International
**IOR** Rectifier

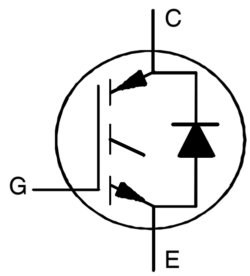
PD-96288

# IRG7PH35UDPbF
# IRG7PH35UD-EP

***INSULATED GATE BIPOLAR TRANSISTOR WITH ULTRAFAST SOFT RECOVERY DIODE***

## Features

- Low $V_{CE\ (ON)}$ trench IGBT technology
- Low switching losses
- Square RBSOA
- 100% of the parts tested for $I_{LM}$ ①
- Positive $V_{CE\ (ON)}$ temperature co-efficient
- Ultra fast soft recovery co-pak diode
- Tight parameter distribution
- Lead-Free



n-channel

$V_{CES}$ = 1200V

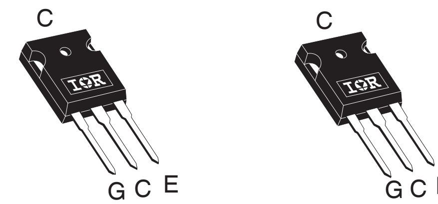
$I_{NOMINAL}$ = 20A

$T_{J(max)}$ = 150°C

$V_{CE(on)}$ typ. = 1.9V

## 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



TO-247AC IRG7PH35UDPbF

TO-247AD IRG7PH35UD-EP

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

## Applications

- U.P.S.
- Welding
- Solar Inverter
- Induction Heating

## Absolute Maximum Ratings

| | Parameter | Max. | Units |
|---|---|---|---|
| $V_{CES}$ | Collector-to-Emitter Voltage | 1200 | V |
| $I_C$ @ $T_C$ = 25°C | Continuous Collector Current | 50 | A |
| $I_C$ @ $T_C$ = 100°C | Continuous Collector Current | 25 | |
| $I_{NOMINAL}$ | Nominal Current | 20 | |
| $I_{CM}$ | Pulse Collector Current, $V_{GE}$=15V | 60 | |
| $I_{LM}$ | Clamped Inductive Load Current, $V_{GE}$=20V ① | 80 | |
| $I_F$ @ $T_C$ = 25°C | Diode Continous Forward Current | 50 | |
| $I_F$ @ $T_C$ = 100°C | Diode Continous Forward Current | 25 | |
| $I_{FM}$ | Diode Maximum Forward Current ② | 80 | |
| $V_{GE}$ | Continuous Gate-to-Emitter Voltage | ±30 | V |
| $P_D$ @ $T_C$ = 25°C | Maximum Power Dissipation | 180 | W |
| $P_D$ @ $T_C$ = 100°C | Maximum Power Dissipation | 70 | |
| $T_J$ <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) ④ | ––– | ––– | 0.70 | °C/W |
| $R_{\theta JC}$ (Diode) | Thermal Resistance Junction-to-Case-(each Diode) | ––– | ––– | 0.65 | |
| $R_{\theta CS}$ | 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°C (unless otherwise specified)

| | Parameter | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| $V_{(BR)CES}$ | Collector-to-Emitter Breakdown Voltage | 1200 | — | — | V | $V_{GE}$ = 0V, $I_C$ = 250µA ③ |
| $\Delta V_{(BR)CES}/\Delta T_J$ | Temperature Coeff. of Breakdown Voltage | — | 1.2 | — | V/°C | $V_{GE}$ = 0V, $I_C$ = 1mA (25°C-150°C) |
| $V_{CE(on)}$ | Collector-to-Emitter Saturation Voltage | — | 1.9 | 2.2 | V | $I_C$ = 20A, $V_{GE}$ = 15V, $T_J$ = 25°C |
| | | — | 2.3 | — | | $I_C$ = 20A, $V_{GE}$ = 15V, $T_J$ = 150°C |
| $V_{GE(th)}$ | Gate Threshold Voltage | 3.0 | — | 6.0 | V | $V_{CE}$ = $V_{GE}$, $I_C$ = 600µA |
| $\Delta V_{GE(th)}/\Delta TJ$ | Threshold Voltage temp. coefficient | — | -16 | — | mV/°C | $V_{CE}$ = $V_{GE}$, $I_C$ = 600µA (25°C - 150°C) |
| gfe | Forward Transconductance | — | 22 | — | S | $V_{CE}$ = 50V, $I_C$ = 20A, PW = 30µs |
| $I_{CES}$ | Collector-to-Emitter Leakage Current | — | 2.0 | 100 | µA | $V_{GE}$ = 0V, $V_{CE}$ = 1200V |
| | | — | 2000 | — | | $V_{GE}$ = 0V, $V_{CE}$ = 1200V, $T_J$ = 150°C |
| $V_{FM}$ | Diode Forward Voltage Drop | — | 2.8 | 3.6 | V | $I_F$ = 20A |
| | | — | 2.5 | — | | $I_F$ = 20A, $T_J$ = 150°C |
| $I_{GES}$ | Gate-to-Emitter Leakage Current | — | — | ±100 | nA | $V_{GE}$ = ±30V |

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

| | Parameter | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| $Q_g$ | Total Gate Charge (turn-on) | — | 85 | 130 | nC | $I_C$ = 20A |
| $Q_{ge}$ | Gate-to-Emitter Charge (turn-on) | — | 15 | 20 | | $V_{GE}$ = 15V |
| $Q_{gc}$ | Gate-to-Collector Charge (turn-on) | — | 35 | 50 | | $V_{CC}$ = 600V |
| $E_{on}$ | Turn-On Switching Loss | — | 1060 | 1300 | µJ | $I_C$ = 20A, $V_{CC}$ = 600V, $V_{GE}$ = 15V |
| $E_{off}$ | Turn-Off Switching Loss | — | 620 | 850 | | $R_G$ = 10Ω, L = 200uH, $L_S$ = 150nH, $T_J$ = 25°C |
| $E_{total}$ | Total Switching Loss | — | 1680 | 2150 | | Energy losses include tail & diode reverse recovery |
| $t_{d(on)}$ | Turn-On delay time | — | 30 | 50 | ns | $I_C$ = 20A, $V_{CC}$ = 600V, $V_{GE}$ = 15V |
| $t_r$ | Rise time | — | 15 | 30 | | $R_G$ = 10Ω, L = 200uH, $L_S$ = 150nH, $T_J$ = 25°C |
| $t_{d(off)}$ | Turn-Off delay time | — | 160 | 180 | | |
| $t_f$ | Fall time | — | 80 | 105 | | |
| $E_{on}$ | Turn-On Switching Loss | — | 1750 | — | µJ | $I_C$ = 20A, $V_{CC}$ = 600V, $V_{GE}$=15V |
| $E_{off}$ | Turn-Off Switching Loss | — | 1120 | — | | $R_G$=10Ω, L=200uH, $L_S$=150nH, $T_J$ = 150°C ③ |
| $E_{total}$ | Total Switching Loss | — | 2870 | — | | Energy losses include tail & diode reverse recovery |
| $t_{d(on)}$ | Turn-On delay time | — | 30 | — | ns | $I_C$ = 20A, $V_{CC}$ = 600V, $V_{GE}$ = 15V |
| $t_r$ | Rise time | — | 15 | — | | $R_G$ = 10Ω, L = 200uH, $L_S$ = 150nH |
| $t_{d(off)}$ | Turn-Off delay time | — | 190 | — | | $T_J$ = 150°C |
| $t_f$ | Fall time | — | 210 | — | | |
| $C_{ies}$ | Input Capacitance | — | 1940 | — | pF | $V_{GE}$ = 0V |
| $C_{oes}$ | Output Capacitance | — | 120 | — | | $V_{CC}$ = 30V |
| $C_{res}$ | Reverse Transfer Capacitance | — | 40 | — | | f = 1.0Mhz |
| RBSOA | Reverse Bias Safe Operating Area | FULL SQUARE | | | | $T_J$ = 150°C, $I_C$ = 80A<br>$V_{CC}$ = 960V, Vp =1200V<br>Rg = 10Ω, $V_{GE}$ = +20V to 0V |
| Erec | Reverse Recovery Energy of the Diode | — | 790 | — | µJ | $T_J$ = 150°C |
| $t_{rr}$ | Diode Reverse Recovery Time | — | 105 | — | ns | $V_{CC}$ = 600V, $I_F$ = 20A |
| $I_{rr}$ | Peak Reverse Recovery Current | — | 40 | — | A | $V_{GE}$ = 15V, Rg = 10Ω, L =1.0mH, $L_s$ = 150nH |

