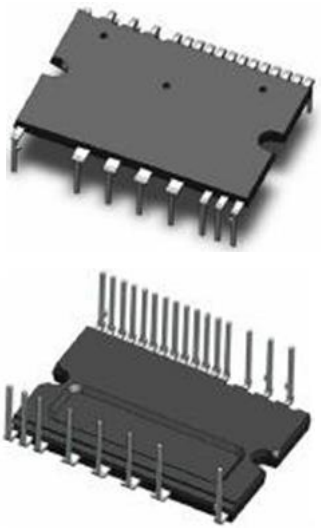
SPE06S60F-A

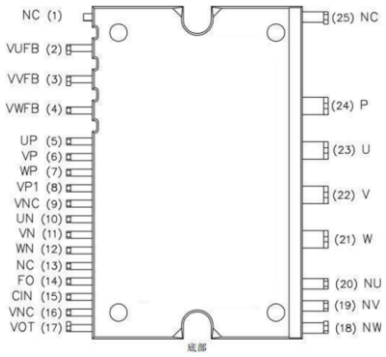
主要参数 MAIN CHARACTERISTICS

600V/6A IGBT 三相全桥智能功率模块	
V_{CES}	600V
± I_C	6A
± I_{CP}	12A

封装 Package



DIP25-FP



PIN1-PIN25

用途 APPLICATIONS

- 冰箱压缩机 • Refrigerator compressor
- 油烟机 • Lampblack machine
- 风扇 • Electric fan
- 空气净化器 • Air purifier
- 洗碗机水泵 • Dishwasher pump

产品特性

- 下臂 IGBT 发射极输出，内置自举二极管。
- 600V/6A 三相逆变器，内置低损耗沟道栅-场截止型 IGBT。
- IGBT 驱动：增强型输入滤波，上下臂互锁，高速 600V 电平转换，电源欠压保护，短路（过流）保护。
- 故障信号：对应于短路（过流）和 VP1 电源欠压故障。
- 输入接口：兼容 3.3V &5V 输入信号，高电平有效。
- 温度检测：负温度系数热敏电阻检测输出。

FEATURES

- Lower arm IGBT emitter output, built-in bootstrap diode.
- 600V/6A three-phase inverter with built-in low-loss trench gate-field stop IGBT.
- IGBT drive: enhanced input filtering, interlocking of upper and lower arms, high-speed 600V level conversion, power supply undervoltage protection, short circuit (overcurrent) protection.
- Fault signal: corresponds to short cir cuit (overcurrent) and VP1 power undervoltage fault.
- Input interface: compatible with 3.3V&5V input signals, high level effective.
- Temperature detection: negative temperature coefficient thermistor detection output.

订货信息 ORDER MESSAGE

订 货 料 号 Order number	产 品 信 息 Product information			
	无卤-条管 Halogen-Free-Tube	无卤-编带 Halogen-Free-Reel	印 记 Marking	封 装 Package
2A01-0355-16	SPE06S60F-A	N/A	SPE06S60F-A	DIP25-FP

