

Resonant Mode Combi IGBT®

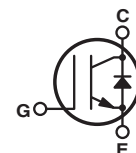
The Thunderbolt IGBT® used in this Resonant Mode Combi is a new generation of high voltage power IGBTs. Using Non-Punch-Through Technology, the Thunderbolt IGBT® offers superior ruggedness and ultrafast switching speed.

Features

- Low Forward Voltage Drop
- Low Tail Current
- Integrated Gate Resistor
- Low EMI, High Reliability
- Low forward Diode Voltage (V_F)
- RoHS Compliant
- Ultra soft recovery diode
- RBSOA and SCSOA Rated
- High Frequency Switching to 50KHz
- Ultra Low Leakage Current

Typical Applications

- ZVS Phase Shifted Bridge
- Resonant Mode Switching
- Phase Shifted Bridge
- Welding
- Induction heating
- High Frequency SMPS



Maximum Ratings

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

Symbol	Parameter	Ratings	Unit
V_{CES}	Collector-Emitter Voltage	600	Volts
V_{GE}	Gate-Emitter Voltage	± 30	
I_{C1}	Continuous Collector Current @ $T_C = 25^\circ C$	148	Amps
I_{C2}	Continuous Collector Current @ $T_C = 100^\circ C$	80	
I_{CM}	Pulsed Collector Current ^①	300	
SSOA	Switching Safe Operating Area @ $T_J = 150^\circ C$	300A @ 600V	
P_D	Total Power Dissipation	500	Watts
T_J, T_{STG}	Operating and Storage Junction Temperature Range	-55 to 150	$^\circ C$

Static Electrical Characteristics

Symbol	Characteristic / Test Conditions	Min	Typ	Max	Unit
$V_{(BR)CES}$	Collector-Emitter Breakdown Voltage ($V_{GE} = 0V, I_C = 4mA$)	600	-	-	Volts
$V_{GE(TH)}$	Gate Threshold Voltage ($V_{CE} = V_{GE}, I_C = 2.0mA, T_J = 25^\circ C$)	3	4	5	
$V_{CE(ON)}$	Collector Emitter On Voltage ($V_{GE} = 15V, I_C = 100A, T_J = 25^\circ C$)	1.7	2.1	2.5	
	Collector Emitter On Voltage ($V_{GE} = 15V, I_C = 100A, T_J = 125^\circ C$)	-	2.5	-	
I_{CES}	Collector Cut-off Current ($V_{CE} = 600V, V_{GE} = 0V, T_J = 25^\circ C$) ^②	-	-	75	μA
	Collector Cut-off Current ($V_{CE} = 600V, V_{GE} = 0V, T_J = 125^\circ C$) ^②	-	-	1500	
I_{GES}	Gate-Emitter Leakage Current ($V_{GE} = \pm 30V$)	-	-	300	nA



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

Dynamic Characteristic

APT100GT60JRDL

Symbol	Characteristic	Test Conditions	Min	Typ	Max	Unit
C_{ies}	Input Capacitance	$V_{GE} = 0V, V_{CE} = 25V$ $f = 1MHz$	-	5150	-	pF
C_{oes}	Output Capacitance		-	475	-	
C_{res}	Reverse Transfer Capacitance		-	295	-	
V_{GEP}	Gate-to-Emitter Plateau Voltage	Gate Charge $V_{GE} = 15V$ $V_{CE} = 300V$ $I_C = 100A$	-	8.0	-	V
Q_g	Total Gate Charge ^③		-	460	-	nC
Q_{ge}	Gate-Emitter Charge		-	40	-	
Q_{gc}	Gate-Collector Charge		-	210	-	
SSOA	Switching Safe Operating Area	$T_J = 150^{\circ}C, R_G = 4.3\Omega, V_{GE} = 15V,$ $L = 100\mu H, V_{CE} = 600V$	300			A
$t_{d(on)}$	Turn-On Delay Time	Inductive Switching (25°C) $V_{CC} = 400V$ $V_{GE} = 15V$ $I_C = 100A$ $R_G = 4.3\Omega$ $T_J = +25^{\circ}C$	-	40	-	ns
t_r	Current Rise Time		-	75	-	
$t_{d(off)}$	Turn-Off Delay Time		-	320	-	
t_f	Current Fall Time		-	100	-	
E_{on1}	Turn-On Switching Energy ^④	Inductive Switching (125°C) $V_{CC} = 400V$ $V_{GE} = 15V$ $I_C = 100A$ $R_G = 4.3\Omega$ $T_J = +125^{\circ}C$	-	3250	-	μJ
E_{on2}	Turn-On Switching Energy ^⑤		-	3525	-	
E_{off}	Turn-Off Switching Energy ^⑥		-	3125	-	ns
$t_{d(on)}$	Turn-On Delay Time		-	40	-	
t_r	Current Rise Time		-	75	-	
$t_{d(off)}$	Turn-Off Delay Time		-	350	-	
t_f	Current Fall Time		-	100	-	
E_{on1}	Turn-On Switching Energy ^④		-	3275	-	μJ
E_{on2}	Turn-On Switching Energy ^⑤		-	4650	-	
E_{off}	Turn-Off Switching Energy ^⑥		-	3750	-	

Thermal and Mechanical Characteristics

Symbol	Characteristic / Test Conditions	Min	Typ	Max	Unit
$R_{\theta JC}$	Junction to Case (IGBT)	-	-	0.25	$^{\circ}C/W$
$R_{\theta JC}$	Junction to Case (DIODE)	-	-	0.34	
W_T	Package Weight	-	29.2	-	g
Torque	Terminals and Mounting Screws	-	-	10	in-lbf
		-	-	1.1	N·m
$V_{Isolation}$	RMS Voltage (50-60Hz Sinusoidal Waveform from Terminals to Mounting Base for 1 Min.)	2500	-	-	Volts

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 R_G is external gate resistance not including gate driver impedance.

