**Introduction**

The purpose of this application note is to describe the use of the E-meter PLM demonstration board both in standalone and network mode. The E-meter demonstration board can be used as a guideline to design a typical energy-meter board for smart metering applications.

The document describes how to configure the board and how to interact with it; buttons, LEDs, configuration jumpers, and all hardware components used are described in detail, as well as the meaning of LCD data. A full description of the power line communication and its configuration and commands is provided too.

The E-meter demonstration board is based on the STM32F103VE microcontroller, ST7580 PLM module, and the STPMC1 poly-phase energy metering IC. It implements a PLM smart-meter node which allows the final utility to monitor energy consumption and other electrical parameters on one or more phases.

The voltage, current, power, power factor, THD, active and reactive energy, and other stored info can be shown on an LCD locally, or sent to a PLM data concentrator through a power line communication network.

- **Section 1** describes document and library rules
- **Section 2** describes the smart E-meter hardware demonstration board, its modes, uses and limitations
- **Section 3** highlights how to use the E-meter board in a PLC network and describes the PLM frames to be used in order to manage the board from another PLM node
- **Section 4** shows board schematics and the BOM list. Refer to UM0997 for more hardware details.
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1 Document and library rules

This document uses the conventions described in the sections below.

1.1 Acronyms

Table 1 lists the acronyms used in this document.

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>APP</td>
<td>Application</td>
</tr>
<tr>
<td>API</td>
<td>Application programming interface</td>
</tr>
<tr>
<td>HAL</td>
<td>Hardware abstraction layer</td>
</tr>
<tr>
<td>RTOS</td>
<td>Real-time operating system</td>
</tr>
<tr>
<td>PLM</td>
<td>Power line modem</td>
</tr>
<tr>
<td>PLC</td>
<td>Power line communication</td>
</tr>
<tr>
<td>MCU</td>
<td>Microcontroller unit</td>
</tr>
<tr>
<td>SPI</td>
<td>Serial peripheral interface</td>
</tr>
<tr>
<td>OOP</td>
<td>Object oriented programming</td>
</tr>
</tbody>
</table>
2 E-meter PLM demonstration board

2.1 Board introduction

The application described in this document refers to the STEVAL-IPP001V2 demonstration board (see related UM0997 user manual).

The E-meter demonstration board can be used as a guideline to design a typical energy-meter board for smart metering applications. It was designed to include advanced features as well as to fit the requirements for next generation energy-meters. These extra features can be added to the board by modules for easy customizing. The board includes the following functions shown in the block diagram of Figure 2:

- Energy measurement by external metrology board
- Power line communication up to 28.8 kbps
- LCD display to show energy consumption information
- USB and RS232/IrDA connectivity
- Optional ZigBee® communication capability
- Optional MEMS module support
- Expansion capability for smartcard interface.
Warning: The board must be used only by expert technicians. Due to the high voltage (220 Vac) special care should be taken with regard to user safety. There is no protection against accidental human contact with a high voltage. After disconnection of the board from the mains, none of the live parts should be touched immediately because of the energized capacitors. It is mandatory to use a mains insulation transformer to perform any debugging/tests on the board in which debugging and test instruments such as USB-JTAG dongles, spectrum analyzers, or oscilloscopes are used. Do not connect any oscilloscope probes to high voltage sections in order to avoid damaging instruments and demonstration tools. ST assumes no responsibility for any consequences which may result from the improper use of this tool.

2.2 Main hardware components

The E-meter demonstration board main hardware components are:
- An STM32F103VE microcontroller running the application firmware
- An external STPMC1 multiphase energy metering IC; the external STEVAL-IPE010V1 demonstration board based on STPMC1 has been used in this firmware release
- An MB542B-01 320x240 color TFT LCD module; used to show data locally
- An ST7580 power line modem; used to provide PLC connectivity to the system
- 3 status LEDs; 1 green, 1 yellow, 1 red LED for application status scope
- 5 configuration jumpers (SW19, 20, 21, 22, and 23); used for software configuration scope
- 1 user button (S1) and 1 joystick (U8); used for user application scope
- 1 microcontroller reset button (SW4); used to force an MCU reset
- 1 modem reset button (SW1); used to force an ST7580 reset.

