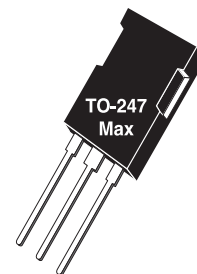


## Ultra Fast NPT - IGBT® with Ultra Soft Recovery Diode

The Ultra Fast 650V NPT-IGBT® family of products is the newest generation of IGBTs optimized for outstanding ruggedness and best trade-off between conduction and switching losses.

### Features

- Low Saturation Voltage
- Low Tail Current
- RoHS Compliant 
- Smooth Reverse Recovery
- Short Circuit Withstand Rated
- High Frequency Switching
- Ultra Low Leakage Current
- Snap-free Switching



Combi (IGBT and Diode)



Unless stated otherwise, Microsemi discrete IGBTs contain a single IGBT die. This device is recommended for applications such as induction heating (IH), motor control, general purpose inverters and uninterruptible power supplies (UPS).

### MAXIMUM RATINGS

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

| Symbol         | Parameter                                                                                  | Ratings    | Unit             |
|----------------|--------------------------------------------------------------------------------------------|------------|------------------|
| $V_{CES}$      | Collector Emitter Voltage                                                                  | 650        | V                |
| $V_{GE}$       | Gate-Emitter Voltage                                                                       | $\pm 30$   |                  |
| $I_{C1}$       | Continuous Collector Current @ $T_C = 25^\circ\text{C}$                                    | 118        | A                |
| $I_{C2}$       | Continuous Collector Current @ $T_C = 110^\circ\text{C}$                                   | 56         |                  |
| $I_{CM}$       | Pulsed Collector Current <sup>①</sup>                                                      | 224        |                  |
| SCWT           | Short Circuit Withstand Time: $V_{CE} = 325V$ , $V_{GE} = 15V$ , $T_C = 125^\circ\text{C}$ | 10         | $\mu\text{s}$    |
| $P_D$          | Total Power Dissipation @ $T_C = 25^\circ\text{C}$                                         | 543        | W                |
| $T_J, T_{STG}$ | 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        | Parameter                                                                                              | Min | Typ | Max       | Unit          |
|---------------|--------------------------------------------------------------------------------------------------------|-----|-----|-----------|---------------|
| $V_{(BR)CES}$ | Collector-Emitter Breakdown Voltage ( $V_{GE} = 0V$ , $I_C = 350\mu\text{A}$ )                         | 650 |     |           | Volts         |
| $V_{GE(TH)}$  | Gate Threshold Voltage ( $V_{CE} = V_{GE}$ , $I_C = 2.5\text{mA}$ , $T_J = 25^\circ\text{C}$ )         | 3.5 | 5.0 | 6.5       |               |
| $V_{CE(ON)}$  | Collector-Emitter On Voltage ( $V_{GE} = 15V$ , $I_C = 45A$ , $T_J = 25^\circ\text{C}$ )               |     | 1.9 | 2.4       |               |
|               | Collector-Emitter On Voltage ( $V_{GE} = 15V$ , $I_C = 45A$ , $T_J = 125^\circ\text{C}$ )              |     | 2.4 |           |               |
|               | Collector-Emitter On Voltage ( $V_{GE} = 15V$ , $I_C = 90A$ , $T_J = 25^\circ\text{C}$ )               |     | 2.6 |           |               |
| $I_{CES}$     | Collector Cut-off Current ( $V_{CE} = 650V$ , $V_{GE} = 0V$ , $T_J = 25^\circ\text{C}$ ) <sup>②</sup>  |     | 20  | 350       | $\mu\text{A}$ |
|               | Collector Cut-off Current ( $V_{CE} = 650V$ , $V_{GE} = 0V$ , $T_J = 125^\circ\text{C}$ ) <sup>②</sup> |     | 200 |           |               |
| $I_{GES}$     | Gate-Emitter Leakage Current ( $V_{GE} = \pm 20V$ )                                                    |     |     | $\pm 250$ | nA            |



