

## IPS5551T

### FULLY PROTECTED HIGH SIDE POWER MOSFET SWITCH

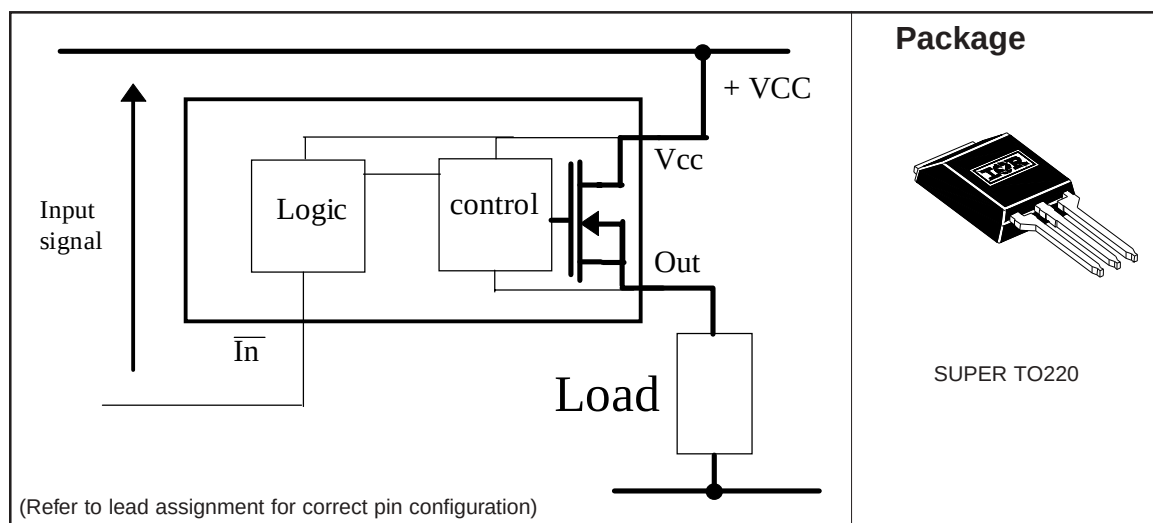
#### Features

- Over temperature shutdown
- Over current shutdown
- Active clamp
- Input referenced to + V<sub>CC</sub>
- E.S.D protection
- Input referenced to V<sub>CC</sub>

#### Description

The IPS5551T is a fully protected three terminal high side switch with built-in short-circuit, over-temperature, ESD protection, inductive load capability. The input signal is referenced to V<sub>CC</sub>. When the input voltage V<sub>CC</sub> - V<sub>in</sub> is higher than the specified threshold, the output power MOSFET is turned on. When the V<sub>CC</sub> - V<sub>in</sub> is lower than the specified V<sub>il</sub> threshold, the output MOSFET is turned off. Input noise immunity is improved by an hysteresis. When the input is left floating, an internal current source pulls it up to V<sub>CC</sub>. The over-current protection latches off the high side switch if the output current exceeds the specified I<sub>sd</sub>. The over-temperature protection latches off the switch if the junction temperature exceeds the specified value T<sub>sd</sub>. The device is reset by opening the input pin high.

#### Typical Connection



#### Product Summary

|                       |             |
|-----------------------|-------------|
| R <sub>ds(on)</sub>   | 6.0mΩ (max) |
| V <sub>clamp</sub>    | 40V         |
| I <sub>shutdown</sub> | 100A        |
| V <sub>CC</sub> (op.) | 5.5 - 18V   |

#### Truth Table

| Op. Conditions   | $\overline{In}$ (3) | Out         |
|------------------|---------------------|-------------|
| Normal           | L                   | H           |
| Normal           | H                   | L           |
| Over current     | L                   | L (latched) |
| Over current     | H                   | L           |
| Over-temperature | L                   | L (latched) |
| Over-temperature | H                   | L           |

(3)  $\overline{In}$  is referenced to V<sub>CC</sub>.

