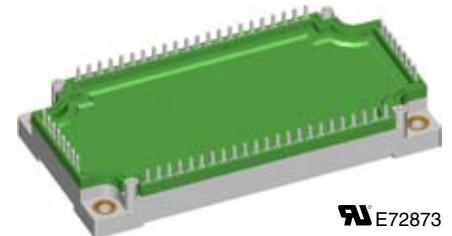
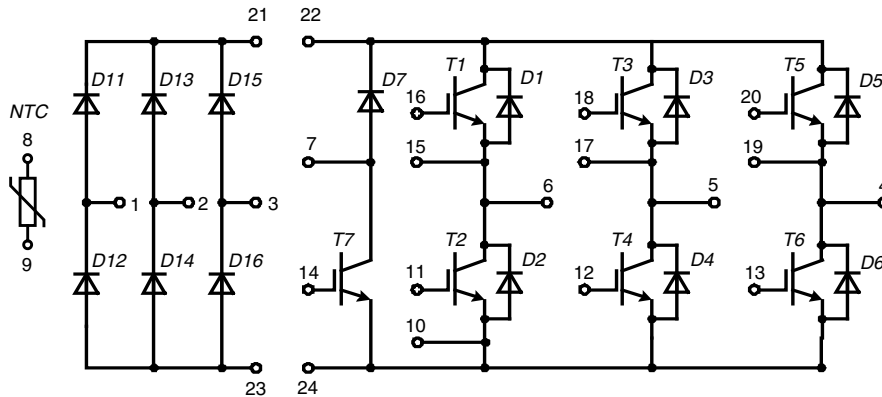


# Converter - Brake - Inverter Module (CBI3) with Trench IGBT technology



E72873

| Three Phase Rectifier      | Brake Chopper                 | Three Phase Inverter          |
|----------------------------|-------------------------------|-------------------------------|
| $V_{RRM} = 2200 \text{ V}$ | $V_{CES} = 1700 \text{ V}$    | $V_{CES} = 1700 \text{ V}$    |
| $I_{FAVM} = 60 \text{ A}$  | $I_{C25} = 48 \text{ A}$      | $I_{C25} = 74 \text{ A}$      |
| $I_{FSM} = 550 \text{ A}$  | $V_{CE(sat)} = 2.1 \text{ V}$ | $V_{CE(sat)} = 2.0 \text{ V}$ |

| Input Rectifier Bridge D11 - D16 |                                                             |                 |   |
|----------------------------------|-------------------------------------------------------------|-----------------|---|
| Symbol                           | Conditions                                                  | Maximum Ratings |   |
| $V_{RRM}$                        |                                                             | 2200            | V |
| $I_{FAV}$                        | $T_C = 80^\circ\text{C}$ ; sine $180^\circ$                 | 40              | A |
| $I_{DAVM}$                       | $T_C = 80^\circ\text{C}$ ; rectangular; $d = 1/3$ ; bridge  | 130             | A |
| $I_{FSM}$                        | $T_C = 25^\circ\text{C}$ ; $t = 10 \text{ ms}$ ; sine 50 Hz | 550             | A |
| $P_{tot}$                        | $T_C = 25^\circ\text{C}$                                    | 110             | W |

| Symbol            | Conditions                                                                               | Characteristic Values                                |              |      |          |
|-------------------|------------------------------------------------------------------------------------------|------------------------------------------------------|--------------|------|----------|
|                   |                                                                                          | (T <sub>VJ</sub> = 25°C, unless otherwise specified) |              |      |          |
|                   |                                                                                          | min.                                                 | typ.         | max. |          |
| V <sub>F</sub>    | I <sub>F</sub> = 50 A;<br>T <sub>VJ</sub> = 25°C<br>T <sub>VJ</sub> = 125°C              |                                                      | 1.25<br>1.25 | 1.5  | V<br>V   |
| I <sub>R</sub>    | V <sub>R</sub> = V <sub>RRM</sub> ;<br>T <sub>VJ</sub> = 25°C<br>T <sub>VJ</sub> = 125°C |                                                      | 0.8          | 0.05 | mA<br>mA |
| R <sub>thJC</sub> | (per diode)                                                                              |                                                      |              | 1.1  | K/W      |

## Application: AC motor drives with

- Input from single or three phase grid
- Three phase synchronous or asynchronous motor
- Electric braking operation

## Features

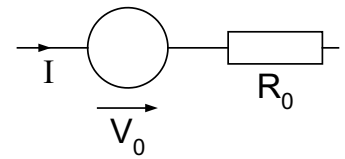
- High level of integration - only one power semiconductor module required for the whole drive
- IGBT technology with low saturation voltage, low switching losses and tail current, high RBSOA and short circuit ruggedness
- Epitaxial free wheeling diodes with Hyperfast and soft reverse recovery
- Industry standard package with insulated copper base plate and soldering pins for PCB mounting
- Temperature sense included

