

### CURRENT SENSE HIGH SIDE SWITCH

#### Features

- Suitable 24V battery operation
- Over current shutdown
- Over temperature shutdown
- Current sensing
- Active clamp
- Low current
- ESD protection
- Optimized Turn On/Off for EMI

#### Applications

- Solenoid
- 24V loads for trucks

#### Description

The AUIPS71411G is a fully protected four terminal high side switch specifically designed for 24V battery application. It features current sensing, over-current, over-temperature, ESD protection and drain to source active clamp. 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. The  $I_{fb}$  pin is used for current sensing.

#### Product Summary

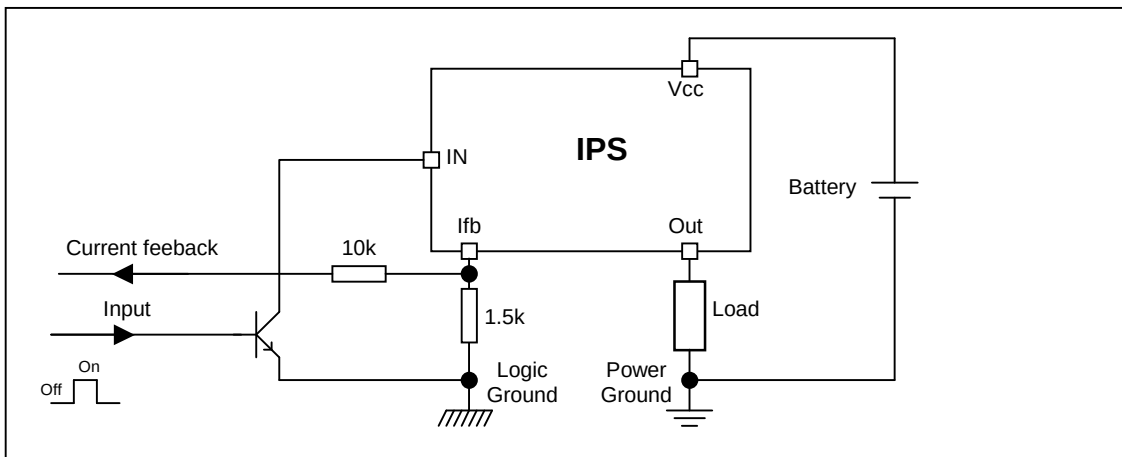
|                  |                    |
|------------------|--------------------|
| $R_{ds(on)}$     | 100m $\Omega$ max. |
| $V_{clamp}$      | 65V                |
| Current shutdown | 5A min.            |

#### Packages



SO8

#### Typical Connection



## Qualification Information<sup>†</sup>

|                                   |                      |                                                                                                                                                                               |
|-----------------------------------|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Qualification Level</b>        |                      | Automotive<br>(per AEC-Q100 <sup>††</sup> )                                                                                                                                   |
|                                   |                      | Comments: This family of ICs has passed an Automotive qualification. IR's Industrial and Consumer qualification level is granted by extension of the higher Automotive level. |
| <b>Moisture Sensitivity Level</b> |                      | SOIC-8L<br><br>MSL2, 260°C<br>(per IPC/JEDEC J-STD-020)                                                                                                                       |
| <b>ESD</b>                        | Machine Model        | Class M2 (200 V)<br>(per AEC-Q100-003)                                                                                                                                        |
|                                   | Human Body Model     | Class H1C (1500 V)<br>(per AEC-Q100-002)                                                                                                                                      |
|                                   | Charged Device Model | Class C5 (1000 V)<br>(per AEC-Q100-011)                                                                                                                                       |
| <b>IC Latch-Up Test</b>           |                      | ClassII, Level A<br>(per AEC-Q100-004)                                                                                                                                        |
| <b>RoHS Compliant</b>             |                      | Yes                                                                                                                                                                           |

† Qualification standards can be found at International Rectifier's web site <http://www.irf.com/>

†† Exceptions to AEC-Q100 requirements are noted in the qualification report.

## Absolute Maximum Ratings

Absolute maximum ratings indicate sustained limits beyond which damage to the device may occur. All voltage parameters are referenced to the ground lead. ( $T_{\text{ambient}}=25^{\circ}\text{C}$  unless otherwise specified).

| Symbol       | Parameter                                                                           | Min.   | Max.    | Units |
|--------------|-------------------------------------------------------------------------------------|--------|---------|-------|
| Vout         | Maximum output voltage                                                              | Vcc-60 | Vcc+0.3 | V     |
| Vcc-Vin max. | Maximum Vcc voltage                                                                 | -16    | 65      | V     |
| Iifb, max.   | Maximum feedback current                                                            | -50    | 10      | mA    |
| Vcc sc.      | Maximum Vcc voltage with short circuit protection see page 6                        | —      | 50      | V     |
| Pd           | Maximum power dissipation (internally limited by thermal protection)<br>Rth=100°C/W | —      | 1.25    | W     |
| Tj max.      | Max. storage & operating junction temperature                                       | -40    | 150     | °C    |

