

INSULATED GATE BIPOLAR TRANSISTOR WITH  
ULTRAFAST SOFT RECOVERY DIODE

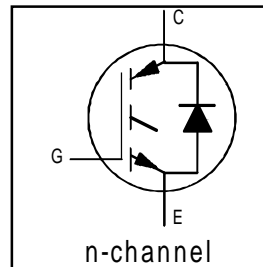
**IRGS6B60KD**  
**IRGSL6B60KD**

**Features**

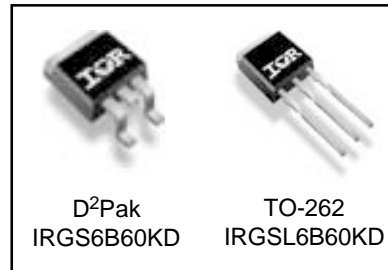
- Low VCE (on) Non Punch Through IGBT Technology.
- Low Diode VF.
- 10µs Short Circuit Capability.
- Square RBSOA.
- Ultrasoft Diode Reverse Recovery Characteristics.
- Positive VCE (on) Temperature Coefficient.

**Benefits**

- Benchmark Efficiency for Motor Control.
- Rugged Transient Performance.
- Low EMI.
- Excellent Current Sharing in Parallel Operation.



$V_{CES} = 600V$   
 $V_{CE(on)} \text{ typ.} = 1.8V$   
@  $V_{GE} = 15V,$   
 $I_{CE} = 5.0A, T_J = 25^\circ C$



**Absolute Maximum Ratings**

	Parameter	Max.	Units
$V_{CES}$	Collector-to-Emitter Voltage	600	V
$I_C @ T_C = 25^\circ C$	Continuous Collector Current	13	A
$I_C @ T_C = 100^\circ C$	Continuous Collector Current	7.0	
$I_{CM}$	Pulsed Collector Current	26	
$I_{LM}$	Clamped Inductive Load Current	26	
$I_F @ T_C = 25^\circ C$	Diode Continuous Forward Current	13	µs
$I_F @ T_C = 100^\circ C$	Diode Continuous Forward Current	7.0	
$I_{FM}$	Diode Maximum Forward Current	26	A
$V_{GE}$	Gate-to-Emitter Voltage	± 20	V
$P_D @ T_C = 25^\circ C$	Maximum Power Dissipation	90	W
$P_D @ T_C = 100^\circ C$	Maximum Power Dissipation	36	
$T_J$	Operating Junction and	-55 to +150	°C
$T_{STG}$	Storage Temperature Range		
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	

**Thermal Resistance**

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case - IGBT	—	—	1.4	°C/W
$R_{\theta JC}$	Junction-to-Case - Diode	—	—	4.4	
$R_{\theta CS}$	Case-to-Sink, flat, greased surface	—	0.50	—	
$R_{\theta JA}$	Junction-to-Ambient, typical socket mount	—	—	62	
$R_{\theta JA}$	Junction-to-Ambient (PCB Mount, steady state)	—	—	40	
Wt	Weight	—	1.44	—	g

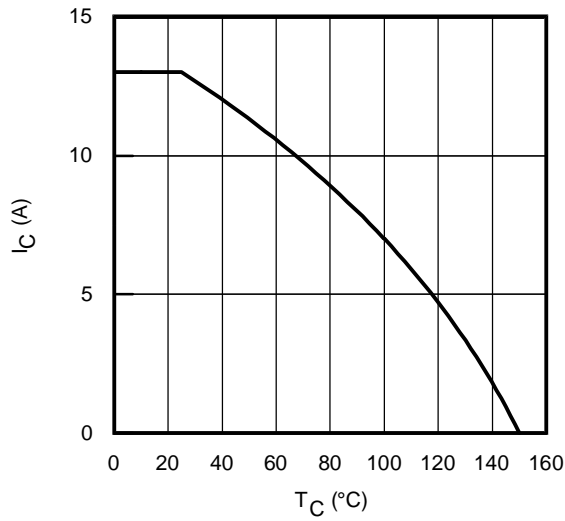
**Electrical Characteristics @ T<sub>J</sub> = 25°C (unless otherwise specified)**

	Parameter	Min.	Typ.	Max.	Units	Conditions	Ref.Fig.
V <sub>(BR)CES</sub>	Collector-to-Emitter Breakdown Voltage	600	—	—	V	V <sub>GE</sub> = 0V, I <sub>C</sub> = 500μA	
ΔV <sub>(BR)CES</sub> /ΔT <sub>J</sub>	Temperature Coeff. of Breakdown Voltage	—	0.3	—	V/°C	V <sub>GE</sub> = 0V, I <sub>C</sub> = 1.0mA, (25°C-150°C)	
V <sub>CE(on)</sub>	Collector-to-Emitter Saturation Voltage	1.5	1.80	2.00	V	I <sub>C</sub> = 5.0A, V <sub>GE</sub> = 15V	5, 6, 7
		—	2.20	2.45		I <sub>C</sub> = 5.0A, V <sub>GE</sub> = 15V, T <sub>J</sub> = 150°C	9, 10, 11
V <sub>GE(th)</sub>	Gate Threshold Voltage	3.5	4.5	5.5		V <sub>CE</sub> = V <sub>GE</sub> , I <sub>C</sub> = 250μA	9, 10, 11
ΔV <sub>GE(th)</sub> /ΔT <sub>J</sub>	Temperature Coeff. of Threshold Voltage	—	-10	—	mV/°C	V <sub>CE</sub> = V <sub>GE</sub> , I <sub>C</sub> = 1.0mA, (25°C-150°C)	
g <sub>fe</sub>	Forward Transconductance	—	3.0	—	S	V <sub>CE</sub> = 50V, I <sub>C</sub> = 5.0A, PW=80μs	
I <sub>CES</sub>	Zero Gate Voltage Collector Current	—	1.0	20	μA	V <sub>GE</sub> = 0V, V <sub>CE</sub> = 600V	
		—	200	500		V <sub>GE</sub> = 0V, V <sub>CE</sub> = 600V, T <sub>J</sub> = 150°C	
V <sub>FM</sub>	Diode Forward Voltage Drop	—	1.25	1.45	V	I <sub>C</sub> = 5.0A	8
		—	1.20	1.40		I <sub>C</sub> = 5.0A, T <sub>J</sub> = 150°C	
I <sub>GES</sub>	Gate-to-Emitter Leakage Current	—	—	±100	nA	V <sub>GE</sub> = ±20V	

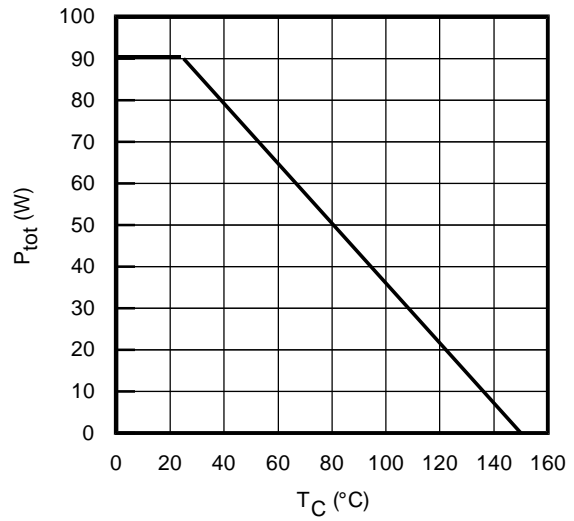
**Switching Characteristics @ T<sub>J</sub> = 25°C (unless otherwise specified)**

