

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

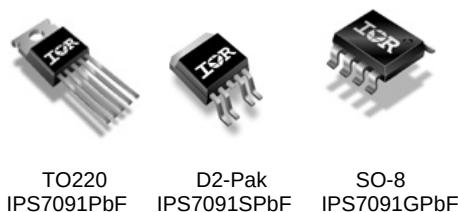
Product Summary

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

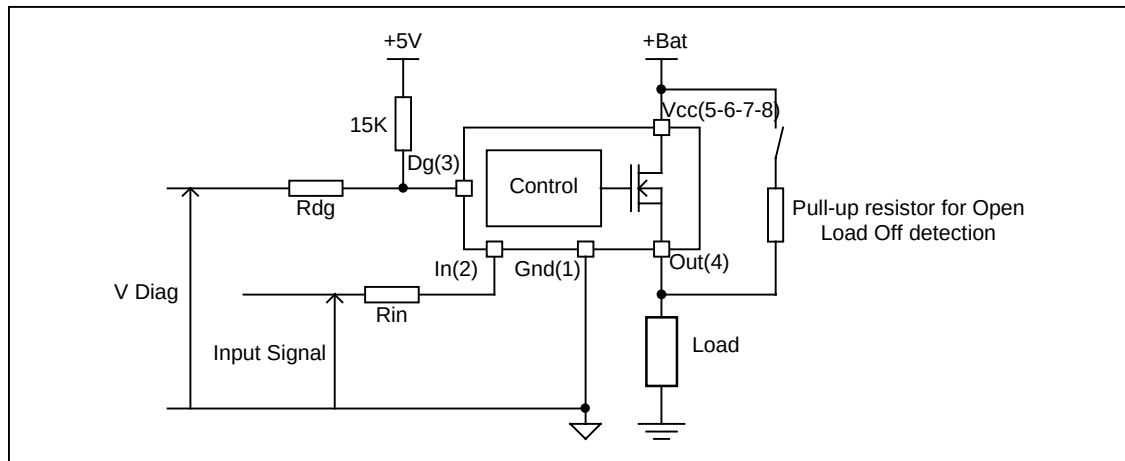
Description

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 _{dg} max.	Maximum diagnostic output current	-1	10	
V _{dg}	Maximum diagnostic output voltage	-0.3	5.5	
Pd	Maximum power dissipation (internally limited by thermal protection) Rth=100°C/W	—	1.25	W
I _{sd} 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 Ω	$V_{in}=5\text{V}$, $I_{out}=2\text{A}$
	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	μA	$V_{in}=0\text{V}$, $V_{out}=0\text{V}$
Icc On	Supply current when On	—	2.5	3.5	mA	$V_{in}=5\text{V}$
Iout@0V	Output leakage current	—	—	10	μA	$V_{out}=0\text{V}$
Iout@6V	Output leakage current	—	20	—		$V_{out}=6\text{V}$
I _{dg} leakage	Diagnostic output leakage current	—	—	10		$V_{dg}=5.5\text{V}$
V _{dgl}	Low level diagnostic output voltage	—	0.2	0.3	V	$I_{dg}=1.6\text{mA}$
V _{ih}	Input high threshold voltage	—	2.5	3.5		
V _{il}	Input low threshold voltage	1	2	—		
I _{n hys}	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 _{in} On	Input current when device is On	—	40	80	μA	$V_{in}=5\text{V}$

Switching Electrical Characteristics

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

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Tdon	Turn-on delay time	—	12	35	μs	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	$\text{V}/\mu\text{s}$	
EOn	Turn On energy	—	250	—	μJ	
Tdoff	Turn-off delay time	—	20	45	μs	
Tf	Fall time to $V_{out}=0.1 \times V_{CC}$	—	6	25	μs	
dV/dt (Off)	Turn Off dV/dt	—	1.8	5.5	$\text{V}/\mu\text{s}$	See Fig. 4 and Fig. 12
EOff	Turn Off energy	—	20	—	μJ	
Tdiag	Vout to Vdiag propagation delay	—	15	—	μs	

