

主要功能及额定参数:

- 600V/15A 三相逆变器
- 内置低损耗沟道栅-场截止型 IGBT
- 下臂 IGBT 发射极输出
- 内置自举二极管

应用:

- 冰箱压缩机
- 油烟机
- 风扇
- 空气净化器
- 洗碗机水泵

特点:

- 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。

Main Function and Parameter:

- 600V/15A three-phase inverter
- Built-in low-loss trench-gate field-stop IGBT
- Open emitter type
- Built-in bootstrap diode

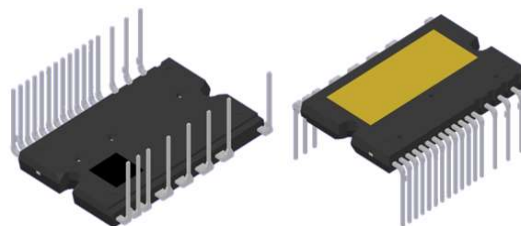
Application:

- Air Fan
- Range hoods
- Air purifier
- The dishwasher pump
- Freezer compressor

Features:

- IGBT Driver: Advanced input filter, Shoot through prevention, High voltage high-speed level shifting, Control supply under-voltage (UV) protection.
- Fault signaling : Corresponding to an SC fault (Upper&Lower-leg IGBT), a UV fault (Lower-side supply).
- Input/Output interface: 3.3V&5V input signal is compatible, high active .
- Temperature Detection: Negative temperature coefficient thermistor detection output

封装 Package



DIP25-CU

产品名称	封装形式	打印名称
SPE15S60F-E	DIP25-CU	SPE15S60F-E

订货信息 ORDER MESSAGE

订货型号 Order codes	印记 Marking	封装 Package	无卤素 Halogen Free	包装 Packaging	器件重量 Device Weight
SPE15S60F-E	SPE15S60F-E	DIP25-CU	否 NO	条管 Tube	

模块内部电路图 Internal Block Diagram

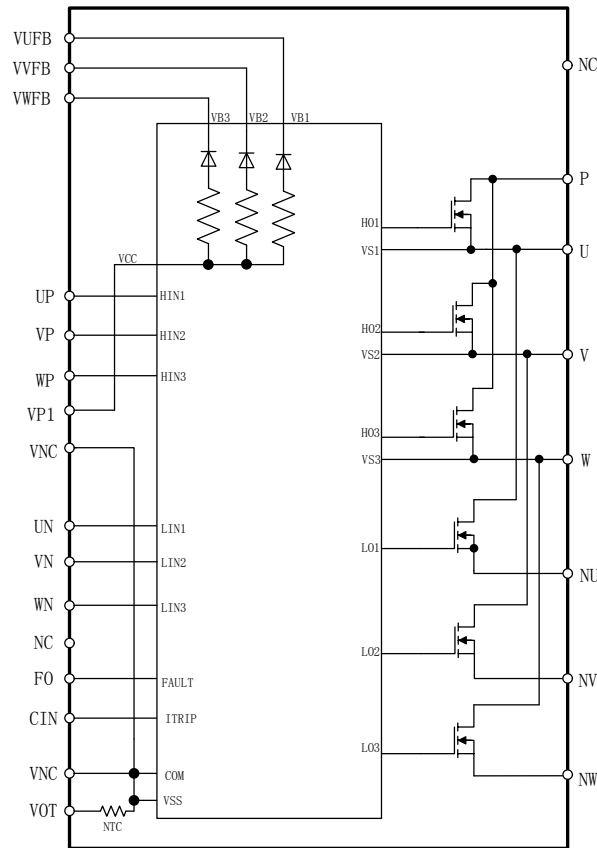


图 1: 内部电路图 Fig 1: Internal Block Diagram (Bottom View)

管脚说明 Pin configuration

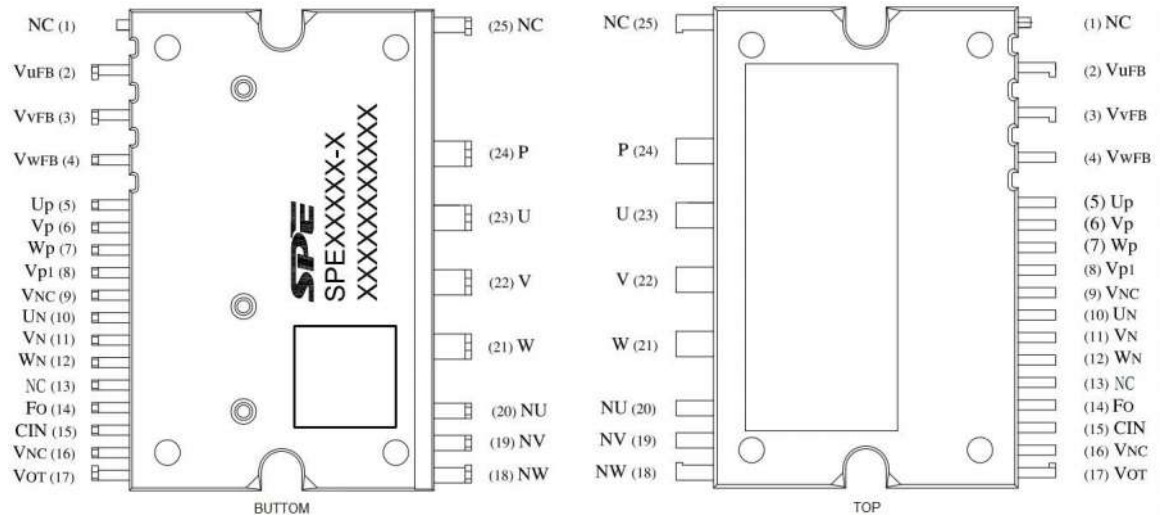


图 2: 引脚图 Fig 2: Pin figure

管脚描述 Pin Description

管脚编号 Pin Number	管脚名称 Pin Name	管脚描述 Pin Description
1	NC	无连接 No connection
2	VUFB	U 相上臂驱动电源端子 U-phase high side floating IC supply voltage
3	VVFB	V 相上臂驱动电源端子 V-phase high side floating IC supply voltage
4	VWFB	W 相上臂驱动电源端子 W-phase high side floating IC supply voltage
5	UP	U 相上臂控制信号输入端子 U-phase high side gate driver input
6	VP	V 相上臂控制信号输入端子 V-phase high side gate driver input
7	WP	W 相上臂控制信号输入端子 W-phase high side gate driver input
8	VP1	控制电源端子 IC supply voltage
9	VNC	控制电源 GND 端子 Common Supply Ground
10	UN	U 相下臂控制信号输入端子 U-phase low side gate driver input
11	VN	V 相下臂控制信号输入端子 V-phase low side gate driver input
12	WN	W 相下臂控制信号输入端子 W-phase low side gate driver input
13	NC	无连接 No connection
14	FO	故障输出端子 Fault output
15	CIN	短路保护触发电压检测端子 Analog input for over current shutdown
16	VNC	控制电源 GND 端子 Common Supply Ground
17	VOT	温度检测输出端子 Analog output for temperature monitor
18	NW	W 相下臂 MOSFET 源极端子 Negative DC-Link input for W-phase
19	NV	V 相下臂 MOSFET 源极端子 Negative DC-Link input for V-phase
20	NU	U 相下臂 MOSFET 源极端子 Negative DC-Link input for U-phase
21	W	W 相输出端子 Motor W-phase output
22	V	V 相输出端子 Motor V-phase output
23	U	U 相输出端子 Motor U-phase output
24	P	逆变器直流输入端子 Positive bus input voltage
25	NC	无连接 No connection

