

# EMP25P12B

PIM+

## EMP Features:

### ■ Power Module:

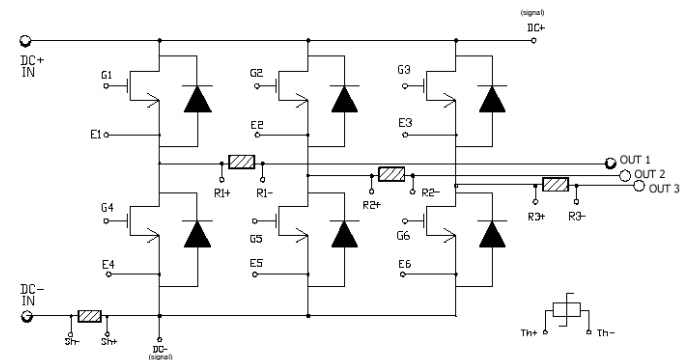
- NPT IGBTs 25A, 1200V
- 10us Short Circuit capability
  - Square RBSOA
  - Low  $V_{ce(on)}$  (2.28Vtyp @ 25A, 25°C)
  - Positive  $V_{ce(on)}$  temperature coefficient
- Gen III HexFred Technology
  - Low diode  $V_F$  (1.76Vtyp @ 25A, 25°C)
  - Soft reverse recovery
- 4mΩ sensing resistors on all phase outputs and DCbus minus rail
  - Thermal coefficient < 50ppm/°C

## Package:



EMP – Inverter (EconoPack 2 outline compatible)

## Power Module schematic:



Three phase inverter with current sensing resistors on all output phases and thermistor

## Description

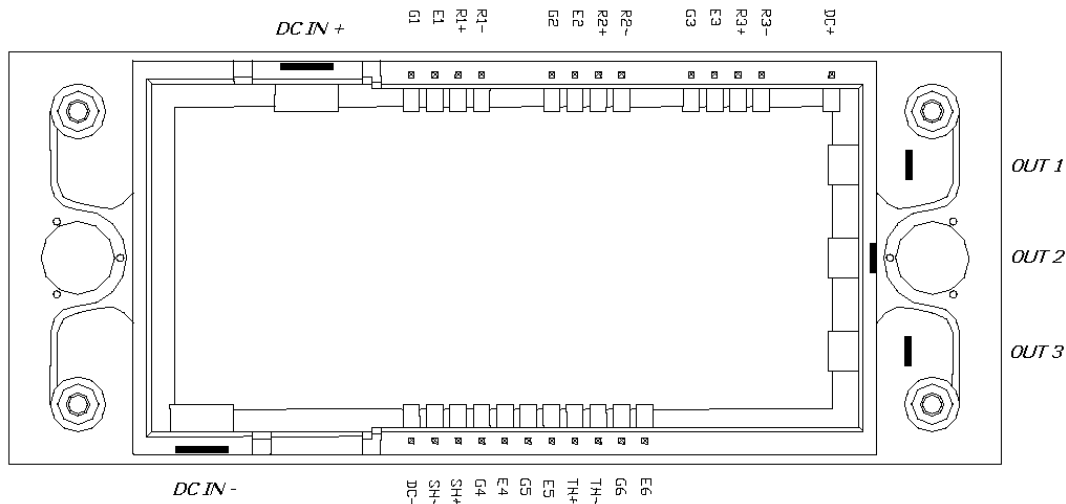
The EMP25P12B is a Power Integrated Module for Motor Driver applications with embedded sensing resistors on all three-phase output currents.

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.

## Pins Mapping



## Pins Mapping

Symbol	Lead Description
DC +	DC Bus plus input signal
DC -	DC Bus minus input signal (internally connected to COM)
Th +	Thermal sensor positive input
Th -	Thermal sensor negative input (internally connected to COM)
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)

## 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 ( $T_C = 100^{\circ}\text{C}$ , fig. 1)		25	A
	$I_C @ 25^{\circ}\text{C}$	IGBTs continuous collector current ( $T_C = 25^{\circ}\text{C}$ , fig 1)		50	
	$I_{CM}$	Pulsed Collector Current (Fig. 3, Fig. CT.5)		100	
	$I_F @ 100^{\circ}\text{C}$	Diode Continuous Forward Current ( $T_C = 100^{\circ}\text{C}$ )		25	
	$I_F @ 25^{\circ}\text{C}$	Diode Continuous Forward Current ( $T_C = 25^{\circ}\text{C}$ )		50	
	$I_{FM}$	Diode Maximum Forward Current		100	
	$V_{GE}$	Gate to Emitter Voltage	-20	+20	V
	$P_D @ 25^{\circ}\text{C}$	Power Dissipation (One transistor)		192	W
	$P_D @ 100^{\circ}\text{C}$	Power Dissipation (One transistor, $T_C = 100^{\circ}\text{C}$ )		77	
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<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		2.28	2.48	V	I <sub>C</sub> = 25A, V <sub>GE</sub> = 15V	5, 6
			3.2	3.65		I <sub>C</sub> = 50A, V <sub>GE</sub> = 15V	7, 9
			2.74	3.10		I <sub>C</sub> = 25A, V <sub>GE</sub> = 15V, T <sub>J</sub> = 125 °C	10, 11
V <sub>GE(th)</sub>	Gate Threshold Voltage	4.0	5.0	6.0	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		-1.2		mV/°C	V <sub>CE</sub> = V <sub>GE</sub> , I <sub>C</sub> = 1mA (25 - 125 °C)	
g <sub>fe</sub>	Forward Transconductance	14.8	16.9	19.0	S	V <sub>CE</sub> = 50V, I <sub>C</sub> = 25A, PW = 80μs	
I <sub>CES</sub>	Zero Gate Voltage Collector Current			250	μA	V <sub>GE</sub> = 0V, V <sub>CE</sub> = 1200V	
			325	675		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		1.76	2.06	V	I <sub>C</sub> = 25A	8
			1.87	2.18		I <sub>C</sub> = 25A, T <sub>J</sub> = 125 °C	8
I <sub>RM</sub>	Diode Reverse Leakage Current			20	μA	V <sub>R</sub> = 1200V, T <sub>J</sub> = 25 °C	
I <sub>GES</sub>	Gate To Emitter Leakage Current			±100	nA	V <sub>GE</sub> = ± 20V	
R1/2/3	Sensing Resistors	3.96	4	4.04	mΩ		
Rsh	DC bus minus series shunt resistor	3.96	4	4.04			

