

INTELLIGENT POWER HIGH SIDE SWITCH

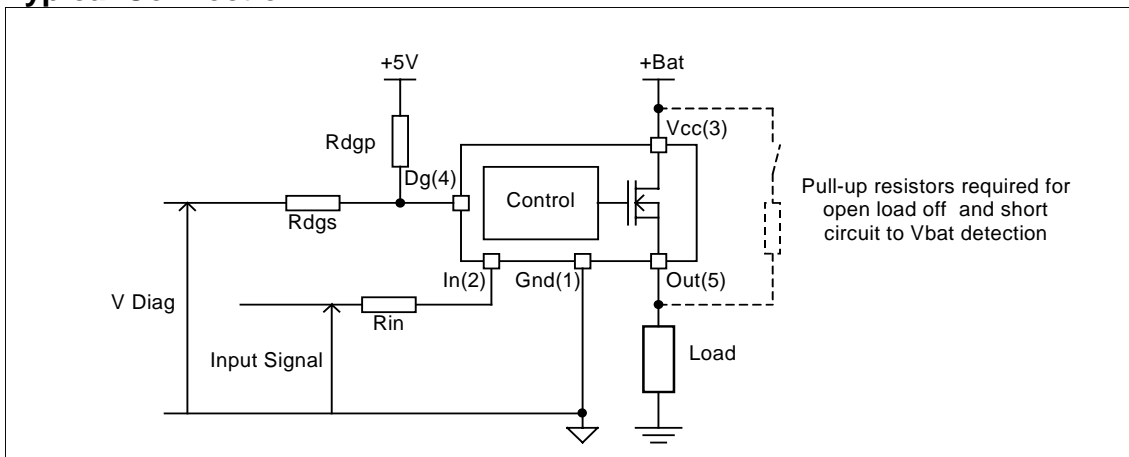
Features

- Over temperature shutdown (with auto-restart)
- Short circuit protection (current limit)
- Reverse battery protection (turns On the MOSFET)
- Full diagnostic capability (short circuit to battery)
- Active clamp
- Open load detection in On and Off state
- Ground loss protection
- Logic ground isolated from power ground
- ESD protection

Description

The IPS6031(S)(R)PbF is a five terminal Intelligent Power Switch (IPS) for use in a high side configuration. It features short circuit, over-temperature, ESD protection, inductive load capability and diagnostic feedback. The output current is limited to the I_{lim} value. The current limitation is activated until the thermal protection acts. The over-temperature protection turns off the device if the junction temperature exceeds the T_{shutdown} value. It will automatically restart after the junction has cooled 7°C below the T_{shutdown} value. The reverse battery protection turns On the MOSFET. A diagnostic pin provides different voltage levels for each fault condition. The double level shifter circuitry will allow large offsets between the logic and load ground.

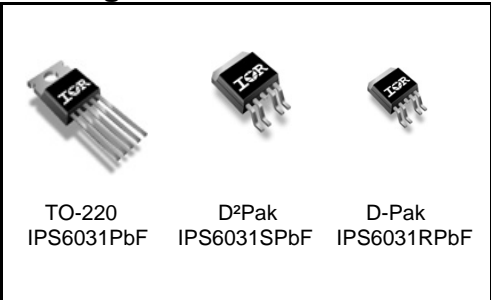
Typical Connection



Product Summary

R _{ds(on)}	60mΩ max.
V _{clamp}	39V
I _{Limit}	16A
Open load	3V / 0.55A

Packages



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_{ambient}=25°C unless otherwise specified).

