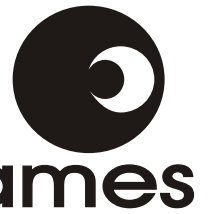


# Application Note: Energy Meter Evaluation Module



## PM2002DP

### INTRODUCTION

This application note describes the functionality of the SA2002D metering integrated circuit using the PM2002DP evaluation module.

The SA2002 enables the meter manufacturer to build a meter that measures the energy consumption, and records it to a mechanical counter. Energy flow direction as well as energy metering activity is indicated by means of LEDs. This application note will focus on the practical use of the SA2002D, more detailed information specific to the SA2002D can be found in the applicable datasheet.

### THE SA2002D PIN PROGRAMMABLE MONOCHIP METER

| Setting    | Calibrated LED imp/kWh | Pin Status             |
|------------|------------------------|------------------------|
| 6A / 220V  | 6400                   | R0 = 0, R1 = 0, R2 = 1 |
| 10A / 220V | 6400                   | R0 = 0, R1 = 0, R2 = 0 |
| 20A / 220V | 3200                   | R0 = 1, R1 = 0, R2 = 0 |
| 30A / 220V | 3200                   | R0 = 1, R1 = 0, R2 = 1 |
| 40A / 220V | 1600                   | R0 = 0, R1 = 1, R2 = 0 |
| 60A / 220V | 1600                   | R0 = 0, R1 = 1, R2 = 1 |
| 80A / 220V | 800                    | R0 = 1, R1 = 1, R2 = 0 |

Table 1: A summary of the pin settings possible with the SA2002D. Pin status 0 indicates connection to VSS and 1 indicates connection to VDD.

### CONNECTORS ON MODULE

The PM2002DP module connects directly to live and neutral on SCK1. The module is referenced to live and should be kept in mind when connecting test equipment to the module. The current is measured by the shunt on the top of the PCB. The left terminal of the shunt is connected to live. The live out will be connected to the right terminal of the shunt.

| Name | Function Description   |
|------|--|
| SCK1 | Mains connector for module power and voltage sense                                 |
| JP2  | Optional current transformer connector. (Underneath shunt resistor)                |
| JP3  | Optional Stepper motor connector. (Remove jumper J6 to disconnect impulse counter) |

Table 2: Connector descriptions

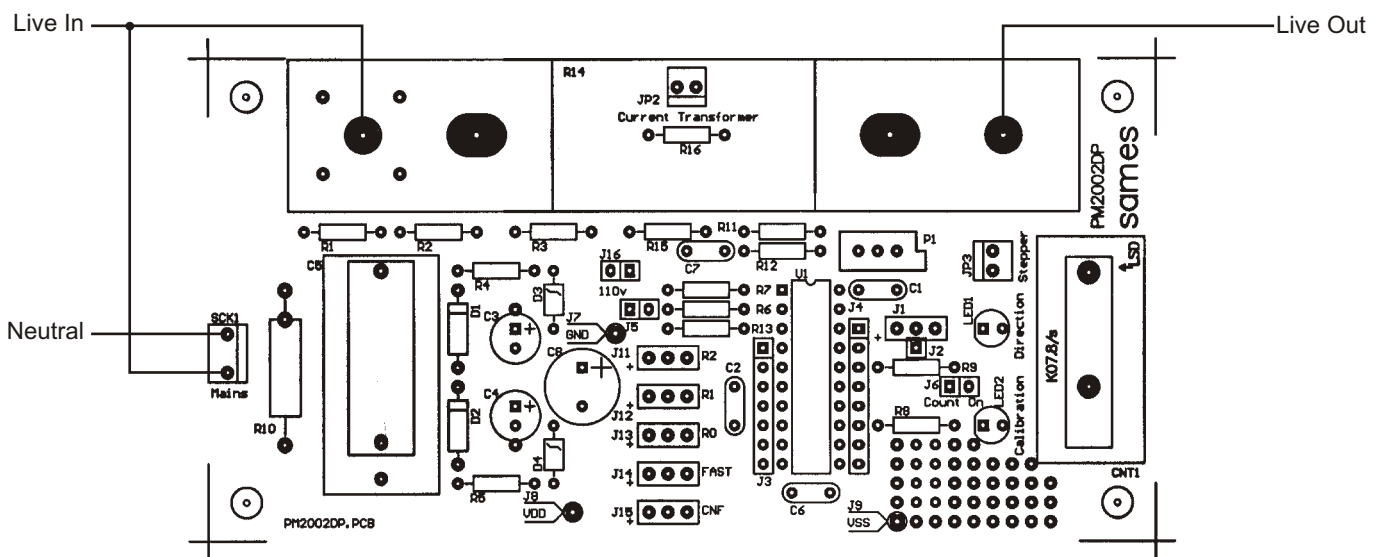


Figure 1: Connection and jumper settings for 80A / 220V bi-directional meter module



**MODULE SETUP**

The PM2002DP module is setup for use with the SA2002D integrated circuit. Resistor values used on the module are calculated for rated conditions of 80A/220V.

