



### General Description

- Latest AlphaGBT (αIGBT) technology
- 650V breakdown voltage
- Very low  $V_{CE(sat)}$
- Very fast and soft recovery freewheeling diode
- High efficient turn-on di/dt controllability
- Low Turn-Off switching loss and softness
- Very good EMI behavior

### Applications

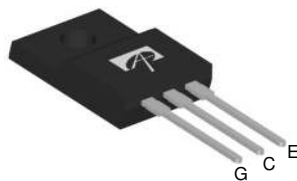
- Motor drives
- Power tools and sewing machines
- Mid to high range switching frequency converters
- Other hard switching applications

### Product Summary

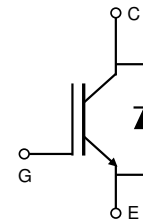
|  |       |
|--|-------|
| $V_{CE}$                                 | 650V  |
| $I_C$ ( $T_C=100^\circ\text{C}$ )        | 20A   |
| $V_{CE(sat)}$ ( $T_J=25^\circ\text{C}$ ) | 1.54V |



TO-220F



AOTF20B65LN2



| Orderable Part Number | Package Type | Form | Minimum Order Quantity |
|-----------------------|--------------|------|------------------------|
| AOTF20B65LN2          | TO220F       | Tube | 1000                   |

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

| Parameter  | Symbol         | AOTF20B65LN2            | 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><br>$V_{GE}=15\text{V}$ , $V_{CC} \leq 400\text{V}$ , $T_J \leq 150^\circ\text{C}$ | $t_{SC}$       | 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          | AOTF20B65LN2 | Units              |
|--------------------------------|-----------------|--------------|--------------------|
| Maximum Junction-to-Ambient    | $R_{\theta JA}$ | 65           | $^\circ\text{C/W}$ |
| Maximum IGBT Junction-to-Case  | $R_{\theta JC}$ | 2.8          | $^\circ\text{C/W}$ |
| Maximum Diode Junction-to-Case | $R_{\theta JC}$ | 3.2          | $^\circ\text{C/W}$ |

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

(2) TO220F  $I_C$  follows TO220/TO263.

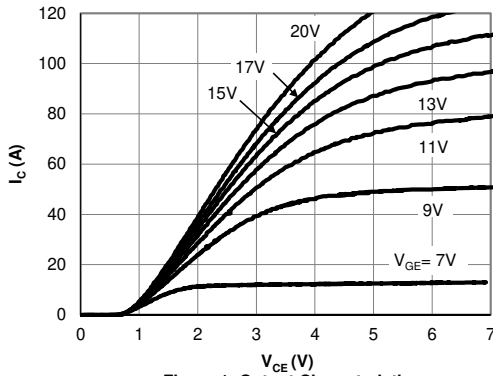
**Electrical Characteristics (T<sub>J</sub>=25°C unless otherwise noted)**

