

EMP50P12B

PIM+



EMP Features:

Power Module:

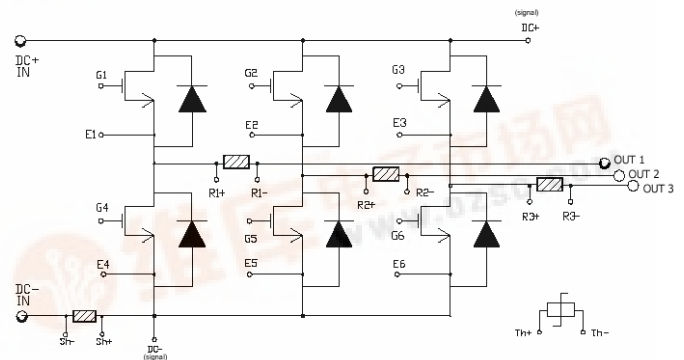
- NPT IGBTs 50A, 1200V
- 10us Short Circuit capability
 - Square RBSOA
 - Low $V_{ce(on)}$ (2.15Vtyp @ 50A, 25°C)
 - Positive $V_{ce(on)}$ temperature coefficient
- Gen III HexFred Technology
 - Low diode V_F (1.78Vtyp @ 50A, 25°C)
 - Soft reverse recovery
- 2mΩ sensing resistors on all phase outputs and DCbus minus rail
 - T/C < 50ppm/°C

Package:



EMP – Inverter (EconoPack 2 outline compatible)

Power Module schematic:



Three phase inverter with current sensing resistors on all output phases

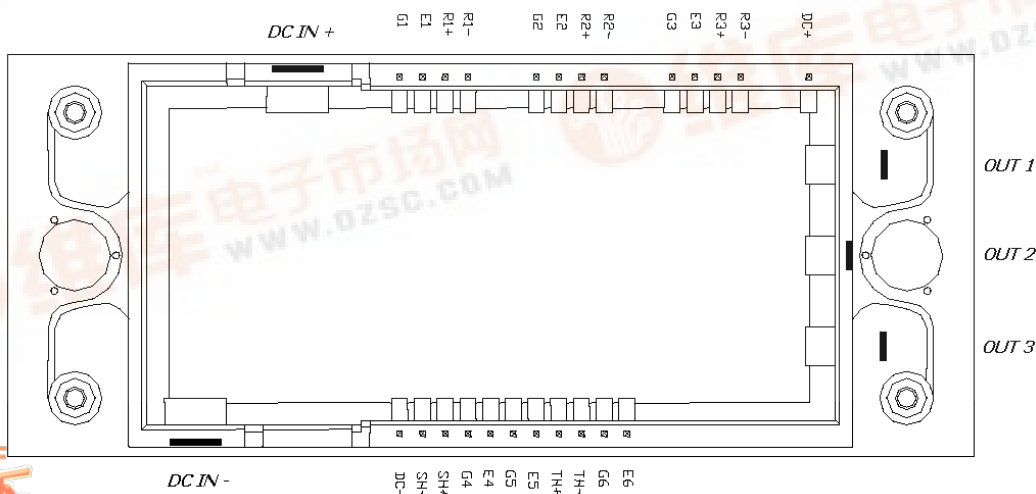
Description

The EMP50P12B is a Power Integrated Module for Motor Driver applications with embedded sensing resistors on all three-phase output currents.

Each sensing resistor's head is directly bonded to an external pin to reduce parasitic effects and achieve high accuracy on feedback voltages. Since their thermal coefficient is very low, no value compensation is required across the complete operating temperature range.

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

Power module frame pins mapping



Pins mapping

| Symbol | Lead Description |
|----------|---|
| DC IN+ | DC Bus plus power input pin |
| DC IN- | DC Bus minus power input pin |
| DC + | DC Bus plus signal connection (Kelvin point) |
| DC - | DC Bus minus signal connection (Kelvin point) |
| Th + | Thermal sensor positive input |
| Th - | Thermal sensor negative input |
| Sh + | DC Bus minus series shunt positive input (Kelvin point) |
| Sh - | DC Bus minus series shunt negative input (Kelvin point) |
| 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) |
| OUT1/2/3 | Three phase power output pins |

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 | V_{DC} | DC Bus Voltage | 0 | 1000 | V |
| | V_{CES} | Collector Emitter Voltage | 0 | 1200 | |
| | $I_C @ 100^{\circ}\text{C}$ | IGBTs continuous collector current ($T_C = 100^{\circ}\text{C}$) | | 50 | A |
| | $I_C @ 25^{\circ}\text{C}$ | IGBTs continuous collector current ($T_C = 25^{\circ}\text{C}$) | | 100 | |
| | I_{CM} | Pulsed Collector Current (Fig. 3, Fig. CT.5) | | 200 | |
| | $I_F @ 100^{\circ}\text{C}$ | Diode Continuous Forward Current ($T_C = 100^{\circ}\text{C}$) | | 50 | |
| | $I_F @ 25^{\circ}\text{C}$ | Diode Continuous Forward Current ($T_C = 25^{\circ}\text{C}$) | | 100 | |
| | I_{FM} | Diode Maximum Forward Current | | 200 | |
| | V_{GE} | Gate to Emitter Voltage | -20 | +20 | V |
| | $P_D @ 25^{\circ}\text{C}$ | Power Dissipation (One transistor) | | 354 | W |
| | $P_D @ 100^{\circ}\text{C}$ | Power Dissipation (One transistor, $T_C = 100^{\circ}\text{C}$) | | 142 | |
| Power Module | MT | Mounting Torque | | 3.5 | Nm |
| | T_J | Operating Junction Temperature | -40 | +150 | $^{\circ}\text{C}$ |
| | T_{STG} | Storage Temperature Range | -40 | +125 | |
| | Vc-iso | Isolation Voltage to Base Copper Plate | -2500 | +2500 | V |

Electrical Characteristics:

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

T_J = 25°C (unless otherwise specified)

| Symbol | Parameter Definition | Min. | Typ. | Max. | Units | Test Conditions | Fig. |
|---------------------------------------|---|------|------|------|-------|--|--------|
| V _{(BR)CES} | Collector To Emitter Breakdown Voltage | 1200 | | | V | V _{GE} = 0V, I _C = 250μA | |
| ΔV _{(BR)CES / ΔT} | Temperature Coeff. of Breakdown Voltage | | +1.2 | | V/°C | V _{GE} = 0V, I _C = 1mA (25 - 125 °C) | |
| V _{CE(on)} | Collector To Emitter Saturation Voltage | | 2.15 | 2.55 | V | I _C = 50A, V _{GE} = 15V | 5, 6 |
| | | | 2.70 | 3.78 | | I _C = 100A, V _{GE} = 15V | 7, 9 |
| | | | 2.45 | 3.22 | | I _C = 50A, V _{GE} = 15V, T _J = 125 °C | 10, 11 |
| V _{GE(th)} | Gate Threshold Voltage | 4.4 | 4.7 | 5.5 | V | V _{CE} = V _{GE} , I _C = 250μA | 12 |
| ΔV _{GE(th) / ΔT_J} | Temp. Coeff. of Threshold Voltage | | -1.2 | | mV/°C | V _{CE} = V _{GE} , I _C = 1mA (25 - 125 °C) | |
| g _{fe} | Forward Transconductance | 29 | 33 | 38 | S | V _{CE} = 50V, I _C = 50A, PW = 80μs | |
| I _{CES} | Zero Gate Voltage Collector Current | | | 500 | μA | V _{GE} = 0V, V _{CE} = 1200V | |
| | | | 650 | 1350 | | V _{GE} = 0V, V _{CE} = 1200V, T _J = 125 °C | |
| | | | | 4000 | | V _{GE} = 0V, V _{CE} = 1200V, T _J = 150 °C | |
| V _{FM} | Diode Forward Voltage Drop | | 1.78 | 2.1 | V | I _C = 50A | 8 |
| | | | 1.90 | 2.22 | | I _C = 50A, T _J = 125 °C | 8 |
| I _{RM} | Diode Reverse Leakage Current | | | 20 | μA | V _R = 1200V, T _J = 25 °C | |
| I _{GES} | Gate To Emitter Leakage Current | | | ±200 | nA | V _{GE} = 20V | |
| R1/2/3 | Sensing Resistors | 1.98 | 2 | 2.02 | mΩ | | |
| Rsh | DC bus minus series shunt resistor | 1.98 | 2 | 2.02 | | | |

General Description

The EMP module contains six IGBTs and HexFreds Diodes in a standard inverter configuration. IGBTs used are the new NPT 1200V-50A (current rating measured at 100C°), generation V from International Rectifier; the HexFred diodes have been designed specifically as pair elements for these power transistors. Thanks to the new design and technological realization, these devices do not need any negative gate voltage for their complete turn off; moreover the tail effect is also substantially reduced compared to competitive devices of the same family. This feature tremendously simplifies the gate driving stage. Another innovative feature in this type of power modules is the presence of sensing resistors in the three output phases, for precise motor current sensing and short circuit protections, as well as another resistor of the same value in the DC bus minus line, needed only for device protections purposes. A complete schematic of the EMP module is shown on page 1 where all sensing resistors have been clearly evidenced, a thermal sensor with negative temperature coefficient is also embedded in the device structure.

