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# FSBB15CH60

## Motion SPM® 3 系列

### 特性

- 通过 UL 第 E209204 号认证 (UL1557)
- 600 V - 15 A 三相 IGBT 逆变器, 包含栅极驱动和保护的控制 IC
- 低损耗、短路额定的 IGBT
- 采用 DBC ( $Al_2O_3$ ) 基板实现非常低的热阻
- 专用的 Vs 引脚以简化印刷电路板布局
- 低端 IGBT 的独立发射极开路引脚用于三相电流感测
- 单接地电源供电
- 绝缘等级: 2500 V<sub>rms</sub> / 分钟

### 应用

- 运动控制 - 家用设备 / 工业电机

### 相关资料

- [AN-9035 - Motion SPM 3 Series Ver.2 User's Guide](#)

### 概述

FSBB15CH60 是 Motion SPM® 3 模块, 为交流感应、无刷直流电机和 PMSM 电机提供非常全面的高性能逆变器输出平台。这些模块综合优化了内置 IGBT 的栅极驱动以最小化电磁干扰和能量损耗。同时也提供多重模组保护特性, 集成欠压闭锁, 过流保护和故障报告。内置的高速 HVIC 只需要一个单电源电压, 将逻辑电平栅极输入转化为适合驱动模块内部 IGBT 的高电压, 高电流驱动信号。独立的 IGBT 负端在每个相位均有效, 可支持大量不同种类的控制算法。

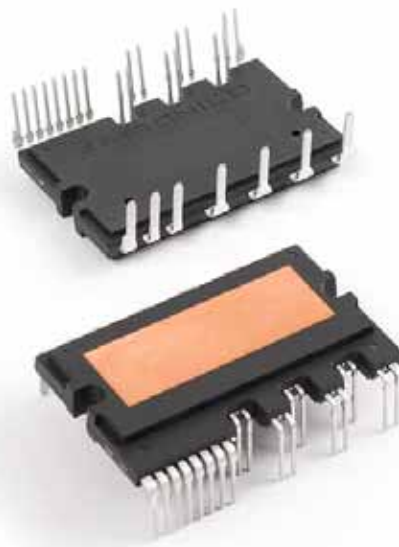


图 1. 封装概览

### 封装标识与订购信息

器件	器件标识	封装	包装类型	数量
FSBB15CH60	FSBB15CH60	SPMCA-027	Rail	10

### 集成的功率功能

- 600 V - 15 A IGBT 逆变器，适用于三相 DC / AC 功率转换（请参阅图 3）

### 集成的驱动、保护和系统控制功能

- 对于逆变器高端 IGBT：栅极驱动电路、高压隔离的高速电平转换控制电路欠压锁定保护（UVLO）  
注：可用自举电路示例如图 10 和图 11 所示。
- 对于逆变器低端 IGBT：栅极驱动电路、短路保护 (SCP)、控制电源欠压锁定保护（UVLO）
- 故障信号：对应 UVLO（低端电源）和短路故障
- 输入接口：高电平有效接口，可用于 3.3 / 5 V 逻辑电平，施密特触发脉冲输入

