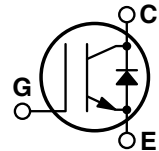


### POWER MOS 7® IGBT

The POWER MOS 7® 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**
- **Low Gate Charge**
- **Ultrafast Tail Current shutoff**
- **100 kHz operation @ 400V, 25A**
- **200 kHz operation @ 400V, 16A**
- **SSOA rated**



#### MAXIMUM RATINGS

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

Symbol	Parameter	APT40GP60JDF2	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 @ $T_C = 25^\circ\text{C}$	86	Amps
$I_{C2}$	Continuous Collector Current @ $T_C = 110^\circ\text{C}$	40	
$I_{CM}$	Pulsed Collector Current <sup>①</sup> @ $T_C = 150^\circ\text{C}$	160	
SSOA	Switching Safe Operating Area @ $T_J = 150^\circ\text{C}$	160A @ 600V	
$P_D$	Total Power Dissipation	284	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	UNIT
$BV_{CES}$	Collector-Emitter Breakdown Voltage ( $V_{GE} = 0V, I_C = 250\mu\text{A}$ )	600			Volts
$V_{GE(TH)}$	Gate Threshold Voltage ( $V_{CE} = V_{GE}, I_C = 1\text{mA}, T_J = 25^\circ\text{C}$ )	3	4.5	6	
$V_{CE(ON)}$	Collector-Emitter On Voltage ( $V_{GE} = 15V, I_C = 40A, T_J = 25^\circ\text{C}$ )		2.2	2.7	
	Collector-Emitter On Voltage ( $V_{GE} = 15V, I_C = 40A, T_J = 125^\circ\text{C}$ )		2.1		
$I_{CES}$	Collector Cut-off Current ( $V_{CE} = 600V, V_{GE} = 0V, T_J = 25^\circ\text{C}$ ) <sup>②</sup>			500	$\mu\text{A}$
	Collector Cut-off Current ( $V_{CE} = 600V, V_{GE} = 0V, T_J = 125^\circ\text{C}$ ) <sup>②</sup>			3000	
$I_{GES}$	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

APT40GP60JDF2

Symbol	Characteristic	Test Conditions	MIN	TYP	MAX	UNIT	
$C_{ies}$	Input Capacitance	<b>Capacitance</b> $V_{GE} = 0V, V_{CE} = 25V$ $f = 1 \text{ MHz}$		4610		pF	
$C_{oes}$	Output Capacitance			395			
$C_{res}$	Reverse Transfer Capacitance			25			
$V_{GEP}$	Gate-to-Emitter Plateau Voltage	<b>Gate Charge</b> $V_{GE} = 15V$ $V_{CE} = 300V$ $I_C = 40A$		7.5		V	
$Q_g$	Total Gate Charge <sup>③</sup>			135		nC	
$Q_{ge}$	Gate-Emitter Charge			30			
$Q_{gc}$	Gate-Collector ("Miller") Charge			40			
SSOA	Switching SOA	$T_J = 150^\circ\text{C}, R_G = 5\Omega, V_{GE} = 15V, L = 100\mu\text{H}, V_{CE} = 600V$	160			A	
$t_{d(on)}$	Turn-on Delay Time	<b>Inductive Switching (25°C)</b> $V_{CC}(\text{Peak}) = 400V$ $V_{GE} = 15V$ $I_C = 40A$ $R_G = 5\Omega$ $T_J = +25^\circ\text{C}$		20		ns	
$t_r$	Current Rise Time			29			
$t_{d(off)}$	Turn-off Delay Time			64			
$t_f$	Current Fall Time			45			
$E_{on1}$	Turn-on Switching Energy <sup>④</sup>				385		μJ
$E_{on2}$	Turn-on Switching Energy (Diode) <sup>⑤</sup>				644		
$E_{off}$	Turn-off Switching Energy <sup>⑥</sup>				352	450	
$t_{d(on)}$	Turn-on Delay Time		<b>Inductive Switching (125°C)</b> $V_{CC}(\text{Peak}) = 400V$ $V_{GE} = 15V$ $I_C = 40A$ $R_G = 5\Omega$ $T_J = +125^\circ\text{C}$		20		ns
$t_r$	Current Rise Time			29			
$t_{d(off)}$	Turn-off Delay Time			89			
$t_f$	Current Fall Time			69			
$E_{on1}$	Turn-on Switching Energy <sup>④</sup>				385		μJ
$E_{on2}$	Turn-on Switching Energy (Diode) <sup>⑤</sup>				972		
$E_{off}$	Turn-off Switching Energy <sup>⑥</sup>				615	950	

## THERMAL AND MECHANICAL CHARACTERISTICS

Symbol	Characteristic	MIN	TYP	MAX	UNIT
$R_{\theta JC}$	Junction to Case (IGBT)			.44	°C/W
$R_{\theta JC}$	Junction to Case (DIODE)			1.21	
$W_T$	Package Weight			29.2	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 Figure24.)
- 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.)
- APT Reserves the right to change, without notice, the specifications and information contained herein.**

