

WARP2 SERIES IGBT WITH
ULTRAFAST SOFT RECOVERY DIODE

Applications

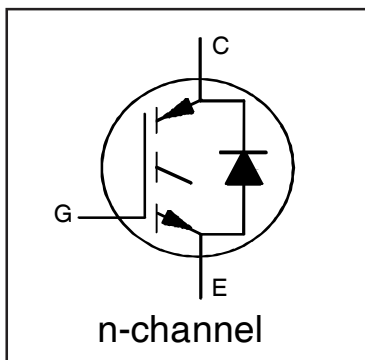
- Telecom and Server SMPS
- PFC and ZVS SMPS Circuits
- Uninterruptable Power Supplies
- Consumer Electronics Power Supplies
- Lead-Free

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

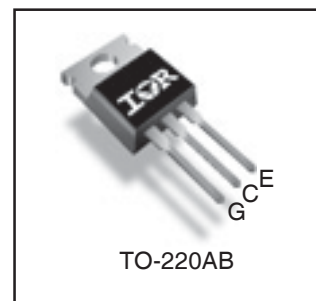
- Parallel Operation for Higher Current Applications
- Lower Conduction Losses and Switching Losses
- Higher Switching Frequency up to 150kHz



$V_{CES} = 600V$
 $V_{CE(on)} \text{ typ.} = 2.05V$
 @ $V_{GE} = 15V$ $I_C = 13.0A$

**Equivalent MOSFET
Parameters ①**

$R_{CE(on)} \text{ typ.} = 158m\Omega$
 $I_D \text{ (FET equivalent)} = 20A$



Absolute Maximum Ratings

	Parameter	Max.	Units
V_{CES}	Collector-to-Emitter Voltage	600	V
$I_C @ T_C = 25^\circ C$	Continuous Collector Current	40	A
$I_C @ T_C = 100^\circ C$	Continuous Collector Current	22	
I_{CM}	Pulse Collector Current (Ref. Fig. C.T.4)	80	
I_{LM}	Clamped Inductive Load Current ②	80	
$I_F @ T_C = 25^\circ C$	Diode Continuous Forward Current	10	
$I_F @ T_C = 100^\circ C$	Diode Continuous Forward Current	4	
I_{FRM}	Maximum Repetitive Forward Current ③	16	V
V_{GE}	Gate-to-Emitter Voltage	± 20	
$P_D @ T_C = 25^\circ C$	Maximum Power Dissipation	215	W
$P_D @ T_C = 100^\circ C$	Maximum Power Dissipation	86	
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)	
	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)	—	—	0.58	$^\circ C/W$
$R_{\theta JC}$ (Diode)	Thermal Resistance Junction-to-Case-(each Diode)	—	—	5.0	
$R_{\theta CS}$	Thermal Resistance, Case-to-Sink (flat, greased surface)	—	0.50	—	
$R_{\theta JA}$	Thermal Resistance, Junction-to-Ambient (typical socket mount)	—	—	80	
	Weight	—	2 (0.07)	—	g (oz)

IRGB20B60PD1PbF

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

International
IR Rectifier

	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	—	0.32	—	V/ $^\circ\text{C}$	$V_{GE} = 0V, I_C = 1mA (25^\circ\text{C}-125^\circ\text{C})$	
R_G	Internal Gate Resistance	—	4.3	—	Ω	1MHz, Open Collector	
$V_{CE(on)}$	Collector-to-Emitter Saturation Voltage	—	2.05	2.35	V	$I_C = 13A, V_{GE} = 15V$	4, 5, 6, 8, 9
		—	2.50	2.80		$I_C = 20A, V_{GE} = 15V$	
		—	2.65	3.00		$I_C = 13A, V_{GE} = 15V, T_J = 125^\circ\text{C}$	
		—	3.30	3.70		$I_C = 20A, V_{GE} = 15V, T_J = 125^\circ\text{C}$	
$V_{GE(th)}$	Gate Threshold Voltage	3.0	4.0	5.0	V	$I_C = 250\mu A$	7, 8, 9
$\Delta V_{GE(th)}/\Delta T_J$	Threshold Voltage temp. coefficient	—	-11	—	mV/ $^\circ\text{C}$	$V_{CE} = V_{GE}, I_C = 1.0mA$	
g_{fe}	Forward Transconductance	—	19	—	S	$V_{CE} = 50V, I_C = 40A, PW = 80\mu s$	
I_{CES}	Collector-to-Emitter Leakage Current	—	1.0	250	μA	$V_{GE} = 0V, V_{CE} = 600V$	
		—	0.1	—	mA	$V_{GE} = 0V, V_{CE} = 600V, T_J = 125^\circ\text{C}$	
V_{FM}	Diode Forward Voltage Drop	—	1.5	1.8	V	$I_F = 4.0A, V_{GE} = 0V$	10
		—	1.4	1.7		$I_F = 4.0A, V_{GE} = 0V, T_J = 125^\circ\text{C}$	
I_{GES}	Gate-to-Emitter Leakage Current	—	—	± 100	nA	$V_{GE} = \pm 20V, V_{CE} = 0V$	

