

# PIIPM15P12D007



## Programmable Isolated IPM

### PI-IPM Features:

#### ■ Power Module:

- NPT IGBTs 15A, 1200V
- 10us Short Circuit capability
  - Square RBSOA
  - Low  $V_{ce(on)}$  (2.7Vtyp @ 15A, 25°C)
  - Positive  $V_{ce(on)}$  temperature coefficient
- Gen III HexFred Technology
  - Low diode  $V_F$  (2.32Vtyp @ 15A, 25°C)
  - Soft reverse recovery
- 10mΩ sensing resistors on all phase outputs
  - Thermal coefficient < 50ppm/°C

#### ■ Embedded driving board

- Programmable 40 Mips DSP
- Current sensing feedback from two phases
- Full protection from ground and line to line faults
- UVLO, OVLO on DCbus voltage
- Embedded flyback smps for floating stages (single 15Vdc @ 300mA input required)
- Asynchronous isolated 2.5Mbps serial port for DSP communication and/or programming
- Synchronous isolated 10Mbps serial port for DSP communication and/or programming
- IEEE standard 1149.1 (JTAG port interface) for program downloading and debugging
- Separated turn on / turn off outputs for IGBTs di/dt control
- Hall effect sensors, sin/cos and quadrature encoder interfaces
- On board 64kbits I<sup>2</sup>C EEPROM

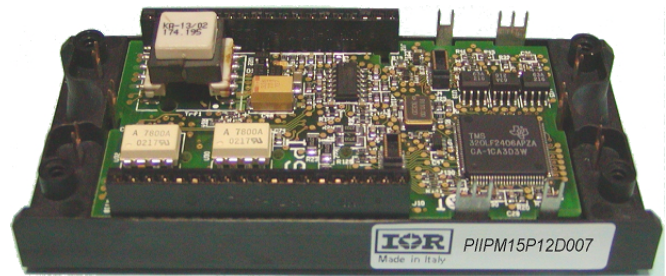
### Description

The PIIPM15P12D007 is a fully integrated Intelligent Power Module for high performances Servo Motor Driver applications.

The device core is a state of the art DSP, the TMS320LF2406A at 40 Mips, interfaced with a full set of peripherals designed to handle all analog feedback and control signals needed to correctly manage the power section of the device. A 64kbits EEPROM is also available to store calibration data. The PIIPM has been designed and tailored to implement internally all functions needed to close the current, speed and position loops of a high performances servo motor driver.

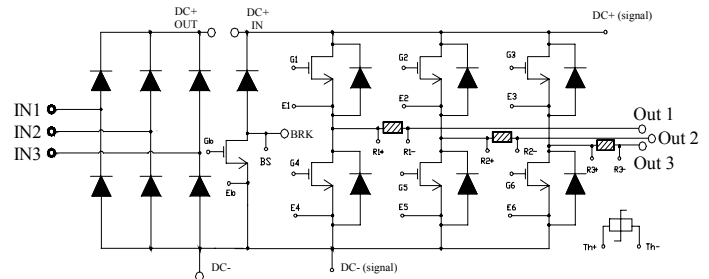
The use of the flash memory version of the DSP and the JTAG port connector allows the user to easily develop and download his own proprietary algorithm.

### Package:



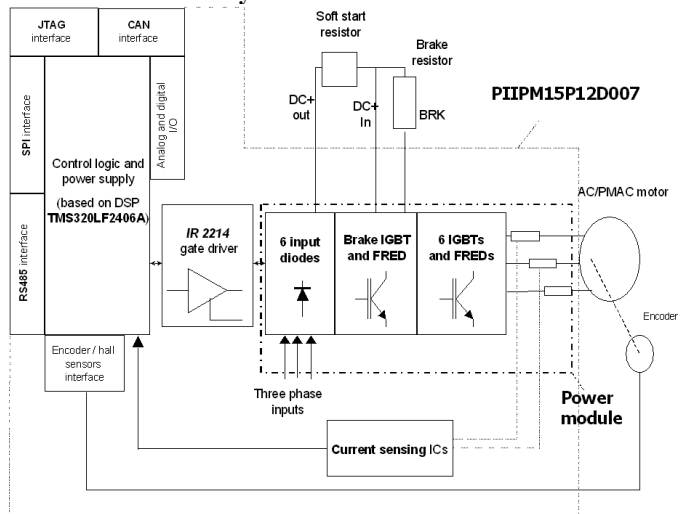
PIIPM – BBI (EconoPack 2 outline compatible)

### Power Module schematic:



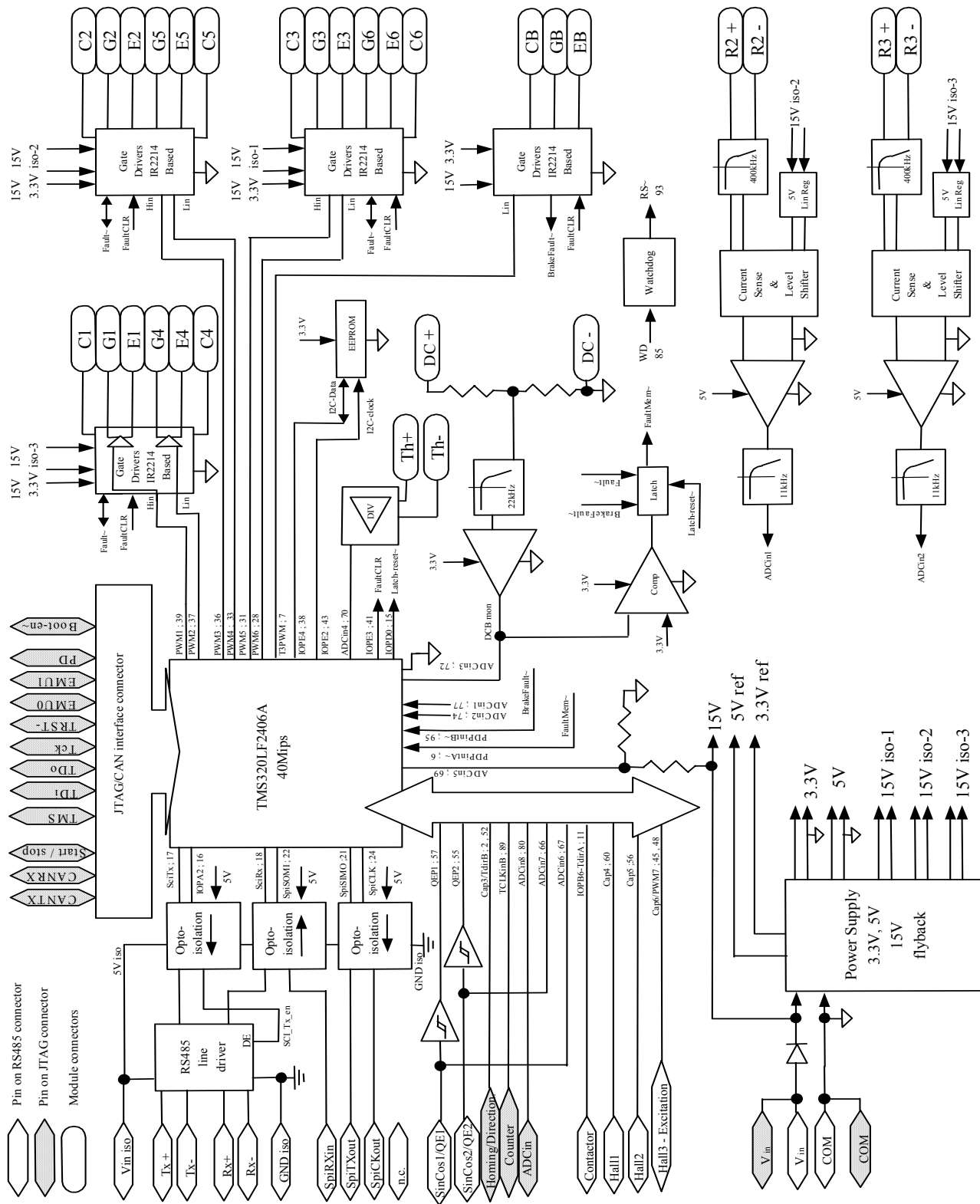
Input bridge, brake and three phases inverter (BBI) with current sensing resistors on all output phases and thermistor

### PIIPM15P12D007 System Block Schematic:



The device comes in the EMP<sup>TM</sup> package, fully compatible in length, width and height with the popular EconoPack 2 outline.

## Embedded driving board block schematic



## Signal pins on RS485 connector

| Symbol             | Lead Description                                                             | State  | Connector pin number |
|--------------------|------------------------------------------------------------------------------|--------|----------------------|
| Tx+                | RS485 Trasmmitter Non inverting Driver Output                                | Output | 1                    |
| Tx-                | RS485 Trasmmitter Inverting Driver Output                                    | Output | 2                    |
| Rx-                | RS485 Receiver Inverting Driver Input                                        | Input  | 3                    |
| Rx+                | RS485 Receiver Non inverting Driver Input                                    | Input  | 4                    |
| SpiCKout           | SPI clock output (GND iso referenced)                                        | Output | 5                    |
| Vin iso            | External 5V supply voltage for opto-couplers and line driver supply          | Input  | 6                    |
| GND iso            | Extenal 5V supply ground reference for opto-couplers and line driver supply  | Input  | 7                    |
| SpiTXout           | SPI transmitter output (GND iso referenced)                                  | Output | 8                    |
| SpiRXin            | SPI receiver input (GND iso referenced)                                      | Input  | 10                   |
| SinCos1 / QE1      | SinCos encoder input 1 / Quadrature encoder input 1                          | Input  | 11                   |
| SinCos2 / QE2      | SinCos encoder input 2 / Quadrature encoder input 2                          | Input  | 12                   |
| Contactor          | General purpose I/O                                                          | I/O    | 13                   |
| Hall1              | Hall effect sensor input 1                                                   | Input  | 14                   |
| Hall2              | Hall effect sensor input 2                                                   | Input  | 15                   |
| Hall3 / Excitation | Hall effect sensor input 3 / Resolver excitation                             | I/O    | 16                   |
| Vin                | External 15V supply voltage. Internally referred to DC bus minus pin (DC -)  | Input  | 17-18                |
| COM                | External 15V supply ground reference. This pin is directly connected to DC - | Input  | 19-20                |

## Signal pins on IEEE1149.1 JTAG connector

**CAUTION: DO NOT APPLY DC BUS VOLTAGE WHEN JTAG INTERFACE IS CONNECTED, SEVERE DAMAGE MAY OCCUR ON POWER MODULE AND ON YOUR EQUIPMENT!**

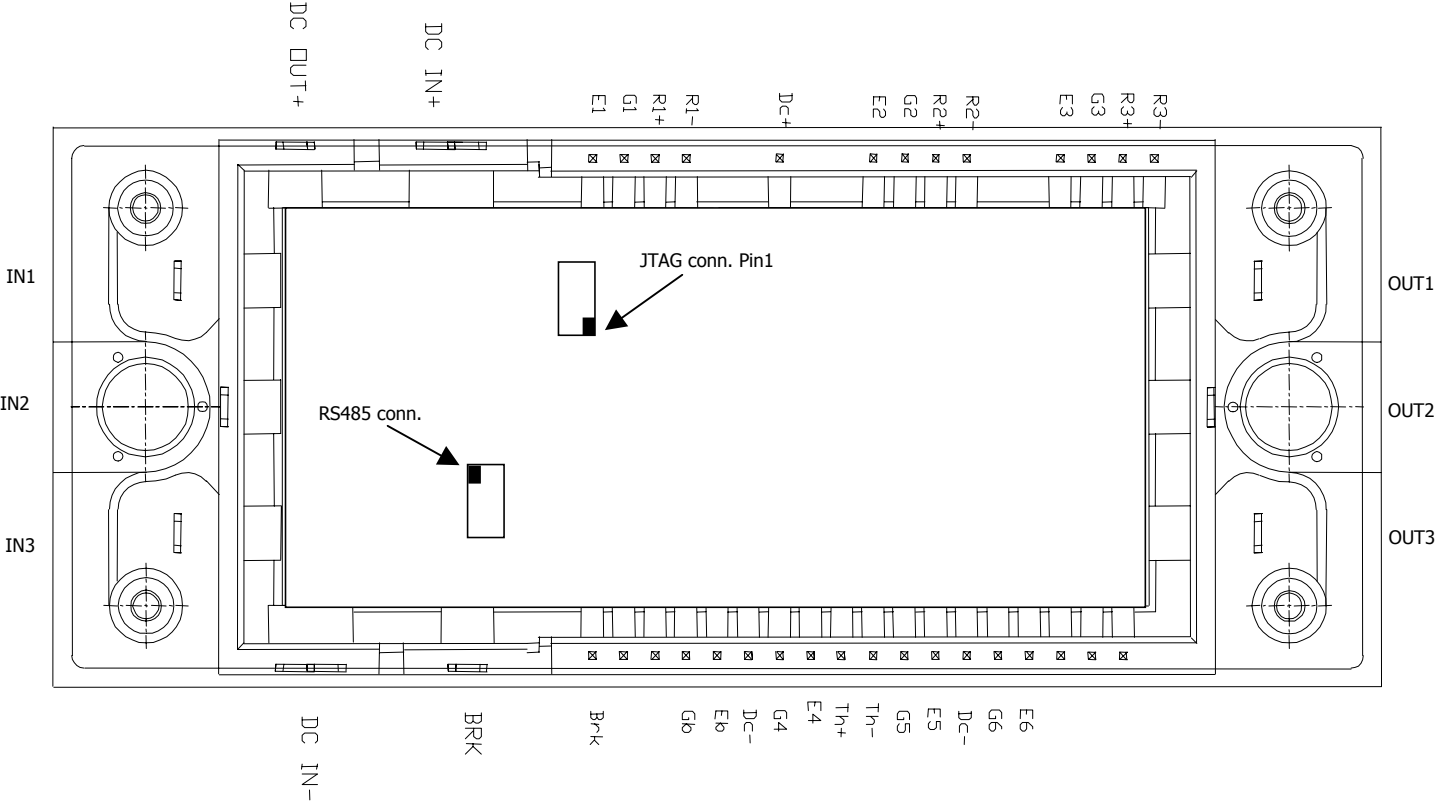
| Symbol             | Lead Description                                                                                                                                                     | State  | Connector pin number |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------------------|
| PD                 | Presence detect.<br>Indicates that the emulation cable is connected and that the PIIPM logic is powered up. PD is tied to the DSP 3.3V supply through a 1k resistor. | Output | 3                    |
| Homing / Direction | Homing signal / Counter direction                                                                                                                                    | Input  | 4                    |
| Start/Stop         | Start/Stop signal                                                                                                                                                    | Input  | 5                    |
| CAN Tx             | CAN transmitter signal                                                                                                                                               | Output | 6                    |
| CAN Rx             | CAN receiver signal                                                                                                                                                  | Input  | 7                    |
| EMU1/OFF~          | Emulation pin 1                                                                                                                                                      | I/O    | 8                    |
| Counter            | Counter signal                                                                                                                                                       | Output | 9                    |
| EMU0               | Emulation pin 0                                                                                                                                                      | I/O    | 10                   |
| TRST~              | JTAG test reset                                                                                                                                                      | Input  | 13                   |

|          |                                                                                                                                                                                    |        |      |
|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------|
| TMS      | JTAG test mode select                                                                                                                                                              | Input  | 14   |
| TDO      | JTAG test data output                                                                                                                                                              | Output | 15   |
| TDI      | JTAG test data input                                                                                                                                                               | Input  | 16   |
| TCKRET   | JTAG test clock return. Test clock input to the emulator.<br>Internally short circuited to TCK.                                                                                    | Output | 17   |
| TCK      | JTAG test clock. TCK is a 10MHz clock source from the emulation pod. This signal can be used to drive the system test clock.                                                       | Input  | 18   |
| Boot-En~ | Boot ROM enable. This pin is sampled during DSP reset, pulling it low enables DSP boot ROM through SCI serial line at 40Mhz operation (Flash versions only). 47k internal pull up. | Input  | 19   |
| ADCin    | General purpose analog input                                                                                                                                                       | Input  | 20   |
| COM      | External 15V supply ground reference. This pin is directly connected to DC -                                                                                                       | input  | 1-11 |
| Vin      | External 15V supply voltage. Internally referred to DC bus minus pin (DC-)                                                                                                         | Input  | 2-12 |

