

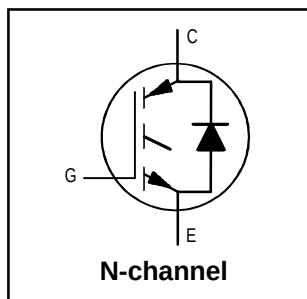
# IRGP20B120UD-E

## INSULATED GATE BIPOLAR TRANSISTOR WITH ULTRAFAST SOFT RECOVERY DIODE

## UltraFast CoPack IGBT

### Features

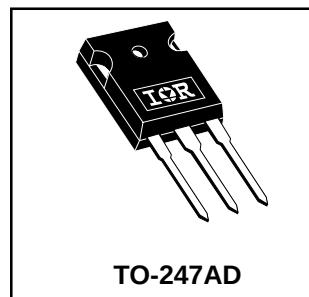
- UltraFast Non Punch Through (NPT) Technology
- Low Diode  $V_F$  (1.67V Typical @ 20A & 25°C)
- 10  $\mu$ s Short Circuit Capability
- Square RBSOA
- UltraSoft Diode Recovery Characteristics
- Positive  $V_{CE(on)}$  Temperature Coefficient
- Extended Lead TO-247AD Package



$V_{CES} = 1200V$   
 $V_{CE(on)} \text{ typ.} = 3.05V$   
 $V_{GE} = 15V, I_C = 20A, 25^\circ C$

### Benefits

- Benchmark Efficiency Above 20KHz
- Optimized for Welding, UPS, and Induction Heating Applications
- Rugged with UltraFast Performance
- Low EMI
- Significantly Less Snubber Required
- Excellent Current Sharing in Parallel Operation
- Longer Leads for Easier Mounting



### Absolute Maximum Ratings

|                           | Parameter                                           | Max.                               | Units      |
|---------------------------|-----------------------------------------------------|------------------------------------|------------|
| $V_{CES}$                 | Collector-to-Emitter Breakdown Voltage              | 1200                               | V          |
| $I_C @ T_C = 25^\circ C$  | Continuous Collector Current (Fig.1)                | 40                                 | A          |
| $I_C @ T_C = 100^\circ C$ | Continuous Collector Current (Fig.1)                | 20                                 |            |
| $I_{CM}$                  | Pulsed Collector Current (Fig.3, Fig. CT.5)         | 120                                |            |
| $I_{LM}$                  | Clamped Inductive Load Current (Fig.4, Fig. CT.2)   | 120                                |            |
| $I_F @ T_C = 100^\circ C$ | Diode Continuous Forward Current                    | 20                                 |            |
| $I_{FM}$                  | Diode Maximum Forward Current                       | 120                                |            |
| $V_{GE}$                  | Gate-to-Emitter Voltage                             | $\pm 20$                           | V          |
| $P_D @ T_C = 25^\circ C$  | Maximum Power Dissipation (Fig.2)                   | 300                                | W          |
| $P_D @ T_C = 100^\circ C$ | Maximum Power Dissipation (Fig.2)                   | 120                                |            |
| $T_J$<br>$T_{STG}$        | Operating Junction and<br>Storage Temperature Range | -55 to + 150                       | $^\circ C$ |
|                           | Soldering Temperature, for 10 seconds               | 300, (0.063 in. (1.6mm) from case) |            |
|                           | Mounting Torque, 6-32 or M3 screw.                  | 10 lbf•in (1.1N•m)                 |            |

### Thermal Resistance

|                 | Parameter                                             | Min. | Typ.     | Max. | Units        |
|-----------------|-------------------------------------------------------|------|----------|------|--------------|
| $R_{\theta JC}$ | Junction-to-Case - IGBT                               | —    | —        | 0.42 | $^\circ C/W$ |
| $R_{\theta JC}$ | Junction-to-Case - Diode                              | —    | —        | 0.83 |              |
| $R_{\theta CS}$ | Case-to-Sink, flat, greased surface                   | —    | 0.24     | —    |              |
| $R_{\theta JA}$ | Junction-to-Ambient, typical socket mount             | —    | —        | 40   |              |
| $W_t$           | Weight                                                | —    | 6 (0.21) | —    | g (oz)       |
| $Z_{\theta JC}$ | Transient Thermal Impedance Junction-to-Case (Fig.24) |      |          |      |              |

## Electrical Characteristics @ T<sub>J</sub> = 25°C (unless otherwise specified)

|                                         | Parameter                               | Min. | Typ.  | Max. | Units | Conditions                                                             | Fig.       |
|-----------------------------------------|-----------------------------------------|------|-------|------|-------|------------------------------------------------------------------------|------------|
| V <sub>(BR)CES</sub>                    | Collector-to-Emitter Breakdown Voltage  | 1200 |       |      | V     | V <sub>GE</sub> = 0V, I <sub>C</sub> = 250 μA                          |            |
| ΔV <sub>(BR)CES</sub> / ΔT <sub>J</sub> | Temperature Coeff. of Breakdown Voltage |      | +1.2  |      | V/°C  | V <sub>GE</sub> = 0V, I <sub>C</sub> = 1 mA ( 25 -125 °C )             |            |
| V <sub>CE(on)</sub>                     | Collector-to-Emitter Saturation Voltage |      | 3.05  | 3.45 | V     | I <sub>C</sub> = 20A, V <sub>GE</sub> = 15V                            | 5, 6       |
|                                         |                                         |      | 3.37  | 3.80 |       | I <sub>C</sub> = 25A, V <sub>GE</sub> = 15V                            | 7, 9       |
|                                         |                                         |      | 4.23  | 4.85 |       | I <sub>C</sub> = 40A, V <sub>GE</sub> = 15V                            | 10         |
|                                         |                                         |      | 3.89  | 4.50 |       | I <sub>C</sub> = 20A, V <sub>GE</sub> = 15V, T <sub>J</sub> = 125°C    | 11         |
|                                         |                                         |      | 4.31  | 5.06 |       | I <sub>C</sub> = 25A, V <sub>GE</sub> = 15V, T <sub>J</sub> = 125°C    |            |
| V <sub>GE(th)</sub>                     | Gate Threshold Voltage                  | 4.0  | 5.0   | 6.0  | V     | V <sub>CE</sub> = V <sub>GE</sub> , I <sub>C</sub> = 250 μA            | 9,10,11,12 |
| ΔV <sub>GE(th)</sub> / ΔT <sub>J</sub>  | Temperature Coeff. of Threshold Voltage |      | - 1.2 |      | mV/°C | V <sub>CE</sub> = V <sub>GE</sub> , I <sub>C</sub> = 1 mA (25 -125 °C) |            |
| g <sub>fe</sub>                         | Forward Transconductance                | 13.6 | 15.7  | 17.8 | S     | V <sub>CE</sub> = 50V, I <sub>C</sub> = 20A, PW=80μs                   |            |
| I <sub>CES</sub>                        | Zero Gate Voltage Collector Current     |      |       | 250  | μA    | V <sub>GE</sub> = 0V, V <sub>CE</sub> = 1200V                          |            |
|                                         |                                         |      | 420   | 750  |       | V <sub>GE</sub> = 0V, V <sub>CE</sub> = 1200V, T <sub>J</sub> =125°C   |            |
|                                         |                                         |      | 1482  | 2200 |       | V <sub>GE</sub> = 0V, V <sub>CE</sub> = 1200V, T <sub>J</sub> =150°C   |            |
| V <sub>FM</sub>                         | Diode Forward Voltage Drop              |      | 1.67  | 1.96 | V     | I <sub>C</sub> = 20A                                                   | 8          |
|                                         |                                         |      | 1.76  | 2.06 |       | I <sub>C</sub> = 25A                                                   |            |
|                                         |                                         |      | 1.73  | 2.03 |       | I <sub>C</sub> = 20A, T <sub>J</sub> = 125°C                           |            |
|                                         |                                         |      | 1.87  | 2.18 |       | I <sub>C</sub> = 25A, T <sub>J</sub> = 125°C                           |            |
| I <sub>GES</sub>                        | Gate-to-Emitter Leakage Current         |      |       | ±100 | nA    | V <sub>GE</sub> = ±20V                                                 |            |

