International
IOR Rectifier

November, 29th 2009
Automotive grade

# AUIPS7111S

## 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 Vcc - Vin is higher than the specified threshold, the output power Mosfet is turned on. When the Vcc - Vin is lower than the specified Vil threshold, the output Mosfet is turned off. The Ifb pin is used for current sensing.

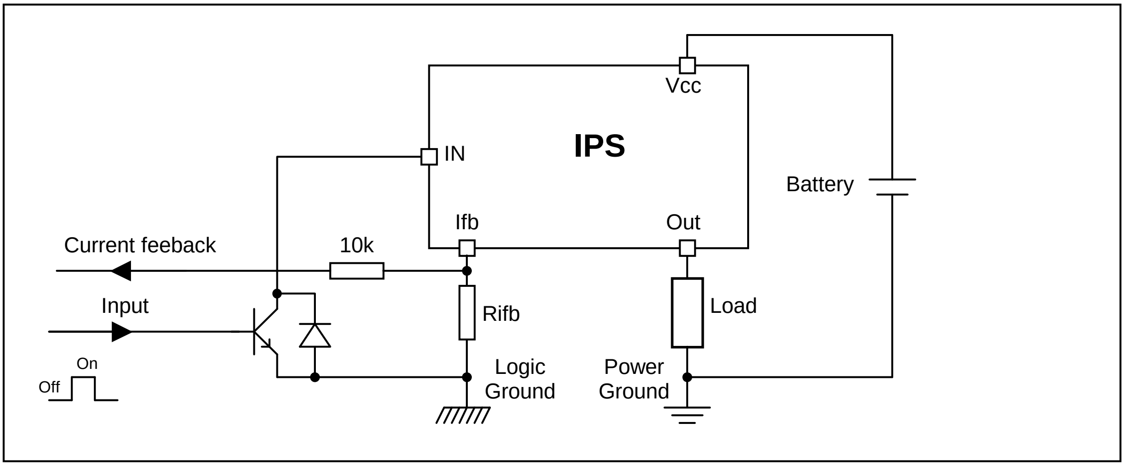
### Product Summary

| | |
|---|---|
| Rds(on) | 7.5 mΩ max. |
| Vclamp | 65V |
| Current shutdown | 30A min. |

### Package

D²Pak-5 leads

### Typical Connection



## Qualification Information[†]

| | | | |
|---|---|---|---|
| **Qualification Level** | | Automotive<br>(per AEC-Q100[††]) | |
| | | 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. | |
| **Moisture Sensitivity Level** | | D2PAK-5L | MSL1, 260°C<br>(per IPC/JEDEC J-STD-020) |
| **ESD** | Machine Model | Class M3 (300V)<br>(per AEC-Q100-003) | |
| | Human Body Model | Class H2 (2,500 V)<br>(per AEC-Q100-002) | |
| | Charged Device Model | Class C4 (1000 V)<br>(per AEC-Q100-011) | |
| **IC Latch-Up Test** | | Class II, Level A<br>(per AEC-Q100-004) | |
| **RoHS Compliant** | | 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. (Tj= -40°C..150°C, Vcc=8..50V unless otherwise specified).

| Symbol | Parameter | Min. | Max. | Units |
|---|---|---|---|---|
| Vout | Maximum output voltage | Vcc-60 | Vcc+0.3 | V |
| Vcc-Vin max. | Maximum Vcc voltage | -32 | 60 | V |
| Ifb, max. | Maximum feedback current | -50 | 10 | mA |
| Pd | Maximum power dissipation (internally limited by thermal protection) | | | W |
| | Tambient=25°C, Tj=150°C Rth=50°C/W D²Pack 6cm² footprint | — | 2.5 | |
| Tj max. | Max. storage & operating junction temperature | -40 | 150 | °C |

