TH400AN10U3-S500

三电平 IGBT 模块 3-level IGBT Module

中国中车 CRRC

产品数据手册 Product Datasheet 版本 Ver 23.12

关键参数 Key Parameters

V_{CES}		950	V
$V_{CE(sat)}$	Typ.	1.28	V
I_C	Max.	400	A
$I_{C(RM)}$	Max.	800	A

典型应用 Typical Applications

- 三电平应用 3-level-applications Converters
- 光伏应用 Solar applications
- UPS 系统 UPS Systems

特点 Features

- SiC 二极管 Ultra-fast SiC Diode
- 低开关损耗 Low Switching Losses
- 低感设计 Low Inductive Design
- 集成 NTC Integrated NTC

电路结构 Circuit Configuration

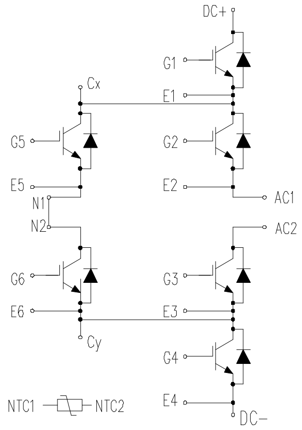


图 1. 电路结构

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

IGBT T1/T4，二极管 D1/D4　IGBT T1/T4, Diode D1/D4

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	950	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_C = 90 °C, $T_{vj\ max}$=175°C	220	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_C = 25 °C, $T_{vj\ max}$=175°C	1.07	kW
I^2t	二极管 I^2t 值 Diode I^2t	V_R =0V, t_P = 10ms, T_{vj} = 150 °C	2.05	kA^2s

热数据 Thermal 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
$R_{th(J-C)\ IGBT}$	IGBT 结壳热阻 Thermal resistance – IGBT				140	K / kW
$R_{th(J-C)\ Diode}$	二极管结壳热阻 Thermal resistance – Diode				290	K / kW
$R_{th(C-H)\ IGBT}$	接触热阻(IGBT) Thermal resistance – case to heatsink (IGBT)	安装力矩 1.3Nm，导热脂 3.3W/m·K Mounting torque 1.3Nm, with mounting grease 3.3W/m·K		100		K / kW
$R_{th(C-H)\ Diode}$	接触热阻(Diode) Thermal resistance – case to heatsink (Diode)	安装力矩 1.3Nm，导热脂 3.3W/m·K Mounting torque 1.3Nm, with mounting grease 3.3W/m·K		280		K / kW

IGBT T1/T4，二极管 D1/D4 IGBT T1/T4, Diode D1/D4

IGBT T1/T4，二极管 D1/D4 IGBT T1/T4, Diode D1/D4

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 =150A, V_{CE} = 500V, V_{GE} = -7.5/+15V, $R_{G(OFF)}$ = 20Ω, L_S = 25nH, dv/dt =5500V/μs (T_{vj}= 150 °C).	T_{vj}= 25 °C		665		ns
			T_{vj}= 125 °C		725		
			T_{vj}= 150 °C		745		
t_f	下降时间 Fall time		T_{vj}= 25 °C		75		ns
			T_{vj}= 125 °C		95		
			T_{vj}= 150 °C		105		
E_{OFF}	关断损耗 Turn-off energy loss		T_{vj}= 25 °C		6.4		mJ
			T_{vj}= 125 °C		7.7		
			T_{vj}= 150 °C		8.3		
$t_{d(on)}$	开通延迟时间 Turn-on delay time	I_C =150A, V_{CE} = 500V, V_{GE} = -7.5/+15V, $R_{G(ON)}$ = 5Ω, L_S = 25nH, di/dt = 3700A/μs (T_{vj}= 150 °C).	T_{vj}= 25 °C		165		ns
			T_{vj}= 125 °C		160		
			T_{vj}= 150 °C		160		
t_r	上升时间 Rise time		T_{vj}= 25 °C		34		ns
			T_{vj}= 125 °C		38		
			T_{vj}= 150 °C		39		
E_{ON}	开通损耗 Turn-on energy loss		T_{vj}= 25 °C		3.4		mJ
			T_{vj}= 125 °C		3.6		
			T_{vj}= 150 °C		3.8		
Q_{rr}	二极管反向恢复电荷 Diode reverse recovery charge	I_F =150A, V_{CE} = 500V, $R_{G(ON)}$ = 5Ω, - di_F/dt = 3200A/μs (T_{vj}= 150 °C).	T_{vj}= 25 °C		6		μC
			T_{vj}= 125 °C		11		
			T_{vj}= 150 °C		12		
I_{rr}	二极管反向恢复电流 Diode reverse recovery current		T_{vj}= 25 °C		65		A
			T_{vj}= 125 °C		84		
			T_{vj}= 150 °C		85		
E_{rec}	二极管反向恢复损耗 Diode reverse recovery energy		T_{vj}= 25 °C		1.6		mJ
			T_{vj}= 125 °C		3.7		
			T_{vj}= 150 °C		3.9		

IGBT T2/T3，二极管 D2/D3 IGBT T2/T3, Diode D2/D3

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	950	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_C = 90 °C, $T_{vj\,max}$=175°C	295	A
	额定电流 Rating Current		400	A
$I_{C(PK)}$	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_C = 25 °C, $T_{vj\,max}$=175°C	1.07	kW
I^2t	二极管 I^2t 值 Diode I^2t	V_R =0V, t_P = 10ms, T_{vj} = 150 °C	2.05	kA^2s

热数据 Thermal 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
$R_{th(J-C)\,IGBT}$	IGBT 结壳热阻 Thermal resistance – IGBT				140	K / kW
$R_{th(J-C)\,Diode}$	二极管结壳热阻 Thermal resistance – Diode				290	K / kW
$R_{th(C-H)\,IGBT}$	接触热阻(IGBT) Thermal resistance – case to heatsink (IGBT)	安装力矩 1.3Nm，导热脂 3.3W/m·K Mounting torque 1.3Nm, with mounting grease 3.3W/m·K		100		K / kW
$R_{th(C-H)\,Diode}$	接触热阻(Diode) Thermal resistance – case to heatsink (Diode)	安装力矩 1.3Nm，导热脂 3.3W/m·K Mounting torque 1.3Nm, with mounting grease 3.3W/m·K		280		K / kW

IGBT T2/T3，二极管 D2/D3 IGBT T2/T3, Diode D2/D3

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} =125 °C			5	mA
		V_{GE} = 0V, V_{CE} = V_{CES}, T_{vj} =150 °C			10	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}	4.70	5.30	5.90	V
$V_{CE\ (sat)}$(*1)	集电极-发射极饱和电压 Collector-emitter saturation voltage	V_{GE} =15V, I_C = 150A		1.05	1.35	V
		V_{GE} =15V, I_C = 150A, T_{vj} = 125 °C		1.05		V
		V_{GE} =15V, I_C = 150A, T_{vj} = 150 °C		1.05		V
I_F	二极管正向直流电流 Diode forward current	DC		150		A
	二极管额定正向电流 Diode ratingforward current			200		A
I_{FRM}	二极管正向重复峰值电流 Diode peak forward current	t_P = 1ms		400		A
V_F(*1)	二极管正向电压 Diode forward voltage	I_F = 150A, V_{GE} = 0V		2.05	2.45	V
		I_F = 150A, V_{GE} = 0V, T_{vj} = 125 °C		2.25		V
		I_F = 150A, V_{GE} = 0V, T_{vj} = 150 °C		2.20		V
C_{ies}	输入电容 Input capacitance	V_{CE} = 25V, V_{GE} = 0V, f = 100kHz		41		nF
Q_g	栅极电荷 Gate charge	-7.5/+15V		2.2		μC
C_{res}	反向传输电容 Reverse transfer capacitance	V_{CE} = 25V, V_{GE} = 0V, f = 100kHz		0.14		nF
R_{Gint}	内部栅极电阻 Internal gate resistor			3		Ω

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}).

IGBT T2/T3，二极管 D2/D3 IGBT T2/T3, Diode D2/D3

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 =150A, V_{CE} = 500V, V_{GE} = -7.5/+15V, $R_{G(OFF)}$ = 5Ω, L_S = 55nH, d*v*/dt =2200V/μs (T_{vj}= 150 °C).	T_{vj}= 25 °C		765		ns
			T_{vj}= 125 °C		850		
			T_{vj}= 150 °C		870		
t_f	下降时间 Fall time		T_{vj}= 25 °C		160		ns
			T_{vj}= 125 °C		235		
			T_{vj}= 150 °C		265		
E_{OFF}	关断损耗 Turn-off energy loss		T_{vj}= 25 °C		15		mJ
			T_{vj}= 125 °C		20		
			T_{vj}= 150 °C		21		
$t_{d(on)}$	开通延迟时间 Turn-on delay time	I_C =150A, V_{CE} = 500V, V_{GE} = -7.5/+15V, $R_{G(ON)}$ = 5Ω, L_S = 55nH, d*i*/dt = 5200A/μs (T_{vj}= 150 °C).	T_{vj}= 25 °C		290		ns
			T_{vj}= 125 °C		285		
			T_{vj}= 150 °C		280		
t_r	上升时间 Rise time		T_{vj}= 25 °C		34		ns
			T_{vj}= 125 °C		35		
			T_{vj}= 150 °C		38		
E_{ON}	开通损耗 Turn-on energy loss		T_{vj}= 25 °C		1.5		mJ
			T_{vj}= 125 °C		2.8		
			T_{vj}= 150 °C		3.3		
Q_{rr}	二极管反向恢复电荷 Diode reverse recovery charge	I_F =150A, V_{CE} = 500V, $R_{G(ON)}$ = 5Ω, - di_F/dt = 5200A/μs (T_{vj}= 150 °C).	T_{vj}= 25 °C		6		μC
			T_{vj}= 125 °C		12		
			T_{vj}= 150 °C		13		
I_{rr}	二极管反向恢复电流 Diode reverse recovery current		T_{vj}= 25 °C		140		A
			T_{vj}= 125 °C		145		
			T_{vj}= 150 °C		150		
E_{rec}	二极管反向恢复损耗 Diode reverse recovery energy		T_{vj}= 25 °C		2.5		mJ
			T_{vj}= 125 °C		4.6		
			T_{vj}= 150 °C		4.9		

IGBT T5/T6，二极管 D5/D6 IGBT T5/T6, Diode D5/D6

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	950	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_C = 90 °C, $T_{vj\ max}$=175°C	115	A
	额定电流 Rating Current		200	A
$I_{C(PK)}$	集电极峰值电流 Peak collector current	t_P=1ms	400	A
P_{max}	晶体管部分最大损耗 Max. transistor power dissipation	T_C = 25 °C, $T_{vj\ max}$=175°C	0.54	kW
I^2t	二极管 I^2t 值 Diode I^2t	V_R =0V, t_P = 10ms, T_{vj} = 150 °C	2.3	kA^2s

