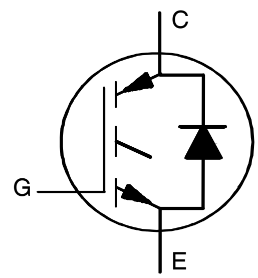
International
IOR Rectifier

SMPS IGBT

IRGP50B60PD

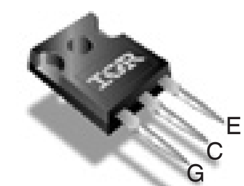
WARP2 SERIES IGBT WITH
ULTRAFAST SOFT RECOVERY DIODE



n-channel

V_{CES} = 600V
$V_{CE(on)}$ typ. = 2.00V
@ V_{GE} = 15V I_C = 33A

Equivalent MOSFET Parameters①
$R_{CE(on)}$ typ. = 61mΩ
I_D (FET equivalent) = 50A



TO-247AC

Applications
- Telecom and Server SMPS
- PFC and ZVS SMPS Circuits
- Uninterruptable Power Supplies
- Consumer Electronics Power Supplies

Features
- NPT Technology, Positive Temperature Coefficient
- Lower V_{CE}(SAT)
- Lower Parasitic Capacitances
- Minimal Tail Current
- HEXFRED Ultra Fast Soft-Recovery Co-Pack Diode
- Tighter Distribution of Parameters
- Higher Reliability

Benefits
- Parallel Operation for Higher Current Applications
- Lower Conduction Losses and Switching Losses
- Higher Switching Frequency up to 150kHz

Absolute Maximum Ratings

	Parameter	Max.	Units
V_{CES}	Collector-to-Emitter Voltage	600	V
I_C @ T_C = 25°C	Continuous Collector Current	75	
I_C @ T_C = 100°C	Continuous Collector Current	42	
I_{CM}	Pulse Collector Current (Ref. Fig. C.T.4)	150	
I_{LM}	Clamped Inductive Load Current ②	150	A
I_F @ T_C = 25°C	Diode Continous Forward Current	50	
I_F @ T_C = 100°C	Diode Continous Forward Current	25	
I_{FRM}	Maximum Repetitive Forward Current ③	100	
V_{GE}	Gate-to-Emitter Voltage	±20	V
P_D @ T_C = 25°C	Maximum Power Dissipation	370	W
P_D @ T_C = 100°C	Maximum Power Dissipation	150	
T_J T_{STG}	Operating Junction and Storage Temperature Range	-55 to +150	°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)	—	—	0.34	°C/W
$R_{\theta JC}$ (Diode)	Thermal Resistance Junction-to-Case-(each Diode)	—	—	0.64	
$R_{\theta CS}$	Thermal Resistance, Case-to-Sink (flat, greased surface)	—	0.50	—	
$R_{\theta JA}$	Thermal Resistance, Junction-to-Ambient (typical socket mount)	—	—	40	
	Weight	—	6.0 (0.21)	—	g (oz)

Electrical Characteristics @ T_J = 25°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 = 500μA	
$\Delta V_{(BR)CES}/\Delta T_J$	Temperature Coeff. of Breakdown Voltage	—	0.61	—	V/°C	V_{GE} = 0V, I_C = 1mA (25°C-125°C)	
R_G	Internal Gate Resistance	—	1.2	—	Ω	1MHz, Open Collector	
$V_{CE(on)}$	Collector-to-Emitter Saturation Voltage	—	2.0	2.2	V	I_C = 33A, V_{GE} = 15V	4, 5,6,8,9
		—	2.4	2.6		I_C = 50A, V_{GE} = 15V	
		—	2.6	2.9		I_C = 33A, V_{GE} = 15V, T_J = 125°C	
		—	3.2	3.6		I_C = 50A, V_{GE} = 15V, T_J = 125°C	
$V_{GE(th)}$	Gate Threshold Voltage	3.0	4.0	5.0	V	I_C = 250μA	7,8,9
$\Delta V_{GE(th)}/\Delta TJ$	Threshold Voltage temp. coefficient	—	-7.07	—	mV/°C	V_{CE} = V_{GE}, I_C = 1.0mA	
gfe	Forward Transconductance	—	42	—	S	V_{CE} = 50V, I_C = 33A, PW = 80μs	
I_{CES}	Collector-to-Emitter Leakage Current	—	5.0	500	μA	V_{GE} = 0V, V_{CE} = 600V	
		—	1.0	—	mA	V_{GE} = 0V, V_{CE} = 600V, T_J = 125°C	
V_{FM}	Diode Forward Voltage Drop	—	1.3	1.7	V	I_F = 25A, V_{GE} = 0V	
		—	1.5	2.0		I_F = 50A, V_{GE} = 0V	10
		—	1.3	1.7		I_F = 25A, V_{GE} = 0V, T_J = 125°C	
I_{GES}	Gate-to-Emitter Leakage Current	—	—	±100	nA	V_{GE} = ±20V, V_{CE} = 0V	

