

# STARPOWER

SEMICONDUCTOR

IGBT

## GD50PIY120C5SN

1200V/50A PIM 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 general inverters and UPS.



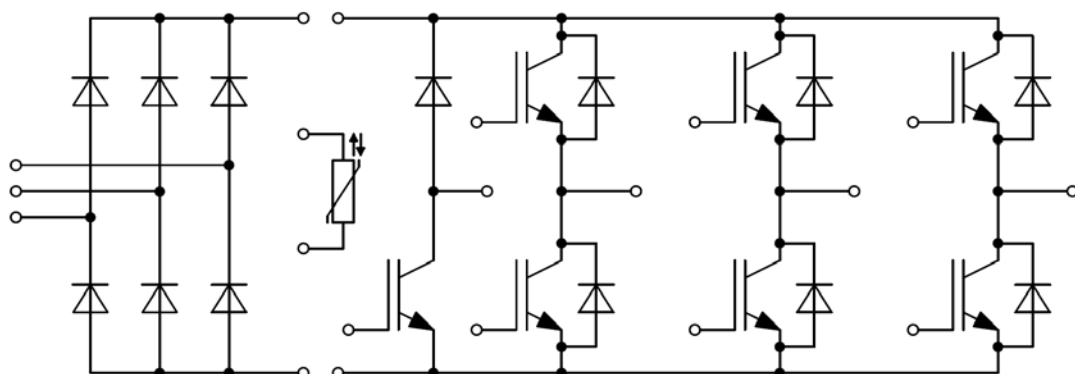
### Features

- Low  $V_{CE(sat)}$  Trench IGBT technology
- 10 $\mu$ s short circuit capability
- $V_{CE(sat)}$  with positive temperature coefficient
- Maximum junction temperature 175°C
- Low inductance case
- Fast & soft reverse recovery anti-parallel FWD
- Isolated copper baseplate using DBC technology

### Typical Applications

- Inverter for motor drive
- AC and DC servo drive amplifier
- Uninterruptible power supply

### Equivalent Circuit Schematic



**Absolute Maximum Ratings**  $T_C=25^{\circ}\text{C}$  unless otherwise noted**IGBT-inverter**

| Symbol    | Description                                           | Value    | Unit |
|-----------|-------------------------------------------------------|----------|------|
| $V_{CES}$ | Collector-Emitter Voltage                             | 1200     | V    |
| $V_{GES}$ | Gate-Emitter Voltage                                  | $\pm 20$ | V    |
| $I_C$     | Collector Current @ $T_C=25^{\circ}\text{C}$          | 85       | A    |
|           | @ $T_C=100^{\circ}\text{C}$                           | 50       | A    |
| $I_{CM}$  | Pulsed Collector Current $t_p=1\text{ms}$             | 100      | A    |
| $P_D$     | Maximum Power Dissipation @ $T_j=175^{\circ}\text{C}$ | 292      | W    |

**Diode-inverter**

| 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 $t_p=1\text{ms}$ | 100   | A    |

**Diode-rectifier**

| Symbol    | Description                                                                    | Value | Unit                 |
|-----------|--------------------------------------------------------------------------------|-------|----------------------|
| $V_{RRM}$ | Repetitive Peak Reverse Voltage                                                | 1600  | V                    |
| $I_O$     | Average Output Current 50Hz/60Hz,sine wave                                     | 50    | A                    |
| $I_{FSM}$ | Surge Forward Current $V_R=0\text{V}, t_p=10\text{ms}, T_j=45^{\circ}\text{C}$ | 850   | A                    |
| $I^2t$    | $I^2t$ -value, $V_R=0\text{V}, t_p=10\text{ms}, T_j=45^{\circ}\text{C}$        | 3610  | $\text{A}^2\text{s}$ |

**IGBT-brake**

| Symbol    | Description                                           | Value    | Unit |
|-----------|-------------------------------------------------------|----------|------|
| $V_{CES}$ | Collector-Emitter Voltage                             | 1200     | V    |
| $V_{GES}$ | Gate-Emitter Voltage                                  | $\pm 20$ | V    |
| $I_C$     | Collector Current @ $T_C=25^{\circ}\text{C}$          | 62       | A    |
|           | @ $T_C=100^{\circ}\text{C}$                           | 35       | A    |
| $I_{CM}$  | Pulsed Collector Current $t_p=1\text{ms}$             | 70       | A    |
| $P_D$     | Maximum Power Dissipation @ $T_j=175^{\circ}\text{C}$ | 218      | W    |

**Diode-brake**

| 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 $t_p=1\text{ms}$ | 50    | A    |

**Module**

| Symbol     | Description                                  | Value       | Unit               |
|------------|----------------------------------------------|-------------|--------------------|
| $T_{jmax}$ | Maximum Junction Temperature(inverter,brake) | 175         | $^{\circ}\text{C}$ |
|            | Maximum Junction Temperature (rectifier)     | 150         | $^{\circ}\text{C}$ |
| $T_{jop}$  | Operating Junction Temperature               | -40 to +150 | $^{\circ}\text{C}$ |
| $T_{STG}$  | Storage Temperature Range                    | -40 to +125 | $^{\circ}\text{C}$ |
| $V_{ISO}$  | Isolation Voltage RMS,f=50Hz,t=1min          | 2500        | V                  |

