中国中车 CRRC

产品数据手册 Product Datasheet 版本 Ver 25.07

TG400FF12S3-S5A03

六单元 IGBT 模块 Six-Pack IGBT Module

关键参数 Key Parameters

V_{CES}		1200	V
$V_{CE(sat)}$	Typ.	1.35	V
I_C	Max.	400	A
$I_{C(RM)}$	Max.	800	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

- 椭圆铜针翅基板 Elliptical Cu Pin-fin Baseplate
- 低开关损耗 Low Switching Losses
- 1200V 额定电压 Blocking Voltage 1200V
- 低感设计 Low Inductive Design

电路结构 Circuit Configuration

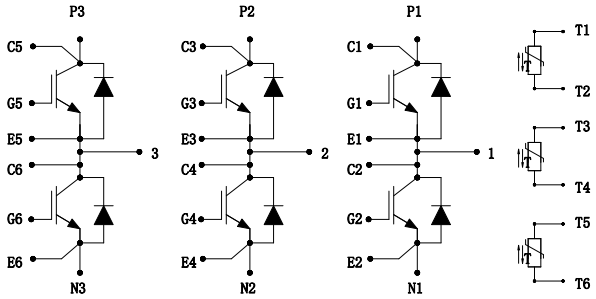


图 1.电路结构

Fig. 1 Circuit configuration

模块外形 Module Appearance

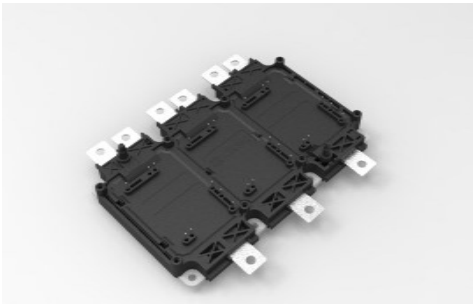


图 2. 模块外形

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_{CES}	集电极-发射极电压 Collector-emitter voltage	V_{GE} = 0V, T_C= 25 °C	1200	V
V_{GES}	栅极-发射极电压 Gate-emitter voltage	T_C= 25 °C	± 20	V
I_C	集电极电流 Collector-emitter current	T_F= 70 °C， T_{vj} max = 175°C	300	A
	额定电流 Rating Current		400	A
$I_{C(RM)}$	集电极峰值电流 Peak collector current	t_P=1ms	800	A
P_{max}	晶体管部分最大损耗 Max. transistor power dissipation	T_F= 75 °C， $T_{vj\,max}$ = 175°C	625	W
I^2t	二极管 I^2t 值 Diode I^2t	V_R =0V, t_P = 10ms, T_{vj} = 175°C	7.53	kA^2s
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	9	mm
	端子-端子 Terminal to terminal	9	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)		＞150	

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
$R_{th(J-F)\ IGBT}$	IGBT 结液热阻 Junction to cooling fluid thermal resistance – IGBT	冷却液：50%乙二醇溶液；△V/△t=10 dm^3/min； T_F = 75 °C Cooling Fluid：50% water / 50% ethylenglycol；△V/△t=10 dm^3/min； T_F= 75 °C		150	160	K / kW
$R_{th(J-F)\ Diode}$	二极管结液热阻 Junction to cooling fluid thermal resistance –Diode			218	230	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 = 25 °C Cooling Fluid：50% water / 50% ethylenglycol；△V/△t=10 dm^3/min； T_F= 25 °C		68		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	IGBT 芯片（IGBT）	-40		175	°C
		二极管芯片(Diode)	-40		175	°C
T_{stg}	存储温度 Storage temperature range		-40		125	°C
M	安装力矩 Screw torque	安装紧固用 - M4 Mounting – M4	1.8	2.0	2.2	Nm
		PCB 安装用 PCB Mounting	0.95	1.0	1.05	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_{CES}	集电极截止电流 Collector cut-off current	V_{GE} = 0V,V_{CE} = V_{CES}			1	mA
		V_{GE} = 0V, V_{CE} = V_{CES}, T_{vj} =150 °C			15	mA
		V_{GE} = 0V, V_{CE} = V_{CES}, T_{vj} =175 °C			20	mA
I_{GES}	栅极漏电流 Gate leakage current	V_{GE} = ±20V, V_{CE} = 0V			0.5	μA
$V_{GE\ (th)}$	栅极-发射极阈值电压 Gate threshold voltage	I_C = 10mA, V_{GE} = V_{CE}	5.35	5.95	6.55	V
$V_{CE\ (sat)}$ (*1)	集电极-发射极饱和电压 Collector-emitter saturation voltage	V_{GE} =15V, I_C = 300A		1.35	1.65	V
		V_{GE} =15V, I_C = 300A,T_{vj} = 150 °C		1.55		V
		V_{GE} =15V, I_C = 300A,T_{vj} = 175 °C		1.60		V
		V_{GE} =15V, I_C = 400A		1.50		V
I_F	二极管正向直流电流 Diode forward current	DC		300		A
	二极管额定正向电流 Diode rating forward current			400		A
I_{FRM}	二极管正向重复峰值电流 Diode peak forward current	t_P = 1ms		800		A
V_F (*1)	二极管正向电压 Diode forward voltage	I_F = 300A, V_{GE} = 0V		1.95	2.25	V
		I_F = 300A, V_{GE} = 0V, T_{vj} = 150 °C		1.90		V
		I_F = 300A, V_{GE} = 0V, T_{vj} = 175 °C		2.10		V
		I_F = 400A, V_{GE} = 0V		2.10		V
I_{SC}	短路电流 Short circuit current	T_{vj} = 175°C, V_{CC} =800V, V_{GE}≤15V, t_p≤3μs, $V_{CE(max)}$ = V_{CES} – $L^{(*2)}$×di/dt, IEC 60747-9		1700		A

