

INTELLIGENT POWER HIGH SIDE SWITCH

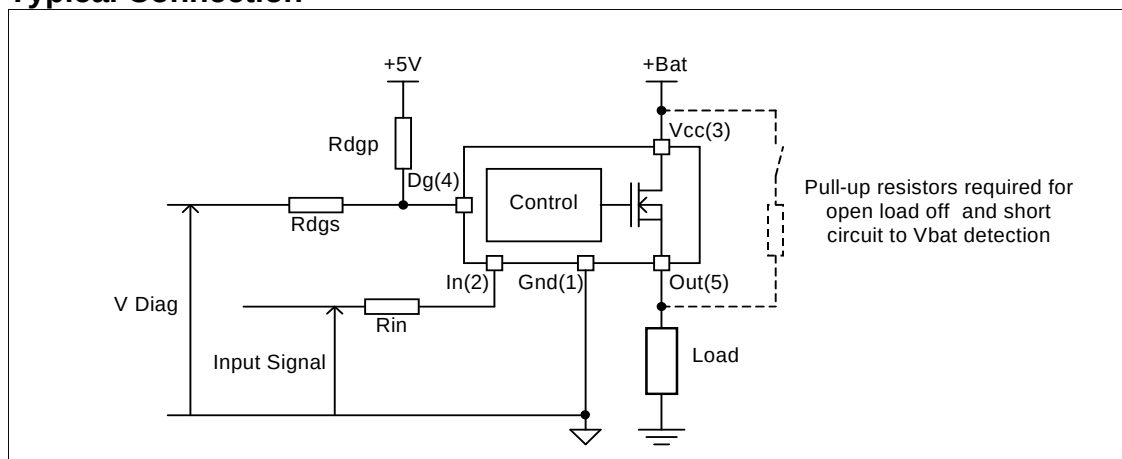
Features

- 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 IPS6011(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

$R_{ds(on)}$	14m Ω max.
V_{clamp}	39V
I_{Limit}	60A
Open load	3V / 2.4A

Packages



TO-220
IPS6011PbF



D2Pak
IPS6011SPbF



D-Pak
IPS6011RPbF

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-35	Vcc+0.3	V
Voffset	Maximum logic ground to load ground offset	Vcc-35	Vcc+0.3	
Vin	Maximum input voltage	-0.3	5.5	
Vcc max.	Maximum Vcc voltage	—	36	
Vcc cont.	Maximum continuous Vcc voltage	—	28	
Vcc sc.	Maximum Vcc voltage with short circuit protection	—	24	
Iin max.	Maximum IN current	-3	10	mA
I _{dg} max.	Maximum diagnostic output current	-3	10	
V _{dg}	Maximum diagnostic output voltage	-0.3	5.5	V
Pd	Maximum power dissipation (internally limited by thermal protection)			W
	Rth=5°C/W IPS6011	—	25	
	Rth=40°C/W IPS6011S 1" sqrt. footprint	—	3.1	
ESD	Rth=50°C/W IPS6011R 1" sqrt. footprint	—	2.5	V
	Electrostatic discharge voltage (Human body) C=100pF, R=1500Ω			
	Between In and Vcc	—	1500	
	Other combinations	—	4000	
	Electrostatic discharge voltage (Machine Model) C=200pF, R=0Ω, L=10μH			
	Between In and Vcc	—	100	
Tj max.	Max. storage & operating temperature junction temperature	-40	150	°C
	Other combinations	—	500	
Tsoldering	Soldering temperature (10 seconds)	—	300	°C

Thermal Characteristics

Symbol	Parameter	Typ.	Max.	Units
Rth1	Thermal resistance junction to ambient IPS6011 TO220 free air	50	—	°C/W
Rth2	Thermal resistance junction to case IPS6011 TO220	1.2	—	
Rth1	Thermal resistance junction to ambient IPS6011S D ² Pak std. footprint	60	—	
Rth2	Thermal resistance junction to ambient IPS6011S D ² Pak 1" sqrt. footprint	40	—	
Rth3	Thermal resistance junction to case IPS6011S D ² Pak	1.2	—	
Rth1	Thermal resistance junction to ambient IPS6011R D-Pak std. footprint	70	—	
Rth2	Thermal resistance junction to ambient IPS6011R D-Pak 1" sqrt. footprint	50	—	
Rth3	Thermal resistance junction to case IPS6011R D-Pak	1.2	—	