## Switching Characteristics @ T<sub>J</sub> = 25°C (unless otherwise specified)

|                  | Parameter                            | Min.        | Typ. | Max. | Units | Conditions                                                                                                                                            | Fig.       |
|------------------|--------------------------------------|-------------|------|------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| Q <sub>g</sub>   | Total Gate charge (turn-on)          |             | 169  | 254  | nC    | I <sub>C</sub> = 20A                                                                                                                                  | 23         |
| Q <sub>ge</sub>  | Gate - Emitter Charge (turn-on)      |             | 24   | 36   |       | V <sub>CC</sub> = 600V                                                                                                                                | CT1        |
| Q <sub>gc</sub>  | Gate - Collector Charge (turn-on)    |             | 82   | 126  |       | V <sub>GE</sub> = 15V                                                                                                                                 |            |
| E <sub>on</sub>  | Turn-On Switching Loss               |             | 850  | 1050 | μJ    | I <sub>C</sub> = 20A, V <sub>CC</sub> = 600V                                                                                                          | CT4        |
| E <sub>off</sub> | Turn-Off Switching Loss              |             | 425  | 650  |       | V <sub>GE</sub> = 15V, R <sub>g</sub> = 5Ω, L = 200μH                                                                                                 | WF1        |
| E <sub>tot</sub> | Total Switching Loss                 |             | 1275 | 1800 |       | T <sub>J</sub> = 25°C, Energy losses include tail and diode reverse recovery                                                                          | WF2        |
| E <sub>on</sub>  | Turn-on Switching Loss               |             | 1350 | 1550 | μJ    | I <sub>C</sub> = 20A, V <sub>CC</sub> = 600V                                                                                                          | 13, 15     |
| E <sub>off</sub> | Turn-off Switching Loss              |             | 610  | 875  |       | V <sub>GE</sub> = 15V, R <sub>g</sub> = 5Ω, L = 200μH                                                                                                 | CT4        |
| E <sub>tot</sub> | Total Switching Loss                 |             | 1960 | 2425 |       | T <sub>J</sub> = 125°C, Energy losses include tail and diode reverse recovery                                                                         | WF1 & 2    |
| td(on)           | Turn - on delay time                 |             | 50   | 65   | ns    | I <sub>C</sub> = 20A, V <sub>CC</sub> = 600V                                                                                                          | 14, 16     |
| tr               | Rise time                            |             | 20   | 30   |       | V <sub>GE</sub> = 15V, R <sub>g</sub> = 5Ω, L = 200μH                                                                                                 | CT4        |
| td(off)          | Turn - off delay time                |             | 204  | 230  |       | T <sub>J</sub> = 125°C                                                                                                                                | WF1        |
| tf               | Fall time                            |             | 24   | 35   |       |                                                                                                                                                       | WF2        |
| C <sub>ies</sub> | Input Capacitance                    |             | 2200 |      | pF    | V <sub>GE</sub> = 0V                                                                                                                                  | 22         |
| C <sub>oes</sub> | Output Capacitance                   |             | 210  |      |       | V <sub>CC</sub> = 30V                                                                                                                                 |            |
| C <sub>res</sub> | Reverse Transfer Capacitance         |             | 85   |      |       | f = 1.0 MHz                                                                                                                                           |            |
| RBSOA            | Reverse bias safe operating area     | FULL SQUARE |      |      |       | T <sub>J</sub> = 150°C, I <sub>C</sub> = 120A<br>V <sub>CC</sub> = 1000V, V <sub>P</sub> = 1200V<br>R <sub>g</sub> = 5Ω, V <sub>GE</sub> = +15V to 0V | 4<br>CT2   |
| SCSOA            | Short Circuit Safe Operating Area    | 10          | ---- | ---- | μs    | T <sub>J</sub> = 150°C<br>V <sub>CC</sub> = 900V, V <sub>P</sub> = 1200V<br>R <sub>g</sub> = 5Ω, V <sub>GE</sub> = +15V to 0V                         | CT3<br>WF4 |
| E <sub>rec</sub> | Reverse recovery energy of the diode |             | 1600 | 2100 | μJ    | T <sub>J</sub> = 125°C                                                                                                                                | 17,18,19   |
| trr              | Diode Reverse recovery time          |             | 300  |      | ns    | V <sub>CC</sub> = 600V, I <sub>C</sub> = 20A                                                                                                          | 20, 21     |
| I <sub>rr</sub>  | Peak Reverse Recovery Current        |             | 32   | 36   | A     | V <sub>GE</sub> = 15V, R <sub>g</sub> = 5Ω, L = 200μH                                                                                                 | CT4, WF3   |
| Le               | Internal Emitter Inductance          |             | 13   |      | nH    | Measured 5 mm from the package.                                                                                                                       |            |