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

(2) Reference to V_{CC}

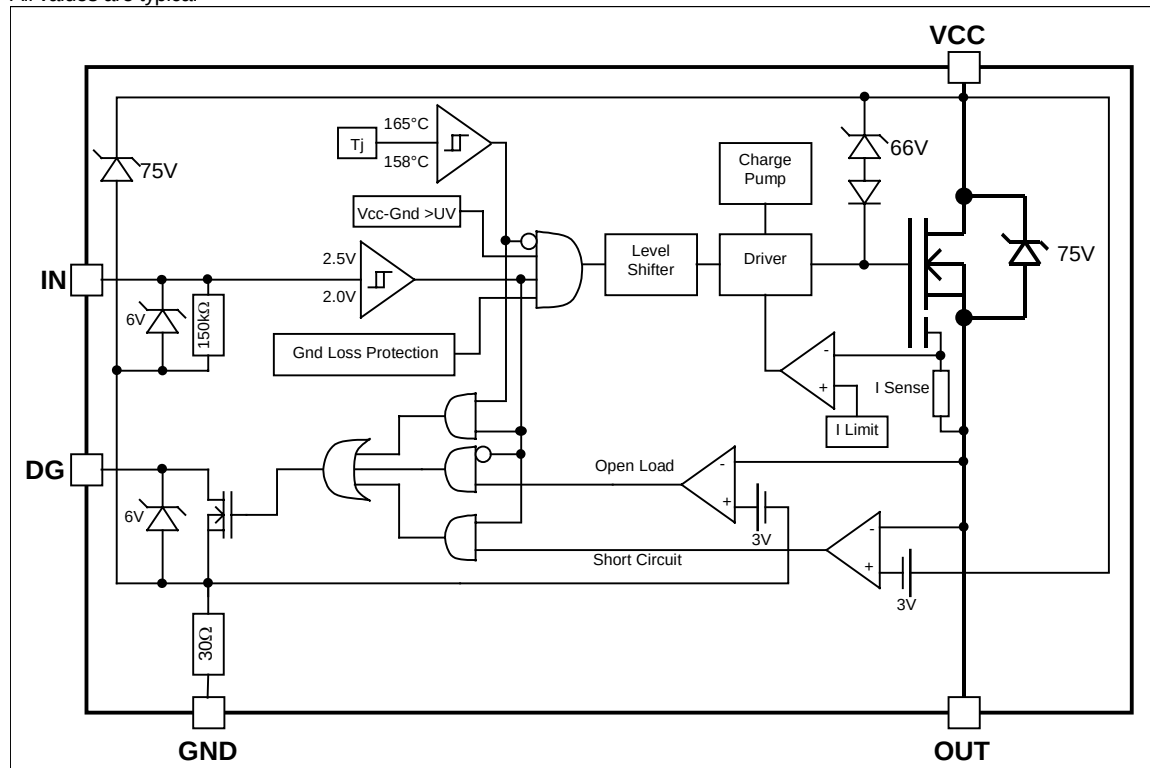
Operating Conditions	IN	OUT	DG pin
Normal	H	H	H
Normal	L	L	L
Open Load	H	H	H
Open Load ⁽³⁾	L	H	H
Short circuit to Gnd	H	L (limiting)	L
Short circuit to Gnd	L	L	L
Over-temperature	H	L (cycling)	L
Over-temperature	L	L	L

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

The diagram illustrates three different package types for the 74VHC04:

- SO8:** A small surface-mount package with 8 pins. Pin 1 is Gnd, Pin 2 is In, Pin 3 is DG, Pin 4 is Out, and Pins 5-8 are Vcc.
- TO220:** A through-hole package with 5 pins. Pin 1 is Gnd, Pin 2 is In, Pin 3 is Vcc, Pin 4 is Dg, and Pin 5 is Out.
- D²Pak:** A surface-mount package with 5 pins. Pin 1 is Gnd, Pin 2 is In, Pin 3 is Vcc, Pin 4 is Dg, and Pin 5 is Out.

