

### 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

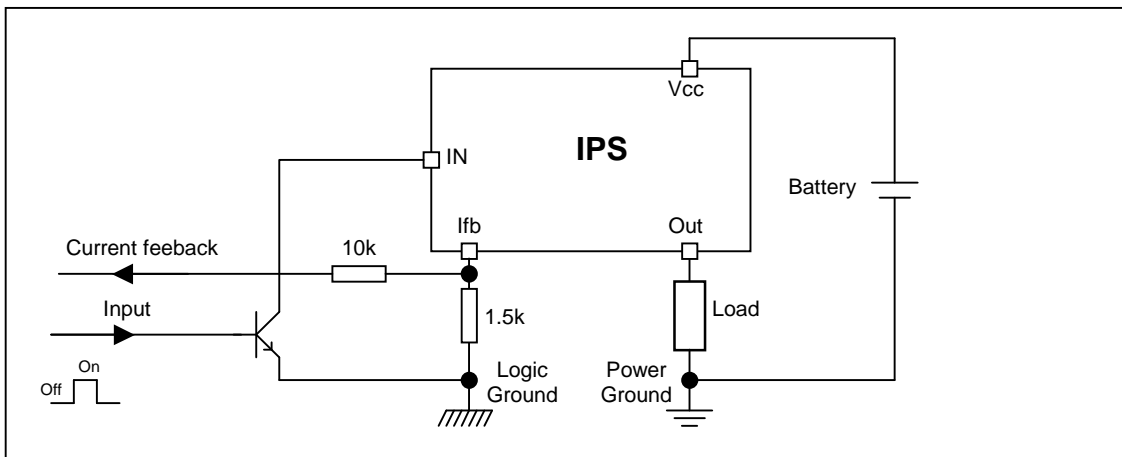
$R_{ds(on)}$	100m $\Omega$ max.
$V_{clamp}$	65V
Current shutdown	5A min.

#### Packages



SO8

#### Typical Connection



**Qualification Information<sup>†</sup>**

<b>Qualification Level</b>		Automotive (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  MSL2, 260°C (per IPC/JEDEC J-STD-020)
<b>ESD</b>	Machine Model	Class M2 (200 V) (per AEC-Q100-003)
	Human Body Model	Class H1C (1500 V) (per AEC-Q100-002)
	Charged Device Model	Class C5 (1000 V) (per AEC-Q100-011)
<b>IC Latch-Up Test</b>		ClassII, Level A (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<sub>ambient</sub>=25°C unless otherwise specified).

Symbol	Parameter	Min.	Max.	Units
V <sub>out</sub>	Maximum output voltage	V <sub>cc</sub> -60	V <sub>cc</sub> +0.3	V
V <sub>cc</sub> -V <sub>in</sub> max.	Maximum V <sub>cc</sub> voltage	-16	65	V
I <sub>ifb</sub> , max.	Maximum feedback current	-50	10	mA
V <sub>cc</sub> sc.	Maximum V <sub>cc</sub> voltage with short circuit protection see page 6	—	50	V
P <sub>d</sub>	Maximum power dissipation (internally limited by thermal protection) R <sub>th</sub> =100°C/W	—	1.25	W
T <sub>j</sub> max.	Max. storage & operating junction temperature	-40	150	°C

## Thermal Characteristics

Symbol	Parameter	Typ.	Max.	Units
R <sub>th1</sub>	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
I <sub>out</sub>	Continuous output current, T <sub>ambient</sub> =85°C, T <sub>j</sub> =125°C R <sub>th</sub> =100°C/W	—	1.5	A
R <sub>I<sub>fb</sub></sub>	I <sub>fb</sub> resistor	1.5	—	kΩ

