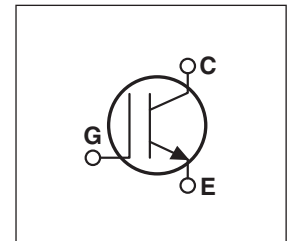
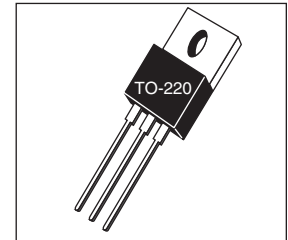


Thunderbolt IGBT®

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
- Low Tail Current
- RBSOA and SCSOA Rated
- High Freq. Switching to 150KHz
- Ultra Low Leakage Current



MAXIMUM RATINGS

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

Symbol	Parameter	APT15GT60KR(G)	UNIT
V_{CES}	Collector-Emitter Voltage	600	Volts
V_{GE}	Gate-Emitter Voltage	± 30	
I_{C1}	Continuous Collector Current @ $T_C = 25^\circ\text{C}$	42	Amps
I_{C2}	Continuous Collector Current @ $T_C = 110^\circ\text{C}$	20	
I_{CM}	Pulsed Collector Current ^①	45	
SSOA	Switching Safe Operating Area @ $T_J = 150^\circ\text{C}$	45A @ 600V	
P_D	Total Power Dissipation	184	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 ($V_{GE} = 0\text{V}, I_C = 250\mu\text{A}$)	600			Volts
$V_{GE(TH)}$	Gate Threshold Voltage ($V_{CE} = V_{GE}, I_C = 700\mu\text{A}, T_J = 25^\circ\text{C}$)	3	4	5	
$V_{CE(ON)}$	Collector-Emitter On Voltage ($V_{GE} = 15\text{V}, I_C = 15\text{A}, T_J = 25^\circ\text{C}$)	1.6	2.0	2.5	
	Collector-Emitter On Voltage ($V_{GE} = 15\text{V}, I_C = 15\text{A}, T_J = 125^\circ\text{C}$)		2.8		
I_{CES}	Collector Cut-off Current ($V_{CE} = 600\text{V}, V_{GE} = 0\text{V}, T_J = 25^\circ\text{C}$) ^②			25	μA
	Collector Cut-off Current ($V_{CE} = 600\text{V}, V_{GE} = 0\text{V}, T_J = 125^\circ\text{C}$) ^②			1500	
I_{GES}	Gate-Emitter Leakage Current ($V_{GE} = \pm 20\text{V}$)			± 100	nA



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

DYNAMIC CHARACTERISTICS

APT15GT60KR(G)

Symbol	Characteristic	Test Conditions	MIN	TYP	MAX	UNIT	
C_{ies}	Input Capacitance	Capacitance $V_{GE} = 0V, V_{CE} = 25V$ $f = 1 \text{ MHz}$		800		pF	
C_{oes}	Output Capacitance			84			
C_{res}	Reverse Transfer Capacitance			52			
V_{GEP}	Gate-to-Emitter Plateau Voltage	Gate Charge		7.5		V	
Q_g	Total Gate Charge ^③	$V_{GE} = 15V$		75		nC	
Q_{ge}	Gate-Emitter Charge	$V_{CE} = 300V$		6			
Q_{gc}	Gate-Collector ("Miller") Charge	$I_C = 15A$		34			
SSOA	Switching Safe Operating Area	$T_J = 150^\circ\text{C}, R_G = 10\Omega, V_{GE} = 15V, L = 100\mu\text{H}, V_{CE} = 600V$	45			A	
$t_{d(on)}$	Turn-on Delay Time	Inductive Switching (25°C) $V_{CC} = 400V$ $V_{GE} = 15V$ $I_C = 15A$ $R_G = 10\Omega$ $T_J = +25^\circ\text{C}$		6		ns	
t_r	Current Rise Time			8			
$t_{d(off)}$	Turn-off Delay Time			105			
t_f	Current Fall Time			55			
E_{on1}	Turn-on Switching Energy ^④				150		μJ
E_{on2}	Turn-on Switching Energy (Diode) ^⑤			195			
E_{off}	Turn-off Switching Energy ^⑥			215			
$t_{d(on)}$	Turn-on Delay Time	Inductive Switching (125°C) $V_{CC} = 400V$ $V_{GE} = 15V$ $I_C = 15A$ $R_G = 10\Omega$ $T_J = +125^\circ\text{C}$		6		ns	
t_r	Current Rise Time			8			
$t_{d(off)}$	Turn-off Delay Time			125			
t_f	Current Fall Time			100			
E_{on1}	Turn-on Switching Energy ^④				150		μJ
E_{on2}	Turn-on Switching Energy (Diode) ^⑤				325		
E_{off}	Turn-off Switching Energy ^⑥				325		