最大额定值 (T_j= 25°C,除非特殊说明)Absolute Maximum Ratings (T_j= 25°C, Unless Otherwise Specified)

逆变部分 Inverter Part

记号 Symbol	项目 Parameter	条件 Conditions	额定值 Ratings	单位 Unit
V _{CC}	电源电压 Supply Voltage	应用于 P- NU, NV, NW 之间 Applied between P- NU, NV, NW	450	V
V _{CC(Surge)}	电源电压 (含浪涌) Supply Voltage (Surge)	应用于 P- NU, NV, NW 之间 Applied between P- NU, NV, NW	500	V
V _{CES}	集电极-发射极间电压 Collector-emitter Voltage		600	V
± I _C	集电极电流	T _C = 25°C (T _C 测试方法见图 3)	15	A

	Each IGBT Collector Current	(T _c refer to Fig:3)		
$\pm I_{CP}$	集电极电流 (峰值) Each IGBT Collector Current (Peak)	T _c = 25°C, 脉冲宽度小于 1ms T _c = 25°C, less than 1ms	30	A
P _C	集电极功耗 Collector Dissipation	T _c = 25°C, 单晶片 T _c = 25°C, Per One Chip	39	W
T _j	结温 Operating Junction Temperature	(见备注 1) (NOTE 1)	-40~+150	°C

备注 1: IPM 功率芯片最大额定结温为 175°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 T_{j(av)} ≤ 150°C (@表面温度 T_c ≤ 100°C)。

NOTE 1: To insure safe operation of the IPM, the average junction temperature should be limited to T_{j(av)} ≤ 150°C (@T_c ≤ 100°C)。

控制部分 Control Part

记号 Symbol	项目 Parameter	条件 Conditions	额定值 Ratings	单位 Unit
V _{DB}	上桥臂控制电源电压 High side floating supply voltage	应用于 UFB – U, VFB-V, WFB-W 之间 Applied between UFB - U, VFB-V, WFB-W	17.5	V
V _D	控制电源电压 Low side supply voltage	应用于 VP1 – VNC 之间 Applied between VP1,VN1 - VNC	17.5	V
V _{IN}	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
V _{FO}	故障输出电压 Fault Output Supply Voltage	应用于 FO – V _{NC} 之间 Applied between FO - VNC	-0.5~VD+0.5	V
I _{FO}	故障输出电流 Fault Output Current	FO 端子吸入电流值 Sink Current at FO Pin	1.5	mA
V _{SC}	电流检测端输入电压 Current Sensing Input Voltage	应用于 CIN – V _{NC} 之间 Applied between CIN - VNC	-0.5~VD+0.5	V

全系统 Total System

记号 Symbol	项目 Parameter	条件 Conditions	额定值 Ratings	单位 Unit
V _{CC(PROT)}	电源电压自己保护范围 (短路) Self Protection Supply Voltage Limit (Short Circuit Protection Capability)	V _D = V _{DB} = 13.5 ~ 16.5V T _j = 150°C, 无重复, 时间小于 2us V _D = V _{DB} = 13.5 ~ 16.5V T _j = 125°C, Non-repetitive, less than 2u	400	V
T _c	模块正常工作壳体温度 Module Case Operation Temperature	-20°C ≤ T _j ≤ 150°C	-20 ~ +100	°C

Tstg	贮存温度 Storage Temperature		-40 ~ +125	°C
Viso	绝缘耐压 Isolation Voltage	正弦波60Hz, AC 1分钟, 在插脚和散热片之间60Hz, Sinusoidal, AC 1 minute, between pins and heat-sink plate	2500	Vrms

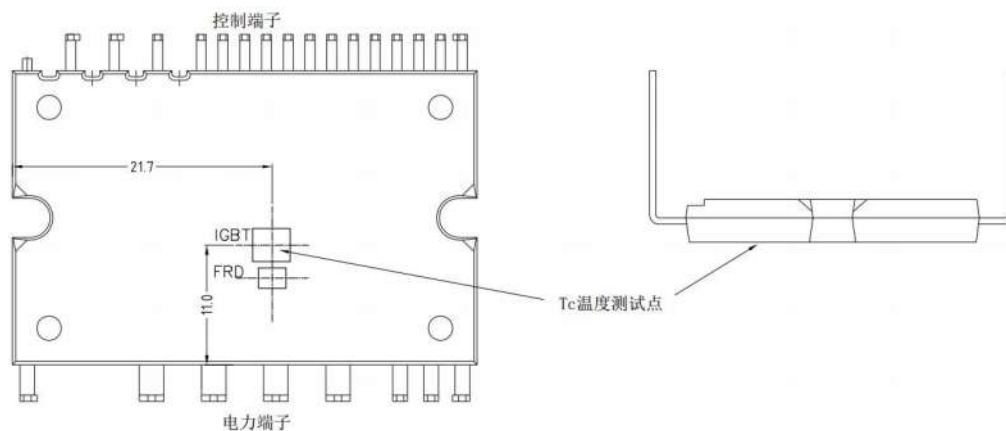


图 3: 壳温测试点 Fig 3. Tc measurement point

热阻 Thermal Resistance

记号 Symbol	项目 Parameter	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 For each IGBT part	-	-	3.2	°C/W
Rth(j-c)F		单个 FRD 元件 For each FRD part	-	-	4.0	°C/W

电气特性 (Tj= 25°C, 除非特殊说明)

Electrical Characteristics (Tj = 25°C, Unless Otherwise Specified)

