



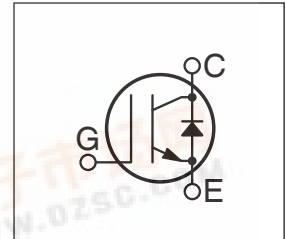
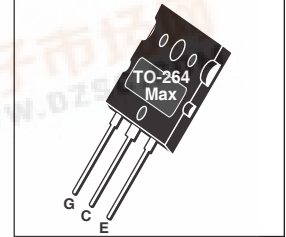
**600V**  
**APT65GP60L2DQ2**  
**APT65GP60L2DQ2G\***

\*G Denotes RoHS Compliant, Pb Free Terminal Finish.

## POWER MOS 7<sup>®</sup> IGBT

The POWER MOS 7<sup>®</sup> IGBT 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.

- **Low Conduction Loss**                      • **100 kHz operation @ 400V, 54A**
- **Low Gate Charge**                         • **50 kHz operation @ 400V, 76A**
- **Ultrafast Tail Current shutoff**         • **SSOA Rated**



### MAXIMUM RATINGS

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

Symbol	Parameter	APT65GP60L2DQ2	UNIT
$V_{CES}$	Collector-Emitter Voltage	600	Volts
$V_{GE}$	Gate-Emitter Voltage	$\pm 30$	
$I_{C1}$	Continuous Collector Current <sup>(7)</sup> @ $T_C = 25^\circ\text{C}$	198	Amps
$I_{C2}$	Continuous Collector Current @ $T_C = 110^\circ\text{C}$	96	
$I_{CM}$	Pulsed Collector Current <sup>(1)</sup> @ $T_C = 150^\circ\text{C}$	250	
SSOA	Switching Safe Operating Area @ $T_J = 150^\circ\text{C}$	250A @ 600V	
$P_D$	Total Power Dissipation	833	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 ( $V_{GE} = 0V, I_C = 1000\mu\text{A}$ )	600			Volts
$V_{GE(TH)}$	Gate Threshold Voltage ( $V_{CE} = V_{GE}, I_C = 2.5\text{mA}, T_J = 25^\circ\text{C}$ )	3	4.5	6	
$V_{CE(ON)}$	Collector-Emitter On Voltage ( $V_{GE} = 15V, I_C = 65A, T_J = 25^\circ\text{C}$ )		2.2	2.7	
	Collector-Emitter On Voltage ( $V_{GE} = 15V, I_C = 65A, T_J = 125^\circ\text{C}$ )		2.1		
$I_{CES}$	Collector Cut-off Current ( $V_{CE} = 600V, V_{GE} = 0V, T_J = 25^\circ\text{C}$ ) <sup>(2)</sup>			1250	$\mu\text{A}$
	Collector Cut-off Current ( $V_{CE} = 600V, V_{GE} = 0V, T_J = 125^\circ\text{C}$ ) <sup>(2)</sup>			5500	
$I_{GES}$	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

APT65GP60L2DQ2

Symbol	Characteristic	Test Conditions	MIN	TYP	MAX	UNIT	
$C_{ies}$	Input Capacitance	<b>Capacitance</b> $V_{GE} = 0V, V_{CE} = 25V$ $f = 1\text{ MHz}$		7400		pF	
$C_{oes}$	Output Capacitance			580			
$C_{res}$	Reverse Transfer Capacitance			35			
$V_{GEP}$	Gate-to-Emitter Plateau Voltage	Gate Charge $V_{GE} = 15V$ $V_{CE} = 300V$ $I_C = 65A$		7.5		V	
$Q_g$	Total Gate Charge <sup>③</sup>			210		nC	
$Q_{ge}$	Gate-Emitter Charge			50			
$Q_{gc}$	Gate-Collector ("Miller") Charge			65			
SSOA	Switching Safe Operating Area	$T_J = 150^\circ\text{C}, R_G = 5\Omega, V_{GE} = 15V, L = 100\mu\text{H}, V_{CE} = 600V$	250			A	
$t_{d(on)}$	Turn-on Delay Time	<b>Inductive Switching (25°C)</b> $V_{CC} = 400V$ $V_{GE} = 15V$ $I_C = 65A$ $R_G = 5\Omega$ $T_J = +25^\circ\text{C}$		30		ns	
$t_r$	Current Rise Time			55			
$t_{d(off)}$	Turn-off Delay Time			90			
$t_f$	Current Fall Time			65			
$E_{on1}$	Turn-on Switching Energy <sup>④</sup>				605		μJ
$E_{on2}$	Turn-on Switching Energy (Diode) <sup>⑤</sup>				1410		
$E_{off}$	Turn-off Switching Energy <sup>⑥</sup>				895		
$t_{d(on)}$	Turn-on Delay Time	<b>Inductive Switching (125°C)</b> $V_{CC} = 400V$ $V_{GE} = 15V$ $I_C = 65A$ $R_G = 5\Omega$ $T_J = +125^\circ\text{C}$		30		ns	
$t_r$	Current Rise Time			55			
$t_{d(off)}$	Turn-off Delay Time			130			
$t_f$	Current Fall Time			90			
$E_{on1}$	Turn-on Switching Energy <sup>④</sup>				605		μJ
$E_{on2}$	Turn-on Switching Energy (Diode) <sup>⑤</sup>				1925		
$E_{off}$	Turn-off Switching Energy <sup>⑥</sup>				1470		