# TYPICAL PERFORMANCE CURVES

APT40GP60JDF2

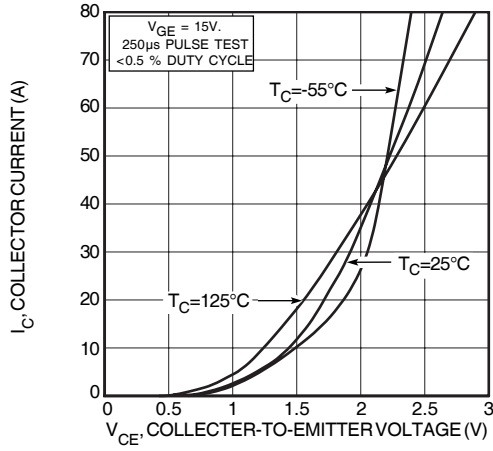


FIGURE 1, Output Characteristics ( $V_{GE} = 15V$ )

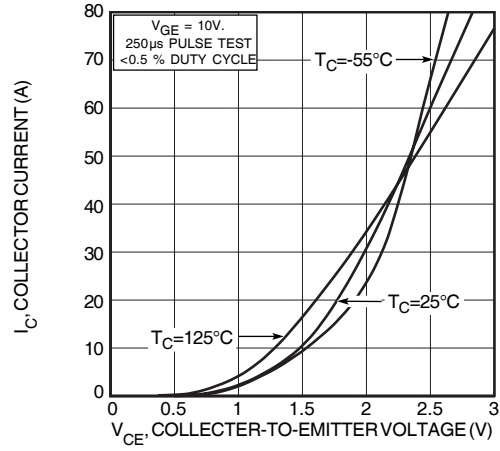


FIGURE 2, Output Characteristics ( $V_{GE} = 10V$ )

