Microsemi
POWER PRODUCTS GROUP

Thunderbolt HS™

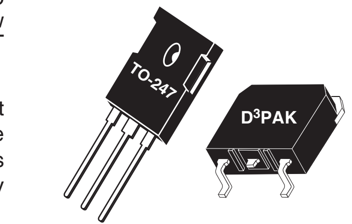
APT50GS60BR(G)
APT50GS60SR(G)

600V, 50A, $V_{CE(ON)}$ = 2.8V Typical

Thunderbolt® High Speed NPT IGBT

The Thunderbolt HS™ series is based on thin wafer non-punch through (NPT) technology similar to the Thunderbolt® series, but trades higher $V_{CE(ON)}$ for significantly lower turn-on energy E_{off}. The low switching losses enable operation at switching frequencies over 100kHz, approaching power MOSFET performance but lower cost.

An extremely tight parameter distribution combined with a positive $V_{CE(ON)}$ temperature coefficient make it easy to parallel Thunderbolts HS™ IGBT's. Controlled slew rates result in very good noise and oscillation immunity and low EMI. The short circuit duration rating of 10μs make these IGBT's suitable for motor drive and inverter applications. Reliability is further enhanced by avalanche energy ruggedness. Combi versions are packaged with a high speed, soft recovery DQ series diode.



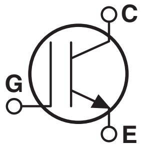
APT50GS60BR(G) **APT50GS60SR(G)**

Features

- **Fast Switching with low EMI**
- **Very Low E_{OFF} for Maximum Efficiency**
- **Short circuit rated**
- **Low Gate Charge**
- **Tight parameter distribution**
- **Easy paralleling**
- **RoHS Compliant**

Typical Applications

- **ZVS Phase Shifted and other Full Bridge**
- **Half Bridge**
- **High Power PFC Boost**
- **Welding**
- **Induction heating**
- **High Frequency SMPS**



Absolute Maximum Ratings

Symbol	Parameter	Rating	Unit
I_{C1}	Continuous Collector Current T_C = @ 25°C	93	A
I_{C1}	Continuous Collector Current T_C = @ 100°C	50	
I_{CM}	Pulsed Collector Current ①	195	
V_{GE}	Gate-Emitter Voltage	±30V	V
SSOA	Switching Safe Operating Area	195	
E_{AS}	Single Pulse Avalanche Energy②	280	mJ
t_{SC}	Short Circut Withstand Time③	10	μs

Thermal and Mechanical Characteristics

Symbol	Parameter		Min	Typ	Max	Unit
P_D	Total Power Dissipation T_C = @ 25°C		-	-	415	W
$R_{\theta JC}$	Junction to Case Thermal Resistance	IGBT	-	-	0.30	°C/W
$R_{\theta CS}$	Case to Sink Thermal Resistance, Flat Greased Surface		-	0.11	-	
T_J, T_{STG}	Operating and Storage Junction Temperature Range		-55	-	150	°C
T_L	Soldering Temperature for 10 Seconds (1.6mm from case)		-	-	300	
W_T	Package Weight		-	0.22	-	oz
			-	5.9	-	g
Torque	Mounting Torque (TO-247), 6-32 M3 Screw		-	-	10	in·lbf
			-	-	1.1	N·m