**IGBT-inverter Characteristics**  $T_C=25^{\circ}\text{C}$  unless otherwise noted

| Symbol        | Parameter                               | Test Conditions                                                                                                     | Min. | Typ. | Max. | Unit          |
|---------------|-----------------------------------------|---------------------------------------------------------------------------------------------------------------------|------|------|------|---------------|
| $V_{CE(sat)}$ | Collector to Emitter Saturation Voltage | $I_C=50\text{A}, V_{GE}=15\text{V}, T_j=25^{\circ}\text{C}$                                                         |      | 1.70 | 2.15 | V             |
|               |                                         | $I_C=50\text{A}, V_{GE}=15\text{V}, T_j=125^{\circ}\text{C}$                                                        |      | 1.95 |      |               |
|               |                                         | $I_C=50\text{A}, V_{GE}=15\text{V}, T_j=150^{\circ}\text{C}$                                                        |      | 2.00 |      |               |
| $V_{GE(th)}$  | Gate-Emitter Threshold Voltage          | $I_C=1.25\text{mA}, V_{CE}=V_{GE}, T_j=25^{\circ}\text{C}$                                                          | 5.2  | 6.0  | 6.8  | V             |
| $I_{CES}$     | Collector Cut-Off Current               | $V_{CE}=V_{CES}, V_{GE}=0\text{V}, T_j=25^{\circ}\text{C}$                                                          |      |      | 1.0  | mA            |
| $I_{GES}$     | Gate-Emitter Leakage Current            | $V_{GE}=V_{GES}, V_{CE}=0\text{V}, T_j=25^{\circ}\text{C}$                                                          |      |      | 100  | nA            |
| $R_{Gint}$    | Internal Gate Resistance                |                                                                                                                     |      | 0    |      | $\Omega$      |
| $Q_G$         | Gate Charge                             | $V_{GE}=-15\dots+15\text{V}$                                                                                        |      | 0.46 |      | $\mu\text{C}$ |
| $t_{d(on)}$   | Turn-On Delay Time                      | $V_{CC}=600\text{V}, I_C=50\text{A}, R_G=15\Omega, V_{GE}=\pm 15\text{V}, T_j=25^{\circ}\text{C}$                   |      | 171  |      | ns            |
| $t_r$         | Rise Time                               |                                                                                                                     |      | 32   |      | ns            |
| $t_{d(off)}$  | Turn-Off Delay Time                     |                                                                                                                     |      | 340  |      | ns            |
| $t_f$         | Fall Time                               |                                                                                                                     |      | 82   |      | ns            |
| $E_{on}$      | Turn-On Switching Loss                  |                                                                                                                     |      | 6.10 |      | mJ            |
| $E_{off}$     | Turn-Off Switching Loss                 |                                                                                                                     |      | 2.88 |      | mJ            |
| $t_{d(on)}$   | Turn-On Delay Time                      | $V_{CC}=600\text{V}, I_C=50\text{A}, R_G=15\Omega, V_{GE}=\pm 15\text{V}, T_j=125^{\circ}\text{C}$                  |      | 182  |      | ns            |
| $t_r$         | Rise Time                               |                                                                                                                     |      | 43   |      | ns            |
| $t_{d(off)}$  | Turn-Off Delay Time                     |                                                                                                                     |      | 443  |      | ns            |
| $t_f$         | Fall Time                               |                                                                                                                     |      | 155  |      | ns            |
| $E_{on}$      | Turn-On Switching Loss                  |                                                                                                                     |      | 8.24 |      | mJ            |
| $E_{off}$     | Turn-Off Switching Loss                 |                                                                                                                     |      | 4.43 |      | mJ            |
| $t_{d(on)}$   | Turn-On Delay Time                      | $V_{CC}=600\text{V}, I_C=50\text{A}, R_G=15\Omega, V_{GE}=\pm 15\text{V}, T_j=150^{\circ}\text{C}$                  |      | 182  |      | ns            |
| $t_r$         | Rise Time                               |                                                                                                                     |      | 43   |      | ns            |
| $t_{d(off)}$  | Turn-Off Delay Time                     |                                                                                                                     |      | 464  |      | ns            |
| $t_f$         | Fall Time                               |                                                                                                                     |      | 175  |      | ns            |
| $E_{on}$      | Turn-On Switching Loss                  |                                                                                                                     |      | 8.99 |      | mJ            |
| $E_{off}$     | Turn-Off Switching Loss                 |                                                                                                                     |      | 4.94 |      | mJ            |
| $I_{SC}$      | SC Data                                 | $t_p \leq 10\mu\text{s}, V_{GE}=15\text{V}, T_j=150^{\circ}\text{C}, V_{CC}=900\text{V}, V_{CEM} \leq 1200\text{V}$ |      | 200  |      | A             |

**Diode-inverter Characteristics**  $T_C=25^{\circ}\text{C}$  unless otherwise noted

| Symbol    | Parameter                     | Test Conditions                                                                                                          | Min. | Typ. | Max. | Unit          |
|-----------|-------------------------------|--------------------------------------------------------------------------------------------------------------------------|------|------|------|---------------|
| $V_F$     | Diode Forward Voltage         | $I_F=50\text{A}, V_{GE}=0\text{V}, T_j=25^{\circ}\text{C}$                                                               |      | 1.70 | 2.15 | V             |
|           |                               | $I_F=50\text{A}, V_{GE}=0\text{V}, T_j=125^{\circ}\text{C}$                                                              |      | 1.65 |      |               |
|           |                               | $I_F=50\text{A}, V_{GE}=0\text{V}, T_j=150^{\circ}\text{C}$                                                              |      | 1.65 |      |               |
| $Q_r$     | Recovered Charge              | $V_R=600\text{V}, I_F=50\text{A},$<br>$-di/dt=1400\text{A}/\mu\text{s}, V_{GE}=-15\text{V}$<br>$T_j=25^{\circ}\text{C}$  |      | 5.2  |      | $\mu\text{C}$ |
| $I_{RM}$  | Peak Reverse Recovery Current |                                                                                                                          |      | 51   |      | A             |
| $E_{rec}$ | Reverse Recovery Energy       |                                                                                                                          |      | 1.62 |      | mJ            |
| $Q_r$     | Recovered Charge              | $V_R=600\text{V}, I_F=50\text{A},$<br>$-di/dt=1400\text{A}/\mu\text{s}, V_{GE}=-15\text{V}$<br>$T_j=125^{\circ}\text{C}$ |      | 8.4  |      | $\mu\text{C}$ |
| $I_{RM}$  | Peak Reverse Recovery Current |                                                                                                                          |      | 57   |      | A             |
| $E_{rec}$ | Reverse Recovery Energy       |                                                                                                                          |      | 2.85 |      | mJ            |
| $Q_r$     | Recovered Charge              | $V_R=600\text{V}, I_F=50\text{A},$<br>$-di/dt=1400\text{A}/\mu\text{s}, V_{GE}=-15\text{V}$<br>$T_j=150^{\circ}\text{C}$ |      | 9.5  |      | $\mu\text{C}$ |
| $I_{RM}$  | Peak Reverse Recovery Current |                                                                                                                          |      | 60   |      | A             |
| $E_{rec}$ | Reverse Recovery Energy       |                                                                                                                          |      | 3.52 |      | mJ            |

**Diode-rectifier Characteristics**  $T_C=25^{\circ}\text{C}$  unless otherwise noted

| Symbol | Parameter             | Test Conditions                                             | Min. | Typ. | Max. | Unit |
|--------|-----------------------|-------------------------------------------------------------|------|------|------|------|
| $V_F$  | Diode Forward Voltage | $I_F=50\text{A}, V_{GE}=0\text{V}, T_j=150^{\circ}\text{C}$ |      | 1.14 |      | V    |
| $I_R$  | Reverse Current       | $T_j=150^{\circ}\text{C}, V_R=1600\text{V}$                 |      |      | 3.0  | mA   |

