Data Sheet No.PD60156-J

International
IOR Rectifier

# IPS511G/IPS512G/IPS514G

## 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 gound isolated from power ground

### Product Summary

| | |
|---|---|
| $R_{ds(on)}$ | 150mΩ (max) |
| $V_{clamp}$ | 50V |
| $I_{Limit}$ | 5A |
| $V_{open\ load}$ | 3V |

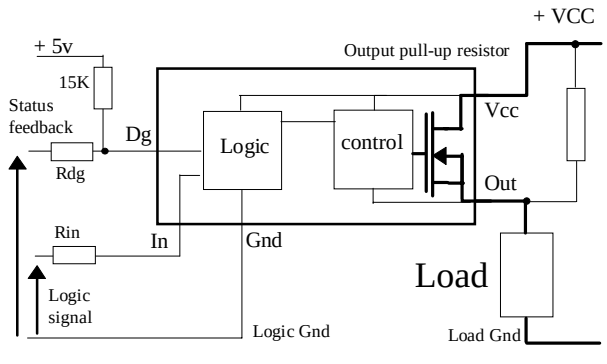
### Description

The IPS511G/IPS512G/IPS514G are fully protected five terminal high side switches 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 Tshutdown. It will automatically restart after the junction has cooled 7°C below Tshutdown. 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.

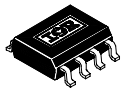
### Truth Table

| 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 |

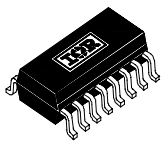
### Typical Connection



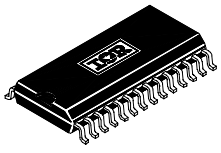

### Available Package



8 Lead SOIC
(Single)
IPS511G



16 Lead SOIC
(Dual)
IPS512G



28 Lead SOIC WB
(Quad)
IPS514G

## 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°C unless otherwise specified).

| Symbol | Parameter | Min. | Max. | Units | Test Conditions |
|---|---|---|---|---|---|
| $V_{out}$ | Maximum output voltage | $V_{cc}$-50 | $V_{cc}$+0.3 | | |
| $V_{offset}$ | 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 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. continuous current (1) (IPS511G) | — | 1.4 | | |
| | (per leg/both legs ON - IPS512G) | — | 0.8 | | |
| | (per leg/all legs ON - IPS514G) | — | 0.7 | | |
| $I_{sd\ pulsed}$ | Diode max. pulsed current (1) | — | 10 | | |
| ESD1 | Electrostatic discharge voltage (Human Body) | — | 4 | | C=100pF, R=1500Ω, |
| ESD2 | Electrostatic discharge voltage (Machine Model) | — | 0.5 | | C=200pF, R=0Ω, L=10μH |
| $P_d$ | Maximum power dissipation (rth=125°C/W) IPS511G | — | 1 | | |
| | (rth=85°C/W, both legs on) IPS512G | — | 1.5 | | |
| | (rth=50°C/W, all legs on) IPS514G | — | 2.5 | | |
| $T_j$ max. | Max. storage & operating junction temp. | -40 | +150 | °C | |
| Vcc max. | Maximum Vcc voltage | — | 50 | V | |

## Thermal Characteristics

| Symbol | Parameter | Min. | Typ. | Max. | Units | Test Conditions |
|---|---|---|---|---|---|---|
| $R_{th1}$ | Thermal resistance with standard footprint | — | 100 | | | |
| $R_{th2}$ | Thermal resistance with 1" square footprint | — | 80 | | | |
| $R_{th1}$ (2 mos on) | Thermal resistance with standard footprint (2 mosfets on) | — | 85 | | | |
| $R_{th2}$ (1) (1 mos on) | Thermal resistance with standard footprint (1 mosfet on) | — | 100 | | | |
| $R_{th2}$ (2 mos on) | Thermal resistance with 1" square footprint (2 mosfets on) | — | 50 | — | | |
| $R_{th1}$ | Thermal resistance with standard footprint | — | 60 | — | | |
| $R_{th2}$ (2 mos on) | Thermal resistance with standard footprint (2 mosfets on) | — | 55 | — | | |
| $R_{th3}$ (4 mos on) | Thermal resistance with standard footprint (4 mosfets on) | — | 50 | — | | |
| $R_{th1}$ | Thermal resistance with 1" square footprint | — | 45 | — | | |
| $R_{th2}$ (2 mos on) | Thermal resistance with 1" square footprint (2 mosfets on) | — | 40 | — | | |
| $R_{th3}$ 4 mos on) | Thermal resistance with 1" square footprint (4 mosfets on) | — | 35 | — | | |

