
EVALSTPM3x-3PH evaluation board and graphical user interface (GUI)

Introduction

This user manual describes the EVALSTPM3x-3PH evaluation board and the related graphical user interface (GUI).

The STPM3x is a family of mixed signal ASSP designed for high accuracy measurement of power and energy in power line systems using the Rogowski coil, current transformer or shunt current sensors. The device has up to two voltage and two current channels.

The EVALSTPM3x-3PH evaluation board implements a 3-phase meter using current transformers for current sensing, the STPM34 and STPM33 as metrology devices and the STM8S903K3 microcontroller for synchronization and supervision functions, and to manage UART communication to PC GUI.

The STPM34 and the STPM33 perform R, S and T phase measurements of voltage and current RMS, active and reactive energy and power. The STM8S903K3 integrates information coming from the metering devices to calculate total energy and power, generates LED pulses for active and reactive power, and manages communication with host (GUI software).

Through the GUI, it is possible to read and write either from each metrology device (the STPM34 and STPM33) or from the STM8S903K3.

Main features of the system are:

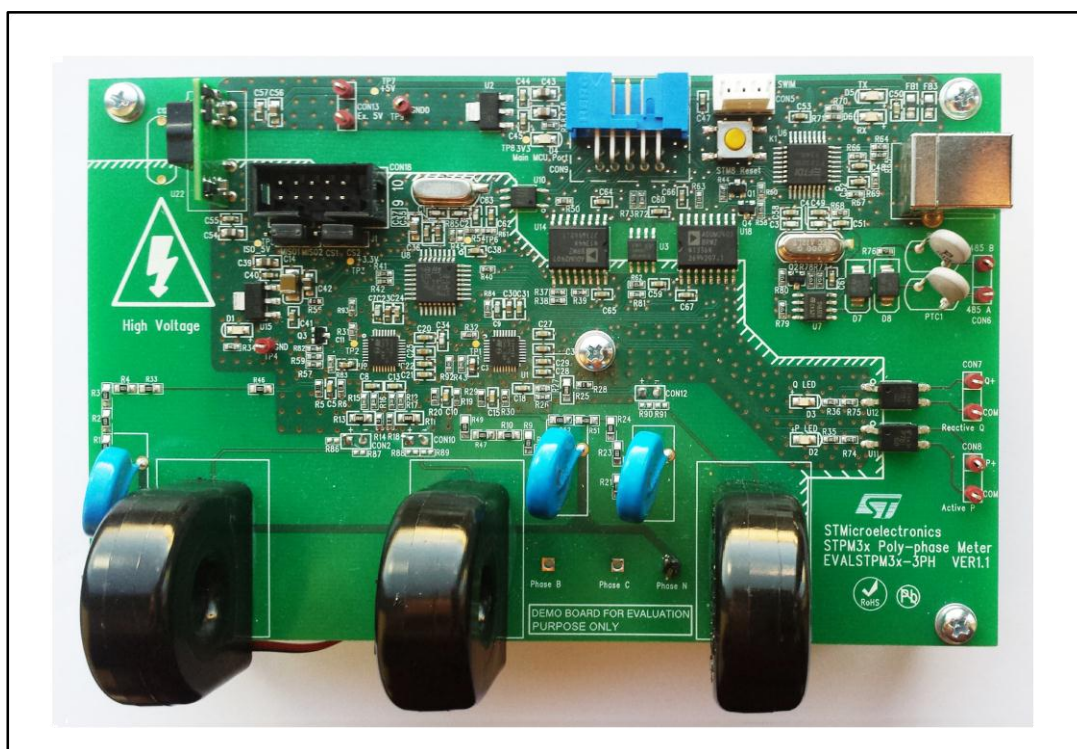
- 0.2% accuracy poly-phase meter evaluation board
- $V_{NOM} = 140$ to 300 V RMS
- $I_{NOM} / I_{MAX.} = 5/100$ A RMS
- $f_{line} = 50/60$ Hz $\pm 10\%$
- USB isolated connector to PC GUI
- Power supply 3.3 V through USB connector
- SPI/UART connector for the STPM33/34 direct access
- SWIM connector for firmware upgrade
- SPI/UART connector for expansion to external MCU
- 2x LEDs on board for active-reactive power output
- IEC61000 standard compliant
- RoHS compliant

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1 Overview

Figure 1: EVALSTP3x-3PH evaluation board



1.1 Safety rules

This board can be connected to mains voltage (230 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 only (national accident prevention rules must be observed).