## Thermal Characteristics

| Symbol | Parameter | Typ. | Max. | Units |
|---|---|---|---|---|
| Rth1 | Thermal resistance junction to ambient D²Pak Std footprint | 60 | — | °C/W |
| Rth2 | Thermal resistance junction to ambient D²pak 6cm² footprint | 40 | — | |
| Rth3 | Thermal resistance junction to case D²pak | 0.8 | — | |

## Recommended Operating Conditions

These values are given for a quick design.

| Symbol | Parameter | Min. | Max. | Units |
|---|---|---|---|---|
| Iout | Continuous output current, Tambient=85°C, Tj=125°C | | | A |
| | Rth=40°C/W, D²pak 6cm² footprint | — | 10 | |
| Rifb | | 1.5 | — | kΩ |

## Static Electrical Characteristics

Tj=-40..150°C, Vcc=8..50V (unless otherwise specified)

| Symbol | Parameter | Min. | Typ. | Max. | Units | Test Conditions |
|---|---|---|---|---|---|---|
| Vcc op. | Operating voltage range | 8 | — | 50 | V | |
| Rds(on) | ON state resistance Tj=25°C | — | 6 | 7.5 | mΩ | Ids=10A |
| | ON state resistance Tj=150°C | — | 12 | 15 | | |
| Icc off | Supply leakage current | — | 2 | 6 | µA | Vin=Vcc=28V,Vifb=Vgnd |
| Iout off | Output leakage current | — | 2 | 6 | | Vout=Vgnd, Tj=25°C |
| 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 Tj=25°C | — | 7 | 10 | mΩ | Isd=10A, |
| | Reverse On state resistance Tj=150°C | — | 13 | 18 | | Vcc-Vin=7..32V |
| Vf | Forward body diode voltage Tj=25°C | — | 0.75 | 0.8 | V | If=10A |
| | Forward body diode voltage Tj=125°C | — | 0.6 | 0.65 | | |
| Rin | Internal input resistor | 180 | 250 | 350 | Ω | Tj=-40°C..125°C |

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

## Switching Electrical Characteristics

Vcc=28V, Resistive load=3Ω, Tj=25°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

Tj=-40..150°C, Vcc=8..50V (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 | Ifb after an over-current or an over-temperature (latched) | 2.4 | 4 | 6 | mA | See fig. 3 |

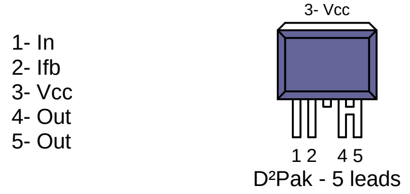
## Current Sensing Characteristics

Tj=-40..150°C, Vcc=8..50V (unless otherwise specified)

| Symbol | Parameter | Min. | Typ. | Max. | Units | Test Conditions |
|---|---|---|---|---|---|---|
| Ratio | I load / Ifb current ratio | 11000 | 13000 | 14500 | | Iout=10A |
| Ratio_TC | I load / Ifb variation over temperature | -5% | 0 | +5 | % | |
| I offset | Load current offset | -0.25 | 0 | 0.25 | A | Iout<10A |
| Ifb leakage | Ifb leakage current on | 0 | 6 | 15 | µA | Iout=0A, Tj=25°C |