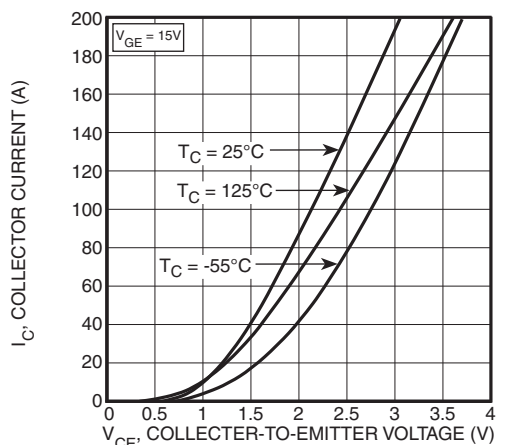


FIGURE 1, Output Characteristics ($V_{GE} = 15V$)

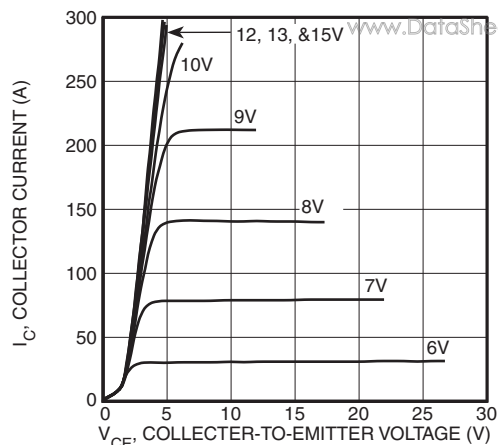


FIGURE 2, Output Characteristics ($T_J = 125^\circ C$)

