International
IOR Rectifier

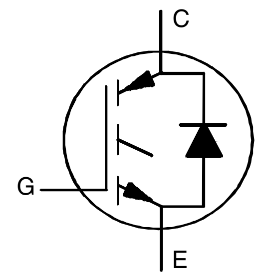
**SMPS IGBT**

# IRGP20B60PD

## 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

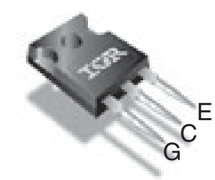


n-channel

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

**Equivalent MOSFET Parameters** ①
$R_{CE(on)}$ typ. = 158mΩ
$I_D$ (FET equivalent) = 20A

### 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



TO-247AC

### 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 | 40 | A |
| $I_C$ @ $T_C$ = 100°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°C | Diode Continous Forward Current | 31 | |
| $I_F$ @ $T_C$ = 100°C | Diode Continous Forward Current | 12 | |
| $I_{FRM}$ | Maximum Repetitive Forward Current ③ | 42 | |
| $V_{GE}$ | Gate-to-Emitter Voltage | ±20 | V |
| $P_D$ @ $T_C$ = 25°C | Maximum Power Dissipation | 220 | W |
| $P_D$ @ $T_C$ = 100°C | Maximum Power Dissipation | 86 | |
| $T_J$<br>$T_{STG}$ | Operating Junction and<br>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) | ––– | ––– | 0.58 | °C/W |
| $R_{\theta JC}$ (Diode) | Thermal Resistance Junction-to-Case-(each Diode) | ––– | ––– | 2.5 | |
| $R_{\theta CS}$ | Thermal Resistance, Case-to-Sink (flat, greased surface) | ––– | 0.24 | ––– | |
| $R_{\theta JA}$ | Thermal Resistance, Junction-to-Ambient (typical socket mount) | ––– | ––– | 40 | |
| | Weight | ––– | 6 (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 | — | 0.32 | — | V/°C | $V_{GE}$ = 0V, $I_C$ = 1mA (25°C-125°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°C | |
| | | — | 3.30 | 3.70 | | $I_C$ = 20A, $V_{GE}$ = 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 | — | -11 | — | mV/°C | $V_{CE}$ = $V_{GE}$, $I_C$ = 1.0mA | |
| gfe | Forward Transconductance | — | 19 | — | S | $V_{CE}$ = 50V, $I_C$ = 40A, PW = 80μs | |
| $I_{CES}$ | 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°C | |
| $V_{FM}$ | Diode Forward Voltage Drop | — | 1.4 | 1.7 | V | $I_F$ = 12A, $V_{GE}$ = 0V | 10 |
| | | — | 1.3 | 1.6 | | $I_F$ = 12A, $V_{GE}$ = 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) | — | 68 | 102 | nC | $I_C$ = 13A | 17 |
| $Q_{gc}$ | Gate-to-Collector Charge (turn-on) | — | 24 | 36 | | $V_{CC}$ = 400V | CT1 |
| $Q_{ge}$ | 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, $R_G$ = 10Ω, L = 200μH | |
| $E_{total}$ | Total Switching Loss | — | 195 | 285 | | $T_J$ = 25°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, $R_G$ = 10Ω, L = 200μH | |
| $t_{d(off)}$ | Turn-Off delay time | — | 115 | 135 | | $T_J$ = 25°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 |
| $E_{off}$ | Turn-Off Switching Loss | — | 150 | 195 | | $V_{GE}$ = +15V, $R_G$ = 10Ω, L = 200μH | 11,13 |
| $E_{total}$ | Total Switching Loss | — | 315 | 410 | | $T_J$ = 125°C ④ | WF1,WF2 |
| $t_{d(on)}$ | Turn-On delay time | — | 19 | 25 | ns | $I_C$ = 13A, $V_{CC}$ = 390V | CT3 |
| $t_r$ | Rise time | — | 6.0 | 8.0 | | $V_{GE}$ = +15V, $R_G$ = 10Ω, L = 200μH | 12,14 |
| $t_{d(off)}$ | Turn-Off delay time | — | 125 | 140 | | $T_J$ = 125°C ④ | WF1,WF2 |
| $t_f$ | Fall time | — | 13 | 17 | | | |
| $C_{ies}$ | Input Capacitance | — | 1570 | — | pF | $V_{GE}$ = 0V | 16 |
| $C_{oes}$ | Output Capacitance | — | 130 | — | | $V_{CC}$ = 30V | |
| $C_{res}$ | Reverse Transfer Capacitance | — | 20 | — | | f = 1Mhz | |
| $C_{oes}$ eff. | Effective Output Capacitance (Time Related) ⑤ | — | 94 | — | | $V_{GE}$ = 0V, $V_{CE}$ = 0V to 480V | 15 |
| $C_{oes}$ eff. (ER) | Effective Output Capacitance (Energy Related) ⑤ | — | 76 | — | | | |
| RBSOA | Reverse Bias Safe Operating Area | FULL SQUARE | | | | $T_J$ = 150°C, $I_C$ = 80A<br>$V_{CC}$ = 480V, Vp =600V<br>Rg = 22Ω, $V_{GE}$ = +15V to 0V | 3<br>CT2 |
| $t_{rr}$ | Diode Reverse Recovery Time | — | 42 | 60 | ns | $T_J$ = 25°C $I_F$ = 12A, $V_R$ = 200V, | 19 |
| | | — | 80 | 120 | | $T_J$ = 125°C di/dt = 200A/μs | |
| $Q_{rr}$ | Diode Reverse Recovery Charge | — | 80 | 180 | nC | $T_J$ = 25°C $I_F$ = 12A, $V_R$ = 200V, | 21 |
| | | — | 220 | 600 | | $T_J$ = 125°C di/dt = 200A/μs | |
| $I_{rr}$ | Peak Reverse Recovery Current | — | 3.5 | 6.0 | A | $T_J$ = 25°C $I_F$ = 12A, $V_R$ = 200V, | 19,20,21,22 |
| | | — | 5.6 | 10 | | $T_J$ = 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. = 2.05V 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 = 28μH, $R_G$ = 22Ω.

