



SPE04M60TW-AD

主要参数 MAIN CHARACTERISTICS

600V/4A 3 相全桥驱动	
V _{CES}	600V
I _D	2A
V _{ISO}	1500V

用途

- 风机
- 水泵
- 冰箱

APPLICATIONS

- Fan motor
- Water pump
- Fridge

产品特性

- 内置 6 个 600V/4A 快恢复功率 MOS。
- 信号高电平有效，兼容 3.3V 和 5V 的 MCU。
- 内置自举二极管。
- 内置欠压保护、过流保护、过温保护。
- 内置使能关断功能。
- 内部集成温度检测输出。

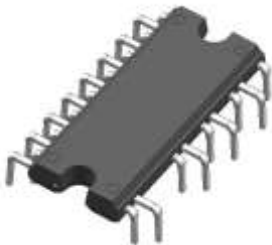
FEATURES

- Build-in six 600V/4A fast recovery MOSFET
- Signal high level active, compatible with 3.3v and 5V MCU.
- Built-in bootstrap diode.
- Built-in undervoltage protection、Over current protection、Over temperature protection
- Build-in shut-Down Input.
- Internal integrated temperature detection output.

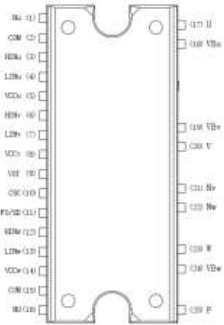
订货信息 ORDER MESSAGE

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
2A01-1052	SPE04M60TW-AD	N/A	SPE04M60TW-AD	DIP23WD-FP