The package chosen is mechanically compatible with the well known EconoPack outline, Also the height of the plastic cylindrical nuts for the external PCB positioned on

its top is the same as the EconoPack II, so that, with the only re-layout of the main motherboard, this module can fit into the same mechanical fixings of the standard EconoPack II package thus speeding up the device evaluation in an already existing driver. An important feature of this new device is the presence of Kelvin connections for all feedback and command signals between the board and the module with the advantage of having all emitter and resistor sensing independent from the main power path. The final benefit is that all low power signal from/to the controlling board are unaffected by parasitic inductances or resistances inevitably present in the module power layout. The new package outline is shown on bottom of page 1. Notice that because of high current spikes on those inputs the DC bus power pins are doubled in size compared to the other power pins. Module technology uses the standard and well know DBC (Direct Bondable Copper): over a thick Copper base an alumina (Al₂O₃) substrate with a 300μm copper foil on both side is placed and IGBTs and Diodes dies are directly soldered, through screen printing process. These dies are then bonded with a 15 mils aluminum wire for power and signal connections. All components are then completely covered by a silicone gel for mechanical protection and electrical isolation purposes.

Switching Characteristics:

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

T_J = 25°C (unless otherwise specified)

| Symbol | Parameter Definition | Min | Typ | Max | Units | Test Conditions | Fig. |
|---------------------|---|-------------|-------|-------|-------|---|------------------------------------|
| Q _g | Total Gate Charge (turn off) | | 400 | 411 | nC | I _C = 50A | 23 CT1 |
| Q _{ge} | Gate – Emitter Charge (turn off) | | 46 | 55 | | V _{CC} = 600V | |
| Q _{gc} | Gate – Collector Charge (turn off) | | 181 | 200 | | V _{GE} = 15V | |
| E _{on} | Turn on Switching Loss | | 2814 | 3220 | μJ | I _C = 50A, V _{CC} = 600V, T _J = 25 °C | CT4 WF1 WF2 |
| E _{off} | Turn off Switching Loss | | 5293 | 5825 | | V _{GE} = 15V, R _G = 10Ω, L = 250μH | |
| E _{tot} | Total Switching Loss | | 8107 | 9145 | | Tail and Diode Rev. Recovery included | |
| E _{on} | Turn on Switching Loss | | 3963 | 4415 | μJ | I _C = 50A, V _{CC} = 600V, T _J = 125 °C | 13, 15 CT4 WF1 WF2 |
| E _{off} | Turn off Switching Loss | | 7810 | 8965 | | V _{GE} = 15V, R _G = 10Ω, L = 250μH | |
| E _{tot} | Total Switching Loss | | 11773 | 13380 | | Tail and Diode Rev. Recovery included | |
| td (on) | Turn on delay time | | 66 | 72 | ns | I _C = 50A, V _{CC} = 600V, T _J = 125 °C V _{GE} = 15V, R _G = 10Ω, L = 250μH | 14,16 CT4 WF1 WF2 |
| Tr | Rise time | | 72 | 83 | | | |
| td (off) | Turn off delay time | | 593 | 641 | | | |
| Tf | Fall time | | 95 | 117 | | | |
| C _{ies} | Input Capacitance | | 5884 | 6052 | pF | V _{CC} = 30V | 22 |
| C _{oes} | Output Capacitance | | 950 | 968 | | V _{GE} = 0V | |
| C _{res} | Reverse Transfer Capacitance | | 167 | 193 | | f = 1MHz | |
| RBSOA | Reverse Bias Safe Operating Area | FULL SQUARE | | | | T _J = 150 °C, I _C = 200A, V _{GE} = 15V to 0V V _{CC} = 1000V, V _p = 1200V, R _G = 5Ω | 4 CT2 |
| SCSOA | Short Circuit Safe Operating Area | 10 | | | μs | T _J = 150 °C, V _{GE} = 15V to 0V V _{CC} = 900V, V _p = 1200V, R _G = 5Ω | CT3 WF4 |
| E _{REC} | Diode reverse recovery energy | 693 | 1114 | 1535 | μJ | T _J = 125 °C | 17,18 19,20 21 CT4 WF3 |
| t _{rr} | Diode reverse recovery time | 156 | 260 | 363 | ns | I _F = 50A, V _{CC} = 600V, | |
| I _{rr} | Peak reverse recovery current | 35 | 42 | 43 | A | V _{GE} = 15V, R _G = 10Ω, L = 250μH | |
| R _{thJC-T} | Each IGBT to copper plate thermal resistance | | | 0.35 | °C/W | See also fig.24 and 25 | 24,25 |
| R _{thJC-D} | Each Diode to copper plate thermal resistance | | | 0.70 | °C/W | | |
| R _{thC-H} | Module copper plate to heat sink thermal resistance. Silicon grease applied = 0.1mm | | | 0.03 | °C/W | | |
| P _{diss} | Total Dissipated Power | | 100 | | W | I _C = 7A, V _{DC} = 530V, f _{sw} = 8kHz, T _C = 55 °C | PD1 |
| | | | 150 | | | I _C = 10A, V _{DC} = 530V, f _{sw} = 8kHz, T _C = 55 °C | PD2 |
| | | | 250 | | | I _C = 10A, V _{DC} = 530V, f _{sw} = 16kHz T _C = 55 °C, | PD3 |
| | | | 200 | | | I _C = 20A, V _{DC} = 530V, f _{sw} = 4kHz, T _C = 40°C | |

