

## IPS5451/IPS5451S

### FULLY PROTECTED HIGH SIDE POWER MOSFET SWITCH

#### Features

- Over temperature protection (with auto-restart)
- Over current shutdown
- Active clamp
- E.S.D protection
- Status feedback
- Open load detection
- Logic ground isolated from power ground

#### Description

The IPS5451/IPS5451S are fully protected five terminal high side switch with built in short circuit, over-temperature, ESD protection, inductive load capability and diagnostic feedback. The over-current protection latches off the device if the output current exceeds  $I_{shutdown}$ . It can be reset by turning the input pin low. The over-temperature protection turns off the high side switches if the junction temperature exceeds  $T_{shutdown}$ . It will automatically restart after the junction has cooled  $7^{\circ}\text{C}$  below  $T_{shutdown}$ . A diagnostic pin is provided for status feedback of over-current, over-temperature and open load detection. The double level shifter circuitry allows large offsets between the logic ground and the load ground.

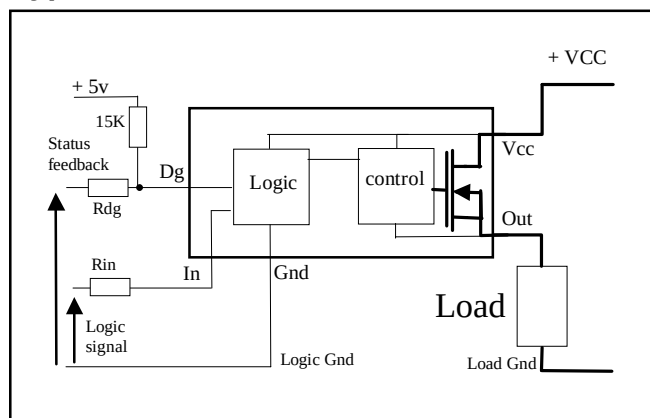
#### Product Summary

|                  |                    |
|------------------|--------------------|
| $R_{ds(on)}$     | 25m $\Omega$ (max) |
| $V_{clamp}$      | 50V                |
| $I_{shutdown}$   | 35A                |
| $I_{open\ load}$ | 1A                 |

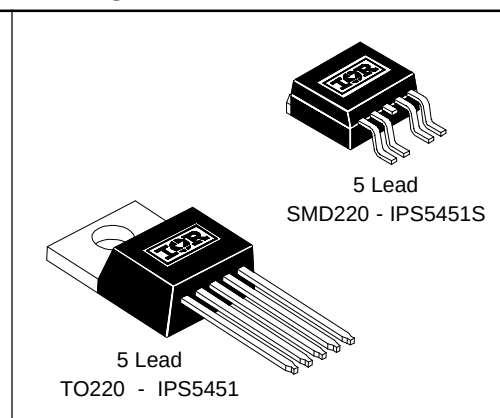
#### Truth Table

| Op. Conditions   | In | Out         | Dg          |
|------------------|----|-------------|-------------|
| Normal           | H  | H           | H           |
| Normal           | L  | L           | H           |
| Open load        | H  | H           | L           |
| Open load        | L  | X           | H           |
| Over current     | H  | L (latched) | L           |
| Over current     | L  | L           | H           |
| Over-temperature | H  | L (cycling) | L (cycling) |
| Over-temperature | L  | L           | H           |

#### Typical Connection



#### Packages



## 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. (T<sub>Ambient</sub> = 25°C unless otherwise specified).

| Symbol                 | Parameter                                       | Min.                | Max.                 | Units | Test Conditions       |
|------------------------|-------------------------------------------------|---------------------|----------------------|-------|-----------------------|
| V <sub>out</sub>       | Maximum output voltage                          | V <sub>CC</sub> -45 | V <sub>CC</sub> +0.3 | V     |                       |
| V <sub>offset</sub>    | Maximum logic ground to load ground offset      | V <sub>CC</sub> -45 | V <sub>CC</sub> +0.3 |       |                       |
| V <sub>in</sub>        | Maximum Input voltage                           | -0.3                | 5.5                  |       |                       |
| I <sub>in, max</sub>   | Maximum IN current                              | -5                  | 10                   | mA    |                       |
| V <sub>dg</sub>        | Maximum diagnostic output voltage               | -0.3                | 5.5                  | V     |                       |
| I <sub>dg, max</sub>   | Maximum diagnostic output current               | -1                  | 10                   | mA    |                       |
| I <sub>sd cont.</sub>  | Diode max. continuous current <sup>(1)</sup>    |                     |                      | A     |                       |
|                        | (r <sub>th</sub> =62°C/W) IPS5451               | —                   | 2.8                  |       |                       |
|                        | (r <sub>th</sub> =80°C/W) IPS5451S              | —                   | 2.2                  |       |                       |
| I <sub>sd pulsed</sub> | Diode max. pulsed current <sup>(1)</sup>        | —                   | 45                   |       |                       |
| ESD1                   | Electrostatic discharge voltage (Human Body)    | —                   | 4                    | kV    | C=100pF, R=1500Ω,     |
| ESD2                   | Electrostatic discharge voltage (Machine Model) | —                   | 0.5                  |       | C=200pF, R=0Ω, L=10μH |
| P <sub>d</sub>         | Maximum power dissipation <sup>(1)</sup>        |                     |                      | W     |                       |
|                        | (r <sub>th</sub> =62°C/W) IPS5451               | —                   | 2                    |       |                       |
|                        | (r <sub>th</sub> =80°C/W) IPS5451S              | —                   | 1.56                 |       |                       |
| T <sub>j max.</sub>    | Max. storage & operating junction temp.         | -40                 | +150                 | °C    |                       |
| T <sub>lead</sub>      | Lead temperature (soldering 10 seconds)         | —                   | 300                  |       |                       |
| V <sub>cc max.</sub>   | Maximum V <sub>cc</sub> voltage                 | —                   | 45                   | V     |                       |

