UM1082
User manual

The STPM10 single-phase meter evaluation boards

Introduction

The STPM01 and STPM10 devices are energy meter ASSPs (application specific standard products), which address to a wide range of electricity metering requirements thanks to their built-in functions such as: signal conditioning, signal processing, data conversion, input/output signals, and voltage reference.

The STPM10 is dedicated for peripheral use in microcontroller-based applications only, while the STPM01 works as a peripheral and as a standalone device, since it can permanently store configuration and calibration data.

This user manual refers to the following STPM10 single-phase meter evaluation boards:

- STEVAL-IPE015V1: STPM10 single-phase meter with two CTs
- STEVAL-IPE016V1: STPM10 single-phase meter with CT and shunt
- STEVAL-IPE017V1: STPM10 single-phase meter with shunt
- STEVAL-IPE018V1: STPM10 single-phase meter with CT

These metering modules can be used to build a Class 0.5 single-phase microprocessor-based meter, with or without tamper detection, for power line systems of V_{NOM}=140 to 300 V_{RMS}, I_{NOM}/I_{MAX}=2/20 A_{RMS}, f_{LIN}=45 to 65 Hz and T_{AMB}=-40 to +85 °C.

The reading of the following documents is recommended:

- STPM10 datasheet
- AN2159 application note
- AN2299 application note
- UM1599 user manual
- UM1750 user manual

Contents

1 Getting started

1.1 Safety rules

This board can be connected to the mains voltage (220 V/110 V). In the case of improper use, wrong installation or malfunction, there is a danger of serious personal injury and damage to property. All operations such as transport, installation, and commissioning, as well as maintenance, should be carried out by skilled technical personnel (national accident prevention rules must be observed) only.

Due to the risk of death when this prototype is used on the mains voltage (220 V/110 V), “skilled technical personnel” only, who are familiar with the installation, mounting, commissioning, and operation of power electronic systems and have the qualifications needed to perform these functions may use this prototype.

As the serial port P1 of the boards is not isolated, for PC connection through the parallel programmer/reader, the use of an isolated AC power supply to protect the parallel port and avoid board damage is strongly recommended.

1.2 Conventions

In this user manual, the upper case is used to indicate the name of the pin of the module or the device or the corresponding signal; the underlined typeface is used to indicate the name of the configuration signal and italic is used to name software registers. The lowest analog and digital power supply voltage is called VSS. All voltage specifications for digital input/output pins are referred to as VSS. The highest OTP writing power supply voltage is VOTP. The highest power supply voltage of the device is VCC.

Positive currents flow into a pin. Sinking means that the current flows into the pin while sourcing means that the current flows out of the pin.

Timing specifications of signals are relative to the CLKOUT. This signal is fed by a 4.194 MHz onboard crystal oscillator.

Timing specifications of the SPI interface signals are relative to the SCLNLC, which do not need to be in phase with CLKOUT.

A positive logic convention is present in all equations.

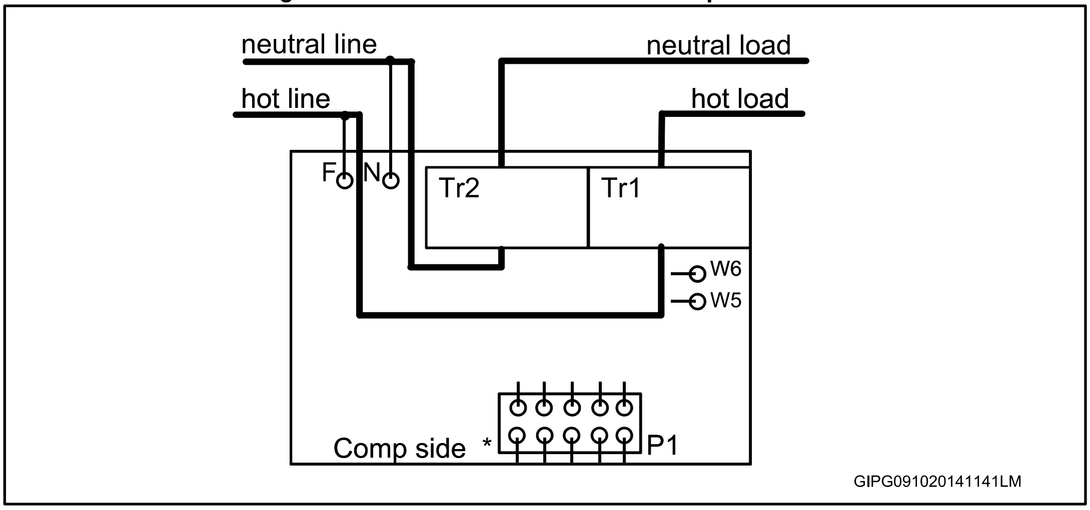
2 Board setup

2.1 Connection for board with two CTs (STEVAL-IPE015V1)

The connection of line signals to the module is shown in *Figure 1: "Connection of two CTs to the power line"*:

1. The hot line voltage wire must be connected to pin F of the module. Normally, this wire is also connected to the hot line current wire but, during the production or verification phases, this wire may be connected to a line voltage source.
2. The neutral line voltage wire must be connected to pin N of the module. This wire is also connected to the neutral line current wire.
3. The hot line current wire must pass through the hole of the current transformer Tr1 becoming a hot load wire using an isolated 4 mm^2 copper wire.
4. The neutral line current wire must pass through the hole of the current transformer Tr2 becoming a neutral load wire using an isolated 4 mm^2 copper wire.

