

### CURRENT SENSE HIGH SIDE SWITCH

#### Features

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

#### Applications

- 24V loads for trucks

#### Description

The AUIPS7111S is a fully protected four terminal high side switch. 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

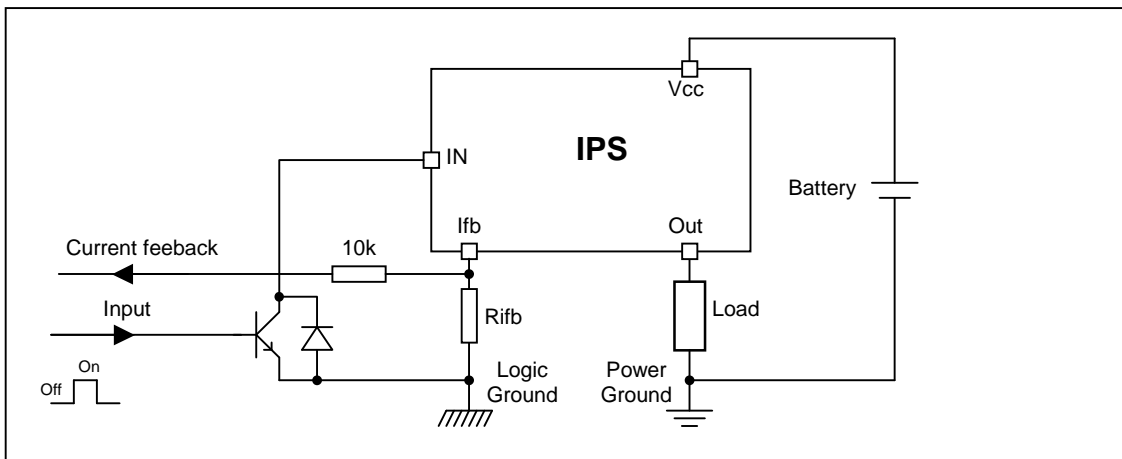
$R_{ds(on)}$	7.5 m $\Omega$ max.
$V_{clamp}$	65V
Current shutdown	30A min.

#### Package



D<sup>2</sup>Pak-5 leads

#### 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>		D2PAK-5L	MSL1, 260°C (per IPC/JEDEC J-STD-020)
<b>ESD</b>	Machine Model	Class M3 (300V) (per AEC-Q100-003)	
	Human Body Model	Class H2 (2,500 V) (per AEC-Q100-002)	
	Charged Device Model	Class C4 (1000 V) (per AEC-Q100-011)	
<b>IC Latch-Up Test</b>		Class II, Level A (per AEC-Q100-004)	
<b>RoHS Compliant</b>		Yes	

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

<sup>††</sup> 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. ( $T_j = -40^{\circ}\text{C}..150^{\circ}\text{C}$ ,  $V_{cc}=8..50\text{V}$  unless otherwise specified).

Symbol	Parameter	Min.	Max.	Units
Vout	Maximum output voltage	$V_{cc}-60$	$V_{cc}+0.3$	V
Vcc-Vin max.	Maximum Vcc voltage	-32	60	V
I <sub>fb</sub> , max.	Maximum feedback current	-50	10	mA
Pd	Maximum power dissipation (internally limited by thermal protection)			W
	T <sub>ambient</sub> =25°C, T <sub>j</sub> =150°C R <sub>th</sub> =50°C/W D <sup>2</sup> Pack 6cm <sup>2</sup> footprint	—	2.5	
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 D <sup>2</sup> Pak Std footprint	60	—	°C/W
R <sub>th2</sub>	Thermal resistance junction to ambient D <sup>2</sup> pak 6cm <sup>2</sup> footprint	40	—	
R <sub>th3</sub>	Thermal resistance junction to case D <sup>2</sup> pak	0.8	—	

## Recommended Operating Conditions

These values are given for a quick design.