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

Microsemi Website - http://www.microsemi.com

Static Characteristics T_J = 25°C unless otherwise specified

Symbol	Parameter	Test Conditions		Min	Typ	Max	Unit
$V_{BR(CES)}$	Collector-Emitter Breakdown Voltage	$V_{GE} = 0V$, $I_C = 250\mu A$		600	-	-	V
$V_{BR(ECS)}$	Emitter-Collector Breakdown Voltage	$V_{GE} = 0V$, $I_C = 1A$		-	25	-	
$\Delta V_{BR(CES)}/\Delta T_J$	Breakdown Voltage Temperature Coeff	Reference to 25°C, $I_C = 250\mu A$		-	0.60	-	V/°C
$V_{CE(ON)}$	Collector-Emitter On Voltage④	$V_{GE} = 15V$ $I_C = 50A$	$T_J = 25°C$	-	2.8	3.15	V
			$T_J = 125°C$	-	3.25	-	
V_{EC}	Diode Forward Voltage④	$I_C = 50A$	$T_J = 25°C$	-	2.15	-	
			$T_J = 125°C$	-	1.8	-	
$V_{GE(th)}$	Gate-Emitter Threshold Voltage	$V_{GE} = V_{CE}$, $I_C = 1mA$		3	4	5	
$\Delta V_{GE(th)}/\Delta T_J$	Threshold Voltage Temp Coeff			-	6.7	-	mV/°C
I_{CES}	Zero Gate Voltage Collector Current	$V_{CE} = 600V$, $V_{GE} = 0V$	$T_J = 25°C$	-	-	50	μA
			$T_J = 125°C$	-	-	TBD	
I_{GES}	Gate-Emitter Leakage Current	$V_{GE} = \pm 20V$		-	-	±100	nA

Dynamic Characteristics T_J = 25°C unless otherwise specified

Symbols	Parameter	Test Conditions	Min	Typ	Max	Unit
g_{fs}	Forward Transconductance	$V_{CE} = 50V$, $I_C = 50A$	-	31	-	S
C_{ies}	Input Capacitance	$V_{GE} = 0V$, $V_{CE} = 25V$ f = 1MHz	-	2635	-	pF
C_{oes}	Output Capacitance		-	240	-	
C_{res}	Reverse Transfer Capacitance		-	145	-	
$C_{o(cr)}$	Reverse Transfer Capacitance Charge Related ⑤	$V_{GE} = 0V$ $V_{CE} = 0$ to $400V$	-	115	-	
$C_{o(er)}$	Reverse Transfer Capacitance Current Related ⑥			85		
Q_g	Total Gate Charge	$V_{GE} = 0$ to $15V$ $I_C = 50A$, $V_{CE} = 300V$	-	235	-	nC
Q_{ge}	Gate-Emitter Charge		-	18	-	
G_{gc}	Gate-Collector Charge		-	100	-	
$t_{d(on)}$	Turn-On Delay Time	Inductive Switching IGBT and Diode: $T_J = 25°C$, $V_{CC} = 400V$, $I_C = 50A$ $R_G = 4.7\Omega$⑦, $V_{GG} = 15V$	-	16	-	ns
t_r	Rise Time		-	33	-	
$t_{d(off)}$	Turn-Off Delay Time		-	225	-	
t_f	Fall Time		-	37	-	
E_{on1}	Turn-On Switching Energy ⑧		-	TBD	-	mJ
E_{on2}	Turn-On Switching Energy ⑨		-	1.2	-	
E_{off}	Turn-Off Switching Energy ⑩		-	0.755	-	
$t_{d(on)}$	Turn-On Delay Time	Inductive Switching IGBT and Diode: $T_J = 125°C$, $V_{CC} = 400V$, $I_C = 50A$ $R_G = 4.7\Omega$⑦, $V_{GG} = 15V$	-	33	-	ns
t_r	Rise Time		-	33	-	
$t_{d(off)}$	Turn-Off Delay Time		-	250	-	
t_f	Fall Time		-	23	-	
E_{on1}	Turn-On Switching Energy ⑧		-	TBD	-	mJ
E_{on2}	Turn-On Switching Energy ⑨		-	1.7	-	
E_{off}	Turn-Off Switching Energy ⑩		-	0.950	-	

