

### General Description

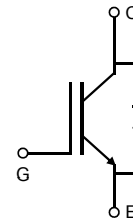
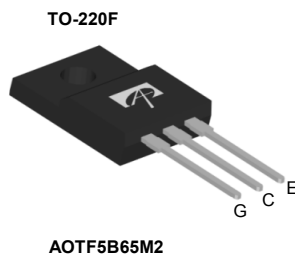
- Latest AlphaIGBT ( $\alpha$  IGBT) technology
- 650V breakdown voltage
- Very fast and soft recovery freewheeling diode
- High efficient turn-on di/dt controllability
- Low VCE(SAT) enables high efficiencies
- Low turn-off switching loss and softness
- Very good EMI behavior
- High short-circuit ruggedness

### Applications

- Motor Drives
- Home appliance applications such as refrigerators and washing machines
- Fan, Pumps, Vacuum Cleaner
- Other Hard Switching Applications

### Product Summary

$V_{CE}$	650V
$I_C$ ( $T_C=100^\circ\text{C}$ )	5A
$V_{CE(sat)}$ ( $T_J=25^\circ\text{C}$ )	1.57V



Orderable Part Number	Package Type	Form	Minimum Order Quantity
AOTF5B65M2	TO220F	Tube	1000

### Absolute Maximum Ratings $T_A=25^\circ\text{C}$ unless otherwise noted

Parameter	Symbol	AOTF5B65M2	Units
Collector-Emitter Voltage	$V_{CE}$	650	V
Gate-Emitter Voltage	$V_{GE}$	$\pm 30$	V
Continuous Collector Current	$I_C$	$T_C=25^\circ\text{C}$	$10^2$
		$T_C=100^\circ\text{C}$	$5^2$
Pulsed Collector Current, Limited by $T_{Jmax}$	$I_{CM}$	15	A
Turn off SOA, $V_{CE} \leq 650\text{V}$ , Limited by $T_{Jmax}$	$I_{LM}$	15	A
Continuous Diode Forward Current	$I_F$	$T_C=25^\circ\text{C}$	$10^2$
		$T_C=100^\circ\text{C}$	$5^2$
Diode Pulsed Current, Limited by $T_{Jmax}$	$I_{FM}$	15	A
Short circuit withstanding time <sup>1)</sup> $V_{GE}=15\text{V}$ , $V_{CC} \leq 400\text{V}$ , $T_J \leq 150^\circ\text{C}$	$t_{SC}$	5	$\mu\text{s}$
Power Dissipation	$P_D$	$T_C=25^\circ\text{C}$	25
		$T_C=100^\circ\text{C}$	10
Junction and Storage Temperature Range	$T_J, T_{STG}$	-55 to 150	$^\circ\text{C}$
Maximum lead temperature for soldering purpose, 1/8" from case for 5 seconds	$T_L$	300	$^\circ\text{C}$

### Thermal Characteristics

Parameter	Symbol	AOTF5B65M2	Units
Maximum Junction-to-Ambient	$R_{\theta JA}$	65	$^\circ\text{C/W}$
Maximum IGBT Junction-to-Case	$R_{\theta JC}$	5	$^\circ\text{C/W}$
Maximum Diode Junction-to-Case	$R_{\theta JC}$	7	$^\circ\text{C/W}$

1) Allowed number of short circuits: <1000; time between short circuits: >1s.

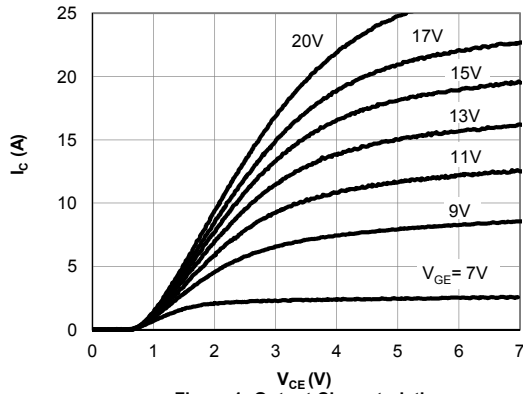
2) TO220F  $I_C$  follows TO220/TO263.