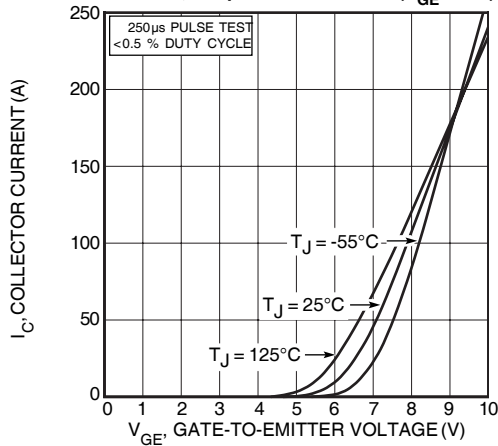


FIGURE 3, Transfer Characteristics

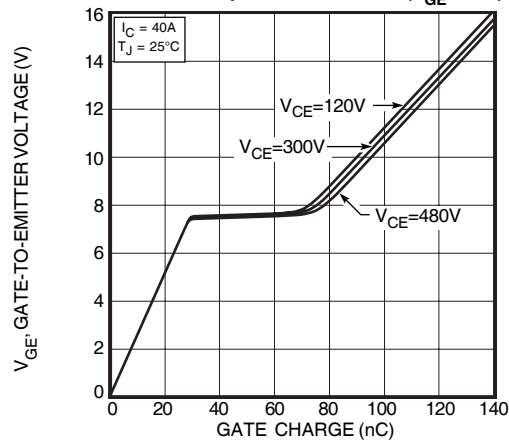


FIGURE 4, Gate Charge

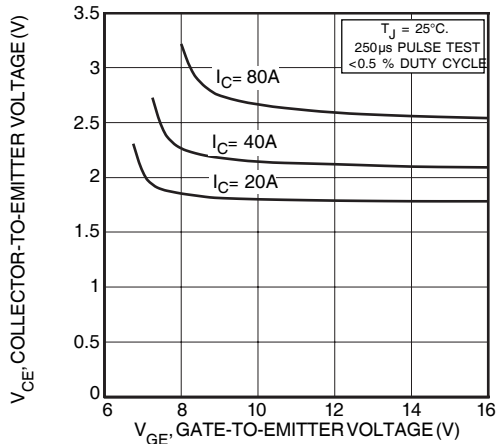


FIGURE 5, On State Voltage vs Gate-to-Emitter Voltage

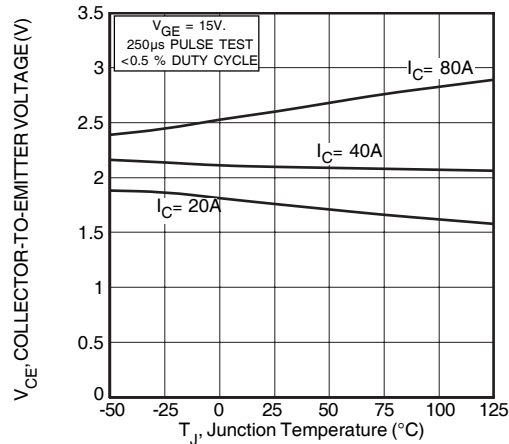


FIGURE 6, On State Voltage vs Junction Temperature

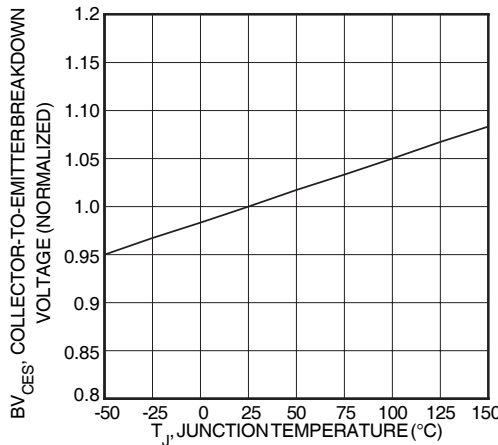


FIGURE 7, Breakdown Voltage vs. Junction Temperature

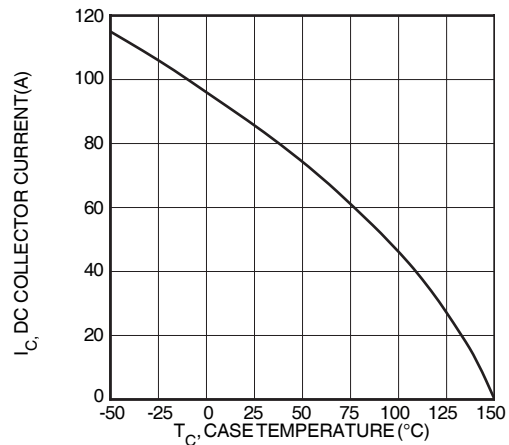


FIGURE 8, DC Collector Current vs Case Temperature

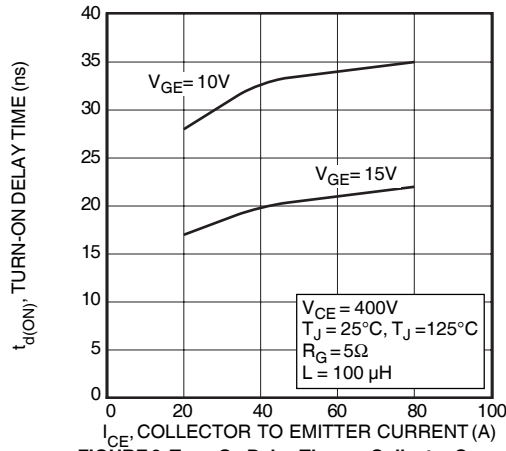


FIGURE 9, Turn-On Delay Time vs Collector Current

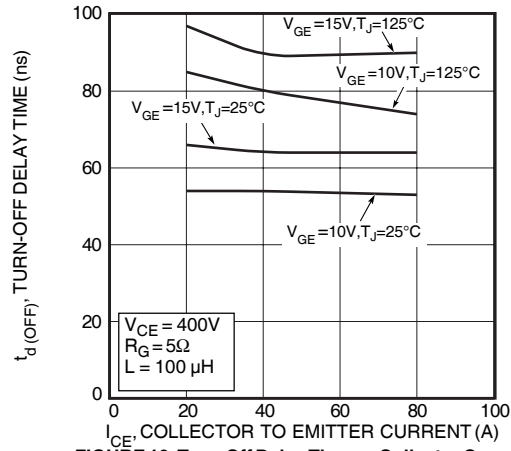