## Thermal Characteristics

| Symbol            | Parameter                                   | Min. | Typ. | Max. | Units | Test Conditions             |
|-------------------|---------------------------------------------|------|------|------|-------|-----------------------------|
| R <sub>th 1</sub> | Thermal resistance junction to case         | —    | 2    | —    | °C/W  | TO-220                      |
| R <sub>th 2</sub> | Thermal resistance junction to ambient      | —    | 55   | —    |       |                             |
| R <sub>th 1</sub> | Thermal resistance with standard footprint  | —    | 60   | —    |       | D <sup>2</sup> PAK (SMD220) |
| R <sub>th 2</sub> | Thermal resistance with 1" square footprint | —    | 35   | —    |       |                             |
| R <sub>th 3</sub> | Thermal resistance junction to case         | —    | 5    | —    |       |                             |

(1) Limited by junction temperature (pulsed current limited also by internal wiring)

## 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 |
|------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|-------|
| V <sub>CC</sub>                          | Continuous V <sub>CC</sub> voltage                                                                                                                                                                               | 5.5  | 18   | V     |
| V <sub>IH</sub>                          | High level input voltage                                                                                                                                                                                         | 4    | 5.5  |       |
| V <sub>IL 1</sub>                        | Low level input voltage                                                                                                                                                                                          | -0.3 | 0.9  |       |
| I <sub>out</sub>                         | Continuous output current<br>(T <sub>Ambient</sub> = 85°C, T <sub>J</sub> = 125°C, R <sub>th</sub> = 62°C/W) IPS5451<br>(T <sub>Ambient</sub> = 85°C, T <sub>J</sub> = 125°C, R <sub>th</sub> = 80°C/W) IPS5451S | —    | 4    | A     |
| I <sub>out</sub><br>T <sub>C</sub> =85°C | Continuous output current<br>(T <sub>Case</sub> = 85°C, I <sub>N</sub> = 5V, T <sub>J</sub> = 125°C, R <sub>th</sub> = 5°C/W)                                                                                    | —    | 3.5  |       |
|                                          |                                                                                                                                                                                                                  | —    | 14   |       |
| R <sub>in</sub>                          | Recommended resistor in series with IN pin                                                                                                                                                                       | 4    | 6    | kΩ    |
| R <sub>dg</sub>                          | Recommended resistor in series with DG pin                                                                                                                                                                       | 10   | 20   |       |

## Static Electrical Characteristics

(T<sub>J</sub> = 25°C, V<sub>CC</sub> = 14V unless otherwise specified.)

| Symbol                                        | Parameter                                     | Min. | Typ. | Max. | Units | Test Conditions                                        |
|-----------------------------------------------|-----------------------------------------------|------|------|------|-------|--------------------------------------------------------|
| R <sub>ds(on)</sub><br>@T <sub>J</sub> =25°C  | ON state resistance T <sub>J</sub> = 25°C     | —    | 19   | 25   | mΩ    | V <sub>in</sub> = 5V, I <sub>out</sub> = 14A           |
| R <sub>ds(on)</sub><br>(V <sub>CC</sub> =6V)  | ON state resistance @ V <sub>CC</sub> = 6V    | —    | 22   | 30   |       | V <sub>in</sub> = 5V, I <sub>out</sub> = 7A            |
| R <sub>ds(on)</sub><br>@T <sub>J</sub> =150°C | ON state resistance T <sub>J</sub> = 150°C    | —    | 32   | —    |       | V <sub>in</sub> = 5V, I <sub>out</sub> = 14A           |
| V <sub>CC oper.</sub>                         | Functional operating range                    | 5.5  | —    | 18   | V     |                                                        |
| V <sub>clamp 1</sub>                          | V <sub>CC</sub> to OUT clamp voltage 1        | 45   | 49   | —    |       | I <sub>d</sub> = 10mA (see Fig.1 & 2)                  |
| V <sub>clamp 2</sub>                          | V <sub>CC</sub> to OUT clamp voltage 2        | —    | 50   | 60   |       | I <sub>d</sub> = I <sub>shutdown</sub> (see Fig.1 & 2) |
| V <sub>f</sub>                                | Body diode forward voltage                    | —    | 0.9  | 1.2  | μA    | I <sub>d</sub> = 14A, V <sub>in</sub> = 0V             |
| I <sub>out</sub><br>leakage                   | Output leakage current                        | —    | 10   | 50   |       | V <sub>out</sub> = 0V, T <sub>J</sub> = 25°C           |
| I <sub>CC off</sub>                           | Supply current when OFF                       | —    | 10   | 50   |       | V <sub>in</sub> = 0V, V <sub>out</sub> = 0V            |
| I <sub>CC on</sub>                            | Supply current when ON                        | —    | 3.5  | 10   | mA    | V <sub>in</sub> = 5V                                   |
| I <sub>CC ac</sub>                            | Ripple current when ON (AC RMS)               | —    | 20   | —    | μA    | V <sub>in</sub> = 5V                                   |
| V <sub>dgl</sub>                              | Low level diagnostic output voltage           | —    | 0.1  | 0.4  | V     | I <sub>dg</sub> = 1.6 mA                               |
| I <sub>dg</sub><br>leakage                    | Diagnostic output leakage current             | —    | 1.5  | 10   | μA    | V <sub>dg</sub> = 4.5V                                 |
| V <sub>ih</sub>                               | IN high threshold voltage                     | —    | 2.7  | 3.4  | V     |                                                        |
| V <sub>il</sub>                               | IN low threshold voltage                      | 1    | 2.0  | —    |       |                                                        |
| I <sub>in, on</sub>                           | On state IN positive current                  | —    | 30   | 80   | μA    | V <sub>in</sub> = 4V                                   |
| V <sub>CCUV+</sub>                            | V <sub>CC</sub> UVLO positive going threshold | —    | 4.7  | 5.5  | V     |                                                        |
| V <sub>CCUV-</sub>                            | V <sub>CC</sub> UVLO negative going threshold | 3.0  | 4.4  | —    |       |                                                        |
| I <sub>nhyst.</sub>                           | Input hysteresis                              | 0.2  | 0.6  | 1.5  |       |                                                        |

