

## IPS7091(G)(S)PbF

### INTELLIGENT POWER HIGH SIDE SWITCH

#### Features

- Over temperature shutdown (with auto-restart)
- Short circuit protection (current limit)
- Active clamp
- Open load detection
- Logic ground isolated from power ground
- ESD protection
- Ground loss protection
- Status feedback

#### Product Summary

|              |                    |
|--------------|--------------------|
| $R_{ds(on)}$ | 120m $\Omega$ max. |
| $V_{clamp}$  | 70V                |
| I Limit      | 5A (typ.)          |
| Open load    | 3V                 |

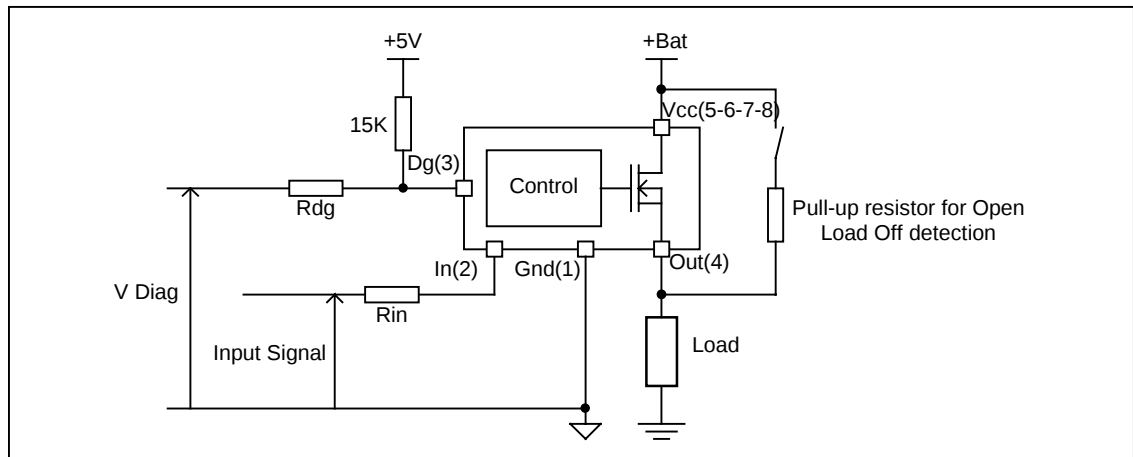
#### Description

The IPS7091(G)(S)PbF is a five terminal Intelligent Power Switch (IPS) with built in short circuit, over-temperature, ESD protection, inductive load capability and diagnostic feedback. The output current is limited at  $I_{lim}$  value. Current limitation is activated until the thermal protection acts. The over-temperature protection turns off the device if the junction temperature exceeds  $T_{shutdown}$ . It will automatically restart after the junction has cooled 7°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.

#### Package



#### Typical Connection



## 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. (Tambient=25°C unless otherwise specified).

| Symbol                | Parameter                                                                           | Min.   | Max.    | Units |
|-----------------------|-------------------------------------------------------------------------------------|--------|---------|-------|
| Vout                  | Maximum output voltage                                                              | Vcc-65 | Vcc+0.3 | V     |
| Voffset               | Maximum logic ground to load ground offset                                          | Vcc-65 | Vcc+0.3 |       |
| Vin                   | Maximum input voltage                                                               | -0.3   | 5.5     |       |
| Vcc max.              | Maximum Vcc voltage                                                                 | —      | 65      |       |
| Vcc cont.             | Maximum continuous Vcc voltage                                                      | —      | 35      | mA    |
| Iin max.              | Maximum IN current                                                                  | -1     | 10      |       |
| I <sub>dg</sub> max.  | Maximum diagnostic output current                                                   | -1     | 10      |       |
| V <sub>dg</sub>       | Maximum diagnostic output voltage                                                   | -0.3   | 5.5     |       |
| Pd                    | Maximum power dissipation (internally limited by thermal protection)<br>Rth=100°C/W | —      | 1.25    | W     |
| I <sub>sd</sub> cont. | Maximum continuous diode current (Rth=100°C/W)                                      | —      | 1.8     | A     |
| ESD1                  | Electrostatic discharge voltage (Human body) 100pF, 1500Ω                           | —      | 4       | kV    |
| ESD2                  | Electrostatic discharge voltage (Machine Model) C=200pF, R=0Ω, L=10μH               | —      | 0.5     |       |
| Tj max.               | Max. storage & operating temperature junction temperature                           | -40    | +150    | °C    |

## Thermal Characteristics

| Symbol | Parameter                                                       | Typ. | Max. | Units |
|--------|-----------------------------------------------------------------|------|------|-------|
| Rth1   | Thermal resistance junction to ambient SO8 std. footprint       | 100  | —    | °C/W  |
| Rth1   | Thermal resistance junction to ambient TO220 free air           | 60   | —    |       |
| Rth1   | Thermal resistance junction to ambient D2Pak std. footprint     | 60   | —    |       |
| Rth2   | Thermal resistance junction to ambient D2Pak 1" sqrt. footprint | 40   | —    |       |
| Rth3   | Thermal resistance junction to case D2pak/TO220                 | 4    | —    |       |

