International
IOR Rectifier

EMP25P12B

PIM+

EMP Features:

- **Power Module:**
  - NPT IGBTs 25A, 1200V
  - 10us Short Circuit capability
    - Square RBSOA
    - Low $Vce_{(on)}$ (2.28Vtyp @ 25A, 25°C)
    - Positive $Vce_{(on)}$ 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

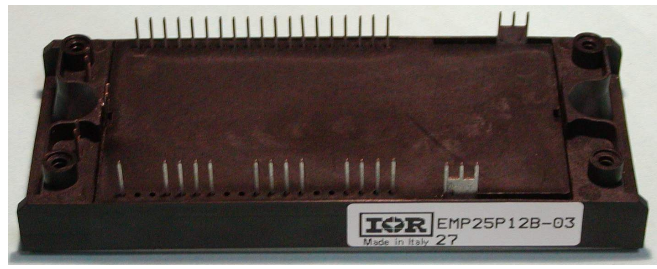
Description

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.

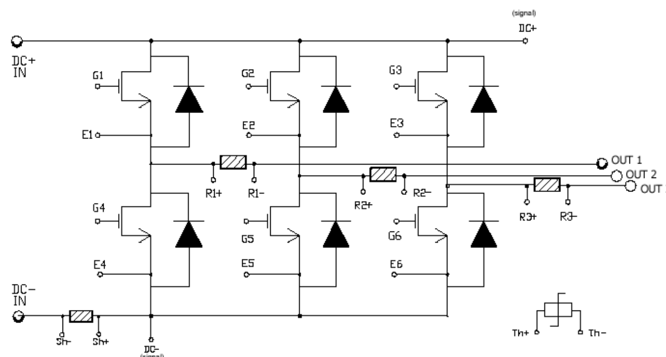
The device comes in the EMP package, fully compatible in length, width and height with EconoPack 2 outline.

Package:



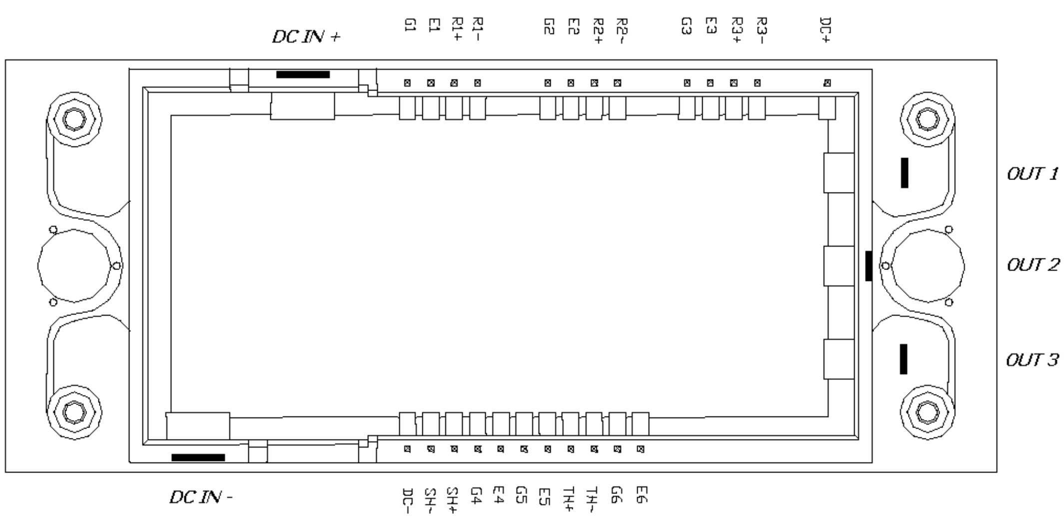
EMP – Inverter (EconoPack 2 outline compatible)

Power Module schematic:



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

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=25ºC)

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	
	$I_{C\ @\ 100C}$	IGBTs continuous collector current (T_C = 100 °C, fig. 1)		25	A
	$I_{C\ @\ 25C}$	IGBTs continuous collector current (T_C = 25 °C,fig 1)		50	
	I_{CM}	Pulsed Collector Current (Fig. 3, Fig. CT.5)		100	
	$I_{F\ @\ 100C}$	Diode Continuous Forward Current (T_C = 100 °C)		25	
	$I_{F\ @\ 25C}$	Diode Continuous Forward Current (T_C = 25 °C)		50	
	I_{FM}	Diode Maximum Forward Current		100	
	V_{GE}	Gate to Emitter Voltage	-20	+20	V
	$P_{D\ @\ 25°C}$	Power Dissipation (One transistor)		192	W
	$P_{D\ @\ 100°C}$	Power Dissipation (One transistor, T_C = 100 °C)		77	
Power Module	MT	Mounting Torque		3.5	Nm
	T_J	Operating Junction Temperature	-40	+150	ºC
	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	
$\Delta V_{(BR)CES} / \Delta T$	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		2.28	2.48	V	I_C = 25A, V_{GE} = 15V	5, 6
			3.2	3.65		I_C = 50A, V_{GE} = 15V	7, 9
			2.74	3.10		I_C = 25A, V_{GE} = 15V, T_J = 125 °C	10, 11
$V_{GE(th)}$	Gate Threshold Voltage	4.0	5.0	6.0	V	V_{CE} = V_{GE}, I_C = 250μA	12
$\Delta V_{GE(th)} / \Delta T_j$	Temp. Coeff. of Threshold Voltage		-1.2		mV/°C	V_{CE} = V_{GE}, I_C = 1mA (25 - 125 °C)	
g_{fe}	Forward Trasconductance	14.8	16.9	19.0	S	V_{CE} = 50V, I_C = 25A, PW = 80μs	
I_{CES}	Zero Gate Voltage Collector Current			250	μA	V_{GE} = 0V, V_{CE} = 1200V	
			325	675		V_{GE} = 0V, V_{CE} = 1200V, T_J = 125 °C	
				2000		V_{GE} = 0V, V_{CE} = 1200V, T_J = 150 °C	
V_{FM}	Diode Forward Voltage Drop		1.76	2.06	V	I_C = 25A	8
			1.87	2.18		I_C = 25A, 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			±100	nA	V_{GE} =± 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 allumina (Al_2O_3) 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 on)		169	254	nC	I_C = 25A	23
Q_{ge}	Gate – Emitter Charge (turn on)		19	29		V_{CC} = 600V	CT1
Q_{gc}	Gate – Collector Charge (turn on)		82	123		V_{GE} = 15V	
E_{on}	Turn on Switching Loss		Tbd	Tbd	µJ	I_C = 25A, V_{CC} = 600V, T_J = 25 °C	CT4
E_{off}	Turn off Switching Loss		Tbd	Tbd		V_{GE} = 15V, R_G =10Ω, L = 200µH	WF1
E_{tot}	Total Switching Loss		Tbd	Tbd		Tail and Diode Rev. Recovery included	WF2
E_{on}	Turn on Switching Loss		Tbd	Tbd	µJ	I_C = 25A, V_{CC} = 600V, T_J = 125 °C	13, 15
E_{off}	Turn off Switching Loss		Tbd	Tbd		V_{GE} = 15V, R_G =10Ω, L = 200µH	CT4 WF1
E_{tot}	Total Switching Loss		Tbd	Tbd		Tail and Diode Rev. Recovery included	WF2
td (on)	Turn on delay time		Tbd	Tbd	ns	I_C = 25A, V_{CC} = 600V, T_J = 125 °C	14,16
Tr	Rise time		Tbd	Tbd			CT4
td (off)	Turn off delay time		Tbd	Tbd		V_{GE} = 15V, R_G =10Ω, L = 200µH	WF1
Tf	Fall time		Tbd	Tbd			WF2
C_{ies}	Input Capacitance		2200		pF	V_{CC} = 30V	22
C_{oes}	Output Capacitance		210			V_{GE} = 0V	
C_{res}	Reverse Transfer Capacitance		85			f = 1MHz	
RBSOA	Reverse Bias Safe Operating Area		FULL SQUARE			T_J = 150 °C, I_C =100A, 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} = 1000V, Vp= 1200V, R_G = 5Ω	CT3 WF4
E_{REC}	Diode reverse recovery energy		1820	2400	µJ	T_J = 125 °C	17,18 19,20
Trr	Diode reverse recovery time		300		ns	I_F= 25A, V_{CC} = 600V,	21
Irr	Peak reverse recovery current		25	32	A	V_{GE} = 15V, R_G =10Ω, L = 200µH	CT4 WF3
Rth_{J-C_T}	Each IGBT to copper plate thermal resistance			0.65	°C/W	See also fig. 24	24
Rth_{J-C_D}	Each Diode to copper plate thermal resistance			1.05	°C/W		
Rth_{C-H}	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 temperature

