

**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 IPS521G is a 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  $7^{\circ}C$  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.

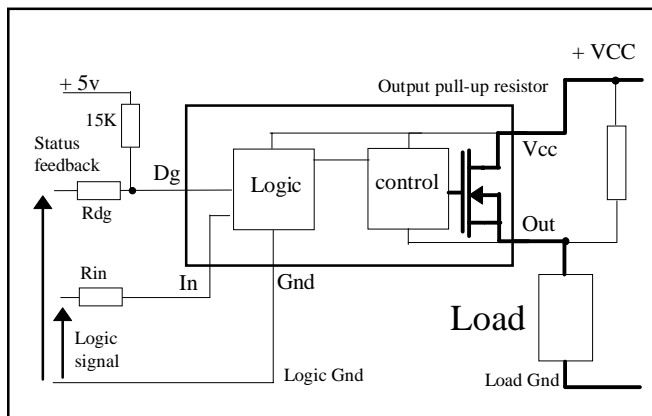
**Product Summary**

$R_{ds(on)}$	100m $\Omega$ (max)
$V_{clamp}$	50V
I Limit	10A
$V_{open\ load}$	3V

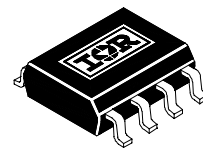
**Truth Table**

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**



**Package**



8 Lead SOIC

## 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. ( $T_j = 25^\circ\text{C}$  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	5.5		
$I_{in, max}$	Maximum positive IN current	-5	10	mA	
$V_{dg}$	Maximum diagnostic output voltage	-0.3	5.5	V	
$I_{dg, max}$	Maximum diagnostic output current	-1	10	mA	
$I_{sd cont.}$	Diode max. permanent current <sup>(1)</sup> ( $r_{th} = 125^\circ\text{C}/\text{W}$ )	—	1.4	A	
$I_{sd pulsed}$	Diode max. pulsed current <sup>(1)</sup>	—	10		
ESD1	Electrostatic discharge voltage (Human Body)	—	4	kV	C=100pF, R=1500 $\Omega$ ,
ESD2	Electrostatic discharge voltage (Machine Model)	—	0.5		C=200pF, R=0 $\Omega$ , L=10 $\mu\text{H}$
$P_d$	Maximum power dissipation <sup>(1)</sup> ( $r_{th}=125^\circ\text{C}/\text{W}$ )	—	1		
$T_j \text{ max.}$	Max. storage & operating junction temp.	-40	+150	$^\circ\text{C}$	
$V_{cc \text{ max.}}$	Maximum $V_{cc}$ voltage	—	50	V	

## Thermal Characteristics

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$R_{th1}$	Thermal resistance with standard footprint	—	100	—	$^\circ\text{C}/\text{W}$	8 Lead SOIC
$R_{th2}$	Thermal resistance with 1" square footprint	—	80	—		

## 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
$V_{CC}$	Continuous $V_{CC}$ voltage	5.5	35	V
$V_{IH}$	High level input voltage	4	5.5	
$V_{IL}$	Low level input voltage	-0.3	0.9	
$I_{out}$ $T_c=85^\circ\text{C}$	Continuous output current ( $T_{Ambient} = 85^\circ\text{C}$ , $T_j = 125^\circ\text{C}$ , $R_{th} = 100^\circ\text{C}/\text{W}$ )	—	1.6	A
$R_{in}$	Recommended resistor in series with IN pin	4	6	$k\Omega$
$R_{dg}$	Recommended resistor in series with DG pin	10	20	

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

### 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	—	80	100	mΩ	V <sub>in</sub> = 5V, I <sub>out</sub> = 5A
R <sub>ds(on)</sub> (V <sub>CC</sub> =6V)	ON state resistance @ V <sub>CC</sub> = 6V	—	80	100		V <sub>in</sub> = 5V, I <sub>out</sub> = 2.5A
R <sub>ds(on)</sub> @T <sub>j</sub> =150°C	ON state resistance T <sub>j</sub> = 150°C	—	125	160		V <sub>in</sub> = 5V, I <sub>out</sub> = 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	55	—		I <sub>d</sub> = 10mA (see Fig.1 & 2)
V clamp 2	V <sub>CC</sub> to OUT clamp voltage 2	—	56	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	—	13	50	μA	V <sub>in</sub> = 0V, V <sub>out</sub> = 0V
I <sub>CC on</sub>	Supply current when ON	—	0.6	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>dgl</sub>	Low level diagnostic output voltage	—	0.4	—	V	I <sub>dg</sub> = 1.6 mA
I <sub>oh</sub>	Output leakage current	—	50	120	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	—	2.2	3	V	
V <sub>il</sub>	IN low threshold voltage	1	1.9	—		
I <sub>in, on</sub>	On state IN positive current	—	70	200	μA	V <sub>in</sub> = 5V
I <sub>n hyst.</sub>	Input hysteresis	0.1	0.25	0.5	V	

