



**THE DATASHEET OF  
AOK60B60D1**



### General Description

The Alpha IGBT™ line of products offers best-in-class performance in conduction and switching losses, with robust short circuit capability. They are designed for ease of paralleling, minimal gate spike under high dV/dt conditions and resistance to oscillations. The soft co-packaged diode is targeted for minimal losses in Welding machines, Solar Inverter and UPS applications.

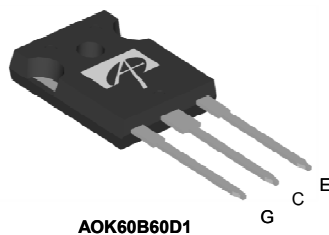
### Product Summary

$V_{CE}$	600V
$I_C$ ( $T_C=100^\circ\text{C}$ )	60A
$V_{CE(sat)}$ ( $T_C=25^\circ\text{C}$ )	1.85V

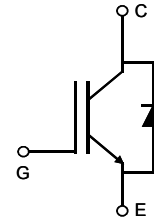


Top View

TO-247



AOK60B60D1



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

Parameter	Symbol	AOK60B60D1	Units	
Collector-Emitter Voltage	$V_{CE}$	600	V	
Gate-Emitter Voltage	$V_{GE}$	$\pm 20$	V	
$V_{GE}$ Spike	500ns	$V_{SPIKE}$	24	V
Continuous Collector Current	$I_C$	$T_C=25^\circ\text{C}$	120	A
		$T_C=100^\circ\text{C}$	60	
Pulsed Collector Current, Limited by $T_{Jmax}$	$I_{CM}$	210	A	
Turn off SOA, $V_{CE} \leq 600\text{V}$ , Limited by $T_{Jmax}$	$I_{LM}$	210	A	
Continuous Diode Forward Current	$I_F$	$T_C=25^\circ\text{C}$	60	A
		$T_C=100^\circ\text{C}$	30	
Diode Pulsed Current, Limited by $T_{Jmax}$	$I_{FM}$	210	A	
Short circuit withstanding time $V_{GE} = 15\text{V}$ , $V_{CE} \leq 400\text{V}$ , Delay between short circuits $\geq 1.0\text{s}$ , $T_C=25^\circ\text{C}$	$t_{SC}$	10	$\mu\text{s}$	
Power Dissipation	$P_D$	$T_C=25^\circ\text{C}$	417	W
		$T_C=100^\circ\text{C}$	167	
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

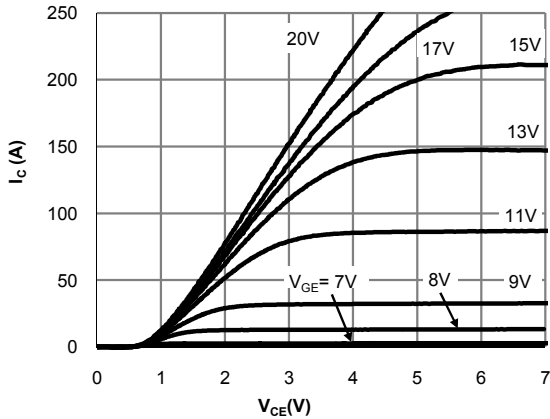
Parameter	Symbol	AOK60B60D1	Units
Maximum Junction-to-Ambient	$R_{\theta JA}$	40	$^\circ\text{C/W}$
Maximum IGBT Junction-to-Case	$R_{\theta JC}$	0.3	$^\circ\text{C/W}$
Maximum Diode Junction-to-Case	$R_{\theta JC}$	0.95	$^\circ\text{C/W}$

