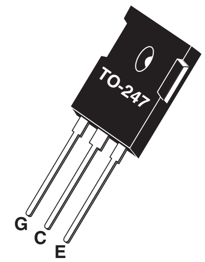
**APT15GP60BDL(G)**

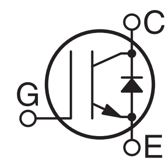
**600V, 15A, $V_{CE(ON)}$ = 2.2V Typical**

Microsemi POWER PRODUCTS GROUP

# Resonant Mode Combi IGBT®

The POWER MOS 7® IGBT used in this resonant mode combi is a new generation of high voltage power IGBTs. Using Punch Through Technology this IGBT is ideal for many high frequency, high voltage switching applications and has been optimized for high frequency switchmode power supplies.




**Features**

- **Low Conduction Loss**
- **Low Gate Charge**
- **Ultrafast Tail Current shutoff**
- **Low forward Diode Voltage ($V_F$)**
- **Ultrasoft Recovery Diode**
- **SSOA Rated**
- **RoHS Compliant**

**Typical Applications**

- **Induction Heating**
- **Welding**
- **Medical**
- **High Power Telecom**
- **Resonant Mode Phase Shifted Bridge**

## MAXIMUM RATINGS

All Ratings: $T_C$ = 25°C unless otherwise specified.

| Symbol | Parameter | Ratings | UNIT |
|---|---|---|---|
| $V_{CES}$ | Collector-Emitter Voltage | 600 | Volts |
| $V_{GE}$ | Gate-Emitter Voltage | ±20 | |
| $V_{GEM}$ | Gate-Emitter Voltage Transient | ±30 | |
| $I_{C1}$ | Continuous Collector Current @ $T_C$ = 25°C | 56 | Amps |
| $I_{C2}$ | Continuous Collector Current @ $T_C$ = 110°C | 27 | |
| $I_{CM}$ | Pulsed Collector Current ① @ $T_C$ = 25°C | 65 | |
| SSOA | Switching Safe Operating Area @ $T_J$ = 150°C | 65A @ 600V | |
| $P_D$ | Total Power Dissipation | 250 | Watts |
| $T_J$,$T_{STG}$ | Operating and Storage Junction Temperature Range | -55 to 150 | °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 | UNIT |
|---|---|---|---|---|---|
| $BV_{CES}$ | Collector-Emitter Breakdown Voltage ($V_{GE}$ = 0V, $I_C$ = 1.0mA) | 600 | | | Volts |
| $V_{GE(TH)}$ | Gate Threshold Voltage ($V_{CE}$ = $V_{GE}$, $I_C$ = 1mA, $T_j$ = 25°C) | 3 | 4.5 | 6 | |
| $V_{CE(ON)}$ | Collector-Emitter On Voltage ($V_{GE}$ = 15V, $I_C$ = 15A, $T_j$ = 25°C) | | 2.2 | 2.7 | |
| | Collector-Emitter On Voltage ($V_{GE}$ = 15V, $I_C$ = 15A, $T_j$ = 125°C) | | 2.1 | | |
| $I_{CES}$ | Collector Cut-off Current ($V_{CE}$ = 600V, $V_{GE}$ = 0V, $T_j$ = 25°C) ② | | | 275 | µA |
| | Collector Cut-off Current ($V_{CE}$ = 600V, $V_{GE}$ = 0V, $T_j$ = 125°C) ② | | | 2750 | |
| $I_{GES}$ | Gate-Emitter Leakage Current ($V_{GE}$ = ±20V) | | | ±100 | nA |

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

## DYNAMIC CHARACTERISTICS

| Symbol | Characteristic | Test Conditions | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $C_{ies}$ | Input Capacitance | **Capacitance** $V_{GE}$ = 0V, $V_{CE}$ = 25V f = 1 MHz | | 1685 | | pF |
| $C_{oes}$ | Output Capacitance | | | 210 | | |
| $C_{res}$ | Reverse Transfer Capacitance | | | 15 | | |
| $V_{GEP}$ | Gate-to-Emitter Plateau Voltage | **Gate Charge** $V_{GE}$ = 15V $V_{CE}$ = 300V $I_C$ = 15A | | 7.5 | | V |
| $Q_g$ | Total Gate Charge ③ | | | 55 | | nC |
| $Q_{ge}$ | Gate-Emitter Charge | | | 12 | | |
| $Q_{gc}$ | Gate-Collector ("Miller") Charge | | | 15 | | |
| SSOA | Switching Safe Operating Area | $T_J$ = 150°C, $R_G$ = 5Ω, $V_{GE}$ = 15V, L = 100µH, $V_{CE}$ = 600V | 65 | | | A |
| $t_{d(on)}$ | Turn-on Delay Time | **Inductive Switching (25°C)** $V_{CC}$ = 400V $V_{GE}$ = 15V $I_C$ = 15A $R_G$ = 5Ω $T_J$ = +25°C | | 8 | | ns |
| $t_r$ | Current Rise Time | | | 12 | | |
| $t_{d(off)}$ | Turn-off Delay Time | | | 29 | | |
| $t_f$ | Current Fall Time | | | 58 | | |
| $E_{on1}$ | Turn-on Switching Energy ④ | | | 130 | | µJ |
| $E_{on2}$ | Turn-on Switching Energy (With Diode) ⑤ | | | 152 | | |
| $E_{off}$ | Turn-off Switching Energy ⑥ | | | 121 | | |
| $t_{d(on)}$ | Turn-on Delay Time | **Inductive Switching (125°C)** $V_{CC}$ = 400V $V_{GE}$ = 15V $I_C$ = 15A $R_G$ = 5Ω $T_J$ = +125°C | | 8 | | ns |
| $t_r$ | Current Rise Time | | | 12 | | |
| $t_{d(off)}$ | Turn-off Delay Time | | | 69 | | |
| $t_f$ | Current Fall Time | | | 88 | | |
| $E_{on1}$ | Turn-on Switching Energy ④ | | | 130 | | µJ |
| $E_{on2}$ | Turn-on Switching Energy (With Diode) ⑤ | | | 267 | | |
| $E_{off}$ | Turn-off Switching Energy ⑥ | | | 268 | | |