### Switching Electrical Characteristics

V<sub>CC</sub> = 14V, Resistive Load = 2.8Ω, T<sub>j</sub> = 25°C, (unless otherwise specified).

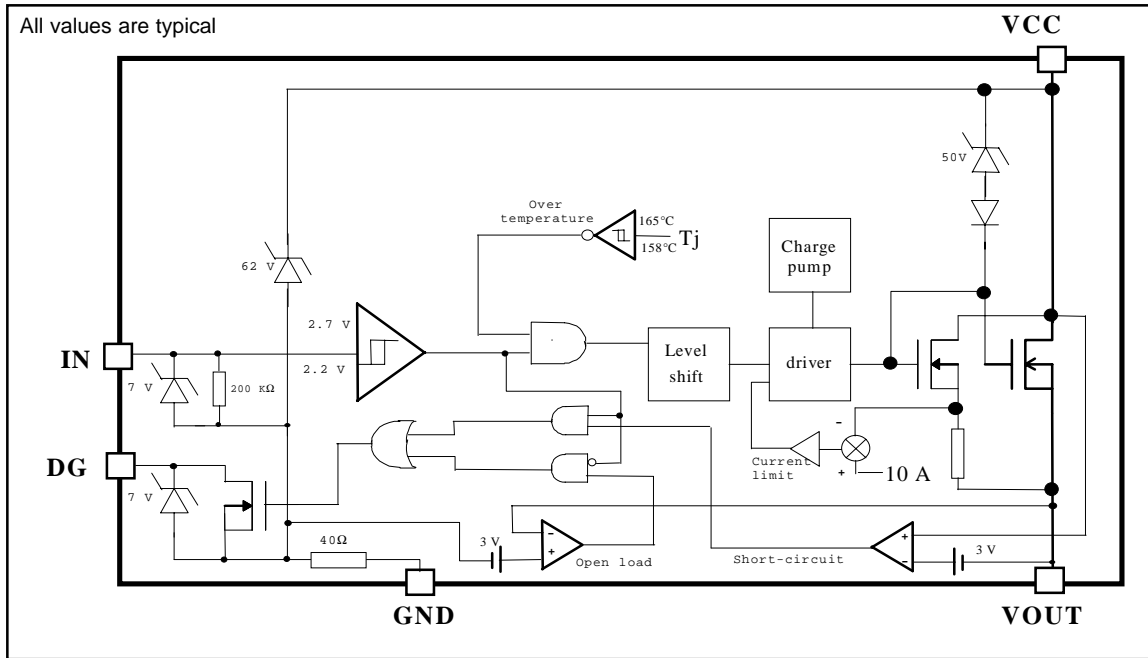
Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
T <sub>d on</sub>	Turn-on delay time	—	10	40	μs	See figure 3
T <sub>r1</sub>	Rise time to V <sub>out</sub> = V <sub>CC</sub> - 5V	—	25	60		
T <sub>r2</sub>	Rise time V <sub>CC</sub> - 5V to V <sub>out</sub> = 90% of V <sub>CC</sub>	—	130	200		
dV/dt (on)	Turn ON dV/dt	—	0.7	2	V/μs	
E <sub>on</sub>	Turn ON energy	—	1500	—	μJ	
T <sub>d off</sub>	Turn-off delay time	—	35	70	μs	See figure 4
T <sub>f</sub>	Fall time to V <sub>out</sub> = 10% of V <sub>CC</sub>	—	16	50		
dV/dt (off)	Turn OFF dV/dt	—	0.9	3		
E <sub>off</sub>	Turn OFF energy	—	250	—	μJ	
T <sub>diag</sub>	V <sub>out</sub> to V <sub>diag</sub> propagation delay	—	5	15	μs	See figure 6

