# AN3287
# Application note

## PLM smartplug guide to getting started

## Introduction

The purpose of this guide is to help the user fully use the PLM smartplug demonstration 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 demonstration board is based on the STM32F103VE microcontroller, the ST7540 PLM module, and the STPM01 mono-phase energy metering IC. It implements a PLM smartplug node which allows to monitor energy consumption of a mains plug and to control it in on/off mode by a relay or in dimming through the T2035H Triac.

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 demonstration 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 UM1006 user manual for more firmware and communication protocol details
- *Section 4* shows the board schematics and BOM list. Refer to the PLM smartplug HW UM1005 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* lists 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 demonstration board

## 2.1 Board introduction

The application described in this document refers to the STEVAL-IHP002V1 demonstration board (see UM1005).

**Figure 1. STEVAL-IHP002V1 smartplug demonstration board**
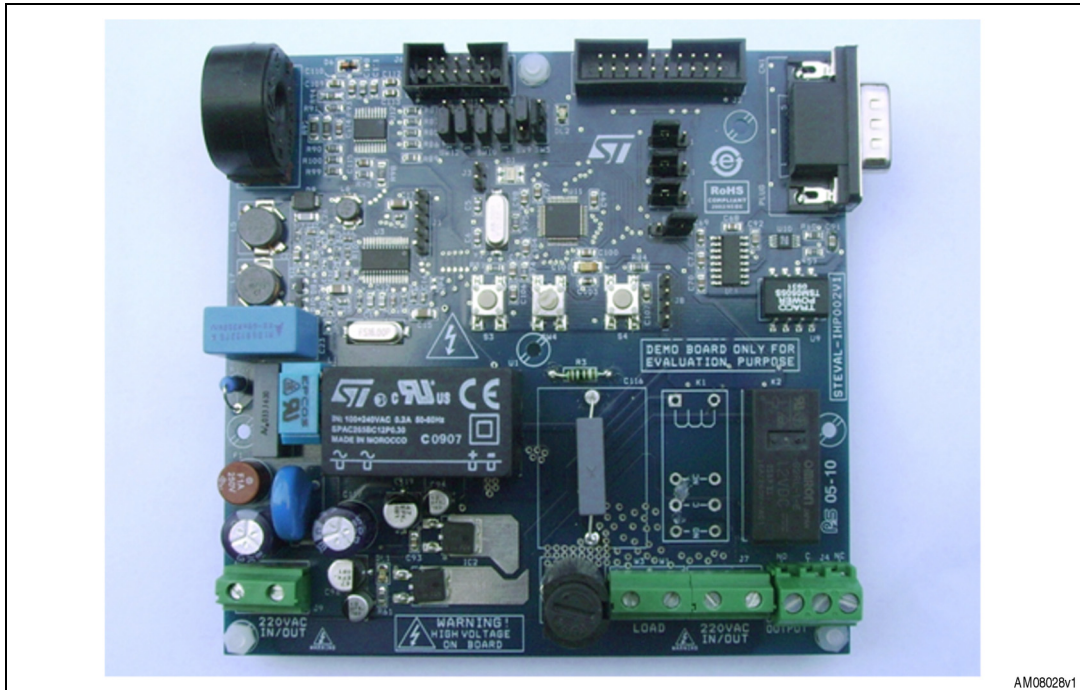


The board includes the following functions shown in the block diagram of *Figure 2*:

● Energy measurement by STPM01 IC
● Power line communication by ST7540 up to 4.8 kbps
● Isolated RS232 connectivity
● Main AC load driving by Relay or Triac (by T2035H)
● Auxiliary on/off contact for generic load driving.

