

International IR Rectifier

INSULATED GATE BIPOLAR TRANSISTOR WITH ULTRAFAST SOFT RECOVERY DIODE

PD - 94382D

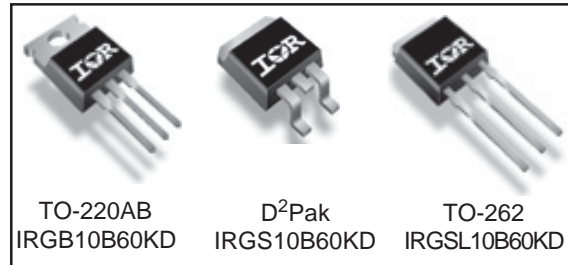
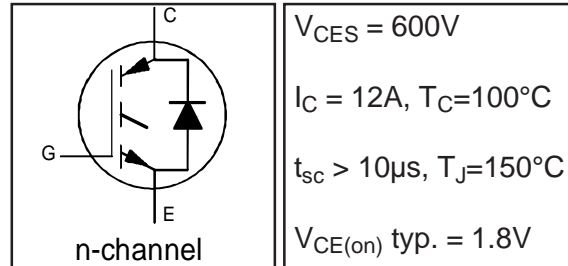
IRGB10B60KD
IRGS10B60KD
IRGSL10B60KD

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.



Absolute Maximum Ratings

	Parameter	Max.	Units
V_{CES}	Collector-to-Emitter Voltage	600	V
$I_C @ T_C = 25^\circ C$	Continuous Collector Current	22	A
$I_C @ T_C = 100^\circ C$	Continuous Collector Current	12	
I_{CM}	Pulsed Collector Current	44	
I_{LM}	Clamped Inductive Load Current ④	44	
$I_F @ T_C = 25^\circ C$	Diode Continuous Forward Current	22	
$I_F @ T_C = 100^\circ C$	Diode Continuous Forward Current	10	
I_{FM}	Diode Maximum Forward Current	44	
V_{GE}	Gate-to-Emitter Voltage	± 20	V
$P_D @ T_C = 25^\circ C$	Maximum Power Dissipation	156	W
$P_D @ T_C = 100^\circ C$	Maximum Power Dissipation	62	
T_J	Operating Junction and	-55 to +150	$^\circ C$
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	—	—	0.8	$^\circ C/W$
$R_{\theta JC}$	Junction-to-Case - Diode	—	—	3.4	
$R_{\theta CS}$	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

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8/18/04

IRG/B/S/SL10B60KD

International
IRF RectifierElectrical Characteristics @ $T_J = 25^\circ\text{C}$ (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Conditions	Ref.Fig.
$V_{(BR)CES}$	Collector-to-Emitter Breakdown Voltage	600	—	—	V	$V_{GE} = 0V, I_C = 500\mu A$	
$\Delta V_{(BR)CES}/\Delta T_J$	Temperature Coeff. of Breakdown Voltage	—	0.3	—	V/ $^\circ\text{C}$	$V_{GE} = 0V, I_C = 1.0mA, (25^\circ\text{C}-150^\circ\text{C})$	
$V_{CE(on)}$	Collector-to-Emitter Saturation Voltage	1.5	1.80	2.20	V	$I_C = 10A, V_{GE} = 15V$	5, 6, 7
		—	2.20	2.50		$I_C = 10A, V_{GE} = 15V, T_J = 150^\circ\text{C}$	9, 10, 11
$V_{GE(th)}$	Gate Threshold Voltage	3.5	4.5	5.5	V	$V_{CE} = V_{GE}, I_C = 250\mu A$	9, 10, 11
$\Delta V_{GE(th)}/\Delta T_J$	Temperature Coeff. of Threshold Voltage	—	-10	—	mV/ $^\circ\text{C}$	$V_{CE} = V_{GE}, I_C = 1.0mA, (25^\circ\text{C}-150^\circ\text{C})$	12
g_{fe}	Forward Transconductance	—	7.0	—	S	$V_{CE} = 50V, I_C = 10A, PW=80\mu s$	
I_{CES}	Zero Gate Voltage Collector Current	—	3.0	150	μA	$V_{GE} = 0V, V_{CE} = 600V$	
		—	300	700		$V_{GE} = 0V, V_{CE} = 600V, T_J = 150^\circ\text{C}$	
V_{FM}	Diode Forward Voltage Drop	—	1.30	1.45	V	$I_C = 10A$	8
		—	1.30	1.45		$I_C = 10A, T_J = 150^\circ\text{C}$	
I_{GES}	Gate-to-Emitter Leakage Current	—	—	± 100	nA	$V_{GE} = \pm 20V$	

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

	Parameter	Min.	Typ.	Max.	Units	Conditions	Ref.Fig.
Q_g	Total Gate Charge (turn-on)	—	38	—	nC	$I_C = 10A$	CT1
Q_{ge}	Gate - Emitter Charge (turn-on)	—	4.3	—		$V_{CC} = 400V$	
Q_{gc}	Gate - Collector Charge (turn-on)	—	16.3	—		$V_{GE} = 15V$	
E_{on}	Turn-On Switching Loss	—	140	247	μJ	$I_C = 10A, V_{CC} = 400V$	CT4
E_{off}	Turn-Off Switching Loss	—	250	360		$V_{GE} = 15V, R_G = 47\Omega, L = 200\mu H$	
E_{tot}	Total Switching Loss	—	390	607		$L_s = 150nH, T_J = 25^\circ\text{C}$ ③	
$t_{d(on)}$	Turn-On Delay Time	—	30	39	ns	$I_C = 10A, V_{CC} = 400V$	CT4
t_r	Rise Time	—	20	29		$V_{GE} = 15V, R_G = 47\Omega, L = 200\mu H$	
$t_{d(off)}$	Turn-Off Delay Time	—	230	262		$L_s = 150nH, T_J = 25^\circ\text{C}$	
t_f	Fall Time	—	23	32			
E_{on}	Turn-On Switching Loss	—	230	340	μJ	$I_C = 10A, V_{CC} = 400V$	CT4
E_{off}	Turn-Off Switching Loss	—	350	464		$V_{GE} = 15V, R_G = 47\Omega, L = 200\mu H$	
E_{tot}	Total Switching Loss	—	580	804		$L_s = 150nH, T_J = 150^\circ\text{C}$ ③	
$t_{d(on)}$	Turn-On Delay Time	—	30	39	ns	$I_C = 10A, V_{CC} = 400V$	14, 16
t_r	Rise Time	—	20	28		$V_{GE} = 15V, R_G = 47\Omega, L = 200\mu H$	
$t_{d(off)}$	Turn-Off Delay Time	—	250	274		$L_s = 150nH, T_J = 150^\circ\text{C}$	
t_f	Fall Time	—	26	34			
C_{ies}	Input Capacitance	—	620	—	pF	$V_{GE} = 0V$	
C_{oes}	Output Capacitance	—	62	—		$V_{CC} = 30V$	
C_{res}	Reverse Transfer Capacitance	—	22	—		$f = 1.0MHz$	
RBSOA	Reverse Bias Safe Operating Area	FULL SQUARE				$T_J = 150^\circ\text{C}, I_C = 44A, V_p = 600V$ $V_{CC} = 500V, V_{GE} = +15V \text{ to } 0V, R_G = 47\Omega$	4 CT2
SCSOA	Short Circuit Safe Operating Area	10	—	—	μs	$T_J = 150^\circ\text{C}, V_p = 600V, R_G = 47\Omega$ $V_{CC} = 360V, V_{GE} = +15V \text{ to } 0V$	CT3 WF4
E_{rec}	Reverse Recovery energy of the diode	—	245	330	μJ	$T_J = 150^\circ\text{C}$	17, 18, 19
t_{rr}	Diode Reverse Recovery time	—	90	105	ns	$V_{CC} = 400V, I_F = 10A, L = 200\mu H$	20, 21
I_{rr}	Diode Peak Reverse Recovery Current	—	19	22	A	$V_{GE} = 15V, R_G = 47\Omega, L_s = 150nH$	CT4, WF3