模块示意图 **Module diagram**

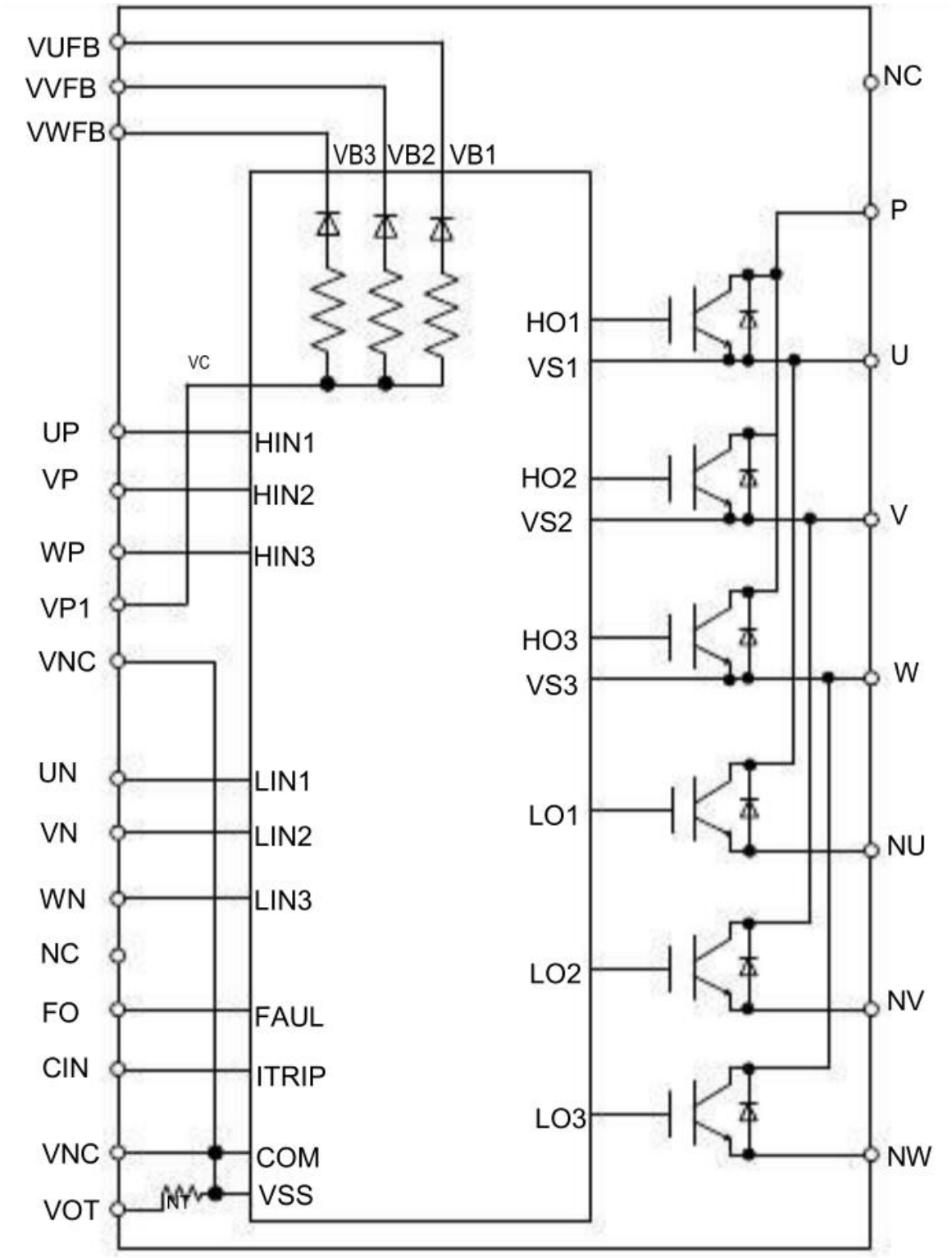


图 1：模块内部电路示意图

Fig 1: Internal circuit

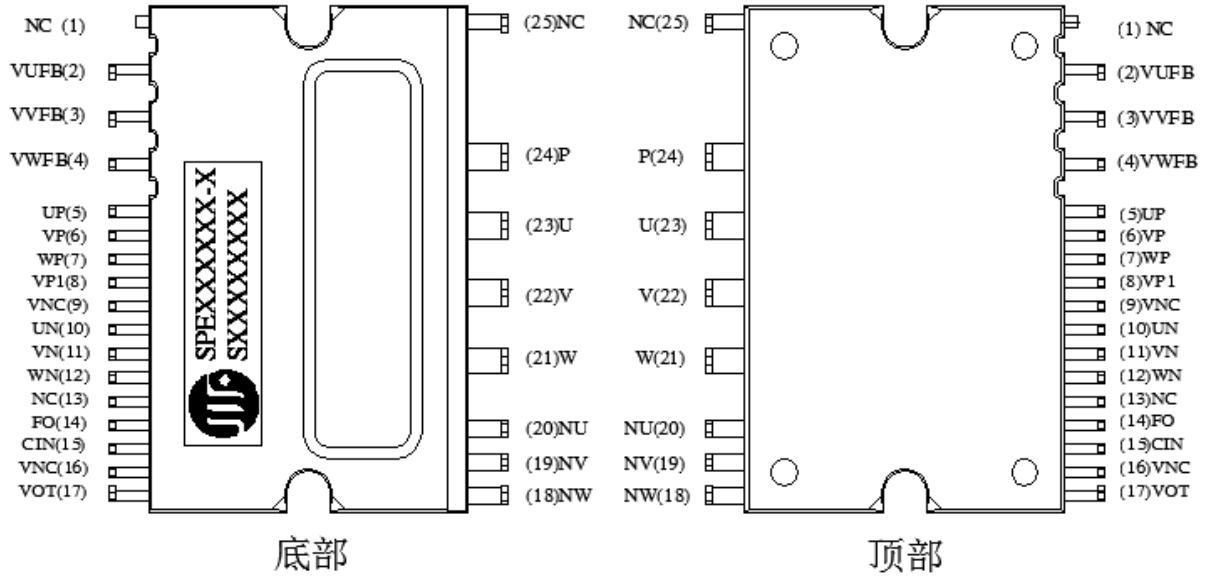


图 2：模块引脚分布示意图

Fig 2: Distribution of pin

管脚编号 Pin Number	管脚名称 Pin Names	管脚描述 Pin Description
1	NC	无连接 connectionless
2	VUFB	U 相上臂驱动电源端子 U-phase upper arm drive power terminal
3	VVFB	V 相上臂驱动电源端子 V phase upper arm drive power terminal
4	VWFB	W 相上臂驱动电源端子 W phase upper arm drive power terminal
5	UP	U 相上臂控制信号输入端子 U-phase upper arm control signal input terminal
6	VP	V 相上臂控制信号输入端子 V phase upper arm control signal input terminal
7	WP	W 相上臂控制信号输入端子 W phase upper arm control signal input terminal
8	VP1	控制电源端子 Control power terminal
9	VNC	控制电源 GND 端子 Control power GND terminal
10	UN	U 相下臂控制信号输入端子 U-phase lower arm control signal input terminal
11	VN	V 相下臂控制信号输入端子 V phase lower arm control signal input terminal
12	WN	W 相下臂控制信号输入端子 W phase lower arm control signal input terminal
13	NC	无连接 connectionless
14	FO	故障输出端子 Fault output terminal
15	CIN	短路保护触发电压检测端子 Short circuit protection trigger voltage detection terminal

16	VNC	控制电源 GND 端子 Control power GND terminal
17	VOT	温度检测输出端子 Temperature detection output terminal
18	NW	W 相下臂 IGBT 发射极端子 W phase lower arm IGBT emitter terminal
19	NV	V 相下臂 IGBT 发射极端子 V phase lower arm IGBT emitter terminal
20	NU	U 相下臂 IGBT 发射极端子 U phase lower arm IGBT emitter terminal
21	W	W 相输出端子 W phase output terminal
22	V	V 相输出端子 V phase output terminal
23	U	U 相输出端子 U phase output terminal
24	P	逆变器直流输入端子 Dc input terminal of inverter
25	NC	无连接 connectionless

图 3：模块引脚功能定义表

Fig 3: Pin function

最大额定值 (T_j= 25℃,除非特殊说明）

Absolute Maximum Ratings （T_j= 25℃, Unless otherwise Specified）

逆变部分 Inverter Part

记号 Mark	项目 Project	条件 Condition	额定值 Ratings	单位 Units
V_{CC}	电源电压 supply voltage	应用于 P- NU, NV, NW 之间 It applies between p-nu, NV, and NW	450	V
VCC(Surge)	电源电压（含浪涌） Supply voltage (including surge)	应用于 P- NU, NV, NW 之间 It applies between p-nu, NV, and NW	500	V
V_{CES}	集电极-发射极间电压 Collector to emitter voltage	/	600	V
± I_C	集电极电流 Collector current	T_C = 25°C（Tc 测试方法见图 4） TC = 25°C (see Figure 4 for Tc test method)	6	A
± I_{CP}	集电极电流（峰值） Collector current (peak)	T_C= 25°C, 脉冲宽度小于 1ms TC = 25°C, pulse width is less than 1ms	12	A
P_C	集电极功耗 Collector power consumption	T_C = 25°C，单晶片 TC = 25°C, single chip	23	W
Tj	结温 Junction temperature	(见备注 1) (See note 1)	-40~+150	°C

备注 1：IPM 功率晶片最大额定结温为 150°C(@表面温度 T_C≤ 100°C)。然而,为了确保 IPM 运行安全，结温应限定于 Tj(av) ≤ 125°C (@表面温度 Tc ≤ 100°C)。

Remark 1: The maximum rated junction temperature of the IPM power chip is 150°C (@surface temperature TC≤ 100°C). However, to ensure safe operation of the IPM, the junction temperature should be limited to Tj(av) ≤ 125°C (@surface

temperature Tc ≤ 100°C).

