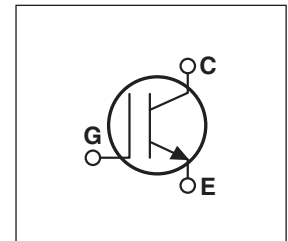
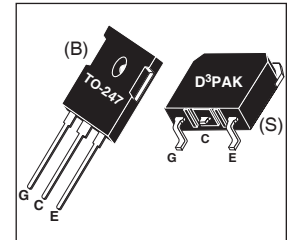


## Thunderbolt IGBT®

The Thunderbolt IGBT® is a new generation of high voltage power IGBTs. Using Non-Punch Through Technology, the Thunderbolt IGBT® offers superior ruggedness and ultrafast switching speed.

- Low Forward Voltage Drop
- High Freq. Switching to 100KHz
- Low Tail Current
- Ultra Low Leakage Current
- RBSOA and SCSOA Rated



### MAXIMUM RATINGS

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

Symbol	Parameter	APT50GT60BR_SR(G)	UNIT
$V_{CES}$	Collector-Emitter Voltage	600	Volts
$V_{GE}$	Gate-Emitter Voltage	$\pm 30$	
$I_{C1}$	Continuous Collector Current <sup>⑦</sup> @ $T_C = 25^\circ\text{C}$	110	Amps
$I_{C2}$	Continuous Collector Current @ $T_C = 110^\circ\text{C}$	52	
$I_{CM}$	Pulsed Collector Current <sup>①</sup>	150	
SSOA	Switching Safe Operating Area @ $T_J = 150^\circ\text{C}$	150A @ 600V	
$P_D$	Total Power Dissipation	446	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	Units
$V_{(BR)CES}$	Collector-Emitter Breakdown Voltage ( $V_{GE} = 0V, I_C = 2mA$ )	600			Volts
$V_{GE(TH)}$	Gate Threshold Voltage ( $V_{CE} = V_{GE}, I_C = 1mA, T_J = 25^\circ\text{C}$ )	3	4	5	
$V_{CE(ON)}$	Collector-Emitter On Voltage ( $V_{GE} = 15V, I_C = 50A, T_J = 25^\circ\text{C}$ )	1.7	2.0	2.5	
	Collector-Emitter On Voltage ( $V_{GE} = 15V, I_C = 50A, T_J = 125^\circ\text{C}$ )		2.2		
$I_{CES}$	Collector Cut-off Current ( $V_{CE} = 600V, V_{GE} = 0V, T_J = 25^\circ\text{C}$ ) <sup>②</sup>			25	μA
	Collector Cut-off Current ( $V_{CE} = 600V, V_{GE} = 0V, T_J = 125^\circ\text{C}$ ) <sup>②</sup>			TBD	
$I_{GES}$	Gate-Emitter Leakage Current ( $V_{GE} = \pm 20V$ )			120	nA

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

## DYNAMIC CHARACTERISTICS

APT50GT60BR\_SR(G)