THERMAL AND MECHANICAL CHARACTERISTICS

Symbol	Characteristic	MIN	TYP	MAX	UNIT
$R_{\theta JC}$	Junction to Case (IGBT)			.68	°C/W
$R_{\theta JC}$	Junction to Case (DIODE)			N/A	
W_T	Package Weight		1.9		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.)

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

TYPICAL PERFORMANCE CURVES

APT15GT60KR(G)

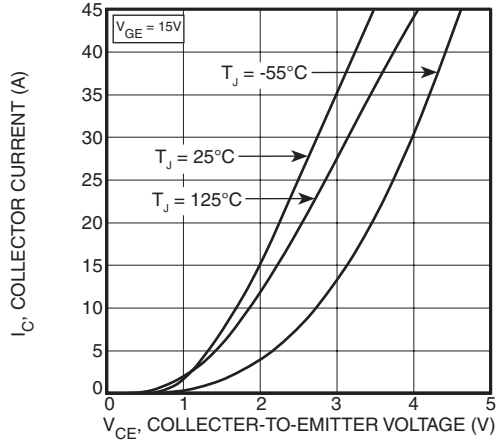


FIGURE 1, Output Characteristics ($T_J = 25^\circ\text{C}$)

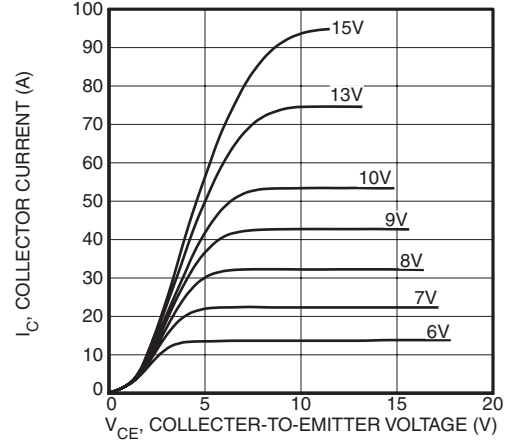


FIGURE 2, Output Characteristics ($T_J = 125^\circ\text{C}$)

