# AN3970
# Application note

## PLM smartplug V2 getting started

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## Introduction

The purpose of this guide is to help the user fully use the PLM smartplug evaluation board in a network with other smartplug boards and a data concentrator.

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. A full description of the power line communication and its configuration and commands is also provided.

The PLM smartplug evaluation board is based on the STM32F103CB microcontroller, the ST7540 PLM module, and the STPM01 mono-phase energy metering IC. It implements a PLM smartplug node which allows to monitor the energy consumption of a mains plug and to control any kind of load in on/off mode by a relay. If the user wants to control a load supplied by the monitored mains plug, it is necessary to respect a specific cabling scheme described in *Section 2*. Moreover it is designed to fit a standard "503" wall box.

The voltage, current, power, active energy and the output status can be sent to a PLM data concentrator through a power line communication network on request. Moreover, if the power consumption changes, it is sent asynchronously to the data concentrator.

- *Section 1* describes document and library rules

- *Section 2* describes the smartplug hardware evaluation board, its modes, uses and limitations

- *Section 3* highlights how to use the smartplug board in a PLC network. Refer to the PLM smartplug FW UM1459 user manual for more firmware and communication protocol details

*Section 4* shows the board schematics and bill of material. Refer to the PLM smartplug HW UM1458 user manual 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* list the acronyms used in this document.

**Table 1. List of acronyms**

| Acronym | Meaning |
|---------|---------|
| APP | Application |
| API | Application programming interface |
| HAL | Hardware abstraction layer |
| RTOS | Real time operating system |
| PLM | Power line modem |
| PLC | Power line communication |
| MCU | Microcontroller unit |
| SPI | Serial peripheral interface |
| OOP | Object oriented programming |

# 2 PLM smartplug evaluation board

## 2.1 Board introduction

The application described in this document refers to the STEVAL-IHP002V2 evaluation board (see UM1458).

**Figure 1. STEVAL-IHP002V2 smartplugV2 evaluation board**
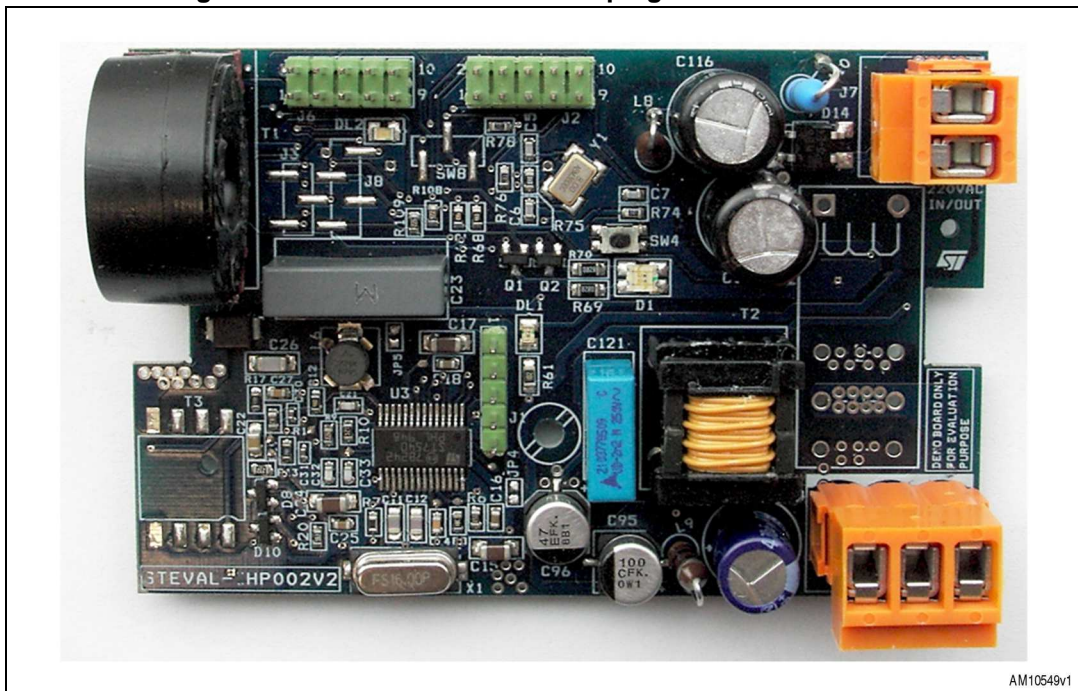


The board includes the following functions shown in the block diagram of *Figure 2*:

- Energy measurement by STPM01 IC
- Power line communication by ST7540 up to 4.8 kbps
- UART connectivity or expansion connector
- Output with two contacts (NO/NC) and common contact for generic load.

**Figure 2. STEVAL-IHP002V2 PLM smartplugV2 evaluation board block diagram**



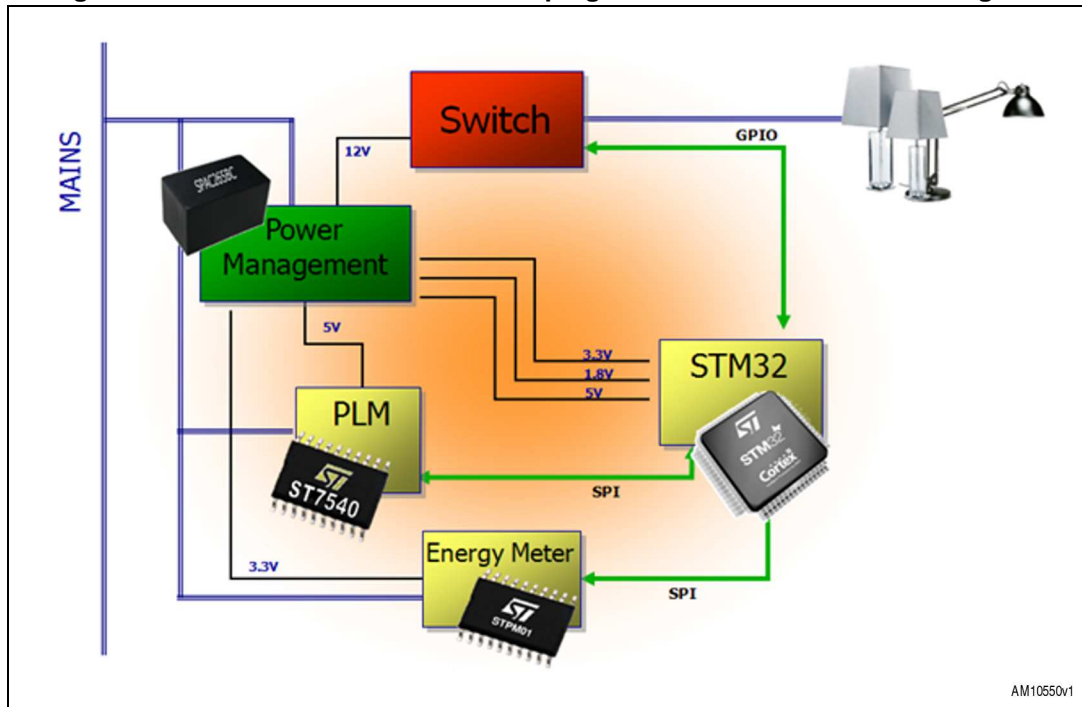**Warning:** The board must be used only by expert technicians. Due to the high voltage (220 Vac) special care should be taken with regard to human safety. There is no protection against accidental human contact with high voltages. After disconnection of the board from the mains, none of the live parts 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 like 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 evaluation tools. STMicroelectronics assumes no responsibility for any consequences which may result from the improper use of this tool.