Due to the risk of death when this prototype is used on mains voltage (230 V/110 V), "skilled technical personnel" only, who are familiar with installation, mounting, commissioning, and operating with power electronic systems, and have the qualifications needed to perform these functions, may use this prototype.

1.2 Operating conditions

Table 1: Operating conditions

Parameter	Value
V_N nominal voltage	230 V_{RMS}
I_N nominal current	5 A_{RMS}
I_{Max} maximum current	100 A_{RMS}
f_{line} line frequency	50/60 Hz $\pm$ 10%
T_{OP} operating temperature	-40/+85 °C

1.3 Prerequisites

The EVALSTPM3x-3PH GUI requires installation of FTDI virtual COM drivers to communicate with the PC.

1.4 Recommended readings

This document describes how to use and set up a basic test session with a GUI interface. Additional information is available in the following documents:

- STPM3x datasheet
- EVALSTPM3x-3PH schematic
- STPM32 schematic
- STPM33 schematic
- STPM34 schematic

1.5 Getting technical support

All our customers receive free technical assistance through local ST distributor/office or by visiting www.st.com; upgrades are also available free of charge on www.st.com/metering. Customers should work with the latest version of software/firmware before contacting us.

2 Hardware description

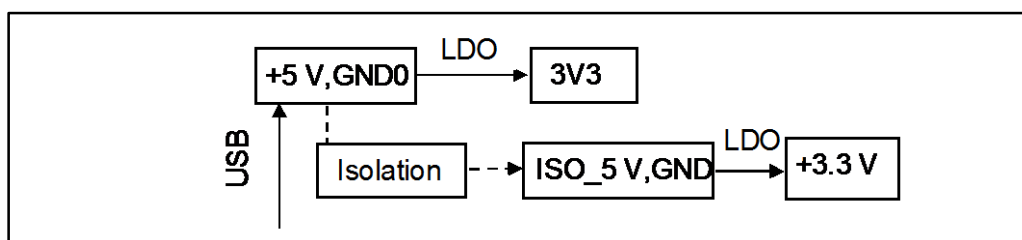
2.1 Power supply

The board does not contain a power supply. Supply voltage is provided externally, through USB cable. Four supply sources are present on the board.

1. 3V3: swim (debugging interface for the STM8S903K3), interface to external MCU
2. +3.3 V: STPM3x, STM8S903K3
3. +5 V: USB, RS485
4. ISO_5 V: derived from +5 V by a power isolation chip

Power supply system is shown in the figure below.

Figure 2: Power supply distribution



2.2 On-board connectors

The EVALSTPM3x-3PH can be interfaced to PC through a USB cable A/B. This connector also supplies all board components with power.

The following connectors are available on the board.

Table 2: EVALSTPM3x-3PH evaluation board connectors

Name	Description
CON4	USB connector to PC
CON5	Swim connector
CON9	MCU port
CON18	Connector to the STPM33/34
J1	Position 1-2: MISO selection of the STPM34
	Position 2-3: MISO selection of the STPM33
J2	Position 1-2: CS selection of the STPM34
	Position 2-3: CS selection of the STPM33
CON6	RS485 interface
CON7	Reactive power LED output
CON8	Active power LED output

2.3 Metrology

Current sensing is performed through four CTs, while voltage sensing is performed through voltage dividers.

The STPM34 board has two current and two voltage channels, sensing primary and secondary phase current and voltage, while the STPM33 senses third phase current and voltage.

Analog front end component values of the board are reported in table below.