**Following pins are intended for signal communication between driving board and power module only, though here described for completeness, they are on purpose not available to the user.**

| Symbol   | Lead Description                                                                          | Pin number                                            |
|----------|-------------------------------------------------------------------------------------------|-------------------------------------------------------|
| DC +     | DC Bus plus input signal                                                                  | Lateral<br>connectors on<br>embedded<br>driving board |
| DC -     | DC Bus minus input signal (internally connected to COM)                                   |                                                       |
| Th +     | Thermal sensor positive input                                                             |                                                       |
| Th -     | Thermal sensor negative input (internally connected to COM)                               |                                                       |
| G1/2/3   | Gate connections for high side IGBTs                                                      |                                                       |
| E1/2/3   | Emitter connections for high side IGBTs (Kelvin points)                                   |                                                       |
| R1/2/3 + | Output current sensing resistor positive input (IGBTs emitters 1/2/3 side, Kelvin points) |                                                       |
| R1/2/3 - | Output current sensing resistor negative input (Motor side, Kelvin points)                |                                                       |
| G4/5/6   | Gate connections for low side IGBTs                                                       |                                                       |
| E4/5/6   | Emitter connections for low side IGBTs (Kelvin points)                                    |                                                       |
| Gb       | Gate connections for brake IGBT                                                           |                                                       |
| Eb       | Emitter connection for brake IGBT (Kelvin point)                                          |                                                       |
| Brk      | Collector connection for brake IGBT (Kelvin point)                                        |                                                       |

**Power Module Frame Pins Mapping**



### Absolute Maximum Ratings ( $T_C=25^{\circ}\text{C}$ )

Absolute Maximum Ratings indicate sustained limits beyond which damage to the device may occur.

All voltage parameters are absolute voltages referenced to  $V_{DC-}$ , all currents are defined positive into any lead.

Thermal Resistance and Power Dissipation ratings are measured at still air conditions.

|                        | Symbol                                                                                                     | Parameter Definition                                                                              |                                                       | Min.     | Max.        | Units |
|------------------------|------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|-------------------------------------------------------|----------|-------------|-------|
| Inverter and Brake     | V <sub>DC</sub>                                                                                            | DC Bus Voltage                                                                                    |                                                       | 0        | 1000        | V     |
|                        | V <sub>CES</sub>                                                                                           | Collector Emitter Voltage                                                                         |                                                       | 0        | 1200        |       |
|                        | I <sub>C</sub> @ 100C                                                                                      | IGBTs continuous collector current (T <sub>C</sub> = 100 °C, fig. 1)                              |                                                       |          | 15          | A     |
|                        | I <sub>C</sub> @ 25C                                                                                       | IGBTs continuous collector current (T <sub>C</sub> = 25 °C,fig 1)                                 |                                                       |          | 30          |       |
|                        | I <sub>CM</sub>                                                                                            | Pulsed Collector Current (Fig. 3, Fig. CT.5)                                                      |                                                       |          | 60          |       |
|                        | I <sub>F</sub> @ 100C                                                                                      | Diode Continuous Forward Current (T <sub>C</sub> = 100 °C)                                        |                                                       |          | 15          |       |
|                        | I <sub>F</sub> @ 25C                                                                                       | Diode Continuous Forward Current (T <sub>C</sub> = 25 °C)                                         |                                                       |          | 30          |       |
|                        | I <sub>FM</sub>                                                                                            | Diode Maximum Forward Current                                                                     |                                                       |          | 60          | V     |
|                        | V <sub>GE</sub>                                                                                            | Gate to Emitter Voltage                                                                           |                                                       | -20      | +20         |       |
|                        | P <sub>D</sub> @ 25°C                                                                                      | Power Dissipation (One transistor)                                                                |                                                       |          | 140         | W     |
|                        | P <sub>D</sub> @ 100°C                                                                                     | Power Dissipation (One transistor, T <sub>C</sub> = 100 °C)                                       |                                                       |          | 55          |       |
| Bridge                 | V <sub>RRM</sub>                                                                                           | repetitive peak reverse voltage (T <sub>J</sub> = 150 °C)                                         | T <sub>J</sub> = 150 °C<br>I <sub>rrm</sub> (max)=5mA |          | 1400        | V     |
|                        | V <sub>RSM</sub>                                                                                           | non repetitive peak reverse voltage                                                               |                                                       |          | 1500        |       |
|                        | I <sub>o</sub>                                                                                             | Diode Continuous Forward Current (T <sub>C</sub> = 100 °C, 120° Rect conduction angle)            |                                                       |          | 45          | A     |
|                        | I <sub>FSM</sub>                                                                                           | One-cycle forward. Non-repetitive on state surge current (t=10ms, Initial T <sub>J</sub> = 150°C) | 100% V <sub>RRM</sub> reapplied                       |          | 225         |       |
|                        |                                                                                                            |                                                                                                   | No voltage reapplied                                  |          | 270         |       |
|                        | I <sup>2</sup> t                                                                                           | Current I <sup>2</sup> t for fusing (t=10ms, Initial T <sub>J</sub> = 150°C)                      | 100% V <sub>RRM</sub> reapplied                       |          | 253         | A²s   |
|                        |                                                                                                            |                                                                                                   | No voltage reapplied                                  |          | 365         |       |
| I <sup>2</sup> √t      | Current I <sup>2</sup> √t for fusing (t=0.1 to 10ms, no voltage reapplied, Initial T <sub>J</sub> = 150°C) |                                                                                                   |                                                       | 3650     | A²√s        |       |
| Embedded Driving Board | V <sub>in</sub>                                                                                            | Non isolated supply voltage (DC- referenced)                                                      |                                                       | -20      | 20          | V     |
|                        | V <sub>in-iso</sub>                                                                                        | Isolated supply voltage (GND iso referenced)                                                      |                                                       | -5       | 5.5         |       |
|                        | R <sub>x</sub>                                                                                             | RS485 Receiver input voltage (GND iso referenced)                                                 |                                                       | -7       | 12          |       |
|                        | T <sub>A-EDB</sub>                                                                                         | Operating Ambient Temperature Range                                                               |                                                       | -25      | +70         | °C    |
|                        | T <sub>STG-EDB</sub>                                                                                       | Board Storage Temperature Range                                                                   |                                                       | -40      | +125        |       |
|                        | V <sub>ISO-CONT R485</sub>                                                                                 | Input-Output Continuous Withstand Voltage (RH ≤ 50%, -40°C ≤ T <sub>A</sub> ≤ 85°C )              |                                                       | AC<br>DC | 800<br>1000 | V     |
|                        | V <sub>ISO-TEMP RS485</sub>                                                                                | Input-Output Momentary Withstand Voltage (RH ≤ 50%, t = 1 min, T <sub>A</sub> = 25°C)             | RMS                                                   | 2500     |             |       |
| Power Module           | MT                                                                                                         | Mounting Torque                                                                                   |                                                       |          | 3.5         | Nm    |
|                        | T <sub>J</sub>                                                                                             | Operating Junction Temperature                                                                    |                                                       | -40      | +150        | °C    |
|                        | T <sub>STG</sub>                                                                                           | Storage Temperature Range                                                                         |                                                       | -40      | +125        |       |
|                        | V <sub>c-iso</sub>                                                                                         | Isolation Voltage to Base Copper Plate                                                            |                                                       | -2500    | +2500       | V     |

### Electrical Characteristics: Inverter and Brake

For proper operation the device should be used within the recommended conditions.

**T<sub>J</sub> = 25°C (unless otherwise specified)**

| Symbol                                 | Parameter Definition                    | Min. | Typ.  | Max. | Units | Test Conditions                                                        | Fig.   |
|----------------------------------------|-----------------------------------------|------|-------|------|-------|------------------------------------------------------------------------|--------|
| V <sub>(BR)CES</sub>                   | Collector To Emitter Breakdown Voltage  | 1200 |       |      | V     | V <sub>GE</sub> = 0V, I <sub>C</sub> = 250μA                           |        |
| ΔV <sub>(BR)CES</sub> / ΔT             | Temperature Coeff. of Breakdown Voltage |      | +1.2  |      | V/°C  | V <sub>GE</sub> = 0V, I <sub>C</sub> = 1mA (25 - 125 °C)               |        |
| V <sub>CE(on)</sub>                    | Collector To Emitter Saturation Voltage |      | 2.70  | 3.00 | V     | I <sub>C</sub> = 15A, V <sub>GE</sub> = 15V                            | 5, 6   |
|                                        |                                         |      | 3.74  | 4.24 |       | I <sub>C</sub> = 30A, V <sub>GE</sub> = 15V                            | 7, 9   |
|                                        |                                         |      | 3.14  | 3.61 |       | I <sub>C</sub> = 15A, V <sub>GE</sub> = 15V, T <sub>J</sub> = 125 °C   | 10, 11 |
| V <sub>GE(th)</sub>                    | Gate Threshold Voltage                  | 4.68 | 4.89  | 5.30 | V     | V <sub>CE</sub> = V <sub>GE</sub> , I <sub>C</sub> = 250μA             | 12     |
| ΔV <sub>GE(th)</sub> / ΔT <sub>J</sub> | Temp. Coeff. of Threshold Voltage       |      | -9.80 |      | mV/°C | V <sub>CE</sub> = V <sub>GE</sub> , I <sub>C</sub> = 1mA (25 - 125 °C) |        |
| g <sub>fe</sub>                        | Forward Transconductance                | 8    | 9     | 10   | S     | V <sub>CE</sub> = 50V, I <sub>C</sub> = 15A, PW = 80μs                 |        |
| I <sub>CES</sub>                       | Zero Gate Voltage Collector Current     |      |       | 125  | μA    | V <sub>GE</sub> = 0V, V <sub>CE</sub> = 1200V                          |        |
|                                        |                                         |      | 376   | 1110 |       | V <sub>GE</sub> = 0V, V <sub>CE</sub> = 1200V, T <sub>J</sub> = 125 °C |        |
|                                        |                                         |      |       | 2000 |       | V <sub>GE</sub> = 0V, V <sub>CE</sub> = 1200V, T <sub>J</sub> = 150 °C |        |
| V <sub>FM</sub>                        | Diode Forward Voltage Drop              |      | 2.32  | 2.52 | V     | I <sub>C</sub> = 15A                                                   | 8      |
|                                        |                                         |      | 2.47  | 2.64 |       | I <sub>C</sub> = 15A, T <sub>J</sub> = 125 °C                          |        |
| I <sub>GES</sub>                       | Gate To Emitter Leakage Current         |      |       | ±100 | nA    | V <sub>GE</sub> = ±20V                                                 |        |
| R1/2/3                                 | Sensing Resistors                       | 9.9  | 10    | 10.1 | mΩ    |                                                                        |        |

### Electrical Characteristics: Bridge

For proper operation the device should be used within the recommended conditions.

**T<sub>J</sub> = 25°C (unless otherwise specified)**

| Symbol             | Parameter Definition    | Min. | Typ. | Max. | Units | Test Conditions                                | Fig. |
|--------------------|-------------------------|------|------|------|-------|------------------------------------------------|------|
| V <sub>FM</sub>    | Forward Voltage Drop    |      | 1.24 | 1.76 | V     | t <sub>p</sub> = 400μs, I <sub>pk</sub> = 30A  | 24   |
|                    |                         |      | 1.08 | 1.27 |       | t <sub>p</sub> = 400μs, I <sub>pk</sub> = 15A  |      |
| V <sub>F(TO)</sub> | Threshold voltage       |      | 0.78 |      | V     | T <sub>J</sub> = 125 °C                        |      |
| I <sub>rm</sub>    | Reverse Leakage Current |      |      | 5    | mA    | T <sub>J</sub> = 125 °C V <sub>R</sub> = 1200V |      |

## Switching Characteristics: Inverter and Brake

For proper operation the device should be used within the recommended conditions.