## THERMAL AND MECHANICAL CHARACTERISTICS

| Symbol | Characteristic | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|
| $R_{\theta JC}$ | Junction to Case (IGBT) | | | .50 | °C/W |
| $R_{\theta JC}$ | Junction to Case (DIODE) | | | 1.00 | |
| $W_T$ | Package Weight | | | 5.90 | gm |

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

② For Combi devices, $I_{ces}$ includes both IGBT and diode 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. A Combi device is used for the clamping diode as shown in the $E_{on2}$ test circuit. (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.)

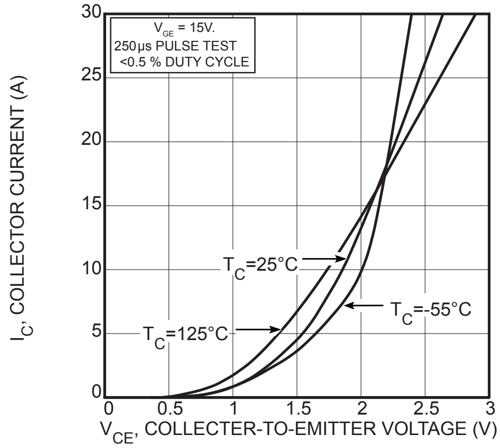



**FIGURE 1, Output Characteristics($V_{GE}$ = 15V)**

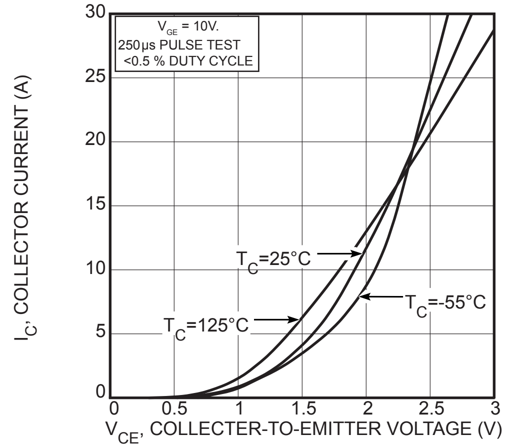



**FIGURE 2, Output Characteristics ($V_{GE}$ = 10V)**

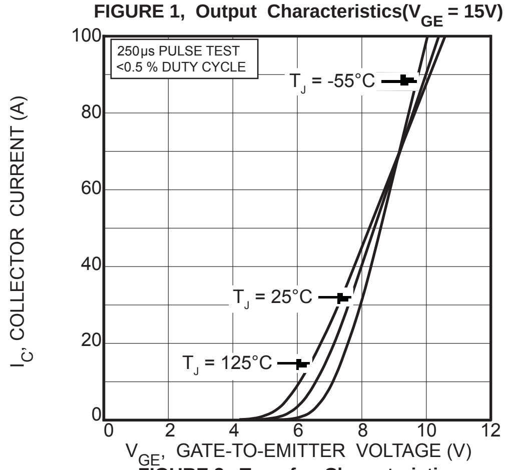



**FIGURE 3, Transfer Characteristics**

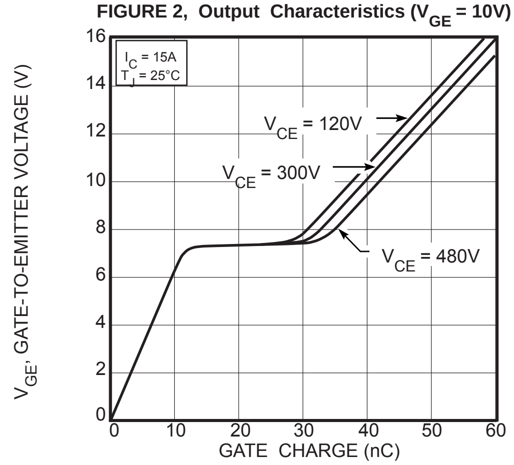



**FIGURE 4, Gate Charge**

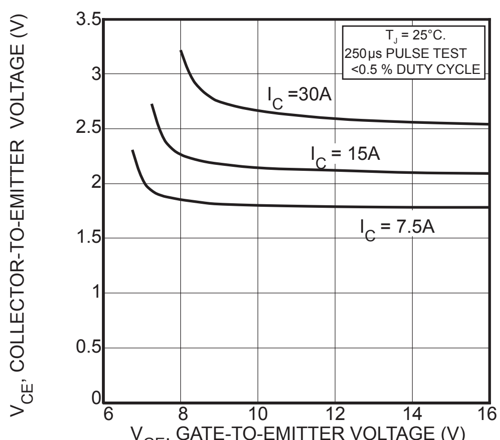