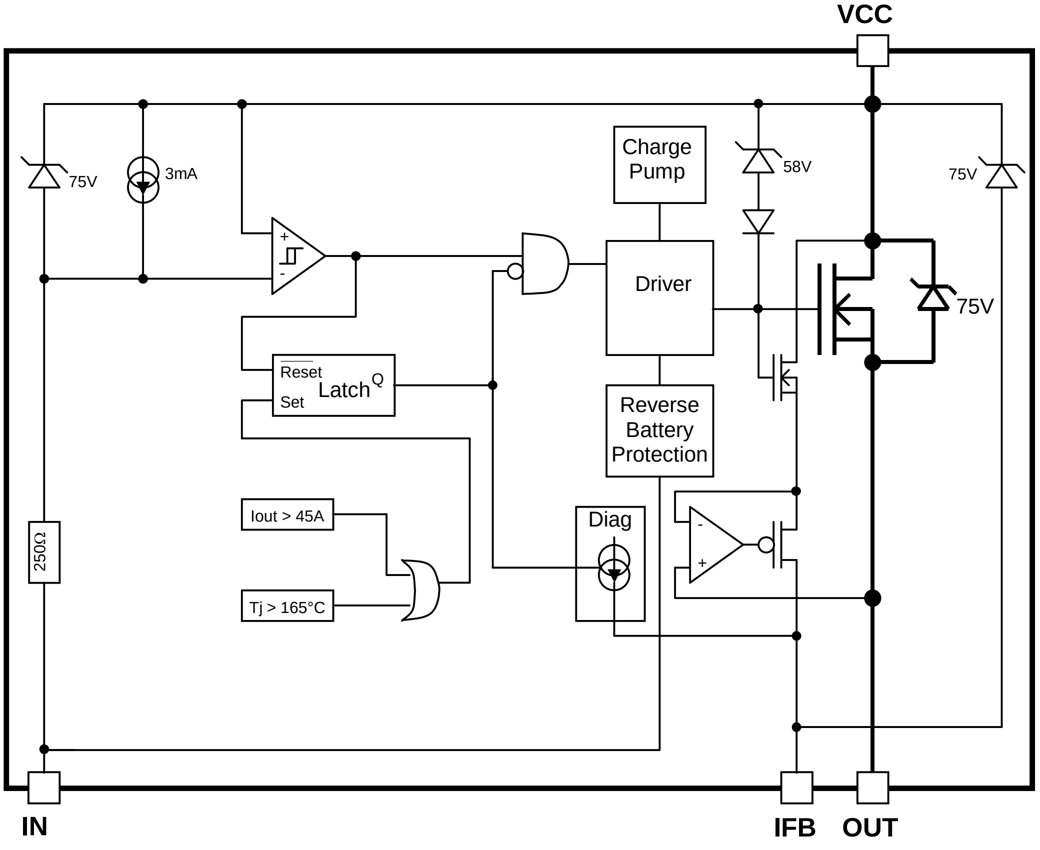
(3) Guaranteed by design

## Lead Assignments




## Functional Block Diagram

All values are typical



## Truth Table

| Op. Conditions | Input | Output | Ifb pin voltage |
|---|---|---|---|
| Normal mode | H | L | 0V |
| Normal mode | L | H | I load x Rfb / Ratio |
| Open load | H | L | 0V |
| Open load | L | H | Ifb leakage x Rifb |
| Short circuit to GND | H | L | 0V |
| Short circuit to GND | L | L | I fault x Rifb (latched) |
| Over temperature | H | L | 0V |
| Over temperature | L | L | I fault x Rifb (latched) |

## Operating voltage

**Maximum Vcc voltage** : this is the maximum voltage before the breakdown of the IC process.
**Operating voltage** : This is the Vcc 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 = Rdson rev * I load² + Vcc² / 250 ( internal input resistor ).
If the power dissipation I too hight in Rifb, 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:

$$\Delta_{Tj} = P_{CL} \cdot Z_{TH}(t_{CLAMP})$$

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

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

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

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

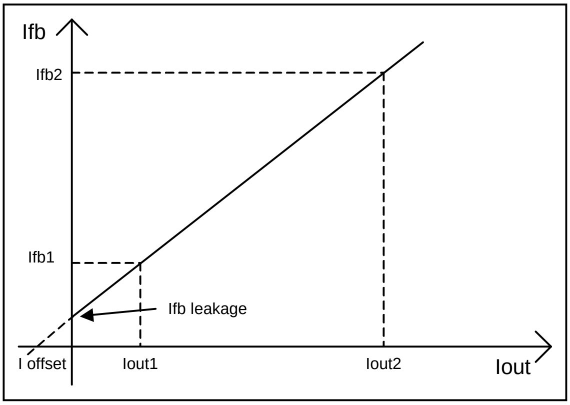
$\frac{di}{dt} = \frac{V_{Battery} - V_{CL}}{L}$ : Demagnetization current

