

# QMFF450R12EFF

## 1200V 450A IGBT Module

### **Electrical Features**

- Trench/Fieldstop IGBT
- Half-bridge
- Standard package
- High short circuit capability
- Including anti-parallel FWD



## **Typical Applications**

- Motor Drives
- Servo Drives
- UPS System
- High Power Converters
- Wind Turbines

### IGBT, Inverter

Maximu	m Rated Values						
Symbol	Item	Conditions			Rating		Unit
IGBT							
Vces	Collector- emitter voltage	T <sub>vj</sub> =25°C			1200		V
V <sub>GES</sub>	Gate-emitter voltage	-			±2	20	V
Ic	Collector current,DC	$T_{C}=100^{\circ}\text{C}, T_{vj}=175^{\circ}\text{C}$			450		A
ICRM	Repetitive peak collector current	t <sub>p</sub> = 1ms			900		A
$t_{SC}$	Short circuit withstand time	V <sub>GE</sub> = 15V, V <sub>CC</sub> =600V, T <sub>vj</sub> ≤ 150°C			1	10	
P <sub>tot</sub>	Total power dissipation	T <sub>C</sub> =25°C ,T <sub>vj</sub> = 175°C			24	20	W
Characte	ristics Values						
Symbol	Item	Conditions V		Values			Unit
IGBT				Min.	Тур.	Max.	
Ices	Collector-emitter cut-off current	V <sub>CE</sub> = 1200V,V <sub>GE</sub> =0V,T <sub>vj</sub> =25°C		-	-	1	mA
Iges	Gate leakage current	V <sub>CE</sub> =0V,V <sub>GE</sub> =20V,T <sub>vj</sub> =25°C		-	-	250	nA
$V_{\text{GE(th)}}$	Gate-emitter threshold voltage	$I_C=16\text{mA}, V_{CE}=V_{GE}, T_{vj}=25^{\circ}\text{C}$		5	5.78	7	
	Collector-emitter saturation voltage	$I_C=450A$ $V_{GE}=15V$	T <sub>vj</sub> =25°C	_	2.04	2.4	$\frac{1}{V}$
$V_{\text{CEsat}}$			$T_{vj}=125$ °C	_	2.48	-	V
			$T_{vj}=150$ °C	_	2.59	ı	
Cies	Input capacitance	- V <sub>CE</sub> =25V,V <sub>GE</sub> =0V - f=1MHz,T <sub>vj</sub> =25°C		_	31.1	ı	
Coes	Output capacitance			_	1.4	ı	nF
Cres	Reverse transfer capacitance			-	1.35	ı	
Q <sub>G</sub>	Gate charge	V <sub>CC</sub> =600V, I <sub>C</sub> =450A, V <sub>GE</sub> = 15V		-	2.16	-	μС
Rg	Internal gate resistance	$T_{vj}=25$ °C		_	1.25	_	Ω