热数据 Thermal 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
$R_{th(J-C)\ IGBT}$	IGBT 结壳热阻 Thermal resistance – IGBT				280	K / kW
$R_{th(J-C)\ Diode}$	二极管结壳热阻 Thermal resistance – Diode				260	K / kW
$R_{th(C-H)\ IGBT}$	接触热阻(IGBT) Thermal resistance – case to heatsink (IGBT)	安装力矩 1.3Nm，导热脂 3.3W/m·K Mounting torque 1.3Nm, with mounting grease 3.3W/m·K		171		K / kW
$R_{th(C-H)\ Diode}$	接触热阻(Diode) Thermal resistance – case to heatsink (Diode)	安装力矩 1.3Nm，导热脂 3.3W/m·K Mounting torque 1.3Nm, with mounting grease 3.3W/m·K		214		K / kW

IGBT T5/T6，二极管 D5/D6 IGBT T5/T6, Diode D5/D6

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} =125 °C			3	mA
		V_{GE} = 0V, V_{CE} = V_{CES}, T_{vj} =150 °C			5	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 = 5mA, V_{GE} = V_{CE}	5.00	5.60	6.20	V
$V_{CE\ (sat)}$(*1)	集电极-发射极饱和电压 Collector-emitter saturation voltage	V_{GE} =15V, I_C = 150A		1.60	2.00	V
		V_{GE} =15V, I_C = 150A, T_{vj} = 125 °C		1.95		V
		V_{GE} =15V, I_C = 150A, T_{vj} = 150 °C		2.05		V
I_F	二极管正向直流电流 Diode forward current	DC		100		A
I_{FRM}	二极管正向重复峰值电流 Diode peak forward current	t_P = 1ms		200		A
V_F(*1)	二极管正向电压 Diode forward voltage	I_F = 100A, V_{GE} = 0V		1.55	1.85	V
		I_F = 100A, V_{GE} = 0V, T_{vj} = 125 °C		2.05		V
		I_F = 100A, V_{GE} = 0V, T_{vj} = 150 °C		2.15		V
C_{ies}	输入电容 Input capacitance	V_{CE} = 25V, V_{GE} = 0V, f = 100kHz		12		nF
Q_g	栅极电荷 Gate charge	-7.5/+15V		0.6		μC
C_{res}	反向传输电容 Reverse transfer capacitance	V_{CE} = 25V, V_{GE} = 0V, f = 100kHz		0.04		nF
R_{Gint}	内部栅极电阻 Internal gate resistor			2.2		Ω

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}).

IGBT T5/T6，二极管 D5/D6 IGBT T5/T6, Diode D5/D6

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 =150A, V_{CE} = 500V, V_{GE} = -7.5/+15V, $R_{G(OFF)}$ = 33Ω, L_S = 25nH, dv/dt =7200V/μs (T_{vj}= 150 °C).	T_{vj}= 25 °C		554		ns
			T_{vj}= 125 °C		580		
			T_{vj}= 150 °C		590		
t_f	下降时间 Fall time		T_{vj}= 25 °C		70		ns
			T_{vj}= 125 °C		85		
			T_{vj}= 150 °C		100		
E_{OFF}	关断损耗 Turn-off energy loss		T_{vj}= 25 °C		6.5		mJ
			T_{vj}= 125 °C		7.7		
			T_{vj}= 150 °C		8.6		
$t_{d(on)}$	开通延迟时间 Turn-on delay time	I_C =150A, V_{CE} = 500V, V_{GE} = -7.5/+15V, $R_{G(ON)}$ = 5Ω, L_S = 25nH, di/dt = 3200A/μs (T_{vj}= 150 °C).	T_{vj}= 25 °C		100		ns
			T_{vj}= 125 °C		95		
			T_{vj}= 150 °C		95		
t_r	上升时间 Rise time		T_{vj}= 25 °C		30		ns
			T_{vj}= 125 °C		35		
			T_{vj}= 150 °C		40		
E_{ON}	开通损耗 Turn-on energy loss		T_{vj}= 25 °C		6.0		mJ
			T_{vj}= 125 °C		7.6		
			T_{vj}= 150 °C		8.3		
Q_{rr}	二极管反向恢复电荷 Diode reverse recovery charge	I_F =100A, V_{CE} = 500V, $R_{G(ON)}$ = 5Ω, - di_F/dt = 3700A/μs (T_{vj}= 150 °C).	T_{vj}= 25 °C		0.5		μC
			T_{vj}= 125 °C		1.0		
			T_{vj}= 150 °C		1.2		
I_{rr}	二极管反向恢复电流 Diode reverse recovery current		T_{vj}= 25 °C		30		A
			T_{vj}= 125 °C		31		
			T_{vj}= 150 °C		32		
E_{rec}	二极管反向恢复损耗 Diode reverse recovery energy		T_{vj}= 25 °C		0.10		mJ
			T_{vj}= 125 °C		0.11		
			T_{vj}= 150 °C		0.12		

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	R100 偏差 Deviation of R100	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

模块 Module

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	11.5	mm
	端子-端子 Terminal to terminal	6.8	mm
绝缘间隙 Clearance	端子-散热器 Terminal to heatsink	9.4	mm
	端子-端子 Terminal to terminal	5.5	mm
相对漏电起痕指数 CTI (Comparative Tracking Index)		>400	
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 base plate), AC RMS,1 min, 50Hz,T_C= 25 °C	3200	V

模块 Module

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
L_{sCE}	模块电感 Module inductance			15		nH
$T_{vj\ op}$	工作结温 Operating junction temperature	IGBT 芯片(IGBT)	-40		150	°C
		二极管芯片(Diode)	-40		150	°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 Mounting	1.3		1.5	Nm

IGBT T1/T4，二极管 D1/D4 IGBT T1/T4, Diode D1/D4

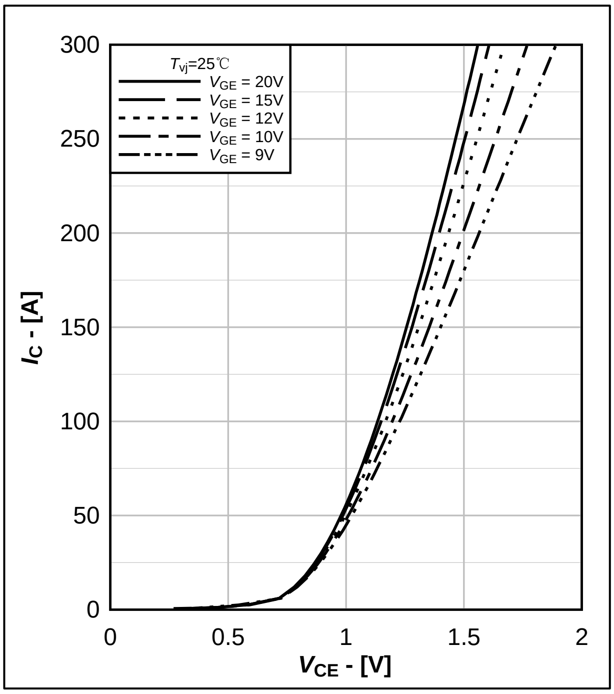


图 3. IGBT 输出特性典型曲线, I_C= f (V_{CE})

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

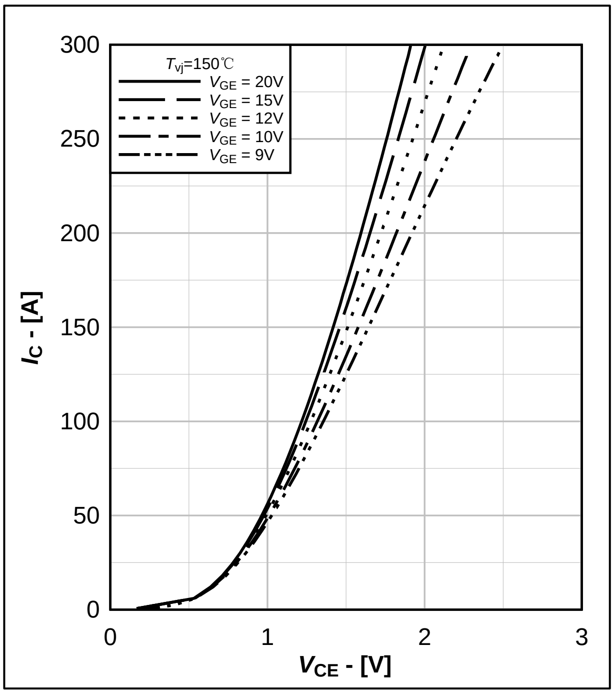


图 4. IGBT 输出特性典型曲线, I_C= f (V_{CE})

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

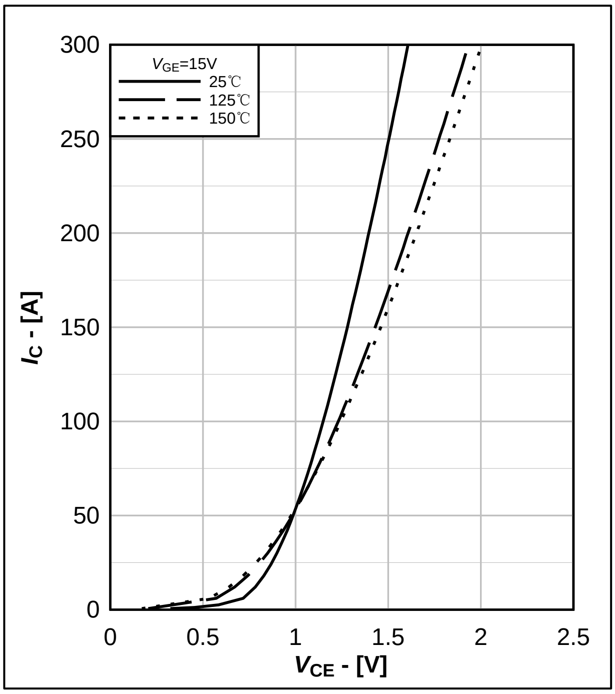


图 5. IGBT 输出特性典型曲线, I_C= f (V_{CE})

