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FSB32560

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
- 使用陶瓷基板实现低热阻
- 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_{rms} / 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

FSB32560 是一款 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，可支持大量不同类型的控制算法。

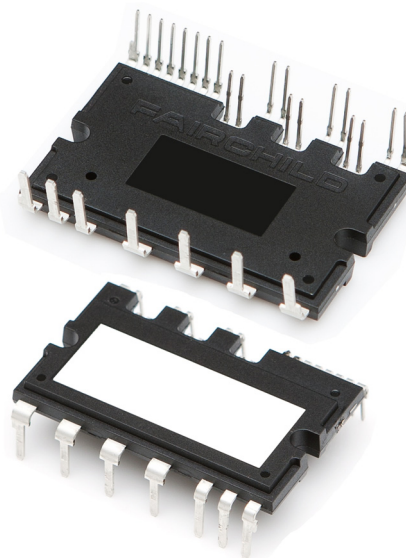


图 1. 封装概览

封装标识与订购信息

器件	器件标识	封装	包装类型	数量
FSB32560	FSB32560	SPMBA-027	Rail	10

集成的功率功能

- 600 V - 25 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

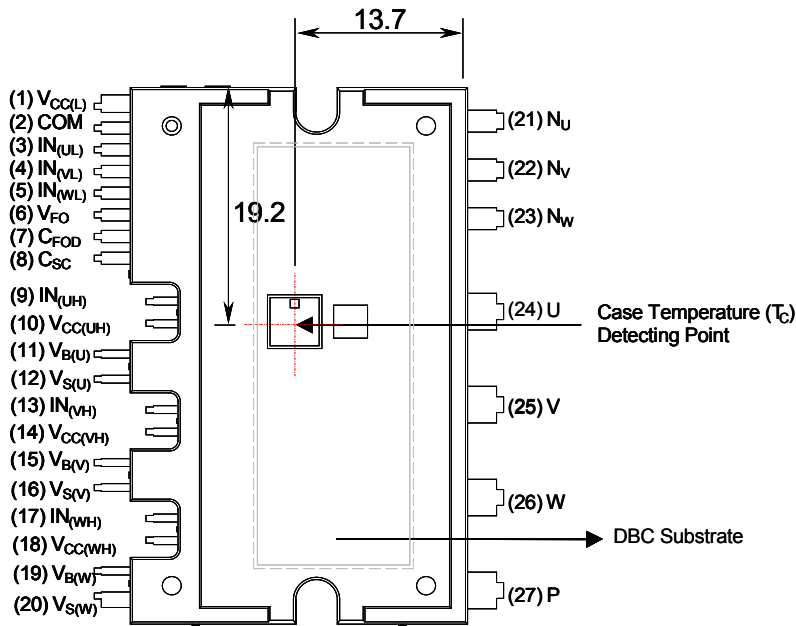


图 2. 俯视图

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

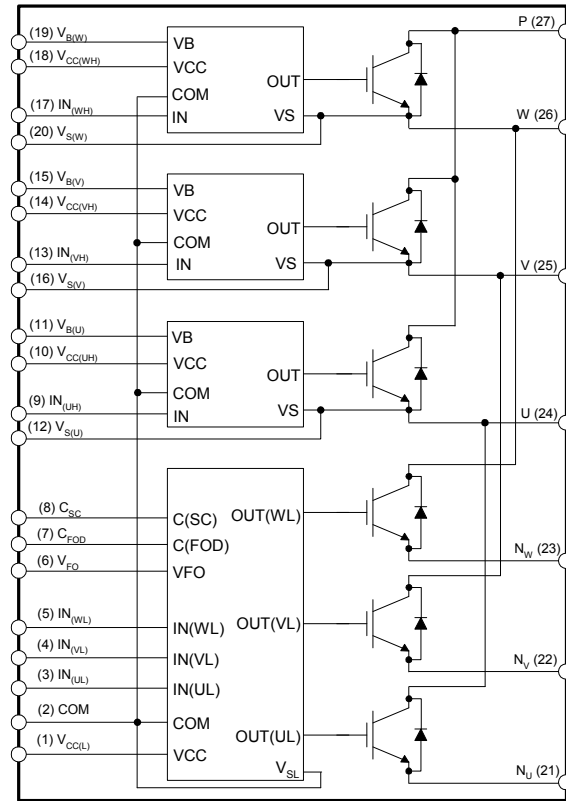


图 3. 内部框图

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 ($T_J = 25^\circ\text{C}$, 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	450	V
V_{PN} (浪涌)	电源电压 (浪涌)	施加在 P- N_U , N_V , N_W	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	$T_C = 25^\circ\text{C}$	25	A
		$T_C = 100^\circ\text{C}$	12	A
P_C	集电极功耗	$T_C = 25^\circ\text{C}$, 单个芯片	29	W
T_J	工作结温	(注 1)	-20 ~ 125	$^\circ\text{C}$

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 $T_C \leq 100^\circ\text{C}$)。但是, 为保证 Motion SPM 3 产品的安全工作, 平均结温应限制为 $T_{J(\text{ave})} \leq 125^\circ\text{C}$ (at $T_C \leq 100^\circ\text{C}$)

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 $V_{CC(UH)}$, $V_{CC(VH)}$, $V_{CC(WH)}$, $V_{CC(L)}$ - COM	20	V