| Output Inverter T1 - T6                                                                                              |                                                                                                                                            |                                                                                                                                             |                                                            |            |                                  |     |
|----------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|------------|----------------------------------|-----|
| Symbol                                                                                                               | Conditions                                                                                                                                 | Maximum Ratings                                                                                                                             |                                                            |            |                                  |     |
| V <sub>CES</sub>                                                                                                     | T <sub>VJ</sub> = 25°C to 150°C                                                                                                            | 1700                                                                                                                                        | V                                                          |            |                                  |     |
| V <sub>GES</sub>                                                                                                     | Continuous                                                                                                                                 | ± 20                                                                                                                                        | V                                                          |            |                                  |     |
| I <sub>C25</sub>                                                                                                     | T <sub>C</sub> = 25°C                                                                                                                      | 74                                                                                                                                          | A                                                          |            |                                  |     |
| I <sub>C80</sub>                                                                                                     | T <sub>C</sub> = 80°C                                                                                                                      | 53                                                                                                                                          | A                                                          |            |                                  |     |
| I <sub>CM</sub>                                                                                                      | T <sub>C</sub> = 80°C; t <sub>p</sub> = 1 ms                                                                                               | 100                                                                                                                                         | A                                                          |            |                                  |     |
| P <sub>tot</sub>                                                                                                     | T <sub>C</sub> = 25°C                                                                                                                      | 290                                                                                                                                         | W                                                          |            |                                  |     |
| Symbol                                                                                                               | Conditions                                                                                                                                 | Characteristic Values                                                                                                                       |                                                            |            |                                  |     |
| (T <sub>VJ</sub> = 25°C, unless otherwise specified)                                                                 |                                                                                                                                            |                                                                                                                                             |                                                            |            |                                  |     |
|                                                                                                                      |                                                                                                                                            | min.                                                                                                                                        | typ.                                                       | max.       |                                  |     |
| V <sub>CE(sat)</sub>                                                                                                 | I <sub>C</sub> = 50 A; V <sub>GE</sub> = 15 V<br>T <sub>VJ</sub> = 25°C<br>T <sub>VJ</sub> = 125°C                                         |                                                                                                                                             | 2.0<br>2.4                                                 | 2.4        | V<br>V                           |     |
| V <sub>GE(th)</sub>                                                                                                  | I <sub>C</sub> = 2 mA; V <sub>GE</sub> = V <sub>CE</sub>                                                                                   | 5                                                                                                                                           |                                                            | 6.5        | V                                |     |
| I <sub>CES</sub>                                                                                                     | V <sub>CE</sub> = V <sub>CES</sub> ; V <sub>GE</sub> = 0 V<br>T <sub>VJ</sub> = 25°C<br>T <sub>VJ</sub> = 125°C                            |                                                                                                                                             |                                                            | 0.4<br>1.0 | mA<br>mA                         |     |
| I <sub>GES</sub>                                                                                                     | V <sub>CE</sub> = 0 V; V <sub>GE</sub> = ± 20 V                                                                                            |                                                                                                                                             |                                                            | 400        | nA                               |     |
| C <sub>ies</sub>                                                                                                     | V <sub>CE</sub> = 25 V; V <sub>GE</sub> = 0 V; f = 1 MHz                                                                                   |                                                                                                                                             | 4.4                                                        |            | nF                               |     |
| Q <sub>Gon</sub>                                                                                                     | V <sub>CE</sub> = 900 V; V <sub>GE</sub> = 15 V; I <sub>C</sub> = 75 A                                                                     |                                                                                                                                             | 600                                                        |            | nC                               |     |
| t <sub>d(on)</sub><br>t <sub>r</sub><br>t <sub>d(off)</sub><br>t <sub>f</sub><br>E <sub>on</sub><br>E <sub>off</sub> | Inductive load, T <sub>VJ</sub> = 125°C<br>V <sub>CE</sub> = 900 V; I <sub>C</sub> = 50 A<br>V <sub>GE</sub> = ±15 V; R <sub>G</sub> = 8 Ω |                                                                                                                                             | 250<br>50<br>500<br>480<br>11<br>12                        |            | ns<br>ns<br>ns<br>ns<br>mJ<br>mJ |     |
| RBSOA                                                                                                                |                                                                                                                                            | I <sub>C</sub> = I <sub>CM</sub> ; V <sub>GE</sub> = 15 V<br>R <sub>G</sub> = 27 Ω; T <sub>VJ</sub> = 125°C                                 | V <sub>CEK</sub> ≤ V <sub>CES</sub> - L <sub>S</sub> di/dt |            |                                  | V   |
| t <sub>SC</sub><br>(SCSOA)                                                                                           |                                                                                                                                            | V <sub>CE</sub> = 1000 V; V <sub>GE</sub> = ±15 V; R <sub>G</sub> = 27 Ω<br>t <sub>p</sub> ≤ 10 μs; non-repetitive; T <sub>VJ</sub> = 125°C |                                                            | 10         |                                  | μs  |
| R <sub>thJC</sub>                                                                                                    |                                                                                                                                            |                                                                                                                                             |                                                            |            | 0.43                             | K/W |

| Output Inverter D1 - D6 |                                                                                                                                           |                       |      |      |               |
|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|------|------|---------------|
| Symbol                  | Conditions                                                                                                                                | Maximum Ratings       |      |      |               |
| $I_{F25}$               | $T_C = 25^{\circ}\text{C}$                                                                                                                | 56                    |      |      | A             |
| $I_{F80}$               | $T_C = 80^{\circ}\text{C}$                                                                                                                | 39                    |      |      | A             |
| Symbol                  | Conditions                                                                                                                                | Characteristic Values |      |      |               |
|                         |                                                                                                                                           | min.                  | typ. | max. |               |
| $V_F$                   | $I_F = 50 \text{ A}; T_{VJ} = 25^{\circ}\text{C}$                                                                                         |                       | 2.0  | 2.4  | V             |
|                         | $T_{VJ} = 125^{\circ}\text{C}$                                                                                                            |                       | 2.0  |      | V             |
| $I_{RM}$                | $I_F = 50 \text{ A}; di_F/dt = -1200 \text{ A}/\mu\text{s};$<br>$T_{VJ} = 125^{\circ}\text{C}; V_R = 900 \text{ V}; V_{GE} = 0 \text{ V}$ |                       | 80   |      | A             |
| $Q_{rr}$                |                                                                                                                                           |                       | 20   |      | $\mu\text{C}$ |
| $t_{rr}$                |                                                                                                                                           |                       | 650  |      | ns            |
| $E_{rec}$               |                                                                                                                                           |                       | 9    |      | mJ            |
| $R_{thJC}$              | (per diode)                                                                                                                               |                       |      | 0.65 | K/W           |