# IRGP20B120UD-E

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

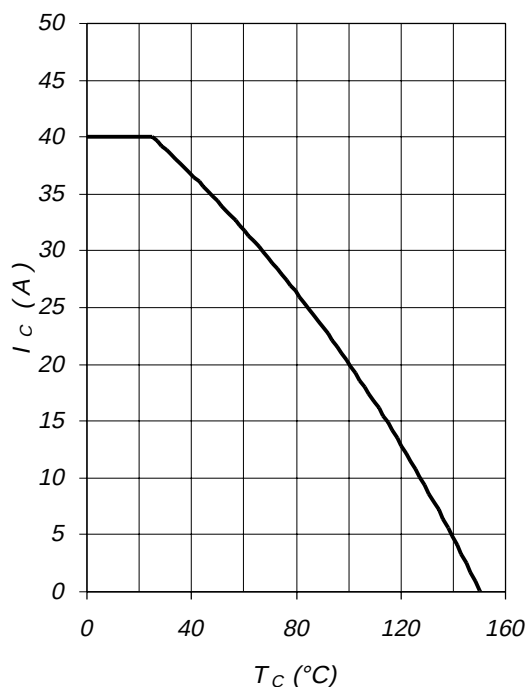


Fig.2 - Power Dissipation vs. Case Temperature

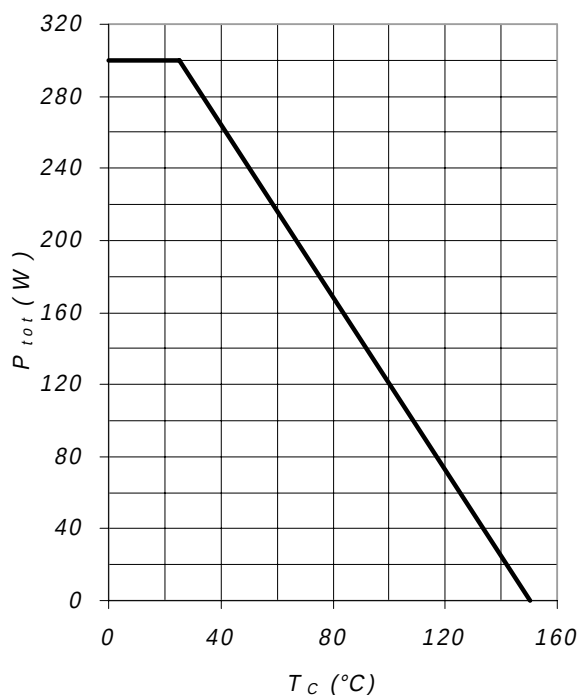


Fig.3 - Forward SOA  
 $T_C=25^\circ\text{C}$ ;  $T_J \leq 150^\circ\text{C}$

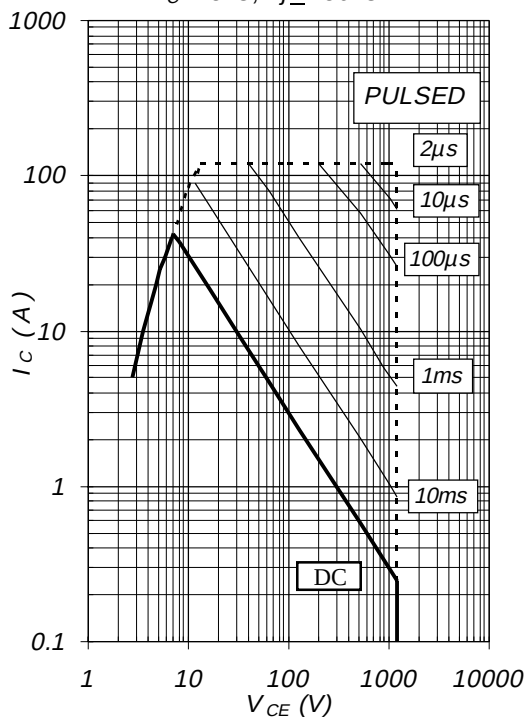


Fig.4 - Reverse Bias SOA  
 $T_J = 150^\circ\text{C}$ ,  $V_{GE} = 15\text{V}$

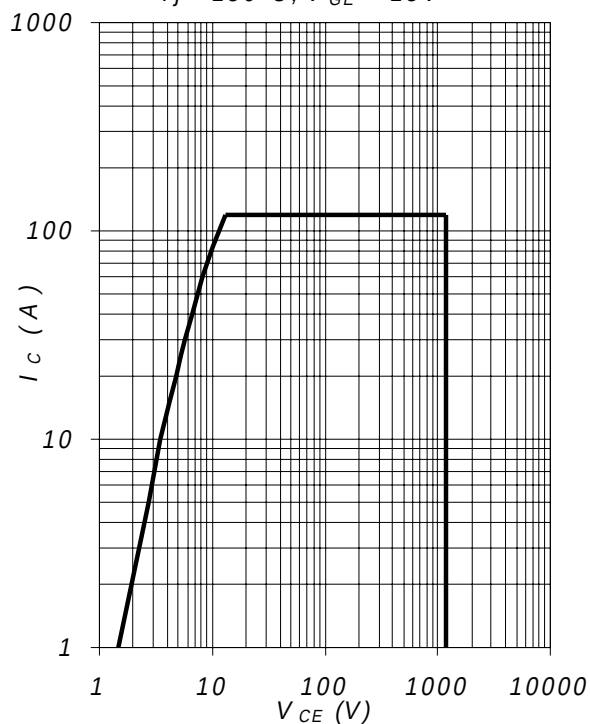


Fig.5 - Typical IGBT Output Characteristics  
 $T_j = -40^{\circ}\text{C}$ ;  $t_p = 300\mu\text{s}$

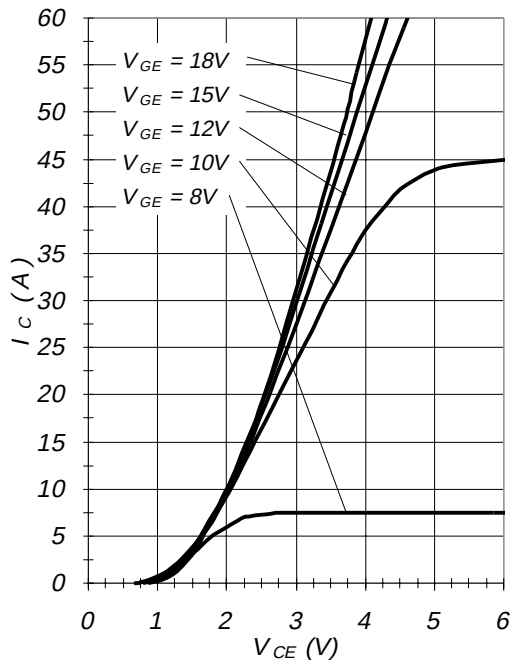


Fig.6 - Typical IGBT Output Characteristics  
 $T_j = 25^{\circ}\text{C}$ ;  $t_p = 300\mu\text{s}$

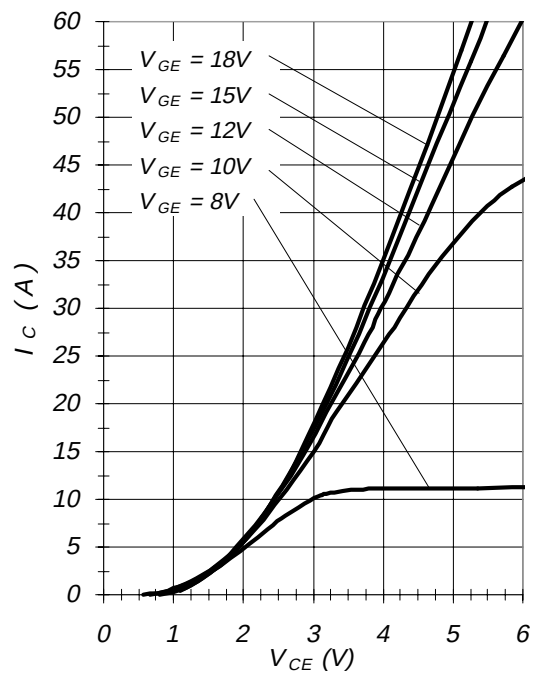


Fig.7 - Typical IGBT Output Characteristics  
 $T_j = 125^{\circ}\text{C}$ ;  $t_p = 300\mu\text{s}$

