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# IPS1021(S)(R)

## INTELLIGENT POWER LOW SIDE SWITCH

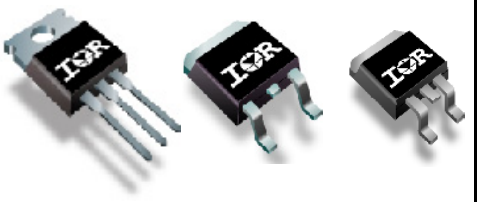
### Features

- Over temperature shutdown
- Over current shutdown
- Active clamp
- Low current & logic level input
- ESD protection
- Optimized Turn On/Off for EMI
- Diagnostic on the input current

### Product Summary

| | |
|---|---|
| Rds(on) | 25mΩ (max.) |
| Vclamp | 36V |
| Ishutdown | 35A (typ.) |

### Packages

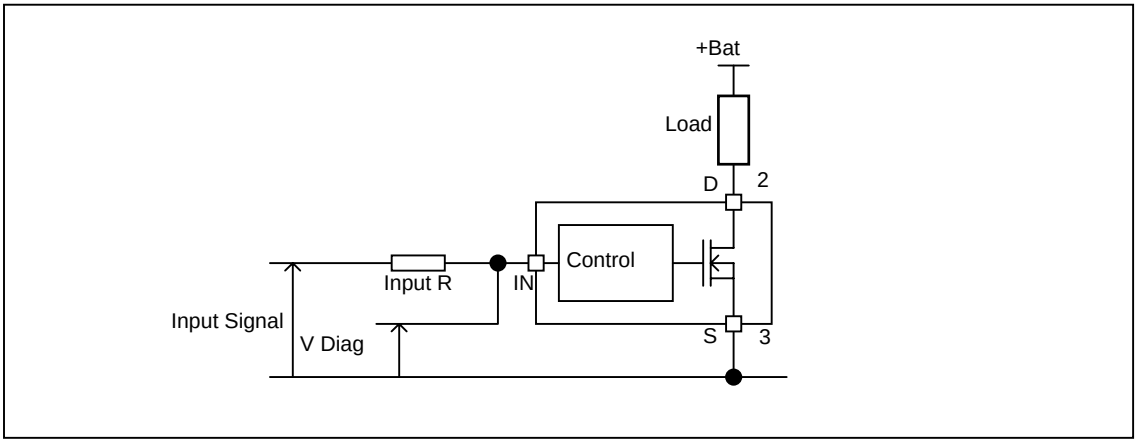


TO-220 IPS1021 | D²Pak IPS1021S | D-Pak IPS1021R

### Description

The IPS1021(S)(R) is a three terminal Intelligent Power Switch (IPS) that features a low side MOSFET with over-current, over-temperature, ESD protection and drain to source active clamp. This device offers protections and the high reliability required in harsh environments. The switch provides efficient protection by turning OFF the power MOSFET when the temperature exceeds 165°C or when the drain current reaches 35A. The device restarts once the input is cycled. A serial resistance connected to the input provides the diagnostic. The avalanche capability is significantly enhanced by the active clamp and covers most inductive load demagnetizations.

### Typical Connection

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## Absolute Maximum Ratings

Absolute maximum ratings indicate sustained limits beyond which damage to the device may occur. All voltage parameters are referenced to Ground lead. (Tambient=25°C unless otherwise specified).

| Symbol | Parameter | Min. | Max. | Units |
|---|---|---|---|---|
| Vds | Maximum drain to source voltage | -0.3 | 36 | V |
| Vds cont. | Maximum continuous drain to source voltage | - | 28 | V |
| Vin | Maximum input voltage | -0.3 | 6 | V |
| Isd cont. | Max. diode continuous current (limited by thermal dissipation) | — | 4.5 | A |
| Pd | Maximum power dissipation (internally limited by thermal protection) | | | |
| | Rth=5°C/W IPS1021 | — | 25 | W |
| | Rth=40°C/W IPS1021S 1" sqr. footprint | — | 3.1 | |
| | Rth=50°C/W IPS1021R 1" sqr. footprint | — | 2.5 | |
| ESD | Electrostatic discharge voltage (Human body) C=100pF, R=1500Ω | | | kV |
| | Between drain and source | — | 4 | |
| | Other combinations | — | 3 | |
| | Electrostatic discharge voltage (Machine Model) C=200pF,R=0Ω | | | |
| | Between drain and source | — | 0.5 | |
| | Other combinations | — | 0.3 | |
| Tj max. | Max. storage & operating temperature junction temperature | -40 | 150 | °C |
| Tsoldering | Lead soldering temperature (10 seconds) | — | 300 | °C |