| Symbol   | Parameter                            | Conditions  | Min   | Typ  | Max  | Units |    |
|--|--------------------------------------|---|---|------|------|-------|----|
| <b>STATIC PARAMETERS</b>   |                                      |   |   |      |      |       |    |
| BV <sub>CES</sub>  | Collector-Emitter Breakdown Voltage  | I <sub>C</sub> =1mA, V <sub>GE</sub> =0V, T <sub>J</sub> =25°C  | 650   | -    | -    | V     |    |
| V <sub>CE(sat)</sub>   | Collector-Emitter Saturation Voltage | V <sub>GE</sub> =15V, I <sub>C</sub> =20A   | T <sub>J</sub> =25°C                                      | -    | 1.54 | 1.95  | V  |
|  |                                      |   | T <sub>J</sub> =125°C                                     | -    | 1.83 | -     |    |
|  |                                      |   | T <sub>J</sub> =150°C                                     | -    | 1.91 | -     |    |
| V <sub>F</sub>   | Diode Forward Voltage                | V <sub>GE</sub> =0V, I <sub>F</sub> =20A  | T <sub>J</sub> =25°C                                      | -    | 1.6  | 2.1   | V  |
|  |                                      |   | T <sub>J</sub> =125°C                                     | -    | 1.66 | -     |    |
|  |                                      |   | T <sub>J</sub> =150°C                                     | -    | 1.63 | -     |    |
| V <sub>GE(th)</sub>  | Gate-Emitter Threshold Voltage       | V <sub>CE</sub> =5V, I <sub>C</sub> =1mA  | -   | 4.7  | -    | V     |    |
| I <sub>CES</sub>   | Zero Gate Voltage Collector Current  | V <sub>CE</sub> =650V, V <sub>GE</sub> =0V  | T <sub>J</sub> =25°C                                      | -    | -    | 10    | μA |
|  |                                      |   | T <sub>J</sub> =125°C                                     | -    | -    | 500   |    |
|  |                                      |   | T <sub>J</sub> =150°C                                     | -    | -    | 1000  |    |
| I <sub>GES</sub>   | Gate-Emitter leakage current         | V <sub>CE</sub> =0V, V <sub>GE</sub> =±30V  | -   | -    | ±100 | nA    |    |
| g <sub>FS</sub>  | Forward Transconductance             | V <sub>CE</sub> =20V, I <sub>C</sub> =20A   | -   | 19   | -    | S     |    |
| <b>DYNAMIC PARAMETERS</b>  |                                      |   |   |      |      |       |    |
| C <sub>ies</sub>   | Input Capacitance                    | V <sub>GE</sub> =0V, V <sub>CC</sub> =25V, f=1MHz   | -   | 1237 | -    | pF    |    |
| C <sub>oes</sub>   | Output Capacitance                   |   | -   | 124  | -    | pF    |    |
| C <sub>res</sub>   | Reverse Transfer Capacitance         |   | -   | 38   | -    | pF    |    |
| Q <sub>g</sub>   | Total Gate Charge                    | V <sub>GE</sub> =15V, V <sub>CC</sub> =520V, I <sub>C</sub> =20A  | -   | 52   | -    | nC    |    |
| Q <sub>ge</sub>  | Gate to Emitter Charge               |   | -   | 14   | -    | nC    |    |
| Q <sub>gc</sub>  | Gate to Collector Charge             |   | -   | 22   | -    | nC    |    |
| I <sub>C(SC)</sub>   | Short Circuit Collector Current      | V <sub>GE</sub> =15V, V <sub>CC</sub> =400V,<br>t <sub>sc</sub> ≤5μs, T <sub>J</sub> ≤150°C                       | -   | 150  | -    | A     |    |
| R <sub>g</sub>   | Gate resistance                      | V <sub>GE</sub> =0V, V <sub>CC</sub> =0V, f=1MHz  | -   | 11   | -    | Ω     |    |
| <b>SWITCHING PARAMETERS, (Load Inductive, T<sub>J</sub>=25°C)</b>  |                                      |   |   |      |      |       |    |
| T <sub>d(on)</sub>   | Turn-On Delay Time                   | T <sub>J</sub> =25°C<br>V <sub>GE</sub> =15V, V <sub>CC</sub> =400V, I <sub>C</sub> =20A,<br>R <sub>G</sub> =15Ω  | -   | 23   | -    | ns    |    |
| T <sub>r</sub>   | Turn-On Rise Time                    |   | -   | 23   | -    | ns    |    |
| T <sub>d(off)</sub>  | Turn-Off Delay Time                  |   | -   | 135  | -    | ns    |    |
| T <sub>f</sub>   | Turn-Off Fall Time                   |   | -   | 12   | -    | ns    |    |
| E <sub>on</sub>  | Turn-On Energy                       |   | -   | 0.45 | -    | mJ    |    |
| E <sub>off</sub>   | Turn-Off Energy                      |   | -   | 0.26 | -    | mJ    |    |
| E <sub>total</sub>   | Total Switching Energy               |   | -   | 0.71 | -    | mJ    |    |
| T <sub>rr</sub>  | Diode Reverse Recovery Time          |   | -   | 266  | -    | ns    |    |
| Q <sub>rr</sub>  | Diode Reverse Recovery Charge        |   | I <sub>F</sub> =20A, dI/dt=200A/μs, V <sub>CC</sub> =400V | -    | 0.6  | -     | μC |
| I <sub>rm</sub>  | Diode Peak Reverse Recovery Current  |   | -   | -    | 5.4  | -     | A  |
| <b>SWITCHING PARAMETERS, (Load Inductive, T<sub>J</sub>=150°C)</b> |                                      |   |   |      |      |       |    |
| T <sub>d(on)</sub>   | Turn-On Delay Time                   | T <sub>J</sub> =150°C<br>V <sub>GE</sub> =15V, V <sub>CC</sub> =400V, I <sub>C</sub> =20A,<br>R <sub>G</sub> =15Ω | -   | 22   | -    | ns    |    |
| T <sub>r</sub>   | Turn-On Rise Time                    |   | -   | 24   | -    | ns    |    |
| T <sub>d(off)</sub>  | Turn-Off Delay Time                  |   | -   | 160  | -    | ns    |    |
| T <sub>f</sub>   | Turn-Off Fall Time                   |   | -   | 20   | -    | ns    |    |
| E <sub>on</sub>  | Turn-On Energy                       |   | -   | 0.49 | -    | mJ    |    |
| E <sub>off</sub>   | Turn-Off Energy                      |   | -   | 0.44 | -    | mJ    |    |
| E <sub>total</sub>   | Total Switching Energy               |   | -   | 0.93 | -    | mJ    |    |
| T <sub>rr</sub>  | Diode Reverse Recovery Time          |   | -   | 363  | -    | ns    |    |
| Q <sub>rr</sub>  | Diode Reverse Recovery Charge        |   | I <sub>F</sub> =20A, dI/dt=200A/μs, V <sub>CC</sub> =400V | -    | 1.3  | -     | μC |
| I <sub>rm</sub>  | Diode Peak Reverse Recovery Current  |   | -   | -    | 6.9  | -     | A  |