# IPS5451/IPS5451S

International  
**IR** Rectifier

## Switching Electrical Characteristics

V<sub>CC</sub> = 14V, Resistive Load = 1Ω, T<sub>j</sub> = 25°C, (unless otherwise specified).

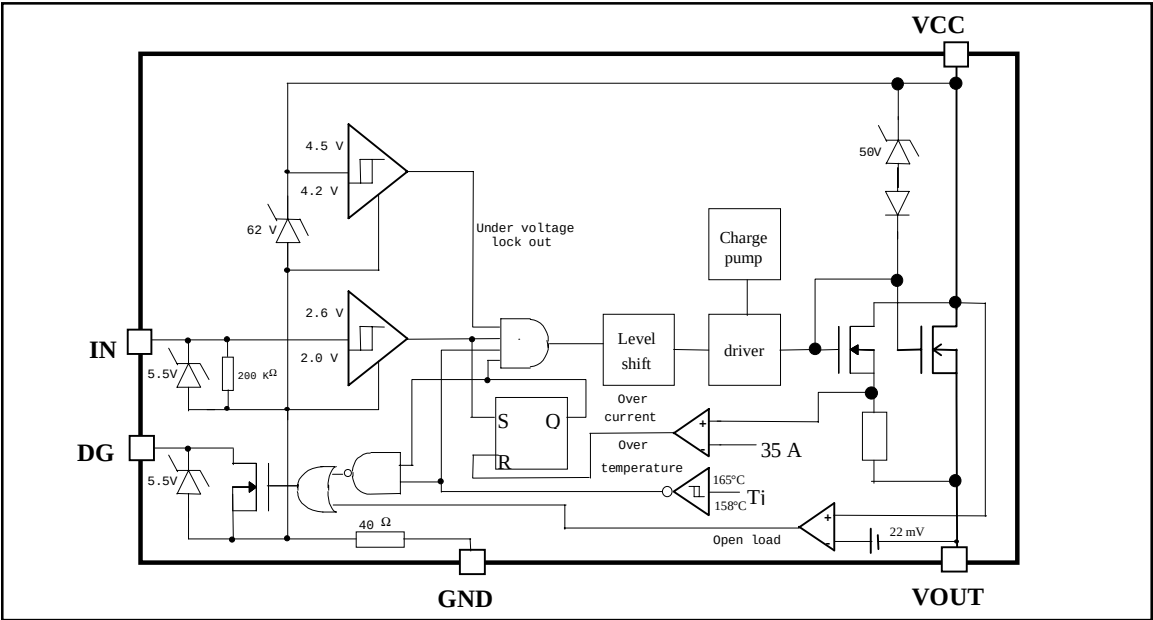
| Symbol            | Parameter                                                                              | Min. | Typ. | Max. | Units | Test Conditions |
|-------------------|----------------------------------------------------------------------------------------|------|------|------|-------|-----------------|
| T <sub>don</sub>  | Turn-on delay time                                                                     | —    | 5    | 20   | μs    | See figure 3    |
| T <sub>r1</sub>   | Rise time to V <sub>out</sub> = V <sub>CC</sub> - 5V                                   | —    | 4    | 20   |       |                 |
| T <sub>r2</sub>   | Rise time from the end of T <sub>r1</sub> to V <sub>out</sub> = 90% of V <sub>CC</sub> | —    | 65   | 150  |       |                 |
| dV/dt (on)        | Turn ON dV/dt                                                                          | —    | 3    | 6    | V/μs  | See figure 4    |
| E <sub>on</sub>   | Turn ON energy                                                                         | —    | 3    | —    | mJ    |                 |
| T <sub>doff</sub> | Turn-off delay time                                                                    | —    | 65   | 150  | μs    |                 |
| T <sub>f</sub>    | Fall time to V <sub>out</sub> = 10% of V <sub>CC</sub>                                 | —    | 8    | 20   | V/μs  |                 |
| dV/dt (off)       | Turn OFF dV/dt                                                                         | —    | 5    | 10   |       |                 |
| E <sub>off</sub>  | Turn OFF energy                                                                        | —    | 0.75 | —    | mJ    |                 |

