

# IPS511/IPS511S

## FULLY PROTECTED HIGH SIDE POWER MOSFET SWITCH

### Features

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

### Description

The IPS511/IPS511S are fully protected five terminal high side switch with built in short circuit, over-temperature, ESD protection, inductive load capability and diagnostic feedback. The output current is controlled when it reaches  $I_{lim}$  value. The current limitation is activated until the thermal protection acts. The over-temperature protection turns off the high side switch 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 short-circuit, over-temperature and open load detection. The double level shifter circuitry allows large offsets between the logic ground and the load ground.

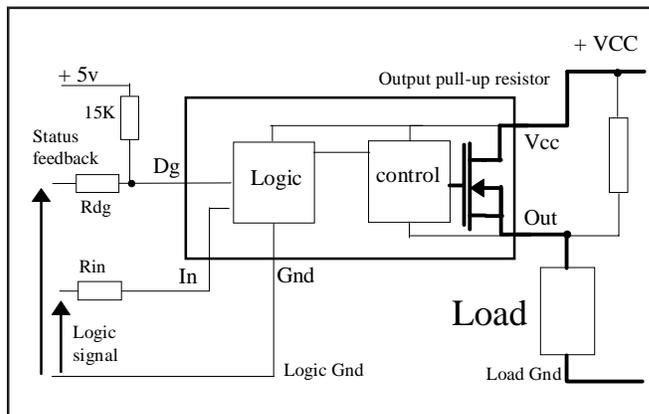
### Product Summary

$R_{ds(on)}$	130m $\Omega$ (max)
$V_{clamp}$	50V
I Limit	5A
$T_{shutdown}$	165 $^{\circ}\text{C}$
$V_{open\ load}$	3V

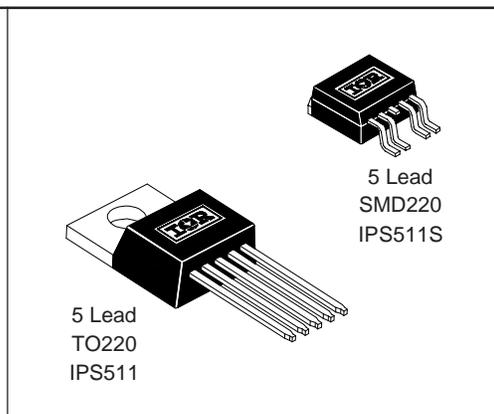
### Truth Table

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

### Typical Connection



### Available Package



## Absolute Maximum Ratings

Absolute maximum ratings indicates sustained limits beyond which damage to the device may occur. All voltage parameters are referenced to GROUND lead. ( $T_j = 25^\circ\text{C}$  unless otherwise specified).

Symbol	Parameter	Min.	Max.	Units	Test Conditions
$V_{out}$	Maximum output voltage	$V_{CC}-50$	$V_{CC}+0.3$	V	
$V_{offset}$	Maximum logic ground to load ground offset	$V_{CC}-50$	$V_{CC}+0.3$		
$V_{in}$	Maximum Input voltage	-0.3	7		
$I_{in, max.}$	Maximum IN current	-1	10	mA	
$V_{dg}$	Maximum diagnostic output voltage	-0.3	7	V	
$I_{dg, max.}$	Maximum diagnostic output current	-1	10	mA	
$I_{sd cont.}$	Diode max. permanent current <sup>(1)</sup>	—	2.2	A	
$I_{sd pulsed}$	Diode max. pulsed current <sup>(1)</sup>	—	10		
ESD1	Electrostatic discharge voltage (Human Body)	—	4000	V	C=100pF, R=1500Ω,
ESD2	Electrostatic discharge voltage (Machine Model)	—	500		C=200pF, R=0Ω,
$P_d$	Maximum power dissipation <sup>(1)</sup> (TC=25°C) IPS511	—	25	W	
		(rth=80°C/W) IPS511S	—		1.56
$T_j max.$	Max. storage & operating junction temp.	-40	+150	°C	
$T_{lead}$	Lead temperature (soldering 10 seconds)	—	300		