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

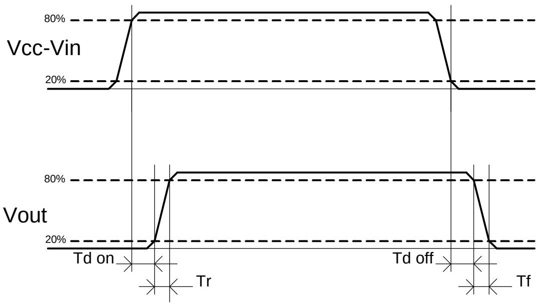
The parameters in the datasheet are computed with the following formula :
Ratio = ( Iout2 – Iout1 )/( Ifb2 – Ifb1)
I offset = Ifb1 x Ratio – Iout1

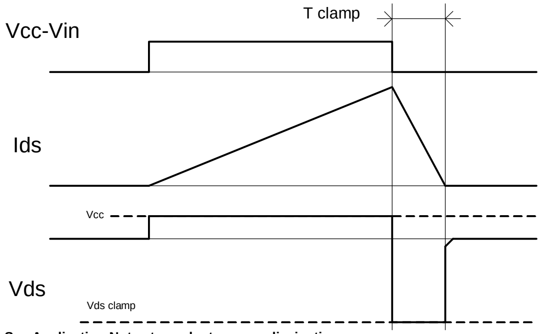
This allows the designer to evaluate the Ifb for any Iout value using :
Ifb = ( Iout + I offset ) / Ratio if Ifb > Ifb leakage

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 4.
The Ioffset variation depends directly of the Rdson :
I offset@-40°C= I offset@25°C / 0.7
I offset@150°C= I offset@25°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 Isd. 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).