FIGURE 10, Turn-Off Delay Time vs Collector Current

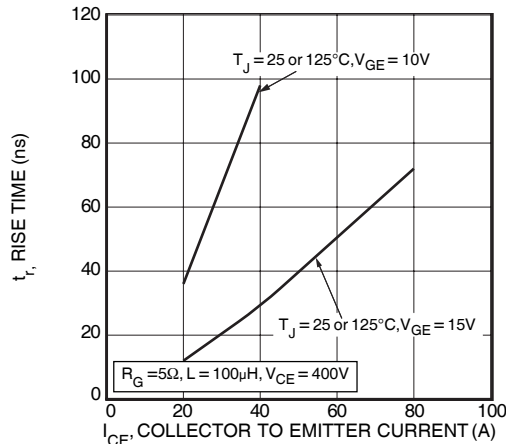


FIGURE 11, Current Rise Time vs Collector Current

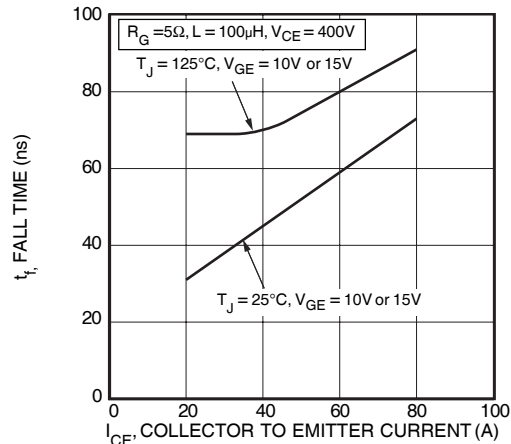


FIGURE 12, Current Fall Time vs Collector Current

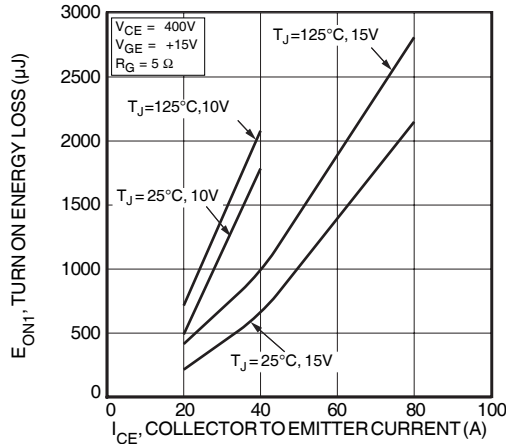


FIGURE 13, Turn-On Energy Loss vs Collector Current

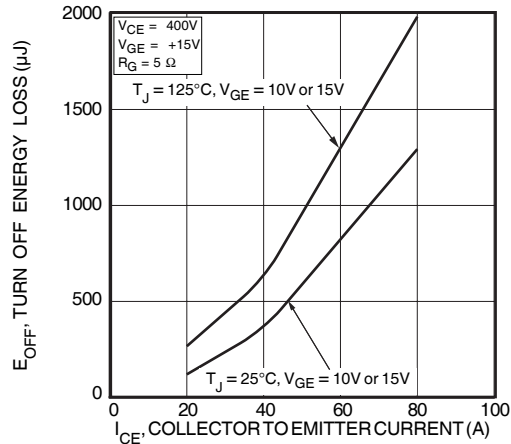


FIGURE 14, Turn Off Energy Loss vs Collector Current

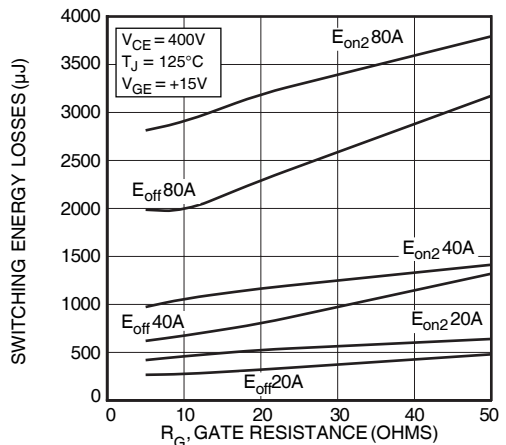


FIGURE 15, Switching Energy Losses vs. Gate Resistance

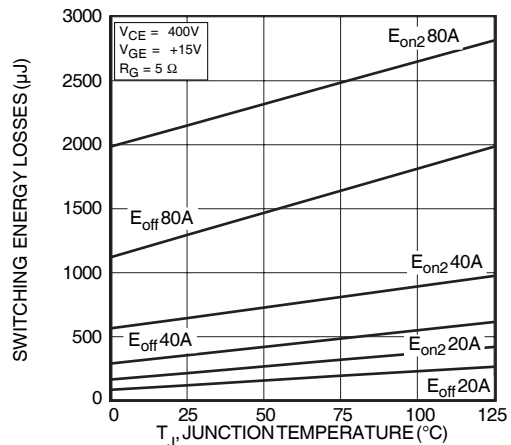
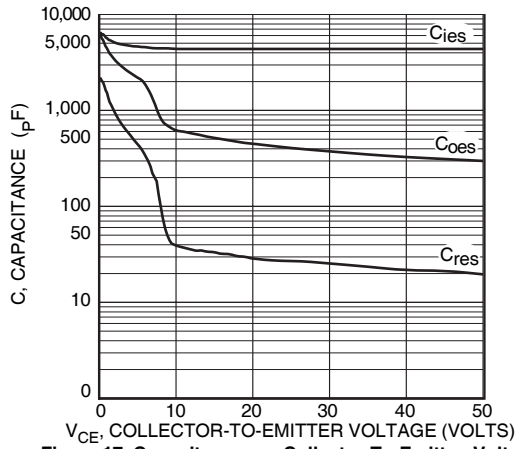


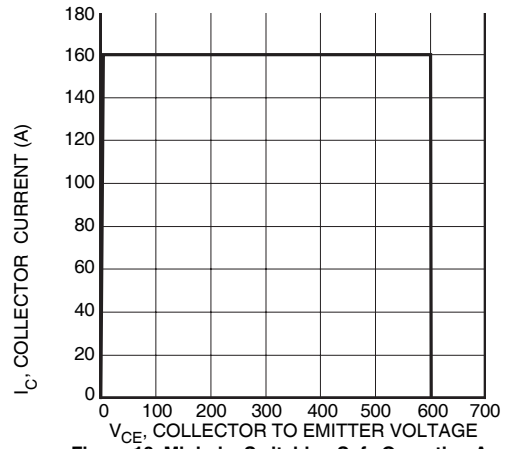
FIGURE 16, Switching Energy Losses vs Junction Temperature