Symbol	Parameter	Min.	Max.	Units
V _{out}	Maximum output voltage	V _{CC} -35	V _{CC} +0.3	V
V _{offset}	Maximum logic ground to load ground offset	V _{CC} -35	V _{CC} +0.3	
V _{in}	Maximum input voltage	-0.3	5.5	
V _{CC} max.	Maximum V _{CC} voltage	—	36	
V _{CC} cont.	Maximum continuous V _{CC} voltage	—	28	
V _{CC} sc.	Maximum V _{CC} voltage with short circuit protection	—	30	
I _{in} max.	Maximum I _N current	-3	10	mA
I _{dg} max.	Maximum diagnostic output current	-3	10	
V _{dg}	Maximum diagnostic output voltage	-0.3	5.5	V
P _d	Maximum power dissipation (internally limited by thermal protection)			W
	R _{th} =5°C/W IPS6031	—	25	
	R _{th} =40°C/W IPS6031S 1" sqrt. footprint	—	3.1	
	R _{th} =50°C/W IPS6031R 1" sqrt. footprint	—	2.5	
ESD	Electrostatic discharge voltage (Human body) C=100pF, R=1500Ω			V
	Between I _n and V _{CC}	—	1500	
	Other combinations	—	4000	
	Electrostatic discharge voltage (Machine Model) C=200pF, R=0Ω, L=10μH			
	Between I _n and V _{CC}	—	100	
	Other combinations	—	500	
T _j max.	Max. storage & operating temperature junction temperature	-40	150	°C
T _{soldering}	Soldering temperature (10 seconds)	—	300	°C

Thermal Characteristics

Symbol	Parameter	Typ.	Max.	Units
R _{th1}	Thermal resistance junction to ambient IPS6031 TO220 free air	50	—	°C/W
R _{th2}	Thermal resistance junction to case IPS6031 TO220	3.8	—	
R _{th1}	Thermal resistance junction to ambient IPS6031S D ² Pak std. footprint	60	—	
R _{th2}	Thermal resistance junction to ambient IPS6031S D ² Pak 1" sqrt. footprint	40	—	
R _{th3}	Thermal resistance junction to case IPS6031S D ² Pak	3.8	—	
R _{th1}	Thermal resistance junction to ambient IPS6031R D-Pak std. footprint	70	—	
R _{th2}	Thermal resistance junction to ambient IPS6031R D-Pak 1" sqrt. footprint	50	—	
R _{th3}	Thermal resistance junction to case IPS6031R D-Pak	3.8	—	

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 _{IH}	High level input voltage	4	5.5	
V _{IL}	Low level input voltage	0	0.9	
I _{out}	Continuous drain current, T _{ambient} =85°C, T _j =125°C, V _{in} =5V			A
	R _{th} =5°C/W IPS6031	—	8.9	
	R _{th} =40°C/W IPS6031S 1" sqrt. footprint	—	3.1	
	R _{th} =50°C/W IPS6031R 1" sqrt. footprint	—	2.8	
R _{in}	Recommended resistor in series with I _N pin	4	10	kΩ
R _{dgS}	Recommended resistor in series with DG pin for reverse battery protection	4	20	
R _{dgP}	Recommended pull-up resistor for DG	4	20	
R _{ol}	Recommended pull-up resistor for open load detection	5	100	
F _{max}	Max. switching frequency	—	2.5	

Static Electrical Characteristics

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

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
R _{ds(on)}	ON state resistance T _j =25°C	—	46	60	mΩ	V _{in} =5V, I _{out} =5A
	ON state resistance T _j =150°C	—	83	100		V _{in} =5V, I _{out} =5A
	ON state resistance T _j =25°C, V _{cc} =6V	—	55	72		V _{in} =5V, I _{out} =2.5A
	ON state resistance during reverse battery	—	60	80		V _{cc} -Gnd=14V
V _{cc op.}	Operating voltage range	6	—	28	V	
V clamp 1	V _{cc} to Out clamp voltage 1	37	39	—		I _{out} =30mA
V clamp 2	V _{cc} to Out clamp voltage 2	—	40	42		I _{out} =4A (see Fig. 1)
I _{cc Off}	Supply current when Off	—	4	9	μA	V _{in} =0V, V _{out} =0V
I _{cc On}	Supply current when On	—	2.2	5	mA	V _{in} =5V
V _{ih}	Input high threshold voltage	—	2.5	2.9	V	
V _{il}	Input low threshold voltage	1.5	2	—		
I _{n hyst.}	Input hysteresis	0.2	0.5	1		
I _{in On}	Input current when device is On	—	45	100		μA
I _{dg}	Dg leakage current	—	0.1	10	V	V _{dg} =5V
V _{dg}	Low level DG voltage	—	0.25	0.4		I _{dg} =1.6mA