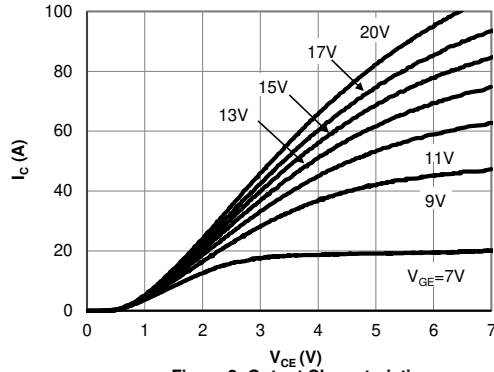
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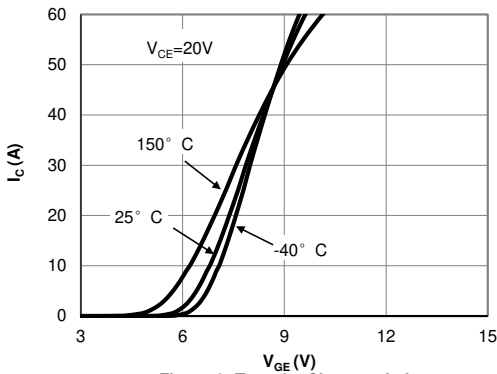
**TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS**



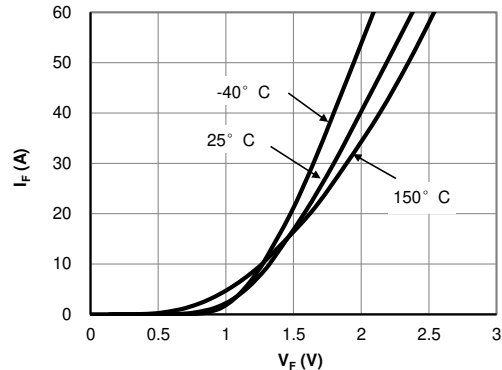
**Figure 1: Output Characteristic**  
( $T_j=25^\circ\text{C}$ )



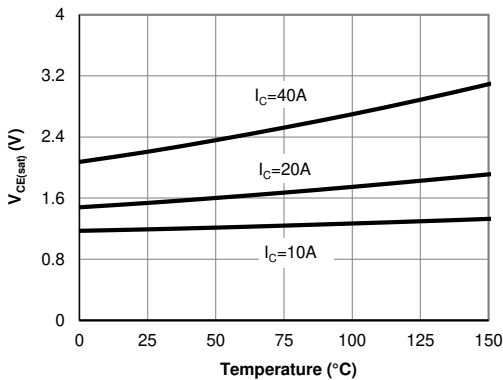
**Figure 2: Output Characteristic**  
( $T_j=150^\circ\text{C}$ )



