

## AUIPS6031(S)(R)

Done please find

### INTELLIGENT POWER HIGH SIDE SWITCH

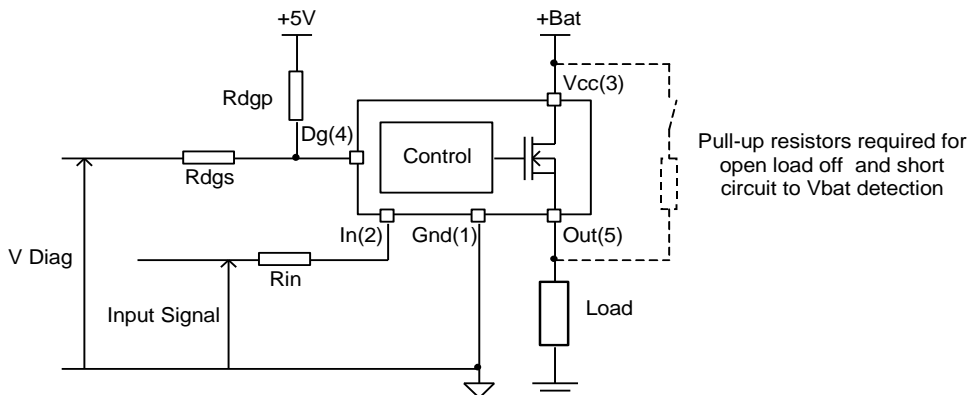
#### Features

- 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
- Lead Free and RoHS compliant

#### Description

The AUIPS6031(S)(R) 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  $7^{\circ}\text{C}$  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

$R_{ds(on)}$	60m $\Omega$ max.
$V_{clamp}$	39V
$I_{Limit}$	16A
Open load	3V / 0.55A

#### Packages



TO-220  
AUIPS6031



D2Pak  
AUIPS6031S



D-Pak  
AUIPS6031R

## Qualification Information<sup>†</sup>

Qualification Level		Automotive (per AEC-Q100 <sup>††</sup> )	
		Comments: This family of ICs has passed an Automotive qualification. IR's Industrial and Consumer qualification level is granted by extension of the higher Automotive level.	
Moisture Sensitivity Level		D2PAK-5L	MSL1, 260°C (per IPC/JEDEC J-STD-020)
		TO-220	Not applicable (non-surface mount package style)
		DPAK-5L	MSL1, 260°C (per IPC/JEDEC J-STD-020)
ESD	Machine Model	Class <b>M2</b> (+/-150V) <sup>†††</sup> (per AEC-Q100-003)	
	Human Body Model	Class <b>H1C</b> (+/-1500V) <sup>†††</sup> (per AEC-Q100-002)	
	Charged Device Model (DPAK,D2PAK)	Class <b>C4</b> (+/-900V) <sup>†††</sup> (per AEC-Q100-011)	
	Charged Device Model (TO220)	Class <b>C3B</b> (+/-750V) <sup>†††</sup> (per AEC-Q100-011)	
IC Latch-Up Test		Class II, Level <b>A</b> (per AEC-Q100-004)	
RoHS Compliant		Yes	

† Qualification standards can be found at International Rectifier's web site <http://www.irf.com/>

†† Exceptions to AEC-Q100 requirements are noted in the qualification report.

††† Passing voltage level

## 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.  $T_j = -40^{\circ}\text{C}..150^{\circ}\text{C}$ ,  $V_{cc}=6..35\text{V}$  (unless otherwise specified).

Symbol	Parameter	Min.	Max.	Units
Vout	Maximum output voltage	$V_{cc}-35$	$V_{cc}+0.3$	V
Voffset	Maximum logic ground to load ground offset	$V_{cc}-35$	$V_{cc}+0.3$	
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	—	30	
Iin max.	Maximum IN current	-3	10	mA
I <sub>dg</sub> max.	Maximum diagnostic output current	-3	10	
V <sub>dg</sub>	Maximum diagnostic output voltage	-0.3	5.5	V
Pd	Maximum power dissipation (internally limited by thermal protection)			W
	R <sub>th</sub> =5°C/W AUIPS6031	—	25	
	R <sub>th</sub> =40°C/W AUIPS6031S 1"sq <sub>rt</sub> . footprint	—	3.1	
	R <sub>th</sub> =50°C/W AUIPS6031R 1"sq <sub>rt</sub> . footprint	—	2.5	
T <sub>j</sub> max.	Max. storage & operating temperature junction temperature	-40	150	°C