	Parameter	Min.	Typ.	Max.	Units	Conditions	Ref.Fig.
Q <sub>g</sub>	Total Gate Charge (turn-on)	—	18.2	—	nC	I <sub>C</sub> = 5.0A	CT1
Q <sub>ge</sub>	Gate - Emitter Charge (turn-on)	—	1.9	—		V <sub>CC</sub> = 400V	
Q <sub>gc</sub>	Gate - Collector Charge (turn-on)	—	9.2	—		V <sub>GE</sub> = 15V	
E <sub>on</sub>	Turn-On Switching Loss	—	110	210	μJ	I <sub>C</sub> = 5.0A, V <sub>CC</sub> = 400V	CT4
E <sub>off</sub>	Turn-Off Switching Loss	—	135	245		V <sub>GE</sub> = 15V, R <sub>G</sub> = 100Ω, L = 1.4mH	
E <sub>tot</sub>	Total Switching Loss	—	245	455		L <sub>s</sub> = 150nH, T <sub>J</sub> = 25°C ①	
t <sub>d(on)</sub>	Turn-On Delay Time	—	25	34	ns	I <sub>C</sub> = 5.0A, V <sub>CC</sub> = 400V	CT4
t <sub>r</sub>	Rise Time	—	17	26		V <sub>GE</sub> = 15V, R <sub>G</sub> = 100Ω, L = 1.4mH	
t <sub>d(off)</sub>	Turn-Off Delay Time	—	215	230		L <sub>s</sub> = 150nH, T <sub>J</sub> = 25°C	
t <sub>f</sub>	Fall Time	—	13.2	22			
E <sub>on</sub>	Turn-On Switching Loss	—	150	260	μJ	I <sub>C</sub> = 5.0A, V <sub>CC</sub> = 400V	CT4
E <sub>off</sub>	Turn-Off Switching Loss	—	190	300		V <sub>GE</sub> = 15V, R <sub>G</sub> = 100Ω, L = 1.4mH	
E <sub>tot</sub>	Total Switching Loss	—	340	560		L <sub>s</sub> = 150nH, T <sub>J</sub> = 150°C ①	13, 15 WF1, WF2
t <sub>d(on)</sub>	Turn-On Delay Time	—	28	37	ns	I <sub>C</sub> = 5.0A, V <sub>CC</sub> = 400V	14, 16
t <sub>r</sub>	Rise Time	—	17	26		V <sub>GE</sub> = 15V, R <sub>G</sub> = 100Ω, L = 1.4mH	
t <sub>d(off)</sub>	Turn-Off Delay Time	—	240	255		L <sub>s</sub> = 150nH, T <sub>J</sub> = 150°C	
t <sub>f</sub>	Fall Time	—	18	27			
C <sub>ies</sub>	Input Capacitance	—	290	—	pF	V <sub>GE</sub> = 0V	
C <sub>oes</sub>	Output Capacitance	—	34	—		V <sub>CC</sub> = 30V	
C <sub>res</sub>	Reverse Transfer Capacitance	—	10	—		f = 1.0MHz	
RBSOA	Reverse Bias Safe Operating Area	FULL SQUARE				T <sub>J</sub> = 150°C, I <sub>C</sub> = 26A, V <sub>p</sub> = 600V V <sub>CC</sub> = 500V, V <sub>GE</sub> = +15V to 0V, R <sub>G</sub> = 100Ω	4 CT2
SCSOA	Short Circuit Safe Operating Area	10	—	—	μs	T <sub>J</sub> = 150°C, V <sub>p</sub> = 600V, R <sub>G</sub> = 100Ω V <sub>CC</sub> = 360V, V <sub>GE</sub> = +15V to 0V	CT3 WF4
E <sub>rec</sub>	Reverse Recovery energy of the diode	—	90	175	μJ	T <sub>J</sub> = 150°C	17, 18, 19
t <sub>rr</sub>	Diode Reverse Recovery time	—	70	80	ns	V <sub>CC</sub> = 400V, I <sub>F</sub> = 5.0A, L = 1.4mH	20, 21
I <sub>rr</sub>	Diode Peak Reverse Recovery Current	—	10	14	A	V <sub>GE</sub> = 15V, R <sub>G</sub> = 100Ω, L <sub>s</sub> = 150nH	CT4, WF3

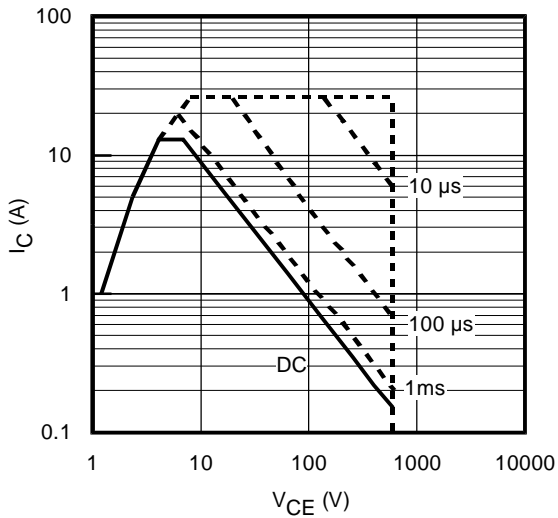
① Energy losses include "tail" and diode reverse recovery.



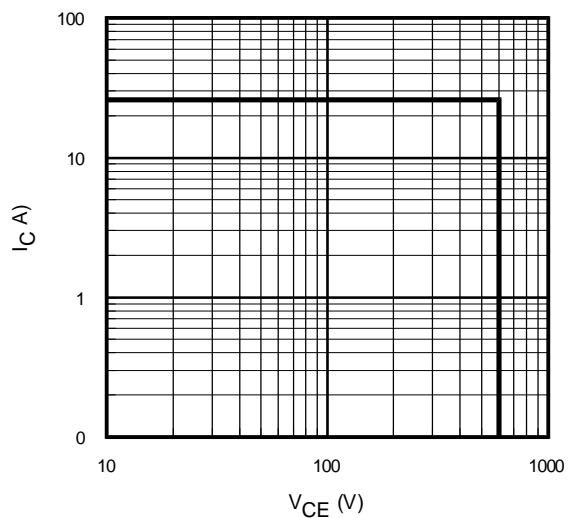
**Fig. 1** - Maximum DC Collector Current vs. Case Temperature