## Thermal Characteristics

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$R_{th 1}$	Thermal resistance junction to case	—	—	5	°C/W	TO-220
$R_{th 2}$	Thermal resistance junction to ambient	—	—	62		
$R_{th 1}$	Thermal resistance with standard footprint	—	58	80		D <sup>2</sup> PAK (SMD220)
$R_{th 2}$	Thermal resistance with 1" square footprint	—	35	50		
$R_{th 3}$	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	35	V
V <sub>IH</sub>	High level input voltage	4	5.5	
V <sub>IL</sub>	Low level input voltage	-0.3	0.9	
I <sub>out</sub> T <sub>amb</sub> =85°C	Continuous output current (T <sub>Ambient</sub> = 85°C, T <sub>J</sub> = 125°C, R <sub>th</sub> < 30°C/W) IPS511 (T <sub>Ambient</sub> = 85°C, T <sub>J</sub> = 125°C, R <sub>th</sub> = 60°C/W) IPS511 free air	—	2.5 1.9	A
R <sub>in</sub>	Recommended resistor in series with IN pin	10	20	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> @T <sub>J</sub> =25°C	ON state resistance T <sub>J</sub> = 25°C	—	110	130	mΩ	V <sub>in</sub> = 5V, I <sub>out</sub> = 2.5A
R <sub>ds(on)</sub> (V <sub>CC</sub> =6V)	ON state resistance @ V <sub>CC</sub> = 6V	—	110	—		V <sub>in</sub> = 5V, I <sub>out</sub> = 1A
R <sub>ds(on)</sub> @T <sub>J</sub> =150°C	ON state resistance T <sub>J</sub> = 150°C	—	190	—		V <sub>in</sub> = 5V, I <sub>out</sub> = 2.5A
V <sub>CC oper.</sub>	Operating voltage range	5.5	—	35	V	
V clamp 1	V <sub>CC</sub> to OUT clamp voltage 1	50	56	—		I <sub>d</sub> = 10mA (see Fig.1 & 2)
V clamp 2	V <sub>CC</sub> to OUT clamp voltage 2	—	58	65		I <sub>d</sub> = I <sub>sd</sub> (see Fig.1 & 2)
V <sub>f</sub>	Body diode forward voltage	—	0.9	1.2		I <sub>d</sub> = 2.5A, V <sub>in</sub> = 0V
I <sub>CC off</sub>	Supply current when OFF	—	16	50	μA	V <sub>in</sub> = 0V, V <sub>out</sub> = 0V
I <sub>CC on</sub>	Supply current when ON	—	0.7	2	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>dg1</sub>	Low level diagnostic output voltage	—	0.15	—	V	I <sub>dg</sub> = 1.6 mA
I <sub>oh</sub>	Output leakage current	—	50	—	μA	V <sub>out</sub> = 6V
I <sub>ol</sub>	Output leakage current	0	—	25		V <sub>out</sub> = 0V
I <sub>dg leakage</sub>	Diagnostic output leakage current	—	—	10		V <sub>dg</sub> = 5.5V
V <sub>ih</sub>	IN high threshold voltage	—	2.0	2.5	V	
V <sub>il</sub>	IN low threshold voltage	1	1.8	—		
I <sub>in, on</sub>	On state IN positive current	—	70	—	μA	V <sub>in</sub> = 5V

## Switching Electrical Characteristics

$V_{CC} = 14V$ , Resistive Load =  $5.6\Omega$ ,  $T_j = 25^\circ C$ , (unless otherwise specified).

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$T_{don}$	Turn-on delay time	—	10	—	$\mu s$	See figure 3
$T_{r1}$	Rise time to $V_{out} = V_{CC} - 5V$	—	10	—		
$T_{r2}$	Rise time to $V_{out} = 90\%$ of $V_{CC}$	—	40	—		
$dV/dt$ (on)	Turn ON $dV/dt$	—	1.3	—	$V/\mu s$	
$E_{on}$	Turn ON energy	—	400	—	$\mu J$	
$T_{doff}$	Turn-off delay time	—	15	—	$\mu s$	See figure 4
$T_f$	Fall time to $V_{out} = 10\%$ of $V_{CC}$	—	10	—		
$dV/dt$ (off)	Turn OFF $dV/dt$	—	2	—	$V/\mu s$	
$E_{off}$	Turn OFF energy	—	300	—	$\mu J$	
$T_{diag}$	$V_{out}$ to $V_{diag}$ propagation delay	—	tbd	—	$\mu s$	