All values are typical



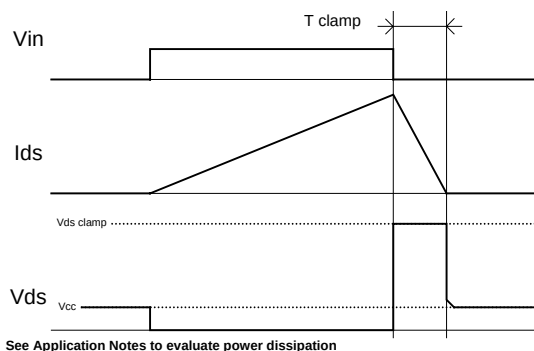


Figure 1 – Active clamp waveforms

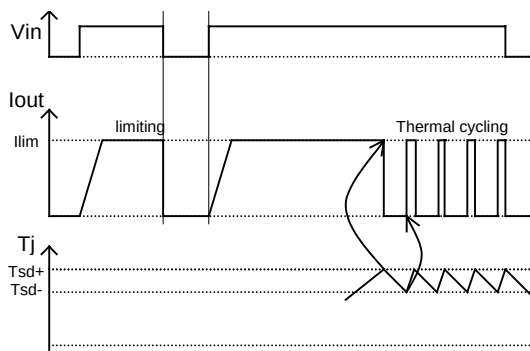


Figure 2 – Protection timing diagram

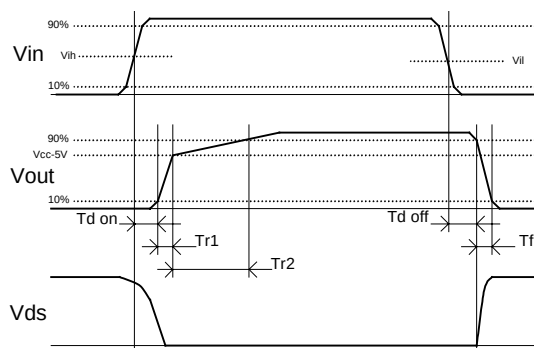


Figure 3 – Switching times definition

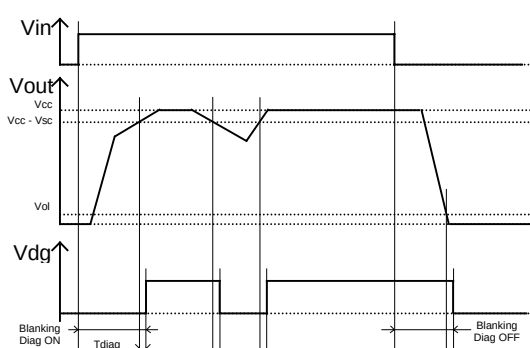


Figure 4 – Diagnostic delay definition

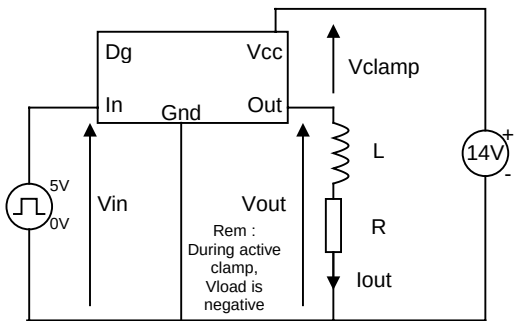


Figure 5 – Active clamp test circuit

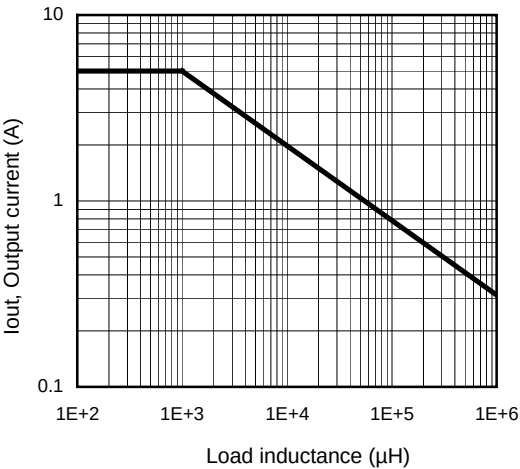


Figure 6 – Max. Output current (A) Vs Load inductance (μH)

