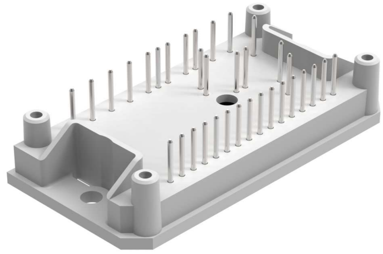
## *flow* IPM 1B — 600 V / 10 A

### Features

- CIP-topology (converter + inverter + PFC)
- Optimized for PFC frequencies up to 150 kHz *
- Integrated PFC controller circuit with programmable DC output voltage and PWM frequency
- Inverter gate drive including bootstrap circuit for high side power supply
- Over current and short circuit protection
- Open emitter or emitter shunts
- Temperature sensor

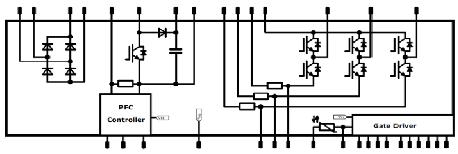
### *flow* 1B 17 mm housing



### Target Applications

- Embedded Drives
- Industrial Drives

### Schematic




### Types

- 20-1B06IPB010RC02-L815A49
- 20-1B06IPB010RC02-L815A49-/3/

# Maximum Ratings

$T_j$=25°C, unless otherwise specified

| Parameter | Symbol | Condition | | Value | Unit |
|---|---|---|---|---|---|
| **Input Rectifier Diode** | | | | | |
| Repetitive peak reverse voltage | $V_{RRM}$ | | | 1600 | V |
| DC forward current | $I_{FAV}$ | $T_j = T_{jmax}$ | $T_s$ = 80 °C | 13 | A |
| Surge (non-repetitive) forward current | $I_{FSM}$ | $t_p$ = 10 ms<br>50 Hz half sine wave | $T_j$ = 150 °C | 130 | A |
| $I^2$t-value | $I^2t$ | | | 80 | $A^2s$ |
| Power dissipation | $P_{tot}$ | $T_j = T_{jmax}$ | $T_s$ = 80 °C | 15 | W |
| Maximum Junction Temperature | $T_{jmax}$ | | | 150 | °C |

# Maximum Ratings

$T_j$=25°C, unless otherwise specified

| Parameter | Symbol | Condition | | Value | Unit |
|---|---|---|---|---|---|
| **PFC Switch** | | | | | |
| Collector-emitter breakdown voltage | $V_{CE}$ | | | 650 | V |
| DC collector current | $I_C$ | $T_j = T_{jmax}$ | $T_s$ = 80 °C | 12 | A |
| Repetitive peak collector current | $I_{CRM}$ | $t_p$ limited by $T_{jmax}$ | | 90 | A |
| Turn off safe operating area | | $V_{CE} \leq 650$ V, $T_j \leq T_{op\ max}$ | | 90 | A |
| Power dissipation | $P_{tot}$ | $T_j = T_{jmax}$ | $T_s$ = 80 °C | 19 | W |
| Gate-emitter peak voltage | $V_{GE}$ | | | ±20 | V |
| Maximum Junction Temperature | $T_{jmax}$ | | | 175 | °C |

* The integrated PFC controller operating at switching frequencies > 100 kHz might show some limitations depending on the application.
Please contact our sales representative for further details.

| Parameter | Symbol | Condition | | Value | Unit |
|---|---|---|---|---|---|
| **PFC Inverse Diode** | | | | | |
| Peak Repetitive Reverse Voltage | $V_{RRM}$ | | | 650 | V |
| DC forward current | $I_F$ | $T_j = T_{jmax}$ | $T_s$ = 80 °C | 5 | A |
| Repetitive peak forward current | $I_{FRM}$ | $t_p$ limited by $T_{jmax}$ | | 12 | A |
| Power dissipation | $P_{tot}$ | $T_j = T_{jmax}$ | $T_s$ = 80 °C | 10 | W |
| Maximum Junction Temperature | $T_{jmax}$ | | | 175 | °C |

| Parameter | Symbol | Condition | | Value | Unit |
|---|---|---|---|---|---|
| **PFC Diode** | | | | | |
| Peak Repetitive Reverse Voltage | $V_{RRM}$ | | | 650 | V |
| DC forward current | $I_F$ | $T_j = T_{jmax}$ | $T_s$ = 80 °C | 7 | A |
| Repetitive peak forward current | $I_{FRM}$ | $t_p$ limited by $T_{jmax}$ | | 35 | A |
| Power dissipation | $P_{tot}$ | $T_j = T_{jmax}$ | $T_s$ = 80 °C | 11 | W |
| Maximum Junction Temperature | $T_{jmax}$ | | | 175 | °C |

# Maximum Ratings

$T_j$=25°C, unless otherwise specified

| Parameter | Symbol | Condition | | Value | Unit |
|---|---|---|---|---|---|
| **Inverter Switch** | | | | | |
| Collector-emitter breakdown voltage | $V_{CE}$ | | | 600 | V |
| DC collector current | $I_C$ | $T_j = T_{jmax}$ | $T_s$ = 80 °C | 8 | A |
| Repetitive peak collector current | $I_{CRM}$ | $t_p$ limited by $T_{jmax}$ | | 30 | A |
| Turn off safe operating area | | $V_{CE}$ ≤ 600 V, $T_j$ ≤ 150 °C | | 20 | A |
| Power dissipation | $P_{tot}$ | $T_j = T_{jmax}$ | $T_s$ = 80 °C | 16 | W |
| Gate-emitter peak voltage | $V_{GE}$ | | | ±20 | V |
| Short circuit ratings | $t_{SC}$<br>$V_{CC}$ | $T_j$ ≤ 150 °C<br>$V_{GE}$ = 15 V | | 5<br>400 | µs<br>V |
| Maximum Junction Temperature | $T_{jmax}$ | | | 175 | °C |
| **Inverter Diode** | | | | | |
| Peak Repetitive Reverse Voltage | $V_{RRM}$ | | | 600 | V |
| DC forward current | $I_F$ | $T_j = T_{jmax}$ | $T_s$ = 80 °C | 8 | A |
| Power dissipation | $P_{tot}$ | $T_j = T_{jmax}$ | $T_s$ = 80 °C | 14 | W |
| Maximum Junction Temperature | $T_{jmax}$ | | | 175 | °C |
| **PFC Shunt** | | | | | |
| DC forward current | $I_F$ | | $T_c$ = 25 °C | 10 | A |
| Power dissipation | $P_{tot}$ | | $T_c$ = 25 °C | 4 | W |
| **PFC Controller*** | | | | | |
| VCC supply voltage | $V_{CC}$ | $V_{CC}$ common with gate driver IC | | 26 | V |
| Vsense voltage | $V_{VSENSE}$ | | | 26 | V |
| Vsense current | $I_{VSENSE}$ | | | 800 | µA |
| FREQ pin voltage | $V_{FREQ}$ | | | 5,3 | V |
| Maximum Junction Temperature | $T_{jmax}$ | | | 125 | °C |

*For more information please contact VIN sales representative for the updated release of ICE3PCS02 datasheet

| Parameter | Symbol | Condition | Value | Unit |
|---|---|---|---|---|
| **DC - Shunt** | | | | |
| DC forward current | $I_F$ | | 8 | A |
| Power dissipation | $P_{tot}$ | | 2 | W |

# Maximum Ratings

$T_j$=25°C, unless otherwise specified

| Parameter | Symbol | Condition | Value | Unit |
|---|---|---|---|---|
| **DC link Capacitor** | | | | |
| Maximum DC voltage | $V_{MAX}$ | $T_c$ = 25 °C | 500 | V |
| **Gate Driver*** | | | | |
| Supply voltage | $U_{CC}$ | | 20 | V |
| Input voltage (LIN, HIN, EN) | $U_{IN}$ | | 10 | V |
| Output voltage (FAULT) | $U_{OUT}$ | | VCC+0,5 | V |

* for more information see infineon's datasheet 6ED003L02-F2

| Parameter | Symbol | Condition | Value | Unit |
|---|---|---|---|---|
| **Thermal Properties** | | | | |
| Storage temperature | $T_{stg}$ | | -40…+125 | °C |
| Operation temperature under switching con | $T_{op}$ | | -40…+(Tjmax - 25) | °C |
| **Isolation Properties** | | | | |
| Isolation voltage | $V_{is}$ | t = 2 s DC voltage | 4000 | V |
| Creepage distance | | | min 12,7 | mm |
| Clearance | | | min 12,7 | mm |
| Comparative tracking index | CTI | | >200 | |

## Characteristic Values

| Parameter | Symbol | Conditions | | | | | Value | | | Unit |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | $V_{GE}$ [V]<br>$V_{GS}$ [V] | $V_r$ [V]<br>$V_{CE}$ [V]<br>$V_{DS}$ [V] | $I_C$ [A]<br>$I_F$ [A]<br>$I_D$ [A] | $T_j$ [°C] | Min | Typ | Max | |
| **Input Rectifier Diode** | | | | | | | | | | |
| Forward voltage | $V_F$ | | | | 7 | 25<br>125 | | 1,04<br>0,97 | | V |
| Threshold voltage (for power loss calc. only) | $V_{to}$ | | | | 7 | 25<br>125 | | 0,87<br>0,74 | | V |
| Slope resistance (for power loss calc. only) | $r_t$ | | | | 7 | 25<br>125 | | 25<br>33 | | mΩ |
| Reverse current | $I_r$ | | | 1600 | | 25 | | | 0,01 | mA |
| Thermal resistance junction to sink | $R_{th(j-s)}$ | phase-change material<br>$\lambda$ = 3,4 W/mK | | | | | | 4,56 | | K/W |
| **PFC Switch** | | | | | | | | | | |
| Gate emitter threshold voltage | $V_{GE(th)}$ | $V_{CE} = V_{GE}$ | | | 0,0003 | 25 | 3,3 | 4 | 4,7 | V |
| Collector-emitter saturation voltage | $V_{CEsat}$ | | 15 | | 10 | 25<br>125 | | 1,28<br>1,28 | 1,9 | V |
| Collector-emitter cut-off | $I_{CES}$ | | 0 | 650 | | 25 | | | 0,04 | mA |
| Turn-on delay time | $t_{d(on)}$ | | | | | 25<br>125 | | 21<br>20 | | |
| Rise time | $t_r$ | | | | | 25<br>125 | | 6<br>8 | | ns |
| Turn-off delay time | $t_{d(off)}$ | | $U_{CC}$=15 V | 400 | 10 | 25<br>125 | | 160<br>192 | | |
| Fall time | $t_f$ | | | | | 25<br>125 | | 2<br>2 | | |
| Turn-on energy loss | $E_{on}$ | | | | | 25<br>125 | | 0,086<br>0,084 | | mWs |
| Turn-off energy loss | $E_{off}$ | | | | | 25<br>125 | | 0,034<br>0,061 | | |
| Input capacitance | $C_{ies}$ | | | | | | | 2100 | | |
| Output capacitance | $C_{oss}$ | $f$ = 1 MHz | 0 | 25 | | 25 | | 45 | | pF |
| Reverse transfer capacitance | $C_{rss}$ | | | | | | | 7,7 | | |
| Thermal resistance junction to sink | $R_{th(j-s)}$ | phase-change material<br>$\lambda$ = 3,4 W/mK | | | | | | 4,96 | | K/W |
| **PFC Inverse Diode** | | | | | | | | | | |
| Diode forward voltage | $V_F$ | | | | 6 | 25<br>125 | 1,23 | 1,73<br>0,97 | 2,15 | V |
| Thermal resistance junction to sink | $R_{th(j-s)}$ | phase-change material<br>$\lambda$ = 3,4 W/mK | | | | | | 9,56 | | K/W |
| **PFC Diode** | | | | | | | | | | |
| Forward voltage | $V_F$ | | | | 8 | 25<br>125 | | 1,65<br>1,55 | 2,1 | V |
| Reverse leakage current | $I_{rm}$ | | | 400 | 10 | 25 | | | 160 | μA |
| Peak recovery current | $I_{RRM}$ | | | | | 25<br>125 | | 3<br>3 | | A |
| Reverse recovery time | $t_{rr}$ | | | | | 25<br>125 | | 16,7<br>16 | | ns |
| Reverse recovery charge | $Q_{rr}$ | | $U_{CC}$=15 V | 400 | 10 | 25<br>125 | | 0,03<br>0,04 | | μC |
| Reverse recovered energy | $E_{rec}$ | | | | | 25<br>125 | | 0,0060<br>0,009 | | mWs |
| Peak rate of fall of recovery current | $(di_{rf}/dt)_{max}$ | | | | | 25<br>125 | | 711<br>893 | | A/μs |
| Thermal resistance junction to sink | $R_{th(j-s)}$ | phase-change material<br>$\lambda$ = 3,4 W/mK | | | | | | 9,02 | | K/W |
| **PFC Shunt** | | | | | | | | | | |
| $R_4$ value | $R$ | | | | | | | 40 | | mΩ |