## General Description

The EMP module contains six IGBTs and HexFreds Diodes in a standard inverter configuration. IGBTs used are the new NPT 1200V-25A (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 (Al<sub>2</sub>O<sub>3</sub>) 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<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)		169	254	nC	I <sub>C</sub> = 25A V <sub>CC</sub> = 600V V <sub>GE</sub> = 15V	23 CT1
Q <sub>ge</sub>	Gate – Emitter Charge (turn on)		19	29			
Q <sub>gc</sub>	Gate – Collector Charge (turn on)		82	123			
E <sub>on</sub>	Turn on Switching Loss		1.9	3.6	mJ	I <sub>C</sub> = 25A, V <sub>CC</sub> = 600V, T <sub>J</sub> = 25 °C V <sub>GE</sub> = 15V, R <sub>G</sub> = 20Ω, L = 200μH Tail and Diode Rev. Recovery included	CT4
E <sub>off</sub>	Turn off Switching Loss		1.3	2.0			WF1
E <sub>tot</sub>	Total Switching Loss		3.2	5.6			WF2
E <sub>on</sub>	Turn on Switching Loss		2.7	4.6	mJ	I <sub>C</sub> = 25A, V <sub>CC</sub> = 600V, T <sub>J</sub> = 125 °C V <sub>GE</sub> = 15V, R <sub>G</sub> = 20Ω, L = 200μH Tail and Diode Rev. Recovery included	13, 15 CT4 WF1 WF2
E <sub>off</sub>	Turn off Switching Loss		2.0	2.3			
E <sub>tot</sub>	Total Switching Loss		4.7	6.9			
t <sub>d</sub> (on)	Turn on delay time		192	210	ns	I <sub>C</sub> = 25A, V <sub>CC</sub> = 600V, T <sub>J</sub> = 125 °C V <sub>GE</sub> = 15V, R <sub>G</sub> = 20Ω, L = 200μH	14,16 CT4 WF1 WF2
T <sub>r</sub>	Rise time		33	49			
t <sub>d</sub> (off)	Turn off delay time		213	227			
T <sub>f</sub>	Fall time		210	379			
C <sub>ies</sub>	Input Capacitance		2200		PF	V <sub>CC</sub> = 30V V <sub>GE</sub> = 0V f = 1MHz	22
C <sub>oes</sub>	Output Capacitance		210				
C <sub>res</sub>	Reverse Transfer Capacitance		85				
RBSOA	Reverse Bias Safe Operating Area	FULL SQUARE				T <sub>J</sub> = 150 °C, I <sub>C</sub> = 100A, V <sub>GE</sub> = 15V to 0V V <sub>CC</sub> = 1000V, V <sub>p</sub> = 1200V, R <sub>G</sub> = 5Ω	4 CT2
SCSOA	Short Circuit Safe Operating Area	10			μs	T <sub>J</sub> = 150 °C, V <sub>GE</sub> = 15V to 0V V <sub>CC</sub> = 1000V, V <sub>p</sub> = 1200V, R <sub>G</sub> = 5Ω	CT3 WF4
E <sub>REC</sub>	Diode reverse recovery energy		1820	2400	μJ	T <sub>J</sub> = 125 °C I <sub>F</sub> = 25A, V <sub>CC</sub> = 600V, V <sub>GE</sub> = 15V, R <sub>G</sub> = 20Ω, L = 200μH	17,18 19,20 21 CT4 WF3
T <sub>rr</sub>	Diode reverse recovery time		300		ns		
I <sub>rr</sub>	Peak reverse recovery current		25	32	A		
R <sub>thJC-T</sub>	Each IGBT to copper plate thermal resistance			0.65	°C/W		24
R <sub>thJC-D</sub>	Each Diode to copper plate thermal resistance			1.05	°C/W		
R <sub>thC-H</sub>	Module copper plate to heat sink thermal resistance. Silicon grease applied = 0.1mm			0.03	°C/W		

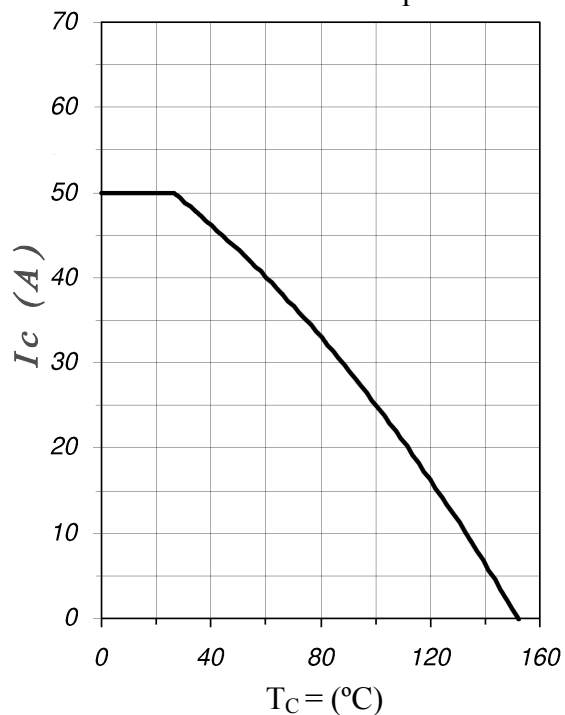
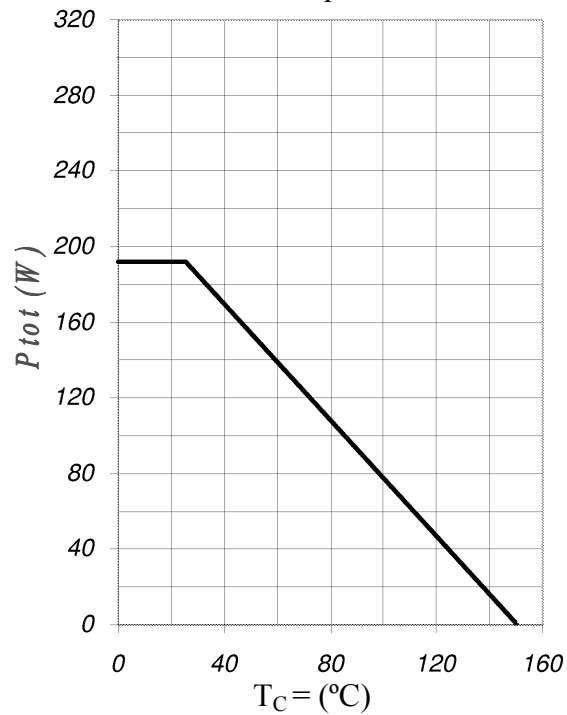
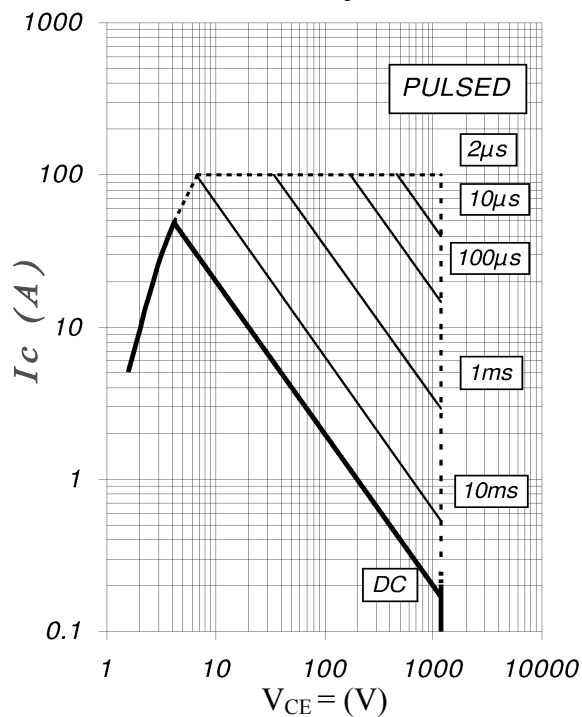
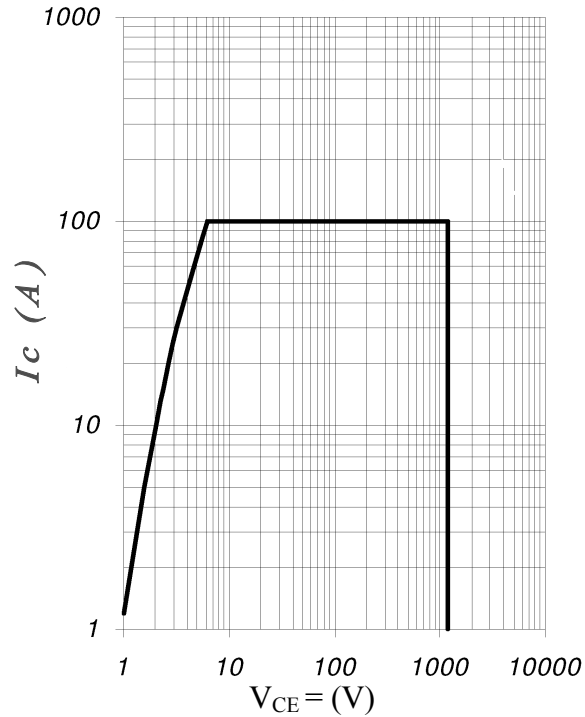
Fig. 1 – Maximum DC collector  
Current vs. case temperatureFig. 2 – Power Dissipation vs.  
Case TemperatureFig. 3 – Forward SOA  
 $T_C = 25^\circ\text{C}$ ;  $T_J \leq 150^\circ\text{C}$ Fig. 4 – Reverse Bias SOA  
 $T_J = 150^\circ\text{C}$ ,  $V_{GE} = 15\text{V}$ 

