中国中车 CRRC

TM540FF12S7P-F3A02

六单元 SiC MOSFET 模块 Six-Pack SiC MOSFET Module

产品数据手册 Product Datasheet 版本 Ver 25.07

初版 Preliminary

关键参数 Key Parameters

V_{DSS}		1200	V
$R_{DS(on)}$	Typ.	2.11	mΩ
I_D	Max.	540	A
I_{DM}	Max.	1080	A

典型应用 Typical Applications

- 电动汽车 Automotive Applications
- 混合动力/纯电动车 Hybrid/Electrical Vehicles
- 电机驱动 Motor Drives

特点 Features

- 铜针翅基板 Cu Pin-fin Baseplate
- 低开关损耗 Low Switching Losses
- 低反向恢复损耗 Low Reverse Recovery Loss
- 低感设计 Low Inductive Design
- Si_3N_4 衬板 Si_3N_4 AMB Substrate

电路结构 Circuit Configuration

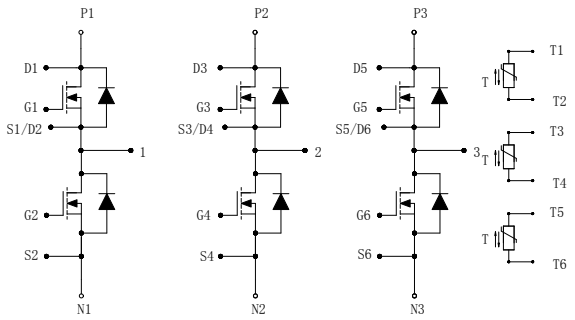


图 1.电路结构

Fig. 1 Circuit configuration

模块外形 Module Appearance

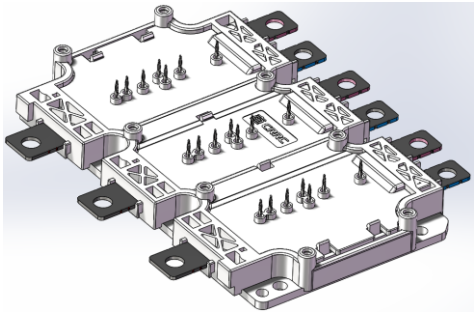


图 2. 模块外形

Fig. 2 Module appearance

模块标签说明 Module Label Code Instruction

数据位置 Data position	数据内容 Content of data
1--8	模块批次号 Module batch number
9--12	模块序列号 Module serial number

最大额定值 Absolute Maximum Ratings

符号 Symbol	参数名称 Parameter	测试条件 Test Conditions	数值 Value	单位 Unit
V_{DSS}	漏源极电压 Drain-source voltage	V_{GS} = 0V, T_F= 25 °C	1200	V
V_{GSmax}	栅源电压 Gate-source voltage	T_F= 25 °C	-8/+23	V
V_{GSop}	栅源电压 Gate-source voltage	T_F= 25 °C	-4/+18	V
I_D	额定漏极电流 Rating drain current	T_F=65°C， $T_{vj\ max}$ = 175°C	540	A
I_{DM}	漏极峰值电流 Peak drain current	t_P=1ms	1080	A
P_{max}	晶体管部分最大损耗 Max. transistor power dissipation	T_F=65 °C, $T_{vj\ max}$=175°C	1068	W
V_{isol}	绝缘电压(模块) Isolation voltage – per module	短接所有端子，端子与基板间施加电压 (Connected terminals to baseplate), RMS,f=0 Hz,t=1 sec ,T_C= 25 °C	4200	V

热和机械数据 Thermal & Mechanical Data

参数 Symbol	说明 Explanation	值 Value	单位 Unit
爬电距离 Creepage distance	端子-散热器 Terminal to heatsink	6.5	mm
	端子-端子 Terminal to terminal	6.5	mm
绝缘间隙 Clearance	端子-散热器 Terminal to heatsink	4.5	mm
	端子-端子 Terminal to terminal	4.5	mm
相对漏电起痕指数 CTI (Comparative tracking index)		＞600	

热和机械数据 Thermal & Mechanical Data

符号 Symbol	参数名称 Parameter	测试条件 Test Conditions	最小值 Min.	典型值 Typ.	最大值 Max.	单位 Unit
$R_{th(J-F)\ MOSFET}$	MOSFET 热阻 Thermal resistance –MOSFET	冷却液：50%乙二醇溶液；△V/△t=10 dm^3/min； T_F = 65 °C Cooling Fluid：50% water / 50% ethylene glycol；△V/△t=10 dm^3/min； T_F= 65 °C		103	113	K / kW
△P	冷却液流阻 Pressure drop in cooling circuit	冷却液：50%乙二醇溶液；△V/△t=10 dm^3/min； T_F = 65 °C Cooling Fluid：50% water / 50% ethylenglycol；△V/△t=10dm^3/min； T_F= 65 °C		50		mbar
P	冷却液最大压力 Maximum pressure in cooling circuit				2.5	bar
$T_{vj\ op}$	工作结温 Operating junction temperature		-40		175	°C
T_{stg}	存储温度 Storage temperature range		-40		125	°C
M	安装力矩 Screw torque	电路互连用– M5 Electrical connections – M5	1.8	2.0	2.2	Nm
		PCB 安装用 PCB Mounting	0.80	0.85	0.90	Nm