**FIGURE 5, On State Voltage vs Gate-to- Emitter Voltage**

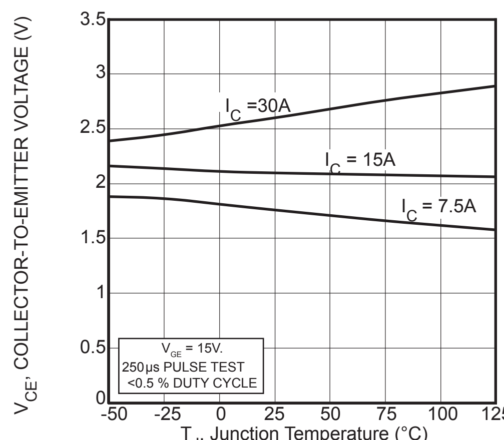



**FIGURE 6, On State Voltage vs Junction Temperature**

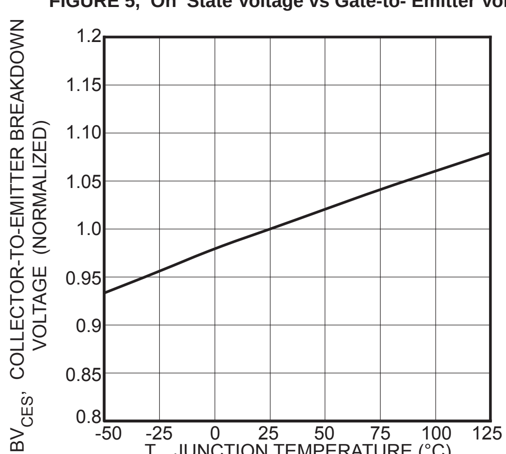



**FIGURE 7, Breakdown Voltage vs. Junction Temperature**

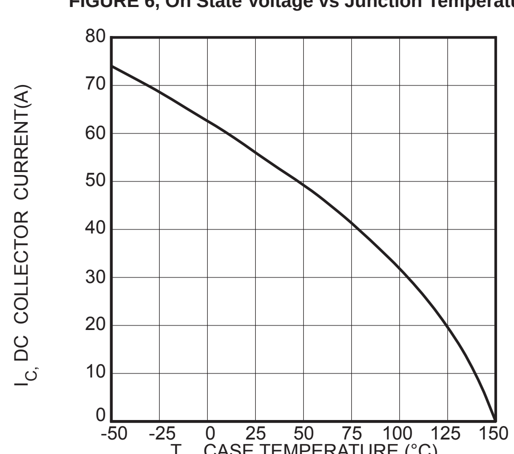



**FIGURE 8, DC Collector Current vs Case Temperature**

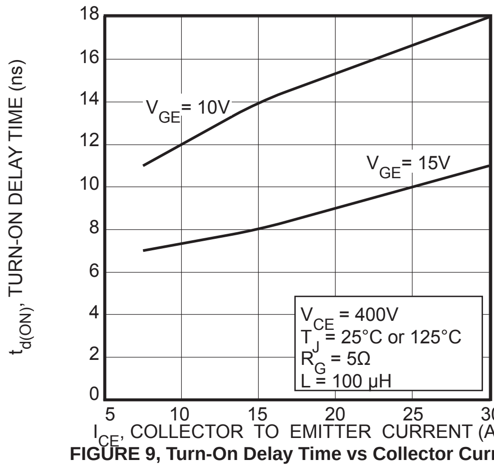



**FIGURE 9, Turn-On Delay Time vs Collector Current**

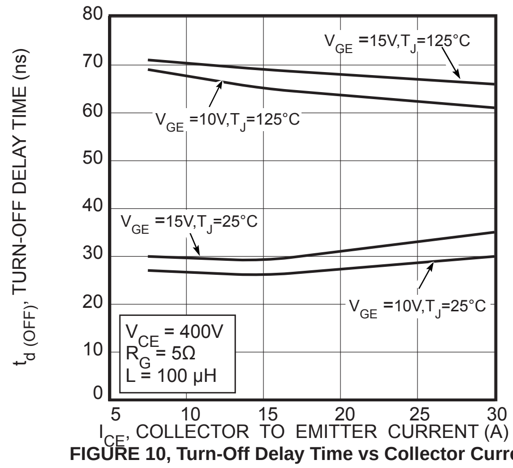



**FIGURE 10, Turn-Off Delay Time vs Collector Current**

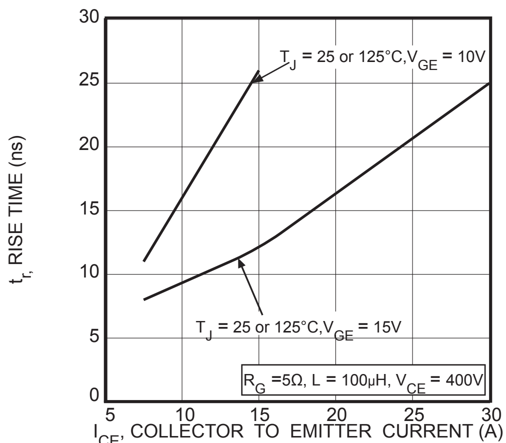



**FIGURE 11, Current Rise Time vs Collector Current**

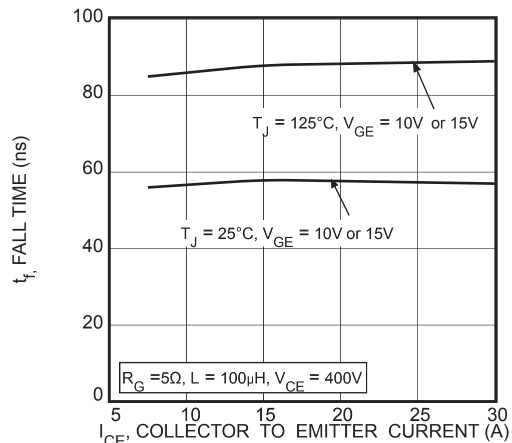



**FIGURE 12, Current Fall Time vs Collector Current**

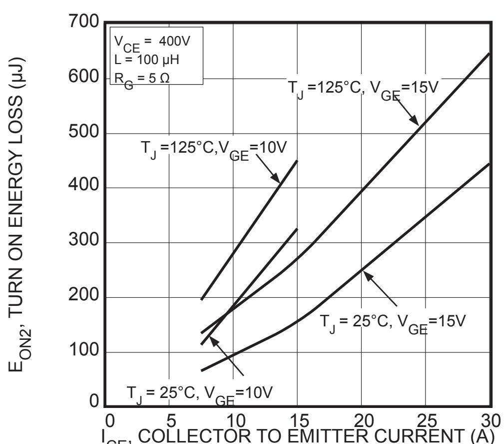



**FIGURE 13, Turn-On Energy Loss vs Collector Current**

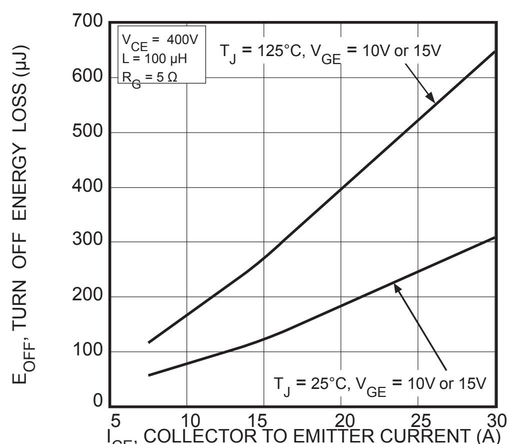



**FIGURE 14, Turn Off Energy Loss vs Collector Current**

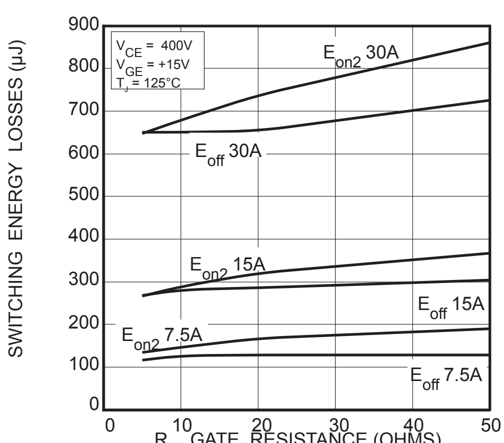