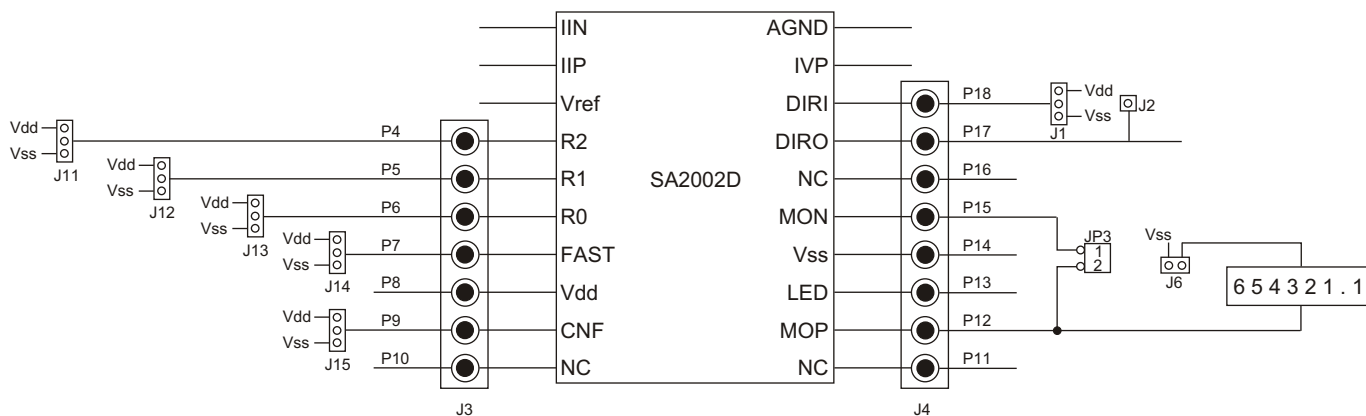


Figure 2: Jumper schematic, digital IO's

| Name             | Function Description   |
|------------------|--|
| J1               | J1 is used to select the energy direction ( DIRI pin). The three options available are:<br>P18 connected to Vdd - Negative energy measurement<br>P18 connected to Vss - Positive energy measurement<br>P18 connected to J2 (P17) - Bi-directional energy measurement<br>P18 should not be left floating and must be connected to one of the options described above. |
| J2               | J2 is only used to select bi-directional energy measurement when connected to P18  |
| J3 and J4        | These are test points placed next to the digital pins of the SA2002E   |
| J5               | Not fitted This is the current sense input ground. If a current transformer is used for current sensing the two pins of J5 must be connected.  |
| J6               | Connects the impulse to VSS. If a stepper motor is connected to JP3 then J6 should be left open.   |
| J7               | Analog ground test point (see figure 1)  |
| J8               | Positive supply test point (Vdd) (see figure 1)  |
| J9               | Negative supply test point (Vss) (see figure 1)  |
| J11, J12 and J13 | Used to select the R2, R1 and R0 pins of the SA2002D for the various rated conditions. Refer to table 1 for the possible settings  |
| J14              | Used to select fast calibration mode. Connecting P7 to Vdd selects fast calibration mode. For normal operation P7 must be connected to Vss   |
| J15              | Used to select between normal and configure / test modes. For normal operation connect P9 to Vss.  |
| J16              | Used to select between 220V and 110V mains systems (See figure 3). Leave open for 220V mains.  |

Table 3: Jumper settings for various device options



### ANALOG SECTION

The analog (metering) interface described in this section is designed for measuring 220V/80A with precision better than Class 1.

The most important external components for the SA2002D integrated circuit are the current sense resistors, the voltage sense resistors and the bias setting resistor. The resistors used in the metering section should be of the same type so temperature effects are minimized.