## 2.2 Main hardware components

The following is a list of the PLM smartplug evaluation board main hardware components:

- An STM32F103CB microcontroller running the application firmware
- An STPM01 mono-phase energy metering IC
- An ST7540 power line modem: used to provide PLC connectivity to the system
- 1 bi-color status LED: green/red LED for application status scope
- 1 configuration jumper (SW8): used to inform the MCU that the STPM01 calibration tool is connected
- 1 microcontroller reset button (SW4): used to force an MCU reset
- 1 USART expansion connector for configuration (J3)
- 1 I²C expansion connector for dual-interface EEPROM connection (J8).

Detailed information about the PLM smartplug evaluation board hardware can be found in the UM1458 user manual.

## 2.3 Power-on and board usage

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

**Table 2. Jumper default position**

| Jumper | Description | Default |
|--------|-------------|---------|
| SW8 | – Fitted (1-2): calibration mode<br>– Fitted (2-3): normal mode | Fitted (2-3) |

### 2.3.1 PLM smartplug application configuration

The STPM01 is configured to work using the internal shadow latch which is loaded with parameters stored in the internal flash of the MCU; however the STPM01 can be calibrated by putting jumper SW8 in calibration mode and using the on-board calibration connector before powering up the board. For details please refer to the UM1458 user manual.

The first time the board is powered up, information regarding the addresses used for the communication protocol and the network functions, which are stored in the MCU embedded Flash, are blank; therefore, after the first boot this information must be initialized using a PC software application running on a PC connected to the board by the RS232 port adaptor connected to the expansion connectors J3 and J1; for details about this configuration procedure please refer to the AN3046 application note. For the PLM smartplug board the procedure described in AN3046 must be used only for configuration purposes.

## 2.3.2 PLM smartplug application running

After configuration, the board can be used in a network; the address configuration of each board must be consistent with the chosen network topology: *Figure 3* shows an example of a network and the related network addresses and node function configuration.

**Figure 3. Network example**
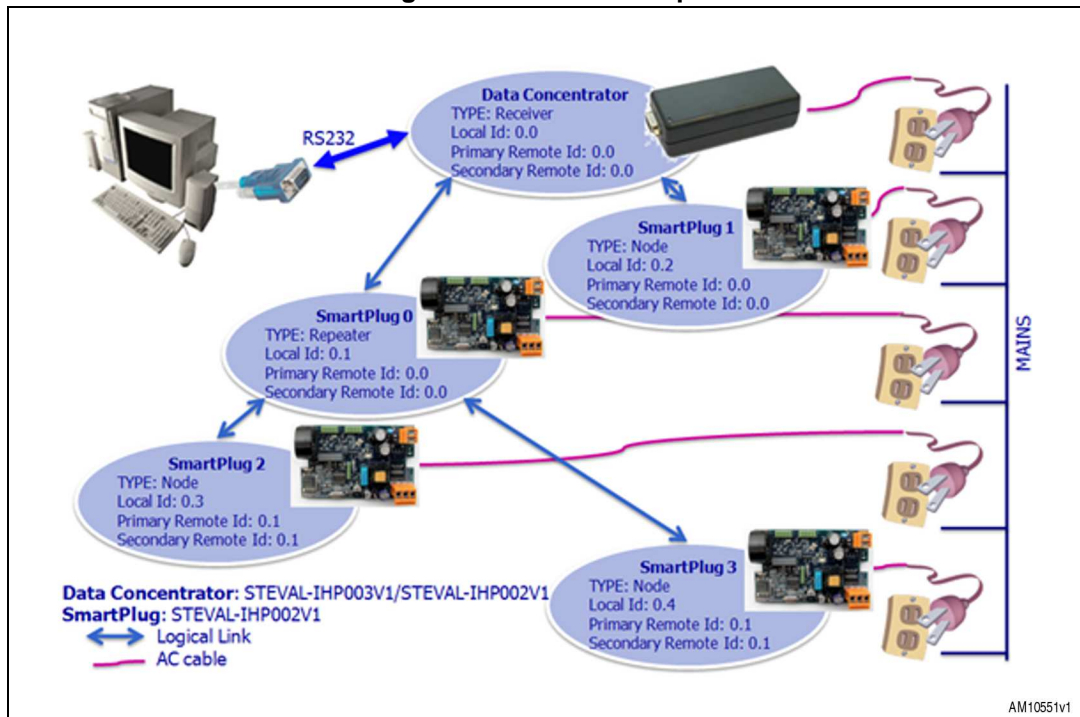


The data concentrator firmware is also provided in order to build a complete network solution; it can be loaded into one of the available smartplug boards (STEVAL-IHP002V2) or it is possible to order STEVAL-IHP003V1 separately, which has a better form factor for PC connection, and program it with the data concentrator firmware.

The data concentrator accepts commands, provides the command responses, and also the asynchronous messages from smartplugs and some debug information through the RS232 connection; a basic I/O text terminal has been implemented through this connection in order to provide the commands and print responses by text using a terminal PC software such as "HyperTerminal"; the local echo of the terminal software must be enabled in order to have a visual text feedback. Each text command must be completed by the <enter> key and is "case" sensitive. The following commands are implemented:

**Table 3. Terminal commands**

| Commands | Description |
|---|---|
| "get" | Used to request information to a remote smartplug. After the command the modem answers with the string "COMMAND->GET" to confirm the command acquisition and waits for one of the command classes which identify the data to request. The command classes are described in *Table 4*. |
| "set" | Used to write information to a remote smartplug. After the command the modem answers with the string "COMMAND->SET" to confirm the command acquisition and waits for one of the command classes which identify the data to write. The command classes are described in *Table 4*. |
| "identify" | Used to identify a specific smartplug inside the network. After the command the modem answers with the string "COMMAND->IDENTIFY" to confirm the command acquisition and wait for the string "single" followed by the <enter> key to complete the command. The command completion is confirmed by the string "CLS-> single"; after the command the modem waits for the node ID to identify printing the string "<NODE_ID>". The smartplug identified by the inserted node ID flashes its LEDs. |
| "list" | Used to list the smartplug in the network already connected to the data concentrator. After the command the modem answers with the string "COMMAND->LIST NODES" and with the list of the smartplug ID and address |
| "route" | Used to print the routing table. After the command the modem answers with the string "COMMAND->ROUTE" and with the routing table |

For the commands "get" and "set" it is possible to specify the class variable to write/read; *Table 4* describes these variables. The text terminal interface is also used to show debug information: each received frame is printed in hexadecimal format and the payload information is printed too, as shown in the following examples for the frame transferring all measurement information and for the one transferring the status information:

```
Frame Rx ->
00 00 03 00 00 02 01 BC 82 03 00 00 00 00 00 00 00 00 00 00 00 00 00 00
01 BC 82 03 00 00 00 00 00 00 00 00 00 00 00 00 00
RSP Voltage -> 230076   Current -> 0    Power -> 0     Energy -> 0


Frame Rx ->
00 00 03 00 01 02 02 01 FF FF
02 01 FF FF
RSP Type -> 1   Main Val -> 255 Aux Val -> 255
```

In addition to the debug information, the information extracted by the application layer is printed, as shown in the following example:

Smartplug-id: voltage; current; power;

Where

- id: smartplug ID (0..255)
- voltage: mains voltage in mVolt
- current: load current in mAmpere
- power: load power consumption in Watt.

After setting a new status of the mains output the smartplug sends back a frame with the new status and the data concentrator prints out the following text message:

Status-id: status;

Where

- id: smartplug ID (0..255)
- status: smartplug output status (0..255).

These strings can easily interpreted by a PC application for a better presentation.

