

### CURRENT SENSE HIGH SIDE SWITCH

#### Features

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

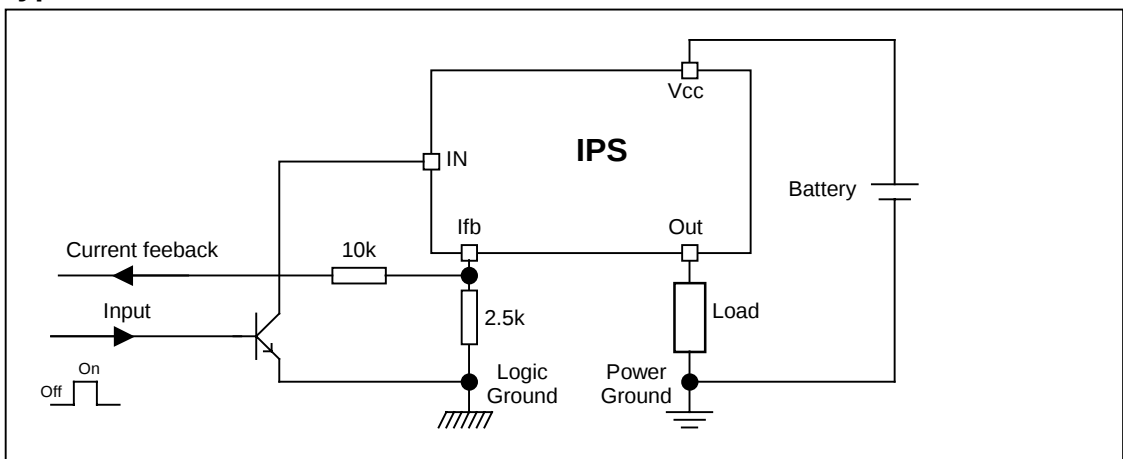
#### Applications

- 21W Filament lamp
- Solenoid
- 24V loads for trucks

#### Description

The AUIPS7141R is a fully protected four terminal high side switch specifically designed for driving lamp. 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. The over-current shutdown is higher than inrush current of the lamp.

#### Typical Connection



#### Product Summary

|                  |                    |
|------------------|--------------------|
| $R_{ds(on)}$     | 100m $\Omega$ max. |
| $V_{clamp}$      | 65V                |
| Current shutdown | 20A min.           |

#### Packages



DPak

## 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> |                      | <div> <div> DPAK-5L </div> <div> MSL1, 260°C<br/>(per IPC/JEDEC J-STD-020) </div> </div>                                                                                      |
| <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>           |                      | Class II, 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.

††† Higher MSL ratings may be available for the specific package types listed here. Please contact your International Rectifier sales representative for further information.

## Absolute Maximum Ratings

Absolute maximum ratings indicate sustained limits beyond which damage to the device may occur. ( $T_{\text{ambient}}=25^{\circ}\text{C}$  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    | 60      | V     |
| Iifb, max.   | Maximum feedback current                                                                                            | -50    | 10      | mA    |
| Vcc sc.      | Maximum Vcc voltage with short circuit protection see page 7                                                        | —      | 50      | V     |
| Pd           | Maximum power dissipation (internally limited by thermal protection)<br>Rth=50°C/W DPack 6cm <sup>2</sup> footprint | —      | 2.5     | W     |
| Tj max.      | Max. storage & operating junction temperature                                                                       | -40    | 150     | °C    |

## Thermal Characteristics

| Symbol | Parameter                                                              | Typ. | Max. | Units |
|--------|------------------------------------------------------------------------|------|------|-------|
| Rth1   | Thermal resistance junction to ambient DPak Std footprint              | 70   | —    | °C/W  |
| Rth2   | Thermal resistance junction to ambient Dpak 6cm <sup>2</sup> footprint | 50   | —    |       |
| Rth3   | Thermal resistance junction to case Dpak                               | 4    | —    |       |

## Recommended Operating Conditions

These values are given for a quick design.