封装 Packag



DIP23WD-FP



PIN1-PIN25



模块分布示意图 Module distribution diagram

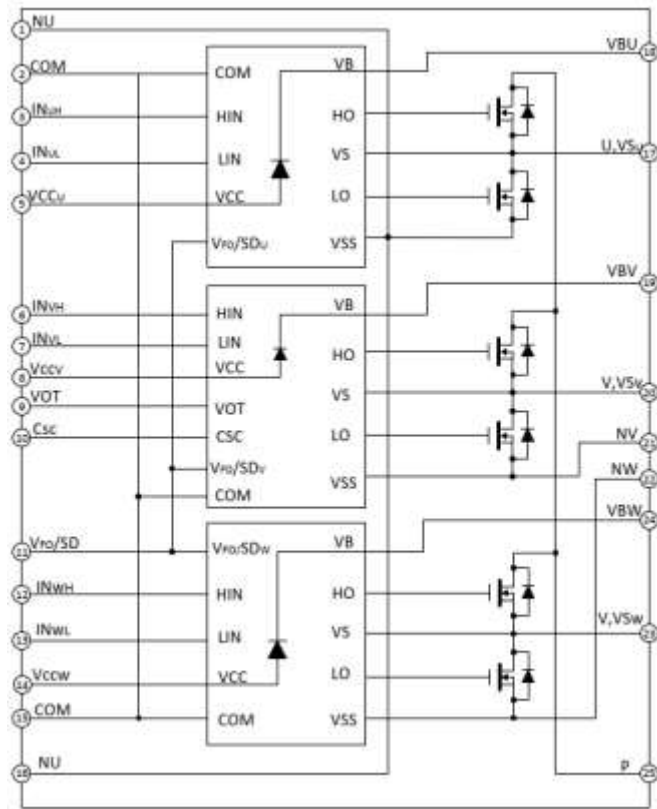


图 1：模块内部电路示意图
Fig 1: Internal circuit

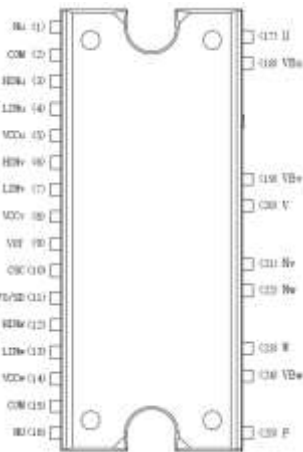


图 2：模块引脚分布示意图
Fig 2: Distribution of pin



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引脚编号 Number	引脚名称 Name	引脚描述 Description
1	NU	U 相下臂 MOSFET 源极端子 U phase lower arm MOSFET source terminal
2	COM	公共电源接地 GND Common Supply Ground
3	HIN _U	U 相上臂控制信号输入端子 U phase upper arm control signal input terminal
4	LIN _U	U 相下臂控制信号输入端子 U phase lower arm control signal input terminal
5	VCC _U	控制电源端子 Control power terminal
6	HIN _V	V 相上臂控制信号输入端子 V phase upper arm control signal input terminal
7	LIN _V	V 相下臂控制信号输入端子 V phase lower arm control signal input terminal
8	VCC _V	控制电源端子 Control power terminal
9	VOT	HVIC 温度输出 Output for HVIC Temperature Sensing
10	CIN	过流和短路保护关闭输入端子 Shut Down Input for Over Current and Short Circuit Protection
11	/FO, /SDW	故障输出, W 相输入关闭 Fault Output, Shut-Down Input for W Phase, Temperature Output
12	HIN _W	W 相上臂控制信号输入端子 W phase upper arm control signal input terminal
13	LIN _W	W 相下臂控制信号输入端子 W phase lower arm control signal input terminal
14	VCC _W	控制电源端子 Control power terminal
15	COM	公共电源接地 GND Common Supply Ground
16	NU	U 相下臂 MOSFET 源极端子 U phase lower arm MOSFET source terminal
17	U	U 相输出和 U 相高侧驱动偏置电压地 Output for U-Phase & Bias Voltage Ground for U-phase High-Side Driving
18	VB _U	U 相上臂驱动电源端子 U-phase upper arm drive power terminal
19	VB _V	V 相上臂驱动电源端子 V-phase upper arm drive power terminal
20	V	V 相输出和 V 相高侧驱动偏置电压地 V output for V-Phase & Bias Voltage Ground for V-phase High-Side Driving
21	NV	V 相下臂 MOSFET 源极端子 V phase lower arm MOSFET source terminal
22	NW	W 相下臂 MOSFET 源极端子 W phase lower arm MOSFET source terminal
23	W	W 相输出和 W 相高侧驱动偏置电压地 W output for U-Phase & Bias Voltage Ground for W-phase High-Side Driving
24	VB _W	W 相上臂驱动电源端子 W-phase upper arm drive power terminal
25	P	逆变器直流输入端子 DC input terminal of inverter

图 3：模块引脚功能定义表

Fig 3: Pin function

最大额定值 ($T_j = 25^\circ\text{C}$, 除非特殊说明)Absolute Maximum Ratings ($T_j = 25^\circ\text{C}$, Unless otherwise Specified)

逆变部分 Inverter Part

记号 Symbol	参数 Parameter	条件 Condition	额定值 Ratings	单位 Units
V_{PN}	电源电压 Power supply voltage	应用于 P- NU, NV, NW 之间 Applied between P- NU, NV, NW	450	V
$V_{PN(\text{Surge})}$	电源电压 (含浪涌) Power supply voltage (including surge)	应用于 P- NU, NV, NW 之间 Applied between P- NU, NV, NW	500	V
V_{DSS}	漏-源电压 Drain-Source Voltage of Each MOSFET	/	600	V
I_D	漏极连续电流 Each MOSFET Current, Continuous	$T_c = 25^\circ\text{C}$	2	A
I_{DM}	漏极电流 (峰值) Each MOSFET Pulse Current, Peak	$T_c = 25^\circ\text{C}$, 脉冲宽度小于 100us $T_c = 25^\circ\text{C}$, less than 100us	4	A
P_D	最大功耗 Maximum Power Dissipation	$T_c = 25^\circ\text{C}$, 每个 MOSFET $T_c = 25^\circ\text{C}$, For Each MOSFET	7.96	W
T_j	结温 Junction Temperature	(见备注 1) Note1	-40~150	$^\circ\text{C}$

控制部分 Control Part

记号 Symbol	参数 Parameter	条件 Condition	额定值 Ratings	单位 Units
V_{CC}	控制电源电压 Control Supply Voltage	VCC-COM 之间 Applied between VCC and COM	20	V
V_{BS}	高侧控制电压 High-side Bias Voltage	VB-VS 之间 Applied between VB and VS	20	V
V_{IN}	输入信号电压 Input Signal Voltage	VIN-COM 之间 Applied between VIN and COM	$-0.3 \sim V_{CC} + 0.3$	V
I_{FO}	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
V_{SC}	电流检测端输入电压 Input voltage of current detection terminal	应用于 CSC-COM 之间 Applied between CSC-COM	$-0.3 \sim V_{CC} + 0.3$	V
V_{FO}	故障输出电压 Fault output voltage	应用于 FO-COM 之间 Applied between FO-COM	$-0.3 \sim V_{CC} + 0.3$	V