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)	—	68	102	nC	$I_C = 13A$	17 CT1
Q_{gc}	Gate-to-Collector Charge (turn-on)	—	24	36		$V_{CC} = 400V$	
Q_{ge}	Gate-to-Emitter Charge (turn-on)	—	10	15		$V_{GE} = 15V$	
E_{on}	Turn-On Switching Loss	—	95	140	μJ	$I_C = 13A, V_{CC} = 390V$	CT3
E_{off}	Turn-Off Switching Loss	—	100	145		$V_{GE} = +15V, R_G = 10\Omega, L = 200\mu H$	
E_{total}	Total Switching Loss	—	195	285		$T_J = 25^\circ\text{C}$ ④	
$t_{d(on)}$	Turn-On delay time	—	20	26	ns	$I_C = 13A, V_{CC} = 390V$	CT3
t_r	Rise time	—	5.0	7.0		$V_{GE} = +15V, R_G = 10\Omega, L = 200\mu H$	
$t_{d(off)}$	Turn-Off delay time	—	115	135		$T_J = 25^\circ\text{C}$ ④	
t_f	Fall time	—	6.0	8.0			
E_{on}	Turn-On Switching Loss	—	165	215	μJ	$I_C = 13A, V_{CC} = 390V$	CT3 11, 13 WF1, WF2
E_{off}	Turn-Off Switching Loss	—	150	195		$V_{GE} = +15V, R_G = 10\Omega, L = 200\mu H$	
E_{total}	Total Switching Loss	—	315	410		$T_J = 125^\circ\text{C}$ ④	
$t_{d(on)}$	Turn-On delay time	—	19	25	ns	$I_C = 13A, V_{CC} = 390V$	CT3 12, 14 WF1, WF2
t_r	Rise time	—	6.0	8.0		$V_{GE} = +15V, R_G = 10\Omega, L = 200\mu H$	
$t_{d(off)}$	Turn-Off delay time	—	125	140		$T_J = 125^\circ\text{C}$ ④	
t_f	Fall time	—	13	17			
C_{ies}	Input Capacitance	—	1560	—	pF	$V_{GE} = 0V$	16
C_{oes}	Output Capacitance	—	95	—		$V_{CC} = 30V$	
C_{res}	Reverse Transfer Capacitance	—	20	—		$f = 1Mhz$	
$C_{oes\ eff.}$	Effective Output Capacitance (Time Related) ⑤	—	83	—		$V_{GE} = 0V, V_{CE} = 0V \text{ to } 480V$	15
$C_{oes\ eff. (ER)}$	Effective Output Capacitance (Energy Related) ⑤	—	61	—			
RBSOA	Reverse Bias Safe Operating Area	FULL SQUARE				$T_J = 150^\circ\text{C}, I_C = 80A$ $V_{CC} = 480V, V_p = 600V$ $R_g = 22\Omega, V_{GE} = +15V \text{ to } 0V$	3 CT2
t_{rr}	Diode Reverse Recovery Time	—	28	42	ns	$T_J = 25^\circ\text{C}$ $I_F = 4.0A, V_R = 200V,$	19
		—	38	57		$T_J = 125^\circ\text{C}$ $di/dt = 200A/\mu s$	
Q_{rr}	Diode Reverse Recovery Charge	—	40	60	nC	$T_J = 25^\circ\text{C}$ $I_F = 4.0A, V_R = 200V,$	21
		—	70	105		$T_J = 125^\circ\text{C}$ $di/dt = 200A/\mu s$	
I_{rr}	Peak Reverse Recovery Current	—	2.9	5.2	A	$T_J = 25^\circ\text{C}$ $I_F = 4.0A, V_R = 200V,$	19, 20, 21, 22
		—	3.7	6.7		$T_J = 125^\circ\text{C}$ $di/dt = 200A/\mu s$	

Notes:

- ① $R_{CE(on)}$ typ. = equivalent on-resistance = $V_{CE(on)}$ typ. / I_C , where $V_{CE(on)}$ typ. = 2.05V and $I_C = 13A$. 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 $V_{CC} = 80\% (V_{CES}), V_{GE} = 15V, L = 28\mu H, R_G = 22\Omega$.
- ③ Pulse width limited by max. junction temperature.
- ④ Energy losses include "tail" and diode reverse recovery. Data generated with use of Diode 8ETH06.
- 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} .