A general description of the E-meter PLM demonstration board is provided in Figure 3:

**Figure 3.** STEVAL-IPP001V2 hardware description

1. TFT LCD color display 320x240
2. General purpose application red, green, yellow LEDs
3. General purpose application joystick; switch meter user data
4. General purpose user application button; switch the phase view on LCD from 3, R, S, T
5. Energy-meter configuration jumper (SW10) to use SPI-MISO or SPI-MOSI for data line LCD configuration jumpers (SW16, SW17, SW18) to control LCD via SPI or GPIO
6. RS232 USART connector
7. USB connector
8. General purpose application configuration jumpers (SW19, SW20, SW21, SW22, SW23)
9. Energy-meter external board connector (e.g. IPE010V1)
10. STM32 JTAG 20-pin connector
11. STM32 boot configuration jumpers (SW7, SW9)
12. Enable/disable DL2 LED
13. Enable/disable DL1 LED
14. STM32F103VE 32-bit high density microcontroller
15. Battery enabled/disabled configuration jumper (SW12)
16. Battery for STM32 VBAT supply
17. 85 V - 256 V board power supply. Suggested 110 V - 220 Vac
18. ST7580 JTAG 10-pin connector
19. ST7580 power line modem IC
20. RTC calibration/normal mode configuration jumpers
21. STM32 microcontroller reset button
22. ST7580 PLM IC UART connection connector
23. ST7580 PLM IC reset button.

2.3 Power-on and board use

Before turning on the board for the first time, make sure the following configuration jumpers are fitted or unfitted according to the following default table:

<table>
<thead>
<tr>
<th>Jumper</th>
<th>Description</th>
<th>Default</th>
</tr>
</thead>
<tbody>
<tr>
<td>JP6</td>
<td>DL1 enable</td>
<td>Fitted</td>
</tr>
<tr>
<td></td>
<td>– Fitted: DL1 enabled</td>
<td></td>
</tr>
<tr>
<td></td>
<td>– Not fitted: DL1 disabled</td>
<td></td>
</tr>
<tr>
<td>JP7</td>
<td>DL2 enable</td>
<td>Fitted</td>
</tr>
<tr>
<td></td>
<td>– Fitted: DL2 enabled</td>
<td></td>
</tr>
<tr>
<td></td>
<td>– Not fitted: DL2 disabled</td>
<td></td>
</tr>
<tr>
<td>JP8</td>
<td>To connect mains ground to board ground</td>
<td>Not fitted</td>
</tr>
<tr>
<td></td>
<td>– Fitted: grounds connected</td>
<td></td>
</tr>
<tr>
<td></td>
<td>– Not fitted: grounds not connected</td>
<td></td>
</tr>
<tr>
<td>SW3, SW5, SW6</td>
<td>EEPROM address setting</td>
<td>Fitted (2-3)</td>
</tr>
<tr>
<td></td>
<td>– Fitted (1-2): address bit 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>– Fitted (2-3): address bit 0</td>
<td></td>
</tr>
<tr>
<td>SW7, SW9</td>
<td>Boot option</td>
<td>Fitted (1-2)</td>
</tr>
<tr>
<td></td>
<td>– Fitted (1-2): boot option bit 0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>– Fitted (2-3): boot option bit 1</td>
<td></td>
</tr>
<tr>
<td>SW12</td>
<td>STM32 VBAT option</td>
<td>Fitted (1-2)</td>
</tr>
<tr>
<td></td>
<td>– Fitted (1-2): VBAT from power supply</td>
<td></td>
</tr>
<tr>
<td></td>
<td>– Fitted (2-3): VBAT from battery θ</td>
<td></td>
</tr>
<tr>
<td>SW13, SW14, SW15</td>
<td>RTC calibration mode</td>
<td>Fitted (1-2)</td>
</tr>
<tr>
<td></td>
<td>– Fitted (1-2): normal mode</td>
<td></td>
</tr>
<tr>
<td></td>
<td>– Fitted (2-3): RTC calibration mode</td>
<td></td>
</tr>
</tbody>
</table>
Once configuration is set according to the above description, connect and cable the STEVAL-IPE010V1 poly-phase energy-meter demonstration board before powering on the smart E-meter board.

### 2.3.1 STEVAL-IPE010V1 energy-meter board use

The STEVAL-IPE010V1 must be calibrated. It means that STPMC1 OTP calibration registers have been calibrated in order to read coherent voltage, current, and energy data through the STPMS1 daughter boards connected to the board for each monitored phase. Figure 4 shows the cabling-schema for the STEVAL-IPP001V2 plus STEVAL-IPE010V1 3-phase system.