控制部分 Control Part

记号 Mark	项目 Project	条件 Condition	额定值 Ratings	单位 Units
VDB	上桥臂控制电源电压 Upper arm control supply voltage	应用于 UFB – U, VFB-V, WFB-W 之间 Applied between UFB-U, VFB-V, WFB-W	17.5	V
VD	控制电源电压 Control supply voltage	应用于 VP1 – VNC 之间 Applied between VP1-VNC	17.5	V
VIN	输入信号电压 Input signal voltage	应用于 UP, VP, WP, UN ,VN ,WN-VNC之间 Applied between UP, VP, WP, UN, VN, WN-VNC	-1~10	V
VFO	故障输出电压 Fault output voltage	应用于 FO – V_{NC} 之间 Applied between FO-VNC	-0.5~VD+0.5	V
IFO	故障输出电流 Fault output current	FO 端子吸入电流值 FO terminal sink current value	1.5	mA
VSC	电流检测端输入电压 Input voltage of current detection terminal	应用于 CIN – V_{NC} 之间 Applied between CIN-VNC	-0.5~VD+0.5	V

整个系统 Total System

记号 Mark	项目 Project	条件 Condition	额定值 Ratings	单位 Units
VCC(PROT)	电源电压自己保护范围（短路） Power supply voltage self-protection range (short circuit)	V_D = V_{DB} = 13.5 ~ 16.5V Tj= 150°C, 无重复, 时间小于 2us Tj = 150°C, no repetition, time is less than 2us	400	V
Tc	模块正常工作壳体温度 Module working temperature	-20℃≤Tj ≤150°C	-20 ~ +100	°C
Tstg	贮存温度 Storage temperature	/	-40 ~ +125	°C
Viso	绝缘耐压 Insulation withstand voltage	正弦波60Hz，AC 1分钟，在插脚和散热片之间 Sine wave 60Hz, AC for 1 minute, between pin and heat sink	1500	Vrms

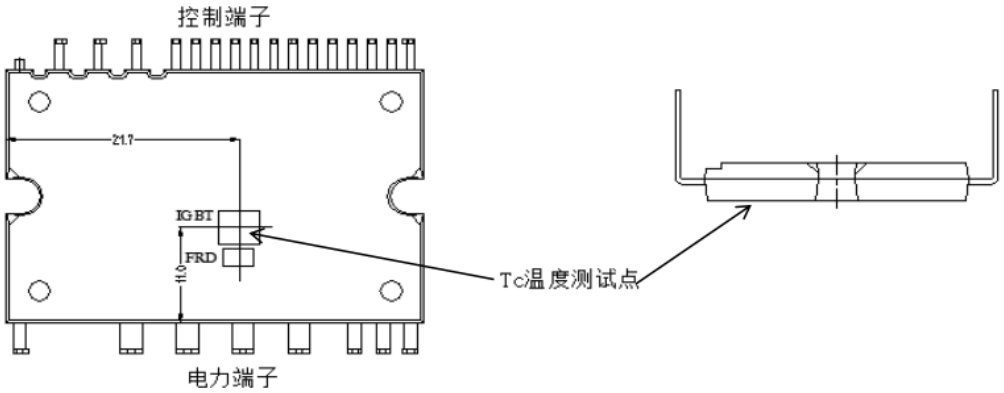


图 4：壳温 Tc 测试点

Fig 4：Case Temperature Measurement

热阻 Thermal Resistance

记号 Mark	项目 Project	条件 Condition	最小值 Min.	典型值 Typ.	最大值 Max.	单位 Unit
Rth(j-c)Q	结点到壳的热阻 Junction to case thermal resistance	单个 IGBT 元件 Single IGBT element	-	-	5.5	°C/W
Rth(j-c)F		单个 FRD 元件 Single FRD element	-	-	6.2	°C/W

电气特性 (Tj=25℃，除非特殊说明)

Electrical Characteristics (TJ=25℃, Unless Otherwise Specified)

逆变部分 Inverter Part

记号 Mark	项目 Project	条件 Condition	最小值 Min.	典型值 Typ.	最大值 Max.	单位 Unit
$V_{CE(sat)}$	集电极与发射极间饱和电压 Saturation voltage between collector and emitter	$V_D = V_{DB}$ = 15V V_{IN} = 5V, I_C =6A, Tj= 25°C	-	1.6	2.2	V
		$V_D = V_{DB}$ = 15V V_{IN} = 5V, IC =6A, Tj= 125°C	-	1.85	-	V
V_F	FWD 正向导通电压 FWD forward voltage	V_{IN} = 0V，I_C =-6A, Tj = 25°C		1.4	2.1	V
t_{ON}	开关时间（备注 2） Switching time (Note 2)	V_{CC} = 300V, $V_D = V_{DB}$ = 15V, I_C =6A V_{IN} = 0V-5V，感性负载	-	620	-	nS
$t_{C(ON)}$			-	95	-	nS
t_{OFF}			-	700	-	nS
$t_{C(OFF)}$			-	70	-	nS
t_{rr}			-	95	-	nS
E_{on}	开通损耗 Turn-on loss	I_C = 6A，V_{CC} = 400V，V_D = V_{DB}= 15V，L=1mH，Tj= 25°C	-	42	92	uJ
E_{off}	关断损耗 Turn-off loss		-	90	142	uJ

I_{CES}	集电极到发射极漏电流 Collector to emitter leakage current	V_{CE}= V_{CES} Tj= 25°C	-	-	75	uA
		V_{CE}= V_{CES} Tj= 125°C	-	-	1	mA

备注 2：t_{ON} 和 t_{OFF} 包括驱动 IC 内部传输延迟时间。 $t_{C(ON)}$ 和 $t_{C(OFF)}$ 是 IGBT 自身被内部给定门极驱动条件下的开关时间。详见图 5。

Remark 2: t_{ON} and t_{OFF} include the internal transmission delay time of the driver IC. $t_{C(ON)}$ and $t_{C(OFF)}$ are the switching times of the IGBT itself driven by the internally given gate. See Figure 5 for details.