**Electrical Characteristics (T<sub>J</sub>=25°C unless otherwise noted)**

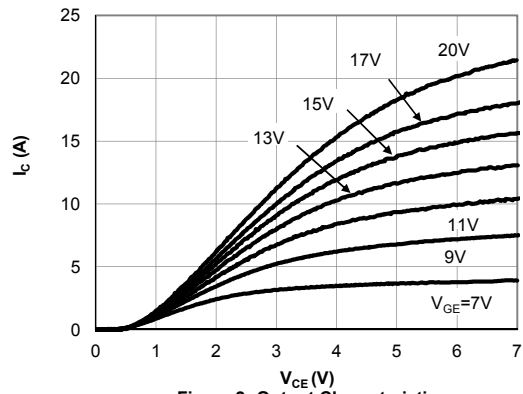
Symbol	Parameter	Conditions	Min	Typ	Max	Units	
<b>STATIC PARAMETERS</b>							
$BV_{CES}$	Collector-Emitter Breakdown Voltage	$I_C=1mA, V_{GE}=0V, T_J=25^\circ C$	650	-	-	V	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$V_{GE}=15V, I_C=5A$	$T_J=25^\circ C$	-	1.57	1.98	V
			$T_J=125^\circ C$	-	1.87	-	
			$T_J=150^\circ C$	-	1.95	-	
$V_F$	Diode Forward Voltage	$V_{GE}=0V, I_C=5A$	$T_J=25^\circ C$	-	1.48	1.9	V
			$T_J=125^\circ C$	-	1.49	-	
			$T_J=150^\circ C$	-	1.46	-	
$V_{GE(th)}$	Gate-Emitter Threshold Voltage	$V_{CE}=5V, I_C=1mA$	-	5.1	-	V	
$I_{CES}$	Zero Gate Voltage Collector Current	$V_{CE}=650V, V_{GE}=0V$	$T_J=25^\circ C$	-	-	10	$\mu A$
			$T_J=125^\circ C$	-	-	100	
			$T_J=150^\circ C$	-	-	500	
$I_{GES}$	Gate-Emitter leakage current	$V_{CE}=0V, V_{GE}=\pm 30V$	-	-	$\pm 100$	nA	
$g_{FS}$	Forward Transconductance	$V_{CE}=20V, I_C=5A$	-	4.1	-	S	
<b>DYNAMIC PARAMETERS</b>							
$C_{ies}$	Input Capacitance	$V_{GE}=0V, V_{CC}=25V, f=1MHz$	-	348	-	pF	
$C_{oes}$	Output Capacitance		-	40	-	pF	
$C_{res}$	Reverse Transfer Capacitance		-	13	-	pF	
$Q_g$	Total Gate Charge	$V_{GE}=15V, V_{CC}=520V, I_C=5A$	-	14	-	nC	
$Q_{ge}$	Gate to Emitter Charge		-	3	-	nC	
$Q_{gc}$	Gate to Collector Charge		-	6.5	-	nC	
$I_{C(SC)}$	Short circuit collector current	$V_{GE}=15V, V_{CC}=400V,$ $t_{sc} \leq 5\mu s, T_J \leq 150^\circ C$	-	30	-	A	
$R_g$	Gate resistance	$V_{GE}=0V, V_{CC}=0V, f=1MHz$	-	6	-	$\Omega$	
<b>SWITCHING PARAMETERS, (Load Inductive, T<sub>J</sub>=25°C)</b>							
$t_{D(on)}$	Turn-On Delay Time	$T_J=25^\circ C$ $V_{GE}=15V, V_{CC}=400V, I_C=5A,$ $R_G=60\Omega$	-	8.5	-	ns	
$t_r$	Turn-On Rise Time		-	13	-	ns	
$t_{D(off)}$	Turn-Off Delay Time		-	106	-	ns	
$t_f$	Turn-Off Fall Time		-	18	-	ns	
$E_{on}$	Turn-On Energy		-	0.08	-	mJ	
$E_{off}$	Turn-Off Energy		-	0.07	-	mJ	
$E_{total}$	Total Switching Energy		-	0.15	-	mJ	
$t_{rr}$	Diode Reverse Recovery Time		$T_J=25^\circ C$	-	173	-	ns
$Q_{rr}$	Diode Reverse Recovery Charge		$I_F=5A, dI/dt=200A/\mu s, V_{CC}=400V$	-	0.27	-	$\mu C$
$I_{rm}$	Diode Peak Reverse Recovery Current			-	3.5	-	A
<b>SWITCHING PARAMETERS, (Load Inductive, T<sub>J</sub>=150°C)</b>							
$t_{D(on)}$	Turn-On Delay Time	$T_J=150^\circ C$ $V_{GE}=15V, V_{CC}=400V, I_C=5A,$ $R_G=60\Omega$	-	7	-	ns	
$t_r$	Turn-On Rise Time		-	14	-	ns	
$t_{D(off)}$	Turn-Off Delay Time		-	127	-	ns	
$t_f$	Turn-Off Fall Time		-	30	-	ns	
$E_{on}$	Turn-On Energy		-	0.09	-	mJ	
$E_{off}$	Turn-Off Energy		-	0.12	-	mJ	
$E_{total}$	Total Switching Energy		-	0.21	-	mJ	
$t_{rr}$	Diode Reverse Recovery Time		$T_J=150^\circ C$	-	273	-	ns
$Q_{rr}$	Diode Reverse Recovery Charge		$I_F=5A, dI/dt=200A/\mu s, V_{CC}=400V$	-	0.48	-	$\mu C$
$I_{rm}$	Diode Peak Reverse Recovery Current			-	4.4	-	A