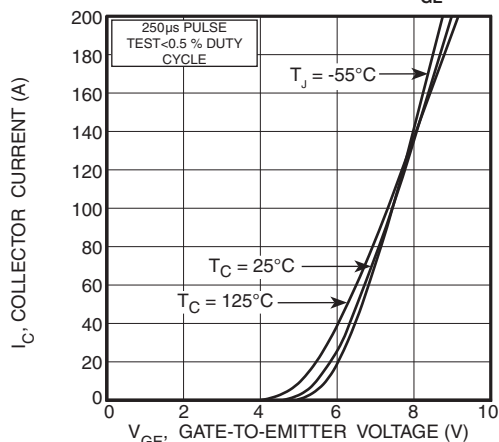


FIGURE 3, Transfer Characteristics

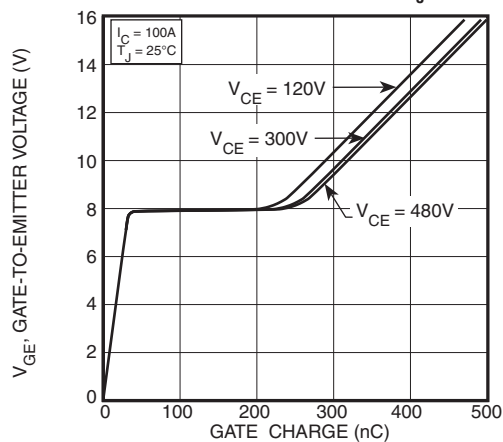


FIGURE 4, Gate Charge

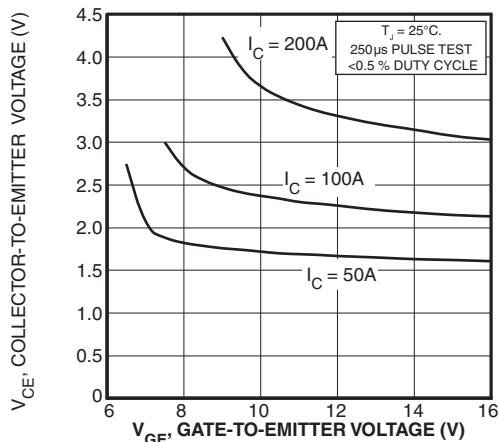


FIGURE 5, On State Voltage vs Gate-to-Emitter Voltage

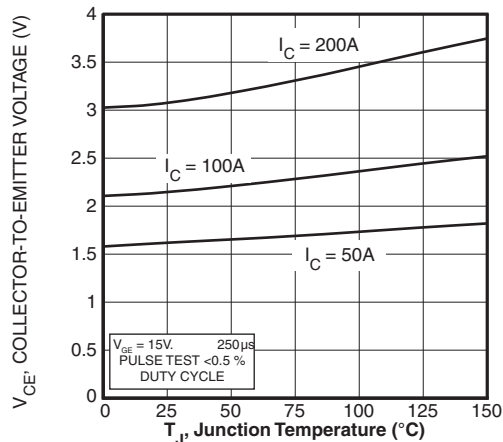
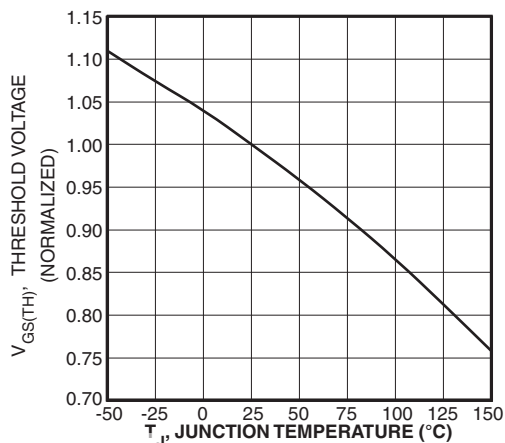


