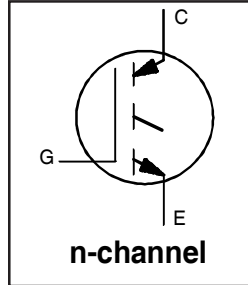


# IRG4BC40WPbF

## INSULATED GATE BIPOLAR TRANSISTOR

### Features

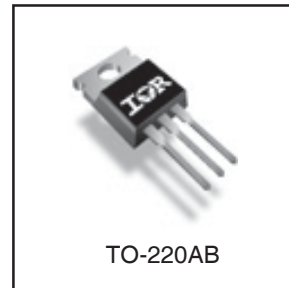
- Designed expressly for Switch-Mode Power Supply and PFC (power factor correction) applications
- Industry-benchmark switching losses improve efficiency of all power supply topologies
- 50% reduction of Eoff parameter
- Low IGBT conduction losses
- Latest-generation IGBT design and construction offers tighter parameters distribution, exceptional reliability
- Lead-Free



$V_{CES} = 600V$
$V_{CE(on) typ.} = 2.05V$
@ $V_{GE} = 15V, I_C = 20A$

### Benefits

- Lower switching losses allow more cost-effective operation than power MOSFETs up to 150KHz ("hard switched" mode)
- Of particular benefit to single-ended converters and boost PFC topologies 150W and higher
- Low conduction losses and minimal minority-carrier recombination make these an excellent option for resonant mode switching as well (up to >>300KHz)



### Absolute Maximum Ratings

	Parameter	Max.	Units
$V_{CES}$	Collector-to-Emitter Breakdown Voltage	600	V
$I_C @ T_C = 25^\circ C$	Continuous Collector Current	40	A
$I_C @ T_C = 100^\circ C$	Continuous Collector Current	20	
$I_{CM}$	Pulsed Collector Current ①	160	
$I_{LM}$	Clamped Inductive Load Current ②	160	
$V_{GE}$	Gate-to-Emitter Voltage	$\pm 20$	V
$E_{ARV}$	Reverse Voltage Avalanche Energy ③	160	mJ
$P_D @ T_C = 25^\circ C$	Maximum Power Dissipation	160	W
$P_D @ T_C = 100^\circ C$	Maximum Power Dissipation	65	
$T_J$	Operating Junction and	-55 to + 150	°C
$T_{STG}$	Storage Temperature Range		
	Soldering Temperature, for 10 seconds	300 (0.063 in. (1.6mm) from case )	
	Mounting torque, 6-32 or M3 screw.	10 lbf•in (1.1N•m)	

### Thermal Resistance

	Parameter	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	---	0.77	°C/W
$R_{\theta CS}$	Case-to-Sink, Flat, Greased Surface	0.5	---	
$R_{\theta JA}$	Junction-to-Ambient, typical socket mount	---	80	
Wt	Weight	2.0 (0.07)	---	g (oz)

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## Electrical Characteristics @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