## Thermal Characteristics

Symbol	Parameter	Typ.	Max.	Units
Rth1	Thermal resistance junction to ambient AUIPS6031 TO220 free air	50	—	°C/W
Rth2	Thermal resistance junction to case AUIPS6031 TO220	3.8	—	
Rth1	Thermal resistance junction to ambient AUIPS6031S D <sup>2</sup> Pak std. footprint	60	—	
Rth2	Thermal resistance junction to ambient AUIPS6031S D <sup>2</sup> Pak 1" sq <sub>rt</sub> . footprint	40	—	
Rth3	Thermal resistance junction to case AUIPS6031S D <sup>2</sup> Pak	3.8	—	
Rth1	Thermal resistance junction to ambient AUIPS6031R D-Pak std. footprint	70	—	
Rth2	Thermal resistance junction to ambient AUIPS6031R D-Pak 1" sq <sub>rt</sub> . footprint	50	—	
Rth3	Thermal resistance junction to case AUIPS6031R 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 <sub>IH</sub>	High level input voltage	4	5.5	A
V <sub>IL</sub>	Low level input voltage	0	0.9	
I <sub>out</sub>	Continuous drain current, T <sub>ambient</sub> =85°C, T <sub>j</sub> =125°C, V <sub>in</sub> =5V			
	R <sub>th</sub> =5°C/W AUIPS6031	—	8.9	
	R <sub>th</sub> =40°C/W AUIPS6031S 1" sq <sub>rt</sub> . footprint	—	3.1	kΩ
	R <sub>th</sub> =50°C/W AUIPS6031R 1" sq <sub>rt</sub> . footprint	—	2.8	
R <sub>in</sub>	Recommended resistor in series with IN pin	4	10	
R <sub>dg</sub> s	Recommended resistor in series with DG pin for reverse battery protection	4	20	
R <sub>dg</sub> p	Recommended pull-up resistor for DG	4	20	kHz
R <sub>ol</sub>	Recommended pull-up resistor for open load detection	5	100	
F max.	Max. switching frequency	—	2.5	

## Static Electrical Characteristics

$T_j = -40^{\circ}\text{C}..150^{\circ}\text{C}$ ,  $V_{cc} = 6..28\text{V}$  (unless otherwise specified), typical values are given for  $V_{cc} = 14\text{V}$  and  $T_j = 25^{\circ}\text{C}$

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Rds(on)	ON state resistance $T_j = 25^{\circ}\text{C}$	—	46	60	m $\Omega$	Vin=5V, Iout=5A
	ON state resistance $T_j = 150^{\circ}\text{C}$	—	83	100		Vin=5V, Iout=5A
	ON state resistance $T_j = 25^{\circ}\text{C}$ , $V_{cc} = 6\text{V}$	—	55	70		Vin=5V, Iout=2.5A
	ON state resistance during reverse battery $T_j = 25^{\circ}\text{C}$	—	60	80		Vcc-Gnd=-14V
Vcc op.	Operating voltage range	6	—	28	V	
V clamp 1	Vcc to Out clamp voltage 1	37	39	43		Iout=30mA
V clamp 2	Vcc to Out clamp voltage 2	—	40	—		Iout=4A (see Fig. 1)
Icc Off	Supply current when Off and Vout connected to ground with $R < 4\Omega$	—	4	9	$\mu\text{A}$	Vin=0V, Vout=0V, $T_j = 25^{\circ}\text{C}$ , $V_{cc} = 14\text{V}$
Icc On	Supply current when On	—	2.2	5	mA	Vin=5V, $V_{cc} = 14\text{V}$
Vih	Input high threshold voltage	—	2.5	3	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	$\mu\text{A}$	Vin=5V
I <sub>dg</sub>	Dg leakage current	—	0.1	10		V <sub>dg</sub> =5V
V <sub>dg</sub>	Low level DG voltage	—	0.25	0.4	V	I <sub>dg</sub> =1.6mA

## Switching Electrical Characteristics

$V_{cc} = 14\text{V}$ , Resistive load=6 $\Omega$ , Vin=5V,  $T_j = -40^{\circ}\text{C}..150^{\circ}\text{C}$ , typical values are given for  $T_j = 25^{\circ}\text{C}$

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
Tdon	Turn-on delay time	—	8	25	μs	see Fig. 3
Tr1	Rise time to Vout=Vcc-5V	—	5	20		
Tr2	Rise time to Vout=0.9 x Vcc	—	8	35		
dV/dt (On)	Turn On dV/dt	—	1.5	—	V/μs	
EOn	Turn On energy	—	150	—	μJ	
Tdoff	Turn-off delay time	—	20	45	μs	
Tf	Fall time to Vout=0.1 x Vcc	—	9	30		
dV/dt (Off)	Turn Off dV/dt	—	3	—	V/μs	
EOff	Turn Off energy	—	65	—	μJ	

## Protection Characteristics

T<sub>j</sub>=-40°C..150°C, V<sub>cc</sub>=6..28V (unless otherwise specified), typical values are given for V<sub>cc</sub>=14V and T<sub>j</sub>=25°C

