IRGP6650DPbF
IRGP6650D-EPbF

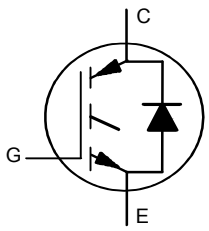
Insulated Gate Bipolar Transistor with Ultrafast Soft Recovery Diode

V_{CES} = 600V

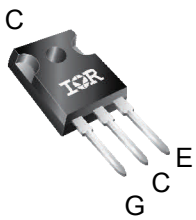
I_C = 50A, T_C =100°C

$t_{SC} \geq$ 5µs, $T_{J(max)}$ = 175°C

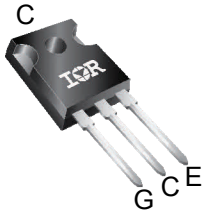
$V_{CE(ON)}$ typ. = 1.65V @ I_C = 35A



n-channel



IRGP6650DPbF
TO-247AC



IRGP6650D-EPbF
TO-247AD

Applications

- Welding
- H Bridge Converters

G	C	E
Gate	Collector	Emitter

Features	→	Benefits
Low $V_{CE(ON)}$ and Switching Losses		High Efficiency in a Wide Range of Applications
Optimized Diode for Full Bridge Hard Switch Converters		Optimized for Welding and H Bridge Converters
Square RBSOA and Maximum Temperature of 175°C		Improved Reliability due to Rugged Hard Switching Performance and High Power Capability
5µs Short Circuit		Enables Short Circuit Protection Operation
Positive $V_{CE\ (ON)}$ Temperature Co-efficient		Excellent Current Sharing in Parallel Operation
Lead-free, RoHS compliant		Environmentally friendly

Base part number	Package Type	Standard Pack		Orderable Part Number
		Form	Quantity	
IRGP6650DPbF	TO-247AC	Tube	25	IRGP6650DPbF
IRGP6650D-EPbF	TO-247AD	Tube	25	IRGP6650D-EPbF

Absolute Maximum Ratings

	Parameter	Max.	Units
V_{CES}	Collector-to-Emitter Voltage	600	V
I_C @ T_C = 25°C	Continuous Collector Current	80	A
I_C @ T_C = 100°C	Continuous Collector Current	50	
I_{CM}	Pulse Collector Current, V_{GE} = 15V	105	
I_{LM}	Clamped Inductive Load Current, V_{GE} = 20V ①	140	
I_{FRM} @ T_C = 100°C	Diode Repetitive Peak Forward Current④⑥	25	
I_{FM}	Diode Maximum Forward Current ④	140	
V_{GE}	Continuous Gate-to-Emitter Voltage	±20	V
P_D @ T_C = 25°C	Maximum Power Dissipation	306	W
P_D @ T_C = 100°C	Maximum Power Dissipation	153	
T_J T_{STG}	Operating Junction and Storage Temperature Range	-40 to +175	°C
	Soldering Temperature, for 10 sec.	300 (0.063 in. (1.6mm) from case)	
	Mounting Torque, 6-32 or M3 Screw	10 lbf·in (1.1 N·m)	

Thermal Resistance

	Parameter	Min.	Typ.	Max.	Units
$R_{\theta JC}$ (IGBT)	Thermal Resistance Junction-to-Case-(each IGBT) ②	—	—	0.49	°C/W
$R_{\theta JC}$ (Diode)	Thermal Resistance Junction-to-Case-(each Diode) ②	—	—	3.35	
$R_{\theta CS}$	Thermal Resistance, Case-to-Sink (flat, greased surface)	—	0.24	—	
$R_{\theta JA}$	Thermal Resistance, Junction-to-Ambient (typical socket mount)	—	—	40	

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Electrical Characteristics @ T_J = 25°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 = 100µA ③
$\Delta V_{(BR)CES}/\Delta T_J$	Temperature Coeff. of Breakdown Voltage	—	0.45	—	V/°C	V_{GE} = 0V, I_C = 1.0mA (25°C-175°C)
$V_{CE(on)}$	Collector-to-Emitter Saturation Voltage	—	1.65	1.95	V	I_C = 35A, V_{GE} = 15V, T_J = 25°C
		—	2.05	—		I_C = 35A, V_{GE} = 15V, T_J = 150°C
		—	2.10	—		I_C = 35A, V_{GE} = 15V, T_J = 175°C
$V_{GE(th)}$	Gate Threshold Voltage	4.0	—	6.5	V	V_{CE} = V_{GE}, I_C = 1.0mA
$\Delta V_{GE(th)}/\Delta T_J$	Threshold Voltage Temperature Coeff.	—	-18	—	mV/°C	V_{CE} = V_{GE}, I_C = 1.0mA (25°C-175°C)
gfe	Forward Transconductance	—	22	—	S	V_{CE} = 50V, I_C = 35A, PW = 20µs
I_{CES}	Collector-to-Emitter Leakage Current	—	1.0	50	µA	V_{GE} = 0V, V_{CE} = 600V
		—	600	—		V_{GE} = 0V, V_{CE} = 600V, T_J = 175°C
I_{GES}	Gate-to-Emitter Leakage Current	—	—	±100	nA	V_{GE} = ±20V
V_F	Diode Forward Voltage Drop	—	1.80	2.80	V	I_F = 8A
		—	1.30	—		I_F = 8A, T_J = 175°C

Switching Characteristics @ T_J = 25°C (unless otherwise specified)

	Parameter	Min.	Typ.	Max	Units	Conditions
Q_g	Total Gate Charge (turn-on)	—	75	—	nC	I_C = 35A
Q_{ge}	Gate-to-Emitter Charge (turn-on)	—	20	—		V_{GE} = 15V
Q_{gc}	Gate-to-Collector Charge (turn-on)	—	30	—		V_{CC} = 400V
E_{on}	Turn-On Switching Loss	—	300	—	µJ	I_C = 35A, V_{CC} = 400V, V_{GE}=15V R_G = 10Ω, L=210µH, T_J = 25°C Energy losses include tail & diode reverse recovery ⑤
E_{off}	Turn-Off Switching Loss	—	630	—		
E_{total}	Total Switching Loss	—	930	—		
$t_{d(on)}$	Turn-On delay time	—	40	—	ns	
t_r	Rise time	—	30	—		
$t_{d(off)}$	Turn-Off delay time	—	105	—		
t_f	Fall time	—	20	—		
E_{on}	Turn-On Switching Loss	—	640	—	µJ	I_C = 35A, V_{CC} = 400V, V_{GE}=15V R_G = 10Ω, L=210µH, T_J = 175°C Energy losses include tail & diode reverse recovery ⑤
E_{off}	Turn-Off Switching Loss	—	930	—		
E_{total}	Total Switching Loss	—	1570	—		
$t_{d(on)}$	Turn-On delay time	—	40	—	ns	
t_r	Rise time	—	30	—		
$t_{d(off)}$	Turn-Off delay time	—	120	—		
t_f	Fall time	—	60	—		
C_{ies}	Input Capacitance	—	2220	—	pF	V_{GE} = 0V
C_{oes}	Output Capacitance	—	130	—		V_{CC} = 30V
C_{res}	Reverse Transfer Capacitance	—	65	—		f = 1.0MHz
RBSOA	Reverse Bias Safe Operating Area	FULL SQUARE				T_J = 175°C, I_C = 140A V_{CC} = 480V, Vp ≤ 600V V_{GE} = +20V to 0V
SCSOA	Short Circuit Safe Operating Area	5	—	—	µs	T_J = 150°C,V_{CC} = 400V, Vp ≤ 600V V_{GE} = +15V to 0V
Erec	Reverse Recovery Energy of the Diode	—	165	—	µJ	T_J = 175°C
t_{rr}	Diode Reverse Recovery Time	—	50	—	ns	V_{CC} = 400V, I_F = 8A, V_{GE} = 15V
I_{rr}	Peak Reverse Recovery Current	—	14	—	A	Rg = 22Ω, L=1.0mH, Ls=150nH

Notes:

① V_{CC} = 80% (V_{CES}), V_{GE} = 20V, Rg = 10Ω, L=210µH.