Fig. 1 – Maximum DC collector Current vs. case temperature

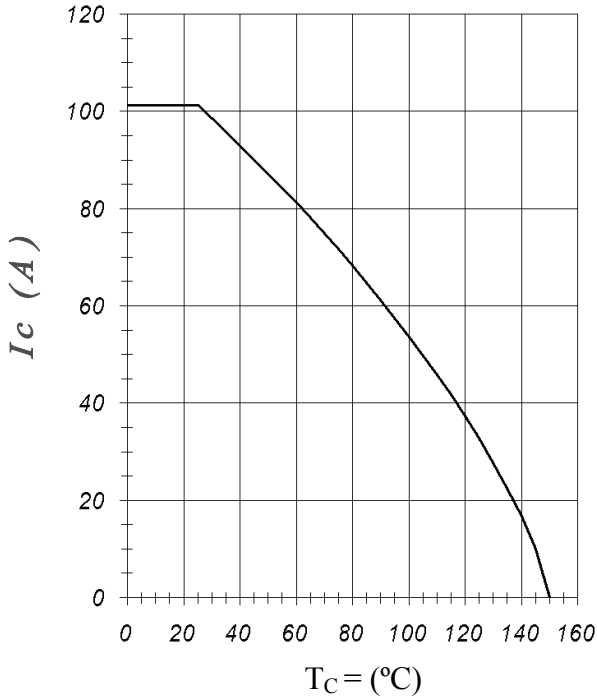


Fig. 2 – Power Dissipation vs. Case Temperature

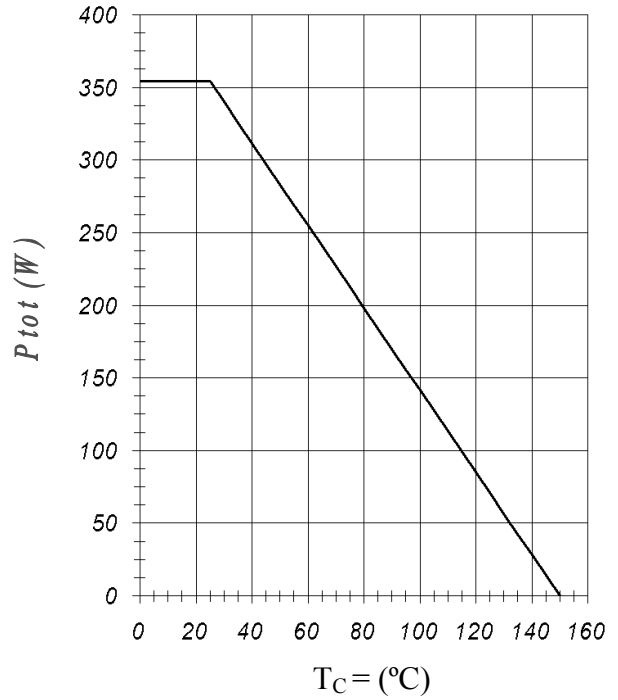


Fig. 3 – Forward SOA
 $T_c = 25^\circ\text{C}; T_j \leq 150^\circ\text{C}$

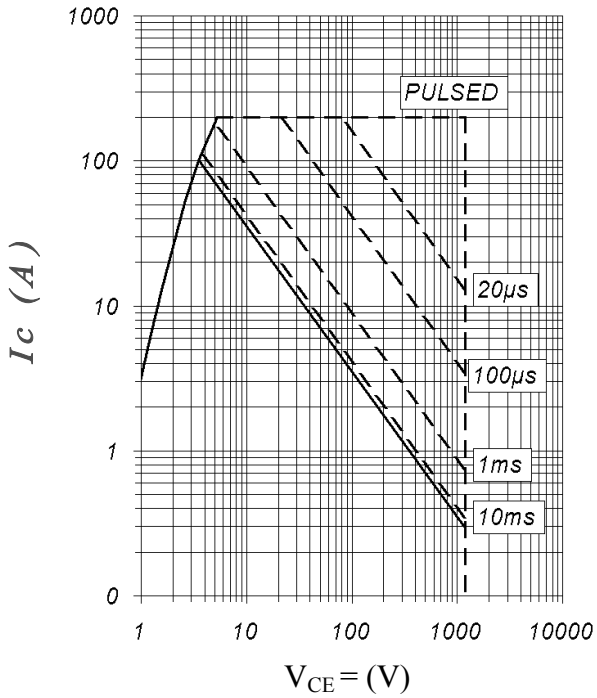


Fig. 4 – Reverse Bias SOA
 $T_j = 150^\circ\text{C}, V_{GE} = 15\text{V}$

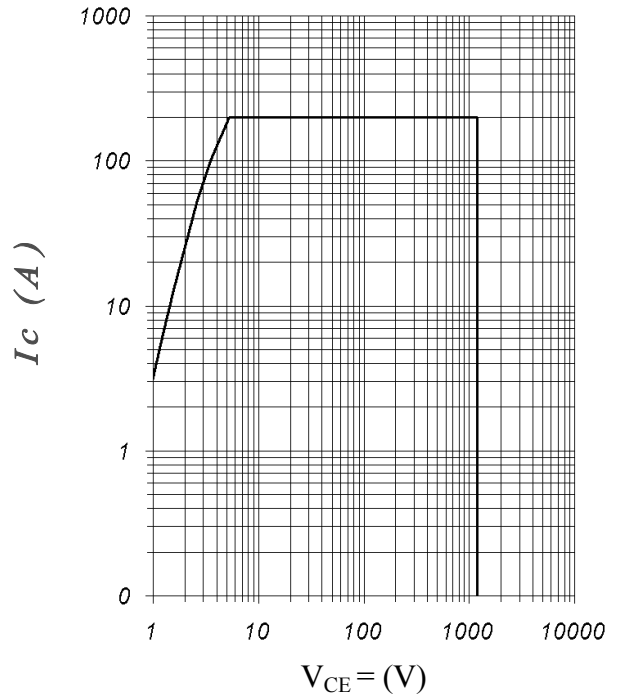


Fig. 5 – Typical IGBT Output Characteristics
 $T_j = -40^{\circ}\text{C}$; $t_p = 500\mu\text{s}$

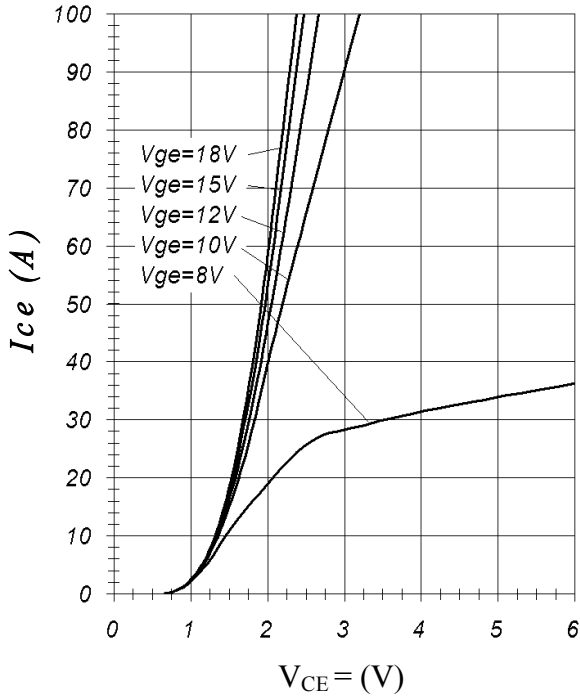


Fig. 6 – Typical IGBT Output characteristics
 $T_j = 25^{\circ}\text{C}$; $t_p = 500\mu\text{s}$

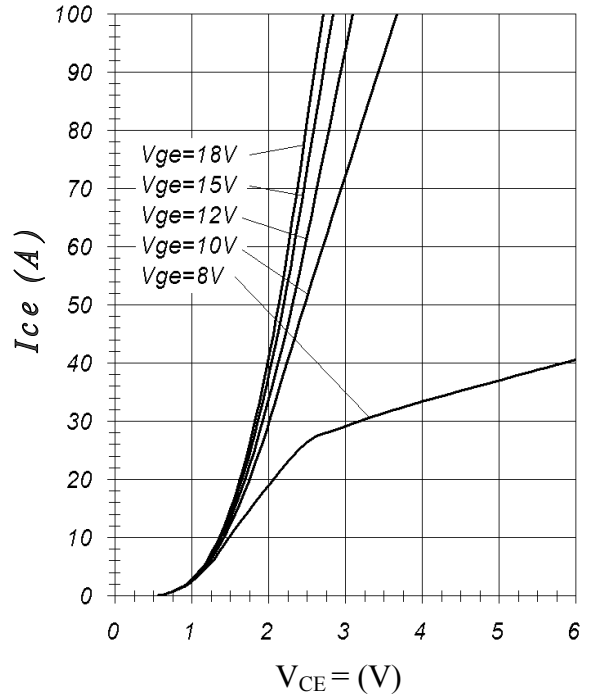


Fig. 7 – Typical IGBT Output Characteristics
 $T_j = 125^{\circ}\text{C}$; $t_p = 500\mu\text{s}$