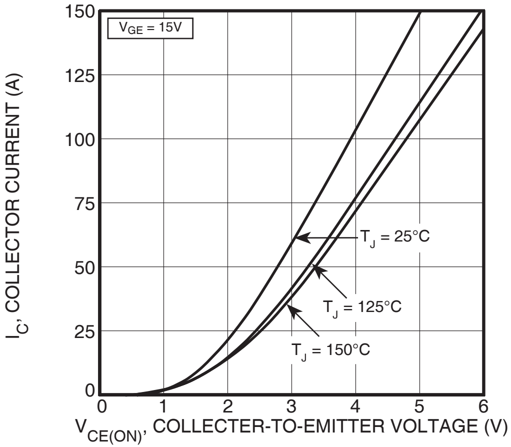


FIGURE 1, Output Characteristics

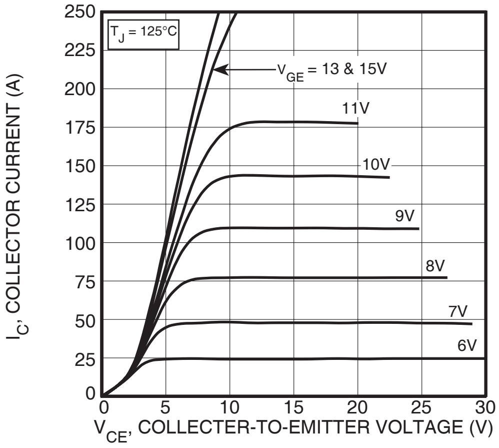


FIGURE 2, Output Characteristics

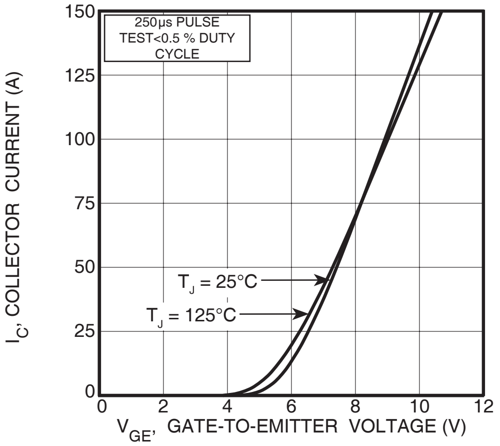


FIGURE 3, Transfer Characteristics

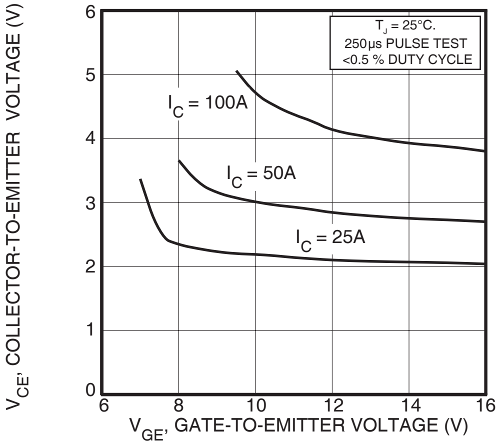


FIGURE 4, On State Voltage vs Gate-to- Emitter Voltage

I_C = 25A
T_J = 25°C

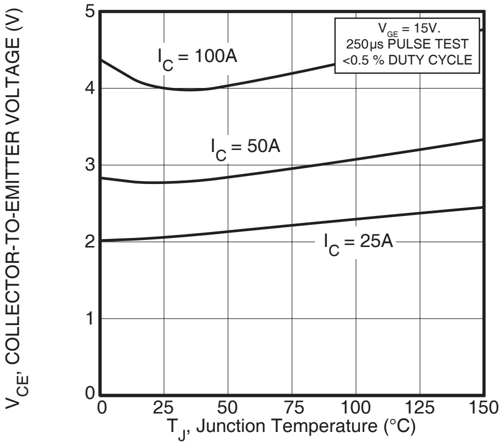


FIGURE 5, On State Voltage vs Junction Temperature