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

	Parameter	Min.	Typ.	Max.	Units	Conditions	Ref.Fig
Qg	Total Gate Charge (turn-on)	—	240	360	nC	I_C = 33A	17
Q_{gc}	Gate-to-Collector Charge (turn-on)	—	41	82		V_{CC} = 400V	CT1
Q_{ge}	Gate-to-Emitter Charge (turn-on)	—	84	130		V_{GE} = 15V	
E_{on}	Turn-On Switching Loss	—	360	590	μJ	I_C = 33A, V_{CC} = 390V	CT3
E_{off}	Turn-Off Switching Loss	—	380	420		V_{GE} = +15V, R_G = 3.3Ω, L = 210μH	
E_{total}	Total Switching Loss	—	740	960		TJ = 25°C ④	
$t_{d(on)}$	Turn-On delay time	—	34	44	ns	I_C = 33A, V_{CC} = 390V	CT3
t_r	Rise time	—	26	36		V_{GE} = +15V, R_G = 3.3Ω, L = 210μH	
$t_{d(off)}$	Turn-Off delay time	—	130	140		T_J = 25°C ④	
t_f	Fall time	—	43	56			
E_{on}	Turn-On Switching Loss	—	610	880	μJ	I_C = 33A, V_{CC} = 390V	CT3
E_{off}	Turn-Off Switching Loss	—	460	530		V_{GE} = +15V, R_G = 3.3Ω, L = 210μH	11,13
E_{total}	Total Switching Loss	—	1070	1410		T_J = 125°C ④	WF1,WF2
$t_{d(on)}$	Turn-On delay time	—	33	43	ns	I_C = 33A, V_{CC} = 390V	CT3
t_r	Rise time	—	26	36		V_{GE} = +15V, R_G = 3.3Ω, L = 200μH	12,14
$t_{d(off)}$	Turn-Off delay time	—	140	160		T_J = 125°C ④	WF1,WF2
t_f	Fall time	—	50	65			
C_{ies}	Input Capacitance	—	4750	—	pF	V_{GE} = 0V	16
C_{oes}	Output Capacitance	—	390	—		V_{CC} = 30V	
C_{res}	Reverse Transfer Capacitance	—	58	—		f = 1Mhz	
C_{oes} eff.	Effective Output Capacitance (Time Related) ⑤	—	280	—		V_{GE} = 0V, V_{CE} = 0V to 480V	15
C_{oes} eff. (ER)	Effective Output Capacitance (Energy Related) ⑤	—	190	—			
RBSOA	Reverse Bias Safe Operating Area	FULL SQUARE				T_J = 150°C, I_C = 150A V_{CC} = 480V, Vp =600V Rg = 22Ω, V_{GE} = +15V to 0V	3 CT2
t_{rr}	Diode Reverse Recovery Time	—	50	75	ns	T_J = 25°C I_F = 25A, V_R = 200V,	19
		—	105	160		T_J = 125°C di/dt = 200A/μs	
Q_{rr}	Diode Reverse Recovery Charge	—	112	375	nC	T_J = 25°C I_F = 25A, V_R = 200V,	21
		—	420	4200		T_J = 125°C di/dt = 200A/μs	
I_{rr}	Peak Reverse Recovery Current	—	4.5	10	A	T_J = 25°C I_F = 25A, V_R = 200V,	19,20,21,22
		—	8.0	15		T_J = 125°C di/dt = 200A/μs	CT5

Notes:

① $R_{CE(on)}$ typ. = equivalent on-resistance = $V_{CE(on)}$ typ./ I_C, where $V_{CE(on)}$ typ.= 2.00V and I_C =33A. I_D (FET Equivalent) is the equivalent MOSFET I_D rating @ 25°C for applications up to 150kHz. These are provided for comparison purposes (only) with equivalent MOSFET solutions.

② V_{CC} = 80% (V_{CES}), V_{GE} = 20V, L = 28 μH, R_G = 22 Ω.

③ Pulse width limited by max. junction temperature.

④ Energy losses include "tail" and diode reverse recovery, Data generated with use of Diode 30ETH06.

⑤ C_{oes} eff. is a fixed capacitance that gives the same charging time as C_{oes} while V_{CE} is rising from 0 to 80% V_{CES}.
C_{oes} eff.(ER) is a fixed capacitance that stores the same energy as C_{oes} while V_{CE} is rising from 0 to 80% V_{CES}.