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

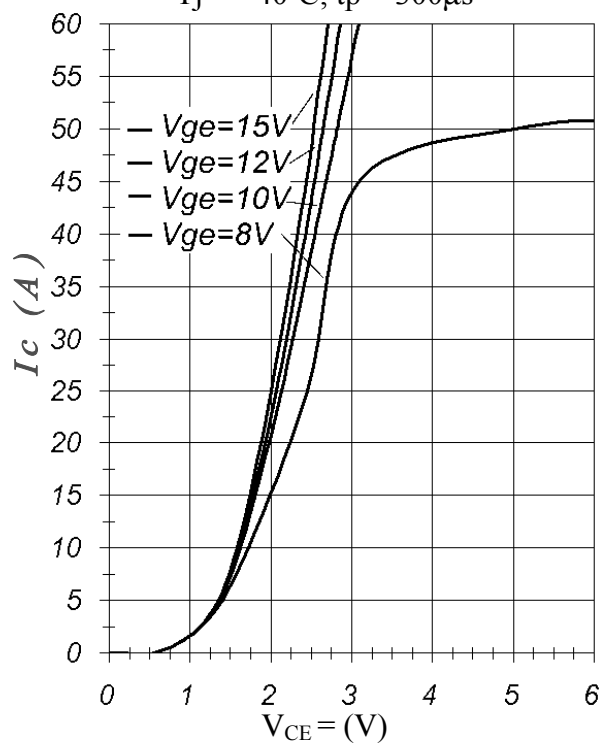


Fig. 6 – Typical IGBT Output Characteristics  
 $T_j = 25^{\circ}\text{C}$ ;  $t_p = 300\mu\text{s}$

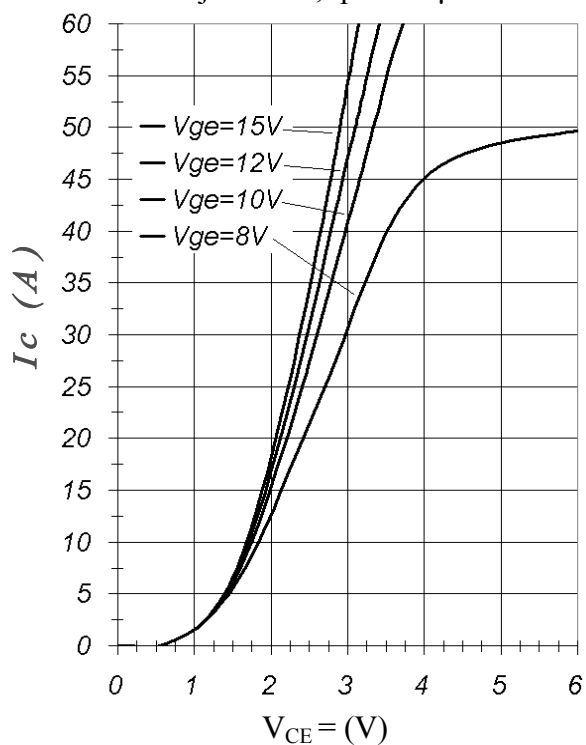


Fig. 7 – Typical IGBT Output Characteristics  
 $T_j = 125^{\circ}\text{C}$ ;  $t_p = 300\mu\text{s}$

