ALPHA & OMEGA SEMICONDUCTOR

# AOK40B120M1

## 1200V, 40A Alpha IGBT™

## With soft and fast recovery anti-parallel diode

### General Description

- Latest Alpha IGBT (α IGBT) technology
- 1200V breakdown voltage
- Fast and soft recovery freewheeling diode
- High efficient turn-on di/dt controllability
- High switching speed
- Low turn-off switching loss and softness
- Very good EMI behavior

### Applications

- Welding Machines
- UPS & Solar Inverters
- Very High Switching Frequency Applications

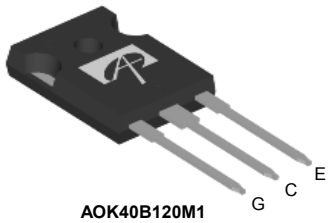
### Product Summary

| | |
|---|---|
| $V_{CE}$ | 1200V |
| $I_C$ ($T_C$=100°C) | 40A |
| $V_{CE(sat)}$ ($T_J$=25°C) | 1.95V |

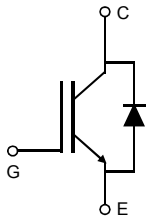
RoHS Compliant

Top View

TO-247




AOK40B120M1




| Orderable Part Number | Package Type | Form | Minimum Order Quantity |
|---|---|---|---|
| AOK40B120M1 | TO247 | Tube | 240 |

**Absolute Maximum Ratings $T_A$=25°C unless otherwise noted**

| Parameter | | Symbol | AOK40B120M1 | Units |
|---|---|---|---|---|
| Collector-Emitter Voltage | | $V_{CE}$ | 1200 | V |
| Gate-Emitter Voltage | | $V_{GE}$ | ±30 | V |
| Continuous Collector Current | $T_C$=25°C | $I_C$ | 80 | A |
| | $T_C$=100°C | | 40 | |
| Pulsed Collector Current, Limited by $T_{Jmax}$ | | $I_{CM}$ | 120 | A |
| Turn off SOA, $V_{CE} \leqslant$ 650V, Limited by $T_{Jmax}$ | | $I_{LM}$ | 120 | A |
| Continuous Diode Forward Current | $T_C$=25°C | $I_F$ | 80 | A |
| | $T_C$=100°C | | 40 | |
| Diode Pulsed Current, Limited by $T_{Jmax}$ | | $I_{FM}$ | 120 | A |
| Power Dissipation | $T_C$=25°C | $P_D$ | 600 | W |
| | $T_C$=100°C | | 300 | |
| Junction and Storage Temperature Range | | $T_J$, $T_{STG}$ | -55 to 175 | °C |
| Maximum lead temperature for soldering purpose, 1/8" from case for 5 seconds | | $T_L$ | 300 | °C |

**Thermal Characteristics**

| Parameter | Symbol | AOK40B120M1 | Units |
|---|---|---|---|
| Maximum Junction-to-Ambient | $R_{\theta JA}$ | 40 | °C/W |
| Maximum IGBT Junction-to-Case | $R_{\theta JC}$ | 0.25 | °C/W |
| Maximum Diode Junction-to-Case | $R_{\theta JC}$ | 0.4 | °C/W |