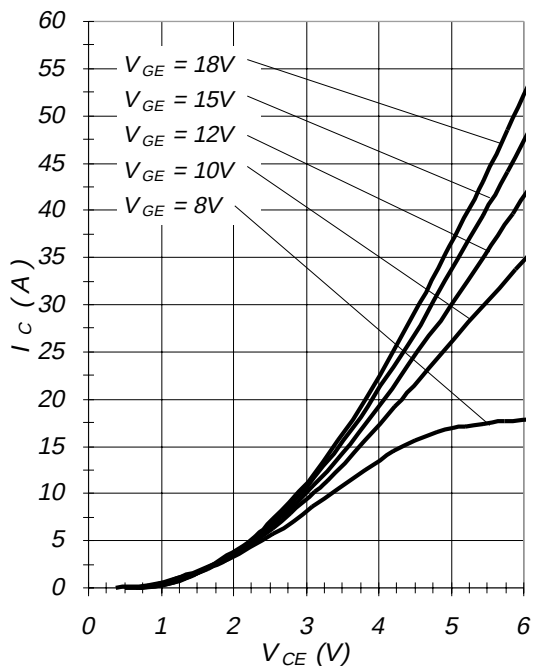


Fig.8 - Typical Diode Forward Characteristic  
 $t_p = 300\mu\text{s}$

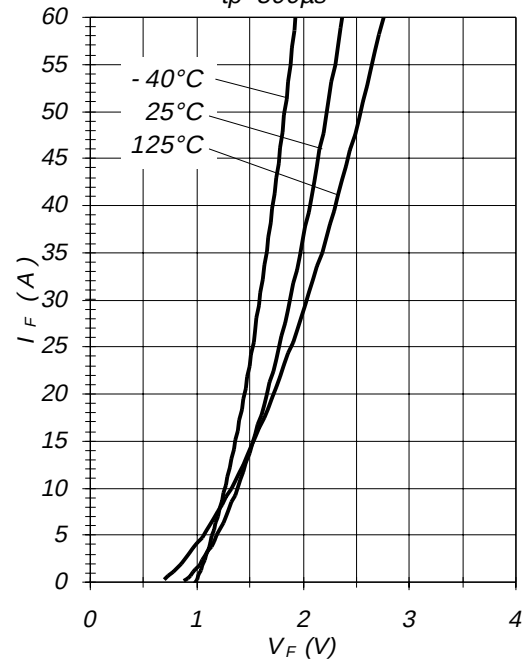


Fig.9 - Typical  $V_{CE}$  vs  $V_{GE}$   
 $T_j = -40^\circ\text{C}$

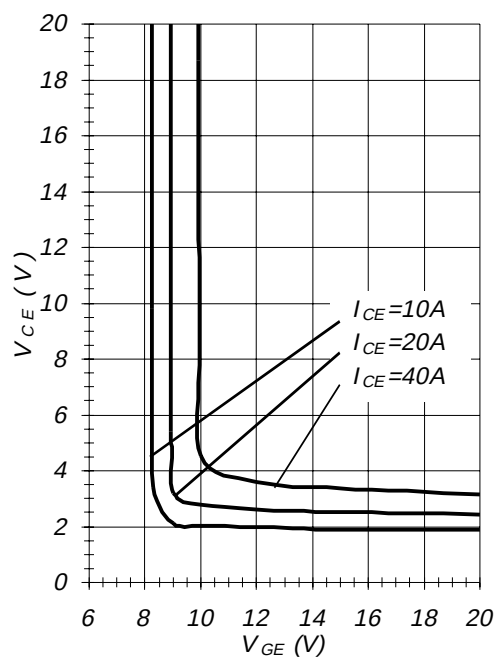


Fig.10 - Typical  $V_{CE}$  vs  $V_{GE}$   
 $T_j = 25^\circ\text{C}$

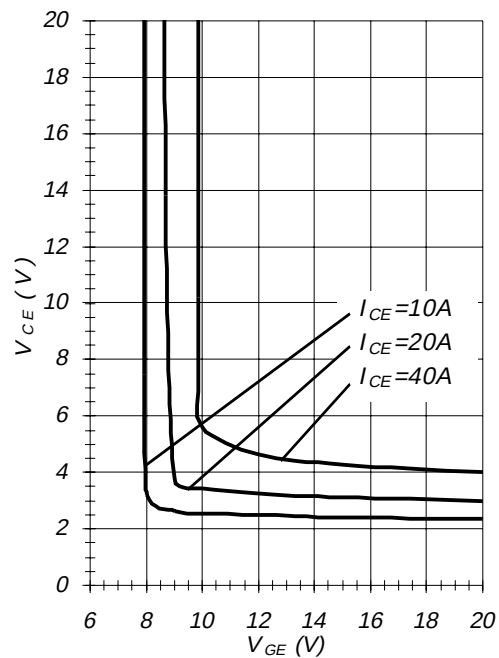


Fig.11 - Typical  $V_{CE}$  vs  $V_{GE}$   
 $T_j = 125^\circ\text{C}$

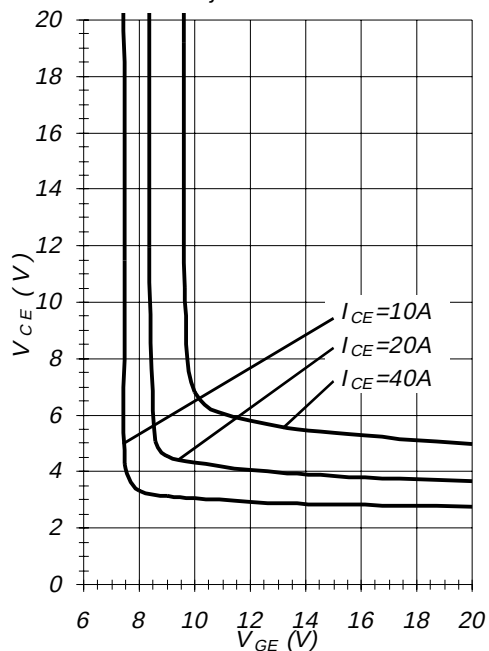
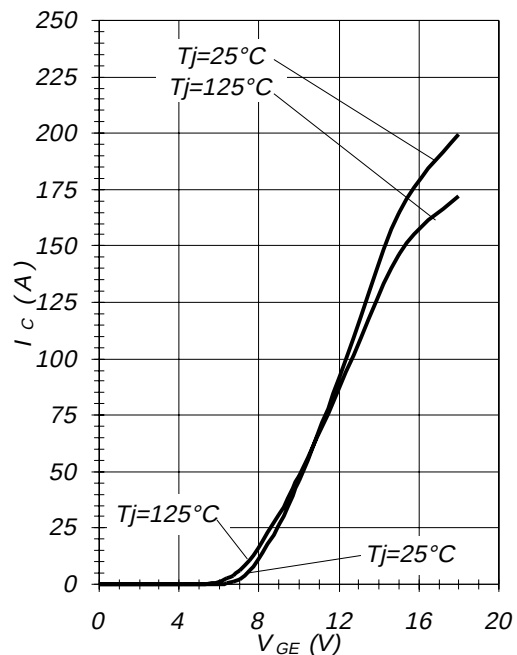


Fig.12 - Typ. Transfer Characteristics  
 $V_{CE} = 20\text{V}$ ;  $t_p = 20\mu\text{s}$



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Fig.13 - Typical Energy Loss vs  $I_C$   
 $T_j=125^\circ\text{C}$ ;  $L=200\mu\text{H}$ ;  $V_{CE}=600\text{V}$ ;  
 $R_g=22\Omega$ ;  $V_{GE}=15\text{V}$

