UM0402
User manual

Single-phase multi-tariff energy meter

Introduction

This user manual describes the functions and features of the single-phase multi-tariff energy meter.

The reference board is an integrated system designed to provide a complete, ready-to-use energy meter application. It is a medium-end solution for power metering, using the ST72F321 microcontroller, the M41T94 Real Time Clock, the M95256 EEPROM and the STPM14 energy meter ASSP device.

The multi-tariff energy meter reference board implements several features including multi-tariff management, absolute and average maximum demand calculation, two types of tamper management and power failure management. It can therefore be used as a platform for evaluation and development of meter applications.

The aim of this guide is to provide:

- Procedures for getting the reference board functioning quickly
- An overview of the implementation of meter main features
- The information required to be able to customize meter features.

Contents

1 Overview

1.1 Safety rules

This board can be connected to mains voltage (220V). 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 only by skilled technical personnel (regional accident prevention rules must be observed).

Danger: **Due to the risk of death when using this prototype on mains voltage (220V), only skilled technical personnel 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.**

1.2 Conventions

The lowest analog and digital power supply voltage is called V_{SS}. All voltage specifications for digital input/output pins are referred to as V_{SS}. The highest OTP writing power supply voltage is V_{OTP}. The highest power supply voltage of the device is V_{CC}.

Positive currents flow into a pin. Sinking means that the current flows to the pin while sourcing means that the current flows from the pin.

Timing specifications of signals treated by the device are relative to the CLKOUT. This signal is fed from a 4.194 MHz on-board crystal oscillator.

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

A positive logic convention is used in all equations.

1.3 Multi tariff meter description

The single-phase multi-tariff energy meter reference board is designed using STPM14 metering ASSP and ST72F321BR6 microcontroller.

The STPM14 belongs to STPM1x metering devices family. It measures the active energy that is output as a pulse train with a frequency proportional to the measured power. It supports tamper detection, monitoring both phase and neutral line wires, where two current transformers are used as current sensors. The clock to STPM14 is supplied by a crystal of frequency 4.194304 MHz.

The microcontroller drives the LCD, processes measurements coming from the ASSP and manages RTC and EEPROM functionalities, for example saving relevant data in EEPROM before moving to halt mode during power down. It also manages maximum demand calculation on a daily, monthly or three-month base.

A 16 MHz crystal is used for obtaining an 8 MHz CPU clock for the micro.

This meter has SPI EEPROM (M95256) with 256 Kb of memory, and SPI RTC (M41T94) for date and time functions. 3V rechargeable battery is used to supply RTC for when the line power is down and the battery is fully discharged.

Figure 1. Multi-tariff meter board

The board has a Viper12-based switching power supply. When line power is not available, power to the application is supplied by 4.8V rechargeable battery.

An LCD display is present with 24x4 segments, customized for electricity meter use.

This board also supports IRDA protocol IEC62056-21 mode C.

There are two 10-pin connectors, one to program STPM14 internal OTP registers, and one for microcontroller ICP.

Two jumpers are used for the microcontroller reset and to simulate a box tamper. A push button is used to display various parameters on the LCD display. 30 seconds after the switch is pressed without further activity, the LCD screen once again displays the first screen showing accumulated kWh and eventual error symbols. However, repeated presses of the button cycle through the display of additional information.

See *Table 8 on page 19* for full details on the parameters displayed on the LCD.

1.4 Multi tariff meter features

- Cost-effective and flexible, based on STPM14
- Fulfils class 1 accuracy for Ib=5A and Imax=80A according to IEC 61036:1996 + A1: 2000, Static meter for active energy (classes 1 and 2)
- Operating Voltage range 220V ±20%
- Continuously detects and displays No load condition, Reverse direction and fraud & case Tamper conditions
- Configurable number of tariffs (1 to 4) and Maximum demand Type (day type, one month type or three month type)
- Accumulated data for whole meter life (Total kWh consumption, Average MDs, Total number of Tariffs, Tariff time slots, consumption under different tariff rates, power failure date/time)
- Data for last 12 months (Consumption under Tamper mode for each month, First/last Case/fraud Tamper Date/time, total Tamper time and power failure accumulating time for each month)
- Data for Absolute Maximum Demand (Absolute MD, Date/Time) according toType of MD requested
- SW LCD driver for 24X4 segments LCD glass with contrast control
- RTC with SPI exists for real Date/Time
- EEPROM with SPI for storing 256 Kbit of data
- Case tamper detection in power down also
- External switch to see all the data stored into EEPROM sequentially even when AC power is not available
- Battery backup to detect tampering and see all the parameters stored in EEPROM during power down also
- Single point and fast calibration of STPM14 for Class 1 meter

1.5 Recommended reading

This documentation describes how to use the Multi Tariff Meter Reference Board.

Additional information can be found in the following documents:

- STPM14 datasheet;
- Components datasheets;
- inDART-STX for ST7 User's Manuals;
- IEC 62056 IrDA Protocol Mode C;
- IrDA module for Multitariff Meter user manual.

1.6 Obtaining technical support

Technical assistance is provided free to all customers. For technical assistance, documentation, information and updates about products and services, please refer to your local ST distributor/office.

2 Getting started

2.1 Multi-tariff meter checklist

The Multi-tariff meter reference kit includes the following items:

- Reference design board (*Figure 1*)
- STPM14 programmer
- An interactive CD-ROM with software and documentation.

2.2 Equipment requirements

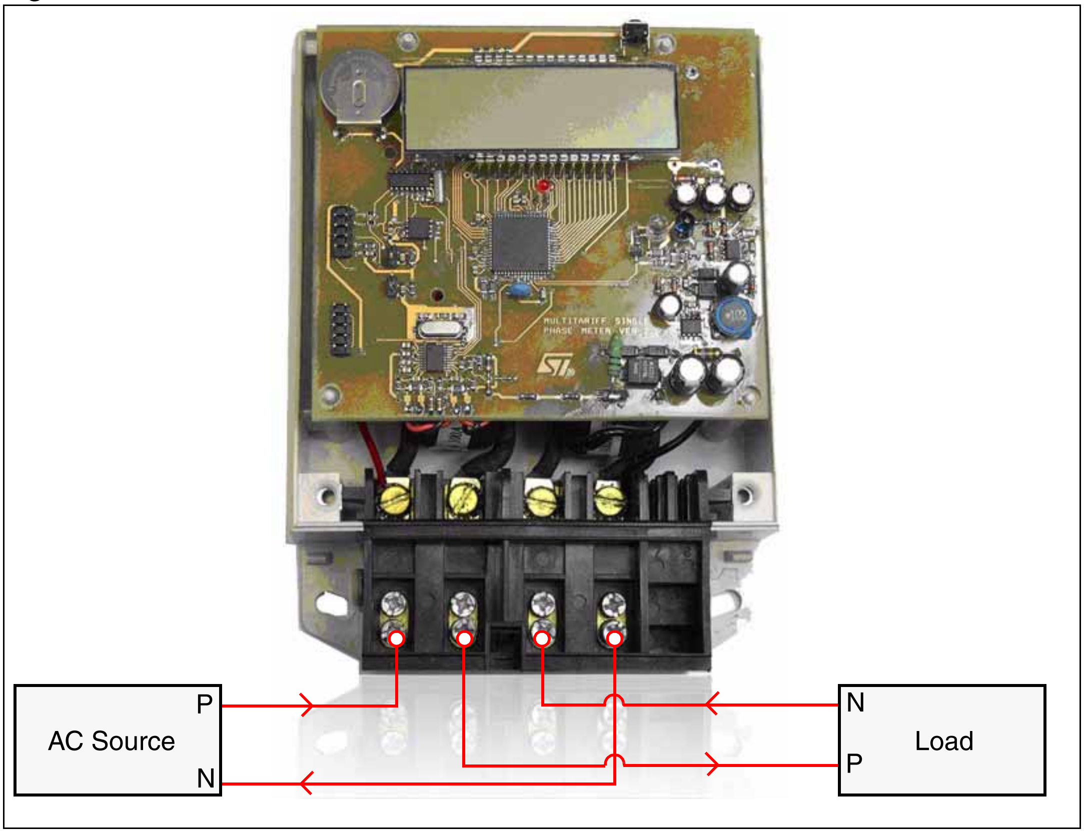
To operate the multi-tariff meter reference board it is necessary to use a 220 V, 50 Hz AC supplier or a simple connection to the line voltage.

