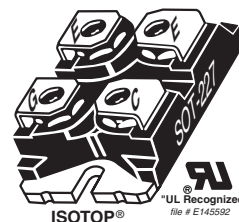


Resonant Mode Combi IGBT®

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.

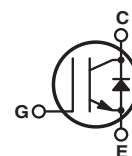


Features

- 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	APT200GT60JRDL	UNIT
V_{CES}	Collector-Emitter Voltage	600	Volts
V_{GE}	Gate-Emitter Voltage	± 30	
I_{C1}	Continuous Collector Current @ $T_C = 25^\circ C$	195	Amps
I_{C2}	Continuous Collector Current @ $T_C = 100^\circ C$	100	
I_{CM}	Pulsed Collector Current ^①	600	
SSOA	Switching Safe Operating Area @ $T_J = 150^\circ C$	600A @ 600V	
P_D	Total Power Dissipation	595	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	Units
$V_{(BR)CES}$	Collector-Emitter Breakdown Voltage ($V_{GE} = 0V, I_C = 1.0mA$)	600			Volts
$V_{GE(TH)}$	Gate Threshold Voltage ($V_{CE} = V_{GE}, I_C = 4mA, T_J = 25^\circ C$)	3	4	5	
$V_{CE(ON)}$	Collector-Emitter On Voltage ($V_{GE} = 15V, I_C = 200A, T_J = 25^\circ C$)	1.6	2.0	2.5	
	Collector-Emitter On Voltage ($V_{GE} = 15V, I_C = 200A, T_J = 125^\circ C$)		2.5		
I_{CES}	Collector Cut-off Current ($V_{CE} = 600V, V_{GE} = 0V, T_J = 25^\circ C$) ^②			50	μA
	Collector Cut-off Current ($V_{CE} = 600V, V_{GE} = 0V, T_J = 125^\circ C$) ^②			1500	
I_{GES}	Gate-Emitter Leakage Current ($V_{GE} = \pm 30V$)			600	nA

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

DYNAMIC CHARACTERISTICS

APT200GT60JRDL

Symbol	Characteristic	Test Conditions	MIN	TYP	MAX	UNIT
C_{ies}	Input Capacitance	Capacitance $V_{GE} = 0V, V_{CE} = 25V$ $f = 1\text{ MHz}$		8650		pF
C_{oes}	Output Capacitance			546		
C_{res}	Reverse Transfer Capacitance			1180		
V_{GEP}	Gate-to-Emitter Plateau Voltage	Gate Charge $V_{GE} = 15V$ $V_{CE} = 300V$ $I_C = 200A$		7.5		V
Q_g	Total Gate Charge ^③			946		nC
Q_{ge}	Gate-Emitter Charge			58		
Q_{gc}	Gate-Collector ("Miller") Charge			430		
SSOA	Switching Safe Operating Area	$T_J = 150^\circ C, R_G = 4.3\Omega, V_{GE} = 15V, L = 100\mu H, V_{CE} = 600V$	600			A
$t_{d(on)}$	Turn-on Delay Time	Inductive Switching ($25^\circ C$) $V_{CC} = 400V$ $V_{GE} = 15V$ $I_C = 200A$ $R_G = 2.2\Omega$ $T_J = +25^\circ C$		72		ns
t_r	Current Rise Time			160		
$t_{d(off)}$	Turn-off Delay Time			952		
t_f	Current Fall Time			212		
E_{on1}						μJ
E_{on2}	Turn-on Switching Energy (Diode) ^⑤			9193		
E_{off}	Turn-off Switching Energy ^⑥			19290		
$t_{d(on)}$	Turn-on Delay Time	Inductive Switching ($125^\circ C$) $V_{CC} = 400V$ $V_{GE} = 15V$ $I_C = 200A$ $R_G = 2.2\Omega$ $T_J = +125^\circ C$		71		ns
t_r	Current Rise Time			157		
$t_{d(off)}$	Turn-off Delay Time			1030		
t_f	Current Fall Time			202		
E_{on1}	Turn-on Switching Energy ^④					μJ
E_{on2}	Turn-on Switching Energy (Diode) ^⑤			10460		
E_{off}	Turn-off Switching Energy ^⑥			20210		