## Thermal Characteristics

| Symbol | Parameter | Typ. | Max. | Units |
|---|---|---|---|---|
| Rth1 | Thermal resistance junction to ambient IPS1021 TO-220 free air | 50 | — | °C/W |
| Rth2 | Thermal resistance junction to case IPS1021 TO-220 | 2.6 | — | |
| Rth1 | Thermal resistance junction to ambient IPS1021S D²Pak std. footprint | 60 | — | |
| Rth2 | Thermal resistance junction to ambient IPS1021S D²Pak 1" sqr. footprint | 40 | — | |
| Rth3 | Thermal resistance junction to case IPS1021S D²Pak | 2.6 | — | |
| Rth1 | Thermal resistance junction to ambient IPS1021R D-Pak std. footprint | 70 | — | |
| Rth2 | Thermal resistance junction to ambient IPS1021R D-Pak 1" sqr. footprint | 50 | — | |
| Rth3 | Thermal resistance junction to case IPS1021R D-Pak | 2.6 | — | |

## 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 |
|---|---|---|---|---|
| VIH | High level input voltage | 4.5 | 5.5 | |
| VIL | Low level input voltage | 0 | 0.5 | |
| Ids | Continuous drain current, Tambient=85°C, Tj=125°C, Vin=5V | | | A |
| | Rth=5°C/W IPS1021 | — | 13.5 | |
| | Rth=40°C/W IPS1021S 1" sqr. footprint | — | 4.8 | |
| | Rth=50°C/W IPS1021R 1" sqr. footprint | — | 4.3 | |
| Rin | Recommended resistor in series with IN pin to generate a diagnostic | 0.5 | 10 | kΩ |
| Max L | Max. recommended load inductance (including line inductance) (1) | — | 20 | µH |
| Max F | Max. frequency (switching losses = conduction losses) | — | 500 | Hz |
| Max t rise | Max. input rising time | — | 1 | µs |

(1) Higher inductance is possible if maximum load current is limited - see figure 11

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## Static Electrical Characteristics

Tj=25°C, Vcc=14V (unless otherwise specified)

| Symbol | Parameter | Min. | Typ. | Max. | Units | Test Conditions |
|---|---|---|---|---|---|---|
| Rds(on) | ON state resistance Tj=25°C | — | 20 | 25 | mΩ | Vin=5V, Ids=8A |
| | ON state resistance Tj=150°C (2) | — | 38 | 48 | | |
| Idss1 | Drain to source leakage current | — | 0.1 | 10 | µA | Vcc=14V, Tj=25°C |
| Idss2 | Drain to source leakage current | — | 0.2 | 20 | | Vcc=28V, Tj=25°C |
| V clamp1 | Drain to source clamp voltage 1 | 36 | 39 | — | V | Id=20mA |
| V clamp2 | Drain to source clamp voltage 2 | — | 40 | 42 | | Id=2A |
| Vin clamp | IN to source pin clamp voltage | 5.5 | 6.5 | 7.5 | | Iin=1mA |
| Vth | Input threshold voltage | — | 1.7 | — | | Id=10mA |

## Switching Electrical Characteristics

Vcc=14V, Resistive load=1.5Ω, Rinput=0Ω, Vin=5V, Tj=25°C

| Symbol | Parameter | Min. | Typ. | Max. | Units | Test Conditions |
|---|---|---|---|---|---|---|
| Tdon | Turn-on delay time to 20% | 10 | 30 | 100 | µs | See figure 2 |
| Tr | Rise time 20% to 80% | 10 | 30 | 60 | | |
| Tdoff | Turn-off delay time to 80% | 40 | 150 | 400 | | |
| Tf | Fall time 80% to 20% | 15 | 30 | 60 | | |
| Eon + Eoff | Turn on and off energy | — | 2 | — | mJ | |

## Protection Characteristics

| Symbol | Parameter | Min. | Typ. | Max. | Units | Test Conditions |
|---|---|---|---|---|---|---|
| Tsd | Over temperature threshold | 150(2) | 165 | — | °C | See figure 1 |
| Isd | Over current threshold | 32 | 45 | 58 | A | See figure 1 |
| OV | Over voltage protection ( not active when the device is ON ) | 34 | 37 | — | V | |
| Vreset | IN protection reset threshold | — | 1.7 | — | V | |
| Treset | Time to reset protection | 15(2) | 50 | 200 | µs | Vin=0V |

## Diagnostic

| Symbol | Parameter | Min. | Typ. | Max. | Units | Test Conditions |
|---|---|---|---|---|---|---|
| Iin, on | ON state IN positive current | 15 | 32 | 70 | µA | Vin=5V |
| Iin, off | OFF state IN positive current (after protection latched) | 150 | 230 | 350 | | Vin=5V |