② R_θ is measured at T_J of approximately 90°C.

③ Refer to AN-1086 for guidelines for measuring $V_{(BR)CES}$ safely.

④ Pulse width limited by max. junction temperature.

⑤ Values influenced by parasitic L and C in measurement.

⑥ fsw =40KHz, refer to figure 26.

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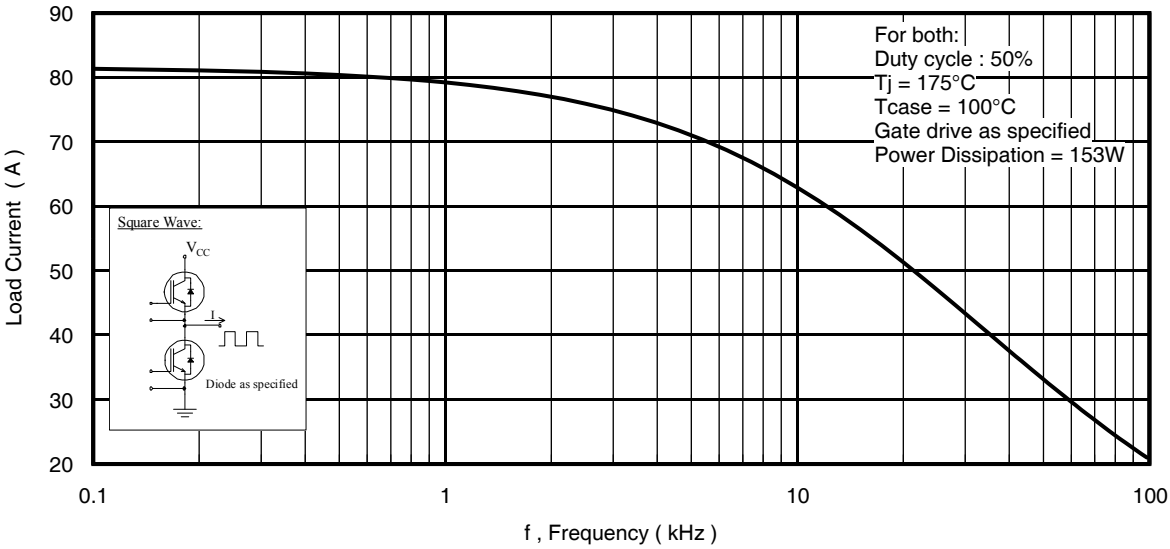


Fig. 1 - Typical Load Current vs. Frequency
(Load Current = I_{RMS} of fundamental)

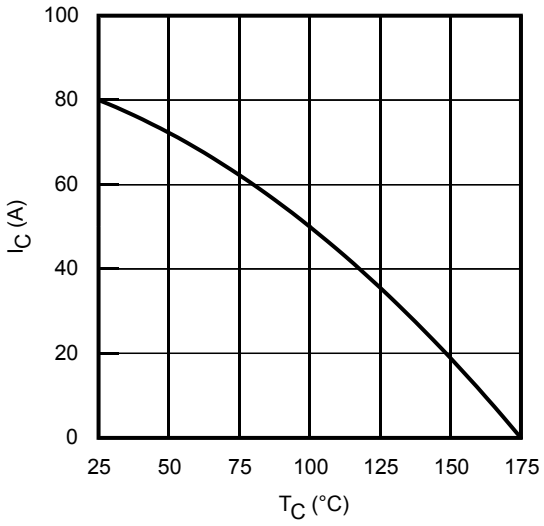


Fig. 2 - Maximum DC Collector Current vs. Case Temperature

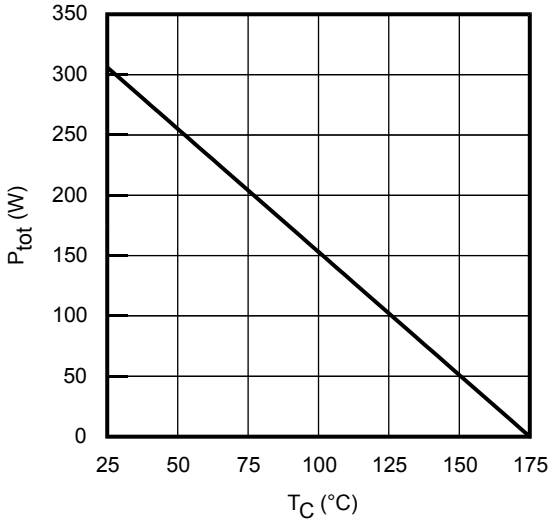


Fig. 3 - Power Dissipation vs. Case Temperature

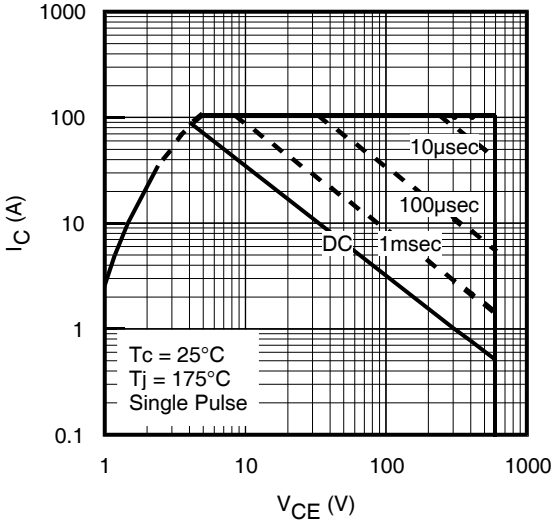


Fig. 4 - Forward SOA
T_C = 25°C; T_J ≤ 175°C; V_{GE} = 15V

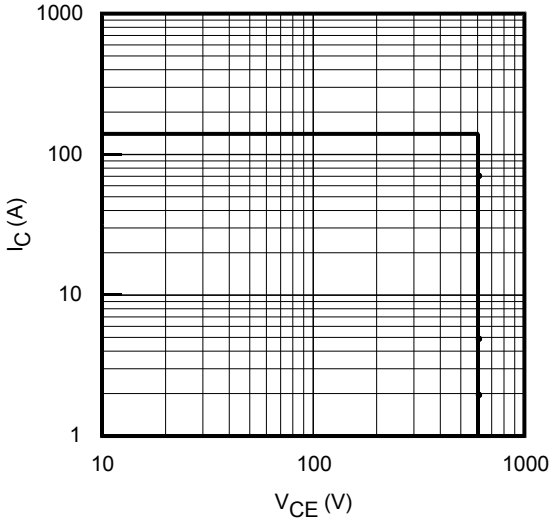


Fig. 5 - Reverse Bias SOA
T_J = 175°C; V_{GE} = 20V

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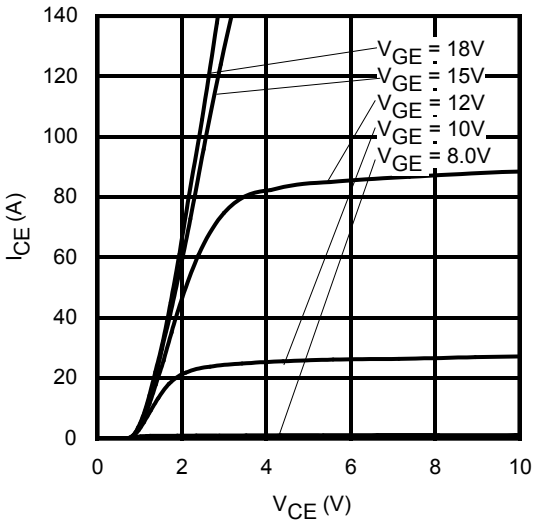


