

### SINGLE/DUAL CHANNEL INTELLIGENT POWER LOW SIDE SWITCH

#### Features

- Over temperature shutdown
- Over current shutdown
- Active clamp
- Low current & logic level input
- ESD protection
- Optimized Turn On/Off for EMI
- Diagnostic on the input current

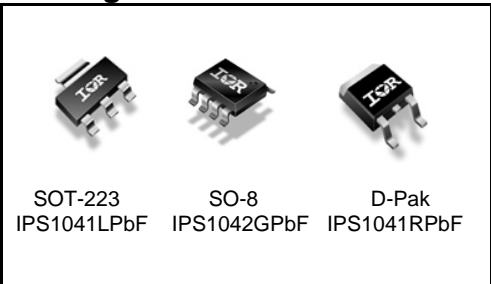
#### Description

The IPS1041(L)(R)PbF and IPS1042GPbF are three terminal Intelligent Power Switches (IPS) featuring low side MOSFETs with over-current, over-temperature, ESD protection and drain to source active clamp. The IPS1042G is a dual channel device while the IPS1041 is a single channel. These devices offer protections and the high reliability required in harsh environments. Each switch provides efficient protection by turning OFF the power MOSFET when the temperature exceeds 165°C or when the drain current reaches 4.5A. The device restarts once the input is cycled. A serial resistance connected to the input provides the diagnostic. The avalanche capability is significantly enhanced by the active clamp and covers most inductive load demagnetizations.

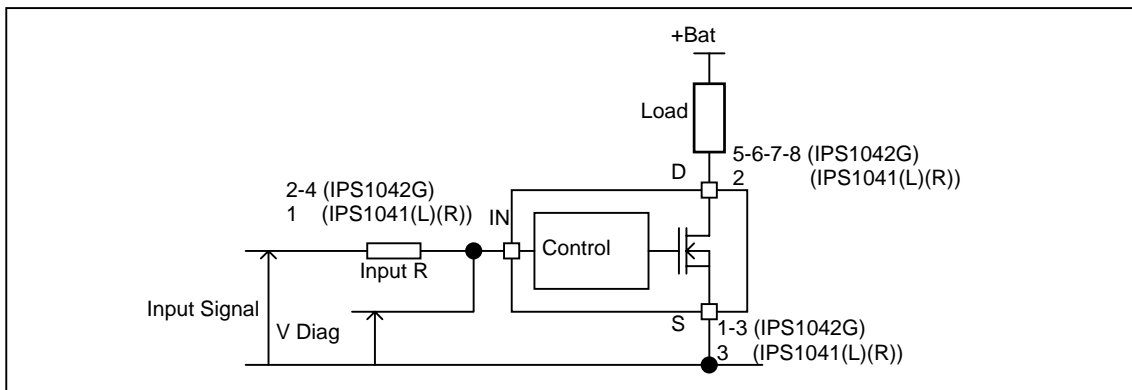
#### Product Summary

Rds(on)	100mΩ (max.)
Vclamp	39V
Ishutdown	4.5A (typ.)

#### Packages



#### 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
Vds	Maximum drain to source voltage	-0.3	36	V
Vds cont	Maximum continuous drain to source voltage	-	28	V
Vin	Maximum input voltage	-0.3	6	V
Isd cont.	Max diode continuous current (limited by thermal dissipation)	—	1.5	A
Pd	Maximum power dissipation (internally limited by thermal protection)			
	Rth=60°C/W IPS1041L 1" sqr. footprint Rth=100°C/W IPS1042G std. footprint		2 1.25	W
ESD	Electrostatic discharge voltage (Human body) C=100pF, R=1500Ω			
	Between drain and source	—	4	kV
	Other combinations	—	3	
	Electrostatic discharge voltage (Machine Model) C=200pF, R=0Ω			
Between drain and source Other combinations	—	0.5 0.3		
Tj max.	Max. storage & operating temperature junction temperature	-40	150	°C
Tsoldering	Lead soldering temperature (10 seconds)	—	300	°C

## Thermal Characteristics

Symbol	Parameter	Typ.	Max.	Units
Rth1	Thermal resistance junction to ambient IPS1041L SOT-223 std. footprint	100	—	°C/W
Rth2	Thermal resistance junction to ambient IPS1041L SOT-223 1" sqr. footprint	60	—	
Rth1	Thermal resistance junction to ambient IPS1041R D-Pak std. footprint	70	—	
Rth2	Thermal resistance junction to case IPS1041R D-Pak	6	—	
Rth1	Thermal resistance junction to ambient IPS1042G SO-8 std. Footprint 1 die active	100	—	
Rth1	Thermal resistance junction to ambient IPS1042G SO-8 std. footprint 2 die active	130	—	