整个系统 Total System

记号 Symbol	参数 Parameter	条件 Condition	额定值 Ratings	单位 Units
$V_{PN(\text{PROT})}$	自我保护电源电压限制 Self-protecting power supply voltage limit	$V_{CC} = V_{BS} = 13.5\text{V} \sim 16.5\text{V}$, $T_j = 125^\circ\text{C}$, 非重复性, $< 2\mu\text{s}$	400	V
T_C	模块壳体工作温度 Module shell temperature	-	-20~100	$^\circ\text{C}$
T_{STG}	贮存温度 Storage Temperature	-	-40~125	$^\circ\text{C}$
V_{ISO}	绝缘耐压 Isolation Voltage	60Hz, 正弦, AC 1 分钟, 连接管脚到散热器 60Hz, Sinusoidal, AC 1 min, between pins and heat-sink plate	1500	Vrms





T	安装力矩 Mounting Torque	安装螺丝: M3	0.6	N.m
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备注 1: IPM 功率芯片最大额定结温为 150℃(@表面温度 $T_C \leq 100^\circ\text{C}$)。然而,为了确保 IPM 运行安全,结温应限定于 $T_{j(av)} \leq 125^\circ\text{C}$ (@表面温度 $T_C \leq 100^\circ\text{C}$)。

Note 1: The maximum rated junction temperature of the IPM power chip is 150°C (@surface temperature $T_C \leq 100^\circ\text{C}$).
However, to ensure safe operation of the IPM, the junction temperature should be limited to $T_{j(av)} \leq 125^\circ\text{C}$ (@surface temperature $T_C \leq 100^\circ\text{C}$)

热阻 Thermal Resistance

记号 Symbol	参数 Parameter	条件 Condition	额定值 Ratings	单位 Units
$R_{th(j-c)}$	结到外壳的热阻 Junction to Case Thermal resistance	每个 MOSFET For Each MOSFET	15.7	$^\circ\text{C}/\text{W}$

电气特性 ($T_J=25^\circ\text{C}$, 除非特殊说明)

Electrical Characteristics ($T_J=25^\circ\text{C}$, Unless Otherwise Specified)

逆变部分 Inverter Part

记号 Symbol	参数 Parameter	条件 Condition	最小值 Min.	典型值 Typ.	最大值 Max.	单位 Unit
BV_{DSS}	漏-源击穿电压 Drain-Source Breakdown Voltage	$V_{IN}=0V$, $I_D=1mA$ (备注 2) (Note2)	600	-	-	V
I_{DSS}	零栅极电压漏极电流 Zero Gate Voltage Drain Current	$V_{IN}=0V$, $V_{DS}=600V$	-	-	1	mA
V_{SD}	源-漏二极管正向电压 Drain-Source Diode Forward Voltage	$V_{CC}=V_{BS}=15V$, $V_{IN}=0V$, $I_D=-1A$	-	0.9	-	V
$R_{DS(on)}$	漏-源导通电阻 Drain-Source Turn-On Resistance	$V_{CC}=V_{BS}=15V$, $V_{IN}=5V$, $I_D=1A$	-	2.4	-	ohm
t_{ON}	开关时间(备注 2) Switching Times(备注 2)	$V_{PN}=400V$, $V_{CC}=V_{BS}=15V$, $I_C=4A$, $V_{IN}=0/5V$, 感性负载(Inductive Load)(备注 2) (Note2)	-	820	-	nS
$t_{C(ON)}$			-	180	-	nS
t_{OFF}			-	800	-	nS
$t_{C(OFF)}$			-	70	-	nS
t_{rr}			-	130	-	nS

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 MOSFET 自身被内部给定门极驱动条件下的开关时间。详见图 5。

Note 2: t_{ON} and t_{OFF} include the internal propagation delay time of the driver IC. $t_{C(ON)}$ and $t_{C(OFF)}$ are the switching times of the MOSFET itself driven by the internally given gate. See Figure 4 for details.

