International
IOR Rectifier

EMP15P12D

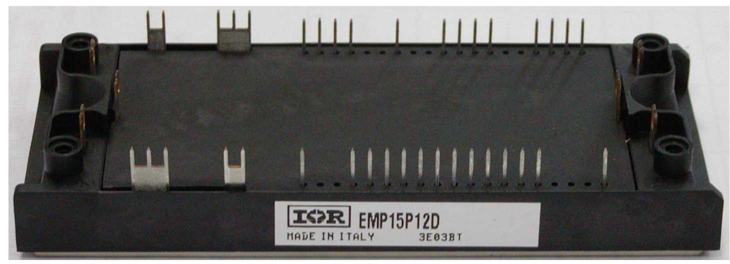
iNTERO

PIM+

EMP Features:

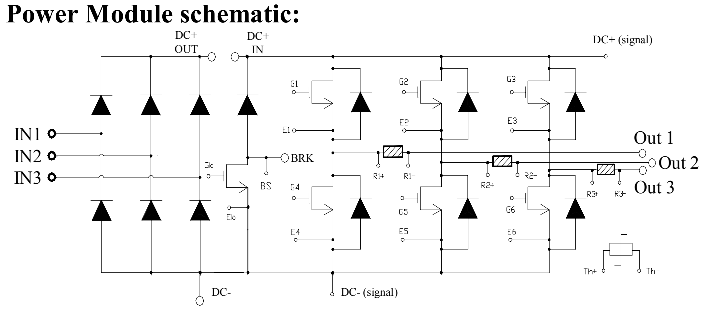
- **Power Module:**
  - NPT IGBTs 15A, 1200V
  - 10us Short Circuit capability
    - Square RBSOA
    - Low $Vce_{(on)}$ (2.7Vtyp @ 15A, 25°C)
    - Positive $Vce_{(on)}$ temperature coefficient
  - Gen III HexFred Technology
    - Low diode V_F (2.32Vtyp @ 15A, 25°C)
    - Soft reverse recovery
  -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

Package:



EMP – Bridge Brake inverter (EconoPack 2 outline compatible)

Power Module schematic:



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

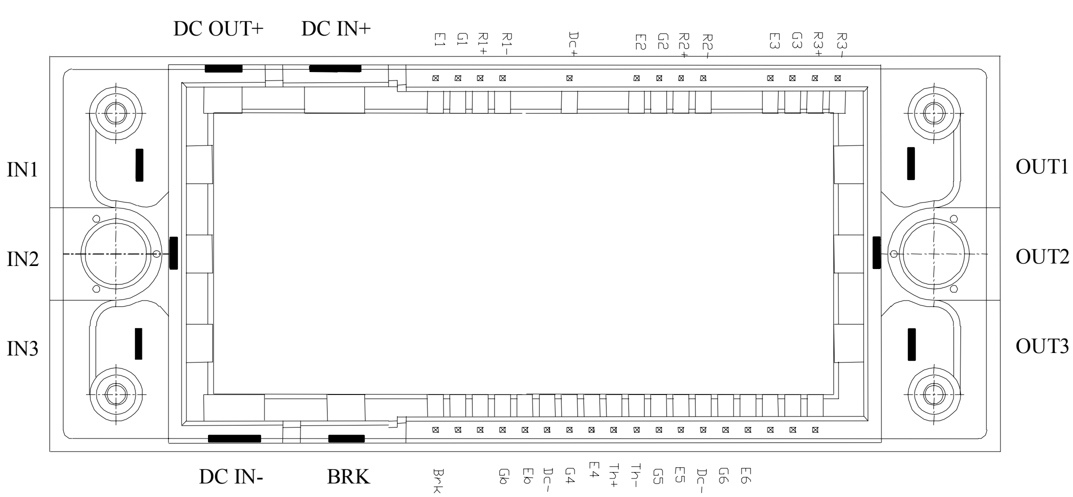
Description

The EMP15P12D 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
IN1/2/3	Diode Bridge power input pins
DC OUT+	DC Bus plus power output pin
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 connections (Kelvin points)
BRK	Brake power output pin
Brk	Brake signal connection (Kelvin point)
Th +	Thermal sensor positive input
Th -	Thermal sensor negative input
G1/2/3	Gate connections for high side IGBTs
E1/2/3	Emitter connections for high side IGBTs (Kelvin points)
Gb	Gate connection for brake IGBT (Kelvin point)
Eb	Emitter connection for brake IGBT (Kelvin point)
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

General Description

The EMP module contains six IGBTs and HexFreds Diodes in a standard inverter configuration. IGBTs used are the new NPT 1200V-15A (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.

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 and Brake	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)			15	A
	$I_{C\ @\ 25C}$	IGBTs continuous collector current (T_C = 25 °C,fig 1)			30	
	I_{CM}	Pulsed Collector Current (Fig. 3, Fig. CT.5)			60	
	$I_{F\ @\ 100C}$	Diode Continuous Forward Current (T_C = 100 °C)			15	
	$I_{F\ @\ 25C}$	Diode Continuous Forward Current (T_C = 25 °C)			30	
	I_{FM}	Diode Maximum Forward Current			60	
	V_{GE}	Gate to Emitter Voltage		-20	+20	V
	$P_{D\ @\ 25°C}$	Power Dissipation (One transistor)			140	W
	$P_{D\ @\ 100°C}$	Power Dissipation (One transistor, T_C = 100 °C)			55	
Bridge	V_{RRM}	repetitive peak reverse voltage (T_j = 150 °C)	T_j = 150 °C Irrm(max)=5mA		1400	V
	V_{RSM}	non repetitive peak reverse voltage			1500	
	I_o	Diode Continuous Forward Current (T_C = 100 °C, 120° Rect conduction angle)			45	A
	I_{FSM}	One-cycle forward. Non-repetitive on state surge current (t=10ms, Initial T_j = 150°C)	100% V_{RRM} reapplied		225	
			No voltage reapplied		270	
	I^2t	Current I^2t for fusing (t=10ms, Initial T_j = 150°C)	100% V_{RRM} reapplied		253	A^2s
			No voltage reapplied		365	
	$I^2\sqrt{t}$	Current $I^2\sqrt{t}$ for fusing (t=0.1 to 10ms, no voltage reapplied, Initial T_j = 150°C)			3650	$A^2\sqrt{s}$
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: Inverter and Brake

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		2.70	3.00	V	I_C = 15A, V_{GE} = 15V	5, 6
			3.74	4.24		I_C = 30A, V_{GE} = 15V	7, 9
			3.14	3.61		I_C = 15A, V_{GE} = 15V, T_J = 125 °C	10, 11
$V_{GE(th)}$	Gate Threshold Voltage	4.68	4.89	5.30	V	V_{CE} = V_{GE}, I_C = 250µA	12
$\Delta V_{GE(th)} / \Delta Tj$	Temp. Coeff. of Threshold Voltage		-9.80		mV/°C	V_{CE} = V_{GE}, I_C = 1mA (25 - 125 °C)	
g_{fe}	Forward Trasconductance	8	9	10	S	V_{CE} = 50V, I_C = 15A, PW = 80µs	
I_{CES}	Zero Gate Voltage Collector Current			125	µA	V_{GE} = 0V, V_{CE} = 1200V	
			376	1110		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		2.32	2.52	V	I_C = 15A	8
			2.47	2.64		I_C = 15A, T_J = 125 °C	
I_{GES}	Gate To Emitter Leakage Current			±100	nA	V_{GE} =± 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_J = 25°C (unless otherwise specified)

Symbol	Parameter Definition	Min.	Typ.	Max.	Units	Test Conditions	Fig.
V_{FM}	Forward Voltage Drop		1.24	1.76	V	t_p = 400µs, I_{pk} = 30A	24
			1.08	1.27		t_p = 400µs, I_{pk} = 15A	
$V_{F(TO)}$	Threshold voltage		0.78		V	T_J = 125 °C	
I_{rm}	Reverse Leakage Current			5	mA	T_J = 125 °C V_R = 1200V	