**FIGURE 15, Switching Energy Losses vs. Gate Resistance**

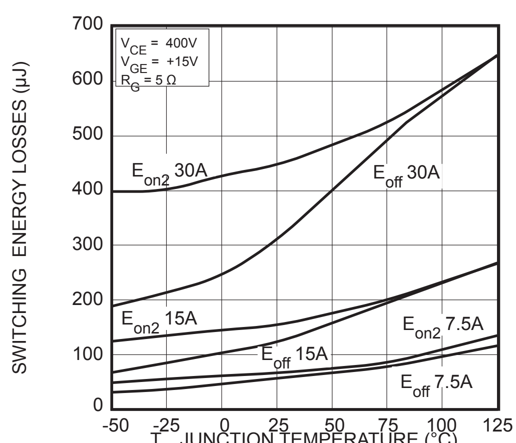



**FIGURE 16, Switching Energy Losses vs Junction Temperature**

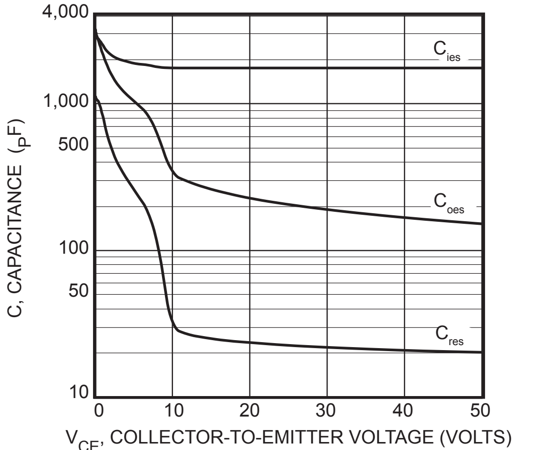



**Figure 17, Capacitance vs Collector-To-Emitter Voltage**

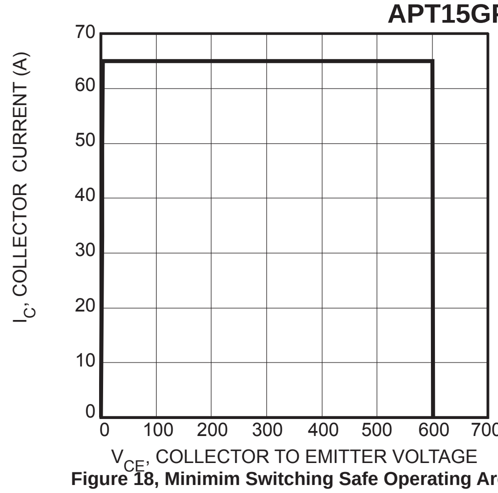



**Figure 18, Minimim Switching Safe Operating Area**

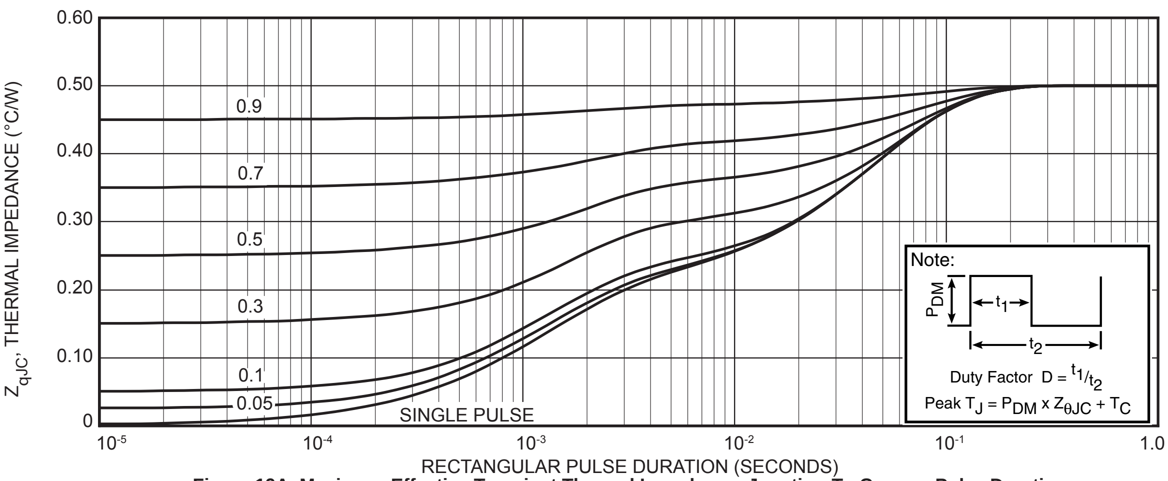



**Figure 19A, Maximum Effective Transient Thermal Impedance, Junction-To-Case vs Pulse Duration**

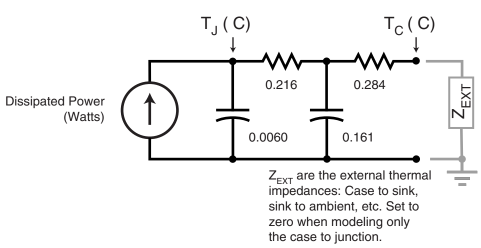



**FIGURE 19B, TRANSIENT THERMAL IMPEDANCE MODEL**

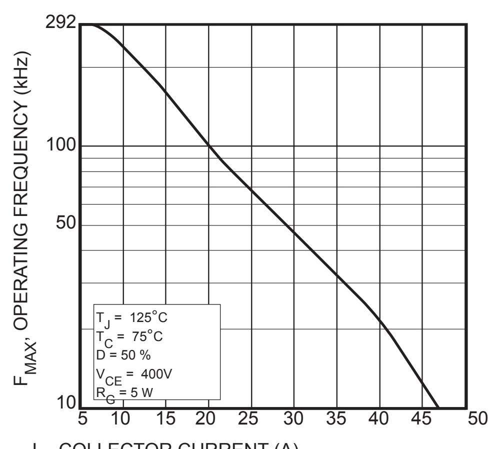



**Figure 20, Operating Frequency vs Collector Current**

$$F_{max} = \min(f_{max1}, f_{max2})$$

$$f_{max1} = \frac{0.05}{t_{d(on)} + t_r + t_{d(off)} + t_f}$$

$$f_{max2} = \frac{P_{diss} - P_{cond}}{E_{on2} + E_{off}}$$

$$P_{diss} = \frac{T_J - T_C}{R_{\theta JC}}$$

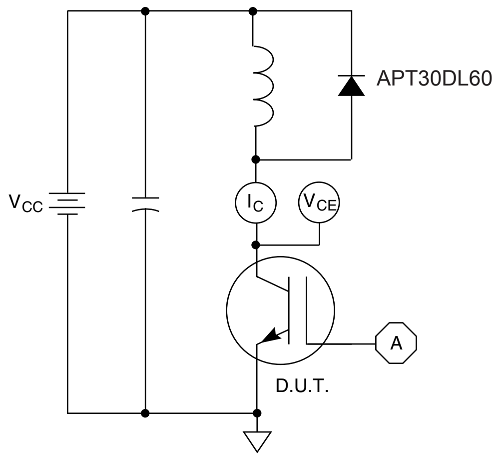



**Figure 21, Inductive Switching Test Circuit**

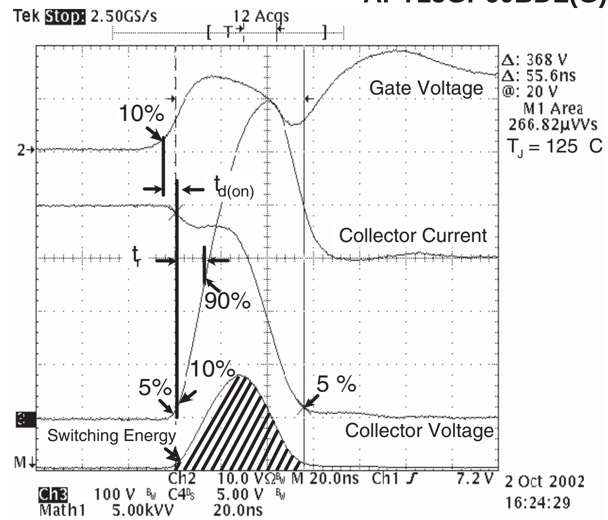