## 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	5.5	V
VIL	Low level input voltage	0	0.5	V
Ids	Continuous drain current, Tambient=85°C, Tj=125°C, Vin=5V Rth=60°C/W IPS1041L 1" sqr. Footprint	—	1.95	A
	Continuous drain current, Tambient=85°C, Tj=125°C, Vin=5V Rth=50°C/W IPS1041R 1" sqr. Footprint	—	2.2	
	Continuous drain current, Tambient=85°C, Tj=125°C, Vin=5V Rth=100°C/W IPS1042G 1" sqr. Footprint - 1 die active	—	1.5	
	Continuous drain current, Tambient=85°C, Tj=125°C, Vin=5V Rth=130°C/W IPS1042G 1" sqr. Footprint - 2 die active	—	0.7	
Rin	Recommended resistor in series with IN pin to generate a diagnostic	0.5	10	kΩ
Max L	Max. recommended load inductance ( including line inductance ) (1)	—	20	μH
Max. F	Max. frequency	—	2000	Hz
Max. t rise	Max. input rising time	—	1	μs

(1) Higher inductance is possible if maximum load current is limited - see figure 11

## Static Electrical Characteristics

T<sub>j</sub>=25°C, V<sub>cc</sub>=14V (unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
R <sub>ds(on)</sub>	ON state resistance T <sub>j</sub> =25°C	—	80	100	mΩ	V <sub>in</sub> =5V, I <sub>ds</sub> =3A
	ON state resistance T <sub>j</sub> =150°C	—	135	175		
I <sub>dss1</sub>	Drain to source leakage current	—	0.1	5	μA	V <sub>cc</sub> =14V, T <sub>j</sub> =25°C
I <sub>dss2</sub>	Drain to source leakage current	—	0.2	10		V <sub>cc</sub> =28V, T <sub>j</sub> =25°C
V <sub>clamp1</sub>	Drain to source clamp voltage 1	36	38	—	V	I <sub>d</sub> =10mA
V <sub>clamp2</sub>	Drain to source clamp voltage 2	—	39	42		I <sub>d</sub> =1A
V <sub>in clamp</sub>	IN to source pin clamp voltage	5.5	6.5	7.5		I <sub>in</sub> =1mA
V <sub>th</sub>	Input threshold voltage	—	1.7	—		I <sub>d</sub> =10mA

## Switching Electrical Characteristics

V<sub>cc</sub>=14V, Resistive load=5Ω, R<sub>input</sub>=0Ω, V<sub>in</sub>=5V, T<sub>j</sub>=25°C

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
T <sub>don</sub>	Turn-on delay time to 20%	3	10	23	μs	See figure 2
T <sub>r</sub>	Rise time 20% to 80%	2	7	20		
T <sub>doff</sub>	Turn-off delay time to 80%	15	40	150		
T <sub>f</sub>	Fall time 80% to 20%	4	10	20		
E <sub>on</sub> + E <sub>off</sub>	Turn on and off energy	—	0.2	—	mJ	

## Protection Characteristics

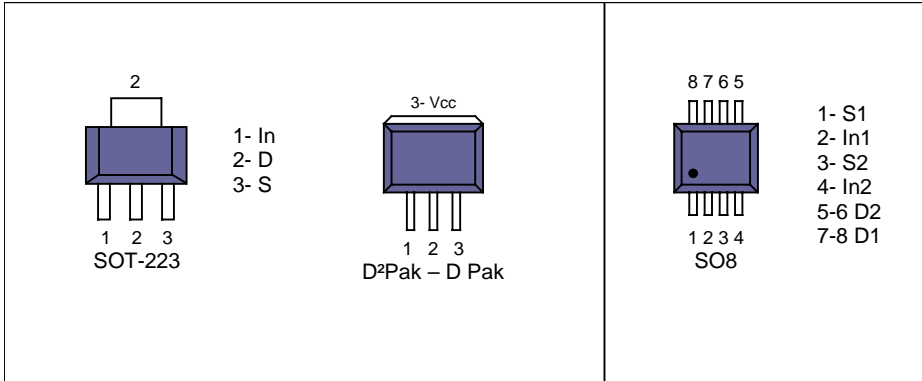
Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
T <sub>sd</sub>	Over temperature threshold	150(2)	165	—	°C	See figure 1
I <sub>sd</sub>	Over current threshold	3	4.5	6	A	See figure 1
OV	Over voltage protection ( not active when the device is ON )	34	37	—	V	
V <sub>reset</sub>	IN protection reset threshold	—	1.7	—	V	
T <sub>reset</sub>	Time to reset protection	15(2)	50	200	μs	V <sub>in</sub> =0V, T <sub>j</sub> =25°C

