

## AUIPS6041(G)(R)(S)

### 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

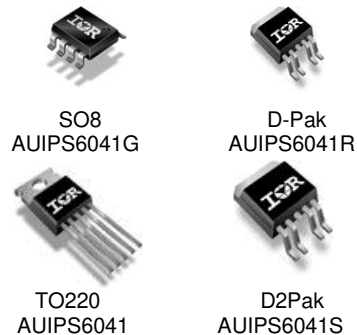
#### Description

The AUIPS6041(G)(R)(S) 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.

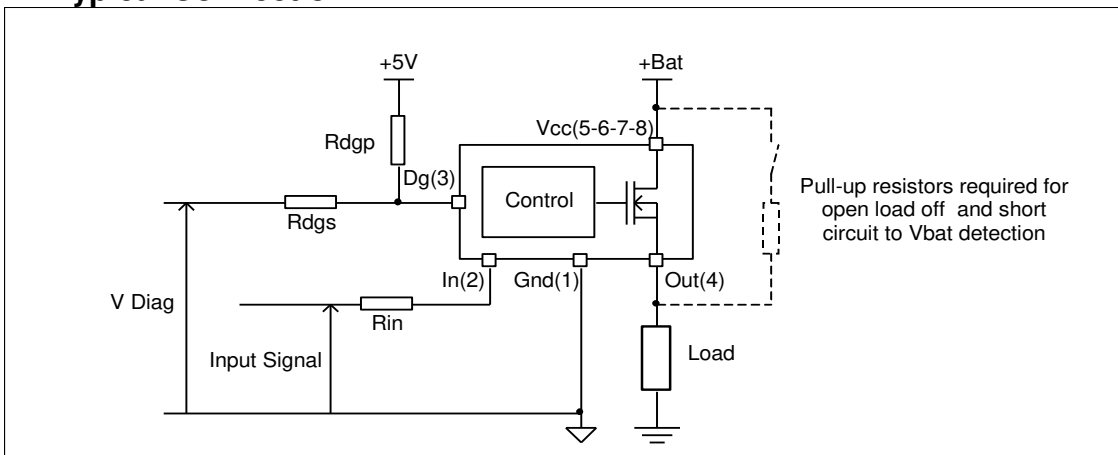
#### Product Summary

$R_{ds(on)}$	130m $\Omega$ max.
$V_{clamp}$	39V
I Limit	7A
Open load	3V / 0.22A

#### Packages



#### Typical Connection



## Qualification Information†

<b>Qualification Level</b>		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.	
<b>Moisture Sensitivity Level</b>		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)
		SOIC-8L	MSL2, 260°C (per IPC/JEDEC J-STD-020)
<b>ESD</b>	Machine Model	Class <b>M2 (+/-150V)</b> <sup>†††</sup> (per AEC-Q100-003)	
	Human Body Model	Class <b>H1C (+/-1500V)</b> <sup>†††</sup> (per AEC-Q100-002)	
	Charged Device Model (SOIC, DPAK, D2PAK)	Class <b>C4 (+/-900V)</b> <sup>†††</sup> (per AEC-Q100-011)	
	Charged Device Model (TO220)	Class <b>C3B (+/-750V)</b> <sup>†††</sup> (per AEC-Q100-011)	
<b>IC Latch-Up Test</b>		Class II, Level A (per AEC-Q100-004)	
<b>RoHS Compliant</b>		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<sub>j</sub>= -40°C..150°C, V<sub>cc</sub>=6..35V (unless otherwise specified).

Symbol	Parameter	Min.	Max.	Units
V <sub>out</sub>	Maximum output voltage	V <sub>cc</sub> -35	V <sub>cc</sub> +0.3	V
V <sub>offset</sub>	Maximum logic ground to load ground offset	V <sub>cc</sub> -35	V <sub>cc</sub> +0.3	
V <sub>in</sub>	Maximum input voltage	-0.3	5.5	
V <sub>cc max.</sub>	Maximum V <sub>cc</sub> voltage	—	36	
V <sub>cc cont.</sub>	Maximum continuous V <sub>cc</sub> voltage	—	28	
I <sub>in max.</sub>	Maximum IN current	-3	10	mA
I <sub>dg max.</sub>	Maximum diagnostic output current	-3	10	
V <sub>dg</sub>	Maximum diagnostic output voltage	-0.3	5.5	V
Pulse 2a max	Maximum voltage ISO pulse 2a x 500cy (ISO7637)	—	55	V
P <sub>d</sub>	Maximum power dissipation (internally limited by thermal protection) R <sub>th</sub> =100°C/W AUIPS6041G	—	1.25	W
		—	2.5	
T <sub>j max.</sub>	Max. storage & operating temperature junction temperature	-40	150	°C

