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# **IGBT Designer's Manual**

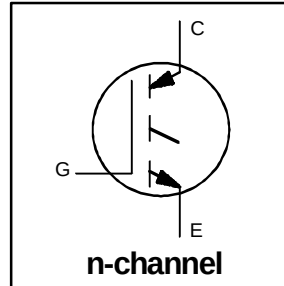
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## **Data Sheets**

The IGBT devices listed in this Designer's Manual represent International Rectifier's IGBT line as of August, 1994. The data presented in this manual supersedes all previous specifications.

### Features

- Switching-loss rating includes all "tail" losses
- Optimized for line frequency operation ( to 400 Hz)  
See Fig. 1 for Current vs. Frequency curve



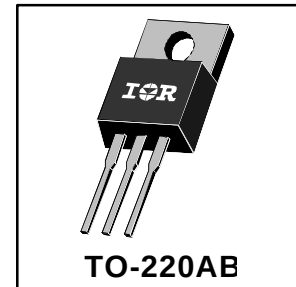
$$V_{CES} = 600V$$

$$V_{CE(sat)} \leq 2.4V$$

$$@V_{GE} = 15V, I_C = 10A$$

### Description

Insulated Gate Bipolar Transistors (IGBTs) from International Rectifier have higher usable current densities than comparable bipolar transistors, while at the same time having simpler gate-drive requirements of the familiar power MOSFET. They provide substantial benefits to a host of high-voltage, high-current applications.



### Absolute Maximum Ratings

|                           | Parameter                          | Max.                              | Units      |
|---------------------------|------------------------------------|-----------------------------------|------------|
| $V_{CES}$                 | Collector-to-Emitter Voltage       | 600                               | V          |
| $I_C @ T_C = 25^\circ C$  | Continuous Collector Current       | 19                                | A          |
| $I_C @ T_C = 100^\circ C$ | Continuous Collector Current       | 10                                |            |
| $I_{CM}$                  | Pulsed Collector Current ①         | 76                                |            |
| $I_{LM}$                  | Clamped Inductive Load Current ②   | 38                                |            |
| $V_{GE}$                  | Gate-to-Emitter Voltage            | $\pm 20$                          | V          |
| $E_{ARV}$                 | Reverse Voltage Avalanche Energy ③ | 5.0                               | mJ         |
| $P_D @ T_C = 25^\circ C$  | Maximum Power Dissipation          | 60                                | W          |
| $P_D @ T_C = 100^\circ C$ | Maximum Power Dissipation          | 24                                |            |
| $T_J$                     | 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 (1.1N•m)                |            |

### Thermal Resistance

|                 | Parameter                                 | Min. | Typ.       | Max. | Units        |
|-----------------|-------------------------------------------|------|------------|------|--------------|
| $R_{\theta JC}$ | Junction-to-Case                          | —    | —          | 2.1  | $^\circ C/W$ |
| $R_{\theta CS}$ | Case-to-Sink, flat, greased surface       | —    | 0.50       | —    |              |
| $R_{\theta JA}$ | Junction-to-Ambient, typical socket mount | —    | —          | 80   |              |
| Wt              | Weight                                    | —    | 2.0 (0.07) | —    | g (oz)       |