Turn-on delay time								
t,   Rise time				T <sub>vj</sub> =25°C	-	203.8	-	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	$t_{d(on)}$	Turn-on delay time			-	209.6	-	
Lason   Turn-off delay time   Le=450A   Vog=±15V   Tsp=150°C   208.5       Recons   5.1 Ω   Tsp=150°C     208.5       Recons   5.1 Ω   Tsp=150°C     208.5       Recons   5.1 Ω   Tsp=150°C     208.5       Turn-off delay time   Recons   5.1 Ω   Tsp=125°C     208.5       Tsp=150°C     713.6       Tsp=150°C     724.8       Tsp=150°C     713.6       Tsp=150°C     713.6       Tsp=150°C     713.6       Tsp=150°C     713.6       Tsp=150°C     713.7       Tsp=					_	200. 1	-	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	$t_{\rm r}$	Rise time	V <sub>CC</sub> =600V	$T_{vj}=25$ °C	_	202.5	_	
Turn-off delay time   Ross   5.1 Ω   Ross   5.1 Ω   Ty   25°C     649.1				$T_{vj}=125$ °C	-	208.5	_	
$ \begin{array}{c} t_{\alpha_{eff}} \\ t_{r} \\ \\ t_{r} \\ \\ \\ E_{off} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ $				$T_{vj}=150$ °C	_	209. 1	_	
Inductive load			` '	T <sub>vj</sub> =25°C	_	649. 1	_	ns
$t_{t}  \text{Fall time}  \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$t_{\text{d(off)}}$	Turn-off delay time		$T_{vj}$ = 125°C	_	713.6	_	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$			Inductive load	$T_{vj}$ = 150°C	_	724.8	_	
$ E_{on} = \begin{cases} T_{vj} = 150^{\circ}C & . & 174.4 & . \\ T_{vj} = 150^{\circ}C & . & 174.4 & . \\ T_{vj} = 25^{\circ}C & . & 88.4 & . \\ T_{vj} = 125^{\circ}C & . & 118.5 & . \\ T_{vj} = 125^{\circ}C & . & 118.5 & . \\ T_{vj} = 125^{\circ}C & . & 118.5 & . \\ T_{vj} = 150^{\circ}C & . & 174.4 & . \\ T_{vj} = 125^{\circ}C & . & 188.4 & . \\ T_{vj} = 125^{\circ}C & . & 118.5 & . \\ T_{vj} = 150^{\circ}C & . & 127.7 & . \\ T_{vj} = 150^{\circ}C & . & 127.7 & . \\ T_{vj} = 150^{\circ}C & . & 127.7 & . \\ T_{vj} = 150^{\circ}C & . & 52.7 & . \\ T_{vj} = 150^{\circ}C & . & 52.7 & . \\ T_{vj} = 150^{\circ}C & . & 56.1 & . \end{cases} $ **Mathematical Nont-circuit current***  **Part of the major of t				T <sub>vj</sub> =25°C	_	98.5	_	
$E_{on} = \begin{cases} Turn-on energy (per pulse) & V_{Ce} = 600V, I_{c} = 450A \\ V_{Ge} = 15V, \\ RoosyRoosp = 5, 1, \Omega \\ divide = 2676A / \mus \\ du/dt = 5700V / \mus \\ Inductive load & T_{vp} = 125^{\circ}C & . & . & . & . \\ T_{vp} = 150^{\circ}C & . & . & . & . & . \\ T_{vp} = 150^{\circ}C & . & . & . & . & . \\ T_{vp} = 150^{\circ}C & . & . & . & . & . \\ T_{vp} = 150^{\circ}C & . & . & . & . & . \\ T_{vp} = 150^{\circ}C & . & . & . & . & . \\ T_{vp} = 150^{\circ}C & . & . & . & . & . \\ T_{vp} = 125^{\circ}C & . & . & . & . & . \\ T_{vp} = 125^{\circ}C & . & . & . & . & . \\ T_{vp} = 125^{\circ}C & . & . & . & . & . \\ T_{vp} = 125^{\circ}C & . & . & . & . \\ T_{vp} = 125^{\circ}C & . & . & . & . \\ T_{vp} = 125^{\circ}C & . & . & . & . \\ T_{vp} = 125^{\circ}C & . & . & . & . \\ T_{vp} = 125^{\circ}C & . & . & . & . \\ T_{vp} = 125^{\circ}C & . & . & . & . \\ T_{vp} = 125^{\circ}C & . & . & . & . \\ T_{vp} = 125^{\circ}C & . & . & . & . \\ T_{vp} = 125^{\circ}C & . & . & . & . \\ T_{vp} = 125^{\circ}C & . & . & . & . \\ T_{vp} = 125^{\circ}C & . & . & . & . \\ T_{vp} = 125^{\circ}C & . & . & . & . \\ T_{vp} = 125^{\circ}C & . &$	$t_{\mathrm{f}}$	Fall time		$T_{vj}$ = 125°C	_	129.6	_	
