

Insulated Gate Bipolar Transistor with Ultrafast Soft Recovery Diode

$$V_{CES} = 600V$$

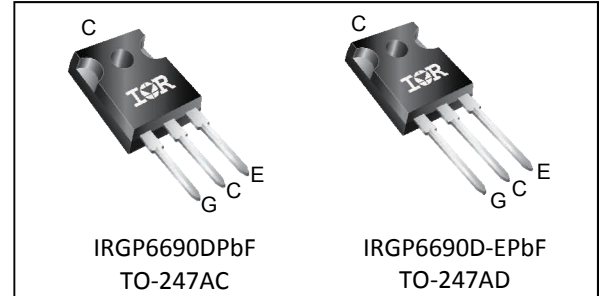
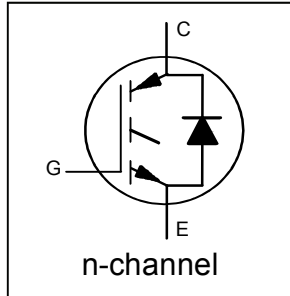
$$I_C = 90A, T_C = 100^\circ C$$

$$t_{SC} \geq 5\mu s, T_{J(max)} = 175^\circ C$$

$$V_{CE(ON)} \text{ typ.} = 1.65V @ I_C = 75A$$

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 junction temperature $175^\circ C$	Improved reliability due to rugged hard switching performance and higher power capability
$5\mu s$ short circuit SOA	Enables short circuit protection scheme
Positive $V_{CE(ON)}$ temperature coefficient	Excellent current sharing in parallel operation
Lead-free, RoHS compliant	Environmentally friendly

Base part number	Package Type	Standard Pack		Orderable Part Number
		Form	Quantity	
IRGP6690DPBF	TO-247AC	Tube	25	IRGP6690DPBF
IRGP6690D-EPBF	TO-247AD	Tube	25	IRGP6690D-EPBF

Absolute Maximum Ratings

	Parameter	Max.	Units
V_{CES}	Collector-to-Emitter Voltage	600	V
$I_C @ T_C = 25^\circ C$	Continuous Collector Current	140	A
$I_C @ T_C = 100^\circ C$	Continuous Collector Current	90	
I_{CM}	Pulse Collector Current, $V_{GE} = 15V$	225	
I_{LM}	Clamped Inductive Load Current, $V_{GE} = 20V$ ①	300	
$I_{FRM} @ T_C = 100^\circ C$	Diode Repetitive Peak Forward Current ④⑥	45	
I_{FM}	Diode Maximum Forward Current ④	300	V
V_{GE}	Continuous Gate-to-Emitter Voltage	± 20	
$P_D @ T_C = 25^\circ C$	Maximum Power Dissipation	483	W
$P_D @ T_C = 100^\circ C$	Maximum Power Dissipation	241	
T_J	Operating Junction and Storage Temperature Range	-40 to +175	C
T_{STG}	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	—	—	0.31	$^\circ C/W$
$R_{\theta JC}$ (Diode)	Thermal Resistance Junction-to-Case-(each Diode) ②	—	—	2.10	
$R_{\theta CS}$	Thermal Resistance, Case-to-Sink (flat, greased surface)	—	0.24	—	
$R_{\theta JA}$	Thermal Resistance, Junction-to-Ambient (typical socket mount)	—	—	40	

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

	Parameter	Min.	Typ.	Max.	Units	Conditions
$V_{(BR)CES}$	Collector-to-Emitter Breakdown Voltage	600	—	—	V	$V_{GE} = 0\text{V}$, $I_C = 100\mu\text{A}$ ③
$\Delta V_{(BR)CES}/\Delta T_J$	Temperature Coeff. of Breakdown Voltage	—	0.55	—	V/ $^\circ\text{C}$	$V_{GE} = 0\text{V}$, $I_C = 3\text{mA}$ (25°C - 175°C)
$V_{CE(on)}$	Collector-to-Emitter Saturation Voltage	—	1.65	1.95	V	$I_C = 75\text{A}$, $V_{GE} = 15\text{V}$, $T_J = 25^\circ\text{C}$
		—	2.05	—		$I_C = 75\text{A}$, $V_{GE} = 15\text{V}$, $T_J = 150^\circ\text{C}$
		—	2.10	—		$I_C = 75\text{A}$, $V_{GE} = 15\text{V}$, $T_J = 175^\circ\text{C}$
$V_{GE(th)}$	Gate Threshold Voltage	4.0	—	6.5	V	$V_{CE} = V_{GE}$, $I_C = 2.1\text{mA}$
$\Delta V_{GE(th)}/\Delta T_J$	Threshold Voltage Temperature Coeff.	—	-19	—	mV/ $^\circ\text{C}$	$V_{CE} = V_{GE}$, $I_C = 2.1\text{mA}$ (25°C - 175°C)
g_{fe}	Forward Transconductance	—	50	—	S	$V_{CE} = 50\text{V}$, $I_C = 75\text{A}$, $PW = 20\mu\text{s}$
I_{CES}	Collector-to-Emitter Leakage Current	—	1.5	100	μA	$V_{GE} = 0\text{V}$, $V_{CE} = 600\text{V}$
		—	1.4	—	mA	$V_{GE} = 0\text{V}$, $V_{CE} = 600\text{V}$, $T_J = 175^\circ\text{C}$
I_{GES}	Gate-to-Emitter Leakage Current	—	—	± 200	nA	$V_{GE} = \pm 20\text{V}$
V_{FM}	Diode Forward Voltage Drop	—	2.3	3.3	V	$I_F = 18\text{A}$
		—	1.5	—		$I_F = 18\text{A}$, $T_J = 175^\circ\text{C}$

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

	Parameter	Min.	Typ.	Max	Units	Conditions
Q_g	Total Gate Charge	—	140	—	nC	$I_C = 75\text{A}$ $V_{GE} = 15\text{V}$ $V_{CC} = 400\text{V}$
Q_{ge}	Gate-to-Emitter Charge	—	40	—		
Q_{gc}	Gate-to-Collector Charge	—	60	—		
E_{on}	Turn-On Switching Loss	—	2.4	—	mJ	$I_C = 75\text{A}$, $V_{CC} = 400\text{V}$, $V_{GE} = 15\text{V}$ $R_G = 10\Omega$, $L = 400\mu\text{H}$, $T_J = 25^\circ\text{C}$
E_{off}	Turn-Off Switching Loss	—	2.2	—		
E_{total}	Total Switching Loss	—	4.6	—		
$t_{d(on)}$	Turn-On delay time	—	85	—	ns	Energy losses include tail & diode reverse recovery ⑤
t_r	Rise time	—	86	—		
$t_{d(off)}$	Turn-Off delay time	—	222	—		
t_f	Fall time	—	53	—		
E_{on}	Turn-On Switching Loss	—	3.1	—	mJ	$I_C = 75\text{A}$, $V_{CC} = 400\text{V}$, $V_{GE} = 15\text{V}$ $R_G = 10\Omega$, $L = 400\mu\text{H}$, $T_J = 175^\circ\text{C}$
E_{off}	Turn-Off Switching Loss	—	2.8	—		
E_{total}	Total Switching Loss	—	5.9	—		
$t_{d(on)}$	Turn-On delay time	—	67	—	ns	Energy losses include tail & diode reverse recovery ⑤
t_r	Rise time	—	92	—		
$t_{d(off)}$	Turn-Off delay time	—	227	—		
t_f	Fall time	—	78	—		
C_{ies}	Input Capacitance	—	4720	—	pF	$V_{GE} = 0\text{V}$ $V_{CC} = 30\text{V}$ $f = 1.0\text{MHz}$
C_{oes}	Output Capacitance	—	270	—		
C_{res}	Reverse Transfer Capacitance	—	140	—		
RBSOA	Reverse Bias Safe Operating Area	FULL SQUARE				$T_J = 175^\circ\text{C}$, $I_C = 300\text{A}$ $V_{CC} = 480\text{V}$, $V_p \leq 600\text{V}$ $V_{GE} = +20\text{V}$ to 0V
SCSOA	Short Circuit Safe Operating Area	5	—	—	μs	$T_J = 150^\circ\text{C}$, $V_{CC} = 400\text{V}$, $V_p \leq 600\text{V}$ $V_{GE} = +15\text{V}$ to 0V
E_{rec}	Reverse Recovery Energy of the Diode	—	210	—	μJ	$T_J = 175^\circ\text{C}$
t_{rr}	Diode Reverse Recovery Time	—	90	—	ns	$V_{CC} = 400\text{V}$, $I_F = 18\text{A}$
I_{rr}	Peak Reverse Recovery Current	—	26	—	A	$V_{GE} = 15\text{V}$, $R_g = 10\Omega$

