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### General Description

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

### Applications

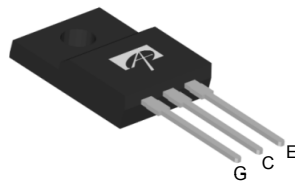
- Motor Drives
- Sewing Machines
- Servo and General Purpose Inverters.
- Fan, Pumps, Vacuum Cleaner
- Other Hard Switching Applications

### Product Summary

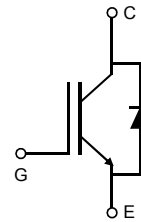
$V_{CE}$	650V
$I_C$ ( $T_C=100^\circ\text{C}$ )	20A
$V_{CE(sat)}$ ( $T_J=25^\circ\text{C}$ )	1.7V



TO-220F



AOTF20B65M2



Orderable Part Number	Package Type	Form	Minimum Order Quantity
AOTF20B65M2	TO220F	Tube	1000

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

Parameter	Symbol	AOTF20B65M2	Units
Collector-Emitter Voltage	$V_{CE}$	650	V
Gate-Emitter Voltage	$V_{GE}$	$\pm 30$	V
Continuous Collector Current	$I_C$	$T_C=25^\circ\text{C}$	40 <sup>2)</sup>
		$T_C=100^\circ\text{C}$	20 <sup>2)</sup>
Pulsed Collector Current, Limited by $T_{Jmax}$	$I_{CM}$	60	A
Turn off SOA, $V_{CE} \leq 650\text{V}$ , Limited by $T_{Jmax}$	$I_{LM}$	60	A
Continuous Diode Forward Current	$I_F$	$T_C=25^\circ\text{C}$	40 <sup>2)</sup>
		$T_C=100^\circ\text{C}$	20 <sup>2)</sup>
Diode Pulsed Current, Limited by $T_{Jmax}$	$I_{FM}$	60	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	$P_D$	$T_C=25^\circ\text{C}$	45
		$T_C=100^\circ\text{C}$	18
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	AOTF20B65M2	Units
Maximum Junction-to-Ambient	$R_{\theta JA}$	65	$^\circ\text{C}/\text{W}$
Maximum IGBT Junction-to-Case	$R_{\theta JC}$	2.8	$^\circ\text{C}/\text{W}$
Maximum Diode Junction-to-Case	$R_{\theta JC}$	3.2	$^\circ\text{C}/\text{W}$

1) Allowed number of short circuits: &lt;1000; time between short circuits: &gt;1s.

 2) TO220F  $I_C$  follows TO220/TO263.

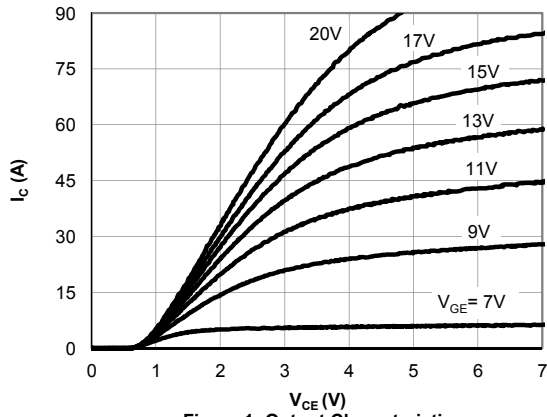
**Electrical Characteristics (T<sub>J</sub>=25°C unless otherwise noted)**