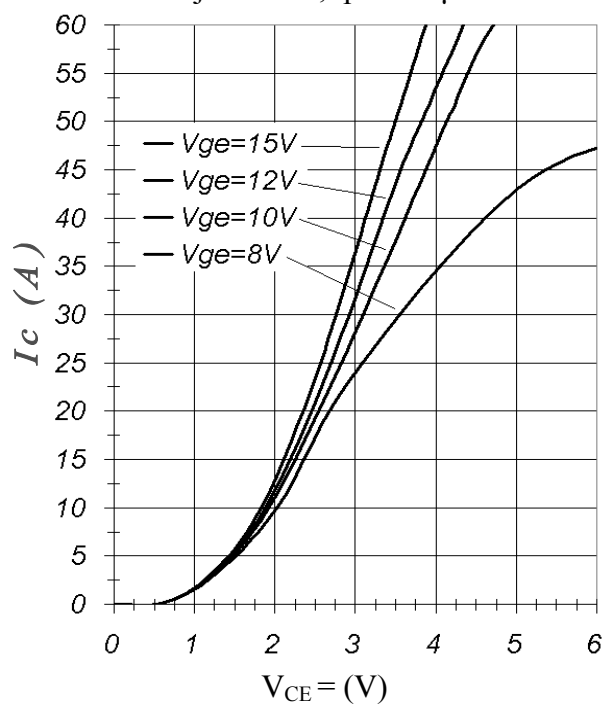


Fig. 8 – Typical Diode Forward Characteristics  
 $t_p = 300\mu\text{s}$

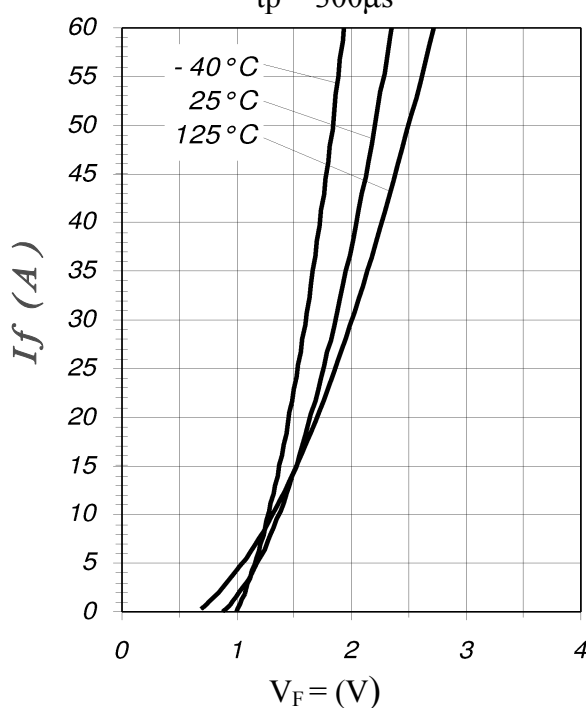


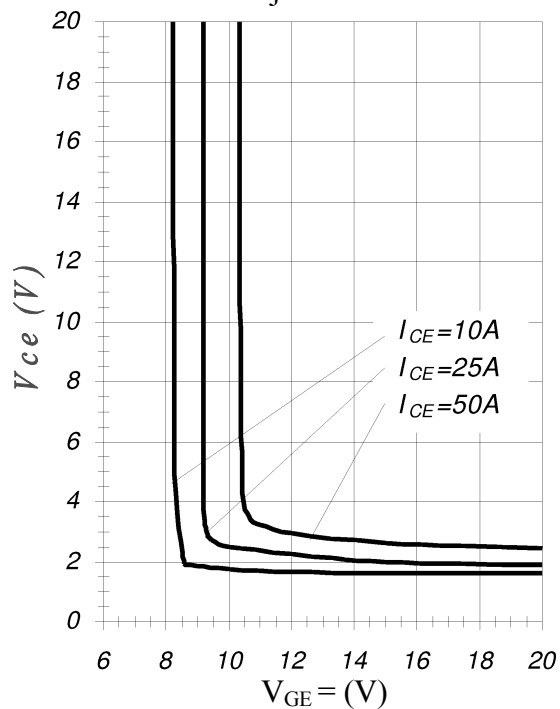
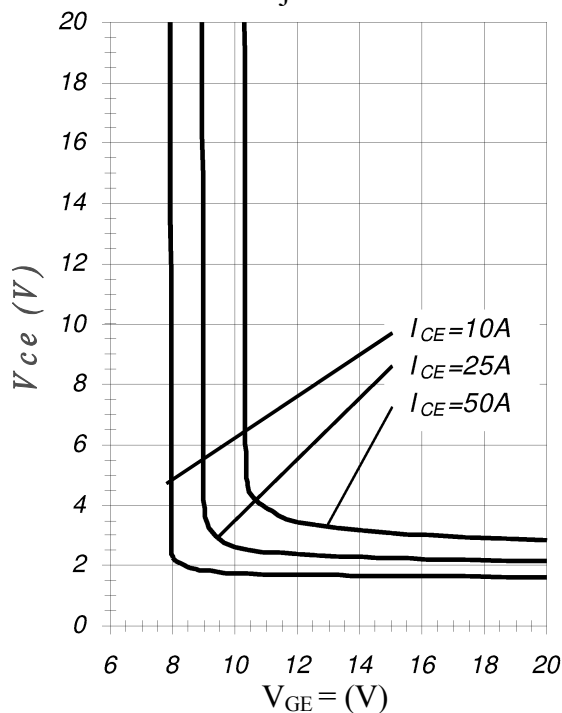
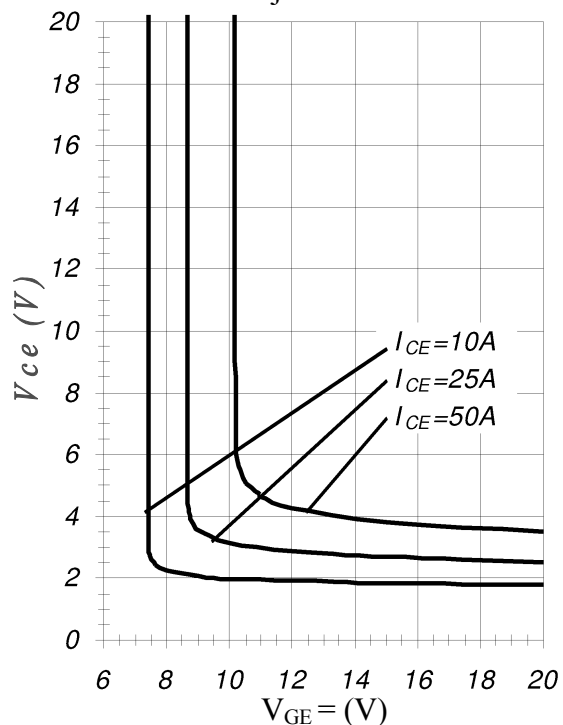
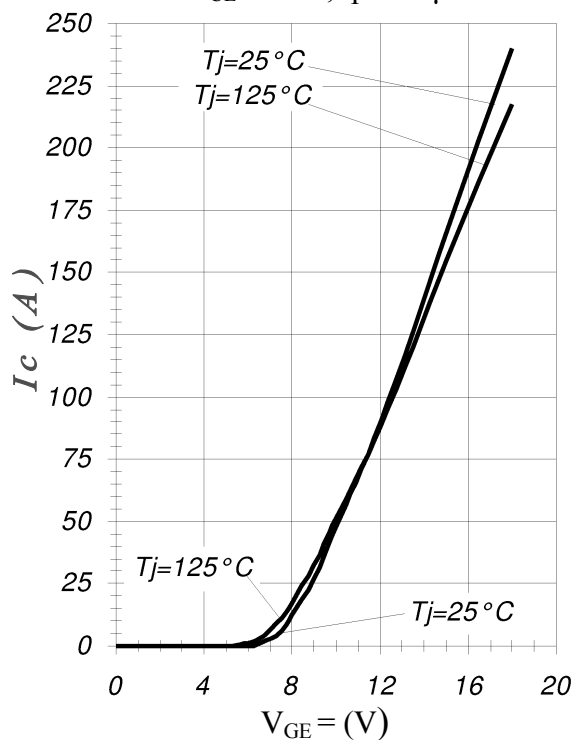
Fig. 9 – Typical  $V_{CE}$  vs.  $V_{GE}$   
 $T_j = -40^\circ\text{C}$ Fig. 10 – Typical  $V_{CE}$  vs.  $V_{GE}$   
 $T_j = 25^\circ\text{C}$ Fig. 11 – Typical  $V_{CE}$  vs.  $V_{GE}$   
 $T_j = 125^\circ\text{C}$ Fig. 12 – Typical Transfer Characteristics  
 $V_{CE} = 20\text{V}$ ;  $t_p = 20\mu\text{s}$ 

Fig. 13 – Typical Energy Loss vs.  $I_C$   
 $T_j = 125^\circ\text{C}$ ;  $L = 200\mu\text{H}$ ;  $V_{CE} = 600\text{V}$ ;  
 $R_g = 10\Omega$ ;  $V_{GE} = 15\text{V}$

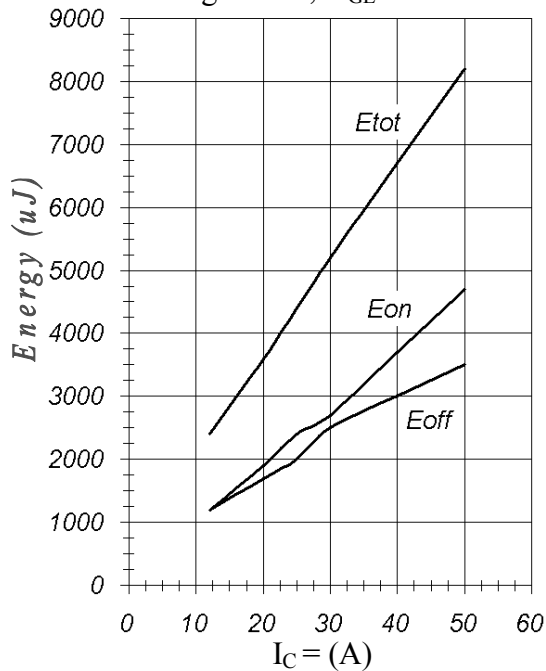


Fig. 14 – Typical Switching Time vs.  $I_C$   
 $T_j = 125^\circ\text{C}$ ;  $L = 200\mu\text{H}$ ;  $V_{CE} = 600\text{V}$ ;  
 $R_g = 10\Omega$ ;  $V_{GE} = 15\text{V}$

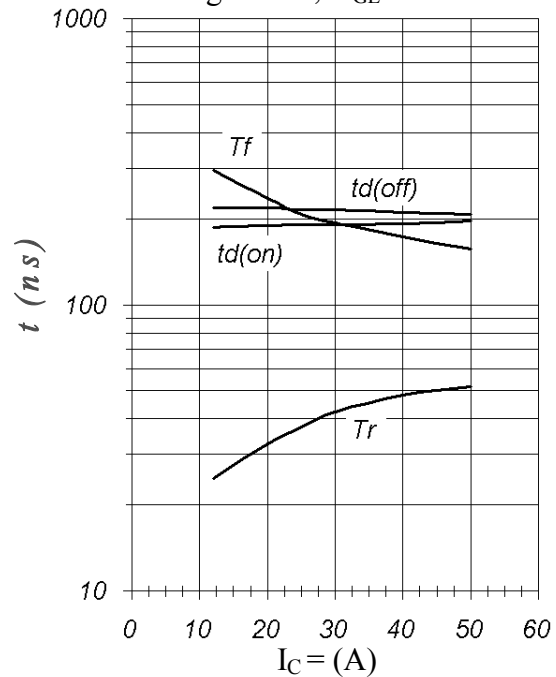


Fig. 15 – Typical Energy Loss vs.  $R_g$   
 $T_j = 125^\circ\text{C}$ ;  $L = 200\mu\text{H}$ ;  $V_{CE} = 600\text{V}$ ;  
 $I_{CE} = 25\text{A}$ ;  $V_{GE} = 15\text{V}$