Note ① to ④ are on page 15

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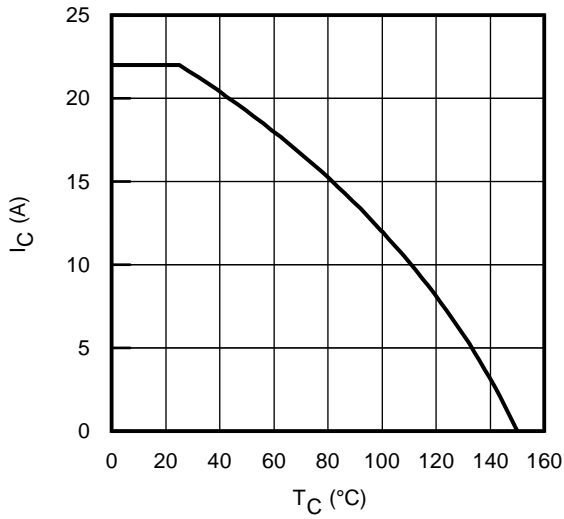


Fig. 1 - Maximum DC Collector Current vs. Case Temperature

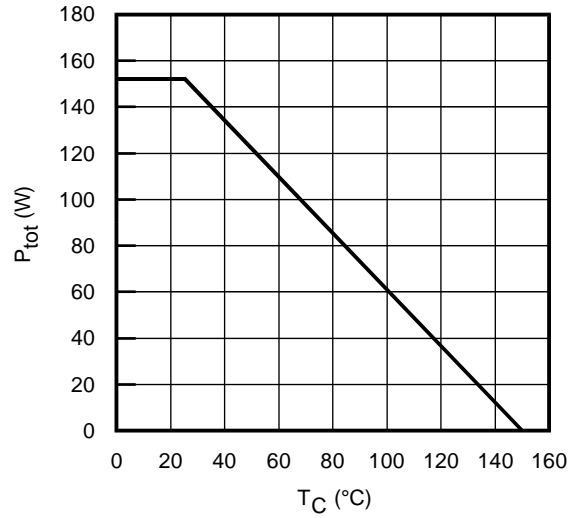


Fig. 2 - Power Dissipation vs. Case Temperature

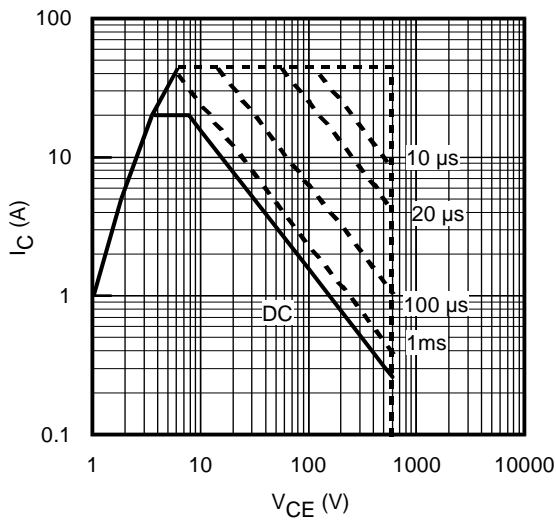


Fig. 3 - Forward SOA
 $T_C = 25^\circ\text{C}$; $T_J \leq 150^\circ\text{C}$

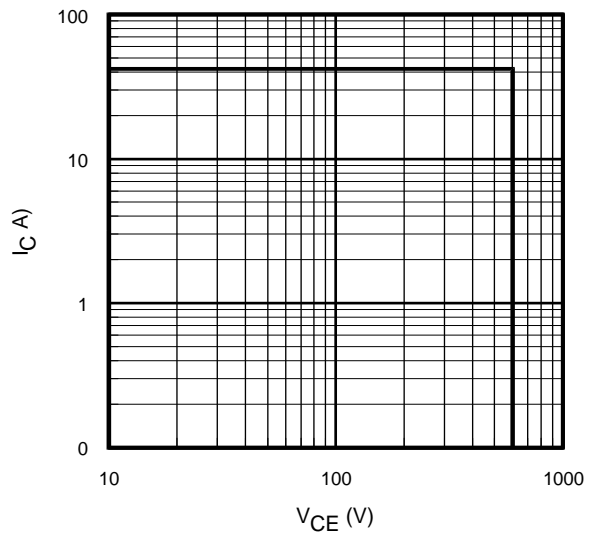


Fig. 4 - Reverse Bias SOA
 $T_J = 150^\circ\text{C}$; $V_{GE} = 15\text{V}$

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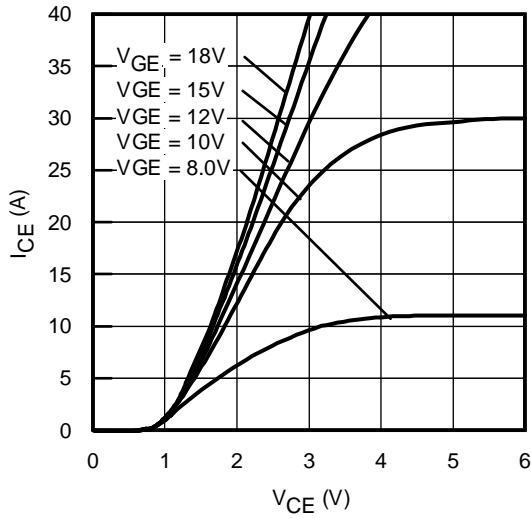


Fig. 5 - Typ. IGBT Output Characteristics
 $T_J = -40^\circ\text{C}$; $t_p = 80\mu\text{s}$

