R_{LIM} = 1.74\text{ k}\Omega$   
EN Voltage Divider Resistors,  $1\text{ M}\Omega$  and  $127\text{ k}\Omega$



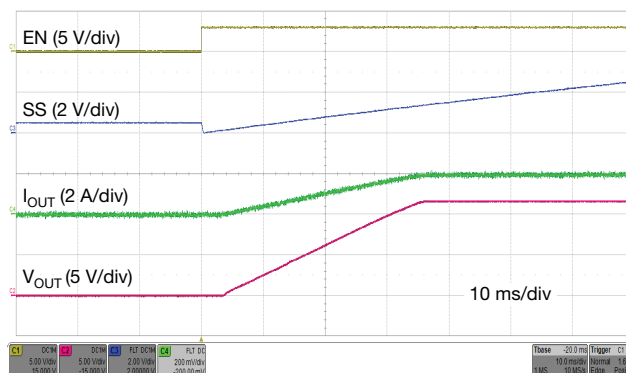
**Fig. 22 - Turn Off by EN**  
 $V_{IN} = 12\text{ V}$ ,  $R_L = 6\ \Omega$ ,  $C_L = 220\ \mu\text{F}$ ,  $C_{SS} = 22\text{ nF}$ ,  $R_{LIM} = 1.74\text{ k}\Omega$



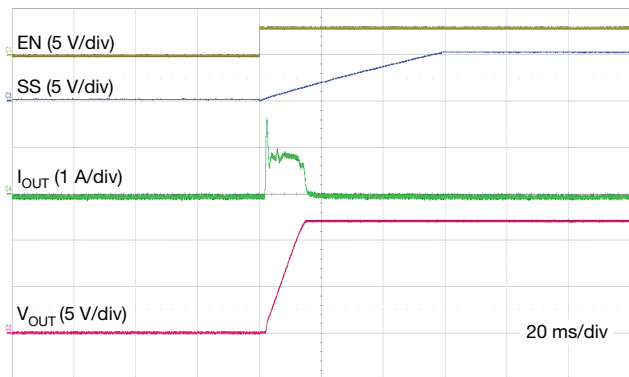
**Fig. 25 - Turn On by  $V_{IN}$  When EN is 3 V**  
 $V_{IN} = 12\text{ V}$ ,  $R_L = 6\ \Omega$ ,  $C_L = 220\ \mu\text{F}$ ,  $C_{SS} = 133\text{ nF}$ ,  $R_{LIM} = 1.74\text{ k}\Omega$



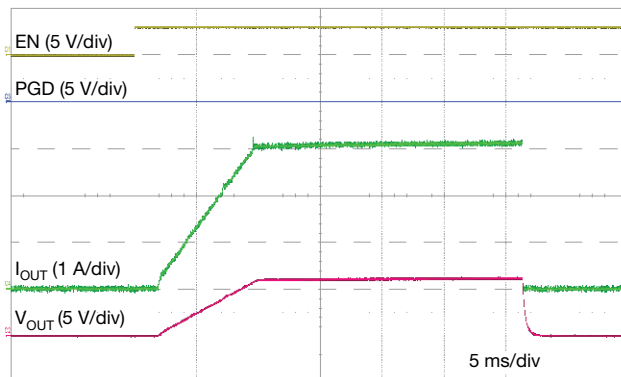
**Fig. 23 - Turn On by  $V_{IN}$**   
 $V_{IN} = 12\text{ V}$ ,  $R_L = 6\ \Omega$ ,  $C_L = 220\ \mu\text{F}$ ,  $C_{SS} = 133\text{ nF}$ ,  $R_{LIM} = 1.74\text{ k}\Omega$   
EN Voltage Divider Resistors,  $1\text{ M}\Omega$  and  $127\text{ k}\Omega$



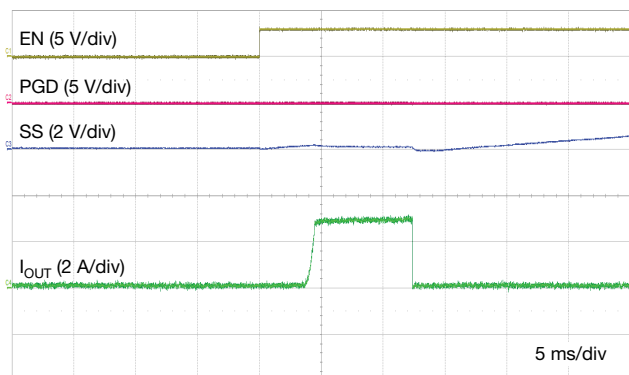
**Fig. 26 - Turn On by EN Into Resistive Load**  
 $V_{IN} = 12\text{ V}$ ,  $R_L = 6\ \Omega$ ,  $C_{SS} = 133\text{ nF}$ ,  $R_{LIM} = 1.74\text{ k}\Omega$