### 引脚布局

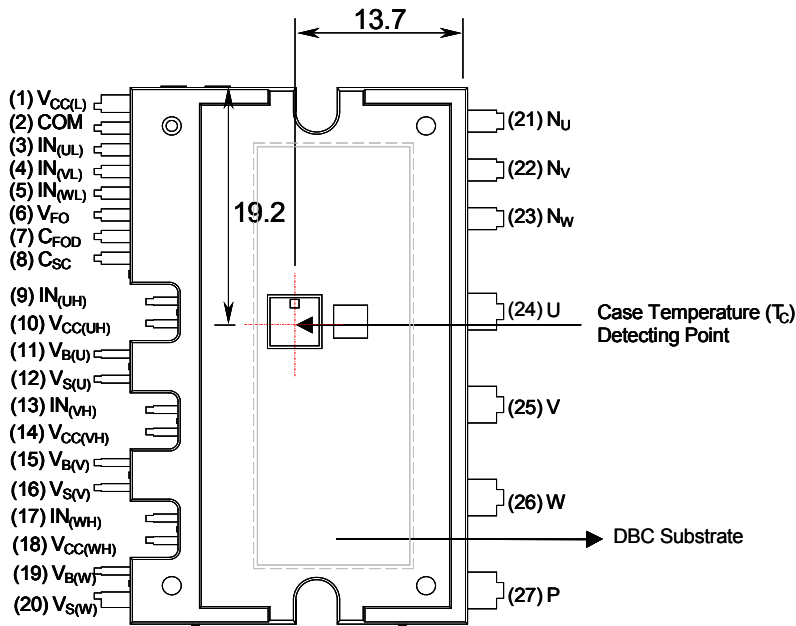


图 2. 俯视图

## 引脚描述

引脚号	引脚名	引脚描述
1	$V_{CC(L)}$	IC 和 IGBT 驱动的低端公共偏压
2	COM	公共电源接地
3	$IN_{(UL)}$	低端 U 相的信号输入
4	$IN_{(VL)}$	低端 V 相的信号输入
5	$IN_{(WL)}$	低端 W 相的信号输入
6	$V_{FO}$	故障输出
7	$C_{FOD}$	设置故障输出持续时间的电容
8	$C_{SC}$	短路电流感测输入电容（低通滤波器）
9	$IN_{(UH)}$	高端 U 相的信号输入
10	$V_{CC(UH)}$	U 相 IC 的高端偏压
11	$V_{B(U)}$	U 相 IGBT 驱动的高端偏压
12	$V_{S(U)}$	U 相 IGBT 驱动的高端偏压接地
13	$IN_{(VH)}$	高端 V 相的信号输入
14	$V_{CC(VH)}$	V 相 IC 的高端偏压
15	$V_{B(V)}$	V 相 IGBT 驱动的高端偏压
16	$V_{S(V)}$	V 相 IGBT 驱动的高端偏压接地
17	$IN_{(WH)}$	高端 W 相的信号输入
18	$V_{CC(WH)}$	W 相 IC 的高端偏压
19	$V_{B(W)}$	W 相 IGBT 驱动的高端偏压
20	$V_{S(W)}$	W 相 IGBT 驱动的高端偏压接地
21	$N_U$	U 相的直流输入负端
22	$N_V$	V 相的直流输入负端
23	$N_W$	W 相的直流输入负端
24	U	U 相输出
25	V	V 相输出
26	W	W 相输出
27	P	直流输入正端

内部等效电路与输入 / 输出引脚

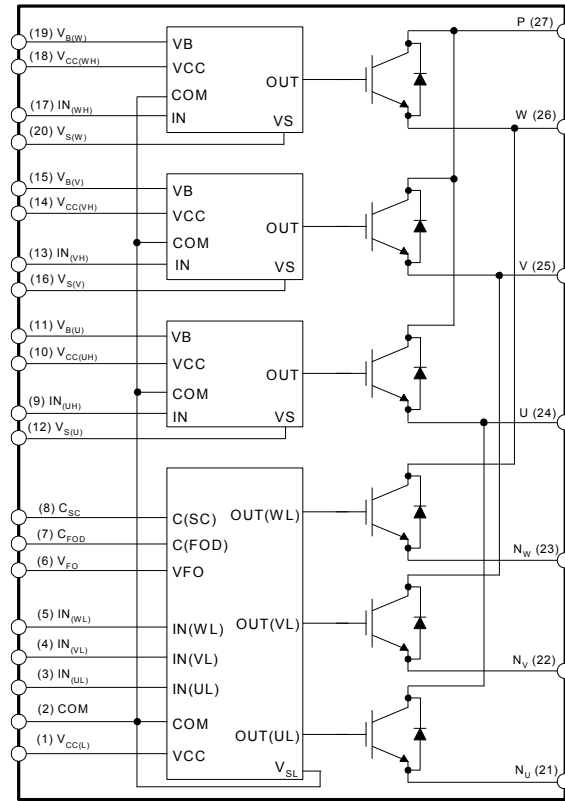


图 3. 内部框图

注:

1. 逆变器的低端由三个 IGBT 及相应的续流二极管和一个控制 IC 组成。具有栅极驱动和保护功能。
2. 逆变器的功率端由逆变器的四个直流母线输入端和三个输出端组成。
3. 逆变器高端由三个 IGBT 以及相应的续流二极管和驱动 IC 组成。

## 绝对最大额定值 (T<sub>J</sub> = 25°C, 除非另有说明。)

### 逆变器部分

符号	参数	工作条件	额定值	单位
V <sub>PN</sub>	电源电压	施加在 P- N <sub>U</sub> , N <sub>V</sub> , N <sub>W</sub>	450	V
V <sub>PN</sub> (浪涌)	电源电压 (浪涌)	施加在 P- N <sub>U</sub> , N <sub>V</sub> , N <sub>W</sub>	500	V
V <sub>CES</sub>	集电极 - 发射极之间电压		600	V
± I <sub>C</sub>	单个 IGBT 的集电极电流	T <sub>C</sub> = 25°C	15	A
± I <sub>CP</sub>	单个 IGBT 的集电极电流 (峰值)	T <sub>C</sub> = 25°C, 脉冲宽度小于 1 ms	30	A
P <sub>C</sub>	集电极功耗	T <sub>C</sub> = 25°C, 单个芯片	50	W
T <sub>J</sub>	工作结温	(注 1)	-20 ~ 125	°C

注:

1. Motion SPM® 3 产品中集成的功率芯片的最大结温额定值为 150°C (当 T<sub>C</sub> ≤ 100°C)。但是, 为保证 Motion SPM 3 产品的安全工作, 平均结温应限制为 T<sub>J(ave)</sub> ≤ 125°C (at T<sub>C</sub> ≤ 100°C)

### 控制部分

符号	参数	工作条件	额定值	单位
V <sub>CC</sub>	控制电源电压	施加在 V <sub>CC(UH)</sub> , V <sub>CC(VH)</sub> , V <sub>CC(WH)</sub> , V <sub>CC(L)</sub> - COM	20	V
V <sub>BS</sub>	高端控制偏置电压	施加在 V <sub>B(U)</sub> - V <sub>S(U)</sub> , V <sub>B(V)</sub> - V <sub>S(V)</sub> , V <sub>B(W)</sub> - V <sub>S(W)</sub>	20	V
V <sub>IN</sub>	输入信号电压	施加在 IN <sub>(UH)</sub> , IN <sub>(VH)</sub> , IN <sub>(WH)</sub> , IN <sub>(UL)</sub> , IN <sub>(VL)</sub> , IN <sub>(WL)</sub> - COM 之间	-0.3 ~ 17	V
V <sub>FO</sub>	故障输出电源电压	施加在 V <sub>FO</sub> - COM 之间	-0.3 ~ V <sub>CC</sub> +0.3	V
I <sub>FO</sub>	故障输出电流	V <sub>FO</sub> 引脚处的灌电流	5	mA
V <sub>SC</sub>	电流感测输入电压	施加在 C <sub>SC</sub> - COM 之间	-0.3 ~ V <sub>CC</sub> +0.3	V