## Thermal Characteristics

| Symbol | Parameter                                  | Typ. | Max. | Units |
|--------|--------------------------------------------|------|------|-------|
| Rth1   | Thermal resistance junction to ambient SO8 | 100  | —    | °C/W  |

## 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, $T_{\text{ambient}}=85^{\circ}\text{C}$ , $T_j=125^{\circ}\text{C}$<br>Rth=100°C/W | —    | 1.5  | A     |
| Rlfb   | Ifb resistor                                                                                                  | 1.5  | —    | kΩ    |

## Static Electrical Characteristics

T<sub>J</sub>=25°C, V<sub>CC</sub>=28V (unless otherwise specified)

| Symbol               | Parameter                                           | Min. | Typ. | Max. | Units | Test Conditions                                                                                             |
|----------------------|-----------------------------------------------------|------|------|------|-------|-------------------------------------------------------------------------------------------------------------|
| V <sub>CC op.</sub>  | Operating voltage                                   | 6    | —    | 60   | V     |                                                                                                             |
| R <sub>DS(on)</sub>  | ON state resistance T <sub>J</sub> =25°C            | —    | 75   | 100  | mΩ    | I <sub>DS</sub> =2A                                                                                         |
|                      | ON state resistance T <sub>J</sub> =150°C(2)        | —    | 135  | 180  |       |                                                                                                             |
| I <sub>CC off</sub>  | Supply leakage current                              | —    | 1    | 3    | μA    | V <sub>IN</sub> =V <sub>CC</sub> / V <sub>IFB</sub> =V <sub>GND</sub><br>V <sub>OUT</sub> =V <sub>GND</sub> |
| I <sub>OUT off</sub> | Output leakage current                              | —    | 1    | 3    |       |                                                                                                             |
| I <sub>IN on</sub>   | Input current while on                              | 0.6  | 1.6  | 3    | mA    | V <sub>CC</sub> -V <sub>IN</sub> =28V                                                                       |
| V <sub>CLAMP1</sub>  | V <sub>CC</sub> to V <sub>OUT</sub> clamp voltage 1 | 60   | 64   | —    | V     | I <sub>D</sub> =10mA                                                                                        |
| V <sub>CLAMP2</sub>  | V <sub>CC</sub> to V <sub>OUT</sub> clamp voltage 2 | 60   | 65   | 72   |       | I <sub>D</sub> =6A see fig. 2                                                                               |
| V <sub>IH(1)</sub>   | High level Input threshold voltage                  | —    | 3    | 4.5  |       | I <sub>D</sub> =10mA                                                                                        |
| V <sub>IL(1)</sub>   | Low level Input threshold voltage                   | 1.5  | 2.3  | —    |       |                                                                                                             |
|                      | Forward body diode voltage T <sub>J</sub> =25°C     | —    | 0.8  | 0.9  |       | I <sub>F</sub> =1A                                                                                          |
|                      | Forward body diode voltage T <sub>J</sub> =125°C    | —    | 0.65 | 0.75 |       |                                                                                                             |

(1) Input thresholds are measured directly between the input pin and the tab.

## Switching Electrical Characteristics

V<sub>CC</sub>=28V, Resistive load=27Ω, T<sub>J</sub>=25°C

| Symbol | Parameter                        | Min. | Typ. | Max. | Units | Test Conditions |
|--------|----------------------------------|------|------|------|-------|-----------------|
| Tdon   | Turn on delay time to 20%        | 4    | 10   | 20   | μs    | See fig. 1      |
| Tr     | Rise time from 20% to 80% of Vcc | 2    | 5    | 10   |       |                 |
| Tdoff  | Turn off delay time              | 20   | 40   | 80   | μs    |                 |
| Tf     | Fall time from 80% to 20% of Vcc | 2.5  | 5    | 10   |       |                 |

## Protection Characteristics

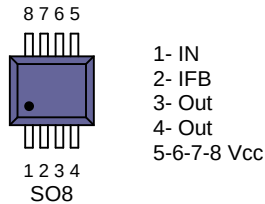
| Symbol             | Parameter                                                              | Min.   | Typ. | Max. | Units | Test Conditions        |
|--------------------|------------------------------------------------------------------------|--------|------|------|-------|------------------------|
| T <sub>SD</sub>    | Over temperature threshold                                             | 150(2) | 165  | —    | °C    | See fig. 3 and fig. 11 |
| I <sub>SD</sub>    | Over-current shutdown                                                  | 5      | 7    | 10   | A     | See fig. 3 and page 6  |
| I <sub>fault</sub> | I <sub>FB</sub> after an over-current or an over-temperature (latched) | 2.7    | 3.3  | 4    | mA    | See fig. 3             |