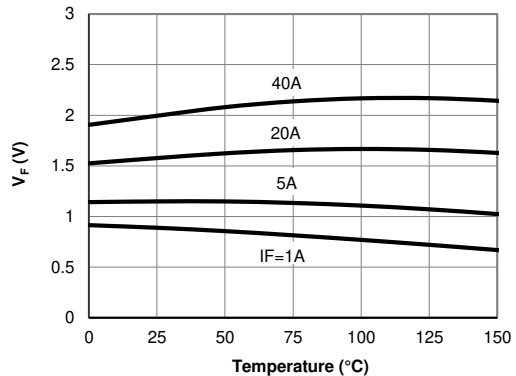
**Figure 3: Transfer Characteristic**



**Figure 4: Diode Characteristic**

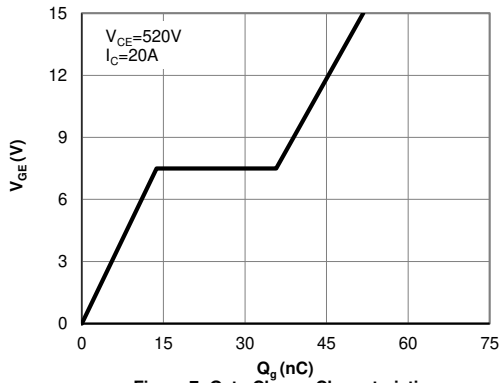


**Figure 5: Collector-Emitter Saturation Voltage vs. Junction Temperature**

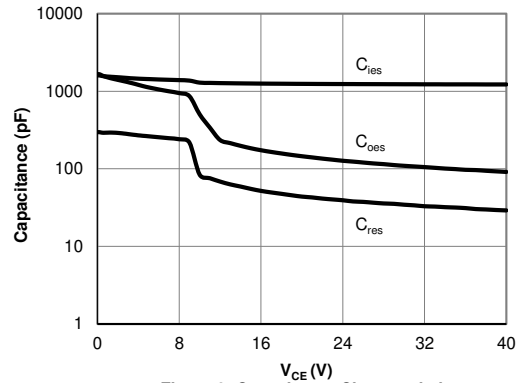


**Figure 6: Diode Forward voltage vs. Junction Temperature**

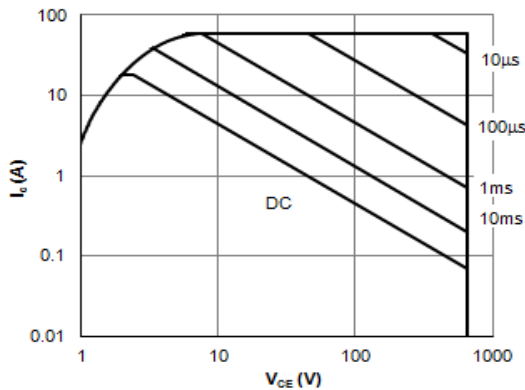
**TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS**



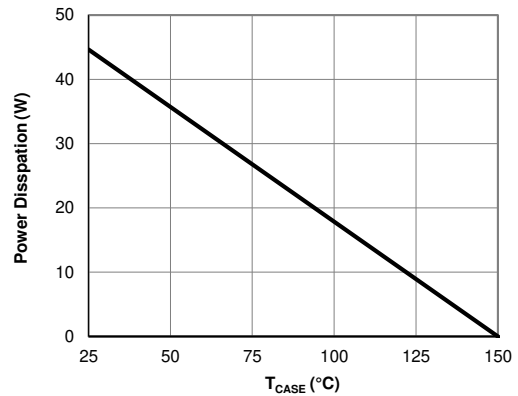
**Figure 7: Gate-Charge Characteristics**



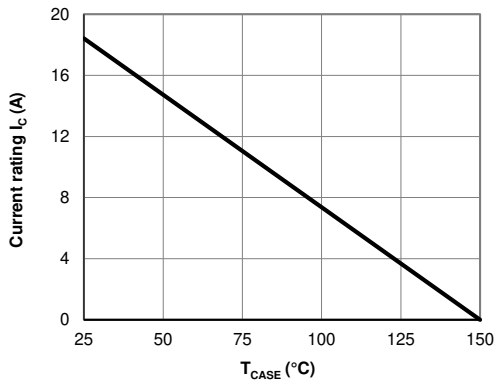
**Figure 8: Capacitance Characteristic**



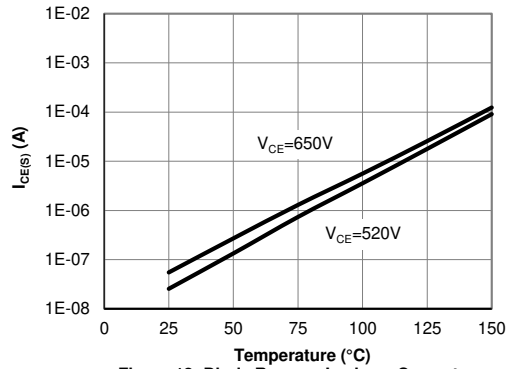
**Figure 9: Forward Bias Safe Operating Area (T\_C=25°C, V\_OE=15V)**