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	$V_{GE}=15V, I_C=20A$	$T_J=25^\circ C$	-	1.7	2.15	V
			$T_J=125^\circ C$	-	2.02	-	
			$T_J=150^\circ C$	-	2.11	-	
$V_F$	Diode Forward Voltage	$V_{GE}=0V, I_C=20A$	$T_J=25^\circ C$	-	1.56	2	V
			$T_J=125^\circ C$	-	1.65	-	
			$T_J=150^\circ C$	-	1.63	-	
$V_{GE(th)}$	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	μA
			$T_J=125^\circ C$	-	-	500	
			$T_J=150^\circ C$	-	-	1000	
$I_{GES}$	Gate-Emitter leakage current	$V_{CE}=0V, V_{GE}=\pm 30V$	-	-	±100	nA	
$g_{FS}$	Forward Transconductance	$V_{CE}=20V, I_C=20A$	-	14	-	S	
<b>DYNAMIC PARAMETERS</b>							
$C_{ies}$	Input Capacitance	$V_{GE}=0V, V_{CC}=25V, f=1MHz$	-	1216	-	pF	
$C_{oes}$	Output Capacitance		-	156	-	pF	
$C_{res}$	Reverse Transfer Capacitance		-	50	-	pF	
$Q_g$	Total Gate Charge	$V_{GE}=15V, V_{CC}=520V, I_C=20A$	-	46	-	nC	
$Q_{ge}$	Gate to Emitter Charge		-	12	-	nC	
$Q_{gc}$	Gate to Collector Charge		-	21	-	nC	
$I_{C(SC)}$	Short circuit collector current	$V_{GE}=15V, V_{CC}=400V,$ $t_{sc} \leq 5\mu s, T_J \leq 150^\circ C$	-	115	-	A	
$R_g$	Gate resistance	$V_{GE}=0V, V_{CC}=0V, f=1MHz$	-	13	-	Ω	
<b>SWITCHING PARAMETERS, (Load Inductive, T<sub>J</sub>=25°C)</b>							
$t_{D(on)}$	Turn-On Delay Time	$T_J=25^\circ C$ $V_{GE}=15V, V_{CC}=400V, I_C=20A,$ $R_G=15\Omega$	-	26	-	ns	
$t_r$	Turn-On Rise Time		-	32	-	ns	
$t_{D(off)}$	Turn-Off Delay Time		-	123	-	ns	
$t_f$	Turn-Off Fall Time		-	14	-	ns	
$E_{on}$	Turn-On Energy		-	0.58	-	mJ	
$E_{off}$	Turn-Off Energy		-	0.28	-	mJ	
$E_{total}$	Total Switching Energy		-	0.86	-	mJ	
$t_{rr}$	Diode Reverse Recovery Time		$T_J=25^\circ C$	-	292	-	ns
$Q_{rr}$	Diode Reverse Recovery Charge	$I_F=20A, di/dt=200A/\mu s, V_{CC}=400V$	-	0.8	-	μC	
$I_{rm}$	Diode Peak Reverse Recovery Current		-	5.6	-	A	
<b>SWITCHING PARAMETERS, (Load Inductive, T<sub>J</sub>=150°C)</b>							
$t_{D(on)}$	Turn-On Delay Time	$T_J=150^\circ C$ $V_{GE}=15V, V_{CC}=400V, I_C=20A,$ $R_G=15\Omega$	-	25	-	ns	
$t_r$	Turn-On Rise Time		-	34	-	ns	
$t_{D(off)}$	Turn-Off Delay Time		-	146	-	ns	
$t_f$	Turn-Off Fall Time		-	22	-	ns	
$E_{on}$	Turn-On Energy		-	0.64	-	mJ	
$E_{off}$	Turn-Off Energy		-	0.44	-	mJ	
$E_{total}$	Total Switching Energy		-	1.08	-	mJ	
$t_{rr}$	Diode Reverse Recovery Time		$T_J=150^\circ C$	-	432	-	ns
$Q_{rr}$	Diode Reverse Recovery Charge	$I_F=20A, di/dt=200A/\mu s, V_{CC}=400V$	-	1.5	-	μC	
$I_{rm}$	Diode Peak Reverse Recovery Current		-	7.2	-	A	