**Fig. 2** - Power Dissipation vs. Case Temperature

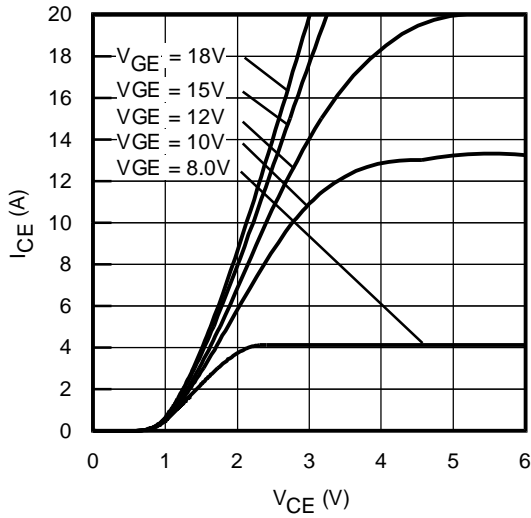


**Fig. 3** - Forward SOA  
 $T_C = 25^\circ\text{C}$ ;  $T_J \leq 150^\circ\text{C}$

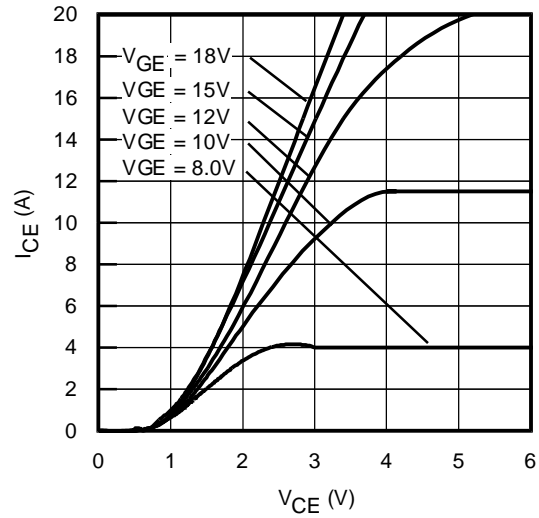


**Fig. 4** - Reverse Bias SOA  
 $T_J = 150^\circ\text{C}$ ;  $V_{GE} = 15\text{V}$

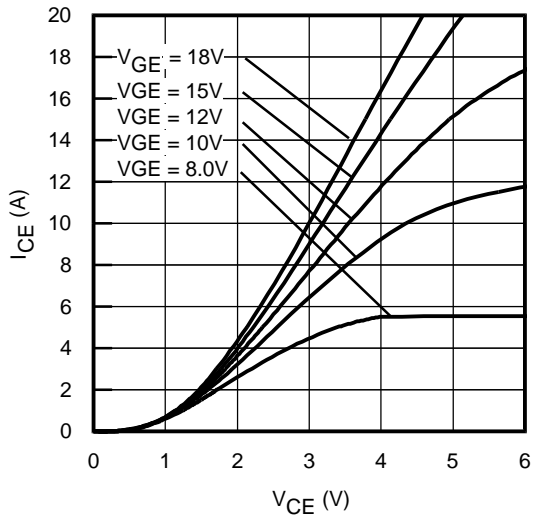
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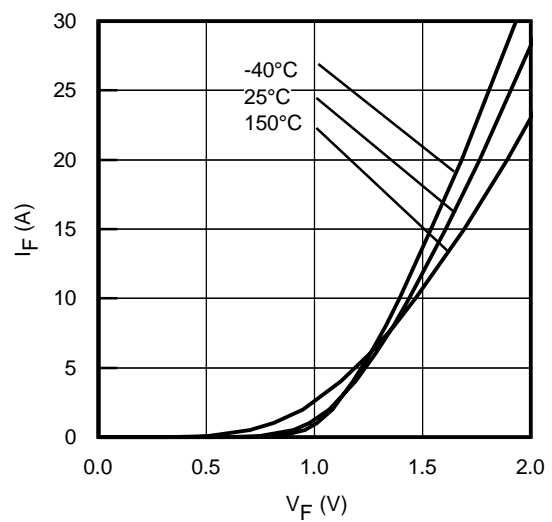
**Fig. 5** - Typ. IGBT Output Characteristics  
 $T_J = -40^\circ\text{C}$ ;  $t_p = 80\mu\text{s}$



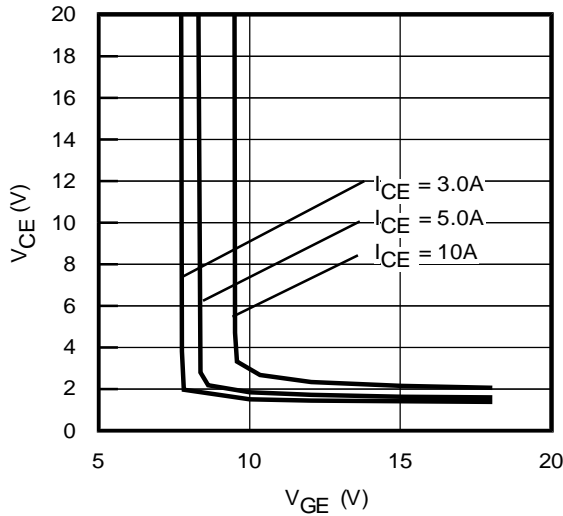
**Fig. 6** - Typ. IGBT Output Characteristics  
 $T_J = 25^\circ\text{C}$ ;  $t_p = 80\mu\text{s}$



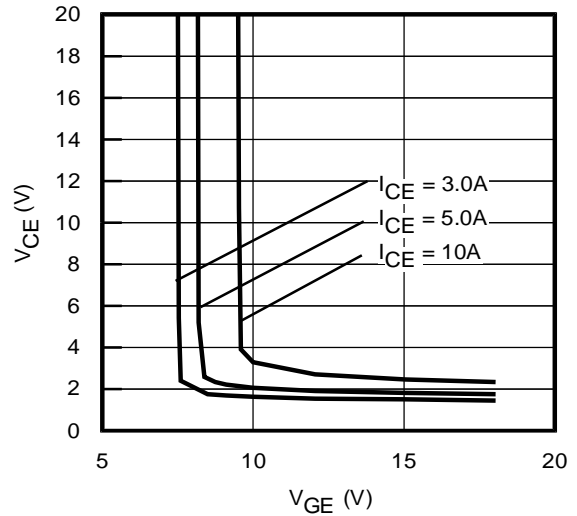
**Fig. 7** - Typ. IGBT Output Characteristics  
 $T_J = 150^\circ\text{C}$ ;  $t_p = 80\mu\text{s}$



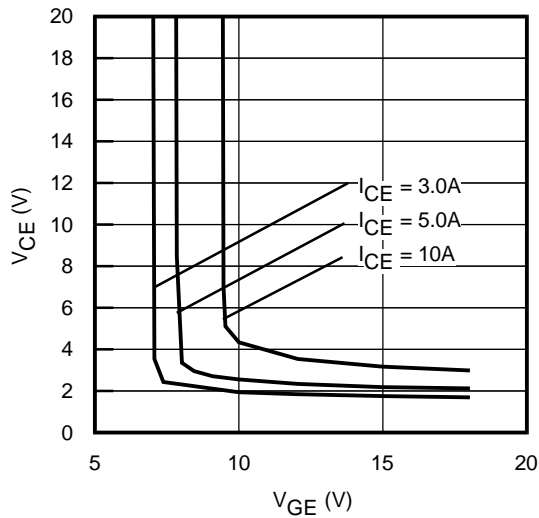
**Fig. 8** - Typ. Diode Forward Characteristics  
 $t_p = 80\mu\text{s}$



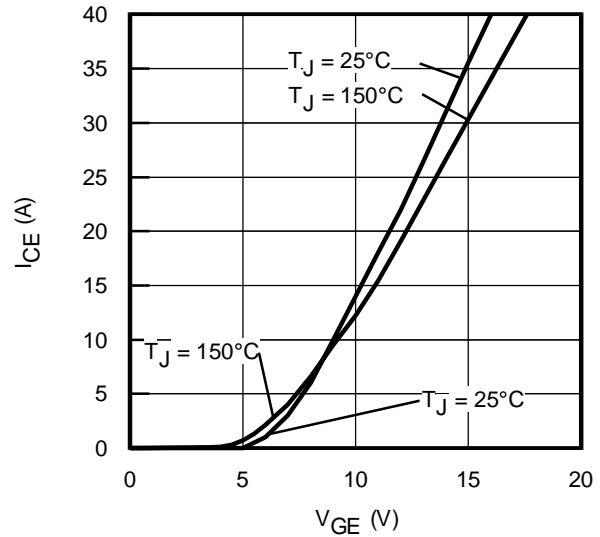
**Fig. 9** - Typical  $V_{CE}$  vs.  $V_{GE}$   
 $T_J = -40^\circ\text{C}$