Notes:

- ① $V_{CC} = 80\%$ (V_{CES}), $V_{GE} = 20\text{V}$, $L = 400\mu\text{H}$, $R_G = 10\Omega$.
- 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 $f_{sw} = 40\text{KHz}$, refer to figure 26.

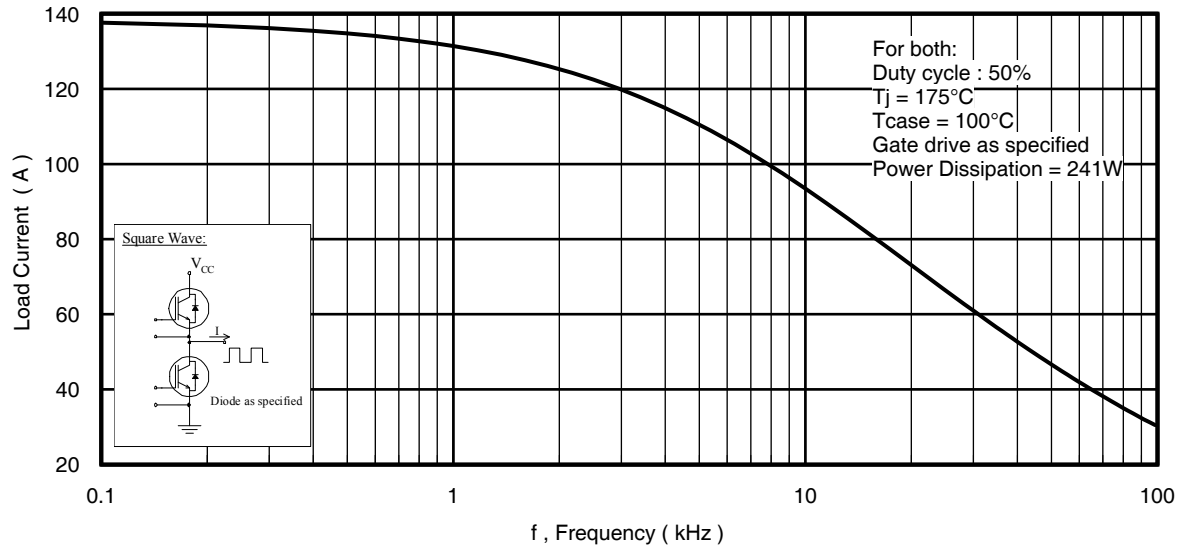


Fig. 1 - Typical Load Current vs. Frequency
(Load Current = I_{RMS} of fundamental)

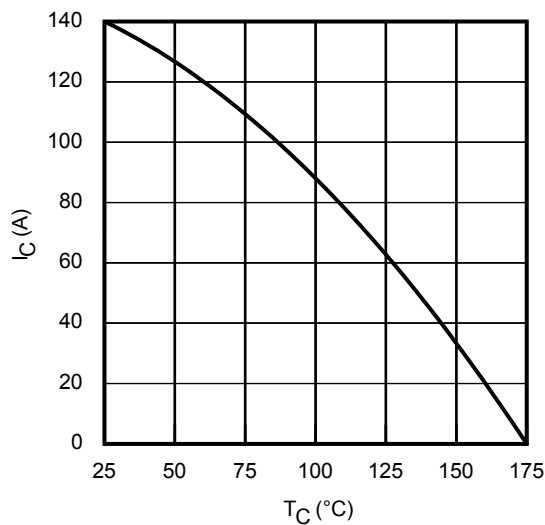


Fig. 2 - Maximum DC Collector Current vs. Case Temperature

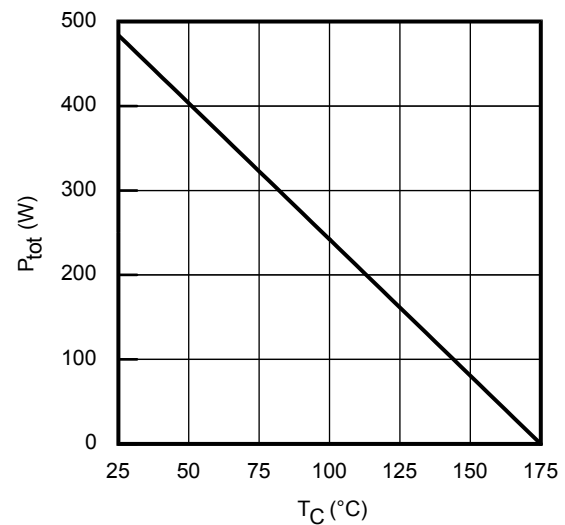


Fig. 3 - Power Dissipation vs. Case Temperature

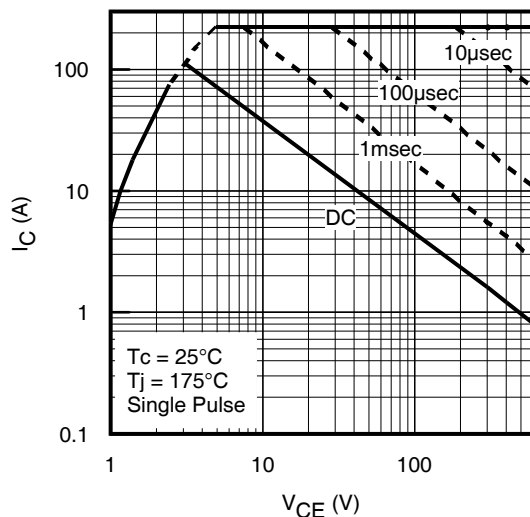


Fig. 4 - Forward SOA
 $T_C = 25^{\circ}\text{C}$; $T_j \leq 175^{\circ}\text{C}$; $V_{\text{GE}} = 15\text{V}$

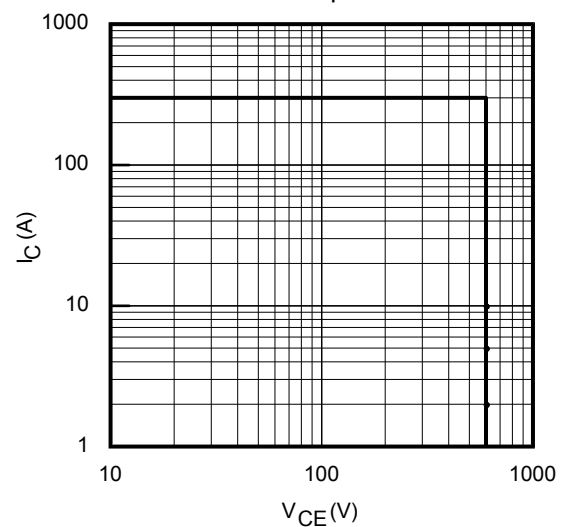


Fig. 5 - Reverse Bias SOA
 $T_j = 175^{\circ}\text{C}$; $V_{\text{GE}} = 20\text{V}$