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> =40°C/W, D <sup>2</sup> pak 6cm <sup>2</sup> footprint		10	A
R <sub>ifb</sub>		1.5	—	kΩ

## Static Electrical Characteristics

 $T_j = -40..150^{\circ}\text{C}$ ,  $V_{cc} = 8..50\text{V}$  (unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Vcc op.	Operating voltage range	8	—	50	V	
Rds(on)	ON state resistance $T_j = 25^{\circ}\text{C}$	—	6	7.5	mΩ	Ids=10A
	ON state resistance $T_j = 150^{\circ}\text{C}$	—	12	15		
Icc off	Supply leakage current	—	2	6	μA	Vin=Vcc=28V, Vifb=Vgnd Vout=Vgnd, $T_j = 25^{\circ}\text{C}$
Iout off	Output leakage current	—	2	6		
V clamp1	Vcc to Vout clamp voltage 1	60	65	—	V	Id=10mA
V clamp2	Vcc to Vout clamp voltage 2	—	66	—		Id=10A see fig. 2
Vih(2)	High level Input threshold voltage	—	5.5	6.8		Id=10mA
Vil(2)	Low level Input threshold voltage	3.5	5	—		
Rds(on) rev	Reverse On state resistance $T_j = 25^{\circ}\text{C}$	—	7	10	mΩ	Isd=10A, Vcc-Vin=7..32V
	Reverse On state resistance $T_j = 150^{\circ}\text{C}$	—	13	18		
Vf	Forward body diode voltage $T_j = 25^{\circ}\text{C}$	—	0.75	0.8	V	If=10A
	Forward body diode voltage $T_j = 125^{\circ}\text{C}$	—	0.6	0.65		
Rin	Internal input resistor	180	250	350	Ω	$T_j = -40^{\circ}\text{C}..125^{\circ}\text{C}$

(2) Input thresholds are measured directly between the input pin and the tab. See also page 6

## Switching Electrical Characteristics

 $V_{cc} = 28\text{V}$ , Resistive load=3Ω,  $T_j = 25^{\circ}\text{C}$ 

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
tdon	Turn on delay time to 20%	25	35	50	μs	See fig. 1
tr	Rise time from 20% to 80% of Vcc	8	17	25		
tdoff	Turn off delay time	50	80	120	μs	
tf	Fall time from 80% to 20% of Vcc	5	13	35		

## Protection Characteristics

 $T_j = -40..150^{\circ}\text{C}$ ,  $V_{cc} = 8..50\text{V}$  (unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Tsd	Over temperature threshold	150(3)	165	—	°C	See fig. 3 and fig. 10
Isd	Over-current shutdown	30	45	60	A	See fig. 3 and page 7
I fault	I <sub>fb</sub> after an over-current or an over-temperature (latched)	2.4	4	6	mA	See fig. 3

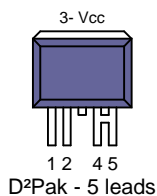
## Current Sensing Characteristics

 $T_j = -40..150^{\circ}\text{C}$ ,  $V_{cc} = 8..50\text{V}$  (unless otherwise specified)

