# STARPOWER

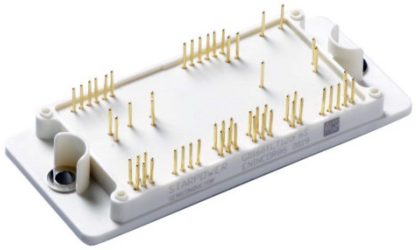
**SEMICONDUCTOR** **IGBT**

# GD160TLT120F6S

**1200V/160A 3-level in one-package**

## General Description

STARPOWER IGBT Power Module provides ultra low conduction loss as well as short circuit ruggedness. They are designed for the applications such as UPS and solar power.



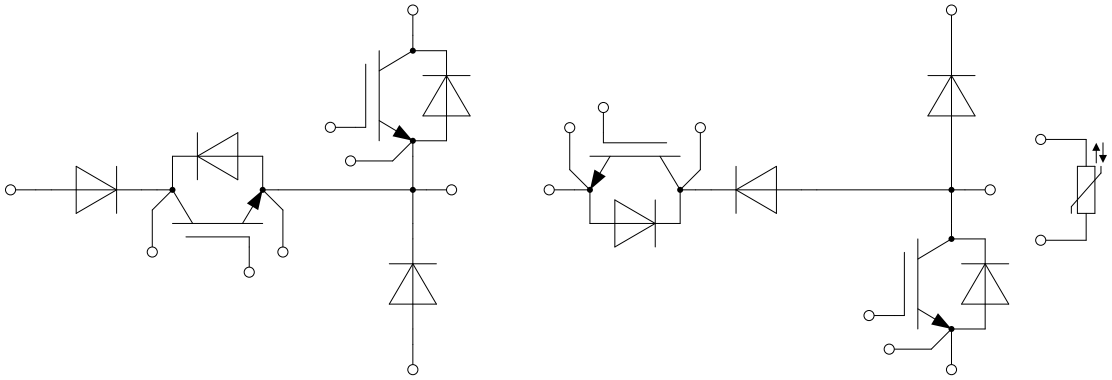
## Features

- Low $V_{CE(sat)}$ Trench IGBT technology
- Low switching loss
- $V_{CE(sat)}$ with positive temperature coefficient
- High short circuit capability
- Maximum junction temperature 175°C
- Low inductance case
- Fast & soft reverse recovery anti-parallel FWD

## Typical Applications

- 3-level-applications
- Uninterruptible power supply
- Solar Power

## Equivalent Circuit Schematic



## Absolute Maximum Ratings $T_C$=25°C unless otherwise noted

### TI,T6 IGBT

| Symbol | Description | Value | Unit |
|---|---|---|---|
| $V_{CES}$ | Collector-Emitter Voltage | 1200 | V |
| $V_{GES}$ | Gate-Emitter Voltage | ±20 | V |
| $I_C$ | Collector Current @ $T_C$=25°C<br>@ $T_C$=100°C | 240<br>160 | A |
| $I_{CM}$ | Pulsed Collector Current $t_p$=1ms | 320 | A |
| $P_D$ | Maximum Power Dissipation @ $T_j$=175°C | 968 | W |

### D1,D6 Diode

| Symbol | Description | Value | Unit |
|---|---|---|---|
| $V_{RRM}$ | Repetitive Peak Reverse Voltage | 1200 | V |
| $I_F$ | Diode Continuous Forward Current | 25 | A |
| $I_{FM}$ | Diode Maximum Forward Current $t_p$=1ms | 50 | A |

### D2,D5 Diode

| Symbol | Description | Value | Unit |
|---|---|---|---|
| $V_{RRM}$ | Repetitive Peak Reverse Voltage | 1200 | V |
| $I_F$ | Diode Continuous Forward Current | 50 | A |
| $I_{FM}$ | Diode Maximum Forward Current $t_p$=1ms | 100 | A |

## T4,T7 IGBT

| Symbol | Description | Value | Unit |
|---|---|---|---|
| $V_{CES}$ | Collector-Emitter Voltage | 650 | V |
| $V_{GES}$ | Gate-Emitter Voltage | ±20 | V |
| $I_C$ | Collector Current @ $T_C$=25°C<br>@ $T_C$=85°C | 140<br>100 | A |
| $I_{CM}$ | Pulsed Collector Current $t_p$=1ms | 200 | A |
| $P_D$ | Maximum Power Dissipation @ $T_j$=175°C | 360 | W |

## D4,D7 Diode

| Symbol | Description | Value | Unit |
|---|---|---|---|
| $V_{RRM}$ | Repetitive Peak Reverse Voltage | 650 | V |
| $I_F$ | Diode Continuous Forward Current | 50 | A |
| $I_{FM}$ | Diode Maximum Forward Current $t_p$=1ms | 100 | A |

## D3,D8 Diode

| Symbol | Description | Value | Unit |
|---|---|---|---|
| $V_{RRM}$ | Repetitive Peak Reverse Voltage | 650 | V |
| $I_F$ | Diode Continuous Forward Current | 100 | A |
| $I_{FM}$ | Diode Maximum Forward Current $t_p$=1ms | 200 | A |

## Module

| Symbol | Description | Value | Unit |
|---|---|---|---|
| $T_{jmax}$ | Maximum Junction Temperature | 175 | °C |
| $T_{jop}$ | Operating Junction Temperature | -40 to +150 | °C |
| $T_{STG}$ | Storage Temperature Range | -40 to +125 | °C |
| $V_{ISO}$ | Isolation Voltage RMS,f=50Hz,t=1min | 4000 | V |

## T1,T6 IGBT Characteristics $T_C$=25°C unless otherwise noted

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{CE(sat)}$ | Collector to Emitter Saturation Voltage | $I_C$=160A,$V_{GE}$=15V, $T_j$=25°C | | 2.05 | 2.40 | V |
| | | $I_C$=160A,$V_{GE}$=15V, $T_j$=125°C | | 2.50 | | |
| | | $I_C$=160A,$V_{GE}$=15V, $T_j$=150°C | | 2.60 | | |
| $V_{GE(th)}$ | Gate-Emitter Threshold Voltage | $I_C$=6.0mA,$V_{CE}$=$V_{GE}$, $T_j$=25°C | 5.3 | 5.8 | 6.3 | V |
| $I_{CES}$ | Collector Cut-Off Current | $V_{CE}$=$V_{CES}$,$V_{GE}$=0V, $T_j$=25°C | | | 1.0 | mA |
| $I_{GES}$ | Gate-Emitter Leakage Current | $V_{GE}$=$V_{GES}$,$V_{CE}$=0V, $T_j$=25°C | | | 400 | nA |
| $R_{Gint}$ | Internal Gate Resistance | | | 0 | | Ω |
| $C_{ies}$ | Input Capacitance | $V_{CE}$=25V,f=1MHz, $V_{GE}$=0V | | 4.66 | | nF |
| $C_{res}$ | Reverse Transfer Capacitance | | | 0.23 | | nF |
| $Q_G$ | Gate Charge | $V_{GE}$=15V | | 0.74 | | μC |
| $t_{d(on)}$ | Turn-On Delay Time | $V_{CC}$=600V,$I_C$=160A, $R_G$=4.1Ω,$V_{GE}$=±15V, $T_j$=25°C | | 180 | | ns |
| $t_r$ | Rise Time | | | 55 | | ns |
| $t_{d(off)}$ | Turn-Off Delay Time | | | 225 | | ns |
| $t_f$ | Fall Time | | | 140 | | ns |
| $E_{on}$ | Turn-On Switching Loss | | | 7.40 | | mJ |
| $E_{off}$ | Turn-Off Switching Loss | | | 5.52 | | mJ |
| $t_{d(on)}$ | Turn-On Delay Time | $V_{CC}$=600V,$I_C$=160A, $R_G$=4.1Ω,$V_{GE}$=±15V, $T_j$=125°C | | 185 | | ns |
| $t_r$ | Rise Time | | | 58 | | ns |
| $t_{d(off)}$ | Turn-Off Delay Time | | | 250 | | ns |
| $t_f$ | Fall Time | | | 195 | | ns |
| $E_{on}$ | Turn-On Switching Loss | | | 12.5 | | mJ |
| $E_{off}$ | Turn-Off Switching Loss | | | 9.28 | | mJ |
| $t_{d(on)}$ | Turn-On Delay Time | $V_{CC}$=600V,$I_C$=160A, $R_G$=4.1Ω,$V_{GE}$=±15V, $T_j$=150°C | | 186 | | ns |
| $t_r$ | Rise Time | | | 59 | | ns |
| $t_{d(off)}$ | Turn-Off Delay Time | | | 255 | | ns |
| $t_f$ | Fall Time | | | 205 | | ns |
| $E_{on}$ | Turn-On Switching Loss | | | 12.7 | | mJ |
| $E_{off}$ | Turn-Off Switching Loss | | | 9.48 | | mJ |
| $I_{SC}$ | SC Data | $t_P$≤10μs,$V_{GE}$=15V, $T_j$=150°C,$V_{CC}$=900V, $V_{CEM}$≤1200V | | 640 | | A |

## D1,D6 Diode Characteristics $T_C$=25°C unless otherwise noted

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_F$ | Diode Forward Voltage | $I_F$=25A,$V_{GE}$=0V,$T_j$=25°C | | 2.10 | 2.45 | V |
| | | $I_F$=25A,$V_{GE}$=0V,$T_j$=125°C | | 2.15 | | |
| | | $I_F$=25A,$V_{GE}$=0V,$T_j$=150°C | | 2.15 | | |
| $Q_r$ | Recovered Charge | $V_R$=600V,$I_F$=25A, -di/dt=900A/μs,$V_{GE}$=-15V $T_j$=25°C | | 1.3 | | μC |
| $I_{RM}$ | Peak Reverse Recovery Current | | | 31 | | A |
| $E_{rec}$ | Reverse Recovery Energy | | | 0.68 | | mJ |
| $Q_r$ | Recovered Charge | $V_R$=600V,$I_F$=25A, -di/dt=900A/μs,$V_{GE}$=-15V $T_j$=125°C | | 2.2 | | μC |
| $I_{RM}$ | Peak Reverse Recovery Current | | | 38 | | A |
| $E_{rec}$ | Reverse Recovery Energy | | | 1.46 | | mJ |
| $Q_r$ | Recovered Charge | $V_R$=600V,$I_F$=25A, -di/dt=900A/μs,$V_{GE}$=-15V $T_j$=150°C | | 2.4 | | μC |
| $I_{RM}$ | Peak Reverse Recovery Current | | | 40 | | A |
| $E_{rec}$ | Reverse Recovery Energy | | | 1.91 | | mJ |