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
I <sub>lim</sub>	Internal current limit	10	16	23	A	V <sub>out</sub> =0V, T <sub>j</sub> =25°C
T <sub>sd+</sub>	Over temperature high threshold	150(1)	165	—	°C	See fig. 2
T <sub>sd-</sub>	Over temperature low threshold	—	158	—		
V <sub>sc</sub>	Short-circuit detection voltage(2)	2	3	4	V	
UV+	Under voltage protection V <sub>cc</sub> going up	—	5	6.2		
UV-	Under voltage protection V <sub>cc</sub> going down	—	4.5	5.8		
VOL Off	Open load detection threshold	2	3	4		
I <sub>OL</sub> On	Open load detection threshold	0.15	0.4	0.65	A	T <sub>j</sub> =-40..25°C
		0.15	0.4	0.55		T <sub>j</sub> =25..150°C

(1) Guaranteed by design

(2) Reference to V<sub>cc</sub>

## True Table

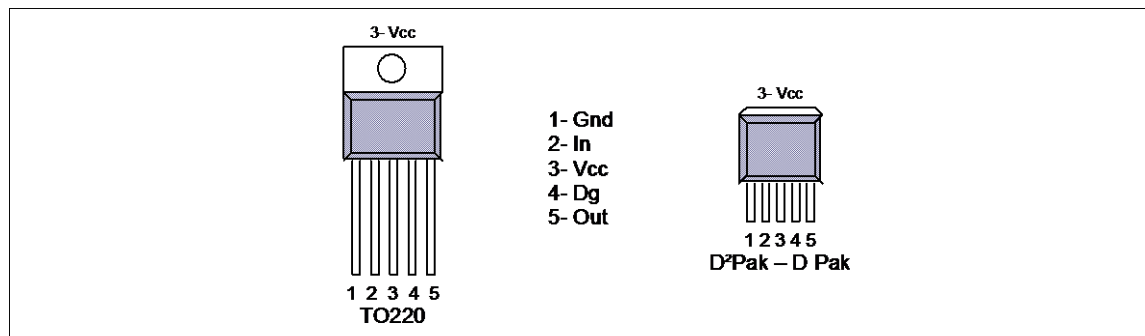
Operating Conditions	IN	OUT	DG
Normal	H	H	H
Normal	L	L	H
Open Load	H	H	L
Open Load (3)	L	H	L
Short circuit to Gnd	H	L	L
Short circuit to Gnd	L	L	H
Short circuit to V <sub>cc</sub>	H	H	L (4)
Short circuit to V <sub>cc</sub> (5)	L	H	L
Over-temperature	H	L	L
Over-temperature	L	L	H

(3) With a pull-up resistor connected between the output and V<sub>cc</sub>.

(4) V<sub>ds</sub> lower than 10mV.

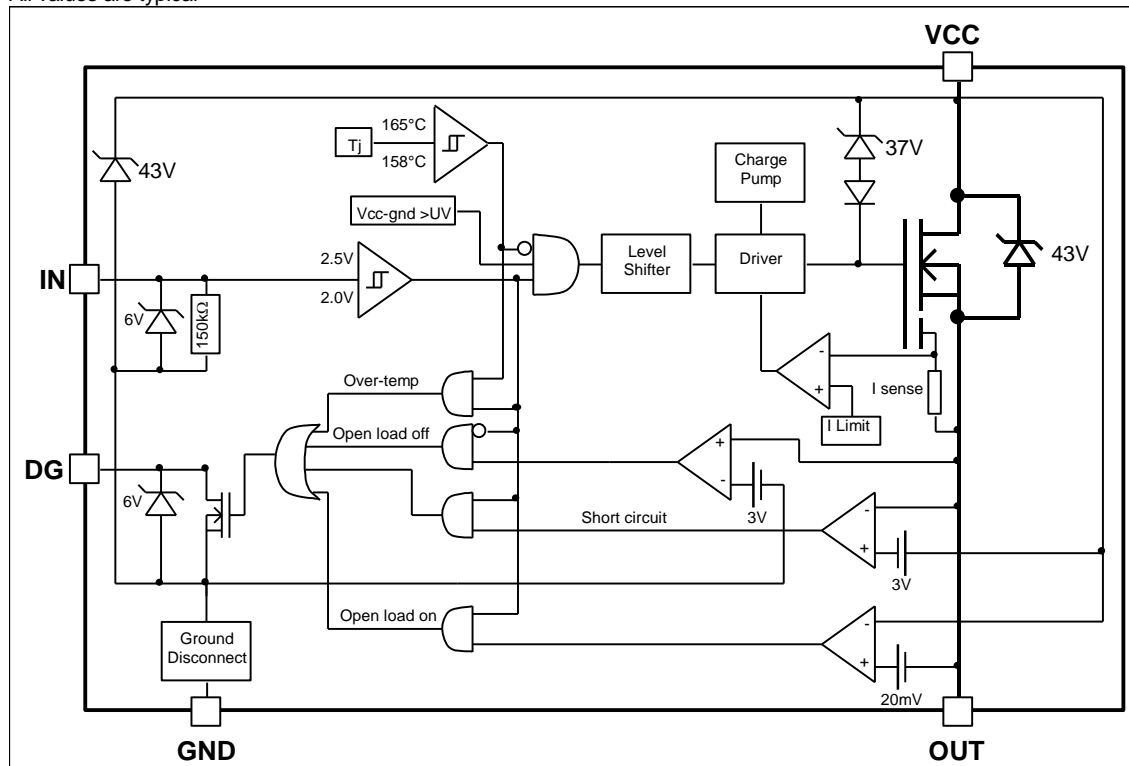
(5) Without a pull-up resistor connected between the output and V<sub>cc</sub>.