(2) Guaranteed by design

## Diagnostic

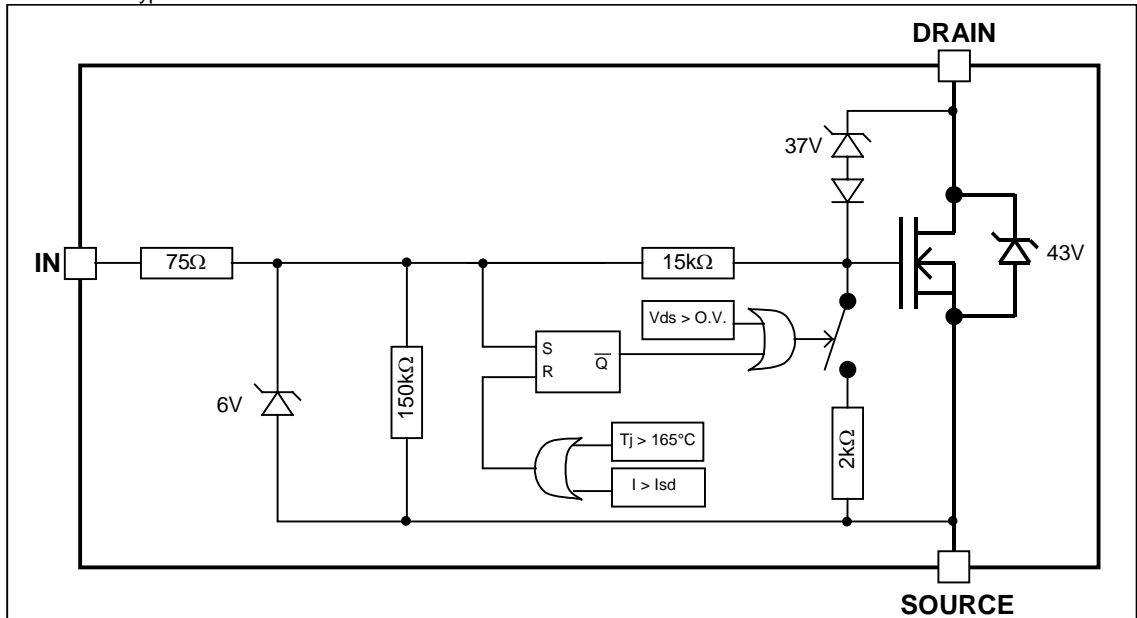
Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
I <sub>in, on</sub>	ON state IN positive current	15	32	70	μA	V <sub>in</sub> =5V
I <sub>in, off</sub>	OFF state IN positive current ( after protection latched )	150	230	350		V <sub>in</sub> =5V

## Lead Assignments



## Functional Block Diagram

All values are typical



All curves are typical values. Operating in the shaded area is not recommended.