$ E_{off} \qquad Turn-on energy (per pulse) \qquad Vcr=600V, Ic=450A \\ Vcr=-15V, \\ Reconst Reconstruction Structure of the triangle of the structure of$				T <sub>vj</sub> = 150°C		174.4	_	
$E_{off} = \begin{bmatrix} Turn-off energy (per pulse) & Rotoup Rotoup -5.1 \Omega & T_y = 150^{\circ}C & & 127.7 & & Inductive load & T_y = 150^{\circ}C & & 43.7 & & Inductive load & T_y = 150^{\circ}C & & 56.1 & & Inductive load & T_y = 150^{\circ}C & & 56.1 & & Inductive load & T_y = 150^{\circ}C & & 56.1 & & Inductive load & T_y = 150^{\circ}C & & 56.1 & & Inductive load & T_y = 150^{\circ}C & & 56.1 & & Inductive load & T_y = 150^{\circ}C & & 56.1 & & Inductive load & T_y = 150^{\circ}C & & 56.1 & & Inductive load & T_y = 150^{\circ}C & & 56.1 & & Inductive load & T_y = 150^{\circ}C & & 56.1 & & Inductive load & T_y = 150^{\circ}C & & 56.1 & & Inductive load & T_y = 150^{\circ}C & & 56.1 & & Inductive load & T_y = 150^{\circ}C & & 56.1 & & Inductive load & T_y = 150^{\circ}C & & 56.1 & & Inductive load & T_y = 150^{\circ}C & & 56.1 & & Inductive load & Inductiv$			V <sub>CC</sub> =600V, I <sub>C</sub> =450A	T <sub>vj</sub> =25°C	_	88.4	_	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	Eon	Turn-on energy (per pulse)	$V_{GE}=\pm 15V$ ,	T <sub>vj</sub> = 125°C	_	118.5	_	-
$ E_{\rm eff} = \begin{array}{c ccccccccccccccccccccccccccccccccccc$			$R_{G(on)}/R_{G(on)}=5.1 \Omega$	$T_{\rm vj}=150^{\circ}{\rm C}$		127.7	_	_
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$			di/dt=2676A/μs	T <sub>vj</sub> =25°C	_		_	mJ
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	Fass	Turn-off energy (per pulse)	du/dt=5700V/ μs	$T_{vj}$ = 125°C			_	-
SC data Short-circuit current $V_{CE=600V, V_{GE} \le 15V, T_{V_{I}}=25^{\circ}C}$ $V_{CES} \le 1200V, v_{D} \le 10\mu s$ . 2160 . A R <sub>max</sub> Thermal resistance, junction to case Per IGBT	Lon	25 (4 1 )	Inductive load	T <sub>vj</sub> = 150°C				
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$			V <sub>CC</sub> =600V,V <sub>GE</sub> ≤ 15V	/,T <sub>vi</sub> =25°C	_		_	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	SC data	Short-circuit current				2160	-	A
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	RthIC	Thermal resistance, junction to case	ner ICRT			_	0.062	K/W
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		Thermalresistance, case to heatsink	1			0.031	_	K/W
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		Temperature under switching						0.0
	$T_{vjop}$	conditions			-40		150	°C
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	Diode,	Inverter				1		
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	Maximui	n Rated Values						
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	Symbol	Item	~ 4					
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	Vrrm		Conditions			Rat	ting	Unit
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		Repetitive peak reverse voltage						
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$I_F$					12	200	V
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		Forward current,DC	T <sub>vj</sub> =25°C			12 45	200	V A