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	0.9	
Iout	Continuous drain current, Tambient=85°C, Tj=125°C, Vin=5V			A
	Rth=5°C/W IPS6011	—	18	
	Rth=40°C/W IPS6011S 1" sqrt. footprint	—	6.3	
	Rth=50°C/W IPS6011R 1" sqrt. footprint	—	5.6	
Rin	Recommended resistor in series with IN pin	4	10	kΩ
Rdgs	Recommended resistor in series with DG pin for reverse battery protection	4	20	
Rdgp	Recommended pull-up resistor for DG	4	20	
Rol	Recommended pull-up resistor for open load detection	5	100	
F max.	Max. switching frequency	—	0.3	kHz

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 $T_j=25^{\circ}\text{C}$	—	11	14	m Ω	$V_{in}=5\text{V}$, $I_{out}=20\text{A}$
	ON state resistance $T_j=150^{\circ}\text{C}$	—	19.5	25		$V_{in}=5\text{V}$, $I_{out}=20\text{A}$
	ON state resistance $T_j=25^{\circ}\text{C}$, $V_{cc}=6\text{V}$	—	12	17		$V_{in}=5\text{V}$, $I_{out}=20\text{A}$
	ON state resistance during reverse battery	—	15	20		$V_{cc}-Gnd=14\text{V}$
Vcc op.	Operating voltage range with short circuit protection	6	—	24	V	
V clamp 1	Vcc to Out clamp voltage 1	37	39	—		$I_{out}=50\text{mA}$
V clamp 2	Vcc to Out clamp voltage 2	—	40	42		$I_{out}=16\text{A}$ (see Fig. 1)
Icc Off	Supply current when Off	—	4	9	μA	$V_{in}=0\text{V}$, $V_{out}=0\text{V}$
Icc On	Supply current when On	—	2.2	5	mA	$V_{in}=5\text{V}$
Vih	Input high threshold voltage	—	2.5	2.9	V	
Vil	Input low threshold voltage	1.5	2	—		
In hyst.	Input hysteresis	0.2	0.5	1		
Iin On	Input current when device is On	—	40	100	μA	$V_{in}=5\text{V}$
Idg	Dg leakage current	—	0.1	10		$V_{dg}=5\text{V}$
Vdg	Low level DG voltage	—	0.25	0.4	V	$I_{dg}=1.6\text{mA}$

Switching Electrical Characteristics

$V_{cc}=14\text{V}$, Resistive load= 1Ω , $V_{in}=5\text{V}$, $T_j=25^{\circ}\text{C}$

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Tdon	Turn-on delay time	—	30	60	μs	see Fig. 3
Tr1	Rise time to Vout=Vcc-5V	—	25	50		
Tr2	Rise time to Vout=0.9 x Vcc	—	40	100		
dV/dt (On)	Turn On dV/dt	—	0.3	0.8	V/μs	
EOn	Turn On energy	—	4	—	mJ	
Tdoff	Turn-off delay time	—	70	140	μs	
Tf	Fall time to Vout=0.1 x Vcc	—	30	80		
dV/dt (Off)	Turn Off dV/dt	—	0.7	2	V/μs	
EOff	Turn Off energy	—	1.5	—	mJ	

Protection Characteristics

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Ilim	Internal current limit	35	60	85	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	
UV+	High undervoltage lockout	—	5	5.9		
UV-	Low undervoltage lockout	3.2	4.4	5.8		
VOL Off	Open load detection threshold	2	3	4	A	
I OL On	Open load detection threshold	0.5	1.6	2.4		