Switching Electrical Characteristics

V_{cc}=14V, Resistive load=6Ω, V_{in}=5V, T_j=25°C

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
T _{don}	Turn-on delay time	—	8	25	μs	see Fig. 3
Tr1	Rise time to V _{out} =V _{cc} -5V	—	5	20		
Tr2	Rise time to V _{out} =0.9 x V _{cc}	—	8	35		
dV/dt (On)	Turn On dV/dt	—	1.5	2.5	V/μs	
E _{On}	Turn On energy	—	150	—	μJ	
T _{doff}	Turn-off delay time	—	20	45	μs	
T _f	Fall time to V _{out} =0.1 x V _{cc}	—	9	30	V/μs	
dV/dt (Off)	Turn Off dV/dt	—	3	10		
E _{Off}	Turn Off energy	—	65	—	μJ	

Protection Characteristics

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Ilim	Internal current limit	10	16	23	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		
UV		—	5	5.9	V	
UV hyst.		0.25	—	1.6		
VOL Off	Open load detection threshold	2	3	4		
I OL On	Open load detection threshold	0.15	0.4	0.55	A	

(1) Guaranteed by design

(2) Reference to Vcc

True Table

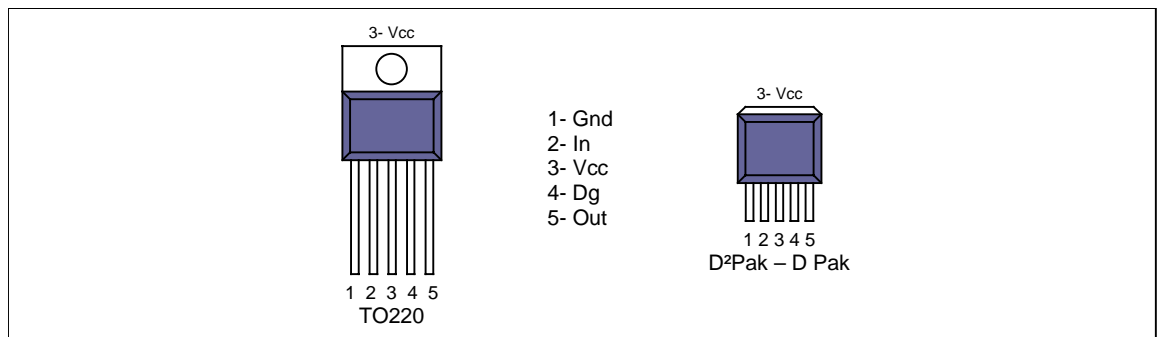
Operating Conditions	IN	OUT	DG
Normal	H	H	H
Normal	L	L	H
Open Load	H	H	L
Open Load (3)	L	H	L
Short circuit to Gnd	H	L	L
Short circuit to Gnd	L	L	H
Short circuit to Vcc	H	H	L (4)
Short circuit to Vcc (5)	L	H	L
Over-temperature	H	L	L
Over-temperature	L	L	H

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

(4) Vds lower than 10mV.