(2) Guaranteed by design

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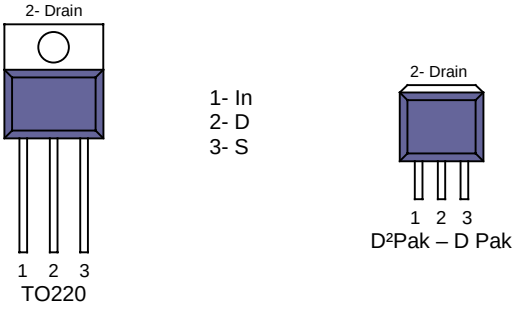
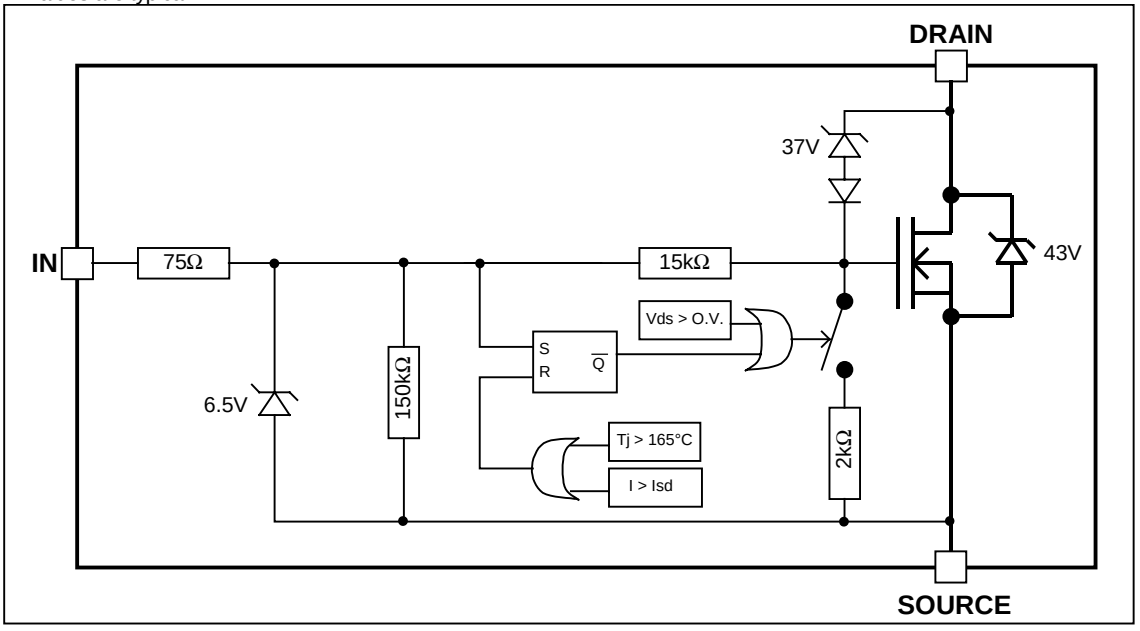
## Lead Assignments




## Functional Block Diagram

All values are typical

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All curves are typical values. Operating in the shaded area is not recommended.

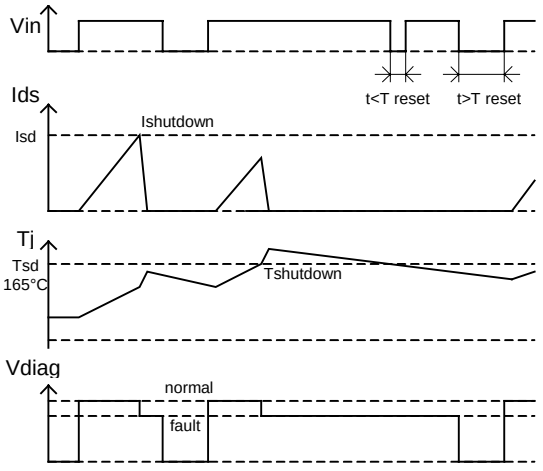



**Figure 1 – Timing diagram**

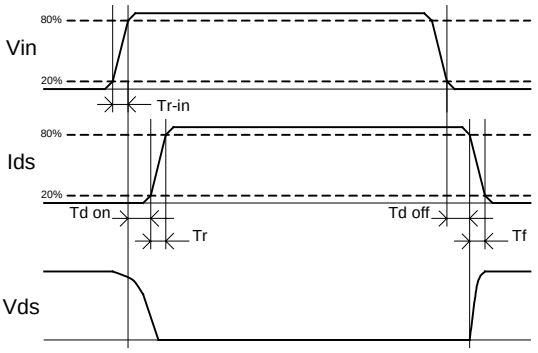
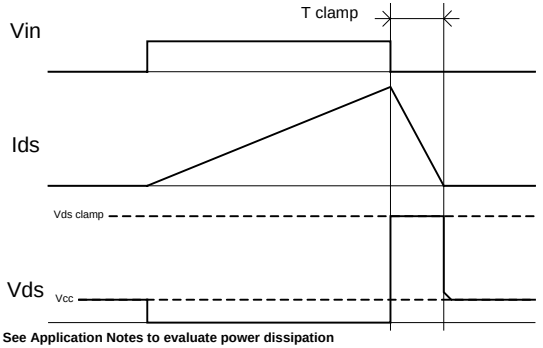