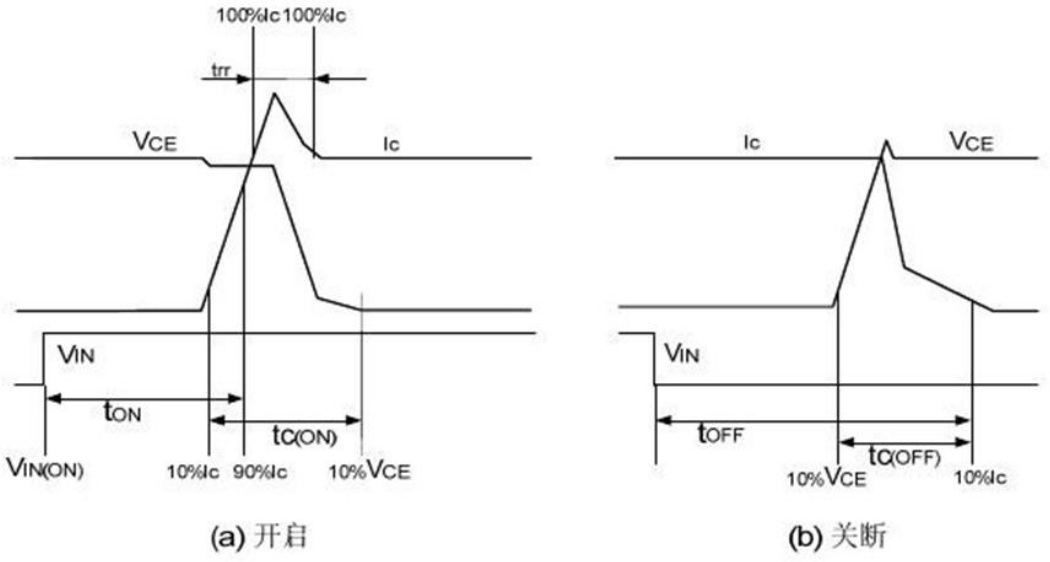


图 5：开关时间定义

Fig 5: Switching Time Definition

控制部分 Control Part

记号 Mark	项目 Project	条件 Condition		最小值 Min.	典型值 Typ.	最大值 Max.	单位 Unit
ID	VD 静态电流 VD Quiescent Current	VD = 15V VIN = 5V	VP1-VNC	-	0.35	1	mA
IDB	VDB 静态电流 VDB Quiescent Current	VDB = 15V VIN = 5V	UFB - U, VFB - V, WFB - W	-	300	550	uA
V_{FOH}	故障输出电压 Fault output voltage	Vsc = 0V, FO 脚通过 10K 电阻上拉至5V Vsc = 0V, FO pin is pulled up to 5V through 10K resistor		4.6	-	-	V
V_{FOL}		Vsc =1V, I_{FO}=1.5mA		-	-	0.3	V
Vsc,TH+	短路正向触发阈值 Short circuit forward trigger threshold	V_D = 15V		0.37	0.47	0.65	V
Vsc,TH-	短路负向触发阈值 Short circuit negative trigger threshold	V_D= 15V		0.2	0.4	-	V
UV_{DD}	电源欠压保护控制	触发电平 Trigger level		9.5	10.4	11.0	V

UV_{DR}	Power undervoltage protection contro	复位电平 Reset level	11.0	12.1	12.8	
UVDBD		触发电平 Trigger level	9.5	10.4	11.0	
UVDBR		复位电平 Reset level	11.0	12.1	12.8	
Ron,FLT	故障低有效阻抗 Fault low effective impedance	I=1.5mA		50	90	ohm
T_{FO}	故障输出脉冲宽度 Fault output pulse width	-	40	76	120	uS
tFIL,IN	输入信号滤过时间 (UP/VP/WP, UN/VN/WN) Input signal filtering time	V_{IN} = 0 V & 5 V	140	290		nS
tCINMIN	CIN 输入信号滤过时间 CIN input signal filtering time	V_{IN} = 0 V or 5 V,V_{CIN} = 5 V	270	530	780	nS
VIN(ON)	开启阈值电压 Turn on threshold voltage	应用于 UP,VP,WP,UN,VN,WN 和 VNC之间 Applied between UP, VP, WP, UN, VN, WN and VNC	1.6	2.1	2.5	V
VIN(OFF)	关断阈值电压 Turn-off threshold voltage		0.8	0.94	1.2	
VOT	温度输出，备注 3 Temperature output, remark 3	Tc=90℃	1.53	1.59	1.65	V
		Tc=25℃	4.15	4.17	4.19	
V_F	BSD 正向电压 BSD forward voltage	I_F=10mA 包含电压 I_F=10mA Including voltage	-	3.25	5	V
R_{BSD}	BSD限流电阻 BSD current limiting resistor	VF1=4V, VF2=5V	18	30	42	ohm

备注 3：当温度达到极限时，IPM 不能自动够关闭 IGBT 和输出故障信号。当温度超出使用者定义的限定值时，应使用控制器（单片机）关闭 IPM。IPM 的 VOT 输出特性曲线请参考图 6，图 6 曲线是以 20K 上拉电阻测试结果。

Remark 3: When the temperature reaches the limit, the IPM cannot automatically turn off the IGBT and output a fault signal. When the temperature exceeds the user-defined limit value, the controller (microcontroller) should be used to turn off the IPM. Please refer to Figure 6 for the VOT output characteristic curve of IPM. The curve in Figure 6 is the test result of 20K pull-up resistor.