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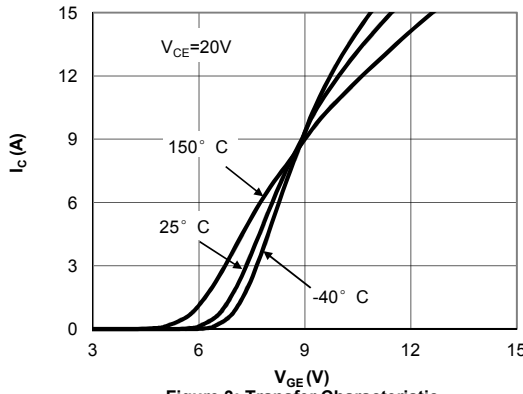
**TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS**



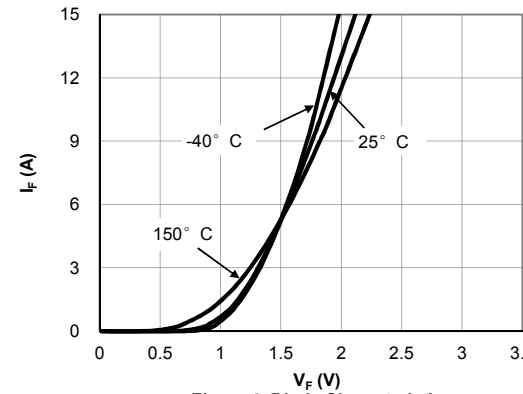
**Figure 1: Output Characteristic**  
( $T_j=25^\circ\text{C}$ )



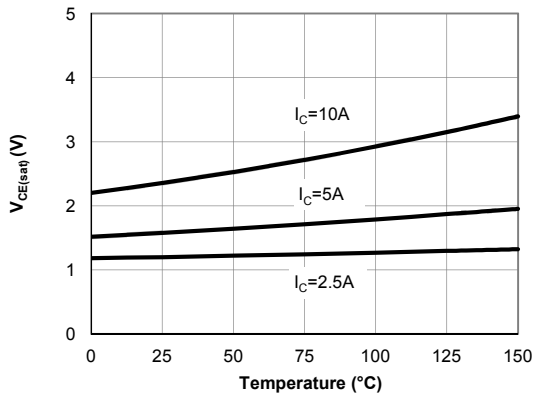
**Figure 2: Output Characteristic**  
( $T_j=150^\circ\text{C}$ )



