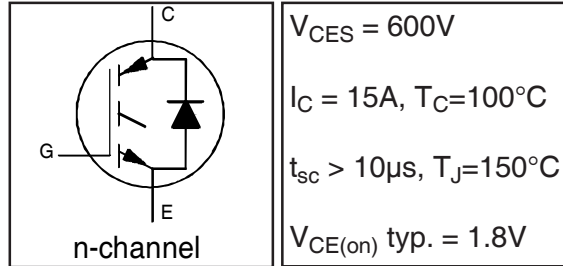


INSULATED GATE BIPOLAR TRANSISTOR WITH  
ULTRAFAST SOFT RECOVERY DIODE

IRGB15B60KDPbF  
IRGS15B60KDPbF  
IRGSL15B60KDPbF

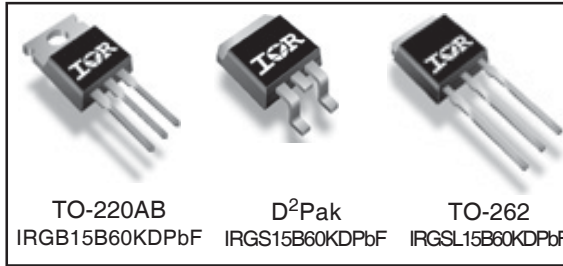
**Features**

- 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.
- Lead-Free



**Benefits**

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



**Absolute Maximum Ratings**

	Parameter	Max.	Units
$V_{CES}$	Collector-to-Emitter Voltage	600	V
$I_C @ T_C = 25^\circ C$	Continuous Collector Current	31	A
$I_C @ T_C = 100^\circ C$	Continuous Collector Current	15	
$I_{CM}$	Pulsed Collector Current	62	
$I_{LM}$	Clamped Inductive Load Current ④	62	
$I_F @ T_C = 25^\circ C$	Diode Continuous Forward Current	31	
$I_F @ T_C = 100^\circ C$	Diode Continuous Forward Current	15	
$I_{FM}$	Diode Maximum Forward Current	64	
$V_{GE}$	Gate-to-Emitter Voltage	$\pm 20$	V
$P_D @ T_C = 25^\circ C$	Maximum Power Dissipation	208	W
$P_D @ T_C = 100^\circ C$	Maximum Power Dissipation	83	
$T_J$	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	—	—	0.6	°C/W
$R_{\theta JC}$	Junction-to-Case - Diode	—	—	2.1	
$R_{\theta CS}$	Case-to-Sink, flat, greased surface	—	0.50	—	
$R_{\theta JA}$	Junction-to-Ambient, typical socket mount①	—	—	62	
$R_{\theta JA}$	Junction-to-Ambient (PCB Mount, steady state)②	—	—	40	
Wt	Weight	—	1.44	—	g

# IRGB/S/SL15B60KDPbF

International  
**IR** Rectifier

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

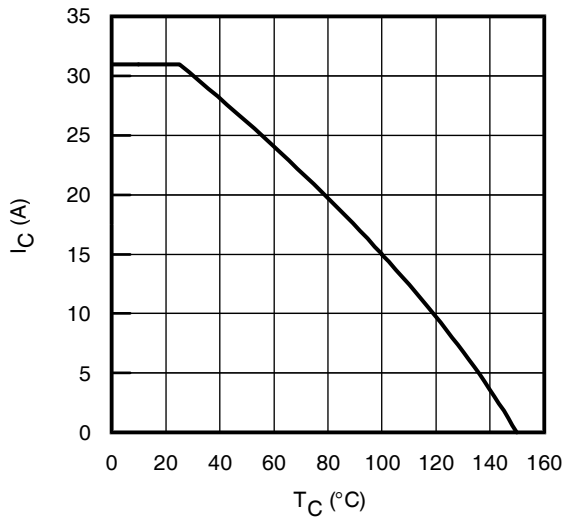
	Parameter	Min.	Typ.	Max.	Units	Conditions	Ref.Fig.
V <sub>(BR)CES</sub>	Collector-to-Emitter Breakdown Voltage	600	—	—	V	V <sub>GE</sub> = 0V, I <sub>C</sub> = 500μA	
ΔV <sub>(BR)CES</sub> /ΔT <sub>J</sub>	Temperature Coeff. of Breakdown Voltage	—	0.3	—	V/°C	V <sub>GE</sub> = 0V, I <sub>C</sub> = 1.0mA, (25°C-150°C)	
V <sub>CE(on)</sub>	Collector-to-Emitter Saturation Voltage	1.5	1.80	2.20	V	I <sub>C</sub> = 15A, V <sub>GE</sub> = 15V	5, 6,7
		—	2.05	2.50		I <sub>C</sub> = 15A, V <sub>GE</sub> = 15V T <sub>J</sub> = 125°C	9, 10,11
		—	2.10	2.60		I <sub>C</sub> = 15A, V <sub>GE</sub> = 15V T <sub>J</sub> = 150°C	
V <sub>GE(th)</sub>	Gate Threshold Voltage	3.5	4.5	5.5	V	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)	12
g <sub>fe</sub>	Forward Transconductance	—	10.6	—	S	V <sub>CE</sub> = 50V, I <sub>C</sub> = 20A, PW=80μs	
I <sub>CES</sub>	Zero Gate Voltage Collector Current	—	5.0	150	μA	V <sub>GE</sub> = 0V, V <sub>CE</sub> = 600V	
		—	500	1000		V <sub>GE</sub> = 0V, V <sub>CE</sub> = 600V, T <sub>J</sub> = 150°C	
V <sub>FM</sub>	Diode Forward Voltage Drop	—	1.20	1.45	V	I <sub>C</sub> = 15A	8
		—	1.20	1.45		I <sub>C</sub> = 15A 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)

