# STARPOWER

SEMICONDUCTOR **IGBT**

# GD450MMS65L6S

**650V/450A 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
3-level-application.

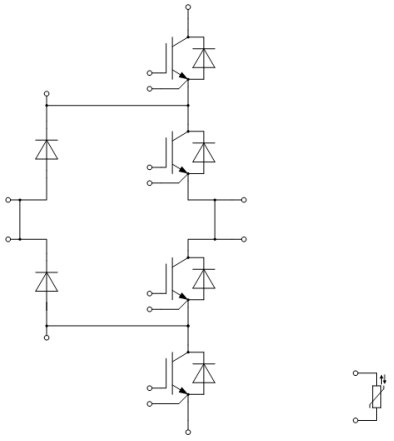
## Features

- Low $V_{CE(sat)}$ Trench IGBT technology
- $V_{CE(sat)}$ with positive temperature coefficient
- Maximum junction temperature 175 $^{o}$C
- Fast & soft reverse recovery anti-parallel FWD
- Isolated copper baseplate using DBC technology
- Qualified for industrial applications according to the relevant tests of IEC 60747,60749 and 60068

## Typical Applications

- Solar power
- 3-level-application

## Equivalent Circuit Schematic



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

## T1,T4 IGBT

| Symbol | Description | Value | Unit |
|---|---|---|---|
| $V_{CES}$ | Collector-Emitter Voltage | 650 | V |
| $V_{GES}$ | Gate-Emitter Voltage | ±20 | V |
| $I_{CN}$ | Implemented Collector Current | 450 | A |
| $I_C$ | Collector Current @ $T_C$=75°C | 370 | A |
| $I_{CRM}$ | Repetitive Peak Collector Current tp limited by $T_{vjop}$ | 900 | A |
| $P_D$ | Maximum Power Dissipation @ $T_{vj}$=175°C | 1136 | W |

## T2,T3 IGBT

| Symbol | Description | Value | Unit |
|---|---|---|---|
| $V_{CES}$ | Collector-Emitter Voltage | 650 | V |
| $V_{GES}$ | Gate-Emitter Voltage | ±20 | V |
| $I_{CN}$ | Implemented Collector Current | 450 | A |
| $I_C$ | Collector Current @ $T_C$=75°C | 370 | A |
| $I_{CRM}$ | Repetitive Peak Collector Current tp limited by $T_{vjop}$ | 900 | A |
| $P_D$ | Maximum Power Dissipation @ $T_{vj}$=175°C | 1136 | W |

## D1-D4 Diode

| Symbol | Description | Value | Unit |
|---|---|---|---|
| $V_{RRM}$ | Repetitive Peak Reverse Voltage | 650 | V |
| $I_{FN}$ | Implemented Forward Current | 400 | A |
| $I_F$ | Diode Continuous Forward Current@ $T_C$=75°C | 305 | A |
| $I_{FRM}$ | Repetitive Peak Forward Current tp limited by $T_{vjop}$ | 800 | A |

## D5,D6 Diode

| Symbol | Description | Value | Unit |
|---|---|---|---|
| $V_{RRM}$ | Repetitive Peak Reverse Voltage | 650 | V |
| $I_{FN}$ | Implemented Forward Current | 400 | A |
| $I_F$ | Diode Continuous Forward Current@ $T_C$=75°C | 269 | A |
| $I_{FRM}$ | Repetitive Peak Forward Current tp limited by $T_{vjop}$ | 800 | A |

## Module

| Symbol | Description | Value | Unit |
|---|---|---|---|
| $T_{vjmax}$ | Maximum Junction Temperature | 175 | °C |
| $T_{vjop}$ | 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 | 3200 | V |
| $d_{Creep}$ | Terminal to Heatsink | >11 | mm |
| $d_{Clear}$ | Terminal to Heatsink | >9 | mm |
| RTI | RTI Elec,housing | 130 | °C |

## T1,T4 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 | $I_C$=450A,$V_{GE}$=15V, $T_{vj}$=25°C | | 1.45 | 1.90 | V |
| | | $I_C$=450A,$V_{GE}$=15V, $T_{vj}$=125°C | | 1.60 | | |
| | | $I_C$=450A,$V_{GE}$=15V, $T_{vj}$=150°C | | 1.65 | | |
| $V_{GE(th)}$ | Gate-Emitter Threshold Voltage | $I_C$=7.20mA,$V_{CE}$=$V_{GE}$, $T_{vj}$=25°C | 4.4 | 5.0 | 5.6 | V |
| $I_{CES}$ | Collector Cut-Off Current | $V_{CE}$=$V_{CES}$,$V_{GE}$=0V, $T_{vj}$=25°C | | | 1.0 | mA |
| $I_{GES}$ | Gate-Emitter Leakage Current | $V_{GE}$=$V_{GES}$,$V_{CE}$=0V, $T_{vj}$=25°C | | | 400 | nA |
| $R_{Gint}$ | Internal Gate Resistance | | | 0.8 | | Ω |
| $C_{ies}$ | Input Capacitance | $V_{CE}$=25V,f=100kHz, $V_{GE}$=0V | | 30.3 | | nF |
| $C_{oes}$ | Onput Capacitance | | | 1.33 | | nF |
| $C_{res}$ | Reverse Transfer Capacitance | | | 0.49 | | nF |
| $Q_G$ | Gate Charge | $V_{GE}$=-15…+15V | | 2.77 | | μC |
| $t_{d(on)}$ | Turn-On Delay Time | $V_{CC}$=470V,$I_C$=230A, $R_{Gon}$=2.2Ω,$R_{Goff}$=4.7Ω, $L_S$=24nH, $V_{GE}$=-8V/+15V, $T_{vj}$=25°C | | 79 | | ns |
| $t_r$ | Rise Time | | | 28 | | ns |
| $t_{d(off)}$ | Turn-Off Delay Time | | | 624 | | ns |
| $t_f$ | Fall Time | | | 34 | | ns |
| $E_{on}$ | Turn-On Switching Loss | | | 4.83 | | mJ |
| $E_{off}$ | Turn-Off Switching Loss | | | 3.63 | | mJ |
| $t_{d(on)}$ | Turn-On Delay Time | $V_{CC}$=470V,$I_C$=230A, $R_{Gon}$=2.2Ω,$R_{Goff}$=4.7Ω, $L_S$=24nH, $V_{GE}$=-8V/+15V, $T_{vj}$=125°C | | 81 | | ns |
| $t_r$ | Rise Time | | | 28 | | ns |
| $t_{d(off)}$ | Turn-Off Delay Time | | | 653 | | ns |
| $t_f$ | Fall Time | | | 30 | | ns |
| $E_{on}$ | Turn-On Switching Loss | | | 7.39 | | mJ |
| $E_{off}$ | Turn-Off Switching Loss | | | 3.98 | | mJ |
| $t_{d(on)}$ | Turn-On Delay Time | $V_{CC}$=470V,$I_C$=230A, $R_{Gon}$=2.2Ω,$R_{Goff}$=4.7Ω, $L_S$=24nH, $V_{GE}$=-8V/+15V, $T_{vj}$=150°C | | 79 | | ns |
| $t_r$ | Rise Time | | | 28 | | ns |
| $t_{d(off)}$ | Turn-Off Delay Time | | | 665 | | ns |
| $t_f$ | Fall Time | | | 32 | | ns |
| $E_{on}$ | Turn-On Switching Loss | | | 7.84 | | mJ |
| $E_{off}$ | Turn-Off Switching Loss | | | 4.09 | | mJ |