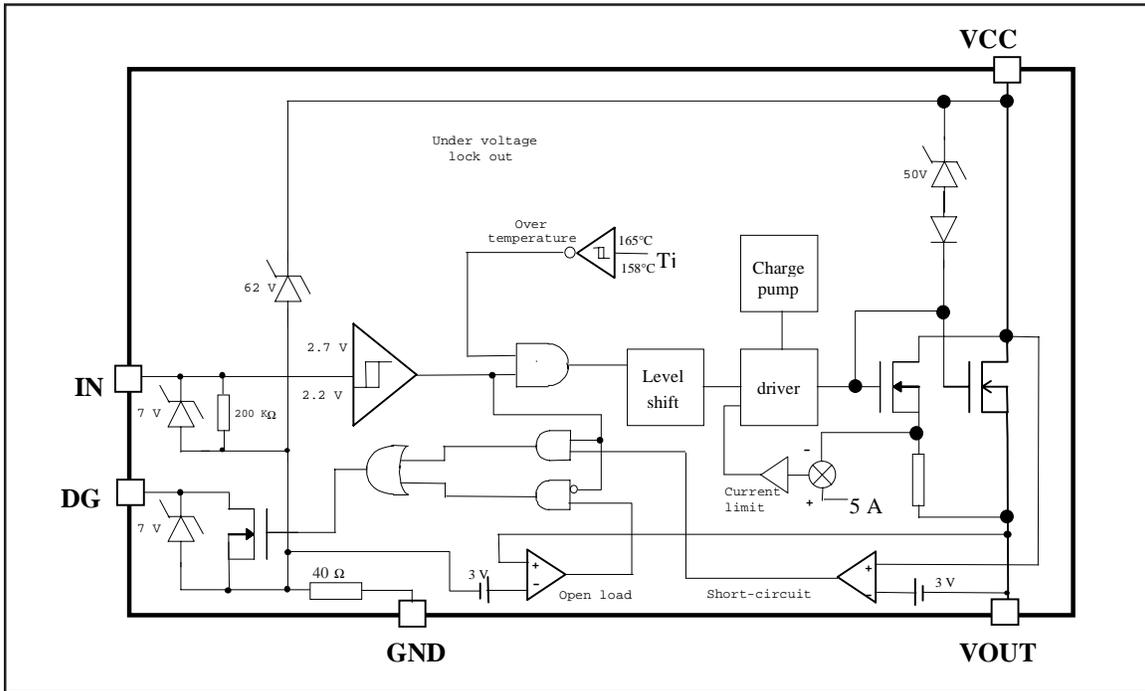
## Protection Characteristics

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_{lim}$	Internal current limit	—	5	—	A	$V_{out} = 0V$
$T_{sd+}$	Over-temp. positive going threshold	—	165	—	$^\circ C$	See fig. 2
$T_{sd-}$	Over-temp. negative going threshold	—	158	—	$^\circ C$	See fig. 2
$V_{sc}$	Short-circuit detection voltage (3)	—	3	—	V	See fig. 2
$V_{open load}$	Open load detection threshold	—	3	—	V	