**Notes:**

① $V_{CC}$ = 80% ($V_{CES}$), $V_{GE}$ = 20V, $R_G$ = 50Ω.
② Pulse width limited by max. junction temperature.
③ Refer to AN-1086 for guidelines for measuring $V_{(BR)CES}$ safely.
④ $R_\theta$ is measured at $T_J$ of approximately 90°C.

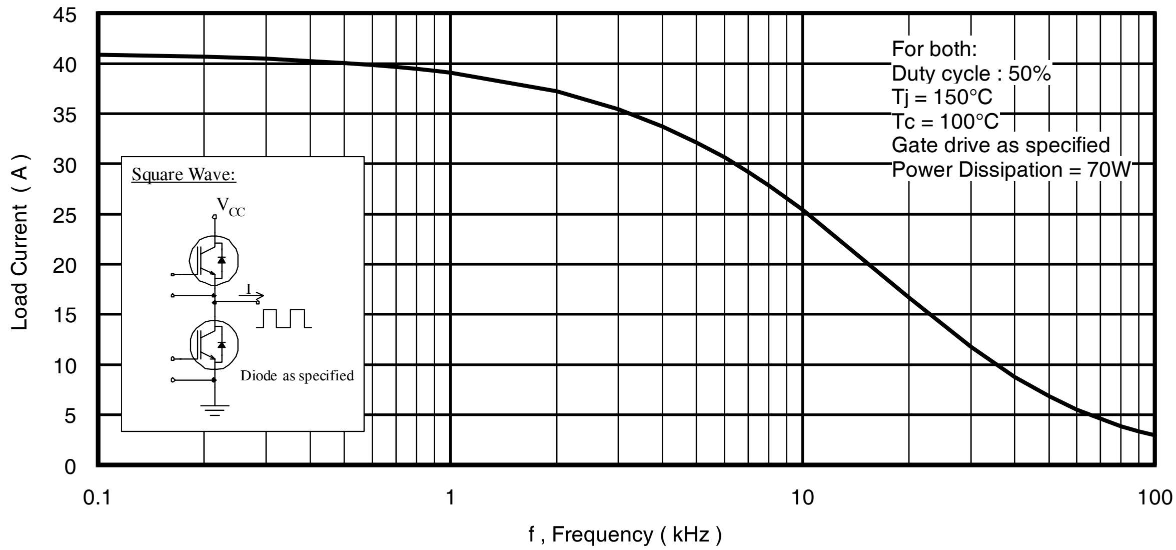



**Fig. 1** - Typical Load Current vs. Frequency
(Load Current = $I_{RMS}$ of fundamental)

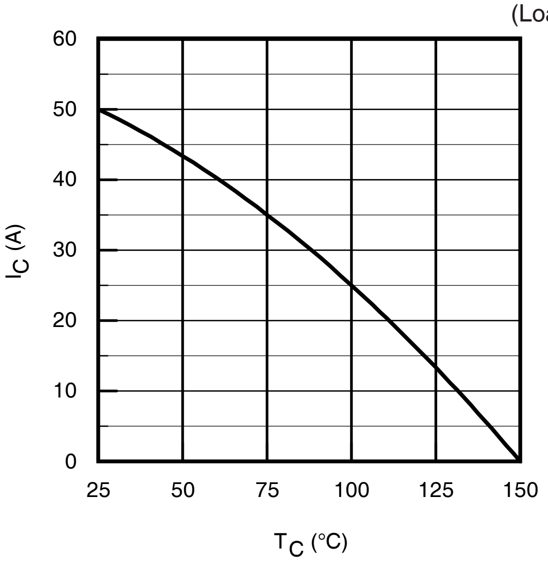



**Fig. 2** - Maximum DC Collector Current vs. Case Temperature

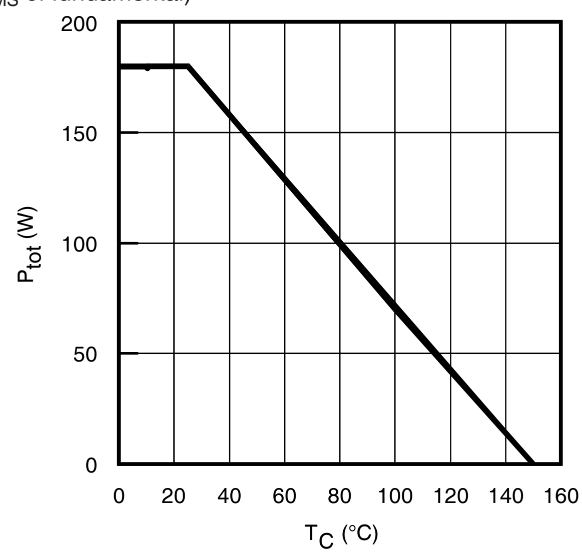



**Fig. 3**- Power Dissipation vs. Case Temperature

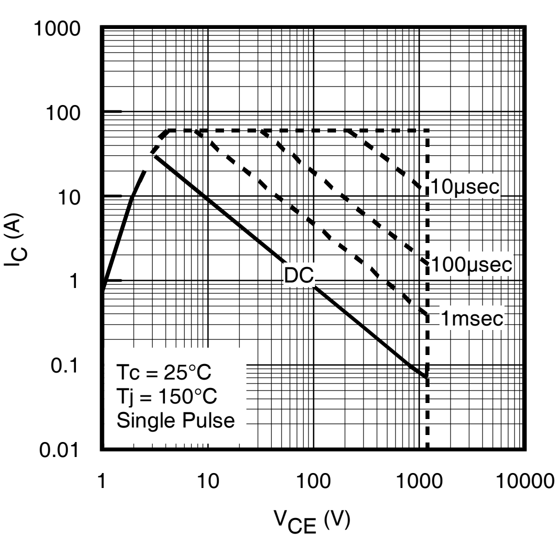



**Fig. 4** - Forward SOA
$T_C$ = 25°C, $T_J \leq$ 150°C; $V_{GE}$ =15V

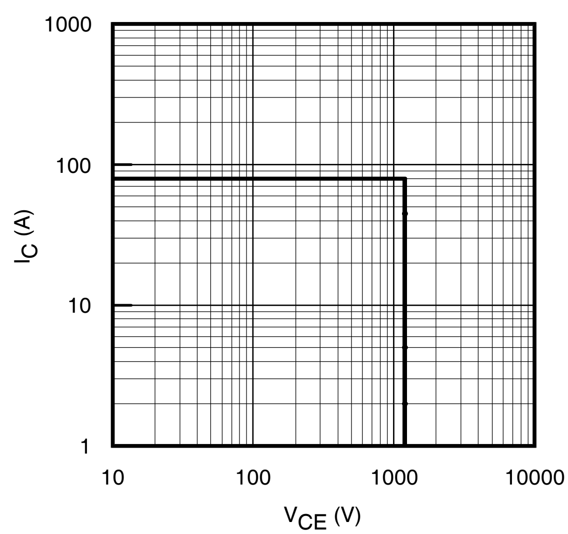