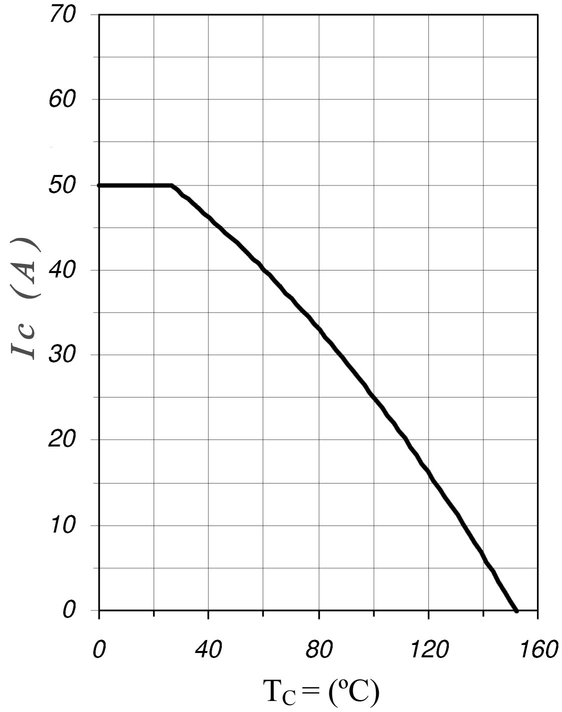


Fig. 2 – Power Dissipation vs. Case Temperature

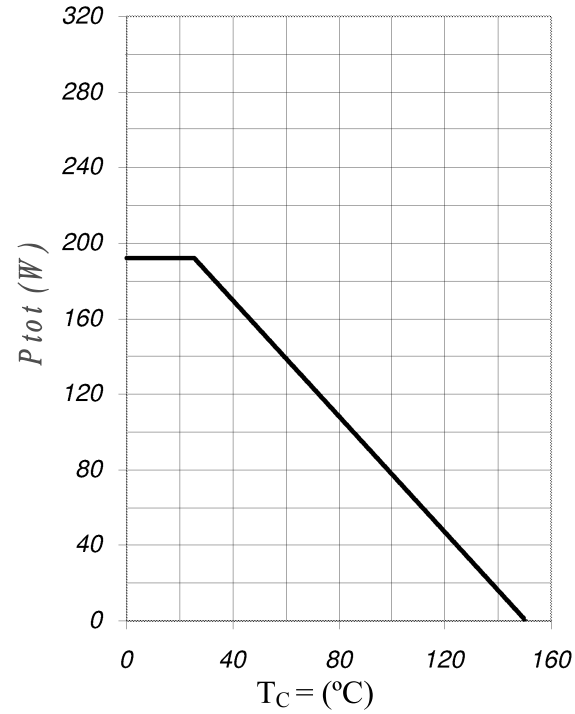


Fig. 3 – Forward SOA
T_C = 25ºC; Tj ≤ 150ºC

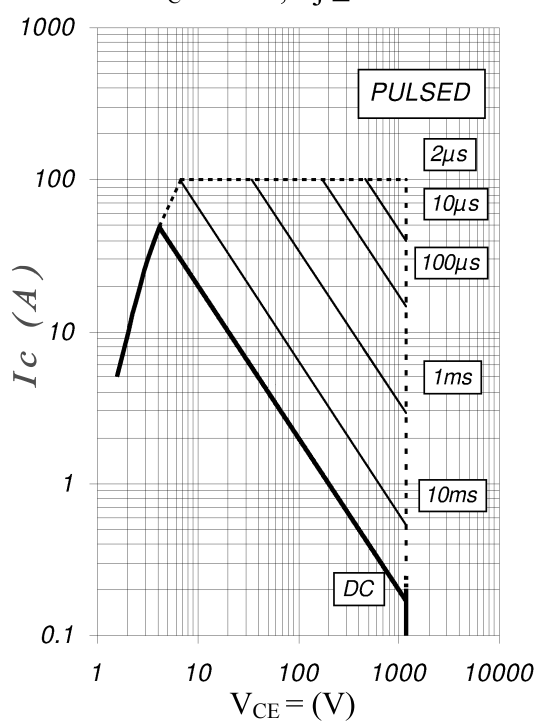


Fig. 4 – Reverse Bias SOA
Tj = 150ºC, V_{GE} = 15V

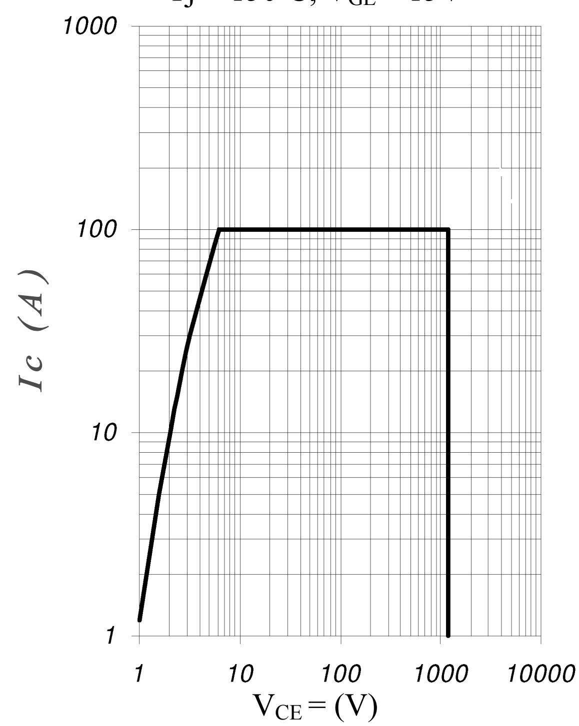


Fig. 5 – Typical IGBT Output Characteristics
Tj = - 40ºC; tp = 300µs

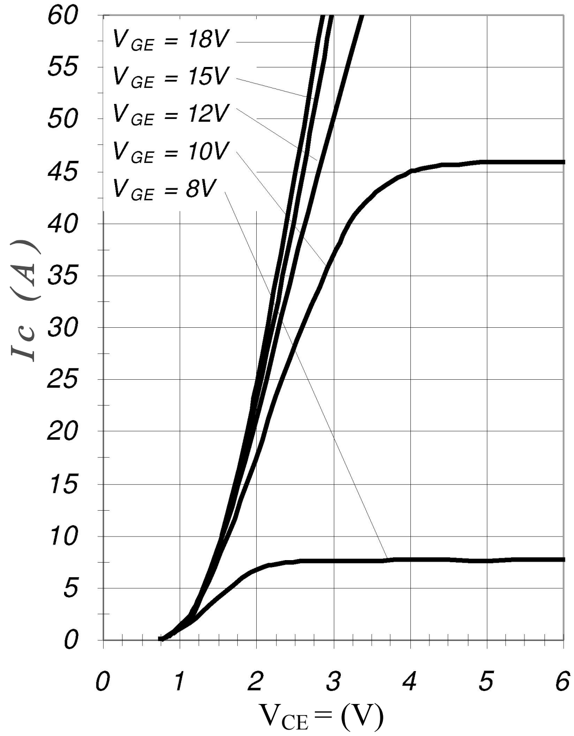


Fig. 6 – Typical IGBT Output Characteristics
