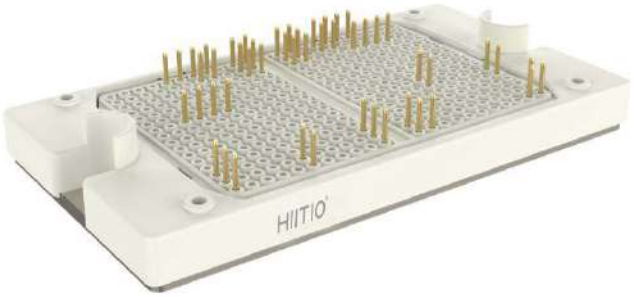
HCG450FL065E3RE
650V/450A 3-Level NPC IGBT Module

I型三电平NPC逆变模块
I Type 3-Level NPC Inverter Module

特性 Features

- I型NPC三电平逆变模块
  I type NPC Three−Level Inverter Module
- 650V 沟槽栅/场截止工艺
  650V Trench Gate/Field-Stop Process
- 低V_{CEsat}/低开关损耗
  Low V_{CEsat} / Low Switching Losses
- V_{CEsat} 正温度系数
  V_{CEsat} with Positive Temperature Coefficient
- 低热阻三氧化二铝（Al_2O_3）衬底
  Al_2O_3 Substrate with Low Thermal Resistance
- 紧凑型&低电感设计
  Compact and Low Inductance Design
- 采用DBC技术的隔离散热器
  Isolated Heatsink using DBC Technology

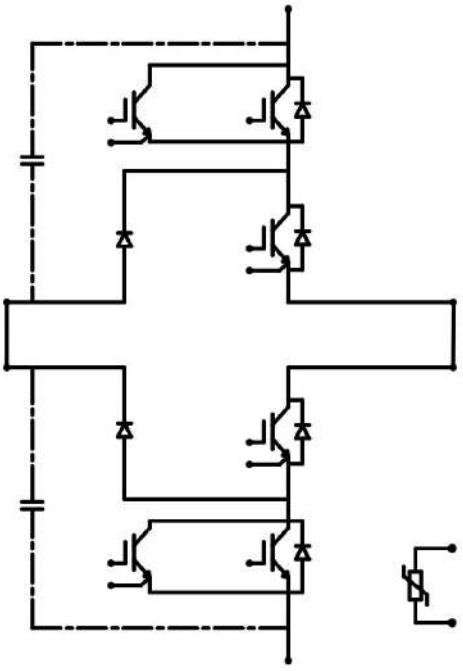
模块外观 Module Appearance



应用 Application

- 三电平应用/3-Level-Applications
- 储能/PCS
- 不间断电源/UPS Systems
- 太阳能系统/Solar Applications
- 电能质量/APF/SVG

电路拓扑 Circuit Topology



关键参数[T1&T4/D5&D6] Key Parameters

Parameter		Symbol	Value	Unit
集电极－发射极电压 Collector-emitter voltage		V_{CES}	650	V
连续集电极直流电流 Continuous DC collector current		I_{Cnom}	450	A
集电极重复峰值电流 Repetitive peak collector current		I_{CRM}	900	A
集电极－发射极饱和电压 Collector-Emitter saturation voltage	T_{vj}=25℃	V_{CEsat}	1.51	V
	T_{vj}=125℃		1.66	
IGBT结－散热器热阻 IGBT thermal resistance		R_{thJH}	0.215	K/W
Diode结－散热器热阻 Diode thermal resistance		R_{thJH}	0.318	K/W
开通损耗能量 Turn-on energy	T_{vj}=25℃	E_{on}	9.89	mJ
	T_{vj}=125℃		12.07	
关断损耗能量 Turn-off energy	T_{vj}=25℃	E_{off}	7.28	
	T_{vj}=125℃		8.57	

RoHS

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封装/ Package

表 1　绝缘参数/Insulation coordination

Parameter	Conditions	Symbol	Value	Unit
绝缘测试电压 Isolation test voltage	RMS, f = 50Hz, t = 60s	V_{ISOL}	3	kV
模块基板材料 Material of module baseplate			Cu	
内部绝缘 Internal isolation	基本绝缘 (class 1, IEC 61140) Basic insulation (class 1, IEC 61140)		Al_2O_3	
爬电距离 Creepage distance		d_{Creep}	＞12.7	mm
电气间隙 Clearance		d_{Clear}	＞12.7	mm
相对电痕指数 Comparative tracking index		*CTI*	≥600	

表 2　特征值/Characteristic values

Parameter	Conditions	Symbol	Value			Unit
			Min.	Typ.	Max.	
杂散电感, 模块 Stray inductance module		L_{sCE}		20		nH
储存温度 Storage temperature		T_{stg}	-40		125	℃
允许开关的温度范围 Temperature under switching conditions		$T_{vj(op)}$	-40		150	℃
重量 Weight		*G*		260		g

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IGBT/ T1&T4

表 3　最大标定值/Maximum rated values

Parameter	Conditions	Symbol	Value	Unit
集电极－发射极电压 Collector-emitter voltage	T_{vj} = 25°C	V_{CES}	650	V
连续集电极直流电流 Continuous DC collector current	T_h = 80°C, $T_{vj\,max}$ = 175°C	I_{CDC}	335	A
集电极重复峰值电流 Repetitive peak collector current	t_p limited by $T_{vj\,max}$	I_{CRM}	900	A
总耗散功率 TTotal Power dissipation	T_h = 80°C, T_{vj} = $T_{vj\,max}$	P_{tot}	442	W
栅极－发射极电压 Gate-emitter peak voltage		V_{GES}	±20	V