| Symbol | Parameter                                                                                                                                     | Min. | Max. | Units |
|--------|-----------------------------------------------------------------------------------------------------------------------------------------------|------|------|-------|
| Iout   | Continuous output current, $T_{\text{ambient}}=85^{\circ}\text{C}$ , $T_j=125^{\circ}\text{C}$<br>Rth=50°C/W, Dpak 6cm <sup>2</sup> footprint | —    | 2.1  | A     |
| Rifb   | Iifb resistor                                                                                                                                 | 1.5  | —    |       |

## 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  | —    |       |                                                                                                             |
| V <sub>F</sub>       | 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                                                  | 20     | 25   | 35   | 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 On in open load                   | 0    | 8    | 100  | μA    | I <sub>OUT</sub> =0A            |

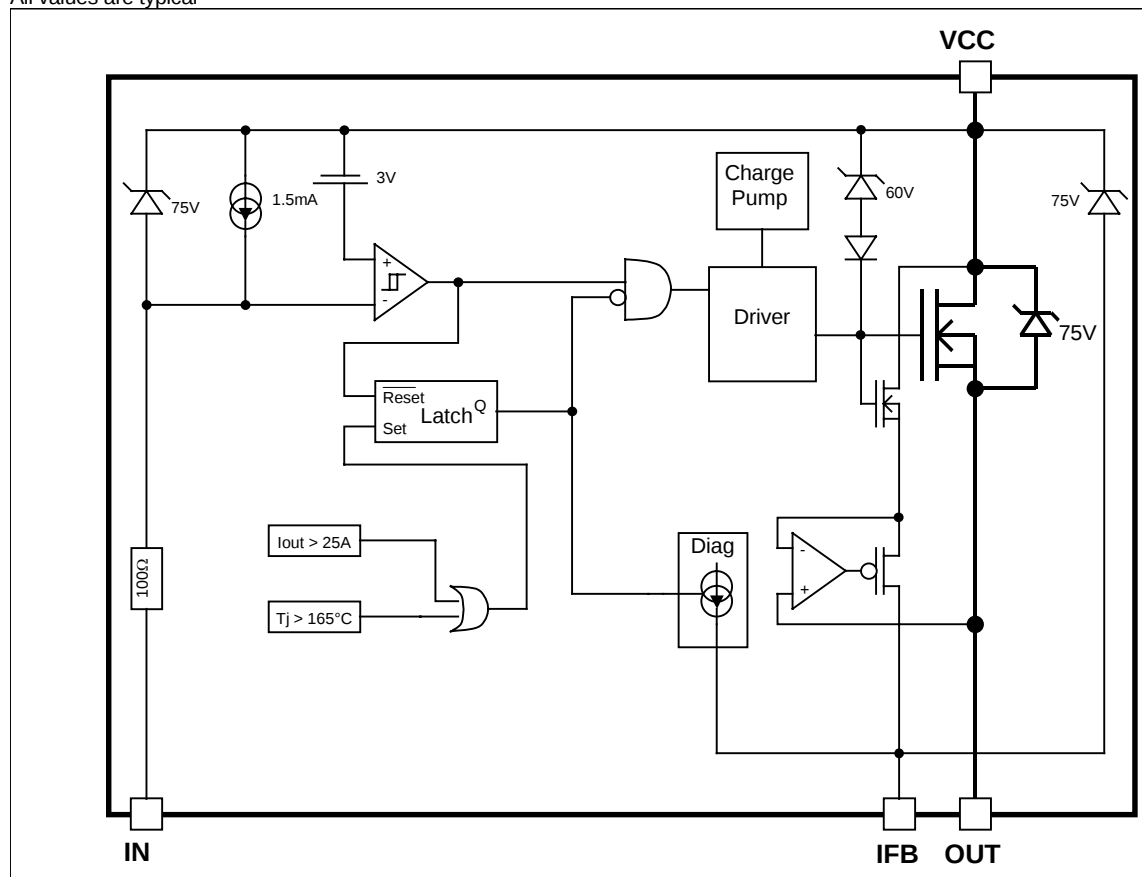
(2) Guaranteed by design

1- NC  
2- In  
3- Vcc  
4- I<sub>fb</sub>  
5- Out



3- Vcc  
1 2 4 5  
DPAK

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 AEC-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 :  $P = I_{load} \times V_f$

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.