## 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 |
|--------|--------------------------------------------------------------------|------|------|-------|
| VIH    | High level input voltage                                           | 4    | 5.5  |       |
| VIL    | Low level input voltage                                            | -0.3 | 0.9  |       |
| Iout   | Continuous drain current, Tamb=85°C, Tj=125°C, Vin=5V, Rth=100°C/W | —    | 1.5  | A     |
| Rin    | Recommended resistor in series with IN pin                         | 10   | 20   | kΩ    |
| Rdgs   | Recommended resistor in series with DG pin                         | 10   | 20   |       |
| Rol    | Recommended pull-up resistor for open load detection               | 5    | 100  |       |

## Static Electrical Characteristics

 $T_J=25^{\circ}\text{C}$ ,  $V_{CC}=14\text{V}$  (unless otherwise specified)

| Symbol                  | Parameter                                                           | Min. | Typ. | Max. | Units         | Test Conditions                          |
|-------------------------|---------------------------------------------------------------------|------|------|------|---------------|------------------------------------------|
| Rds(on)                 | ON state resistance $T_J=25^{\circ}\text{C}$                        | —    | 80   | 120  | m $\Omega$    | $V_{in}=5\text{V}$ , $I_{out}=2\text{A}$ |
|                         | ON state resistance $T_J=150^{\circ}\text{C}$                       | —    | 150  | 230  |               | $V_{in}=5\text{V}$ , $I_{out}=2\text{A}$ |
|                         | ON state resistance $T_J=25^{\circ}\text{C}$ , $V_{CC}=6.5\text{V}$ | —    | 90   | 130  |               | $V_{in}=5\text{V}$ , $I_{out}=2\text{A}$ |
| Vcc op.                 | Operating voltage range                                             | 6    | —    | 35   | V             |                                          |
| V clamp 1               | Vcc to Out clamp voltage 1                                          | 65   | 70   | —    |               | $I_{out}=30\text{mA}$ (see Fig. 1)       |
| V clamp 2               | Vcc to Out clamp voltage 2                                          | —    | 70   | 75   |               | $I_{out}=1\text{A}$ (see Fig. 1)         |
| Vf                      | Body diode forward voltage                                          | —    | 1    | 1.35 |               | $I_{out}=2.5\text{A}$                    |
| Icc Off                 | Supply current when Off                                             | —    | 2.5  | 10   | $\mu\text{A}$ | $V_{in}=0\text{V}$ , $V_{out}=0\text{V}$ |
| Icc On                  | Supply current when On                                              | —    | 2.5  | 3.5  | mA            | $V_{in}=5\text{V}$                       |
| Iout@0V                 | Output leakage current                                              | —    | —    | 10   | $\mu\text{A}$ | $V_{out}=0\text{V}$                      |
| Iout@6V                 | Output leakage current                                              | —    | 20   | —    |               | $V_{out}=6\text{V}$                      |
| I <sub>dg</sub> leakage | Diagnostic output leakage current                                   | —    | —    | 10   |               | $V_{dg}=5.5\text{V}$                     |
| V <sub>dgl</sub>        | Low level diagnostic output voltage                                 | —    | 0.2  | 0.3  | V             | $I_{dg}=1.6\text{mA}$                    |
| V <sub>ih</sub>         | Input high threshold voltage                                        | —    | 2.5  | 3.5  |               |                                          |
| V <sub>il</sub>         | Input low threshold voltage                                         | 1    | 2    | —    |               |                                          |
| I <sub>n hys</sub>      | Input hysteresis                                                    | 0.15 | 0.4  | 1    |               |                                          |
| UV high                 | Under voltage high threshold voltage                                | —    | 5    | 5.9  |               |                                          |
| UV low                  | Under voltage low threshold voltage                                 | 3.4  | 4.5  | —    |               |                                          |
| UV hys                  | Undervoltage hysteresis                                             | 0.1  | 0.8  | 1.5  |               |                                          |
| I <sub>in</sub> On      | Input current when device is On                                     | —    | 40   | 80   | $\mu\text{A}$ | $V_{in}=5\text{V}$                       |