Figure 1: Connection of two CTs to the power line

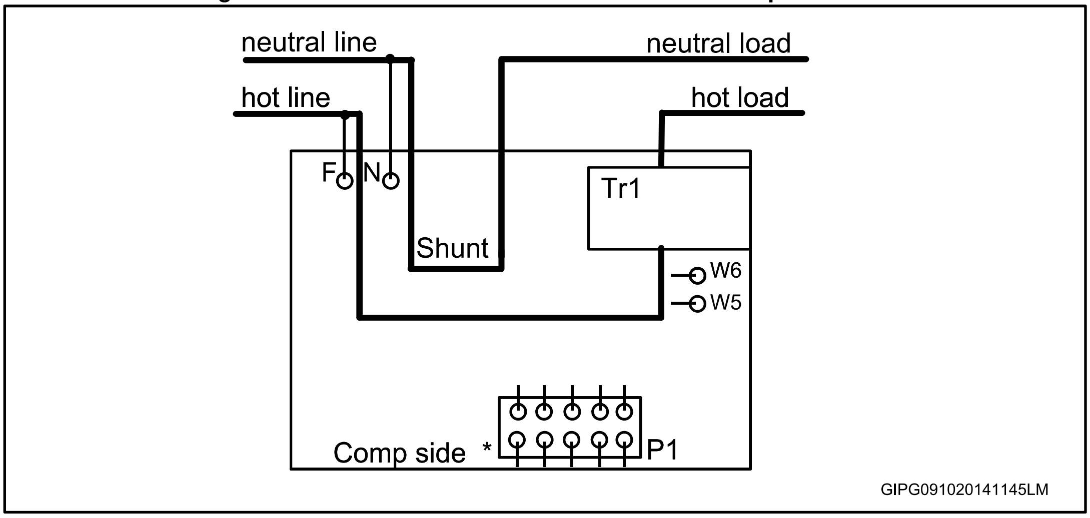


2.2 Connection for the board with CT and shunt (STEVAL-IPE016V1)

The connection of line signals to the module is shown in *Figure 2: "Connection of CT + shunt module to the power line"*:

1. The hot line voltage wire must be connected to pin F of the module. Normally, this wire is also connected to the hot line current wire but, during the production or verification phases, this wire may be connected to a line voltage source.
2. The neutral line voltage wire must be connected to pin N of the module. This wire is also connected to the neutral line current wire.
3. The hot line current wire must be placed through the hole of the current transformer Tr becoming a hot load wire using isolated 4 mm^2 copper wire.
4. The neutral line current wire must be connected to the pole of shunt which is close to pin N of the module using an isolated 4 mm^2 copper wire.
5. The neutral load current wire must be connected to the pole of shunt which is close to the current transformer using an isolated 4 mm^2 copper wire.

Figure 2: Connection of CT + shunt module to the power line

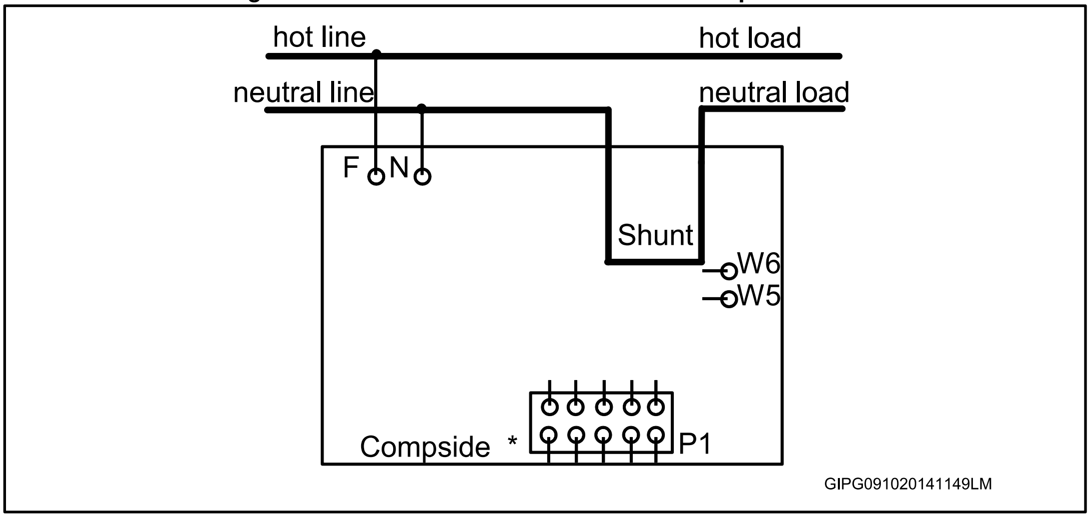


2.3 Connection for the board with shunt (STEVAL-IPE017V1)

The connection of line signals to the module is shown in *Figure 3: "Connection of shunt module to the power line"*:

1. The neutral line voltage wire must be connected to pin N of the module. This wire is also connected to the neutral line current wire.
2. The hot line voltage wire must be connected to pin F of the module. Normally, this wire is also connected to the hot line current wire but, during the production or verification phases, this wire may be connected to a line voltage source.
3. The neutral current wire must be connected to the pole of the shunt which is close to pin N of the module using an isolated 4 mm^2 copper wire.
4. The neutral load current wire must be connected to the pole of the shunt which is close to the edge of the module using an isolated 4 mm^2 copper wire.