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

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

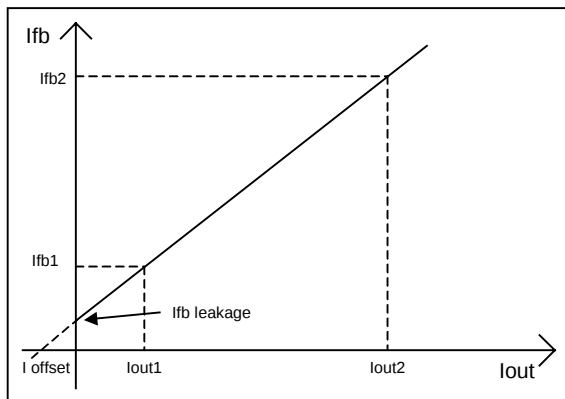
$$\frac{di}{dt} = \frac{V_{Battery} - V_{CL}}{L} : \text{Demagnetization current}$$

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

## Over-current protection

The threshold of the over-current protection is set in order to guarantee 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. This behavior is shown in 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

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 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 4.

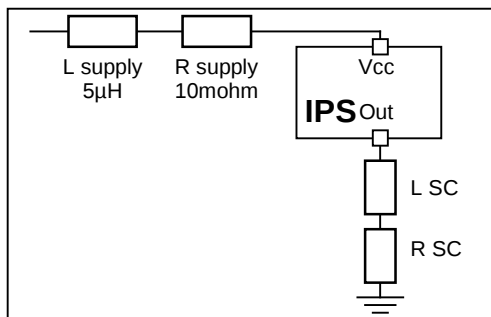
The Ioffset variation depends directly on the Rdson :

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

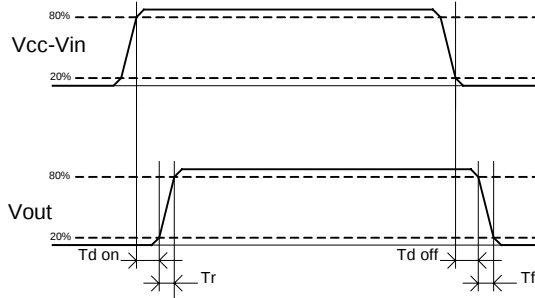
$$I_{offset@150^{\circ}\text{C}} = I_{offset@25^{\circ}\text{C}} / 1.9$$

## Maximum Vcc voltage with short circuit protection

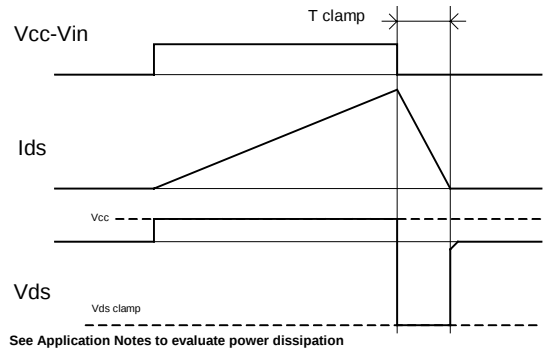
The maximum Vcc voltage with short circuit is the maximum voltage for which the part is able to protect itself under test conditions representative of the application. 2 kind of short circuits are considered : terminal and load short circuit.



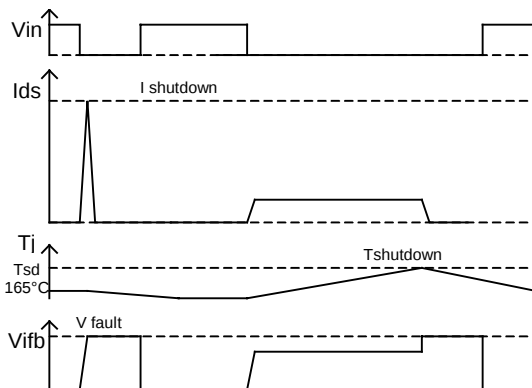
|             | L SC   | R SC     |
|-------------|--------|----------|
| Terminal SC | 0.1 μH | 10 mohm  |
| Load SC     | 10 μH  | 100 mohm |