Symbol	Characteristic	Test Conditions	MIN	TYP	MAX	UNIT	
$C_{ies}$	Input Capacitance	<b>Capacitance</b> $V_{GE} = 0V, V_{CE} = 25V$ $f = 1 \text{ MHz}$		2500		pF	
$C_{oes}$	Output Capacitance			250			
$C_{res}$	Reverse Transfer Capacitance			155			
$V_{GEP}$	Gate-to-Emitter Plateau Voltage	Gate Charge		7.5		V	
$Q_g$	Total Gate Charge <sup>③</sup>	$V_{GE} = 15V$		240		nC	
$Q_{ge}$	Gate-Emitter Charge	$V_{CE} = 300V$		20			
$Q_{gc}$	Gate-Collector ("Miller") Charge	$I_C = 50A$		110			
SSOA	Switching Safe Operating Area	$T_J = 150^\circ\text{C}, R_G = 4.3\Omega, V_{GE} = 15V, L = 100\mu\text{H}, V_{CE} = 600V$	150			A	
$t_{d(on)}$	Turn-on Delay Time	<b>Inductive Switching (25°C)</b> $V_{CC} = 400V$ $V_{GE} = 15V$ $I_C = 50A$ $R_G = 4.3\Omega$ $T_J = +25^\circ\text{C}$		14		ns	
$t_r$	Current Rise Time			32			
$t_{d(off)}$	Turn-off Delay Time			240			
$t_f$	Current Fall Time			36			
$E_{on1}$	Turn-on Switching Energy <sup>④</sup>				995		μJ
$E_{on2}$	Turn-on Switching Energy (Diode) <sup>⑤</sup>			1110			
$E_{off}$	Turn-off Switching Energy <sup>⑥</sup>			1070			
$t_{d(on)}$	Turn-on Delay Time	<b>Inductive Switching (125°C)</b> $V_{CC} = 400V$ $V_{GE} = 15V$ $I_C = 50A$ $R_G = 4.3\Omega$ $T_J = +125^\circ\text{C}$		14		ns	
$t_r$	Current Rise Time			32			
$t_{d(off)}$	Turn-off Delay Time			270			
$t_f$	Current Fall Time			95			
$E_{on1}$	Turn-on Switching Energy <sup>④</sup>				1035		μJ
$E_{on2}$	Turn-on Switching Energy (Diode) <sup>⑤</sup>				1655		
$E_{off}$	Turn-off Switching Energy <sup>⑥</sup>				1505		

## THERMAL AND MECHANICAL CHARACTERISTICS

Symbol	Characteristic	MIN	TYP	MAX	UNIT
$R_{\theta JC}$	Junction to Case ( <b>IGBT</b> )			.28	°C/W
$R_{\theta JC}$	Junction to Case ( <b>DIODE</b> )			N/A	
$W_T$	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. Tested in inductive switching test circuit shown in figure 21, but with a Silicon Carbide diode.

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

APT50GT60BR\_SR(G)

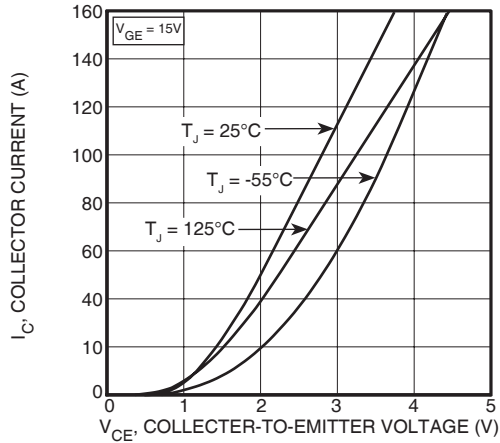


FIGURE 1, Output Characteristics ( $T_J = 25^\circ\text{C}$ )

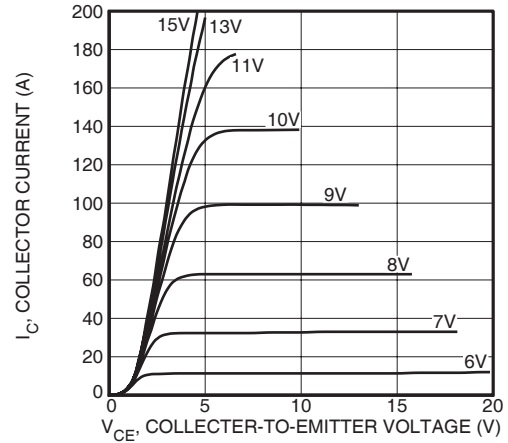


FIGURE 2, Output Characteristics ( $T_J = 125^\circ\text{C}$ )

