International
IOR Rectifier

Bulletin I27148 08/06

EMP50P12B

iNTERO

PIM+

EMP Features:

- **Power Module:**
  - NPT IGBTs 50A, 1200V
  - 10us Short Circuit capability
    - Square RBSOA
    - Low $Vce_{(on)}$ (2.15Vtyp @ 50A, 25°C)
    - Positive $Vce_{(on)}$ 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)

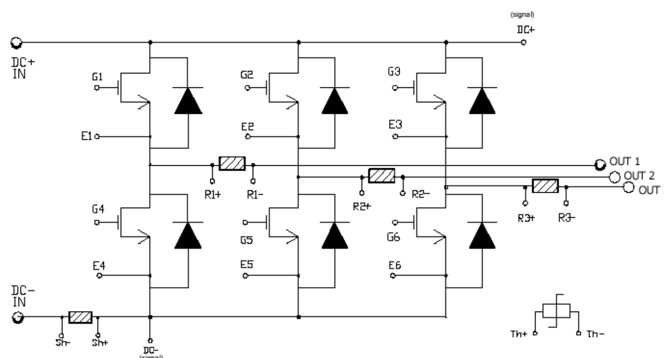
Description

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.

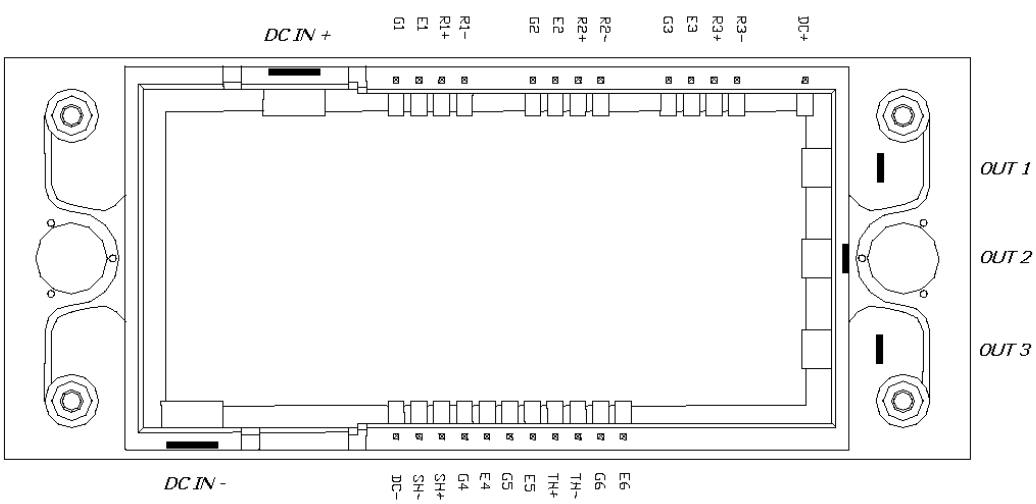
The device comes in the EMP™ package, fully compatible in length, width and height with EconoPack 2 outline.

Power Module schematic:



Three phase inverter with current sensing resistors on all output phases

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=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)		50	A
	$I_{C\ @\ 25C}$	IGBTs continuous collector current (T_C = 25 °C)		100	
	I_{CM}	Pulsed Collector Current (Fig. 3, Fig. CT.5)		200	
	$I_{F\ @\ 100C}$	Diode Continuous Forward Current (T_C = 100 °C)		50	
	$I_{F\ @\ 25C}$	Diode Continuous Forward Current (T_C = 25 °C)		100	
	I_{FM}	Diode Maximum Forward Current		200	
	V_{GE}	Gate to Emitter Voltage	-20	+20	V
	$P_{D\ @\ 25°C}$	Power Dissipation (One transistor)		354	W
	$P_{D\ @\ 100°C}$	Power Dissipation (One transistor, T_C = 100 °C)		142	
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		2.15	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
$\Delta V_{GE(th)} / \Delta Tj$	Temp. Coeff. of Threshold Voltage		-1.2		mV/°C	V_{CE} = V_{GE}, I_C = 1mA (25 - 125 °C)	
g_{fe}	Forward Trasconductance	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 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 off)		400	411	nC	I_C = 50A	23
Q_{ge}	Gate – Emitter Charge (turn off)		46	55		V_{CC} = 600V	
Q_{gc}	Gate – Collector Charge (turn off)		181	200		V_{GE} = 15V	CT1
E_{on}	Turn on Switching Loss		2814	3220	µJ	I_C = 50A, V_{CC} = 600V, T_J = 25 °C	CT4
E_{off}	Turn off Switching Loss		5293	5825		V_{GE} = 15V, R_G =10Ω, L = 250µH	WF1
E_{tot}	Total Switching Loss		8107	9145		Tail and Diode Rev. Recovery included	WF2
E_{on}	Turn on Switching Loss		3963	4415	µJ	I_C = 50A, V_{CC} = 600V, T_J = 125 °C	13, 15
E_{off}	Turn off Switching Loss		7810	8965		V_{GE} = 15V, R_G =10Ω, L = 250µH	CT4 WF1
E_{tot}	Total Switching Loss		11773	13380		Tail and Diode Rev. Recovery included	WF2
td (on)	Turn on delay time		66	72	ns	I_C = 50A, V_{CC} = 600V, T_J = 125 °C	14,16
Tr	Rise time		72	83			CT4
td (off)	Turn off delay time		593	641		V_{GE} = 15V, R_G =10Ω, L = 250µH	WF1
Tf	Fall time		95	117			WF2
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, Vp= 1200V, R_G = 5Ω	CT3 WF4
E_{REC}	Diode reverse recovery energy	693	1114	1535	µJ	T_J = 125 °C	17,18 19,20
trr	Diode reverse recovery time	156	260	363	ns	I_F = 50A, V_{CC} = 600V,	21 CT4
Irr	Peak reverse recovery current	35	42	43	A	V_{GE} = 15V, R_G =10Ω, L = 250µH	WF3
Rth_{JC_T}	Each IGBT to copper plate thermal resistance			0.35	°C/W	See also fig.24 and 25	24,25
Rth_{JC_D}	Each Diode to copper plate thermal resistance			0.70	°C/W		
Rth_{C-H}	Module copper plate to heat sink thermal resistance. Silicon grease applied = 0.1mm			0.03	°C/W		
Pdiss	Total Dissipated Power		100		W	I_C = 7A, V_{DC} = 530V, fsw = 8kHz, T_C = 55 °C	PD1
			150			I_C = 10A, V_{DC} = 530V, fsw = 8kHz, T_C = 55 °C	PD2
			250			I_C = 10A, V_{DC} = 530V, fsw = 16kHz T_C = 55 °C,	
			200			I_C = 20A, V_{DC} = 530V, fsw = 4kHz, T_C = 40°C	PD3