V_{BS}	高端控制偏置电压	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 ~ 17	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}	电流感测输入电压	施加在 C_{SC} - COM 之间	-0.3 ~ $V_{CC}+0.3$	V

整个系统

符号	参数	工作条件	额定值	单位
$V_{PN(\text{PROT})}$	自我保护电源电压限制 (短路保护能力)	$V_{CC} = V_{BS} = 13.5 \sim 16.5 \text{ V}$ $T_J = 125^\circ\text{C}$, 非重复性, 小于 $< 2 \mu\text{s}$	400	V
T_C	模块壳体工作温度	$-20^\circ\text{C} \leq T_J \leq 125^\circ\text{C}$, 见图 2	-20 ~ 100	$^\circ\text{C}$
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	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)	-	-	3.5	$^\circ\text{C/W}$
$R_{th(j-c)F}$		逆变器 FWD 部分 (每 1 / 6 模块)	-	-	4.7	$^\circ\text{C/W}$

注:

2. 关于壳体温度 (T_C) 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	$V_{CC} = V_{BS} = 15\text{ V}$ $V_{IN} = 5\text{ V}$	-	2.15	2.85	V	
V_F	FWD 正向电压	$V_{IN} = 0\text{ V}$	-	2.20	2.90	V	
HS	t_{ON}	开关时间 $V_{PN} = 300\text{ V}, V_{CC} = V_{BS} = 15\text{ V}$ $I_C = 12\text{ A}$ $V_{IN} = 0\text{ V} \leftrightarrow 5\text{ V}$, 电感负载 (注 3)	-	0.31	-	μs	
			$t_{C(ON)}$	-	0.15	-	μs
			t_{OFF}	-	0.90	-	μs
			$t_{C(OFF)}$	-	0.34	-	μs
			t_{rr}	-	0.10	-	μs
LS	t_{ON}	$V_{PN} = 300\text{ V}, V_{CC} = V_{BS} = 15\text{ V}$ $I_C = 12\text{ A}$ $V_{IN} = 0\text{ V} \leftrightarrow 5\text{ V}$, 电感负载 (注 3)	-	0.58	-	μs	
			$t_{C(ON)}$	-	0.30	-	μs
			t_{OFF}	-	0.96	-	μs
			$t_{C(OFF)}$	-	0.37	-	μs
			t_{rr}	-	0.10	-	μs
I_{CES}	集电极 - 发射极间漏电流	$V_{CE} = V_{CES}$	-	-	250	μA	