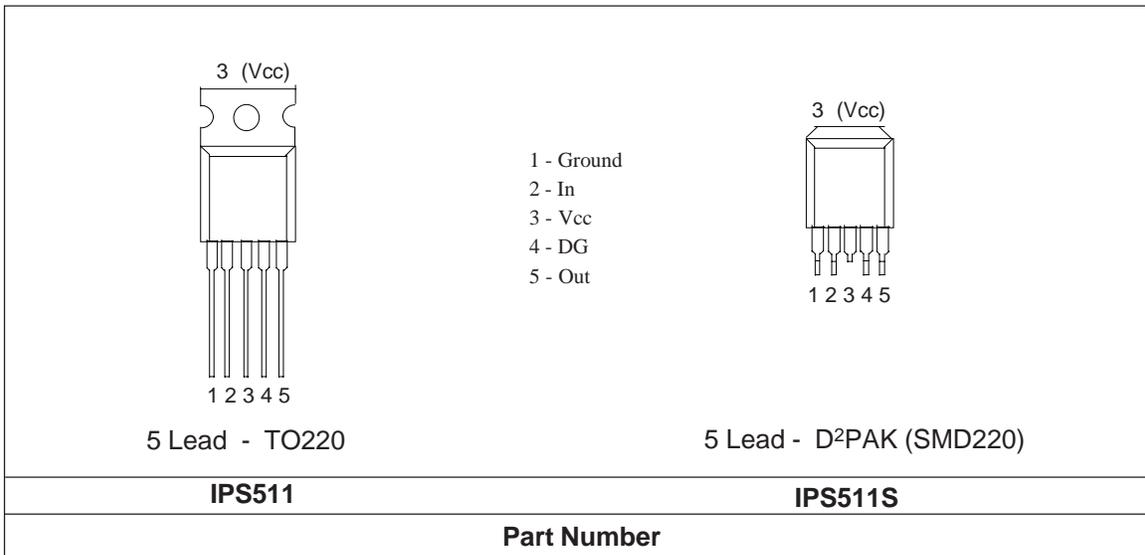
(3) Referenced to  $V_{CC}$

**Functional Block Diagram**

All values are typical



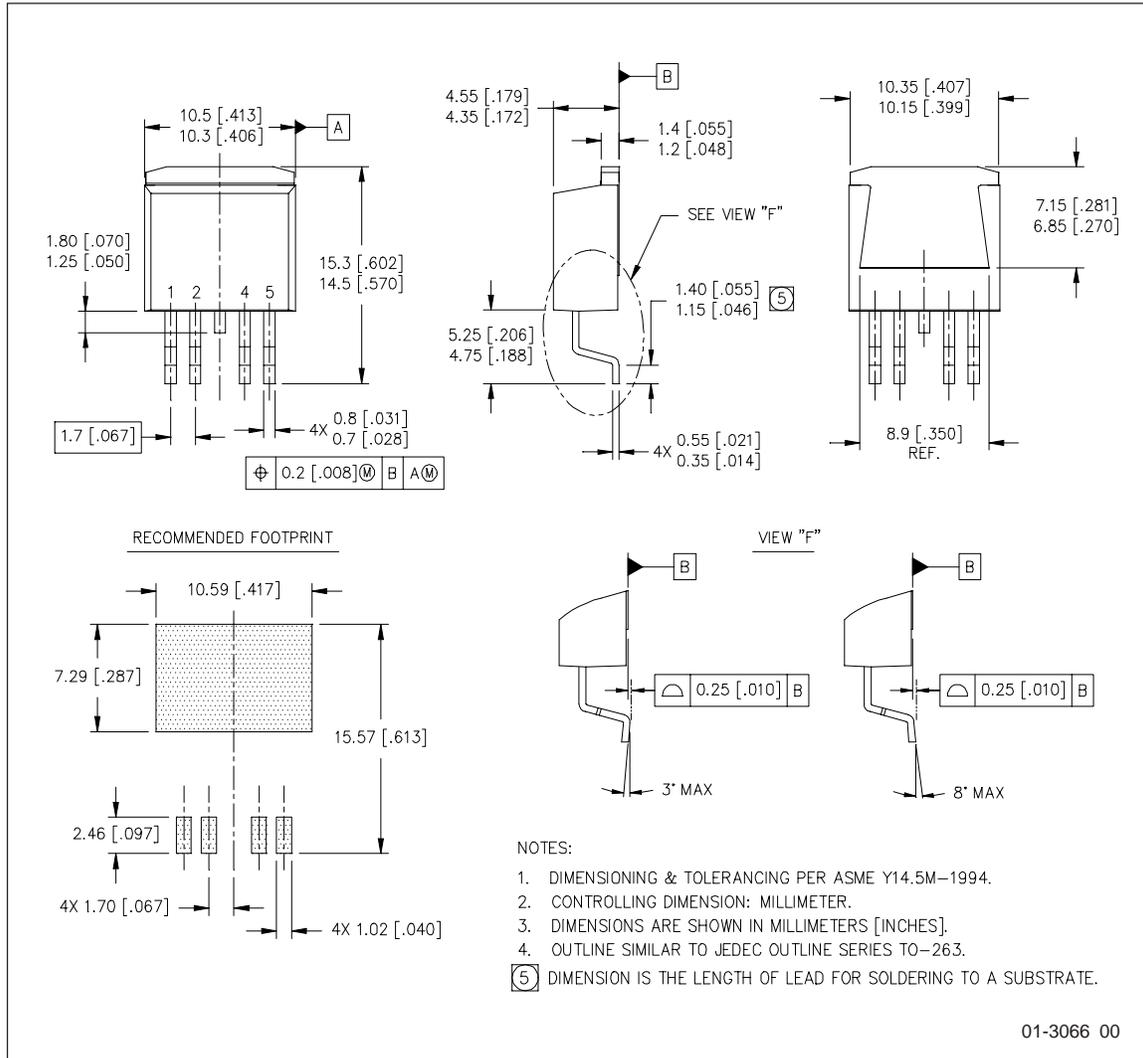
**Lead Assignments**



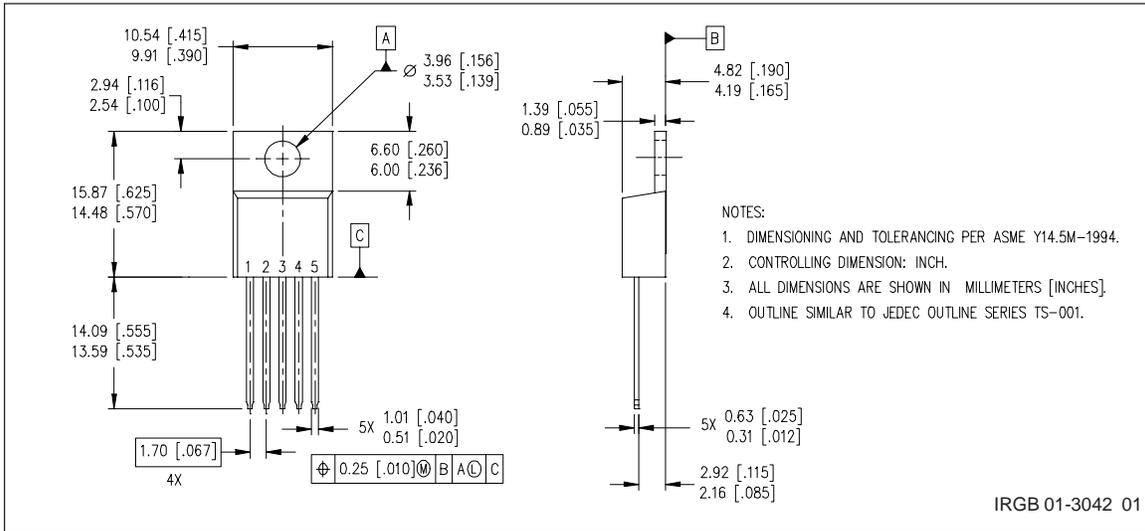