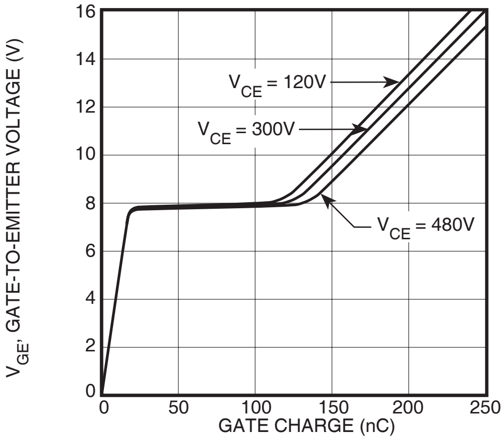


FIGURE 6, Gate Charge

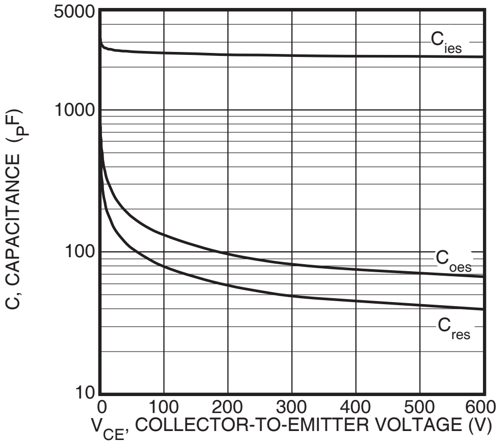


FIGURE 7, Capacitance vs Collector-To-Emitter Voltage

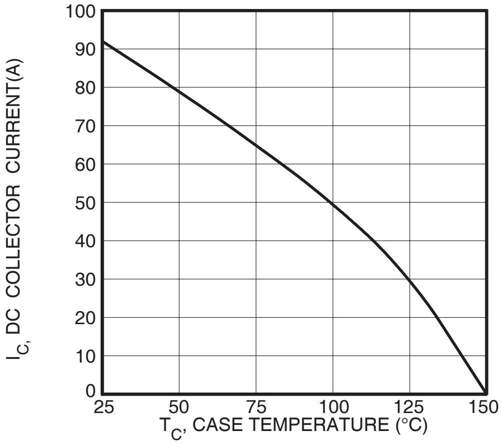


FIGURE 8, DC Collector Current vs Case Temperature

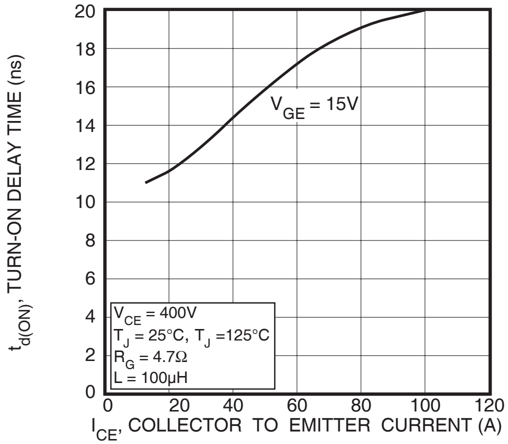


FIGURE 9, Turn-On Delay Time vs Collector Current

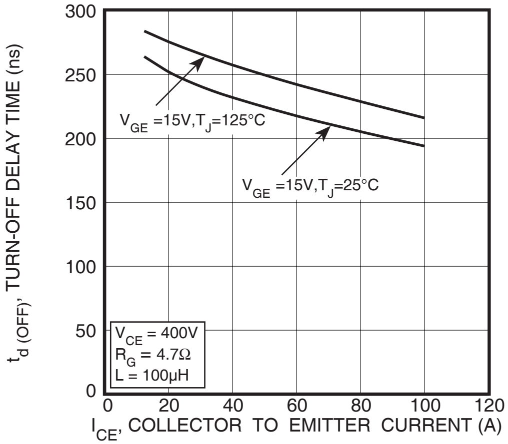


FIGURE 10, Turn-Off Delay Time vs Collector Current