### 整个系统

符号	参数	工作条件	额定值	单位
V <sub>PN(PROT)</sub>	自我保护电源电压限制 (短路保护能力)	V <sub>CC</sub> = V <sub>BS</sub> = 13.5 ~ 16.5 V T <sub>J</sub> = 125°C, 非重复性, 小于 < 2 μs	400	V
T <sub>C</sub>	模块壳体工作温度	-20°C ≤ T <sub>J</sub> ≤ 125°C, 见图 2	-20 ~ 100	°C
T <sub>STG</sub>	存储温度		-40 ~ 125	°C
V <sub>ISO</sub>	绝缘电压	60 Hz, 正弦波形, 交流 1 分钟, 连接陶瓷基板到引脚	2500	V <sub>rms</sub>

### 热阻

符号	参数	条件	最小值	典型值	最大值	单位
R <sub>th(j-c)Q</sub>	结点 - 壳体的热阻	逆变器 IGBT 部分 (每 1 / 6 模块)	-	-	2.02	°C/W
R <sub>th(j-c)F</sub>		逆变器 FWD 部分 (每 1 / 6 模块)	-	-	3.15	°C/W

注:

2. 关于壳体温度 (T<sub>C</sub>) 的测量点, 请参见图 2。

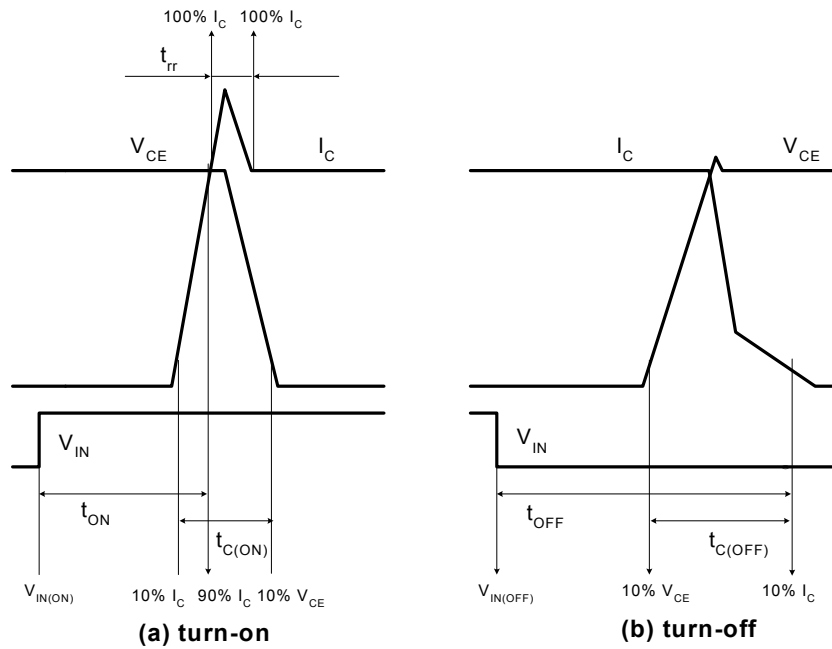
**电气特性** ( $T_J = 25^\circ\text{C}$ , 除非另有说明。)

**逆变器部分**

符号	参数	工作条件	最小值	典型值	最大值	单位	
$V_{CE(SAT)}$	集电极 - 发射极间饱和电压	$V_{CC} = V_{BS} = 15\text{ V}$ $V_{IN} = 5\text{ V}$	-	-	2.3	V	
$V_F$	FWD 正向电压	$V_{IN} = 0\text{ V}$	-	-	2.1	V	
HS	开关时间	$V_{PN} = 300\text{ V}, V_{CC} = V_{BS} = 15\text{ V}$ $I_C = 15\text{ A}$ $V_{IN} = 0\text{ V} \leftrightarrow 5\text{ V}$ , 电感负载 (注 3)	$t_{ON}$	-	0.4	-	$\mu\text{s}$
			$t_{C(ON)}$	-	0.28	-	$\mu\text{s}$
			$t_{OFF}$	-	0.67	-	$\mu\text{s}$
			$t_{C(OFF)}$	-	0.35	-	$\mu\text{s}$
			$t_{rr}$	-	0.10	-	$\mu\text{s}$
LS	开关时间	$V_{PN} = 300\text{ V}, V_{CC} = V_{BS} = 15\text{ V}$ $I_C = 15\text{ A}$ $V_{IN} = 0\text{ V} \leftrightarrow 5\text{ V}$ , 电感负载 (注 3)	$t_{ON}$	-	0.55	-	$\mu\text{s}$
			$t_{C(ON)}$	-	0.24	-	$\mu\text{s}$
			$t_{OFF}$	-	0.73	-	$\mu\text{s}$
			$t_{C(OFF)}$	-	0.34	-	$\mu\text{s}$
			$t_{rr}$	-	0.10	-	$\mu\text{s}$
$I_{CES}$	集电极 - 发射极间漏电流	$V_{CE} = V_{CES}$	-	-	250	$\mu\text{A}$	

