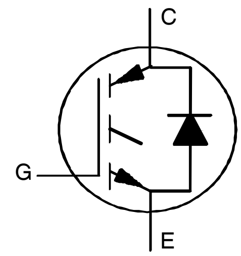
International
IOR Rectifier

# IRGI4061DPbF

## INSULATED GATE BIPOLAR TRANSISTOR WITH ULTRAFAST SOFT RECOVERY DIODE



n-channel

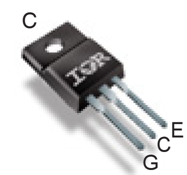
$V_{CES}$ = 600V

$I_C$ = 11A, $T_C$ = 100°C

$t_{sc}$ > 5µs, $T_{jmax}$ = 150°C

$V_{CE(on)\ typ.}$ = 1.35V

### Features
- Low $V_{CE\ (on)}$ Trench IGBT Technology
- Low Switching Losses
- 5µs SCSOA
- Square RBSOA
- 100% of The Parts Tested for $I_{LM}$
- Positive $V_{CE\ (on)}$ Temperature Coefficient.
- Ultra Fast Soft Recovery Co-pak Diode
- Tighter Distribution of Parameters
- Lead-Free Package



TO-220AB
Full-Pak

### Benefits
- High Efficiency in a Wide Range of Applications
- Suitable for a Wide Range of Switching Frequencies due to Low $V_{CE\ (ON)}$ and Low Switching Losses
- Rugged Transient Performance for Increased Reliability
- Excellent Current Sharing in Parallel Operation
- Low EMI

| G | C | E |
|---|---|---|
| Gate | Collector | Emitter |

### Absolute Maximum Ratings

| | Parameter | Max. | Units |
|---|---|---|---|
| $V_{CES}$ | Collector-to-Emitter Breakdown Voltage | 600 | V |
| $I_C$@ $T_C$ = 25°C | Continuous Collector Current | 20 | A |
| $I_C$@ $T_C$ = 100°C | Continuous Collector Current | 11 | |
| $I_{CM}$ | Pulsed Collector Current | 40 | |
| $I_{LM}$ | Clamped Inductive Load Current ① | 40 | |
| $I_F$@$T_C$=25°C | Diode Continuous Forward Current | 20 | |
| $I_F$@$T_C$=100°C | Diode Continuous Forward Current | 11 | |
| $I_{FM}$ | Diode Maximum Forward Current ② | 40 | |
| $V_{GE}$ | Continuous Gate-to-Emitter Voltage | ± 20 | V |
| | Transient Gate-to-Emitter Voltage | ± 30 | |
| $P_D$ @ $T_C$ =25°C | Maximum Power Dissipation | 43 | W |
| $P_D$ @ $T_C$ =100°C | Maximum Power Dissipation | 17 | |
| $T_J$<br>$T_{STG}$ | Operating Junction and<br>Storage Temperature Range | -55 to + 150 | °C |
| | Soldering Temperature, for 10 seconds | 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 |
|---|---|---|---|---|---|
| $R_{\theta JC}$ | Junction-to-Case - IGBT ③ | — | — | 2.90 | °C/W |
| $R_{\theta JC}$ | Junction-to-Case - Diode ③ | — | — | 4.60 | |
| $R_{\theta CS}$ | Case-to-Sink, flat, greased surface | — | 0.5 | — | |
| $R_{\theta JA}$ | Junction-to-Ambient, typical socket mount ③ | — | — | 65 | |
| Wt | Weight | — | 2.0 | — | g |

## 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, $I_c$ = 100 µA ④ |
| $\Delta V_{(BR)CES}/\Delta T_J$ | Temperature Coeff. of Breakdown Voltage | — | 0.75 | — | V/°C | $V_{GE}$ = 0V, $I_c$ = 250 µA ( -55 -150 °C ) ④ |
| $V_{CE(on)}$ | Collector-to-Emitter Saturation Voltage | — | 1.35 | 1.59 | V | $I_C$ = 11A, $V_{GE}$ = 15V, $T_J$ = 25°C |
| | | — | 1.53 | — | | $I_C$ = 11A, $V_{GE}$ = 15V, $T_J$ = 125°C |
| | | — | 1.58 | — | | $I_C$ = 11A, $V_{GE}$ = 15V, $T_J$ = 150°C |
| $V_{GE(th)}$ | Gate Threshold Voltage | 4.0 | | 6.5 | V | $V_{CE}$ = $V_{GE}$, $I_C$ = 500 µA |
| $\Delta V_{GE(th)}/\Delta TJ$ | Threshold Voltage temp. coefficient | — | -15 | — | mV/°C | $V_{CE}$ = $V_{GE}$, $I_C$ = 1.0mA ( 25 -150 °C ) |
| gfe | Forward Transconductance | — | 11 | — | S | $V_{CE}$ = 50V, $I_C$ = 11A, PW =80µs |
| $I_{CES}$ | Collector-to-Emitter Leakage Current | — | 2.0 | 25 | µA | $V_{GE}$ = 0V, $V_{CE}$ = 600V |
| | | — | 550 | — | µA | $V_{GE}$ = 0v, $V_{CE}$ = 600V, $T_J$ =150°C |
| $V_{FM}$ | Diode Forward Voltage Drop | — | 2.20 | 2.6 | V | $I_F$ = 11A |
| | | — | 1.33 | — | | $I_F$ = 11A, $T_J$ = 150°C |
| $I_{GES}$ | Gate-to-Emitter Leakage Current | — | — | ±100 | nA | $V_{GE}$ = ± 20 V |