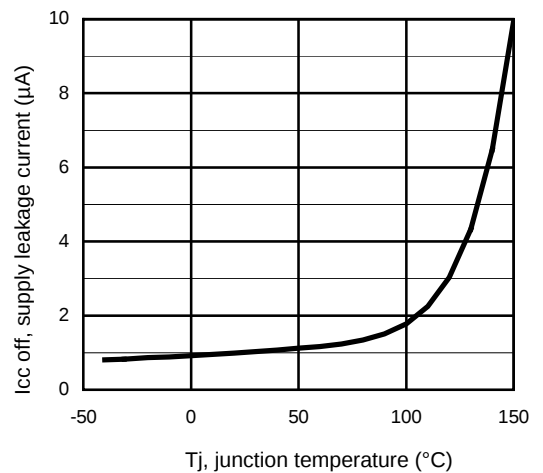
**Figure 1 – IN rise time & switching definitions**



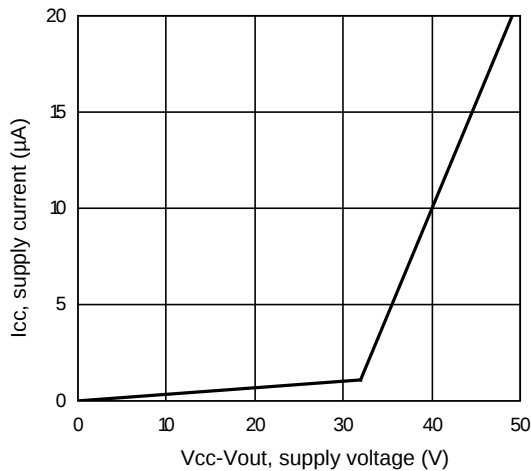
**Figure 2 – Active clamp waveforms**



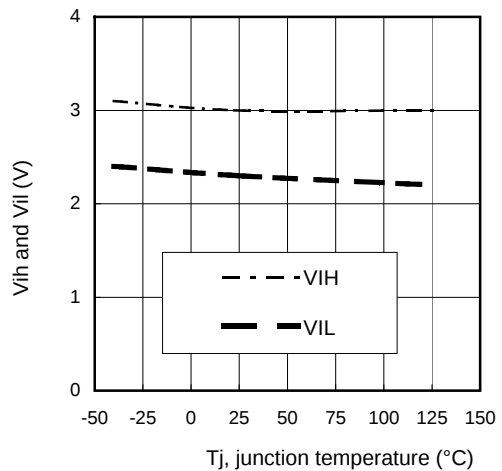
**Figure 3 – Protection timing diagram**



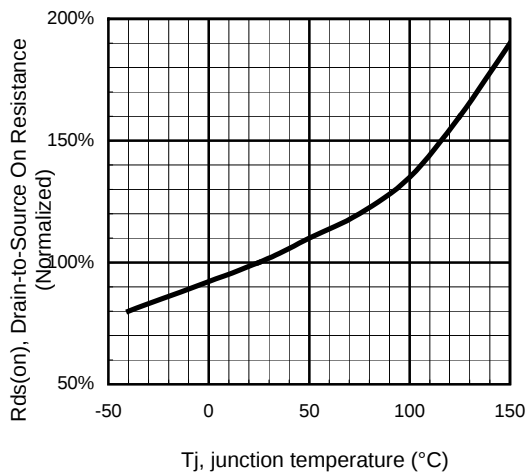
**Figure 4 – Icc off (µA) Vs Tj (°C)**



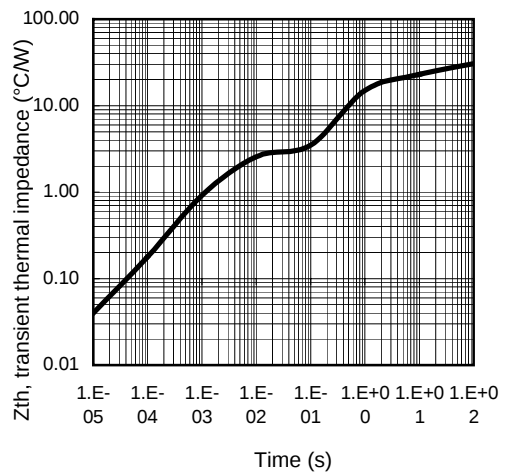
**Figure 5 – Icc off (µA) Vs Vcc-Vout (V)**