## Equivalent Circuits for Simulation

### Conduction



IGBT (typ. at  $V_{GE} = 15 \text{ V}; T_J = 125^{\circ}\text{C}$ )

T1-T6

$$V_0 = 1.0 \text{ V}; R_0 = 25 \text{ m}\Omega$$

T7

$$V_0 = 1.0 \text{ V}; R_0 = 28 \text{ m}\Omega$$

Diode (typ. at  $T_J = 125^{\circ}\text{C}$ )

D1-D6

$$V_0 = 1.35 \text{ V}; R_0 = 15 \text{ m}\Omega$$

D7

$$V_0 = 1.65 \text{ V}; R_0 = 37 \text{ m}\Omega$$

D11-D16

$$V_0 = 0.83 \text{ V}; R_0 = 4.1 \text{ m}\Omega$$

## Brake Chopper T7

| Symbol    | Conditions                                             | Maximum Ratings |   |
|-----------|--------------------------------------------------------|-----------------|---|
| $V_{CES}$ | $T_{VJ} = 25^{\circ}\text{C}$ to $150^{\circ}\text{C}$ | 1700            | V |
| $V_{GES}$ | Continuous                                             | $\pm 20$        | V |
| $I_{C25}$ | $T_C = 25^{\circ}\text{C}$                             | 48              | A |
| $I_{C80}$ | $T_C = 80^{\circ}\text{C}$                             | 34              | A |
| $I_{CM}$  | $T_C = 80^{\circ}\text{C}; t_p = 1 \text{ ms}$         | 60              | A |
| $P_{tot}$ | $T_C = 25^{\circ}\text{C}$                             | 200             | W |

**Symbol Conditions Characteristic Values**  
( $T_{VJ} = 25^{\circ}\text{C}$ , unless otherwise specified)

|                            |                                                                                                                                                        |                                                                 | min. | typ.       | max. |               |
|----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------|------|------------|------|---------------|
| $V_{CE(sat)}$              | $I_C = 30 \text{ A}; V_{GE} = 15 \text{ V}$                                                                                                            | $T_{VJ} = 25^{\circ}\text{C}$<br>$T_{VJ} = 125^{\circ}\text{C}$ |      | 1.9<br>2.1 | 2.2  | V<br>V        |
| $V_{GE(th)}$               | $I_C = 2 \text{ mA}; V_{GE} = V_{CE}$                                                                                                                  |                                                                 | 5    |            | 6.5  | V             |
| $I_{CES}$                  | $V_{CE} = V_{CES}; V_{GE} = 0 \text{ V}$                                                                                                               | $T_{VJ} = 25^{\circ}\text{C}$<br>$T_{VJ} = 125^{\circ}\text{C}$ |      | 0.6        | 0.3  | mA<br>mA      |
| $I_{GES}$                  | $V_{CE} = 0 \text{ V}; V_{GE} = \pm 20 \text{ V}$                                                                                                      |                                                                 |      |            | 400  | nA            |
| $C_{iss}$                  | $V_{CE} = 25 \text{ V}; V_{GE} = 0 \text{ V}; f = 1 \text{ MHz}$                                                                                       |                                                                 |      | 4.4        |      | nF            |
| $Q_{Gon}$                  | $V_{CE} = 900 \text{ V}; V_{GE} = 15 \text{ V}; I_C = 30 \text{ A}$                                                                                    |                                                                 |      | 600        |      | nC            |
| $t_{d(on)}$                | Inductive load, $T_{VJ} = 125^{\circ}\text{C}$<br>$V_{CE} = 900 \text{ V}; I_C = 30 \text{ A}$<br>$V_{GE} = \pm 15 \text{ V}; R_G = 27 \Omega$         |                                                                 |      | 165        |      | ns            |
| $t_r$                      |                                                                                                                                                        |                                                                 |      | 40         |      | ns            |
| $t_{d(off)}$               |                                                                                                                                                        |                                                                 |      | 700        |      | ns            |
| $t_f$                      |                                                                                                                                                        |                                                                 |      | 400        |      | ns            |
| $E_{off}$                  |                                                                                                                                                        |                                                                 |      | 7          |      | mJ            |
| $E_{on}$                   |                                                                                                                                                        |                                                                 |      | 6          |      | mJ            |
| <b>RBSOA</b>               | $I_C = I_{CM}; V_{GE} = 15 \text{ V}$<br>$R_G = 27 \Omega; T_{VJ} = 125^{\circ}\text{C}$                                                               | $V_{CEK} \leq V_{CES} - L_S di/dt$                              |      |            |      | V             |
| $t_{SC}$<br><b>(SCSOA)</b> | $V_{CE} = 900 \text{ V}; V_{GE} = \pm 15 \text{ V}; R_G = 45 \Omega$<br>$t_p \leq 10 \mu\text{s}; \text{non-repetitive}; T_{VJ} = 125^{\circ}\text{C}$ |                                                                 |      | 10         |      | $\mu\text{s}$ |
| $R_{thJC}$                 |                                                                                                                                                        |                                                                 |      |            | 0.62 | K/W           |