**注:**

3.  $t_{ON}$  和  $t_{OFF}$  包括模块内部驱动 IC 的传输延迟时间。 $t_{C(ON)}$  和  $t_{C(OFF)}$  指在内部给定的栅极驱动条件下, IGBT 本身的开关时间。详细信息, 请参见图 4。



**图 4. 开关时间的定义**

## 电气特性 (T<sub>J</sub> = 25°C, 除非另有说明。)

### 控制部分

符号	参数	工作条件	最小值	典型值	最大值	单位	
I <sub>QCCL</sub>	V <sub>CC</sub> 静态电源电流	V <sub>CC</sub> = 15 V I <sub>N(U<sub>L</sub>, V<sub>L</sub>, W<sub>L</sub>)</sub> = 0 V	V <sub>CC(L)</sub> - COM	-	-	23	mA
I <sub>QCCH</sub>		V <sub>CC</sub> = 15 V I <sub>N(U<sub>H</sub>, V<sub>H</sub>, W<sub>H</sub>)</sub> = 0 V	V <sub>CC(U<sub>H</sub>)</sub> , V <sub>CC(V<sub>H</sub>)</sub> , V <sub>CC(W<sub>H</sub>)</sub> - COM	-	-	100	μA
I <sub>QBS</sub>	V <sub>BS</sub> 静态电源电流	V <sub>BS</sub> = 15 V I <sub>N(U<sub>H</sub>, V<sub>H</sub>, W<sub>H</sub>)</sub> = 0 V	V <sub>B(U)</sub> - V <sub>S(U)</sub> , V <sub>B(V)</sub> - V <sub>S(V)</sub> , V <sub>B(W)</sub> - V <sub>S(W)</sub>	-	-	500	μA
V <sub>FOH</sub>	故障输出电压	V <sub>SC</sub> = 0 V, V <sub>FO</sub> 电路: 4.7 kΩ 至 5 V 上拉		4.5	-	-	V
V <sub>FOL</sub>		V <sub>SC</sub> = 1 V, V <sub>FO</sub> 电路: 4.7 kΩ 至 5 V 上拉		-	-	0.8	V
V <sub>SC(ref)</sub>	短路电流触发电平	V <sub>CC</sub> = 15 V (注 4)		0.45	0.50	0.55	V
UV <sub>CCD</sub>	电源电路欠压保护	检测电平		10.7	11.9	13.0	V
UV <sub>CCR</sub>		复位电平		11.2	12.4	13.2	V
UV <sub>BSD</sub>		检测电平		10.1	11.3	12.5	V
UV <sub>BSR</sub>		复位电平		10.5	11.7	12.9	V
t <sub>FOD</sub>		故障输出脉宽	C <sub>FOD</sub> = 33 nF (注 5)		1.0	1.8	-
V <sub>IN(ON)</sub>	导通阈值电压	施加在 I <sub>N(U<sub>H</sub>)</sub> , I <sub>N(V<sub>H</sub>)</sub> , I <sub>N(W<sub>H</sub>)</sub> , I <sub>N(U<sub>L</sub>)</sub> , I <sub>N(V<sub>L</sub>)</sub> , I <sub>N(W<sub>L</sub>)</sub> - COM 之间		3.0	-	-	V
V <sub>IN(OFF)</sub>	关断阈值电压			-	-	0.8	V

注:

4. 短路电流保护仅作用于低端。

5. 故障输出脉宽 t<sub>FOD</sub> 取决于电容 C<sub>FOD</sub> 的值, 可采用下面的近似公式进行计算: C<sub>FOD</sub> = 18.3 × 10<sup>-6</sup> × t<sub>FOD</sub> [F]

### 推荐工作条件

符号	参数	工作条件	最小值	典型值	最大值	单位
V <sub>PN</sub>	电源电压	施加在 P - N <sub>U</sub> , N <sub>V</sub> , N <sub>W</sub> 之间	-	300	400	V
V <sub>CC</sub>	控制电源电压	施加在 V <sub>CC(U<sub>H</sub>)</sub> , V <sub>CC(V<sub>H</sub>)</sub> , V <sub>CC(W<sub>H</sub>)</sub> , V <sub>CC(L)</sub> - COM	13.5	15	16.5	V
V <sub>BS</sub>	高端偏压	施加在 V <sub>B(U)</sub> - V <sub>S(U)</sub> , V <sub>B(V)</sub> - V <sub>S(V)</sub> , V <sub>B(W)</sub> - V <sub>S(W)</sub>	13.0	15	18.5	V
dV <sub>CC</sub> / dt, dV <sub>BS</sub> / dt	控制电源波动		-1	-	1	V / μs
t <sub>dead</sub>	防止桥臂直通的死区时间	适用于每个输入信号	2.0	-	-	μs
f <sub>PWM</sub>	PWM 输入信号	-20°C ≤ T <sub>C</sub> ≤ 100°C, -20°C ≤ T <sub>J</sub> ≤ 125°C	-	-	20	kHz
V <sub>SEN</sub>	电流感测产生的电压	施加在 N <sub>U</sub> , N <sub>V</sub> , N <sub>W</sub> - COM 之间 (包括浪涌电压)	-4		4	V



机械特性和额定值

参数	工作条件		最小值	典型值	最大值	单位
安装扭矩	安装螺钉: M3	建议 0.62 N•m	0.51	0.62	0.72	N•m
器件平面度		见图 5	0	-	+120	μm
重量			-	15.00	-	g