**T<sub>J</sub> = 25°C (unless otherwise specified)**

| Symbol               | Parameter Definition                                                                | Min         | Typ  | Max  | Units | Test Conditions                                                                                                                                    | Fig.                               |
|----------------------|-------------------------------------------------------------------------------------|-------------|------|------|-------|----------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|
| Q <sub>g</sub>       | Total Gate Charge (turn on)                                                         |             | 84   | 127  | nC    | I <sub>C</sub> = 15A                                                                                                                               | 23<br>CT1                          |
| Q <sub>ge</sub>      | Gate – Emitter Charge (turn on)                                                     |             | 10   | 15   |       | V <sub>CC</sub> = 600V                                                                                                                             |                                    |
| Q <sub>gc</sub>      | Gate – Collector Charge (turn on)                                                   |             | 43   | 64   |       | V <sub>GE</sub> = 15V                                                                                                                              |                                    |
| E <sub>on</sub>      | Turn on Switching Loss                                                              |             | 838  | 1207 | μJ    | I <sub>C</sub> = 15A, V <sub>CC</sub> = 600V, T <sub>J</sub> = 25 °C                                                                               | CT4                                |
| E <sub>off</sub>     | Turn off Switching Loss                                                             |             | 632  | 900  |       | V <sub>GE</sub> = 15V, R <sub>G</sub> = 10Ω, L = 500μH                                                                                             | WF1                                |
| E <sub>tot</sub>     | Total Switching Loss                                                                |             | 1470 | 2107 |       | Tail and Diode Rev. Recovery included                                                                                                              | WF2                                |
| E <sub>on</sub>      | Turn on Switching Loss                                                              |             | 1154 | 1512 | μJ    | I <sub>C</sub> = 15A, V <sub>CC</sub> = 600V, T <sub>J</sub> = 125 °C                                                                              | 13,<br>15<br>CT4<br>WF1<br>WF2     |
| E <sub>off</sub>     | Turn off Switching Loss                                                             |             | 933  | 1030 |       | V <sub>GE</sub> = 15V, R <sub>G</sub> = 10Ω, L = 500μH                                                                                             |                                    |
| E <sub>tot</sub>     | Total Switching Loss                                                                |             | 2087 | 2542 |       | Tail and Diode Rev. Recovery included                                                                                                              |                                    |
| td (on)              | Turn on delay time                                                                  |             | 98   | 104  | ns    | I <sub>C</sub> = 15A, V <sub>CC</sub> = 600V, T <sub>J</sub> = 125 °C<br><br>V <sub>GE</sub> = 15V, R <sub>G</sub> = 10Ω, L = 500μH                | 14,16                              |
| Tr                   | Rise time                                                                           |             | 14   | 25   |       |                                                                                                                                                    | CT4                                |
| td (off)             | Turn off delay time                                                                 |             | 132  | 142  |       |                                                                                                                                                    | WF1                                |
| Tf                   | Fall time                                                                           |             | 226  | 247  |       |                                                                                                                                                    | WF2                                |
| C <sub>ies</sub>     | Input Capacitance                                                                   |             | 1323 |      | pF    | V <sub>CC</sub> = 30V                                                                                                                              | 22                                 |
| C <sub>oes</sub>     | Output Capacitance                                                                  |             | 255  |      |       | V <sub>GE</sub> = 0V                                                                                                                               |                                    |
| C <sub>res</sub>     | Reverse Transfer Capacitance                                                        |             | 37   |      |       | f = 1MHz                                                                                                                                           |                                    |
| RBSOA                | Reverse Bias Safe Operating Area                                                    | FULL SQUARE |      |      |       | T <sub>J</sub> = 150 °C, I <sub>C</sub> = 60A, V <sub>GE</sub> = 15V to 0V<br>V <sub>CC</sub> = 1000V, V <sub>p</sub> = 1200V, R <sub>G</sub> = 5Ω | 4<br>CT2                           |
| SCSOA                | Short Circuit Safe Operating Area                                                   | 10          |      |      | μs    | T <sub>J</sub> = 150 °C, V <sub>GE</sub> = 15V to 0V<br>V <sub>CC</sub> = 1000V, V <sub>p</sub> = 1200V, R <sub>G</sub> = 5Ω                       | CT3<br>WF4                         |
| E <sub>REC</sub>     | Diode reverse recovery energy                                                       |             | 711  | 1263 | μJ    | T <sub>J</sub> = 125 °C                                                                                                                            | 17,18<br>19,20<br>21<br>CT4<br>WF3 |
| T <sub>rr</sub>      | Diode reverse recovery time                                                         |             | 113  | 300  | ns    | I <sub>F</sub> = 15A, V <sub>CC</sub> = 600V,                                                                                                      |                                    |
| I <sub>rr</sub>      | Peak reverse recovery current                                                       |             | 36   | 41   | A     | V <sub>GE</sub> = 15V, R <sub>G</sub> = 10Ω, L = 500μH                                                                                             |                                    |
| R <sub>thJ-C,T</sub> | Each IGBT to copper plate thermal resistance                                        |             |      | 0.9  | °C/W  | See also fig. 25, 26                                                                                                                               | 25,26                              |
| R <sub>thJ-C,D</sub> | Each Diode to copper plate thermal resistance                                       |             |      | 1.54 | °C/W  |                                                                                                                                                    |                                    |
| R <sub>thC-H</sub>   | Module copper plate to heat sink thermal resistance. Silicon grease applied = 0.1mm |             |      | 0.03 | °C/W  |                                                                                                                                                    |                                    |
| P <sub>diss</sub>    | Total Dissipated Power                                                              |             | 29   |      | W     | I <sub>C</sub> = 2A, V <sub>DC</sub> = 530V, f <sub>sw</sub> = 8kHz, T <sub>C</sub> = 55 °C                                                        | PD1                                |
|                      |                                                                                     |             | 42   |      |       | I <sub>C</sub> = 3A, V <sub>DC</sub> = 530V, f <sub>sw</sub> = 8kHz, T <sub>C</sub> = 55 °C                                                        | PD2                                |
|                      |                                                                                     |             | 81   |      |       | I <sub>C</sub> = 3A, V <sub>DC</sub> = 530V, f <sub>sw</sub> = 16kHz T <sub>C</sub> = 55 °C,                                                       | PD3                                |
|                      |                                                                                     |             | 40   |      |       | I <sub>C</sub> = 7A, V <sub>DC</sub> = 530V, f <sub>sw</sub> = 4kHz, T <sub>C</sub> = 55°C                                                         |                                    |

## Electrical Characteristics: Embedded Driving Board (EDB) communication ports

For proper operation the device should be used within the recommended conditions.

**V<sub>in</sub> = 15V, V<sub>in-iso</sub> = 5V, T<sub>A</sub> = 0 to 55°C, T<sub>C</sub> = 75°C (unless otherwise specified)**

| Symbol                                              | Parameter Definition                                                                                                                                               | Min.                                                                                                     | Typ. | Max.  | Units | Test Conditions                                                                                   | Type                | Conn. |
|-----------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|------|-------|-------|---------------------------------------------------------------------------------------------------|---------------------|-------|
| V <sub>in</sub>                                     | EDB Input supply Voltage                                                                                                                                           | 12                                                                                                       | 15   | 18    | V     |                                                                                                   | Non isolated Supply | RS485 |
| I <sub>supp</sub>                                   | EDB Input Supply Current                                                                                                                                           |                                                                                                          | 150  | 250   | mA    | V <sub>DC</sub> = 600V, f <sub>PWM</sub> = 16kHz                                                  |                     |       |
| V <sub>in iso</sub>                                 | EDB isolated supply voltage                                                                                                                                        | 4.5                                                                                                      | 5    | 5.5   | V     |                                                                                                   | Isolated supply     |       |
| I <sub>q. iso</sub>                                 | EDB isolated quiescent supply current                                                                                                                              |                                                                                                          | 9    | 15    | mA    | R <sub>x+</sub> = +5V, R <sub>x-</sub> = 0V<br>SPIR <sub>xIn</sub> open                           |                     |       |
| I <sub>supp. iso</sub>                              | EDB isolated supply current                                                                                                                                        | 10                                                                                                       | 15   | 22    | mA    | SPIR <sub>xIn</sub> low<br>R <sub>x+</sub> = 0V, R <sub>x-</sub> = +5V<br>Tx+ and Tx- open        |                     |       |
|                                                     |                                                                                                                                                                    | 50                                                                                                       | 55   | 62    | mA    | SPIR <sub>xIn</sub> low<br>R <sub>x+</sub> = 0V, R <sub>x-</sub> = +5V<br>Tx+ and Tx- on 120Ω     |                     |       |
| V <sub>DO-TX</sub>                                  | Differential Driver Output Voltage                                                                                                                                 | 2                                                                                                        |      |       | V     | R <sub>load</sub> = 120 Ω                                                                         | RS485 port          |       |
| V <sub>CO-TX</sub>                                  | Driver Common mode output voltage                                                                                                                                  |                                                                                                          |      | 3     | V     |                                                                                                   |                     |       |
| V <sub>DI-RX</sub>                                  | Receiver Input Differential Threshold Voltage                                                                                                                      | - 0.2                                                                                                    |      | 0.2   | V     | - 7V ≤ V <sub>CM</sub> ≤ +12V                                                                     |                     |       |
| R <sub>IN-RX</sub>                                  | Receiver Input Resistance                                                                                                                                          |                                                                                                          | 120  |       | Ω     |                                                                                                   |                     |       |
| f <sub>MAX</sub>                                    | RS485 maximum data rate                                                                                                                                            |                                                                                                          |      | 2.5   | Mbps  |                                                                                                   |                     |       |
| SpiR <sub>xIn</sub>                                 | Logic High Input Voltage                                                                                                                                           | 3.8                                                                                                      |      |       | V     |                                                                                                   | SPI port            |       |
|                                                     | Logic Low Input Voltage                                                                                                                                            |                                                                                                          |      | 1.0   | V     |                                                                                                   |                     |       |
|                                                     | Logic Low Input Current                                                                                                                                            |                                                                                                          |      | -5    | mA    |                                                                                                   |                     |       |
| SpiTxOut<br>SpiCkOut                                | Logic Low Output Voltage                                                                                                                                           |                                                                                                          |      | 0,8   | V     | I <sub>out</sub> = -510μA                                                                         |                     |       |
|                                                     |                                                                                                                                                                    |                                                                                                          |      | 1,2   | V     | I <sub>out</sub> = -1,2mA                                                                         |                     |       |
|                                                     | Logic High Output Voltage                                                                                                                                          | 2.4                                                                                                      |      |       | V     | I <sub>out</sub> = 3mA                                                                            |                     |       |
| TMS,TDI,TDO<br>TCK,TRST-<br>EMU0<br>EMU1/OFF~<br>PD | JTAG interface pins ( <b>CAUTION: DO NOT APPLY DC BUS VOLTAGE WHEN JTAG INTERFACE IS CONNECTED, SEVER DAMAGE MAY OCCUR ON POWER MODULE AND ON YOUR EQUIPMENT!)</b> | Please see<br>TMS320LF2406A<br>datasheet from<br>Texas Instruments<br>and V <sub>PD</sub> specifications |      |       |       | Directly connected from DSP<br>to connector pins.<br>EMU0 and EMU1 with 4.7k<br>internal pull up. |                     | JTAG  |
| V <sub>PD</sub>                                     | Presence detect voltage                                                                                                                                            | 3.2                                                                                                      | 3.3  | 3.4   | V     | I <sub>PD</sub> = -100μA                                                                          | JTAG                |       |
| V <sub>Boot-En~</sub>                               | Boot ROM enable input voltage                                                                                                                                      |                                                                                                          |      | 0.5   | V     | Active low                                                                                        | JTAG                |       |
| I <sub>Boot-En~</sub>                               | Boot ROM enable input current                                                                                                                                      |                                                                                                          |      | - 100 | μA    |                                                                                                   | JTAG                |       |
| CAN Tx                                              | Logic Low Output Voltage                                                                                                                                           |                                                                                                          |      | 0.8   | V     | I <sub>out</sub> = - 780μA                                                                        | CAN port            |       |
|                                                     | Logic High Output Voltage                                                                                                                                          | 2.4                                                                                                      |      |       | V     | I <sub>out</sub> = 860μA                                                                          |                     |       |
| CAN Rx                                              | Logic Low Input Voltage                                                                                                                                            |                                                                                                          |      | 0.8   | V     |                                                                                                   |                     |       |
|                                                     | Logic High Input Voltage                                                                                                                                           | 2.4                                                                                                      |      |       | V     |                                                                                                   |                     |       |

~ indicates active low signals

## AC Electrical Characteristics: Embedded Driving Board (EDB)

### DSP pins mapping

For proper operation the device should be used within the recommended conditions.

**V<sub>in</sub> = 15V, V<sub>in-iso</sub> = 5V, T<sub>A</sub> = 0 to 55°C, T<sub>C</sub> = 75°C (unless otherwise specified)**

| Symbol               | Parameter Definition                                                                            |                      | Min.                                                                                                   | Typ. | Max. | Units | Test Conditions               | DSP name; pin N            |
|----------------------|-------------------------------------------------------------------------------------------------|----------------------|--------------------------------------------------------------------------------------------------------|------|------|-------|-------------------------------|----------------------------|
| V <sub>DCgain</sub>  | DC bus voltage feedback partition coefficient                                                   |                      | 2.39                                                                                                   | 2.44 | 2.49 | mV/V  |                               | ADCIN03 ; 72               |
| V <sub>DCpole</sub>  | DC bus voltage feedback second order filter                                                     |                      | -                                                                                                      | 22   | -    | kHz   |                               |                            |
| V <sub>DC-OVth</sub> | DC bus voltage over-voltage threshold                                                           |                      | 870                                                                                                    | 920  | 970  | V     |                               | PDPINTA~ ; 6               |
| V <sub>TH25C</sub>   | Thermal sensor voltage feedback at 25 °C (Fig. TF1)                                             |                      | 2.65                                                                                                   | 2.75 | 2.85 | V     |                               | ADCIN04 ; 70               |
| V <sub>TH100C</sub>  | Thermal sensor voltage feedback at 100 °C (Fig. TF1)                                            |                      | 1.04                                                                                                   | 1.09 | 1.14 | V     |                               |                            |
| V <sub>in-gain</sub> | Input voltage feedback partition coefficient                                                    |                      | 125                                                                                                    | 128  | 131  | mV/V  |                               | ADCIN05 ; 69               |
| V <sub>in-pole</sub> | Input voltage feedback filter pole                                                              |                      | 1600                                                                                                   | 1700 | 1800 | Hz    |                               |                            |
| I <sub>ph-GAIN</sub> | Current feedback gain                                                                           |                      | 78                                                                                                     | 80   | 82   | mV/A  | all two phases                | ADCIN01: 77<br>ADCIN02: 74 |
| I <sub>ph-pole</sub> | Current feedback filter pole                                                                    |                      | 9.8                                                                                                    | 10.9 | 12   | kHz   |                               |                            |
| I <sub>ph-LAT</sub>  | Current feedback signal delay                                                                   |                      |                                                                                                        |      | 5    | μs    |                               |                            |
| I <sub>ph-Zero</sub> | Zero current input voltage level                                                                |                      | 1.62                                                                                                   | 1.65 | 1.68 | V     |                               |                            |
| V <sub>ce_sc</sub>   | V <sub>ce</sub> Short Circuit Threshold detection                                               |                      |                                                                                                        | 7.4  |      | V     | all phases                    | PDPINTA~ ; 6               |
| I <sub>SC-DEL</sub>  | Short Circuit detection delay time                                                              |                      |                                                                                                        | 3    | 6    | μs    |                               |                            |
| WD                   | External watchdog timeout (see also RS~ signal), please see WD internal signal for more details |                      | 0.9                                                                                                    |      |      | Sec   |                               | IOPC1 ; 85                 |
| ADCin                | Generic purpose analog Input                                                                    |                      | 0                                                                                                      |      | 3.3  | V     |                               | ADCIN08 ; 80               |
|                      | Generic purpose analog input filter pole                                                        |                      |                                                                                                        | 4.13 |      | kHz   |                               |                            |
| SinCos1/QE1          | Analog input 1 for sincos resolver                                                              |                      | 0                                                                                                      |      | 3.3  | V     | See also QEP1 internal signal | ADCIN06 ; 67               |
|                      | Analog input for sincos resolver filter pole                                                    |                      |                                                                                                        | 4.13 |      | kHz   |                               |                            |
|                      | QEP1: internal digital signal of QE1                                                            | High level threshold | 2,4                                                                                                    |      |      | V     |                               | QEP1 ; 57                  |
|                      |                                                                                                 | Low level threshold  |                                                                                                        |      | 1    | V     |                               |                            |
| SinCos2/QE2          | Analog input 2 for sincos resolver                                                              |                      | 0                                                                                                      |      | 3.3  | V     | See also QEP2 internal signal | ADCIN07;66                 |
|                      | Analog input for sincos resolver filter pole                                                    |                      |                                                                                                        | 4.13 |      | kHz   |                               |                            |
|                      | QEP2: internal digital signal of QE2                                                            | High level threshold | 2,4                                                                                                    |      |      | V     |                               | QEP2 ; 55                  |
|                      |                                                                                                 | Low level threshold  |                                                                                                        |      | 1    | V     |                               |                            |
| COM                  | DSP Ground                                                                                      |                      | 3, 5, 13, 14, 19, 26, 27, 29, 32, 34, 46, 53,55, 58, 63, 65, 68, 71, 73, 75, 76, 78,79, 81, 84, 90, 97 |      |      |       |                               |                            |
| 3.3V                 | DSP 3.3V supply                                                                                 |                      | 4, 10, 20, 30, 35, 47, 54, 59, 64, 91, 98                                                              |      |      |       |                               |                            |
| Floating             | Not connected to anything                                                                       |                      | 12, 23, 88, 25, 42, 44, 51                                                                             |      |      |       |                               |                            |