**Figure 2 – IN rise time & switching definitions**




**See Application Notes to evaluate power dissipation**

**Figure 3 – Active clamp waveforms**

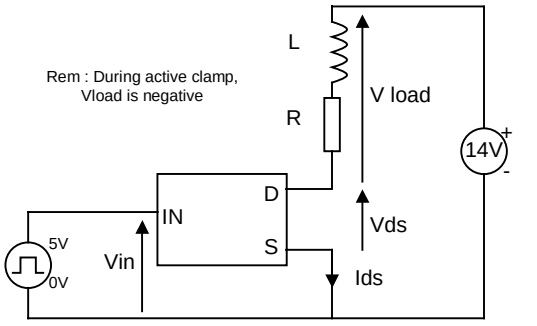



**Figure 4 – Active clamp test circuit**

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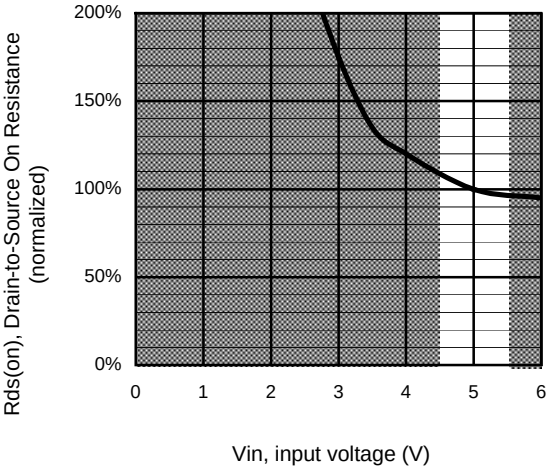