注意： 1.(*1) 表示该参数基于芯片水平给出((*1) indicates it is given at chip level),

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

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_{ies}	输入电容 Input capacitance	V_{CE} = 25V, V_{GE} = 0V, f = 100kHz		58		nF
Q_g	栅极电荷 Gate charge	V_{CE} =600V, I_C = 300A, V_{GE} =-8/+15V		2.23		μC
C_{res}	反向传输电容 Reverse transfer capacitance	V_{CE} = 25V, V_{GE} = 0V, f = 100kHz		0.18		nF
L_{sCE}	模块电感 Module inductance			8		nH
$R_{CC'+EE'}$	模块引线电阻，端子-芯片 Module lead resistance, terminal-chip			0.9		mΩ
R_{Gint}	内部栅极电阻 Internal gate resistor	V_{GE} = 0V		4.5		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_C =400A, V_{CE} = 600V, V_{GE} = -8/+15V, $R_{G(OFF)}$ = 7.0Ω, L_S = 35nH, dv/dt =4000V/μs (T_{vj}= 175 °C).	T_{vj}= 25 °C		440		ns
			T_{vj}= 150 °C		495		
			T_{vj}= 175 °C		510		
t_f	下降时间 Fall time		T_{vj}= 25 °C		55		ns
			T_{vj}= 150 °C		110		
			T_{vj}= 175 °C		110		
E_{OFF}	关断损耗 Turn-off energy loss		T_{vj}= 25 °C		18.7		mJ
			T_{vj}= 150 °C		26.4		
			T_{vj}= 175 °C		27.3		
$t_{d(on)}$	开通延迟时间 Turn-on delay time	I_C =400A, V_{CE} = 600V, V_{GE} = -8/+15V, $R_{G(ON)}$ = 2.7Ω, L_S = 35nH, di/dt = 6600A/μs (T_{vj}= 175 °C).	T_{vj}= 25 °C		240		ns
			T_{vj}= 150 °C		240		
			T_{vj}= 175 °C		240		
t_r	上升时间 Rise time		T_{vj}= 25 °C		80		ns
			T_{vj}= 150 °C		100		
			T_{vj}= 175 °C		100		
E_{ON}	开通损耗 Turn-on energy loss		T_{vj}= 25 °C		14.7		mJ
			T_{vj}= 150 °C		20.1		
			T_{vj}= 175 °C		21.0		
Q_{rr}	二极管反向恢复电荷 Diode reverse recovery charge	I_F =400A, V_{CE} = 600V, - di_F/dt = 6600A/μs (T_{vj}= 175 °C).	T_{vj}= 25 °C		16.0		μC
			T_{vj}= 150 °C		29.8		
			T_{vj}= 175 °C		31.1		
I_{rr}	二极管反向恢复电流 Diode reverse recovery current		T_{vj}= 25 °C		125		A
			T_{vj}= 150 °C		151		
			T_{vj}= 175 °C		227		
E_{rec}	二极管反向恢复损耗 Diode reverse recovery energy		T_{vj}= 25 °C		7.6		mJ
			T_{vj}= 150 °C		17.9		
			T_{vj}= 175 °C		19.1		