## Static Electrical Characteristics

$T_J=25^{\circ}\text{C}$ ,  $V_{CC}=28\text{V}$  (unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$V_{CC\text{ op.}}$	Operating voltage	6	—	60	V	
$R_{ds(on)}$	ON state resistance $T_J=25^{\circ}\text{C}$	—	75	100	$\text{m}\Omega$	$I_{ds}=2\text{A}$
	ON state resistance $T_J=150^{\circ}\text{C}(2)$	—	135	180		
$I_{CC\text{ off}}$	Supply leakage current	—	1	3	$\mu\text{A}$	$V_{in}=V_{CC} / V_{ifb}=V_{gnd}$ $V_{out}=V_{gnd}$
$I_{out\text{ off}}$	Output leakage current	—	1	3		
$I_{in\text{ on}}$	Input current while on	0.6	1.6	3	$\text{mA}$	$V_{CC}-V_{in}=28\text{V}$
$V_{\text{clamp}1}$	$V_{CC}$ to $V_{out}$ clamp voltage 1	60	64	—	V	$I_d=10\text{mA}$
$V_{\text{clamp}2}$	$V_{CC}$ to $V_{out}$ clamp voltage 2	60	65	72		$I_d=6\text{A}$ see fig. 2
$V_{ih(1)}$	High level Input threshold voltage	—	3	4.5		$I_d=10\text{mA}$
$V_{il(1)}$	Low level Input threshold voltage	1.5	2.3	—		
	Forward body diode voltage $T_J=25^{\circ}\text{C}$	—	0.8	0.9		$I_f=1\text{A}$
	Forward body diode voltage $T_J=125^{\circ}\text{C}$	—	0.65	0.75		

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

## Switching Electrical Characteristics

$V_{CC}=28\text{V}$ , Resistive load= $27\Omega$ ,  $T_J=25^{\circ}\text{C}$

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
$T_{sd}$	Over temperature threshold	150(2)	165	—	$^{\circ}\text{C}$	See fig. 3 and fig. 11
$I_{sd}$	Over-current shutdown	5	7	10	A	See fig. 3 and page 6
$I_{\text{fault}}$	$I_{fb}$ after an over-current or an over-temperature (latched)	2.7	3.3	4	$\text{mA}$	See fig. 3