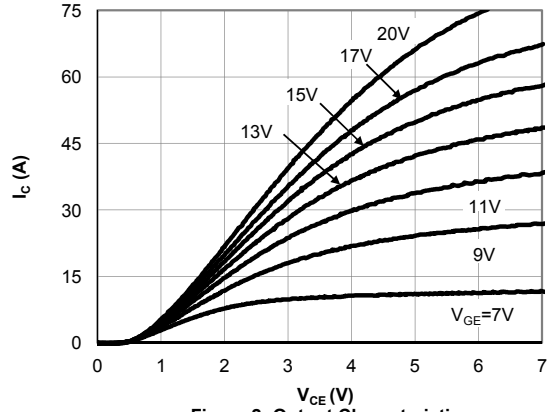
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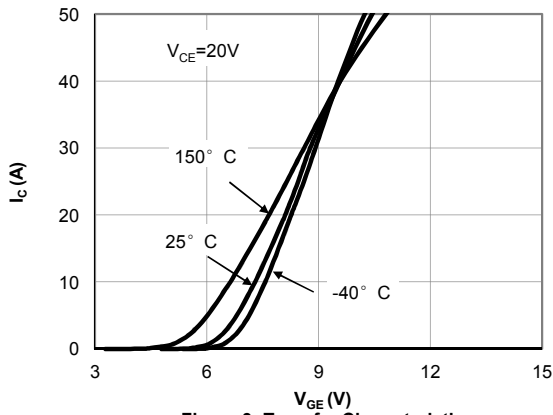
**TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS**



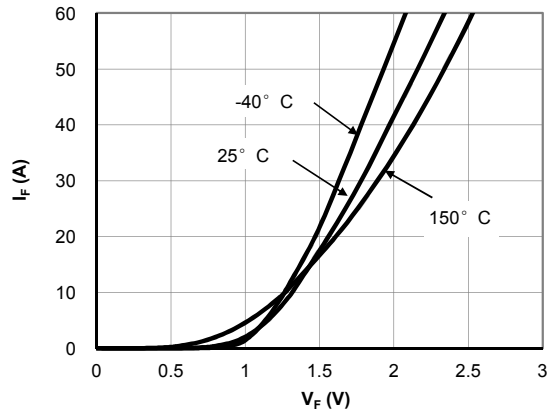
**Figure 1: Output Characteristic**  
( $T_j=25^\circ\text{C}$ )



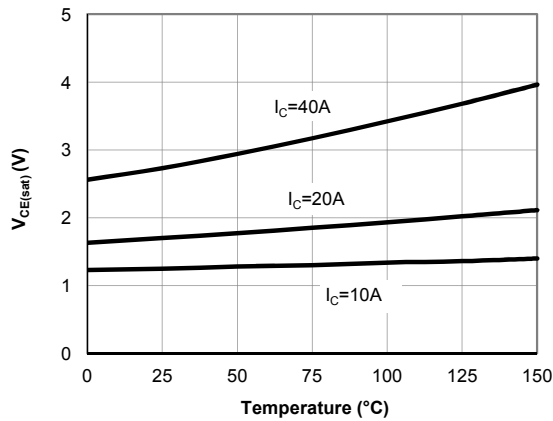
**Figure 2: Output Characteristic**  
( $T_j=150^\circ\text{C}$ )



