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2014 年 9 月

# FSBS10CH60

## Motion SPM® 3 系列

### 特性

- 通过 UL 第 E209204 号认证 (UL1557)
- 600 V - 10 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<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

FSBS10CH60 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。

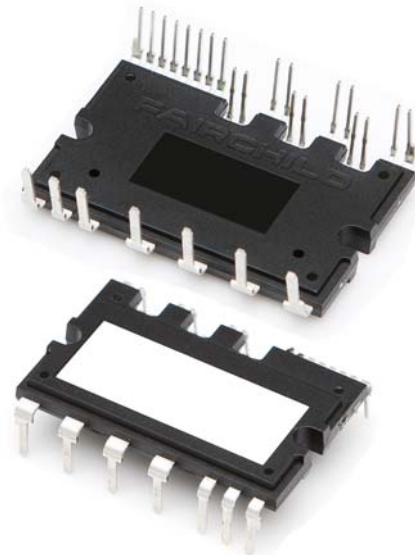


图 1. 封装概览

### 封装标识与订购信息

| 器件         | 器件标识       | 封装        | 包装类型 | 数量 |
|------------|------------|-----------|------|----|
| FSBS10CH60 | FSBS10CH60 | SPMBA-027 | Rail | 10 |

## 集成的功率功能

- 600 V - 10 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

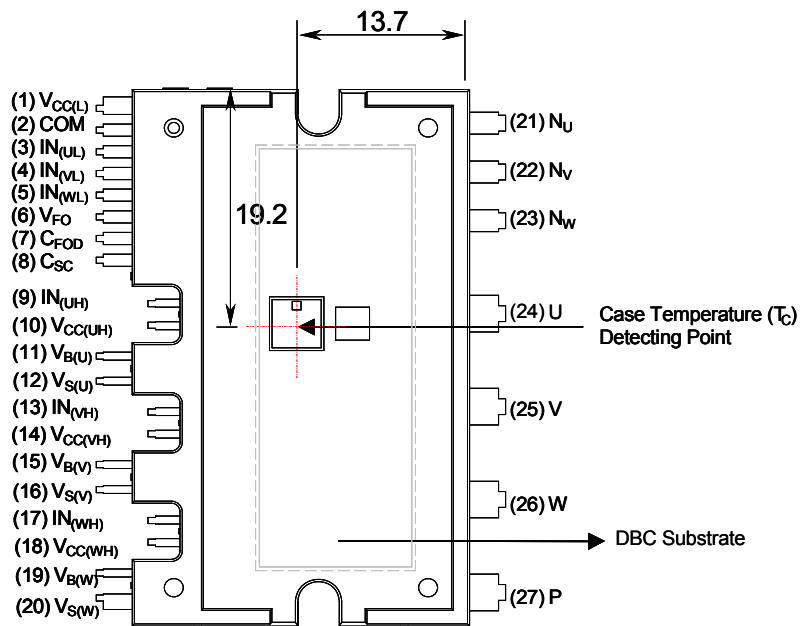


图 2. 俯视图

## 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  | $V_{CC(UH)}$ | 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