~ indicates active low signals

## Other DSP pins mapping to the connector

| Symbol             | Signal Definition                                | DSP name ; pin N                | Comments                                                                   | Connector |
|--------------------|--------------------------------------------------|---------------------------------|----------------------------------------------------------------------------|-----------|
| Hall1              | Hall effect sensor input 1                       | CAP4/QEP3/IOPE7 ; 60            | Digital Input. See elec. characteristic of I/O pins                        | RS485     |
| Hall2              | Hall effect sensor input 2                       | CAP5/QEP4/IOPF0 ; 56            | Digital Input. See elec. characteristic of I/O pins                        |           |
| Hall3 / Excitation | Hall effect sensor input 3 / Resolver excitation | PWM7/IOPE1, CAP6/IOPF1 ; 45, 48 | Digital I/O, Output is type G3. See electrical characteristics of I/O pins |           |
| Contactor          | General purpose I/O                              | IOPB6 ; 11                      | Digital I/O, Output is type G3. See electrical characteristics of I/O pins |           |
| CAN Tx             | CAN transmit data                                | CANTX ; 50                      | Not isolated                                                               | JTAG      |
| CAN Rx             | CAN receive data                                 | CANRX ; 49                      | Not isolated                                                               |           |
| Homing/Direction   | Homing signal/ Counter direction                 | TDIRB/IOPF4, CAP3/IOA5 ; 2, 52  | Avoid electrical conflicts between these two pins                          |           |
| Start/Stop         | Start/Stop signal                                | IOPF6 ; 92                      | Digital Input. See elec. Characteristic of I/O pins                        |           |
| Boot En~           | Boot ROM enable signal                           | BOOT_EN~ ; 86                   | See also EDB electrical characteristics                                    |           |
| Counter            | Counter signal                                   | TCLKINB ; 89                    | Digital Input. See elec. Characteristics of I/O pins                       |           |

## These signals are internal only

| Symbol       | Signal Definition                        | DSP name ; pin N      | Comments                                                                                   |
|--------------|------------------------------------------|-----------------------|--------------------------------------------------------------------------------------------|
| PWM1         | Out 1 high side IGBT gate drive signal   | PWM1 ; 39             | DSP Event Manager A output                                                                 |
| PWM2         | Out 1 low side IGBT gate drive signal    | PWM2 ; 37             | DSP Event Manager A output                                                                 |
| PWM3         | Out 2 high side IGBT gate drive signal   | PWM3 ; 36             | DSP Event Manager A output                                                                 |
| PWM4         | Out 2 low side IGBT gate drive signal    | PWM4 ; 33             | DSP Event Manager A output                                                                 |
| PWM5         | Out 3 high side IGBT gate drive signal   | PWM5 ; 31             | DSP Event Manager A output                                                                 |
| PWM6         | Out 3 low side IGBT gate drive signal    | PWM6 ; 28             | DSP Event Manager A output                                                                 |
| Brake        | Brake IGBT gate drive signal             | T3PWM ; 7             | DSP Event Manager B output                                                                 |
| SpiTXout     | SpiTx output                             | SPISIMO ; 21          | These signal are optically isolated.<br>See also EDB electrical characteristics            |
| SpiRXout     | SpiRx input                              | SPISOMI ; 22          |                                                                                            |
| SpiCKout     | SpiClk output                            | SPICLK ; 24           |                                                                                            |
| Ref3.3V      | 3.3V reference voltage                   | VREFHI, VCCA ; 82, 83 | 3.3V reference and supply voltage for ADC converter                                        |
| 5V supp.     | Flash programming voltage pin            | VCCP ; 40             | Supplied by the embedded flyback regulator                                                 |
| Tx           | SCI transmit data                        | SCITXD ; 17           | Drives Tx+ and Tx- through the opto-isolator and the line driver                           |
| Rx           | SCI receive data                         | SCIRXD ; 18           | Driven by Rx+ and Rx- through the opto-isolator and the line driver                        |
| SCI_Tx_en    | SCI transmitter enable                   | IOPA2 ; 16            | Enable the SCI line driver through an opto-isolator                                        |
| Latch-reset~ | System general fault output reset signal | IOPD0 ; 15            | LFAULT Reset signal, to be activated via software after a fault or system boot, active low |
| FaultCLR     | Gate driver fault output reset signal    | IOPE3 ; 41            | Gate driver reset, to be activated via software after a short-circuit or system boot       |

|             |                                             |               |                                                                                                                                                                                                                                                                                     |
|-------------|---------------------------------------------|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| RS~         | DSP reset input signal (see also WD signal) | RS~ ; 93      | Forces a DSP reset if WD signal holds too long (see also EDB electrical char.)                                                                                                                                                                                                      |
| Xtal1       | PLL oscillator input pin                    | XTAL1 ; 87    | A 10Mhz oscillator at 100ppm frequency stability feeds this pin.                                                                                                                                                                                                                    |
| PLL1F1      | PLL filter input 1                          | PFFL ; 9      | PLL filter for 40Mhz DSP clock frequency                                                                                                                                                                                                                                            |
| PLL1F2      | PLL filter input 2                          | PLL2 ; 8      | PLL filter for 40Mhz DSP clock frequency                                                                                                                                                                                                                                            |
| FaultMem~   | System general fault input                  | PDPINTA~ ; 6  | Activated by short circuits on output phases or brake IGBT and by DC bus over-voltage comparator. Latched signal, see also Latch-reset                                                                                                                                              |
| BrakeFault~ | Brake Protection Interrupt signal           | PDPINTB~ ; 95 | Activated by short circuits on brake                                                                                                                                                                                                                                                |
| QEP1        | Square wave of SinCos1/QE1                  | QEP1 ; 57     | Internal Schmitt trigger, see also AC electrical characteristic                                                                                                                                                                                                                     |
| QEP2        | Square wave of SinCos2/QE2                  | QEP2 ; 55     | Internal Schmitt trigger, see also AC electrical characteristic                                                                                                                                                                                                                     |
| WD          | Output signal for external watchdog         | IOPC1 ; 85    | WD = high impedance, external watchdog is disabled                                                                                                                                                                                                                                  |
|             |                                             |               | WD = high or WD = low, external watchdog is enabled and WD has to be periodically triggered by positive or negative transition. When the supervising system fails to retrigger the ext. watchdog within the time shown on AC electrical Characteristics, RS~ signal becomes active. |
|             |                                             |               |                                                                                                                                                                                                                                                                                     |

~ indicates active low signals

64kbits I<sup>2</sup>C EEprom (please see Microchip 24LC4 for more specifications)

| Symbol                   | Signal Definition        | DSP name ; pin N | Comments                                 |
|--------------------------|--------------------------|------------------|------------------------------------------|
| I <sup>2</sup> C - Clock | I <sup>2</sup> C - Clock | IOPE2 ; 43       | Connected to the I <sup>2</sup> C EEPROM |
| I <sup>2</sup> C - Data  | I <sup>2</sup> C - Clock | IOPE4 ; 38       | Connected to the I <sup>2</sup> C EEPROM |
|                          |                          |                  |                                          |

Electrical characteristic of digital inputs and outputs.

| Symbol            | Parameter Definition              | Min. | Typ. | Max. | Units | Test Conditions             |
|-------------------|-----------------------------------|------|------|------|-------|-----------------------------|
| Input: VIH        | Logic high, generic input voltage | 2.4  |      |      | V     |                             |
| Input: VIL        | Logic low, generic input voltage  |      |      | 0.8  | V     |                             |
| Output Type G1(*) | VOH                               | 2.4  |      |      | V     | I <sub>out</sub> = 700μA    |
|                   | VOL                               |      |      | 0.8  | V     | I <sub>out</sub> = - 700μA  |
| Output Type G2(*) | VOH                               | 2.4  |      |      | V     | I <sub>out</sub> = 850 μA   |
|                   | VOL                               |      |      | 0.8  | V     | I <sub>out</sub> = - 850 μA |
| Output Type G3(*) | VOH                               | 2.4  |      |      | V     | I <sub>out</sub> = 950 μA   |
|                   | VOL                               |      |      | 0.8  | V     | I <sub>out</sub> = -950 μA  |

(\*) Please refer to TMS320LF2406A datasheet from Texas Instruments for more specifications.

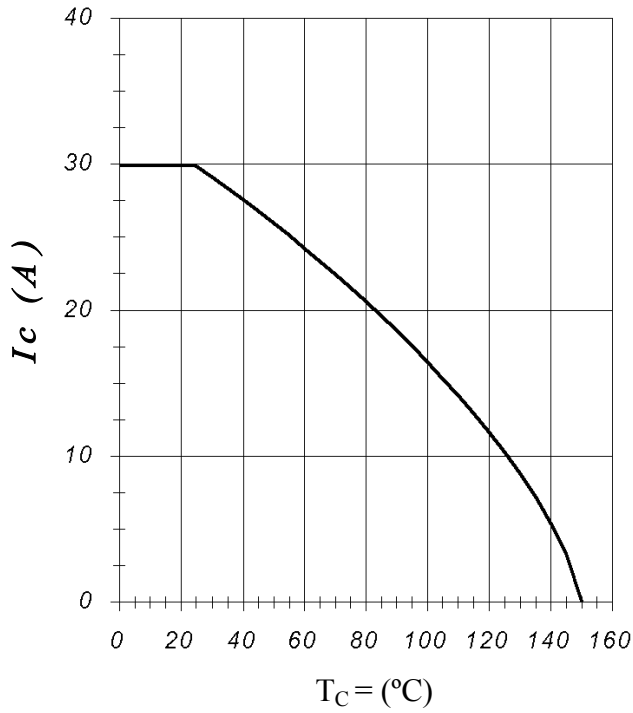
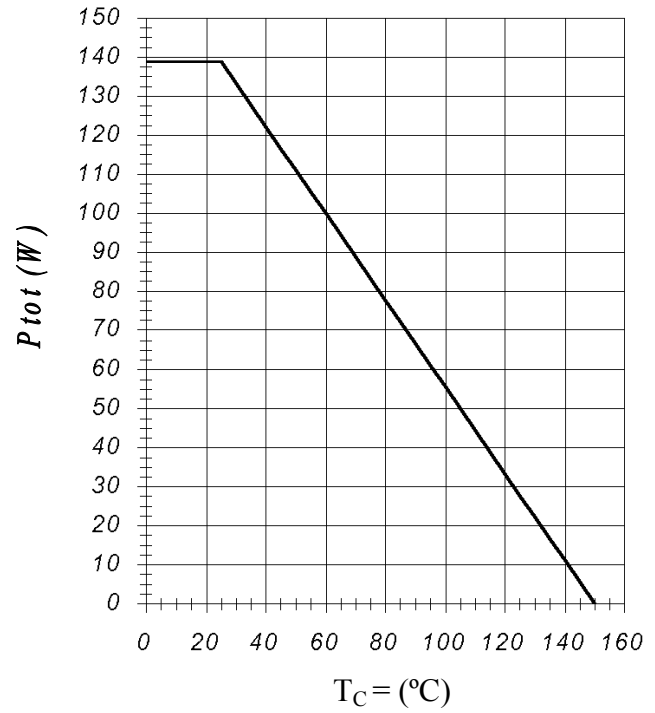
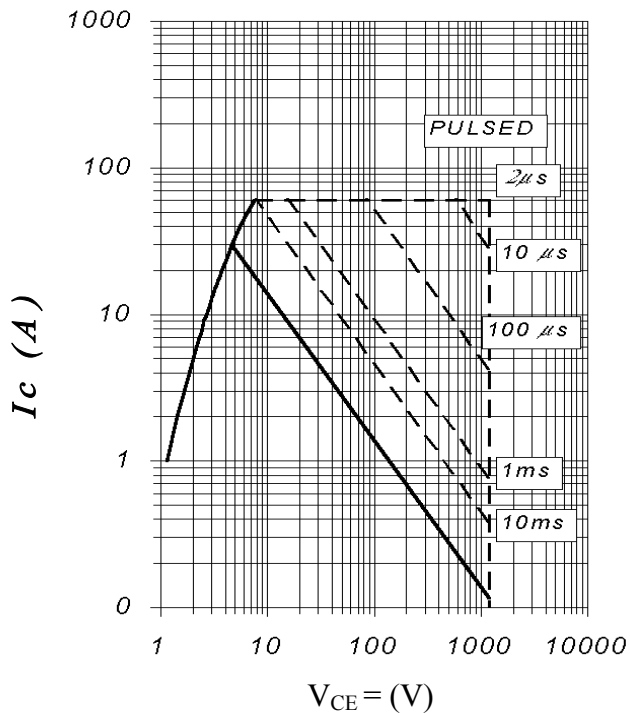
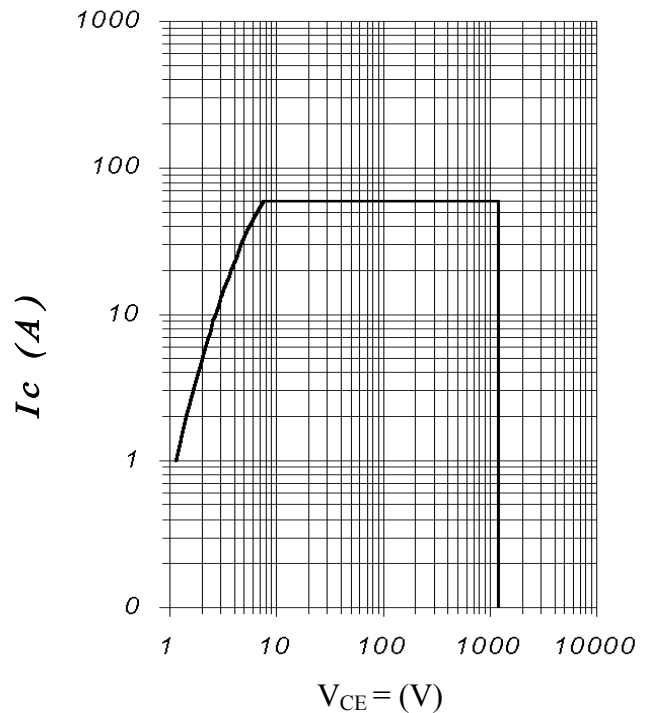
Fig. 1 – Maximum DC collector  
Current vs. case temperatureFig. 2 – Power Dissipation vs.  
Case TemperatureFig. 3 – Forward SOA  
 $T_C = 25^{\circ}\text{C}$ ;  $T_j \leq 150^{\circ}\text{C}$ Fig. 4 – Reverse Bias SOA  
 $T_j = 150^{\circ}\text{C}$ ,  $V_{GE} = 15\text{V}$ 

Fig. 5 – Typical IGBT Output Characteristics  
 $T_j = -40^\circ\text{C}$ ;  $t_p = 300\mu\text{s}$

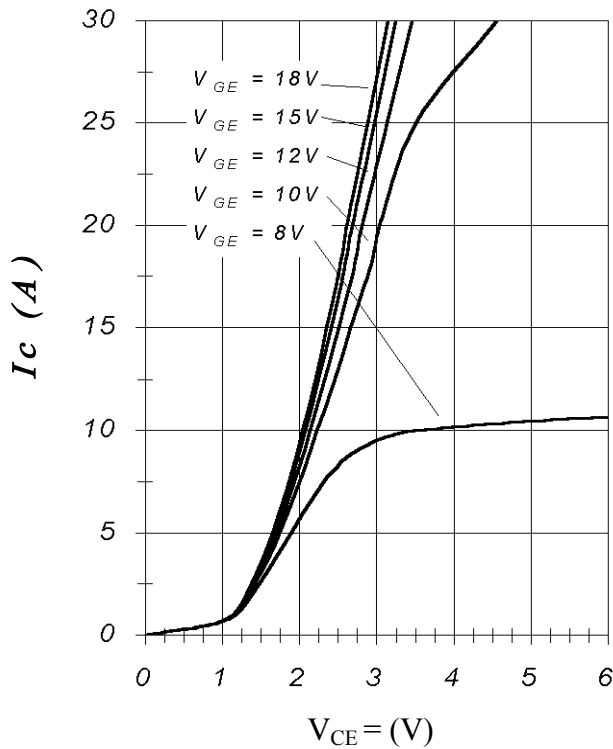


Fig. 6 – Typical IGBT Output Characteristics  
 $T_j = 25^\circ\text{C}$ ;  $t_p = 300\mu\text{s}$