(1) Guaranteed by design

(2) Reference to Vcc

True Table

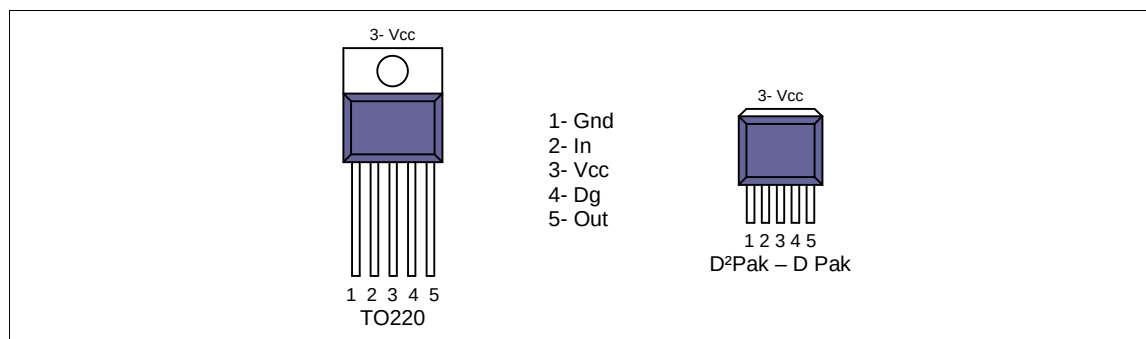
Operating Conditions	IN	OUT	DG
Normal	H	H	H
Normal	L	L	H
Open Load	H	H	L
Open Load (3)	L	H	L
Short circuit to Gnd	H	L	L
Short circuit to Gnd	L	L	H
Short circuit to Vcc	H	H	L (4)
Short circuit to Vcc (5)	L	H	L
Over-temperature	H	L	L
Over-temperature	L	L	H

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

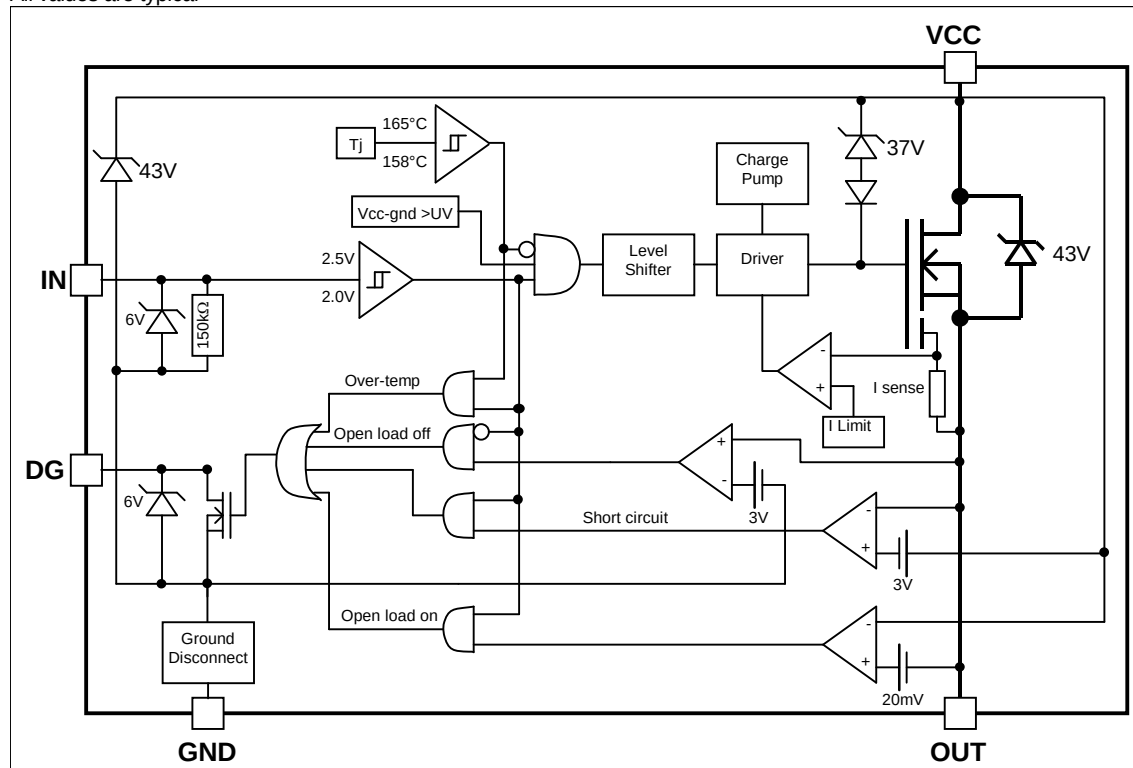
(4) Vds lower than 10mV.