## Protection Characteristics

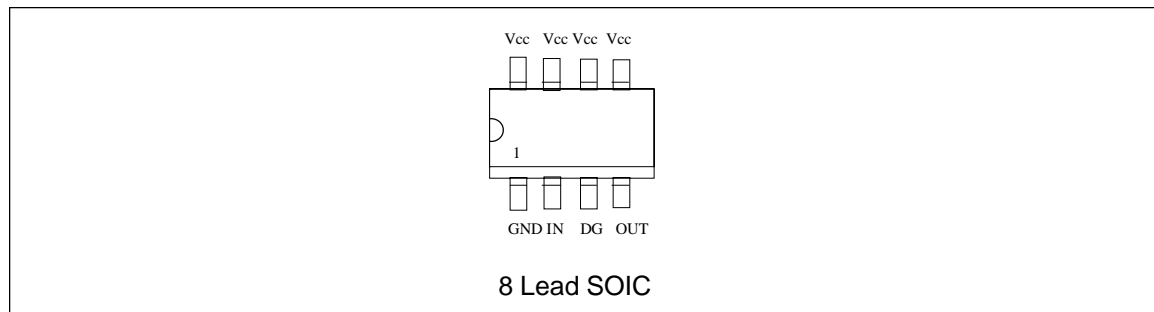
Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
$I_{lim}$	Internal current limit	7	10	14	A	$V_{out} = 0V$
$T_{sd+}$	Over-temp. positive going threshold	—	165	—	°C	See fig. 2
$T_{sd-}$	Over-temp. negative going threshold	—	158	—	°C	See fig. 2
$V_{sc}$	Short-circuit detection voltage (3)	2	3	4	V	See fig. 2
$V_{open\ load}$	Open load detection threshold	2	3	4	V	

(3) Referenced to  $V_{CC}$

## Functional Block Diagram



## Lead Assignments



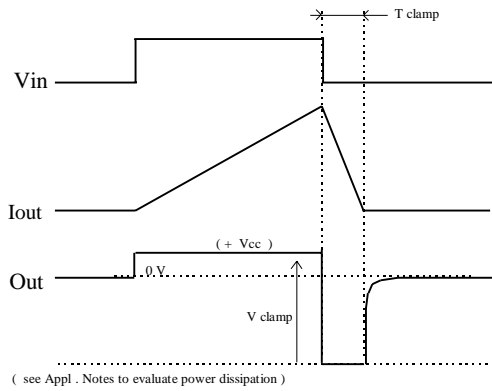


Figure 1 - Active clamp waveforms

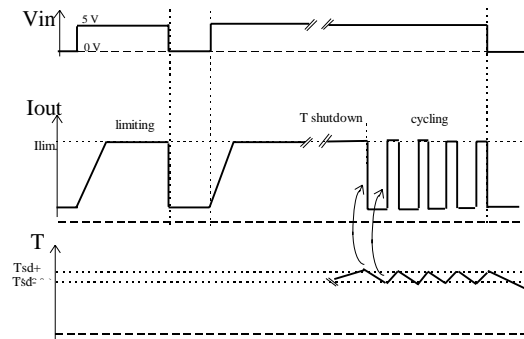


Figure 2 - Protection timing diagram

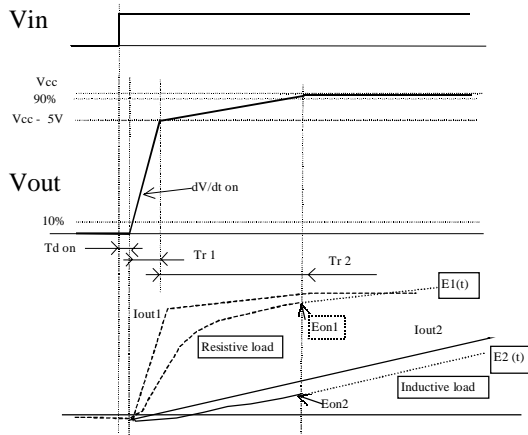


Figure 3 - Switching times definition (turn-on)  
 Turn on energy with a resistive or an inductive load

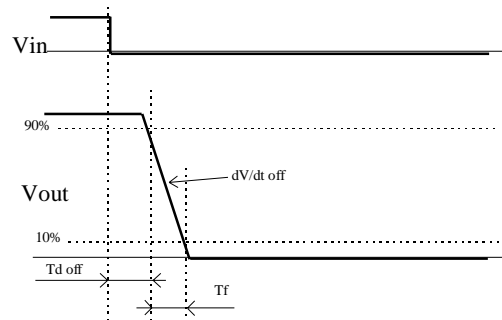


Figure 4 - Switching times definition (turn-off)

