


## Resonant Mode Combi IGBT®

The POWER MOS 7<sup>®</sup> 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.

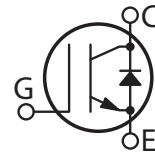
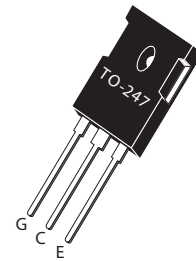
### Features

- 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:  $T_C = 25^\circ C$  unless otherwise specified.

Symbol	Parameter	Ratings	UNIT
$V_{CES}$	Collector-Emitter Voltage	600	Volts
$V_{GE}$	Gate-Emitter Voltage	$\pm 20$	
$V_{GEM}$	Gate-Emitter Voltage Transient	$\pm 30$	
$I_{C1}$	Continuous Collector Current @ $T_C = 25^\circ C$	56	Amps
$I_{C2}$	Continuous Collector Current @ $T_C = 110^\circ C$	27	
$I_{CM}$	Pulsed Collector Current <sup>①</sup> @ $T_C = 25^\circ C$	65	
SSOA	Switching Safe Operating Area @ $T_J = 150^\circ C$	65A @ 600V	
$P_D$	Total Power Dissipation	250	Watts
$T_J, T_{STG}$	Operating and Storage Junction Temperature Range	-55 to 150	$^\circ C$
$T_L$	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 ( $V_{CE} = V_{GE}, I_C = 1mA, T_J = 25^\circ C$ )	3	4.5	6	
$V_{CE(ON)}$	Collector-Emitter On Voltage ( $V_{GE} = 15V, I_C = 15A, T_J = 25^\circ C$ )		2.2	2.7	
	Collector-Emitter On Voltage ( $V_{GE} = 15V, I_C = 15A, T_J = 125^\circ C$ )		2.1		
$I_{CES}$	Collector Cut-off Current ( $V_{CE} = 600V, V_{GE} = 0V, T_J = 25^\circ C$ ) <sup>②</sup>			275	$\mu A$
	Collector Cut-off Current ( $V_{CE} = 600V, V_{GE} = 0V, T_J = 125^\circ C$ ) <sup>②</sup>			2750	
$I_{GES}$	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**

**APT15GP60BDL(G)**

Symbol	Characteristic	Test Conditions	MIN	TYP	MAX	UNIT	
$C_{ies}$	Input Capacitance	<b>Capacitance</b> $V_{GE} = 0V, V_{CE} = 25V$ $f = 1\text{ MHz}$		1685		pF	
$C_{oes}$	Output Capacitance			210			
$C_{res}$	Reverse Transfer Capacitance			15			
$V_{GEP}$	Gate-to-Emitter Plateau Voltage	<b>Gate Charge</b> $V_{GE} = 15V$ $V_{CE} = 300V$ $I_C = 15A$		7.5		V	
$Q_g$	Total Gate Charge <sup>③</sup>			55		nC	
$Q_{ge}$	Gate-Emitter Charge			12			
$Q_{gc}$	Gate-Collector ("Miller") Charge			15			
SSOA	Switching Safe Operating Area	$T_J = 150^\circ C, R_G = 5\Omega, V_{GE} = 15V, L = 100\mu H, V_{CE} = 600V$	65			A	
$t_{d(on)}$	Turn-on Delay Time	<b>Inductive Switching (25°C)</b> $V_{CC} = 400V$ $V_{GE} = 15V$ $I_C = 15A$ $R_G = 5\Omega$ $T_J = +25^\circ C$		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 <sup>④</sup>				130		μJ
$E_{on2}$	Turn-on Switching Energy (With Diode) <sup>⑤</sup>				152		
$E_{off}$	Turn-off Switching Energy <sup>⑥</sup>				121		
$t_{d(on)}$	Turn-on Delay Time		<b>Inductive Switching (125°C)</b> $V_{CC} = 400V$ $V_{GE} = 15V$ $I_C = 15A$ $R_G = 5\Omega$ $T_J = +125^\circ C$		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 <sup>④</sup>				130		μJ
$E_{on2}$	Turn-on Switching Energy (With Diode) <sup>⑤</sup>				267		
$E_{off}$	Turn-off Switching Energy <sup>⑥</sup>				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.)

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

# TYPICAL PERFORMANCE CURVES

APT15GP60BDL(G)

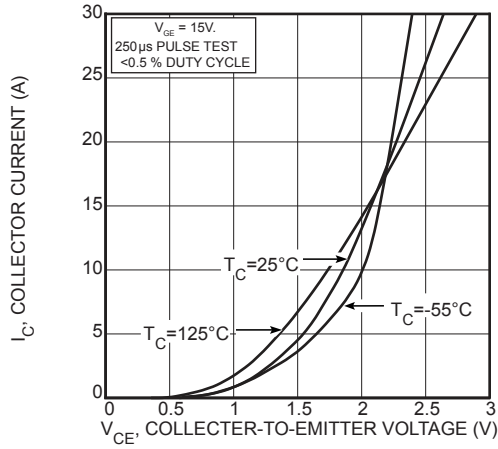


FIGURE 1, Output Characteristics ( $V_{GE} = 15V$ )