(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 |
|---|---|---|---|---|
| $V_{cc}$ | Continuous $V_{cc}$ voltage | 5.5 | 35 | |
| $V_{IH}$ | High level input voltage | 4 | 5.5 | |
| $V_{IL}$ | Low level input voltage | -0.3 | 0.9 | |
| $I_{out}$ Tamb=85°C | Continuous output current (TAmbient = 85°C, Tj = 125°C, rth = 100°C/W) IPS511G | — | 1.4 | |
| $I_{out}$ Tamb=85°C | Continuous output current per leg (TAmbient = 85°C, Tj = 125°C $R_{th}$ = 85°C/W both legs on) IPS512G | — | 1.0 | A |
| $I_{out}$ Tamb=85°C | Continuous output current per leg (TAmbient = 85°C, Tj = 125°C $R_{th}$ = 60°C/W all legs on) IPS514G | — | 0.85 | |
| Rin | Recommended resistor in series with IN pin | 4 | 6 | |
| Rdg | Recommended resistor in series with DG pin | 10 | 20 | kΩ |

## Static Electrical Characteristics

($T_j$ = 25°C, $V_{cc}$ = 14V unless otherwise specified.)

| Symbol | Parameter | Min. | Typ. | Max. | Units | Test Conditions |
|---|---|---|---|---|---|---|
| $R_{ds(on)}$ @Tj=25°C | ON state resistance $T_j$ = 25°C | — | 130 | 150 | | $V_{in}$ = 5V, $I_{out}$ = 2.5A |
| $R_{ds(on)}$ ($V_{cc}$=6V) | ON state resistance @ $V_{cc}$ = 6V | — | 130 | 150 | | $V_{in}$ = 5V, $I_{out}$ = 1A |
| $R_{ds(on)}$ @Tj=150°C | ON state resistance Tj = 150°C | — | 220 | — | | $V_{in}$ = 5V, $I_{out}$ = 2.5A |
| $V_{cc}$ oper. | Operating voltage range | 5.5 | — | 35 | | |
| V clamp 1 | $V_{cc}$ to OUT clamp voltage 1 | 50 | 56 | — | | $I_d$ = 10mA (see Fig.1 & 2) |
| V clamp 2 | $V_{cc}$ to OUT clamp voltage 2 | — | 58 | 65 | | $I_d$ = $I_{sd}$ (see Fig.1 & 2) |
| $V_f$ | Body diode forward voltage | — | 0.9 | 1.2 | | $I_d$ = 2.5A, $V_{in}$ = 0V |
| $I_{cc}$ off | Supply current when OFF | — | 16 | 50 | µA | $V_{in}$ = 0V, $V_{out}$ = 0V |
| $I_{cc}$ on | Supply current when ON | — | 0.7 | 2 | mA | $V_{in}$ = 5V |
| $I_{cc}$ ac | Ripple current when ON (AC RMS) | — | 20 | — | µA | $V_{in}$ = 5V |
| Vdgl | Low level diagnostic output voltage | — | 0.15 | 0.4 | V | $I_{dg}$ = 1.6 mA |
| $I_{oh}$ | Output leakage current | — | 60 | 120 | | $V_{out}$ = 6V |
| $I_{ol}$ | Output leakage current | 0 | — | 25 | | $V_{out}$ = 0V |
| $I_{dg}$ leakage | Diagnostic output leakage current | — | — | 10 | | $V_{dg}$ = 5.5V |
| $V_{ih}$ | IN high threshold voltage | — | 2.3 | 3 | | |
| $V_{il}$ | IN low threshold voltage | 1 | 2 | — | | |
| $I_{in,\ on}$ | On state IN positive current | — | 70 | 200 | µA | $V_{in}$ = 5V |
| In, hyst. | Input hysteresis | 0.1 | 0.25 | 0.5 | V | |

## Switching Electrical Characteristics

$V_{cc}$ = 14V, Resistive Load = 5.6Ω, $T_j$ = 25°C, (unless otherwise specified).