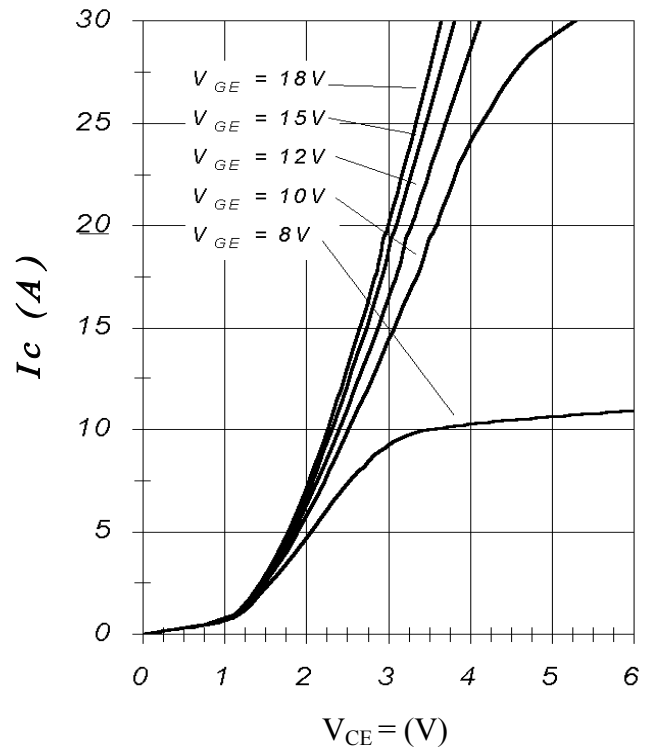


Fig. 7 – Typical IGBT Output Characteristics  
 $T_j = 125^\circ\text{C}$ ;  $t_p = 300\mu\text{s}$

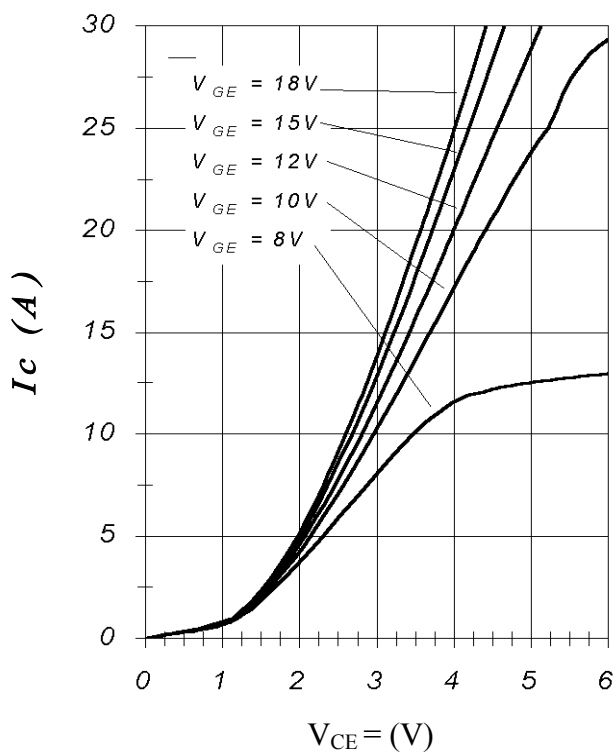


Fig. 8 – Typical Diode Forward Characteristics  
 $t_p = 300\mu\text{s}$

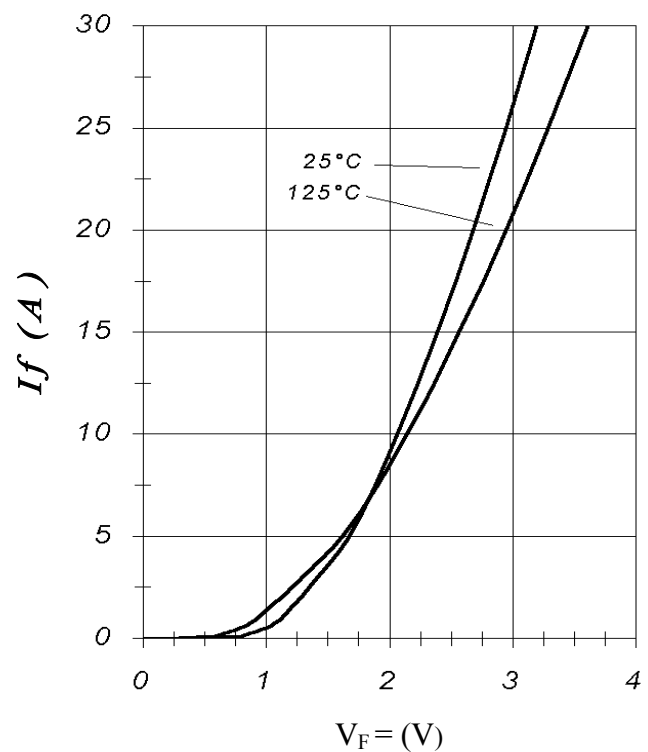


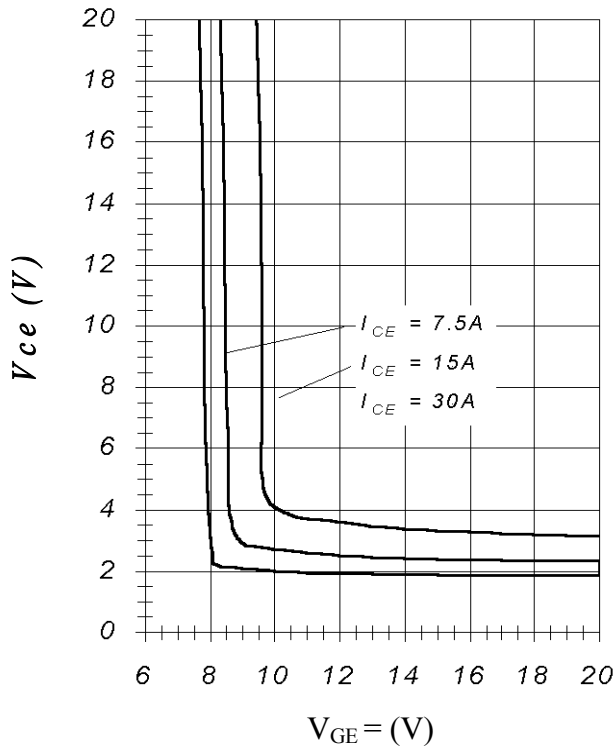
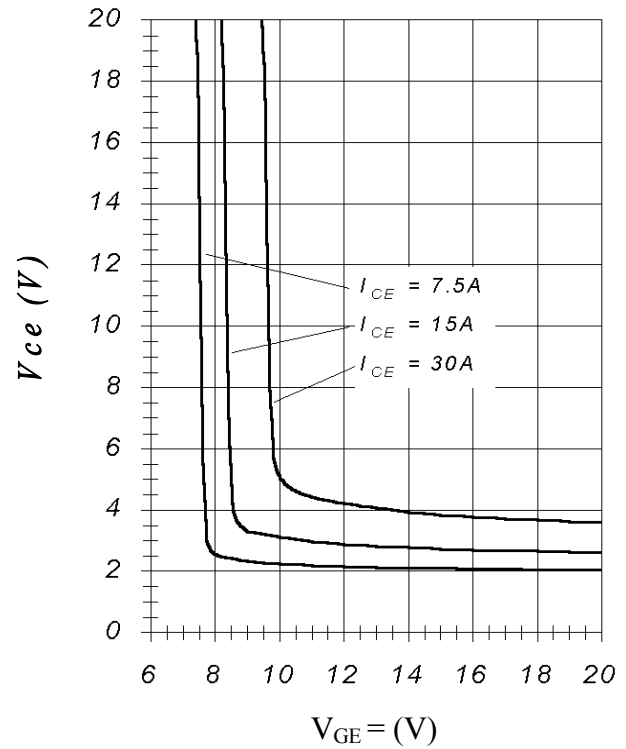
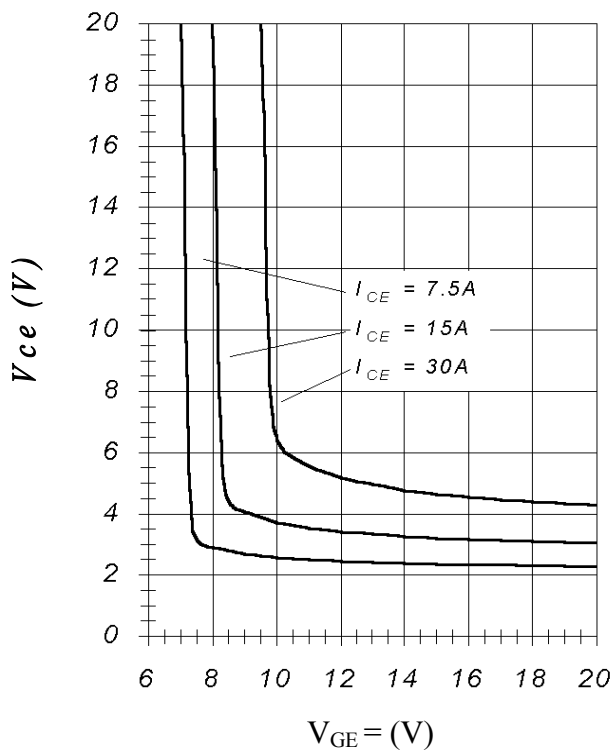
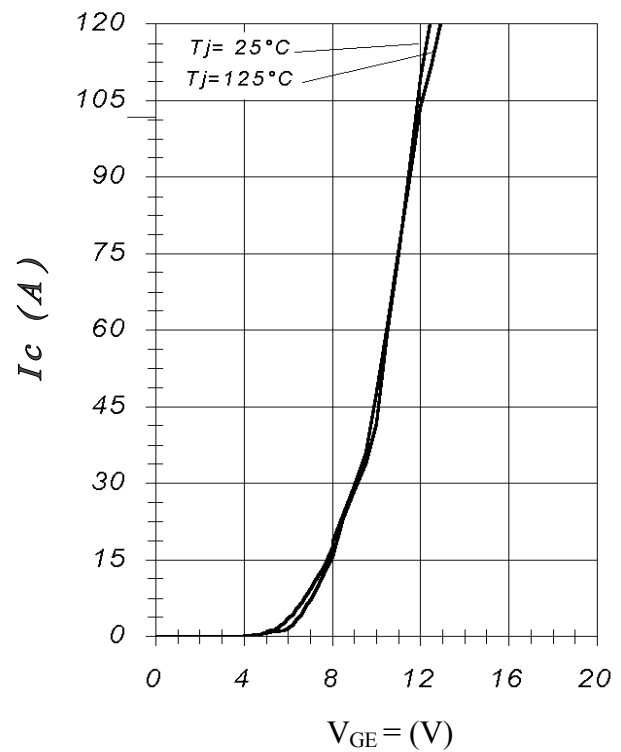
Fig. 9 – Typical  $V_{CE}$  vs.  $V_{GE}$   
 $T_j = -40^\circ\text{C}$ Fig. 10 – Typical  $V_{CE}$  vs.  $V_{GE}$   
 $T_j = 25^\circ\text{C}$ Fig. 11 – Typical  $V_{CE}$  vs.  $V_{GE}$   
 $T_j = 125^\circ\text{C}$ Fig. 12 – Typical Transfer Characteristics  
 $V_{CE} = 20\text{V}$ ;  $t_p = 20\mu\text{s}$ 

Fig. 13 – Typical Energy Loss vs.  $I_C$   
 $T_j = 125^\circ\text{C}$ ;  $L = 500\mu\text{H}$ ;  $V_{CE} = 600\text{V}$ ;  
 $R_g = 10\Omega$ ;  $V_{GE} = 15\text{V}$

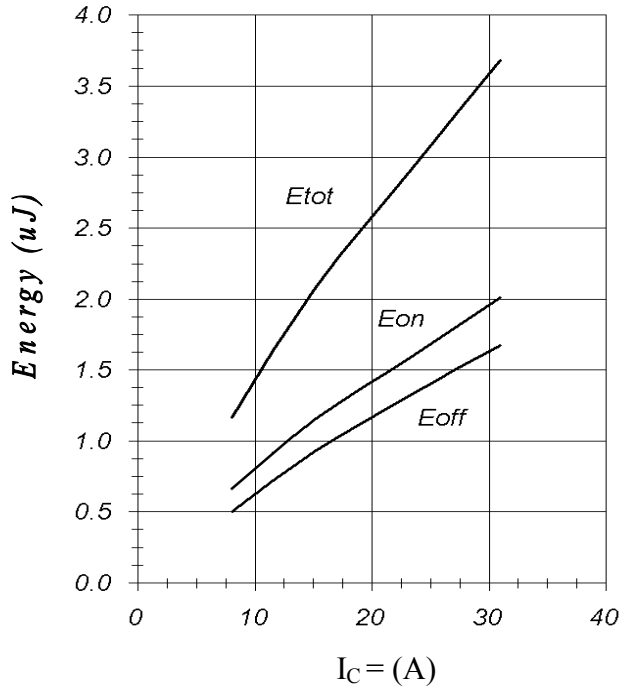


Fig. 14 – Typical Switching Time vs.  $I_C$   
 $T_j = 125^\circ\text{C}$ ;  $L = 500\mu\text{H}$ ;  $V_{CE} = 600\text{V}$ ;  
 $R_g = 10\Omega$ ;  $V_{GE} = 15\text{V}$

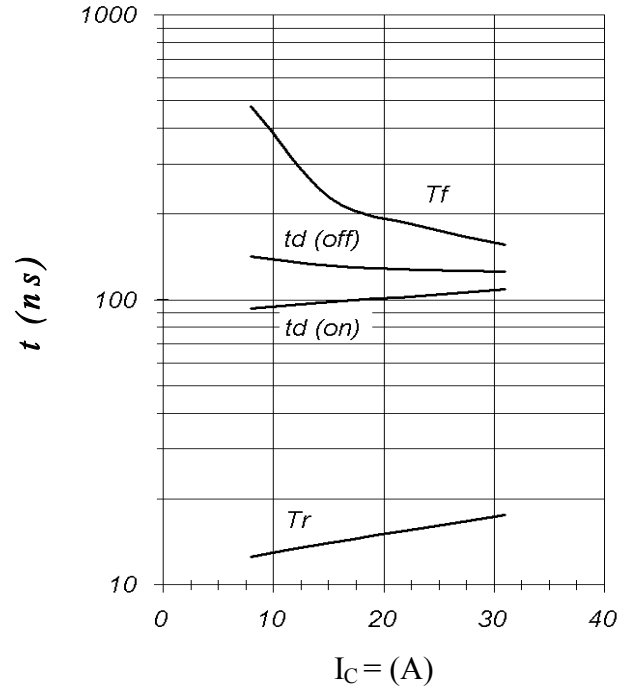


Fig. 15 – Typical Energy Loss vs.  $R_g$   
 $T_j = 125^\circ\text{C}$ ;  $L = 500\mu\text{H}$ ;  $V_{CE} = 600\text{V}$ ;  
 $I_{CE} = 15\text{A}$ ;  $V_{GE} = 15\text{V}$