## Protection Characteristics

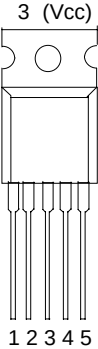
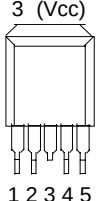
| Symbol                 | Parameter                           | Min. | Typ. | Max. | Units | Test Conditions                          |
|------------------------|-------------------------------------|------|------|------|-------|------------------------------------------|
| T <sub>sd+</sub>       | Over-temp. positive going threshold | —    | 165  | —    | °C    | See fig. 2                               |
| T <sub>sd-</sub>       | Over-temp. negative going threshold | —    | 158  | —    | °C    | See fig. 2                               |
| I <sub>sd</sub>        | Over-current threshold              | 22   | 35   | 50   | A     | See fig. 2                               |
| I <sub>open load</sub> | Open load detection threshold       | 0.3  | 1    | 2    | A     |                                          |
| T <sub>reset</sub>     | Minimum time to reset protections   | —    | 50   | —    | μs    | V <sub>in</sub> = 0V                     |
| T <sub>dg</sub>        | Blanking time before considering Dg | —    | 7    | 100  | μs    | Part turned on with V <sub>in</sub> = 5V |

## Functional Block Diagram

All values are typical



## Lead Assignments

|                                                                                                                                         |                                                                     |                                                                                                                                                               |
|-----------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p>3 (Vcc)</p> <p>1 2 3 4 5</p> <p>5 Lead - TO220</p> | <p>1 - Ground<br/> 2 - In<br/> 3 - Vcc<br/> 4 - DG<br/> 5 - Out</p> |  <p>3 (Vcc)</p> <p>1 2 3 4 5</p> <p>5 Lead - D<sup>2</sup>PAK (SMD220)</p> |
| <b>IPS5451</b>                                                                                                                          |                                                                     | <b>IPS5451S</b>                                                                                                                                               |
| <b>Part Number</b>                                                                                                                      |                                                                     |                                                                                                                                                               |

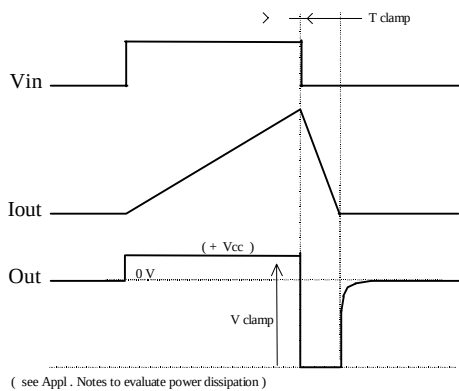


Figure 1 - Active clamp waveforms

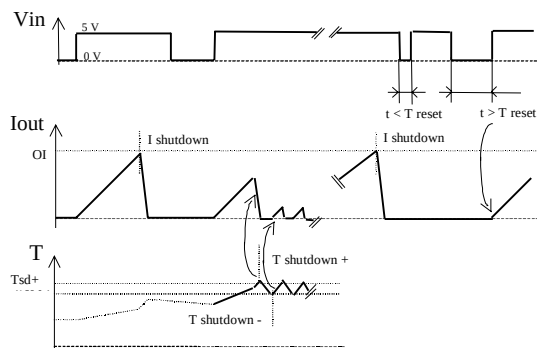


Figure 2 - Protection timing diagram

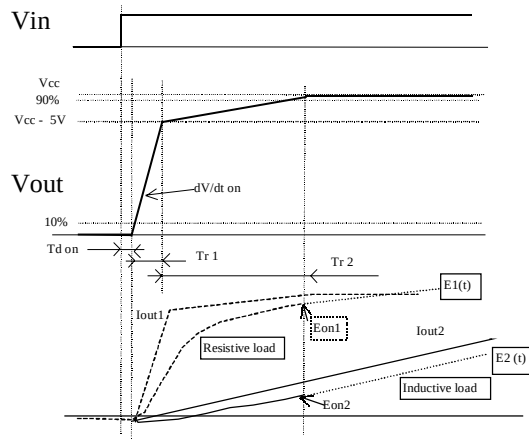


Figure 3 - Switching times definition (turn-on)  
Turn on energy with a resistive or an inductive load

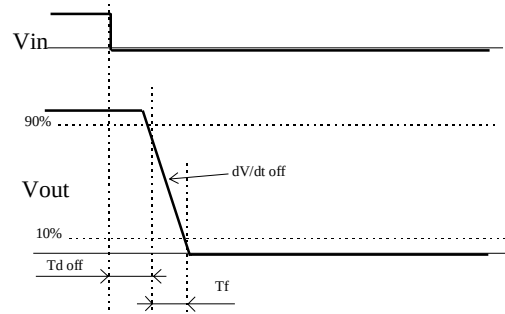


Figure 4 - Switching times definition (turn-off)

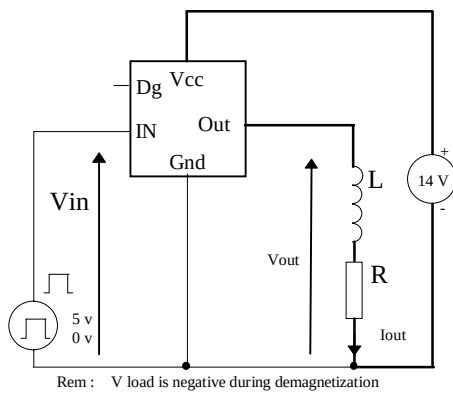


Figure 5 - Active clamp test circuit

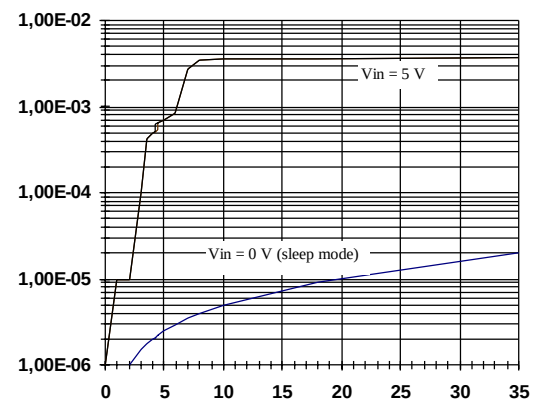


Figure 6 -  $I_{cc}$  (mA) Vs  $V_{cc}$  (V)