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

Lead Assignments



All values are typical



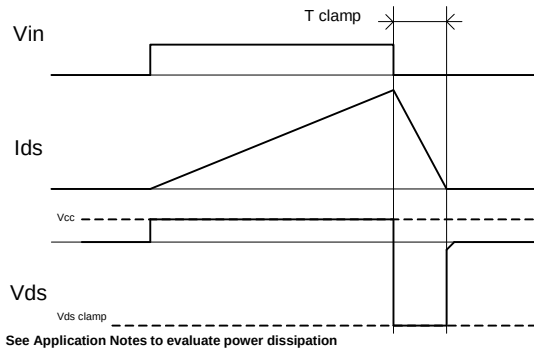


Figure 1 – Active clamp waveforms

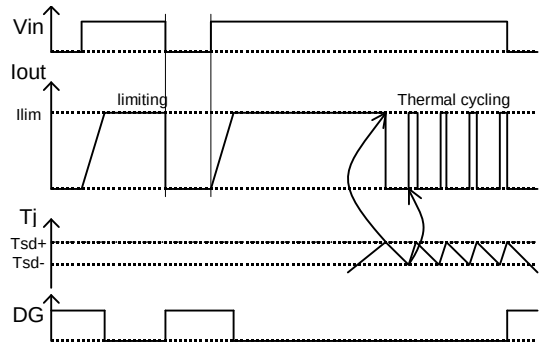


Figure 2 – Protection timing diagram

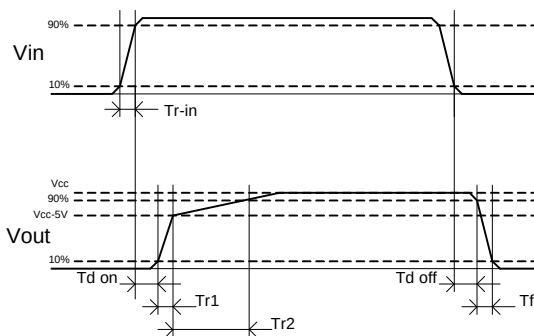


Figure 3 – Switching times definitions

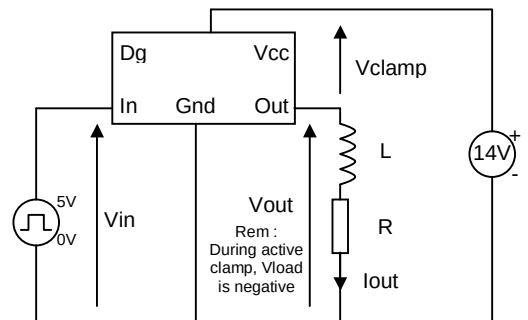


Figure 4 – Active clamp test circuit

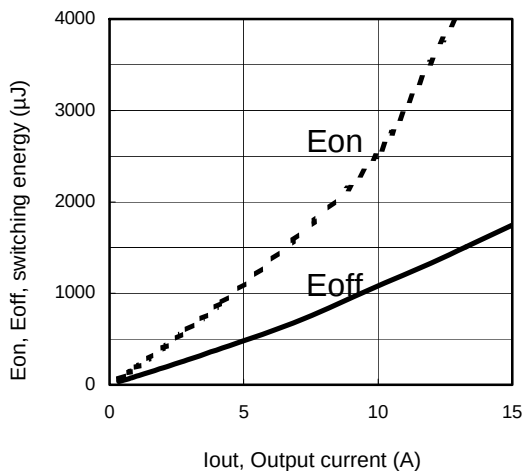


Figure 5 – Switching energy (μJ) Vs Output current (A)