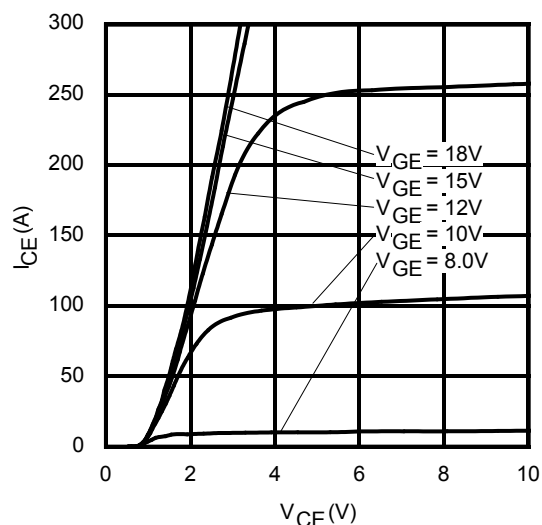


Fig. 6 - Typ. IGBT Output Characteristics
 $T_J = -40^{\circ}\text{C}$; $t_p = 20\mu\text{s}$

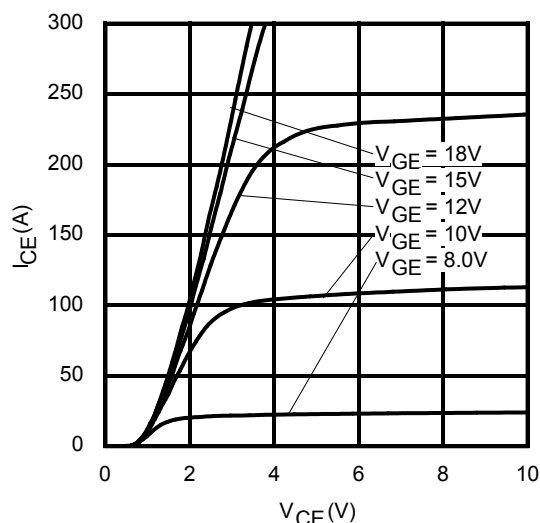


Fig. 7 - Typ. IGBT Output Characteristics
 $T_J = 25^{\circ}\text{C}$; $t_p = 20\mu\text{s}$

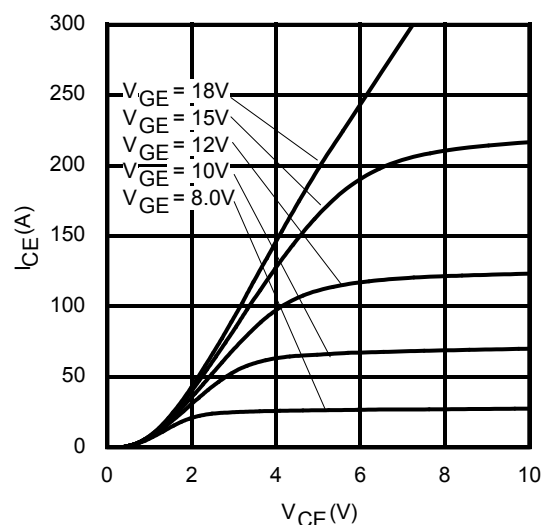


Fig. 8 - Typ. IGBT Output Characteristics
 $T_J = 175^{\circ}\text{C}$; $t_p = 20\mu\text{s}$