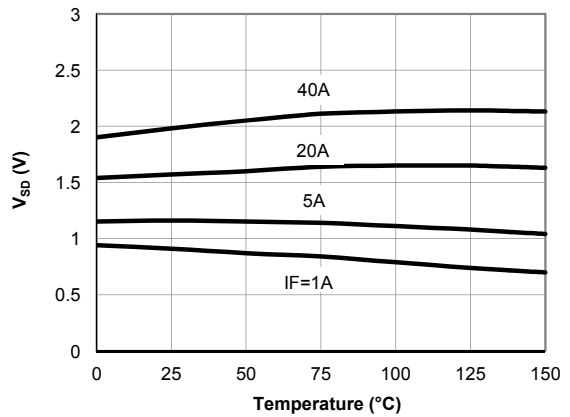
**Figure 3: Transfer Characteristic**



**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**

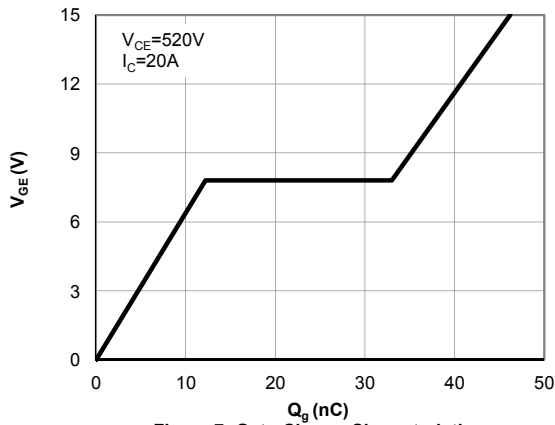


Figure 7: Gate-Charge Characteristics

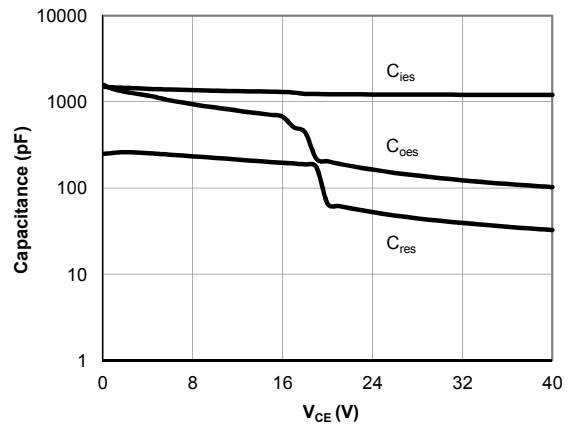


Figure 8: Capacitance Characteristic

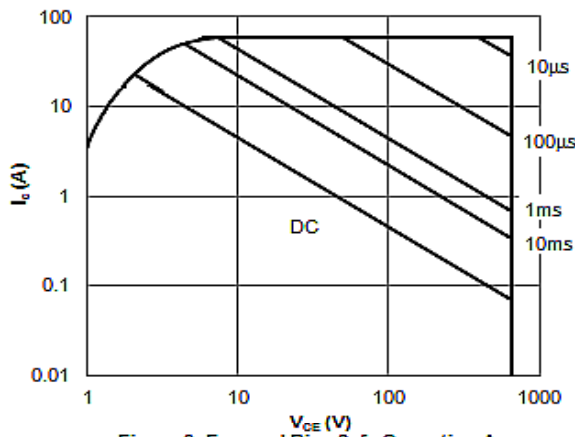


Figure 9: Forward Bias Safe Operating Area  
( $T_c=25^\circ\text{C}$ ,  $V_{GE}=15\text{V}$ )