# IPS511/IPS511S

International  
**IOR** Rectifier

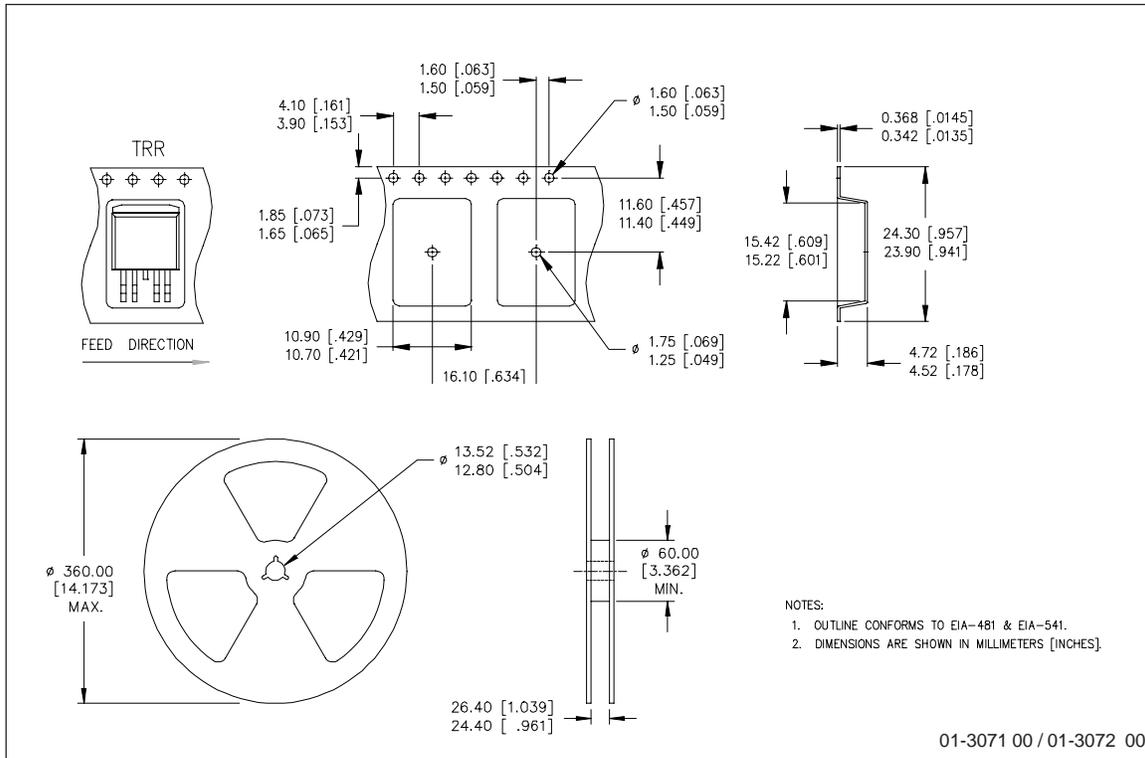
## Case Outline 5 Lead - D<sup>2</sup>PAK (SMD220)



**Case Outline 5 Lead - TO220**



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



