

## IR3316(S)PbF

### LOW EMI CURRENT SENSE HIGH SIDE SWITCH

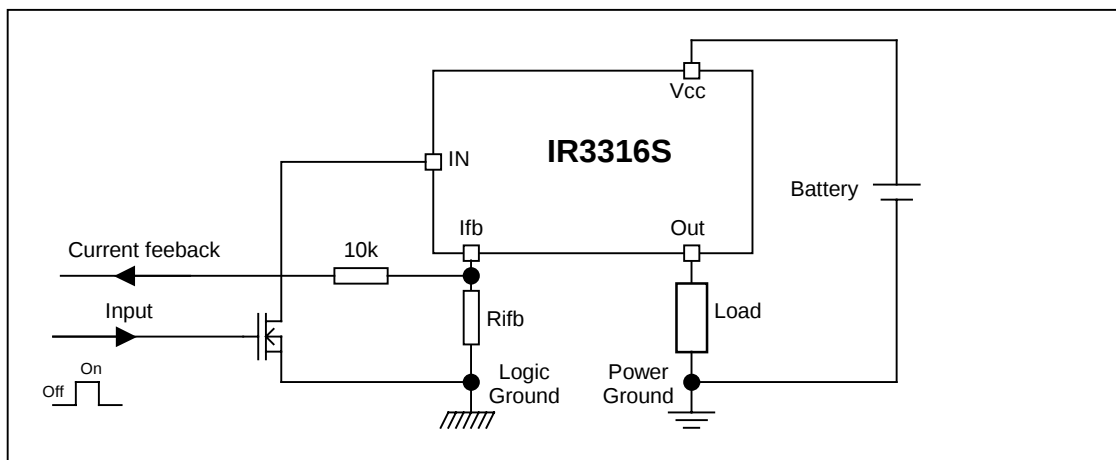
#### Features

- Load current feedback
- Programmable over current shutdown
- Active clamp
- ESD protection
- Input referenced to Vcc
- Over temperature shutdown
- Switching time optimized for low EMI
- Reverse battery protection

#### Description

The IR3316(S)PbF is a fully protected 4 terminals high side switch. The input signal is referenced to Vcc. When the input voltage  $V_{cc} - V_{in}$  is higher than the specified threshold, the output power Mosfet is turned on. When the  $V_{cc} - V_{in}$  is lower than the specified  $V_{il}$  threshold, the output Mosfet is turned off. A current proportional to the power Mosfet current is sourced to the Ifb pin. Over current shutdown occurs when  $V_{st} - V_{in} > 4.5V$ . The current shutdown threshold is adjusted by selecting the proper Rlfb. Either over current and over temperature latches off the switch. The device is reset by pulling the input pin high. Other integrated protections (ESD, reverse battery, active clamp) make the switch very rugged in automotive environment.

#### Typical Connection



#### Product Summary

|                 |           |
|-----------------|-----------|
| Rds(on)         | 7 mΩ max. |
| Vcc op.         | 6 to 26V  |
| Current Ratio   | 8800      |
| Prog. Ishutdown | 10 to 90A |
| Vclamp          | 40V       |

#### Packages



TO-220  
IR3316



D2Pak  
Pin 4 and 5 fused  
IR3316S

## Absolute Maximum Ratings

Absolute maximum ratings indicate sustained limits beyond which damage to the device may occur. All voltage parameters are referenced to Vcc lead. (Tambient=25°C unless otherwise specified).

| Symbol        | Parameter                                                     | Min. | Max. | Units |
|---------------|---------------------------------------------------------------|------|------|-------|
| Vcc-Vin       | Maximum Vcc voltage                                           | -16  | 37   | V     |
| Vcc-Vin cont. | Maximum continuous Vcc voltage                                | -16  | 26   |       |
| Vcc-Vfb       | Maximum Ifb voltage                                           | -16  | 33   |       |
| Vcc-Vout      | Maximum output voltage                                        | -0.3 | 37   |       |
| Ids cont.     | Maximum body diode continuous current Rth=60°C/W (1)          | —    | 2.8  | A     |
| Ids pulsed    | Maximum body diode pulsed current (1)                         | —    | 100  |       |
| Pd            | Maximum power dissipation Rth=60°C/W                          | —    | 2    | W     |
| ESD1          | Electrostatic discharge voltage (Human body) C=100pF, R=1500Ω | —    | 4    | kV    |
| ESD2          | Electrostatic discharge voltage (Machine Model) C=200pF, R=0Ω | —    | 0.5  |       |
| Tj max.       | Max. storage & operating temperature junction temperature     | -40  | 150  | °C    |
| Min Rfb       | Minimum on the resistor on Ifb pin                            | 0.3  | —    | kΩ    |
| Ifb max.      | Max. Ifb current                                              | -50  | 50   | mA    |