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。

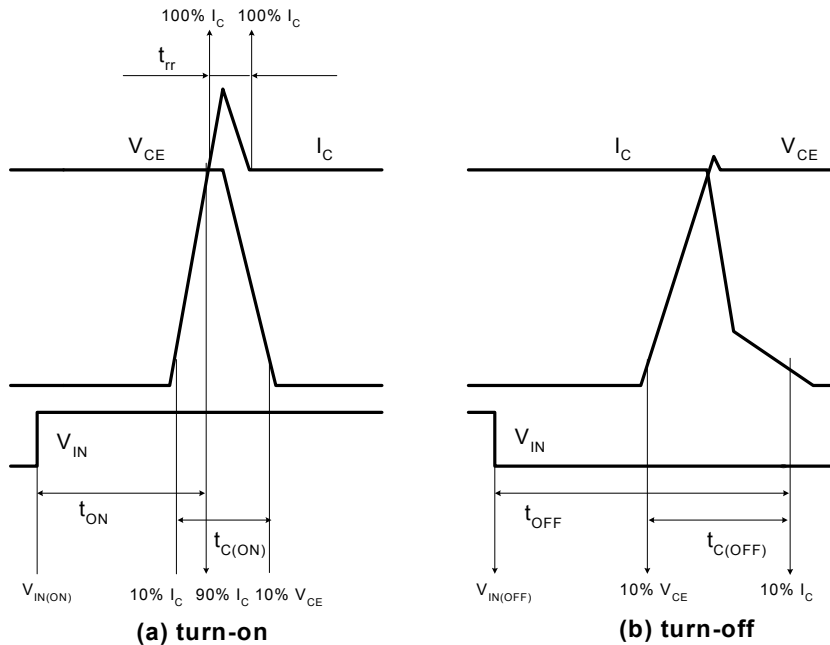


图 4. 开关时间的定义

电气特性 (T_J = 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 _{QCCL}	V _{CC} 静态电源电流	V _{CC} = 15 V I _{N(U_L, V_L, W_L)} = 0 V	V _{CC(L)} - COM	-	-	23	mA
I _{QCCH}		V _{CC} = 15 V I _{N(U_H, V_H, W_H)} = 0 V	V _{CC(U_H)} , V _{CC(V_H)} , V _{CC(W_H)} - COM	-	-	200	μA
I _{QBS}	V _{BS} 静态电源电流	V _{BS} = 15 V I _{N(U_H, V_H, W_H)} = 0 V	V _{B(U)} - V _{S(U)} , V _{B(V)} - V _{S(V)} , V _{B(W)} - V _{S(W)}	-	-	500	μA
V _{FOH}	故障输出电压	V _{SC} = 0 V, V _{FO} 电路: 4.7 kΩ 至 5 V 上拉	4.5	-	-	V	
V _{FOL}		V _{SC} = 1 V, V _{FO} 电路: 4.7 kΩ 至 5 V 上拉	-	-	0.8	V	
V _{SC(ref)}	短路电流触发电平	V _{CC} = 15 V (注 4)	0.45	0.50	0.55	V	
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	13.2	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 nF (注 5)	1.0	1.8	-	ms
V _{IN(ON)}	导通阈值电压	施加在 I _{N(U_H)} , I _{N(V_H)} , I _{N(W_H)} , I _{N(U_L)} , I _{N(V_L)} , I _{N(W_L)} - COM 之间	3.0	-	-	V	
V _{IN(OFF)}	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_{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 × 10⁻⁶ × t_{FOD} [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 _{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(U_H)} , V _{CC(V_H)} , V _{CC(W_H)} , V _{CC(L)} - COM	13.5	15	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	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	适用于每个输入信号	2.0	-	-	μs
f _{PWM}	PWM 输入信号	-20°C ≤ T _C ≤ 100°C, -20°C ≤ T _J ≤ 125°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	0.72	N•m
器件平面度		见图 5	0	-	+120	μm
重量			-	15.40	-	g