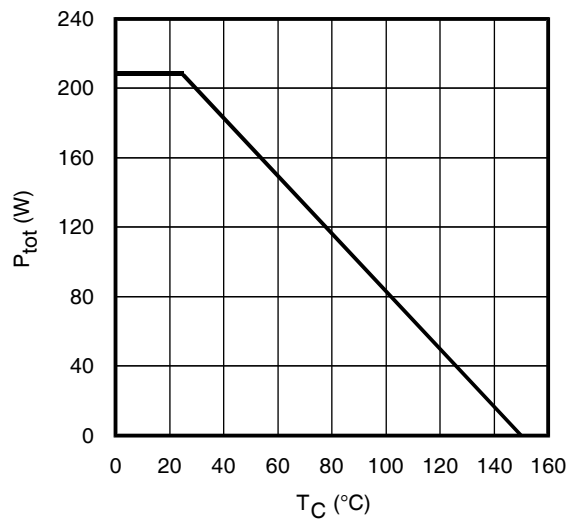
	Parameter	Min.	Typ.	Max.	Units	Conditions	Ref.Fig.
Q <sub>g</sub>	Total Gate Charge (turn-on)	—	56	84	nC	I <sub>C</sub> = 15A	CT1
Q <sub>ge</sub>	Gate - Emitter Charge (turn-on)	—	7.0	10		V <sub>CC</sub> = 400V	
Q <sub>gc</sub>	Gate - Collector Charge (turn-on)	—	26	39		V <sub>GE</sub> = 15V	
E <sub>on</sub>	Turn-On Switching Loss	—	220	330	μJ	I <sub>C</sub> = 15A, V <sub>CC</sub> = 400V	CT4
E <sub>off</sub>	Turn-Off Switching Loss	—	340	455		V <sub>GE</sub> = 15V, R <sub>G</sub> = 22Ω, L = 200μH	
E <sub>tot</sub>	Total Switching Loss	—	560	785		L <sub>s</sub> = 150nH T <sub>J</sub> = 25°C ③	
t <sub>d(on)</sub>	Turn-On Delay Time	—	34	44	ns	I <sub>C</sub> = 15A, V <sub>CC</sub> = 400V	CT4
t <sub>r</sub>	Rise Time	—	16	22		V <sub>GE</sub> = 15V, R <sub>G</sub> = 22Ω, L = 200μH	
t <sub>d(off)</sub>	Turn-Off Delay Time	—	184	200		L <sub>s</sub> = 150nH, T <sub>J</sub> = 25°C	
t <sub>f</sub>	Fall Time	—	20	26			
E <sub>on</sub>	Turn-On Switching Loss	—	355	470	μJ	I <sub>C</sub> = 15A, V <sub>CC</sub> = 400V	CT4
E <sub>off</sub>	Turn-Off Switching Loss	—	490	600		V <sub>GE</sub> = 15V, R <sub>G</sub> = 22Ω, L = 200μH	
E <sub>tot</sub>	Total Switching Loss	—	835	1070		L <sub>s</sub> = 150nH T <sub>J</sub> = 150°C ③	
t <sub>d(on)</sub>	Turn-On Delay Time	—	34	44	ns	I <sub>C</sub> = 15A, V <sub>CC</sub> = 400V	14, 16
t <sub>r</sub>	Rise Time	—	18	25		V <sub>GE</sub> = 15V, R <sub>G</sub> = 22Ω, L = 200μH	
t <sub>d(off)</sub>	Turn-Off Delay Time	—	203	226		L <sub>s</sub> = 150nH, T <sub>J</sub> = 150°C	
t <sub>f</sub>	Fall Time	—	28	36			
C <sub>ies</sub>	Input Capacitance	—	850	—	pF	V <sub>GE</sub> = 0V	
C <sub>oes</sub>	Output Capacitance	—	75	—		V <sub>CC</sub> = 30V	
C <sub>res</sub>	Reverse Transfer Capacitance	—	35	—		f = 1.0MHz	
RBSOA	Reverse Bias Safe Operating Area	FULL SQUARE				T <sub>J</sub> = 150°C, I <sub>C</sub> = 62A, V <sub>p</sub> = 600V V <sub>CC</sub> = 500V, V <sub>GE</sub> = +15V to 0V, R <sub>G</sub> = 22Ω	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> = 22Ω V <sub>CC</sub> = 360V, V <sub>GE</sub> = +15V to 0V	CT3 WF4
E <sub>rec</sub>	Reverse Recovery energy of the diode	—	540	720	μJ	T <sub>J</sub> = 150°C	17, 18, 19
t <sub>rr</sub>	Diode Reverse Recovery time	—	92	111	ns	V <sub>CC</sub> = 400V, I <sub>F</sub> = 15A, L = 200μH	20, 21
I <sub>rr</sub>	Diode Peak Reverse Recovery Current	—	29	33	A	V <sub>GE</sub> = 15V, R <sub>G</sub> = 22Ω, L <sub>s</sub> = 150nH	CT4, WF3

Note ① to ④ are on page 15

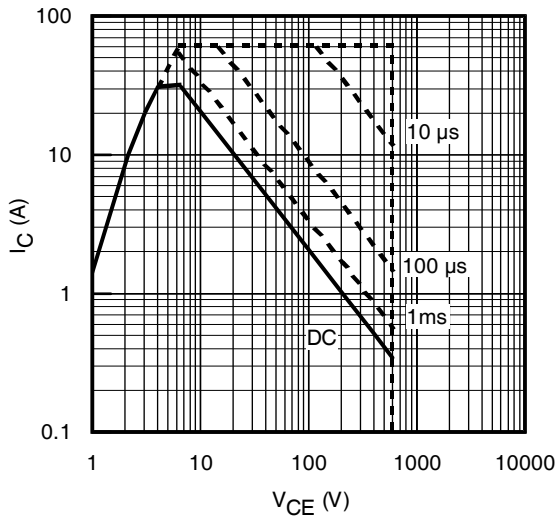
8



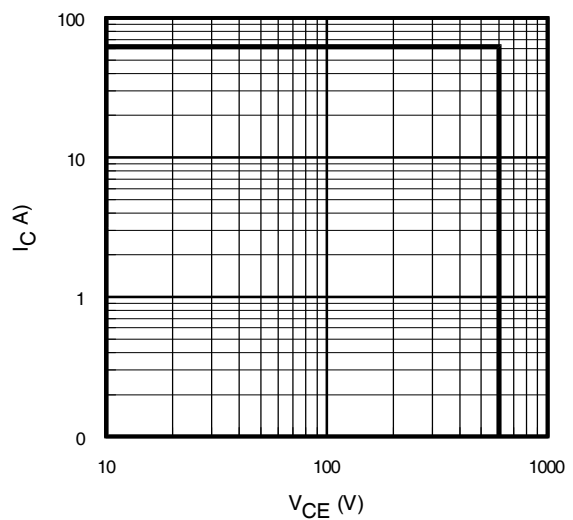
**Fig. 1** - Maximum DC Collector Current vs. Case Temperature