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

| | Parameter | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| $Q_g$ | Total Gate Charge (turn-on) | — | 35 | 53 | nC | $I_C$ = 11A |
| $Q_{ge}$ | Gate-to-Emitter Charge (turn-on) | — | 8.0 | 12 | | $V_{CC}$ = 400V |
| $Q_{gc}$ | Gate-to-Collector Charge (turn-on) | — | 13 | 23 | | $V_{GE}$ = 15V |
| $E_{on}$ | Turn-On Switching Loss | — | 52 | 95 | µJ | $I_C$ = 11A, $V_{CC}$ = 400V, $V_{GE}$ = 15V |
| $E_{off}$ | Turn-Off Switching Loss | — | 231 | 340 | | $R_G$ = 22Ω, L=1mH, $L_S$= 150nH, $T_J$ = 25°C |
| $E_{total}$ | Total Switching Loss | — | 283 | 435 | | Energy losses include tail and diode reverse recovery |
| $t_{d(on)}$ | Turn-On delay time | — | 37 | 46 | ns | $I_C$ = 11A, $V_{CC}$ = 400V |
| $t_r$ | Rise time | — | 18 | 26 | | $R_G$ = 22Ω, L=1mH, $L_S$= 150nH |
| $t_{d(off)}$ | Turn-Off delay time | — | 111 | 129 | | $T_J$ = 25°C |
| $t_f$ | Fall time | — | 30 | 41 | | |
| $E_{on}$ | Turn-On Switching Loss | — | 143 | — | µJ | $I_C$ = 11A, $V_{CC}$ = 400V, $V_{GE}$ = 15V |
| $E_{off}$ | Turn-Off Switching Loss | — | 316 | — | | $R_G$ = 22Ω, L=1mH, $L_S$= 150nH, $T_J$ = 150°C |
| $E_{total}$ | Total Switching Loss | — | 459 | — | | Energy losses include tail and diode reverse recovery |
| $t_{d(on)}$ | Turn-On delay time | — | 35 | — | ns | $I_C$ = 11A, $V_{CC}$ = 400V |
| $t_r$ | Rise time | — | 19 | — | | $R_G$ = 22Ω, L=1mH, $L_S$= 150nH |
| $t_{d(off)}$ | Turn-Off delay time | — | 134 | — | | $T_J$ = 150°C |
| $t_f$ | Fall time | — | 45 | — | | |
| $C_{ies}$ | Input Capacitance | — | 1050 | — | pF | $V_{GE}$ = 0V |
| $C_{oes}$ | Output Capacitance | — | 89 | — | | $V_{CC}$ = 30V |
| $C_{res}$ | Reverse Transfer Capacitance | — | 30 | — | | f = 1Mhz |
| RBSOA | Reverse Bias Safe Operating Area | FULL SQUARE | | | | $T_J$ = 150°C, $I_C$ = 40A<br>$V_{CC}$ = 480V, Vp =600V<br>Rg = 22Ω, $V_{GE}$ = +15V to 0V |
| SCSOA | Short Circuit Safe Operating Area | 5 | — | — | µs | $V_{CC}$ = 400V, Vp =600V<br>$R_G$ = 22Ω, $V_{GE}$ = +15V to 0V |
| Erec | Reverse recovery energy of the diode | — | 211 | — | µJ | $T_J$ = 150°C |
| trr | Diode Reverse recovery time | — | 60 | — | ns | $V_{CC}$ = 400V, $I_F$ = 11A |
| Irr | Peak Reverse Recovery Current | — | 18 | — | A | $V_{GE}$ = 15V, Rg = 22Ω, L=1mH, $L_S$=150nH |

Notes:

① $V_{CC}$ = 80% ($V_{CES}$), $V_{GE}$ = 15V, L = 28 µH, $R_G$ = 22 Ω.
② Pulse width limited by max. junction temperature.
③ $R_\theta$ is measured at $T_J$ approximately 90°C
④ Refer to AN-1086 for guidelines for measuring $V_{(BR)CES}$ safely

