Quick Start for MK30XEMETER

Project name:
MQX-Based Kinetis (MK30X256) Single-Phase Electricity Meter Reference Design

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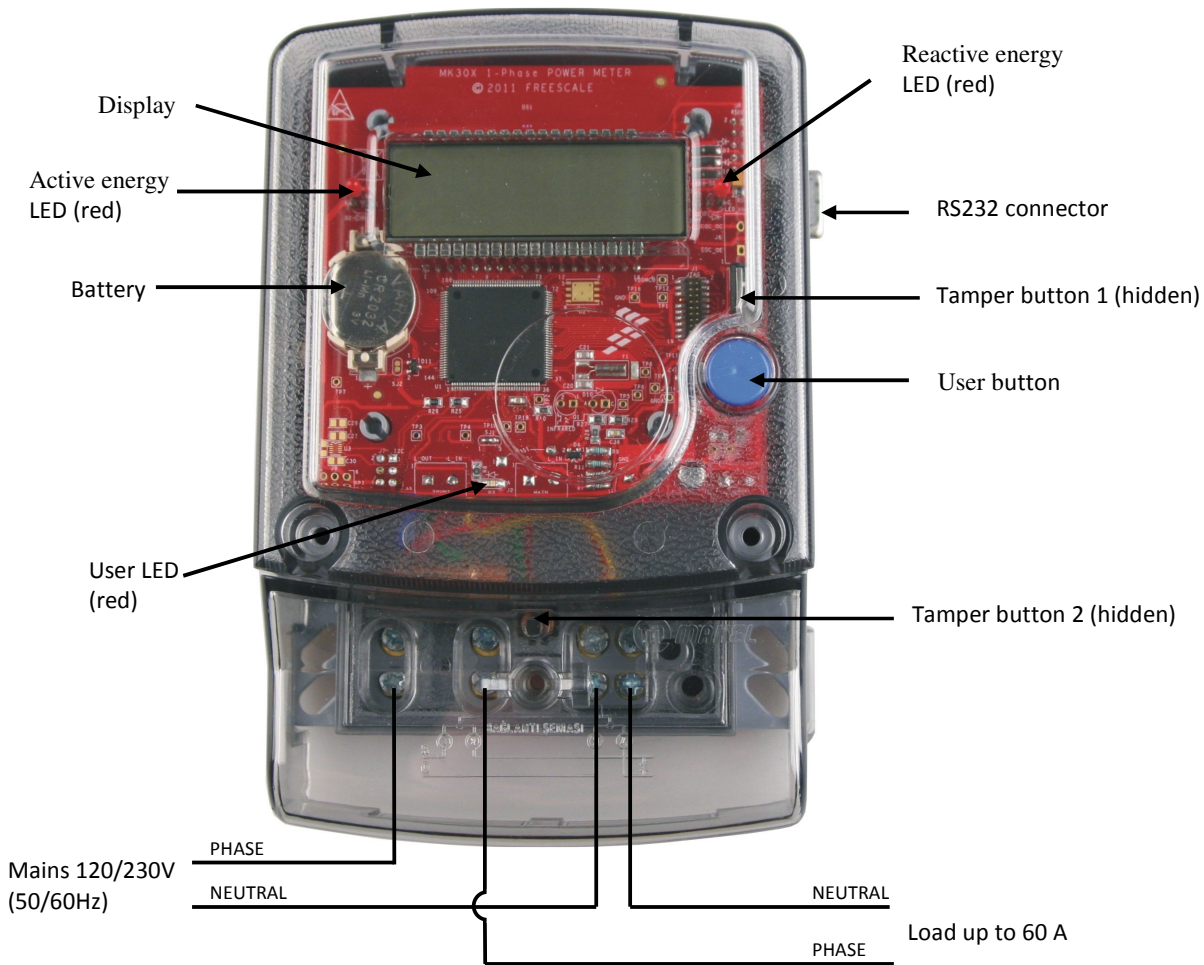
1. INTRODUCTION