2.3 Installing the hardware

Connect the board to line and neutral wires of voltage source and to load, as displayed below.

The line and neutral voltage source wires can be either connected to a plug, to be plugged into the line socket, or to an AC voltage source, providing 220 VAC.

Figure 2. Multi-tariff meter board connections



3 Hardware Features

3.1 Electrical parameters

The following table summarizes the electrical parameters, which are specified for V_{CC} = 3.6V, T_{AMB} = +25 C, unless otherwise noted.

Table 1. Electrical parameters

Parameter	Min	Typ	Max	Units	Test Conditions or Comments
Target applications:					
Nominal line voltage V_{NOM}	140	220	300	V_{RMS}	
Nominal frequency F_L	45.0	50.0	65.0	Hz	
Nominal line current I_{NOM}		2		A_{RMS}	
Maximal line current I_{MAX}		20	30	A_{RMS}	
Ambient temperature T_{AMB}	-40	+25	+85	C	
Class of accuracy		0.2	0.5		
Digital inputs:					
Pull up I_{IL}		15		A	Valid also for IO pins when they are used as inputs
Voltage input low V_{IL}	-0.3		0.25V_{CC}	V	
Voltage input high V_{IH}	0.75V_{CC}		5.3	V	
Digital outputs:					
Voltage output low V_{OL}			0.4	V	I_{OL} = +2mA
Voltage output high V_{OH}	V_{CC}-0.4			V	I_{OH} = -2mA
Transition time t_{TR}			5	ns	C_L = 50pF, V_{CC} = 3.2V
OTP programming:					
No programming level V_{VOTP}		V_{DDA}-0.65		V	Internally generated
Programming level V_{VOTP}	14		20	V	
Programming current I_{VOTP}	1	1.5	3	mA	To program 1 bit at a time
Programming time t_{WE}	100	200	300	s	To program 1 bit at a time
Power supply:					
Supply level V_{CC}	3.165	3.6	5.5	V	
Quiescent current I_{CC}	4	5	6	mA	No loads
Supply level V_{DDA}	2.85	3	3.15	V	C_L = 100nF, V_{CC} = 3.2V
Nominal frequency F_L	45.0	50.0	65.0	Hz	
Power on reset V_{CCPOR}		2.5		V	
SPI interface timings:					
Data write speed f_{SCL}			100	kHz	

Table 1. Electrical parameters (continued)

Parameter	Min	Typ	Max	Units	Test Conditions or Comments
Data set up time t_{DS}	20			ns	
Data hold time t_{DH}	0			ns	
Data driver on time t_{ON}			20	ns	
Data driver off time t_{OFF}			20	ns	
SYN active width t_{SYN}	1000			ns	

3.2 Mechanical outlines

The size of PCB of the module can be seen from an appended drawing. The overall volume is determined by the size of maximal element, which is a current transformer:

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

4 Firmware features

4.1 Multi Tariff management and configuration

It is possible to define up to four tariffs to apply to the energy count.

The number of tariffs must be defined in EEPROM_Union structure in the *EEPROM.c* file.

Tariff-change time should also be given in the EEPROM_Union structure in 24-hour HH:MM:SS format.

Tariff times in the *EEPROM.c* file should be defined in increasing order starting from the first definition.

For example, if the number of tariffs defined in EEPROM_Union structure is 3, we should give three tariff times in increasing order starting from first as shown below:

```
{
{0x05, 0x00, 0x00},// Change of tariff from A3 to A1 at 5:00 AM
{0x10, 0x30, 0x00},// Change of tariff from A1 to A2 at 10:30 AM
{0x21, 0x00, 0x00},// Change of tariff from A2 to A3 at 9:00 PM
{0x00, 0x00, 0x00},// Not defined
}
```

Tariff rates are defined in EEPROM_Union structure in *EEPROM.c* file in the same order as tariff times.

For example, if the number of tariffs defined in EEPROM_Union structure is 3 (as in the above case), the tariff rate should be defined as below:

```
{
{
3.000,   // Tariff rate defined for A1
      {0, 0}   // kWh_Energy and Pulse count initialized to 0
},
{
2.001,   // Tariff rate defined for A2
{0, 0}   // kWh_Energy and Pulse count initialized to 0
   },
   {
2.852, // Tariff rate defined for A3
      {0, 0}   // kWh_Energy and Pulse count initialized to 0
   },
   {
      0.0,     // Not Defined
      {0, 0}
   },
},
```

To set and change the tariff, a function `Set_TARIFF()` is called every second.

Energy consumption is calculated as total and for each tariff.

4.2 Maximum demand management and configuration

The maximum demand (MD) is the maximum continuous load (kW) which remains for a certain period. This period is programmable and can be chosen from 1 minute up to 60 minutes. There are three types of absolute maximum demand which are defined:

a) Daily based,

b) Monthly based,

c) Quarterly based.

According to this selection, the absolute maximum demand will be calculated and stored for each day, or for each month or for each quarter in a 12 month base.

Out of these three options, one can be selected by the user in the *lib.h* file by preprocessor directive; in the same way it is possible to program the period of constant load.

An example definition is given below:

```
/* define type for MD*/
#defineMD_minutes 1

// #defineDAY1
#defineONE_MONTH 1
// #defineTHREE_MONTHS 1
```

In every case the average of these maximum demands is calculated and stored for a year as:

- last three months average maximum demand,
- second last three months average maximum demand,
- third last three months average maximum demand,
- fourth last three months average maximum demand,
- last six months average maximum demand,
- last nine months average maximum demand
- last twelve months average maximum demand.

In the following paragraphs the three types of MD will be explained in detail.

4.2.1 Day type maximum demand

In this type the storing period is chosen and programmed to be one day.

As an example, the maximum load period is chosen and programmed to be 15 minutes.

If on the first day (e.g. 25th Dec'06) there is a continuous load of 150 kW for 15 minutes starting from 10:15PM to 10:30PM, and another one of 200 kW for 10 minutes starting from 11:11PM to 11:21PM, the meter stores the value of 150 kW as the "maximum demand" of that day with date 25th Dec'06 and time 22:30:00 in 24Hour HH:MM:SS format.

The meter acts the same way for each day. Average maximum demands are calculated using the MD values of each day.

Then at the end of the month, the meter calculates and stores:

- maximum demand for each day of the month,
- average maximum demands of all types.

In EEPROM, the storing of the day type MD for each day is defined as below:

Name	1st Jan	2nd Jan	:	:	:	27th Feb	28th Feb	29th Feb	1st March	:	:	:	:	:	:	:	:	:	:	:	:	31st Dec
Index	0	1	..	..	..	57	58	59	60	..	..	..	..	..	..	..	..	..	..	..	..	365

If the particular year is a leap year, then 59th index data will be filled by 29th Feb maximum demand, otherwise index will be incremented by 2 which leaves the 59th index maximum demand data as it was.

4.2.2 Month type maximum demand

In this type the storing period is chosen and programmed to be one month.

As an example, the maximum load period is chosen and programmed to be 15 minutes.

The maximum demand of a day is calculated as in the previous case.

If the first day the absolute maximum demand is 150 kW, and the second day it is 75 kW, the meter keeps the value of the 150 kW of the previous day as the maximum demand value.

If the third day the maximum demand is 200 kW, the meter stores 200 kW with new date and time instead of the 150 kW as maximum demand of the month.

At the end of the month the meter stores only one value of maximum demand, and calculates average maximum demands using the MD values of each month.

Then at the end of the month, the meter calculates and stores:

- maximum demand of the month,
- average maximum demands of all types.

In EEPROM, the storing of month type MD for each month is defined as below:

Name	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Index	0	1	2	3	4	5	6	7	8	9	10	11

4.2.3 Quarter type maximum demand

In this type the storing period is chosen and programmed to be three months.

Let suppose that the maximum load period is chosen and programmed to be 15 minutes.

The maximum demand of each month is calculated as in the previous case.

Moreover, at the end of each month the maximum demand of the quarter is calculated as the maximum demand of the three months of the quarter, and average maximum demands are calculated using the MD values of each month.

Summarizing, at the end of month meter calculates and stores:

- maximum demand of the month,
- maximum demand of the quarter,
- average maximum demands of all types.