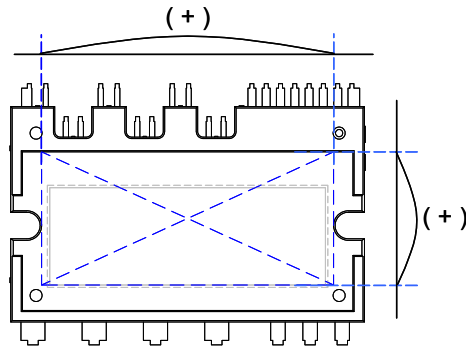
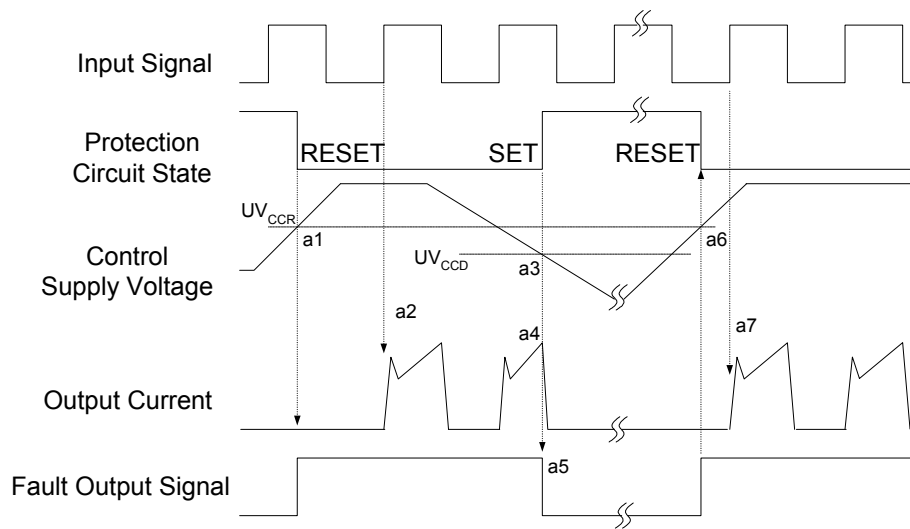


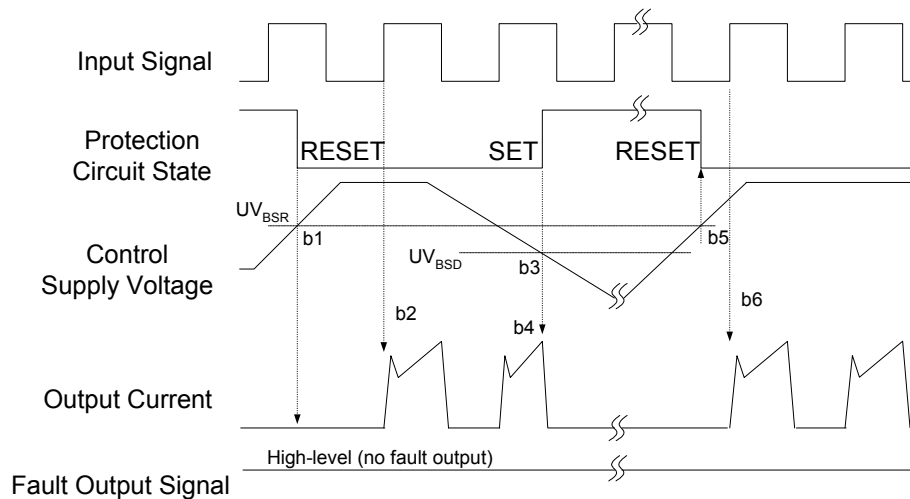
图 5. 平面度测量位置

保护功能时序图



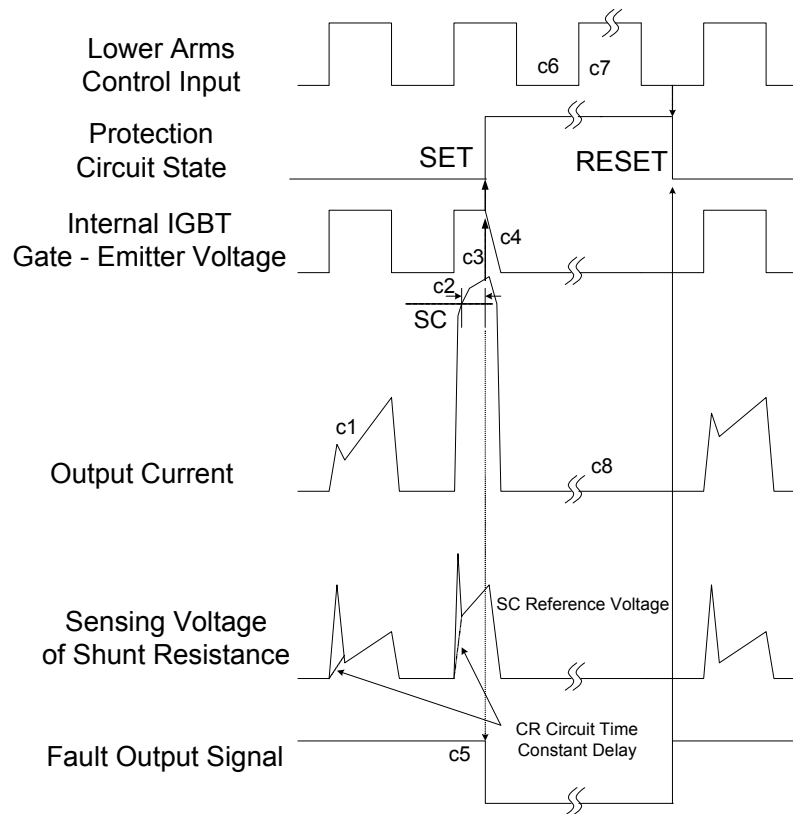
- a1: 控制电源电压上升: 当电压上升到 UV_{CCR} 后, 等到下一个开通信号时, 对应的电路才开始动作。
a2: 正常工作: IGBT 导通并加载负载电流。
a3: 欠压检测 (UV_{CCD})。
a4: 不论控制输入的条件, IGBT 都关断。
a5: 故障输出工作启动。
a6: 欠压复位 (UV_{CCR})。
a7: 正常工作: IGBT 导通并加载负载电流。