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% $V_{CES}$.

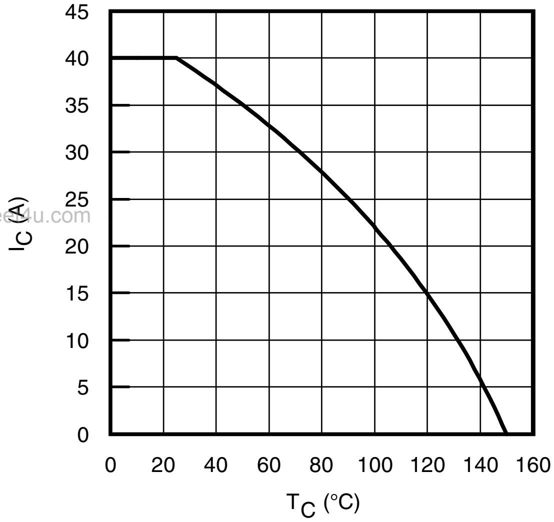





**Fig. 1** - Maximum DC Collector Current vs. Case Temperature

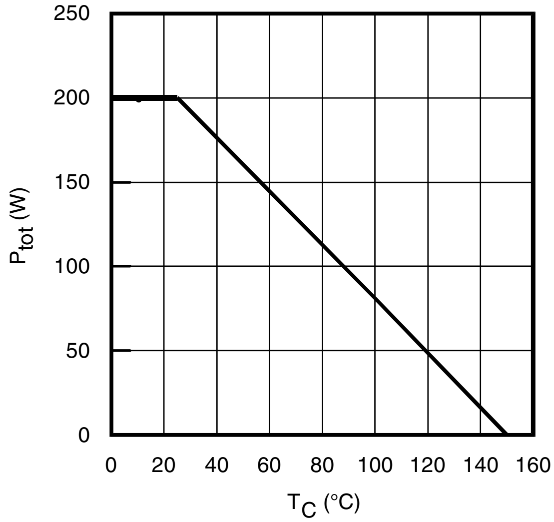



**Fig. 2** - Power Dissipation vs. Case Temperature

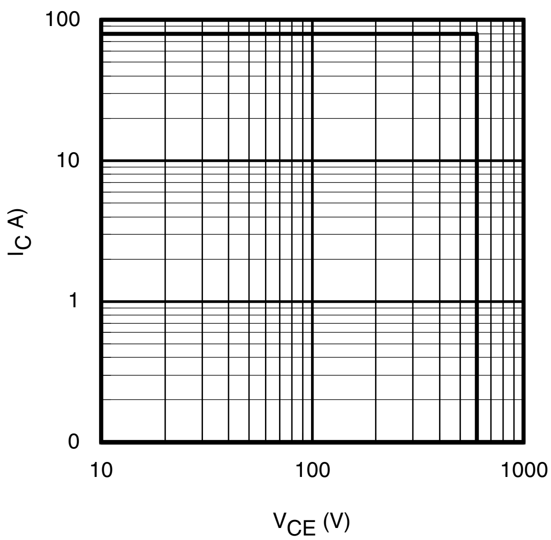



**Fig. 3** - Reverse Bias SOA
$T_J$ = 150°C; $V_{GE}$ =15V

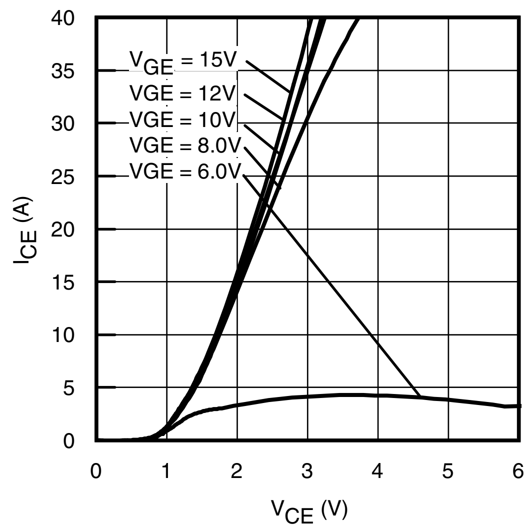



**Fig. 4** - Typ. IGBT Output Characteristics
$T_J$ = -40°C; tp = 80µs

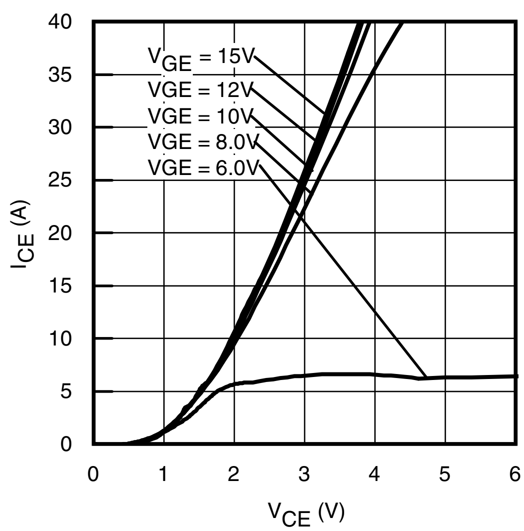



**Fig. 5** - Typ. IGBT Output Characteristics
$T_J$ = 25°C; tp = 80µs

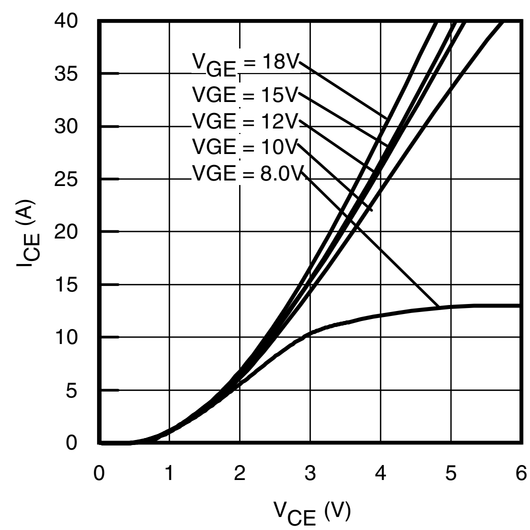