## Current Sensing Characteristics

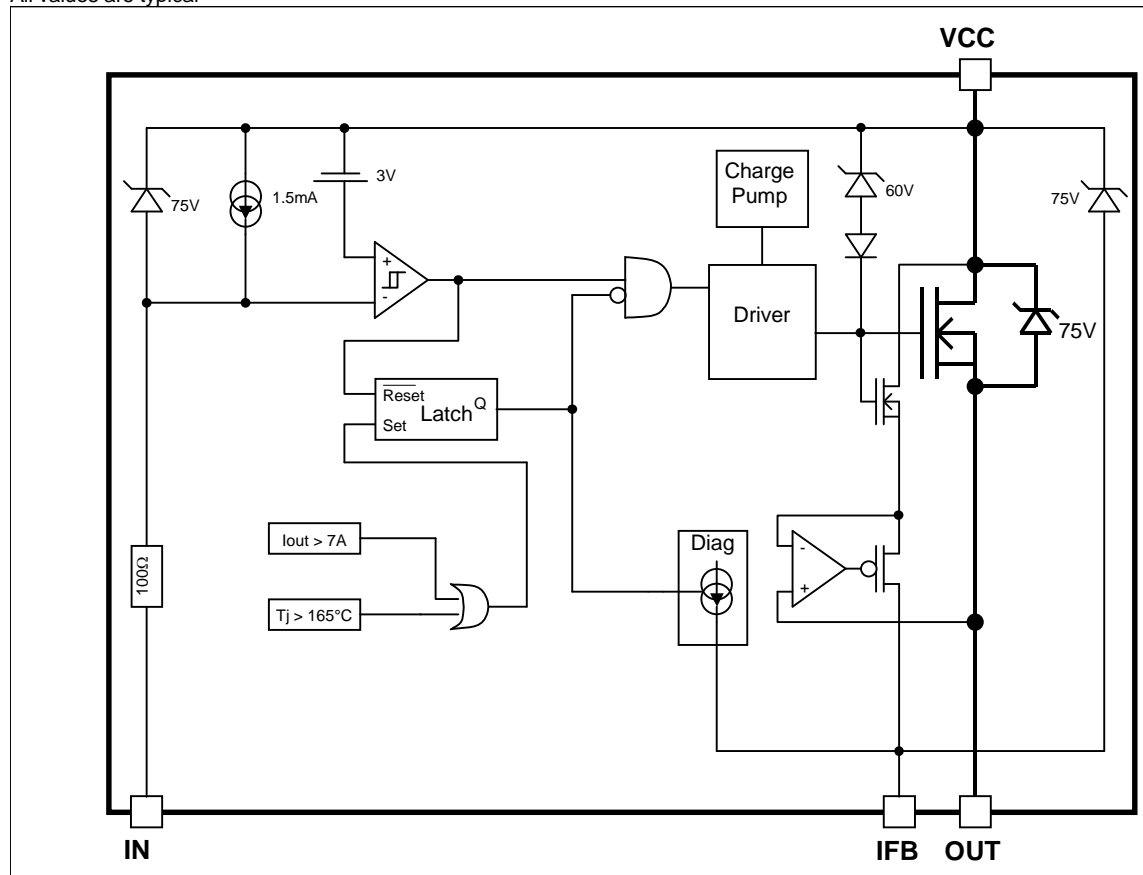
Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Ratio	$I_{\text{load}} / I_{fb}$ current ratio	2000	2400	2800		$I_{\text{load}}=2\text{A}$
Ratio_TC	$I_{\text{load}} / I_{fb}$ variation over temperature(2)	-5%	0	+5	%	$T_J=-40^{\circ}\text{C}$ to $+150^{\circ}\text{C}$
$I_{\text{offset}}$	Load current offset	-0.2	0	0.2	A	$I_{out}<2\text{A}$
$I_{fb\text{ leakage}}$	$I_{fb}$ leakage current	0	8	100	$\mu\text{A}$	$I_{out}=0\text{A}$

(2) Guaranteed by design

Diagram of an SO8 package with pin numbers 1-8 and a list of pin functions:

- 1- IN
- 2- IFB
- 3- Out
- 4- Out
- 5-6-7-8 Vcc

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.

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

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

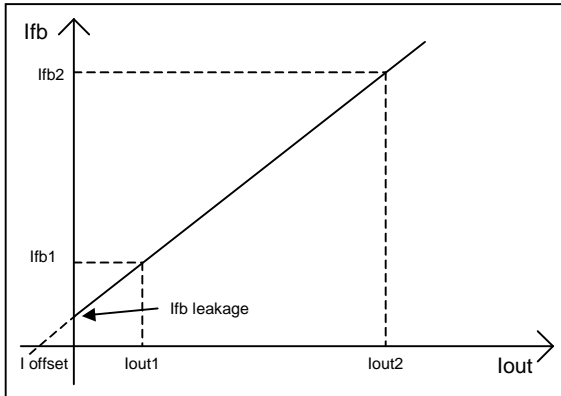
$$\frac{di}{dt} = \frac{V_{Battery} - V_{CL}}{L} : \text{Demagnetization current}$$

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 :

- Ifb1 for Iout1
- Ifb2 for Iout2
- Ifb leakage for Iout=0

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

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

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

This allows the designer to evaluate the Ifb for any Iout value using :

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

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.