#### Voltage Input IVP

The voltage input of the SA2002D (IVP) is driven with a current of 14µA at nominal mains voltage. This voltage input saturates at approximately 17µA. At a nominal voltage current of 14µA allows for 20% overdriving. The mains voltage is divided with a voltage divider to 14V that is fed to the voltage input pins via a 1M resistor

#### Voltage Divider

The voltage divider is (Figure 3) calculated for a voltage drop of 14V. Treat C7 as a short circuit and ignore J16. Equations for the voltage divider in figure 3 are:

$$RB = R1 + R2 + R3 + R15 + R10$$

$$RB = R12 \parallel (R11 + P1 / 2)$$

Combining the two equations gives:

$$(RA + RB) / 220V = RB / 14V$$

Values for resistors R10 = 47 , R11 = 22k , P1=10k and R12 = 1M is chosen.

Substituting the values result in:

$$RB = 26.29k$$

$$RA = RB \times (220V / 14V - 1)$$

$$RA = 386.84k$$

Standard resistor values of R1, R2, R3 and R15 are chosen to be 47k , 150k , 47k and 150k . The resistor RA is divided so that the voltage drop across one resistor is within the specified limits of the resistor type that is used, usually 200VDC. The resistor value ratios are chosen so that shorting J16 the module could be used on a 110VAC mains system.

#### CURRENT SENSOR INPUT RESISTORS FIGURE 4 (USING A SHUNT RESISTOR)

The resistors R6, R7 define the current level into the current sense inputs the device. The voltage drop across the shunt should be at least 20mV at rated conditions. A shunt resistor with a value of 50mV @80A was chosen for the application module for its ease of use. The resistor values are calculated for an input current of 16µA on the current inputs at rated conditions. For a 80A meter the resistor values are calculated as follows:

$$R6 = R7 = (I_L / 16\mu A) \times R_{SH} / 2$$

$$= 80A / 16\mu A \times 625\mu / 2$$

$$= 1.5625k$$

I<sub>L</sub> = Line current

A standard value of 1.6k is chosen.

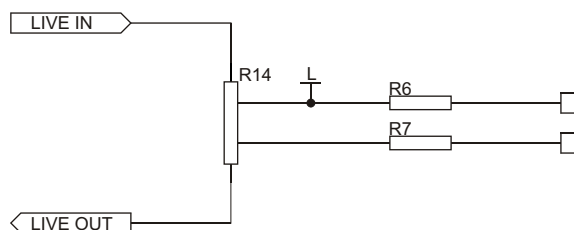


Figure 4: Current input configuration

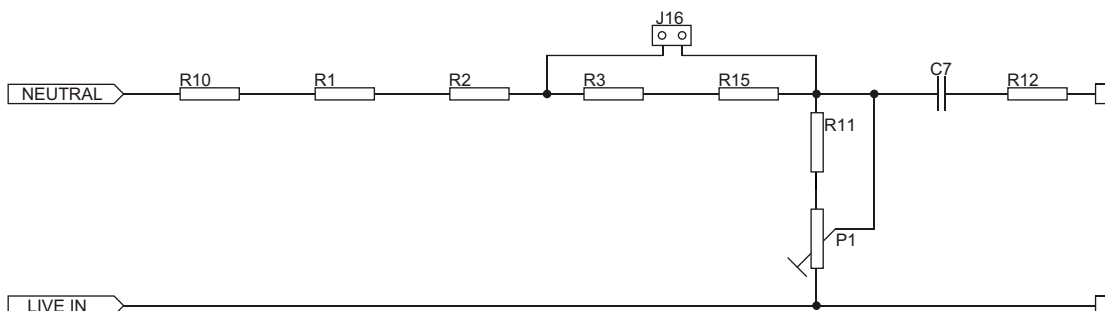


Figure 3: Mains voltage divider



**CT TERMINATION RESISTOR**

Provision is made for the use of a current transformer on the module. The existing shunt needs to be removed and the current sense resistors will have to be recalculated for the specific current transformer. The voltage drop across the CT termination resistor at rated current should be at least 20mV. The CT's used should have a low phase shift and a ratio of 1:2500. The CT is terminated with a 2.7 resistor giving a voltage drop of 864mV across the termination resistor at rated conditions

**CURRENT SENSOR INPUT RESISTORS FIGURE 5 (USING A CURRENT TRANSFORMER)**

The resistors R6, R7 define the current level into the current sense inputs the device. The resistor values are selected for an input current of 16µA on the current inputs at rated conditions. For an 80A-rated meter the resistor values are calculated as follows:

$$R6 = R7 = (I_L / 16\mu A) \times R_{SH} / 2$$
$$= 80A / 16\mu A \times 2.7 / 2$$
$$= 2.7k$$