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

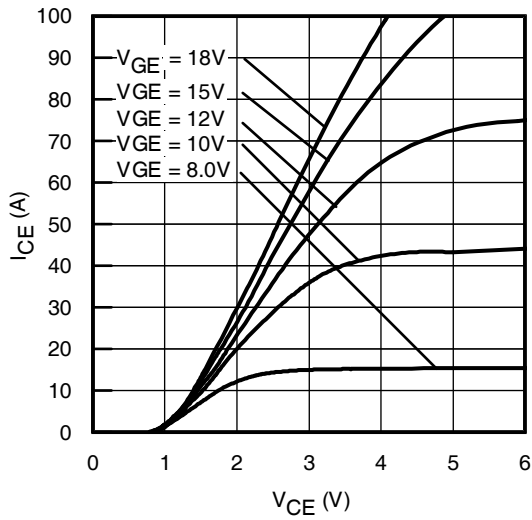


**Fig. 3** - Forward SOA  
 $T_C = 25^\circ\text{C}$ ;  $T_J \leq 150^\circ\text{C}$

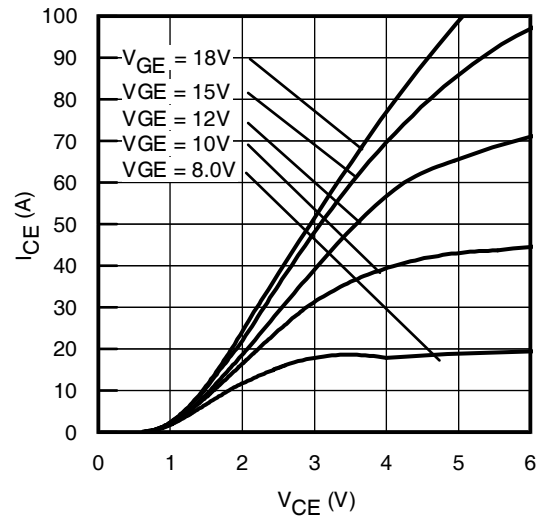


**Fig. 4** - Reverse Bias SOA  
 $T_J = 150^\circ\text{C}$ ;  $V_{GE} = 15\text{V}$

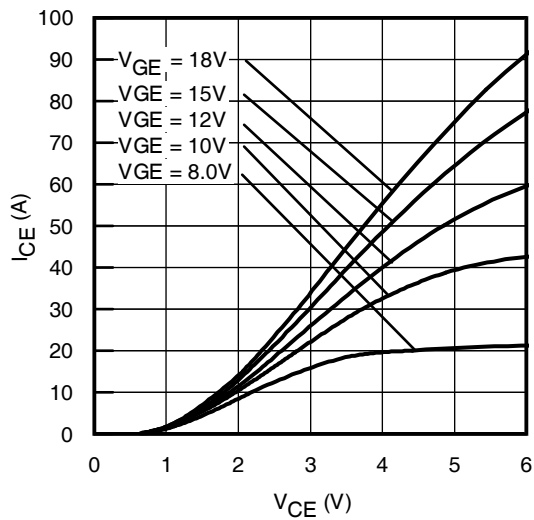
# IRGB/S/SL15B60KDPbF



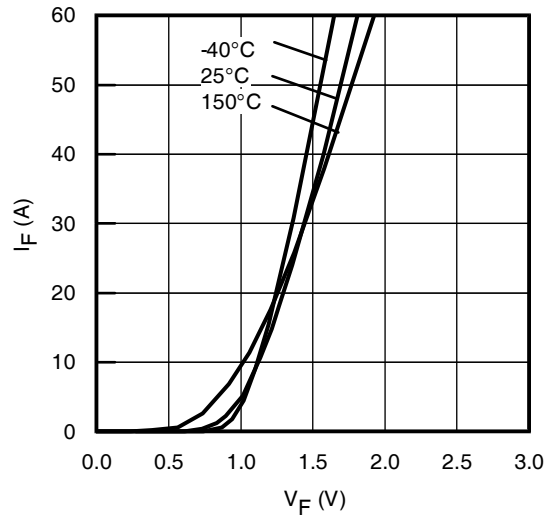
**Fig. 5** - Typ. IGBT Output Characteristics  
 $T_J = -40^\circ\text{C}$ ;  $t_p = 300\mu\text{s}$



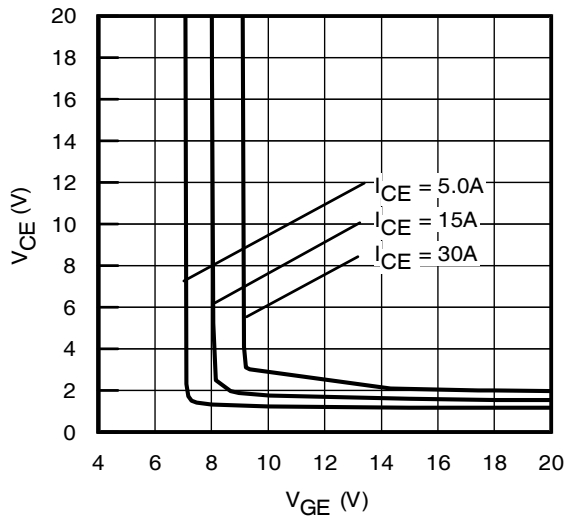
**Fig. 6** - Typ. IGBT Output Characteristics  
 $T_J = 25^\circ\text{C}$ ;  $t_p = 300\mu\text{s}$



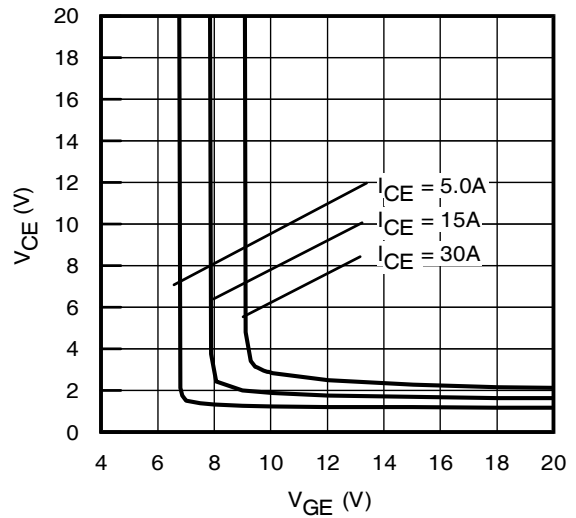
**Fig. 7** - Typ. IGBT Output Characteristics  
 $T_J = 150^\circ\text{C}$ ;  $t_p = 300\mu\text{s}$



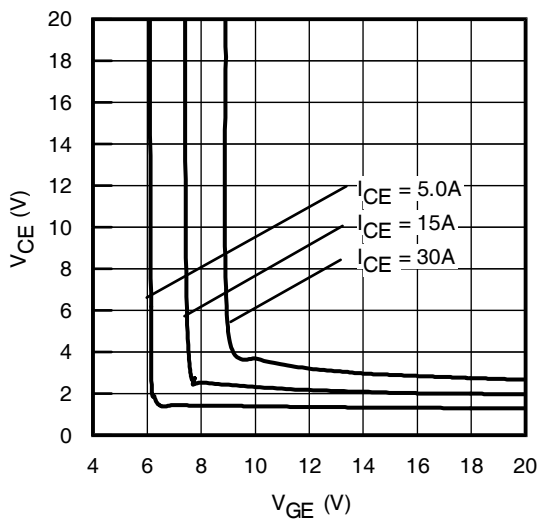
**Fig. 8** - Typ. Diode Forward Characteristics  
 $t_p = 80\mu\text{s}$



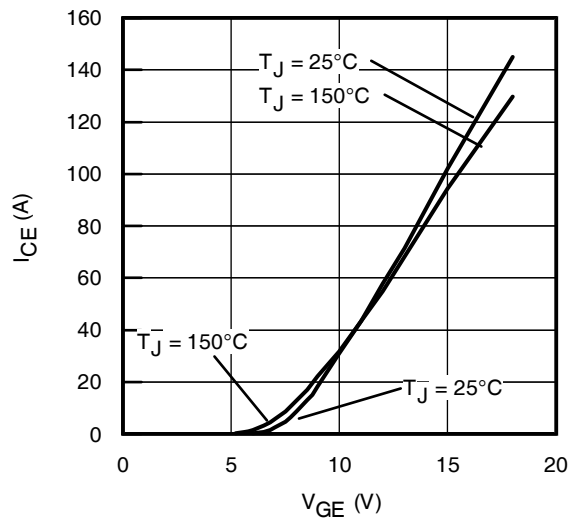
**Fig. 9** - Typical V<sub>CE</sub> vs. V<sub>GE</sub>  
T<sub>J</sub> = -40°C