**Table 4. Classes variables description**

| Class | Description |
|-------|-------------|
| "cons" | Information variable that stores the power consumption. It is a read-only variable. |
| "all" | Information variable that stores all measurements:<br>– Voltage [mVolt]<br>– Current [mA]<br>– Power [mW]<br>– Energy [Wh]<br>It is a read-only variable. |
| "status" | Information variable that stores the status the output relay. It is a read/write variable. |

## 2.4 Board and application limitations

The smartplug is for evaluation purposes only so there are some limitations:

- At startup there is a delay before the smartplugs start to send data to the concentrator
- The STPM01 calibration hasn't been done to obtain the accuracy necessary for fiscal metrology
- The relay has been tested with a maximum load equal to 1.8 kW.

# 3 PLM network and frames

Details regarding the network information and frames can be found in the PLM smartplug FW UM1459 user manual and in the AN3046 application note.

## 3.1 PLM network parameters

During startup, each node configures the ST7540 with the following parameters:

**Table 5. ST7540 configuration**

| Configuration parameter | Parameter value |
|---|---|
| Carrier frequency | 132.5 kHz |
| Baud rate | 2400 bps |
| Deviation | 0.5 |
| Watchdog | Disabled |
| Transmission timeout | Disabled |
| Frequency detection time | 300 msec. |
| Detection method | Preamble detection with conditioning |
| Mains interfacing mode | Synchronous |
| Output clock | Off |
| Output voltage level freeze | Disabled |
| Header recognition | Enabled |
| Frame length count | Disabled |
| Header length | 16 bits |
| Extended register | Enabled |
| Sensitivity mode | Sensitivity high |
| Input filter | Enabled |
| Frame header | 0xE389 |
| Frame length | 1 |
| Configuration bytes values | 0x1 0x89 0xE3 0xF7 0x94 0x17 |

# 4 Bill of material and schematics

**Table 6. BOM (part 1)**

| Reference | Part / value | Tolerance% | Voltage current | Watt | Technology information | Package-foot-print |
|---|---|---|---|---|---|---|
| C5, C6 | 22 pF | +/-10% | 50 V | | Ceramic capacitor X7R | SMD 0603 |
| C122 | 470 nF | +/-10% | 50 V | | Ceramic capacitor X7R | SMD 0805 |
| C7 | 22 pF | +/-10% | 50 V | | Ceramic capacitor X7R | SMD 0603 |
| C11, C12 | 33 pF | +/-10% | 50 V | | Ceramic capacitor X7R | SMD 0805 |
| C14, C27, C103, C114, C115 | 10 nF | ±10% | 50 V | | Ceramic capacitorX7R | SMD 0603 |
| C15, C17, C24 | 10 µF | ±10% | 16 V | | Ceramic capacitorX7R | SMD 1206 |
| C16, C18, C25, C109, C110, C111, C112, C113, C97, C98, C99, C100, C104 | 100 nF | ±10% | 50 V | | Ceramic capacitorX7R | SMD 0603 |
| C21,C33 | 100 pF | ±5% | 50 V | | Ceramic capacitor COG | SMD 0603 |
| C22 | 10 µF | ±10% | 10 V | | Ceramic capacitor X5R | SMD 0805 |
| C23 | 68 nF | ±20% | 300 V | | X2 capacitor | Through hole |
| C26 | 6.8 nF | ±5% | 50 V | | Ceramic capacitor COG | SMD 1206 |
| C30 | 15 pF | ±5% | 50 V | | Ceramic capacitor COG | SMD 0402 |
| C31 | 22 pF | ±5% | 50 V | | Ceramic capacitor COG | SMD 0402 |
| C32 | 270 pF | ±5% | 50 V | | Ceramic capacitor COG | SMD 0603 |
| C95 | 100 µF | +/-20% | 16 V | | Electrolytic capacitor | SMD |
| C96 | 47 µF | +/-20% | 25 V | | Electrolytic capacitor | SMD |
| C101 | 10 µF | 10% | 10 V | | Tantalium capacitor | SMD |
| C123 | 10 nF | +/-10% | 50 V | | Ceramic capacitor X7R | SMD 0805 |

**Table 6. BOM (part 1) (continued)**

| Reference | Part / value | Tolerance% | Voltage current | Watt | Technology information | Package-foot-print |
|---|---|---|---|---|---|---|
| C124 | 1 nF | +/-10% | 50 V | | Ceramic capacitor X7R | SMD 0805 |
| C108 | 1 nF | +/-10% | 50 V | | Ceramic capacitor X7R | SMD 0603 |
| C116, C117 | 4.7 µF | +/-20% | 400 V | | Electrolytic capacitor | Through hole |
| C118 | 470 pF | +/-10% | 400 V | | Ceramic capacitor X7R | SMD 1206 |
| C119 | 470 µF | +/-20% | 16 V | | Electrolytic capacitor low ESR | Through hole |
| C120 | 2.2 µF | +/-10% | 35 V | | Tantalium capacitor | SMD |
| C121 | 2.2 nF | +/-20% | 250 V | | Y2 ceramic capacitor | Through hole |
| DL1 | Red | | | | Chip LED | SMD 0805 |
| DL2 | Blue | | | | Chip LED | SMD 0805 |
| D1 | Bi-color LED red/green | | | | LED bi-red, green | SMD |
| D6, D13, D17 | LL4148 | | | | Switching diode_ | SOD-80 |
| D8, D10 | BAT54S | | | | Small signal Schottky diodes | SOT-23 |
| D9 | SM6T15CA | | | | Transil | SMB |
| D14 | MB6S-RC | | | | Diode bridge | SOIC4 |
| D15 | STPS1H100A | | | | High voltage power Schottky rectifier | SMA |
| D16 | STTH1L06A | | | | Turbo 2 ultrafast high voltage rectifier | SMA |
| F1 | 1 A | | | | Fuse with clip    1 A | SMD |
| IC3 | LD1117ADT33TR | | | | Low drop fixed and adjustable positive voltage regulators | DPAK |
| JP4, JP5 | Close | | | | Do not fit | Do not fit |
| J1 | Peak meter connector | | | | 5-way single row stripline connector (male connector) 2,54 mm pitch | Vertical through hole |
| J2 | JTAG | | | | 2x10-way double row stripline connector (male connector) 2,54 mm pitch | Vertical through hole |
| J3 | USART | | | | 3-way single row stripline connector (male connector) 2,54 mm pitch | SMD |

**Table 6. BOM (part 1) (continued)**

| Reference | Part / value | Tolerance% | Voltage current | Watt | Technology information | Package-foot-print |
|---|---|---|---|---|---|---|
| J4 | CON3 | | | | 3-way vertical closed header, 5.08 mm pitch | Through hole |
| J6 | CAL CON | | | | 2x10-way double row stripline connector (male connector) 2,54mm pitch | Vertical through hole |
| J7 | CON2 | | | | 2-way vertical closed header, 5.08 mm pitch | Through hole |
| J8 | RFID reader | | | | 4-way single row stripline connector (male connector) 2,54 mm pitch | SMD |
| L5 | 22 µH | ±10% | 2.1 A | | SMD inductor | SMD |
| L6 | 220 µH | ±10% | 240 mA | | SMD inductor | SMD |
| L8 | 470 µH | +/-5% | 170 mA | | Inductor | Through hole |
| L9 | 10 µH | +/-10% | 500 mA | | Inductor | Through hole |
| Q1, Q2 | BC857B | | | | PNP transistor | SOT23 |
| Q5 | 2STR1215 | | | | Low voltage fast-switching NPN power transistor | SOT-23 |
| R6 | 1.1 kΩ | +/-1% | | 0.1 W | Resistor | SMD 0603 |
| R7 | 47 kΩ | +/-1% | | 0.1 W | Resistor | SMD 0603 |
| R8 | 15 kΩ | +/-1% | | 0.1 W | Resistor | SMD 0603 |
| R9, R88, R71, R72, R73, R108, R109 | 4.7 kΩ | +/-1% | | 0.1 W | Resistor | SMD 0603 |
| R10 | 13 kΩ | +/-1% | | 0.1 W | Resistor | SMD 0603 |
| R12, R62, R68, R90, R93 | 1 kΩ | +/-1% | | 0.1 W | Resistor | SMD 0603 |
| R13 | 2.7 kΩ | +/-1% | | 0.1 W | Resistor | SMD 0603 |
| R14 | 1.8 kΩ | +/-1% | | 0.1 W | Resistor | SMD 0603 |
| R17 | 470 Ω | +/-1% | | 0.1 W | Resistor | SMD 0603 |
| R19, R85, R86, R87 | 2.4 kΩ | +/-1% | | 0.1 W | Resistor | SMD 0603 |
| R20 | 56 kΩ | +/-1% | | 0.1 W | Resistor | SMD 0603 |
| R21, R22, R96, R97, R101, R102 | 261 kΩ | +/-1% | | 1/8 W | Mini melf resistor | SMD 0805 |
| R61, R106 | 1 kΩ | +/-5% | | 1/8 W | Resistor | SMD 0805 |