$\overline{In}$  = L means (V<sub>CC</sub> - V<sub>in</sub>) > V<sub>ih</sub>

$\overline{In}$  = H means (V<sub>CC</sub> - V<sub>in</sub>) < V<sub>il</sub>

## Absolute Maximum Ratings

Absolute maximum ratings indicate sustained limits beyond which damage to the device may occur. All voltage parameters are referenced to  $V_{CC}$  lead. ( $T_j = 25^{\circ}\text{C}$  unless otherwise specified). PCB mounting uses the standard footprint with 70 $\mu\text{m}$  copper thickness

| Symbol                  | Parameter                                                                | Min. | Max. | Units              | Test Conditions                                 |
|-------------------------|--------------------------------------------------------------------------|------|------|--------------------|-------------------------------------------------|
| $V_{CC} - V_{in\ max}$  | Maximum input voltage                                                    | -0.3 | 30   | V                  |                                                 |
| $V_{CC} - V_{in1\ max}$ | Max. transient Input voltage (less than 1s)                              | -0.3 | 40   |                    |                                                 |
| $I_{in\ max}$           | Maximum input current                                                    | -1   | 20   | mA                 |                                                 |
| $V_{CC} - V_{out\ max}$ | Maximum output voltage                                                   | -0.3 | 40   | V                  |                                                 |
| $I_{sd\ cont.}$         | Diode max. continuous current (1)<br>( $r_{th} = 62^{\circ}\text{C/W}$ ) | —    | 2.8  | A                  |                                                 |
| $I_{sd1\ cont.}$        | Diode max. continuous current (1)<br>( $r_{th} = 5^{\circ}\text{C/W}$ )  | —    | 35   |                    |                                                 |
| $I_{sd\ pulsed}$        | Diode max. pulsed current (1)                                            | —    | 100  |                    |                                                 |
| $P_d$                   | Power dissipation ( $r_{th} = 62^{\circ}\text{C/W}$ )                    | —    | 2    | W                  |                                                 |
| ESD1                    | Electrostatic discharge voltage (Human Body)                             | —    | tbd  | kV                 | C = 100 pF, R = 1500 $\Omega$                   |
| ESD2                    | Electrostatic discharge voltage (Machine Model)                          | —    | tbd  |                    | C = 200 pF, R = 0 $\Omega$ , L=10 $\mu\text{H}$ |
| $T_{stor.}$             | Max. storage temperature                                                 | -55  | 150  | $^{\circ}\text{C}$ |                                                 |
| $T_j\ max.$             | Max. junction temperature                                                | -40  | 150  |                    |                                                 |
| $T_{lead}$              | Lead temperature (soldering 10 seconds)                                  | —    | 300  |                    |                                                 |

## Thermal Characteristics

| Symbol      | Parameter                                  | Typ. | Max. | Units                | Test Conditions |
|-------------|--------------------------------------------|------|------|----------------------|-----------------|
| $R_{th\ 1}$ | Thermal resistance free air                | 60   | —    | $^{\circ}\text{C/W}$ |                 |
| $R_{th\ 2}$ | Thermal resistance with standard footprint | 60   | —    |                      |                 |
| $R_{th\ 3}$ | Thermal resistance with 1" footprint       | 35   | —    |                      |                 |
| $R_{th\ 4}$ | Thermal resistance junction to case        | 0.7  | —    |                      |                 |

## 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 |
|-------------------------------------------|-------------------------------------------------------------------------------------------------------------|------|------|-------|
| $V_{CC} - V_{in}$                         | Continuous input voltage                                                                                    | 6    | 18   | V     |
| $V_{CC}$                                  | Supply to power ground voltage                                                                              | 6    | 18   |       |
| $I_{out}$                                 | Continuous output current ( $r_{th\ c/amb.} < 5^{\circ}\text{C/W}$ , $T_j = 125^{\circ}\text{C}$ )          | —    | 35   | A     |
| $I_{out}$<br>$T_{amb}=85^{\circ}\text{C}$ | Continuous output current<br>( $T_{Ambient} = 85^{\circ}\text{C}$ , $T_j = 125^{\circ}\text{C}$ , free air) | —    | 8    |       |

(1) Limited by junction temperature. Pulsed current is also limited by wiring

## Static Electrical Characteristics

( $T_j = 25^\circ\text{C}$  and  $V_{cc} = 14\text{V}$  unless otherwise specified.)