**IGBT-brake Characteristics**  $T_C=25^{\circ}\text{C}$  unless otherwise noted

| Symbol        | Parameter                               | Test Conditions                                                                                                     | Min. | Typ. | Max. | Unit          |
|---------------|-----------------------------------------|---------------------------------------------------------------------------------------------------------------------|------|------|------|---------------|
| $V_{CE(sat)}$ | Collector to Emitter Saturation Voltage | $I_C=35\text{A}, V_{GE}=15\text{V}, T_j=25^{\circ}\text{C}$                                                         |      | 1.70 | 2.15 | V             |
|               |                                         | $I_C=35\text{A}, V_{GE}=15\text{V}, T_j=125^{\circ}\text{C}$                                                        |      | 1.95 |      |               |
|               |                                         | $I_C=35\text{A}, V_{GE}=15\text{V}, T_j=150^{\circ}\text{C}$                                                        |      | 2.00 |      |               |
| $V_{GE(th)}$  | Gate-Emitter Threshold Voltage          | $I_C=0.88\text{mA}, V_{CE}=V_{GE}, T_j=25^{\circ}\text{C}$                                                          | 5.2  | 6.0  | 6.8  | V             |
| $I_{CES}$     | Collector Cut-Off Current               | $V_{CE}=V_{CES}, V_{GE}=0\text{V}, T_j=25^{\circ}\text{C}$                                                          |      |      | 1.0  | mA            |
| $I_{GES}$     | Gate-Emitter Leakage Current            | $V_{GE}=V_{GES}, V_{CE}=0\text{V}, T_j=25^{\circ}\text{C}$                                                          |      |      | 400  | nA            |
| $R_{Gint}$    | Internal Gate Resistance                |                                                                                                                     |      | 0    |      | $\Omega$      |
| $Q_G$         | Gate Charge                             | $V_{GE}=-15\dots+15\text{V}$                                                                                        |      | 0.33 |      | $\mu\text{C}$ |
| $t_{d(on)}$   | Turn-On Delay Time                      | $V_{CC}=600\text{V}, I_C=35\text{A}, R_G=13\Omega, V_{GE}=\pm 15\text{V}, T_j=25^{\circ}\text{C}$                   |      | 156  |      | ns            |
| $t_r$         | Rise Time                               |                                                                                                                     |      | 28   |      | ns            |
| $t_{d(off)}$  | Turn-Off Delay Time                     |                                                                                                                     |      | 215  |      | ns            |
| $t_f$         | Fall Time                               |                                                                                                                     |      | 323  |      | ns            |
| $E_{on}$      | Turn-On Switching Loss                  |                                                                                                                     |      | 1.94 |      | mJ            |
| $E_{off}$     | Turn-Off Switching Loss                 |                                                                                                                     |      | 2.55 |      | mJ            |
| $t_{d(on)}$   | Turn-On Delay Time                      | $V_{CC}=600\text{V}, I_C=35\text{A}, R_G=13\Omega, V_{GE}=\pm 15\text{V}, T_j=125^{\circ}\text{C}$                  |      | 156  |      | ns            |
| $t_r$         | Rise Time                               |                                                                                                                     |      | 30   |      | ns            |
| $t_{d(off)}$  | Turn-Off Delay Time                     |                                                                                                                     |      | 229  |      | ns            |
| $t_f$         | Fall Time                               |                                                                                                                     |      | 507  |      | ns            |
| $E_{on}$      | Turn-On Switching Loss                  |                                                                                                                     |      | 2.38 |      | mJ            |
| $E_{off}$     | Turn-Off Switching Loss                 |                                                                                                                     |      | 3.83 |      | mJ            |
| $t_{d(on)}$   | Turn-On Delay Time                      | $V_{CC}=600\text{V}, I_C=35\text{A}, R_G=13\Omega, V_{GE}=\pm 15\text{V}, T_j=150^{\circ}\text{C}$                  |      | 153  |      | ns            |
| $t_r$         | Rise Time                               |                                                                                                                     |      | 32   |      | ns            |
| $t_{d(off)}$  | Turn-Off Delay Time                     |                                                                                                                     |      | 234  |      | ns            |
| $t_f$         | Fall Time                               |                                                                                                                     |      | 522  |      | ns            |
| $E_{on}$      | Turn-On Switching Loss                  |                                                                                                                     |      | 2.60 |      | mJ            |
| $E_{off}$     | Turn-Off Switching Loss                 |                                                                                                                     |      | 4.02 |      | mJ            |
| $I_{SC}$      | SC Data                                 | $t_p \leq 10\mu\text{s}, V_{GE}=15\text{V}, T_j=150^{\circ}\text{C}, V_{CC}=900\text{V}, V_{CEM} \leq 1200\text{V}$ |      | 140  |      | A             |

**Diode-brake Characteristics**  $T_C=25^{\circ}\text{C}$  unless otherwise noted

| Symbol    | Parameter                     | Test Conditions                                                                                                         | Min. | Typ. | Max. | Unit          |
|-----------|-------------------------------|-------------------------------------------------------------------------------------------------------------------------|------|------|------|---------------|
| $V_F$     | Diode Forward Voltage         | $I_F=25\text{A}, V_{GE}=0\text{V}, T_j=25^{\circ}\text{C}$                                                              |      | 2.10 | 2.55 | V             |
|           |                               | $I_F=25\text{A}, V_{GE}=0\text{V}, T_j=125^{\circ}\text{C}$                                                             |      | 2.15 |      |               |
|           |                               | $I_F=25\text{A}, V_{GE}=0\text{V}, T_j=150^{\circ}\text{C}$                                                             |      | 2.15 |      |               |
| $Q_r$     | Recovered Charge              | $V_R=600\text{V}, I_F=25\text{A},$<br>$-di/dt=900\text{A}/\mu\text{s}, V_{GE}=-15\text{V}$<br>$T_j=25^{\circ}\text{C}$  |      | 1.3  |      | $\mu\text{C}$ |
| $I_{RM}$  | Peak Reverse Recovery Current |                                                                                                                         |      | 31   |      | A             |
| $E_{rec}$ | Reverse Recovery Energy       |                                                                                                                         |      | 0.68 |      | mJ            |
| $Q_r$     | Recovered Charge              | $V_R=600\text{V}, I_F=25\text{A},$<br>$-di/dt=900\text{A}/\mu\text{s}, V_{GE}=-15\text{V}$<br>$T_j=125^{\circ}\text{C}$ |      | 2.2  |      | $\mu\text{C}$ |
| $I_{RM}$  | Peak Reverse Recovery Current |                                                                                                                         |      | 38   |      | A             |
| $E_{rec}$ | Reverse Recovery Energy       |                                                                                                                         |      | 1.46 |      | mJ            |
| $Q_r$     | Recovered Charge              | $V_R=600\text{V}, I_F=25\text{A},$<br>$-di/dt=900\text{A}/\mu\text{s}, V_{GE}=-15\text{V}$<br>$T_j=150^{\circ}\text{C}$ |      | 2.4  |      | $\mu\text{C}$ |
| $I_{RM}$  | Peak Reverse Recovery Current |                                                                                                                         |      | 40   |      | A             |
| $E_{rec}$ | Reverse Recovery Energy       |                                                                                                                         |      | 1.91 |      | mJ            |