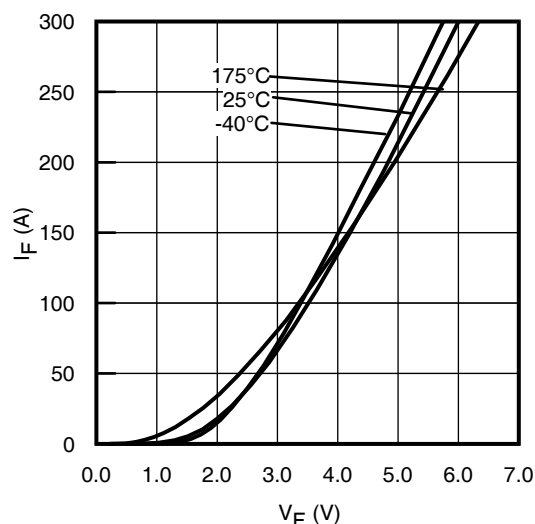


Fig. 9 - Typ. Diode Forward Voltage Drop Characteristics

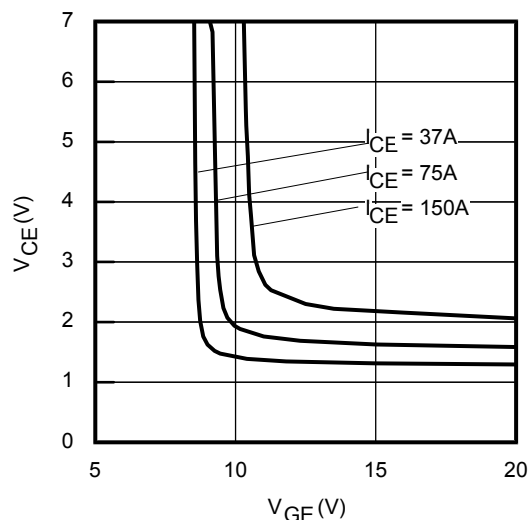


Fig. 10 - Typical V_{CE} vs. V_{GE}
 $T_J = -40^{\circ}\text{C}$

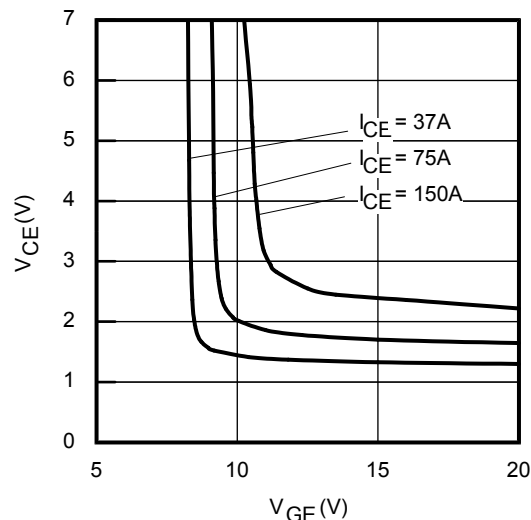


Fig. 11 - Typical V_{CE} vs. V_{GE}
 $T_J = 25^{\circ}\text{C}$

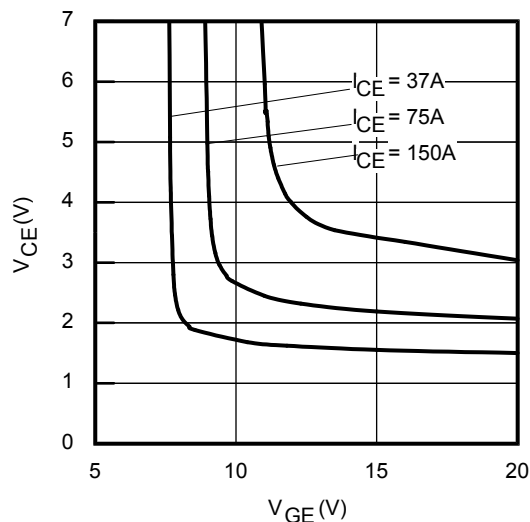


Fig. 12 - Typical V_{CE} vs. V_{GE}
 $T_J = 175^\circ\text{C}$

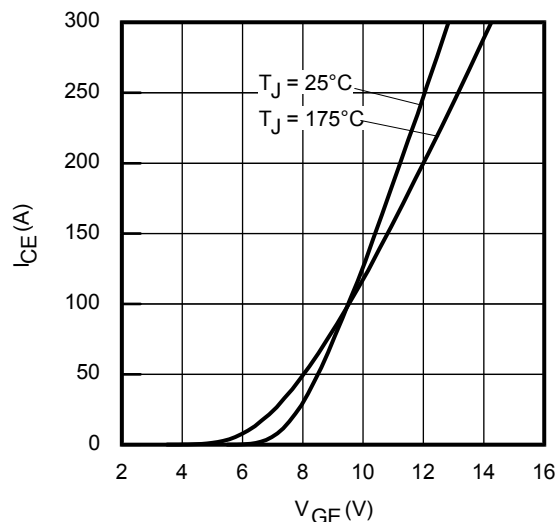


Fig. 13 - Typ. Transfer Characteristics
 $V_{CE} = 50\text{V}$; $t_p = 20\mu\text{s}$

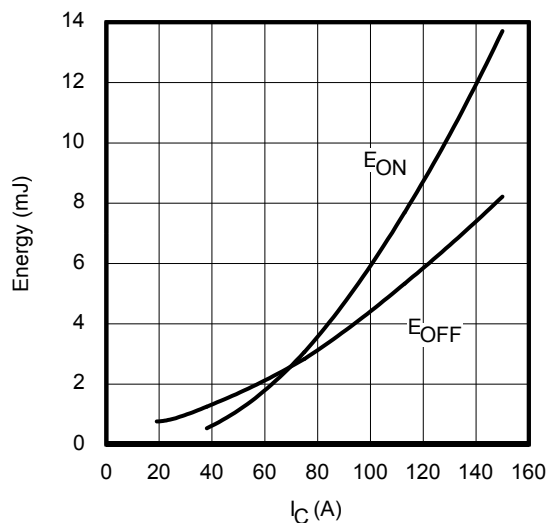


Fig. 14 - Typ. Energy Loss vs. I_C
 $T_J = 175^\circ\text{C}$; $L = 400\mu\text{H}$; $V_{CE} = 400\text{V}$; $R_G = 10\Omega$; $V_{GE} = 15\text{V}$

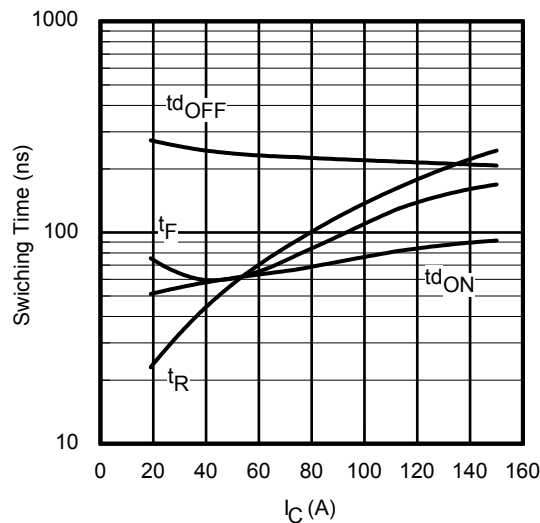


Fig. 15 - Typ. Switching Time vs. I_C
 $T_J = 175^\circ\text{C}$; $L = 400\mu\text{H}$; $V_{CE} = 400\text{V}$; $R_G = 10\Omega$; $V_{GE} = 15\text{V}$

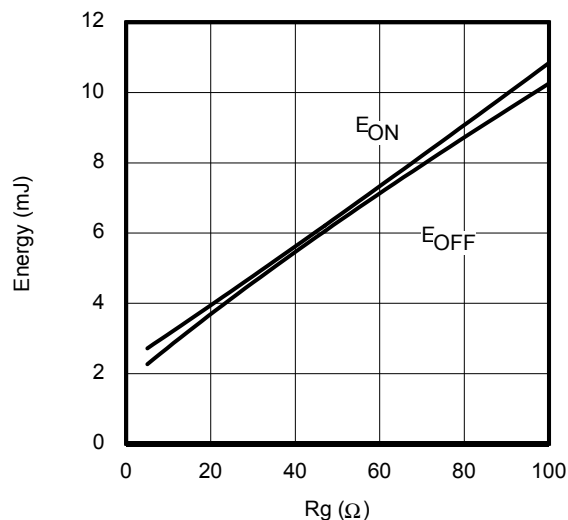


Fig. 16 - Typ. Energy Loss vs. R_G
 $T_J = 175^\circ\text{C}$; $L = 400\mu\text{H}$; $V_{CE} = 400\text{V}$; $I_{CE} = 75\text{A}$; $V_{GE} = 15\text{V}$

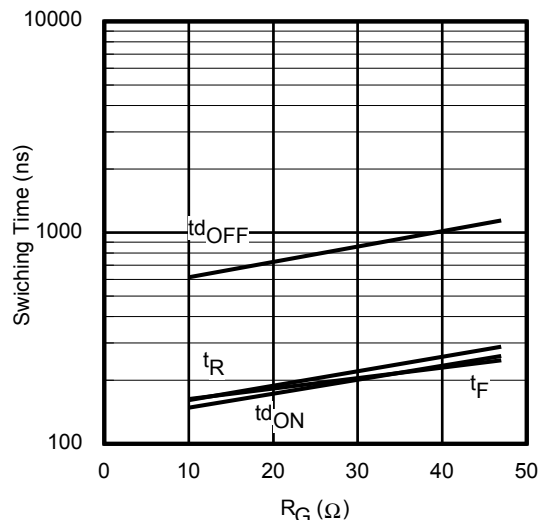


Fig. 17 - Typ. Switching Time vs. R_G
 $T_J = 175^\circ\text{C}$; $L = 400\mu\text{H}$; $V_{CE} = 400\text{V}$; $I_{CE} = 75\text{A}$; $V_{GE} = 15\text{V}$