## Switching Electrical Characteristics

 $V_{CC}=14\text{V}$ , Resistive load=14 $\Omega$ ,  $V_{in}=5\text{V}$ ,  $T_J=25^{\circ}\text{C}$ 

| Symbol      | Parameter                                | Min. | Typ. | Max. | Units            | Test Conditions        |
|-------------|------------------------------------------|------|------|------|------------------|------------------------|
| Tdon        | Turn-on delay time                       | —    | 12   | 35   | $\mu\text{s}$    | See Fig. 3             |
| Tr1         | Rise time to $V_{out}=V_{CC}-5\text{V}$  | —    | 7    | 40   |                  |                        |
| Tr2         | Rise time to $V_{out}=0.9 \times V_{CC}$ | —    | 14   | 50   |                  |                        |
| dV/dt (On)  | Turn On dV/dt                            | —    | 0.95 | 3.5  | V/ $\mu\text{s}$ |                        |
| EOn         | Turn On energy                           | —    | 250  | —    | $\mu\text{J}$    |                        |
| Tdoff       | Turn-off delay time                      | —    | 20   | 45   | $\mu\text{s}$    |                        |
| Tf          | Fall time to $V_{out}=0.1 \times V_{CC}$ | —    | 6    | 25   | $\mu\text{s}$    |                        |
| dV/dt (Off) | Turn Off dV/dt                           | —    | 1.8  | 5.5  | V/ $\mu\text{s}$ | See Fig. 4 and Fig. 12 |
| EOff        | Turn Off energy                          | —    | 20   | —    | $\mu\text{J}$    |                        |
| Tdiag       | Vout to Vdiag propagation delay          | —    | 15   | —    | $\mu\text{s}$    |                        |

## Protection Characteristics

| Symbol     | Parameter                                      | Min.               | Typ. | Max. | Units | Test Conditions |
|------------|------------------------------------------------|--------------------|------|------|-------|-----------------|
| Ilim       | Internal current limit                         | 2                  | 5    | 8    | A     | Vout=0V         |
| Tsd+       | Over temperature high threshold                | 150 <sup>(1)</sup> | 165  | —    | °C    | See Fig. 2      |
| Tsd-       | Over temperature low threshold                 | —                  | 158  | —    | °C    |                 |
| Vsc        | Short-circuit detection voltage <sup>(2)</sup> | 2                  | 3    | 4    | V     |                 |
| Vopen load | Open load detection threshold                  | 2                  | 3    | 4    | V     |                 |

<sup>(1)</sup> Guaranteed by design

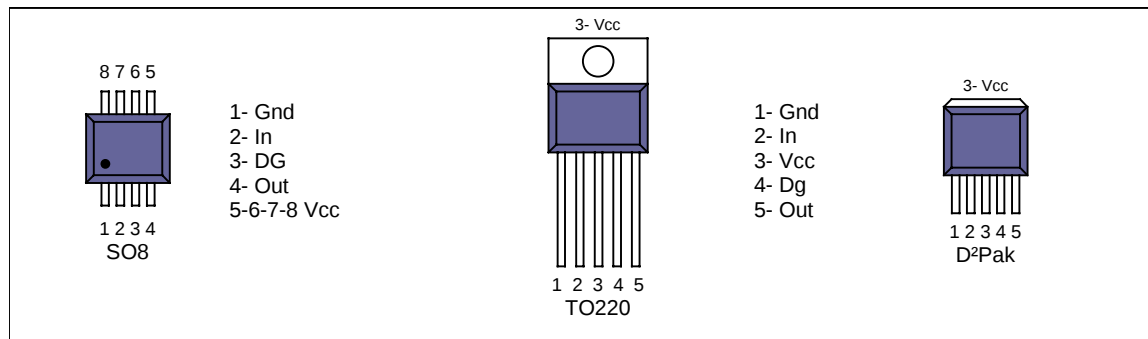
<sup>(2)</sup> Reference to Vcc

## Truth Table

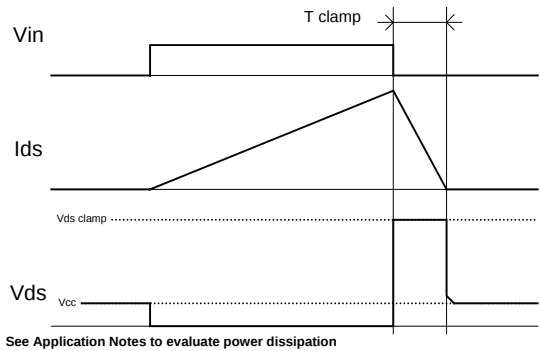
| Operating Conditions     | IN | OUT          | DG pin |
|--------------------------|----|--------------|--------|
| Normal                   | H  | H            | H      |
| Normal                   | L  | L            | L      |
| Open Load                | H  | H            | H      |
| Open Load <sup>(3)</sup> | L  | H            | H      |
| Short circuit to Gnd     | H  | L (limiting) | L      |
| Short circuit to Gnd     | L  | L            | L      |
| Over-temperature         | H  | L (cycling)  | L      |
| Over-temperature         | L  | L            | L      |

<sup>(3)</sup> With a pull-up resistor connected between the output and Vcc.