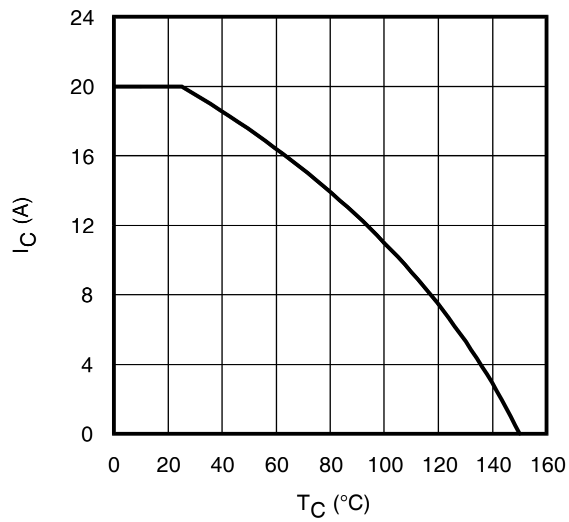



**Fig. 1** - Maximum DC Collector Current vs. Case Temperature

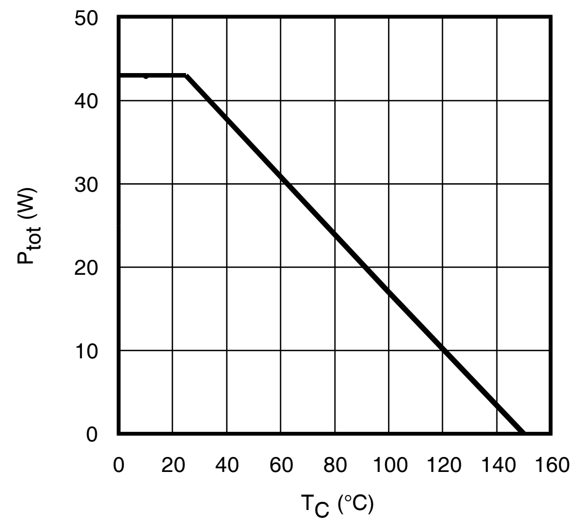



**Fig. 2** - Power Dissipation vs. Case Temperature

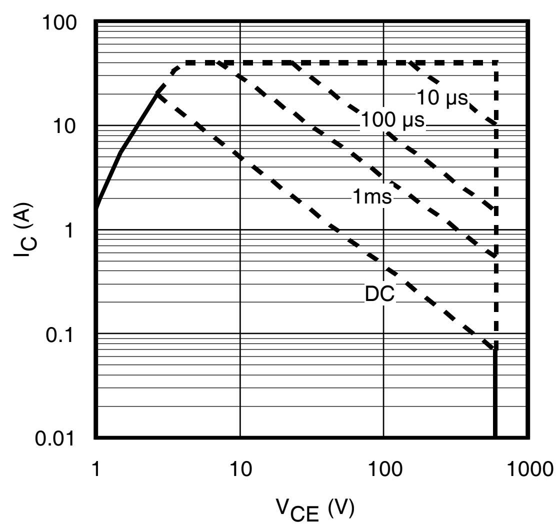



**Fig. 3** - Forward SOA, $T_C$ = 25°C; $T_J \leq$ 150°C

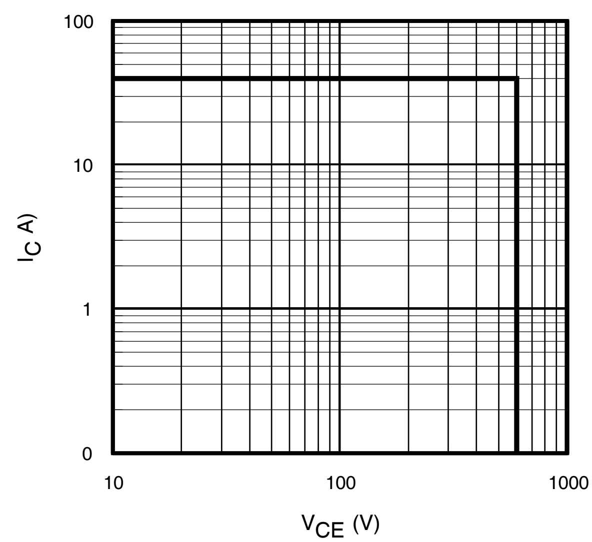



**Fig. 4** - Reverse Bias SOA $T_J$ = 150°C; $V_{CE}$ = 15V

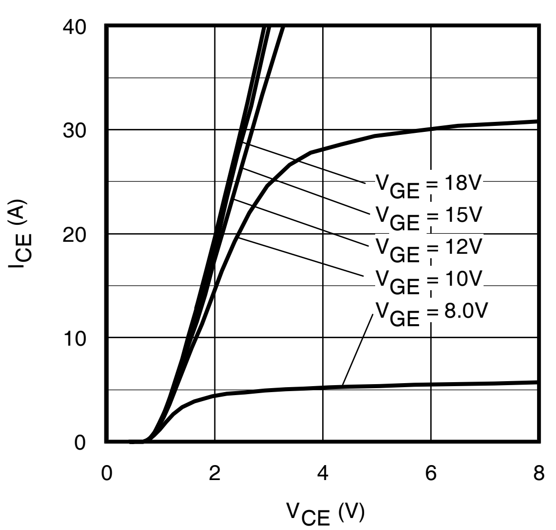



**Fig. 5** - Typ. IGBT Output Characteristics $T_J$ = -40°C; tp <60µs

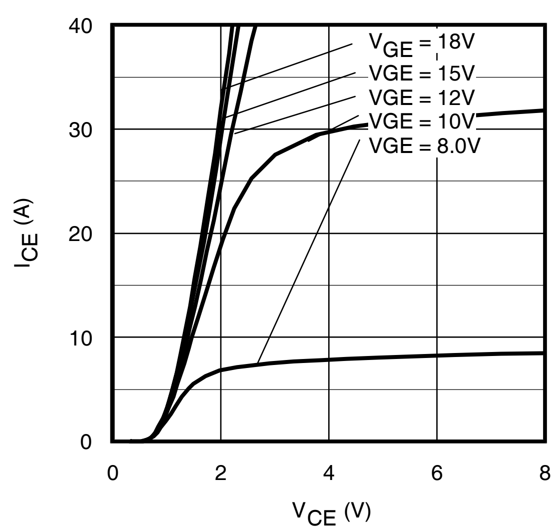



**Fig. 6** - Typ. IGBT Output Characteristics $T_J$ = 25°C; tp < 60µs

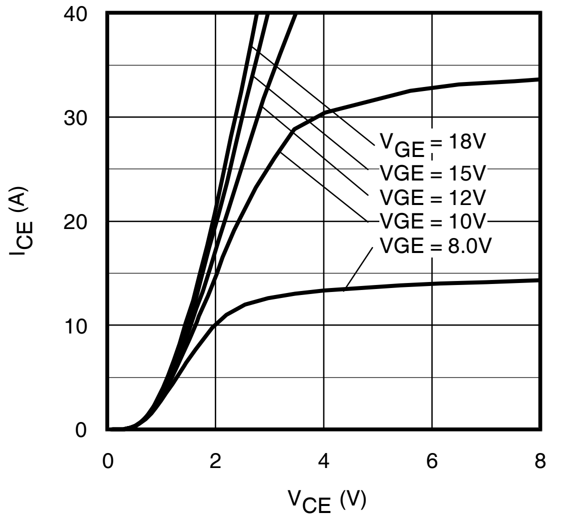



**Fig. 7** - Typ. IGBT Output Characteristics
$T_J$ = 150°C; tp < 60µs

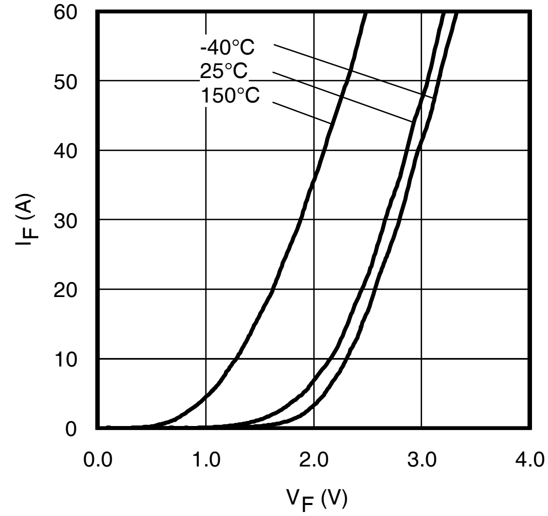