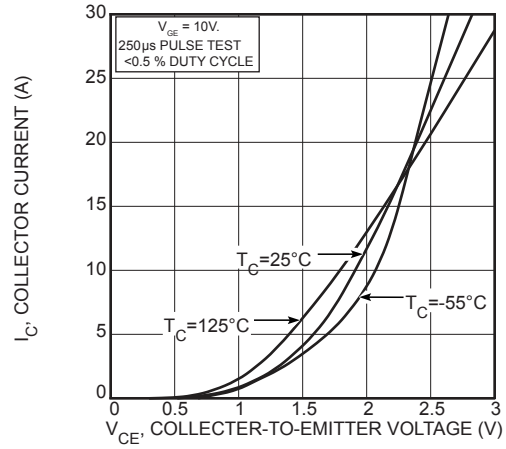


FIGURE 2, Output Characteristics ( $V_{GE} = 10V$ )

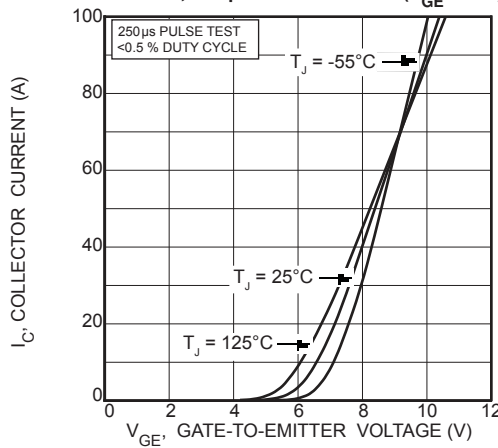


FIGURE 3, Transfer Characteristics

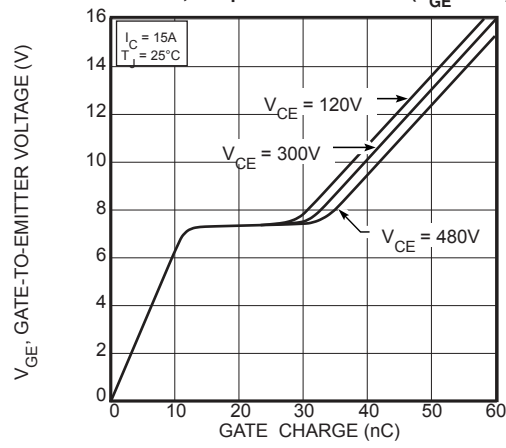


FIGURE 4, Gate Charge

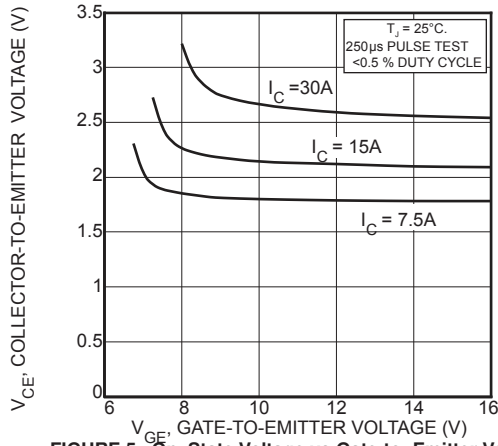


FIGURE 5, On State Voltage vs Gate-to-Emitter Voltage

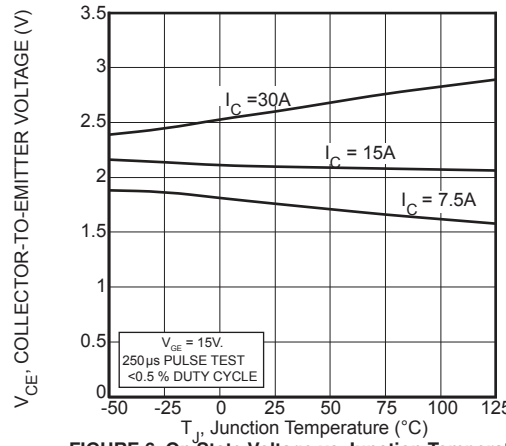


FIGURE 6, On State Voltage vs Junction Temperature

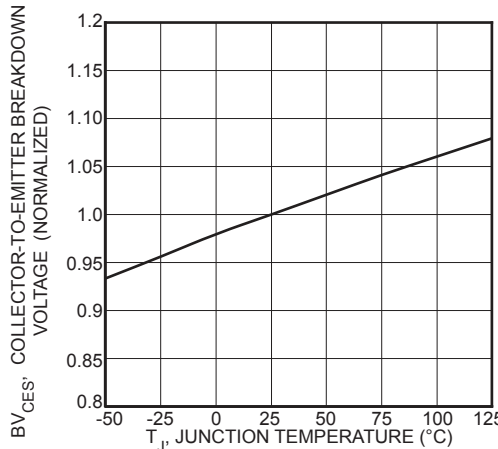


FIGURE 7, Breakdown Voltage vs. Junction Temperature

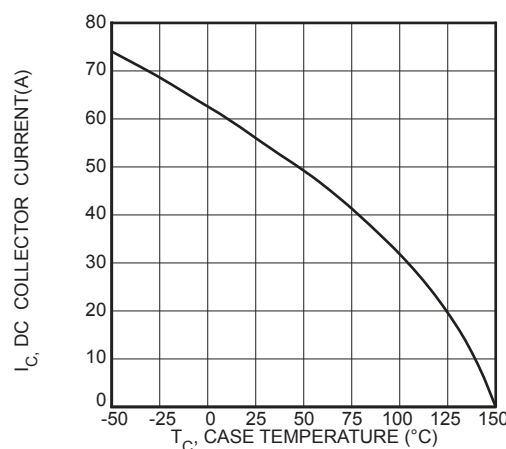