## Current Sensing Characteristics

| Symbol                  | Parameter                                                         | Min. | Typ. | Max. | Units | Test Conditions                 |
|-------------------------|-------------------------------------------------------------------|------|------|------|-------|---------------------------------|
| Ratio                   | I <sub>load</sub> / I <sub>FB</sub> current ratio                 | 2000 | 2400 | 2800 |       | I <sub>load</sub> =2A           |
| Ratio <sub>TC</sub>     | I <sub>load</sub> / I <sub>FB</sub> variation over temperature(2) | -5%  | 0    | +5   | %     | T <sub>J</sub> =-40°C to +150°C |
| I <sub>offset</sub>     | Load current offset                                               | -0.2 | 0    | 0.2  | A     | I <sub>OUT</sub> <2A            |
| I <sub>FB leakage</sub> | I <sub>FB</sub> leakage current                                   | 0    | 8    | 100  | μA    | I <sub>OUT</sub> =0A            |

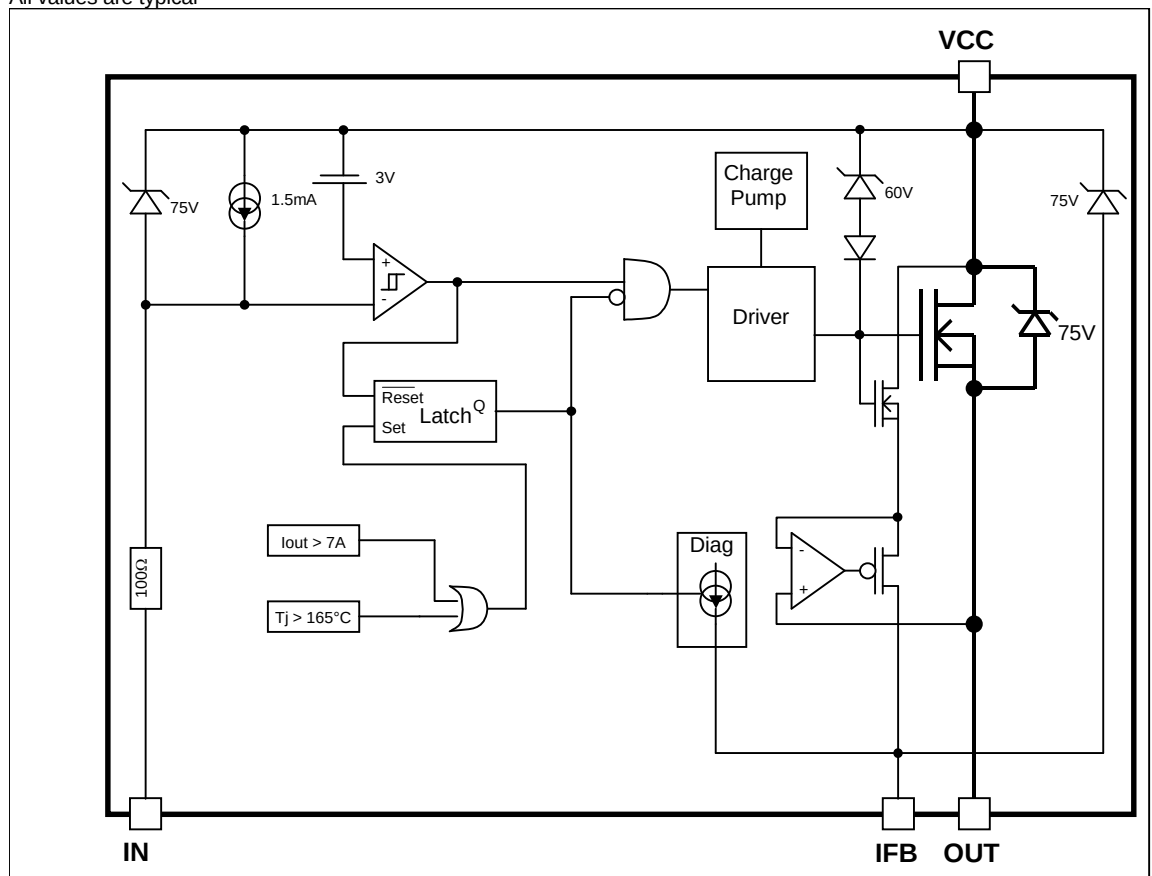
(2) Guaranteed by design

## Lead Assignments



## Functional Block Diagram

All values are typical



## Truth Table

| Op. Conditions       | Input | Output | I <sub>fb</sub> pin voltage                 |
|----------------------|-------|--------|---------------------------------------------|
| Normal mode          | H     | L      | 0V                                          |
| Normal mode          | L     | H      | I <sub>load</sub> x R <sub>fb</sub> / Ratio |
| Open load            | H     | L      | 0V                                          |
| Open load            | L     | H      | 0V                                          |
| Short circuit to GND | H     | L      | 0V                                          |
| Short circuit to GND | L     | L      | V <sub>fault</sub> (latched)                |
| Over temperature     | H     | L      | 0V                                          |
| Over temperature     | L     | L      | V <sub>fault</sub> (latched)                |

## Operating voltage

**Maximum V<sub>cc</sub> voltage** : this is the maximum voltage before the breakdown of the IC process.

**Operating voltage** : This is the V<sub>cc</sub> range in which the functionality of the part is guaranteed. The Q100 qualification is run at the maximum operating voltage specified in the datasheet.