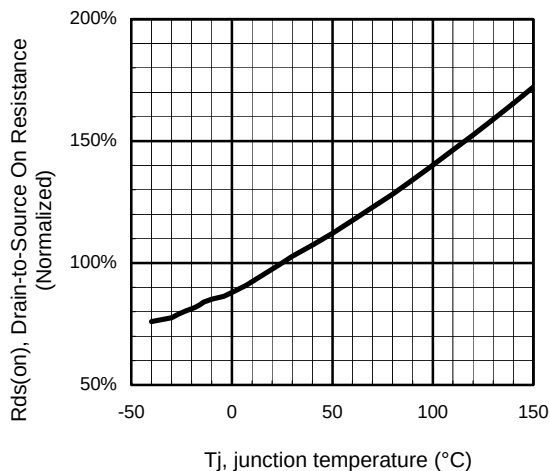


Figure 6 - Normalized $R_{ds(on)}$ (%) Vs T_j ($^{\circ}C$)

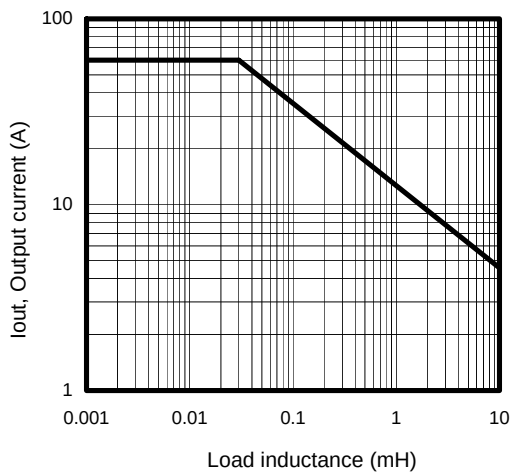


Figure 7 – Max. Output current (A) Vs Load inductance (mH)

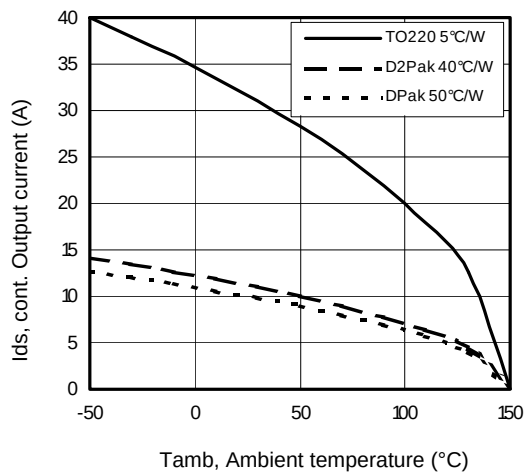


Figure 8 – Max. output current (A) Vs Ambient temperature ($^{\circ}C$)

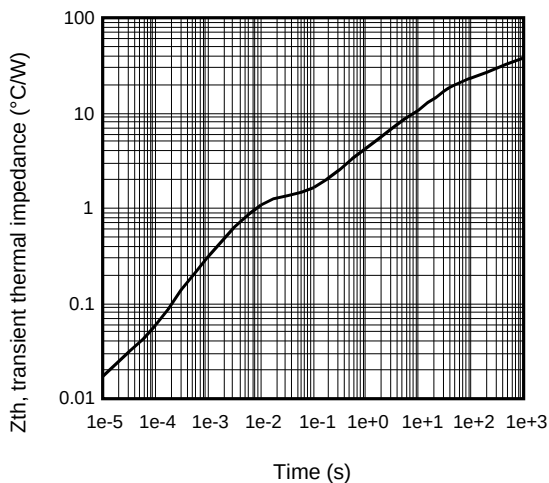


Figure 9 – Transient thermal impedance ($^{\circ}\text{C/W}$) Vs time (s)