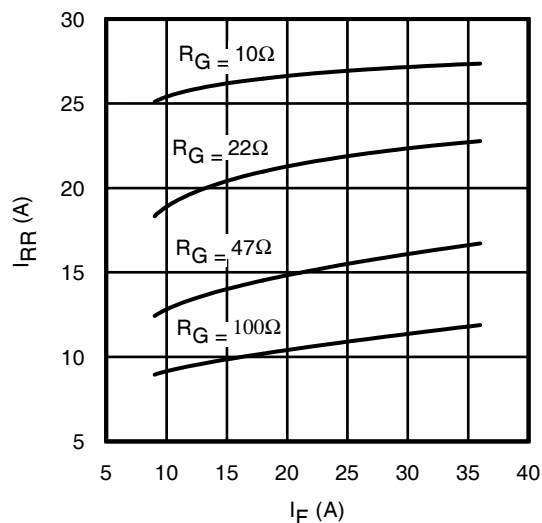


Fig. 18 - Typ. Diode I_{RR} vs. I_F
 $T_J = 175^\circ\text{C}$

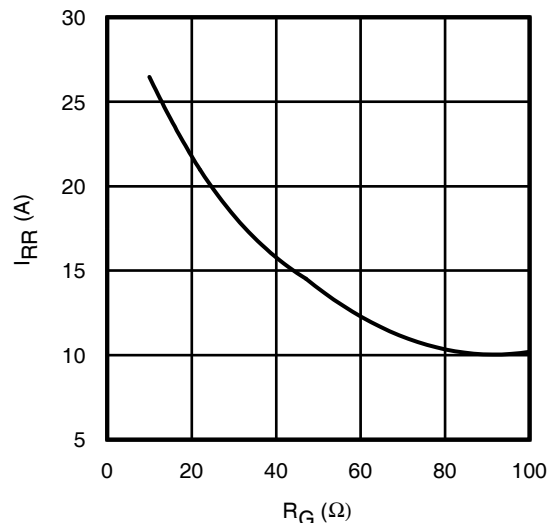


Fig. 19 - Typ. Diode I_{RR} vs. R_G
 $T_J = 175^\circ\text{C}$

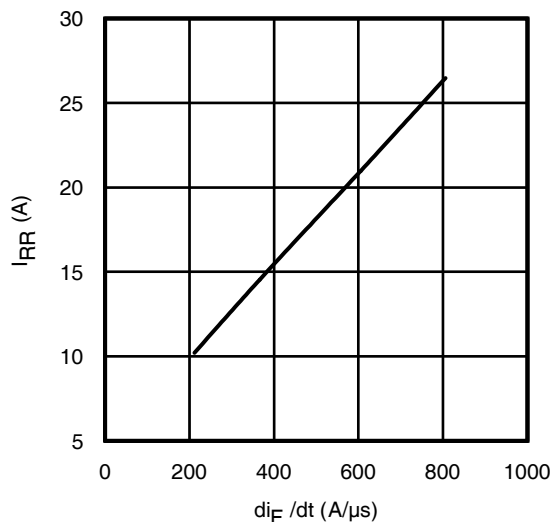


Fig. 20 - Typ. Diode I_{RR} vs. di_F/dt
 $V_{CC} = 400\text{V}$; $V_{GE} = 15\text{V}$; $I_F = 18\text{A}$; $T_J = 175^\circ\text{C}$

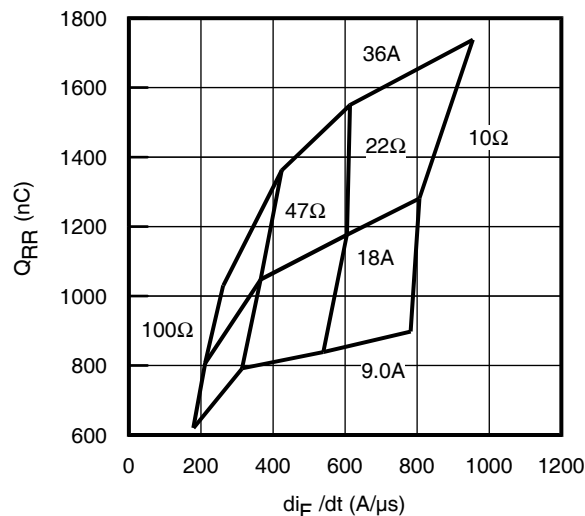


Fig. 21 - Typ. Diode Q_{RR} vs. di_F/dt
 $V_{CC} = 400\text{V}$; $V_{GE} = 15\text{V}$; $T_J = 175^\circ\text{C}$

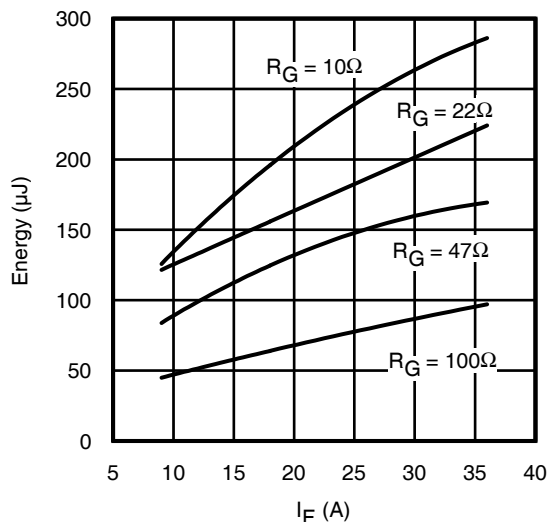


Fig. 22 - Typ. Diode E_{RR} vs. I_F
 $T_J = 175^\circ\text{C}$

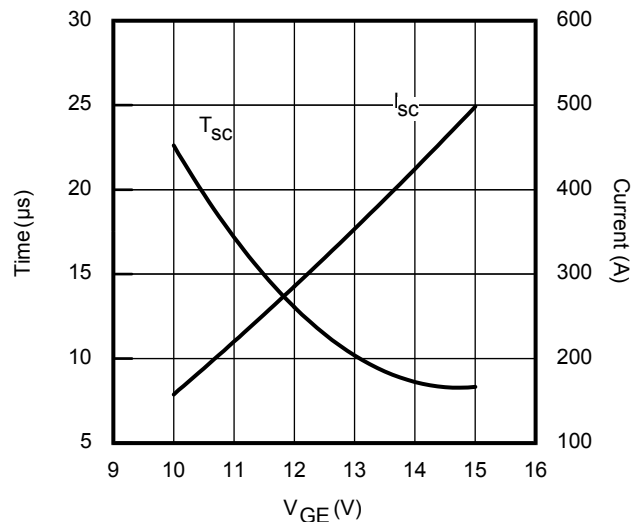


Fig. 23 - V_{GE} vs. Short Circuit Time
 $V_{CC} = 400\text{V}$; $T_C = 25^\circ\text{C}$