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

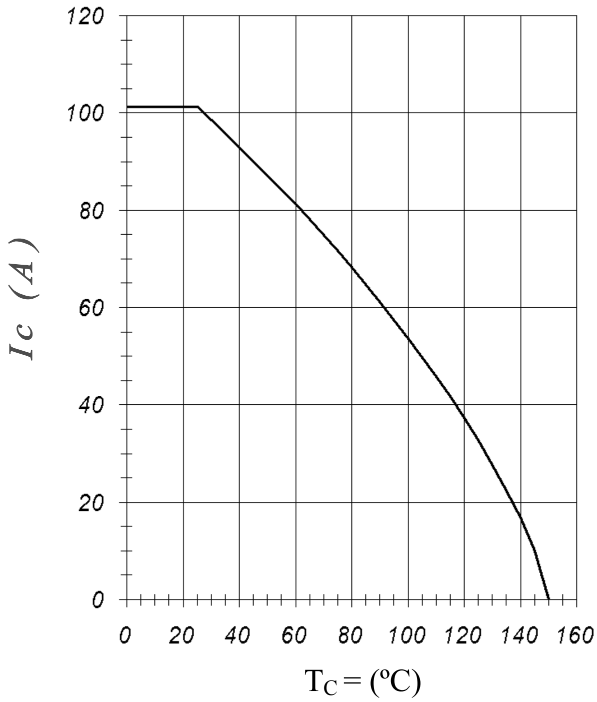


Fig. 2 – Power Dissipation vs.
Case Temperature

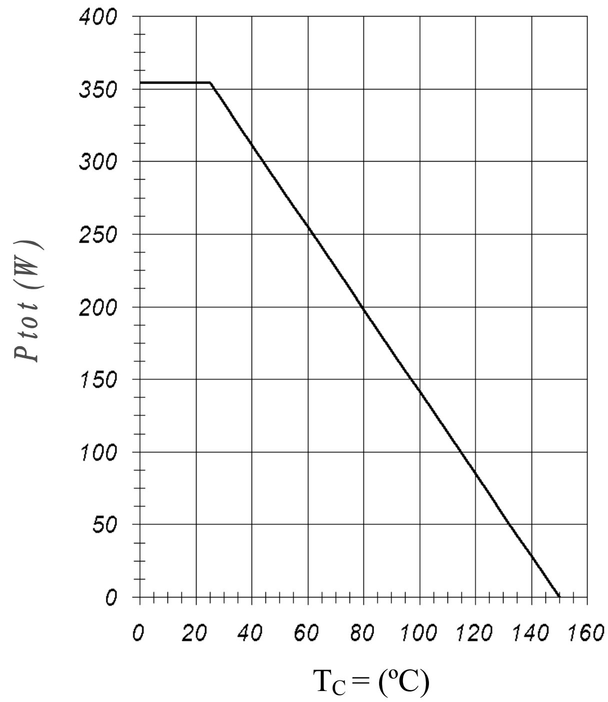


Fig. 3 – Forward SOA
T_C = 25ºC; Tj ≤ 150ºC

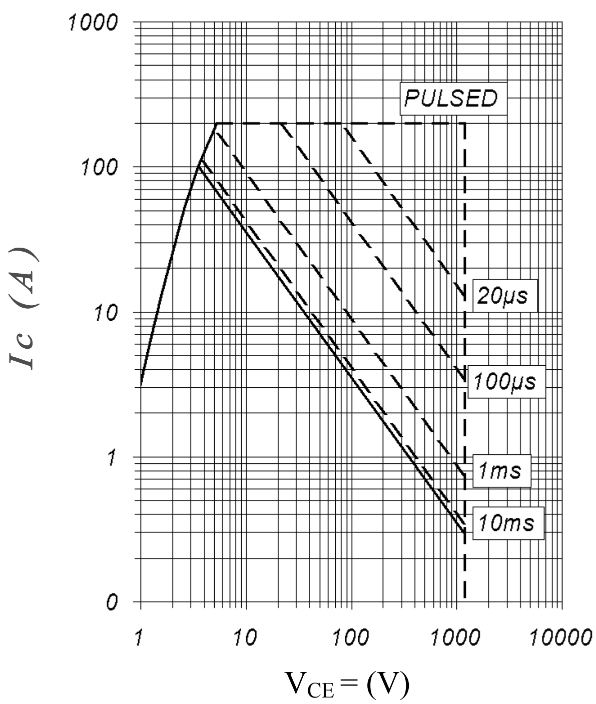


Fig. 4 – Reverse Bias SOA
Tj = 150ºC, V_{GE} = 15V

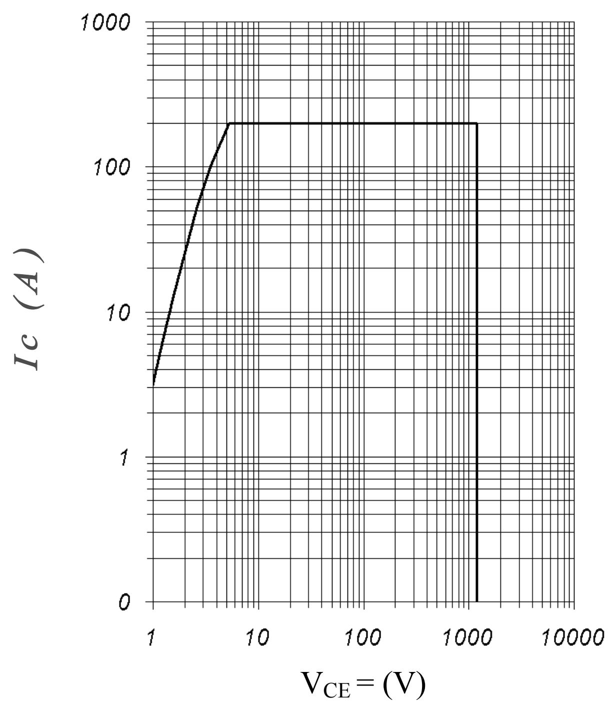


Fig. 5 – Typical IGBT Output Characteristics
Tj = - 40ºC; tp = 500µs

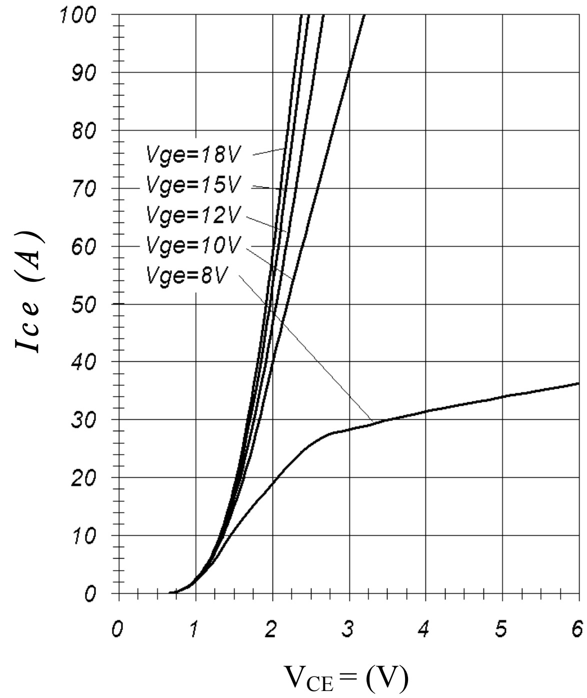


Fig. 6 – Typical IGBT Output haracteristics
Tj = 25ºC; tp = 500µs

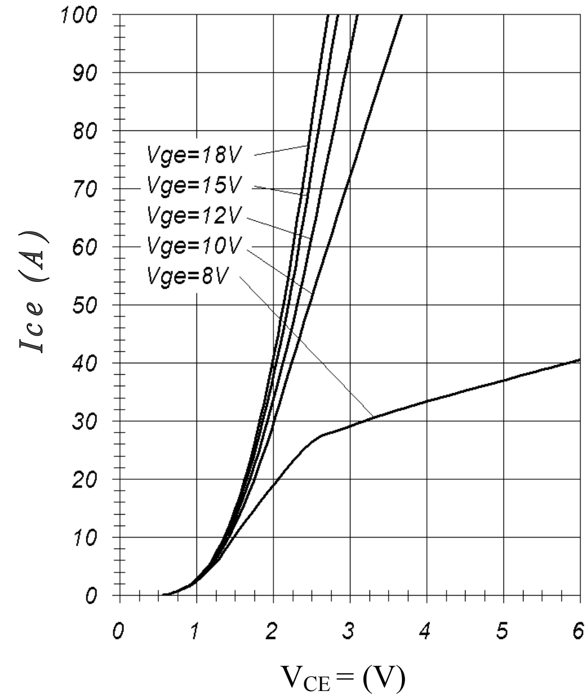