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

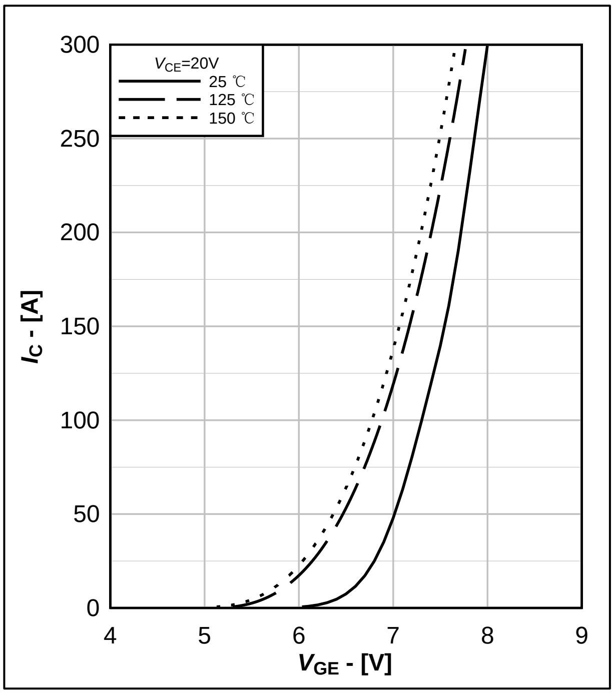


图 6. IGBT 传输特性典型曲线, I_C= f (V_{GE})

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

IGBT T1/T4，二极管 D1/D4 IGBT T1/T4, Diode D1/D4

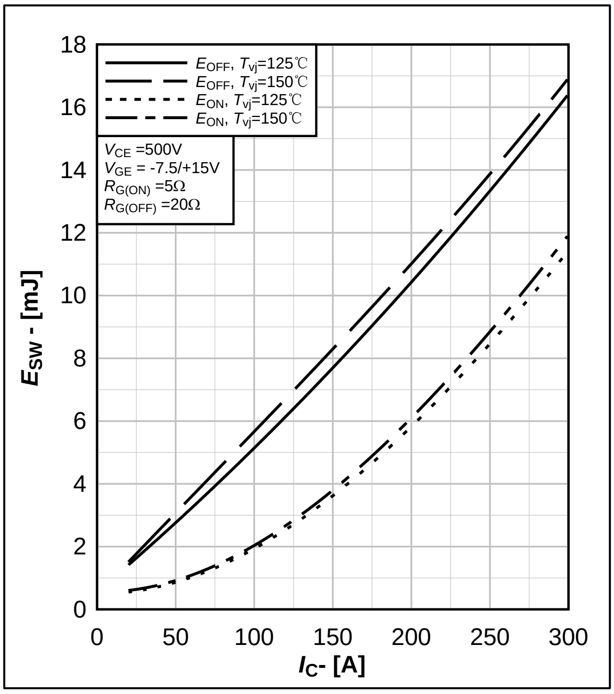


图 7. IGBT 开关损耗典型曲线, E_{on}= f (I_C), E_{off}= f (I_C)

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

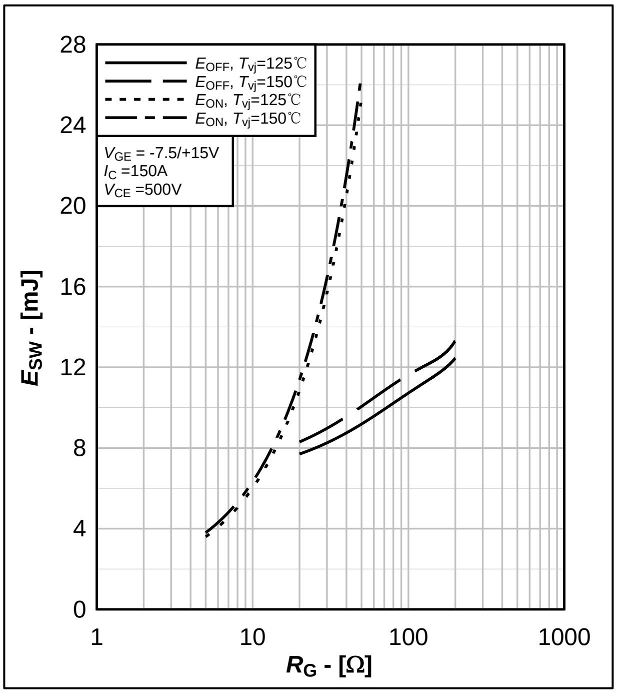


图 8. IGBT 开关损耗典型曲线, E_{on}= f (R_G), E_{off}= f (R_G)

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

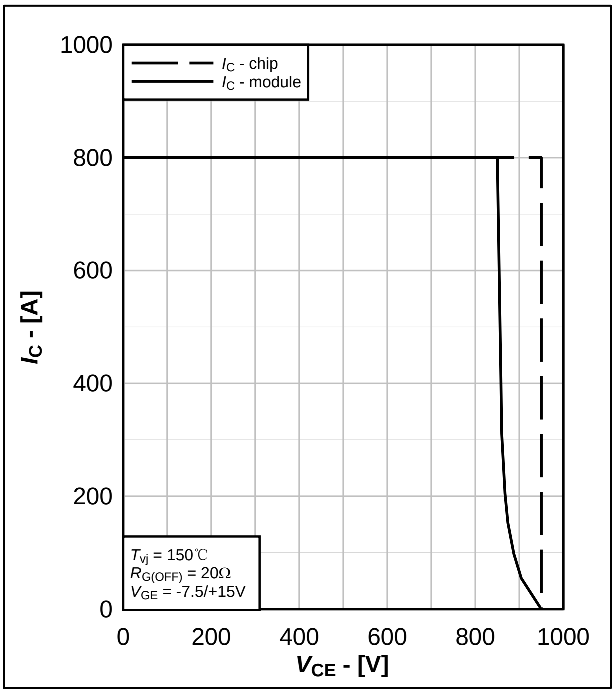


图 9. IGBT 反偏安全工作区, I_C = f (V_{CE})

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

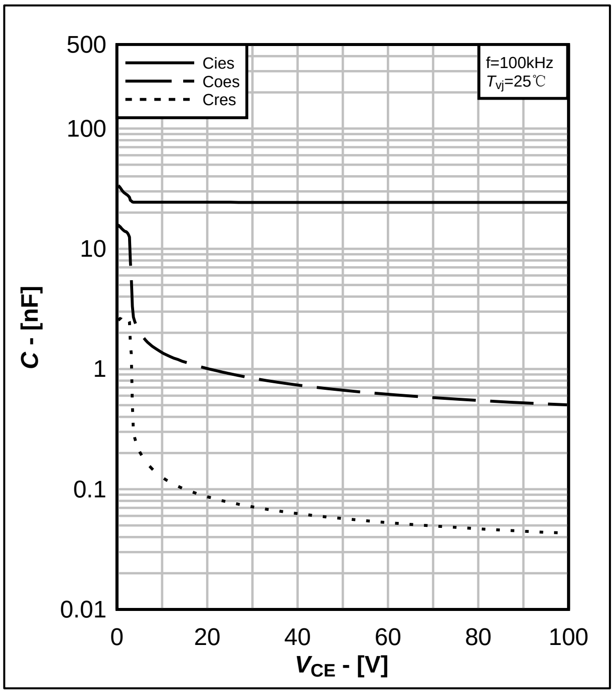


图 10. 电容特性典型曲线, C= f (V_{CE})

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

IGBT T1/T4，二极管 D1/D4 IGBT T1/T4, Diode D1/D4

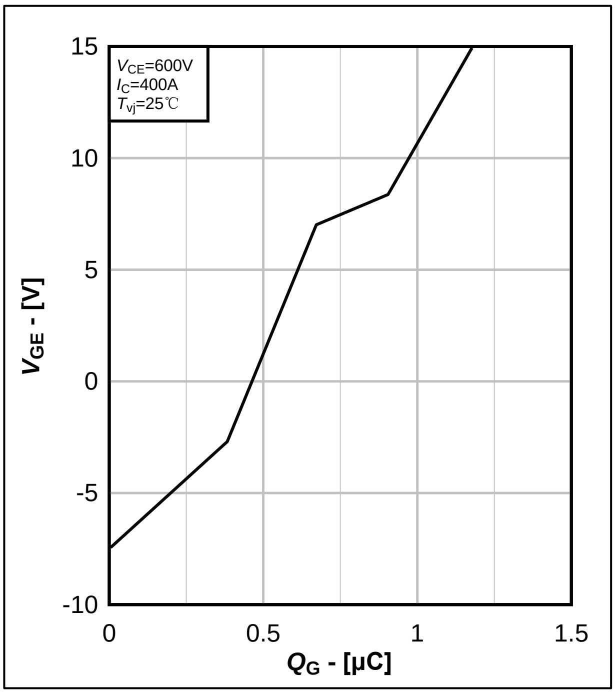


图 11. 栅极电荷特性典型曲线, V_{GE} = f (Q_G)

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

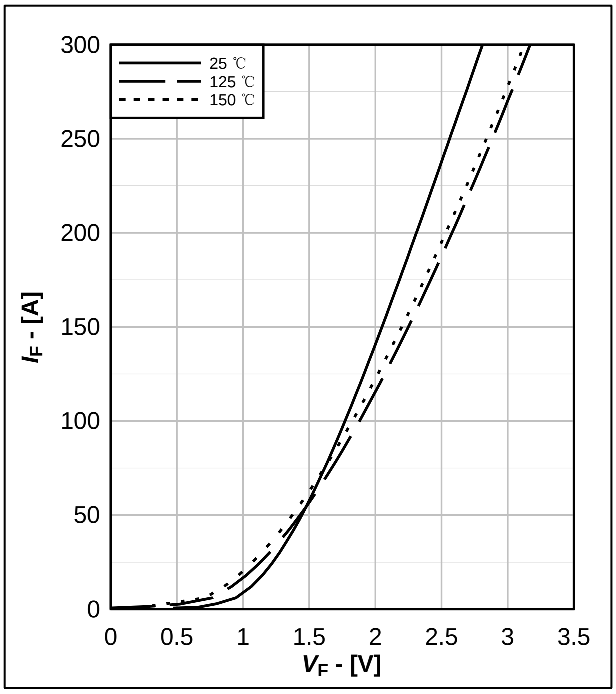


图 12. FRD 输出特性典型曲线, I_F = f (V_F)