**Electrical Characteristics ($T_J$=25°C unless otherwise noted)**

| Symbol | Parameter | Conditions | | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|---|
| **STATIC PARAMETERS** | | | | | | | |
| $BV_{CES}$ | Collector-Emitter Breakdown Voltage | $I_C$=1mA, $V_{GE}$=0V, $T_J$=25°C | | 1200 | - | - | V |
| $V_{CE(sat)}$ | Collector-Emitter Saturation Voltage | $V_{GE}$=15V, $I_C$=40A | $T_J$=25°C | - | 1.95 | 2.45 | V |
| | | | $T_J$=125°C | - | 2.35 | - | |
| | | | $T_J$=175°C | - | 2.55 | - | |
| $V_F$ | Diode Forward Voltage | $V_{GE}$=0V, $I_C$=40A | $T_J$=25°C | - | 2.5 | 3.15 | V |
| | | | $T_J$=125°C | - | 2.75 | - | |
| | | | $T_J$=175°C | - | 2.55 | - | |
| $V_{GE(th)}$ | Gate-Emitter Threshold Voltage | $V_{CE}$=5V, $I_C$=1mA | | - | 5.8 | - | V |
| $I_{CES}$ | Zero Gate Voltage Collector Current | $V_{CE}$=1200V, $V_{GE}$=0V | $T_J$=25°C | - | - | 0.1 | mA |
| | | | $T_J$=125°C | - | - | 4 | |
| | | | $T_J$=175°C | - | - | 20 | |
| $I_{GES}$ | Gate-Emitter leakage current | $V_{CE}$=0V, $V_{GE}$=±30V | | - | - | ±100 | nA |
| $g_{FS}$ | Forward Transconductance | $V_{CE}$=20V, $I_C$=40A | | - | 28 | - | S |
| **DYNAMIC PARAMETERS** | | | | | | | |
| $C_{ies}$ | Input Capacitance | $V_{GE}$=0V, $V_{CC}$=25V, f=1MHz | | - | 4770 | - | pF |
| $C_{oes}$ | Output Capacitance | | | - | 270 | - | pF |
| $C_{res}$ | Reverse Transfer Capacitance | | | - | 85 | - | pF |
| $Q_g$ | Total Gate Charge | $V_{GE}$=15V, $V_{CC}$=960V, $I_C$=40A | | - | 140 | - | nC |
| $Q_{ge}$ | Gate to Emitter Charge | | | - | 62 | - | nC |
| $Q_{gc}$ | Gate to Collector Charge | | | - | 48 | - | nC |
| $R_g$ | Gate resistance | $V_{GE}$=0V, $V_{CC}$=0V, f=1MHz | | - | 15 | - | Ω |
| **SWITCHING PARAMETERS, (Load Inductive, $T_J$=25°C)** | | | | | | | |
| $t_{D(on)}$ | Turn-On DelayTime | $T_J$=25°C<br>$V_{GE}$=15V, $V_{CC}$=600V, $I_C$=40A,<br>$R_G$=7.5Ω | | - | 90 | - | ns |
| $t_r$ | Turn-On Rise Time | | | - | 85 | - | ns |
| $t_{D(off)}$ | Turn-Off Delay Time | | | - | 226 | - | ns |
| $t_f$ | Turn-Off Fall Time | | | - | 46 | - | ns |
| $E_{on}$ | Turn-On Energy | | | - | 3.87 | - | mJ |
| $E_{off}$ | Turn-Off Energy | | | - | 1.25 | - | mJ |
| $E_{total}$ | Total Switching Energy | | | - | 5.12 | - | mJ |
| $t_{rr}$ | Diode Reverse Recovery Time | $T_J$=25°C<br>$I_F$=40A, di/dt=200A/µs, $V_{CC}$=600V | | - | 340 | - | ns |
| $Q_{rr}$ | Diode Reverse Recovery Charge | | | - | 1.5 | - | µC |
| $I_{rm}$ | Diode Peak Reverse Recovery Current | | | - | 9.3 | - | A |
| **SWITCHING PARAMETERS, (Load Inductive, $T_J$=175°C)** | | | | | | | |
| $t_{D(on)}$ | Turn-On DelayTime | $T_J$=175°C<br>$V_{GE}$=15V, $V_{CC}$=600V, $I_C$=40A,<br>$R_G$=7.5Ω | | - | 86 | - | ns |
| $t_r$ | Turn-On Rise Time | | | - | 92 | - | ns |
| $t_{D(off)}$ | Turn-Off Delay Time | | | - | 287 | - | ns |
| $t_f$ | Turn-Off Fall Time | | | - | 144 | - | ns |
| $E_{on}$ | Turn-On Energy | | | - | 4.48 | - | mJ |
| $E_{off}$ | Turn-Off Energy | | | - | 2.44 | - | mJ |
| $E_{total}$ | Total Switching Energy | | | - | 6.92 | - | mJ |
| $t_{rr}$ | Diode Reverse Recovery Time | $T_J$=175°C<br>$I_F$=40A, di/dt=200A/µs, $V_{CC}$=600V | | - | 605 | - | ns |
| $Q_{rr}$ | Diode Reverse Recovery Charge | | | - | 4.7 | - | µC |
| $I_{rm}$ | Diode Peak Reverse Recovery Current | | | - | 15.5 | - | A |

## TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS

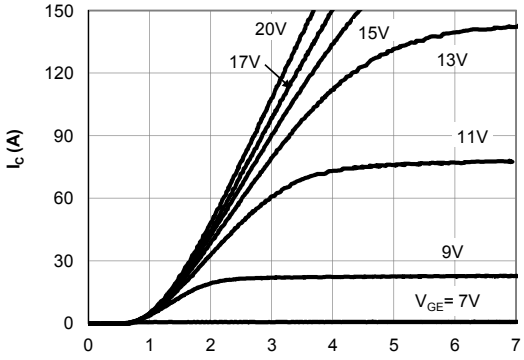



**Figure 1: Output Characteristic ($T_j$=25°C)**

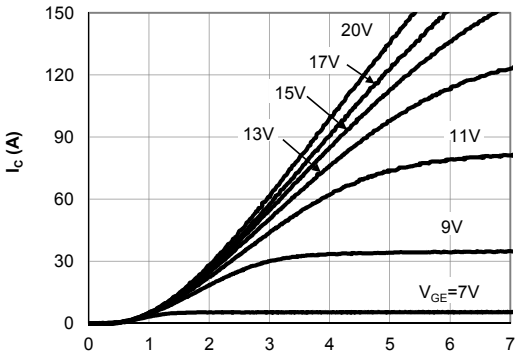



**Figure 2: Output Characteristic ($T_j$=175°C)**

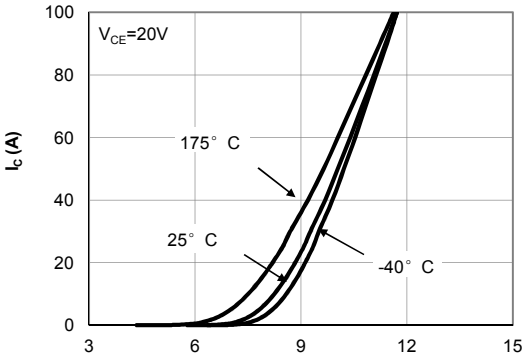



**Figure 3: Transfer Characteristic**

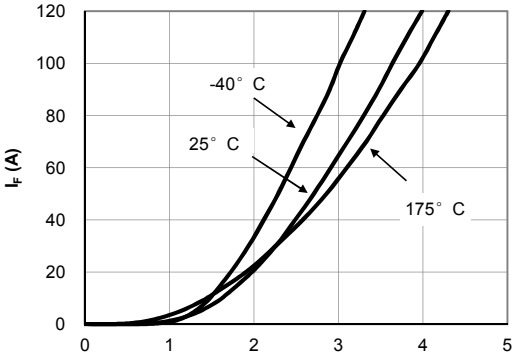



**Figure 4: Diode Characteristic**

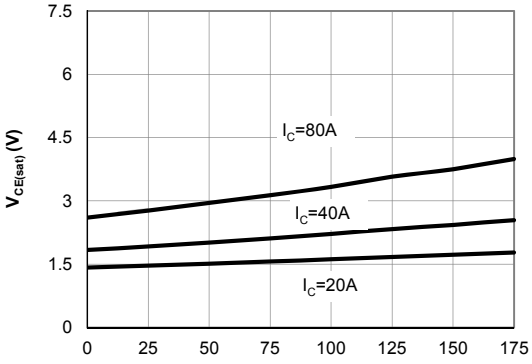



**Figure 5: Collector-Emitter Saturation Voltage vs. Junction Temperature**

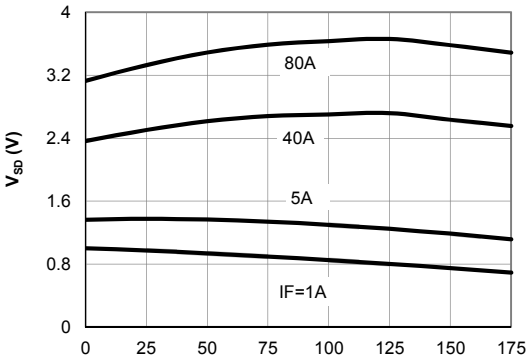



**Figure 6: Diode Forward voltage vs. Junction Temperature**

## TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS

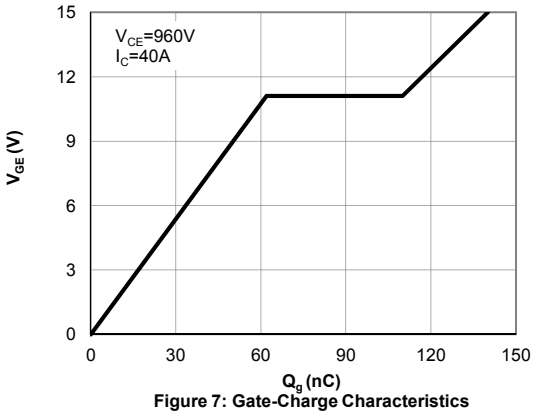



Figure 7: Gate-Charge Characteristics

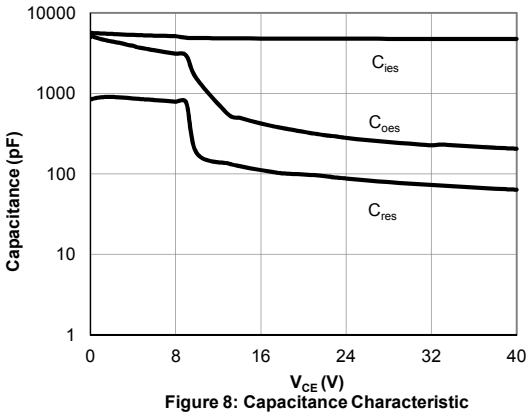



Figure 8: Capacitance Characteristic

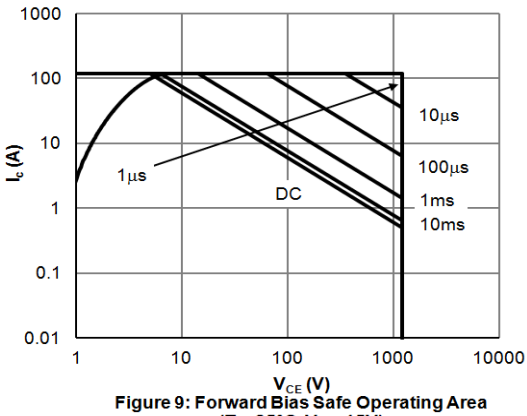



Figure 9: Forward Bias Safe Operating Area
($T_C$=25°C, $V_{GE}$=15V)