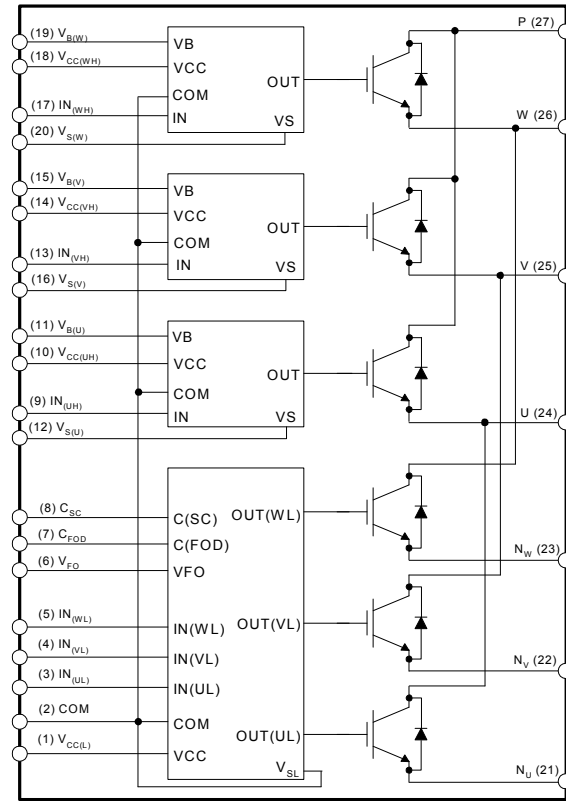


图 3. 内部框图

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      | $T_C = 25^{\circ}\text{C}$               | 10        | A                  |
| $\pm I_{CP}$  | 单个 IGBT 的集电极电流 (峰值) | $T_C = 25^{\circ}\text{C}$ , 脉冲宽度小于 1 ms | 20        | A                  |
| $P_C$         | 集电极功耗               | $T_C = 25^{\circ}\text{C}$ , 单个芯片        | 27        | 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  $150^{\circ}\text{C}$  (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 $V_{CC(UH)}$ , $V_{CC(VH)}$ , $V_{CC(WH)}$ , $V_{CC(L)} - \text{COM}$                             | 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 $IN_{(UH)}$ , $IN_{(VH)}$ , $IN_{(WH)}$ , $IN_{(UL)}$ , $IN_{(VL)}$ , $IN_{(WL)} - \text{COM}$ 之间 | -0.3 ~ 17           | V  |
| $V_{FO}$ | 故障输出电源电压 | 施加在 $V_{FO} - \text{COM}$ 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 $C_{SC} - \text{COM}$ 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) | $V_{CC} = V_{BS} = 13.5 \sim 16.5 \text{ V}$<br>$T_J = 125^{\circ}\text{C}$ , 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      | $V_{\text{rms}}$   |

**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) | -   | -   | 3.7 | $^{\circ}\text{C/W}$ |
| $R_{th(j-c)F}$ |            | 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<sub>J</sub> = 25°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 <sub>CE(SAT)</sub> | 集电极 - 发射极间饱和电压      | V <sub>CC</sub> = V <sub>BS</sub> = 15 V<br>V <sub>IN</sub> = 5 V<br>I <sub>C</sub> = 10 A, T <sub>J</sub> = 25°C                        | -   | -    | 2.3 | V  |
| V <sub>F</sub>       | FWD 正向电压            | V <sub>IN</sub> = 0 V<br>I <sub>C</sub> = 10 A, T <sub>J</sub> = 25°C                                                                    | -   | -    | 2.1 | V  |
| HS                   | t <sub>ON</sub>     | V <sub>PN</sub> = 300 V, V <sub>CC</sub> = V <sub>BS</sub> = 15 V<br>I <sub>C</sub> = 10 A<br>V <sub>IN</sub> = 0 V ↔ 5 V, 电感负载<br>(注 3) | -   | 0.39 | -   | μs |
|                      | t <sub>C(ON)</sub>  |                                                                                                                                          | -   | 0.27 | -   | μs |
|                      | t <sub>OFF</sub>    |                                                                                                                                          | -   | 0.59 | -   | μs |
|                      | t <sub>C(OFF)</sub> |                                                                                                                                          | -   | 0.31 | -   | μs |
|                      | t <sub>rr</sub>     |                                                                                                                                          | -   | 0.10 | -   | μs |
| LS                   | t <sub>ON</sub>     | V <sub>PN</sub> = 300 V, V <sub>CC</sub> = V <sub>BS</sub> = 15 V<br>I <sub>C</sub> = 10 A<br>V <sub>IN</sub> = 0 V ↔ 5 V, 电感负载<br>(注 3) | -   | 0.52 | -   | μs |
|                      | t <sub>C(ON)</sub>  |                                                                                                                                          | -   | 0.24 | -   | μs |
|                      | t <sub>OFF</sub>    |                                                                                                                                          | -   | 0.66 | -   | μs |
|                      | t <sub>C(OFF)</sub> |                                                                                                                                          | -   | 0.33 | -   | μs |
|                      | t <sub>rr</sub>     |                                                                                                                                          | -   | 0.10 | -   | μs |
| I <sub>CES</sub>     | 集电极 - 发射极间漏电流       | V <sub>CE</sub> = V <sub>CES</sub>                                                                                                       | -   | -    | 250 | μA |