## T2,T3 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 | $I_C$=450A,$V_{GE}$=15V, $T_{vj}$=25°C | | 1.45 | 1.90 | V |
| | | $I_C$=450A,$V_{GE}$=15V, $T_{vj}$=125°C | | 1.60 | | |
| | | $I_C$=450A,$V_{GE}$=15V, $T_{vj}$=150°C | | 1.65 | | |
| $V_{GE(th)}$ | Gate-Emitter Threshold Voltage | $I_C$=7.20mA,$V_{CE}$=$V_{GE}$, $T_{vj}$=25°C | 4.4 | 5.0 | 5.6 | V |
| $I_{CES}$ | Collector Cut-Off Current | $V_{CE}$=$V_{CES}$,$V_{GE}$=0V, $T_{vj}$=25°C | | | 1.0 | mA |
| $I_{GES}$ | Gate-Emitter Leakage Current | $V_{GE}$=$V_{GES}$,$V_{CE}$=0V, $T_{vj}$=25°C | | | 400 | nA |
| $R_{Gint}$ | Internal Gate Resistance | | | 0.8 | | Ω |
| $C_{ies}$ | Input Capacitance | $V_{CE}$=25V,f=100kHz, $V_{GE}$=0V | | 30.3 | | nF |
| $C_{oes}$ | Onput Capacitance | | | 1.33 | | nF |
| $C_{res}$ | Reverse Transfer Capacitance | | | 0.49 | | nF |
| $Q_G$ | Gate Charge | $V_{GE}$=-15…+15V | | 2.77 | | μC |
| $t_{d(on)}$ | Turn-On Delay Time | $V_{CC}$=470V,$I_C$=230A, $R_{Gon}$=2.2Ω,$R_{Goff}$=15Ω, $L_S$=28nH, $V_{GE}$=-8V/+15V, $T_{vj}$=25°C | | 68 | | ns |
| $t_r$ | Rise Time | | | 38 | | ns |
| $t_{d(off)}$ | Turn-Off Delay Time | | | 1428 | | ns |
| $t_f$ | Fall Time | | | 278 | | ns |
| $E_{on}$ | Turn-On Switching Loss | | | 4.82 | | mJ |
| $E_{off}$ | Turn-Off Switching Loss | | | 15.4 | | mJ |
| $t_{d(on)}$ | Turn-On Delay Time | $V_{CC}$=470V,$I_C$=230A, $R_{Gon}$=2.2Ω,$R_{Goff}$=15Ω, $L_S$=28nH, $V_{GE}$=-8V/+15V, $T_{vj}$=125°C | | 71 | | ns |
| $t_r$ | Rise Time | | | 38 | | ns |
| $t_{d(off)}$ | Turn-Off Delay Time | | | 1532 | | ns |
| $t_f$ | Fall Time | | | 304 | | ns |
| $E_{on}$ | Turn-On Switching Loss | | | 5.85 | | mJ |
| $E_{off}$ | Turn-Off Switching Loss | | | 17.1 | | mJ |
| $t_{d(on)}$ | Turn-On Delay Time | $V_{CC}$=470V,$I_C$=230A, $R_{Gon}$=2.2Ω,$R_{Goff}$=15Ω, $L_S$=28nH, $V_{GE}$=-8V/+15V, $T_{vj}$=150°C | | 71 | | ns |
| $t_r$ | Rise Time | | | 40 | | ns |
| $t_{d(off)}$ | Turn-Off Delay Time | | | 1556 | | ns |
| $t_f$ | Fall Time | | | 252 | | ns |
| $E_{on}$ | Turn-On Switching Loss | | | 5.95 | | mJ |
| $E_{off}$ | Turn-Off Switching Loss | | | 15.0 | | mJ |

## D1-D4 Diode Characteristics $T_C$=25°C unless otherwise noted

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_F$ | Diode Forward Voltage | $I_F$=400A,$V_{GE}$=0V,$T_j$=25°C | | 1.60 | 2.05 | V |
| | | $I_F$=400A,$V_{GE}$=0V,$T_j$=125°C | | 1.65 | | |
| | | $I_F$=400A,$V_{GE}$=0V,$T_j$=150°C | | 1.65 | | |
| $Q_r$ | Recovered Charge | $V_R$=470V,$I_F$=230A, -di/dt=3350A/μs,$L_S$=28nH, $V_{GE}$=-8V,$T_{vj}$=25°C | | 15.0 | | μC |
| $I_{RM}$ | Peak Reverse Recovery Current | | | 282 | | A |
| $E_{rec}$ | Reverse Recovery Energy | | | 4.83 | | mJ |
| $Q_r$ | Recovered Charge | $V_R$=470V,$I_F$=230A, -di/dt=3290A/μs, $L_S$=28nH, $V_{GE}$=-8V,$T_{vj}$=125°C | | 24.9 | | μC |
| $I_{RM}$ | Peak Reverse Recovery Current | | | 351 | | A |
| $E_{rec}$ | Reverse Recovery Energy | | | 8.49 | | mJ |
| $Q_r$ | Recovered Charge | $V_R$=470V,$I_F$=230A, -di/dt=3160A/μs, $L_S$=28nH, $V_{GE}$=-8V,$T_{vj}$=150°C | | 27.2 | | μC |
| $I_{RM}$ | Peak Reverse Recovery Current | | | 361 | | A |
| $E_{rec}$ | Reverse Recovery Energy | | | 9.23 | | mJ |

## D5,D6 Diode Characteristics $T_C$=25°C unless otherwise noted

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_F$ | Diode Forward Voltage | $I_F$=400A,$V_{GE}$=0V,$T_j$=25°C | | 1.60 | 2.05 | V |
| | | $I_F$=400A,$V_{GE}$=0V,$T_j$=125°C | | 1.65 | | |
| | | $I_F$=400A,$V_{GE}$=0V,$T_j$=150°C | | 1.65 | | |
| $Q_r$ | Recovered Charge | $V_R$=470V,$I_F$=230A, -di/dt=9350A/μs, $L_S$=24nH, $V_{GE}$=-8V,$T_{vj}$=25°C | | 21.8 | | μC |
| $I_{RM}$ | Peak Reverse Recovery Current | | | 307 | | A |
| $E_{rec}$ | Reverse Recovery Energy | | | 7.11 | | mJ |
| $Q_r$ | Recovered Charge | $V_R$=470V,$I_F$=230A, -di/dt=9910A/μs, $L_S$=24nH, $V_{GE}$=-8V,$T_{vj}$=125°C | | 27.6 | | μC |
| $I_{RM}$ | Peak Reverse Recovery Current | | | 358 | | A |
| $E_{rec}$ | Reverse Recovery Energy | | | 8.60 | | mJ |
| $Q_r$ | Recovered Charge | $V_R$=470V,$I_F$=230A, -di/dt=9770A/μs, $L_S$=24nH, $V_{GE}$=-8V,$T_{vj}$=150°C | | 30.5 | | μC |
| $I_{RM}$ | Peak Reverse Recovery Current | | | 381 | | A |
| $E_{rec}$ | Reverse Recovery Energy | | | 9.57 | | mJ |