Fig. 6 - Typ. IGBT Output Characteristics
T_J = -40°C; tp = 20µs

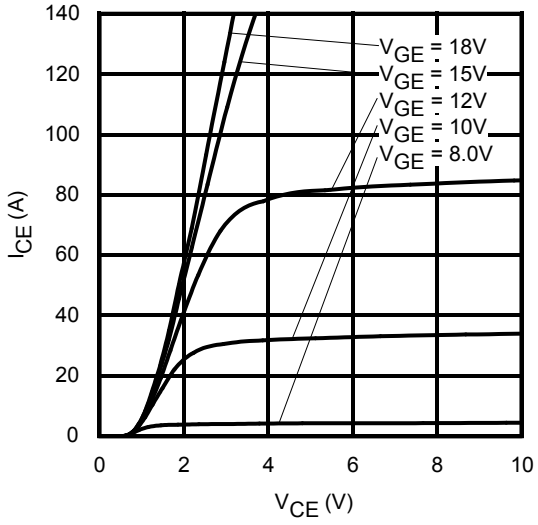


Fig. 7 - Typ. IGBT Output Characteristics
T_J = 25°C; tp = 20µs

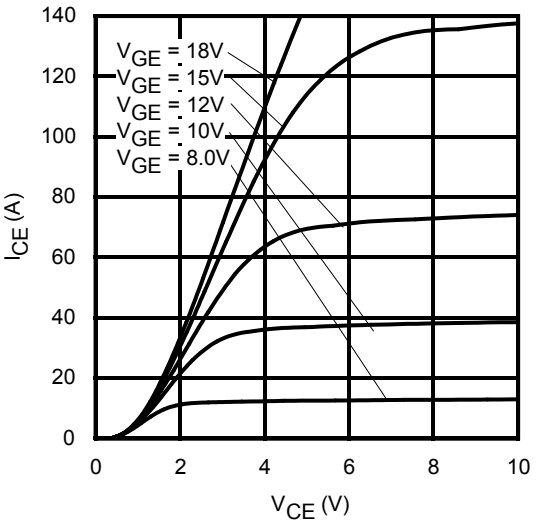


Fig. 8 - Typ. IGBT Output Characteristics
T_J = 175°C; tp = 20µs

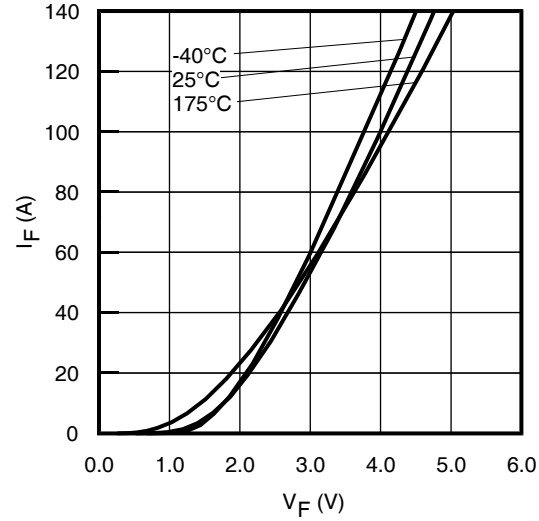


Fig. 9 - Typ. Diode Forward Voltage Drop Characteristics

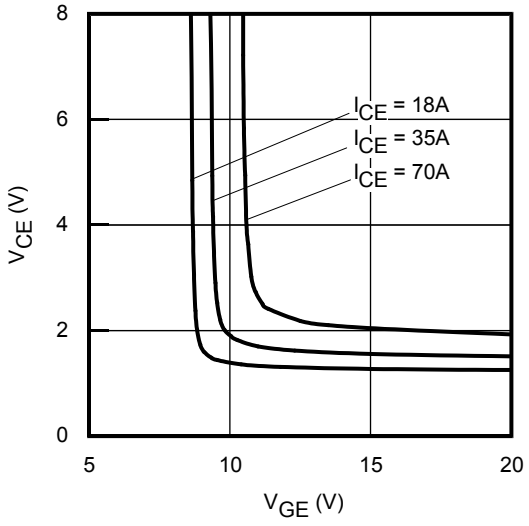


Fig. 10 - Typical V_{CE} vs. V_{GE}
T_J = -40°C

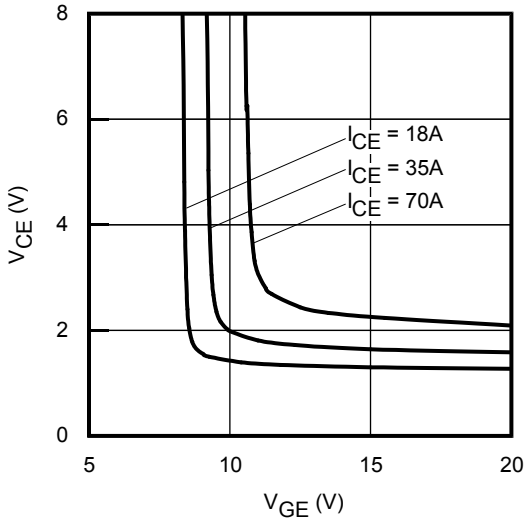


Fig. 11 - Typical V_{CE} vs. V_{GE}
T_J = 25°C

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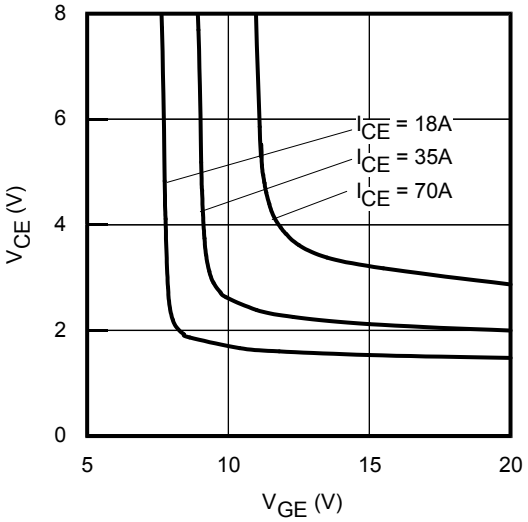


Fig. 12 - Typical V_{CE} vs. V_{GE}
T_J = 175°C

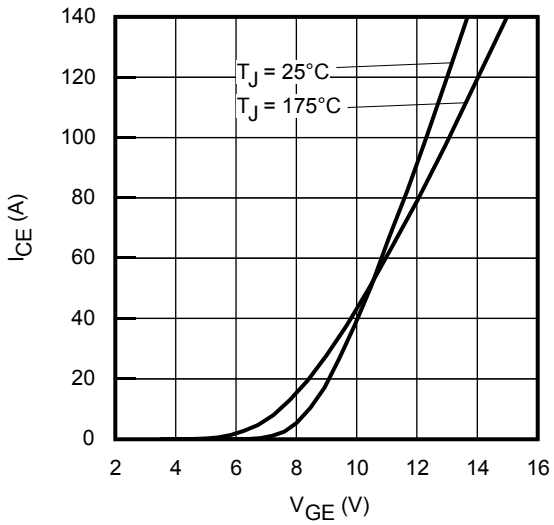


Fig. 13 - Typ. Transfer Characteristics
V_{CE} = 50V; tp = 20µs

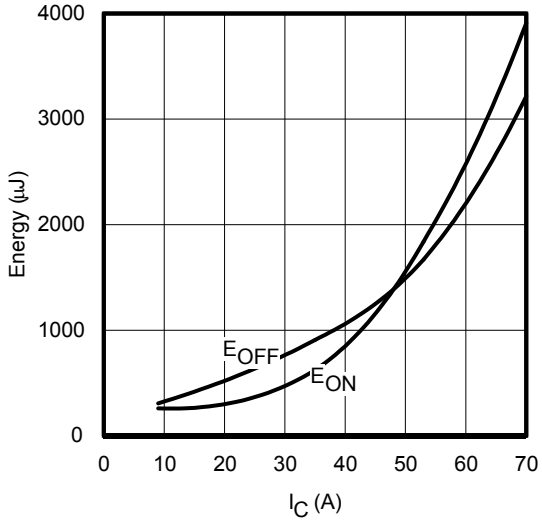


Fig. 14 - Typ. Energy Loss vs. I_C
T_J = 175°C; ; V_{CE} = 400V, R_G = 10Ω; V_{GE} = 15V