FIGURE 8, DC Collector Current vs Case Temperature

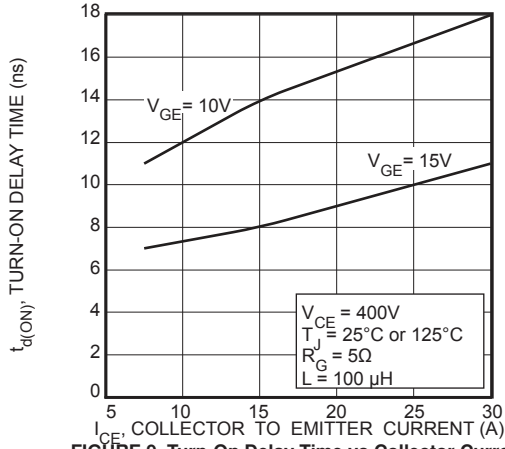


FIGURE 9, Turn-On Delay Time vs Collector Current

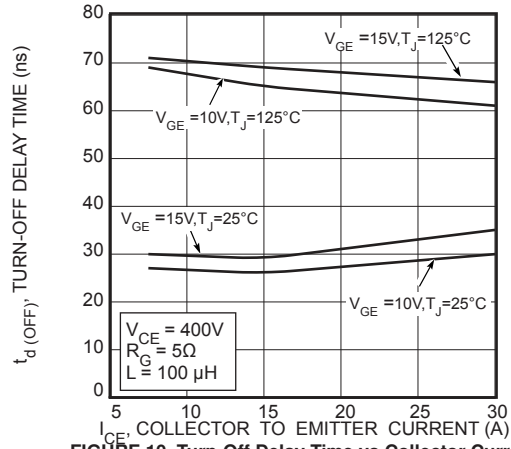


FIGURE 10, Turn-Off Delay Time vs Collector Current

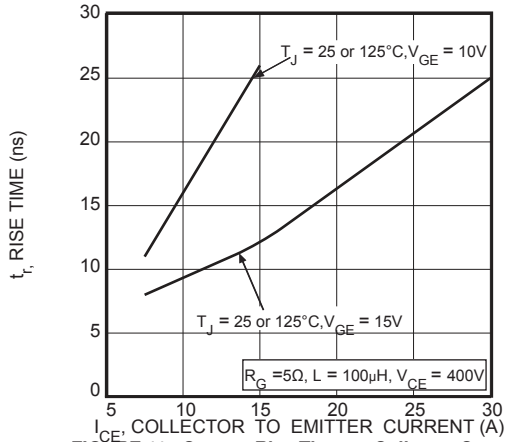


FIGURE 11, Current Rise Time vs Collector Current

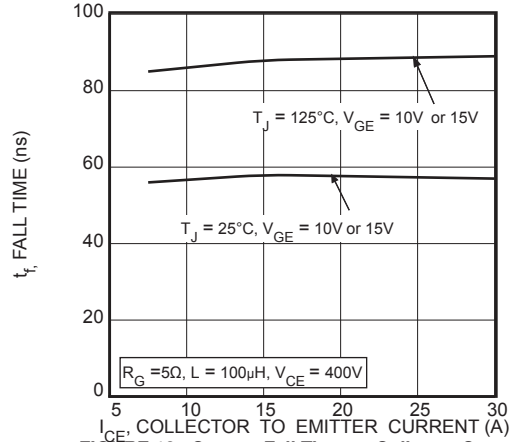


FIGURE 12, Current Fall Time vs Collector Current

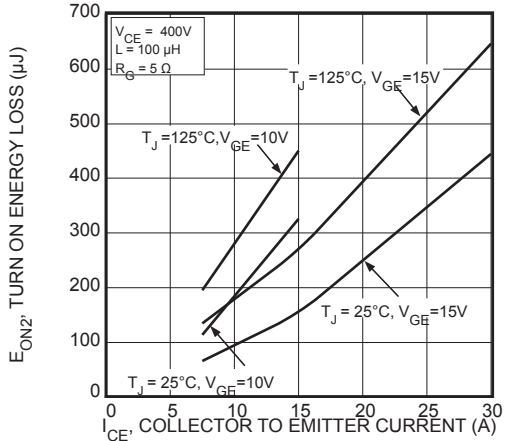


FIGURE 13, Turn-On Energy Loss vs Collector Current

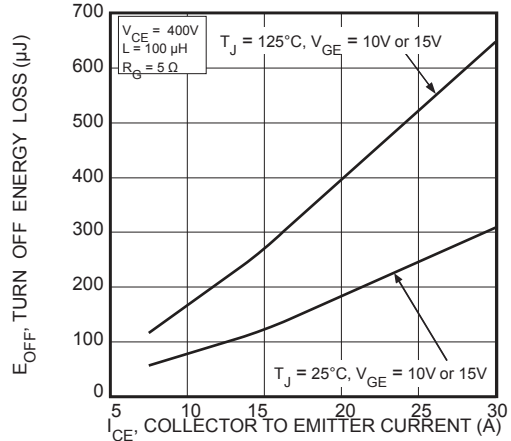


FIGURE 14, Turn Off Energy Loss vs Collector Current