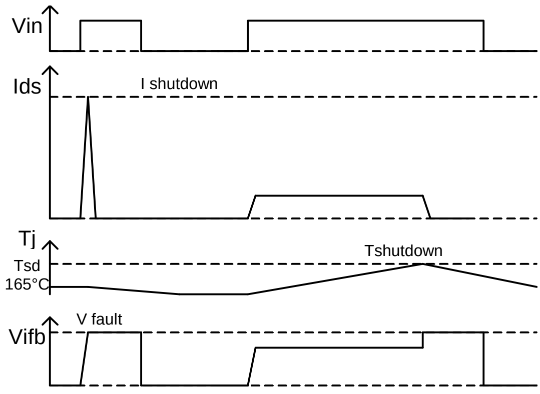



**See Application Notes to evaluate power dissipation**

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

**Figure 2 – Active clamp waveforms**



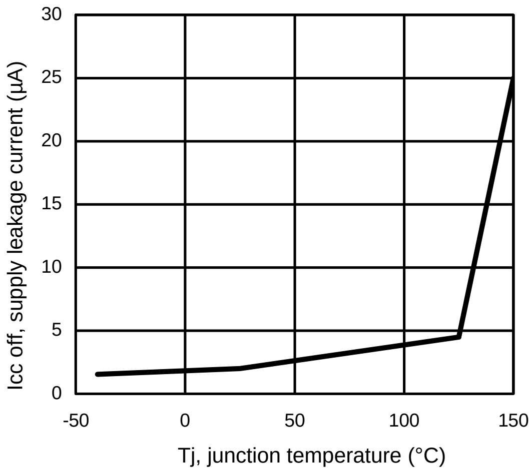




**Figure 3 – Protection timing diagram**

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

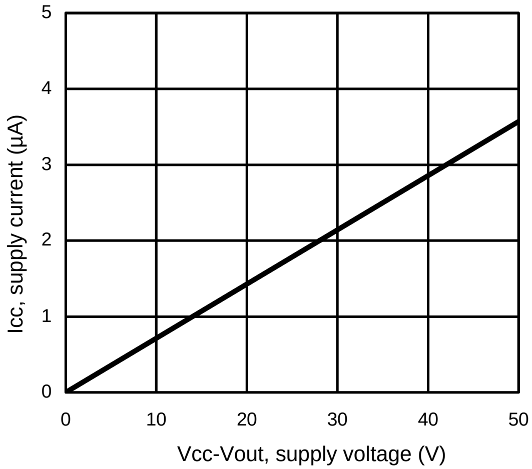



**Figure 5 – Icc Off(µA) Vs Vcc-Vout (V)**

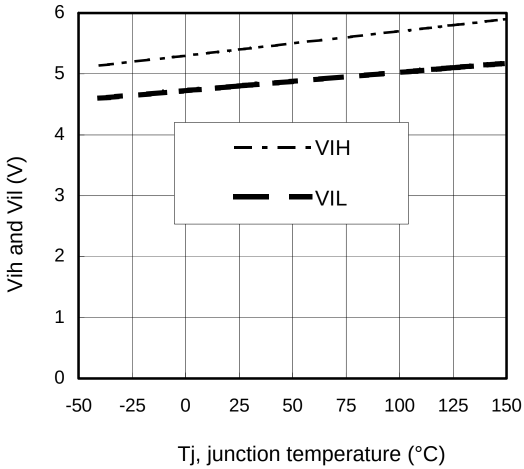



**Figure 6 – Vih and Vil (V) Vs Tj (°C)**

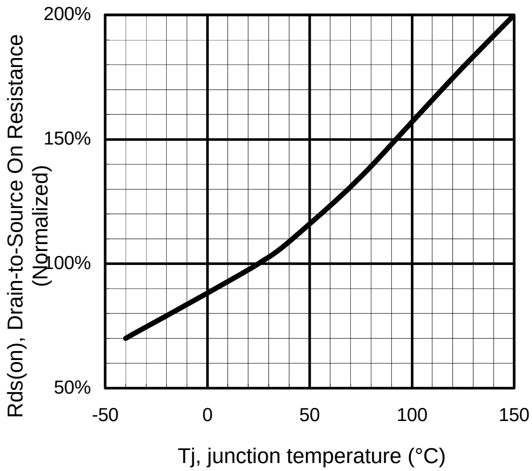



**Figure 7 - Normalized Rds(on) (%) Vs Tj (°C)**

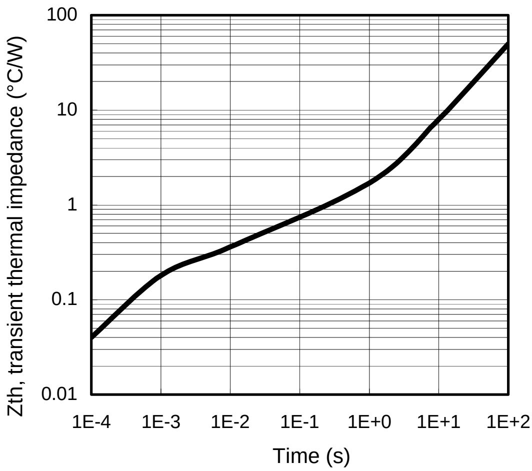



**Figure 8 – Transient thermal impedance (°C/W) Vs time (s)**

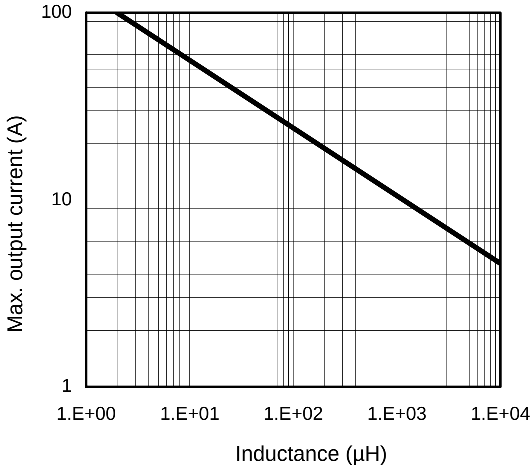



**Figure 9 – Max. Iout (A) Vs inductance (µH)**

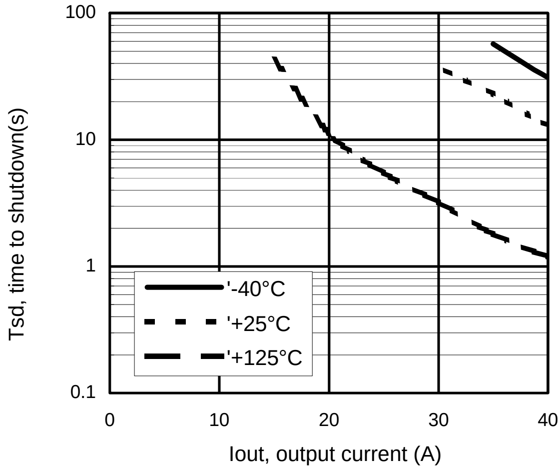
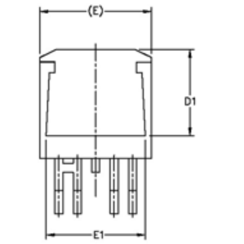
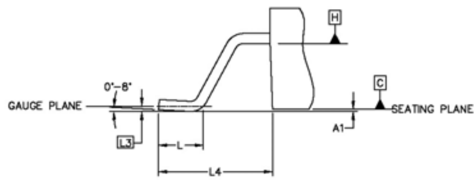



**Figure 10 – Tsd (s) Vs I out (A)**
**SMD with 6cm²**

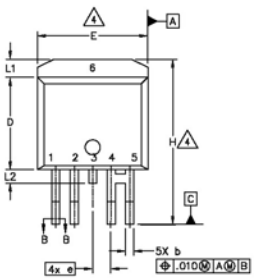
## Case Outline   D2PAK - 5 Leads

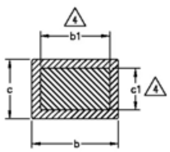



VIEW A–A