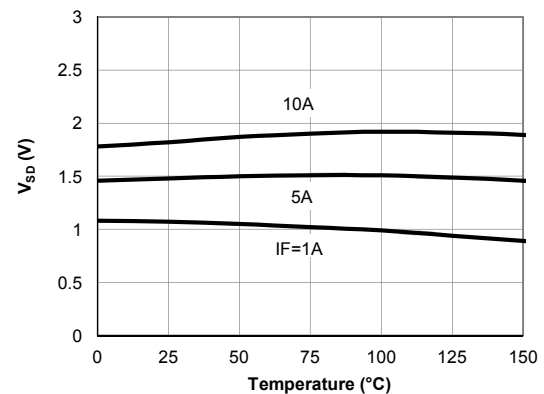
**Figure 3: Transfer Characteristic**



**Figure 4: Diode Characteristic**



**Figure 5: Collector-Emitter Saturation Voltage vs. Junction Temperature**



**Figure 6: Diode Forward voltage vs. Junction Temperature**

**TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS**

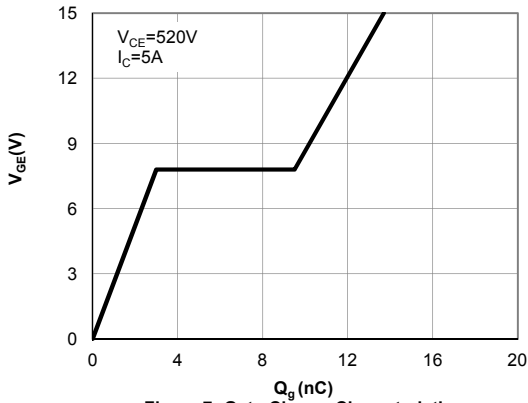


Figure 7: Gate-Charge Characteristics

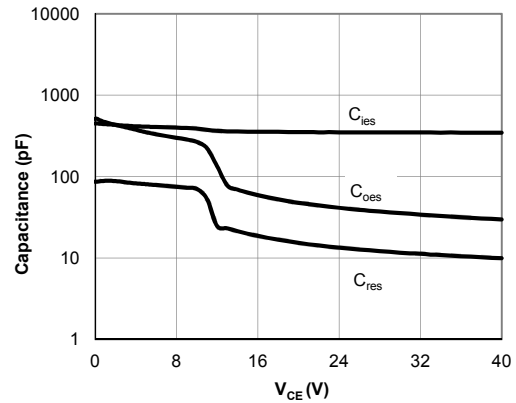


Figure 8: Capacitance Characteristic

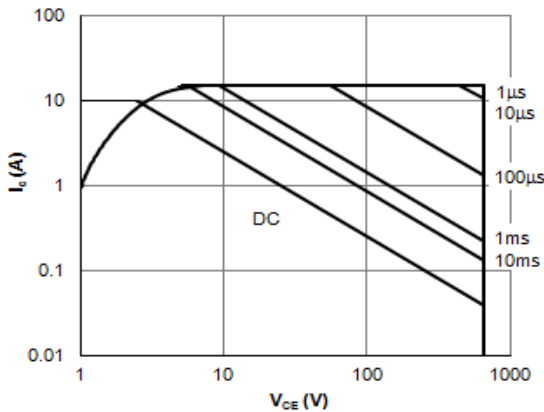


Figure 9: Forward Bias Safe Operating Area  
( $T_C=25^\circ\text{C}$ ,  $V_{GE}=15\text{V}$ )