## Thermal Characteristics

Symbol	Parameter	Typ.	Max.	Units
R <sub>th1</sub>	Thermal resistance junction to ambient AUIPS6041G	100	—	°C/W
R <sub>th1</sub>	Thermal resistance junction to ambient AUIPS6041R D-Pak std. footprint	70	—	
R <sub>th2</sub>	Thermal resistance junction to ambient AUIPS6041R D-Pak 1" sqrt. footprint	50	—	
R <sub>th3</sub>	Thermal resistance junction to case AUIPS6041(R)(S) D-Pak/D2pak/TO220	6	—	
R <sub>th1</sub>	Thermal resistance junction to ambient AUIPS6041(S) D2Pak/TO220 std. footprint	60	—	
R <sub>th2</sub>	Thermal resistance junction to ambient AUIPS6041S D2Pak 1" sqrt. footprint	40	—	

## 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	
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> =100°C/W AUIPS6041G R <sub>th</sub> =50°C/W AUIPS6041R 1" sqrt. footprint	— —	1.6 2.3	A
R <sub>in</sub>	Recommended resistor in series with IN pin	4	10	kΩ
R <sub>dgs</sub>	Recommended resistor in series with DG pin for reverse battery protection	4	20	
R <sub>dgp</sub>	Recommended pull-up resistor for DG	4	20	
R <sub>ol</sub>	Recommended pull-up resistor for open load detection	5	100	
F max.	Max. switching frequency	—	3.5	

## Static Electrical 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
R <sub>ds(on)</sub>	ON state resistance T <sub>j</sub> =25°C	—	110	130	mΩ	V <sub>in</sub> =5V, I <sub>out</sub> =2.5A
	ON state resistance T <sub>j</sub> =150°C	—	190	230		V <sub>in</sub> =5V, I <sub>out</sub> =2.5A
	ON state resistance T <sub>j</sub> =25°C, V <sub>cc</sub> =6V	—	125	155		V <sub>in</sub> =5V, I <sub>out</sub> =1.5A
	ON state resistance during reverse battery T <sub>j</sub> =25°C	—	140	180		V <sub>cc</sub> -Gnd=-14V
V <sub>cc op.</sub>	Operating voltage range	6	—	28	V	
V clamp 1	V <sub>cc</sub> to Out clamp voltage 1	37	39	43		I <sub>out</sub> =20mA
V clamp 2	V <sub>cc</sub> to Out clamp voltage 2	—	40	—		I <sub>out</sub> =2.5A (see Fig. 1)
I <sub>cc Off</sub>	Supply current when Off and with V <sub>out</sub> connected to ground R <sub>connection</sub> <4Ω	—	4	9	μA	V <sub>in</sub> =0V, V <sub>out</sub> =0V, T <sub>j</sub> =25°C, V <sub>cc</sub> =14V
I <sub>cc On</sub>	Supply current when On	—	2.2	5	mA	V <sub>in</sub> =5V, V <sub>cc</sub> =14V
V <sub>ih</sub>	Input high threshold voltage	—	2.5	3	V	
V <sub>il</sub>	Input low threshold voltage	1.5	2	—		
I <sub>n hyst.</sub>	Input hysteresis	0.2	0.5	1		
I <sub>in On</sub>	Input current when device is On	—	40	100	μA	V <sub>in</sub> =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

## Switching Electrical Characteristics

V<sub>cc</sub>=14V, Resistive load=6Ω, V<sub>in</sub>=5V, T<sub>j</sub>=-40°C..150°C, typical values are given for T<sub>j</sub>=25°C

Symbol	Parameter	Min.	Typ.	Max.	Units	Test Conditions
T <sub>don</sub>	Turn-on delay time	—	5	15	μs	see Fig. 3
Tr1	Rise time to V <sub>out</sub> =V <sub>cc</sub> -5V	—	3	10		
Tr2	Rise time to V <sub>out</sub> =0.9 x V <sub>cc</sub>	—	4	30		
dV/dt (On)	Turn On dV/dt	—	2.5	—	V/μs	
E <sub>On</sub>	Turn On energy	—	100	—	μJ	
T <sub>doff</sub>	Turn-off delay time	—	10	20	μs	
T <sub>f</sub>	Fall time to V <sub>out</sub> =0.1 x V <sub>cc</sub>	—	3	10		
dV/dt (Off)	Turn Off dV/dt	—	6.5	—	V/μs	
E <sub>Off</sub>	Turn Off energy	—	50	—	μJ	

## Protection 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
Ilim	Internal current limit	4	7	10	A	$V_{out} = 0\text{V}$ , $T_j = 25^{\circ}\text{C}$
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	6.2	V	
UV-		—	4.5	5.8		
VOL Off	Open load detection threshold	2	3	4		
IOL On	Open load detection threshold	0.05	0.17	0.27	A	$T_j = -40..25^{\circ}\text{C}$
		0.05	0.15	0.22		$T_j = 25..150^{\circ}\text{C}$