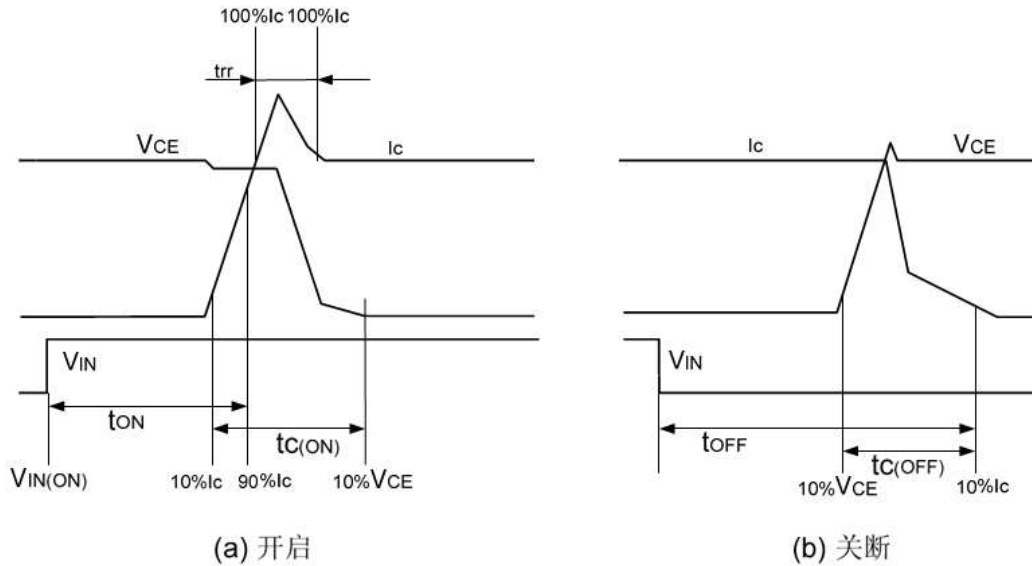


图 5：开关时间定义

Fig 5: Switching Time Definition

控制部分 Control Part

记号 Symbol	参数 Parameter	条件 Condition		最小值 Min.	典型值 Typ.	最大值 Max.	单位 Unit
I _{QCC}	VCC 静态电流 Quiescent VCC Supply Current	VCC=15V VIN=5V	VCC-COM 之间 Applied between VCC and COM	-	-	1500	uA
I _{QBS}	VBS 静态电流 Quiescent VBS Supply Current	VBS=15V VIN=5V	VB(U)-U, VB(V)-V, VB(W)-W 之间 Applied between VB(U)-U, VB(V)-V, VB(W)-W	-	-	500	uA
V _{FOH}	故障输出电压 Fault Out Voltage	VSC=0V, /FO Circuit: 10K to 5V pull-up		4.9	-	-	V
V _{FOL}		VSC=1V, /FO Circuit: 1mA		-	-	0.9	
V _{SC(ref)}	短路跳闸阈值 Short-Circuit Trip Level	V _{CC} =15 V		0.44	0.48	0.51	V
U _{VCCD}	低侧欠压保护(图 5) Low-Side Under-Voltage Protection (Fig 5)	检测电平 Detection Level		7.6	8.6	9.6	V
U _{VCCR}		复位电平 Reset Level		8.3	9.3	10.3	V
U _{VBSD}	高侧欠压保护(图 6) High-Side Under-Voltage Protection (Fig 6)	检测电平 Detection Level		7.6	8.6	9.6	V
U _{VBSR}		复位电平 Reset Level		8.3	9.3	10.3	V
T _{FO}	故障输出脉冲宽度 Fault-Out Pulse Width			20	-	-	uS
V _{OT}	温度输出, 备注 3 Temperature output, remark 3	Tc=90℃		2.63	2.77	2.91	V
		Tc=25℃		0.88	1.13	1.39	V
V _{FSDR}	使能关断复位电平 Shut-down Reset level	SDx-COM		1.8	2.3	2.6	V



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V_{FSDD}	使能关断阈值电压 Shut-down Detection level	SDx-COM	0.8	1.3	1.5	V
I_{IN}	输入偏执电流 Input bias current	$V_{IN}=5V$	0.7	1.0	1.5	mA
V_{IH}	导通阈值电压 ON Threshold Voltage	逻辑高电平 Logic high level	- 施加在 V_{IN} 和COM之间 Applied between V_{in} -COM	2.2	2.6	V
V_{IL}	关断阈值电压 OFF Threshold Voltage	逻辑低电平 Logic low level		0.8	1.3	- V

备注 4: IPM 温度输出电流曲线请参考图 6.0

Note 4: Please refer to figure 6.0 for the temperature output current characteristic curve of IPM.