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

| Symbol          | Parameter                       | Test Conditions                                                                                                                    | Min | Typ  | Max  | Unit |
|-----------------|---------------------------------|------------------------------------------------------------------------------------------------------------------------------------|-----|------|------|------|
| $C_{ies}$       | Input Capacitance               | Capacitance<br>$V_{GE} = 0V, V_{CE} = 25V$<br>$f = 1MHz$                                                                           |     | 2900 |      | pF   |
| $C_{oes}$       | Output Capacitance              |                                                                                                                                    |     | 548  |      |      |
| $C_{res}$       | Reverse Transfer Capacitance    |                                                                                                                                    |     | 268  |      |      |
| $V_{GEP}$       | Gate to Emitter Plateau Voltage | Gate Charge<br>$V_{GE} = 15V$<br>$V_{CE} = 325V$<br>$I_C = 45A$                                                                    |     | 7.5  |      | V    |
| $Q_g^{(3)}$     | Total Gate Charge               |                                                                                                                                    |     | 150  | 203  | nC   |
| $Q_{ge}$        | Gate-Emitter Charge             |                                                                                                                                    |     | 18   | 24   |      |
| $Q_{gc}$        | Gate- Collector Charge          |                                                                                                                                    |     | 74   | 100  |      |
| $t_{d(on)}$     | Turn-On Delay Time              | Inductive Switching (25°C)<br>$V_{CC} = 433V$<br>$V_{GE} = 15V$<br>$I_C = 45A$<br>$R_G = 4.3\Omega^{(4)}$<br>$T_J = +25^\circ C$   |     | 15   |      | ns   |
| $t_r$           | Current Rise Time               |                                                                                                                                    |     | 32   |      |      |
| $t_{d(off)}$    | Turn-Off Delay Time             |                                                                                                                                    |     | 100  |      |      |
| $t_f$           | Current Fall Time               |                                                                                                                                    |     | 50   |      |      |
| $E_{on2}^{(5)}$ | Turn-On Switching Energy        |                                                                                                                                    |     | 1100 | 1650 | μJ   |
| $E_{off}^{(6)}$ | Turn-Off Switching Energy       |                                                                                                                                    |     | 540  | 870  |      |
| $t_{d(on)}$     | Turn-On Delay Time              | Inductive Switching (125°C)<br>$V_{CC} = 433V$<br>$V_{GE} = 15V$<br>$I_C = 45A$<br>$R_G = 4.3\Omega^{(4)}$<br>$T_J = +125^\circ C$ |     | 15   |      | ns   |
| $t_r$           | Current Rise Time               |                                                                                                                                    |     | 32   |      |      |
| $t_{d(off)}$    | Turn-Off Delay Time             |                                                                                                                                    |     | 123  |      |      |
| $t_f$           | Current Fall Time               |                                                                                                                                    |     | 52   |      |      |
| $E_{on2}^{(5)}$ | Turn-On Switching Energy        |                                                                                                                                    |     | 1600 | 2400 | μJ   |
| $E_{off}^{(6)}$ | Turn-Off Switching Energy       |                                                                                                                                    |     | 800  | 1160 |      |

## THERMAL AND MECHANICAL CHARACTERISTICS

| Symbol          | Characteristic                              | Min | Typ  | Max  | Unit |
|-----------------|---------------------------------------------|-----|------|------|------|
| $R_{\theta JC}$ | Junction to Case Thermal Resistance (IGBT)  |     |      | 0.23 | °C/W |
|                 | Junction to Case Thermal Resistance (Diode) |     |      | 0.80 |      |
| $R_{\theta JA}$ | Junction to Ambient Thermal Resistance      |     |      | 40   |      |
| $W_T$           | Package Weight                              |     | 0.22 |      | oz   |
|                 |                                             |     | 6.2  |      | g    |

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

2 Pulse test: Pulse Width < 380μs, duty cycle < 2%.

3 See Mil-Std-750 Method 3471.

4  $R_G$  is external gate resistance, not including internal gate resistance or gate driver impedance. (MIC4452)

5  $E_{on2}$  is the energy loss at turn-on and includes the charge stored in the freewheeling diode.

6  $E_{off}$  is the clamped inductive turn-off energy measured in accordance with JEDEC standard JESD24-1.

Microsemi reserves the right to change, without notice, the specifications and information contained herein.

## TYPICAL PERFORMANCE CURVES

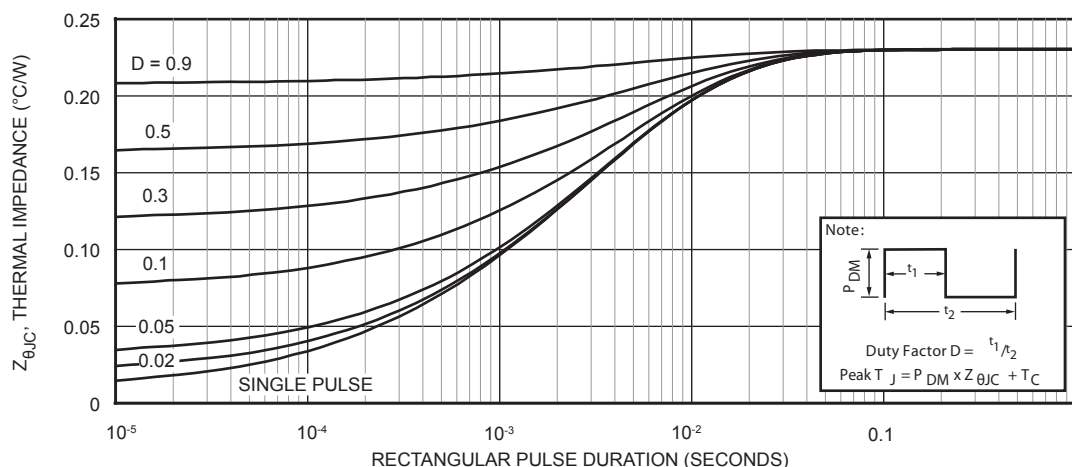


FIGURE 1, Maximum Effective Transient Thermal Impedance, Junction-To-Case vs Pulse Duration