In EEPROM, in the case of three months type MD the storing of month-wise maximum demand and three month-wise maximum demand is defined as below:

Name	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Index	0	1	2	3	4	5	6	7	8	9	10	11
Name	JAN, FEB, MAR			APR, MAY, JUN			JUL, AUG, SEP			OCT, NOV, DEC		
Index	0			1			2			3		

4.3 Date and time configuration

RTC date and time can be set by the firmware itself. There is a `RTC_init()` function which initializes the RTC with the specified date and time. The date and time to be initialized in RTC should be specified in RTC_table[10] array. The definition of array is as below:

RTC_table[0] = write command and 7 bit address(0x00) = 0x80

RTC_table[1] = Seconds up to 0.01 in BCD format = value given by user

RTC_table[2] = ST and Seconds in BCD format = value given by user

RTC_table[3] = Minutes in BCD format = value given by user

RTC_table[4] = CEB, CB and Hours in BCD format = value given by user

RTC_table[5] = Day of week = value given by user

RTC_table[6] = Date of month in BCD format = value given by user

RTC_table[7] = Month in BCD format = value given by user

RTC_table[8] = Year = value given by user

RTC_table[9] = calibration value = value given by user

For more information, please refer to M41T94 datasheet of RTC used in the board.

Date and time can also be set by using the IRDA protocol. Please refer to the IEC 62056 PROTOCOL MODE C user manual.

4.4 Memory structure

The meter sensitive data are stored in EEPROM. M95256 256 Kbit EEPROM is used.

Below are details on memory organization.

4.4.1 Common storage for all maximum demand types

There is some common data stored at the start of EEPROM.

This data is saved in 89 Bytes of EEPROM_Union structure of EEPROM_DATA_Union data type, and represents the energy count, the average maximum demand, application flags, tariff definitions, energy counts and power down information.

Two pages of 64 Bytes are used for storing these 89 Bytes, as shown below:

Table 2. EEPROM common information

EEPROM Address	Description	Data Type
00h	kWh_Energy	unsigned long
04h	Pulse_Count	unsigned int
06h	Av_Max_Demmand_1st_three	unsigned int
08h	Av_Max_Demmand_2nd_three	unsigned int
0Ah	Av_Max_Demmand_3rd_three	unsigned int
0Ch	Av_Max_Demmand_4th_three	unsigned int
0Eh	Av_Max_Demmand_last_six	unsigned int
10h	Av_Max_Demmand_last_nine	unsigned int
12h	Av_Max_Demmand_last_twelve	unsigned int
14h	IRQTAMPER	Bool
14h	TMPD	Bool
14h	E_TAMPER	Bool
14h	First_Fraud	Bool
14h	First_Box	Bool
14h	Installation_Check	Bool
15h	Total_No_Tarrifs	unsigned char
16h	Tarrif_Time[0] : Hour,Min,Sec	unsigned char
19h	Tarrif_Time[1] : Hour,Min,Sec	unsigned char
1Ch	Tarrif_Time[2] : Hour,Min,Sec	unsigned char
1Fh	Tarrif_Time[3] : Hour,Min,Sec	unsigned char
22h	Tarrif[0] : Tarrif_Rate	float
26h	Tarrif[0] : kWh_Energy_Tarrif	volatile unsigned long
2Ah	Tarrif[0] : Pulse_Count_Tarrif	volatile unsigned int
2Ch	Tarrif[1] : Tarrif_Rate	float
30h	Tarrif[1] : kWh_Energy_Tarrif	volatile unsigned long
34h	Tarrif[1] : Pulse_Count_Tarrif	volatile unsigned int
36h	Tarrif[2] : Tarrif_Rate	float
3Ah	Tarrif[2] : kWh_Energy_Tarrif	volatile unsigned long
3Eh	Tarrif[2] : Pulse_Count_Tarrif	volatile unsigned int
40h	Tarrif[3] : Tarrif_Rate	float
44h	Tarrif[3] : kWh_Energy_Tarrif	volatile unsigned long
48h	Tarrif[3] : Pulse_Count_Tarrif	volatile unsigned int
4Ah	Index_Month_Data	volatile unsigned char
4Bh	Index_day_three_mon_Data	volatile unsigned int

Table 2. EEPROM common information

EEPROM Address	Description	Data Type
4Dh	power_down_date: Day, Month, Year	volatile unsigned char
50h	power_down_time: Sec, Min, Hour	volatile unsigned char
53h	pwr_dn_index_year	volatile unsigned char
54h	pwr_dn_index_mon	volatile unsigned char
55h	Index_Box_Tamper	volatile unsigned int
57h	Index_Fraud_Tamper	volatile unsigned int

Twelve pages of 64 Bytes are used for storing 456 Bytes (12x38 Bytes) of EEPROM_month_Union structure of EEPROM_DATA_Month_Union data type.

Each page of 64 Bytes of EEPROM is separately storing 38 Bytes of data related to each month. The information stored for each month is:

- Energy consumption during tamper;
- First and last box tamper time and date;
- First and last line tamper time and date;
- Total month tamper time;
- Total month power down time.

EEPROM_month_Union structure is stored as below:

Table 3. EEPROM common information (for each month)

EEPROM Address	Description	Data Type
80h	kWh_Energy_Tamp	volatile unsigned long
84h	Pulse_Count_Tamp	volatile unsigned int
86h	First_Tamper_Time_Box : Sec, Min, Hour	volatile unsigned char
89h	First_Tamper_Date_Box : Day, Month, Year	volatile unsigned char
8Ch	Last_Tamper_Time_Box : Sec, Min, Hour	volatile unsigned char
8Fh	Last_Tamper_Date_Box : Day, Month, Year	volatile unsigned char
92h	First_Tamper_Time_Fraud : Sec, Min, Hour	volatile unsigned char
95h	First_Tamper_Date_Fraud : Day, Month, Year	volatile unsigned char
98h	Last_Tamper_Time_Fraud : Sec, Min, Hour	volatile unsigned char
9Bh	Last_Tamper_Date_Fraud : Day, Month, Year	volatile unsigned char
9Eh	Total_Tamper_Time : Sec, Min	volatile unsigned char
A0h	Total_Tamper_Time : Hour_Tamper_Time: Hour	volatile unsigned int
A2h	Power_Failure_Time: Sec, Min	volatile unsigned char
A5h	Power_Failure_Time: Hour_Tamper_Time: Hour	volatile unsigned int

In EEPROM, twelve EEPROM_month_Union structures each having 38 Bytes are stored as below:

Name	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Index	0	1	2	3	4	5	6	7	8	9	10	11

4.4.2 Storage specific for day type MD

46 pages of 64 Bytes are used for storing 366 structures of EEPROM_AMD_Union data type. Current EEPROM_MD_Union structure contains the Maximum Demand information of the current day.

So, there are 2928 Bytes (366x8 Bytes) of data present in EEPROM related to day type Maximum Demand.

EEPROM_MD_Union structure of EEPROM_AMD_Union data type is stored as below:

Table 4. EEPROM day type MD information

EEPROM Address	Description	Data Type
380h	Absolute_MD	unsigned int
382h	Time_Ab_MD : Sec, Min, Hour	volatile unsigned char
385h	Date_Ab_MD : Day, Month, Year	volatile unsigned char

In EEPROM, 366 EEPROM_MD_Union structures each having 8 Bytes of data are stored as below:

Name	1st Jan	2nd Jan	:	:	:	27th Feb	28th Feb	29th Feb	1st March	:	:	:	:	:	:	:	:	:	:	:	:	31st Dec
Index	0	1	..	..	..	57	58	59	60	..	..	..	..	..	..	..	..	..	..	..	..	365

4.4.3 Storage specific for month type MD

2 pages of 64 Bytes are used for storing 12 structures of EEPROM_AMD_Union data type. Current EEPROM_MD_Union structure contains the Maximum Demand information of the current month. So, there are 96 Bytes (12x8 Bytes) of data present in EEPROM related to month type Maximum Demand.

EEPROM_MD_Union structure of EEPROM_AMD_Union data type is stored as below:

Table 5. EEPROM month type MD information

EEPROM Address	Description	Data Type
380h	Absolute_MD	unsigned int
382h	Time_Ab_MD : Sec, Min, Hour	volatile unsigned char
385h	Date_Ab_MD : Day, Month, Year	volatile unsigned char

In EEPROM, 12 EEPROM_MD_Union structures each having 8 Bytes of data are stored as below:

Name	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Index	0	1	2	3	4	5	6	7	8	9	10	11

4.4.4 Storage specific for quarter type maximum demand

2 pages of 64 Bytes are used for storing 12 structures of EEPROM_AMD_Union data type for Maximum demand information of each month and 1 page of 64 Bytes are used for storing 4 structures of EEPROM_AMD_Union data type for Maximum demand information of 4 - three months blocks.