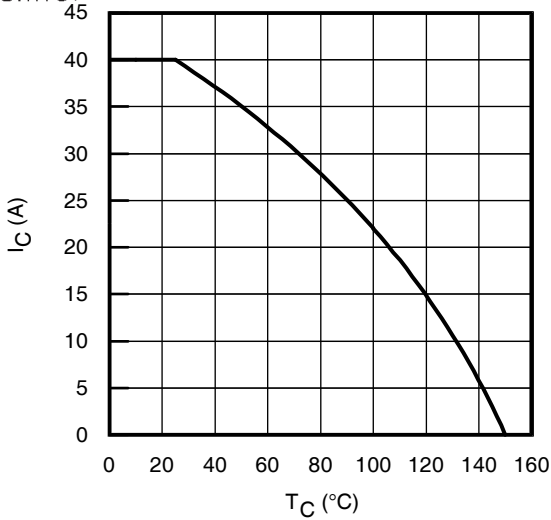


Fig. 1 - Maximum DC Collector Current vs. Case Temperature

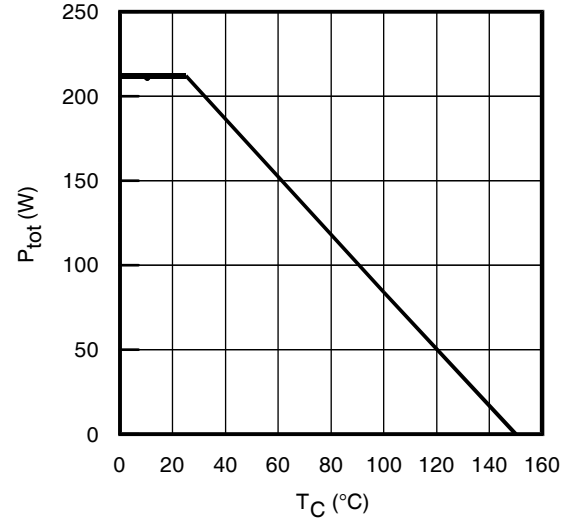


Fig. 2 - Power Dissipation vs. Case Temperature

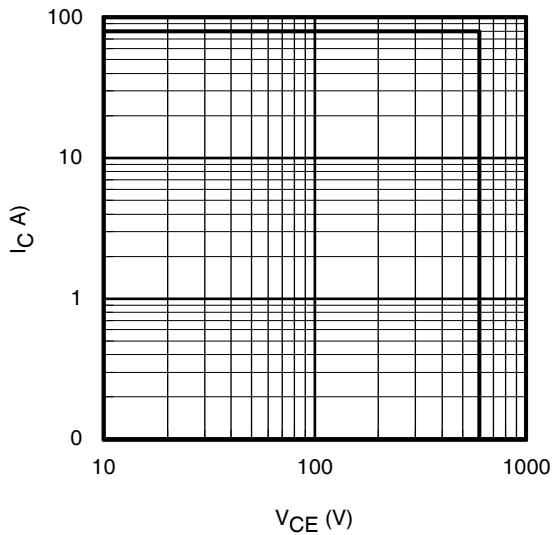


Fig. 3 - Reverse Bias SOA
 $T_J = 150^\circ\text{C}$; $V_{GE} = 15\text{V}$

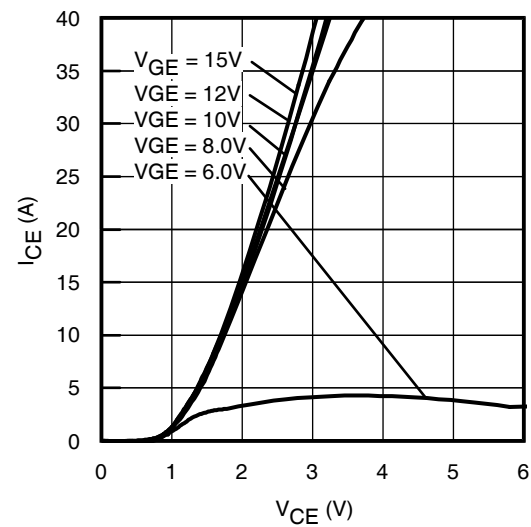


Fig. 4 - Typ. IGBT Output Characteristics
 $T_J = -40^\circ\text{C}$; $t_p = 80\mu\text{s}$

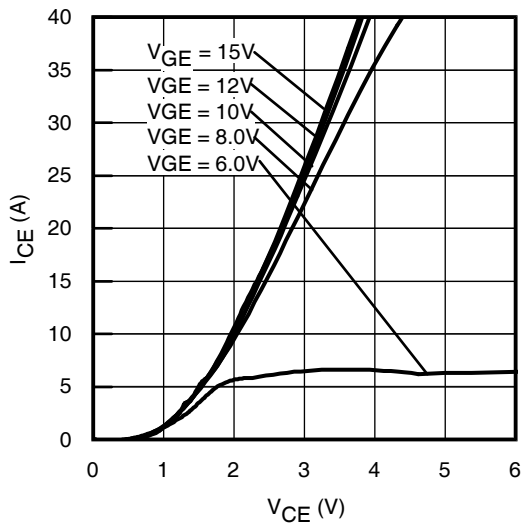


Fig. 5 - Typ. IGBT Output Characteristics
 $T_J = 25^\circ\text{C}$; $t_p = 80\mu\text{s}$

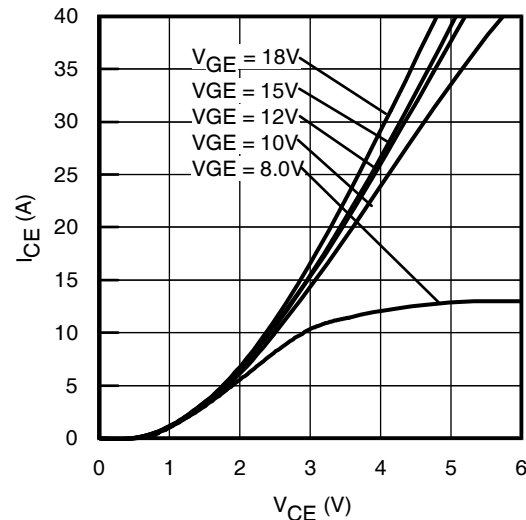


Fig. 6 - Typ. IGBT Output Characteristics
 $T_J = 125^\circ\text{C}$; $t_p = 80\mu\text{s}$