## Characteristic Values

| Parameter | Symbol | Conditions | $V_{GE}$ [V]<br>$V_{GS}$ [V] | $V_r$ [V]<br>$V_{CE}$ [V]<br>$V_{DS}$ [V] | $I_C$ [A]<br>$I_F$ [A]<br>$I_D$ [A] | $T_j$ [°C] | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|---|---|---|
| **Inverter Switch** | | | | | | | | | | |
| Gate emitter threshold voltage | $V_{GE(th)}$ | $V_{CE} = V_{GE}$ | | | 0,00017 | 25 | 4,4 | 5 | 5,6 | V |
| Collector-emitter saturation voltage* | $V_{CEsat}$ | | 15 | | 10 | 25<br>125 | 1,7 | 2,20<br>2,32 | 2,95 | V |
| Collector-emitter cut-off current incl. Diode | $I_{CES}$ | | 0 | 600 | | 25 | | | 0,1 | mA |
| Gate-emitter leakage current | $I_{GES}$ | | 20 | 0 | | 25 | | | 120 | nA |
| Integrated Gate resistor | $R_{gint}$ | | | | | | | none | | Ω |
| Turn-on delay time ** | $t_{d(on)}$ | | $U_{CC}$=15 V<br>$U_{IN}$= 5 V | 400 | 6 | 25<br>125 | | 582<br>631 | | ns |
| Rise time | $t_r$ | | | | | 25<br>125 | | 20<br>25 | | |
| Turn-off delay time ** | $t_{d(off)}$ | | | | | 25<br>125 | | 837<br>950 | | |
| Fall time | $t_f$ | | | | | 25<br>125 | | 16<br>22 | | |
| Turn-on energy loss | $E_{on}$ | | | | | 25<br>125 | | 0,1950<br>0,3241 | | mWs |
| Turn-off energy loss | $E_{off}$ | | | | | 25<br>125 | | 0,1611<br>0,2042 | | |
| Input capacitance | $C_{ies}$ | $f$ = 1 MHz | 0 | 25 | | 25 | | 655 | | pF |
| Output capacitance | $C_{oss}$ | | | | | | | 37 | | |
| Reverse transfer capacitance | $C_{rss}$ | | | | | | | 22 | | |
| Gate charge | $Q_G$ | | 15 | 480 | 10 | 25 | | 64 | | nC |
| Thermal resistance junction to sink | $R_{th(j-s)}$ | phase-change material<br>$\lambda$ = 3,4 W/mK | | | | | | 5,79 | | K/W |

* chip data
** including gate driver

| Parameter | Symbol | Conditions | $V_{GE}$ [V]<br>$V_{GS}$ [V] | $V_r$ [V]<br>$V_{CE}$ [V]<br>$V_{DS}$ [V] | $I_C$ [A]<br>$I_F$ [A]<br>$I_D$ [A] | $T_j$ [°C] | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|---|---|---|
| **Inverter Diode** | | | | | | | | | | |
| Diode forward voltage | $V_F$ | | | | 10 | 25<br>125 | 1,5 | 2,23<br>2,18 | 2,85 | V |
| Peak reverse recovery current | $I_{RRM}$ | | $U_{CC}$=15 V<br>$U_{IN}$= 5 V | 400 | 6 | 25<br>125 | | 6<br>6 | | A |
| Reverse recovery time | $t_{rr}$ | | | | | 25<br>125 | | 179<br>276 | | ns |
| Reverse recovered charge | $Q_{rr}$ | | | | | 25<br>125 | | 0,3566<br>0,6738 | | μC |
| Peak rate of fall of recovery current | $(di_{rf}/dt)_{max}$ | | | | | 25<br>125 | | 181<br>46 | | A/μs |
| Reverse recovered energy | $E_{rec}$ | | | | | 25<br>125 | | 0,0867<br>0,1610 | | mWs |
| Thermal resistance junction to sink | $R_{th(j-s)}$ | phase-change material<br>$\lambda$ = 3,4 W/mK | | | | | | 6,66 | | K/W |
| **DC - Shunt** | | | | | | | | | | |
| $R_2$ value | $R$ | | | | | 25 | | 30 | | mΩ |
| **DC link Capacitor** | | | | | | | | | | |
| $C$ value | C | | | | | | | 100 | | nF |

## Characteristic Values

| Parameter | Symbol | Conditions | $V_{GE}$ [V] $V_{GS}$ [V] | $V_r$ [V] $V_{CE}$ [V] $V_{DS}$ [V] | $I_C$ [A] $I_F$ [A] $I_D$ [A] | $T_j$ [°C] | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|---|---|---|
| **Gate Driver** | | | | | | | | | | |
| Supply voltage | $U_{CC}$ | | | | | | 13 | 15 | 17,5 | V |
| Quiescent Vcc supply current | $I_{QCC}$ | $U_{LIN}$ = 0 V; $U_{HIN}$ = 3,3 V | | | | | | 1,3 | 2 | mA |
| Input voltage (LIN, HIN, EN) | $U_{IN}$ | | | | | | 0 | | 5 | |
| Logic "0" input voltage (LIN, HIN) | $U_{IH}$ | | | | | | 1,7 | 2,1 | 2,4 | |
| Logic "1" input voltage (LIN, HIN) | $U_{IL}$ | $U_{CC}$ = 15 V | | | | | 0,7 | 0,9 | 1,1 | V |
| Positive going threshold voltage (EN) | $U_{EN,TH+}$ | | | | | | 1,9 | 2,1 | 2,3 | |
| Negative going threshold voltage (EN) | $U_{EN,TH-}$ | | | | | | 1,1 | 1,3 | 1,5 | |
| Input clamp voltage (LIN, HIN, EN) | $U_{IN,CLAMP}$ | $I_{IN}$ = 4 mA | | | | | 9 | 10,3 | 12 | |
| ITRIP positive going threshold | $U_{TR,TH+}$ | | | | | | 380 | 445 | 510 | mV |
| Input bias current LIN high | $I_{LIN+}$ | $U_{LIN}$ = 3,3 V | | | | | | 70 | 100 | |
| Input bias current LIN low | $I_{LIN-}$ | $U_{LIN}$ = 0 V | | | | 25 | | 110 | 200 | |
| Input bias current HIN high | $I_{HIN+}$ | $U_{HIN}$ = 3,3 V | | | | | | 70 | 100 | µA |
| Input bias current HIN low | $I_{HIN-}$ | $U_{HIN}$ = 0 V | | | | | | 110 | 120 | |
| Input bias current EN high | $I_{EN+-}$ | $U_{HIN}$ = 3,3 V | | | | | | 45 | 120 | |
| Output voltage (FAULT) | $U_{FLT}$ | | | | | | 0 | | $U_{CC}$ | V |
| Low on resistor of pull down trans. (FAULT) | $R_{ON,FLT}$ | $U_{FAULT}$ = 0,5 V | | | | | | 45,0 | 100 | Ω |
| Pulse width for ON or OFF | $t_{IN}$ | | | | | | 1 | | | µs |
| Turn-on propagation delay (LIN, HIN) | $t_{ON}$ | $U_{LIN/HIN}$ = 0 V or 3,3 V | | | | | 400 | 530 | 800 | ns |
| Turn-off propagation delay (LIN, HIN) | $t_{OFF}$ | | | | | | 360 | 490 | 760 | |
| FAULT reset time | $t_{RST}$ | | | | | | | 4 | | ms |
| Fixed deadtime between high and low side | $t_{DT}$ | $U_{LIN/HIN}$ = 0 V & 3,3 V | | | | | 150 | 310 | | ns |
| **PFC Controller** | | | | | | | | | | |
| Supply voltage* | $V_{CC}$ | | | | | | 15 | | 26 | V |
| VCC turn-on threshold | $V_{CCon}$ | | | | | | 11,5 | 12,0 | 12,9 | V |
| VCC turn-off threshold | $V_{CCUVLO}$ | | | | | | 10,5 | 11,0 | 11,9 | V |
| Operating current with active GATE | $I_{CCHG}$ | $C_L$ = 1 nF | | | | | | 6,4 | 8,5 | mA |
| Operating current during standby | $I_{CCstby}$ | | | | | | | 3,5 | 4,7 | mA |
| PFC switching frequency | $F_{SWnom}$ | Set with an internal resistor $R_{FREQ}$ = 91 kΩ** | | | | | | 50 | | kHz |
| PFC disable threshold | $V_{dis\ PFC}$ | pull Vsense higher than Vdis PFC to disable PFC operation | | | | | 14 | | | V |
| DC link voltage | DC2+ | Set with an internal resistor divider*** | | | | 25 | 325 | | 410 | V |
| DC link treshold (OVP1) low to high | $V_{OVP1L2H}$ | | | | | | | 108 | | % |
| DC link treshold (OVP1) high to low | $V_{OVP1H2L}$ | relative to output voltage with VSENSE pin unconnected<br>VSENSE pin voltage $V_{DClink}$/130 | | | | | | 100 | | % |
| Blanking time for OVP1 | $t_{OVP1}$ | | | | | | | 12 | | µs |
| DC link treshold (OVP1) hysteresis | $V_{OVP1\_HYS}$ | | | | | | 6 | 8 | 11 | % |
| DC link treshold (OVP2) low to high | $V_{OVP2\_L2H}$ | | | | | | 428 | 443 | 460 | V |
| DC link treshold (OVP2) high to low | $V_{OVP2\_H2L}$ | relative to OVP2 | | | | | | 92 | | % |
| Blanking time for OVP2 | $t_{OVP2}$ | | | | | | | 12 | | µs |

*recommended supply voltage range: 15-18 V
**switching frequency is setable by an external resistor between pins 14-16 (see figure on page24 for values)
***DC link voltage is setable by an external resistor between pins 14-15 (see figure on page24 for values)