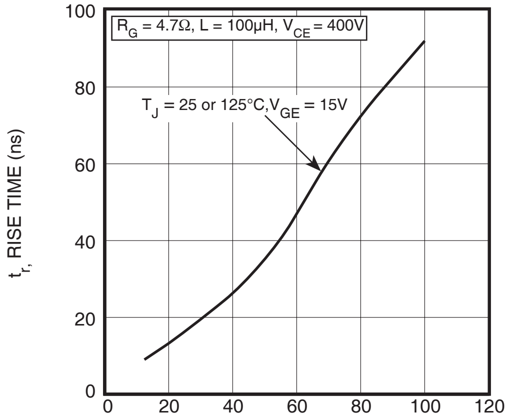


FIGURE 11, Current Rise Time vs Collector Current

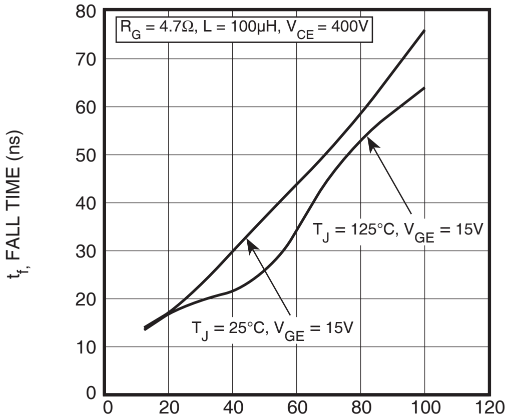


FIGURE 12, Current Fall Time vs Collector Current

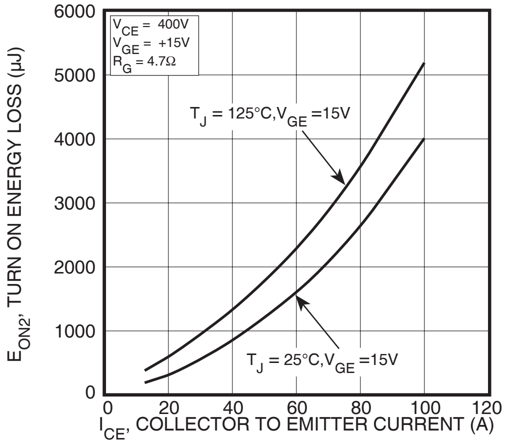


FIGURE 13, Turn-On Energy Loss vs Collector Current

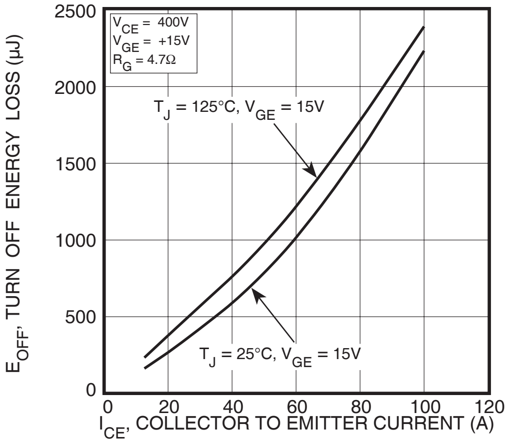


FIGURE 14, Turn Off Energy Loss vs Collector Current

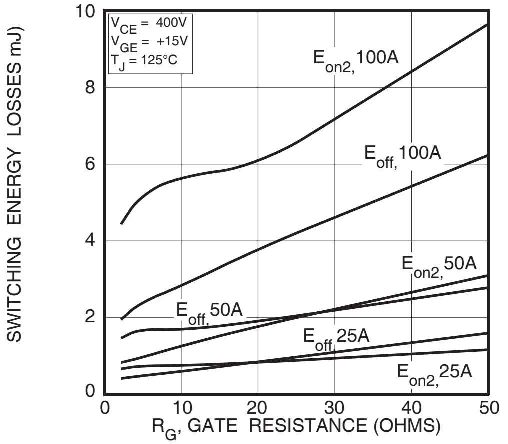