热敏电阻数据 NTC-Thermistor Data

符号 Symbol	参数名称 Parameter	测试条件 Test Conditions	最小值 Min.	典型值 Typ.	最大值 Max.	单位 Unit
R_{25}	额定电阻值 Rated resistance	T_C = 25 °C		5		kΩ
△R/R	R_{100} 偏差 Deviation of R_{100}	T_C = 100 °C, R_{100}=493Ω	-5		5	%
P_{25}	耗散功率 Power dissipation	T_C = 25 °C			20	mW
$B_{25/50}$	B -值 B -value	$R_2 = R_{25} \exp [B_{25/50}(1/T_2 - 1/(298.15\ K))]$		3375		K
$B_{25/80}$	B -值 B -value	$R_2 = R_{25} \exp [B_{25/80}(1/T_2 - 1/(298.15\ K))]$		3411		K
$B_{25/100}$	B -值 B -value	$R_2 = R_{25} \exp [B_{25/100}(1/T_2 - 1/(298.15\ K))]$		3433		K

电特性值 Electrical Characteristics

除非特别声明，否则 T_C= 25 °C　　T_C= 25 °C unless otherwise stated

符号 Symbol	参数名称 Parameter	条件 Test Conditions	最小值 Min.	典型值 Typ.	最大值 Max.	单位 Unit
I_{DSS}	零栅压漏极电流 Zero gate voltage drain current	V_{GS} = 0V,V_{DS} = V_{DSS}			100	μA
		V_{GS} = 0V, V_{DS} = V_{DSS}, T_{vj} =150 °C			500	μA
		V_{GS} = 0V, V_{DS} = V_{DSS}, T_{vj} =175 °C			1000	μA
I_{GSS}	栅极漏电流 Gate leakage current	V_{GS} = -8/+23V, V_{DS} = 0V			500	nA
$V_{GS(th)}$	栅极-源极阈值电压 Gate threshold voltage	I_D = 60mA, V_{GS} = V_{DS}	2.10	2.70	3.30	V
$R_{DS(on)}$ (*1)	漏极-源极通态电阻 Drain-source on-state resistance	V_{GS} =18V, I_D =540A		2.11		mΩ
		V_{GS} =18V, I_D = 540A,T_{vj} = 150 °C		3.09		mΩ
		V_{GS} =18V, I_D = 540A,T_{vj} = 175 °C		3.30		mΩ
g_{fs}	跨导 Forward transconductance	V_{DS} =20V, I_D = 540A		503		S
V_{SD} (*1)	二极管正向电压 Diode forward voltage	I_{SD} = 540A, V_{GS} = -4V		4.3		V
		I_{SD} = 540A, V_{GS} = -4V, T_{vj} = 150 °C		4.0		V
		I_{SD} = 540A, V_{GS} = -4V, T_{vj} = 175 °C		3.5		V
I_{SC}	短路电流 Short circuit current	T_{vj} = 175°C, V_{DD} =850V, V_{GS}≤18V, t_p≤TBDμs, $V_{DS(max)}$ = V_{DSS} – L (*2)×di/dt, IEC 60747-8		TBD		KA

注意： 1.(*1) 表示该参数的测试点为辅助母排端子((*1) indicates it is measured at the auxiliary busbar terminal),

Note: 2.(*2) 表示 L 是电路杂散电感加上 L_{sDS} ((*2) indicates L is the circuit stray inductance plus L_{sDS}).

电特性值 Electrical Characteristics

除非特别声明，否则 T_C= 25 °C　　T_C= 25 °C unless otherwise stated

符号 Symbol	参数名称 Parameter	条件 Test Conditions	最小值 Min.	典型值 Typ.	最大值 Max.	单位 Unit
C_{iss}	输入电容 Input capacitance	V_{DS} = 600V, V_{GS} = 0V, f = 100kHz		38		nF
Q_g	栅极电荷 Gate charge	V_{DS} = 850V, I_D =700A, V_{GS} =-4/+18V		1.6		μC
C_{rss}	反向传输电容 Reverse transfer capacitance	V_{DS} = 600V, V_{GS} = 0V, f =100kHz		0.09		nF
L_{sDS}	模块电感 Module inductance			11		nH
$R_{DD'+SS'}$	模块引线电阻，端子-芯片 Module lead resistance, terminal-chip			0.7		mΩ
R_{Gint}	内部栅极电阻 Internal gate resistor	V_{GS}=0V		1.6		Ω