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

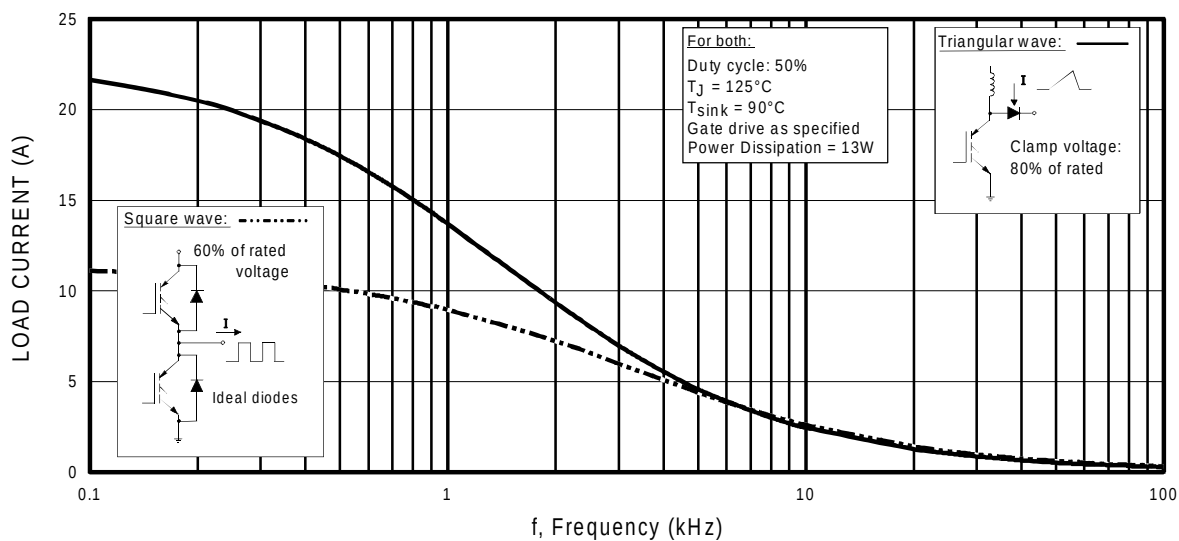
|                                 | Parameter                                | Min. | Typ. | Max.      | Units   | Conditions                                            |
|---------------------------------|------------------------------------------|------|------|-----------|---------|-------------------------------------------------------|
| $V_{(BR)CES}$                   | Collector-to-Emitter Breakdown Voltage   | 600  | —    | —         | V       | $V_{GE} = 0V, I_C = 250\mu A$                         |
| $V_{(BR)ECS}$                   | Emitter-to-Collector Breakdown Voltage ④ | 20   | —    | —         | V       | $V_{GE} = 0V, I_C = 1.0A$                             |
| $\Delta V_{(BR)CES}/\Delta T_J$ | Temperature Coeff. of Breakdown Voltage  | —    | 0.75 | —         | V/°C    | $V_{GE} = 0V, I_C = 1.0mA$                            |
| $V_{CE(on)}$                    | Collector-to-Emitter Saturation Voltage  | —    | 1.8  | 2.4       | V       | $I_C = 10A$ $V_{GE} = 15V$                            |
|                                 |                                          | —    | 2.4  | —         |         | $I_C = 19A$ See Fig. 2, 5                             |
|                                 |                                          | —    | 1.9  | —         |         | $I_C = 10A, T_J = 150^\circ\text{C}$                  |
| $V_{GE(th)}$                    | Gate Threshold Voltage                   | 3.0  | —    | 5.5       |         | $V_{CE} = V_{GE}, I_C = 250\mu A$                     |
| $\Delta V_{GE(th)}/\Delta T_J$  | Temperature Coeff. of Threshold Voltage  | —    | -11  | —         | mV/°C   | $V_{CE} = V_{GE}, I_C = 250\mu A$                     |
| $g_{fe}$                        | Forward Transconductance ⑤               | 2.0  | 5.8  | —         | S       | $V_{CE} = 100V, I_C = 10A$                            |
| $I_{CES}$                       | Zero Gate Voltage Collector Current      | —    | —    | 250       | $\mu A$ | $V_{GE} = 0V, V_{CE} = 600V$                          |
|                                 |                                          | —    | —    | 1000      |         | $V_{GE} = 0V, V_{CE} = 600V, T_J = 150^\circ\text{C}$ |
| $I_{GES}$                       | Gate-to-Emitter Leakage Current          | —    | —    | $\pm 100$ | nA      | $V_{GE} = \pm 20V$                                    |

