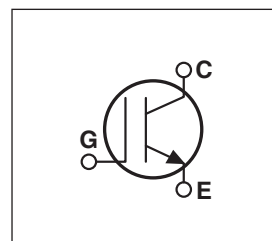
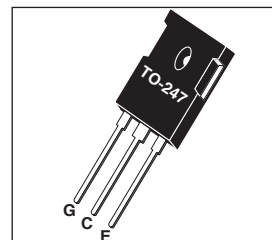


## Thunderbolt IGBT®

The Thunderbolt IGBT® is a new generation of high voltage power IGBTs. Using Non-Punch Through Technology, the Thunderbolt IGBT® offers superior ruggedness and ultrafast switching speed.

- Low Forward Voltage Drop
- High Freq. Switching to 150KHz
- Low Tail Current
- Ultra Low Leakage Current
- RBSOA and SCSOA Rated



### MAXIMUM RATINGS

All Ratings:  $T_C = 25^\circ\text{C}$  unless otherwise specified.

| Symbol         | Parameter                                                         | APT20GT60BR(G) | UNIT             |
|----------------|-------------------------------------------------------------------|----------------|------------------|
| $V_{CES}$      | Collector-Emitter Voltage                                         | 600            | Volts            |
| $V_{GE}$       | Gate-Emitter Voltage                                              | $\pm 30$       |                  |
| $I_{C1}$       | Continuous Collector Current @ $T_C = 25^\circ\text{C}$           | 43             | Amps             |
| $I_{C2}$       | Continuous Collector Current @ $T_C = 110^\circ\text{C}$          | 20             |                  |
| $I_{CM}$       | Pulsed Collector Current <sup>①</sup> @ $T_C = 150^\circ\text{C}$ | 80             |                  |
| SSOA           | Switching Safe Operating Area @ $T_J = 150^\circ\text{C}$         | 80A @ 600V     |                  |
| $P_D$          | Total Power Dissipation                                           | 174            | Watts            |
| $T_J, T_{STG}$ | Operating and Storage Junction Temperature Range                  | -55 to 150     | $^\circ\text{C}$ |
| $T_L$          | Max. Lead Temp. for Soldering: 0.063" from Case for 10 Sec.       | 300            |                  |

### STATIC ELECTRICAL CHARACTERISTICS

| Symbol        | Characteristic / Test Conditions                                                                 | MIN | TYP | MAX       | Units   |
|---------------|--------------------------------------------------------------------------------------------------|-----|-----|-----------|---------|
| $V_{(BR)CES}$ | Collector-Emitter Breakdown Voltage ( $V_{GE} = 0V, I_C = 0.5mA$ )                               | 600 |     |           | Volts   |
| $V_{GE(TH)}$  | Gate Threshold Voltage ( $V_{CE} = V_{GE}, I_C = 500\mu A, T_J = 25^\circ\text{C}$ )             | 3   | 4   | 5         |         |
| $V_{CE(ON)}$  | Collector-Emitter On Voltage ( $V_{GE} = 15V, I_C = 20A, T_J = 25^\circ\text{C}$ )               | 1.6 | 2.0 | 2.5       |         |
|               | Collector-Emitter On Voltage ( $V_{GE} = 15V, I_C = 20A, T_J = 125^\circ\text{C}$ )              |     | 2.8 |           |         |
| $I_{CES}$     | Collector Cut-off Current ( $V_{CE} = 600V, V_{GE} = 0V, T_J = 25^\circ\text{C}$ ) <sup>②</sup>  |     |     | 25        | $\mu A$ |
|               | Collector Cut-off Current ( $V_{CE} = 600V, V_{GE} = 0V, T_J = 125^\circ\text{C}$ ) <sup>②</sup> |     |     | 1000      |         |
| $I_{GES}$     | Gate-Emitter Leakage Current ( $V_{GE} = \pm 20V$ )                                              |     |     | $\pm 100$ | nA      |