表 4　特征值/Characteristic values

Parameter	Conditions		Symbol	Value			Unit
				Min.	Typ.	Max.	
集电极-发射极饱和电压 Collector-emitter saturation voltage	I_C = 450A, V_{GE} = 15V	T_{vj} = 25°C	$V_{CE(sat)}$		1.51	1.9	V
		T_{vj} = 125°C			1.66		
		T_{vj} = 150°C			1.72		
栅极阈值电压 Gate threshold voltage	I_C = 3mA, V_{GE} = V_{CE}, T_{vj} = 25°C		V_{GEth}	3.5	4.0	4.5	V
栅极电荷 Gate charge	V_{GE} = ±15 V, V_{CE} = 400V, Ic=450A		Q_G		1278		nC
输入电容 Input capacitance	f = 1MHz, T_{vj} = 25°C, V_{CE} = 30V, V_{GE} = 0V		C_{ies}		35.88		nF
反向传输电容 Reverse transfer capacitance	f = 1MHz, T_{vj} = 25°C, V_{CE} = 30V, V_{GE} = 0V		C_{res}		0.708		nF
集电极－发射极截止电流 Collector-emitter cut-off current	V_{CE} = 650V, V_{GE} = 0V, T_{vj} = 25°C		I_{CES}			100	μA
栅极－发射极漏电流 Gate-emitter leakage current	V_{CE} = 0V, V_{GE} = ±30V, T_{vj} = 25°C		I_{GES}			±1.2	μA
开通延迟时间（感性负载） Turn-on delay time (inductive load)	V_{CE} = 400V I_C = 200A V_{GE} = +15/-5V R_{Gon} = R_{Goff} =12Ω Inductive Load	T_{vj} = 25°C	$t_{d(on)}$		513		ns
		T_{vj} = 125°C			479		
		T_{vj} = 150°C			478		
上升时间（感性负载） Rise time (inductive load)		T_{vj} = 25°C	t_r		106		ns
		T_{vj} = 125°C			117		
		T_{vj} = 150°C			122		
关断延迟时间（感性负载） Turn-off delay time (inductive load)	V_{CE} = 400V I_C = 200A V_{GE} = +15/-5V R_{Gon} = R_{Goff} =12Ω Inductive Load	T_{vj} = 25°C	$t_{d(off)}$		985		ns
		T_{vj} = 125°C			900		
		T_{vj} = 150°C			1017		
下降时间（感性负载） Fall time (inductive load)		T_{vj} = 25°C	t_f		73		ns
		T_{vj} = 125°C			74		
		T_{vj} = 150°C			75		
开通耗损能量（每脉冲） Turn-on energy loss per pulse	V_{CE} = 400V I_C = 200A V_{GE} = +15/-5V R_{Gon} = R_{Goff} =12Ω Inductive Load	T_{vj} = 25°C	E_{on}		9.89		mJ
		T_{vj} = 125°C			12.07		
		T_{vj} = 150°C			14.31		
关断损耗能量（每脉冲） Turn-off energy loss per pulse	V_{CE} = 400V I_C = 200A V_{GE} = +15/-5V R_{Gon} = R_{Goff} =12Ω Inductive Load	T_{vj} = 25°C	E_{off}		7.28		mJ
		T_{vj} = 125°C			8.57		
		T_{vj} = 150°C			9.49		

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（续）特征值/ Characteristic values

Parameter	Conditions	Symbol	Value			Unit
			Min.	Typ.	Max.	
结－散热器热阻 Thermal resistance, junction to heatsink	每个IGBT，λgrease = 3.4W/(m*K) Per IGBT，λgrease = 3.4W/(m*K)	R_{thJH}		0.215		K/W
最高结温 $T_{vj\ max}$		$T_{vj\ max}$		175		℃

Diode/ D5&D6

表 5　最大标定值/Maximum rated values

Parameter	Conditions	Symbol	Value	Unit
反向重复峰值电压 Repetitive peak reverse voltage	T_{vj} = 25℃	V_{RRM}	650	V
连续正向直流电流 Continuous DC forward current	T_h = 80℃, $T_{vj\ max}$ = 175℃	I_F	252	A
总耗散功率 Total Power dissipation	T_h = 80℃, T_{vj} = $T_{vj\ max}$	P_{tot}	298	W
正向重复峰值电流 Repetitive peak forward current	t_p limited by $T_{vj\ max}$	I_{FRM}	640	A

表 6　特征值/Characteristic values

Parameter	Conditions		Symbol	Value			Unit
				Min.	Typ.	Max.	
正向电压 Forward voltage	I_F = 320A, V_{GE} = 0V	T_{vj} = 25℃	V_F		1.39	1.9	V
		T_{vj} = 125℃			1.47		
		T_{vj} = 150℃			1.48		
反向恢复峰值电流 Peak reverse recovery current	V_R= 400V I_F = 200A V_{GE} = +15/-5V R_{Gon} = R_{Goff} =12Ω Inductive Load	T_{vj} = 25℃	I_{RM}		83		A
		T_{vj} = 125℃			102		
		T_{vj} = 150℃			110		
反向恢复电荷 Recovered charge		T_{vj} = 25℃	Q_r		4		μC
		T_{vj} = 125℃			9		
		T_{vj} = 150℃			11		
反向恢复损耗（每脉冲） Reverse recovery energy		T_{vj} = 25℃	E_{rec}		0.78		mJ
		T_{vj} = 125℃			1.68		
		T_{vj} = 150℃			2.07		
结－散热器热阻 Thermal resistance, junction to heatsink	每个IGBT，λgrease = 3.4W/(m*K) Per IGBT，λgrease = 3.4W/(m*K)		R_{thJH}		0.318		K/W
最高结温 $T_{vj\ max}$			$T_{vj\ max}$		175		℃

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IGBT/ T2&T3

表 7　最大标定值/Maximum rated values

Parameter	Conditions	Symbol	Value	Unit
集电极－发射极电压 Collector-emitter voltage	T_{vj} = 25℃	V_{CES}	650	V
连续集电极直流电流 Continuous DC collector current	T_h = 80℃, $T_{vj\,max}$ = 175℃	I_{CDC}	299	A
集电极重复峰值电流 Repetitive peak collector current	t_p limited by $T_{vj\,max}$	I_{CRM}	640	A
总耗散功率 TTotal Power dissipation	T_h = 80℃, T_{vj} = $T_{vj\,max}$	P_{tot}	358	W
栅极－发射极电压 Gate-emitter peak voltage		V_{GES}	±20	V

表 8　特征值/Characteristic values

Parameter	Conditions		Symbol	Value			Unit
				Min.	Typ.	Max.	
集电极-发射极饱和电压 Collector-emitter saturation voltage	I_C = 360A, V_{GE} = 15V	T_{vj} = 25℃	$V_{CE(sat)}$		1.32	1.9	V
		T_{vj} = 125℃			1.40		
		T_{vj} = 150℃			1.42		
栅极阈值电压 Gate threshold voltage	I_C = 1.5mA, V_{GE} = V_{CE}, T_{vj} = 25℃		V_{GEth}	4	4.5	5	V
栅极电荷 Gate charge	V_{GE} = ±15 V, V_{CE} = 400V		Q_G		1431		nC
输入电容 Input capacitance	f = 1MHz, T_{vj} = 25℃, V_{CE} = 30V, V_{GE} = 0V		C_{ies}		33.87		nF
反向传输电容 Reverse transfer capacitance	f = 1MHz, T_{vj} = 25℃, V_{CE} = 30V, V_{GE} = 0V		C_{res}		0.624		nF
集电极－发射极截止电流 Collector-emitter cut-off current	V_{CE} = 650V, V_{GE} = 0V, T_{vj} = 25℃		I_{CES}			100	μA
栅极－发射极漏电流 Gate-emitter leakage current	V_{CE} = 0V, V_{GE} = ±30V, T_{vj} = 25℃		I_{GES}			±0.3	μA
开通延迟时间（感性负载） Turn-on delay time (inductive load)	V_{CE} = 400V I_C = 200A V_{GE} = +15/-5V R_{Gon} = R_{Goff} =15Ω Inductive Load	T_{vj} = 25℃	$t_{d(on)}$		536		ns
		T_{vj} = 125℃			506		
		T_{vj} = 150℃			507		
上升时间（感性负载） Rise time (inductive load)		T_{vj} = 25℃	t_r		136		ns
		T_{vj} = 125℃			139		
		T_{vj} = 150℃			135		
关断延迟时间（感性负载） Turn-off delay time (inductive load)	V_{CE} = 400V I_C = 200A V_{GE} = +15/-5V R_{Gon} = R_{Goff} =15Ω Inductive Load	T_{vj} = 25℃	$t_{d(off)}$		958		ns
		T_{vj} = 125℃			923		
		T_{vj} = 150℃			1018		
下降时间（感性负载） Fall time (inductive load)		T_{vj} = 25℃	t_f		116		ns
		T_{vj} = 125℃			100		
		T_{vj} = 150℃			96		
开通耗损能量（每脉冲） Turn-on energy loss per pulse	V_{CE} = 400V I_C = 200A V_{GE} = +15/-5V R_{Gon} = R_{Goff} =15Ω Inductive Load	T_{vj} = 25℃	E_{on}		14.52		mJ
		T_{vj} = 125℃			17.12		
		T_{vj} = 150℃			18.23		
关断损耗能量（每脉冲） Turn-off energy loss per pulse	V_{CE} = 400V I_C = 200A V_{GE} = +15/-5V R_{Gon} = R_{Goff} =15Ω Inductive Load	T_{vj} = 25℃	E_{off}		14.94		mJ
		T_{vj} = 125℃			15.31		
		T_{vj} = 150℃			15.74		