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	IFRM I <sup>2</sup> t	Forward current,DC Repetitive peak forward current	$T_{vj}$ =25°C $t_p$ =1ms	: 150°C		12 45 90	200 50 00	V A A
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	IFRM I <sup>2</sup> t	Forward current,DC  Repetitive peak forward current  I²t-value	$T_{vj}$ =25°C $t_p$ =1ms	: 150°C		12 45 90	200 50 00	V A A
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	IFRM I <sup>2</sup> t	Forward current,DC  Repetitive peak forward current  I²t-value	$T_{vj}$ =25°C $t_p$ =1ms $V_R$ =0V, $t_p$ =10ms, $T_{vj}$ =			12 45 90 320	200 50 50 00 000	V A A
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	IFRM I <sup>2</sup> t Characte	Forward current,DC Repetitive peak forward current I²t-value ristic Values	$T_{vj}$ =25°C $t_p$ =1ms $V_R$ =0V, $t_p$ =10ms, $T_{vj}$ =	T <sub>vj</sub> =25°C	_	12 45 90 320	200 50 50 00 000	V A A A A²s
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	IFRM I <sup>2</sup> t	Forward current,DC Repetitive peak forward current I²t-value ristic Values	$T_{vj}$ =25°C $t_p$ =1ms $V_R$ =0V, $t_p$ =10ms, $T_{vj}$ =	$T_{vj}=25$ °C $T_{vj}=125$ °C	-	12 45 90 320 1.82 1.59	200 50 50 00 000	V A A A A²s
$V_{R}=600V \\ I_{F}=450A \\ -di_{F}/dt=2950A/\ \mu s \\ V_{GE}=-15V $ Recovered charge $V_{R}=600V \\ T_{vj}=150^{\circ}C  274.8  275.8  27$	IFRM I <sup>2</sup> t Characte	Forward current,DC Repetitive peak forward current I²t-value ristic Values	$T_{vj}$ =25°C $t_p$ =1ms $V_R$ =0V, $t_p$ =10ms, $T_{vj}$ =	$T_{vj}=25^{\circ}C$ $T_{vj}=125^{\circ}C$ $T_{vj}=150^{\circ}C$		12 45 90 320 1.82 1.59 1.53	200 50 50 00 000	V A A A A²s
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	IFRM I <sup>2</sup> t Characte V <sub>F</sub>	Forward current,DC Repetitive peak forward current I²t-value ristic Values  Continuous forward voltage	$T_{vj}$ =25°C $t_p$ =1ms $V_R$ =0V, $t_p$ =10ms, $T_{vj}$ =	$T_{vj}=25^{\circ}C$ $T_{vj}=125^{\circ}C$ $T_{vj}=150^{\circ}C$ $T_{vj}=25^{\circ}C$	-	12 45 90 320 1.82 1.59 1.53 146.3	200 50 50 00 000	V A A A A 2 s
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	IFRM I <sup>2</sup> t Characte	Forward current,DC Repetitive peak forward current I²t-value ristic Values  Continuous forward voltage	$T_{vj}$ =25°C $t_p$ =1ms $V_R$ =0V, $t_p$ =10ms, $T_{vj}$ = $I_F$ =450A $V_{GE}$ =0V	$T_{vj}=25 \text{ °C}$ $T_{vj}=125 \text{ °C}$ $T_{vj}=150 \text{ °C}$ $T_{vj}=25 \text{ °C}$ $T_{vj}=125 \text{ °C}$	-	12 45 90 320 1.82 1.59 1.53 146.3 246.9	200 50 50 00 000	V A A A A 2 s
$V_{GE}=-15V \begin{tabular}{c ccccc} $T_{vj}=150^{\circ}C$ & $Z=761.9$ & $T_{vj}=150^{\circ}C$ & $Z=761.9$ & $Z=70.25^{\circ}C$ & $Z=70$	IFRM I <sup>2</sup> t Characte V <sub>F</sub>	Forward current,DC Repetitive peak forward current I²t-value ristic Values  Continuous forward voltage	$T_{vj} = 25  ^{\circ}\text{C}$ $t_p = 1 \text{ms}$ $V_R = 0  V, t_p = 10 \text{ms}, T_{vj} = 10  \text{ms}$ $I_F = 450  \text{A}$ $V_{GE} = 0  \text{V}$ $V_R = 600  \text{V}$	$T_{vj}=25 \text{ °C}$ $T_{vj}=125 \text{ °C}$ $T_{vj}=150 \text{ °C}$ $T_{vj}=25 \text{ °C}$ $T_{vj}=125 \text{ °C}$ $T_{vj}=150 \text{ °C}$	-	12 45 90 320 1.82 1.59 1.53 146.3 246.9 274.8	200 50 50 00 000	V A A A A 2 s