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

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

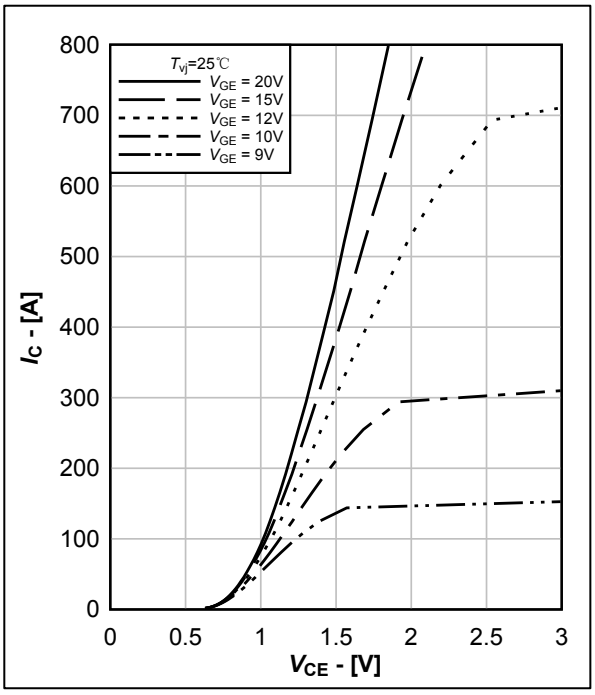


图 3. IGBT 输出特性典型曲线, I_C= f (V_{CE})

Fig.3 Typical IGBT output characteristic, I_C= f (V_{CE})

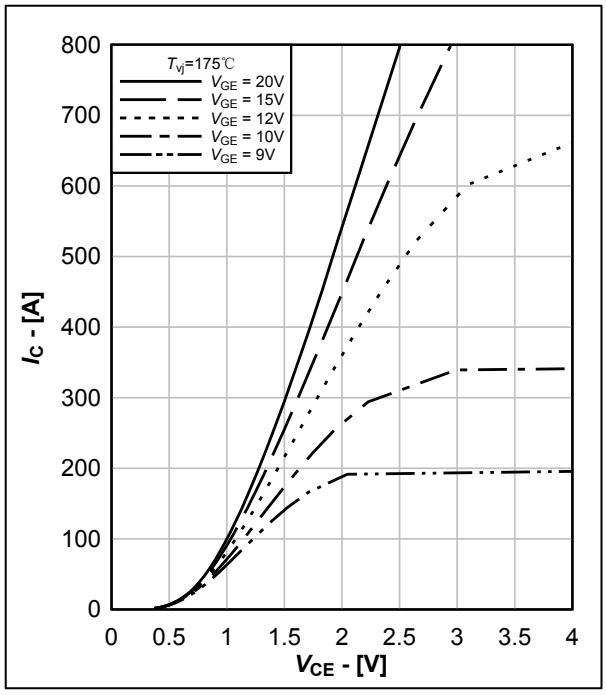


图 4. IGBT 输出特性典型曲线, I_C= f (V_{CE})

Fig.4 Typical IGBT output characteristic, I_C= f (V_{CE})

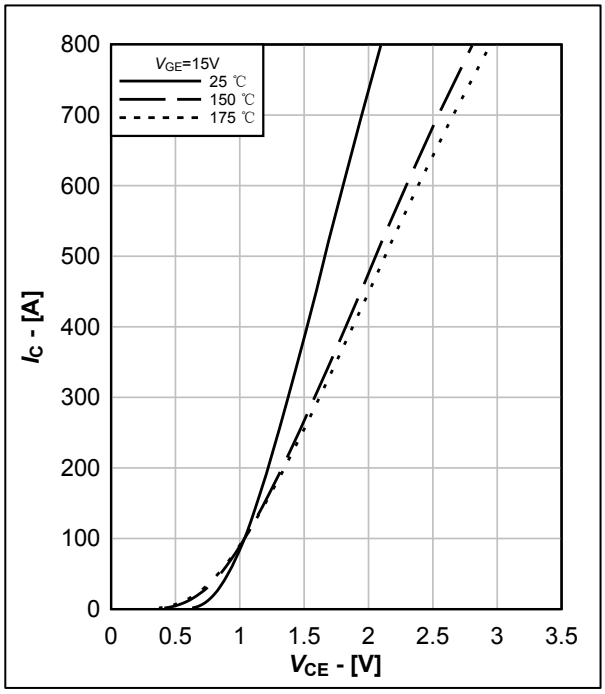


图 5. IGBT 输出特性典型曲线, I_C= f (V_{CE})

Fig.5 Typical IGBT output characteristic, I_C= f (V_{CE})