FIGURE 6, On State Voltage vs Junction Temperature



Threshold Voltage vs. Junction Temperature

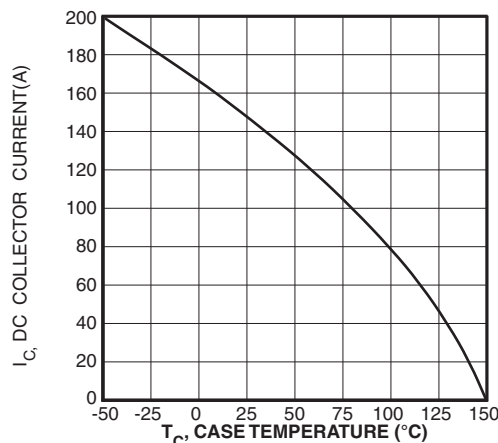


FIGURE 8, DC Collector Current vs Case Temperature

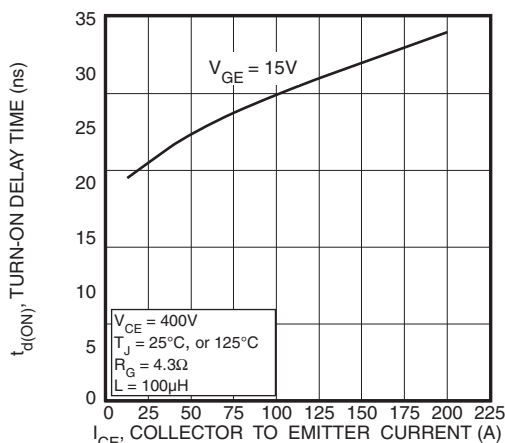


FIGURE 9, Turn-On Delay Time vs Collector Current

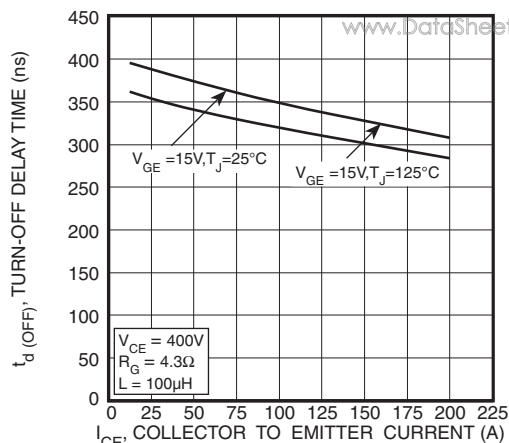


FIGURE 10, Turn-Off Delay Time vs Collector Current

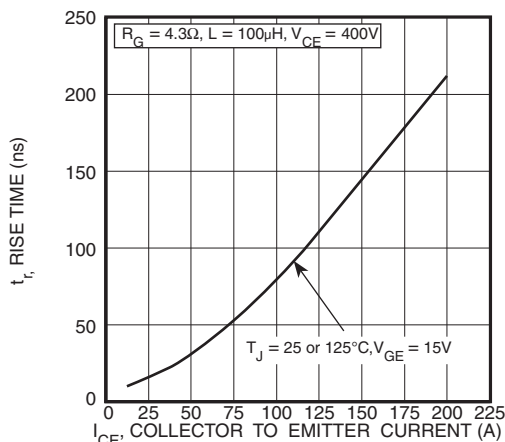


FIGURE 11, Current Rise Time vs Collector Current

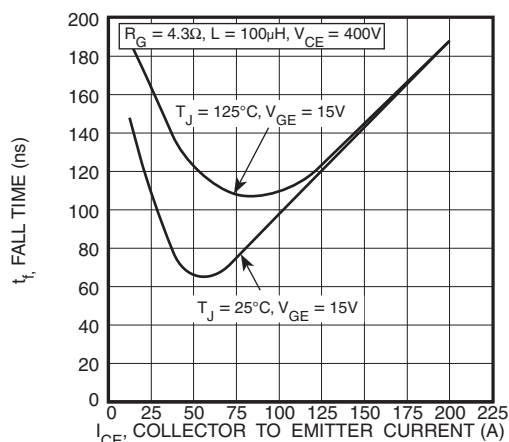


FIGURE 12, Current Fall Time vs Collector Current

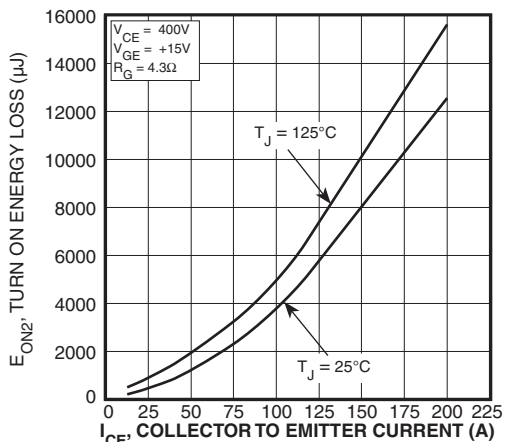


FIGURE 13, Turn-On Energy Loss vs Collector Current