1.1 Connection to the Mains

Figure 1 Single-Phase Power Meter Introduction

- Connect the Power Meter directly to the mains.
- Connect an external load to the Power Meter.
- For a better practical demonstration of the Power Meter, the metering case may be placed on a perspex base alternatively where an outlet is also placed (for load connection) and a cable with a plug (for connection to the power mains). The whole configuration is also called the Power Meter Demo[1] – see Figure 2.
- After connecting the Power Meter to the mains, display turns on and shows the last value.
- User can also see other values on the display by pressing the user button. Here is the list of these values:

Value	Units	Format	OBIS code
Line voltage	V_{RMS}	0.01 V	32.7.0
Line current	A_{RMS}	0.001 A	31.7.0
Signed active power	W	0.1 W (+ forward, - reverse)	1.7.0
Signed reactive power	VAr	0.1 VAr (+ lag, - lead)	3.7.0
Apparent power	VA	0.1 VA	9.7.0
Power factor	-	0.0001	13.7.0
Active energy - import	kWh (Wh)	0.0001 kWh, 0.01 Wh, 0.001 Wh	1.8.0
Active energy - export	kWh (Wh)	0.0001 kWh, 0.01 Wh, 0.001 Wh	2.8.0
Reactive energy - import	kVArh (VArh)	0.0001 kVArh, 0.01 VArh, 0.001 VArh	3.8.0
Reactive energy - export	kVArh (VArh)	0.0001 kVArh, 0.01 VArh, 0.001 VArh	4.8.0
Frequency	Hz	0.001 Hz	14.7.0
Time[2]	hour, min, sec	HH:MM:SS	0.9.1
Date[2]	year, month, day	YYYY:MM:DD	0.9.2

- All of energies (four counters) are saved into non-volatile memory. These energies remain in memory after resetting the Power Meter. For clearing the energy counters you must use FreeMASTER application (see section 1.2) and apply the Command clear energies.

- There are two tampers hidden under the cover. When you remove the cover, tamper symbol(s) is (are) shown on the LCD. This symbol remains on the LCD even after reset, because this information is saved into non-volatile memory. For clearing the tamper status you must use FreeMASTER application (see section 1.2) and apply the Command clear tampers.

- When you push user button during power-on, the LCD shows actual version of the internal SW.

- Both energy LEDs flash simultaneously with the internal energy counters.

- 3V Battery is used for the RTC function[2].

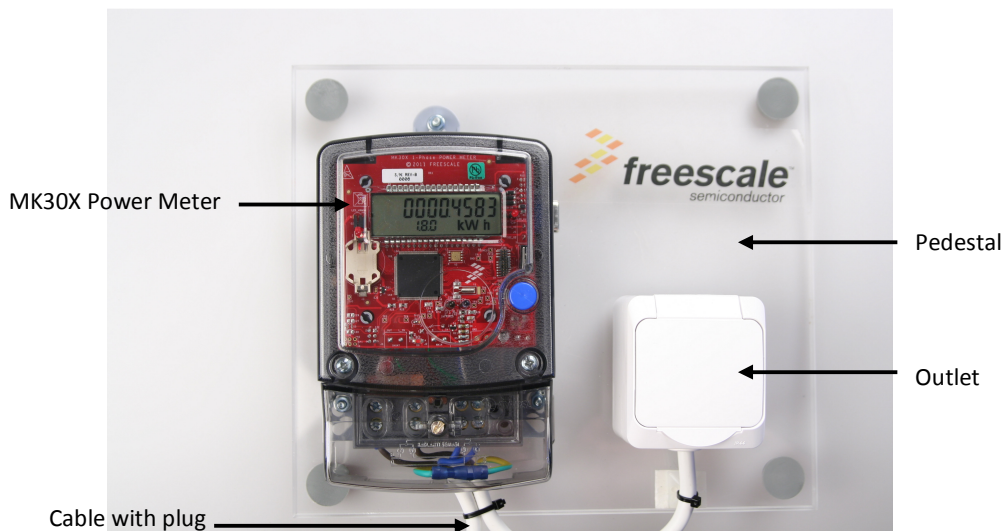- RS232 plug is used for FreeMASTER data visualization and calibration.