**Figure 2.    STEVAL-IHP002V1 PLM smartplug demonstration board block diagram**
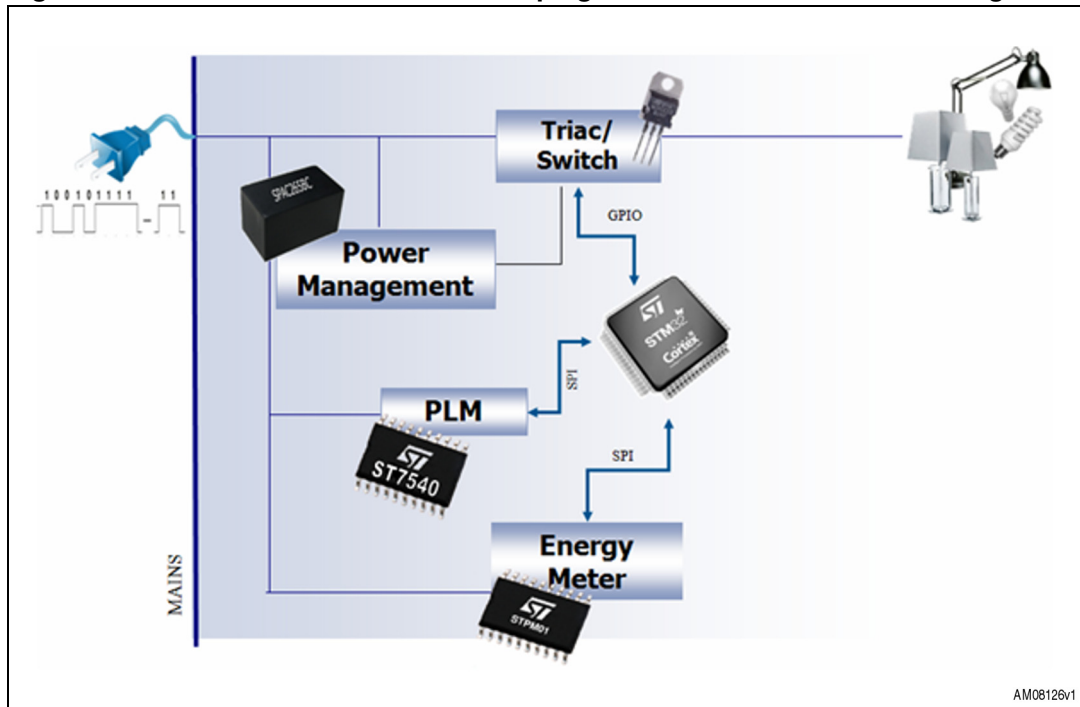


> **Warning:**     **The board must be used only by expert technicians. Due to the high voltage (220 Vac) special care should be taken with regard to human safety. There is no protection against accidental human contact with high voltages. After disconnection of the board from the mains, none of the 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 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 following is a list of the PLM smartplug demonstration 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
● 3 configuration jumpers (SW3, SW6, SW7): used for software configuration scope
● 2 user buttons (S3 and S4): used for user application scope
● 1 microcontroller reset button (SW4): used to force an MCU reset
● 4 jumpers for STPM01 calibration setting.

Detailed information about the PLM smartplug demonstration board hardware can be found in the UM1005 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 the following default table:

**Table 2.     Jumper default position**

| Jumper | Description | Default |
|---|---|---|
| SW2, SW5 | Boot option<br>– Fitted (1-2): boot option bit 0<br>– Fitted (2-3): boot option bit 1 | Fitted (1-2) |
| SW3, SW6, SW7, | General purpose configuration bit<br>– Fitted (1-2): configuration bit 1<br>– Fitted (2-3): configuration bit 0 | Fitted (2-3) |
| SW8, SW10, SW11, SW12 | STPM01 calibration mode<br>– Fitted (1-2): normal mode<br>– Fitted (2-3): calibration mode | Fitted (1-2) |
| SW9 | Energy meter data line option<br>– Fitted (1-2): data line connected to SPI2-MISO<br>– Fitted (2-3): data line connected to SPI2-MOSI | Fitted (1-2) |

### 2.3.1 PLM smartplug application configuration

The general purpose configuration jumpers are used to configure the smartplug type:

● Relay: SW6=0, SW7=0, SW3=0
● Dimmer: SW6=1, SW7=0, SW3=0

Before powering up the board, these jumpers must be set according to the board type. 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 the jumpers SW8, SW10, SW11, and SW12 in calibration mode and using the on-