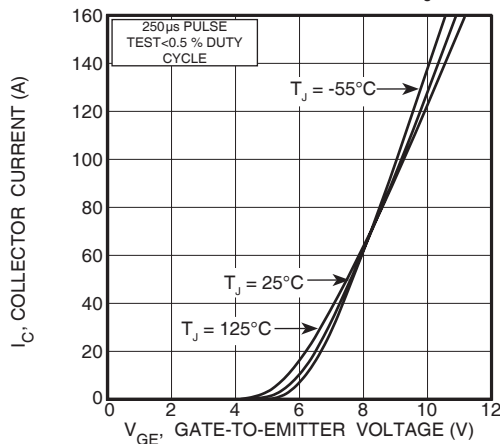


FIGURE 3, Transfer Characteristics

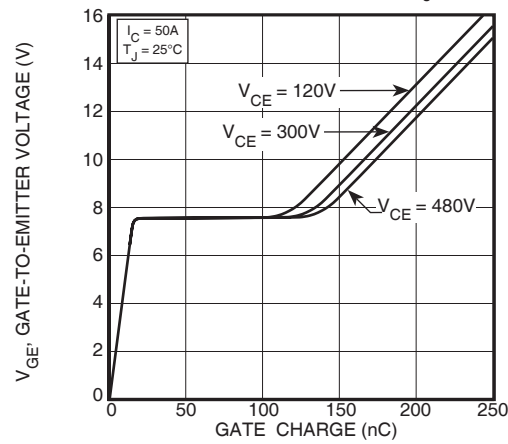


FIGURE 4, Gate Charge

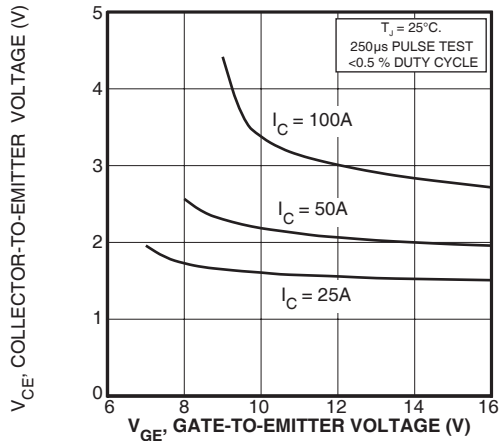


FIGURE 5, On State Voltage vs Gate-to-Emitter Voltage

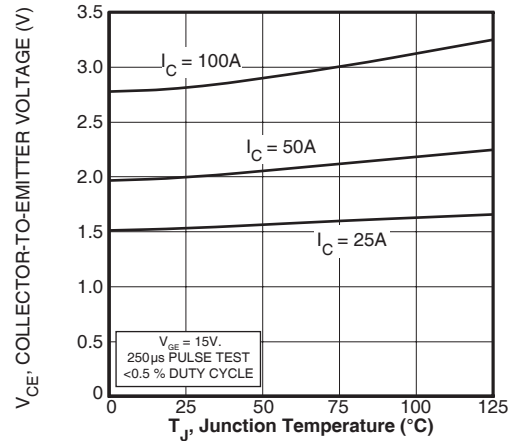


FIGURE 6, On State Voltage vs Junction Temperature

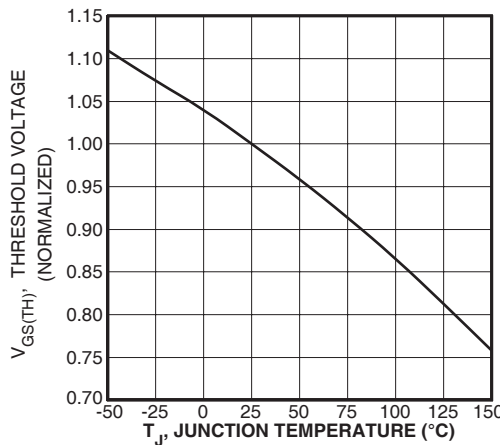


FIGURE 7, Threshold Voltage vs. Junction Temperature