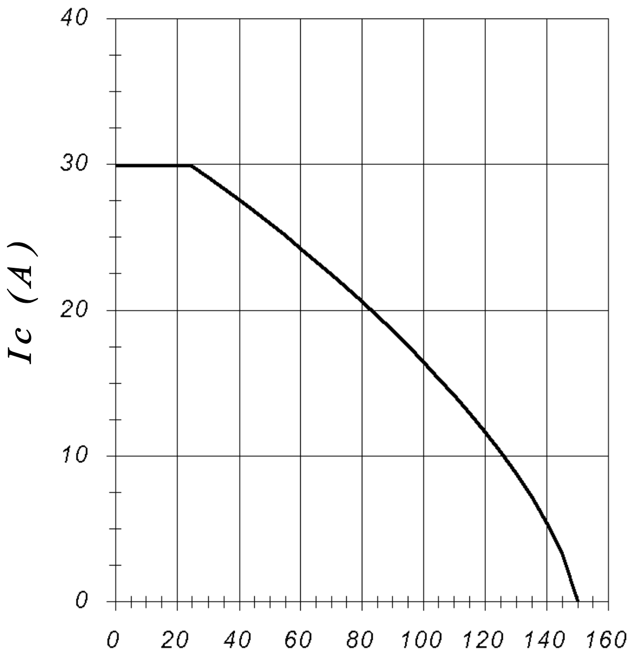
Switching Characteristics: Inverter and Brake

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

T_J = 25°C (unless otherwise specified)

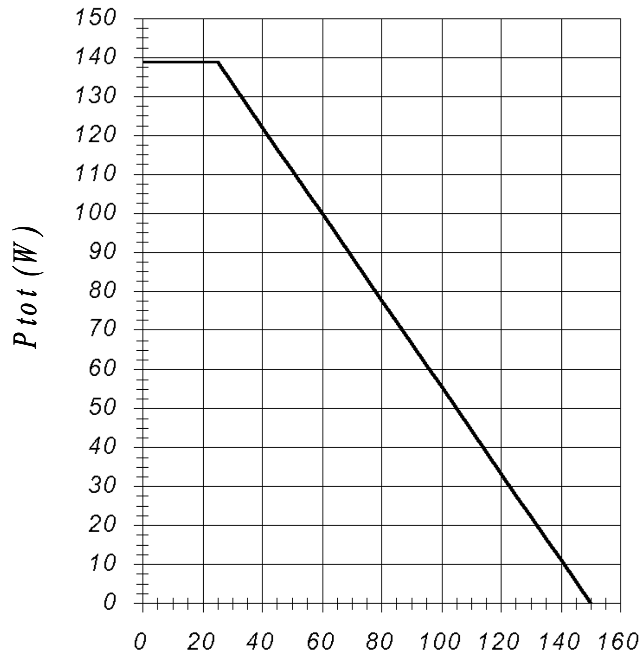
Symbol	Parameter Definition	Min	Typ	Max	Units	Test Conditions	Fig.
Q_g	Total Gate Charge (turn on)		84	127	nC	I_C = 15A	23
Q_{ge}	Gate – Emitter Charge (turn on)		10	15		V_{CC} = 600V	CT1
Q_{gc}	Gate – Collector Charge (turn on)		43	64		V_{GE} = 15V	
E_{on}	Turn on Switching Loss		838	1207	µJ	I_C = 15A, V_{CC} = 600V, T_J = 25 °C	CT4
E_{off}	Turn off Switching Loss		632	900		V_{GE} = 15V, R_G =10Ω, L = 500µH	WF1
E_{tot}	Total Switching Loss		1470	2107		Tail and Diode Rev. Recovery included	WF2
E_{on}	Turn on Switching Loss		1154	1512	µJ	I_C = 15A, V_{CC} = 600V, T_J = 125 °C	13, 15
E_{off}	Turn off Switching Loss		933	1030		V_{GE} = 15V, R_G =10Ω, L = 500µH	CT4 WF1
E_{tot}	Total Switching Loss		2087	2542		Tail and Diode Rev. Recovery included	WF2
td (on)	Turn on delay time		98	104	ns	I_C = 15A, V_{CC} = 600V, T_J = 125 °C	14,16
Tr	Rise time		14	25			CT4
td (off)	Turn off delay time		132	142		V_{GE} = 15V, R_G =10Ω, L = 500µH	WF1
Tf	Fall time		226	247			WF2
C_{ies}	Input Capacitance		1323		pF	V_{CC} = 30V	22
C_{oes}	Output Capacitance		255			V_{GE} = 0V	
C_{res}	Reverse Transfer Capacitance		37			f = 1MHz	
RBSOA	Reverse Bias Safe Operating Area	FULL SQUARE				T_J = 150 °C, I_C =60A, 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		711	1263	µJ	T_J = 125 °C	17,18 19,20
Trr	Diode reverse recovery time		113	300	ns	I_F= 15A, V_{CC} = 600V,	21 CT4
Irr	Peak reverse recovery current		36	41	A	V_{GE} = 15V, R_G =10Ω, L = 500µH	WF3
Rth_{J-C_T}	Each IGBT to copper plate thermal resistance			0.9	°C/W	See also fig. 25, 26	25,26
Rth_{J-C_D}	Each Diode to copper plate thermal resistance			1.54	°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



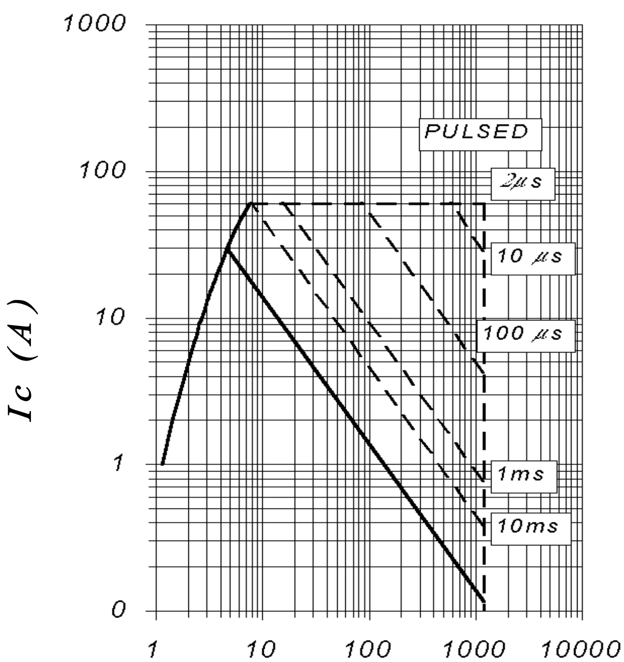
T_C = (ºC)

Fig. 2 – Power Dissipation vs. Case Temperature



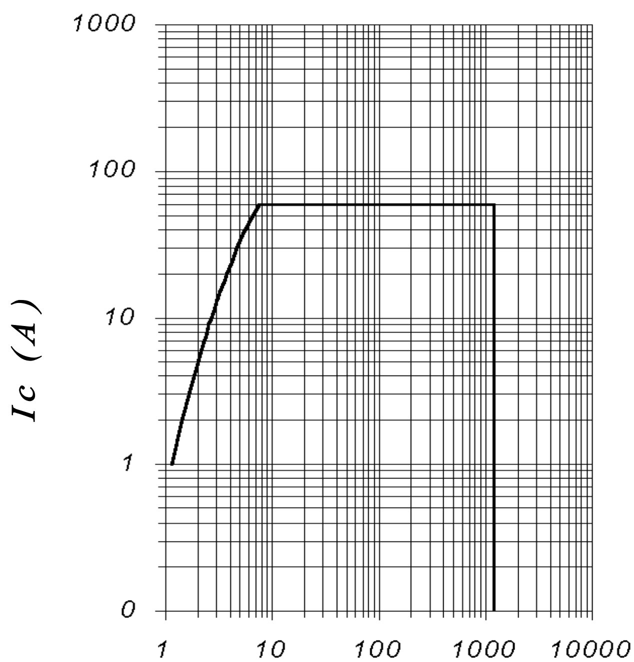
T_C = (ºC)