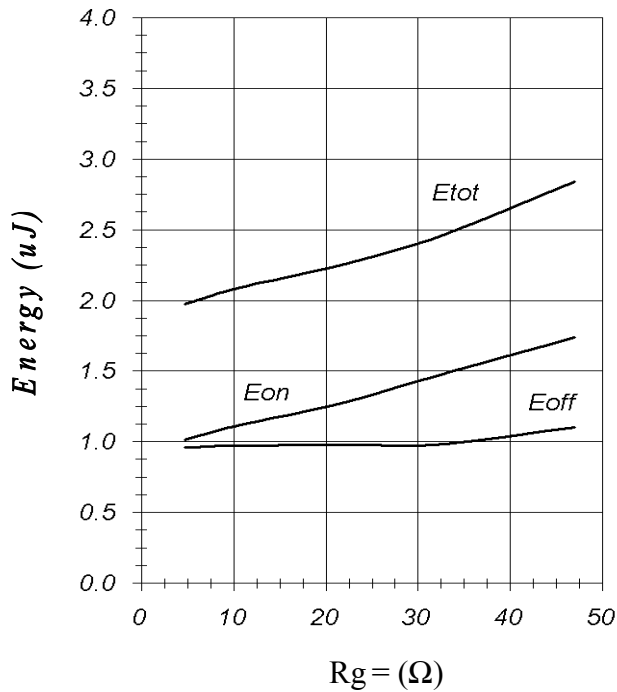


Fig. 16 – Typical Switching Time vs.  $R_g$   
 $T_j = 125^\circ\text{C}$ ;  $L = 500\mu\text{H}$ ;  $V_{CE} = 600\text{V}$ ;  
 $I_{CE} = 15\text{A}$ ;  $V_{GE} = 15\text{V}$

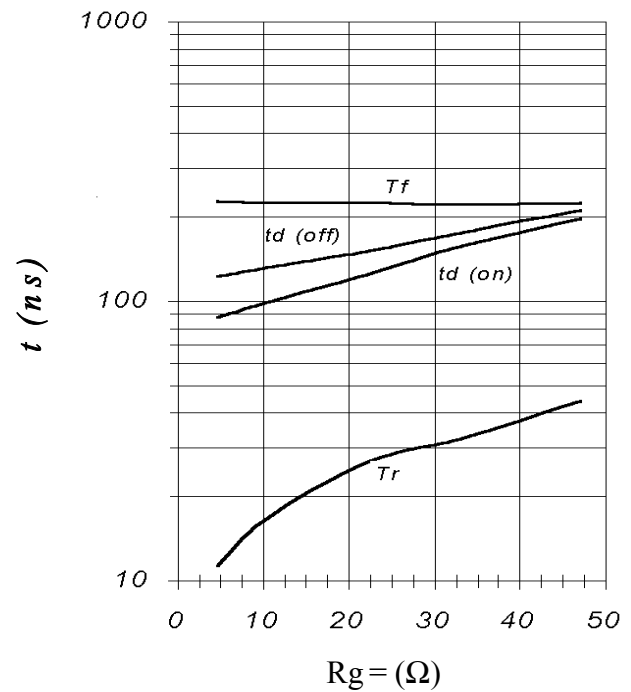


Fig. 17 – Typical Diode  $I_{RR}$  vs.  $I_F$   
 $T_j = 125^\circ\text{C}$

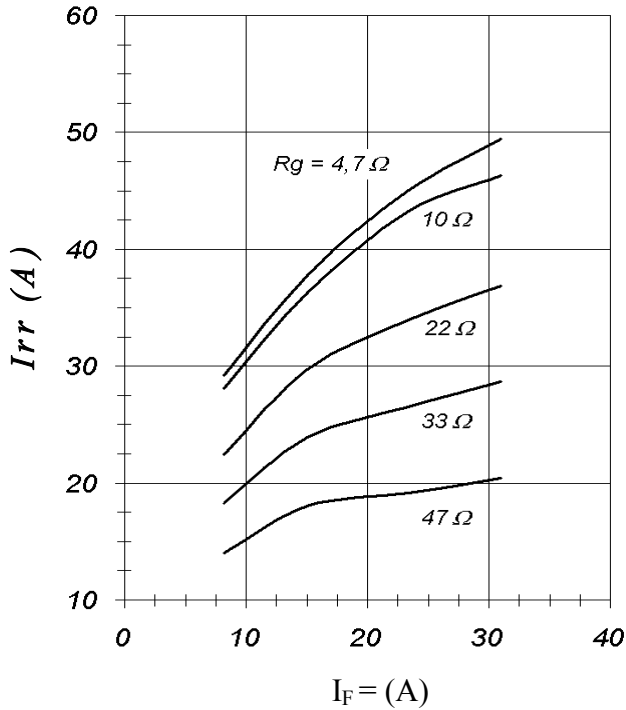


Fig. 18 – Typical Diode  $I_{RR}$  vs.  $R_g$   
 $I_F = 15\text{A}$ ;  $T_j = 125^\circ\text{C}$

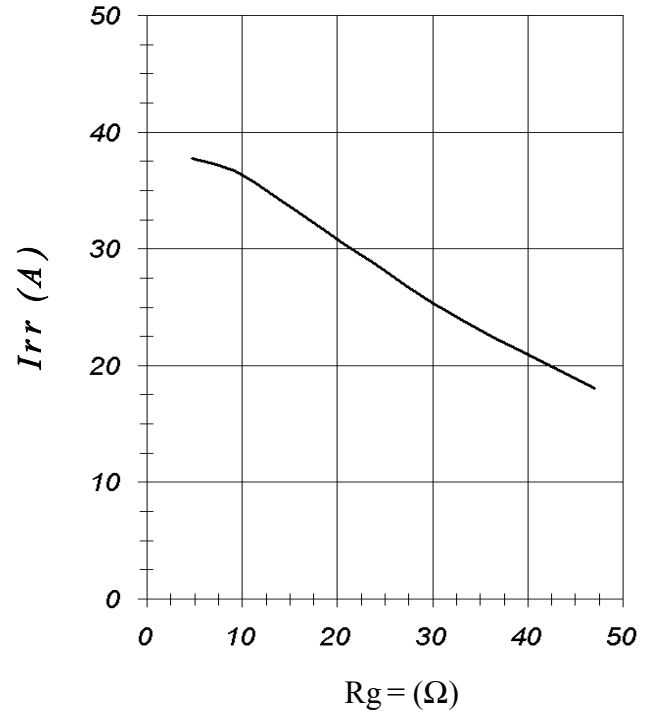


Fig. 19 – Typical Diode  $I_{RR}$  vs.  $dI_F/dt$   
 $V_{DC} = 600\text{V}$ ;  $V_{GE} = 15\text{V}$ ;  $I_F = 15\text{A}$ ;  $T_j = 125^\circ\text{C}$

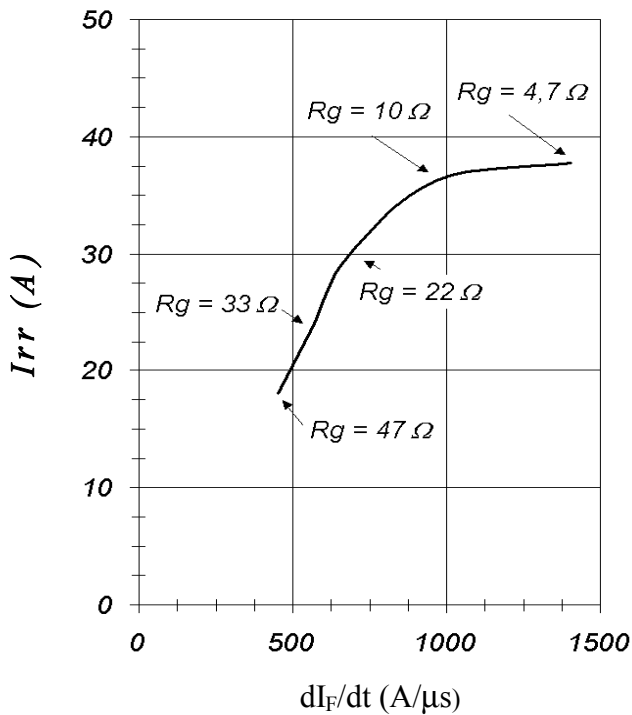


Fig. 20 – Typical Diode  $Q_{RR}$   
 $V_{DC} = 600\text{V}$ ;  $V_{GE} = 15\text{V}$ ;  $T_j = 125^\circ\text{C}$

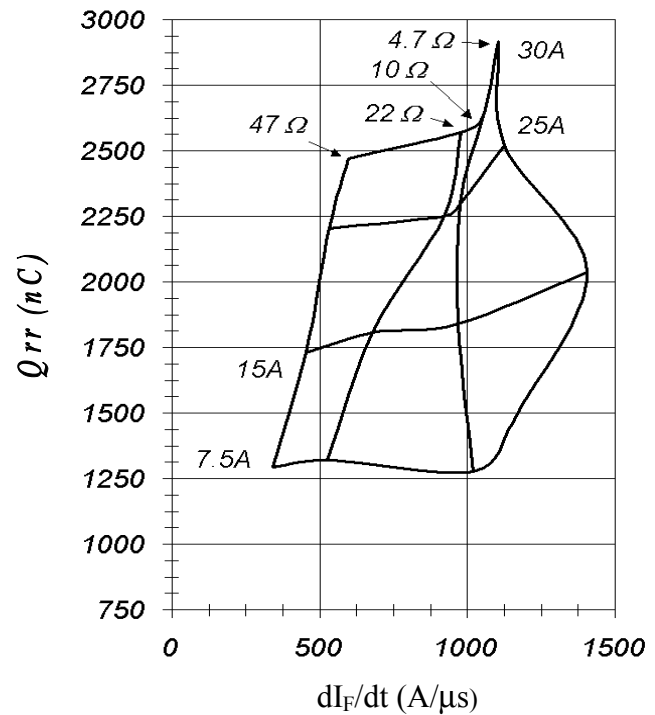


Fig. 21 – Typical Diode  $E_{REC}$  vs.  $I_F$   
 $T_j = 125^\circ\text{C}$

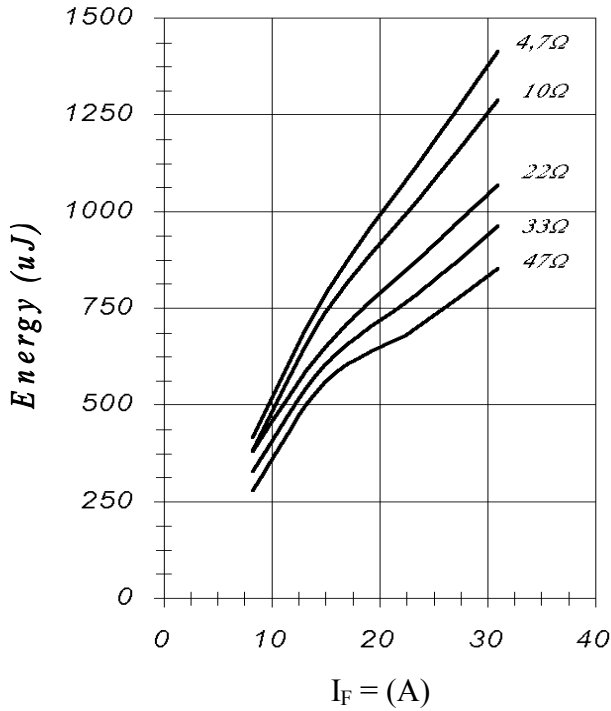


Fig. 22 – Typical Capacitance vs.  $V_{CE}$   
 $V_{GE} = 0\text{V}$ ;  $f = 1\text{MHz}$

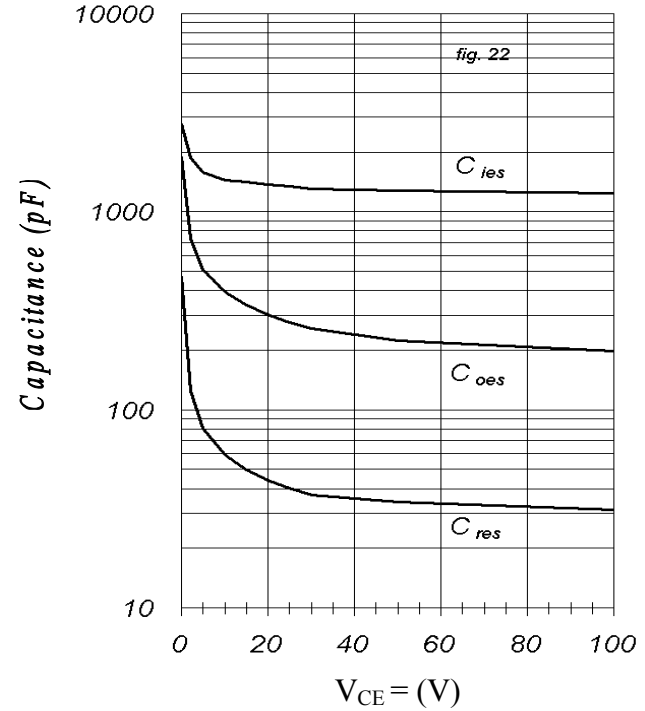


Fig. 23 – Typical Gate Charge vs.  $V_{GE}$   
 $I_C = 15\text{A}$ ;  $L = 600\mu\text{H}$ ;  $V_{CC} = 600\text{V}$

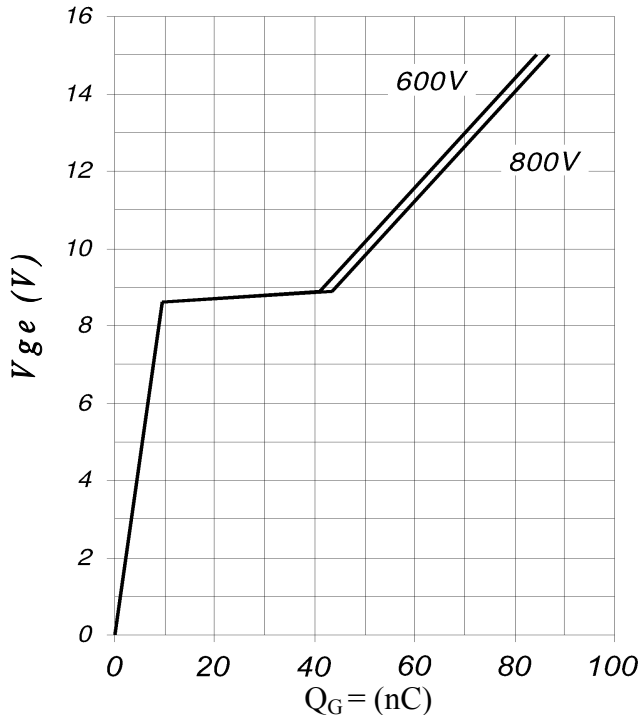


Fig. 24 – On state Voltage Drop characteristic  
 $V_{FM}$  vs  $I_F$   $t_p = 400\mu\text{s}$

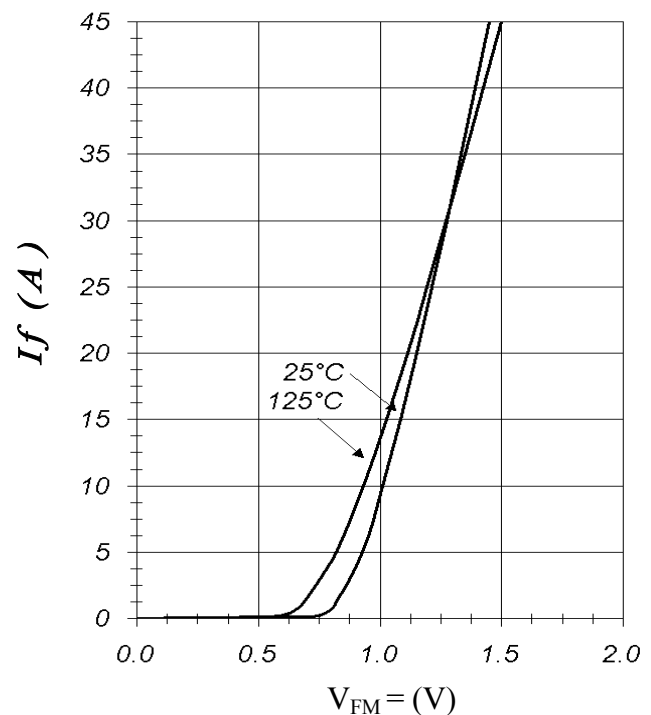


Fig. 25 – Normalized Transient Thermal Impedance, Junction-to-copper plate (IGBTs)