自举二极管部分 Bootstrap Diode Part

记号 Symbol	参数 Parameter	条件 Condition	最小值 Min.	典型值 Typ.	最大值 Max.	单位 Unit
RER_{BSD}	自举电阻 Bootstrap diode on resistor		-	160	-	Ω

推荐工作条件 Recommended Operating Conditions

记号 Symbol	参数 Parameter	条件 Condition	最小值 Min.	典型值 Typ.	最大值 Max.	单位 Unit
V_{PN}	电源电压 Supply Voltage	施加在P和N之间 Between P and N	-	300	400	V
V_{CC}	控制电源电压 Control Supply Voltage	施加在 V_{CC} 和 COM之间 Between V_{CC} and COM	13.5	15.0	16.5	V
V_{BS}	高端偏压 High-Side Bias Voltage	施加在 V_B 和 V_S 之间 Between V_B and V_S	13.5	15.0	16.5	V
dv_{CC}/dt_i dv_{BS}/dt_i	控制电源波动 Control power fluctuation	-	-1	-	1	V/us
t_{dead}	防止桥臂直通的死区时间 Blanking Time for Preventing Arm-Short	$V_{CC} = V_{BS} = 13.5 \sim 16.5 V, T_j \leq 150^\circ C$	1.0	-	-	us
$P_{WIN(ON)}$	输入信号最小开启脉宽 Minimum On pulse width of input signal	-	0.7	-	-	us
$P_{WIN(off)}$	输入信号最小关闭脉宽 Minimum Off Pulse Width of	-	0.7	-	-	



	Input Signal					
F_{PWM}	PWM 开关频率 PWM Switching Frequency	$T_j \leq 150^{\circ}\text{C}$	-	-	20	KHz