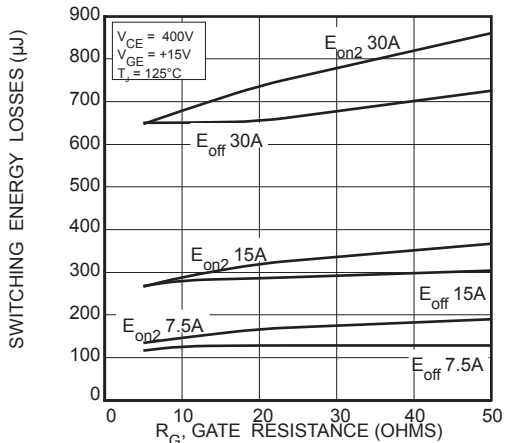


FIGURE 15, Switching Energy Losses vs. Gate Resistance

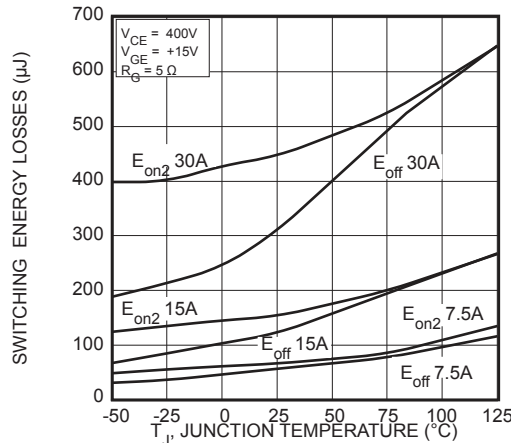


FIGURE 16, Switching Energy Losses vs Junction Temperature

# TYPICAL PERFORMANCE CURVES

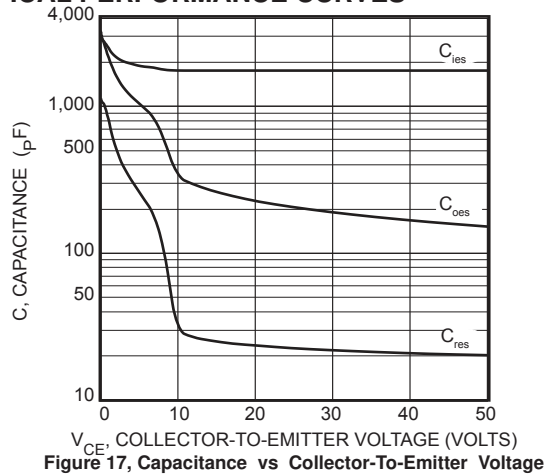


Figure 17, Capacitance vs Collector-To-Emitter Voltage

# APT15GP60BDL(G)

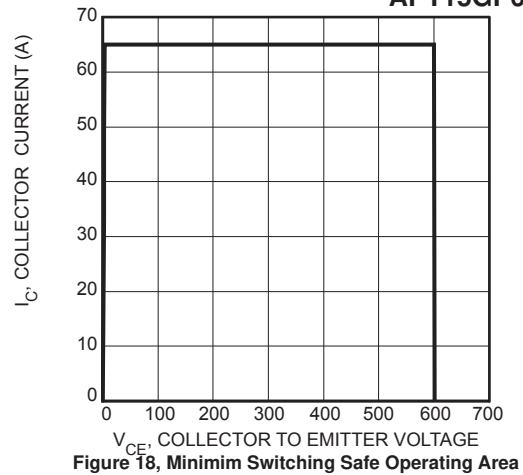


Figure 18, Minimum Switching Safe Operating Area

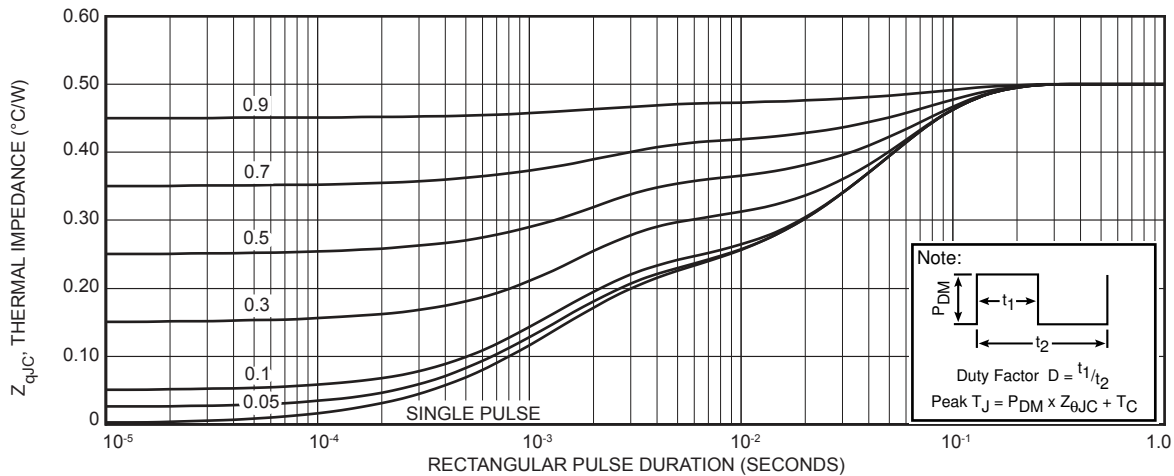


Figure 19A, Maximum Effective Transient Thermal Impedance, Junction-To-Case vs Pulse Duration