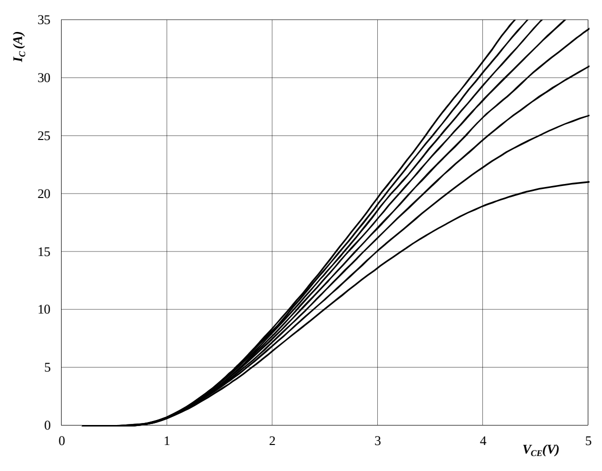
| Parameter | Symbol | Conditions | $V_{GE}$ [V] $V_{GS}$ [V] | $V_r$ [V] $V_{CE}$ [V] $V_{DS}$ [V] | $I_C$ [A] $I_F$ [A] $I_D$ [A] | $T_j$ [°C] | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|---|---|---|
| **Thermistor** | | | | | | | | | | |
| Rated resistance | $R$ | | | | | 25 | | 22000 | | Ω |
| Deviation of $R_{100}$ | $\Delta R/R$ | $R_{100}$ = 1486 Ω | | | | 100 | -12 | | 12 | % |
| Power dissipation | $P$ | | | | | 25 | | 200 | | mW |
| Power dissipation constant | | | | | | 25 | | 2 | | mW/K |
| B-value | $B_{(25/50)}$ | Tol. ±3% | | | | 25 | | 3950 | | K |
| B-value | $B_{(25/100)}$ | Tol. ±3% | | | | 25 | | 3998 | | K |
| Vincotech NTC Reference | | | | | | | | | B | |

# Output Inverter

| figure 1. | Output inverter IGBT |
|---|---|

**Typical output characteristics**

$I_C = f(V_{CE})$



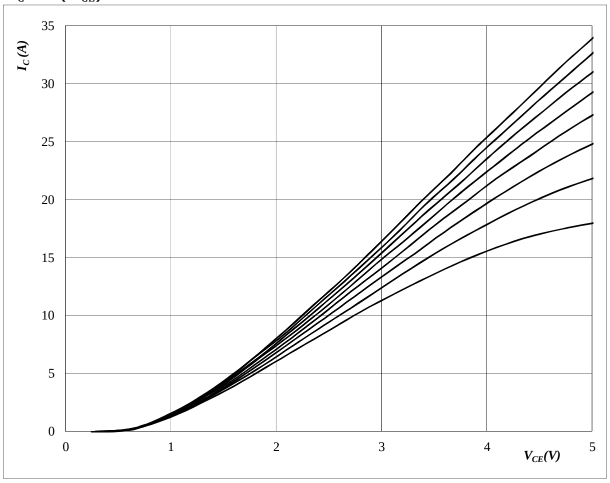

**At**

| | | |
|---|---|---|
| $t_p$ = | 250 | µs |
| $T_j$ = | 25 | °C |
| $U_{CC}$ from | 10 V to 17 V in steps of 1 V | |

| figure 2. | Output inverter IGBT |
|---|---|

**Typical output characteristics**

$I_C = f(V_{CE})$



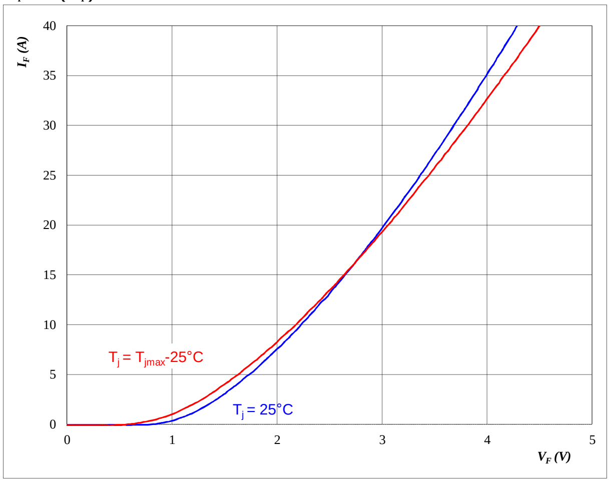

**At**

| | | |
|---|---|---|
| $t_p$ = | 250 | µs |
| $T_j$ = | 125 | °C |
| $U_{CC}$ from | 10 V to 17 V in steps of 1 V | |

| figure 3. | Output inverter FWD |
|---|---|

**Typical diode forward current as a function of forward voltage**

$I_F = f(V_F)$




**At**

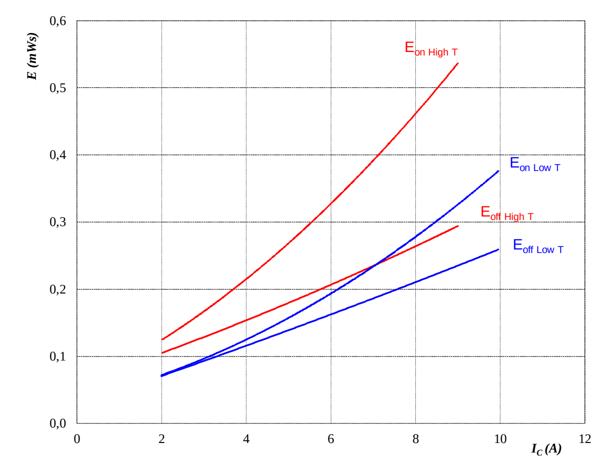
| | | |
|---|---|---|
| $t_p$ = | 250 | µs |

# Output Inverter

| figure 4. | Output inverter IGBT |
|---|---|

**Typical switching energy losses**
**as a function of collector current**

$E = f(I_C)$



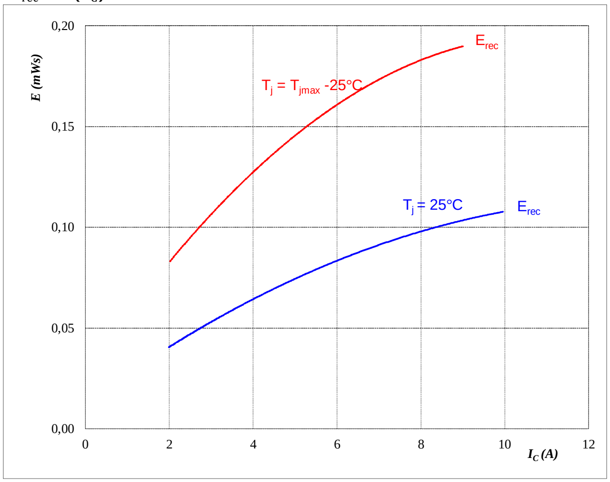

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 400 | V |
| $U_{CC}$ = | 15 | V |

| figure 5. | Output inverter FWD |
|---|---|

**Typical reverse recovery energy loss**
**as a function of collector current**

$E_{rec} = f(I_C)$




With an inductive load at

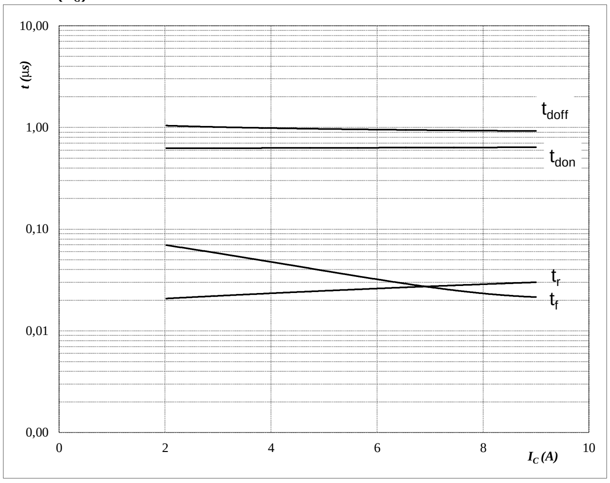
| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 400 | V |
| $U_{CC}$ = | 15 | V |

# Output Inverter

**figure 6.** **Output inverter IGBT**

**Typical switching times as a function of collector current**

$t = f(I_C)$



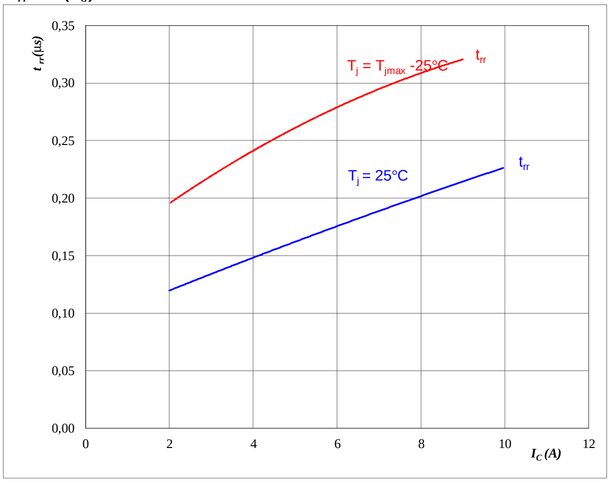

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 125 | °C |
| $V_{CE}$ = | 400 | V |
| $U_{CC}$ = | 15 | V |

**figure 7.** **Output inverter FWD**

**Typical reverse recovery time as a function of collector current**

$t_{rr} = f(I_C)$




**At**

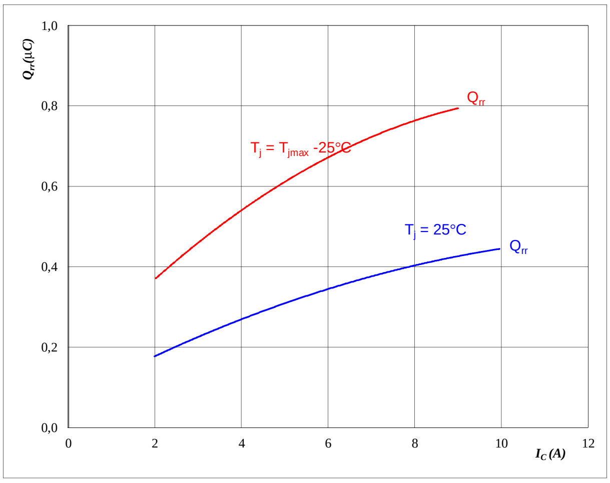
| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 400 | V |
| $U_{CC}$ = | 15 | V |

# Output Inverter

| figure 8. | Output inverter FWD |
|---|---|

**Typical reverse recovery charge as a function of collector current**

$Q_{rr} = f(I_C)$



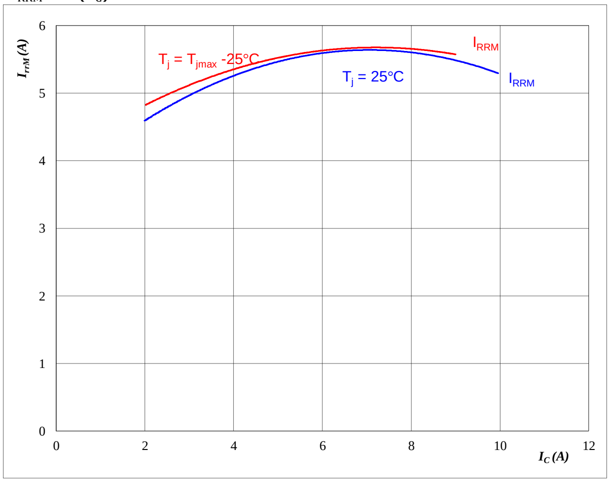

**At**

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 400 | V |
| $U_{CC}$ = | 15 | V |

| figure 9. | Output inverter FWD |
|---|---|

**Typical reverse recovery current as a function of collector current**

$I_{RRM} = f(I_C)$




**At**

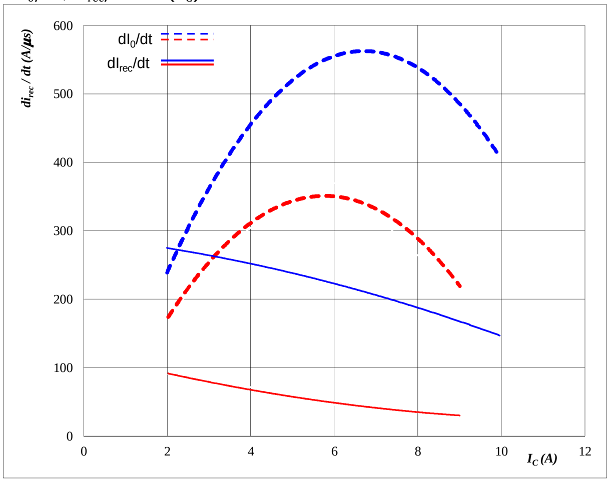
| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 400 | V |
| $U_{CC}$ = | 15 | V |