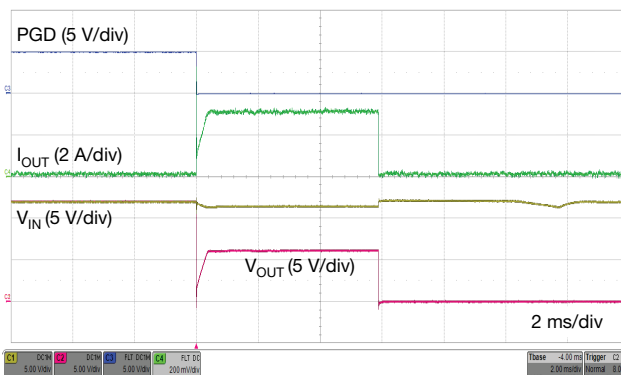
**Fig. 27 - Turn On by EN Into Capacitive Load**  
 $V_{IN} = 12\text{ V}$ ,  $C_L = 220\text{ }\mu\text{F}$ ,  $C_{SS} = 47\text{ nF}$ ,  $R_{LIM} = 1.74\text{ k}\Omega$



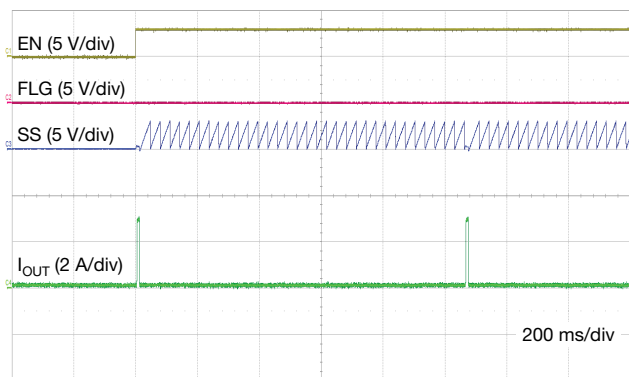
**Fig. 30 - Turn On by EN Into OCP Load**  
 $V_{IN} = 12\text{ V}$ ,  $R_L = 2\text{ }\Omega$ ,  $C_L = 220\text{ }\mu\text{F}$ ,  $C_{SS} = 133\text{ nF}$ ,  $R_{LIM} = 1.74\text{ k}\Omega$



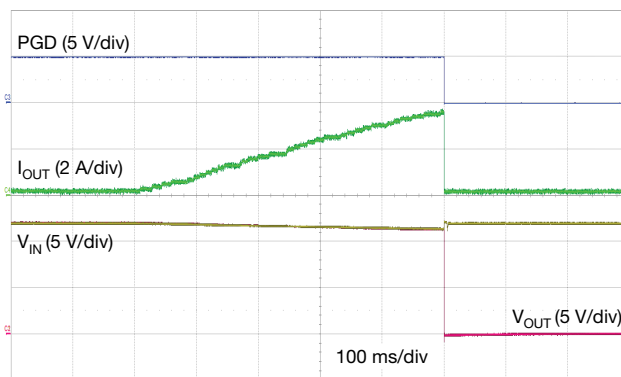
**Fig. 28 - Turn On Into Output Short**  
 $V_{IN} = 12\text{ V}$ ,  $C_{SS} = 133\text{ nF}$ ,  $I_{LIM} = 1.74\text{ k}\Omega$



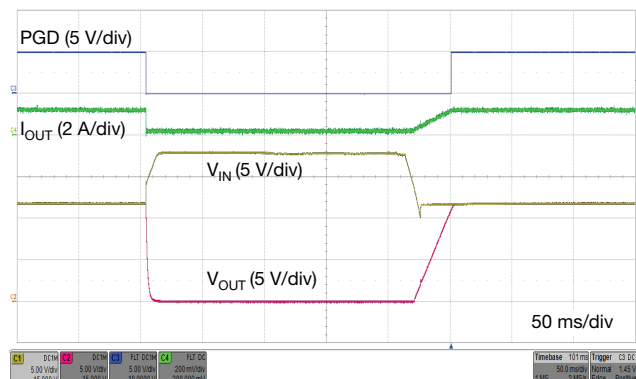
**Fig. 31 - Output Short With a 2  $\Omega$  Load**  
 $V_{IN} = 12\text{ V}$ ,  $R_L = 2\text{ }\Omega$ ,  $C_{SS} = 133\text{ nF}$ ,  $R_{LIM} = 1.74\text{ k}\Omega$



**Fig. 29 - Turn On Into Output Short, Auto-Retry**  
 $V_{IN} = 12\text{ V}$ ,  $C_{SS} = 133\text{ }\mu\text{F}$ ,  $R_{LIM} = 1.74\text{ k}\Omega$



**Fig. 32 - Over Current Protection**  
**Increase Load Current Slowly**  
 $V_{IN} = 12\text{ V}$ ,  $C_L = 220\text{ }\mu\text{F}$ ,  $C_{SS} = 133\text{ nF}$ ,  $R_{LIM} = 1.74\text{ k}\Omega$



**Fig. 33 - Over Voltage Protection**  
 $R_L = 12 \Omega$ ,  $C_L = 100 \mu F$ ,  $C_{SS} = 27 \text{ nF}$ ,  $R_{LIM} = 1.74 \text{ k}\Omega$ ,  
 OVP Set to 15.6 V

## OVERVIEW

The SIP32434A and SIP32434B are eFuses with comprehensive integrated control features that simplify the design and increase the reliability of the circuitry connected to the switch.