**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**

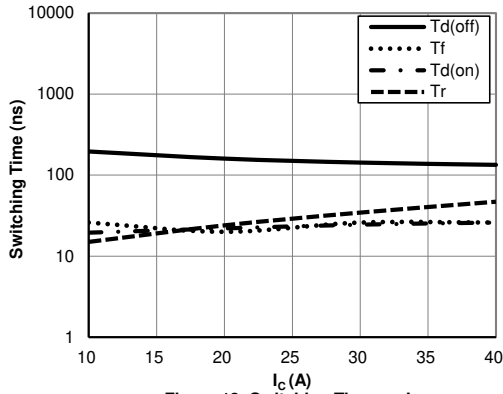


Figure 13: Switching Time vs.  $I_C$   
( $T_J=150^\circ\text{C}$ ,  $V_{GE}=15\text{V}$ ,  $V_{CE}=400\text{V}$ ,  $R_g=15\Omega$ )

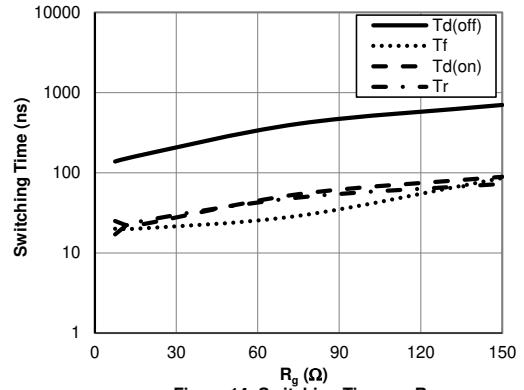


Figure 14: Switching Time vs.  $R_g$   
( $T_J=150^\circ\text{C}$ ,  $V_{GE}=15\text{V}$ ,  $V_{CE}=400\text{V}$ ,  $I_C=20\text{A}$ )

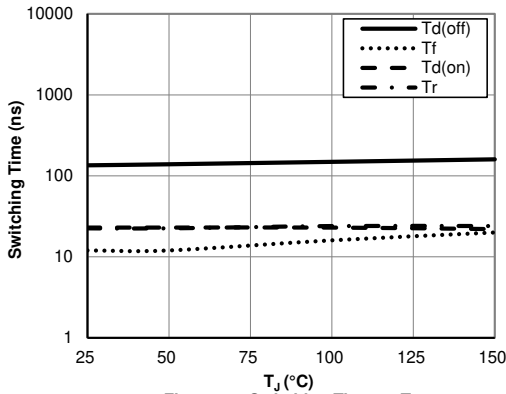


Figure 15: Switching Time vs.  $T_J$   
( $V_{GE}=15\text{V}$ ,  $V_{CE}=400\text{V}$ ,  $I_C=20\text{A}$ ,  $R_g=15\Omega$ )

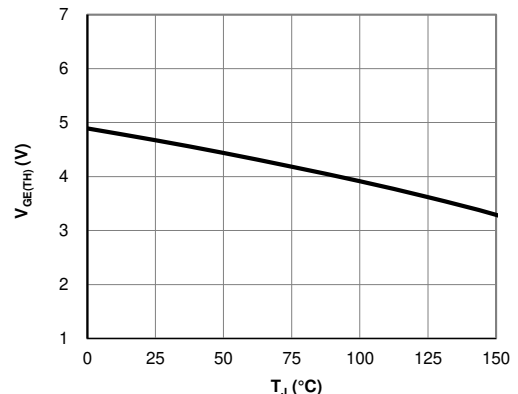
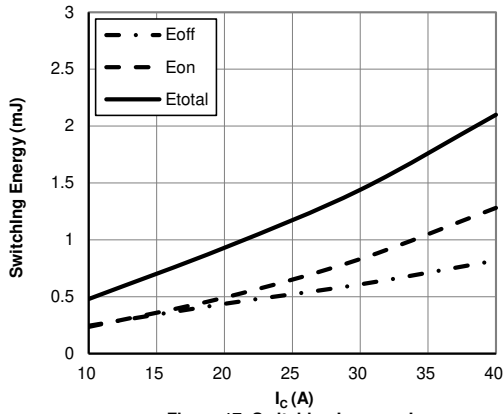
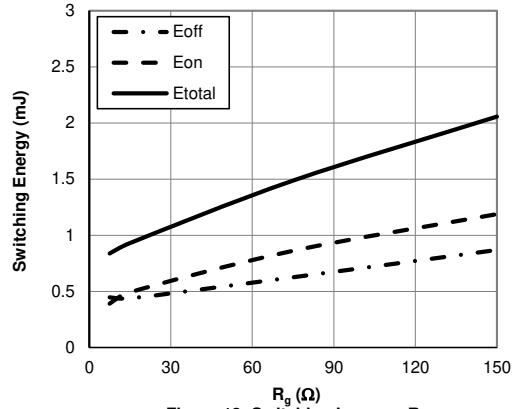