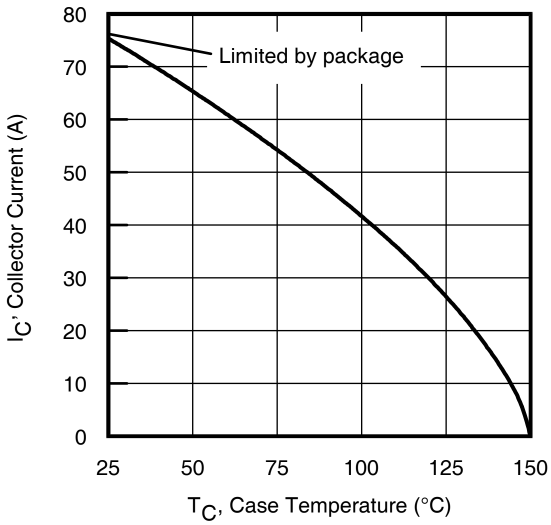


Fig. 1 - Maximum DC Collector Current vs. Case Temperature

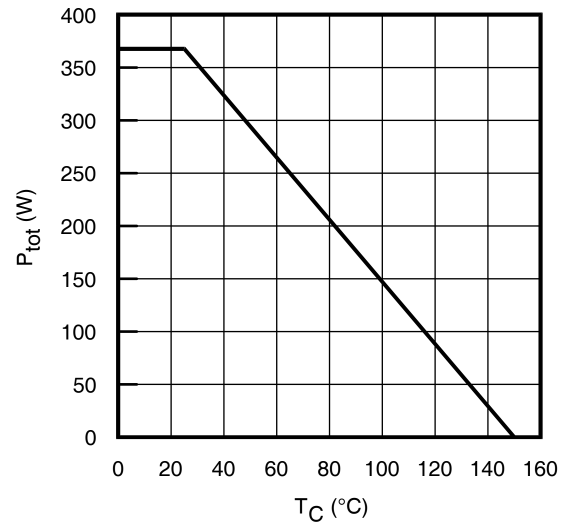


Fig. 2 - Power Dissipation vs. Case Temperature

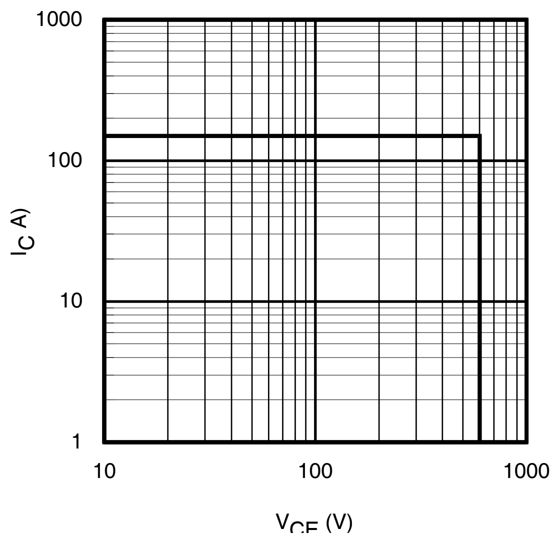


Fig. 3 - Reverse Bias SOA
T_J = 150°C; V_{GE} =15V

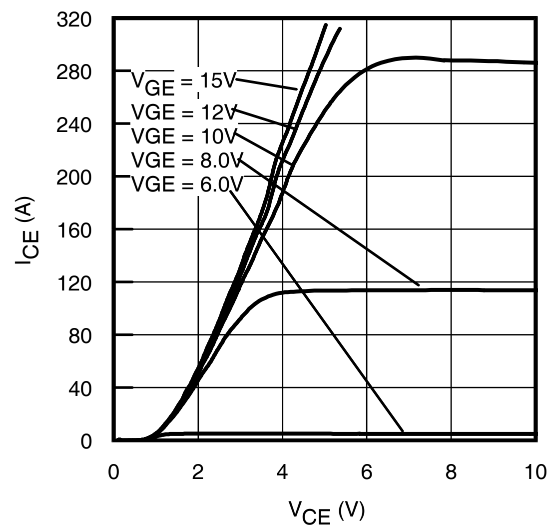


Fig. 4 - Typ. IGBT Output Characteristics
T_J = -40°C; tp = 80μs

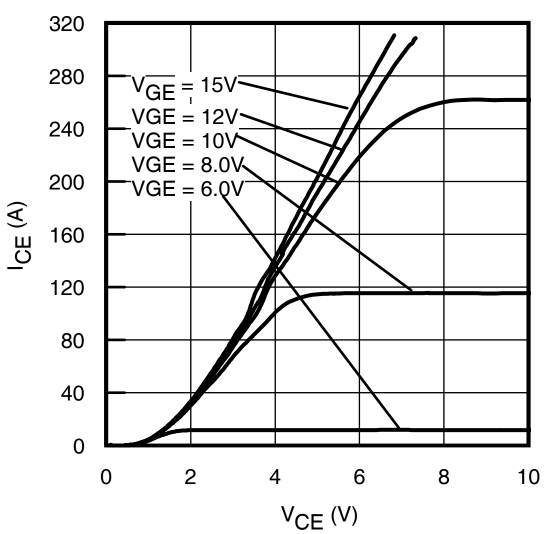


Fig. 5 - Typ. IGBT Output Characteristics
T_J = 25°C; tp = 80μs

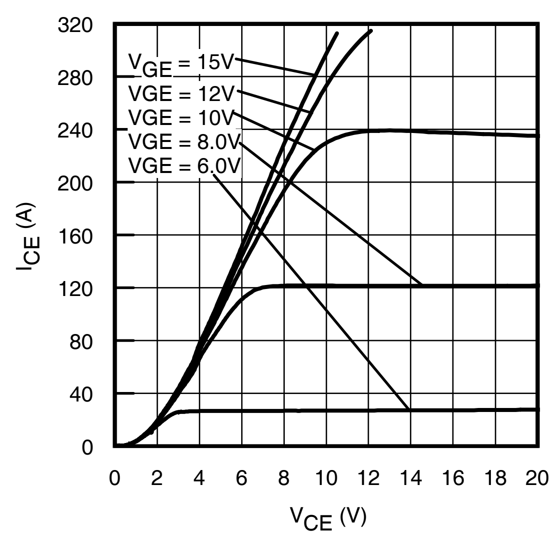


Fig. 6 - Typ. IGBT Output Characteristics
T_J = 125°C; tp = 80μs

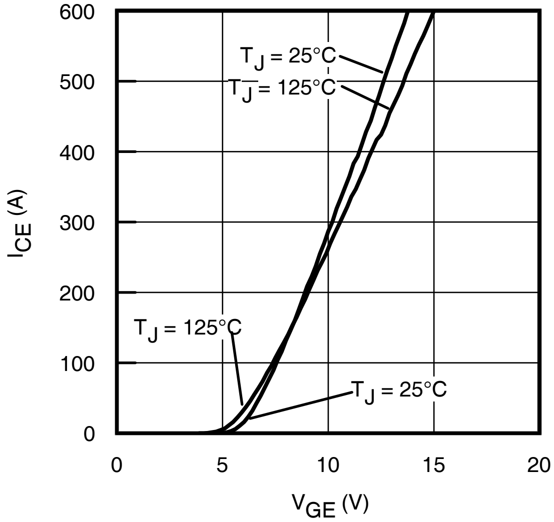


Fig. 7 - Typ. Transfer Characteristics
V_{CE} = 50V; tp = 10µs

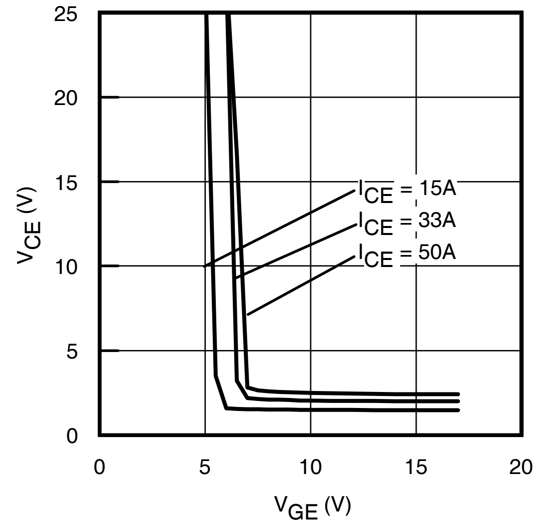


Fig. 8 - Typical V_{CE} vs. V_{GE}
T_J = 25°C

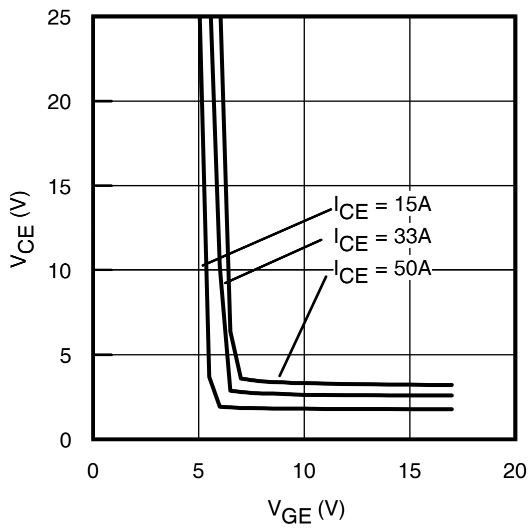