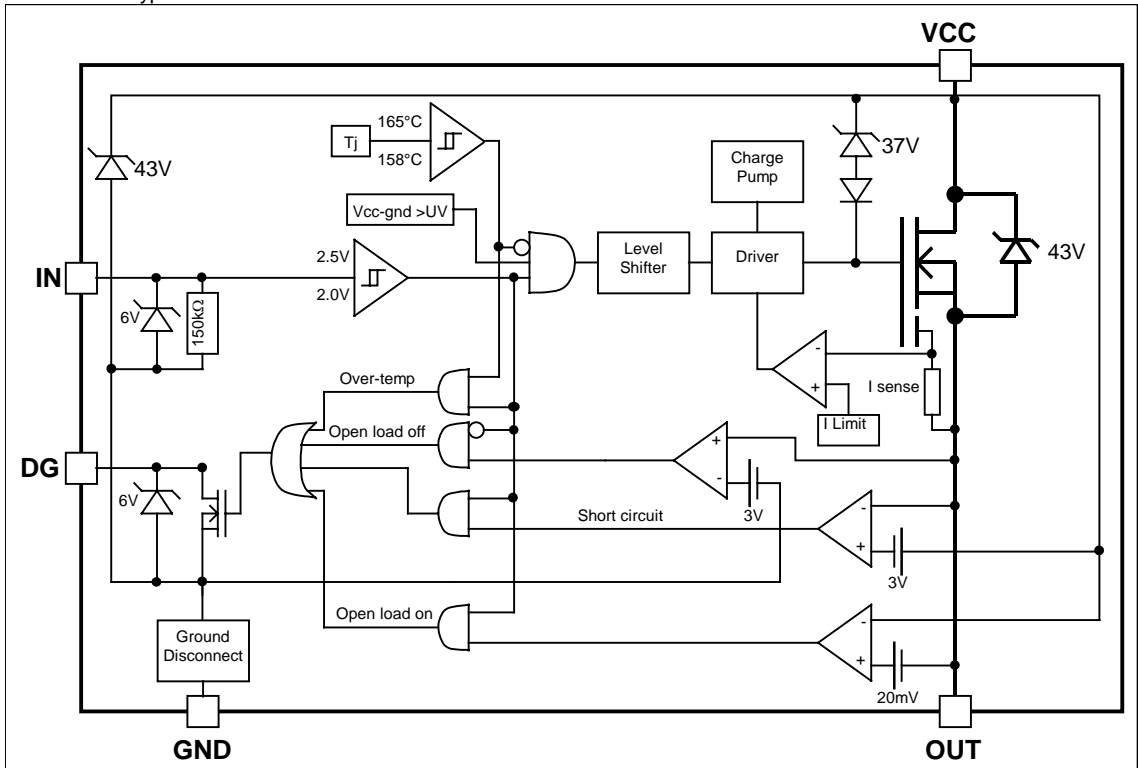
(5) Without a pull-up resistor connected between the output and Vcc.