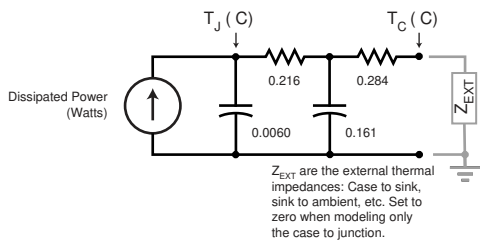


FIGURE 19B, TRANSIENT THERMAL IMPEDANCE MODEL

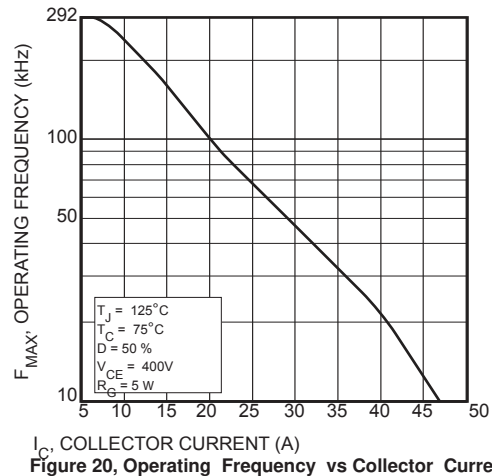


Figure 20, Operating Frequency vs Collector Current

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

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

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

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

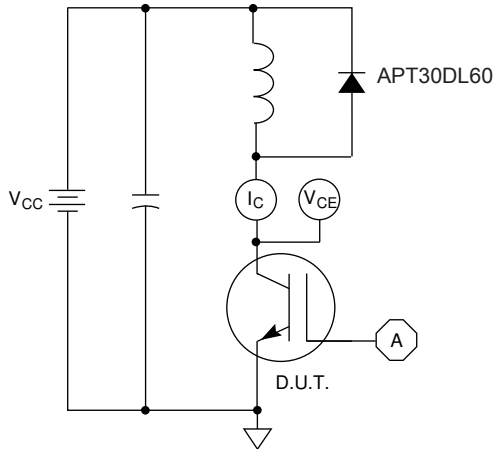


Figure 21, Inductive Switching Test Circuit

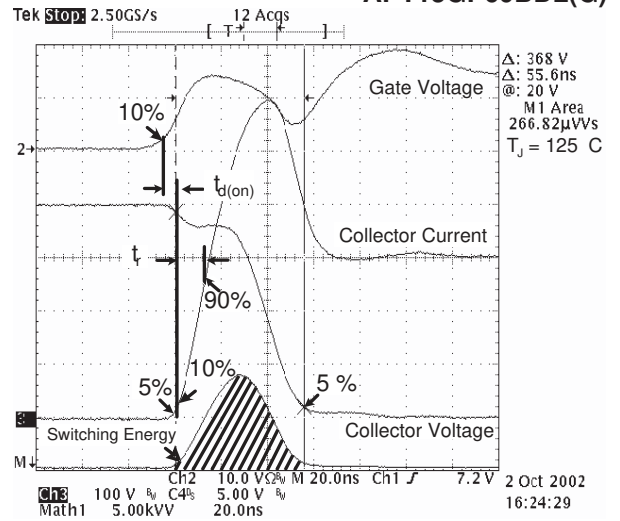


Figure 22, Turn-on Switching Waveforms and Definitions

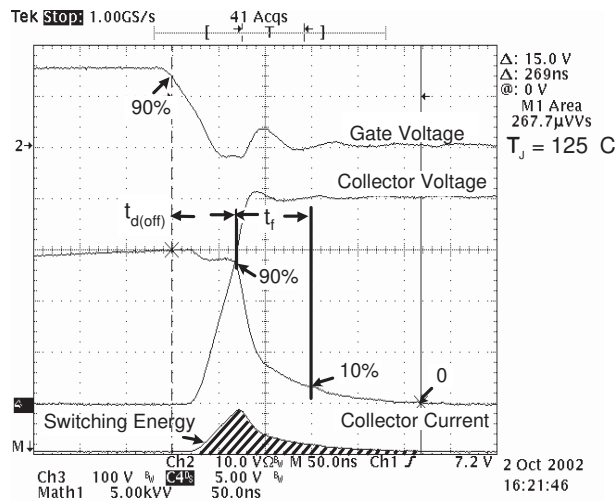


Figure 23, Turn-off Switching Waveforms and Definitions

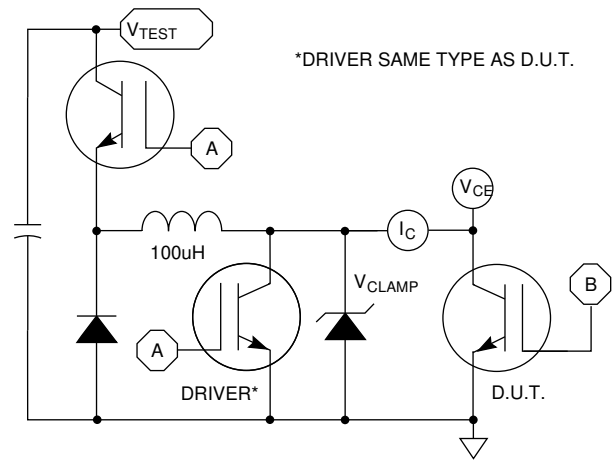


Figure 24, E<sub>ON1</sub> Test Circuit