**Figure 5 – Normalized Rds(on) (%) Vs Input voltage (V)**

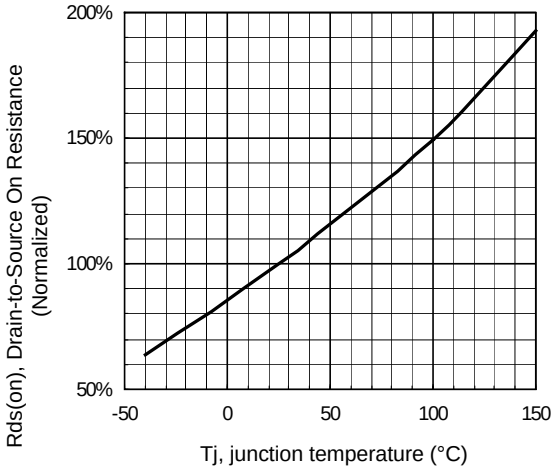


**Figure 6 - Normalized Rds(on) (%) Vs Tj (°C)**

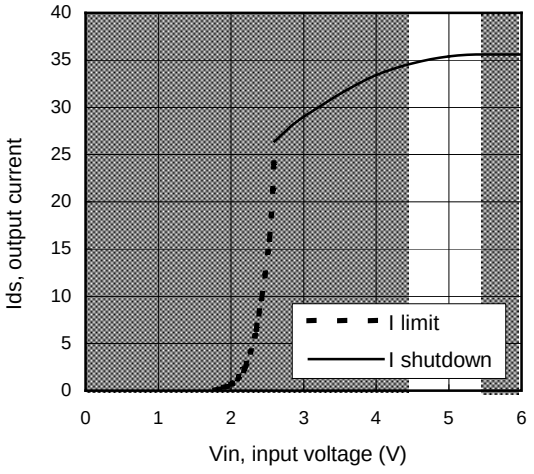


**Figure 7 – Current limitation and current shutdown Vs Input voltage (V)**

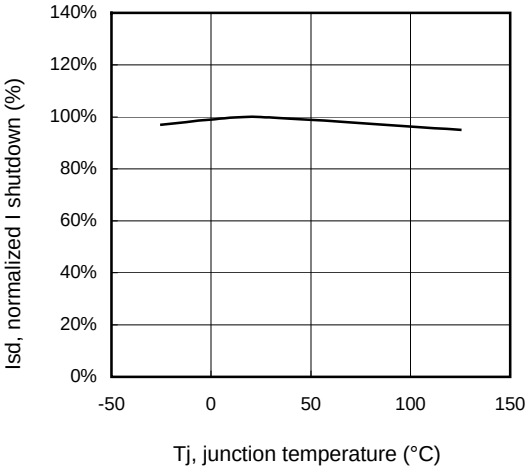


**Figure 8 – Normalized I shutdown (%) Vs junction temperature (°C)**

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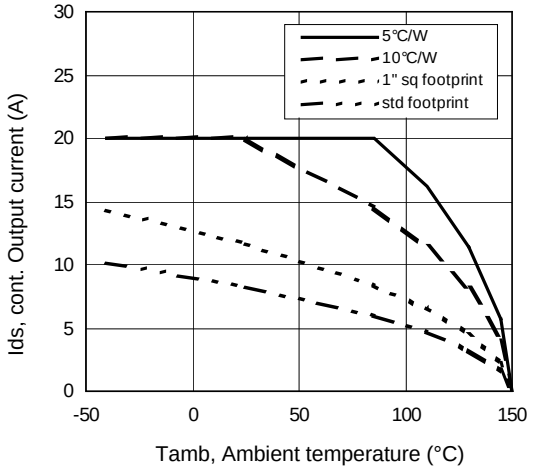


**Figure 9 – Max. continuous output current (A) Vs Ambient temperature (°C)**

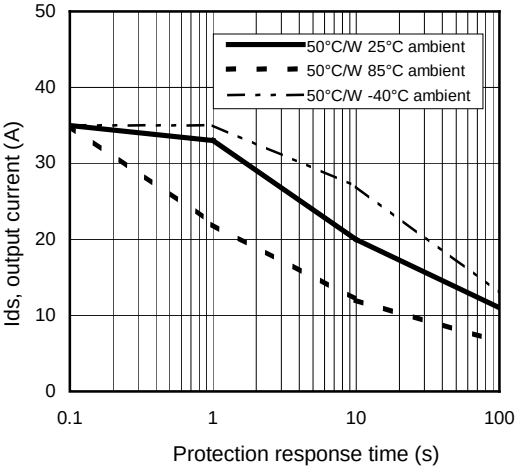


**Figure 10 – Ids (A) Vs over temperature protection response time (s)**

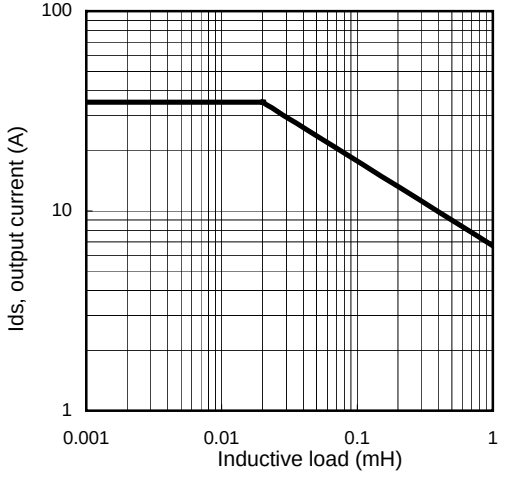


**Figure 11 – Max. ouput current (A) Vs Inductive load (mH)**

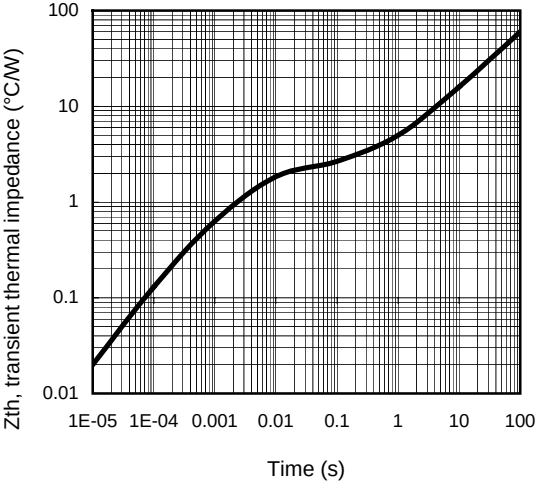


**Figure 12 – Transient thermal impedance (°C/W) Vs time (s)**

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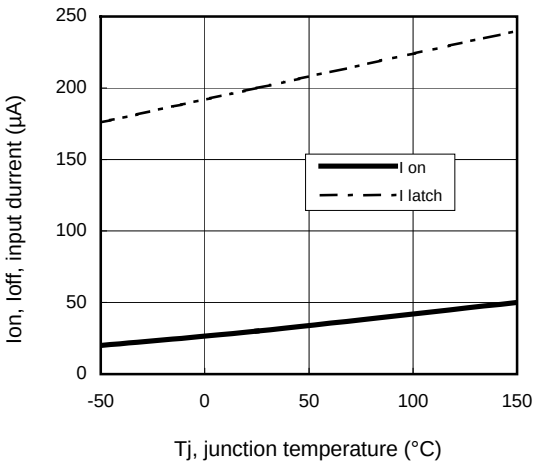