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

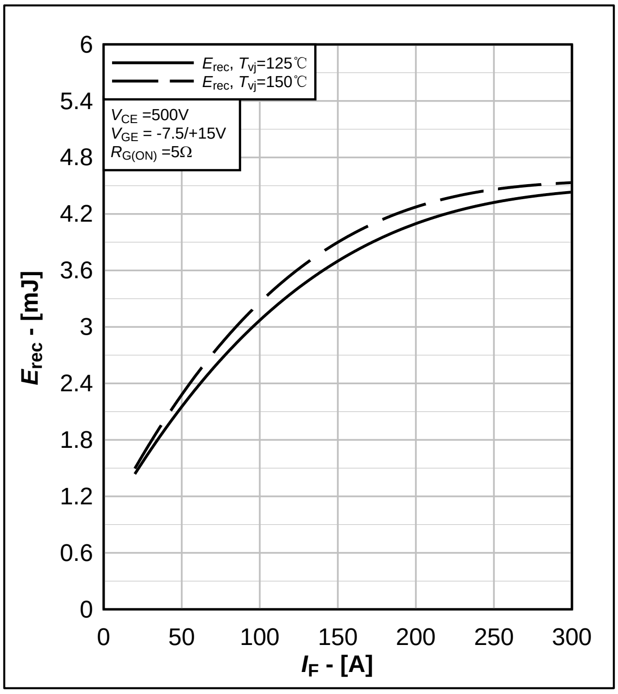


图 13. FRD 反向恢复损耗典型曲线, E_{rec}=f(I_F)

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

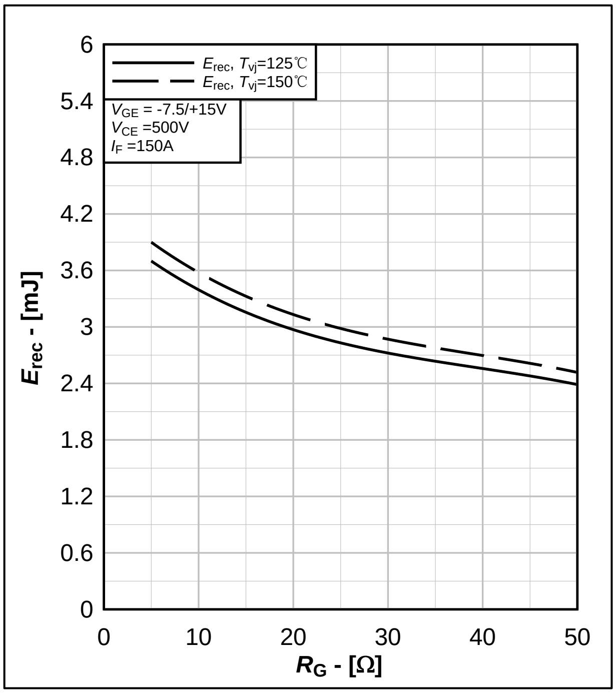


图 14. FRD 反向恢复损耗典型曲线, E_{rec}=f(R_G)

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

IGBT T1/T4，二极管 D1/D4 IGBT T1/T4, Diode D1/D4

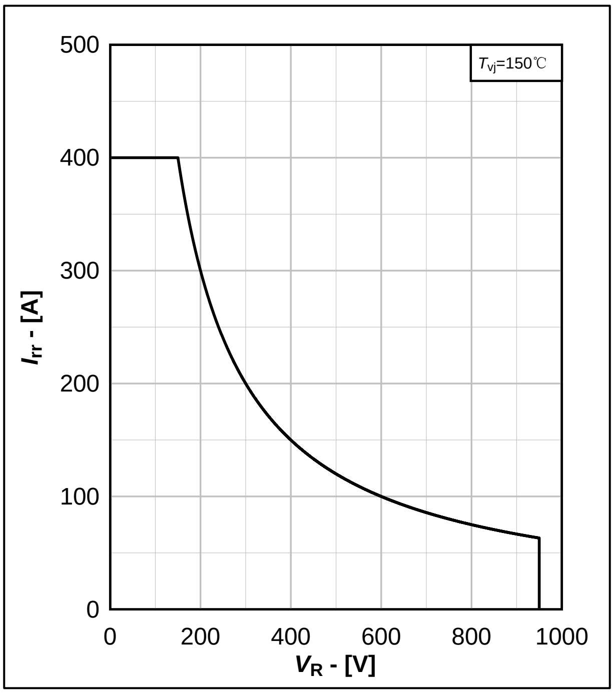


图 15. FRD 反偏安全工作区, I_{rr} = f (V_R)

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

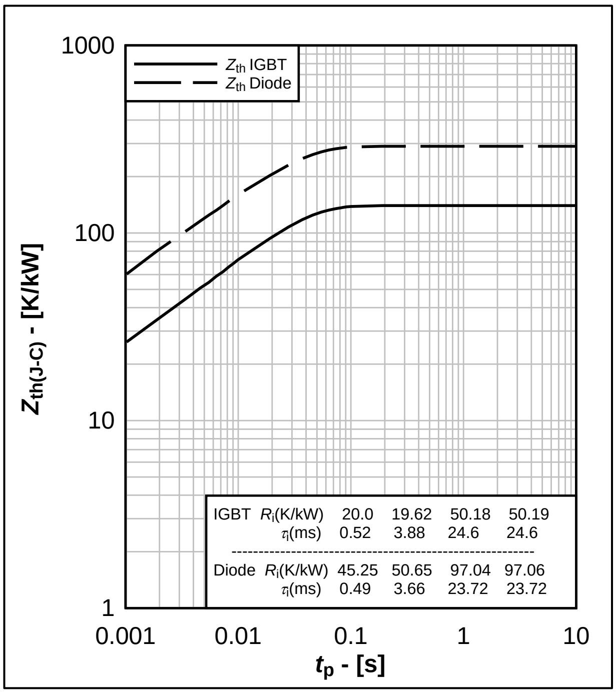


图 16. 瞬态热阻抗曲线, $Z_{th(J-C)}$ = f (t_p)

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

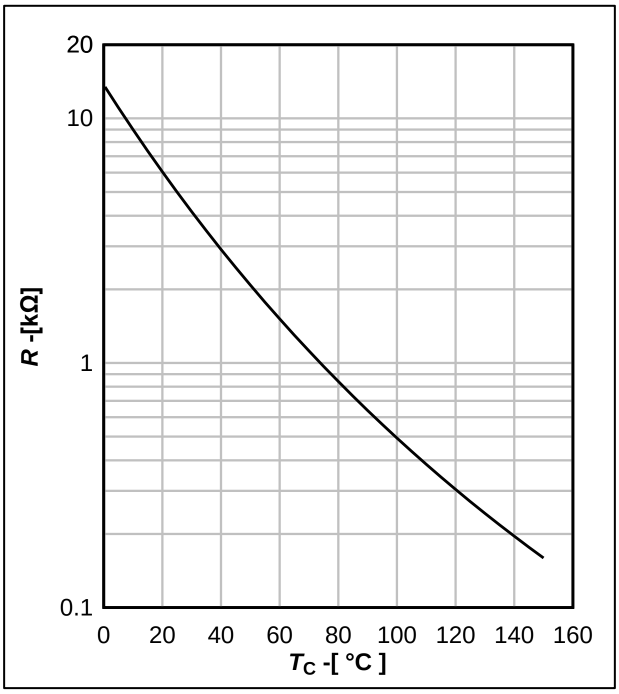


图 17. 热敏电阻典型特性曲线, R= f (T_C)

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

IGBT T2/T3，二极管 D2/D3 IGBT T2/T3, Diode D2/D3

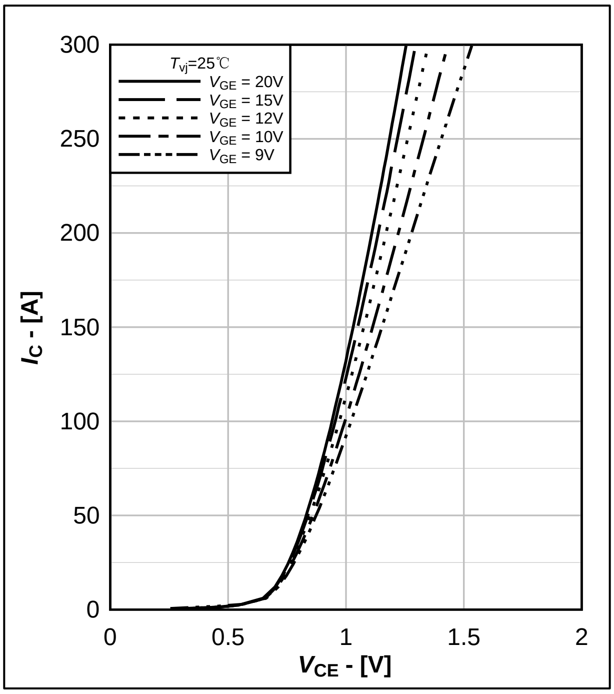


图 18. IGBT 输出特性典型曲线, I_C= f (V_{CE})

Fig.18 Typical IGBT output characteristic, I_C= f (V_{CE})

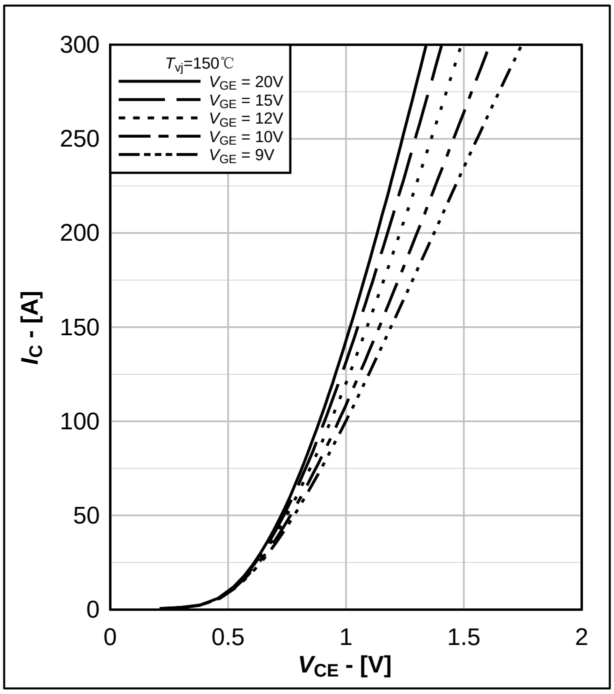


图 19. IGBT 输出特性典型曲线, I_C= f (V_{CE})

Fig.19 Typical IGBT output characteristic, I_C= f (V_{CE})