## THERMAL AND MECHANICAL CHARACTERISTICS

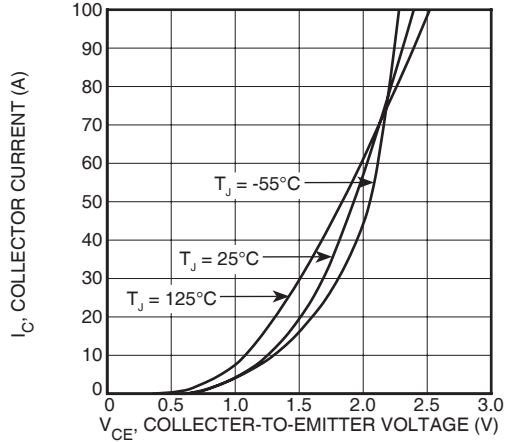
Symbol	Characteristic	MIN	TYP	MAX	UNIT
$R_{\theta JC}$	Junction to Case ( <b>IGBT</b> )			.15	°C/W
$R_{\theta JC}$	Junction to Case ( <b>DIODE</b> )			.67	
$W_T$	Package Weight		5.9		gm

- 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.)
- ⑦ Continuous current limited by package lead temperature.

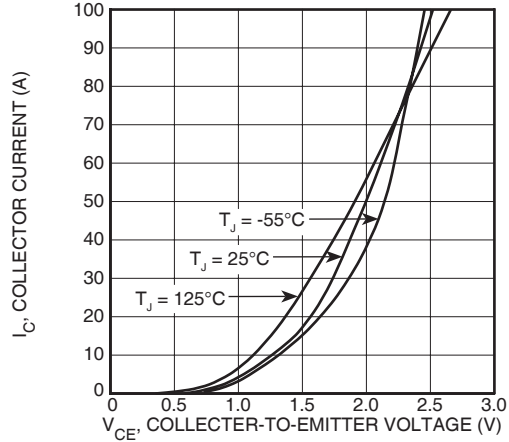
APT Reserves the right to change, without notice, the specifications and information contained herein.

**TYPICAL PERFORMANCE CURVES**

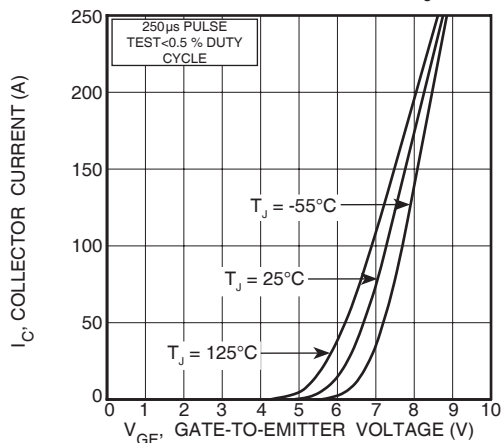
**APT65GP60L2DQ2**



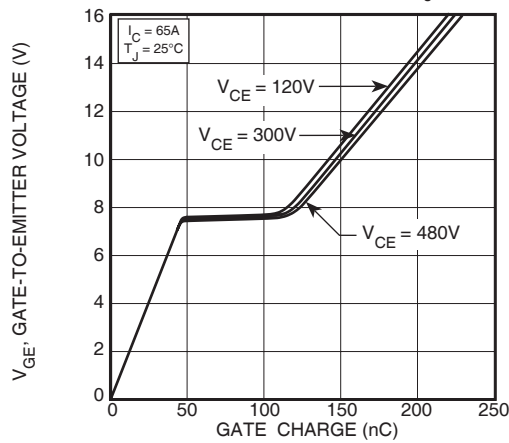
**FIGURE 1, Output Characteristics ( $T_J = 25^\circ\text{C}$ )**



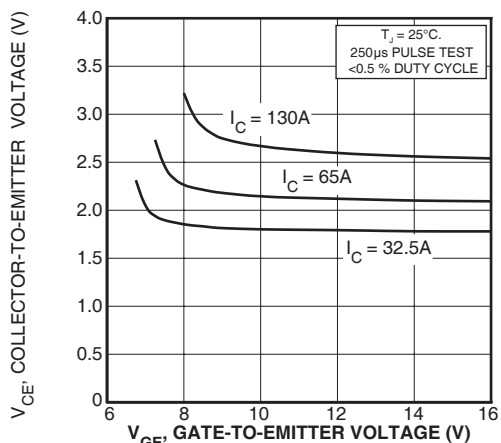
**FIGURE 2, Output Characteristics ( $T_J = 125^\circ\text{C}$ )**