Table 3: STPM34 evaluation board parameters

Channel	Parameter	Value
Current	Current sensor sensitivity k_s	2.72 mV/A
Voltage	Voltage divider upper resistor R_1	1800000 Ω
C_P	Voltage divider upper resistor R_2	1200 Ω
	Final constant pulse output	400 pulses/kWh
C_P fast	Device internal constant pulse	51200 pulses/kWh

A capacitor with value 22 nF, in parallel with R_2 , implements an antialiasing filter for the voltage signal. For current signal, the antialiasing filter is implemented through 10 nF capacitor and 1 k Ω resistor.

Current sensor sensitivity k_s of 2.72 mV/A is obtained with a burden resistor $R_B = 6.8 \Omega$ in parallel with a current transformer with turn ratio $n = 2500$.

The application should be calibrated to get a default C_P from the devices of 51200 pulses/kWh; the microcontroller then implements the cumulative energy calculation and scales the output to the final value of 400 pulses/kWh.

2.4 LED

LED output generation is performed by the microcontroller, feeding two LED connectors, P and Q, for active and reactive power respectively.

2.5 Clock

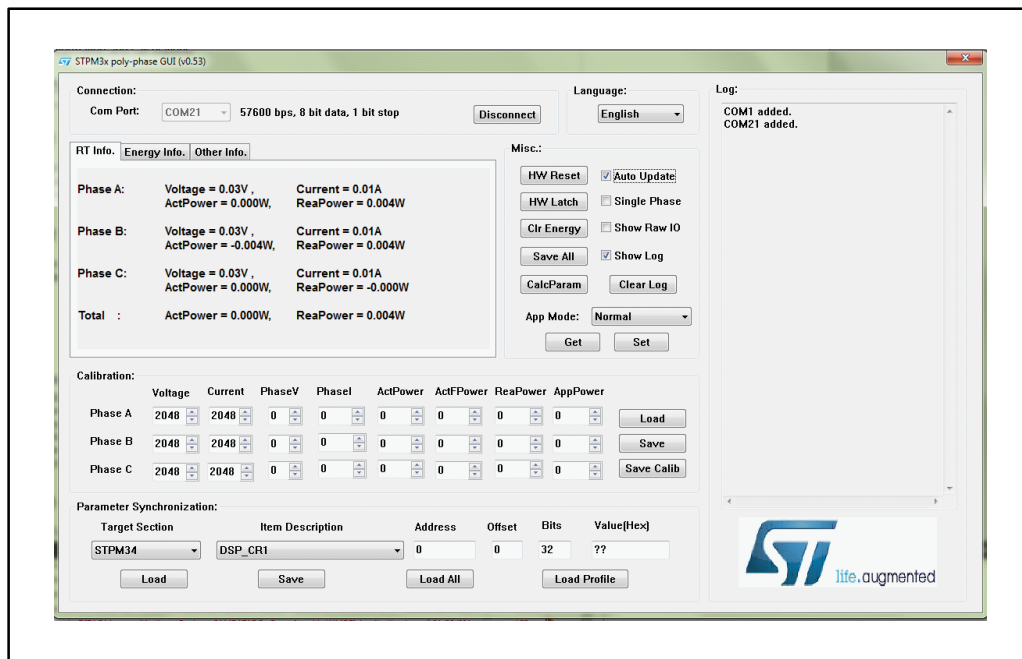
The STM8S903K3 provides 16 MHz clock to both metrology devices. 16 MHz are derived by the micro from a 16 MHz crystal oscillator, or could also be provided by MCU connector COM9.

3 Graphical user interface description

3.1 Application working area

The application working area is divided into several sections logically grouping the relevant information and calculations.

Figure 3: Application working area



3.2 Connection

In the top most section of the working area, on the left, there is an available group-box for the connection to the device. After the USB cable is plugged, verify on PC device manager the proper COM port, described as "USB serial port". USB driver installation has to be completed.

After the COM port is selected, press "Connect".