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（续）特征值/ Characteristic values

Parameter	Conditions	Symbol	Value			Unit
			Min.	Typ.	Max.	
结－散热器热阻 Thermal resistance, junction to heatsink	每个IGBT，λgrease = 3.4W/(m*K) Per IGBT，λgrease = 3.4W/(m*K)	R_{thJH}		0.265		K/W
最高结温 $T_{vj\ max}$		$T_{vj\ max}$		175		℃

Diode/ D1&D4

表 9　最大标定值/Maximum rated values

Parameter	Conditions	Symbol	Value	Unit
反向重复峰值电压 Repetitive peak reverse voltage	T_{vj} = 25℃	V_{RRM}	650	V
连续正向直流电流 Continuous DC forward current	T_h = 80℃, $T_{vj\ max}$ = 175℃	I_F	176	A
总耗散功率 Total Power dissipation	T_h = 80℃, T_{vj} = $T_{vj\ max}$	P_{tot}	225	W
正向重复峰值电流 Repetitive peak forward current	t_p limited by $T_{vj\ max}$	I_{FRM}	480	A

表 10　特征值/Characteristic values

Parameter	Conditions		Symbol	Value			Unit
				Min.	Typ.	Max.	
正向电压 Forward voltage	I_F =240A, V_{GE} = 0V	T_{vj} = 25℃	V_F		1.58	1.9	V
		T_{vj} = 125℃			1.69		
		T_{vj} = 150℃			1.71		
反向恢复峰值电流 Peak reverse recovery current	V_R= 400V I_F = 200A V_{GE} = +15/-5V R_{Gon} = R_{Goff} =15Ω Inductive Load	T_{vj} = 25℃	I_{RM}		64		A
		T_{vj} = 125℃			88		
		T_{vj} = 150℃			95		
反向恢复电荷 Recovered charge		T_{vj} = 25℃	Q_r		4		μC
		T_{vj} = 125℃			8		
		T_{vj} = 150℃			9		
反向恢复损耗（每脉冲） Reverse recovery energy		T_{vj} = 25℃	E_{rec}		0.73		mJ
		T_{vj} = 125℃			1.51		
		T_{vj} = 150℃			1.71		
结－散热器热阻 Thermal resistance, junction to heatsink	每个IGBT，λgrease = 3.4W/(m*K) Per IGBT，λgrease = 3.4W/(m*K)		R_{thJH}		0.423		K/W
最高结温 $T_{vj\ max}$			$T_{vj\ max}$		175		℃

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Diode/ D2&D3

表 11　最大标定值/Maximum rated values

Parameter	Conditions	Symbol	Value	Unit
反向重复峰值电压 Repetitive peak reverse voltage	T_{vj} = 25℃	V_{RRM}	650	V
连续正向直流电流 Continuous DC forward current	T_C = 80℃, $T_{vj\,max}$ = 175℃	I_F	218	A
总耗散功率 Total Power dissipation	T_C = 80℃, T_{vj} = $T_{vj\,max}$	P_{tot}	257	W
正向重复峰值电流 Repetitive peak forward current	t_p limited by $T_{vj\,max}$	I_{FRM}	480	A

表 12　特征值/Characteristic values

Parameter	Conditions		Symbol	Value			Unit
				Min.	Typ.	Max.	
正向电压 Forward voltage	I_F = 225A, V_{GE} = 0V	T_{vj} = 25℃	V_F		1.43	1.9	V
		T_{vj} = 125℃			1.27		
		T_{vj} = 150℃			1.20		
结一散热器热阻 Thermal resistance, junction to heatsink	每个IGBT，λgrease = 3.4W/(m*K) Per IGBT，λgrease = 3.4W/(m*K)		R_{thJH}		0.369		K/W
最高结温 $T_{vj\,max}$			$T_{vj\,max}$		175		℃

负温度系数热敏电阻/ NTC-Thermistor

表 13　特征值/Characteristic values

Parameter	Conditions	Symbol	Value	Unit
额定电阻值 Rated resistance	T_{NTC} = 25 °C	R_{25}	5	kΩ
R_{100}偏差 Deviation of R_{100}	T_{NTC} = 100 °C, R_{100} = 493 Ω	$\Delta R/R$	±5	%
耗散功率 Power dissipation	T_{NTC} = 25 °C	P_{25}	20.0	mW
B-值 B-value	$R_2 = R_{25}\exp[B_{25/50}(1/T2-1/(298{,}15\ K))]$	$B_{25/50}$	3375	K
B-值 B-value	$R_2 = R_{25}\exp[B_{25/100}(1/T_2-1/(298{,}15\ K))]$	$B_{25/100}$	3433	K

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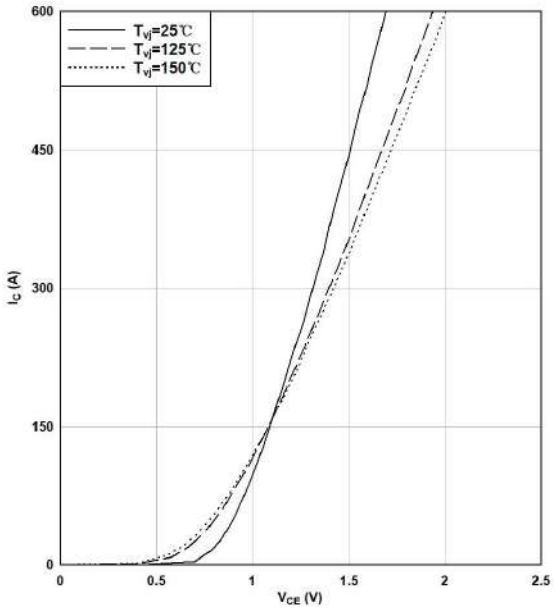
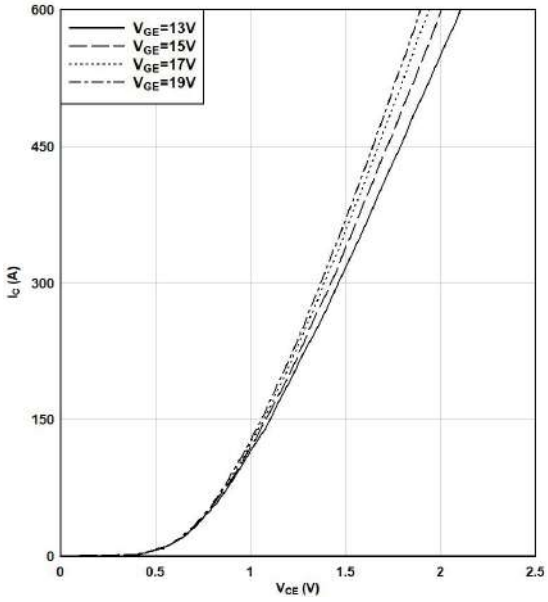
特征参数图表/ Characteristics Diagrams