**Figure 13 – Input current (µA) On and Off Vs junction temperature (°C)**

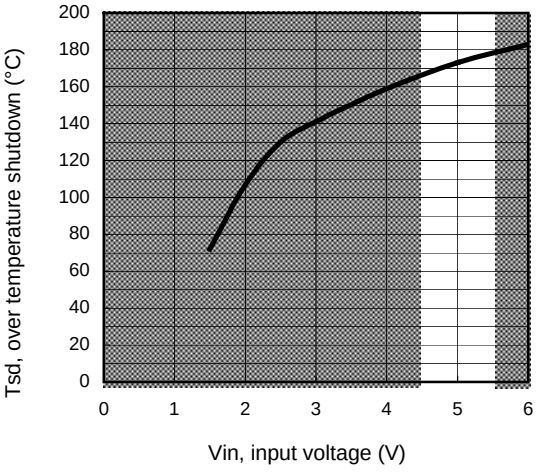


**Figure 14 – Over temperature shutdown (°C) Vs input voltage (V)**

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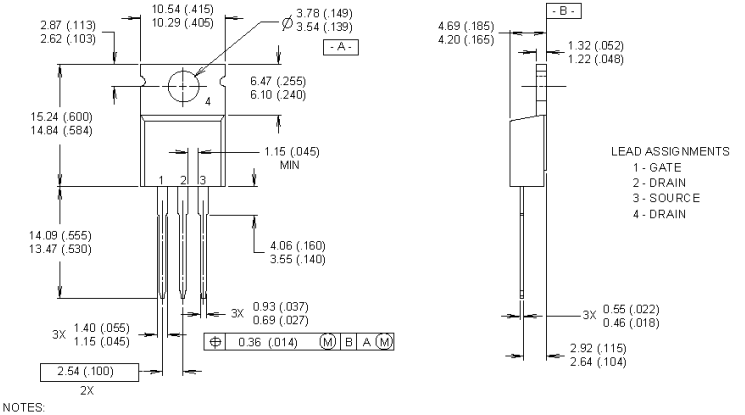
## Case Outline – TO-220 AB




NOTES:

1 DIMENSIONING & TOLERANCING PER ANSI Y14.5M, 1982.
2 CONTROLLING DIMENSION : INCH
3 OUTLINE CONFORMS TO JEDEC OUTLINE TO-220-AB.
4 HEATSINK & LEAD MEASUREMENTS DO NOT INCLUDE BURRS.
5 LEADS ARE SOLDER DIPPED: 63%/37% Sn/Pb; DRAIN CONTACT IS NICKEL PLATED.

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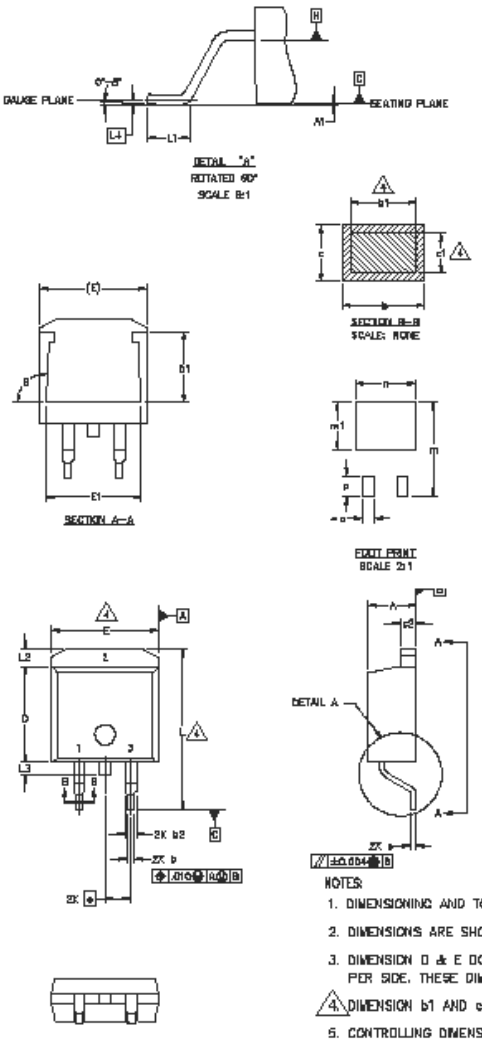
## Case Outline - D²Pak (SMD-220)