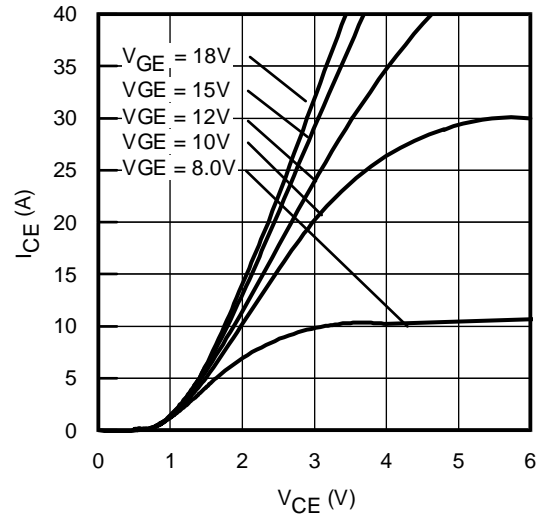


Fig. 6 - Typ. IGBT Output Characteristics
 $T_J = 25^\circ\text{C}$; $t_p = 80\mu\text{s}$

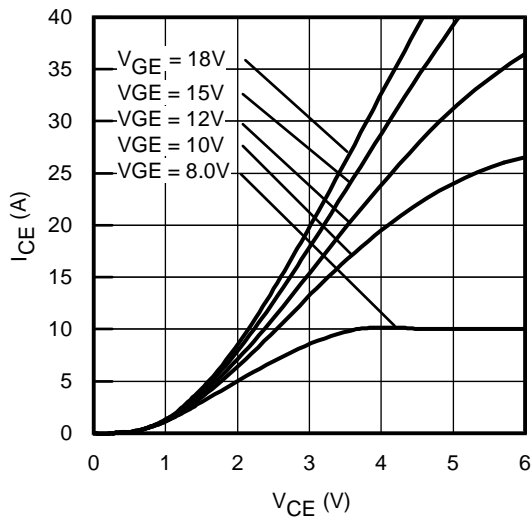


Fig. 7 - Typ. IGBT Output Characteristics
 $T_J = 150^\circ\text{C}$; $t_p = 80\mu\text{s}$

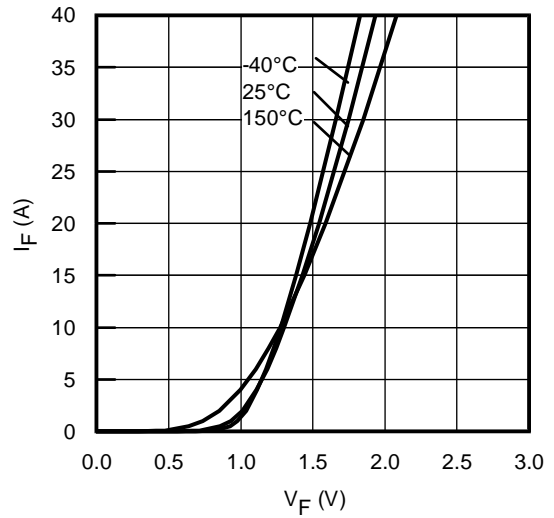


Fig. 8 - Typ. Diode Forward Characteristics
 $t_p = 80\mu\text{s}$

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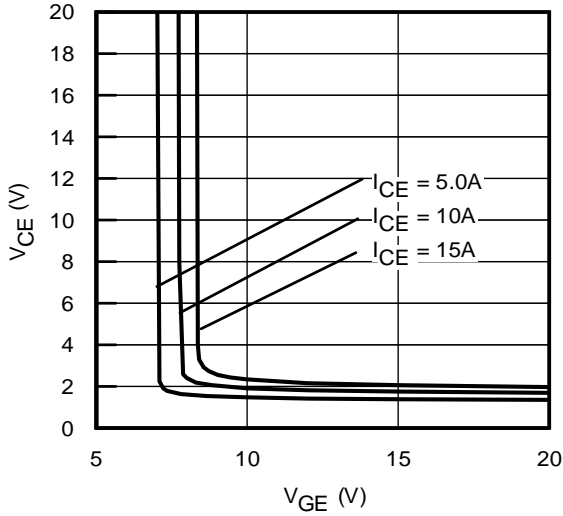