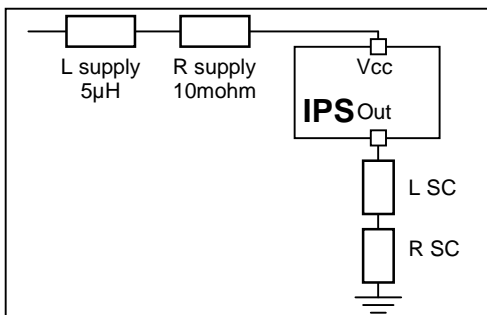
The Ioffset variation depends directly of the Rdson :

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

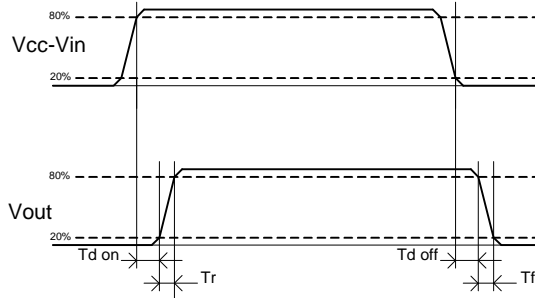
$$I_{offset@150^{\circ}\text{C}} = I_{offset@25^{\circ}\text{C}} / 1.9$$

## Maximum Vcc voltage with short circuit protection

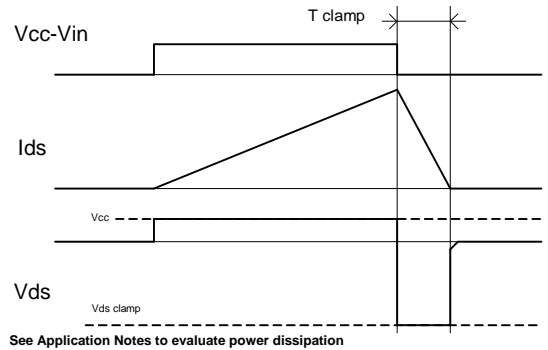
The maximum Vcc voltage with short circuit is the maximum voltage for which the part is able to protect itself under test conditions representative of the application. 2 kind of short circuits are considered : terminal and load short circuit.



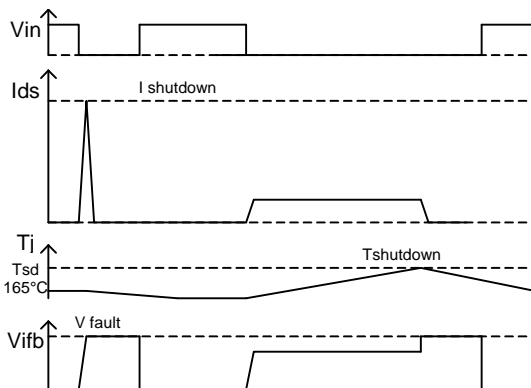
	L SC	R SC
Terminal SC	0.1 μH	10 mohm
Load SC	10 μH	100 mohm



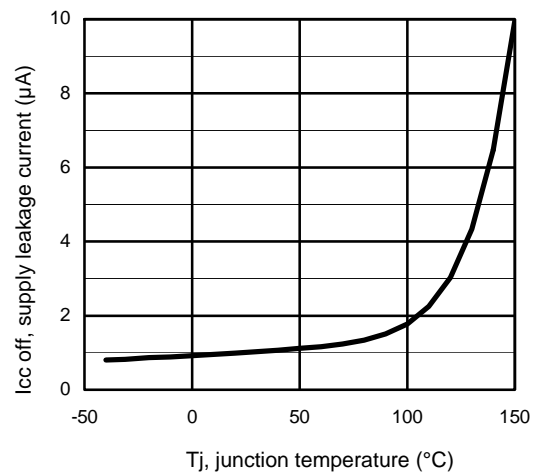
**Figure 1 – IN rise time & switching definitions**