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

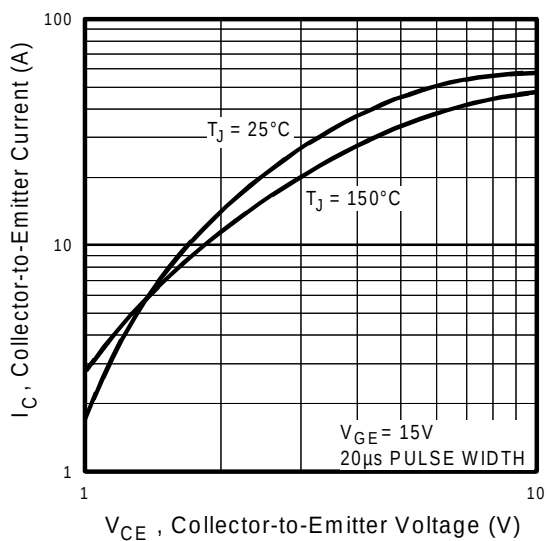
|              | Parameter                         | Min. | Typ. | Max. | Units | Conditions                     |
|--------------|-----------------------------------|------|------|------|-------|--------------------------------|
| $Q_g$        | Total Gate Charge (turn-on)       | —    | 16   | 26   | nC    | $I_C = 10A$                    |
| $Q_{ge}$     | Gate - Emitter Charge (turn-on)   | —    | 2.3  | 4.0  |       | $V_{CC} = 400V$ See Fig. 8     |
| $Q_{gc}$     | Gate - Collector Charge (turn-on) | —    | 7.0  | 12   |       | $V_{GE} = 15V$                 |
| $t_{d(on)}$  | Turn-On Delay Time                | —    | 24   | —    | ns    | $T_J = 25^\circ\text{C}$       |
| $t_r$        | Rise Time                         | —    | 23   | —    |       | $I_C = 10A, V_{CC} = 480V$     |
| $t_{d(off)}$ | Turn-Off Delay Time               | —    | 820  | 1200 |       | $V_{GE} = 15V, R_G = 50\Omega$ |
| $t_f$        | Fall Time                         | —    | 910  | 1600 |       | Energy losses include "tail"   |
| $E_{on}$     | Turn-On Switching Loss            | —    | 0.24 | —    | mJ    | See Fig. 9, 10, 11, 14         |
| $E_{off}$    | Turn-Off Switching Loss           | —    | 3.9  | —    |       |                                |
| $E_{ts}$     | Total Switching Loss              | —    | 4.1  | 6.0  |       |                                |
| $t_{d(on)}$  | Turn-On Delay Time                | —    | 26   | —    | ns    | $T_J = 150^\circ\text{C},$     |
| $t_r$        | Rise Time                         | —    | 30   | —    |       | $I_C = 10A, V_{CC} = 480V$     |
| $t_{d(off)}$ | Turn-Off Delay Time               | —    | 1100 | —    |       | $V_{GE} = 15V, R_G = 50\Omega$ |
| $t_f$        | Fall Time                         | —    | 1800 | —    |       | Energy losses include "tail"   |
| $E_{ts}$     | Total Switching Loss              | —    | 7.0  | —    | mJ    | See Fig. 10, 14                |
| $L_E$        | Internal Emitter Inductance       | —    | 7.5  | —    | nH    | Measured 5mm from package      |
| $C_{ies}$    | Input Capacitance                 | —    | 360  | —    | pF    | $V_{GE} = 0V$                  |
| $C_{oes}$    | Output Capacitance                | —    | 36   | —    |       | $V_{CC} = 30V$ See Fig. 7      |
| $C_{res}$    | Reverse Transfer Capacitance      | —    | 5.2  | —    |       | $f = 1.0MHz$                   |