Figure 3: Connection of shunt module to the power line

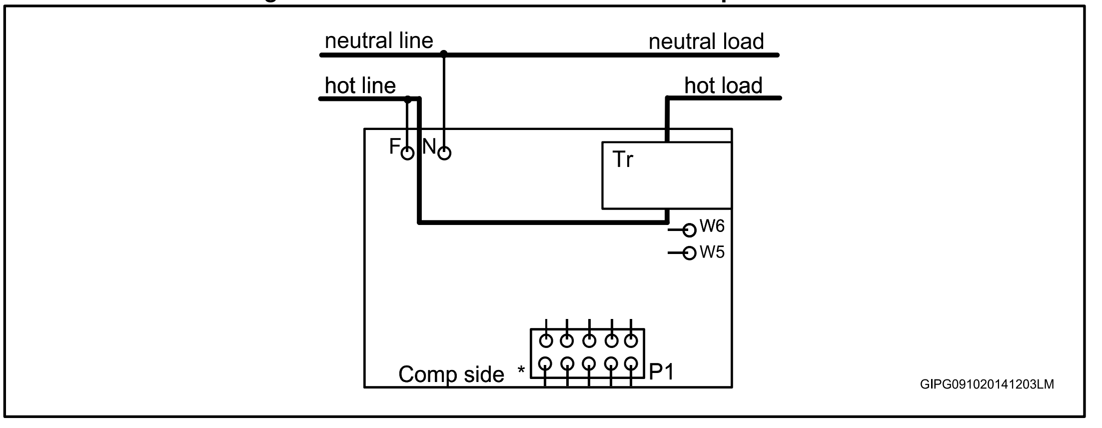


2.4 Connection for the board with CT (STEVAL-IPE018V1)

The connection of line signals to the module is shown in *Figure 4: "Connection of CT module to the power line"*:

1. The hot line voltage wire must be connected to pin F of the module. Normally, this wire is also connected to the hot line current wire but, during the production or verification phases, this wire may be connected to a line voltage source.
2. The neutral line voltage wire must be connected to pin N of the module. This wire is also connected to the neutral line current wire.
3. The hot line current wire must pass through the hole of the current transformer Tr becoming a hot load wire using an isolated 4 mm^2 copper wire.

Figure 4: Connection of CT module to the power line



3 Application configuration

3.1 Microprocessor-based

In this type of application, a control board with a microprocessor should be connected to the “male” P1 connector of the module using a 10-wire flat cable. *Table 1: "Pin number, signal name and signal description of connector P1"* below describes the signals corresponding to the pins of this connector. The four SPI signals are multipurpose pins and they actually reflect the functions of the corresponding pins on the onboard metering device. By using this type of connection, the control board is able to read data records or access configuration bits and mode signals of the metering device thanks to a dedicated protocol, it can draw up to 4 mA at +3.0 V from the module.

Table 1: Pin number, signal name and signal description of connector P1

Pin	Name	Functional description of signal
1		Not used
2		Not used
3	GND	Signal reference level 0 V and power supply return
4	SDA	Digital I/O for SPI data signal or tamper indicator
5	SCS	Digital for SPI enable signal
6	SCL	Digital I/O for SPI clock signal or no load condition indicator
7	LED	Device pulsed output
8	SYN	Digital I/O for SPI data direction, latching request or negative power indicator
9		Not used
10	VCC	Power out of +5.0 V. Up to 25 mA can be drawn from this pin

This kind of application may still use any LED element of the module for the purposes shown in *Table 1: "Pin number, signal name and signal description of connector P1"* or it may generate an alternative set of signals from the control board. In this case, the control board may also recalibrate any result read.