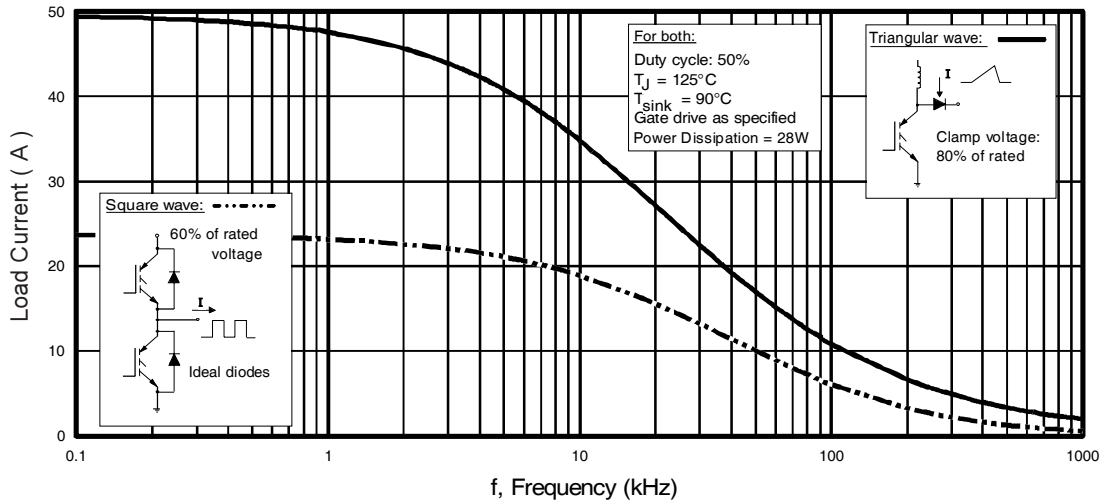
	Parameter	Min.	Typ.	Max.	Units	Conditions
$V_{(BR)CES}$	Collector-to-Emitter Breakdown Voltage	600	—	—	V	$V_{GE} = 0V, I_C = 250\mu A$
$V_{(BR)ECS}$	Emitter-to-Collector Breakdown Voltage ④	18	—	—	V	$V_{GE} = 0V, I_C = 1.0A$
$\Delta V_{(BR)CES}/\Delta T_J$	Temperature Coeff. of Breakdown Voltage	—	0.44	—	V/°C	$V_{GE} = 0V, I_C = 1.0mA$
$V_{CE(ON)}$	Collector-to-Emitter Saturation Voltage	—	2.05	2.5	V	$I_C = 20A$ $V_{GE} = 15V$
		—	2.36	—		$I_C = 40A$ See Fig.2, 5
		—	1.90	—		$I_C = 20A, T_J = 150^\circ\text{C}$
$V_{GE(th)}$	Gate Threshold Voltage	3.0	—	6.0		$V_{CE} = V_{GE}, I_C = 250\mu A$
$\Delta V_{GE(th)}/\Delta T_J$	Temperature Coeff. of Threshold Voltage	—	13	—	mV/°C	$V_{CE} = V_{GE}, I_C = 250\mu A$
$g_{fe}$	Forward Transconductance ⑤	18	28	—	S	$V_{CE} = 100V, I_C = 20A$
$I_{CES}$	Zero Gate Voltage Collector Current	—	—	250	$\mu A$	$V_{GE} = 0V, V_{CE} = 600V$
		—	—	2.0		$V_{GE} = 0V, V_{CE} = 10V, T_J = 25^\circ\text{C}$
		—	—	2500		$V_{GE} = 0V, V_{CE} = 600V, T_J = 150^\circ\text{C}$
$I_{GES}$	Gate-to-Emitter Leakage Current	—	—	$\pm 100$	nA	$V_{GE} = \pm 20V$