$I_L$  = Line current  
RSH = CT Termination resistor  
2500 = CT ratio

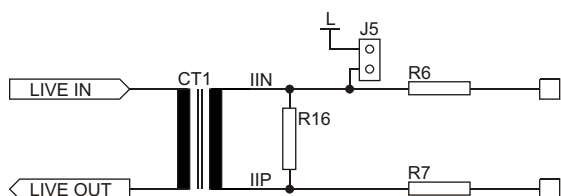


Figure 5: Current input configuration

**Phase Compensation (When using a current transformer)**

Phase shift caused by the current transformer may be corrected by inserting a capacitor in the voltage divider circuit. See Figure 6, Capacitor C7. To compensate for a phase shift of 0.18 degrees the capacitor value is calculated as follows:

$$C = 1 / (2 \times \text{Mains frequency} \times R5 \times \tan(\text{Phase shift angle}))$$
$$C = 1 / (2 \times 50 \times 1M \times \tan(0.18 \text{ degrees}))$$
$$C = 1.013\mu F$$

**Reference Voltage VREF**

The VREF pin of the SA2002D is connected to a resistor that determines the on chip bias current.

**Ground GND**

The GND pin of the SA2002D is to the live phase, which is halfway between VDD and VSS. Note that supply bypass capacitors C1 and C2 are positioned as close as possible to the supply pins of the device, and connected to a solid ground plane.

**COMPONENT LISTS**

The following component list covers all components fitted on the PM2002DP module as shipped

| Symbol     | Description                               | Detail |
|------------|---|--------|
| U1         | SA2002D                                   | DIP-20 |
| D1, D2     | Diode, Silicon, 1N4007                    |        |
| D3, D4     | Diode, Zener, 2.4V                        |        |
| R1, R3     | Resistor, 47k, 1/4W, 1%, metal            |        |
| R2, R15    | Resistor, 150k, 1/4W, 1%, metal           |        |
| R4, R5     | Resistor, 100R, 1/4W, 1%, metal           |        |
| R6, R7     | Resistor, 1.6k, 1/4W, 1%, metal           | Note 1 |
| R8, R9     | Resistor, 2.4k, 1/4W, 1%, metal           |        |
| R10        | Resistor, 47R, 2W, 5%, wire wound         |        |
| R11        | Resistor, 22k, 1/4W, 1%, metal            |        |
| R12        | Resistor, 1M, 1/4W, 1%, metal             |        |
| R13        | Resistor, 24k, 1/4W, 1%, metal            |        |
| R14        | Shunt resistor, 80A / 50mV                |        |
| R16        | Resistor, 1/4W, 1%, metal                 | Note 1 |
| P1         | Resistor, 1/4W, 1%, metal                 |        |
| C1, C2     | Capacitor, 220nF                          |        |
| C3, C4     | Capacitor, 220nF, 16V, electrolytic       |        |
| C5         | Capacitor, 470nF, 250VAC                  |        |
| C6         | Capacitor, 820nF                          |        |
| C7         | Capacitor                                 | Note 2 |
| C8         | Capacitor, 2200uF, 16V, electrolytic      |        |
| LED1, LED2 | 3mm Light emitting diode                  |        |
| CNT1       | Impulse counter, Kuebler, K07.80          |        |
| SCK1       | Molex 3 pin connector, 200mil pin spacing |        |
| JP3        | Molex 2 pin connector, 100mil pin spacing |        |
| 6          | Jumpers                                   |        |
| 24         | Header pins                               |        |

**Note1:** In case a current transformer is used on the board R16 is the termination resistor. Resistors R6 and R7 values may need to be changed to match the CT used.