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

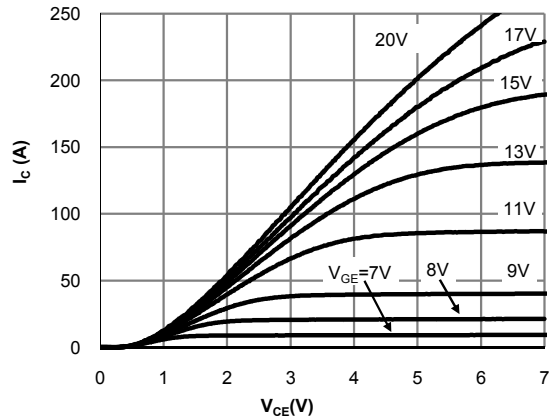
Symbol	Parameter	Conditions	Min	Typ	Max	Units	
<b>STATIC PARAMETERS</b>							
$BV_{CES}$	Collector-Emitter Breakdown Voltage	$I_C=1mA, V_{GE}=0V, T_J=25^\circ C$	600	-	-	V	
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	$V_{GE}=15V, I_C=60A$	$T_J=25^\circ C$	-	1.85	2.4	V
			$T_J=125^\circ C$	-	2.2	-	
			$T_J=150^\circ C$	-	2.3	-	
$V_F$	Diode Forward Voltage	$V_{GE}=0V, I_C=30A$	$T_J=25^\circ C$	-	1.34	1.9	V
			$T_J=125^\circ C$	-	1.31	-	
			$T_J=150^\circ C$	-	1.28	-	
$V_{GE(th)}$	Gate-Emitter Threshold Voltage	$V_{CE}=5V, I_C=1mA$	-	5.4	-	V	
$I_{CES}$	Zero Gate Voltage Collector Current	$V_{CE}=600V, V_{GE}=0V$	$T_J=25^\circ C$	-	-	10	$\mu A$
			$T_J=125^\circ C$	-	-	1000	
			$T_J=150^\circ C$	-	-	5000	
$I_{GES}$	Gate-Emitter leakage current	$V_{CE}=0V, V_{GE}=\pm 20V$	-	-	$\pm 100$	nA	
$g_{FS}$	Forward Transconductance	$V_{CE}=20V, I_C=60A$	-	25	-	S	
<b>DYNAMIC PARAMETERS</b>							
$C_{ies}$	Input Capacitance	$V_{GE}=0V, V_{CE}=25V, f=1MHz$	-	3288	-	pF	
$C_{oes}$	Output Capacitance		-	369	-	pF	
$C_{res}$	Reverse Transfer Capacitance		-	11.3	-	pF	
$Q_g$	Total Gate Charge	$V_{GE}=15V, V_{CE}=480V, I_C=60A$	-	75	-	nC	
$Q_{ge}$	Gate to Emitter Charge		-	27.3	-	nC	
$Q_{gc}$	Gate to Collector Charge		-	24.7	-	nC	
$I_{C(SC)}$	Short circuit collector current, Max. 1000 short circuits, Delay between short circuits $\geq 1.0s$	$V_{GE}=15V, V_{CE}=400V, R_G=25\Omega$	-	210	-	A	
$R_g$	Gate resistance	$f=1MHz$	-	1.4	-	$\Omega$	
<b>SWITCHING PARAMETERS, (Load Inductive, T<sub>J</sub>=25°C)</b>							
$t_{D(on)}$	Turn-On DelayTime	$T_J=25^\circ C$ $V_{GE}=15V, V_{CE}=400V, I_C=60A,$ $R_G=5\Omega,$ Parasitic Inductance=150nH	-	32	-	ns	
$t_r$	Turn-On Rise Time		-	76	-	ns	
$t_{D(off)}$	Turn-Off Delay Time		-	74	-	ns	
$t_f$	Turn-Off Fall Time		-	16	-	ns	
$E_{on}$	Turn-On Energy		-	3.1	-	mJ	
$E_{off}$	Turn-Off Energy		-	0.73	-	mJ	
$E_{total}$	Total Switching Energy		-	3.8	-	mJ	
$t_{rr}$	Diode Reverse Recovery Time		$T_J=25^\circ C$	-	137	-	ns
$Q_{rr}$	Diode Reverse Recovery Charge		$I_F=30A, di/dt=200A/\mu s, V_{CE}=400V$	-	0.84	-	$\mu C$
$I_{rm}$	Diode Peak Reverse Recovery Current			-	10	-	A
<b>SWITCHING PARAMETERS, (Load Inductive, T<sub>J</sub>=150°C)</b>							
$t_{D(on)}$	Turn-On DelayTime	$T_J=150^\circ C$ $V_{GE}=15V, V_{CE}=400V, I_C=60A,$ $R_G=5\Omega,$ Parasitic Inductance=150nH	-	31	-	ns	
$t_r$	Turn-On Rise Time		-	78	-	ns	
$t_{D(off)}$	Turn-Off Delay Time		-	89	-	ns	
$t_f$	Turn-Off Fall Time		-	16	-	ns	
$E_{on}$	Turn-On Energy		-	3.5	-	mJ	
$E_{off}$	Turn-Off Energy		-	1.2	-	mJ	
$E_{total}$	Total Switching Energy		-	4.7	-	mJ	
$t_{rr}$	Diode Reverse Recovery Time		$T_J=150^\circ C$	-	234	-	ns
$Q_{rr}$	Diode Reverse Recovery Charge		$I_F=30A, di/dt=200A/\mu s, V_{CE}=400V$	-	1.7	-	$\mu C$
$I_{rm}$	Diode Peak Reverse Recovery Current			-	13.8	-	A