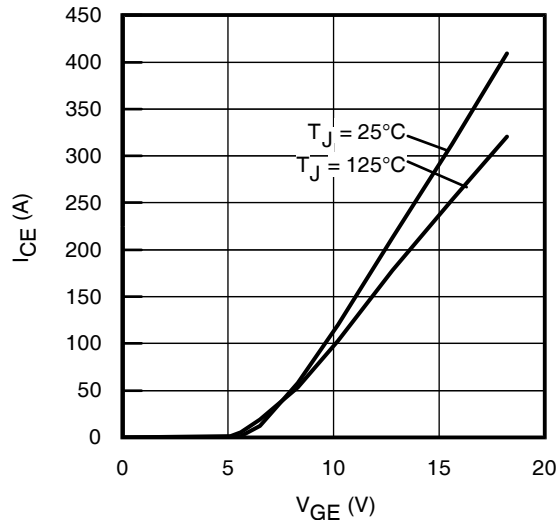


Fig. 7 - Typ. Transfer Characteristics
 $V_{CE} = 50V$; $t_p = 10\mu s$

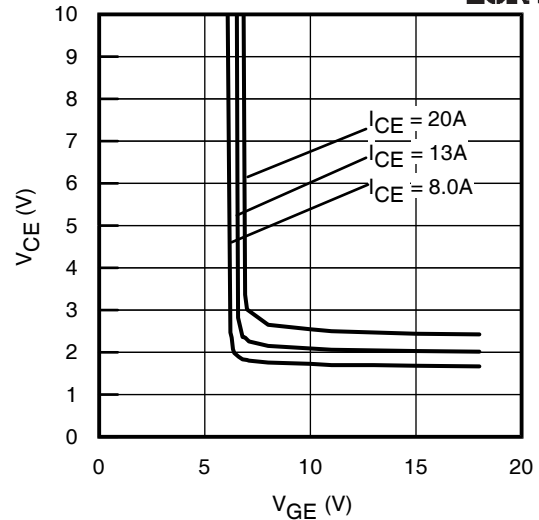


Fig. 8 - Typical V_{CE} vs. V_{GE}
 $T_J = 25^\circ C$

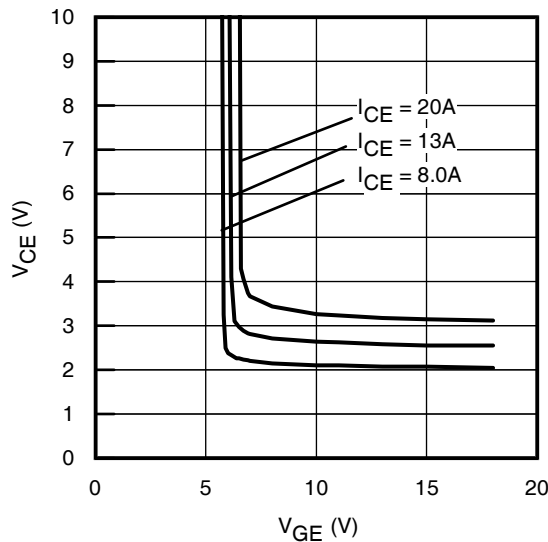


Fig. 9 - Typical V_{CE} vs. V_{GE}
 $T_J = 125^\circ C$

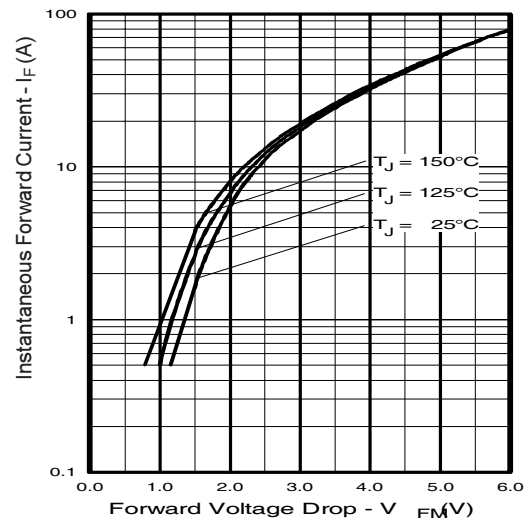


Fig. 10 - Typ. Diode Forward Characteristics
 $t_p = 80\mu s$

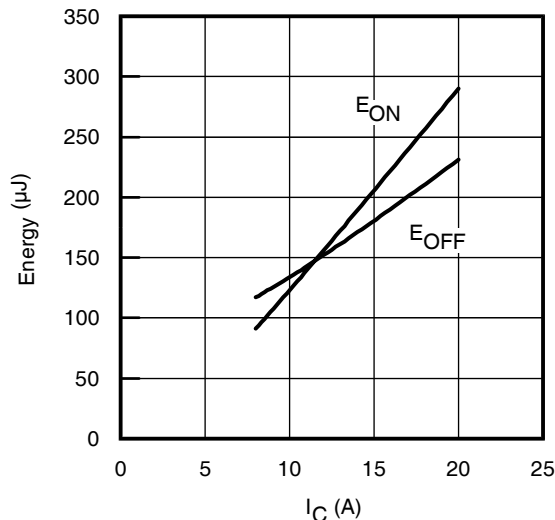


Fig. 11 - Typ. Energy Loss vs. I_C
 $T_J = 125^\circ C$; $L = 200\mu H$; $V_{CE} = 390V$; $R_G = 10\Omega$; $V_{GE} = 15V$.
Diode clamp used: 8ETH06 (See C.T.3)

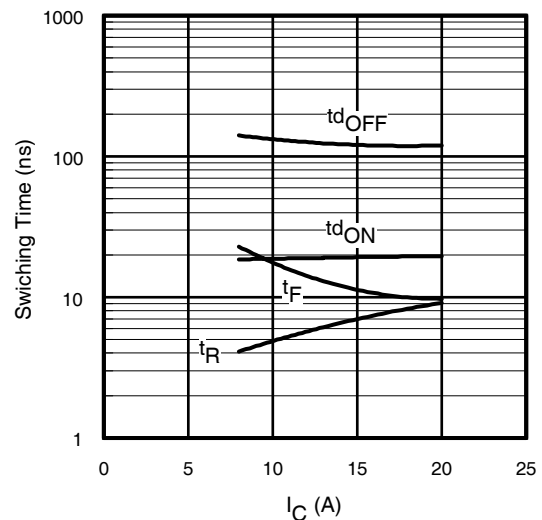


Fig. 12 - Typ. Switching Time vs. I_C
 $T_J = 125^\circ C$; $L = 200\mu H$; $V_{CE} = 390V$; $R_G = 10\Omega$; $V_{GE} = 15V$.
Diode clamp used: 8ETH06 (See C.T.3)

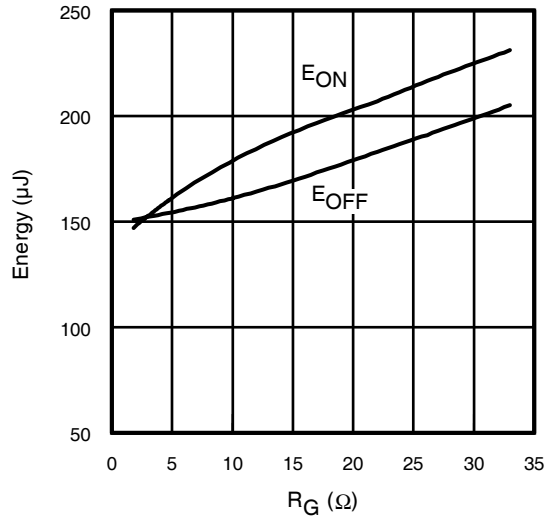


Fig. 13 - Typ. Energy Loss vs. R_G
 $T_J = 125^\circ\text{C}$; $L = 200\mu\text{H}$; $V_{CE} = 390\text{V}$; $I_{CE} = 13\text{A}$; $V_{GE} = 15\text{V}$
 Diode clamp used: 8ETH06 (See C.T.3)

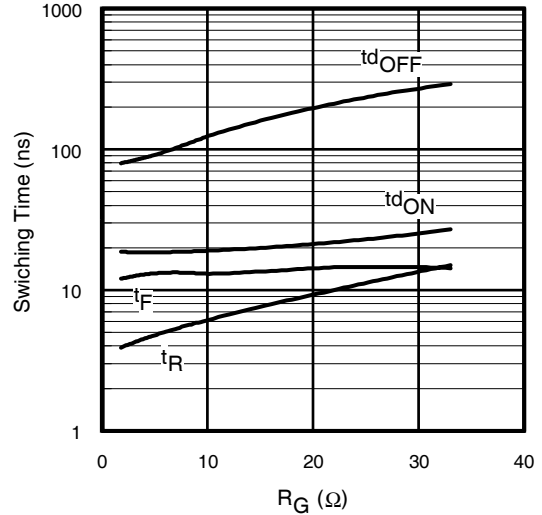


Fig. 14 - Typ. Switching Time vs. R_G
 $T_J = 125^\circ\text{C}$; $L = 200\mu\text{H}$; $V_{CE} = 390\text{V}$; $I_{CE} = 13\text{A}$; $V_{GE} = 15\text{V}$
 Diode clamp used: 8ETH06 (See C.T.3)