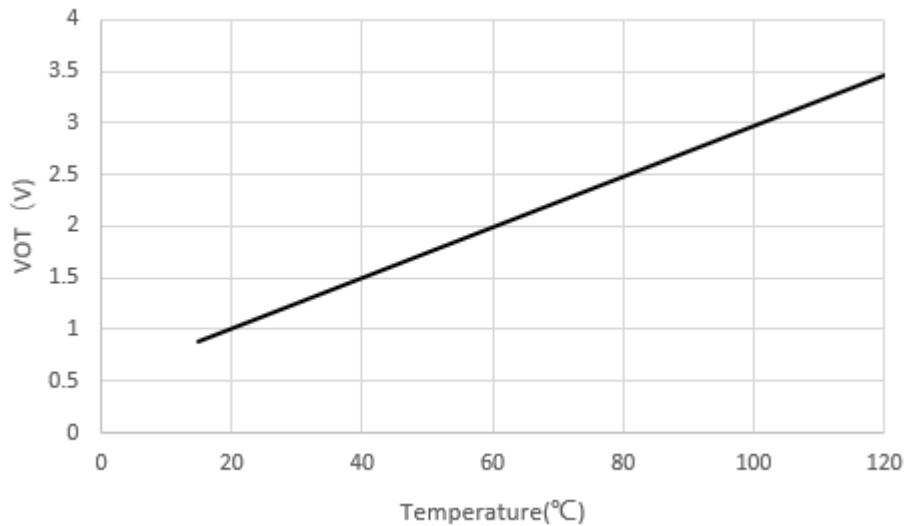


图 6.0: VOT 输出电压曲线

Figure 6.0: VOT output voltage curve

保护功能时序图 Time Charts of Protective Function

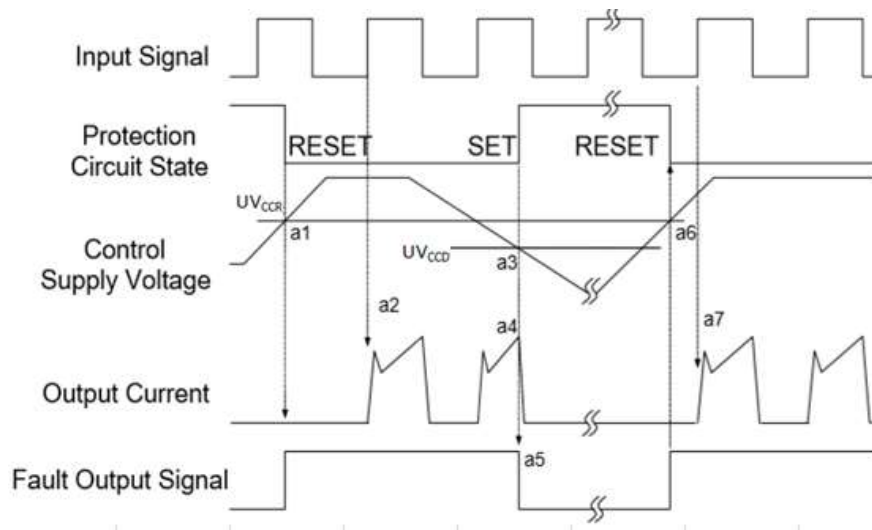


图 7: 欠压保护时序图(低侧)

Fig 7: Undervoltage protection sequence diagram (low side)

a1 :电源电压上升: 电压上升至 UV_{CCR} , 当下一个输入信号到来时电路开始工作;



- a1 : Control supply voltage rises: after the voltage rises UV_{CCR} , the circuits start to operate when next input is applied.
- a2: 正常运行: MOSFET 开启并加载电流。
- a2: Normal operation: MOSFET turns on and loads current.
- a3: 欠压检测点(UV_{CCD})。
- a3: Undervoltage detection point (UV_{CCD}).
- a4: 不管输入是什么信号, MOSFET 都是关闭状态。
- a4: No matter what signal is input, the MOSFET is off.
- a5: 故障输出开启。
- a5: Fault output is on.
- a6: 欠压恢复(UV_{CCR})。
- a6: Undervoltage recovery (UV_{CCR}).
- a7: 正常运行: MOSFET 导通并加载负载电流。
- a7: Normal operation: MOSFET is turned on and load current is loaded.

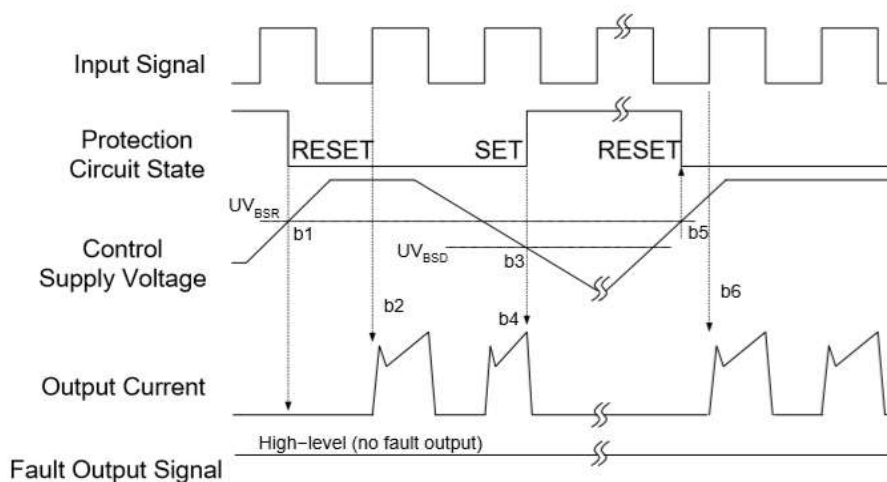


图 8: 欠压保护时序图(高侧)

Fig 8: Undervoltage protection sequence diagram (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: MOSFET 导通并加载负载电流。
- b2: Normal operation: MOSFET is turned on and load current is applied.
- b3: 欠压检测 (UV_{BSD})。
- b3: Undervoltage detection (UV_{BSD}).
- b4: 不管输入是什么信号, MOSFET 都是关闭状态。
- b4: No matter what signal is input, MOSFET is off.
- b5: 欠压恢复(UV_{BSR})。
- b5: Undervoltage recovery (UV_{BSR})。 .
- b6: 正常运行: MOSFET 导通并加载负载电流。
- b6: Normal operation: MOSFET is turned on and load current is applied.