(1) Limited by junction temperature. Pulsed is also limited by wiring

## Thermal Characteristics

| Symbol | Parameter                                                                | Typ. | Max. | Units |
|--------|--------------------------------------------------------------------------|------|------|-------|
| Rth1   | Thermal resistance junction to ambient D <sup>2</sup> -Pak Std footprint | 60   | —    | °C/W  |
| Rth2   | Thermal resistance junction to case D <sup>2</sup> -Pak                  | 0.7  | —    |       |
| Rth2   | Thermal resistance junction to case TO220                                | 0.7  | —    |       |

## Recommended Operating Conditions

These values are given for a quick design. For operation outside these conditions, please consult the application notes.

| Symbol     | Parameter                           | Min. | Max.    | Units |
|------------|-------------------------------------|------|---------|-------|
| Iout       | Continuous output current           | —    | 23<br>7 | A     |
|            | Tambient=85°C, Rth=5°C/W, Tj=125°C  |      |         |       |
|            | Tambient=85°C, Rth=60°C/W, Tj=125°C |      |         |       |
| Rifb       | Recommended Ifb resistor (2)(3)     | 0.5  | 3.5     | kΩ    |
| Pulse min. | Minimum turn-on pulse width         | 1    | —       | ms    |
| Fmax.      | Maximum operating frequency         | —    | 200     | Hz    |

2) If Rifb is too low, the device can be damaged.

3) If Rifb is too high, the device may not switch on.

## Protection Characteristics

 $T_J=25^{\circ}\text{C}$ ,  $R_{\text{ifb}}=500$  to  $5\text{k}\Omega$ 

| Symbol                   | Parameter                             | Min. | Typ. | Max. | Units         | Test Conditions                                     |
|--------------------------|---------------------------------------|------|------|------|---------------|-----------------------------------------------------|
| V <sub>fb-Vin@Isd</sub>  | Over-current shutdown threshold       | 4    | 4.7  | 5.6  | V             |                                                     |
| T <sub>sd</sub>          | Over temperature threshold            | —    | 165  | —    | °C            | See fig. 5                                          |
| OV                       | Over voltage protection (not latched) | 26   | 29   | 33   | V             |                                                     |
| Isdf                     | Fixed over current shutdown           | 90   | 120  | 140  | A             | V <sub>fb</sub> <V <sub>fb-Vin@Isd</sub>            |
| Isd_1k                   | Programmable over current shutdown 1k | 30   | 40   | 50   |               | R <sub>ifb</sub> =1k $\Omega$                       |
| T <sub>reset</sub>       | Time to reset protection              | —    | 50   | 500  | $\mu\text{s}$ | See fig. 5                                          |
| Min. pulse               | Min. pulse width (no WAIT state)      | 400  | 900  | 2000 |               |                                                     |
| WAIT                     | WAIT function timer                   | 0.4  | 1    | 2    | ms            | See fig. 4 and 5                                    |
| R <sub>ds(on)</sub> rev. | Reverse battery On state resistance   | 4    | 6.7  | 10   | m $\Omega$    | V <sub>cc-Vin</sub> =-14V,<br>I <sub>out</sub> =30A |

## Static Electrical Characteristics

 $T_J=25^{\circ}\text{C}$ , V<sub>cc</sub>=14V (unless otherwise specified)

| Symbol              | Parameter                                            | Min. | Typ. | Max. | Units         | Test Conditions                                                                           |
|---------------------|------------------------------------------------------|------|------|------|---------------|-------------------------------------------------------------------------------------------|
| V <sub>cc op.</sub> | Operating Voltage range                              | 6    | —    | 26   | V             |                                                                                           |
| I <sub>cc off</sub> | Supply leakage current                               | —    | 1.5  | 5    | $\mu\text{A}$ | V <sub>in</sub> =V <sub>cc</sub> , V <sub>cc-Vout</sub> =14V,<br>V <sub>cc-Vfb</sub> =14V |
| I <sub>in, on</sub> | On state I <sub>N</sub> positive current             | 1.5  | 3    | 6    | mA            | V <sub>cc-Vin</sub> =14V                                                                  |
| V <sub>ih</sub>     | High level Input threshold voltage (4)               | —    | 5.4  | 6.2  | V             |                                                                                           |
| V <sub>il</sub>     | Low level Input threshold voltage (4)                | 4    | 4.9  | 5.8  |               |                                                                                           |
| V <sub>hyst</sub>   | Input hysteresis V <sub>ih</sub> -V <sub>il</sub>    | 0.2  | 0.4  | 1    |               |                                                                                           |
| I <sub>out</sub>    | Drain to source leakage current                      | —    | 1.2  | 5    | $\mu\text{A}$ | V <sub>in</sub> =V <sub>cc</sub> , V <sub>cc-Vfb</sub> =0V,<br>V <sub>cc-Vout</sub> =14V  |
| R <sub>ds(on)</sub> | On state resistance (5) $T_J=25^{\circ}\text{C}$     | 4    | 5.5  | 7    | m $\Omega$    | I <sub>out</sub> =30A, V <sub>cc-Vin</sub> =14V                                           |
|                     | On state resistance (5) $T_J=25^{\circ}\text{C}$     | 4    | 6    | 10   |               | I <sub>out</sub> =17A, V <sub>cc-Vin</sub> =6V                                            |
|                     | On state resistance (5)(6) $T_J=150^{\circ}\text{C}$ | 7    | 10.5 | 13.5 |               | I <sub>out</sub> =30A, V <sub>cc-Vin</sub> =14V                                           |
| V clamp1            | V <sub>cc</sub> to V <sub>out</sub> clamp voltage 1  | 36   | 39   | —    | V             | I <sub>out</sub> =50mA                                                                    |
| V clamp2            | V <sub>cc</sub> to V <sub>out</sub> clamp voltage 2  | —    | 40   | 43   |               | I <sub>out</sub> =30A                                                                     |