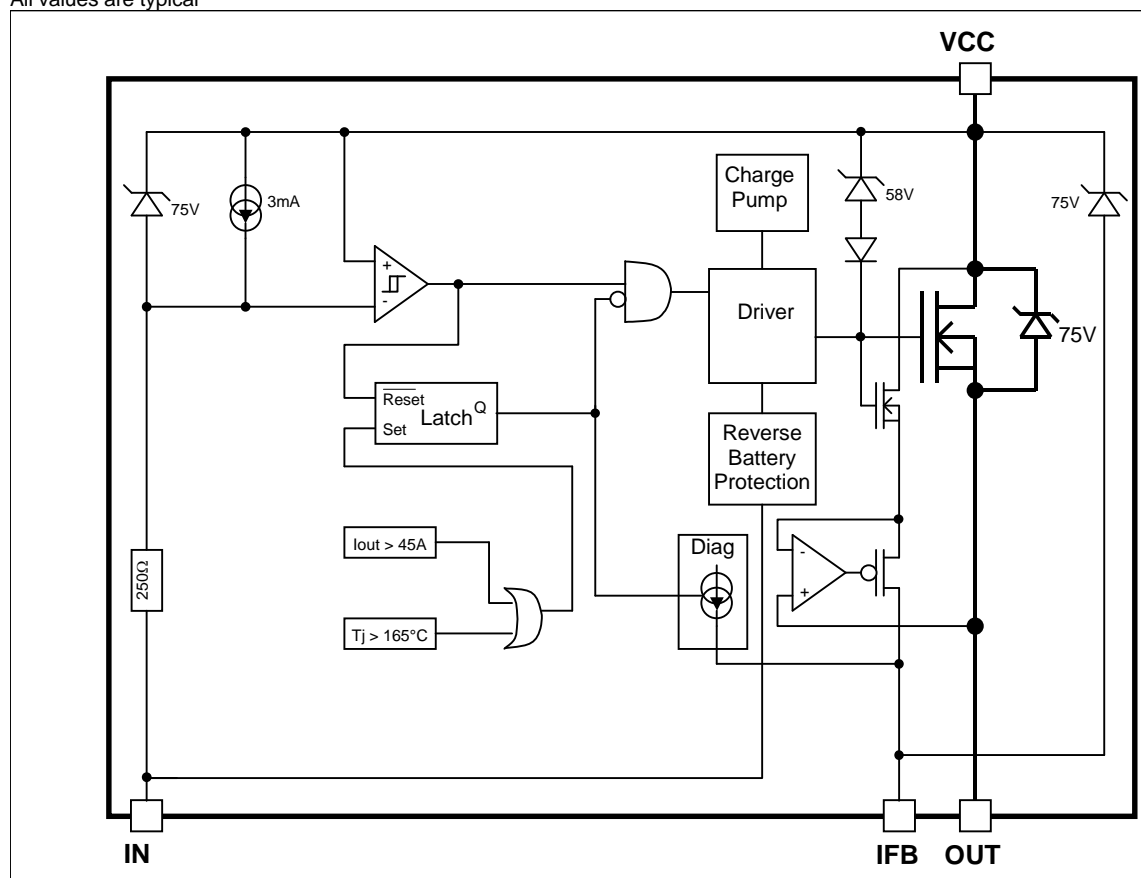
Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Ratio	I <sub>load</sub> / I <sub>fb</sub> current ratio	11000	13000	14500		Iout=10A
Ratio_TC	I <sub>load</sub> / I <sub>fb</sub> variation over temperature	-5%	0	+5	%	
I offset	Load current offset	-0.25	0	0.25	A	Iout<10A
I <sub>fb</sub> leakage	I <sub>fb</sub> leakage current on	0	6	15	μA	Iout=0A, $T_j = 25^{\circ}\text{C}$

(3) Guaranteed by design

1- In  
2- Ifb  
3- Vcc  
4- Out  
5- Out



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	I <sub>fb</sub> leakage x R <sub>fb</sub>
Short circuit to GND	H	L	0V
Short circuit to GND	L	L	I <sub>fault</sub> x R <sub>fb</sub> (latched)
Over temperature	H	L	0V
Over temperature	L	L	I <sub>fault</sub> x R <sub>fb</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 AEC-Q100 qualification is run at the maximum operating voltage specified in the datasheet.

## Reverse battery

During the reverse battery the Mosfet is turned on if the input pin is powered with a diode in parallel of the input transistor. Power dissipation in the IPS :  $P = R_{\text{dson rev}} \cdot I_{\text{load}}^2 + V_{\text{cc}}^2 / 250$  ( internal input resistor ).