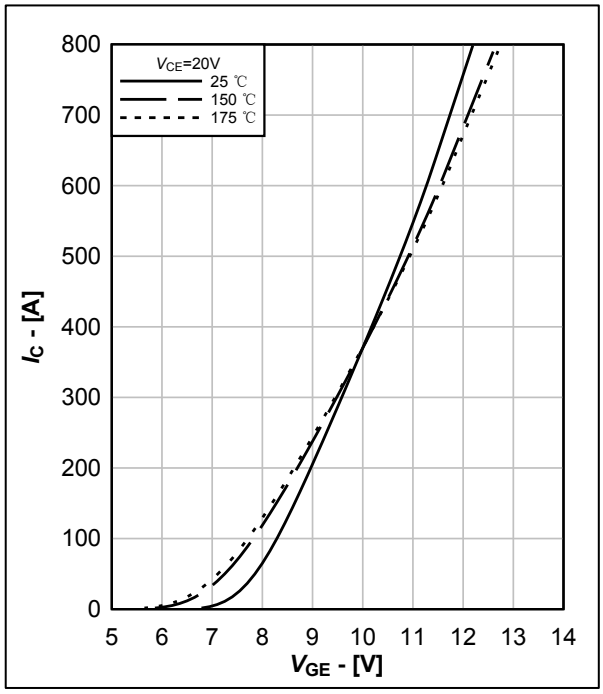


图 6. IGBT 传输特性典型曲线, I_C= f (V_{GE})

Fig.6 Typical IGBT transfer characteristic, I_C= f (V_{GE})

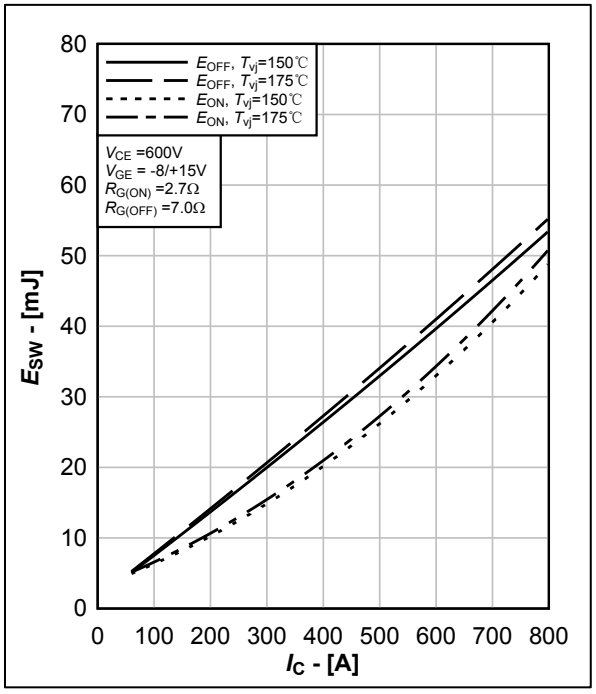


图 7. IGBT 开关损耗典型曲线, E_{on}= f (I_C), E_{off}= f (I_C)

Fig.7 Typical IGBT switching energy, E_{on}= f (I_C), E_{off}= f (I_C)

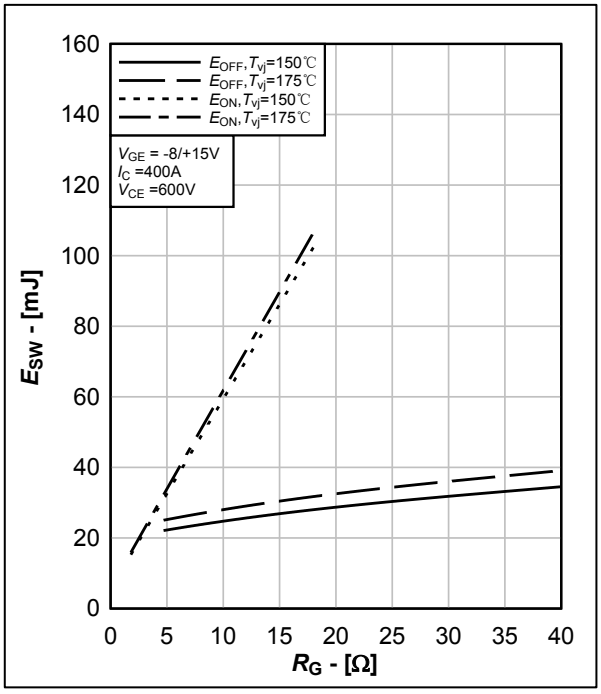


图 8. IGBT 开关损耗典型曲线, E_{on}= f (R_G), E_{off}= f (R_G)