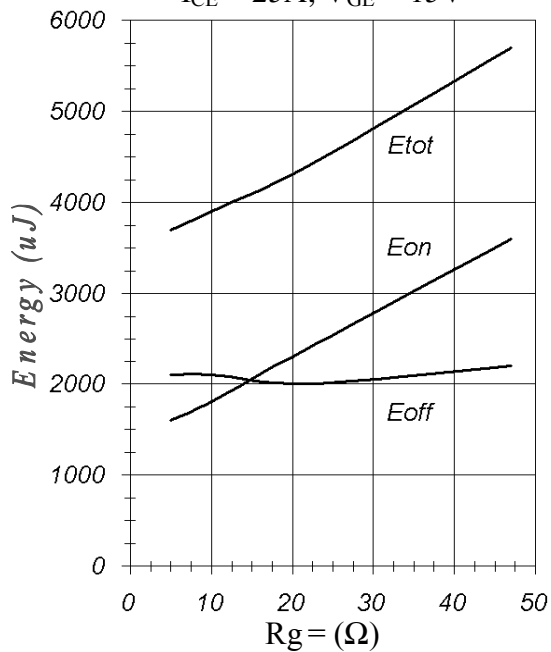


Fig. 16 – Typical Switching Time vs.  $R_g$   
 $T_j = 125^\circ\text{C}$ ;  $L = 200\mu\text{H}$ ;  $V_{CE} = 600\text{V}$ ;  
 $I_{CE} = 25\text{A}$ ;  $V_{GE} = 15\text{V}$

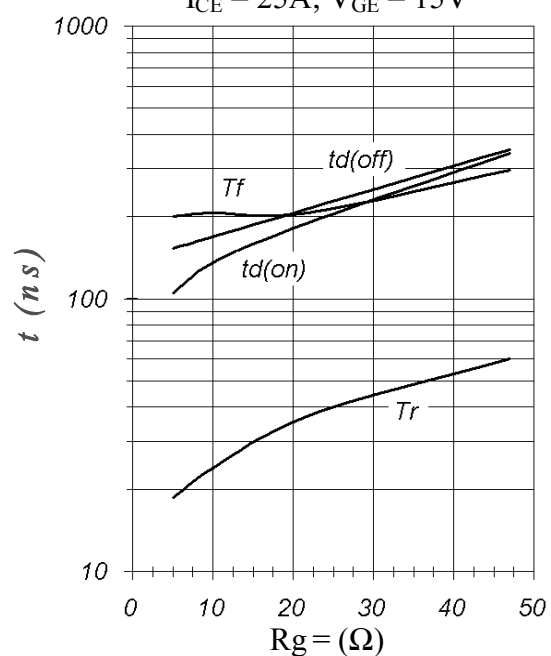




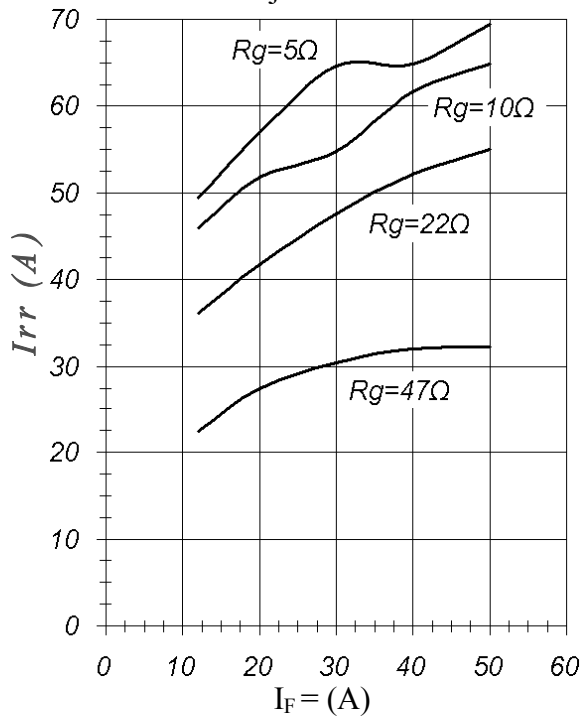
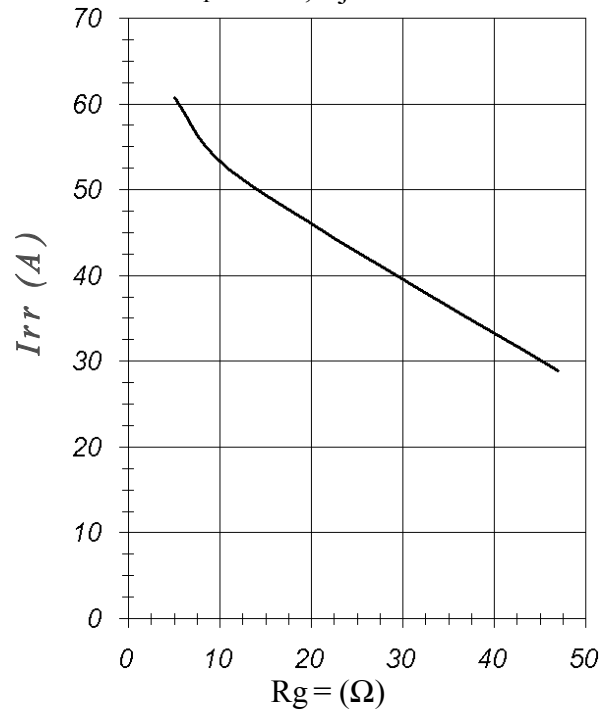
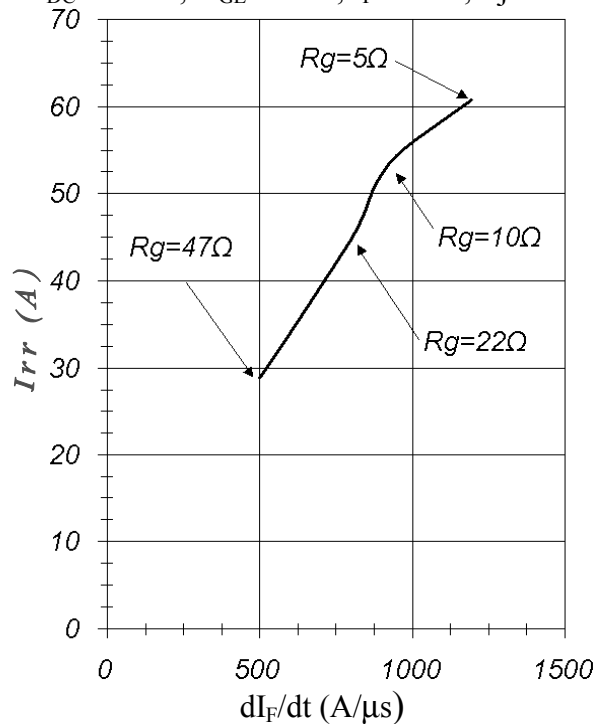
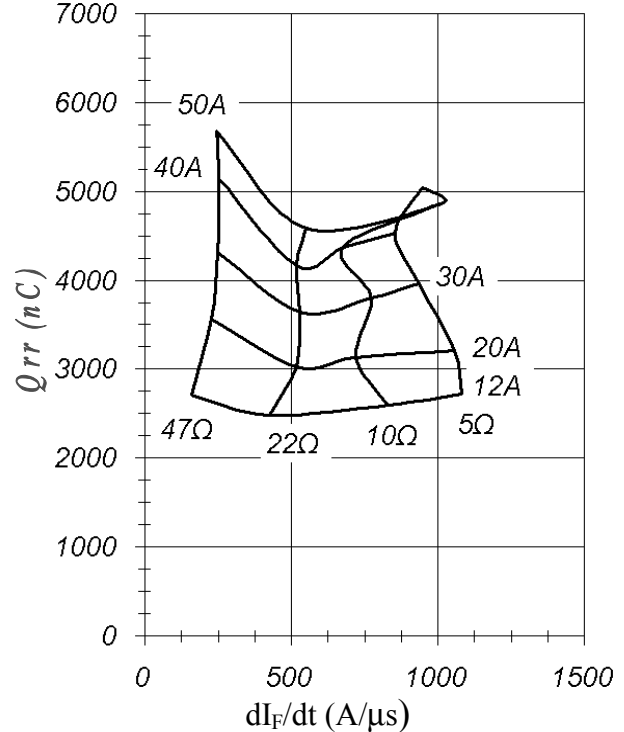
Fig. 17 – Typical Diode  $I_{RR}$  vs.  $I_F$   
 $T_j = 125^\circ\text{C}$ Fig. 18 – Typical Diode  $I_{RR}$  vs.  $R_g$   
 $I_F = 25\text{A}; T_j = 125^\circ\text{C}$ Fig. 19 – Typical Diode  $I_{RR}$  vs.  $dI_F/dt$   
 $V_{DC} = 600\text{V}; V_{GE} = 15\text{V}; I_F = 25\text{A}; T_j = 125^\circ\text{C}$ 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.  $I_F$   
 $T_j = 125^\circ\text{C}$