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

## 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:

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

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

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

$V_{\text{CL}} = 39\text{V}$  : Typical  $V_{\text{CLAMP}}$  value

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

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

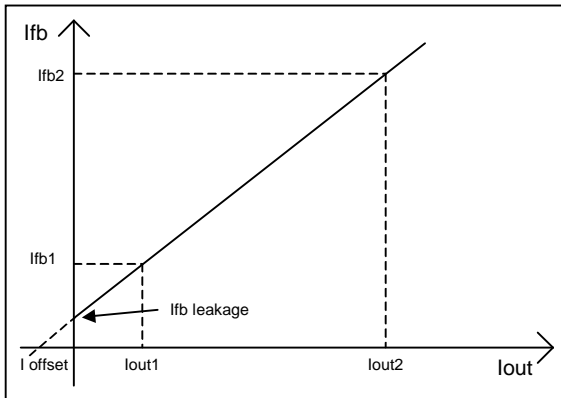
$$\frac{di}{dt} = \frac{V_{\text{Battery}} - V_{\text{CL}}}{L} : \text{Demagnetization current}$$

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.

## Input level VIH/VIL

The input level are referenced to Vcc. When Vcc-Vin exceed VIH the part turns on and when Vcc-Vin goes below VIL the part turns off

## 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  $I_{out}=0$

The parameters in the datasheet are computed with 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  $I_{fb}$  for any  $I_{out}$  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  $\text{Ratio}_{TC}$  specified in page 4.

The  $I_{offset}$  variation depends directly of the  $R_{ds(on)}$  :

$$I_{offset@-40^{\circ}\text{C}} = I_{offset@25^{\circ}\text{C}} / 0.7$$

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

## 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  $I_{sd}$ . Nevertheless for high current and high temperature the device may switch off for a lower current due to the over-temperature protection (see Figure 10).