(1) Guaranteed by design

(2) Reference to Vcc

## True Table

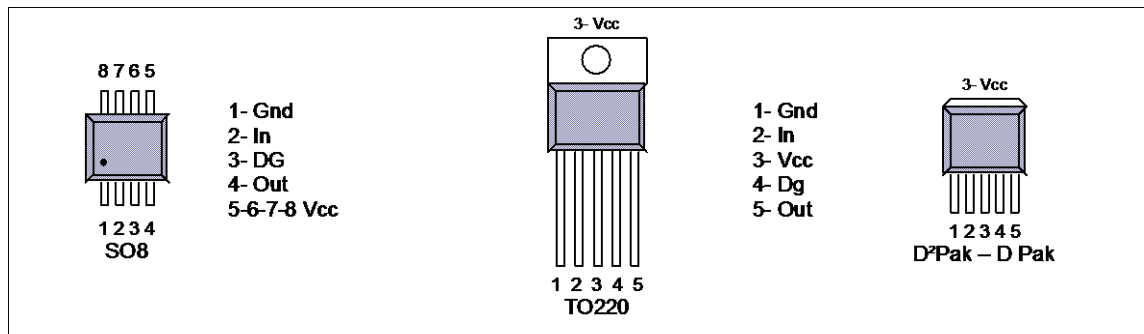
Operating Conditions	IN	OUT	DG
Normal	H	H	H
Normal	L	L	H
Open Load	H	H	L
Open Load (3)	L	H	L
Short circuit to Gnd	H	L	L
Short circuit to Gnd	L	L	H
Short circuit to Vcc	H	H	L (4)
Short circuit to Vcc (5)	L	H	L
Over-temperature	H	L	L
Over-temperature	L	L	H

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

(4) Vds lower than 10mV.

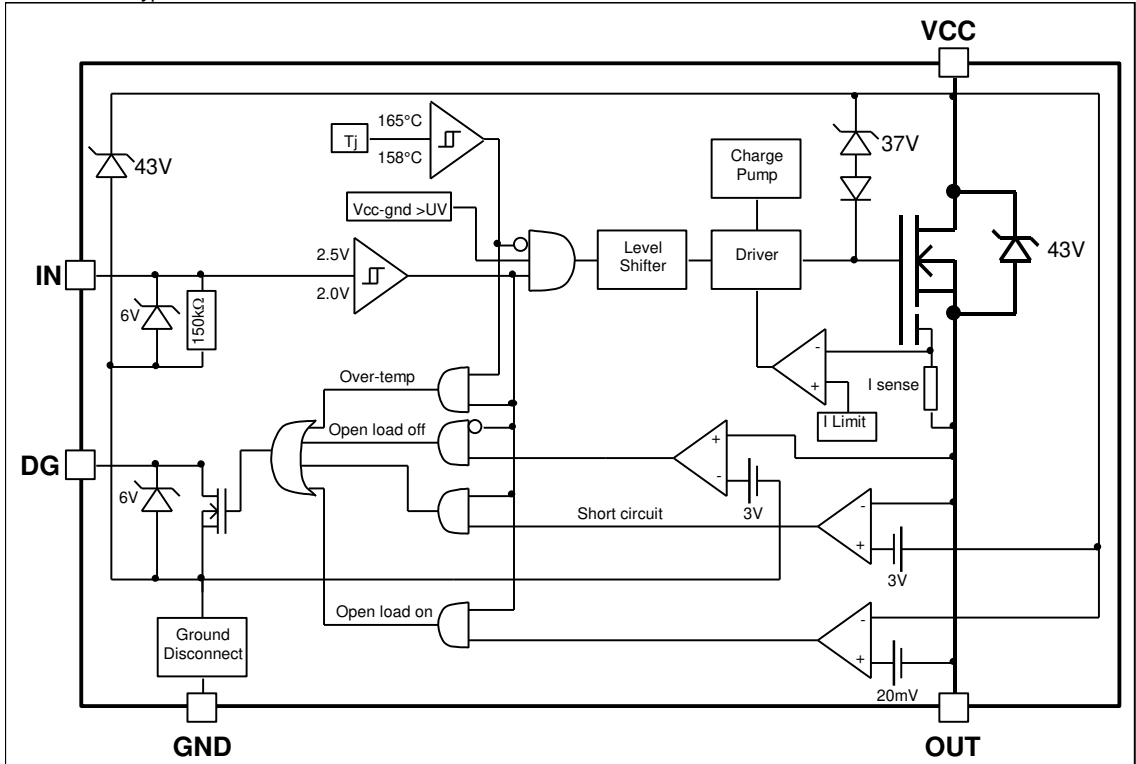
(5) Without a pull-up resistor connected between the output and Vcc.