## Reverse battery

During the reverse battery the Mosfet is kept off and the load current is flowing into the body diode of the power Mosfet. Power dissipation in the IPS :  $P = I_{load} \cdot V_f$

If the power dissipation is too high in R<sub>fb</sub>, a diode in serial can be added to block the current.

The transistor used to pull-down the input should be a bipolar in order to block the reverse current. The 100ohm input resistor can not sustain continuously 16V (see V<sub>cc</sub>-V<sub>in</sub> max. in the Absolute Maximum Ratings section)

## Active clamp

The purpose of the active clamp is to limit the voltage across the MOSFET to a value below the body diode break down voltage to reduce the amount of stress on the device during switching.

The temperature increase during active clamp can be estimated as follows:

$$\Delta T_J = P_{CL} \cdot Z_{TH}(t_{CLAMP})$$

Where:  $Z_{TH}(t_{CLAMP})$  is the thermal impedance at  $t_{CLAMP}$  and can be read from the thermal impedance curves given in the data sheets.

$P_{CL} = V_{CL} \cdot I_{CLavg}$  : Power dissipation during active clamp

$V_{CL} = 65V$  : Typical  $V_{CLAMP}$  value.

$$I_{CLavg} = \frac{I_{CL}}{2} : \text{Average current during active clamp}$$

$$t_{CL} = \frac{I_{CL}}{\left| \frac{di}{dt} \right|} : \text{Active clamp duration}$$

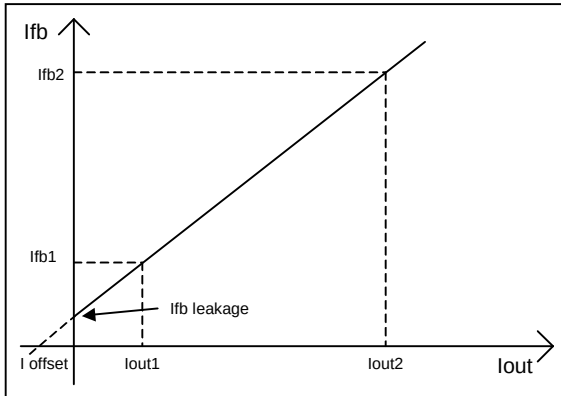
$$\frac{di}{dt} = \frac{V_{Battery} - V_{CL}}{L} : \text{Demagnetization current}$$

Figure 9 gives the maximum inductance versus the load current in the worst case : the part switch off after an over temperature detection. If the load inductance exceed the curve, a free wheeling diode is required.

## Over-current protection

The threshold of the over-current protection is set in order to guaranteed that the device is able to turn on a load with an inrush current lower than the minimum of I<sub>sd</sub>. Nevertheless for high current and high temperature the device may switch off for a lower current due to the over-temperature protection (see Figure 11).

## Current sensing accuracy



The current sensing is specified by measuring 3 points :

- I\_fb1 for I\_out1
- I\_fb2 for I\_out2
- I\_fb leakage for I\_out=0

Then the parameters of the datasheet are computed by the following formula :

$$\text{Ratio} = (I_{\text{out2}} - I_{\text{out1}}) / (I_{\text{fb2}} - I_{\text{fb1}})$$

$$I_{\text{offset}} = I_{\text{fb1}} \times \text{Ratio} - I_{\text{out1}}$$

This allows the designer to evaluate the I\_fb for any I\_out value using :

$$I_{\text{fb}} = (I_{\text{out}} + I_{\text{offset}}) / \text{Ratio} \text{ if } I_{\text{fb}} > I_{\text{fb leakage}}$$

For some applications, a calibration is required. In that case, the accuracy of the system will depends on the variation of the I\_offset and the ratio over the temperature range. The ratio variation is given by Ratio\_TC specified in page 3.