**Fig. 8** - Typ. Diode Forward Characteristics
tp < 60µs

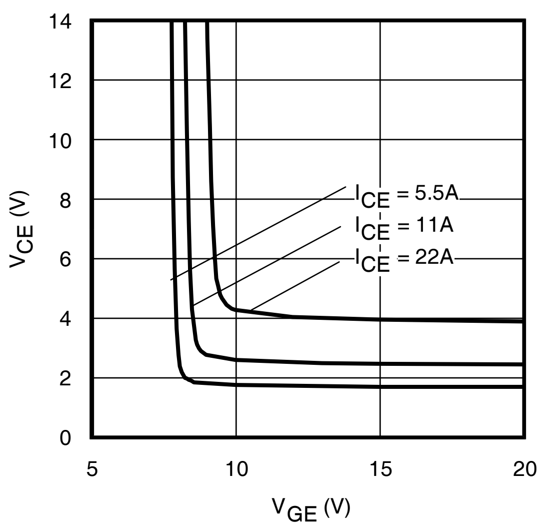



**Fig. 9** - Typical $V_{CE}$ vs. $V_{GE}$
$T_J$ = -40°C

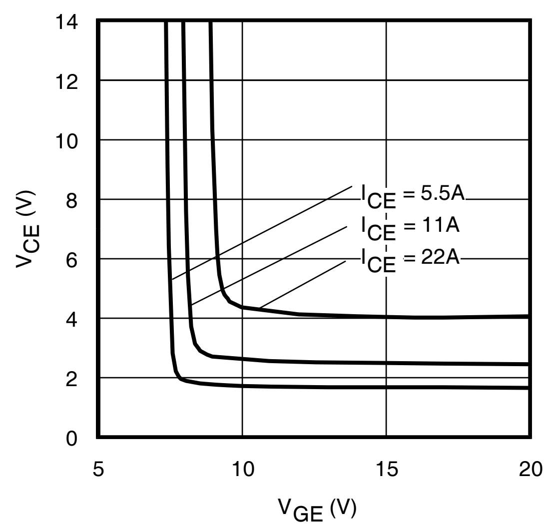



**Fig. 10** - Typical $V_{CE}$ vs. $V_{GE}$
$T_J$ = 25°C

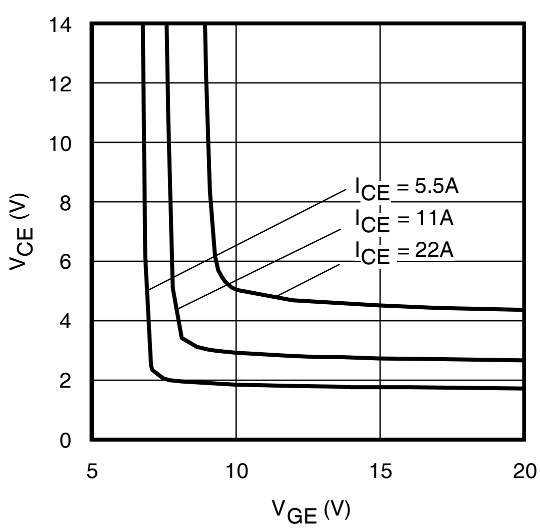



**Fig. 11** - Typical $V_{CE}$ vs. $V_{GE}$
$T_J$ = 150°C

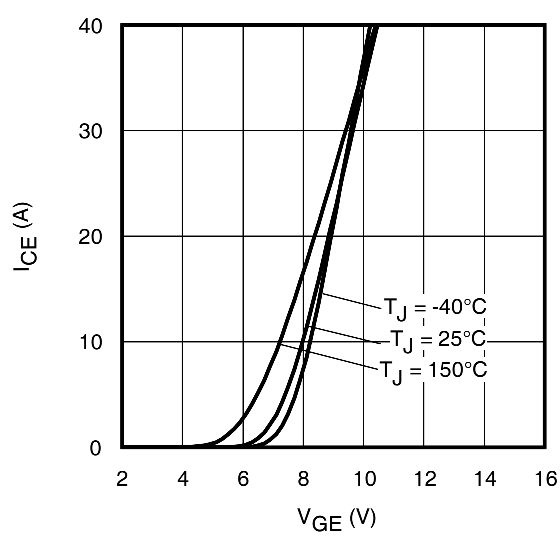



**Fig. 12** - Typ. Transfer Characteristics
$V_{CE}$ = 50V; tp < 60µs

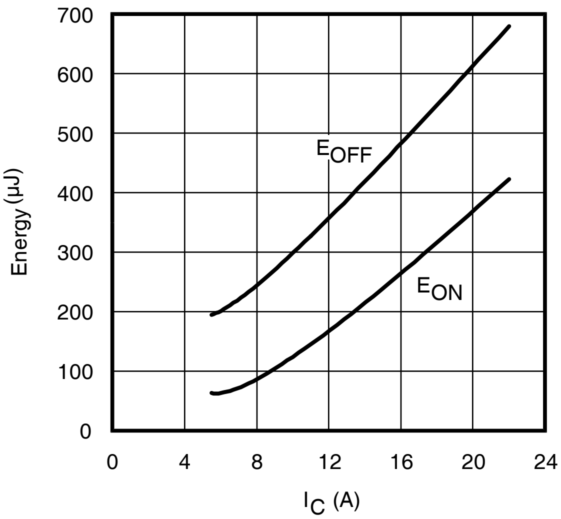



**Fig. 13** - Typ. Energy Loss vs. $I_C$
$T_J$ = 150°C; L = 1mH; $V_{CE}$ = 400V, $R_G$ = 22Ω; $V_{GE}$ = 15V.

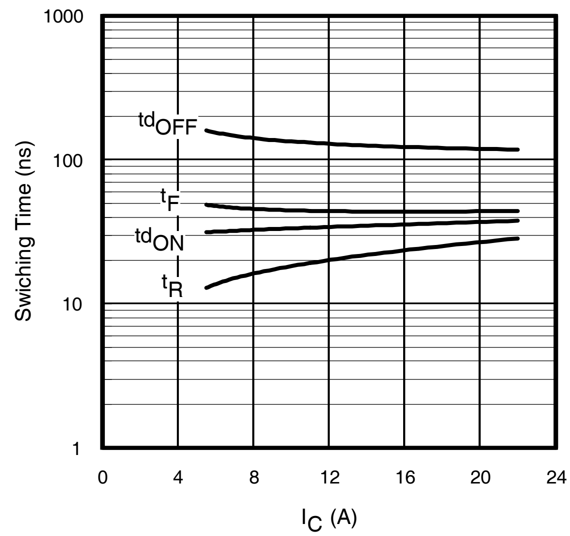



**Fig. 14** - Typ. Switching Time vs. $I_C$
$T_J$ = 150°C; L=1mH; $V_{CE}$= 400V
$R_G$= 22Ω; $V_{GE}$= 15V

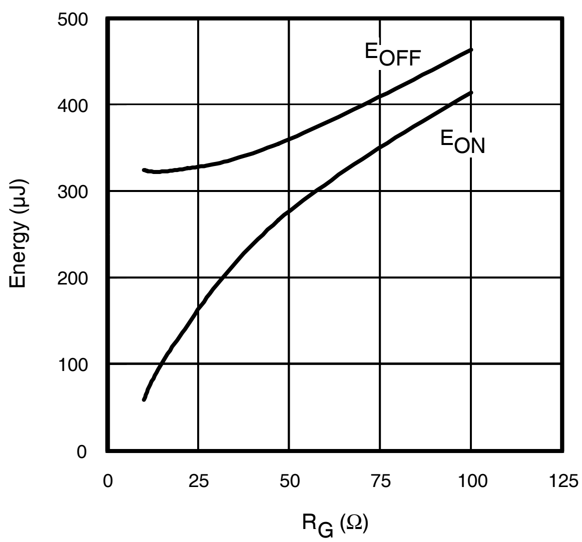