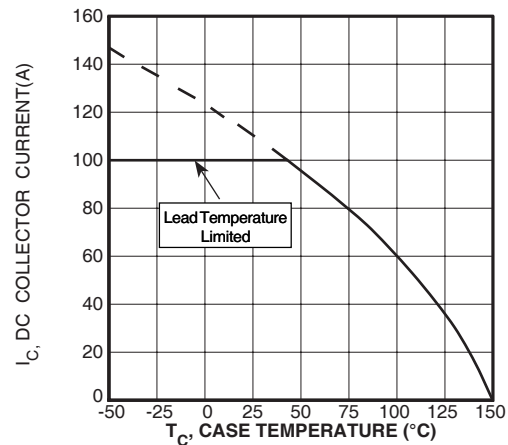


FIGURE 8, DC Collector Current vs Case Temperature

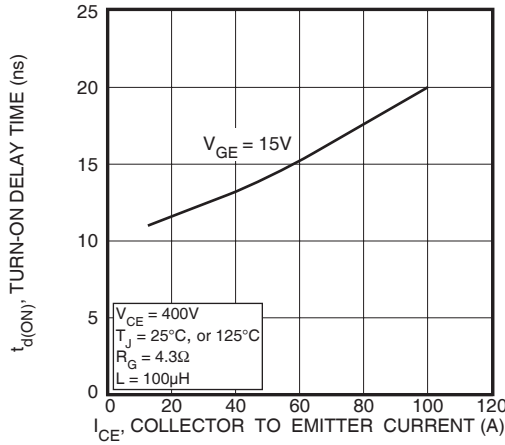


FIGURE 9, Turn-On Delay Time vs Collector Current

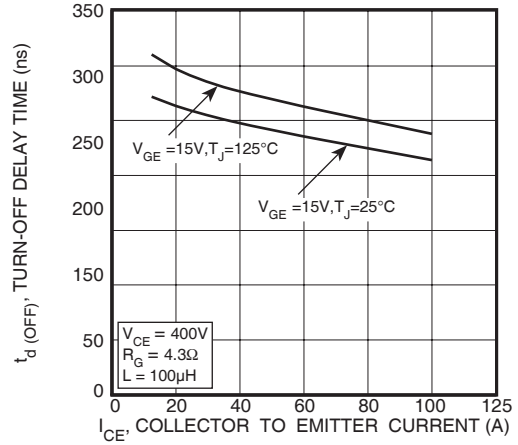


FIGURE 10, Turn-Off Delay Time vs Collector Current

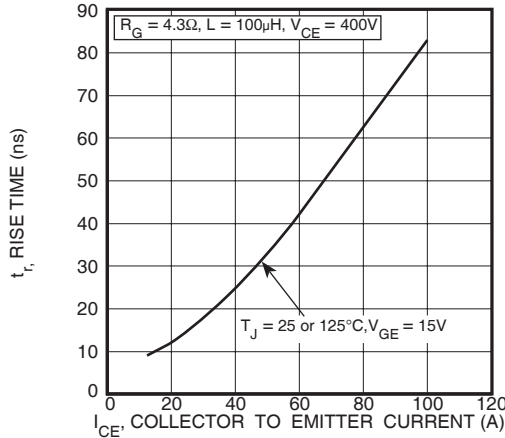


FIGURE 11, Current Rise Time vs Collector Current

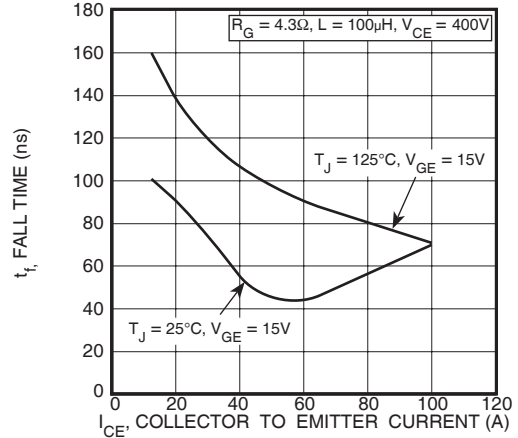