逆变部分 Inverter Part

记号 Symbol	项目 Parameter	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 Collector – Emitter Saturation Voltage	V _D = V _{DB} = 15V V _{IN} = 5V, I _C = 15A, Tj = 25°C	-	1.6	1.9	V
		V _D = V _{DB} = 15V V _{IN} = 5V, I _C = 15A, Tj = 125°C	-	1.9	-	V
V _F	FWD 正向导通电压 FWD Forward Voltage	V _{IN} = 0V, I _C = -15A, Tj = 25°C		2.5	3.1	V
t _{ON}	开关时间 (备注 2) Switching Times (NOTE 2)	V _{CC} = 300V, V _D = V _{DB} = 15V I _C = 15A V _{IN} = 0V—5V, 感性负载 Inductive Load	-	0.8	-	μs
t _{C(ON)}			-	0.2	-	μs
t _{OFF}			-	1.04	-	μs
t _{C(OFF)}			-	0.23	-	μs
t _{rr}			-	0.20	-	μs

E_{on}	开通损耗 Turn-on loss	$I_C = 15A, V_{CC} = 400V, V_{DB} = V_D = 15V, R_G = 22\Omega, L = 1mH, T_j = 25^\circ C$	-	47	85	uJ
E_{off}	关断损耗 Turn-off loss		-	240	370	
I_{CES}	集电极到发射极漏电流 Collector-Emitter Leakage Current	$V_{CE} = V_{CES} T_j = 25^\circ C$	-	-	75	uA
		$V_{CE} = V_{CES} T_j = 125^\circ C$	-	-	1	mA

备注 2: t_{ON} 和 t_{OFF} 包括驱动 I_C 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 4。

NOTE 2: t_{ON} and t_{OFF} include the propagation delay time of the internal drive IC. $t_{C(ON)}$ and $t_{C(OFF)}$ are the switching time of IGBT itself under the given gate driving condition internally. For the detailed information, Please Refer to Fig 4.