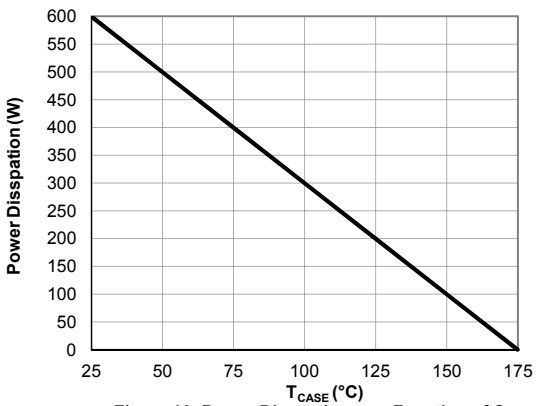



Figure 10: Power Disspation as a Function of Case

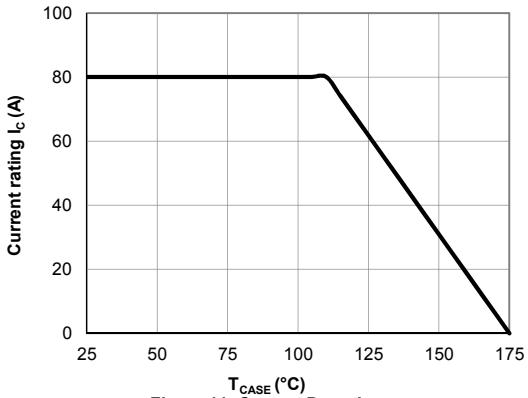



Figure 11: Current De-rating

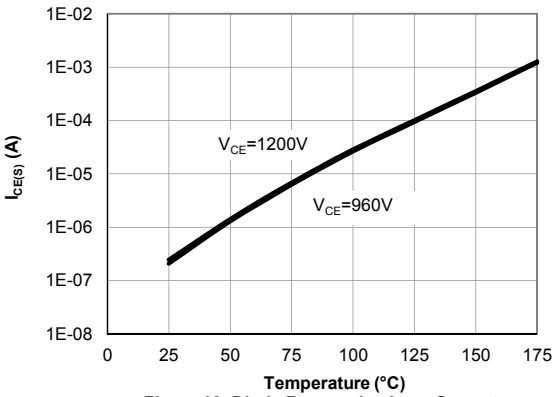



Figure 12: Diode Reverse Leakage Current vs. Junction Temperature

## TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS

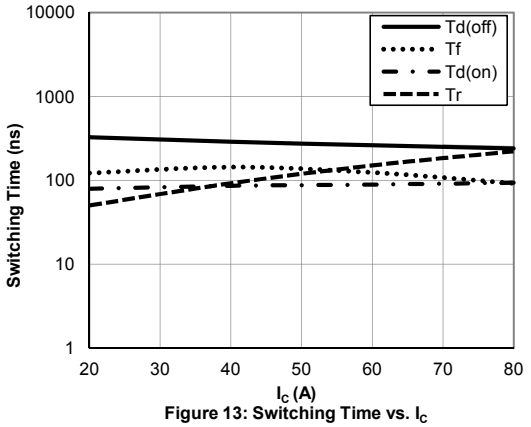



**Figure 13: Switching Time vs. $I_C$**
**($T_j$=175°C, $V_{GE}$=15V, $V_{CE}$=600V, $R_g$=7.5Ω)**

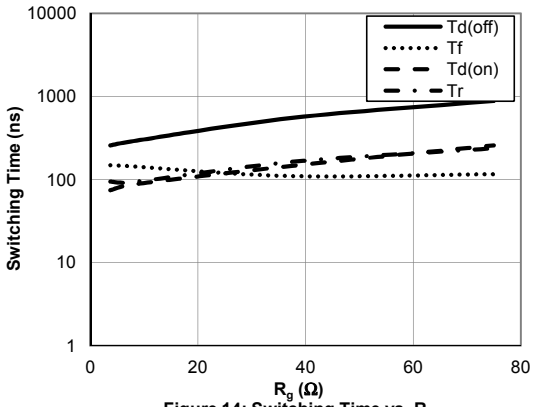