Fig. 9 - Typical V_{CE} vs. V_{GE}
 $T_J = -40^\circ C$

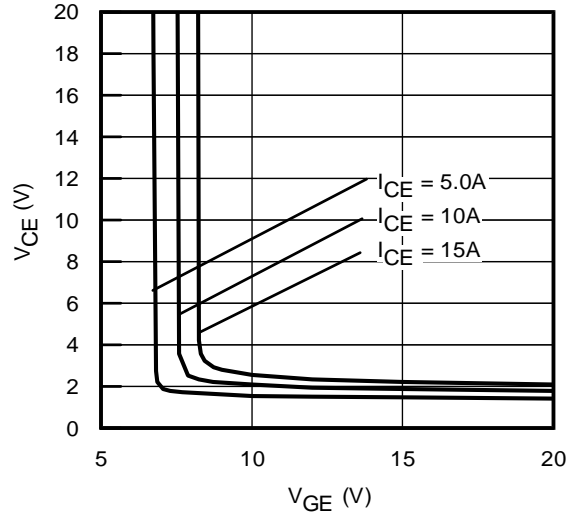


Fig. 10 - Typical V_{CE} vs. V_{GE}
 $T_J = 25^\circ C$

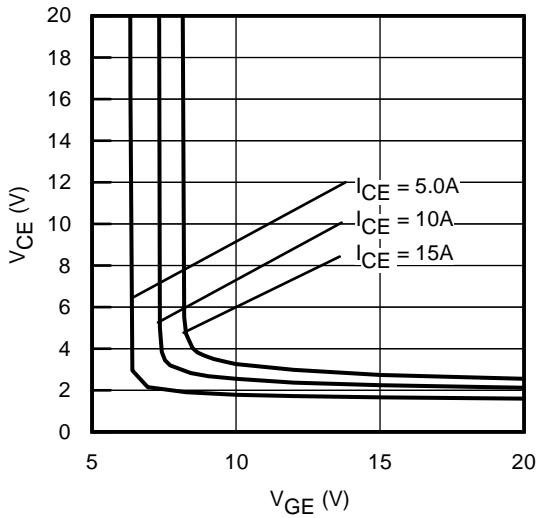


Fig. 11 - Typical V_{CE} vs. V_{GE}
 $T_J = 150^\circ C$

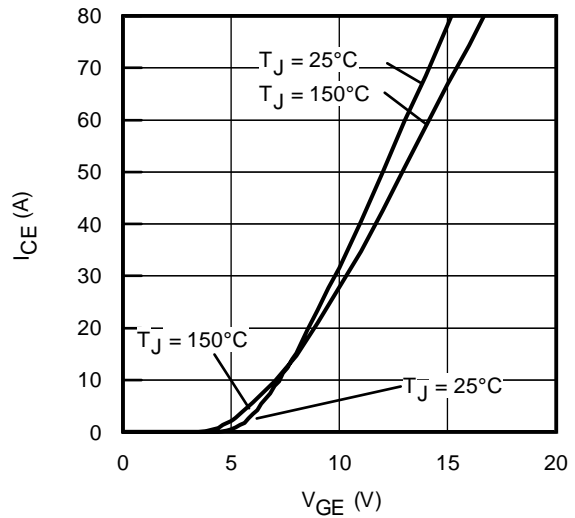


Fig. 12 - Typ. Transfer Characteristics
 $V_{CE} = 50V$; $t_p = 10\mu s$

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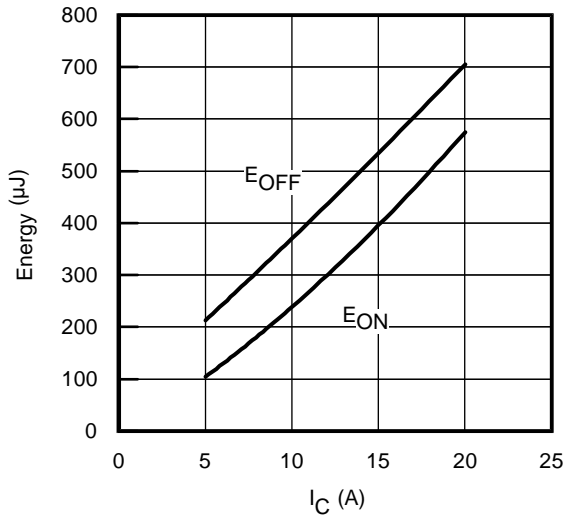


Fig. 13 - Typ. Energy Loss vs. I_C
 $T_J = 150^\circ\text{C}$; $L=200\mu\text{H}$; $V_{CE}= 400\text{V}$
 $R_G= 47\Omega$; $V_{GE}= 15\text{V}$

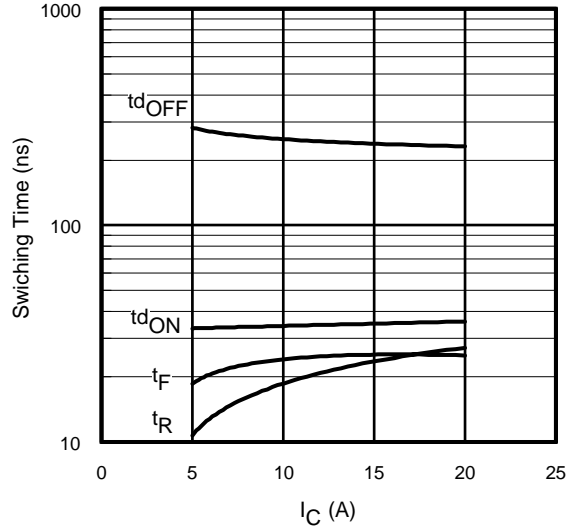


Fig. 14 - Typ. Switching Time vs. I_C
 $T_J = 150^\circ\text{C}$; $L=200\mu\text{H}$; $V_{CE}= 400\text{V}$
 $R_G= 47\Omega$; $V_{GE}= 15\text{V}$

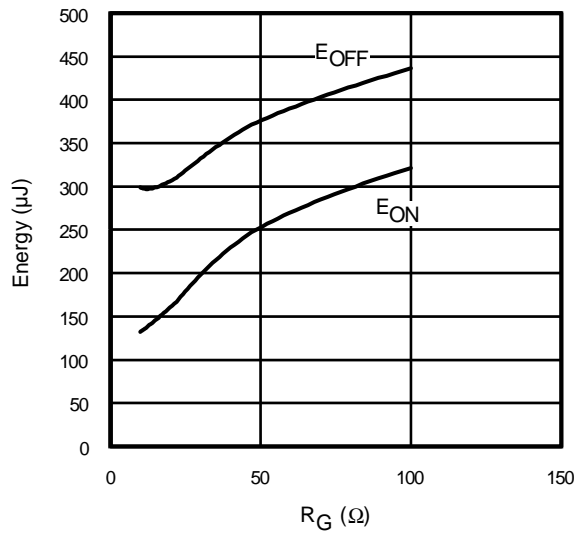


Fig. 15 - Typ. Energy Loss vs. R_G
 $T_J = 150^\circ\text{C}$; $L=200\mu\text{H}$; $V_{CE}= 400\text{V}$
 $I_{CE}= 10\text{A}$; $V_{GE}= 15\text{V}$

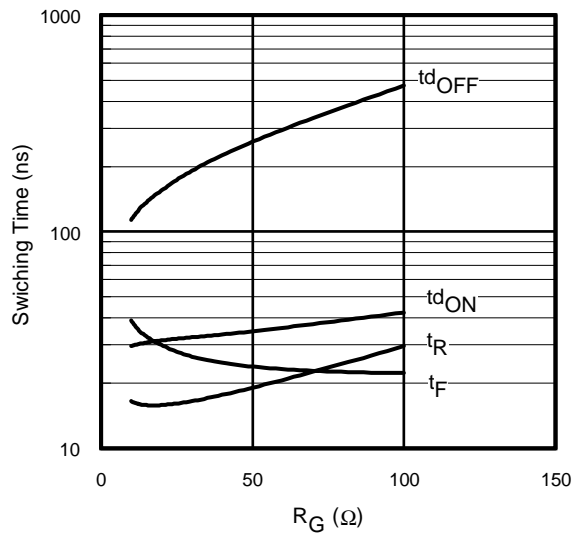


Fig. 16 - Typ. Switching Time vs. R_G
 $T_J = 150^\circ\text{C}$; $L=200\mu\text{H}$; $V_{CE}= 400\text{V}$
 $I_{CE}= 10\text{A}$; $V_{GE}= 15\text{V}$

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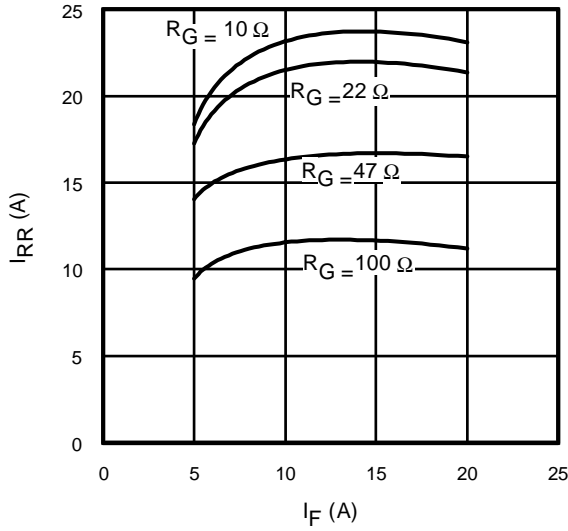