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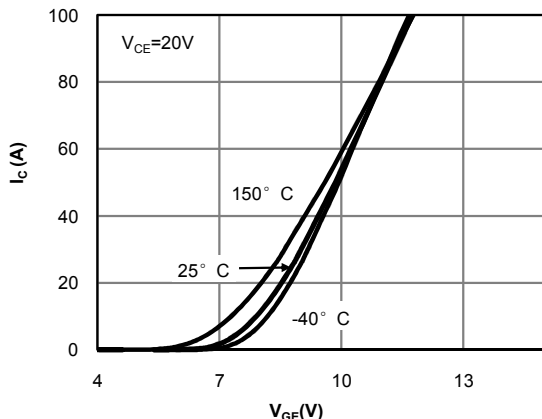
**TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS**



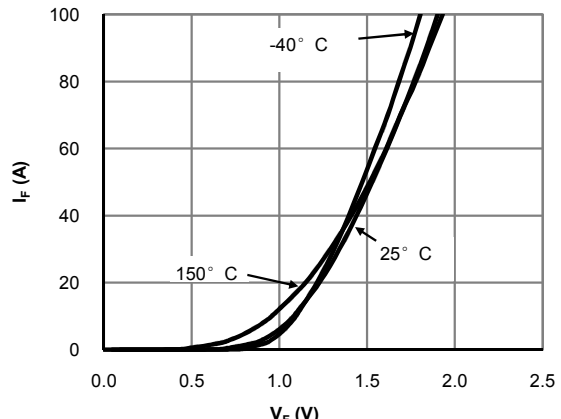
**Fig 1: Output Characteristic**  
( $T_j=25^\circ\text{C}$ )



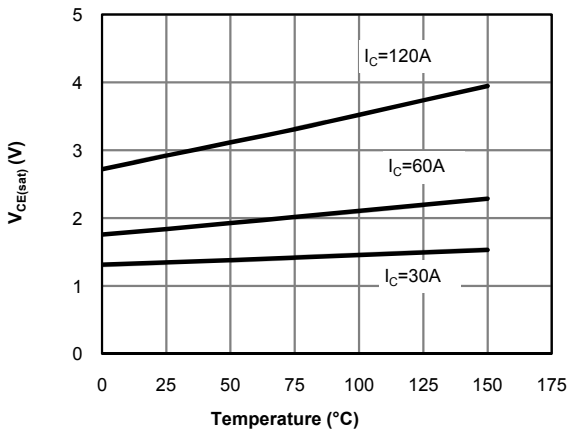
**Fig 2: Output Characteristic**  
( $T_j=150^\circ\text{C}$ )