$V_{GE}=13V$ Recovered charge $T_{vj}=25^{\circ}C$ $T_{vj}=125^{\circ}C$ $T_{vj}=125^{\circ}C$ $T_{vj}=150^{\circ}C$ $T_{vj}=150^{\circ}C$	IFRM I2t Characte VF	Forward current,DC Repetitive peak forward current I²t-value ristic Values  Continuous forward voltage  Peak reverse recovery current	$T_{vj}=25 ^{\circ}\text{C}$ $t_{p}=1 \text{ms}$ $V_{R}=0 V, t_{p}=10 \text{ms}, T_{vj}=10 \text{ms}$ $I_{F}=450 \text{A}$ $V_{GE}=0 V$ $V_{R}=600 V$ $I_{F}=450 \text{A}$	$T_{vj} = 25 \text{ °C}$ $T_{vj} = 125 \text{ °C}$ $T_{vj} = 150 \text{ °C}$ $T_{vj} = 25 \text{ °C}$ $T_{vj} = 125 \text{ °C}$ $T_{vj} = 150 \text{ °C}$ $T_{vj} = 25 \text{ °C}$	-	1.82 1.59 1.53 146.3 246.9 274.8 172.2	200 50 00 000	V A A A²s
Q <sub>r</sub> Recovered charge $T_{vj}=125^{\circ}C$ _ 71.8 _ $\mu C$	IFRM I <sup>2</sup> t Characte V <sub>F</sub>	Forward current,DC Repetitive peak forward current I²t-value ristic Values  Continuous forward voltage  Peak reverse recovery current	$T_{vj} = 25  ^{\circ}\text{C}$ $t_p = 1 \text{ms}$ $V_R = 0 \text{V}, t_p = 10 \text{ms}, T_{vj} = 10 ms$	$T_{vj}=25 \text{ °C}$ $T_{vj}=125 \text{ °C}$ $T_{vj}=150 \text{ °C}$ $T_{vj}=25 \text{ °C}$ $T_{vj}=125 \text{ °C}$ $T_{vj}=150 \text{ °C}$ $T_{vj}=25 \text{ °C}$ $T_{vj}=125 \text{ °C}$	-	1.82 1.59 1.53 146.3 246.9 274.8 172.2 698.7	2.6	V A A A²s
$T_{vi} = 150^{\circ}C$	IFRM I2t Characte VF	Forward current,DC Repetitive peak forward current I²t-value ristic Values  Continuous forward voltage  Peak reverse recovery current	$T_{vj} = 25  ^{\circ}\text{C}$ $t_p = 1 \text{ms}$ $V_R = 0 \text{V}, t_p = 10 \text{ms}, T_{vj} = 10 ms$	$T_{vj}{=}25^{\circ}C$ $T_{vj}{=}125^{\circ}C$ $T_{vj}{=}150^{\circ}C$ $T_{vj}{=}25^{\circ}C$ $T_{vj}{=}125^{\circ}C$ $T_{vj}{=}150^{\circ}C$ $T_{vj}{=}25^{\circ}C$ $T_{vj}{=}25^{\circ}C$ $T_{vj}{=}125^{\circ}C$ $T_{vj}{=}125^{\circ}C$	-	1.82 1.59 1.53 146.3 246.9 274.8 172.2 698.7 761.9	2.6	V A A A²s
1 100 0 0 09.3 -	IFRM I2t Characte VF IRM	Forward current,DC Repetitive peak forward current I²t-value ristic Values  Continuous forward voltage  Peak reverse recovery current  Reverse recovery time	$T_{vj} = 25  ^{\circ}\text{C}$ $t_p = 1 \text{ms}$ $V_R = 0 \text{V}, t_p = 10 \text{ms}, T_{vj} = 10 ms$	$T_{vj}=25 ^{\circ}\text{C}$ $T_{vj}=125 ^{\circ}\text{C}$ $T_{vj}=150 ^{\circ}\text{C}$ $T_{vj}=25 ^{\circ}\text{C}$ $T_{vj}=125 ^{\circ}\text{C}$ $T_{vj}=150 ^{\circ}\text{C}$ $T_{vj}=125 ^{\circ}\text{C}$ $T_{vj}=125 ^{\circ}\text{C}$ $T_{vj}=150 ^{\circ}\text{C}$ $T_{vj}=25 ^{\circ}\text{C}$ $T_{vj}=25 ^{\circ}\text{C}$		12 45 90 320 1.82 1.59 1.53 146.3 246.9 274.8 172.2 698.7 761.9 22.7	2.6	V A A A <sup>2</sup> s
	IFRM I2t Characte VF	Forward current,DC Repetitive peak forward current I²t-value ristic Values  Continuous forward voltage  Peak reverse recovery current  Reverse recovery time	$T_{vj} = 25  ^{\circ}\text{C}$ $t_p = 1 \text{ms}$ $V_R = 0 \text{V}, t_p = 10 \text{ms}, T_{vj} = 10 ms$	$T_{vj}{=}25^{\circ}C$ $T_{vj}{=}125^{\circ}C$ $T_{vj}{=}150^{\circ}C$ $T_{vj}{=}150^{\circ}C$ $T_{vj}{=}125^{\circ}C$ $T_{vj}{=}150^{\circ}C$ $T_{vj}{=}25^{\circ}C$ $T_{vj}{=}125^{\circ}C$ $T_{vj}{=}150^{\circ}C$ $T_{vj}{=}150^{\circ}C$ $T_{vj}{=}150^{\circ}C$ $T_{vj}{=}150^{\circ}C$ $T_{vj}{=}150^{\circ}C$		12 45 90 320 1.82 1.59 1.53 146.3 246.9 274.8 172.2 698.7 761.9 22.7	2.6	V A A A <sup>2</sup> s