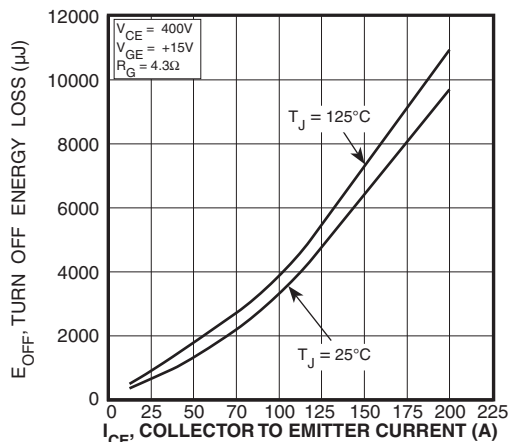


FIGURE 14, Turn Off Energy Loss vs Collector Current

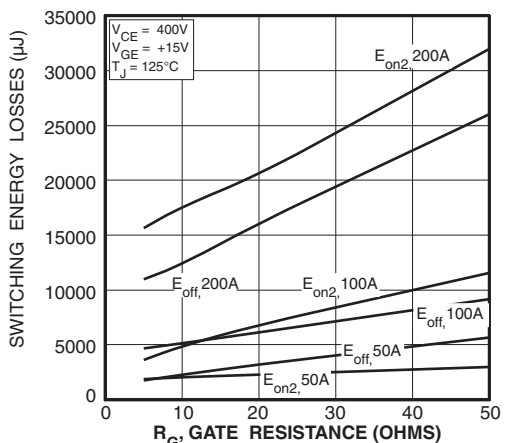


FIGURE 15, Switching Energy Losses vs. Gate Resistance

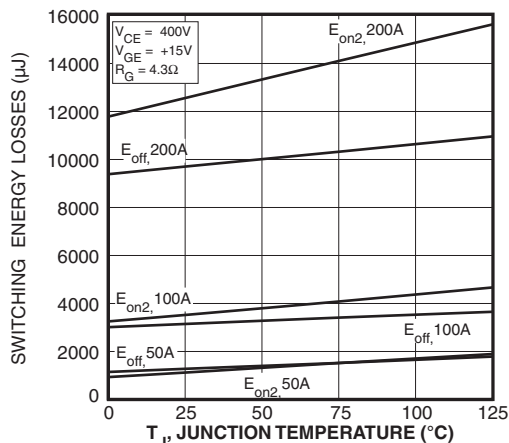


FIGURE 16, Switching Energy Losses vs Junction Temperature

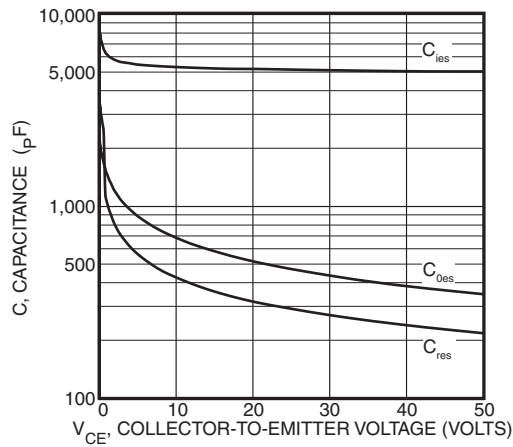


Figure 17, Capacitance vs Collector-To-Emitter Voltage

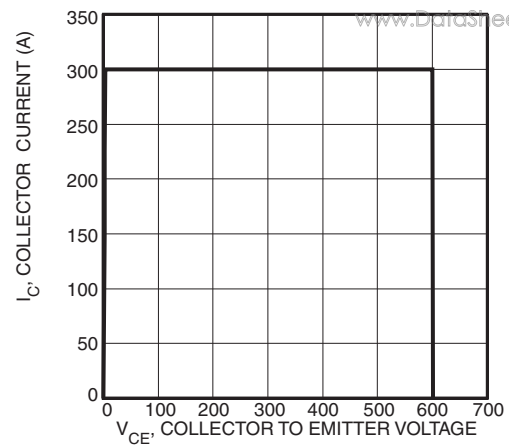


Figure 18, Minimum Switching Safe Operating Area

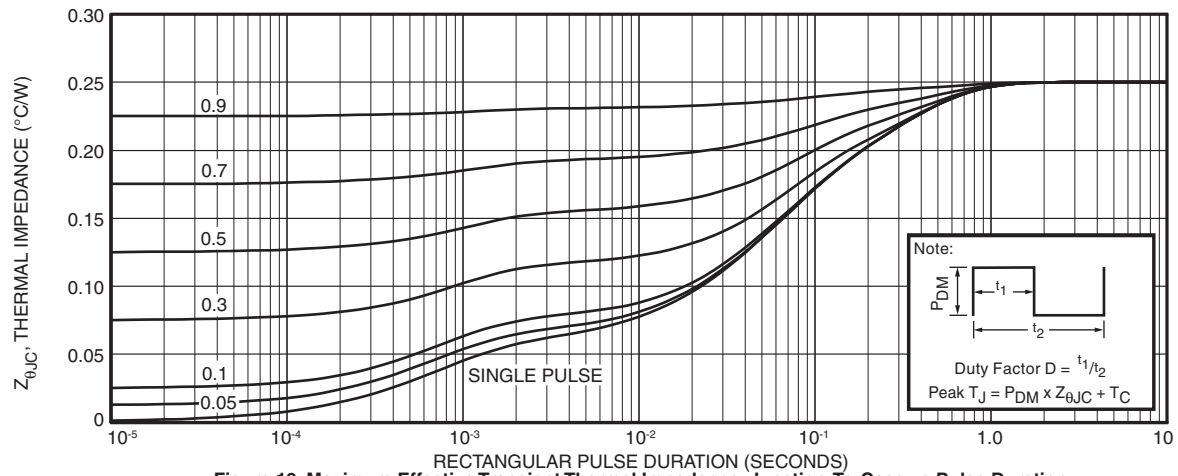


Figure 19, Maximum Effective Transient Thermal Impedance, Junction-To-Case vs Pulse Duration