**NTC Characteristics**  $T_C=25^{\circ}\text{C}$  unless otherwise noted

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

**Module Characteristics**  $T_C=25^{\circ}\text{C}$  unless otherwise noted

| Symbol                         | Parameter                                                                                                                                                                                                       | Min. | Typ.                                               | Max.                                      | Unit       |
|--------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|----------------------------------------------------|-------------------------------------------|------------|
| $L_{CE}$                       | Stray Inductance                                                                                                                                                                                                |      | 35                                                 |                                           | nH         |
| $R_{CC'+EE'}$<br>$R_{AA'+CC'}$ | Module Lead Resistance, Terminal to Chip                                                                                                                                                                        |      | 4.00<br>3.00                                       |                                           | m $\Omega$ |
| $R_{thJC}$                     | Junction-to-Case (per IGBT-inverter)<br>Junction-to-Case (per Diode-inverter)<br>Junction-to-Case (per Diode-rectifier)<br>Junction-to-Case (per IGBT-brake)<br>Junction-to-Case (per Diode-brake)              |      |                                                    | 0.512<br>0.793<br>0.813<br>0.685<br>1.134 | K/W        |
| $R_{thCH}$                     | Case-to-Sink (per IGBT-inverter)<br>Case-to-Sink (per Diode-inverter)<br>Case-to-Sink (per Diode-rectifier)<br>Case-to-Sink (per IGBT-brake)<br>Case-to-Sink (per Diode-brake)<br>Case-to-Sink (per per Module) |      | 0.297<br>0.460<br>0.472<br>0.397<br>0.658<br>0.020 |                                           | K/W        |
| M                              | Mounting Torque, Screw:M5                                                                                                                                                                                       | 3.0  |                                                    | 6.0                                       | N.m        |
| G                              | Weight of Module                                                                                                                                                                                                |      | 200                                                |                                           | g          |

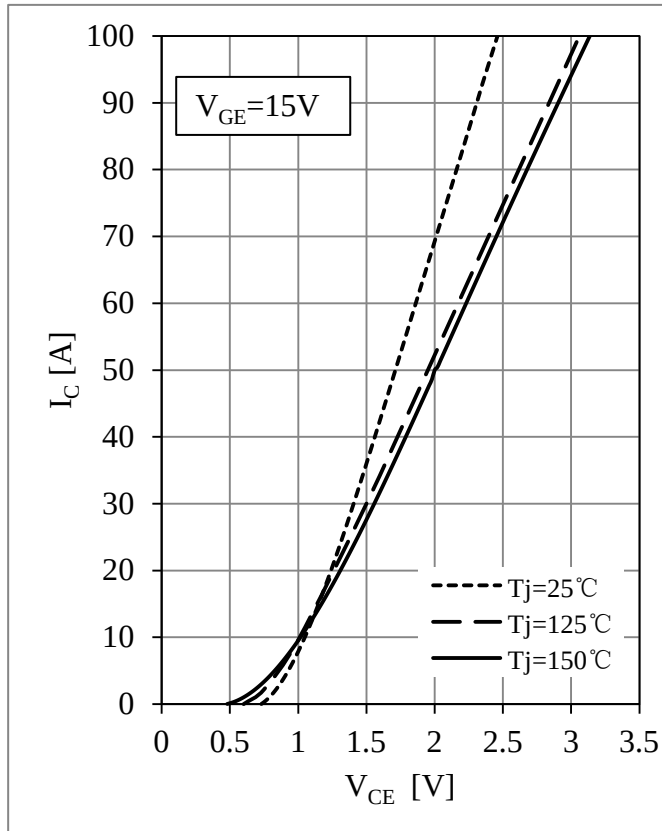


Fig 1. IGBT-inverter Output Characteristics

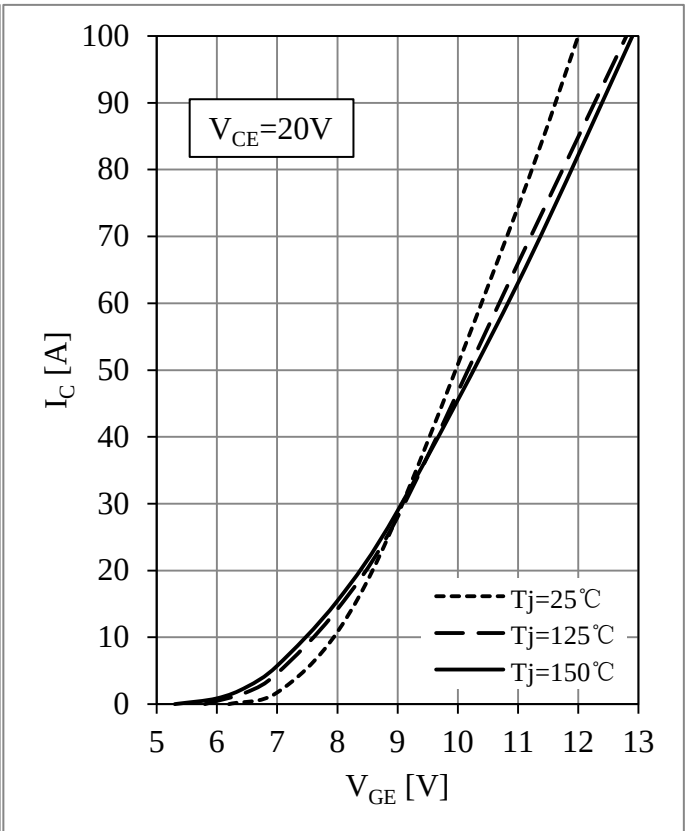
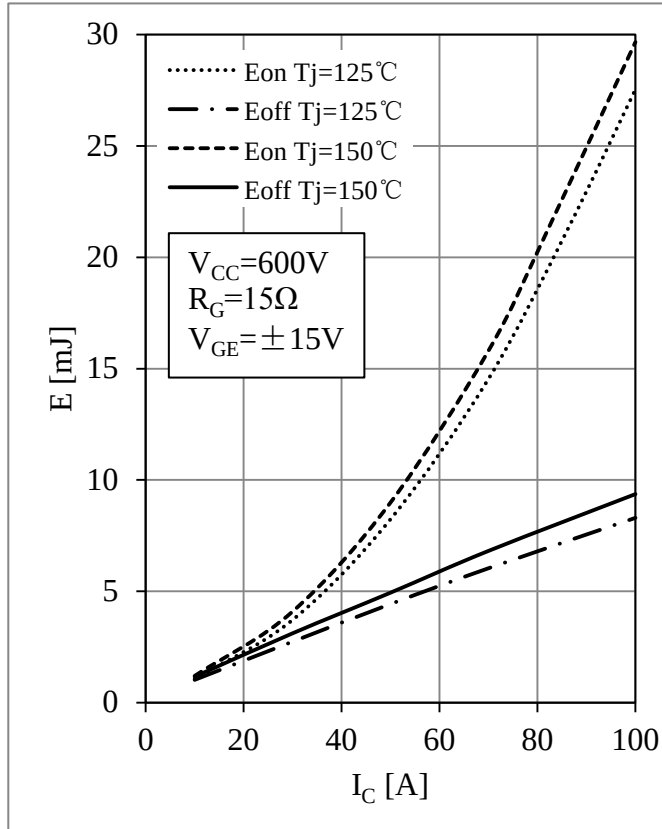
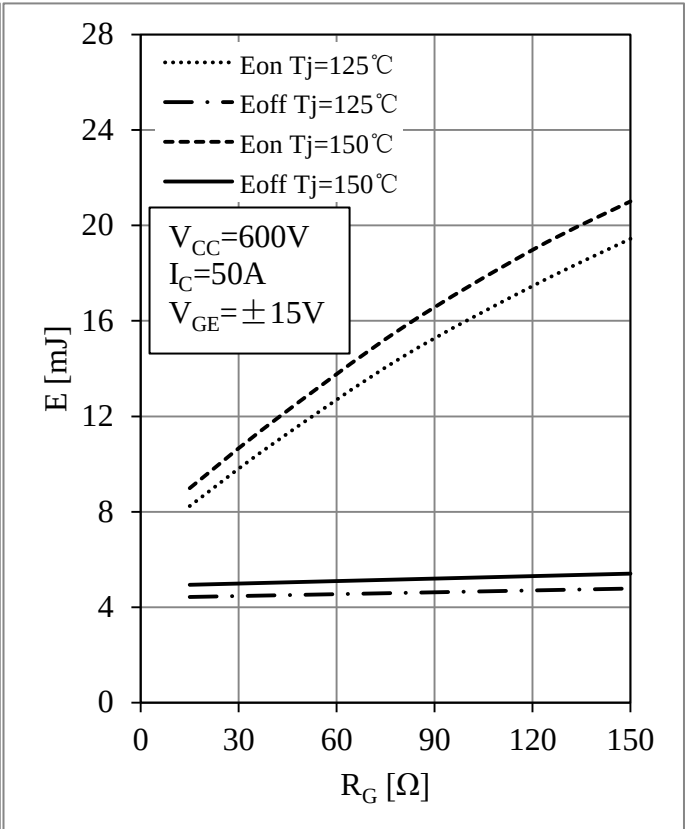