Fig. 7 – Typical IGBT Output Characteristics
Tj = 125ºC; tp = 500µs

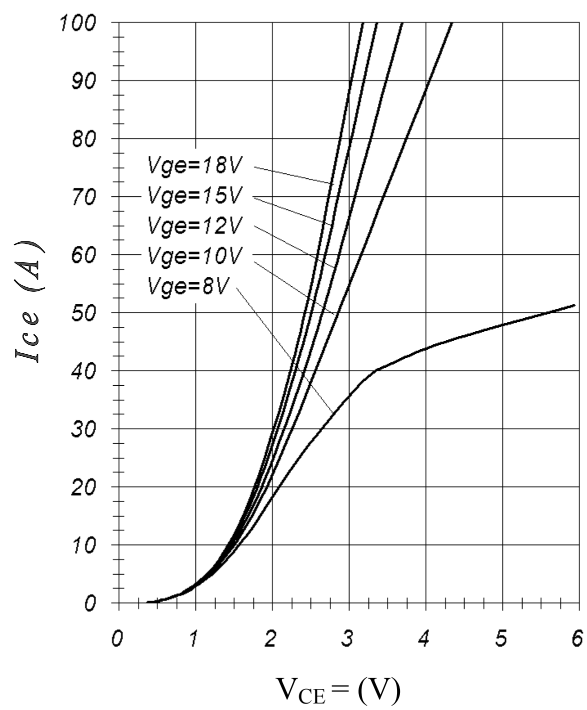


Fig. 8 – Typical Diode Forward Characteristics
tp = 500µs

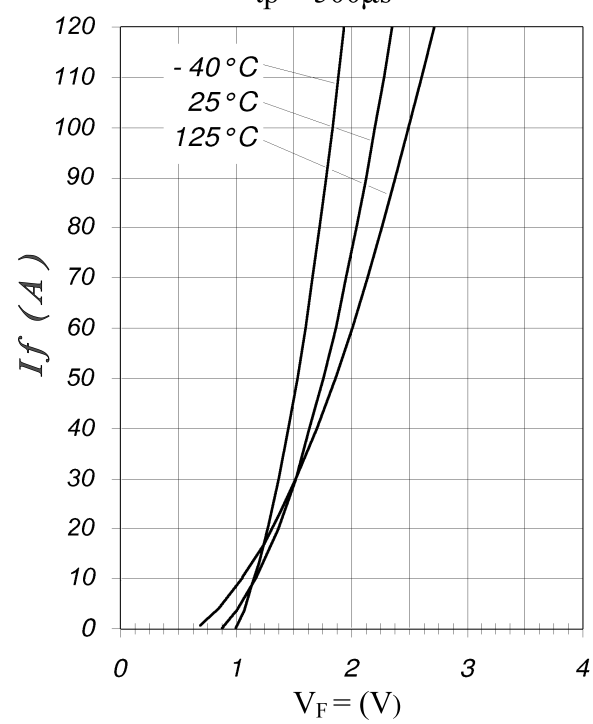


Fig. 9 – Typical V_{CE} vs. V_{GE}
Tj = - 40ºC

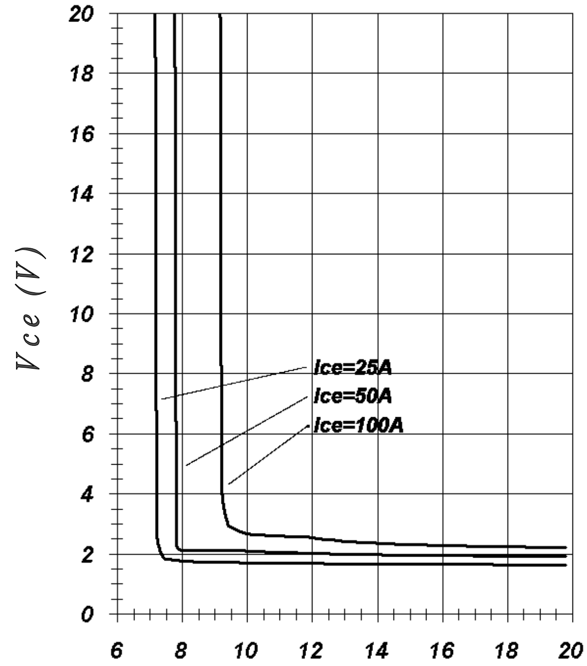


Fig. 10 – Typical V_{CE} vs. V_{GE}
Tj = 25ºC

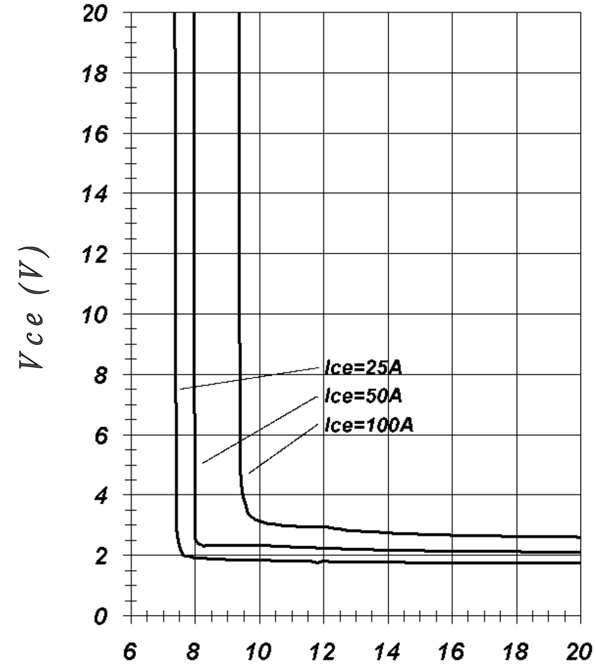


Fig. 11 – Typical V_{CE} vs. V_{GE}
Tj = 125ºC

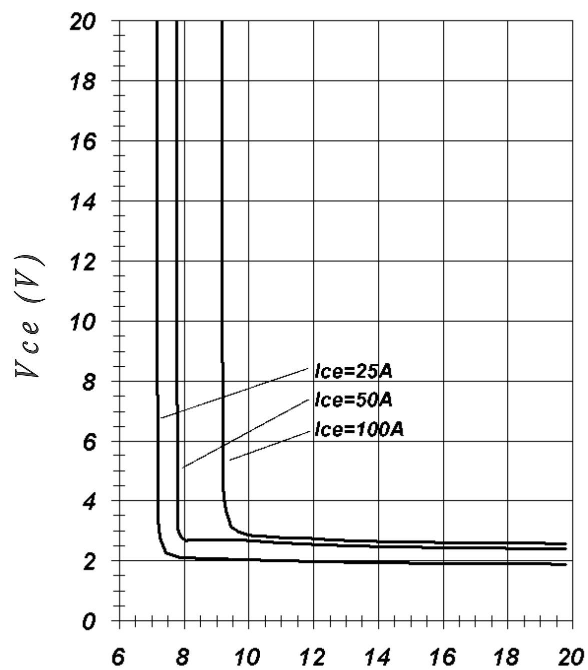


Fig. 12 – Typical Transfer Characteristics
V_{CE} = 20V; tp = 20µs