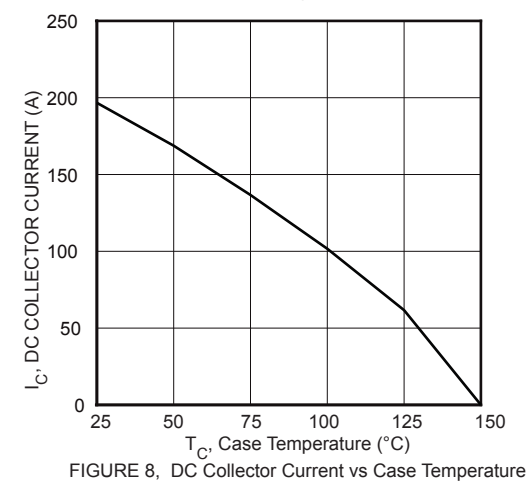
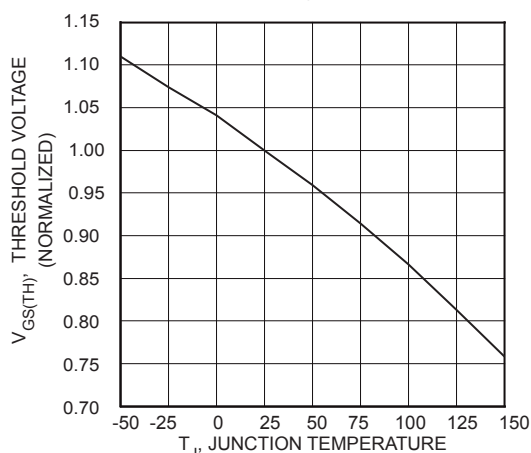
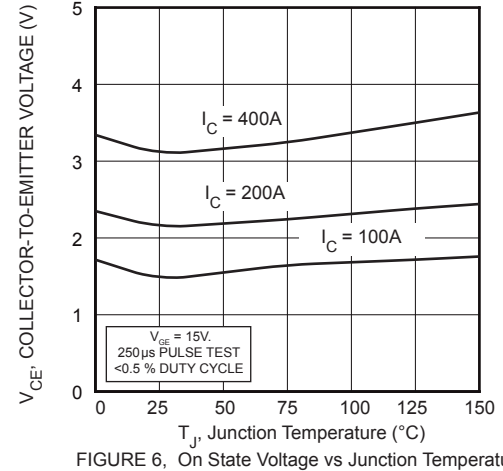
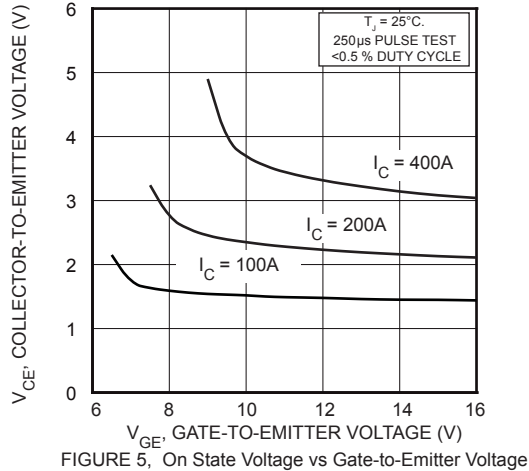
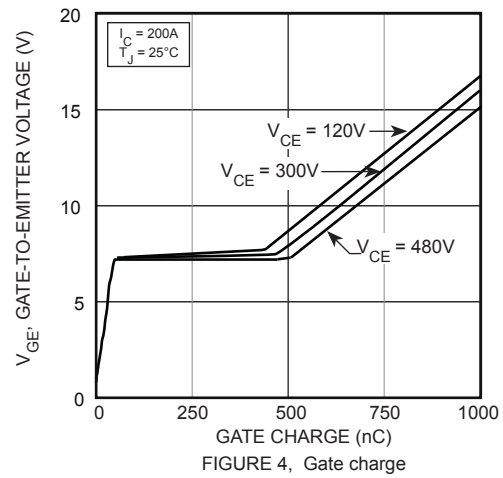
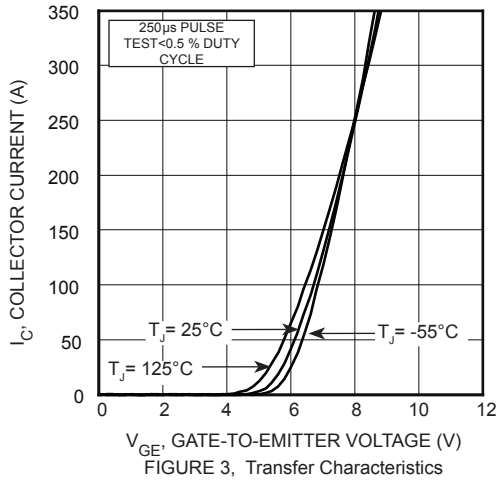
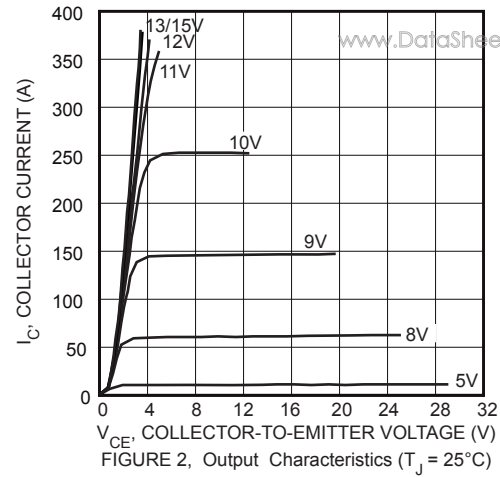
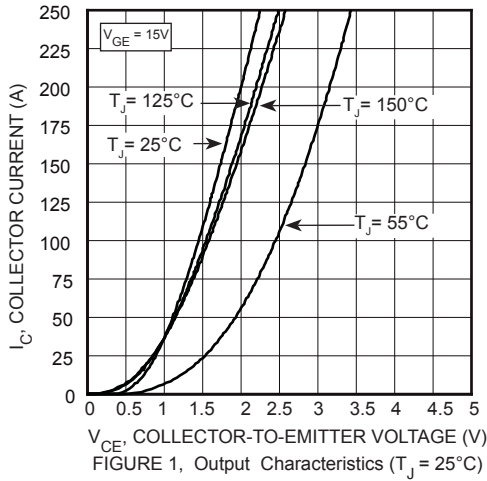
THERMAL AND MECHANICAL CHARACTERISTICS

Symbol	Characteristic	MIN	TYP	MAX	UNIT
$R_{\theta JC}$	Junction to Case (IGBT)			.21	$^\circ C/W$
$R_{\theta JC}$	Junction to Case (DIODE)			.61	
W_T	Package Weight	29.2			gm
$V_{Isolation}$	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.)