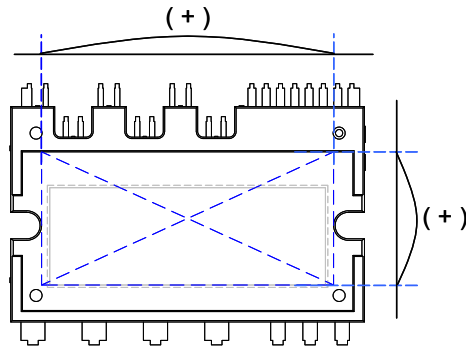
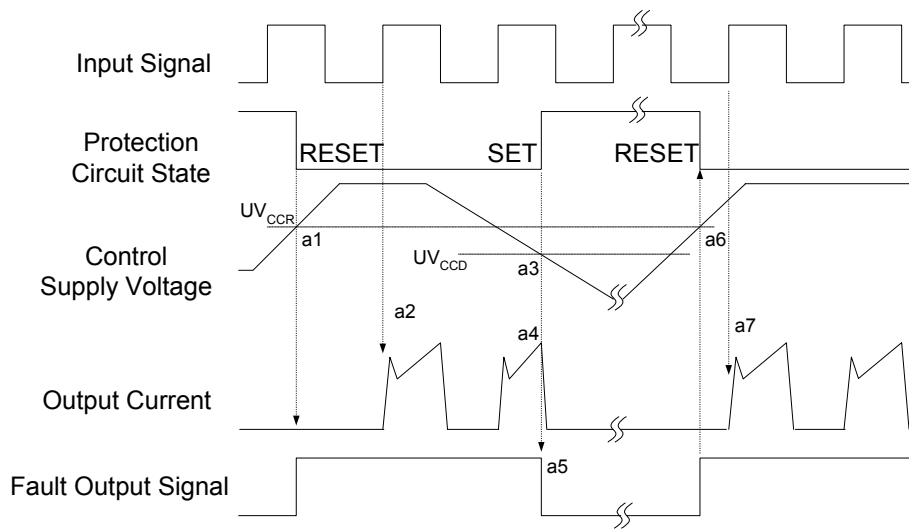


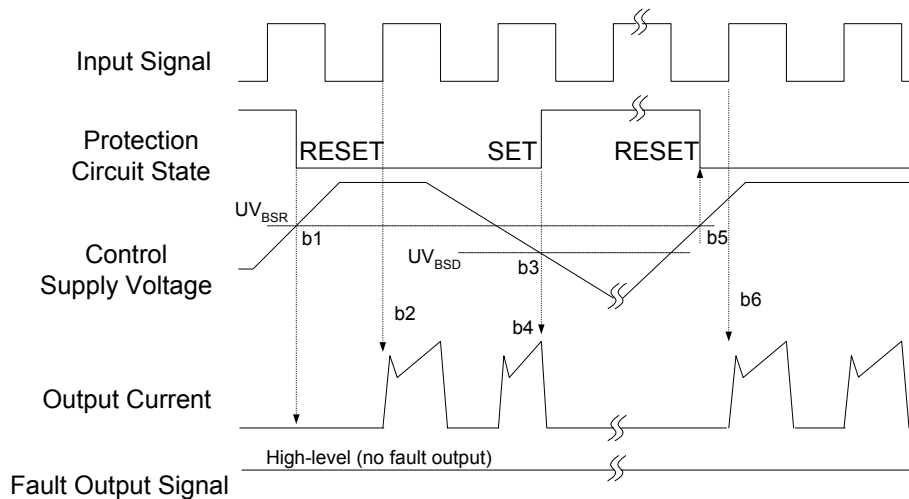
图 5. 平面度测量位置

### 保护功能时序图



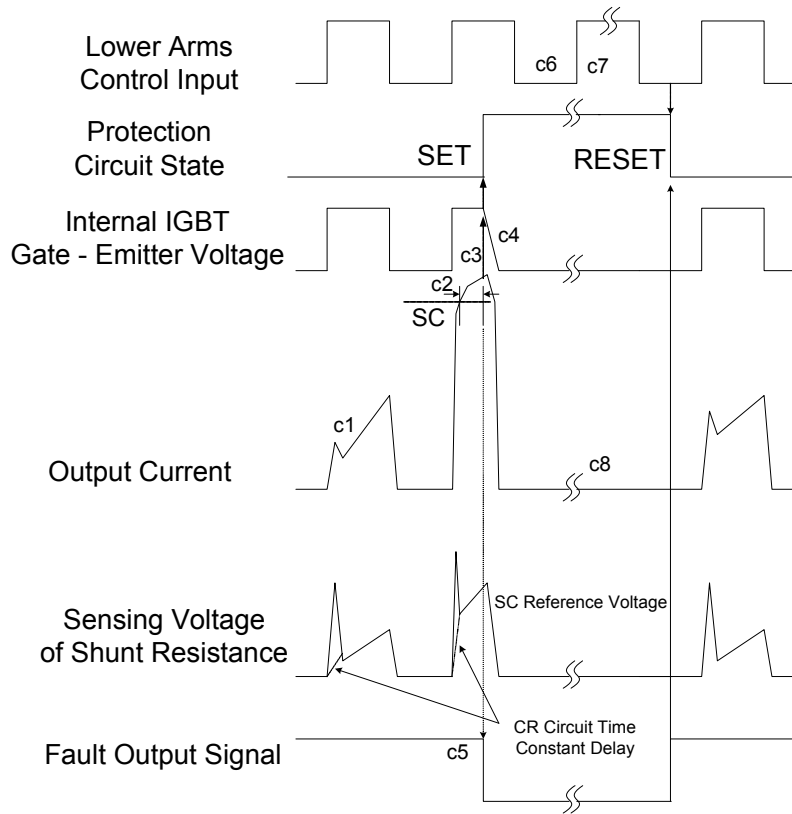
- a1: 控制电源电压上升: 当电压上升到  $UV_{CCR}$  后, 等到下一个开通信号时, 对应的电路才开始动作。
- a2: 正常工作: IGBT 导通并加载负载电流。
- a3: 欠压检测 ( $UV_{CCD}$ )。
- a4: 不论控制输入的条件, IGBT 都关断。
- a5: 故障输出工作启动。
- a6: 欠压复位 ( $UV_{CCR}$ )。
- a7: 正常工作: IGBT 导通并加载负载电流。