**Figure 22, Turn-on Switching Waveforms and Definitions**

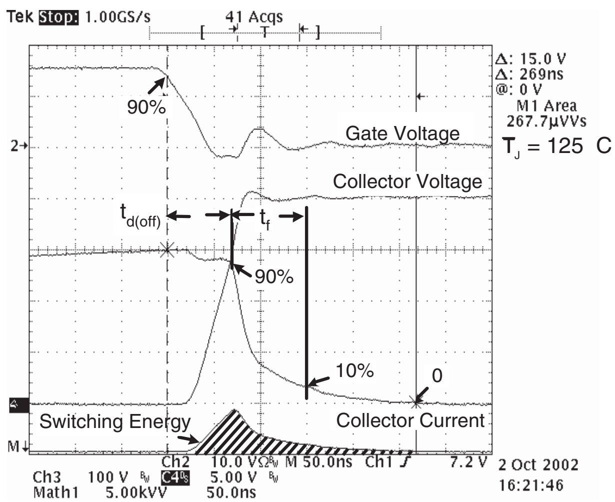



**Figure 23, Turn-off Switching Waveforms and Definitions**

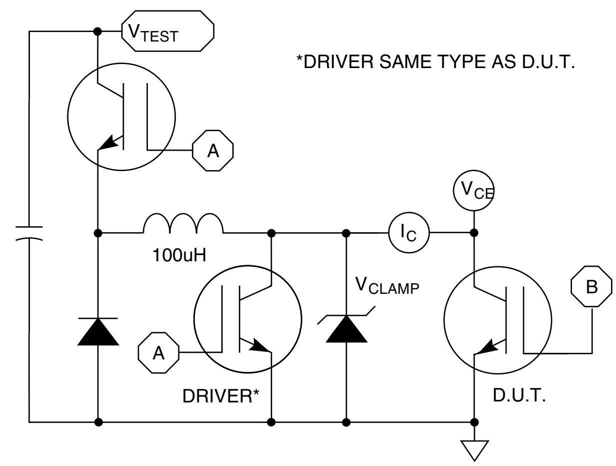



**Figure 24, $E_{ON1}$ Test Circuit**

# ULTRAFAST SOFT RECOVERY ANTI-PARALLEL DIODE

## MAXIMUM RATINGS

All Ratings: $T_C$ = 25°C unless otherwise specified.

| Symbol | Characteristic / Test Conditions | APT15GP60BDL(G) | UNIT |
|---|---|---|---|
| $I_F(AV)$ | Maximum Average Forward Current ($T_C$ = 126°C, Duty Cycle = 0.5) | 30 | Amps |
| $I_F(RMS)$ | RMS Forward Current (Square wave, 50% duty) | 51 | Amps |
| $I_{FSM}$ | Non-Repetitive Forward Surge Current ($T_J$ = 45°C, 8.3ms) | 320 | Amps |

## STATIC ELECTRICAL CHARACTERISTICS

| Symbol | Characteristic / Test Conditions | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $V_F$ | Forward Voltage | $I_F$ = 30A | | 1.25 | 1.6 | Volts |
| | | $I_F$ = 60A | | 2.0 | | |
| | | $I_F$ = 30A, $T_J$ = 125°C | | 1.25 | | |