**Fig. 6** - Typ. IGBT Output Characteristics
$T_J$ = 125°C; tp = 80µs

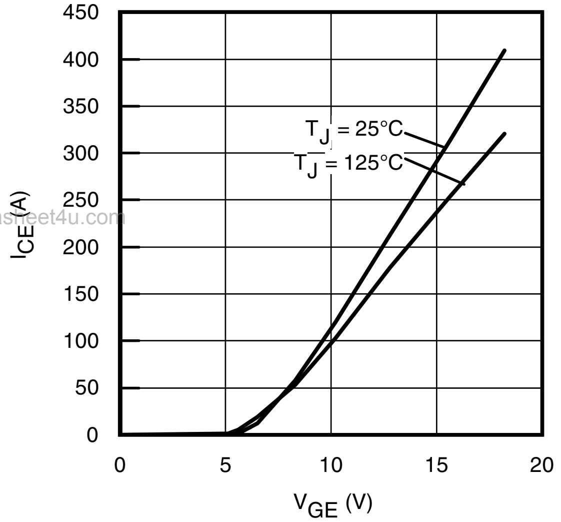



**Fig. 7** - Typ. Transfer Characteristics
$V_{CE}$ = 50V; tp = 10µs



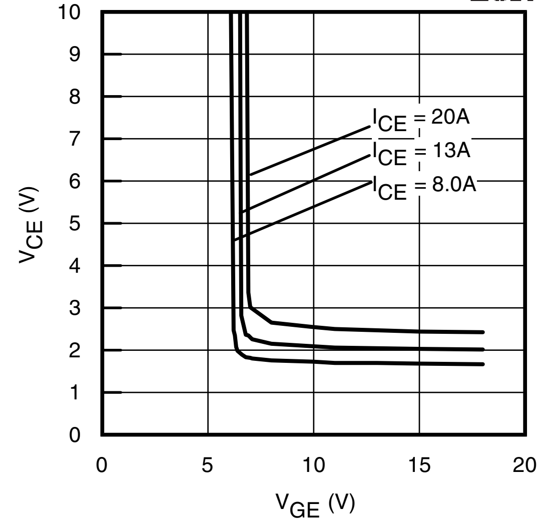



**Fig. 8** - Typical $V_{CE}$ vs. $V_{GE}$
$T_J$ = 25°C

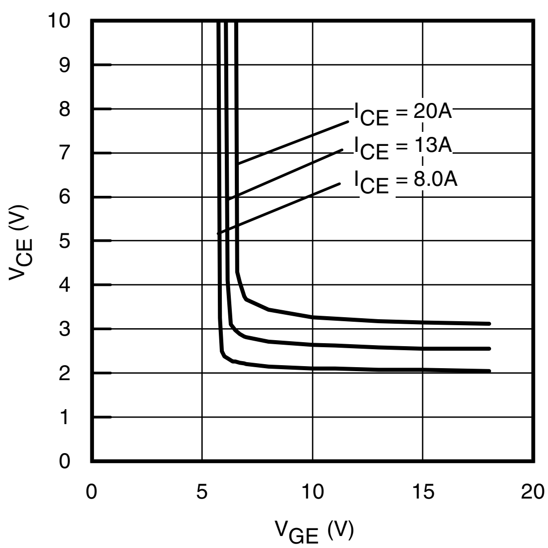



**Fig. 9** - Typical $V_{CE}$ vs. $V_{GE}$
$T_J$ = 125°C

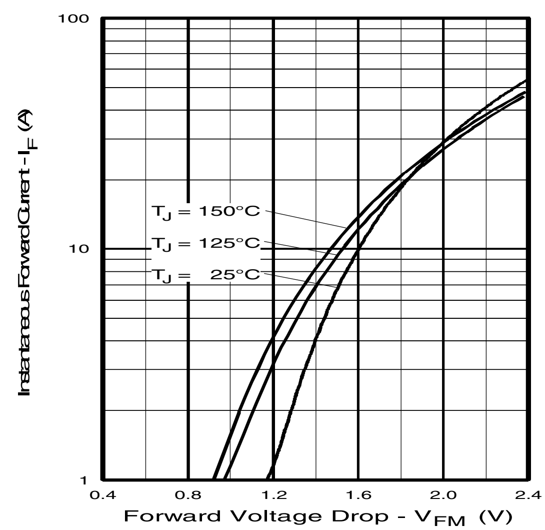



**Fig. 10** - Typ. Diode Forward Characteristics
tp = 80µs

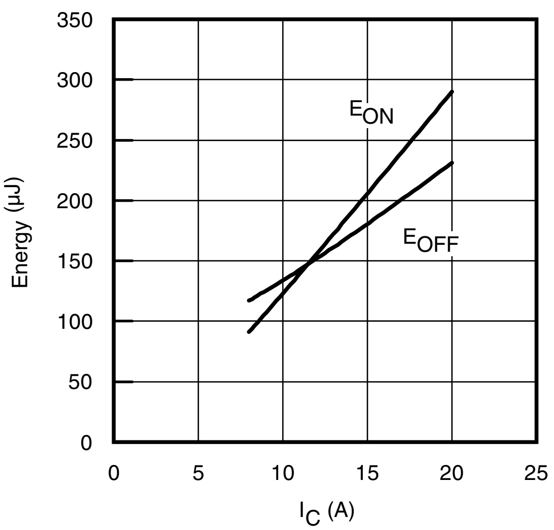



**Fig. 11** - Typ. Energy Loss vs. $I_C$
$T_J$ = 125°C; L = 200µH; $V_{CE}$ = 390V, $R_G$ = 10Ω; $V_{GE}$ = 15V.
Diode clamp used: 8ETH06 (See C.T.3)