**Note2:** Capacitor values may be selected to compensate for phase errors caused by current transformers.

Table 4: Components for PM200DP module set up for 220V/80A

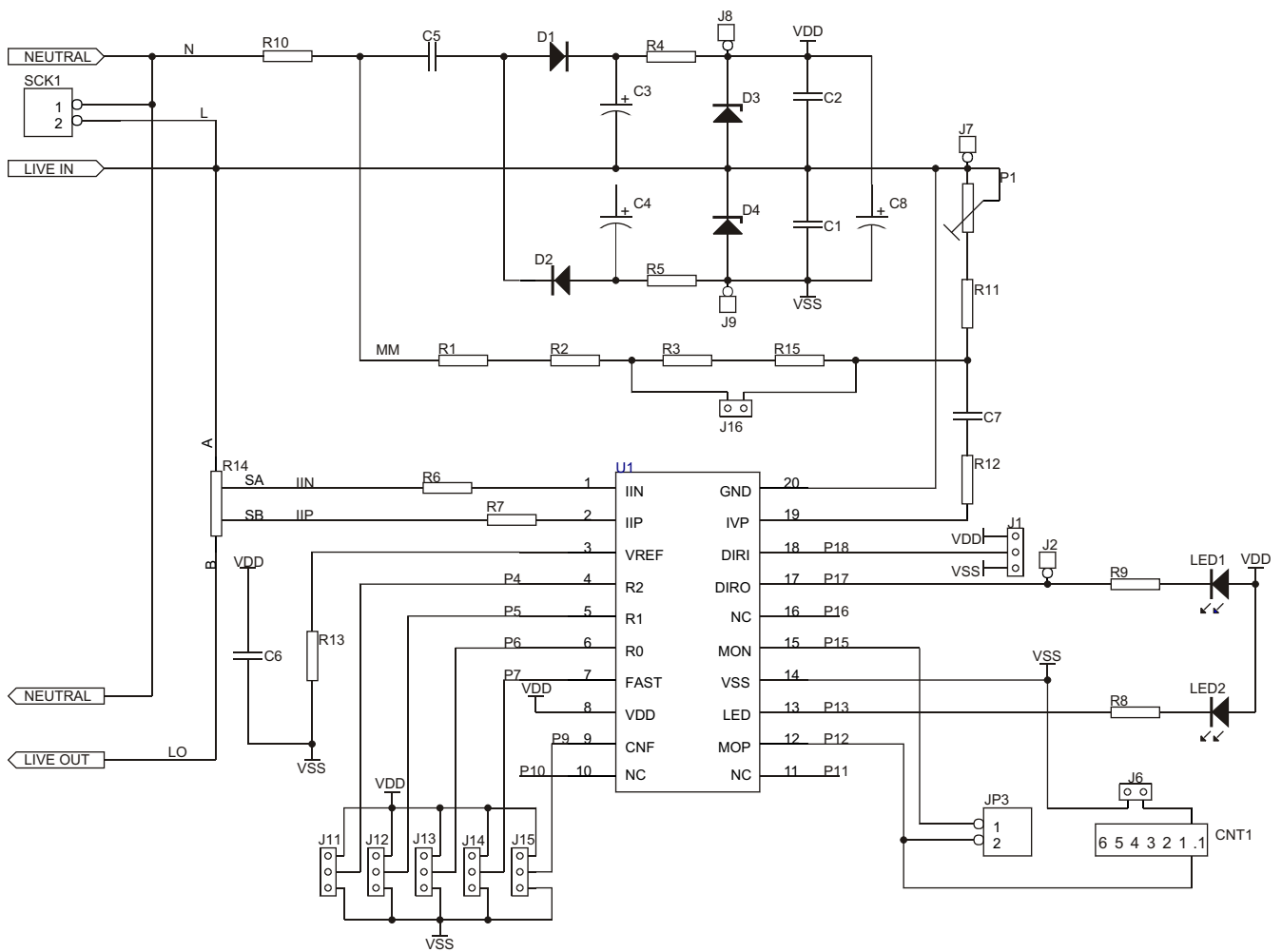


Figure 6: Schematic diagram of the complete PM2002DP module



PCB LAYOUT

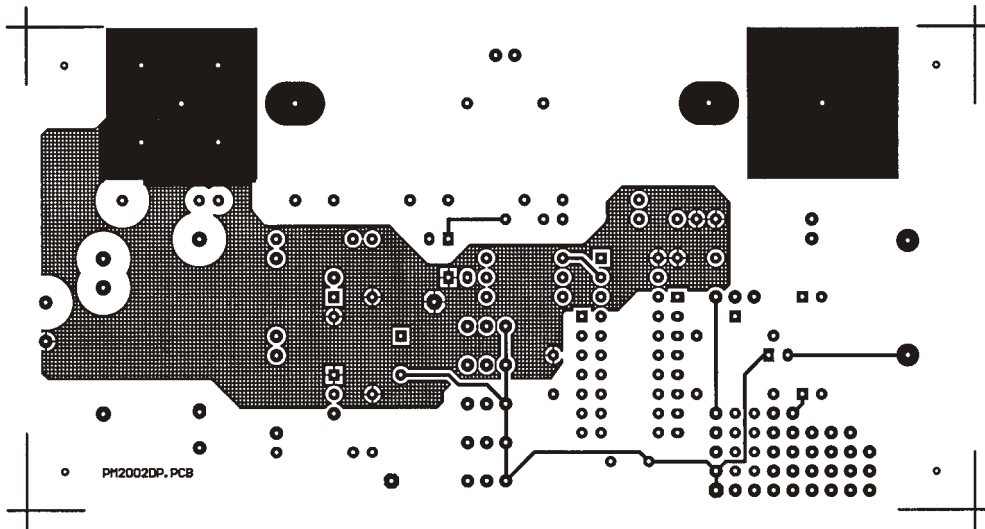