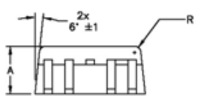

DETAIL "A"
ROTATED 90°
SCALE 8:1

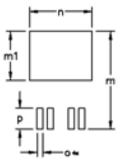


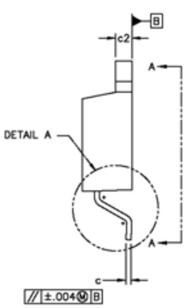

SECTION B–B
SCALE: NONE

| SYMBOL | DIMENSIONS | | | | NOTES |
|---|---|---|---|---|---|
| | MILLIMETERS | | INCHES | | |
| | MIN. | MAX. | MIN. | MAX. | |
| A | 4.06 | 4.83 | .160 | .190 | |
| A1 | | 0.254 | | .010 | |
| b | 0.66 | 0.91 | .026 | .036 | 4 |
| b1 | 0.66 | 0.81 | .026 | .032 | |
| c | 0.38 | 0.74 | .015 | .029 | |
| c1 | 0.38 | 0.58 | .015 | .023 | 4 |
| c2 | 1.14 | 1.65 | .045 | .065 | |
| D | 8.51 | 9.65 | .335 | .380 | 3 |
| D1 | 6.86 | | .270 | | |
| E | 9.65 | 10.67 | .380 | .420 | 3 |
| E1 | 6.22 | | .245 | | |
| e | 1.70 BSC | | .067 BSC | | |
| H | 14.73 | 15.49 | .580 | .609 | |
| L | 1.14 | 1.39 | .045 | .055 | |
| L1 | | 1.65 | | .065 | |
| L2 | 1.27 | 1.78 | .050 | .070 | |
| L3 | 0.25 BSC | | .010 BSC | | |
| L4 | 4.78 | 5.28 | .188 | .208 | |
| m | 17.78 | | .700 | | |
| m1 | 8.89 | | .350 | | |
| n | 11.43 | | .450 | | |
| o | 1.93 | | .076 | | |
| p | 3.81 | | .150 | | |
| R | 0.51 | 0.71 | .020 | .028 | |