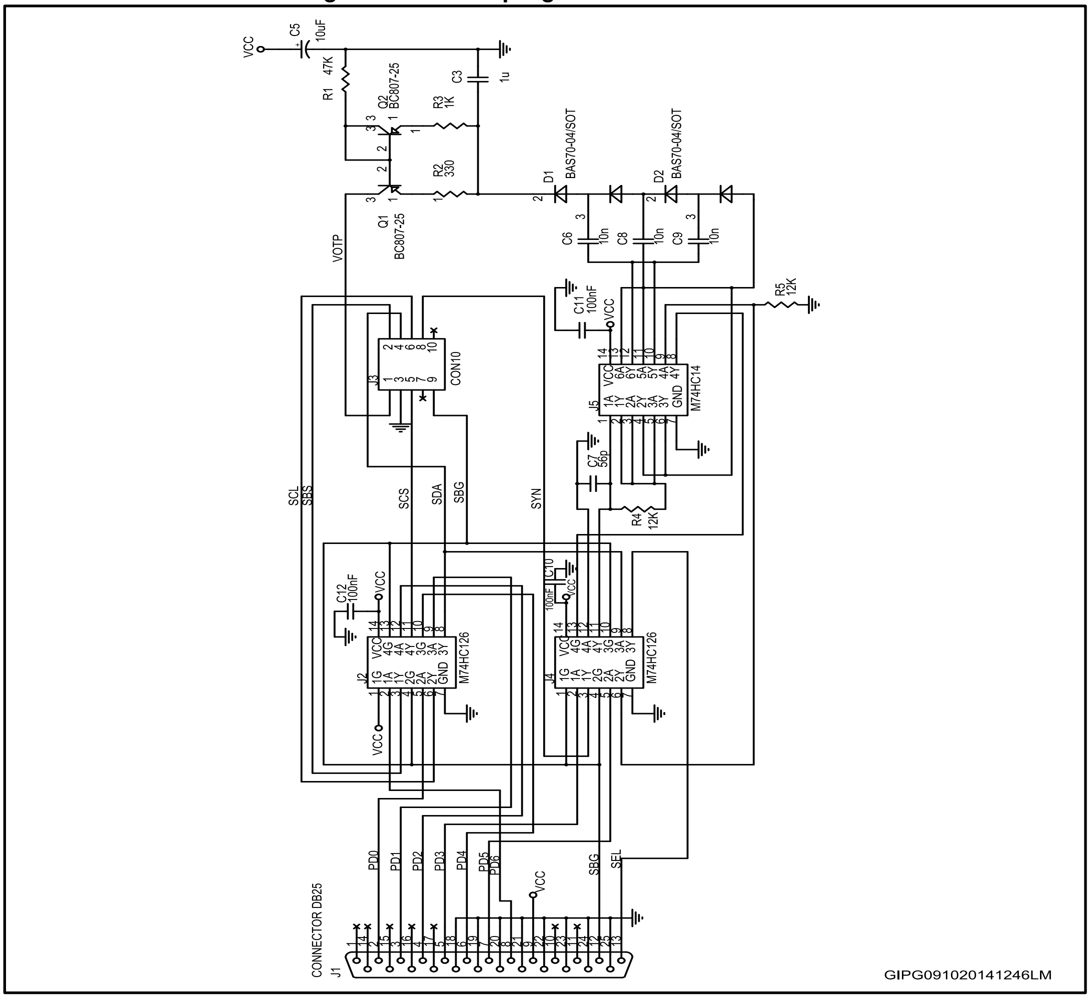
4 Communication with the module

4.1 Module evaluation with PC through the STPM1x evaluation software

The metering module and the device features can be evaluated by a dedicated graphical user interface running on a PC.

For this purpose, the module should be connected to the PC through a parallel programmer, shown in *Figure 5: "Parallel programmer schematics"* or to USB isolated hardware interface, available as a separate evaluation board with the code STEVAL-IPE023V1.

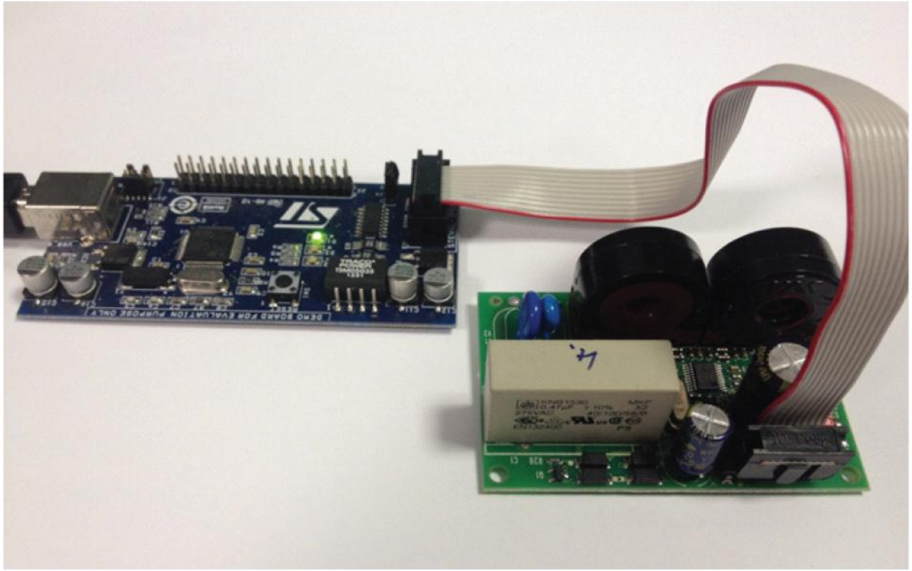
Figure 5: Parallel programmer schematics



To communicate with the device through the evaluation software, the selected hardware programmer has to be connected to both the PC and the evaluation board. Please take care that pin 1 of the cable is connected with the correct pin on the board, whose mark is printed on the PCB, close to the edge of the board.

The correct connection for the STEVAL-IPE023V1 is shown in the picture below.

Figure 6: Connection of the module to the STEVAL-IPE023V1



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If the parallel interface is used, the evaluation board must be powered on. If the STEVAL-IPE023V1 is used, please make sure that jumper J4 is in 2-3 position, in this way it directly supplies the STPM10 evaluation board with 5 V.

The evaluation software is available on http://www.st.com.

4.2 SPI communication

A host system can communicate with the module using SPI signals and connect via the P1 connector. In fact, it communicates to the metering device, which is the key element of the module. This device always acts as an SPI slave while the host system acts as an SPI master. A control board of an application or an external system can be considered as a host. For details on SPI communication with the device please refer to the AN2159 and to the device datasheet.

5 Technical data

5.1 Electrical parameters

Table 2: "Electrical parameters" summarizes the electrical parameters, which are specified for V_{CC} = 3.6 V, T_{AMB} = +25 °C, unless otherwise specified.