| Symbol        | Parameter                                     | Min. | Typ. | Max. | Units         | Test Conditions                                                |
|---------------|-----------------------------------------------|------|------|------|---------------|----------------------------------------------------------------|
| $R_{ds(on)1}$ | ON state resistance                           | —    | 4.6  | 6.0  | m $\Omega$    | $I_{out}=35\text{A}, V_{cc} - V_{in}=12\text{V}$<br>see Fig. 6 |
| $R_{ds(on)2}$ | ON state resistance                           | —    | 4.6  | —    |               | $I_{out}=17\text{A}, V_{cc} - V_{in}= 6\text{V}$               |
| $R_{ds(on)3}$ | ON state resistance $T_j = 150^\circ\text{C}$ | —    | 7.4  | —    |               | $I_{out} = 35\text{A}, T_j = 150^\circ\text{C}$                |
| $V_{clamp1}$  | $V_{cc}$ to $V_{out}$ active clamp voltage    | 35   | 40   | —    | V             | $I_{out} = 10\text{mA}$                                        |
| $V_{clamp2}$  | $V_{cc}$ to $V_{out}$ active clamp voltage    | —    | 42   | 48   |               | $I_{out} = 35\text{A} - t < 100\mu\text{s}$                    |
| $V_{sd}$      | Body diode forward voltage                    | —    | 0.85 | 1    |               | $I_d = 35\text{A}, V_{cc} - V_{in} = 0\text{V}$                |
| $V_{cc (op)}$ | Operating voltage range                       | 5.5  | —    | 28   |               |                                                                |
| $I_q$         | Quiescent current                             | —    | 13   | 50   | $\mu\text{A}$ | $V_{cc}-V_{in}=0\text{V}, V_{cc}-V_{out}= 12\text{V}$          |
| $I_{in}$      | Input current                                 | 3    | 6.5  | 12   | mA            | $V_{cc} - V_{in} = 14\text{V}$                                 |
| $I_{in, on}$  | Input current when ON                         | —    | 1.3  | —    |               | $V_{cc} - V_{in} = V_{ih}$                                     |
| $V_{ih}$      | High level input threshold voltage            | —    | 4.75 | 5.5  | V             | $V_{cc} - V_{in}$ (note 2)                                     |
| $V_{il}$      | Low level input threshold voltage             | 3    | 4.05 | —    |               | $V_{cc} - V_{in}$ (note 2)                                     |
| $V_{hys}$     | Input hysteresis                              | 0.3  | 0.6  | 1.5  |               |                                                                |

## Switching Electrical Characteristics

$V_{cc} = 14\text{V}$ , Resistive Load =  $0.4\Omega$ ,  $T_j = 25^\circ\text{C}$ , (unless otherwise specified).

| Symbol      | Parameter                                            | Min. | Typ. | Max. | Units | Test Conditions |
|-------------|------------------------------------------------------|------|------|------|-------|-----------------|
| Tdon        | Turn-on delay time to VCC -Vout = 0.9 VCC            | —    | 10   | 30   | μs    | See figure 2    |
| Tr 1        | Rise time to VCC -Vout = 5 V                         | —    | 16   | 50   |       |                 |
| Tr 2        | Rise time from the end of Tr1 to Vcc -Vout = 0.1 Vcc | —    | 200  | 400  |       |                 |
| dV/dt (on)  | Turn on dV/dt                                        | —    | 1.2  | 5    | V/μs  |                 |
| Eon         | Turn ON energy                                       | —    | 25   | —    | mJ    | See figure 3    |
| Tdoff       | Turn-off delay time VCC -Vout = 0.1 VCC              | —    | 130  | 300  | μs    |                 |
| Tf          | Fall time to VCC -Vout = 0.9 VCC                     | —    | 25   | 50   |       |                 |
| dV/dt (off) | Turn OFF dV/dt                                       | —    | 2    | 6    | V/μs  |                 |
| Eoff        | Turn OFF energy                                      | —    | 6    | —    | mJ    |                 |