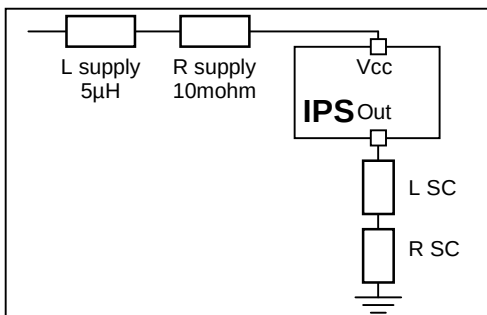
The I\_offset variation depends directly of the R\_dson :

$$I_{\text{offset@-40}^{\circ}\text{C}} = I_{\text{offset@25}^{\circ}\text{C}} / 0.8$$

$$I_{\text{offset@150}^{\circ}\text{C}} = I_{\text{offset@25}^{\circ}\text{C}} / 1.9$$

## Maximum Vcc voltage with short circuit protection

The maximum Vcc voltage with short circuit is the maximum voltage for which the part is able to protect itself under test conditions representative of the application. 2 kind of short circuits are considered : terminal and load short circuit.



|             | L SC   | R SC     |
|-------------|--------|----------|
| Terminal SC | 0.1 μH | 10 mohm  |
| Load SC     | 10 μH  | 100 mohm |

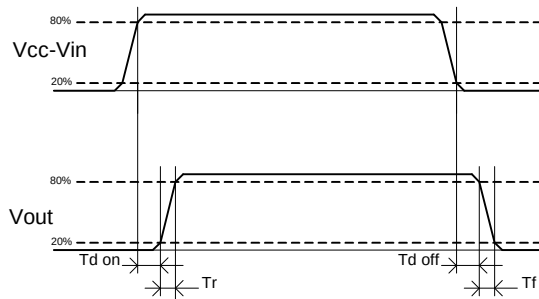


Figure 1 – IN rise time & switching definitions

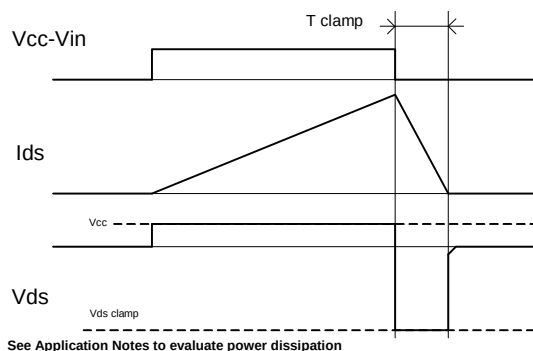


Figure 2 – Active clamp waveforms

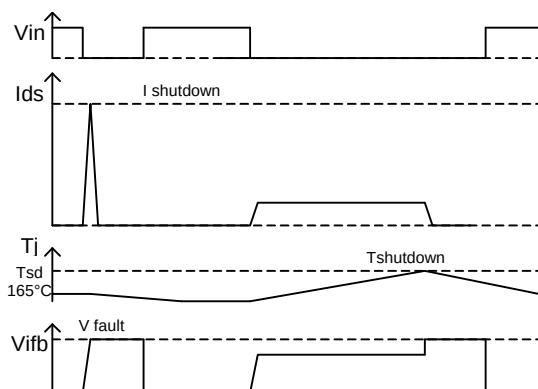


Figure 3 – Protection timing diagram

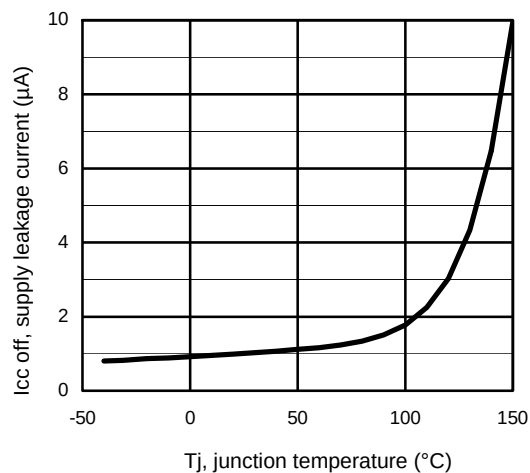
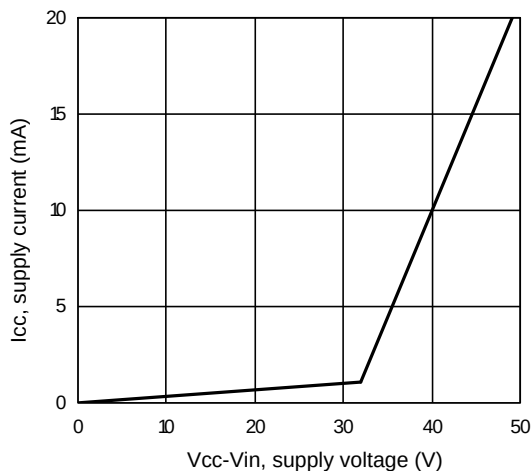
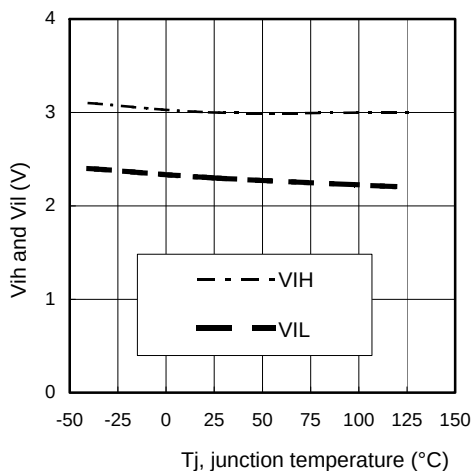