## D2,D5 Diode Characteristics $T_C$=25°C unless otherwise noted

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_F$ | Diode Forward Voltage | $I_F$=50A,$V_{GE}$=0V,$T_j$=25°C | | 1.70 | 2.05 | V |
| | | $I_F$=50A,$V_{GE}$=0V,$T_j$=125°C | | 1.65 | | |
| | | $I_F$=50A,$V_{GE}$=0V,$T_j$=150°C | | 1.65 | | |
| $Q_r$ | Recovered Charge | $V_R$=600V,$I_F$=50A, -di/dt=1200A/μs,$V_{GE}$=-15V $T_j$=25°C | | 3.0 | | μC |
| $I_{RM}$ | Peak Reverse Recovery Current | | | 46 | | A |
| $E_{rec}$ | Reverse Recovery Energy | | | 1.72 | | mJ |
| $Q_r$ | Recovered Charge | $V_R$=600V,$I_F$=50A, -di/dt=1200A/μs,$V_{GE}$=-15V $T_j$=125°C | | 7.2 | | μC |
| $I_{RM}$ | Peak Reverse Recovery Current | | | 56 | | A |
| $E_{rec}$ | Reverse Recovery Energy | | | 3.15 | | mJ |
| $Q_r$ | Recovered Charge | $V_R$=600V,$I_F$=50A, -di/dt=1200A/μs,$V_{GE}$=-15V $T_j$=150°C | | 7.8 | | μC |
| $I_{RM}$ | Peak Reverse Recovery Current | | | 57 | | A |
| $E_{rec}$ | Reverse Recovery Energy | | | 3.24 | | mJ |

## T4,T7 IGBT Characteristics $T_C$=25°C unless otherwise noted

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{CE(sat)}$ | Collector to Emitter Saturation Voltage | $I_C$=100A,$V_{GE}$=15V, $T_j$=25°C | | 1.45 | 1.90 | V |
| | | $I_C$=100A,$V_{GE}$=15V, $T_j$=125°C | | 1.60 | | |
| | | $I_C$=100A,$V_{GE}$=15V, $T_j$=150°C | | 1.70 | | |
| $V_{GE(th)}$ | Gate-Emitter Threshold Voltage | $I_C$=1.6mA,$V_{CE}$=$V_{GE}$, $T_j$=25°C | 5.1 | 5.8 | 6.4 | V |
| $I_{CES}$ | Collector Cut-Off Current | $V_{CE}$=$V_{CES}$,$V_{GE}$=0V, $T_j$=25°C | | | 1.0 | mA |
| $I_{GES}$ | Gate-Emitter Leakage Current | $V_{GE}$=$V_{GES}$,$V_{CE}$=0V, $T_j$=25°C | | | 400 | nA |
| $R_{Gint}$ | Internal Gate Resistance | | | 0 | | Ω |
| $C_{ies}$ | Input Capacitance | $V_{CE}$=25V,f=1MHz, $V_{GE}$=0V | | 6.28 | | nF |
| $C_{res}$ | Reverse Transfer Capacitance | | | 0.19 | | nF |
| $Q_G$ | Gate Charge | $V_{GE}$=15V | | 0.62 | | μC |
| $t_{d(on)}$ | Turn-On Delay Time | $V_{CC}$=300V,$I_C$=100A, $R_G$=4.1Ω,$V_{GE}$=±15V, $T_j$=25°C | | 195 | | ns |
| $t_r$ | Rise Time | | | 67 | | ns |
| $t_{d(off)}$ | Turn-Off Delay Time | | | 236 | | ns |
| $t_f$ | Fall Time | | | 140 | | ns |
| $E_{on}$ | Turn-On Switching Loss | | | 1.04 | | mJ |
| $E_{off}$ | Turn-Off Switching Loss | | | 2.96 | | mJ |
| $t_{d(on)}$ | Turn-On Delay Time | $V_{CC}$=300V,$I_C$=100A, $R_G$=4.1Ω,$V_{GE}$=±15V, $T_j$=125°C | | 195 | | ns |
| $t_r$ | Rise Time | | | 69 | | ns |
| $t_{d(off)}$ | Turn-Off Delay Time | | | 246 | | ns |
| $t_f$ | Fall Time | | | 184 | | ns |
| $E_{on}$ | Turn-On Switching Loss | | | 1.25 | | mJ |
| $E_{off}$ | Turn-Off Switching Loss | | | 3.79 | | mJ |
| $t_{d(on)}$ | Turn-On Delay Time | $V_{CC}$=300V,$I_C$=100A, $R_G$=4.1Ω,$V_{GE}$=±15V, $T_j$=150°C | | 196 | | ns |
| $t_r$ | Rise Time | | | 70 | | ns |
| $t_{d(off)}$ | Turn-Off Delay Time | | | 249 | | ns |
| $t_f$ | Fall Time | | | 200 | | ns |
| $E_{on}$ | Turn-On Switching Loss | | | 1.30 | | mJ |
| $E_{off}$ | Turn-Off Switching Loss | | | 4.09 | | mJ |
| $I_{SC}$ | SC Data | $t_P$≤6μs,$V_{GE}$=15V, $T_j$=150°C,$V_{CC}$=360V, $V_{CEM}$≤650V | | 500 | | A |

## D4,D7 Diode Characteristics $T_C$=25°C unless otherwise noted

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_F$ | Diode Forward Voltage | $I_F$=50A,$V_{GE}$=0V,$T_j$=25°C | | 1.35 | 1.70 | V |
| | | $I_F$=50A,$V_{GE}$=0V,$T_j$=125°C | | 1.37 | | |
| | | $I_F$=50A,$V_{GE}$=0V,$T_j$=150°C | | 1.40 | | |
| $Q_r$ | Recovered Charge | $V_R$=300V,$I_F$=50A, -di/dt=1600A/μs,$V_{GE}$=-15V $T_j$=25°C | | 2.3 | | μC |
| $I_{RM}$ | Peak Reverse Recovery Current | | | 33 | | A |
| $E_{rec}$ | Reverse Recovery Energy | | | 0.56 | | mJ |
| $Q_r$ | Recovered Charge | $V_R$=300V,$I_F$=50A, -di/dt=1600A/μs,$V_{GE}$=-15V $T_j$=125°C | | 4.3 | | μC |
| $I_{RM}$ | Peak Reverse Recovery Current | | | 58 | | A |
| $E_{rec}$ | Reverse Recovery Energy | | | 1.11 | | mJ |
| $Q_r$ | Recovered Charge | $V_R$=300V,$I_F$=50A, -di/dt=1600A/μs,$V_{GE}$=-15V $T_j$=150°C | | 5.1 | | μC |
| $I_{RM}$ | Peak Reverse Recovery Current | | | 60 | | A |
| $E_{rec}$ | Reverse Recovery Energy | | | 1.22 | | mJ |

## D3,D8 Diode Characteristics $T_C$=25°C unless otherwise noted

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_F$ | Diode Forward Voltage | $I_F$=100A,$V_{GE}$=0V,$T_j$=25°C | | 1.55 | 1.95 | V |
| | | $I_F$=100A,$V_{GE}$=0V,$T_j$=125°C | | 1.50 | | |
| | | $I_F$=100A,$V_{GE}$=0V,$T_j$=150°C | | 1.45 | | |
| $Q_r$ | Recovered Charge | $V_R$=300V,$I_F$=100A, -di/dt=1600A/μs,$V_{GE}$=-15V $T_j$=25°C | | 3.6 | | μC |
| $I_{RM}$ | Peak Reverse Recovery Current | | | 34 | | A |
| $E_{rec}$ | Reverse Recovery Energy | | | 1.16 | | mJ |
| $Q_r$ | Recovered Charge | $V_R$=300V,$I_F$=100A, -di/dt=1600A/μs,$V_{GE}$=-15V $T_j$=125°C | | 6.7 | | μC |
| $I_{RM}$ | Peak Reverse Recovery Current | | | 61 | | A |
| $E_{rec}$ | Reverse Recovery Energy | | | 2.03 | | mJ |
| $Q_r$ | Recovered Charge | $V_R$=300V,$I_F$=100A, -di/dt=1600A/μs,$V_{GE}$=-15V $T_j$=150°C | | 7.5 | | μC |
| $I_{RM}$ | Peak Reverse Recovery Current | | | 62 | | A |
| $E_{rec}$ | Reverse Recovery Energy | | | 2.40 | | mJ |

## NTC Characteristics $T_C$=25°C unless otherwise noted

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $R_{25}$ | Rated Resistance | | | 22.0 | | kΩ |
| ΔR/R | Deviation of $R_{100}$ | $T_C$=100 °C,$R_{100}$=1486.1Ω | -5 | | 5 | % |
| $P_{25}$ | Power Dissipation | | | | 200 | mW |
| $B_{25/50}$ | B-value | $R_2=R_{25}\exp[B_{25/50}(1/T_2-1/(298.15K))]$ | | 4000 | | K |

## Module Characteristics $T_C$=25°C unless otherwise noted

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| $R_{\theta JC}$ | Junction-to-Case (per T1,T6 IGBT)<br>Junction-to-Case (per D1,D6 Diode)<br>Junction-to-Case (per D2,D5 Diode)<br>Junction-to-Case (per T4,T7 IGBT)<br>Junction-to-Case (per D4,D7 Diode)<br>Junction-to-Case (per D3,D8 Diode) | | 0.141<br>1.210<br>0.681<br>0.379<br>1.041<br>0.694 | | K/W |
| $R_{\theta CS}$ | Case-to-Sink (per T1,T6 IGBT)<br>Case-to-Sink (per D1,D6 Diode)<br>Case-to-Sink (per D2,D5 Diode)<br>Case-to-Sink (per T4,T7 IGBT)<br>Case-to-Sink (per D4,D7 Diode)<br>Case-to-Sink (per D3,D8 Diode) | | 0.069<br>0.594<br>0.334<br>0.186<br>0.511<br>0.340 | | K/W |
| $R_{\theta CS}$ | Case-to-Sink | | 0.017 | | K/W |
| M | Mounting Torque, Screw M5 | 3.0 | | 6.0 | N.m |