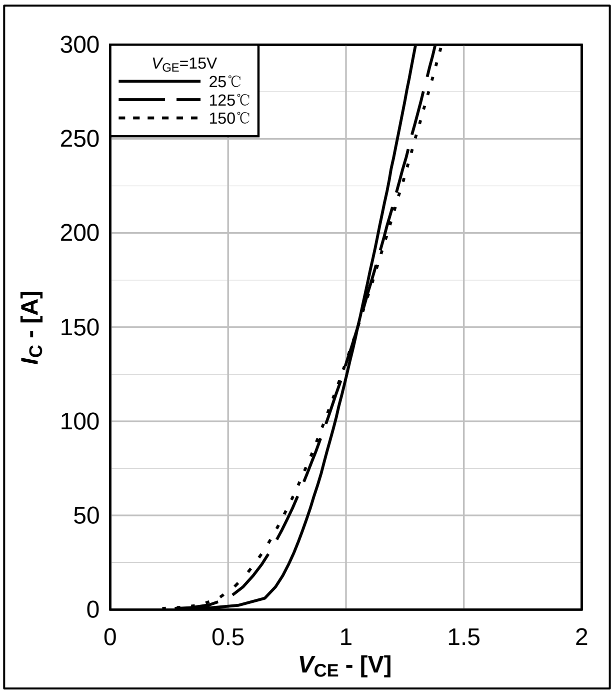


图 20. IGBT 输出特性典型曲线, I_C= f (V_{CE})

Fig.20 Typical IGBT output characteristic, I_C= f (V_{CE})

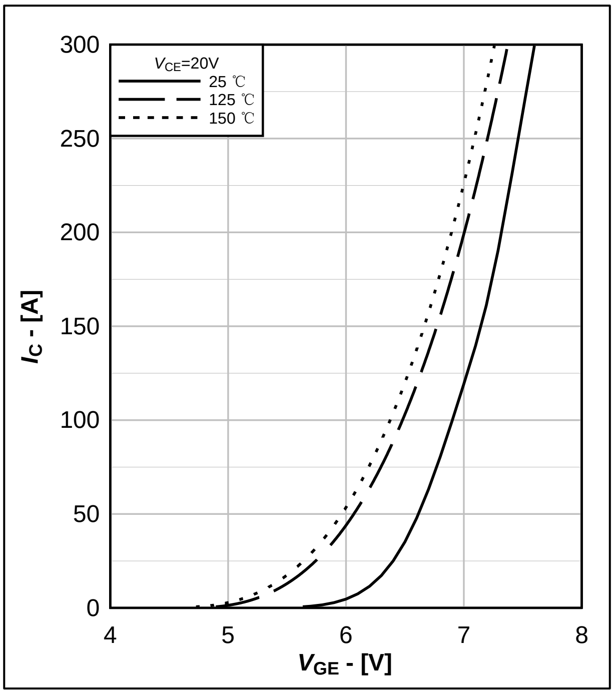


图 21. IGBT 传输特性典型曲线, I_C= f (V_{GE})

Fig.21 Typical IGBT transfer characteristic, I_C= f (V_{GE})

IGBT T2/T3，二极管 D2/D3　　IGBT T2/T3, Diode D2/D3

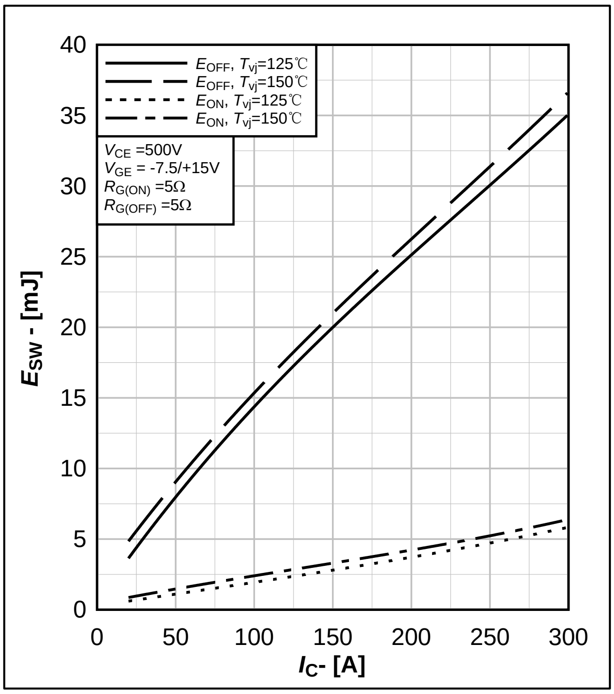


图 22. IGBT 开关损耗典型曲线, E_{on}= f (I_C), E_{off}= f (I_C)

Fig.22 Typical IGBT switching energy, E_{on}= f (I_C), E_{off}= f (I_C)

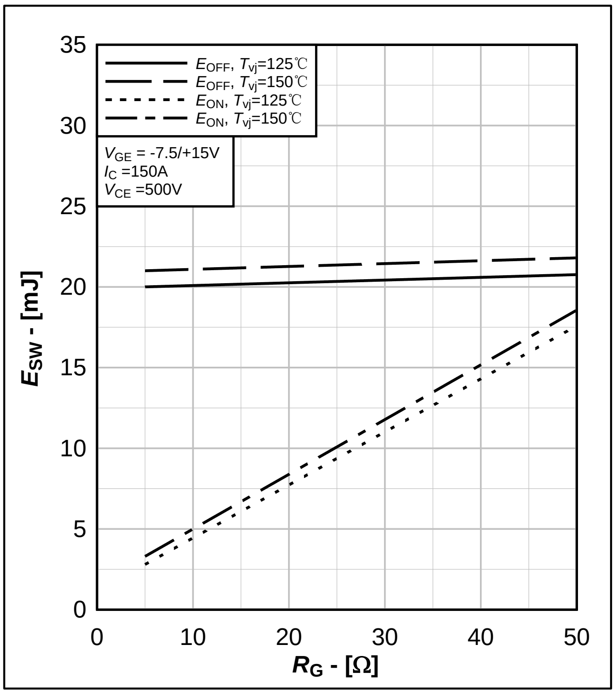


图 23. IGBT 开关损耗典型曲线, E_{on}= f (R_G), E_{off}= f (R_G)

Fig.23 Typical IGBT switching energy, E_{on}= f(R_G), E_{off}= f (R_G)

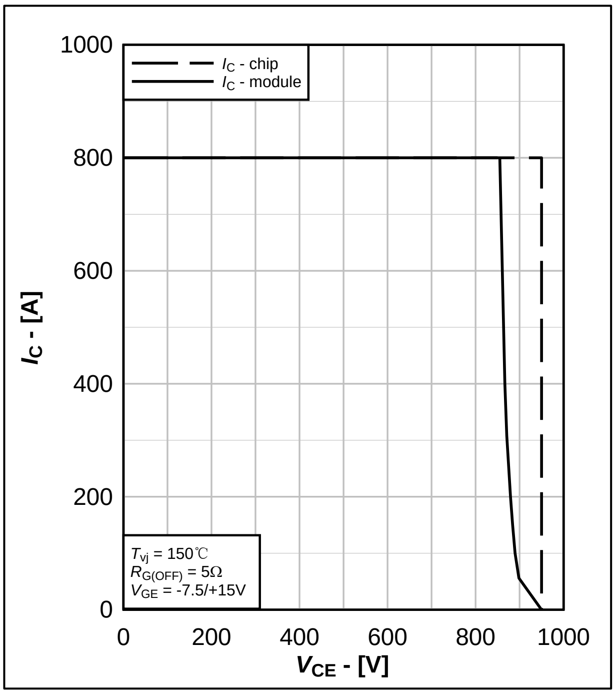


图 24. IGBT 反偏安全工作区, I_C = f (V_{CE})

Fig.24 Reverse bias safe operating area of IGBT, I_C = f (V_{CE})

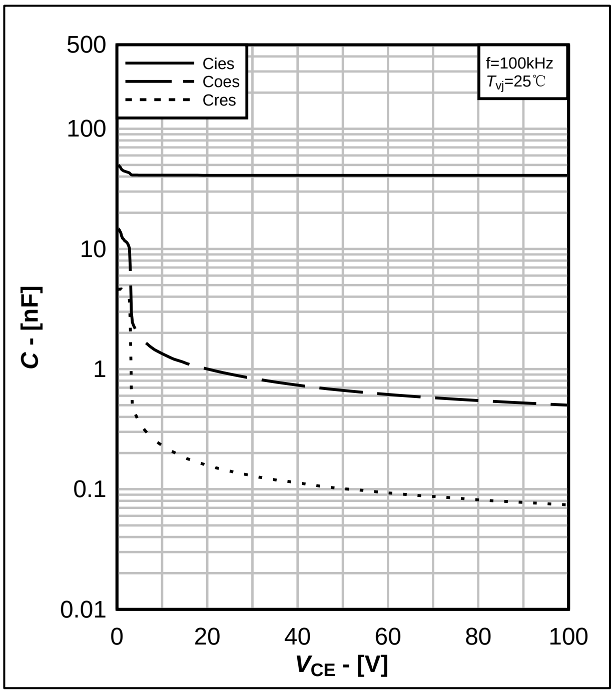


图 25. 电容特性典型曲线, C= f (V_{CE})

Fig.25 Typical capacity characteristic, C= f (V_{CE})

IGBT T2/T3，二极管 D2/D3　　IGBT T2/T3, Diode D2/D3

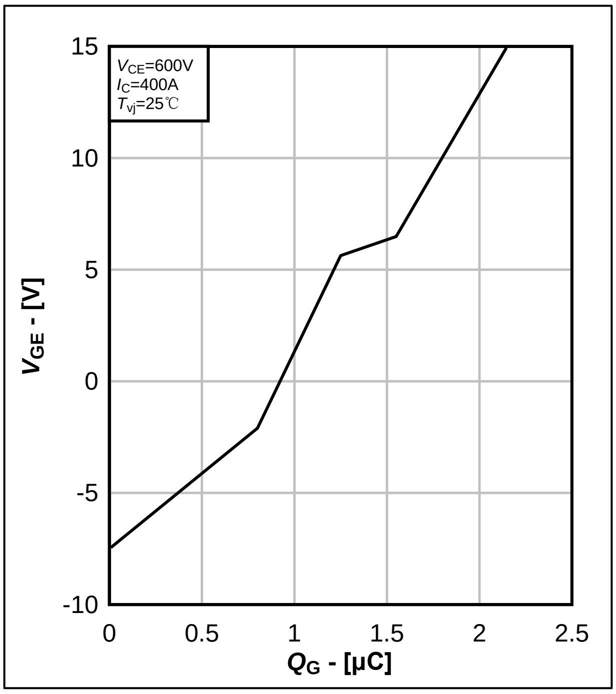


图 26. 栅极电荷特性典型曲线, V_{GE} = f (Q_G)

Fig.26 Typical gate charge characteristic, V_{GE}= f (Q_G)