**Figure 2 – Active clamp waveforms**

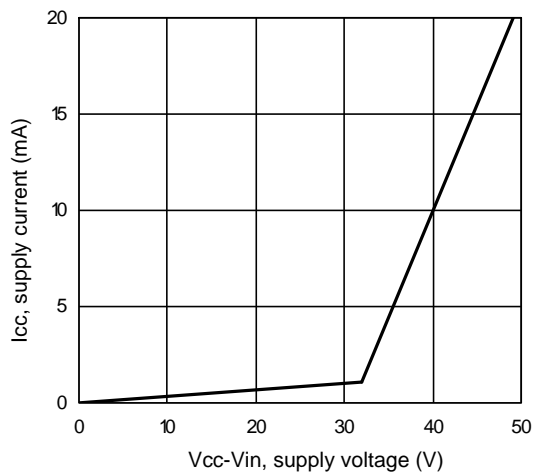


**Figure 3 – Protection timing diagram**

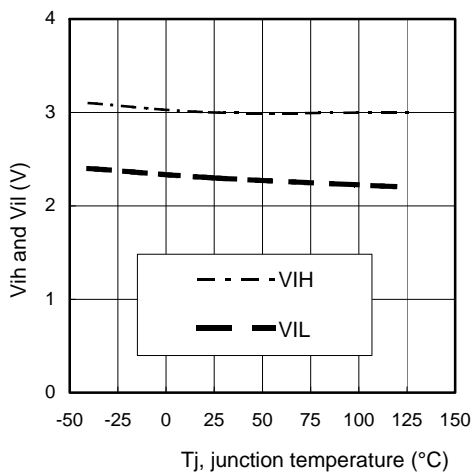


**Figure 4 – Icc off (µA) Vs Tj (°C)**

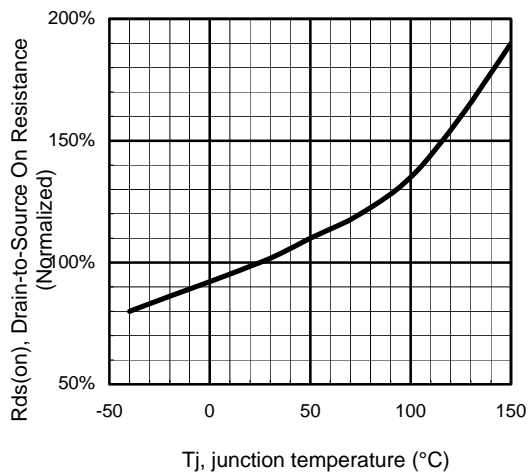




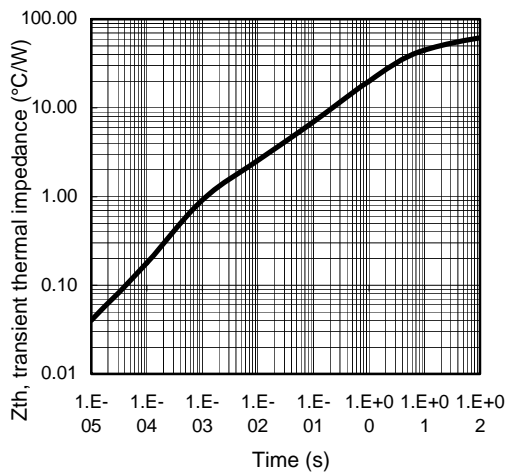
**Figure 5 – Icc (mA) Vs Vcc-Vin (V)**



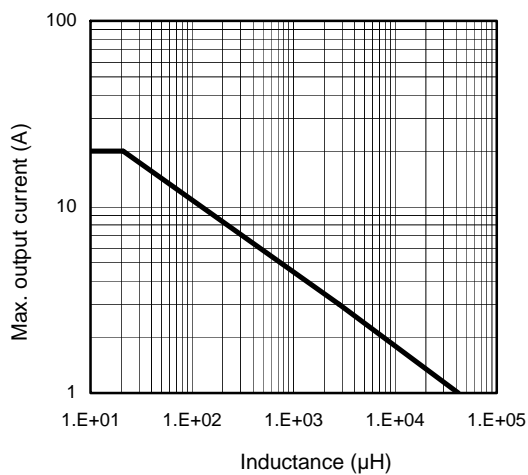
**Figure 6 – Vih and Vil (V) Vs Tj (°C)**