# Output Inverter

| figure 10. | Output inverter FWD |
|---|---|

**Typical rate of fall of forward and reverse recovery current as a function of collector current**

$dI_0/dt, dI_{rec}/dt = f(I_C)$



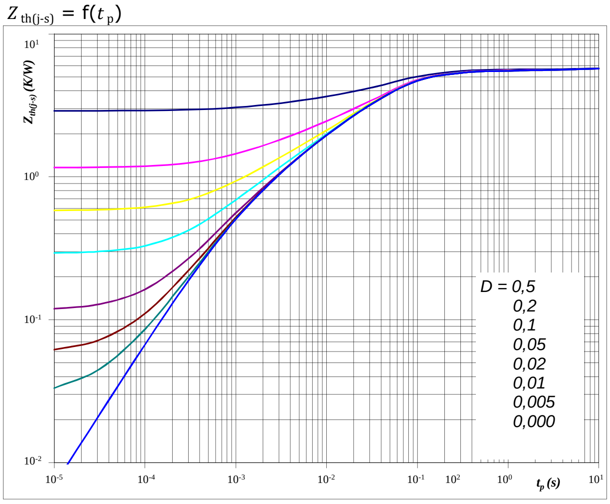

**At**

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 400 | V |
| $U_{CC}$ = | 15 | V |

| figure 11. | Output inverter IGBT |
|---|---|

**IGBT transient thermal impedance as a function of pulse width**

$Z_{th(j\text{-}s)} = f(t_p)$




**At**

| | | |
|---|---|---|
| $D$ = | $t_p / T$ | |
| $R_{th(j\text{-}s)}$ = | 5,79 | K/W |

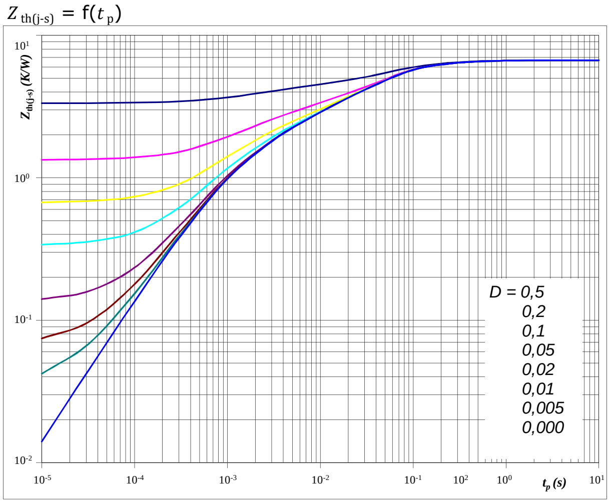
IGBT thermal model values

| R (K/W) | Tau (s) |
|---|---|
| 3,03E-01 | 6,63E+00 |
| 6,11E-01 | 2,13E-01 |
| 3,21E+00 | 4,88E-02 |
| 8,43E-01 | 1,03E-02 |
| 5,62E-01 | 2,85E-03 |
| 2,59E-01 | 7,40E-04 |

| figure 12. | Output inverter FWD |
|---|---|

**FWD transient thermal impedance as a function of pulse width**

$Z_{th(j\text{-}s)} = f(t_p)$




**At**

| | | |
|---|---|---|
| $D$ = | $t_p / T$ | |
| $R_{th(j\text{-}s)}$ = | 6,66 | K/W |

FWD thermal model values

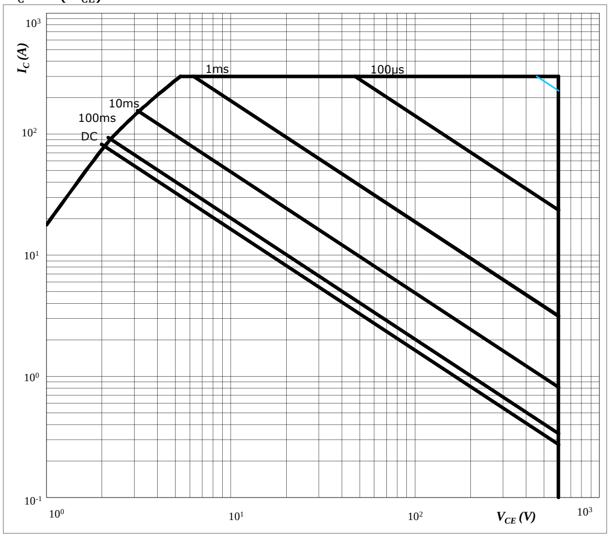
| R (K/W) | Tau (s) |
|---|---|
| 6,16E-01 | 3,13E-01 |
| 3,07E+00 | 5,41E-02 |
| 7,56E-01 | 2,30E-02 |
| 1,19E+00 | 4,70E-03 |
| 9,47E-01 | 9,78E-04 |
| 7,59E-02 | 7,51E-04 |

# Output Inverter

| figure 17. | Output inverter IGBT |
|---|---|

**Safe operating area as a function of collector-emitter voltage**

$I_C = f(V_{CE})$



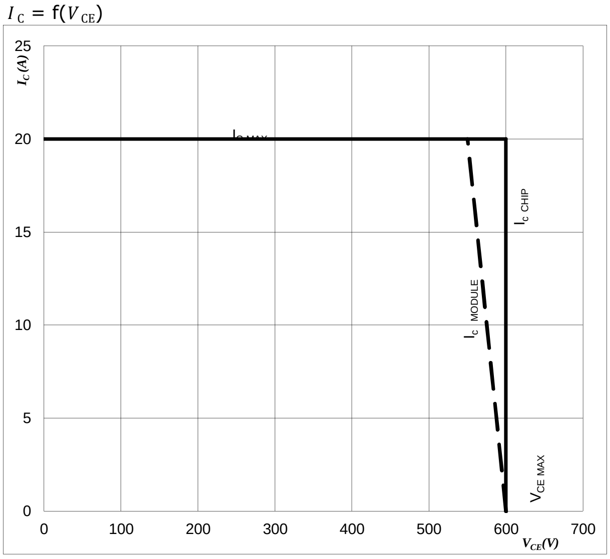

**At**

| | | |
|---|---|---|
| $T_j \leq$ | $T_{jmax}$ | |
| $U_{CC}$ = | 15 | V |

| figure 18. | Output inverter IGBT |
|---|---|

**Reverse bias safe operating area**

$I_C = f(V_{CE})$




**At**

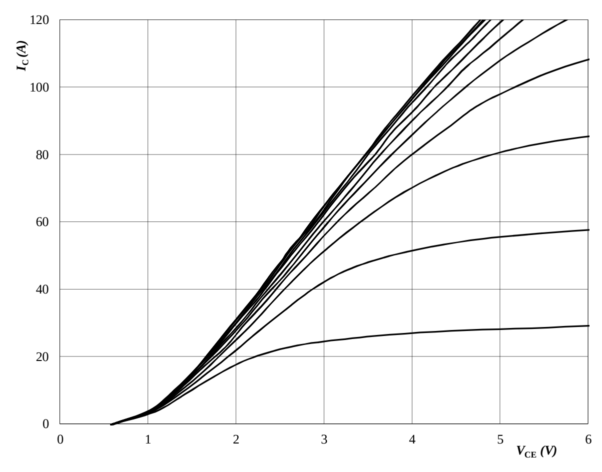
| | | |
|---|---|---|
| $T_j$ = | $T_{jmax}$-25 | ºC |

# PFC

**figure 1.** **PFC IGBT**

**Typical output characteristics**

$I_C = f(V_{CE})$



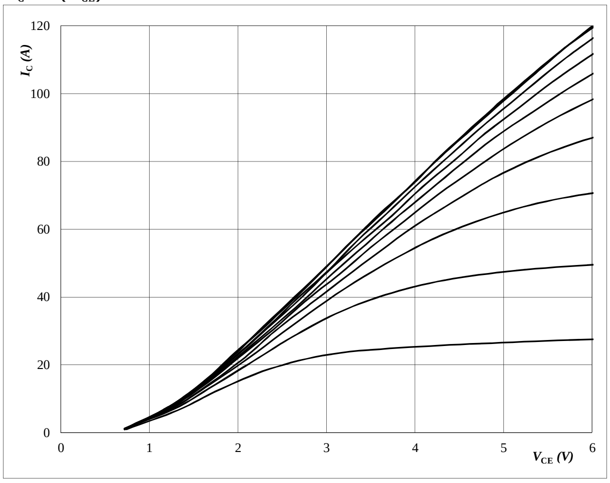

**At**

| | | |
|---|---|---|
| $t_p$ = | 250 | µs |
| $T_j$ = | 25 | °C |
| $U_{CC}$ from | 7 V to 17 V in steps of 1 V | |

**figure 2.** **PFC IGBT**

**Typical output characteristics**

$I_C = f(V_{CE})$



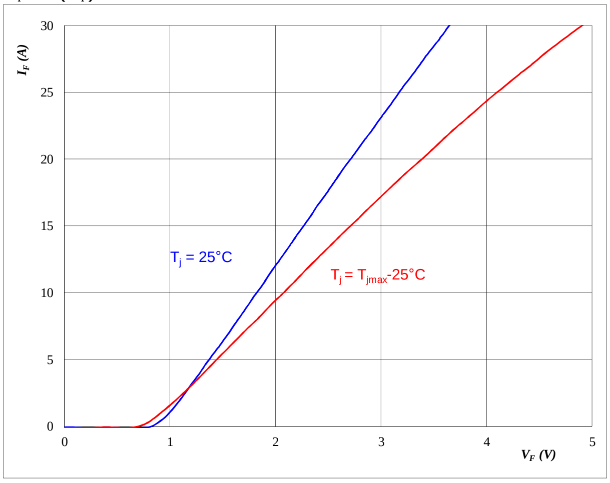

**At**

| | | |
|---|---|---|
| $t_p$ = | 250 | µs |
| $T_j$ = | 125 | °C |
| $U_{CC}$ from | 7 V to 17 V in steps of 1 V | |

**figure 3.** **PFC FWD**

**Typical diode forward current as a function of forward voltage**

$I_F = f(V_F)$




**At**

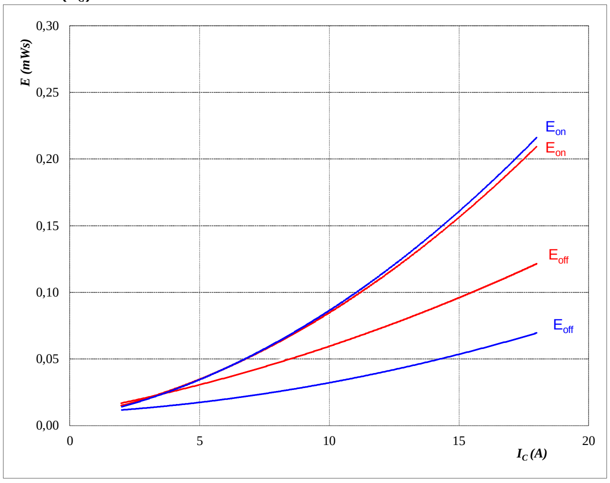
| | | |
|---|---|---|
| $t_p$ = | 250 | µs |