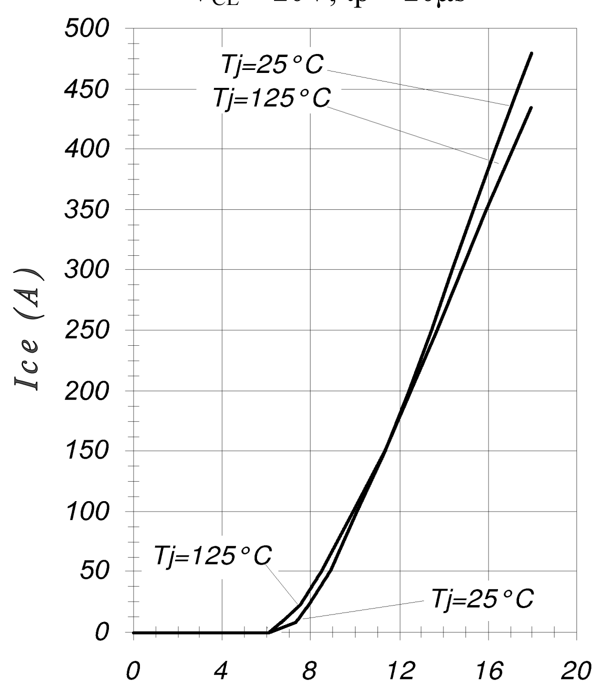


Fig. 13 – Typical Energy Loss vs. I_C
Tj = 125ºC; L = 250µH; V_{CE} = 600V;
Rg = 10Ω; V_{GE} = 15V

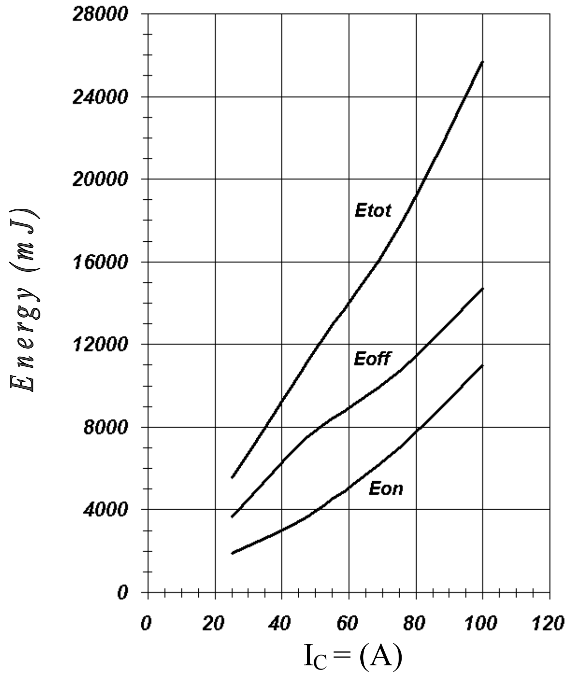


Fig. 14 – Typical Switching Time vs. I_C
Tj = 125ºC; L = 250µH; V_{CE} = 600V;
Rg = 10Ω; V_{GE} = 15V

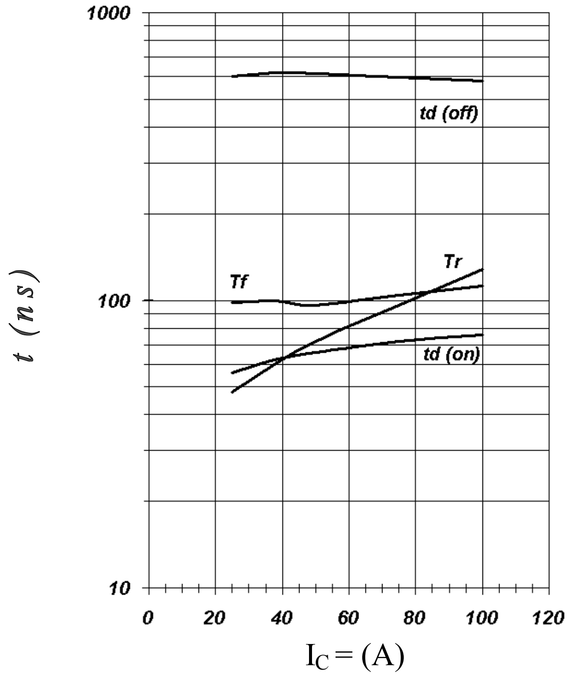


Fig. 15 – Typical Energy Loss vs. Rg
Tj = 125ºC; L = 250µH; V_{CE} = 600V;
I_{CE} = 50A; V_{GE} = 15V

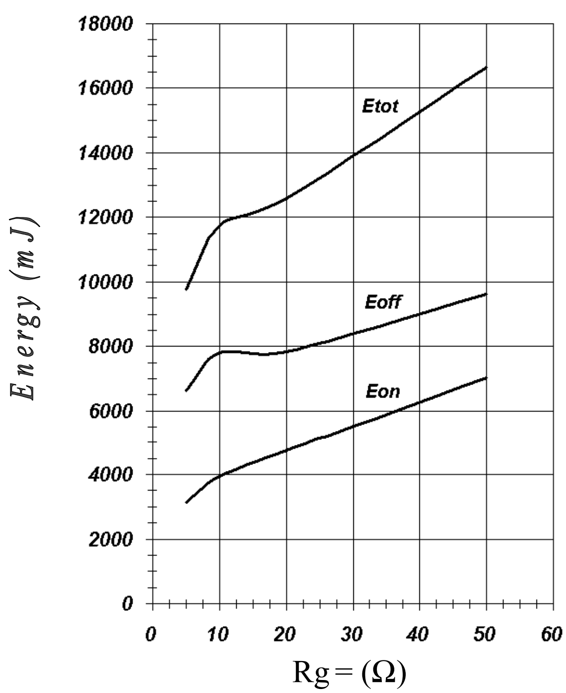


Fig. 16 – Typical Switching Time vs. Rg
Tj = 125ºC; L = 250µH; V_{CE} = 600V;
I_{CE} = 50A; V_{GE} = 15V