**CAUTION:** These Devices are Sensitive to Electrostatic Discharge. Proper Handling Procedures Should Be Followed.

# DYNAMIC CHARACTERISTICS

APT20GT60BR(G)

| Symbol       | Characteristic                                | Test Conditions                                                                                                                       | MIN | TYP  | MAX | UNIT    |
|--------------|-----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|-----|------|-----|---------|
| $C_{ies}$    | Input Capacitance                             | <b>Capacitance</b><br>$V_{GE} = 0V, V_{CE} = 25V$<br>$f = 1 \text{ MHz}$                                                              |     | 1100 |     | pF      |
| $C_{oes}$    | Output Capacitance                            |                                                                                                                                       |     | 110  |     |         |
| $C_{res}$    | Reverse Transfer Capacitance                  |                                                                                                                                       |     | 65   |     |         |
| $V_{GEP}$    | Gate-to-Emitter Plateau Voltage               | Gate Charge<br>$V_{GE} = 15V$<br>$V_{CE} = 300V$<br>$I_C = 20A$                                                                       |     | 7.5  |     | V       |
| $Q_g$        | Total Gate Charge <sup>③</sup>                |                                                                                                                                       |     | 100  |     | nC      |
| $Q_{ge}$     | Gate-Emitter Charge                           |                                                                                                                                       |     | 7    |     |         |
| $Q_{gc}$     | Gate-Collector ("Miller") Charge              |                                                                                                                                       |     | 43   |     |         |
| SSOA         | Switching Safe Operating Area                 | $T_J = 150^\circ C, R_G = 5\Omega, V_{GE} = 15V, L = 100\mu H, V_{CE} = 600V$                                                         | 80  |      |     | A       |
| $t_{d(on)}$  | Turn-on Delay Time                            | <b>Inductive Switching (25°C)</b><br><br>$V_{CC} = 400V$<br>$V_{GE} = 15V$<br>$I_C = 20A$<br>$R_G = 5\Omega$<br>$T_J = +25^\circ C$   |     | 8    |     | ns      |
| $t_r$        | Current Rise Time                             |                                                                                                                                       |     | 9    |     |         |
| $t_{d(off)}$ | Turn-off Delay Time                           |                                                                                                                                       |     | 80   |     |         |
| $t_f$        | Current Fall Time                             |                                                                                                                                       |     | 39   |     |         |
| $E_{on1}$    | Turn-on Switching Energy <sup>④</sup>         |                                                                                                                                       |     | 215  |     | $\mu J$ |
| $E_{on2}$    | Turn-on Switching Energy (Diode) <sup>⑤</sup> |                                                                                                                                       |     | 210  |     |         |
| $E_{off}$    | Turn-off Switching Energy <sup>⑥</sup>        |                                                                                                                                       |     | 245  |     |         |
| $t_{d(on)}$  | Turn-on Delay Time                            | <b>Inductive Switching (125°C)</b><br><br>$V_{CC} = 400V$<br>$V_{GE} = 15V$<br>$I_C = 20A$<br>$R_G = 5\Omega$<br>$T_J = +125^\circ C$ |     | 8    |     | ns      |
| $t_r$        | Current Rise Time                             |                                                                                                                                       |     | 9    |     |         |
| $t_{d(off)}$ | Turn-off Delay Time                           |                                                                                                                                       |     | 100  |     |         |
| $t_f$        | Current Fall Time                             |                                                                                                                                       |     | 60   |     |         |
| $E_{on1}$    | Turn-on Switching Energy <sup>④</sup>         |                                                                                                                                       |     | 215  |     | $\mu J$ |
| $E_{on2}$    | Turn-on Switching Energy (Diode) <sup>⑤</sup> |                                                                                                                                       |     | 375  |     |         |
| $E_{off}$    | Turn-off Switching Energy <sup>⑥</sup>        |                                                                                                                                       |     | 395  |     |         |

# THERMAL AND MECHANICAL CHARACTERISTICS

| Symbol          | Characteristic           | MIN | TYP | MAX | UNIT         |
|-----------------|--------------------------|-----|-----|-----|--------------|
| $R_{\theta JC}$ | Junction to Case (IGBT)  |     |     | .72 | $^\circ C/W$ |
| $R_{\theta JC}$ | Junction to Case (DIODE) |     |     | N/A |              |
| $W_T$           | Package Weight           |     | 5.9 |     | gm           |

① Repetitive Rating: Pulse width limited by maximum junction temperature.