## Lead Assignments



## Functional Block Diagram

All values are typical



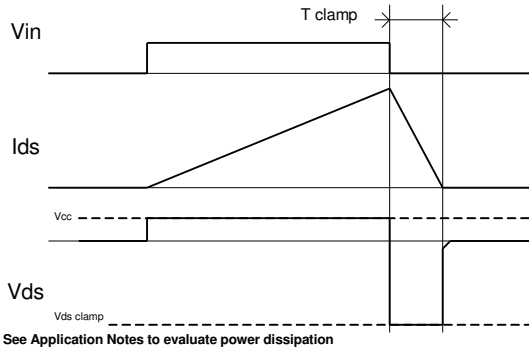


Figure 1 – Active clamp waveforms

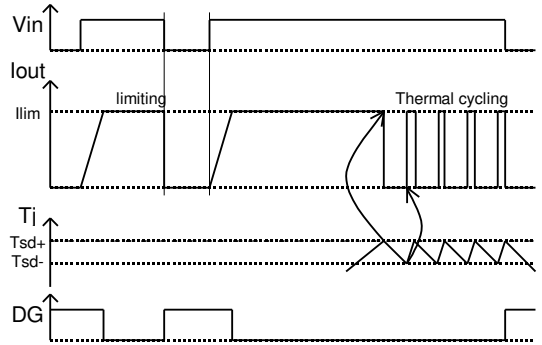


Figure 2 – Protection timing diagram

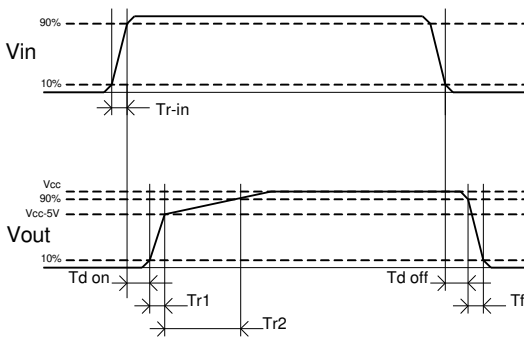


Figure 3 – Switching times definitions

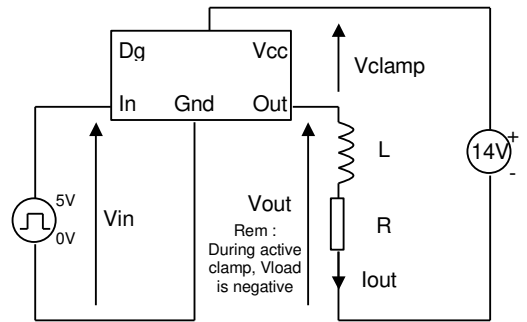
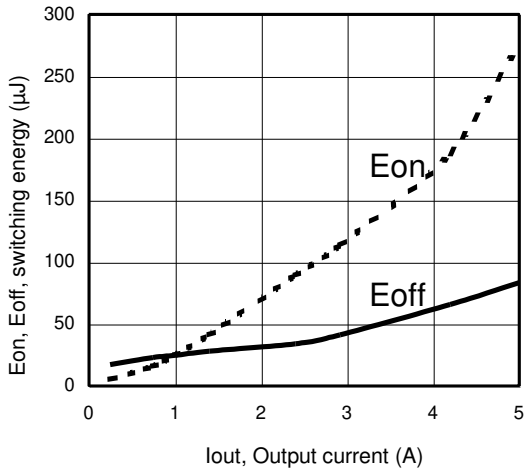
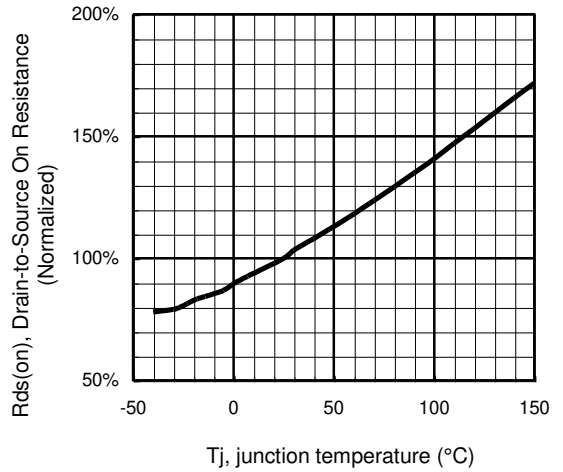


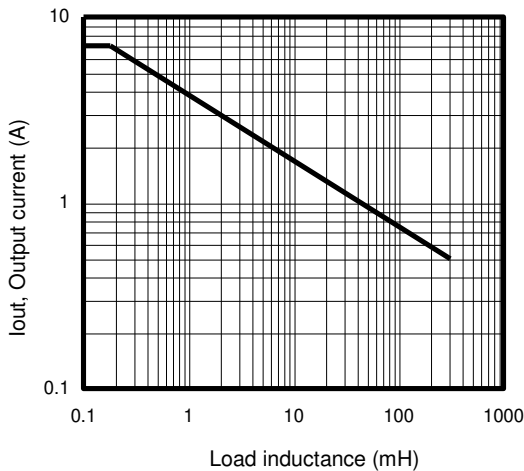
Figure 4 – Active clamp test circuit



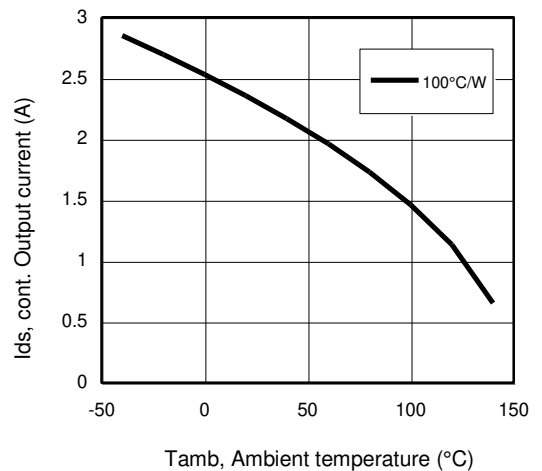
**Figure 5 – Switching energy ( $\mu\text{J}$ ) Vs Output current (A)**