Fig 2. IGBT-inverter Transfer Characteristics

Fig 3. IGBT-inverter Switching Loss vs.  $I_C$ Fig 4. IGBT-inverter Switching Loss vs.  $R_G$



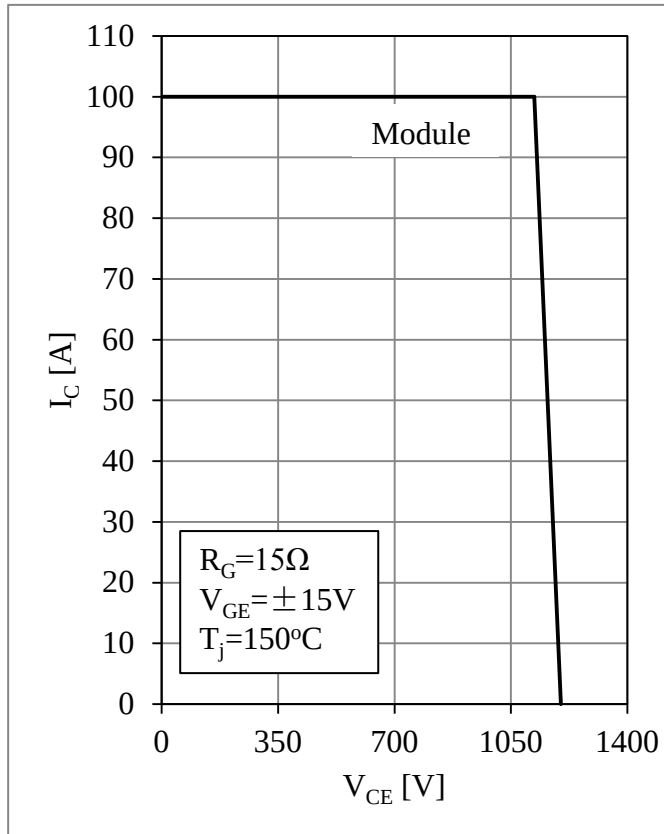


Fig 5. IGBT-inverter RBSOA

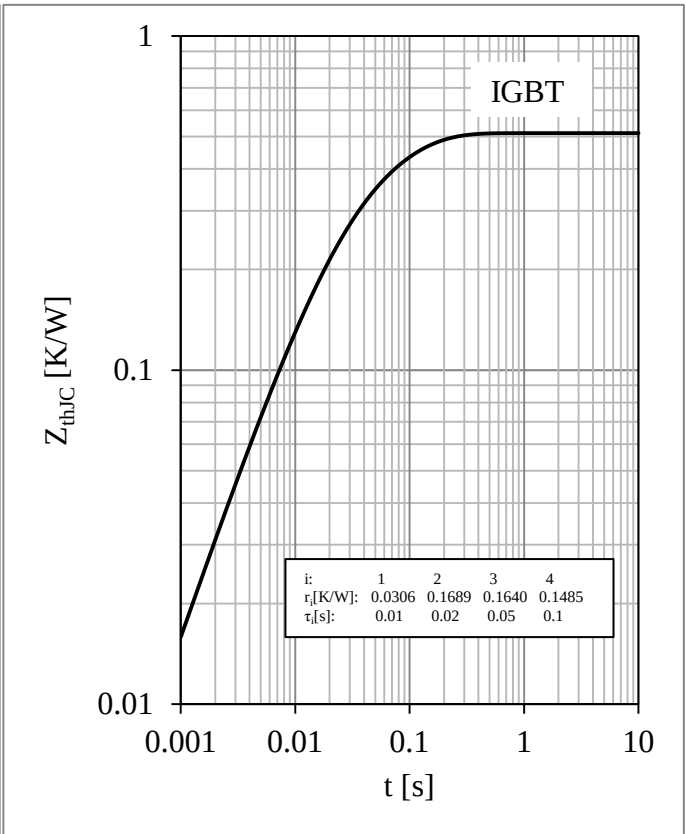


Fig 6. IGBT-inverter Transient Thermal Impedance

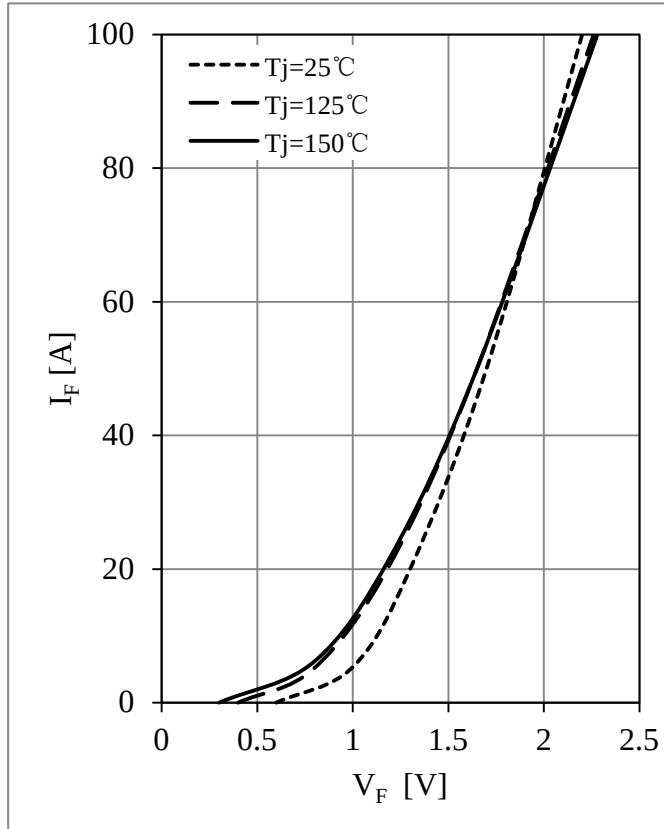
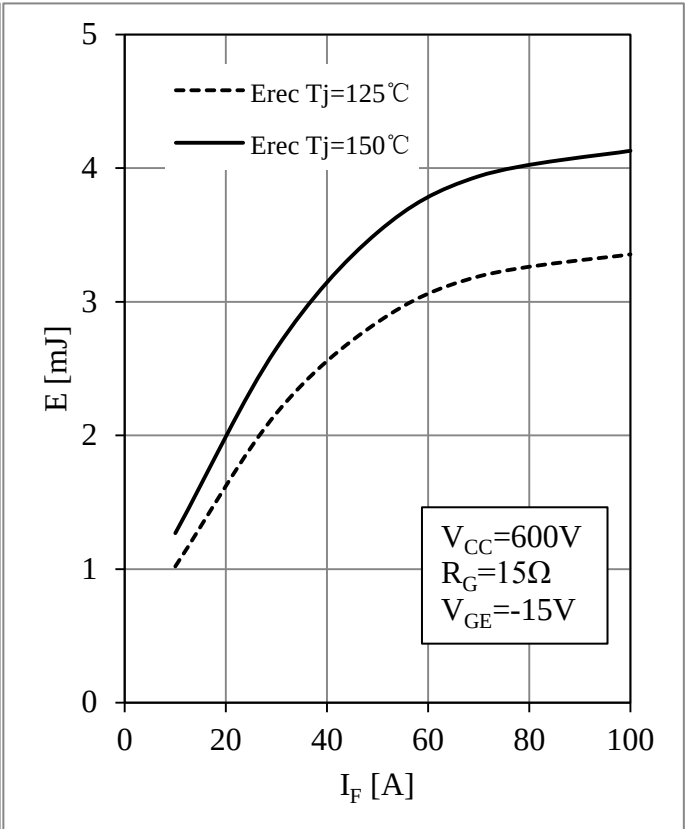


