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FSBF5CH60B

Motion SPM® 3 系列

特性

- 通过 UL 第 E209204 号认证 (UL1557)
- 600 V - 5 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
- 内置自举二极管和专用的 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_{rms} / 分钟

应用

- 运动控制 - 家用设备 / 工业电机

相关资料

- [AN-9044 - Motion SPM® 3 Series Users Guide](#)

概述

FSBF5CH60B 是一款先进的 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。

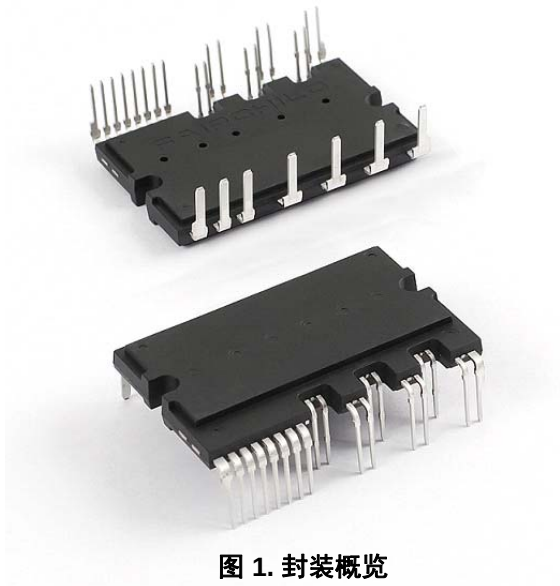


图 1. 封装概览

封装标识与订购信息

器件	器件标识	封装	包装类型	数量
FSBF5CH60B	FSBF5CH60B	SPMJA-027	Rail	10

集成的功率功能

- 600 V - 5 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 12 和图 13 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

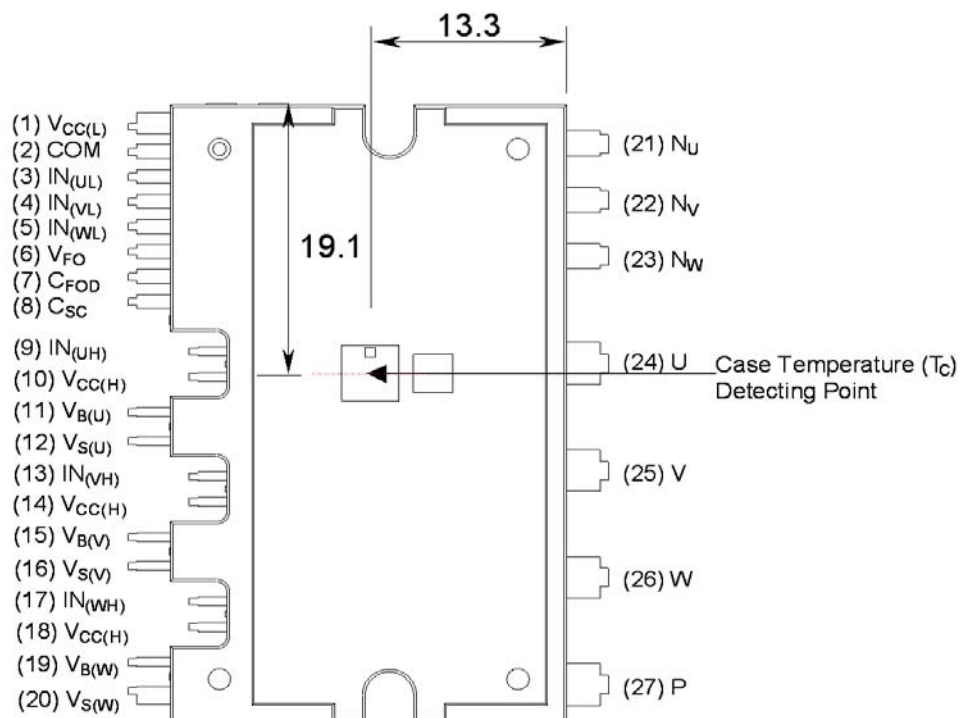


图 2. 俯视图

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}	短路电流检测输入电容（低通滤波器）
9	$IN_{(UH)}$	高端 U 相的信号输入
10	$V_{CC(H)}$	IC 和 IGBT 驱动的高端公共偏压
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	$V_{CC(H)}$	IC 和 IGBT 驱动的高端公共偏压
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	$V_{CC(H)}$	IC 和 IGBT 驱动的高端公共偏压
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