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

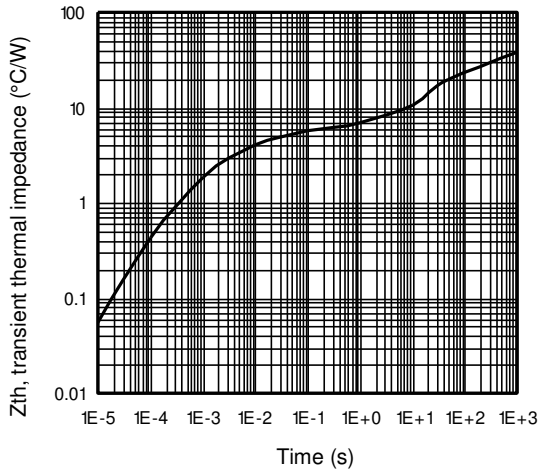


**Figure 7 – Max. Output current (A) Vs Load inductance (mH)**

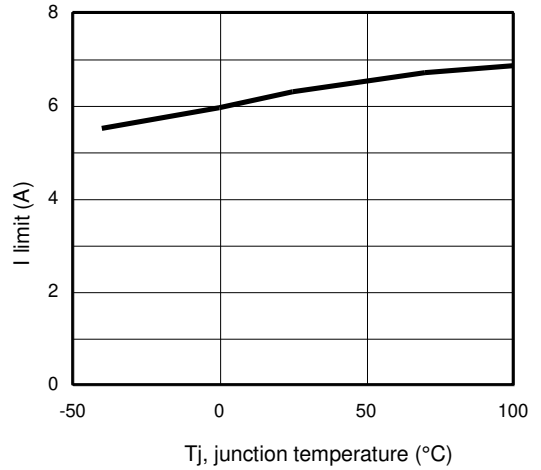


**Figure 8 – Max. output current (A) Vs Ambient temperature ( $^{\circ}\text{C}$ )**

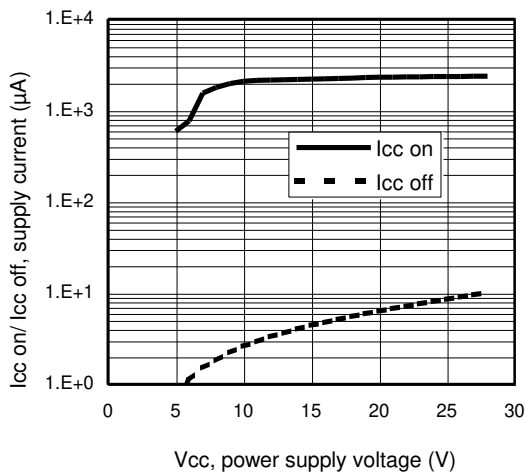




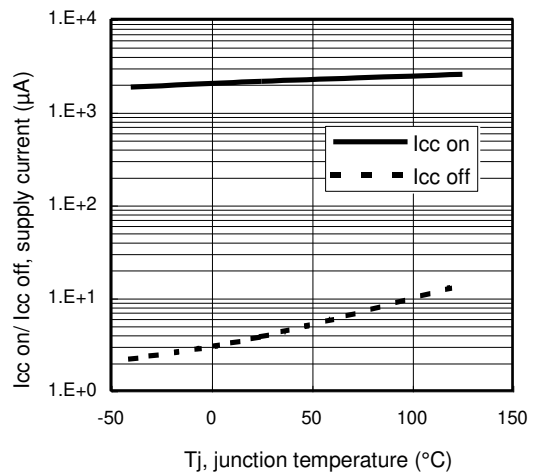
**Figure 9 – Transient thermal impedance (°C/W) Vs time (s)**



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



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

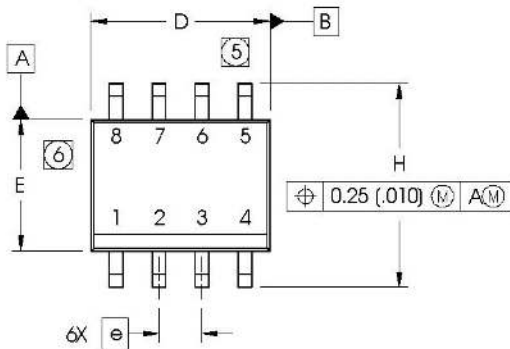


**Figure 12 – Icc on/ Icc off (µA) Vs Tj (°C)\***

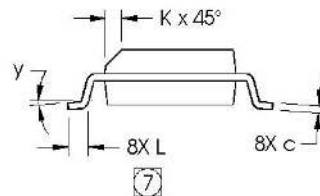
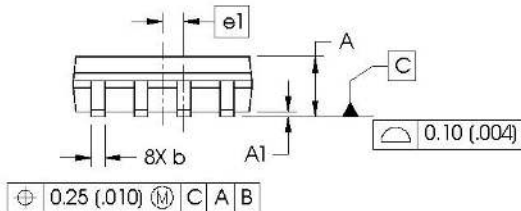
\*Vout connected to ground with  $R < 4\Omega$