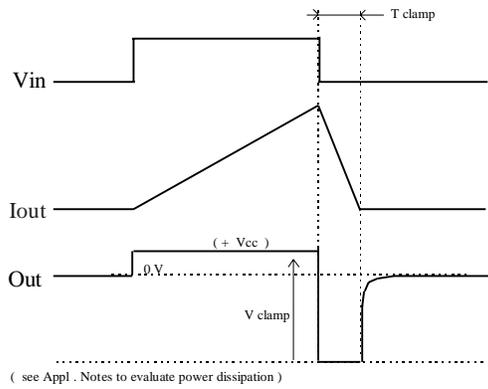


Figure 1 - Active clamp waveforms

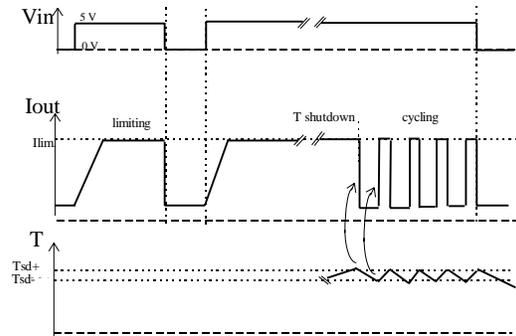


Figure 2 - Protection timing diagram

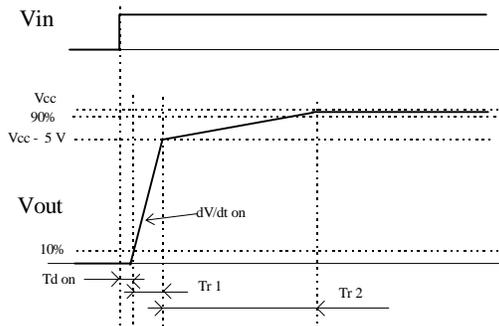


Figure 3 - Switching times definition (turn-on)