电特性值 Electrical Characteristics

符号 Symbol	参数名称 Parameter	测试条件 Test Conditions		最小值 Min.	典型值 Typ.	最大值 Max.	单位 Unit
$t_{d(off)}$	关断延迟时间 Turn-off delay time	I_D =700A, V_{DS} = 850V, V_{GS} = -4/+18V, $R_{G(OFF)}$ = 4.7Ω, L_S = 25nH, dv/dt =9740V/μs (T_{vj}= 175 °C).	T_{vj}= 25 °C		415		ns
			T_{vj}= 150 °C		489		
			T_{vj}= 175 °C		497		
t_f	下降时间 Fall time		T_{vj}= 25 °C		94		ns
			T_{vj}= 150 °C		98		
			T_{vj}= 175 °C		107		
E_{OFF}	关断损耗 Turn-off energy loss		T_{vj}= 25 °C		49.09		mJ
			T_{vj}= 150 °C		51.67		
			T_{vj}= 175 °C		53.83		
$t_{d(on)}$	开通延迟时间 Turn-on delay time	I_D =700A, V_{DS} = 850V, V_{GS} = -4/+18V, $R_{G(ON)}$ = 10.0Ω, L_S = 25nH, di/dt =4015A/μs (T_{vj}= 175 °C).	T_{vj}= 25 °C		146		ns
			T_{vj}= 150 °C		138		
			T_{vj}= 175 °C		136		
t_r	上升时间 Rise time		T_{vj}= 25 °C		182		ns
			T_{vj}= 150 °C		156		
			T_{vj}= 175 °C		156		
E_{ON}	开通损耗 Turn-on energy loss		T_{vj}= 25 °C		69.41		mJ
			T_{vj}= 150 °C		77.12		
			T_{vj}= 175 °C		80.08		
Q_{rr}	二极管反向恢复电荷 Diode reverse recovery charge	I_D =700A, V_{DS} = 850V, - di_{SD}/dt = 4015A/μs (T_{vj}= 175 °C).	T_{vj}= 25 °C		2		μC
			T_{vj}= 150 °C		6		
			T_{vj}= 175 °C		7		
I_{rr}	二极管反向恢复电流 Diode reverse recovery current		T_{vj}= 25 °C		111		A
			T_{vj}= 150 °C		168		
			T_{vj}= 175 °C		201		
E_{rec}	二极管反向恢复损耗 Diode reverse recovery energy		T_{vj}= 25 °C		0.35		mJ
			T_{vj}= 150 °C		1.79		
			T_{vj}= 175 °C		2.29		

注意：
Note:

1.(*1) dv/dt：定义为关断波形电压 V_{DS} 上升段，40% V_{DS} 至 60% V_{DS} 区间段的斜率((*1) dv/dt：Defined as the slope of waveform of 40% V_{DS} to 60% V_{DS} dv/dt during turn off)

2.(*2) di/dt：定义为开通波形电流 I_D 上升段，40% I_D 至 60%I_D 区间段的斜率((*2) di/dt：Defined as the slope of waveform of 40% I_D to 60% I_D di/dt during turn on)

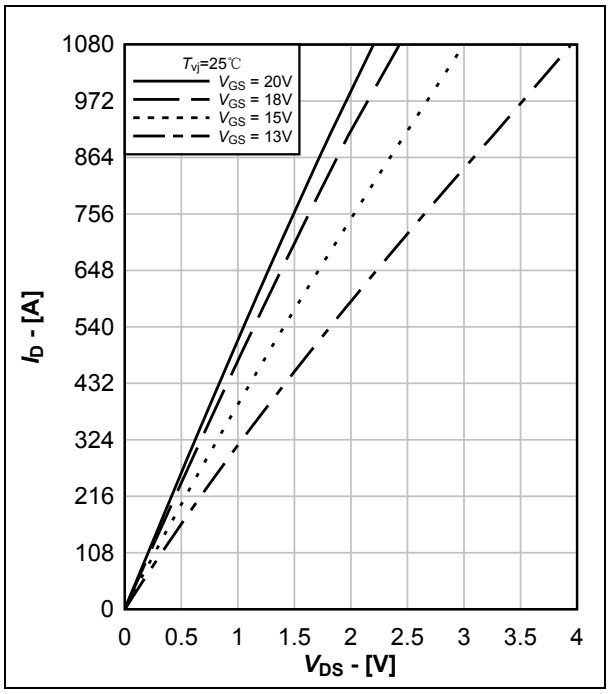


图 3. MOSFET 输出特性典型曲线, I_D= f (V_{DS})

Fig.3 Typical MOSFET output characteristics, I_D= f (V_{DS})

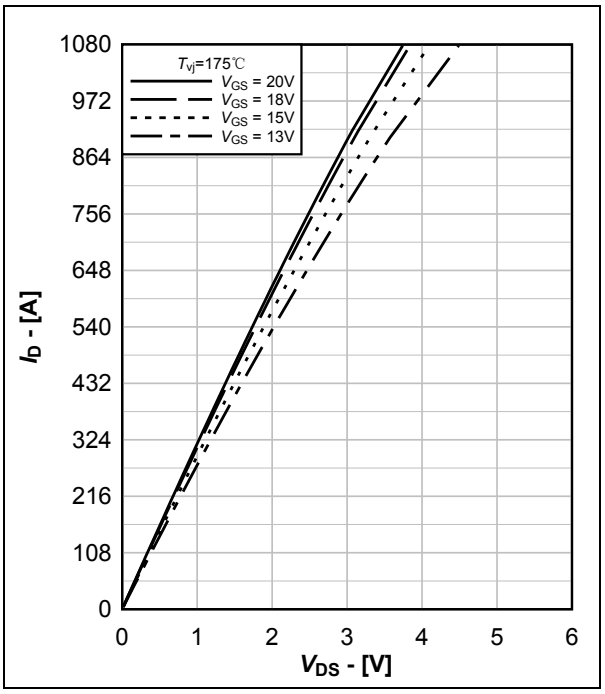


图 4. MOSFET 输出特性典型曲线, I_D= f (V_{DS})