② For Combi devices,  $I_{ces}$  includes both IGBT and FRED leakages

③ See MIL-STD-750 Method 3471.

④  $E_{on1}$  is the clamped inductive turn-on-energy of the IGBT only, without the effect of a commutating diode reverse recovery current adding to the IGBT turn-on loss. (See Figure 24.)

⑤  $E_{on2}$  is the clamped inductive turn-on energy that includes a commutating diode reverse recovery current in the IGBT turn-on switching loss. (See Figures 21, 22.)

⑥  $E_{off}$  is the clamped inductive turn-off energy measured in accordance with JEDEC standard JESD24-1. (See Figures 21, 23.)

APT Reserves the right to change, without notice, the specifications and information contained herein.

# TYPICAL PERFORMANCE CURVES

APT20GT60BR(G)

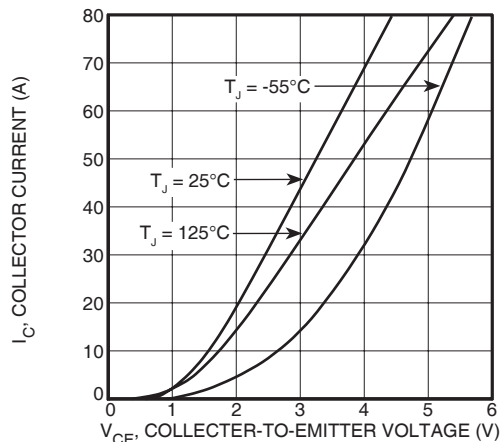


FIGURE 1, Output Characteristics( $T_J = 25^\circ\text{C}$ )

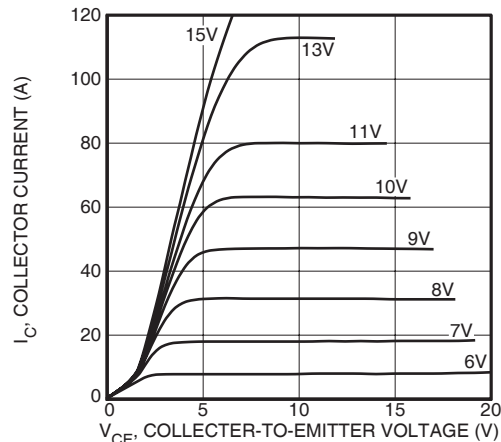


FIGURE 2, Output Characteristics ( $T_J = 125^\circ\text{C}$ )