| SYMBOL | DIMENSIONS | | | | NOTES |
|---|---|---|---|---|---|
| | MILLIMETERS | | INCHES | | |
| | MIN. | MAX. | MIN. | MAX. | |
| A | 4.06 | 4.83 | .160 | .190 | |
| A1 | | 0.127 | | .005 | |
| b | 0.51 | 0.99 | .020 | .039 | |
| b1 | 0.51 | 0.89 | .020 | .035 | 4 |
| b2 | 1.14 | 1.40 | .045 | .055 | |
| c | 0.38 | 0.74 | .015 | .029 | |
| c1 | 0.43 | 0.63 | .017 | .025 | 4 |
| c2 | 1.14 | 1.40 | .045 | .055 | |
| D | 8.51 | 9.65 | .335 | .380 | 3 |
| D1 | 5.33 | | .210 | | |
| E | 9.65 | 10.67 | .380 | .420 | 3 |
| E1 | 6.22 | | .245 | | |
| e | 2.54 BSC | | .100 BSC | | |
| L | 14.61 | 15.88 | .575 | .625 | |
| L1 | 1.78 | 2.79 | .070 | .110 | |
| L2 | | 1.65 | | .065 | |
| L3 | 1.27 | 1.78 | .050 | .070 | |
| L4 | 0.25 BSC | | .010 BSC | | |
| m | 17.78 | | .700 | | |
| m1 | 8.89 | | .350 | | |
| n | 11.43 | | .450 | | |
| o | 2.08 | | .082 | | |
| p | 3.81 | | .150 | | |
| θ | 90° | 93° | 90° | 93° | |

LEAD ASSIGNMENTS

| HEXFET | IGBTs, CoPACK | DIODES |
|---|---|---|
| 1.- GATE | 1.- GATE | 1.- ANODE * |
| 2.- DRAIN | 2.- COLLECTOR | 2.- CATHODE |
| 3.- SOURCE | 3.- EMITTER | 3.- ANODE |

* PART DEPENDENT.

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: INCH.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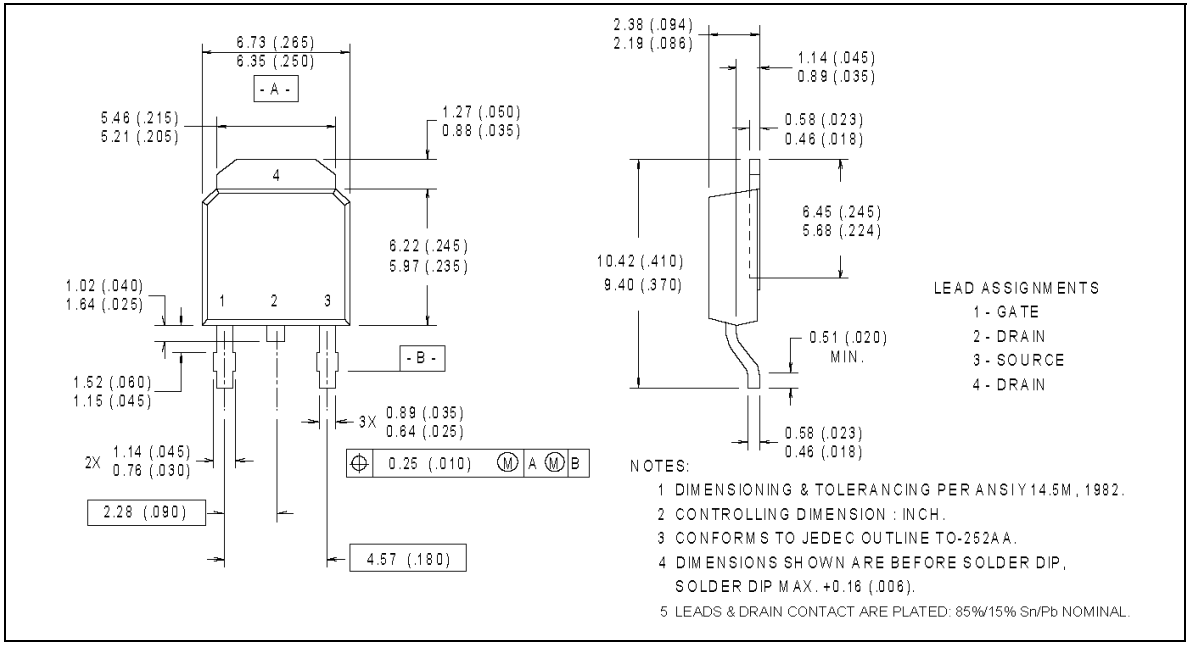
## Case Outline – D-Pak