**TYPICAL PERFORMANCE CURVES**

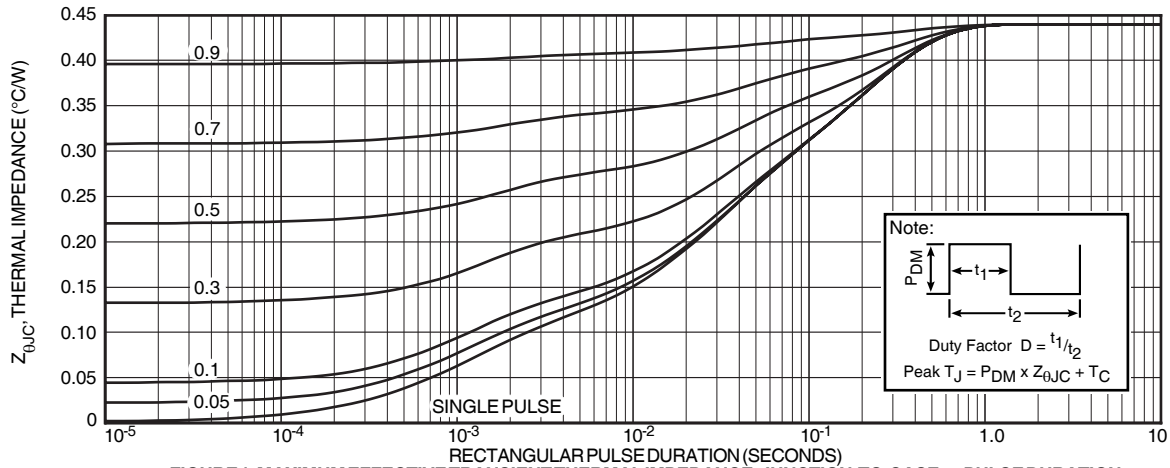
**APT40GP60JDF2**



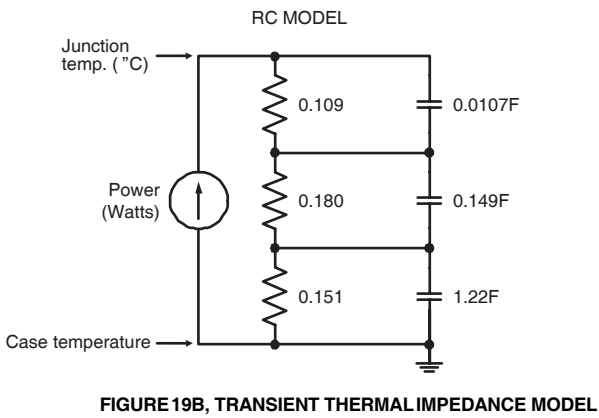
**Figure 17, Capacitance vs Collector-To-Emitter Voltage**



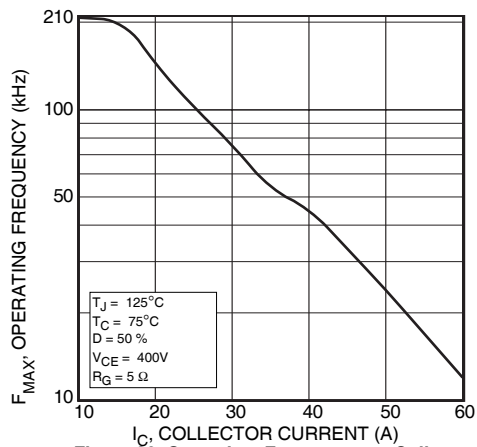
**Figure 18, Minimum Switching Safe Operating Area**