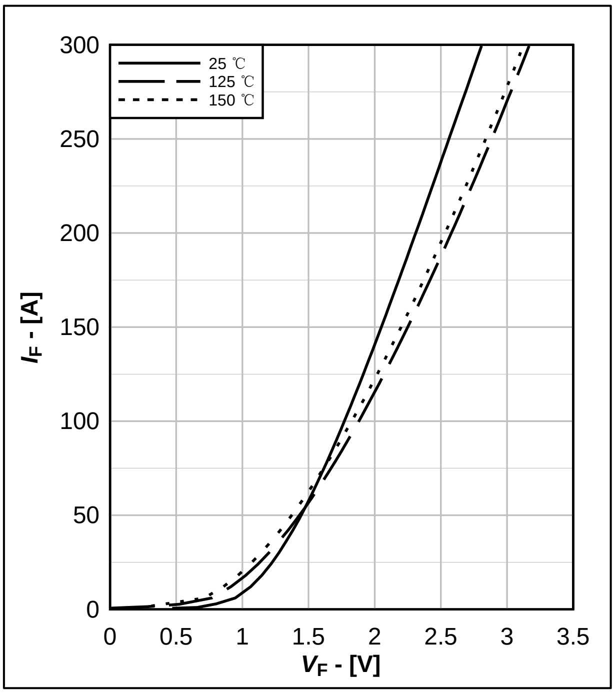


图 27. FRD 输出特性典型曲线, I_F = f (V_F)

Fig.27 Typical FRD output characteristic, I_F = f (V_F)

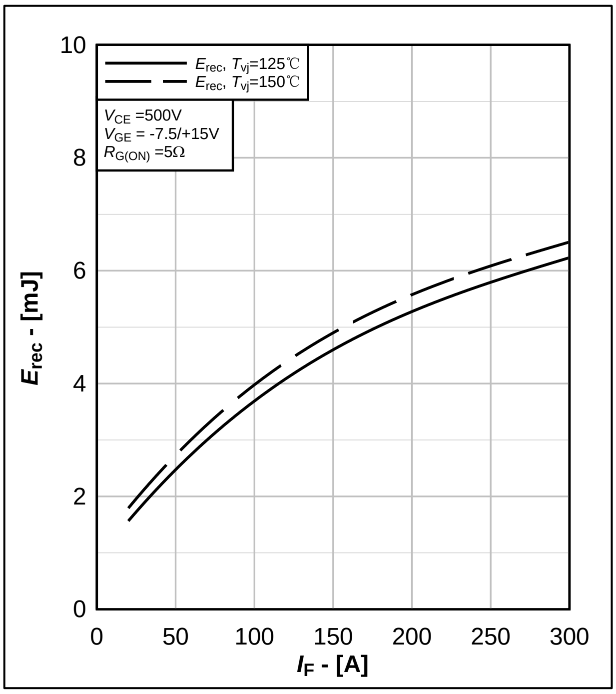


图 28. FRD 反向恢复损耗典型曲线, E_{rec}=f(I_F)

Fig.28 Typical FRD switching loss E_{rec}, E_{rec}=f(I_F)

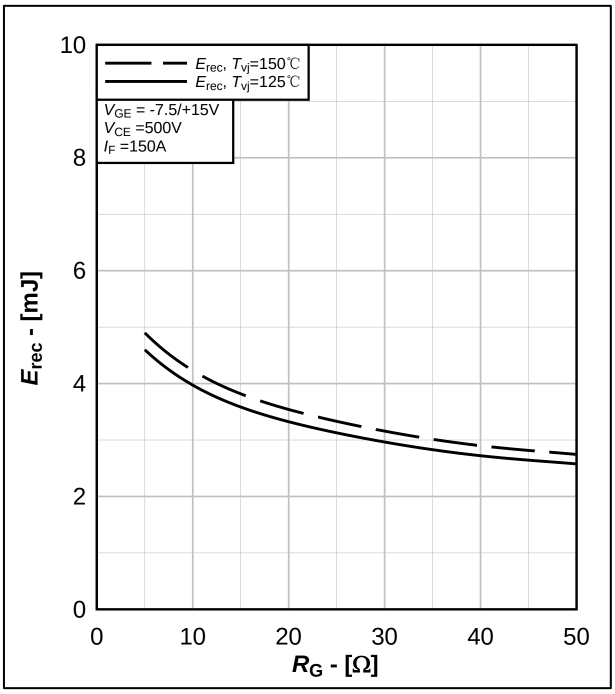


图 29. FRD 反向恢复损耗典型曲线, E_{rec}=f(R_G)

Fig.29 Typical FRD switching loss E_{rec}, E_{rec}=f(R_G)

IGBT T2/T3，二极管 D2/D3

IGBT T2/T3, Diode D2/D3

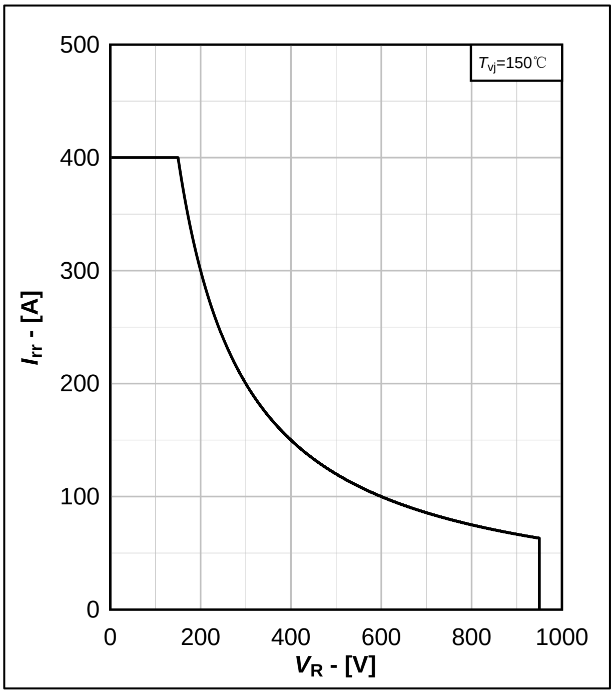


图 30. FRD 反偏安全工作区, I_{rr} = f (V_R)

Fig.30 Reverse bias safe operating area of FRD, I_{rr} = f (V_R)

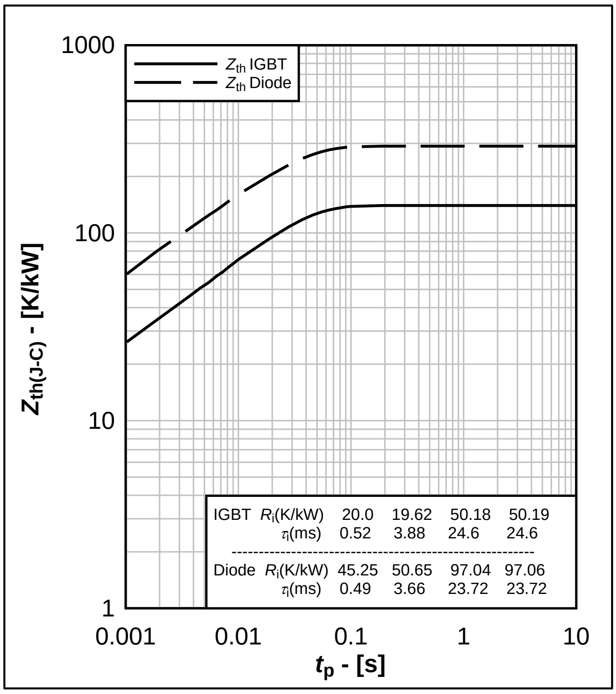


图 31. 瞬态热阻抗曲线, $Z_{th(J-C)}$ = f (t_p)

Fig.31 Transient thermal impedance, $Z_{th(J-C)}$ = f (t_p)

IGBT T5/T6，二极管 D5/D6 IGBT T5/T6, Diode D5/D6

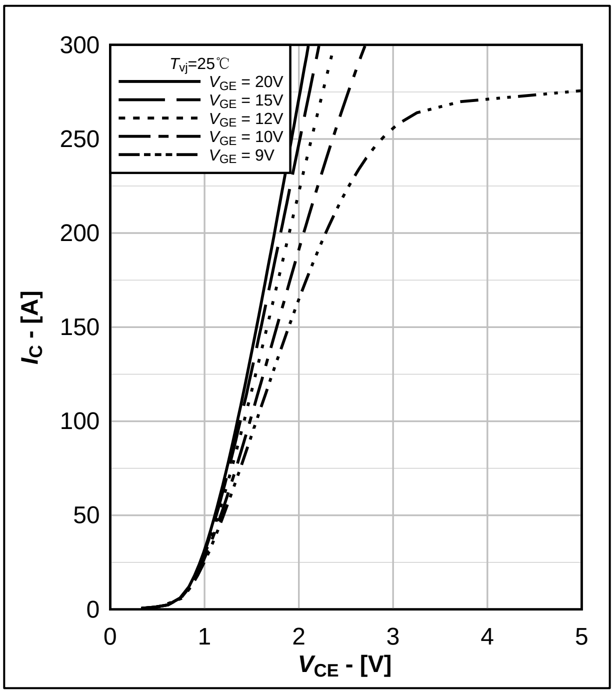


图 32. IGBT 输出特性典型曲线, I_C= f (V_{CE})

Fig.32 Typical IGBT output characteristic, I_C= f (V_{CE})

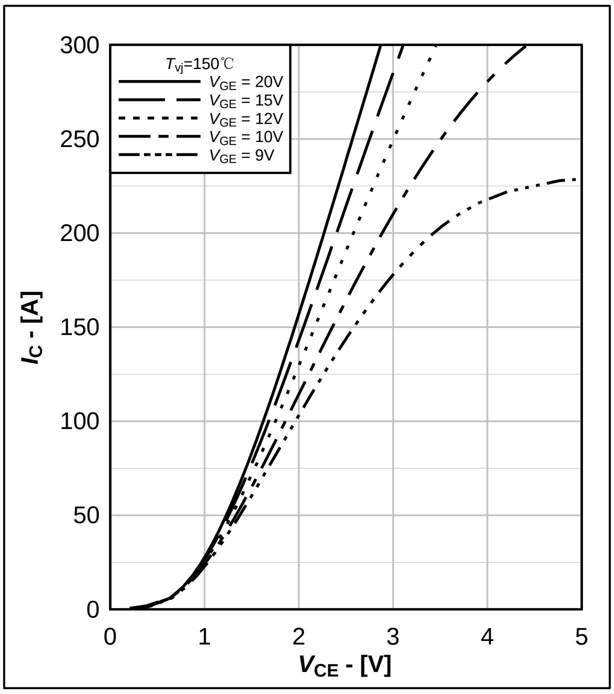


图 33. IGBT 输出特性典型曲线, I_C= f (V_{CE})