**Fig. 5** - Reverse Bias SOA
$T_J$ = 150°C; $V_{GE}$ = 20V

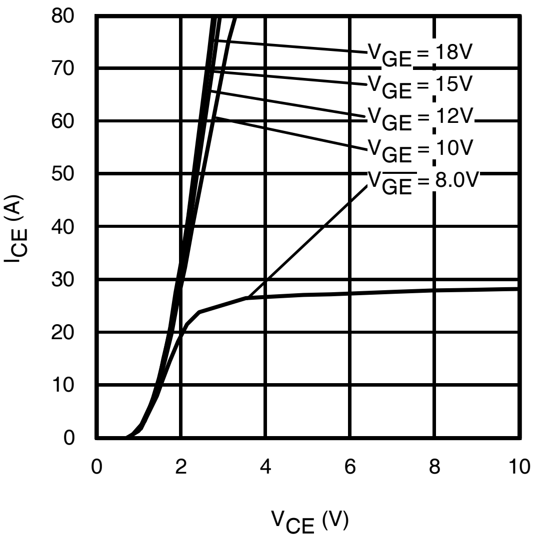



**Fig. 6**- Typ. IGBT Output Characteristics
$T_J$ = -40°C; tp = 30µs

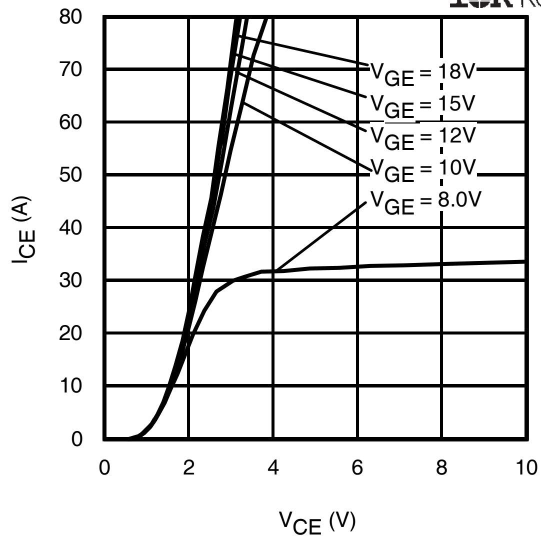



**Fig. 7** - Typ. IGBT Output Characteristics
$T_J$ = 25°C; tp = 30µs

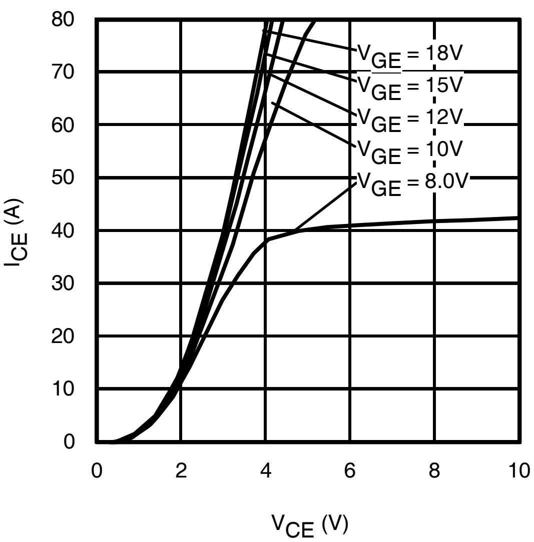



**Fig. 8** - Typ. IGBT Output Characteristics
$T_J$ = 150°C; tp = 30µs

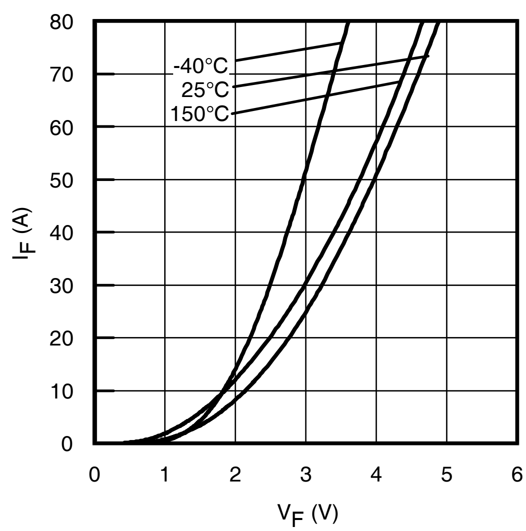



**Fig. 9** - Typ. Diode Forward Characteristics
tp = 380µs

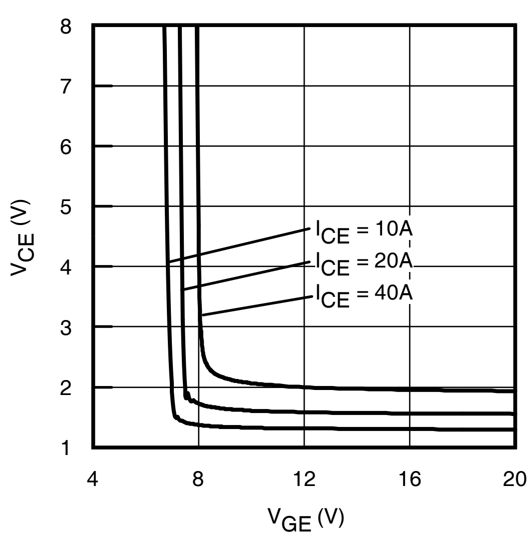



**Fig. 10** - Typical $V_{CE}$ vs. $V_{GE}$
$T_J$ = -40°C

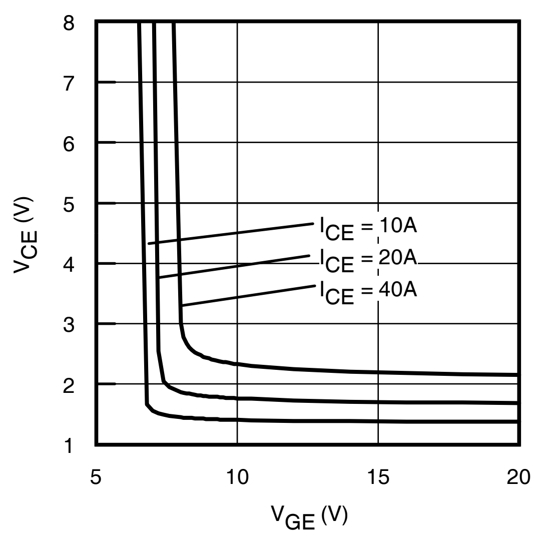



**Fig. 11** - Typical $V_{CE}$ vs. $V_{GE}$
$T_J$ = 25°C