**Figure 14: Switching Time vs. $R_g$**
**($T_j$=175°C, $V_{GE}$=15V, $V_{CE}$=600V, $I_C$=40A)**

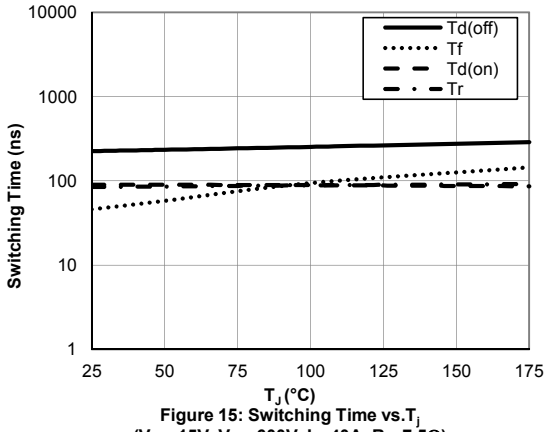



**Figure 15: Switching Time vs.$T_j$**
**($V_{GE}$=15V, $V_{CE}$=600V, $I_C$=40A, $R_g$=7.5Ω)**

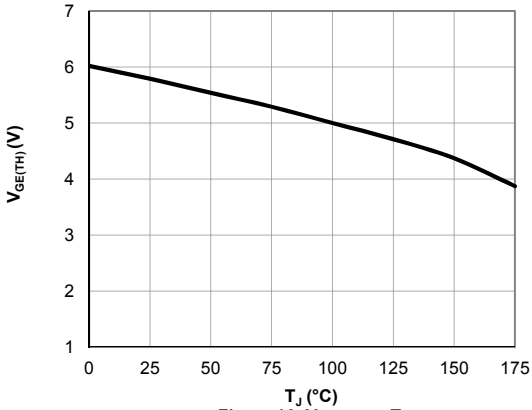



**Figure 16: $V_{GE(TH)}$ vs. $T_j$**

## TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS

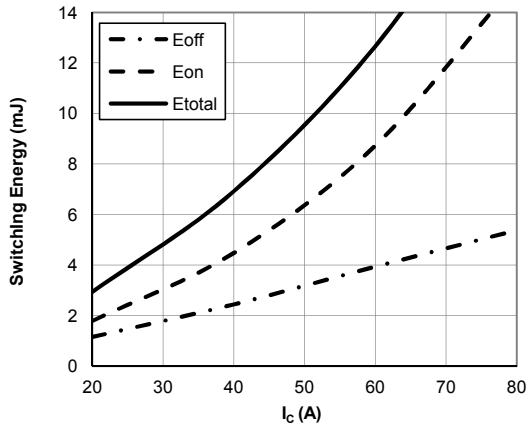



Figure 17: Switching Loss vs. $I_C$
($T_j$=175°C, $V_{GE}$=15V, $V_{CE}$=600V, $R_g$=7.5Ω)

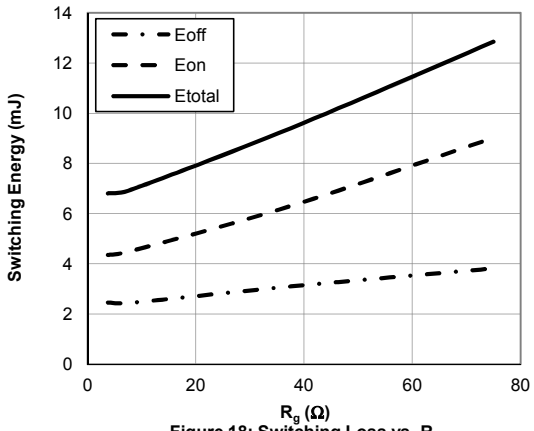



Figure 18: Switching Loss vs. $R_g$
($T_j$=175°C, $V_{GE}$=15V, $V_{CE}$=600V, $I_C$=40A)