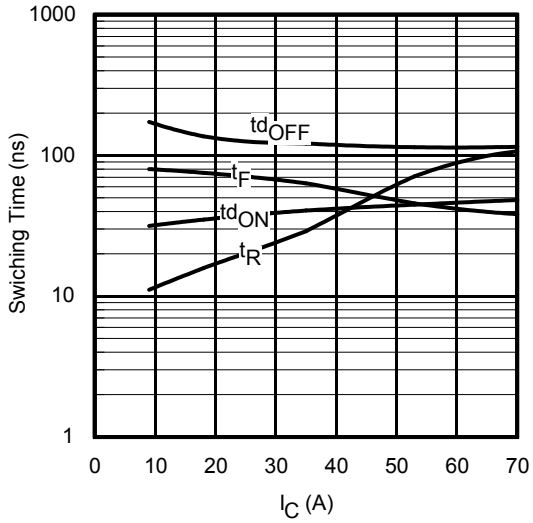


Fig. 15 - Typ. Switching Time vs. I_C
T_J = 175°C; V_{CE} = 400V, R_G = 10Ω; V_{GE} = 15V

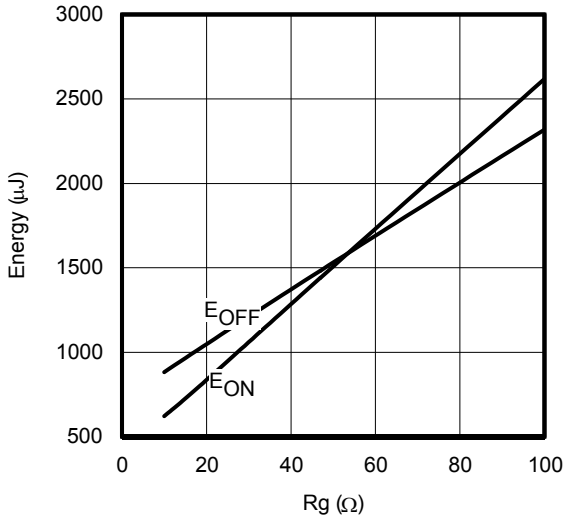


Fig. 16 - Typ. Energy Loss vs. R_G
T_J = 175°C; V_{CE} = 400V, I_{CE} = 35A; V_{GE} = 15V

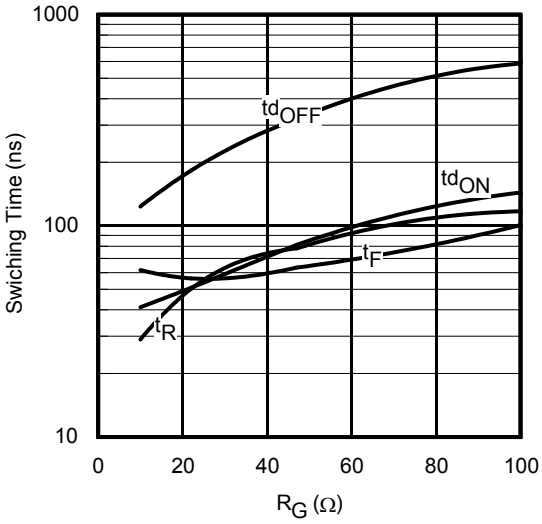


Fig. 17 - Typ. Switching Time vs. R_G
T_J = 175°C; V_{CE} = 400V, I_{CE} = 35A; V_{GE} = 15V

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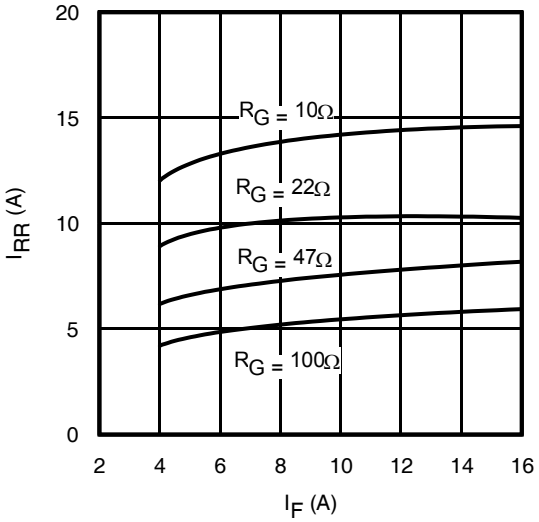


Fig. 18 - Typ. Diode I_{RR} vs. I_F
T_J = 175°C

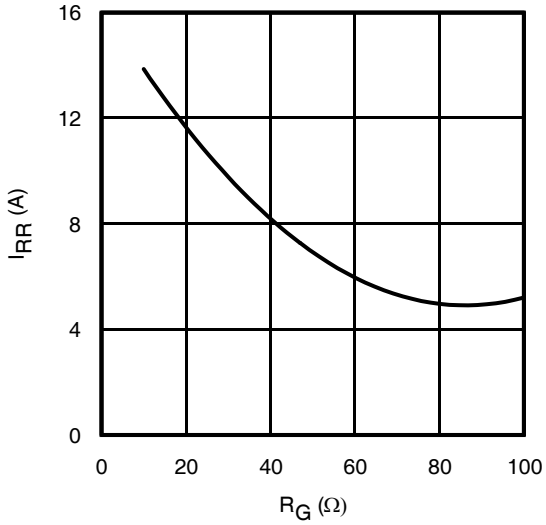


Fig. 19 - Typ. Diode I_{RR} vs. R_G
T_J = 175°C

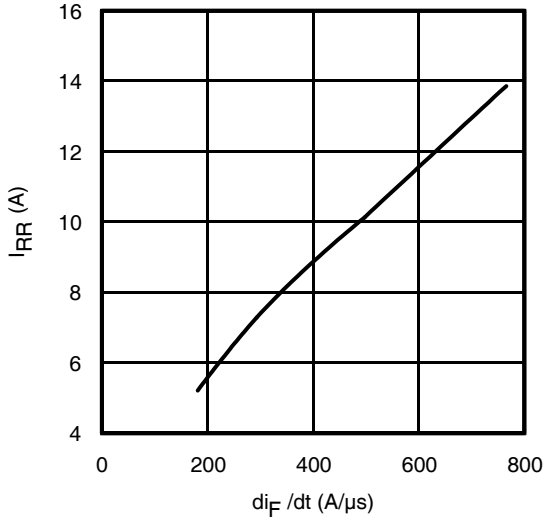


Fig. 20 - Typ. Diode I_{RR} vs. di_F/dt
V_{CC} = 400V; V_{GE} = 15V; I_F = 8A; T_J = 175°C