Fig.33 Typical IGBT output characteristic, I_C= f (V_{CE})

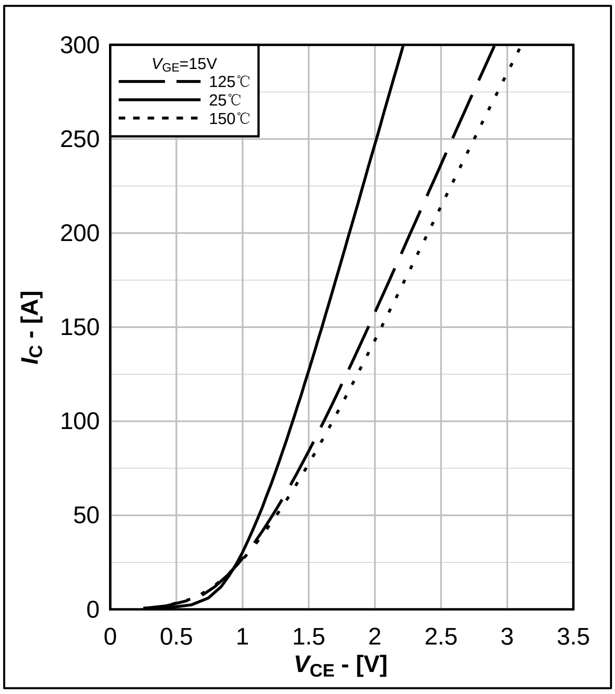


图 34. IGBT 输出特性典型曲线, I_C= f (V_{CE})

Fig.34 Typical IGBT output characteristic, I_C= f (V_{CE})

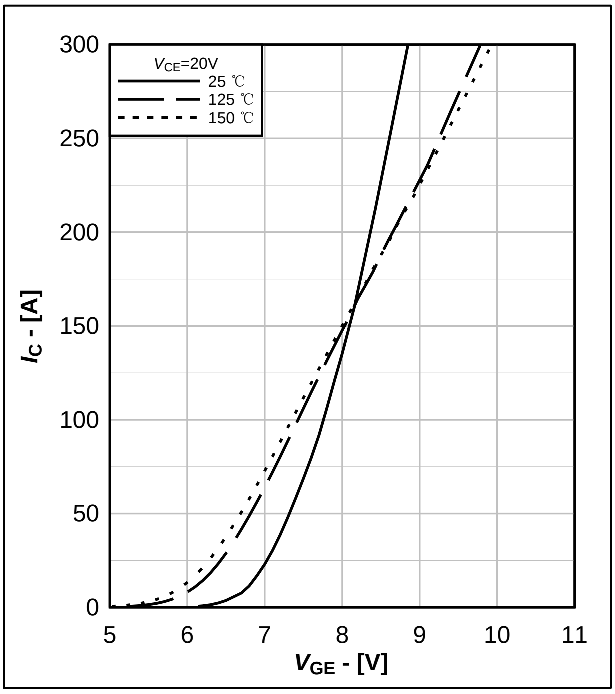


图 35. IGBT 传输特性典型曲线, I_C= f (V_{GE})

Fig.35 Typical IGBT transfer characteristic, I_C= f (V_{GE})

IGBT T5/T6，二极管 D5/D6　　IGBT T5/T6, Diode D5/D6

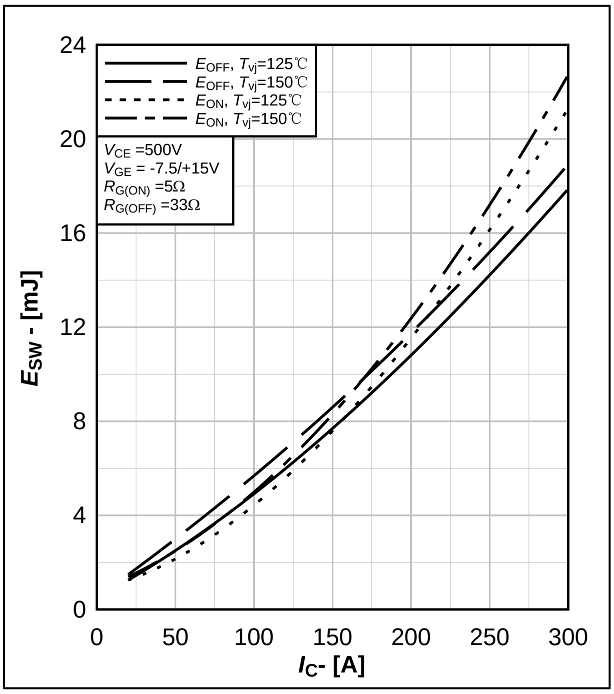


图 36. IGBT 开关损耗典型曲线, E_{on}= f (I_C), E_{off}= f (I_C)

Fig.36　Typical IGBT switching energy, E_{on}= f (I_C), E_{off}= f (I_C)

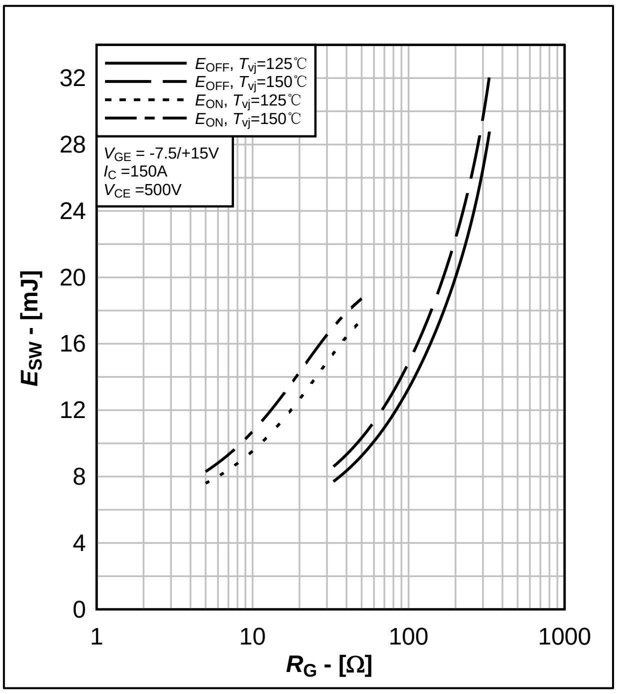


图 37. IGBT 开关损耗典型曲线, E_{on}= f (R_G), E_{off}= f (R_G)

Fig.37　Typical IGBT switching energy, E_{on}= f(R_G), E_{off}= f (R_G)

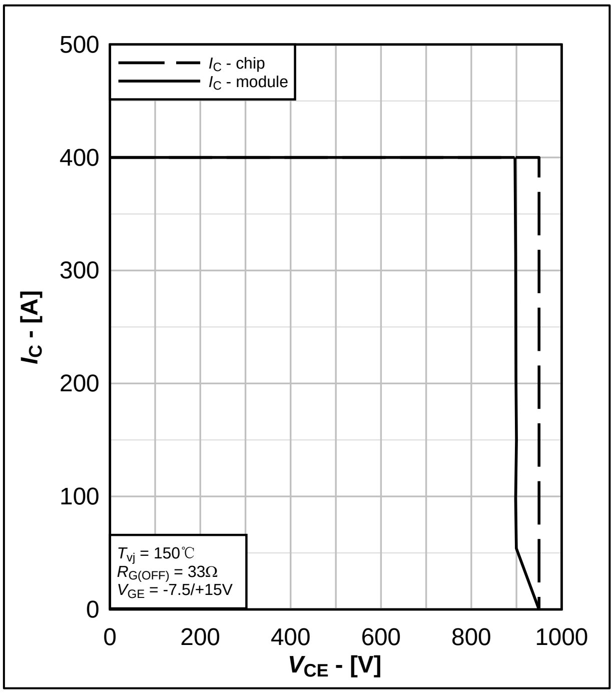


图 38. IGBT 反偏安全工作区, I_C = f (V_{CE})

Fig.38　Reverse bias safe operating area of IGBT, I_C = f (V_{CE})

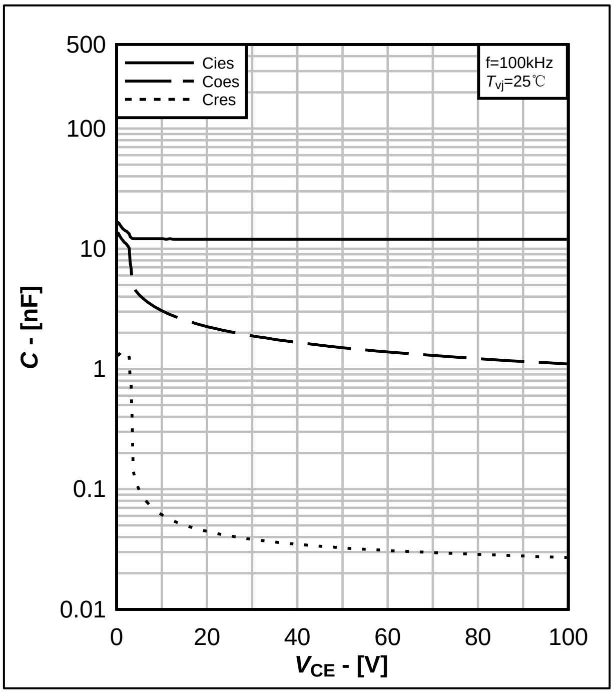


图 39. 电容特性典型曲线, C= f (V_{CE})

Fig.39　Typical capacity characteristic, C= f (V_{CE})

IGBT T5/T6，二极管 D5/D6　　IGBT T5/T6, Diode D5/D6

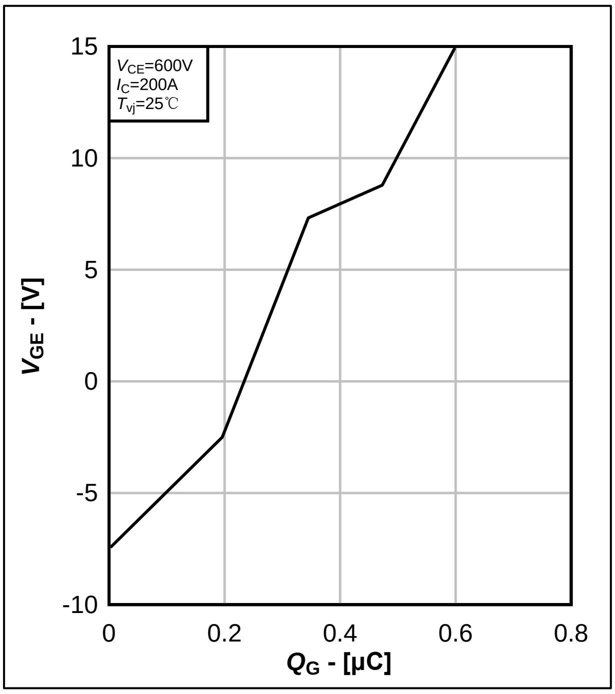


图 40. 栅极电荷特性典型曲线, V_{GE} = f (Q_G)