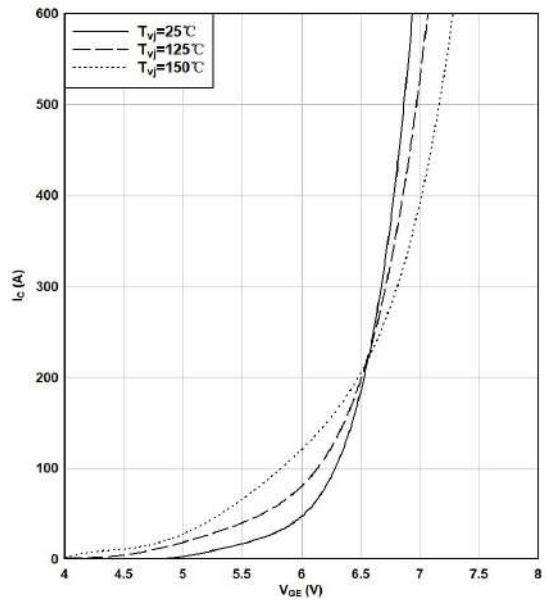
输出特性（典型），IGBT (T1/T4)，逆变器
Output characteristic (typical), IGBT(T1/T4), Inverter
$I_C = f(V_{CE})$
V_{GE} = 15V



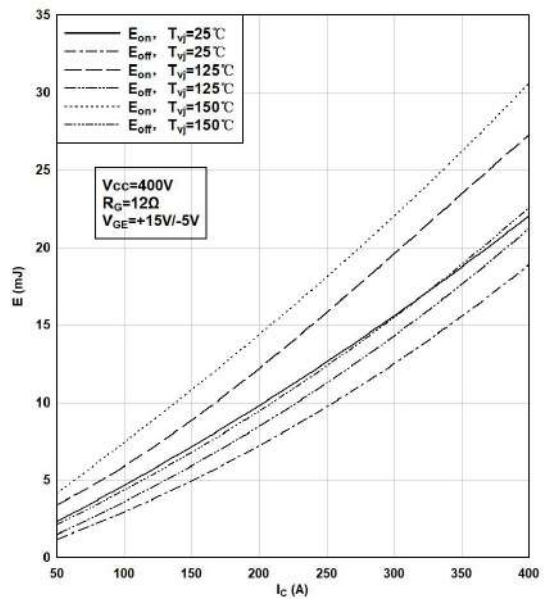
输出特性（典型），IGBT(T1/T4)，逆变器
Output characteristic (typical), IGBT(T1/T4), Inverter
$I_C = f(V_{CE})$
T_{vj}=150℃



传输特性（典型）, IGBT(T1/T4), 逆变器
Transfer characteristic (typical), IGBT(T1/T4), Inverter
$I_C = f(V_{GE})$
V_{CE} = 20V



开关损耗（典型）, IGBT(T1/T4), 逆变器
Switching losses (typical), IGBT(T1/T4), Inverter
$E = f(I_C)$
V_{CE} = 400 V, R_{Gon} =R_{Goff} =12Ω,V_{GE} = +15/-5V



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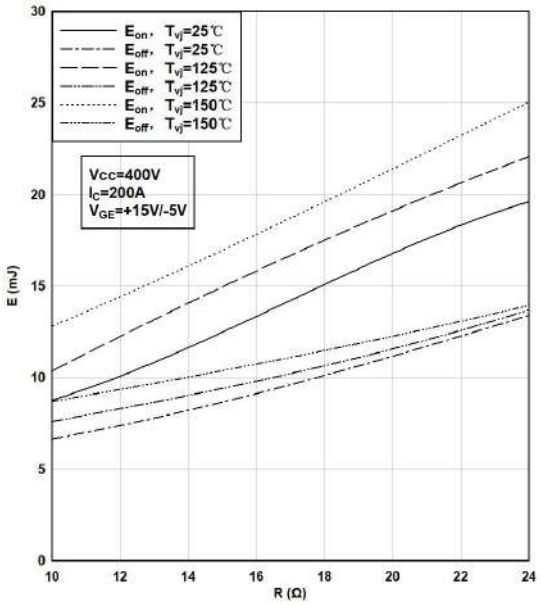
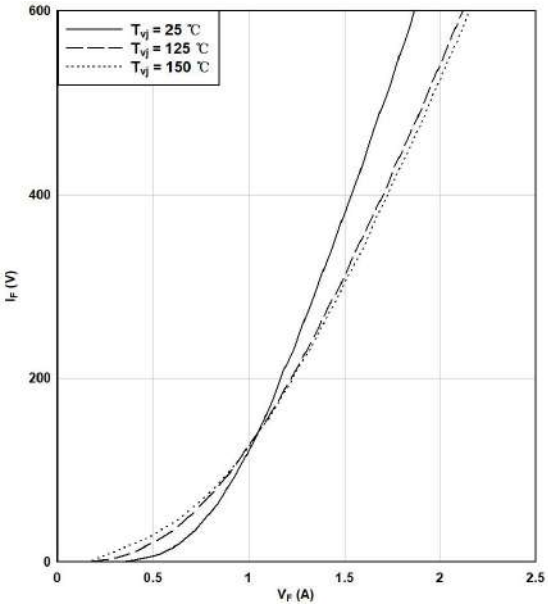
（续）特征参数图表/Characteristics Diagrams