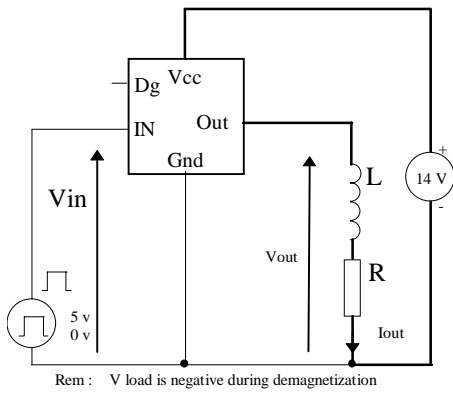


Figure 5 - Active clamp test circuit

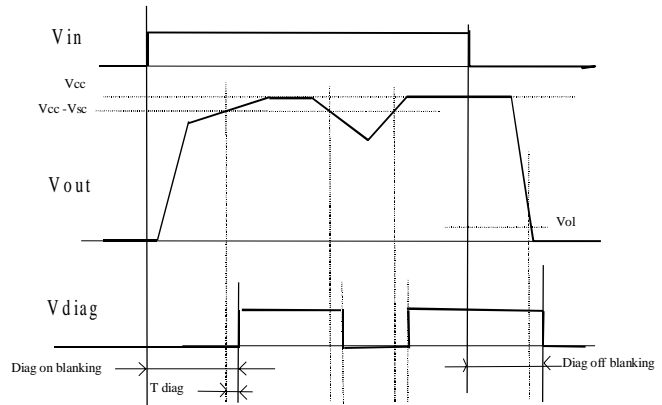


Figure 6 - Diagnostic delay definitions

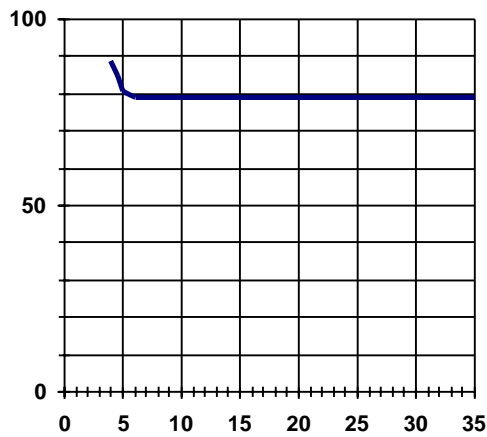


Figure 7 - R<sub>ds(on)</sub> (mΩ) Vs V<sub>cc</sub> (V)

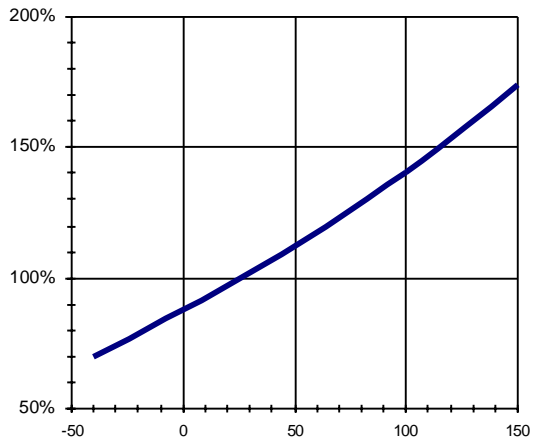


Figure 8 - Normalized R<sub>ds(on)</sub> (mΩ) Vs T<sub>j</sub> (°C)

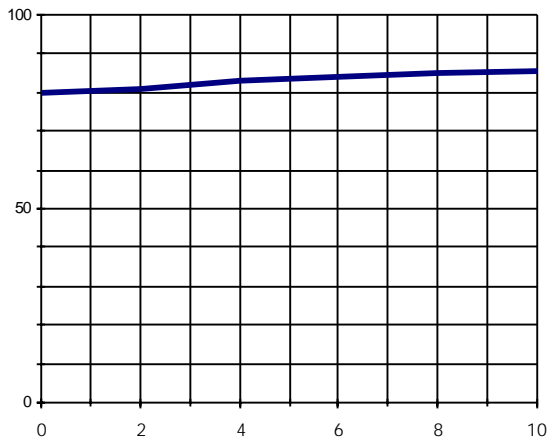


Figure 9 -  $R_{ds(on)}$  (mΩ) Vs  $I_{out}$  (A)