## Case Outline – SO8

Dimensions are shown in millimeters (inches)



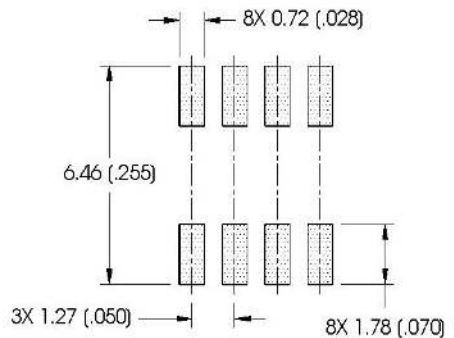
DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	.0532	.0688	1.35	1.75
AI	.0040	.0098	0.10	0.25
b	.013	.020	0.33	0.51
c	.0075	.0098	0.19	0.25
D	.189	.1968	4.80	5.00
E	.1497	.1574	3.80	4.00
e	.050 BASIC		1.27 BASIC	
e1	.025 BASIC		0.635 BASIC	
H	.2284	.2440	5.80	6.20
K	.0099	.0196	0.25	0.50
L	.016	.050	0.40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



### NOTES:

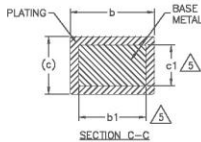
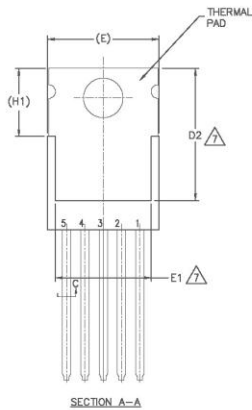
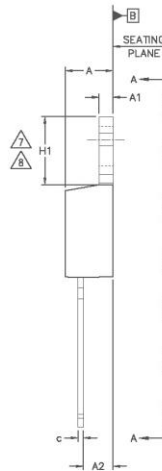
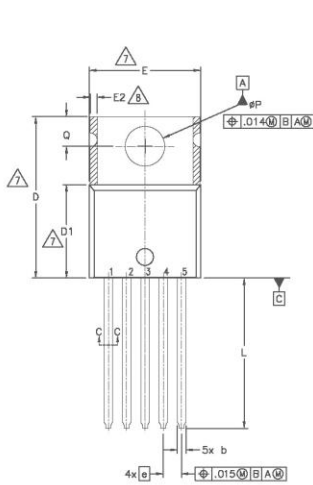
1. DIMENSIONING & TOLERANCING PER ASME Y14.5M-1994.
2. CONTROLLING DIMENSION: MILLIMETER
3. DIMENSIONS ARE SHOWN IN MILLIMETERS (INCHES).
4. OUTLINE CONFORMS TO JEDEC OUTLINE MS-012AA.
- ⑤ DIMENSION DOES NOT INCLUDE MOLD PROTRUSIONS. MOLD PROTRUSIONS NOT TO EXCEED 0.15 (.006).
- ⑥ DIMENSION DOES NOT INCLUDE MOLD PROTRUSIONS. MOLD PROTRUSIONS NOT TO EXCEED 0.25 (.010).
- ⑦ DIMENSION IS THE LENGTH OF LEAD FOR SOLDERING TO A SUBSTRATE.

### FOOTPRINT





## Case Outline - TO220 (5 leads)



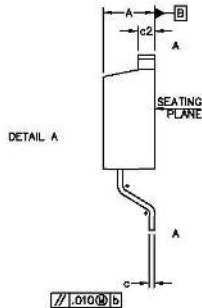
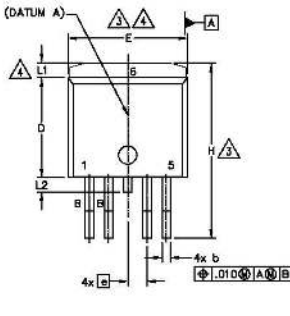
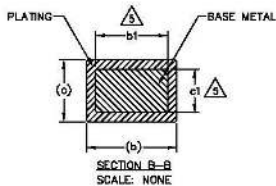
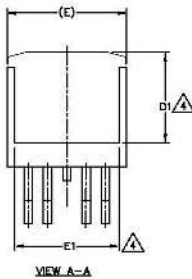
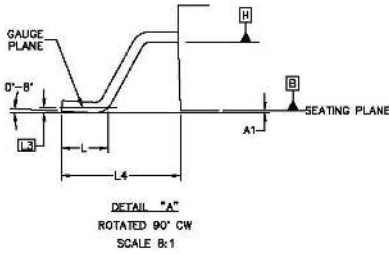
SYMBOL	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	3.56	4.83	.140	.190	
A1	0.51	1.40	.020	.055	
A2	2.03	2.92	.080	.115	
b	0.64	0.89	.025	.035	
b1	0.64	0.84	.025	.033	5
c	0.36	0.61	.014	.024	
c1	0.36	0.56	.014	.022	5
D	14.22	16.51	.560	.650	4
D1	8.38	9.02	.330	.355	
D2	11.68	12.88	.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 <sub>P</sub>	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 Leads - D2PAK