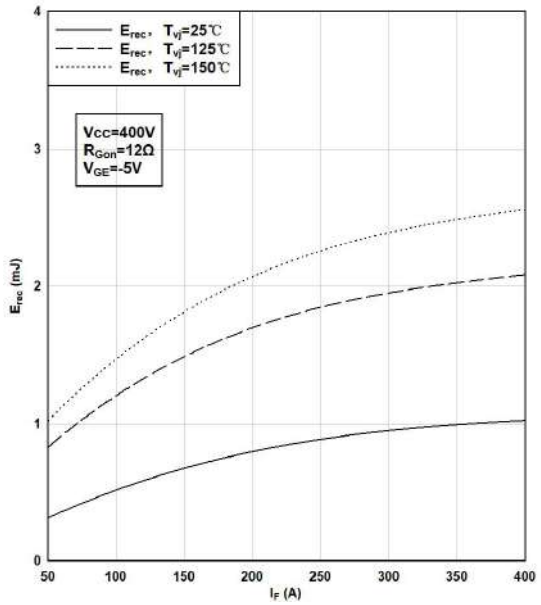
开关损耗 （典型），IGBT(T1/T4)，逆变器
Switching losses (typical), IGBT(T1/T4), Inverter
$E = f(R_G)$
I_C=200A, V_{CE} = 400 V, V_{GE} = +15/-5V



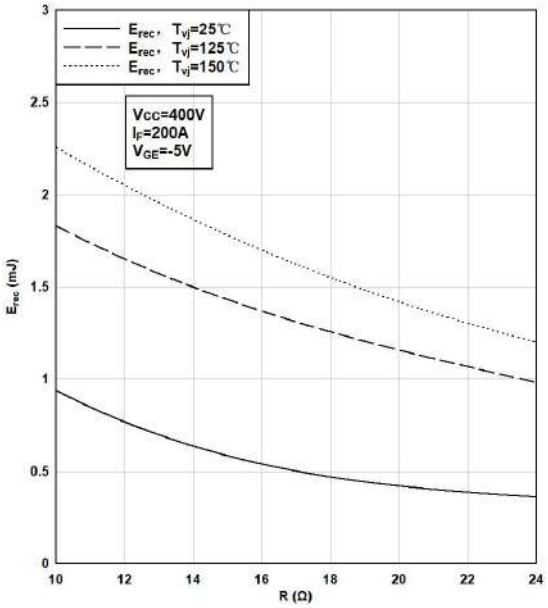
正向特性（典型），二极管(D5/D6)
Forward characteristic (typical), Diode(D5/D6)
$I_F = f(V_F)$



开关损耗（典型），二极管(D5/D6)
Switching losses (typical), Diode(D5/D6)
$E_{rec} = f(I_F)$
V_{CE} = 400V, R_{Gon} = 12Ω



开关损耗（典型），二极管(D5/D6)
Switching losses (typical), Diode(D5/D6)
$E_{rec} = f(R_G)$
I_F=200A, V_{CE} = 400 V



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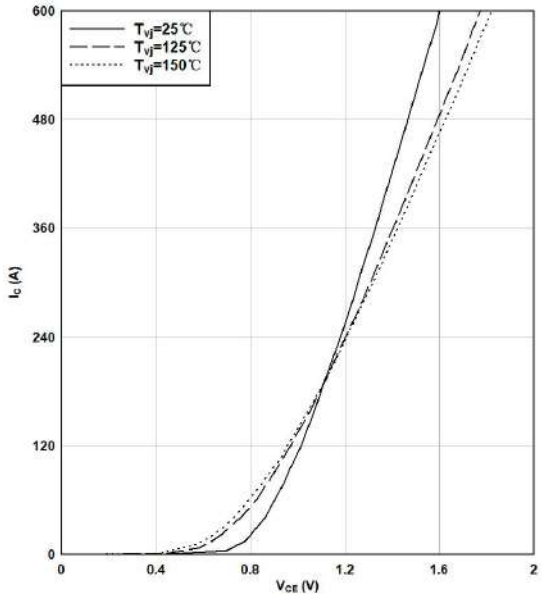
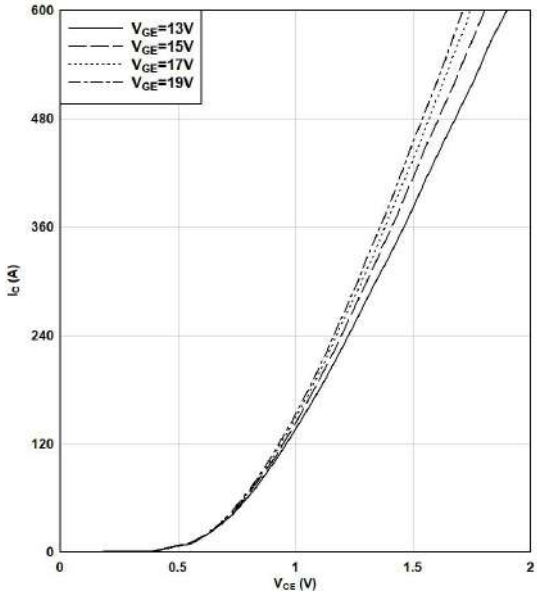
（续）特征参数图表/Characteristics Diagrams

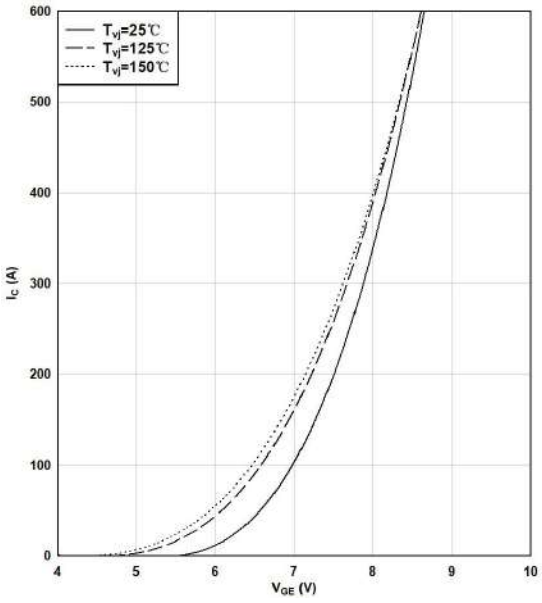
输出特性（典型），IGBT(T2/T3)，逆变器
Output characteristic (typical), IGBT(T2/T3), Inverter
$I_C = f(V_{CE})$
V_{GE} = 15V



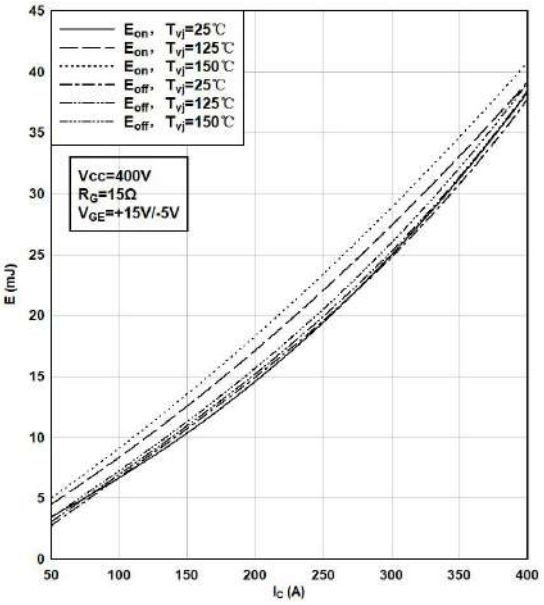
输出特性（典型），IGBT(T2/T3)，逆变器
Output characteristic (typical), IGBT(T2/T3), Inverter
$I_C = f(V_{CE})$
T_{vj}=150℃