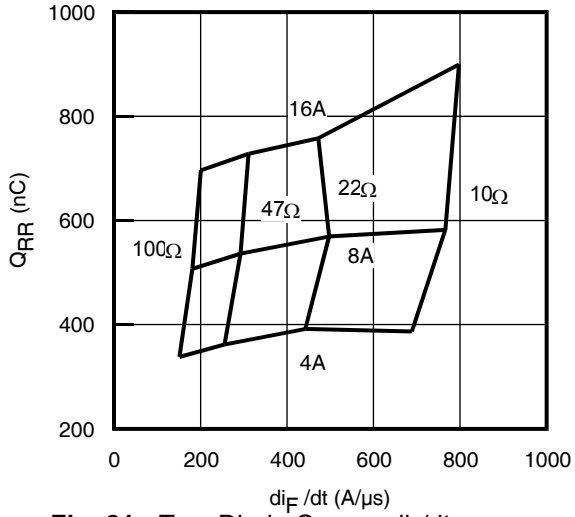


Fig. 21 - Typ. Diode Q_{RR} vs. di_F/dt
V_{CC} = 400V; V_{GE} = 15V; T_J = 175°C

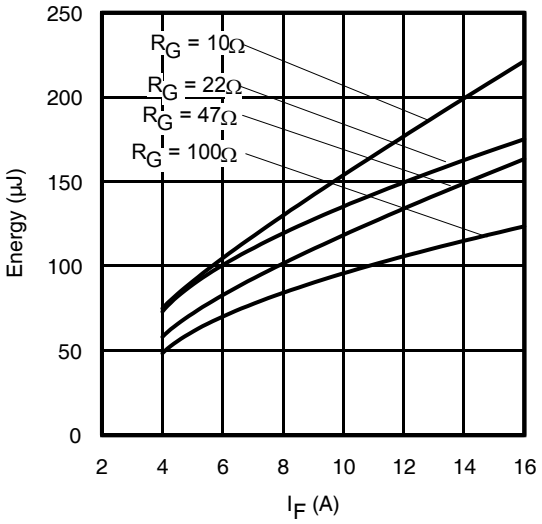


Fig. 22 - Typ. Diode E_{RR} vs. I_F
T_J = 175°C

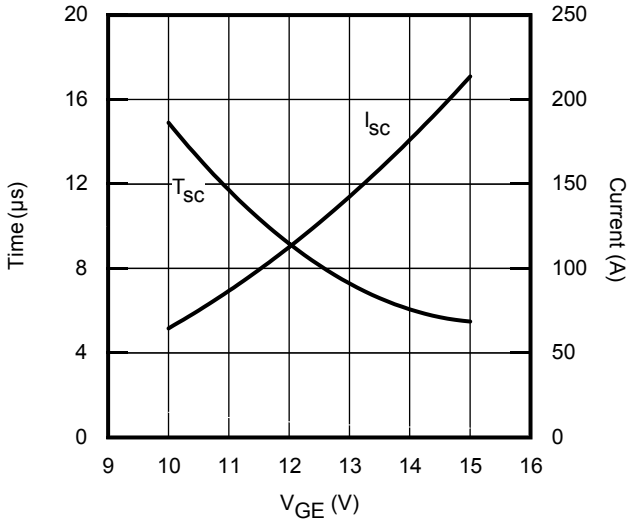


Fig. 23 - V_{GE} vs. Short Circuit Time
V_{CC} = 400V; T_C = 150°C

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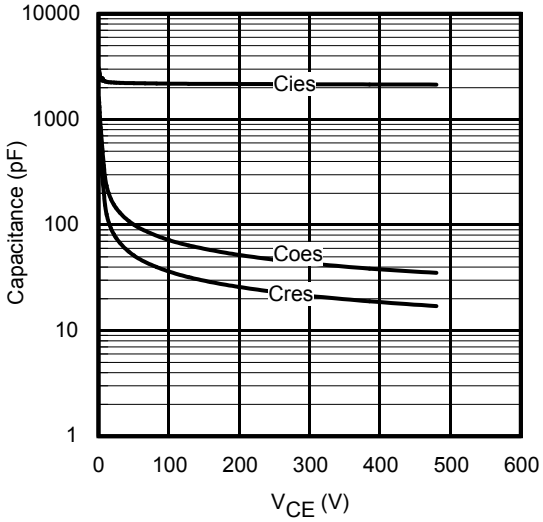