# PFC

| figure 4. | PFC IGBT |
|---|---|

**Typical switching energy losses**
**as a function of collector current**

$E = f(I_C)$



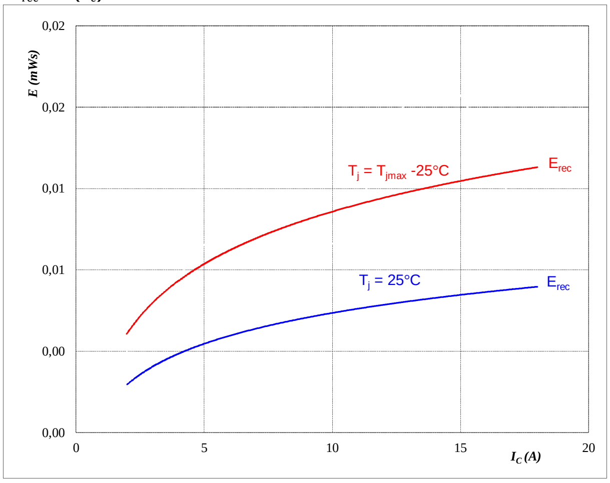

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 400 | V |
| $U_{CC}$ | 15 | V |

| figure 5. | PFC IGBT |
|---|---|

**Typical reverse recovery energy loss**
**as a function of collector current**

$E_{rec} = f(I_c)$




With an inductive load at

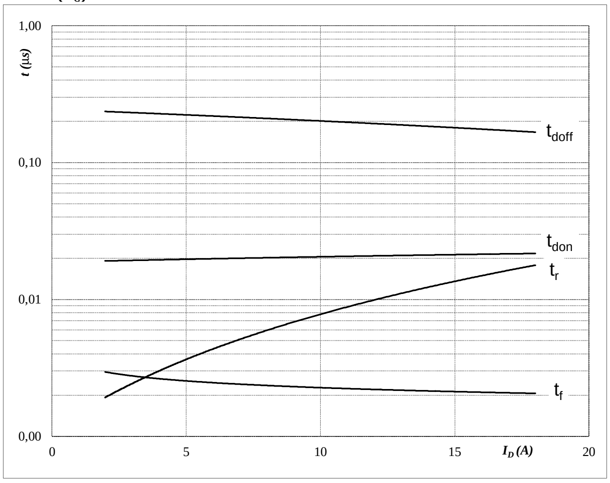
| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 400 | V |
| $U_{CC}$ = | 15 | V |

# PFC

**figure 6.** **PFC IGBT**

**Typical switching times as a function of collector current**

$t = f(I_C)$



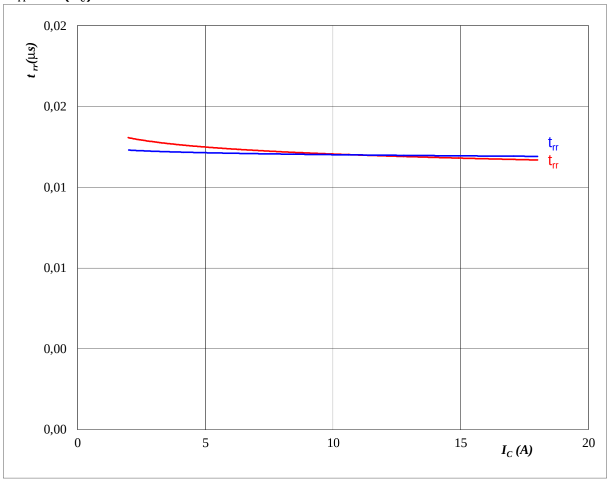

With an inductive load at

| | | |
|---|---|---|
| $T_j$ = | 125 | °C |
| $V_{CE}$ = | 400 | V |
| $U_{CC}$ = | 15 | V |

**figure 7.** **PFC FWD**

**Typical reverse recovery time as a function of collector current**

$t_{rr} = f(I_c)$




**At**

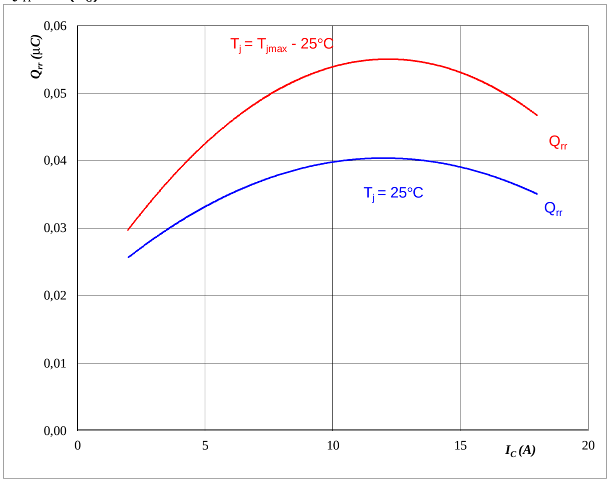
| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 400 | V |
| $U_{CC}$ = | 15 | V |

# PFC

**figure 8.** **PFC FWD**

**Typical reverse recovery charge as a function of collector current**

$Q_{rr} = f(I_C)$



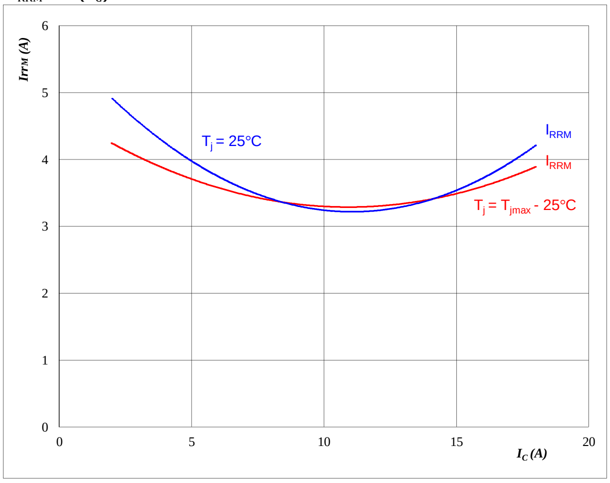

**At**

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 400 | V |
| $U_{CC}$ = | 15 | V |

**figure 9.** **PFC FWD**

**Typical reverse recovery current as a function of collector current**

$I_{RRM} = f(I_C)$




**At**

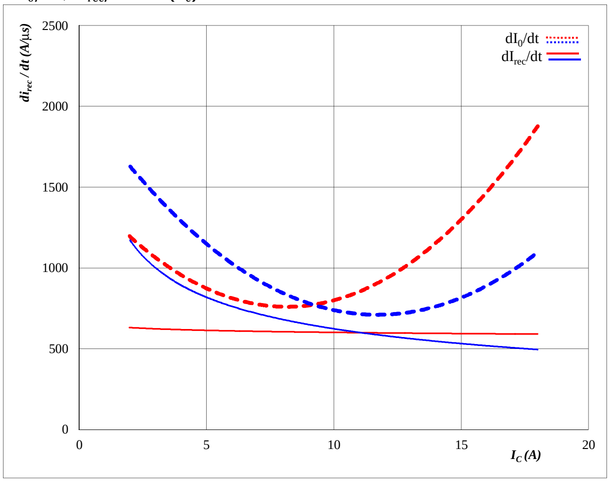
| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 400 | V |
| $U_{CC}$ = | 15 | V |

# PFC

**figure 10.** **PFC FWD**

**Typical rate of fall of forward and reverse recovery current as a function of collector current**

$dI_0/dt, dI_{rec}/dt = f(I_c)$



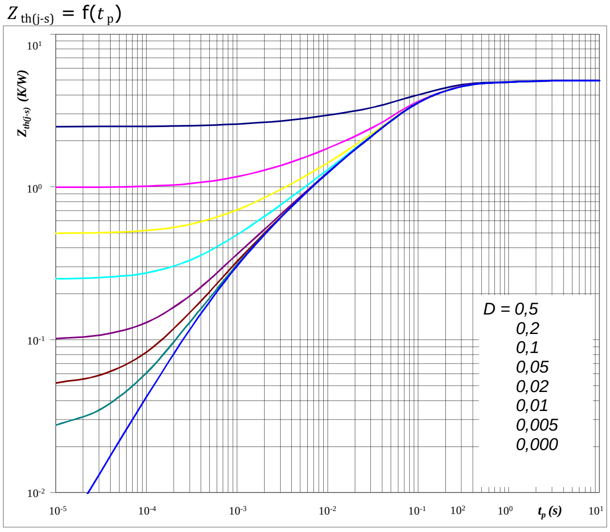

**At**

| | | |
|---|---|---|
| $T_j$ = | 25/125 | °C |
| $V_{CE}$ = | 400 | V |
| $U_{CC}$ = | 15 | V |

**figure 11.** **PFC IGBT**

**IGBT transient thermal impedance as a function of pulse width**

$Z_{th(j-s)} = f(t_p)$




**At**

| | | |
|---|---|---|
| $D$ = | $t_p / T$ | |
| $R_{th(j-s)}$ = | 4,96 | K/W |

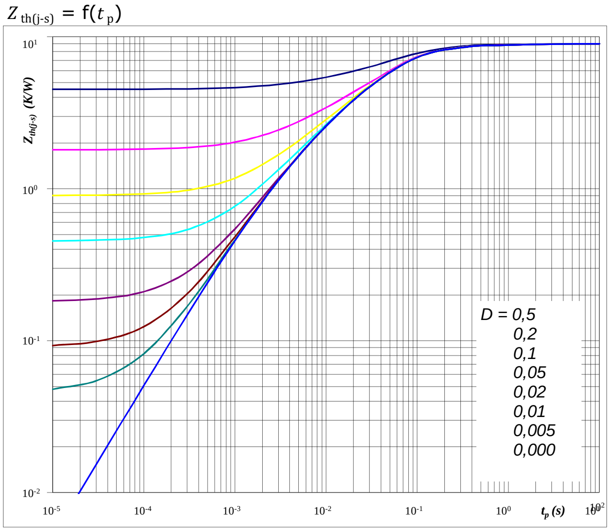
IGBT thermal model values

| $R$ (K/W) | Tau (s) |
|---|---|
| 4,18E-01 | 7,75E-01 |
| 2,55E+00 | 1,04E-01 |
| 1,29E+00 | 3,31E-02 |
| 5,60E-01 | 3,97E-03 |
| 1,42E-01 | 5,99E-04 |

**figure 12.** **PFC FWD**

**FWD transient thermal impedance as a function of pulse width**

$Z_{th(j-s)} = f(t_p)$




**At**

| | | |
|---|---|---|
| $D$ = | $t_p / T$ | |
| $R_{th(j-s)}$ = | 9,02 | K/W |

FWD thermal model values

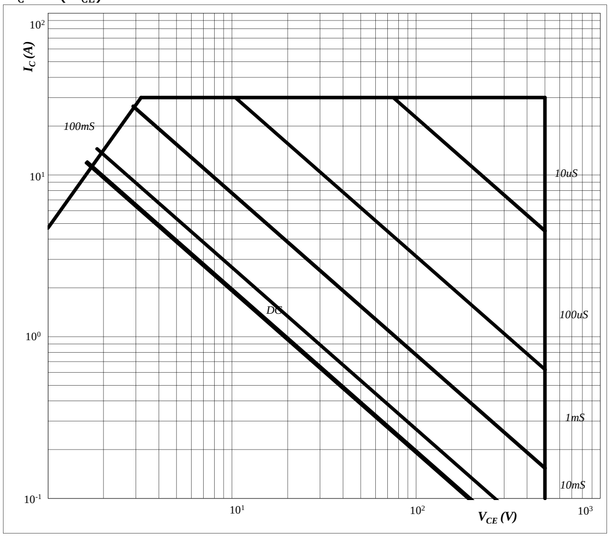
| $R$ (K/W) | Tau (s) |
|---|---|
| 2,70E-01 | 2,21E+00 |
| 9,02E-01 | 2,29E-01 |
| 5,68E+00 | 5,28E-02 |
| 1,76E+00 | 9,35E-03 |
| 4,06E-01 | 1,91E-03 |