# ULTRAFAST SOFT RECOVERY ANTI-PARALLEL DIODE

**MAXIMUM RATINGS**

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

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

**STATIC ELECTRICAL CHARACTERISTICS**

Symbol	Characteristic / Test Conditions	MIN	TYP	MAX	UNIT
$V_F$	Forward Voltage		$I_F = 30\text{A}$	1.25	Volts
			$I_F = 60\text{A}$	2.0	
			$I_F = 30\text{A}, T_J = 125^\circ\text{C}$	1.25	

**DYNAMIC CHARACTERISTICS**

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

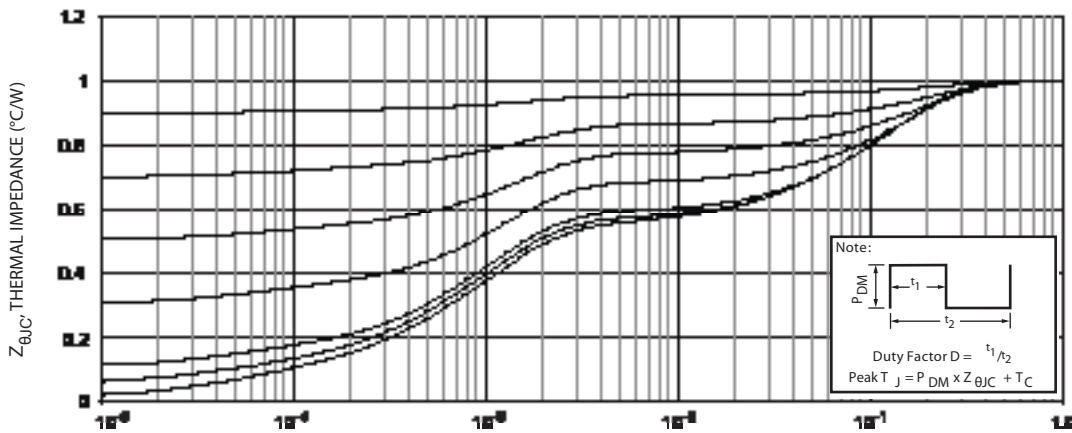


FIGURE 1a. MAXIMUM EFFECTIVE TRANSIENT THERMAL IMPEDANCE, JUNCTION-TO-CASE vs. PULSE DURATION

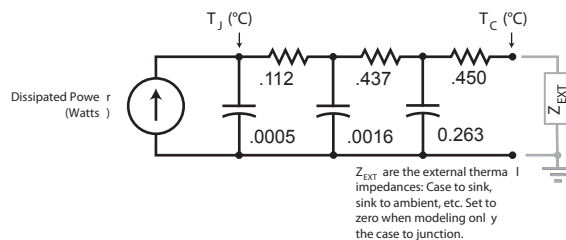


FIGURE 1b, TRANSIENT THERMAL IMPEDANCE MODEL

TYPICAL PERFORMANCE CURVES

APT15GP60BDL(G)