传输特性（典型），IGBT(T2/T3)，逆变器
Transfer characteristic (typical), IGBT(T2/T3), Inverter
$I_C = f(V_{GE})$
V_{CE} = 20V



开关损耗（典型），IGBT(T2/T3)，逆变器
Switching losses (typical), IGBT(T2/T3), Inverter
$E = f(I_C)$
V_{CE} = 400 V, R_{Gon}=R_{Goff} =15Ω,V_{GE} = +15/-5V



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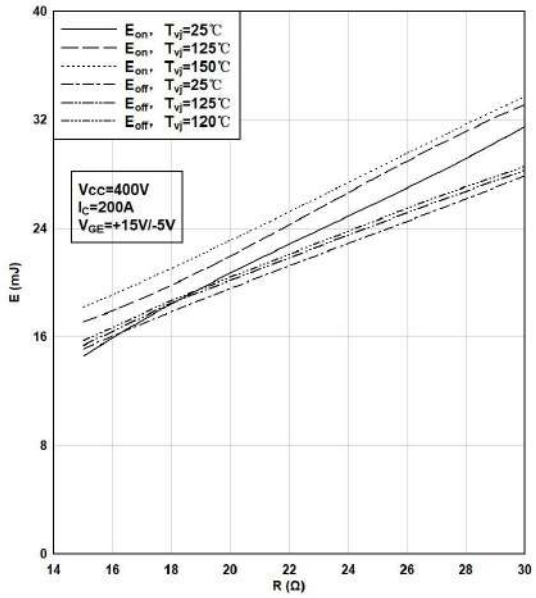
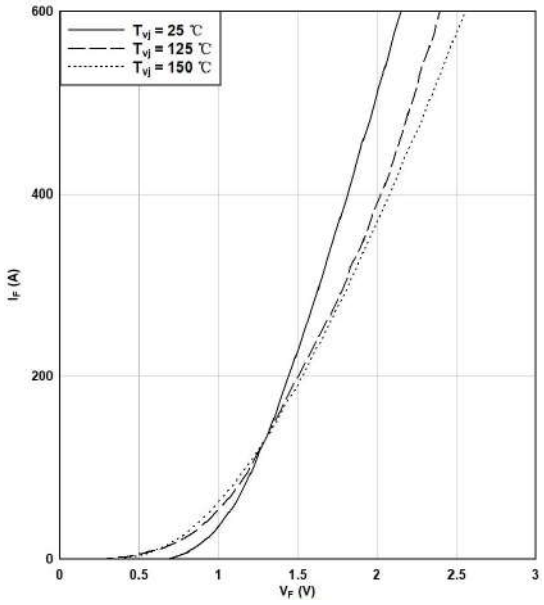
（续）特征参数图表/Characteristics Diagrams

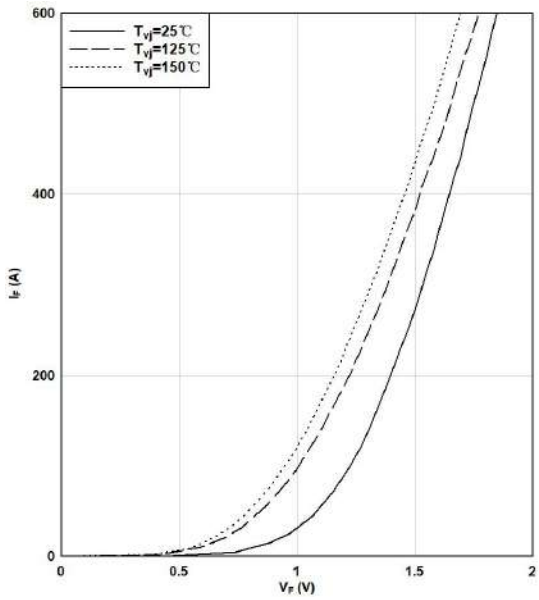
开关损耗 （典型），IGBT(T2/T3)，逆变器
Switching losses (typical), IGBT(T2/T3), Inverter
$E = f(R_G)$
I_C=200A, V_{CE} = 400 V, V_{GE} = +15/-5V



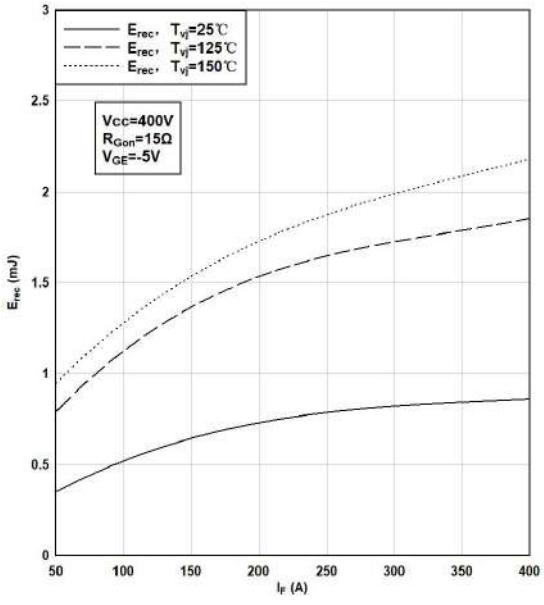
正向特性（典型），二极管(D1/D4)
Forward characteristic (typical), Diode(D1/D4)
$I_F = f(V_F)$



正向特性（典型），二极管(D2/D3)
Forward characteristic (typical), Diode(D2/D3)
$I_F = f(V_F)$



开关损耗（典型），二极管(D1/D4)
Switching losses (typical), Diode(D1/D4)
$E_{rec} = f(I_F)$
V_{CE} = 400V, R_{Gon} = 15Ω



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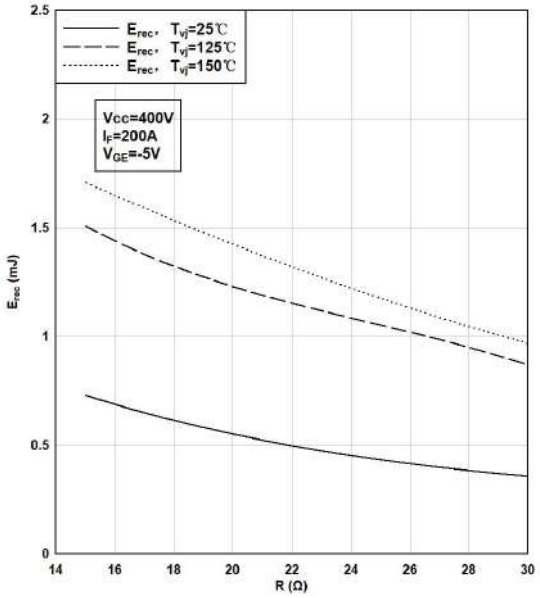
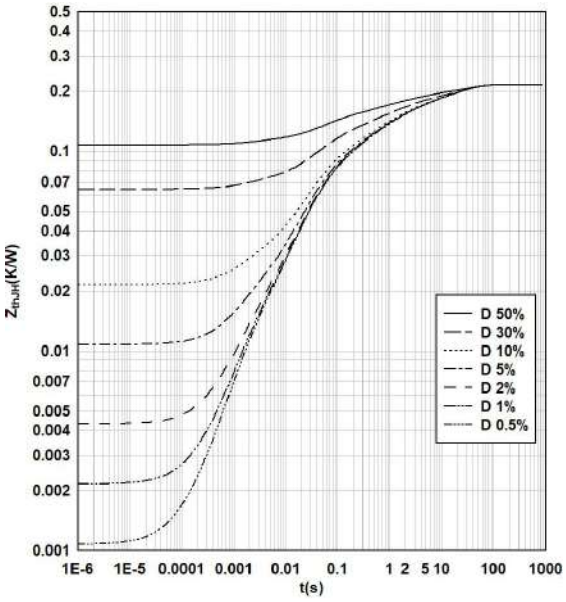
（续）特征参数图表/Characteristics Diagrams