Fig 7. Diode-inverter Forward Characteristics

Fig 8. Diode-inverter Switching Loss vs.  $I_F$

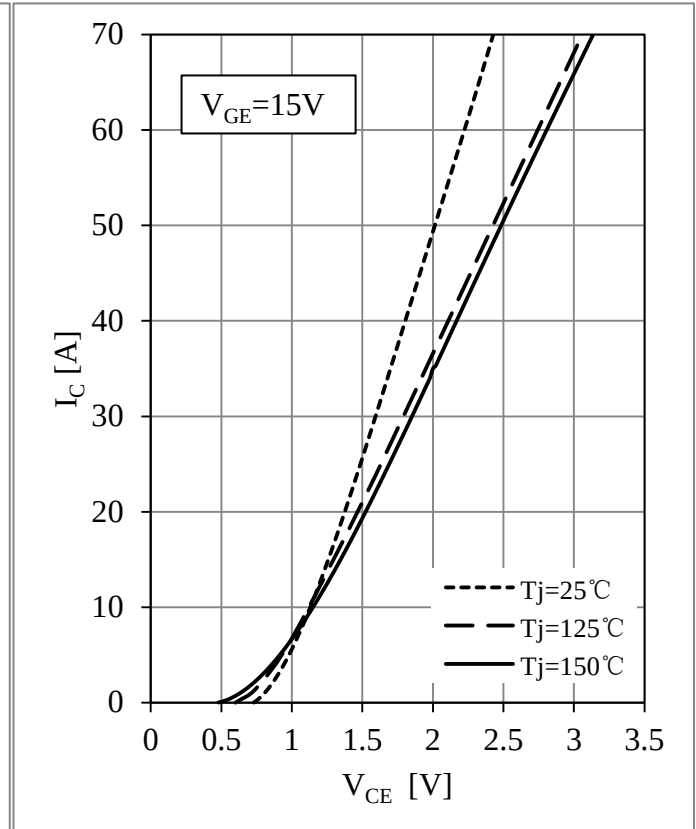
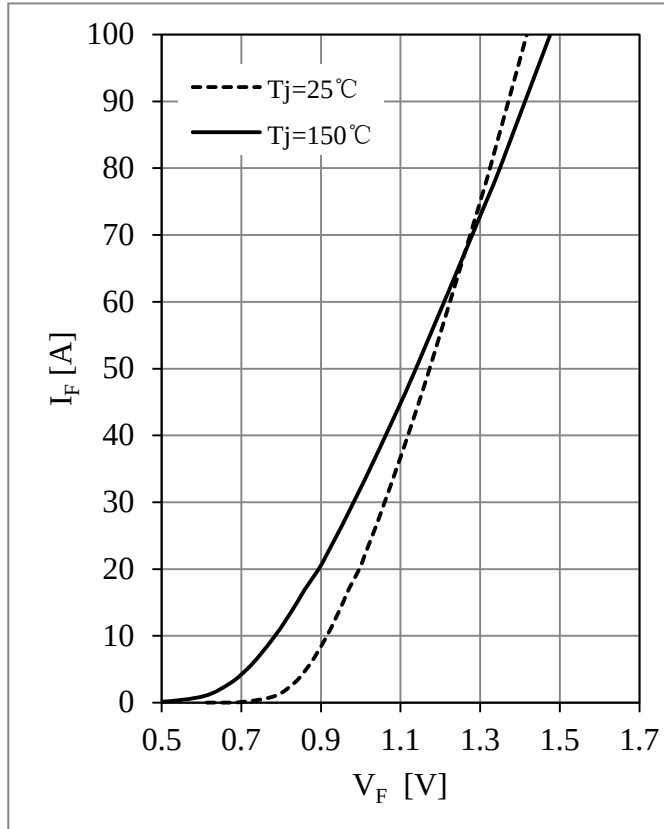
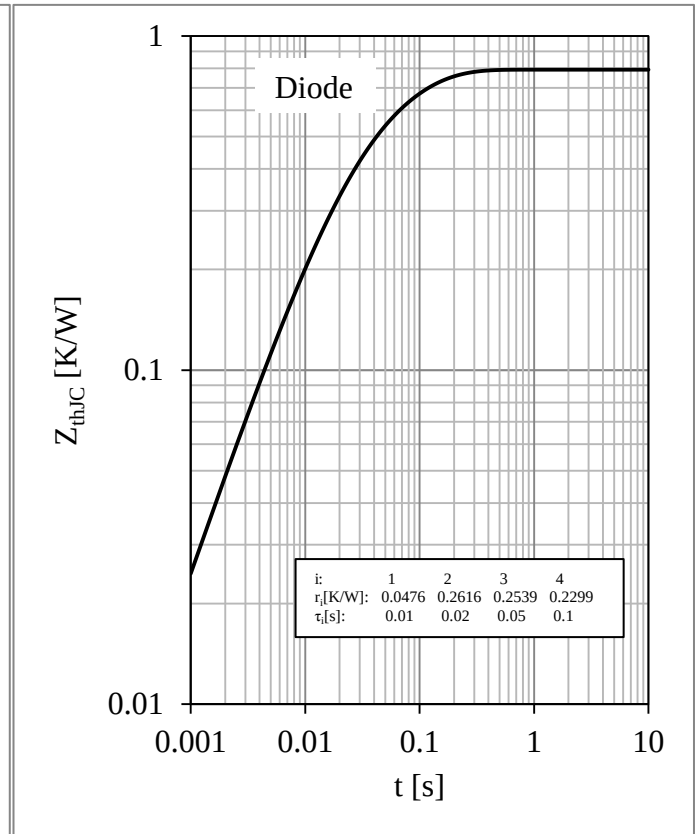
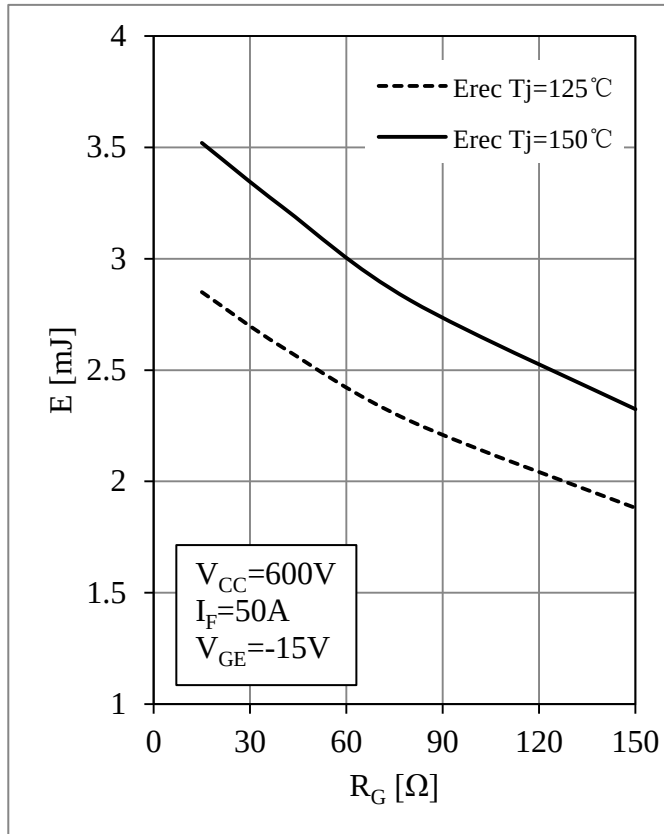