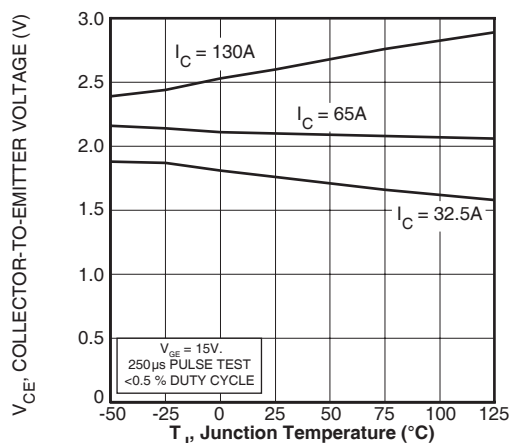
**FIGURE 3, Transfer Characteristics**



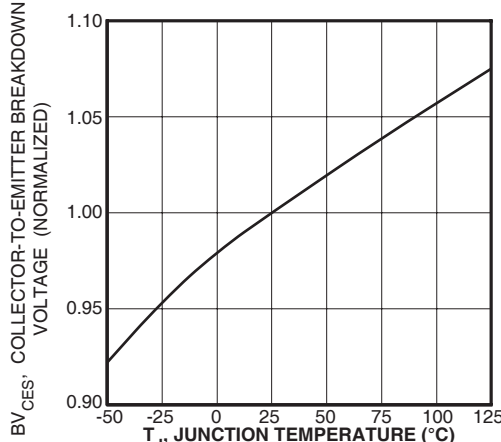
**FIGURE 4, Gate Charge**



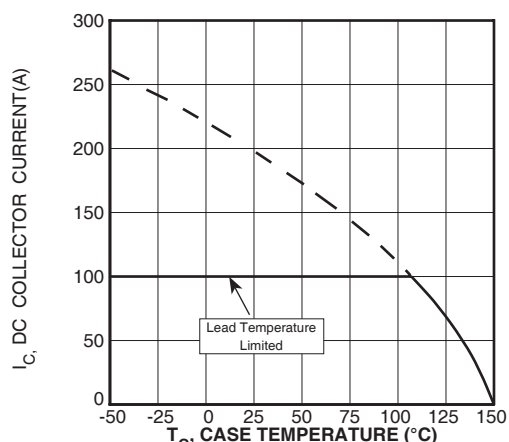
**FIGURE 5, On State Voltage vs Gate-to-Emitter Voltage**