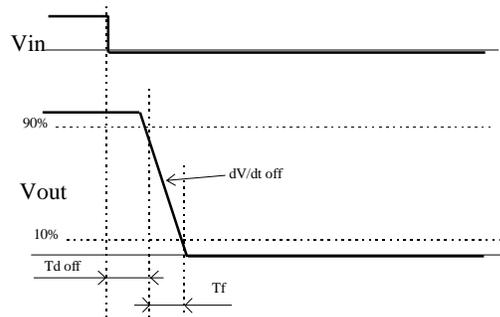


Figure 4 - Switching times definition (turn-off)

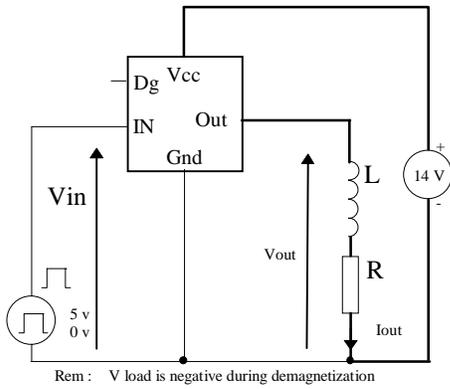


Figure 5 - Active clamp test circuit

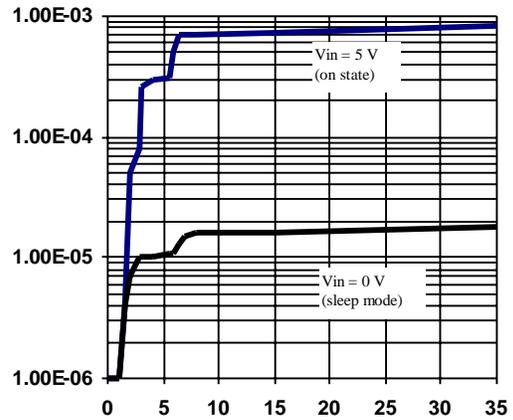


Figure 6 -  $I_{cc}$  (mA) Vs  $V_{CC}$  (V)

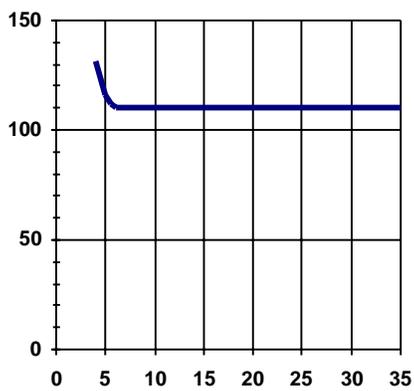


Figure 7 -  $R_{DS(on)}$  (mΩ) Vs  $V_{CC}$  (V)

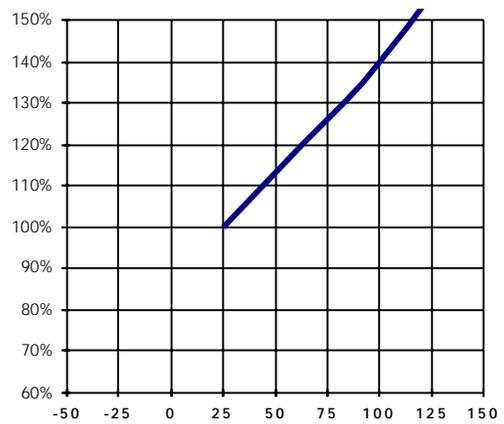


Figure 8 - Normalized  $R_{DS(on)}$  Vs  $T_j$  (°C)

# IPS511/IPS511S

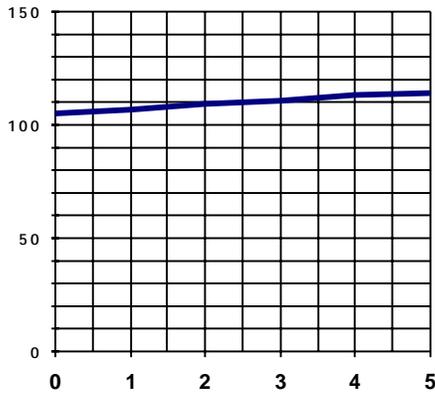


Figure 9 -  $R_{ds(on)}$  ( $m\Omega$ ) Vs  $I_{out}$  (A)