(4) Input thresholds are measured directly between the input pin and the tab. Any parasitic resistance in common between the load current path and the input signal path can significantly affect the thresholds.

(5) R<sub>ds(on)</sub> is measured between the tab and the Out pin, 5mm away from the package.

(6) Guaranteed by design

## Switching Electrical Characteristics

V<sub>cc</sub>=14V, Resistive load=0.5 $\Omega$ ,  $T_J=25^{\circ}\text{C}$ 

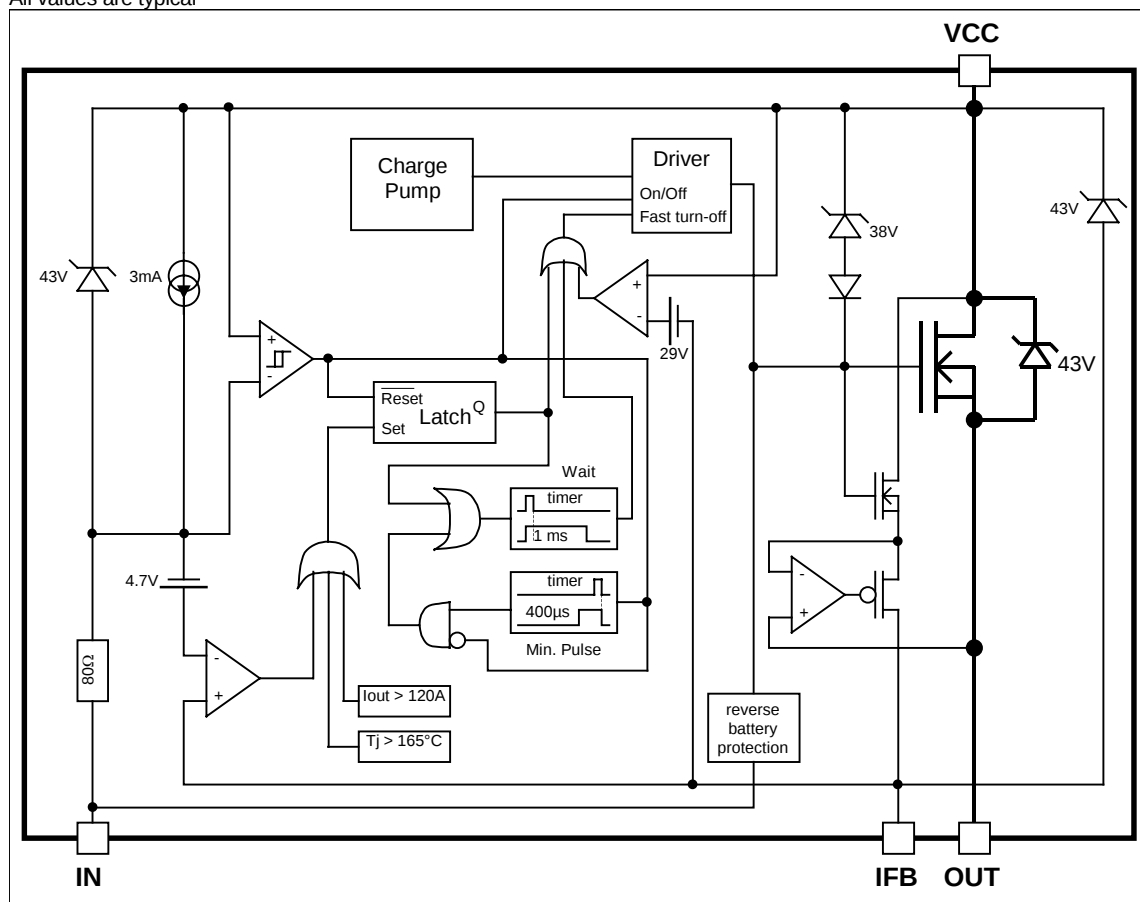
| Symbol | Parameter                     | Min. | Typ. | Max. | Units | Test Conditions |
|--------|-------------------------------|------|------|------|-------|-----------------|
| Tdon   | Turn on delay time to 10% Vcc | 30   | 120  | 300  | μs    | See figure 2    |
| Tr1    | Rise time to Vcc-Vout=5V      | 20   | 50   | 125  |       |                 |
| Tr2    | Rise time to Vcc-Vout=0.1Vcc  | 30   | 80   | 200  |       |                 |
| Eon    | Turn on energy                | —    | 14   | —    | mJ    |                 |
| Tdoff  | Turn off delay time           | 30   | 140  | 350  | μs    |                 |
| Tf     | Fall time to Vout=10% of Vcc  | 35   | 100  | 250  |       |                 |
| Eoff   | Turn off energy               | —    | 7    | —    | mJ    |                 |