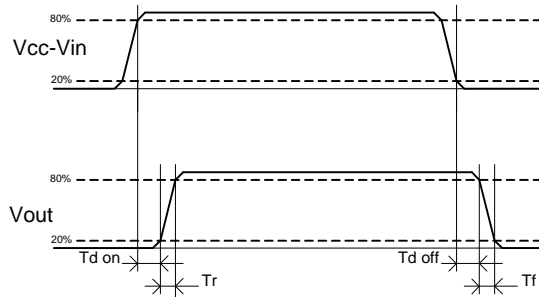


Figure 1 – IN rise time & switching definitions

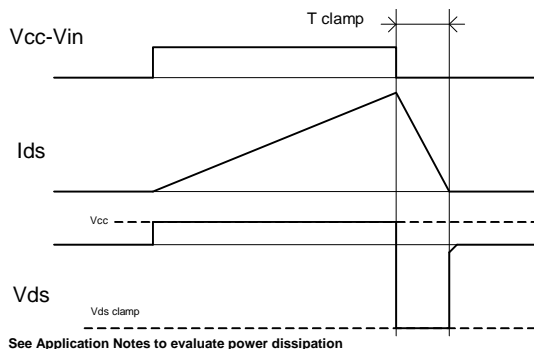


Figure 2 – Active clamp waveforms

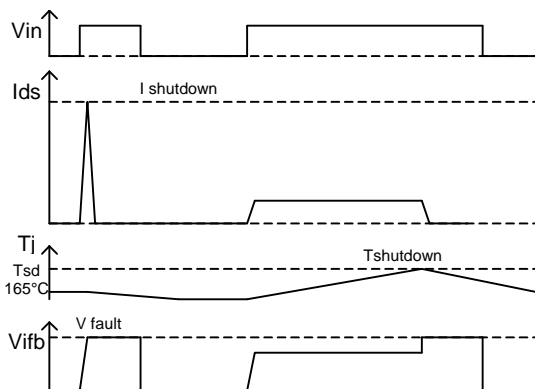


Figure 3 – Protection timing diagram

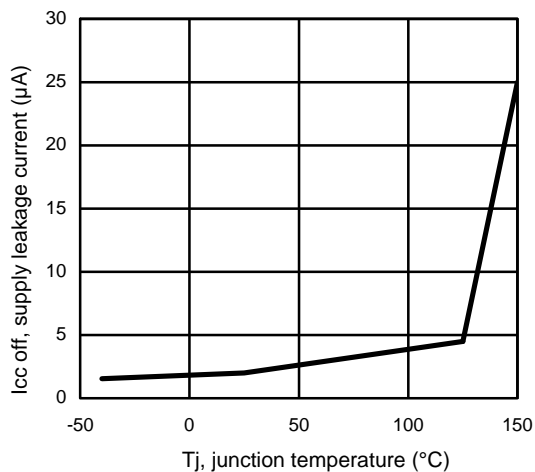
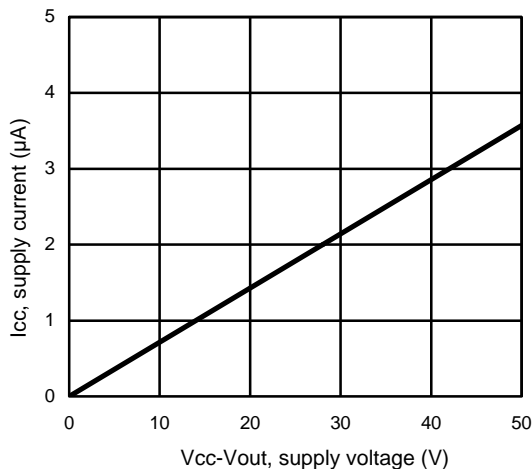
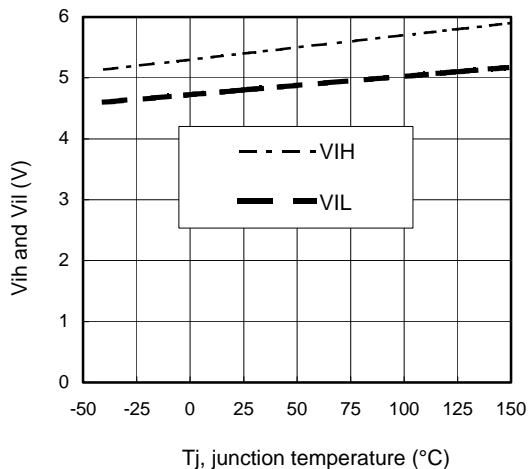


Figure 4 – Icc off (µA) Vs Tj (°C)

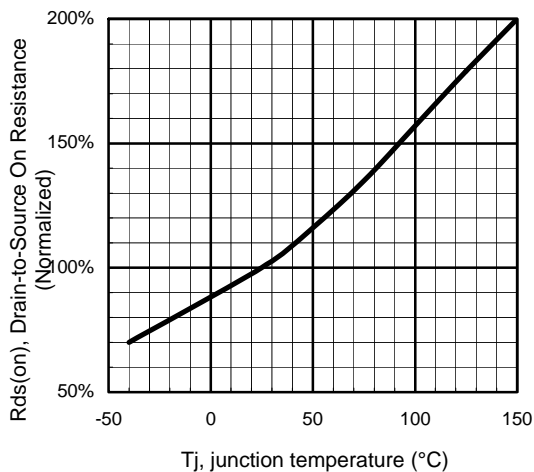




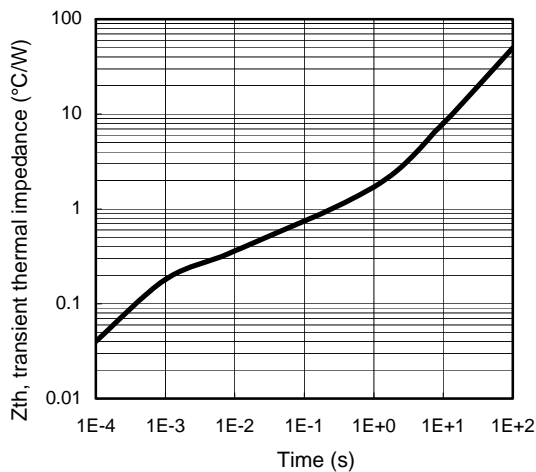
**Figure 5 – Icc Off(μA) Vs Vcc-Vout (V)**