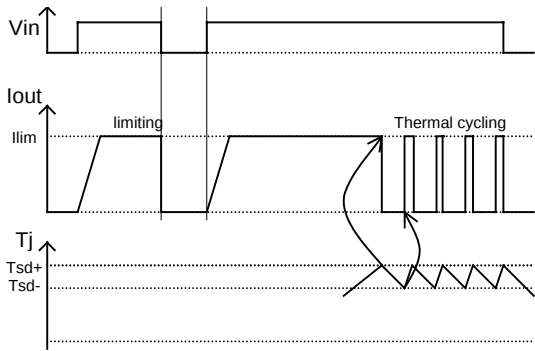
## Lead Assignments



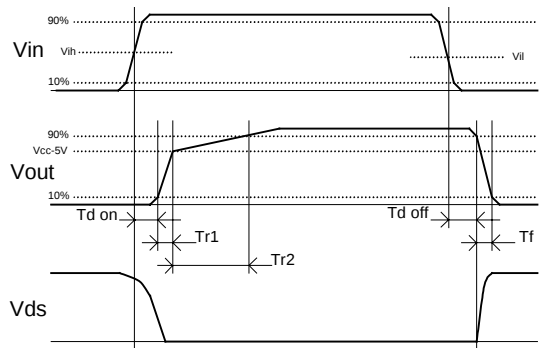
All values are typical



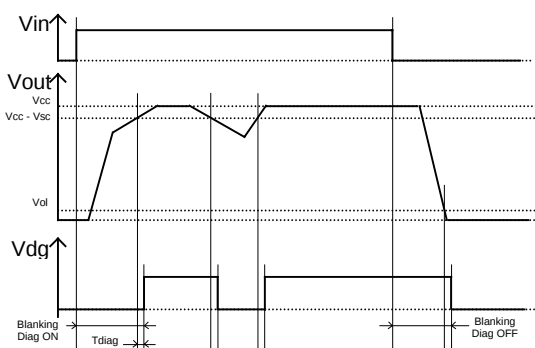
**Figure 1 – Active clamp waveforms**



**Figure 2 – Protection timing diagram**



**Figure 3 – Switching times definition**



**Figure 4 – Diagnostic delay definition**

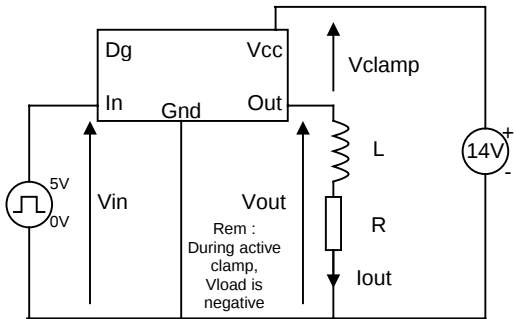


Figure 5 – Active clamp test circuit

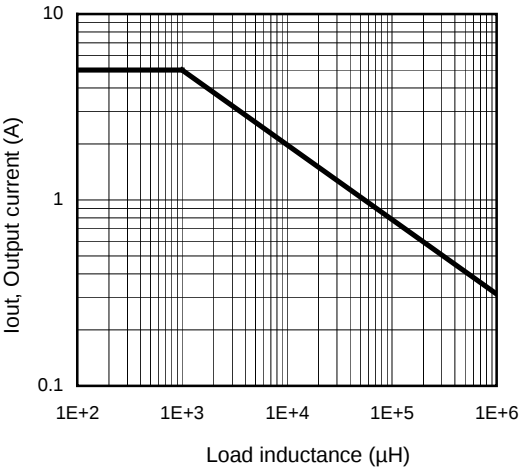


Figure 6 – Max. Output current (A) Vs Load inductance (μH)