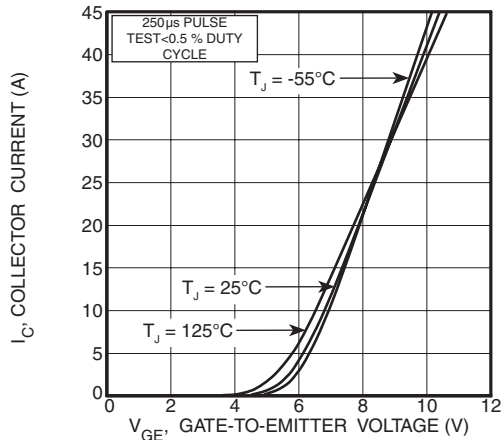


FIGURE 3, Transfer Characteristics

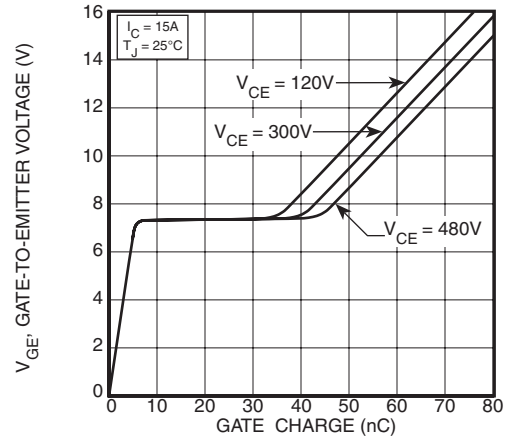


FIGURE 4, Gate Charge

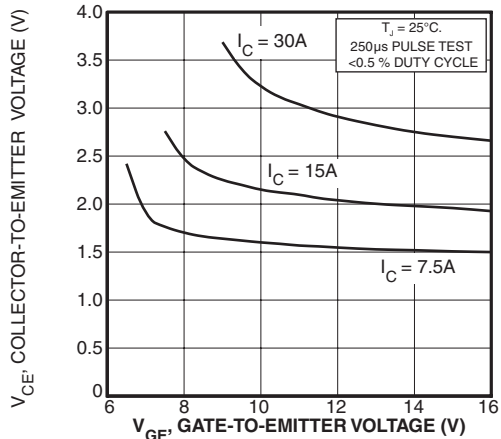


FIGURE 5, On State Voltage vs Gate-to-Emitter Voltage

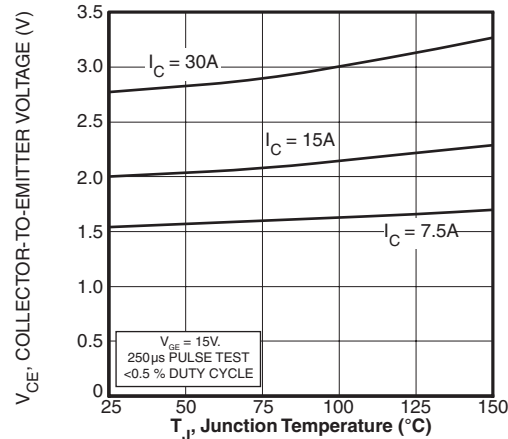


FIGURE 6, On State Voltage vs Junction Temperature

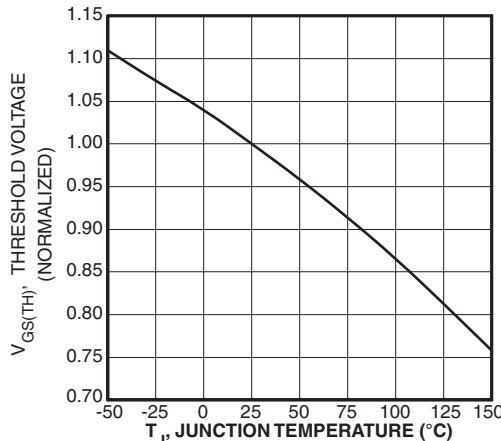


FIGURE 7, Threshold Voltage vs. Junction Temperature