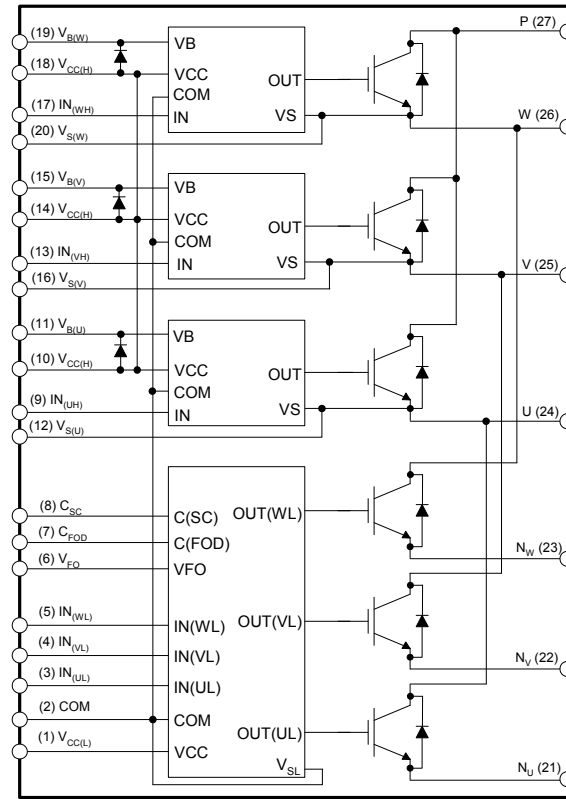


图 3. 内部框图

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 ($T_J = 25^{\circ}\text{C}$, 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_{PN}	电源电压	施加在 P - N_U , N_V , N_W 之间	450	V
V_{PN} (浪涌)	电源电压 (浪涌)	施加在 P - N_U , N_V , N_W 之间	500	V
V_{CES}	集电极 - 发射极之间电压		600	V
$\pm I_C$	单个 IGBT 的集电极电流	$T_C = 25^{\circ}\text{C}$, $T_J \leq 150^{\circ}\text{C}$	5	A
$\pm I_{CP}$	单个 IGBT 的集电极电流 (峰值)	$T_C = 25^{\circ}\text{C}$, $T_J \leq 150^{\circ}\text{C}$, 脉冲宽度小于 1 ms	10	A
P_C	集电极功耗	$T_C = 25^{\circ}\text{C}$, 单个芯片	19	W
T_J	工作结温	(注 1)	- 40 ~ 150	$^{\circ}\text{C}$

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 $T_C \leq 125^{\circ}\text{C}$)。**控制部分**

符号	参数	工作条件	额定值	单位
V_{CC}	控制电源电压	施加在 $V_{CC(H)}$, $V_{CC(L)}$ - COM 之间	20	V
V_{BS}	高端控制偏压	施加在 $V_{B(U)}$ - $V_{S(U)}$, $V_{B(V)}$ - $V_{S(V)}$, $V_{B(W)}$ - $V_{S(W)}$	20	V
V_{IN}	输入信号电压	施加在 $IN_{(UH)}$, $IN_{(VH)}$, $IN_{(WH)}$, $IN_{(UL)}$, $IN_{(VL)}$, $IN_{(WL)}$ - COM 之间	-0.3 ~ $V_{CC} + 0.3$	V
V_{FO}	故障输出电源电压	施加在 V_{FO} - COM 之间	-0.3 ~ $V_{CC} + 0.3$	V
I_{FO}	故障输出电流	V_{FO} 引脚处的灌电流	5	mA
V_{SC}	电流检测输入电压	施加在 C_{SC} - COM 之间	-0.3 ~ $V_{CC} + 0.3$	V

自举二极管部分

符号	参数	工作条件	额定值	单位
V_{RRM}	最大重复反向电压		600	V
I_F	正向电流	$T_C = 25^{\circ}\text{C}$, $T_J \leq 150^{\circ}\text{C}$	0.5	A
I_{FP}	正向电流 (峰值)	$T_C = 25^{\circ}\text{C}$, $T_J \leq 150^{\circ}\text{C}$ 脉冲宽度小于 1 ms	2.0	A
T_J	工作结温		-40 ~ 150	$^{\circ}\text{C}$

整个系统

符号	参数	工作条件	额定值	单位
$V_{PN(Prot)}$	自我保护电源电压限制 (短路保护能力)	$V_{CC} = V_{BS} = 13.5 \sim 16.5 \text{ V}$ $T_J = 150^{\circ}\text{C}$, 非重复性, $< 2 \mu\text{s}$	400	V
T_C	模块壳体工作温度	$-40^{\circ}\text{C} \leq T_J \leq 150^{\circ}\text{C}$, 见图 2	-40 ~ 125	$^{\circ}\text{C}$
T_{STG}	存储温度		-40 ~ 125	$^{\circ}\text{C}$
V_{ISO}	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_{rms}