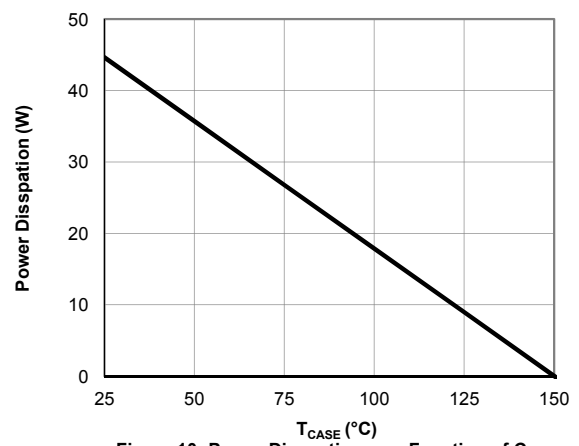


Figure 10: Power Dissipation as a Function of Case

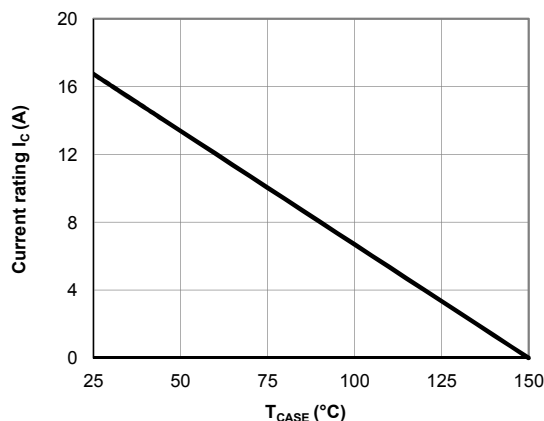


Figure 11: Current De-rating

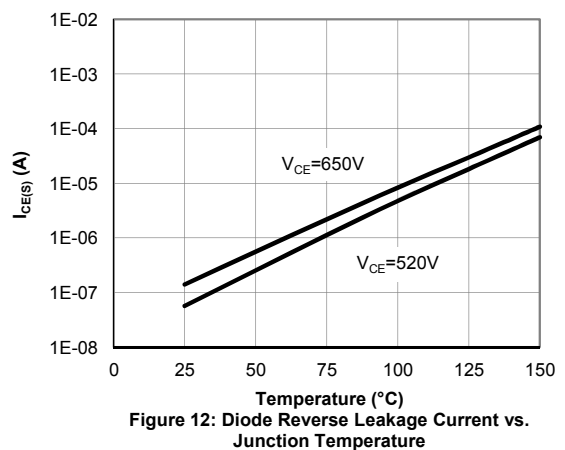
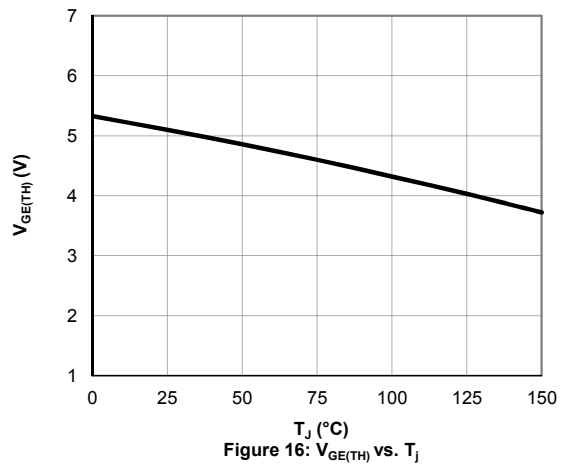
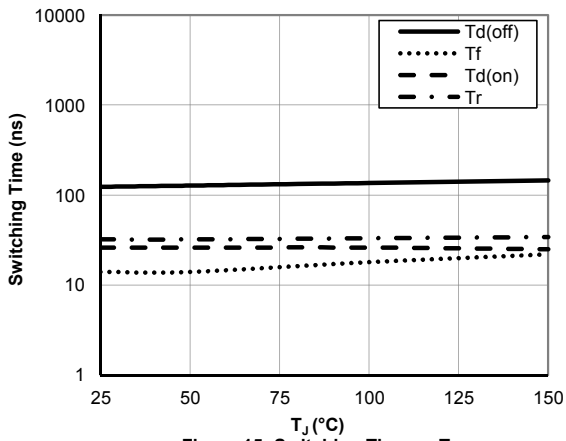
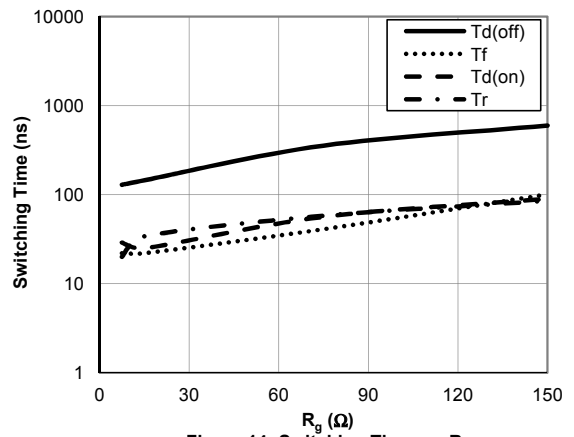
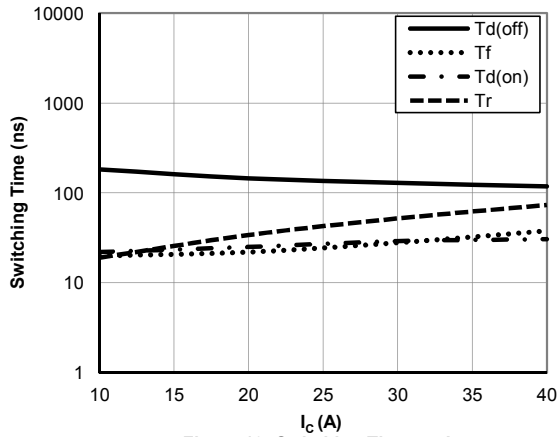
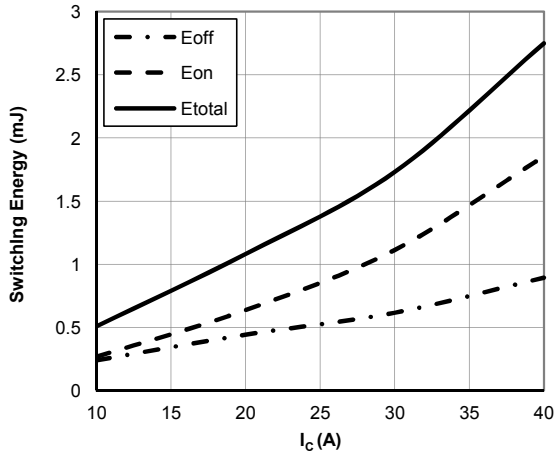