## Brake Chopper D7

| Symbol    | Conditions                                             | Maximum Ratings |   |
|-----------|--------------------------------------------------------|-----------------|---|
| $V_{RRM}$ | $T_{VJ} = 25^{\circ}\text{C}$ to $150^{\circ}\text{C}$ | 1700            | V |
| $I_{F25}$ | $T_C = 25^{\circ}\text{C}$                             | 30              | A |
| $I_{F80}$ | $T_C = 80^{\circ}\text{C}$                             | 21              | A |

**Symbol Conditions Characteristic Values**

|                      |                                                                                                                   |                                                                 | min. | typ.       | max. |          |
|----------------------|-------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------|------|------------|------|----------|
| $V_F$                | $I_F = 30 \text{ A};$                                                                                             | $T_{VJ} = 25^{\circ}\text{C}$<br>$T_{VJ} = 125^{\circ}\text{C}$ |      | 2.5<br>2.6 | 3.3  | V<br>V   |
| $I_R$                | $V_R = V_{RRM};$                                                                                                  | $T_{VJ} = 25^{\circ}\text{C}$<br>$T_{VJ} = 125^{\circ}\text{C}$ |      | 0.2        | 0.05 | mA<br>mA |
| $I_{RM}$<br>$t_{rr}$ | $I_F = 30 \text{ A}; di_F/dt = -800 \text{ A}/\mu\text{s}; T_{VJ} = 125^{\circ}\text{C}$<br>$V_R = 900 \text{ V}$ |                                                                 |      | 35<br>700  |      | A<br>ns  |
| $R_{thJC}$           | (per diode)                                                                                                       |                                                                 |      |            | 0.9  | K/W      |

| Symbol                        | Conditions                   | Characteristic Values |      |      |     |
|-------------------------------|------------------------------|-----------------------|------|------|-----|
|                               |                              | min.                  | typ. | max. |     |
| <b>R<sub>therm-chip</sub></b> | Resistance terminal to chip  |                       | 7    |      | mΩ  |
| <b>d<sub>S</sub></b>          | Creepage distance on surface | 12.7                  |      |      | mm  |
| <b>d<sub>A</sub></b>          | Strike distance in air       | 9.6                   |      |      | mm  |
| <b>R<sub>thCH</sub></b>       | with heatsink compound       |                       | 0.02 |      | K/W |
| <b>Weight</b>                 |                              |                       | 300  |      | g   |

4 - 8

## Input Rectifier Bridge D11 - D16

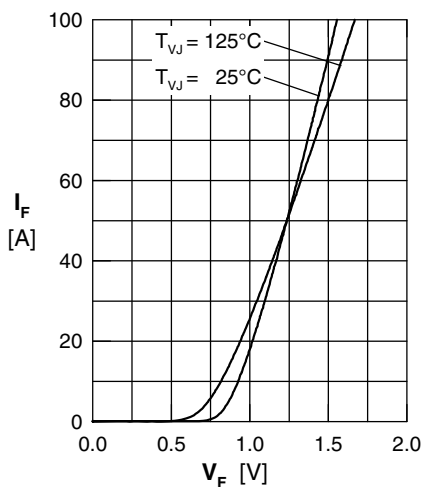


Fig. 1 Typ. forward current vs. voltage drop per diode

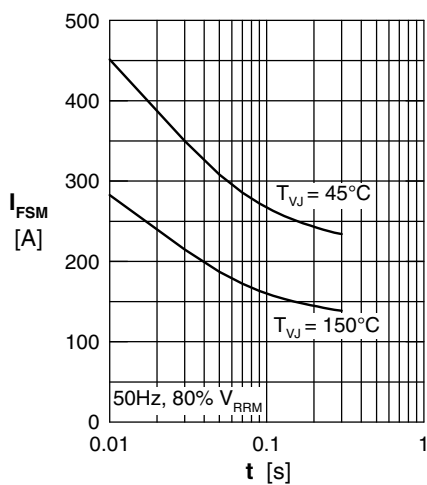


Fig. 2 Surge overload current

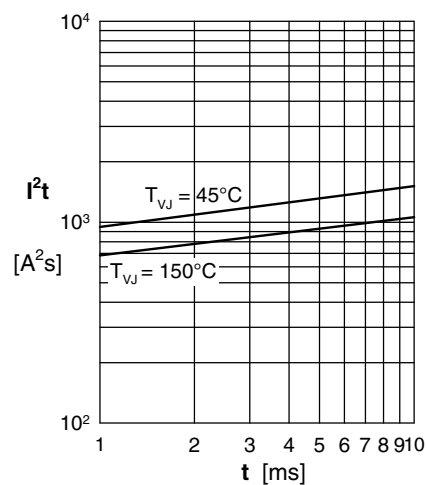


Fig. 3  $I^2t$  versus time per diode

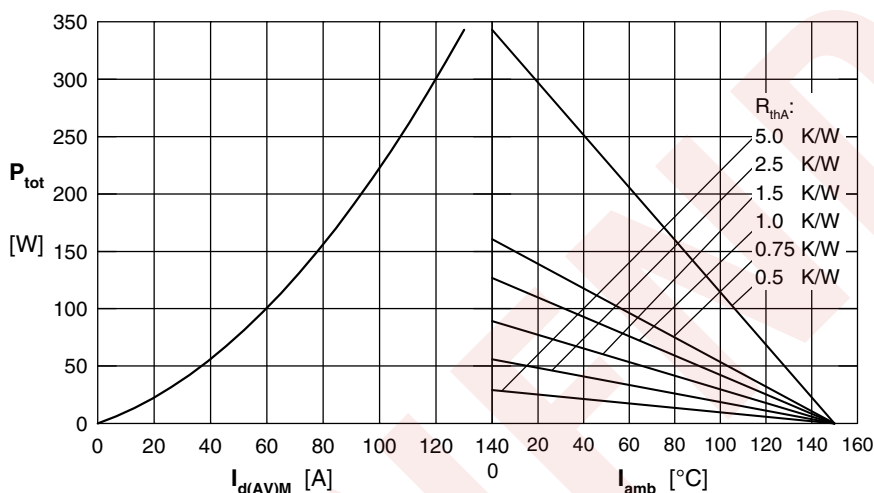


Fig. 4 Power dissipation versus direct output current & ambient temperature, sin 180°