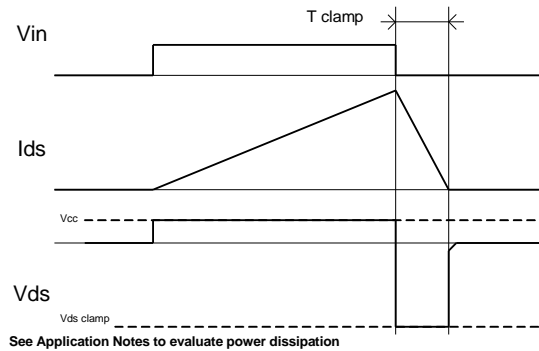
## Lead Assignments



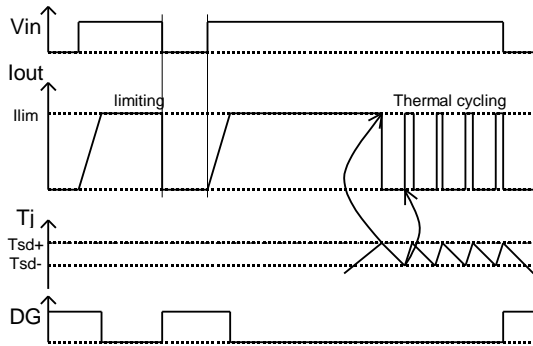
## Functional Block Diagram

All values are typical

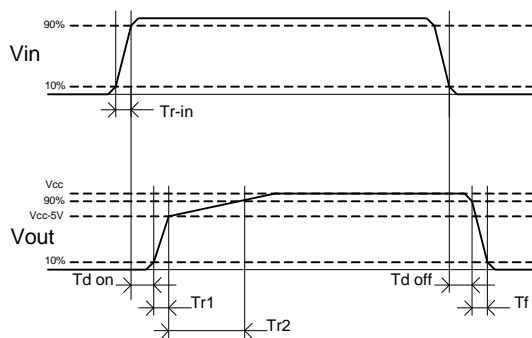




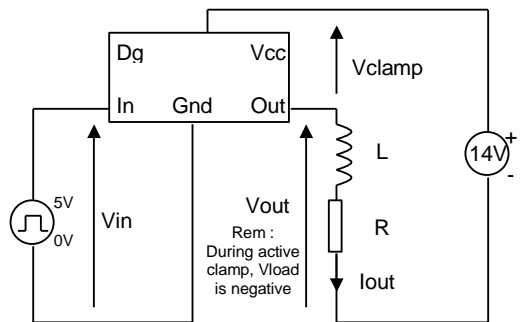
**Figure 1 – Active clamp waveforms**



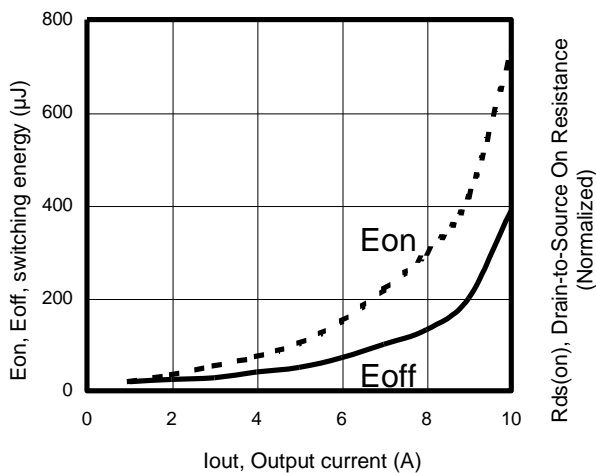
**Figure 2 – Protection timing diagram**