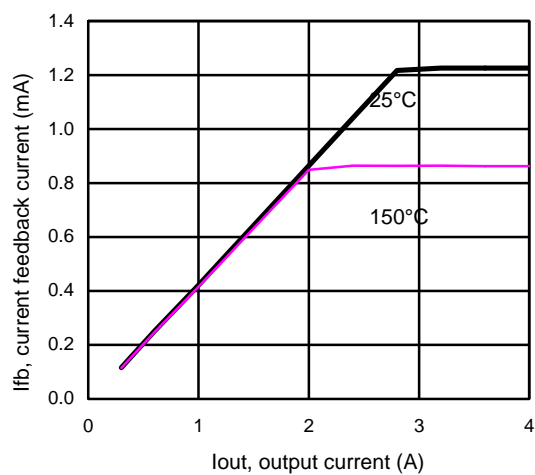
**Figure 7 - Normalized Rds(on) (%) Vs Tj (°C)**



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



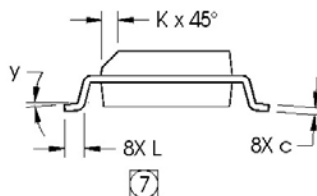
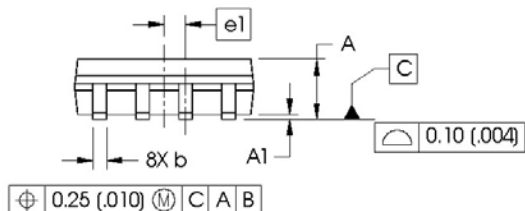
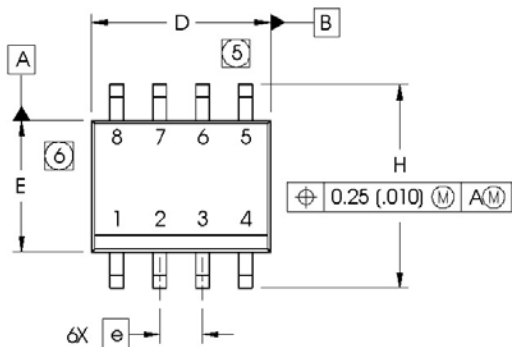
**Figure 9 – Max. Iout (A) Vs inductance (μH)**



**Figure 10 – Ifb (mA) Vs Iout (A)**

## Case Outline - SO-8

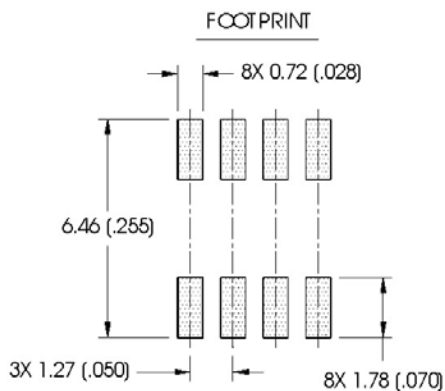
Dimensions are shown in millimeters (inches)