Erec	Reverse recovery energy		T <sub>vj</sub> =25°C	-	66	_	
			T <sub>vj</sub> =125°C	_	19.2	_	mJ
			$T_{vj}$ = 150°C	_	29.2	_	
R <sub>thJC</sub>	Thermal resistance, junction to case	per diode		-	-	0.11	K/W
R <sub>thCH</sub>	Thermalresistance, case to heatsink	per diode/ λgrease= 1W/(m·K)		_	0.055	ı	K/W
$T_{ m vjop}$	Temperature under switching conditions			-40		150	°C

#### Module

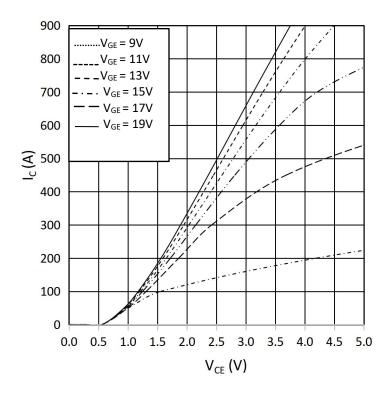
Symbol	Item	Conditions	Rating		Unit		
V <sub>ISOL</sub>	Isolation voltage	Terminals to baseplate, RMS,f=50Hz,t=1min	4000		V		
_	Material of module baseplate	-	Cu		_		
_	Internal isolation	Basic insulation(class 1, IEC 61140)	Al <sub>2</sub> O <sub>3</sub>		_		
T <sub>stg</sub>	Storage temperature	-	-40~125		°C		
Symbol	Item	Conditions	Values			Unit	
Syllibol			Min.	Typ.	Max.		
M	Mounting torque for module mounting	Screw M6	3.0	-	6.0	Nm	
	Terminal connection torque	Screw M6	2.5	_	5.0	Nm	
ds	Creepage distance	Terminal to terminal	_	23	_	mm	
		Terminal to base plate	_	29	_		
da	Clearance	Terminal to terminal	_	11	_	mm	
		Terminal to base plate	_	23	_		
m	Weight	-	_	320	_	g	