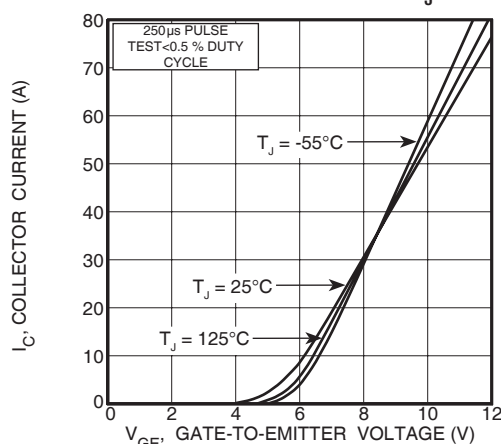


FIGURE 3, Transfer Characteristics

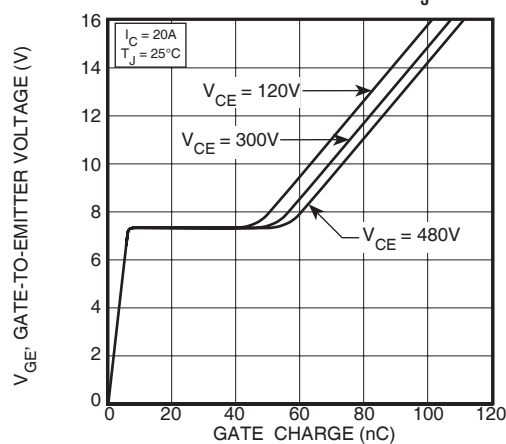


FIGURE 4, Gate Charge

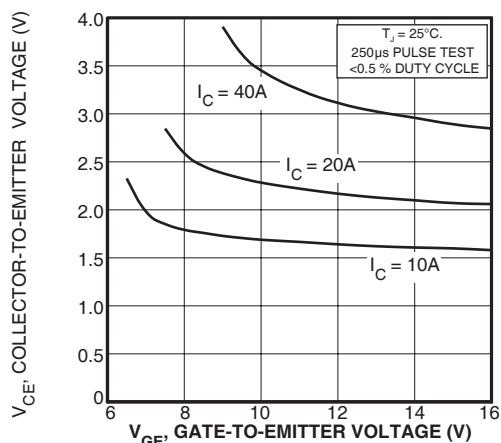


FIGURE 5, On State Voltage vs Gate-to-Emitter Voltage

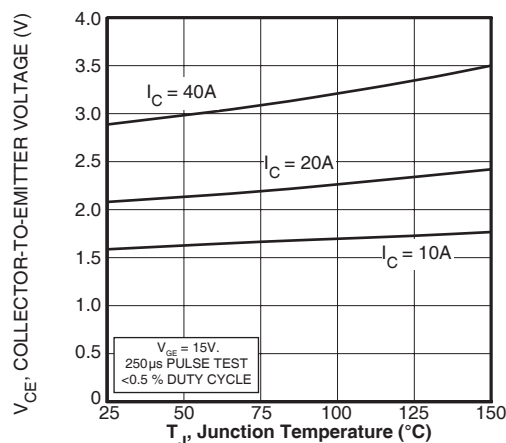


FIGURE 6, On State Voltage vs Junction Temperature

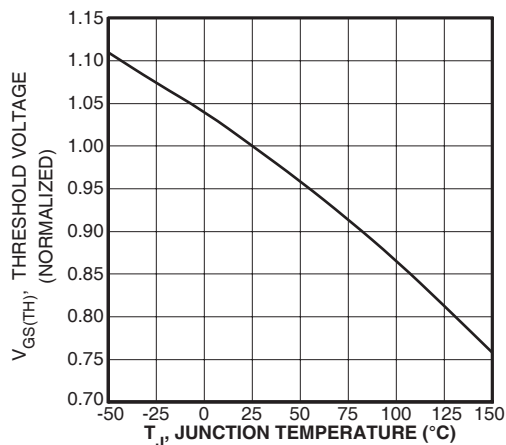


FIGURE 7, Threshold Voltage vs. Junction Temperature

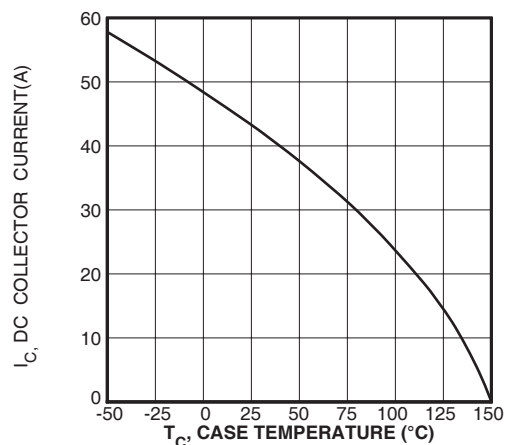


FIGURE 8, DC Collector Current vs Case Temperature

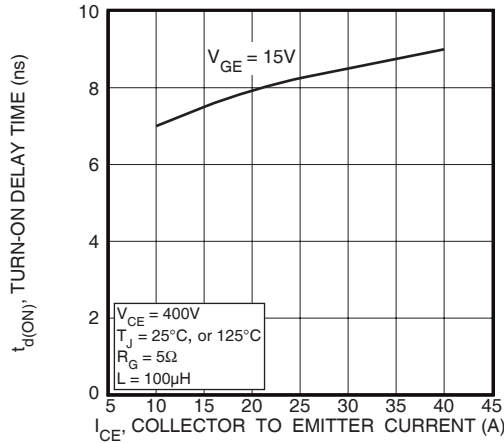