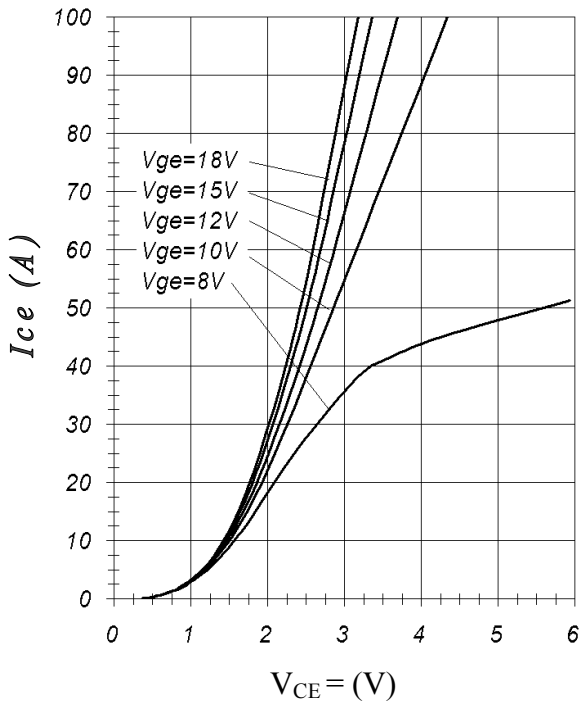


Fig. 8 – Typical Diode Forward Characteristics
 $t_p = 500\mu\text{s}$

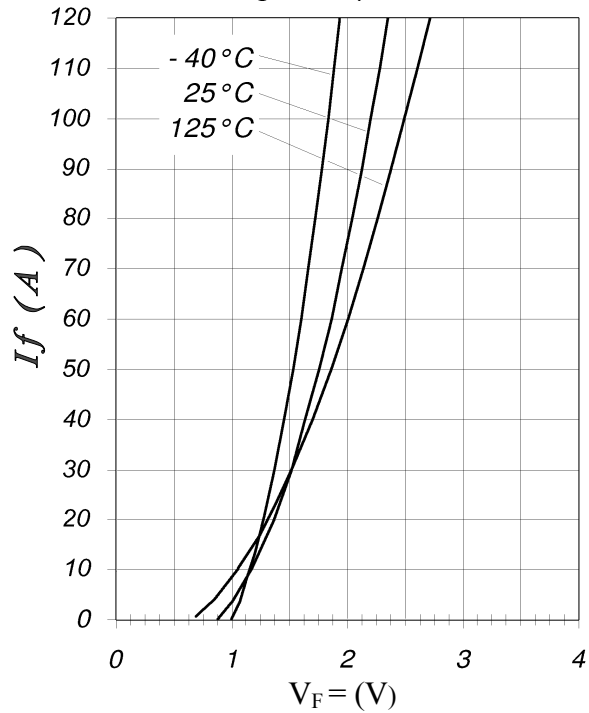


Fig. 9 – Typical V_{CE} vs. V_{GE}
 $T_j = -40^\circ\text{C}$

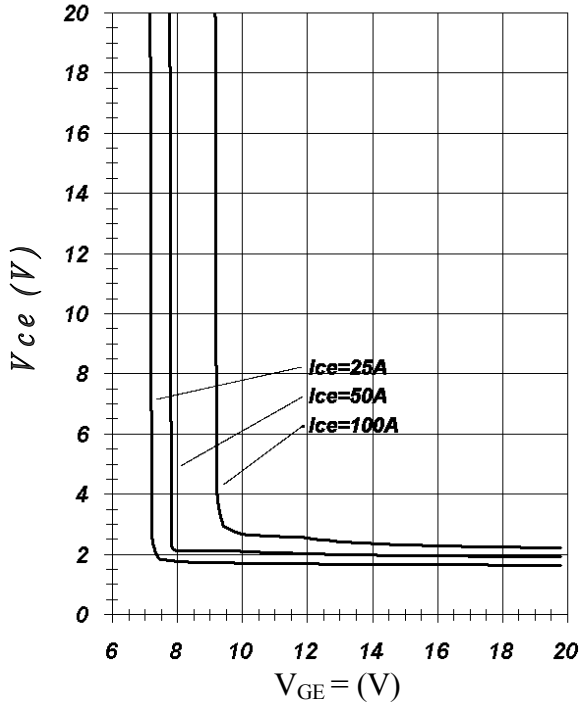


Fig. 10 – Typical V_{CE} vs. V_{GE}
 $T_j = 25^\circ\text{C}$

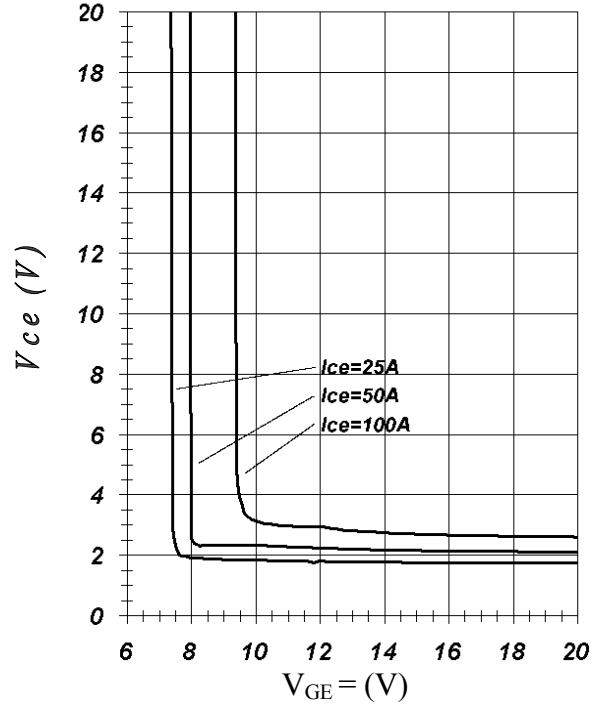


Fig. 11 – Typical V_{CE} vs. V_{GE}
 $T_j = 125^\circ\text{C}$

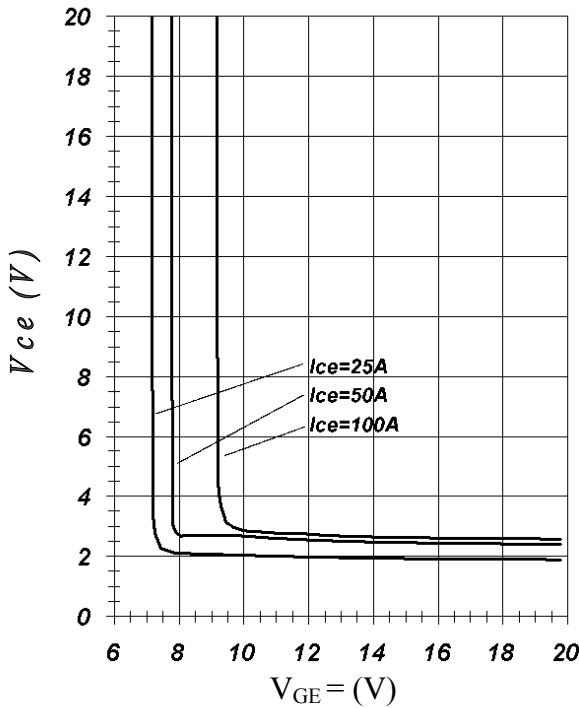


Fig. 12 – Typical Transfer Characteristics
 $V_{CE} = 20\text{V}$; $t_p = 20\mu\text{s}$

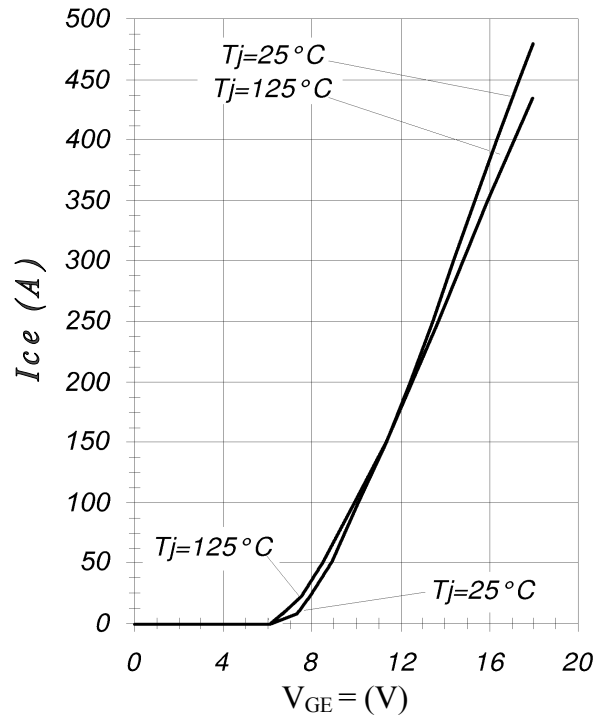


Fig. 13 – Typical Energy Loss vs. I_C
 $T_j = 125^\circ\text{C}$; $L = 250\mu\text{H}$; $V_{CE} = 600\text{V}$;
 $R_g = 10\Omega$; $V_{GE} = 15\text{V}$

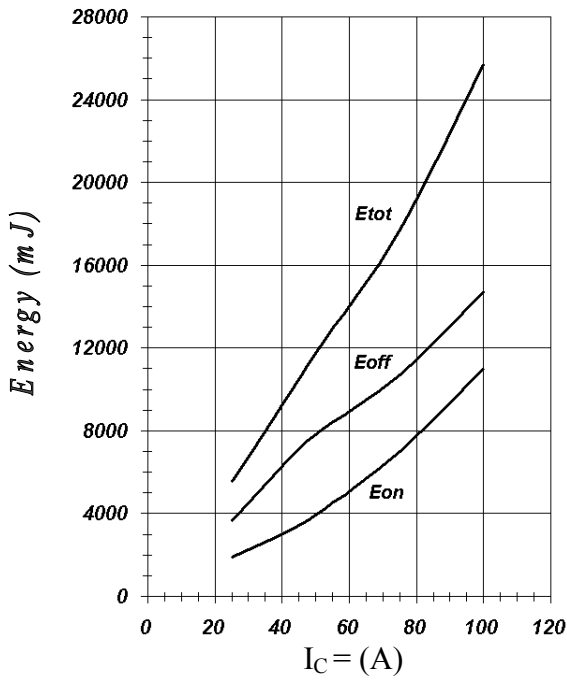


Fig. 14 – Typical Switching Time vs. I_C
 $T_j = 125^\circ\text{C}$; $L = 250\mu\text{H}$; $V_{CE} = 600\text{V}$;
 $R_g = 10\Omega$; $V_{GE} = 15\text{V}$

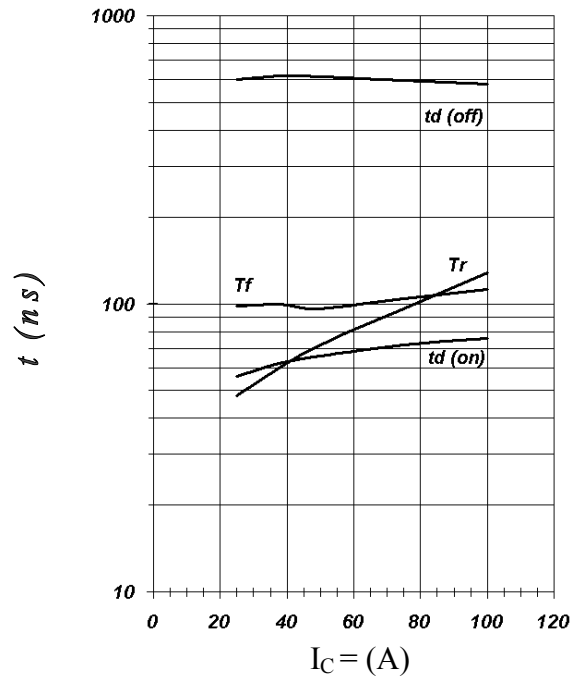


Fig. 15 – Typical Energy Loss vs. R_g
 $T_j = 125^\circ\text{C}$; $L = 250\mu\text{H}$; $V_{CE} = 600\text{V}$;
 $I_{CE} = 50\text{A}$; $V_{GE} = 15\text{V}$