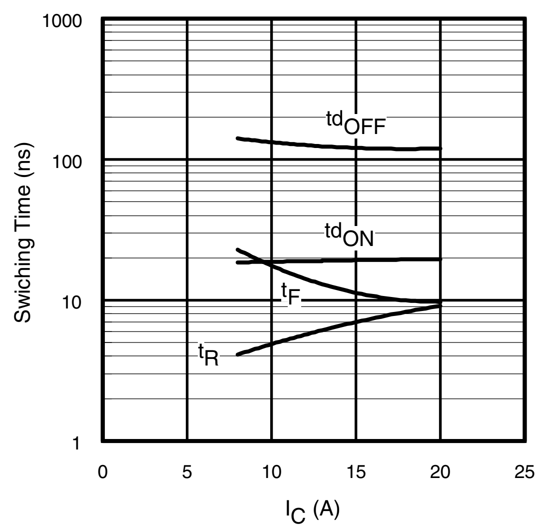



**Fig. 12** - Typ. Switching Time vs. $I_C$
$T_J$ = 125°C; L = 200µH; $V_{CE}$ = 390V, $R_G$ = 10Ω; $V_{GE}$ = 15V.
Diode clamp used: 8ETH06 (See C.T.3)

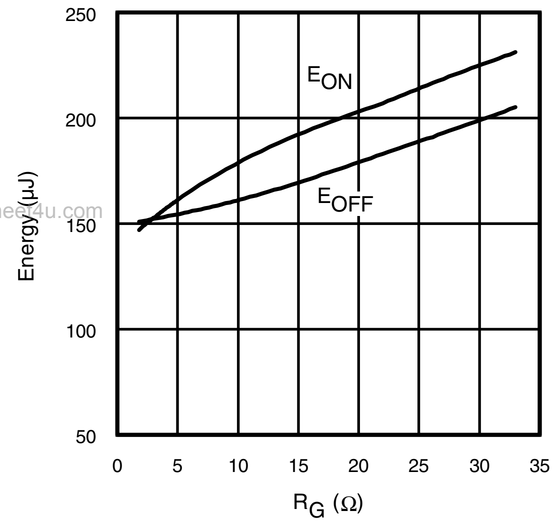



**Fig. 13** - Typ. Energy Loss vs. $R_G$
$T_J$ = 125°C; L = 200μH; $V_{CE}$ = 390V, $I_{CE}$ = 13A; $V_{GE}$ = 15V
Diode clamp used: 8ETH06 (See C.T.3)



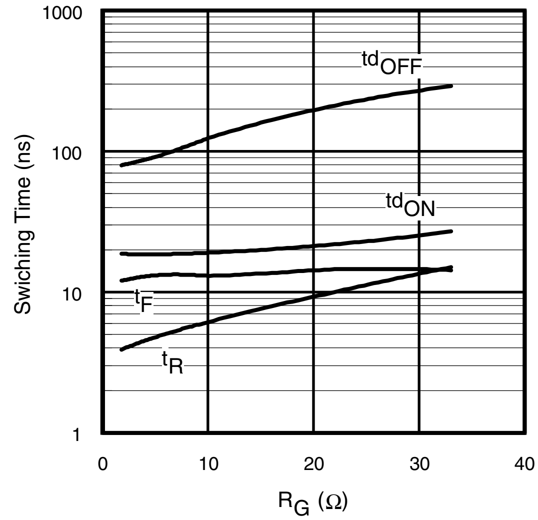



**Fig. 14** - Typ. Switching Time vs. $R_G$
$T_J$ = 125°C; L = 200μH; $V_{CE}$ = 390V, $I_{CE}$ = 13A; $V_{GE}$ = 15V
Diode clamp used: 8ETH06 (See C.T.3)