**Fig. 15** - Typ. Energy Loss vs. $R_G$
$T_J$ = 150°C; L = 1mH; $V_{CE}$ = 400V, $I_{CE}$ = 11A; $V_{GE}$ = 15V

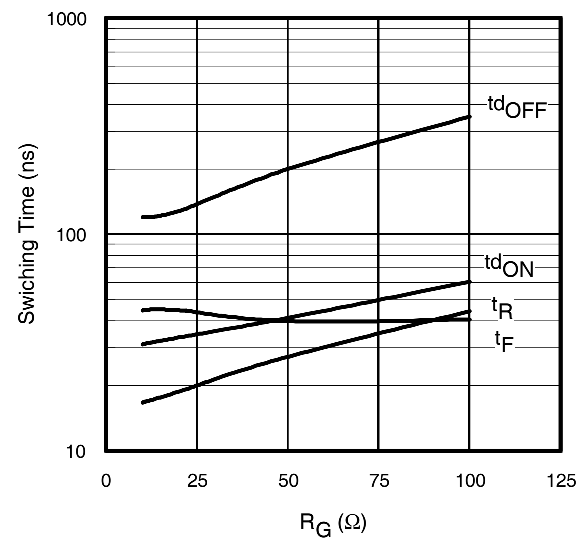



**Fig. 16**- Typ. Switching Time vs. $R_G$
$T_J$ = 150°C; L=1mH; $V_{CE}$= 400V
$I_{CE}$= 11A; $V_{GE}$= 15V

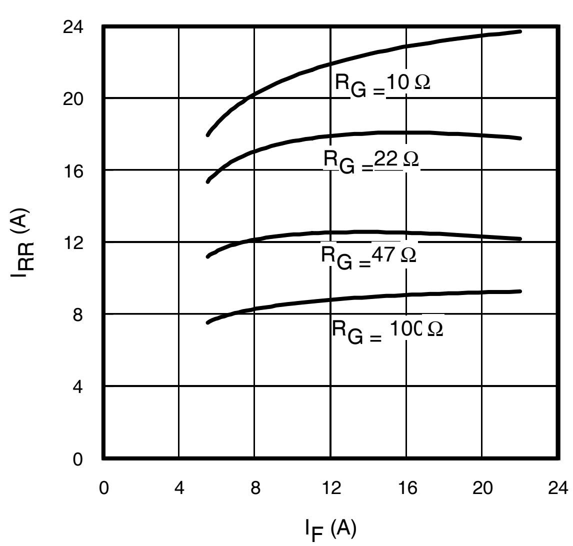



**Fig. 17** - Typical Diode $I_{RR}$ vs. $I_F$
$T_J$ = 150°C

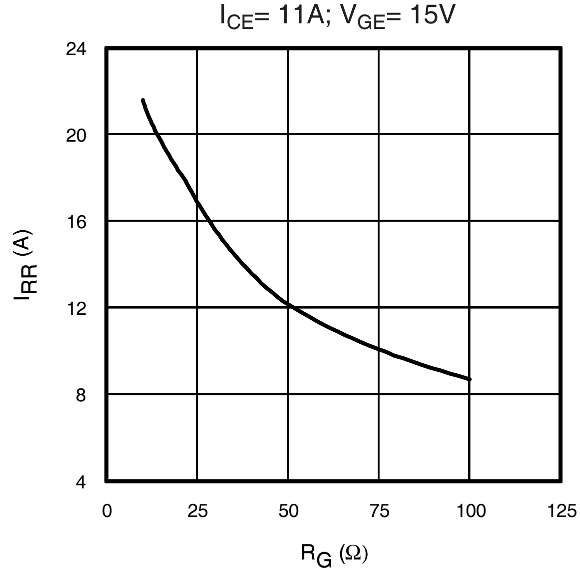



**Fig. 18** - Typical Diode $I_{RR}$ vs. $R_G$
$T_J$ = 150°C; $I_F$ = 11A

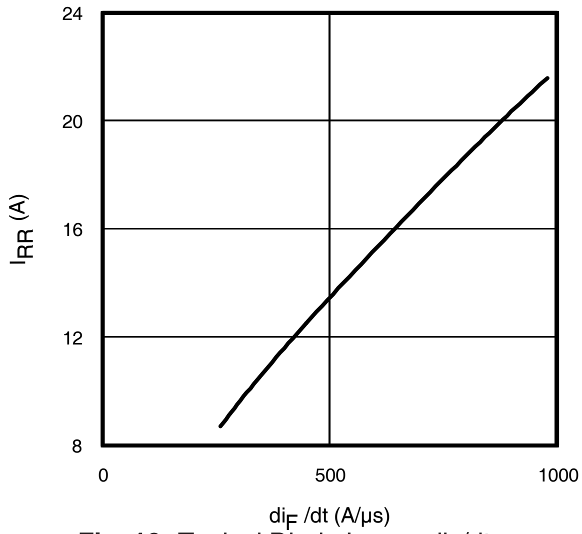



**Fig. 19**- Typical Diode $I_{RR}$ vs. $di_F/dt$
$V_{CC}$= 400V; $V_{GE}$= 15V;
$I_{CE}$= 11A; $T_J$ = 150°C

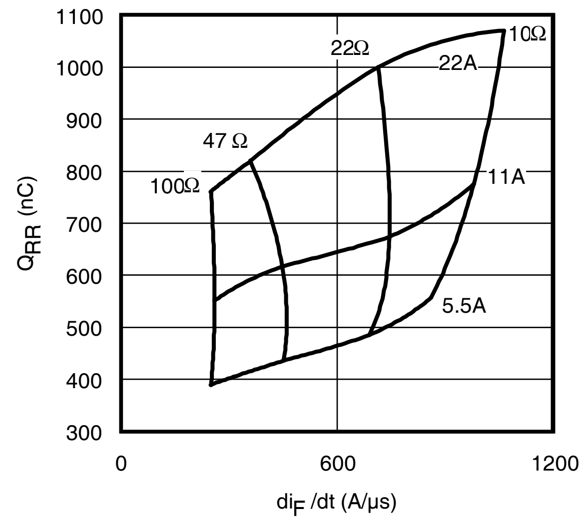



**Fig. 20** - Typical Diode $Q_{RR}$
$V_{CC}$= 400V; $V_{GE}$= 15V; $T_J$ = 150°C

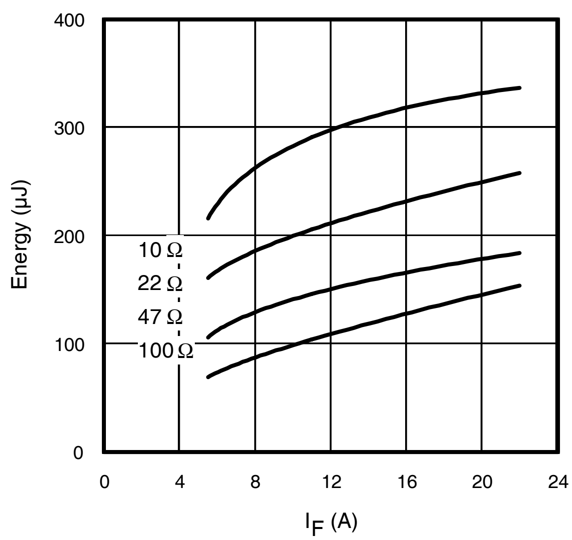