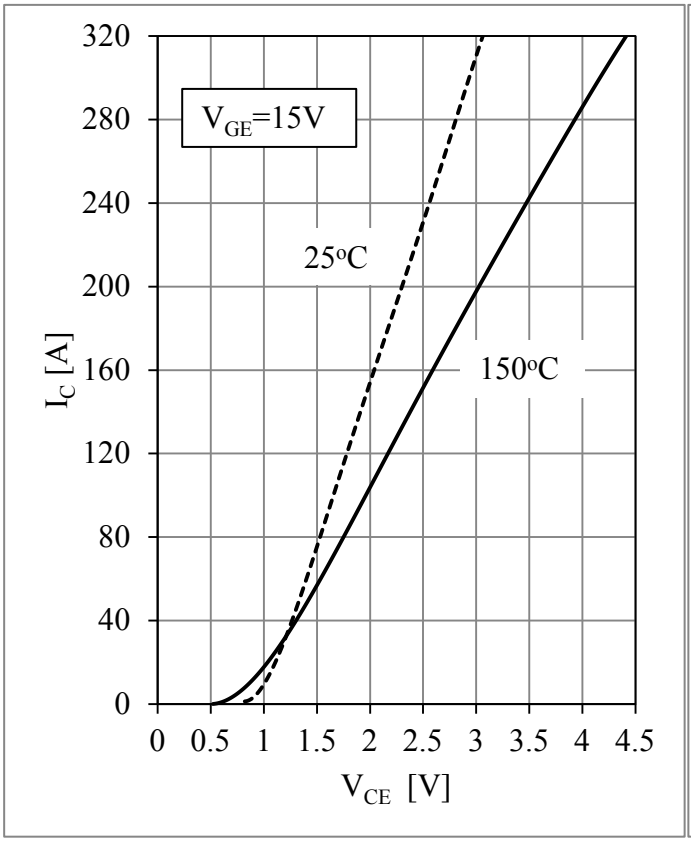



Fig 1. T1,T6 IGBT Output Characteristics

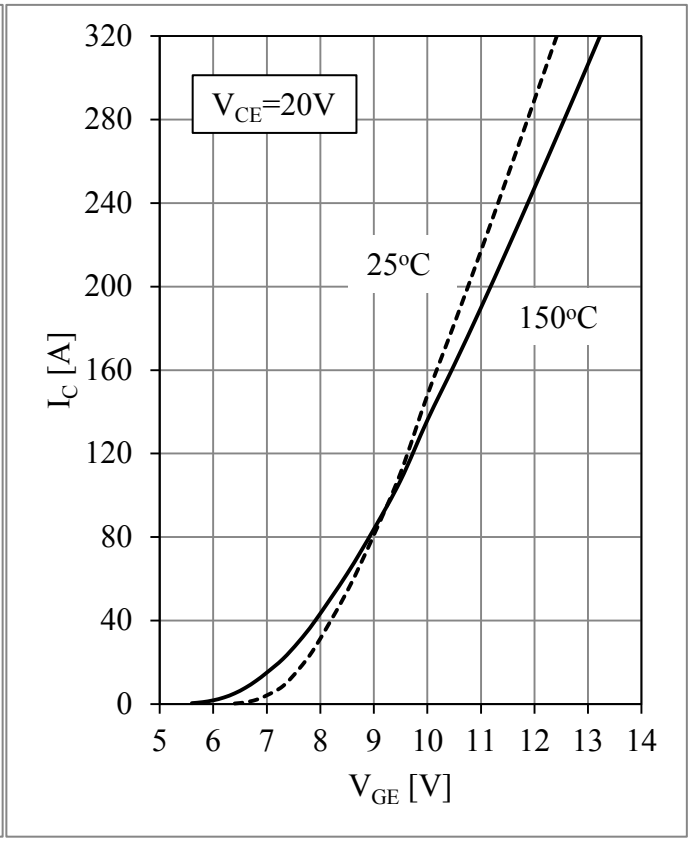



Fig 2. T1,T6 IGBT Transfer Characteristics

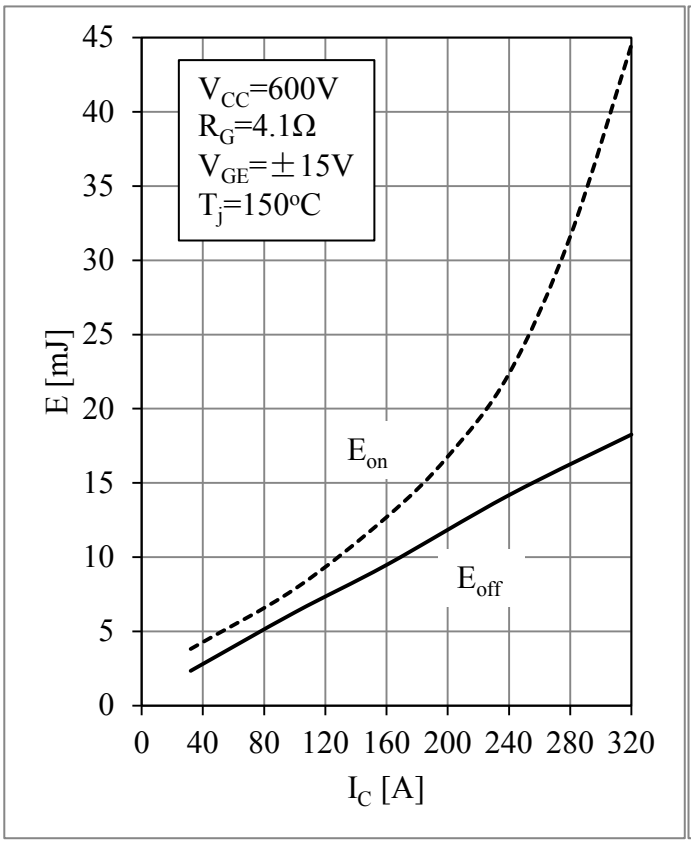



Fig 3. T1,T6 IGBT Switching Loss vs. $I_C$

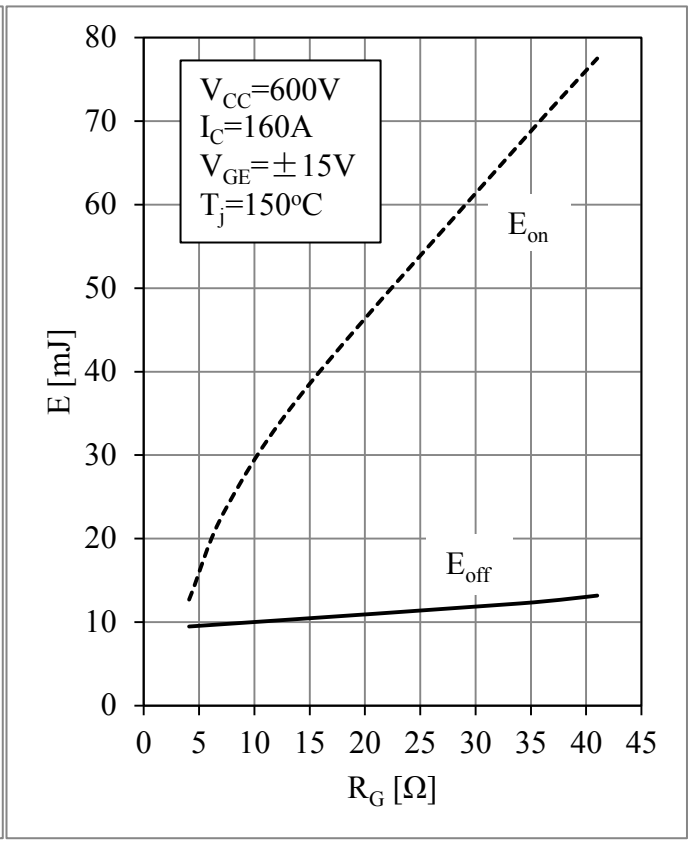



Fig 4. T1,T6 IGBT Switching Loss vs. $R_G$

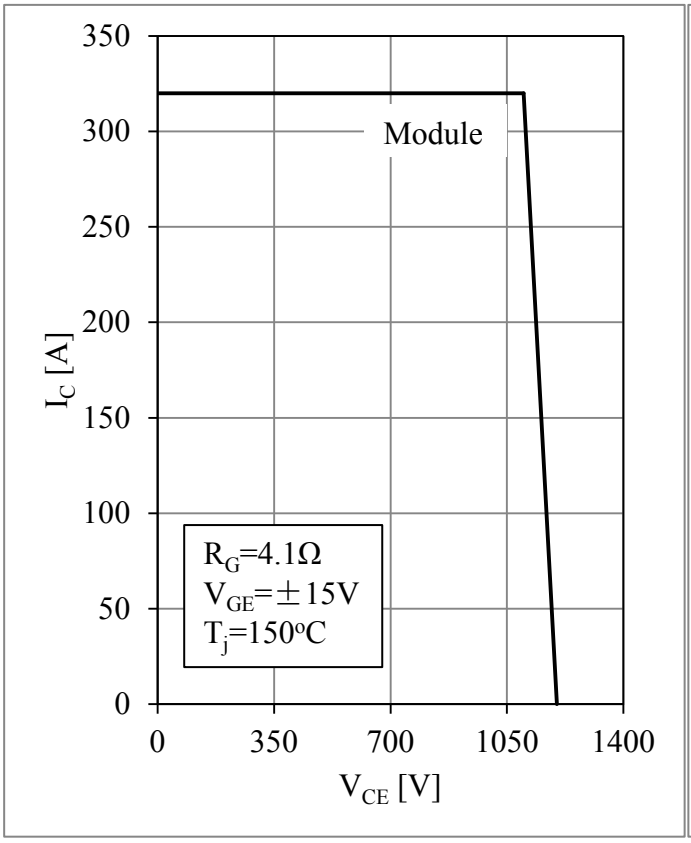



Fig 5. T1,T6 RBSOA

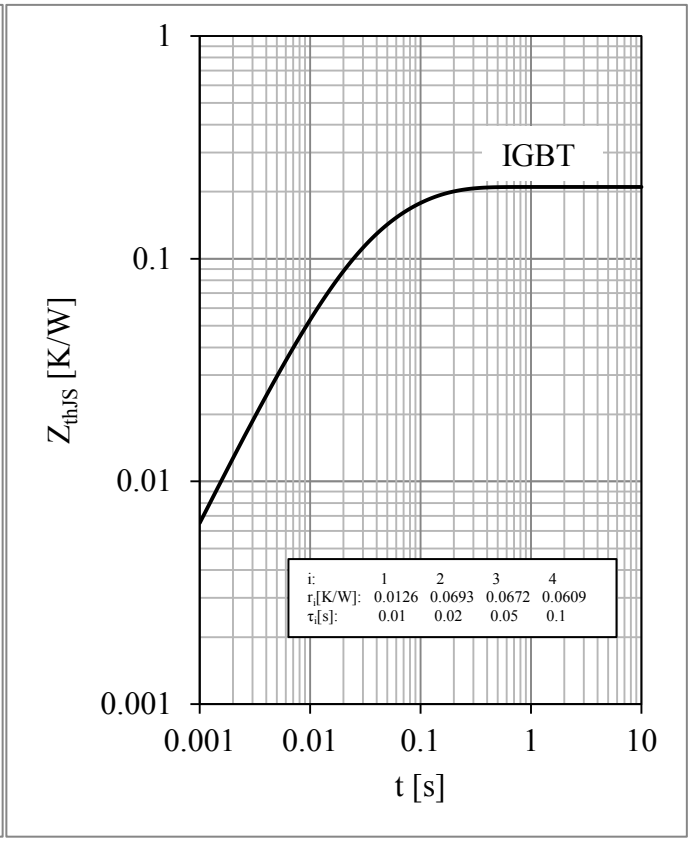