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



V_{CE} = (V)

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



V_{CE} = (V)

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

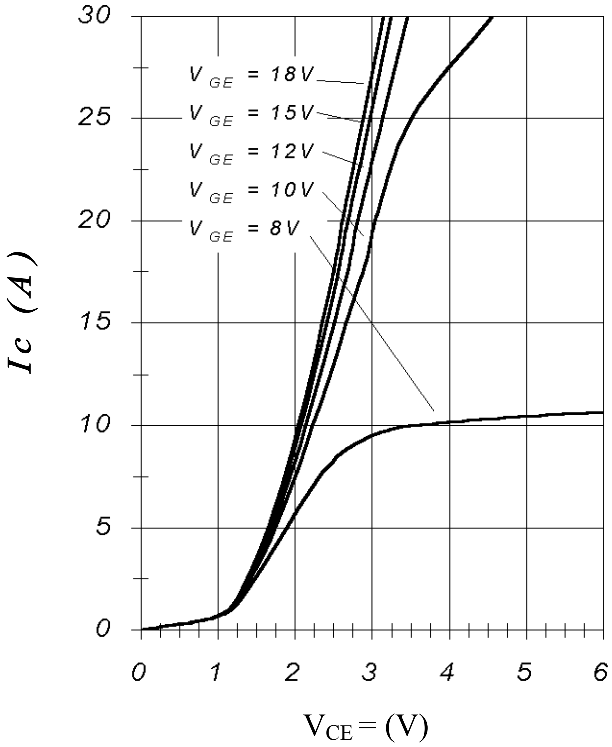


Fig. 6 – Typical IGBT Output Characteristics
Tj = 25ºC; tp = 300µs

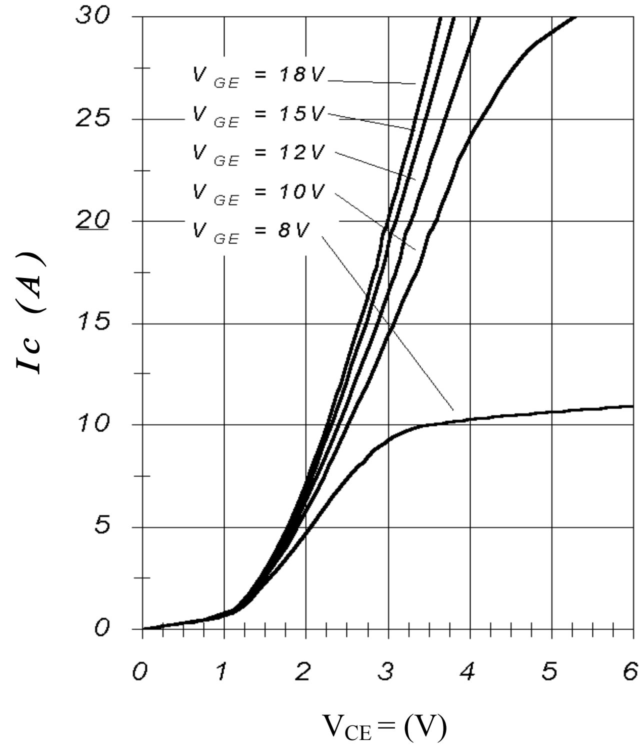


Fig. 7 – Typical IGBT Output Characteristics
Tj = 125ºC; tp = 300µs

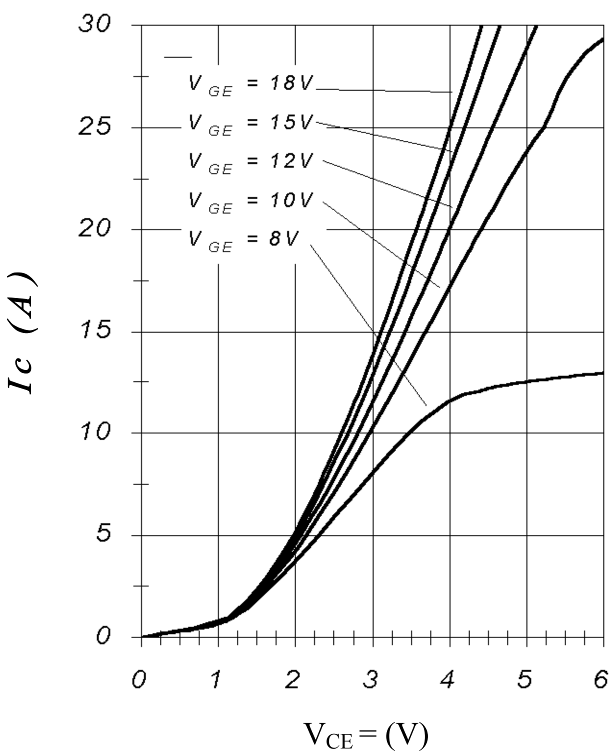


Fig. 8 – Typical Diode Forward
Characteristics tp = 300µs

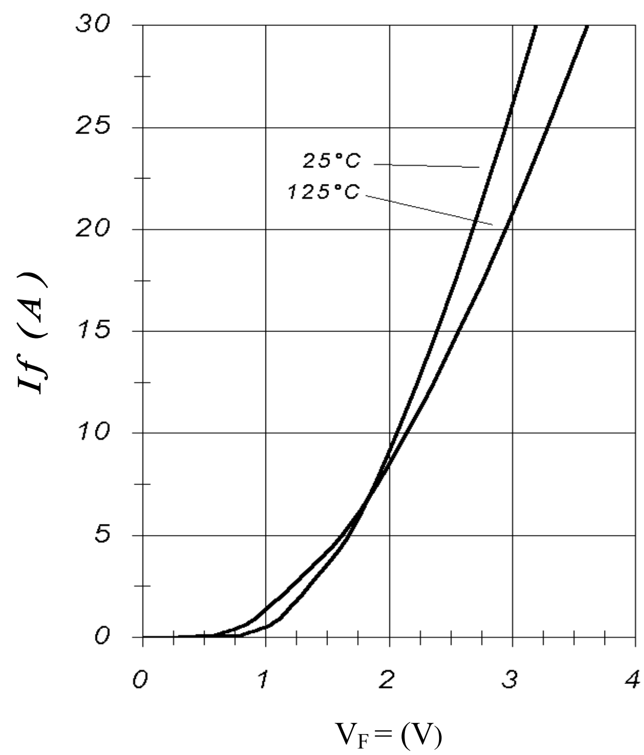