The 32 mΩ switches are designed to operate in the 2.8 V to 23 V range. An internally generated gate drive voltage ensures good  $R_{ON}$  linearity over the input voltage operating range.

The devices start their operation by checking the  $V_{IN}$ ,  $V_{OUT}$ , OVP, and EN / UVLO pins. When the voltages are in the ranges without exceeding under- or over-voltage protection thresholds, the PGD open drain switch is off. A high level on the EN / UVLO pin enables the internal MOSFET to start conducting and allows current to flow from IN to OUT. When EN / UVLO is held low, the internal MOSFET is turned off.

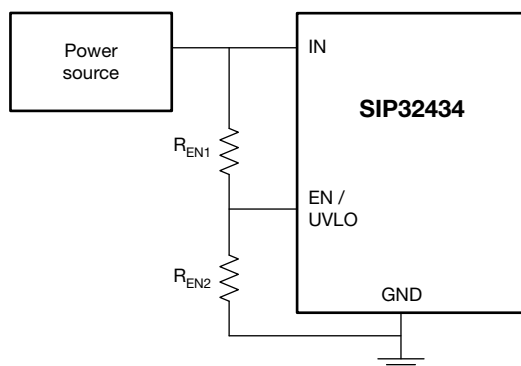
After a successful turn-on sequence, the device now actively monitors its load current, input voltage, and protects the load from harmful over-current, and over-voltage conditions. A built-in thermal sense circuit will detect junction over temperature and shut down the switch for safety.

## SWITCH ON / OFF, AND UNDER-VOLTAGE LOCK OFF PROTECTION - UVLO

EN / UVLO pin controls the on / off of the power switch. When EN / UVLO is at a logic high the switch is on. When EN / UVLO is at a logic low, the switch is off.

The SIP32434A and SIP32434B implement under-voltage protection on the EN / UVLO to turn off the output. It is a user-defined under-voltage protection setting to flexibly select the proper minimum applied voltage for the downstream load or the device's proper operation.

The diagram shows how a resistor divider from supply to GND can be used to set the UVLO set point for a given voltage supply level.



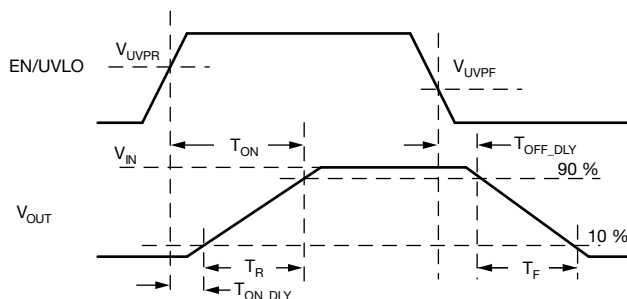
**Fig. 34**

The resistors must be sized large enough to minimize the constant leakage from supply to ground through the resistor divider network. At the same time, keep the current through the resistor network sufficiently larger than the leakage current on the EN / UVLO pin to minimize the error in the resistor divider ratio.

$$R_{EN1} = \frac{R_{EN2}(V_{IN} - V_{UVPR})}{V_{UVPR}}$$

Where  $V_{UVPR}$  is 1.25 V.

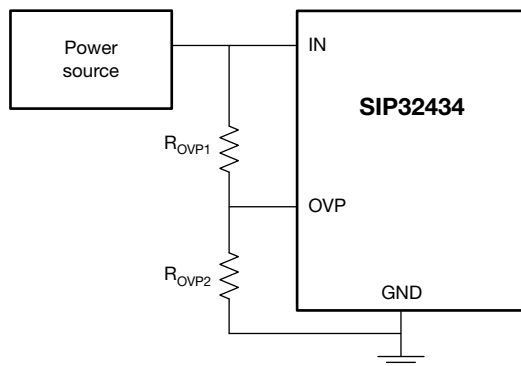
UVLO turn off delay ( $T_{OFF\_DLY}$ ) is typically 550  $\mu$ s and turn on delay  $T_{ON\_DLY}$  is typically 500  $\mu$ s.