Fig.4 Typical MOSFET output characteristics, I_D= f (V_{DS})

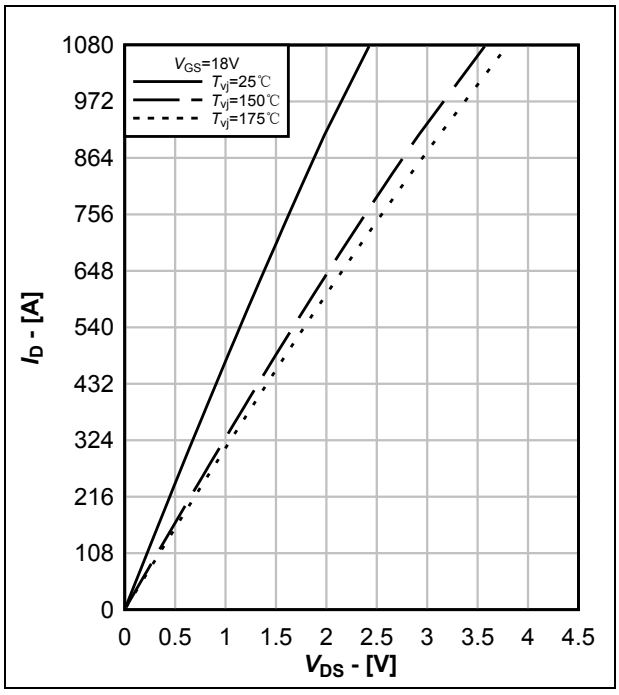


图 5. MOSFET 输出特性典型曲线, I_D= f (V_{DS})

Fig.5 Typical MOSFET output characteristics, I_D= f (V_{DS})

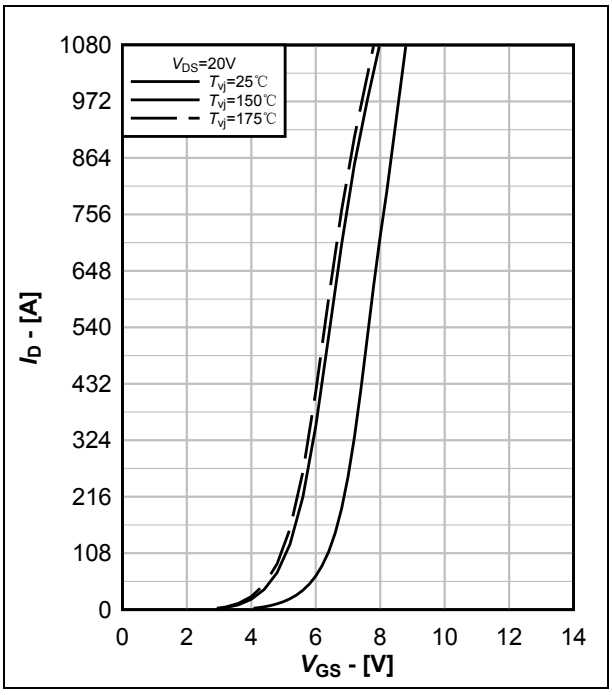


图 6. MOSFET 传输特性典型曲线,I_D= f (V_{GS})

Fig.6 Typical MOSFET transfer characteristics, I_D= f (V_{GS})

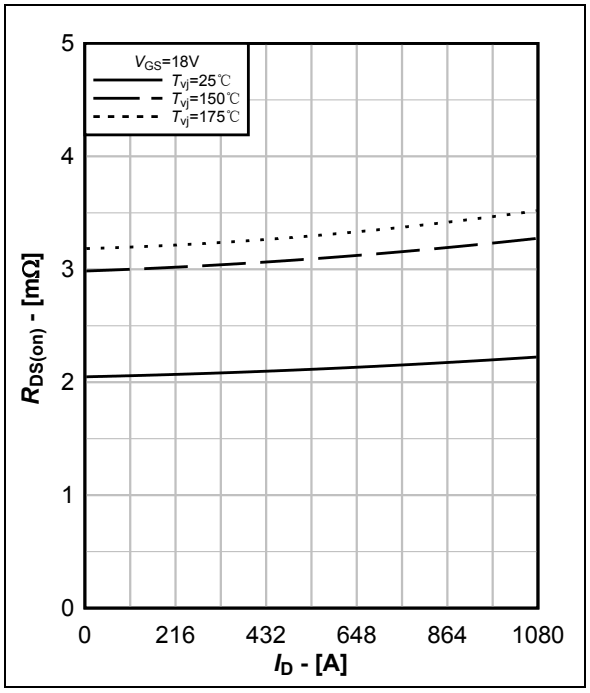


图 7. 导通电阻典型曲线, $R_{DS(on)}$ = f (I_D)

Fig.7 Typical On-Resistance characteristics, $R_{DS(on)}$ = f (I_D)