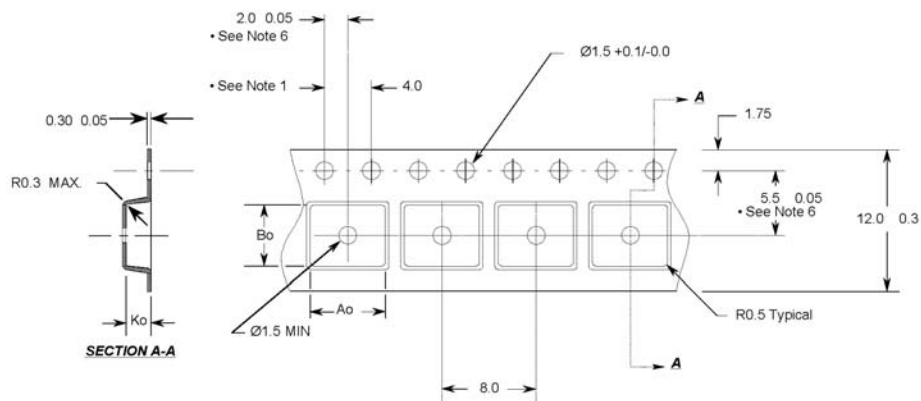
DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	.0532	.0688	1.35	1.75
A1	.0040	.0098	0.10	0.25
b	.013	.020	0.33	0.51
c	.0075	.0098	0.19	0.25
D	.189	.1968	4.80	5.00
E	.1497	.1574	3.80	4.00
e	.050 BASIC		1.27 BASIC	
e1	.025 BASIC		0.635 BASIC	
H	.2284	.2440	5.80	6.20
K	.0099	.0196	0.25	0.50
L	.016	.050	0.40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



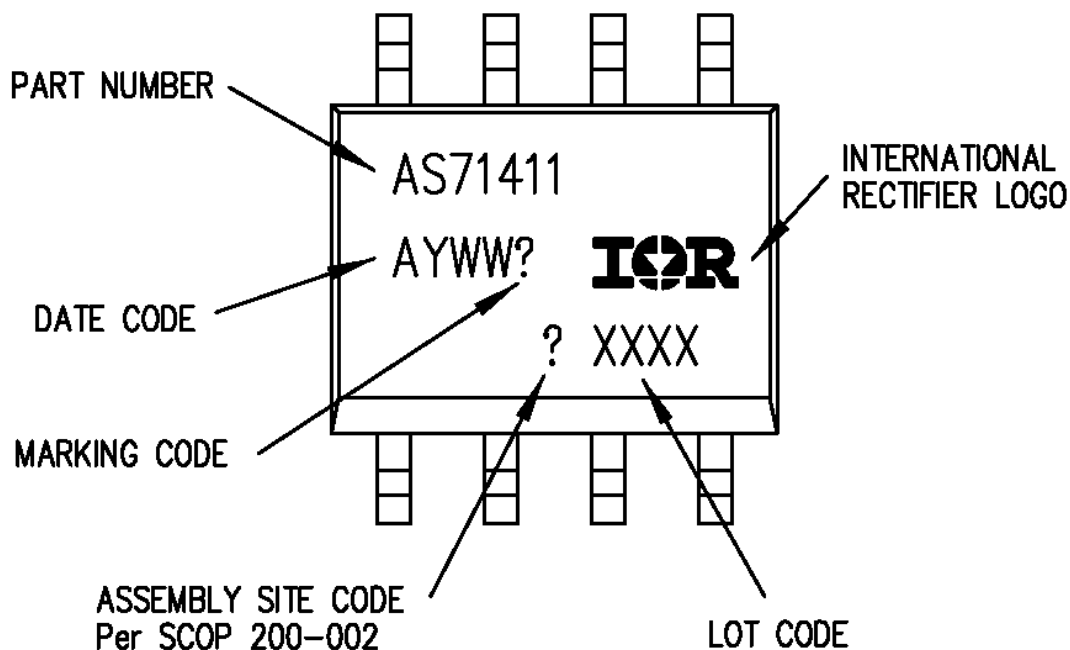
**Notes:**

1. 10 sprocket hole pitch cumulative tolerance 0.2
2. Camber not to exceed 1mm in 100mm
3. Material: Black Conductive Advantek Polystyrene
4.  $A_o$  and  $B_o$  measured on a plane 0.3mm above the bottom of the pocket
5.  $K_o$  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.

$A_o = 6.4$  mm  
 $B_o = 5.2$  mm  
 $K_o = 2.1$  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

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