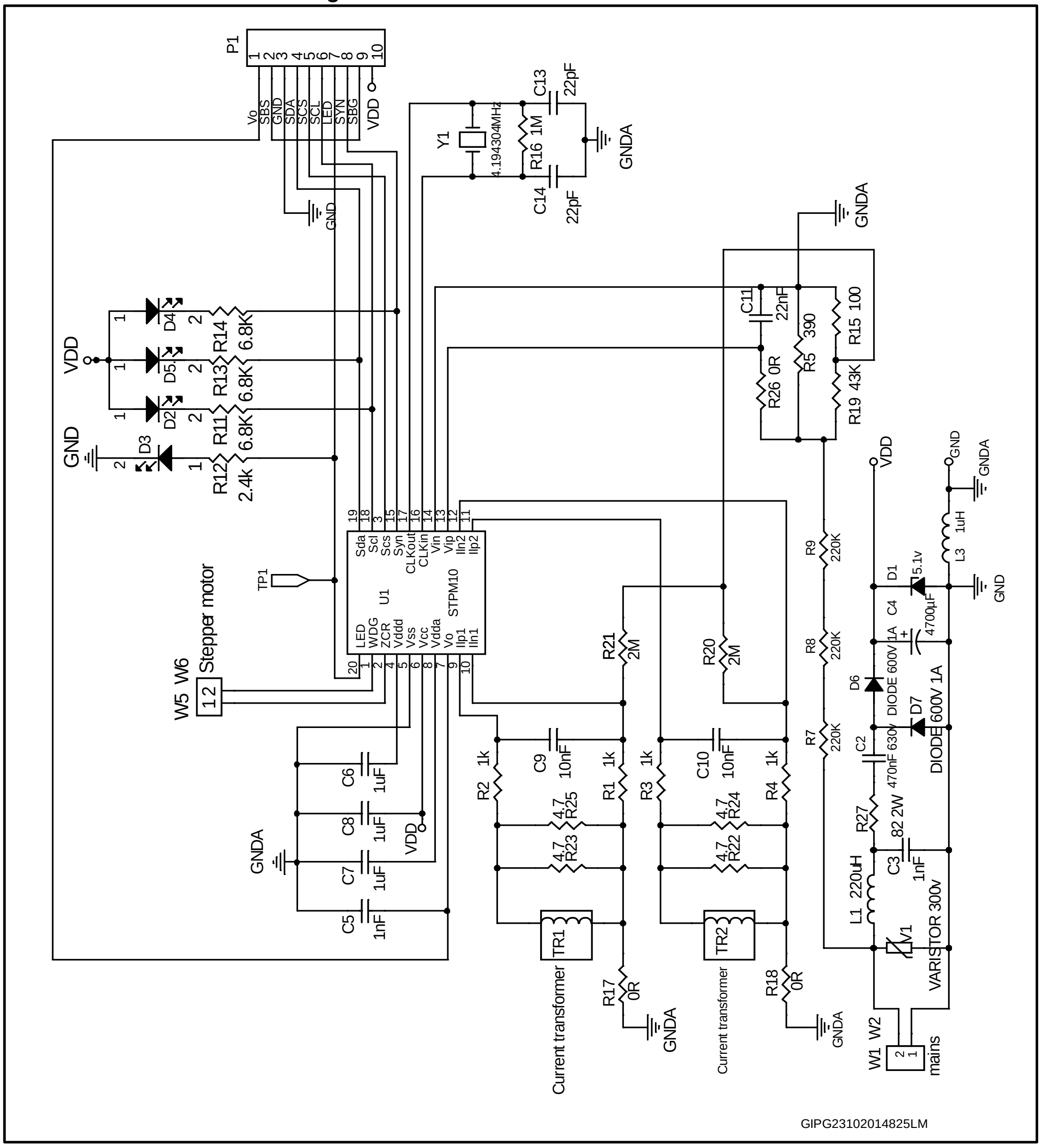
Table 2: Electrical parameters

Symbol	Parameter	Test conditions or comments	Min.	Typ.	Max.	Unit
Target applications						
V_{NOM}	Nominal line voltage		140	220	300	V_{RMS}
F_L	Nominal frequency		45	50	55	Hz
I_{NOM}	Nominal line current			2		A_{RMS}
I_{MAX}	Maximal line current			20	30	A_{RMS}
T_{AMB}	Ambient temperature		-40	25	85	°C
	Class of accuracy			0.2	0.5	
Digital inputs						
I_{IL}	Pull-up	Valid also for I/O pins when they are used as inputs		15		µA
V_{IL}	Voltage input low		-0.3		0.25 V_{CC}	V
V_{IH}	Voltage input high		0.75 V_{CC}		5.3	V
Digital outputs						
V_{OL}	Voltage output low	I_{OL} = +2 mA			0.4	V
V_{OH}	Voltage output high	I_{OH} = +2 mA	V_{CC}-0.4			V
t_{TR}	Transition time	C_L = 50 pF, V_{CC} = 3.2 V			5	ns
Stepper outputs						
V_{OL}	Voltage output low	I_{OL} = +14 mA			0.1 V_{CC}	V
V_{OH}	Voltage output high	I_{OH} = +14 mA	0.9 V_{CC}			V
t_{TR}	Transition time	C_L=50 pF, V_{CC}=5.0 V			5	ns
Power supply						
V_{CC}	Supply level		3.165	5	5.5	V
I_{CC}	Quiescent current		4	5	6	mA
V_{DDA}	Supply level		2.85	3	3.15	V
F_L	Nominal frequency		45.0	50.0	65.0	Hz
V_{CCPOR}	Power-on-reset			2.5		V