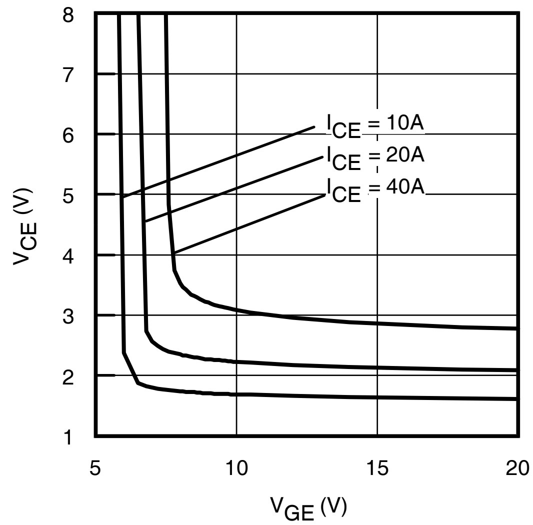



**Fig. 12** - Typical $V_{CE}$ vs. $V_{GE}$
$T_J = 150°C$

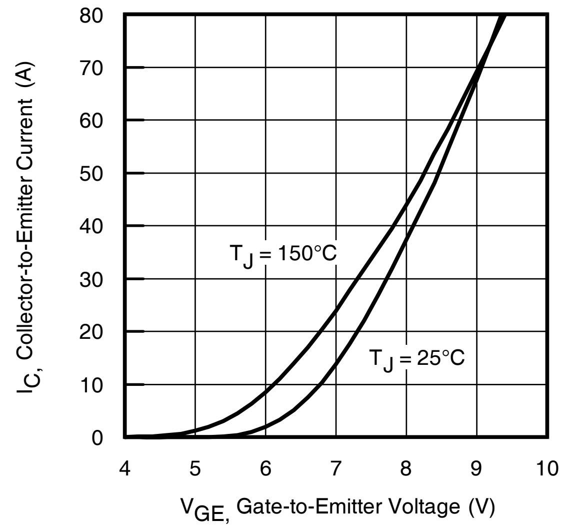



**Fig. 13** - Typ. Transfer Characteristics
$V_{CE} = 50V$, tp = 30µs

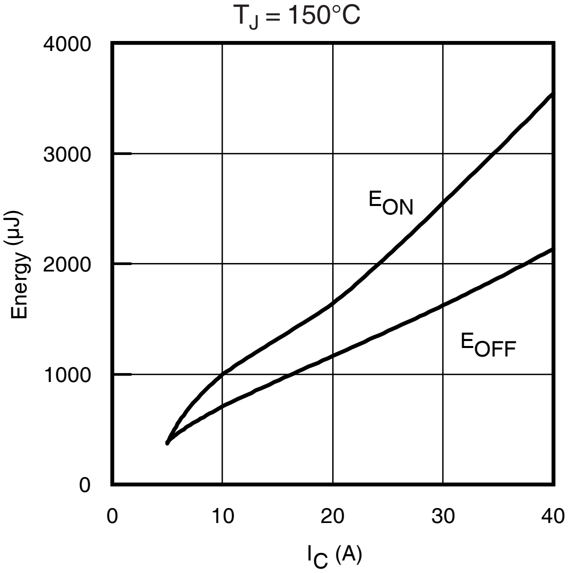



**Fig. 14** - Typ. Energy Loss vs. $I_C$
$T_J = 150°C$; L = 680µH; $V_{CE} = 600V$, $R_G = 10\Omega$; $V_{GE} = 15V$

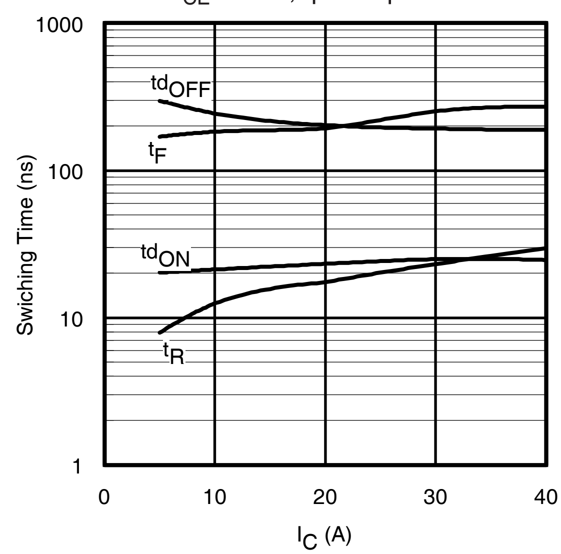



**Fig. 15** - Typ. Switching Time vs. $I_C$
$T_J = 150°C$; L = 680µH; $V_{CE} = 600V$, $R_G = 10\Omega$; $V_{GE} = 15V$

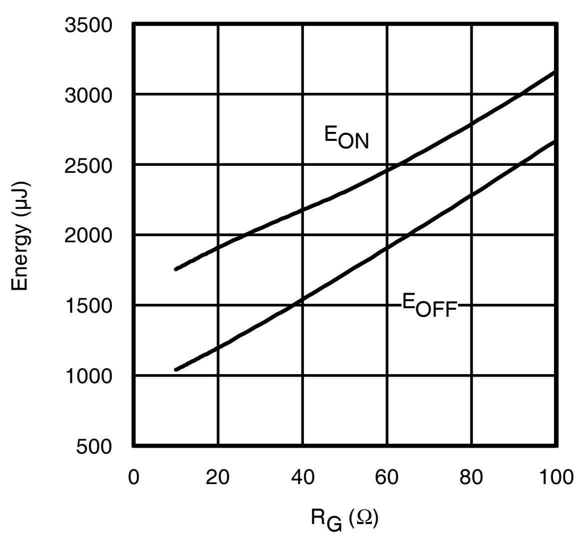



**Fig. 16** - Typ. Energy Loss vs. $R_G$
$T_J = 150°C$; L = 680µH; $V_{CE} = 600V$, $I_{CE} = 20A$; $V_{GE} = 15V$

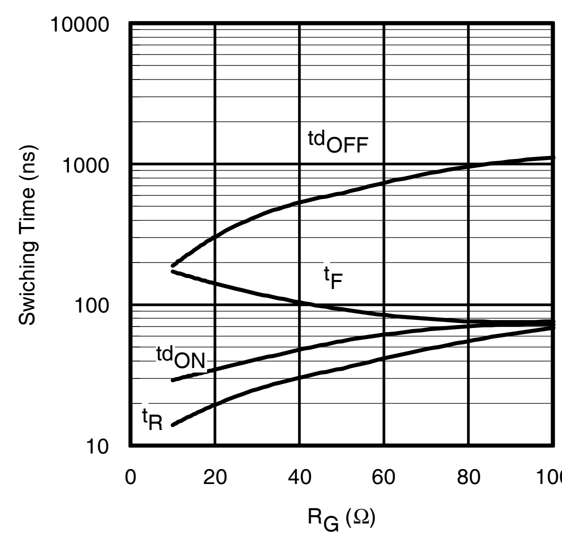