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



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



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

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

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

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

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

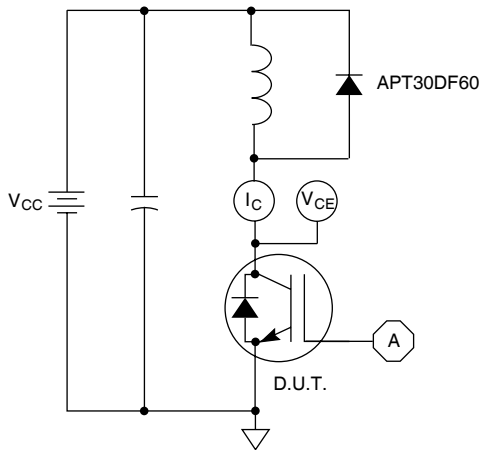


Figure 21, Inductive Switching Test Circuit

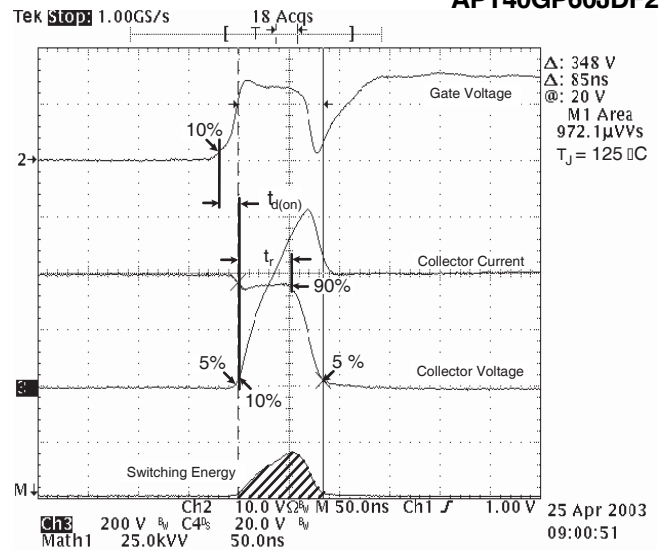


Figure 22, Turn-on Switching Waveforms and Definitions

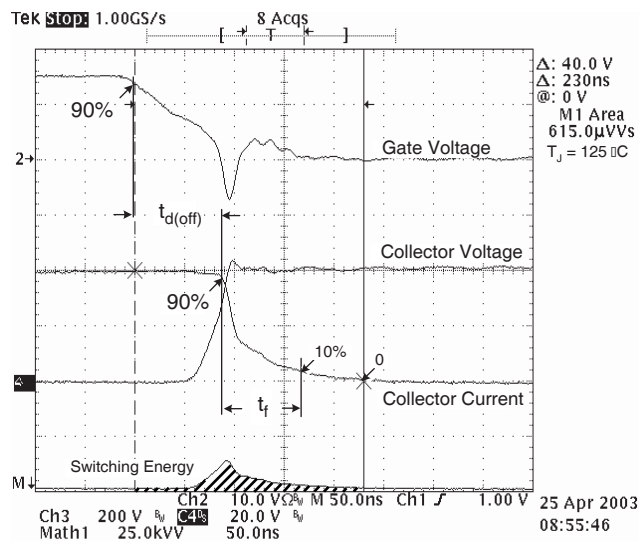


Figure 23, Turn-off Switching Waveforms and Definitions

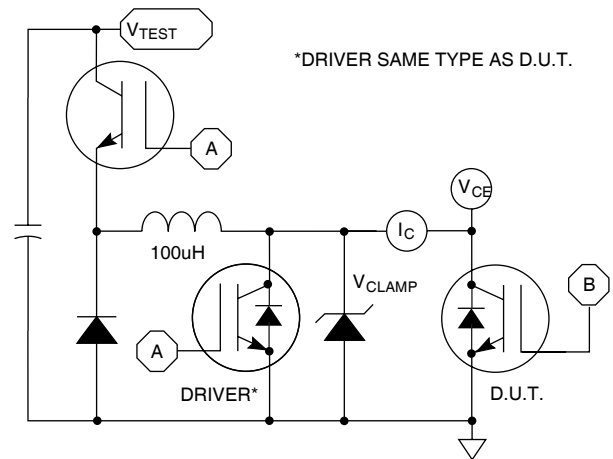


Figure 24, EON1 Test Circuit

# ULTRAFAST SOFT RECOVERY ANTI-PARALLEL DIODE

## MAXIMUM RATINGS

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

Symbol	Characteristic / Test Conditions	APT40GP60JDF2		UNIT
$I_F(AV)$	Maximum Average Forward Current ( $T_C = 99^\circ\text{C}$ , Duty Cycle = 0.5)	30		Amps
$I_F(RMS)$	RMS Forward Current (Square wave, 50% duty)	49		
$I_{FSM}$	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		$I_F = 40\text{A}$	2.4	Volts
			$I_F = 80\text{A}$	3.0	
			$I_F = 40\text{A}, T_J = 125^\circ\text{C}$	1.8	

## DYNAMIC CHARACTERISTICS

Symbol	Characteristic	Test Conditions	MIN	TYP	MAX	UNIT
$t_{rr}$	Reverse Recovery Time	$I_F = 1\text{A}, di_F/dt = -100\text{A}/\mu\text{s}, V_R = 30\text{V}, T_J = 25^\circ\text{C}$	-	21		ns
$t_{rr}$	Reverse Recovery Time	$I_F = 30\text{A}, di_F/dt = -200\text{A}/\mu\text{s}, V_R = 400\text{V}, T_C = 25^\circ\text{C}$	-	62		
$Q_{rr}$	Reverse Recovery Charge		-	65		nC
$I_{RRM}$	Maximum Reverse Recovery Current		-	3	-	Amps
$t_{rr}$	Reverse Recovery Time	$I_F = 30\text{A}, di_F/dt = -200\text{A}/\mu\text{s}, V_R = 400\text{V}, T_C = 125^\circ\text{C}$	-	113		ns
$Q_{rr}$	Reverse Recovery Charge		-	411		nC
$I_{RRM}$	Maximum Reverse Recovery Current		-	7	-	Amps
$t_{rr}$	Reverse Recovery Time	$I_F = 30\text{A}, di_F/dt = -1000\text{A}/\mu\text{s}, V_R = 400\text{V}, T_C = 125^\circ\text{C}$	-	49		ns
$Q_{rr}$	Reverse Recovery Charge		-	704		nC
$I_{RRM}$	Maximum Reverse Recovery Current		-	22		Amps