**Notes:**

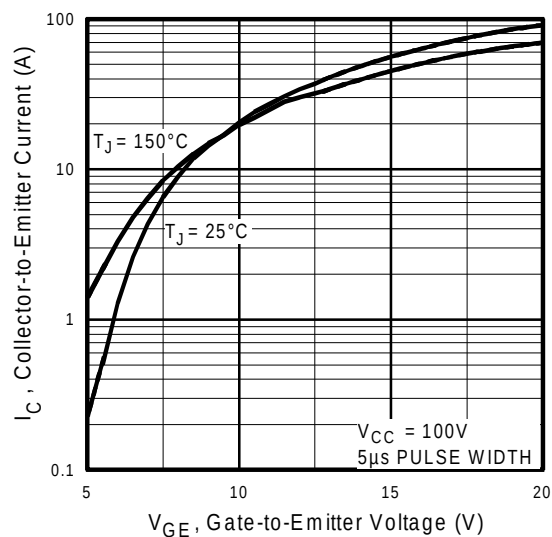
- ① Repetitive rating;  $V_{GE} = 20V$ , pulse width limited by max. junction temperature. ( See fig. 13b )
- ②  $V_{CC} = 80\%(V_{CES}), V_{GE} = 20V, L = 10\mu H, R_G = 50\Omega$ , ( See fig. 13a )
- ③ Repetitive rating; pulse width limited by maximum junction temperature.
- ④ Pulse width  $\leq 80\mu s$ ; duty factor  $\leq 0.1\%$ .
- ⑤ Pulse width  $5.0\mu s$ , single shot.



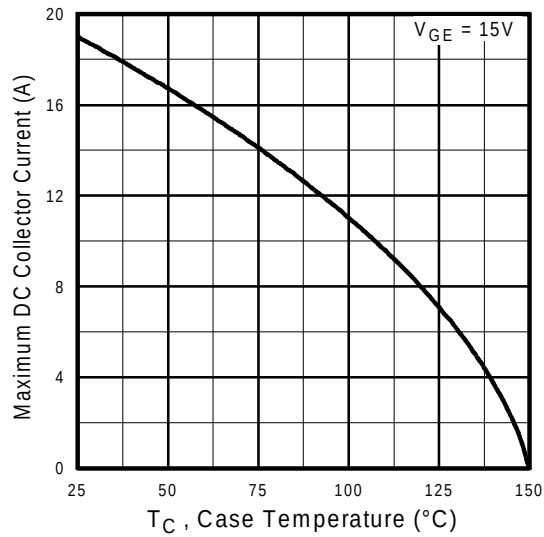
**Fig. 1 - Typical Load Current vs. Frequency**  
(For square wave,  $I = I_{\text{RMS}}$  of fundamental; for triangular wave,  $I = I_{\text{PK}}$ )



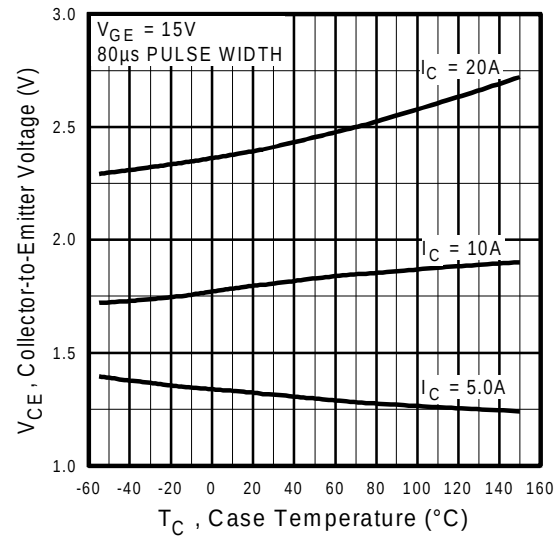
**Fig. 2 - Typical Output Characteristics**