## Switching Characteristics @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

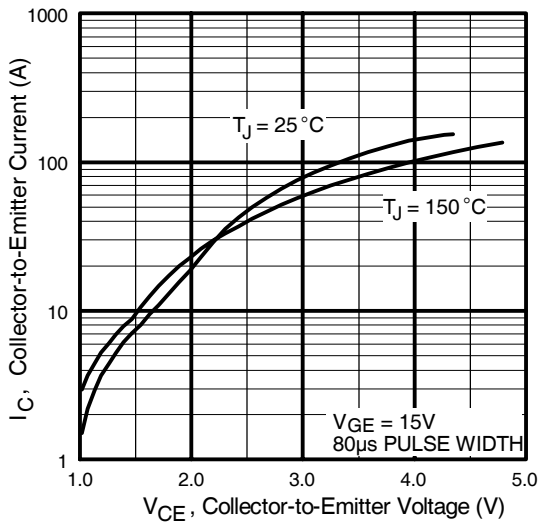
	Parameter	Min.	Typ.	Max.	Units	Conditions
$Q_g$	Total Gate Charge (turn-on)	—	98	147	nC	$I_C = 20A$
$Q_{ge}$	Gate - Emitter Charge (turn-on)	—	12	18		$V_{CC} = 400V$ See Fig.8
$Q_{gc}$	Gate - Collector Charge (turn-on)	—	36	54		$V_{GE} = 15V$
$t_{d(on)}$	Turn-On Delay Time	—	27	—	ns	$T_J = 25^\circ\text{C}$ $I_C = 20A, V_{CC} = 480V$ $V_{GE} = 15V, R_G = 10\Omega$ Energy losses include "tail" See Fig. 9,10, 14
$t_r$	Rise Time	—	22	—		
$t_{d(off)}$	Turn-Off Delay Time	—	100	150		
$t_f$	Fall Time	—	74	110		
$E_{on}$	Turn-On Switching Loss	—	0.11	—	mJ	See Fig. 9,10, 14
$E_{off}$	Turn-Off Switching Loss	—	0.23	—		
$E_{ts}$	Total Switching Loss	—	0.34	0.45	ns	$T_J = 150^\circ\text{C}$ , $I_C = 20A, V_{CC} = 480V$ $V_{GE} = 15V, R_G = 10\Omega$ Energy losses include "tail" See Fig. 10,11, 14
$t_{d(on)}$	Turn-On Delay Time	—	25	—		
$t_r$	Rise Time	—	23	—		
$t_{d(off)}$	Turn-Off Delay Time	—	170	—		
$t_f$	Fall Time	—	124	—		
$E_{ts}$	Total Switching Loss	—	0.85	—	mJ	
$L_E$	Internal Emitter Inductance	—	7.5	—	nH	Measured 5mm from package
$C_{ies}$	Input Capacitance	—	1900	—	pF	$V_{GE} = 0V$ $V_{CC} = 30V$ See Fig. 7 $f = 1.0MHz$
$C_{oes}$	Output Capacitance	—	140	—		
$C_{res}$	Reverse Transfer Capacitance	—	35	—		

### Notes:

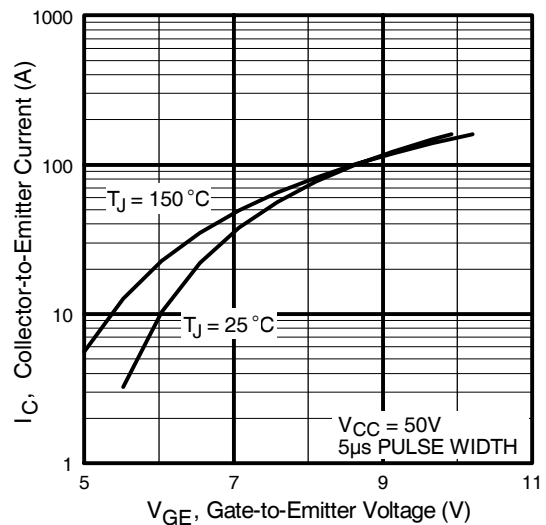
- ① Repetitive rating;  $V_{GE} = 20V$ , pulse width limited by max. junction temperature. ( See fig. 13b )
- ②  $V_{CC} = 80\%(V_{CES}), V_{GE} = 20V, L = 10\mu H, R_G = 10\Omega$ , (See fig. 13a)
- ③ Repetitive rating; pulse width limited by maximum junction temperature.
- ④ Pulse width  $\leq 80\mu s$ ; duty factor  $\leq 0.1\%$ .
- ⑤ Pulse width  $5.0\mu s$ , single shot.