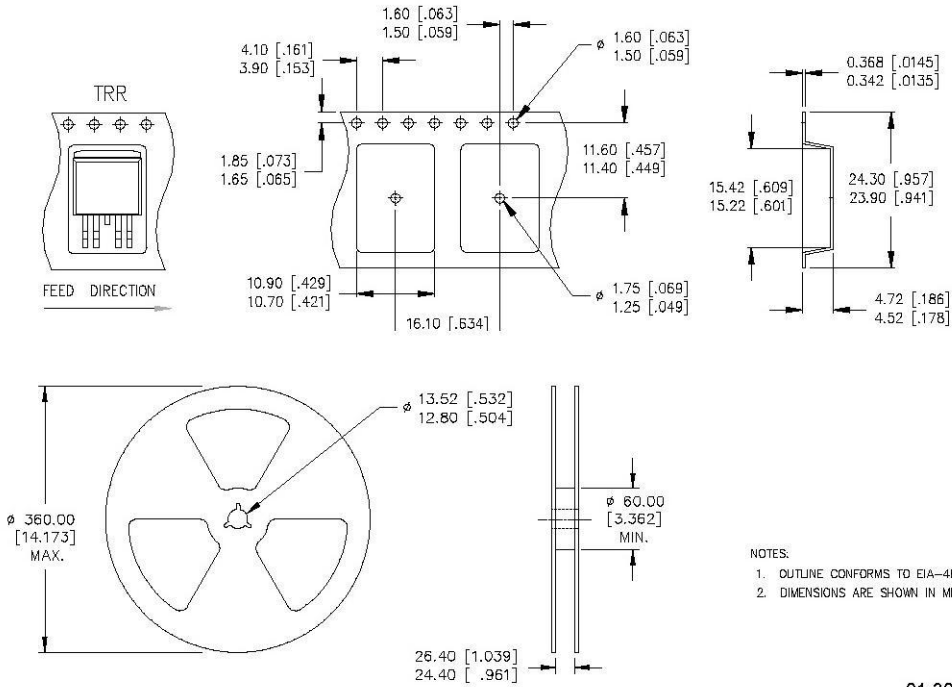


NOTES:

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

SYM- BO- L	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	4.08	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	15.88	.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	

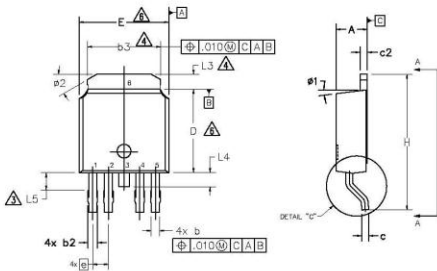
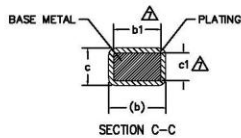
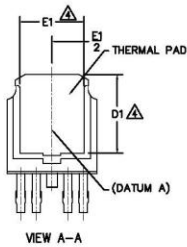
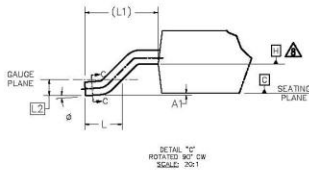
## Tape & Reel 5 Leads - D2PAK



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

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## Case Outline 5 Leads – DPAK

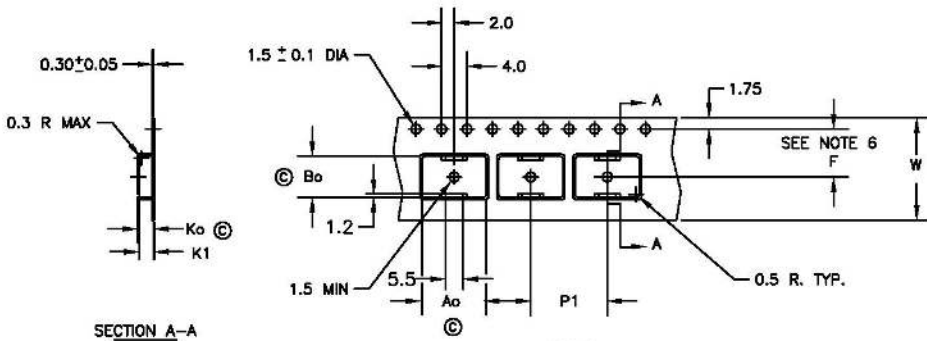


SYMBOL	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	2.18	2.39	.086	.094	2
A1	—	0.13	—	.005	
b	0.56	0.79	.022	.031	2
b1	.056	0.74	.022	.029	
b2	0.65	0.89	.026	.035	2
b3	4.95	5.46	.195	.215	
c	0.46	0.61	.018	.024	3
c1	0.41	0.56	.016	.022	
c2	0.46	0.89	.018	.035	3
D	5.97	6.22	.235	.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
$\phi$	0"	10"	0"	10"	
$\phi 1$	0"	15"	0"	15"	3
$\phi 2$	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