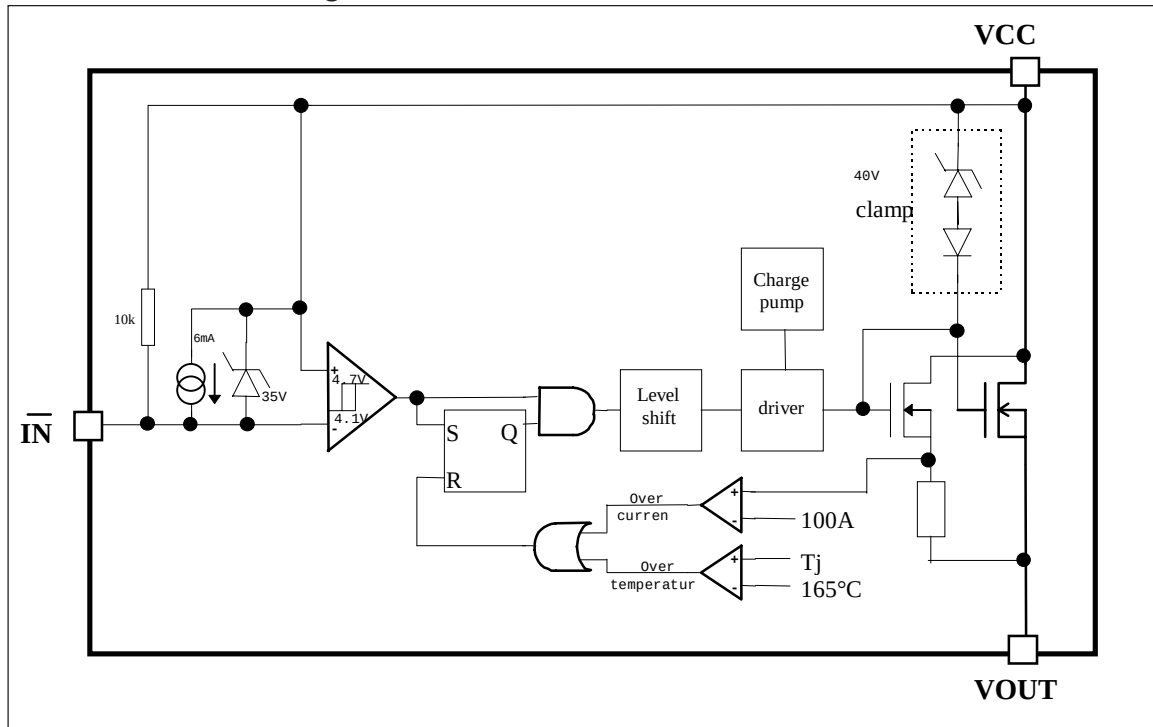
## Protection Characteristics

$T_j = 25^\circ\text{C}$ , and  $V_{cc} = 14\text{V}$  (unless otherwise specified).

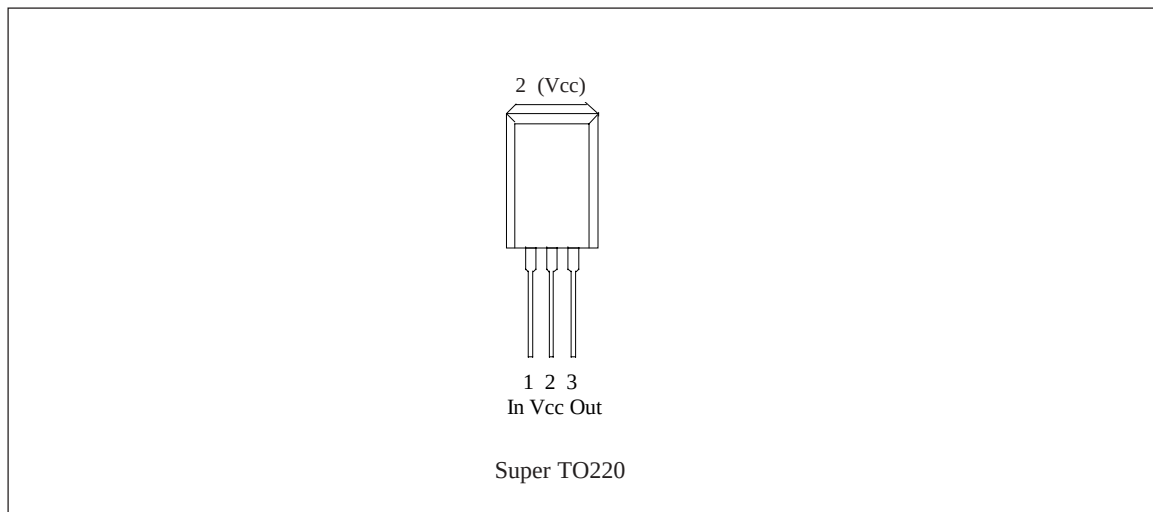
| Symbol      | Parameter                           | Min. | Typ. | Max. | Units            | Test Conditions |
|-------------|-------------------------------------|------|------|------|------------------|-----------------|
| $T_{sd}$    | Over temperature shutdown threshold | —    | 165  | —    | $^\circ\text{C}$ | See fig. 4      |
| $I_{sd}$    | Over current shutdown threshold     | 60   | 100  | 150  | A                |                 |
| $T_{reset}$ | Minimum time for protection reset   | —    | 50   | —    | $\mu\text{s}$    |                 |

(2) Input threshold are measured directly between the input pin and the tab. Any parasitic resistance in common between the load current path and the input signal path can significantly affect the thresholds.

