

## SiC N 型MOSFET 模块 / SiC N-Channel MOSFET Module

### 1. 应用/Applications

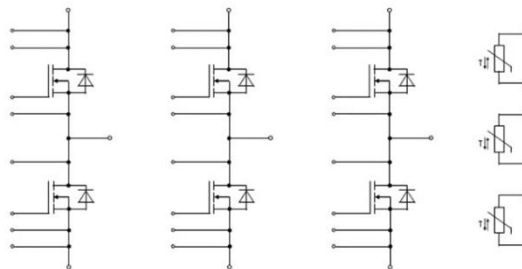
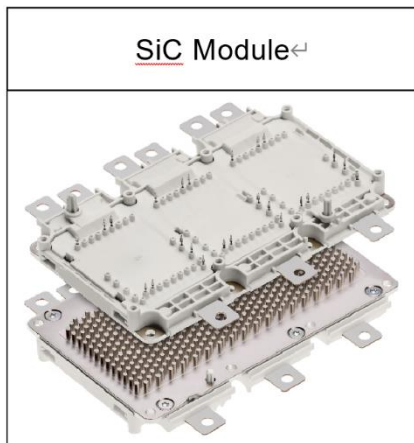
- 汽车应用 / Automotive Applications
- 混合动力电动车辆 / Hybrid Electrical Vehicles (HEV)
- 电机驱动 / Motor Drives
- 商业农业车辆 / Commercial Agriculture Vehicles

### 2. 特征/Features

- 源漏极电压 /  $V_{DSS}=1200V$
- 漏电流 /  $I_{Dnom}=400A$
- 低内阻的新型SiC材料  
New semiconductor material Silicon Carbide Low  $R_{DSon}$
- 低开关损耗 / Low Switching Losses
- 低栅极充电电荷和反向传输电容 / Low  $Q_g$  and  $C_{rss}$
- 低电感设计 / Low Inductive Design  $<10nH$
- 工作结温 /  $T_{vjop}=150^{\circ}C$

### 3. 封装和内部电路 / Packaging and Internal Circuit

名称 / Part Name	封装 / Package	标识 / Marking
SYM3F02R12HPD	SiC Module	3F02R12HPD



## MOSEFET 模块最大额定值 / Mosfet Module Maximum Rated Values

源漏极电压 / Drain-source voltage	$T_{vj}=25^{\circ}\text{C}$	$V_{DSS}$	1200	V
漏电流 / DC drain current	$T_{vj}=25^{\circ}\text{C}$ $V_{GS}=15\text{V}$	$I_{D\text{ nom}}$	400	A
脉冲漏极电流 / Pulsed drain current	设计验证 / verified by design, $t_p$ limited by $T_{vj\text{ max}}$	$I_{D\text{ pulse}}$	800	A
栅极-源极电压 / Gate-source voltage		$V_{GSS}$	-10 / 20	V