board calibration connector before powering up the board. For details please refer to the UM1005 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; 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**
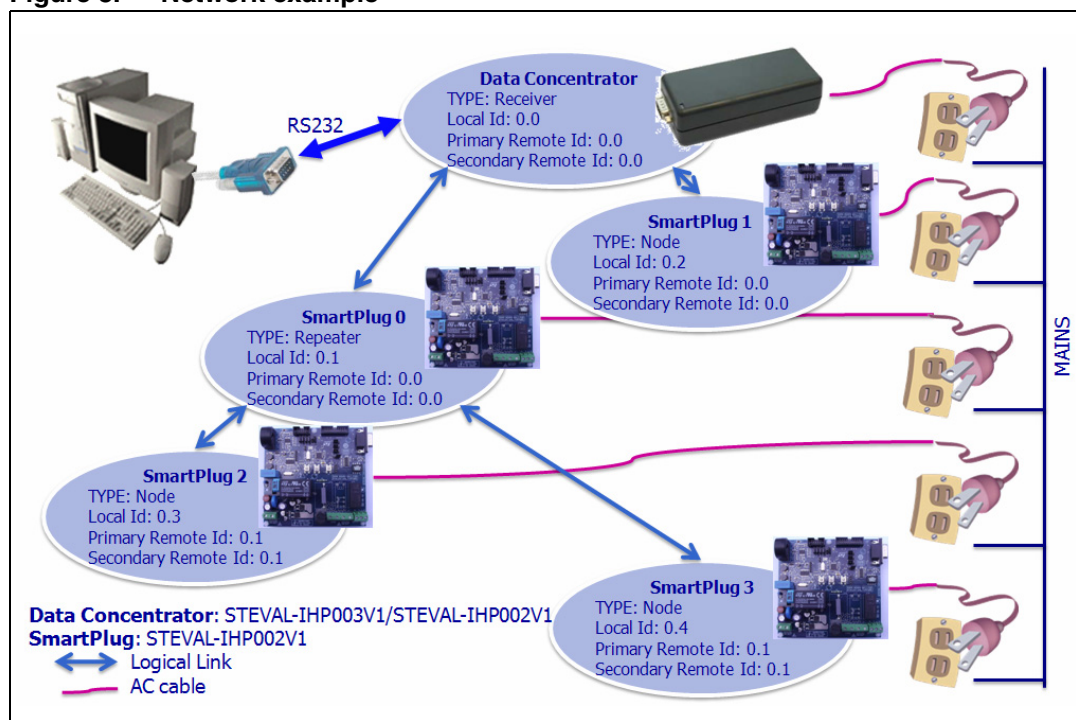


The data concentrator firmware is also provided in order to build a complete network solution; it can be loaded into one of the available smartplug boards (STEVAL-IHP002V1) or it is possible to order STEVAL-IHP003V1 separately, which has a better form factor for PC connection, and program it with the 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 are "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 blinks 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

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 mV
- current: load current in mA
- power: load power consumption in W.

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 be easily interpreted by a PC application for a better presentation.

**Table 4.     Class 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 of both main output (relay/dimmer) and auxiliary output (relay). |

On top of "text user interface" described above, a demo PC GUI has been developed working with only three smartplugs and one data concentrator. When the application is opened, it shows the window in *Figure 4*, which allows to open the COM port for communication with the data concentrator board and to use the text debug command and also show response messages.

**Figure 4.     Network example 1**
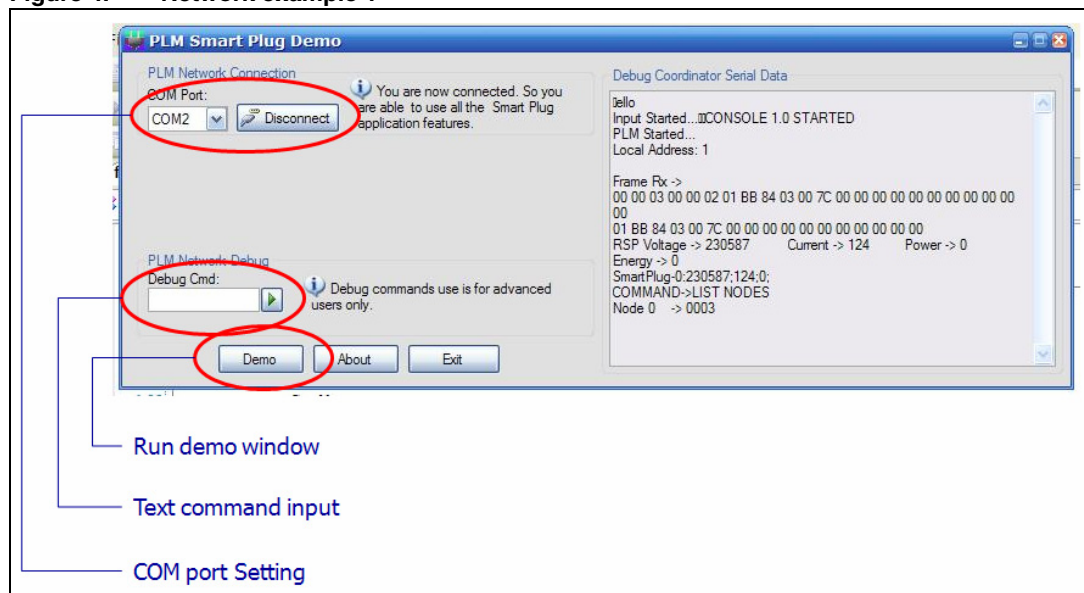
The demo window is shown by clicking on the "Demo" button, the window, illustrated in *Figure 5*, is shown.