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

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $R_{25}$ | Rated Resistance | | | 5.0 | | kΩ |
| ΔR/R | Deviation of $R_{100}$ | $T_C$=100°C,$R_{100}$=493.3Ω | -5 | | 5 | % |
| $P_{25}$ | Power Dissipation | | | | 20.0 | mW |
| $B_{25/50}$ | B-value | $R_2=R_{25}\exp[B_{25/50}(1/T_2-1/(298.15K))]$ | | 3375 | | K |
| $B_{25/80}$ | B-value | $R_2=R_{25}\exp[B_{25/80}(1/T_2-1/(298.15K))]$ | | 3411 | | K |
| $B_{25/100}$ | B-value | $R_2=R_{25}\exp[B_{25/100}(1/T_2-1/(298.15K))]$ | | 3433 | | K |

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

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| $L_{CE}$ | Stray Inductance | | 15 | | nH |
| $R_{thJC}$ | Junction-to-Case (per T1,T4 IGBT)<br>Junction-to-Case (per T2,T3 IGBT)<br>Junction-to-Case (per D1-D4 Diode)<br>Junction-to-Case (per D5,D6 Diode) | | | 0.132<br>0.132<br>0.169<br>0.196 | K/W |
| $R_{thCH}$ | Case-to-Heatsink (per T1,T4 IGBT)<br>Case-to-Heatsink (per T2,T3 IGBT)<br>Case-to-Heatsink (per D1-D4 Diode)<br>Case-to-Heatsink (per D5,D6 Diode) | | 0.056<br>0.056<br>0.054<br>0.066 | | K/W |
| M | Mounting Torque, Screw:M5 | 3.0 | | 5.0 | N.m |
| G | Weight of Module | | 250 | | g |