热阻

符号	参数	工作条件	最小值	典型值	最大值	单位
$R_{th(j-c)Q}$	结点 - 壳体的热阻	逆变器 IGBT 部分 (每 1 / 6 模块)	-	-	6.3	$^{\circ}\text{C} / \text{W}$
$R_{th(j-c)F}$		逆变器 FWD 部分 (每 1 / 6 模块)	-	-	6.5	$^{\circ}\text{C} / \text{W}$

注:

2. 关于壳体温度 (T_C) 的测量点, 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	$V_{CC} = V_{BS} = 15\text{ V}$ $V_{IN} = 5\text{ V}$	-	-	2.0	V
V_F	FWD 正向电压	$V_{IN} = 0\text{ V}$ $I_F = 5\text{ A}$, $T_J = 25^\circ\text{C}$	-	-	2.1	V
HS	t_{ON}	$V_{PN} = 300\text{ V}$, $V_{CC} = V_{BS} = 15\text{ V}$ $I_C = 5\text{ A}$ $V_{IN} = 0\text{ V} \leftrightarrow 5\text{ V}$, 电感负载 (注 3)	-	0.75	-	μs
	$t_{C(ON)}$		-	0.15	-	μs
	t_{OFF}		-	0.60	-	μs
	$t_{C(OFF)}$		-	0.20	-	μs
	t_{rr}		-	0.10	-	μs
LS	t_{ON}	$V_{PN} = 300\text{ V}$, $V_{CC} = V_{BS} = 15\text{ V}$ $I_C = 5\text{ A}$ $V_{IN} = 0\text{ V} \leftrightarrow 5\text{ V}$, 电感负载 (注 3)	-	0.45	-	μs
	$t_{C(ON)}$		-	0.20	-	μs
	t_{OFF}		-	0.60	-	μs
	$t_{C(OFF)}$		-	0.20	-	μs
	t_{rr}		-	0.10	-	μs
I_{CES}	集电极 - 发射极间漏电流	$V_{CE} = V_{CES}$	-	-	1	mA

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。**控制部分**

符号	参数	工作条件	最小值	典型值	最大值	单位
I_{QCCL}	V_{CC} 静态电源电流	$V_{CC} = 15\text{ V}$ $IN_{(UL, VL, WL)} = 0\text{ V}$	-	-	23	mA
I_{QCCH}		$V_{CC} = 15\text{ V}$ $IN_{(UH, VH, WH)} = 0\text{ V}$	-	-	600	μA
I_{QBS}	V_{BS} 静态电源电流	$V_{BS} = 15\text{ V}$ $IN_{(UH, VH, WH)} = 0\text{ V}$	-	-	500	μA
V_{FOH}	故障输出电压	$V_{SC} = 0\text{ V}$, V_{FO} 电路: 4.7 k Ω 至 5 V 上拉	4.5	-	-	V
V_{FOL}		$V_{SC} = 1\text{ V}$, V_{FO} 电路: 4.7 k Ω 至 5 V 上拉	-	-	0.8	V
$V_{SC(ref)}$	短路电流触发电平	$V_{CC} = 15\text{ V}$ (注 4)	0.45	0.50	0.55	V
TSD	过温保护	LVIC 的温度	-	160	-	$^\circ\text{C}$
DTSD	过温 保护迟滞	LVIC 的温度	-	5	-	$^\circ\text{C}$
UV_{CCD}	电源电路欠压保护	检测电平	10.7	11.9	13.0	V
UV_{CCR}		复位电平	11.2	12.4	13.4	V
UV_{BSD}		检测电平	10	11	12	V
UV_{BSR}		复位电平	10.5	11.5	12.5	V
t_{FOD}	故障输出脉宽	$C_{FOD} = 33\text{ nF}$ (注 5)	1.0	1.8	-	ms
$V_{IN(ON)}$	导通阈值电压	施加在 $IN_{(UH)}$, $IN_{(VH)}$, $IN_{(WH)}$, $IN_{(UL)}$, $IN_{(VL)}$,	2.8	-	-	V
$V_{IN(OFF)}$	关断阈值电压	$IN_{(WL)} - \text{COM}$ 之间	-	-	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_{FOD} 取决于电容 C_{FOD} 的值, 可采用下面的近似公式进行计算: $C_{FOD} = 18.3 \times 10^{-6} \times t_{FOD} [\text{F}]$