Lead Assignments



Functional Block Diagram

All values are typical



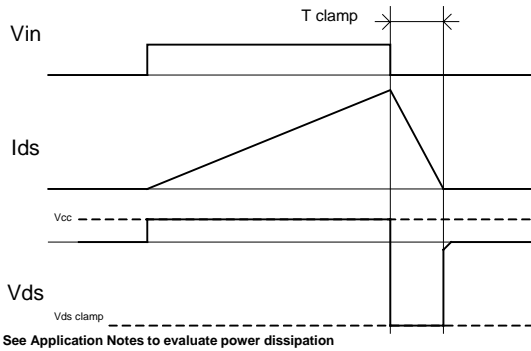


Figure 1 – Active clamp waveforms

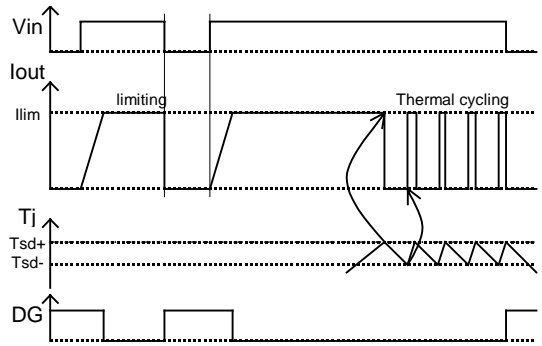


Figure 2 – Protection timing diagram

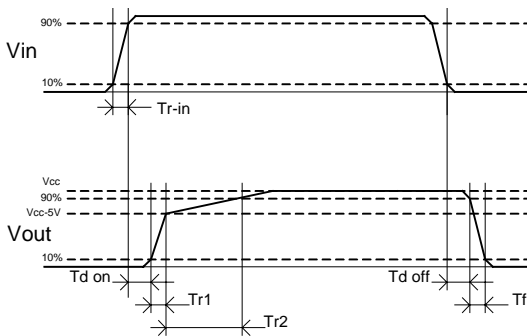


Figure 3 – Switching times definitions

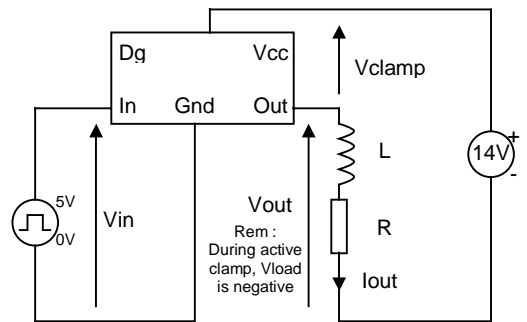


Figure 4 – Active clamp test circuit

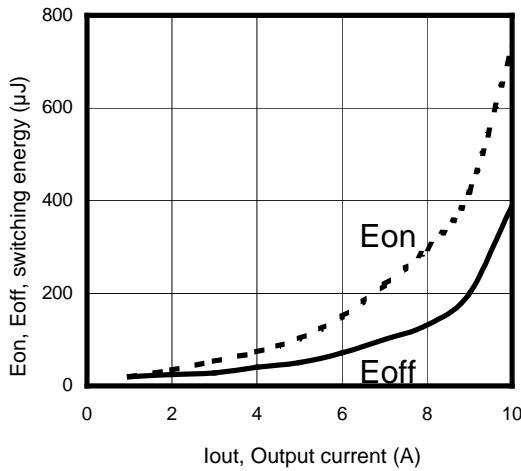


Figure 5 – Switching energy (μJ) Vs Output current (A)

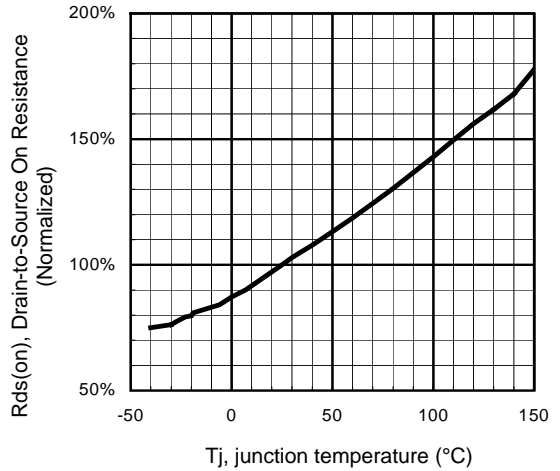


Figure 6 - Normalized $R_{\text{ds(on)}}$ (%) Vs T_j (°C)

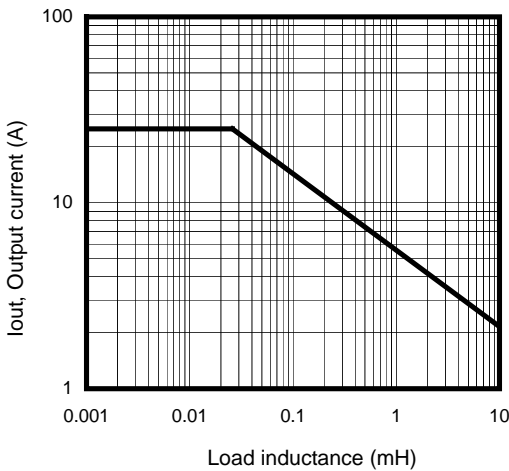


Figure 7 – Max. Output current (A) Vs Load inductance (mH)

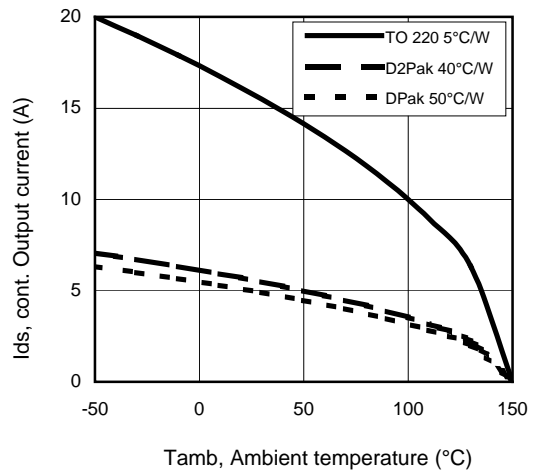


Figure 8 – Max. output current (A) Vs Ambient temperature (°C)