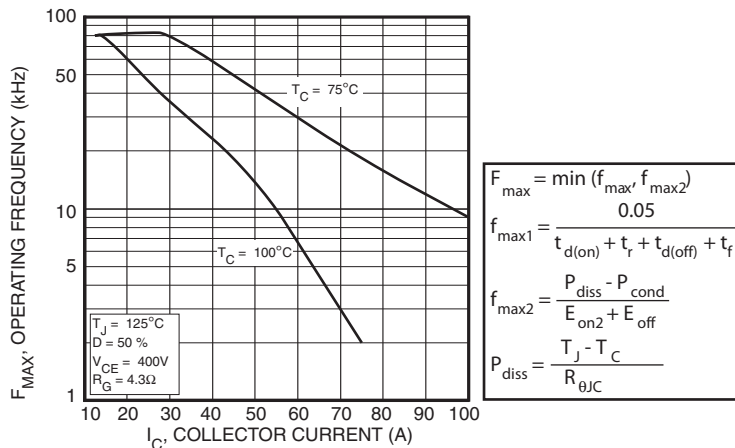


Figure 20, Operating Frequency vs Collector Current

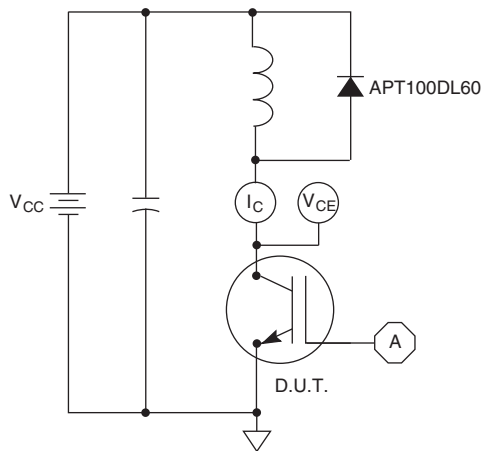


Figure 21, Inductive Switching Test Circuit

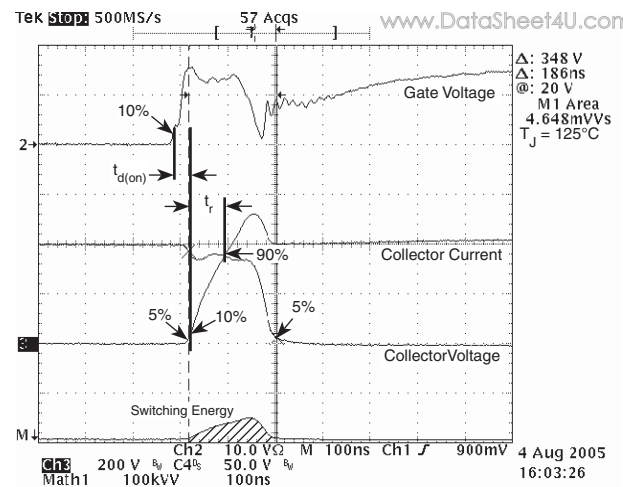


Figure 22, Turn-on Switching Waveforms and Definitions

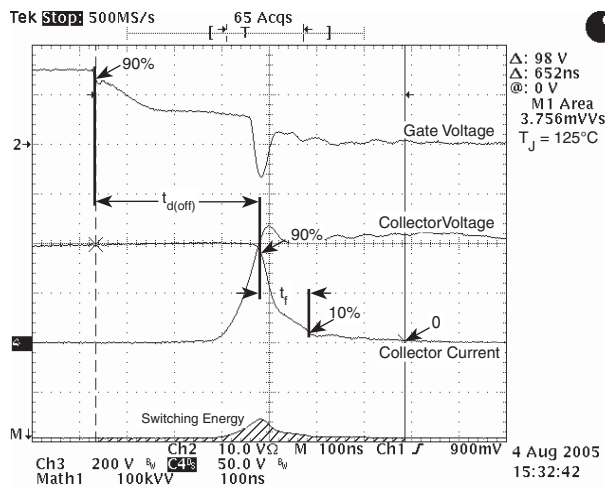


Figure 23, Turn-off Switching Waveforms and Definitions

ULTRAFAST SOFT RECOVERY ANTI-PARALLEL DIODE

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MAXIMUM RATINGS

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

Symbol	Characteristic / Test Conditions	APT100GT60JRDL	Unit
$I_{F(AV)}$	Maximum Average Forward Current ($T_C = 60^\circ\text{C}$, Duty Cycle = 0.5)	100	Amps
$I_{F(RMS)}$	RMS Forward Current (Square wave, 50% duty)	300	
I_{FSM}	Non-Repetitive Forward Surge Current ($T_J = 45^\circ\text{C}$, 8.3 ms)	600	

STATIC ELECTRICAL CHARACTERISTICS

Symbol	Characteristic / Test Conditions		Min	Type	Max	Unit
V _F	Forward Voltage	I _F = 100A	1.6	-	2.1	Volts
		I _F = 200A		2.0		
		I _F = 100A, T _J = 125°C		1.25		

DYNAMIC CHARACTERISTICS

Symbol	Characteristic	Test Conditions	Min	Typ	Max	Unit
t_{rr}	Reverse Recovery Time	$I_F = 1\text{A}, di_F/dt = -100\text{A}/\mu\text{s}, V_R = 30\text{V}, T_J = 25^\circ\text{C}$	-	110	-	ns
t_{rr}	Reverse Recovery Time	$I_F = 100\text{A}, di_F/dt = -200\text{A}/\mu\text{s}, V_R = 400\text{V}, T_C = 25^\circ\text{C}$	-	487	-	ns
Q_{rr}	Reverse Recovery Charge		-	2328	-	nC
I_{RRM}	Maximum Reverse Recovery Current		-	11	-	Amps
t_{rr}	Reverse Recovery Time	$I_F = 100\text{A}, di_F/dt = -200\text{A}/\mu\text{s}, V_R = 400\text{V}, T_C = 125^\circ\text{C}$	-	716	-	ns
Q_{rr}	Reverse Recovery Charge		-	5954	-	nC
I_{RRM}	Maximum Reverse Recovery Current		-	18	-	Amps
t_{rr}	Reverse Recovery Time	$I_F = 100\text{A}, di_F/dt = -1000\text{A}/\mu\text{s}, V_R = 400\text{V}, T_C = 125^\circ\text{C}$	-	333	-	ns
Q_{rr}	Reverse Recovery Charge		-	10002	-	nC
I_{RRM}	Maximum Reverse Recovery Current		-	49	-	Amps