Figure 16:  $V_{GE(\text{TH})}$  vs.  $T_J$

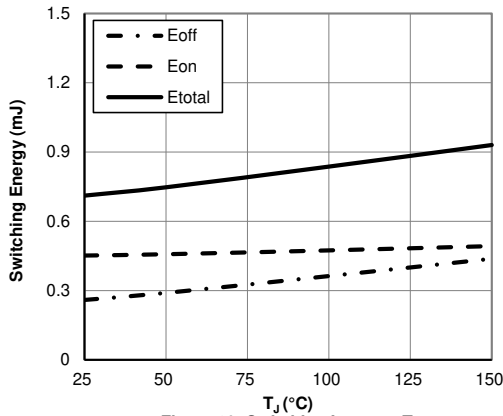
**TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS**



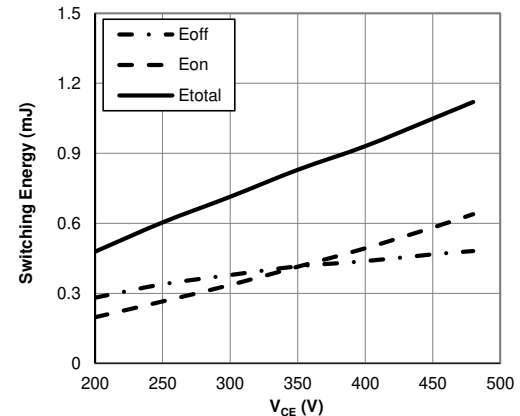
**Figure 17: Switching Loss vs.  $I_C$**   
( $T_J=150^\circ\text{C}$ ,  $V_{GE}=15\text{V}$ ,  $V_{CE}=400\text{V}$ ,  $R_g=15\Omega$ )



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

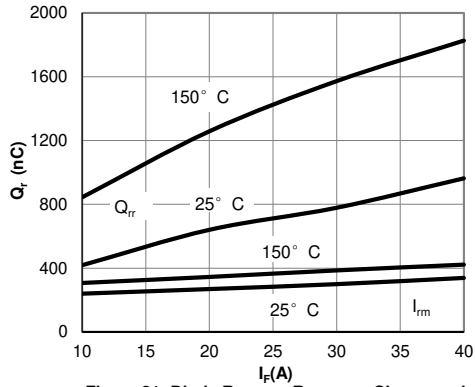


**Figure 19: Switching Loss vs.  $T_J$**   
( $V_{GE}=15\text{V}$ ,  $V_{CE}=400\text{V}$ ,  $I_C=20\text{A}$ ,  $R_g=15\Omega$ )

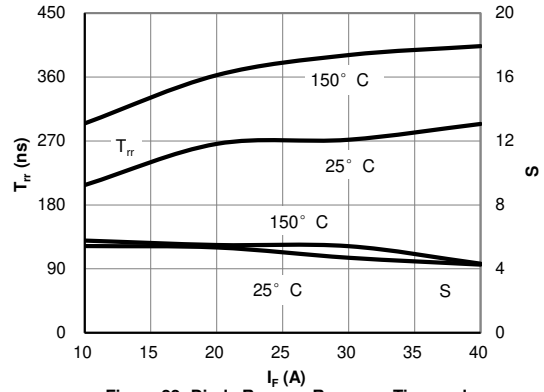


**Figure 20: Switching Loss vs.  $V_{CE}$**   
( $T_J=150^\circ\text{C}$ ,  $V_{GE}=15\text{V}$ ,  $I_C=20\text{A}$ ,  $R_g=15\Omega$ )

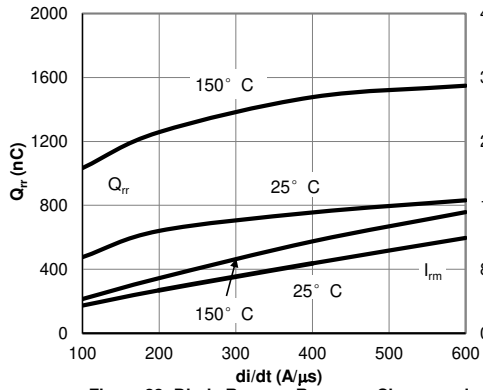
**TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS**