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

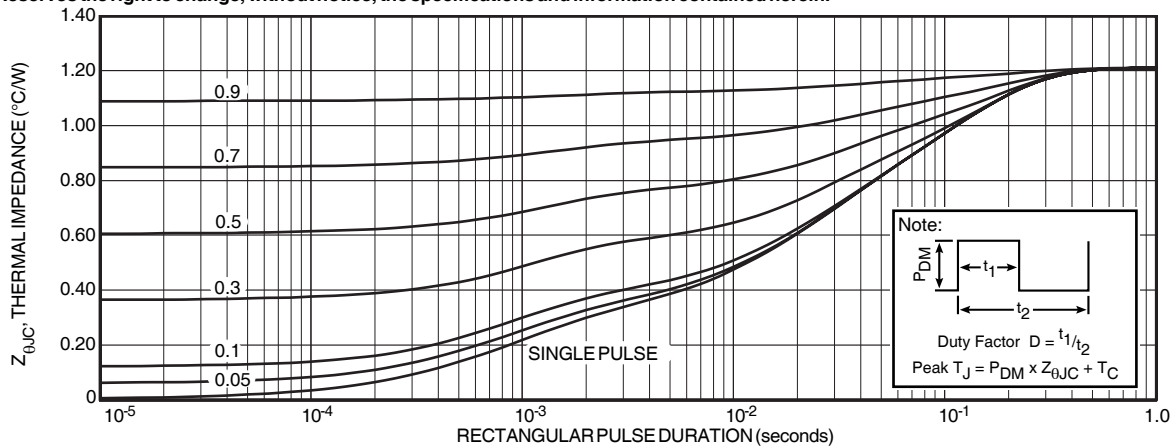


FIGURE 25a. MAXIMUM EFFECTIVE TRANSIENT THERMAL IMPEDANCE, JUNCTION-TO-CASE vs. PULSE DURATION

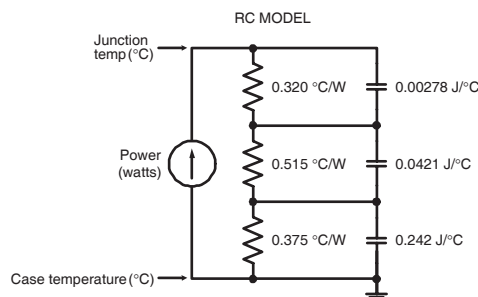


FIGURE 25b. TRANSIENT THERMAL IMPEDANCE MODEL

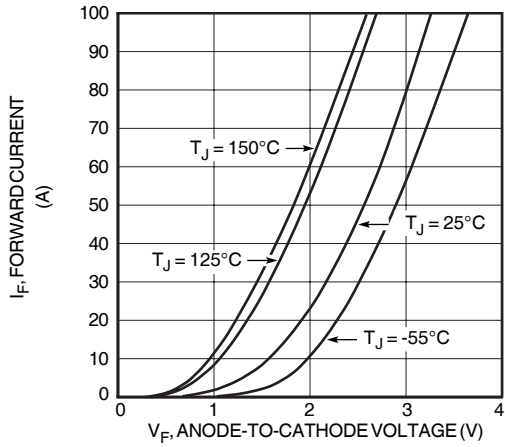


Figure 26. Forward Current vs. Forward Voltage

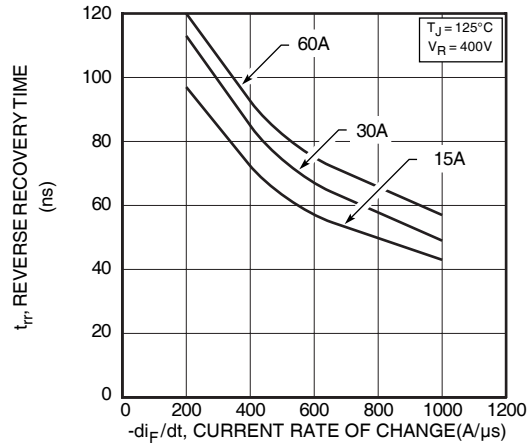


Figure 27. Reverse Recovery Time vs. Current Rate of Change

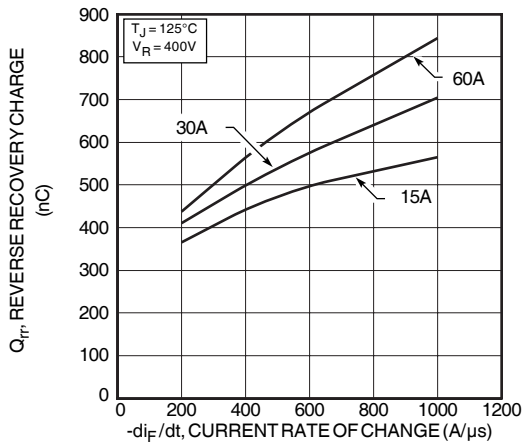


Figure 28. Reverse Recovery Charge vs. Current Rate of Change

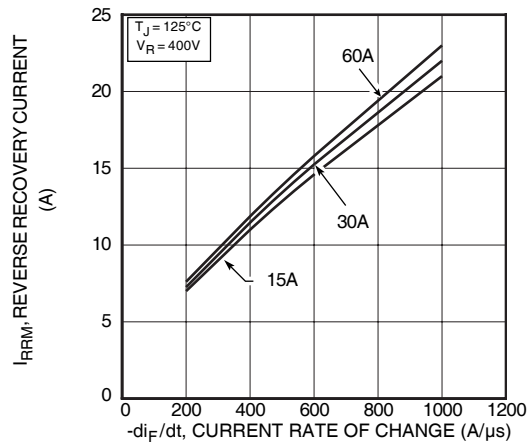


Figure 29. Reverse Recovery Current vs. Current Rate of Change

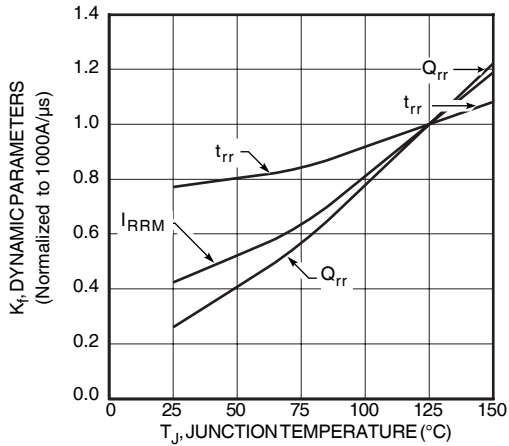