Tj = 25ºC; tp = 300µs

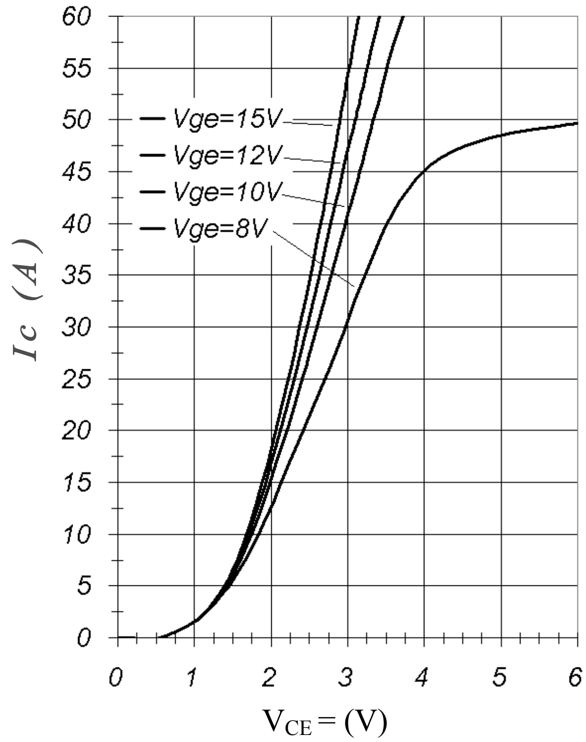


Fig. 7 – Typical IGBT Output Characteristics
Tj = 125ºC; tp = 300µs

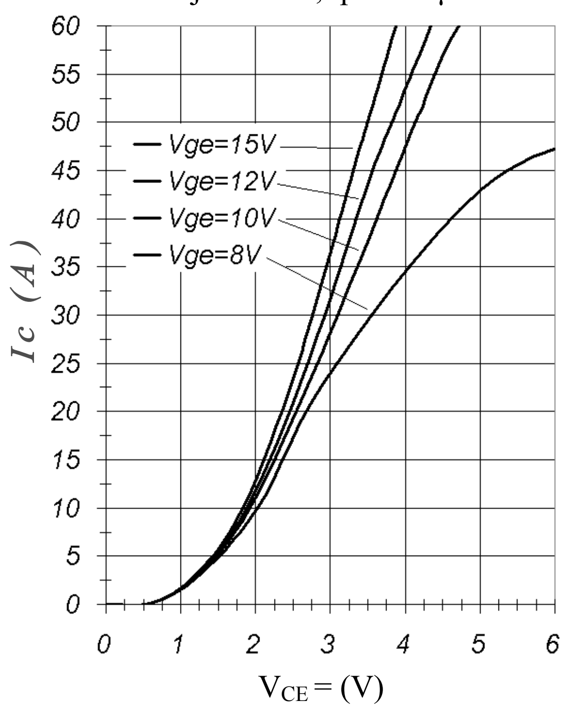


Fig. 8 – Typical Diode Forward Characteristics
tp = 300µs

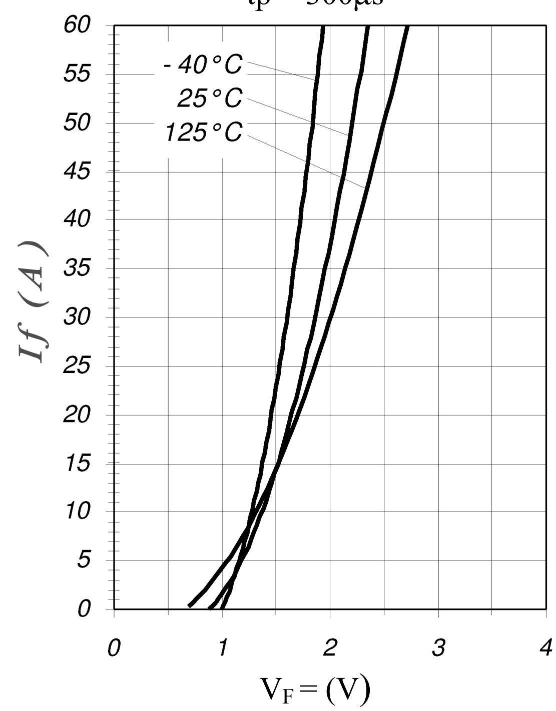


Fig. 9 – Typical V_{CE} vs. V_{GE}
Tj = - 40ºC

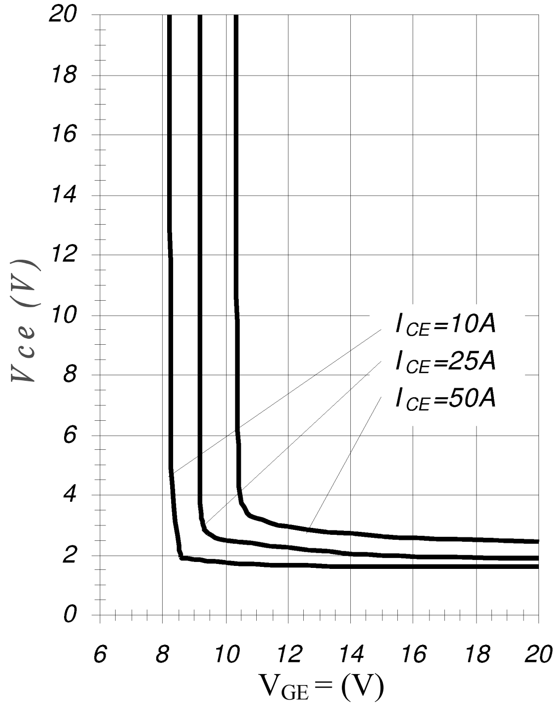


Fig. 10 – Typical V_{CE} vs. V_{GE}
Tj = 25ºC

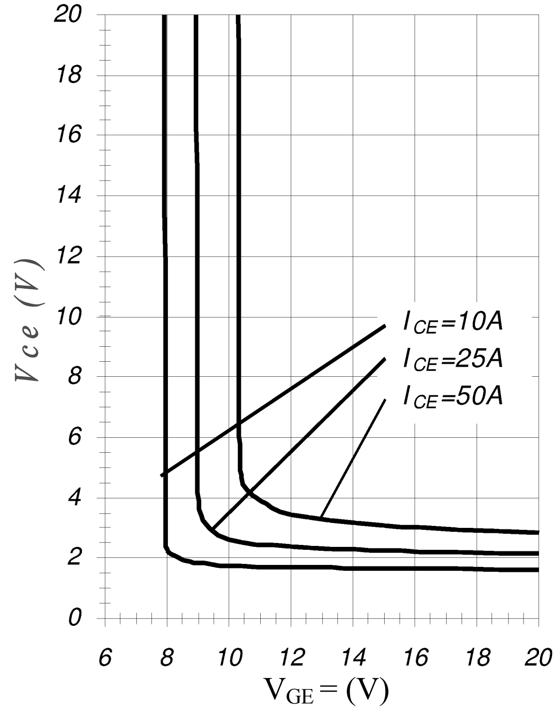