**Fig. 1 - Typical Load Current vs. Frequency**  
(Load Current =  $I_{RMS}$  of fundamental)

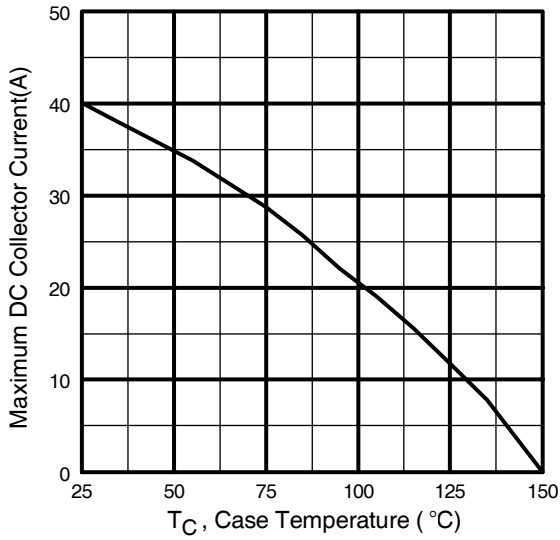


**Fig. 2 - Typical Output Characteristics**

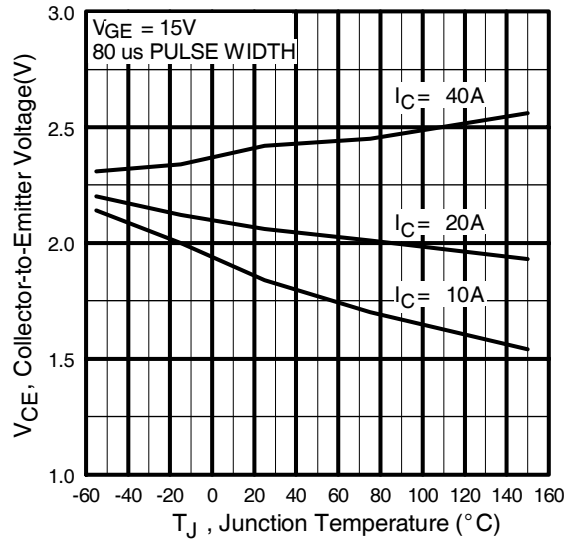


**Fig. 3 - Typical Transfer Characteristics**

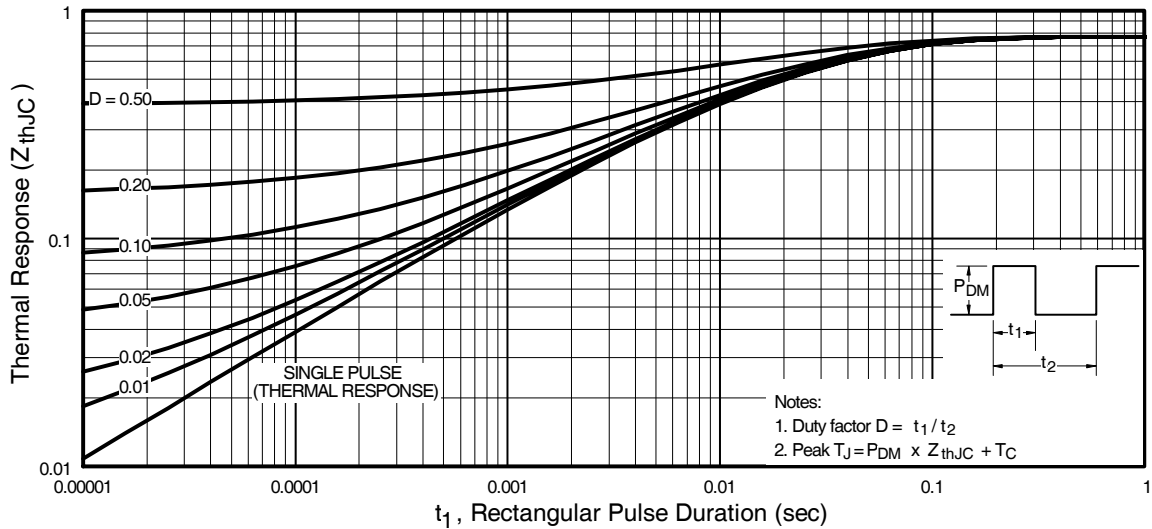
# IRG4BC40WPbF



**Fig. 4 - Maximum Collector Current vs. Case Temperature**

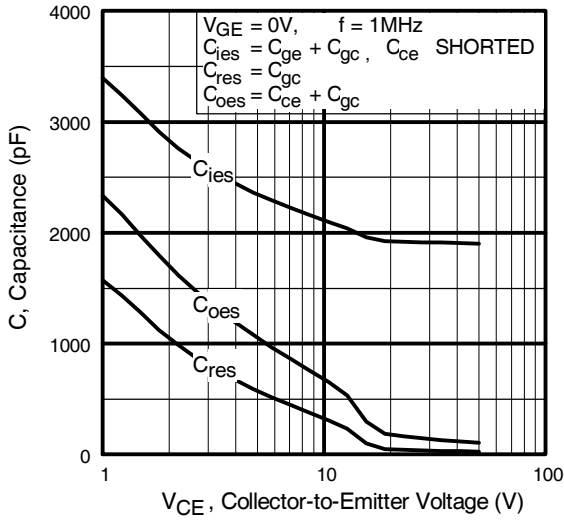