Fig. 17 - Typical Diode I_{RR} vs. I_F
 $T_J = 150^\circ\text{C}$

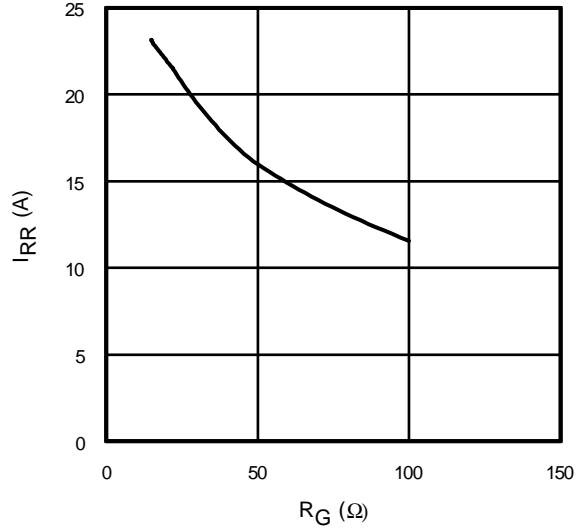


Fig. 18 - Typical Diode I_{RR} vs. R_G
 $T_J = 150^\circ\text{C}; I_F = 10\text{A}$

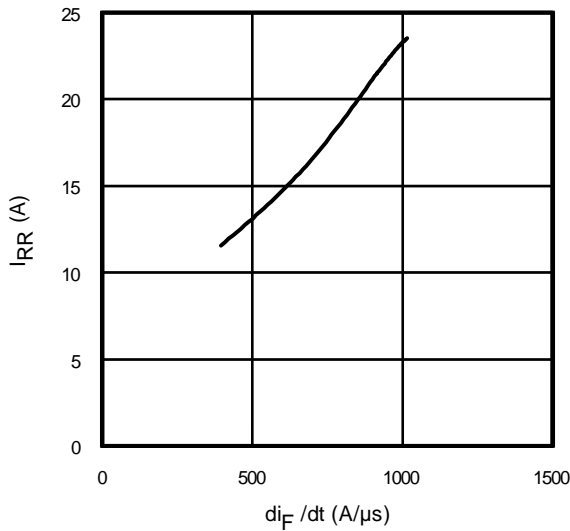


Fig. 19 - Typical Diode I_{RR} vs. di_F/dt
 $V_{CC} = 400\text{V}; V_{GE} = 15\text{V};$
 $I_{CE} = 10\text{A}; T_J = 150^\circ\text{C}$

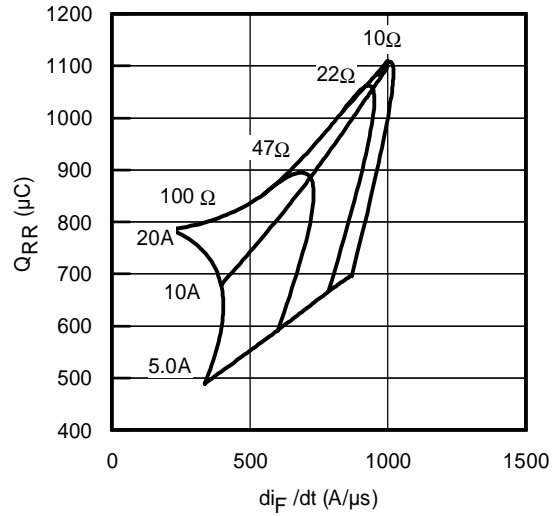


Fig. 20 - Typical Diode Q_{RR}
 $V_{CC} = 400\text{V}; V_{GE} = 15\text{V}; T_J = 150^\circ\text{C}$

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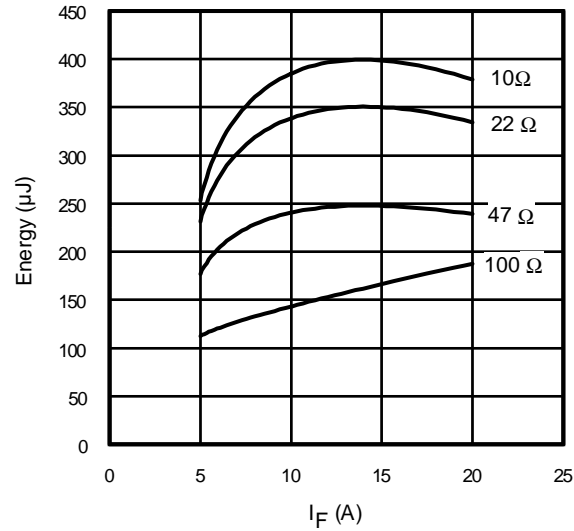


Fig. 21 - Typical Diode E_{RR} vs. I_F
 $T_J = 150^\circ\text{C}$

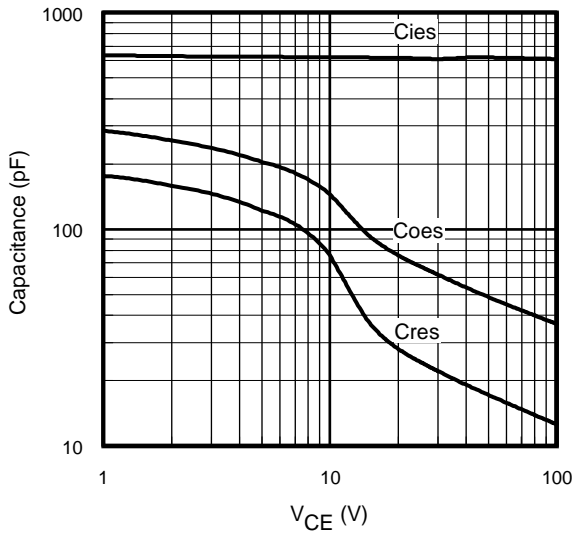


Fig. 22- Typ. Capacitance vs. V_{CE}
 $V_{GE} = 0\text{V}$; $f = 1\text{MHz}$

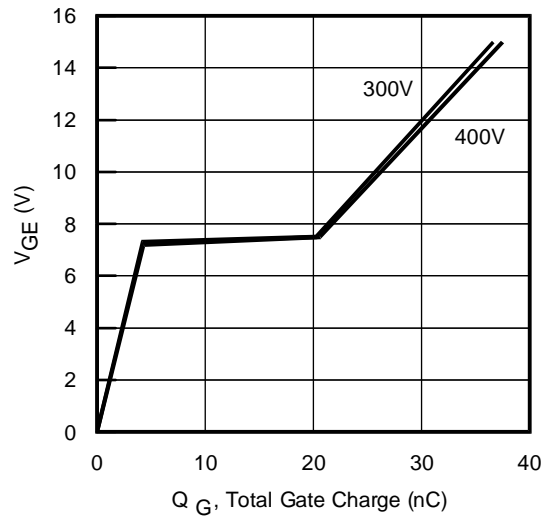


Fig. 23 - Typical Gate Charge vs. V_{GE}
 $I_{CE} = 10\text{A}$; $L = 600\ \mu\text{H}$