Figure 12: Diode Reverse Leakage Current vs. Junction Temperature

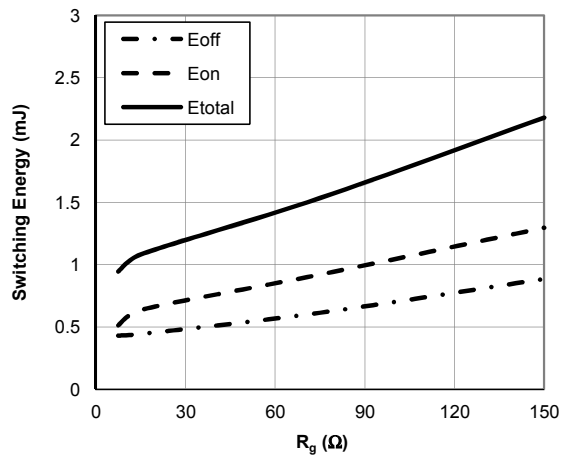
**TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS**



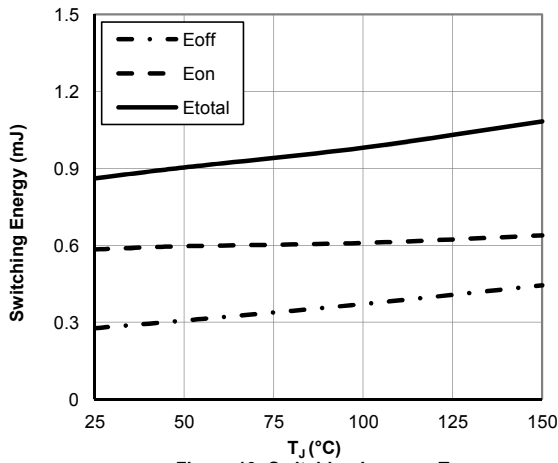
**TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS**



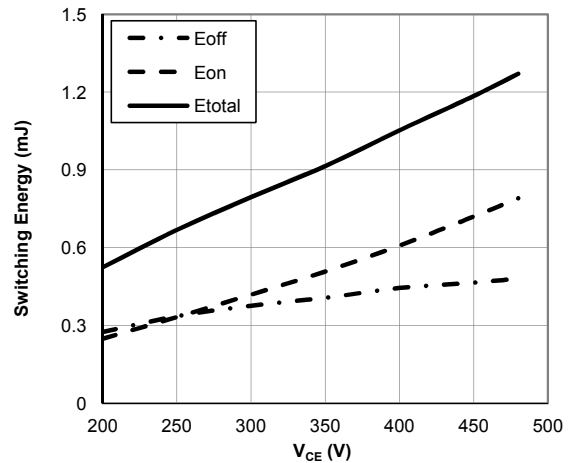
**Figure 17: Switching Loss vs.  $I_C$**   
( $T_J=150^\circ\text{C}$ ,  $V_{GE}=15\text{V}$ ,  $V_{CE}=400\text{V}$ ,  $R_g=15\Omega$ )