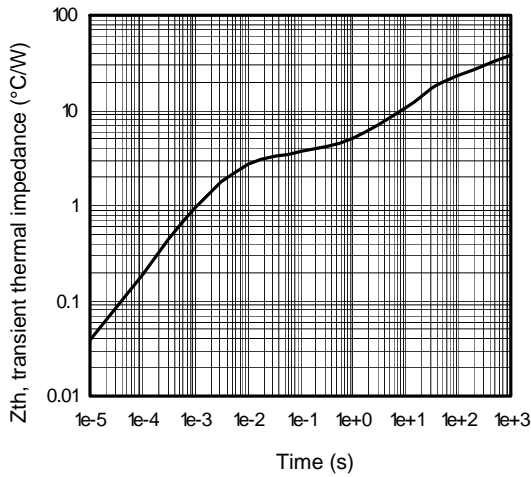


Figure 9 – Transient thermal impedance (°C/W) Vs time (s)

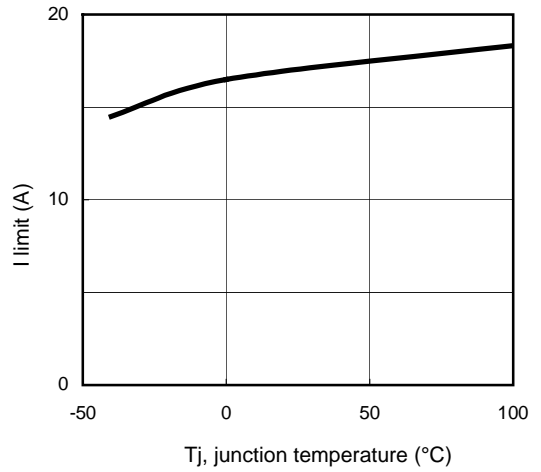


Figure 10 – I limit (A) Vs junction temperature (°C)

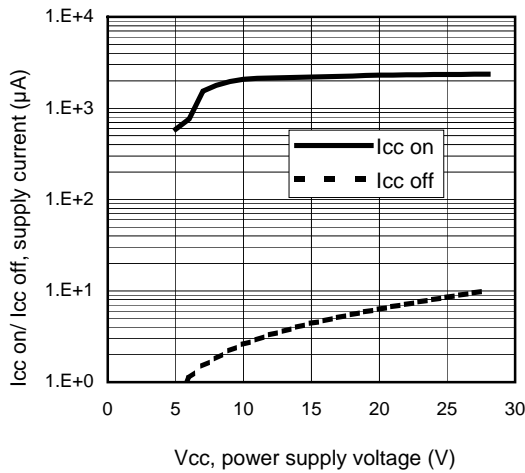


Figure 11 – Icc on/ Icc off (µA) Vs Vcc (V)

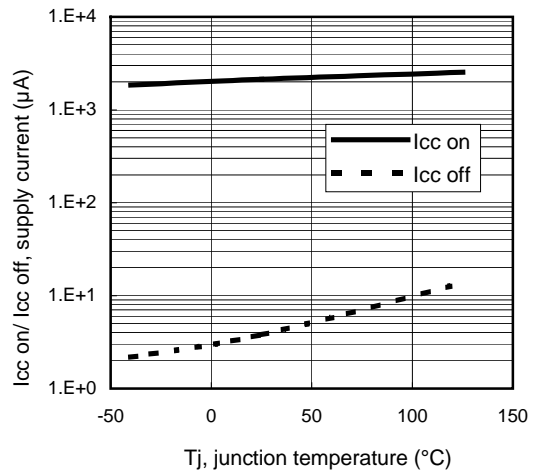
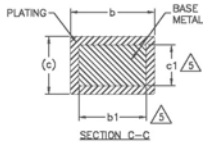
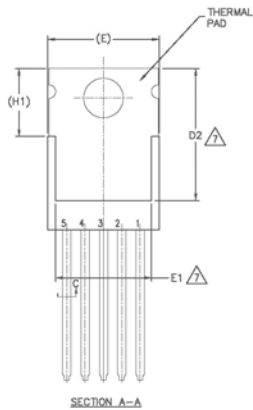
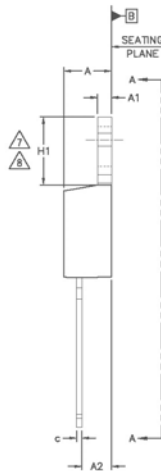
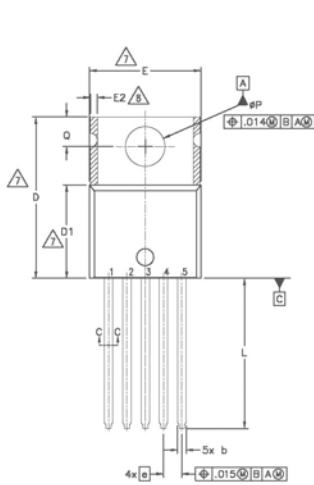