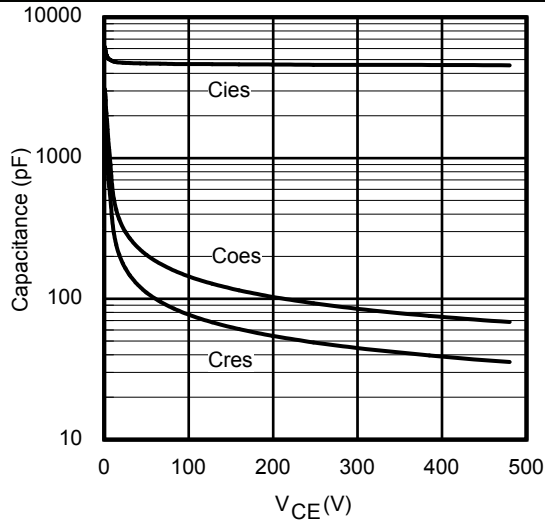


Fig. 24 - Typ. Capacitance vs. V_{CE}
 $V_{GE} = 0V$; $f = 1MHz$

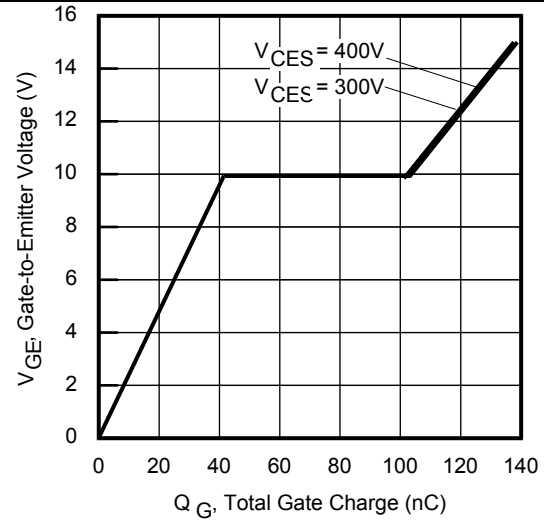


Fig. 25 - Typical Gate Charge vs. V_{GE}
 $I_{CE} = 75A$

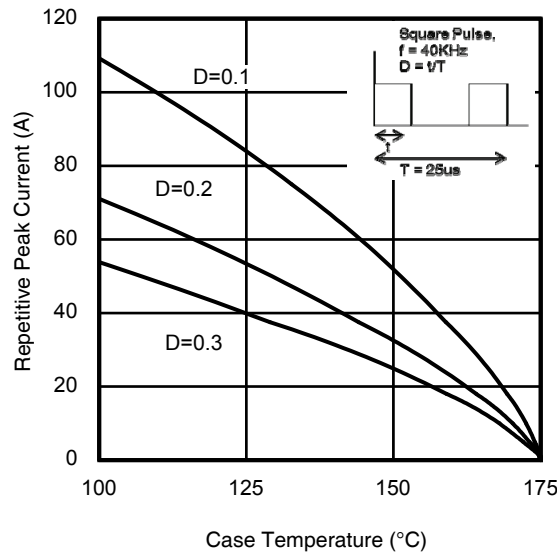


Fig. 26 - Typical Gate Charge vs. V_{GE}

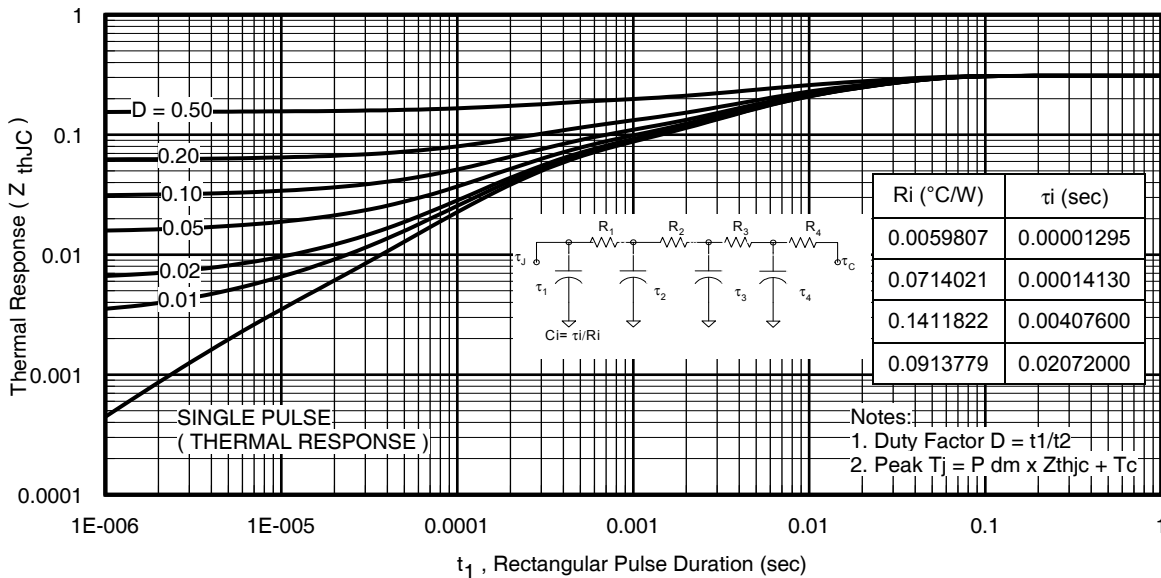


Fig. 27 - Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

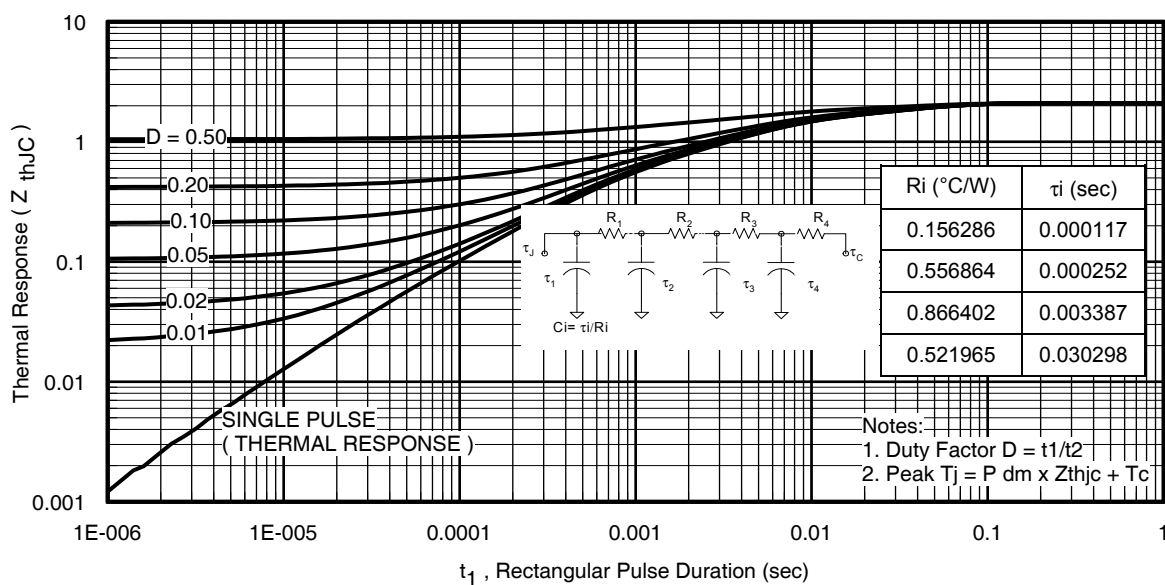
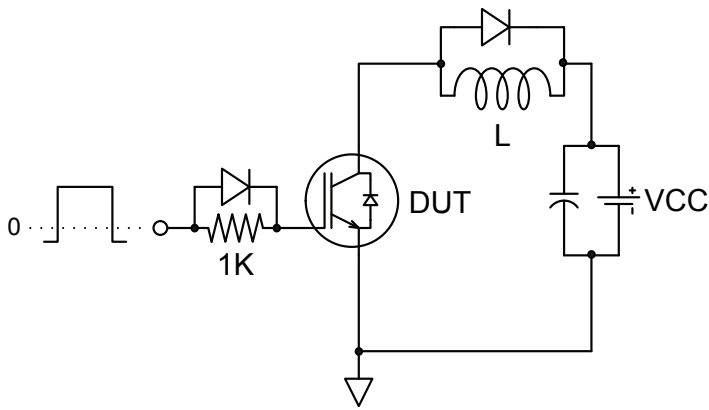
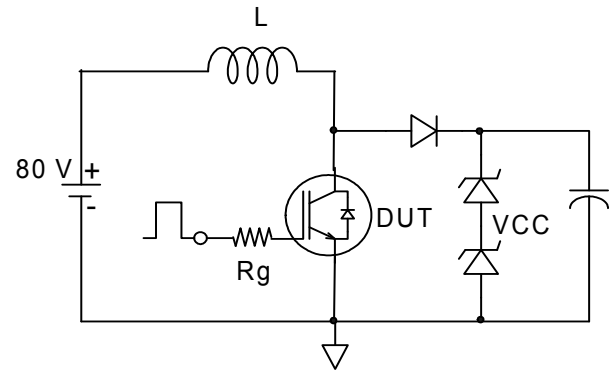
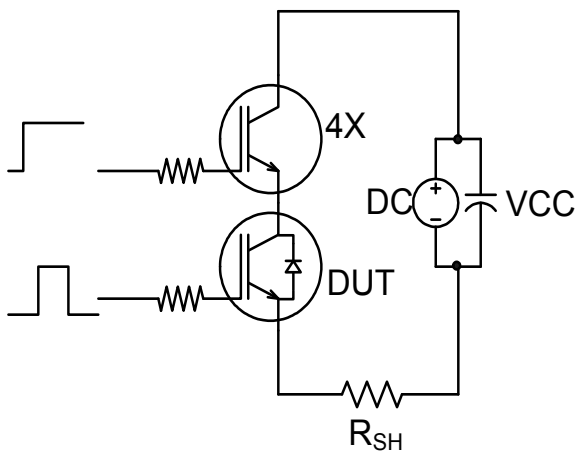
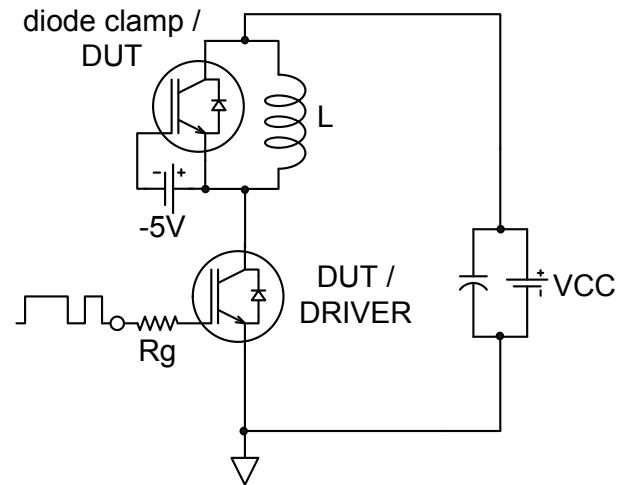
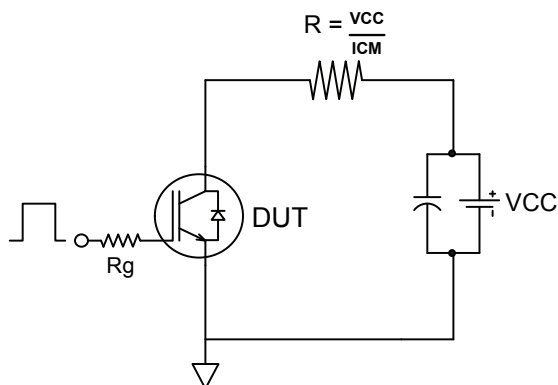
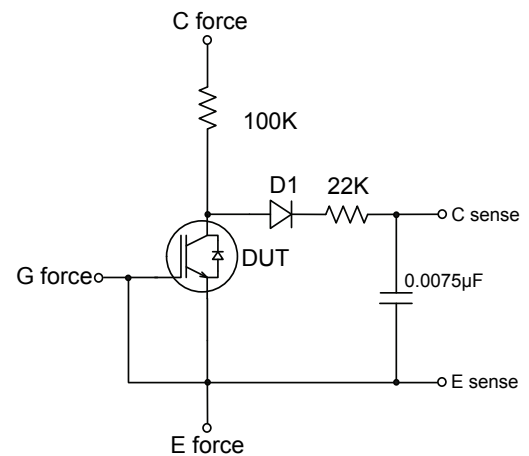