# TYPICAL PERFORMANCE CURVES

APT45GR65B2DU30

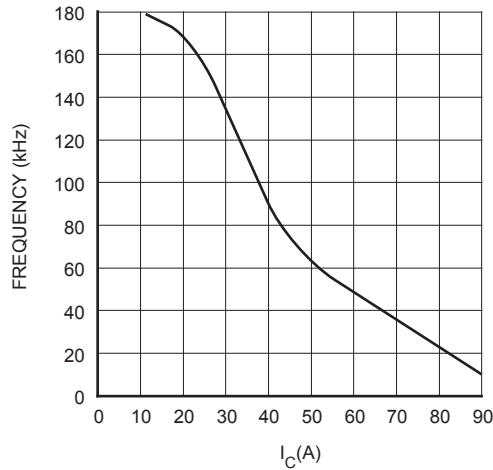


FIGURE 2, Max Frequency vs Current ( $T_{case} = 75^{\circ}C$ )

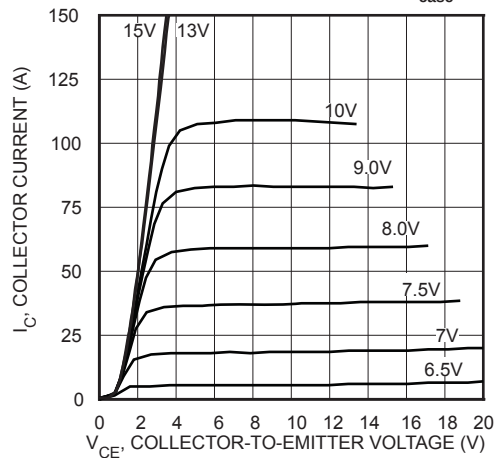


FIGURE 4, Output Characteristics ( $T_J = 25^{\circ}C$ )