Communication has a fixed rate of 57600 bps, 8-bit data, 1-bit stop.

3.3 Language

English or chinese can be selected.

3.4 Log

A log window shows application messages and UART transmitted/received frames between the STM8S903K3 and the PC.

3.5 Calculated values

In the left-central section of the working area, there are three tabs with all measurement data, coming from the metrology devices and calculated by the micro. They are grouped in the following sections:

- **RT info:** real time info is: RMS values of voltage and current, active and reactive power for each phase and cumulative

Voltage and current register readings are converted into physical quantities shown in this section by multiplying them with LSB values, which are calculated as per “parameter calculations” window (see [Section 3.8: “Parameter synchronization”](#)).

Active and reactive power information is calculated in firmware and just displayed in this tab.

- **Energy info:** positive and negative active and reactive energy, for each phase and cumulative

Energy information is calculated in firmware and displayed in this tab.

- **Other info:** in this tab phase frequency and power factor, phase angles etc. are displayed

These values are converted by GUI from the device registers.

3.6 Miscellaneous commands

In this group some command buttons and check-boxes are shown:

- HW reset: hardware reset
- HW latch: not implemented
- Clr energy: reset all energy counters
- Save all: saves all data to EEPROM
- Calc params: open “Parameter calculations” window (see [Section 3.8: “Parameter synchronization”](#))
- Clear log: clear log window
- App mode: the application can work in several modes, according to FW setting. When a new application mode is selected, press “Set” to set it in the microcontroller, “Get” to retrieve the app mode from the micro
 - a. Normal: default at startup, the micro is interfaced with the devices and GUI, the complete application is run (ZCR detection, energy pulse generation, no-load detection, energy accumulation and store)
 - b. MCU bypass: energy pulse generation only
 - c. Direct SPI: the metrology devices can be directly accessed through SPI. The device is selected by J1 and J2 jumpers
 - d. Direct UART: the metrology devices can be directly accessed through UART. The device is selected by J1 and J2 jumpers
 - e. Normal (DBG): debug mode, reserved for testing
 - f. MCU bypass (DBG): debug mode, reserved for testing
 - g. Direct SPI (DBG): debug mode, reserved for testing
 - h. Direct UART (DBG): debug mode, reserved for testing

After the reset, the application starts the mode stored in EEPROM, or enters normal mode if no data are stored. After reset, P and Q LED flash three times if it is one among the debug modes. During running, app mode cannot be changed by GUI if it is a dummy mode (modes 3, 4, 7, 8), but pressing [save all] the new mode is saved to EEPROM and at reset the application enters new app mode.

- Auto update: checking this option, all data are automatically loaded in the GUI

- Single phase: reserved. If the microcontroller FW is updated to work as single-phase, only those data coming from the STPM34 are evaluated
- Show raw IO: checking this option, in the log window UART Tx-Rx data are shown
- Show log: allows application messages to be shown in the log window

3.7 Calibration parameters

For each phase, the following calibration parameters can be read and written:

- Voltage and current amplitude calibration bits
- Phaseshift calibration bits
- Power offset compensation bits

Phase A and phase B refer to primary and secondary channel of the STPM34, while phase C is the STPM33 primary channel.

Using the button “Load”, the register values are loaded from the device and shown in the GUI.

“Save” button writes to the STPM34 and STPM33 registers the calibration parameters shown in the GUI.

“Save calib” saves to EEPROM the calibration parameters directly from the STPM34 and STPM33 registers. At startup, the microcontroller uses data in EEPROM to program the STPM3x devices.

3.8 Parameter synchronization

In this section it is possible to access directly the device to read or write.