**Fig. 17** - Typ. Switching Time vs. $R_G$
$T_J = 150°C$; L = 680µH; $V_{CE} = 600V$, $I_{CE} = 20A$; $V_{GE} = 15V$

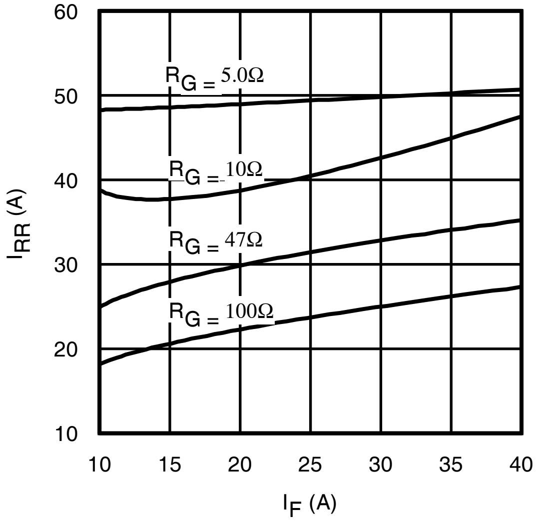



**Fig. 18** - Typ. Diode $I_{RR}$ vs. $I_F$
$T_J$ = 150°C

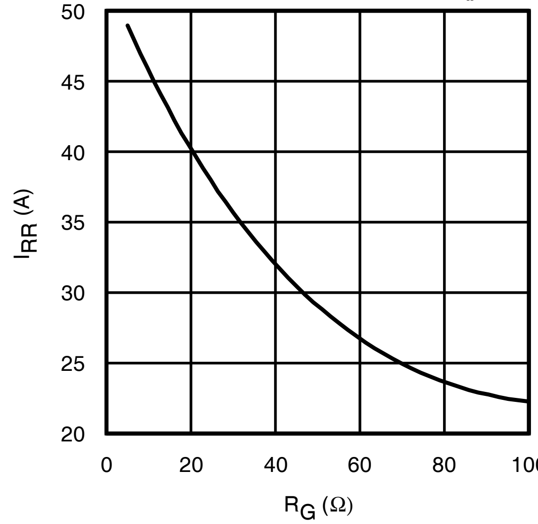



**Fig. 19** - Typ. Diode $I_{RR}$ vs. $R_G$
$T_J$ = 150°C

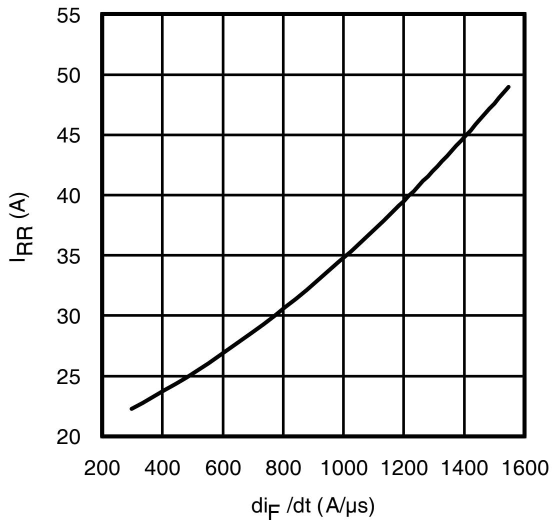



**Fig. 20** - Typ. Diode $I_{RR}$ vs. $di_F$/dt
$V_{CC}$ = 600V; $V_{GE}$ = 15V; $I_F$ = 20A; $T_J$ = 150°C

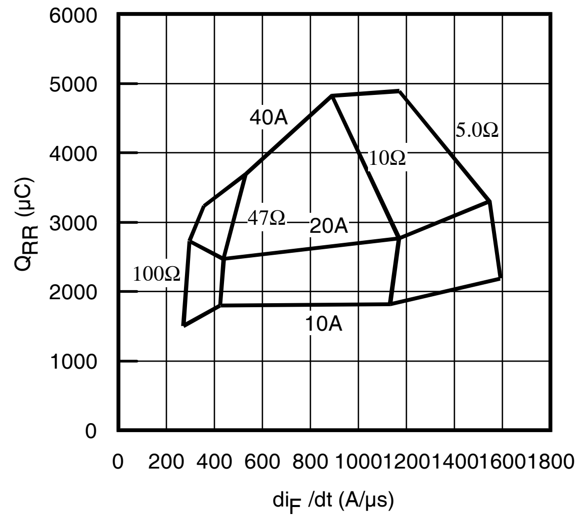



**Fig. 21** - Typ. Diode $Q_{RR}$ vs. $di_F$/dt
$V_{CC}$ = 600V; $V_{GE}$ = 15V; $T_J$ = 150°C

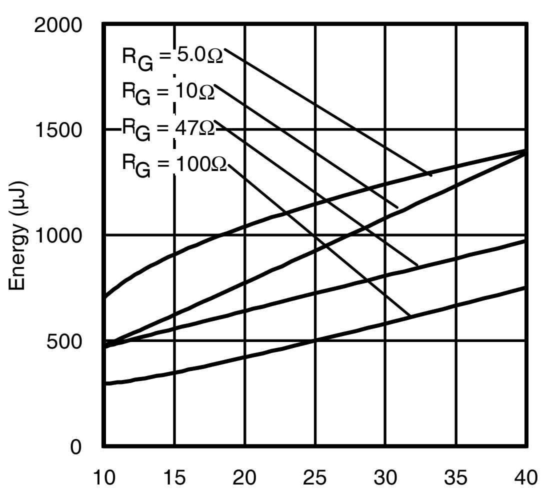



**Fig. 22** - Typ. Diode $E_{RR}$ vs. $I_F$
$T_J$ = 150°C