FIGURE 15, Switching Energy Losses vs. Gate Resistance

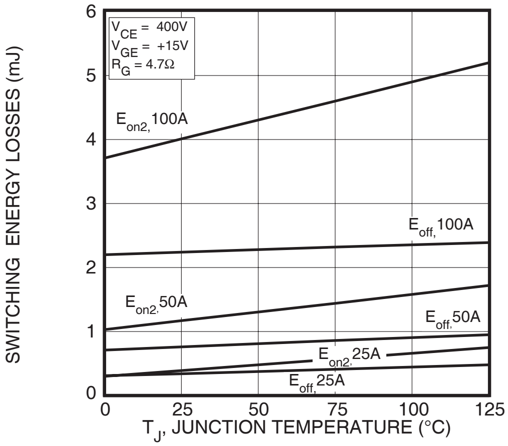


FIGURE 16, Switching Energy Losses vs Junction Temperature

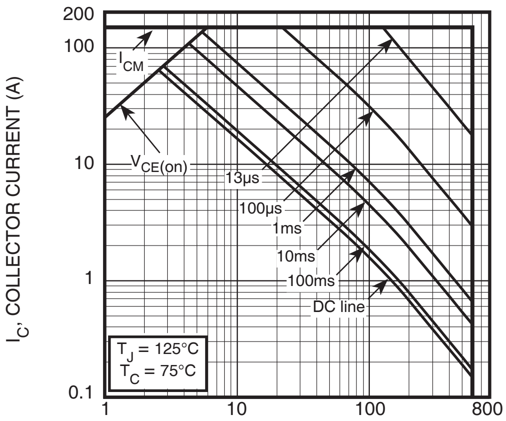


Figure 17, Forward Safe Operating Area

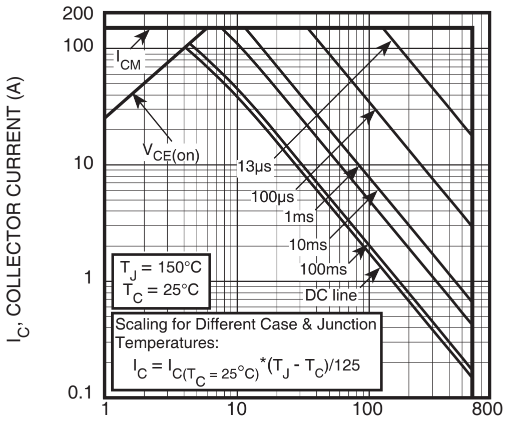


Figure 18, Maximum Forward Safe Operating Area

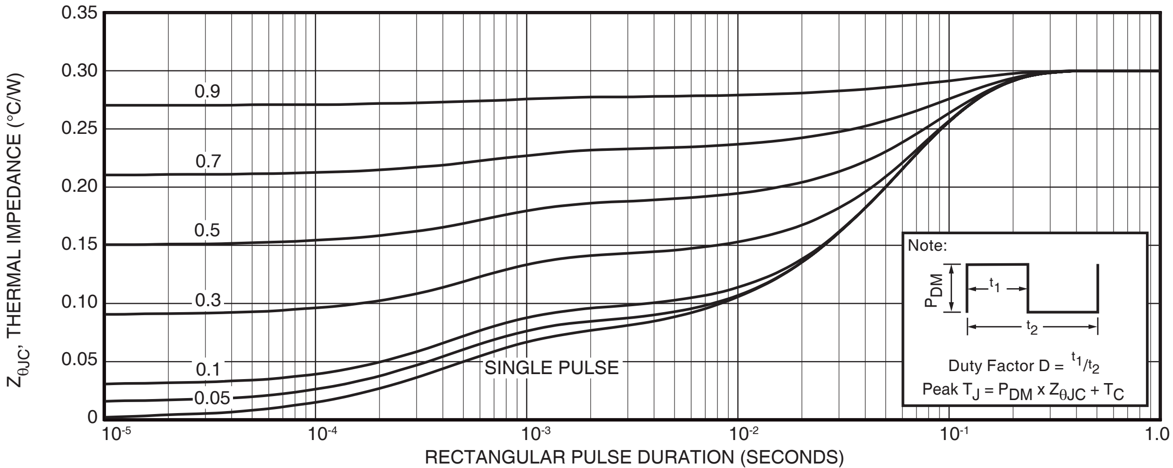


Figure 19, Maximum Effective Transient Thermal Impedance, Junction-To-Case vs Pulse Duration