**Fig. 5 - Typical Collector-to-Emitter Voltage vs. Junction Temperature**

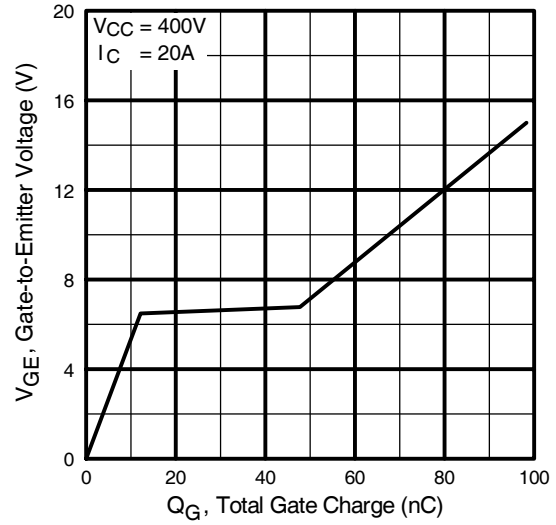


**Fig. 6 - Maximum Effective Transient Thermal Impedance, Junction-to-Case**

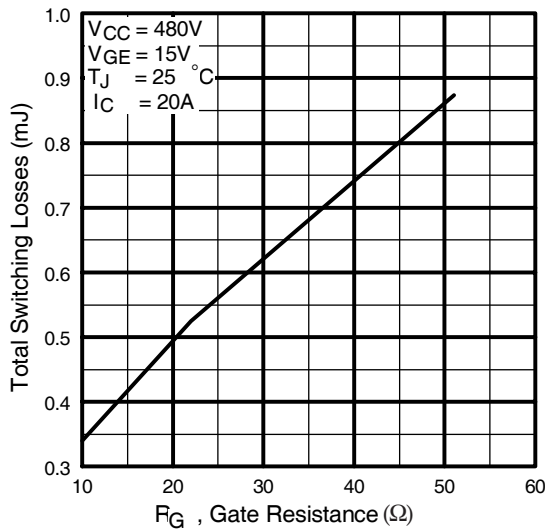
# IRG4BC40WPbF



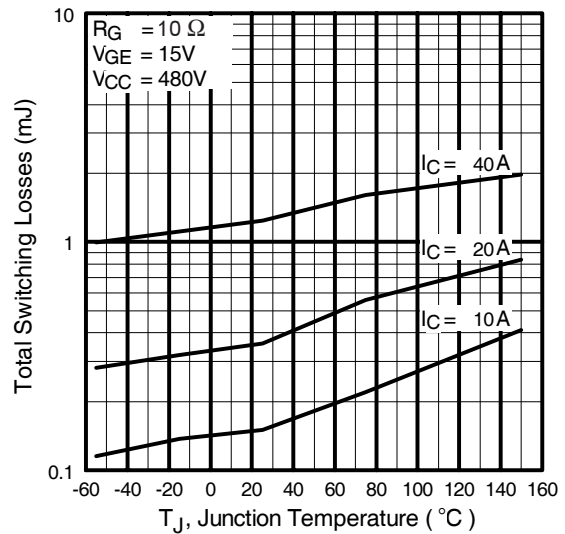
**Fig. 7** - Typical Capacitance vs. Collector-to-Emitter Voltage