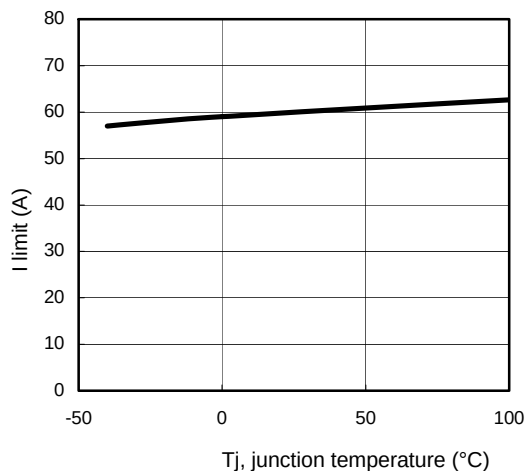


Figure 10 – I_{limit} (A) Vs junction temperature ($^{\circ}\text{C}$)

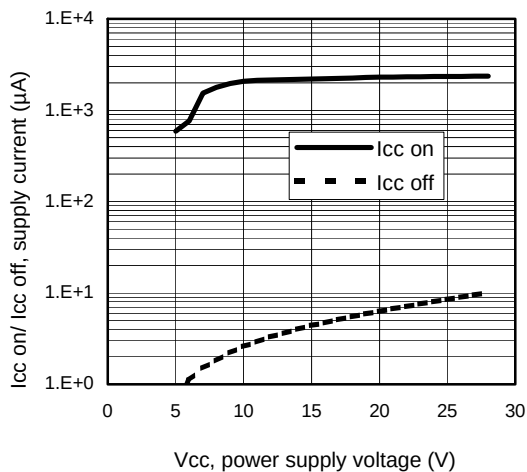


Figure 11 – $I_{cc\ on}/ I_{cc\ off}$ (μA) Vs V_{cc} (V)

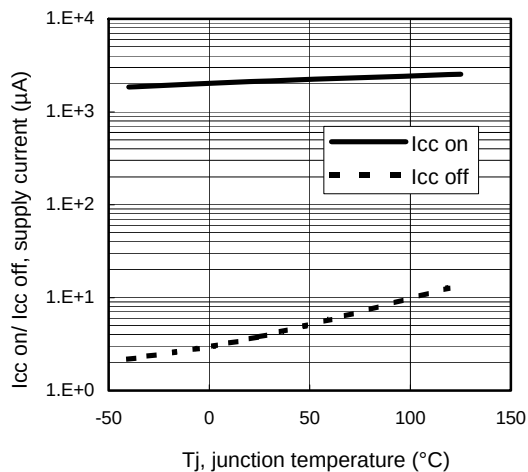
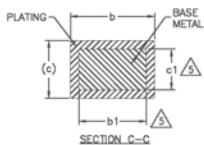
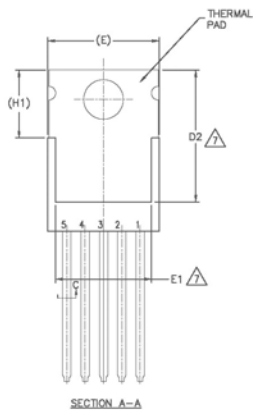
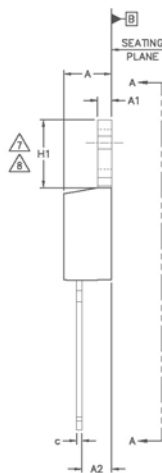
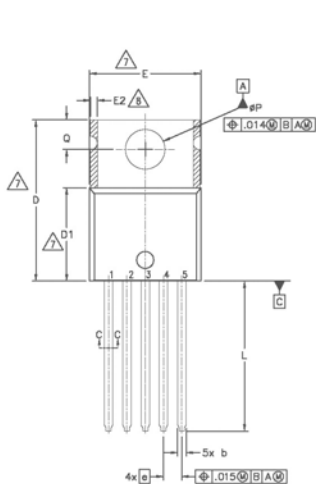


Figure 12 – $I_{cc\ on}/ I_{cc\ off}$ (μA) Vs T_j ($^{\circ}\text{C}$)