### 特征值 / Characteristic Values

			min.	typ.	max.	
源漏极导通电阻 / Drain-source on resistance	$I_{D\text{ nom}}=480\text{A}$ $V_{GS}=20\text{V}$	$T_{vj}=25^{\circ}\text{C}$	$R_{Dson}$	2.55	3.1	$\text{m}\Omega$
栅极阈值电压 / Gate threshold voltage	$I_D=20,0\text{ mA}$ , $V_{DS}=V_{GS}$ (tested after 1ms pulse at $V_{GS}=+20\text{ V}$ )	$T_{vj}=25^{\circ}\text{C}$	$V_{GS(th)}$	2.0	3.0	4.0 V
栅极总电荷 / Total gate charge	$V_{GS}=-5\text{ V} / 15\text{ V}$ $V_{DS}=800\text{ V}$		$Q_G$	1.35		$\mu\text{C}$
内门电阻 / Internal gate resistor		$T_{vj}=25^{\circ}\text{C}$	$R_{Gint}$	0.25		$\Omega$
输入电容 / Input capacitance	$f=1\text{ MHz}$ , $V_{GS}=0\text{ V}$ $V_{DS}=600\text{ V}$	$T_{vj}=25^{\circ}\text{C}$	$C_{iss}$	44.7		nF
输出电容 / Output capacitance	$f=1\text{ MHz}$ , $V_{GS}=0\text{ V}$ $V_{DS}=600\text{ V}$	$T_{vj}=25^{\circ}\text{C}$	$C_{oss}$	1.95		nF
反向传输电容 / Reverse transfer capacitance	$f=1\text{ MHz}$ , $V_{GS}=0\text{ V}$ $V_{DS}=600\text{ V}$	$T_{vj}=25^{\circ}\text{C}$	$C_{rss}$	178		pF
寄生电容产生的能量 / $C_{oss}$ stored energy	$V_{DS}=800\text{ V}$ $V_{GS}=-5\text{ V} / 15\text{ V}$	$T_{vj}=25^{\circ}\text{C}$	$E_{oss}$	459		$\mu\text{J}$
源漏极漏电流 / Drain-source leakage current	$V_{DSS}=1200\text{ V}$ $V_{GS}=-5\text{ V}$	$T_{vj}=25^{\circ}\text{C}$	$I_{DSX}$	2.5	100	$\mu\text{A}$
栅 - 源漏电流 / Gate-source leakage current	$V_{GS}=20\text{ V}$ $V_{DS}=0\text{ V}$	$T_{vj}=25^{\circ}\text{C}$	$I_{GSS}$		400	nA
开通延迟时间 / Turn on delay time	$I_{D\text{ nom}}=400\text{ A}$ , $R_{Gon}=5,10\Omega$ $V_{DS}=600\text{ V}$ $V_{GS}=-5\text{ V} / 15\text{ V}$	$T_{vj}=25^{\circ}\text{C}$	$t_{don}$	195		ns
上升时间 / Rise time, inductive load	$I_{D\text{ nom}}=400\text{ A}$ , $R_{Gon}=5,10\Omega$ $V_{DS}=600\text{ V}$ $V_{GS}=-5\text{ V} / 15\text{ V}$	$T_{vj}=25^{\circ}\text{C}$	$t_r$	392		ns
关断延迟时间 / Turn off delay time	$I_{D\text{ nom}}=400\text{ A}$ , $R_{Gon}=5,10\Omega$ $V_{DS}=600\text{ V}$ $V_{GS}=-5\text{ V} / 15\text{ V}$	$T_{vj}=25^{\circ}\text{C}$	$t_{doff}$	411		ns
下降时间 / Fall time, inductive load	$I_{D\text{ nom}}=400\text{ A}$ , $R_{Gon}=5,10\Omega$ $V_{DS}=600\text{ V}$ $V_{GS}=-5\text{ V} / 15\text{ V}$	$T_{vj}=25^{\circ}\text{C}$	$t_f$	125		ns
开通能量损耗 / Turn-on energy loss per pulse	$I_{D\text{ nom}}=400\text{ A}$ , $R_{Gon}=5,10\Omega$ $V_{DS}=600\text{ V}$ , $di/dt=4\text{ kA}/\mu\text{s}$ $V_{GS}=-5\text{ V} / 15\text{ V}$ , $L=20\text{ nH}$	$T_{vj}=25^{\circ}\text{C}$	$E_{on}$	71.8		mJ
关断能量损耗 / Turn-off energy loss per pulse	$I_{D\text{ nom}}=400\text{ A}$ , $R_{Gon}=5,10\Omega$ $V_{DS}=600\text{ V}$ ; $du/dt=7.3\text{ kV}/\mu\text{s}$ $V_{GS}=-5\text{ V} / 15\text{ V}$ , $L=20\text{ nH}$	$T_{vj}=25^{\circ}\text{C}$	$E_{off}$	44		mJ
短路电流数据 / Short circuit data	$V_{DD}=800\text{ V}$ , $R_{Gon}=5,10\Omega$ $V_{DS}=600\text{ V}$ ; $t_{sc}=3\mu\text{s}$ $V_{GS}=-5\text{ V} / 15\text{ V}$	$T_{vj}=25^{\circ}\text{C}$	$I_{sc}$	5100		A

**特征值 / Characteristic Values**

		min.		typ.		max.	
热阻 Thermal resistance, junction to heatsink	pro MOSFET /per MOSFET	R <sub>thJH</sub>		0.1	0.108	K/W	
开关温度 Temperature under switching conditions		T <sub>vj op</sub>	-40		150	°C	

**体二极管/体二极管最大值**
**Body Diode/Body diode Maximum Rated Values**

直流体二极管正向电流 DC body diode forward current	T <sub>vjmax</sub> = 175°C V <sub>GS</sub> =-5V	T <sub>H</sub> =60°C	I <sub>SD</sub>	210	A	
脉冲体二极管正向电流 Pulsed body diode forward current	Verified by design, T <sub>p</sub> limited by T <sub>vjmax</sub>		I <sub>SD pulse</sub>	800	A	

**特征值 / Characteristic Values**

		min.		typ.		max.	
正向电压 Forward voltage	I <sub>SD</sub> =400 A V <sub>GS</sub> =-5V	T <sub>vj</sub> =25°C	V <sub>DSCR</sub>	5.1	6.0	V	
反向恢复峰值电流 Peak reverse recovery current	I <sub>SD</sub> =400 A, V <sub>r</sub> =600V V <sub>GS</sub> =-5V	T <sub>vj</sub> =25°C	I <sub>rrm</sub>	133	A		
恢复电荷 Recovery Charge	I <sub>SD</sub> =400 A, V <sub>r</sub> =600V V <sub>GS</sub> =-5V	T <sub>vj</sub> =25°C	Q <sub>rr</sub>	3.9	µC		
反向恢复能量 Reverse recoveryenergy	I <sub>SD</sub> =400 A, V <sub>r</sub> =600V V <sub>GS</sub> =-5V	T <sub>vj</sub> =25°C	E <sub>rec</sub>	0.96	mJ		