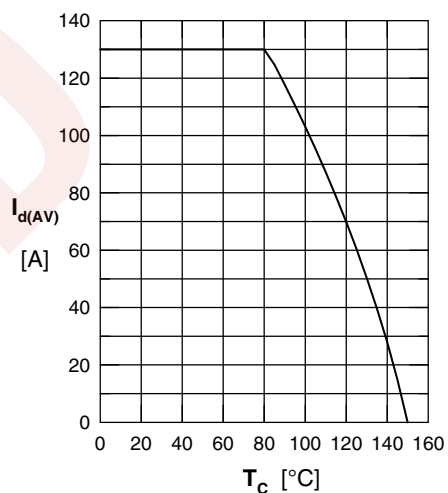


Fig. 5 Max. forward current vs. case temperature

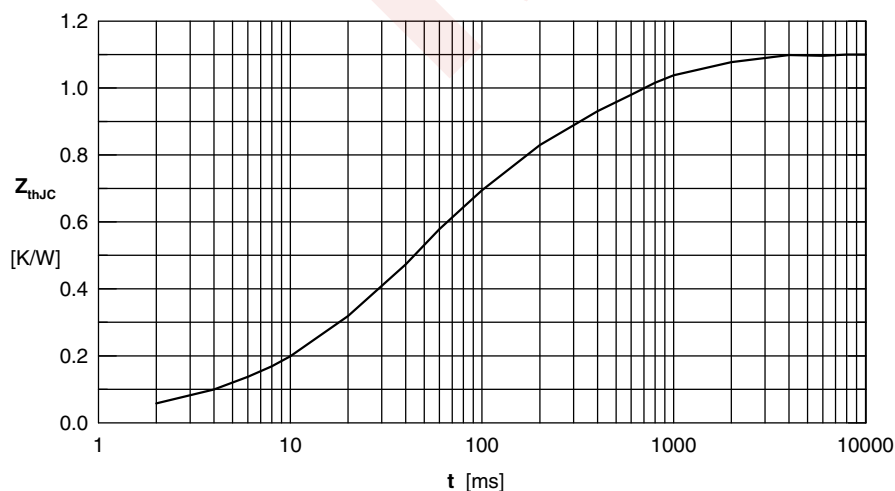
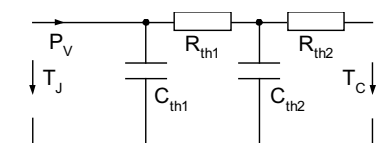


Fig. 6 Transient thermal impedance junction to case



|   | $R_i$ | $\tau_i$ |
|---|-------|----------|
| 1 | 0.06  | 0.0085   |
| 2 | 0.024 | 0.001    |
| 3 | 0.586 | 0.045    |
| 4 | 0.114 | 0.85     |
| 5 | 0.317 | 0.35     |