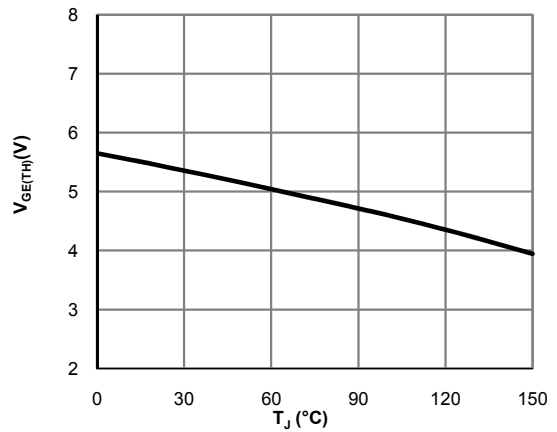
**Fig 3: Transfer Characteristic**



**Fig 4: Diode Characteristic**

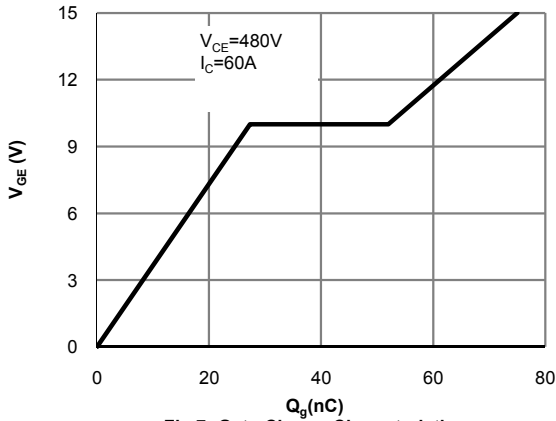


**Fig 5: Collector-Emitter Saturation Voltage vs. Junction Temperature**

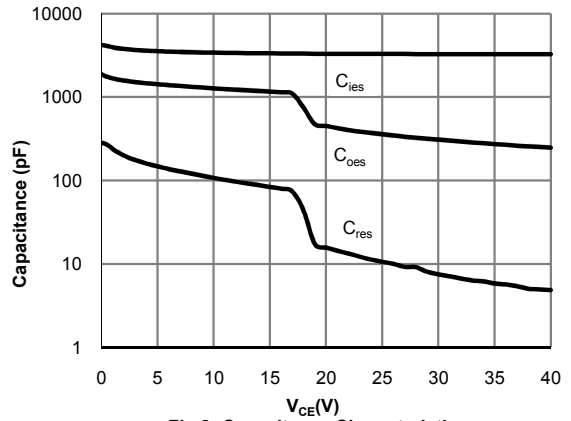


**Figure 6:  $V_{GE(TH)}$  vs.  $T_j$**

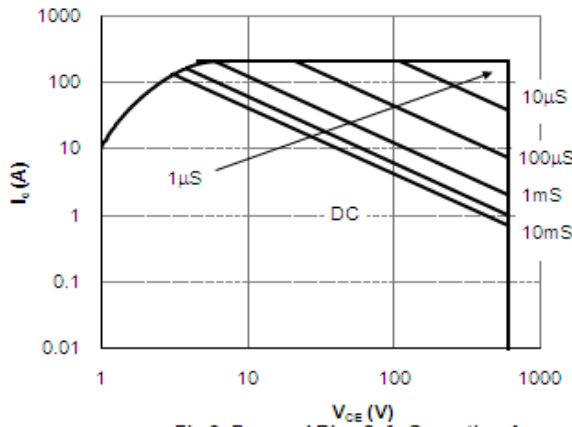
**TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS**