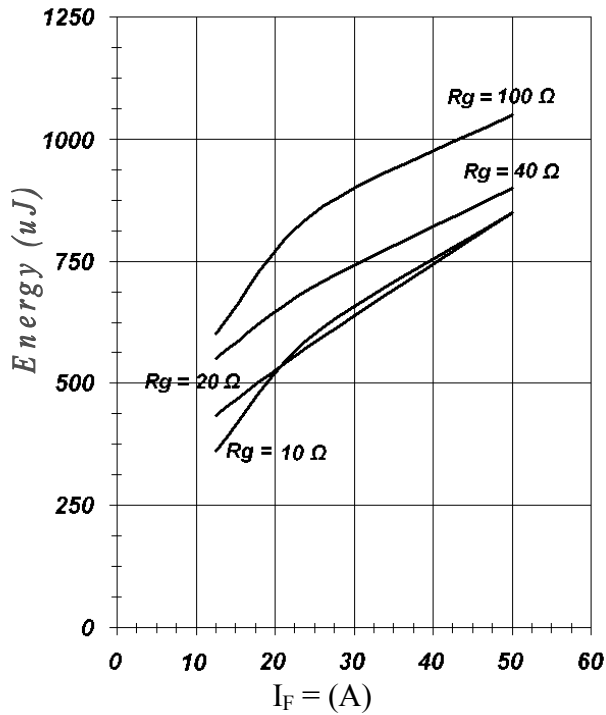


Fig. 22 – Typical Capacitance vs.  $V_{CE}$   
 $V_{GE} = 0\text{V}$ ;  $f = 1\text{MHz}$

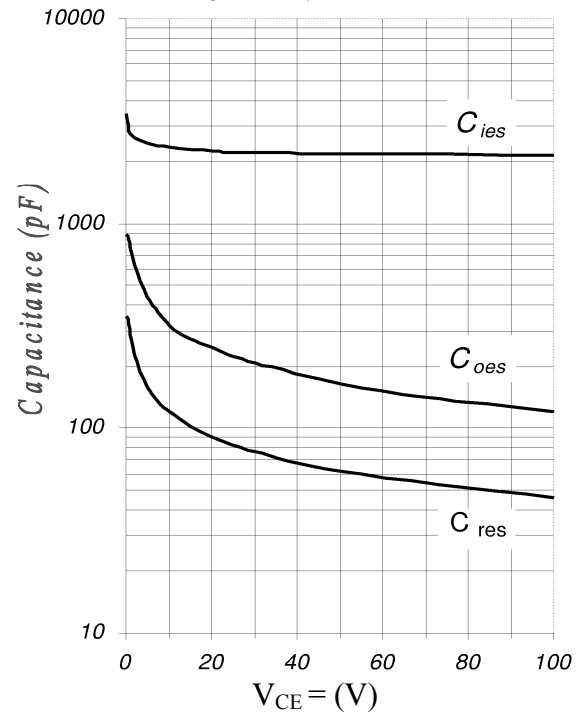


Fig. 23 – Typical Gate Charge vs.  $V_{GE}$   
 $I_C = 25\text{A}$ ;  $L = 600\mu\text{H}$ ;  $V_{CC} = 600\text{V}$