Figure 7: Top layer layout of the PM2002D module

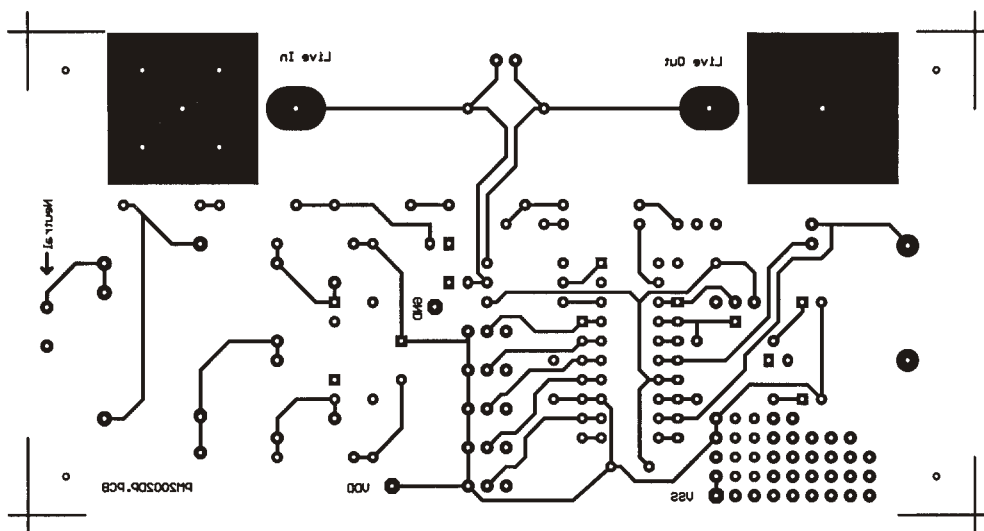


Figure 8: Bottom layer layout of the PM2002D module

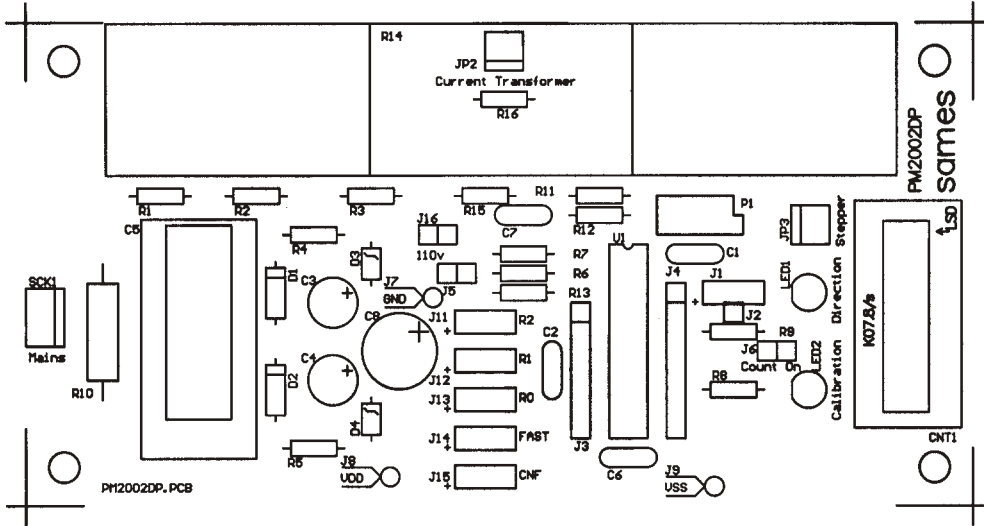


Figure 9: Silkscreen of the PM2002D module





**NOTE:**



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**PM2002DP**

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