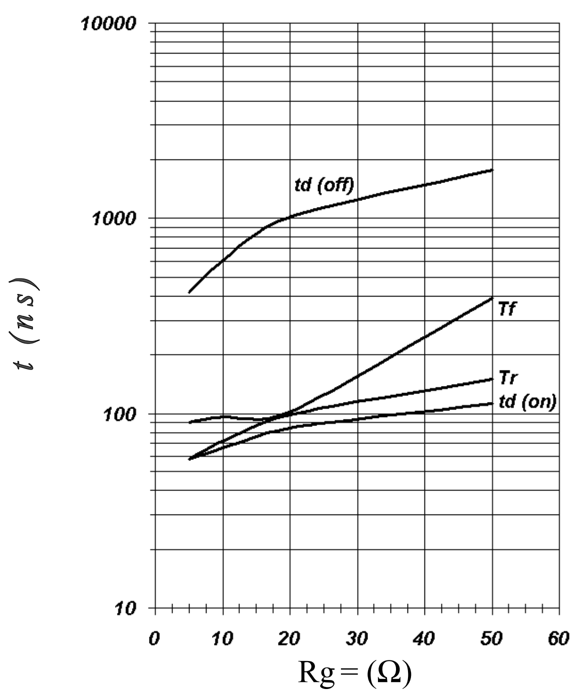
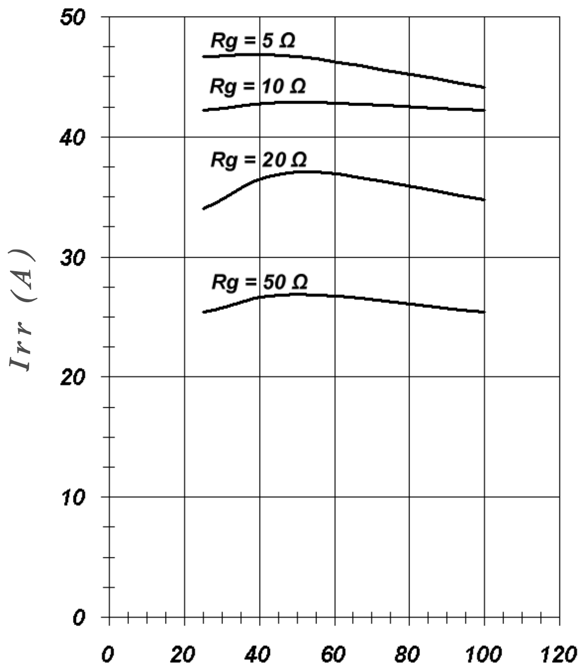
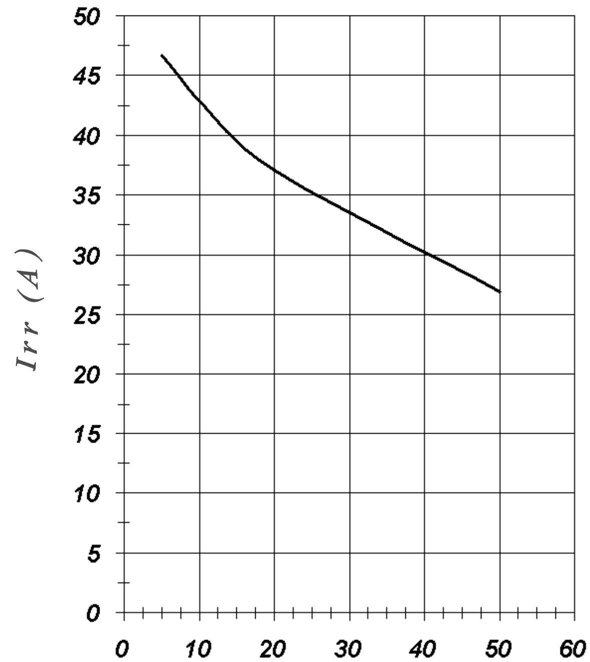


Fig. 17 – Typical Diode I_{RR} vs. I_F
Tj = 125ºC



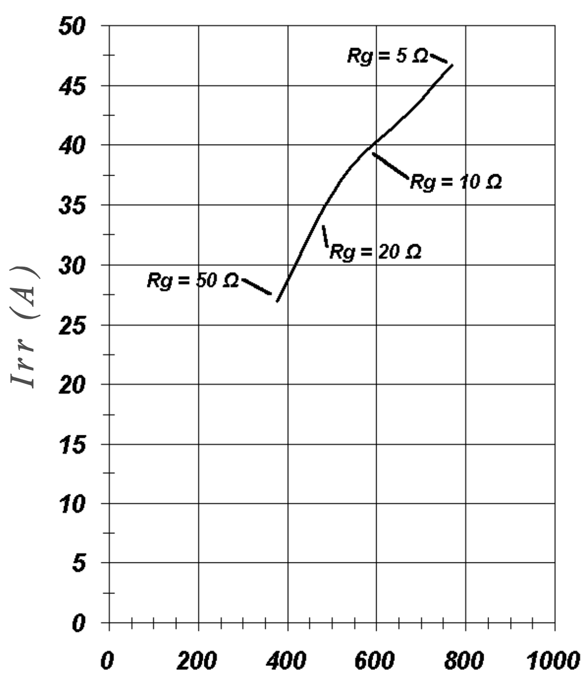
I_F = (A)

Fig. 18 – Typical Diode I_{RR} vs. Rg
I_F = 50A; Tj = 125ºC



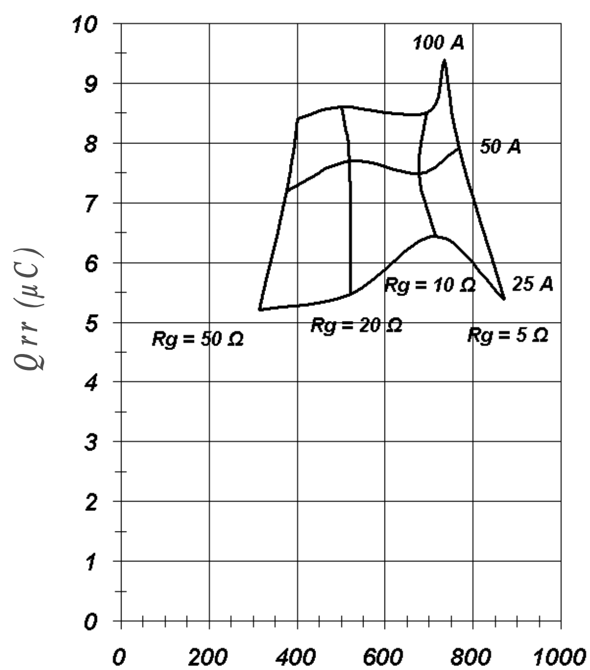
Rg = (Ω)

Fig. 19 – Typical Diode I_{RR} vs. dI_F/dt
V_{DC} = 600V; V_{GE} = 15V; I_F = 50A; Tj = 125ºC



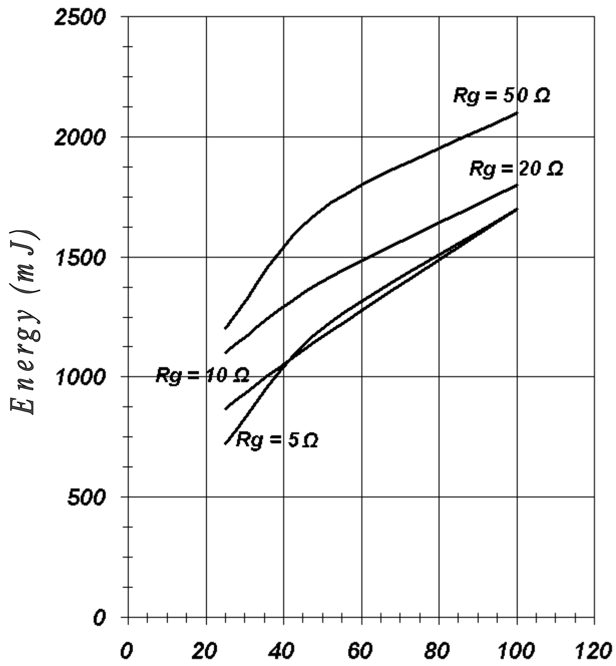
dI_F/dt (A/µs)