**Fig. 35 - Switching Times**

### OVER-VOLTAGE PROTECTION (OVP)

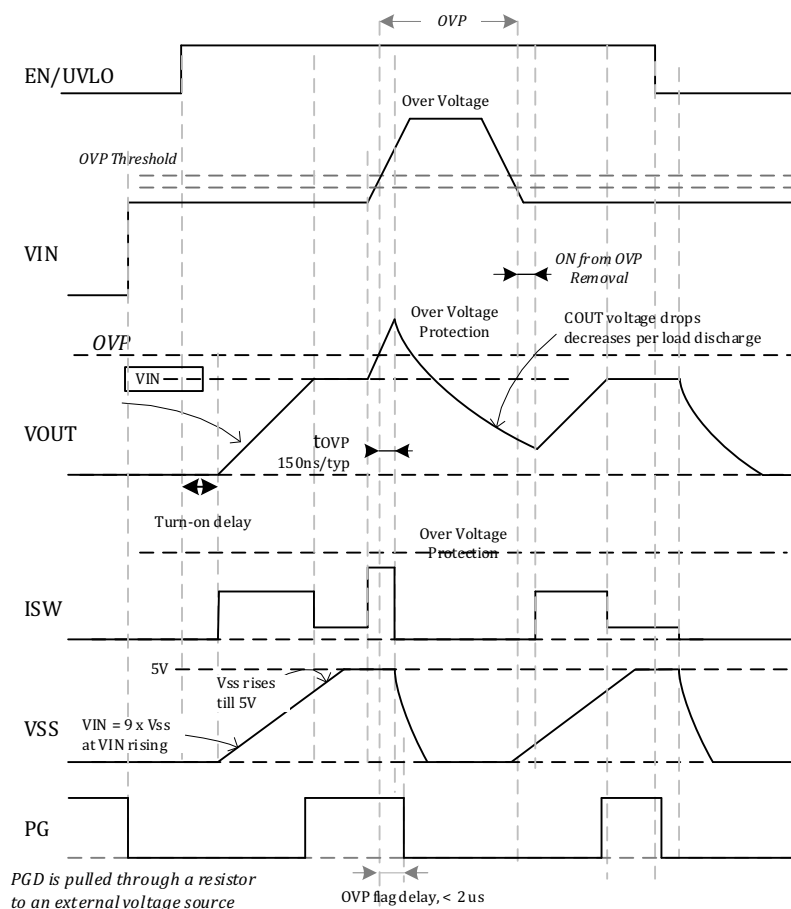
The SIP32434A and SIP32434B implement overvoltage protection (OVP) on both the  $V_{IN}$  and OVP pins to protect the output load in the event of an input over-voltage. When the input exceeds the over-voltage protection thresholds  $V_{OVP(R)}$  or the  $IN_{OVP}$ , which is typically 24 V, the device turns off the output within  $t_{OVP}$ , while the PGD asserts in the meantime. As long as an over-voltage condition is present on the input, the device stays disabled and the output will be turned off. Over-voltage is a non-latchable fault. Once the input voltage returns to the normal operating range, the device attempts to start up normally.



**Fig. 36**

$$\frac{R_{OVP1}}{R_{OVP2}} = \frac{V_{IN(OVP)} - 1.2 \text{ V}}{1.2 \text{ V}}$$

OVP voltage divider resistors total resistance should not be over 2.5 M $\Omega$ .



**Fig. 37**

## INRUSH CURRENT, AND OVER-CURRENT PROTECTION

The SIP32434A and SIP32434B incorporate two protections against over-current:

- Adjustable slew rate (SR) for inrush current control
- Adjustable over-current protection / active current limit to protect against overload conditions

The over-current protection (OCP) is active also during soft start. The over-current protection circuit controls the switch impedance to limit the current to the level programmed by the  $R_{SET}$  resistor.

If the over-current condition persists for more than 6 ms (typ.), the switch shuts off and alert the drain FLG is asserted, pulling the pin to GND.



## SLEW RATE CONTROL

An inrush current happens when the switch turns on into a large output capacitance. If the inrush current is not controlled, it can damage the input connectors and / or cause the system power supply to droop, leading to unexpected restarts elsewhere in the system.

The SIP32434A and SIP32434B provide integrated output slew rate control to manage the inrush current during start-up. This is achieved by forcing the  $V_{OUT}$  to follow the voltage on a soft start capacitor. A constant current source of 5  $\mu A$  charges the  $C_{SS}$ , generating a linear ramp up voltage on  $C_{SS}$ .