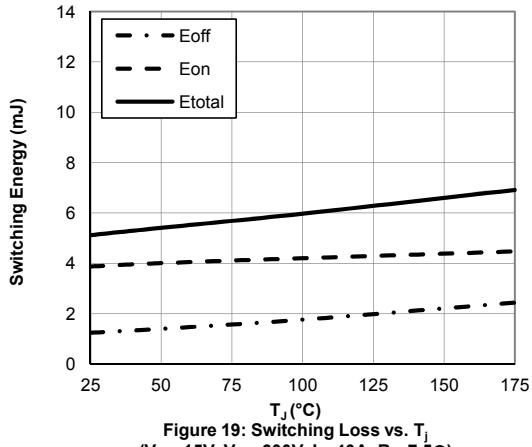



Figure 19: Switching Loss vs. $T_j$
($V_{GE}$=15V, $V_{CE}$=600V, $I_C$=40A, $R_g$=7.5Ω)

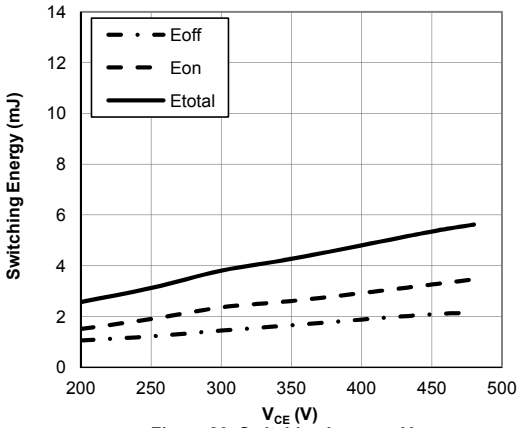



Figure 20: Switching Loss vs. $V_{CE}$
($T_j$=175°C, $V_{GE}$=15V, $I_C$=40A, $R_g$=7.5Ω)

## TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS

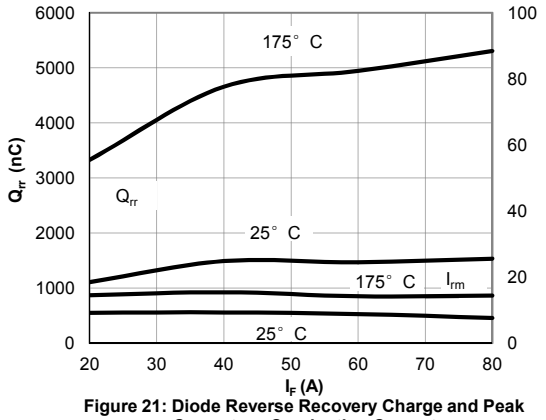



**Figure 21: Diode Reverse Recovery Charge and Peak Current vs. Conduction Current ($V_{GE}$=15V, $V_{CE}$=600V, di/dt=200A/µs)**

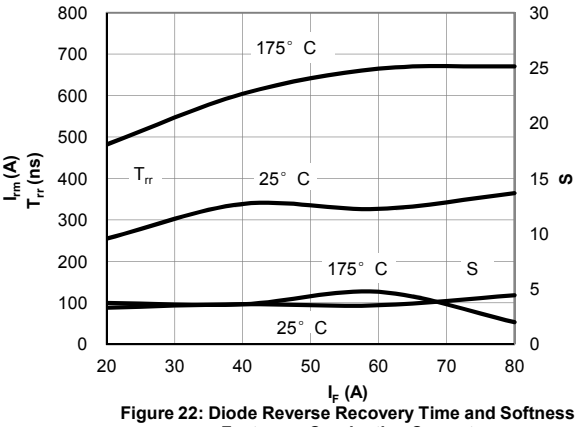



**Figure 22: Diode Reverse Recovery Time and Softness Factor vs. Conduction Current ($V_{GE}$=15V, $V_{CE}$=600V, di/dt=200A/µs)**