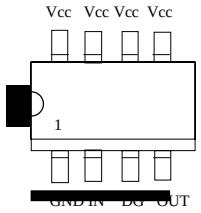
| Symbol | Parameter | Min. | Typ. | Max. | Units | Test Conditions |
|---|---|---|---|---|---|---|
| $T_{don}$ | Turn-on delay time | — | 7 | 50 | | |
| $T_{r1}$ | Rise time to $V_{out}$ = $V_{cc}$ - 5V | — | 10 | 50 | | |
| $T_{r2}$ | Rise time from the end of Tr1 to $V_{out}$ = 90% of $V_{cc}$ | — | 45 | 95 | | |
| $dV/dt$ (on) | Turn ON $dV/dt$ | — | 1.3 | 4 | V/µs | |
| $E_{on}$ | Turn ON energy | — | 400 | — | | |
| $T_{doff}$ | Turn-off delay time | — | 15 | 50 | | |
| $T_f$ | Fall time to $V_{out}$ = 10% of $V_{cc}$ | — | 10 | 50 | | |
| $dV/dt$ (off) | Turn OFF $dV/dt$ | — | 2 | 6 | V/µs | |
| $E_{off}$ | Turn OFF energy | — | 80 | — | µJ | |
| $T_{diag}$ | $V_{out}$ to $V_{diag}$ propagation delay | — | 5 | 15 | µs | See figure 6 |

## Protection Characteristics

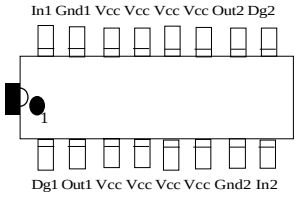
| Symbol | Parameter | Min. | Typ. | Max. | Units | Test Conditions |
|---|---|---|---|---|---|---|
| $I_{lim}$ | Internal current limit | 3 | 5 | 7 | A | $V_{out}$ = 0V |
| $T_{sd+}$ | Over-temp. positive going threshold | — | 165 | — | °C | See fig. 2 |
| $T_{sd-}$ | Over-temp. negative going threshold | — | 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 $V_{cc}$