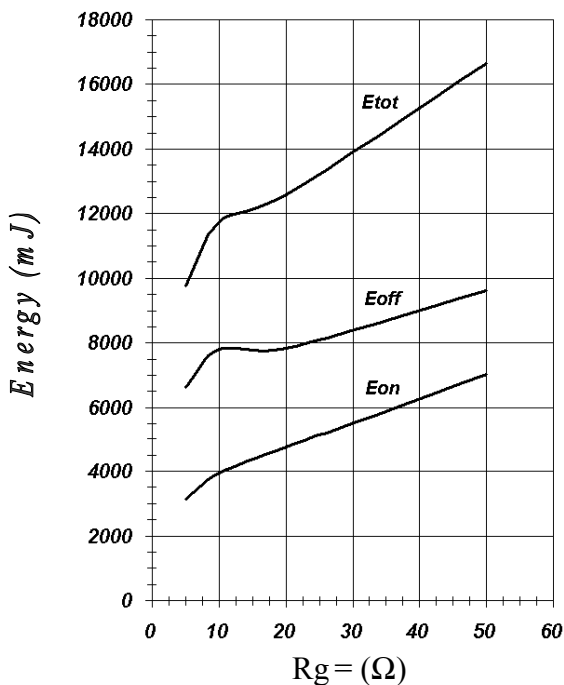


Fig. 16 – Typical Switching Time vs. R_g
 $T_j = 125^\circ\text{C}$; $L = 250\mu\text{H}$; $V_{CE} = 600\text{V}$;
 $I_{CE} = 50\text{A}$; $V_{GE} = 15\text{V}$

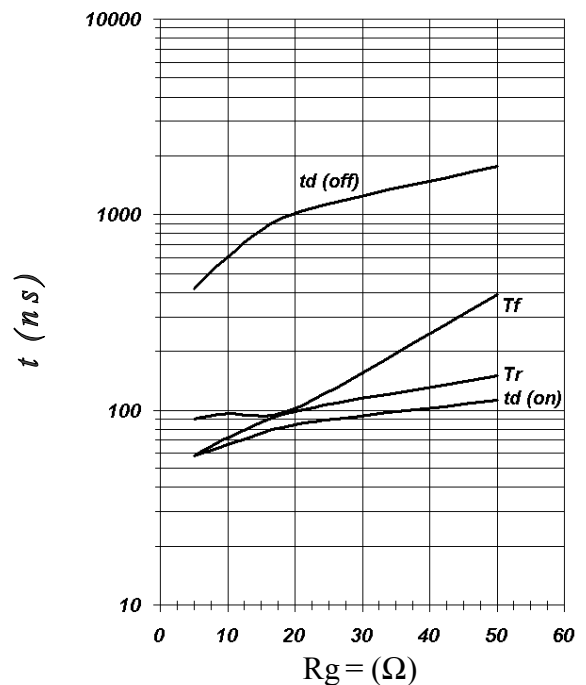


Fig. 17 – Typical Diode I_{RR} vs. I_F
 $T_j = 125^\circ\text{C}$

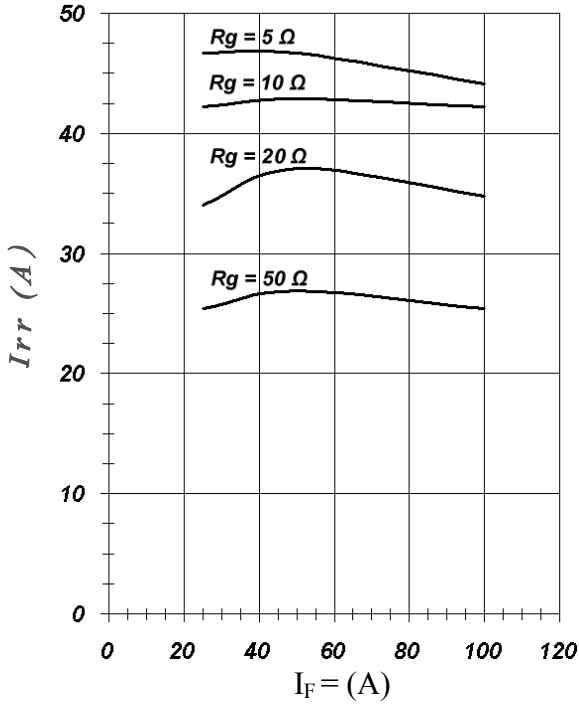


Fig. 18 – Typical Diode I_{RR} vs. R_g
 $I_F = 50\text{A}; T_j = 125^\circ\text{C}$

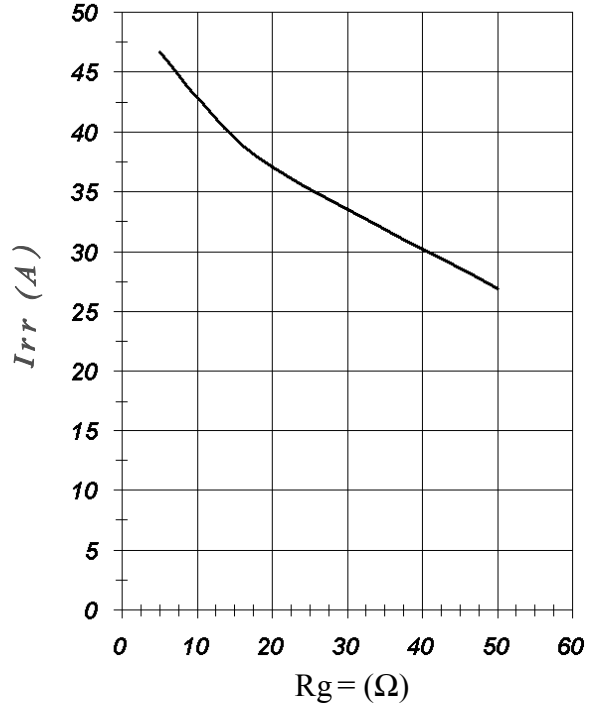


Fig. 19 – Typical Diode I_{RR} vs. dI_F/dt
 $V_{DC} = 600\text{V}; V_{GE} = 15\text{V}; I_F = 50\text{A}; T_j = 125^\circ\text{C}$

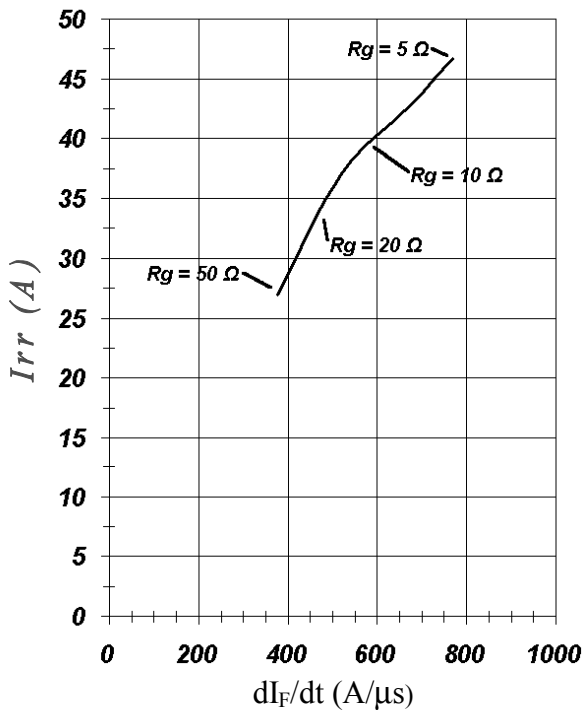


Fig. 20 – Typical Diode Q_{RR}
 $V_{DC} = 600\text{V}; V_{GE} = 15\text{V}; T_j = 125^\circ\text{C}$