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)

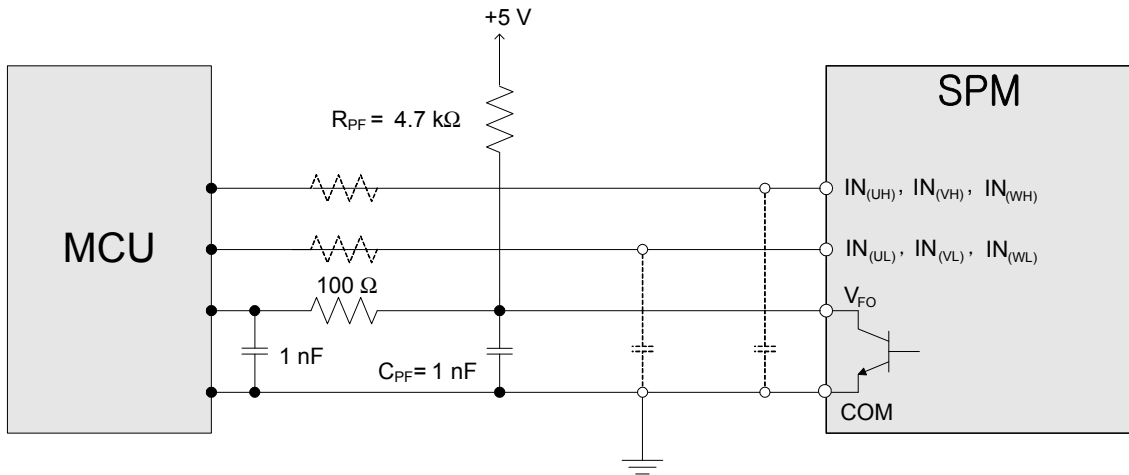


图 9. 推荐的 MCU I/O 接口电路

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。

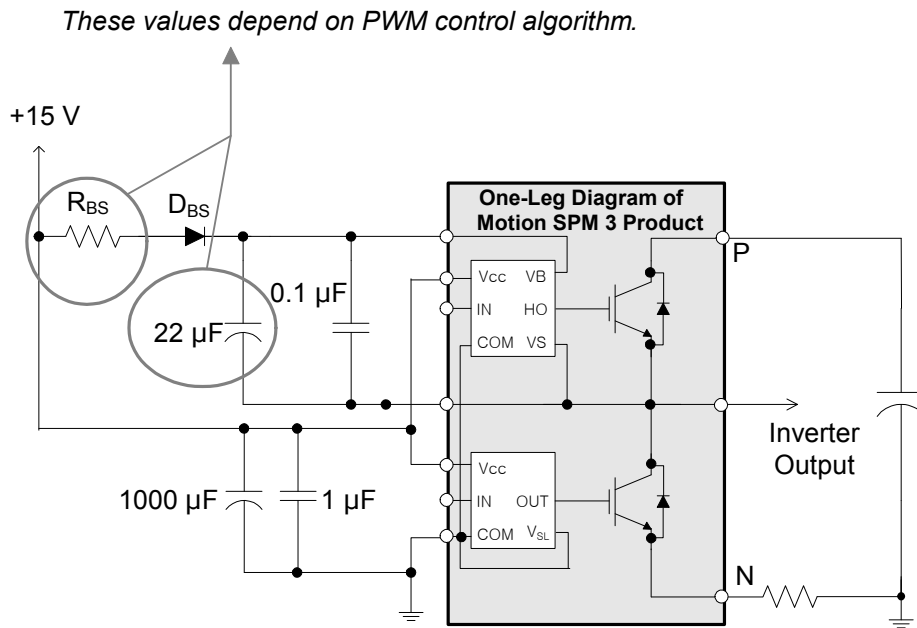


图 10. 推荐的自举工作电路和参数

注:

3. 推荐使用具有软、快恢复特性的自举二极管 D_{BS} 。
4. 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。