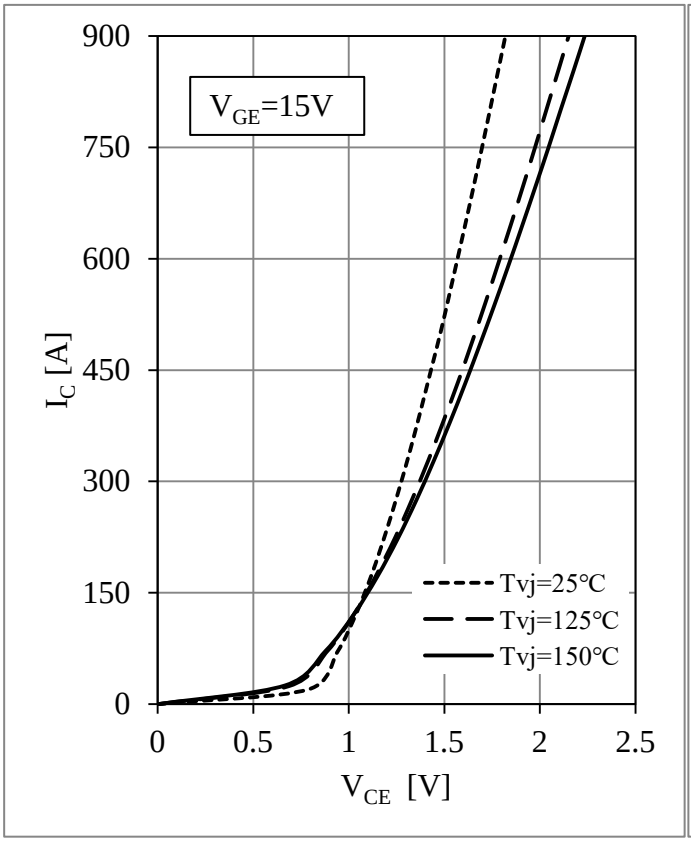



Fig 1. T1/T4 IGBT Output Characteristics

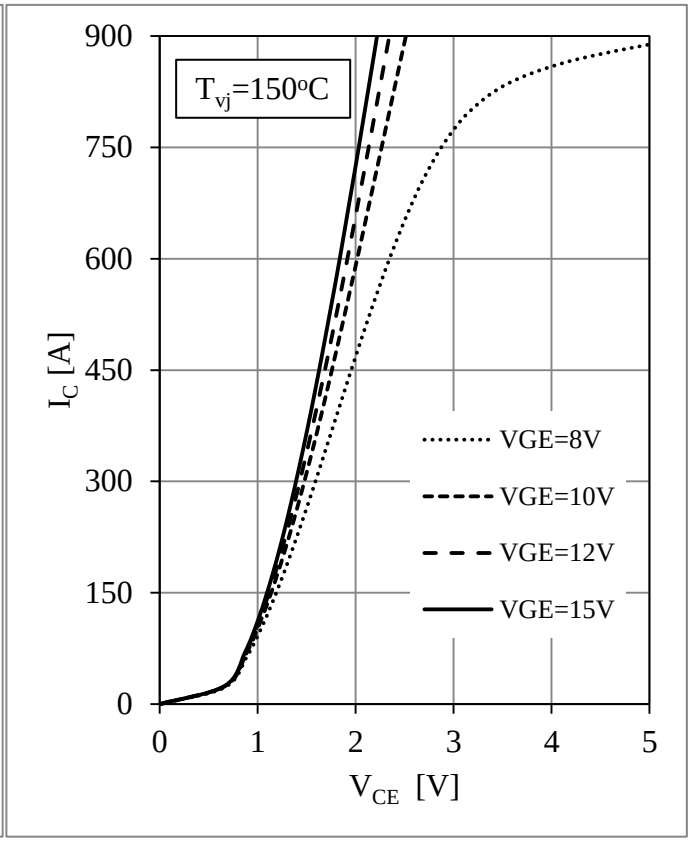



Fig 2. T1/T4 IGBT Output Characteristics

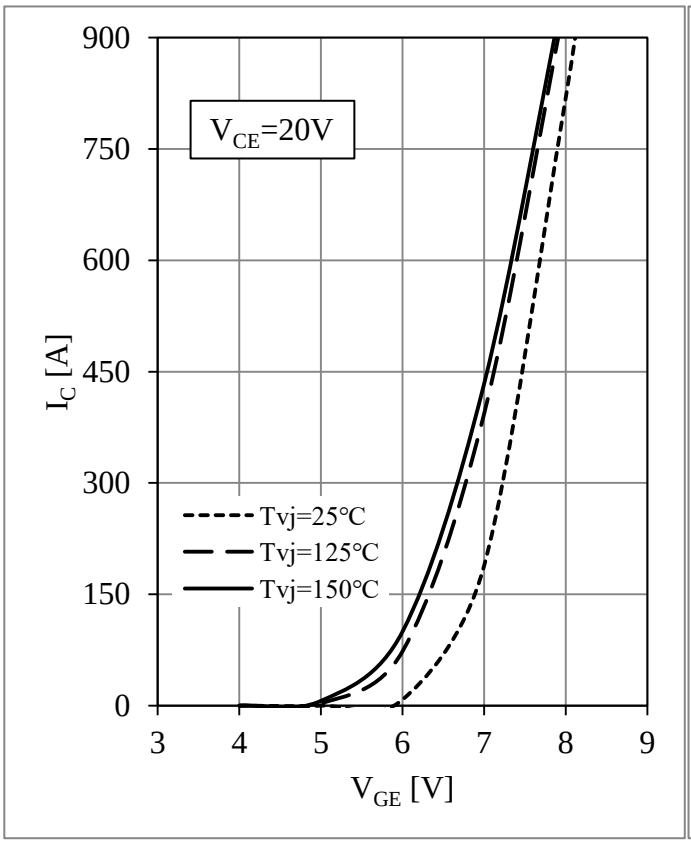



Fig 3. T1/T4 IGBT Transfer Characteristics

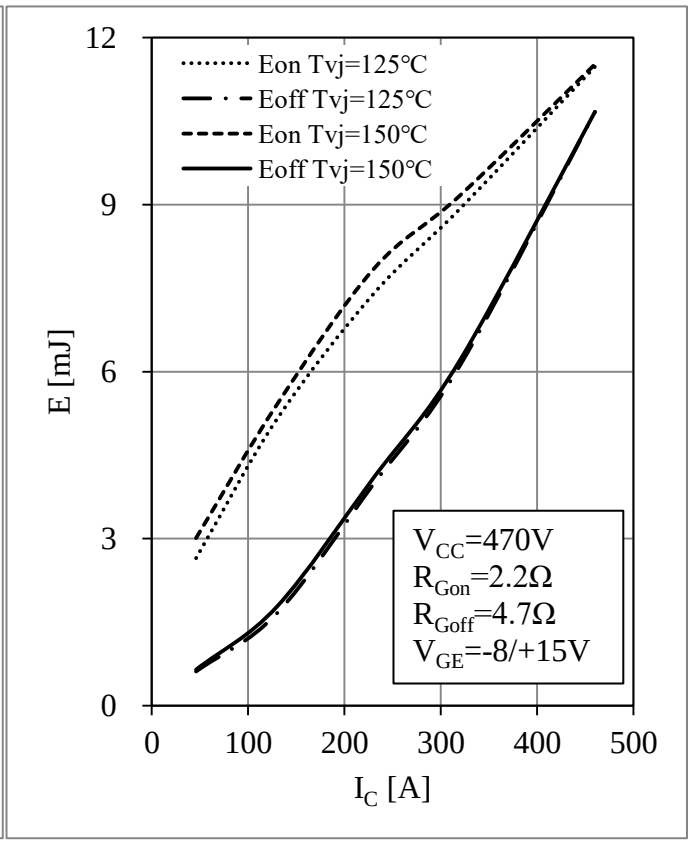



Fig 4. T1/T4 IGBT Switching Loss vs. $I_C$

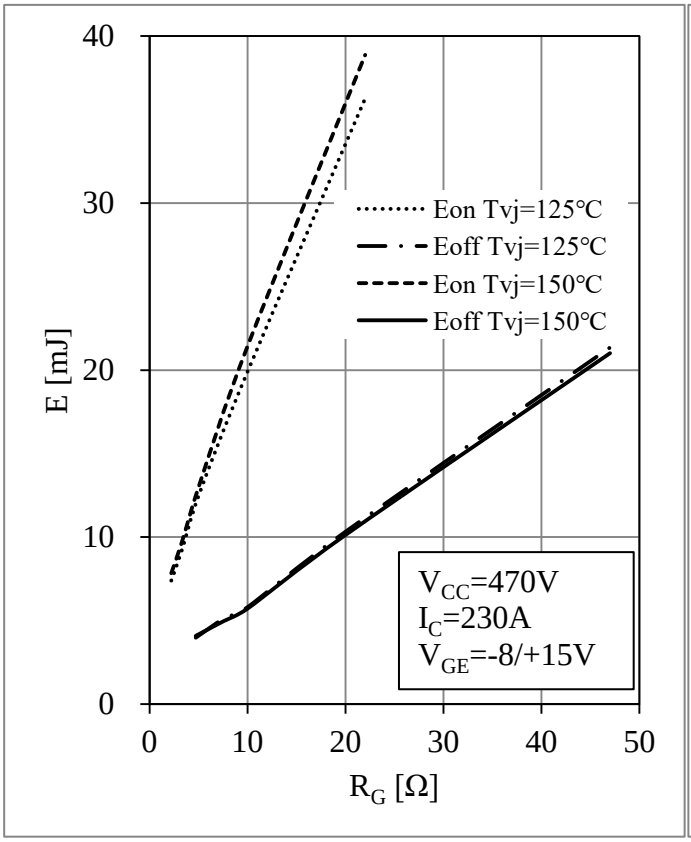



Fig 5. T1/T4 IGBT Switching Loss vs. $R_G$