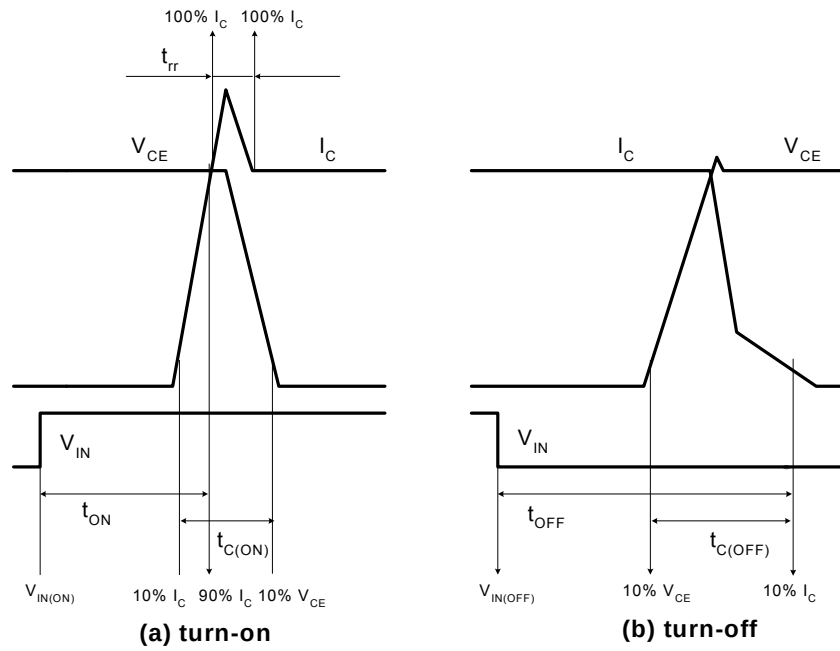


图 4. 开关时间的定义

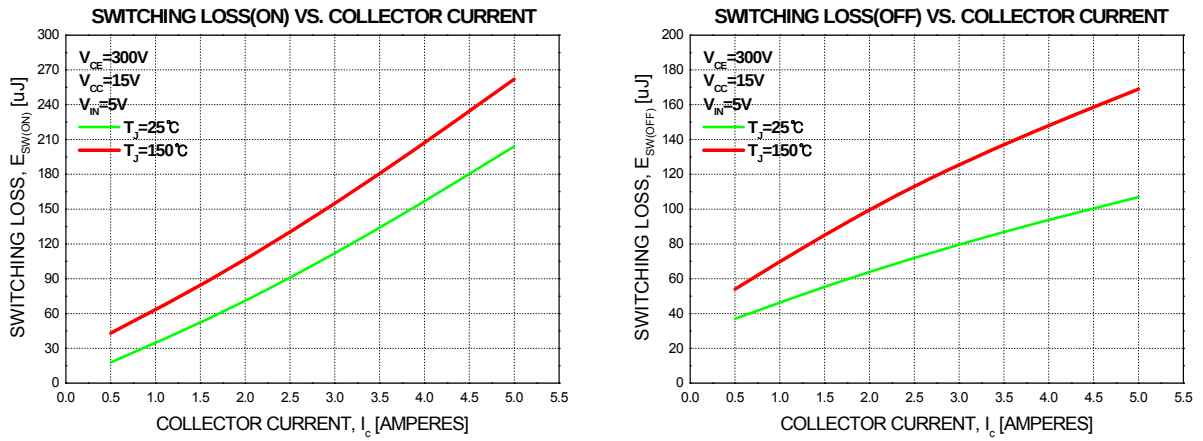


图 5. 开关损耗特性（典型值）

自举二极管部分

符号	参数	工作条件	最小值	典型值	最大值	单位
V_F	正向电压	$I_F = 0.1\text{ A}$, $T_C = 25^\circ\text{C}$	-	2.5	-	V
t_{rr}	反向恢复时间	$I_F = 0.1\text{ A}$, $T_C = 25^\circ\text{C}$	-	80	-	ns