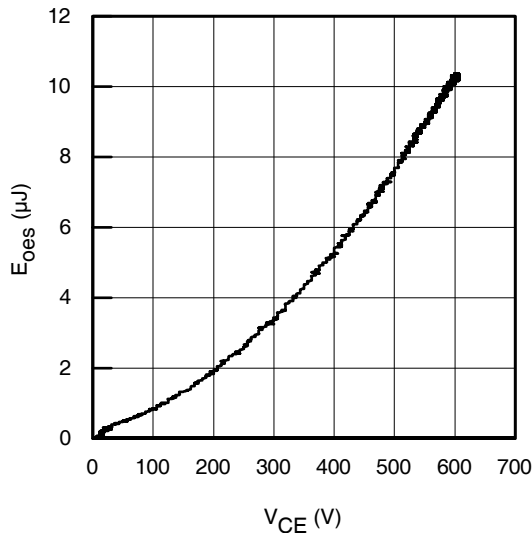


Fig. 15- Typ. Output Capacitance
 Stored Energy vs. V_{CE}

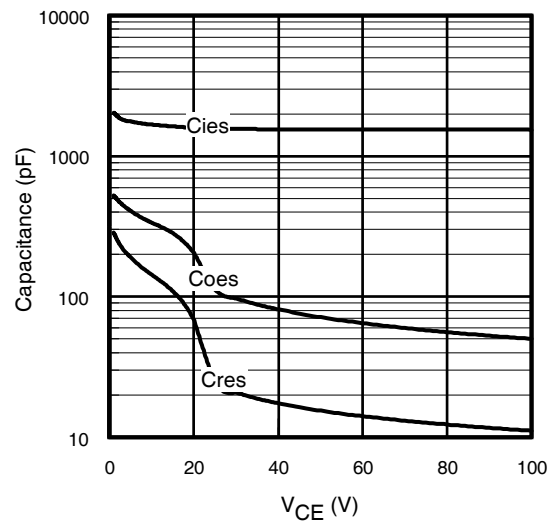


Fig. 16- Typ. Capacitance vs. V_{CE}
 $V_{GE} = 0\text{V}$; $f = 1\text{MHz}$

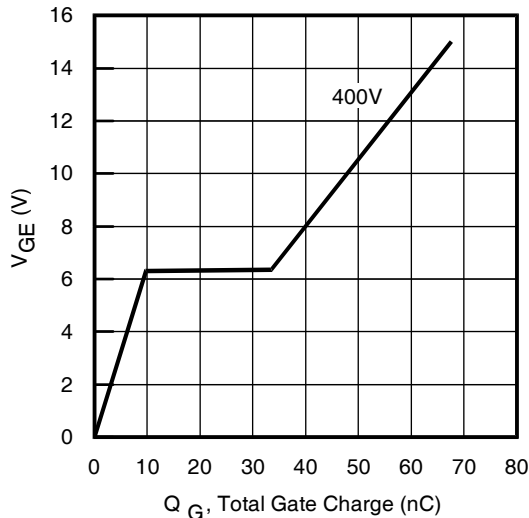


Fig. 17 - Typical Gate Charge vs. V_{GE}
 $I_{CE} = 13\text{A}$

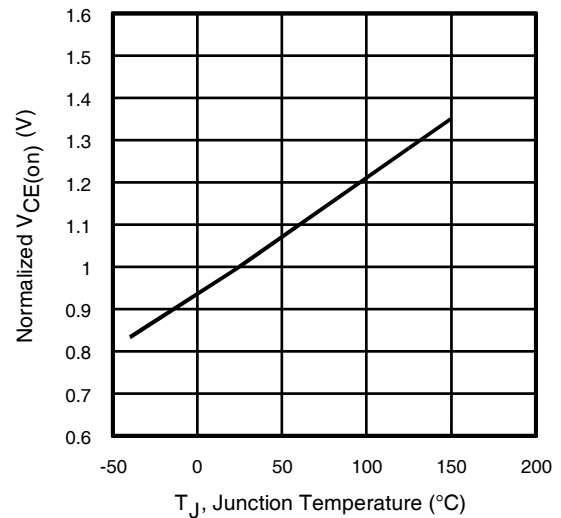


Fig. 18 - Normalized Typical $V_{CE(on)}$ vs.
 Junction Temperature
 $I_{CE} = 13\text{A}$; $V_{GE} = 15\text{V}$