It is also possible to cable the full system in mono-phase schema, using one daughter sensor board only (on top of STEVAL-IPE010V1) and configuring STPMC1 in order to work in mono-phase mode (see the STPMC1 datasheet).
2.3.2 E-meter application running

Once the 3-phase system is put in place, according to the previous description, the system is powered on, the smart E-meter application shows the following view on the LCD:

1. Phase identification (3, R, S, T)
2. Energy counter in watts. Red digit represents tenths of a watt
3. Phase current in ampere
4. Phase reactive energy in kVar
5. Power factor or “no load” if no load condition is detected
6. Meter user data; use joystick to move shown data
7. Phase THD parameter in percentage
8. Phase wide active power in kWatt

If the application is running without any problems a green LED (LED1) is blinking. During counter moving, the red LED (LED0) blinks every time the red number (tenths of a watt) moves to the next step.

To move from a phase view to the next phase view, it’s necessary to press user button S1. Joystick U8 allows to scroll through user data.

2.3.3 E-utility application running

An E-utility application managing up to two smart E-meters has been implemented to test the smart-meter power line communication. The board used to run the E-utility application is the same STEVAL-IPP001V2 and after powering on the board, the E-utility application shows the following view (Figure 6) on the LCD:

Figure 6. STEVAL-IHP001V2 E-utility application view

1. Tablet used to switch the managed E-meter (up to two E-meters can be managed using the joystick)
2. E-meter identification code (also reported on the E-meter LCD view)
3. The selected month which asks the E-meter for data. Use the joystick button to change the month used in the request and use button S1 to send the request via PLM
4. Average power stored for last quarter
5. Average power stored for last year
6. Date and time
7. Maximum demand power for the selected month
8. Average power stored for last six months
9. Total energy consumption of the selected E-meter.

Joystick left/right keys are used to move from the first to the second managed meter; joystick key press is used to change the selected month; user button S1 is used to send a request to the selected E-meter.

2.4 Board and application limitations

The smart E-meter is for evaluation purposes only. The board and running applications have the following limitations:

- Smart E-meter application counter supposes to count active positive energy only. Even if STPMC1 is able to count negative energy, the application doesn't support this kind of energy in this release.
- High voltage disturbance. Sometimes a high voltage disturbance, such as button line spike (and so a button action), is observed during turn on/off of the electric load connected to the smart E-Plug.
- A 7-byte static address has been assigned via firmware to the smart E-meter application, as below. If it is necessary to use more than one smart E-Meter demonstration board in a demonstrator system, this address must be changed manually in order to differentiate STEVA-IPP001V2 boards:

```c
#ifdef METER_1
    u8 DL_ADDRESS[7] = {0xAA, 0xBB, 0xCC, 0xDD, 0xEE, 0xFF, 0x0};
#else
    u8 DL_ADDRESS[7] = {0xAA, 0xBB, 0xCC, 0xDD, 0xEE, 0xF0, 0x0};
#endif.
```

In a future release a limited set of MAC addresses could be managed using the board configuration jumpers.
3  PLM network and frames

This section describes how to use the meter board inside a network with a master/slave architecture. The network includes several meters (slaves) and one data concentrator (master). Each meter maintains a database with the energy consumption data statistics which are stored in an external EEPROM. The master can read the statistics data of each meter, requesting them through commands transferred using the PLM communication.

3.1  PLM Network parameters

During startup each node configures the physical layer of the ST7580 with the following parameters:

Table 3.  PHY layer configuration

<table>
<thead>
<tr>
<th>General settings 1</th>
<th>0x11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency pair</td>
<td>72-86 kHz</td>
</tr>
<tr>
<td>TX channel</td>
<td>High channel</td>
</tr>
<tr>
<td>Rx channel</td>
<td>Only high channel</td>
</tr>
<tr>
<td>Zero-crossing synchronization</td>
<td>Asynchronous</td>
</tr>
<tr>
<td>Current control</td>
<td>Enabled</td>
</tr>
<tr>
<td>General settings 2</td>
<td>0x15</td>
</tr>
<tr>
<td>TX modulation</td>
<td>BPSK</td>
</tr>
<tr>
<td>TX gain</td>
<td>21</td>
</tr>
<tr>
<td>General settings 3</td>
<td>0x0E</td>
</tr>
<tr>
<td>RX high channel modulation</td>
<td>Any PSK</td>
</tr>
<tr>
<td>RX low channel modulation</td>
<td>Any PSK</td>
</tr>
<tr>
<td>PSK preamble length</td>
<td>32 bits</td>
</tr>
<tr>
<td>FSK modulation settings</td>
<td>0x3A</td>
</tr>
<tr>
<td>Baud rate</td>
<td>2400 bps</td>
</tr>
<tr>
<td>Deviation</td>
<td>1</td>
</tr>
<tr>
<td>Preamble length</td>
<td>32 bits</td>
</tr>
<tr>
<td>Unique word length</td>
<td>16 bits</td>
</tr>
<tr>
<td>FSK modulation unique word LSB</td>
<td>0x9B</td>
</tr>
<tr>
<td>FSK modulation unique word MSB</td>
<td>0x58</td>
</tr>
</tbody>
</table>