Fig. 9 – Typical V_{CE} vs. V_{GE}
Tj = - 40ºC

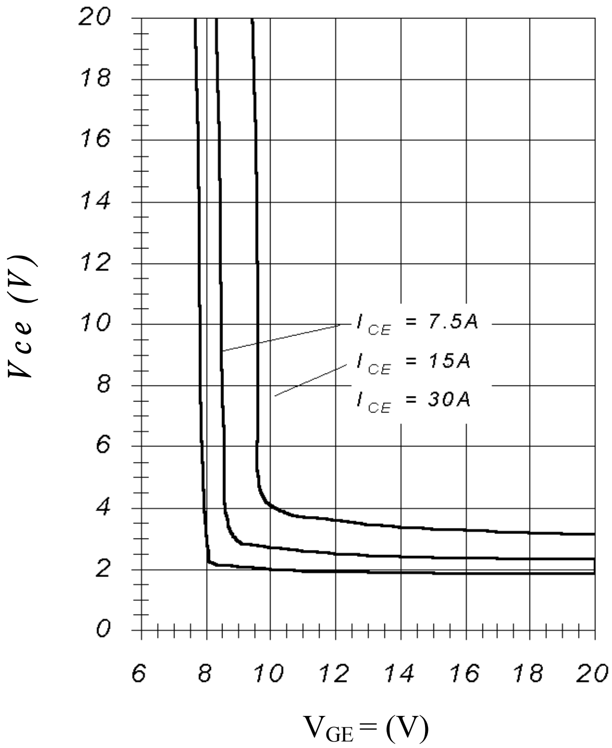


Fig. 10 – Typical V_{CE} vs. V_{GE}
Tj = 25ºC

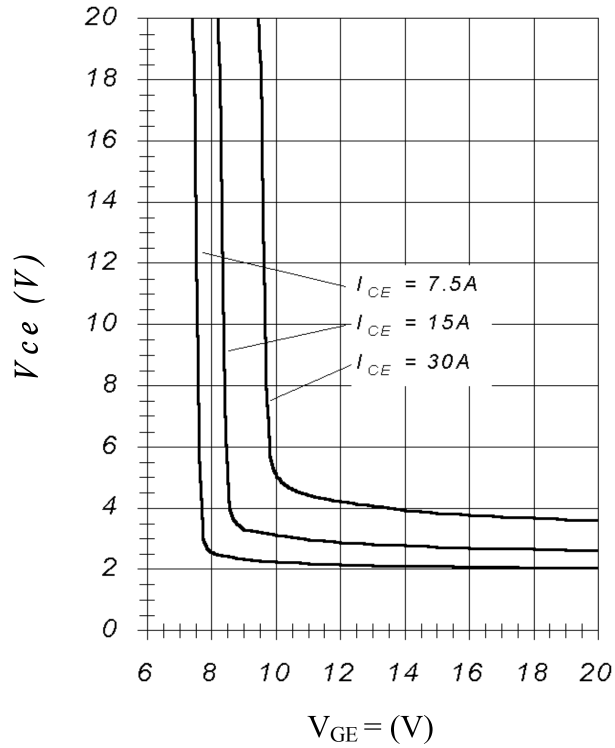


Fig. 11 – Typical V_{CE} vs. V_{GE}
Tj = 125ºC

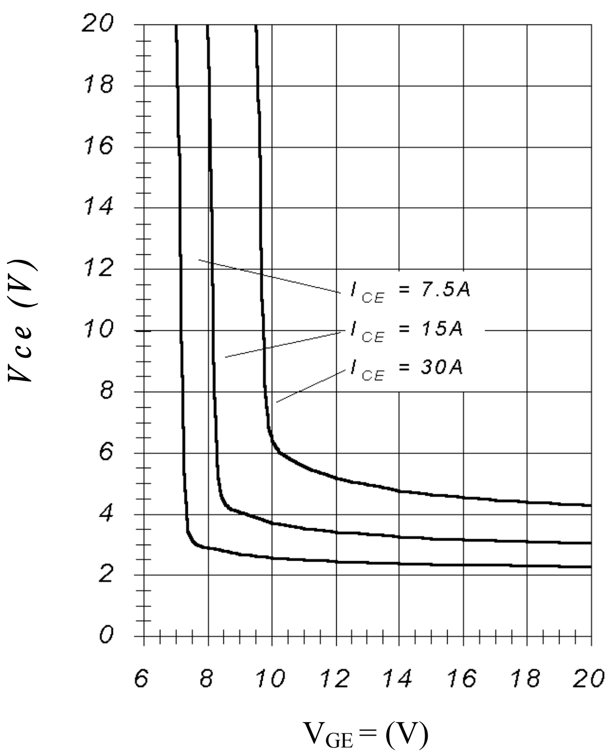


Fig. 12 – Typical Transfer Characteristics
V_{CE} = 20V; tp = 20µs

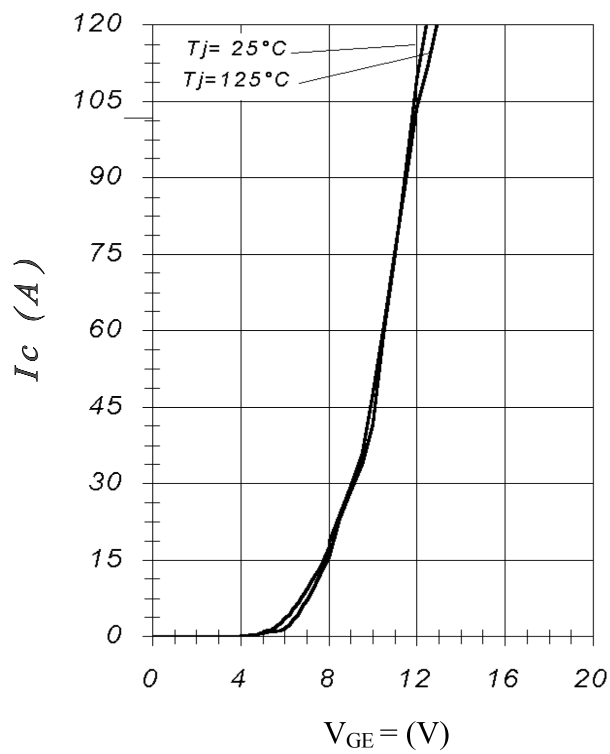
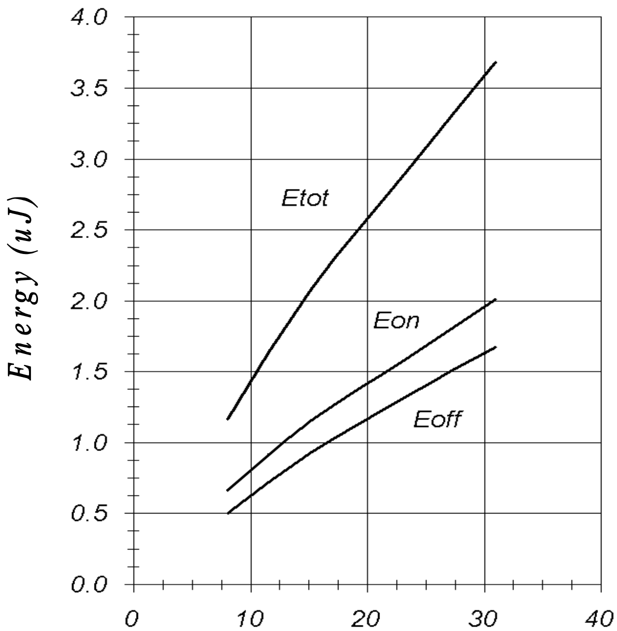
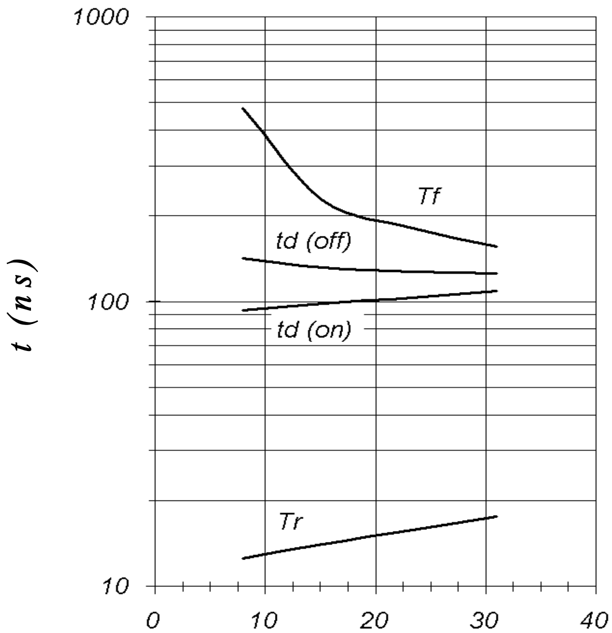


Fig. 13 – Typical Energy Loss vs. I_C
Tj = 125ºC; L = 500µH; V_{CE} = 600V;
Rg = 10Ω; V_{GE} = 15V