Figure 2 Single-Phase Power Meter Demo

1.2   FreeMASTER Data Visualization

For FreeMASTER data visualization you must connect the RS232 cable between the Power Meter and PC first. A FreeMASTER visualization script is the software for remote visualization, remote setting up and calibration of the Power Meter via an RS232 cable. This software runs on the PC which connects to the Power Meter via an RS232 cable. FreeMASTER visualization script is an application which runs under the FreeMASTER software (formerly known as PC Master software). FreeMASTER software is one of the off-chip drivers which supports communication between the target microcontroller and a PC. This tool allows the programmer to remotely control an application using a user-friendly graphical environment running on a PC. It also provides the ability to view some real-time application variables in both textual and graphical form. FreeMASTER software runs under Windows 98, 2000 or XP. It is a versatile tool to be used for multipurpose algorithms and applications. It provides a lot of excellent features, including:

- Real-time debugging
- Diagnostic/visualisation tool
- Demonstration tool
- Education tool

Before running a visualization script, FreeMASTER SW must be installed on your PC. After that, a FreeMASTER visualization script may be started after double-clicking on the *MK30X.pmp* file in directory called *Visualization*. Following this, a visualization script will appear on your PC (see Figure 3).

Now, you should set the proper serial communication port and speed in the menu Project/Option (see at Figure 4), if it has not been done before. After that, you must set the proper *Project.out* project file in menu Project/Option/MAPfiles (see at Figure 5), if it has not been done before. Originally, this file is accessible in the subdirectory called *FLASH_256KB_PFLASH_256KB_DFLASH* in the *Visualization* directory. If all previous settings are correctly done, the FreeMASTER visualization script for the Power Meter is now prepared for running. To do this, you must click on the Start/Stop Communication button (third icon on the upper left side in the GUI). At this time you may see a voltage and current diagram in the time domain and also in the frequency domain (in an FFT window). You may also see other variables in text format such as frequency, V_{RMS}, I_{RMS}, etc.
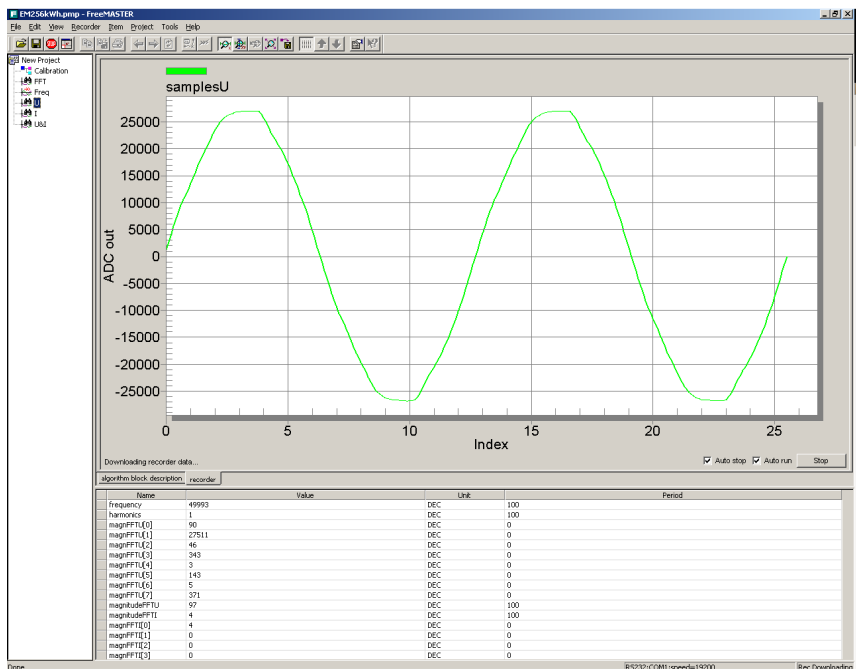