**Fig. 8** - Typical Gate Charge vs. Gate-to-Emitter Voltage

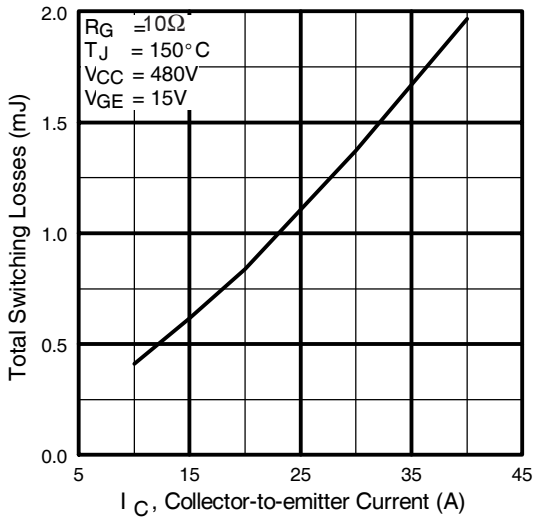


**Fig. 9** - Typical Switching Losses vs. Gate Resistance

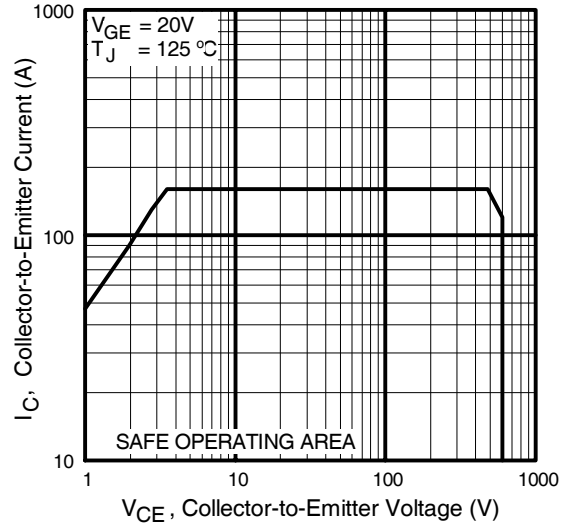


**Fig. 10** - Typical Switching Losses vs. Junction Temperature

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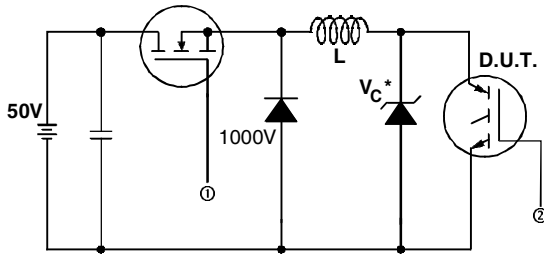


**Fig. 11** - Typical Switching Losses vs. Collector-to-Emitter Current



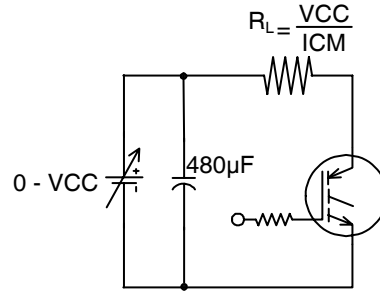
**Fig. 12** - Turn-Off SOA

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\* Driver same type as D.U.T.;  $V_c = 80\%$  of  $V_{ce(max)}$   
 \* Note: Due to the 50V power supply, pulse width and inductor will increase to obtain rated  $I_d$ .