# PFC

| figure 17. | PFC IGBT |
|---|---|

**Safe operating area as a function of collector-emitter voltage**

$I_C = f(V_{CE})$



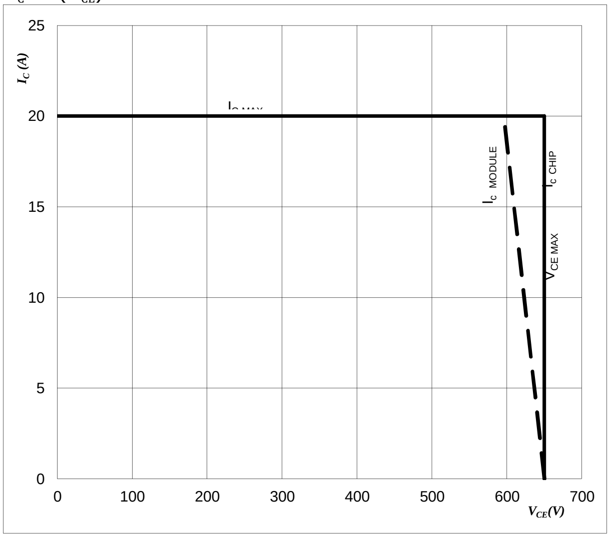

**At**

| | | |
|---|---|---|
| $D$ = | single pulse | |
| $T_s$ = | 80 | ºC |
| $U_{CC}$ = | 15 | V |
| $T_j$ = | $T_{jmax}$ | |

| figure 18. | PFC IGBT |
|---|---|

**Reverse bias safe operating area**

$I_C = f(V_{CE})$




**At**

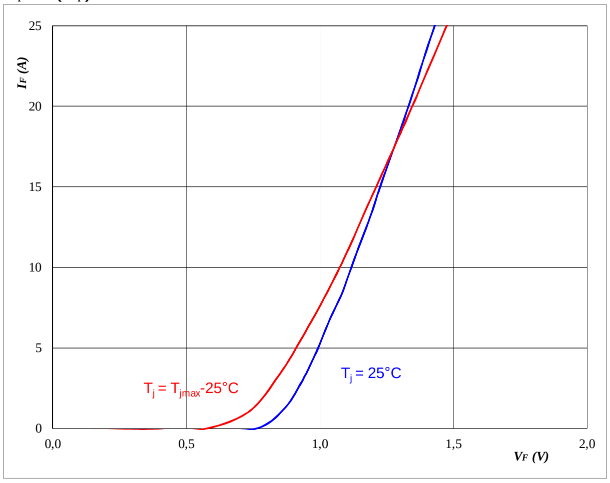
| | | |
|---|---|---|
| $T_j$ = | $T_{jmax}$-25 | ºC |

# Input Rectifier Diode

| **figure 1.** | **Rectifier Diode** |
|---|---|

**Typical diode forward current as a function of forward voltage**

$I_F = f(V_F)$



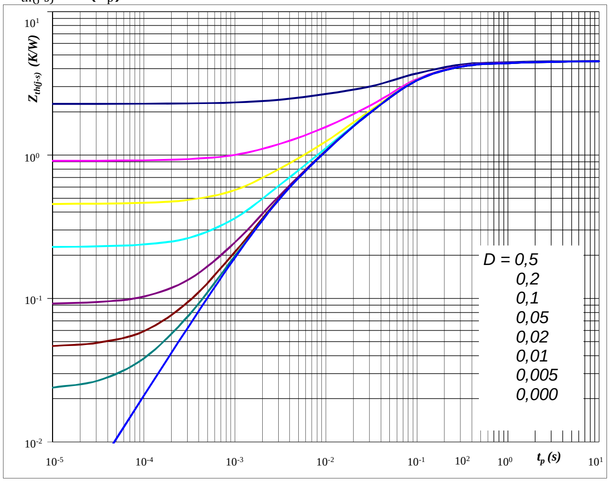

**At**

$t_p$ = 250 µs

| **figure 2.** | **Rectifier Diode** |
|---|---|

**Diode transient thermal impedance as a function of pulse width**

$Z_{th(j-s)} = f(t_p)$




**At**

$D = t_p / T$

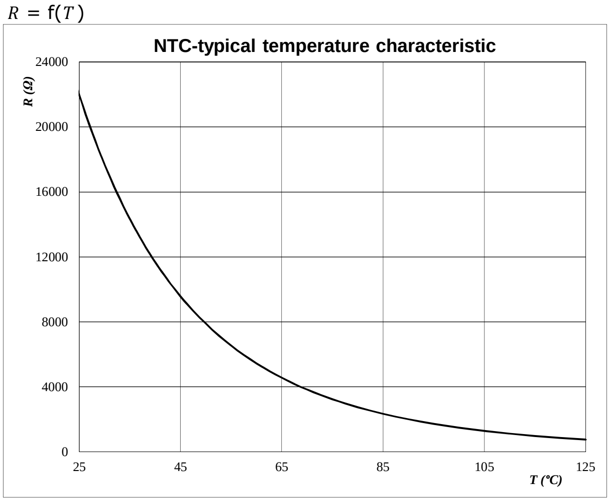
$R_{th(j-s)}$ = 4,56 K/W

# Thermistor

| **figure 1.** | **Thermistor** |
|---|---|

**Typical NTC characteristic as a function of temperature**

$R = f(T)$



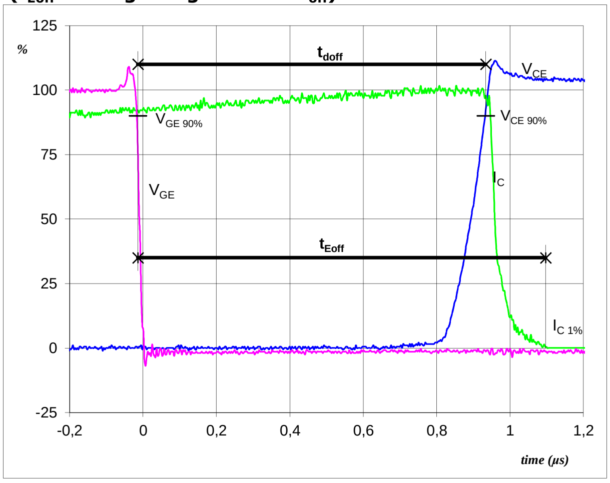
# Switching Definitions Output Inverter

**General conditions**

| | | |
|---|---|---|
| $T_j$ | = | 125 °C |

**figure 1.** Output inverter IGBT

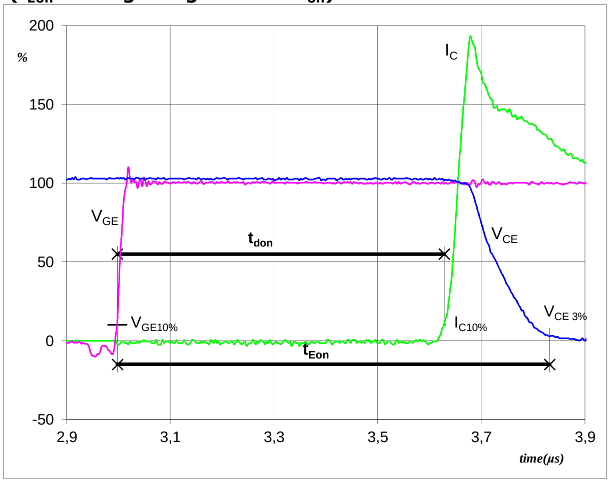
**Turn-off Switching Waveforms & definition of $t_{doff}$, $t_{Eoff}$**
**($t_{Eoff}$ = integrating time for $E_{off}$)**




$U_{IN}$ (0%) = 0 V
$U_{IN}$ (100%) = 5 V
$V_C$ (100%) = 400 V
$I_C$ (100%) = 6 A
$t_{doff}$ = 0,95 µs
$t_{Eoff}$ = 1,11 µs

**figure 2.** Output inverter IGBT

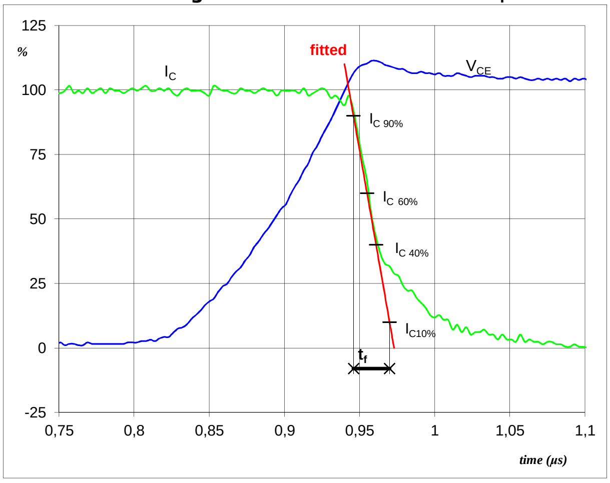
**Turn-on Switching Waveforms & definition of tdon, $t_{Eon}$**
**($t_{Eon}$ = integrating time for $E_{on}$)**




$U_{IN}$ (0%) = 0 V
$U_{IN}$ (100%) = 5 V
$V_C$ (100%) = 400 V
$I_C$ (100%) = 6 A
$t_{don}$ = 0,63 µs
$t_{Eon}$ = 0,83 µs

**figure 3.** Output inverter IGBT

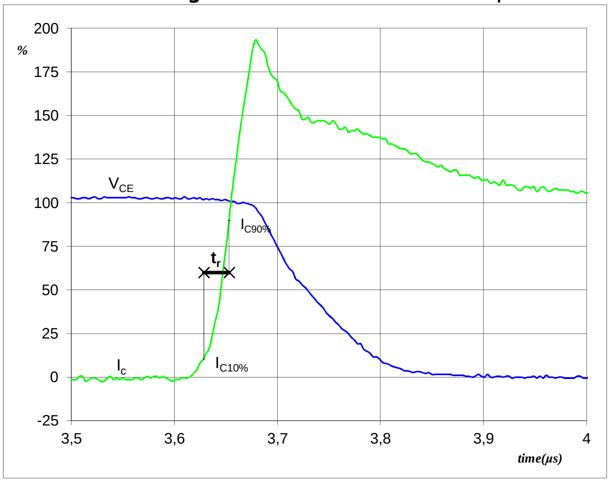
**Turn-off Switching Waveforms & definition of $t_f$**