## Functional Block Diagram



## Lead Assignments



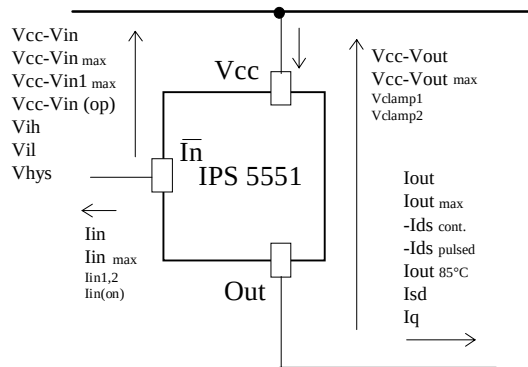


Figure 1 - Voltages and currents definition

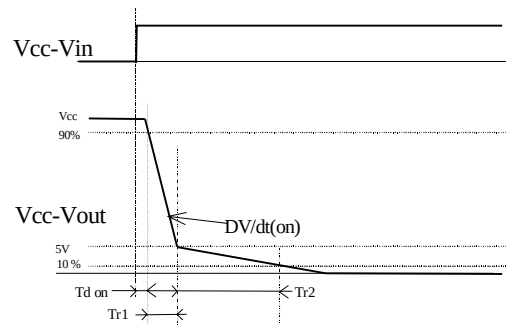


Figure 2 - Switching time definitions (turn-on)

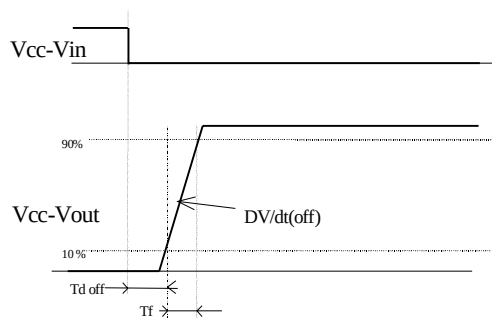


Figure 3 - Switching time definitions (turn-off)

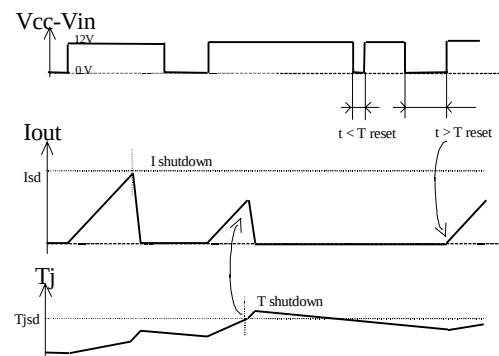


Figure 4 - Protection timing diagram

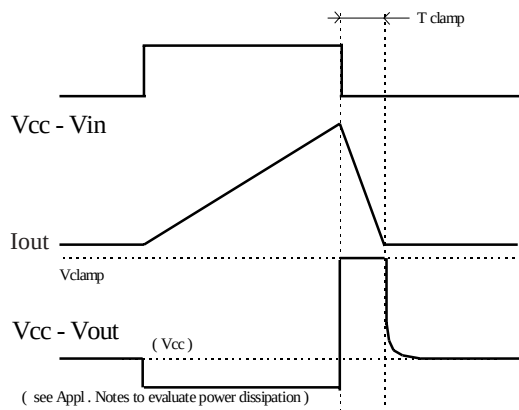


Figure 5 - Active clamp waveforms

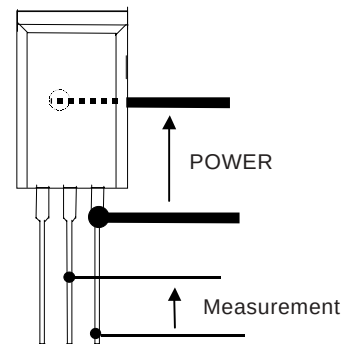


Figure 6 - Rds(on) measurement schematic

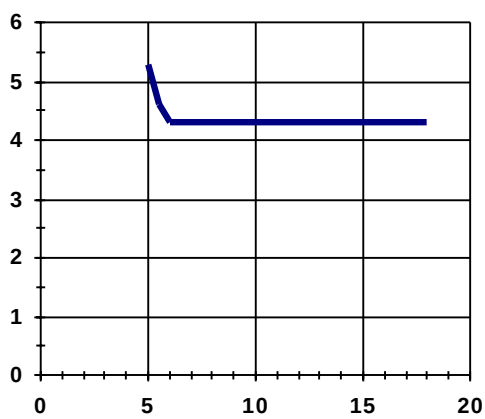


Figure 7 - Rds(on) (mΩ) Vs Vcc-Vin (V)

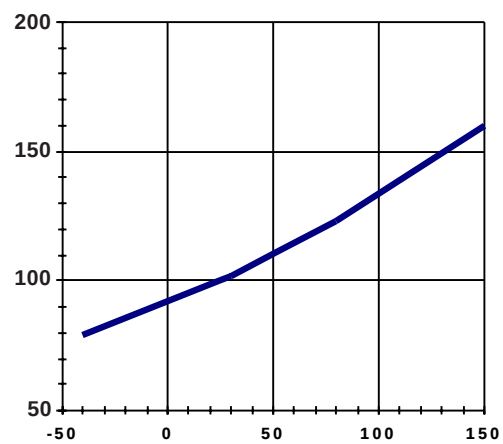


Figure 8 - Normalized Rds(on) (%) Vs Tj (°C)