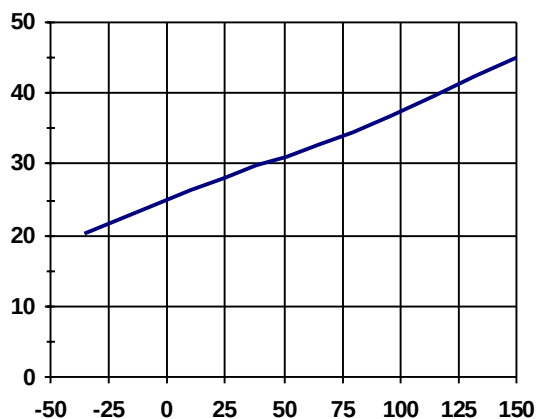


Figure 7 -  $I_{in}$  ( $\mu A$ ) Vs  $T_j$  ( $^{\circ}C$ )

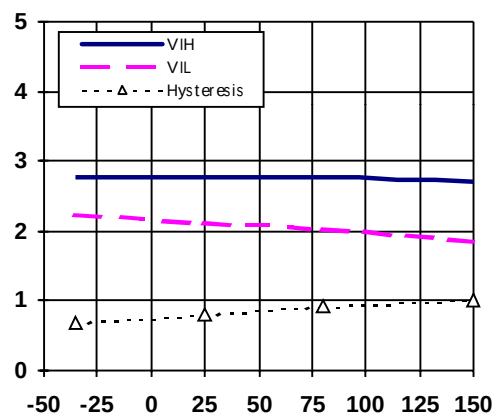


Figure 8 -  $V_{IH}$ ,  $V_{IL}$  threshold (V) Vs  $T_j$  ( $^{\circ}C$ )

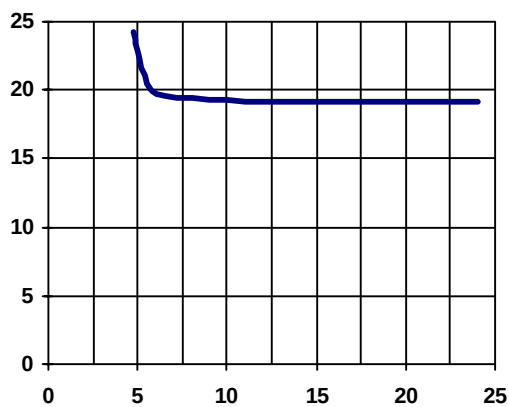


Figure 9 -  $R_{dson}$  (m $\Omega$ ) vs  $V_{cc}$  (V)

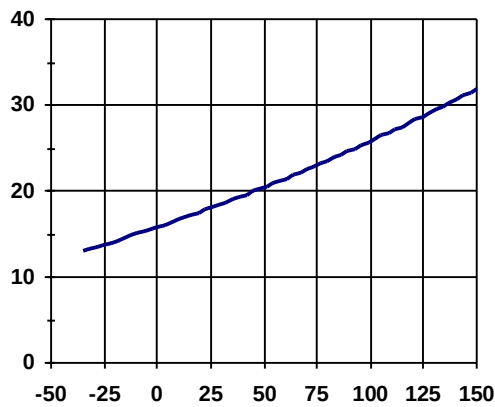


Figure 10 -  $R_{dson}$  (m $\Omega$ ) vs  $T_j$  ( $^{\circ}C$ )

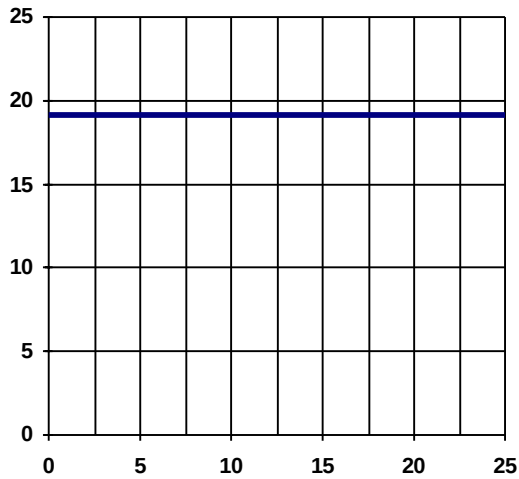


Figure 11 -  $R_{dson}$  (m $\Omega$ ) vs  $I_{out}$  (A)

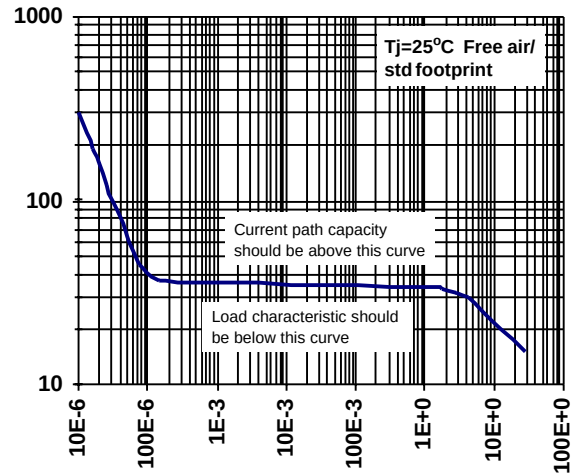


Figure 12 -  $I_{sd}$  (A) vs Time (S)