Figure 12 – Icc on/ Icc off (µA) Vs Tj (°C)

Case Outline - TO220 (5 lead) - Automotive Q100 PbF qualified

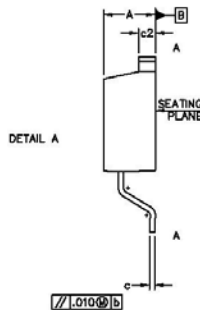
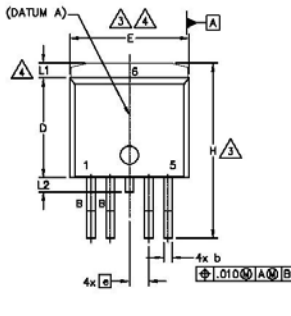
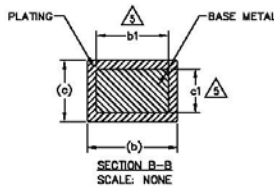
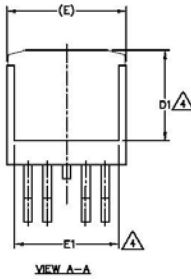
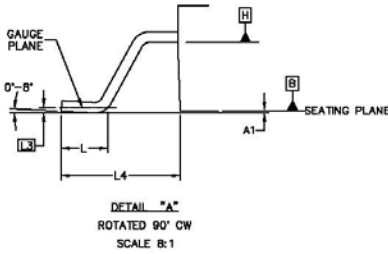


SYMBOL	DIMENSIONS				NOTES	
	MILLIMETERS		INCHES			
	MIN.	MAX.	MIN.	MAX.		
A	3.56	4.83	.140	.190	5	
A1	0.51	1.40	.020	.055		
A2	2.03	2.92	.080	.115		
b	0.64	0.89	.025	.035		
b1	0.64	0.84	.025	.033		
c	0.36	0.61	.014	.024		
c1	0.36	0.56	.014	.022		
D	14.22	16.51	.560	.650		4
D1	8.38	9.02	.330	.355		7
D2	11.68	12.88	.460	.507		
E	9.65	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		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 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 5 Lead - D2PAK - Automotive Q100 PbF MSL1 qualified

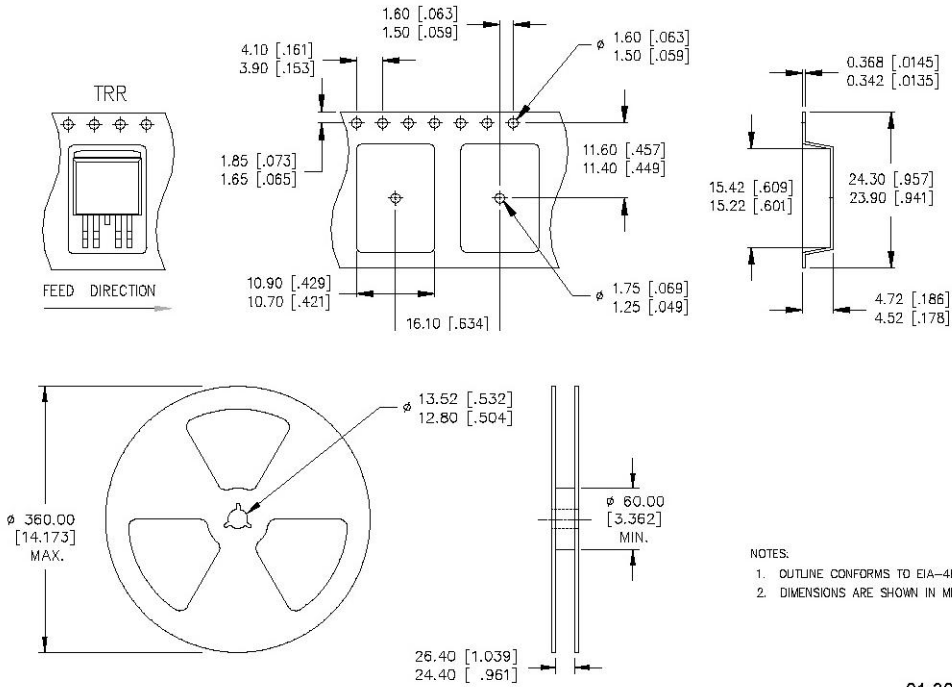


NOTES:

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

SYM- BO- L	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	4.06	4.83	.160	.190	
A1	-	0.254	-	.010	
b	0.51	0.99	.020	.039	4
b1	0.51	0.89	.020	.035	
c	0.38	0.74	.015	.029	
c1	0.38	0.58	.015	.023	4
c2	1.14	1.65	.045	.065	
D	8.38	9.65	.330	.380	3
D1	6.86	-	.270	-	
E	9.65	10.87	.380	.420	3
E1	6.22	-	.245	-	
e	1.70 BSC		.067 BSC		
H	14.61	15.85	.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	

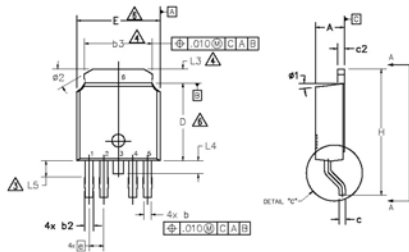
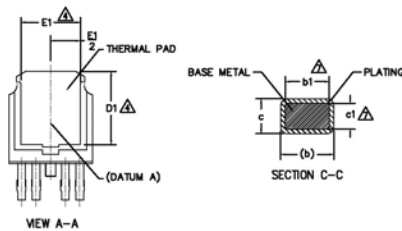
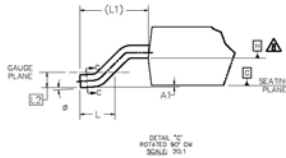
Tape & Reel 5 Lead - D2PAK



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

01-3071 00 / 01-3072 00

Case Outline 5 Lead – DPAK - Automotive Q100 PbF MSL1 qualified



SYMBO L	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	2.18	2.39	.086	.094	
A1	—	0.13	—	.005	
b	0.51	0.89	.020	.035	2
b1	.051	0.84	.020	.033	2
b3	4.95	5.46	.195	.215	2
c	0.46	0.61	.018	.024	
c1	0.41	0.56	.016	.022	2
c2	0.46	0.89	.018	.035	
D	5.97	6.22	.235	.245	3
D1	5.21	—	.205	—	
E	6.35	6.73	.250	.265	3
E1	4.32	—	.170	—	
e	1.14 BSC		.045 BSC		
H	9.40	10.41	.370	.410	
L	1.40	1.78	.055	.070	
L1	2.74 BSC		.108 REF.		
L2	0.51 BSC		.020 BSC		
L3	0.89	1.27	.035	.050	
L4	—	1.02	—	.040	
L5	1.14	1.52	.045	.060	
φ	0"	10"	0"	10"	
φ1	0"	15"	0"	15"	
φ2	28"	32"	28"	32"	

NOTES:

- 1.- DIMENSIONING AND TOLERANCING AS PER ASME Y14.5M-1994
- 2.- DIMENSIONS ARE SHOWN IN INCHES [MILLIMETERS].
- 3.- LEAD DIMENSION UNCONTROLLED IN L5.
- 4.- DIMENSION D1, E1, L3 & b3 ESTABLISH A MINIMUM MOUNTING SURFACE FOR THERMAL PAD.
- 5.- SECTION C-C DIMENSIONS APPLY TO THE FLAT SECTION OF THE LEAD BETWEEN .005 AND 0.10 [0.13 AND 0.25] FROM THE LEAD TIP.
- 6.- DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED .005 [0.13] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY.
- 7.- DIMENSION b1 & c1 APPLIED TO BASE METAL ONLY.
- 8.- DATUM A & B TO BE DETERMINED AT DATUM PLANE H.
- 9.- OUTLINE CONFORMS TO JEDEC OUTLINE TO-252.
10. LEADS AND DRAIN ARE PLATED WITH 100% Sn

Note: For the most current drawings please refer to the IR website at:
<http://www.irf.com/package/>