**Fig. 21** - Typical Diode $E_{RR}$ vs. $I_F$
$T_J$ = 150°C

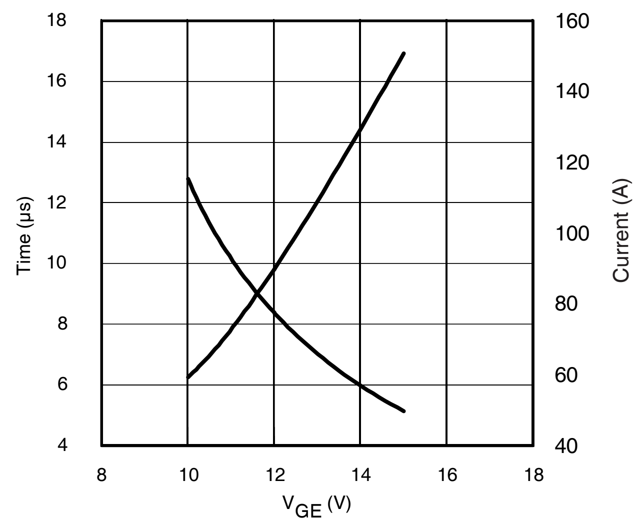



**Fig. 22**- Typ. $V_{GE}$ vs Short Circuit Time
$V_{CC}$=400V, $T_C$ =25°C

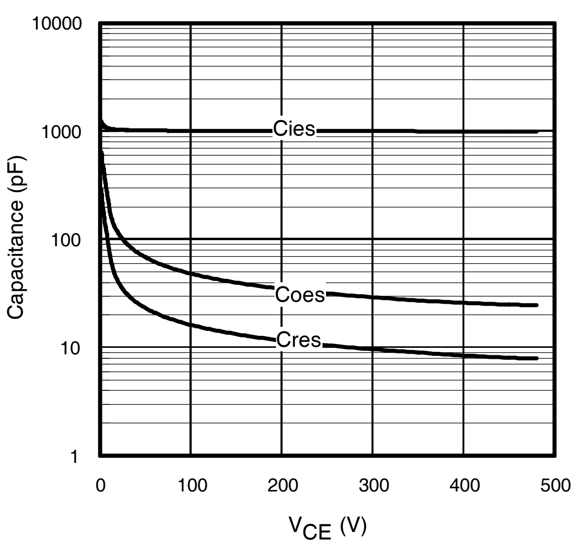



**Fig. 23**- Typ. Capacitance vs. $V_{CE}$
$V_{GE}$= 0V; f = 1MHz

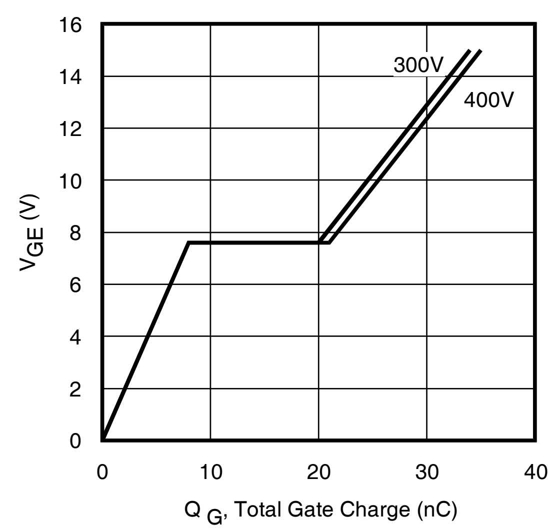
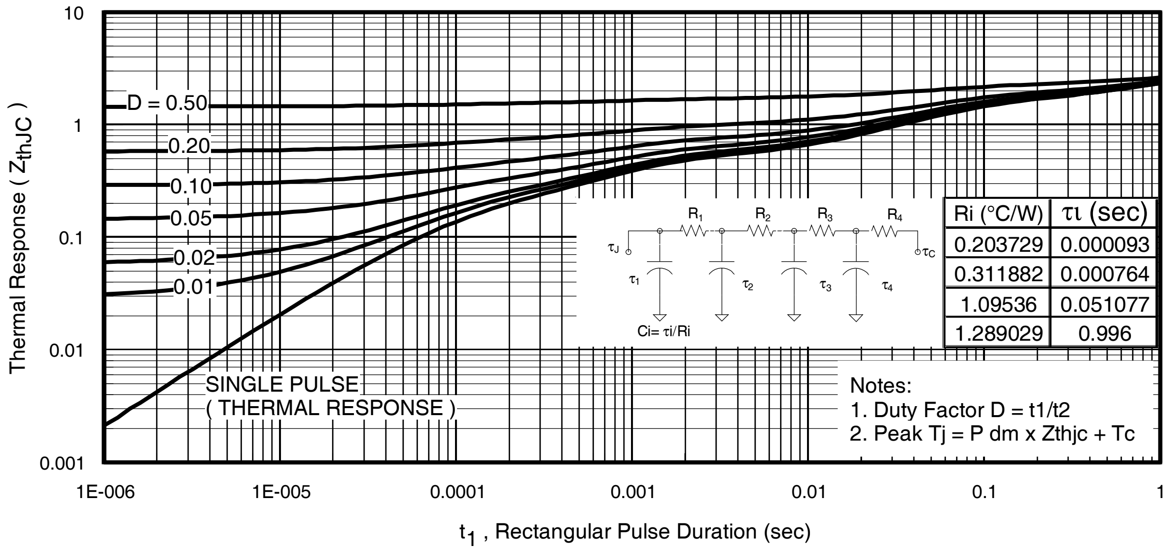
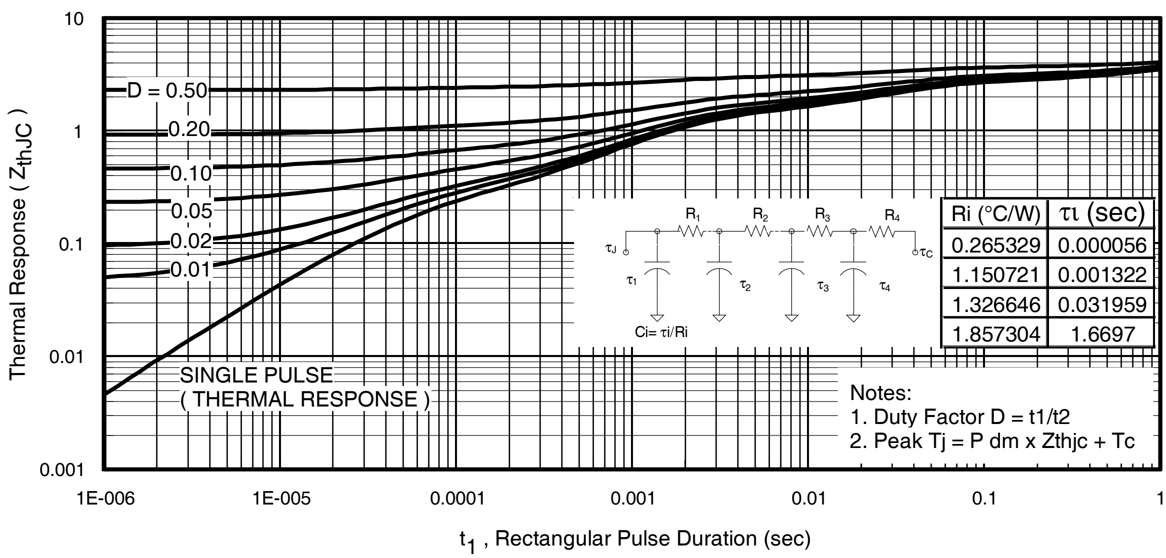



**Fig. 24** - Typical Gate Charge vs. $V_{GE}$
$I_{CE}$ = 11A, L=600µH




| Ri (°C/W) | τι (sec) |
|---|---|
| 0.203729 | 0.000093 |
| 0.311882 | 0.000764 |
| 1.09536 | 0.051077 |
| 1.289029 | 0.996 |

**Fig 25.** Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)




| Ri (°C/W) | τι (sec) |
|---|---|
| 0.265329 | 0.000056 |
| 1.150721 | 0.001322 |
| 1.326646 | 0.031959 |
| 1.857304 | 1.6697 |