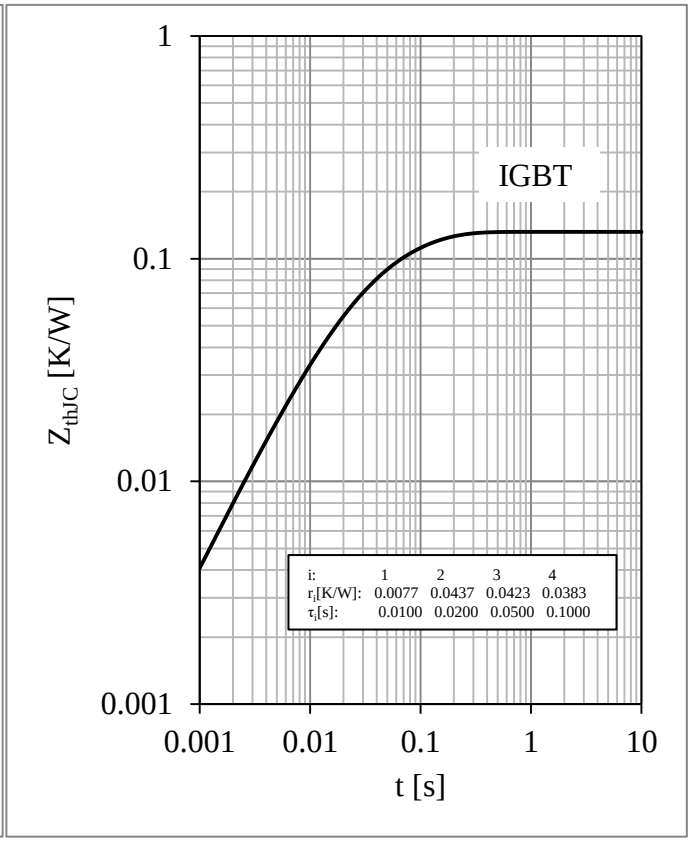



Fig 6. T1/T4 IGBT Transient Thermal Impedance

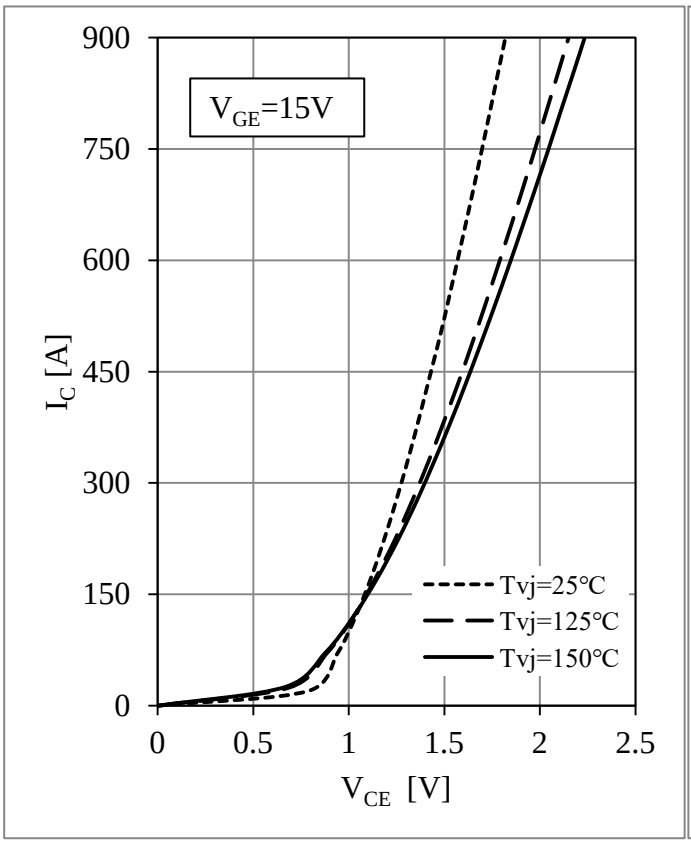



Fig 7. T2/T3 IGBT Output Characteristics

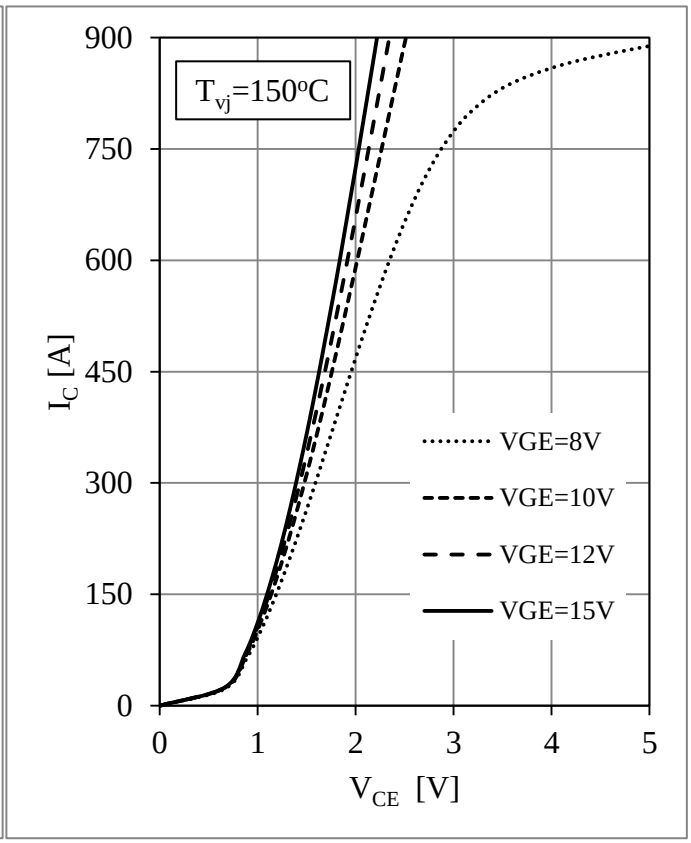



Fig 8. T2/T3 IGBT Output Characteristics

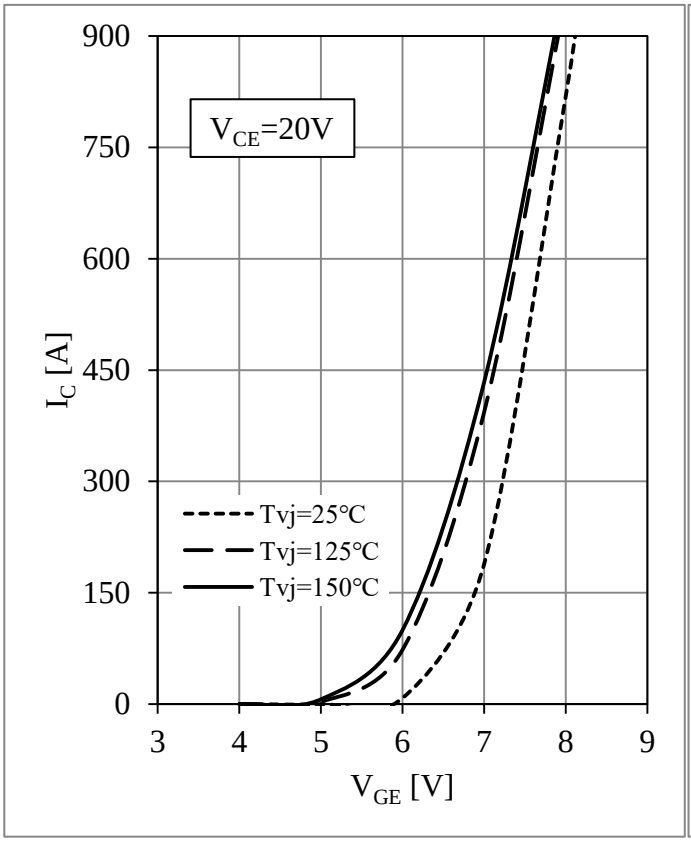



Fig 9. T2/T3 IGBT Transfer Characteristics

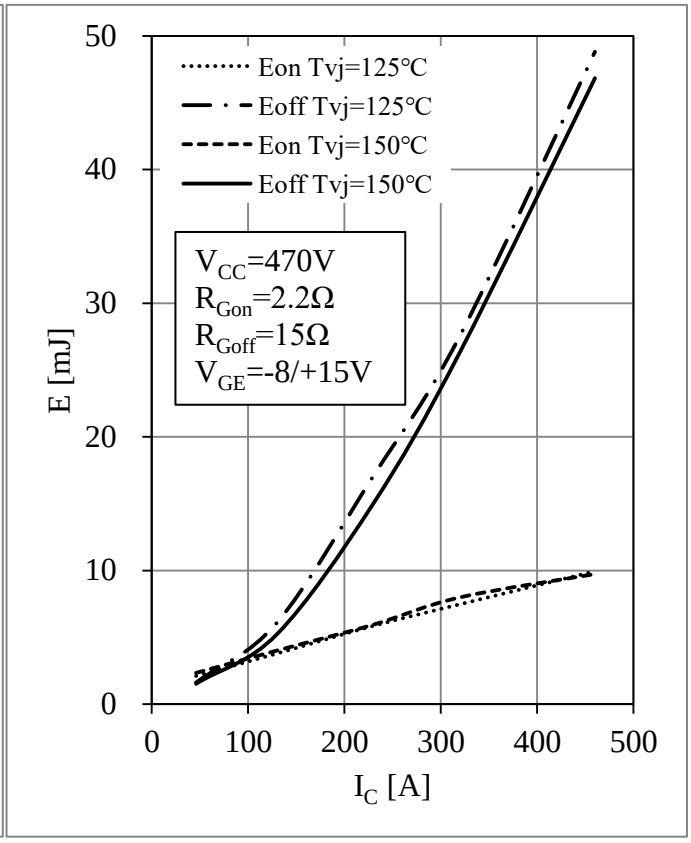