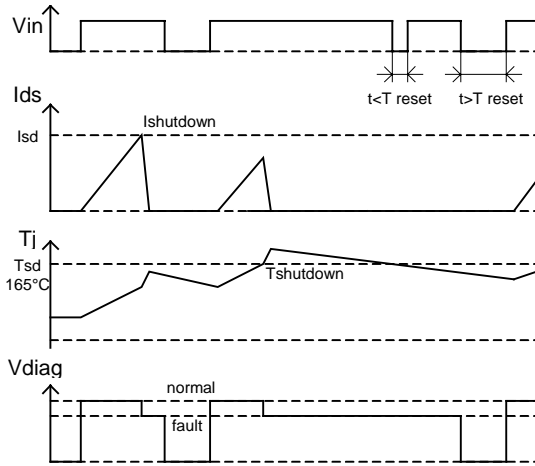


Figure 1 – Timing diagram

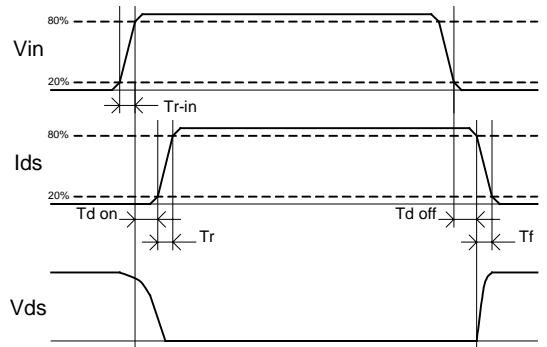


Figure 2 – IN rise time & switching definitions

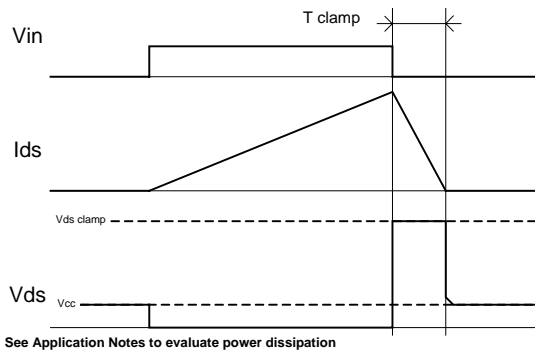


Figure 3 – Active clamp waveforms

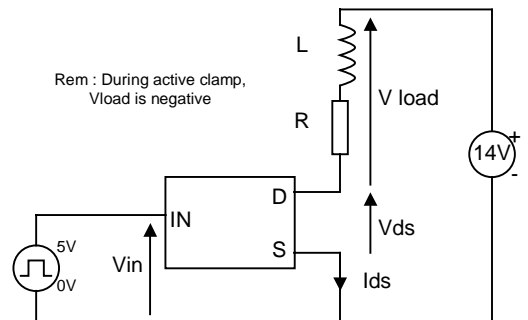
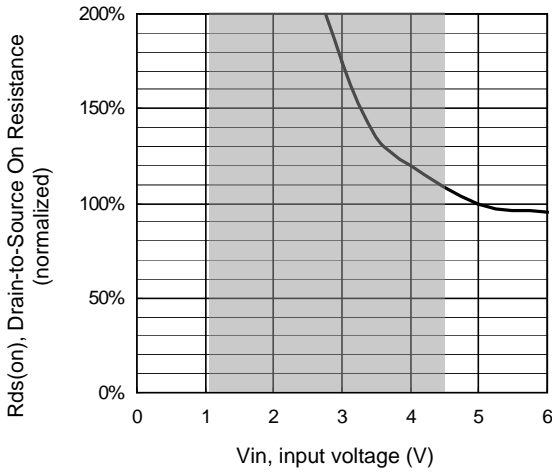
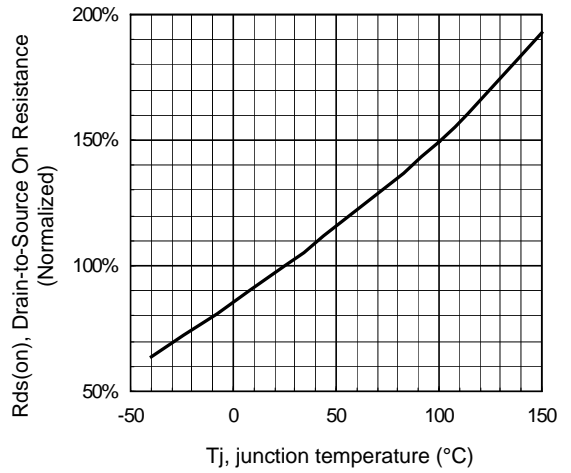


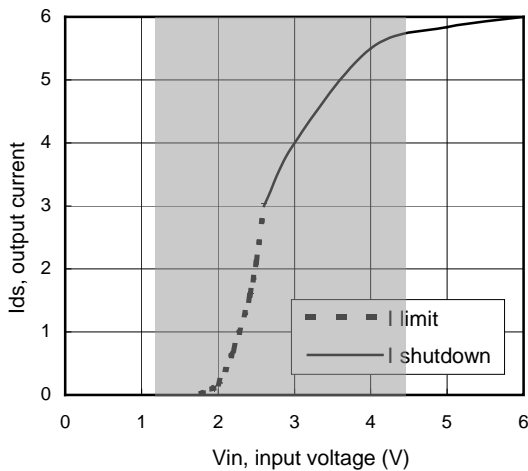
Figure 4 – Active clamp test circuit



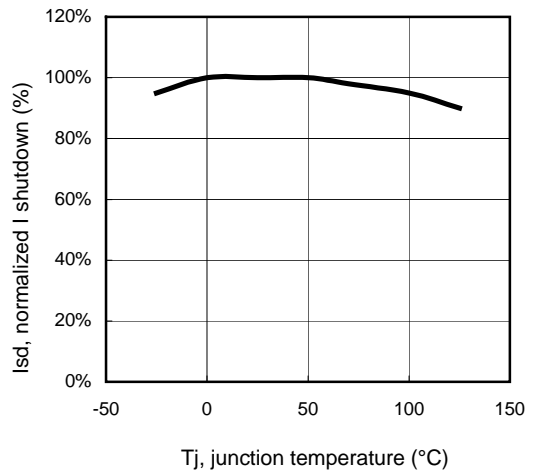
**Figure 5 – Normalized Rds(on) (%) Vs Input voltage (V)**



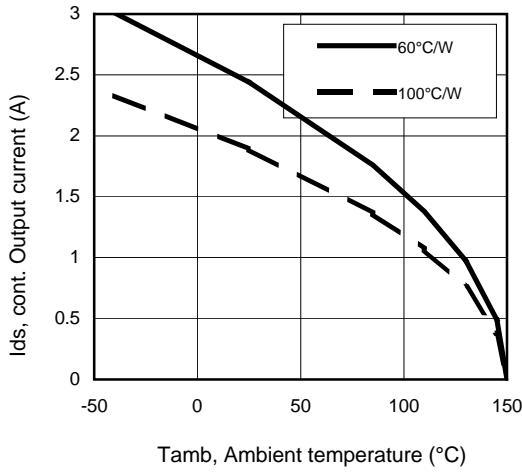
**Figure 6 - Normalized Rds(on) (%) Vs Tj (°C)**