Fig. 11 – Typical V_{CE} vs. V_{GE}
Tj = 125ºC

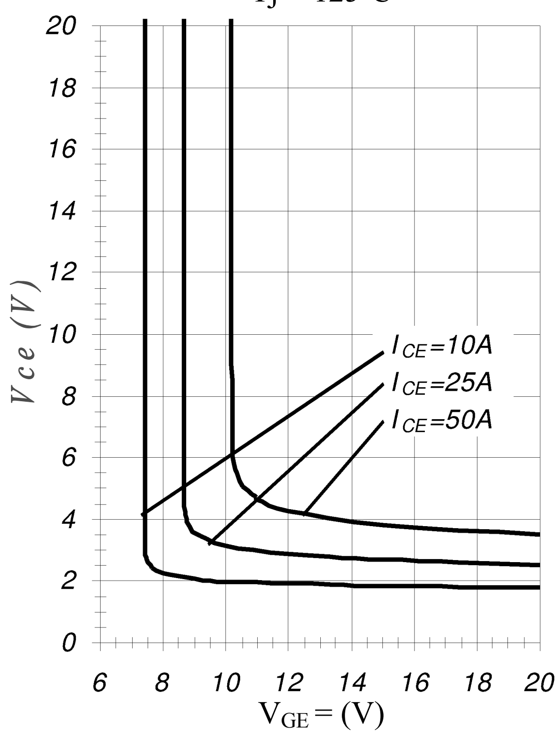


Fig. 12 – Typical Transfer Characteristics
V_{CE} = 20V; tp = 20µs

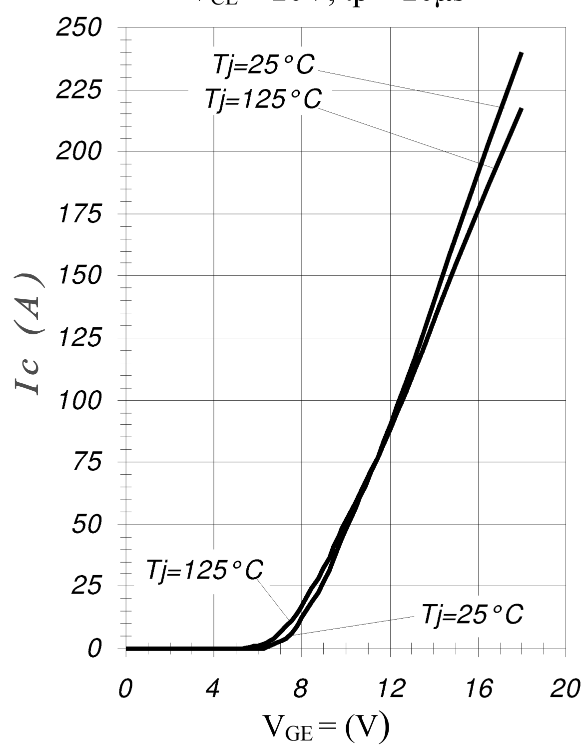


Fig. 13 – Typical Energy Loss vs. I_C
Tj = 125ºC; L = 200µH; V_{CE} = 600V;
Rg = 10Ω; V_{GE} = 15V

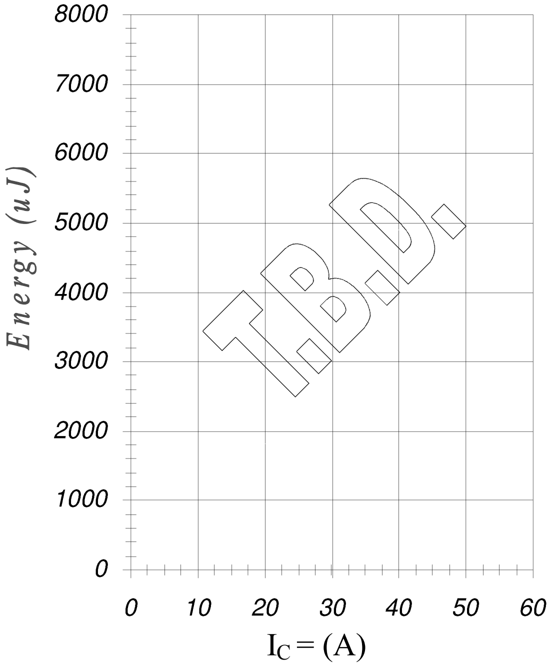


Fig. 14 – Typical Switching Time vs. I_C
Tj = 125ºC; L = 200µH; V_{CE} = 600V;
Rg = 10Ω; V_{GE} = 15V