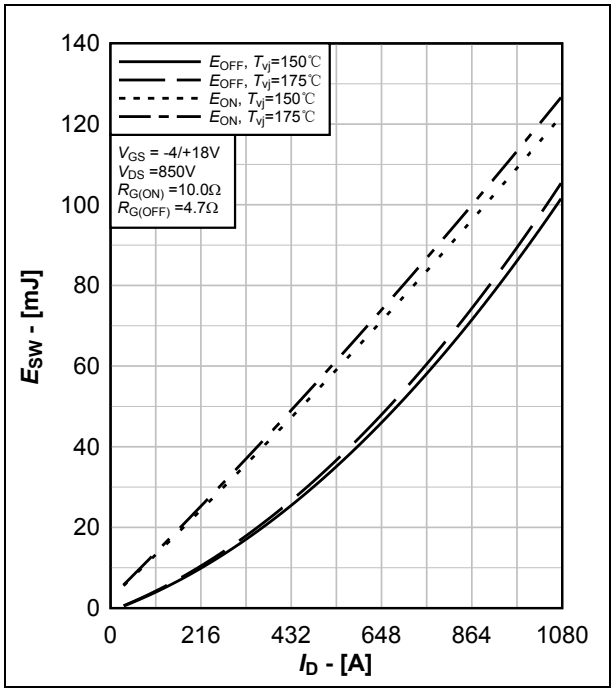


图 8. MOSFET 开关损耗典型曲线, E_{on}= f (I_D), E_{off}= f (I_D)

Fig.8 Typical MOSFET switching energy, E_{on}= f (I_D), E_{off}= f (I_D)

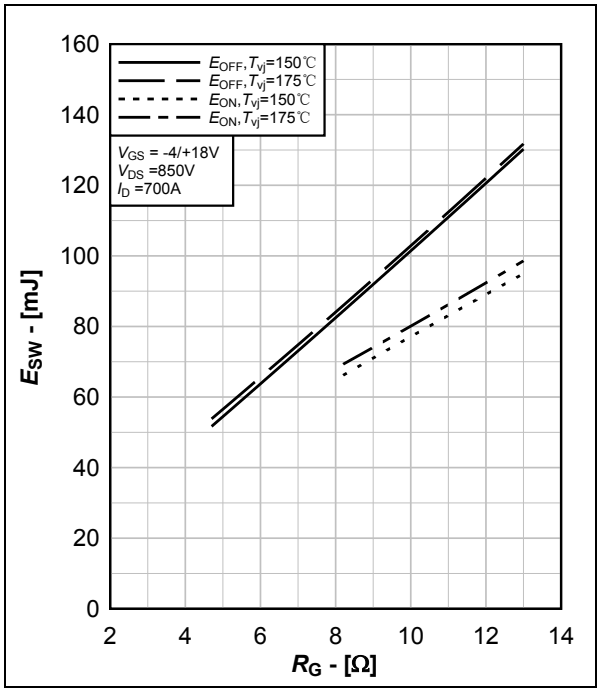


图 9. MOSFET 开关损耗典型曲线, E_{on}= f (R_G), E_{off}= f (R_G)

Fig.9 Typical MOSFET switching energy, E_{on}= f(R_G), E_{off}= f (R_G)

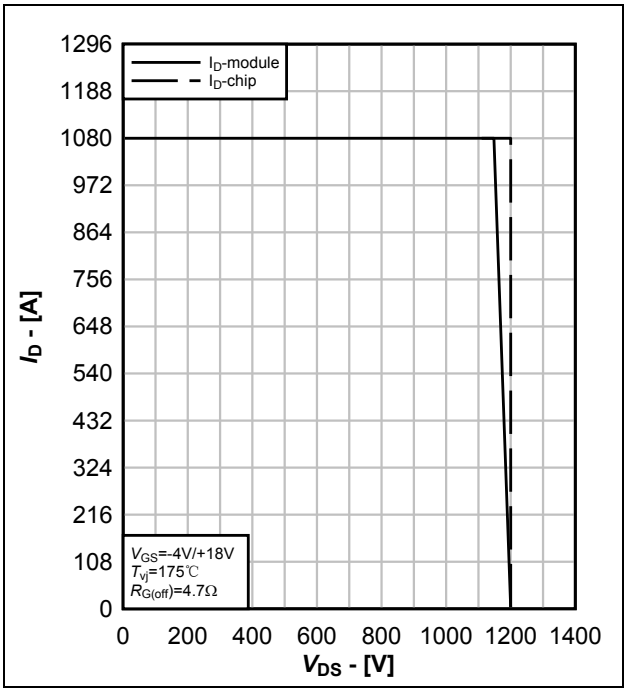


图 10. MOSFET 反偏安全工作区, I_D = f (V_{DS})

Fig.10 Reverse bias safe operating area of MOSFET, I_D = f (V_{DS})