## Current Sense Characteristics

| Symbol   | Parameter                                            | Min.  | Typ.  | Max.  | Units | Test Conditions                                                    |
|----------|------------------------------------------------------|-------|-------|-------|-------|--------------------------------------------------------------------|
| Ratio    | I Load/I <sub>fb</sub> current ratio                 | 7,500 | 8,800 | 9,950 | —     | T <sub>j</sub> =25°C, R <sub>fb</sub> =500Ω, I <sub>out</sub> =60A |
| Ratio_TC | I Load/I <sub>fb</sub> variation aver temperature(6) | -5    | —     | +5    | %     | T <sub>j</sub> =-40°C to 150°C                                     |
| Offset   | Load current diagnostic offset                       | -0.22 | 0     | +0.2  | A     | I <sub>out</sub> =2A                                               |
| Trst     | I <sub>fb</sub> response time (low signal)           | —     | 1     | —     | μs    | 90% of the I <sub>out</sub> step                                   |

## Functional Block Diagram

All values are typical



## Lead Assignments

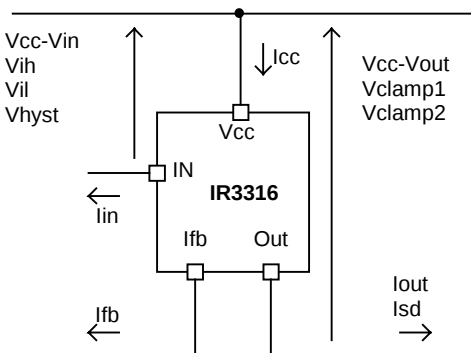
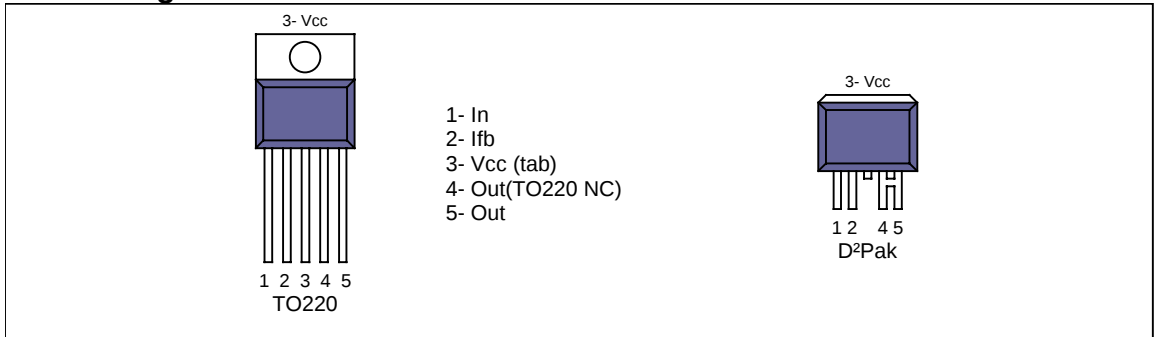


Figure 1 – Voltages and current definitions

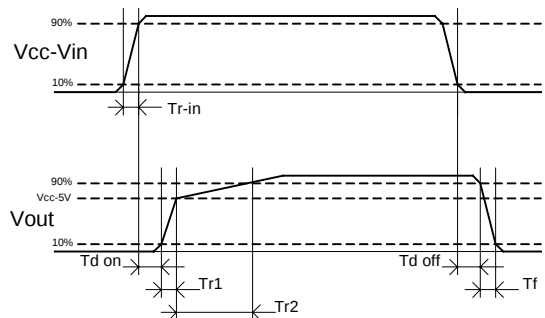
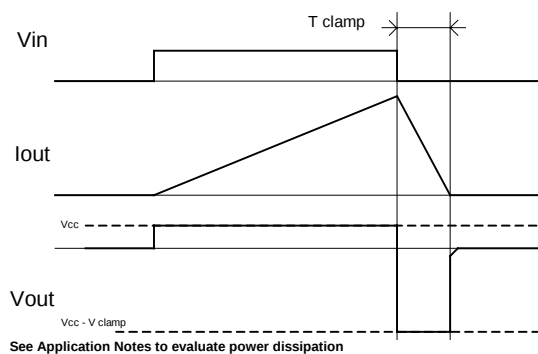
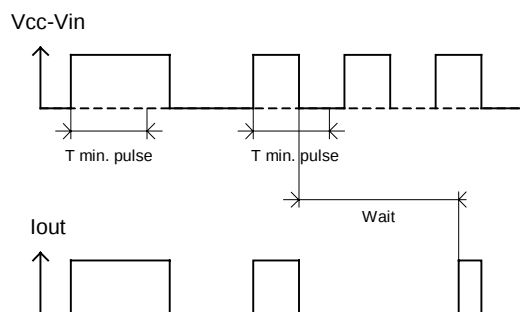