**Fig. 10** - Typical  $V_{CE}$  vs.  $V_{GE}$   
 $T_J = 25^\circ\text{C}$

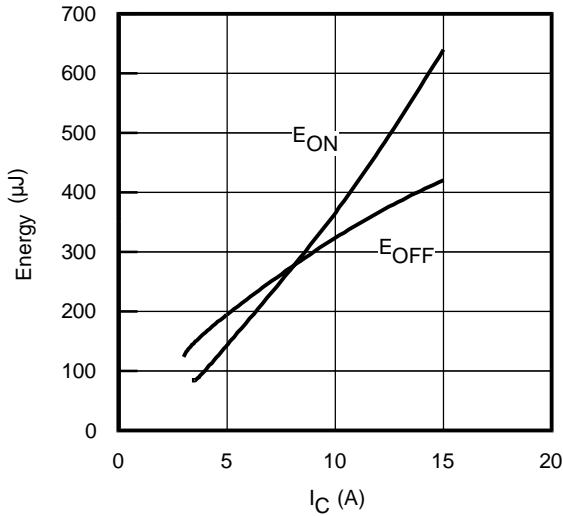


**Fig. 11** - Typical  $V_{CE}$  vs.  $V_{GE}$   
 $T_J = 150^\circ\text{C}$

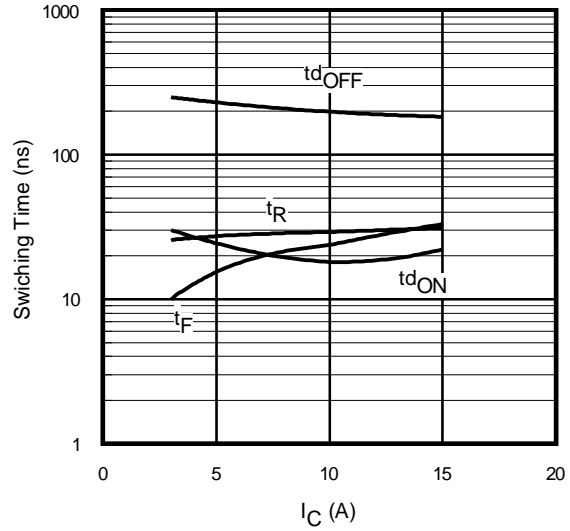


**Fig. 12** - Typ. Transfer Characteristics  
 $V_{CE} = 50\text{V}$ ;  $t_p = 10\mu\text{s}$

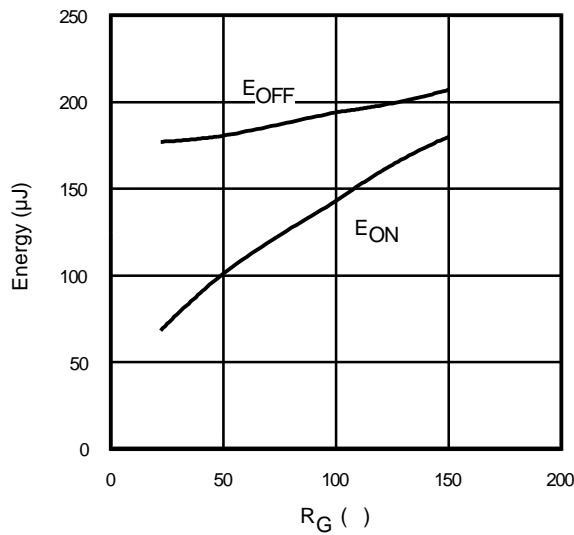
# IRGS/SL6B60KD



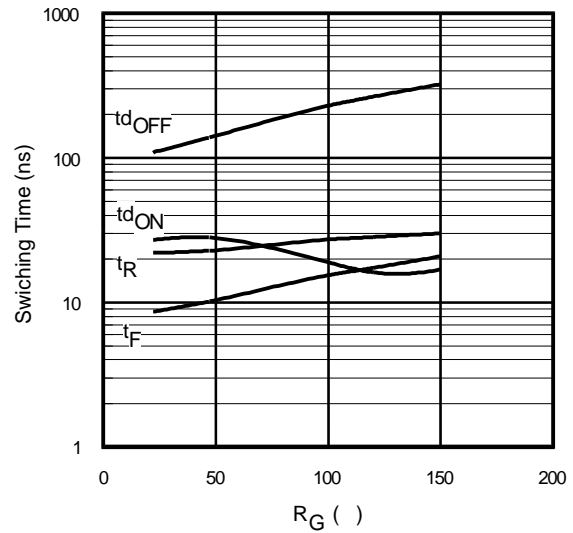
**Fig. 13** - Typ. Energy Loss vs.  $I_C$   
 $T_J = 150^\circ\text{C}$ ;  $L = 1.4\text{mH}$ ;  $V_{CE} = 400\text{V}$   
 $R_G = 100\Omega$ ;  $V_{GE} = 15\text{V}$



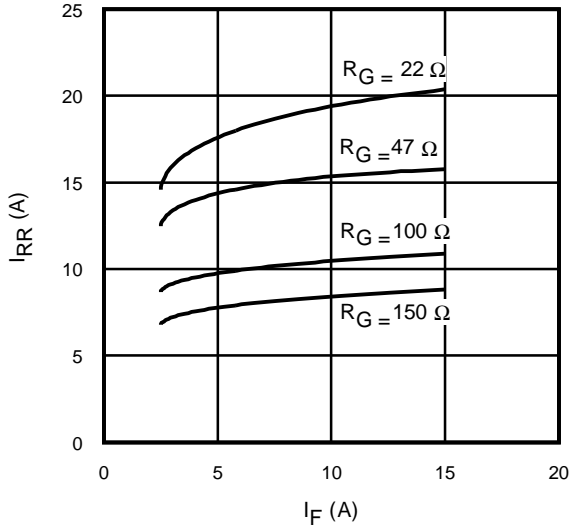
**Fig. 14** - Typ. Switching Time vs.  $I_C$   
 $T_J = 150^\circ\text{C}$ ;  $L = 1.4\text{mH}$ ;  $V_{CE} = 400\text{V}$   
 $R_G = 100\Omega$ ;  $V_{GE} = 15\text{V}$