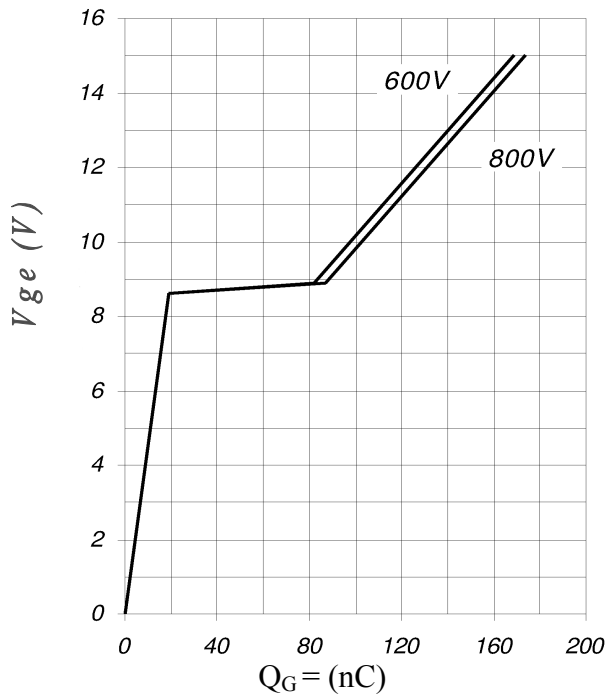


Fig. TF1 – Thermal Sensor Resistance vs. Base-Plate Temperature

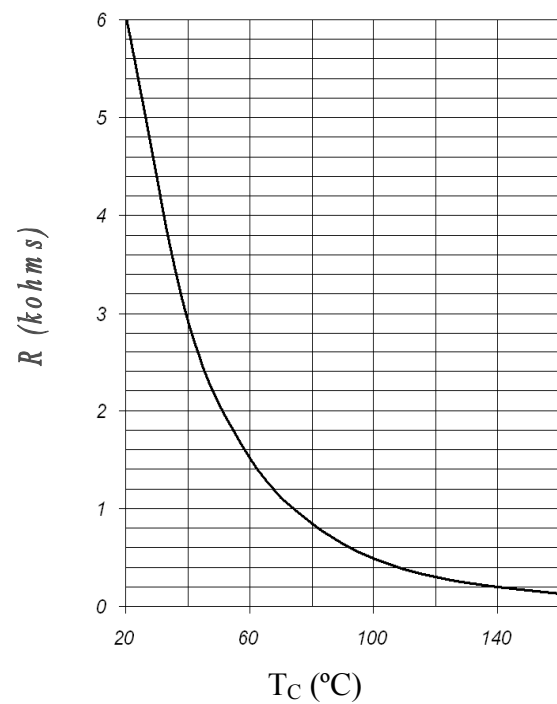
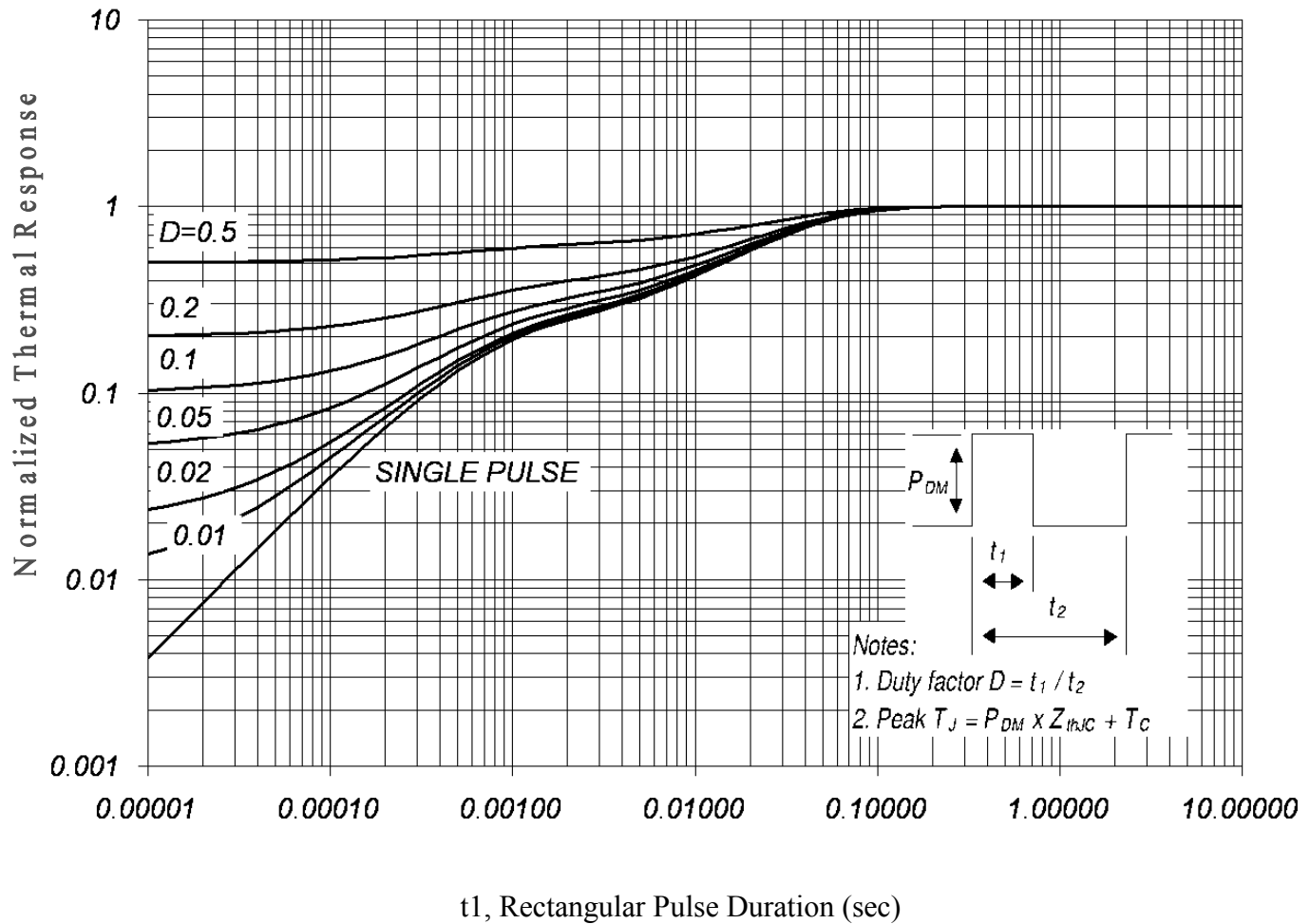
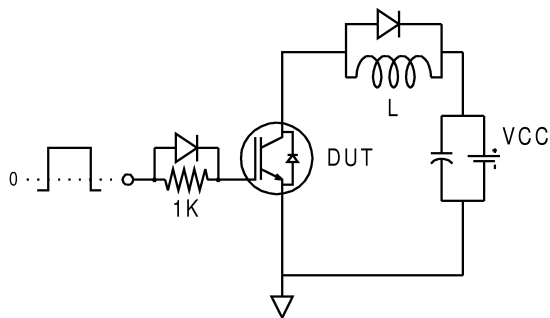


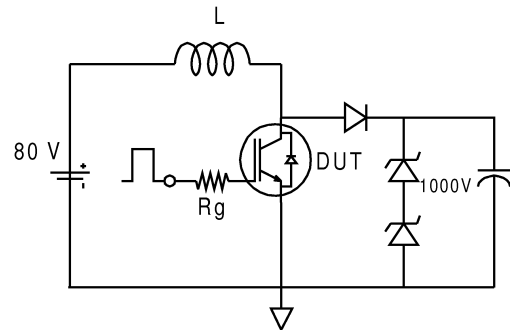
Fig. 24 – Normalized Transient Impedance, Junction-to-copper plate



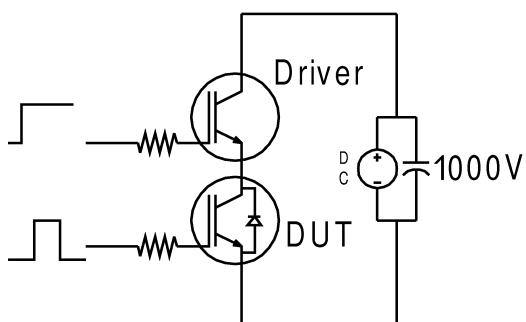
**Fig. CT.1 - Gate Charge Circuit (turn-off)**



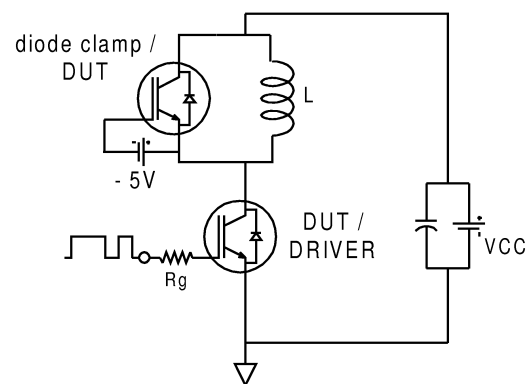
**Fig. CT.2 - RBSOA Circuit**



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



**Fig. CT.4 - Switching Loss Circuit**



**Fig. CT.5 - Resistive Load Circuit**

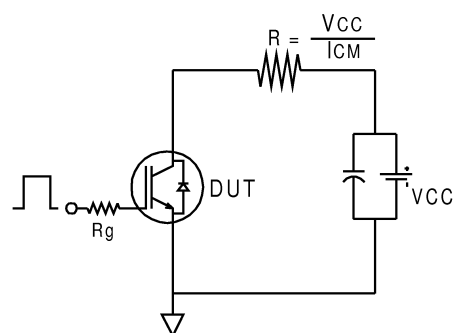


Fig. WF.1 - Typ. Turn-off Loss Waveform  
@  $T_j=125^\circ\text{C}$  using Fig. CT.4

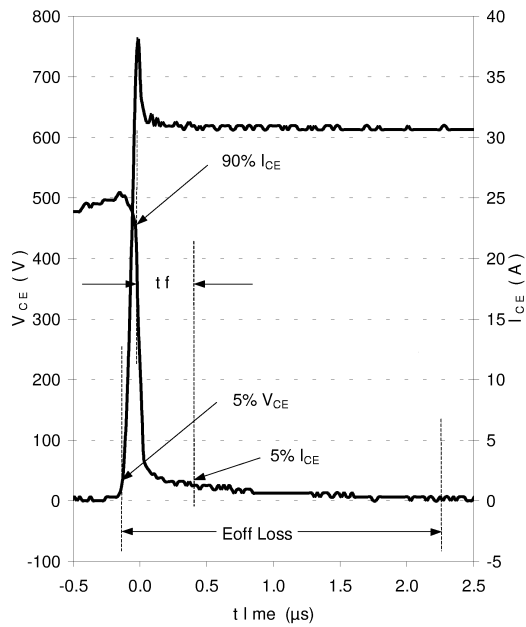


Fig. WF.2 - Typ. Turn-on Loss Waveform  
@  $T_j=125^\circ\text{C}$  using Fig. CT.4