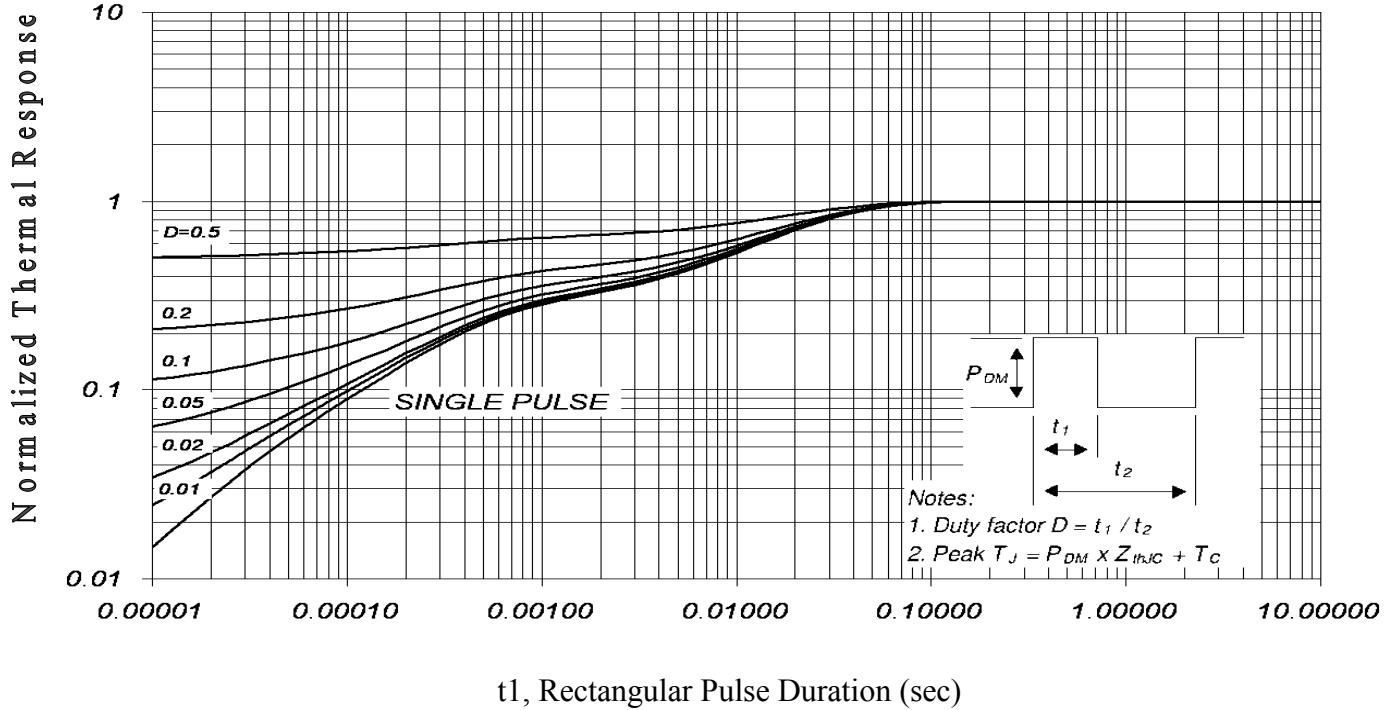


Fig. 26 – Normalized Transient Impedance, Junction-to-copper plate (FRED diodes)

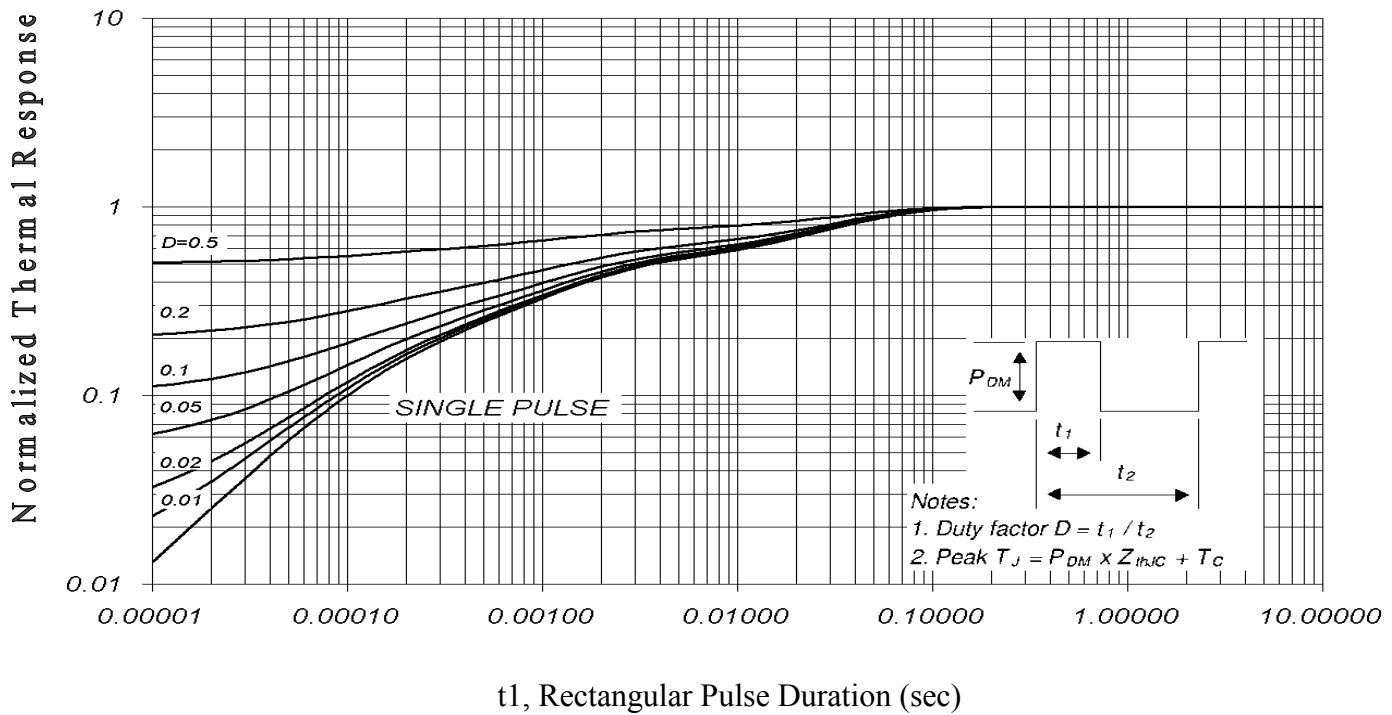


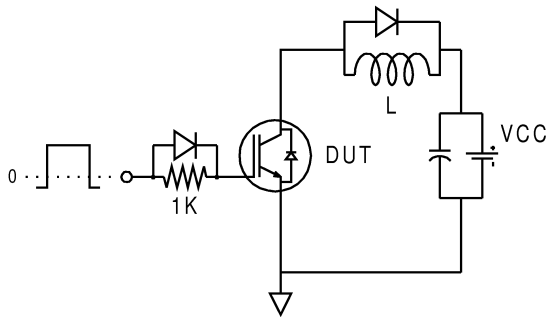
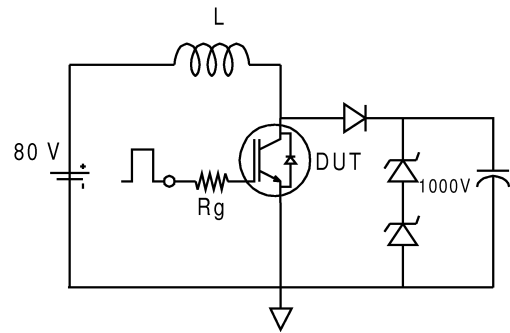
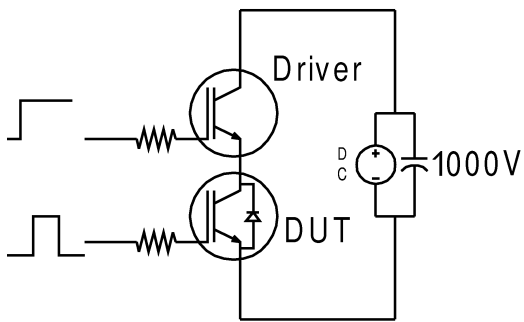
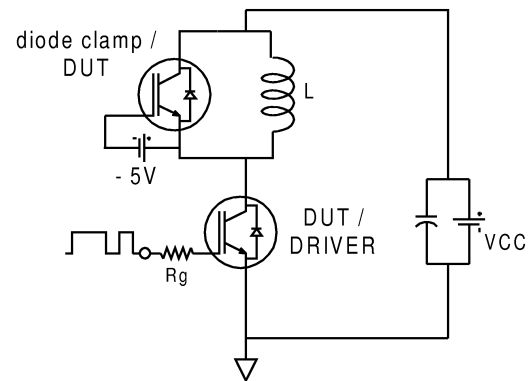
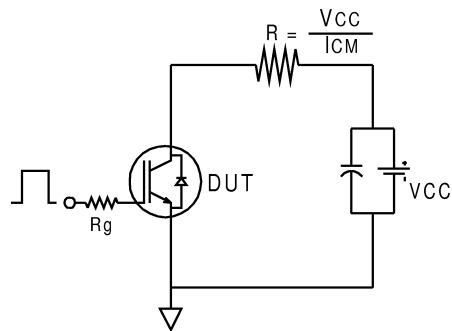
**Fig. CT.1 - Gate Charge Circuit (turn-off)****Fig. CT.2 - RBSOA Circuit****Fig. CT.3 - S.C. SOA Circuit****Fig. CT.4 - Switching Loss Circuit****Fig. CT.5 - Resistive Load Circuit**

**Fig. WF.1 - Typ. Turn-off Loss Waveform**  
@  $T_j=125^\circ\text{C}$  using Fig. CT.4

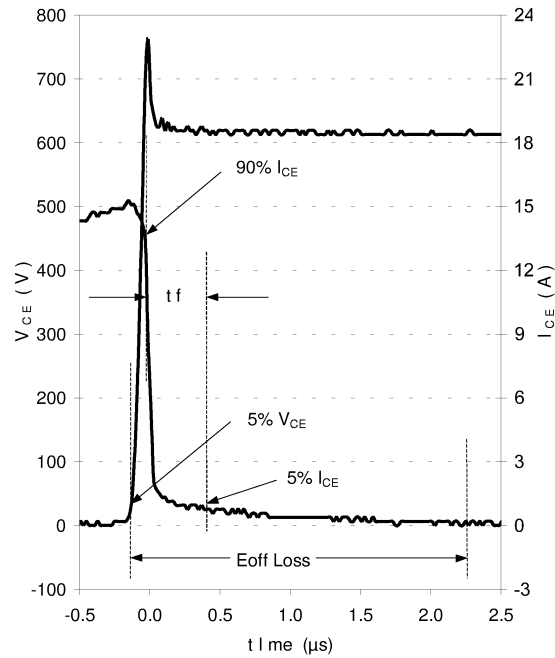


**Fig. WF.2 - Typ. Turn-on Loss Waveform**  
@  $T_j=125^\circ\text{C}$  using Fig. CT.4

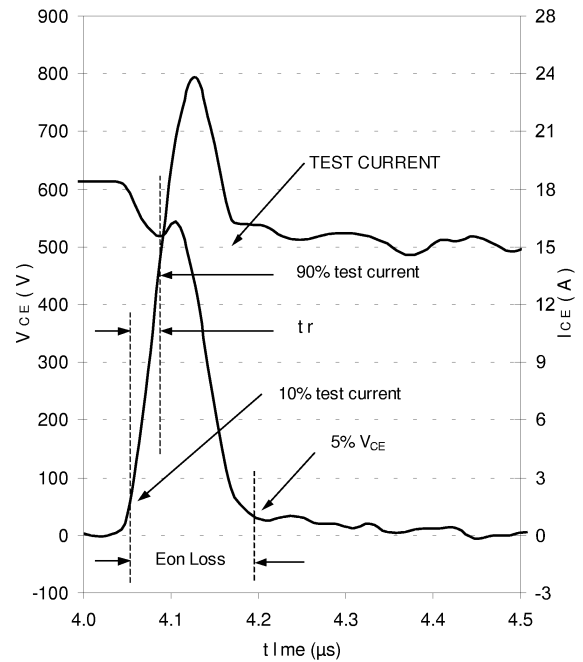


**Fig. WF.3 - Typ. Diode Recovery Waveform**  
@  $T_j=125^\circ\text{C}$  using Fig. CT.4

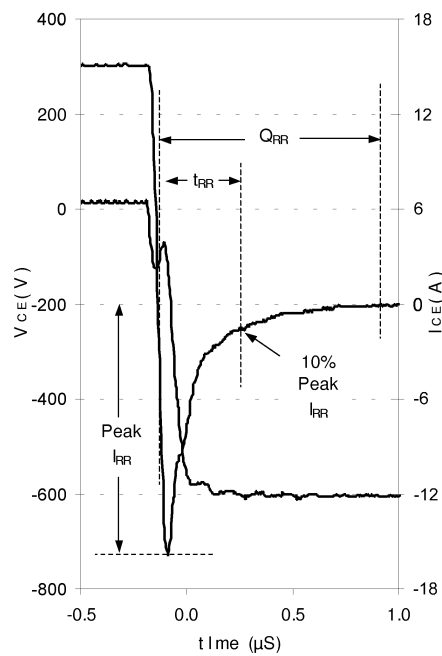


**Fig. WF.4 - Typ. S.C. Waveform**  
@  $T_C=150^\circ\text{C}$  using Fig. CT.3

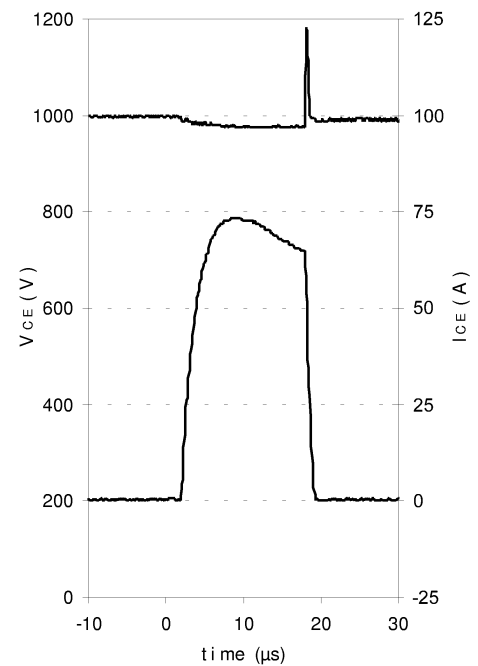


Fig. PD1 – Total Dissipated Power vs.  $f_{SW}$   
 $I_{out_{RMS}} = 2A$ ,  $V_{DC} = 530V$ ,  $T_C = 55^\circ C$