**Tape & Reel 5 Leads – DPAK**



**SECTION A-A**

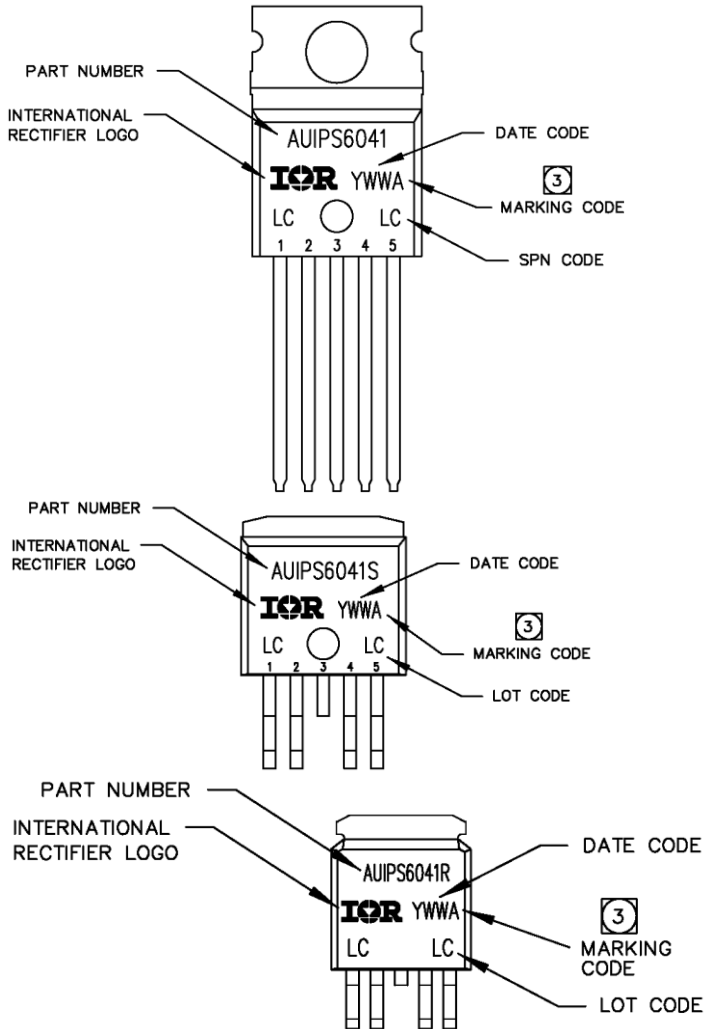
- Ao = 10.5 mm
- Bo = 7.0 mm
- Ko = 2.8 mm
- K1 = 2.4 mm
- F = 7.5 mm
- P1 = 12.0 mm
- W = 16.0 ± .3 mm

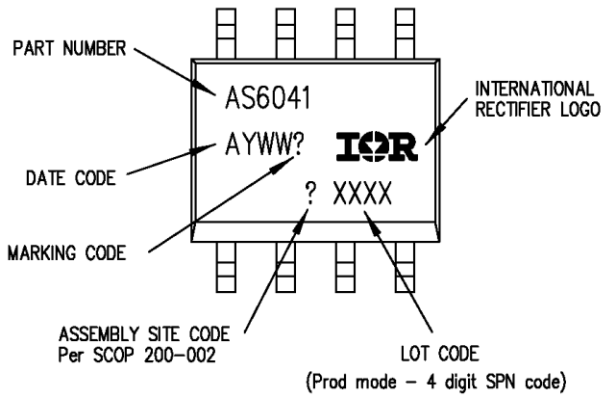
**NOTES:**

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 10\* 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	
AUIPS6041	TO220-5-Leads	Tube	50	AUIPS6041
AUIPS6041S	D2-Pak-5-Leads	Tube	50	AUIPS6041S
		Tape and reel left	800	AUIPS6041STRL
		Tape and reel right	800	AUIPS6041STRR
AUIPS6041R	D-Pak-5-Leads	Tube	75	AUIPS6041R
		Tape and reel	2000	AUIPS6041RTR
		Tape and reel left	3000	AUIPS6041RTRL
		Tape and reel right	3000	AUIPS6041RTRR
AUIPS6041G	SOIC-8	Tube	95	AUIPS6041G
		Tape and reel	2500	AUIPS6041GTR

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**Revision History**

<b>Revision</b>	<b>Date</b>	<b>Notes/Changes</b>
C	February, 28th 2009	AU number update
D	March, 14th 2011	AU release
F	May 15, 2012	Add the test condition for the ICC (off) parameters