Fig 10. T2/T3 IGBT Switching Loss vs. $I_C$

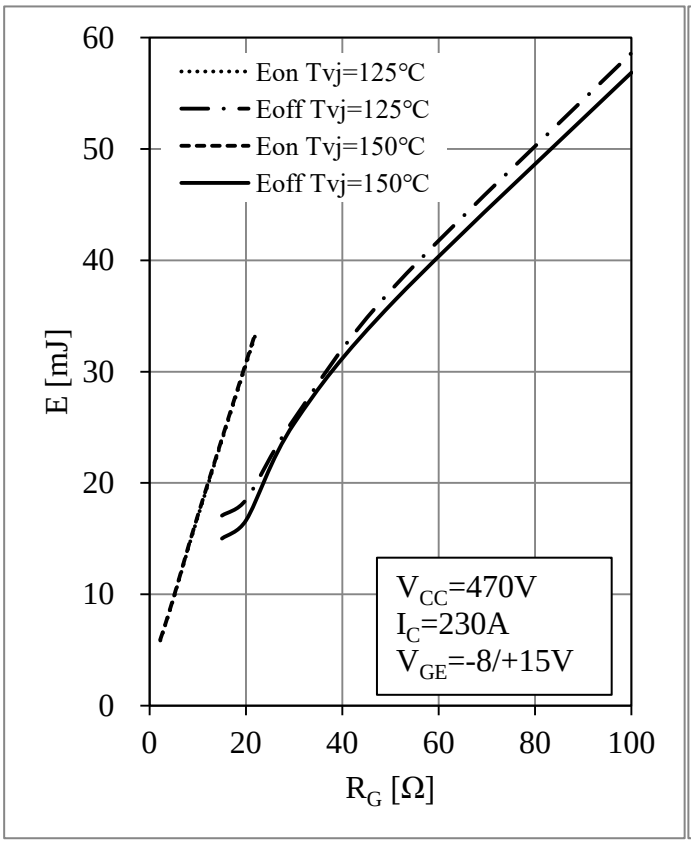



Fig 11. T2/T3 IGBT Switching Loss vs. $R_G$

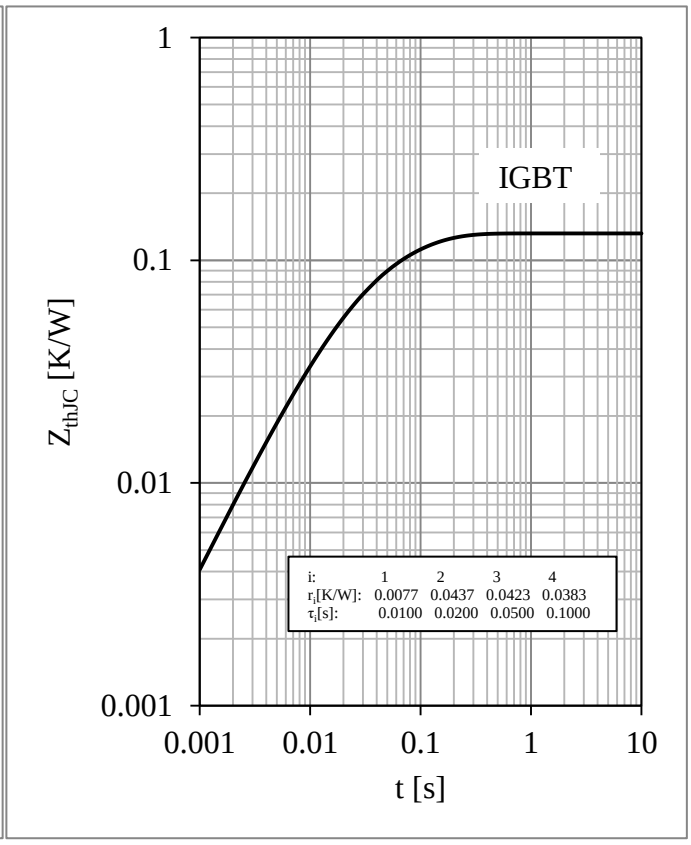



Fig 12. T2/T3 IGBT Transient Thermal Impedance

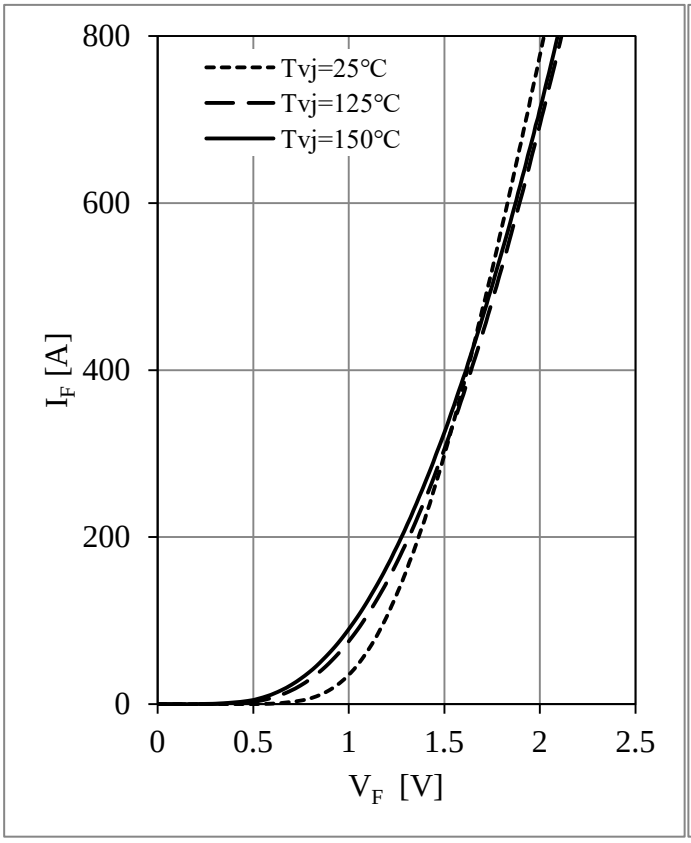



Fig 13. D1-D4 Diode Forward Characteristics

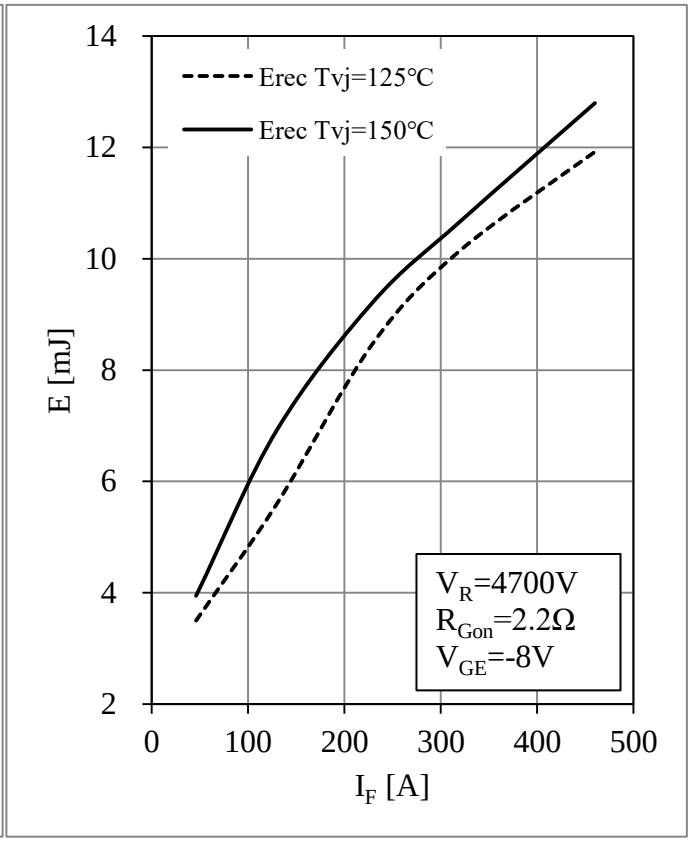



Fig 14. D1-D4 Diode Switching Loss vs. $I_F$