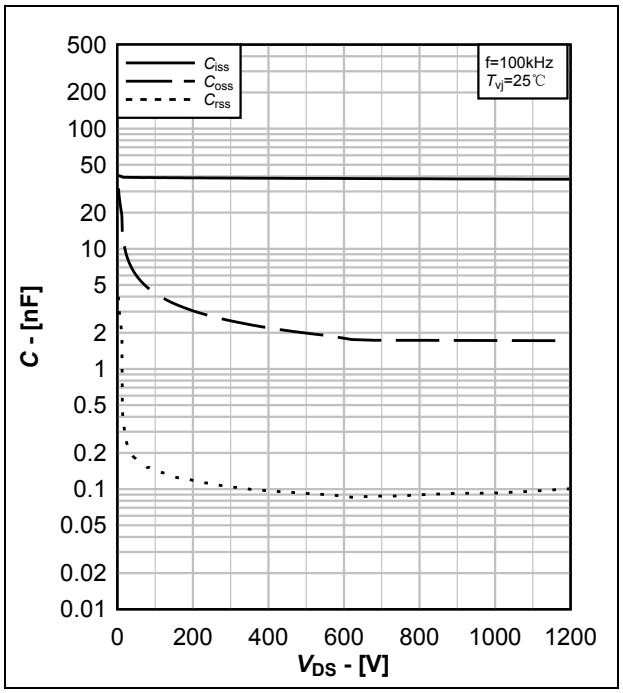


图 11. 电容特性典型曲线, C= f (V_{DS})

Fig.11 Typical capacity characteristic, C= f (V_{DS})

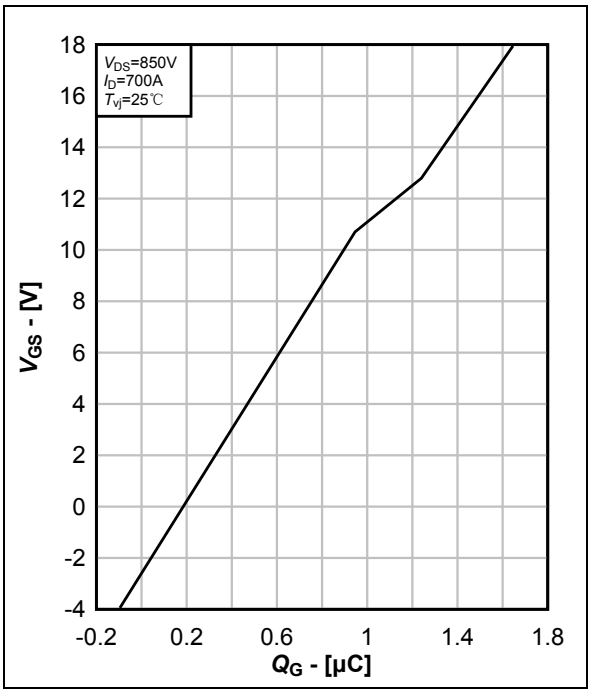


图 12. 栅极电荷特性典型曲线, V_{GS} = f (Q_G)

Fig.12 Typical gate charge characteristic, V_{GS}= f (Q_G)

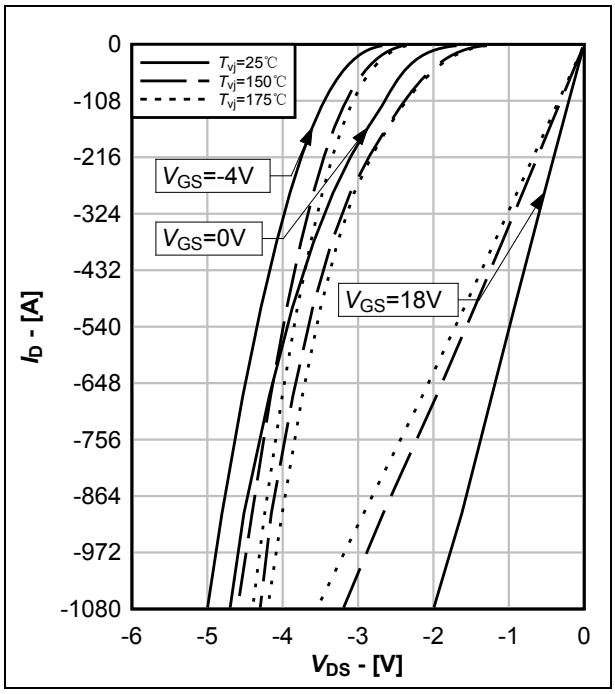


图 13. 体二极管及第三象限输出特性典型曲线, I_D = f (V_{DS})

Fig.13 Typical body diode output and 3rd quadrant characteristic, I_D = f (V_{DS})

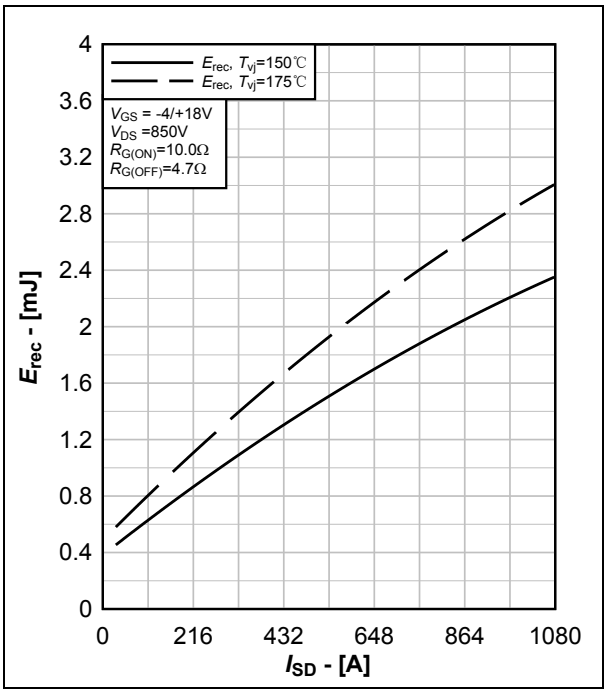


图 14. 体二极管反向恢复损耗典型曲线, E_{rec}=f(I_{SD})