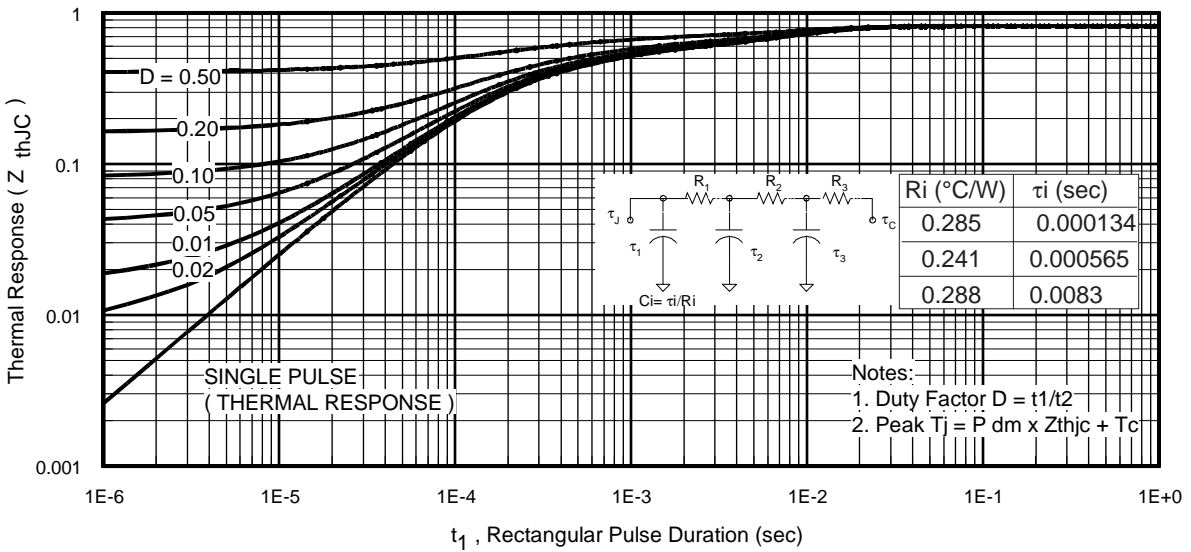


Fig 24. Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

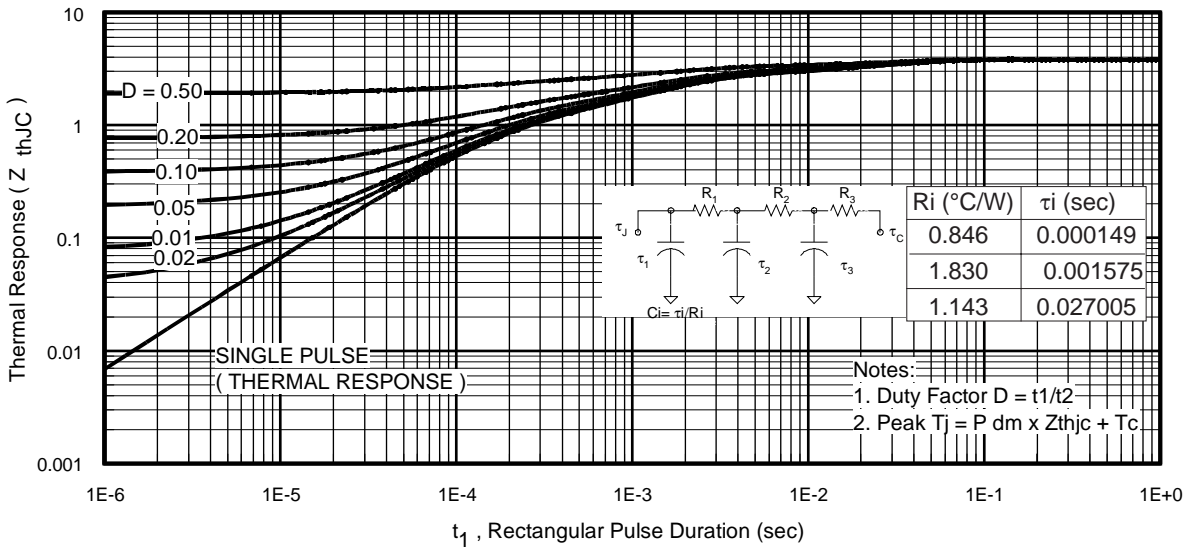


Fig 25. Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)

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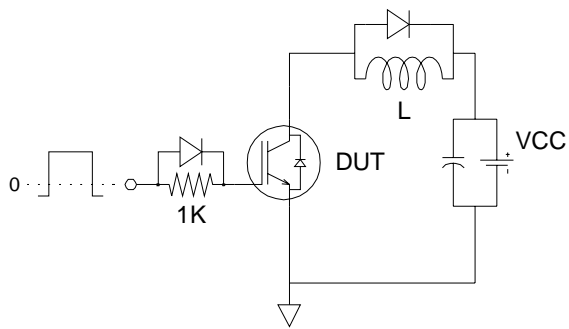


Fig.C.T.1 - Gate Charge Circuit (turn-off)