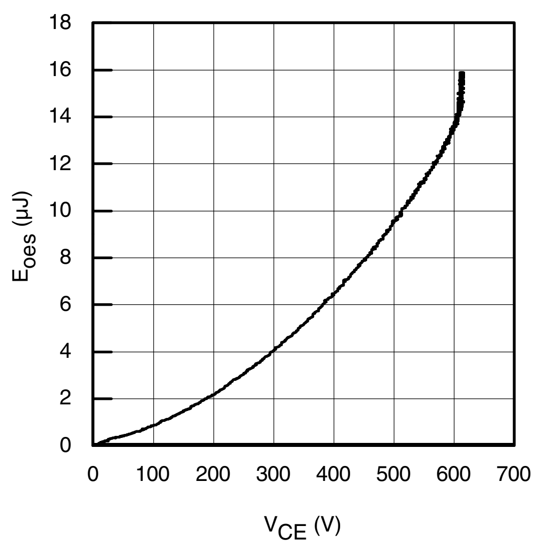



**Fig. 15**- Typ. Output Capacitance Stored Energy vs. $V_{CE}$

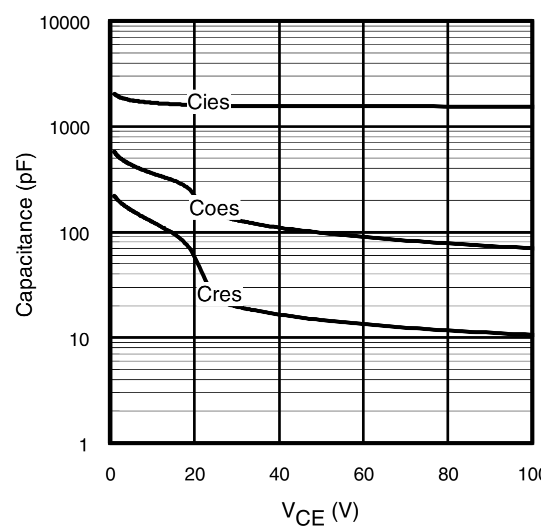



**Fig. 16**- Typ. Capacitance vs. $V_{CE}$
$V_{GE}$= 0V; f = 1MHz

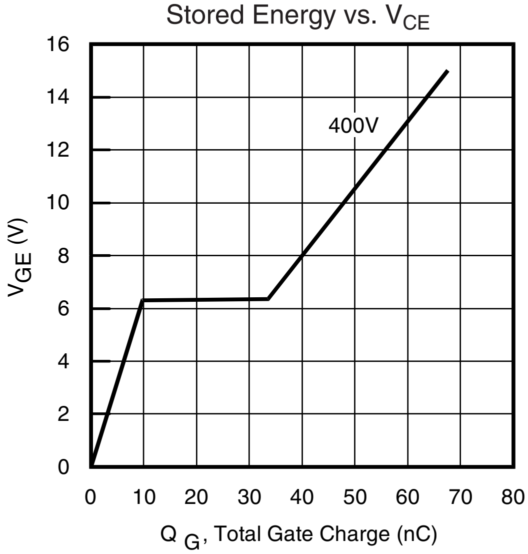



**Fig. 17** - Typical Gate Charge vs. $V_{GE}$
$I_{CE}$ = 13A

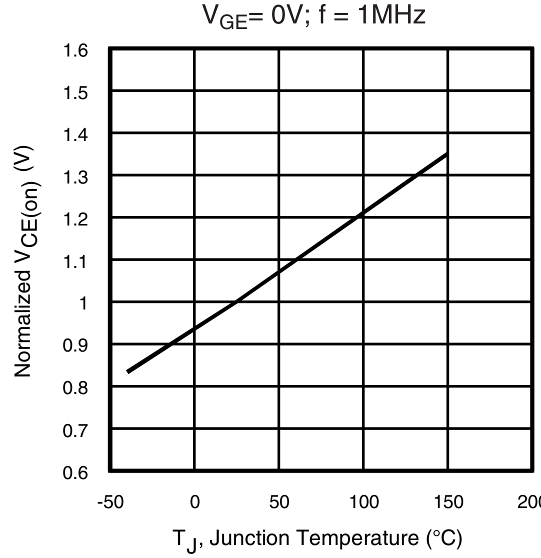



**Fig. 18** - Normalized Typical $V_{CE(on)}$ vs. Junction Temperature
$I_{CE}$ = 13A, $V_{GE}$ = 15V