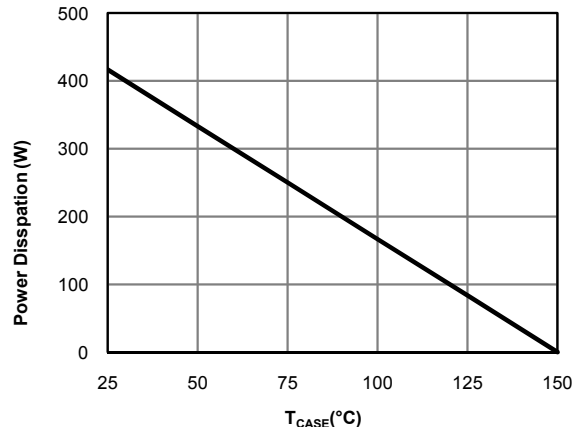
**Fig 7: Gate-Charge Characteristics**



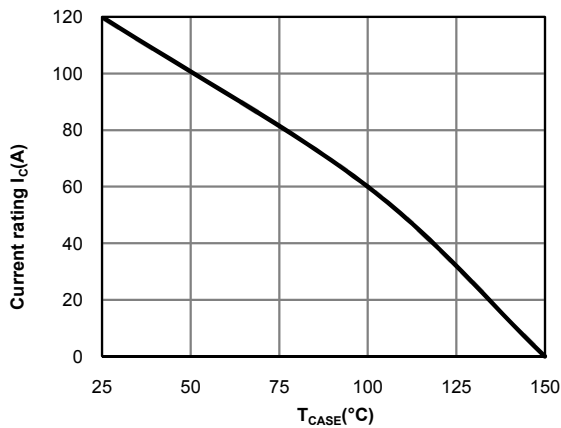
**Fig 8: Capacitance Characteristic**



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

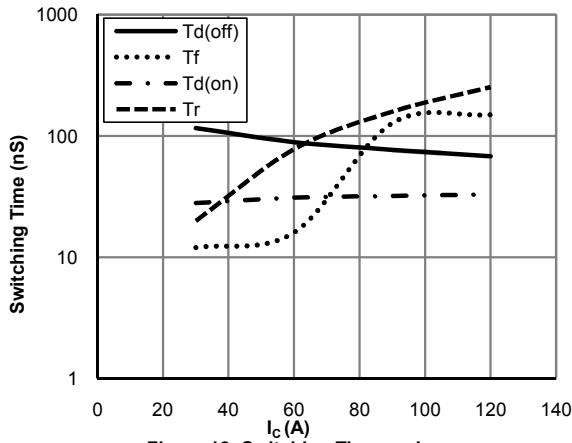


**Fig 10: Power Dissipation as a Function of Case**

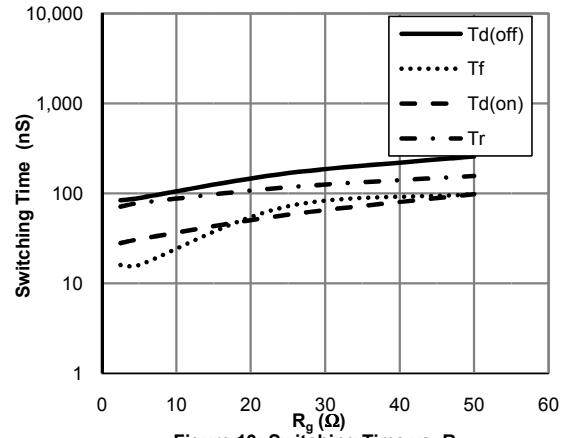


**Fig 11: Current De-rating**

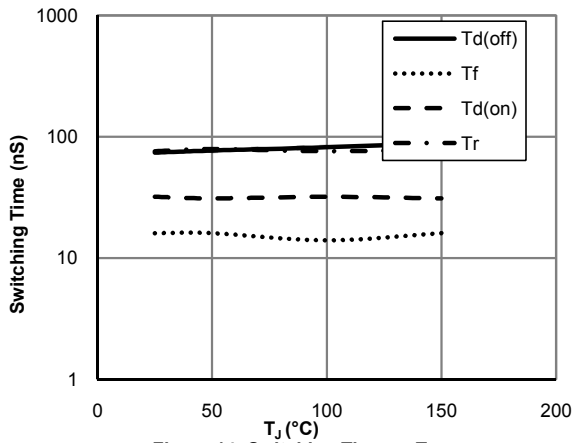
**TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS**



**Figure 12: Switching Time vs.  $I_C$**   
( $T_J=150^{\circ}\text{C}, V_{GE}=15\text{V}, V_{CE}=400\text{V}, R_g=5\Omega$ )

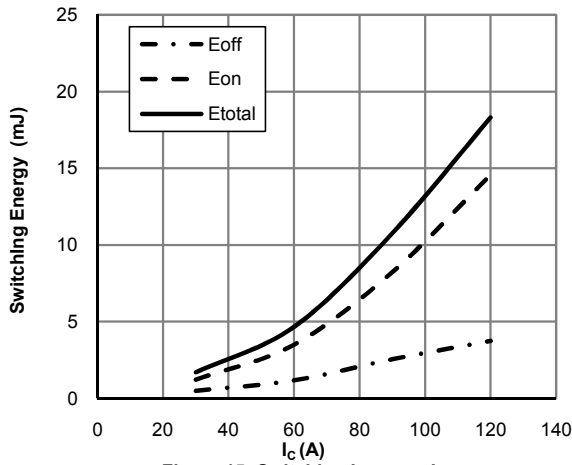


**Figure 13: Switching Time vs.  $R_g$**   
( $T_J=150^{\circ}\text{C}, V_{GE}=15\text{V}, V_{CE}=400\text{V}, I_C=60\text{A}$ )

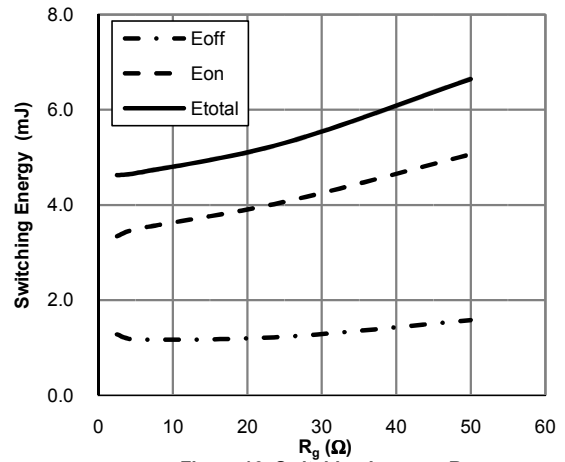


**Figure 14: Switching Time vs.  $T_J$**   
( $V_{GE}=15\text{V}, V_{CE}=400\text{V}, I_C=60\text{A}, R_g=5\Omega$ )

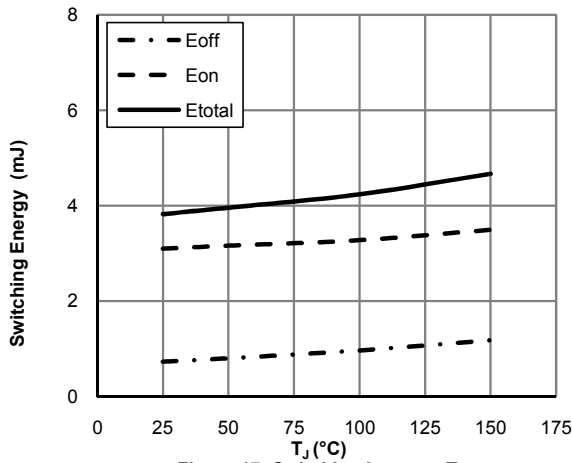
**TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS**