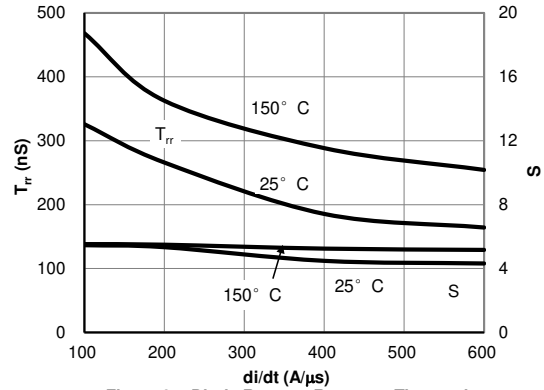
**Figure 21: Diode Reverse Recovery Charge and Peak Current vs. Conduction Current**  
( $V_{GE}=15V$ ,  $V_{CE}=400V$ ,  $di/dt=200A/\mu s$ )



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

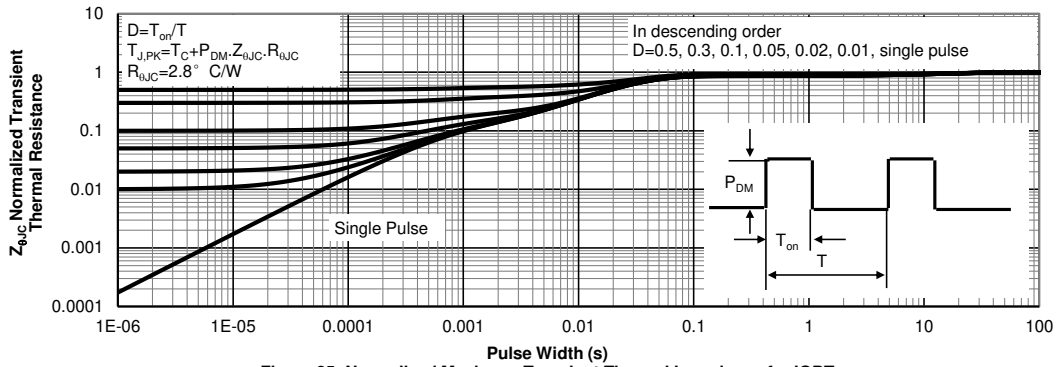


**Figure 23: Diode Reverse Recovery Charge and Peak Current vs. di/dt**  
( $V_{GE}=15V$ ,  $V_{CE}=400V$ ,  $I_F=20A$ )

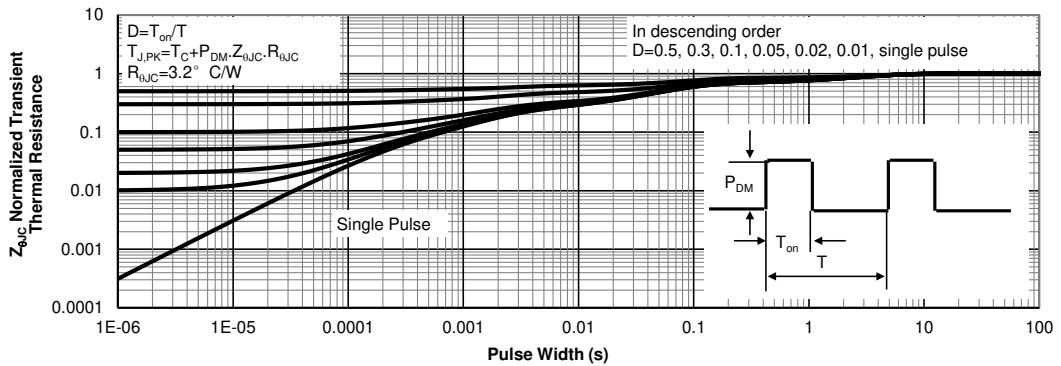


**Figure 24: Diode Reverse Recovery Time and Softness Factor vs. di/dt**  
( $V_{GE}=15V$ ,  $V_{CE}=400V$ ,  $I_F=20A$ )