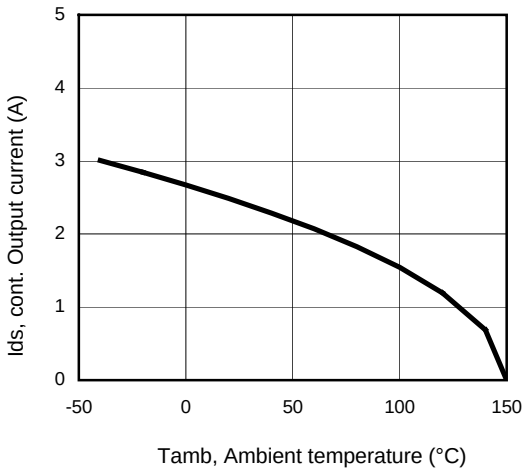


Figure 7 – Max. output current (A) Vs Ambient temperature (°C)

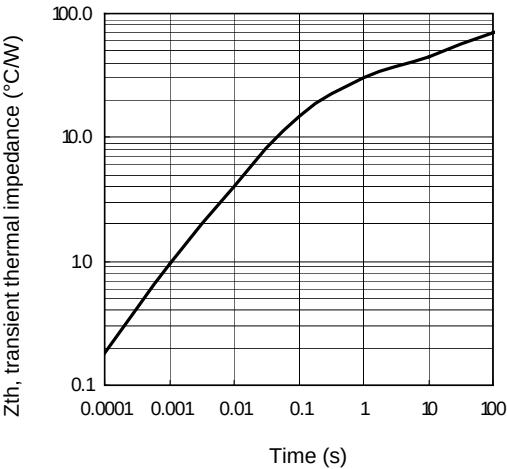
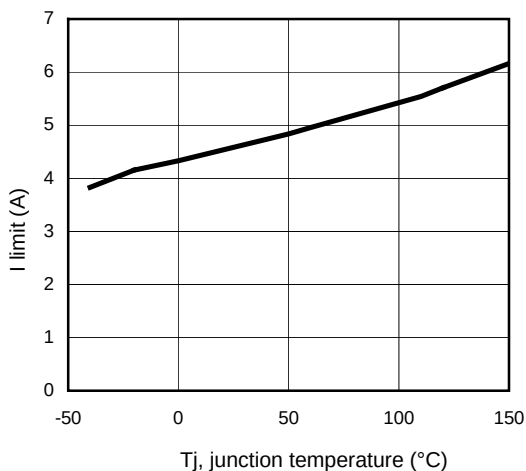
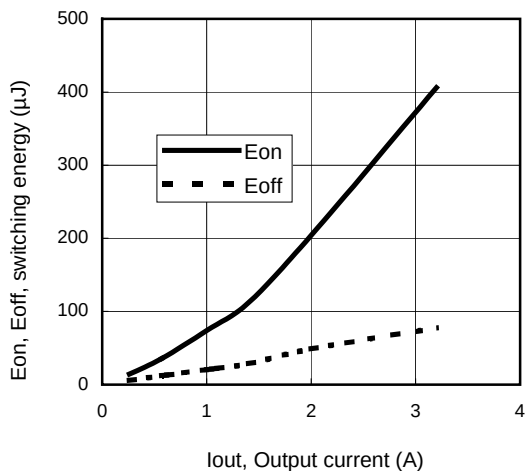


Figure 8 – Transient thermal impedance (°C/W) Vs time (s)



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



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

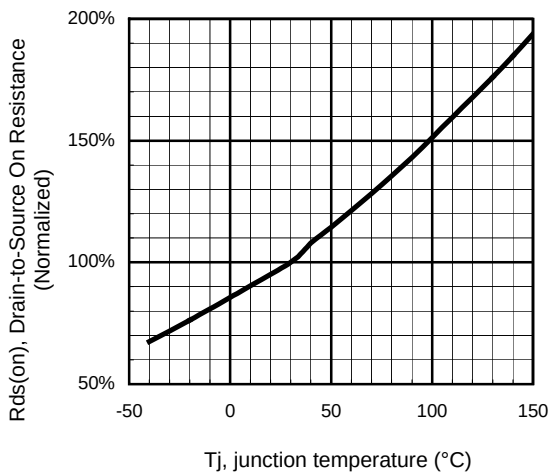
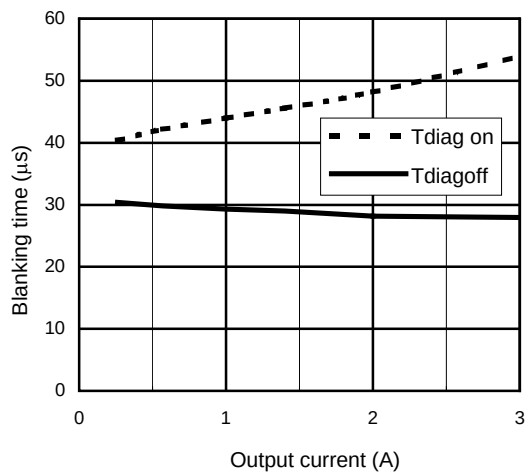