## Output Inverter T1 - T6 / D1 - D6

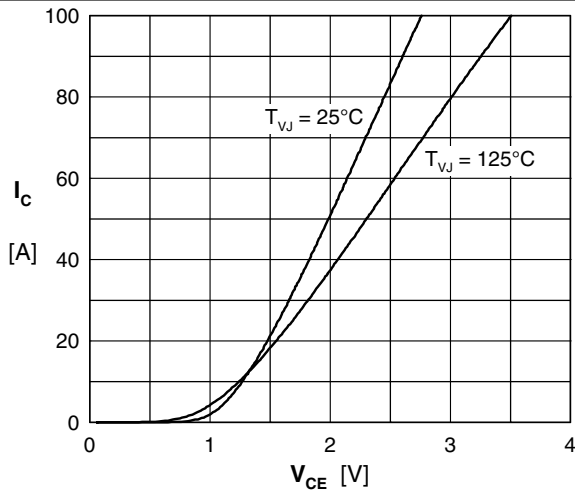


Fig. 7 Typical output characteristic

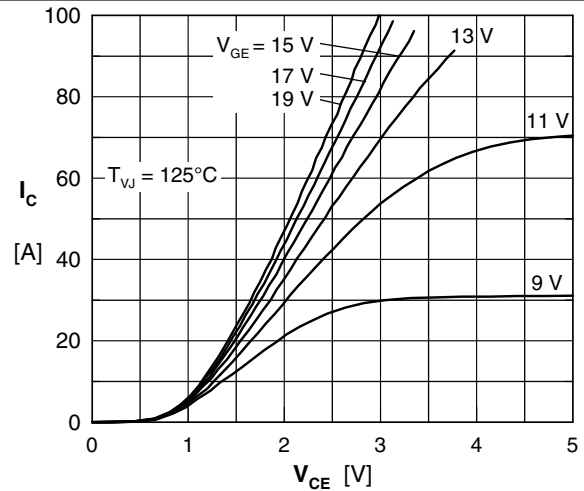


Fig. 8 Typical output characteristic

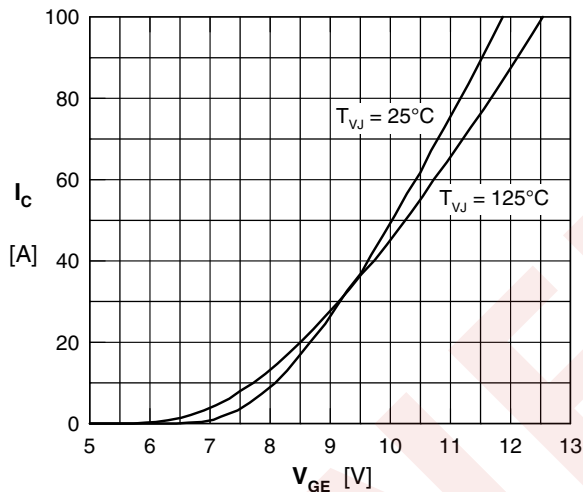


Fig. 9 Typical transfer characteristic

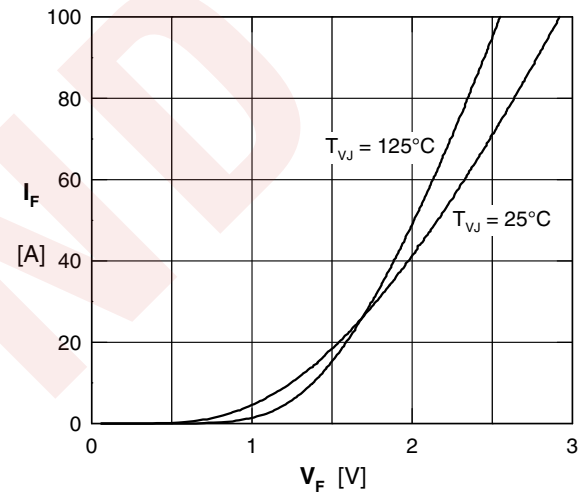


Fig. 10 Typical forward characteristic of free wheeling diode

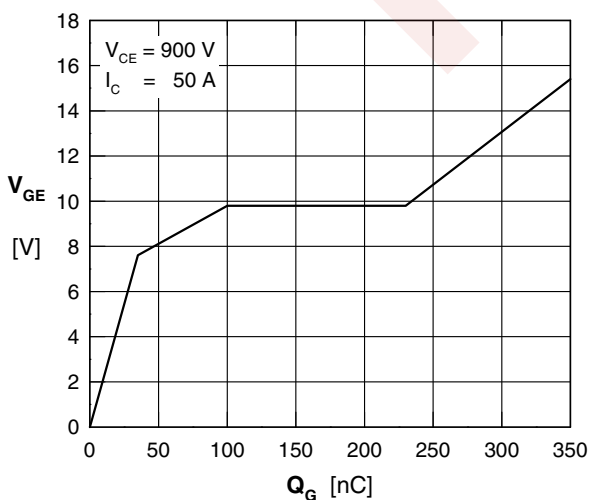


Fig. 11 Typical turn on gate charge

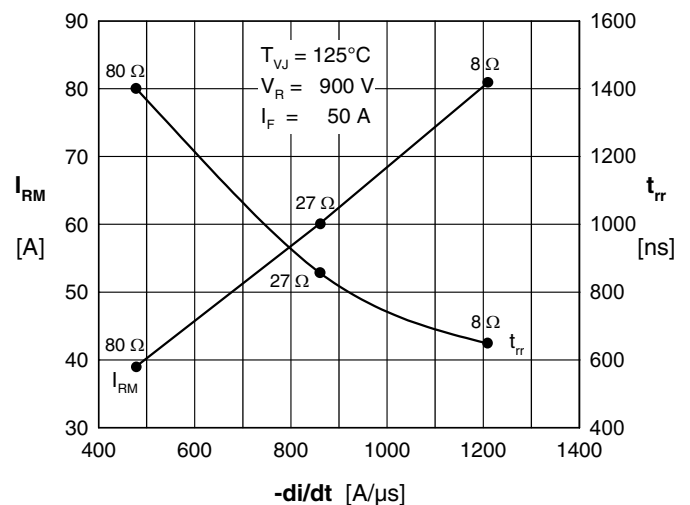


Fig. 12 Typ. turn-off characteristics of free wheeling diode

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## Output Inverter T1 - T6 / D1 - D6