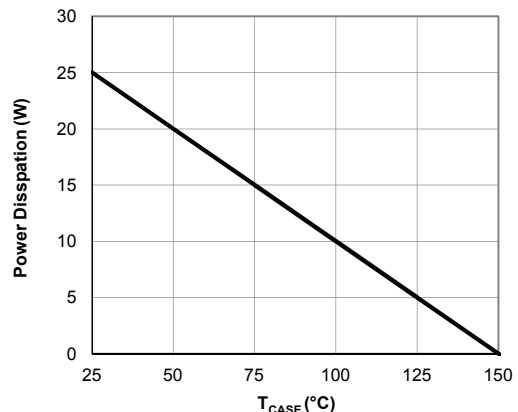


Figure 10: Power Dissipation as a Function of Case

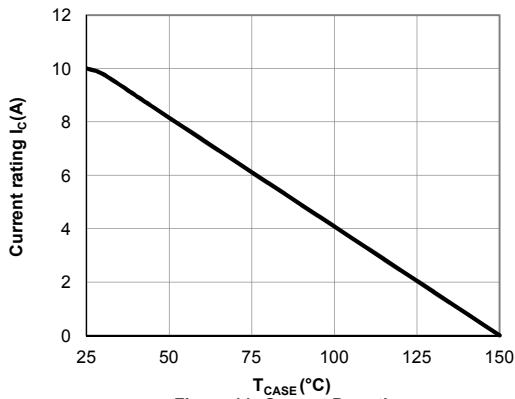


Figure 11: Current De-rating

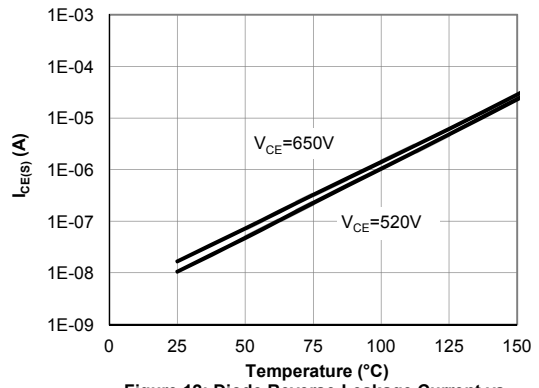
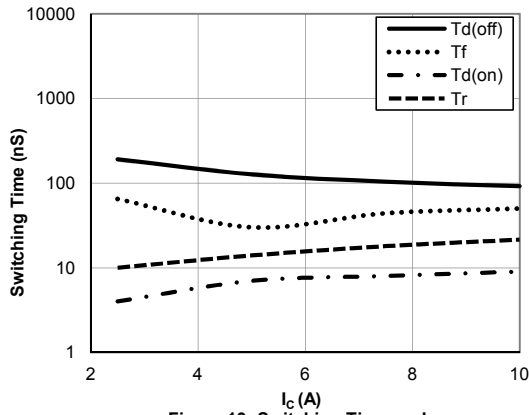
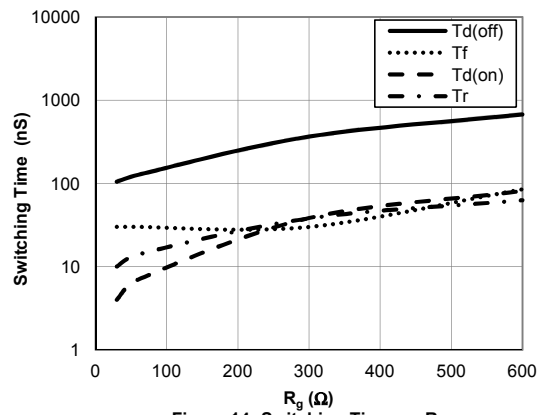


Figure 12: Diode Reverse Leakage Current vs. Junction Temperature

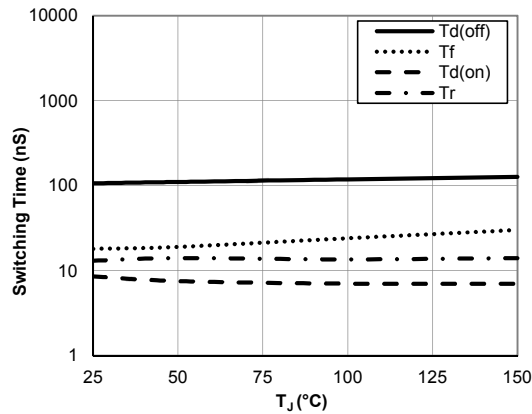
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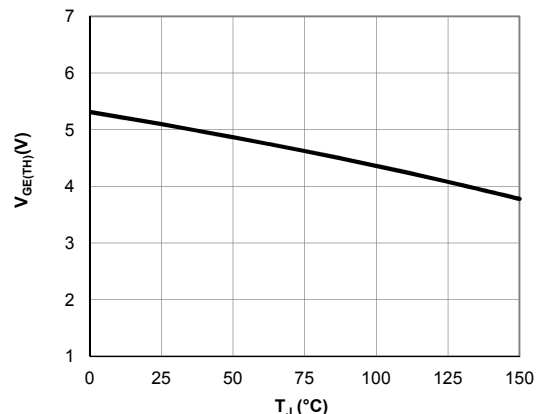
**Figure 13: Switching Time vs.  $I_C$**   
( $T_J=150^\circ\text{C}$ ,  $V_{GE}=15\text{V}$ ,  $V_{CE}=400\text{V}$ ,  $R_g=60\Omega$ )



**Figure 14: Switching Time vs.  $R_g$**   
( $T_J=150^\circ\text{C}$ ,  $V_{GE}=15\text{V}$ ,  $V_{CE}=400\text{V}$ ,  $I_C=5\text{A}$ )

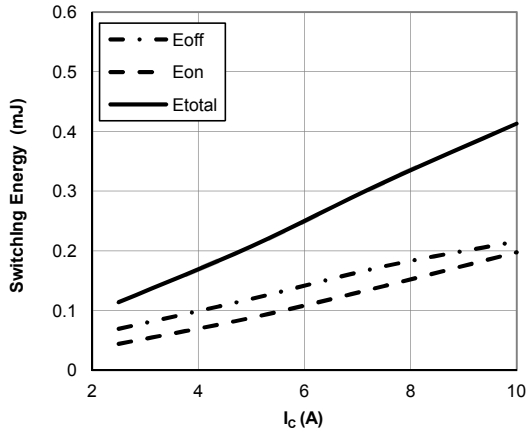


**Figure 15: Switching Time vs.  $T_J$**   
( $V_{GE}=15\text{V}$ ,  $V_{CE}=400\text{V}$ ,  $I_C=5\text{A}$ ,  $R_g=60\Omega$ )