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



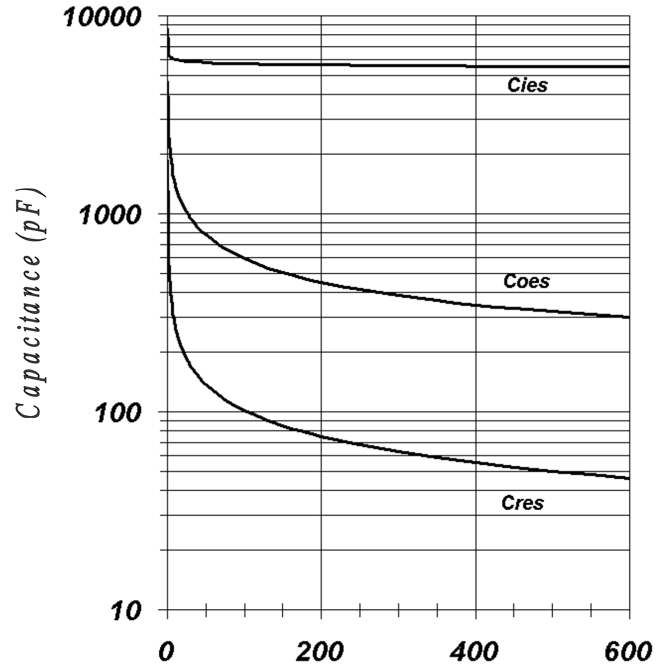
dI_F/dt (A/µs)

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



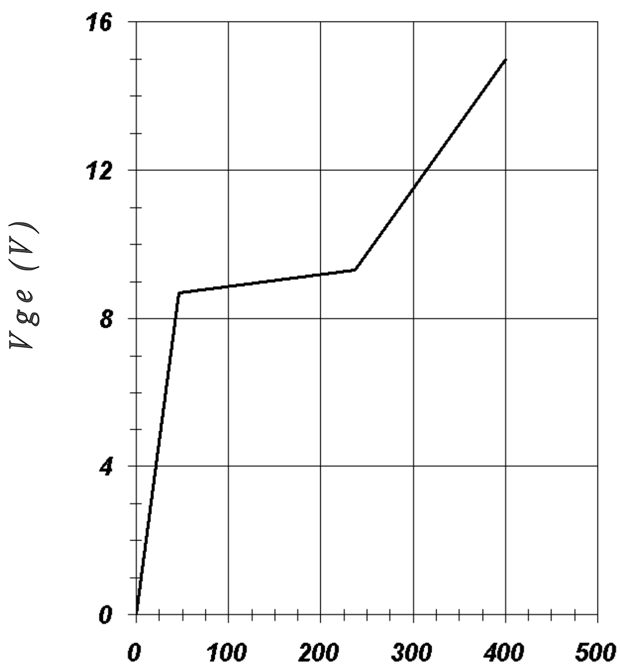
I_F = (A)

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



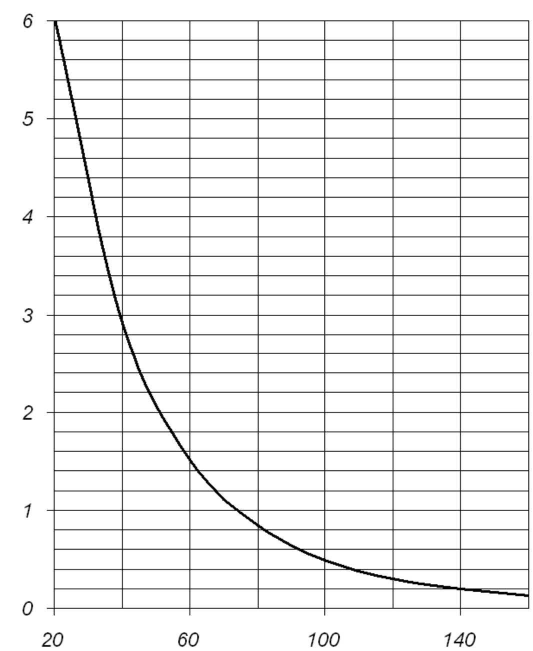
Vce = (V)

Fig. 23 – Typical Gate Charge vs. V_{GE}
I_C = 50A; L = 600µH; V_{CC} = 600V



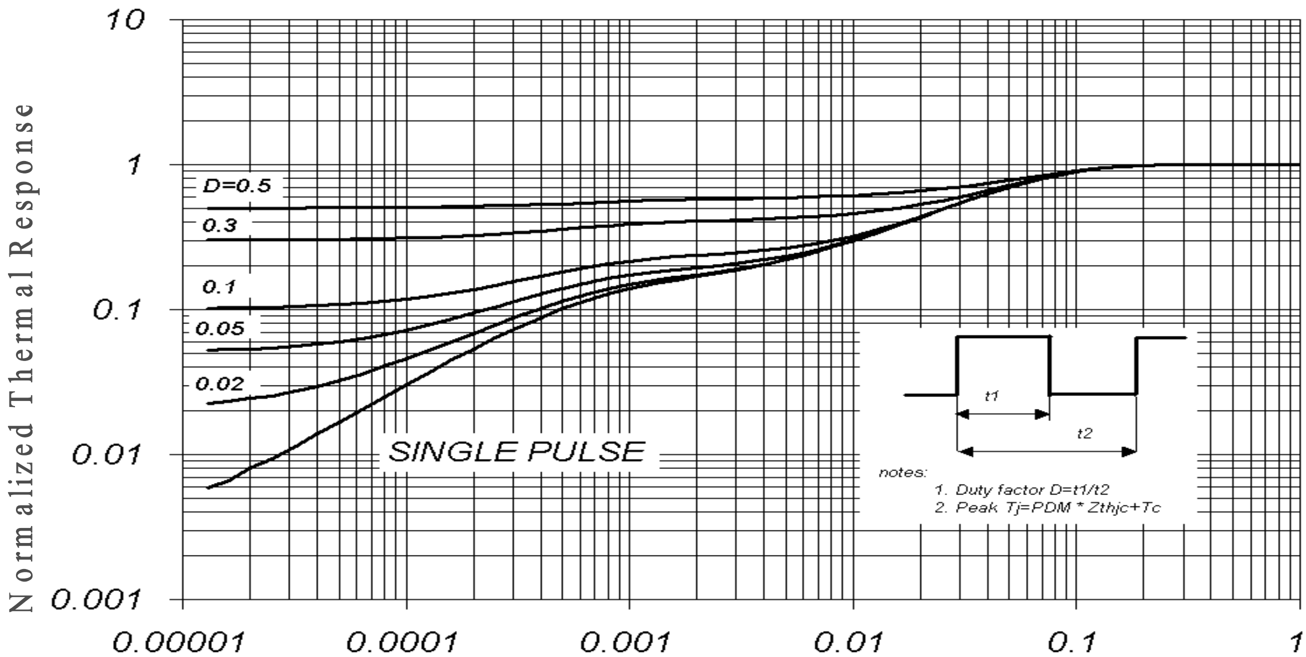
Q_G = (nC)