FIGURE 9, Turn-On Delay Time vs Collector Current

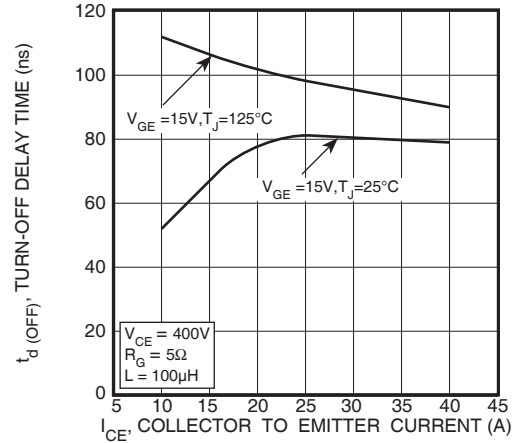


FIGURE 10, Turn-Off Delay Time vs Collector Current

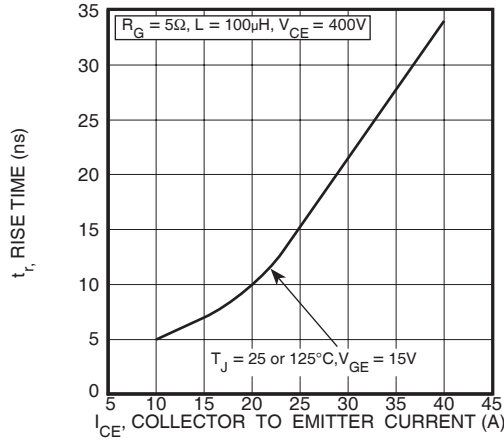


FIGURE 11, Current Rise Time vs Collector Current

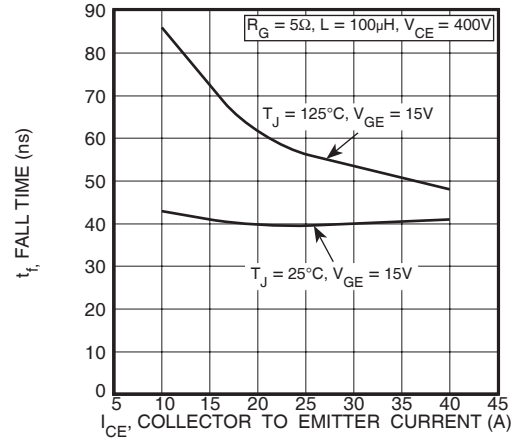


FIGURE 12, Current Fall Time vs Collector Current

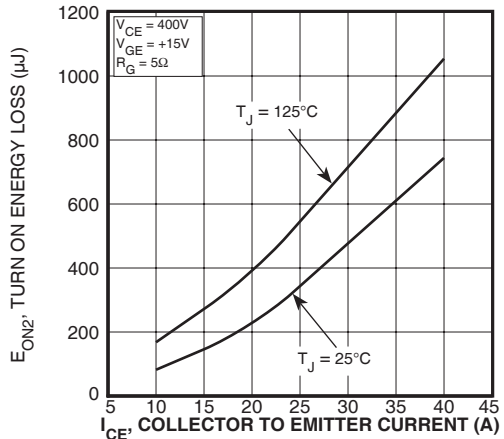


FIGURE 13, Turn-On Energy Loss vs Collector Current

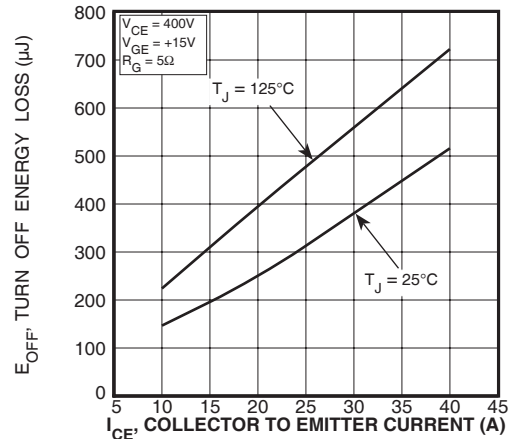


FIGURE 14, Turn Off Energy Loss vs Collector Current