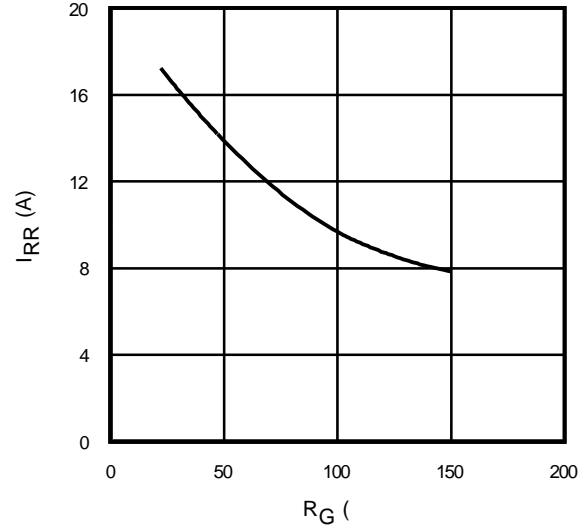
**Fig. 15** - Typ. Energy Loss vs.  $R_G$   
 $T_J = 150^\circ\text{C}$ ;  $L = 1.4\text{mH}$ ;  $V_{CE} = 400\text{V}$   
 $I_{CE} = 5.0\text{A}$ ;  $V_{GE} = 15\text{V}$



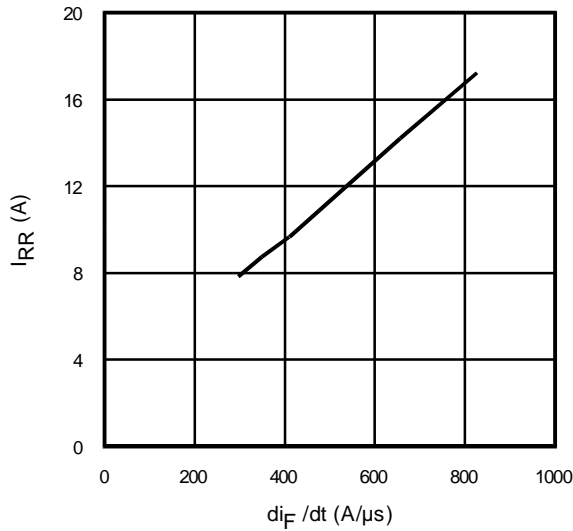
**Fig. 16** - Typ. Switching Time vs.  $R_G$   
 $T_J = 150^\circ\text{C}$ ;  $L = 1.4\text{mH}$ ;  $V_{CE} = 400\text{V}$   
 $I_{CE} = 5.0\text{A}$ ;  $V_{GE} = 15\text{V}$



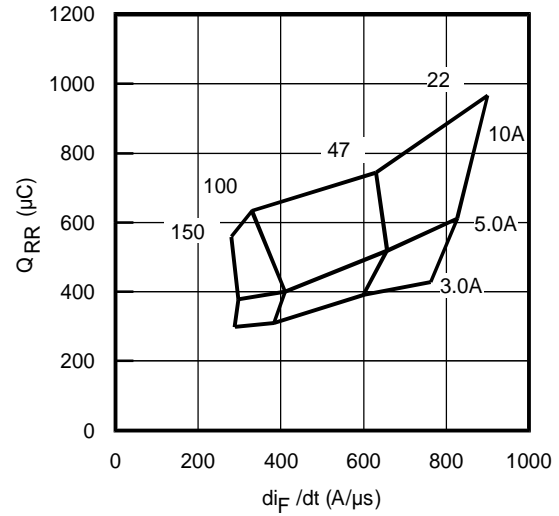
**Fig. 17** - Typical Diode  $I_{RR}$  vs.  $I_F$   
 $T_J = 150^\circ\text{C}$



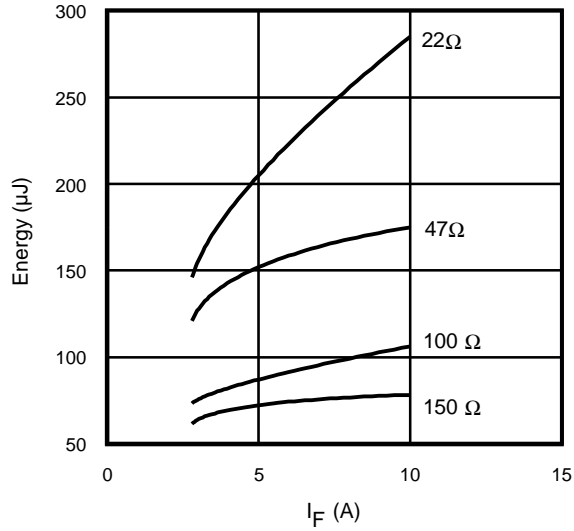
**Fig. 18** - Typical Diode  $I_{RR}$  vs.  $R_G$   
 $T_J = 150^\circ\text{C}$ ;  $I_F = 5.0\text{A}$



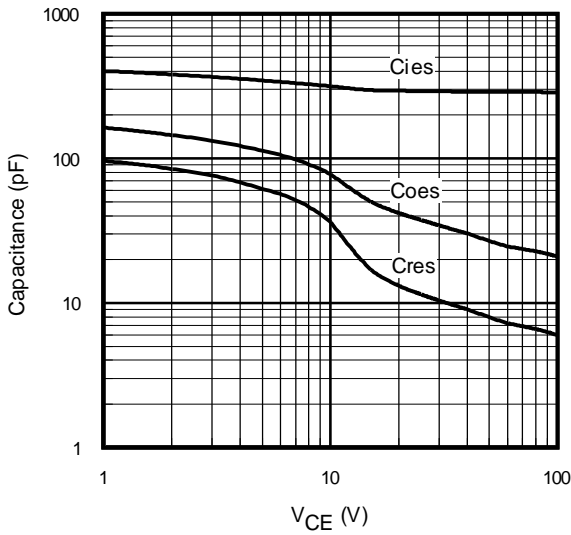
**Fig. 19**- Typical Diode  $I_{RR}$  vs.  $di_F/dt$   
 $V_{CC} = 400\text{V}$ ;  $V_{GE} = 15\text{V}$ ;  
 $I_{CE} = 5.0\text{A}$ ;  $T_J = 150^\circ\text{C}$



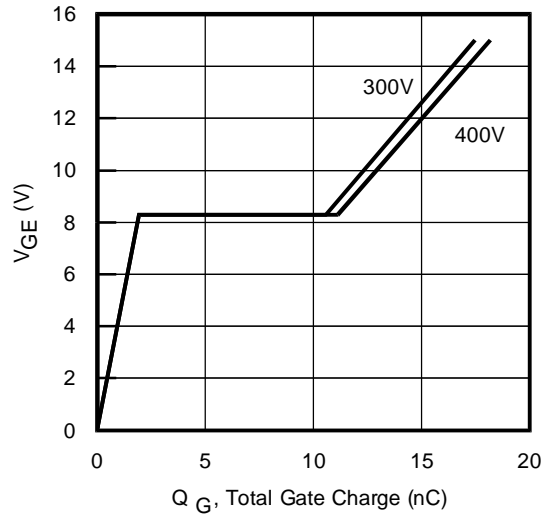
**Fig. 20** - Typical Diode  $Q_{RR}$   
 $V_{CC} = 400\text{V}$ ;  $V_{GE} = 15\text{V}$ ;  $T_J = 150^\circ\text{C}$