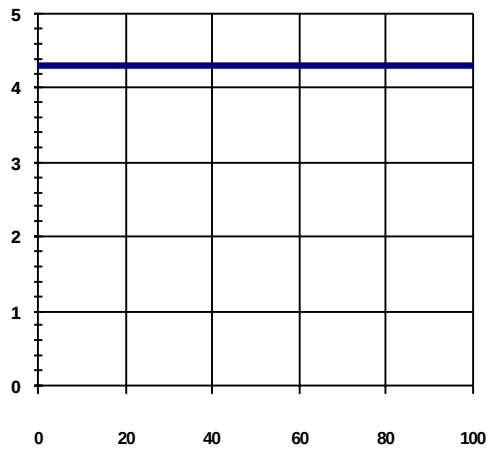


Figure 9 -  $R_{ds(on)}$  (mΩ) Vs  $I_{out}$  (A)

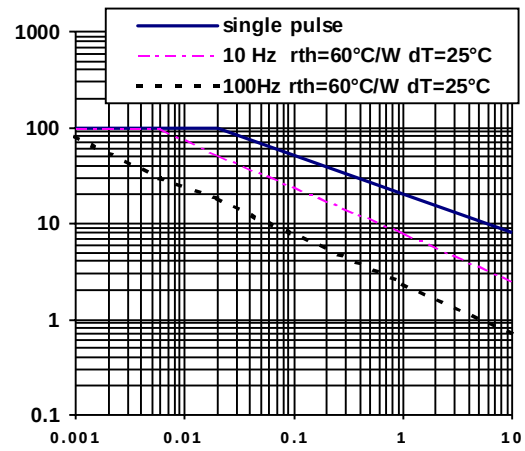


Figure 10 -  $I_{clamp}$  (A) Vs Inductive Load ( $\mu$ H)

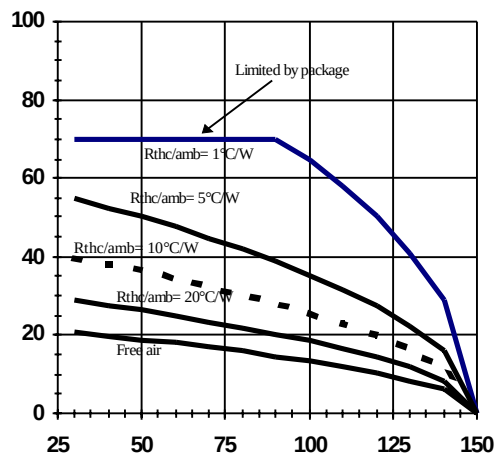


Figure 11 - Max. load current (A)  
Vs Temperature ( $^{\circ}$ C)

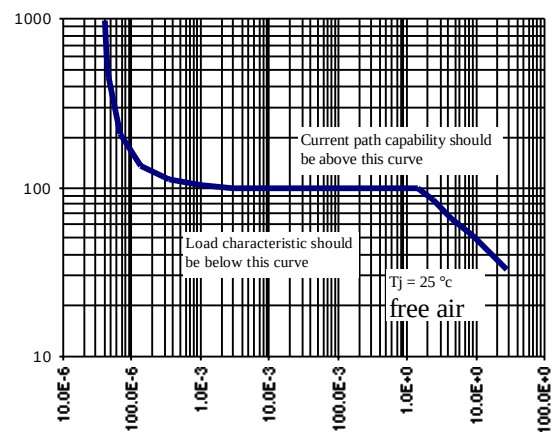


Figure 12 -  $I_{out}$  (A) Vs Protection resp. Time (ms)

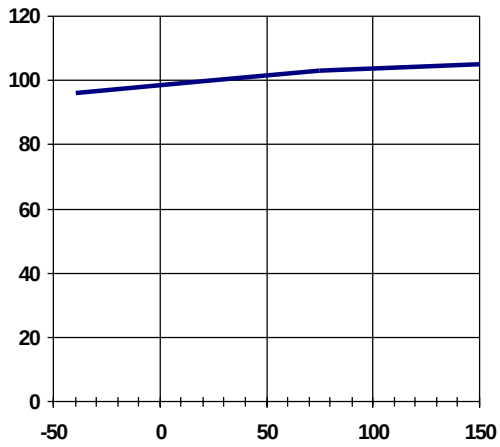


Figure 13 -  $I_{sd}$  (A) Vs  $T_j$  (°C)