**Table 6. BOM (part 1) (continued)**

| Reference | Part / value | Tolerance% | Voltage current | Watt | Technology information | Package-foot-print |
|---|---|---|---|---|---|---|
| R74, R76, R77, R78, R79 | 10 kΩ | +/-5% | | 0.1 W | Resistor | SMD 0603 |
| R112, R118 | 10 kΩ | +/-5% | | 1/8 W | Resistor | SMD 0805 |
| R69, R70 | 82 Ω | +/-5% | | 1/8 W | Resistor | SMD 0805 |
| R75 | 1 MΩ | +/-5% | | 0.1 W | Resistor | SMD 0603 |
| R89 | 560 Ω | +/-1% | | 0.1 W | Resistor | SMD 0603 |
| R91, R92 | 6.8 Ω | +/-1% | | 0.1 W | Resistor | SMD 0603 |
| R94 | 2 MΩ | +/-1% | | 1/4 W | Resistor | SMD 1206 |
| R95 | 0 | +/-1% | | 0.1 W | Resistor | SMD 0603 |
| R98, R103 | 475 Ω | +/-1% | | 1/8 W | Mini melf resistor | SMD 0805 |
| R99 | 43 kΩ | +/-1% | | 0.1 W | Resistor | SMD 0603 |
| R100 | 100 Ω | +/-1% | | 0.1 W | Resistor | SMD 0603 |
| R105 | 1 kΩ (do not fit) | +/-1% | | 1/4 W | Resistor | SMD 1206 |
| R110 | 22 Ω | +/-5% | | 1 W | Fuse resistor | Through hole |
| R111 | 120 kΩ | +/-5% | | 1/4 W | Resistor | SMD 1206 |
| R113 | 10 Ω | +/-5% | | 1/8 W | Resistor | SMD 0805 |
| R114 | 27 kΩ | +/-1% | | 1/8 W | Resistor | SMD 0805 |
| R115 | 4.7 kΩ | +/-1% | | 1/8 W | Resistor | SMD 0805 |
| R116 | 2.2 Ω | +/-1% | | 1/8 W | Resistor | SMD 0805 |
| R117 | 22 Ω | +/-1% | | 1/8 W | Resistor | SMD 0805 |
| RV1 | VAR275V | | 275 V | | SMD varistor | SMD |
| SW4 | Rst | | | | Surface mount tactile switch | SMD |
| SW8 | Calibration settings | | | | 3-way single row stripline connector (male connector) 2,54 mm pitch | SMD |
| TP8, TP9, TP10, TP11, TP12, TP13, TP14, TP15, TP16, TP17, TP18, TP19, TP20, TP21, TP22, TP23, TP25, TP26, TP27 | Test point | | | | Test point | Test point |
| T1 | Current transformer | | | | Current transformer | Through hole |

**Table 6. BOM (part 1) (continued)**

| Reference | Part / value | Tolerance% | Voltage current | Watt | Technology information | Package-foot-print |
|---|---|---|---|---|---|---|
| T2 | Custom transformer | | | | Custom transformer | Through hole |
| T3 | Line transformer | | | | Line transformer | SMD |
| U3 | ST7540 | | | | FSK power line transceiver | HTSSOP28 |
| U11 | STM32F103CBT6 | | | | Medium-density performance line ARM-based 32-bit MCU | LQFP48 |
| U12 | STPM01 | | | | Programmable single-phase energy metering IC with tamper detection | TSSOP20 |
| U13 | ALTAIR05T-800 | | | | | |
| X1 | 16 MHz | | | | 16 MHz crystal | SMD |
| Y1 | 8 MHz | | | | 8 MHz crystal | SMD |
| k2 | 16 A 12 Vdc coil (do not fit) | | 12 V/ 16 A | | Low profile SPDT power relay | Through hole |
| C5, C6 | 22 pF | +/-10% | 50 V | | Ceramic capacitor X7R | SMD 0603 |
| C122 | 470 nF | +/-10% | 50 V | | Ceramic capacitor X7R | SMD 0805 |
| C7 | 22 pF | +/-10% | 50 V | | Ceramic capacitor X7R | SMD 0603 |
| C11, C12 | 33 pF | +/-10% | 50 V | | Ceramic capacitor X7R | SMD 0805 |
| C14, C27, C103, C114, C115 | 10 nF | ±10% | 50 V | | Ceramic capacitorX7R | SMD 0603 |
| C15, C17, C24 | 10 uF | ±10% | 16 V | | Ceramic capacitorX7R | SMD 1206 |
| C16, C18, C25, C109, C110, C111, C112, C113, C97, C98, C99, C100, C104 | 100 nF | ±10% | 50 V | | Ceramic capacitorX7R | SMD 0603 |
| C21,C33 | 100 pF | ±5% | 50 V | | Ceramic capacitor COG | SMD 0603 |
| C22 | 10 µF | ±10% | 10 V | | Ceramic capacitor X5R | SMD 0805 |
| C23 | 68 nF | ±20% | 300 V | | X2 capacitor | Through hole |

**Table 6. BOM (part 1) (continued)**

| Reference | Part / value | Tolerance% | Voltage current | Watt | Technology information | Package-foot-print |
|---|---|---|---|---|---|---|
| C26 | 6.8 nF | ±5% | 50 V | | Ceramic capacitor COG | SMD 1206 |
| C30 | 15 pF | ±5% | 50 V | | Ceramic capacitor COG | SMD 0402 |
| C31 | 22 pF | ±5% | 50 V | | Ceramic capacitor COG | SMD 0402 |
| C32 | 270 pF | ±5% | 50 V | | Ceramic capacitor COG | SMD 0603 |
| C95 | 100 µF | +/-20% | 16 V | | Electrolytic capacitor | SMD |
| J7a | CON3 | | | | 2-way cable mount screw terminal, 5.08 mm | Through hole |

**Table 7. BOM (part 2)**

| Reference | Manufacturer | Manufacturer code | RS/Distrelec/other code | More info |
|---|---|---|---|---|
| C5, C6 | | | | |
| C122 | | | | |
| C7 | | | | |
| C11, C12 | | | | |
| C14, C27, C103, C114, C115 | muRata | GRM188R71H103KA01D | RS code: 204-0779 | |
| C15, C17, C24 | KEMET | C1206C106K4PAC7800 | RS code: 648-0755 | |
| C16, C18, C25, C109, C110, C111, C112, C113, C97, C98, C99, C100, C104 | muRata | GRM188R71H104KA93D | RS code: 624-2480 | |
| C21,C33 | muRata | GRM1885C1H101JA01D | RS code: 653-0327 | |
| C22 | muRata | GRM21BR61A106KE19L | RS code: 106-846 | |
| C23 | Any | | Distrelec code: 821885 | |
| C26 | muRata | GRM3195C1H682JA01D | RS code: 624-2597 | |
| C30 | muRata | GRM1555C1H150JZ01D | RS code: 624-2935 | |
| C31 | muRata | GRM1555C1H220JZ01D | RS code: 624-2187 | |
| C32 | KEMET | C0603C271J5GAC7867 | RS code: 147-207 | |
| C95 | Any | | RS code: 565-695 | |