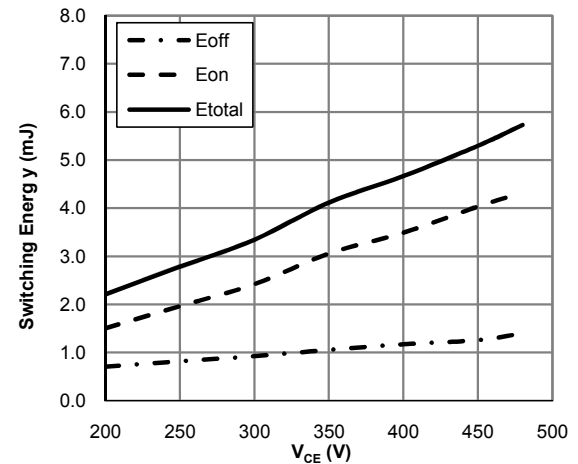
**Figure 15: Switching Loss vs.  $I_C$**   
( $T_J=150^\circ\text{C}, V_{GE}=15\text{V}, V_{CE}=400\text{V}, R_g=5\Omega$ )



**Figure 16: Switching Loss vs.  $R_g$**   
( $T_J=150^\circ\text{C}, V_{GE}=15\text{V}, V_{CE}=400\text{V}, I_C=60\text{A}$ )

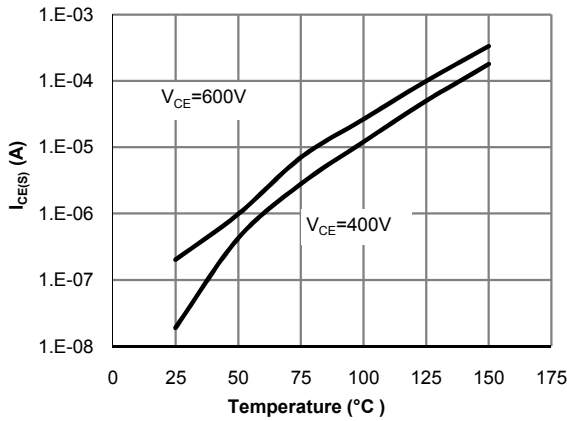


**Figure 17: Switching Loss vs.  $T_J$**   
( $V_{GE}=15\text{V}, V_{CE}=400\text{V}, I_C=60\text{A}, R_g=5\Omega$ )

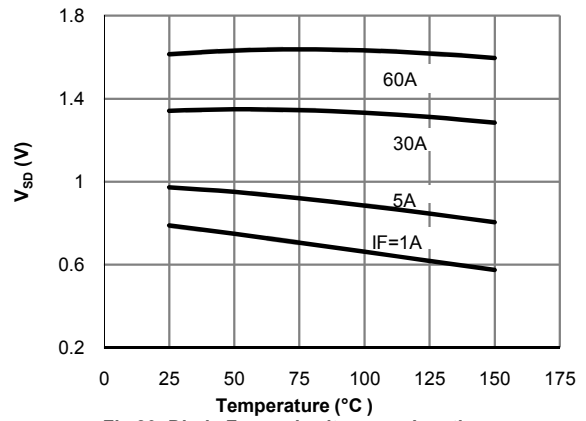


**Figure 18: Switching Loss vs.  $V_{CE}$**   
( $T_J=150^\circ\text{C}, V_{GE}=15\text{V}, I_C=60\text{A}, R_g=5\Omega$ )

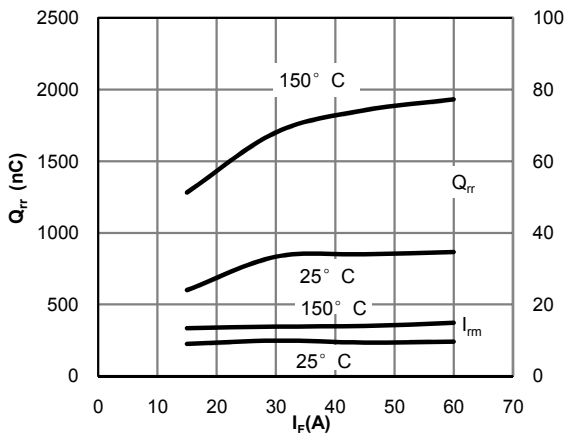
**TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS**



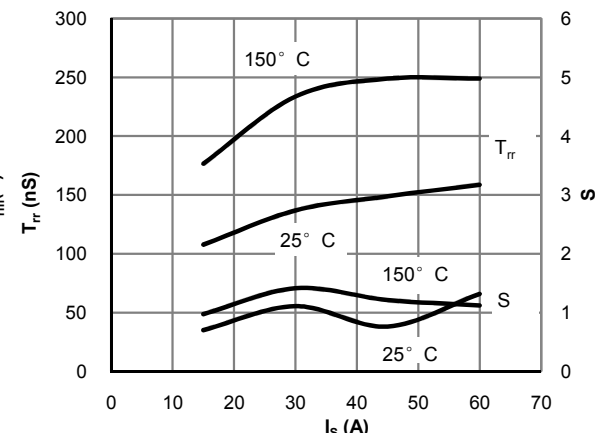
**Fig 19: Diode Reverse Leakage Current vs. Junction Temperature**