Current EEPROM_MD_Union structure contains the Maximum Demand information of the current month and EEPROM_MD_Union_Three_Mon structure contains the maximum demand of the current block of three months. So, there are 128 (96+32) Bytes (12x8 + 4x8 Bytes) of data present in EEPROM related to three months type Maximum Demand.

EEPROM_MD_Union structure of EEPROM_AMD_Union data type is stored as below:

Table 6. EEPROM quarter type MD information

EEPROM Address	Description	Data Type
380h	Absolute_MD	unsigned int
382h	Time_Ab_MD : Sec, Min, Hour	volatile unsigned char
385h	Date_Ab_MD : Day, Month, Year	volatile unsigned char

In EEPROM, 12 EEPROM_MD_Union structures each having 8 Bytes of data are stored as below:

Name	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Index	0	1	2	3	4	5	6	7	8	9	10	11

EEPROM_MD_Union_Three_Mon structure of EEPROM_AMD_Union data type is stored as below:

Table 7. EEPROM quarter type MD information

EEPROM Address	Description	Data Type
400h	Absolute_MD	unsigned int
402h	Time_Ab_MD : Sec, Min, Hour	volatile unsigned char
405h	Date_Ab_MD : Day, Month, Year	volatile unsigned char

In EEPROM, 4 EEPROM_MD_Union_Three_Mon structures each having 8 Bytes of data are stored as below:

Name	JAN, FEB, MAR	APR, MAY, JUN	JUL, AUG, SEP	OCT, NOV, DEC
Index	0	1	2	3

5 Multi-tariff meter operation

5.1 Normal operation

Connect the meter to the voltage source and to the load, as shown in *Figure 2 on page 7*, and power on the board by plugging it into the AC line socket, or by powering on the AC source to which line and neutral wires are connected.

During normal operation, the meter is supplied with the line voltage, the microcontroller is in Run Mode and all devices are powered on.

The red LED just below the LCD blinks with a frequency proportional to active power measured by STPM14 (pulse constant is set to 1000imp/kWh) and the LCD displays active energy measured, current tariff and other symbols, as listed below in details.

5.1.1 Tamper mode

The meter is able to detect and manage two types of tamper:

- box tamper (when the box is opened). This event can be simulated with jumper J1.
- fraud tamper

The STPM14 metering device is also able to detect tamper on the line or voltage wire. If a difference between currents in line and neutral wire is detected the device enters tamper mode.

In normal mode, the current averages with a 50% multiplex ratio between the two channels. In tamper mode only the higher current is used for energy computation and the other current is monitored only to check if tamper is still present. For more details about line tamper please refer to *STPM14 datasheet*.

Both box and line tamper events are detected by the microcontroller, which also records their timestamp and other sensitive data.

During a tamper event the LCD displays the *E bottom* (tamper) symbol. The energy computation is still performed and increases the total energy; moreover the meter computes and stores the total amount of energy consummated during tamper events for each month.

5.1.2 IR Mode

The meter implements a simple IrDA communication, compliant with IEC 62056 protocol mode C, using two led (…) as transmitter and receiver.

In this way it is possible to read all information stored in EEPROM, as energy consumption, tamper information and MD data or to change application parameters without opening the meter case or stopping its operation.

A firmware library has been developed to communicate, through a hand held unit (HHU) connected to PC serial port, with a GUI interface.

With a predefined command set, sent by the GUI and the HHU to the microcontroller, it is possible to:

- read from a specified EEPROM memory location,
- read from microcontroller RAM,
- write in a specified EEPROM memory location,
- reset all EEPROM memory locations
- set RTC time and date.

The GUI allows the baud rate to be set (from 300 to 19200 bps), the parity (odd / even), communication port, data format and other communication parameters.

Two windows are available in the GUI, showing data sent and received from the microcontroller, in hexadecimal and ASCII format.

For further details about the implemented IrDA protocol, refer to the *IEC 62056 Protocol Mode C* document. For the operation of the GUI and the command set please refer to the *IrDA module for multi-tariff meter user manual*.

5.1.3 LCD display

Below is a table listing all the information available for display on the LCD. Each screen of data is displayed one at a time following a press of the push button. Once the push button has been pressed, if it is not pressed in another 30 seconds the LCD returns to the first screen (screen 0).

Table 8. LCD Common Information

Screen n.	Data	Format	Symbol	Meaning
0	Energy Consumption	0000000.0	A	Active energy
			kWh	Measure Unit
			1̃	Phase 1
			A1 / A2 / A3 / A4	Current tariff
			E bottom	Tamper detected
			⅄	Negative Power Direction
			X	No Load Condition detected
1	Instantaneous power consumption	00000.000	P	Power
			kW	Measure Unit
2	Average maximum demand for last 3 months	00000.000	P	Power
			kW	Measure Unit
3	Average maximum demand for second last 3 months	00000.000	P	Power
			kW	Measure Unit
4	Average maximum demand for third 3 months	00000.000	P	Power
			kW	Measure Unit

Table 8. LCD Common Information

Screen n.	Data	Format	Symbol	Meaning
5	Average maximum demand for fourth last 3 months	00000.000	P	Power
			kW	Measure Unit
6	Average maximum demand for last 6 months	00000.000	P	Power
			kW	Measure Unit
7	Average maximum demand for last 9 months	00000.000	P	Power
			kW	Measure Unit
8	Average maximum demand for last 12 months	00000.000	P	Power
			kW	Measure Unit
9	Rate @1st tariff slot	00000.000	A1	Tariff symbol
10	Consumption for 1st tariff slot	0000000.0	A1	Tariff symbol
			1	Tariff
			kWh	Measure Unit
			1̃	Phase 1
11	Rate @2nd tariff slot	00000.000	A2	Tariff symbol
12	Consumption for 2nd tariff slot	0000000.0	A2	Tariff symbol
			2	Tariff
			kWh	Measure Unit
			1̃	Phase 1
13	Rate @3rd tariff slot	00000.000	A3	Tariff symbol
14	Consumption for 3rd tariff slot	0000000.0	A3	Tariff symbol
			3	Tariff
			kWh	Measure Unit
			1̃	Phase 1
15	Rate @4th tariff slot	00000.000	A4	Tariff symbol
16	Consumption for 4th tariff slot	0000000.0	A4	Tariff symbol
			4	Tariff
			kWh	Measure Unit
			1̃	Phase 1

The next block of information is repeated 12 times, the first block displayed is current month data, the others are past months going backwards for 1 year.

Index i=0 refers to current month, it increases by one each button press up to 11 for past months information.

Table 9. LCD Month Information

Screen n.	Data	Format	Symbol	Meaning
17+i*11	Consumption under tamper mode	0000000.0	A	Active energy
			kWh	Measure Unit
			1̃	Phase 1
18+i*11	First box tamper event date	dd.mm.yy	E bottom	Tamper indicator
19+i*11	First box tamper event time	hh.mm.ss	E bottom	Tamper indicator
			Min	Time indicator
20+i*11	Last box tamper event date	dd.mm.yy	E bottom	Tamper indicator
21+i*11	Last box tamper event time	hh.mm.ss	E bottom	Tamper indicator
			Min	Time indicator
22+i*11	First fraud tamper event date	dd.mm.yy	E bottom	Tamper indicator
23+i*11	First fraud tamper event time	hh.mm.ss	E bottom	Tamper indicator
			Min	Time indicator
24+i*11	Last fraud tamper event date	dd.mm.yy	E bottom	Tamper indicator
25+i*11	Last fraud tamper event time	hh.mm.ss	E bottom	Tamper indicator
			Min	Time indicator
26+i*11	Total Tamper Time (Box + Fraud)	hhhh.mm.ss	E top	Power failure indicator
			Min	Time indicator
27+i*11	Total Power Failure Time	hhhh.mm.ss	E top	Power failure indicator
			Min	Time indicator

The next block of information is repeated 4 +12 or 12 or 365 times if the MD mode is quarterly or monthly or daily based respectively. The first block displayed is current quarter or month or day, the others are previous data going backwards for 1 year.

- Quarterly AMD case: j from 0 to 15 (displays 12 months + 4 quarters information).
- Monthly AMD case: j from 0 to 11.
- Daily AMD case: j from 0 to 365.

Index i=0 refers to current quarter, month or day, it increases by one each button press up to the maximum for each case for past information.