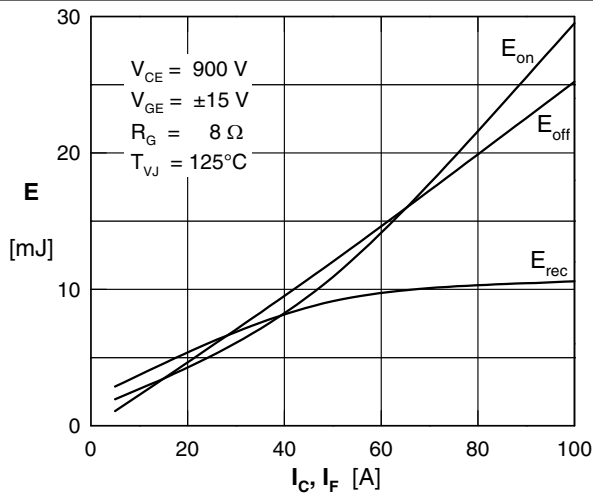


Fig. 13 Typ. turn on energy & switching times versus collector current

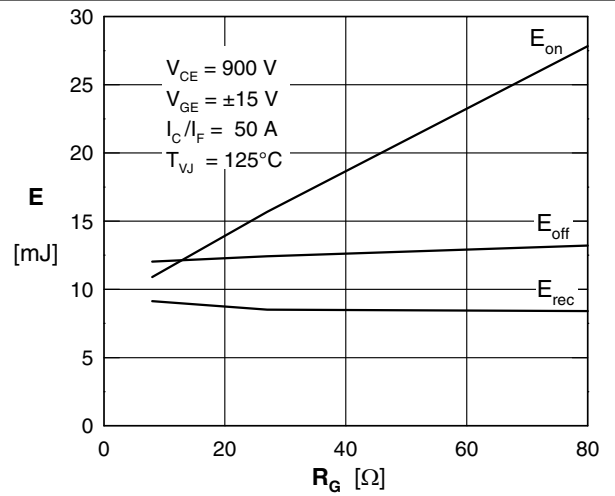


Fig. 14 Typ. turn off energy and switching times versus collector current

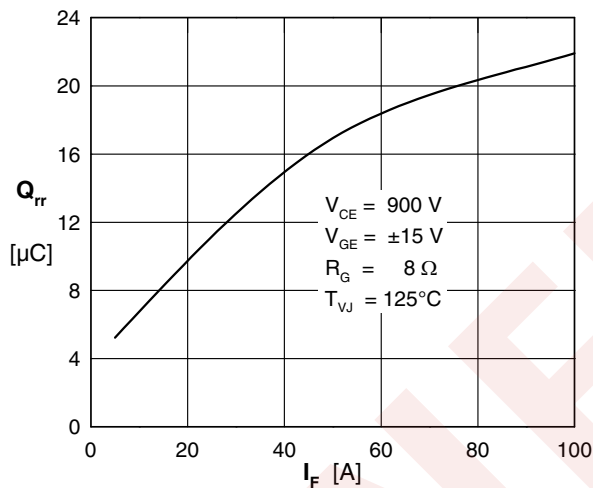


Fig. 15 Typical turn-off characteristics of free wheeling diode

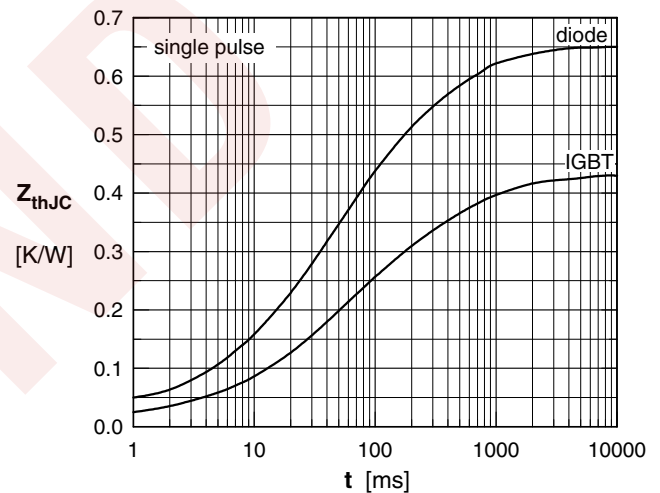


Fig. 16 Transient thermal impedance junction to case

## Temperature Sensor NTC

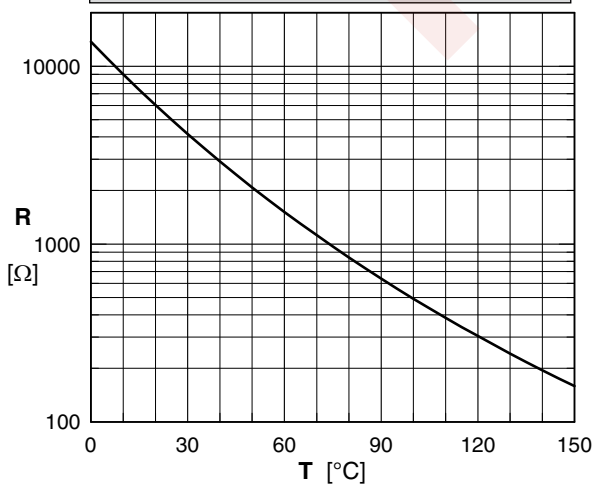
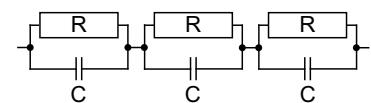


Fig. 17 Typ. NTC resistance vs. temperature

|   | IGBT   |          | Diode  |          |
|---|--------|----------|--------|----------|
|   | $R_i$  | $\tau_i$ | $R_i$  | $\tau_i$ |
| 1 | 0.0326 | 0.0014   | 0.1941 | 0.0206   |
| 2 | 0.1311 | 0.0258   | 0.0542 | 0.0016   |
| 3 | 0.1492 | 0.1099   | 0.2549 | 0.0930   |
| 4 | 0.1169 | 0.6361   | 0.1461 | 0.5958   |