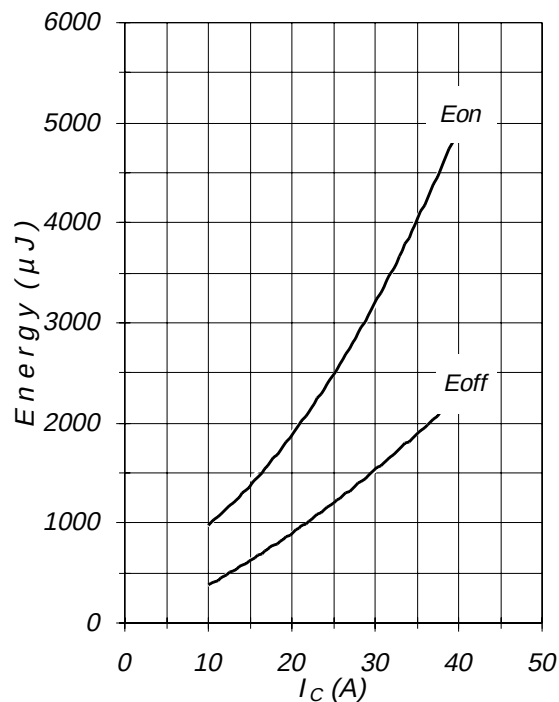


Fig.14 - Typical Switching Time vs  $I_C$   
 $T_j=125^\circ\text{C}$ ;  $L=200\mu\text{H}$ ;  $V_{CE}=600\text{V}$ ;  
 $R_g=22\Omega$ ;  $V_{GE}=15\text{V}$

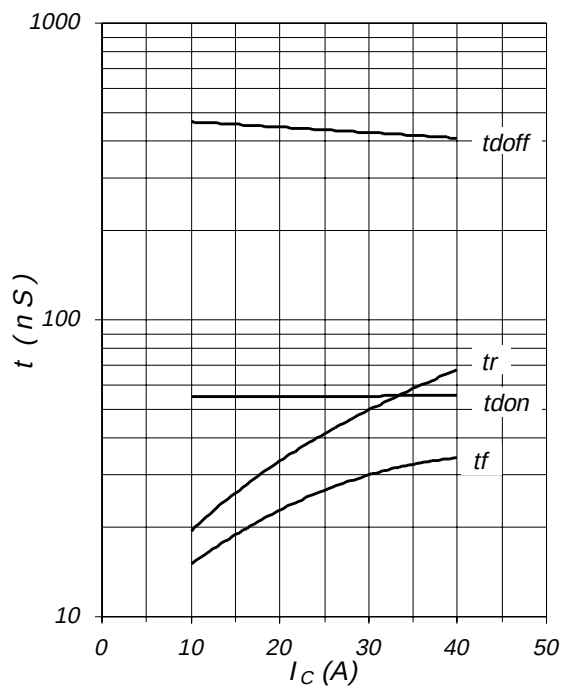


Fig.15 - Typical Energy Loss vs  $R_g$   
 $T_j=125^\circ\text{C}$ ;  $L=200\mu\text{H}$ ;  $V_{CE}=600\text{V}$ ;  
 $I_{CE}=20\text{A}$ ;  $V_{GE}=15\text{V}$

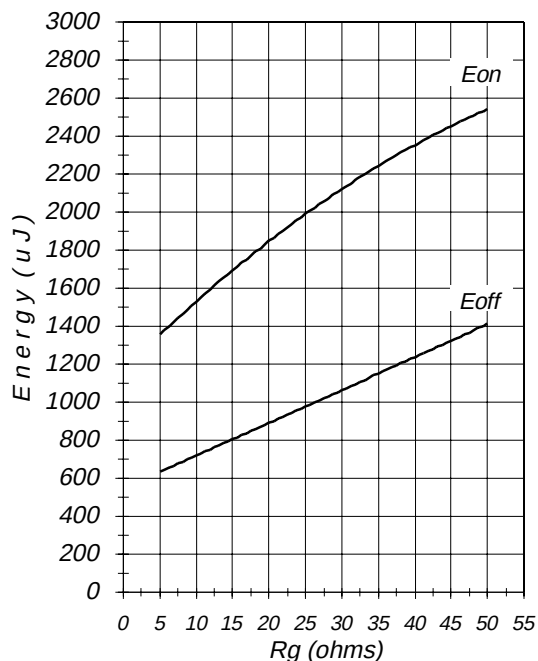


Fig.16 - Typical Switching Time vs  $R_g$   
 $T_j=125^\circ\text{C}$ ;  $L=200\mu\text{H}$ ;  $V_{CE}=600\text{V}$ ;  
 $I_{CE}=20\text{A}$ ;  $V_{GE}=15\text{V}$

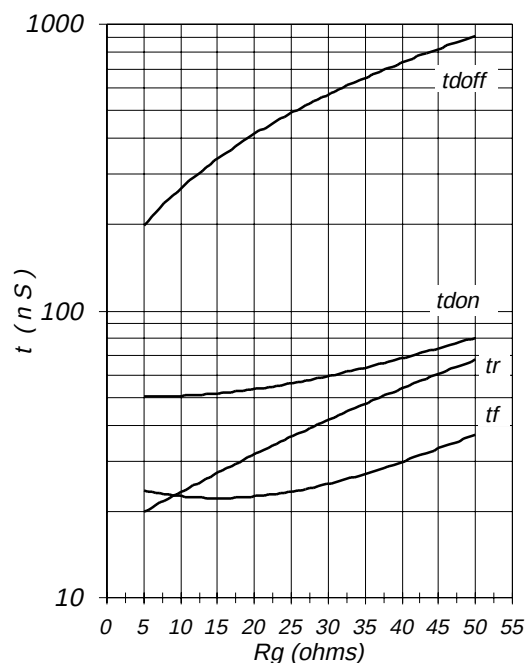


Fig.17 - Typical Diode  $I_{RR}$  vs  $I_F$   
 $T_J=125^\circ\text{C}$

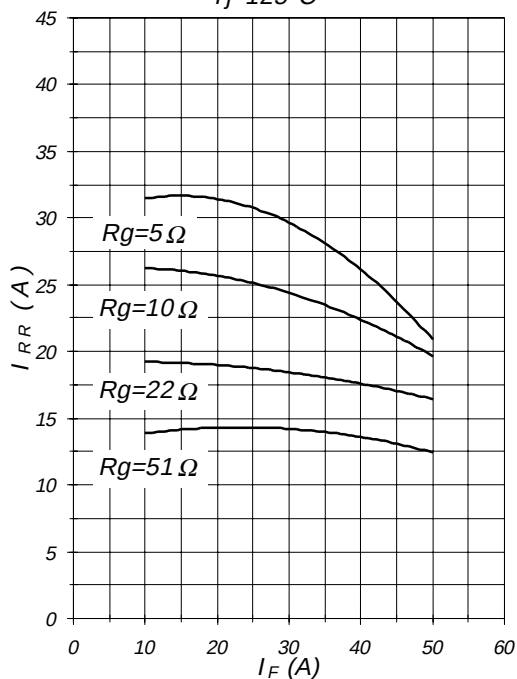


Fig.18 - Typical Diode  $I_{RR}$  vs  $R_g$   
 $T_J=125^\circ\text{C}; I_F=20\text{A}$



Fig.19 - Typical Diode  $I_{RR}$  vs  $dI_F/dt$   
 $V_{CC}=600\text{V}; V_{GE}=15\text{V}$   
 $I_F=20\text{A}; T_J=125^\circ\text{C}$