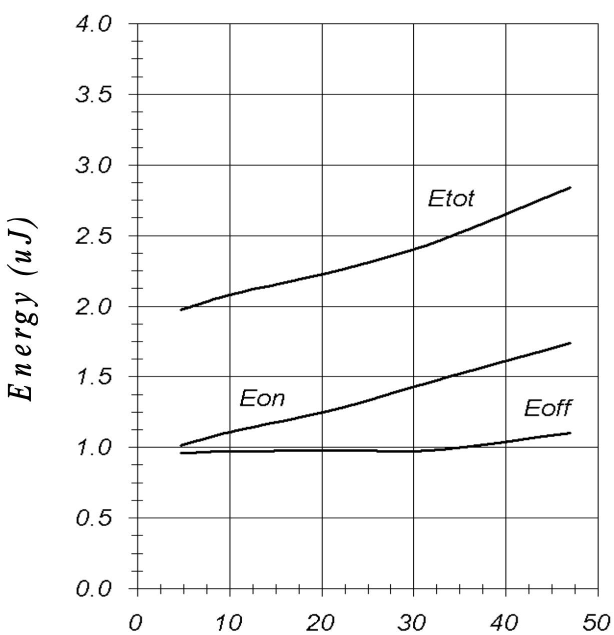
I_C = (A)

Fig. 14 – Typical Switching Time vs. I_C
Tj = 125ºC; L = 500µH; V_{CE} = 600V;
Rg = 10Ω; V_{GE} = 15V



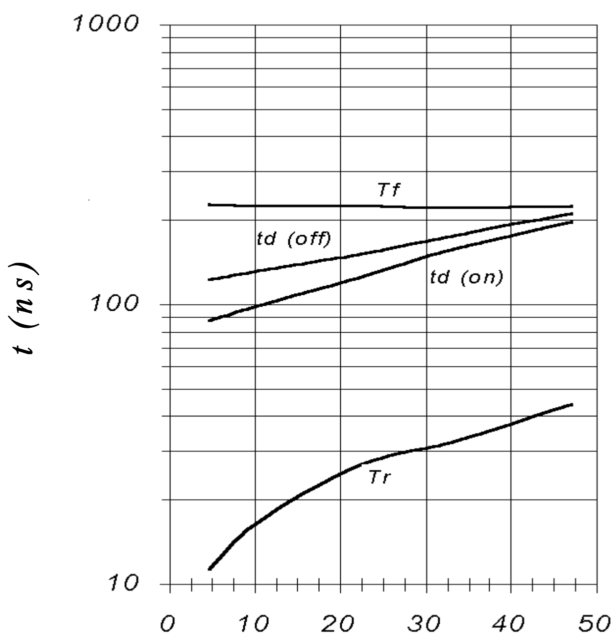
I_C = (A)

Fig. 15 – Typical Energy Loss vs. Rg
Tj = 125ºC; L = 500µH; V_{CE} = 600V;
I_{CE} = 15A; V_{GE} = 15V



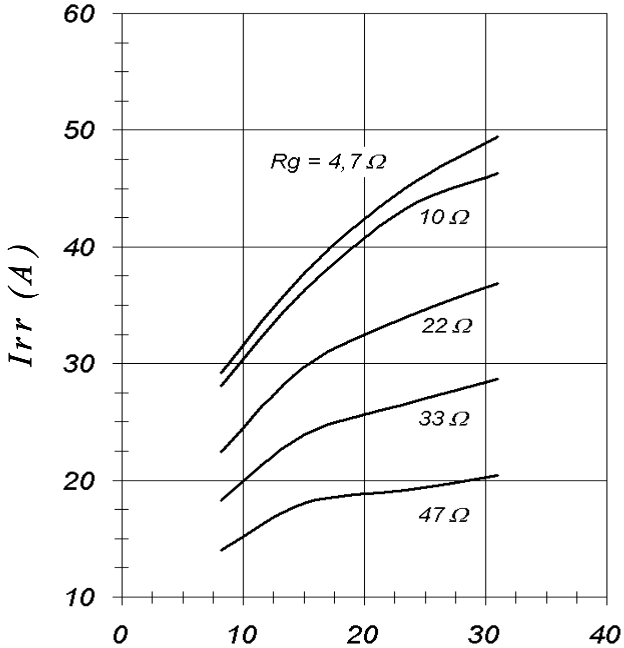
Rg = (Ω)

Fig. 16 – Typical Switching Time vs. Rg
Tj = 125ºC; L = 500µH; V_{CE} = 600V;
I_{CE} = 15A; V_{GE} = 15V



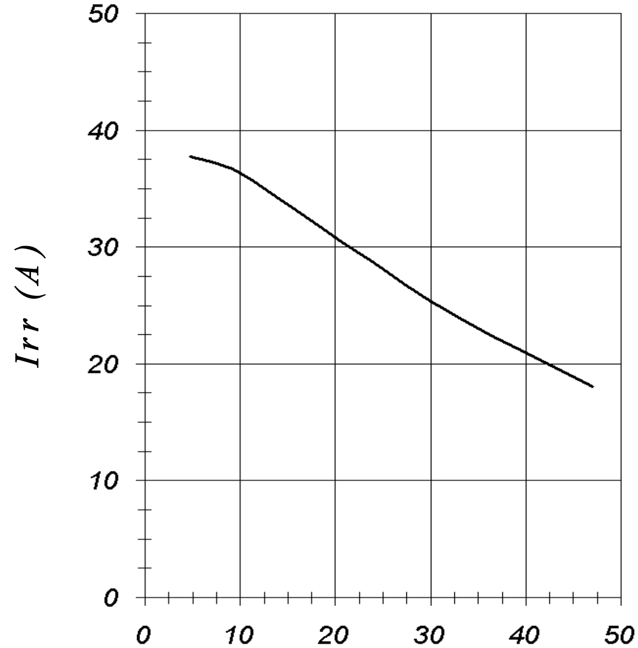
Rg = (Ω)

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



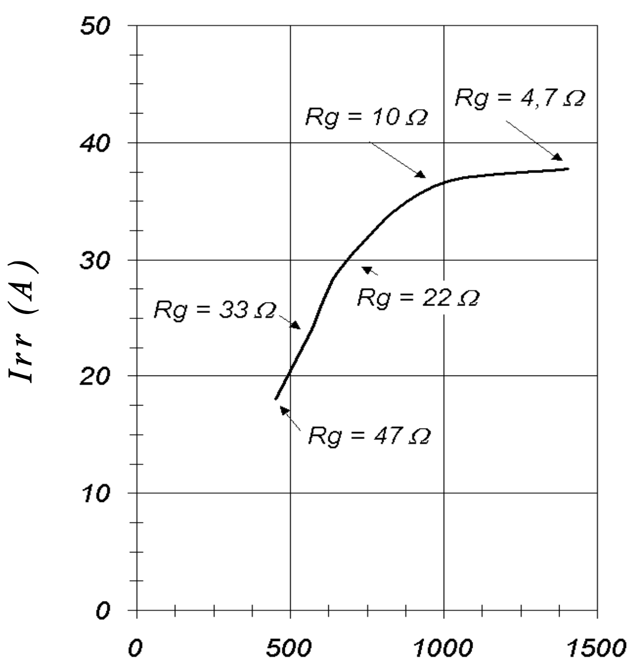
I_F = (A)

Fig. 18 – Typical Diode I_{RR} vs. Rg
I_F = 15A; Tj = 125ºC



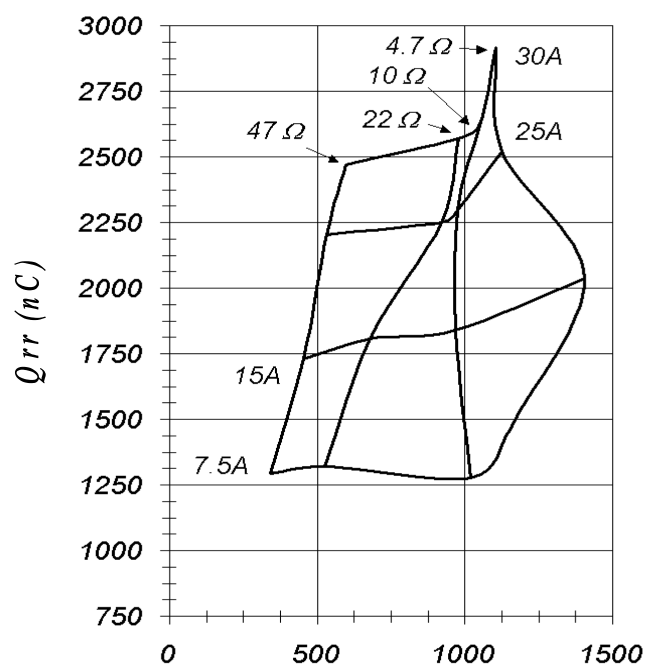
Rg = (Ω)