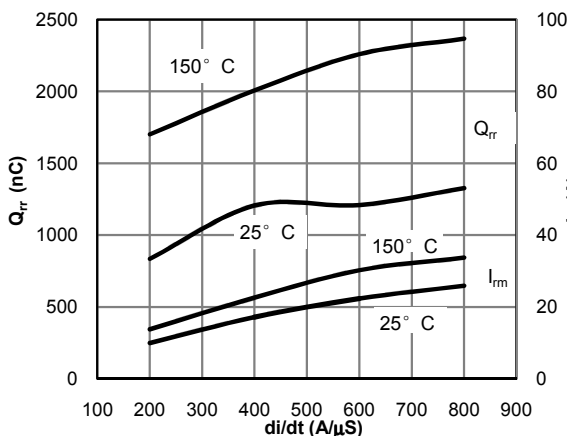
**Fig 20: Diode Forward Voltage vs. Junction Temperature**



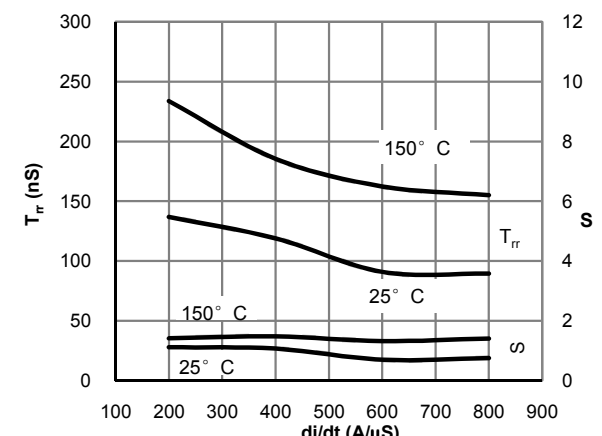
**Fig 21: Diode Reverse Recovery Charge and Peak Current vs. Conduction Current**  
( $V_{GE}=15V, V_{CE}=400V, di/dt=200A/\mu s$ )