Table 10. LCD AMD Information

Screen n.	Data	Format	Icon	Meaning
149+j*3	Absolute maximum demand	00000.000	P	Power
			kW	Measure Unit
150+j*3	Date of occurrence	dd.mm.yy		
151+j*3	Time of occurrence	hh.mm.ss	Min	Time indicator

5.2 Operation during power failure

During a normal operating mode the meter is supplied with the line voltage, the microcontroller is in Run Mode and all devices are powered on.

If a power down occurs the meter is supplied by 4.8 V battery. In this case, the micro moves to HALT mode and LCD, EEPROM and STPM14 are switched off.

As the micro senses the voltage going down, and before moving to HALT mode, it saves in EEPROM all data.

5.2.1 Tamper mode

During power failure, the STPM14 metering device is switched off. Then line tamper is not available, but box tamper is still recognized by the meter.

The behavior of the meter is the same of that during power up, as described in *Section 5.1.1: Tamper mode on page 18*.

5.2.2 IR Mode

The functioning of IrDA module during power down is the same of that described above, except that it is necessary, to wake up the micro from HALT mode, to send a specific command.

5.2.3 LCD Display

During power down LCD is normally switched off. When the push button is pressed, micro wakes up and the LCD displays the information listed above.

Once the push button has been pressed, if it is not pressed in 30 seconds the micro returns to halt mode and the LCD is switched off again.

5.3 LCD icons description

The LCD can display different icons, which meaning is shown below.

Table 11. LCD Icons

Icon	Meaning
A	Active Energy
P	Active Power
kWh	Energy Measure Unit
kW	Power Measure Unit
1̃	Phase 1
A1	A1 tariff
A2	A2 tariff
A3	A3 tariff
A4	A4 tariff
E bottom	Tamper indicator
E top	Power failure indicator
⅄	Negative Power Direction indicator
X	No Load Condition indicator
Min	Time indicator

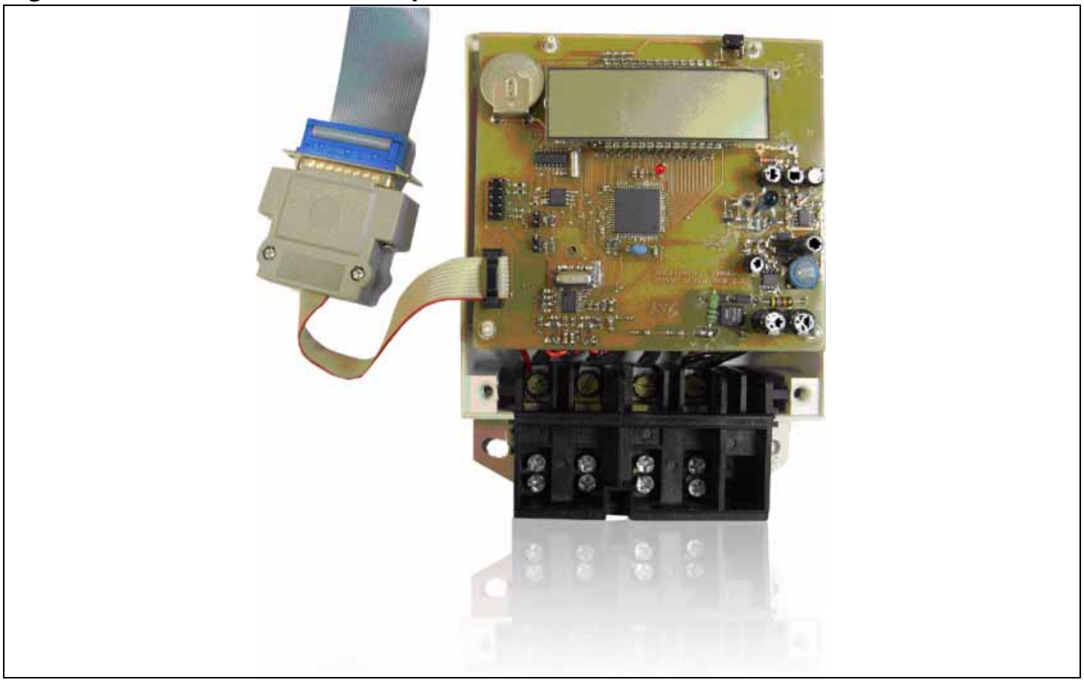
6 Additional features

6.1 STPM14 programming

All the configuration bits that control the operation of the STPM14 device can be written in a temporary or permanent way (respectively in the so-called shadow registers or in the OTP memory) through a serial interface.

Software PC GUI is available with the reference board to write calibration and configuration bits in the device. A parallel hardware programmer interfaces the PC and the reference board through J2 10 pins connector, as shown in *Figure 3*.

Figure 3. Board connected to parallel hardware interface



For more details on calibration and configuration bits please refer to *STPM14 datasheet*.

For more details on GUI interface please refer to user manual *UM0128*.

6.2 In-circuit programming

The ICP feature allows you to update the contents of Flash program memory when the chip is already plugged into the application board. ICP programming uses the ICC (In-Circuit Communication) serial protocol to interface a programming tool like inDART®. ICP offers the following benefits:

- In-circuit debugging
- Real time code execution without probes
- Customization of the application
- Easy application debug.

J1 10 pins connector is available for ICP functionality.