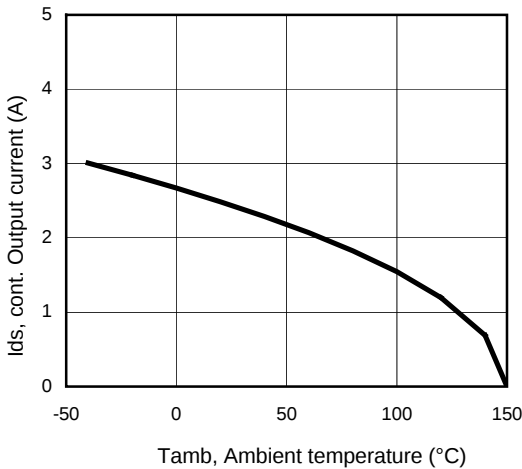


Figure 7 – Max. output current (A) Vs Ambient temperature (°C) Rth=100°C/W

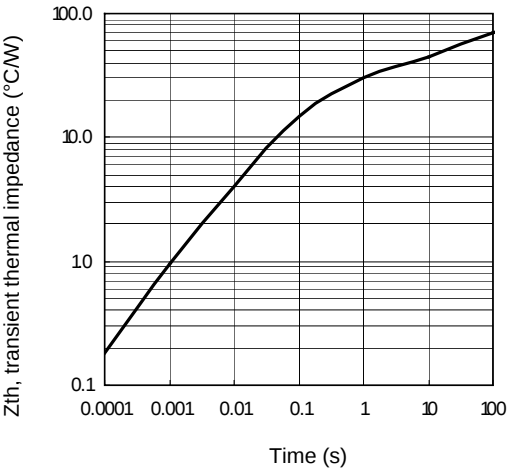
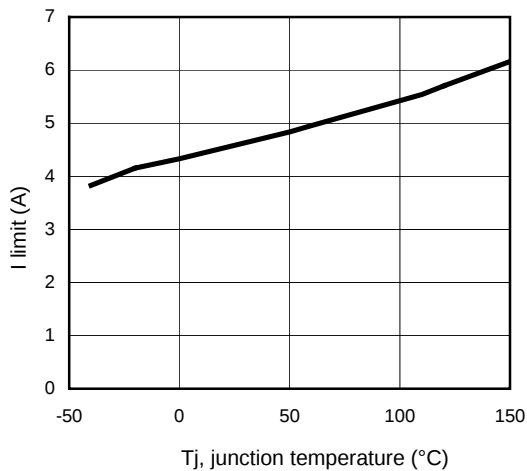
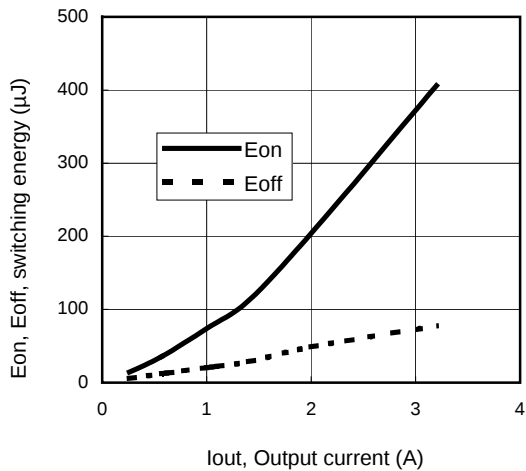


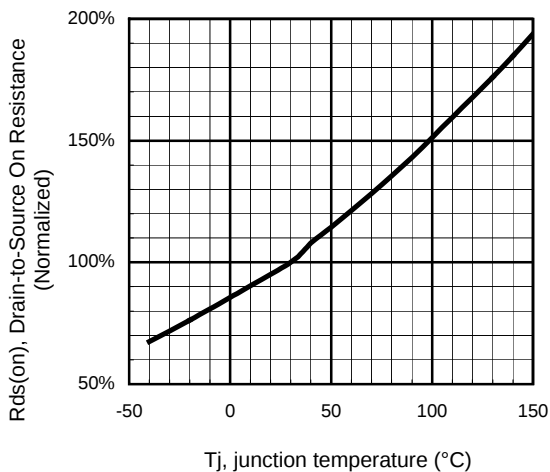
Figure 8 – Transient thermal impedance (°C/W) Vs time (s)



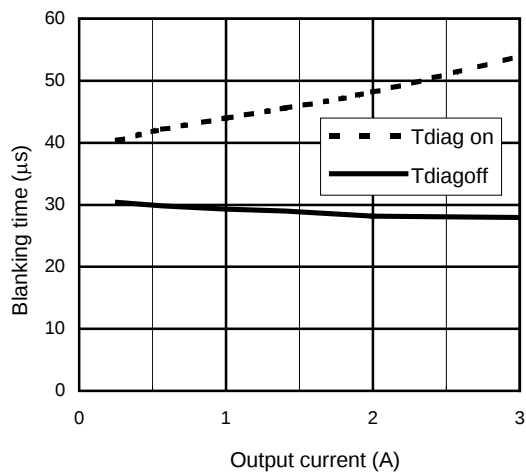
**Figure 9 – I limit (A)  
Vs junction temperature (°C)**



**Figure 10 – Switching energy (μJ)  
Vs Output current (A)**



**Figure 11 - Normalized R<sub>ds(on)</sub> (%) Vs T<sub>j</sub> (°C)**



**Figure 12 – Diagnosis Blanking time (μs)  
Vs Output current (A)**

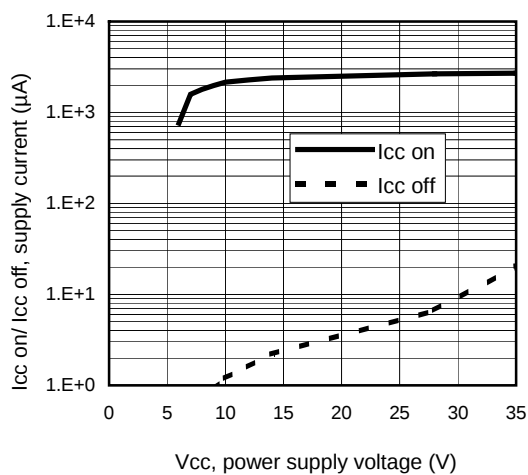


Figure 13 – Icc on/ Icc off (μA) Vs Vcc (V)