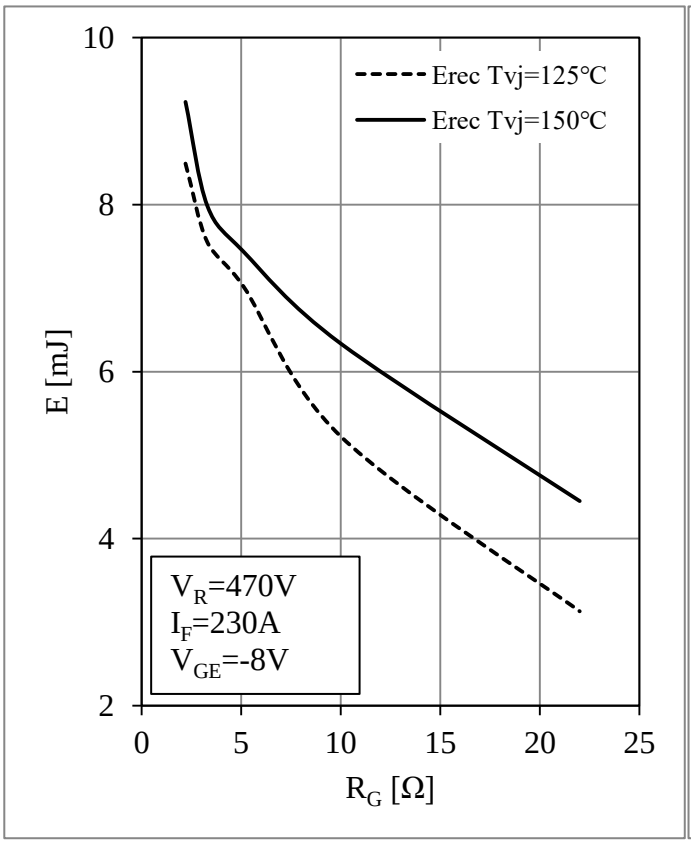



Fig 15. D1-D4 Diode Switching Loss vs. $R_G$

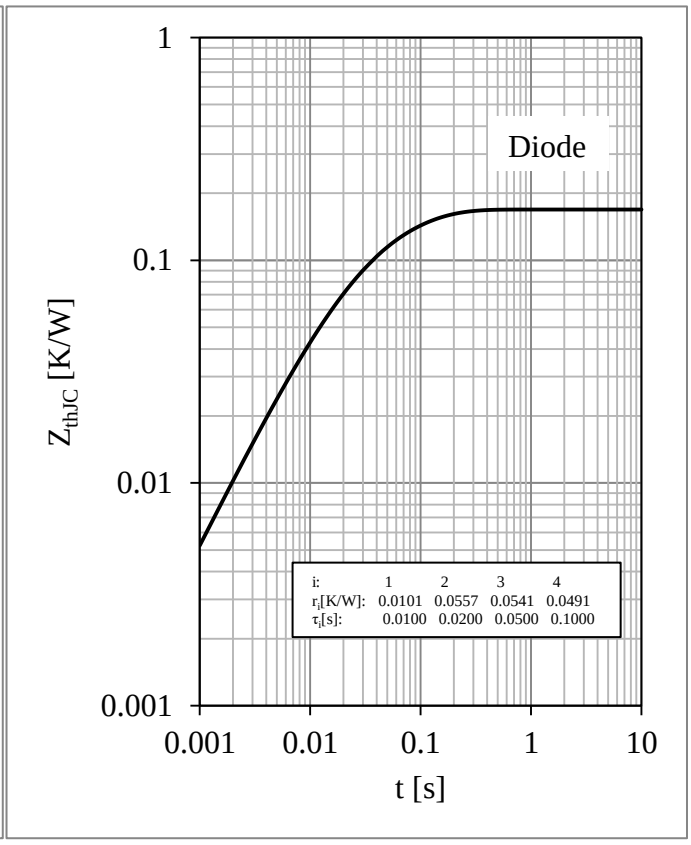



Fig 16. D1-D4 Diode Transient Thermal Impedance

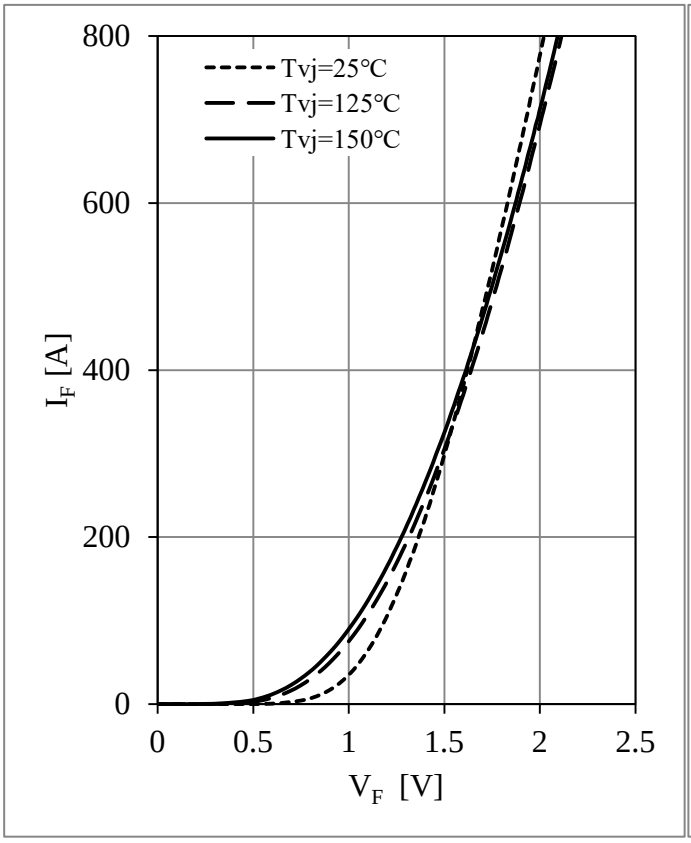



Fig 17. D5,D6 Diode Forward Characteristics

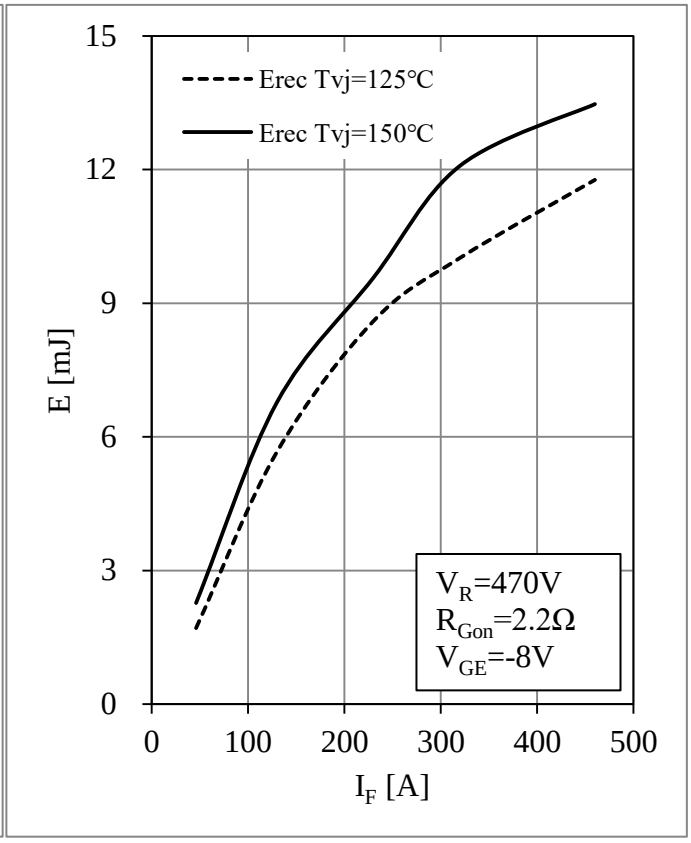



Fig 18. D5,D6 Diode Switching Loss vs. $I_F$

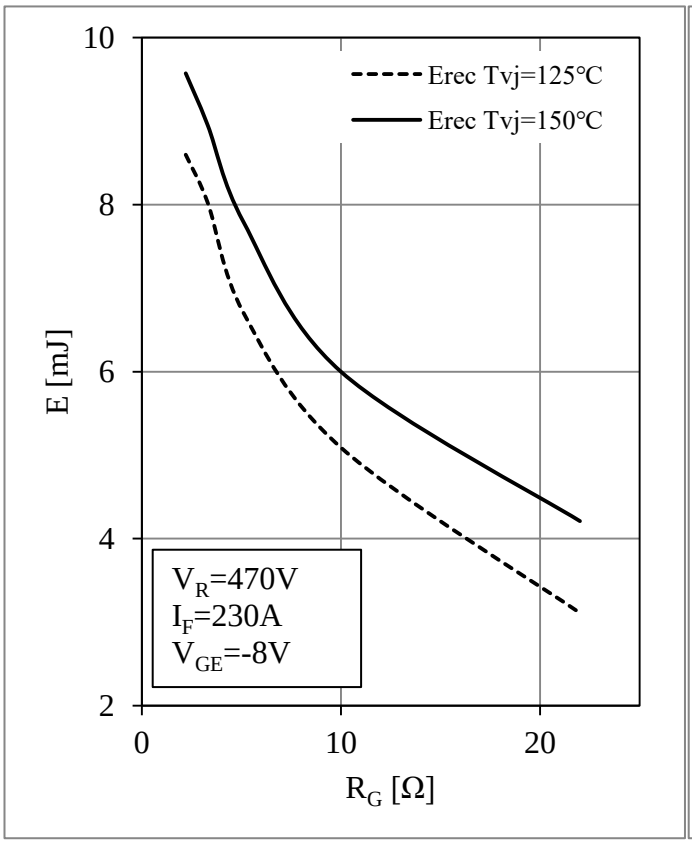