**Table 7. BOM (part 2) (continued)**

| Reference | Manufacturer | Manufacturer code | RS/Distrelec/other code | More info |
|---|---|---|---|---|
| C96 | Any | | RS code: 565-712 | |
| C101 | Any | | RS code: 464-7619 | |
| C123 | | | | |
| C124 | | | | |
| C108 | | | | |
| C116, C117 | Any | | RS code: 365-4745 | |
| C118 | Any | | RS code: 192-718 | |
| C119 | Any | | Distrelec code:801839 | |
| C120 | Any | | RS code: 699-3324 | |
| C121 | Any | | RS code: 216-1595 | |
| DL1 | Any | | Distrelec code: 250154 | |
| DL2 | Any | | Distrelec code: 250159 | |
| D1 | Any | | RS code: 419-053 | |
| D6, D13, D17 | Any | | Distrelec code: 601496 | |
| D8, D10 | STMicroelectronics | BAT54SFILM | | |
| D9 | STMicroelectronics | SM6T15CA | | |
| D14 | Taiwan Semiconductor | | RS code: 652-7501 | |
| D15 | STMicroelectronics | STPS1H100A | | |
| D16 | STMicroelectronics | STTH1L06A | | |
| F1 | Schurter | 3404.2416.22 | RS code: 703-2742 | |
| IC3 | STMicroelectronics | LD1117ADT33TR | | |
| JP4, JP5 | Do not fit | Do not fit | Do not fit | |
| J1 | Any | | RS code:495-8470 | |
| J2 | Any | | RS code: 1732764 | |
| J3 | Tyco Electronics | 1241150-3 | RS code: 528-6237 | |
| J4 | PHOENIX CONTACT | SL 5.08/3/180B | RS code: 294-8443 | |
| J6 | Any | | RS code: 1732764 | |
| J7 | PHOENIX CONTACT | SL 5.08/2/180B4.5 | RS code: 294-7428 | |
| J8 | Tyco Electronics | 1241150-4 | RS code: 528-6243 | |
| L5 | EPCOS | B82464A4223K | RS code: 496-0445 | |
| L6 | EPCOS | B82462A4224K | RS code: 495-8048 | |
| L8 | Any | | RS code: 191-0677 | |

**Table 7. BOM (part 2) (continued)**

| Reference | Manufacturer | Manufacturer code | RS/Distrelec/other code | More info |
|---|---|---|---|---|
| L9 | Any | | RS code: 191-0481 | |
| Q1, Q2 | Any | | RS code: 445-2051 | |
| Q5 | STMicroelectronics | 2STR1215 | | |
| R6 | | | | |
| R7 | | | | |
| R8 | | | | |
| R9, R88, R71, R72, R73, R108, R109 | | | | |
| R10 | | | | |
| R12, R62, R68, R90, R93 | | | | |
| R13 | | | | |
| R14 | | | | |
| R17 | | | | |
| R19, R85, R86, R87 | | | | |
| R20 | | | | |
| R21, R22, R96, R97, R101, R102 | Any | | Digi-Key code: RT0805FRE07261KL-ND | |
| R61, R106 | | | | |
| R74, R76, R77, R78, R79 | | | | |
| R112, R118 | | | | |
| R69, R70 | | | | |
| R75 | | | | |
| R89 | | | | |
| R91, R92 | | | Farnell code: 1500646 | |
| R94 | | | | |
| R95 | | | | |
| R98, R103 | Any | | Digi-Key code: RT0805FRE07475RL | |
| R99 | | | | |
| R100 | | | | |

**Table 7. BOM (part 2) (continued)**

| Reference | Manufacturer | Manufacturer code | RS/Distrelec/other code | More info |
|---|---|---|---|---|
| R105 | | | | |
| R110 | Any | | RS code: 214-0920 | |
| R111 | | | | |
| R113 | | | | |
| R114 | | | | |
| R115 | | | | |
| R116 | | | | |
| R117 | | | | |
| RV1 | EPCOS | B72650M271K72 | Distrelec code: 730096 | |
| SW4 | C & K | Y78B22110FP | RS code 505-9186 | |
| SW8 | Tyco Electronics | 1241150-3 | RS code: 528-6237 | Single stripline 3 poli |
| TP8, TP9, TP10, TP11, TP12, TP13, TP14, TP15, TP16, TP17, TP18, TP19, TP20, TP21, TP22, TP23, TP25, TP26, TP27 | Test point | Test point | Test point | |
| T1 | VAC | T60404-E 4622-X503 | | |
| T2 | MAGNETICA | 1921.0013 rev.2 | | |
| T3 | VAC | T60403-K5024-X044 | | |
| U3 | STMicroelectronics | ST7540TR | | |
| U11 | STMicroelectronics | STM32F103CBT6 | | |
| U12 | STMicroelectronics | STPM01FTR | | |
| U13 | STMicroelectronics | | | |
| X1 | Any | | RS code: 547-6531 | |
| Y1 | ABRACON | ABM3B-8.000 MHz-B2 | RS code: 703-1997 | |
| k2 | OMRON | G2RL-1-E 12DC | RS code: 365-0535 | |
| C5,C6 | | | | |
| C122 | | | | |
| C7 | | | | |
| C11, C12 | | | | |

**Table 7. BOM (part 2) (continued)**

| Reference | Manufacturer | Manufacturer code | RS/Distrelec/other code | More info |
|-----------|--------------|-------------------|-------------------------|-----------|
| C14, C27, C103, C114, C115 | muRata | GRM188R71H103KA01D | RS code: 204-0779 | |
| C15, C17, C24 | KEMET | C1206C106K4PAC7800 | RS code: 648-0755 | |
| C16, C18, C25, C109, C110, C111, C112, C113, C97, C98, C99, C100, C104 | muRata | GRM188R71H104KA93D | RS code: 624-2480 | |
| C21, C33 | muRata | GRM1885C1H101JA01D | RS code: 653-0327 | |
| C22 | muRata | GRM21BR61A106KE19L | RS code: 106-846 | |
| C23 | Any | | Distrelec code: 821885 | |
| C26 | muRata | GRM3195C1H682JA01D | RS code: 624-2597 | |
| C30 | muRata | GRM1555C1H150JZ01D | RS code: 624-2935 | |
| C31 | muRata | GRM1555C1H220JZ01D | RS code: 624-2187 | |
| C32 | KEMET | C0603C271J5GAC7867 | RS code: 147-207 | |
| C95 | Any | | RS code: 565-695 | |
| J7a | Phoenix Contact | BL 5.08/2 | RS code: 403-875 | Not mounted on PCB |