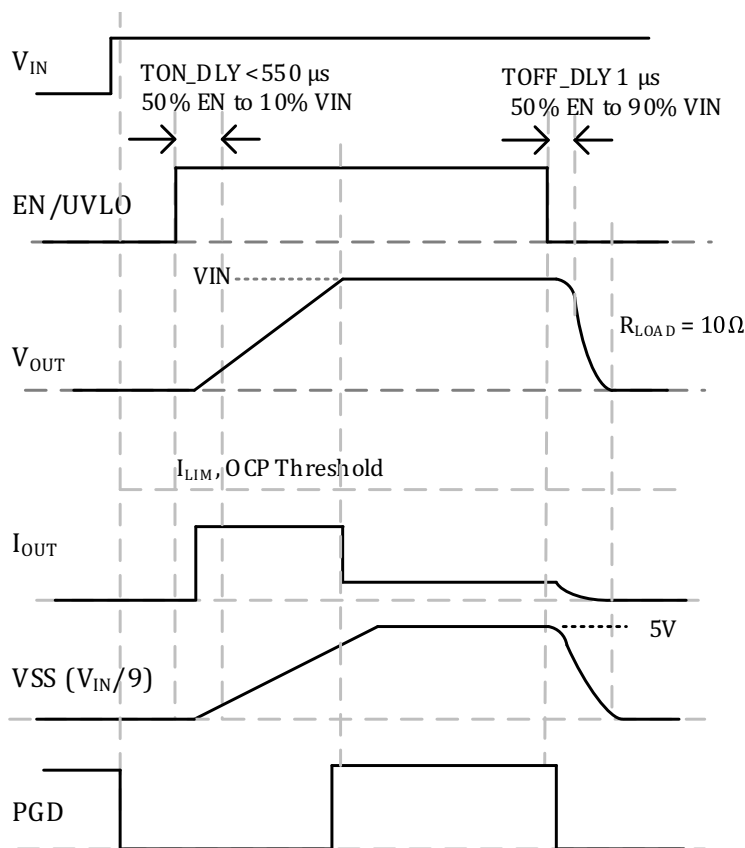
The inrush current is proportional to the load capacitance and rising slew rate. The following equation can be used to calculate the slew rate required to limit the inrush current ( $I_{INRUSH}$ ) for a given load capacitance ( $C_{OUT}$ ):

$$SR (V/ms) = \frac{I_{INRUSH} (mA)}{C_{OUT} (\mu F)}$$
$$T_{SS} = \frac{V_{IN}}{SR} = V_{IN} \times \frac{C_{OUT} (\mu F)}{I_{INRUSH} (mA)}$$

An external capacitor can be connected to the soft start (SS) pin to control the rising slew rate and lower the inrush current during turn-on. The output voltage follows the required  $C_{SS}$  capacitance to produce a given slew rate, which can be calculated using the following formula:

$$C_{SS} = \frac{(I_{SS} \times 9)}{SR}$$

The fastest output slew rate is achieved by leaving the soft start pin open.


**Fig. 38**

## CURRENT LIMIT SETTING

The SIP32434A and SIP32434B actively monitor the current flow through the switch and provide a quick response to over-current conditions by actively regulating the current to a set limit. The current limit is set by connecting a resistor between the  $I_{LIM}$  pin and GND.  $R_{SET}$  can be calculated by the following formula for a desired current limit:

$$SR (V/ms) = \frac{I_{INRUSH} (mA)}{C_{OUT} (\mu F)}$$

$$R_{SET} = \frac{0.6 V}{I_{LIM}} \times 20\,600$$

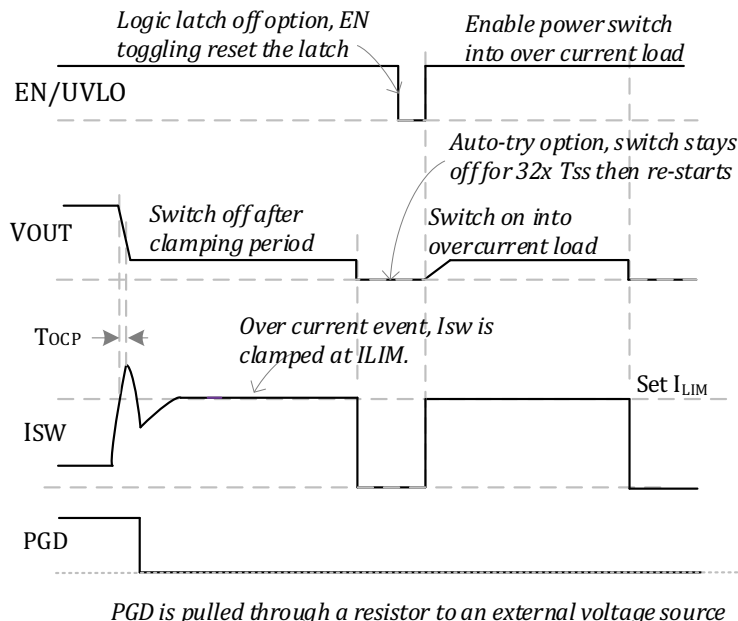
When the load current exceeds the threshold ( $I_{LIM}$ ), the parts respond within 1  $\mu s$  (typ.) to turn off the switch and then regulate the switch gate voltage to limit the output current to the set  $I_{LIM}$  level. During this brief period before the over-current protection circuit is engaged, the parts will see a surge current, especially under a severe output short condition. The magnitude of the surge current developed during the period when the over-current protection is not engaged is determined by impedance in the loop from the input current source to ground and the response time. This impedance is the sum total of the current source impedance, the path resistance and inductance, and the load impedance.

If the over-current condition persists for more than 6 ms / typ., the switch shuts off. When  $V_{OUT}$  falls below 95 % of  $V_{IN}$ , the  $PGD$  is pulled low. The device will exit current limiting when the load current falls below  $I_{LIM}$  before the end of the current limit period. The control circuit will increase the gate drive in the same manner as the soft start when the switch exits from the current limit mode.