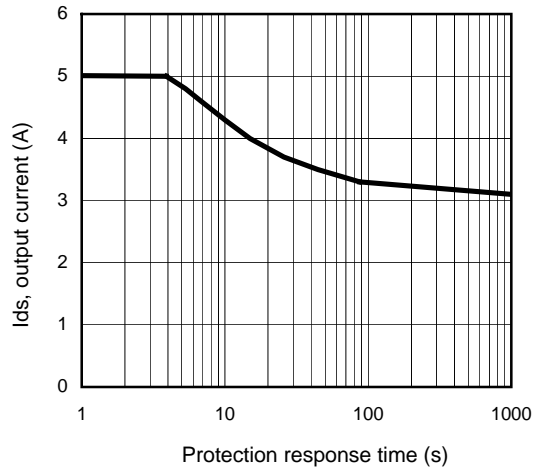
**Figure 7 – Current limitation and current shutdown Vs Input voltage (V)**



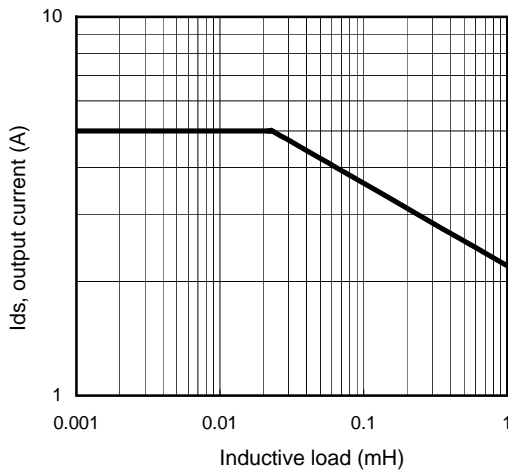
**Figure 8 – Normalized I shutdown (%) Vs junction temperature (°C)**



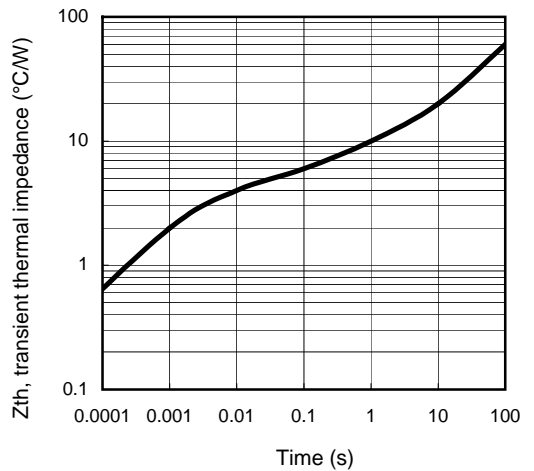
**Figure 9 – Max. continuous output current (A) Vs Ambient temperature (°C)**



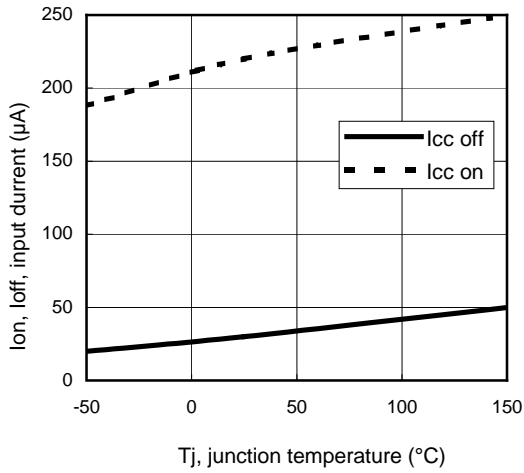
**Figure 10 – Ids (A) Vs over temperature protection response time (s) / IPS1041L**



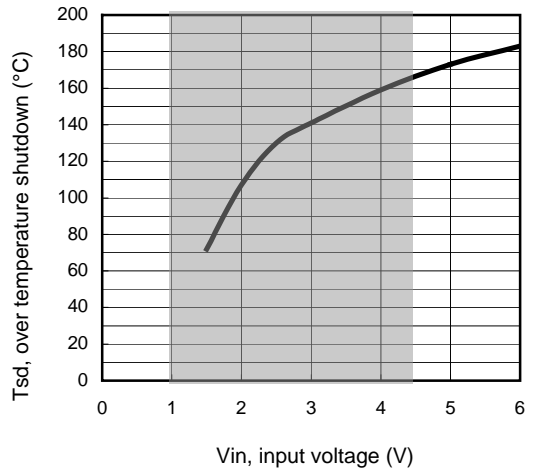
**Figure 11 – Max. output current (A) Vs Inductive load (mH)**