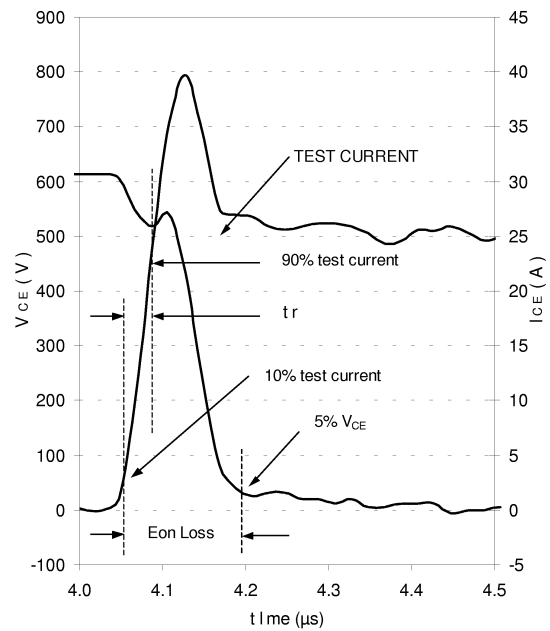


Fig. WF.3 - Typ. Diode Recovery Waveform  
@  $T_j=125^\circ\text{C}$  using Fig. CT.4

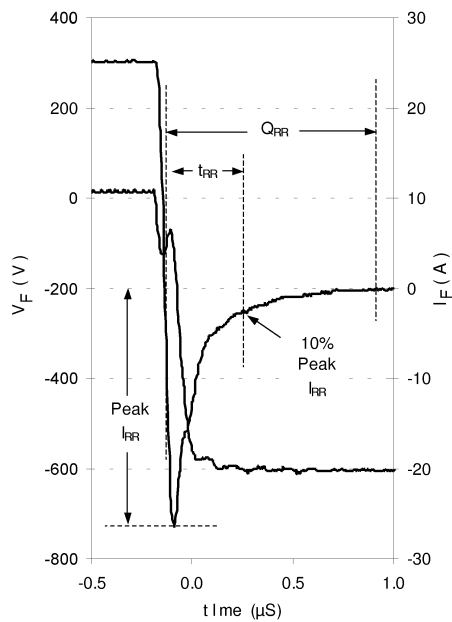
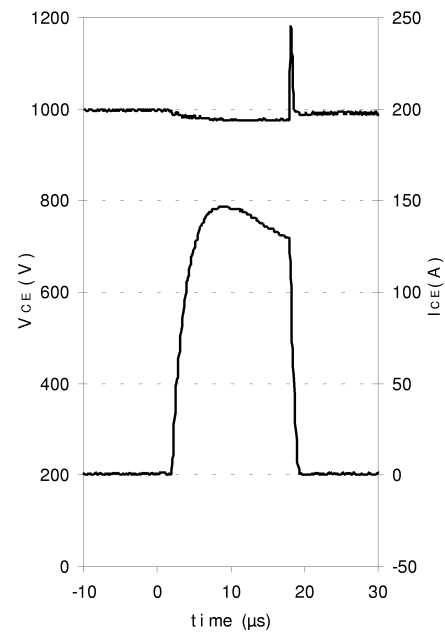
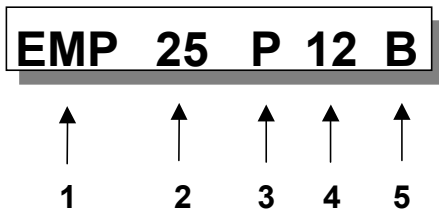


Fig. WF.4 - Typ. S.C. Waveform  
@  $T_C=150^\circ\text{C}$  using Fig. CT.3



## EMP family part number identification



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 = Vrrm

5- Circuit configuration code

A= Bridge brake

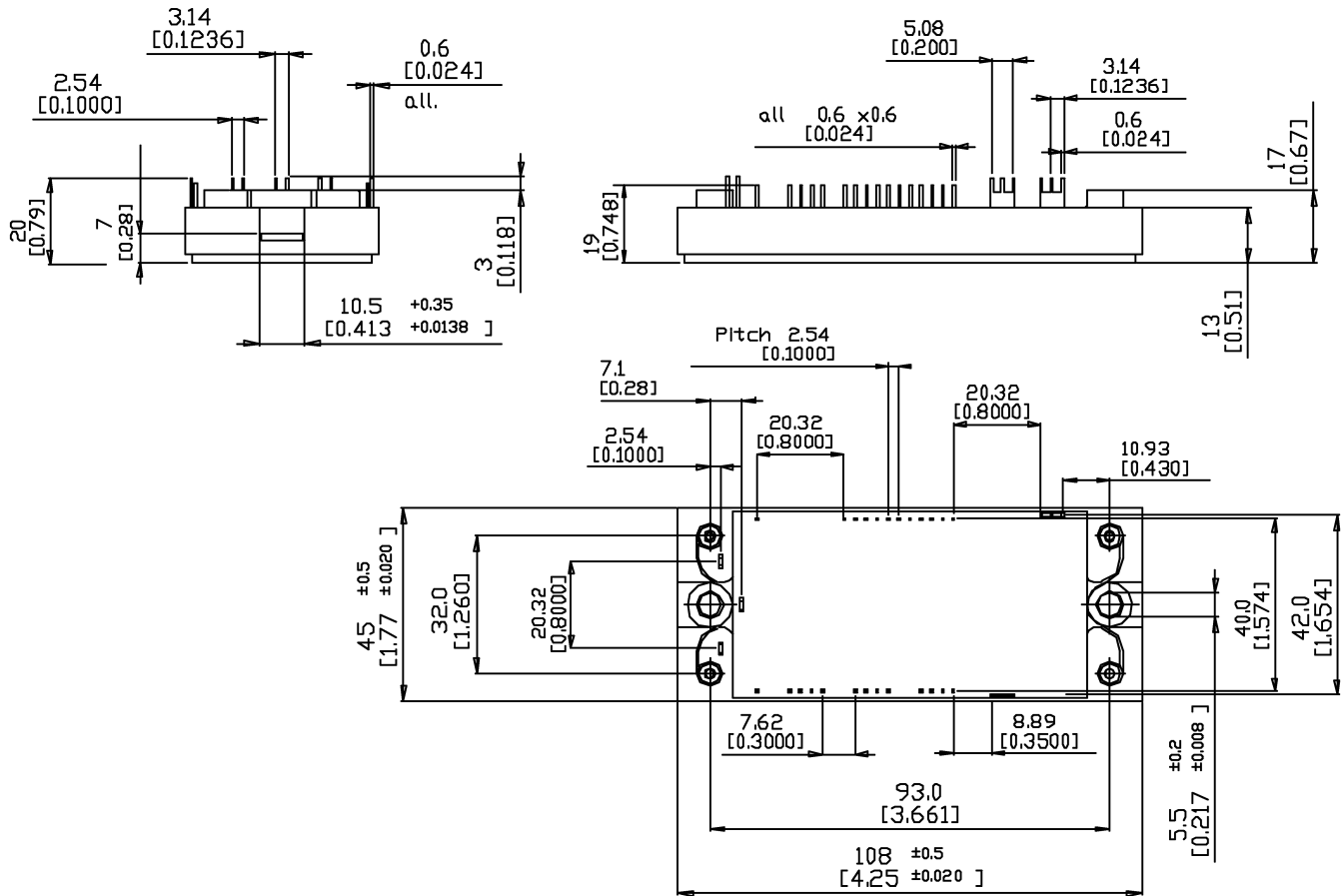
B= Inverter

C= Inverter + brake

D= BBI (Bridge Brake Inverter)

M= Matrix

## EMP25P12B 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.