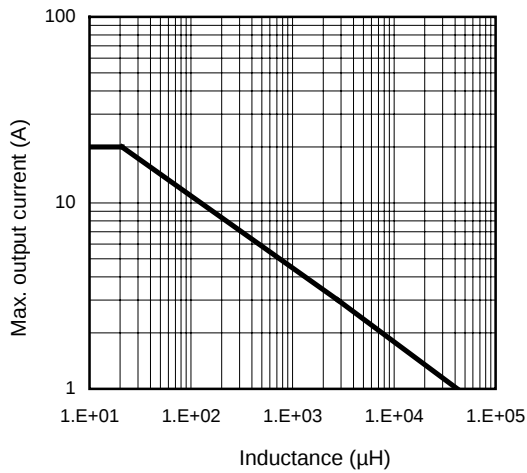
**Figure 6 – Vih and Vil (V) Vs Tj (°C)**



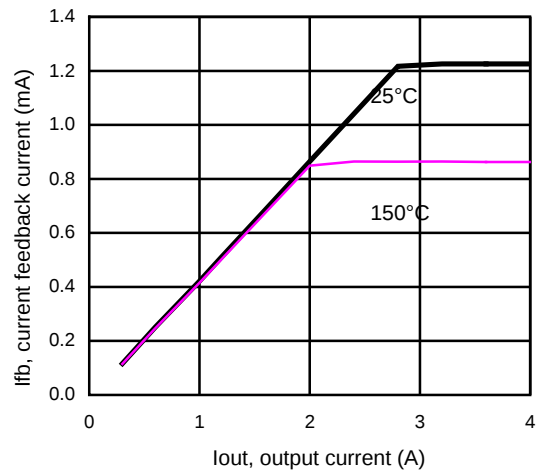
**Figure 7 - Normalized Rds(on) (%) Vs Tj (°C)**



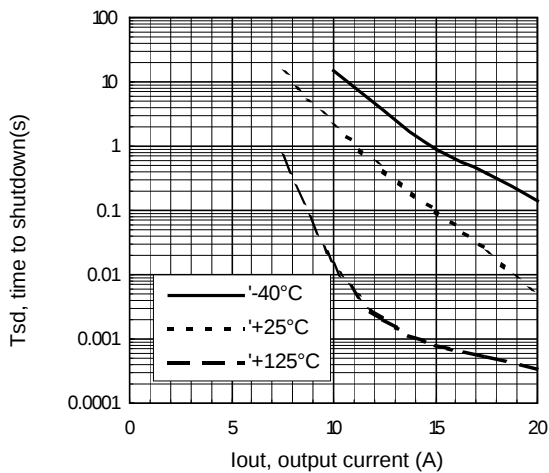
**Figure 8 – Transient thermal impedance (°C/W) Vs time (s)**



**Figure 9 – Max. I<sub>out</sub> (A) Vs inductance (μH)**

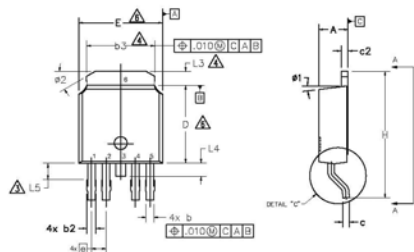
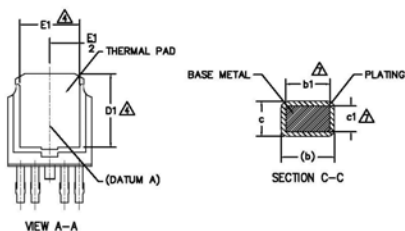
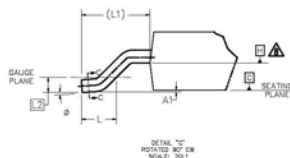