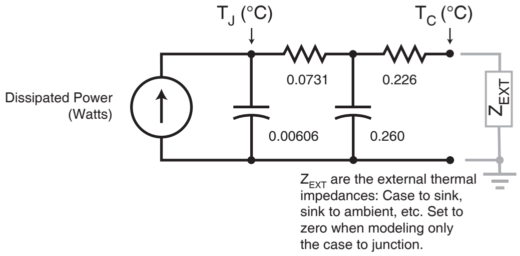
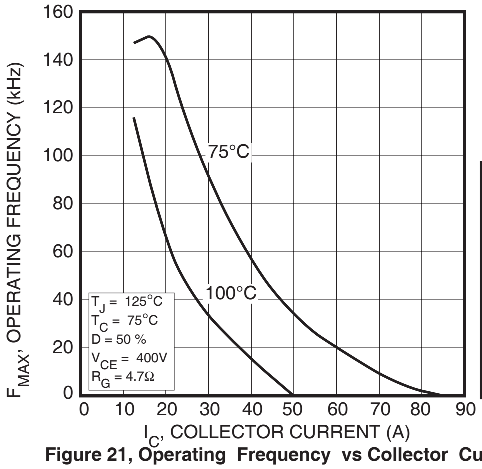


Figure 20, Transient Thermal Impedance Model



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

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

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

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

Figure 21, Operating Frequency vs Collector Current

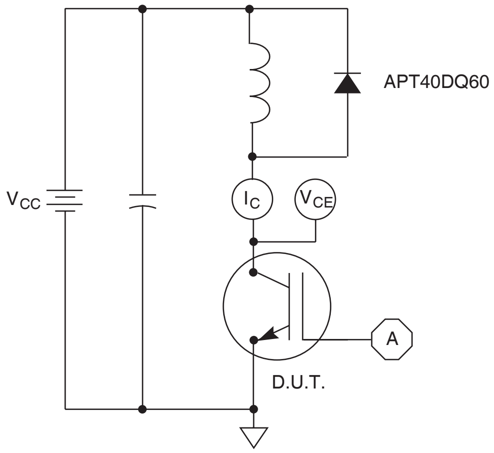


Figure 22, Inductive Switching Test Circuit

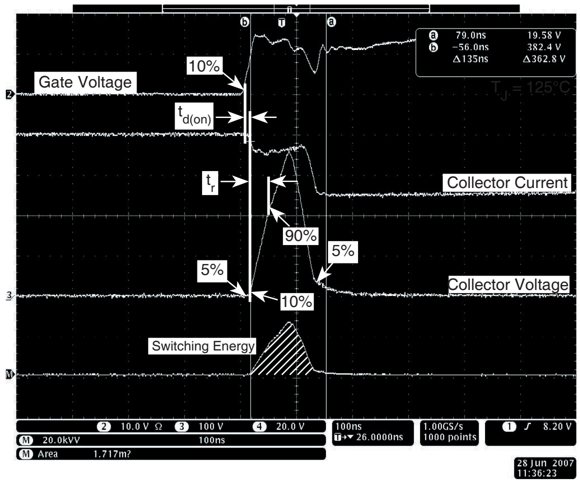


Figure 23, Turn-on Switching Waveforms and Definitions

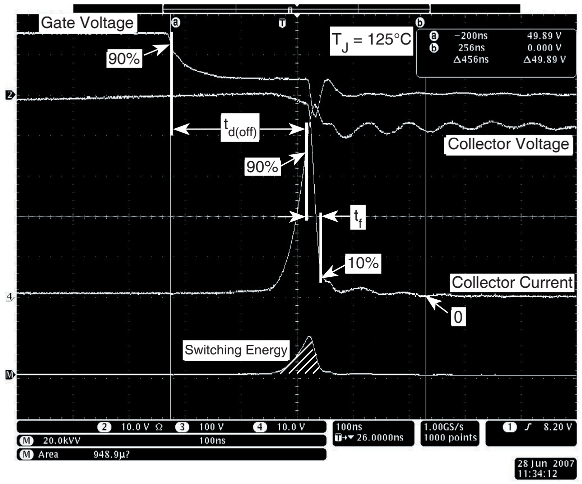


Figure 24, Turn-off Switching Waveforms and Definitions

FOOT NOTE:

① Repetitive Rating: Pulse width and case temperature limited by maximum junction temperature.