**Figure 5.    Network example 2**
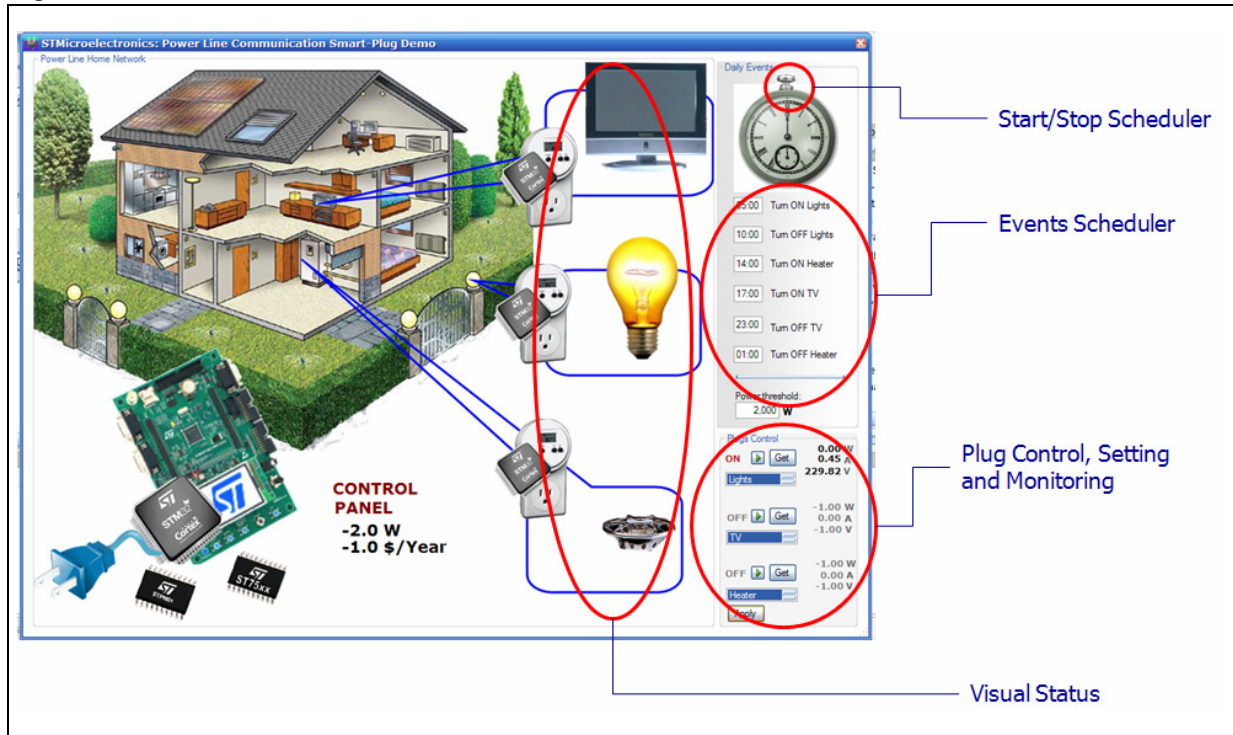


The window allows identifying, setting the label, getting information from each smartplug and monitoring the measurement variables. Once all labels are chosen, click the "Apply" button to assign them. The smartplug can be controlled manually by the "plug control, setting and monitoring" section or automatically by the "events scheduler" section of the window. Once the scheduler is set, click on the clock control to start/stop it. The status of the three smartplugs is also shown visually, considering three typical loads: a television, a lamp, and a heater.

The smartplug application layer sends measurement information periodically only if the measured power consumption changes, in order to avoid unnecessary network overload, so if you want to get "fresh" data click on the "Get" button of the smartplug from which you want data.