**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)**

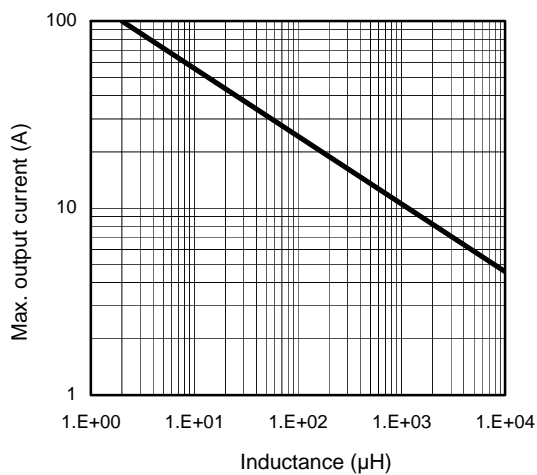


Figure 9 – Max. Iout (A) Vs inductance (μH)

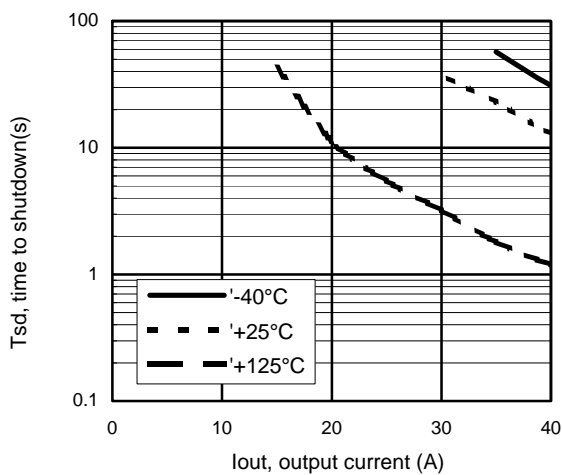
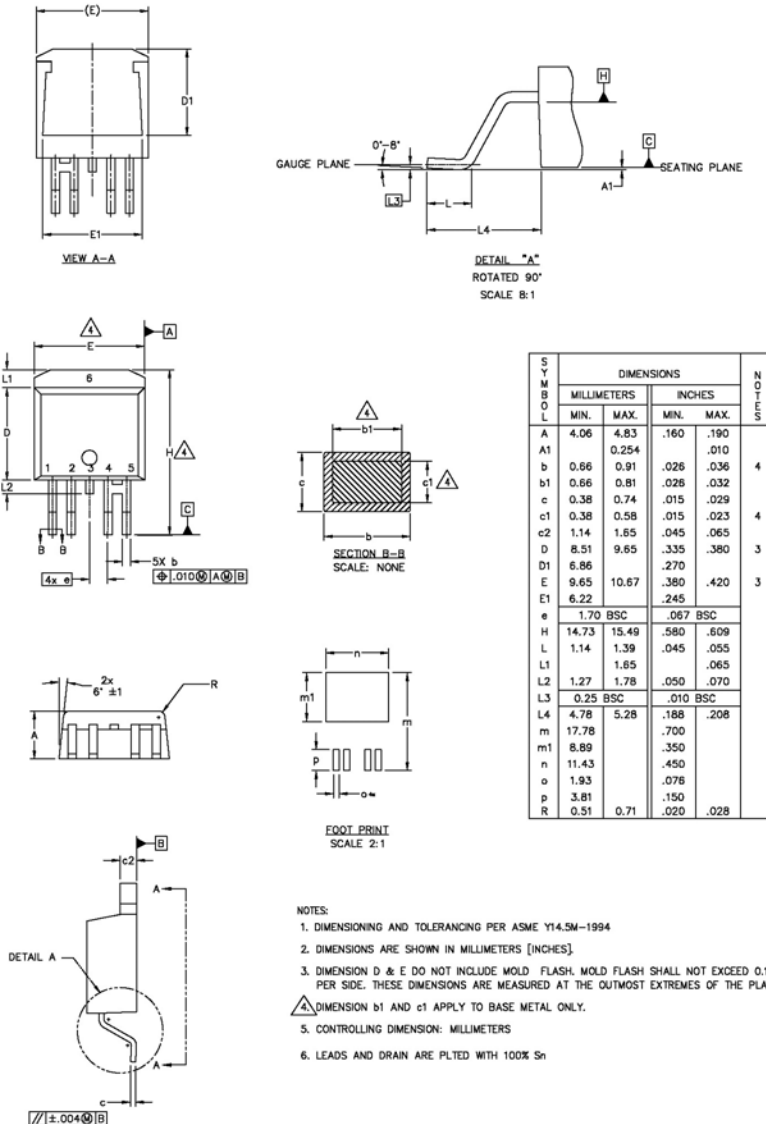
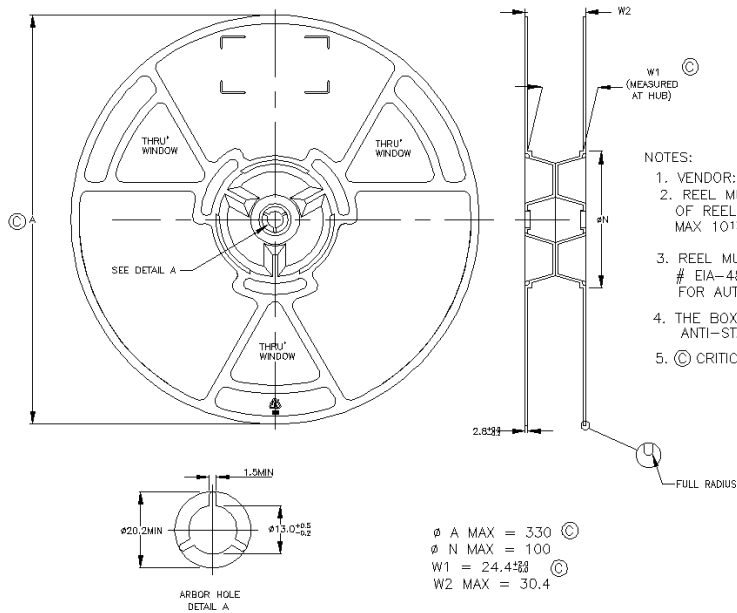