**NTC热敏电阻特性值**
**NTC-Thermistor Characteristic Values**

		min.		typ.		max.	
额定电阻 Rated resistance	T <sub>NTC</sub> =25°C	R <sub>25</sub>		5.00		kΩ	
电阻差 Deviation of R100	T <sub>NTC</sub> =100°C, R <sub>100</sub> =493 Ω	ΔR/R	-5		5	%	
功率耗散 Power dissipation	T <sub>NTC</sub> =25°C	P <sub>25</sub>			20.0	mW	
NTC阻值对温度的敏感度参数 B-value	R <sub>2</sub> =R <sub>25</sub> exp[B <sub>25/50</sub> (1/T <sub>2</sub> -1/(298,15K))]	B <sub>25/50</sub>		3376		K	
NTC阻值对温度的敏感度参数 B-value	R <sub>2</sub> =R <sub>25</sub> exp[B <sub>25/80</sub> (1/T <sub>2</sub> -1/(298,15K))]	B <sub>25/80</sub>		3413		K	
NTC阻值对温度的敏感度参数 B-value	R <sub>2</sub> =R <sub>25</sub> exp[B <sub>25/100</sub> (1/T <sub>2</sub> -1/(298,15K))]	B <sub>25/100</sub>		3435		K	

Specification according to the valid application note.

## Mosfet Module

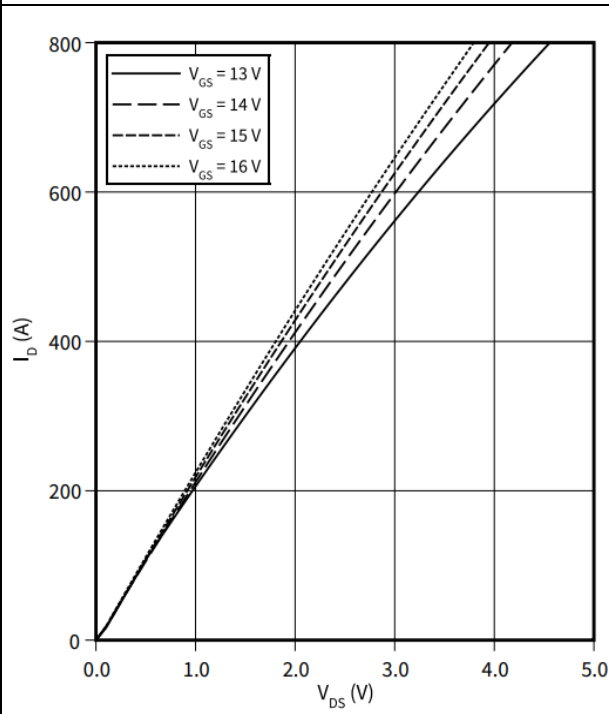
隔离试验电压 Isolation test voltage	RMS, f= 0 Hz, t= 1 sec.	V <sub>ISOL</sub>	4.2		kV
内部隔离 Internal isolation	Basic insulation(class1,IEC61140)		Ni+Cu		
漏电距离 Creepage distance	terminal to heatsink terminal to terminal		9.0 9.0		mm
Clearance	terminal to heatsink terminal to terminal		4.5 4.5		mm
跟踪指数 Comperative tracking index		CTI	>200		
RTI Elec.	housing	RTI	140		°C
min. typ. max.					
杂散电感模块 Stray inductance module		L <sub>sCE</sub>		8.5	nH
储存温度 Storage temperature		T <sub>stg</sub>	-40		125 °C
mountig force per clamp		F	40	-	80 N
重量 Weight		G		720	g

The current under continuous operation is limited to 25 A rms per connector pin.

Important note: The selection of positive and negative gate-source voltages impacts the long-term behavior of the device. The design guide lines described in Application NoteAN2018-09 must be considered to ensure sound operation of the device over the planned lifetime.