Fig 6. T1,T6 IGBT Transient Thermal Impedance

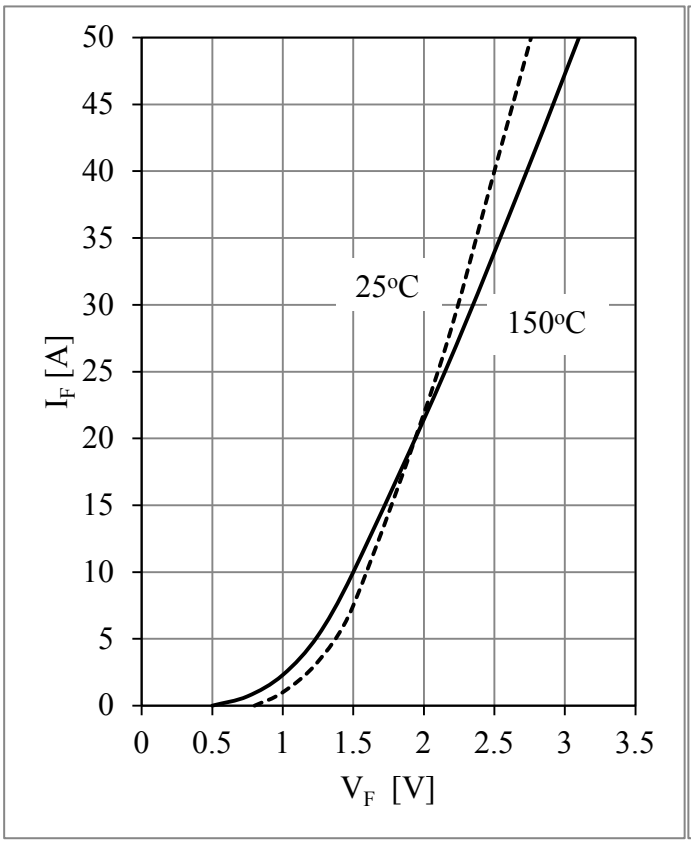



Fig 7. D1,D6 Diode Forward Characteristics

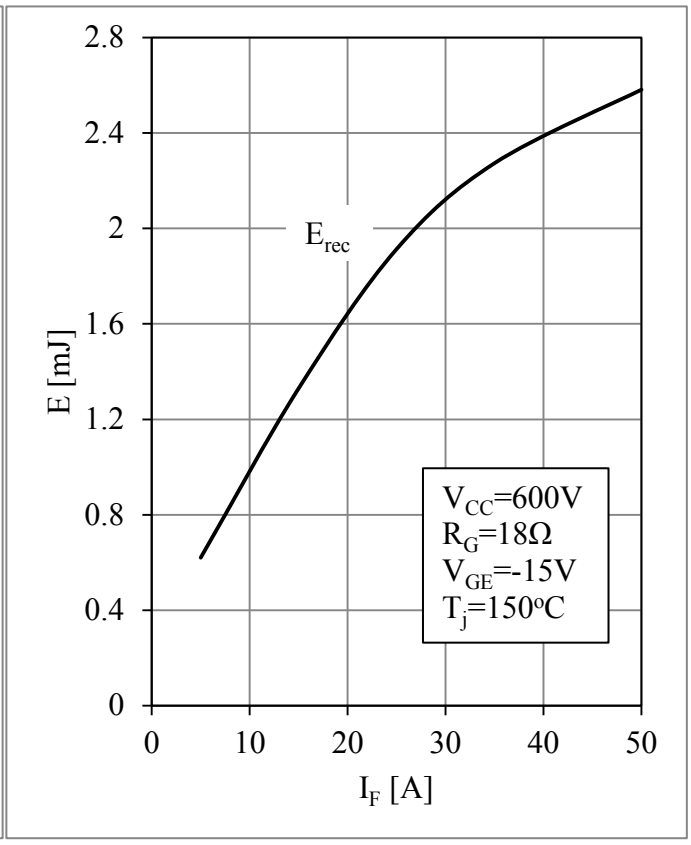



Fig 8. D1,D6 Diode Switching Loss vs. $I_F$

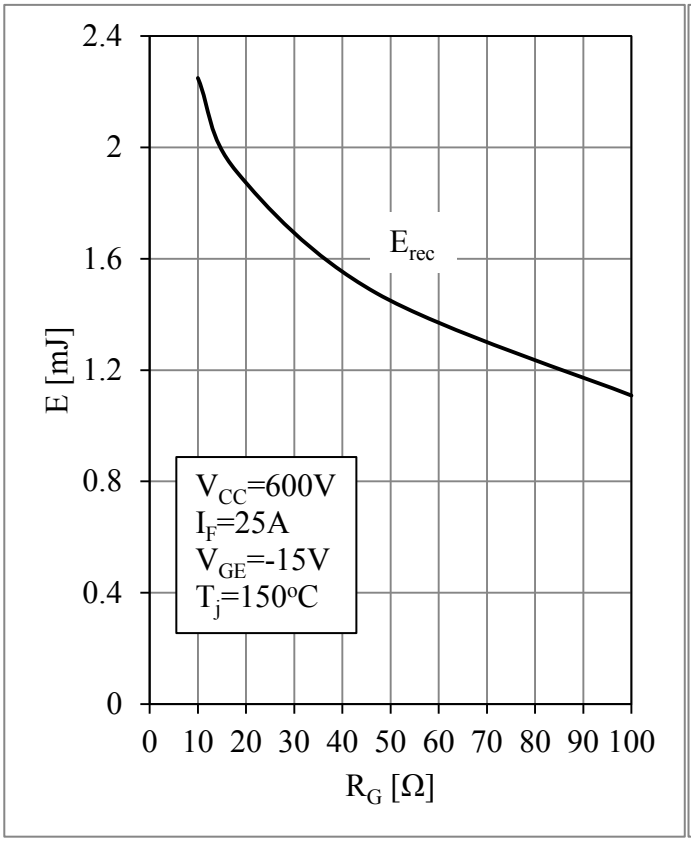



Fig 9. D1,D6 Diode Switching Loss vs. $R_G$

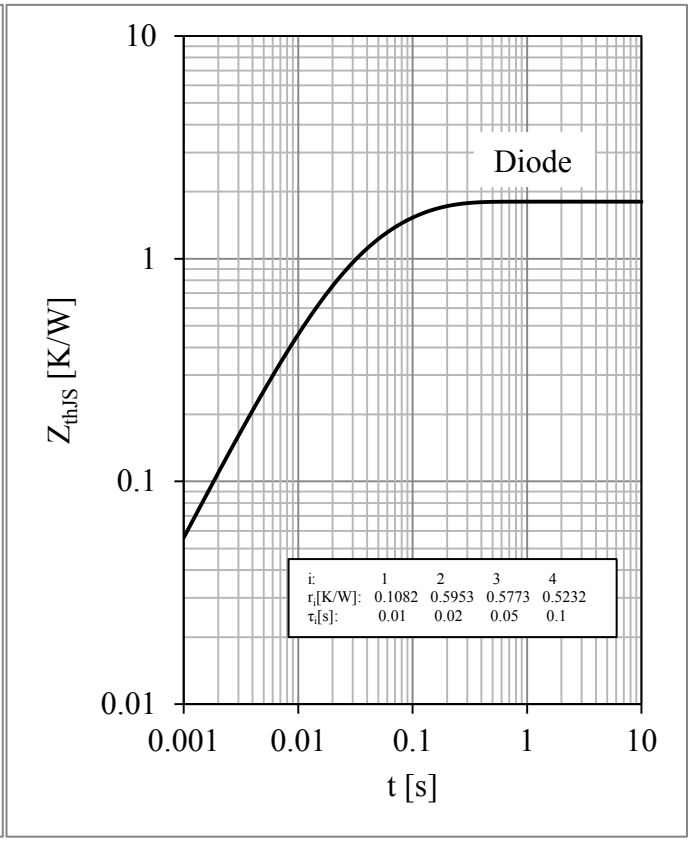



Fig 10. D1,D6 Diode Transient Thermal Impedance

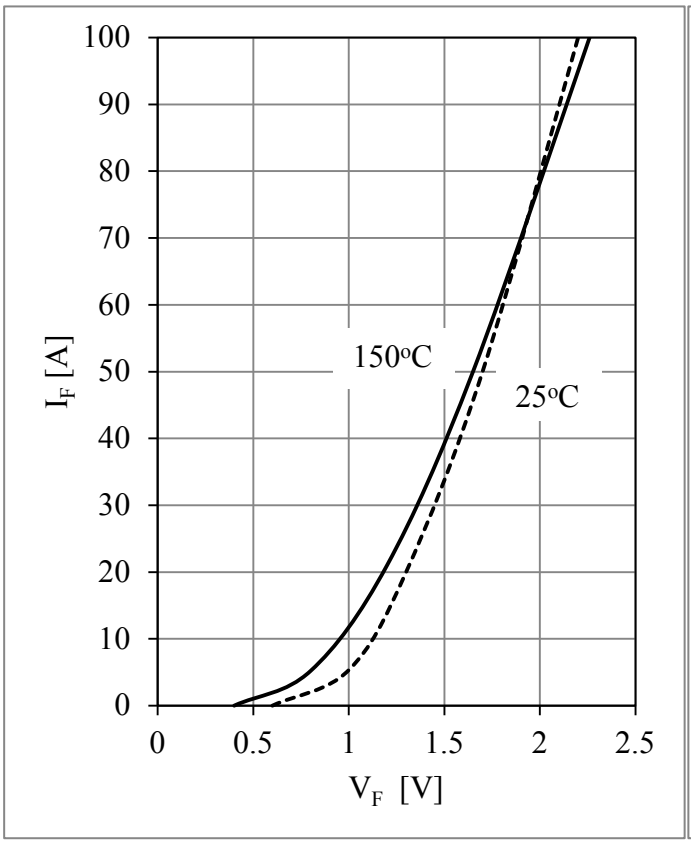