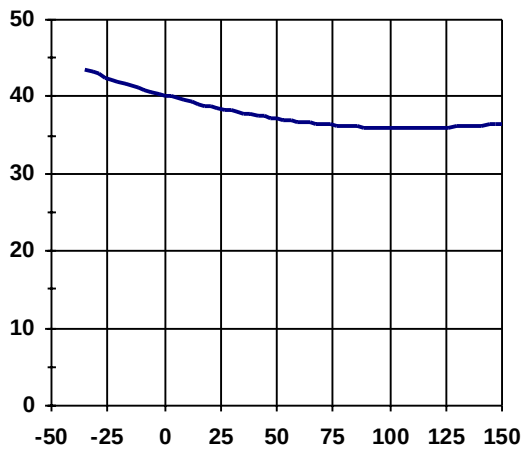


Figure 13 -  $I_{sd}$  (A) vs  $T_j$  (°C)

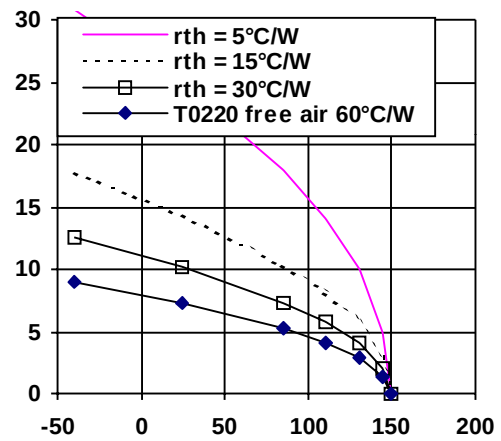


Figure 14 - Max. Cont.  $I_{ds}$  (A) Vs  
Amb. Temperature (°C)



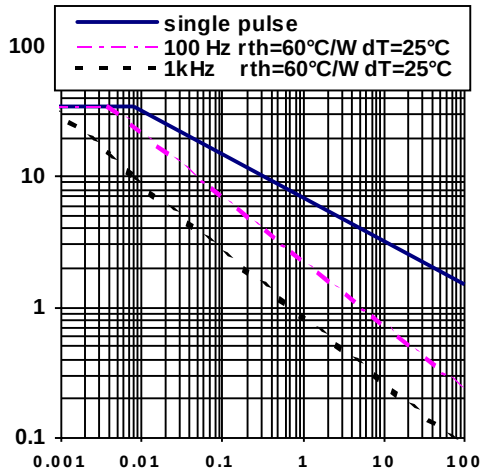


Figure 15 -Max. I clamp (A) Vs Inductive Load (mH)

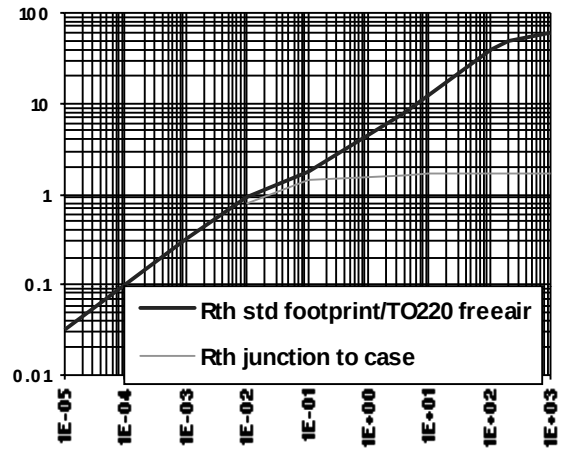


Figure 16 - Transient Rth (°C/W) Vs Time (s)

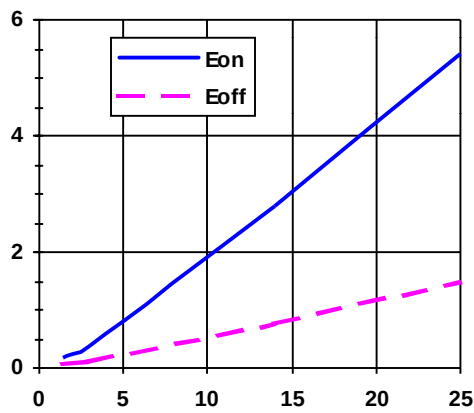


Figure 17 - Eon, Eoff (mJ) vs Iout (A)

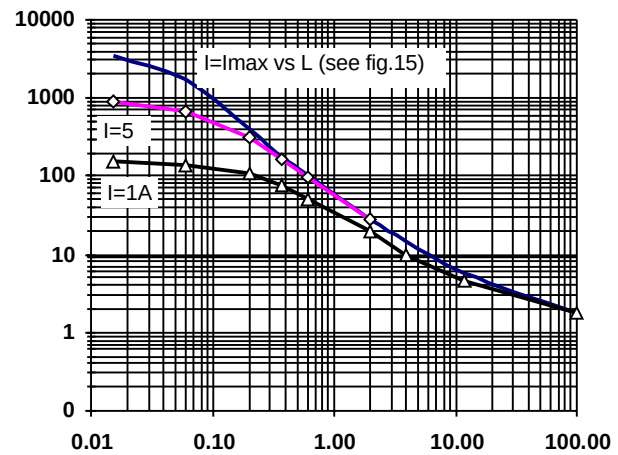


Figure 18 - Eon @ Vcc=14V (mJ) vs Inductance (mH)