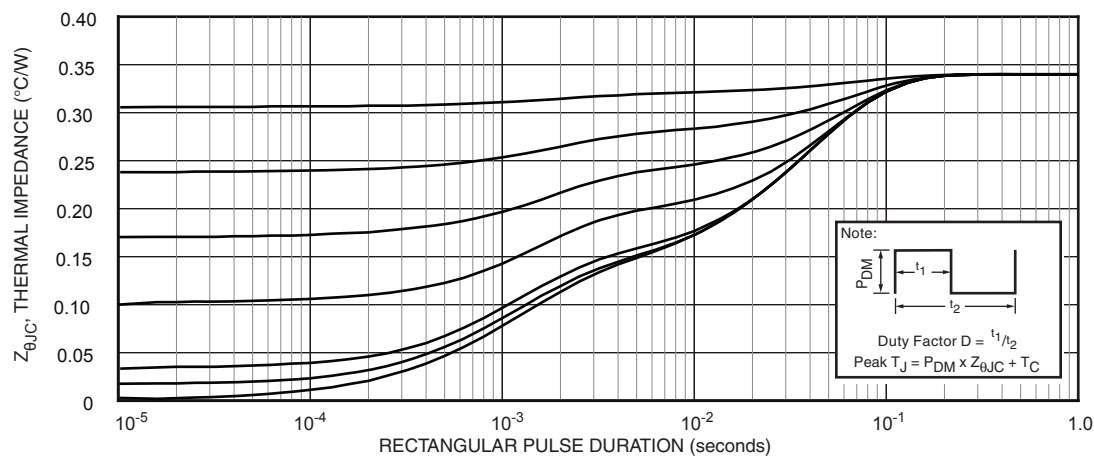


FIGURE 1. MAXIMUM EFFECTIVE TRANSIENT THERMAL IMPEDANCE, JUNCTION-TO-CASE vs. PULSE DURATION

Typical Performance Curves

APT100GT60JRDL

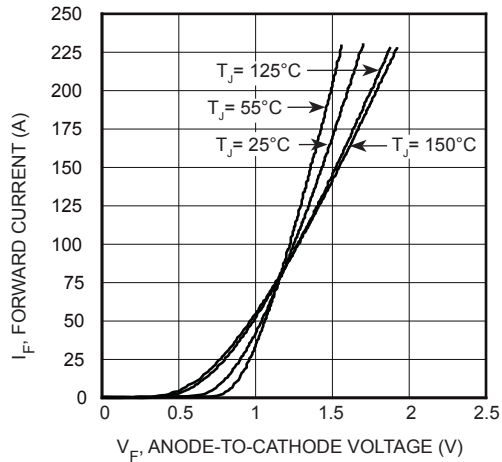


FIGURE 2, Forward Current vs. Forward Voltage

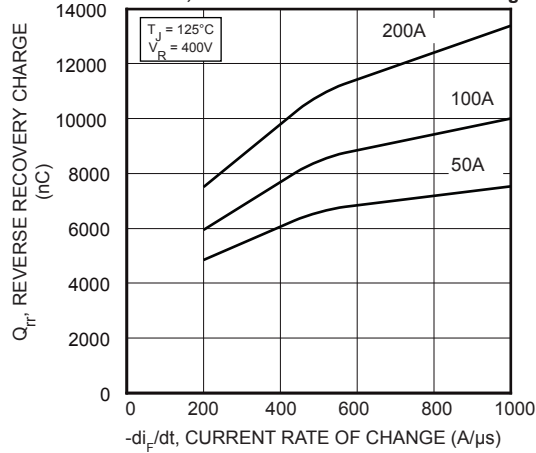


FIGURE 4, Reverse Recovery Charge vs. Current Rate of Change

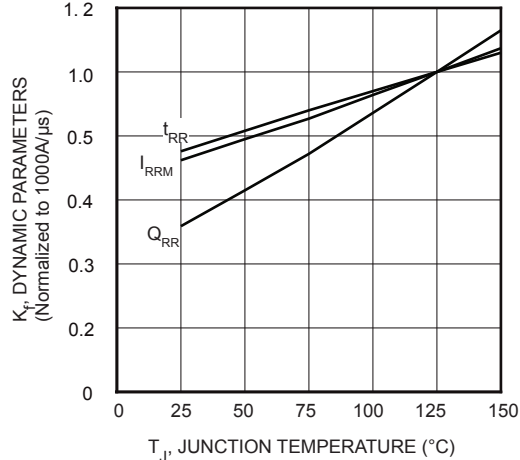


FIGURE 6, Dynamic Parameters vs. Junction Temperature

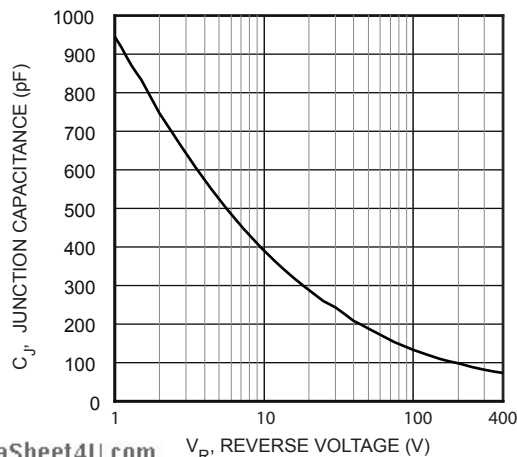


FIGURE 8, Junction Capacitance vs. Reverse Voltage

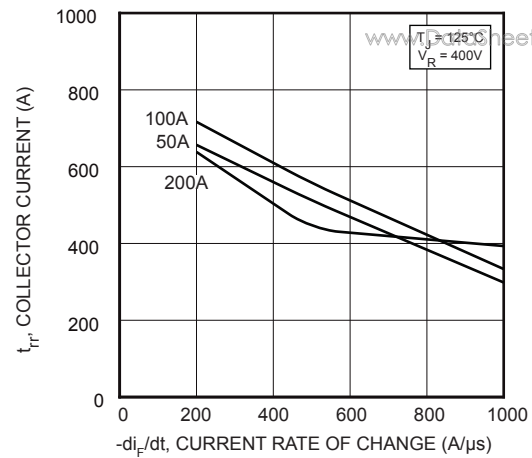