Fig 11. D2,D5 Diode Forward Characteristics

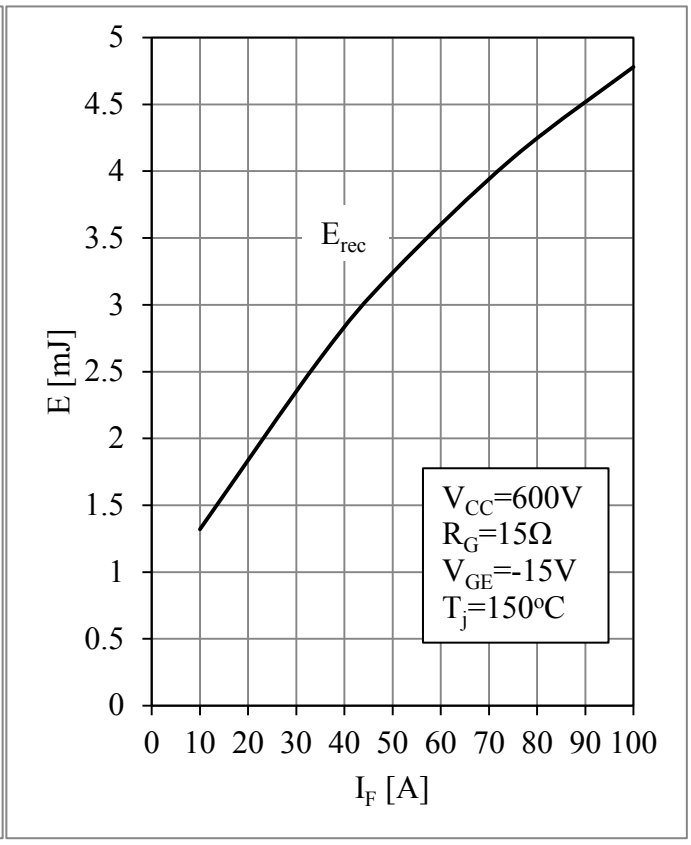



Fig 12. D2,D5 Diode Switching Loss vs. $I_F$

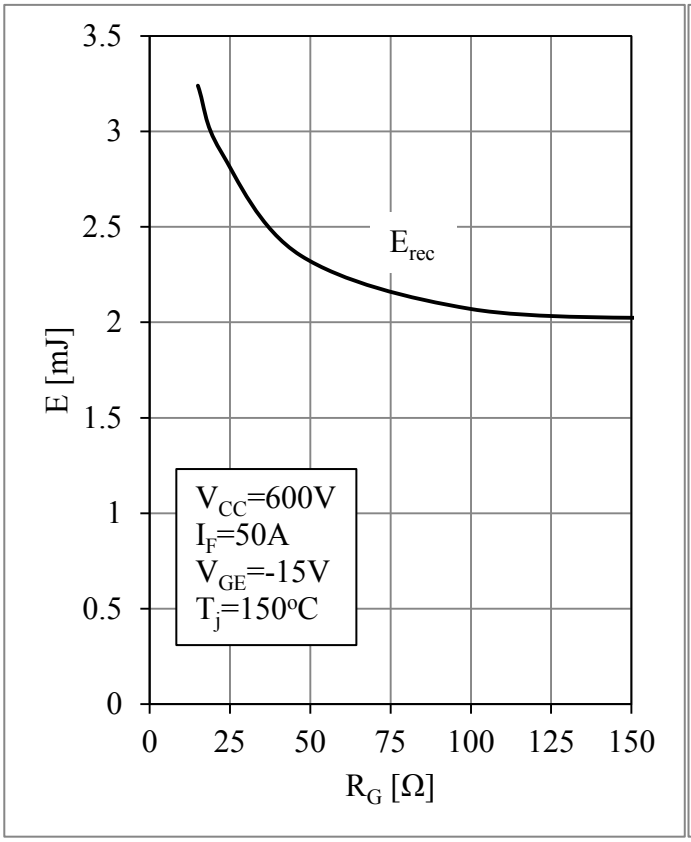



Fig 13. D2,D5 Diode Switching Loss vs. $R_G$

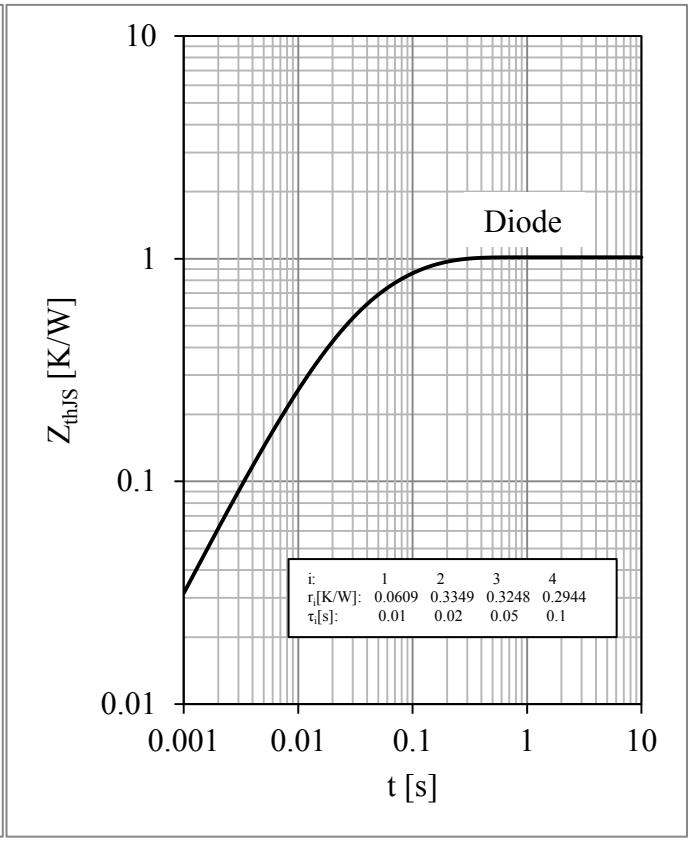



Fig 14. D2,D5 Diode Transient Thermal Impedance

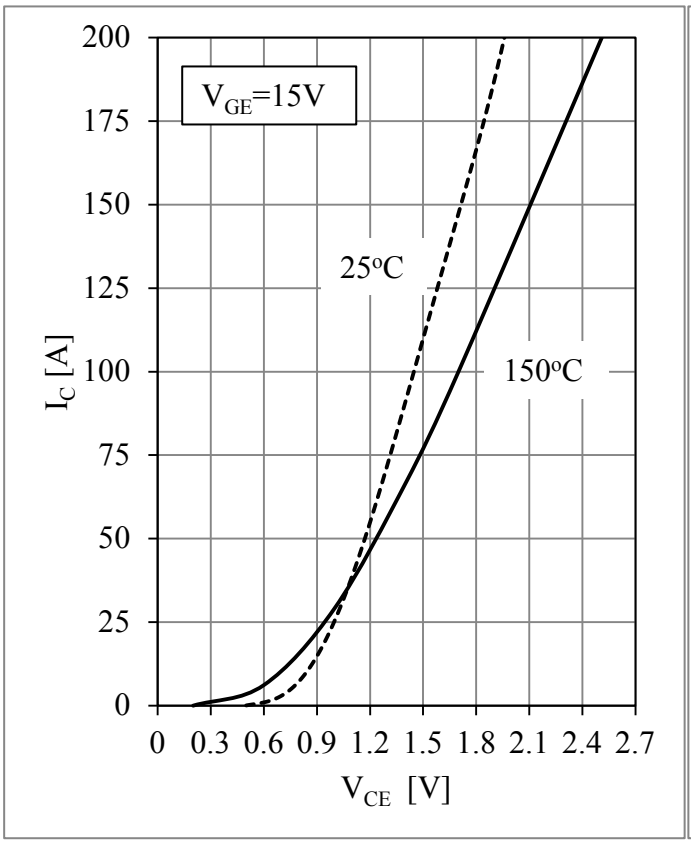



Fig 15. T4,T7 IGBT Output Characteristics

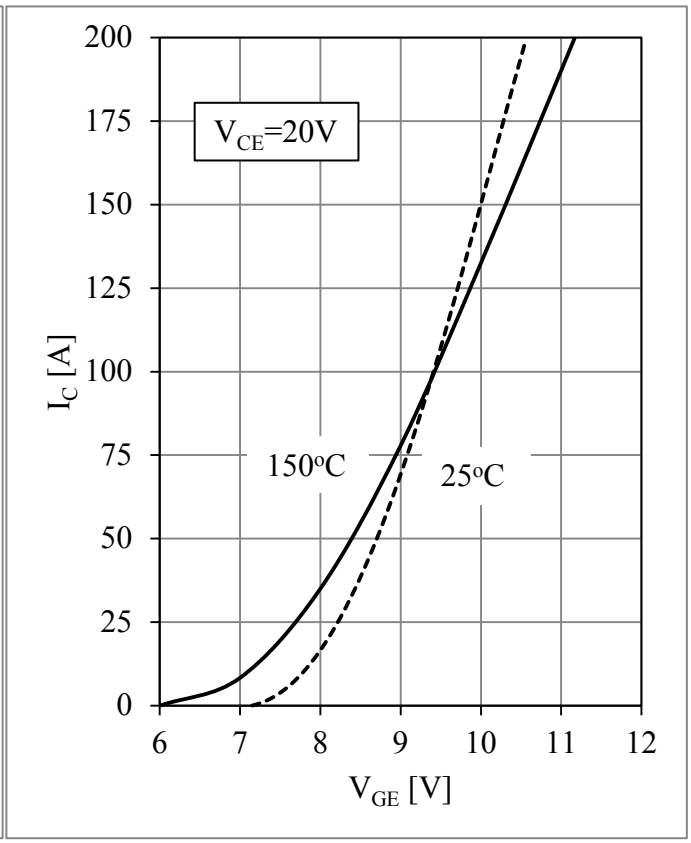