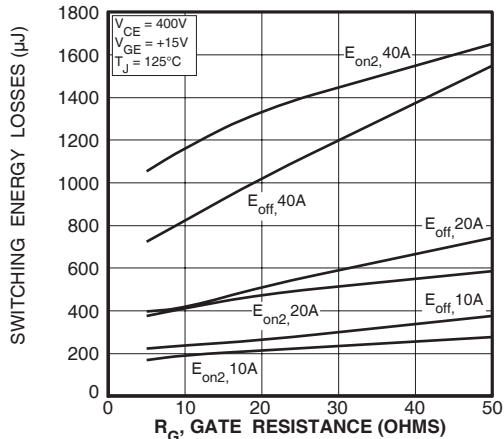


FIGURE 15, Switching Energy Losses vs. Gate Resistance

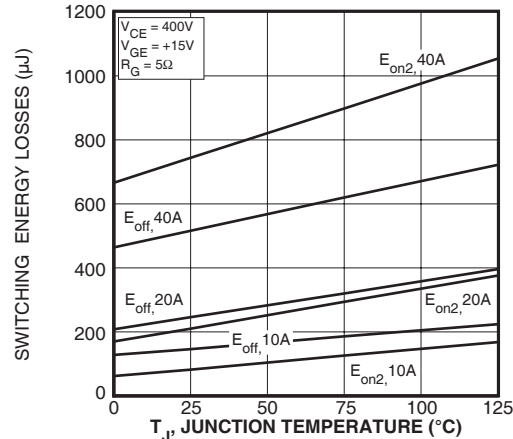


FIGURE 16, Switching Energy Losses vs Junction Temperature

# TYPICAL PERFORMANCE CURVES

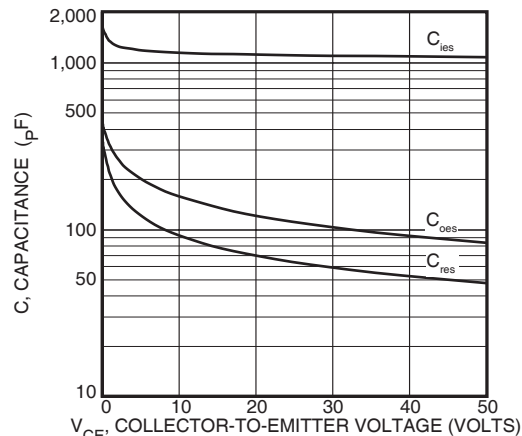


Figure 17, Capacitance vs Collector-To-Emitter Voltage

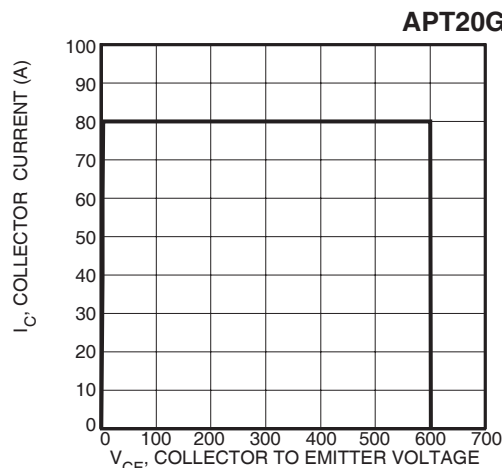


Figure 18, Minimum Switching Safe Operating Area

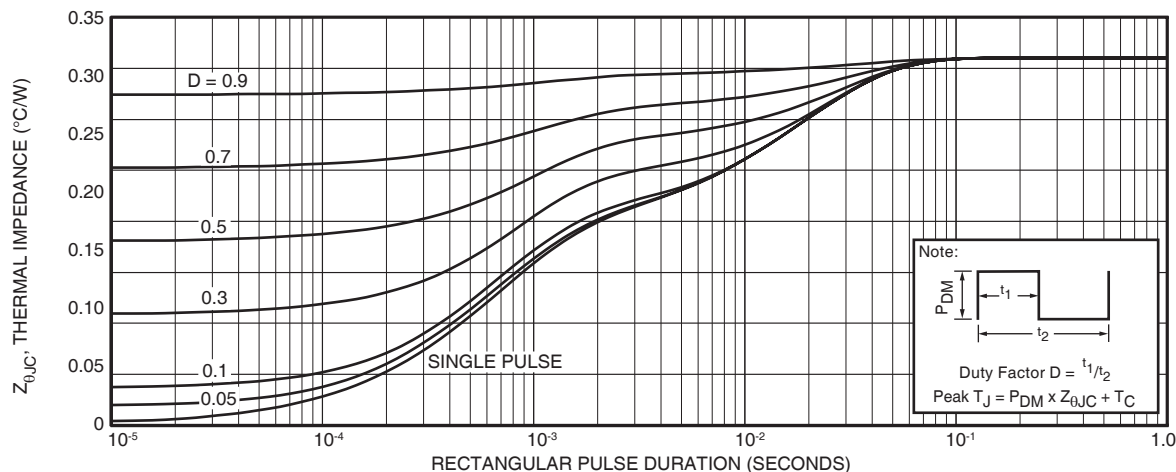


Figure 19a, Maximum Effective Transient Thermal Impedance, Junction-To-Case vs Pulse Duration