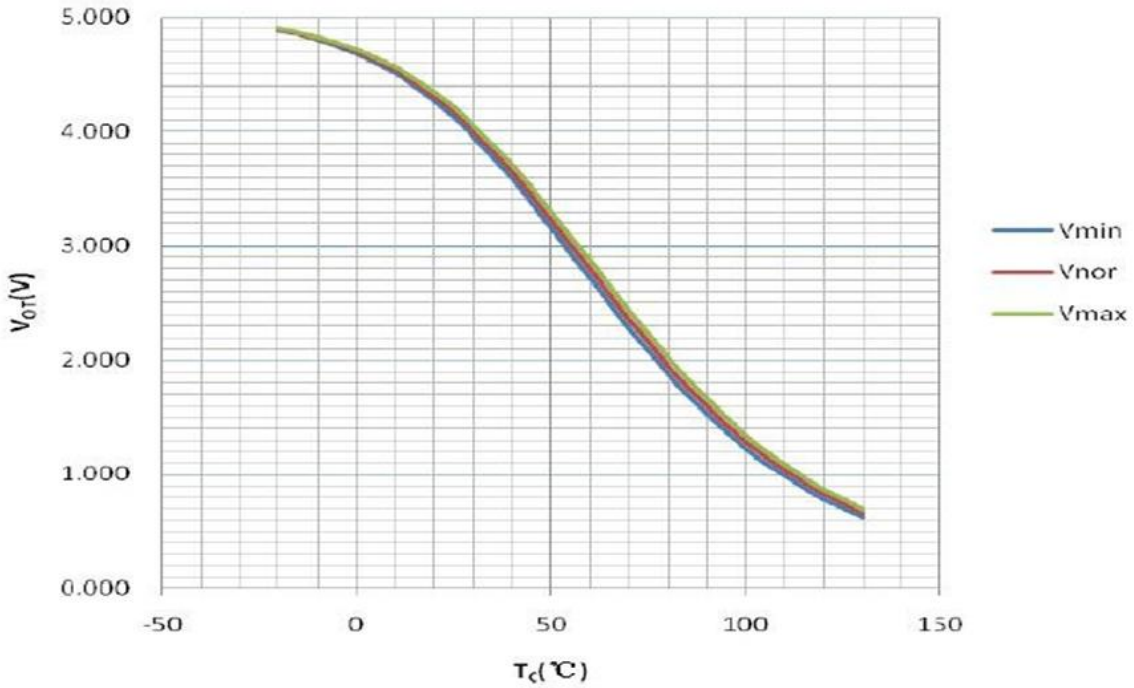


图 6：VOT 输出电压曲线

Figure 6: VOT output voltage curve

推荐工作条件 Recommended Operating Conditions

记号 Mark	项目 Project	条件 Condition	最小值 Min.	典型值 Typ.	最大值 Max.	单位 Unit
Vcc	电源电压 voltage	应用于 P – NU, NV, NW 之间 Applied between P – NU, NV, NW	0	300	400	V
VD	控制电源电压 Control supply voltage	应用于 VP1 – VNC 之间 Applied between VP1-VNC	-	15	-	V
VDS	上臂控制电源电压 Upper arm control power supply voltage	应用于 VUFB – U, VVFB – V, VWFB-W 之间 Applied between VUFB-U, VVFB-V, VWFB-W	-	15	-	V
tdead	死区时间 Dead time	各桥臂输入对应, Tc<=100℃ Corresponding to the input of each bridge arm, Tc<=100℃	1	-	-	us
fPWM	PWM 频率 PWM frequency	-20℃≤Tc ≤+100℃ -20℃≤Tj≤+150℃	-	-	20	kHz
PWM	最小输入信号脉冲宽度 Minimum input signal pulse width	ON	0.7	-	-	us
		OFF	0.7	-	-	us
Tj	结温 Junction temperature	-	-20	-	125	℃

内部 NTC –热阻特性 Internal NTC-thermal resistance characteristics

记号 Mark	项目 Project	条件 Condition	最小值 Min.	典型值 Typ.	最大值 Max.	单位 Unit
RNTC	热敏电阻 Thermistor	TNTC = 25°C	97	100	103	Kohm
		TNTC = 125°C	3.25	3.46	3.69	Kohm
温度范围 temperature range			-40	-	+125	°C

机械特性 Mechanical properties

项目 Project	条件 Condition	最小值 Min.	典型值 Typ.	最大值 Max.	单位 Unit
安装扭矩 Installation torque	螺丝钉尺寸：M3 Screw size: M3	-	0.69	-	N·m
设计平面度 Design flatness	见图 7 Figure 7	-50	-	+120	um
重量 weight	-	-	7	-	g

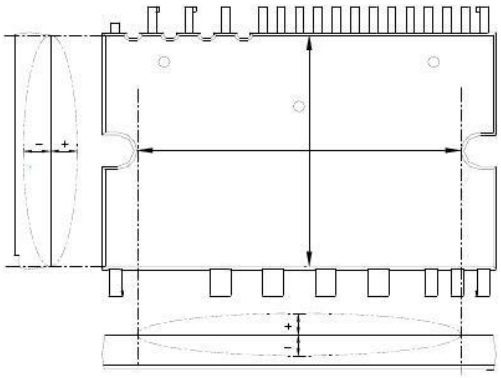


图 7：平面度检测位置

Figure 7: Flatness detection position

应用指南 Application Guide

增强型输入滤波 Enhanced input filtering

增强型滤波器能够改善 HVIC 内部模块的输入/输出脉冲的一致性及有助于滤除尖峰干扰信号和窄脉冲，如下图 8 和图 9 是经典型输入滤波器和增强型输入滤波器演示图。

The enhanced filter can improve the consistency of the input/output pulses of the internal modules of the HVIC and help to filter out the peak interference signals and narrow pulses, as shown in Figures 8 and 9 below are the classic input filter and enhanced input filter demonstration diagram.

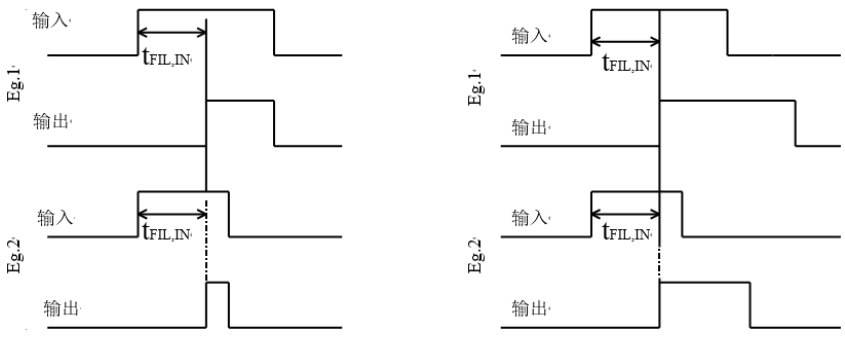


图 8：典型输入滤波　　图 9：增强型输入滤波

Figure 8: Typical input filtering Figure　　9: Enhanced input filtering

保护功能时序图　Timing diagram of protection function

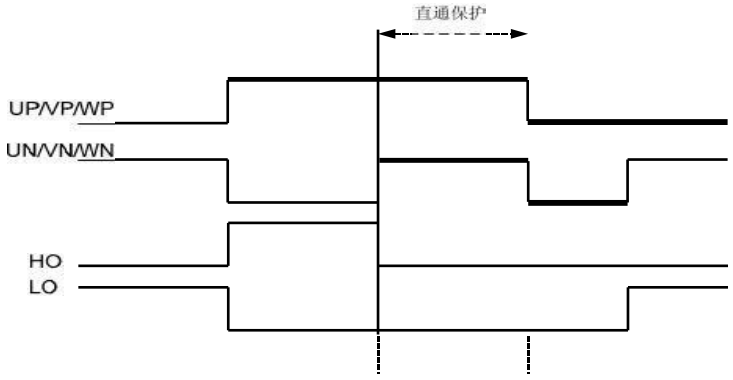


图 10：直通保护

Figure 10: Pass-through protection

备注 4：HO 和 LO 为内部 HVIC 门极输出信号。

Note 4: HO and LO are internal HVIC gate output signals.

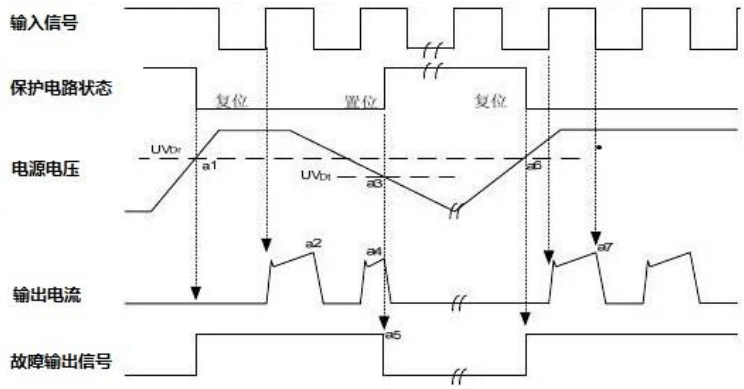


图 11：欠压保护时序图(低侧)

Figure 11: Timing diagram of undervoltage protection (low side)

a1: 电源电压上升：当该电压上升到欠压恢复点，在下一个欠压信号被执行前该线路将启动运行。

a1: ower supply voltage rise: When the voltage rises to the undervoltage recovery point, the line will start running before the next undervoltage signal is executed.

a2: 正常运行: IGBT 开启并加载电流。

a2: Normal operation: IGBT turns on and loads current.

a3: 欠压检测点(UVDt)。

a3: Undervoltage detection point (UVDt).

a4: 不管输入是什么信号，IGBT 都是关闭状态。
a4: No matter what signal is input, the IGBT is off.
a5: 故障输出开启。
a5: Fault output is on.
a6: 欠压恢复(UVDr)。
a6: Undervoltage recovery (UVDr).
a7: 正常运行: IGBT 导通并加载负载电流。
a7: Normal operation: IGBT is turned on and load current is loaded.