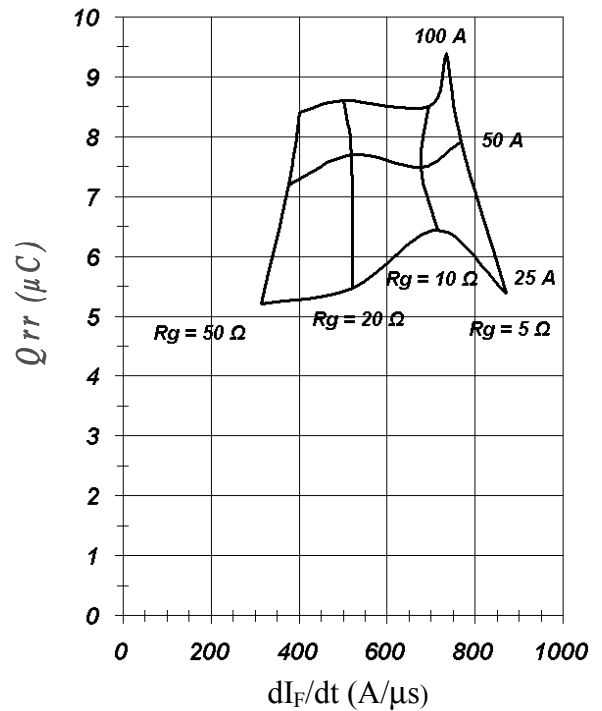


Fig. 21 – Typical Diode E_{REC} vs. I_F
 $T_j = 125^\circ\text{C}$

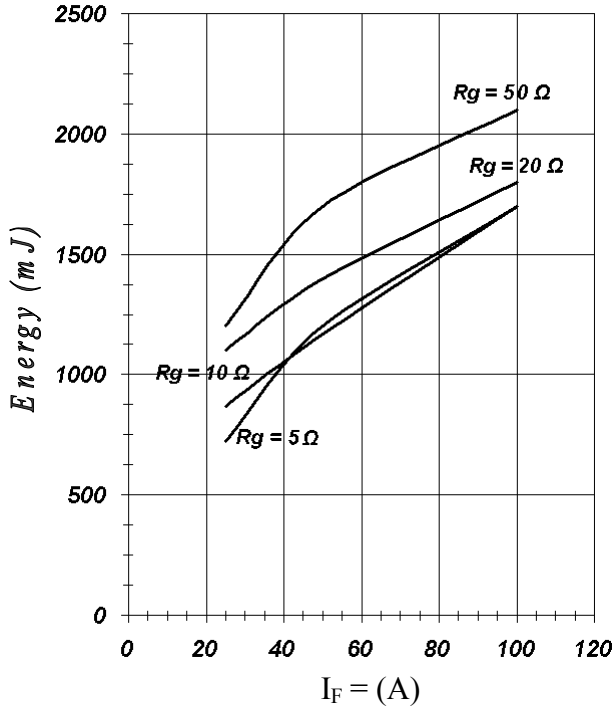


Fig. 22 – Typical Capacitance vs. V_{CE}
 $V_{GE} = 0\text{V}$; $f = 1\text{MHz}$

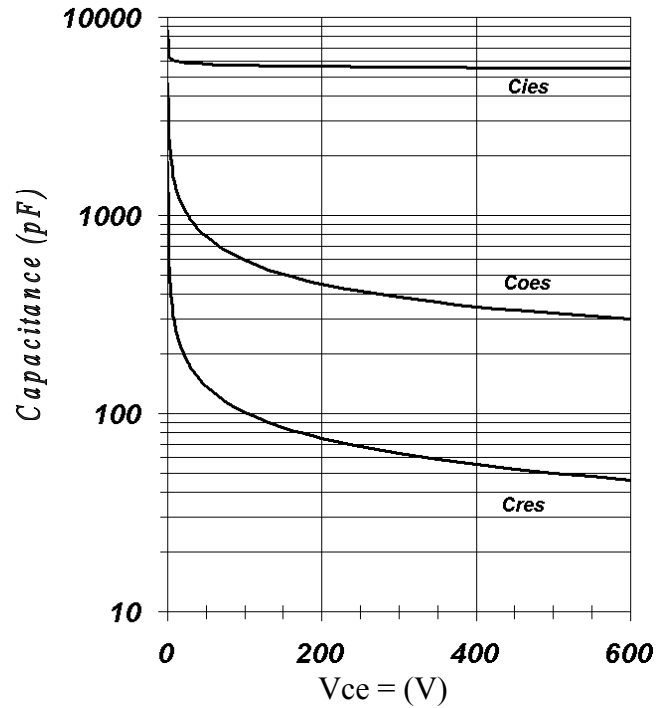


Fig. 23 – Typical Gate Charge vs. V_{GE}
 $I_C = 50\text{A}$; $L = 600\mu\text{H}$; $V_{CC} = 600\text{V}$

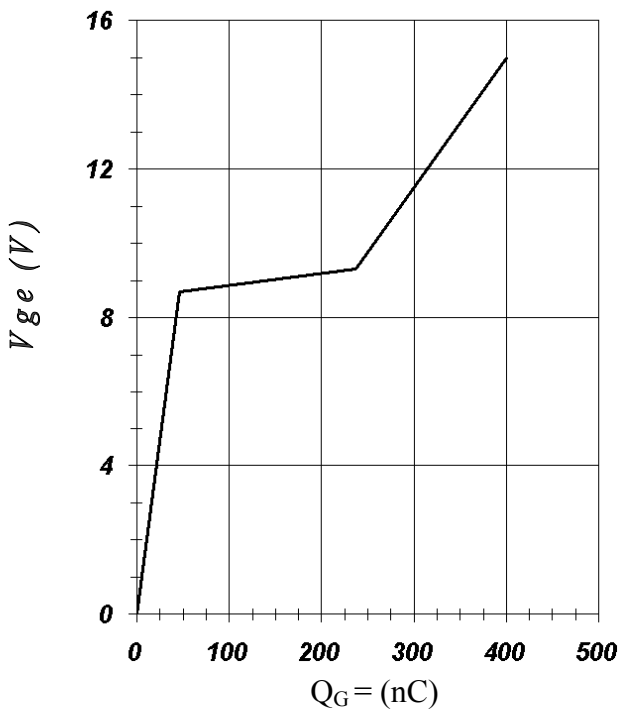


Fig. TF1 – Thermal Sensor Resistance vs. Base-Plate Temperature

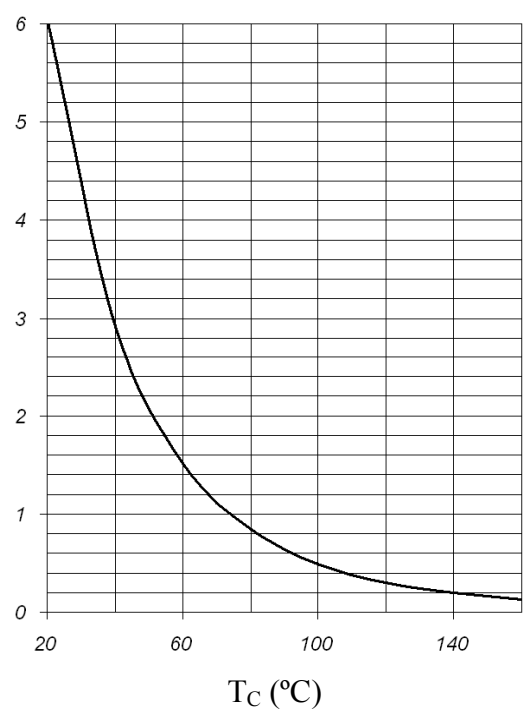


Fig. 24 – Normalized Transient Thermal Impedance, Junction-to-copper plate (IGBTs)