Fig. 28 - Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)


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.C.T.6 - BVCEs Filter Circuit

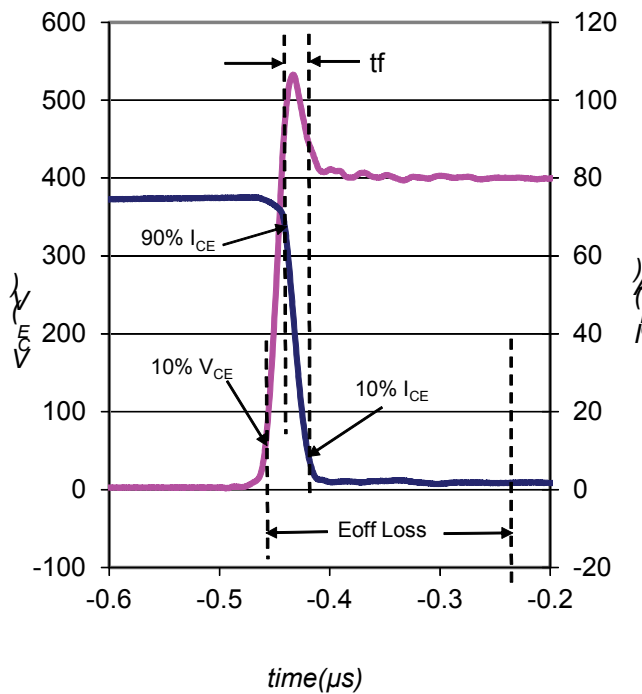


Fig. WF1 - Typ. Turn-off Loss Waveform
@ $T_J = 175^\circ\text{C}$ using Fig. CT.4

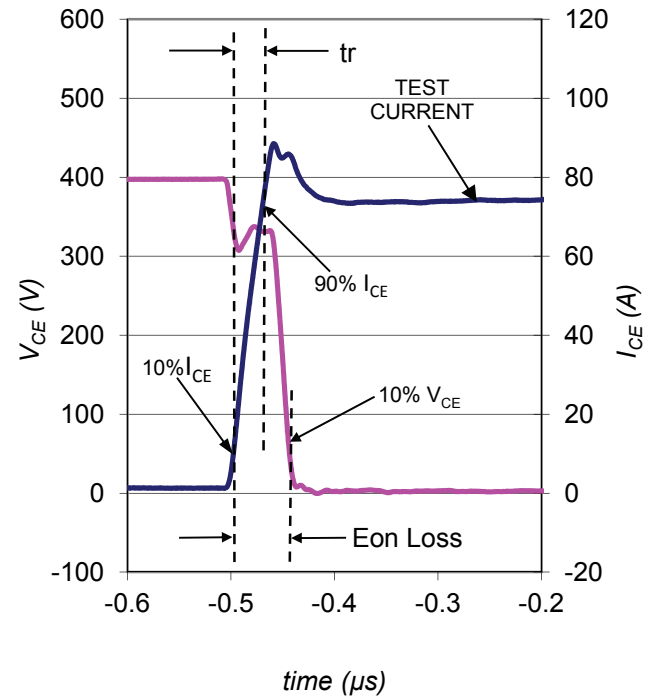


Fig. WF2 - Typ. Turn-on Loss Waveform
@ $T_J = 175^\circ\text{C}$ using Fig. CT.4

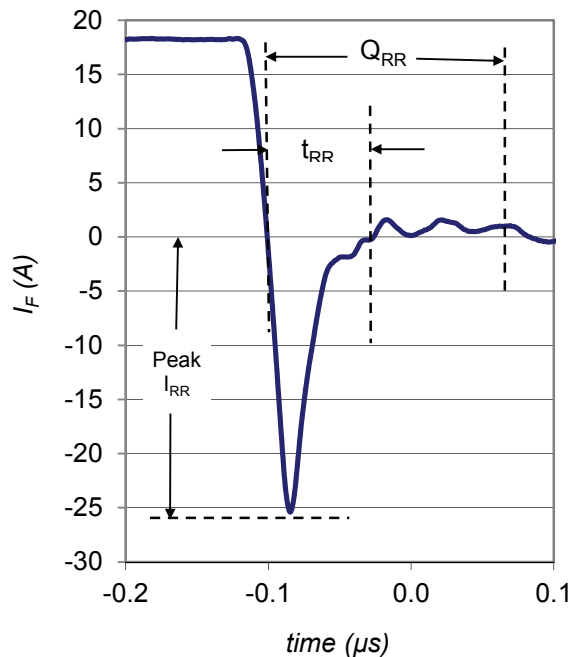


Fig. WF3 - Typ. Diode Recovery Waveform
@ $T_J = 175^\circ\text{C}$ using Fig. CT.4