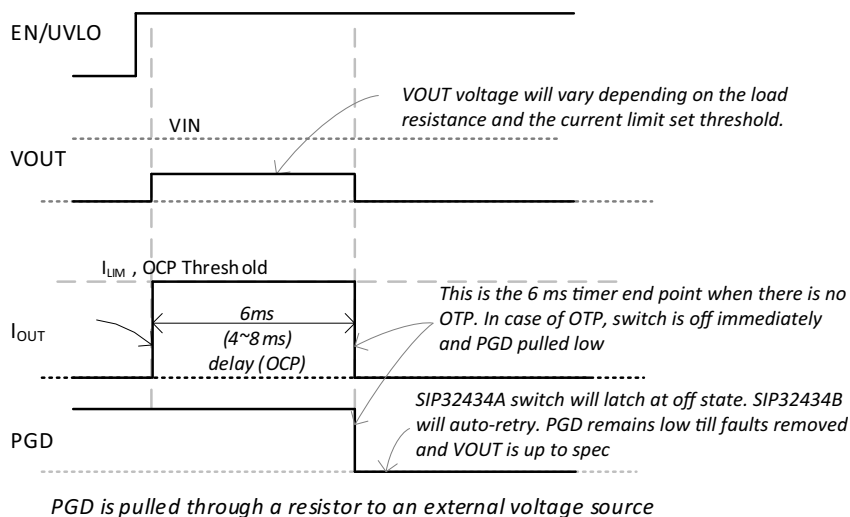


The current limit mode could result in excessive power on the switch, which increases the  $T_J$  quickly. The SIP32434A and SIP32434B have OTP, providing an enhanced level of protection.

Once the device is off due to OCP or OTP faults, the SIP32434A stays in the latch-off state and the SIP32434B auto-retries after 32 times of the programmed soft start time. They can be reset by toggling  $V_{IN}$  or EN / UVLO.



**Fig. 39 - Over-Current Protection**



**Fig. 40 - Turn On Into Over-Current Load**

## OTP, OVER-TEMPERATURE PROTECTION

Over-temperature protection turns off the power switch when the die temperature reaches the OTP threshold of 165 °C. The hysteresis is 45 °C. When the die temperature drops below 120 °C, it is allowed to turn on again.

## PGD, POWER GOOD REPORTING

PGD is an open drain output. A pull-up resistor must be connected pulling to 3 V or 5 V. It is asserted low when  $V_{OUT}$  is below 95 % of  $V_{IN}$ , or an over-current, over-voltage, or over-temperature fault condition occurs.

## INPUT CAPACITOR

While bypass capacitors at the input pins are not required, a 2.2  $\mu$ F or larger capacitors for  $C_{IN}$  is recommended in almost all applications. The bypass capacitors should be placed as physically close to the device's input pins and ground to be effective to minimize transients on the input. Ceramic capacitors are recommended over tantalum because of their ability to withstand input current surges from low impedance sources such as batteries. For hot-plug applications, where input path inductance is negligible, this input capacitor can be minimized or eliminated.

## OUTPUT CAPACITOR

The SIP32434A and SIP32434B do not require an output capacitor for proper operation. A proper value  $C_{OUT}$  is recommended to accommodate load transient per circuit design requirements. There are no ESR or capacitor type requirements.

Protection

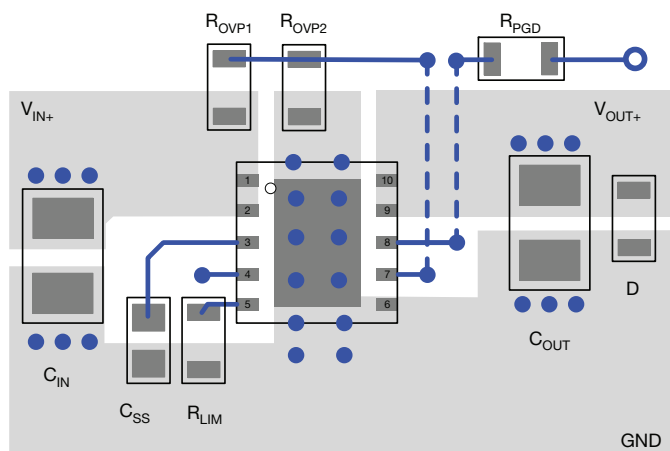
## LAYOUT GUIDELINES

The SIP32434A and SIP32434B are protection switches designed to maintain a constant output load current upon over-current fault. Optimized layout with efficient heat sinking is critical. It is recommended to put as much copper as possible to the devices' central exposed pad which is connected to ground. Connect all ground planes with all possible thermal VIAs.

The circuit setting components should be laid close to their connection pins. The components include current limit setting resistor, soft start setting capacitor, and resistors connected to EN / UVLO and OVP pins.