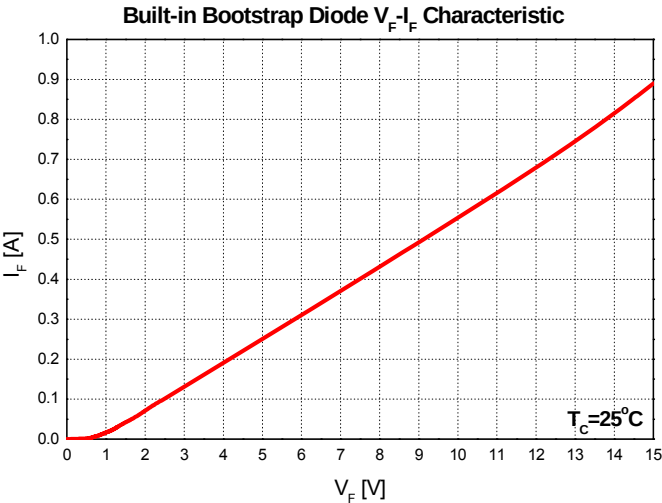


图 6. 内置自举二极管特性

注：
6. 内置自举二极管其阻抗特性约为 $15\ \Omega$ 。

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_{PN}	电源电压	施加在 P - N_U , N_V , N_W 之间	-	300	400	V
V_{CC}	控制电源电压	施加在 $V_{CC(H)}$, $V_{CC(L)}$ - COM 之间	13.5	15.0	16.5	V
V_{BS}	高端偏压	施加在 $V_{B(U)} - V_{S(U)}$, $V_{B(V)} - V_{S(V)}$, $V_{B(W)} - V_{S(W)}$	13.0	15.0	18.5	V
dV_{CC}/dt , dV_{BS}/dt	控制电源波动		-1	-	1	V / μs
t_{dead}	防止桥臂直通的死区时间	每个输入信号	2	-	-	μs
f_{PWM}	PWM 输入信号	$-40^\circ\text{C} \leq T_C \leq 125^\circ\text{C}$, $-40^\circ\text{C} \leq T_J \leq 150^\circ\text{C}$	-	-	20	kHz
V_{SEN}	电流感测产生的电压	施加在 N_U , N_V , N_W - 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	1.00	N•m
器件平面度		见图 7	0	-	+120	μm
重量			-	15.40	-	g

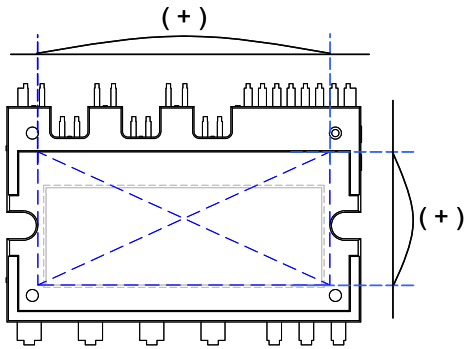
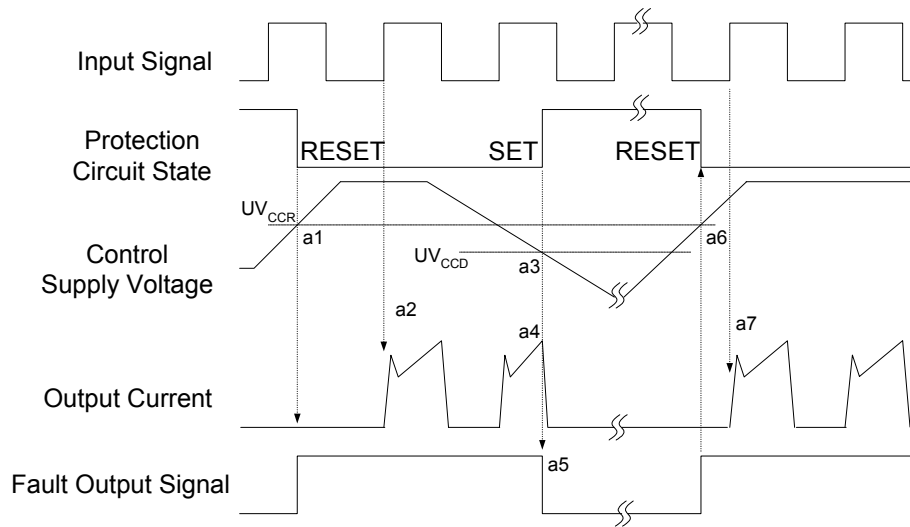


图 7. 平面度测量位置

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})。

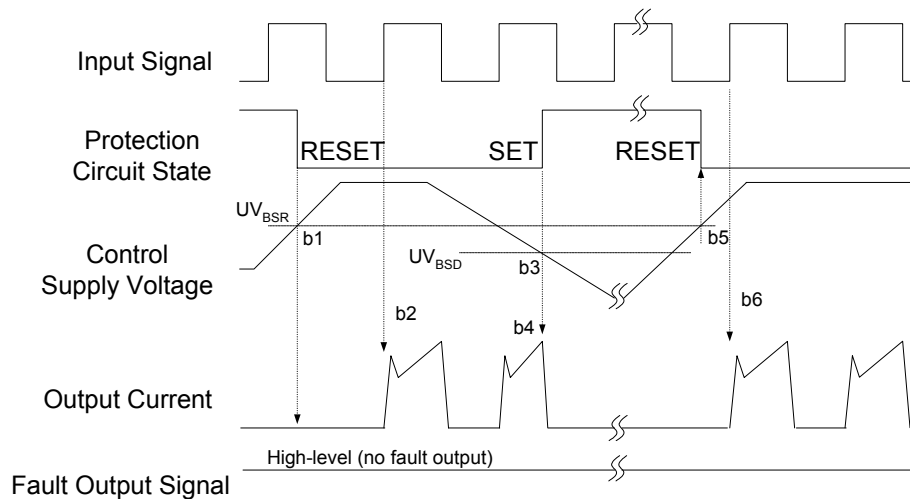
a4 : 不论控制输入的条件, IGBT 都关断。

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 8. 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。