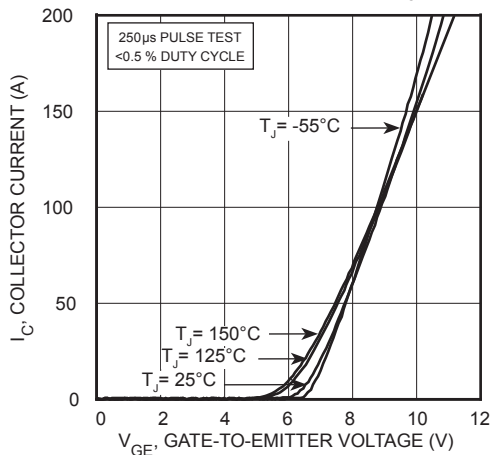


FIGURE 6, Transfer Characteristics

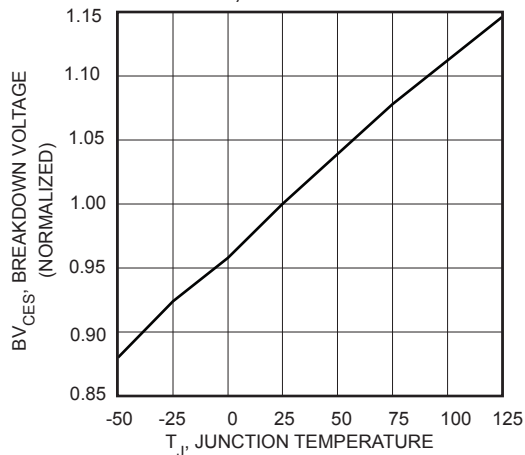


FIGURE 8, Breakdown Voltage vs Junction Temperature

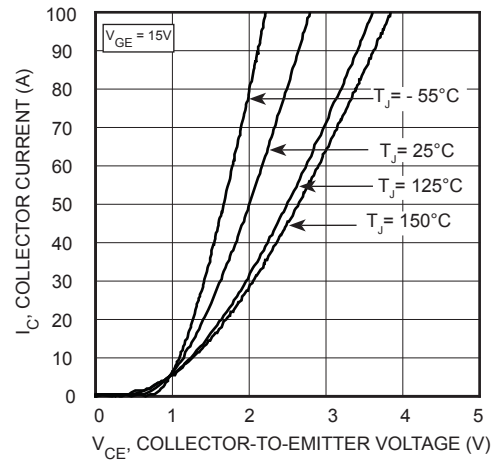


FIGURE 3, Saturation Voltage Characteristics

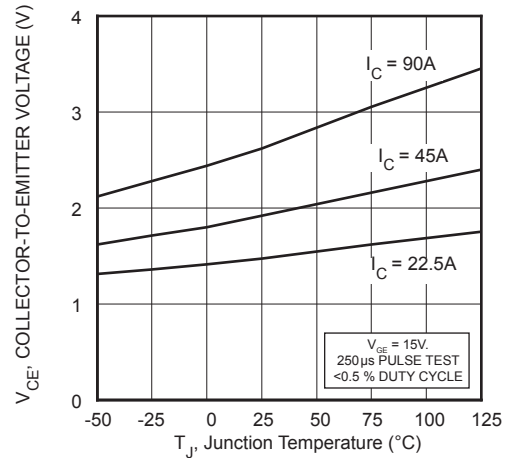


FIGURE 5, On State Voltage vs Junction Temperature

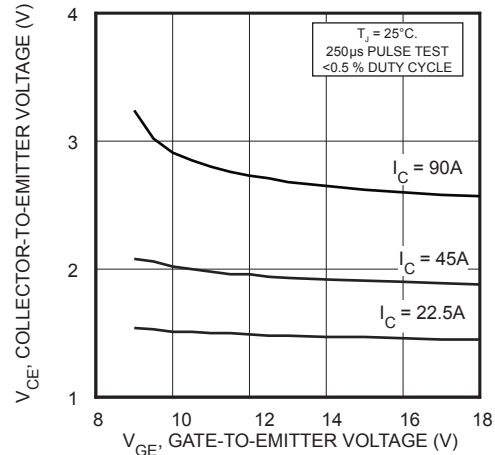


FIGURE 7, On State Voltage vs Gate-to-Emitter Voltage

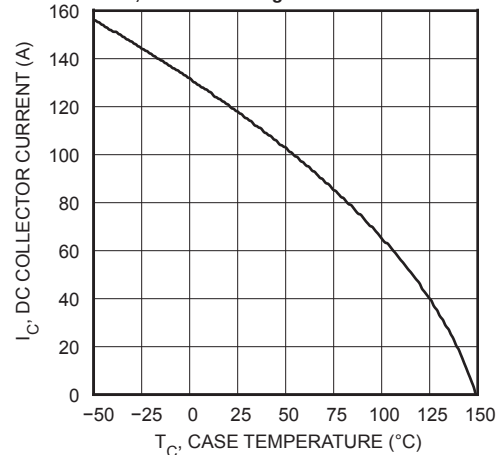


FIGURE 9, DC Collector Current vs Case Temperature

# TYPICAL PERFORMANCE CURVES

APT45GR65B2DU30

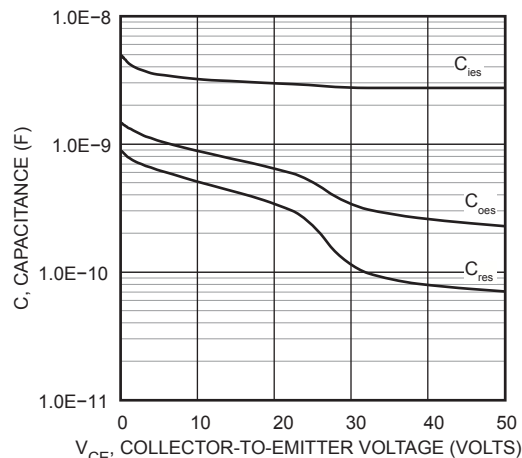


FIGURE 10, Capacitance vs Collector-To-Emitter Voltage

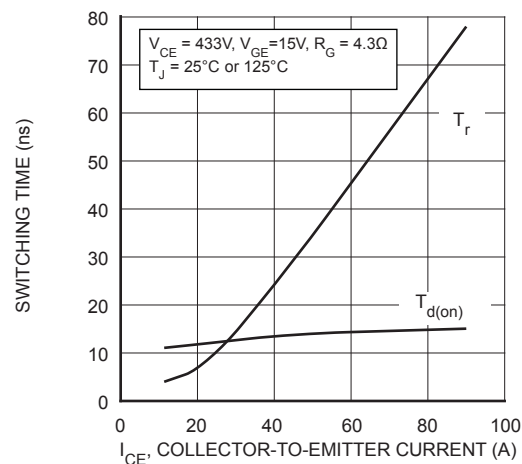


FIGURE 12, Turn-On Time vs Collector Current

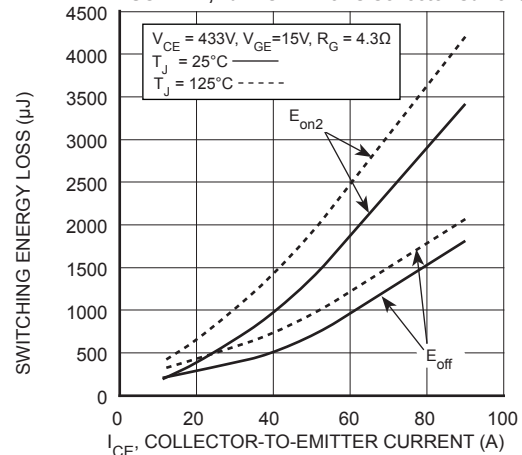


FIGURE 14, Energy Loss vs Collector Current

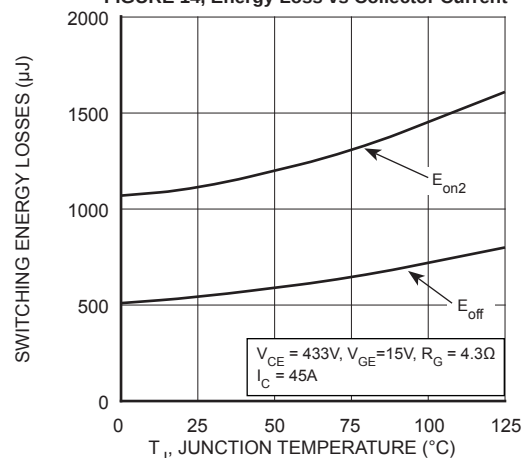


FIGURE 16, Switching Energy vs Junction Temperature

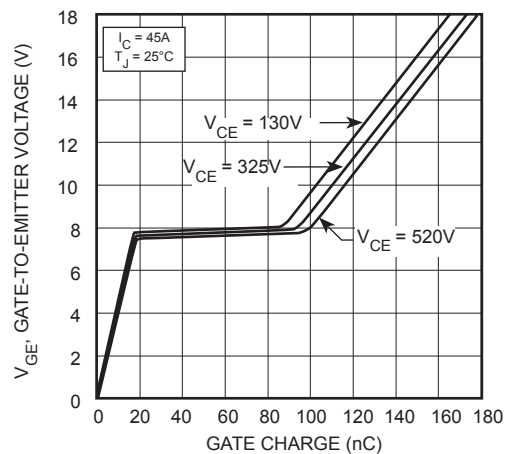


FIGURE 11, Gate charge

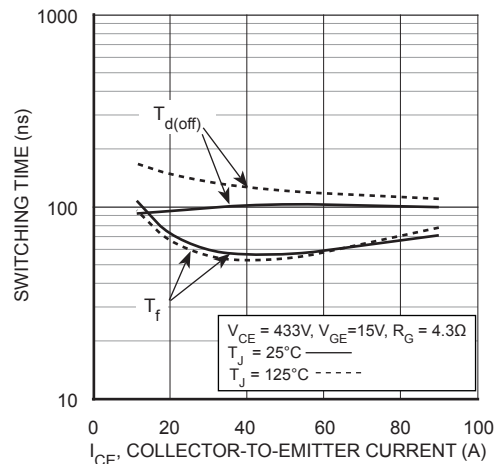


FIGURE 13, Turn-Off Time vs Collector Current

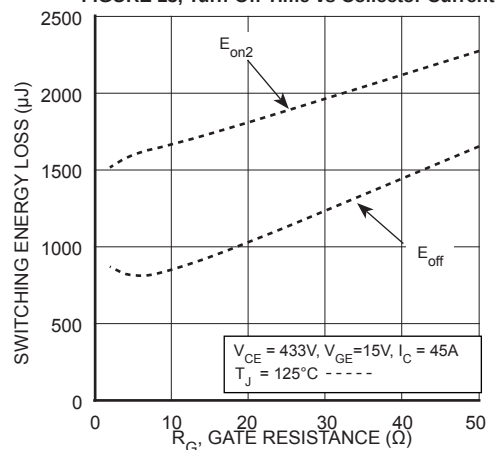


FIGURE 15, Energy Loss vs Gate Resistance

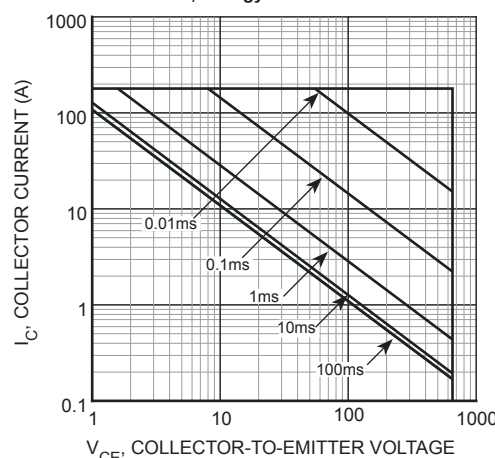


FIGURE 17, Minimum Switching Safe Operating Area