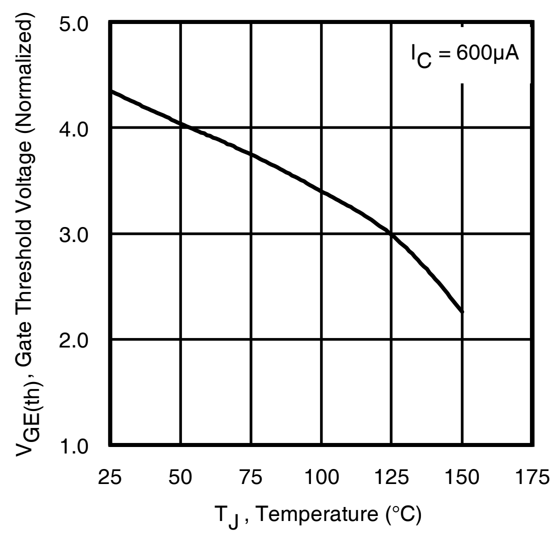



**Fig. 23** - Typical Gate Threshold Voltage (Normalized) vs. Junction Temperature

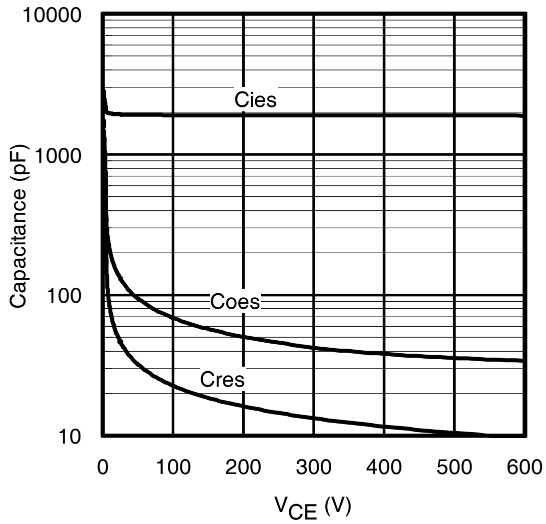



**Fig. 23** - Typ. Capacitance vs. $V_{CE}$
$V_{GE}$= 0V; f = 1MHz

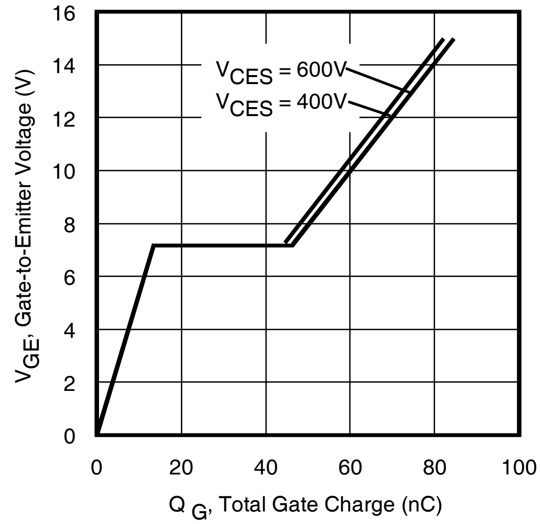



**Fig. 24** - Typical Gate Charge vs. $V_{GE}$
$I_{CE}$ = 20A; L = 2.4mH

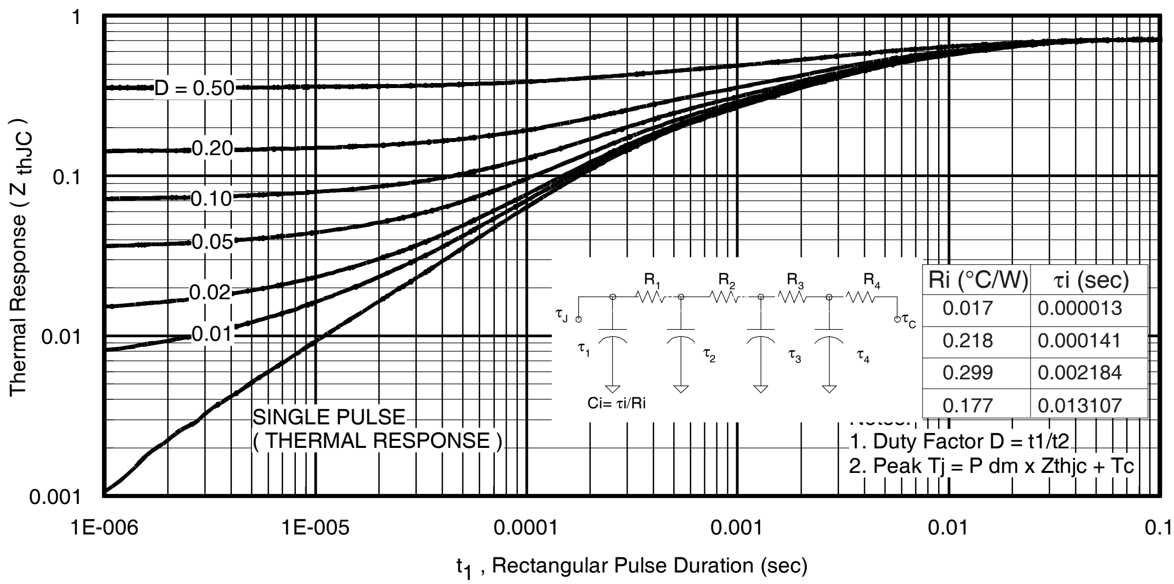



**Fig 25.** Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

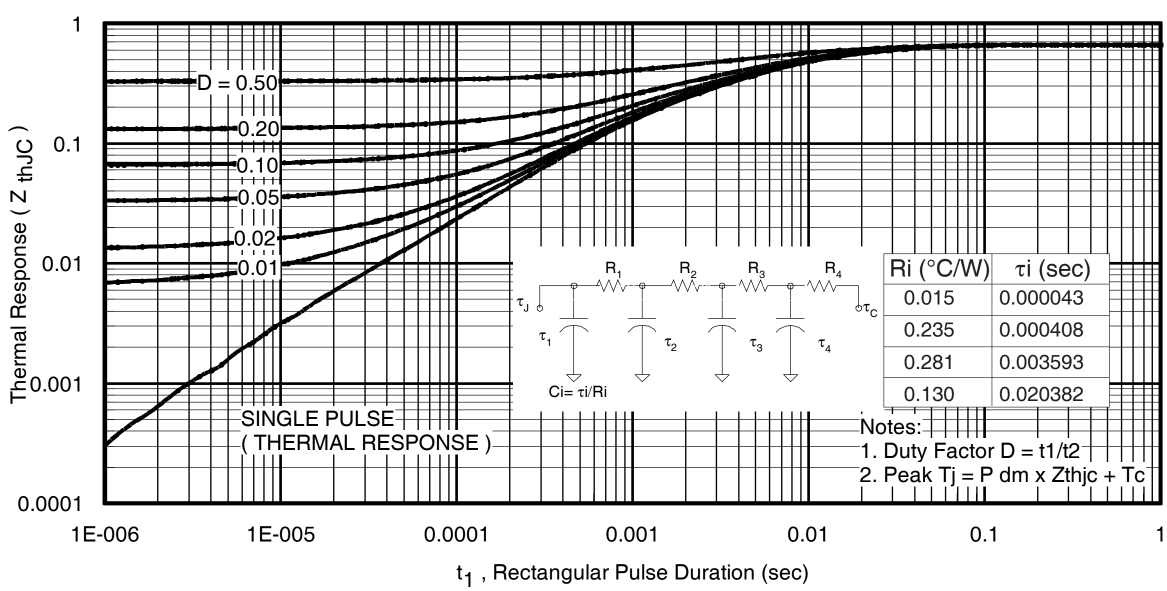



**Fig. 26.** Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)

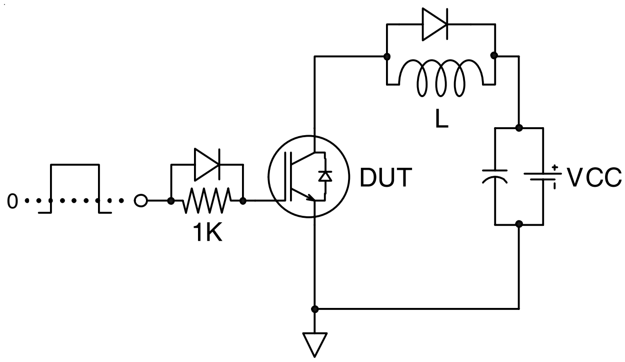



**Fig.C.T.1** - Gate Charge Circuit (turn-off)

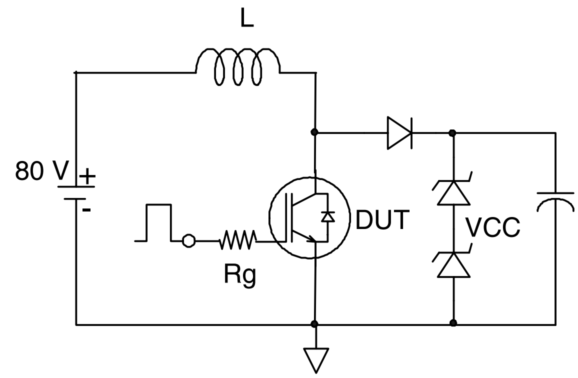