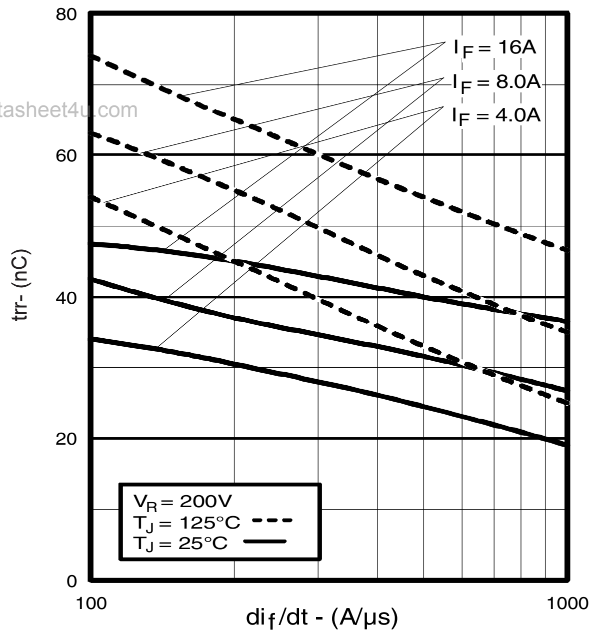



**Fig. 19 -** Typical Reverse Recovery vs. $di_f/dt$

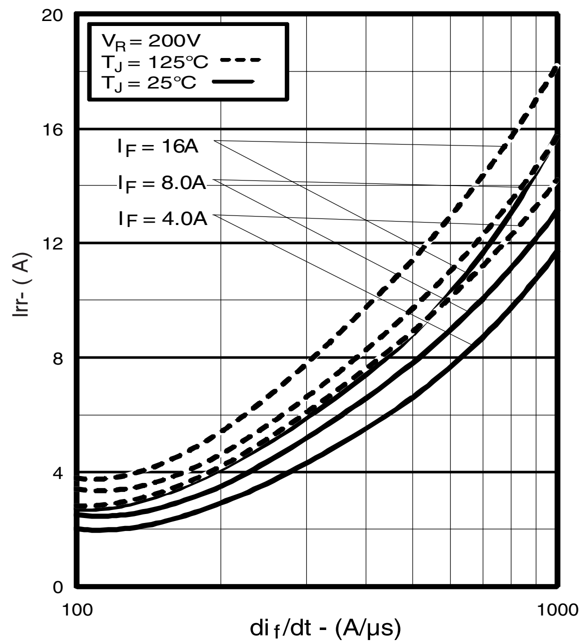



**Fig. 20 -** Typical Recovery Current vs. $di_f/dt$

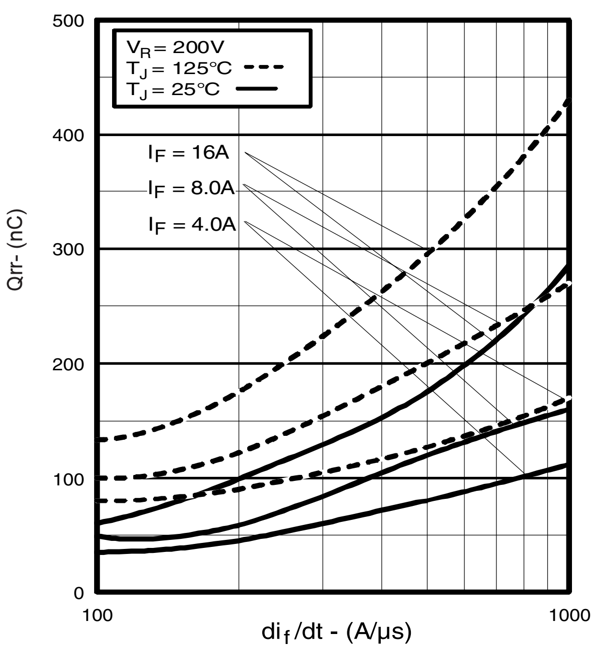



**Fig. 21 -** Typical Stored Charge vs. $di_f/dt$

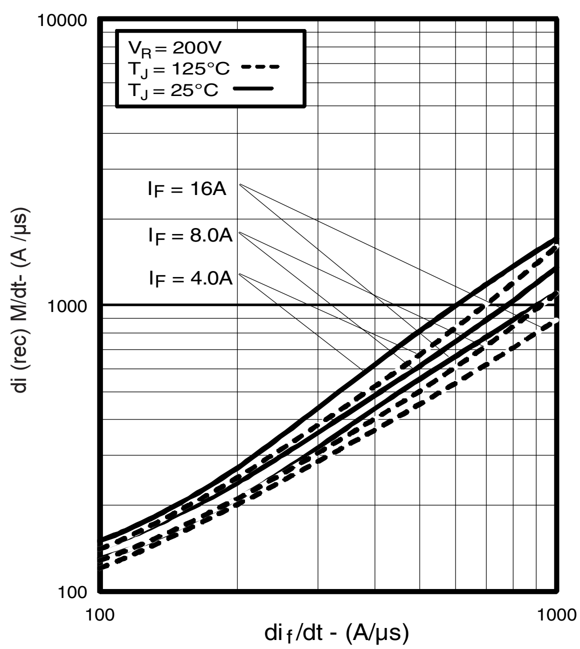
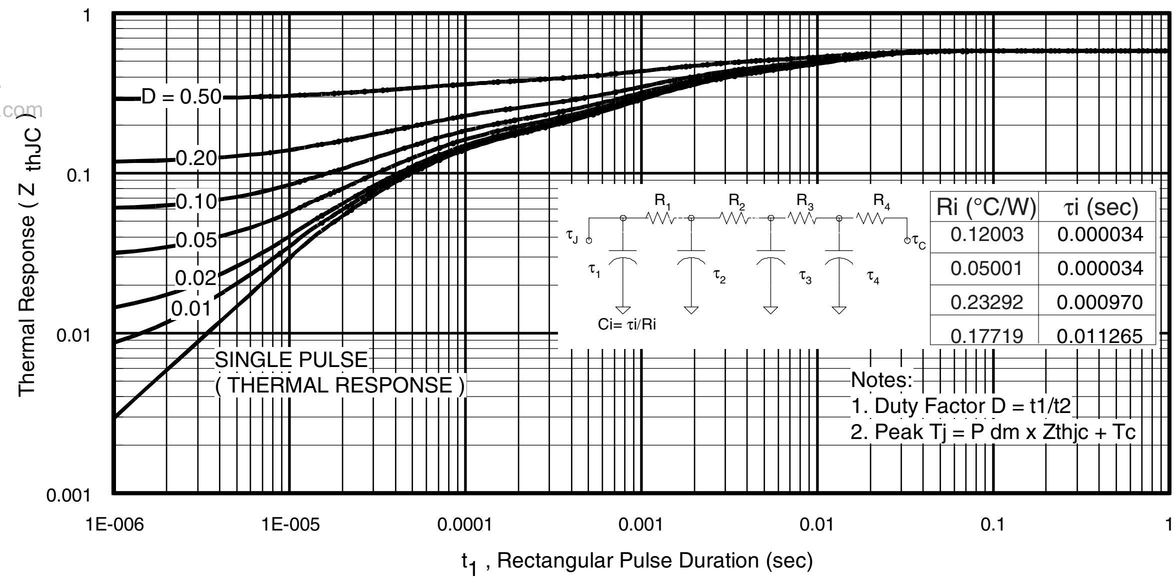
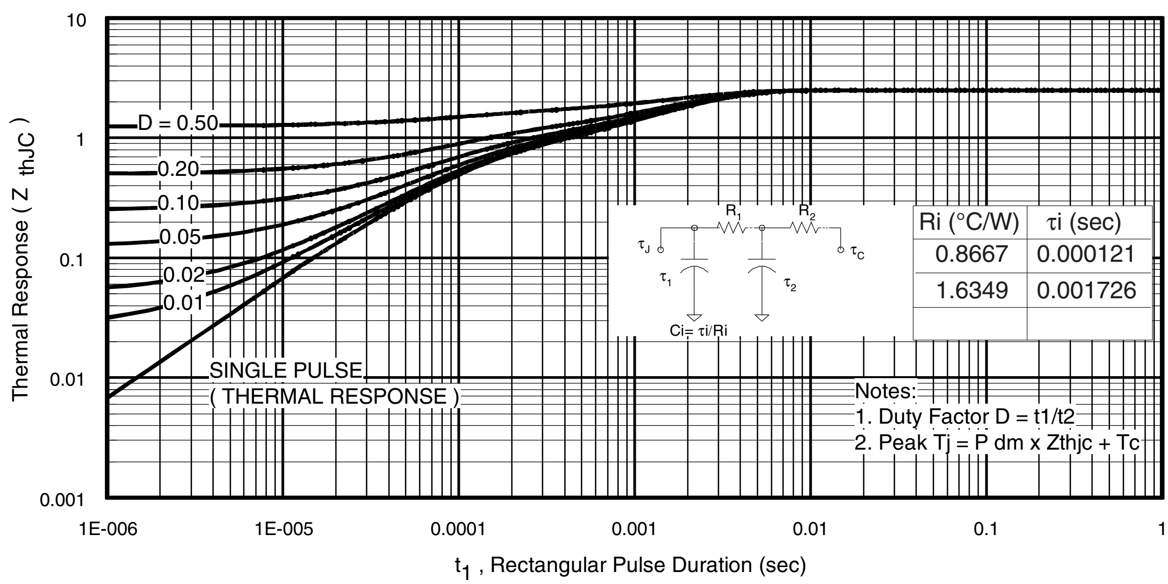