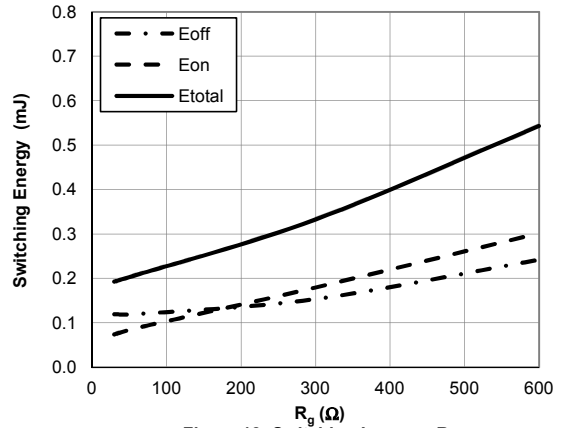


**Figure 16:  $V_{GE(TH)}$  vs.  $T_J$**

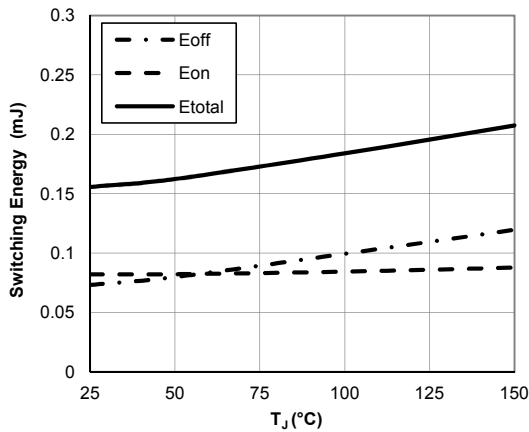
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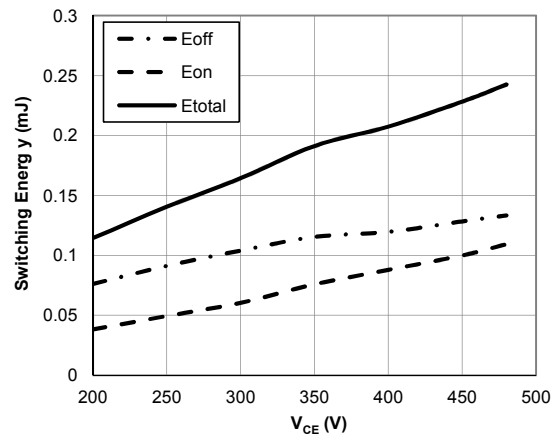
**Figure 17: Switching Loss vs.  $I_c$**   
( $T_j=150^\circ\text{C}$ ,  $V_{GE}=15\text{V}$ ,  $V_{CE}=400\text{V}$ ,  $R_g=60\Omega$ )



**Figure 18: Switching Loss vs.  $R_g$**   
( $T_j=150^\circ\text{C}$ ,  $V_{GE}=15\text{V}$ ,  $V_{CE}=400\text{V}$ ,  $I_c=5\text{A}$ )

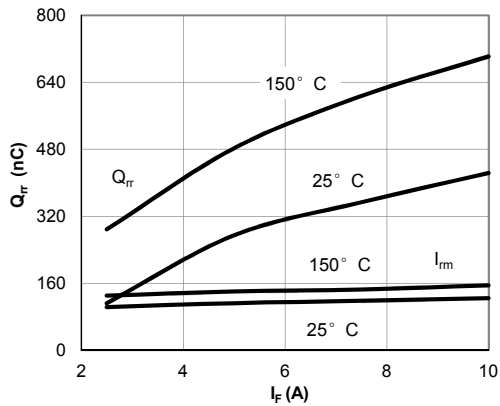


**Figure 19: Switching Loss vs.  $T_j$**   
( $V_{GE}=15\text{V}$ ,  $V_{CE}=400\text{V}$ ,  $I_c=5\text{A}$ ,  $R_g=60\Omega$ )

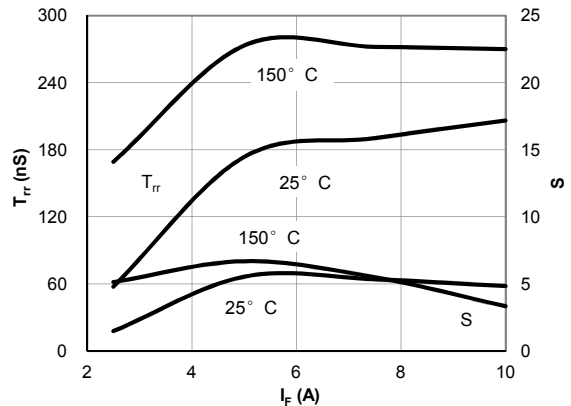


**Figure 20: Switching Loss vs.  $V_{CE}$**   
( $T_j=150^\circ\text{C}$ ,  $V_{GE}=15\text{V}$ ,  $I_c=5\text{A}$ ,  $R_g=60\Omega$ )