TYPICAL PERFORMANCE CURVES

APT200GT60JRD1



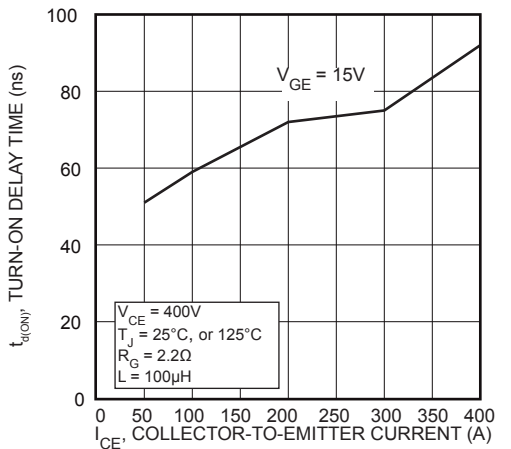


FIGURE 9, Turn-On Delay Time vs Collector Current

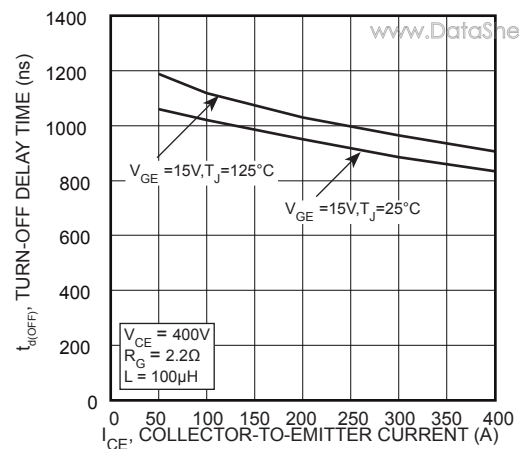


FIGURE 10, Turn-Off Delay Time vs Collector Current

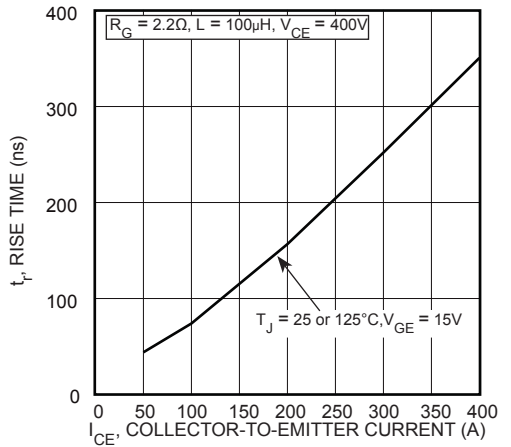


FIGURE 11, Current Rise Time vs Collector Current

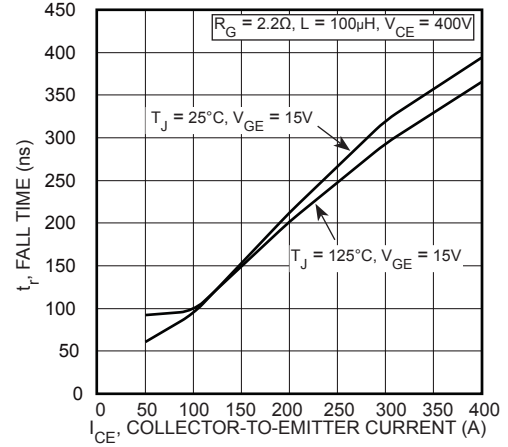


FIGURE 12, Current Fall Time vs Collector Current

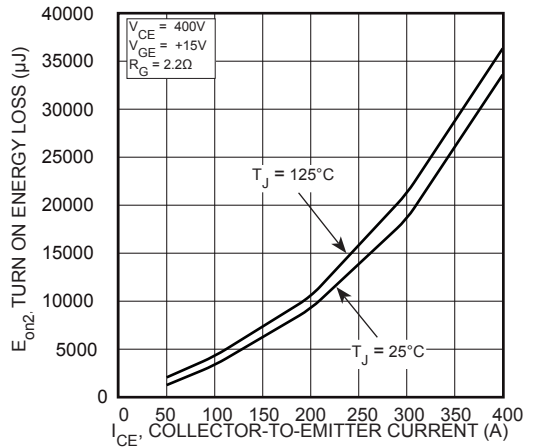


FIGURE 13, Turn-On Energy Loss vs Collector Current

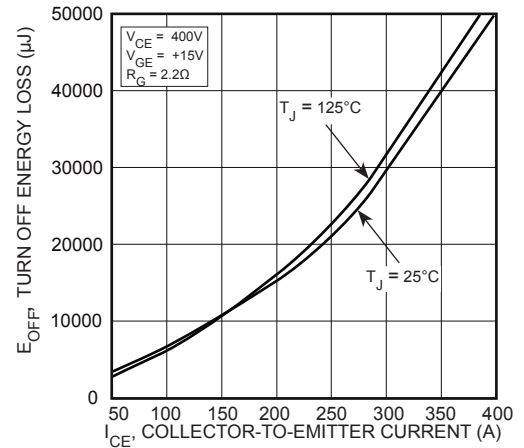


FIGURE 14, Turn-Off Energy Loss vs Collector Current