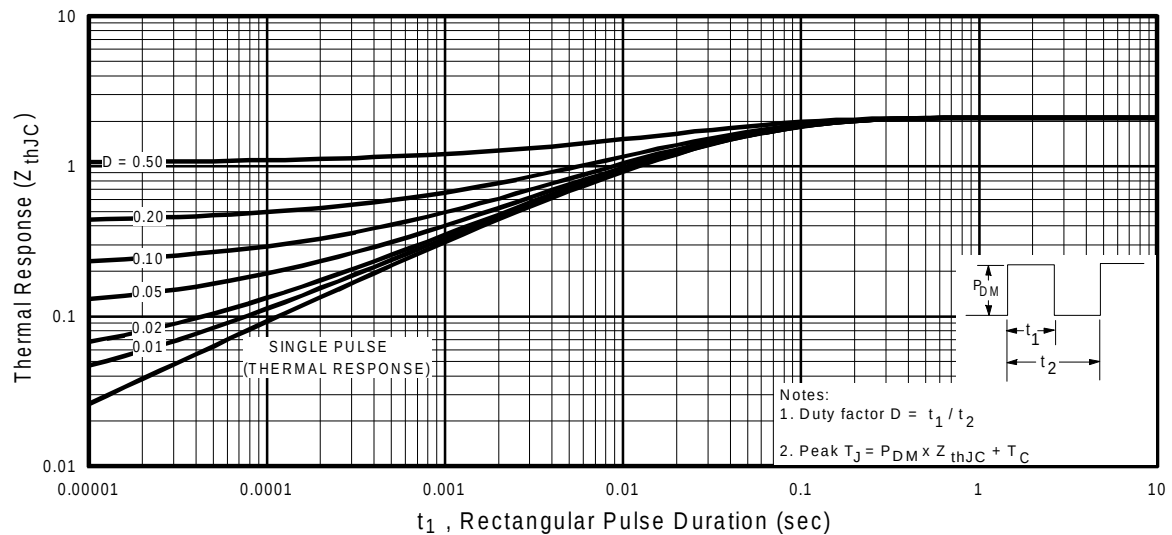
**Fig. 3 - Typical Transfer Characteristics**



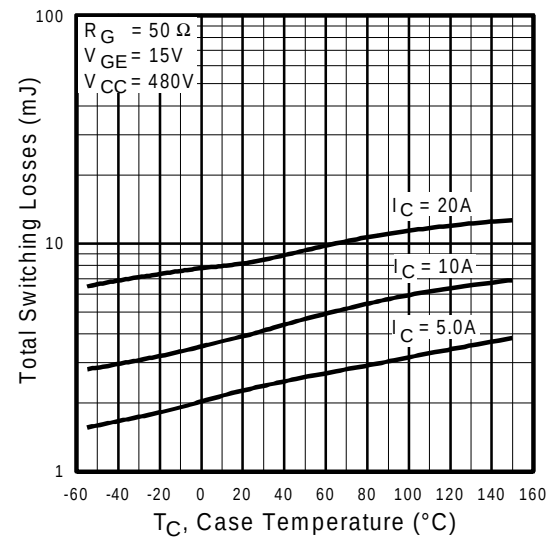
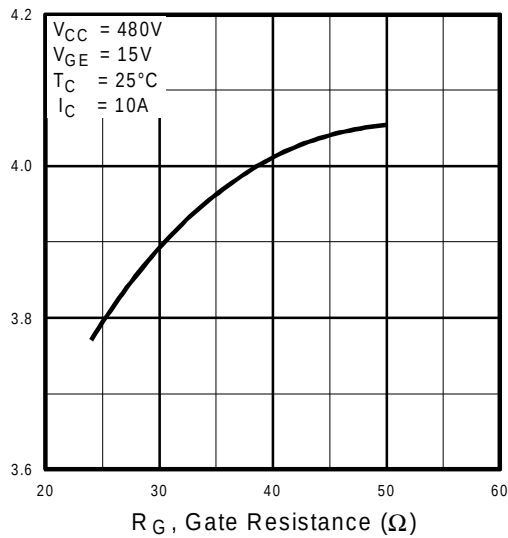
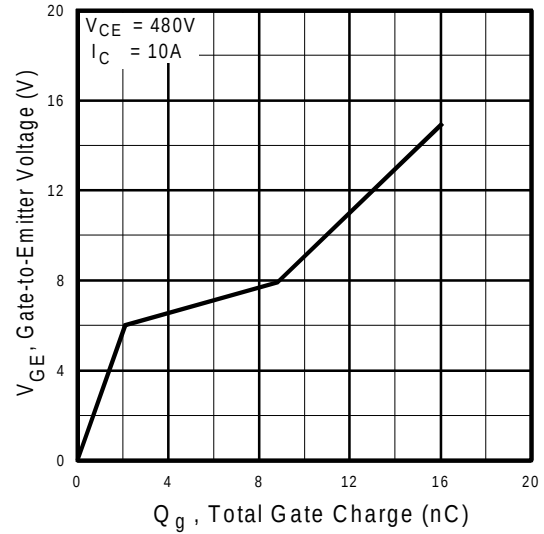
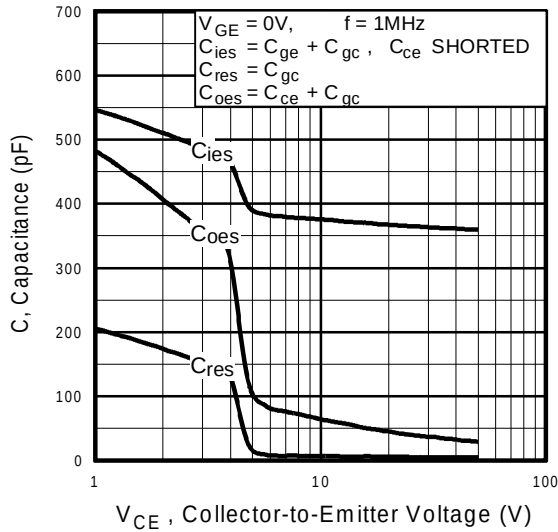
**Fig. 4** - Maximum Collector Current vs. Case Temperature