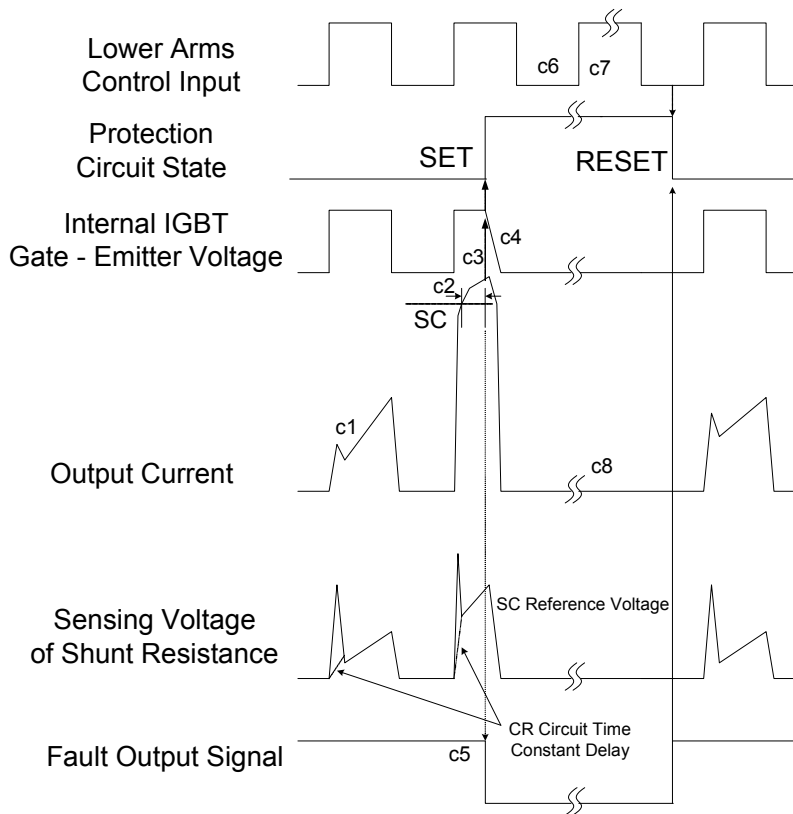
b3 : 欠压检测 (UV_{BSD})。

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 9. 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 10. 短路电流保护 (仅适用于低端的工作)

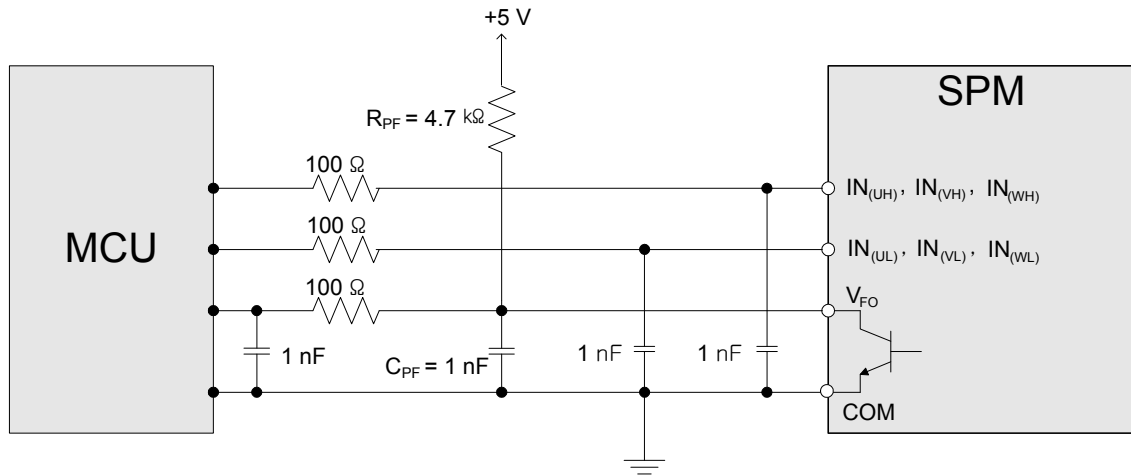


图 11. 推荐的 MCU I/O 接口电路

注:

1. 每个输入端的 RC 耦合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典型值为 5 kΩ 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。