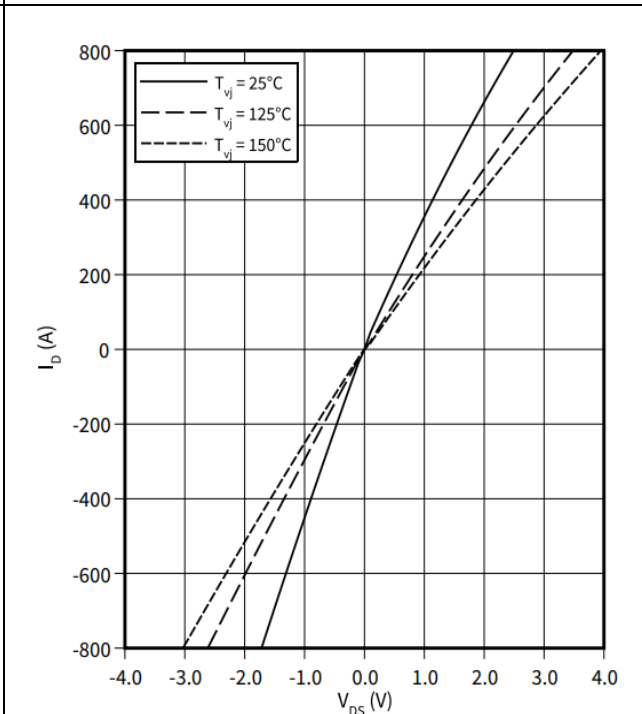
# Electrical characteristics diagram

**Diagram 1: output characteristics**



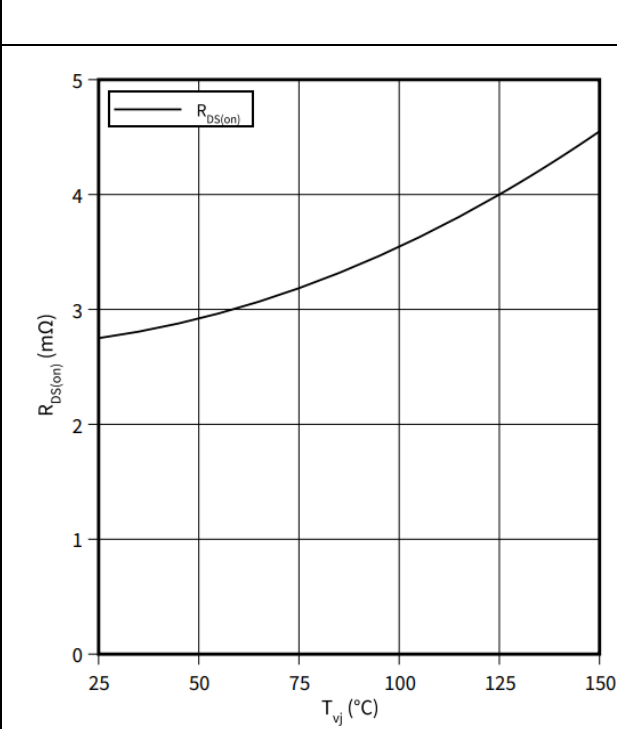
$I_D = f(V_{DS}); T_j = 25^\circ\text{C}; \text{parameter: } V_{GS}$