**Fig. 10** - Typical V<sub>CE</sub> vs. V<sub>GE</sub>  
T<sub>J</sub> = 25°C

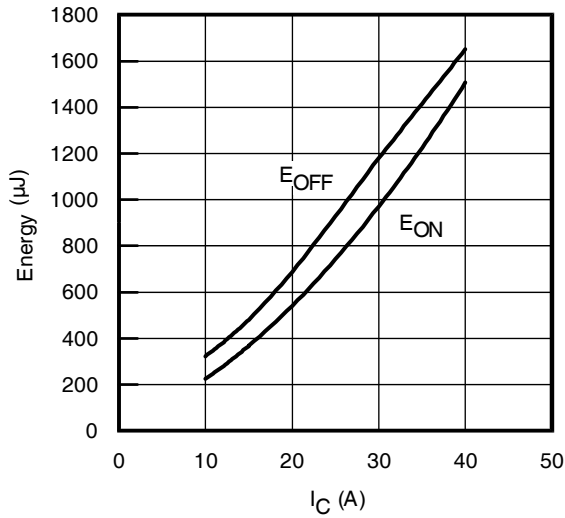


**Fig. 11** - Typical V<sub>CE</sub> vs. V<sub>GE</sub>  
T<sub>J</sub> = 150°C

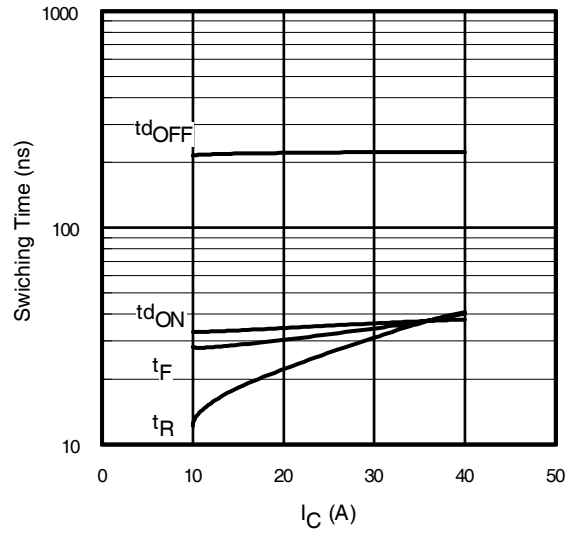


**Fig. 12** - Typ. Transfer Characteristics  
V<sub>CE</sub> = 50V; t<sub>p</sub> = 10μs

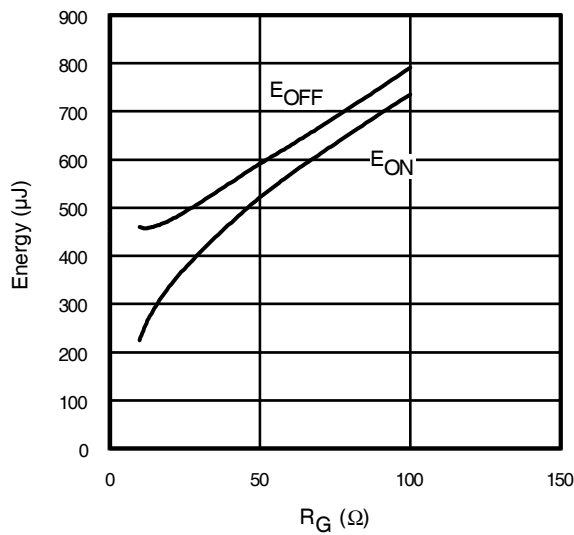
# IRGB/S/SL15B60KDPbF



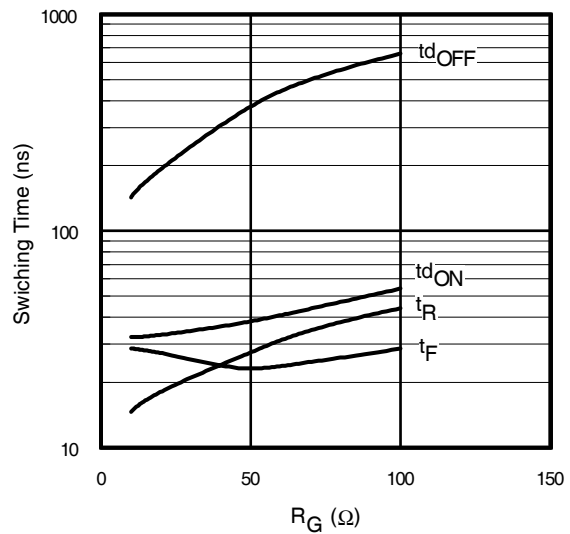
**Fig. 13** - Typ. Energy Loss vs. I<sub>C</sub>  
T<sub>J</sub> = 150°C; L=200μH; V<sub>CE</sub>= 400V  
R<sub>G</sub>= 22Ω; V<sub>GE</sub>= 15V



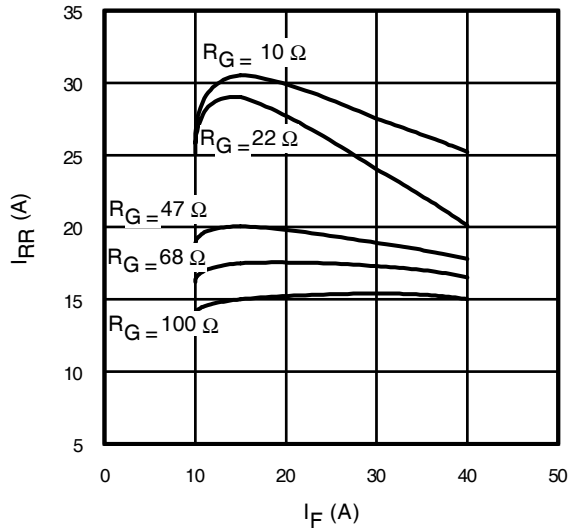
**Fig. 14** - Typ. Switching Time vs. I<sub>C</sub>  
T<sub>J</sub> = 150°C; L=200μH; V<sub>CE</sub>= 400V  
R<sub>G</sub>= 22Ω; V<sub>GE</sub>= 15V



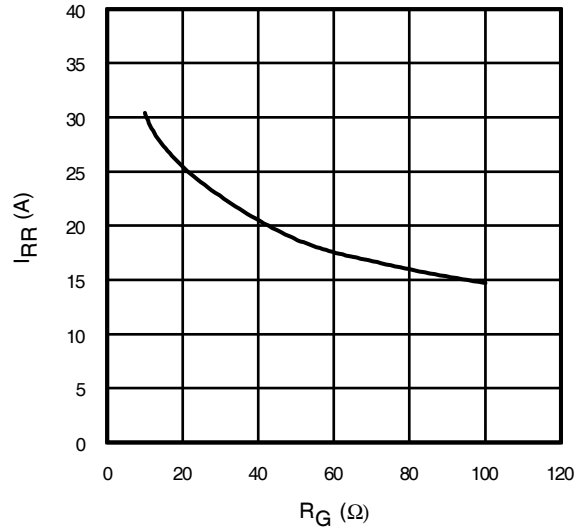
**Fig. 15** - Typ. Energy Loss vs. R<sub>G</sub>  
T<sub>J</sub> = 150°C; L=200μH; V<sub>CE</sub>= 400V  
I<sub>CE</sub>= 15A; V<sub>GE</sub>= 15V



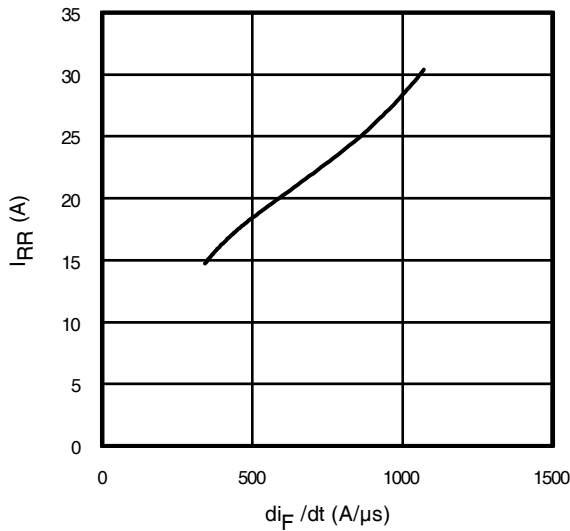
**Fig. 16**- Typ. Switching Time vs. R<sub>G</sub>  
T<sub>J</sub> = 150°C; L=200μH; V<sub>CE</sub>= 600V  
I<sub>CE</sub>= 15A; V<sub>GE</sub>= 15V