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



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



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

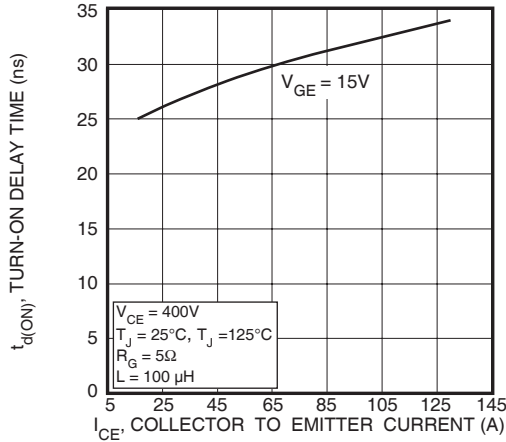


FIGURE 9, Turn-On Delay Time vs Collector Current

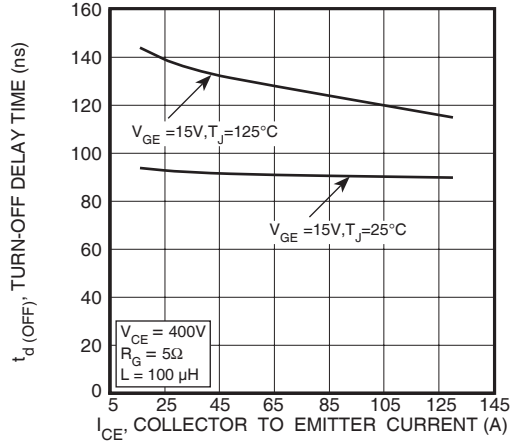


FIGURE 10, Turn-Off Delay Time vs Collector Current

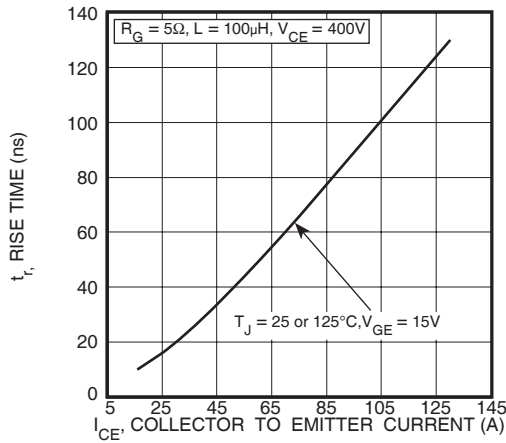


FIGURE 11, Current Rise Time vs Collector Current

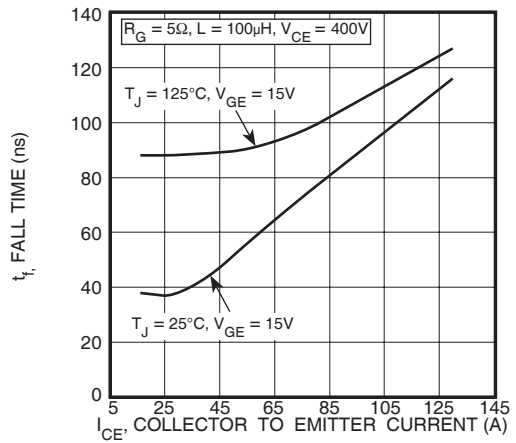


FIGURE 12, Current Fall Time vs Collector Current

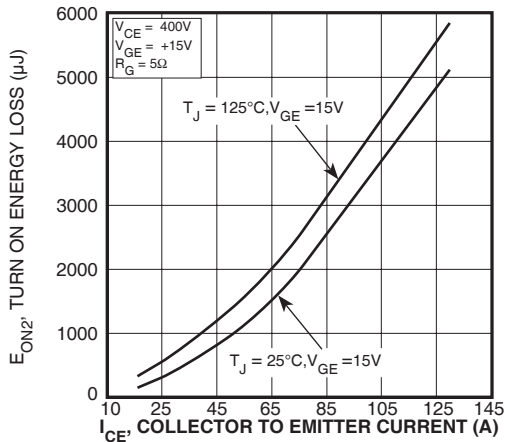


FIGURE 13, Turn-On Energy Loss vs Collector Current

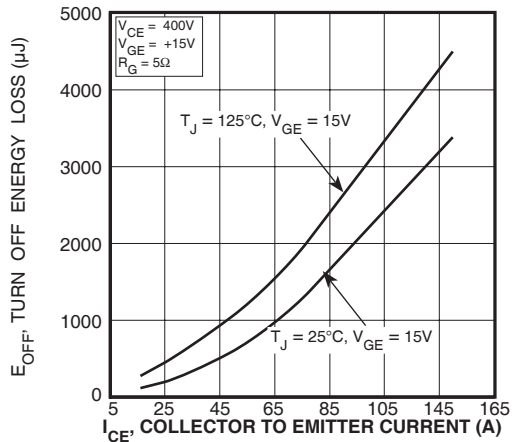


FIGURE 14, Turn Off Energy Loss vs Collector Current

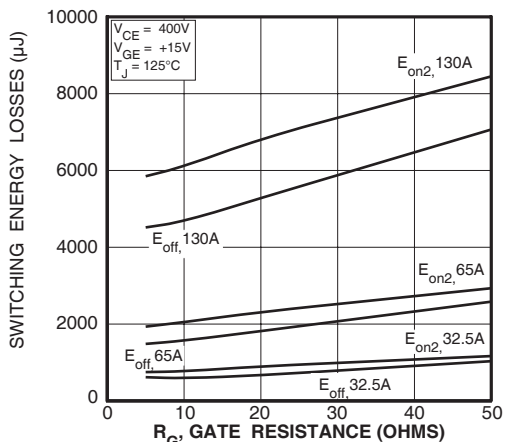


FIGURE 15, Switching Energy Losses vs. Gate Resistance

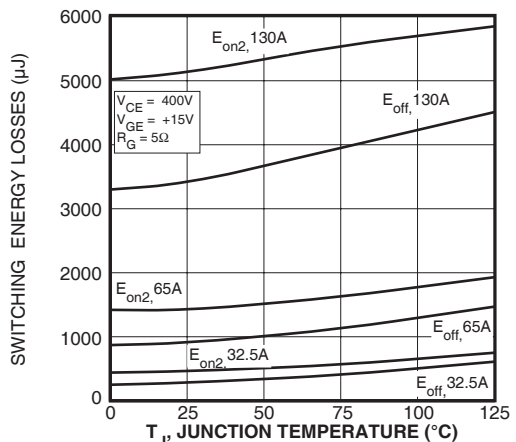