Protection devices such as input TVS or output Schottky diodes must be located close the pins to be protected and routed with short traces to reduce inductance.

Below is a layout example.



**Fig. 41**

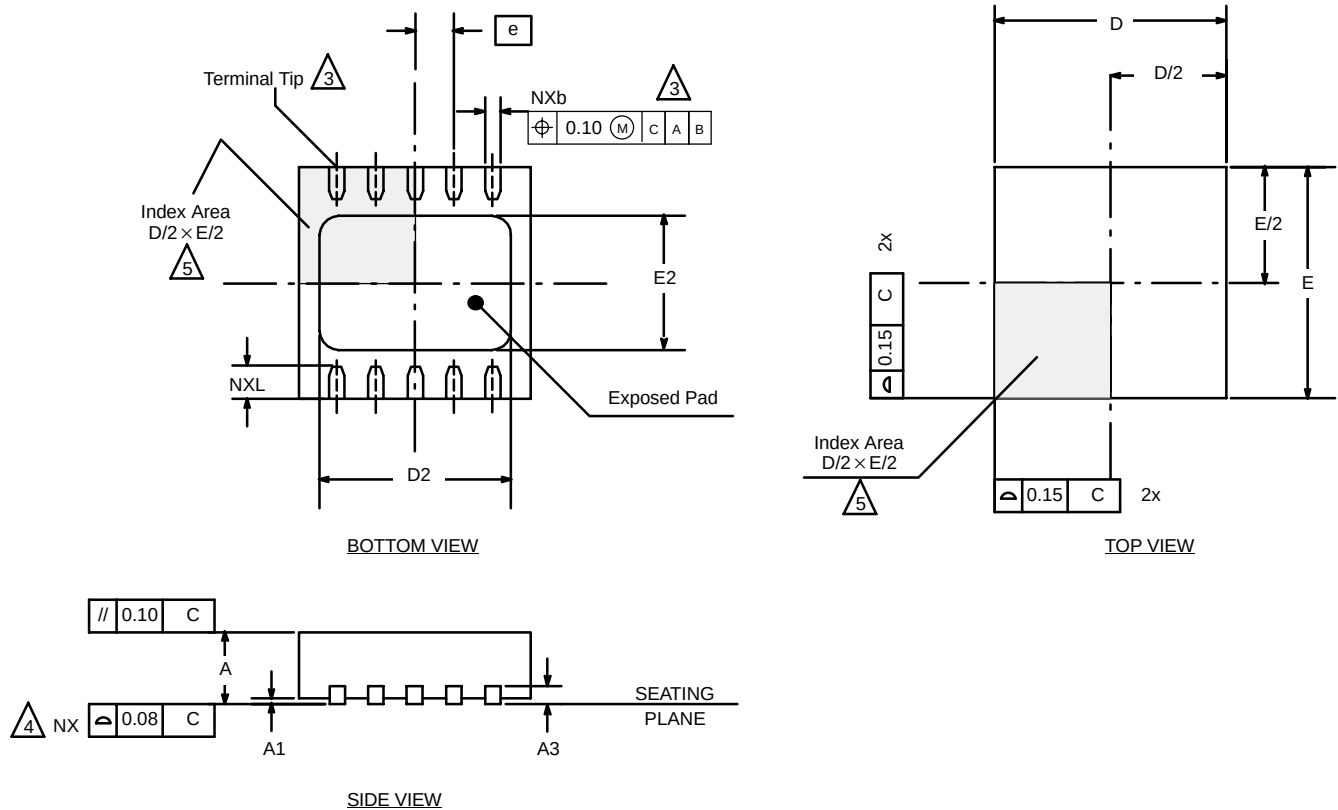
**PRODUCT SUMMARY**

|                                              |                                                                                         |                                                                                          |
|----------------------------------------------|-----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
| Part number                                  | SIP32434A                                                                               | SIP32434B                                                                                |
| Description                                  | 6 A, 33 mΩ, 2.8 V to 23 V,<br>programmable OVP and current limit,<br>latch-off on fault | 6 A, 33 mΩ, 2.8 V to 23 V,<br>programmable OVP and current limit,<br>auto retry on fault |
| Configuration                                | Single                                                                                  | Single                                                                                   |
| Slew rate time (μs)                          | Adjustable                                                                              | Adjustable                                                                               |
| On delay time (μs)                           | 190                                                                                     | 190                                                                                      |
| Input voltage min. (V)                       | 2.8                                                                                     | 2.8                                                                                      |
| Input voltage max. (V)                       | 28                                                                                      | 28                                                                                       |
| On-resistance at input voltage min. (mΩ)     | 33                                                                                      | 33                                                                                       |
| On-resistance at input voltage max. (mΩ)     | 33                                                                                      | 33                                                                                       |
| Quiescent current at input voltage min. (μA) | 180                                                                                     | 180                                                                                      |
| Quiescent current at input voltage max. (μA) | 250                                                                                     | 250                                                                                      |
| Output discharge (yes / no)                  | N                                                                                       | N                                                                                        |
| Reverse blocking (yes / no)                  | N                                                                                       | N                                                                                        |
| Continuous current (A)                       | 6                                                                                       | 6                                                                                        |
| Package type                                 | DFN33-10L                                                                               | DFN33-10L                                                                                |
| Package size (W, L, H) (mm)                  | 3.0 x 3.0 x 0.9                                                                         | 3.0 x 3.0 x 0.9                                                                          |
| Status code                                  | Active                                                                                  | Active                                                                                   |
| Product type                                 | Slew rate, current limit                                                                | Slew rate, current limit                                                                 |
| Applications                                 | Computers, consumer, industrial, healthcare,<br>networking, portable                    | Computers, consumer, industrial, healthcare,<br>networking, portable                     |