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

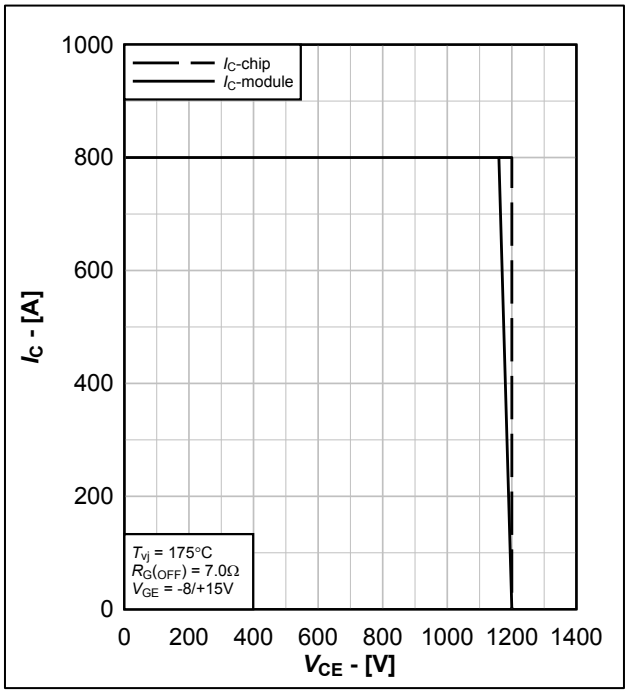


图 9. IGBT 反偏安全工作区, I_C = f (V_{CE})

Fig.9 Reverse bias safe operating area of IGBT, I_C = f (V_{CE})

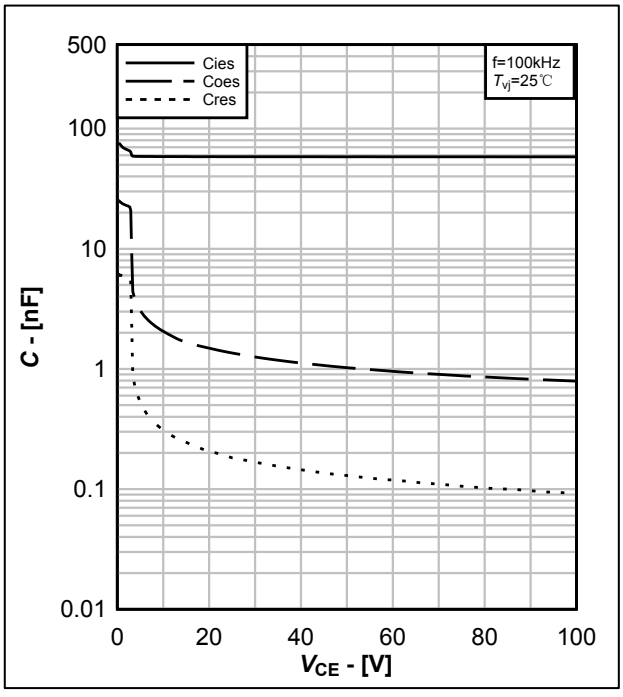


图 10. 电容特性典型曲线, C= f (V_{CE})

Fig.10 Typical capacity characteristic, C= f (V_{CE})

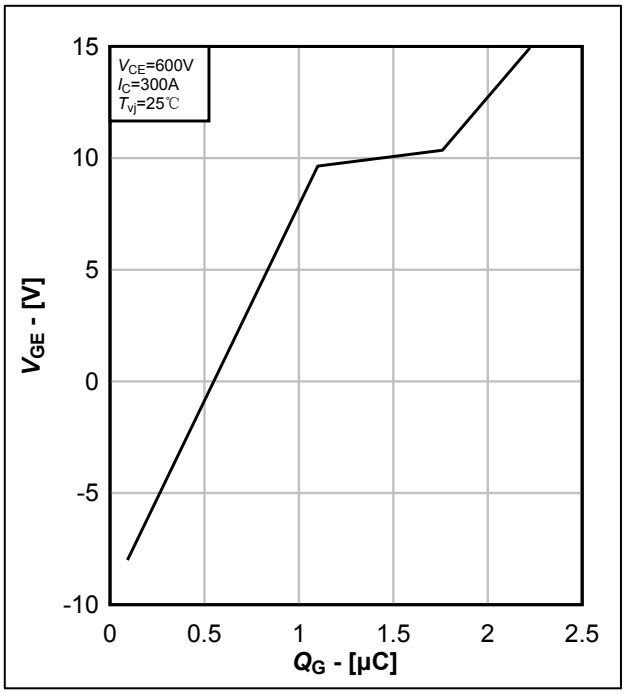


图 11. 栅极电荷特性典型曲线, V_{GE} = f (Q_G)

Fig.11 Typical gate charge characteristic, V_{GE}= f (Q_G)