注:

3. t<sub>ON</sub> 和 t<sub>OFF</sub> 包括模块内部驱动 IC 的传输延迟时间。t<sub>C(ON)</sub> 和 t<sub>C(OFF)</sub> 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。

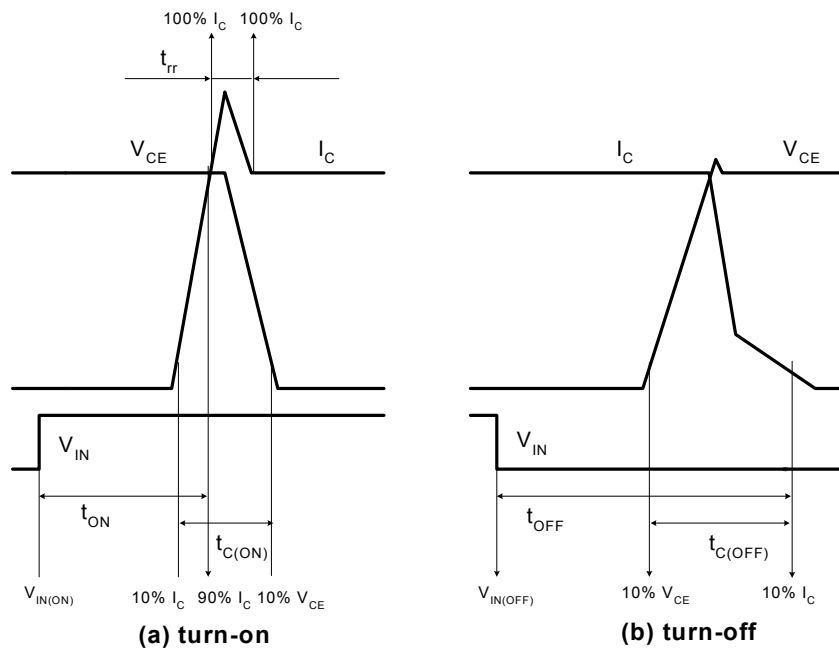


图 4. 开关时间的定义

**电气特性** ( $T_J = 25^\circ\text{C}$ , 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<br>IN <sub>(UL, VL, WL)</sub> = 0 V                                                                                  | V <sub>CC(L)</sub> - COM                                                                                                 | -    | -    | 23   | mA |
| I <sub>QCCH</sub>    |                        | V <sub>CC</sub> = 15 V<br>IN <sub>(UH, VH, WH)</sub> = 0 V                                                                                  | V <sub>CC(UH)</sub> , V <sub>CC(VH)</sub> , V <sub>CC(WH)</sub> - COM                                                    | -    | -    | 100  | μA |
| I <sub>QBS</sub>     | V <sub>BS</sub> 静态电源电流 | V <sub>BS</sub> = 15 V<br>IN <sub>(UH, VH, WH)</sub> = 0 V                                                                                  | V <sub>B(U)</sub> - V <sub>S(U)</sub> , V <sub>B(V)</sub> - V <sub>S(V)</sub> ,<br>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  | -    | ms |