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



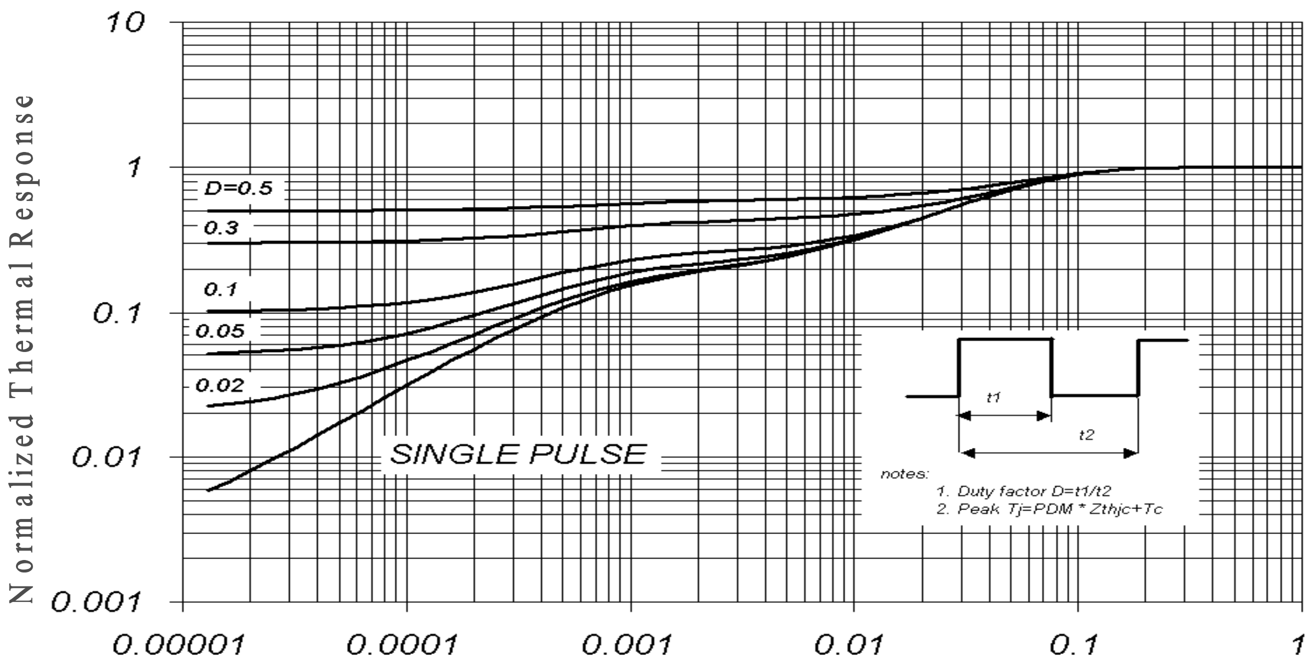
T_C (ºC)

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



t1, Rectangular Pulse Duration (sec)

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



t1, Rectangular Pulse Duration (sec)