FIGURE 16, Switching Energy Losses vs Junction Temperature

### TYPICAL PERFORMANCE CURVES

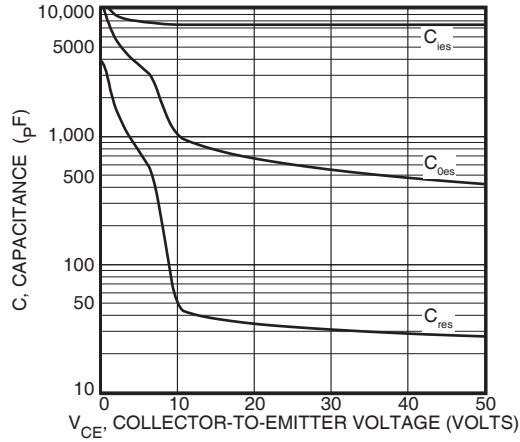


Figure 17, Capacitance vs Collector-To-Emitter Voltage

### APT65GP60L2DQ2

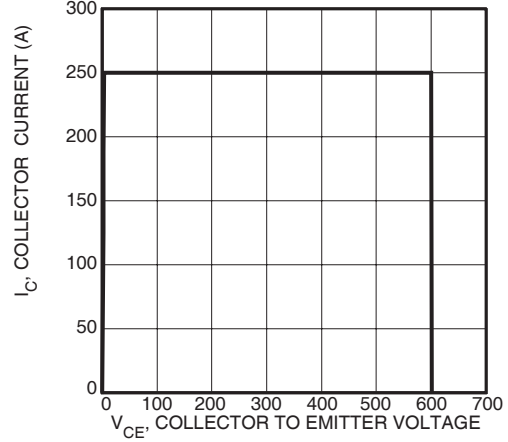


Figure 18, Minimum Switching Safe Operating Area

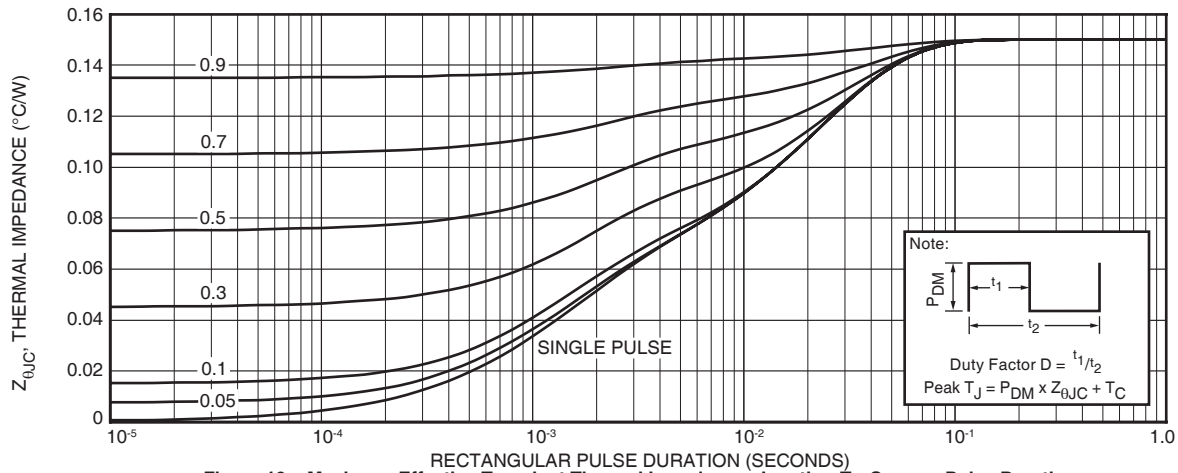


Figure 19a, Maximum Effective Transient Thermal Impedance, Junction-To-Case vs Pulse Duration

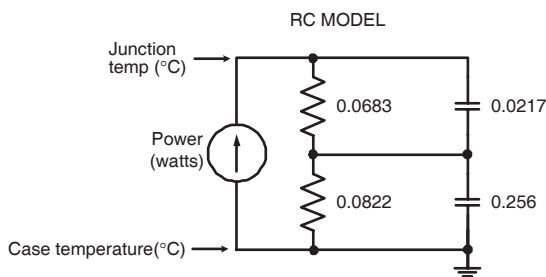


FIGURE 19b, TRANSIENT THERMAL IMPEDANCE MODEL

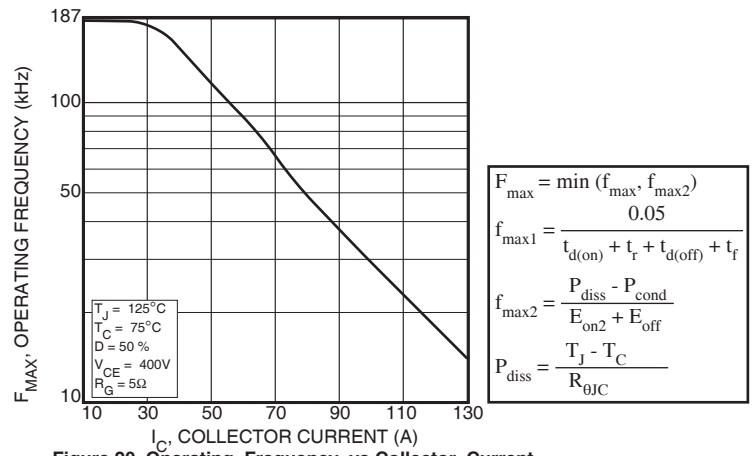


Figure 20, Operating Frequency vs Collector Current

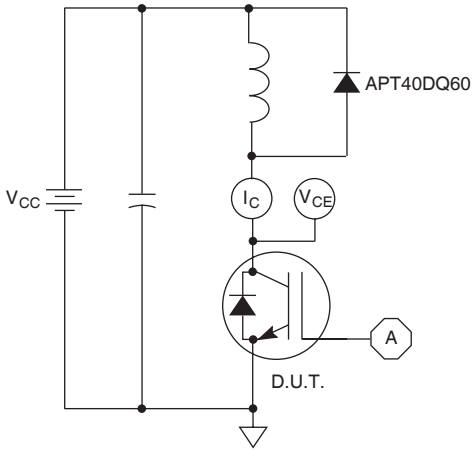
$$F_{max} = \min(f_{max1}, f_{max2})$$

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

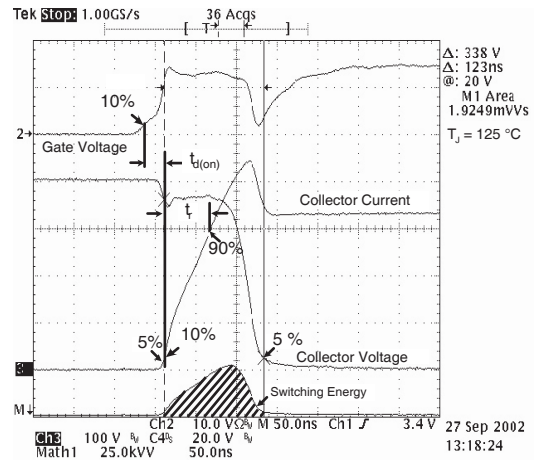
$$f_{max2} = \frac{P_{diss} - P_{cond}}{E_{on2} + E_{off}}$$