图 6. 欠压保护 (低端)



- b1: 控制电源电压上升: 当电压上升到  $UV_{BSR}$  后, 等到下一个输入信号时, 对应的电路才开始动作。
- b2: 正常工作: IGBT 导通并加载负载电流。
- b3: 欠压检测 ( $UV_{BSD}$ )。
- b4: 不论控制输入的条件, IGBT 都关闭, 且无故障输出信号。
- b5: 欠压复位 ( $UV_{BSR}$ )。
- b6: 正常工作: IGBT 导通并加载负载电流。

图 7. 欠压保护 (高端)



(包含外部分流电阻和 CR 连接)

- c1: 正常工作: IGBT 导通并加载负载电流。
- c2: 短路电流感测 (SC 触发)。
- c3: IGBT 栅极硬中断。
- c4: IGBT 关断。
- c5: 故障输出延时工作启动: 故障输出信号的脉宽通过外部电容  $C_{FO}$  设置。
- c6: 输入 "LOW": IGBT 关断状态。
- c7: 输入 "HIGH": IGBT 导通, 但是在故障输出有效的时间内, IGBT 不导通。
- c8: IGBT 关断状态。

图 8. 短路电流保护 (仅适用于低端的工作)

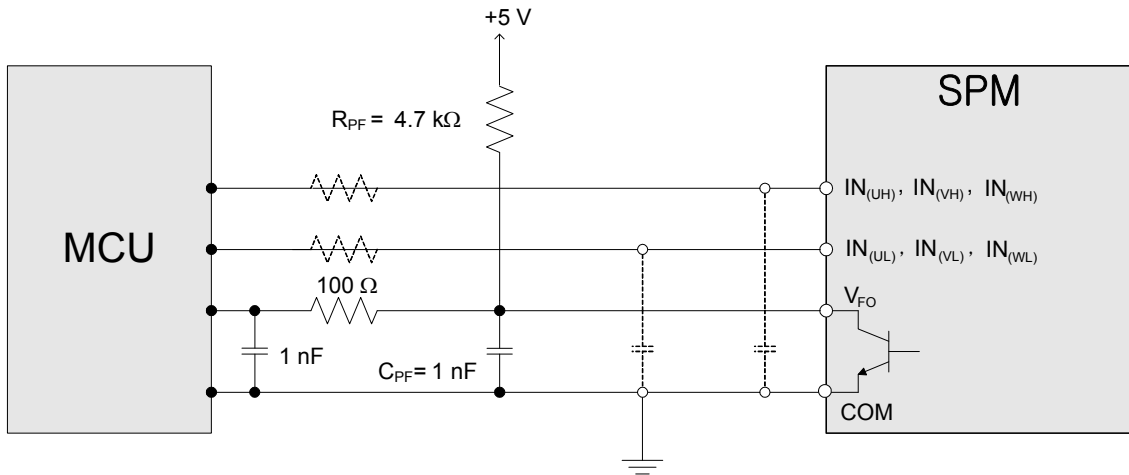


图 9. 推荐的 MCU I/O 接口电路

注:

1. 每个输入端的 RC 耦合（虚线显示部分）可能随着应用程序中使用的 PWM 控制方案和应用程序印刷电路板接线抗阻而改变。Motion SPM® 3 产品的输入信号部分集成了 3.3 kΩ（典型值）的下拉电阻。因此，当使用外部的滤波电阻时，请注意该信号在输入端的压降。
2. 逻辑输入与标准 CMOS 或者 LSTTL 的输出兼容。