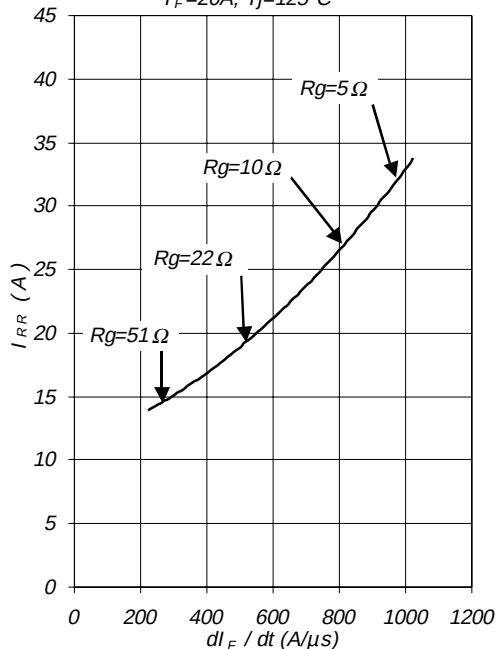
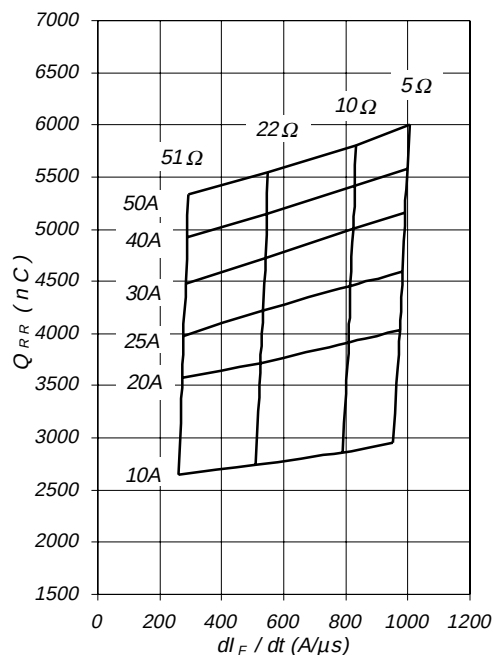


Fig.20 - Typical Diode  $Q_{RR}$   
 $V_{CC}=600\text{V}; V_{GE}=15\text{V}; T_J=125^\circ\text{C}$



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Fig.21 - Typ. Diode  $E_{rec}$  vs.  $I_F$   
 $T_j=125^{\circ}\text{C}$

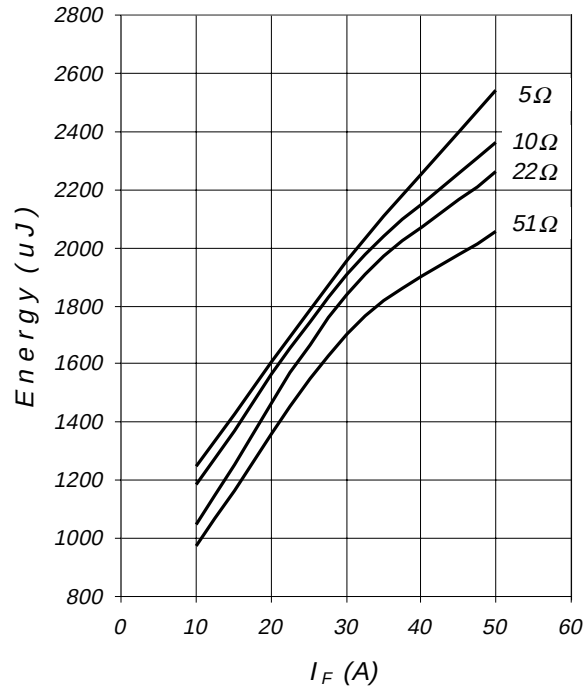


Fig.22 - Typical Capacitance vs  $V_{CE}$   
 $V_{GE}=0\text{V}$ ;  $f=1\text{MHz}$

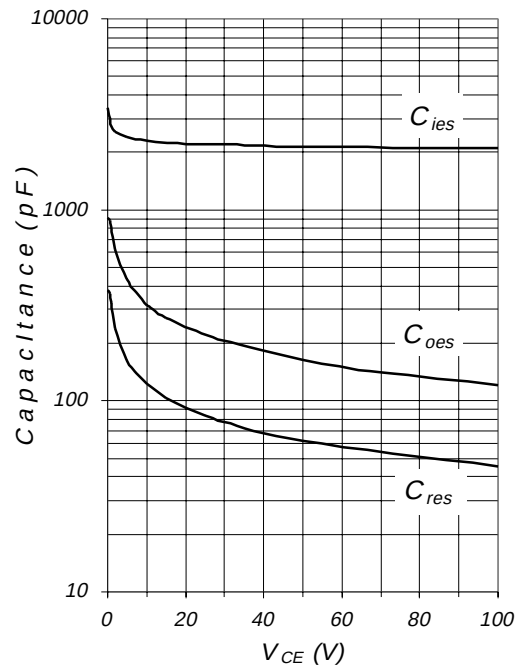


Fig.23 - Typ. Gate Charge vs.  $V_{GE}$   
 $I_C=20\text{A}$ ;  $L=600\mu\text{H}$

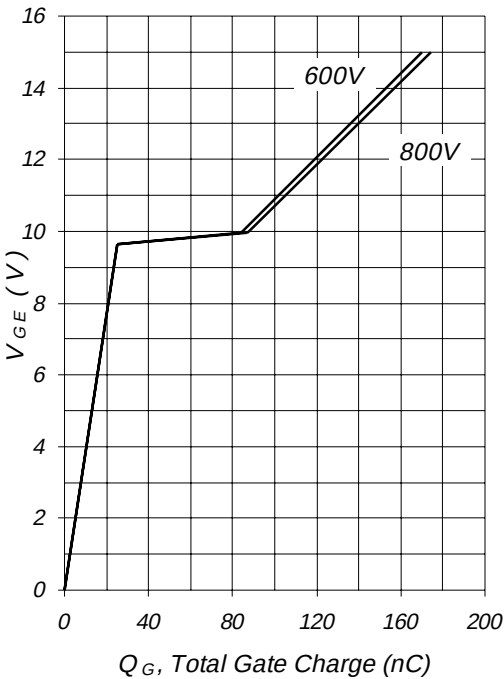
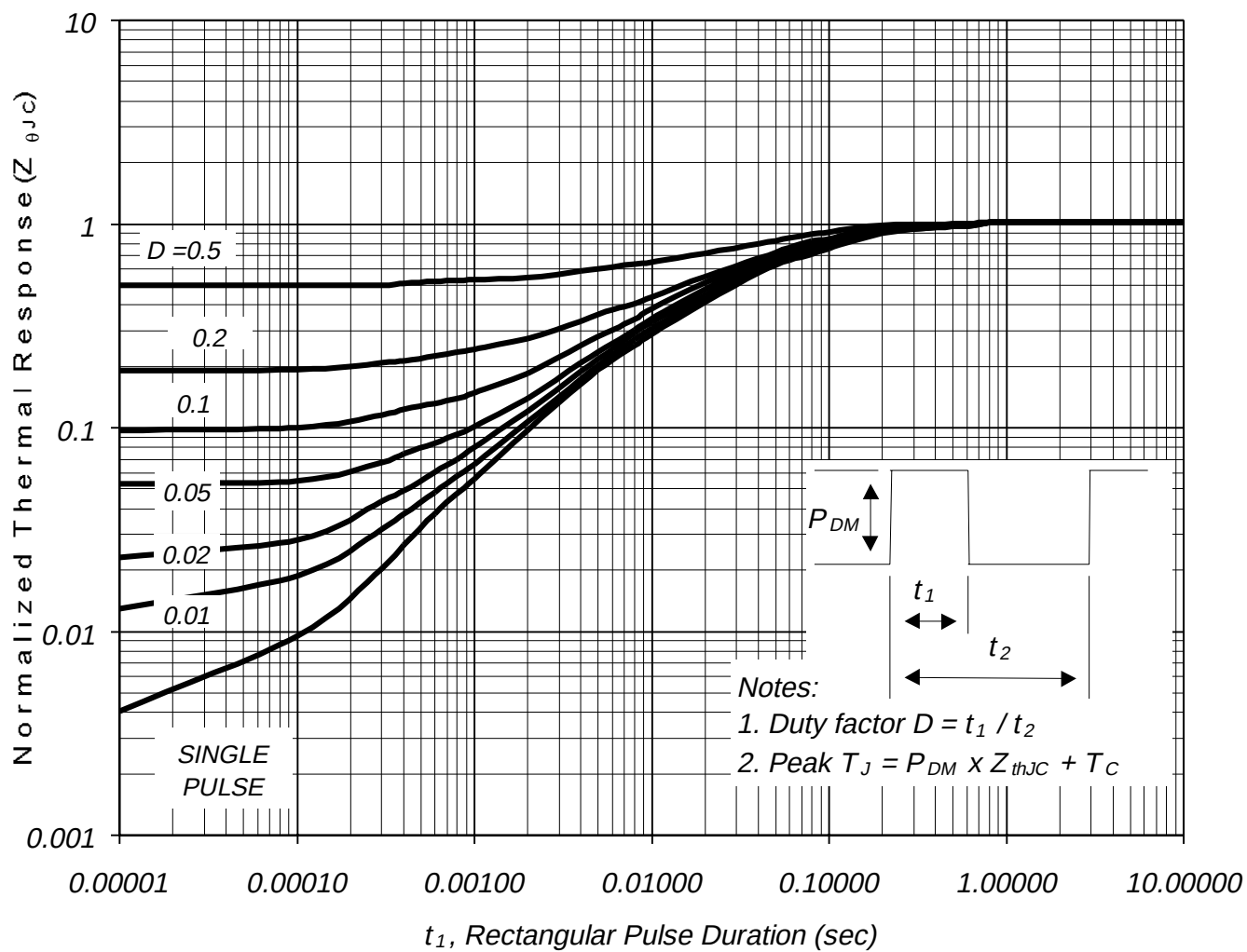