**Figure 12 – Transient thermal impedance (°C/W) Vs time (s)**



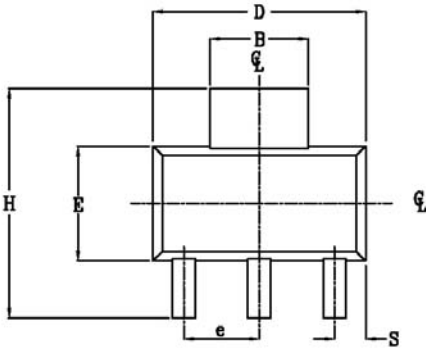
**Figure 13 – Input current (µA) On and Off Vs junction temperature (°C)**



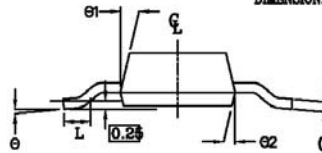
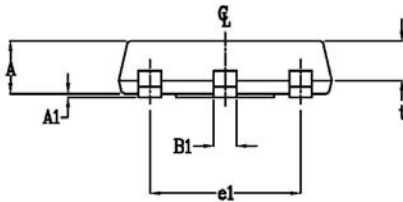
**Figure 14 – Over temperature shutdown (°C) Vs input voltage (V)**



## Case Outline - SOT-223 - Automotive Q100 PbF MSL2 qualified



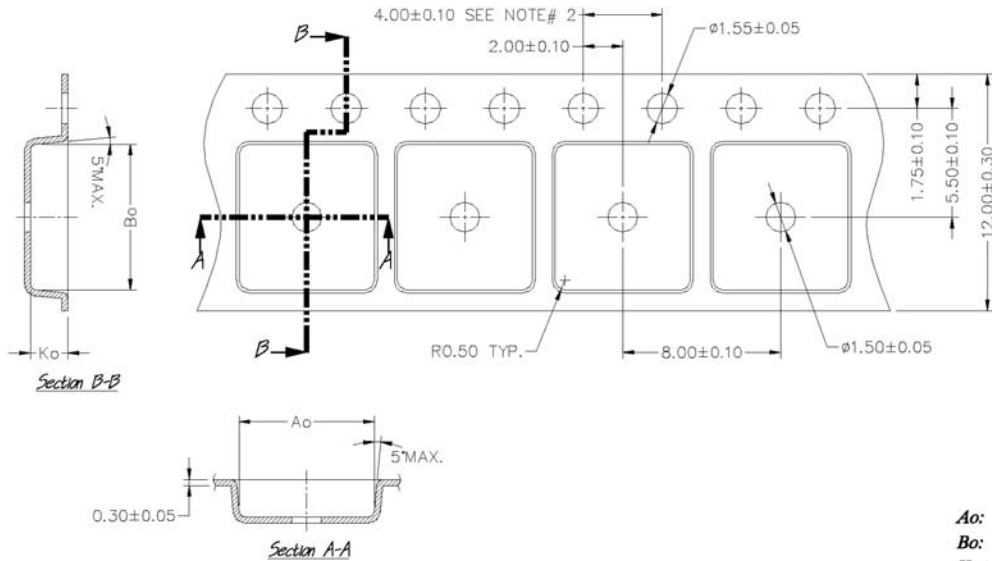
POS	MILLIMETERS		INCHES	
	MAX	MIN	MAX	MIN
I	1.70	1.50	.067	.060
A	0.10	0.02	.004	.0008
A1	3.15	2.95	.124	.116
B	0.85	0.65	.033	.026
B1	0.35	0.25	.014	.010
C	6.70	6.30	.264	.248
D	2.30	NOM	.0905	NOM
e	4.60	NOM	.181	NOM
e1	3.70	3.30	.146	.130
E	7.30	6.70	.287	.264
H	1.05	0.85	.041	.033
S	1.30	1.10	.051	.043
⊖	10° MAX		10° MAX	
⊖1	16°	10°	16°	10°
⊖2	16°	10°	16°	10°
L	0.75 MIN		0.0295 MIN	



NOTE:  
 1. PACKAGE OUTLINE EXCLUSIVE OF ANY MOLD FLASHES DIMENSION.  
 2. PACKAGE OUTLINE EXCLUSIVE OF BURR DIMENSION.