# ULTRA SOFT RECOVERY ANTI-PARALLEL DIODE

## MAXIMUM RATINGS

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

| Symbol       | Characteristic / Test Conditions                                               | APT45GR65B2DU30 | Unit |
|--------------|--------------------------------------------------------------------------------|-----------------|------|
| $I_{F(AV)}$  | Maximum Average Forward Current ( $T_C = 82^\circ\text{C}$ , Duty Cycle = 0.5) | 30              | Amps |
| $I_{F(RMS)}$ | RMS Forward Current (Square wave, 50% duty)                                    | 41              |      |
| $I_{FSM}$    | Non-Repetitive Forward Surge Current ( $T_J = 45^\circ\text{C}$ , 8.3ms)       | 210             |      |

## STATIC ELECTRICAL CHARACTERISTICS

| Symbol | Characteristic / Test Conditions | Min | Typ                                         | Max | Unit  |
|--------|----------------------------------|-----|---------------------------------------------|-----|-------|
| $V_F$  | Forward Voltage                  |     | $I_F = 30\text{A}$                          | 3   | Volts |
|        |                                  |     | $I_F = 60\text{A}$                          | 3.9 |       |
|        |                                  |     | $I_F = 60\text{A}, T_J = 125^\circ\text{C}$ | 3.5 |       |