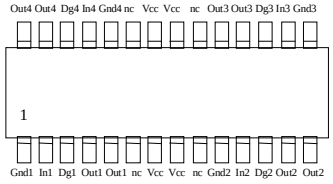
## Lead Assignments




8 Lead SOIC




16 Lead SOIC

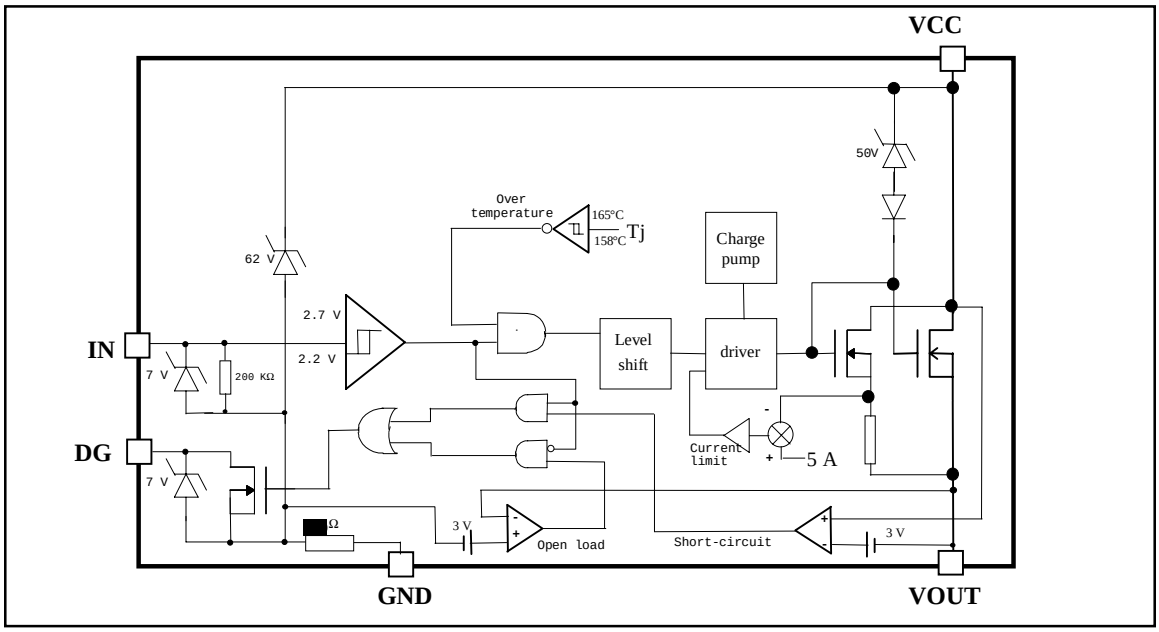



28 Lead SOIC WB

| IPS511G | IPS512G | IPS514G |
|---|---|---|
| Part Number | | |

## Functional Block Diagram

All values are typical



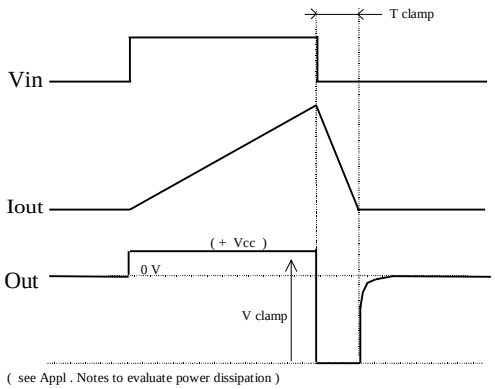




Figure 1 - Active clamp waveforms

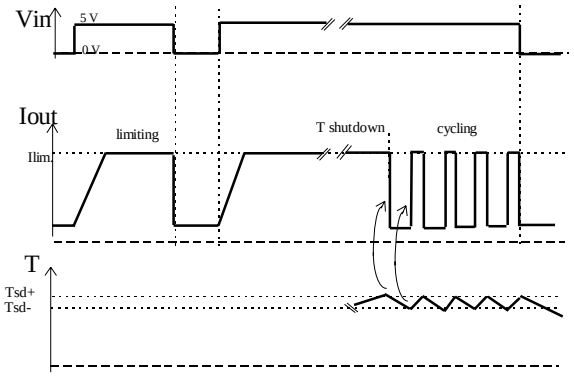



Figure 2 - Protection timing diagram

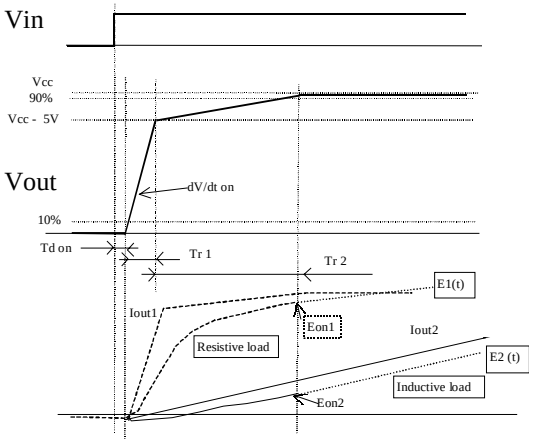



Figure 3 - Switching times definition (turn-on)
Turn on energy with a resistive or an inductive load

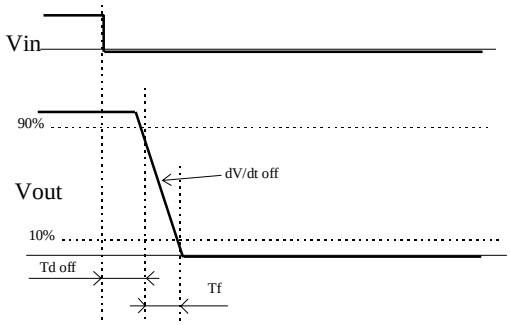



Figure 4 - Switching times definition (turn-off)