**Fig. 26.** Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)

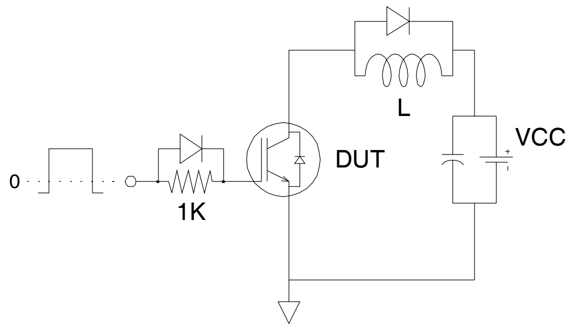



**Fig.C.T.1** - Gate Charge Circuit (turn-off)

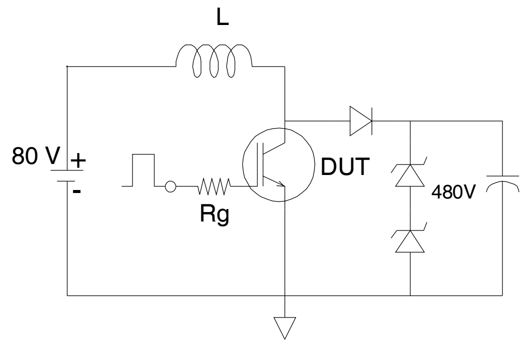



**Fig.C.T.2** - RBSOA Circuit

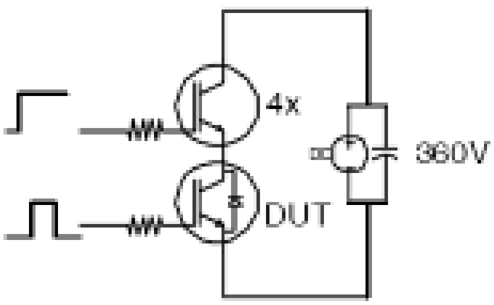



**Fig.C.T.3** - S.C.SOA Circuit

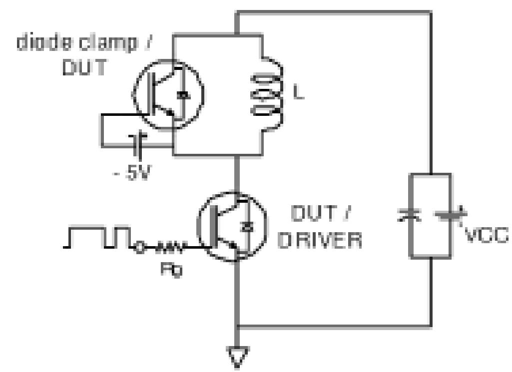



**Fig.C.T.4** - Switching Loss Circuit

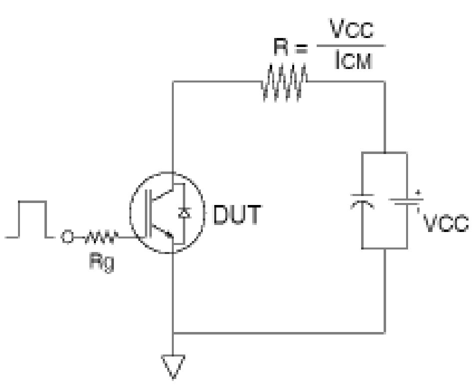



**Fig.C.T.5** - Resistive Load Circuit

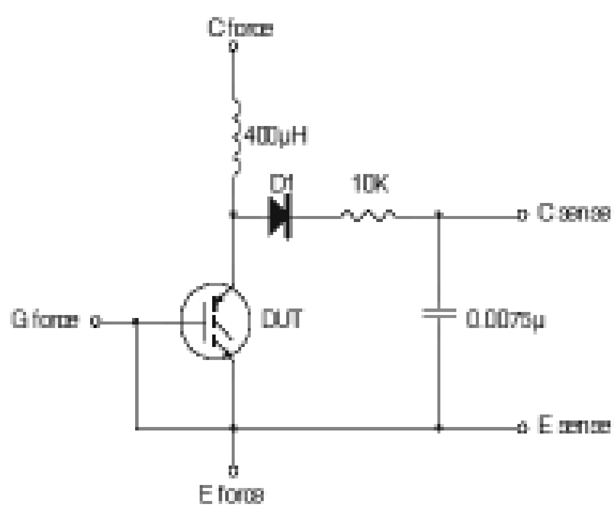



**Fig.C.T.6** - Typical Filter Circuit for $V_{(BR)CES}$ Measurement

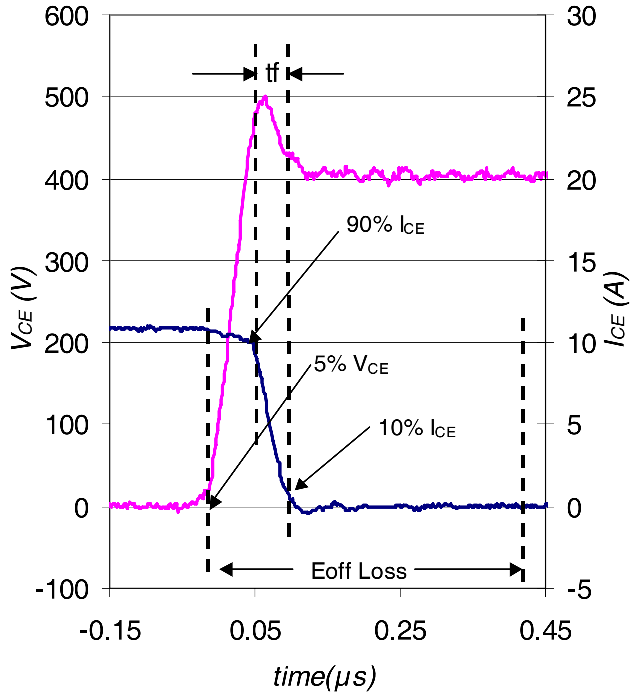



**Fig. WF1** - Typ. Turn-off Loss Waveform
@ $T_J$ = 150°C using Fig. CT.4

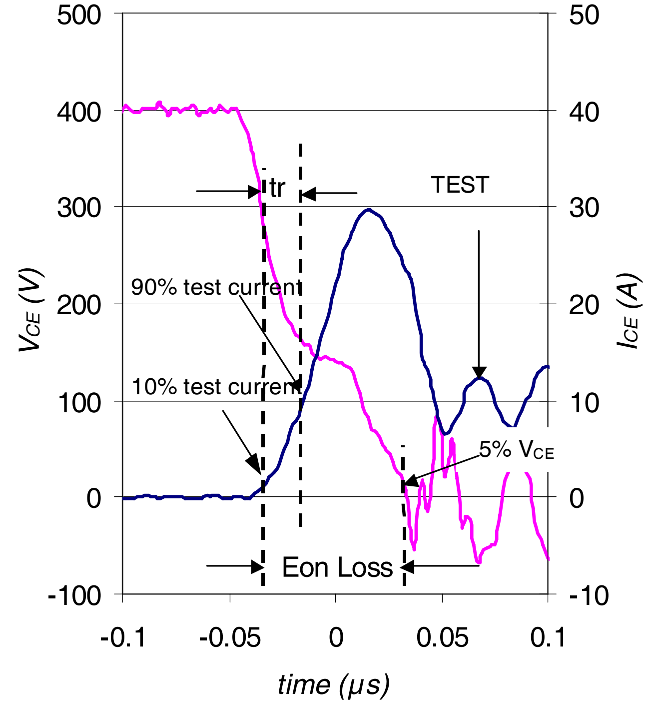
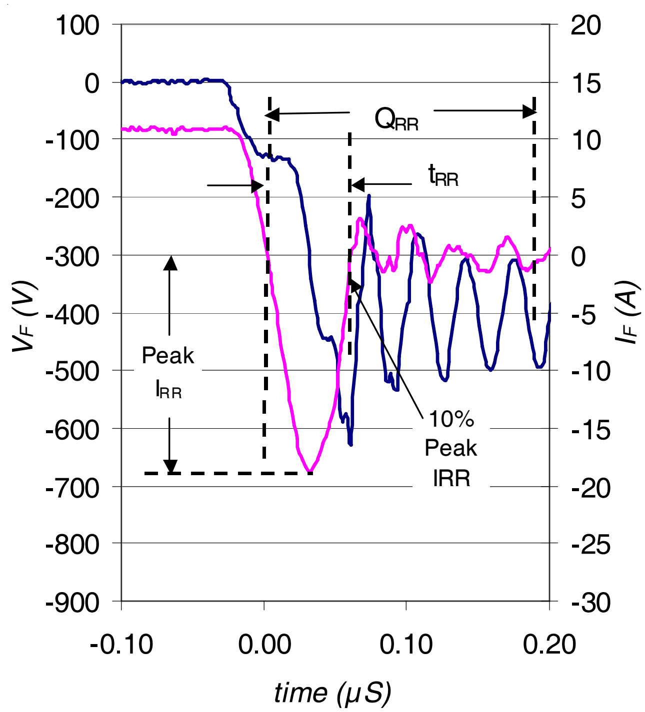
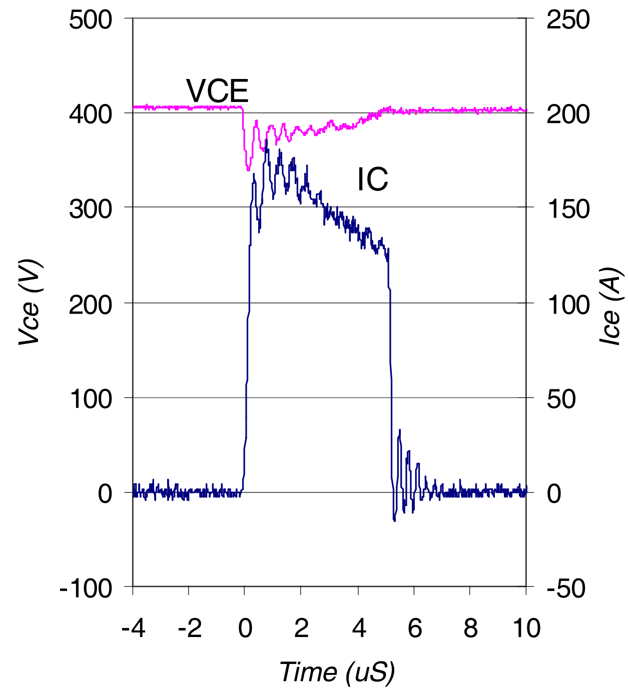