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DFN-10 LEAD (3 X 3)



NOTES:

1. All dimensions are in millimeters and inches.

2. N is the total number of terminals.

3. Dimension b applies to metallized terminal and is measured between 0.15 and 0.30 mm from terminal tip.

4. Coplanarity applies to the exposed heat sink slug as well as the terminal.

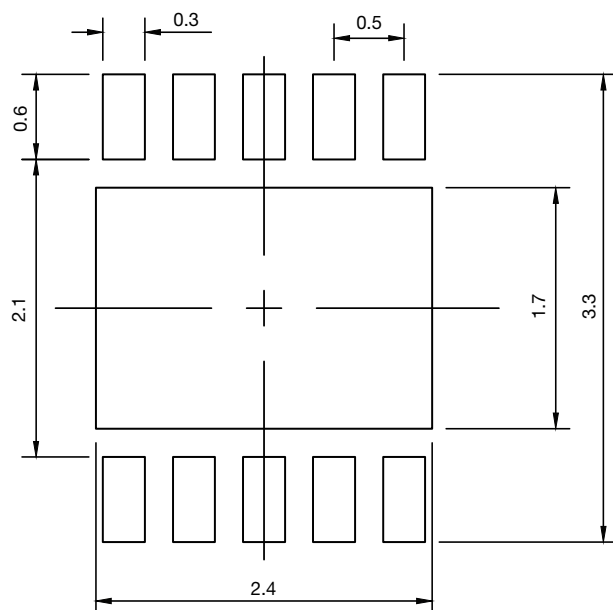
5. The pin #1 identifier may be either a mold or marked feature, it must be located within the zone indicated.

| Dim                                          | MILLIMETERS |      |      | INCHES    |       |       |
|----------------------------------------------|-------------|------|------|-----------|-------|-------|
|                                              | Min         | Nom  | Max  | Min       | Nom   | Max   |
| A                                            | 0.80        | 0.90 | 1.00 | 0.031     | 0.035 | 0.039 |
| A1                                           | 0.00        | 0.02 | 0.05 | 0.000     | 0.001 | 0.002 |
| A3                                           | 0.20 BSC    |      |      | 0.008 BSC |       |       |
| b                                            | 0.18        | 0.23 | 0.30 | 0.007     | 0.009 | 0.012 |
| D                                            | 3.00 BSC    |      |      | 0.118 BSC |       |       |
| D2                                           | 2.20        | 2.38 | 2.48 | 0.087     | 0.094 | 0.098 |
| E                                            | 3.00 BSC    |      |      | 0.118 BSC |       |       |
| E2                                           | 1.49        | 1.64 | 1.74 | 0.059     | 0.065 | 0.069 |
| e                                            | 0.50 BSC    |      |      | 0.020 BSC |       |       |
| L                                            | 0.30        | 0.40 | 0.50 | 0.012     | 0.016 | 0.020 |
| *Use millimeters as the primary measurement. |             |      |      |           |       |       |
| ECN: S-42134—Rev. A, 29-Nov-04               |             |      |      |           |       |       |
| DWG: 5943                                    |             |      |      |           |       |       |

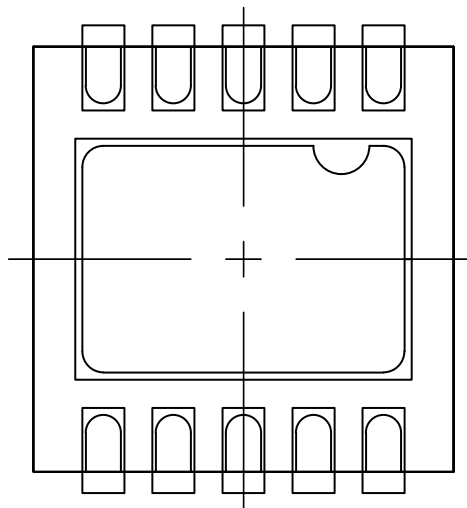


## Recommended Minimum PAD for DFN10 3 mm x 3 mm

Recommended Land Pattern



Recommended Land Pattern vs. Case Outline



Note: Dimension are in millimeters

ECN: S22-0379-Rev. A, 02-May-2022  
DWG: 3008



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