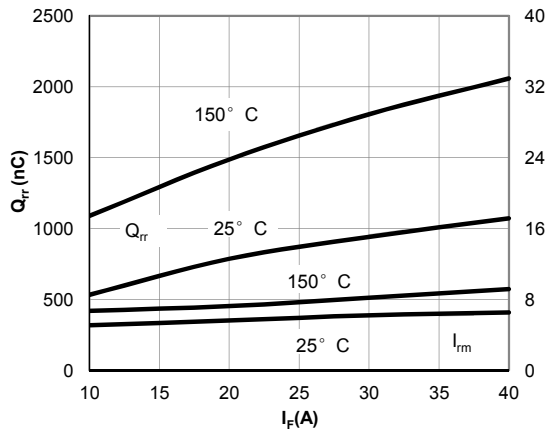
**Figure 18: Switching Loss vs.  $R_g$**   
( $T_J=150^\circ\text{C}$ ,  $V_{GE}=15\text{V}$ ,  $V_{CE}=400\text{V}$ ,  $I_C=20\text{A}$ )



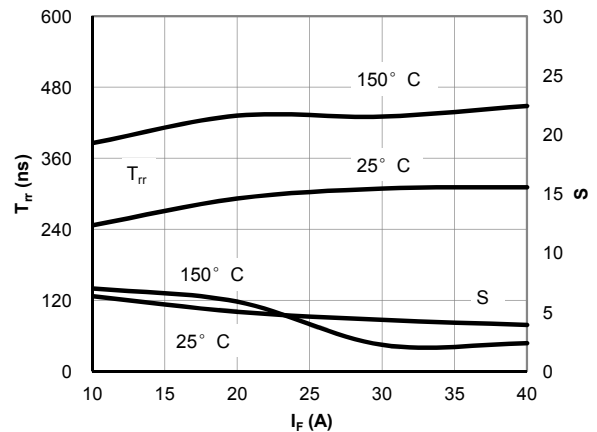
**Figure 19: Switching Loss vs.  $T_J$**   
( $V_{GE}=15\text{V}$ ,  $V_{CE}=400\text{V}$ ,  $I_C=20\text{A}$ ,  $R_g=15\Omega$ )



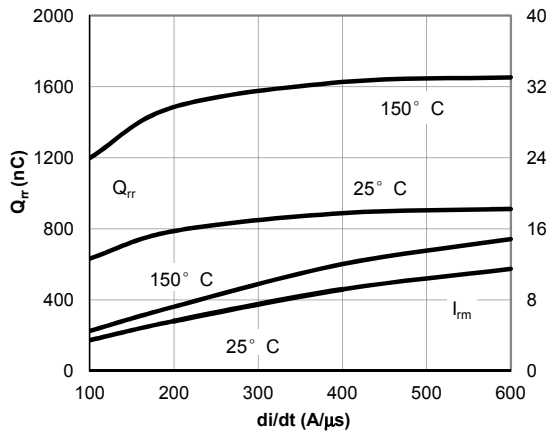
**Figure 20: Switching Loss vs.  $V_{CE}$**   
( $T_J=150^\circ\text{C}$ ,  $V_{GE}=15\text{V}$ ,  $I_C=20\text{A}$ ,  $R_g=15\Omega$ )

**TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS**


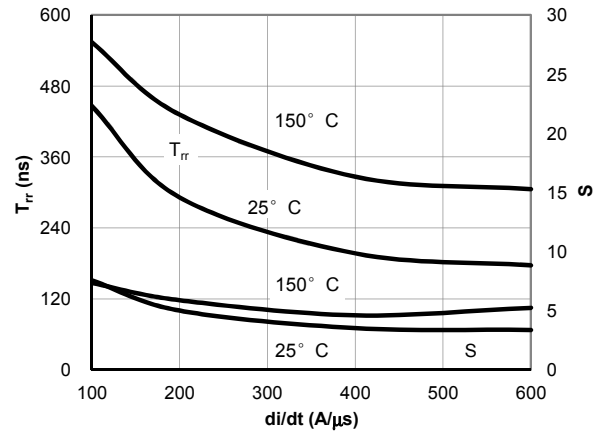
**Figure 21: Diode Reverse Recovery Charge and Peak Current vs. Conduction Current**  
 ( $V_{GE}=15V$ ,  $V_{CE}=400V$ ,  $di/dt=200A/\mu s$ )