Fig. 9 - Typical V_{CE} vs. V_{GE}
T_J = 125°C

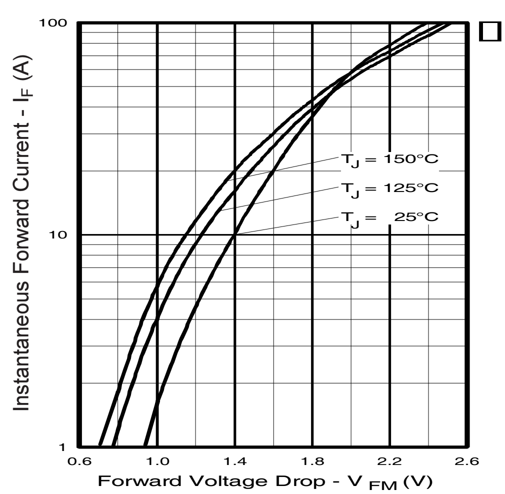


Fig. 10 - Maximum. Diode Forward
Characteristics tp = 80µs

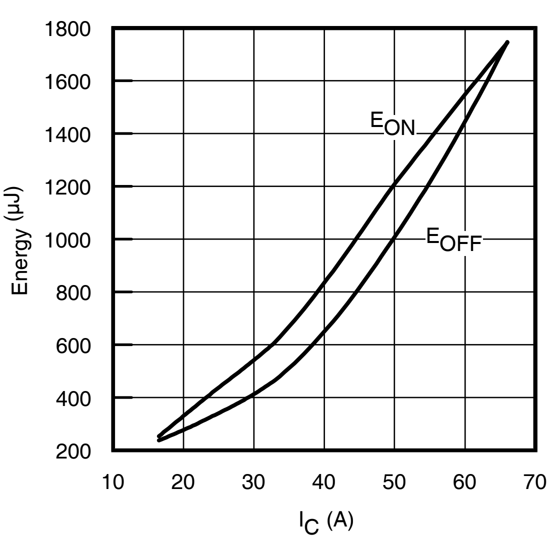


Fig. 11 - Typ. Energy Loss vs. I_C
T_J = 125°C; L = 200µH; V_{CE} = 390V, R_G = 3.3Ω; V_{GE} = 15V.
Diode clamp used: 30ETH06 (See C.T.3)

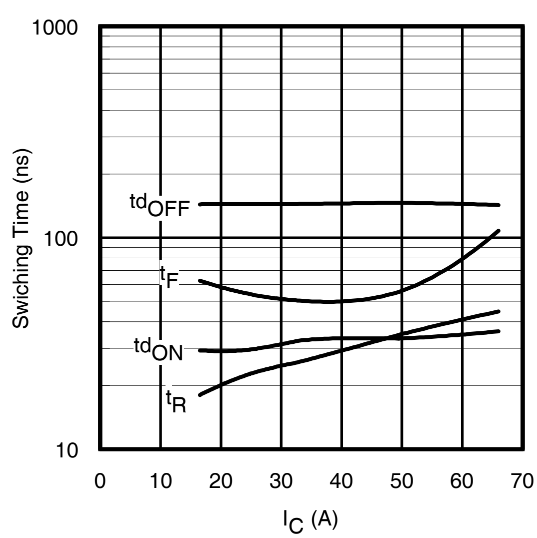


Fig. 12 - Typ. Switching Time vs. I_C
T_J = 125°C; L = 200µH; V_{CE} = 390V, R_G = 3.3Ω; V_{GE} = 15V.
Diode clamp used: 30ETH06 (See C.T.3)

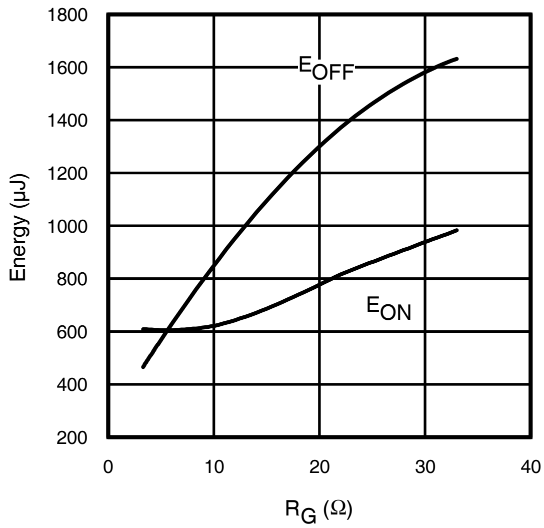


Fig. 13 - Typ. Energy Loss vs. R_G
T_J = 125°C; L = 200µH; V_{CE} = 390V, I_{CE} = 33A; V_{GE} = 15V
Diode clamp used: 30ETH06 (See C.T.3)

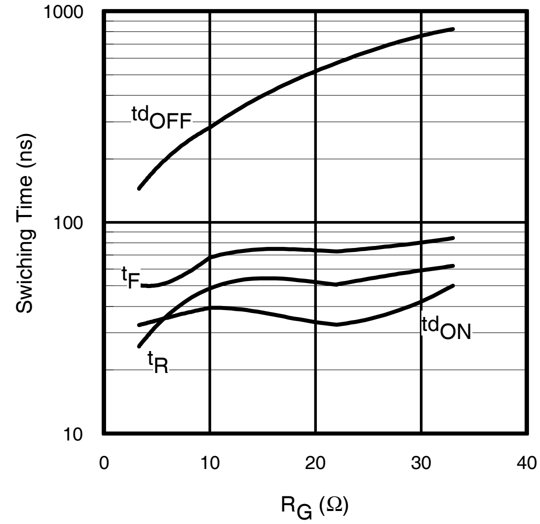


Fig. 14 - Typ. Switching Time vs. R_G
T_J = 125°C; L = 200µH; V_{CE} = 390V, I_{CE} = 33A; V_{GE} = 15V
Diode clamp used: 30ETH06 (See C.T.3)