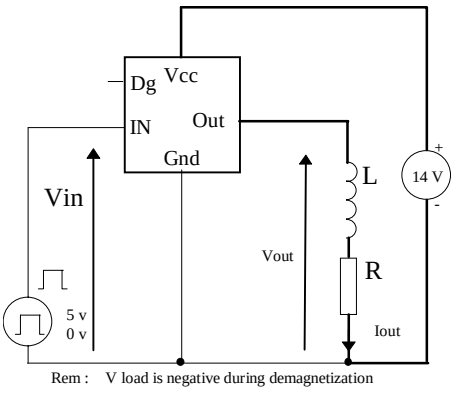



Figure 5 - Active clamp test circuit

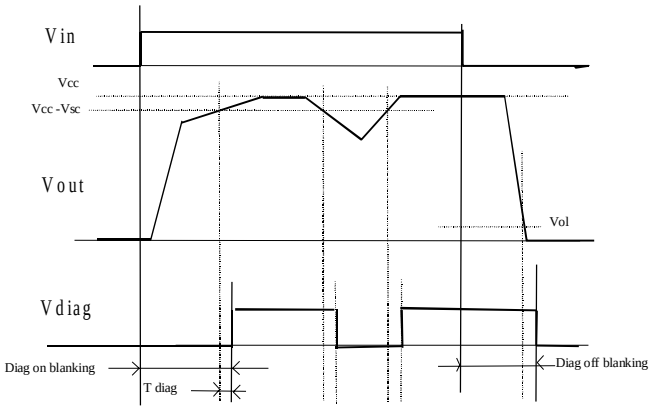



Figure 6 - Diagnostic delay definitions

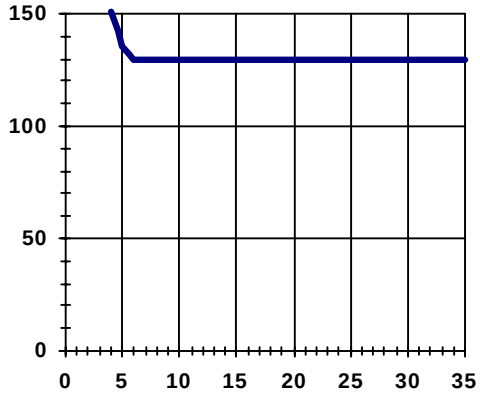



Figure 7 - $R_{ds(on)}$ (mΩ) Vs $V_{cc}$ (V)

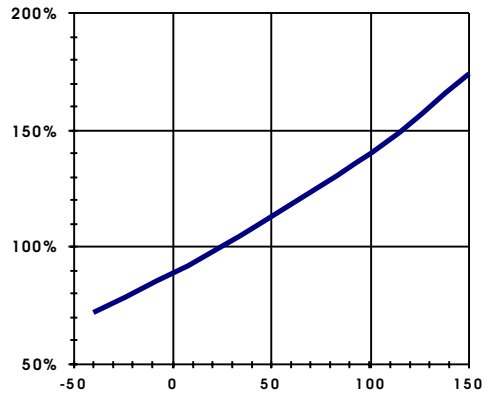



Figure 8 - Normalized $R_{ds(on)}$ (%) Vs $T_j$ ($^oC$)

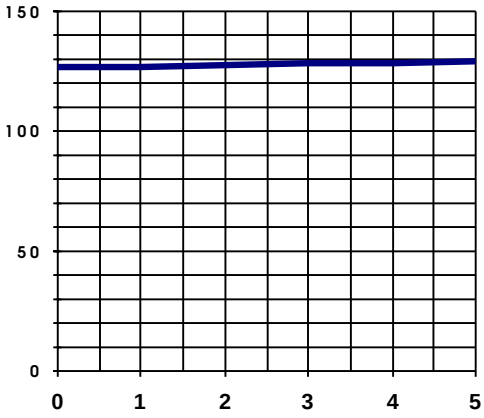



Figure 9 - Rds(on) (mΩ) Vs $I_{out}$ (A)

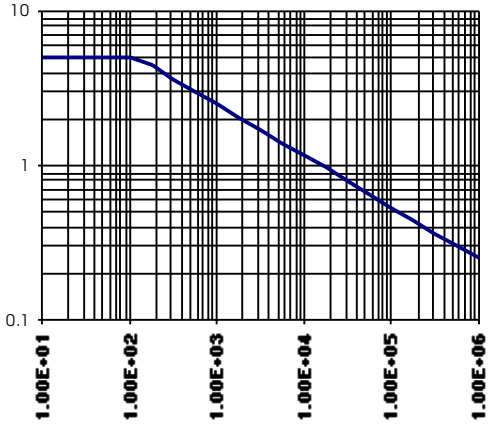



Figure 10 - Max. $I_{out}$ (A) Vs Load Inductance (uH)