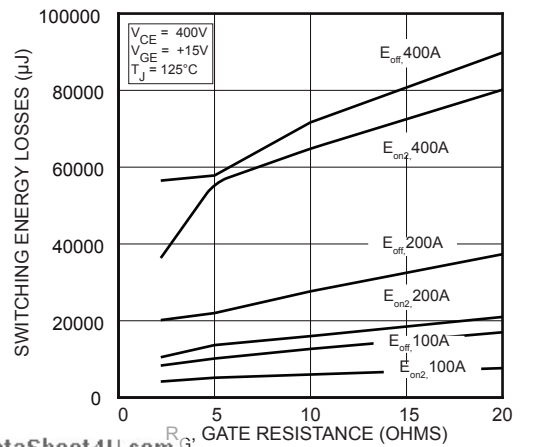


FIGURE 15, Switching Energy Losses vs Gate Resistance

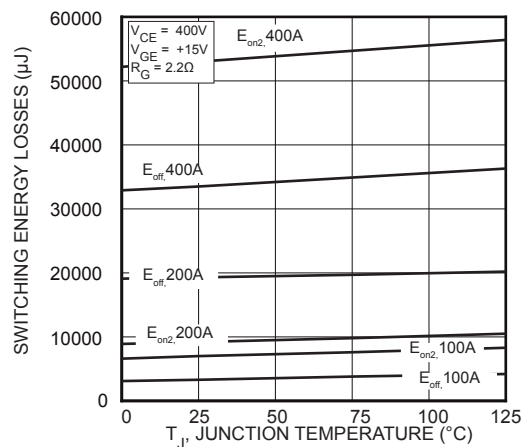


FIGURE 16, Switching Energy Losses vs Junction Temperature

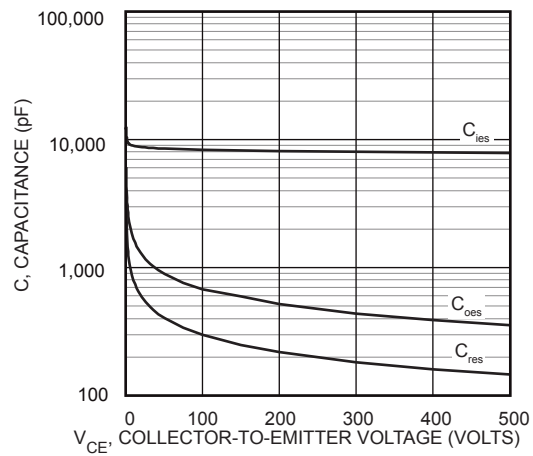


FIGURE 17, Capacitance vs Collector-To-Emitter Voltage

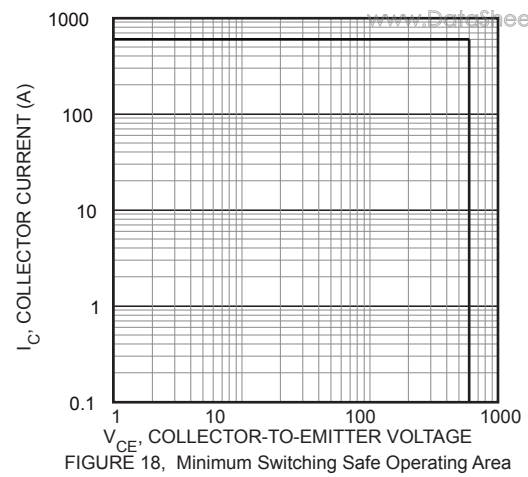


FIGURE 18, Minimum Switching Safe Operating Area

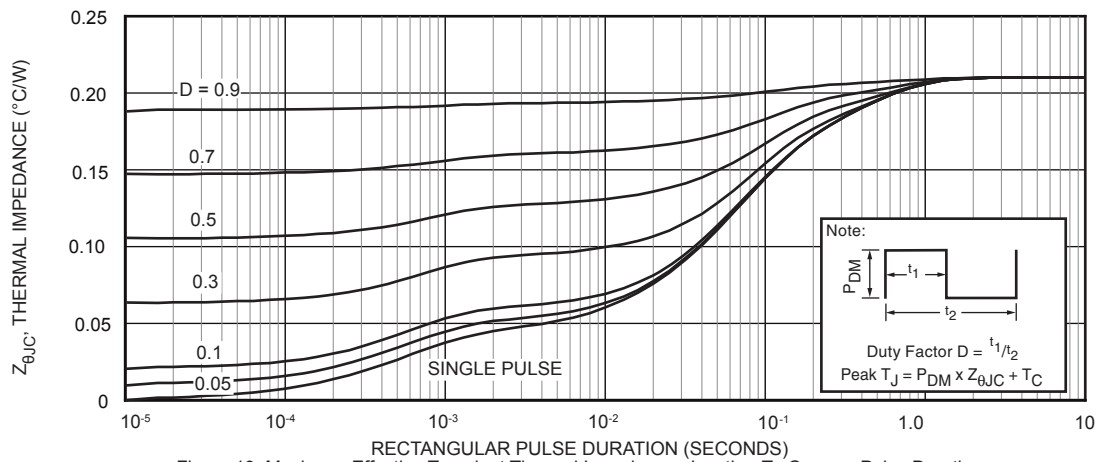


Figure 19, Maximum Effective Transient Thermal Impedance, Junction-To-Case vs Pulse Duration

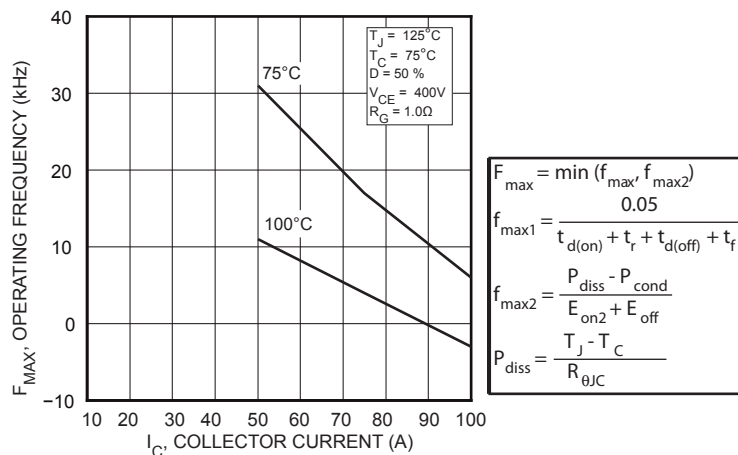


Figure 20, Operating Frequency vs Collector Current