Fig 11. Diode-rectifier Forward Characteristics

Fig 12. IGBT-brake-chopper Output Characteristics

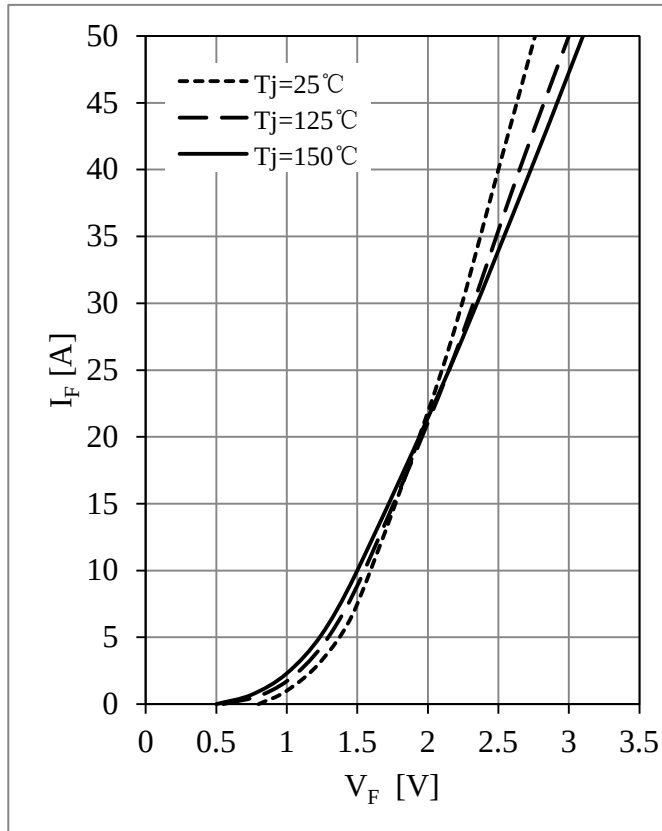


Fig 13. Diode-brake-chopper Forward Characteristics

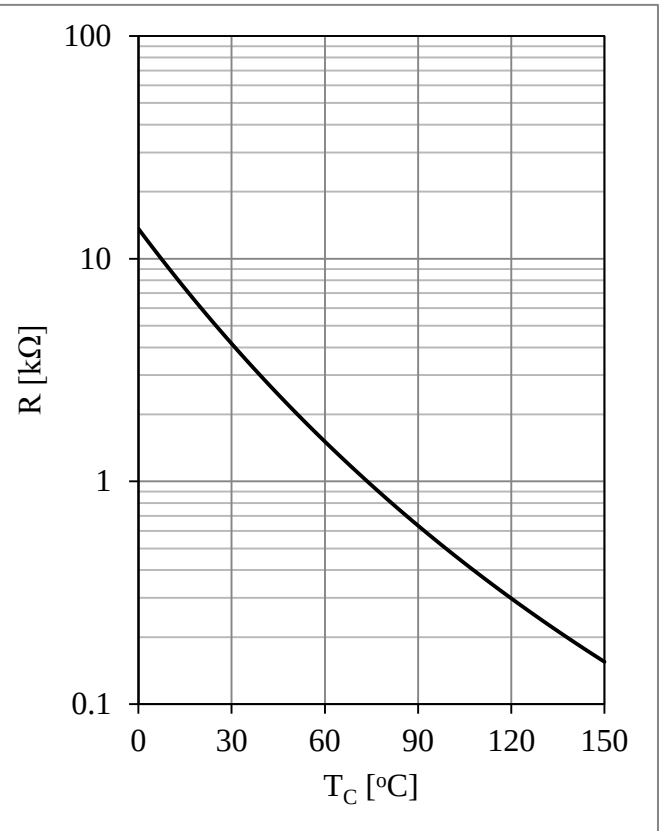
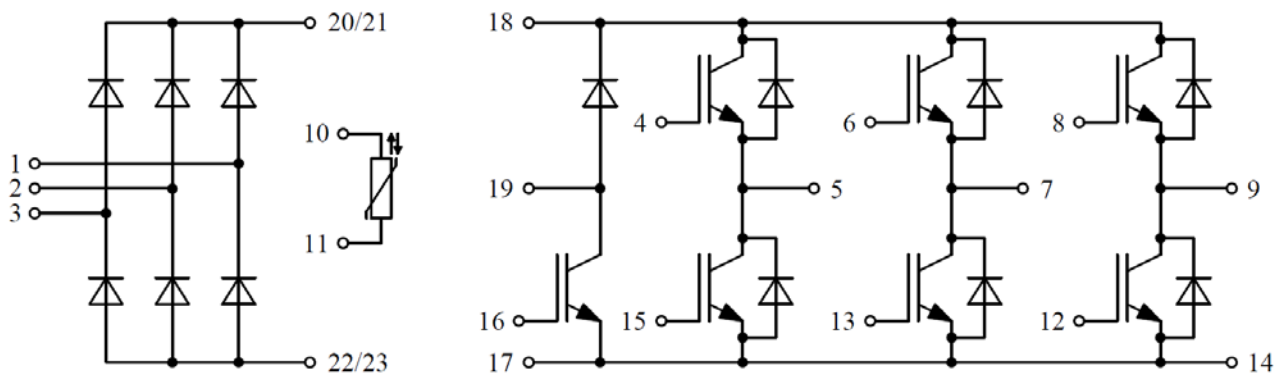