**TYPICAL ELECTRICAL AND THERMAL CHARACTERISTICS**



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



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



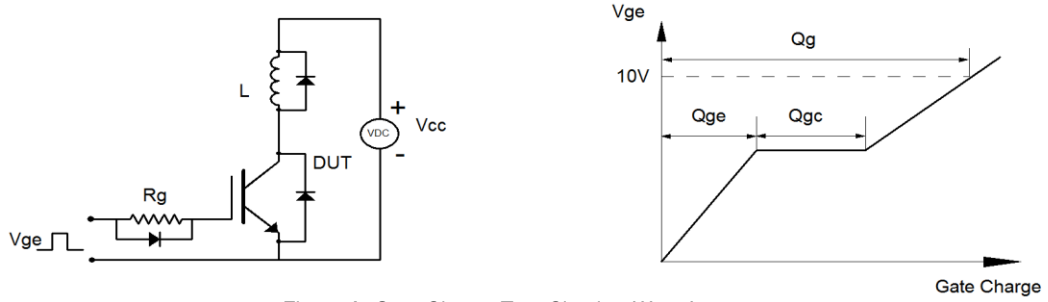


Figure A: Gate Charge Test Circuit & Waveforms

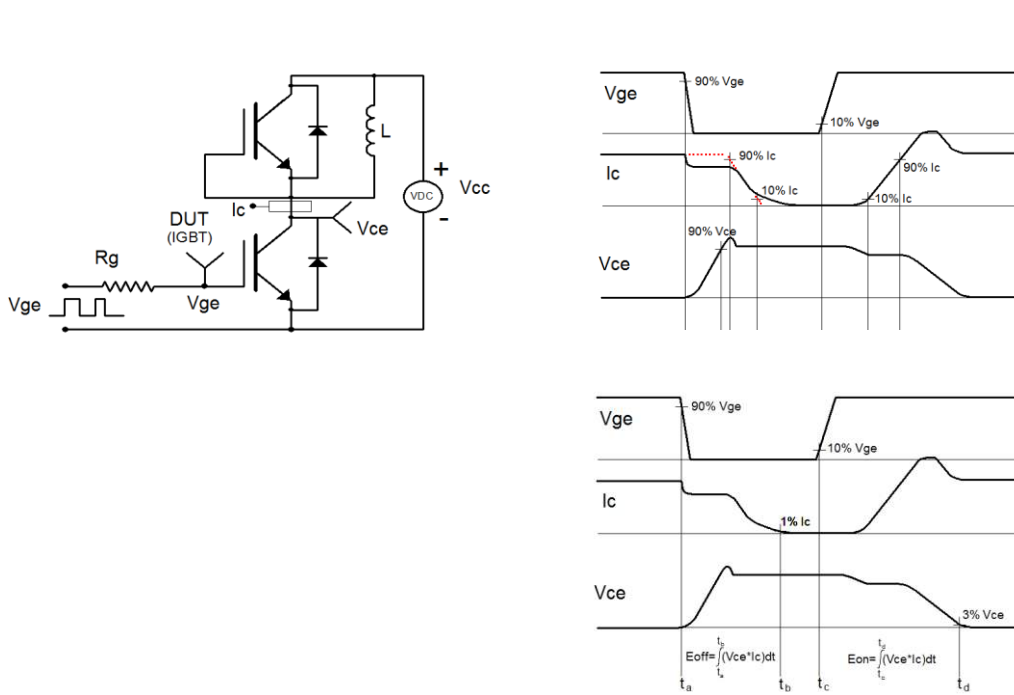


Figure B: Inductive Switching Test Circuit & Waveforms

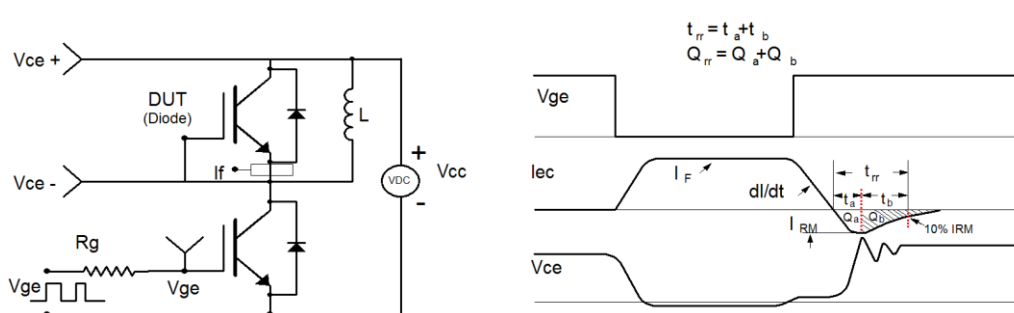


Figure C: Diode Recovery Test Circuit & Waveforms