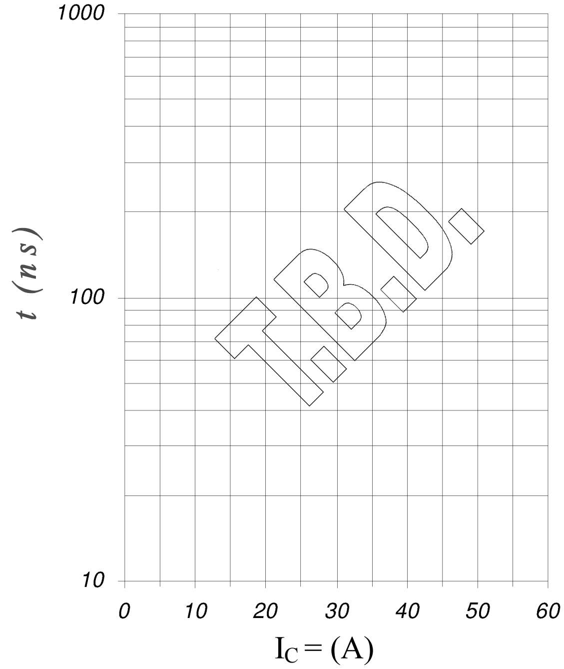


Fig. 15 – Typical Energy Loss vs. Rg
Tj = 125ºC; L = 200µH; V_{CE} = 600V;
I_{CE} = 25A; V_{GE} = 15V

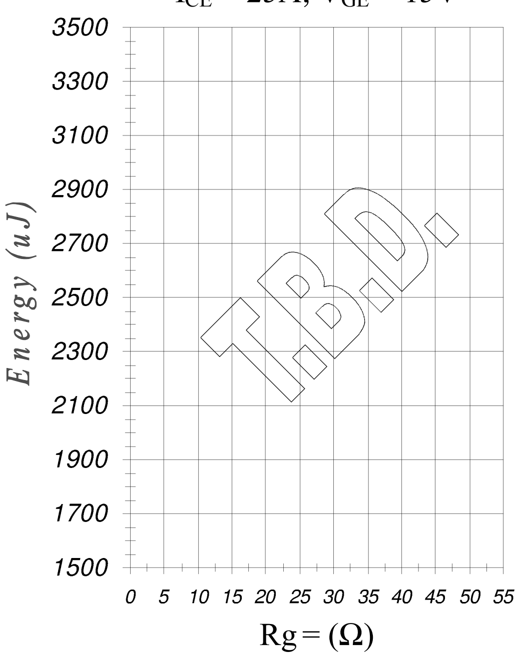


Fig. 16 – Typical Switching Time vs. Rg
Tj = 125ºC; L = 200µH; V_{CE} = 600V;
I_{CE} = 25A; V_{GE} = 15V

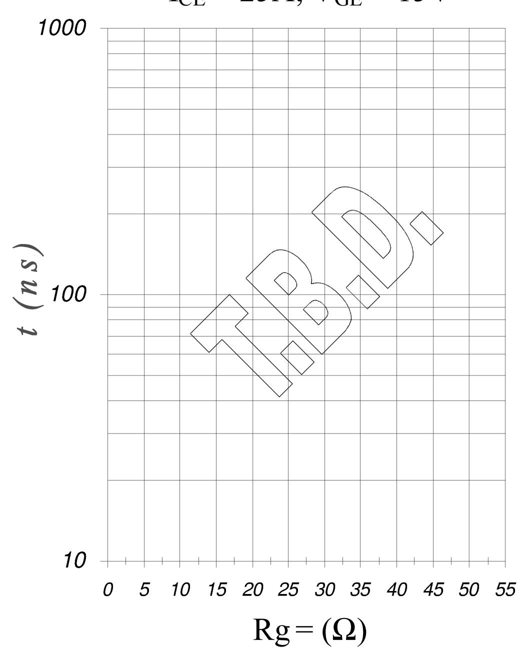


Fig. 17 – Typical Diode I_{RR} vs. I_F
Tj = 125ºC

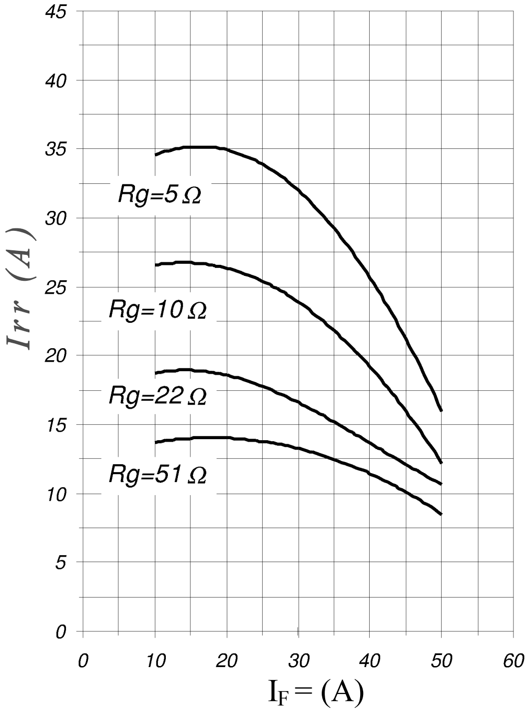


Fig. 18 – Typical Diode I_{RR} vs. Rg
I_F = 25A; Tj = 125ºC

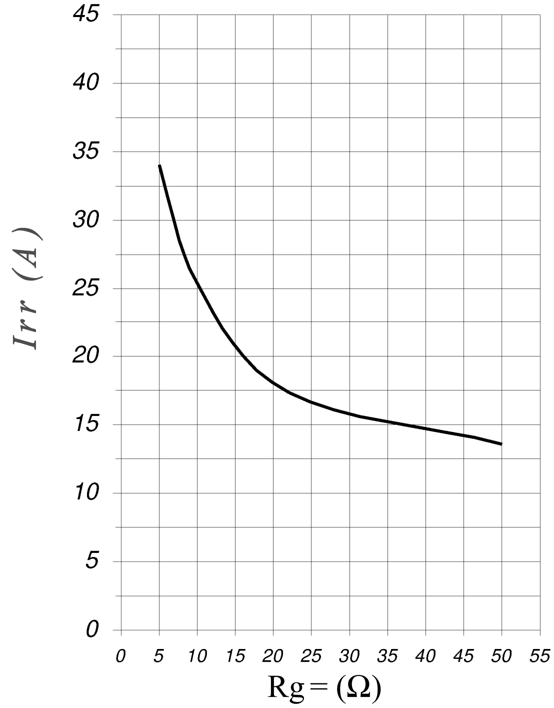


Fig. 19 – Typical Diode I_{RR} vs. dI_F/dt
V_{DC} = 600V; V_{GE} = 15V; I_F = 25A; Tj = 125ºC