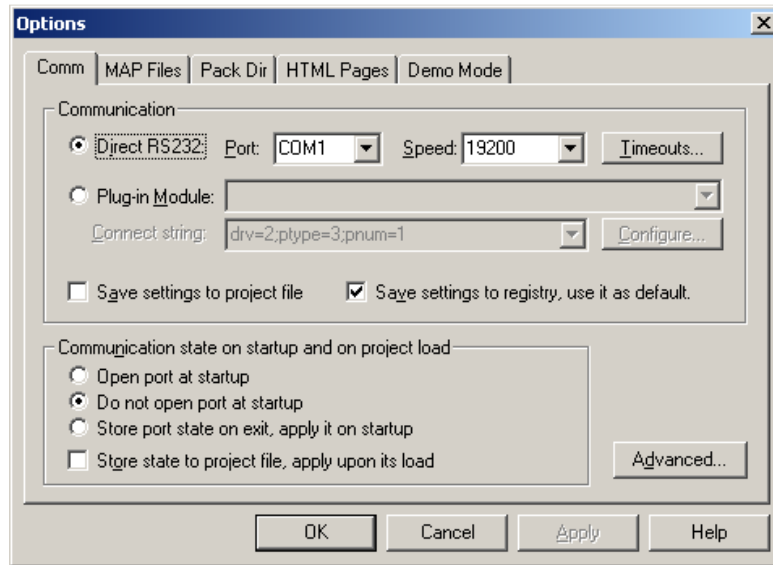Figure 3 FreeMASTER Visualization Script (GUI)

Figure 4 FreeMASTER Communication Port Setting

Alternatively you may set some values, such as impulse number, clock and date, etc. After setting appropriate value in the FreeMASTER software, use right command for transferring this value to the Power Meter. These commands are allowable: clock setting, impulse numbers setting, clear energies, clear tampers. After application of these commands is also suitable to use flash save command for saving this value into non-volatile memory of the MK30X. The user is not allowed to change 'red' values in Calibration section. These values include: voltage and current gain, voltage and/or current phase delay.
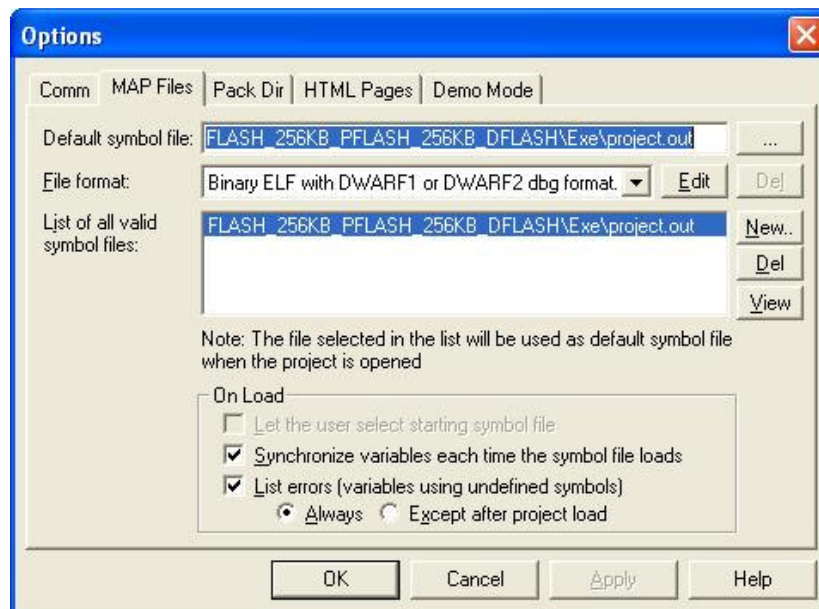

Figure 5 FreeMASTER Project File Setting

1.3 ZigBee communication

ZigBee communication is only optional – it is not implemented in every Power Meter Demo. There is a 2.4GHz RF 1322x module inside the meter. ZigBee module and the Power Meter are connected through the I²C. For joining the Power Meter to a ZigBee network, you will need another 1322x module – this will be like a ZigBee coordinator (see Figure 6). Thanks to it, the Power Meter can easily become part of the Smart Grid.
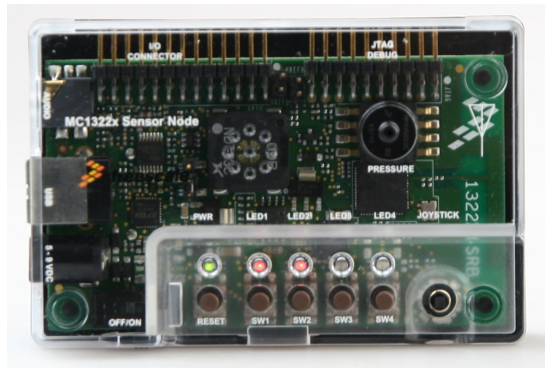