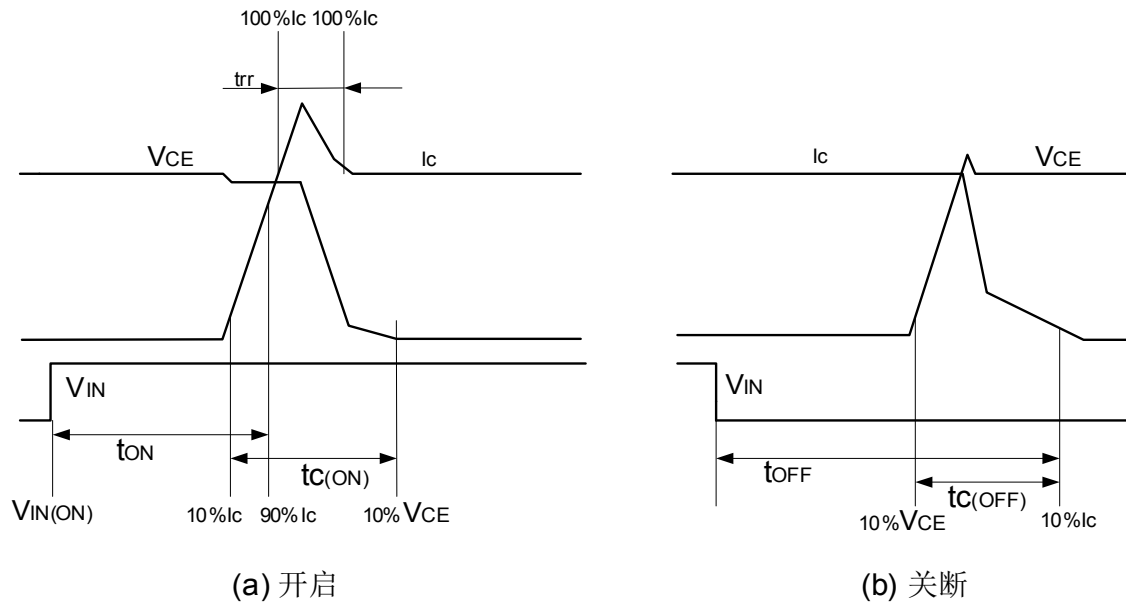


图 4：开关时间定义 Fig 4: Switching Time Definition

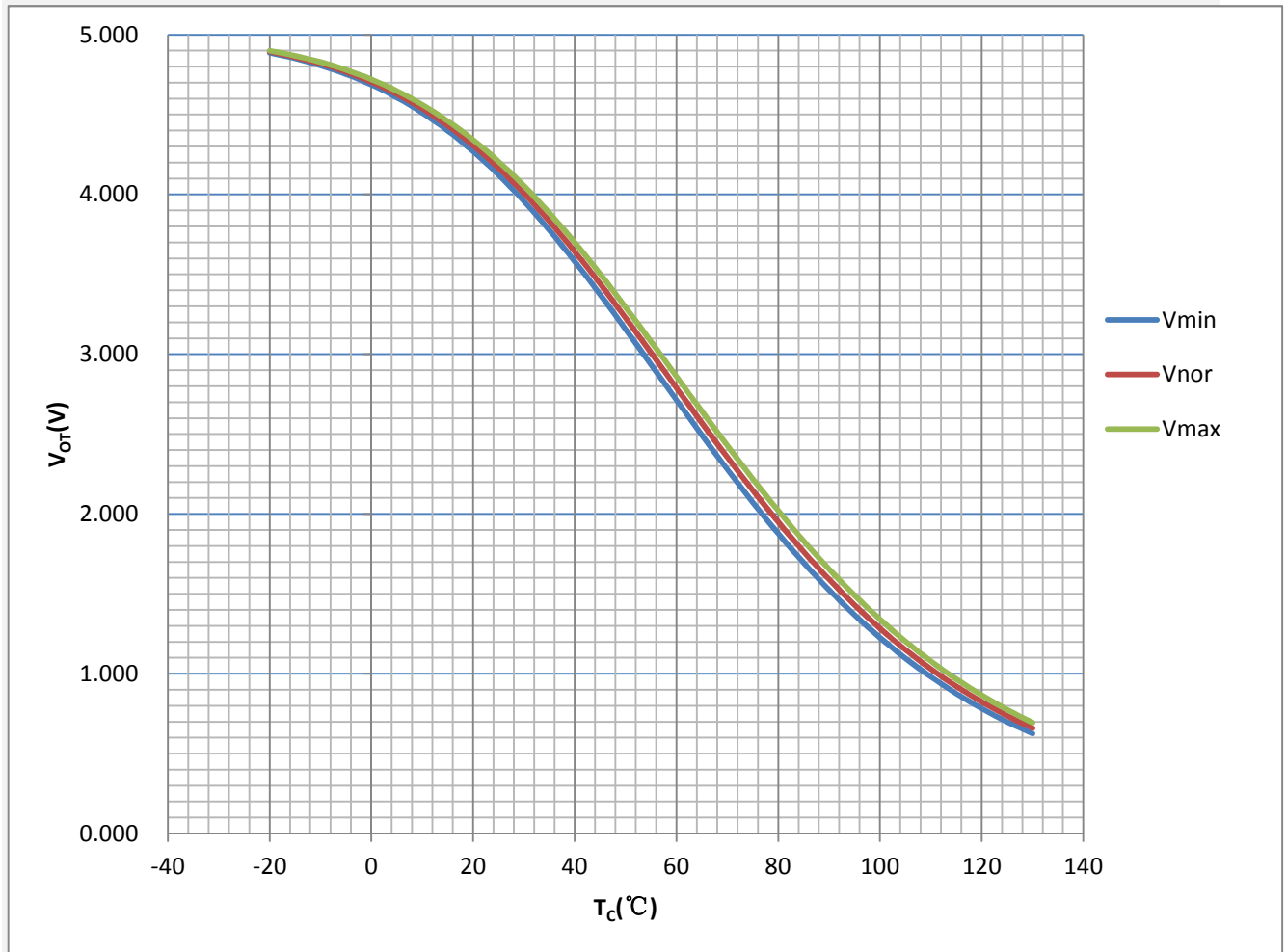
控制部分 Control Part

记号 Symbol	项目 Parameter	条件 Condition		最小值 Min	典型值 Typ	最大值 Max	单位 Unit
I_D	V_D 静态电流 Quiescent V_D Supply Current	$V_D = 15V$ $V_{IN} = 5V$	VP1-VNC	-	0.52	1	mA
I_{DB}	V_{DB} 静态电流 Quiescent V_{DB} Supply Current	$V_{DB} = 15V$ $V_{IN} = 5V$	UFB - U, VFB - V, WFB - W	-	360	550	uA
V_{FOH}	故障输出电压 Fault Output Voltage	$V_{sc} = 0V$, FO 脚通过 10K 电阻上拉至 5V		4.6	-	-	V
V_{FOL}		$V_{sc} = 1V, I_{FO} = 1.5mA$		-	-	0.3	V
$V_{sc,TH+}$	短路正向触发阈值 Short circuit positive going threshold	$V_D = 15V$		0.37	0.47	0.65	V

V _{sc,TH-}	短路负向触发阈值 Short circuit negative going threshold	V _D = 15V	0.2	0.4	-	V
UV _{DD}	电源欠压保护控制 Control supply under-voltage protection	触发电平 Trip Level	11	12.1	12.8	V
UV _{DR}		复位电平 Reset Level	9.5	10.4	11.0	
UV _{DBD}		触发电平 Trip Level	11	12.1	12.8	
UV _{DBR}		复位电平 Reset Level	9.5	10.4	11.0	
R _{on,FLT}	故障低有效阻抗 FLT low on resistance	I=1.5mA		50	90	ohm
T _{FO}	故障输出脉冲宽度		40	65	120	uS
t _{FIL,IN}	输入信号滤过时间 (UP/VP/WP, UN/VN/WN) Input filter time (UP/VP/WP, UN/VN/WN)	V _{IN} = 0 V & 5 V	140	290	-	nS
t _{CINMIN}	CIN 输入信号滤过时间 CIN Input filter time	V _{IN} = 0 V or 5 V, V _{CIN} = 5 V	270	530	780	nS
V _{IN(ON)}	开启阈值电压 ON Threshold Volta	应用于 UP,VP,WP,UN,VN,WN 和 VNC 之间 Applied between UP,VP,WP,UN,VN,WN and VNC	1.7	2.1	2.4	V
V _{IN(OFF)}	关断阈值电压 OFF Threshold Volta		0.7	0.85	1.4	
V _{OT}	温度输出, 备注 3 Temperature Output NOTE 4	T _c =90℃	1.53	1.59	1.65	V
		T _c =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	-	1.0	1.3	V
R _{BSD}	BSD限流电阻 Internal bootstrap diode on	VF1=4V, VF2=5V	22	36	50	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V_{OT}输出特性曲线请参考图5, 图5曲线是以20K上拉电阻测试结果。

NOTE 3: IPM do not shutdown IGBTs and output fault signal automatically when temperature rises excessively. When temperature exceeds the protective level the user defined, controller(MCU)should stop the IPM. Temperature of HVIC vs VOT output characteristics is described as Fig 5, The Fig 5 was tested by 20Kohm pull-up resistor

图5: V_{OT} 输出电压曲线 Fig 5: VOT output voltage VS HVIC temperature

推荐工作条件 Recommended Operating Conditions

记号 Symbol	项目 Parameter	条件 Condition	数值 Value			单位 Unit
			最小值 Min	典型值 Typ	最大值 Max	
V _{CC}	电源电压 Supply Voltage	应用于 P – NU, NV, NW 之间 Applied between P – NU, NV, NW	0	300	400	V
V _D	控制电源电压 Control Supply Voltage	应用于 VP1 – VNC 之间 Applied between VP1 – VNC	-	15	-	V
V _{DS}	上臂控制电源电压 High-side Bias Voltage	应用于 VUFB – U, VVFB – V, VWFB-W 之间 Applied between VUFB – U, VVFB – V, VWFB-W	-	15	-	V

t_{dead}	死区时间 Blanking Time for Preventing Arm-short	各桥臂输入对应, $T_c \leq 100^\circ\text{C}$ For Each Input Signal,, $T_c \leq 100^\circ\text{C}$	1	-	-	us
f_{PWM}	PWM 频率 PWM Input Signal	$-20^\circ\text{C} \leq T_c \leq +100^\circ\text{C}$ $-20^\circ\text{C} \leq T_j \leq +150^\circ\text{C}$	-	-	20	kHz
PWM	最小输入信号脉冲宽度 Minimum Input Pulse Width	ON	0.7	-	-	us
		OFF	0.7	-	-	us
T_j	结温 Junction temperature		-20	-	125	$^\circ\text{C}$

内部 NTC –热阻特性 Internal NTC - Thermistor Characteristics

记号 Symbol	项目 Parameter	条件 Condition	数值 Value			单位 Unit
			最小值 Min	典型值 Typ	最大值 Max	
R _{NTC}	热敏电阻 Resistance of Thermistor	T _{NTC} = 25°C	97	100	103	Kohm
		T _{NTC} = 125°C	3.25	3.46	3.69	Kohm
温度范围 Temperature Range			-40	-	+125	°C

机械特性 Mechanical Characteristics and Ratings

参数 Parameter	条件 Conditions	数值 Value			单位 Unit
		最小值 Min	典型值 Typ	最大值 Max	
安装扭矩 Mounting Torque	螺丝钉尺寸: M3 Mounting Screw: M3	-	0.69	-	N•m
设计平面度 Device Flatness	见图6 Refer to Fig 6.	-50	-	+120	um
重量 Weight		-	7	-	g