$V_C$ (100%) = 400 V
$I_C$ (100%) = 6 A
$t_f$ = 0,02 µs

**figure 4.** Output inverter IGBT

**Turn-on Switching Waveforms & definition of $t_r$**

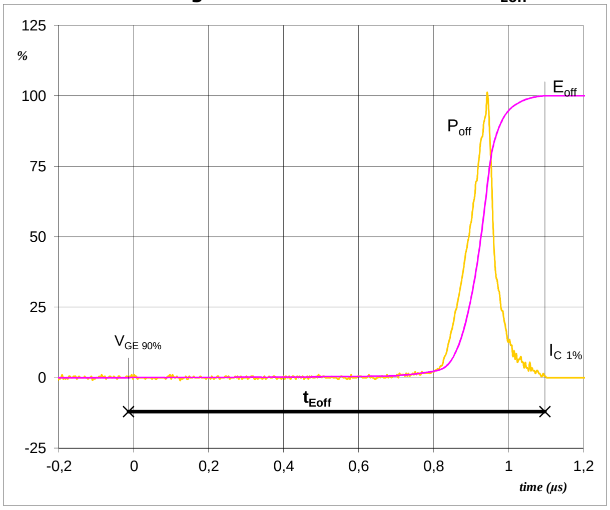



$V_C$ (100%) = 400 V
$I_C$ (100%) = 6 A
$t_r$ = 0,03 µs

# Switching Definitions Output Inverter

**figure 5.** **Output inverter IGBT**

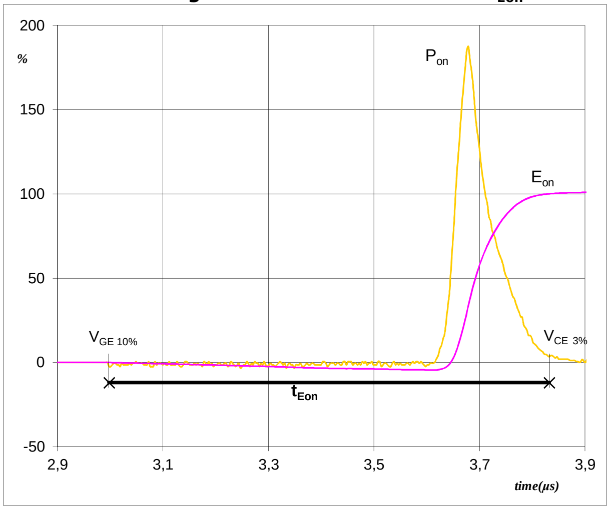
**Turn-off Switching Waveforms & definition of $t_{Eoff}$**




| | | |
|---|---|---|
| $P_{off}$ (100%) = | 2,39 | kW |
| $E_{off}$ (100%) = | 0,20 | mJ |
| $t_{Eoff}$ = | 1,11 | µs |

**figure 6.** **Output inverter IGBT**

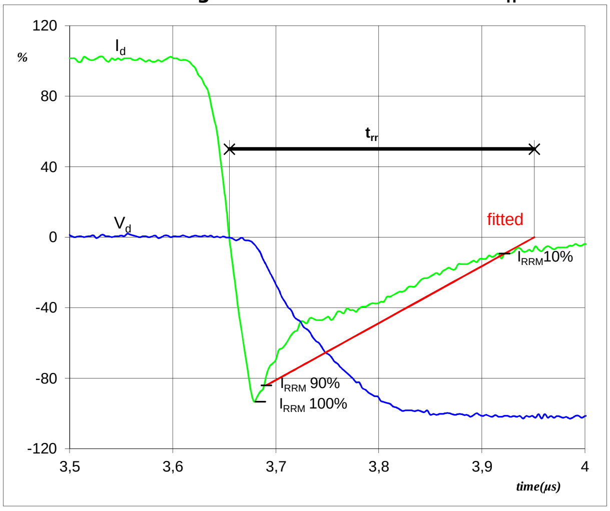
**Turn-on Switching Waveforms & definition of $t_{Eon}$**




| | | |
|---|---|---|
| $P_{on}$ (100%) = | 2,39 | kW |
| $E_{on}$ (100%) = | 0,32 | mJ |
| $t_{Eon}$ = | 0,83 | µs |

**figure 7.** **Output inverter FWD**

**Turn-off Switching Waveforms & definition of $t_{rr}$**

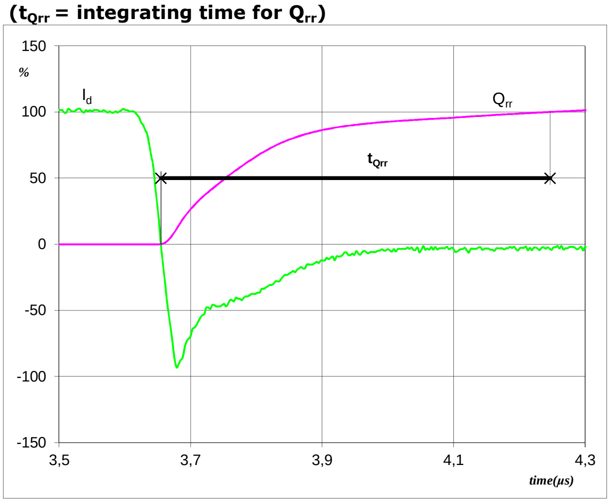



| | | |
|---|---|---|
| $V_d$ (100%) = | 400 | V |
| $I_d$ (100%) = | 6 | A |
| $I_{RRM}$ (100%) = | -6 | A |
| $t_{rr}$ = | 0,28 | µs |

# Switching Definitions Output Inverter

| **figure 8.** | **Output inverter FWD** |
|---|---|

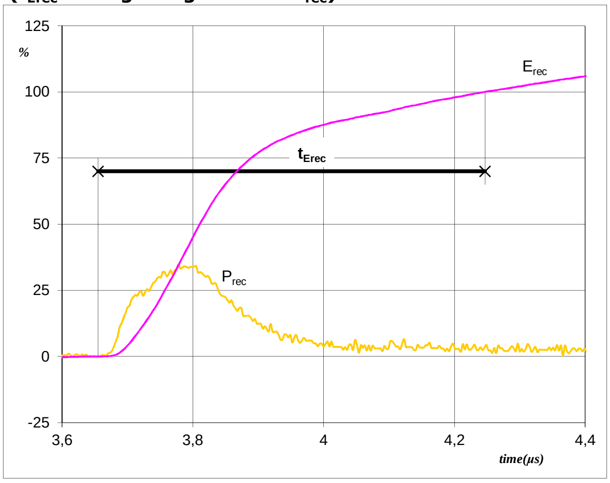
**Turn-on Switching Waveforms & definition of $t_{Qrr}$**
**($t_{Qrr}$ = integrating time for $Q_{rr}$)**




| | | |
|---|---|---|
| $I_d$ (100%) = | 6 | A |
| $Q_{rr}$ (100%) = | 0,67 | µC |
| $t_{Qrr}$ = | 0,59 | µs |

| **figure 9.** | **Output inverter FWD** |
|---|---|

**Turn-on Switching Waveforms & definition of $t_{Erec}$**
**($t_{Erec}$= integrating time for $E_{rec}$)**



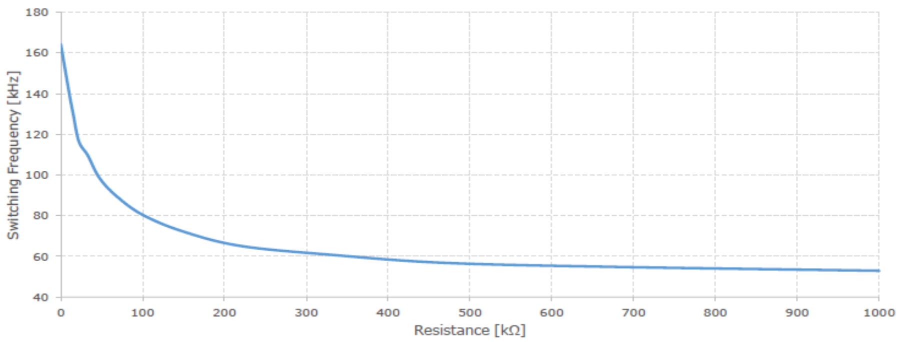

| | | |
|---|---|---|
| $P_{rec}$ (100%) = | 2,39 | kW |
| $E_{rec}$ (100%) = | 0,16 | mJ |
| $t_{Erec}$ = | 0,59 | µs |

# Application data

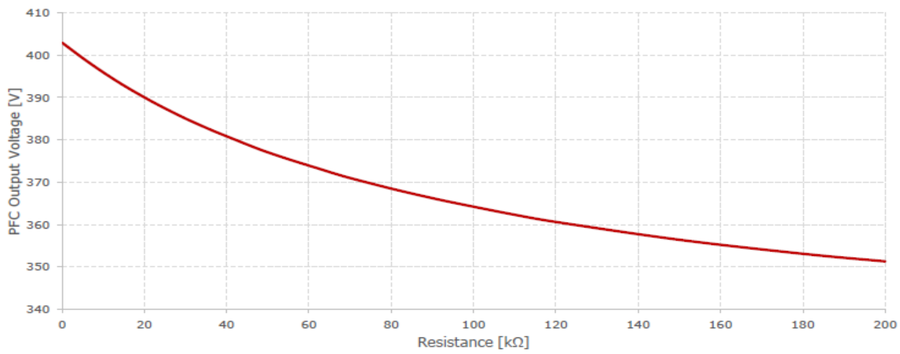
## Static logic funtion table

| $V_{CC}$ | $V_{BS}$ | RCIN | ITRIP | ENABLE | FAULT | LO1,2,3 | HO1,2,3 |
|---|---|---|---|---|---|---|---|
| $<V_{CCUV-}$ | X | X | X | X | 0 | 0 | 0 |
| 15V | $<V_{BSUV-}$ | X | 0 | 3.3V | High imp | /LIN1,2,3 | 0 |
| 15V | 15V | <3.2V↓ | 0 | 3.3V | 0 | 0 | 0 |
| 15V | 15V | X | $> V_{IT,TH+}$ | 3.3V | 0 | 0 | 0 |
| 15V | 15V | $> V_{RCIN,TH}$ | 0 | 3.3V | High imp | /LIN1,2,3 | /HIN1,2,3 |
| 15V | 15V | $> V_{RCIN,TH}$ | 0 | 0 | High imp | 0 | 0 |

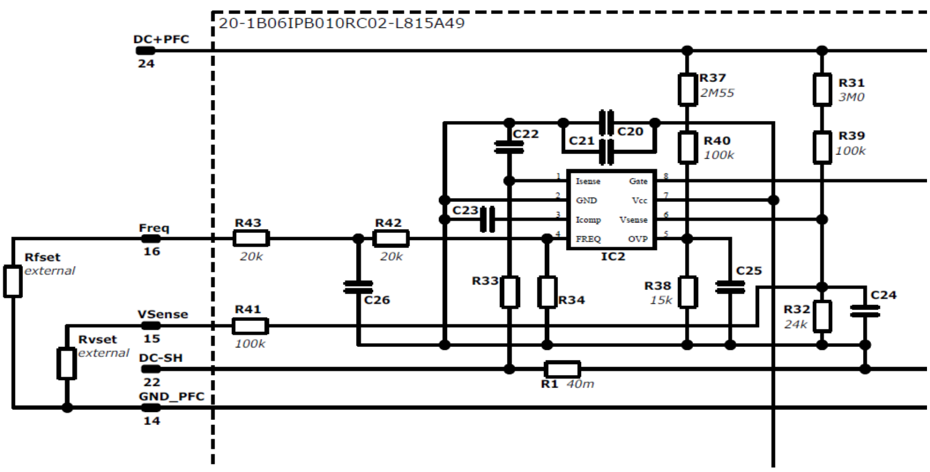
## References for externally setable parameters