**Figure 4. Top page**



AM10554v1
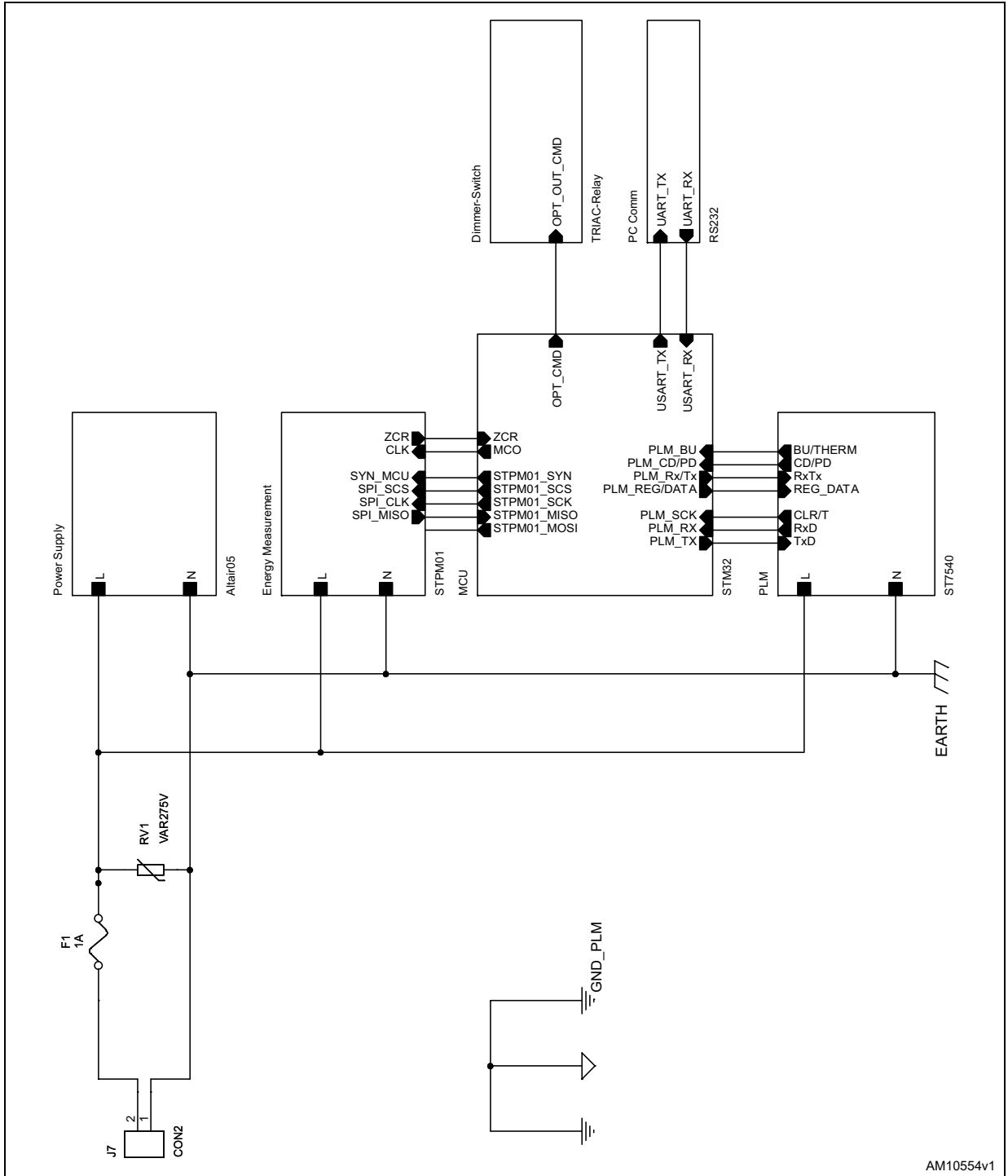
**Figure 5. Power supply section**
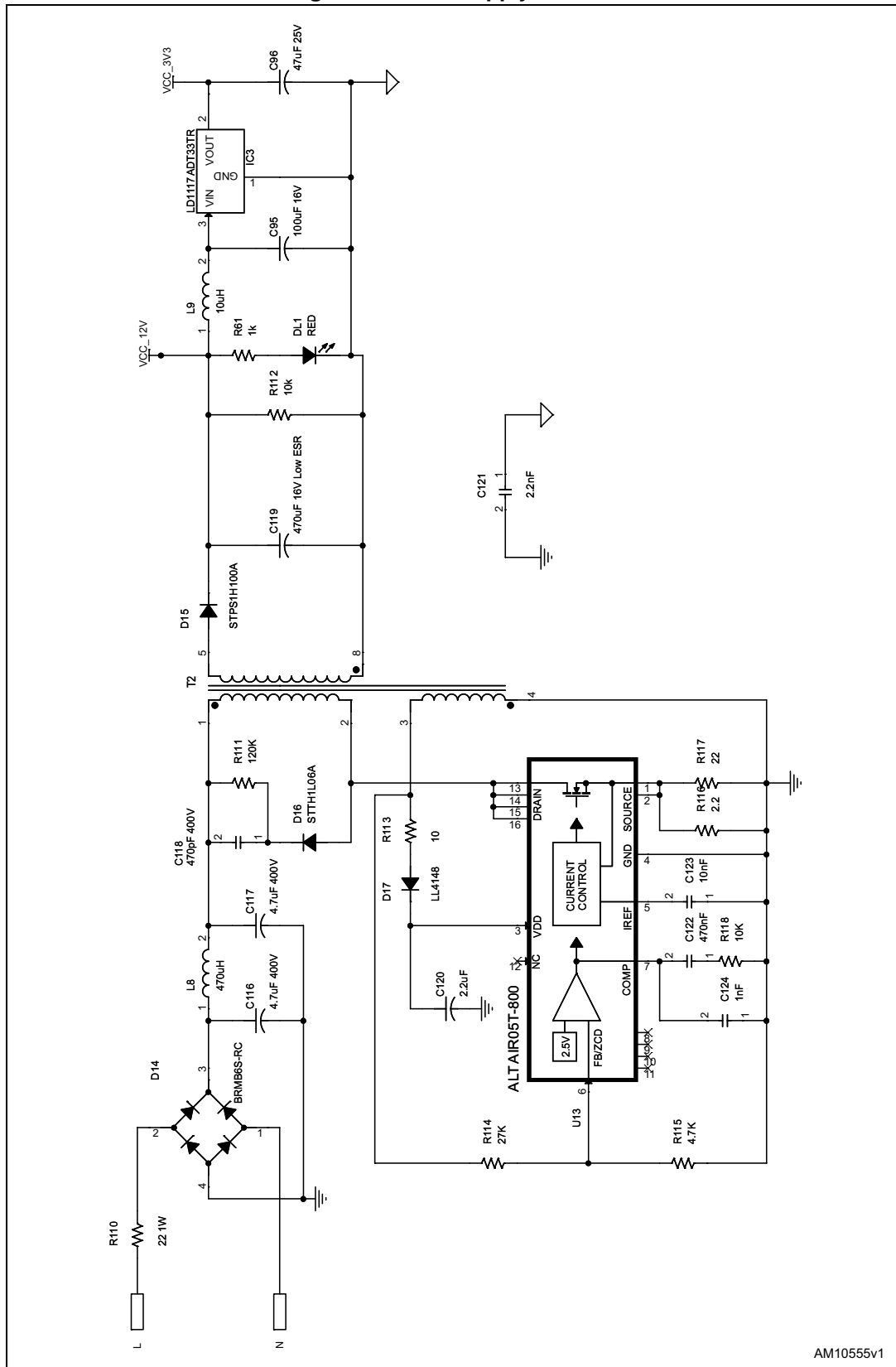