Figure 4 – Icc off (µA) Vs Tj (°C)

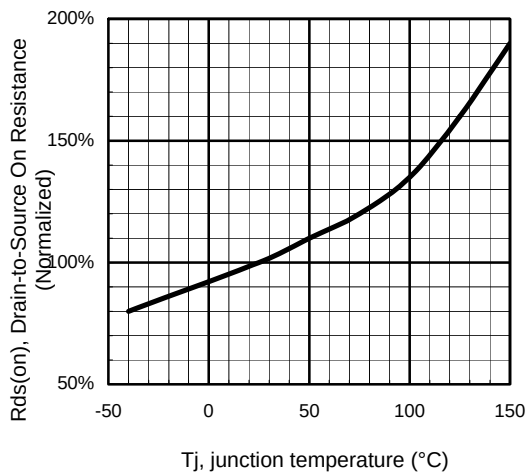




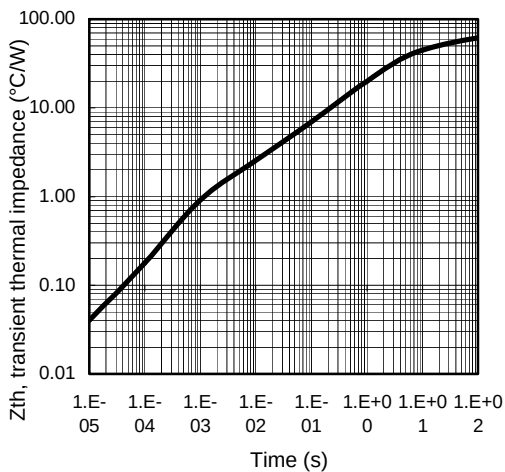
**Figure 5 – Icc (mA) Vs Vcc-Vin (V)**



**Figure 6 – Vih and Vil (V) Vs Tj (°C)**



**Figure 7 - Normalized Rds(on) (%) Vs Tj (°C)**



**Figure 8 – Transient thermal impedance (°C/W) Vs time (s)**

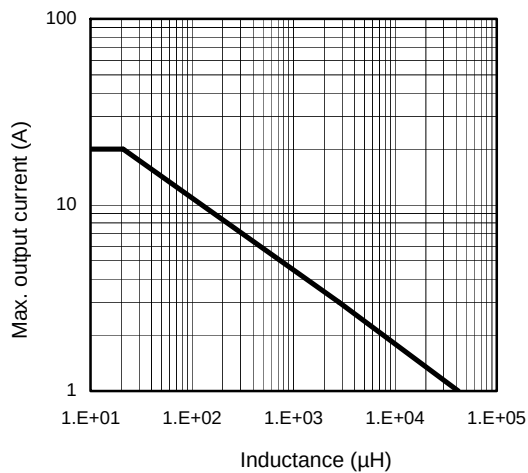


Figure 9 – Max. Iout (A) Vs inductance (μH)

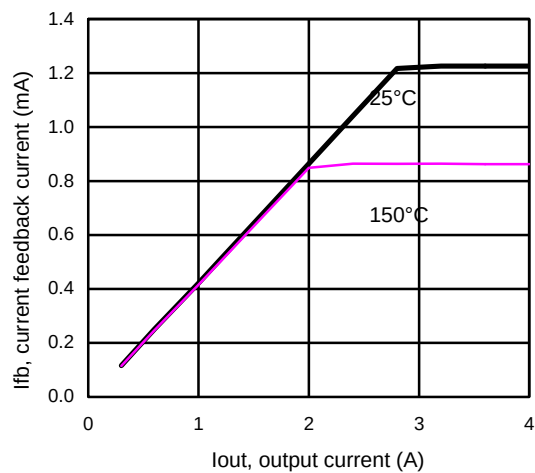
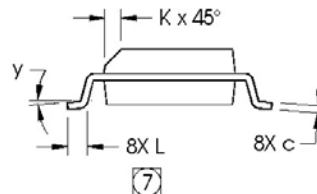
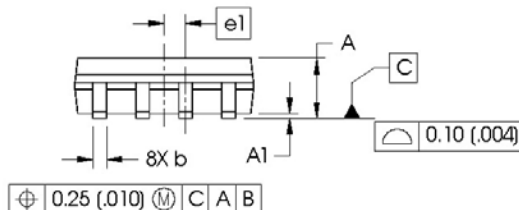
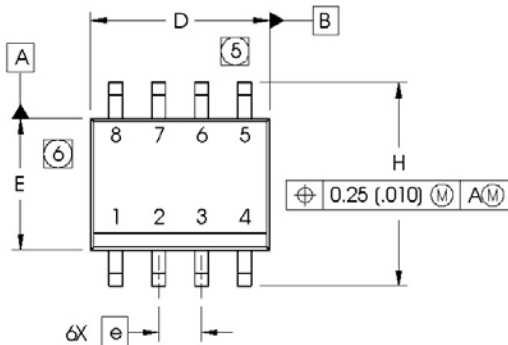