**Fig. 21** - Typical Diode  $E_{RR}$  vs.  $I_F$   
 $T_J = 150^\circ\text{C}$



**Fig. 22**- Typ. Capacitance vs.  $V_{CE}$   
 $V_{GE} = 0\text{V}$ ;  $f = 1\text{MHz}$



**Fig. 23** - Typical Gate Charge vs.  $V_{GE}$   
 $I_{CE} = 5.0\text{A}$ ;  $L = 600\mu\text{H}$



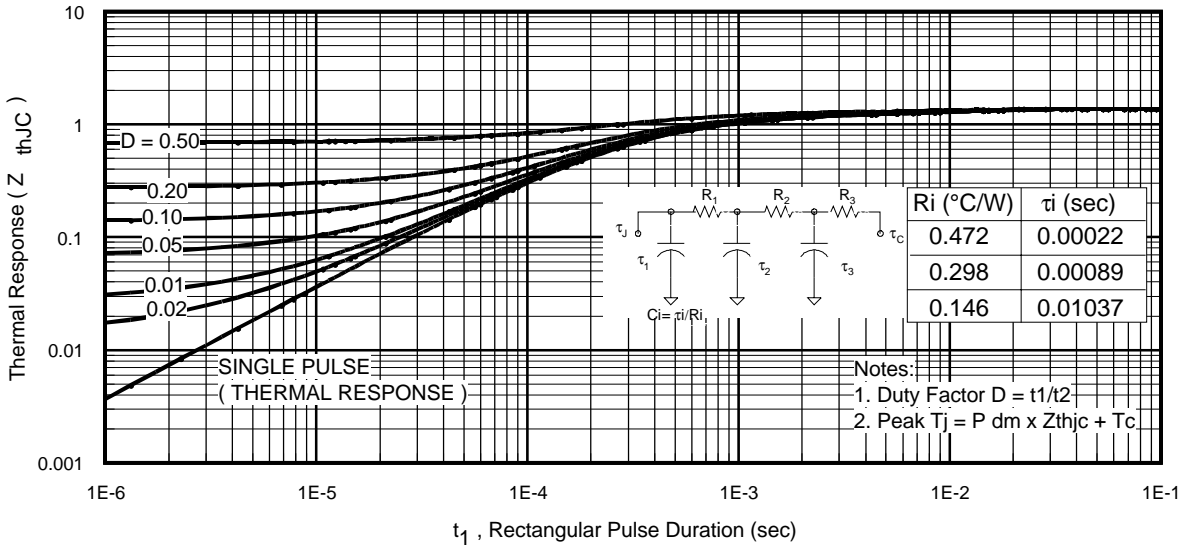


Fig 24. Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

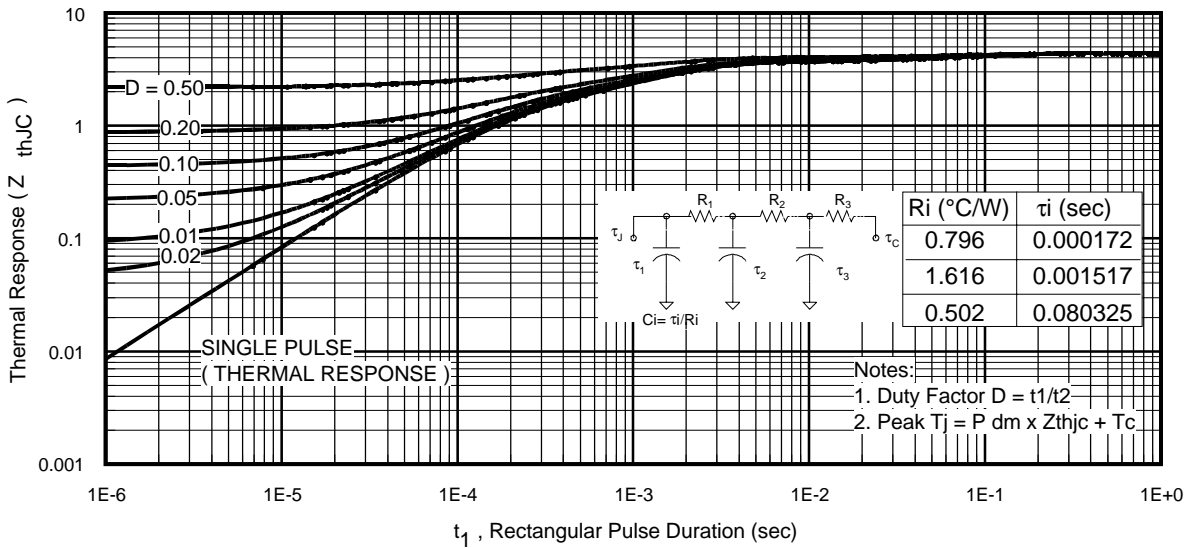
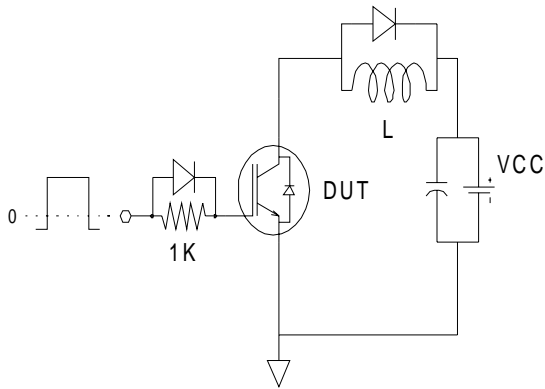
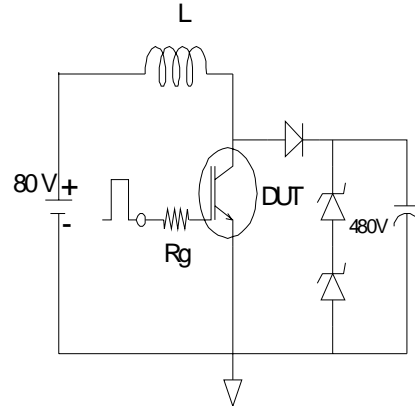


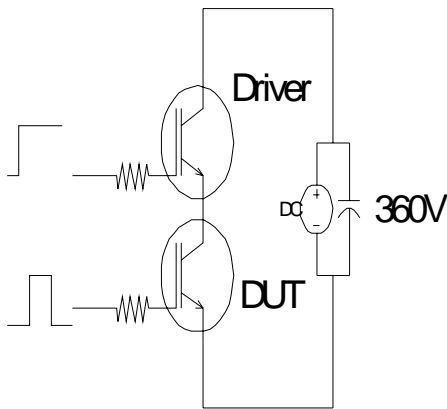
Fig 25. Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)



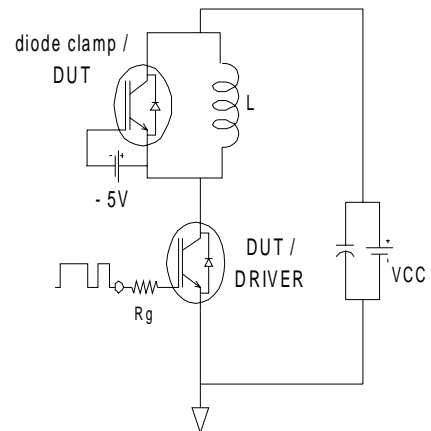
**Fig.C.T.1** - Gate Charge Circuit (turn-off)