The information and the value to read/write are selected in the following textbox:

- Target selection: the following target can be selected
 - STPM34: access the STPM34 device directly
 - STPM33: access the STPM33 device directly
 - STPM34/33: valid when it is possible to write the same data to the same register for both devices^a
 - Virtual 3P: in this mode the STPM34 and STPM33 are integrated and treated as a whole chip. Register addresses are continuous (virtual) and have a virtual name^b
 - EEPROM: access application data saved in EEPROM
 - Meas app: access directly data shown in “RT info”, “Energy info” and “Other info” tabs
- Item description: according to the selected target, a list of selectable items is populated
- Address, offset, bits: upon item selection, its address in memory, the relative offset and the bit length is automatically filled
- Value: field showing the value to write or to read in the specified memory location

The following actions are possible:

- Load: retrieves the information required and shows it in “Value” field
- Save: writes the data set to “Value” field in the specified memory location
- Load all: reads all memory content of the selected target and shows it in log window

^a When reading, it is read back from one of them, according to the previous “g_nStpm3xCs” variable value in the FW.

^b This mode is enabled by definition of “STPM3x_CFG_USE_V3P_REG” in the FW.

3.9 Parameter calculations

In this window, the metering front end parameters are displayed and can be configured. They are used for the following calculations:

- R2: lower resistance of voltage divider
- R1: higher resistance of voltage divider
- RC: current sensor sensitivity
- CP: final LED number of pulses per kWh

According to these values, the following parameters are calculated:

- Max. V RMS: maximum value of RMS voltage, calculated as:

$$V_{MAX} = \frac{1}{2} \cdot \frac{V_{ref}}{A_V \cdot \sqrt{2}} \cdot \frac{R1 + R2}{R2} [V]$$

- Max. I RMS, maximum value of RMS current, calculated as:

$$I_{MAX} = \frac{1}{2} \cdot \frac{V_{ref}}{A_I \cdot \sqrt{2}} \cdot \frac{1}{RC} [A]$$

- Max. power, maximum value of RMS current, calculated as:

$$P_{MAX} = V_{MAX} \cdot I_{MAX}$$

- Voltage LSB, LSB value of RMS current register, calculated as:

$$LSB_{V_{RMS}} = \frac{V_{ref} \cdot (1 + R1/R2)}{cal_V \cdot A_V \cdot 2^{15}} [V/bit]$$

- Current LSB, LSB value of RMS current register, calculated as:

$$LSB_{I_{RMS}} = \frac{V_{ref}}{cal_I \cdot RC \cdot A_I \cdot 2^{17}} [A/bit]$$

- Power LSB, LSB value of power registers, calculated as:

$$LSB_P = \frac{V_{ref}^2 \cdot (1 + R1/R2)}{A_V \cdot A_I \cdot RC \cdot cal_V \cdot cal_I \cdot 2^{28}} \left[\frac{W}{LSB} \right]$$

- Energy LSB, LSB value of energy registers, calculated as:

$$LSB_E = \frac{V_{ref}^2 \cdot (1 + R1/R2)}{DClk \cdot A_V \cdot A_I \cdot RC \cdot cal_V \cdot cal_I \cdot 2^{17}} \left[\frac{Ws}{LSB} \right]$$

- CP fast: pulses per kWh produced by the devices as default
- CP div: divider ratio between the default device CP and the final output CP

Pressing "Calculate" button, LSB and the other ratings are updated with input data R1, R2, RC and CP. Data as RMS voltage, current are into these new values.

For a correct conversion of values, the following parameters must be set:

Table 4: Input parameters

Parameter	Value
R1	1905264 Ohm ^a
R2	1200 Ohm
RC	2.72 mV/A
CP	400 pulses/kWh

^a This is true even if the real value of R1 on the board is 1.8 MOhm. In fact, to obtain from the device the target CP = 51200 p/kWh after calibration, given R2 and RC as in this table, the target value of R1 is 1905264 Ohm. Any difference from this value is compensated by calibrators. After calibration, for a correct computation of RMS values, target values of components must be used in formulas because the difference from real ones has already been compensated by calibrators inside the device.