## DYNAMIC CHARACTERISTICS

| Symbol | Characteristic | Test Conditions | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $t_{rr}$ | Reverse Recovery Time | $I_F$ = 1A, $di_F/dt$ = -100A/µs, $V_R$ = 30V, $T_J$ = 25°C | - | 64 | | ns |
| $t_{rr}$ | Reverse Recovery Time | $I_F$ = 30A, $di_F/dt$ = -200A/µs<br>$V_R$ = 400V, $T_C$ = 25°C | - | 317 | | ns |
| $Q_{rr}$ | Reverse Recovery Charge | | - | 962 | | nC |
| $I_{RRM}$ | Maximum Reverse Recovery Current | | - | 7 | - | Amps |
| $t_{rr}$ | Reverse Recovery Time | $I_F$ =30A, $di_F/dt$ = -200A/µs<br>$V_R$ = 400V, $T_C$ = 125°C | - | 561 | | ns |
| $Q_{rr}$ | Reverse Recovery Charge | | - | 2244 | | nC |
| $I_{RRM}$ | Maximum Reverse Recovery Current | | - | 9 | - | Amps |
| $t_{rr}$ | Reverse Recovery Time | $I_F$ = 30A, $di_F/dt$ = -1000A/µs<br>$V_R$ = 400V, $T_C$ = 125°C | - | 264 | | ns |
| $Q_{rr}$ | Reverse Recovery Charge | | - | 3191 | | nC |
| $I_{RRM}$ | Maximum Reverse Recovery Current | | - | 26 | | Amps |