## DYNAMIC CHARACTERISTICS

| Symbol    | Parameter                        | Test Conditions                                                                                                                       | Min | Typ  | Max | Unit          |
|-----------|----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|-----|------|-----|---------------|
| $t_{rr}$  | Reverse Recovery Time            | $I_F = 1.0\text{A}$ , $\text{dif}/\text{dt} = -100\text{ A}/\mu\text{s}$ , $V_R = 30\text{V}$ , $T_J = 25^\circ\text{C}$              |     | 28   |     | ns            |
| $t_{rr}$  | Reverse Recovery Time            | $I_F = 30\text{Amps}$<br>$\text{dif}/\text{dt} = -200\text{ A}/\mu\text{s}$<br>$V_R = 433\text{ Volts}$<br>$T_J = 25^\circ\text{C}$   |     | 80   |     | ns            |
| $Q_{rr}$  | Reverse Recovery Charge          |                                                                                                                                       |     | 110  |     | nC            |
| $I_{RRM}$ | Maximum Reverse Recovery Current |                                                                                                                                       |     | 3    |     | Amps          |
| $E_{rr}$  | Reverse Recovery Energy          |                                                                                                                                       |     | 2    |     | $\mu\text{J}$ |
| $t_{rr}$  | Reverse Recovery                 | $I_F = 30\text{Amps}$<br>$\text{dif}/\text{dt} = -200\text{ A}/\mu\text{s}$<br>$V_R = 433\text{ Volts}$<br>$T_J = 125^\circ\text{C}$  |     | 343  |     | ns            |
| $Q_{rr}$  | Reverse Recovery Charge          |                                                                                                                                       |     | 965  |     | nC            |
| $I_{RRM}$ | Maximum Reverse Recovery Current |                                                                                                                                       |     | 7    |     | Amps          |
| $E_{rr}$  | Reverse Recovery Energy          |                                                                                                                                       |     | 88   |     | $\mu\text{J}$ |
| $t_{rr}$  | Reverse Recovery                 | $I_F = 30\text{Amps}$<br>$\text{dif}/\text{dt} = -1000\text{ A}/\mu\text{s}$<br>$V_R = 433\text{ Volts}$<br>$T_J = 125^\circ\text{C}$ |     | 124  |     | ns            |
| $Q_{rr}$  | Reverse Recovery Charge          |                                                                                                                                       |     | 1355 |     | nC            |
| $I_{RRM}$ | Maximum Reverse Recovery Current |                                                                                                                                       |     | 24   |     | Amps          |
| $E_{rr}$  | Reverse Recovery Energy          |                                                                                                                                       |     | 211  |     | $\mu\text{J}$ |
| S         | Softness Factor ( $t_b/t_a$ )    | $I_F = 15\text{A}$ , $\text{dif}/\text{dt} = -1000\text{ A}/\mu\text{s}$ , $V_R = 800\text{V}$ , $T_J = 125^\circ\text{C}$            |     | 2    |     |               |