**Fig.C.T.2** - RBSOA Circuit

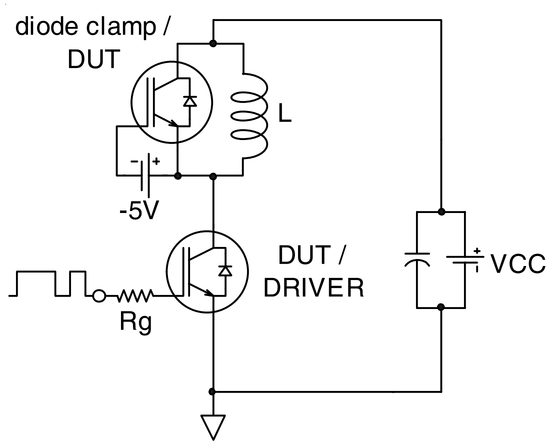



**Fig.C.T.3** - Switching Loss Circuit

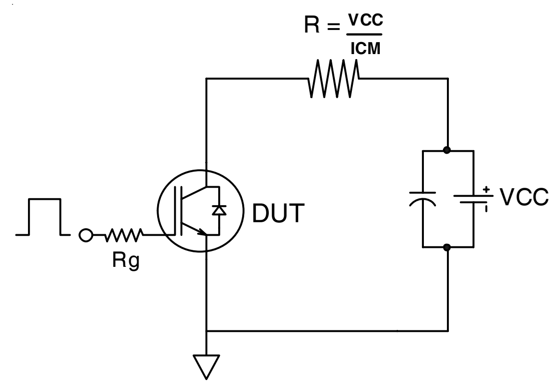



**Fig.C.T.4** - Resistive Load Circuit

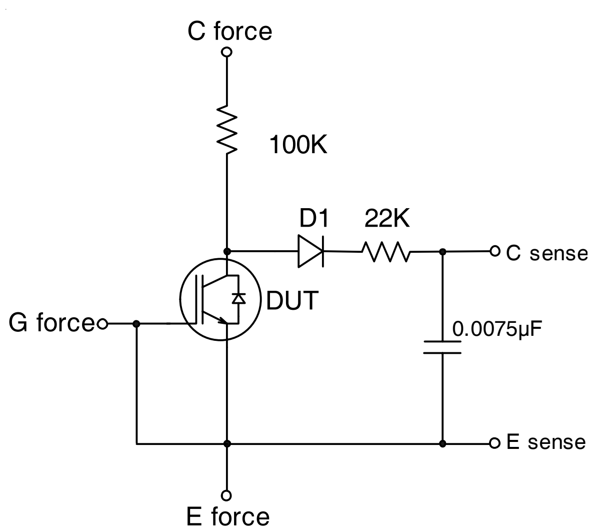



**Fig.C.T.5** - BVCES Filter Circuit

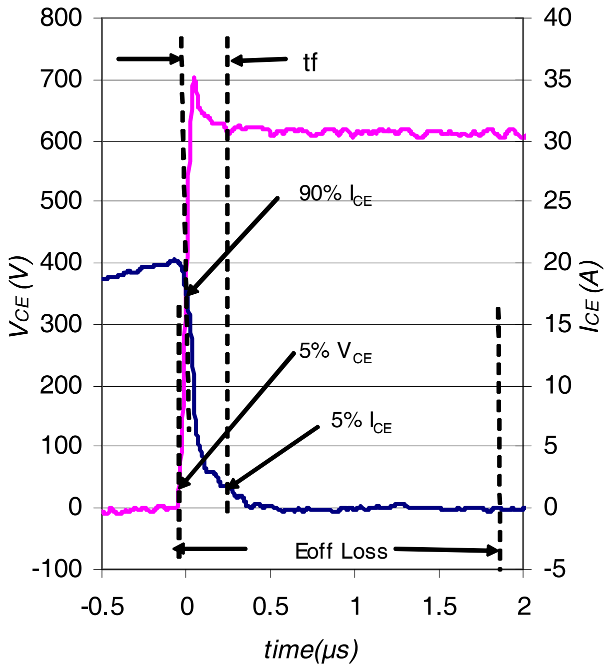



**Fig. WF1** - Typ. Turn-off Loss Waveform
@ $T_J$ = 150°C using Fig. CT.4

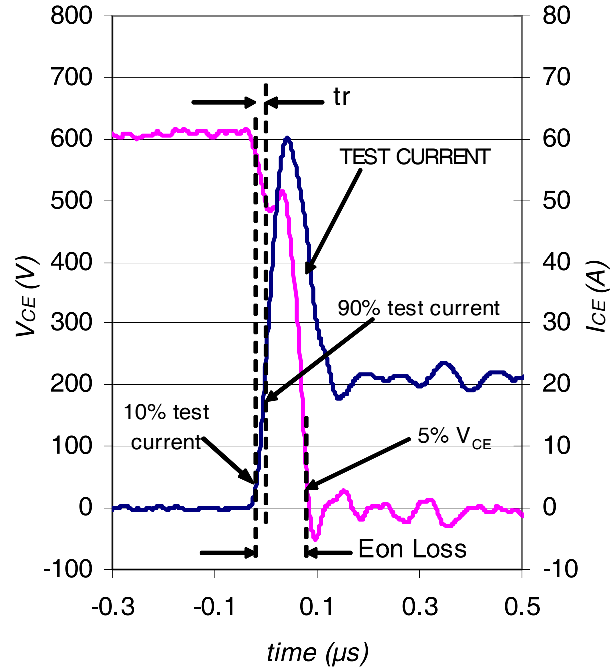



**Fig. WF2** - Typ. Turn-on Loss Waveform
@ $T_J$ = 150°C using Fig. CT.4

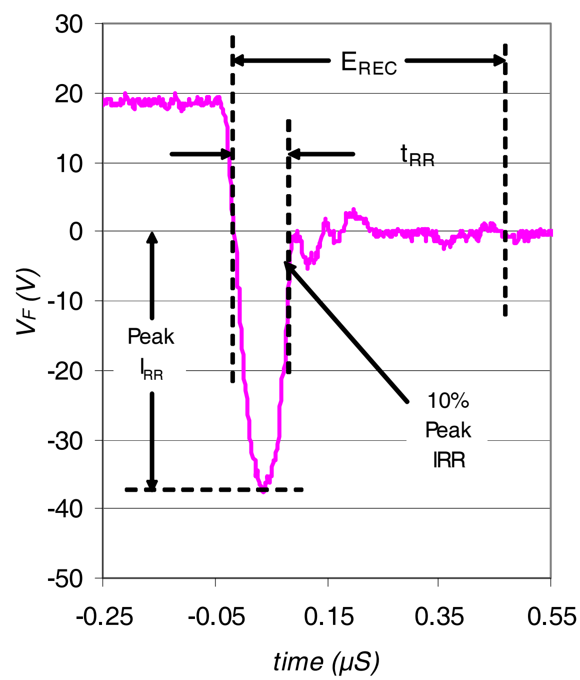
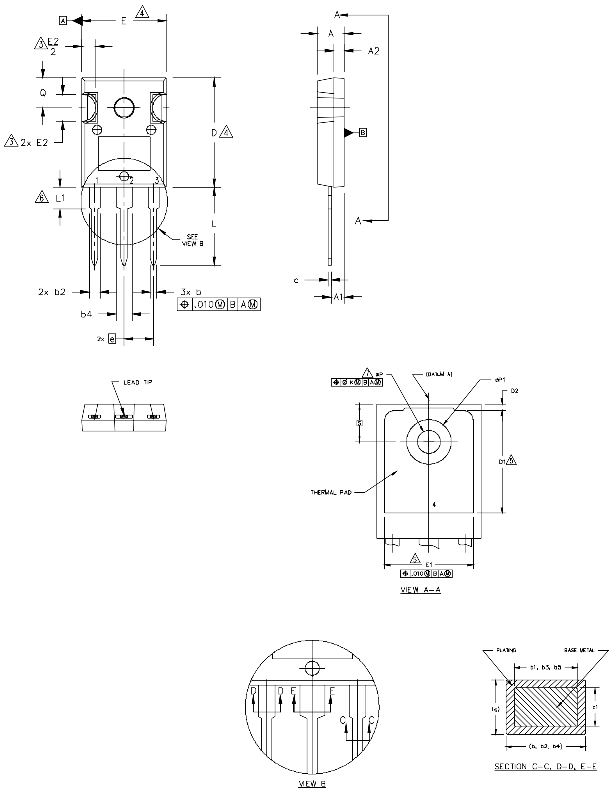



**Fig. WF3** - Typ. Diode Recovery Waveform
@ $T_J$ = 150°C using Fig. CT.4

## 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

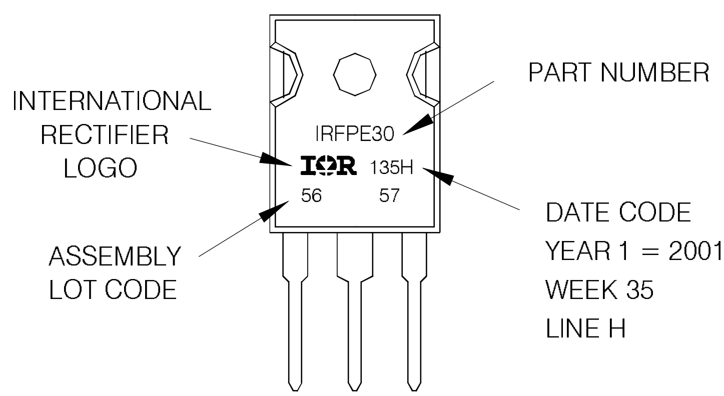