Figure 6 1322x Sensor Node (ZigBee coordinator)

1.3.1 ZigBee communication procedure

1. Install the latest version of the *BeeKit* from the *Freescale web page*. There is a *ZeD* monitor – this is a separate part of the *BeeKit*. You will use the *ZeD* monitor for demonstration of *ZigBee* communication between the Power Meter and the PC.
2. Switch the Power Meter on and connect some load to the Power Meter.
3. Connect the ZigBee coordinator (1322x-SRB) to the PC through a USB cable, and switch the coordinator on. The coordinator must be powered, of course. To do this, plug the AC adaptor to the coordinator (you may also use the internal battery inside the coordinator module), or use a USB power line from the PC side (the best choice). You will have to install the SW driver this equipment after the first connection to the PC. The driver is in directory *Drivers\LuminaryFTDI* or alternatively on the *FTDI web page*.
4. Push the button SW1 on the coordinator – it looks up all ZigBee equipment connected to the ZigBee network at this time. Two red LEDs on the coordinator will be lighted then (see Figure 6).
5. Start the *ZeD* monitor and then click on the *OK button*. Before running the *ZeD* GUI, the ZigBee coordinator must be connected to the PC through a USB cable!
6. At this moment there are several icons of all the devices connected to the ZigBee network - in this case, only the Power Meter + coordinator (see Figure 7). If there is no icon for the Power Meter, you must reset the Power Meter by the reset push-button and also reset the *ZeD* GUI by the F5 key. You may also repeat installation from point 2 in this case.
7. In the *ZeD* GUI menu you may open a new window for showing the ZigBee data transfer. This is in *Tools/Start SE Utility Control Panel* menu. You must address the meter by clicking the *Add New Household ESP Connection...* and then click the *Connect* icon (see Figure 8).
8. For showing data (only kWh) you must click on the *Metering* icon (top right on the screen) and a kWh data table is now refreshed (every 5 seconds). The most important is the *Meter Report* column, where active energy from the power meter is displayed (see Figure 9). These numbers are in HEX format to 0.0001kWh.
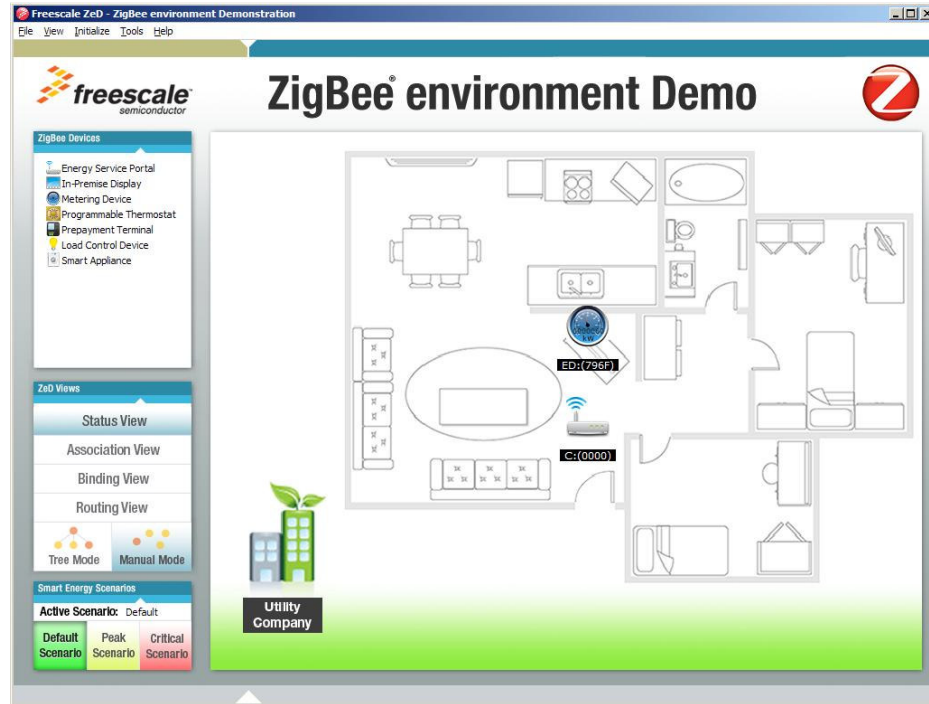
Figure 7 ZeD GUI