# IPS5451/IPS5451S

International  
**IR** Rectifier

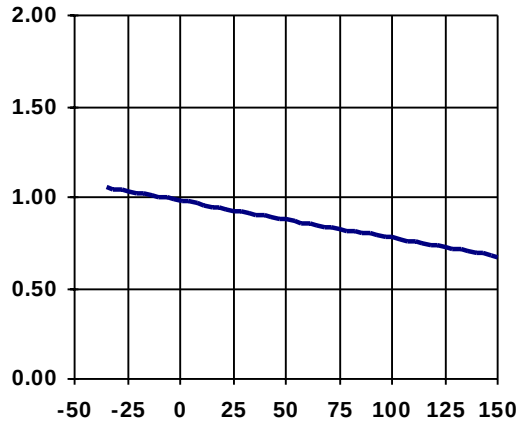


Figure 19 - I open load (A) vs Tj (°C)

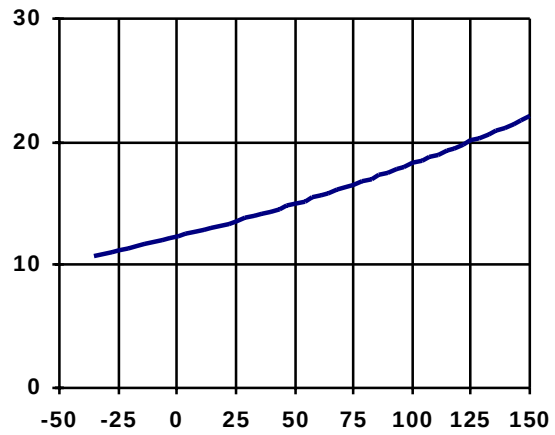
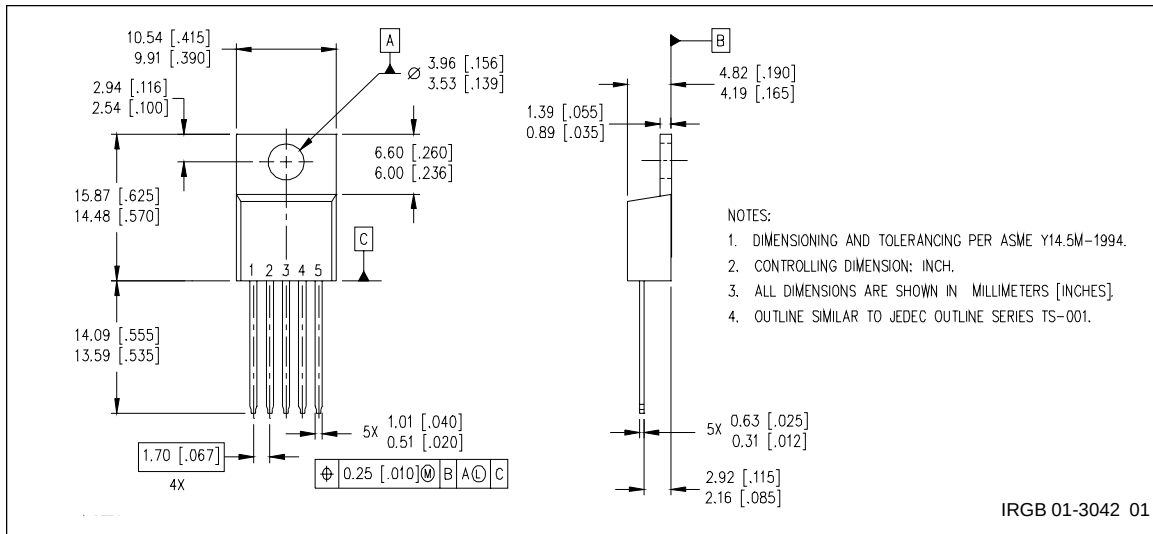
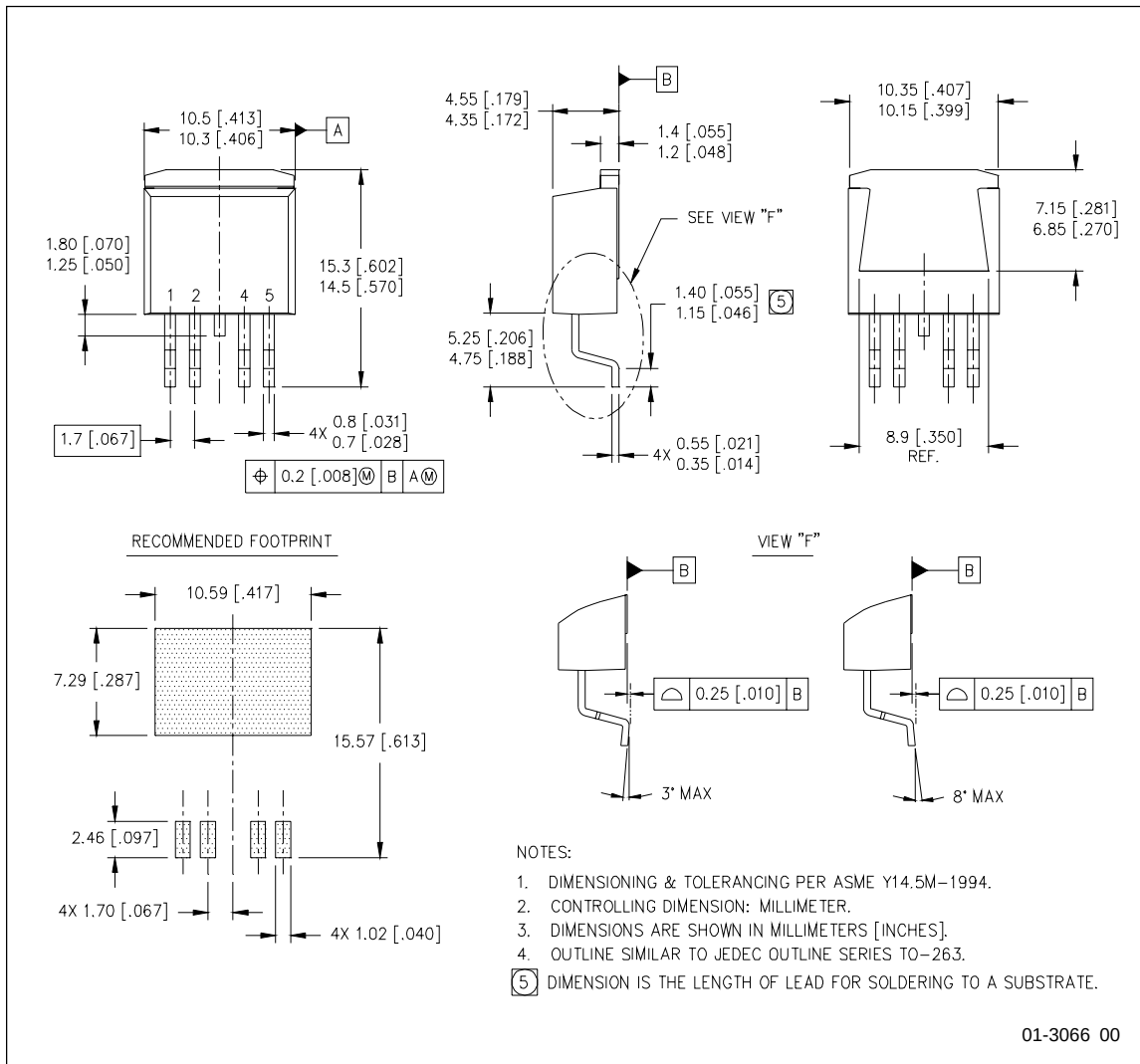