FIGURE 3, Reverse Recovery Time vs. Current Rate of Change

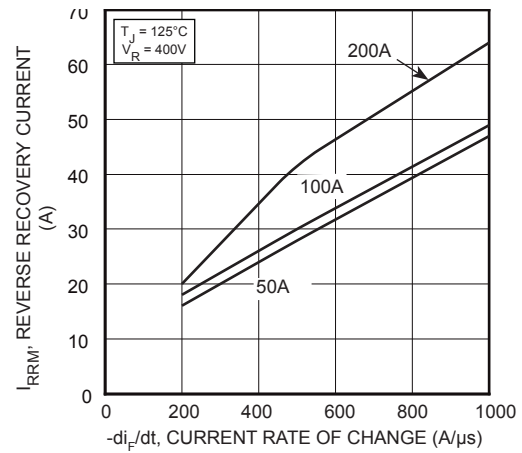


FIGURE 5, Reverse Recovery Current vs. Current Rate of Change

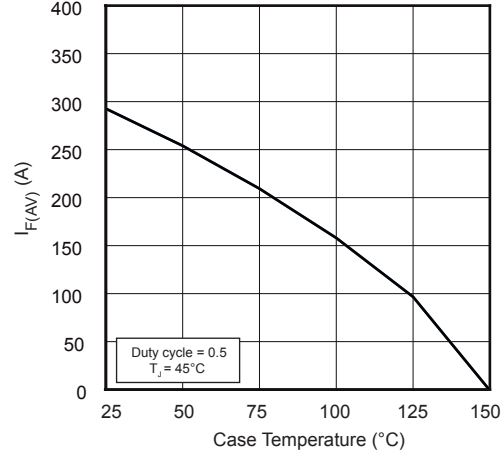


FIGURE 7, Maximum Average Forward Current vs. Case Temperature

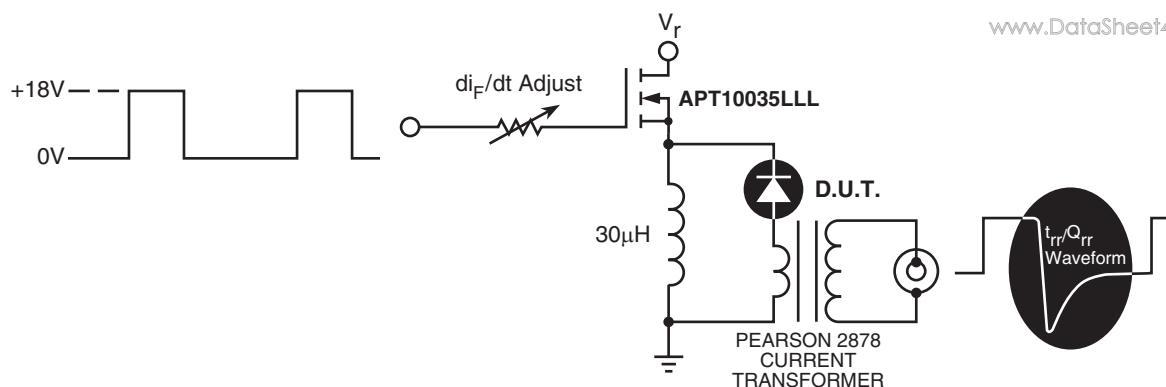


Figure 32, Diode Test Circuit

- 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} .

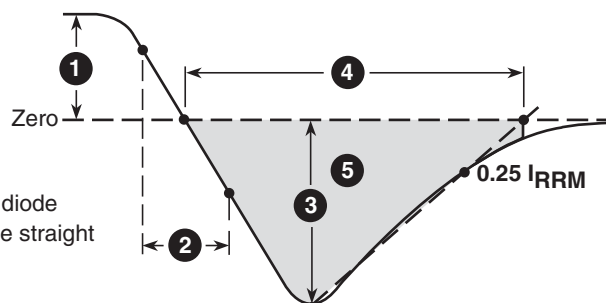
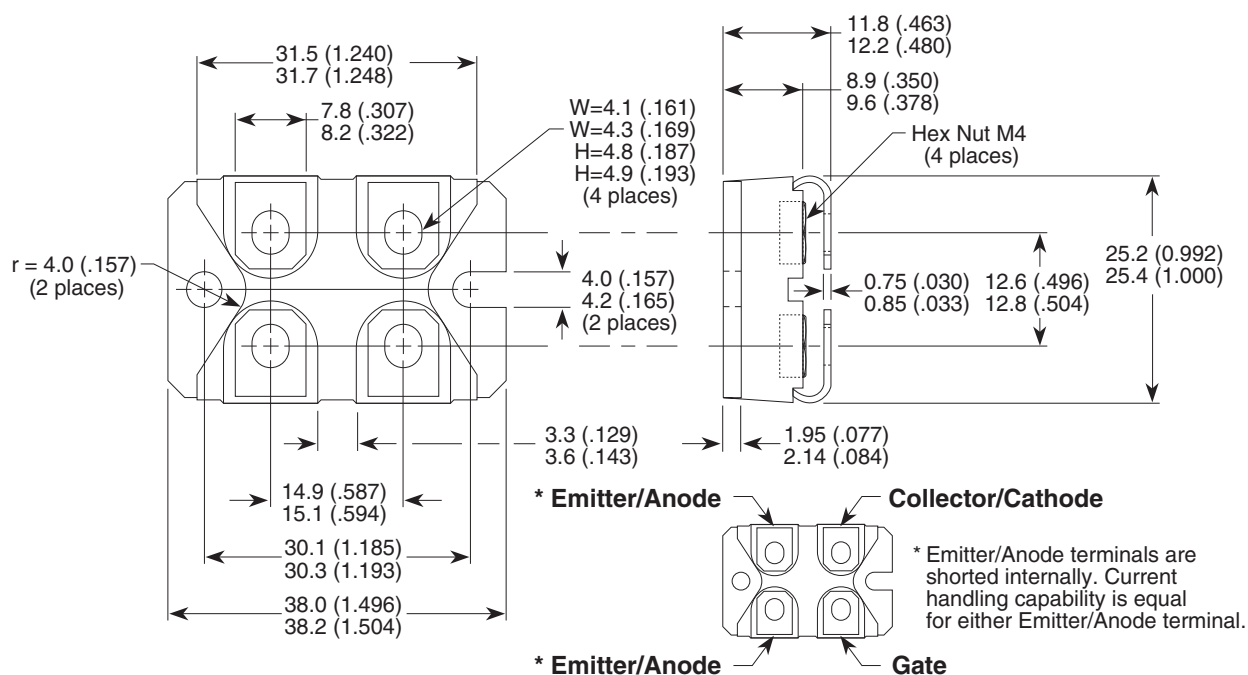


Figure 33, Diode Reverse Recovery Waveform and Definitions

SOT-227 (ISOTOP®) Package Outline



Dimensions in Millimeters and (Inches)