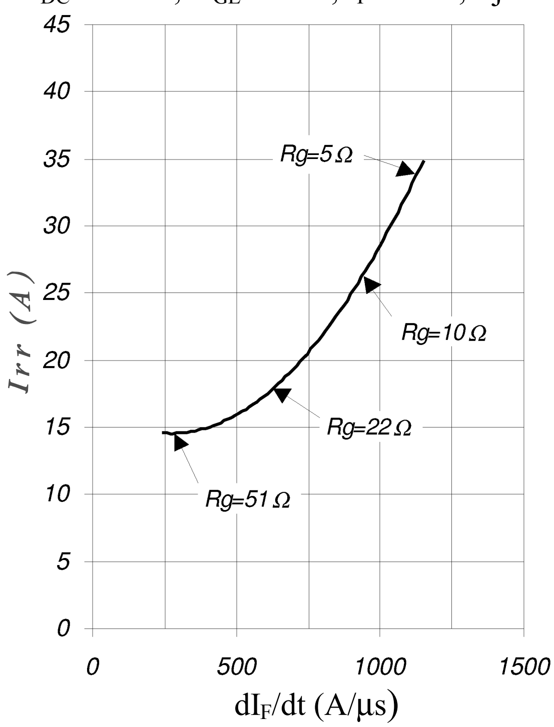


Fig. 20 – Typical Diode Q_{RR}
V_{DC} = 600V; V_{GE} = 15V; Tj = 125ºC

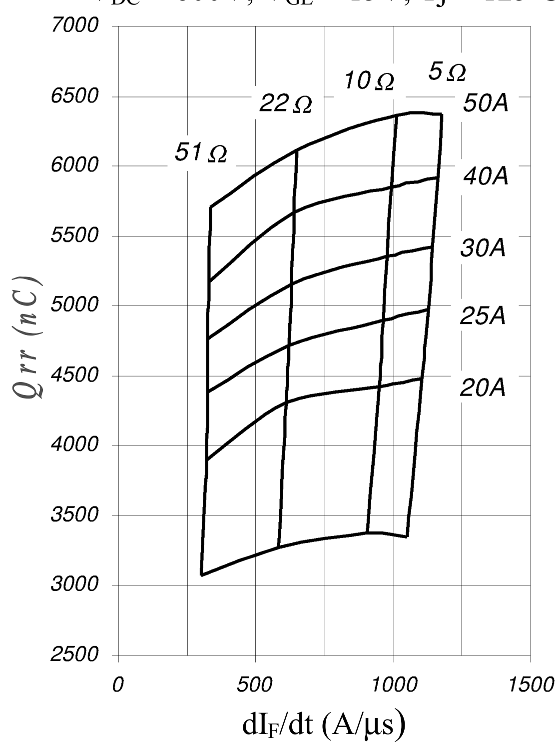


Fig. 21 – Typical Diode E_{REC} vs. I_F
Tj = 125ºC

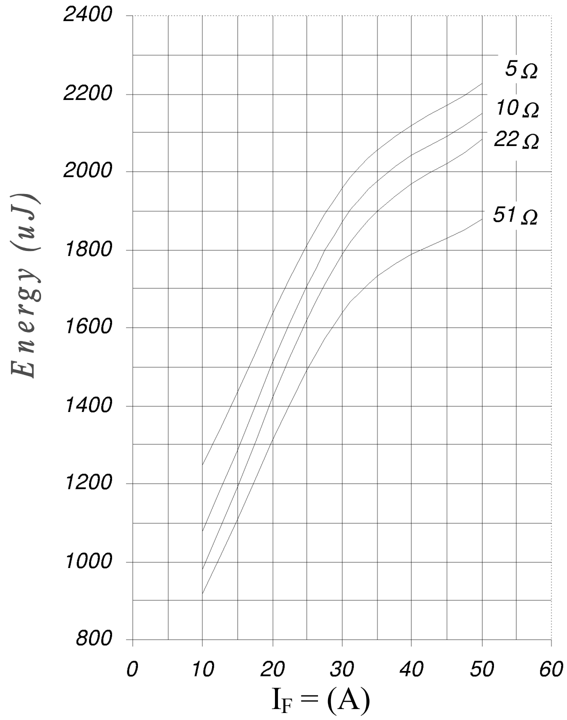


Fig. 22 – Typical Capacitance vs. V_{CE}
V_{GE} = 0V; f = 1MHz

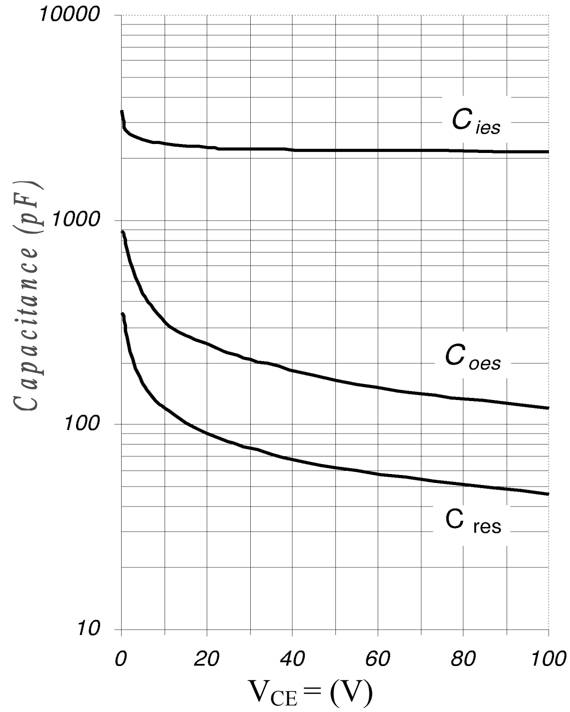


Fig. 23 – Typical Gate Charge vs. V_{GE}
I_C = 25A; L = 600µH; V_{CC} = 600V

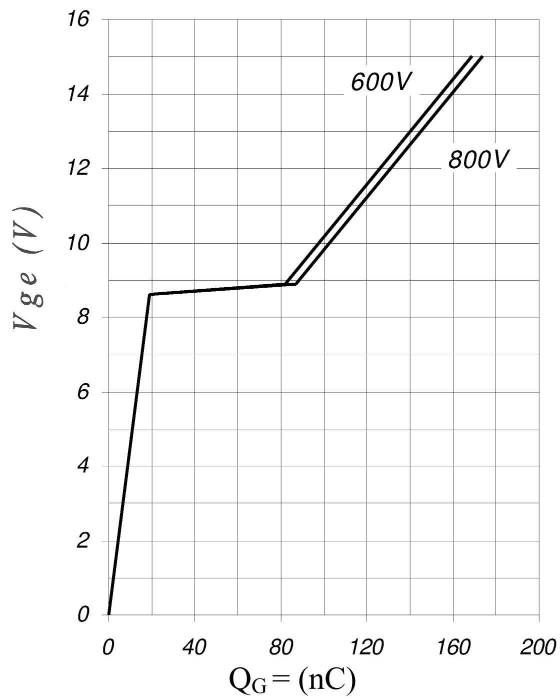


Fig. TF1 – Thermal Sensor Resistance
vs. Base-Plate Temperature

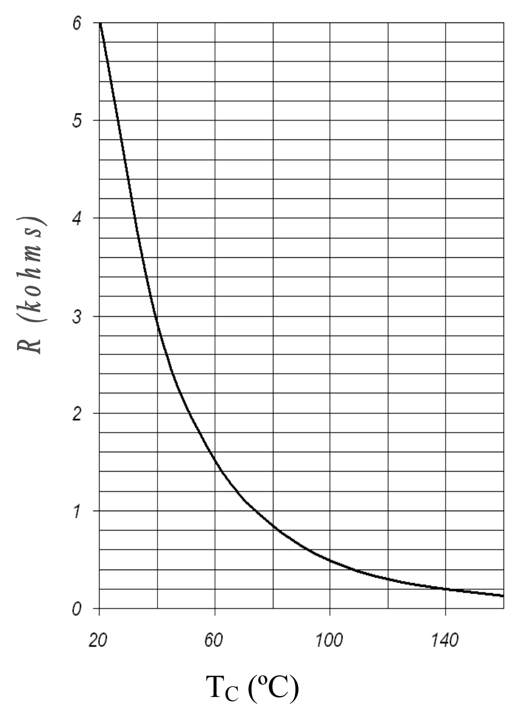


Fig. CT.1 - Gate Charge Circuit (turn-off)