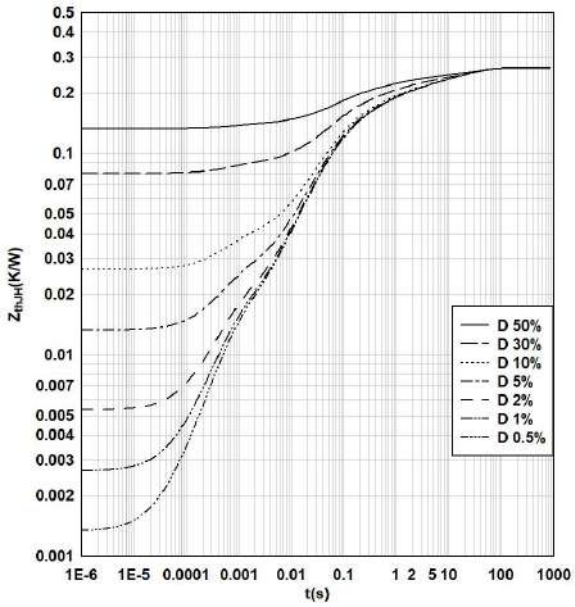
开关损耗（典型），二极管(D1/D4)
Switching losses (typical), Diode(D1/D4)
$E_{rec} = f(R_G)$
I_F=200A, V_{CE} = 400 V



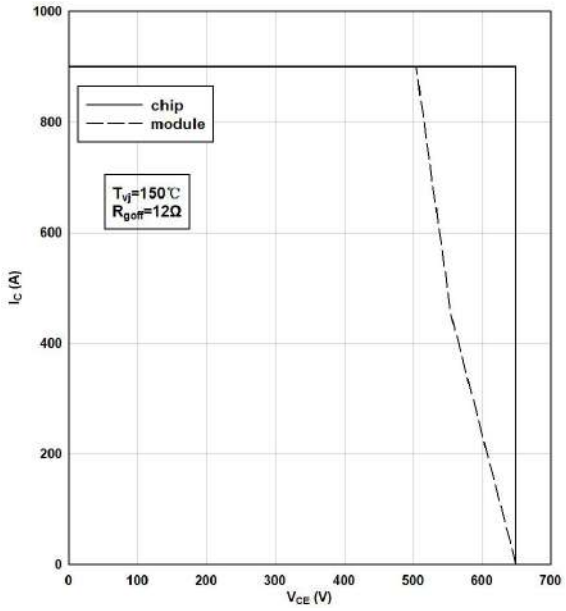
瞬态热阻抗，IGBT(T1/T4)
Transient thermal impedance, IGBT(T1/T4)
Z_{thJF}= f(t)



瞬态热阻抗，IGBT(T2/T3)
Transient thermal impedance, IGBT(T2/T3)
Z_{thJF}= f(t)



反偏安全工作区 IGBT，逆变器 (T1/T4)
Reverse bias safe operating area IGBT, Inverter(T1/T4)
$I_C = f(V_{CE})$



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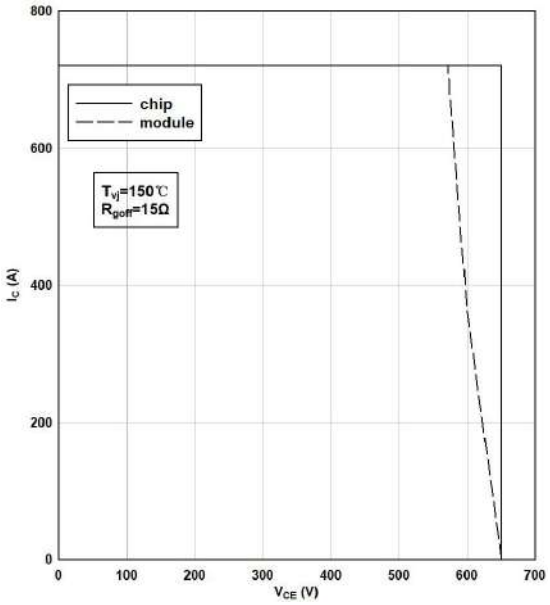
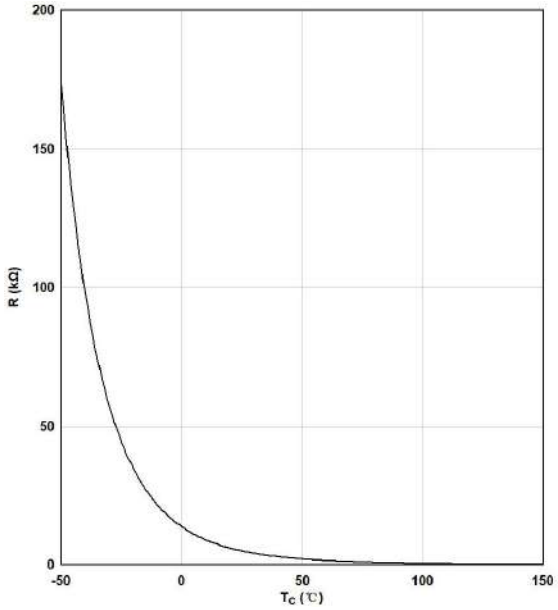
（续）特征参数图表/Characteristics Diagrams

反偏安全工作区 IGBT，逆变器 (T2/T3) Reverse bias safe operating area IGBT, Inverter(T2/T3) $I_C = f(V_{CE})$	负温度系数热敏电阻温度特性 NTC-Thermistor-temperature characteristic(typical) $R = f(T_C)$
	