6 Schematics

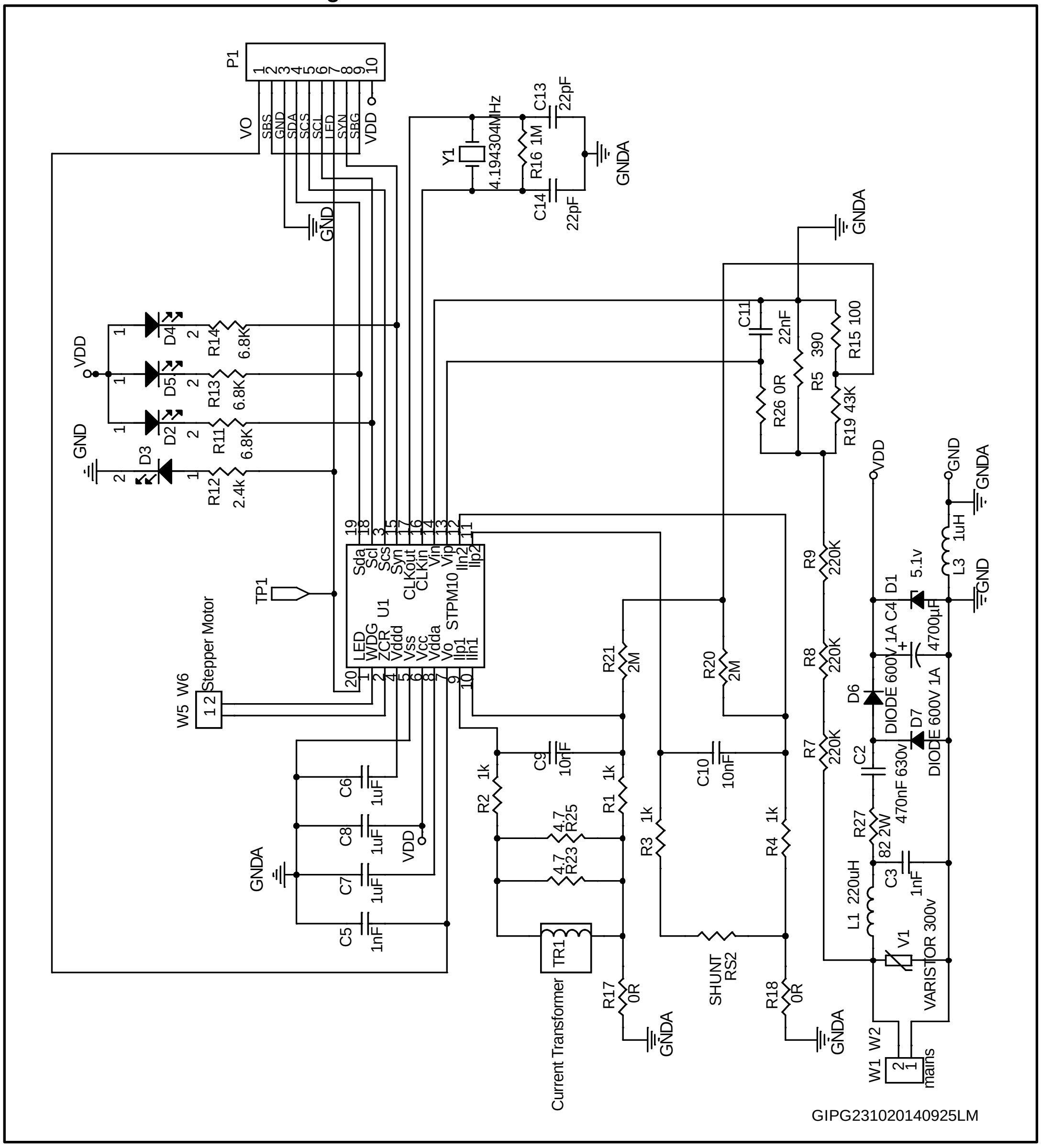
6.1 STEVAL-IPE015V1

Figure 7: STEVAL-IPE015V1 schematic



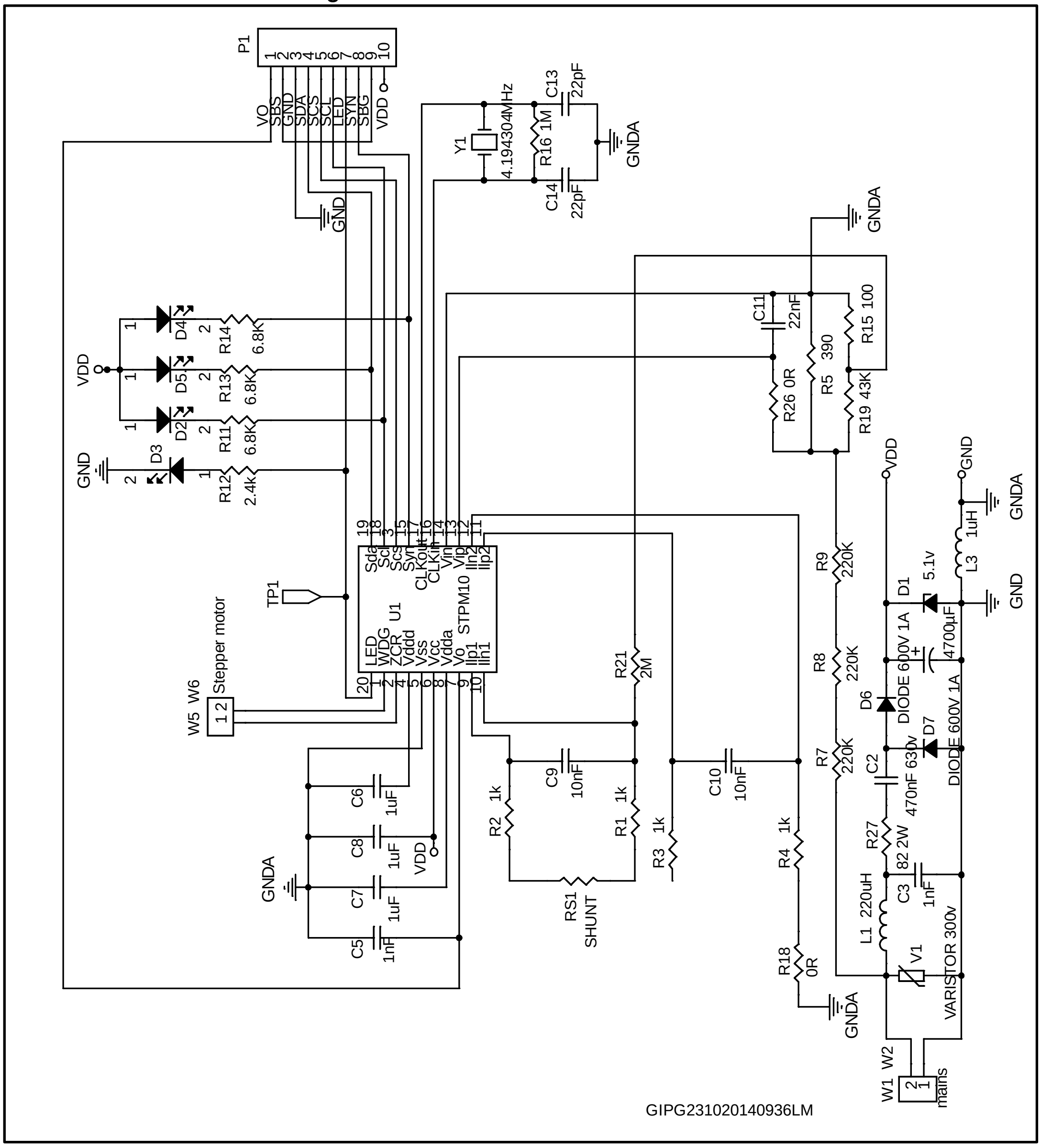
6.2 STEVAL-IPE016V1

Figure 8: STEVAL-IPE016V1 schematic



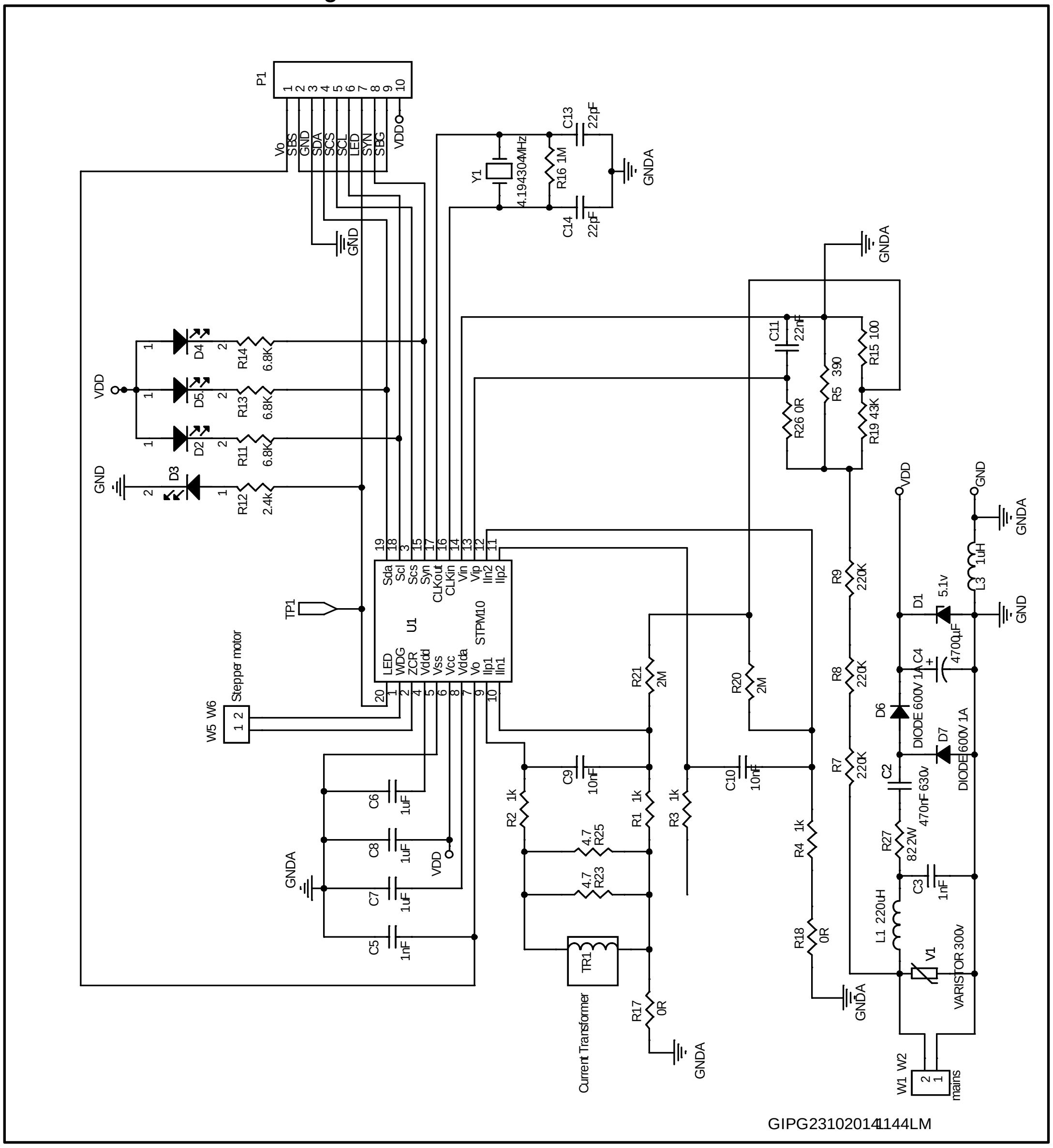
6.3 STEVAL-IPE017V1

Figure 9: STEVAL-IPE017V1 schematic



6.4 STEVAL-IPE018V1

Figure 10: STEVAL-IPE018V1 schematic

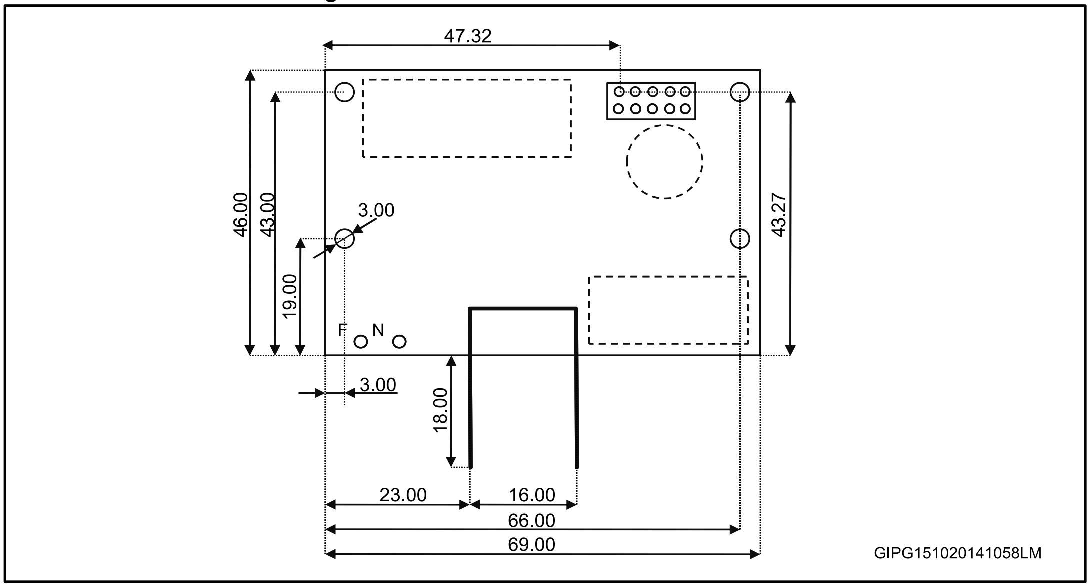


6.5 Mechanical outlines

The size of the PCB of the module can be seen below. The overall volume is determined by the size of the maximal element, which is the current transformer:

L x W x H = 70 mm x 46 mm x 30 mm.

Figure 11: Mechanical dimensions of PCB



All measurements are given in mm

- View is from non-component side
- All high elements are dashed
- P1 has pins on both side
- All mounting holes are equal

7 Power line system migration from 220 V, 50 Hz to 110 V, 60 Hz

With capacitive power supply, the impedance of capacitor C1 and impedance of load $((V_{CC}+0.7)/(I_{CC}+I_Z))$ form a voltage divider. All other elements are needed for other reasons, such as: spike protection and HF rejection.