Figure 11 - Normalized R_{ds(on)} (%) Vs T_j (°C)



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

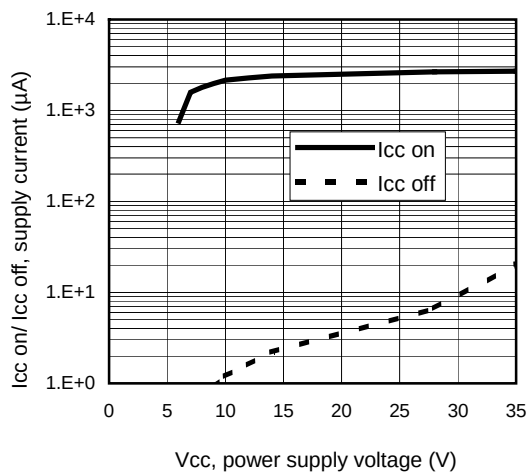


Figure 13 – Icc on/ Icc off (μA) Vs Vcc (V)

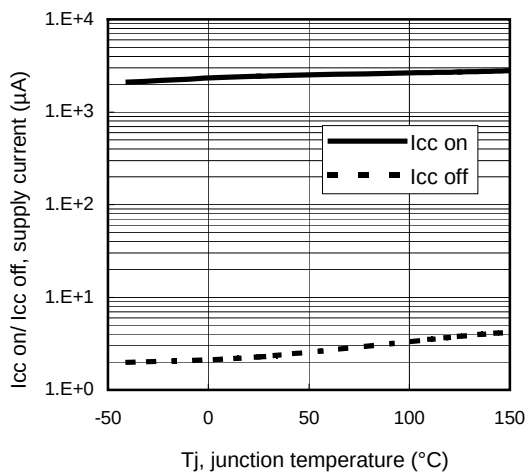
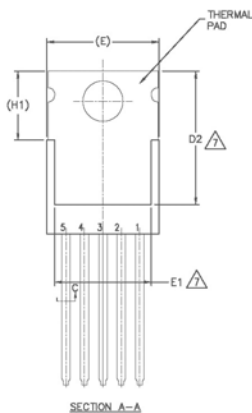
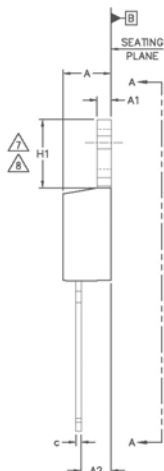
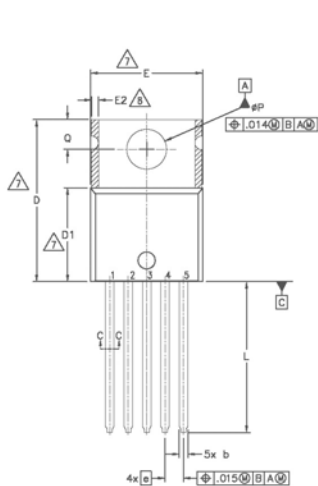


Figure 14 – Icc on/ Icc off (μA) Vs Tj (°C)