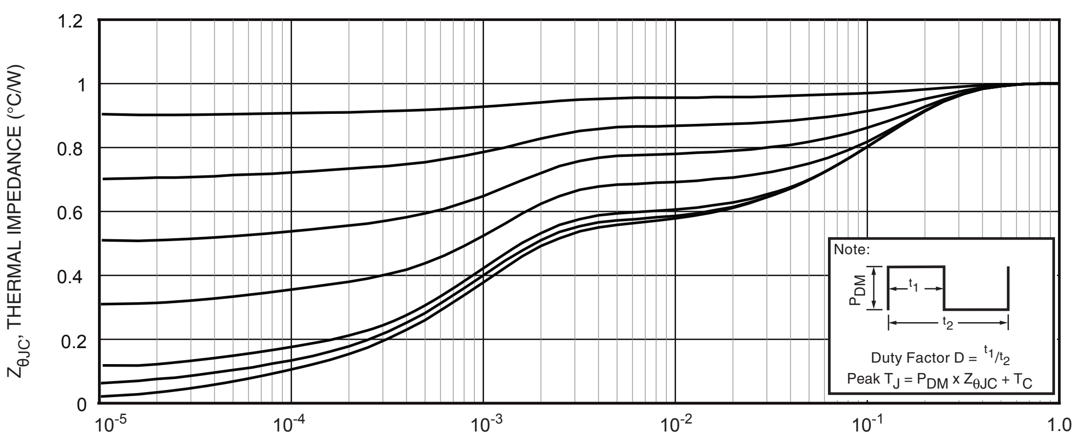



**FIGURE 1a. MAXIMUM EFFECTIVE TRANSIENT THERMAL IMPEDANCE, JUNCTION-TO-CASE vs. PULSE DURATION**

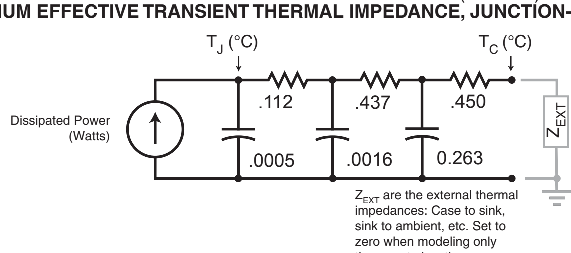



**FIGURE 1b, TRANSIENT THERMAL IMPEDANCE MODEL**

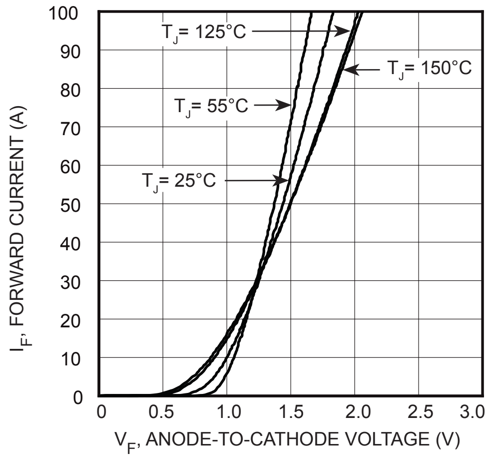


FIGURE 2, Forward Current vs. Forward Voltage

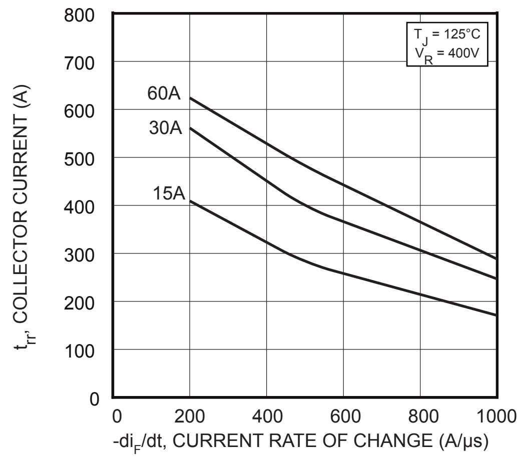


FIGURE 3, Reverse Recovery Time vs. Current Rate of Change

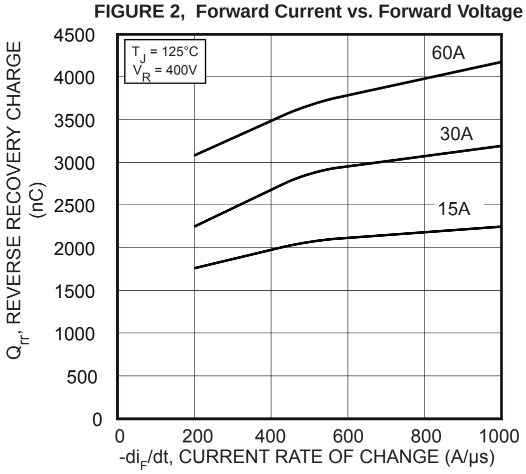


FIGURE 4, Reverse Recovery Charge vs. Current Rate of Change

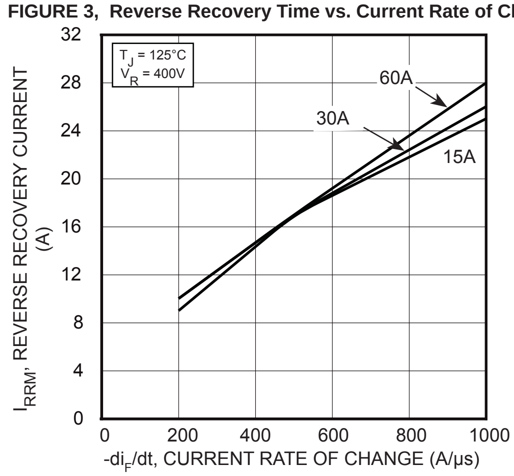


FIGURE 5, Reverse Recovery Current vs. Current Rate of Change

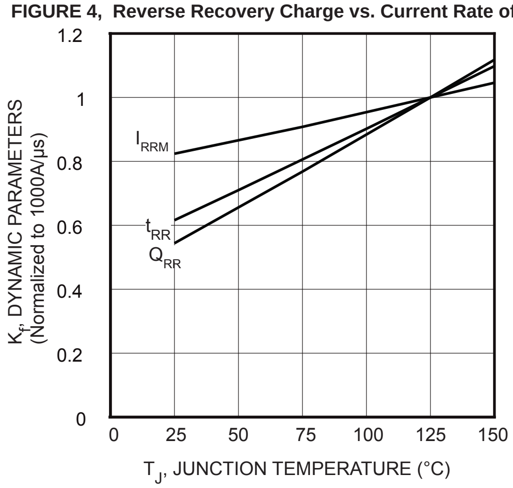


FIGURE 6, Dynamic Parameters vs Junction Temperature

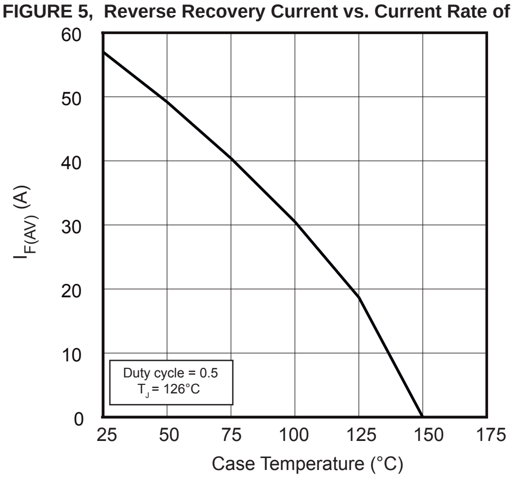


FIGURE 7, Maximum Average Forward Current vs. Case Temperature

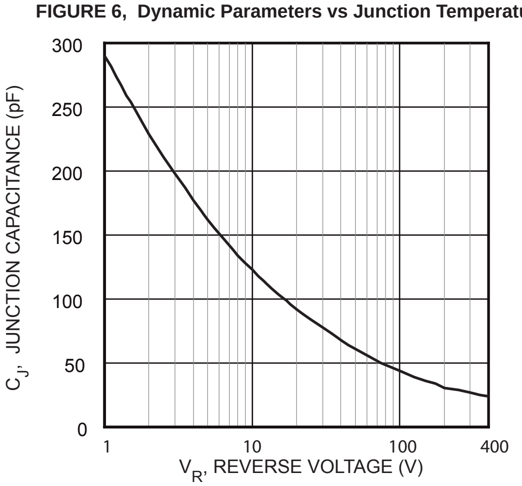