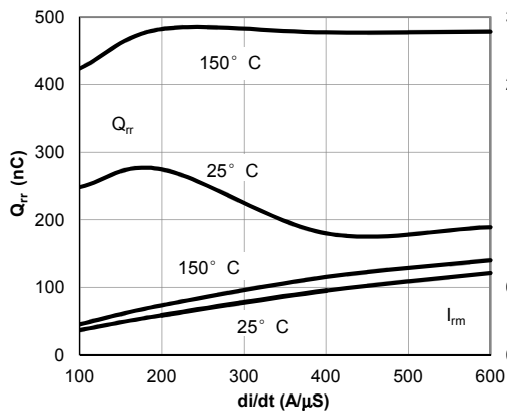
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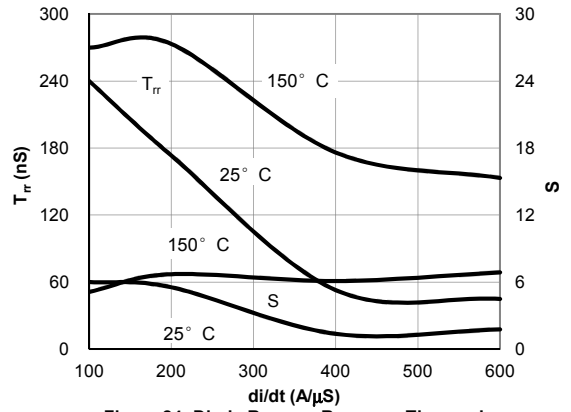
**Figure 21: Diode Reverse Recovery Charge and Peak Current vs. Conduction Current**  
( $V_{GE}=15V, V_{CE}=400V, di/dt=200A/\mu s$ )



**Figure 22: Diode Reverse Recovery Time and Softness Factor vs. Conduction Current**  
( $V_{GE}=15V, V_{CE}=400V, di/dt=200A/\mu s$ )