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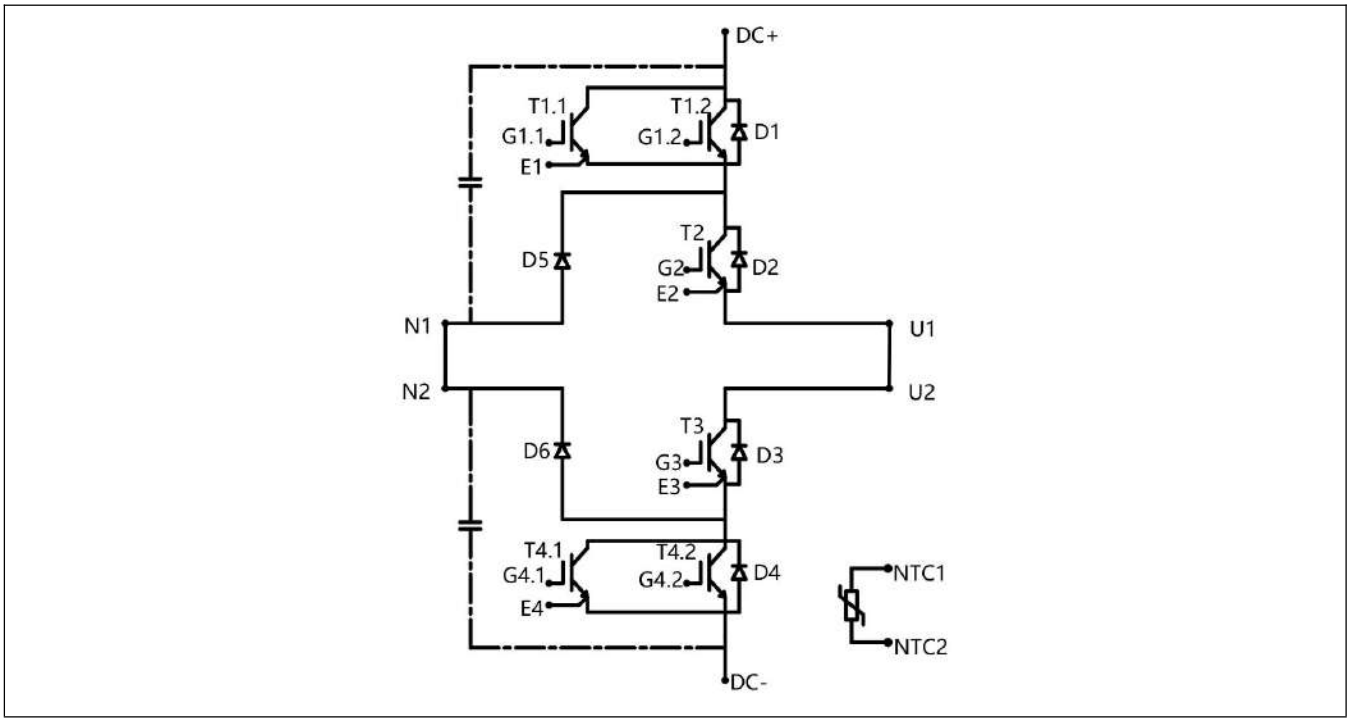
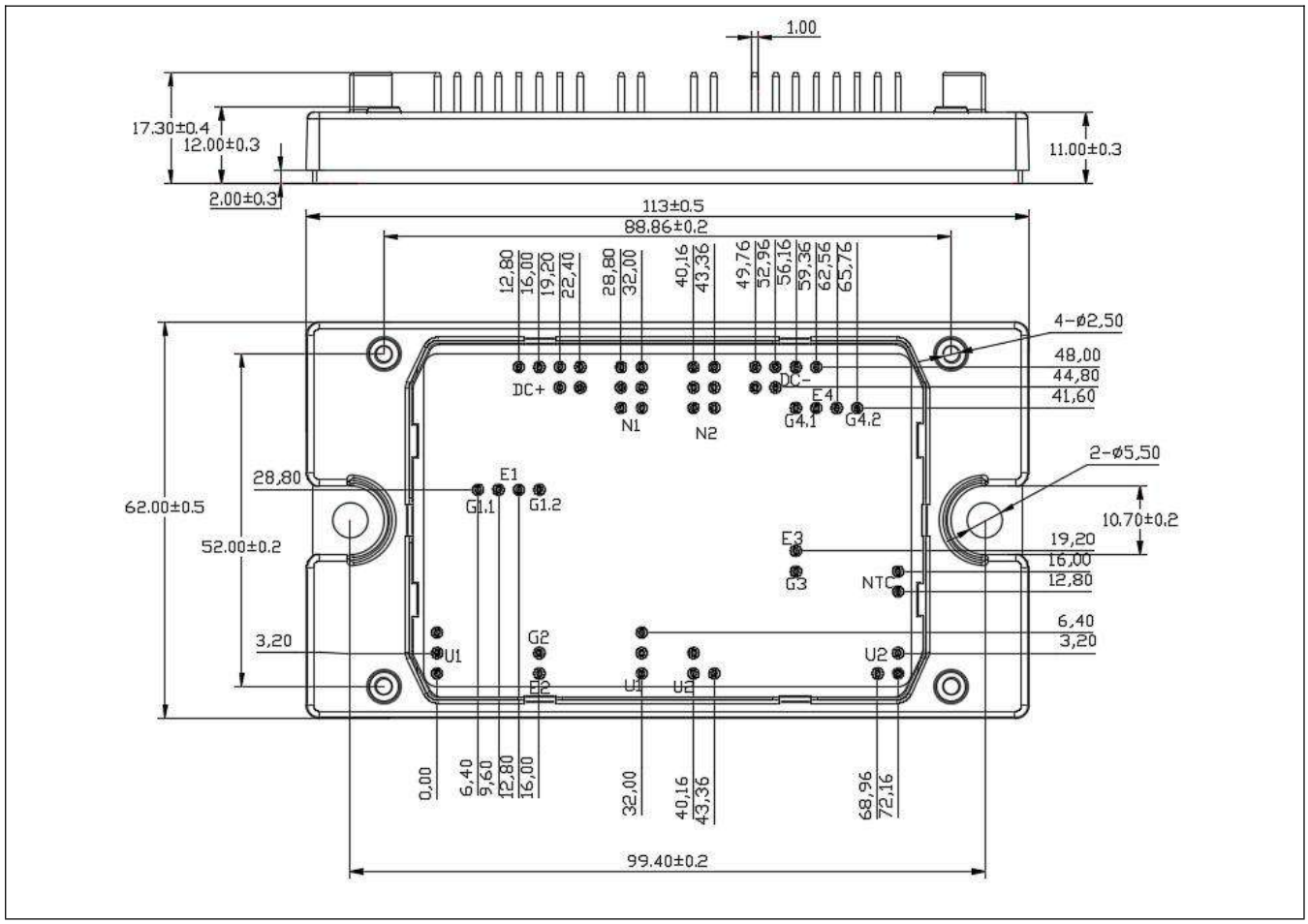
电路拓扑图/ Circuit Diagram



封装尺寸/ Package Outlines



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模块标签信息/ Module Marking Information

Marking Diagram
HCG450FL065E3RE = Specific Device
P4CQ22420010001 = Lot Traceability
ACP-E3 = Package Type

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   When the product is in use, it is strictly forbidden to touch the product. After power off, it is confirmed that there is no residual charge and the product has been completely cooled, and it can only be touched under electrostatic protection measures；

5. 购买产品时请认准我司商标，如有疑问请与本司联系。

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