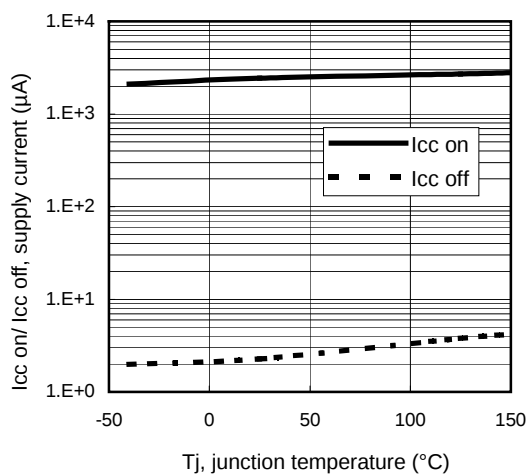
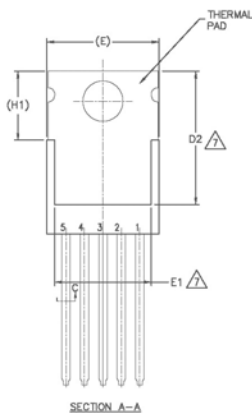
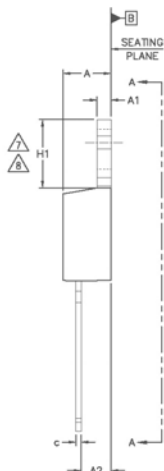
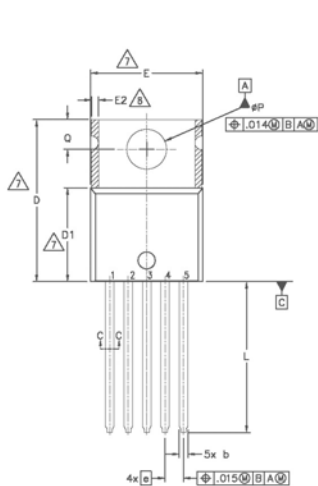


Figure 14 – Icc on/ Icc off (μA) Vs Tj (°C)

## Case outline - TO220

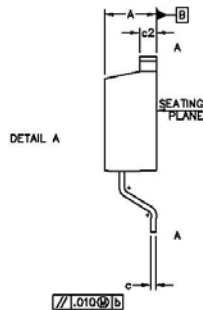
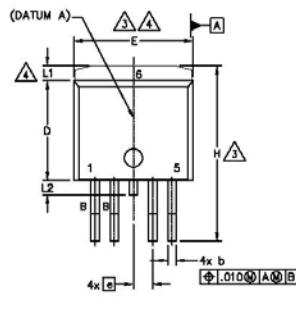
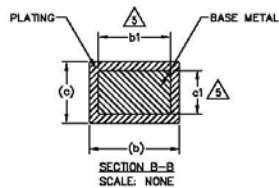
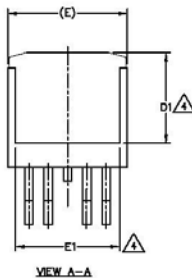
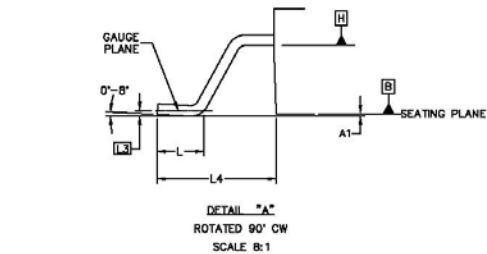


| SYMBOL | DIMENSIONS  |       |          |      | UNIT |
|--------|-------------|-------|----------|------|------|
|        | MILLIMETERS |       | INCHES   |      |      |
|        | MIN.        | MAX.  | MIN.     | MAX. |      |
| A      | 3.56        | 4.83  | .140     | .190 | 5    |
| A1     | 0.51        | 1.40  | .020     | .055 |      |
| A2     | 2.03        | 2.92  | .080     | .115 |      |
| b      | 0.64        | 0.89  | .025     | .035 |      |
| b1     | 0.64        | 0.84  | .025     | .033 |      |
| c      | 0.36        | 0.61  | .014     | .024 | 5    |
| c1     | 0.36        | 0.56  | .014     | .022 |      |
| D      | 14.22       | 16.51 | .560     | .650 | 4    |
| D1     | 8.38        | 9.02  | .330     | .355 |      |
| D2     | 11.68       | 12.88 | .460     | .507 | 7    |
| E      | 9.65        | 10.67 | .380     | .420 |      |
| E1     | 6.86        | 8.89  | .270     | .350 | 7    |
| E2     | —           | 0.76  | —        | .030 |      |
| e      | 1.70 BSC    |       | .067 BSC |      | 7,8  |
| H1     | 5.84        | 6.86  | .230     | .270 |      |
| L      | 12.70       | 14.73 | .500     | .580 |      |
| ϕP     | 3.53        | 3.73  | .139     | .147 |      |
| Q      | 2.54        | 3.05  | .100     | .120 |      |