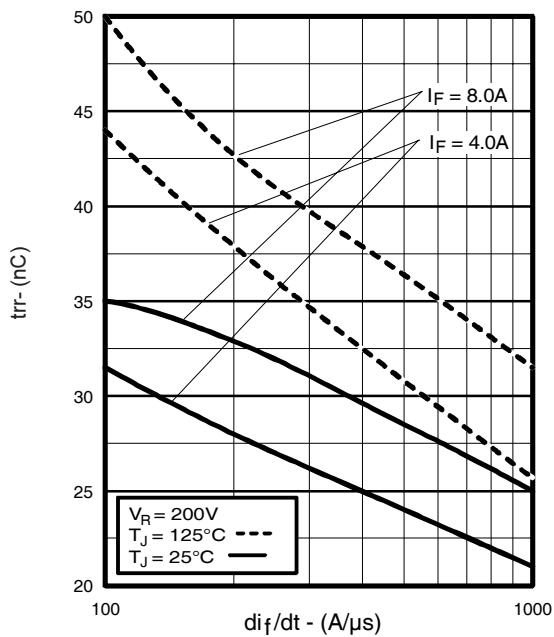


Fig. 19 - Typical Reverse Recovery vs. di_f/dt

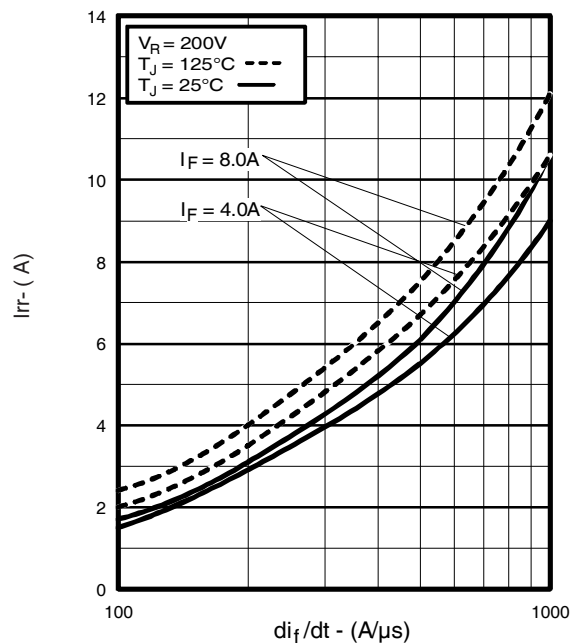


Fig. 20 - Typical Recovery Current vs. di_f/dt

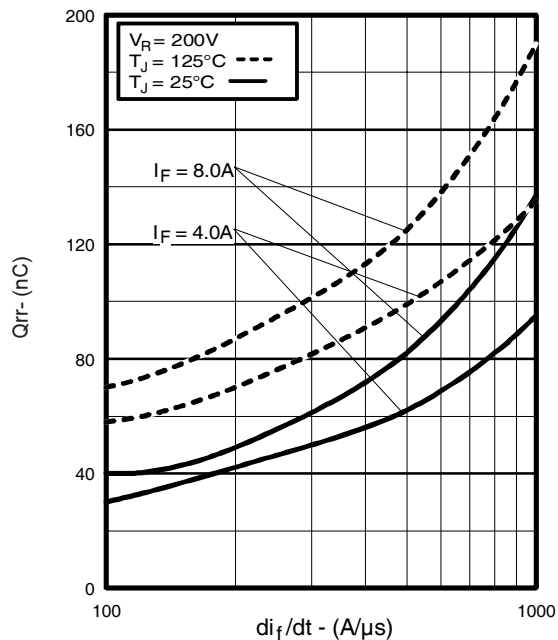


Fig. 21 - Typical Stored Charge vs. di_f/dt

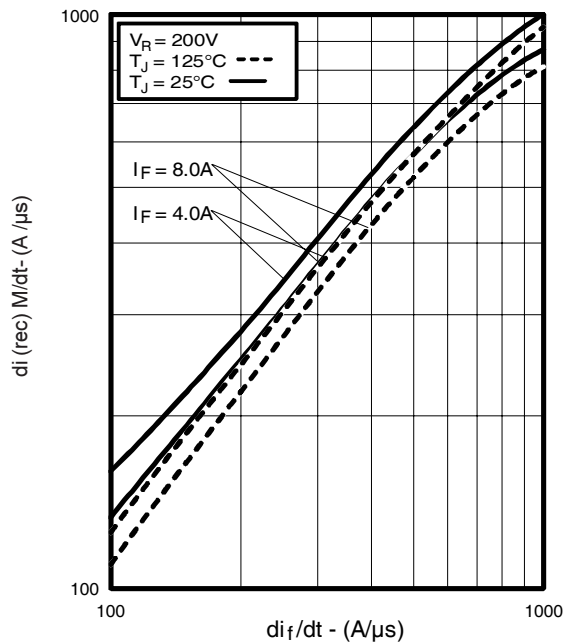


Fig. 22 - Typical $di_{(rec)}M/dt$ vs. di_f/dt ,

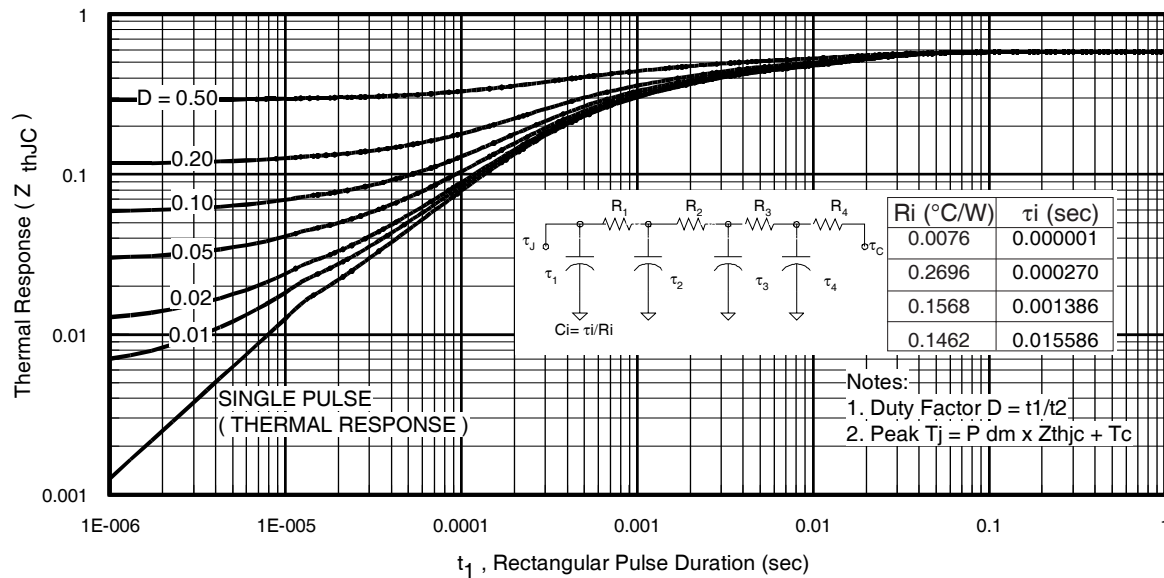


Fig 23. Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

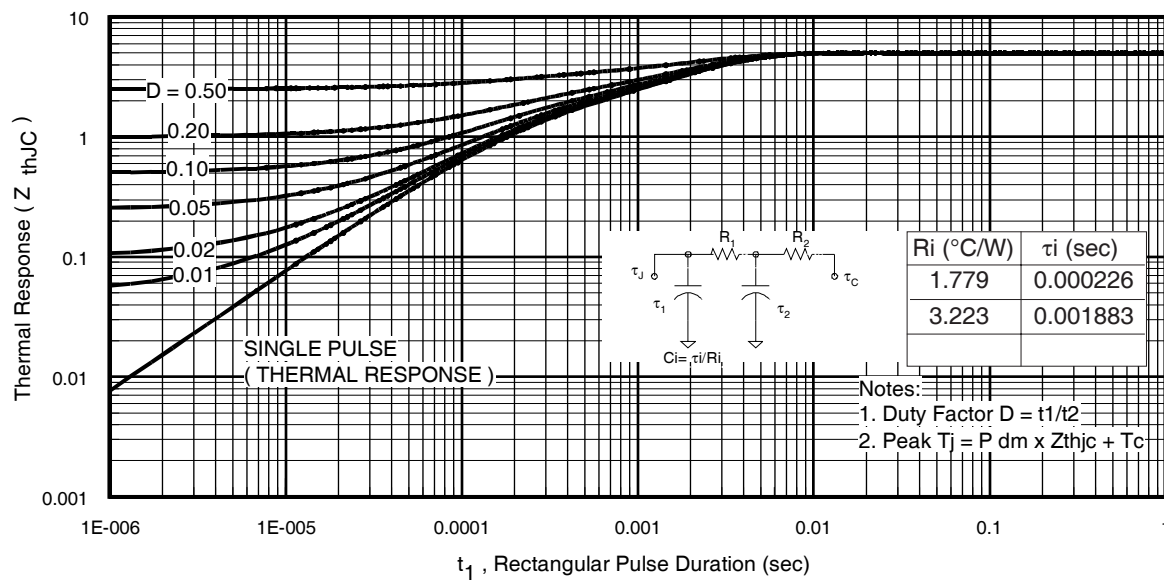


Fig. 24. Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)