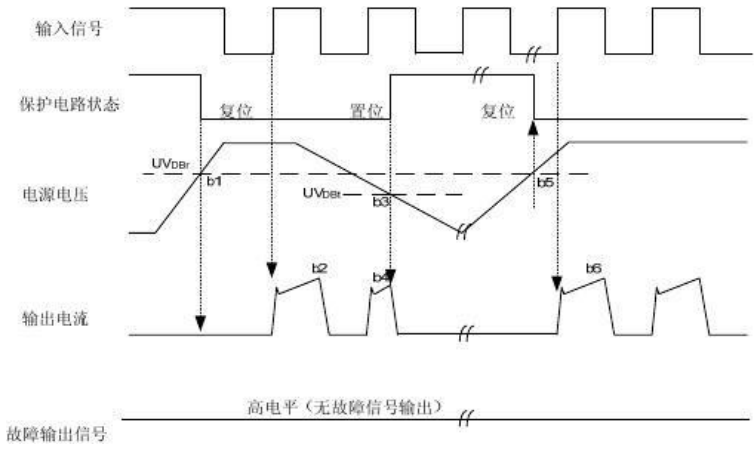


图 12：欠压保护时序图 (高侧)
Figure 12: Timing diagram of undervoltage protection (high side)

b1：电源电压上升：当该电压上升到欠压恢复点，在下一个欠压信号被执行前该线路将启动运行。
b1: Power supply voltage rise: When the voltage rises to the undervoltage recovery point, the line will start running before the next undervoltage signal is executed.
b2：正常运行: IGBT 导通并加载负载电流。
b2: Normal operation: IGBT is turned on and load current is applied.
b3：欠压检测 (UVDBt)。
b3: Undervoltage detection (UVDBt).
b4：不管输入是什么信号，IGBT 都是关闭状态。
b4: No matter what signal is input, IGBT is off.
b5：欠压恢复(UVDBr)。
b5: Undervoltage recovery (UVDBr).
b6：正常运行: IGBT 导通并加载负载电流。
b6: Normal operation: IGBT is turned on and load current is applied.

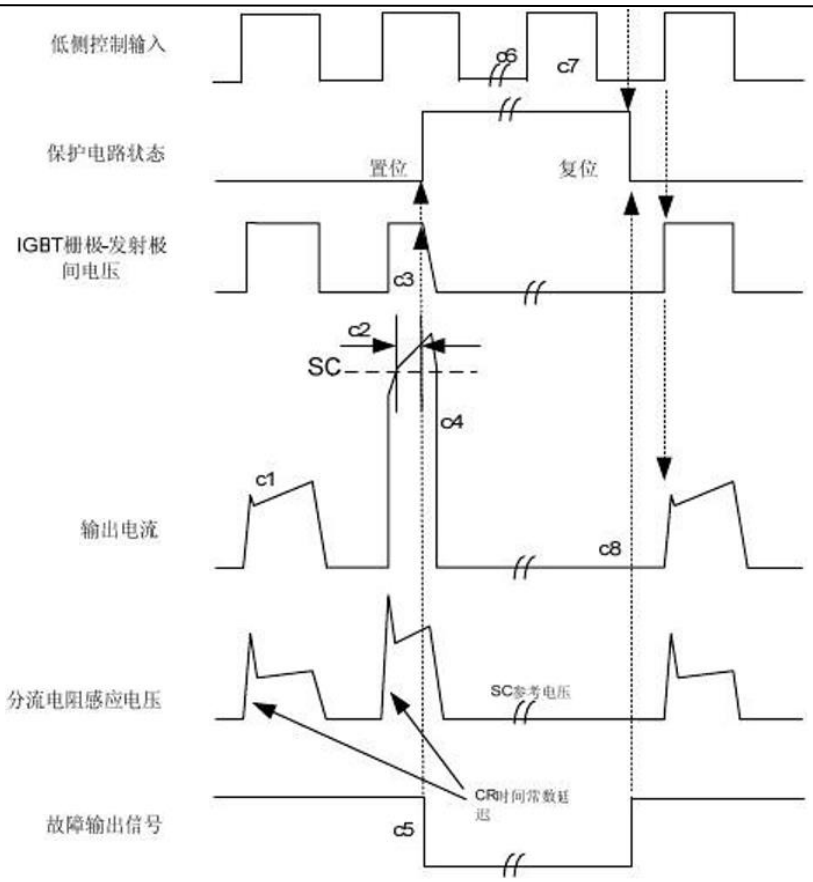


图 13：短路电流保护时序图（只适合于低侧）

(通过外部分流电阻连接)

Figure 13: Timing diagram of short-circuit current protection (only suitable for low side)

(Connected via external shunt resistor)

c1: 正常运行: IGBT 导通载流。

c1: Normal operation: IGBT conducting current.

c2: 短路电流检测（CIN 触发器）。

c2: Short-circuit current detection (CIN trigger).

c3: IGBT 门极被强制关断.

c3: IGBT gate is forcibly turned off. c4: IGBT is turned off.

c4 : IGBT 关断。

c4: IGBT is turned off.

c5: 故障输出定时器开始运行: 故障输出信号的脉冲宽度是由外部电容 CFO 设定。

c5: The fault output timer starts to run: The pulse width of the fault output signal is set by the external capacitor CFO.

c6: 输入“L” : IGBT 关闭。

c6: Input "L": IGBT is off.

c7: 输入 “H”: IGBT 开通，但是故障信号作用期间， IGBT 不导通。

c7: Input "H": The IGBT is turned on, but the IGBT is not turned on during the fault signal.

c8: IGBT 关断。

c8: IGBT is turned off.