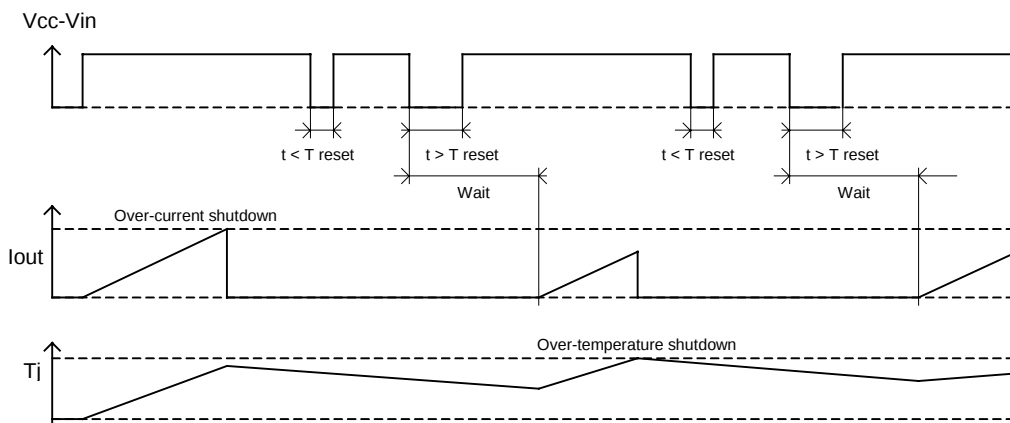
Figure 2 – Switching time definitions



**Figure 3 – Active clamp waveforms**

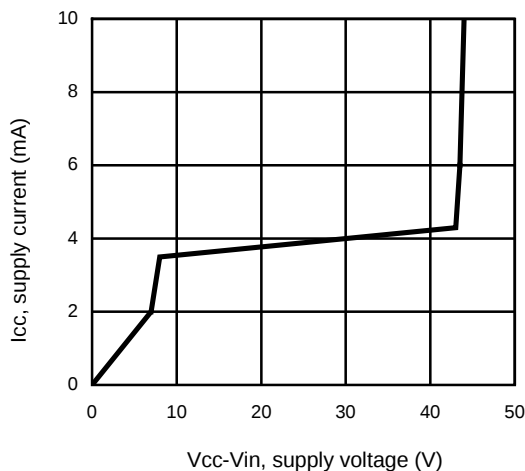


**Figure 4 – Min. pulse and Wait function**

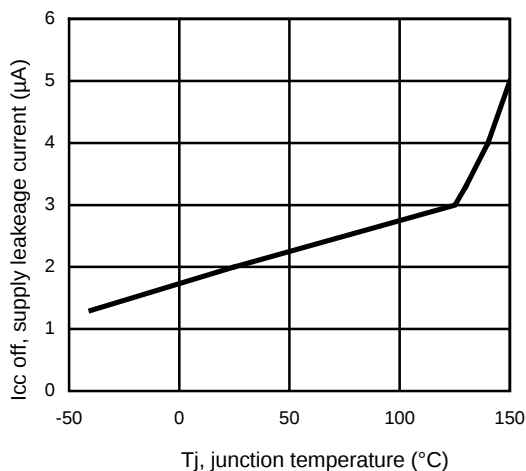


**Figure 5 – Protection Timing Diagrams**

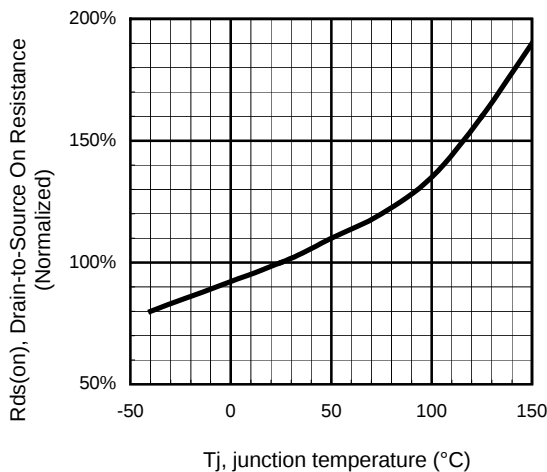
All curves are typical characteristics. Operation in hatched areas is not recommended.  $T_j=25^{\circ}\text{C}$ ,  $R_{\text{fcb}}=500\text{ohm}$ ,  $V_{\text{cc}}=14\text{V}$  (unless otherwise specified).