Appendix A Schematics

Figure 4. Microcontroller section schematic

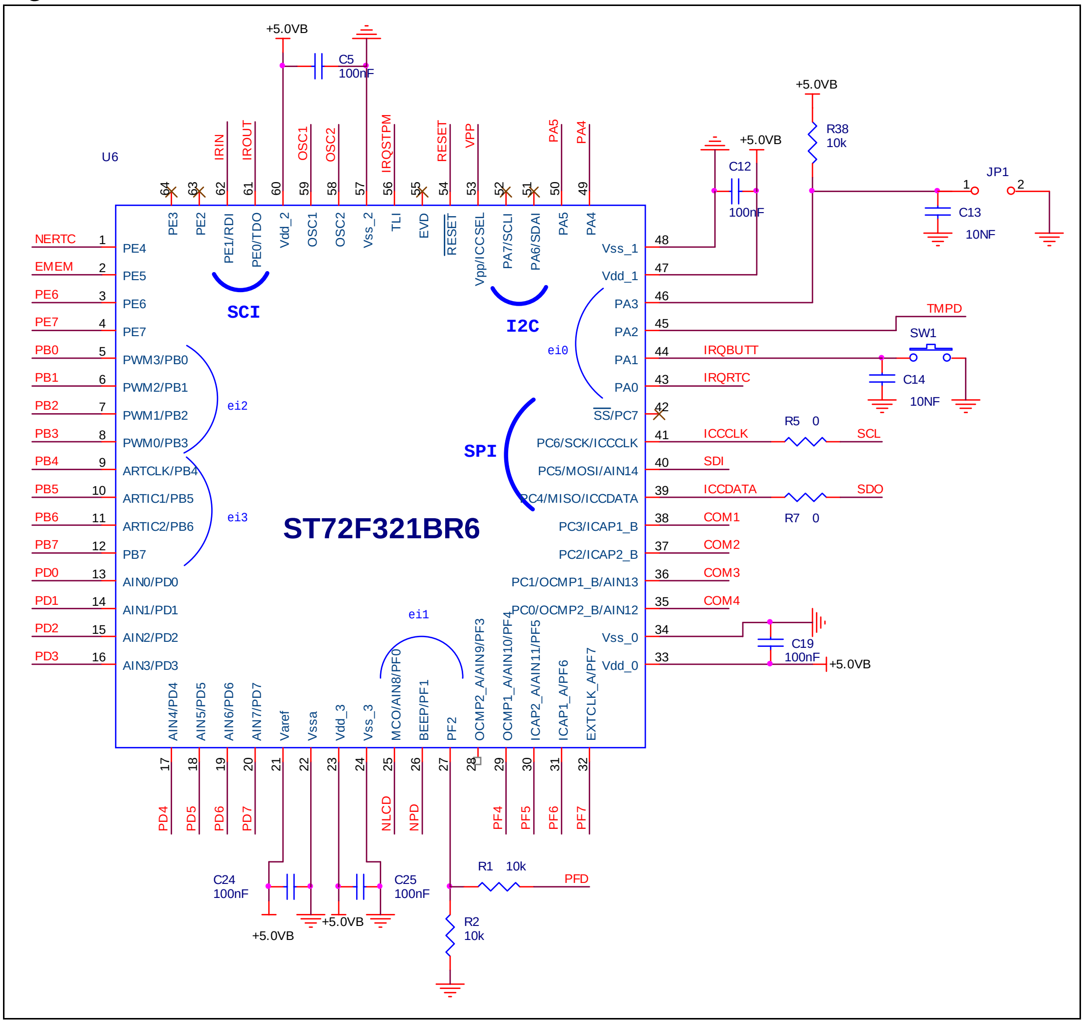


Figure 5. Measurement section schematic

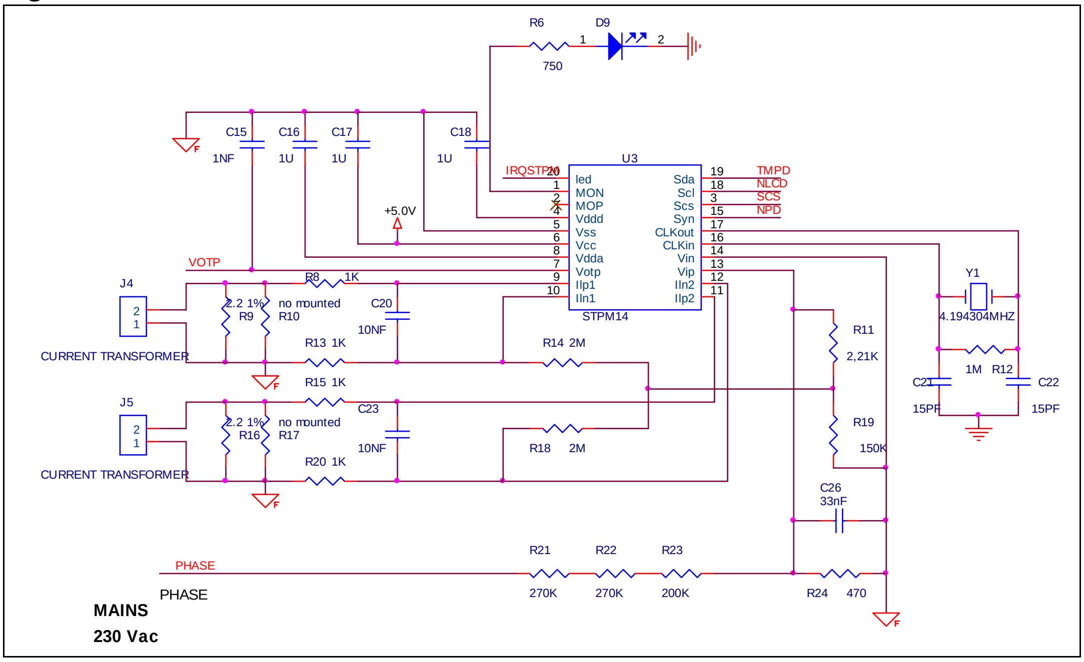


Figure 6. Power supply section schematic

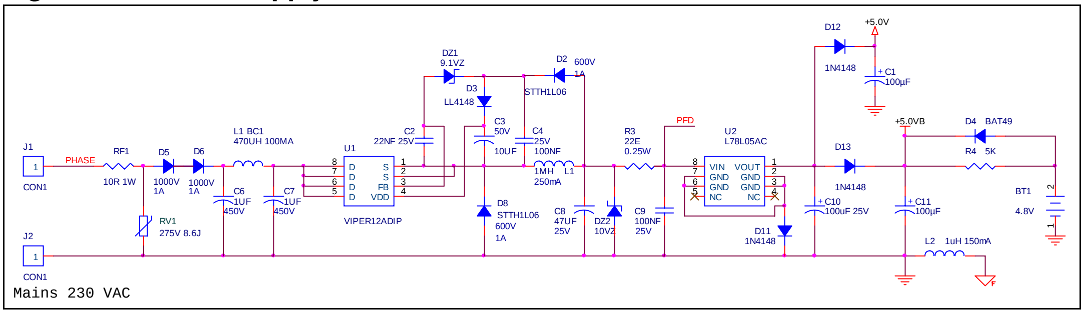


Figure 7. Memory and RTC section schematic

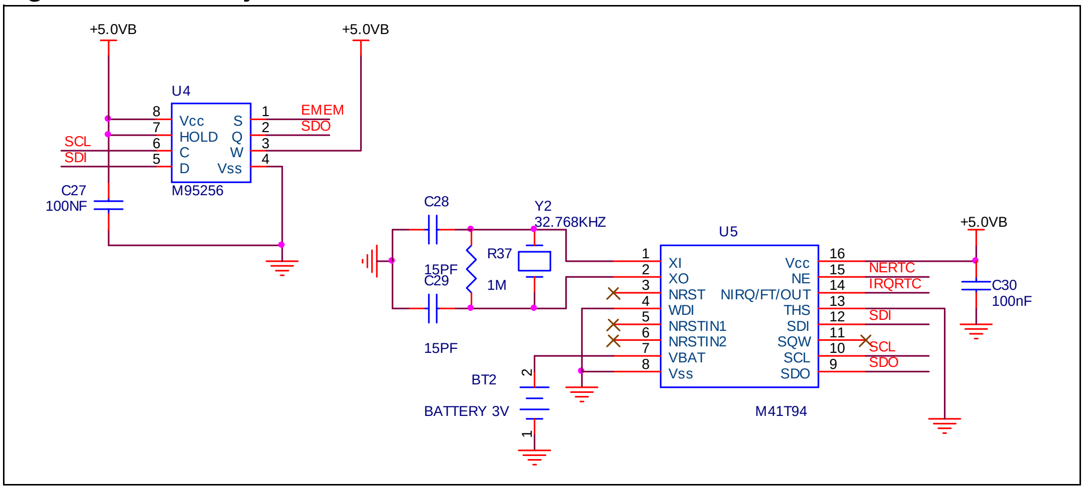


Figure 8. IR and reset schematic

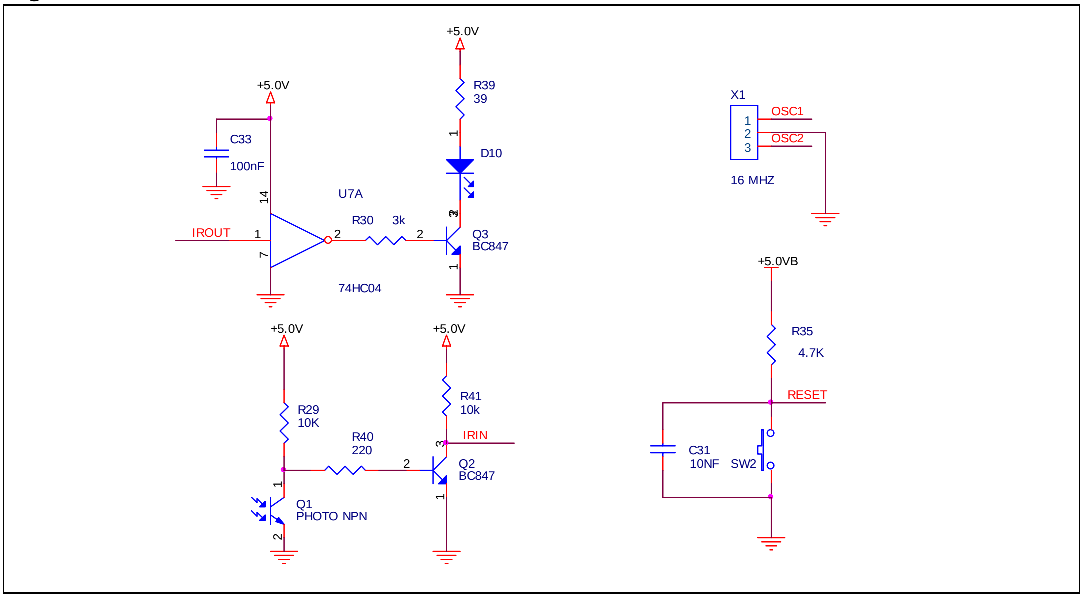
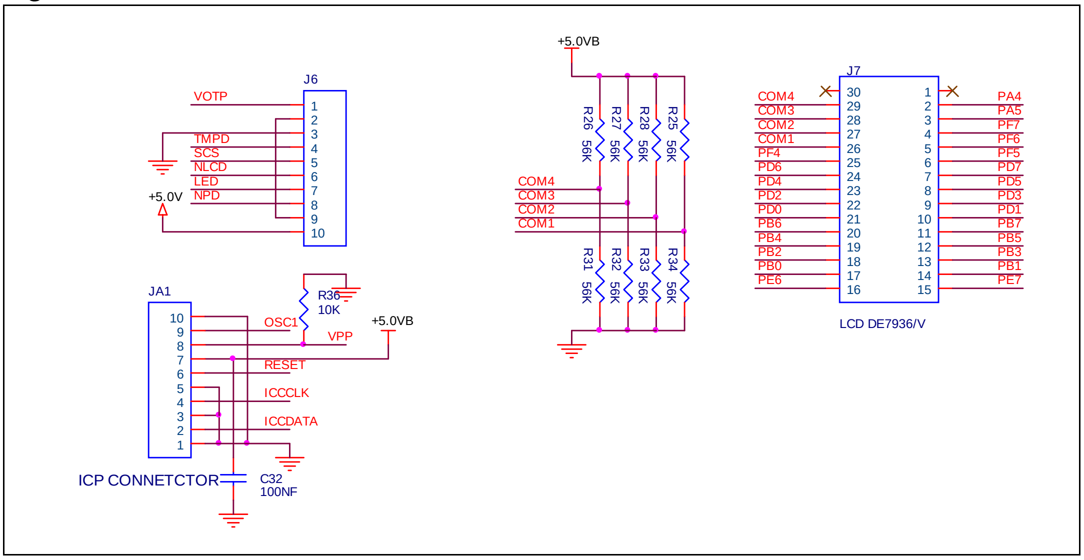