输入/输出接口电路　Input/output interface circuit

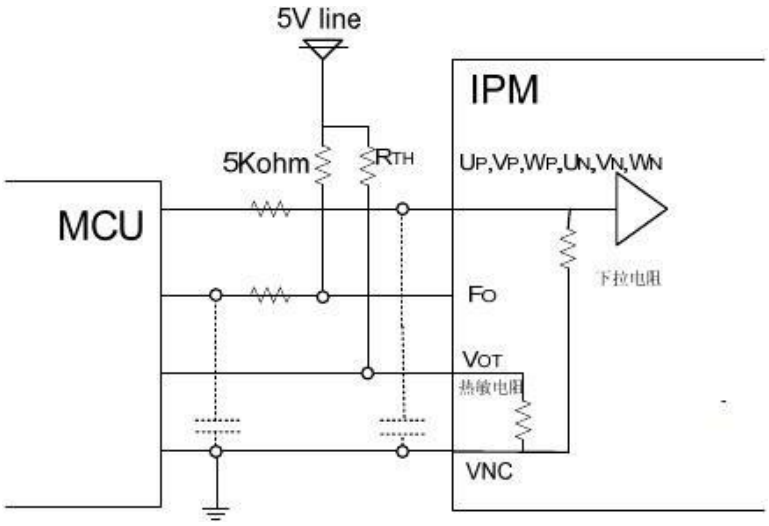


图 14：推荐的 MCU 输入输出接口电路

Figure 14: Recommended MCU input and output interface circuit

备注 5：由于 PWM 的控制方式和实际应用电路的阻抗及线路板的阻抗，RC 去耦可能会有变化。

Note 5: Due to the PWM control method and the impedance of the actual application circuit and the impedance of the circuit board, RC decoupling may change.

备注 6：逻辑输入要和标准的 CMOS 或 LSTTL 输出相匹配。

Note 6: The logic input must match the standard CMOS or LSTTL output.

分流电阻接线　Shunt resistor wiring

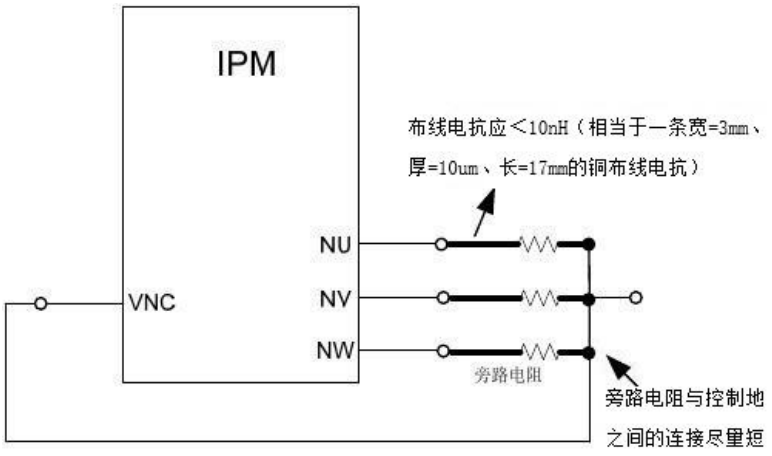


图 15：旁路电阻接线注意事项

Figure 15: Precautions for bypass resistance wiring

典型应用电路图　Typical application circuit diagram

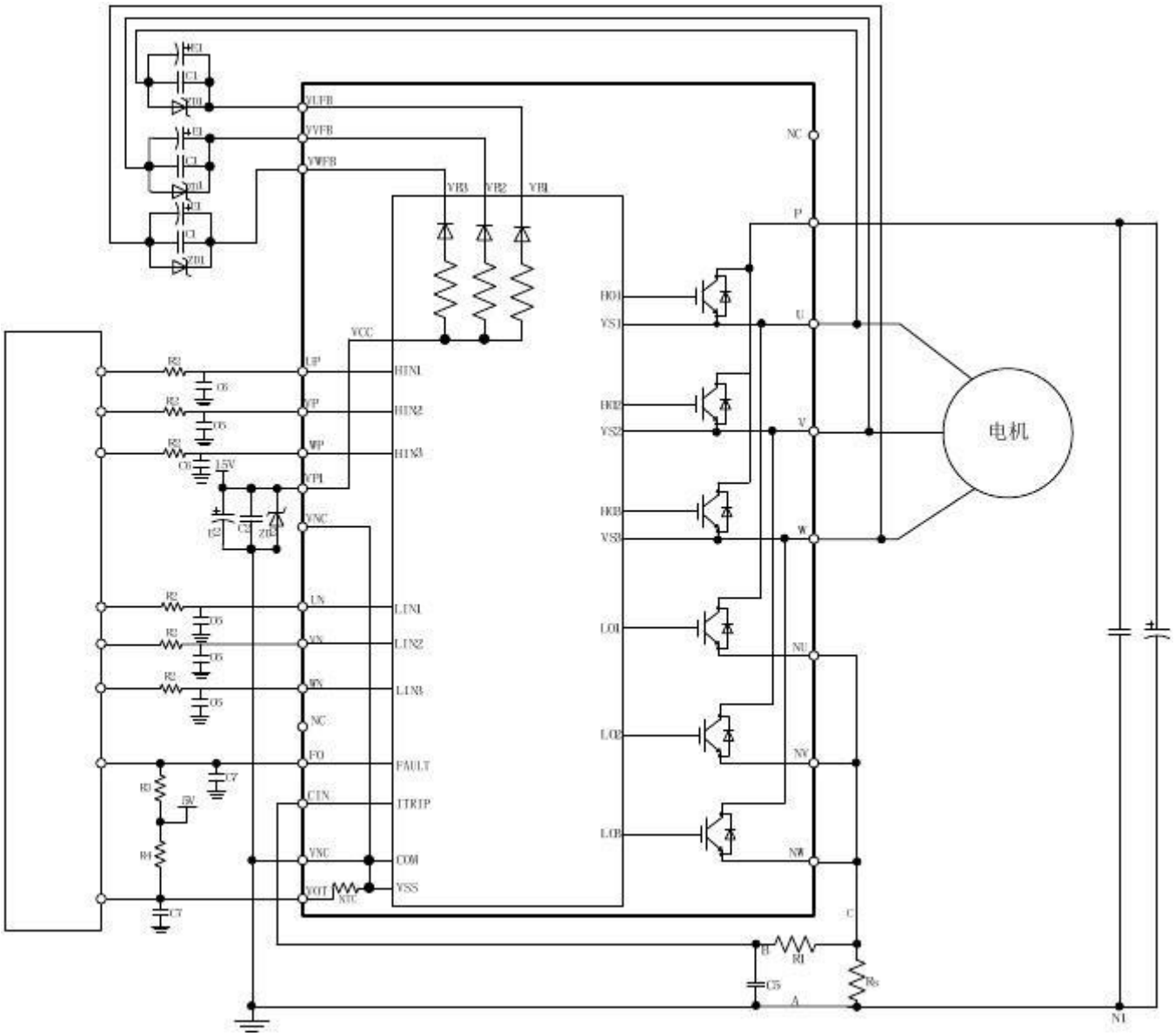


图 16：典型应用电路

Figure 16: Typical application circuit

备注 7：输入驱动高有效；IC 内部集成有一个 5kΩ(典型值)下拉电阻；为防止发生误动作，输入布线应尽可能短；当用 RC 去耦线路时，须确保输入信号达到开启和关断阈值电压范围。

Remark 7: The input drive is highly effective; a 5kΩ (typical value) pull-down resistor is integrated inside the IC; in order to prevent malfunctions, the input wiring should be as short as possible; when using RC decoupling lines, make sure that the input signal reaches on and off Threshold voltage range.