Leads and drain are plated with 100% Sn

## Tape & Reel - SOT-223



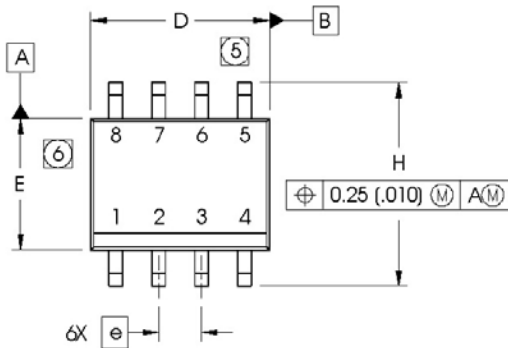
<b><i>A<sub>0</sub></i></b>	<b>6.85</b>
<b><i>B<sub>0</sub></i></b>	<b>7.40</b>
<b><i>K<sub>0</sub></i></b>	<b>1.90</b>
<b><i>Pitch</i></b>	<b>8.00</b>
<b><i>Width</i></b>	<b>12.00</b>

**NOTES:**

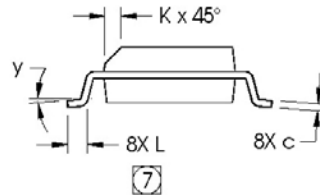
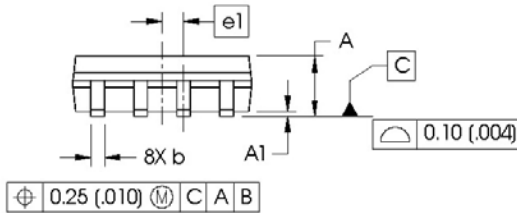
1.  $A_0$  &  $B_0$  are measured at 0.3mm above base of pocket.
2. 10 pitches cumulative tol.  $\pm 0.2$ mm.

## Case Outline - SO-8 - Automotive Q100 PbF MSL2 qualified

Dimensions are shown in millimeters (inches)

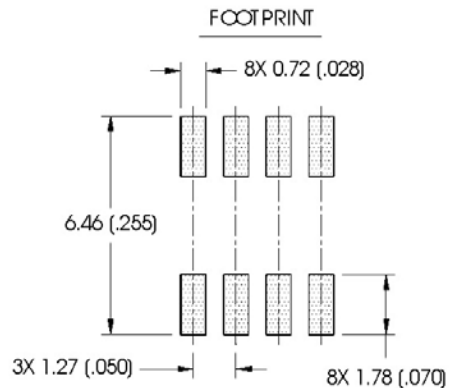


DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	.0532	.0688	1.35	1.75
A1	.0040	.0098	0.10	0.25
b	.013	.020	0.33	0.51
c	.0075	.0098	0.19	0.25
D	.189	.1968	4.80	5.00
E	.1497	.1574	3.80	4.00
e	.050 BASIC		1.27 BASIC	
e1	.025 BASIC		0.635 BASIC	
H	.2284	.2440	5.80	6.20
K	.0099	.0196	0.25	0.50
L	.016	.050	0.40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



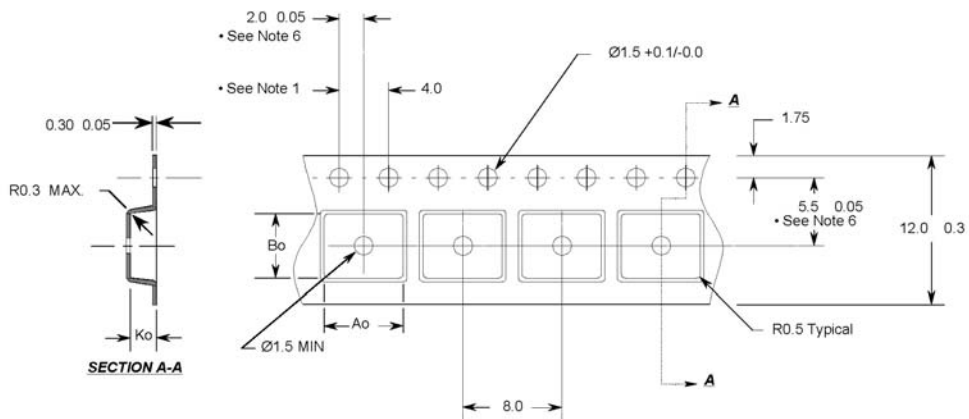
**NOTES:**

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.



Leads and drain are plated with 100% Sn

## Tape & Reel - SO-8



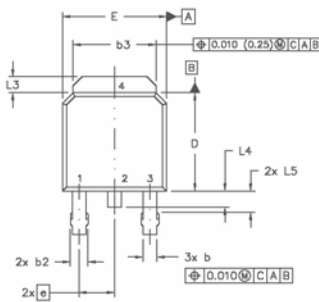
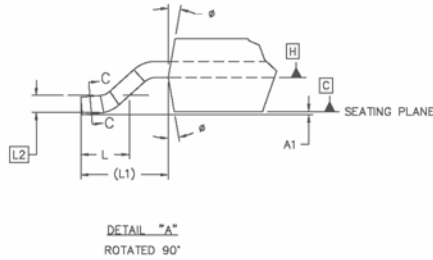
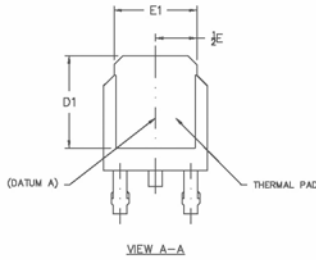
**Notes:**

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.