| V <sub>IN(ON)</sub>  | 导通阈值电压                 | 施加在 IN <sub>(UH)</sub> , IN <sub>(VH)</sub> , IN <sub>(WH)</sub> , IN <sub>(UL)</sub> , IN <sub>(VL)</sub> ,<br>IN <sub>(WL)</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  $t_{FOD}$  取决于电容  $C_{FOD}$  的值, 可采用下面的近似公式进行计算:  $C_{FOD} = 18.3 \times 10^{-6} \times t_{FOD} [\text{F}]$ **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 $V_{CC(U_H)}, V_{CC(V_H)}, V_{CC(W_H)}, V_{CC(L)} - \text{COM}$                                       | 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                 |
| $dV_{CC}/dt$ ,<br>$dV_{BS}/dt$ | 控制电源波动      |                                                                                                           | -1   | -   | 1    | V / $\mu\text{s}$ |
| $t_{\text{dead}}$              | 防止桥臂直通的死区时间 | 适用于每个输入信号                                                                                                 | 2.0  | -   | -    | $\mu\text{s}$     |
| $f_{\text{PWM}}$               | PWM 输入信号    | $-20^\circ\text{C} \leq T_C \leq 100^\circ\text{C}$ , $-20^\circ\text{C} \leq T_J \leq 125^\circ\text{C}$ | -    | -   | 20   | kHz               |
| $V_{\text{SEN}}$               | 电流感测产生的电压   | 施加在 $N_U, N_V, N_W - \text{COM}$ 之间<br>(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   |

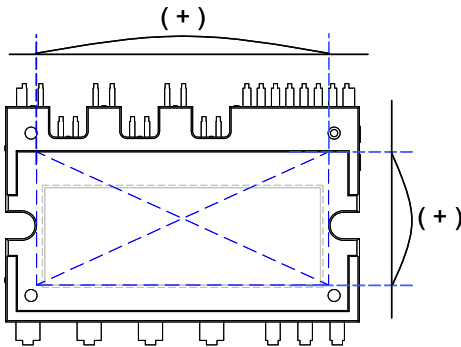
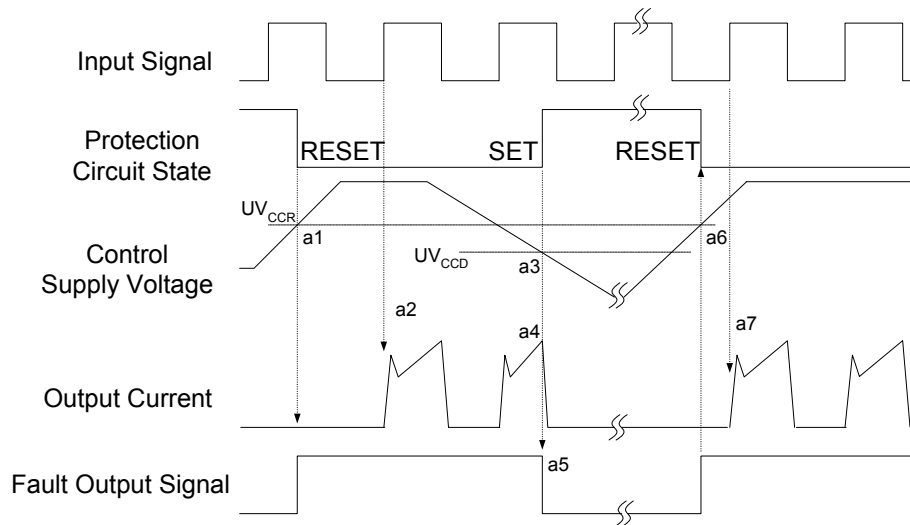