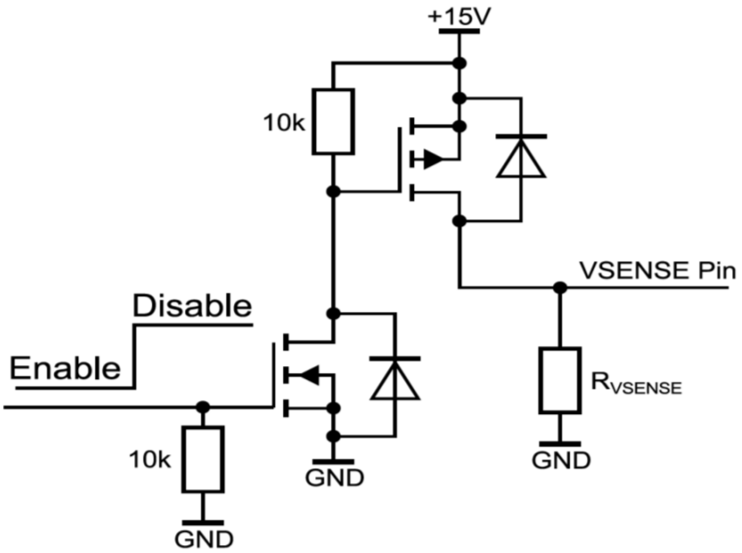

| $R_{fset}$ [kΩ] | Switching Frequency [kHz] |
|---|---|
| 0 | 164 |
| 10 | 141 |
| 15 | 130 |
| 22 | 117 |
| 33 | 110 |
| 47 | 99 |
| 68 | 90 |
| 100 | 80 |
| 150 | 72 |
| 220 | 65 |
| 330 | 61 |
| 470 | 57 |
| 680 | 55 |
| 1000 | 53 |




| $R_{Vset}$ [kΩ] | Output Voltage [V] |
|---|---|
| 0 | 403 |
| 5,1 | 399 |
| 10 | 396 |
| 15 | 393 |
| 20 | 390 |
| 24 | 388 |
| 30 | 385 |
| 36 | 382 |
| 39 | 381 |
| 47 | 378 |
| 51 | 377 |
| 56 | 375 |
| 62 | 373 |
| 68 | 372 |
| 75 | 370 |
| 82 | 368 |
| 91 | 366 |
| 100 | 364 |
| 110 | 362 |
| 120 | 361 |
| 150 | 356 |
| 180 | 353 |
| 200 | 351 |



## PFC enable circuit




## Pin Descriptions

| Pin # | Pin Name | Pin Description |
|---|---|---|
| 1 | Therm1 | Temperature sensor connector 1 |
| 2 | COM | Low-side gate driver reference |
| 3 | ITRIP | Analog input for over-current shot down, activates FAULT |
| 4 | EN | Enable I/O functionality |
| 5 | ¬Fault | Fault output, indicates over current or under voltage (negative logic, open-drain c |
| 6 | ¬LIN3 | Signal input for low-side Ph3 phase |
| 7 | ¬LIN2 | Signal input for low-side Ph2 phase |
| 8 | ¬LIN1 | Signal input for low-side Ph1 phase |
| 9 | ¬HIN3 | Signal input for high-side Ph3 phase |
| 10 | ¬HIN2 | Signal input for high-side Ph2 phase |
| 11 | ¬HIN1 | Signal input for high-side Ph1 phase |
| 12 | $V_{CC}$ | Driver circuit supply voltage |
| 13 | GND_INV | Inverter ground |
| 14 | GND_PFC | PFC ground |
| 15 | VSENSE | PFC Bulk voltage sense |
| 16 | FREQ | PFC Switching frequency adjust |
| 17 | ACIn1 | Rectifier input |
| 18 | ACIn2 | Rectifier input |
| 19 | DC+Rect | Rectifier output DC + |
| 20 | PFC | PFC coil connector |
| 21 | DC-Rect | Rectifier output DC - |
| 22 | DC-SH | Current Sense Input for PFC Controller |
| 23 | DC-PFC | PFC capacitor GND (internally connected to GND_PFC) |
| 24 | DC+PFC | PFC capacitor + (output of the PFC stage) |
| 25 | DC+INV | Inverter input DC + |
| 26 | Ph3 | Output for Ph3 phase |
| 27 | Ph2 | Output for Ph2 phase |
| 28 | Ph1 | Output for Ph1 phase |
| 29 | DC-3 | Inverter input DC - for Ph3 |
| 30 | DC-3SH+ | Inverter Sense Resistor for Ph3 - High Side |
| 31 | DC-2SH+ | Inverter Sense Resistor for Ph2 - High Side |
| 32 | DC-2 | Inverter input DC - for Ph2 |
| 33 | DC-1 | Inverter input DC - for Ph1 |
| 34 | DC-1SH+ | Inverter Sense Resistor for Ph2 - High Side |

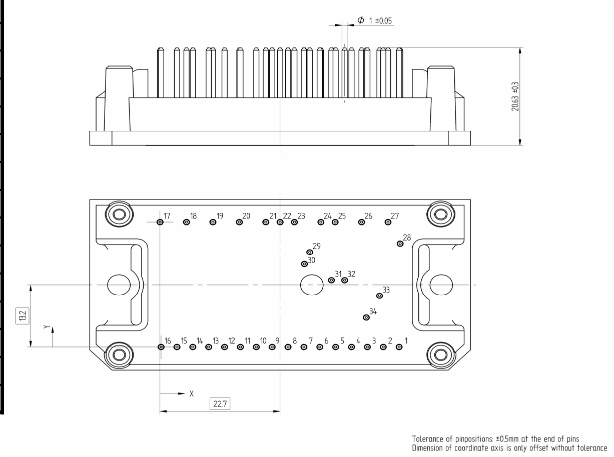
## Ordering Code & Marking

| Version | Ordering Code |
|---|---|
| without thermal paste 17 mm housing with solder pins | 20-1B06IPB010RC02-L815A49 |
| with thermal paste 17 mm housing with solder pins | 20-1B06IPB010RC02-L815A49-/3/ |
| | |
| | |

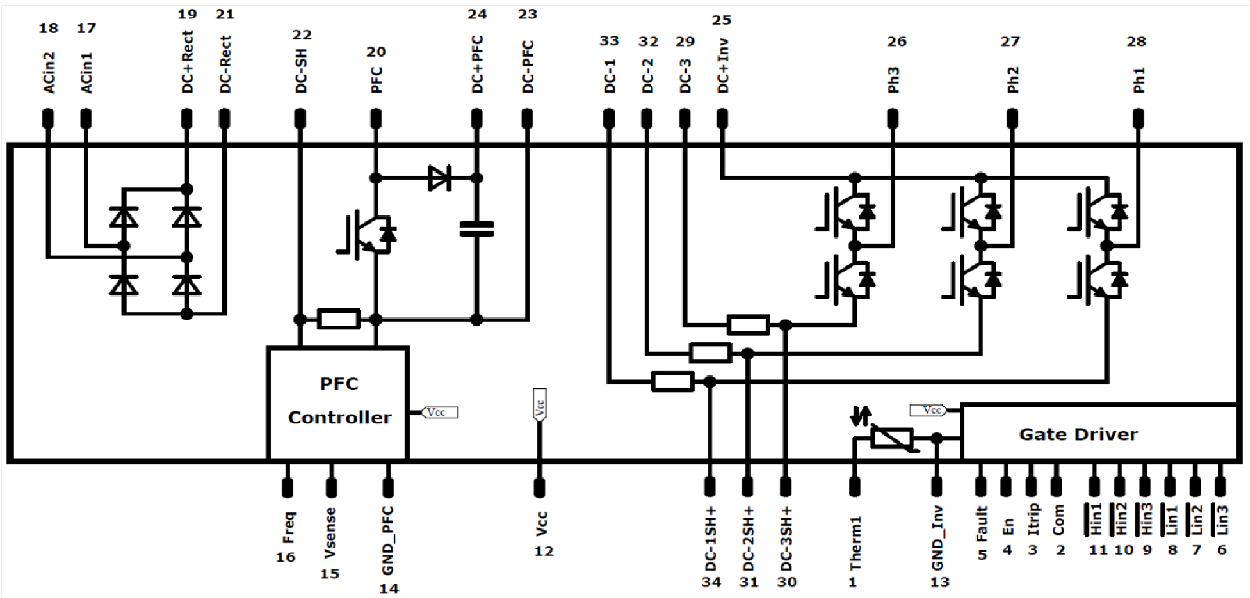

| | Name | | Date code | UL & VIN | Lot | Serial |
|---|---|---|---|---|---|---|
| Text | NN-NNNNNNNNNNNNNN-TTTTTTVV | | WWYY | UL VIN | LLLLL | SSSS |
| | Type&Ver | Lot number | Serial | Date code | | |
| Datamatrix | TTTTTTTVV | LLLLL | SSSS | WWYY | | |

## Outline

| Pin table [mm] | | | | Pin table [mm] | | | |
|---|---|---|---|---|---|---|---|
| Pin | X | Y | Function | Pin | X | Y | Function |
| 1 | 45,2 | 0 | NTC | 19 | 10 | 26,4 | DC+Rect |
| 2 | 42,2 | 0 | COM | 20 | 15 | 26,4 | PFC |
| 3 | 39,2 | 0 | ITRIP | 21 | 20 | 26,4 | DC-Rect |
| 4 | 36,2 | 0 | EN | 22 | 22,7 | 26,4 | DC-SH |
| 5 | 33,2 | 0 | FAULT | 23 | 25,4 | 26,4 | DC-PFC |
| 6 | 30,2 | 0 | LIN3 | 24 | 30,4 | 26,4 | DC+PFC |
| 7 | 27,2 | 0 | LIN2 | 25 | 33,1 | 26,4 | DC+Inv |
| 8 | 24,2 | 0 | LIN1 | 26 | 38,1 | 26,4 | Ph3 |
| 9 | 21,2 | 0 | HIN3 | 27 | 43,1 | 26,4 | Ph2 |
| 10 | 18,2 | 0 | HIN2 | 28 | 45,4 | 21,9 | Ph1 |
| 11 | 15,2 | 0 | HIN1 | 29 | 28,3 | 20,1 | DC-3 |
| 12 | 12,2 | 0 | VCC | 30 | 27,3 | 17,6 | DC-3SH |
| 13 | 9,2 | 0 | GND_INV | 31 | 32,4 | 14,2 | DC-2SH |
| 14 | 6,2 | 0 | GND_PFC | 32 | 34,9 | 14,2 | DC-2 |
| 15 | 3,2 | 0 | VSEN | 33 | 41,5 | 10,9 | DC-1 |
| 16 | 0,2 | 0 | FREQ | 34 | 39 | 6,3 | DC-1SH |
| 17 | 0 | 26,4 | ACIn1 | | | | |
| 18 | 5 | 26,4 | ACIn2 | | | | |



## Pinout




## Identification

| ID | Component | Voltage | Current | Function | Comment |
|---|---|---|---|---|---|
| T1-T6 | IGBT | 600 V | 10 A | Inverter Switch | |
| T27 | IGBT | 650 V | 30 A | PFC Switch | |
| D27 | FWD | 650 V | 8 A | PFC Diode | |
| D47 | FWD | 650 V | 6 A | PFC Inverse Diode | |
| R4 | Resistor | | | PFC Shunt | |
| D31-D34 | Rectifier | 1600 V | 7 A | Rectifier Diode | |
| R1-R3 | Resistor | | | DC Link Shunt | |
| C1 | Capacitor | 500 V | | Capacitor (DC) | |
| Rt | Thermistor | | | Thermistor | |

| Packaging instruction | | | | | |
|---|---|---|---|---|---|
| Standard packaging quantity (SPQ) | **100** | >SPQ | Standard | <SPQ | Sample |

| Handling instruction |
|---|
| Handling instructions for *flow* 1B packages see vincotech.com website. |

| Package data |
|---|
| Package data for *flow* 1B packages see vincotech.com website. |

| UL recognition and file number |
|---|
| This device is certified according to UL 1557 standard, UL file number E192116. For more information see vincotech.com website. |

| Document No.: | Date: | Modification: | Pages |
|---|---|---|---|
| 20-1B06IPB010RC02-L815A49-D5-14 | 18 Sept. 2020 | Update condition of OVP parameters<br>Add simplified schematic to show Rvset, Rfset resistor<br>Correct Pin description table | 7<br>24<br>25 |

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