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



**Fig 23: Diode Reverse Recovery Charge and Peak Current vs. di/dt**  
( $V_{GE}=15V, V_{CE}=400V, I_F=30A$ )



**Fig 24: Diode Reverse Recovery Time and Softness Factor vs. di/dt**  
( $V_{GE}=15V, V_{CE}=400V, I_F=30A$ )

**TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS**

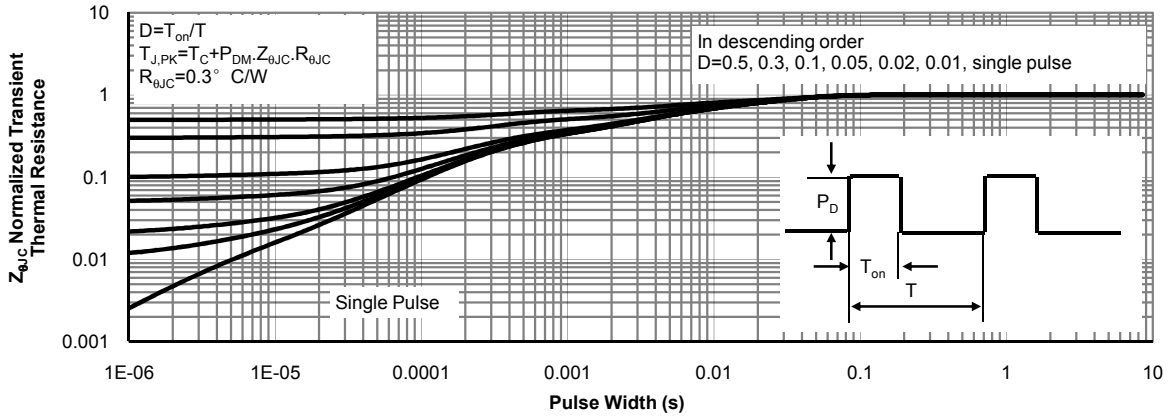


Figure 25: Normalized Maximum Transient Thermal Impedance for IGBT

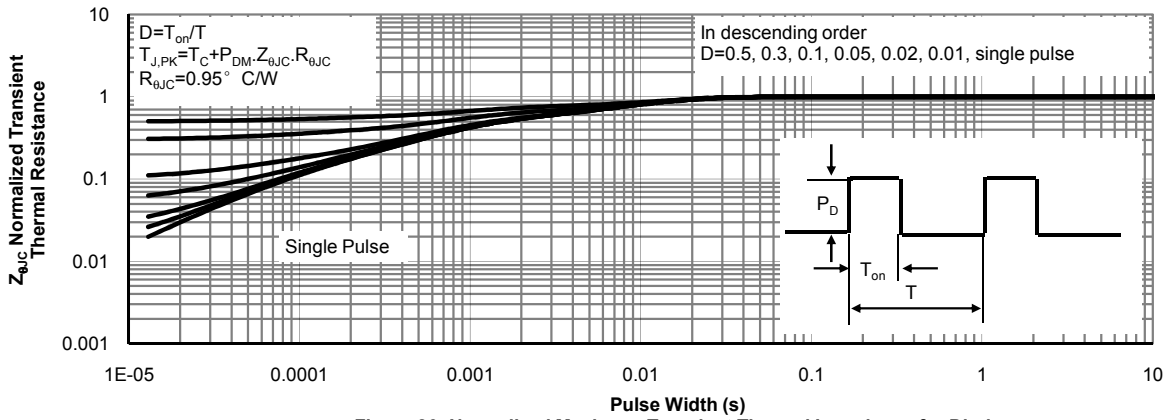
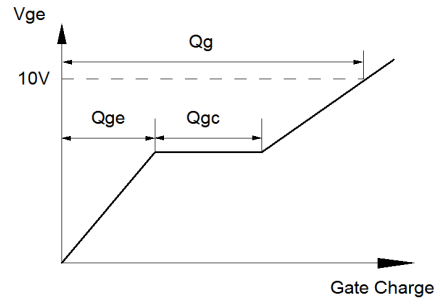
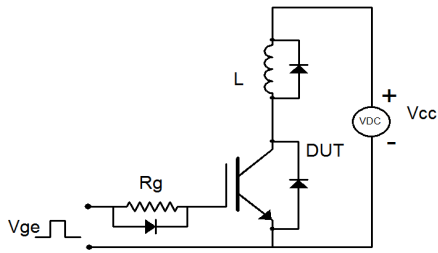
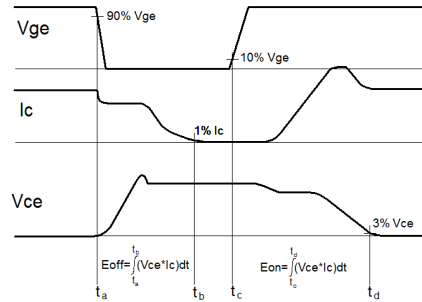
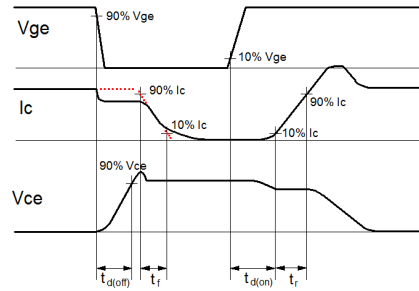
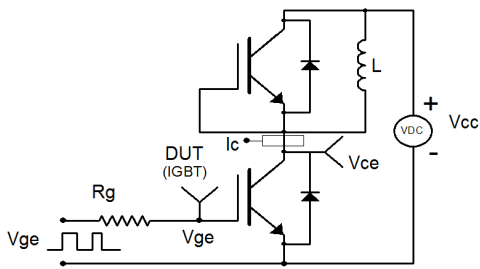


Figure 26: Normalized Maximum Transient Thermal Impedance for Diode

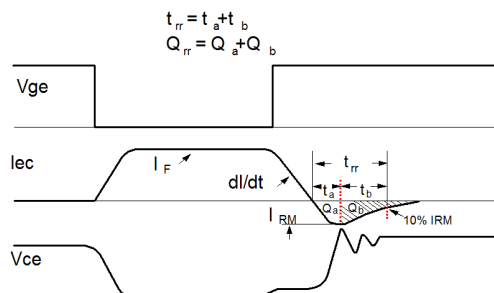
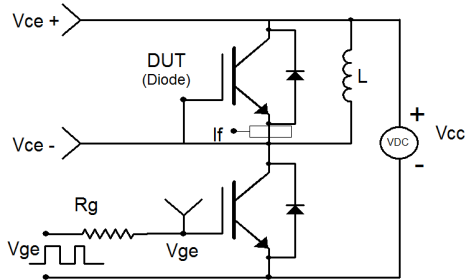
**Gate Charge Test Circuit & Waveform**



**Inductive Switching Test Circuit & Waveforms**



**Diode Recovery Test Circuit & Waveforms**



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