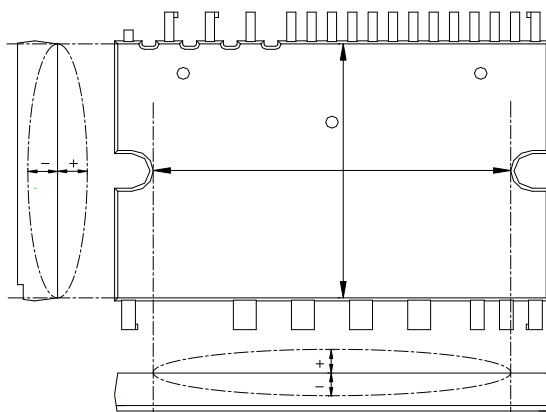


图 6：平面度检测位置 Fig 6: Flatness Measurement Position

应用指南 Application Guide

增强型输入滤波 Advanced input filter

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其有助于滤除尖峰干扰信号和窄脉冲，如下图 7 和图 8 是经典型输入滤波器和增强型输入滤波器演示图。

The advanced input filter allows an improvement in the input/output pulse symmetry of HVIC inside the module and helps to reject noise spikes and short pulses. The advantage of the new filter is shown in Figures 7 and 8

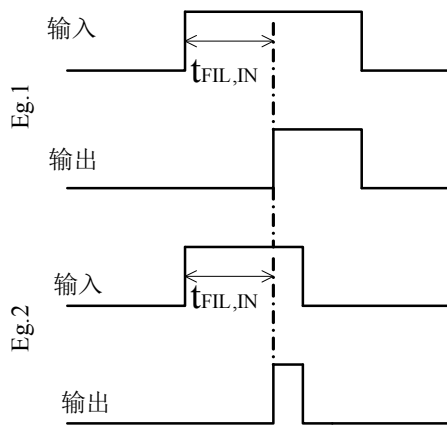


图 7：典型输入滤波

Fig 7: Typical input filter

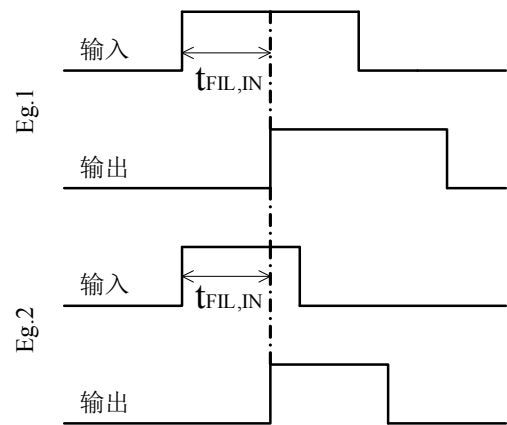


图 8：增强型输入滤波

Fig 8: Advanced input filter

保护功能时序图 Time Charts of Protective Function

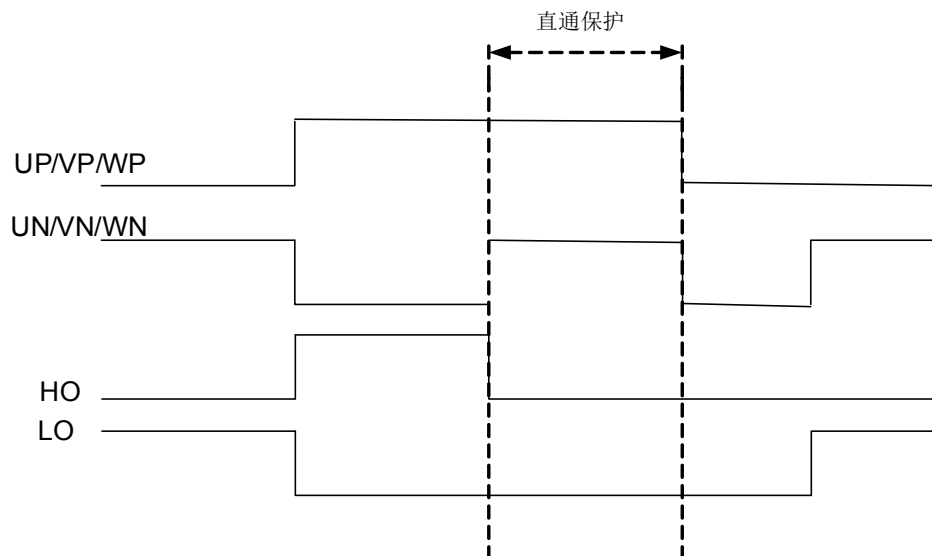


图 9：直通保护

备注4：HO 和 LO 为内部 HVIC 门极输出信号。NOTE 4: The signal HO and LO are gate output of the internal HVIC

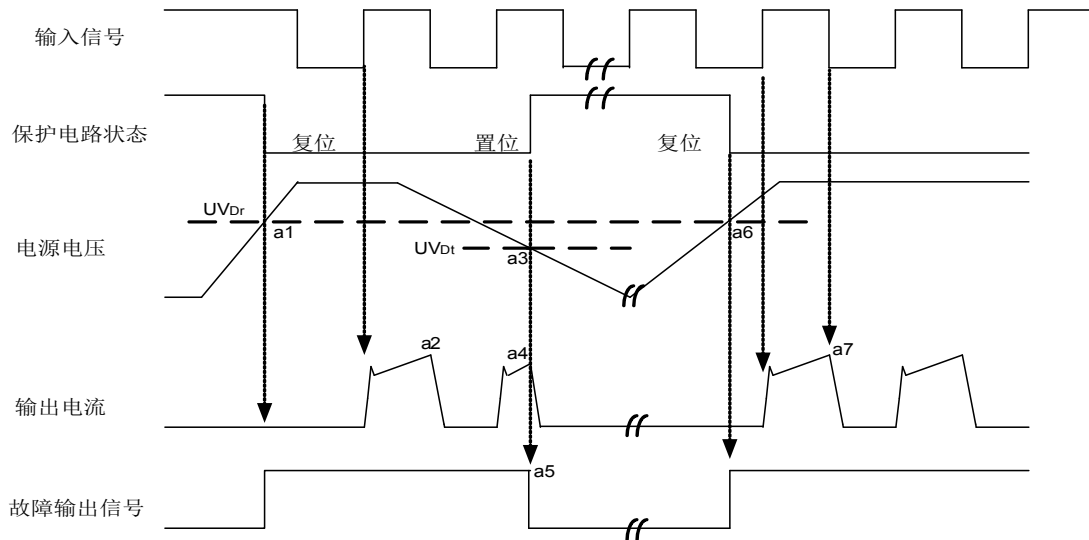


图10: 欠压保护时序图(低侧) Fig 10: Under-Voltage Protection (Low-side Operation)