4 Board setup

4.1 Connection to the line

The board can be connected to the line in several ways, as shown in the below figures:

Figure 4: Board connection to phantom load, 3-phase system

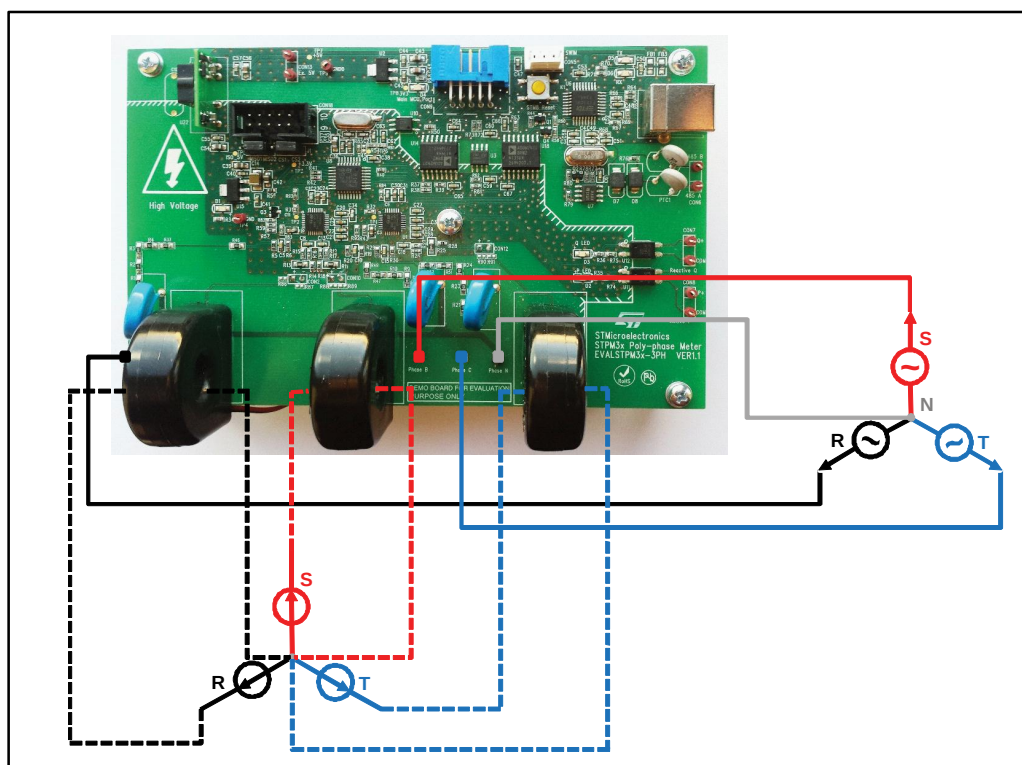
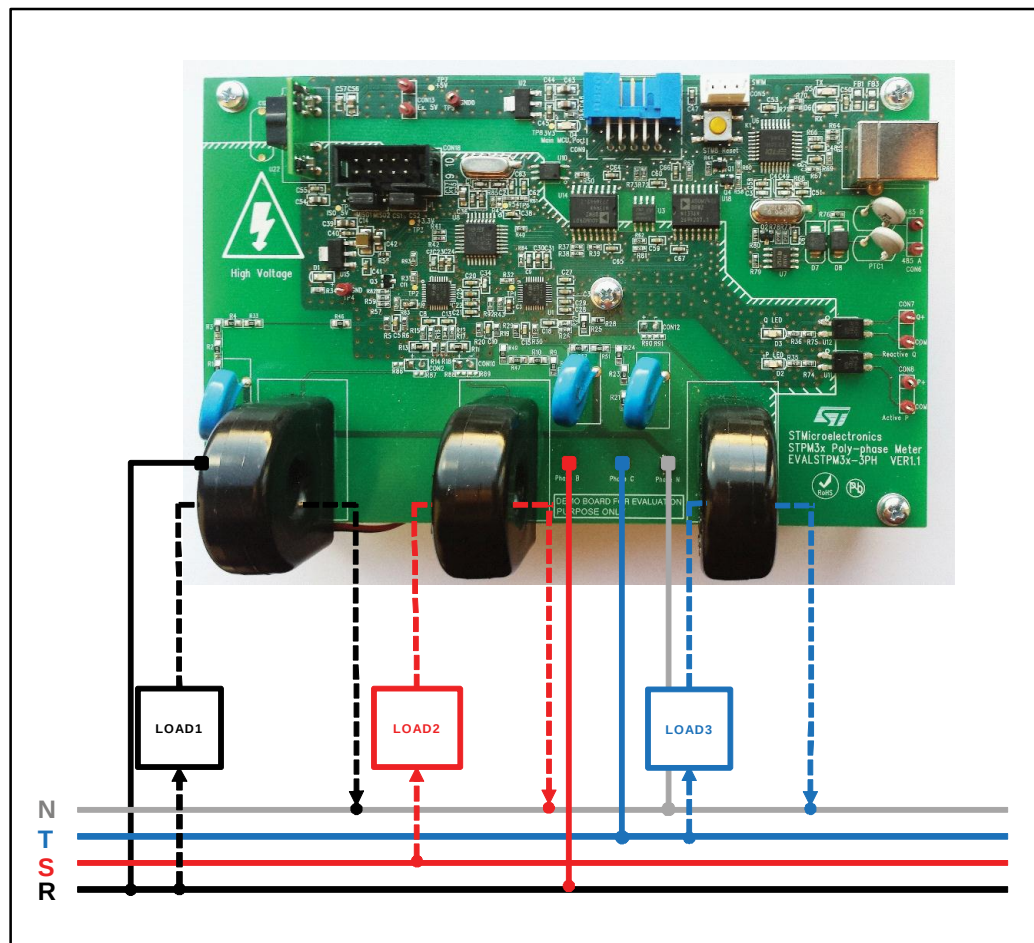