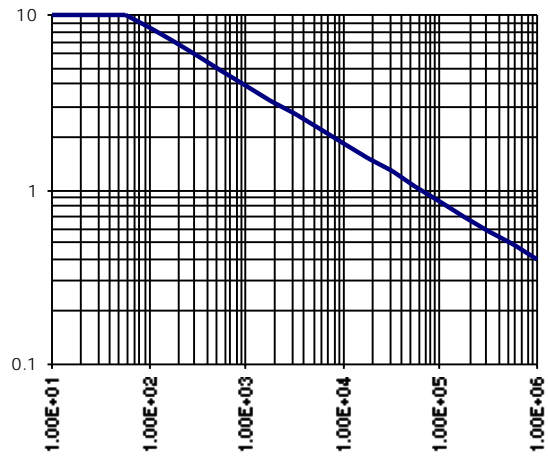


Figure 10 - Max.  $I_{out}$  (A) Vs Load Inductance (uH)

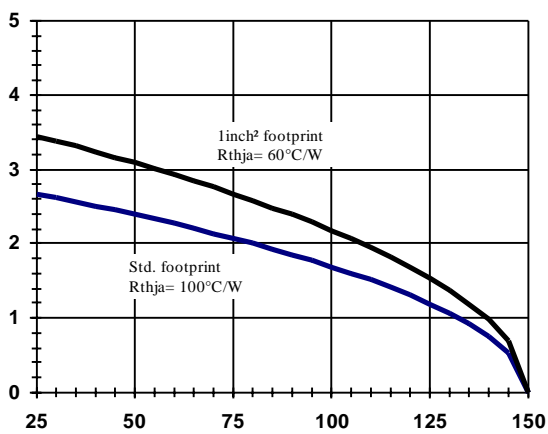


Figure 11 - Max load current (A) Vs  $T_{amb}$  (°C)

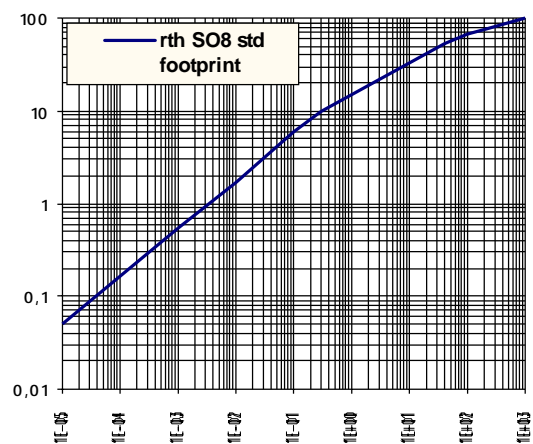


Figure 12 - Transient Thermal Impedance (°C/W) Vs Time (s)

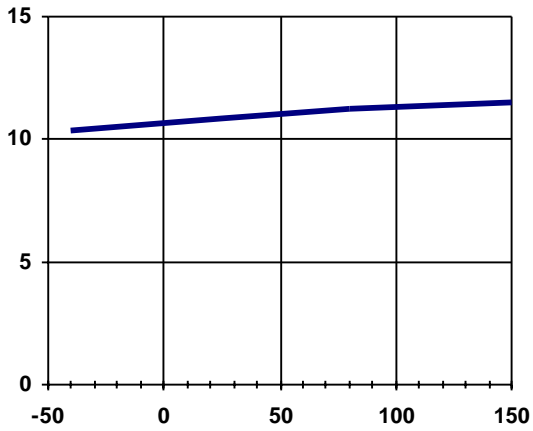


Figure 13 - I<sub>lim</sub> (A) Vs T<sub>j</sub> (°C)