Fig.40 Typical gate charge characteristic, V_{GE}= f (Q_G)

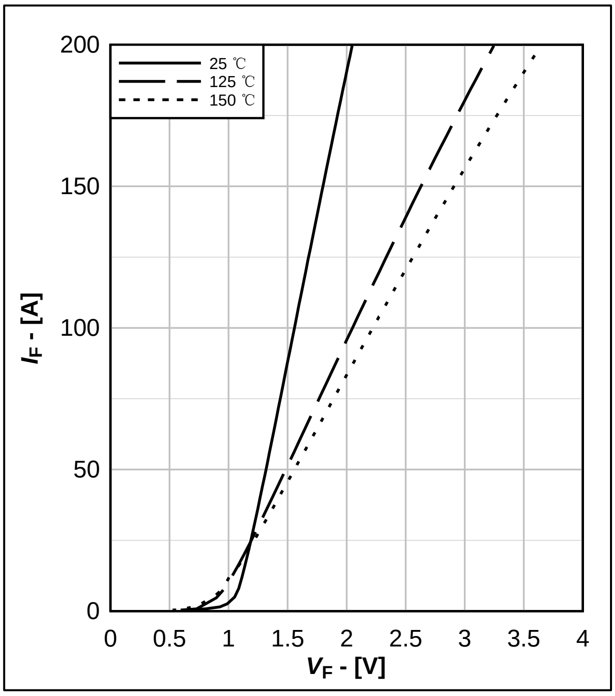


图 41. FRD 输出特性典型曲线, I_F = f (V_F)

Fig.41 Typical FRD output characteristic, I_F = f (V_F)

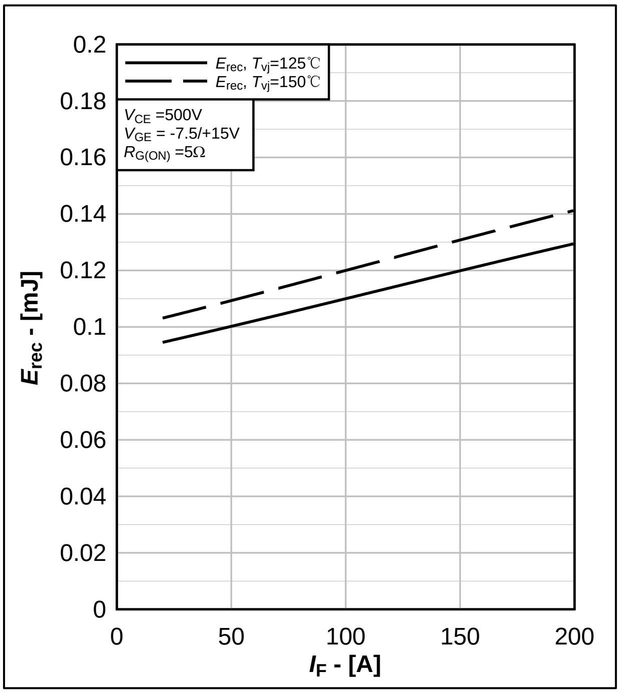


图 42. FRD 反向恢复损耗典型曲线, E_{rec}=f(I_F)

Fig.42 Typical FRD switching loss E_{rec}, E_{rec}=f(I_F)

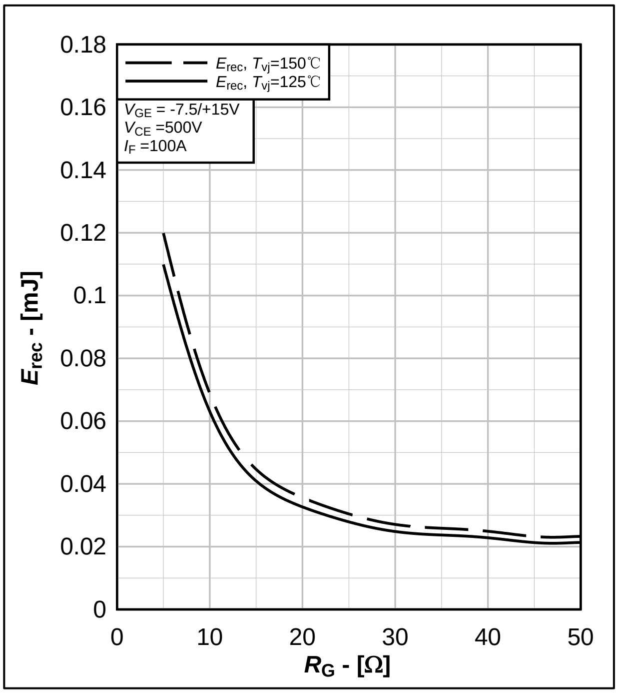


图 43. FRD 反向恢复损耗典型曲线, E_{rec}=f(R_G)

Fig.43 Typical FRD switching loss E_{rec}, E_{rec}=f(R_G)

IGBT T5/T6，二极管 D5/D6

IGBT T5/T6, Diode D5/D6

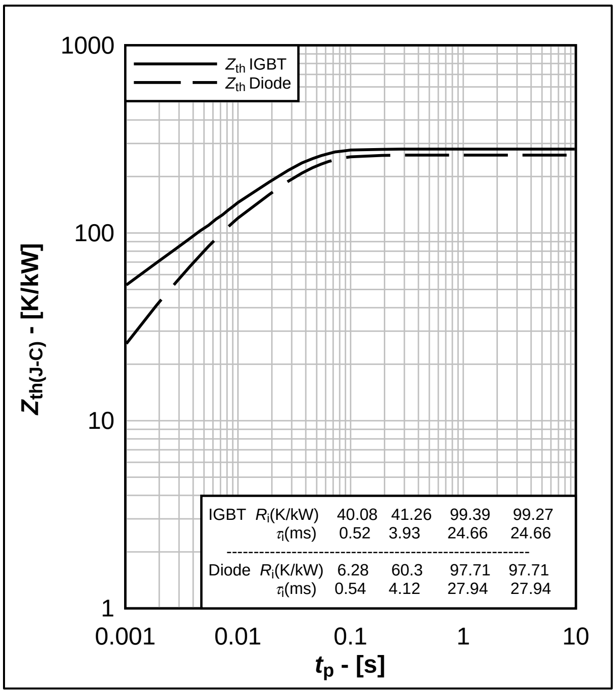
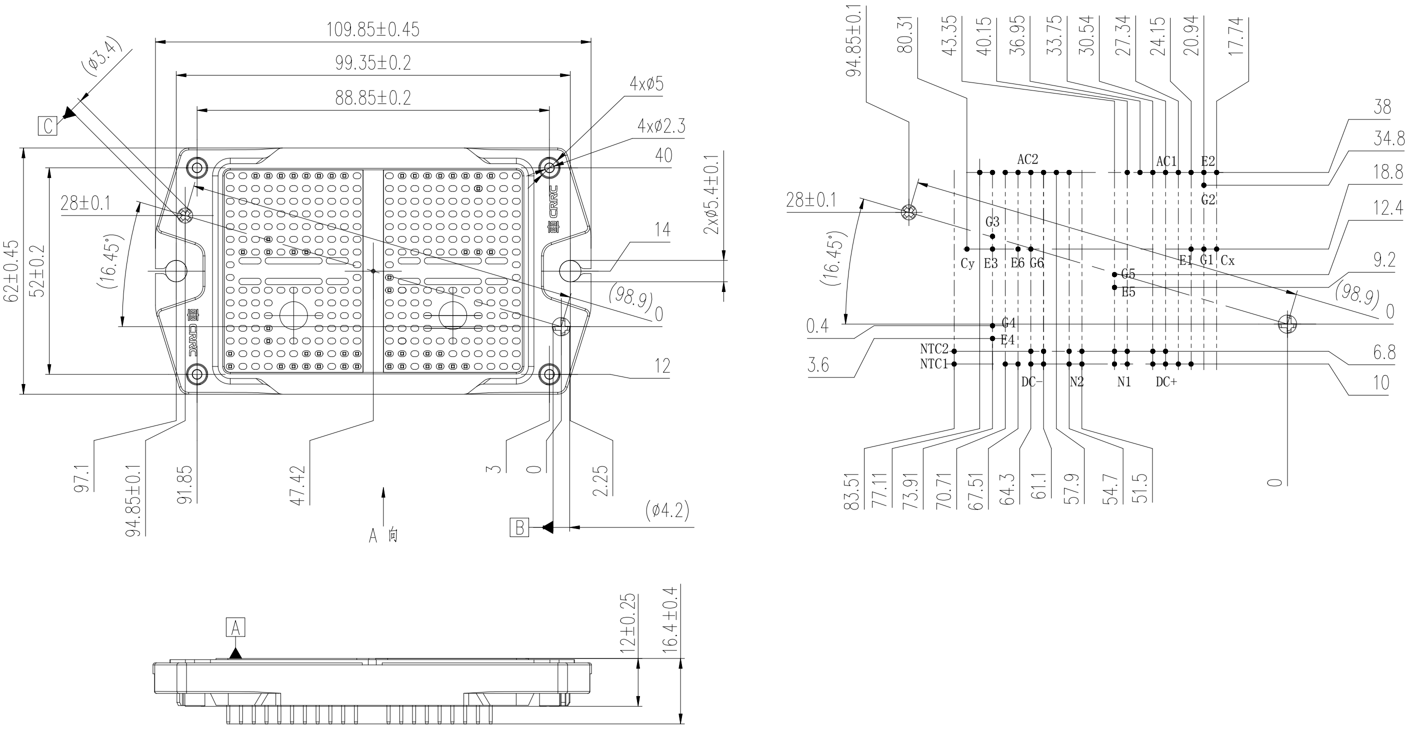


图 44. 瞬态热阻抗曲线, $Z_{th(J-C)} = f(t_p)$

Fig.44 Transient thermal impedance, $Z_{th(J-C)} = f(t_p)$



重量 Weight：84g　　模块外观类型 Module outline code：U3

图 45.　模块外观尺寸

Fig. 45　Module outlines

株洲中车时代半导体有限公司

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网　址	Web Site	http://www.sbu.crrczic.cc	

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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.