## 2.4      Board and application limitations

The smartplug is for demonstration 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 Triac has been tested with a maximum load equal to 1 kW

# 3 PLM network and frames

Details regarding the network information and frames can be found in the PLM smartplug FW UM1006 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

**Table 6.** **BOM**

| Reference | Part / value | Tolerance % | Voltage current | Watt | Technology information | Package-foot-print | Manufacturer | Manufacturer code | RS/Distrelec/ other code | More info |
|---|---|---|---|---|---|---|---|---|---|---|
| CN1 | PORT 0 | | | | 9-way r/a PCB D plug, US footprint 8.1 mm | Through hole | Any | | RS code: 160-2590 | |
| C1 | 2.2 µF | +/-10 % | 50 V | | Ceramic capacitor X7R | SMD 0805 | | | | |
| C5, C6 | 22 pF | +/-10 % | 50 V | | Ceramic capacitor X7R | SMD 0805 | | | | |
| C7 | 470 nF | +/-10 % | 50 V | | Ceramic capacitor X7R | SMD 0805 | | | | |
| C11, C12 | 33 pF | +/-10 % | 50 V | | Ceramic capacitor X7R | SMD 0805 | | | | |
| C14, C27, C103 | 10 nF | ±10 % | 50 V | | Ceramic capacitorX7R | SMD 0603 | muRata | GRM188R71H10 3KA01D | RS code: 204-0779 | |
| C114, C115 | 10 nF | +/-10 % | 50 V | | Ceramic capacitor X7R | SMD 0805 | | | | |
| C15, C17, C24 | 10 µF | ±10 % | 16 V | | Ceramic capacitorX7R | SMD 1206 | Kemet | C1206C106K4PA C7800 | RS code: 648-0755 | |
| C16, C18, C25 | 100 nF | ±10 % | 50 V | | Ceramic capacitorX7R | SMD 0603 | muRata | GRM188R71H10 4KA93D | RS code: 624-2480 | |
| C22 | 10 µF | ±10 % | 10 V | | Ceramic capacitor X5R | SMD 0805 | muRata | GRM21BR61A10 6KE19L | RS code: 106-846 | |
| C116 | 47 nF | +/-10 % | 300 V | | X2 Capacitor | Through Hole | Any | | RS code: 441-9600 | |
| C101 | 10 µF | 10 % | 10 V | | Tantalium capacitor | SMD | Any | | RS code: 464-7619 | |

**Table 6.    BOM (continued)**

| Reference | Part / value | Tolerance % | Voltage current | Watt | Technology information | Package-foot-print | Manufacturer | Manufacturer code | RS/Distrelec/ other code | More info |
|---|---|---|---|---|---|---|---|---|---|---|
| C23 | 68 nF | ±20 % | 300 V | | X2 Capacitor | Through Hole | Any | | Distrelec code: 821885 | |
| C26 | 6.8 nF | ±5 % | 50 V | | Ceramic capacitor COG | SMD 1206 | muRata | GRM3195C1H68 2JA01D | RS code: 624-2597 | |
| C30 | 15 pF | ±5 % | 50 V | | Ceramic capacitor COG | SMD 0402 | muRata | GRM1555C1H15 0JZ01D | RS code: 624-2935 | |
| C31 | 22 pF | ±5 % | 50 V | | Ceramic capacitor COG | SMD 0402 | muRata | GRM1555C1H22 0JZ01D | RS code: 624-2187 | |
| C32 | 270 pF | ±5 % | 50 V | | Ceramic capacitor COG | SMD 0603 | Kemet | C0603C271J5GA C7867 | RS code: 147-207 | |
| C21, C33 | 100 pF | ±5 % | 50 V | | Ceramic capacitor COG | SMD 0603 | muRata | GRM1885C1H10 1JA01D | RS code: 653-0327 | |
| C68,C69, C70,C71, C102,C105 ,C106, C107,C93, C97,C98, C99,C100, C104,C109 ,C110, C111,C112 ,C113 | 100 nF | +/-10 % | 50 V | | Ceramic capacitor X7R | SMD 0805 | | | | |
| C91, C92 | 47 nF | +/-10 % | 50V | | Ceramic capacitor X7R | SMD 0805 | | | | |
| C94, C95 | 10 µF | +/-20 % | 50 V | | Electrolytic capacitor | SMD | Any | | RS code: 536-9859 | |
| C108 | 1 nF | +/-10 % | 50 V | | Ceramic capacitor X7R | SMD 0805 | | | | |