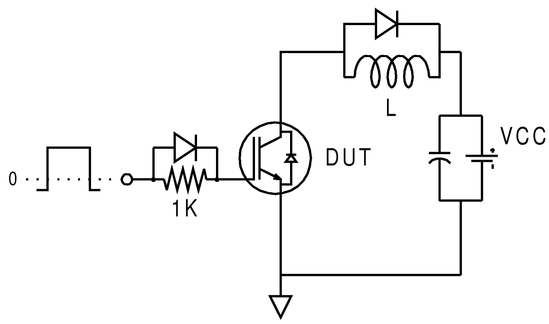


Fig. CT.2 - RBSOA Circuit

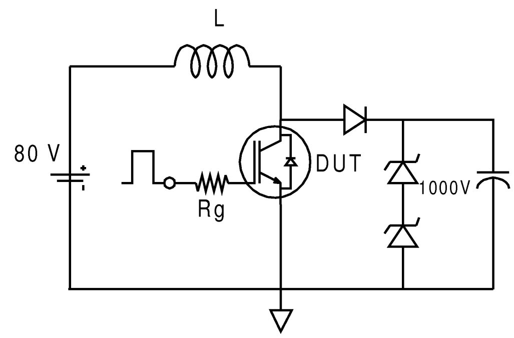


Fig. CT.3 - S.C. SOA Circuit

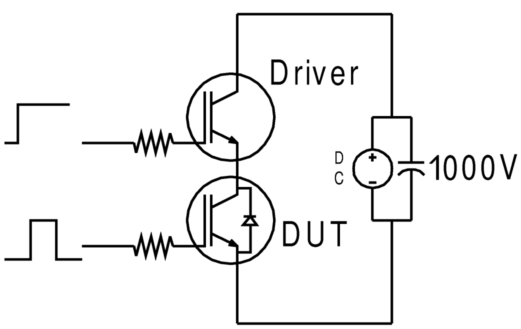


Fig. CT.4 - Switching Loss Circuit

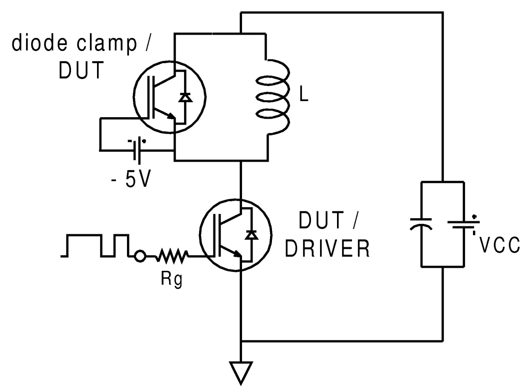


Fig. CT.5 - Resistive Load Circuit

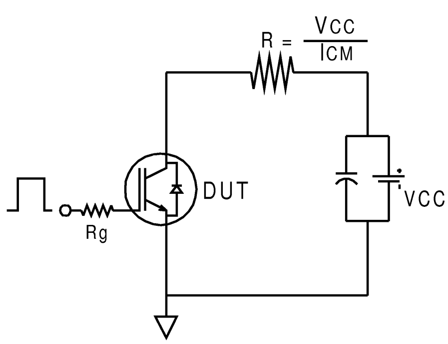


Fig. WF.1 - Typ. Turn-off Loss Waveform @ Tj=125°C using Fig. CT.4

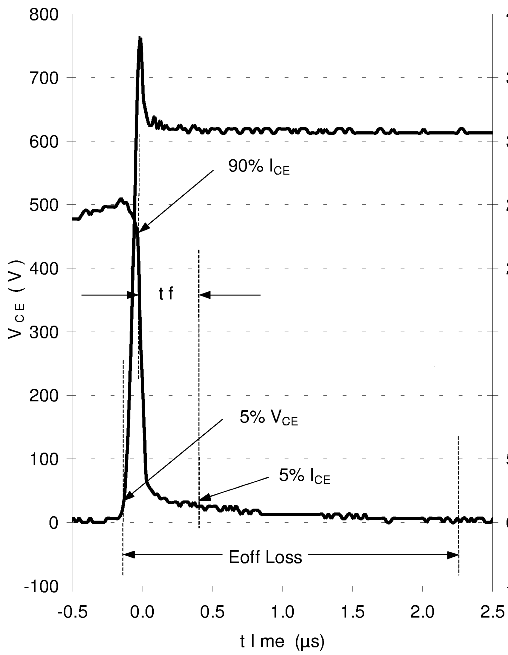


Fig. WF.2 - Typ. Turn-on Loss Waveform @ Tj=125°C using Fig. CT.4