Figure 9. Connectors and LCD schematic



Appendix B BOM list

Table 12. BOM list

Index	Quantity	Reference	Value / Generic Part Number	Package	Manufacturer	Manufacturer's ordering code / Orderable Part Number	Supplier	Supplier's ordering code
1	1	BT1	PCB mount NiMH battery,4.8V 150mAh	THT	VARTA	55615604940	RS	422-400
2	1	BT2	BR2032H2A lithium coincell,3V 190mAh	THT	Panasonic	BR2032/1GURS	RS	597-396
3	3	C1,C10,C11	100uF 25V electrolytic	THT 2.54mm pitch, Diameter=7mm				
4	1	C2	22 nF 25V ceramic	SMD 0805				
5	1	C3	10uF 50V electrolytic	THT 2.54mm pitch, Diameter=5mm				
6	11	C4,C9,C27,C32,C5,C12,C19,C24,C25,C30,C33	100 nF 25V ceramic	SMD 0805				
7	2	C6,C7	1uF 450V electrolytic	THT 3.5mm pitch, Diameter 8mm				
8	1	C8	47uF 25V	THT 2.54mm pitch, Diameter=5mm				
9	5	C13,C14,C20,C23,C31	10nF 25V ceramic	SMD 0805				
10	1	C15	1nF 50V ceramic	SMD 0805				
11	3	C16,C17,C18	1uF 25V ceramic	SMD 0805				
12	4	C21,C22,C28,C29	15 pF 25V ceramic	SMD 0805				
13	1	C26	33nF 25V ceramic	SMD 0805				
14	1	DZ1	zener 9.1V 0.5W	SMD DO-213				
15	1	DZ2	zener 10V 0.5W	SMD DO-213				
16	2	D2,D8	STTH1L06	SMD SMA	ST	STTH1L06A		
17	4	D3,D11,D12,D13	LL4148 Small signal diode	SMD 1206	DIOTEC SEMICONDUCTOR	LL4148	Distrelec	601496
18	1	D4	BAT49	SMD MELF	ST	TMBAT 49		
19	2	D5,D6	GF1M Rectifier diode, 1A 1000V	SMD DO214	General Semiconductor	GF1M	RS	269-451
20	1	D9	3mm red LED	THT				
21	1	D10	IR Emitting Diode 5mm	THT	VISHAY	TSAL6100		
22	1	JA1, J6	5 way 2 row header,0.1in pitch 7mm pin (10 PIN strip line)	THT				
23	2	JP1, SW2	2 way 1 row header,0.1in pitch 7mm pin (2 PIN strip line for jumper)	THT				

Table 12. BOM list (continued)

Index	Quantity	Reference	Value / Generic Part Number	Package	Manufacturer	Manufacturer's ordering code / Orderable Part Number	Supplier	Supplier's ordering code
24	2	J1,J2	1 pin header,0.1in pitch 7mm pin	THT				
25	2	J4,J5	DCT108 1:2500 12.5Ω 0.1% 100A CURRENT TRANSFORMER	THT	OSWELL (www.oswell.com.cn)	DCT108B		
26	1	J7	LCD DE7936/V	THT	Display Elektronik GmbH	DE 7936/V		
27	1	L1	Power-Use SMD Inductor 1MH	SMD	TDK	SLF10145T-102MR29-PF		
28	1	L2	jumper wire					
29	1	L1 BC1	470uH 0.24A, Miniature axial inductor	THT			RS	240-545
30	1	Q1	SILICON PHOTO DIODE	THT	BRIGT LED ELECTRONICS CORP. (www.brightled.com.tw)	BPD-BQA314		
31	2	Q2,Q3	BC847 NPN general purpose transistors	SMD SOT23				
32	1	RF1	10R 1W ROX1S metal oxide film resistor	THT	Tyco Electronics Neohm	ROX1SJ10R	RS	214-0879
33	1	RV1	275V 8.6J SMD varistor	SMD DO214AB	EPCOS	B72650M271K72	Distrelec	730096
34	6	R1,R2,R29,R36,R38,R41	10kΩ	SMD 0805				
35	1	R3	22EΩ	SMD 1206				
36	1	R4	5KΩ	SMD 1206				
37	2	R5,R7	0Ω	SMD 0805				
38	1	R6	750Ω 1%	SMD 0805				
39	4	R8,R13,R15,R20	1kΩ 1%	SMD 0805				
40		R9, R16	2.2Ω 1% Professional MELF resistor	SMD minimelf 1206	BEYSCHLAG	MMA0204	Distrelec	713010
41	4	R10, R17	no mounted					
42	1	R11	2,2kΩ 1%	SMD 0805				
43	2	R12,R37	1MΩ 1%	SMD 0805				
44	2	R14,R18	2MΩ 1% Professional MELF resistor	SMD minimelf 1206	BEYSCHLAG	MMA0204	Distrelec	713153
45	1	R19	150kΩ	SMD 0805				
46	2	R21,R22	270KΩ 1% Professional MELF resistor	SMD minimelf 1206	BEYSCHLAG	MMA0204	Distrelec	713132
47	1	R23	200kΩ 1% Professional MELF resistor	SMD minimelf 1206	BEYSCHLAG	MMA0204	Distrelec	713129
48	1	R24	470Ω 1% Professional MELF resistor	SMD minimelf 1206	BEYSCHLAG	MMA0204	Distrelec	713066

Table 12. BOM list (continued)

Index	Quantity	Reference	Value / Generic Part Number	Package	Manufacturer	Manufacturer's ordering code / Orderable Part Number	Supplier	Supplier's ordering code
49	8	R25,R26,R27, R28,R31,R32, R33,R34	56kΩ	SMD 0805				
50	1	R30	3kΩ	SMD 0805				
51	1	R35	4.7kΩ	SMD 0805				
52	1	R39	39Ω	SMD 1206				
53	1	R40	220Ω	SMD 0805				479-1520
54	1	SW1	6x6mm r/a tactile switch	THT	Tyco	8-1437565-5	RS	
55	1	U1	VIPER12	SMD SO8	ST	VIPer12AS - E		
56	1	U2	L78L05AC	SMD SO8	ST	L78L05ACD13TR		
57	1	U3	STPM14	SMD TSSOP20	ST	STPM14		
58	1	U4	M95256	SMD SO8	ST	M95256MW6P		
59	1	U5	M41T94	SMD SO16	ST	M41T94MQ6E		526-6154
60	1	U7	74HC04	SMP SOP	ST	M74HC04M1R		
61	1	X1	16 MHZ Resonator	THT	Murata	CSTLS16M0X55	RS	335026
62	1	Y1	4.194304 MHZ Quartz	THT	AURIS	HC-49/US SMD	Distrelec	226-1443
63	1	Y2	32.768 kHz Crystal	THT	C-MAC MicroTechnolo gy	XTAL002995	RS	
64	1	U6	ST72F321BR6	SMD	ST	ST72F321BR6T6		