**Diagram 2: output characteristics**



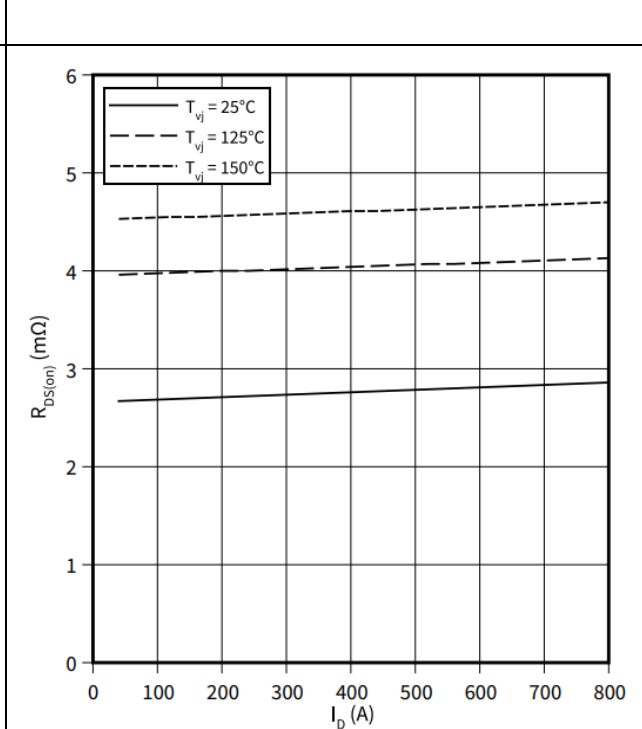
$I_D = f(V_{DS}); V_{GS} = 15\text{V}$

**Diagram 3: on-resistance vs. junction temperature**



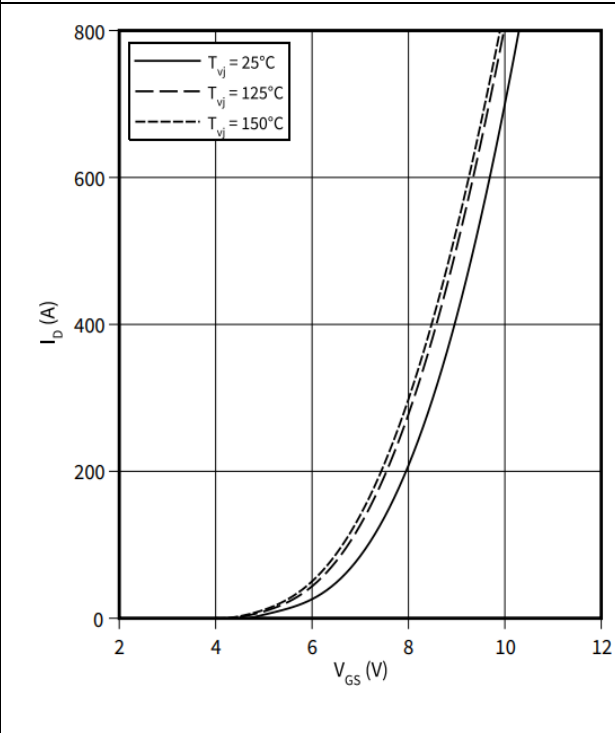
$R_{DS(ON)} = f(T_j); I_{DS} = 400\text{A}, V_{GS} = 15\text{V}$

**Diagram 4: drain source on-resistance vs. Id**



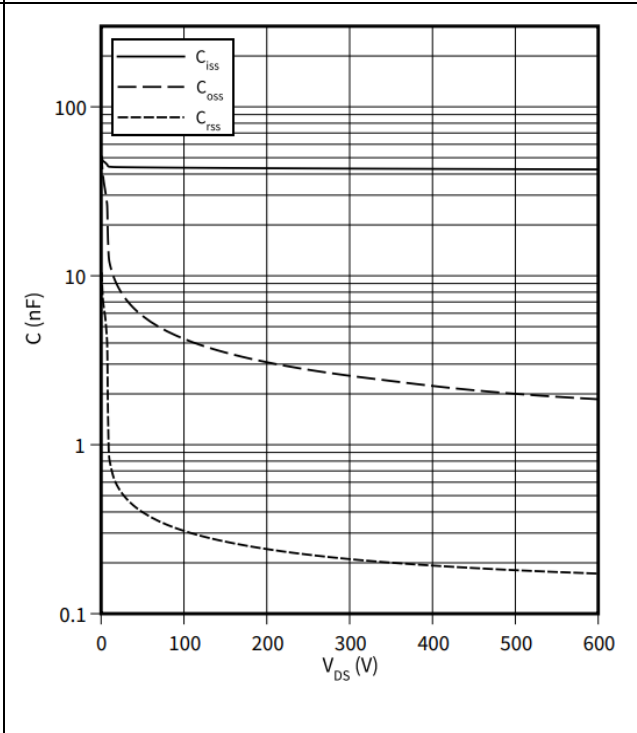
$R_{DS(ON)} = f(I_D)$

**Diagram 5: Typ. transfer characteristics**



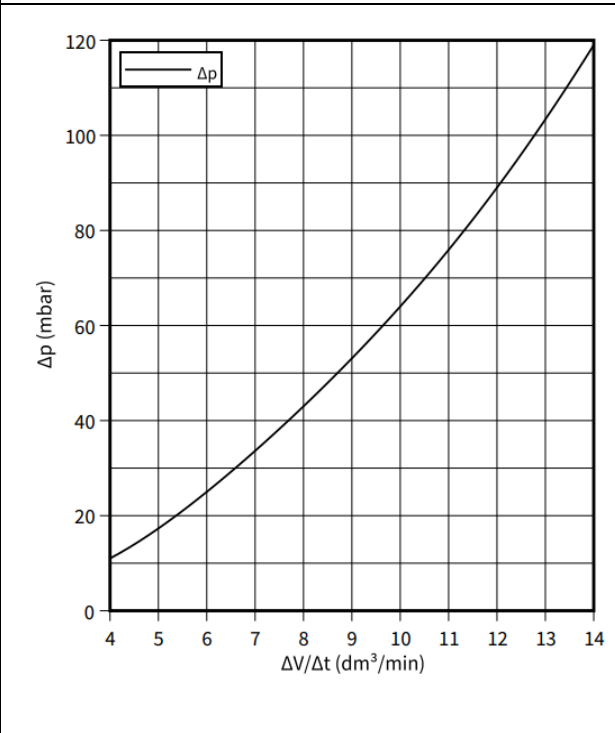
$I_D = f(V_{GS}); V_{DS} = 20V; \text{parameter: } T_j$