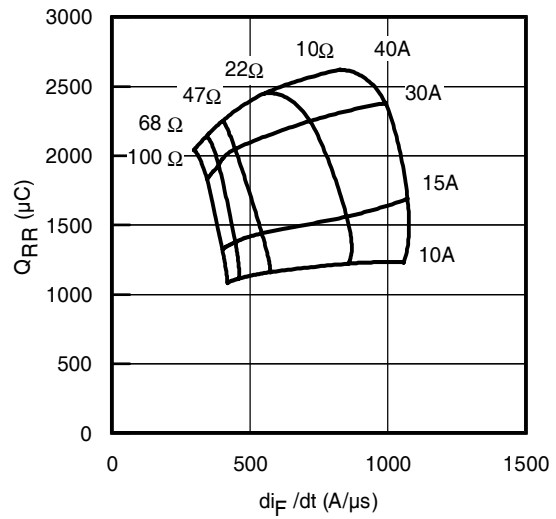
**Fig. 17** - Typical Diode  $I_{RR}$  vs.  $I_F$   
 $T_J = 150^\circ\text{C}$



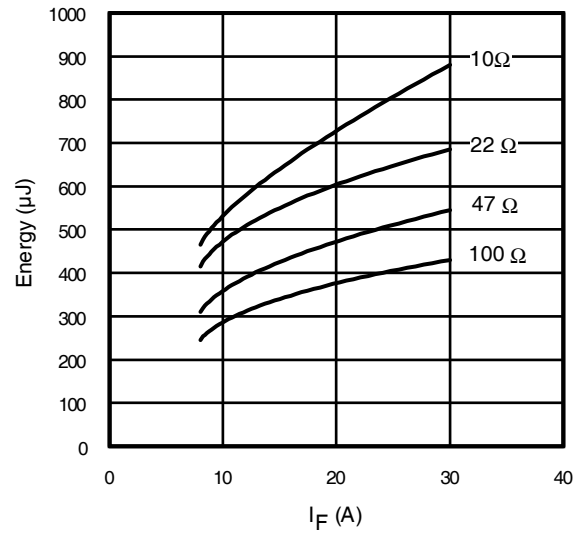
**Fig. 18** - Typical Diode  $I_{RR}$  vs.  $R_G$   
 $T_J = 150^\circ\text{C}; I_F = 15\text{A}$



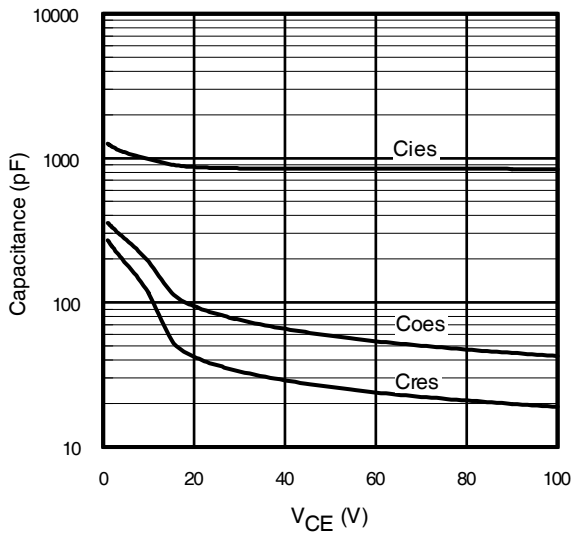
**Fig. 19** - Typical Diode  $I_{RR}$  vs.  $di_F/dt$   
 $V_{CC} = 400\text{V}; V_{GE} = 15\text{V};$   
 $I_{CE} = 15\text{A}; T_J = 150^\circ\text{C}$



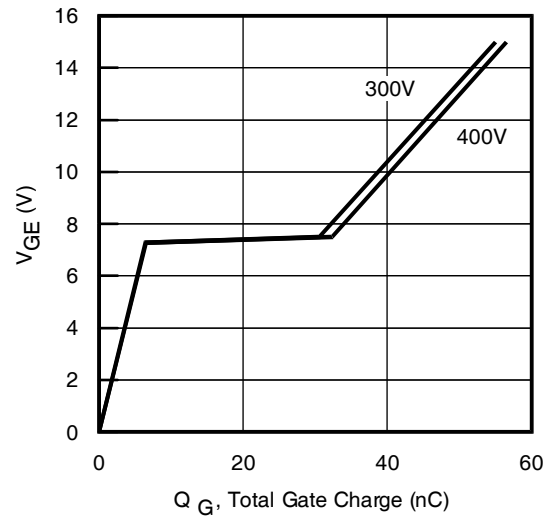
**Fig. 20** - Typical Diode  $Q_{RR}$   
 $V_{CC} = 400\text{V}; V_{GE} = 15\text{V}; T_J = 150^\circ\text{C}$