Fig. 24 - Typ. Capacitance vs. V_{CE}
V_{GE}= 0V; f = 1MHz

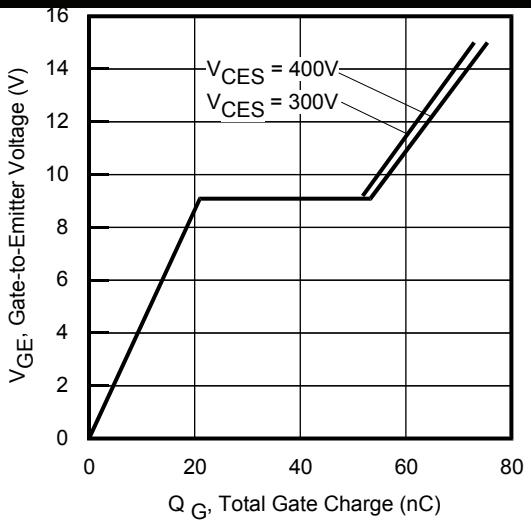


Fig. 25 - Typical Gate Charge vs. V_{GE}
I_{CE} = 35A

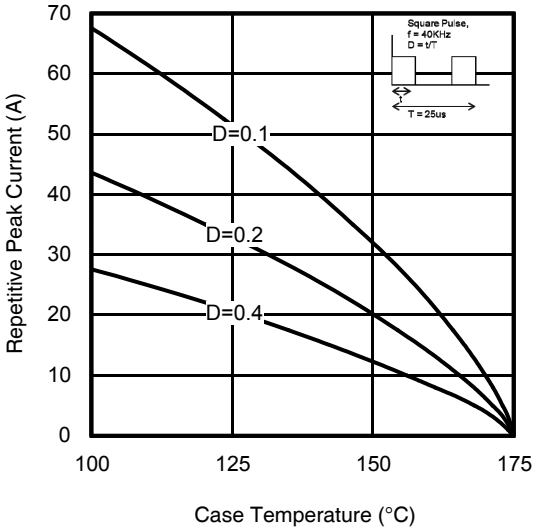


Fig 26. Maximum Diode Repetitive Forward Peak Current vs. Case Temperature

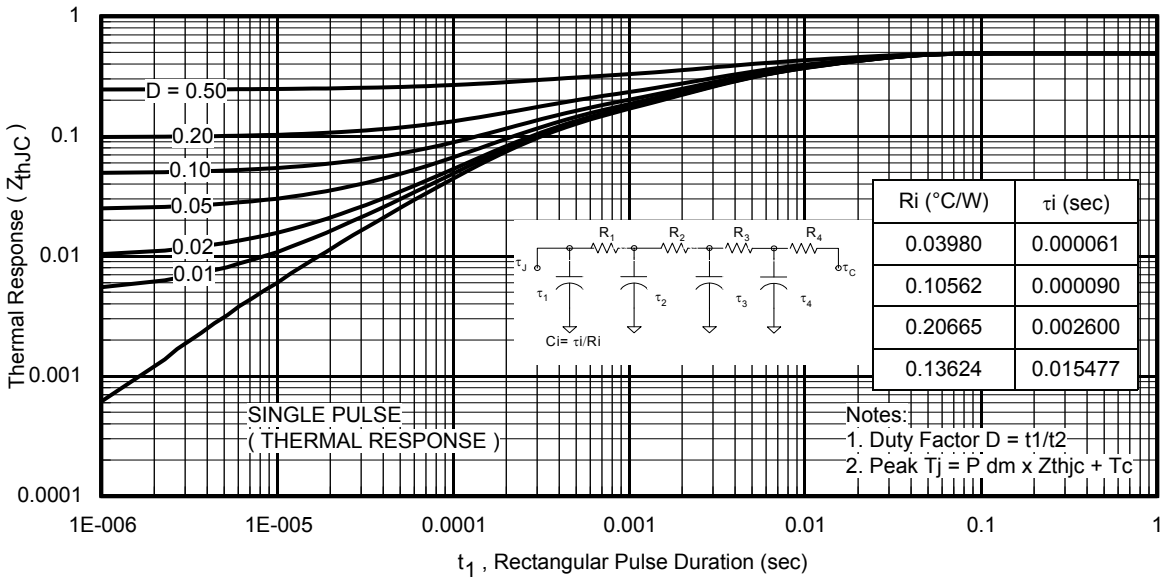


Fig. 27 - Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

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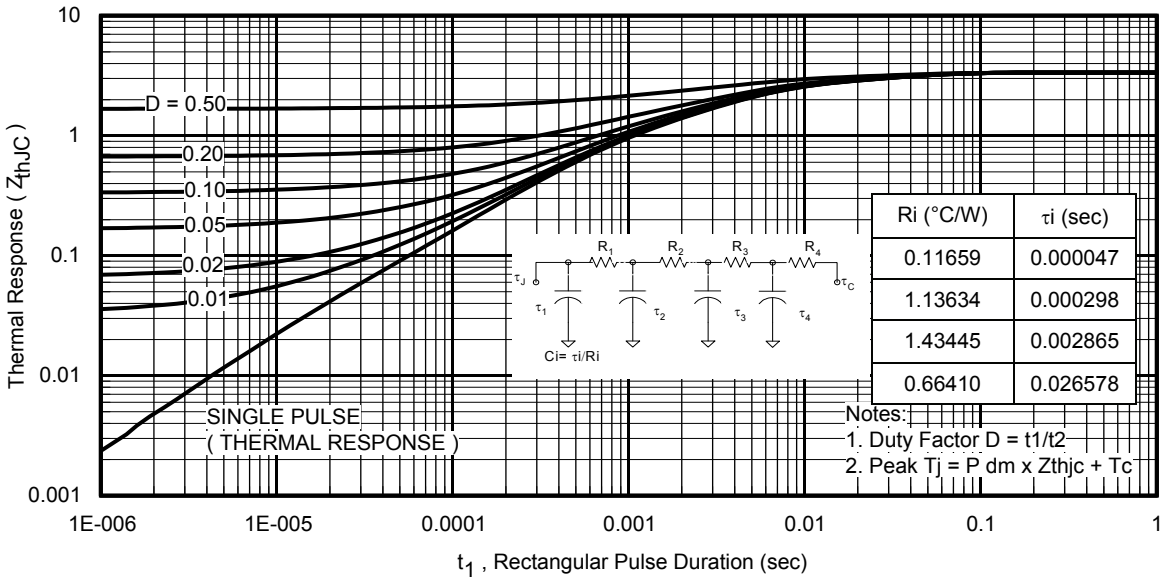


Fig. 28 - Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)

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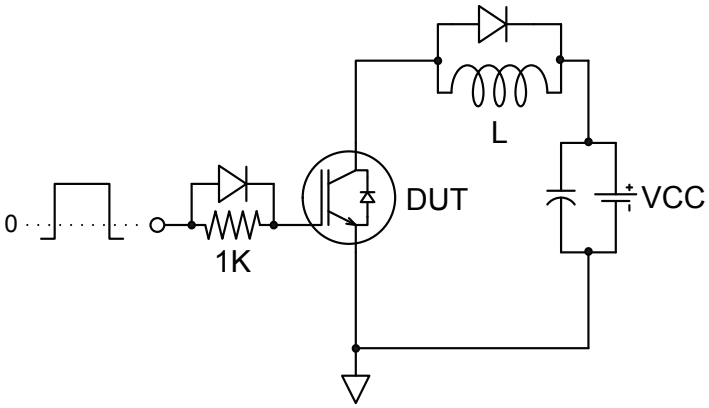


Fig.C.T.1 - Gate Charge Circuit (turn-off)

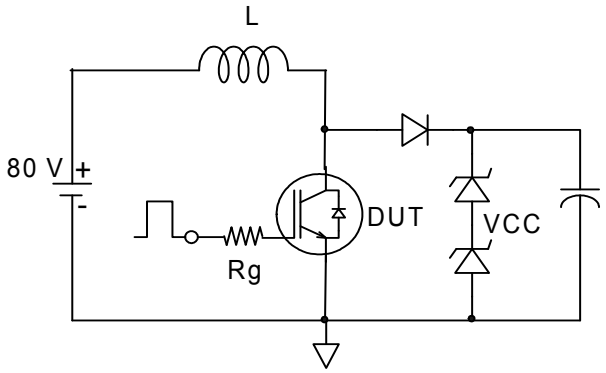


Fig.C.T.2 - RBSOA Circuit

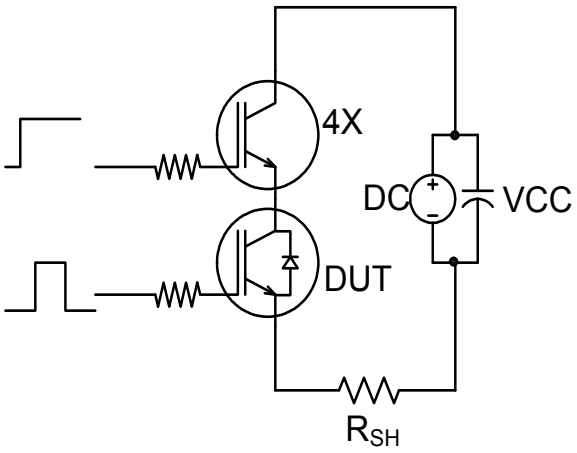


Fig.C.T.3 - S.C. SOA Circuit

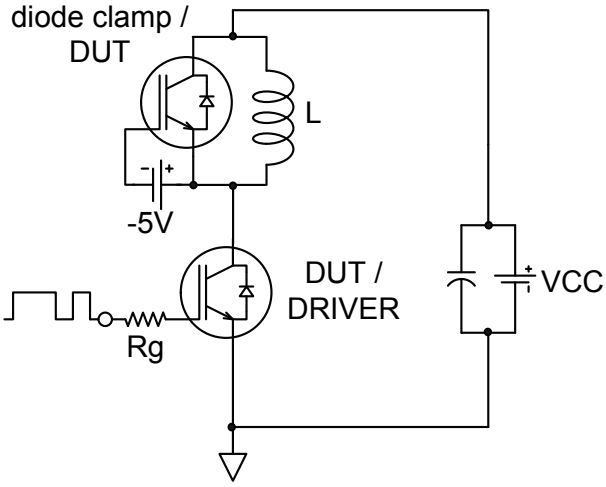


Fig.C.T.4 - Switching Loss Circuit

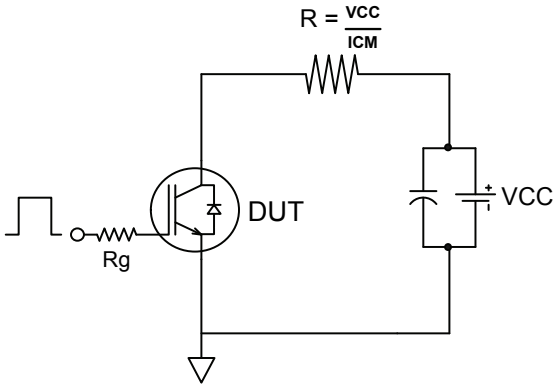


Fig.C.T.5 - Resistive Load Circuit

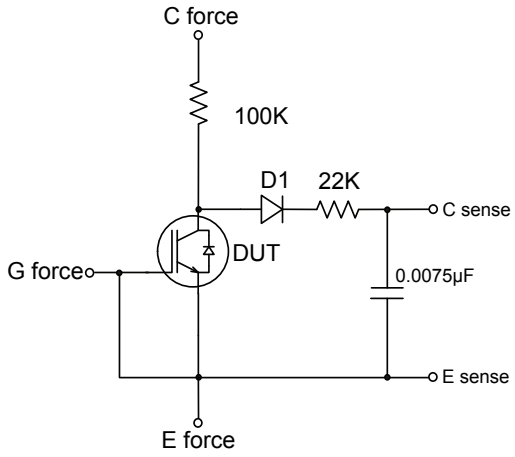


Fig.C.T.6 - BVCES Filter Circuit

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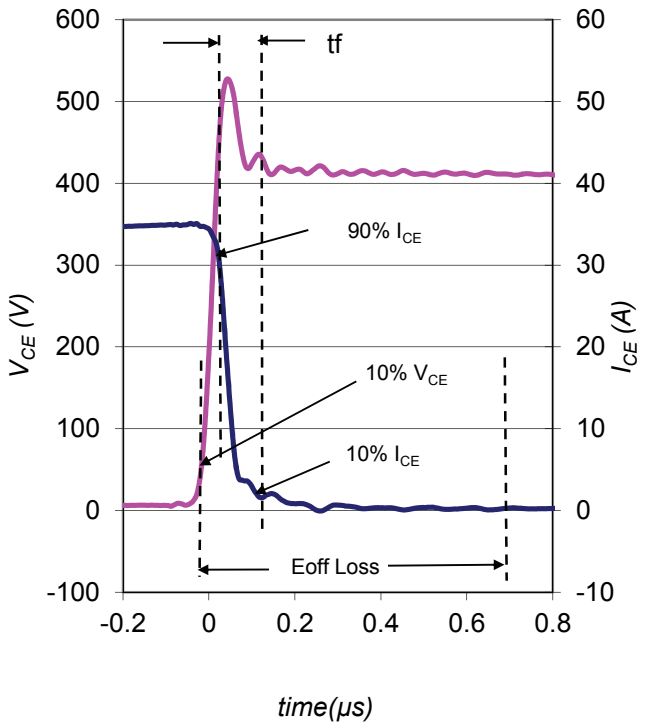