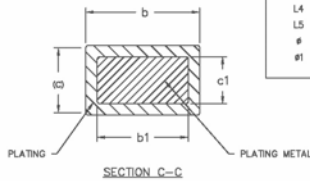
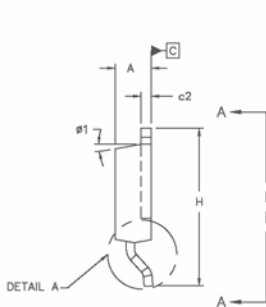
Ao = 6.4 mm  
 Bo = 5.2 mm  
 Ko = 2.1 mm

- All Dimensions in Millimeters -

## Case Outline – D-Pak - Automotive Q100 PbF MSL1 qualified



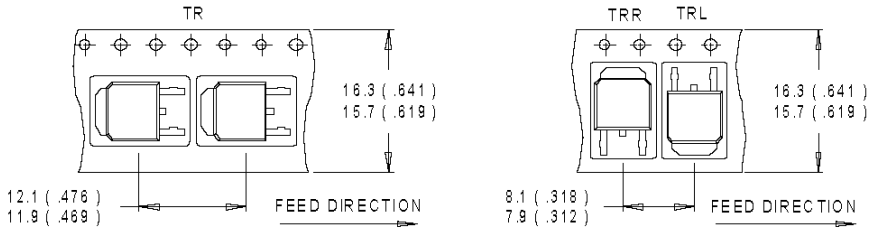
SYMBOL	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	2.18	2.39	.086	.094	
A1		0.13		.005	
b	0.84	0.89	.025	.035	5
b1	0.84	0.79	.025	0.031	5
b2	0.78	1.14	.030	.045	
b3	4.95	5.46	.195	.215	
c	0.46	0.61	.018	.024	5
c1	0.41	0.56	.016	.022	5
c2	.046	0.89	.018	.035	5
D	5.97	6.22	.235	.245	6
D1	5.21	-	.205	-	4
E	6.35	6.73	.250	.265	6
E1	4.32	-	.170	-	4
e	2.29		.090 BSC		
H	9.40	10.41	.370	.410	
L	1.40	1.78	.055	.070	
L1	2.74 REF.		.108 REF.		
L2	0.051 BSC		.020 BSC		
L3	0.89	1.27	.035	.050	
L4		1.02		.040	
L5	1.14	1.52	.045	.060	3
ø	0"	10"	0"	10"	
ø1	0"	15"	0"	15"	



NOTES:

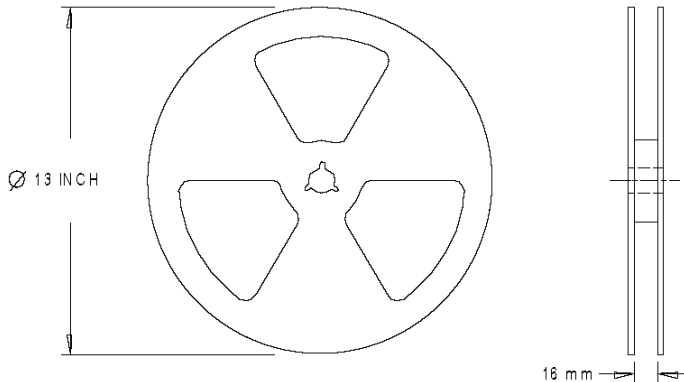
- 1.0 DIMENSIONING AND TOLERANCING PER ASME Y14.5 M- 1994.
- 2.0 DIMENSIONS ARE SHOWN IN INCHES [MILLIMETERS].
- 3.0 LEAD DIMENSION UNCONTROLLED IN L5
- 4.0 DIMENSION D1 AND E1 ESTABLISH A MINIMUM MOUNTING SURFACE FOR THERMAL PAD.
- 5.0 SECTION C-C DIMENSIONS APPLY TO THE FLAT SECTION OF THE LEAD BETWEEN .005 [0.127] AND .010 [0.2540] FROM THE LEAD TIP.
- 6.0 DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED .008" (0.127) PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY.
- 7.0 OUTLINE CONFORMS TO JEDEC OUTLINE TO-252AA.
- 8.0 LEADS AND DRAIN ARE PLATED WITH 100% Sn

## Tape & Reel - D-Pak



NOTES :

1. CONTROLLING DIMENSION : MILLIMETER.
2. ALL DIMENSIONS ARE SHOWN IN MILLIMETERS ( INCHES ).
3. OUTLINE CONFORMS TO EIA-481 & EIA-541.



NOTES :

1. OUTLINE CONFORMS TO EIA-481.

Dimensions are shown in millimeters (inches)

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