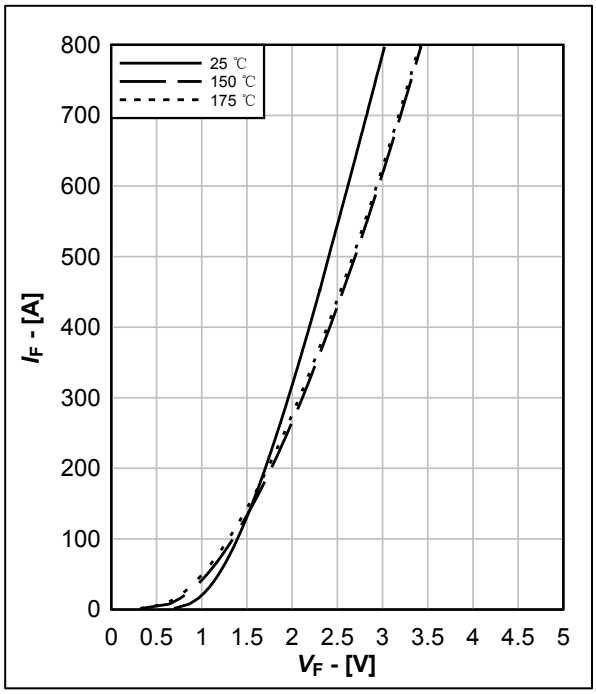


图 12. FRD 输出特性典型曲线, I_F = f (V_F)

Fig.12 Typical FRD output characteristic, I_F = f (V_F)

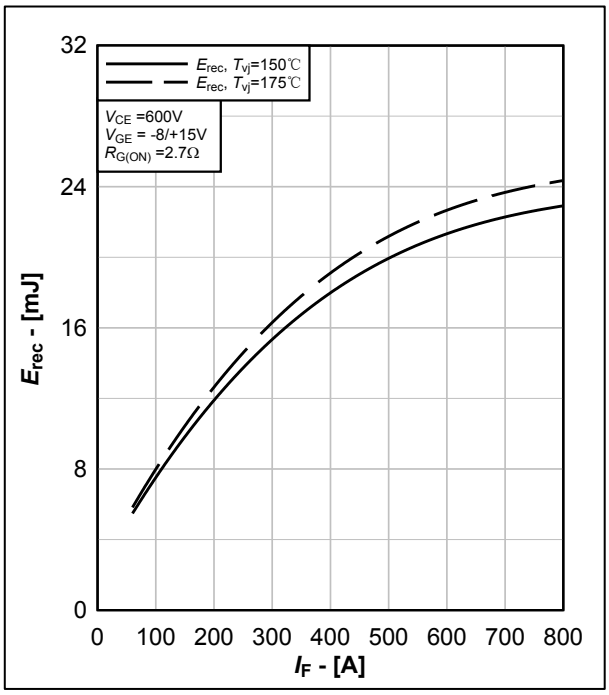


图 13. FRD 反向恢复损耗典型曲线, E_{rec}=f(I_F)

Fig.13 Typical FRD switching loss E_{rec}, E_{rec}=f(I_F)

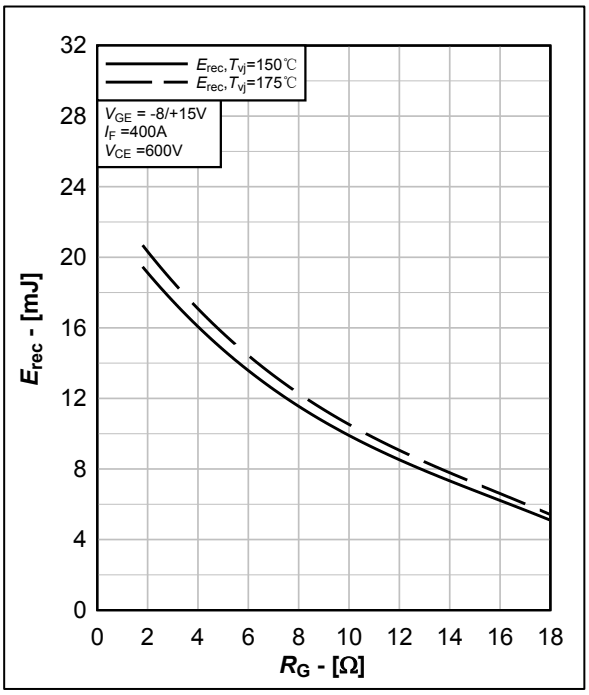


图 14. FRD 反向恢复损耗典型曲线, E_{rec}=f(R_G)

Fig.14 Typical FRD switching loss E_{rec}, E_{rec}=f(R_G)