The master address is configured as AA-BB-CC-DD-EE-00 in hexadecimal format. For a complete list of the possible modem settings refer to the ST7580 data brief.
3.2 Smart E-meter use inside a PLM network

A demo application layer for metering applications has been implemented on top of the PLM communication protocol. The layer implements a command/response protocol with three kinds of frames:

<table>
<thead>
<tr>
<th>Command name</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GET</td>
<td>0x00</td>
<td>Command to read database variable of the remote meter</td>
</tr>
<tr>
<td>SET</td>
<td>0x01</td>
<td>Command to write database variable of the remote meter</td>
</tr>
<tr>
<td>RSP</td>
<td>0x02</td>
<td>Response to a GET request</td>
</tr>
</tbody>
</table>

The database variables are identified by the classes described in Table 5. The same table shows how some classes have sub-classes and also the access permission.

<table>
<thead>
<tr>
<th>Class name</th>
<th>Class code</th>
<th>Sub-class name</th>
<th>Sub-class code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL_CONS</td>
<td>0x00</td>
<td>N/A</td>
<td>N/A</td>
<td>Total energy consumption variable (read only)</td>
</tr>
<tr>
<td>AV_MD</td>
<td>0x01</td>
<td>N/A</td>
<td>N/A</td>
<td>Average maximum demand variables (read only)</td>
</tr>
<tr>
<td>TARIFF_LIST</td>
<td>0x02</td>
<td>TARIFF_NUM</td>
<td>0x00</td>
<td>Number of tariff managed by the meter (read/write)</td>
</tr>
<tr>
<td>TARIFF</td>
<td></td>
<td>TARIFF</td>
<td>0x01</td>
<td>Tariff variable (read/write)</td>
</tr>
<tr>
<td>TAMPER_LIST</td>
<td>0x03</td>
<td>N/A</td>
<td>N/A</td>
<td>List of detected tamper by the meter (read only)</td>
</tr>
<tr>
<td>MD_DB</td>
<td>0x04</td>
<td>DAY</td>
<td>0x00</td>
<td>Daily based maximum demand variable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MONTH</td>
<td>0x01</td>
<td>Monthly based maximum demand variable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>QUARTER</td>
<td>0x02</td>
<td>Quarter based maximum demand variable</td>
</tr>
<tr>
<td>MD_CONFIG</td>
<td>0x05</td>
<td>N/A</td>
<td>N/A</td>
<td>Maximum demand storage configuration (read/write)</td>
</tr>
<tr>
<td>DEMO</td>
<td>0x06</td>
<td>N/A</td>
<td>N/A</td>
<td>Command class used in the demo application</td>
</tr>
</tbody>
</table>

Figure 7 summarizes the generic application layer frame format and also the format for each command.
The meter firmware is released with a monthly based configuration of the maximum demand and the master implements only the DEMO class command which allows the reading of the total consumption, the average maximum demand, and the maximum demand of the month specified by the month index. The data transferred have the following structures:

Table 6. Data structures

<table>
<thead>
<tr>
<th>Variable</th>
<th>Structure format</th>
</tr>
</thead>
</table>
| Tariff       | `typedef struct tariff {
                  float rate;
                  long long kwh;
                  u32 pulse_count;
                  DATE_T change_t;
                  u8 next;
              } TARIFF_T;` |
| Tamper info  | `typedef struct {
                  CONS_T cons;
                  DATE_T f_tamp_box_date;
                  DATE_T l_tamp_box_date;
                  DATE_T f_tamp_fraud_date;
                  DATE_T l_tamp_fraud_date;
                  DATE_T tamper_time;
                  DATE_T fail_time;
              } TAMPER_INFO_T;` |
Table 6. Data structures (continued)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Structure format</th>
</tr>
</thead>
</table>
| Maximum demand | ```
typedef struct {
   MONTH_MD_DB_T DayStore;
   MD_T MonthStore[12];
   MD_T QuarterStore[4];
}MD_DB_T;
``` |
| Total consumption | ```
typedef struct {
   long long kwh;
   u32 pulse_count;
} CONS_T;
``` |
| Average maximum demand | ```
typedef struct {
   u32 last3;
   u32 second_last3;
   u32 third_last3;
   u32 fourth_last3;
   u32 last6;
   u32 last9;
   u32 last12;
}AV_MD_T;
``` |
| Maximum demand storage configuration | ```
typedef struct {
   u32 period; //minutes
   MD_STORAGE_T storage;
   u32 sample_time; //mSec.
} MD_CONFIG_T;
``` |
### Table 7. BOM

<table>
<thead>
<tr>
<th>Reference</th>
<th>Part / value</th>
<th>Tolerance</th>
<th>Voltage current</th>
<th>Watt</th>
<th>Technology information</th>
<th>Package-footprint</th>
<th>Manufacturer</th>
<th>Manufacturer code</th>
<th>RS/Distrelec/other code</th>
<th>More info</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM3</td>
<td>IND-EPCOS-B82721K</td>
<td>Power line chokes 10 mH 0.7 A</td>
<td>Through hole</td>
<td>EPCOS</td>
<td>B82721K2701N020</td>
<td>Digi-Key: 495-2739-ND</td>
<td>Any</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CN1</td>
<td>PORT 0</td>
<td>R/A DB9 male connector (plug)</td>
<td>Through hole</td>
<td>Any</td>
<td>Distrelec: 124164</td>
<td></td>
<td>Any</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CN2</td>
<td>USB_TYPEB</td>
<td>USB socket</td>
<td>Through hole</td>
<td>Any</td>
<td>Distrelec: 124164</td>
<td></td>
<td>Any</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td>120 pF</td>
<td>5 %</td>
<td>50 V</td>
<td>Any</td>
<td>Distrelec: 124164</td>
<td></td>
<td>Any</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C3, C48</td>
<td>100 pF</td>
<td>5 %</td>
<td>50 V</td>
<td>Any</td>
<td>Distrelec: 124164</td>
<td></td>
<td>Any</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reference</td>
<td>Part / value</td>
<td>Tolerance %</td>
<td>Voltage / current</td>
<td>Watt</td>
<td>Technology information</td>
<td>Package-footprint</td>
<td>Manufacturer</td>
<td>Manufacturer code</td>
<td>RS/Distrelec/other code</td>
<td>More info</td>
</tr>
<tr>
<td>-----------</td>
<td>-----------------------</td>
<td>-------------</td>
<td>-------------------</td>
<td>------</td>
<td>------------------------</td>
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<td>--------------</td>
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