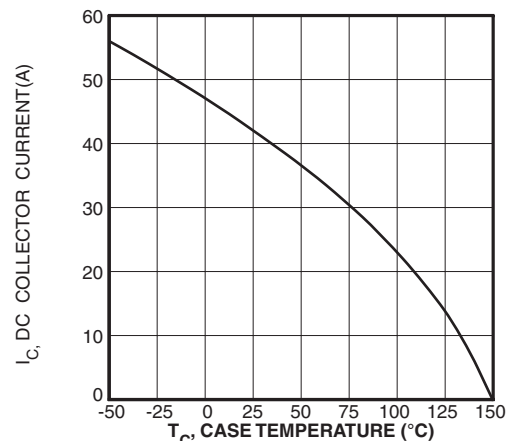


FIGURE 8, DC Collector Current vs Case Temperature

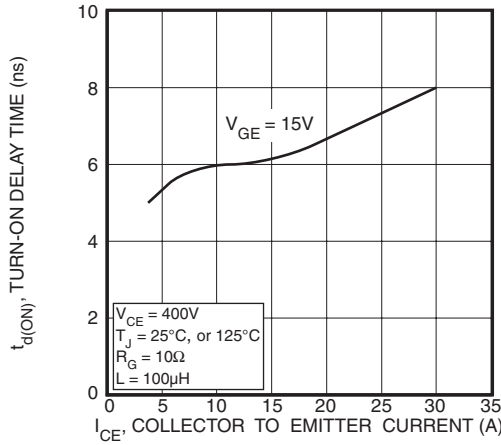


FIGURE 9, Turn-On Delay Time vs Collector Current

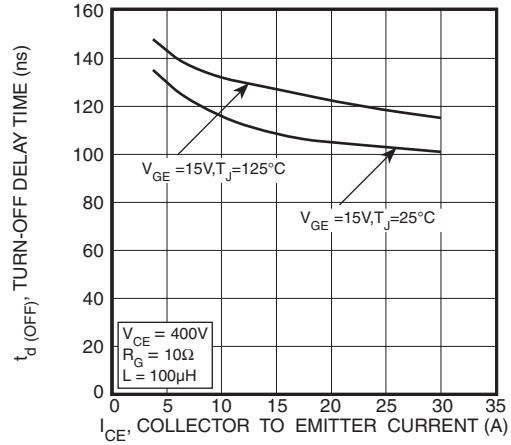


FIGURE 10, Turn-Off Delay Time vs Collector Current

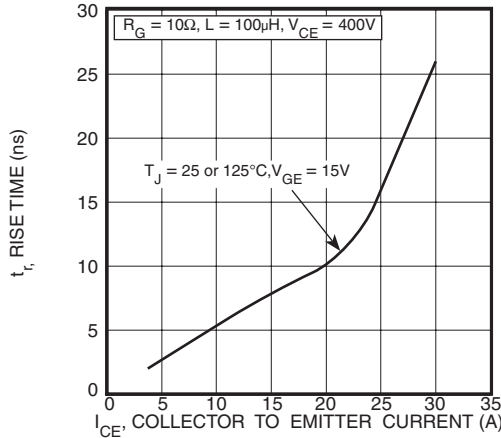


FIGURE 11, Current Rise Time vs Collector Current

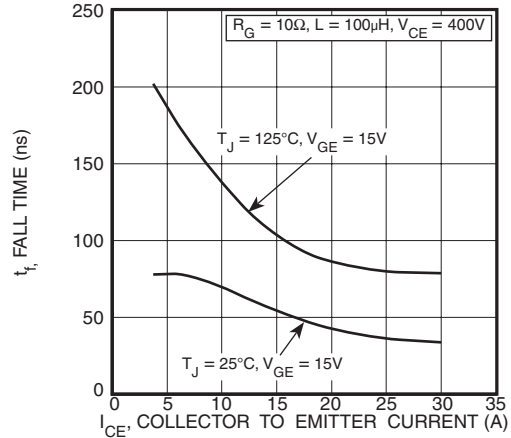


FIGURE 12, Current Fall Time vs Collector Current