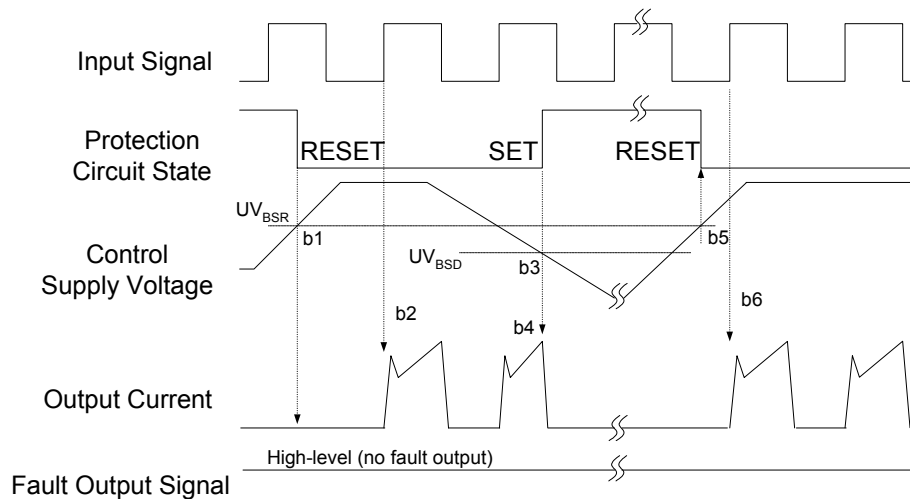
图 5. 平面度测量位置

## 保护功能时序图



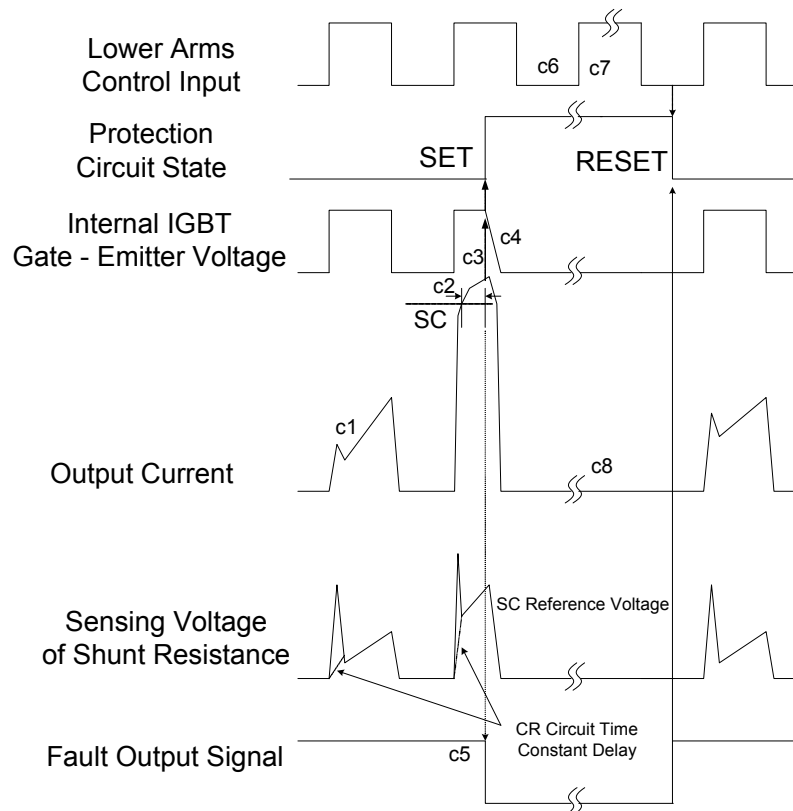
- a1: 控制电源电压上升: 当电压上升到  $UV_{CCR}$  后, 等到下一个开通信号时, 对应的电路才开始动作。
- a2: 正常工作: IGBT 导通并加载负载电流。
- a3: 欠压检测 ( $UV_{CCD}$ )。
- a4: 不论控制输入的条件, IGBT 都关断。
- a5: 故障输出工作启动。
- a6: 欠压复位 ( $UV_{CCR}$ )。
- a7: 正常工作: IGBT 导通并加载负载电流。