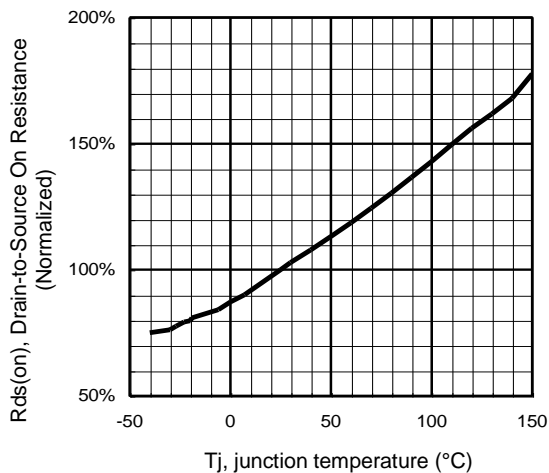
**Figure 3 – Switching times definitions**



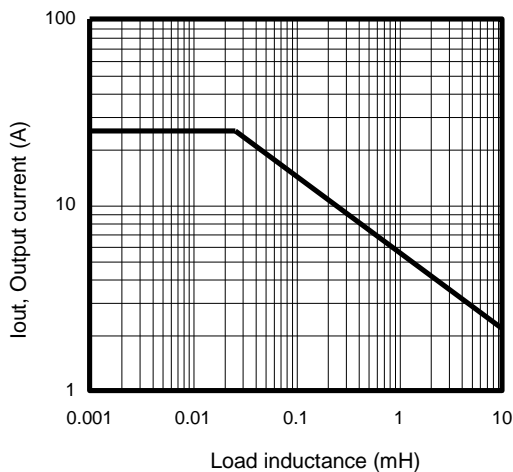
**Figure 4 – Active clamp test circuit**



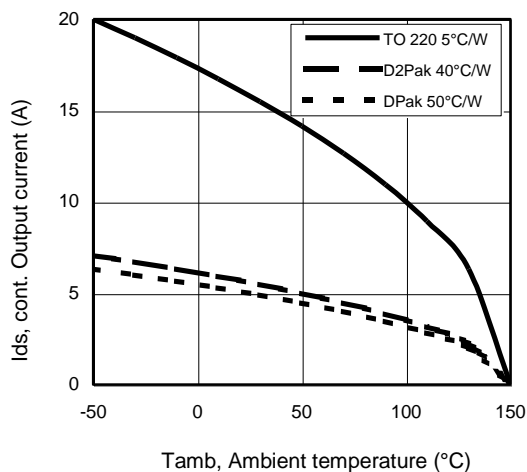
**Figure 5 – Switching energy ( $\mu\text{J}$ ) Vs Output current (A)**