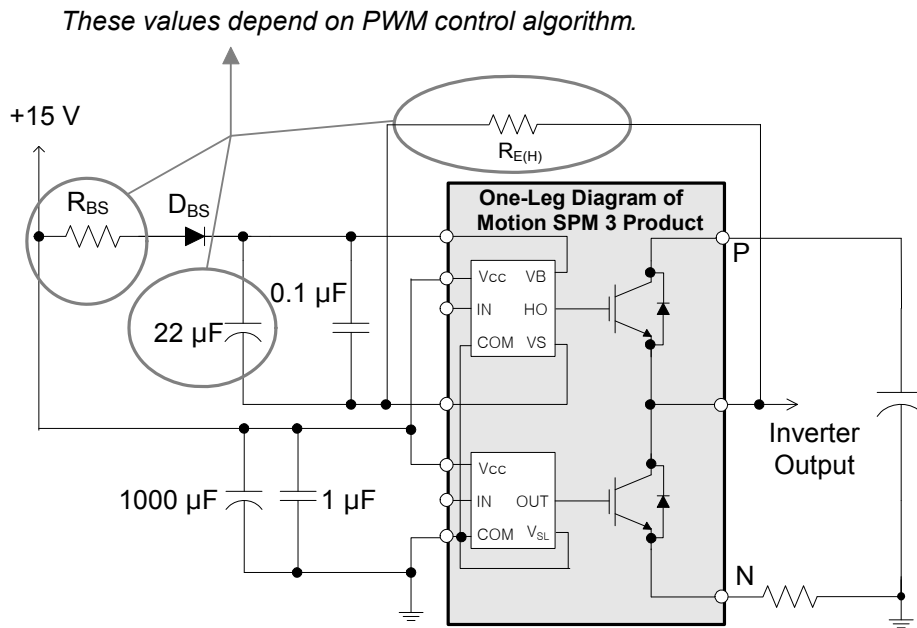


图 10. 推荐的自举工作电路和参数

注:

3. 推荐使用具有软、快恢复特性的自举二极管  $D_{BS}$ 。
4. 自举电阻 ( $R_{BS}$ ) 应比  $R_{E(H)}$  大三倍。 $R_{E(H)}$  的推荐值为 5.6 Ω，但是当高端的 dv/dt 较低时，其取值可提高为 20 Ω（最大值）。
5. 在  $V_{CC}$  - COM 之间的陶瓷电容应大于 1 μF，并且应尽可能靠近 Motion SPM 3 产品的引脚。

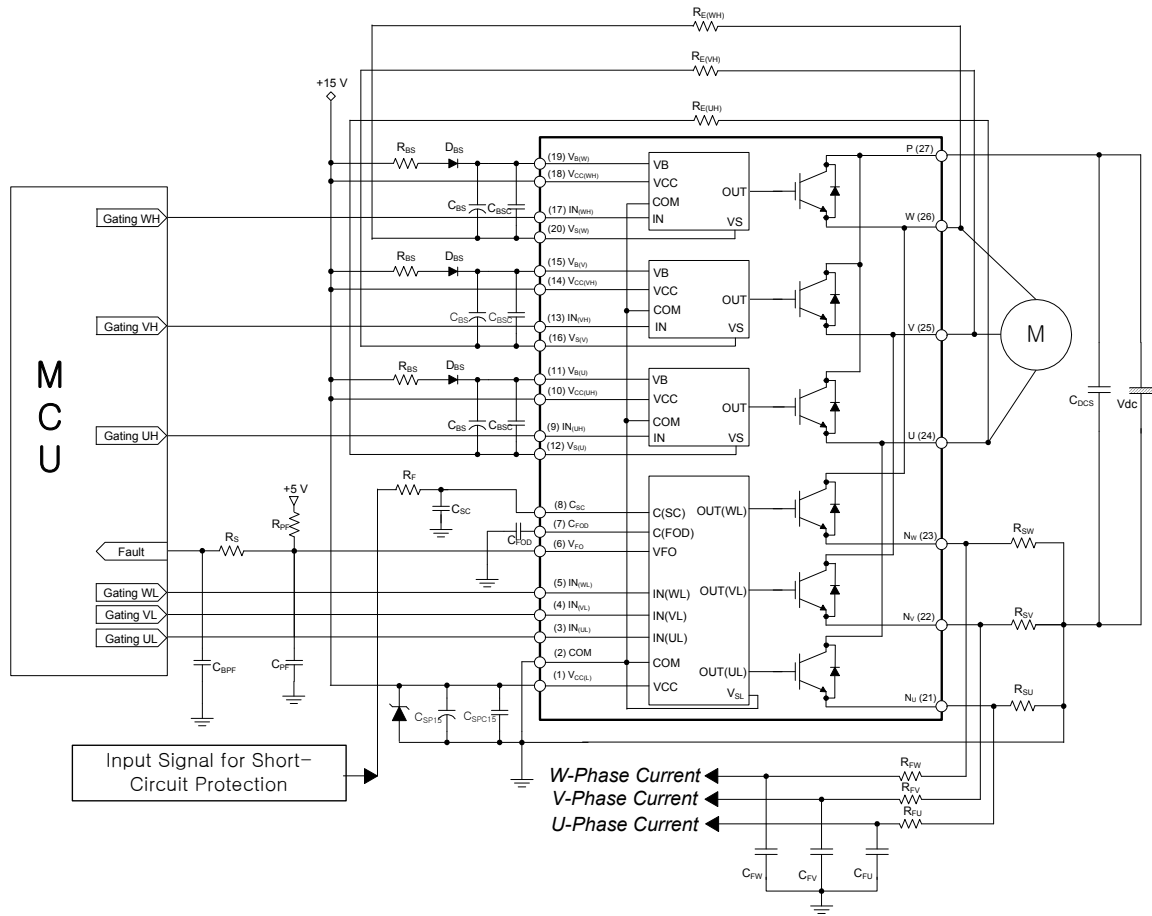
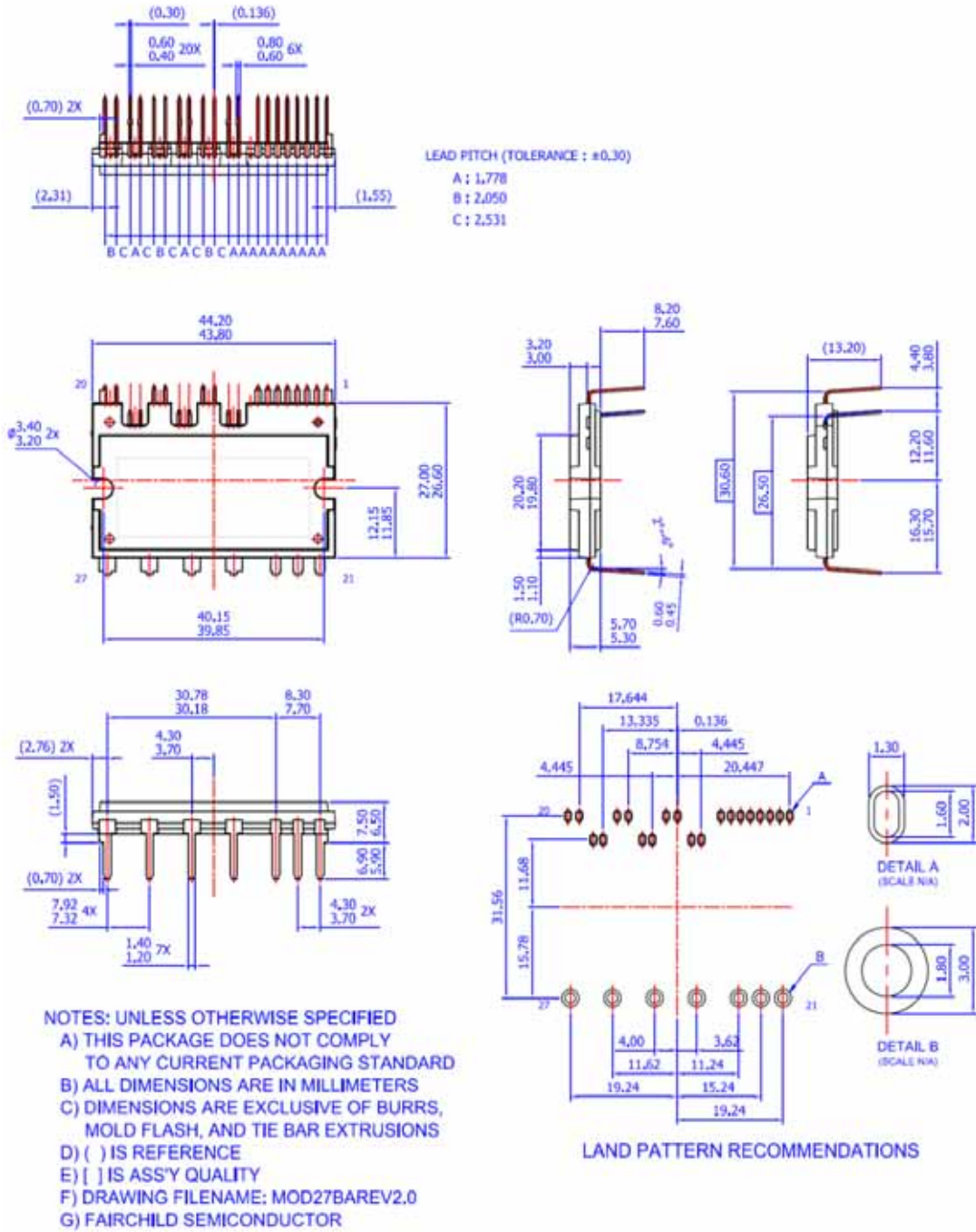