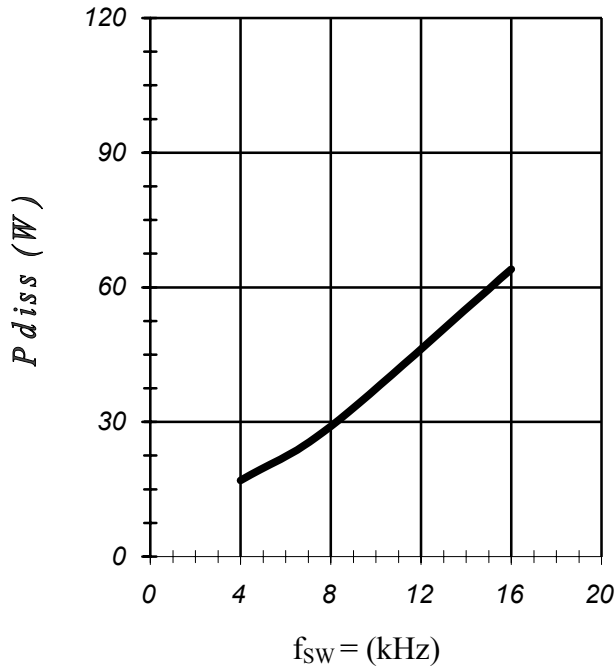


Fig. PD2 – Total Dissipated Power vs.  $f_{SW}$   
 $I_{out_{RMS}} = 3A$ ,  $V_{DC} = 530V$ ,  $T_C = 55^\circ C$

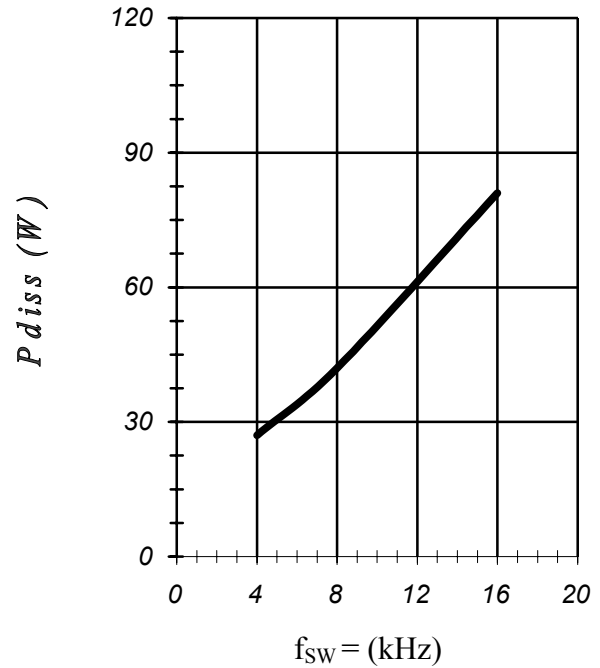


Fig. PD3 – Total Dissipated Power vs.  $f_{SW}$   
 $I_{out_{RMS}} = 7A$ ,  $V_{DC} = 530V$ ,  $T_C = 55^\circ C$

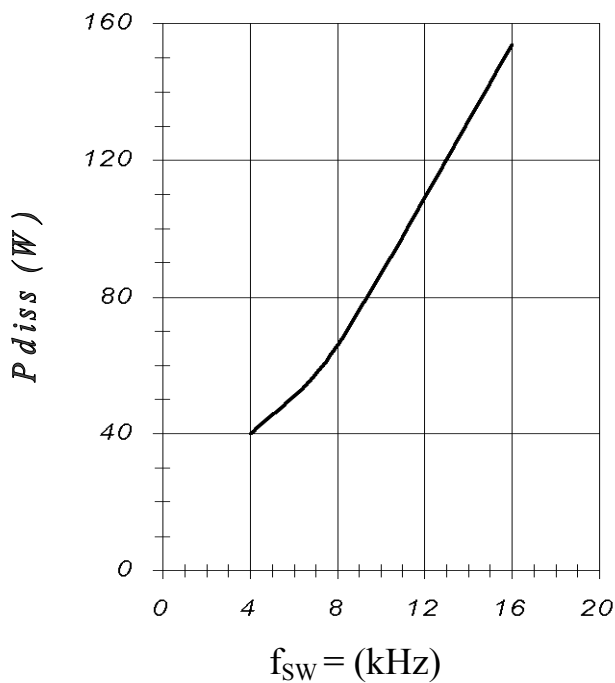
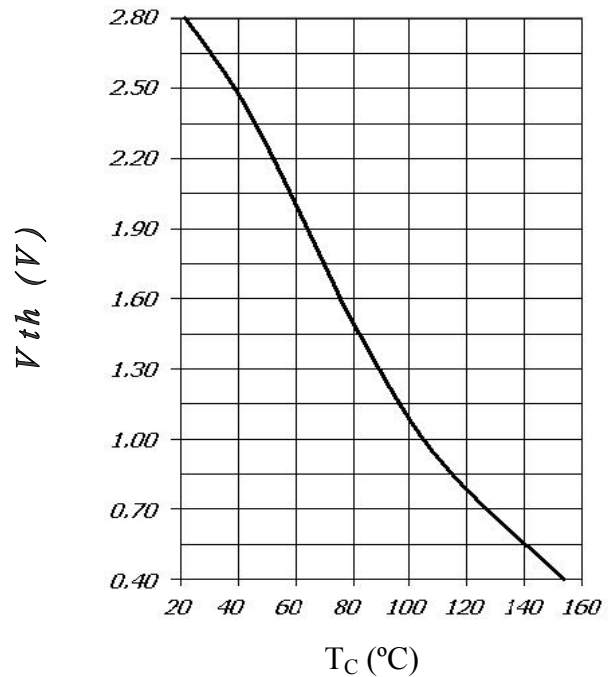
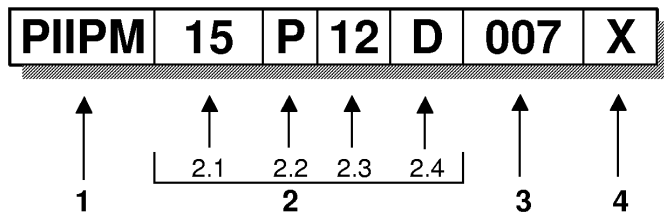


Fig. TF1 – Thermal Sensor Voltage Feedback vs. Base-plate Temperature



## PIIPM family part number identification



1- Device type (**P**rogrammable **I**solated **I**ntelligent **P**ower **M**odule)

2- Power package code

2.1- Current rating Code [A]

2.2- Sensing Resistors configuration

P = on 3 phases

Q = on 2 phases (\*)

R = on 1 phase (only for Matrix config.) (\*)

E = on 3 emitters

F = on 2 emitters (\*)

G = on 1 emitter (\*)

2.3- Voltage rating Code [V/100]

06 = 600V

12 = 1200V

2.4- Power Module configuration code

A = Bridge brake (\*)

B = Inverter

C = Inverter + brake

D = BBI (Bridge Brake Inverter)

M = Matrix (\*)

3- EDB configuration code

See detailed Block Diagram

4- Status code

X = Sample (product with pre-qualification approval)

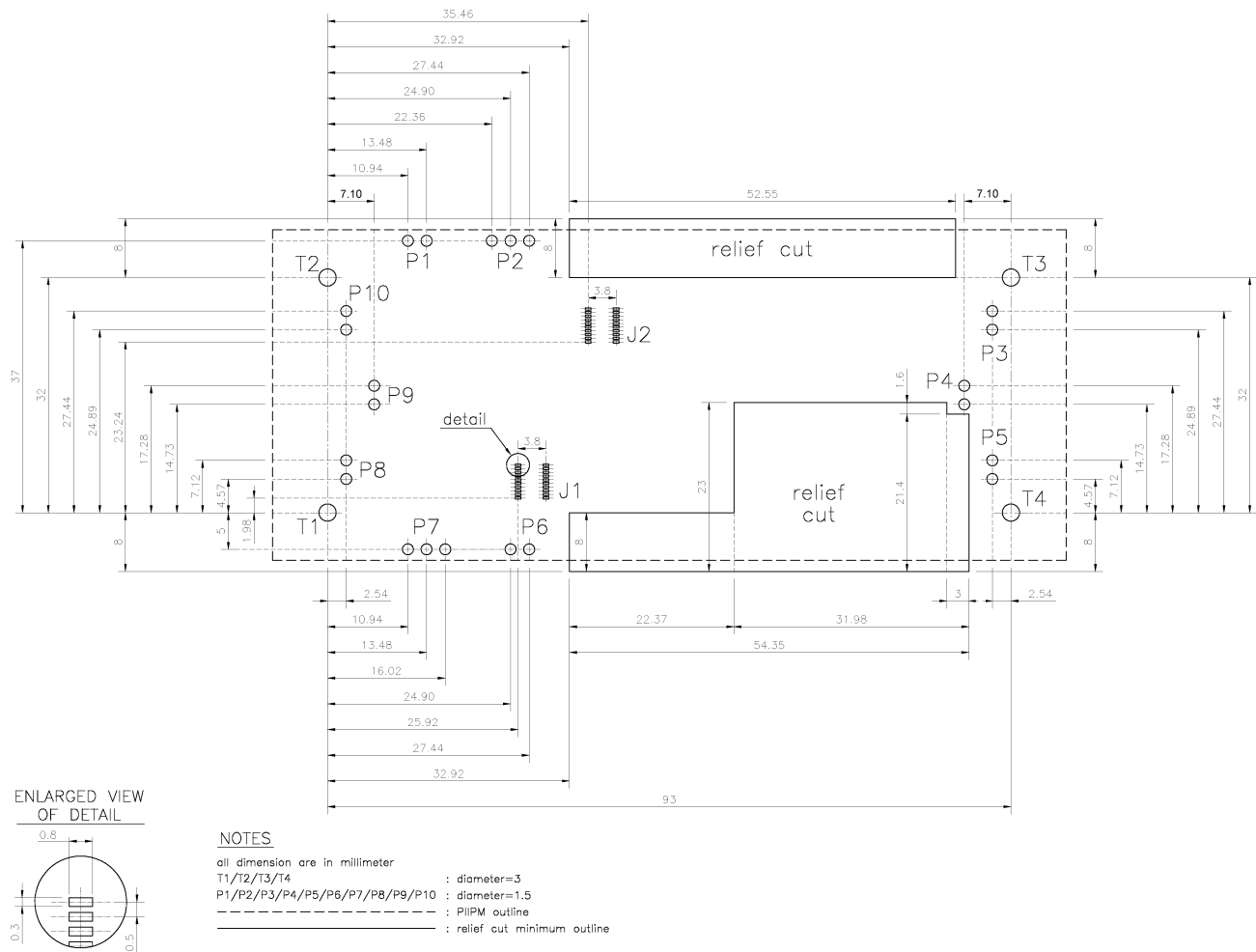
Mating connectors included in the box

blank = Fully qualified product

note: \*= contact factory for availability

## Top board suggested footprint

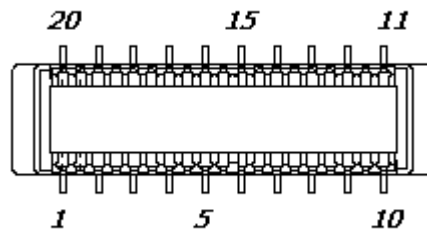
(top view)



## RS485 and JTAG Connectors

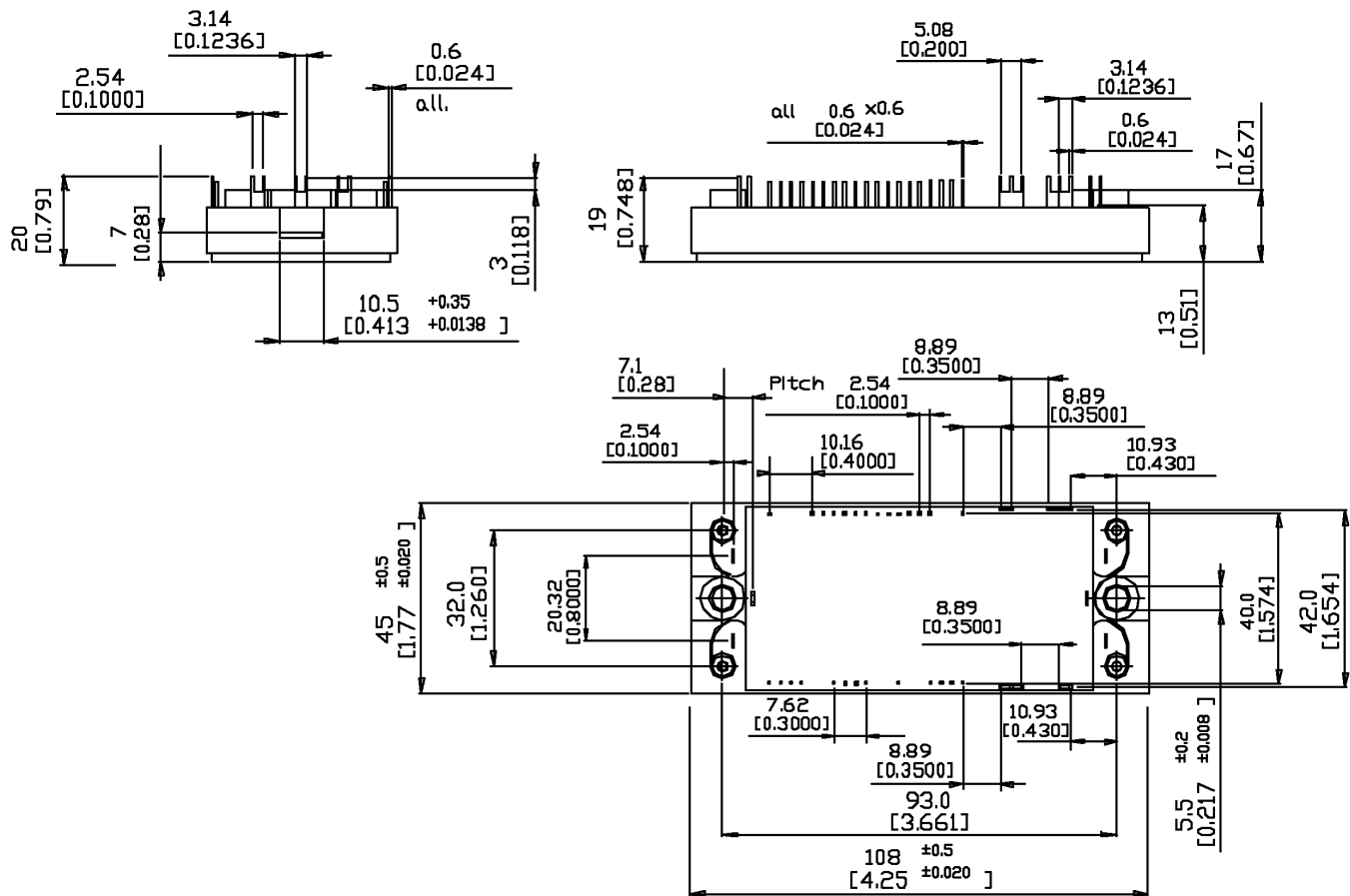
Top view

These connectors do not have any orientation tag; please check their Pin 1 position on Power Module Frame Pins Mapping before inserting mate part.



Molex 53916-0204  
mates with 54167-0208 or 52991-0208

## PIIPM15P12D007 case outline and dimensions



Data and specifications subject to change without notice  
This product has been designed and qualified for Industrial Level.  
Qualification Standards can be found on IR's Web Site.

International  
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IR WORLD HEADQUARTERS: 233 Kansas St., El Segundo, California 90245, Tel: (310) 3252 7105

TAC Fax: (310) 252 7309

Visit us at [www.irf.com](http://www.irf.com) for sales contact information 22 - Sep

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