**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.  $V_{GE}$   
 $I_{CE} = 15\text{A}$ ;  $L = 600\mu\text{H}$



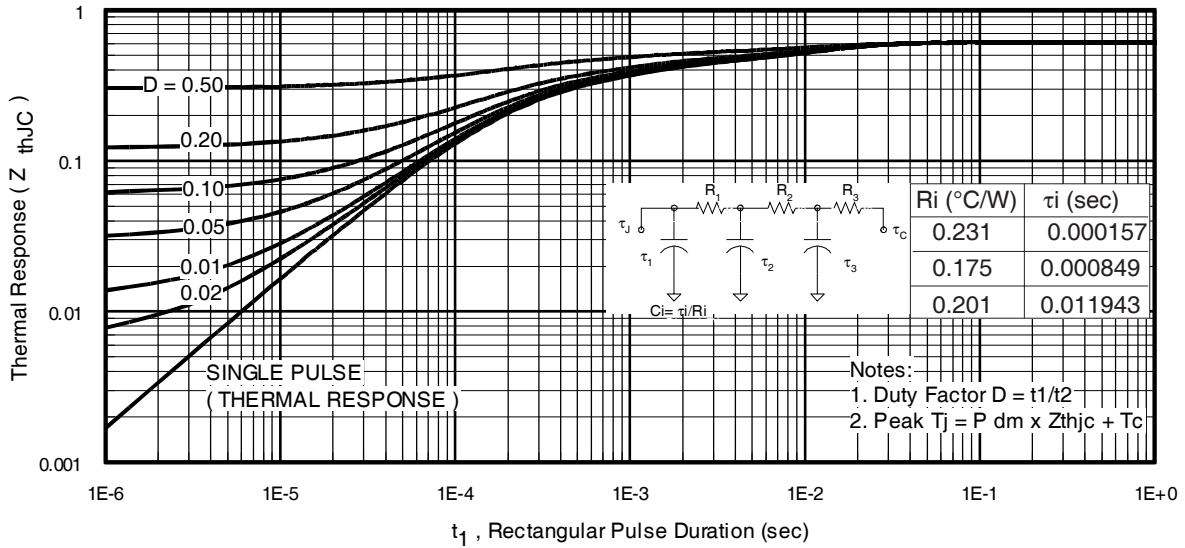


Fig 24. Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

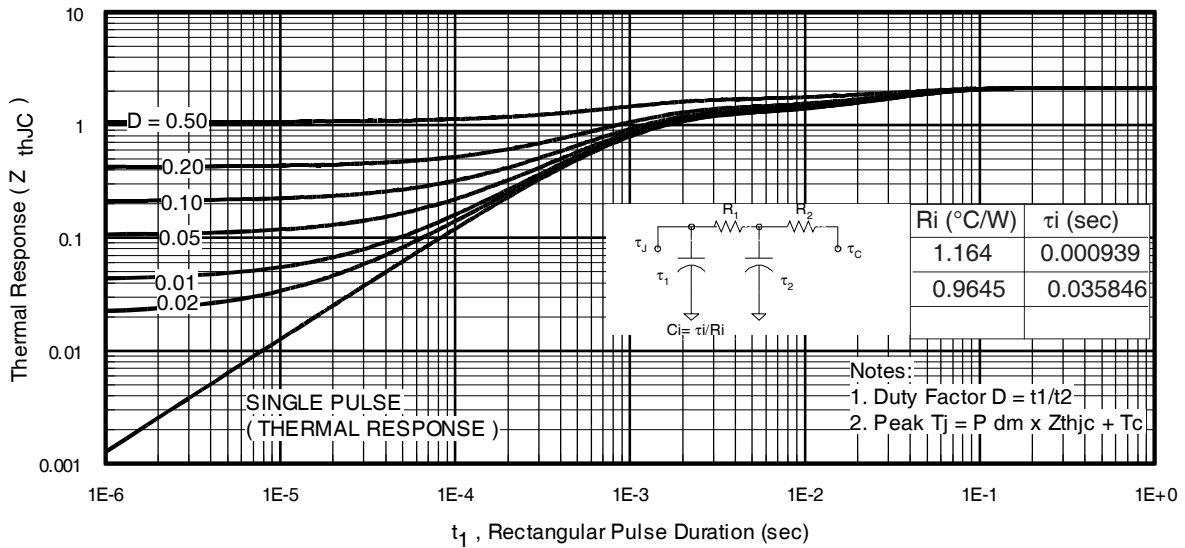
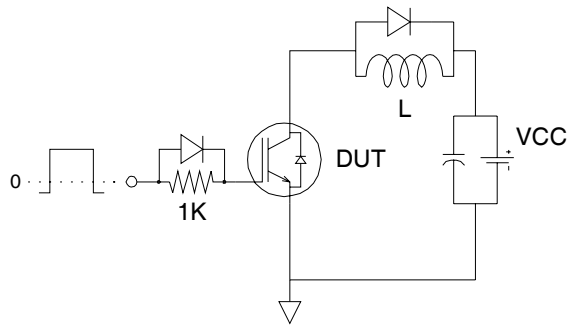


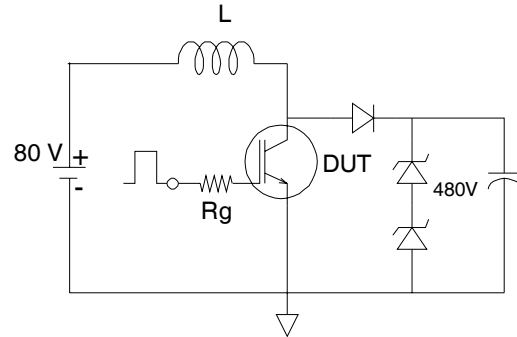
Fig 25. Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)

# IRGB/S/SL15B60KDPbF

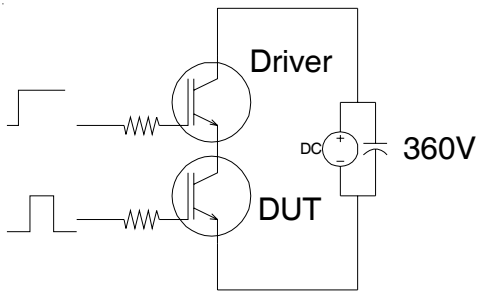
International  
**IR** Rectifier



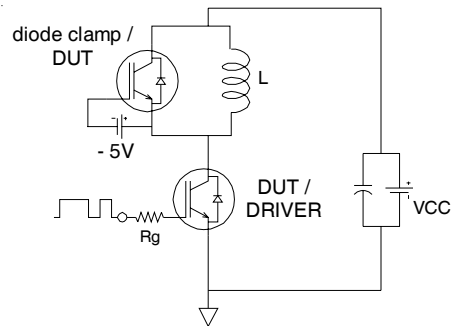
**Fig.C.T.1** - Gate Charge Circuit (turn-off)