Figure 5: Board connection to 3-phase, line and load



4.2 Getting started

To start working with the evaluation board:

1. Connect the EVALSTPM3x-3PH board to either AC line or power source or phantom load as shown in the paragraph above, without powering it on
2. Plug the USB cable on connector CON4 to a PC, it automatically supplies the board. D1 and D4 LEDs are lighted
3. Open the EVALSTPM3x-3PH GUI
4. Select the desired language from the language combo-box
5. Select the proper COM port from connection section and press "Connect" button. The right COM port number can be found in the computer device manager as "USB serial port"
6. Press "Connect" button, TX and RX LED (D5 and D6) blink
7. "App mode" should be set to "Normal"
8. Select "Auto update" checkbox to see measured values
9. Select "Show raw IO" checkbox to see the exchanged data
10. Power on AC source to see measured data

4.3 Calibration

Tolerances from nominal values of analog front end components, the device analog reference and gain affect final board accuracy have to be compensated through calibration procedure.

To calibrate the whole meter, each channel must be calibrated separately.

The EVALSTPM3x-3PH GUI does not provide automatic calibration routine but can be used to read and write data from the devices.

For more details on the STPM3x calibration procedure, instrumentation and setup, please refer to AN4470.

To perform voltage and current amplitude calibration, first of all open the GUI and connect it, flag the auto update check and set input parameters as in [Table 4: "Input parameters"](#).

Follow the below procedure for any channel:

1. Connect the board to PC and apply known voltage and current
2. Set phase voltage and current calibrator to 2048 (medium value)
3. Check voltage and current reading in "RT info" tab
4. Calculate calibrators as :

$$CHV = 14336 * \frac{Real_Voltage}{Meas_Voltage} - 12228$$

$$CHC = 14336 * \frac{Real_Current}{Meas_Current} - 12228$$

where Real_Voltage and Real_Current are the applied values, the Meas_Voltage and Meas_Current are GUI data.

5. Write CHV and CHC to the phase voltage and current calibrators and press "save" and "save calib" to write them to the devices and EEPROM respectively

For phase shift and offset compensation please follow the procedure described in AN4470.

5 Revision history

Table 5: Document revision history

Date	Revision	Changes
27-Oct-2015	1	Initial version.

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