Figure 10 – Tsd (s) Vs Iout (A)  
SMD with 6cm<sup>2</sup>

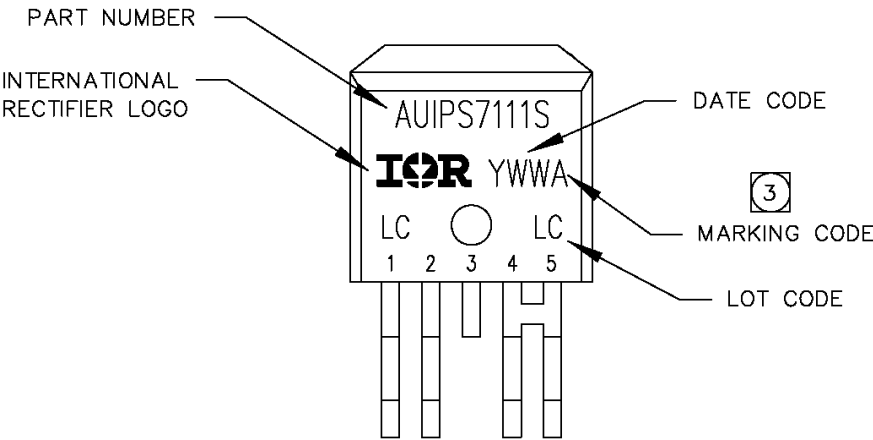
## Case Outline D2PAK - 5 Leads



## Tape & Reel D2PAK - 5 Leads



**Part Marking Information**



**Ordering Information**

Base Part Number	Package Type	Standard Pack		Complete Part Number
		Form	Quantity	
AUIPS7111R	D2-Pak-5-Leads	Tube	50	AUIPS7111S
		Tape and reel left	800	AUIPS7111STRL
		Tape and reel right	800	AUIPS7111STRR

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