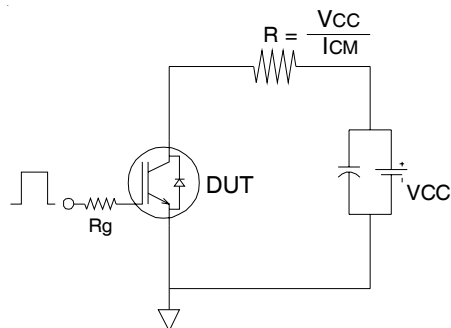
**Fig.C.T.2** - RBSOA Circuit



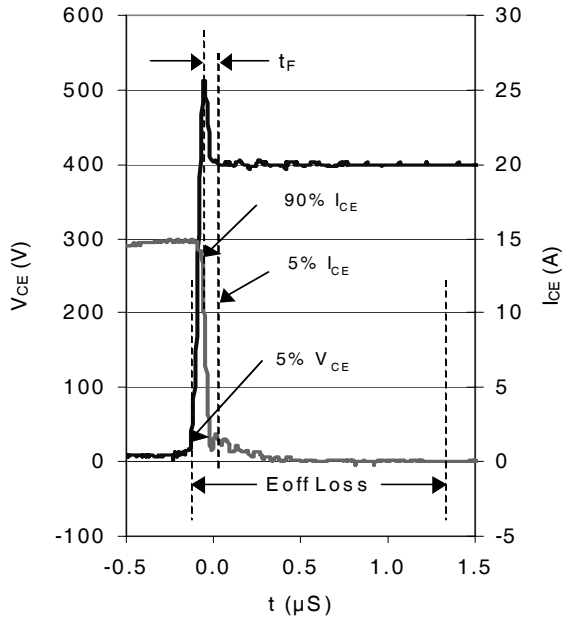
**Fig.C.T.3** - S.C.SOA Circuit



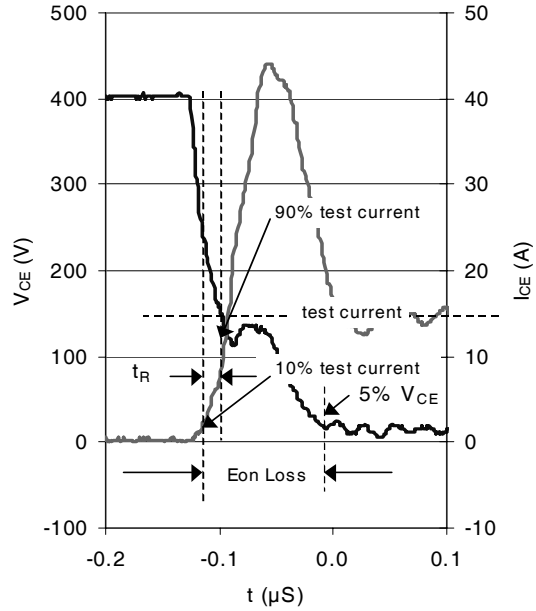
**Fig.C.T.4** - Switching Loss Circuit



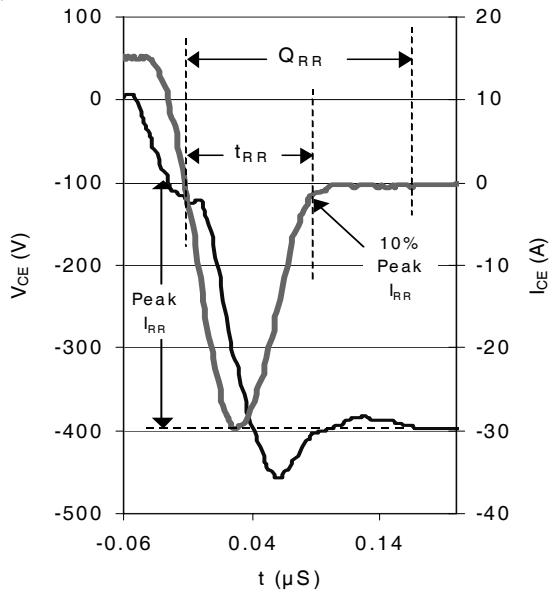
**Fig.C.T.5** - Resistive Load Circuit



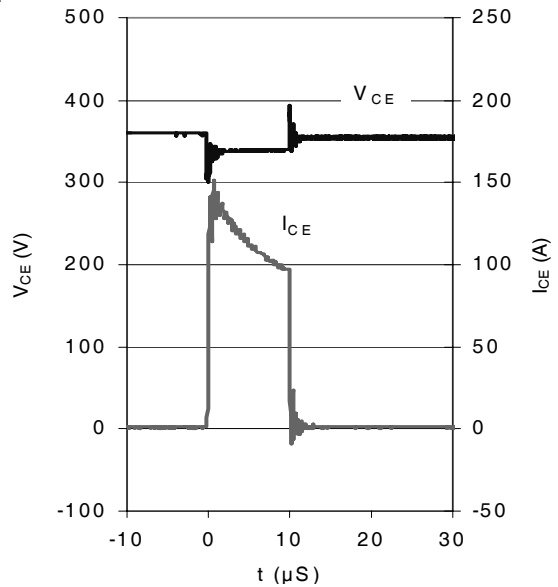
WF.1- Typ. Turn-off Loss  
@  $T_J = 150^\circ\text{C}$  using CT.4



WF.2- Typ. Turn-on Loss  
@  $T_J = 150^\circ\text{C}$  using Fig. CT.4



WF.3- Typ. Reverse Recovery  
@  $T_J = 150^\circ\text{C}$  using CT.4



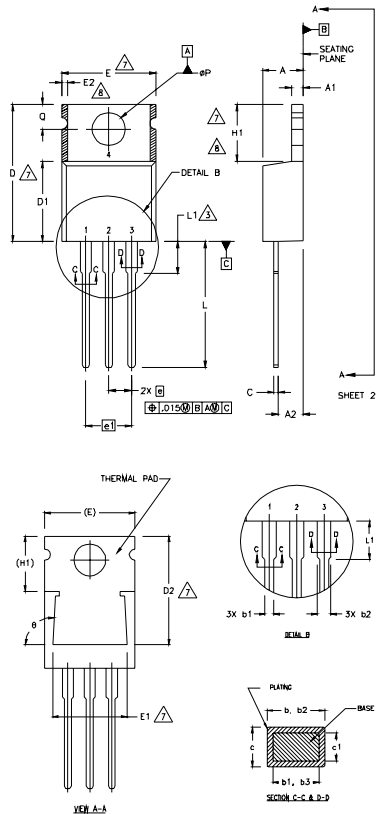
WF.4- Typ. Short Circuit  
@  $T_J = 150^\circ\text{C}$  using CT.3

# IRGB/S/SL15B60KDPbF



## TO-220AB Package Outline

Dimensions are shown in millimeters (inches)



- NOTES:
- 1 DIMENSIONING AND TOLERANCING PER ASME Y14.5 M- 1994.
  - 2 DIMENSIONS ARE SHOWN IN INCHES [MILLIMETERS].
  - 3 LEAD DIMENSION AND FINISH UNCONTROLLED IN L1.
  - 4 DIMENSION D & 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.

LEAD ASSIGNMENTS

- HERFEE  
 1.- GATE  
 2.- DRAIN  
 3.- SOURCE

IGBTs, CoPACK

- 1.- GATE  
 2.- COLLECTOR  
 3.- EMITTER

DIODES

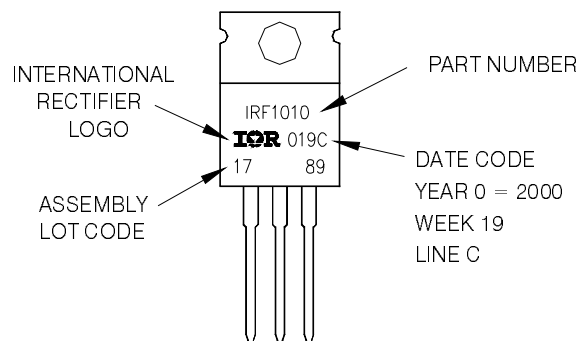
- 1.- ANODE/OPEN  
 2.- CATHODE  
 3.- ANODE

SYMBOL	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	3.56	4.82	.140	.190	
A1	0.51	1.40	.020	.055	
A2	2.04	2.92	.080	.115	
b	0.38	1.01	.015	.040	
b1	0.38	0.96	.015	.038	5
b2	1.15	1.77	.045	.070	
b3	1.15	1.73	.045	.068	
c	0.36	0.61	.014	.024	
c1	0.56	0.56	.014	.022	5
D	14.22	16.51	.560	.650	4
D1	8.38	9.02	.330	.355	
D2	12.19	12.88	.480	.507	7
E	9.66	10.66	.380	.420	4,7
E1	8.38	8.89	.330	.350	7
e	2.54 BSC		.100 BSC		
e1	5.08		2.00 BSC		
H1	5.85	6.55	.230	.270	7,8
L	12.70	14.73	.500	.580	
L1	-	6.35	-	.250	3
øP	3.54	4.08	.139	.161	
O	2.54	3.42	.100	.135	
ø	9.0°-9.3°		9.0°-9.3°		

## TO-220AB Part Marking Information

EXAMPLE: THIS IS AN IRF1010  
 LOT CODE 1789  
 ASSEMBLED ON WW 19, 2000  
 IN THE ASSEMBLY LINE "C"

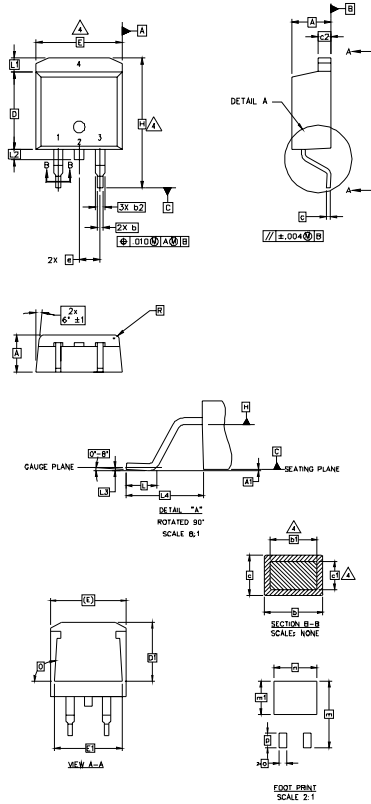
Note: "P" in assembly line position indicates "Lead - Free"



# IRGB/S/SL15B60KDPbF

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

Dimensions are shown in millimeters (inches)