**Diagram 6: Capacitance as a function of drain-source**



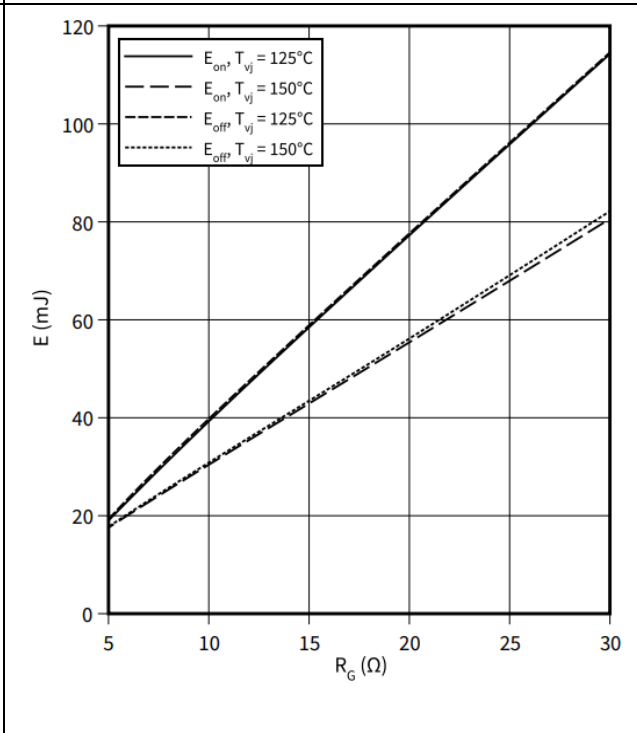
$C = f(V_{DS}); V_{GS} = 0V; f = 1MHz, T_j = 25C$

**Diagram 7: Pressure drop in cooling circuit**



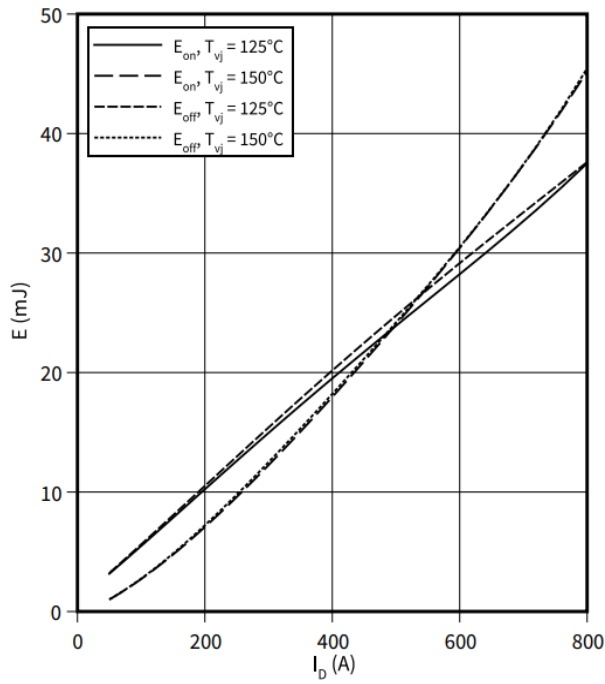
$\Delta p = f(\Delta V/\Delta t)$

**Diagram 8: switching losses(typical), MOSFET**



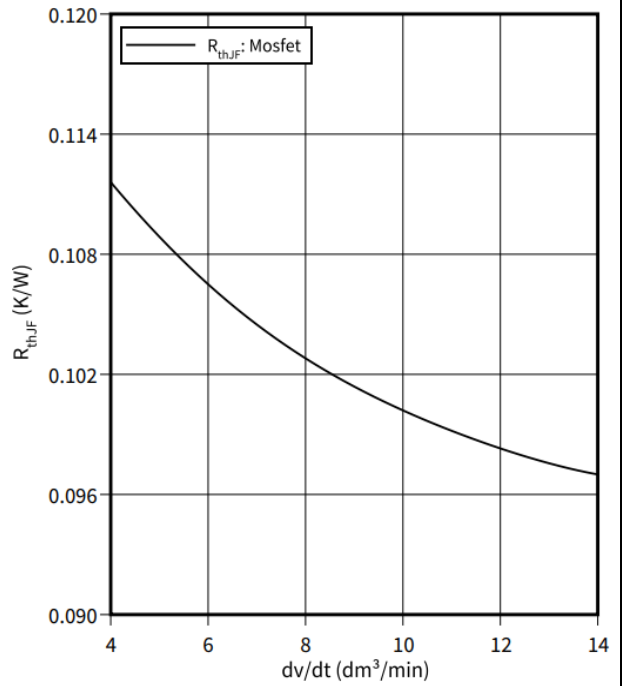
$E = f(R_g); I_D = 400A; V_{DS} = 600V; V_{GS} = -5.0/15.0V$