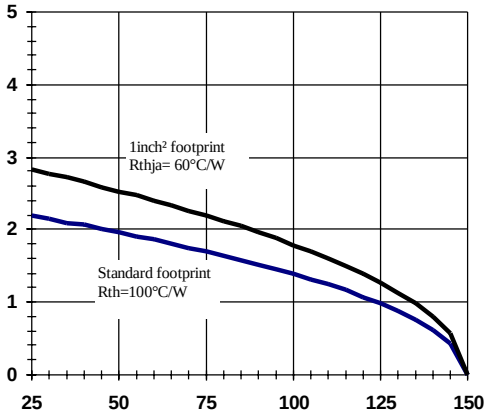



Figure 11a - Max load current (A) Vs Tamb (°C)
IPS511G

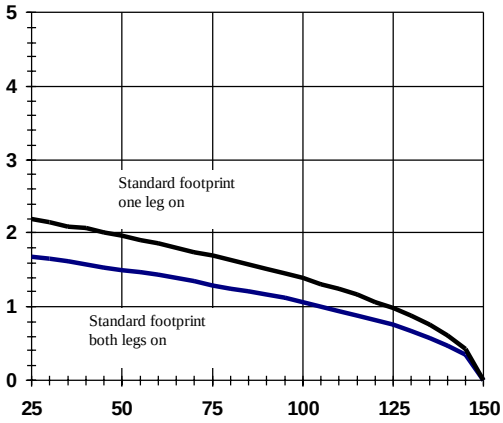



Figure 11b - Max load current (A) Vs Tamb (°C)
IPS512G

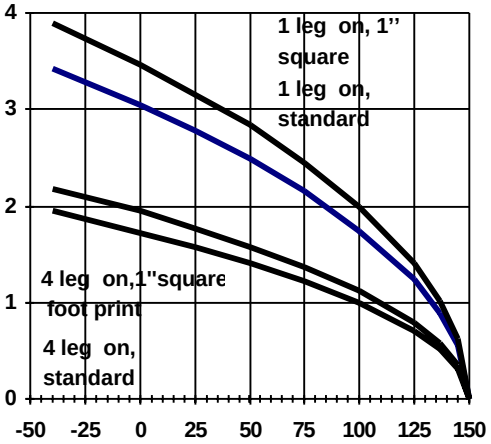



Figure 11c - Max load current (A) Vs Tamb (°C)
IPS514G

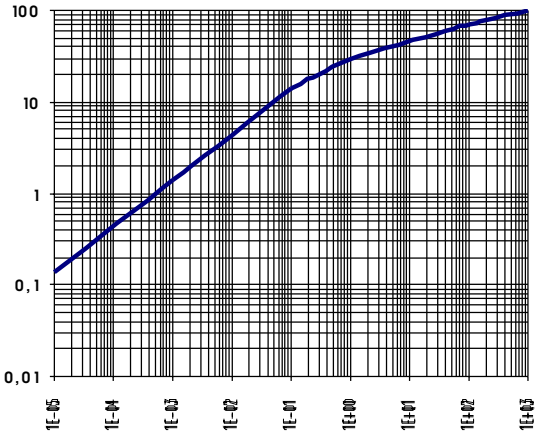



Figure 12a - Transient Thermal Impedance (°C/W)
Vs Time (S) - IPS511G/IPS512G

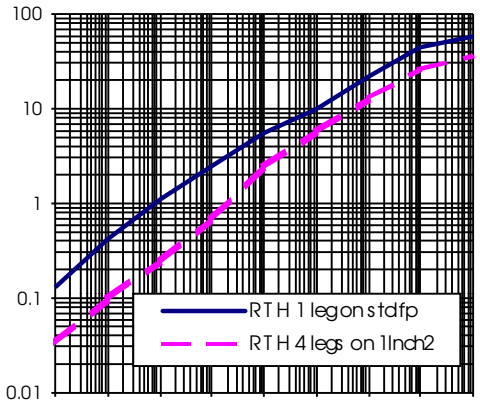



Figure 12b - Transient Thermal Impedance ($^{o}$C/W) Vs Time (S) - IPS514G

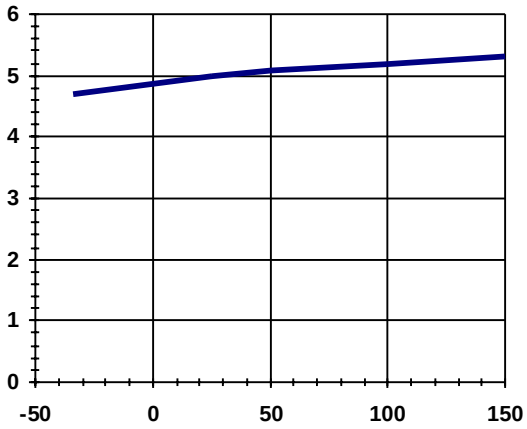



Figure 13 - $I_{lim}$ (A) Vs $T_j$ ($^{o}$C)

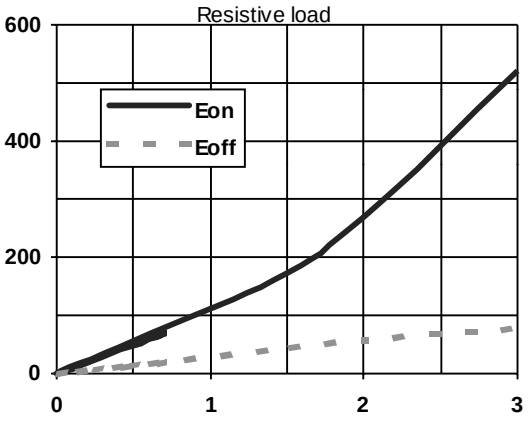



Figure 14 - Eon, Eoff (µJ) vs I (A)