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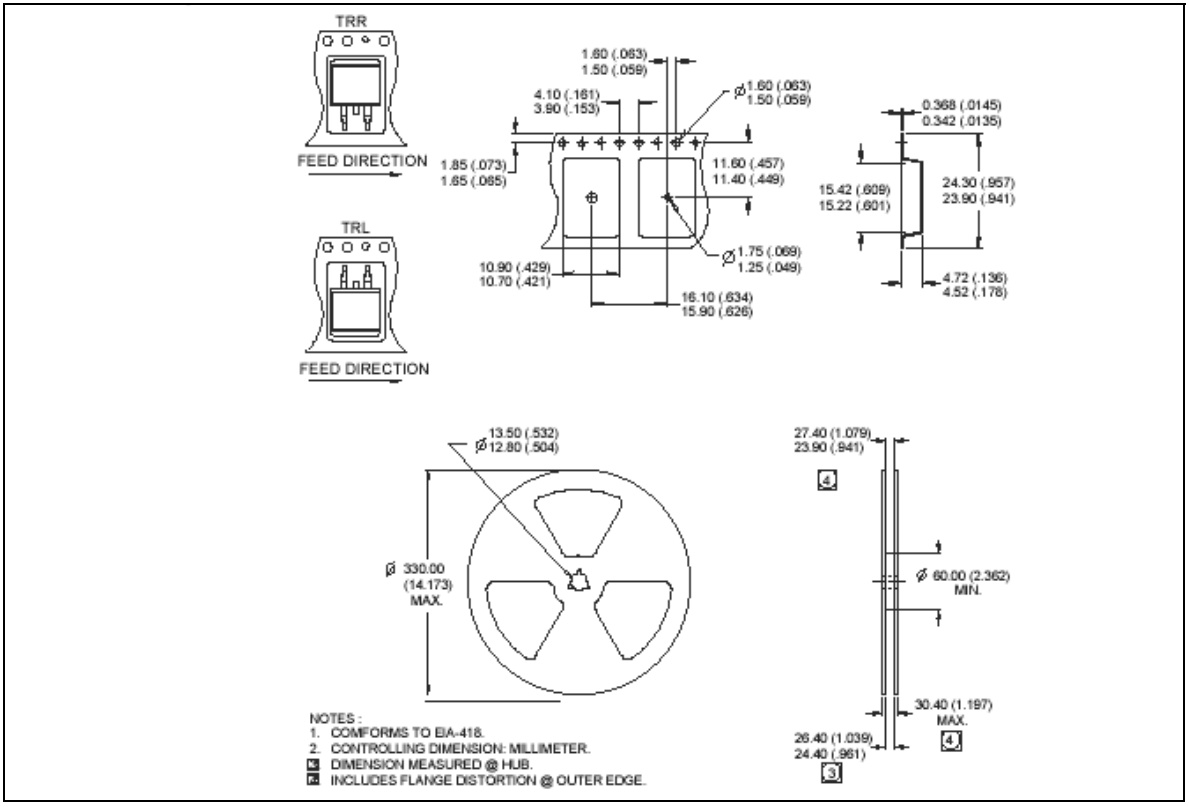
## Tape & Reel - D²Pak (SMD220)

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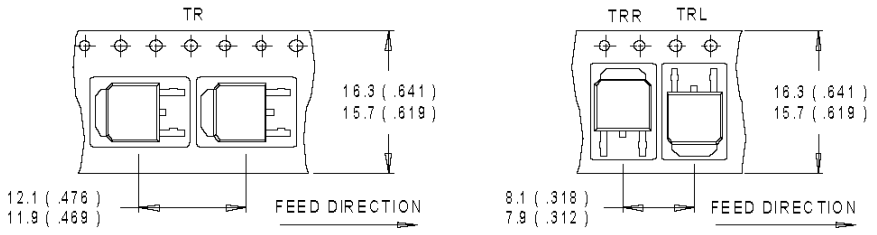
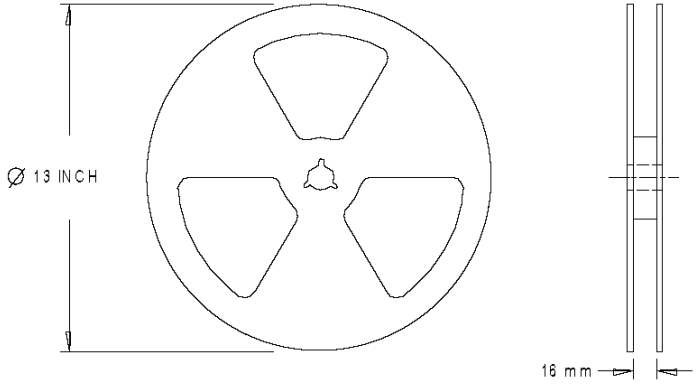
## Tape & Reel - D-Pak




NOTES :
1. CONTROLLING DIMENSION : MILLIMETER.
2. ALL DIMENSIONS ARE SHOWN IN MILLIMETERS ( INCHES ).
3. OUTLINE CONFORMS TO EIA-481 & EIA-541.




NOTES :
1. OUTLINE CONFORMS TO EIA-481.

Dimensions are shown in millimeters (inches)



**IR WORLD HEADQUARTERS:** 233 Kansas St., El Segundo, California 90245 Tel: (310) 252-7105
Data and specifications subject to change without notice.
*This product is designed and qualified for the Automotive [Q100] market. 11/8/2005*

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