### output characteristic IGBT, Inverter (typical)

$$I_{C} = f(V_{CE})$$

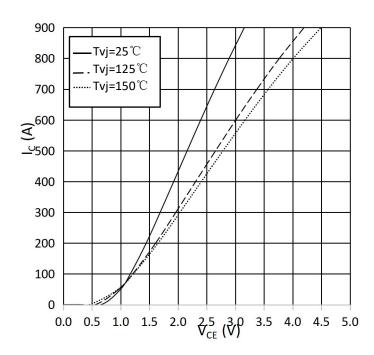
$$T_{vj} = 150 \, \text{C}$$



## output characteristic IGBT, Inverter (typical)

$$I_C = f(V_{CE})$$

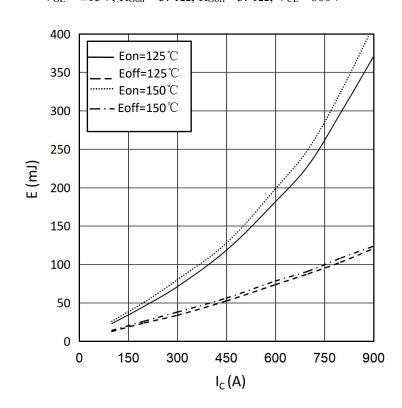
$$V_{GE} = 15 \text{ V}$$



### switching losses IGBT,Inverter(typical)

$$E_{on} = f(I_C), E_{off} = f(I_C)$$

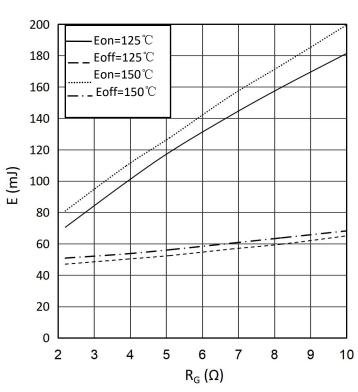
$$V_{GE} = \pm 15V$$
,  $R_{Gon} = 5$ .  $1\Omega$ ,  $R_{Goff} = 5$ .  $1\Omega$ ,  $V_{CE} = 600V$ 



### switching losses IGBT,Inverter(typical)

$$E_{on} = f(R_G), E_{off} = f(R_G)$$

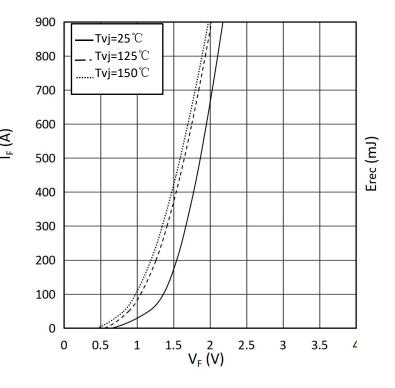
$$V_{GE} = \pm 15V, I_C = 450A, V_{CE} = 600V$$





## forward characteristic of Diode, Inverter (typical)

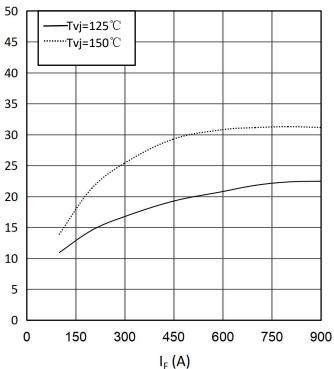
$$I_F = f(V_F)$$



## switching losses Diode, Inverter (typical)

$$E_{rec} = f(I_F)$$

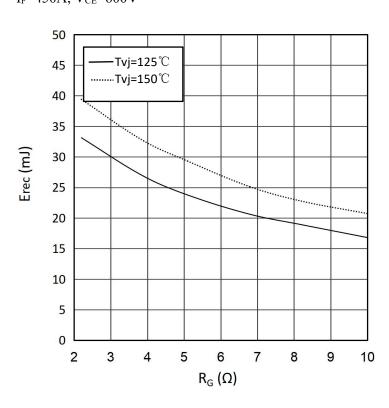
$$R_{Gon}=5.1\Omega$$
,  $V_{CE}=600V$ 



### switching losses Diode, Inverter (typical)

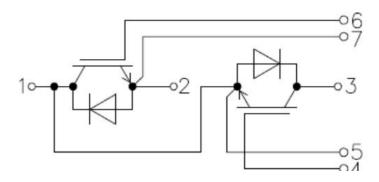
$$E_{rec} = f(R_G)$$

$$I_F=450A, V_{CE}=600V$$

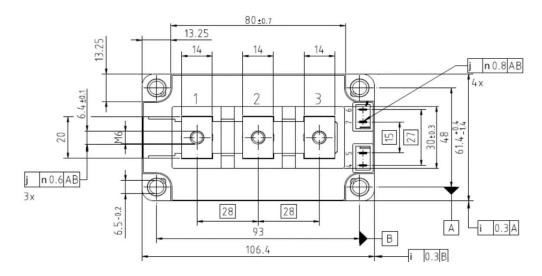


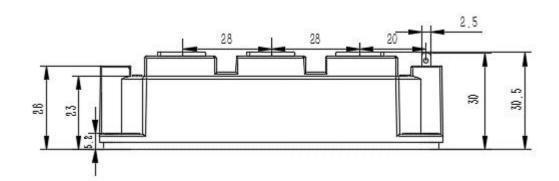


## Circuit diagram headline



## Package outlines (Unit: mm)







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