**Figure 10 – I<sub>fb</sub> (mA) Vs I<sub>out</sub> (A)**



**Figure 11 – Tsd (s) Vs I<sub>out</sub> (A)  
SMD with 6cm<sup>2</sup>**

## Case Outline 5 Lead – DPAK

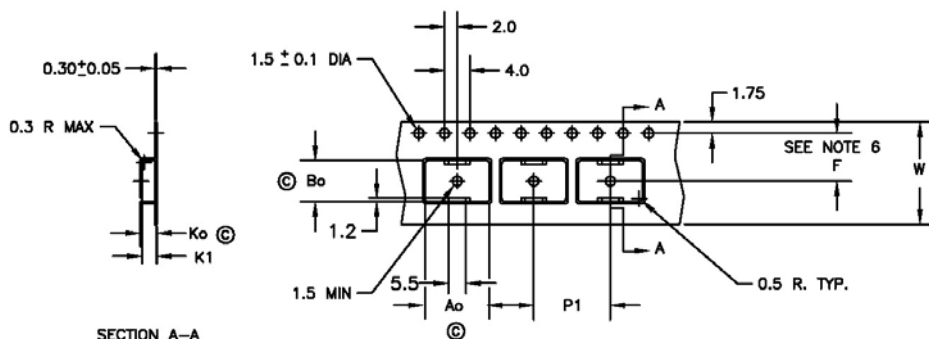


| SYMBOL | DIMENSIONS  |       |           |      | NOTES |
|--------|-------------|-------|-----------|------|-------|
|        | MILLIMETERS |       | INCHES    |      |       |
|        | MIN.        | MAX.  | MIN.      | MAX. |       |
| A      | 2.18        | 2.39  | .086      | .094 |       |
| A1     | —           | 0.13  | —         | .005 |       |
| b      | 0.56        | 0.79  | .022      | .031 |       |
| b1     | .056        | 0.74  | .022      | .029 | 2     |
| b2     | 0.65        | 0.89  | .026      | .035 |       |
| b3     | 4.95        | 5.46  | .195      | .215 | 2     |
| c      | 0.46        | 0.61  | .018      | .024 |       |
| c1     | 0.41        | 0.56  | .016      | .022 | 2     |
| c2     | 0.46        | 0.89  | .018      | .035 |       |
| D      | 5.97        | 6.22  | .235      | .245 | 3     |
| D1     | 5.21        | —     | .205      | —    |       |
| E      | 6.35        | 6.73  | .250      | .265 | 3     |
| E1     | 4.32        | —     | .170      | —    |       |
| e      | 1.14 BSC    |       | .045 BSC  |      |       |
| H      | 9.40        | 10.41 | .370      | .410 |       |
| L      | 1.40        | 1.78  | .055      | .070 |       |
| L1     | 2.74 BSC    |       | .108 REF. |      |       |
| L2     | 0.51 BSC    |       | .020 BSC  |      |       |
| L3     | 0.89        | 1.27  | .035      | .050 |       |
| L4     | —           | 1.02  | —         | .040 |       |
| L5     | 1.14        | 1.52  | .045      | .060 |       |
| ø      | 0"          | 10"   | 0"        | 10"  |       |
| ø1     | 0"          | 15"   | 0"        | 15"  |       |
| ø2     | 28"         | 32"   | 28"       | 32"  |       |

### NOTES:

- 1.— DIMENSIONING AND TOLERANCING AS PER ASME Y14.5M-1994
- 2.— DIMENSIONS ARE SHOWN IN INCHES [MILLIMETERS]
- 3.— LEAD DIMENSION UNCONTROLLED IN L5.
- 4.— DIMENSION D1, E1, L3 & b3 ESTABLISH A MINIMUM MOUNTING SURFACE FOR THERMAL PAD.
- 5.— SECTION C-C DIMENSIONS APPLY TO THE FLAT SECTION OF THE LEAD BETWEEN .005 AND 0.10 [0.13 AND 0.25] FROM THE LEAD TIP.
- 6.— DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED .005 [0.13] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY.
- 7.— DIMENSION b1 & c1 APPLIED TO BASE METAL ONLY.
- 8.— DATUM A & B TO BE DETERMINED AT DATUM PLANE H.
- 9.— OUTLINE CONFORMS TO JEDEC OUTLINE TO-252.
10. LEADS AND DRAIN ARE PLATED WITH 100% Sn