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

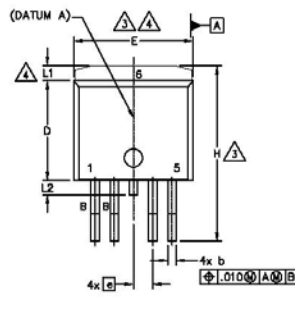
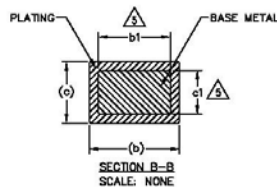
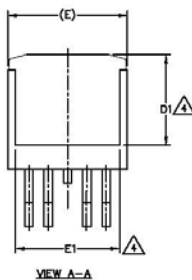
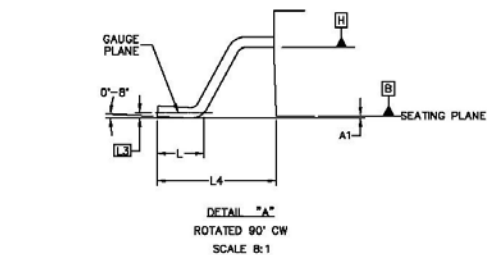


SYMBOL	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	3.56	4.83	.140	.190	5
A1	0.51	1.40	.020	.055	
A2	2.03	2.92	.080	.115	
b	0.64	0.89	.025	.035	5
b1	0.64	0.84	.025	.033	
c	0.38	0.61	.014	.024	
c1	0.38	0.56	.014	.022	4
D	14.22	16.51	.560	.650	
D1	8.38	9.02	.330	.355	
D2	11.68	12.88	.460	.507	7
E	9.65	10.67	.380	.420	
E1	6.86	8.89	.270	.350	
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	
⌀P	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 100X Sn

Case Outline 5 Lead - D2PAK - Automotive Q100 PbF MSL1 qualified

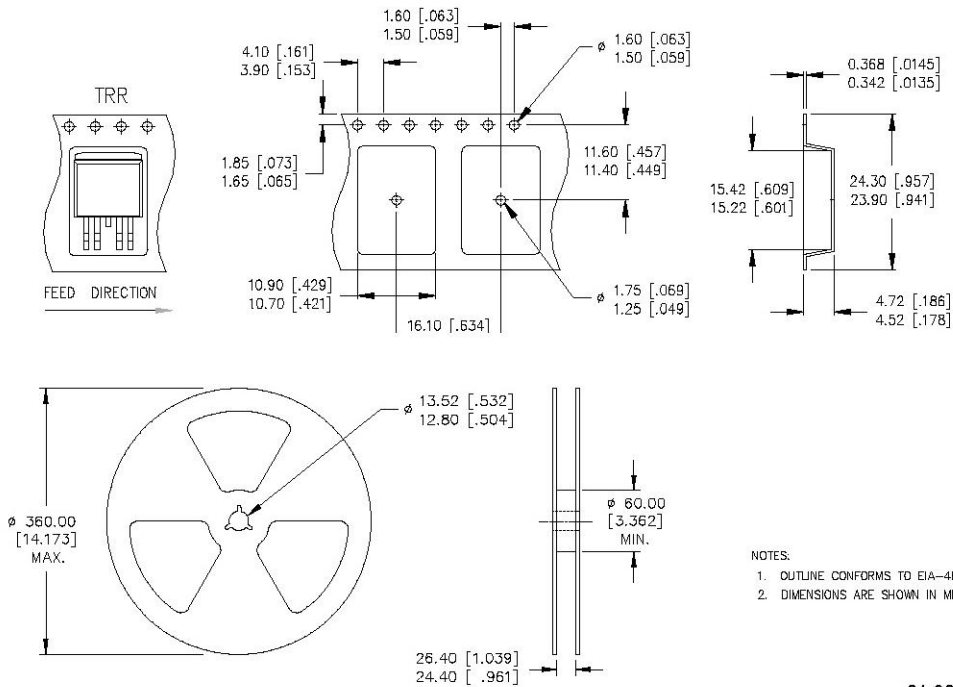


NOTES:

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

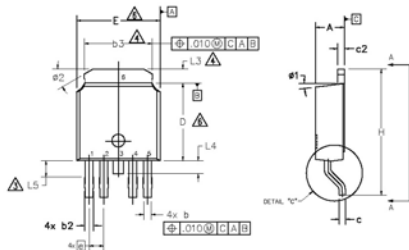
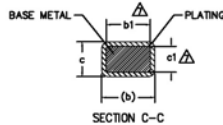
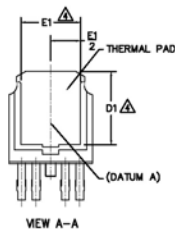
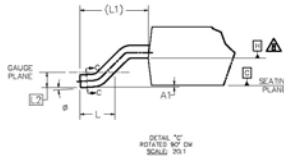
SYMBOL	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	4.06	4.83	.160	.190	4
A1	—	0.254	—	.010	
b	0.51	0.99	.020	.039	
b1	0.51	0.89	.020	.035	
c	0.38	0.74	.015	.029	4
c1	0.38	0.58	.015	.023	
c2	1.14	1.65	.045	.065	4
D	8.38	9.65	.330	.380	
D1	6.86	—	.270	—	3
E	9.65	10.67	.380	.420	
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 & Reel 5 Lead - D2PAK



01-3071 00 / 01-3072 00

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

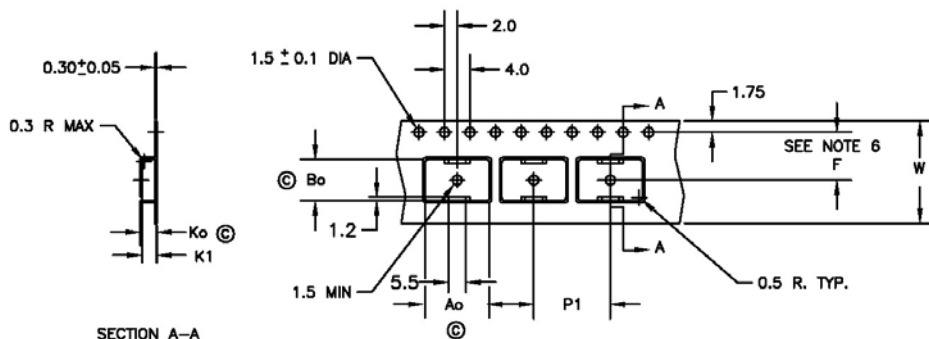


SYM- BOL	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	2.18	2.39	.086	.094	
A1	—	0.13	—	.005	
b	0.51	0.89	.020	.035	2
b1	.051	0.84	.020	.033	
b3	4.95	5.46	.195	.215	2
c	0.46	0.61	.018	.024	
c1	0.41	0.56	.016	.022	2
c2	0.46	0.89	.018	.035	
D	5.97	6.22	.235	.245	3
D1	5.21	—	.205	—	
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.— DIMENSION 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

Tape & Reel 5 Lead – DPAK



SECTION A-A

Ao = 10.5 mm
 Bo = 7.0 mm
 Ko = 2.8 mm
 K1 = 2.4 mm
 F = 7.5 mm
 P1 = 12.0 mm
 W = 16.0 ± .3 mm

NOTES:

1. 10 SPROCKET HOLE PUNCH CUMULATIVE TOLERANCE ±.02
2. CAMBER NOT TO EXCEED 1mm IN 100mm
3. MATERIAL: CONDUCTIVE BLACK 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 THE SPROCKET HOLE MEASURED AS TRUE POSITION OF POCKET, NOT POCKET HOLE
7. VENDOR: (OPTIONAL)
8. MUST ALSO MEET REQUIREMENTS OF EIA STANDARD #EIA-481A, TAPING OF SURFACE-MOUNT COMPONENTS FOR AUTOMATIC PLACEMENT.
9. TOLERANCE TO BE MANUFACTURER STANDARD
10. SURFACE RESISTIVITY OF MOLDED MATL: MUST MEASURE LESS THAN OR EQUAL TO 10⁸ OHMS PER SQUARE. MEASURED IN ACCORDANCE TO PROCEDURE GIVEN IN ASTM D-257 & ASTM D-991 (REF. C-9000 SPEC.)
11. TOTAL LENGTH PER REEL MUST BE 79 METERS
12. © CRITICAL DIMENSION

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