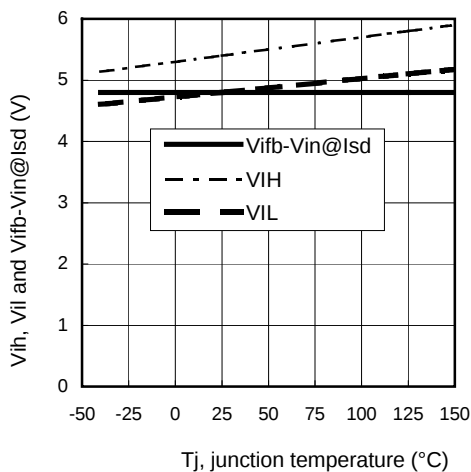
**Figure 6 – Icc (mA) Vs Vcc-Vin (V)**



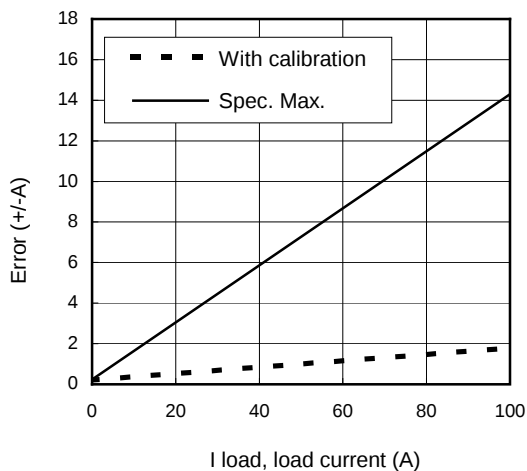
**Figure 7 – Icc off (μA) Vs Tj (°C)**



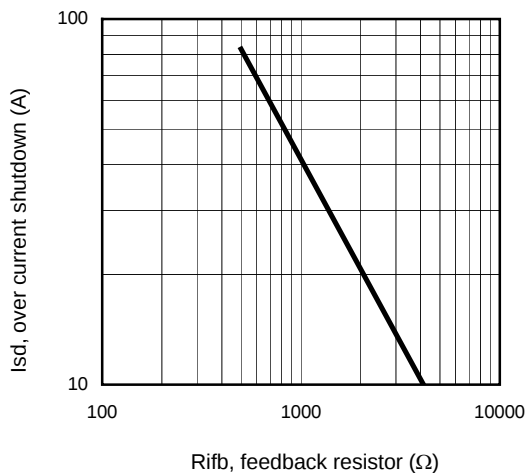
**Figure 8 - Normalized Rds(on) (%) Vs Tj (°C)**



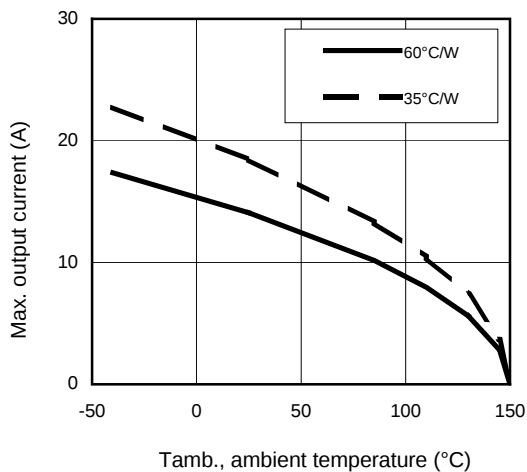
**Figure 9 – Vih, Vil and Vifb-Vin@Isd (V) Vs Tj (°C)**



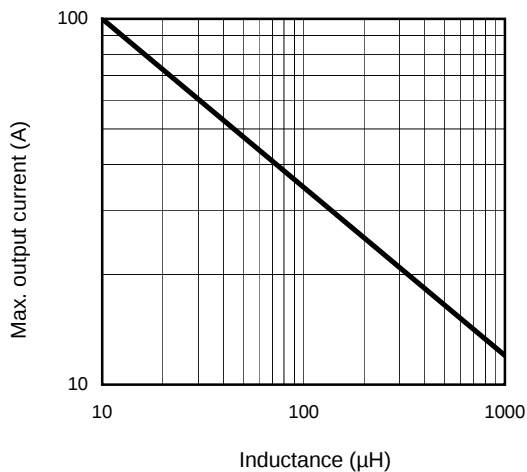
**Figure 10 – Error (+/- A) Vs I load (A)**



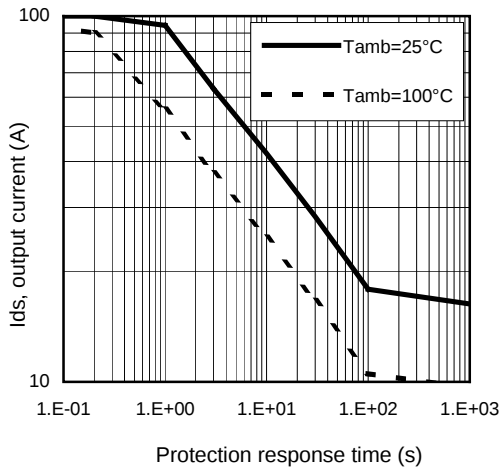
**Figure 11 – Ids (A) Vs Rifb (Ω)**



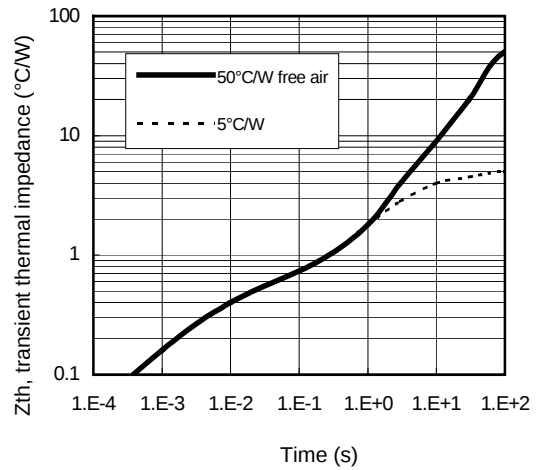
**Figure 12 – Max. iout (A) Vs Tamb. (°C)**