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



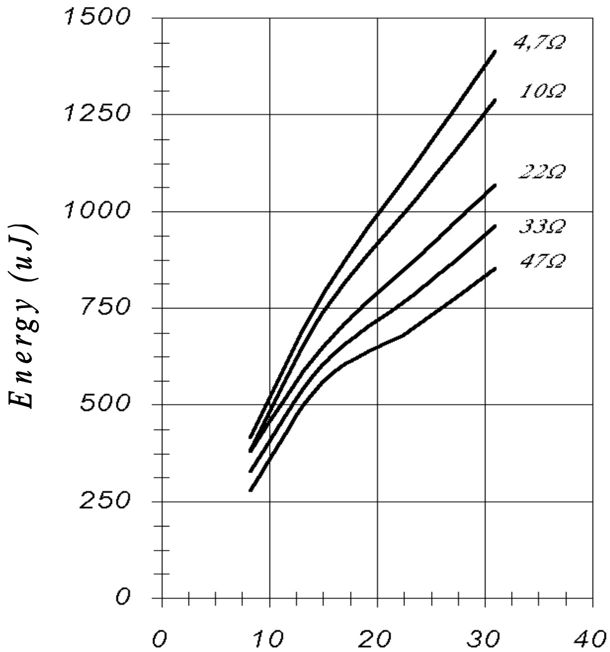
dI_F/dt (A/µs)

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



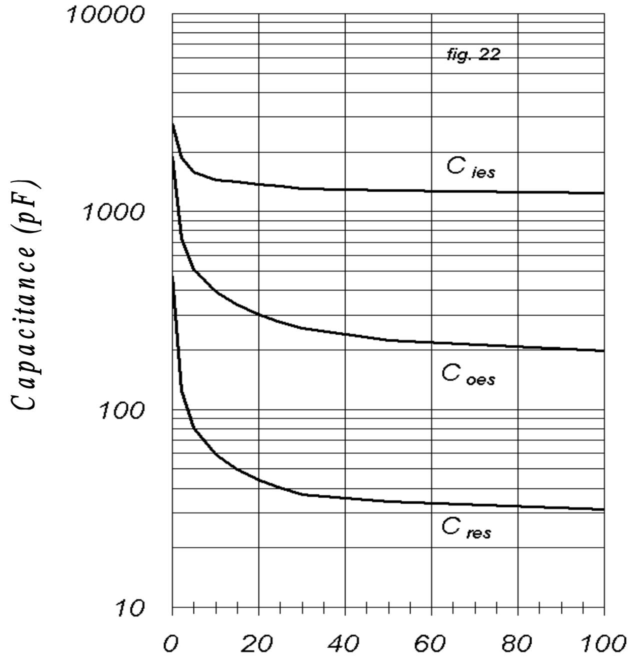
dI_F/dt (A/µs)

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



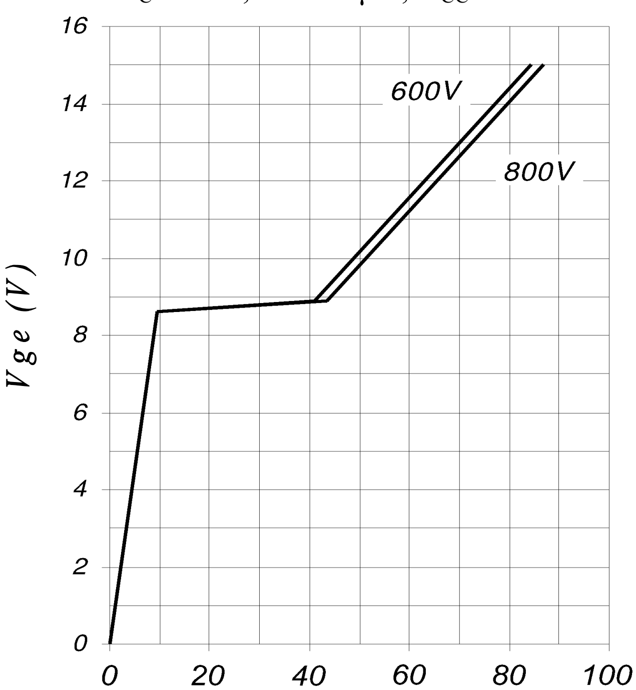
I_F = (A)

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



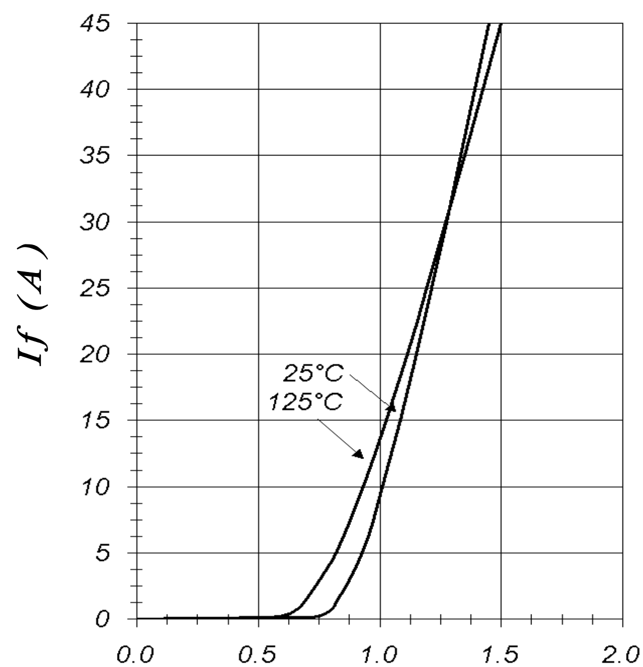
V_{CE} = (V)

Fig. 23 – Typical Gate Charge vs. V_{GE}
I_C = 15A; L = 600µH; V_{CC} = 600V



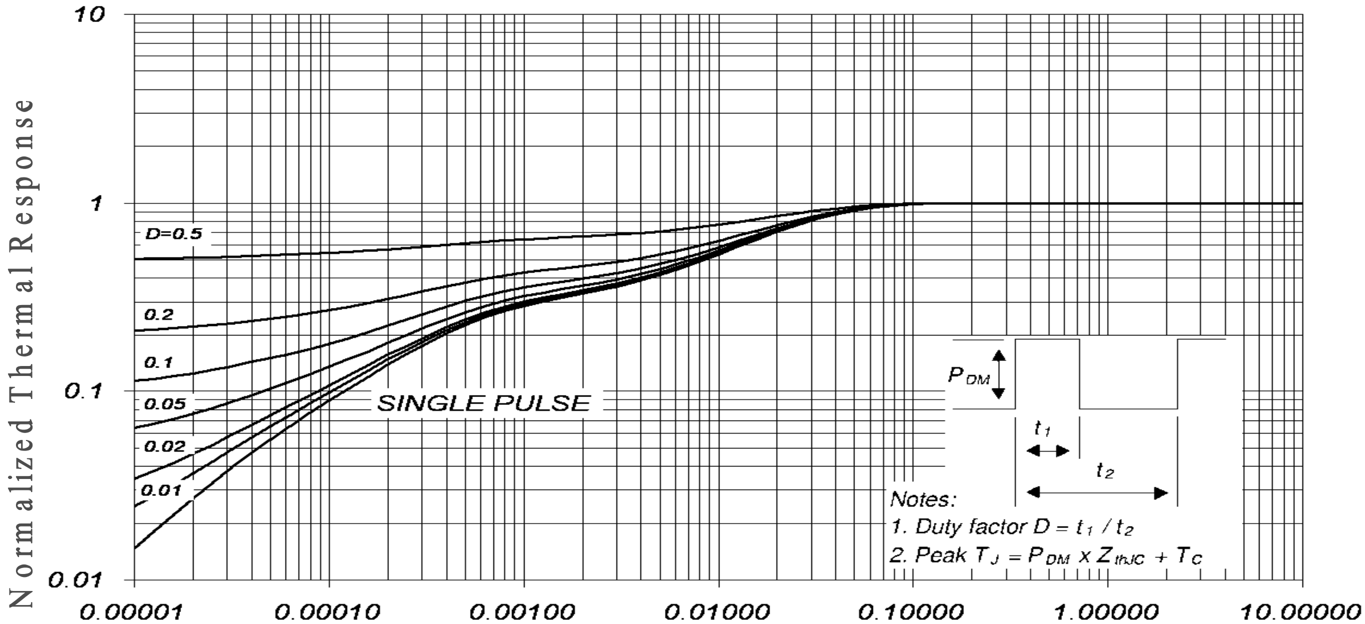
Q_G = (nC)