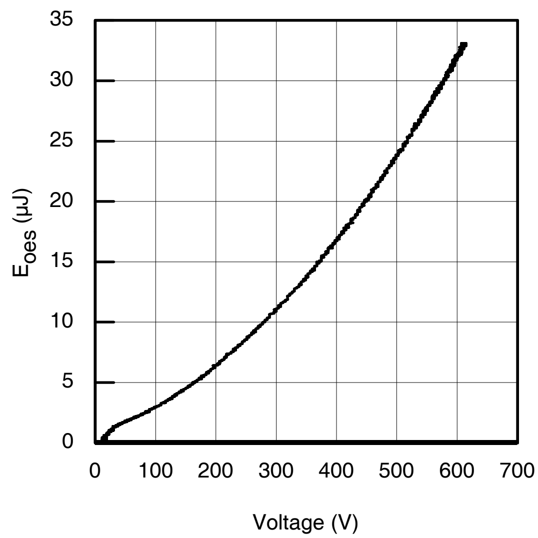


Fig. 15- Typ. Output Capacitance Stored Energy vs. V_{CE}

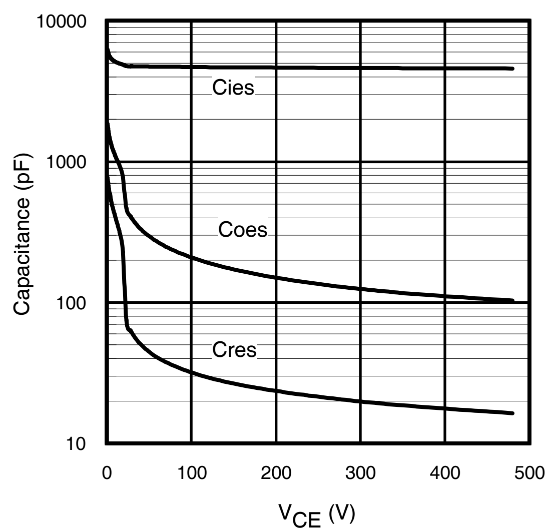


Fig. 16- Typ. Capacitance vs. V_{CE}
V_{GE}= 0V; f = 1MHz

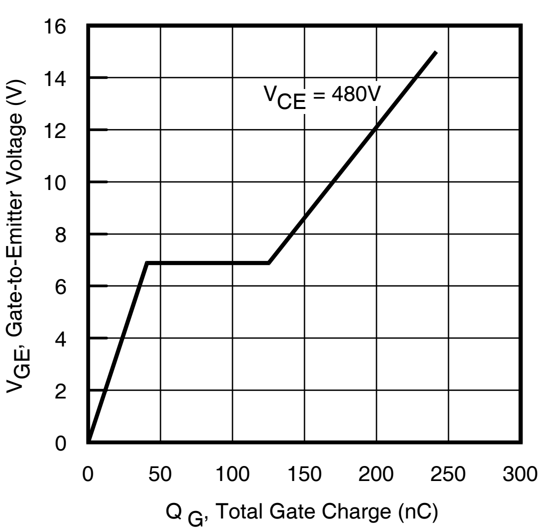


Fig. 17 - Typical Gate Charge vs. V_{GE}
I_{CE} = 33A

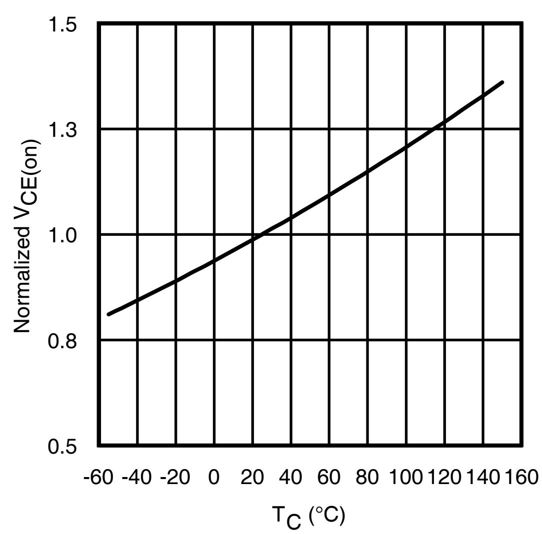


Fig. 18 - Normalized Typ. $V_{CE(on)}$ vs. Junction Temperature
I_C = 33A, V_{GE}= 15V