**Figure 13 – Max. iout (A) Vs inductance (μH)**

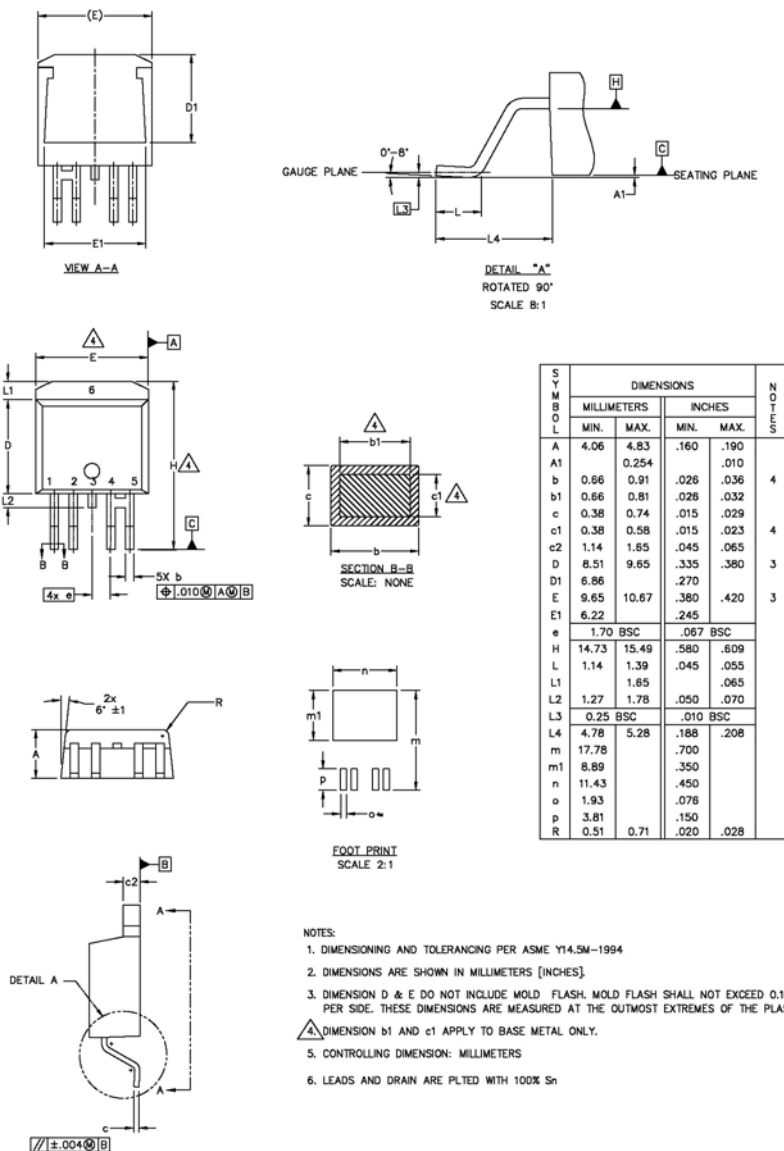


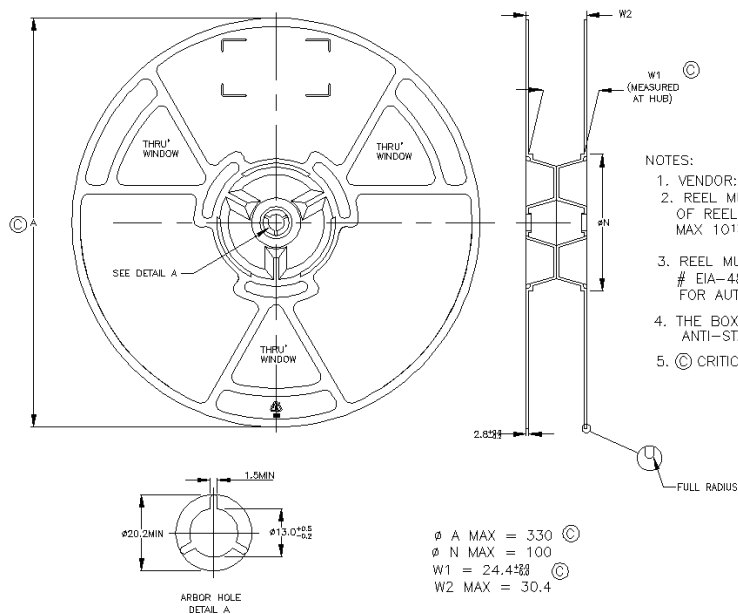
**Figure 14 –  $I_{ds}$  (A) Vs over temperature protection response time (s)**