备注 8：由于模块内置了专用 HVIC，其控制端子可与 CPU 端子直接相连，而不需要任何光耦或变压器等隔离电路。

Remark 8: Since the module has a built-in dedicated HVIC, its control terminal can be directly connected to the CPU terminal without any isolation circuit such as optocoupler or transformer.

备注 9：自举电路负极应直接连接到 U、V、W 的端。
Remark 9: The negative pole of the bootstrap circuit should be directly connected to the U, V, W terminals.

备注 10：FO 是漏极开路型，其信号线应通过一个约 10kΩ 的上拉电阻上拉到+5V/3.3V 电源。
Remark 10: FO is an open-drain type, and its signal line should be pulled up to a +5V/3.3V power supply through a pull-up resistor of about 10kΩ.

备注 11：为防止误保护，A、B、C 连线应尽可能短。
Note 11: To prevent false protection, the A, B, and C wiring should be as short as possible.

备注 12：保护线路 R1、C5 的时间常数建议选取在 1~2uS。关断时间可能随着布线的不同而多少有些变化。建议 R1、C5 选择小容差，温度补偿类型。
Remark 12: The time constant of protection lines R1 and C5 is recommended to be 1~2uS. The turn-off time may vary somewhat depending on the wiring. It is recommended that R1 and C5 choose small tolerance and temperature compensation type.

备注 13：所有电容的位置尽可能的靠近 IPM。
Remark 13: Position all capacitors as close to IPM as possible.

备注 14：为了防止噪声干扰，储能电容与 P&N1 之间的引线应尽可能的短，推荐在 P&N1 端子之间加约 0.1～0.22uF 的 MLCC 低频滤波电容。
Note 14: In order to prevent noise interference, the lead between the storage capacitor and P&N1 should be as short as possible. It is recommended to add about 0.1～0.22uF of MLCC low-frequency filter capacitor between P&N1 terminals.

备注 15：两个 VNC 端（9&16 脚）在 IPM 内部已连接在一起，外部任一 VNC 端子连接到 GND，另一端子允许开路。
Remark 15: The two VNC terminals (pins 9 & 16) are connected together inside the IPM, any external VNC terminal is connected to GND, and the other terminal is allowed to open.

备注 16：如果控制地通过 PCB 走线被连接到功率地，控制信号可能会受到功率地的起伏的影响，推荐使用单点连接。
Remark 16: If the control ground is connected to the power ground through PCB traces, the control signal may be affected by the fluctuation of the power ground. It is recommended to use a single point connection.

外形封装图 Outline package drawing

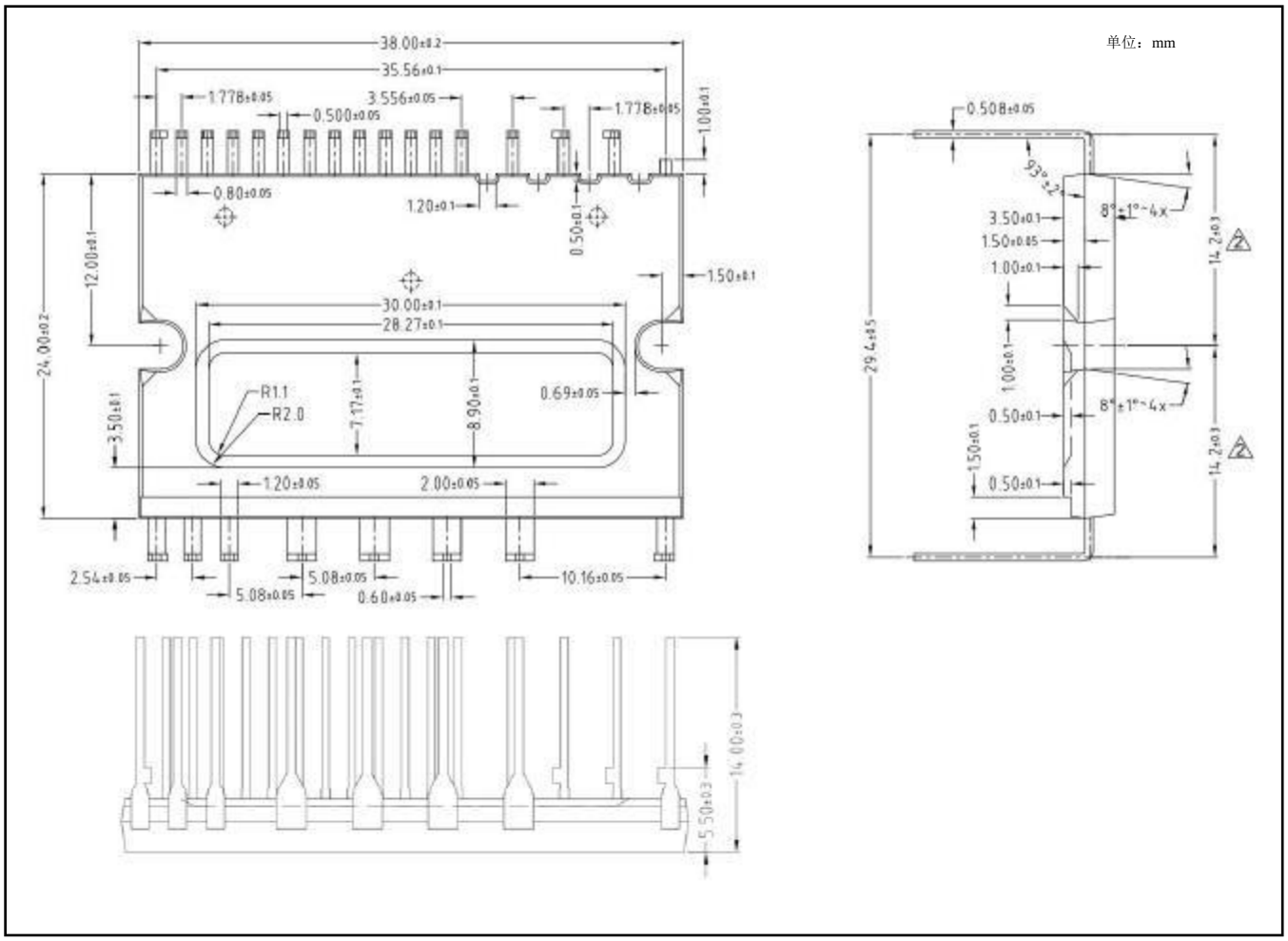


图 17：封装尺寸示意图

Figure 17: Schematic diagram of package size

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