**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**  
 ( $V_{GE}=15V$ ,  $V_{CE}=400V$ ,  $I_F=20A$ )



**Figure 24: Diode Reverse Recovery Time and Softness Factor vs. di/dt**  
 ( $V_{GE}=15V$ ,  $V_{CE}=400V$ ,  $I_F=20A$ )



**TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS**

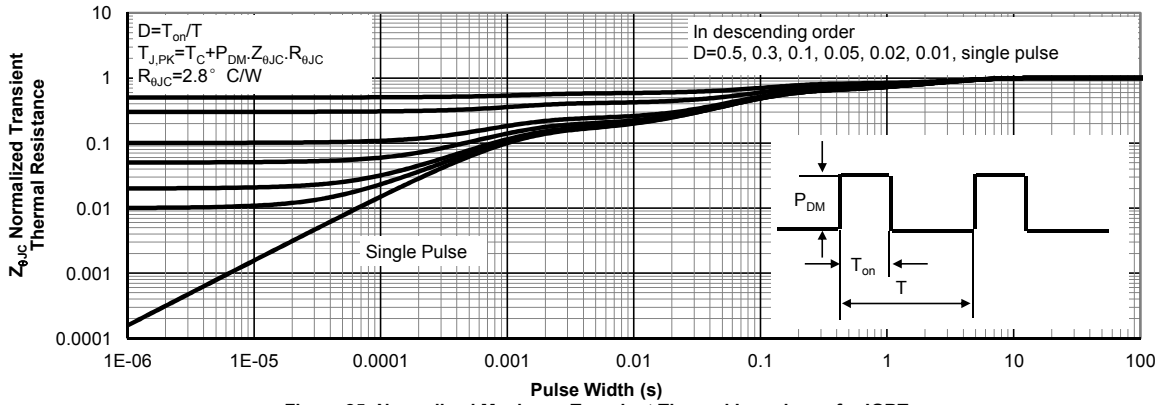


Figure 25: Normalized Maximum Transient Thermal Impedance for IGBT

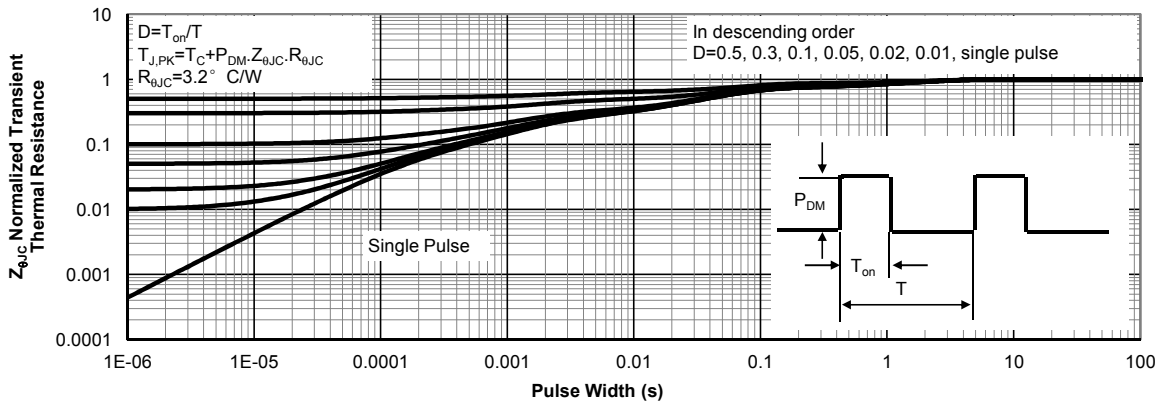


Figure 26: Normalized Maximum Transient Thermal Impedance for Diode