### Table 7. BOM (continued)

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<td>Through hole</td>
<td>Schurter</td>
<td>4300.0099</td>
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<td>J10</td>
<td>CON10</td>
<td></td>
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<td></td>
<td>Right-angled IDC boxed header, 10 way 2row</td>
<td>Through hole 2.54 mm pitch</td>
<td>Any</td>
<td></td>
<td>RS: 473-8349</td>
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<tr>
<td>J11, J20</td>
<td>Jumper</td>
<td></td>
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<td>2-way stripline connector</td>
<td>Through hole 2.54 mm pitch</td>
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<td>RS: 251-8086</td>
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<td>J12</td>
<td>LCD connector</td>
<td></td>
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<td>Mount 2 connectors: 8 way (2x4) double row stripline socket</td>
<td>Through hole 2.54 mm pitch</td>
<td>Any</td>
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<td>J15</td>
<td>JTAG</td>
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<td>Right-angled IDC boxed header, 20 way 2row</td>
<td>Through hole 2.54 mm pitch 90°</td>
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<td>J19</td>
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<td>L1</td>
<td>15 µH</td>
<td>10 %</td>
<td>2.5 A</td>
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<td>Power inductor</td>
<td>SMD 10x10mm body size</td>
<td>EPCOS</td>
<td>B82464A4 153K</td>
<td>Farnell: 7429649</td>
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<td>220 µH</td>
<td>10 %</td>
<td>240 mA</td>
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<td>20 %</td>
<td>2 A</td>
<td></td>
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<td>B82462G4 472M</td>
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<td>L4</td>
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<td>10 %</td>
<td>120 mA</td>
<td></td>
<td>Inductor</td>
<td>SMD 2220</td>
<td>EPCOS</td>
<td>B82442H1 105K</td>
<td>RS: 496-1347</td>
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<td>L5</td>
<td>BEAD</td>
<td>2A</td>
<td></td>
<td></td>
<td>High current (2 A) ferrite chip bead, impedance at 100 MHz: 600 ohm</td>
<td>SMD 0805</td>
<td>KEKITAGAWA</td>
<td>MLB-201209-0600PN</td>
<td>Distrelec: 330138</td>
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<td>NTC1, NTC2</td>
<td>16 Ω</td>
<td>20 %</td>
<td>2.9 A</td>
<td>2.1 W</td>
<td>NTC resistor</td>
<td>Trough hole disc 5 mm lead spacing</td>
<td>EPCOS</td>
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<td>Q2</td>
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<td>SMD SOT23-3L</td>
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<td>R1</td>
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<td>1 %</td>
<td>0.1 W</td>
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<td>SMD 0603</td>
<td>Any</td>
<td>Any</td>
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<td>R2, R3, R5, R6</td>
<td>10 kΩ</td>
<td>1 %</td>
<td>1 W</td>
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<td>Vishay</td>
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<td>R12</td>
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<td>R10, R15, R19, R20, R21, R23, R24, R25, R26, R27, R28, R29, R30, R31, R32, R33, R34, R35, R36, R37, R38, R39, R40, R41, R42, R43</td>
<td>4.7 kΩ</td>
<td>1 %</td>
<td>0.1 W</td>
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<td>R22, R61</td>
<td>1 kΩ</td>
<td>1 %</td>
<td>0.1 W</td>
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<td>Any</td>
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<td>R35, R37</td>
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<td>0.25 W</td>
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<td>SMD 1206</td>
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<td>5 %</td>
<td>0.25 W</td>
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<td>R41</td>
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<td>1 %</td>
<td>0.25 W</td>
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<td>1 %</td>
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<td>R43</td>
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<td>Tolerance %</td>
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<td>0.25 W</td>
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<td>5 %</td>
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<tr>
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<td>330 Ω</td>
<td>5 %</td>
<td>0.25 W</td>
<td>0.25 W</td>
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<td>10 kΩ</td>
<td>1 %</td>
<td>0.1 W</td>
<td>0.1 W</td>
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<td>1 %</td>
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<td>0.1 W</td>
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<td>1 %</td>
<td>0.1 W</td>
<td>0.1 W</td>
<td>Metal film resistor</td>
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<td>0.125 W</td>
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<td>SMD 0805</td>
<td>Any</td>
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<td>Any</td>
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<td>Reference</td>
<td>Part / value</td>
<td>Tolerance %</td>
<td>Voltage current</td>
<td>Watt</td>
<td>Technology information</td>
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<td>Manufacturer</td>
<td>Manufacturer code</td>
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<td>1 %</td>
<td></td>
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5 Schematics

Figure 8. Top
Figure 9. Metrology board connector

Figure 10. User interface
Figure 11. LCD connector section

LCD_CS
LCD_CLK
LCD_DI
LCD_RS
LCD_WR

LCD_DO
RESET#

LCD_COLOR DISPLAY CONNECTORS

VDD
GND
Figure 12. MCU schematic
Figure 13. RTC calibration, meter and LCD level
Figure 14. MEMS module connector

Figure 15. General purpose configuration jumpers
Figure 17. System JTAG connector, ST7580UART interface, and 8051 program flash memory.
Figure 18. Non-isolated zero-crossing, ST7580 reset button, current limit setting, and microcontroller connection

Non-Isolated Zero Crossing

Current Limit Setting

Microcontroller Connection
Figure 20. Power supply (part 2)
Figure 21. Power supply (part 3)

Figure 22. ZigBee module connector
Figure 23. USB connector
6 References

- STM32F103VE datasheet
- RM0008 reference manual
- STM32F10xFWLib 3.0.0 help file
- FreeRTOS official web-site www.freertos.org
- UM0997 user manual
- STPMC1 datasheet
- UM0746 user manual
- ST7580 data brief
7 Revision history

Table 8. Document revision history

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<th>Date</th>
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