Case outline - TO220

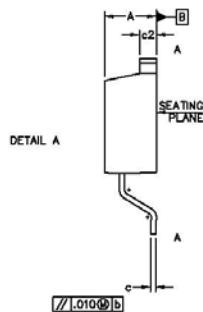
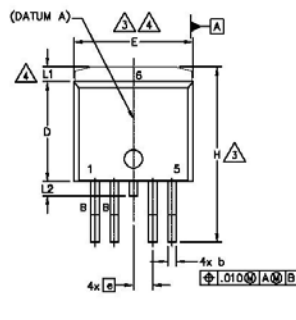
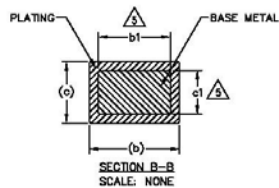
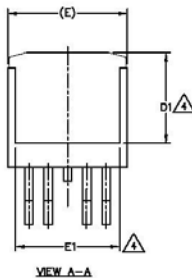
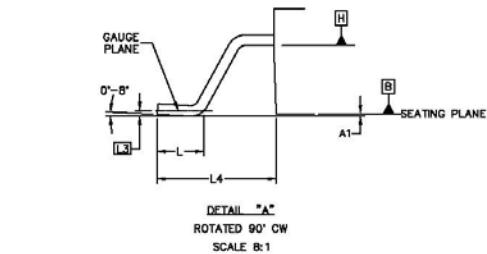


SYMBOL	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	3.56	4.83	.140	.190	
A1	0.51	1.40	.020	.055	
A2	2.03	2.92	.080	.115	
b	0.64	0.89	.025	.035	5
b1	0.64	0.84	.025	.033	
c	0.36	0.61	.014	.024	
c1	0.36	0.56	.014	.022	5
D	14.22	16.51	.560	.650	4
D1	8.38	9.02	.330	.355	
D2	11.68	12.88	.460	.507	7
E	9.68	10.67	.380	.420	4,7
E1	6.86	8.89	.270	.350	7
E2		0.76		.030	8
e	1.70 BSC		.067 BSC		
H1	5.84	6.86	.230	.270	7,8
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 b1 & 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 – D²Pak

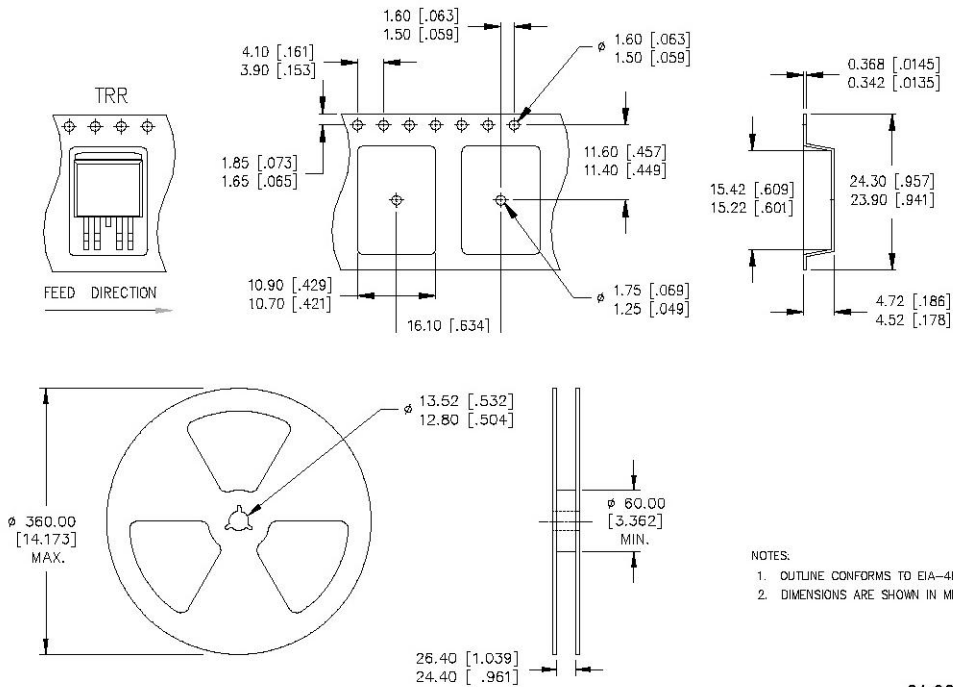


NOTES:

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 [0.005] 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

SYMBO L	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	3
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	