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**Figure 6. USART expansion connector section**
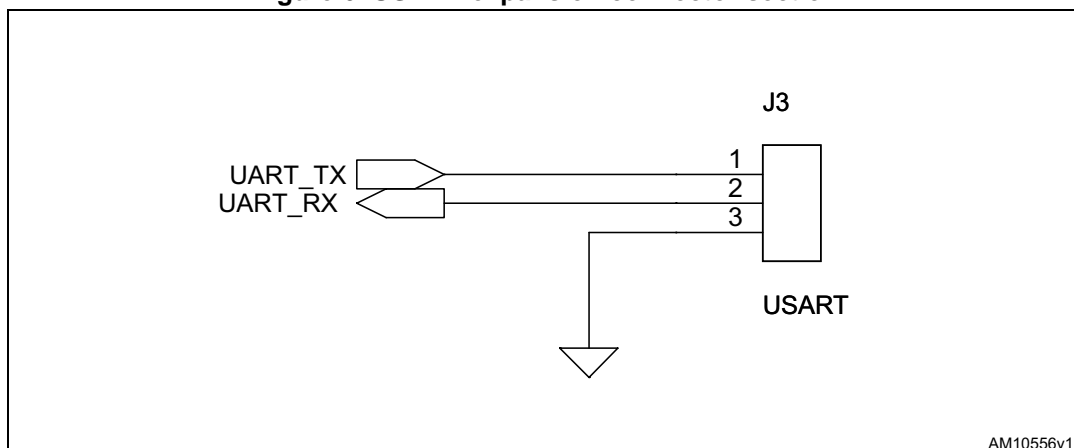
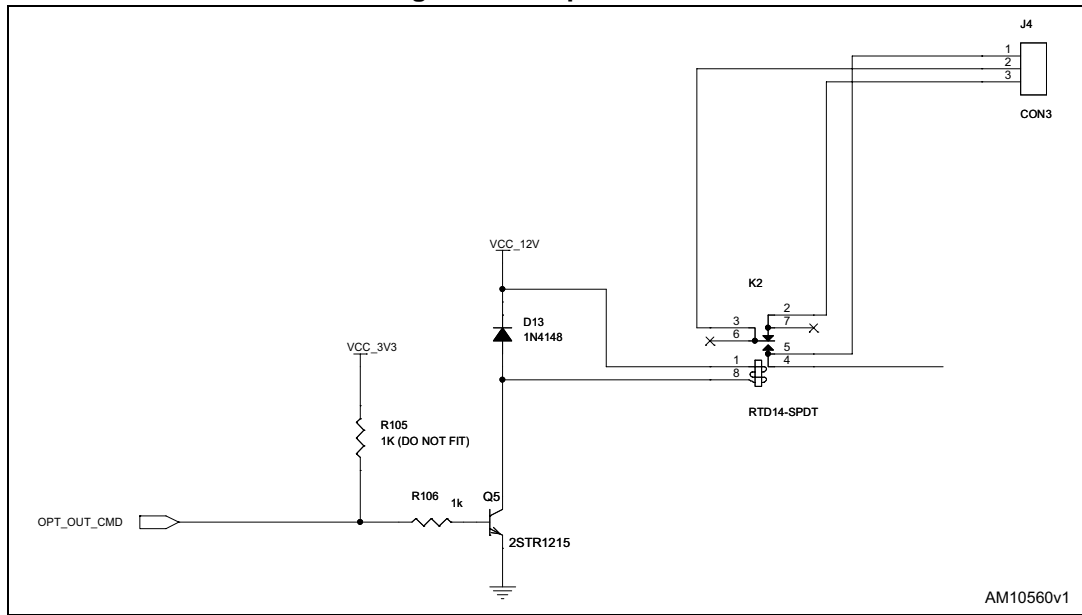**Figure 7. Power line modem section**
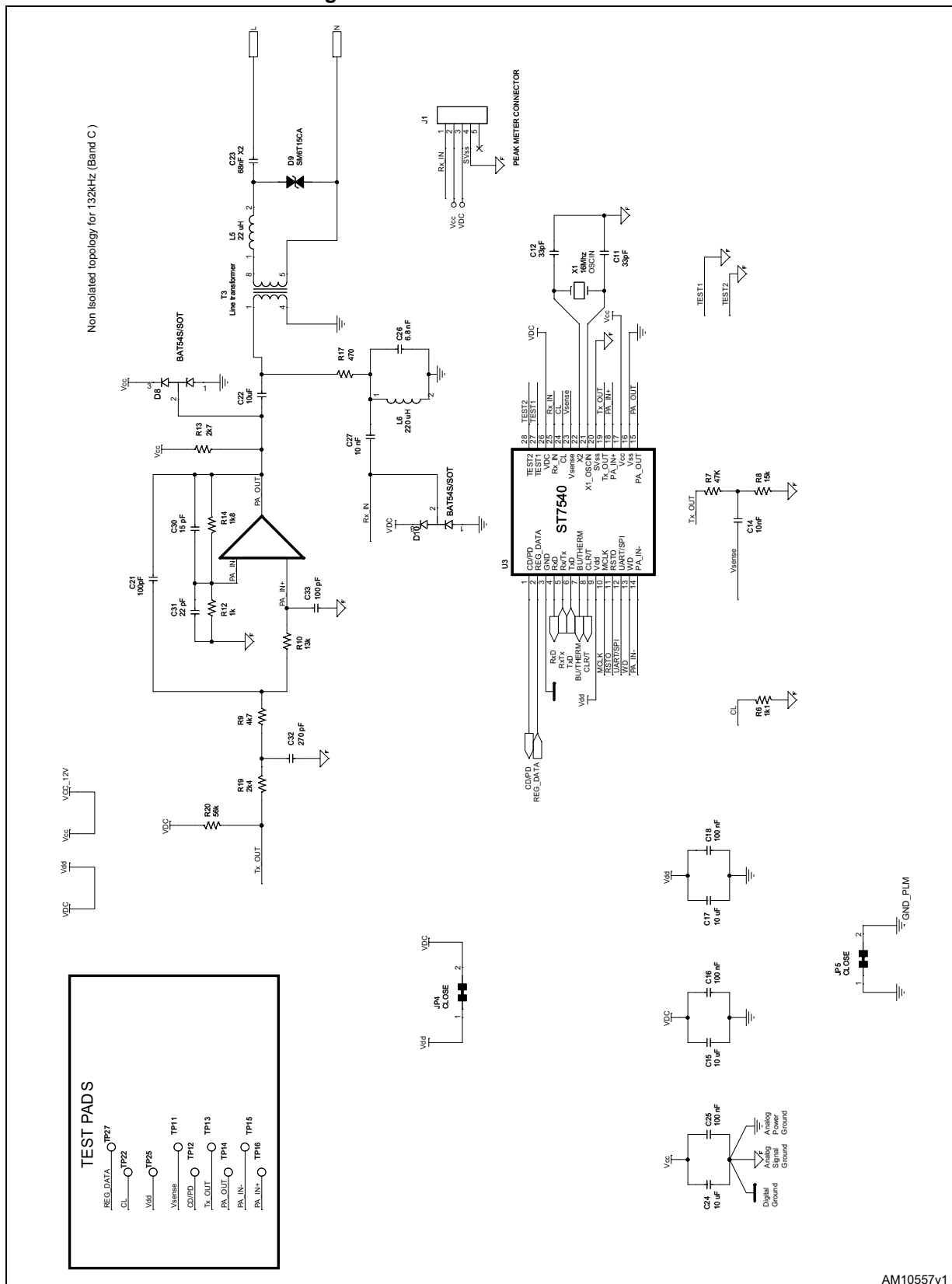