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 : Control supply voltage rises: After the voltage rises UV_{Dr} , the circuits start to operate when next input is applied

a2 : 正常运行: IGBT 开启并加载电流。

a2 : Normal operation: IGBT ON and carrying current

a3 : 欠压检测点(UV_{Dt})。a3 : Under voltage detection (UV_{Dt}).

a4 : 不管输入是什么信号, IGBT都是关闭状态。a4 : IGBT OFF in spite of control input condition

a5 : 故障输出开启。a5 : Fault output operation starts

a6 : 欠压恢复(UV_{Dr})。a6 : Under voltage reset (UV_{Dr})

a7 : 正常运行: IGBT 导通并加载负载电流。a7 : Normal operation: IGBT ON and carrying current

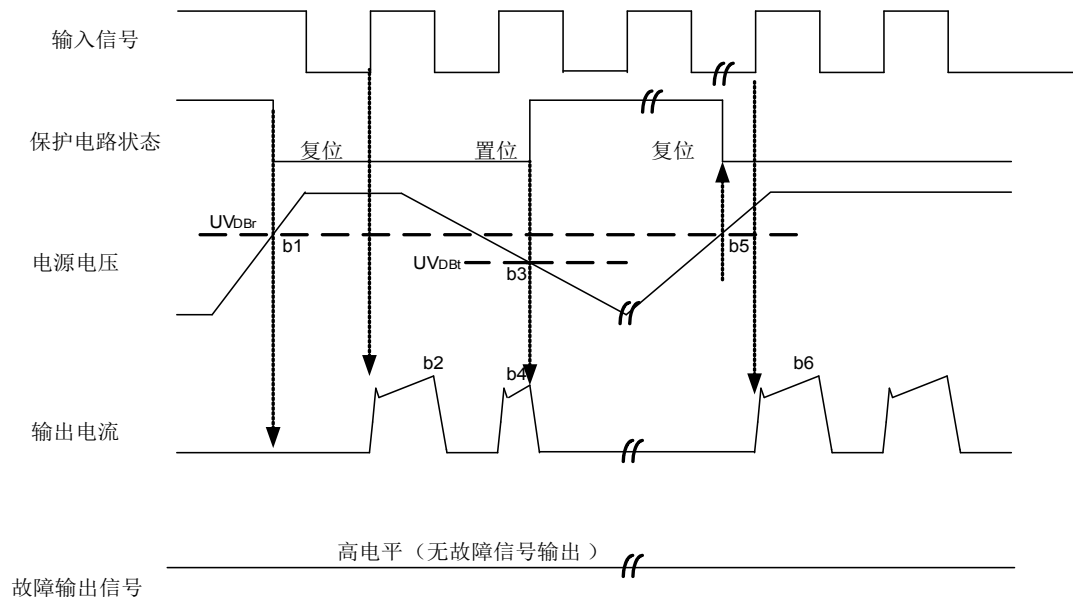


图11: 欠压保护时序图 (高侧) Fig 11: Under-Voltage Protection (High-side Operation only)

- 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 : Control supply voltage rises: After the voltage reaches UVDBr, the circuits start to operate when next input is applied
- b2 : 正常运行: IGBT导通并加载负载电流。 b2 : Normal operation: IGBT ON and carrying current
- b3 : 欠压检测 (UV_{DBt})。 b3 : Under voltage detection (UVDBt)
- b4 : 不管输入是什么信号, IGBT都是关闭状态。
b4 : IGBT OFF in spite of control input condition, but there is no fault output signal.
- b5 : 欠压恢复(UV_{DBr})。 b5 : Under voltage reset (UVDBr)
- b6 : 正常运行: IGBT导通并加载负载电流。 b6 : Normal operation: IGBT ON and carrying current

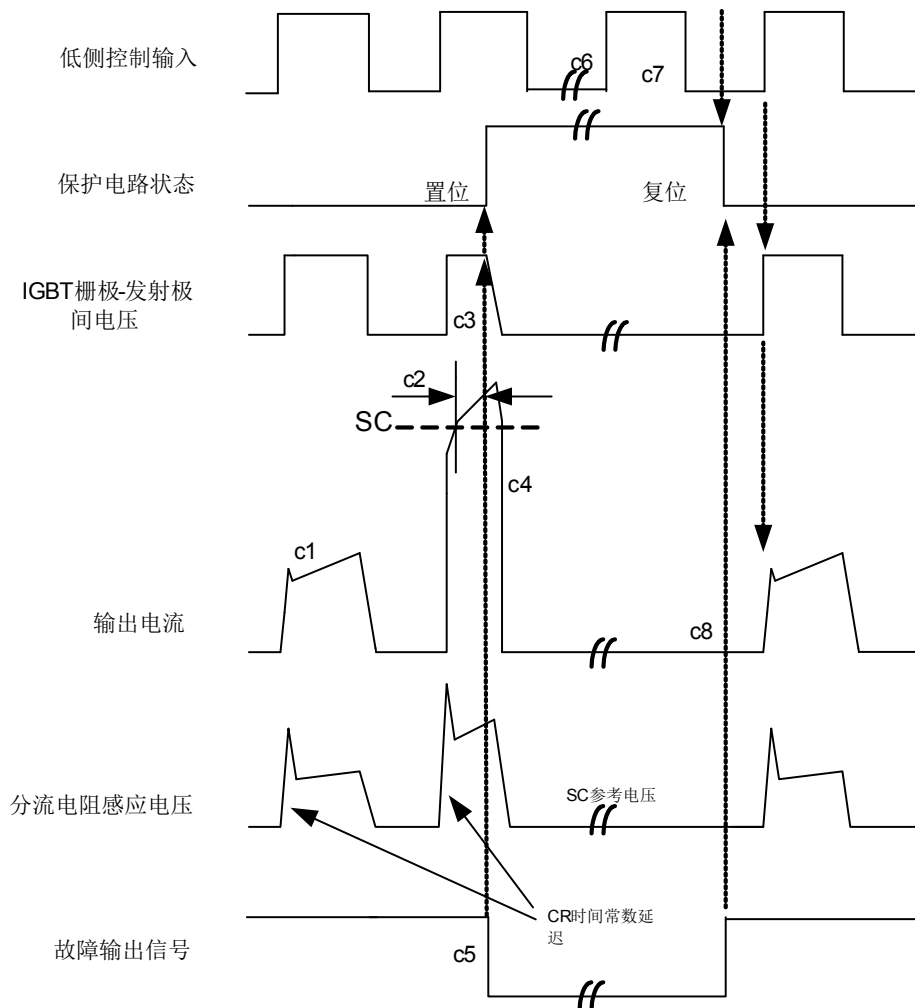


图 12: 短路电流保护时序图 (只适合于低侧)

Fig 12: short-Circuit Current Protection (Low-side And High-side Operation)

(通过外部分流电阻连接) (with the external shunt resistance connection)