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

**APT65GP60L2DQ2**

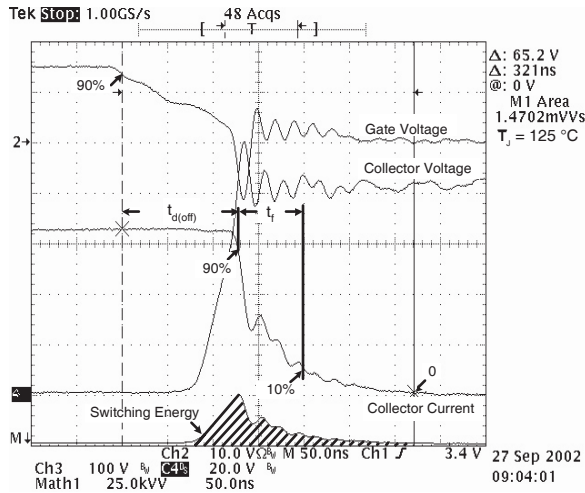


**Figure 21, Inductive Switching Test Circuit**

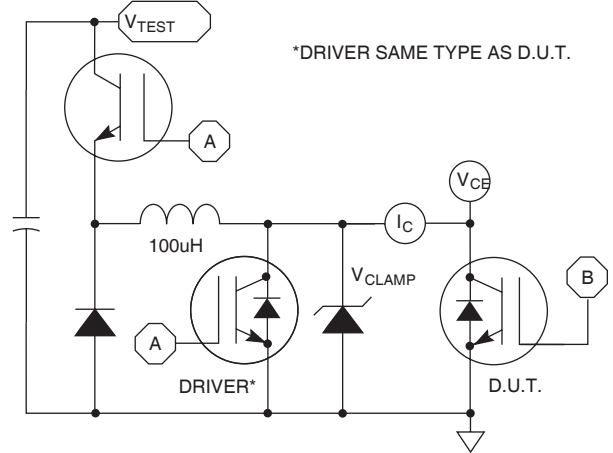


**Figure 22, Turn-on Switching Waveforms and Definitions**

**65GP60B2 @ 125C Eoff**



**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	APT65GP60L2DQ2		UNIT
$I_F(\text{AV})$	Maximum Average Forward Current ( $T_C = 111^\circ\text{C}$ , Duty Cycle = 0.5)	40		Amps
$I_F(\text{RMS})$	RMS Forward Current (Square wave, 50% duty)	63		
$I_{\text{FSM}}$	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	$I_F = 65\text{A}$	2.3		Volts
		$I_F = 130\text{A}$	2.9		
		$I_F = 65\text{A}, T_J = 125^\circ\text{C}$	1.4		

## DYNAMIC CHARACTERISTICS

Symbol	Characteristic	Test Conditions	MIN	TYP	MAX	UNIT
$t_{\text{rr}}$	Reverse Recovery Time	$I_F = 1\text{A}, di_F/dt = -100\text{A}/\mu\text{s}, V_R = 30\text{V}, T_J = 25^\circ\text{C}$	-	22		ns
$t_{\text{rr}}$	Reverse Recovery Time		-	25		
$Q_{\text{rr}}$	Reverse Recovery Charge	$I_F = 40\text{A}, di_F/dt = -200\text{A}/\mu\text{s}, V_R = 400\text{V}, T_C = 25^\circ\text{C}$	-	35		nC
$I_{\text{RRM}}$	Maximum Reverse Recovery Current		-	3	-	Amps
$t_{\text{rr}}$	Reverse Recovery Time	$I_F = 40\text{A}, di_F/dt = -200\text{A}/\mu\text{s}, V_R = 400\text{V}, T_C = 125^\circ\text{C}$	-	160		ns
$Q_{\text{rr}}$	Reverse Recovery Charge		-	480		nC
$I_{\text{RRM}}$	Maximum Reverse Recovery Current		-	6	-	Amps
$t_{\text{rr}}$	Reverse Recovery Time	$I_F = 40\text{A}, di_F/dt = -1000\text{A}/\mu\text{s}, V_R = 400\text{V}, T_C = 125^\circ\text{C}$	-	85		ns
$Q_{\text{rr}}$	Reverse Recovery Charge		-	920		nC
$I_{\text{RRM}}$	Maximum Reverse Recovery Current		-	20		Amps