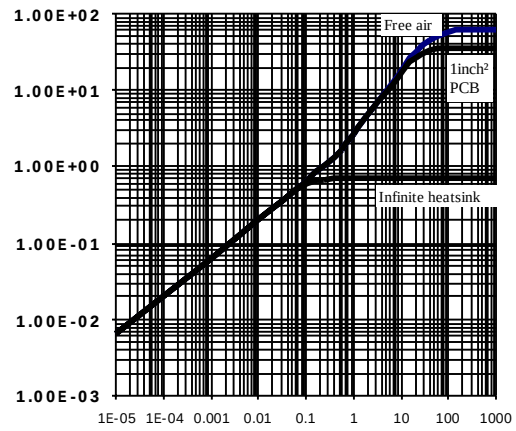


Figure 14 - Transient thermal impedance (°C/W)  
Vs Time (s)

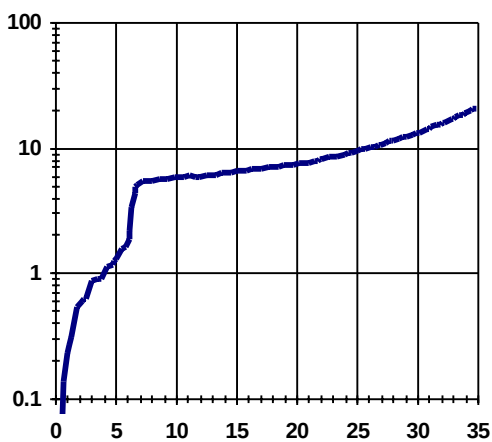


Figure 15 -  $I_{cc}$  (mA) Vs  $V_{cc}-V_{in}$  (V)

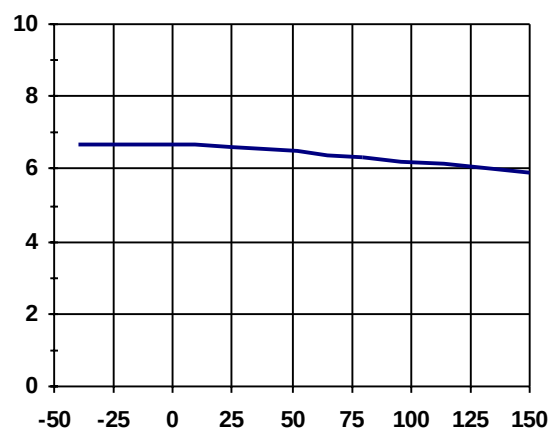


Figure 16 -  $I_{in}$  (mA) Vs  $T_j$  (°C)



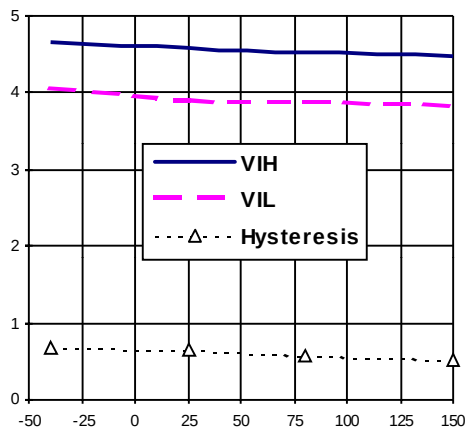


Figure 17 -  $V_{IH}$ ,  $V_{IL}$  threshold (V) Vs  $T_J$  (°C)

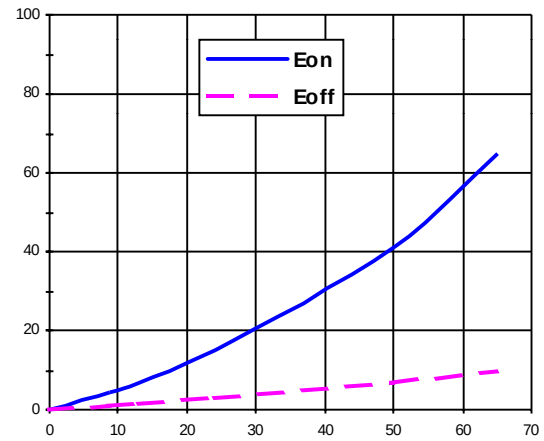


Figure 18 -  $E_{on}$ ,  $E_{off}$  (mJ) Vs  $I_{out}$  (A)