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

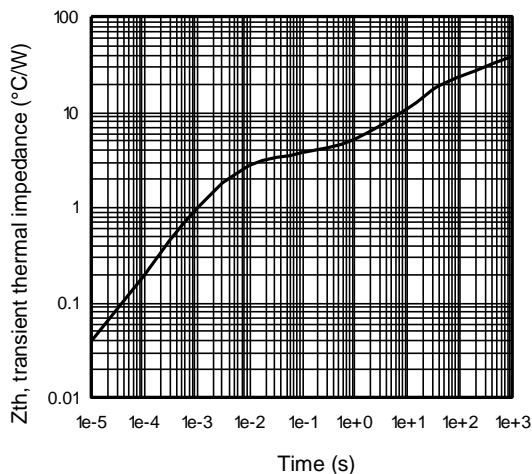


**Figure 7 – Max. Output current (A) Vs Load inductance (mH)**

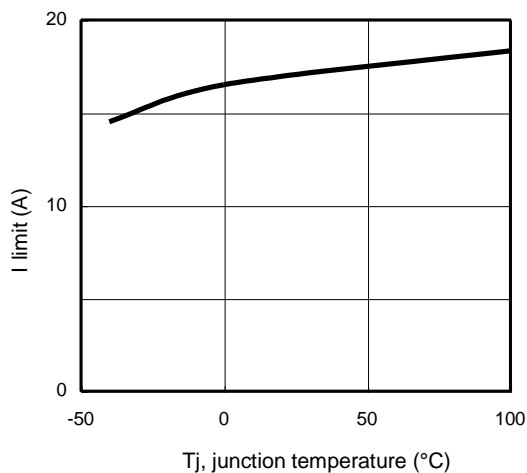


**Figure 8 – Max. output current (A) Vs Ambient temperature (°C)**

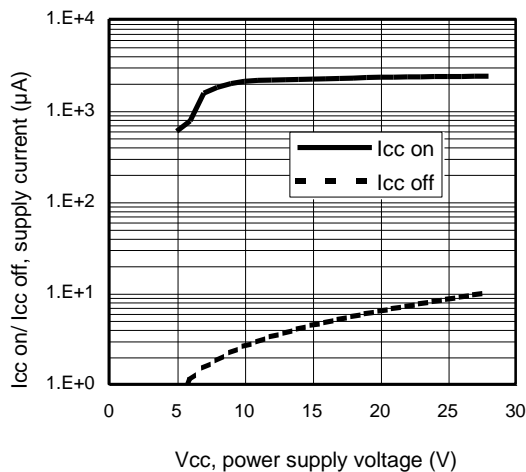




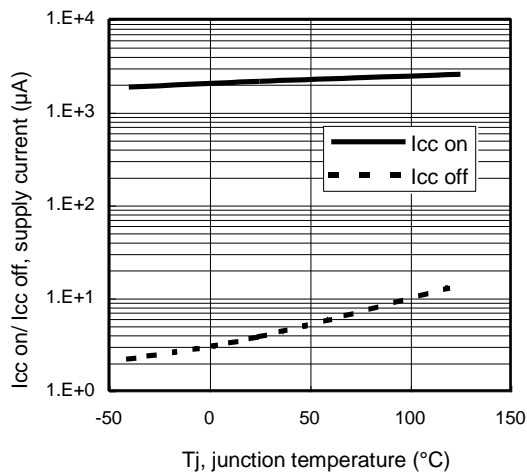
**Figure 9 – Transient thermal impedance ( $^{\circ}\text{C/W}$ ) Vs time (s)**



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



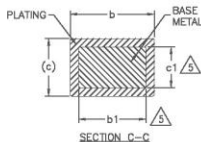
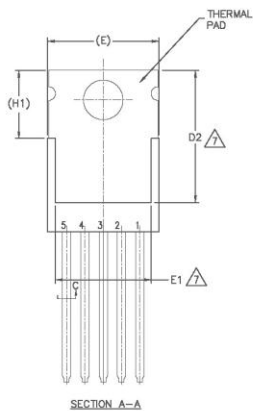
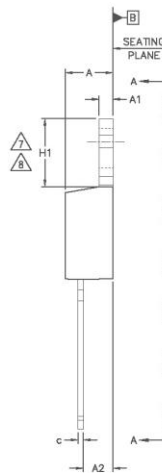
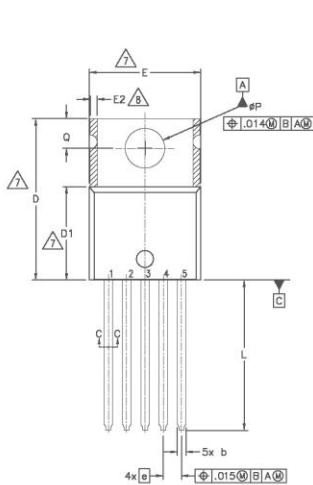
**Figure 11 –  $I_{cc}$  on/  $I_{cc}$  off ( $\mu\text{A}$ ) Vs  $V_{cc}$  (V)\***



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

\* $V_{out}$  connected to ground with  $R < 4\Omega$

## Case Outline - TO220 (5 leads)

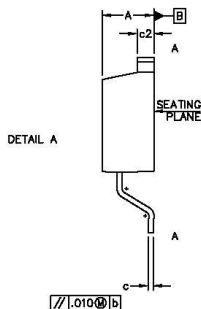
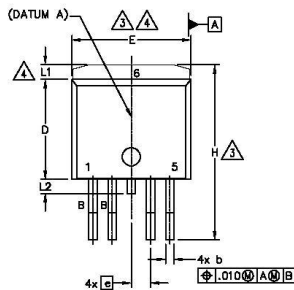
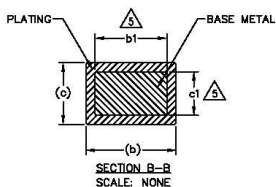
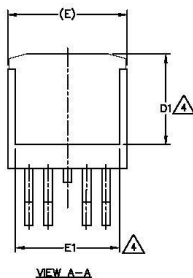
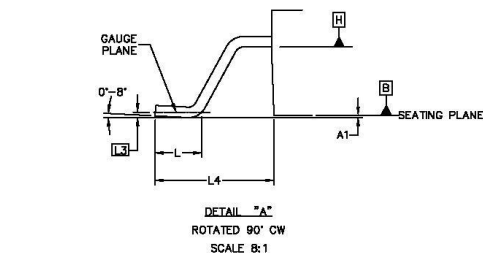


CODE NO.	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	3.56	4.83	.140	.190	
A1	0.51	1.40	.020	.055	
A2	2.03	2.92	.080	.115	
b	0.64	0.89	.025	.035	5
b1	0.64	0.84	.025	.033	
c	0.36	0.61	.014	.024	
c1	0.36	0.56	.014	.022	5
D	14.22	16.51	.560	.650	4
D1	8.38	9.02	.330	.355	
D2	11.68	12.88	.460	.507	7
E	9.65	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		
H1	5.84	6.86	.230	.270	7, 8
L	12.70	14.73	.500	.580	
W	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 - 5 Leads