**Diagram 9: switching losses(typical),MOSFET**



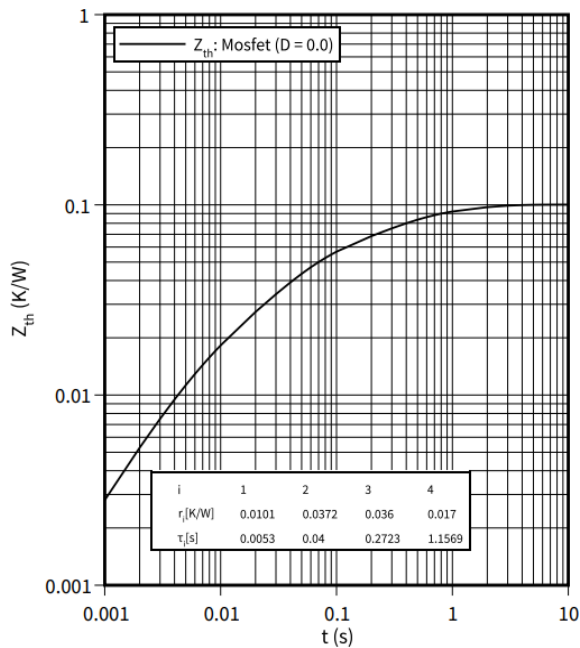
$E=f(I_D)$ ;  $V_{DS}=600V$ ;  $V_{GS}=-5.0/15.0V$ ;  $R_{goff}=5.1\Omega$ ,

**Diagram 10: thermal impedance, MOSFET**



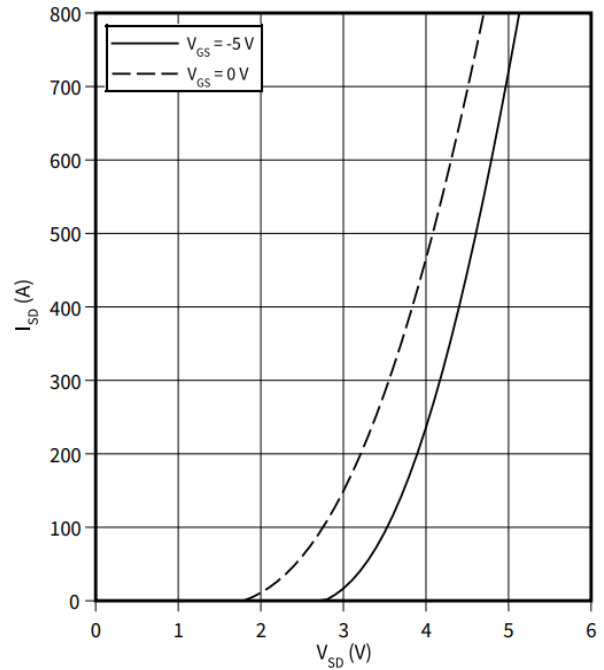
$R_{thJF}=f(dv/dt)$ ;

**Diagram 11: transient thermal impedance**



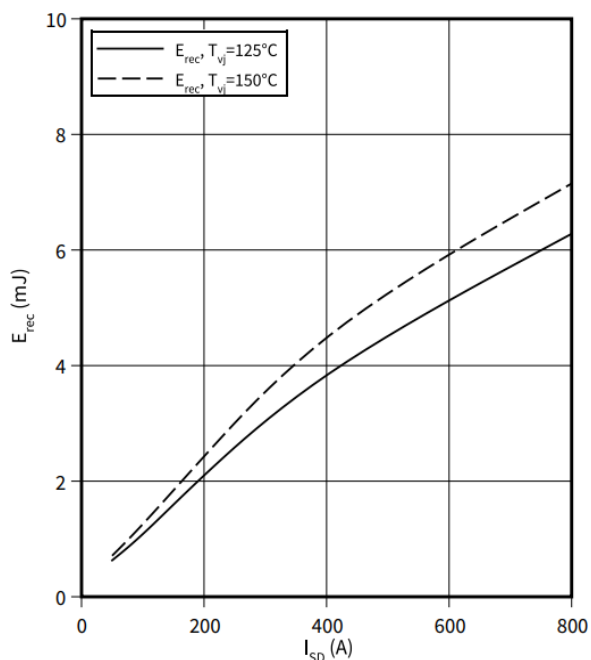
$Z_{th}=f(t)$ ;