Figure 10 – Ifb (mA) Vs Iout (A)

## Case Outline - SO-8

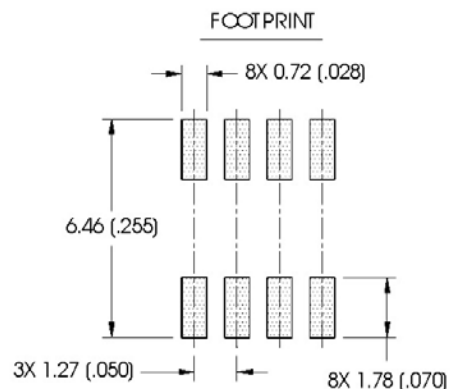
Dimensions are shown in millimeters (inches)



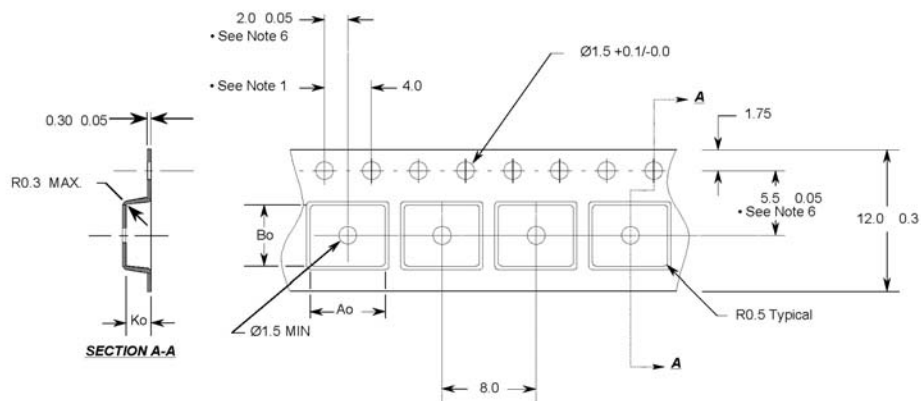
| DIM | INCHES     |       | MILLIMETERS |      |
|-----|------------|-------|-------------|------|
|     | MIN        | MAX   | MIN         | MAX  |
| A   | .0532      | .0688 | 1.35        | 1.75 |
| A1  | .0040      | .0098 | 0.10        | 0.25 |
| b   | .013       | .020  | 0.33        | 0.51 |
| c   | .0075      | .0098 | 0.19        | 0.25 |
| D   | .189       | .1968 | 4.80        | 5.00 |
| E   | .1497      | .1574 | 3.80        | 4.00 |
| e   | .050 BASIC |       | 1.27 BASIC  |      |
| e1  | .025 BASIC |       | 0.635 BASIC |      |
| H   | .2284      | .2440 | 5.80        | 6.20 |
| K   | .0099      | .0196 | 0.25        | 0.50 |
| L   | .016       | .050  | 0.40        | 1.27 |
| y   | 0°         | 8°    | 0°          | 8°   |

### NOTES:

1. DIMENSIONING & TOLERANCING PER ASME Y14.5M-1994.
2. CONTROLLING DIMENSION: MILLIMETER
3. DIMENSIONS ARE SHOWN IN MILLIMETERS (INCHES).
4. OUTLINE CONFORMS TO JEDEC OUTLINE MS-012AA.
5. DIMENSION DOES NOT INCLUDE MOLD PROTRUSIONS. MOLD PROTRUSIONS NOT TO EXCEED 0.15 (.006).
6. DIMENSION DOES NOT INCLUDE MOLD PROTRUSIONS. MOLD PROTRUSIONS NOT TO EXCEED 0.25 (.010).
7. DIMENSION IS THE LENGTH OF LEAD FOR SOLDERING TO A SUBSTRATE.