FIGURE 12, Current Fall Time vs Collector Current

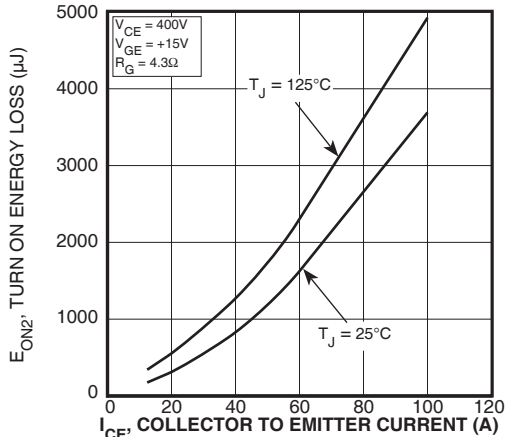


FIGURE 13, Turn-On Energy Loss vs Collector Current

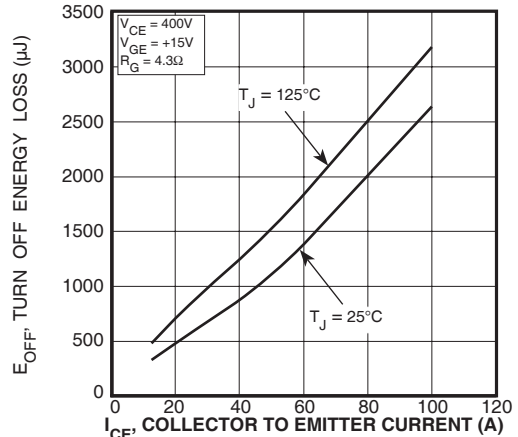


FIGURE 14, Turn Off Energy Loss vs Collector Current

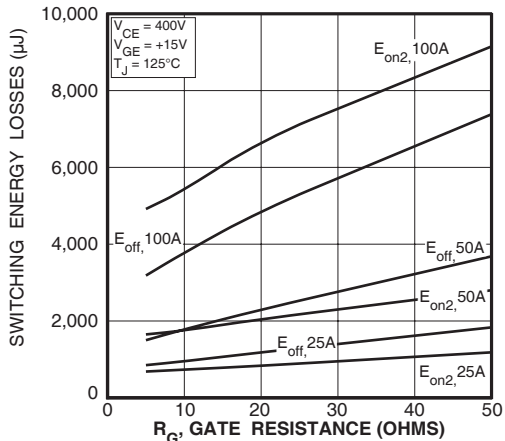


FIGURE 15, Switching Energy Losses vs. Gate Resistance

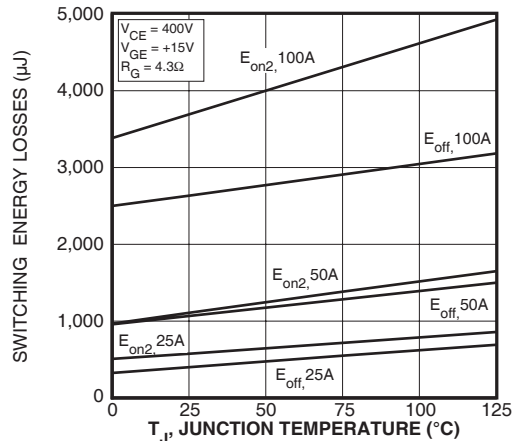