Fig 16. T4,T7 IGBT Transfer Characteristics

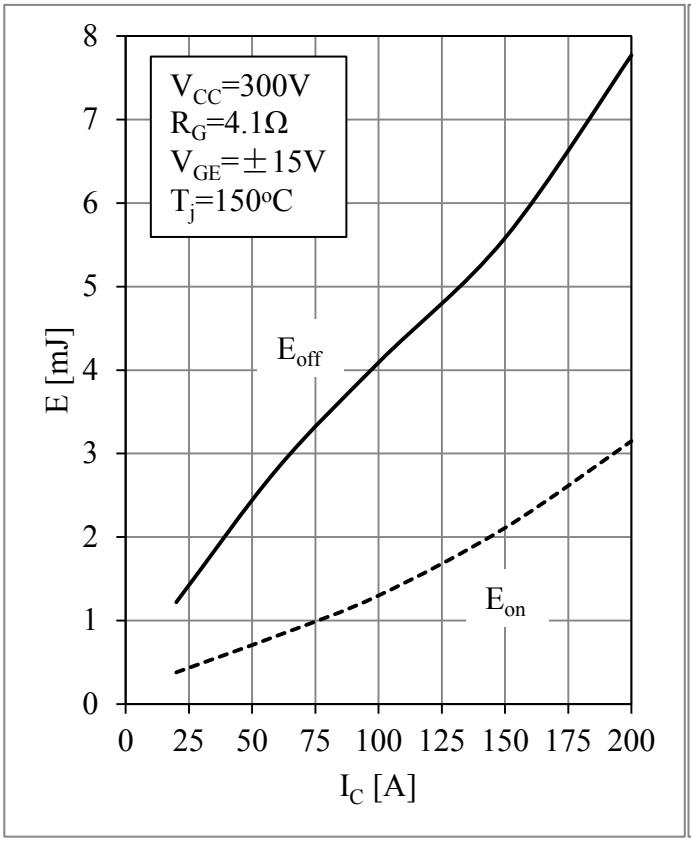



Fig 17. T4,T7 IGBT Switching Loss vs. $I_C$

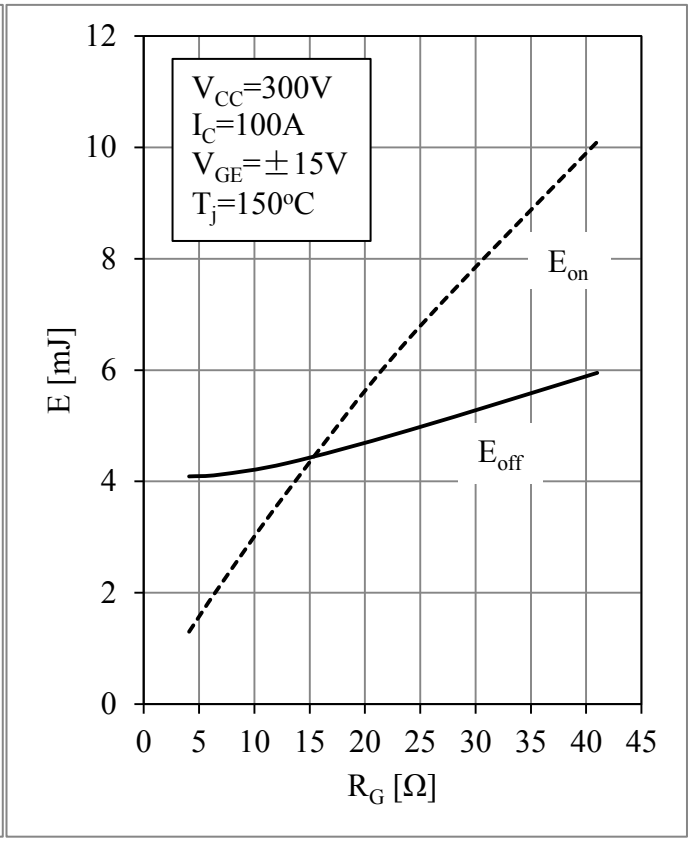



Fig 18. T4,T7 IGBT Switching Loss vs. $R_G$

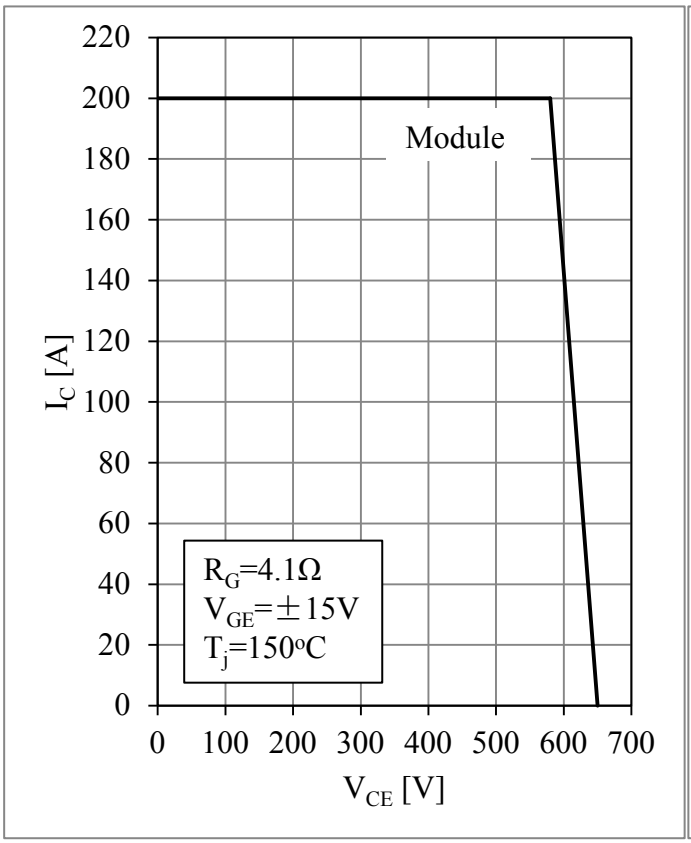



Fig 19. T4,T7 RBSOA

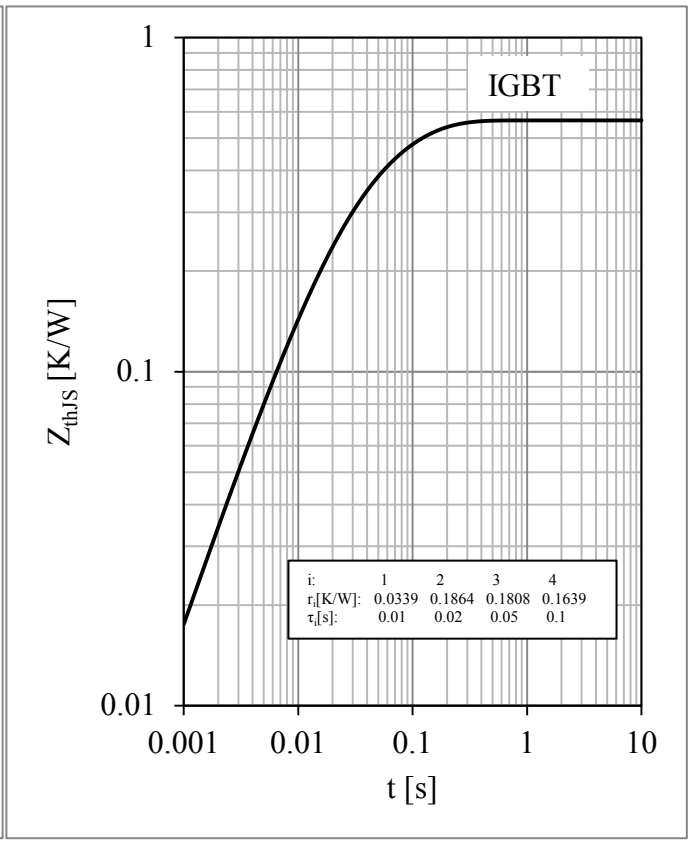



Fig 20. T4,T7 IGBT Transient Thermal Impedance

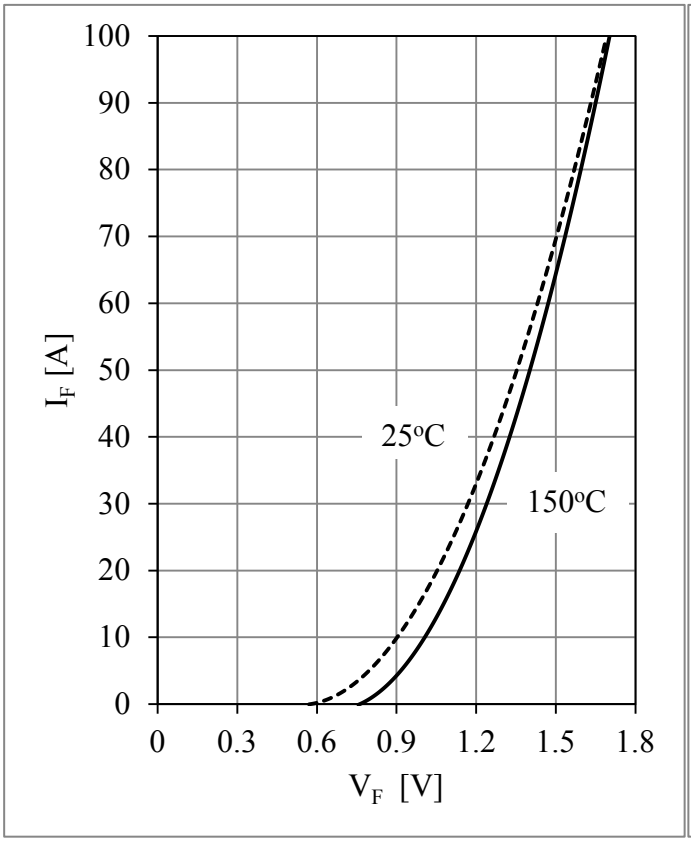



Fig 21. D4,D7 Diode Forward Characteristics