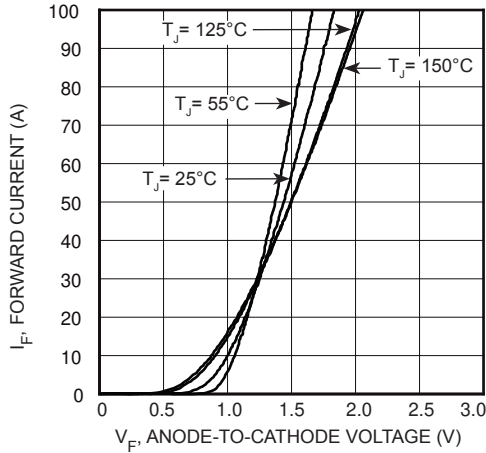


FIGURE 2, Forward Current vs. Forward Voltage

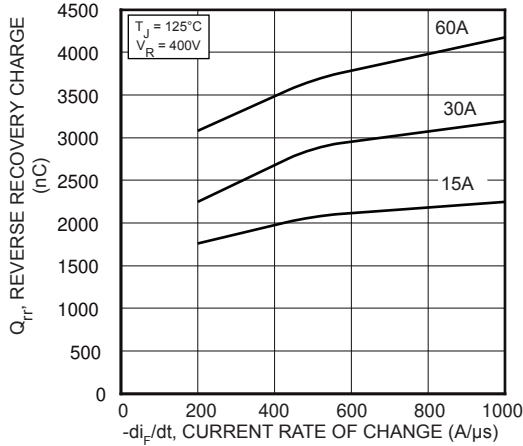


FIGURE 4, Reverse Recovery Charge vs. Current Rate of Change

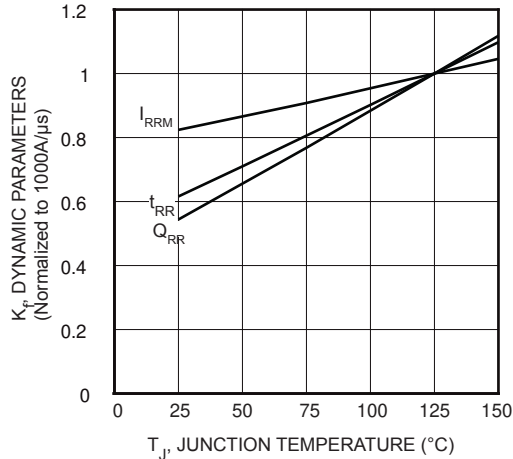


FIGURE 6, Dynamic Parameters vs. Junction Temperature

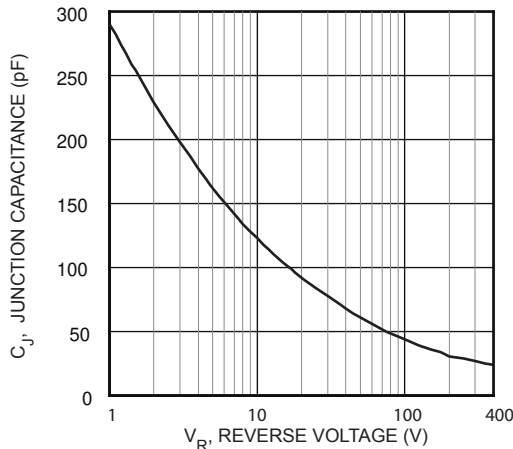


FIGURE 8, Junction Capacitance vs. Reverse Voltage

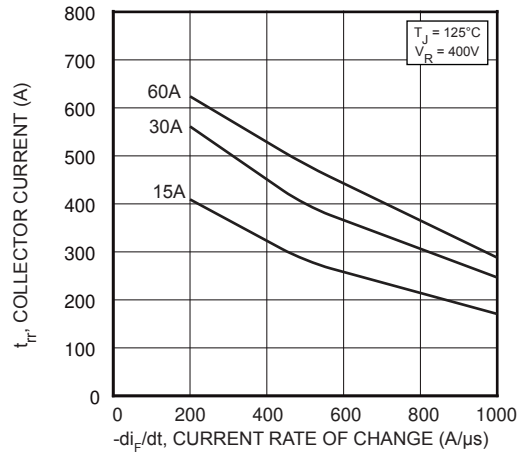


FIGURE 3, Reverse Recovery Time vs. Current Rate of Change

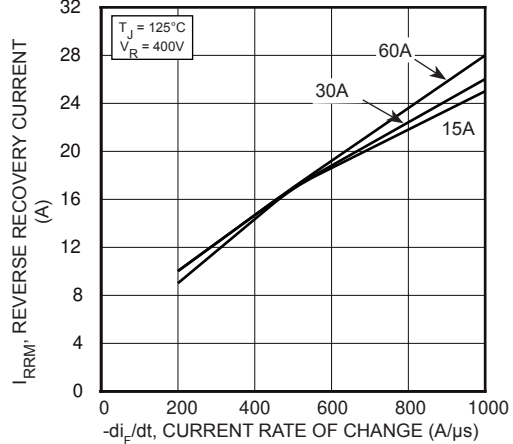


FIGURE 5, Reverse Recovery Current vs. Current Rate of Change