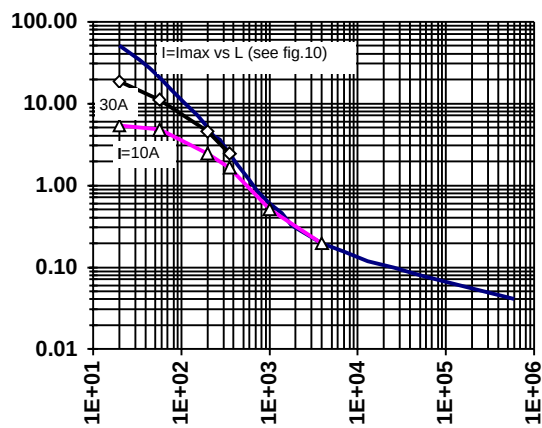


Figure 19 -  $E_{on}$  (mJ) Vs Inductive load ( $\mu H$ )  
( $V_{cc} = 14V$ ,  $R_{load} = 0.5\Omega$ )

# IPS5551T

International  
**IR** Rectifier

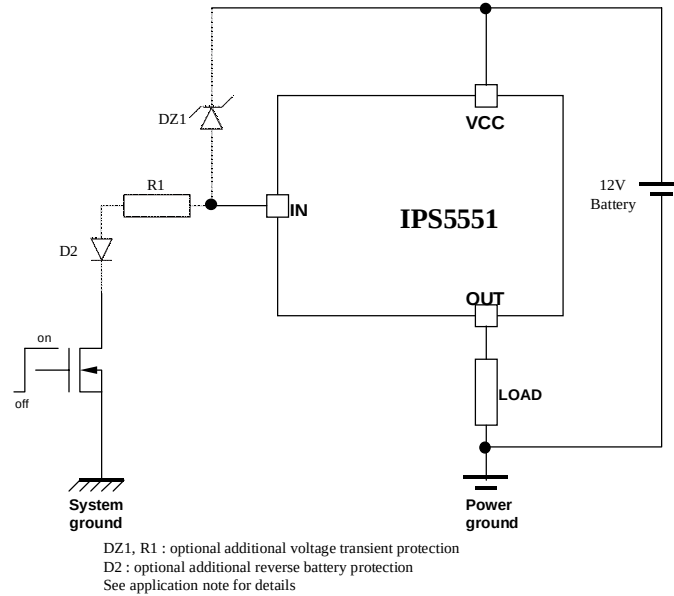
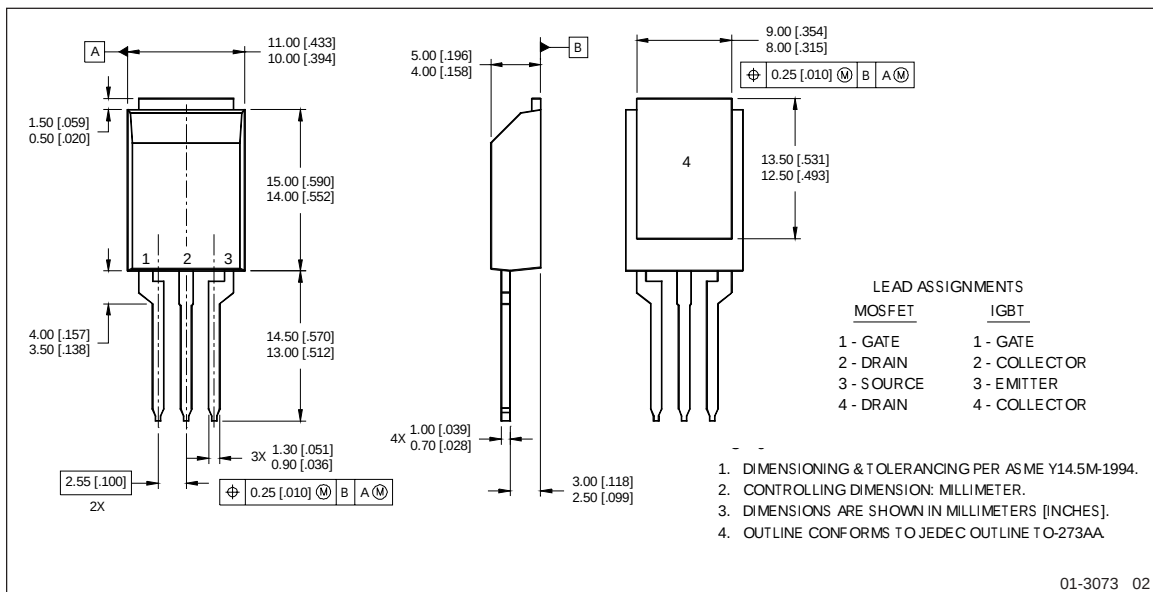


Figure 20 - Automotive typical connection

## Case outline Super TO220



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