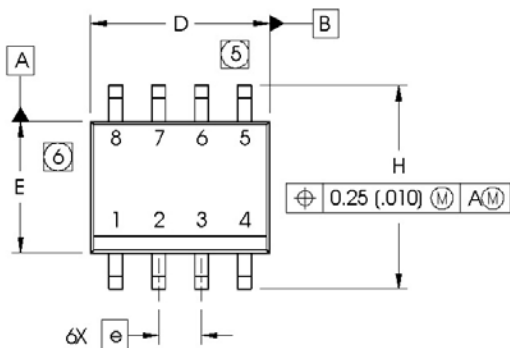
Tape and reel – D²Pak



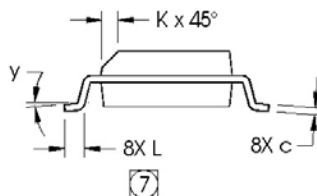
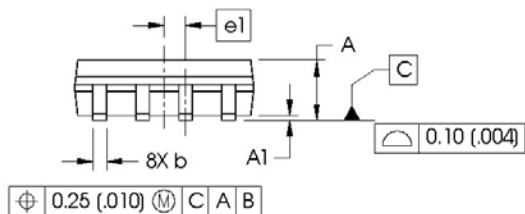
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Case Outline - SO-8

Dimensions are shown in millimeters (inches)

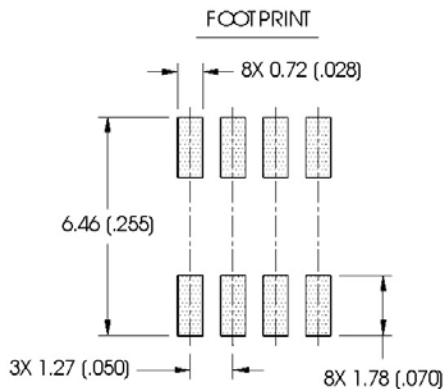


DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	.0532	.0688	1.35	1.75
A1	.0040	.0098	0.10	0.25
b	.013	.020	0.33	0.51
c	.0075	.0098	0.19	0.25
D	.189	.1968	4.80	5.00
E	.1497	.1574	3.80	4.00
e	.050 BASIC		1.27 BASIC	
e1	.025 BASIC		0.635 BASIC	
H	.2284	.2440	5.80	6.20
K	.0099	.0196	0.25	0.50
L	.016	.050	0.40	1.27
y	0°	8°	0°	8°

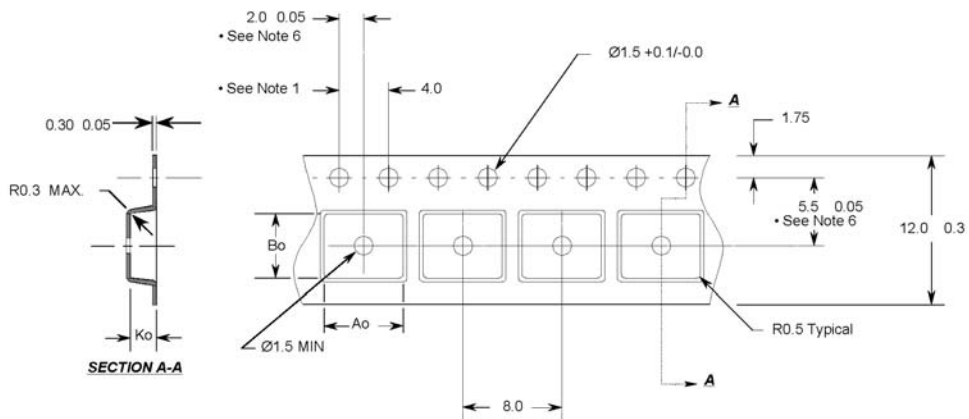


NOTES:

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.



Tape & Reel - SO-8



Notes:

1. 10 sprocket hole pitch cumulative tolerance 0.2
2. Camber not to exceed 1mm in 100mm
3. Material: Black Conductive Advantek Polystyrene
4. Ao and Bo measured on a plane 0.3mm above the bottom of the pocket
5. Ko measured from a plane on the inside bottom of the pocket to the top surface of the carrier.
6. Pocket position relative to sprocket hole measured as true position of pocket, not pocket hole.

$A_o = 6.4 \text{ mm}$
 $B_o = 5.2 \text{ mm}$
 $K_o = 2.1 \text{ mm}$

- All Dimensions in Millimeters -