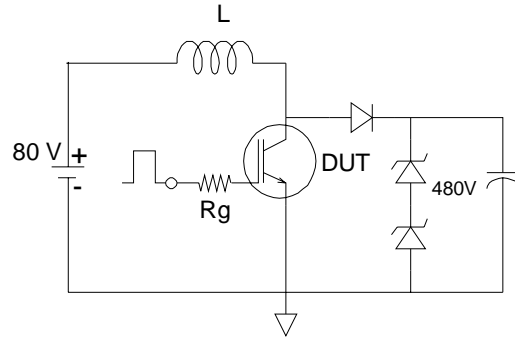


Fig.C.T.2 - RBSOA Circuit

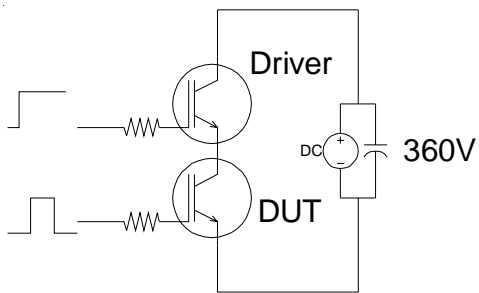


Fig.C.T.3 - S.C.SOA Circuit

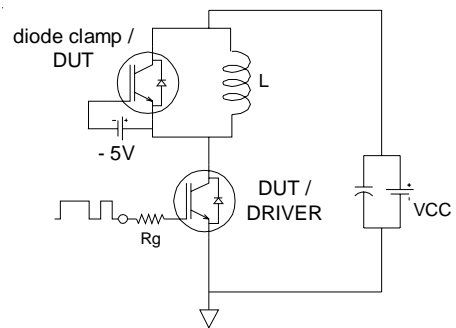


Fig.C.T.4 - Switching Loss Circuit

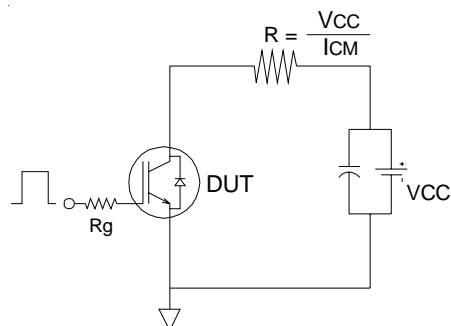


Fig.C.T.5 - Resistive Load Circuit

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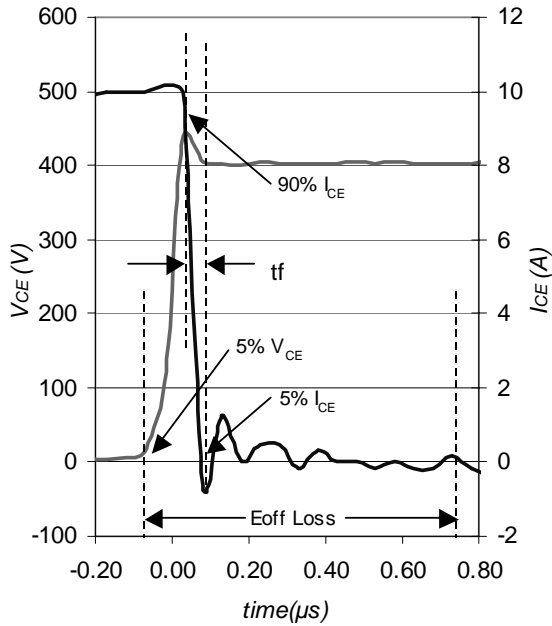


Fig. WF1- Typ. Turn-off Loss Waveform
 @ T_J = 150°C using Fig. CT.4

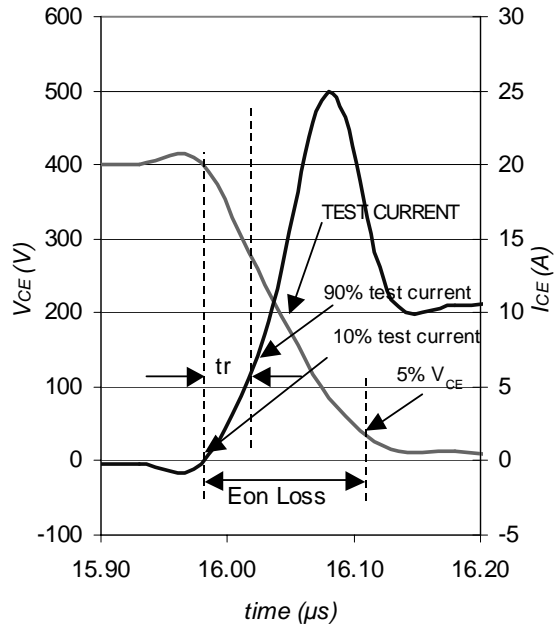


Fig. WF2- Typ. Turn-on Loss Waveform
 @ T_J = 150°C using Fig. CT.4

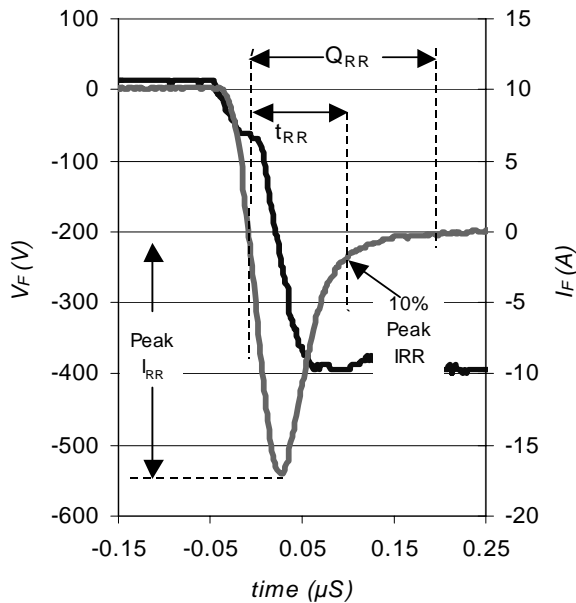


Fig. WF3- Typ. Diode Recovery Waveform
 @ T_J = 150°C using Fig. CT.4

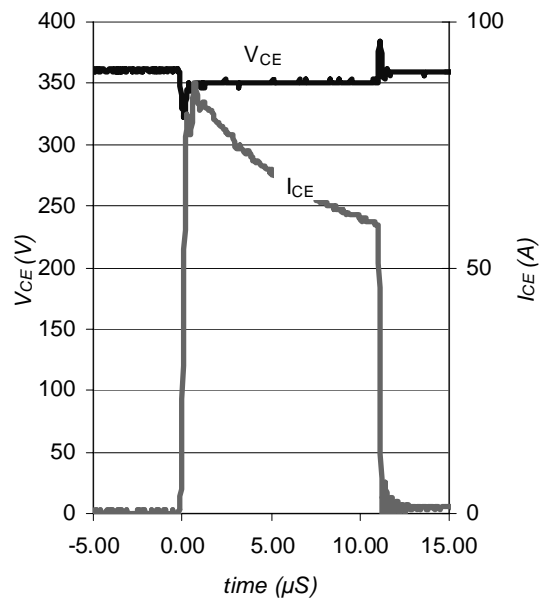


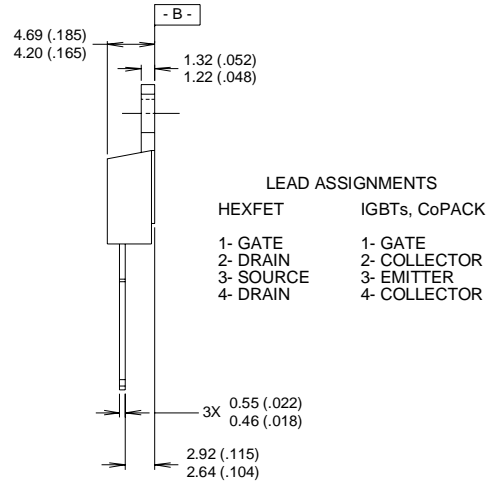
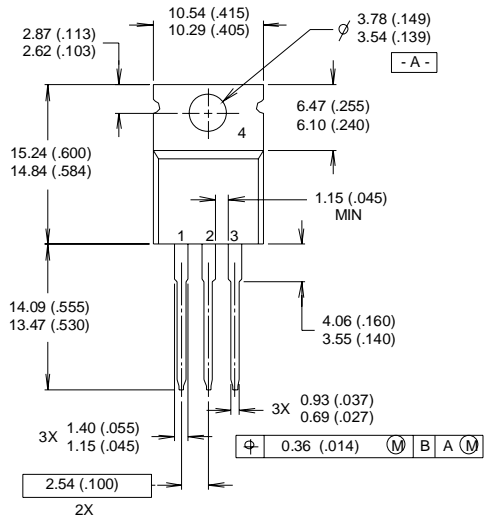
Fig. WF4- Typ. S.C Waveform
 @ T_J = 150°C using Fig. CT.3

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TO-220AB Package Outline

Dimensions are shown in millimeters (inches)



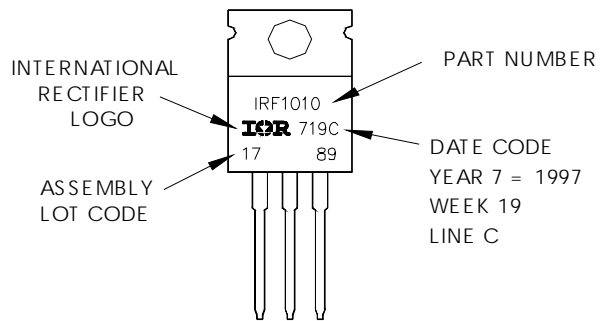
NOTES:

- 1 DIMENSIONING & TOLERANCING PER ANSI Y14.5M, 1982.
- 2 CONTROLLING DIMENSION : INCH

- 3 OUTLINE CONFORMS TO JEDEC OUTLINE TO-220AB.
- 4 HEATSINK & LEAD MEASUREMENTS DO NOT INCLUDE BURRS.