Fig. 24 – On state Voltage Drop characteristic
V_{FM} vs I_F t_p = 400µs



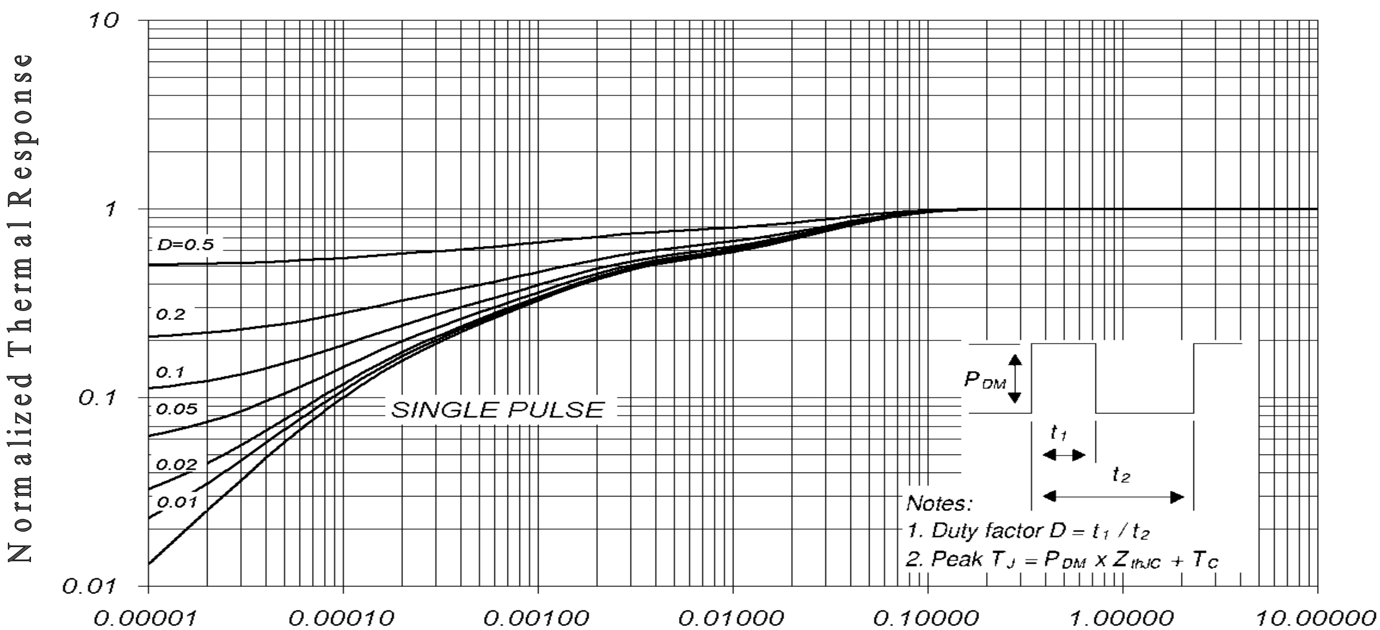
V_{FM} = (V)

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



t1, Rectangular Pulse Duration (sec)

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



t1, Rectangular Pulse Duration (sec)