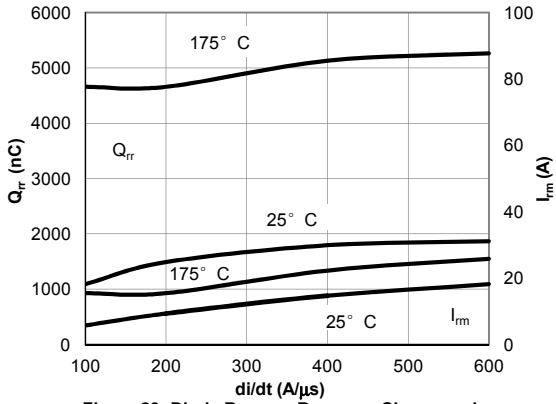



**Figure 23: Diode Reverse Recovery Charge and Peak Current vs. di/dt ($V_{GE}$=15V, $V_{CE}$=600V, $I_F$=40A)**

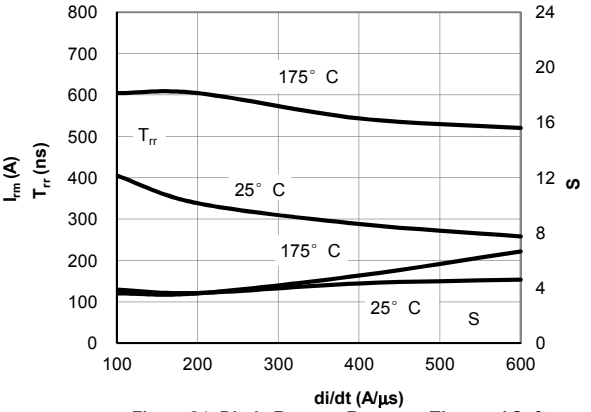



**Figure 24: Diode Reverse Recovery Time and Softness Factor vs. di/dt ($V_{GE}$=15V, $V_{CE}$=600V, $I_F$=40A)**

## TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS

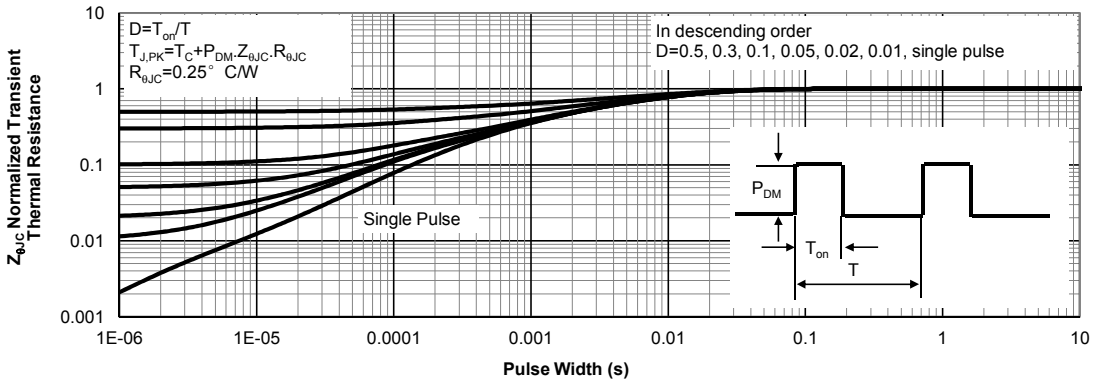