FIGURE 16, Switching Energy Losses vs Junction Temperature

**TYPICAL PERFORMANCE CURVES**

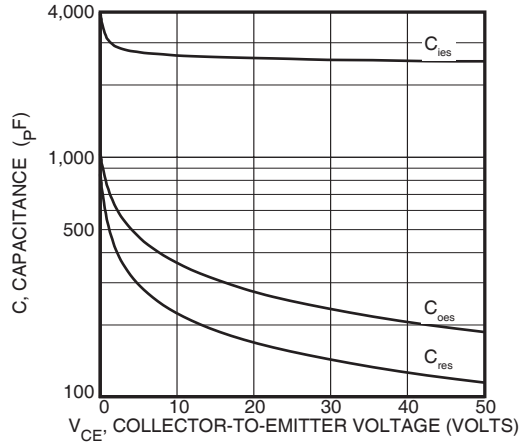


Figure 17, Capacitance vs Collector-To-Emitter Voltage

**APT50GT60BR\_SR(G)**

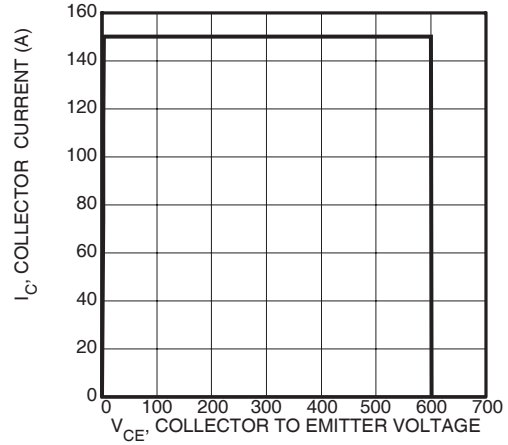


Figure 18, Minimum Switching Safe Operating Area

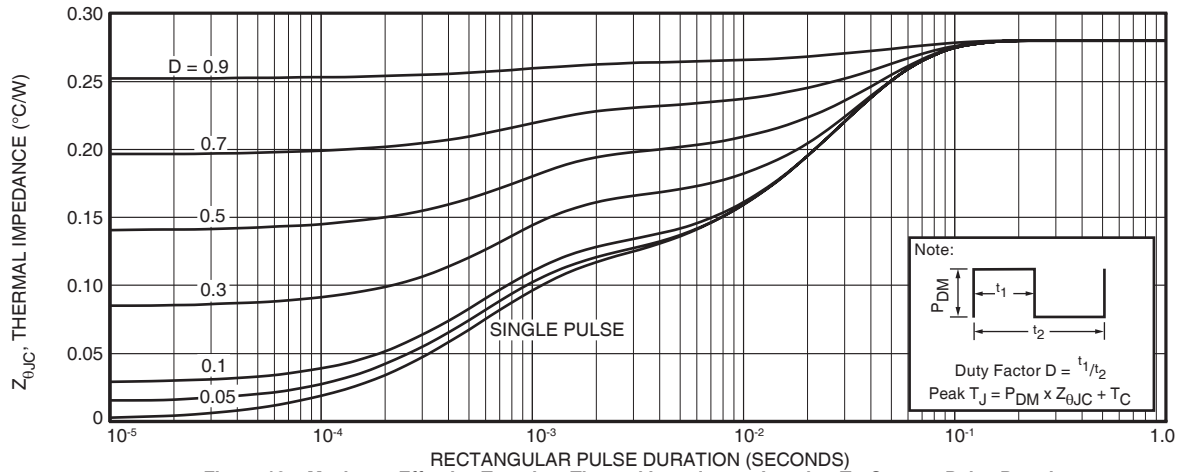


Figure 19a, Maximum Effective Transient Thermal Impedance, Junction-To-Case vs Pulse Duration