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

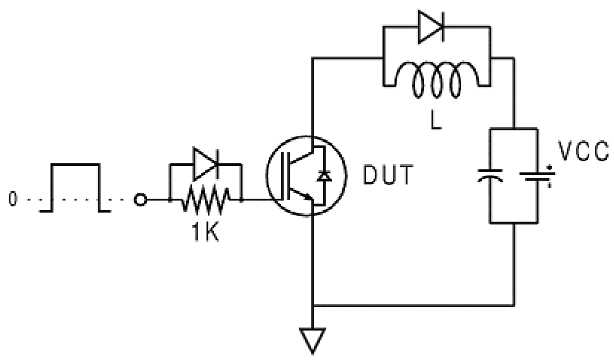


Fig. CT.2 - RBSOA Circuit

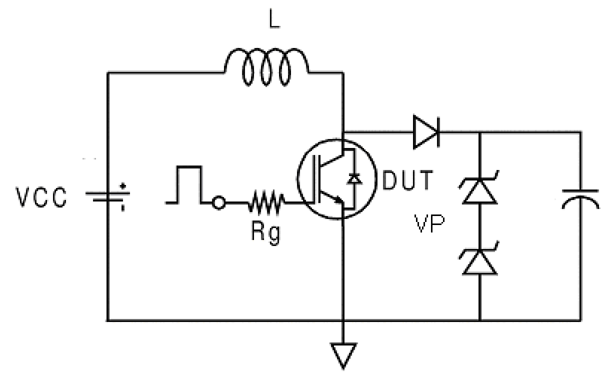


Fig. CT.3 - S.C. SOA Circuit

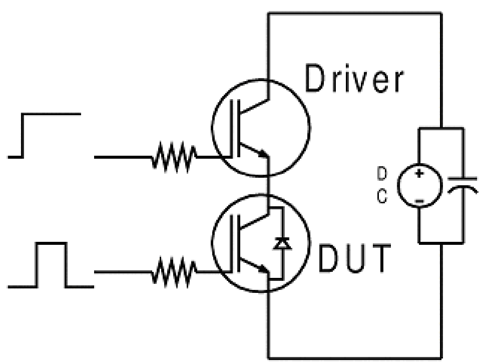


Fig. CT.4 - Switching Loss Circuit

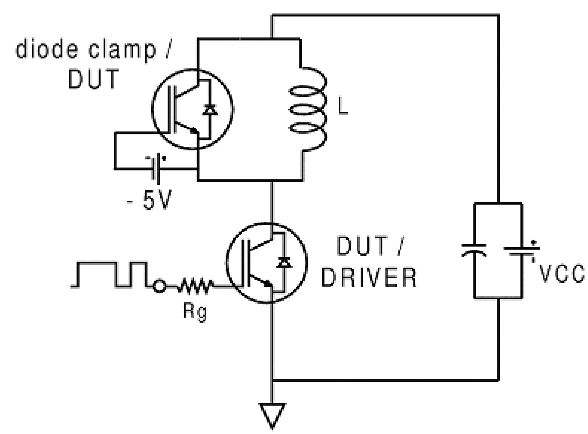


Fig. CT.5 - Resistive Load Circuit

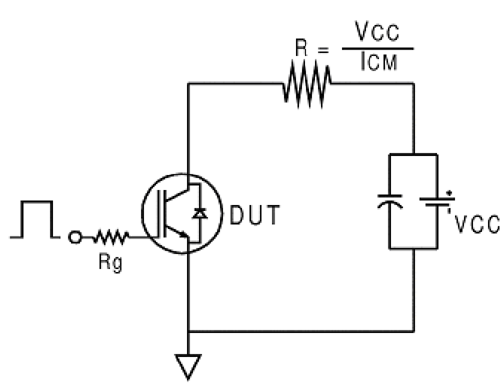


Fig. WF.1 - Typ. Turn-off Loss Waveform @ Tj=125°C using Fig. CT.4

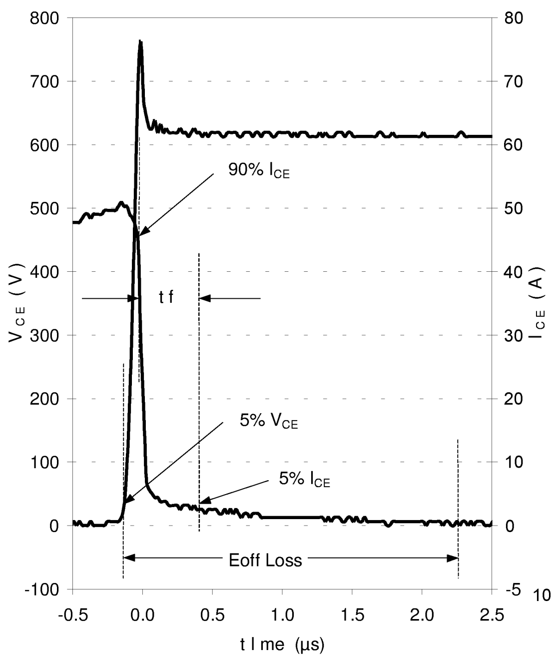


Fig. WF.2 - Typ. Turn-on Loss Waveform @ Tj=125°C using Fig. CT.4

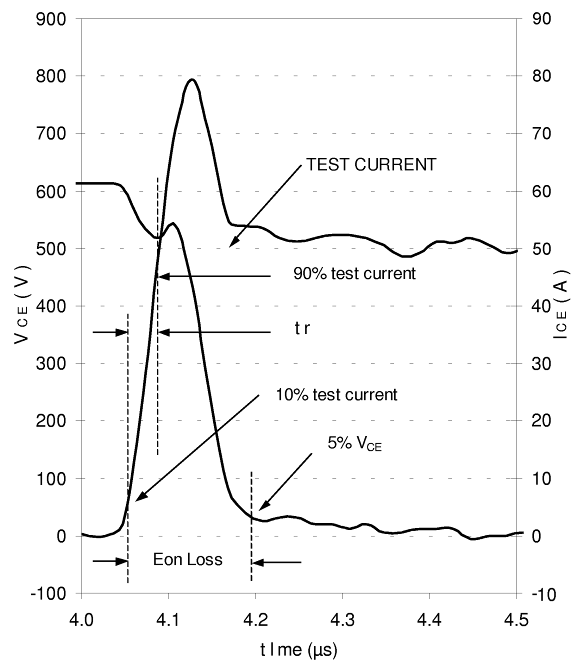


Fig. WF.3 - Typ. Diode Recovery Waveform @ Tj=125°C using Fig. CT.4

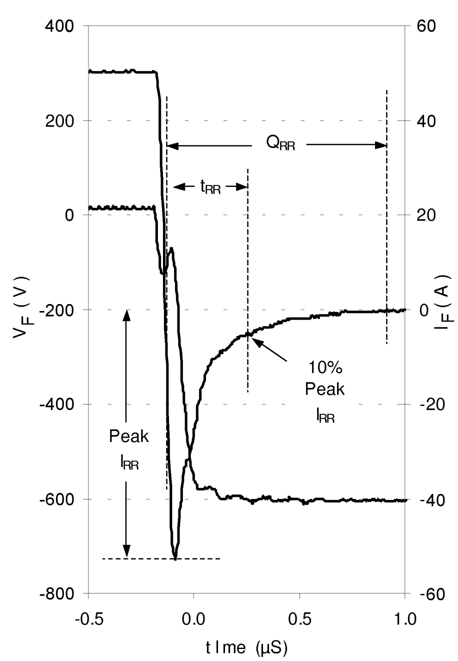
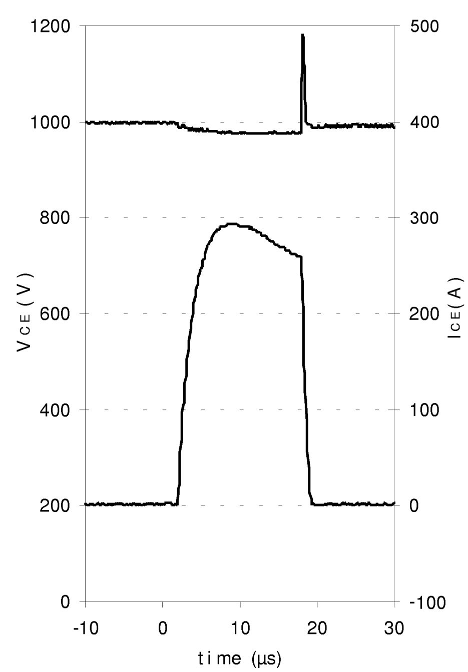


Fig. WF.4 - Typ. S.C. Waveform @ T_C=150°C using Fig. CT.3



EMP family part number identification

EMP 50 P 12 B

↑ ↑ ↑ ↑ ↑

1 2 3 4 5

1- Package type

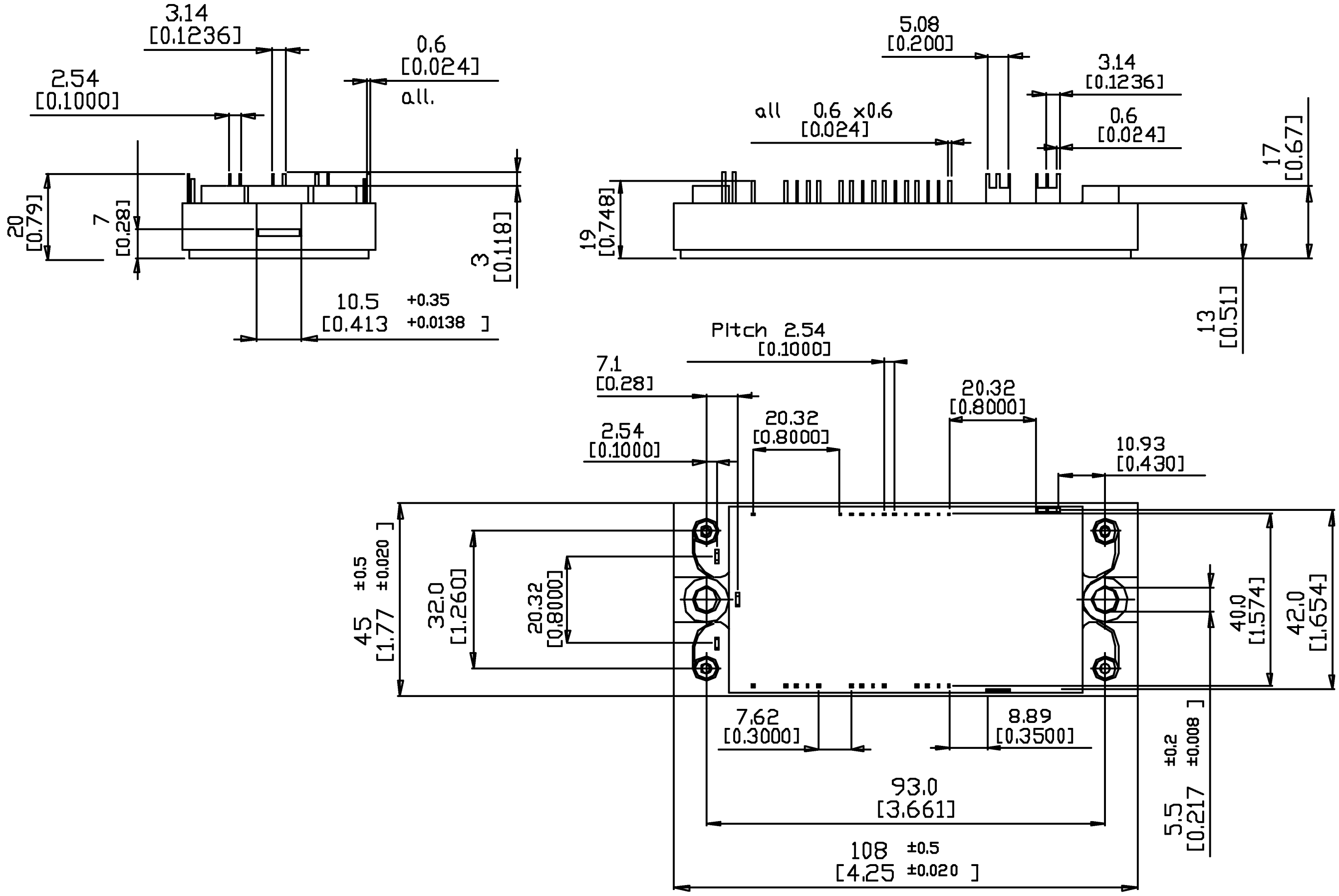
2- Current rating

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

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.

International Rectifier

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