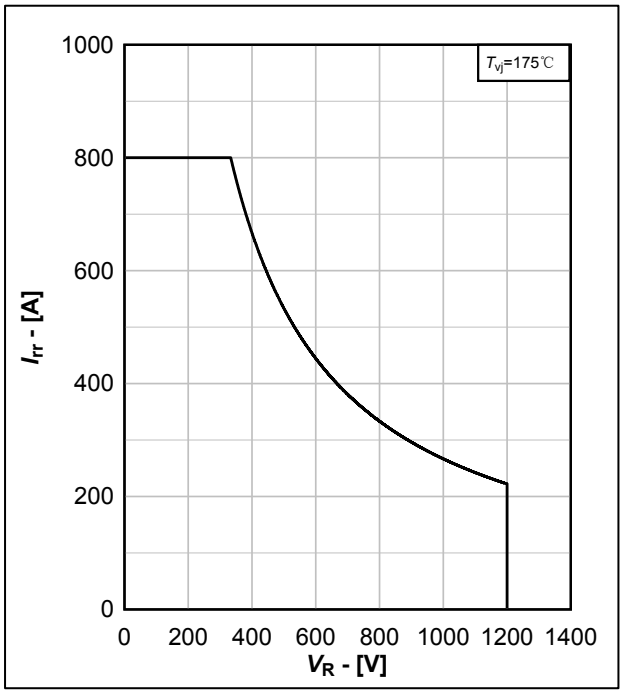


图 15. FRD 反偏安全工作区, I_{rr} = f (V_R)

Fig.15 Reverse bias safe operating area of FRD, I_{rr} = f (V_R)

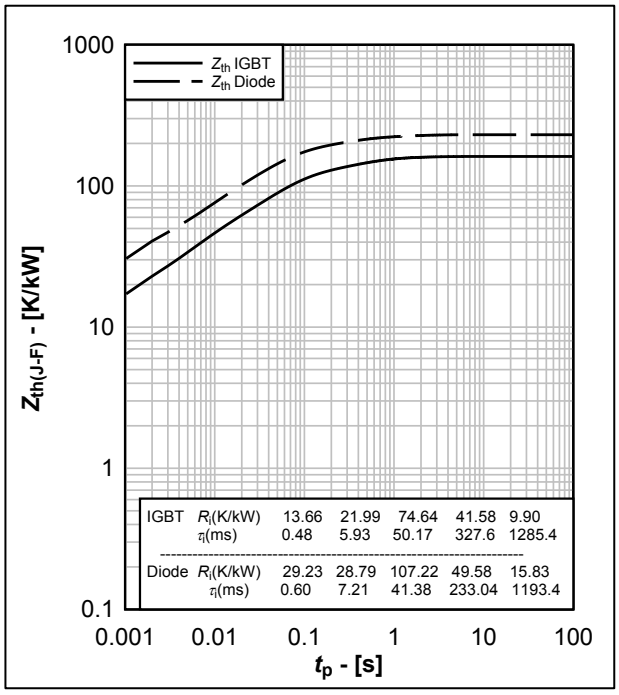


图 16. 瞬态热阻抗曲线, $Z_{th(J-F)}$ = f (t_p)

Fig.16 Transient thermal impedance, $Z_{th(J-F)}$ = f (t_p)