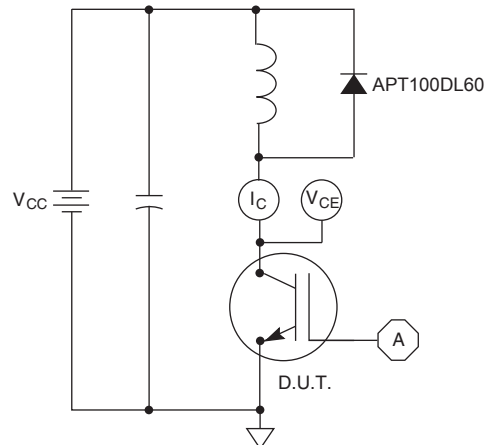


Figure 21, Inductive Switching Test Circuit

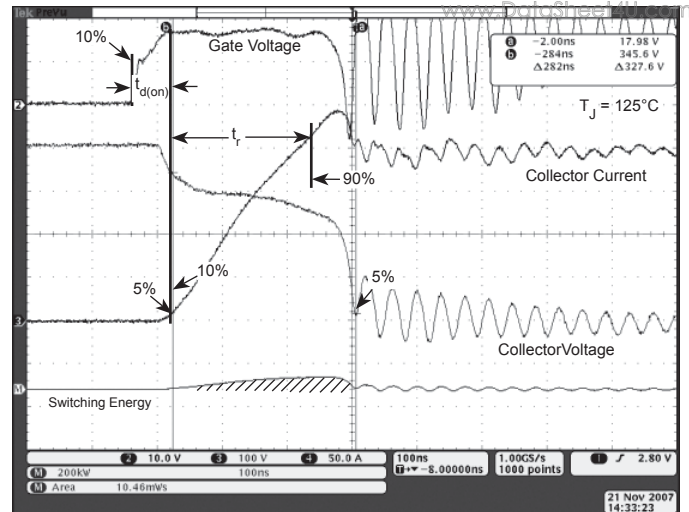


Figure 22, Turn-on Switching Waveforms and Definitions

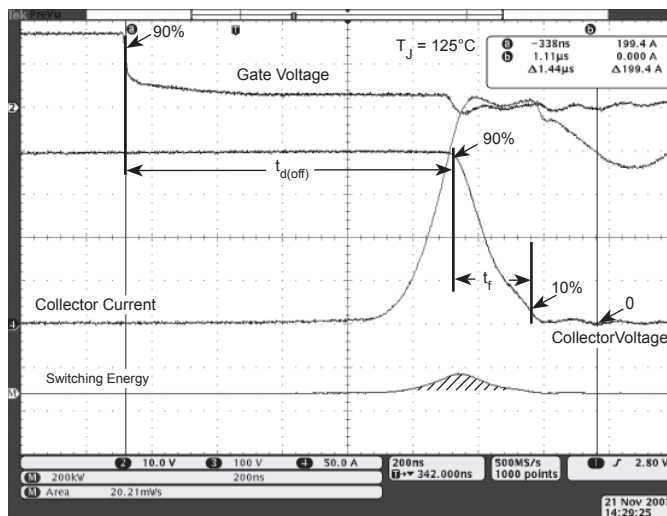


Figure 23, Turn-off Switching Waveforms and Definitions

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	APT200GT60JRDL	Unit
$I_{F(AV)}$	Maximum Average Forward Current ($T_C = 50^\circ\text{C}$, Duty Cycle = 0.5)	100	Amps
$I_{F(RMS)}$	RMS Forward Current (Square wave, 50% duty)	116	
I_{FSM}	Non-Repetitive Forward Surge Current ($T_J = 45^\circ\text{C}$, 8.3 ms)	640	