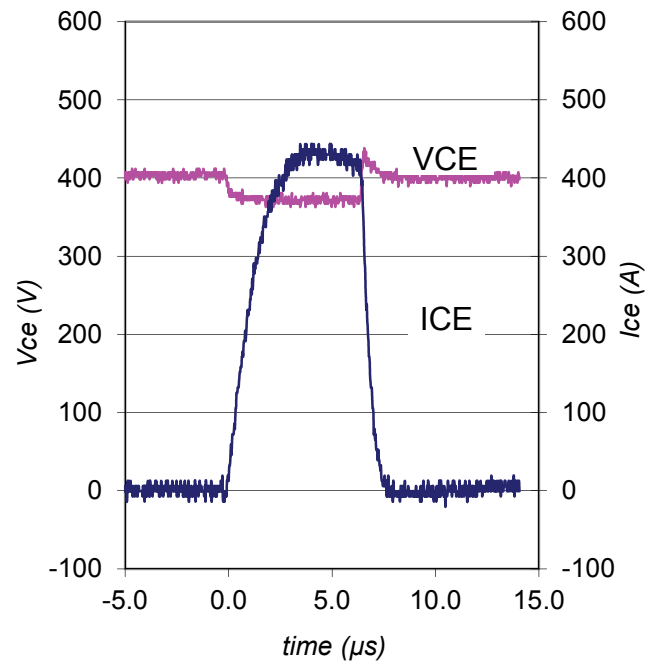
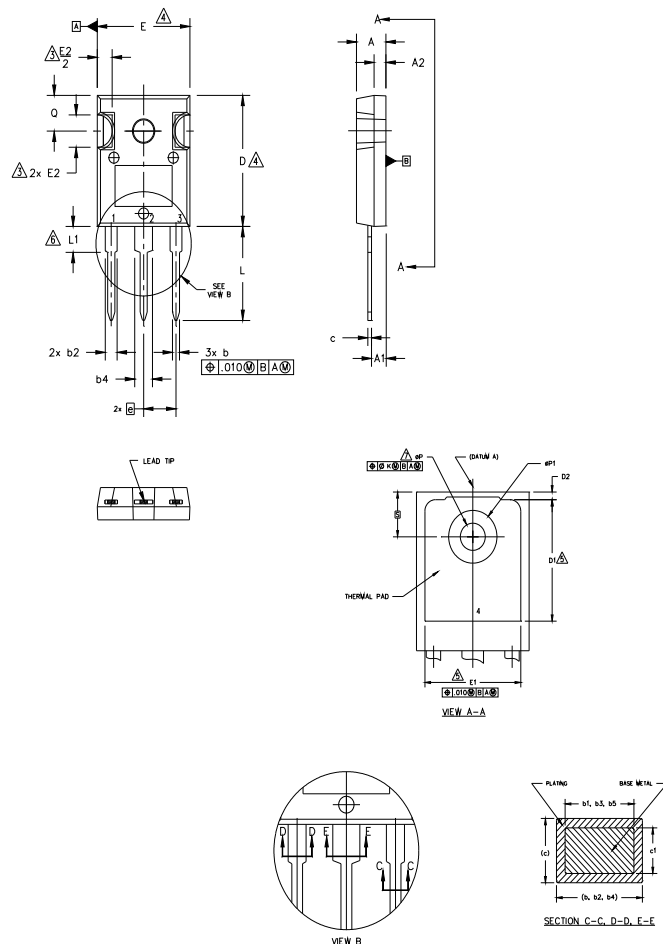


Fig. WF4 - Typ. S.C. Waveform
@ $T_J = 150^\circ\text{C}$ using Fig. CT.3

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

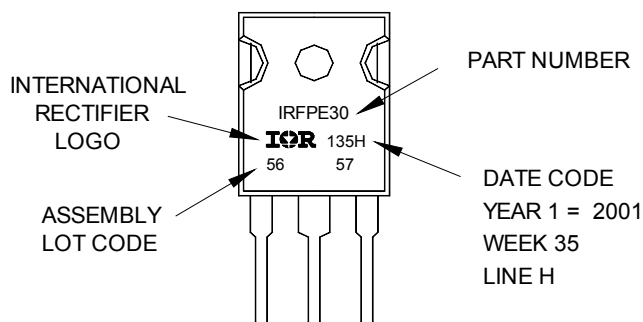
DIODES

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

TO-247AC Part Marking Information

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"

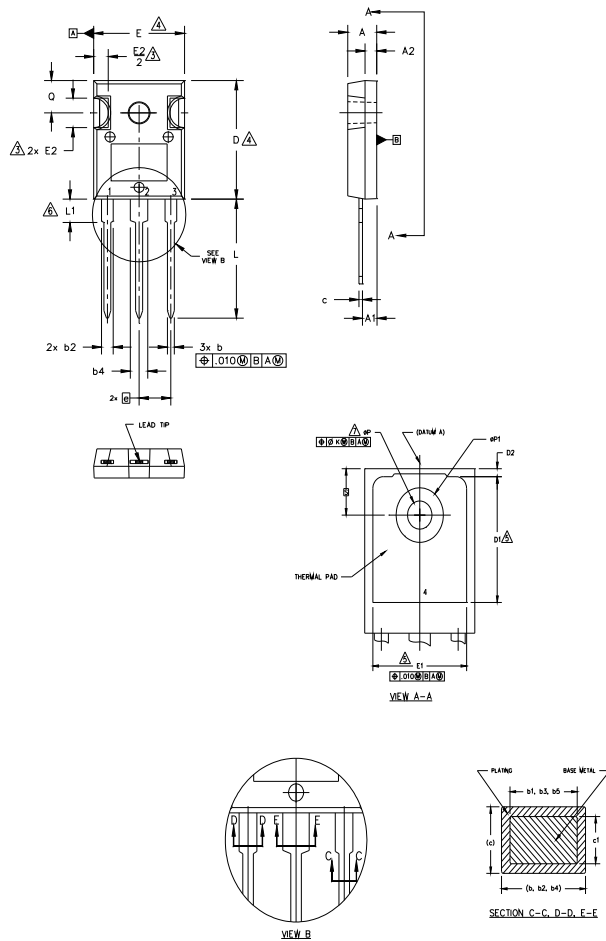


TO-247AC package is not recommended for Surface Mount Application.

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

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. ϕP 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				NOTE
	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

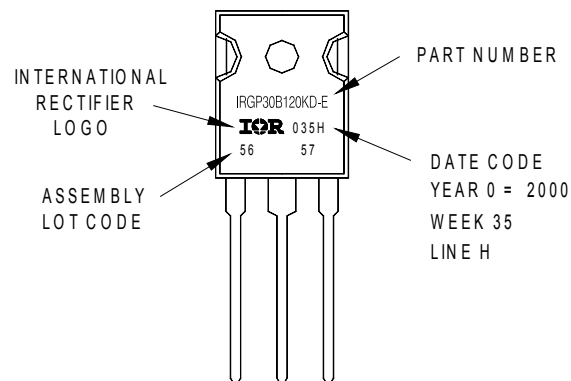
DIODES

- 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/>

Qualification Information[†]

Qualification Level	Industrial (per JEDEC JESD47F) ^{††}	
Moisture Sensitivity Level	TO-247AC	N/A
	TO-247AD	N/A
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 = 300A with the note ④ on page 1. - Removed note ④ from switching losses test condition on page 2.

International
 Rectifier

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To contact International Rectifier, please visit <http://www.irf.com/whoto-call/>

Mouser Electronics

Authorized Distributor

Click to View Pricing, Inventory, Delivery & Lifecycle Information:

[Infineon:](#)

[IRGP6690D-EPBF](#) [IRGP6690DPBF](#)