Fig.14 Typical body diode switching loss E_{rec}, E_{rec}=f(I_{SD})

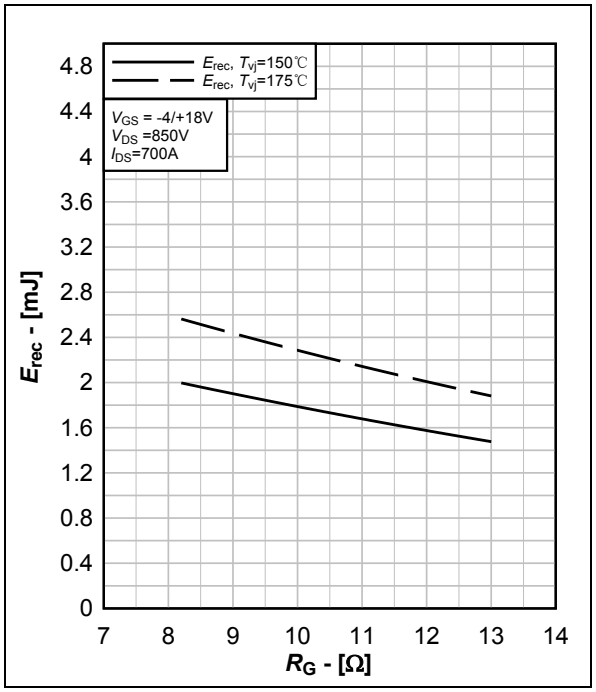


图 15. 体二极管反向恢复损耗典型曲线, E_{rec}=f(R_G)

Fig.15 Typical body diode switching loss E_{rec}, E_{rec}=f(R_G)

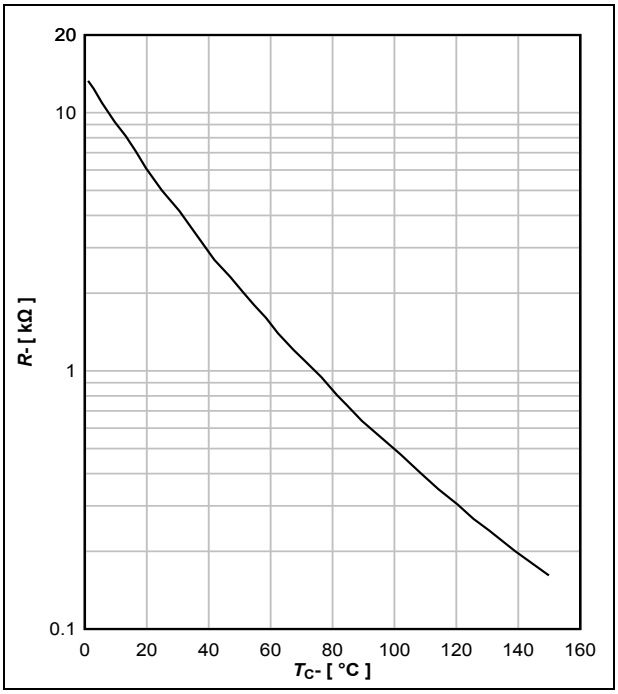


图 16. 热敏电阻典型特性曲线, R= f (T_C)

Fig.16 Typical NTC thermistor characteristic, R= f(T_C)