STATIC ELECTRICAL CHARACTERISTICS

Symbol	Characteristic / Test Conditions	Min	Type	Max	Unit
V_F	Forward Voltage		$I_F = 100\text{A}$	1.25	Volts
			$I_F = 200\text{A}$	2.0	
			$I_F = 50\text{A}, T_J = 125^\circ\text{C}$	1.25	

DYNAMIC CHARACTERISTICS

Symbol	Characteristic	Test Conditions	Min	Typ	Max	Unit
t_{rr}	Reverse Recovery Time	$I_F = 1\text{A}, di_F/dt = -100\text{A}/\mu\text{s}, V_R = 30\text{V}, T_J = 25^\circ\text{C}$	-	56	-	ns
t_{rr}	Reverse Recovery Time	$I_F = 100\text{A}, di_F/dt = -200\text{A}/\mu\text{s}, V_R = 400\text{V}, T_C = 25^\circ\text{C}$	-	379	-	ns
Q_{rr}	Reverse Recovery Charge		-	2202	-	nC
I_{RRM}	Maximum Reverse Recovery Current		-	12	-	Amps
t_{rr}	Reverse Recovery Time	$I_F = 100\text{A}, di_F/dt = -200\text{A}/\mu\text{s}, V_R = 400\text{V}, T_C = 125^\circ\text{C}$	-	580	-	ns
Q_{rr}	Reverse Recovery Charge		-	5925	-	nC
I_{RRM}	Maximum Reverse Recovery Current		-	19	-	Amps
t_{rr}	Reverse Recovery Time	$I_F = 100\text{A}, di_F/dt = -1000\text{A}/\mu\text{s}, V_R = 400\text{V}, T_C = 125^\circ\text{C}$	-	264	-	ns
Q_{rr}	Reverse Recovery Charge		-	9530	-	nC
I_{RRM}	Maximum Reverse Recovery Current		-	61	-	Amps