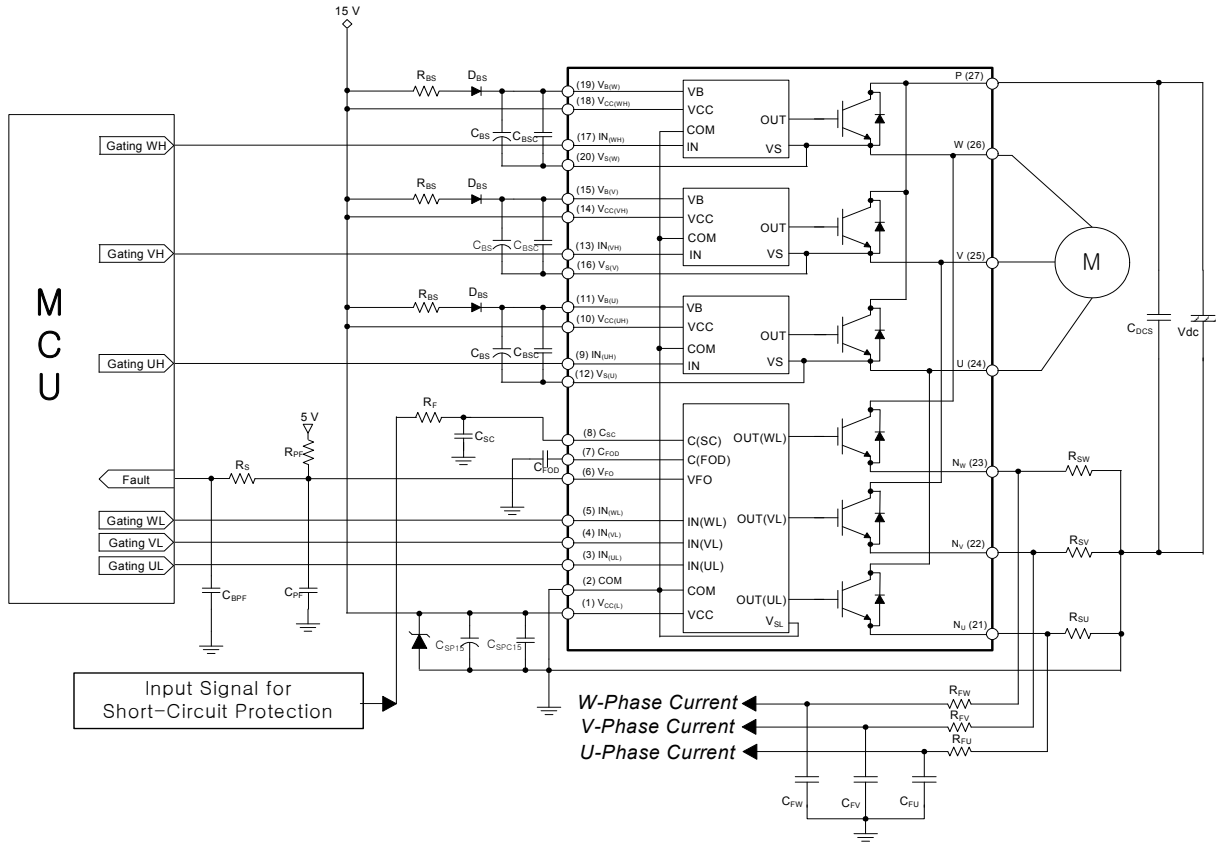
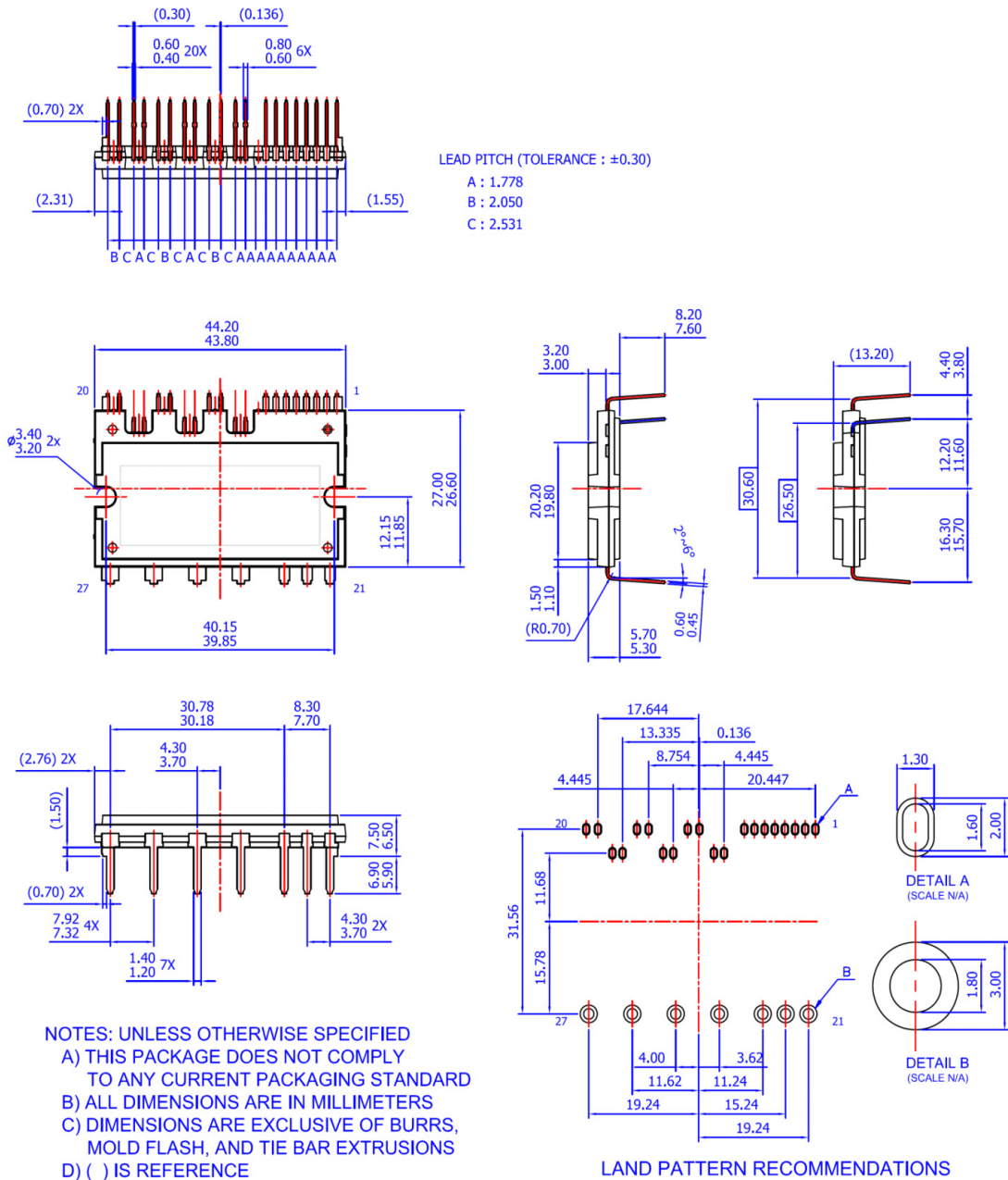


图 11. 典型应用电路

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_{FO} 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_{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 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_F 和 C_{SC} 周围的连线。
8. 在短路保护电路中, R_FC_{SC} 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_{SPC15} 应大于 1 μF, 并尽可能靠近 Motion SPM 3 产品的引脚安装。

封装轮廓详图



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