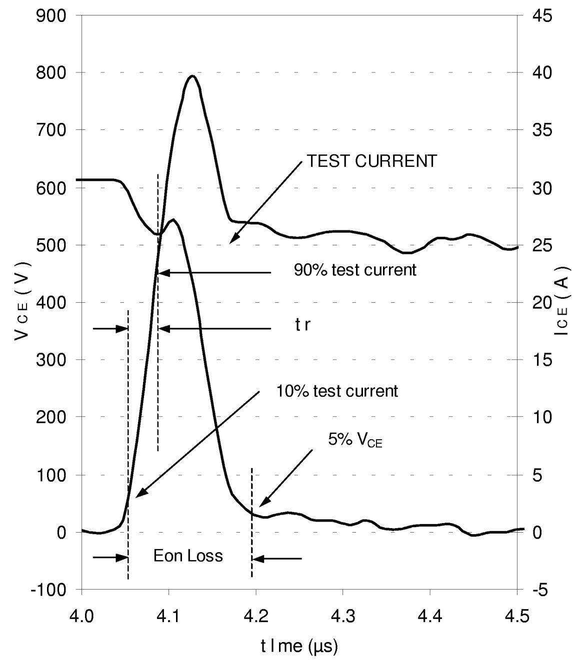


Fig. WF.3 - Typ. Diode Recovery Waveform @ Tj=125°C using Fig. CT.4

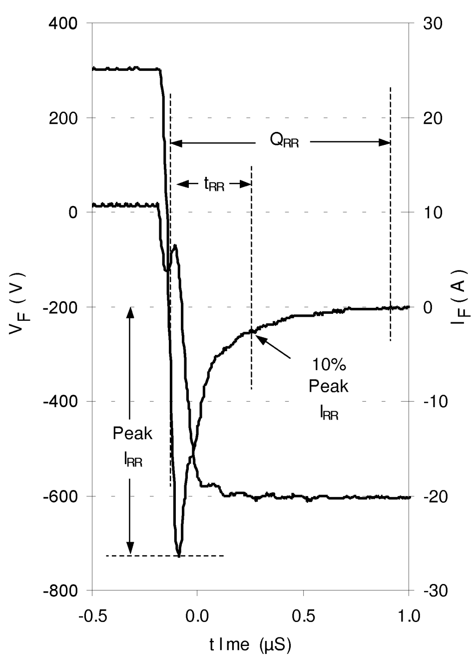
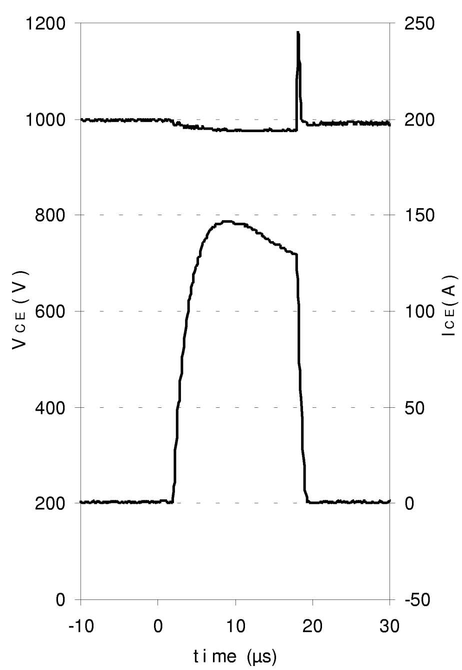
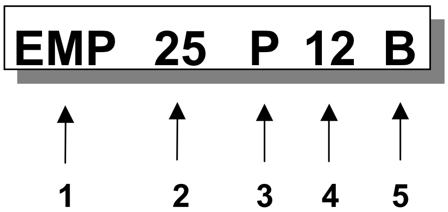


Fig. WF.4 - Typ. S.C. Waveform @ T_C=150°C using Fig. CT.3



EMP family part number identification



1- Package type

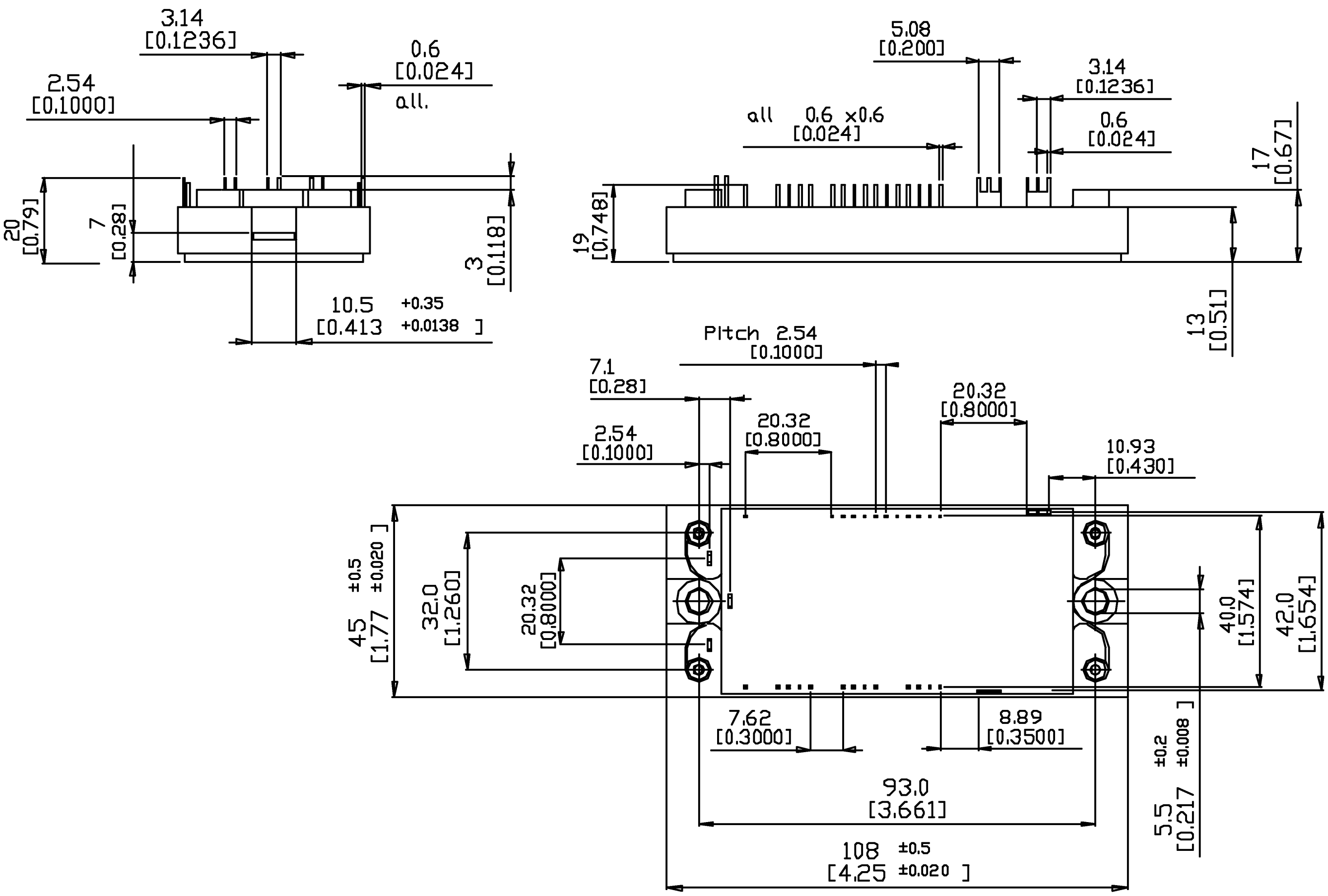
2- Current rating

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



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