**Figure 25: Normalized Maximum Transient Thermal Impedance for IGBT**

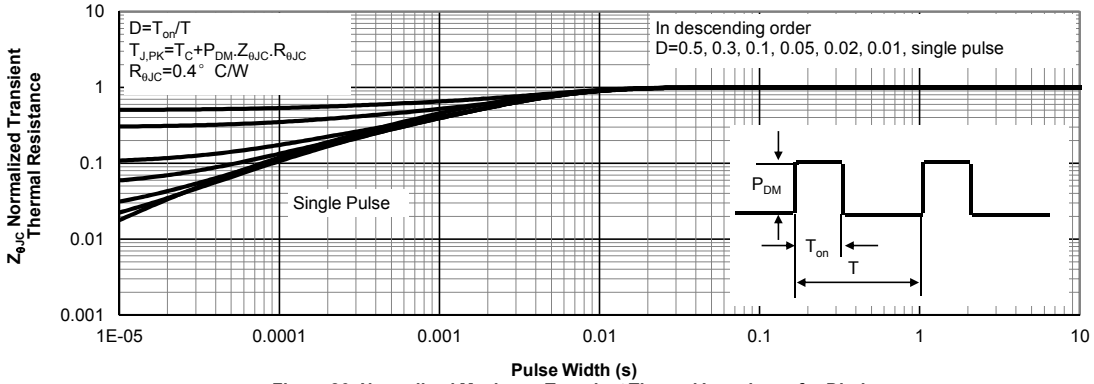



**Figure 26: Normalized Maximum Transient Thermal Impedance for Diode**

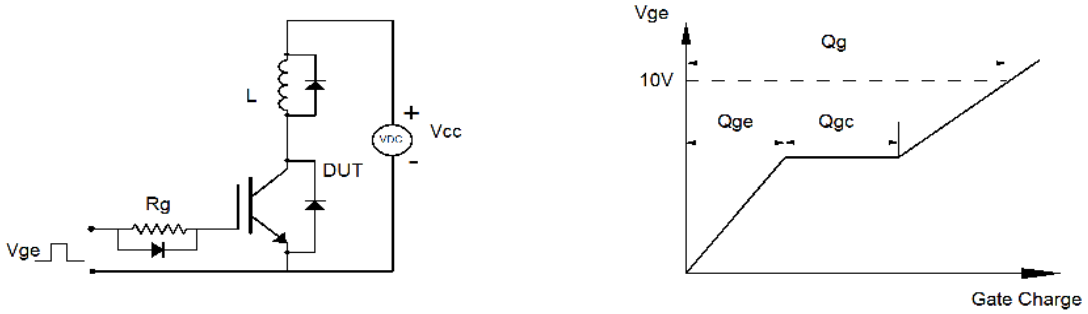



Figure A: Gate Charge Test Circuit & Waveforms

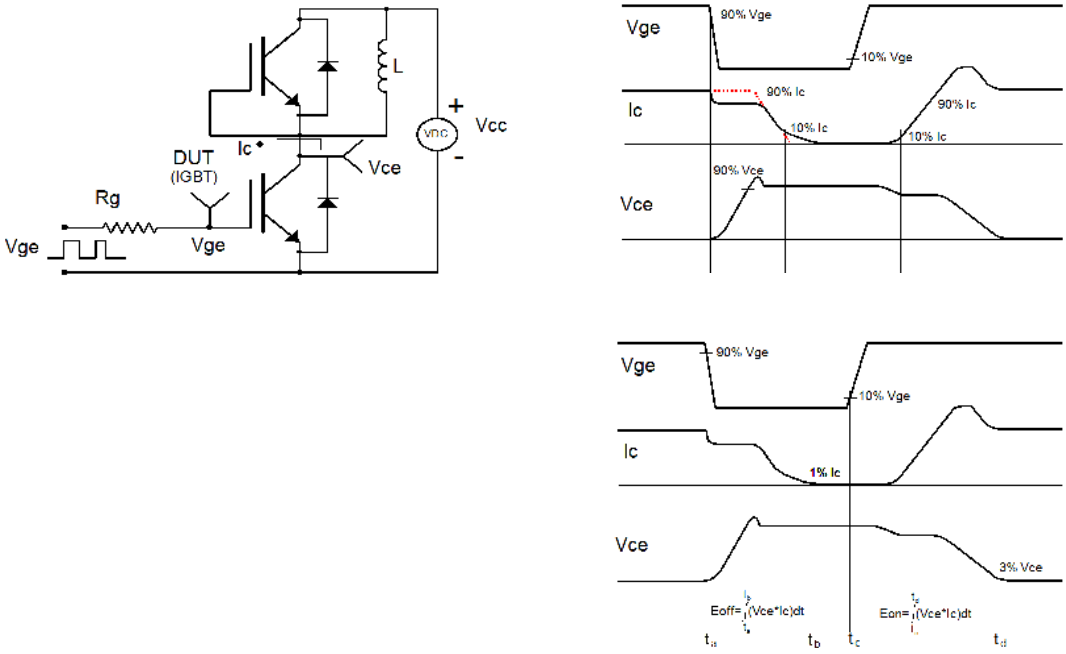



Figure B: Inductive Switching Test Circuit & Waveforms

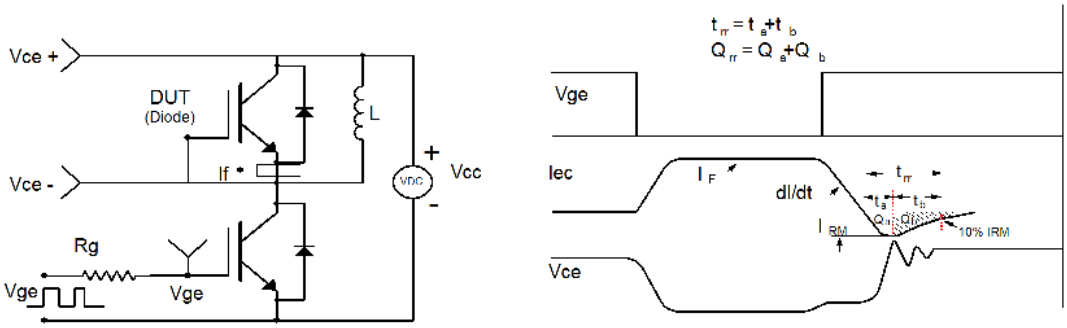



Figure C: Diode Recovery Test Circuit & Waveforms