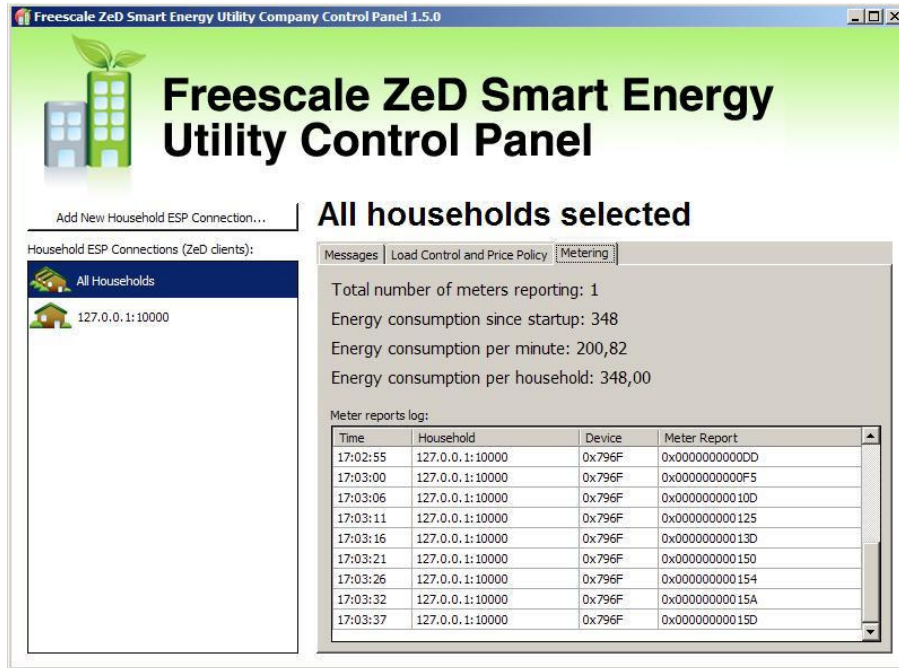Figure 8 Add New Household ESP Connection Dialog Box

Figure 9 Metering Report

2.   POWER METER SPECIFICATION

Type of meter	Single phase residential
Type of measurement	4-quadrant
Metering algorithm	Fast Fourier Transform (FFT)
Precision (accuracy)	IEC50470-3 class B, 1% (for active and reactive energy)
Voltage range	85…264 V_{RMS}
Current Range	0…60 A_{RMS} (5 A is nominal current, peak current is 60A)
Frequency range	47…63 Hz
Meter constant (imp/kWh, imp/kVArh)	500, 1000, 2000, 5000, 10000
Functionality	V, A, kW, kVAr, kVA, kWh (import/export), kVArh (lead/lag), cos φ, Hz, time, date
Voltage sensor	Voltage divider
Current sensor	Shunt 300 μΩ
Energy output pulse interface	two red LEDs (active and reactive energy)
Optoisolated pulse output (optional)	optocoupler (active or reactive energy)
User interface (HMI)	LCD, one push-button, one user LED (red)
Tamper detection	two hidden buttons
Infrared interface (optional only)	For metering data reading (IEC1107)
RS232 serial interface	Optoisolated, 19200 Bd, 8 data bit, 1 stop bit, no parity
ZigBee interface (optional only)	2.4GHz RF 1322x-LPN internal daughter card
Internal battery (for RTC)	3V, type CR2032

[1] *There are European plug and outlet in the Power Meter Demo, for connecting to other mains use adaptors*
[2] *These functions are not implemented now*