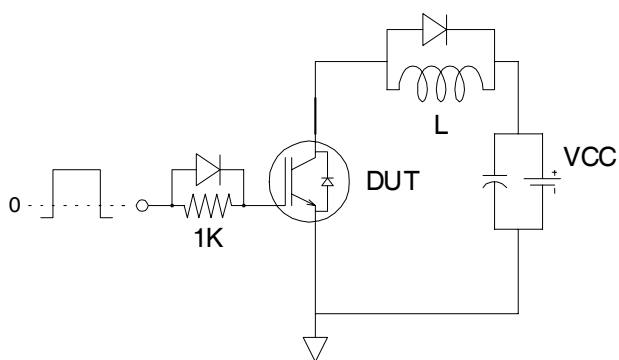


Fig.C.T.1 - Gate Charge Circuit (turn-off)

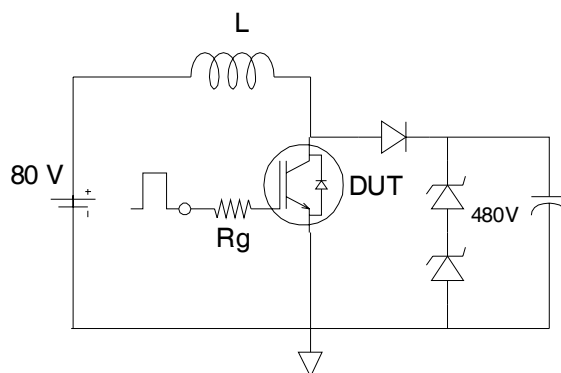


Fig.C.T.2 - RBSOA Circuit

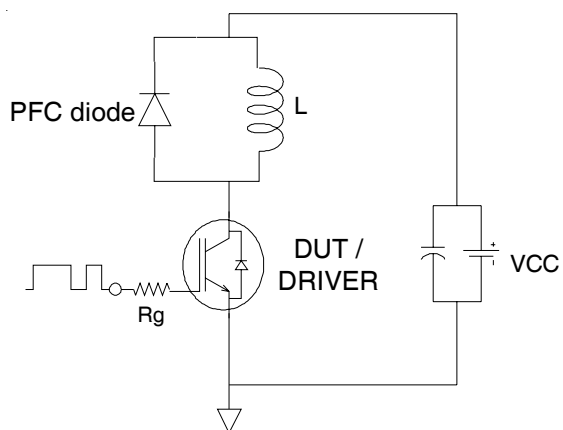


Fig.C.T.3 - Switching Loss Circuit

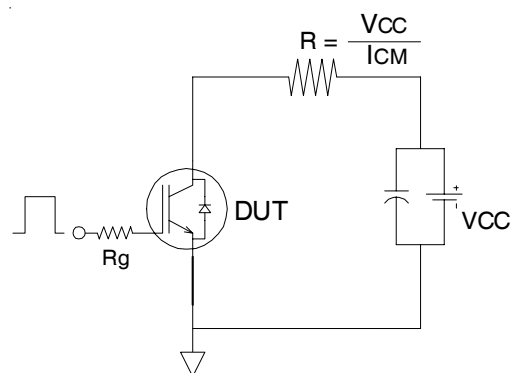


Fig.C.T.4 - Resistive Load Circuit

REVERSE RECOVERY CIRCUIT

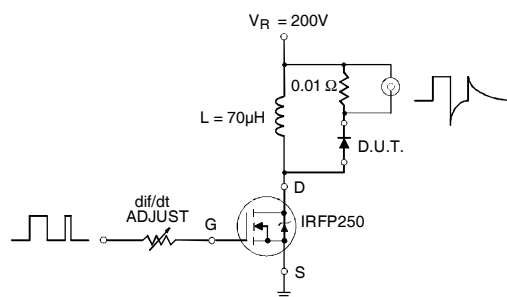


Fig. C.T.5 - Reverse Recovery Parameter Test Circuit

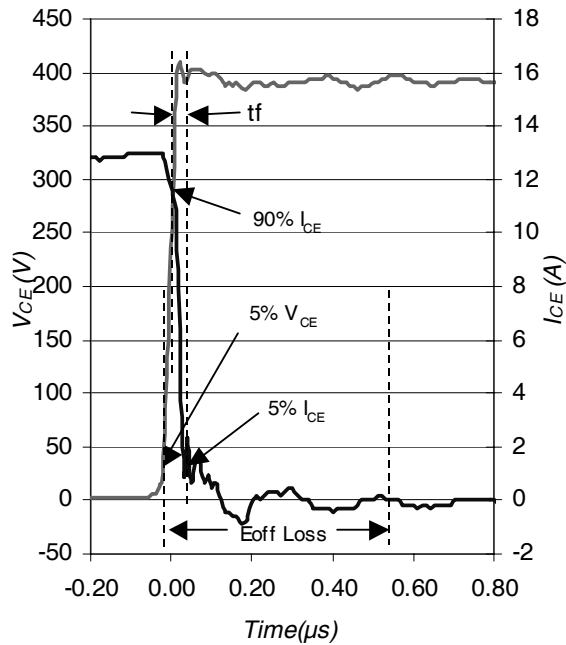


Fig. WF1 - Typ. Turn-off Loss Waveform
@ $T_J = 125^\circ\text{C}$ using Fig. CT.3