FIGURE 8, Junction Capacitance vs. Reverse Voltage

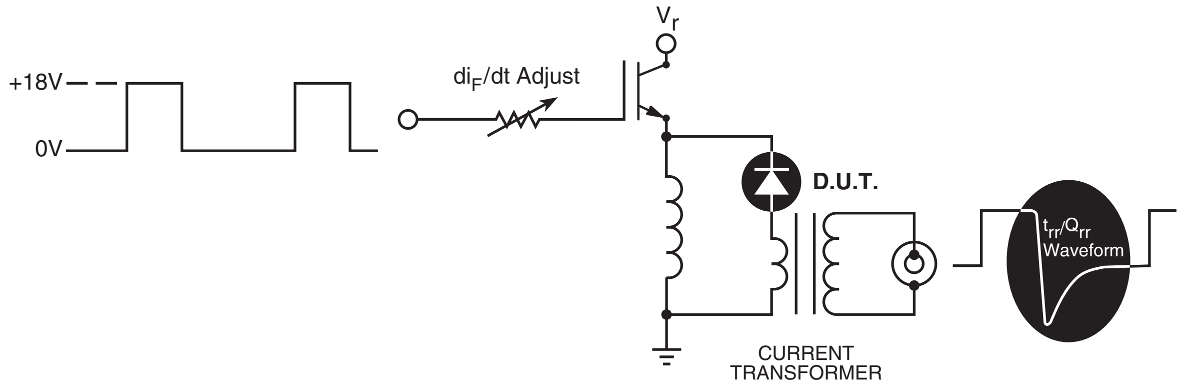



**Figure 9. Diode Test Circuit**

1. $I_F$ - Forward Conduction Current
2. $di_F/dt$ - Rate of Diode Current Change Through Zero Crossing.
3. $I_{RRM}$ - Maximum Reverse Recovery Current.
4. $t_{rr}$ - Reverse Recovery Time, measured from zero crossing where diode current goes from positive to negative, to the point at which the straight line through $I_{RRM}$ and $0.25 \bullet I_{RRM}$ passes through zero.
5. $Q_{rr}$ - Area Under the Curve Defined by $I_{RRM}$ and $t_{rr}$.
6. $di_M/dt$ - Maximum Rate of Current Increase During the Trailing Portion of $t_{rr}$.

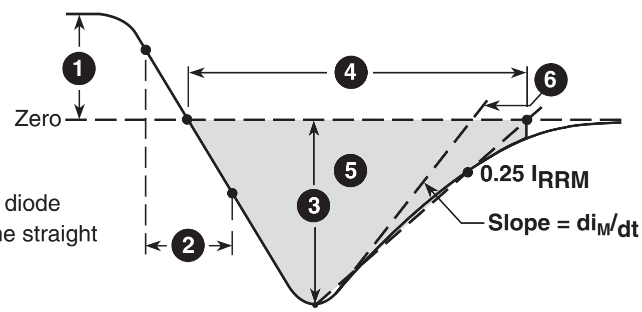
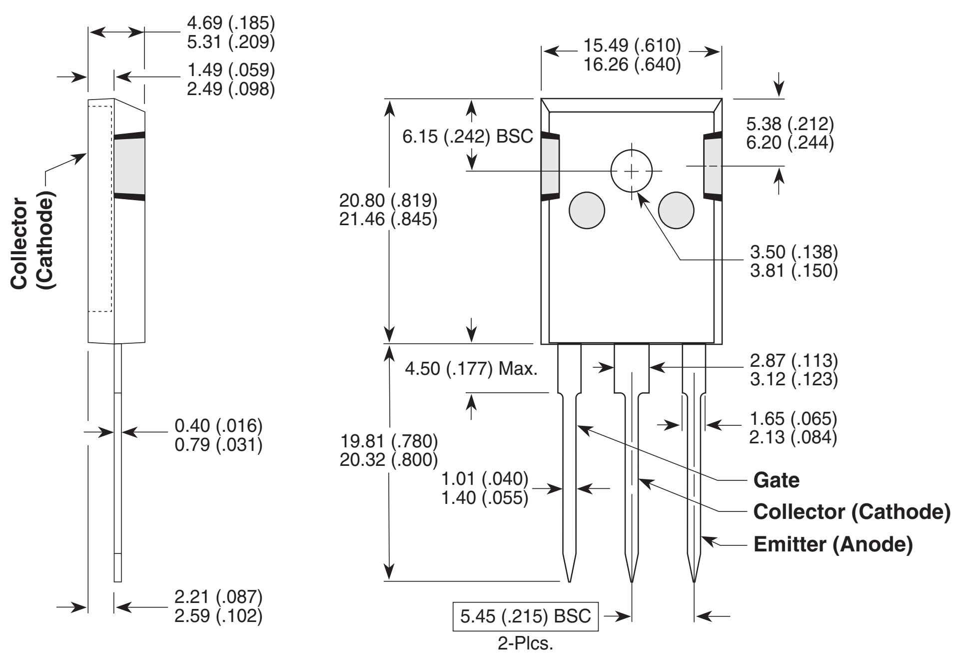



**Figure 10, Diode Reverse Recovery Waveform and Definitions**

## TO-247 (B) Package Outline




Dimensions in Millimeters and (Inches)