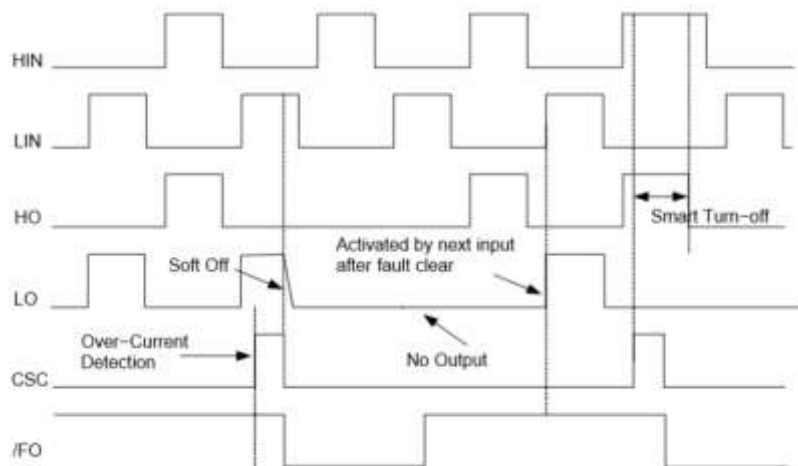


图 9：过流保护时序

Fig9: Fault-Out Function by Over Current Protection

HIN :高侧输入信号;

HIN : High-side Input Signal

LIN : 低侧输入信号;

LIN : Low-side Input Signal

HO : 高侧输出信号;

HO : High-Side Output Signal

LO : 低侧输出信号;

LO : Low-Side Output Signal

CSC :过流侦测信号;

CSC : Over Current Detection Input

/FO:故障输出信号

/FO : Fault Out Function

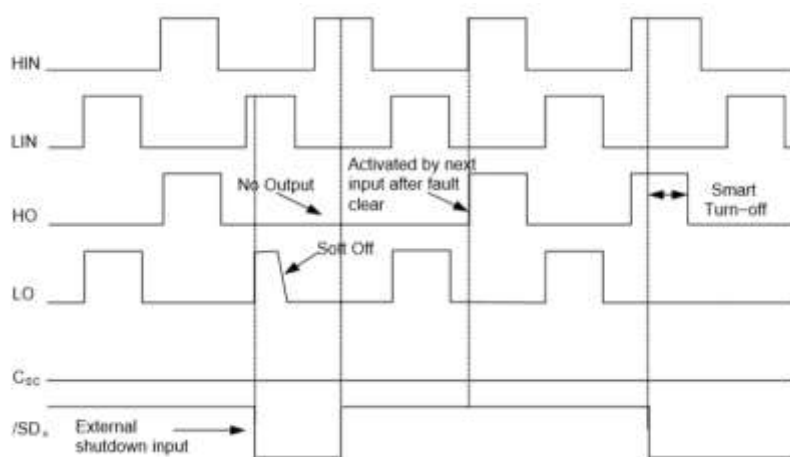


图 10. 外部关断功能时序

Figure 10. Shutdown Input Function by External Command

HIN :高侧输入信号;

HIN : High-side Input Signal

LIN : 低侧输入信号;

LIN : Low-side Input Signal

HO : 高侧输出信号;

HO : High-Side Output Signal

LO : 低侧输出信号;

LO : Low-Side Output Signal

CSC :过流侦测信号;

CSC : Over Current Detection Input

/SDx:外部关断输入信号

/SDx : Shutdown Input Function

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

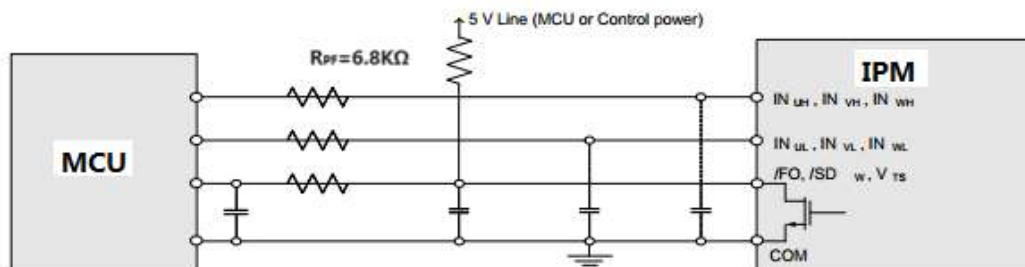


图 11. 推荐的 MCU I/O 接口电路

Figure 11: 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.



Fig 12: Example of Application Circuit

Note 6: Refer to figure 1 for pin location.