DIODES

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"

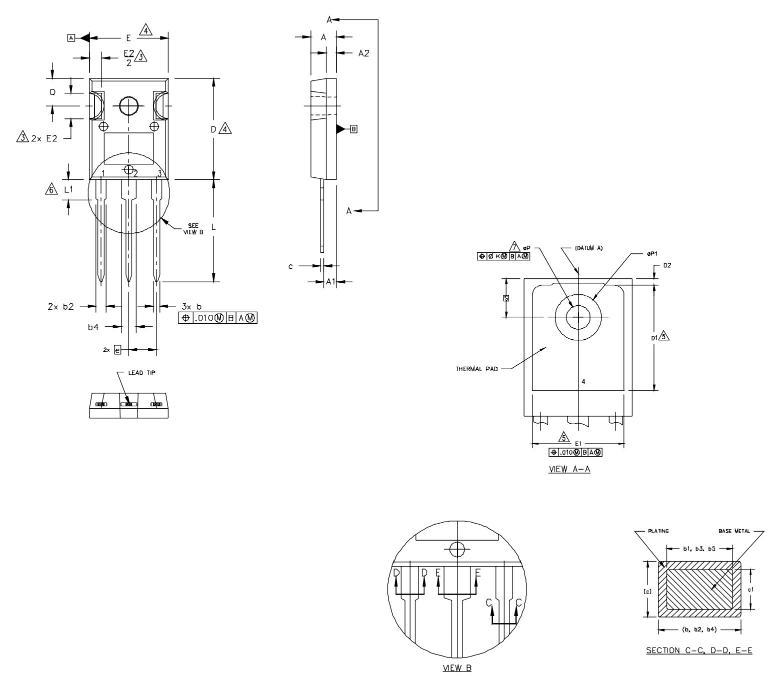



**TO-247AC package is not recommended for Surface Mount Application.**

**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. 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-247AD.

| 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 | .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

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2.- COLLECTOR
3.- EMITTER
4.- COLLECTOR

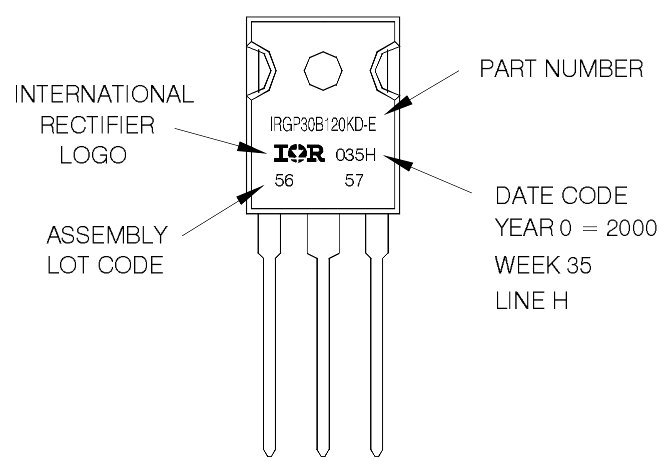
DIODES

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/**

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.

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