- 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	4
A1	0.00	0.254	.000	.010	
b	0.51	0.99	.020	.039	4
b1	0.51	0.89	.020	.035	
b2	1.14	1.78	.045	.070	4
c	0.38	0.74	.015	.029	
c1	0.38	0.58	.015	.023	3
c2	1.14	1.65	.045	.065	
D	8.51	9.65	.335	.380	3
D1	6.86		.270		
E	9.65	10.67	.380	.420	3
E1	6.22		.245		
e	2.54 BSC		.100 BSC		
H	14.61	15.88	.575	.625	
L	1.78	2.79	.070	.110	
L1		1.65		.065	
L2	1.27	1.78	.050	.070	
L3	0.25 BSC		.010 BSC		
L4	4.78	5.28	.188	.208	
m	17.78		.700		
m1	8.89		.350		
n	11.43		.450		
o	2.08		.082		
p	3.81		.150		
R	0.51	0.71	.020	.028	
θ	90°	93°	90°	93°	

**LEAD ASSIGNMENTS**

- HEXFET**
- 1.- GATE
  - 2, 4.- DRAIN
  - 3.- SOURCE

**IGBTs, CoPACK**

- 1.- GATE
- 2, 4.- COLLECTOR
- 3.- EMITTER

**DIODES**

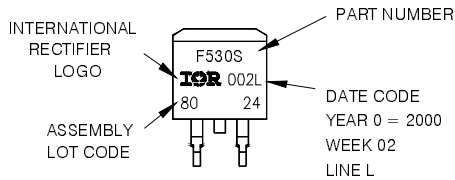
- 1.- ANODE \*
- 2, 4.- CATHODE
- 3.- ANODE

\* PART DEPENDENT.

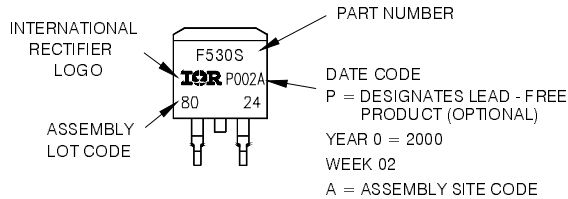
## D<sup>2</sup>Pak Part Marking Information

EXAMPLE: THIS IS AN IRF530S WITH  
LOT CODE 8024  
ASSEMBLED ON WW 02, 2000  
IN THE ASSEMBLY LINE 'L'

Note: "P" in assembly line position  
indicates "Lead - Free"



OR

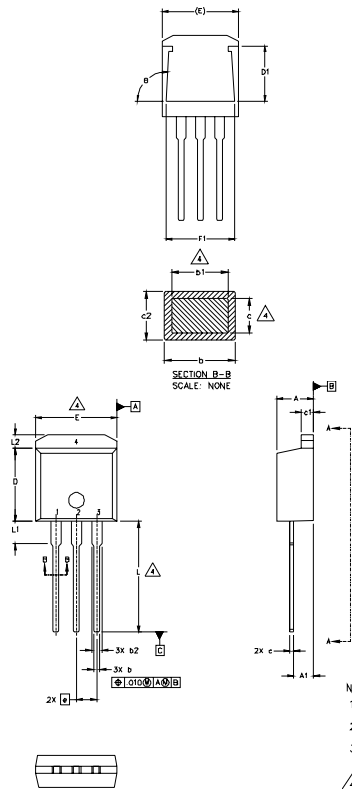


# IRGB/S/SL15B60KDPbF

International  
**IRF** Rectifier

## TO-262 Package Outline

Dimensions are shown in millimeters (inches)



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	4
c	0.38	0.63	.015	.025	
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

- 1. - GATE
- 2. - DRAIN
- 3. - SOURCE
- 4. - DRAIN

#### IGBT

- 1 - GATE
- 2 - COLLECTOR
- 3 - EMITTER

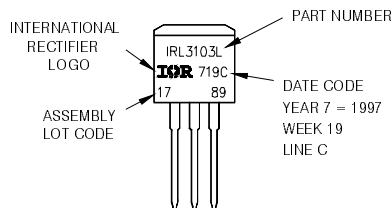
#### NOTES:

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.

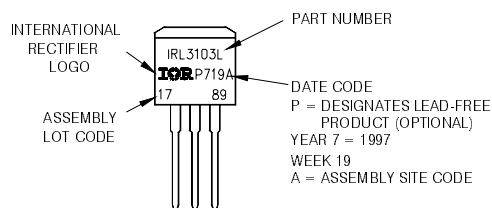
## TO-262 Part Marking Information

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

Note: 'P' in assembly line position indicates 'Lead-Free'

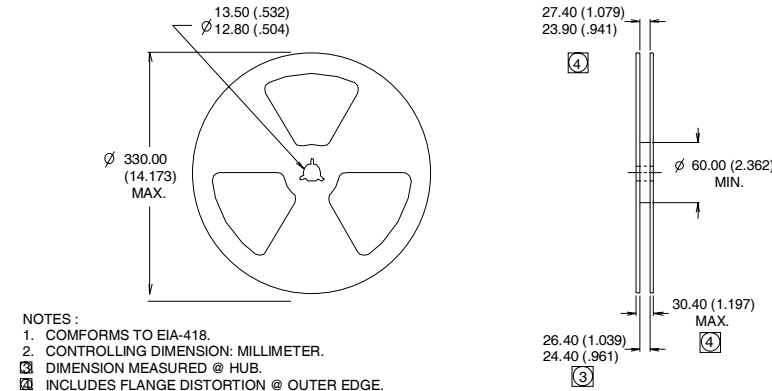
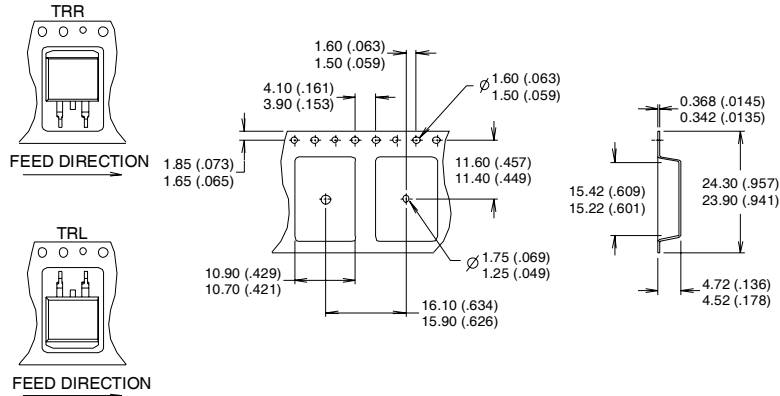


**OR**



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

Dimensions are shown in millimeters (inches)



- NOTES:
1. COMFORMS TO EIA-418.
  2. CONTROLLING DIMENSION: MILLIMETER.
  - ③ DIMENSION MEASURED @ HUB.
  - ④ INCLUDES FLANGE DISTORTION @ OUTER EDGE.

### Notes:

- ① This is only applied to TO-220AB package
- ② This is applied to D<sup>2</sup>Pak, when mounted on 1" square PCB (FR-4 or G-10 Material).  
For recommended footprint and soldering techniques refer to application note #AN-994.
- ③ Energy losses include "tail" and diode reverse recovery.
- ④  $V_{CC} = 80\% (V_{CES})$ ,  $V_{GE} = 20V$ ,  $L = 100\mu H$ ,  $R_G = 22\Omega$ .

TO-220 package is not recommended for Surface Mount Application

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

IR WORLD HEADQUARTERS: 233 Kansas St., El Segundo, California 90245, USA Tel: (310) 252-7105  
 TAC Fax: (310) 252-7903

Visit us at [www.irf.com](http://www.irf.com) for sales contact information.10/05

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



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[RJH60D2DPP-M0#T2](#) [IKP20N60TXKSA1](#) [IHW20N65R5XKSA1](#) [APT70GR120JD60](#) [AOD5B60D](#) [APT70GR120L](#) [STGWT60H65FB](#)  
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