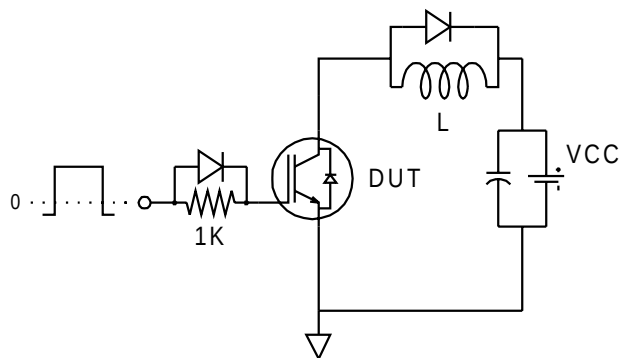
Fig.24 - Normalized Transient Thermal Impedance, Junction-to-Case



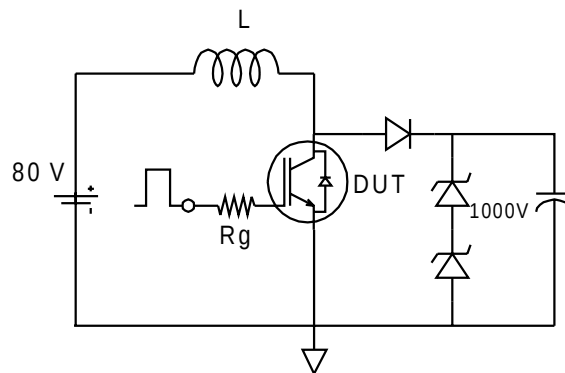
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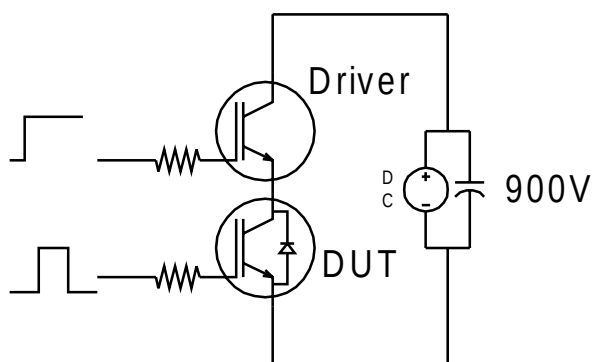
***Fig. CT.1 - Gate Charge Circuit (turn-off)***



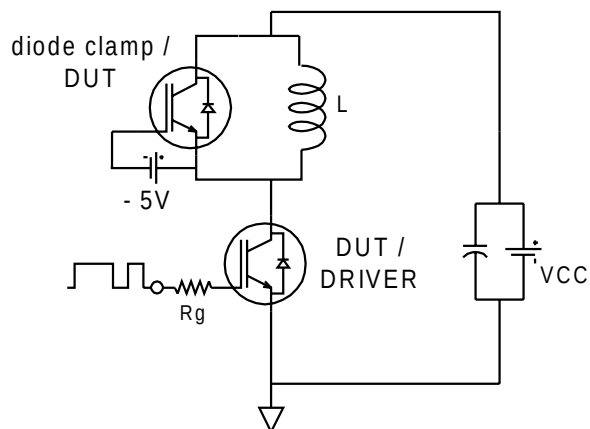
***Fig. CT.2 - RBSOA Circuit***



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



***Fig. CT.4 - Switching Loss Circuit***



***Fig. CT.5 - Resistive Load Circuit***

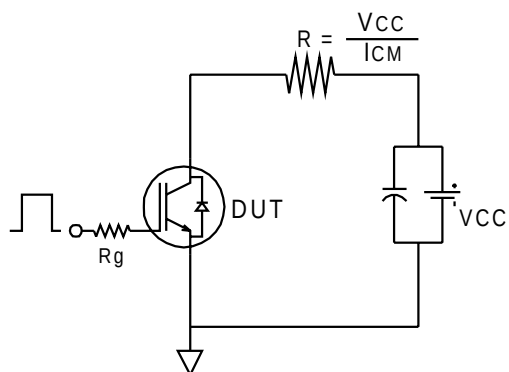


Fig. WF.1 - Typ. Turn-off Loss Waveform  
@  $T_j=125^\circ\text{C}$  using Fig. CT.4

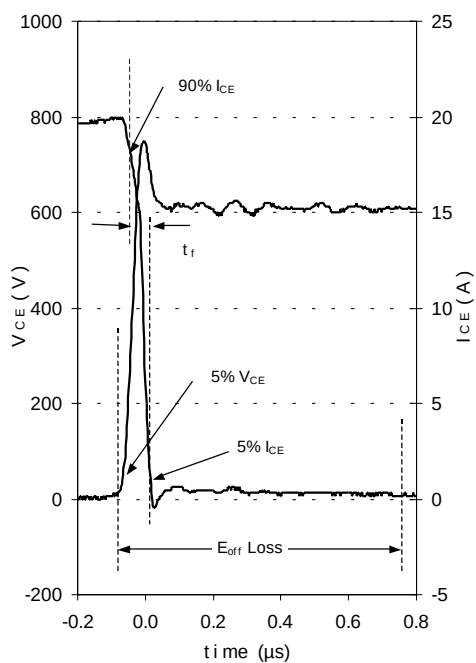


Fig. WF.2 - Typ. Turn-on Loss Waveform  
@  $T_j=125^\circ\text{C}$  using Fig. CT.4