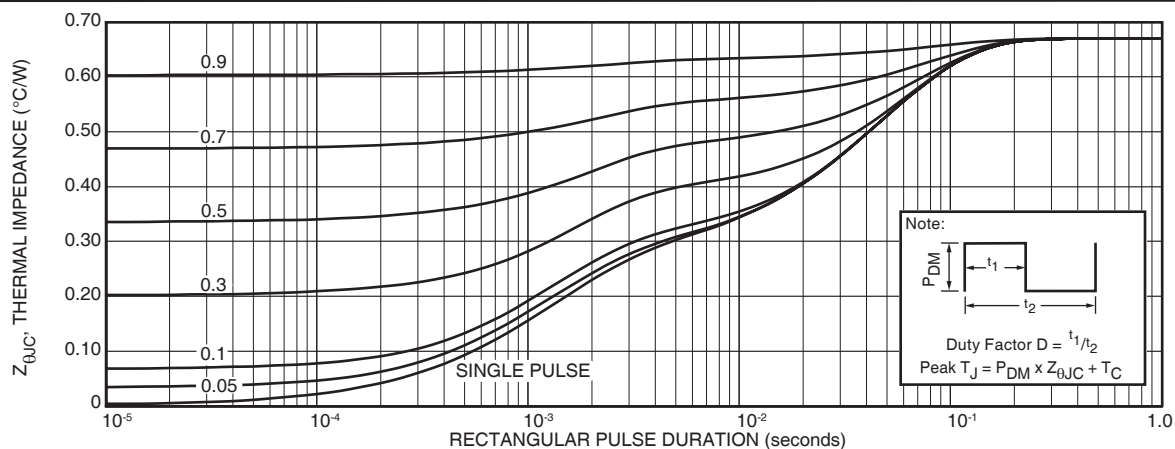
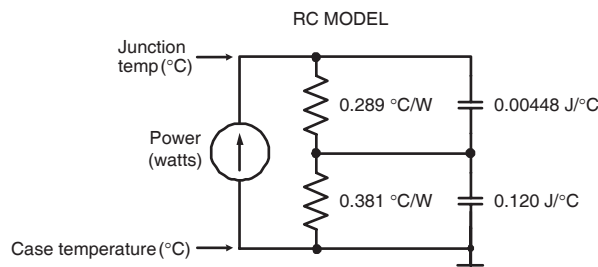