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

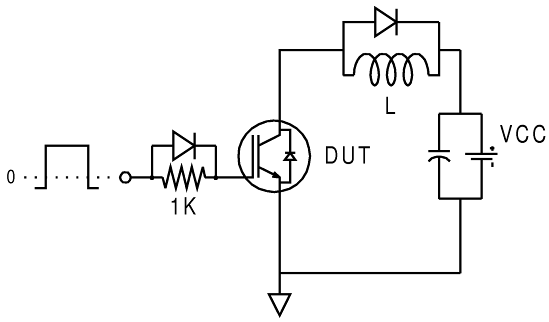


Fig. CT.2 - RBSOA Circuit

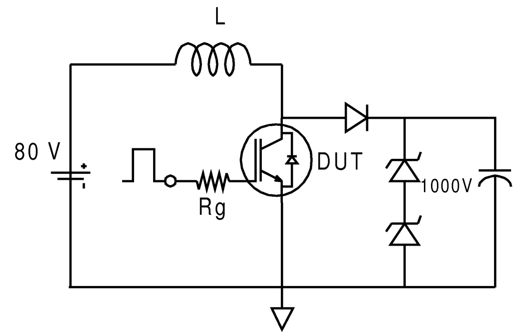


Fig. CT.3 - S.C. SOA Circuit

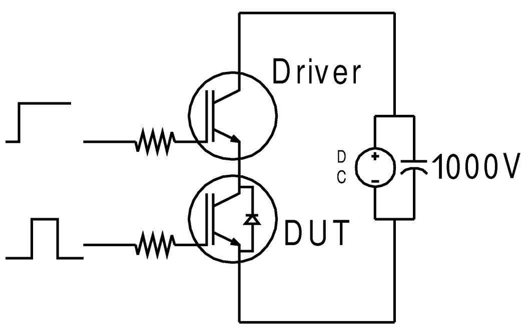


Fig. CT.4 - Switching Loss Circuit

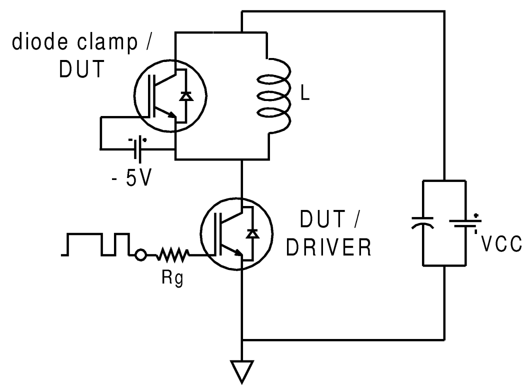


Fig. CT.5 - Resistive Load Circuit

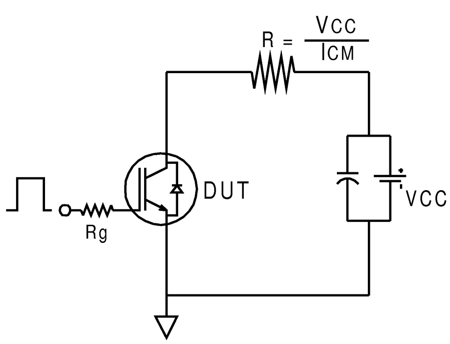


Fig. WF.1 - Typ. Turn-off Loss Waveform
@ Tj=125°C using Fig. CT.4

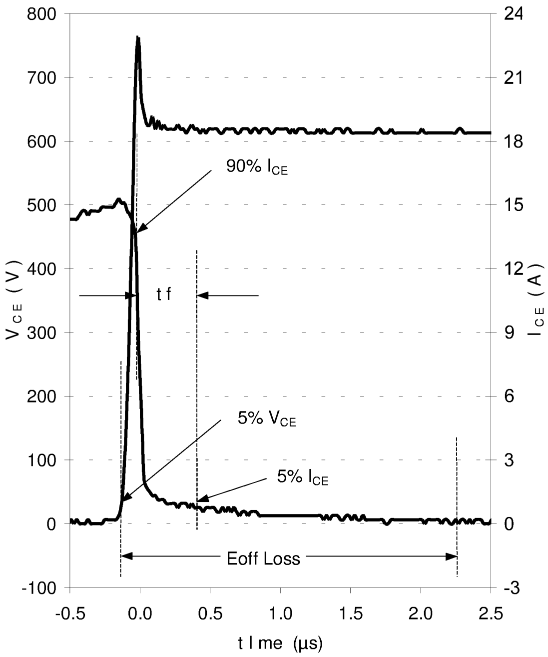


Fig. WF.2 - Typ. Turn-on Loss Waveform
@ Tj=125°C using Fig. CT.4

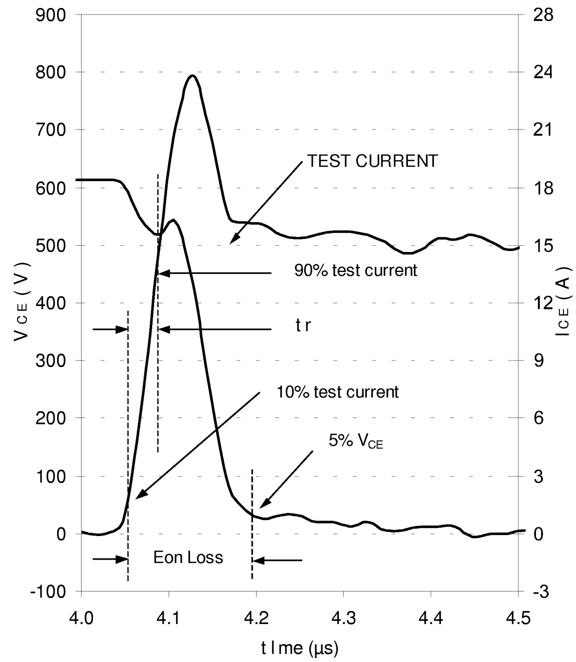


Fig. WF.3 - Typ. Diode Recovery Waveform
@ Tj=125°C using Fig. CT.4

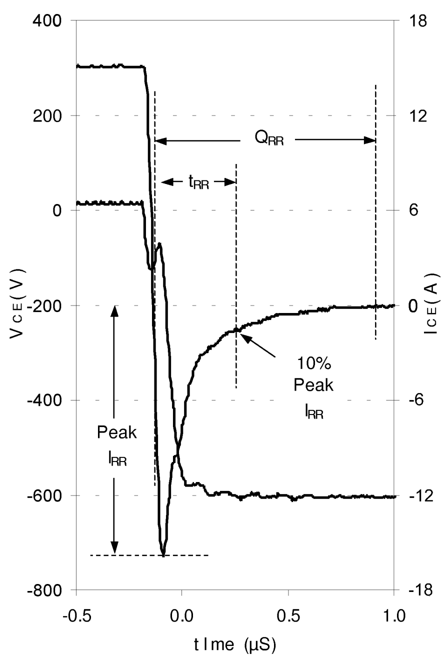
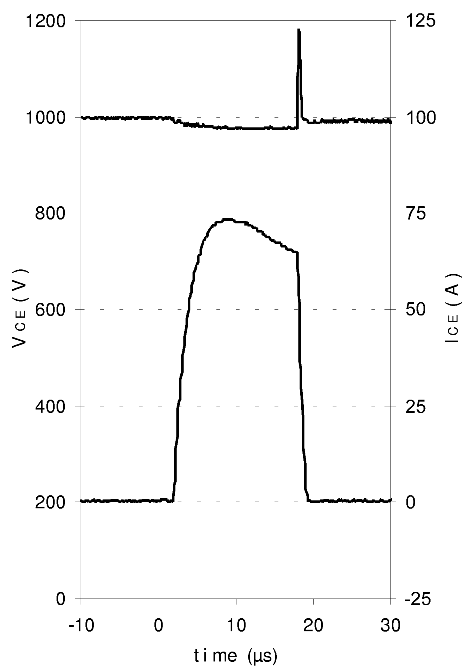


Fig. WF.4 - Typ. S.C. Waveform
@ T_C=150°C using Fig. CT.3



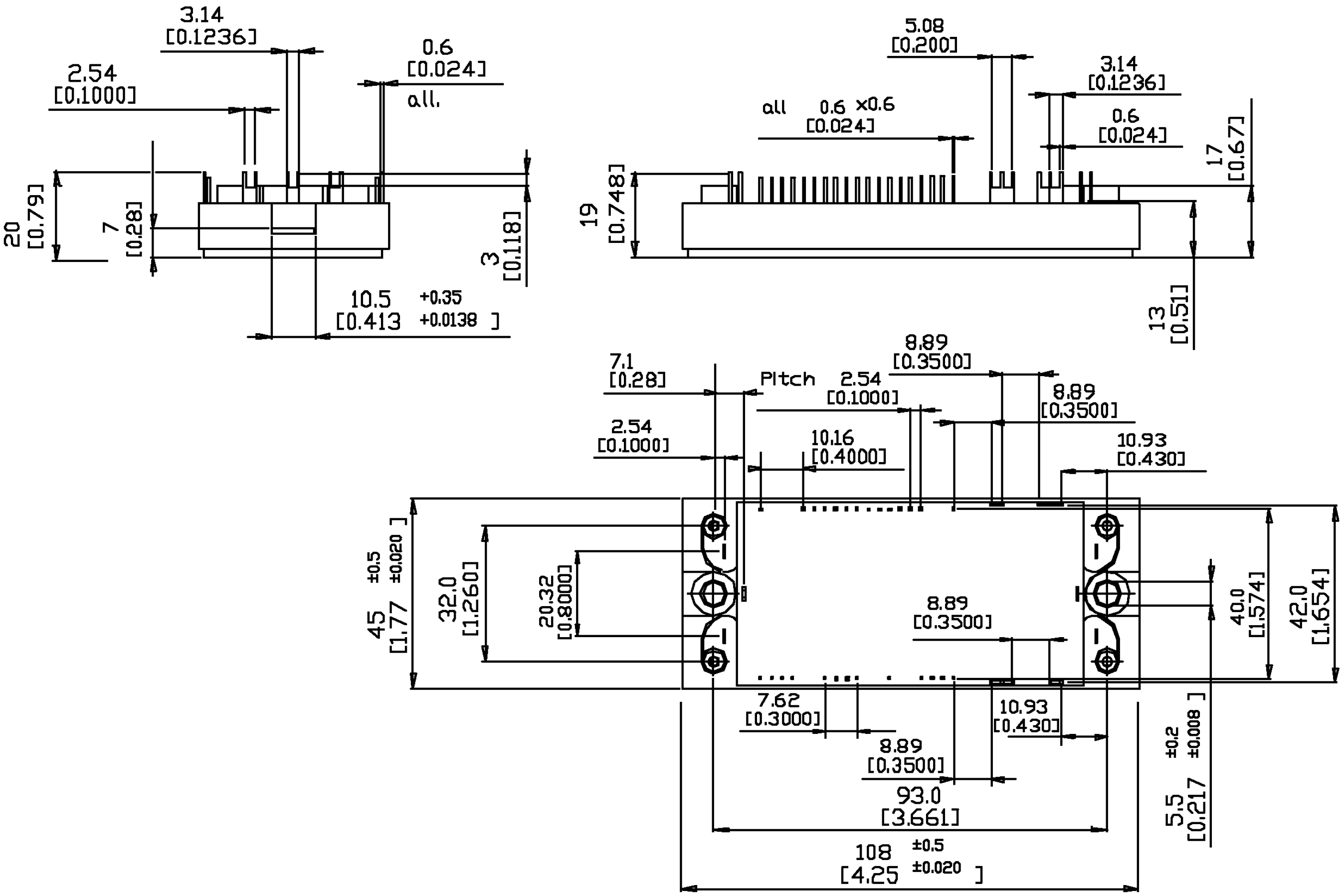
EMP family part number identification

EMP 15 P 12 D

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

EMP15P12D 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 IOR Rectifier

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