Fig 19. D5,D6 Diode Switching Loss vs. $R_G$

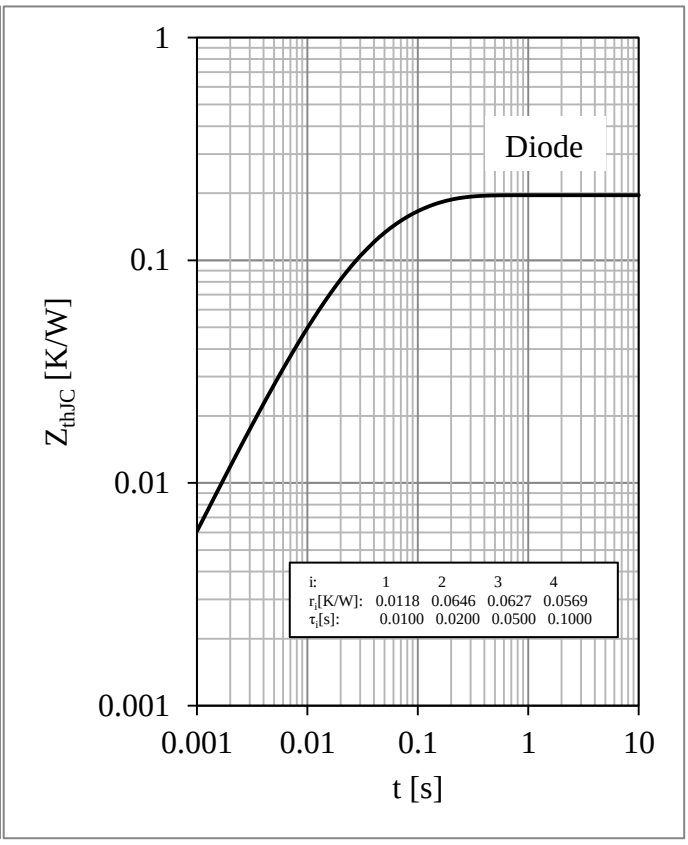
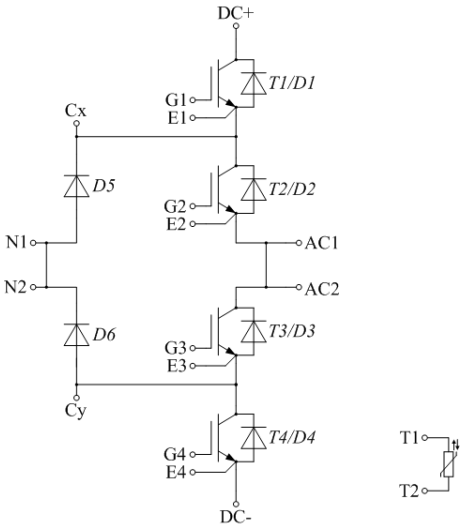


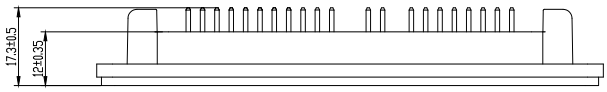

Fig 20. D5,D6 Diode Transient Thermal Impedance

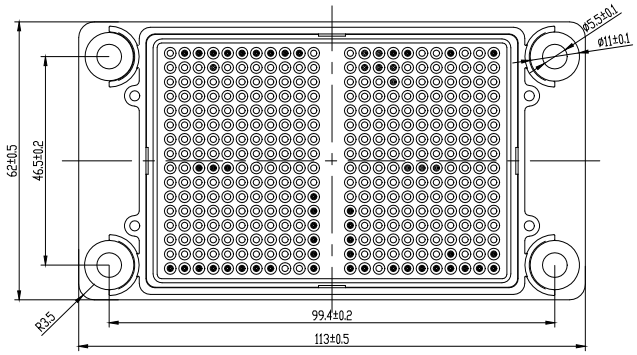
## Circuit Schematic

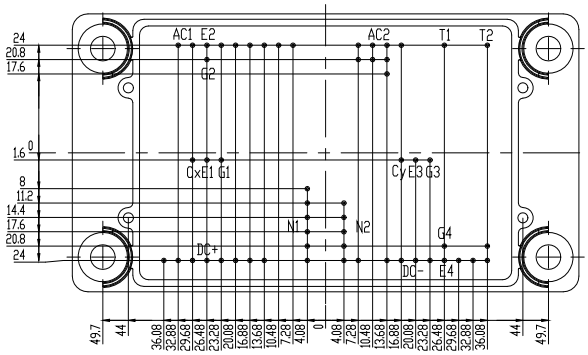



## Package Dimensions

Dimensions in Millimeters



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