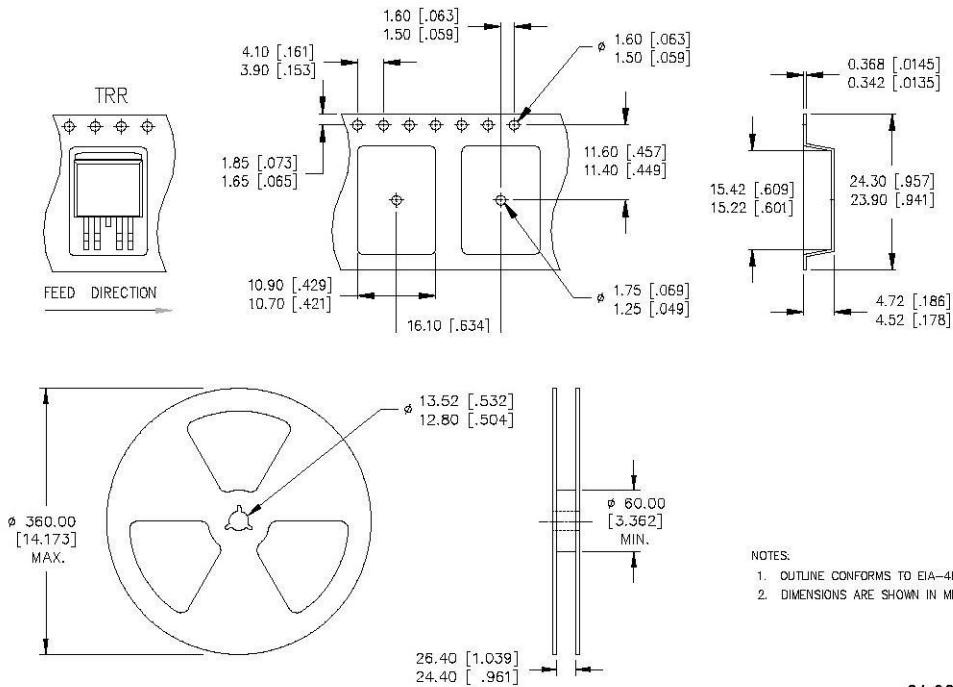


### NOTES:

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	4
A1	—	0.254	—	.010	
b	0.51	0.89	.020	.039	
b1	0.51	0.89	.020	.035	4
c	0.38	0.74	.015	.029	
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	—	
E	9.65	10.67	.380	.420	3
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 D2PAK - 5 Leads

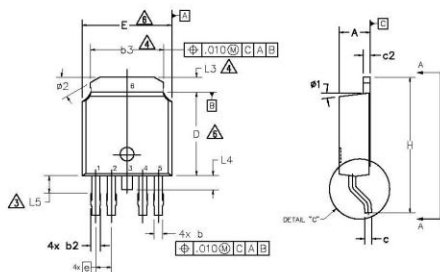
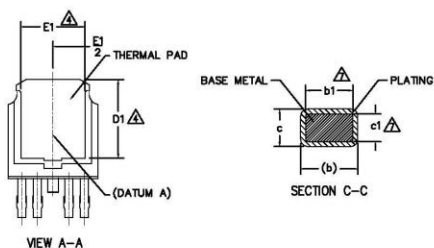
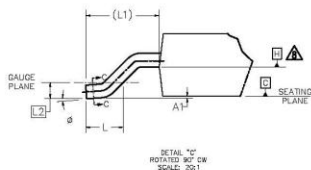


### NOTES:

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

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## Case Outline DPAK - 5 Leads