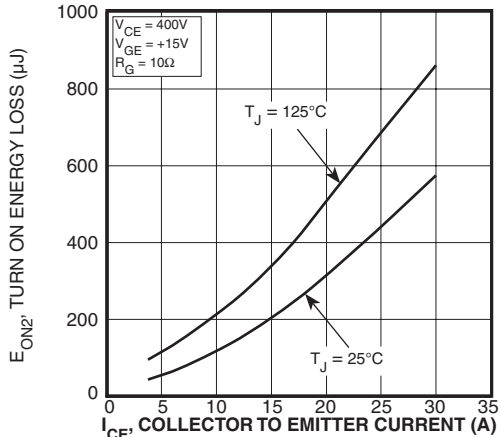


FIGURE 13, Turn-On Energy Loss vs Collector Current

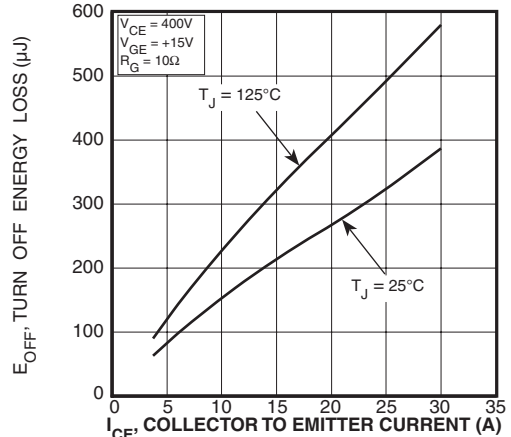


FIGURE 14, Turn Off Energy Loss vs Collector Current

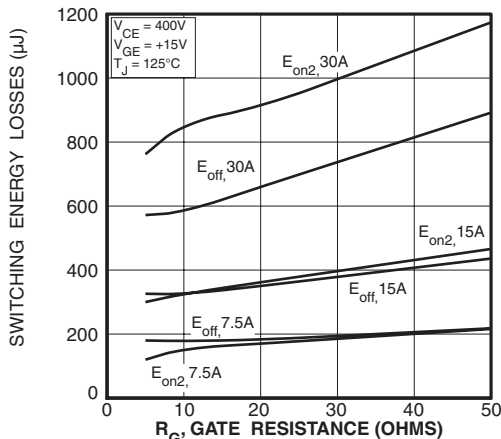


FIGURE 15, Switching Energy Losses vs. Gate Resistance

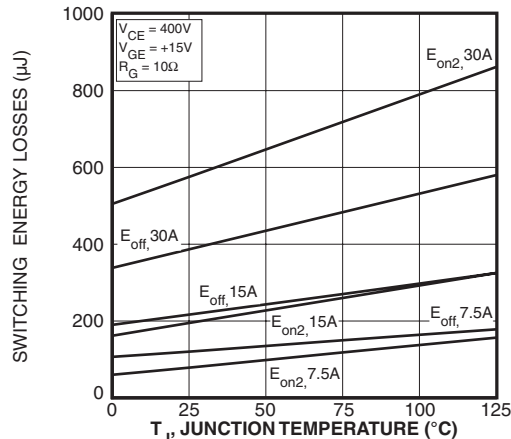


FIGURE 16, Switching Energy Losses vs Junction Temperature

TYPICAL PERFORMANCE CURVES

APT15GT60KR(G)