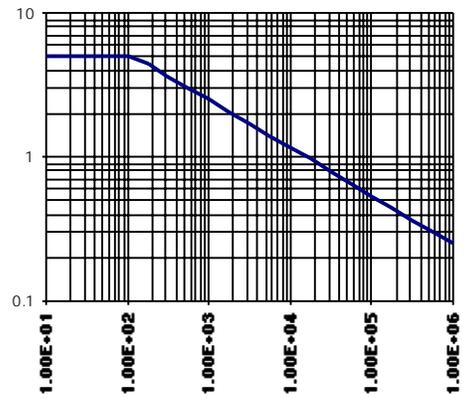


Figure 10 - Max.  $I_{out}$  (A) Vs Load Inductance ( $\mu H$ )

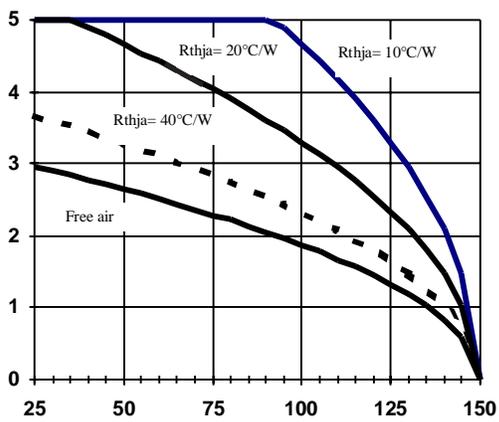


Figure 11a - Max load current (A) Vs  $T_{amb}$  ( $^{\circ}C$ )  
IPS511

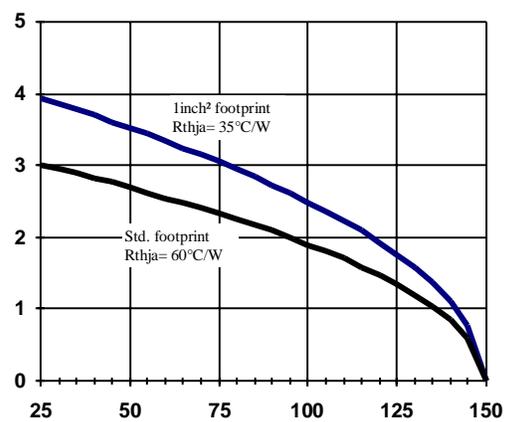


Figure 11b - Max load current (A) Vs  $T_{amb}$  ( $^{\circ}C$ )  
IPS511S

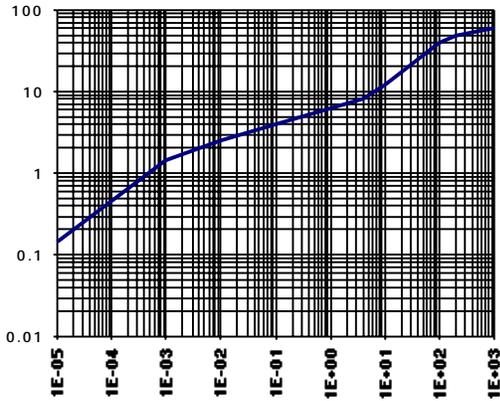


Figure 12 - Transient Thermal Impedance (°C/W)  
 Vs Time (S)

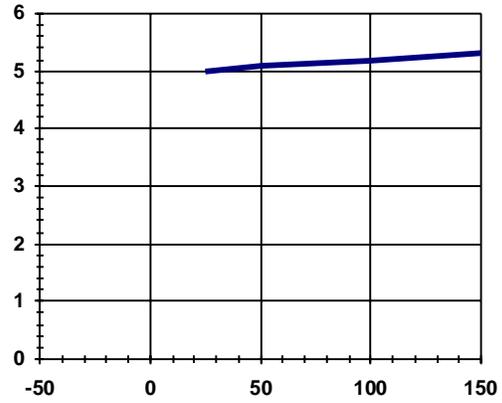


Figure 13 - Ilim (A) Vs Tj (°C)