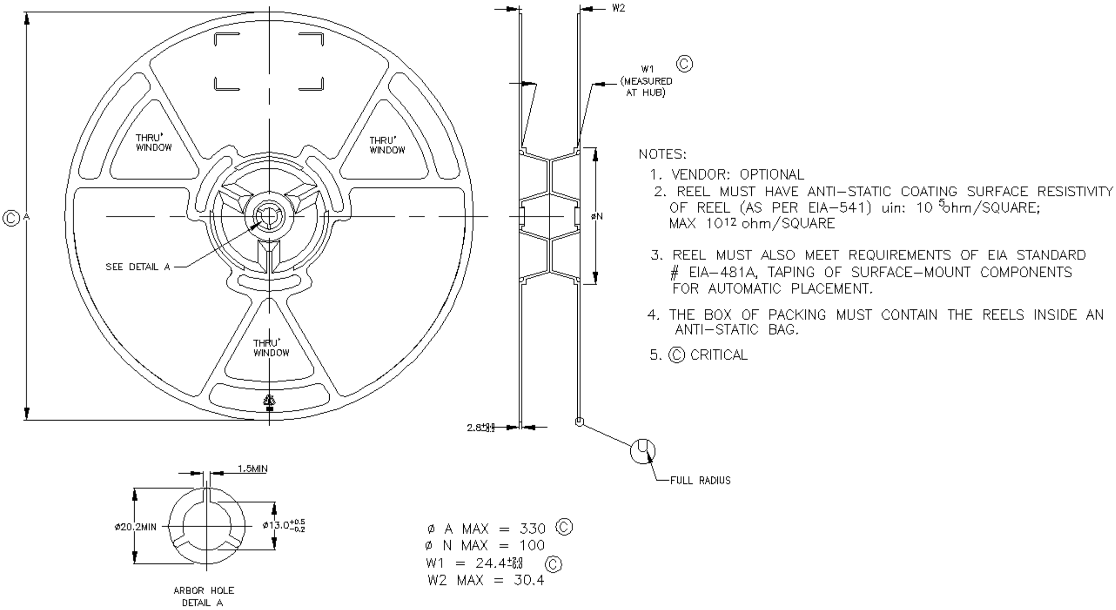

FOOT PRINT
SCALE 2:1



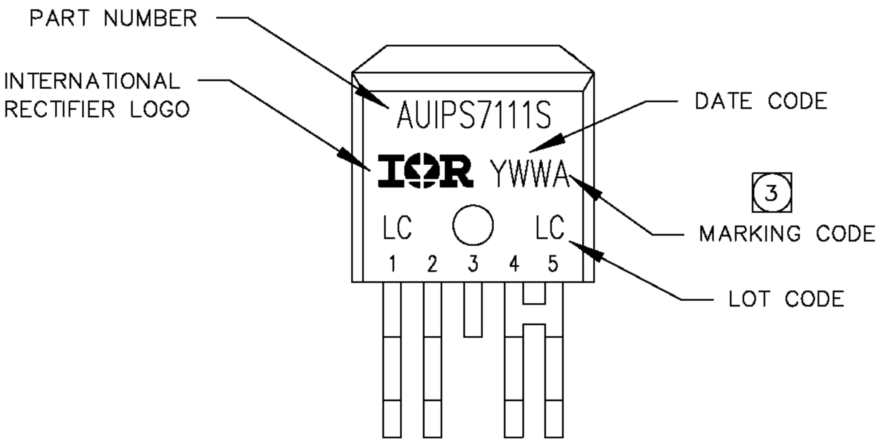

NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M–1994
2. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
3. DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.127 [.005"] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY.
4. DIMENSION b1 AND c1 APPLY TO BASE METAL ONLY.
5. CONTROLLING DIMENSION: MILLIMETERS
6. LEADS AND DRAIN ARE PLTED WITH 100% Sn

## 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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