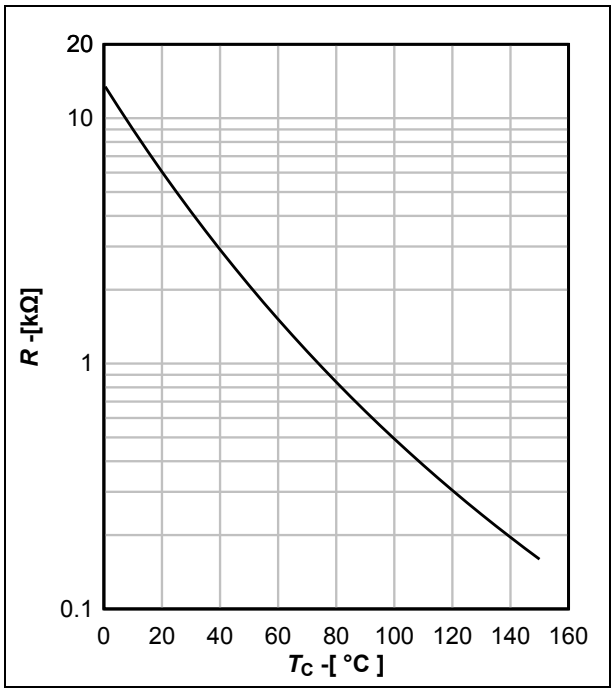
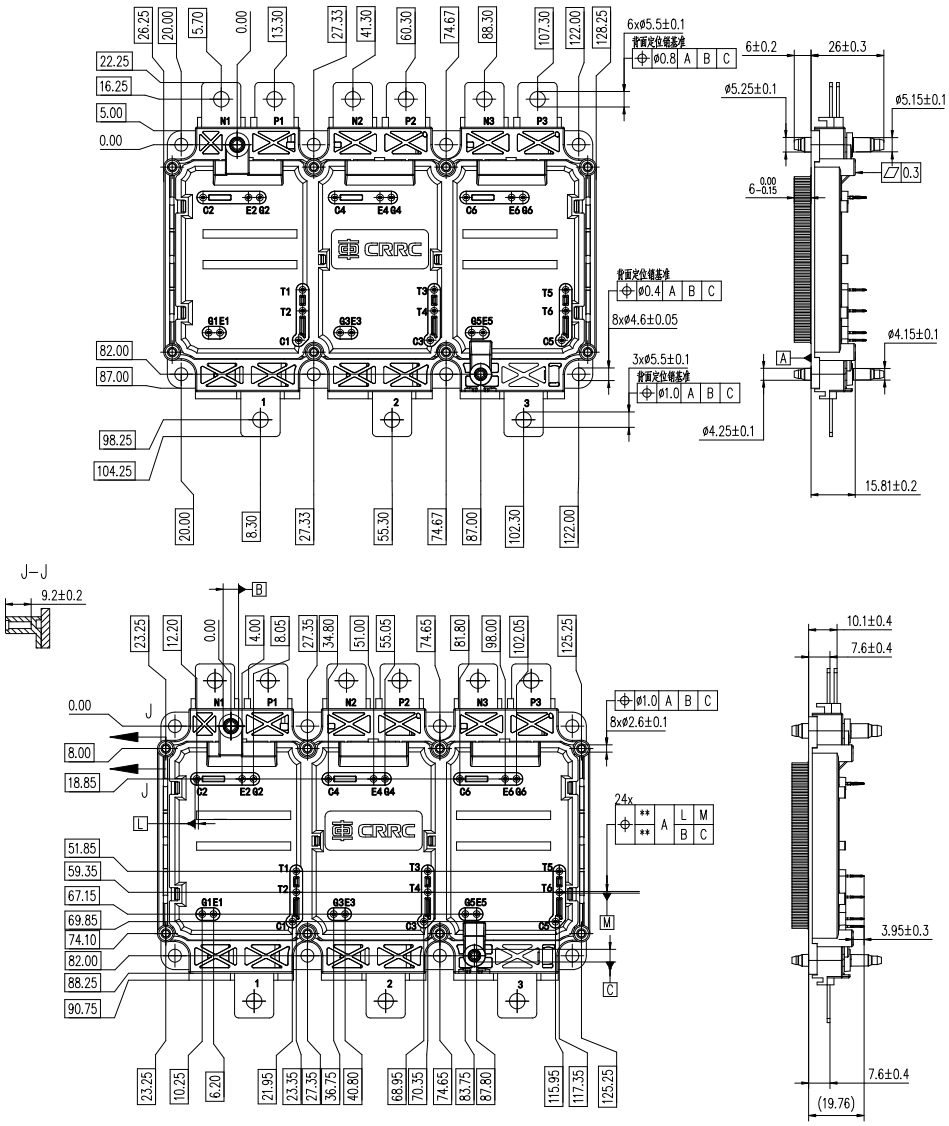


图 17. 热敏电阻典型特性曲线, R= f (T_C)

Fig.17 Typical NTC thermistor characteristic, R= f(T_C)



技术要求

1、未注尺寸X公差，参考GBT-14486-2008《塑料模塑件尺寸公差》中MT5级，参照如下：

(a)X<10 ±0.14 (b)10≤X<30 ±0.25；

(c)30≤X<50 ±0.32 (d)50≤X<100 ±0.5；

(e)100≤X<200 ±0.8；

2、**Pressfit针位置度采用ø1.0mm pin gauge全检

重量 Weight：750g 模块外观类型 Module outline code：S3

图 18. 模块外观尺寸

Fig. 18 Module outlines

株洲中车时代半导体有限公司

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（4）产品使用过程中，如有超出产品数据手册中所定义的产品极限温度、电压、电流或安全工作区范围的情况，我公司无法保证产品的应用可靠性。

（5）产品在使用时，严禁触碰。产品断电后，在确保无电荷残留、产品已冷却后，才可以在有静电防护措施的情况下触碰产品。

（6）产品数据手册首页的右上角，会显示产品的状态。如果它尚未完全批准，会标示**初版（preliminary）**，该标示意味着该产品已完成设计，量产的产品参数正在确定中，数据手册中的产品信息目前是可以参考的，但将来某些细节可能会发生变化。如果产品数据手册首页的右上角没有标注，则表示该产品已可以批量生产。

Terms and conditions of usage

(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,

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(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.