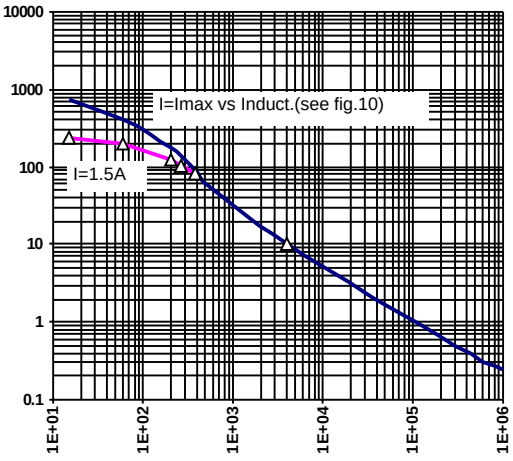



Figure 15 - $E_{on}$ (µJ) Vs Load Inductance (µH) (see Fig. 3)

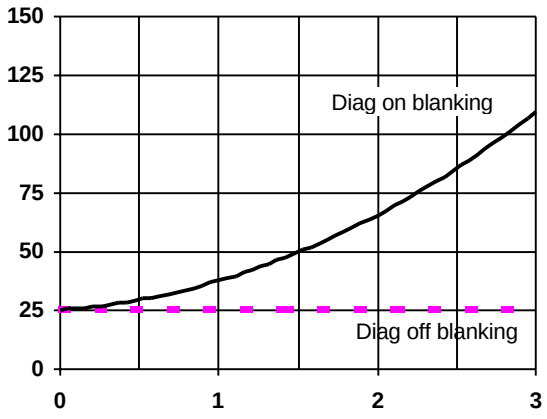



Figure 16 - Diag Blanking time (µS) Vs $I_{out}$ (A)
(resistive load - see Fig. 6)

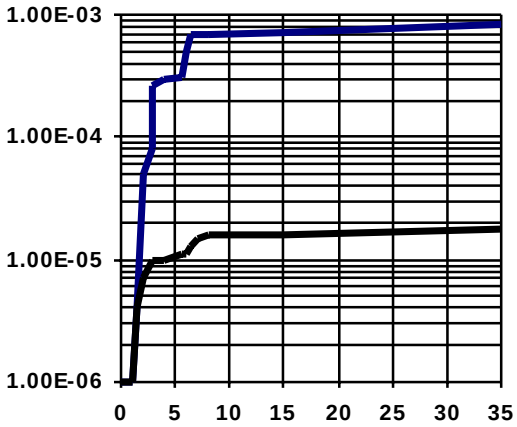
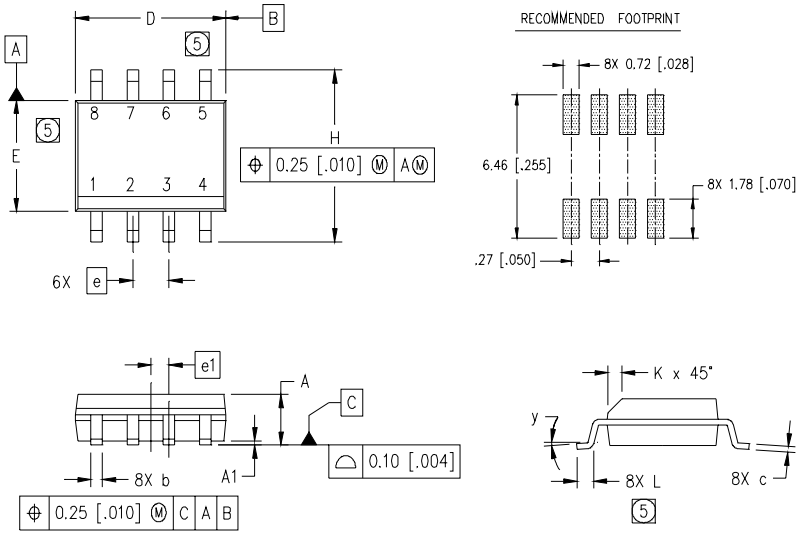



Figure 17 - $I_{CC}$ (mA) Vs $V_{CC}$ (V)