Therefore, the following guidelines can be used.

If the percentage of line frequency changes, the I_{CC} changes the same percentage accordingly:

$df/f = d\, I_{CC} / I_{CC}$

For a 60 Hz system there is the 20% more current available because C1 impedance is the major component of the divider, the change of input voltage must be followed by the same change of C1 impedance, that is dU/U = dZc/Zc.

For a 110 V system, the capacitor C1 is almost doubled, the divider must be designed to work properly at minimal line voltage, frequency and C1 and maximal I_{CC} and therefore, the maximal allowable power consumption (500 mW > IZ * V_{CC}) of the Zener diode D12 must be checked at maximal line voltage, frequency and C1 and minimal I_{CC}.

According to the information below, with the change of power line system from 220 V, 50 Hz to 110 V, 60 Hz, the value of C1 should be changed from 470 nF, 275 V_{AC} to 750 nF, 150 V_{AC}. A 680 nF, 150 V_{AC} element means about 10% less I_{CC}.

No other change to the metering module is necessary because the voltage measurement range is from 20 to 360 V_{RMS}. The current measurement range is from 0.1 to 20 A_{RMS}, till 30 A_{RMS}. If a wider current range is needed, the current transformers and the cross-section of primary winding wires must be increased, by running the risk that they do not fit onto the board of the module. In this case, the module needs to be recalibrated.

8 Revision history

Table 3: Document revision history

Date	Revision	Changes
13-Feb-2012	1	Initial release.
23-Oct-2014	2	Updated *Table 1: "Pin number, signal name and signal description of connector P1"* and *Table 2: "Electrical parameters"*. Updated *Section 2.3: "Connection for the board with shunt (STEVAL-IPE017V1)"* and *Section 4.1: "Module evaluation with PC through the STPM1x evaluation software"*. Changed *Figure 3: "Connection of shunt module to the power line"*. Minor text changes.