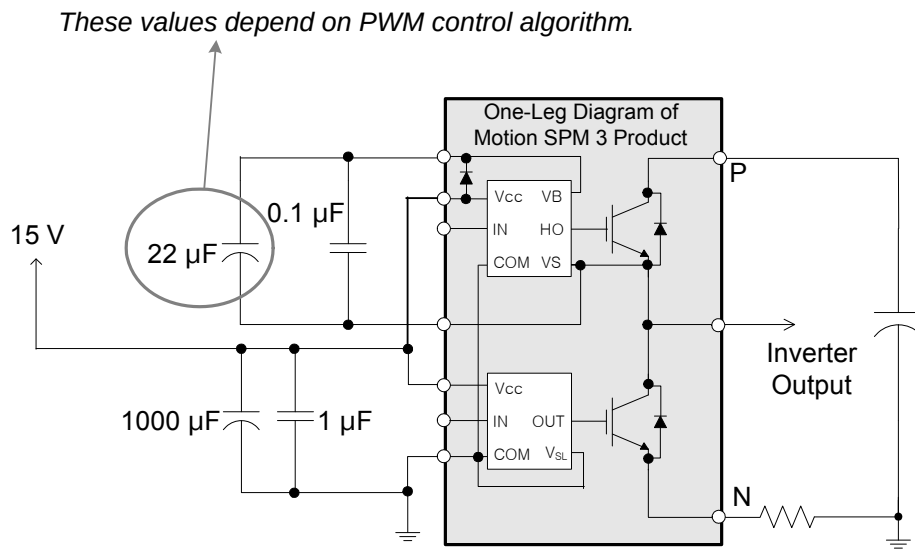


图 12. 推荐的自举工作电路和参数

注:

3. 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。

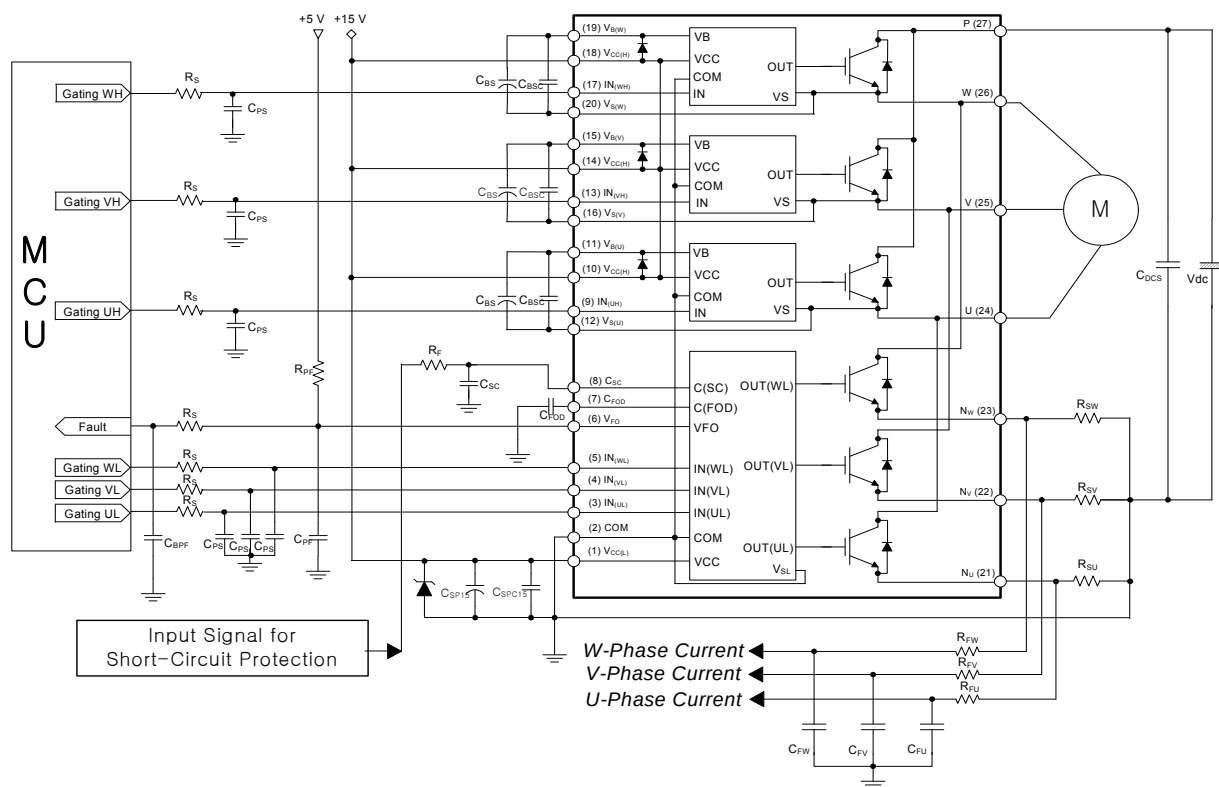
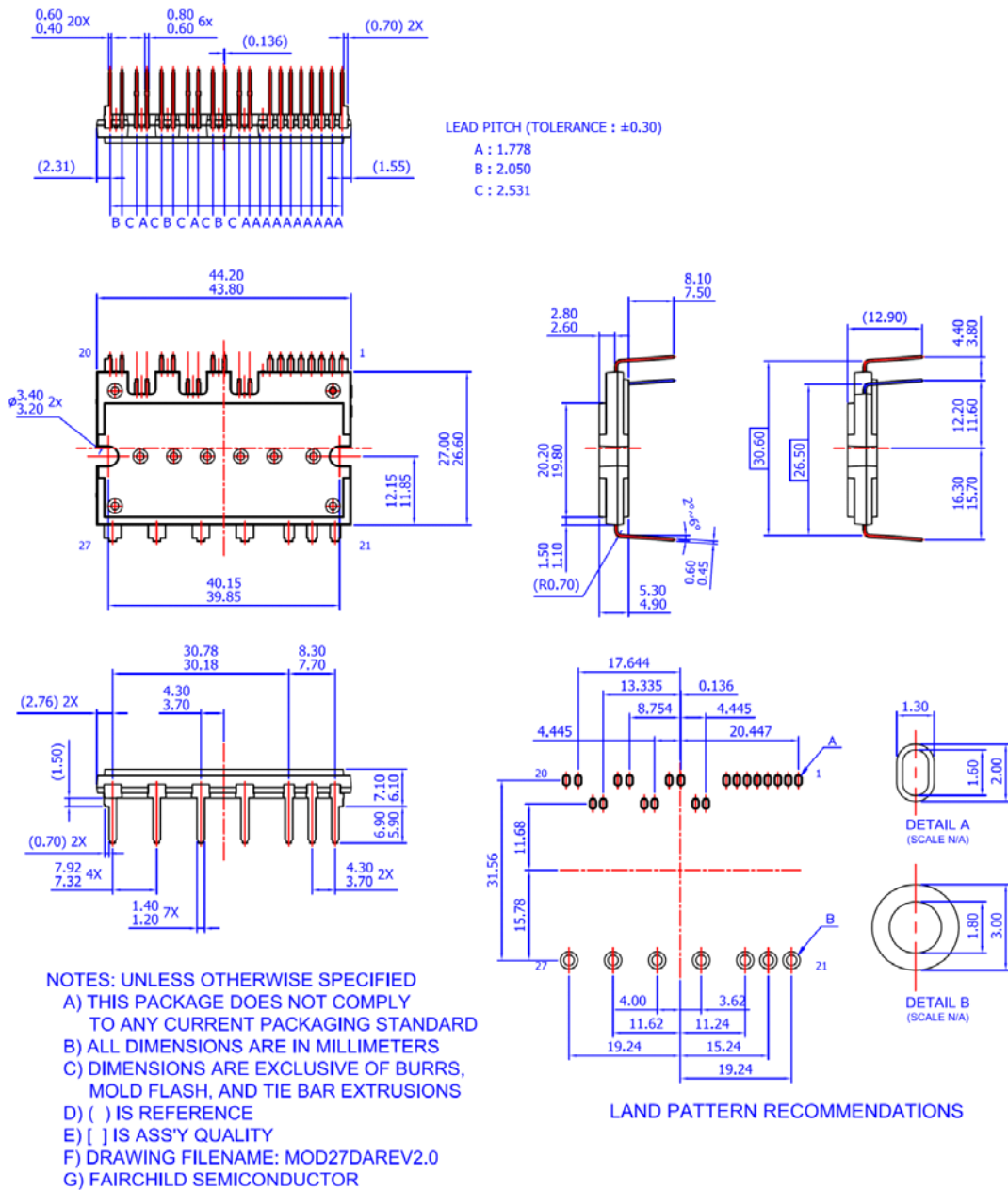