### NOTES:

- 1.— DIMENSIONING AND TOLERANCING AS PER ASME Y14.5 M— 1994.
- 2.— DIMENSIONS ARE SHOWN IN INCHES [MILLIMETERS].
- 3.— LEAD DIMENSION AND FINISH UNCONTROLLED IN L1.
- 4.— DIMENSION D, D1 & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED .005" (0.127) PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY.
- 5.— DIMENSION M1 & c1 APPLY TO BASE METAL ONLY.
- 6.— CONTROLLING DIMENSION : INCHES.
- 7.— THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSIONS E,H1,D2 & E1
- 8.— DIMENSION E2 X H1 DEFINE A ZONE WHERE STAMPING AND SINGULATION IRREGULARITIES ARE ALLOWED
- 9.— OUTLINE CONFORMS TO JEDEC TO-220, EXCEPT A2 (max.) AND D2 (min.) WHERE DIMENSIONS ARE DERIVED FROM THE ACTUAL PACKAGE OUTLINE.
- 10.— LEADS AND DRAIN ARE PLATED WITH 100% Sn

## Case outline – D<sup>2</sup>Pak

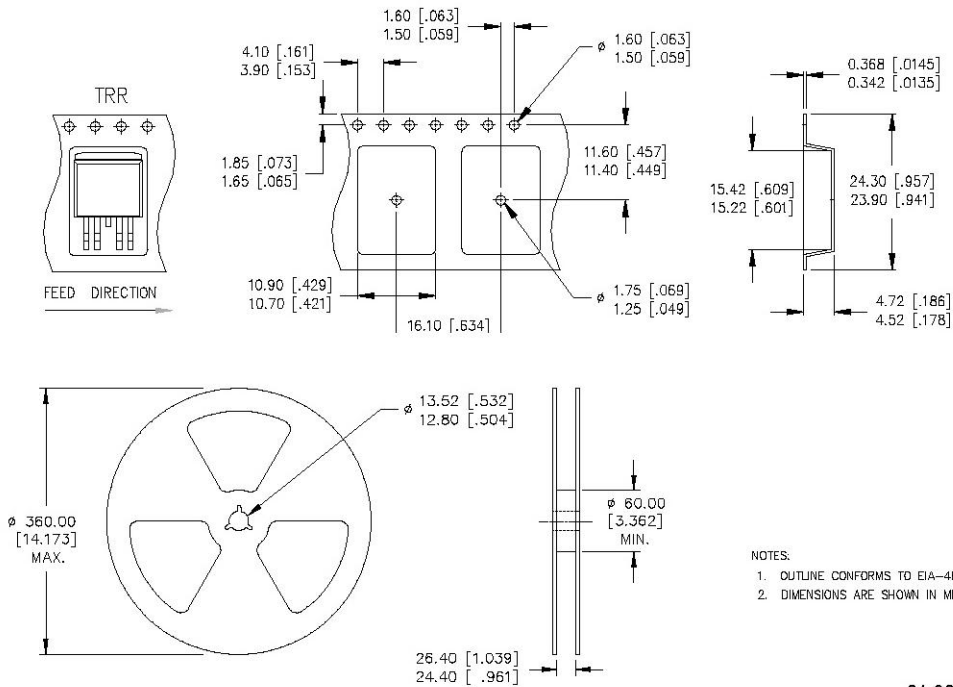


### NOTES:

1. DIMENSIONING AND TOLERANCING AS PER ASME Y14.5M-1994
2. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES]
3. DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.127 [.005"] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY AT DATUM H.
4. THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSION E, L1, D1 & E1.
5. DIMENSION b1 AND c1 APPLY TO BASE METAL ONLY.
6. DATUM A & B TO BE DETERMINED AT DATUM PLANE H.
7. CONTROLLING DIMENSION: INCH.
8. OUTLINE CONFORMS TO JEDEC OUTLINE TO-263BA.
9. LEADS AND DRAIN ARE PLATED : 100% Sn

| SYMBOL | DIMENSIONS  |       |        |      | NOTES |
|--------|-------------|-------|--------|------|-------|
|        | MILLIMETERS |       | INCHES |      |       |
|        | MIN.        | MAX.  | MIN.   | MAX. |       |
| A      | 4.06        | 4.83  | .160   | .190 | 4     |
| A1     | —           | 0.254 | —      | .010 |       |
| b      | 0.51        | 0.99  | .020   | .039 |       |
| b1     | 0.51        | 0.89  | .020   | .035 |       |
| c      | 0.38        | 0.74  | .015   | .029 | 4     |
| c1     | 0.38        | 0.58  | .015   | .023 |       |
| c2     | 1.14        | 1.65  | .045   | .065 |       |
| D      | 8.38        | 9.65  | .330   | .380 |       |
| D1     | 6.86        | —     | .270   | —    | 3     |
| E      | 9.65        | 10.67 | .380   | .420 |       |
| E1     | 6.22        | —     | .245   | —    |       |
| e      | 1.70        | BSC   | .067   | BSC  |       |
| H      | 14.61       | 15.88 | .575   | .625 |       |
| L      | 1.78        | 2.79  | .070   | .110 |       |
| L1     | —           | 1.68  | —      | .066 |       |
| L2     | —           | 1.78  | —      | .070 |       |
| L3     | 0.25        | BSC   | .010   | BSC  |       |
| L4     | 4.78        | 5.28  | .188   | .208 |       |