Figure 30. Dynamic Parameters vs. Junction Temperature

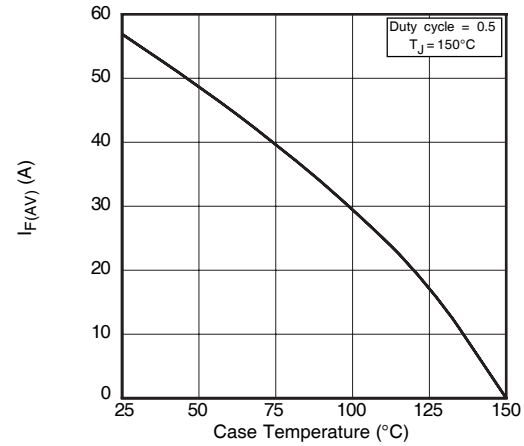


Figure 31. Maximum Average Forward Current vs. Case Temperature

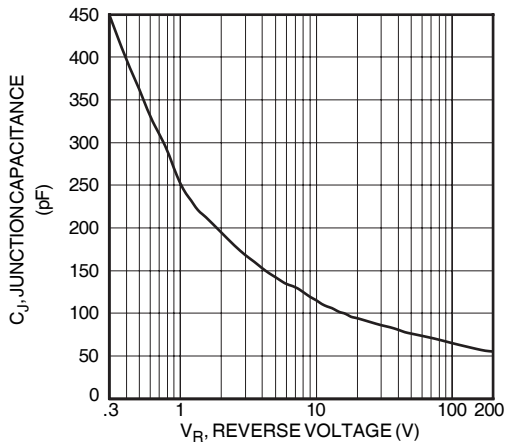


Figure 32. Junction Capacitance vs. Reverse Voltage



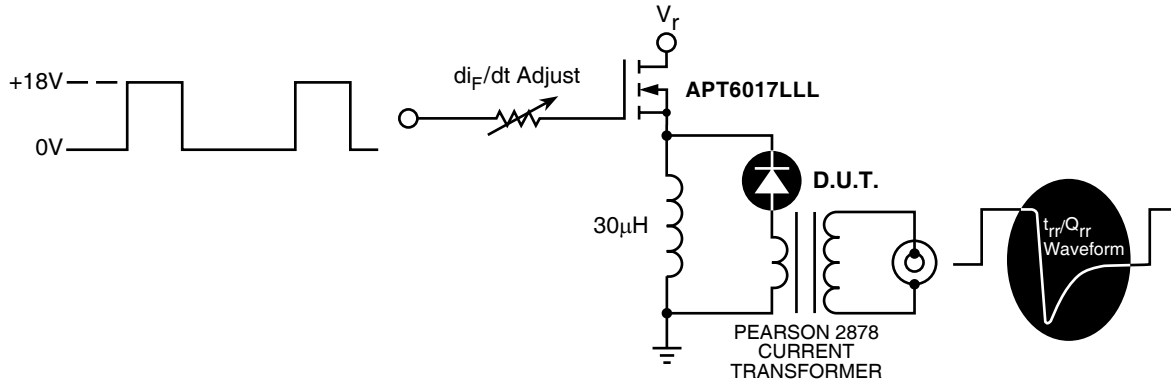


Figure 33. Diode Test Circuit

- 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  $t_{rr}$ .

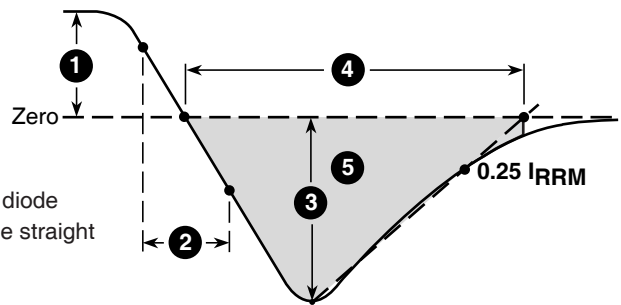
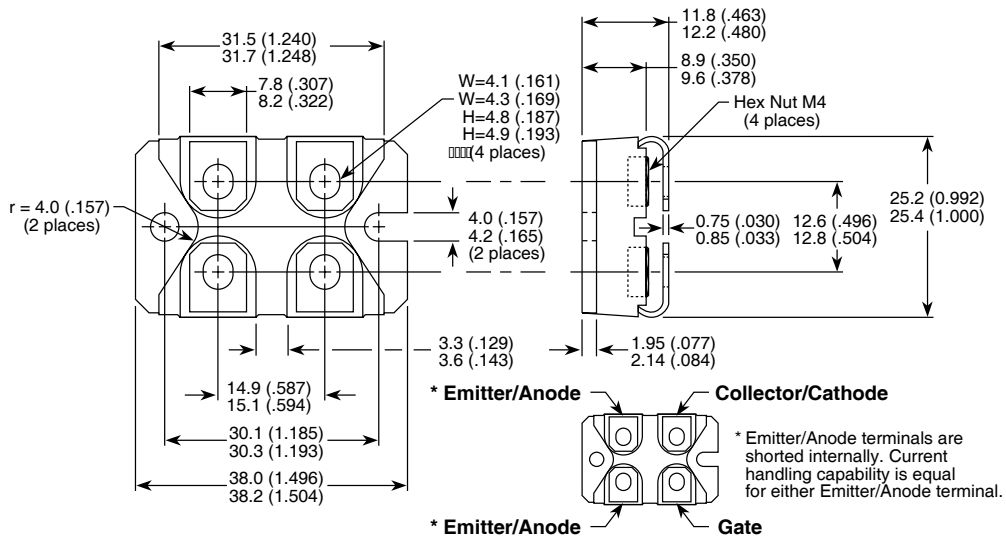


Figure 34. Diode Reverse Recovery Waveform and Definitions

**SOT-227 (ISOTOP®) Package Outline**



Dimensions in Millimeters and (Inches)

ISOTOP® is a Registered Trademark of SGS Thomson. 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.