**Fig. 22 -** Typical $di_{(rec)M}/dt$ vs. $di_f/dt$,




| Ri (°C/W) | τi (sec) |
|---|---|
| 0.12003 | 0.000034 |
| 0.05001 | 0.000034 |
| 0.23292 | 0.000970 |
| 0.17719 | 0.011265 |

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




| Ri (°C/W) | τi (sec) |
|---|---|
| 0.8667 | 0.000121 |
| 1.6349 | 0.001726 |
| | |

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

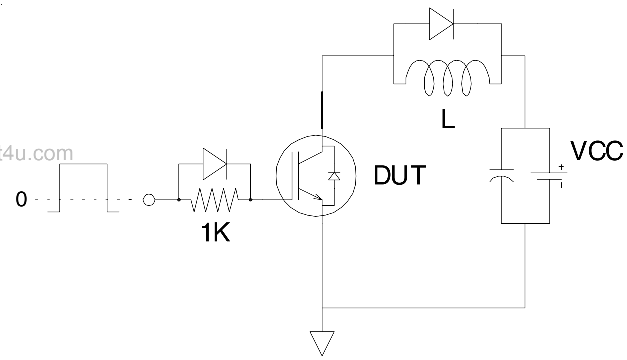



**Fig.C.T.1** - Gate Charge Circuit (turn-off)

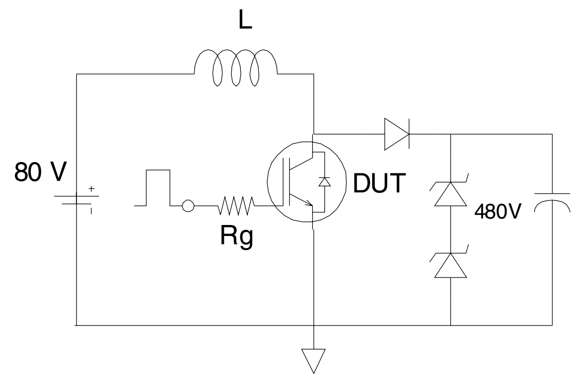



**Fig.C.T.2** - RBSOA Circuit

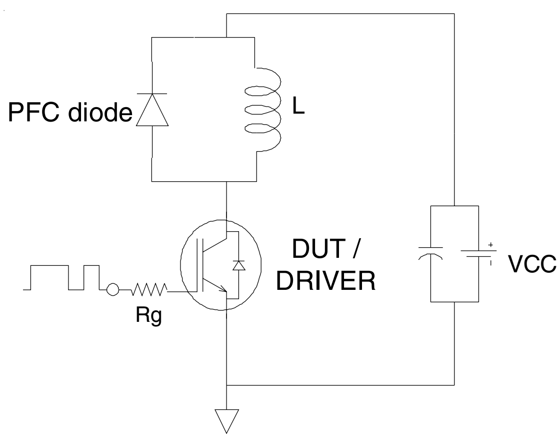



**Fig.C.T.3** - Switching Loss Circuit

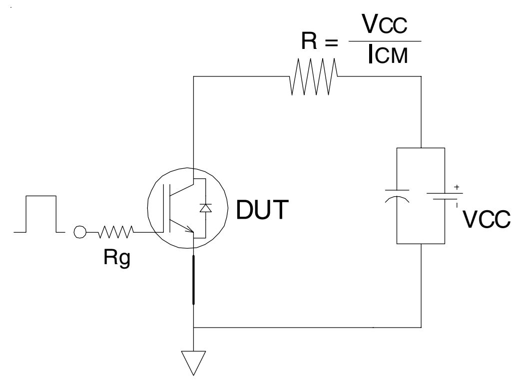



**Fig.C.T.4** - Resistive Load Circuit

REVERSE RECOVERY CIRCUIT

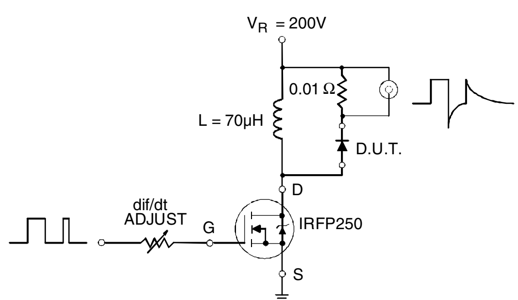



**Fig. C.T.5** - Reverse Recovery Parameter Test Circuit

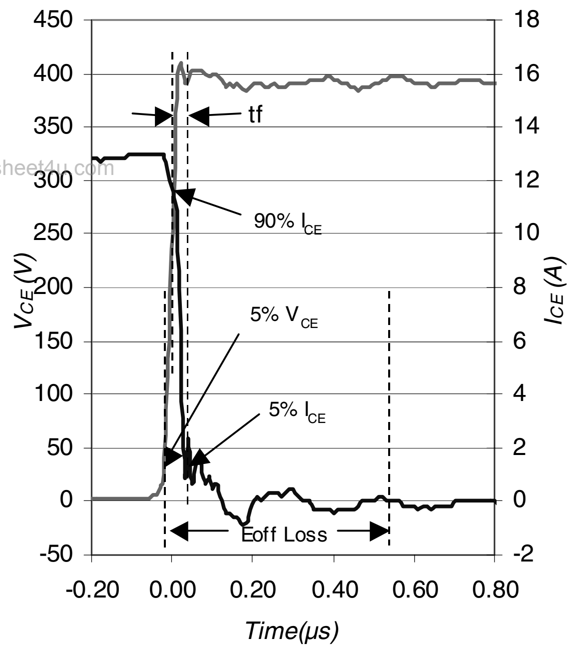



**Fig. WF1** - Typ. Turn-off Loss Waveform
@ $T_J$ = 125°C using Fig. CT.3

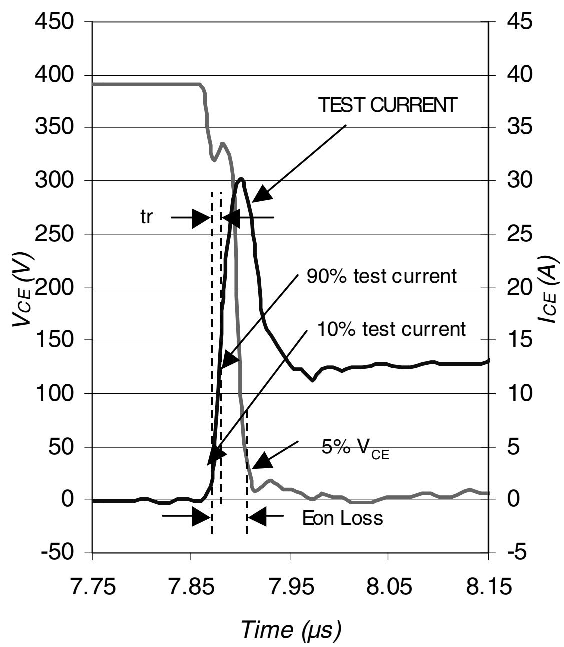
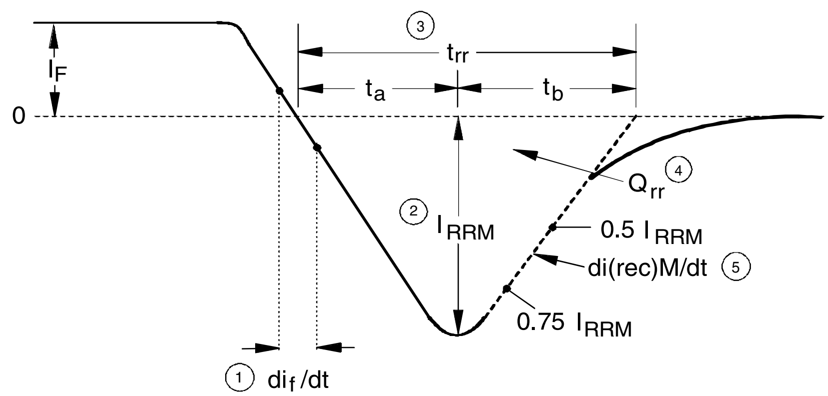



**Fig. WF2** - Typ. Turn-on Loss Waveform
@ $T_J$ = 125°C using Fig. CT.3




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 $I_{RRM}$

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