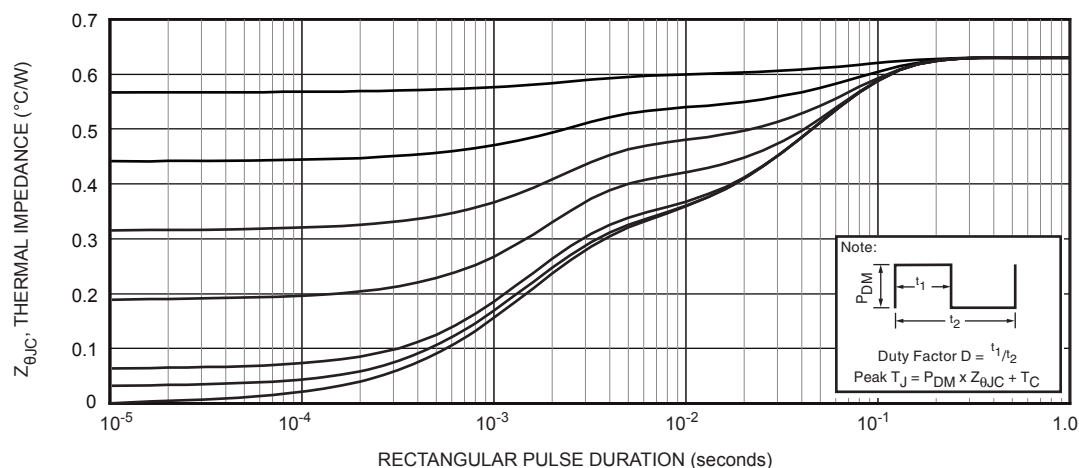


FIGURE 1. MAXIMUM EFFECTIVE TRANSIENT THERMAL IMPEDANCE, JUNCTION-TO-CASE vs. PULSE DURATION

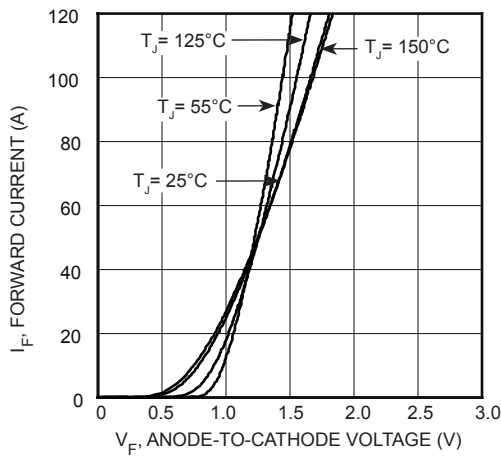


FIGURE 2, Forward Current vs. Forward Voltage

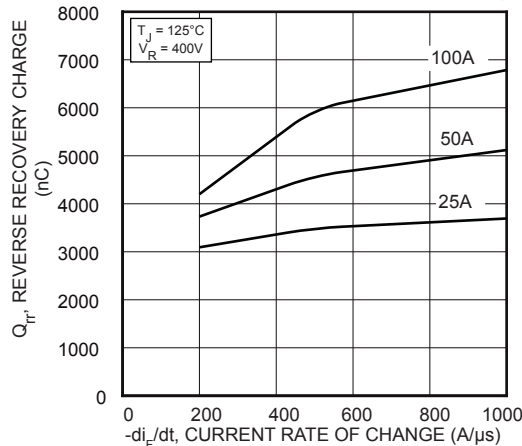


FIGURE 4, Reverse Recovery Charge vs. Current Rate of Change

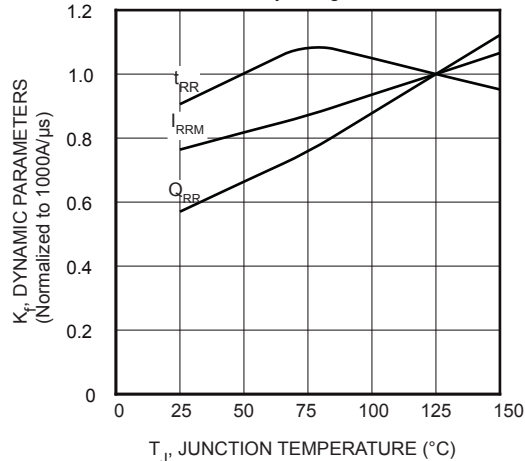


FIGURE 6, Dynamic Parameters vs. Junction Temperature

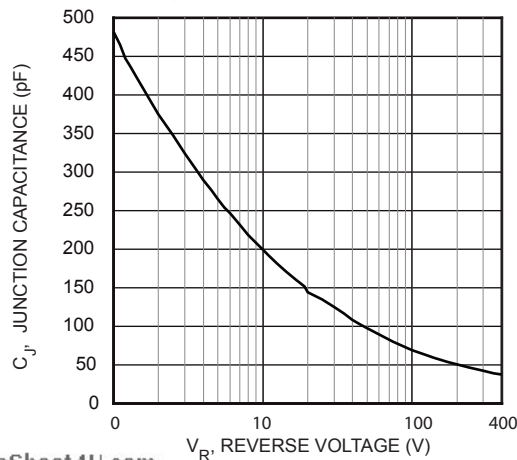


FIGURE 8, Junction Capacitance vs. Reverse Voltage

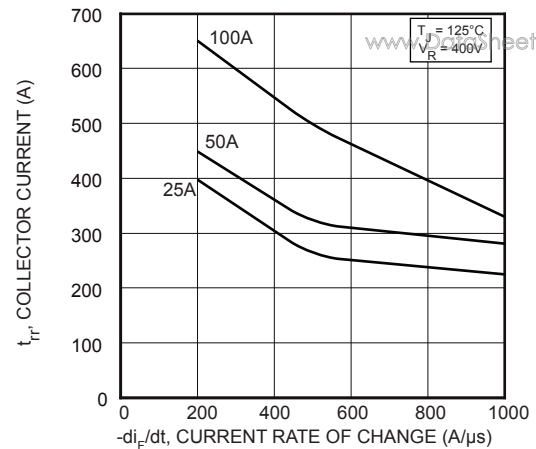