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)



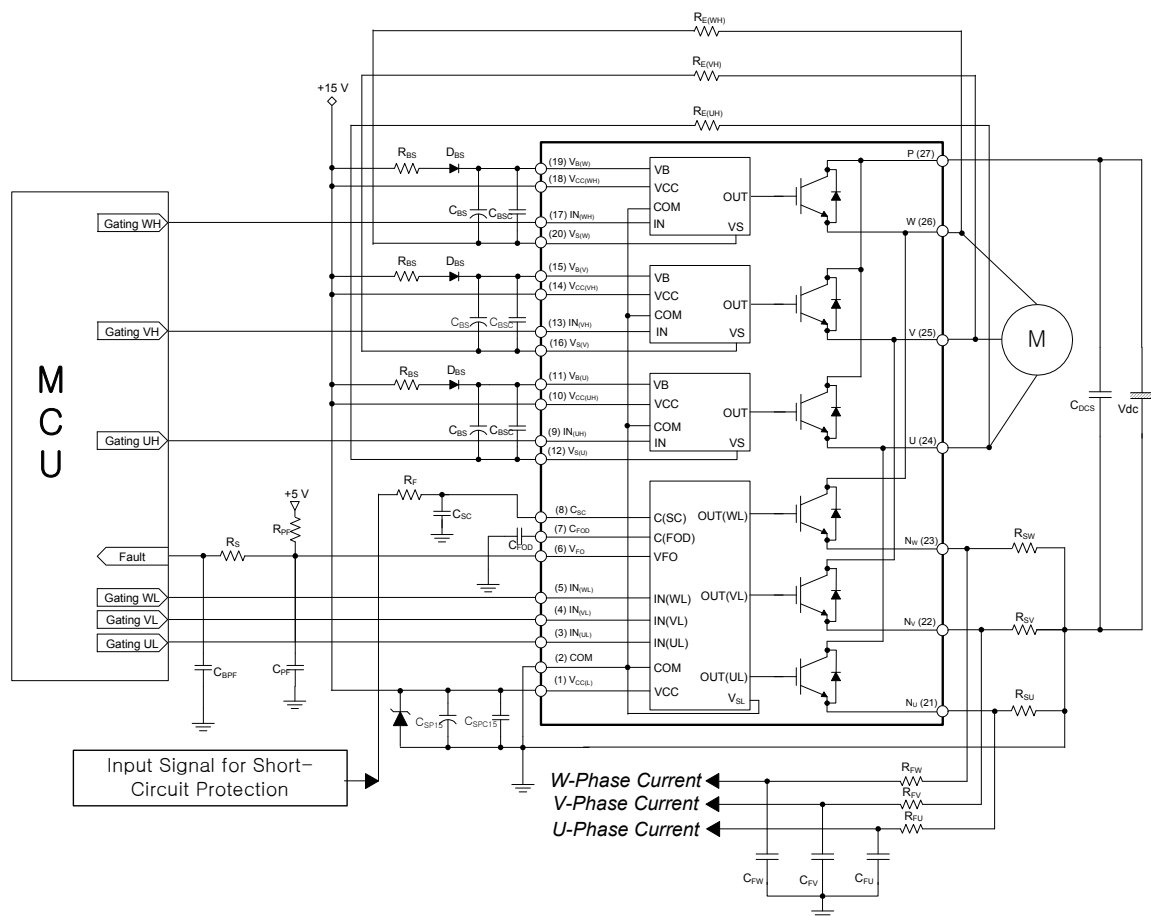


图 11. 典型应用电路

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 k $\Omega$  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 k $\Omega$  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,  $R_F C_{SC}$  的时间常数应在 1.5~2  $\mu$ 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  $\mu$ 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  $\mu$ F, 并尽可能靠近 Motion SPM 3 产品的引脚安装。





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