Fig. WF1 - Typ. Turn-off Loss Waveform
@ T_J = 175°C using Fig. CT.4

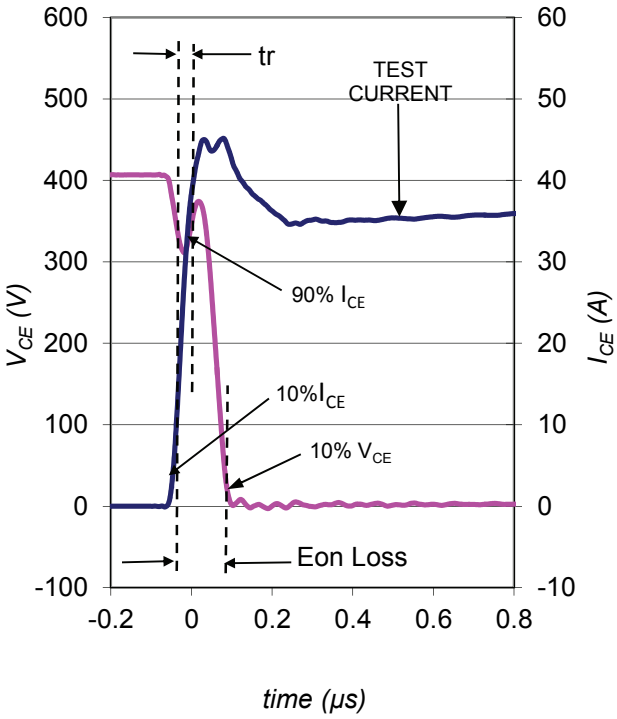


Fig. WF2 - Typ. Turn-on Loss Waveform
@ T_J = 175°C using Fig. CT.4

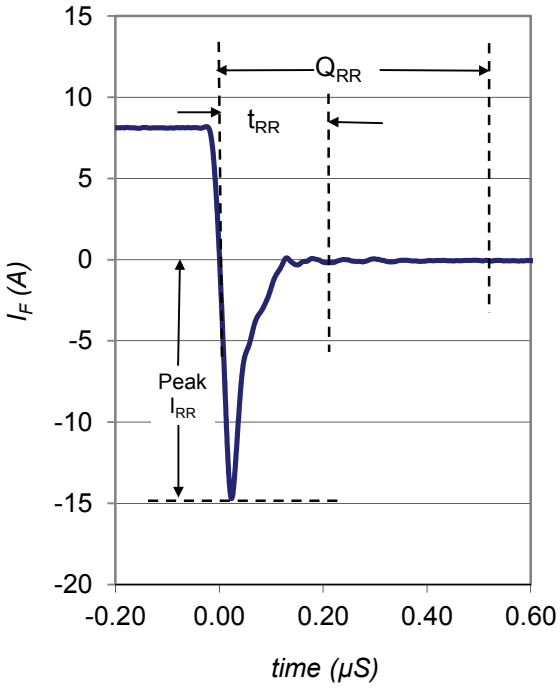


Fig. WF3 - Typ. Diode Recovery Waveform
@ T_J = 175°C using Fig. CT.4

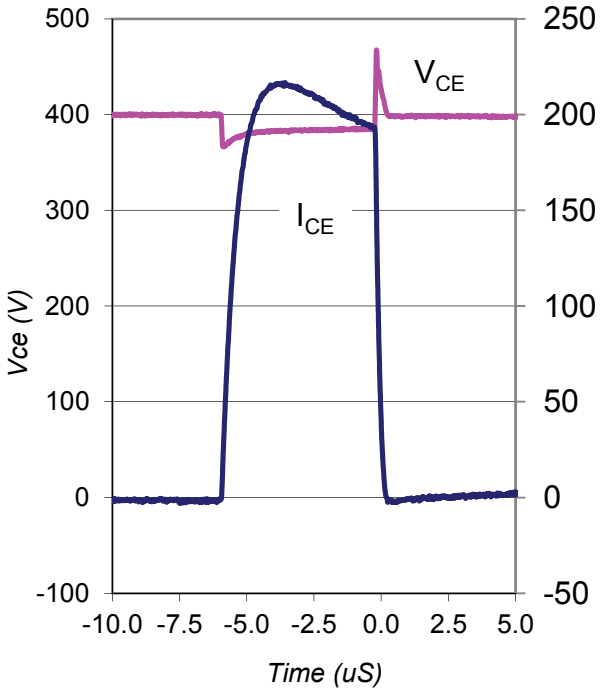
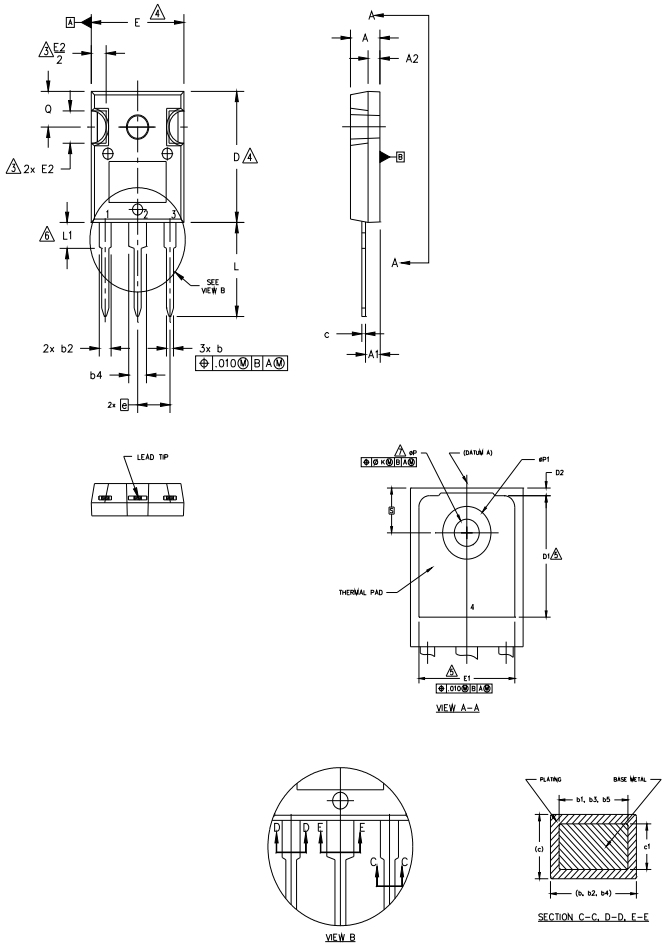


Fig. WF4 - Typ. S.C. Waveform
@ T_J = 150°C using Fig. CT.3

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TO-247AC Package Outline

Dimensions are shown in millimeters (inches)



NOTES:

1. DIMENSIONING AND TOLERANCING AS PER ASME Y14.5M 1994.
2. DIMENSIONS ARE SHOWN IN INCHES.
3. CONTOUR OF SLOT OPTIONAL.
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. THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSIONS D1 & E1.
6. LEAD FINISH UNCONTROLLED IN L1.
7. øP TO HAVE A MAXIMUM DRAFT ANGLE OF 1.5 ° TO THE TOP OF THE PART WITH A MAXIMUM HOLE DIAMETER OF .154 INCH.
8. OUTLINE CONFORMS TO JEDEC OUTLINE TO-247AC .