## Tape & Reel - SO-8



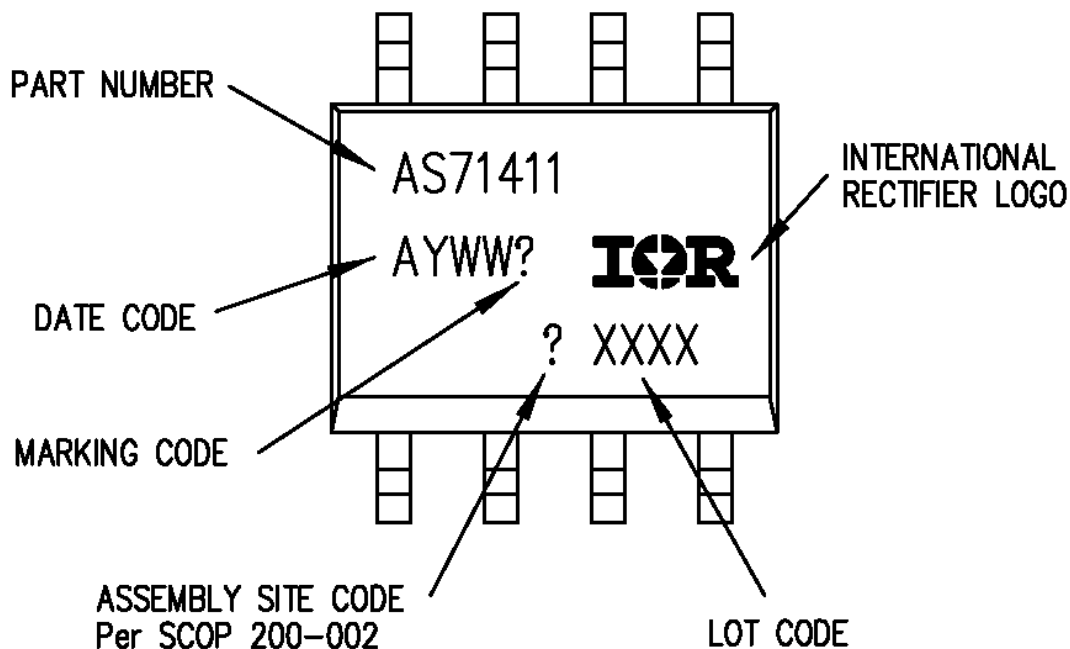
**Notes:**

- Notes:**
1. 10 sprocket hole pitch cumulative tolerance 0.2
  2. Camber not to exceed 1mm in 100mm
  3. Material: Black Conductive Advantek Polystyrene
  4. A<sub>o</sub> and B<sub>o</sub> measured on a plane 0.3mm above the bottom of the pocket
  5. K<sub>o</sub> measured from a plane on the inside bottom of the pocket to the top surface of the carrier.
  6. Pocket position relative to sprocket hole measured as true position of pocket, not pocket hole.

$A_o = 6,4 \text{ mm}$   
 $B_o = 5,2 \text{ mm}$   
 $K_o = 2,1 \text{ mm}$

- All Dimensions in Millimeters -

## Part Marking Information



## Ordering Information

| Base Part Number | Package Type | Standard Pack |          | Complete Part Number |
|------------------|--------------|---------------|----------|----------------------|
|                  |              | Form          | Quantity |                      |
| AUIPS71411G      | SO8          | Tube          | 95       | AUIPS71411G          |
|                  |              | Tape and reel | 2500     | AUIPS71411GTR        |

## **IMPORTANT NOTICE**

Unless specifically designated for the automotive market, International Rectifier Corporation and its subsidiaries (IR) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or services without notice. Part numbers designated with the "AU" prefix follow automotive industry and / or customer specific requirements with regards to product discontinuance and process change notification. All products are sold subject to IR's terms and conditions of sale supplied at the time of order acknowledgment.

IR warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with IR's standard warranty. Testing and other quality control techniques are used to the extent IR deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

IR assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using IR components. To minimize the risks with customer products and applications, customers should provide adequate design and operating safeguards.

Reproduction of IR information in IR data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alterations is an unfair and deceptive business practice. IR is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of IR products or serviced with statements different from or beyond the parameters stated by IR for that product or service voids all express and any implied warranties for the associated IR product or service and is an unfair and deceptive business practice. IR is not responsible or liable for any such statements.

IR products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or in other applications intended to support or sustain life, or in any other application in which the failure of the IR product could create a situation where personal injury or death may occur. Should Buyer purchase or use IR products for any such unintended or unauthorized application, Buyer shall indemnify and hold International Rectifier and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that IR was negligent regarding the design or manufacture of the product.

IR products are neither designed nor intended for use in military/aerospace applications or environments unless the IR products are specifically designated by IR as military-grade or "enhanced plastic." Only products designated by IR as military-grade meet military specifications. Buyers acknowledge and agree that any such use of IR products which IR has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

IR products are neither designed nor intended for use in automotive applications or environments unless the specific IR products are designated by IR as compliant with ISO/TS 16949 requirements and bear a part number including the designation "AU". Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, IR will not be responsible for any failure to meet such requirements.

For technical support, please contact IR's Technical Assistance Center

<http://www.irf.com/technical-info/>

**WORLD HEADQUARTERS:**

233 Kansas St., El Segundo, California 90245

Tel: (310) 252-7105