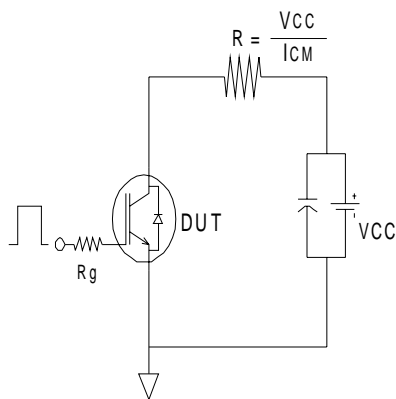
**Fig.C.T.2** - RBSOA Circuit



**Fig.C.T.3** - S.C.SOA Circuit



**Fig.C.T.4** - Switching Loss Circuit



**Fig.C.T.5** - Resistive Load Circuit

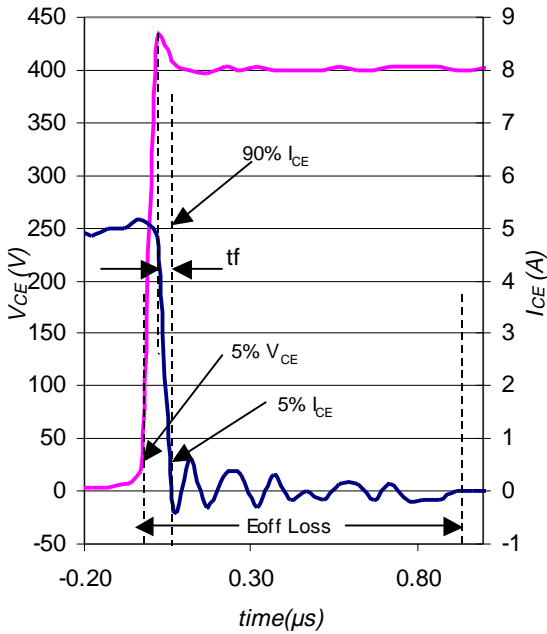


Fig. WF1- Typ. Turn-off Loss Waveform  
@  $T_J = 150^\circ\text{C}$  using Fig. CT.4

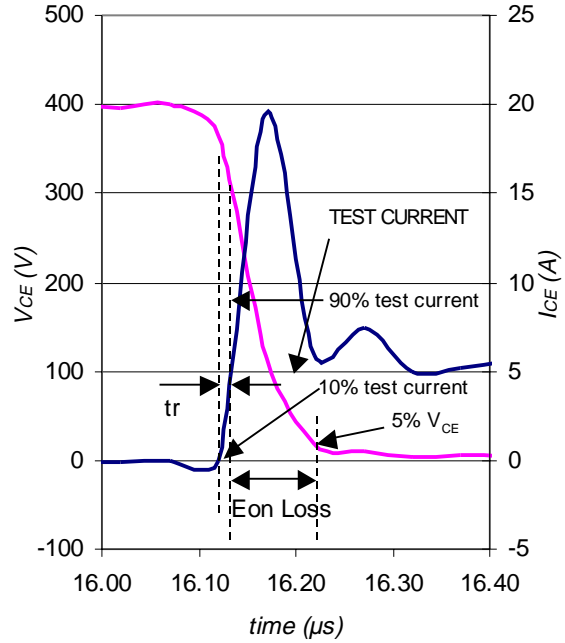


Fig. WF2- Typ. Turn-on Loss Waveform  
@  $T_J = 150^\circ\text{C}$  using Fig. CT.4

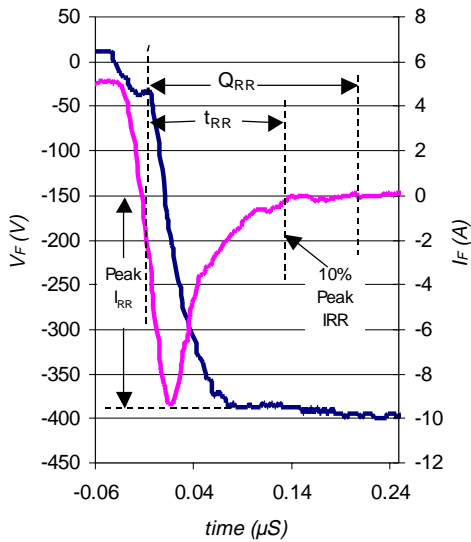


Fig. WF3- Typ. Diode Recovery Waveform  
@  $T_J = 150^\circ\text{C}$  using Fig. CT.4

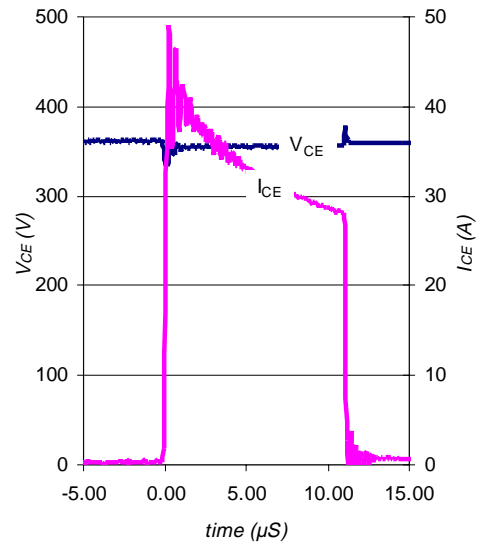
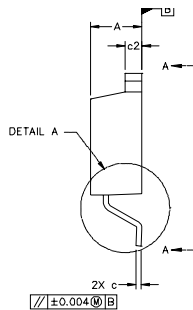
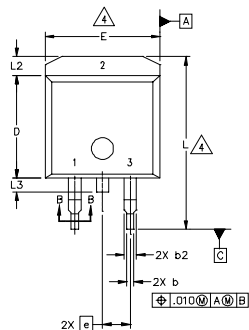
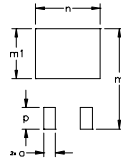
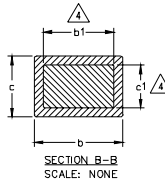
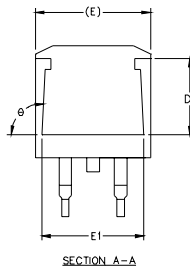
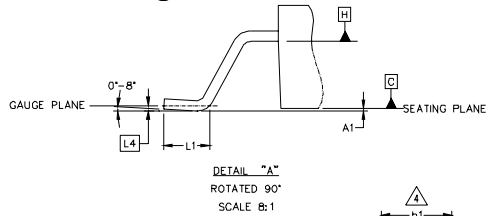


Fig. WF4- Typ. S.C Waveform  
@  $T_J = 150^\circ\text{C}$  using Fig. CT.3

# IRGS/SL6B60KD

## D<sup>2</sup>Pak Package Outline

International  
**IR** Rectifier



### NOTES:

1. DIMENSIONING AND TOLERANCING 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.
4. DIMENSION b1 AND c1 APPLY TO BASE METAL ONLY.
5. CONTROLLING DIMENSION: INCH.