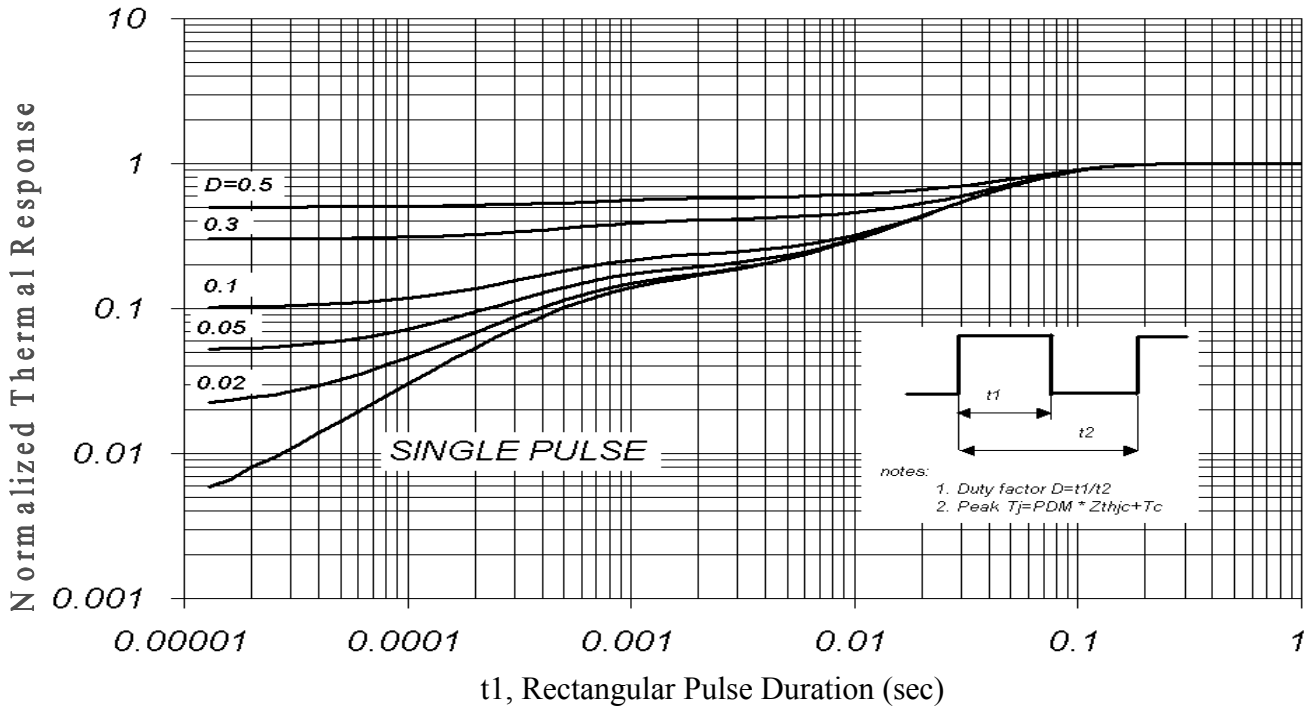


Fig. 25 – Normalized Transient Impedance, Junction-to-copper plate (FRED diodes)

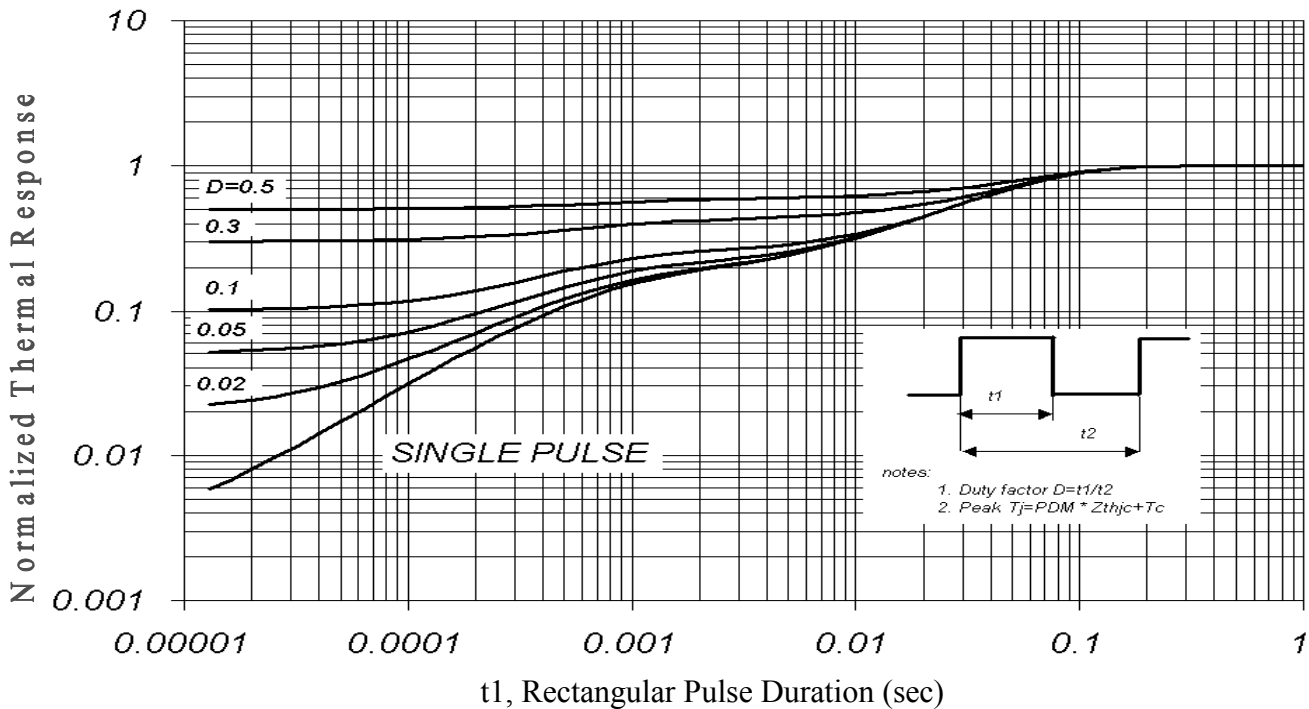


Fig. CT.1 - Gate Charge Circuit (turn-off)

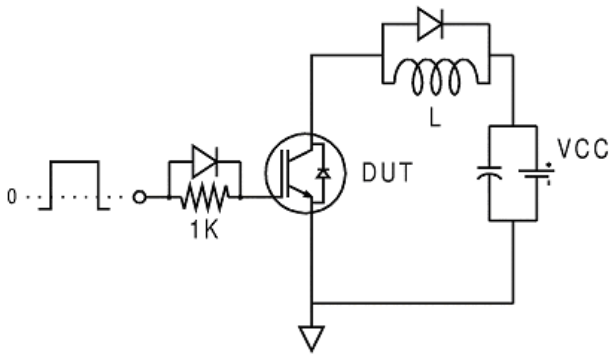


Fig. CT.2 - RBSOA Circuit

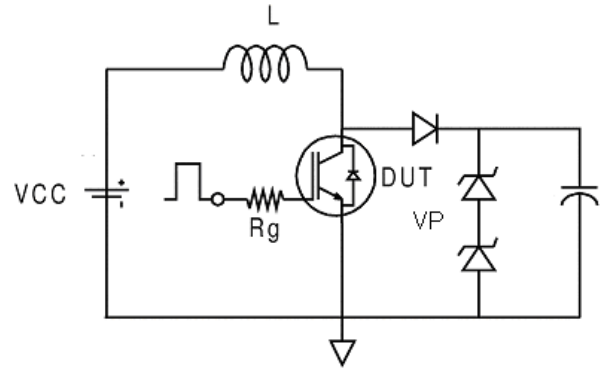


Fig. CT.3 - S.C. SOA Circuit

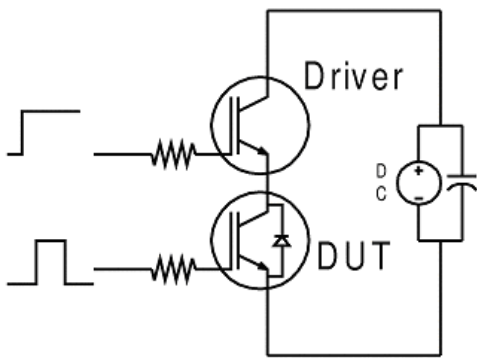


Fig. CT.4 - Switching Loss Circuit

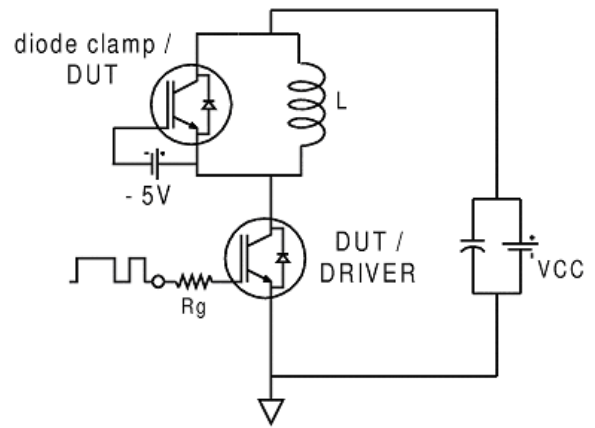


Fig. CT.5 - Resistive Load Circuit

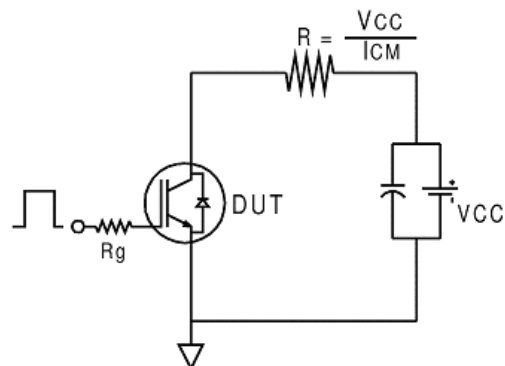


Fig. WF.1 - Typ. Turn-off Loss Waveform
@ $T_j=125^\circ\text{C}$ using Fig. CT.4