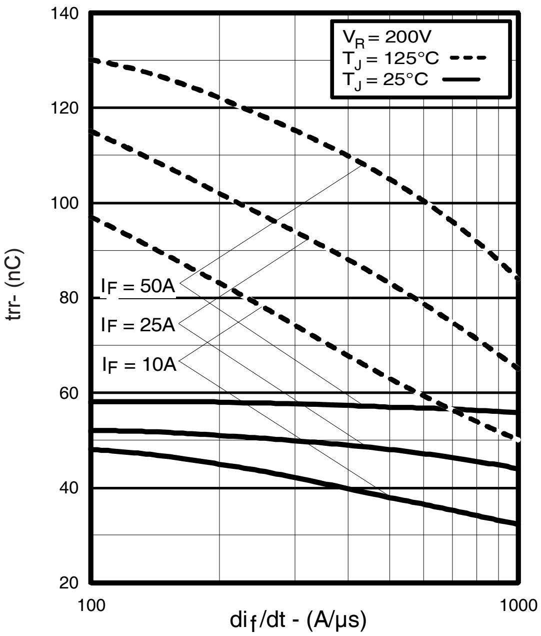


Fig. 19 - Typical Reverse Recovery vs. di_f/dt

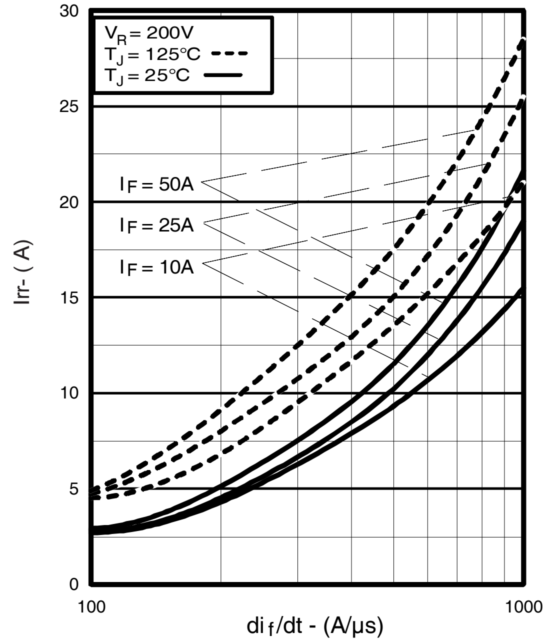


Fig. 20 - Typical Recovery Current vs. di_f/dt

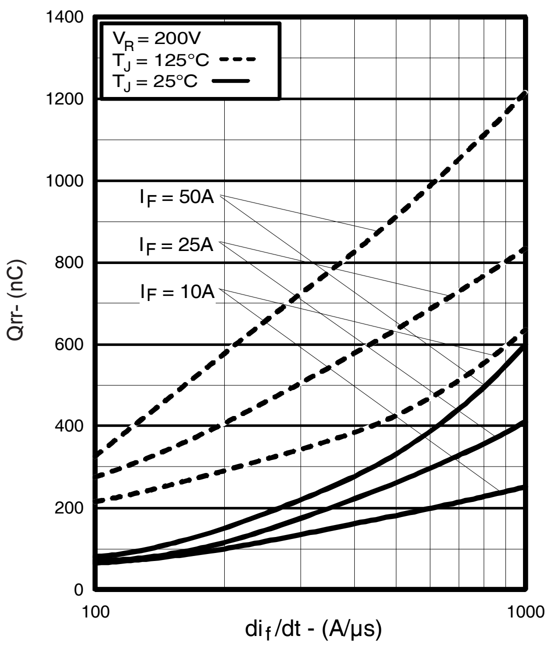


Fig. 21 - Typical Stored Charge vs. di_f/dt

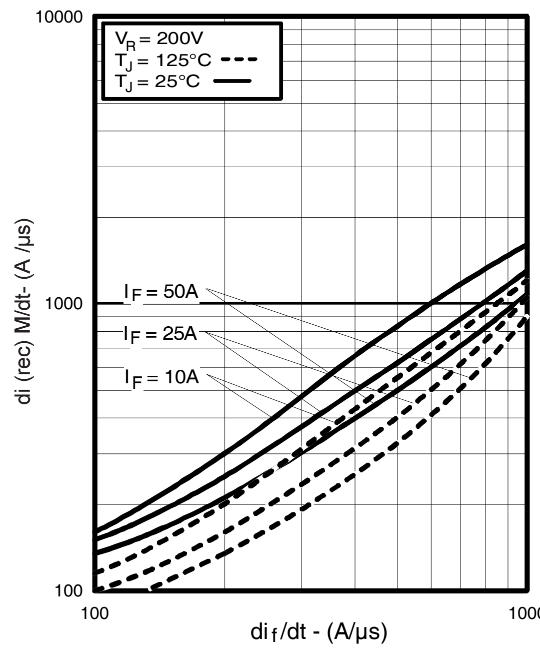
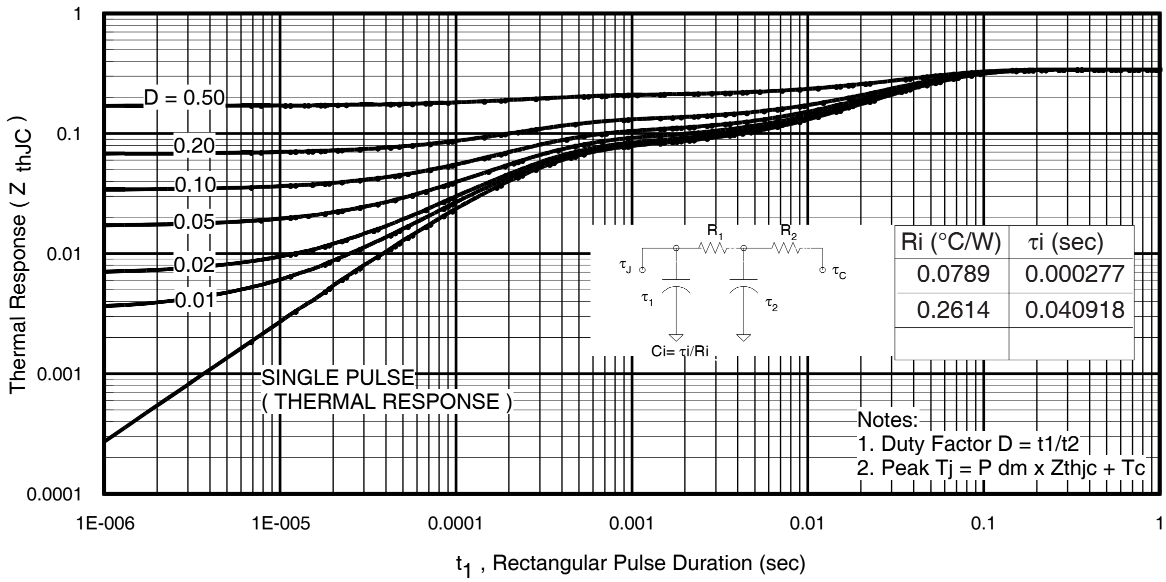
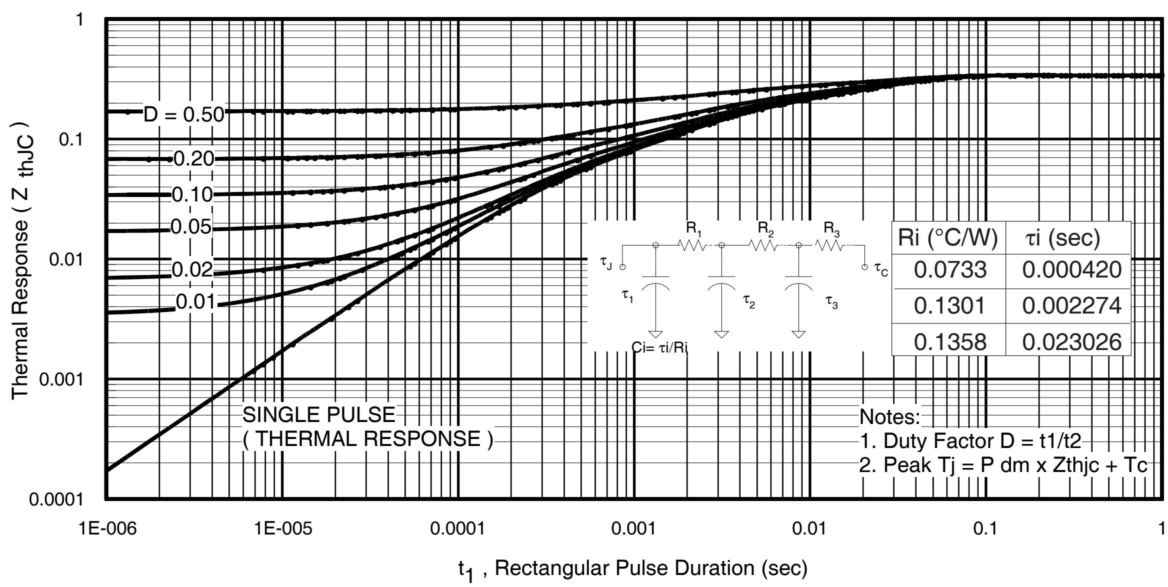


Fig. 22 - Typical $di_{(rec)M}/dt$ vs. di_f/dt,



Ri (°C/W)	τi (sec)
0.0789	0.000277
0.2614	0.040918

Fig 23. Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)