## TYPICAL PERFORMANCE CURVES

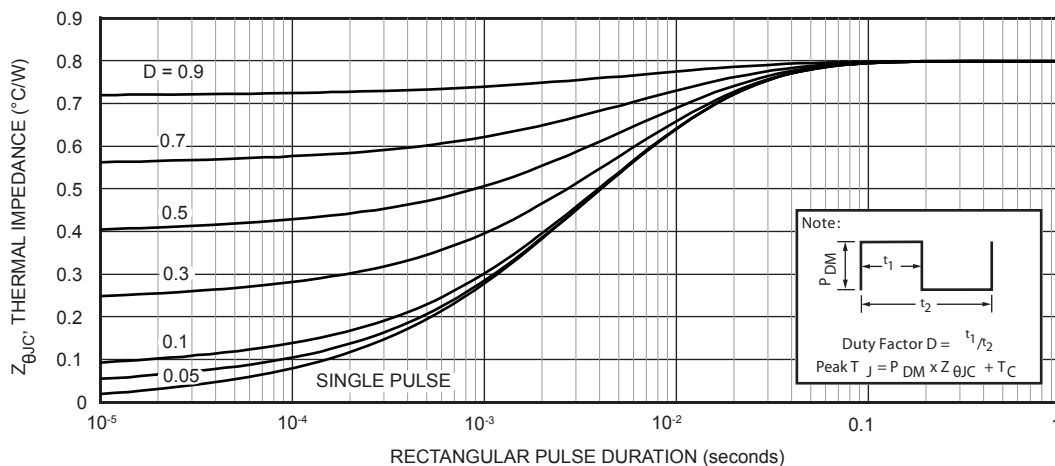


FIGURE 18, MAXIMUM EFFECTIVE TRANSIENT THERMAL IMPEDANCE, JUNCTION-TO-CASE vs. PULSE DURATION

## TYPICAL PERFORMANCE CURVES

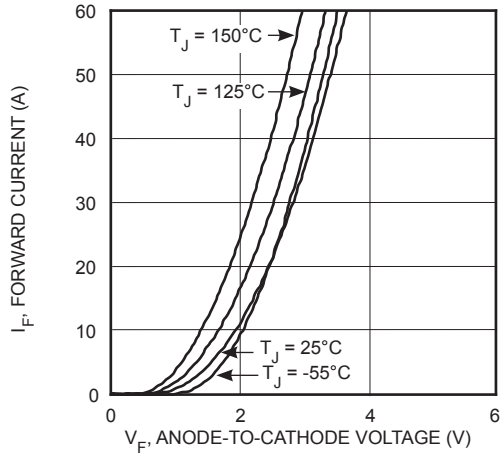


FIGURE 19, F Forward Current vs. Forward Voltage

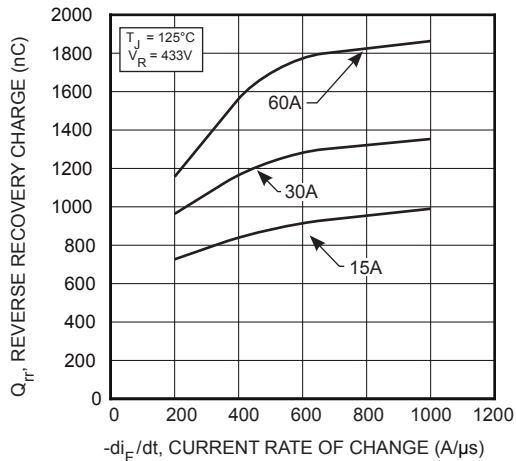


FIGURE 21, Reverse Recovery Charge vs. Current Rate of Change

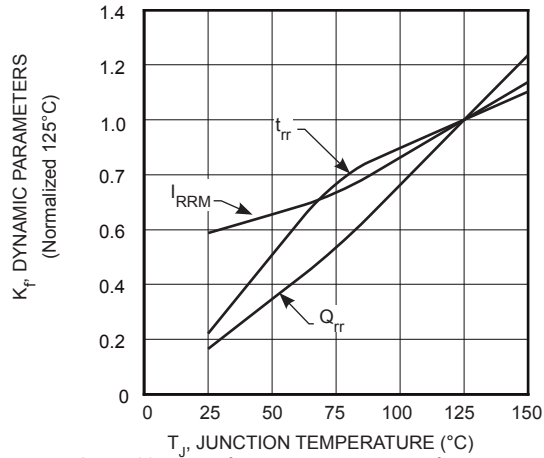


FIGURE 23, Dynamic Parameters vs. Junction Temperature

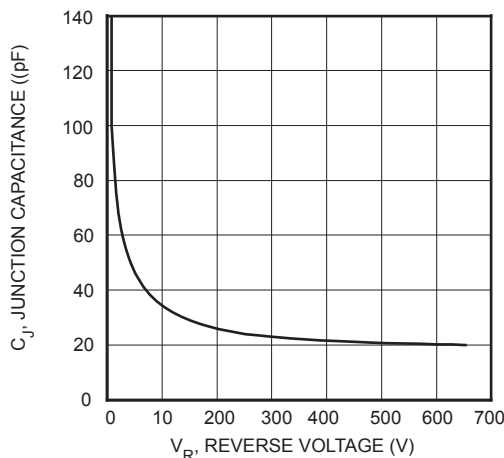


FIGURE 25, Junction Capacitance vs. Reverse Voltage

## APT45GR65B2DU30

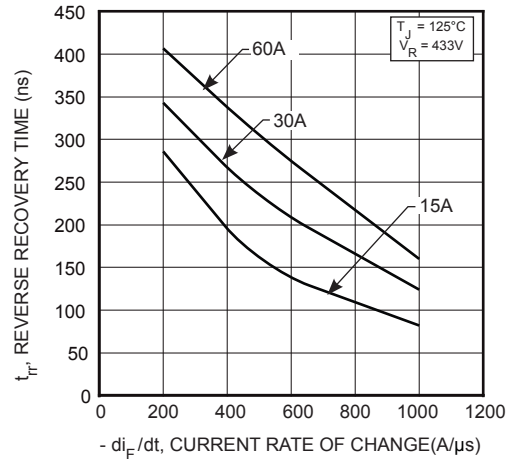


FIGURE 20, Reverse Recovery Time vs. Current Rate of Change

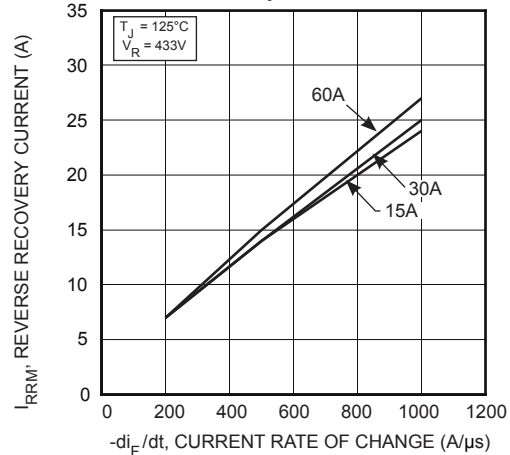


FIGURE 22, Reverse Recovery Current vs. Current Rate of Change

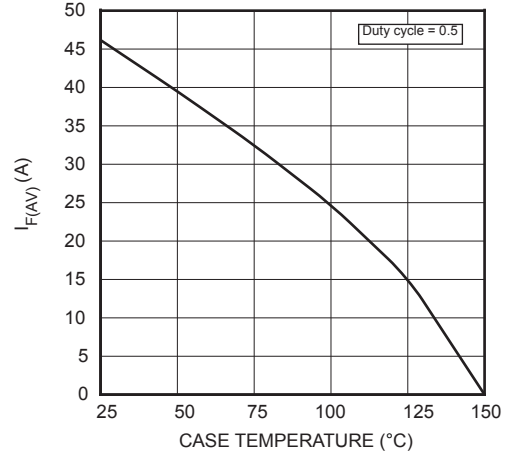


FIGURE 24, Max Average Forward Current vs. Case Temperature