## Case Outline - IPS511G




| 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° |

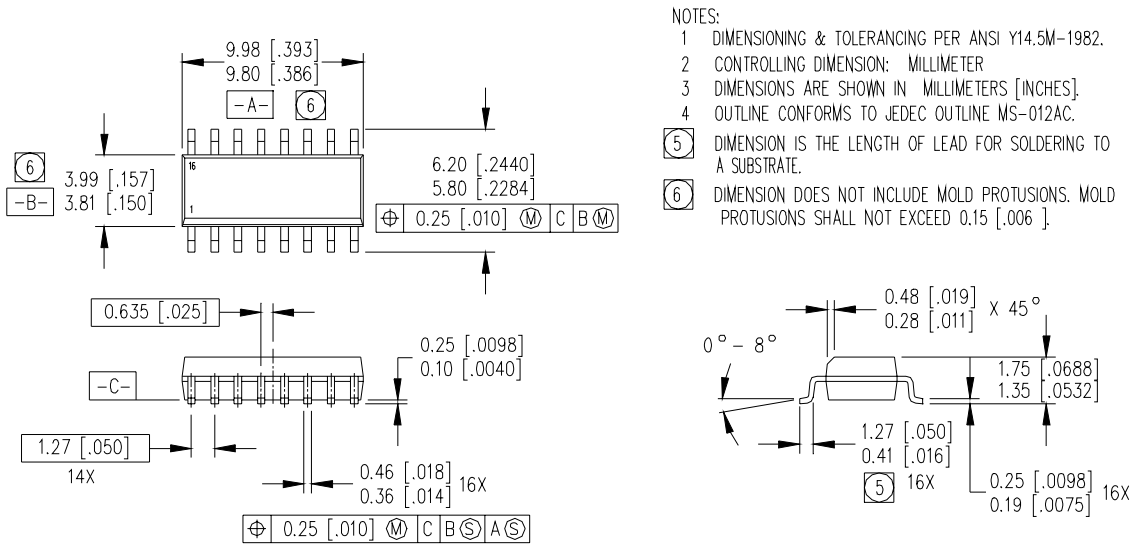
NOTES:
1. DIMENSIONING & TOLERANCING PER ASME Y14.5M-1994.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
4. OUTLINE CONFORMS TO JEDEC OUTLINE MS-012AA.

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.

**8 Lead SOIC**

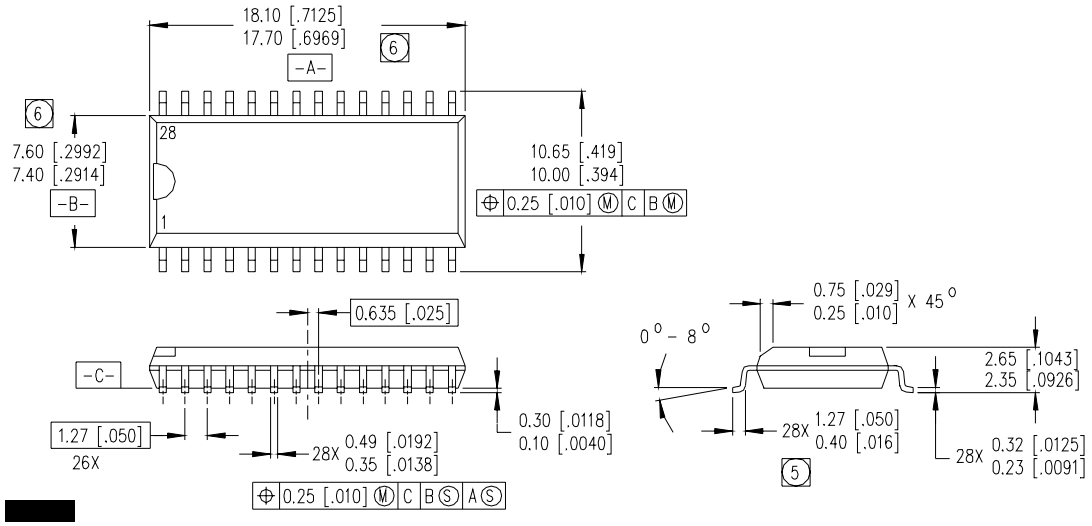
(MS-012AA) 01-0021 09

## Case Outline - IPS512G




**16 Lead SOIC (narrow body)** 01-3064 00

## Case Outline - IPS514G




**NOTES:**

1. DIMENSIONING & TOLERANCING PER ANSI Y14.5M-1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
4. OUTLINE CONFORMS TO JEDEC OUTLINE MS-013AE.

(5) DIMENSION IS THE LENGTH OF LEAD FOR SOLDERING TO A SUBSTRATE.

(6) DIMENSION DOES NOT INCLUDE MOLD PROTUSIONS. MOLD PROTUSIONS SHALL NOT EXCEED 0.15 [.006].

**28 Lead SOIC**

01-3040 02

International
IOR Rectifier

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