## Tape & Reel 5 Lead – DPAK

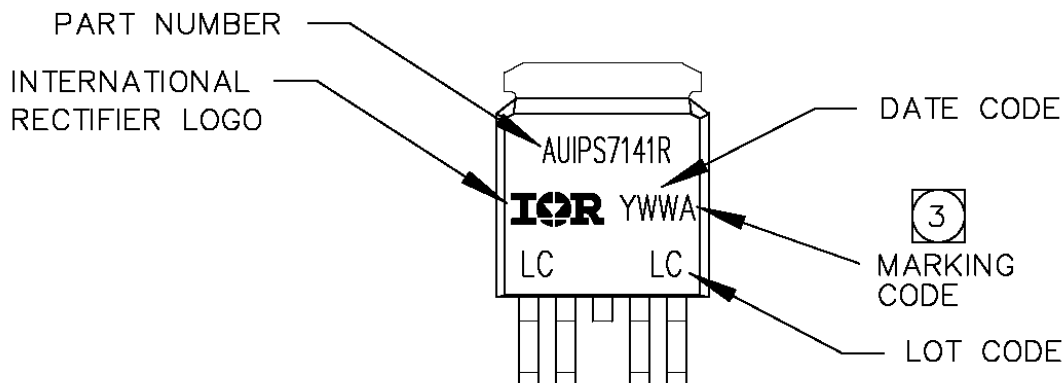


$A_0 = 10.5 \text{ mm}$   
 $B_0 = 7.0 \text{ mm}$   
 $K_0 = 2.8 \text{ mm}$   
 $K_1 = 2.4 \text{ mm}$   
 $F = 7.5 \text{ mm}$   
 $P_1 = 12.0 \text{ mm}$   
 $W = 16.0 \pm .3 \text{ mm}$

### NOTES:

1. 10 SPROCKET HOLE PUNCH CUMULATIVE TOLERANCE  $\pm 0.02$
2. CAMBER NOT TO EXCEED 1mm IN 100mm
3. MATERIAL: CONDUCTIVE BLACK POLYSTYRENE
4.  $A_0$  AND  $B_0$  MEASURED ON A PLANE 0.3mm ABOVE THE BOTTOM OF THE POCKET
5.  $K_0$  MEASURED FROM A PLANE ON THE INSIDE BOTTOM OF THE POCKET TO THE TOP SURFACE OF THE CARRIER
6. POCKET POSITION RELATIVE TO THE SPROCKET HOLE MEASURED AS TRUE POSITION OF POCKET, NOT POCKET HOLE
7. VENDOR: (OPTIONAL)
8. MUST ALSO MEET REQUIREMENTS OF EIA STANDARD #EIA-481A, TAPING OF SURFACE-MOUNT COMPONENTS FOR AUTOMATIC PLACEMENT.
9. TOLERANCE TO BE MANUFACTURER STANDARD
10. SURFACE RESISTIVITY OF MOLDED MATL: MUST MEASURE LESS THAN OR EQUAL TO  $10^8$  OHMS PER SQUARE. MEASURED IN ACCORDANCE TO PROCEDURE GIVEN IN ASTM D-257 & ASTM D-991 (REF. C-9000 SPEC.)
11. TOTAL LENGTH PER REEL MUST BE 79 METERS
12. © CRITICAL DIMENSION

## Part Marking Information



## Ordering Information

| Base Part Number | Package Type | Standard Pack       |          | Complete Part Number |
|------------------|--------------|---------------------|----------|----------------------|
|                  |              | Form                | Quantity |                      |
| AUIPS7141R       | D-Pak-5-Lead | Tube                | 75       | AUIPS7141R           |
|                  |              | Tape and reel       | 3000     | AUIPS7141RTR         |
|                  |              | Tape and reel left  | 2000     | AUIPS7141RTRL        |
|                  |              | Tape and reel right | 2000     | AUIPS7141RTRR        |

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