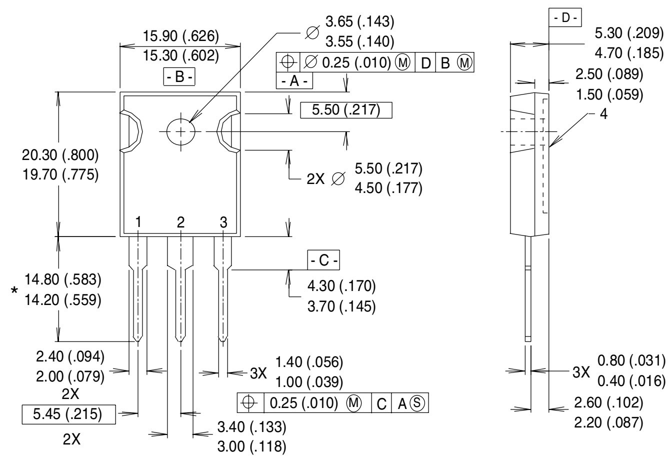
5. $di_{(rec)M}/dt$ - Peak rate of change of current during $t_b$ portion of $t_{rr}$

**Fig. WF3** - Reverse Recovery Waveform and Definitions

## TO-247AC Package Outline

Dimensions are shown in millimeters (inches)






NOTES:
1. DIMENSIONS & TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION : INCH.
3. DIMENSIONS ARE SHOWN MILLIMETERS (INCHES).
4. CONFORMS TO JEDEC OUTLINE TO-247AC.

LEAD ASSIGNMENTS
1 - GATE
2 - COLLECTOR
3 - EMITTER
4 - COLLECTOR

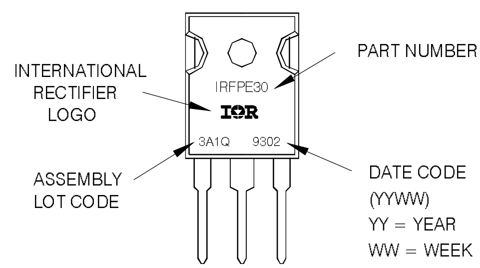
* LONGER LEADED (20mm) VERSION AVAILABLE (TO-247AD) TO ORDER ADD "-E" SUFFIX TO PART NUMBER

**CONFORMS TO JEDEC OUTLINE TO-247AC (TO-3P)**
Dimensions in Millimeters and (Inches)

## TO-247AC Part Marking Information

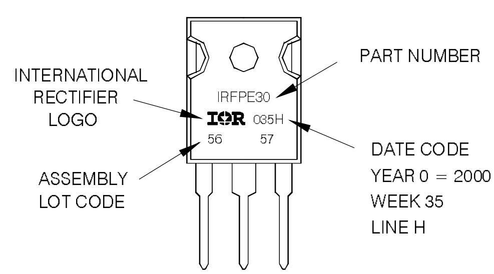
Notes: This part marking information applies to devices produced before 02/26/2001 or for parts manufactured in GB.

EXAMPLE: THIS IS AN IRFPE30 WITH ASSEMBLY LOT CODE 3A1Q




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, 2000 IN THE ASSEMBLY LINE "H"




**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
IOR Rectifier

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