## Brake Chopper T7 / D7

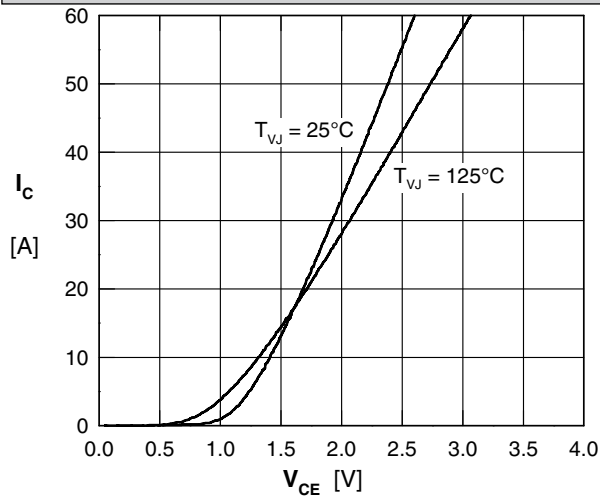


Fig. 18 Typical output characteristic

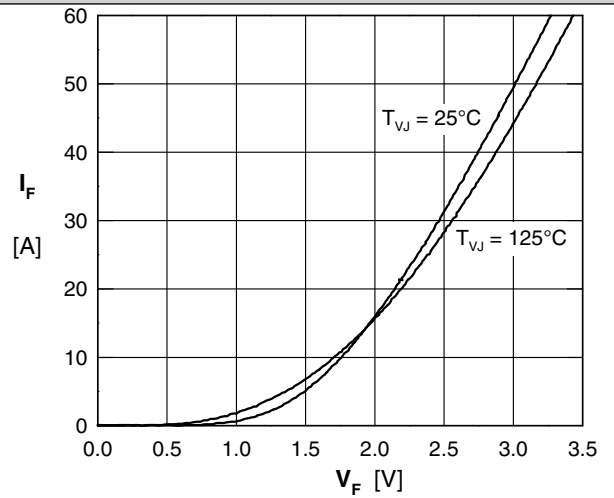


Fig. 19 Typ. forward characteristics of brake diode

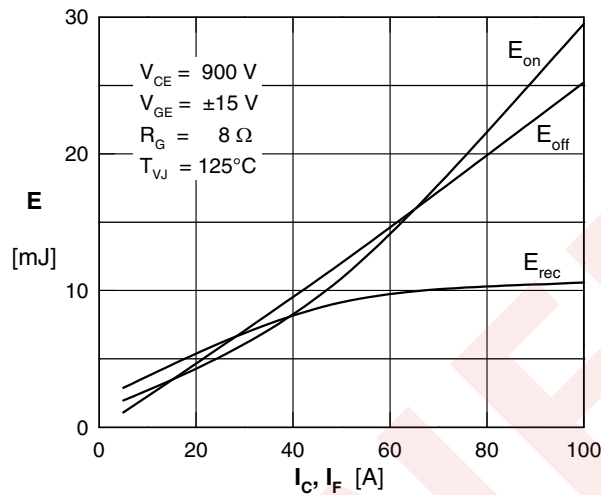


Fig. 20 Typ. turn on energy & switching times versus collector current

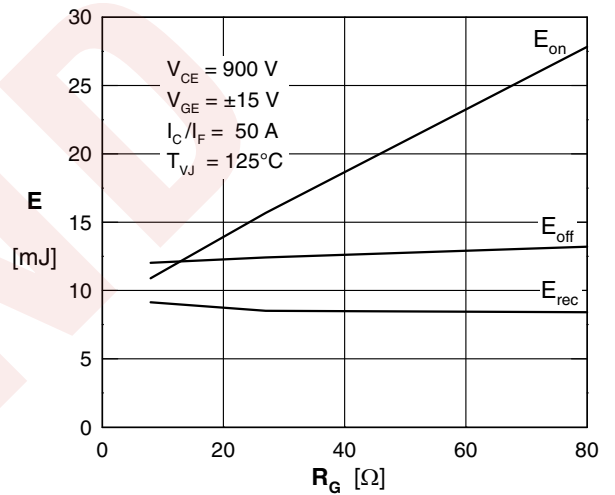


Fig. 21 Typ. turn off energy and switching times versus collector current

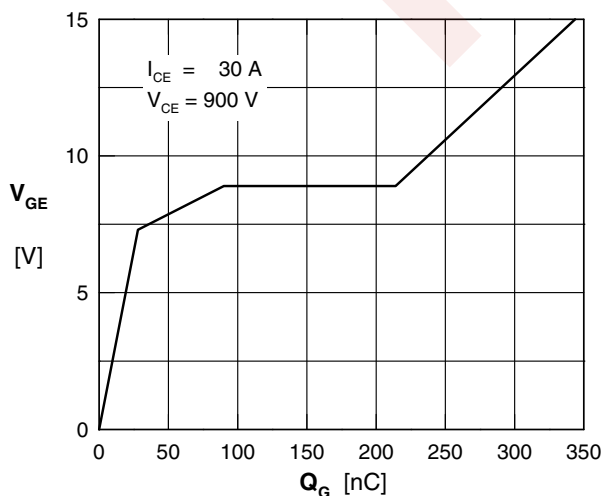


Fig. 22 Typ. turn on gate charge

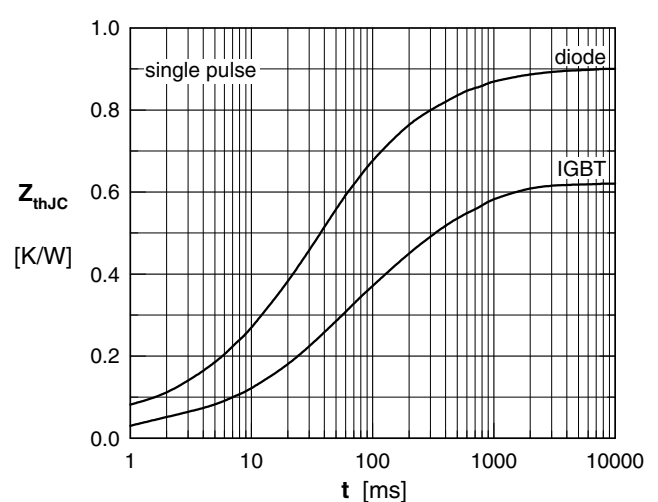


Fig. 23 Transient thermal impedance junction to case

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