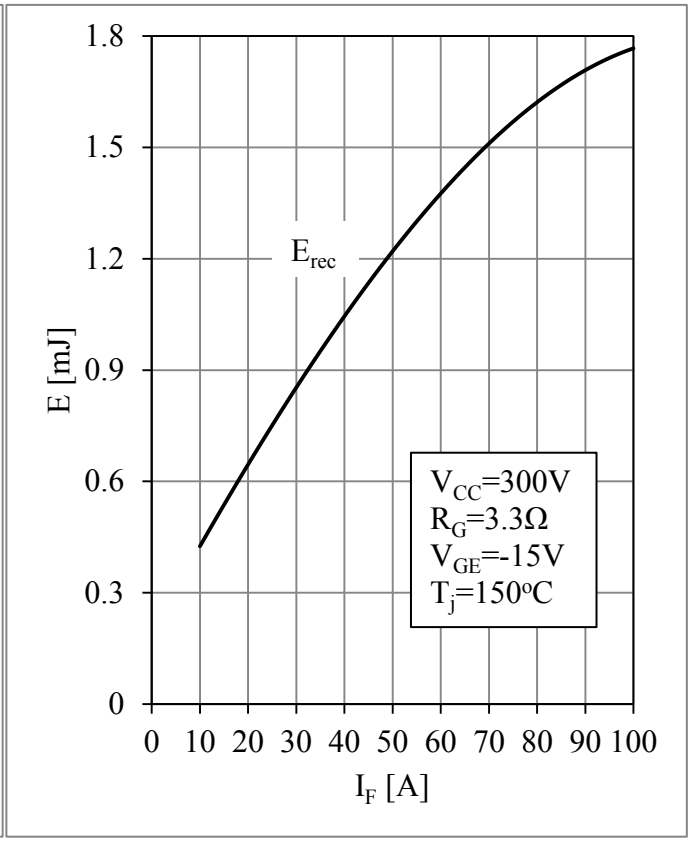



Fig 22. D4,D7 Diode Switching Loss vs. $I_F$

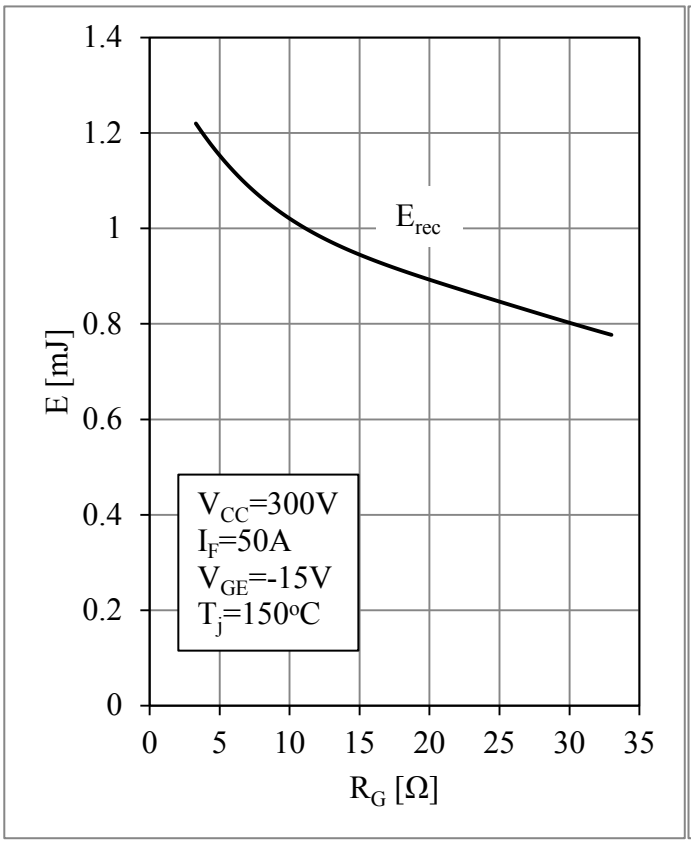



Fig 23. D4,D7 Diode Switching Loss vs. $R_G$

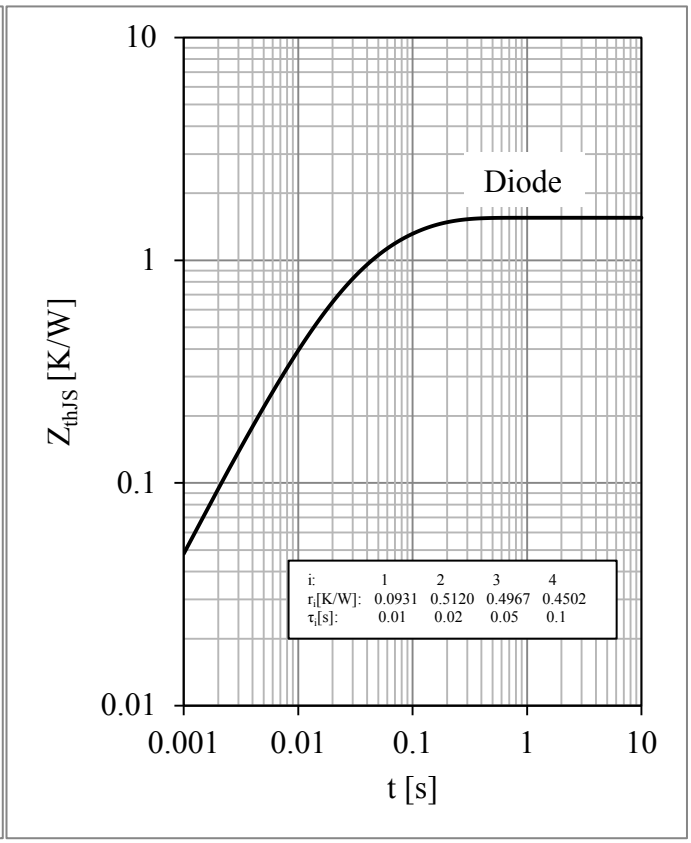



Fig 24. D4,D7 Diode Transient Thermal Impedance

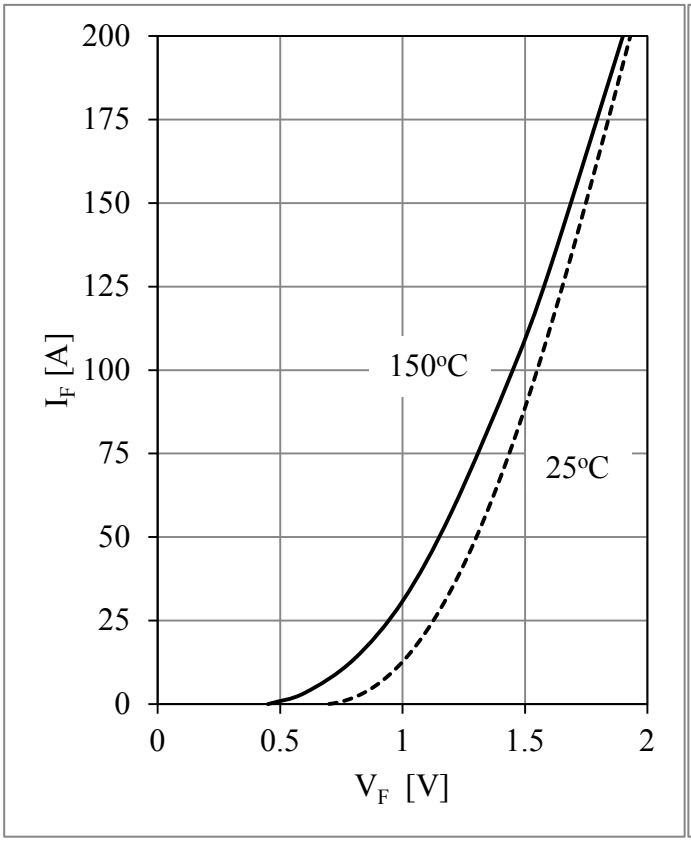



Fig 25. D3,D8 Diode Forward Characteristics

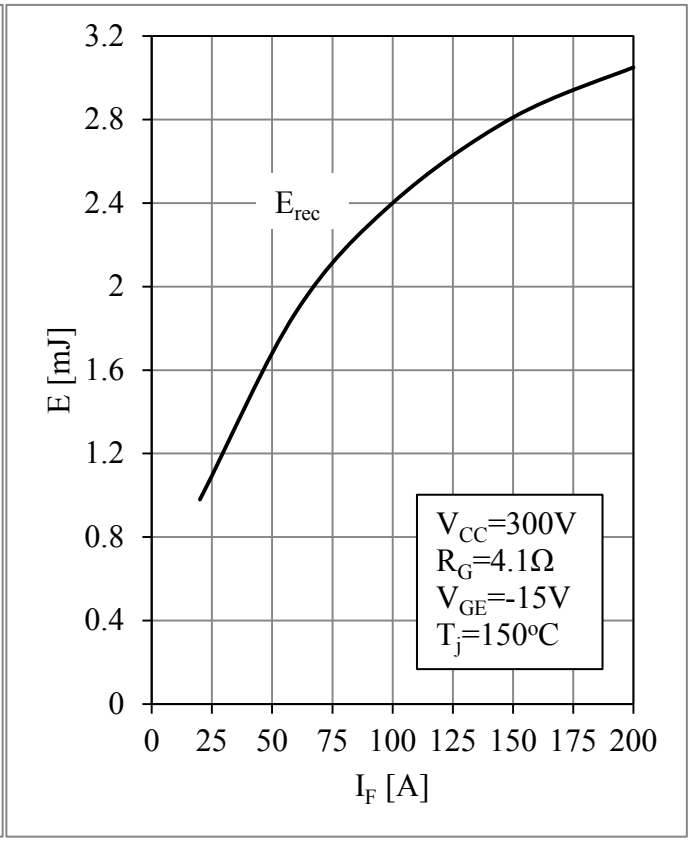



Fig 26. D3,D8 Diode Switching Loss vs. $I_F$