图 13. 典型应用电路

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_{FO} 输出是集电极开路型。该信号线应当采用 4.7 k Ω 电阻上拉至 5V 电源的正极。(请参考图 11)。
4. 推荐 C_{SP15} 的取值应大于自举电容 C_{BS} 的 7 倍左右。
5. V_{FO} 输出脉宽取决于连接在 C_{FOD} (引脚 7) 和 COM (引脚 2) 之间的外部电容 (C_{FOD})。(示例: 若 $C_{FOD} = 33$ nF, 则 $t_{FO} = 1.8$ 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 5 k Ω 的电阻将每一个输入信号线下拉接地。应当采用 RC 耦合电路, 以避免输入信号振荡。 $R_S C_{PS}$ 时间常数应该选择在 50 ~ 150 ns 范围内。 C_{PS} 不应低于 1 nF (推荐 $R_S = 100 \Omega$, $C_{PS} = 1$ nF)。
7. 为避免保护功能出错, 应尽可能缩短 R_F 和 C_{SC} 周围的连线。
8. 在短路保护电路中, $R_F C_{SC}$ 的时间常数应在 1.5 ~ 2.0 μ s 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 μ F 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_{SP15} 应大于 1 μ F, 并尽可能靠近 Motion SPM 3 产品的引脚安装。

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