**Figure 15 – Transient thermal impedance (°C/W) Vs time (s)**

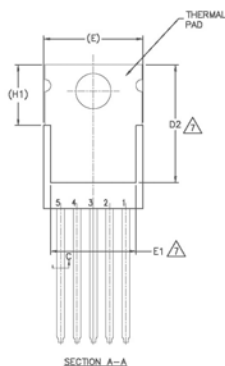
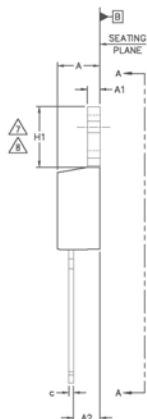
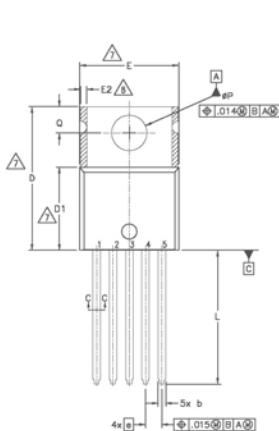
**Case Outline 5 Lead - D2PAK - Automotive Q100 PbF MSL1 qualified**



**Tape & Reel 5 Lead - D2PAK**

- NOTES:
1. VENDOR: OPTIONAL
  2. REEL MUST HAVE ANTI-STATIC COATING SURFACE RESISTIVITY OF REEL (AS PER EIA-541)  $\text{uin: } 10^9 \text{ ohm/SQUARE}$ ;  
MAX  $10^{12} \text{ ohm/SQUARE}$
  3. REEL MUST ALSO MEET REQUIREMENTS OF EIA STANDARD # EIA-481A, TAPING OF SURFACE-MOUNT COMPONENTS FOR AUTOMATIC PLACEMENT.
  4. THE BOX OF PACKING MUST CONTAIN THE REELS INSIDE AN ANTI-STATIC BAG.
  5. Ⓢ CRITICAL

## Case Outline 5 Leads – TO220 – Automotive Q100 PbF qualified



| SYMBOL | DIMENSIONS  |       |          |      | UNITS |
|--------|-------------|-------|----------|------|-------|
|        | MILLIMETERS |       | INCHES   |      |       |
|        | MIN.        | MAX.  | MIN.     | MAX. |       |
|        |             |       |          |      |       |
| A      | 3.56        | 4.83  | .140     | .190 |       |
| A1     | 0.51        | 1.40  | .020     | .055 |       |
| A2     | 2.03        | 2.92  | .080     | .115 |       |
| b      | 0.64        | 0.89  | .025     | .035 |       |
| b1     | 0.64        | 0.84  | .025     | .033 | 5     |
| c      | 0.36        | 0.61  | .014     | .024 |       |
| c1     | 0.36        | 0.56  | .014     | .022 | 5     |
| D      | 14.22       | 16.51 | .560     | .650 | 4     |
| D1     | 8.38        | 9.52  | .330     | .355 |       |
| D2     | 11.68       | 12.88 | .460     | .507 | 7     |
| E      | 9.65        | 10.67 | .380     | .420 | 4, 7  |
| E1     | 6.86        | 8.89  | .270     | .350 | 7     |
| E2     | —           | 0.76  | —        | .030 | 8     |
| e      | 1.70 BSC    |       | .067 BSC |      |       |
| H1     | 5.84        | 6.86  | .230     | .270 | 7, 8  |
| L      | 12.70       | 14.73 | .500     | .580 |       |
| PP     | 3.53        | 3.73  | .139     | .147 |       |
| Q      | 2.54        | 3.05  | .100     | .120 |       |

### NOTES:

- 1.— DIMENSIONING AND TOLERANCING AS PER ASME Y14.5 M-1994.
- 2.— DIMENSIONS ARE SHOWN IN INCHES [MILLIMETERS].
- 3.— LEAD DIMENSION AND FINISH UNCONTROLLED IN L1.
- 4.— DIMENSION D1, D1 & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED .005" (0.127) PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY.
- 5.— DIMENSION b1 & c1 APPLY TO BASE METAL ONLY.
- 6.— CONTROLLING DIMENSION - INCHES.
- 7.— THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSIONS E,H1,D2 & E1.
- 8.— DIMENSION E2 X H1 DEFINE A ZONE WHERE STAMPING AND SINGULATION IRREGULARITIES ARE ALLOWED.
- 9.— OUTLINE CONFORMS TO JEDEC TO-220, EXCEPT A2 (max.) AND D2 (min.) WHERE DIMENSIONS ARE DERIVED FROM THE ACTUAL PACKAGE OUTLINE.

10.— LEADS AND DRAIN ARE PLATED WITH 100% Sn