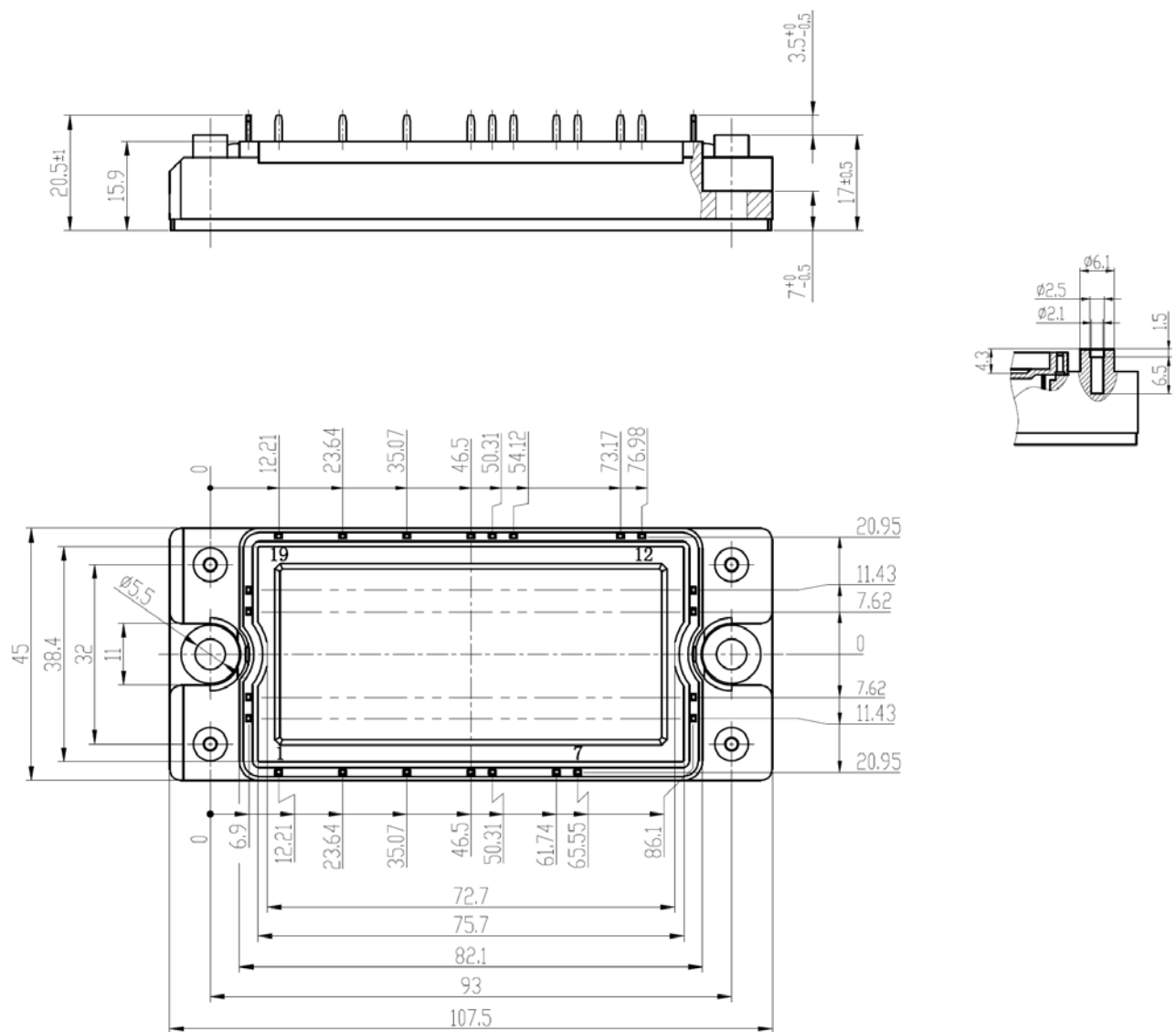
Fig 14. NTC Temperature Characteristic

## Circuit Schematic



## Package Dimensions

Dimensions in Millimeters



## Terms and Conditions of Usage

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