FIGURE 3, Reverse Recovery Time vs. Current Rate of Change

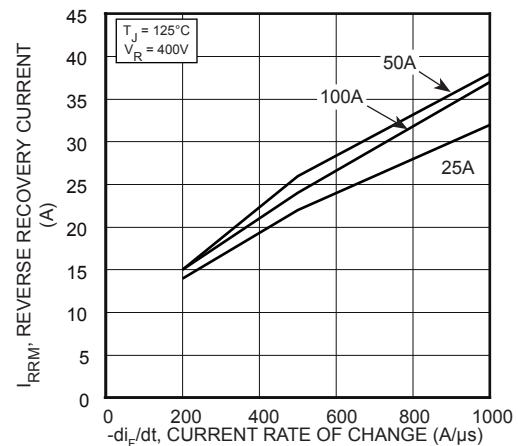


FIGURE 5, Reverse Recovery Current vs. Current Rate of Change

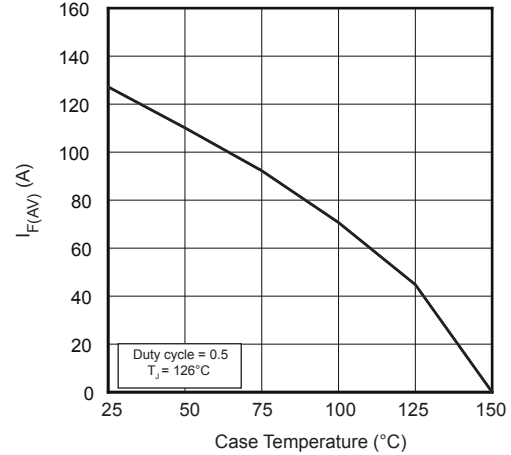


FIGURE 7, Maximum Average Forward Current vs. Case Temperature

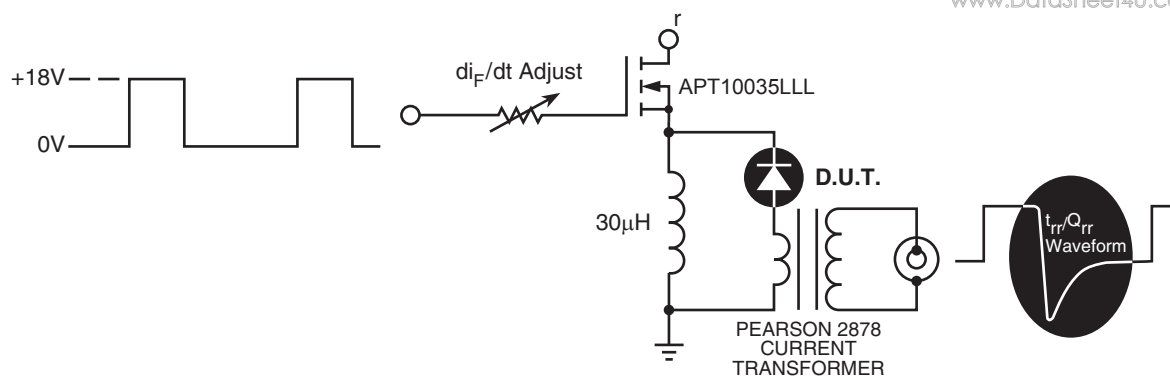


Figure 32, Diode Test Circuit

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} .

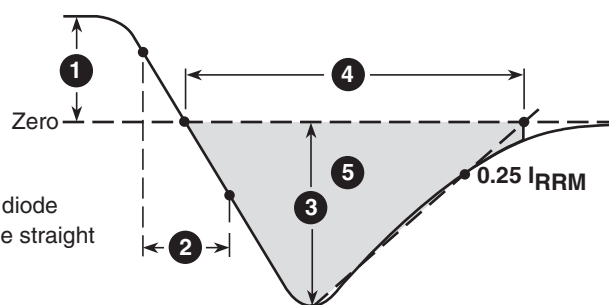
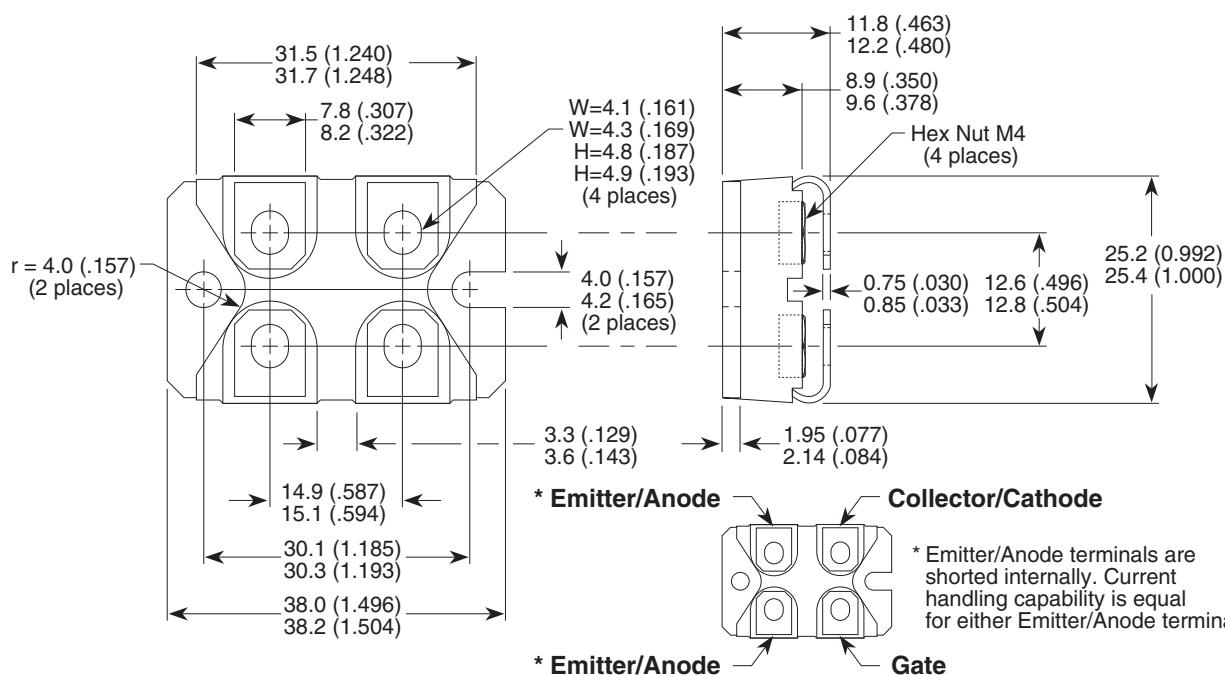


Figure 33, Diode Reverse Recovery Waveform and Definitions

SOT-227 (ISOTOP®) Package Outline



Dimensions in Millimeters and (Inches)