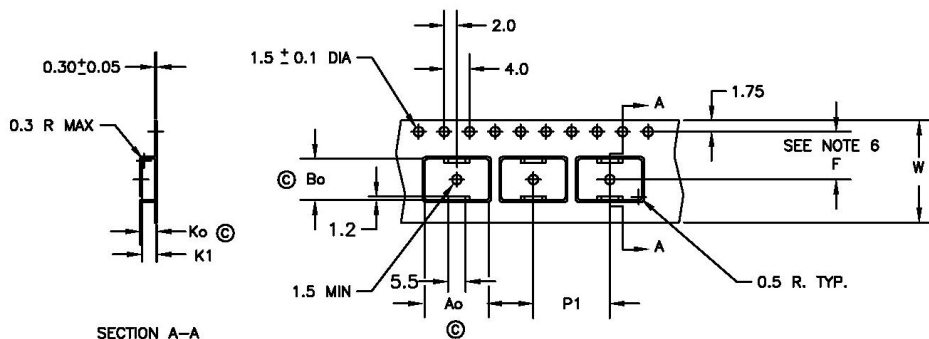


SYMBOL	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	2.18	2.39	.086	.094	2
A1	—	0.13	—	.005	
b	0.56	0.79	.022	.031	2
b1	.056	0.74	.022	.029	
b2	0.65	0.89	.026	.035	2
b3	4.95	5.46	.195	.215	
c	0.46	0.61	.018	.024	2
c1	0.41	0.56	.016	.022	
c2	0.46	0.89	.018	.035	3
D	5.97	6.22	.235	.245	
D1	5.21	—	.205	—	3
E	6.35	6.73	.250	.265	
E1	4.32	—	.170	—	3
e	1.14 BSC		.045 BSC		
H	9.40	10.41	.370	.410	3
L	1.40	1.78	.055	.070	
L1	2.74 BSC		.108 REF.		3
L2	0.51 BSC		.020 BSC		
L3	0.89	1.27	.035	.050	3
L4	—	1.02	—	.040	
L5	1.14	1.52	.045	.060	3
ø	0"	10"	0"	10"	
ø1	0"	15"	0"	15"	3
ø2	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 DPAK - 5 Leads

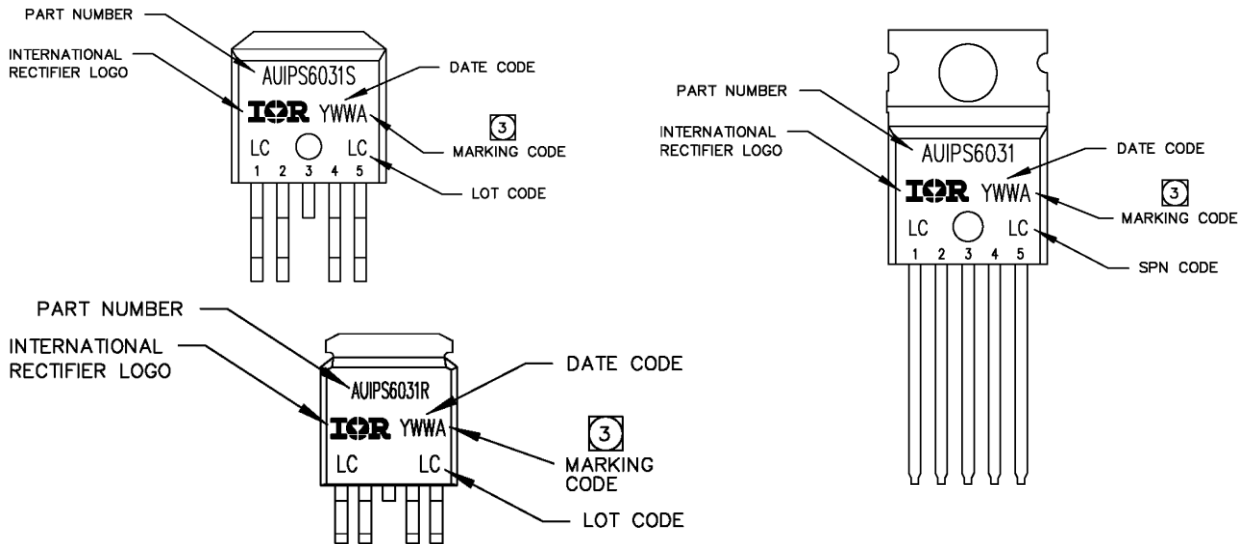


Ao = 10.5 mm  
 Bo = 7.0 mm  
 Ko = 2.8 mm  
 K1 = 2.4 mm  
 F = 7.5 mm  
 P1 = 12.0 mm  
 W = 16.0 ± .3 mm

### 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 10<sup>8</sup> 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

**Part Marking Information**



**Ordering Information**

Base Part Number	Package Type	Standard Pack		Complete Part Number
		Form	Quantity	
AUIPS6031	TO220-5-Leads	Tube	50	AUIPS6031
AUIPS6031S	D2-Pak-5-Leads	Tube	50	AUIPS6031S
		Tape and reel left	800	AUIPS6031STRL
		Tape and reel right	800	AUIPS6031STRR
AUIPS6031R	D-Pak-5-Leads	Tube	75	AUIPS6031R
		Tape and reel	2000	AUIPS6031RTR
		Tape and reel left	3000	AUIPS6031RTRL
		Tape and reel right	3000	AUIPS6031RTRR

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For technical support, please contact IR's Technical Assistance Center  
<http://www.irf.com/technical-info/>

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## Revision History

Revision	Date	Notes/Changes
B	September, 12th 2011	AU release
C	May 15, 2012	Add the test condition for the ICC (off) parameters