**Fig. WF2** - Typ. Turn-on Loss Waveform
@ $T_J$ = 150°C using Fig. CT.4



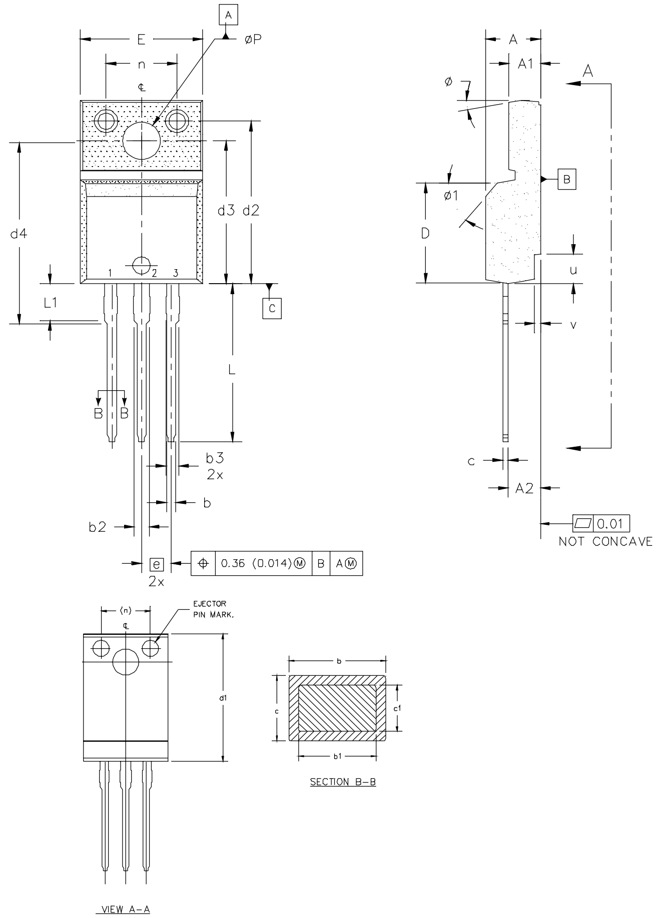

WF.3- Typ. Reverse Recovery Waveform
@ $T_J$ = 150°C using CT.4




WF.4- Typ. Short Circuit Waveform
@ $T_J$ = 25°C using CT.3

## TO-220 Full-Pak Package Outline

Dimensions are shown in millimeters (inches)




NOTES:

1.0 DIMENSIONING AND TOLERANCING PER ASME Y14.5 M- 1994.
2.0 DIMENSIONS ARE SHOWN IN MILLIMETERS [INCHES].
3.0 LEAD DIMENSION AND FINISH UNCONTROLLED IN L1.
4.0 DIMENSION D & E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.005" (0.127) PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY.
5.0 DIMENSION b1 APPLY TO BASE METAL ONLY.
6.0 STEP OPTIONAL ON PLASTIC BODY DEFINED BY DIMENSIONS u & v.
7.0 CONTROLLING DIMENSION : INCHES.

| SYMBOL | DIMENSIONS | | | | NOTES |
|---|---|---|---|---|---|
| | MILLIMETERS | | INCHES | | |
| | MIN. | MAX. | MIN. | MAX. | |
| A | 4.57 | 4.83 | 0.180 | 0.190 | |
| A1 | 2.57 | 2.83 | 0.101 | 0.114 | |
| A2 | 2.51 | 2.85 | 0.099 | 0.112 | |
| b | 0.622 | 0.89 | 0.024 | 0.035 | |
| b1 | 0.622 | 0.838 | 0.024 | 0.033 | 5 |
| b2 | 1.229 | 1.400 | 0.048 | 0.055 | |
| b3 | 1.229 | 1.400 | 0.048 | 0.055 | |
| c | 0.440 | 0.629 | 0.017 | 0.025 | |
| c1 | 0.440 | 0.584 | 0.017 | 0.023 | |
| D | 8.65 | 9.80 | 0.341 | 0.386 | 4 |
| d1 | 15.80 | 16.12 | 0.622 | 0.635 | |
| d2 | 13.97 | 14.22 | 0.550 | 0.560 | |
| d3 | 12.30 | 12.92 | 0.484 | 0.509 | |
| d4 | 8.64 | 9.91 | 0.340 | 0.390 | |
| E | 10.36 | 10.63 | 0.408 | 0.419 | 4 |
| e | 2.54 BSC | | 0.100 BSC | | |
| L | 13.20 | 13.73 | 0.520 | 0.541 | |
| L1 | 3.10 | 3.50 | 0.122 | 0.138 | 3 |
| n | 6.05 | 6.15 | 0.238 | 0.242 | |
| øP | 3.05 | 3.45 | 0.120 | 0.136 | |
| u | 2.40 | 2.50 | 0.094 | 0.098 | 6 |
| v | 0.40 | 0.50 | 0.016 | 0.020 | 6 |
| ø | 3° | 7° | 3° | 7° | |
| ø1 | | 45° | | 45° | |

LEAD ASSIGNMENTS

HEXFET

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

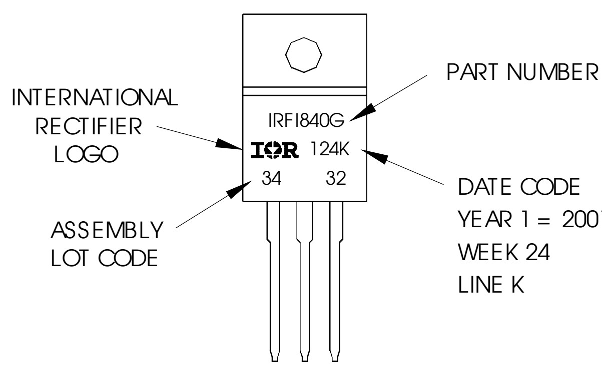
IGBTs, CoPACK

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

## TO-220 Full-Pak Part Marking Information

EXAMPLE: THIS IS AN IRFI840G
WITH ASSEMBLY
LOT CODE 3432
ASSEMBLED ON WW 24, 2001
IN THE ASSEMBLY LINE "K"

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




**TO-220 Full-Pak 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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