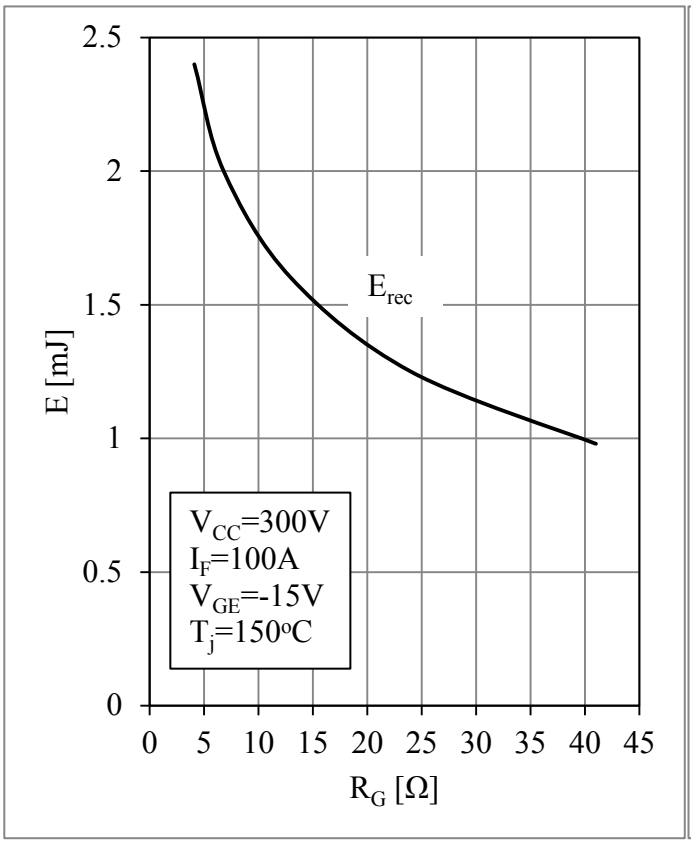



Fig 27. D3,D8 Diode Switching Loss vs. $R_G$

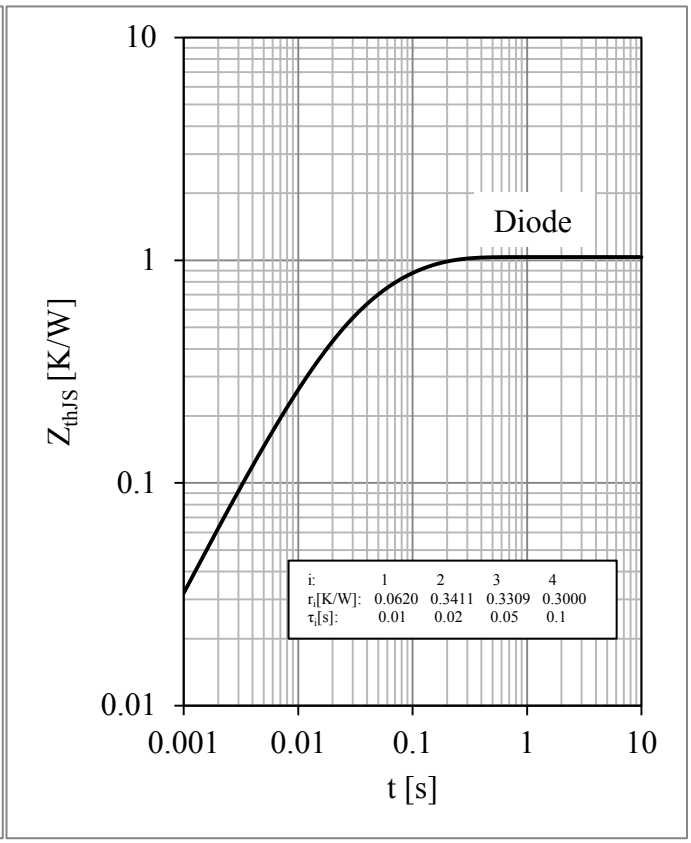



Fig 28. D3,D8 Diode Transient Thermal Impedance

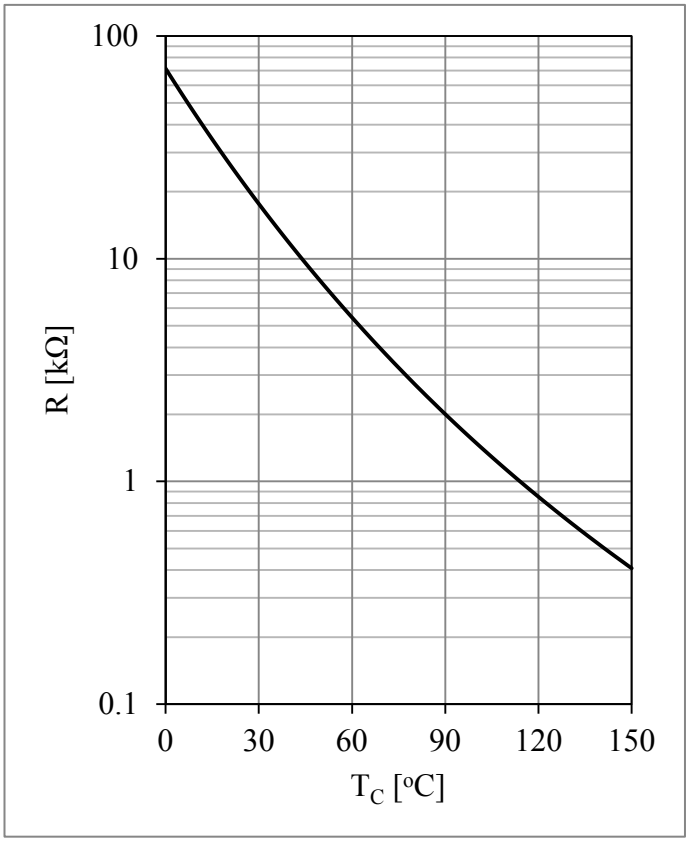
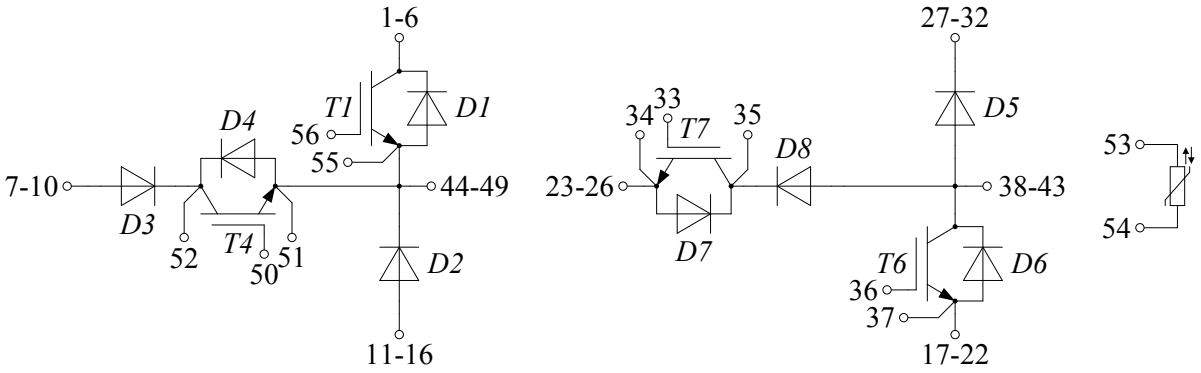


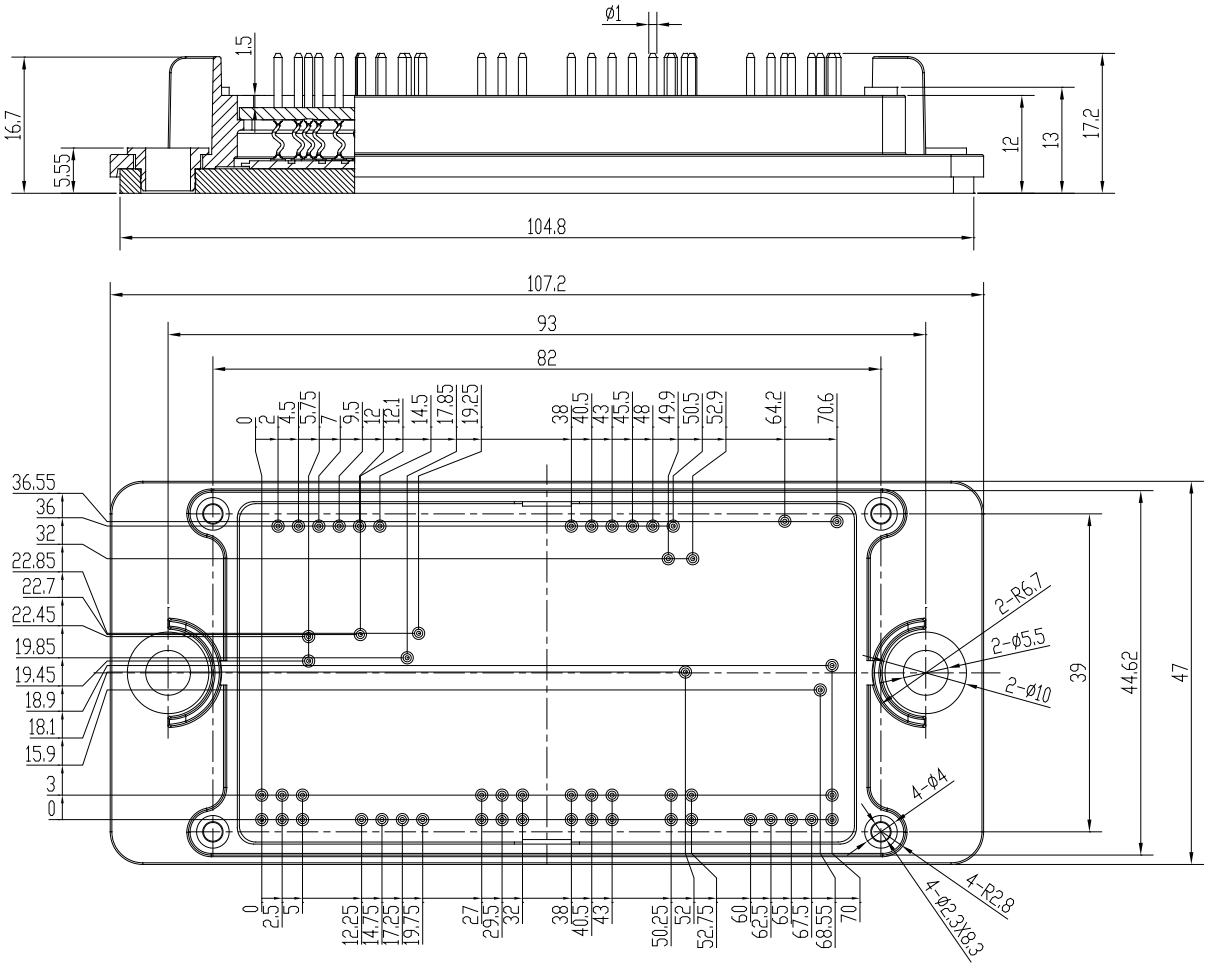

Fig 29. NTC Temperature Characteristic

## Circuit Schematic




## Package Dimensions

Dimensions in Millimeters



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