FIGURE 25a. MAXIMUM EFFECTIVE TRANSIENT THERMAL IMPEDANCE, JUNCTION-TO-CASE vs. PULSE DURATION



APT65GP60L2DQ2

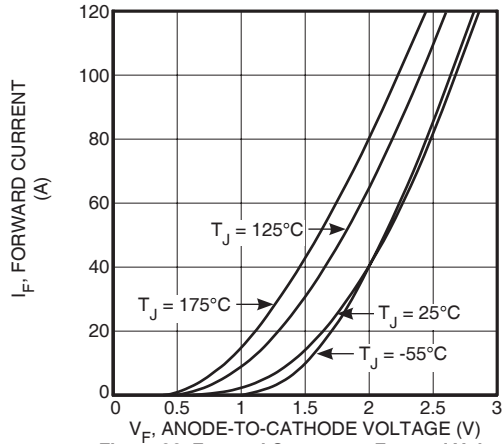


Figure 26. Forward Current vs. Forward Voltage

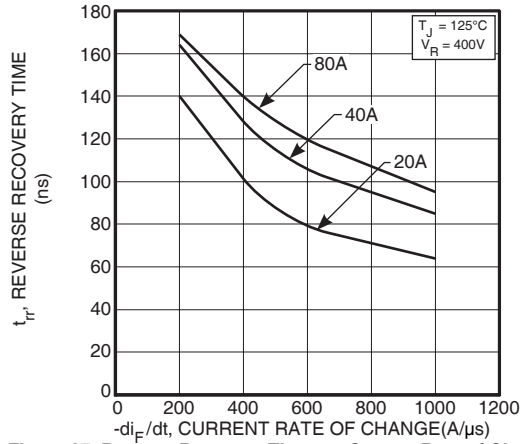


Figure 27. Reverse Recovery Time vs. Current Rate of Change

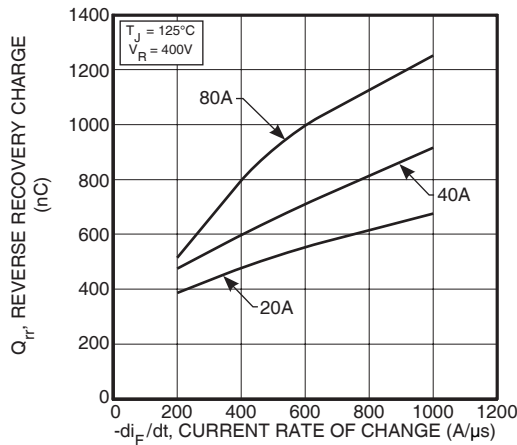


Figure 28. Reverse Recovery Charge vs. Current Rate of Change

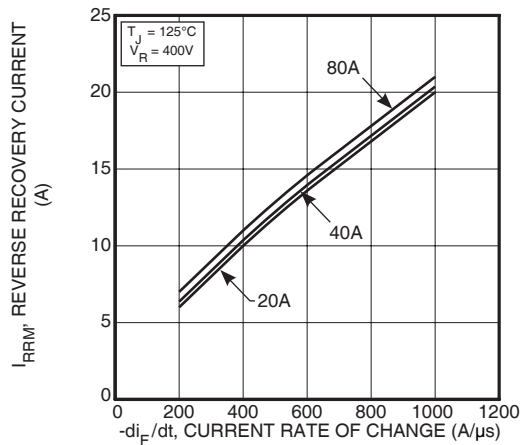


Figure 29. Reverse Recovery Current vs. Current Rate of Change

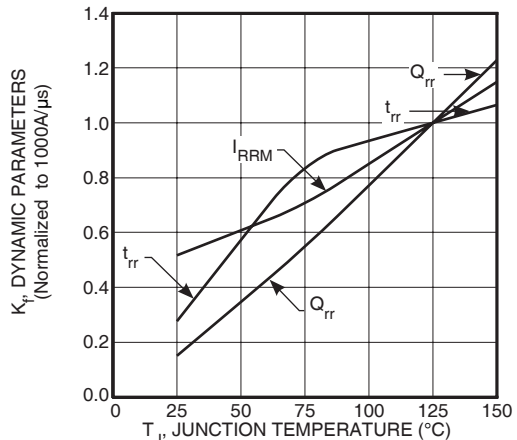


Figure 30. Dynamic Parameters vs. Junction Temperature

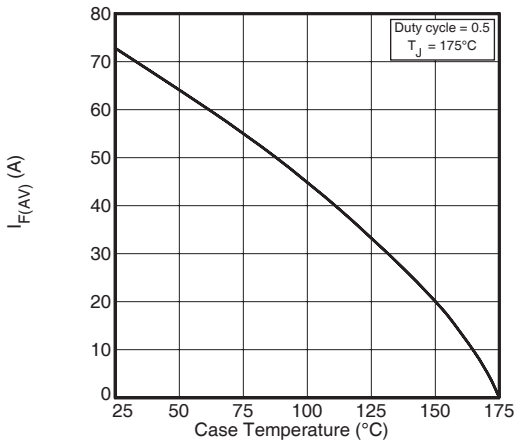


Figure 31. Maximum Average Forward Current vs. Case Temperature

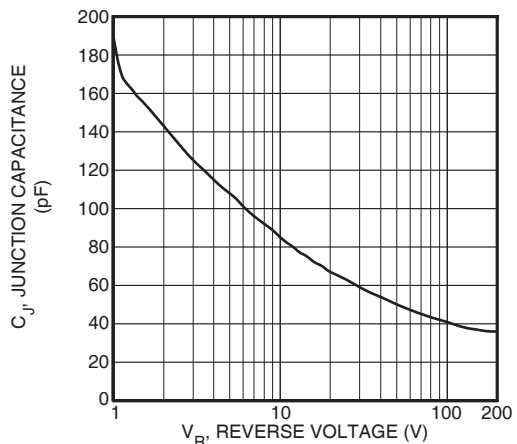


Figure 32. Junction Capacitance vs. Reverse Voltage



TYPICAL PERFORMANCE CURVES

APT65GP60L2DQ2

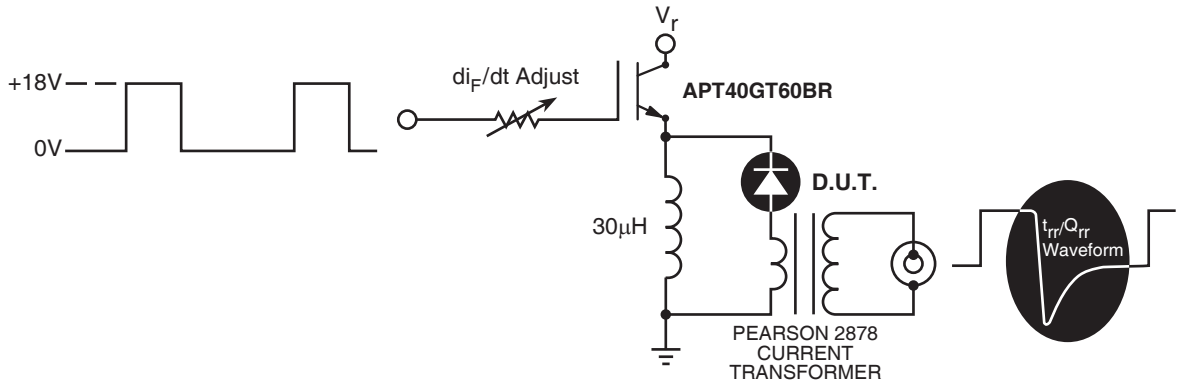


Figure 33. Diode Test Circuit

- 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  $0.25 \cdot I_{RRM}$  passes through zero.
- 5  $Q_{rr}$  - Area Under the Curve Defined by  $I_{RRM}$  and  $t_{rr}$ .

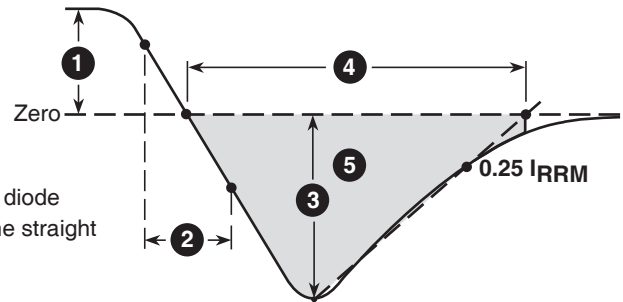


Figure 34, Diode Reverse Recovery Waveform and Definitions

TO-264MAX™ (L2) Package Outline