Appendix C Layout

Figure 10. Top layer

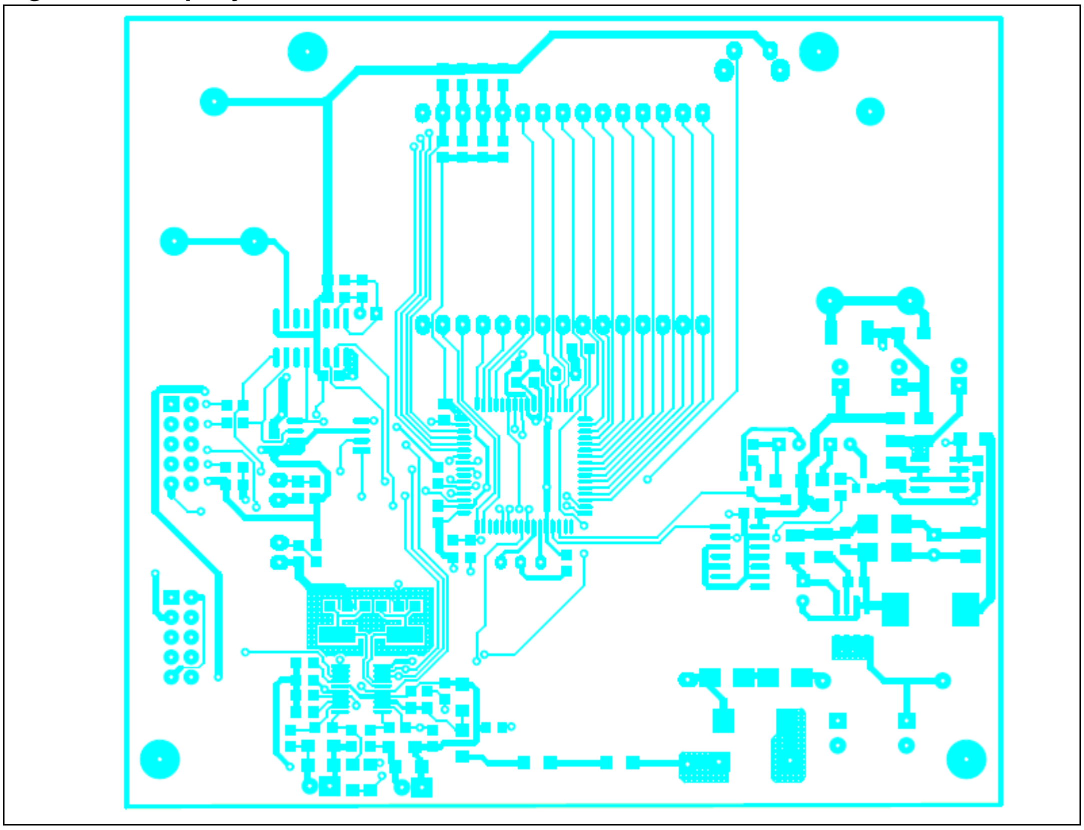


Figure 11. Bottom layer

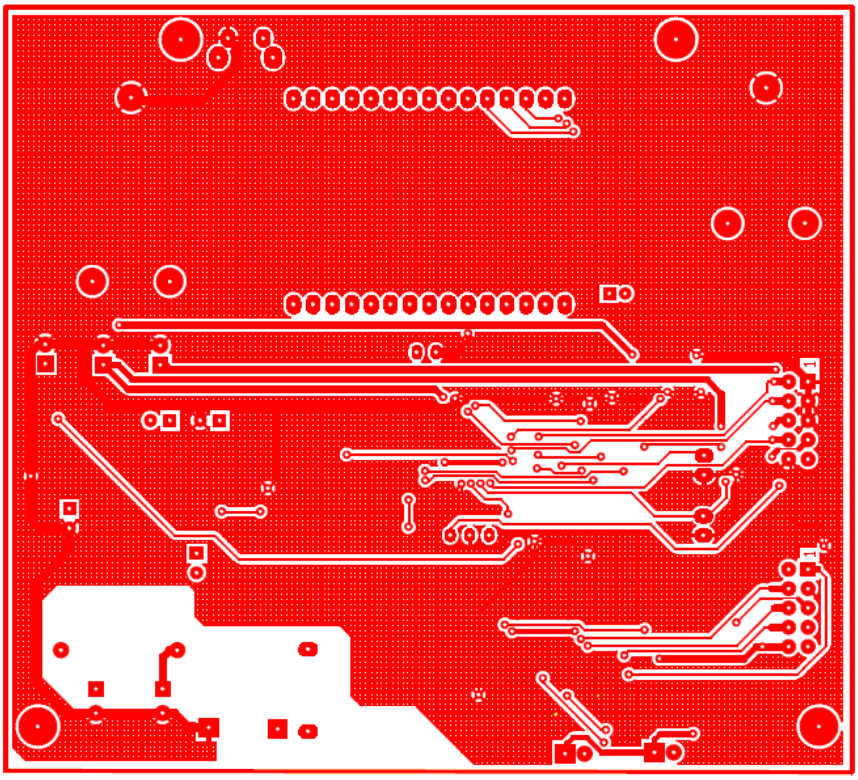
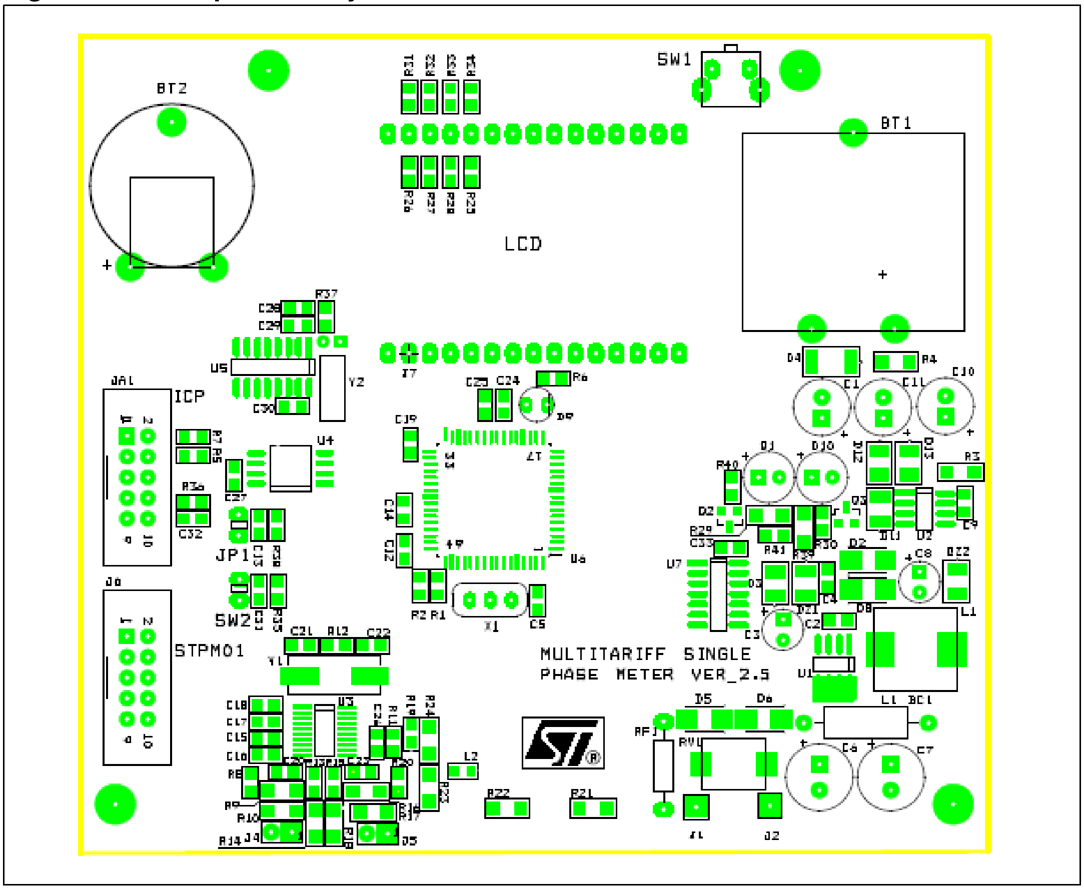


Figure 12. Components layer



7 Revision history

Table 13. Document revision history

Date	Revision	Changes
17-Apr-2007	1	Initial release.