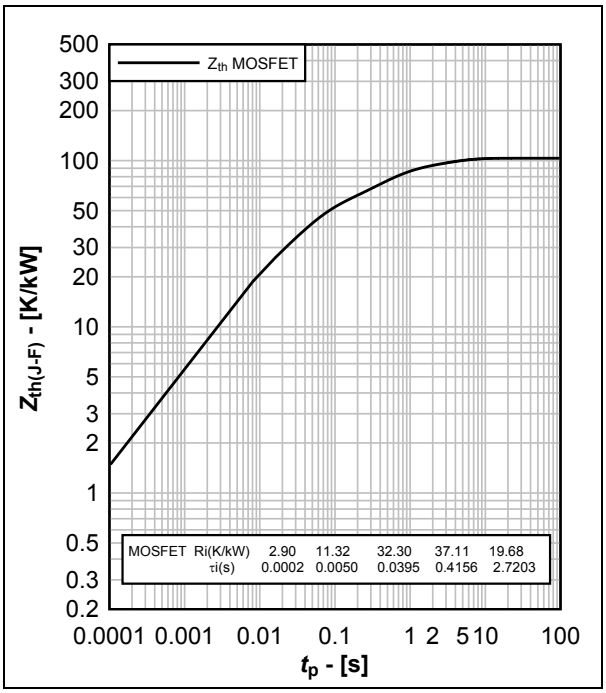
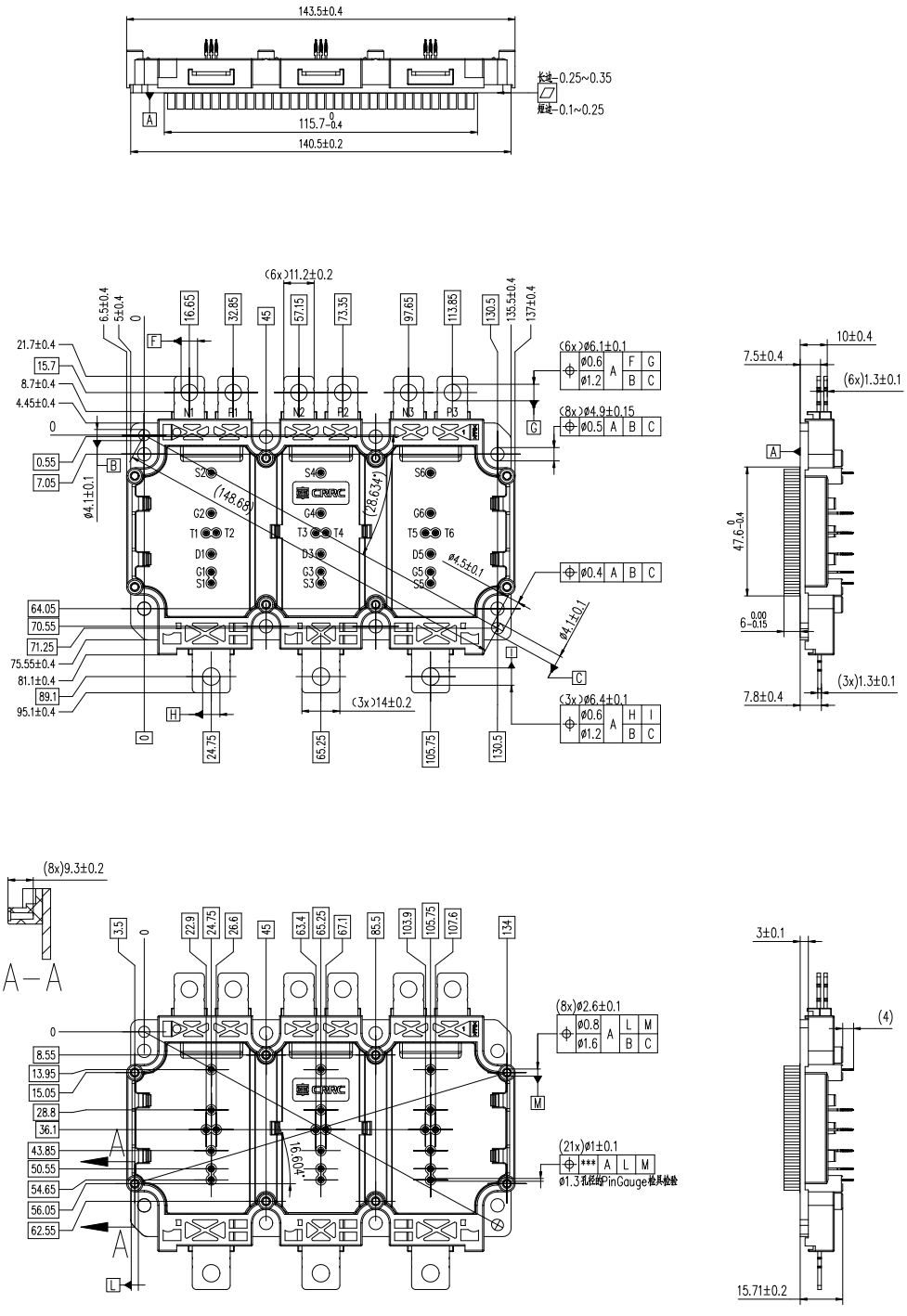


图 17. 瞬态热阻抗曲线, $Z_{th(J-F)}$ = f (t_p)

Fig.17 Transient thermal impedance, $Z_{th(J-F)}$ = f (t_p)



重量 Weight：600g　　模块外观类型 Module outline code：S7P

图 18. 模块外观尺寸

Fig. 18 Module outlines

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(1) The product information in this datasheet are intended for use by technical personnel. Due to the diversity of product applications, the information contained in this document can only be used as a general guide, the application applicability cannot be guaranteed in some special applications. It is recommended that users do the assessment of the application applicability before applied. If users need additional product information and help, please contact our sales or technical support.

(2) Some product data in the datasheet of this product are the typical values, the actual factory testing data may deviate slightly from typical values, but our company guarantees that these deviations will not affect the normal use of the product. If the product information changes, our

company will promptly amend the datasheet, please keeps your attention to product information changing in our company website.

(3) If there are special requirements for the product, or apply it in special industries (such as aerospace, medical, life support, etc.), we strongly recommend that to perform joint application risk and quality assessments, get the quality agreements.

(4) During the application, if the working conditions are beyond the limitation of temperature, voltage, current or safe operating area of the product defined in the product datasheet, our company cannot guarantee the reliability of the product.

(5) When the products are in use, it is strictly prohibited to touch. After power off, to ensure that there is no residual charge and the products have been cooled before they can be touched. And all operations must be under ESD protection measures.

(6) We annotate datasheet in the top right hand corner of the front page, to indicate product status. The annotation“Preliminary”indicates the product design is complete and final characterization for volume production is in progress，the product information in the datasheet is currently can be referenced, but some details may change in the future. There is no annotation indicates the product is capable to produce in batch quantity.