Ri (°C/W)	τi (sec)
0.0733	0.000420
0.1301	0.002274
0.1358	0.023026

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

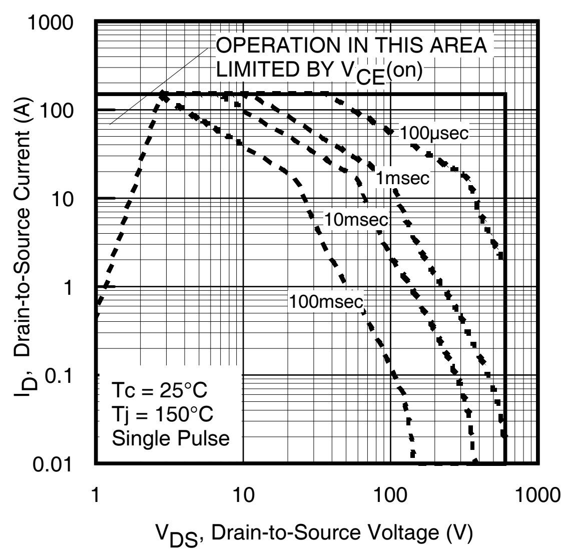


Fig. 25 - Forward SOA, $T_C = 25°C$; $T_J \leq 150°C$

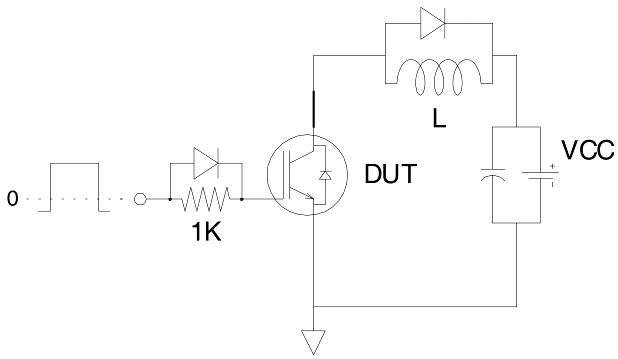


Fig.C.T.1 - Gate Charge Circuit (turn-off)