SYMBOL	DIMENSIONS				NOTES
	INCHES		MILLIMETERS		
	MIN.	MAX.	MIN.	MAX.	
A	.183	.209	4.65	5.31	
A1	.087	.102	2.21	2.59	
A2	.059	.098	1.50	2.49	
b	.039	.055	0.99	1.40	
b1	.039	.053	0.99	1.35	
b2	.065	.094	1.65	2.39	
b3	.065	.092	1.65	2.34	
b4	.102	.135	2.59	3.43	
b5	.102	.133	2.59	3.38	
c	.015	.035	0.38	0.89	
c1	.015	.033	0.38	0.84	
D	.776	.815	19.71	20.70	4
D1	.515	–	13.08	–	5
D2	.020	.053	0.51	1.35	
E	.602	.625	15.29	15.87	4
E1	.530	–	13.46	–	
E2	.178	.216	4.52	5.49	
e	.215 BSC		5.46 BSC		
øk	.010		0.25		
L	.559	.634	14.20	16.10	
L1	.146	.169	3.71	4.29	
øP	.140	.144	3.56	3.66	
øP1	–	.291	–	7.39	
Q	.209	.224	5.31	5.69	
S	.217 BSC		5.51 BSC		

LEAD ASSIGNMENTS

HEXFET

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

IGBTs, CoPACK

1.– GATE
2.– COLLECTOR
3.– EMITTER
4.– COLLECTOR

DIODES

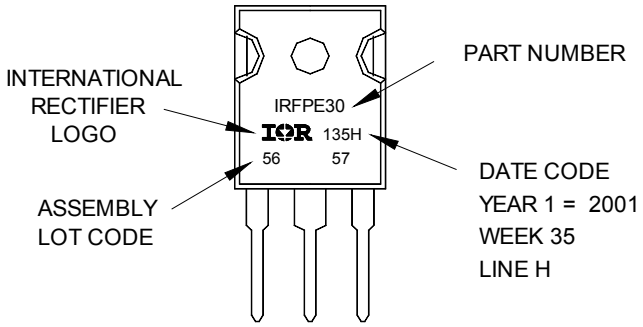
1.– ANODE/OPEN
2.– CATHODE
3.– ANODE

TO-247AC Part Marking Information

Notes: This part marking information applies to devices produced after 02/26/2001

EXAMPLE: THIS IS AN IRFPE30
WITH ASSEMBLY
LOT CODE 5657
ASSEMBLED ON WW 35, 2001
IN THE ASSEMBLY LINE "H"

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



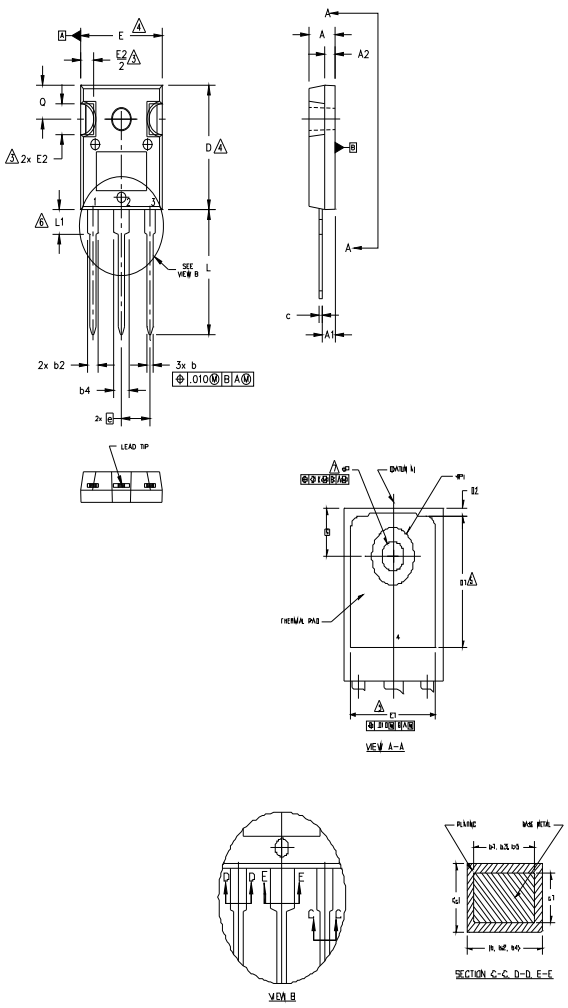
TO-247AC package is not recommended for Surface Mount Application.

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

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TO-247AD Package Outline

Dimensions are shown in millimeters (inches)



NOTES:

1. DIMENSIONING AND TOLERANCING AS PER ASME Y14.5M 1994.
2. DIMENSIONS ARE SHOWN IN INCHES.
3. CONTOUR OF SLOT OPTIONAL.
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. THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSIONS D1 & E1.
6. LEAD FINISH UNCONTROLLED IN L1.
7. øP TO HAVE A MAXIMUM DRAFT ANGLE OF 1.5 ° TO THE TOP OF THE PART WITH A MAXIMUM HOLE DIAMETER OF .154 INCH.
8. OUTLINE CONFORMS TO JEDEC OUTLINE TO-247AD.

SYMBOL	DIMENSIONS				NOTES
	INCHES		MILLIMETERS		
	MIN.	MAX.	MIN.	MAX.	
A	.183	.209	4.65	5.31	
A1	.087	.102	2.21	2.59	
A2	.059	.098	1.50	2.49	
b	.039	.055	0.99	1.40	
b1	.039	.053	0.99	1.35	
b2	.065	.094	1.65	2.39	
b3	.065	.092	1.65	2.34	
b4	.102	.135	2.59	3.43	
b5	.102	.133	2.59	3.38	
c	.015	.035	0.38	0.89	
c1	.015	.033	0.38	0.84	
D	.776	.815	19.71	20.70	4
D1	.515	–	13.08	–	5
D2	.020	.053	0.51	1.35	
E	.602	.625	15.29	15.87	4
E1	.530	–	13.46	–	
E2	.178	.216	4.52	5.49	
e	.215 BSC		5.46 BSC		
øk	.010		0.25		
L	.780	.827	19.57	21.00	
L1	.146	.169	3.71	4.29	
øP	.140	.144	3.56	3.66	
øP1	–	.291	–	7.39	
Q	.209	.224	5.31	5.69	
S	.217 BSC		5.51 BSC		

LEAD ASSIGNMENTS

HEXFET

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

IGBTs, CoPACK

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

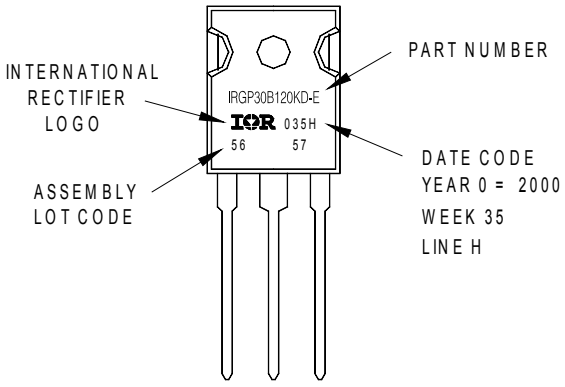
DIODES

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

TO-247AD Part Marking Information

EXAMPLE: THIS IS AN IRGP30B120KD-E
WITH ASSEMBLY
LOT CODE 5657
ASSEMBLED ON WW 35, 2000
IN THE ASSEMBLY LINE "H"

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



TO-247AD package is not recommended for Surface Mount Application.

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

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Qualification Information†

Qualification Level	Industrial (per JEDEC JESD47F)††	
Moisture Sensitivity Level	TO-247AC	N/A
	TO-247AD	
RoHS Compliant	Yes	

† Qualification standards can be found at International Rectifier's web site: http://www.irf.com/product-info/reliability/

†† Applicable version of JEDEC standard at the time of product release.

Revision History

Date	Comments
11/14/2014	• Added I_{FM} Diode Maximum Forward Current = 140A with the note ④ on page 1. • Removed note ④ from switching losses test condition on page 2.

International
IOR Rectifier
IR WORLD HEADQUARTERS: 101 N. Sepulveda Blvd., El Segundo, California 90245, USA
To contact International Rectifier, please visit http://www.irf.com/whoto-call/

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