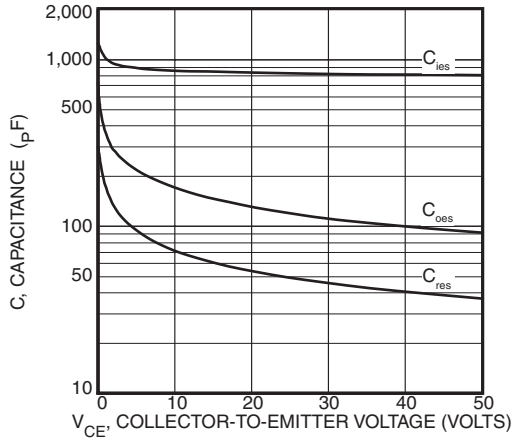


Figure 17, Capacitance vs Collector-To-Emitter Voltage

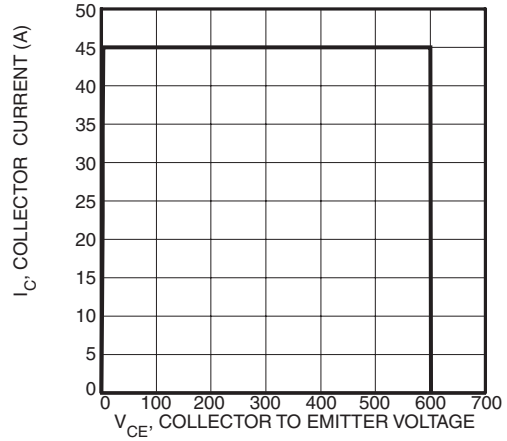


Figure 18, Minimum Switching Safe Operating Area

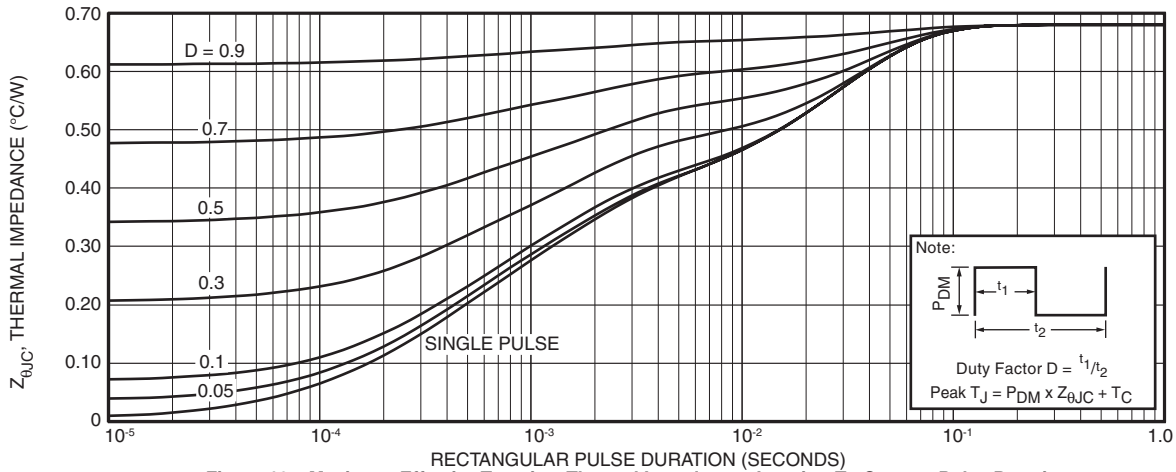


Figure 19a, Maximum Effective Transient Thermal Impedance, Junction-To-Case vs Pulse Duration