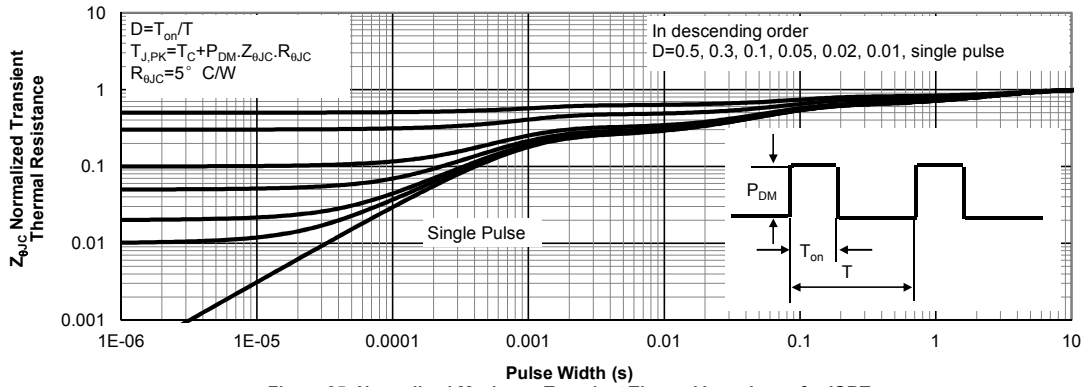


**Figure 23: Diode Reverse Recovery Charge and Peak Current vs. di/dt**  
( $V_{GE}=15V, V_{CE}=400V, I_F=5A$ )

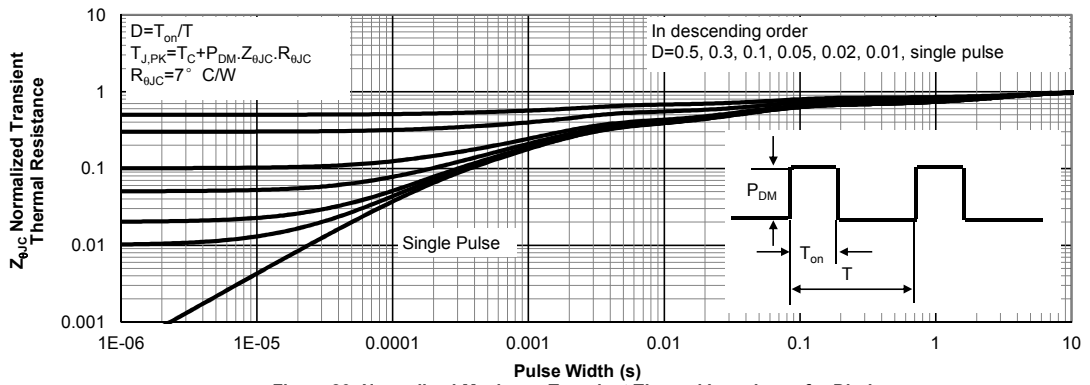


**Figure 24: Diode Reverse Recovery Time and Softness Factor vs. di/dt**  
( $V_{GE}=15V, V_{CE}=400V, I_F=5A$ )

**TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS**



**Figure 25: Normalized Maximum Transient Thermal Impedance for IGBT**



**Figure 26: Normalized Maximum Transient Thermal Impedance for Diode**



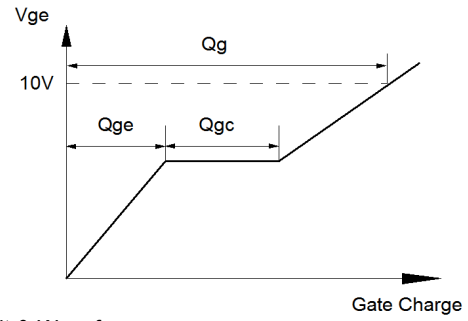
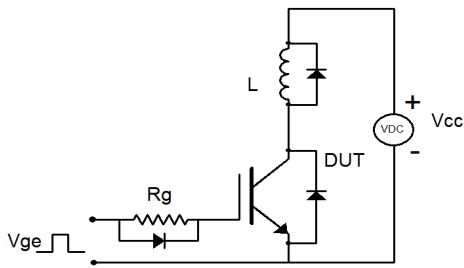


Figure A: Gate Charge Test Circuit & Waveforms

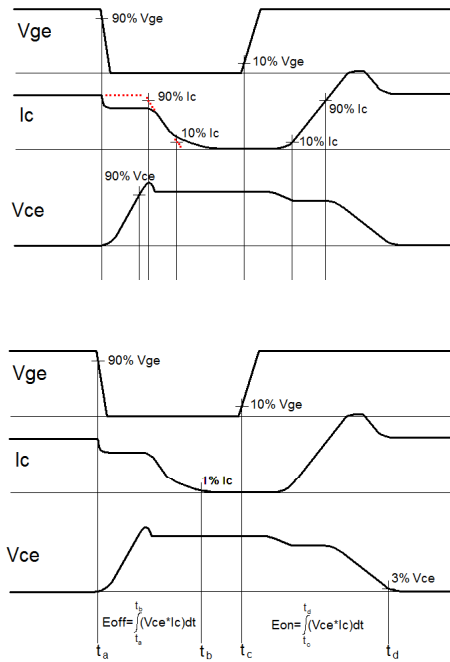
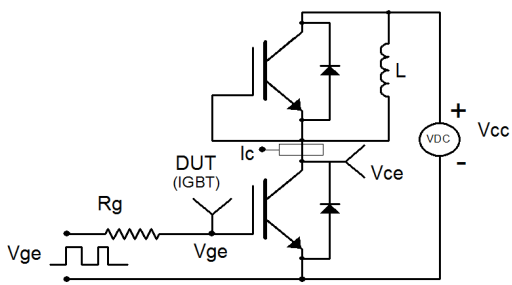


Figure B: Inductive Switching Test Circuit & Waveforms

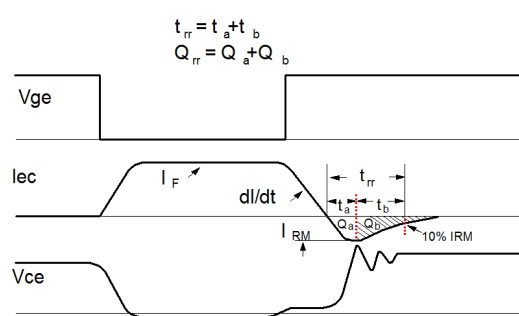
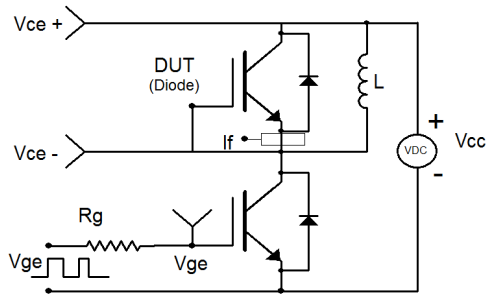


Figure C: Diode Recovery Test Circuit & Waveforms