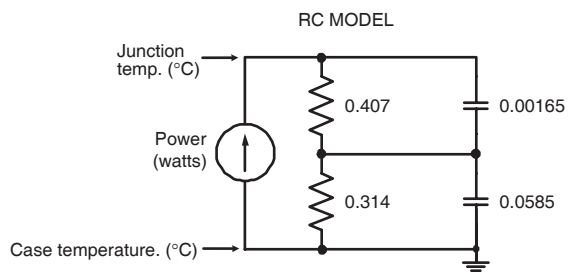


FIGURE 19b, TRANSIENT THERMAL IMPEDANCE MODEL

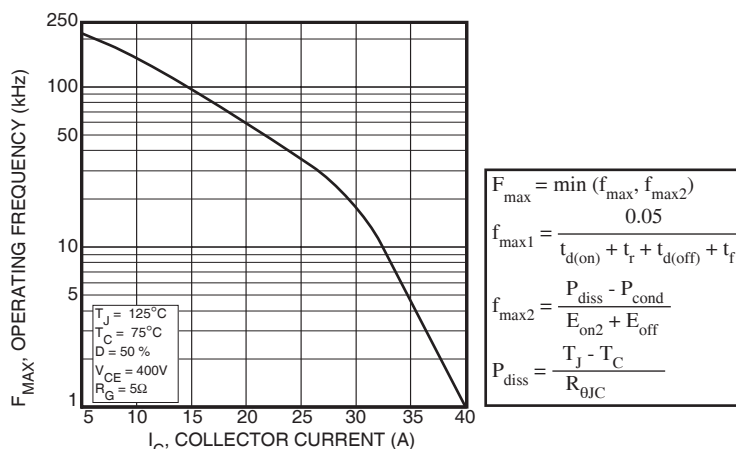


Figure 20, Operating Frequency vs Collector Current

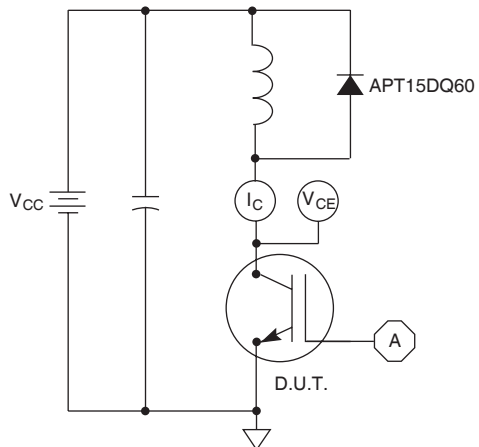


Figure 21, Inductive Switching Test Circuit

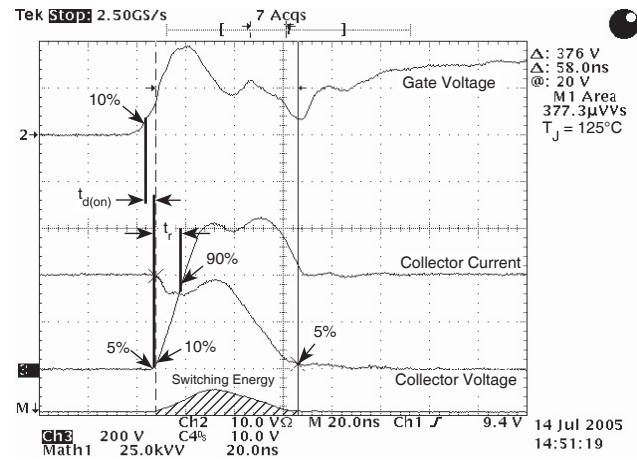


Figure 22, Turn-on Switching Waveforms and Definitions

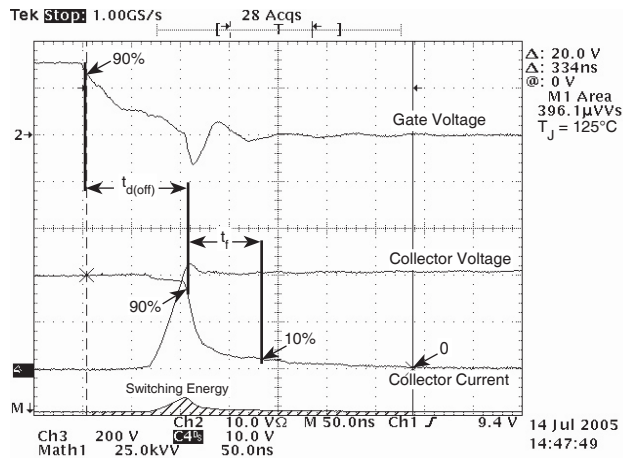
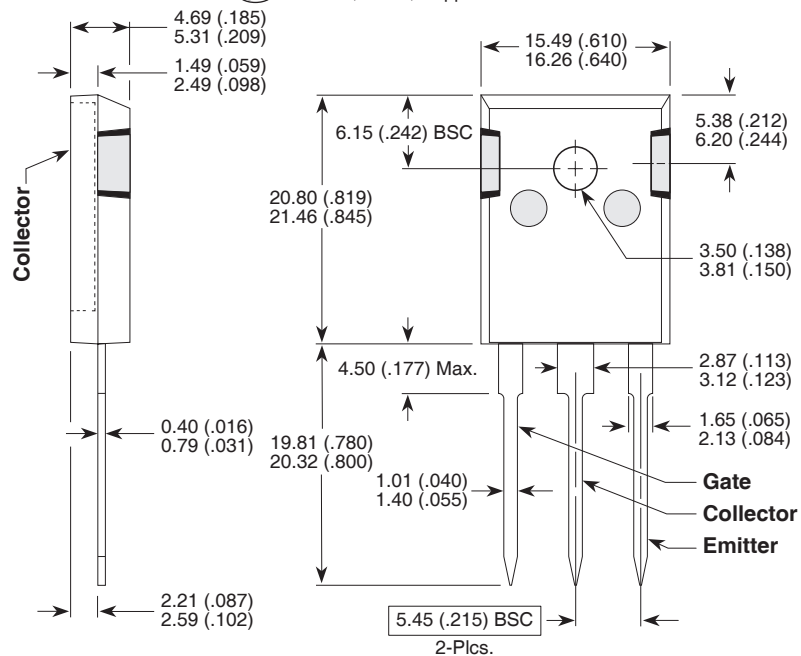


Figure 23, Turn-off Switching Waveforms and Definitions

## TO-247 Package Outline

e1 SAC: Tin, Silver, Copper



Dimensions in Millimeters and (Inches)

APT's products are covered by one or more of U.S. patents 4,895,810 5,045,903 5,089,434 5,182,234 5,019,522

5,262,336 6,503,786 5,256,583 4,748,103 5,283,202 5,231,474 5,434,095 5,528,058 and foreign patents. US and Foreign patents pending. All Rights Reserved.