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**Figure 8. MCU section**



AM10558v1
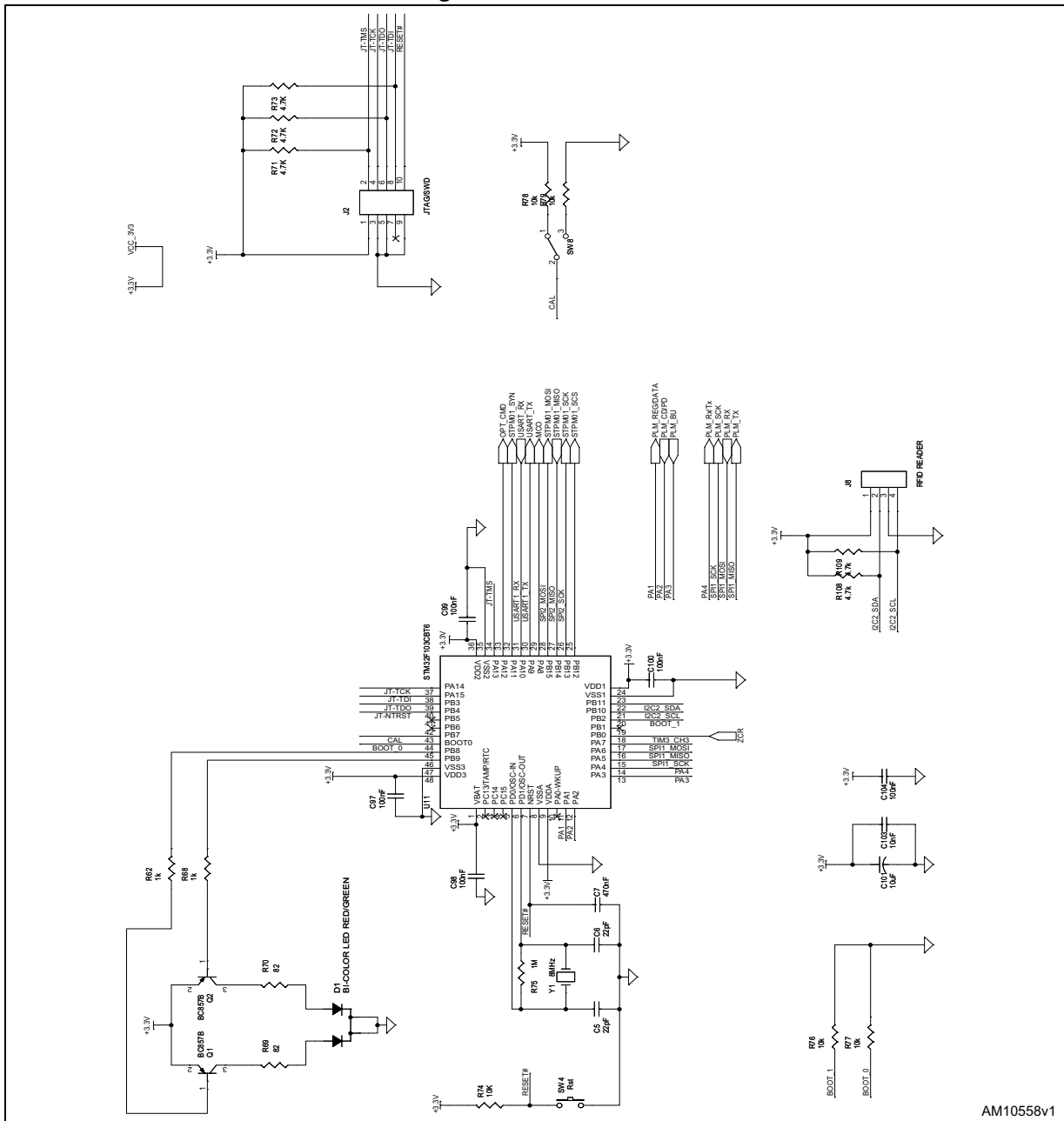
**Figure 9. STPM01**
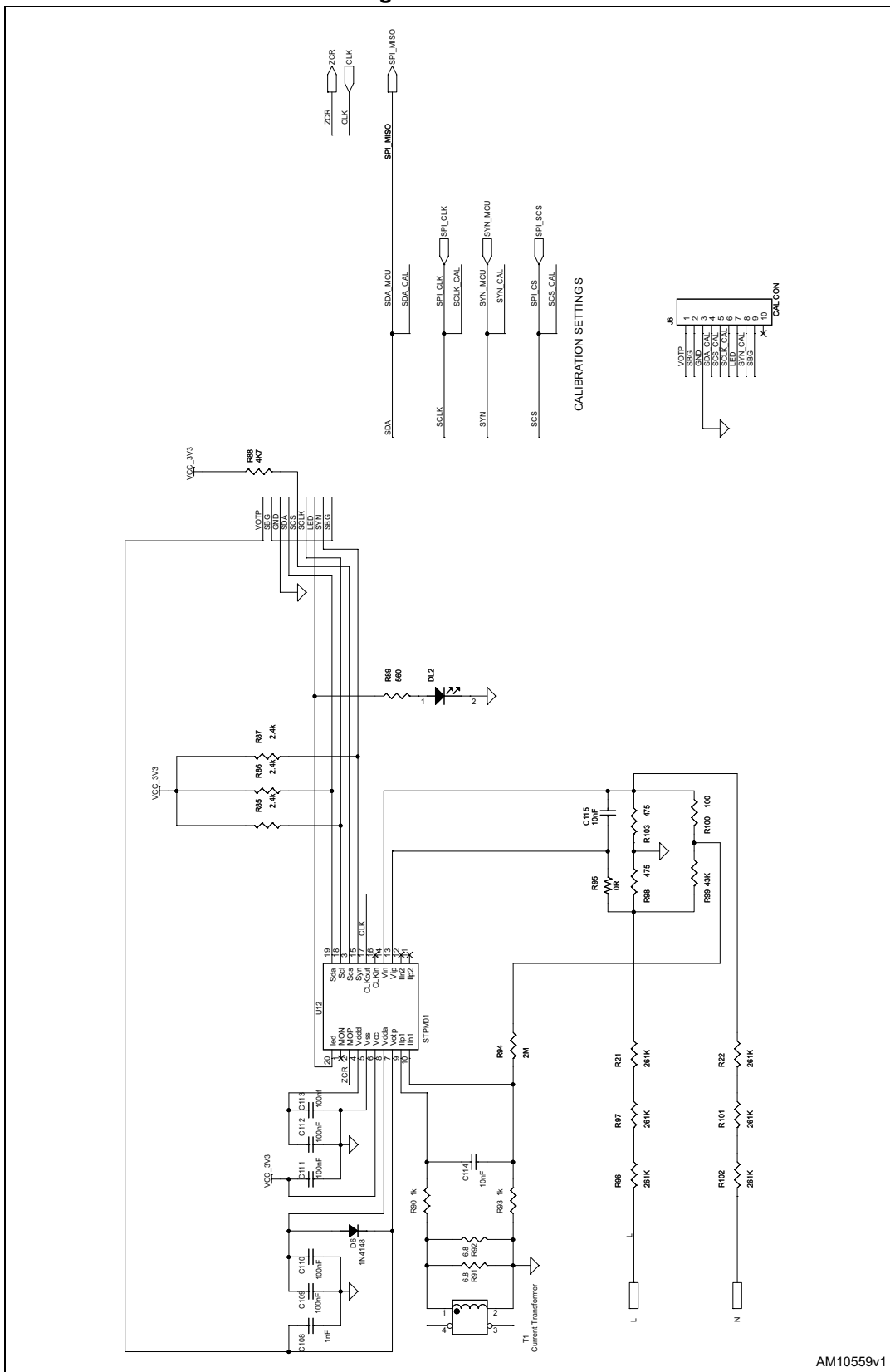


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**Figure 10. Output drivers**



AM10560v1

# 5 Revision history

**Table 8. Document revision history**

| Date | Revision | Changes |
|---|---|---|
| 09-Nov-2011 | 1 | Initial release. |
| 30-Jun-2015 | 2 | Removed section: Demo PC GUI. |

**IMPORTANT NOTICE – PLEASE READ CAREFULLY**