**Table 6.    BOM (continued)**

| Reference | Part / value | Tolerance % | Voltage current | Watt | Technology information | Package-foot-print | Manufacturer | Manufacturer code | RS/Distrelec/ other code | More info |
|---|---|---|---|---|---|---|---|---|---|---|
| C117, C118 | 470 µF | +/-20 % | 25 V | | Electrolytic capacitor low ESR | Through hole | Any | | Distrelec code: 801846 | |
| C96, C119 | 47 µF | +/-20 % | 25 V | | Electrolytic capacitor | SMD | Any | | RS code: 565-712 | |
| C120 | 33 nF | +/-10 % | 275 V | | X2 capacitor | Through hole | Any | | RS code: 118-148 | |
| DL1 | Red | | | | Chip LED | SMD 0805 | Any | | Distrele code: 250154 | |
| DL2 | Blue | | | | Chip LED | SMD 0805 | Any | | Distrele code: 250159 | |
| D1 | Bi-color LED red / green | | | | LED Bi-Red, Green | SMD | Any | | RS code: 419-053 | |
| D6, D12, D13 | LL4148 | | | | Switching diode_ | SOD-80 | Any | | Distrelec code: 601496 | |
| D8, D10 | BAT54S | | | | Small signal Schottky diodes | SOT-23 | STMicroelectronics | BAT54SFILM | | |
| D9 | SM6T15 CA | | | | Transil | SMB | STMicroelectronics | SM6T15CA | | |
| D11 | STPS14 0U | | | | Power Schottky rectifier | SMB | STMicroelectronics | STPS140U | | |
| F1 | 1 A | | | | TR5 anti-surge submin PCB T fuse | Through hole | Any | | RS code: 611-0658 | |
| F2 | 15 A | | 250 V/15 A | | Min fuse 15 A 5x20 mm | | | | RS code: 541-4599 | |
| Socket for F2 | | | | | Socket for F2 | Through hole | Wickmann | 652 | Distrelec code: 273260 | |

**Table 6.     BOM (continued)**

| Reference | Part / value | Tolerance % | Voltage current | Watt | Technology information | Package-foot-print | Manufacturer | Manufacturer code | RS/Distrelec/ other code | More info |
|---|---|---|---|---|---|---|---|---|---|---|
| Cap for socket | Cap for socket | | | | Cap for socket | | Wickmann | 655 | Distrelec code: 273262 | |
| IC1 | ST3232 EBDR | | | | RS-232 drivers and receivers | SO-16 | STMicroelectronics | ST3232EBDR | | |
| IC2 | LD1117 DT50TR | | | | Low drop fixed and adjustable positive voltage regulators | DPAK | STMicroelectronics | LD1117DT50TR | | |
| IC3 | LD1117 ADT33T R | | | | Low drop fixed and adjustable positive voltage regulators | DPAK | STMicroelectronics | LD1117ADT33T R | | |
| JP4,JP5 | Close | | | | Do not fit | Do not fit | Do not fit | Do not fit | Do not fit | |
| J1 | Peak meter connect or | | | | 5-way single row strip line connector (male connector) 2,54 mm pitch | Vertical through hole | Any | | RS code:495-8470 | |
| J8 | Rfid reader | | | | 4-way single row strip line connector (male connector) 2,54 mm pitch | Vertical through hole | Any | | RS code:495-8470 | |
| J2 | JTAG | | | | 20-way IDC low profile boxed header 2,54 mm pitch | Vertical through hole | Any | | RS code: 461770 | |

**Table 6.    BOM (continued)**

| Reference | Part / value | Tolerance % | Voltage current | Watt | Technology information | Package-foot-print | Manufacturer | Manufacturer code | RS/Distrelec/ other code | More info |
|---|---|---|---|---|---|---|---|---|---|---|
| J3 | CON2 | | | | 2-way single row strip line connector (male connector) 2.54 mm pitch | Vertical through hole | Any | | RS code:495-8470 | |
| J4 | CON3 | | | | 3-way screw terminal block 5.08 mm pitch | Through hole | Any | | RS code:189-5865 | |
| J6 | CAL CON | | | | 10-way IDC low profile boxed header 2.54 mm pitch | Vertical through hole | Any | | RS code: 461-742 | |
| J7,J9 | CON2 | | | | 2-way screw terminal block 7.5 mm pitch | Through hole | Phoenix Contact | 1988105 | RS code: 548-7301 | |
| L1 | 2x10 mH | | 0.5 A | | Line filter | Through hole | Any | | Distrelec code: 351276 | |
| L5 | 22 µH | ±10 % | 2.1 A | | Smd inductor | SMD | EPCOS | B82464A4223K | RS code: 496-0445 | |
| L6 | 220 µH | ±10 % | 240 mA | | Smd inductor | SMD | EPCOS | B82462A4224K | RS code: 495-8048 | |
| L7,L9 | 1 mH | ±10 % | 330 mA | | Smd inductor | SMD | EPCOS | B82464A4105K | RS code: 496-0530 | |
| L8 | 10 µH | ±10 % | 1 A | | Smd inductor | SMD | EPCOS | B82442H1103K | RS code: 496-1268 | |
| Q1,Q2 | BC857B | | | | PNP transistor | SOT23 | Any | | RS code: 445-2051 | |