**Fig. 13a** - Clamped Inductive Load Test Circuit



**Fig. 13b** - Pulsed Collector Current Test Circuit



**Fig. 14a** - Switching Loss Test Circuit

\* Driver same type as D.U.T.,  $V_C = 480V$

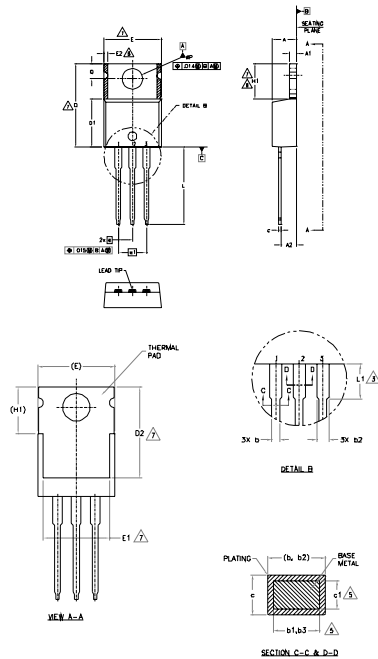


**Fig. 14b** - Switching Loss Waveforms

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## TO-220AB Package Outline (Dimensions are shown in millimeters (inches))



- NOTES:
- 1.- DIMENSIONING AND TOLERANCING AS PER ASME Y14.5 M - 1994.
  - 2.- DIMENSIONS ARE SHOWN IN MILLIMETERS.
  - 3.- LEAD DIMENSION AND FINISH UNCONTROLLED IN L1.
  - 4.- DIMENSION D, D1 & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED .025 (0.010) PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY.
  - 5.- DIMENSION b1, b3 & c1 APPLY TO BASE METAL ONLY.
  - 6.- CONTROLLING DIMENSION - INCHES.
  - 7.- THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSIONS E1, D2 & E1.
  - 8.- DIMENSION E2 + H1 DEFINE A ZONE WHERE STAMPING AND SOLDERABILITY PRECAUTIONS ARE ALLOWED.
  - 9.- OUTLINE CONFORMS TO JEDEC TO-220, EXCEPT A2 (max.) AND D2 (min.) WHERE DIMENSIONS ARE DERIVED FROM THE ACTUAL PACKAGE OUTLINE.

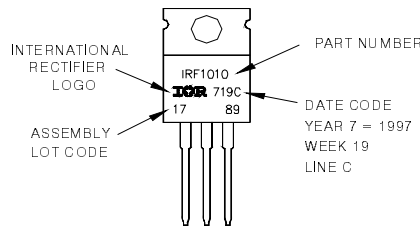
SYMBOL	MILLIMETERS		INCHES		NOTES
	MIN.	MAX.	MIN.	MAX.	
A	3.56	4.83	.140	.190	
A1	0.51	1.40	0.020	0.055	
A2	2.03	2.92	0.080	0.115	
b	0.38	1.01	.015	0.040	5
b1	0.38	0.97	.015	.038	
b2	1.14	1.78	.045	.070	
b3	1.14	1.73	.045	.068	5
c	0.36	0.61	.014	.024	
c1	0.36	0.56	.014	.022	5
D	14.22	16.51	.560	.650	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	-	0.030	8
e	2.54 BSC	-	.100 BSC	-	
e1	5.08 BSC	-	.200 BSC	-	
H1	5.84	6.86	.230	.270	7, 8
L	12.70	14.73	.500	.580	
L1	3.56	4.06	.140	.160	5
ØP	3.54	4.08	.139	.161	
Q	2.54	3.42	.100	.135	

**LEAD ASSIGNMENTS**

- SCALE:  
 1 - DATE  
 2 - SMALL  
 3 - SOURCE
- DATA CHANGE:  
 1 - DATE  
 2 - COLLECTION  
 3 - INTER\*
- DOCS:  
 1 - ANGLE  
 2 - CHANGE  
 3 - ANGLE

## TO-220AB Part Marking Information

EXAMPLE: THIS IS AN IRF1010  
 LOT CODE 1789  
 ASSEMBLED ON WW 19, 1997  
 IN THE ASSEMBLY LINE 'C'  
**Note:** "P" in assembly line position indicates "Lead-Free"



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

Data and specifications subject to change without notice.



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