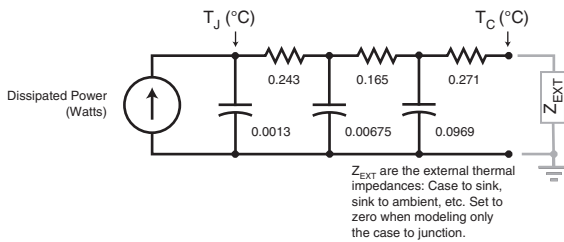


FIGURE 19b, TRANSIENT THERMAL IMPEDANCE MODEL

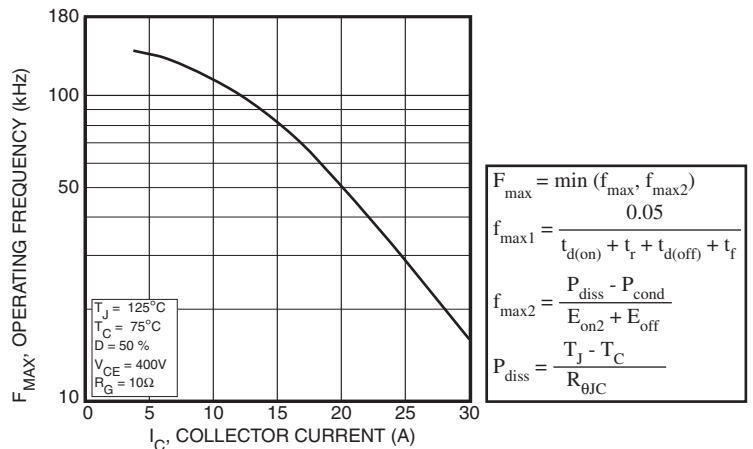


Figure 20, Operating Frequency vs Collector Current

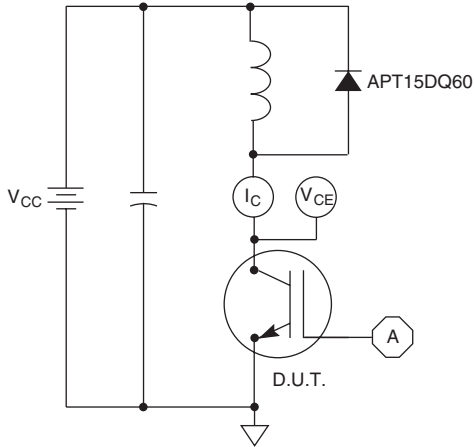


Figure 21, Inductive Switching Test Circuit

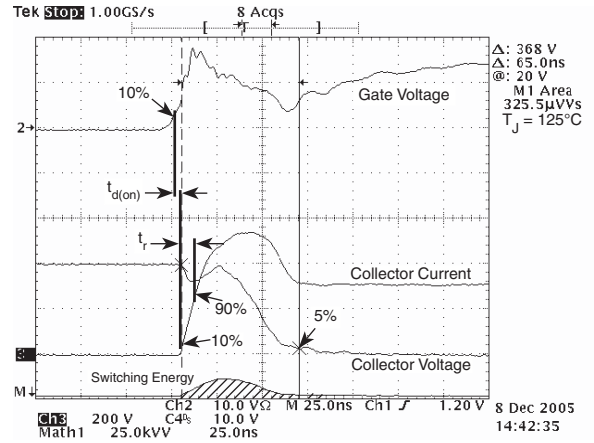


Figure 22, Turn-on Switching Waveforms and Definitions

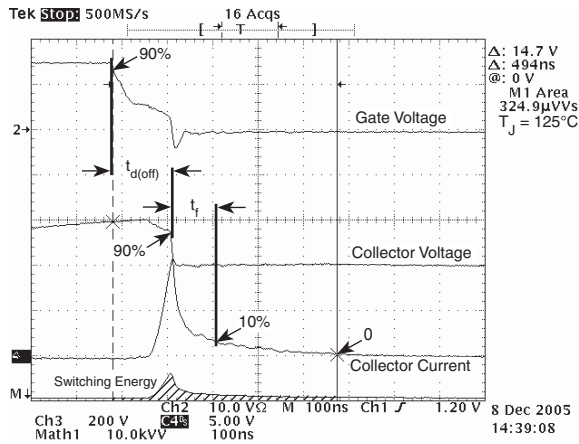
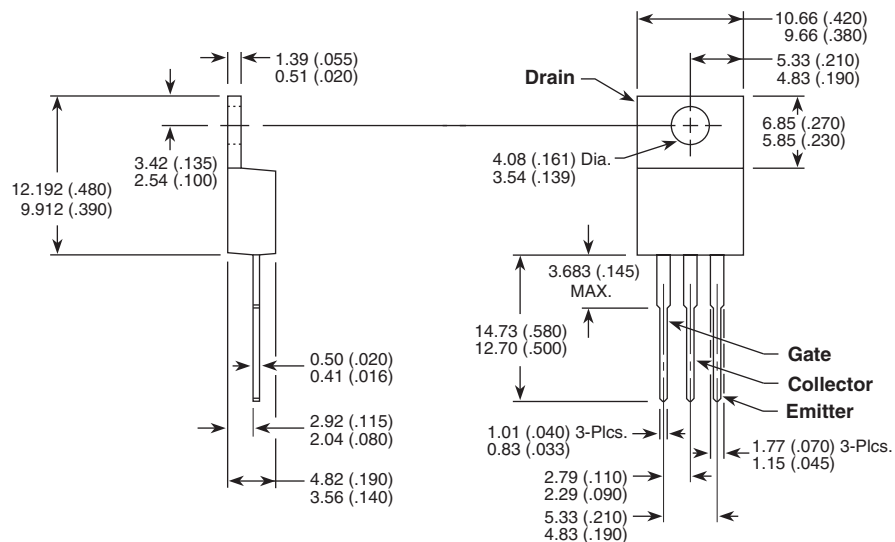


Figure 23, Turn-off Switching Waveforms and Definitions

TO-220 (K) Package Outline

Ⓜ 100% Sn



Dimensions in Millimeters and (Inches)

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.