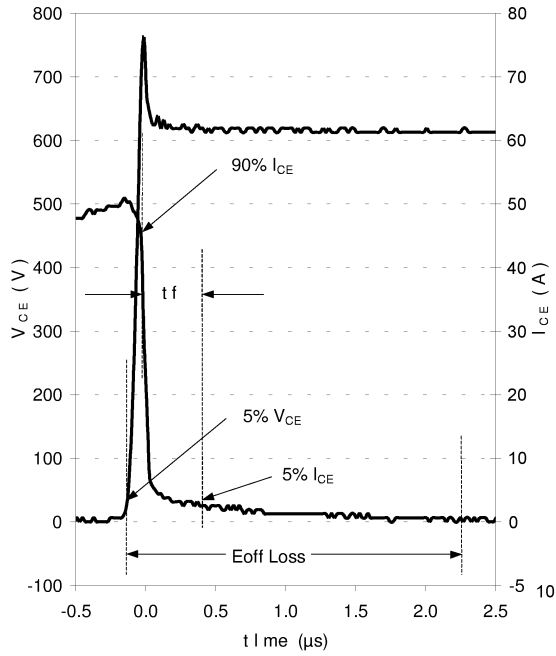


Fig. WF.2 - Typ. Turn-on Loss Waveform
@ $T_j=125^\circ\text{C}$ using Fig. CT.4

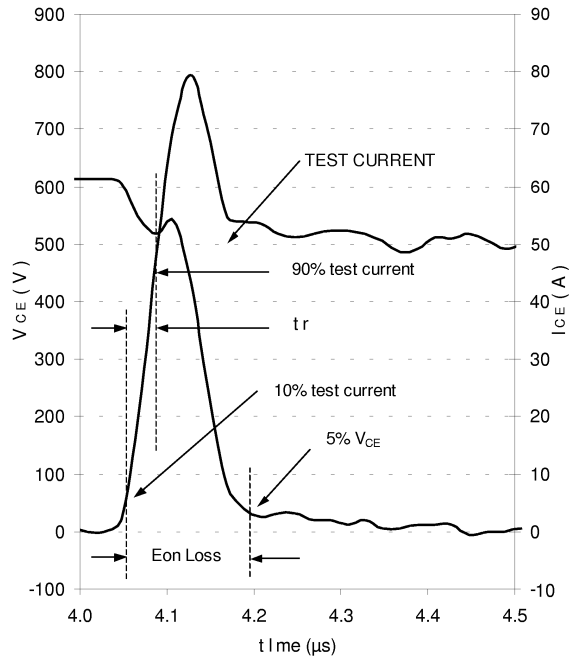


Fig. WF.3 - Typ. Diode Recovery Waveform
@ $T_j=125^\circ\text{C}$ using Fig. CT.4

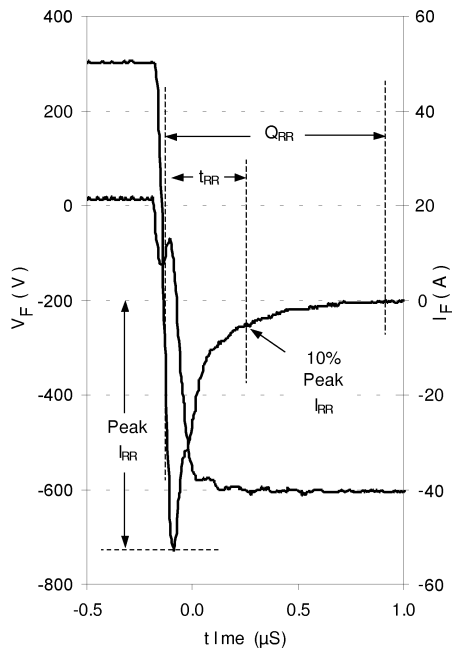
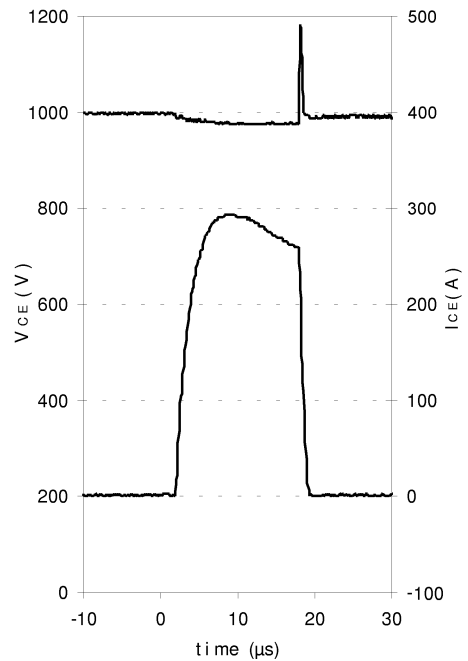
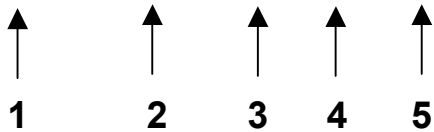


Fig. WF.4 - Typ. S.C. Waveform
@ $T_C=150^\circ\text{C}$ using Fig. CT.3



EMP family part number identification

EMP 50 P 12 B



1- Package type

2- Current rating

3- Current sensing configuration

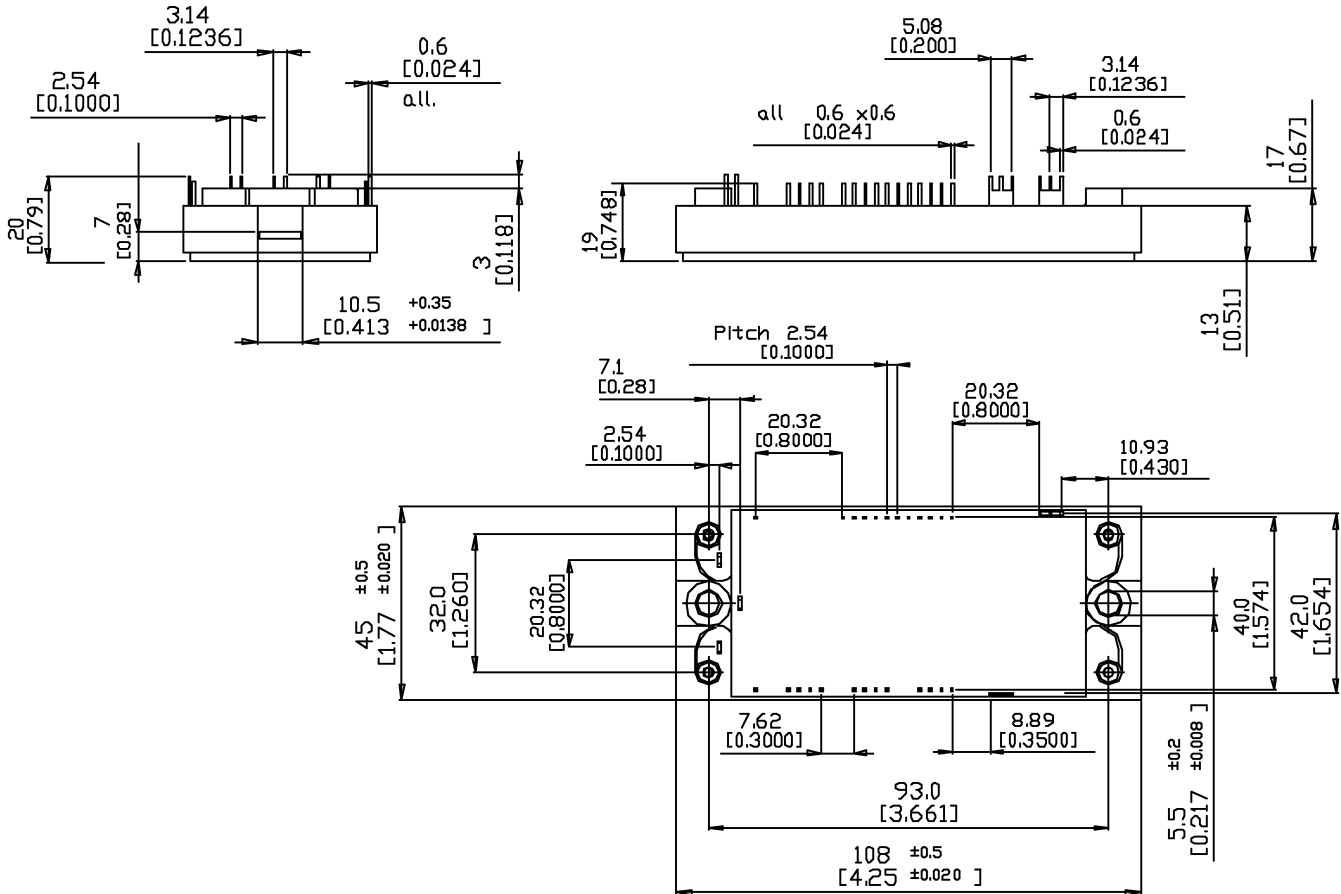
P= on 3 phases
Q= on 2 phases
E= on 3 emitters
F= on 2 emitters
G= on 1 emitter

4- Voltage code: Code x 100 = V_{rrm}

5- Circuit configuration code

A= Bridge brake
B= Inverter
C= Inverter + brake
D= BBI (Bridge Brake Inverter)
M= Matrix

EMP50P12B 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.