## Tape and reel – D<sup>2</sup>Pak



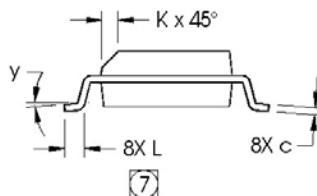
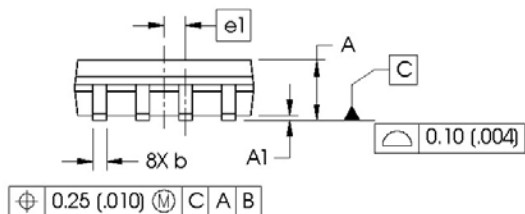
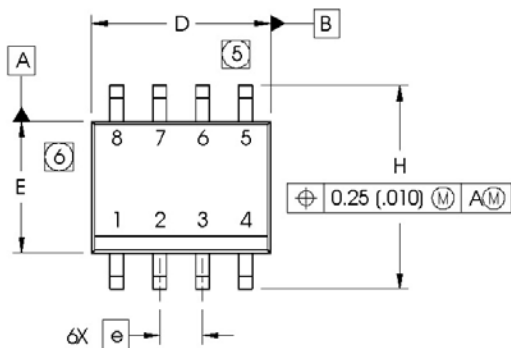
NOTES:

1. OUTLINE CONFORMS TO EIA-481 & EIA-541.
2. DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].

01-3071 00 / 01-3072 00

## Case Outline - SO-8

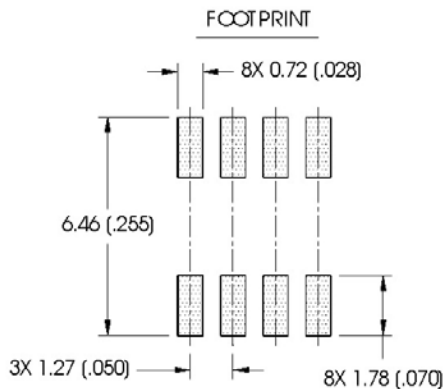
Dimensions are shown in millimeters (inches)



| DIM | INCHES     |       | MILLIMETERS |      |
|-----|------------|-------|-------------|------|
|     | MIN        | MAX   | MIN         | MAX  |
| A   | .0532      | .0688 | 1.35        | 1.75 |
| A1  | .0040      | .0098 | 0.10        | 0.25 |
| b   | .013       | .020  | 0.33        | 0.51 |
| c   | .0075      | .0098 | 0.19        | 0.25 |
| D   | .189       | .1968 | 4.80        | 5.00 |
| E   | .1497      | .1574 | 3.80        | 4.00 |
| e   | .050 BASIC |       | 1.27 BASIC  |      |
| e1  | .025 BASIC |       | 0.635 BASIC |      |
| H   | .2284      | .2440 | 5.80        | 6.20 |
| K   | .0099      | .0196 | 0.25        | 0.50 |
| L   | .016       | .050  | 0.40        | 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 0.15 (.006).
6. DIMENSION DOES NOT INCLUDE MOLD PROTRUSIONS. MOLD PROTRUSIONS NOT TO EXCEED 0.25 (.010).
7. DIMENSION IS THE LENGTH OF LEAD FOR SOLDERING TO A SUBSTRATE.



Technical drawing of a 4-hole flange. The main view shows a rectangular flange with four mounting holes. Key dimensions include:
 

- Overall width: 8.0
- Overall height: 12.0
- Distance between hole centers (pitch): 5.5 ± 0.05 (See Note 6)
- Distance from hole center to outer edge (Bo)
- Distance from hole center to mounting hole center (Ao)
- Mounting hole diameter: Ø1.5 ± 0.1/-0.0
- Flange thickness: 2.0 ± 0.05 (See Note 6)
- Flange outer edge radius: R0.3 MAX.
- Flange mounting hole radius: R0.5 Typical
- Section A-A is indicated across the flange.

 Section A-A shows a cross-section of the flange with dimensions:
 

- Overall width: 0.30 ± 0.05
- Flange thickness: 2.0 ± 0.05 (See Note 6)
- Flange outer edge radius: R0.3 MAX.
- Flange mounting hole radius: R0.5 Typical
- Section A-A is indicated across the flange.

- All Dimensions in Millimeters -

REVISION HISTORY  
IPS7091G

| Revision No. | Date     | PD No. & Rev. Letter | Page No. | Description                             | Reason of Change    |
|--------------|----------|----------------------|----------|-----------------------------------------|---------------------|
| 1            |          | 60291_B              | all      | Add new package version : TO220 / D2pak |                     |
| 2            | 09/09/08 | 60291_C              | 7        | Add Rth=100°C/W figure 7                | Information missing |