**Table 6.    BOM (continued)**

| Reference | Part / value | Tolerance % | Voltage current | Watt | Technology information | Package-foot-print | Manufacturer | Manufacturer code | RS/Distrelec/ other code | More info |
|---|---|---|---|---|---|---|---|---|---|---|
| Q3 | T2035H | | | | High temperature 20 A Snubberless™ Triacs | D2PAK | STMicroelectronics | T2035H-6G-TR | | |
| Q4,Q5 | 2STR12 15 | | | | Low voltage fast-switching NPN power transistor | SOT-23 | STMicroelectronics | 2STR1215 | | |
| R3 | 1 kΩ | +/-5 % | | 1/2 W | Resistor | Axial through hole | | | | |
| 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 | 4.7 kΩ | +/-1 % | | 0.1 W | Resistor | SMD 0603 | | | | |
| R88,R108, R109 | 4.7 kΩ | +/-5 % | | 1/8 W | Resistor | SMD 0805 | | | | |
| R10 | 13 kΩ | +/-1 % | | 0.1 W | Resistor | SMD 0603 | | | | |
| R12 | 1 kΩ | +/-1 % | | 0.1 W | Resistor | SMD 0603 | | | | |
| R62,R68, R104,R106 | 1 kΩ | +/-5 % | | 1/8 W | Resistor | SMD 0805 | | | | |
| 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 | 2.4 kΩ | +/-1 % | | 0.1 W | Resistor | SMD 0603 | | | | |
| R85,R86, R87 | 2.4 kΩ | +/-5 % | | 1/8 W | Resistor | SMD 0805 | | | | |
| R20 | 56 kΩ | +/-1 % | | 0.1 W | Resistor | SMD 0603 | | | | |

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

| Reference | Part / value | Tolerance % | Voltage current | Watt | Technology information | Package-foot-print | Manufacturer | Manufacturer code | RS/Distrelec/ other code | More info |
|---|---|---|---|---|---|---|---|---|---|---|
| R21,R96, R97 | 261 kΩ | +/-1 % | | 1/4 W | Resistor | SMD 1206 | | | | |
| R59,R60 | 0 | +/-5 % | | 1/8 W | Resistor | SMD 0805 | | | | |
| R61,R89 | 560 Ω | +/-5 % | | 1/8 W | Resistor | SMD 0805 | | | | |
| R63,R64, R65,R66, R71,R72, R73,R74, R76,R77, R80,R81, R82,R83, R84 | 10 kΩ | +/-5 % | | 1/8 W | Resistor | SMD 0805 | | | | |
| R67 | (Not mounted ) | +/-5 % | | 1/8 W | Resistor | SMD 0805 | | | | |
| R69,R70 | 82 Ω | +/-5 % | | 1/4 W | Resistor | SMD 1206 | | | | |
| R75 | 1 MΩ | +/-5 % | | 1/8 W | Resistor | SMD 0805 | | | | |
| R91,R92 | 6.8 Ω | +/-1 % | | 1/4 W | Resistor | SMD 1206 | | | | |
| R94 | 2 MΩ | +/-1 % | | 1/8 W | Resistor | SMD 0805 | | | | |
| R98 | 475 Ω | +/-1 % | | 1/4 W | Resistor | SMD 1206 | | | | |
| R99 | 43 kΩ | +/-1 % | | 1/8 W | Resistor | SMD 0805 | | | | |
| R100 | 100 Ω | +/-1 % | | 1/8 W | Resistor | SMD 0805 | | | | |
| R101 | 1 kΩ | +/-1 % | | 1/4 W | Resistor | SMD 1210 | | | | |
| R102 | 22 Ω | +/-1 % | | 1/4 W | Resistor | SMD 1210 | | | | |
| R103,R105 | 1 kΩ (do not fit) | +/-1 % | | 1/4 W | Resistor | SMD 1210 | | | | |
| R90,R93 | 1 kΩ | +/-1 % | | 1/8 W | Resistor | SMD 0805 | | | | |