图 11. 典型应用电路

注:

1. 为了避免故障, 应尽可能缩短每个输入端的连线 (小于 2-3 cm)。
2. 因为 Motion SPM® 3 产品内部集成了一个具有特殊功能的 HVIC, 接口电路与 MCU 端口的直接耦合是可行的, 不需要任何光耦合器或变压器隔离。
3. V<sub>FO</sub> 输出是集电极开路型。该信号线应当采用 4.7 kΩ 电阻上拉至 5 V 电源的正极。(请参考图 9)。
4. 推荐 C<sub>SP15</sub> 的取值应大于自举电容 C<sub>BS</sub> 的 7 倍左右。
5. V<sub>FO</sub> 输出脉宽取决于连接在 C<sub>FOD</sub> (引脚 7) 和 COM (引脚 2) 之间的外部电容 (C<sub>FOD</sub>)。(示例: 若 C<sub>FOD</sub> = 33 nF, 则 t<sub>FO</sub> = 1.8 ms (典型值)) 具体计算方法请参考说明 5。
6. 输入信号为高电平有效。在 IC 中, 有一个 3.3 kΩ 的电阻将每一个输入信号线下拉接地。当采用 RC 耦合电路时, RC 耦合的设置应确保输入信号与关断 / 导通阈值电压相匹配。
7. 为避免保护功能出错, 应尽可能缩短 R<sub>F</sub> 和 C<sub>SC</sub> 周围的连线。
8. 在短路保护电路中, R<sub>F</sub>C<sub>SC</sub> 的时间常数应在 1.5-2 μs 的范围内进行选择。
9. 每个电容都应尽可能地靠近 Motion SPM 3 产品的引脚安装。
10. 为防止浪涌的破坏, 应尽可能缩短滤波电容和 P & GND 引脚间的连线。推荐在 P & GND 引脚间使用 0.1-0.22 μF 的高频无感电容。
11. 在各种家用电器设备中, 几乎都用到了继电器。在这些情况下, MCU 和继电器之间应留有足够的距离。
12. C<sub>SP15</sub> 应大于 1 μF, 并尽可能靠近 Motion SPM 3 产品的引脚安装。

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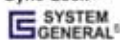



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