**Diagram 12: forward characteristics body**



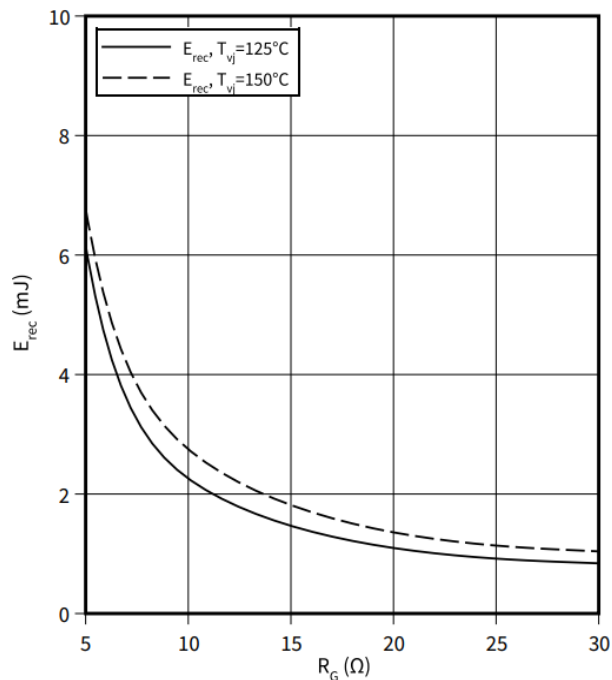
$I_{SD}=f(V_{SD})$ ;  $T_J=25C$

Diagram 13: switching losses body diode



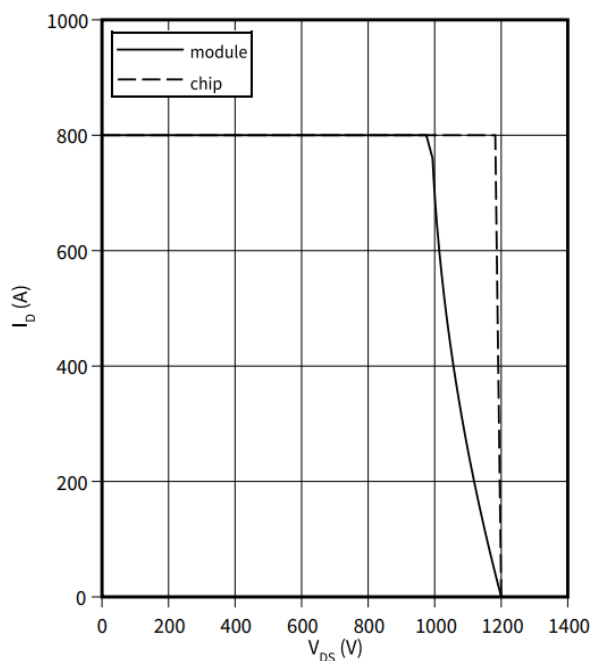
$E_{rec}=f(I_{SD}); V_r=600\text{V}; V_{GS}=-5.0/15.0\text{V}; R_{gon}=5.1\Omega,$

Diagram 14: switching losses body diode



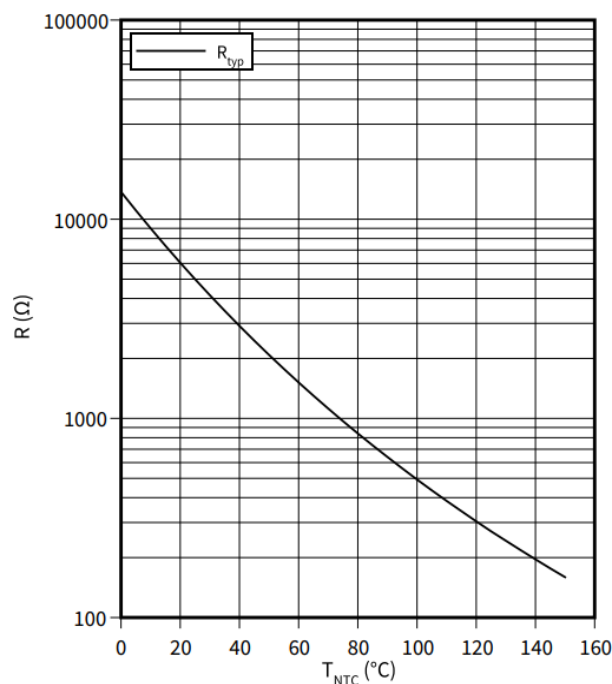
$E_{rec}=f(R_G); V_r=600\text{V}; V_{GS}=-5.0/15.0\text{V}; I_{SD}=400\text{A}$

Diagram 15: Reverse bias safe operating area(RBSOA)



$I_D=f(V_{DS}); V_{GS}=15\text{V}/5\text{V}; R_{goff}=5.1\Omega, T_V=150\text{C}$

Diagram 16: temperature characteristics, NTC-Thermistor



$R=f(T_{NTC})$

# Circuit diagram