- c1 : 正常运行: IGBT 导通载流。 c1 : Normal operation: IGBT ON and carrying 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 : Hard IGBT gate interrupt
- c4 : IGBT关断。 c4 : IGBT turns 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 : Fault output timer operation starts: The pulse width of the fault output signal is set by the internal capacitor

c6 : 输入“L”: IGBT关闭。c6 : Input “L”: IGBT OFF state

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

c7 : Input “H”: IGBT ON state, but during the active period of fault output the IGBT doesn't turn ON

c8 : IGBT 关断。c8 : IGBT OFF state

输入/输出接口电路 Input/Output Interface Circuit

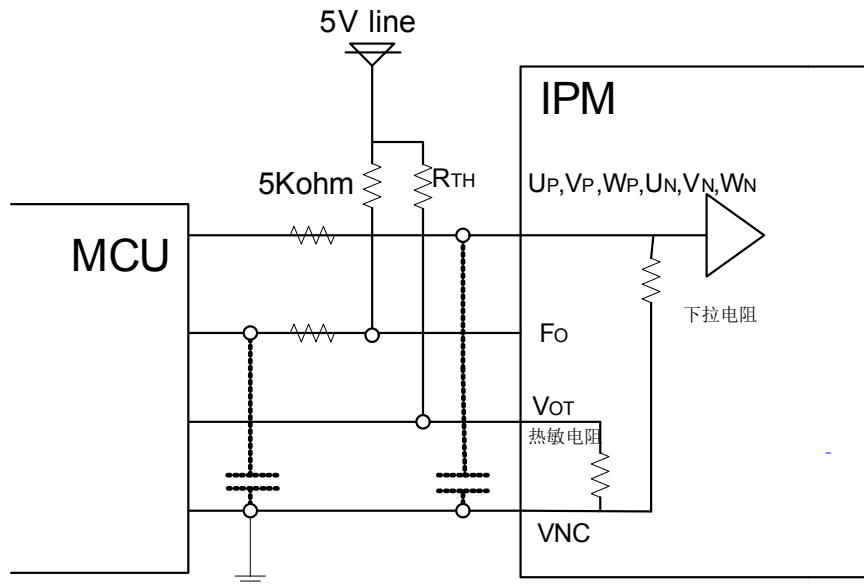


图 13: 推荐的 MCU 输入输出接口电路 Fig 13: Recommended CPU I/O Interface Circuit

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: RC coupling at each input (parts shown dotted) might change depending on the PWM control scheme used in the application and the wiring impedance of the application's printed circuit board.

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 is compatible with standard CMOS or LSTTL outputs

分流电阻接线 Wiring Around The Shunt Resistor

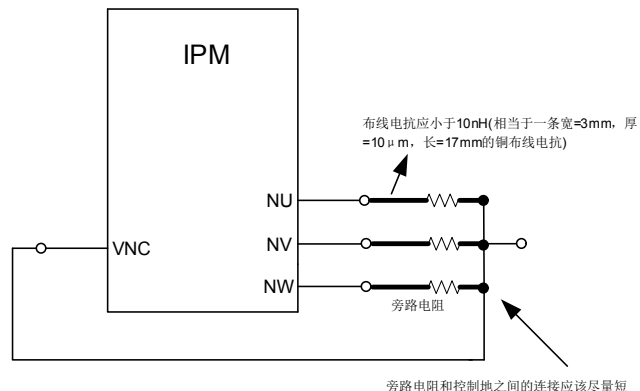


图 14: 旁路电阻接线注意事项 Fig 14: Recommended Wiring Around The Shunt Resistor

典型应用电路图 Typical Application Circuit

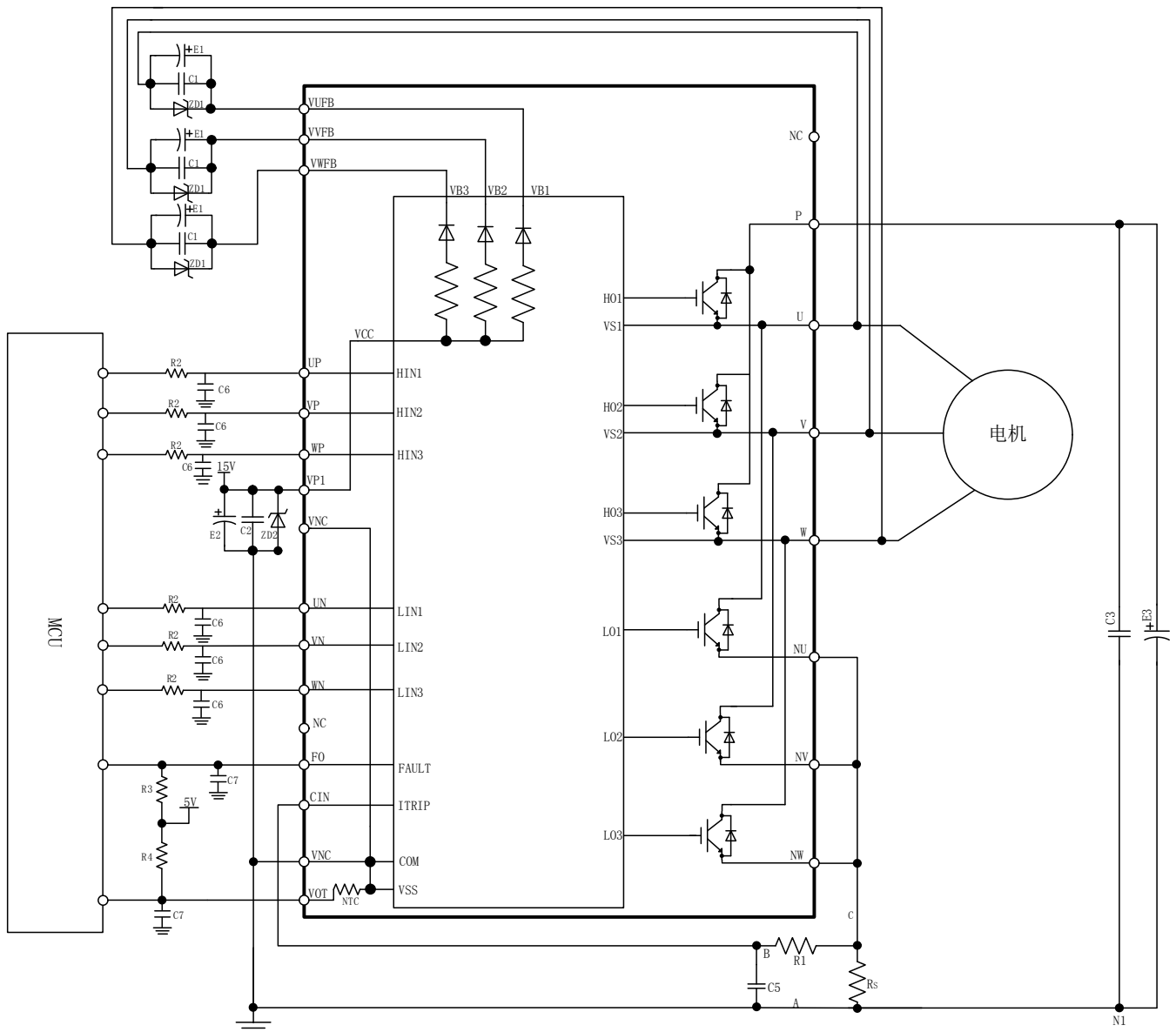


图 15: 典型应用电路 Fig 15: Typical Application Circuit

备注 7: 输入驱动高有效; IC 内部集成有一个 $5k\Omega$ (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。