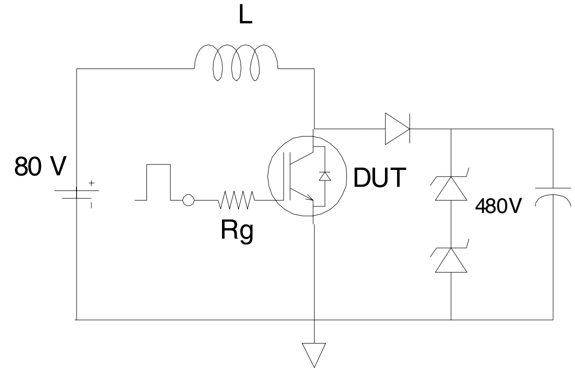


Fig.C.T.2 - RBSOA Circuit

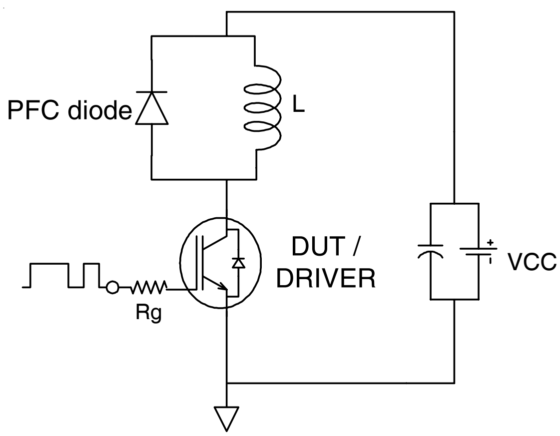


Fig.C.T.3 - Switching Loss Circuit

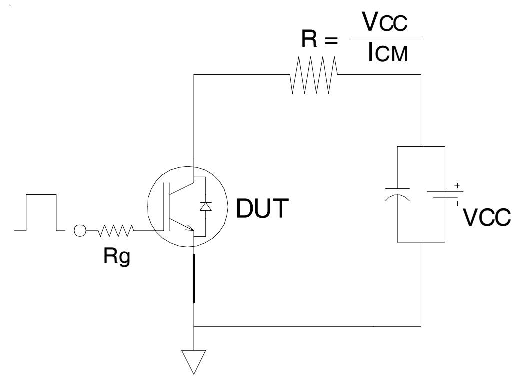


Fig.C.T.4 - Resistive Load Circuit

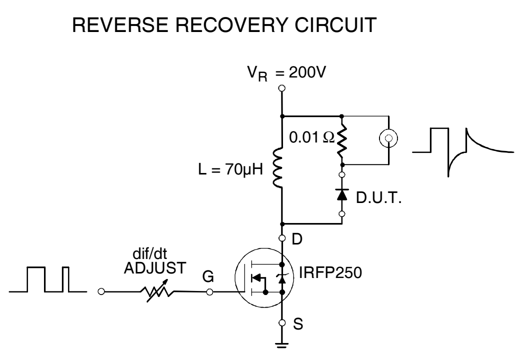


Fig. C.T.5 - Reverse Recovery Parameter Test Circuit

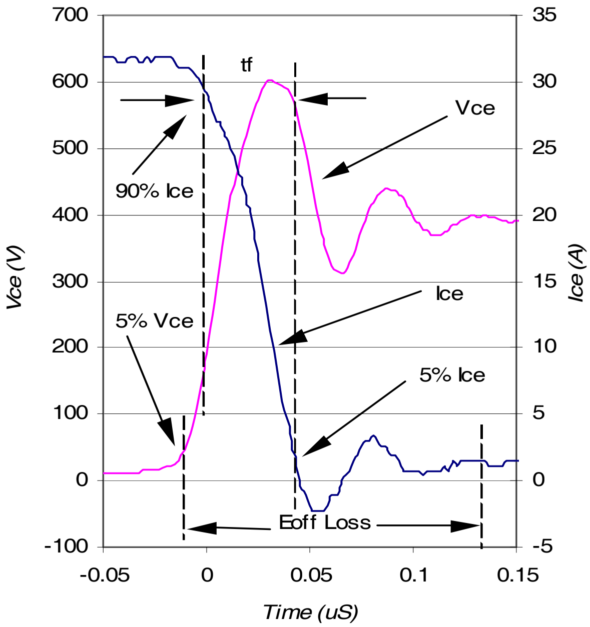


Fig. WF1 - Typ. Turn-off Loss Waveform
@ T_J = 25°C using Fig. CT.3

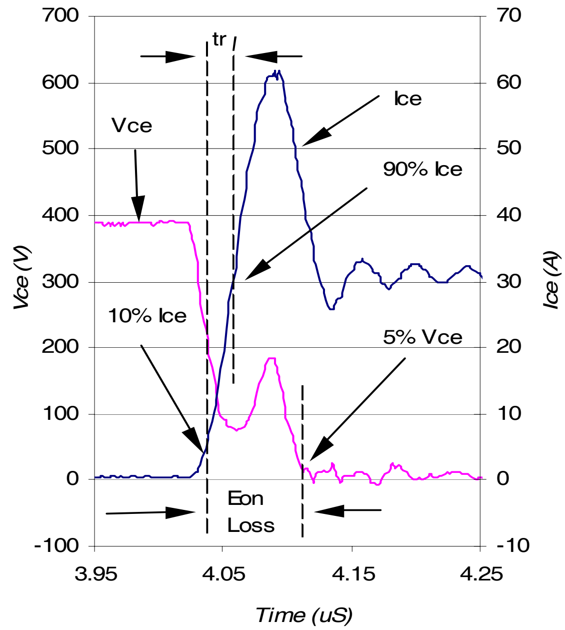
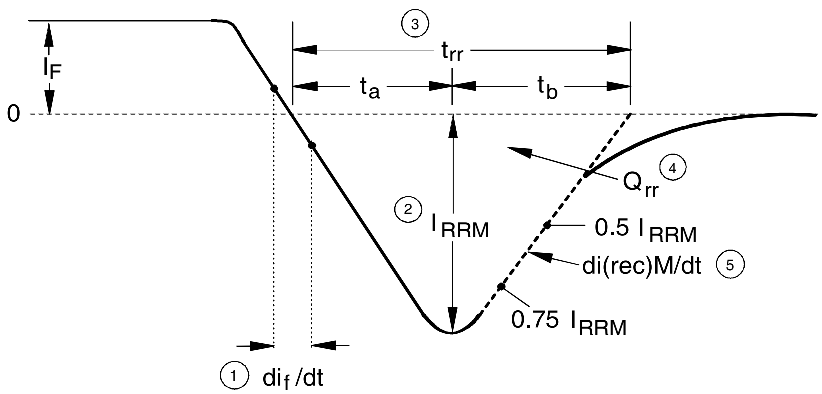


Fig. WF2 - Typ. Turn-on Loss Waveform
@ T_J = 25°C using Fig. CT.3



1. di_f/dt - Rate of change of current through zero crossing
2. I_{RRM} - Peak reverse recovery current
3. trr - Reverse recovery time measured from zero crossing point of negative going I_F to point where a line passing through 0.75 I_{RRM} and 0.50 I_{RRM} extrapolated to zero current
4. Q_{rr} - Area under curve defined by t_{rr} and I_{RRM}

$$Q_{rr} = \frac{t_{rr} \times I_{RRM}}{2}$$

5. $di_{(rec)M}/dt$ - Peak rate of change of current during t_b portion of t_{rr}

Fig. WF3 - Reverse Recovery Waveform and Definitions

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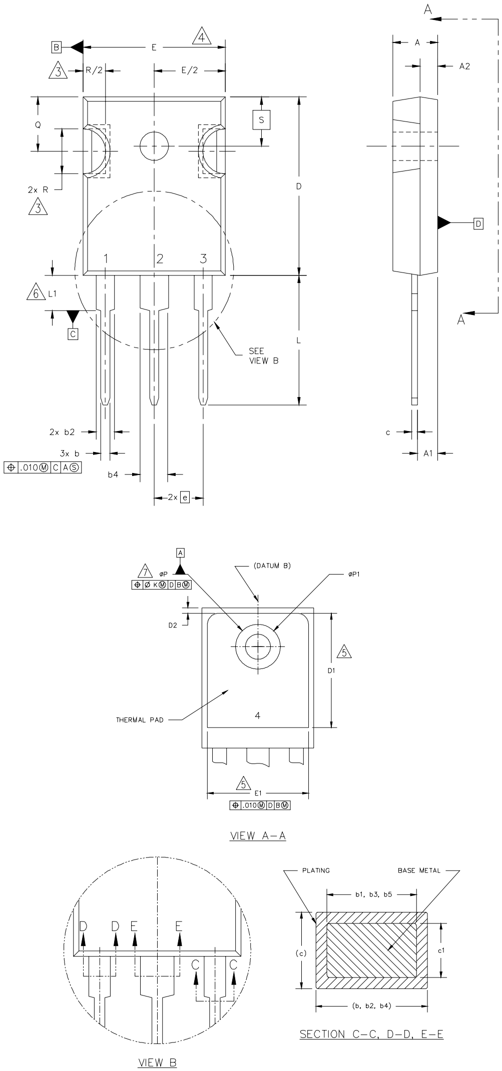
TO-247AC Package Outline

Dimensions are shown in millimeters (inches)



NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M 1994.
2. DIMENSIONS ARE SHOWN IN INCHES [MILLIMETERS]
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 DIMENISONS 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" [3.91].
8. OUTLINE CONFORMS TO JEDEC OUTLINE TO-247 WITH THE EXCEPTION OF DIMENSION c.

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	2.37	
b4	.102	.135	2.59	3.43	
b5	.102	.133	2.59	3.38	
c	.015	.034	0.38	0.86	
c1	.015	.030	0.38	0.76	
D	.776	.815	19.71	20.70	4
D1	.515	–	13.08	–	5
D2	.020	.030	0.51	0.76	
E	.602	.625	15.29	15.87	4
E1	.540	–	15.72	–	
e	.215 BSC		5.46 BSC		
øk	.010		2.54		
L	.559	.634	14.20	16.10	
L1	.146	.169	3.71	4.29	
N	3		7.62 BSC		
øP	.140	.144	3.56	3.66	
øP1	–	.275	–	6.98	
Q	.209	.224	5.31	5.69	
R	.178	.216	4.52	5.49	
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

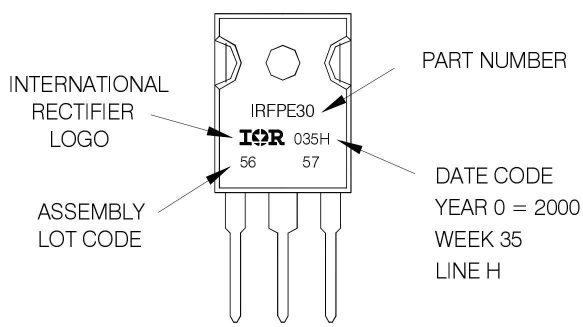
DIODES

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, 2000
IN THE ASSEMBLY LINE "H"

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



TO-247AC 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
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