Figure 20 - Icc off (μA) vs Tj (°C)

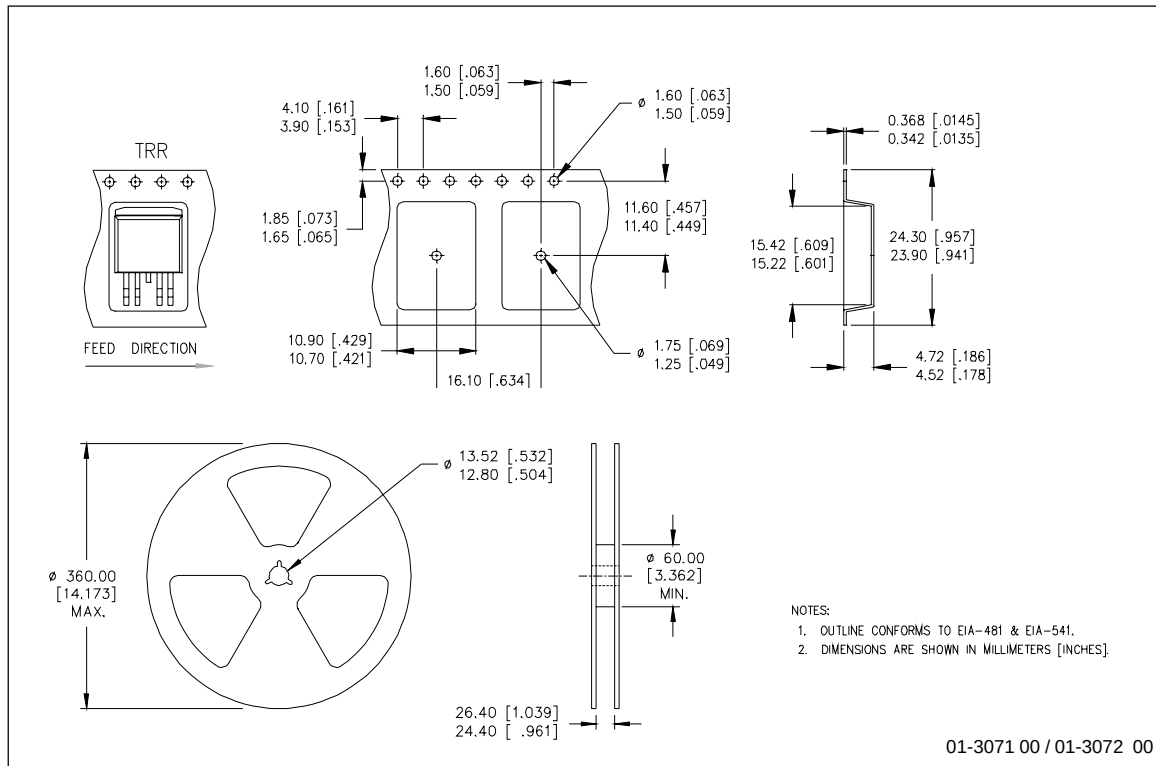
## Case Outline - TO220 (5 lead)



**Case Outline - D<sup>2</sup>PAK (SMD220) - 5 Lead**



## Tape & Reel - D<sup>2</sup>PAK (SMD220) - 5 Lead



Note: For the most current drawings please refer to the IR website at:  
<http://www.irf.com/package/>

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