SYMBOL	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	4.06	4.83	.160	.190	
A1		0.127		.005	
b	0.51	0.99	.020	.039	
b1	0.51	0.89	.020	.035	4
b2	1.14	1.40	.045	.055	
c	0.38	0.74	.015	.029	
c1	0.43	0.63	.017	.025	4
c2	1.14	1.40	.045	.055	
D	8.51	9.65	.335	.380	3
D1	5.33		.210		
E	9.65	10.67	.380	.420	3
E1	6.22		.245		
e	2.54 BSC		.100 BSC		
L	14.61	15.88	.575	.625	
L1	1.78	2.79	.070	.110	
L2		1.65		.065	
L3	1.27	1.78	.050	.070	
L4	0.25 BSC		.010 BSC		
m	17.78		.700		
m1	8.89		.350		
n	11.43		.450		
o	2.08		.082		
p	3.81		.150		
θ	90°	93°	90°	93°	

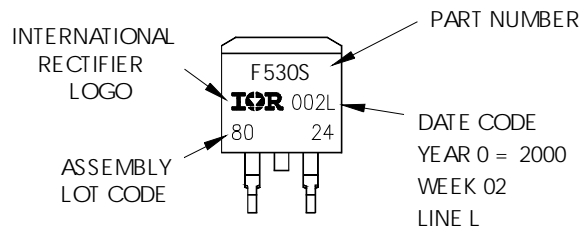
### LEAD ASSIGNMENTS

HEXFET	IGBTs, CoPACK	DIODES
1.- GATE	1.- GATE	1.- ANODE *
2.- DRAIN	2.- COLLECTOR	2.- CATHODE
3.- SOURCE	3.- EMITTER	3.- ANODE

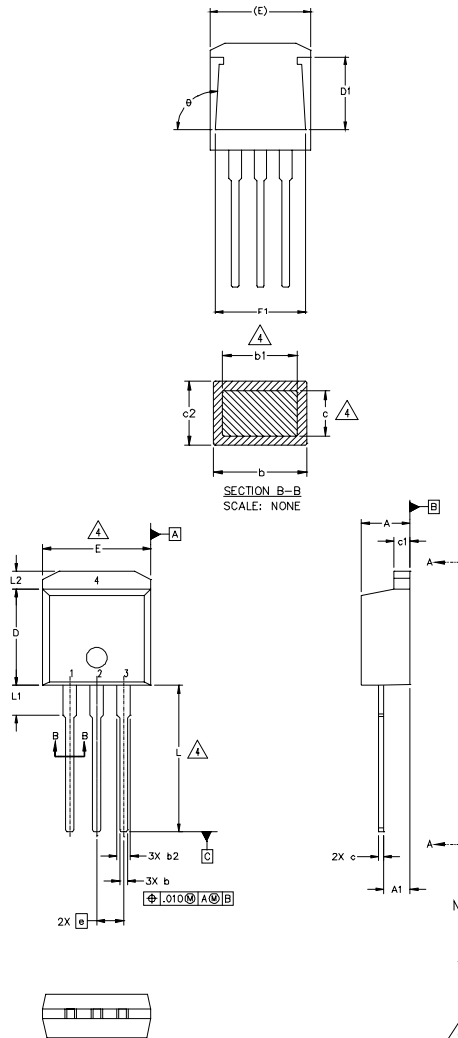
\* PART DEPENDENT.

## D<sup>2</sup>Pak Part Marking Information

EXAMPLE: THIS IS AN IRF530S WITH  
LOT CODE 8024  
ASSEMBLED ON WW02, 2000  
IN THE ASSEMBLY LINE "L"



## TO-262 Package Outline



## IRGS/SL6B60KD

SYMBOL	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	4.06	4.83	.160	.190	
A1	2.03	2.92	.080	.115	
b	0.51	0.99	.020	.039	
b1	0.51	0.89	.020	.035	4
b2	1.14	1.40	.045	.055	
c	0.38	0.63	.015	.025	4
c1	1.14	1.40	.045	.055	
c2	0.43	.063	.017	.029	
D	8.51	9.65	.335	.380	3
D1	5.33		.210		
E	9.65	10.67	.380	.420	3
E1	6.22		.245		
e	2.54 BSC		.100 BSC		
L	13.46	14.09	.530	.555	
L1	3.56	3.71	.140	.146	
L2		1.65		.065	

### LEAD ASSIGNMENTS

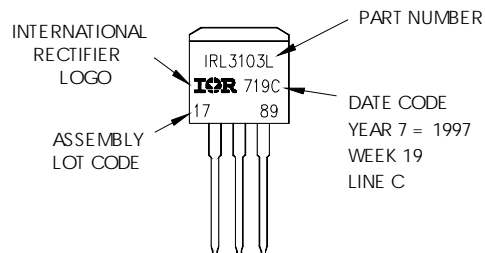
HEXFET	IGBT
1.- GATE	1- GATE
2.- DRAIN	2- COLLECTOR
3.- SOURCE	3- EMITTER
4.- DRAIN	4- COLLECTOR

#### NOTES:

1. DIMENSIONING AND TOLERANCING 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 [ .005" ] PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTMOST EXTREMES OF THE PLASTIC BODY.
4. DIMENSION b1 AND c1 APPLY TO BASE METAL ONLY.
5. CONTROLLING DIMENSION: INCH.

## TO-262 Part Marking Information

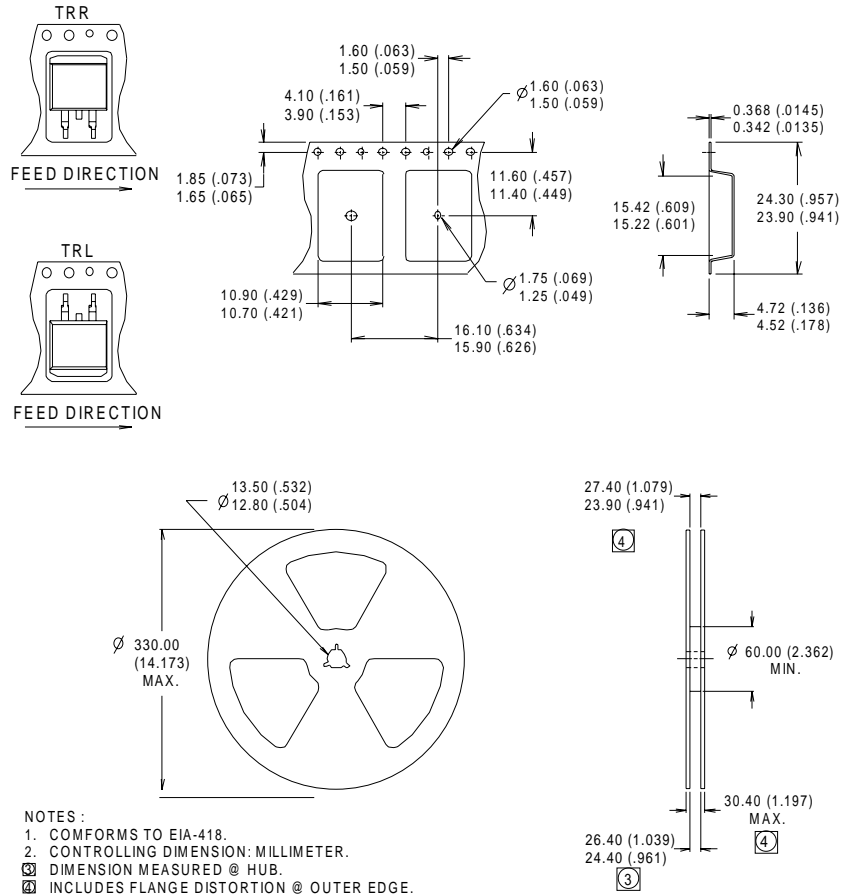
EXAMPLE: THIS IS AN IRL3103L  
 LOT CODE 1789  
 ASSEMBLED ON WW 19, 1997  
 IN THE ASSEMBLY LINE "C"



# IRGS/SL6B60KD

International  
**IR** Rectifier

## D<sup>2</sup>Pak Tape & Reel Information



Data and specifications subject to change without notice.  
This product has been designed and qualified for Industrial market.  
Qualification Standards can be found on IR's Web site.

International  
**IR** Rectifier

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Visit us at [www.irf.com](http://www.irf.com) for sales contact information. 4/02

[www.irf.com](http://www.irf.com)