② Starting at $T_J = 25°C$, $L = 224\mu H$, $R_G = 25\Omega$, $I_C = 50A$

③ Short circuit time: $V_{GE} = 15V$, $V_{CC} \leq 600V$, $T_J \leq 150°C$

④ Pulse test: Pulse width < 380µs, duty cycle < 2%

⑤ $C_{o(cr)}$ is defined as a fixed capacitance with the same stored charge as C_{oes} with V_{CE} = 67% of $V_{(BR)CES}$.

⑥ $C_{o(er)}$ is defined as a fixed capacitance with the same stored energy as C_{oes} with V_{CE} = 67% of $V_{(BR)CES}$. To calculate $C_{o(er)}$ for any value of V_{CE} less than $V_{(BR)CES}$, use this equation: $C_{o(er)}$ = 5.57E-8/V_{DS}^2 + 7.15E-8/V_{DS} + 2.75E-10.

⑦ R_G is external gate resistance, not including internal gate resistance or gate driver impedance (MIC4452).

⑧ E_{on1} is the inductive turn-on energy of the IGBT only, without the effect of a commutating diode reverse recovery current adding to the IGBT turn-on switching loss. It is measured by clamping the inductance with a Silicon Carbide Schottky diode.

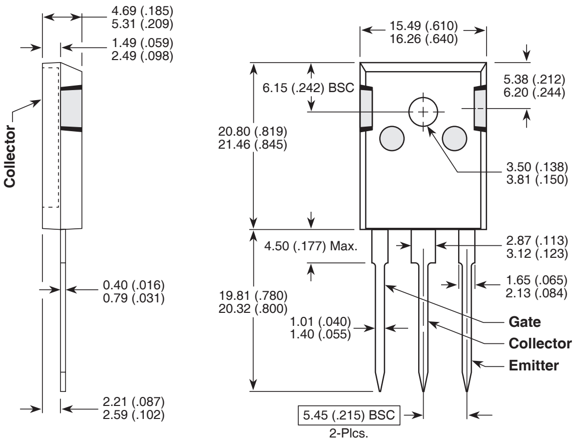
⑨ E_{on2} is the inductive turn-on energy that includes a commutating diode reverse recovery current in the IGBT turn-on energy.

⑩ Eoff is the clamped inductive turn-off energy measured in accordance with JEDEC standard JESD24-1.

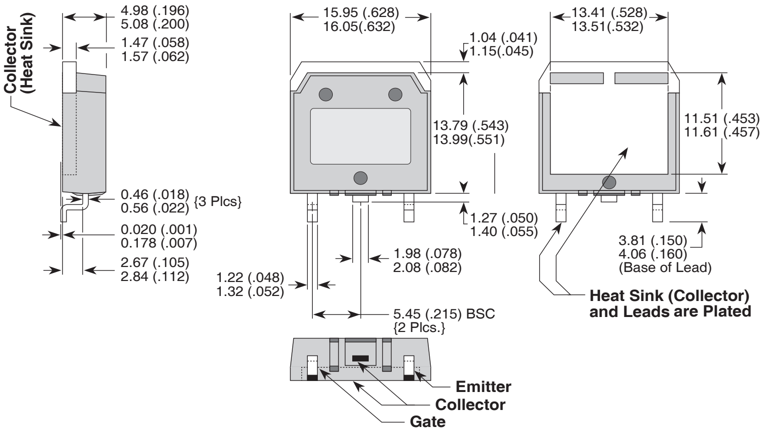
TO-247 Package Outline

D^3 Pak Package Outline

ⓔ1 SAC: Tin, Silver, Copper



Dimensions in Millimeters and (Inches)



Dimensions in Millimeters (Inches)