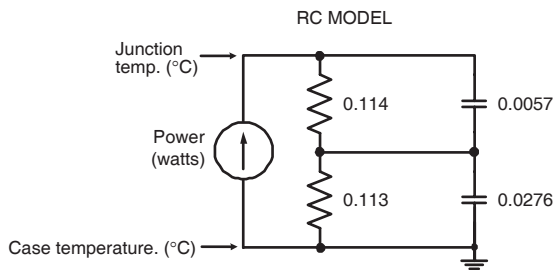


FIGURE 19b, TRANSIENT THERMAL IMPEDANCE MODEL

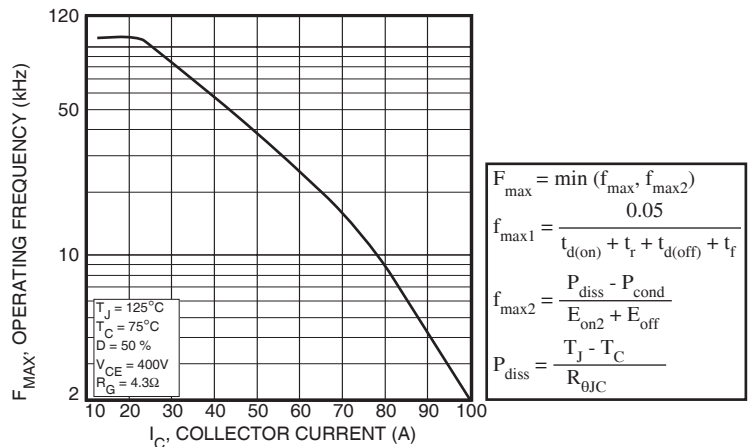


Figure 20, Operating Frequency vs Collector Current

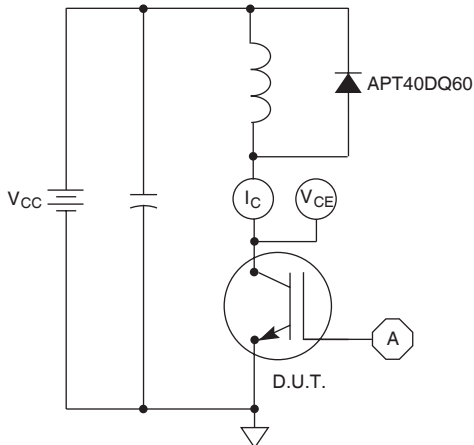


Figure 21, Inductive Switching Test Circuit

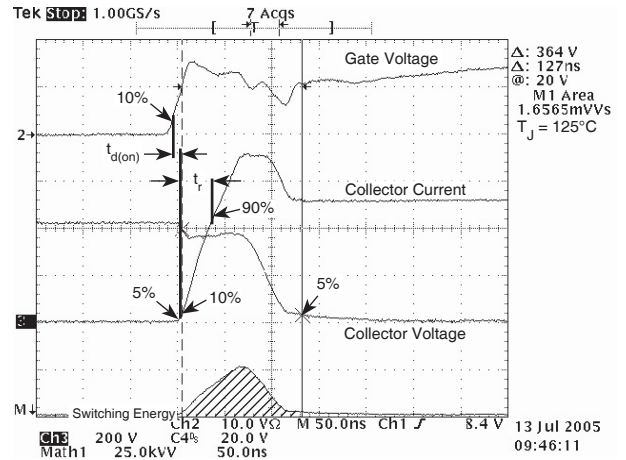


Figure 22, Turn-on Switching Waveforms and Definitions

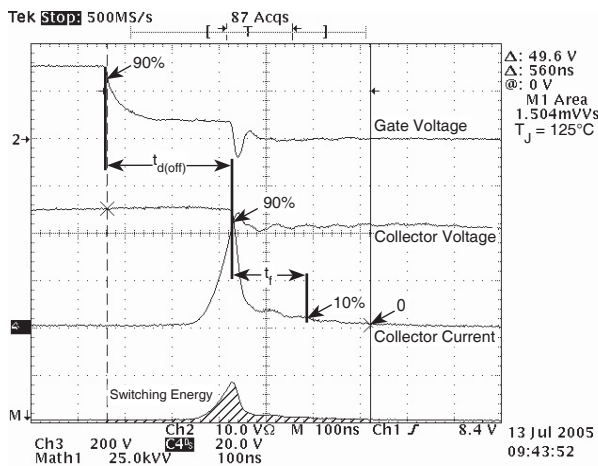
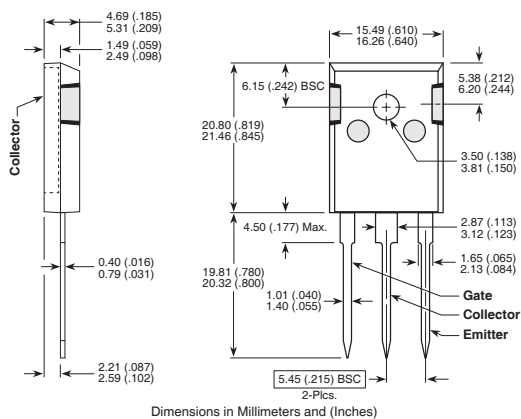


Figure 23, Turn-off Switching Waveforms and Definitions

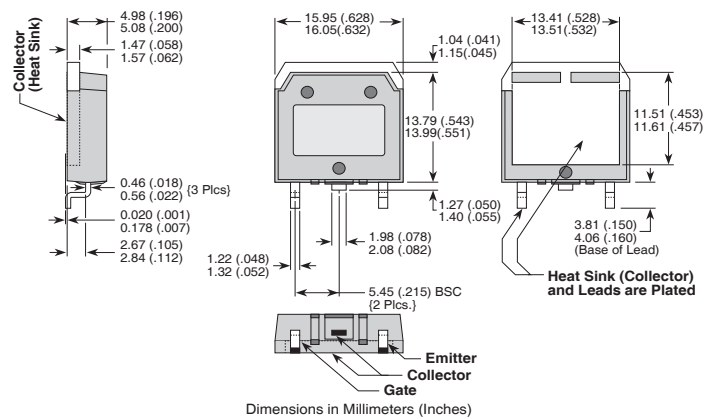
TO-247 Package Outline

(e1) SAC: Tin, Silver, Copper



D<sup>3</sup>PAK Package Outline

(e3) SAC: Tin, Silver, Copper



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