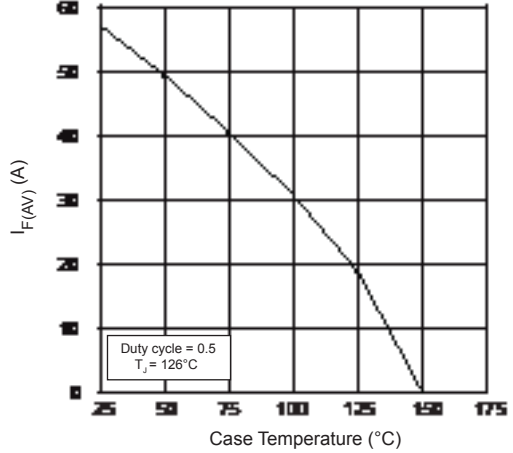


FIGURE 7, Maximum Average Forward Current vs. Case Temperature



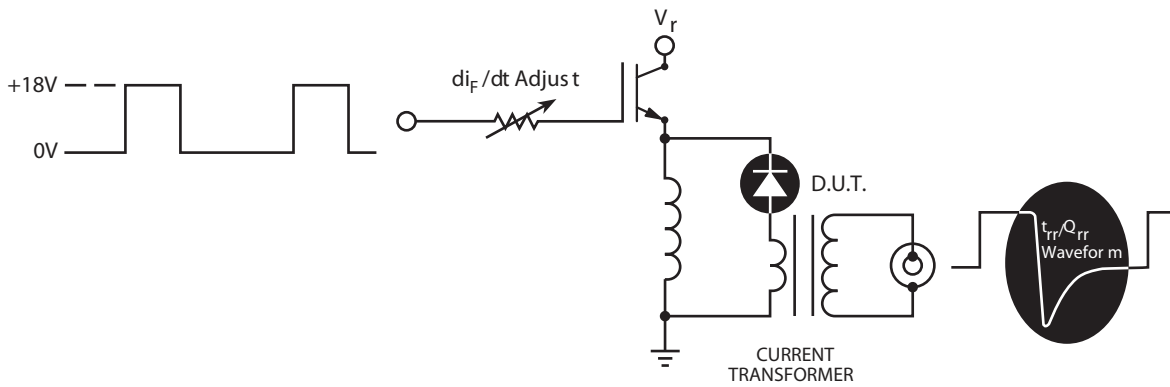


Figure 9. Diode Test Circuit

- 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 the 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.
- 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  $t_{rr}$ .

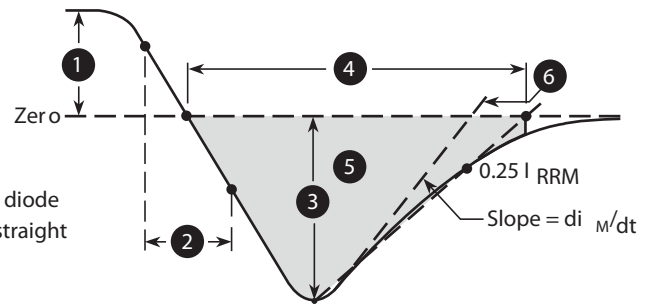
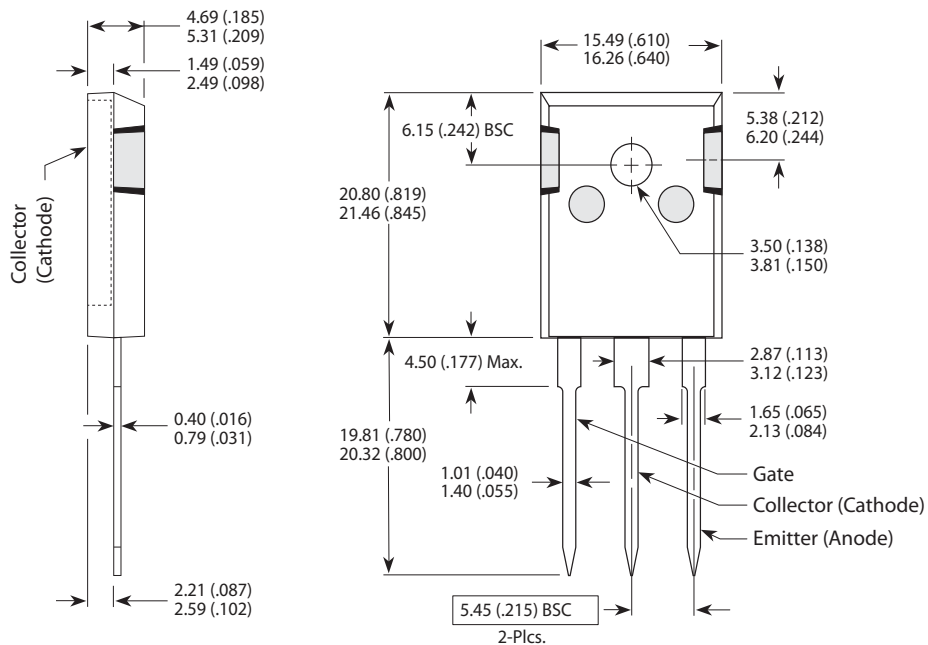


Figure 10, Diode Reverse Recovery Waveform and Definitions

### TO-247 (B) Package Outline



Dimensions in Millimeters and (Inches)