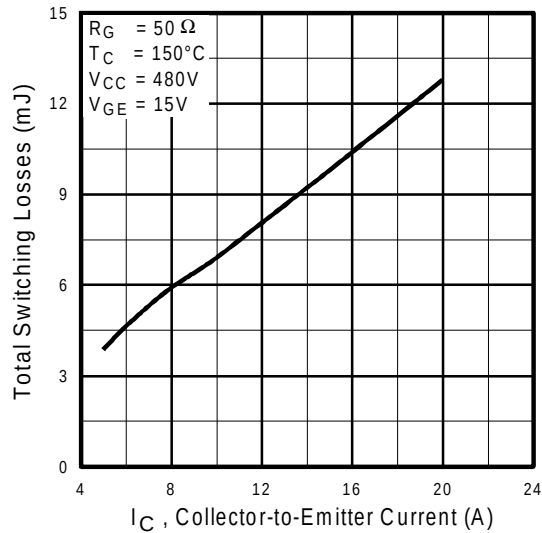


**Fig. 5** - Collector-to-Emitter Voltage vs. Case Temperature

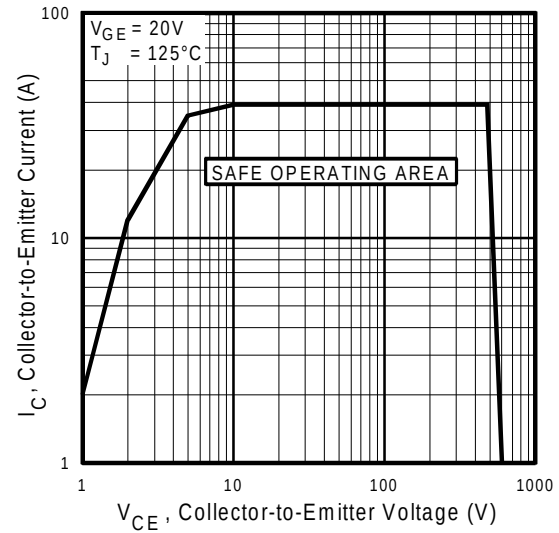


**Fig. 6** - Maximum Effective Transient Thermal Impedance, Junction-to-Case





**Fig. 11** - Typical Switching Losses vs. Collector-to-Emitter Current



**Fig. 12** - Turn-Off SOA

**Refer to Section D for the following:**

**Appendix C: Section D - page D-5**

Fig. 13a - Clamped Inductive Load Test Circuit

Fig. 13b - Pulsed Collector Current Test Circuit

Fig. 14a - Switching Loss Test Circuit

Fig. 14b - Switching Loss Waveform

**Package Outline 1 - JEDEC Outline TO-220AB**

**Section D - page D-12**