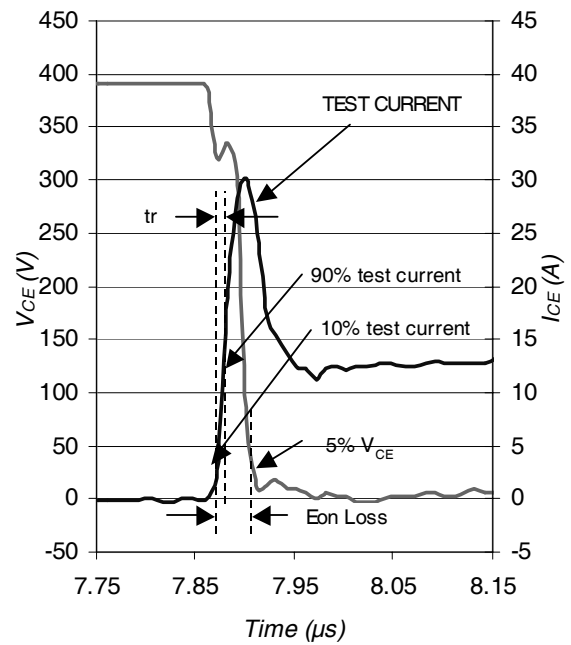


Fig. WF2 - Typ. Turn-on Loss Waveform
@ $T_J = 125^\circ\text{C}$ using Fig. CT.3

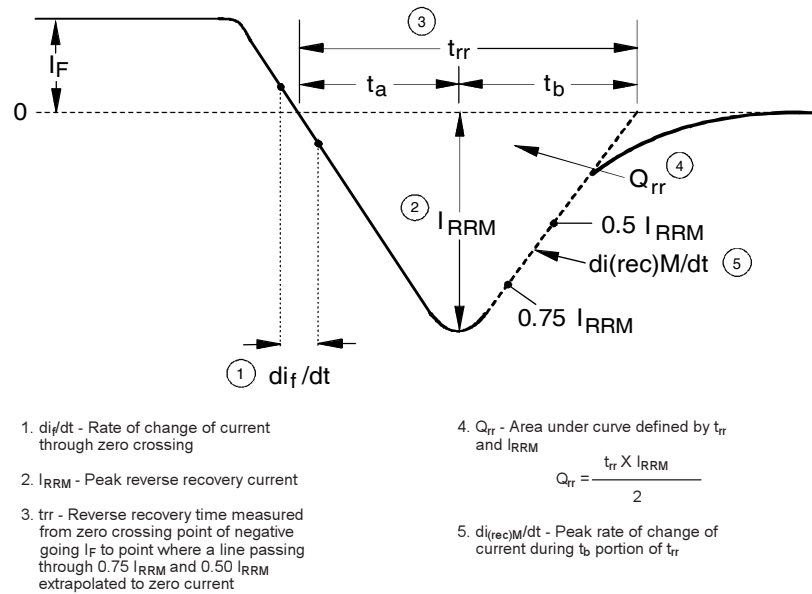
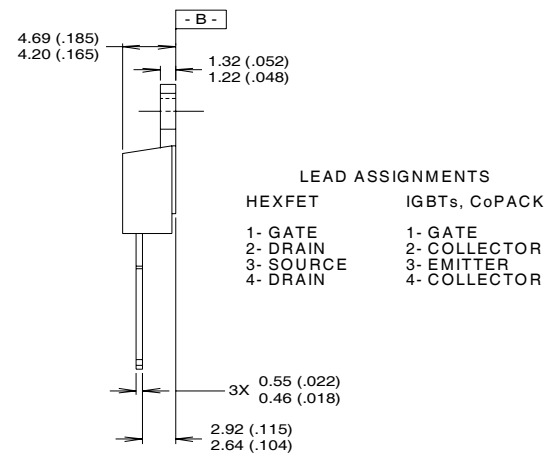
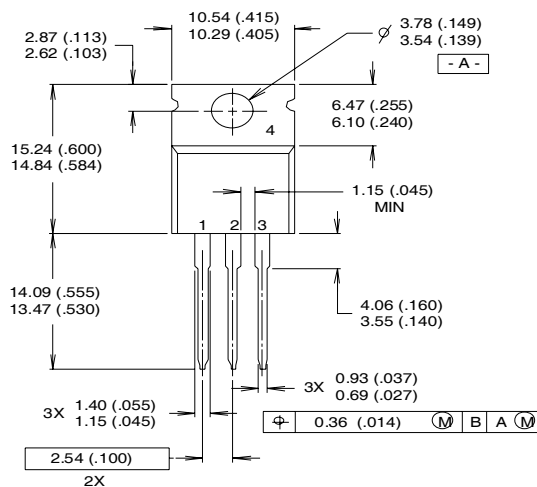


Fig. WF3 - Reverse Recovery Waveform and Definitions

TO-220AB Package Outline

Dimensions are shown in millimeters (inches)



LEAD ASSIGNMENTS	
HEXFET	IGBTs, CoPACK
1- GATE	1- GATE
2- DRAIN	2- COLLECTOR
3- SOURCE	3- EMITTER
4- DRAIN	4- COLLECTOR

NOTES:

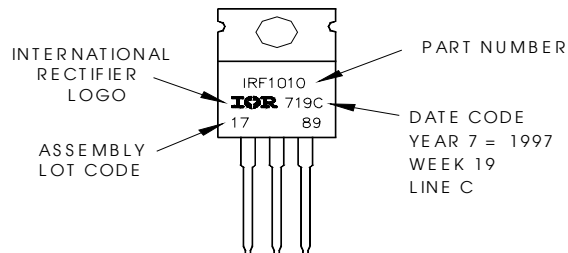
- 1 DIMENSIONING & TOLERANCING PER ANSI Y14.5M, 1982.
- 2 CONTROLLING DIMENSION : INCH

- 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"



TO-220AB 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

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TAC Fax: (310) 252-7903

Visit us at www.irf.com for sales contact information. 08/04

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