NOTE 7: Input drive is High-Active type. There is a 5.1kΩ(typ.) pull-down resistor integrated in the IC input circuit. To prevent malfunction, the wiring of each input should be as short as possible. When using RC coupling circuit, make sure the input signal level meet the turn-on and turn-off threshold voltage.

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。
NOTE8: Thanks for HVIC inside modules, direct coupling to MCU without any opto-coupler or transformer isolation is possible.

备注9: 自举电路负极应直接连接到U、V、W的端。

NOTE 9: Bootstrap negative electrodes should be connected to U, V, W terminals directly and separated from the

main output wires.

备注10: FO是漏极开路型, 其信号线应通过一个约10k Ω 的上拉电阻上拉到+5V/3.3V电源。

NOTE 10: Fo output is open drain type. It should be pulled up to the positive side of a 5V power supply by a resistor of about 10k Ω

备注11: 为防止误保护, A、B、C连线应尽可能短。

NOTE 11: To prevent erroneous protection, the wiring of A, B, C 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1~2 μ S。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。

NOTE 12: The time constant R1、C5 of the protection circuit should be selected in the range of 1.0-2 μ s. SC interrupting time might vary with the wiring pattern. Tight tolerance, temp-compensated type is recommended for R1, C5.

备注13: 所有电容的位置尽可能的靠近IPM。

NOTE 13: All capacitors should be mounted as close to the terminals of the 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0.1~0.22 μ F的MLCC低频滤波电容。

NOTE 14: To prevent surge destruction, the wiring between the smoothing capacitor and the P, N1 terminals should be as short as possible. Generally, a 0.1-0.22 μ F snubber between the P-N1 terminals is recommended

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。

NOTE 15: Two VNC terminals (9 & 16 pin) are connected inside IPM, please connect either one to the 15V power supply GND outside and leave another one 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。

NOTE 16: If control GND is connected to power GND by broad pattern, it may cause malfunction by power GND fluctuation. It is recommended to connect control GND and power GND at only one point.

外形封装图 Detailed Package Outline Drawings

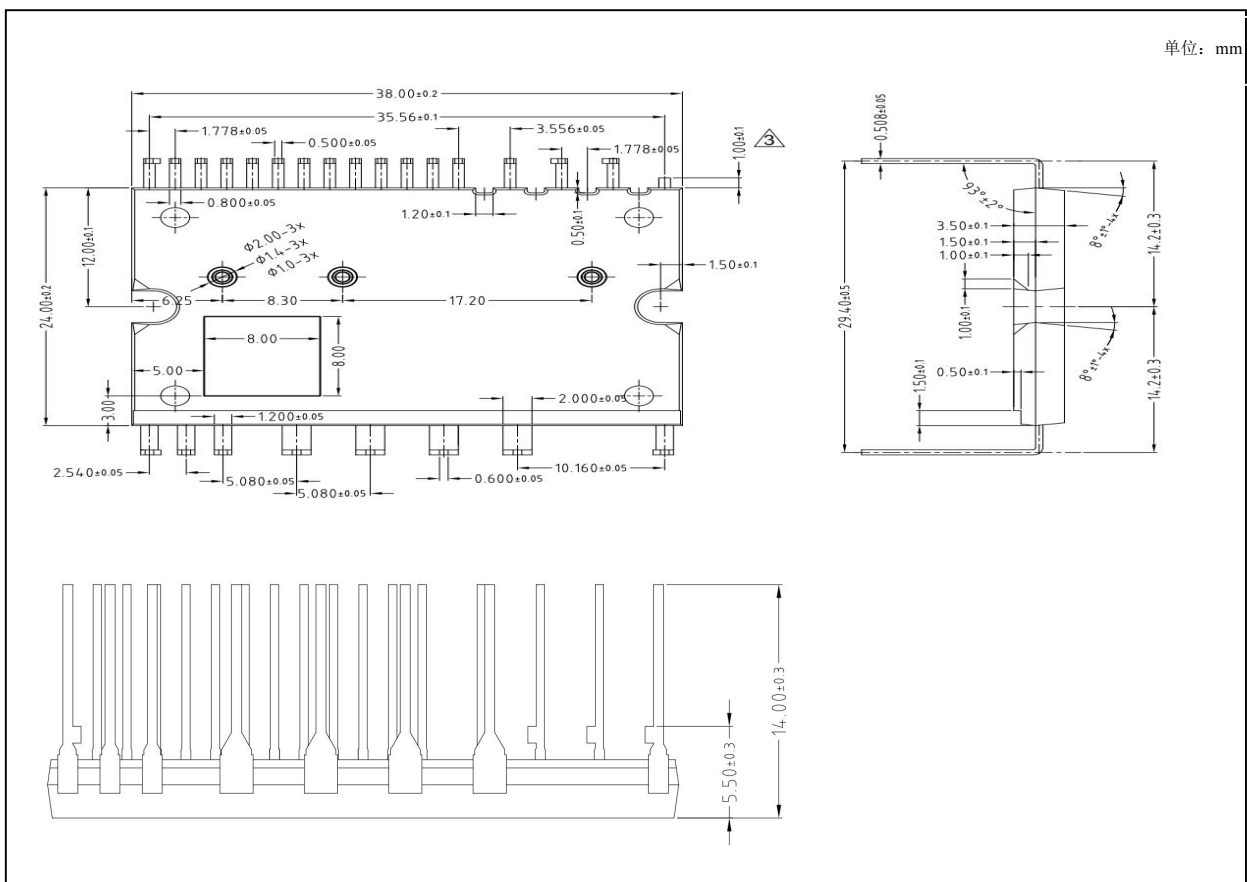


图 16: 封装外形图 Fig 16: Package Outline

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附录 (Appendix): 修订记录 (Revision History)

日期 Date	旧版本 Last Rev.	新版本 New Rev.	修订内容 Description of Changes
2018-01-09	201801A		初始版本