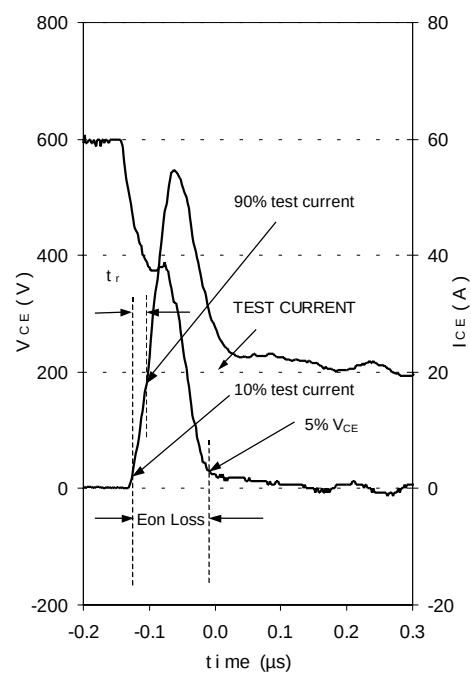


Fig. WF.3 - Typ. Diode Recovery Waveform  
@  $T_j=125^\circ\text{C}$  using Fig. CT.4

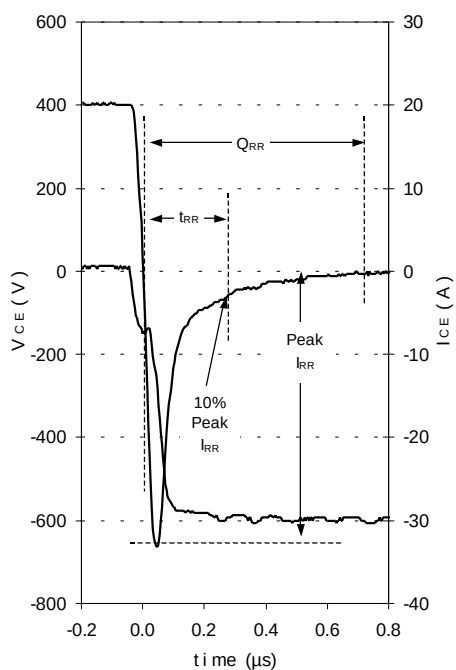
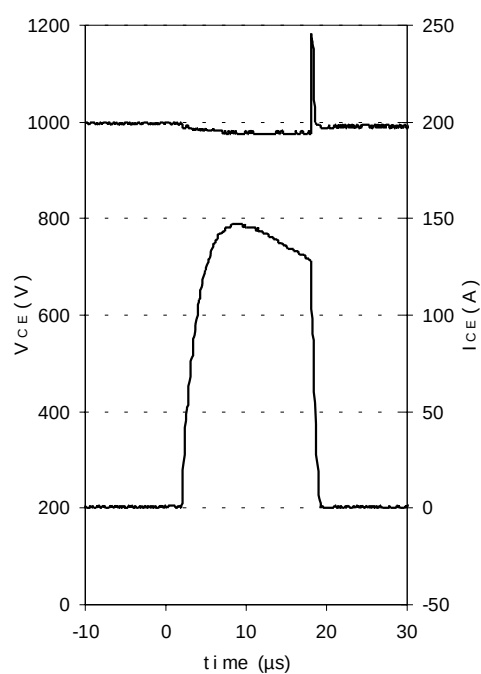


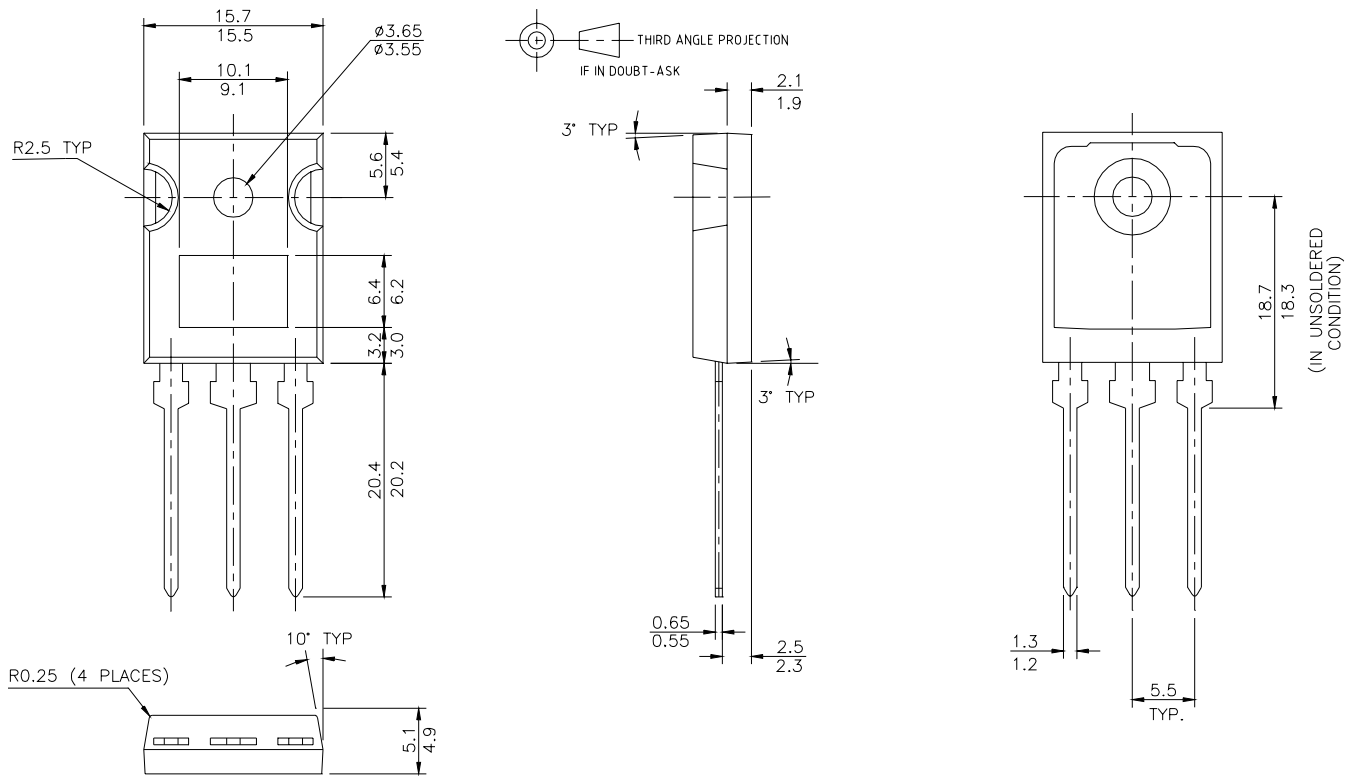
Fig. WF.4 - Typ. S.C. Waveform  
@  $T_C=150^\circ\text{C}$  using Fig. CT.3



# IRGP20B120UD-E

International  
**IOR** Rectifier

## TO-247AD Case Outline and Dimensions



International  
**IOR** Rectifier

**WORLD HEADQUARTERS:** 233 Kansas St., El Segundo, California 90245, Tel: (310) 252-7105

**IR GREAT BRITAIN:** Hurst Green, Oxted, Surrey RH8 9BB, UK Tel: ++ 44 1883 732020

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*Data and specifications subject to change without notice. 12/99*