Note 7: To avoid malfunction, the wiring of each input should be as short as possible

Note 8: To prevent surge destruction, it is recommended to add a high-frequency non inductive smoothing capacitor (0.1 μF ~ 0.22 μF) between PN, and the wiring of the capacitor should be as short as possible.

Note 9: The high level of the input signal is effective, and a pull-down resistor is connected to the ground at the input terminals of each channel of HVIC; It is suggested to add RC filter circuit at the input terminals to prevent input signal oscillation.

Note 10: Position all capacitors as close to IPM as possible.

Note 11: The control ground wire and power ground wire shall be connected at one point, and the wiring shall be as short as possible;

Note 12: In the short-circuit current protection circuit, please select the $R_f C_f$ time constant in the range $1.5 \sim 2 \mu s$. At the same time, the wiring around R_f and C_f shall be as short as possible, and $R_{fwiring}$ shall be close to shunt resistance;

Note 13:/FO and /SD must be connected as short as possible.



外形封装图 Detailed Package Outline Drawings

单位: mm

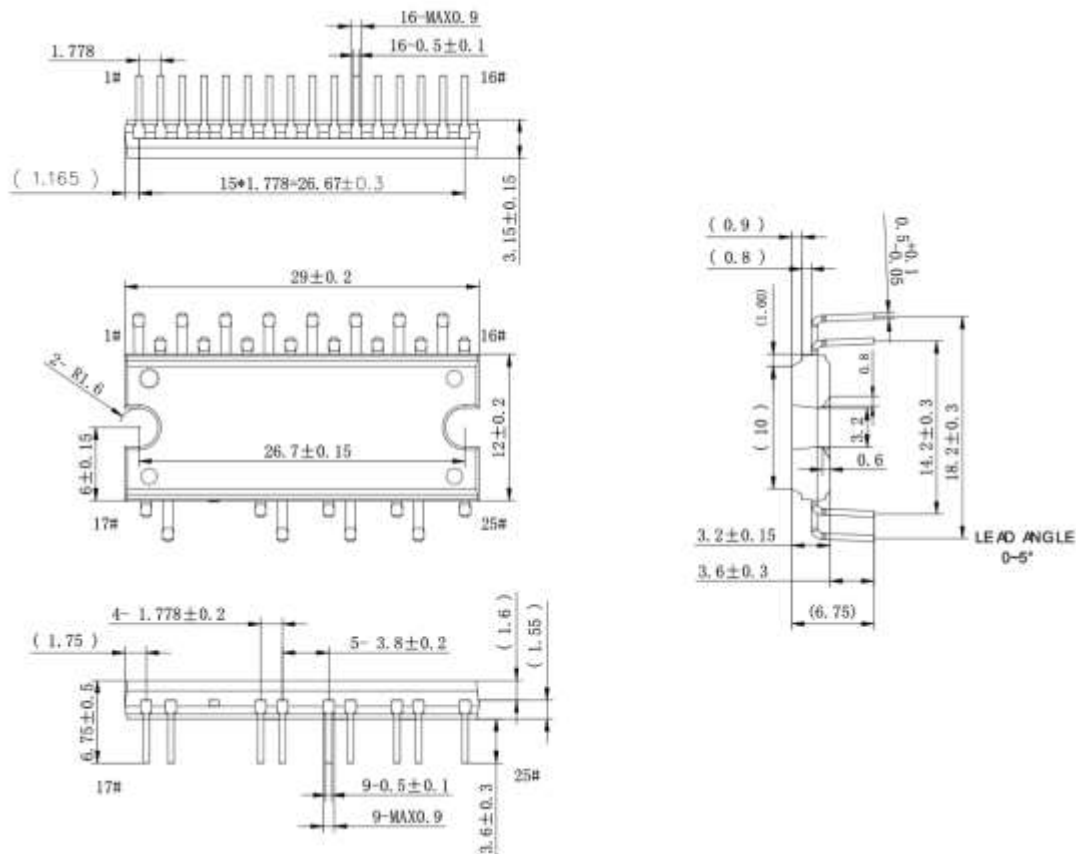


图 15: SPE04M60TW-AD 封装外形图

Fig 15: SPE04M60TW-AD Package Outline Drawings



注意事项

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3. Please do not exceed the absolute maximum ratings of the device when circuit designing.
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