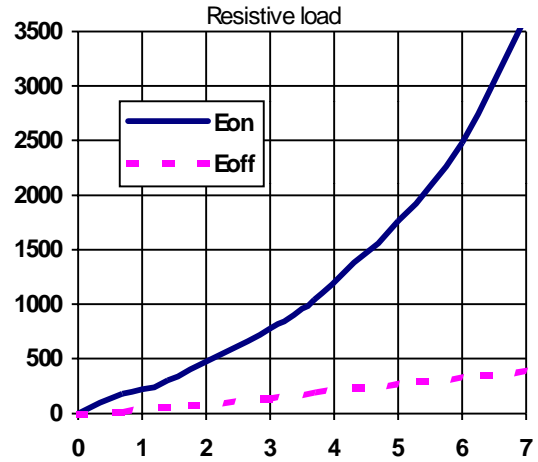


Figure 14 - E<sub>on</sub>, E<sub>off</sub> (μJ) Vs I<sub>out</sub> (A)

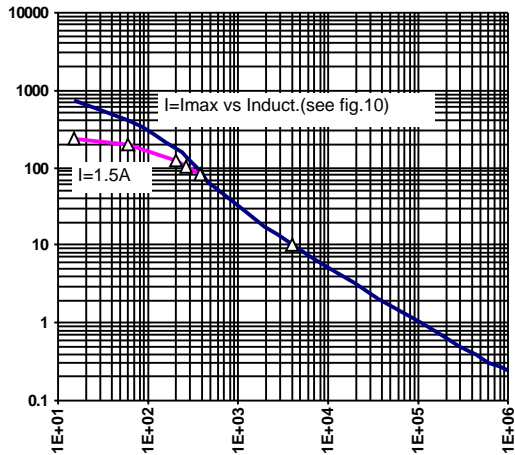


Figure 15 - E<sub>on</sub> (μJ) Vs Load Inductance (μH)  
(see Fig. 3)

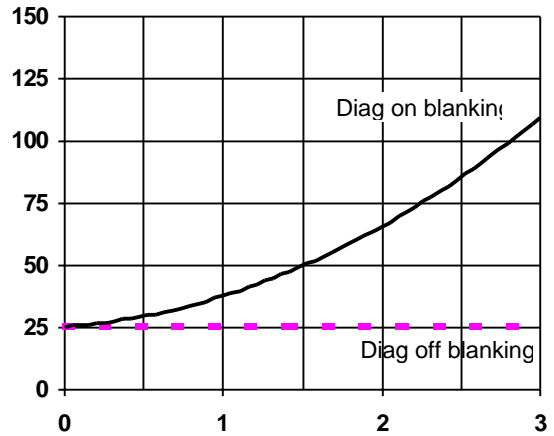


Figure 16 - Diag Blanking time (μS) Vs I<sub>out</sub> (A)  
(resistive load - see Fig. 6)



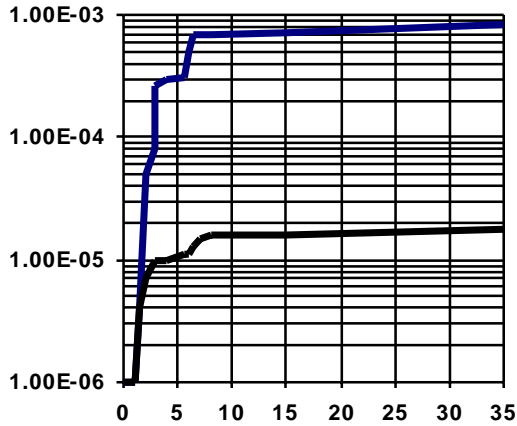


Figure 17 -  $I_{cc}$  (mA) Vs  $V_{cc}$  (V)

**Case Outline - 8 Lead SOIC**

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	.0532	.0688	1.35	1.75
A1	.0040	.0098	0.10	0.25
b	.014	.018	0.36	0.46
c	.0075	.0098	0.19	0.25
D	.189	.196	4.80	4.98
E	.150	.157	3.81	3.99
e	.050	BASIC	1.27	BASIC
e1	.025	BASIC	0.635	BASIC
H	.2284	.2440	5.80	6.20
K	.011	.019	0.28	0.48
L	.016	.050	0.41	1.27
y	0°	8°	0°	8°

NOTES:

- DIMENSIONING & TOLERANCING PER ASME Y14.5M-1994.
- CONTROLLING DIMENSION: MILLIMETER.
- DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
- OUTLINE CONFORMS TO JEDEC OUTLINE MS-012AA.

⑤ DIMENSION DOES NOT INCLUDE MOLD PROTRUSIONS. MOLD PROTRUSIONS NOT TO EXCEED 0.25 [.006].

⑥ DIMENSION IS THE LENGTH OF LEAD FOR SOLDERING TO A SUBSTRATE.

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