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"

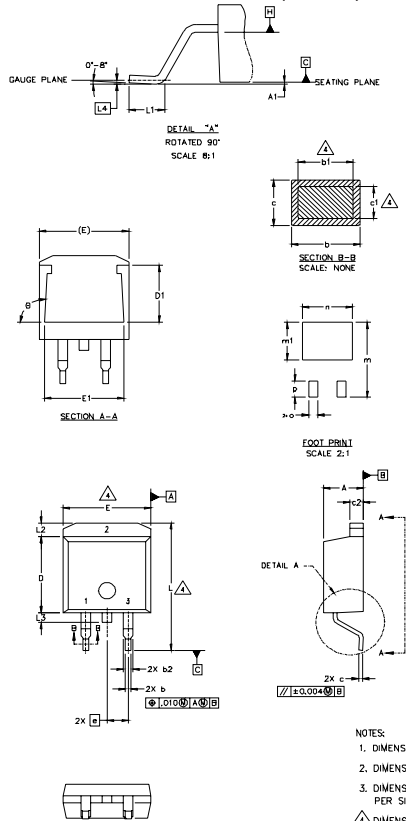


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IR Rectifier

IRG/B/S/SL10B60KD

D²Pak Package Outline

Dimensions are shown in millimeters (inches)



SYMBOL	DIMENSIONS				NOTES
	MILLIMETERS		INCHES		
	MIN.	MAX.	MIN.	MAX.	
A	4.06	4.83	.160	.190	4
A1		0.127		.005	
b	0.51	0.99	.020	.039	
b1	0.51	0.89	.020	.035	
b2	1.14	1.40	.045	.055	
c	0.43	0.63	.017	.025	
c1	0.38	0.74	.015	.029	
c2	1.14	1.40	.045	.055	
D	8.51	9.65	.335	.380	
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

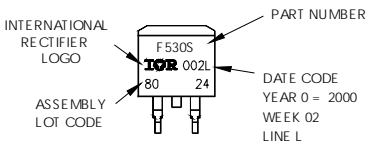
* PART DEPENDENT.

- 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.

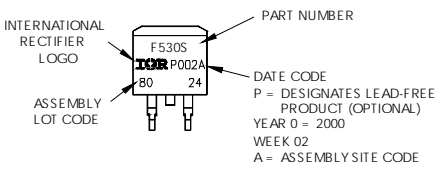
D²Pak Part Marking Information

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

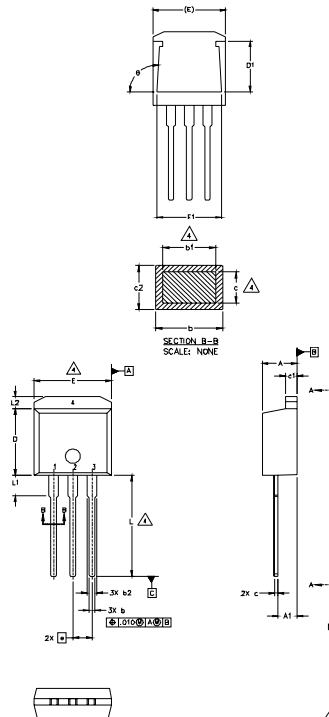


IRG/B/S/SL10B60KD



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	4
b1	0.51	0.89	.020	.035	
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

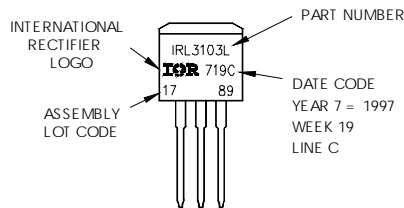
HEXFET	IGBT
1. - GATE	1 - GATE
2. - DRAIN	2 - COLLECTOR
3. - SOURCE	3 - EMITTER
4. - DRAIN	

- 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.

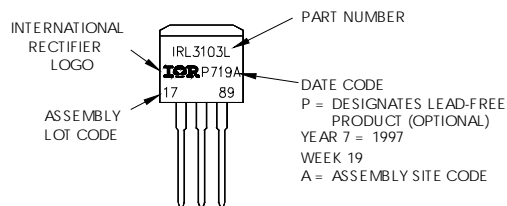
TO-262 Part Marking Information

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"

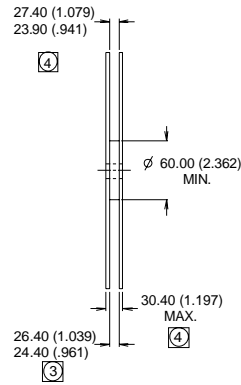
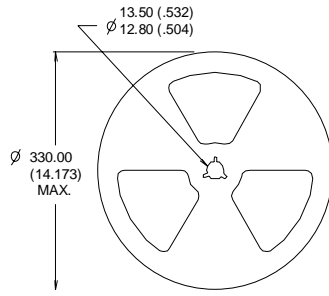
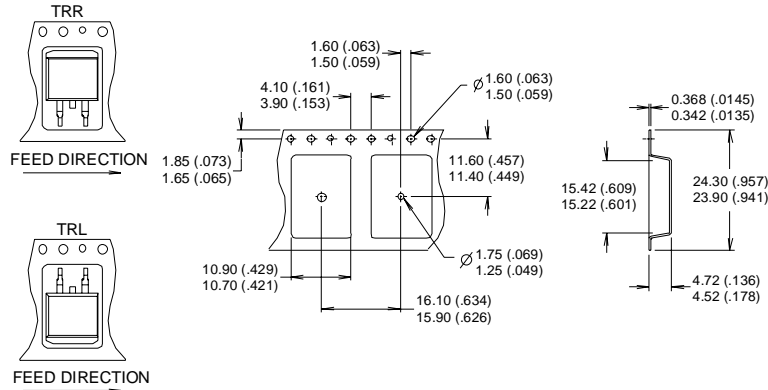


OR



D²Pak Tape & Reel Information

Dimensions are shown in millimeters (inches)



- NOTES:
1. CONFORMS 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 D²Pak, 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 $V_{CC} = 80\% (V_{CES})$, $V_{GE} = 20V$, $L = 100\mu H$, $R_G = 47\Omega$.

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.