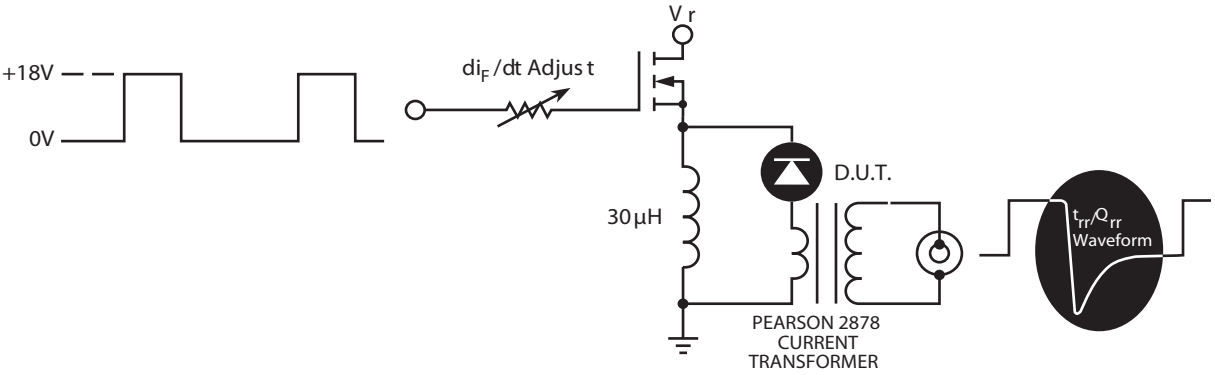


FIGURE 26, Diode Test Circuit

- 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  $t_a$  - Time to reach Maximum Reverse Recovery Current ( $I_{RRM}$ )
- 5  $t_b$  - Time from Maximum Reverse Recovery Current ( $I_{RRM}$ ) to projected zero crossing based on a straight line from  $I_{RRM}$  through 25%  $I_{RRM}$ .
- 6  $t_{rr}$  - 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,  $I_{RRM}$  passes through zero
- 7  $Q_{rr}$  - Area Under the Curve Defined by  $I_{RRM}$  and  $t_{rr}$

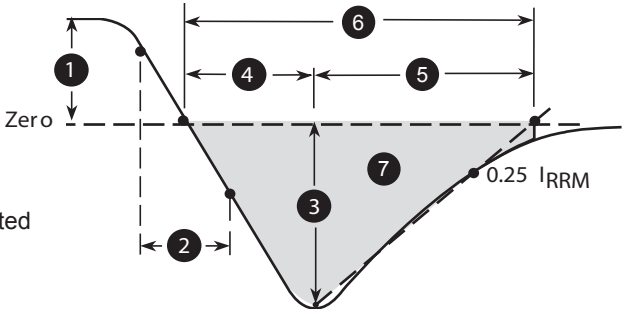
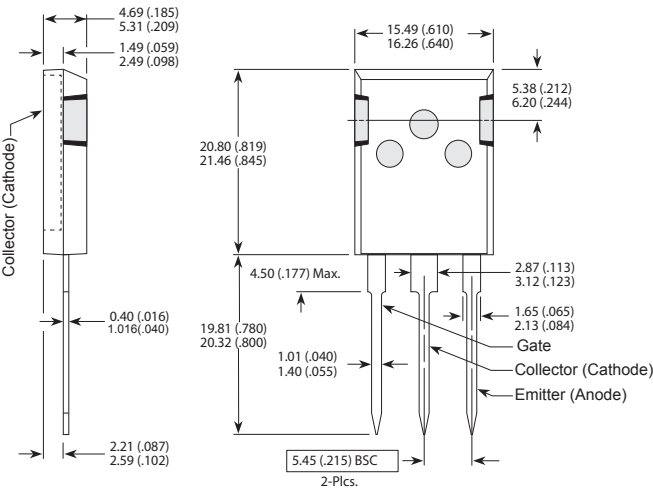


FIGURE 27, Diode Reverse Recovery Waveform Definition

T-MAX® (B2) Package Outline



These dimensions are equal to the TO-247 without the mounting hole.  
Dimensions in Millimeters and (Inches)

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