**Table 6.     BOM (continued)**

| Reference | Part / value | Tolerance % | Voltage current | Watt | Technology information | Package-foot-print | Manufacturer | Manufacturer code | RS/Distrelec/ other code | More info |
|---|---|---|---|---|---|---|---|---|---|---|
| R95 | 0 | +/-1 % | | 1/8 W | Resistor | SMD 0805 | | | | |
| R107 | 10 | 5 % | | 1 W | Fuse resistor | Axial through hole | Any | | RS code: 214-0879 | |
| RV1 | S14K510 | 10 % | 510 VAC | | Disk-shaped metal-oxide varistors | Through hole | Epcos | B72214S0511K101 | Distrelec code: 730933 | |
| SW2 | BOOT_0 | | | | 3-way single row strip line connector (male connector) 2.54 mm pitch | Vertical through hole | Any | | RS code:495-8470 | Single strip line 3 pole |
| SW3 | CONF3 | | | | 3-way single row strip line connector (male connector) 2.54 mm pitch | Vertical through hole | Any | | RS code:495-8470 | Single strip line 3 pole |
| SW4 | Rst | | | | Surface mount tactile switch | SMD | Any | | RS code 183701 | |
| SW5 | BOOT_1 | | | | 3-way single row strip line connector (male connector) 2.54 mm pitch | Vertical through hole | Any | | RS code:495-8470 | Single strip line 3 pole |
| SW6 | CONF0 | | | | 3-way single row strip line connector (male connector) 2.54 mm pitch | Vertical through hole | Any | | RS code:495-8470 | Single strip line 3 pole |

**Table 6.    BOM (continued)**

| Reference | Part / value | Tolerance % | Voltage current | Watt | Technology information | Package-foot-print | Manufacturer | Manufacturer code | RS/Distrelec/ other code | More info |
|---|---|---|---|---|---|---|---|---|---|---|
| SW7 | CONF1 | | | | 3-way single row strip line connector (male connector) 2.54 mm pitch | Vertical through hole | Any | | RS code:495-8470 | Single strip line 3 pole |
| SW8,SW9, SW10,SW 11,SW12 | Calibrati on settings | | | | 3-way single row strip line connector (male connector) 2.54 mm pitch | Vertical through hole | Any | | RS code:495-8470 | Single strip line 3 pole |
| S3,S4 | SW push | | | | Surface mount tactile switch | SMD | Any | | RS code 183701 | |
| 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 | Test point | Test point | Test point | |
| T1 | Current transfor mer | | | | Current transformer | Through Hole | VAC | T60404-E 4622-X503 | | |
| U1 | SPAC26 5-3W | | | | AC-DC switch mode power supply | Through hole | ST Microelectronics | SPAC265BC12P 0.30 | | |
| U3 | ST7540 | | | | FSK power line transceiver | HTSSOP28 | ST Microelectronics | ST7540TR | | |

**Table 6.    BOM (continued)**

| Reference | Part / value | Tolerance % | Voltage current | Watt | Technology information | Package-foot-print | Manufacturer | Manufacturer code | RS/Distrelec/ other code | More info |
|---|---|---|---|---|---|---|---|---|---|---|
| U9 | TSM0505S | | | | DC-DC converter | SOIC-14 | Traco Power | TSM0505S | RS code: 510-5431 | |
| U10 | IL712S-1E | | | | Bi-directional Digi Isolator | MSOP8 | NVE | IL712S-1E | RS code: 418-436 | |
| U11 | STM32F103CBT6 | | | | Medium-density performance line ARM-based 32-bit MCU | LQFP48 | ST Microelectronics | STM32F103CBT6 | | |
| U12 | STPM01 | | | | Programmable single-phase energy metering IC with tamper detection | TSSOP20 | ST Microelectronics | STPM01FTR | | |
| W1 W3 | Load | | | | 2-way screw terminal block 7.5 mm pitch | Through hole | Phoenix contact | 1988105 | RS code: 548-7301 | |
| X1 | 16 MHz | | | | 16 MHz crystal | SMD | Any | | RS code: 547-6531 | |
| Y1 | 8 MHz | | | | 16 MHz crystal | SMD | Any | | RS code: 671-9242 | |
| k1 | 16 A 12 Vdc coil (Do not fit) | | (Do not fit) | | (Do not fit) | (Do not fit) | (Do not fit) | (Do not fit) | (Do not fit) | (Do not fit) |
| k2 | 16 A 12 Vdc coil | | 12 V/16 A | | Lowprofile SPDT power relay | Through hole | OMRON | G2RL-1-E 12DC | RS code: 365-0535 | |

# 5 Schematics

**Figure 6. Top page**
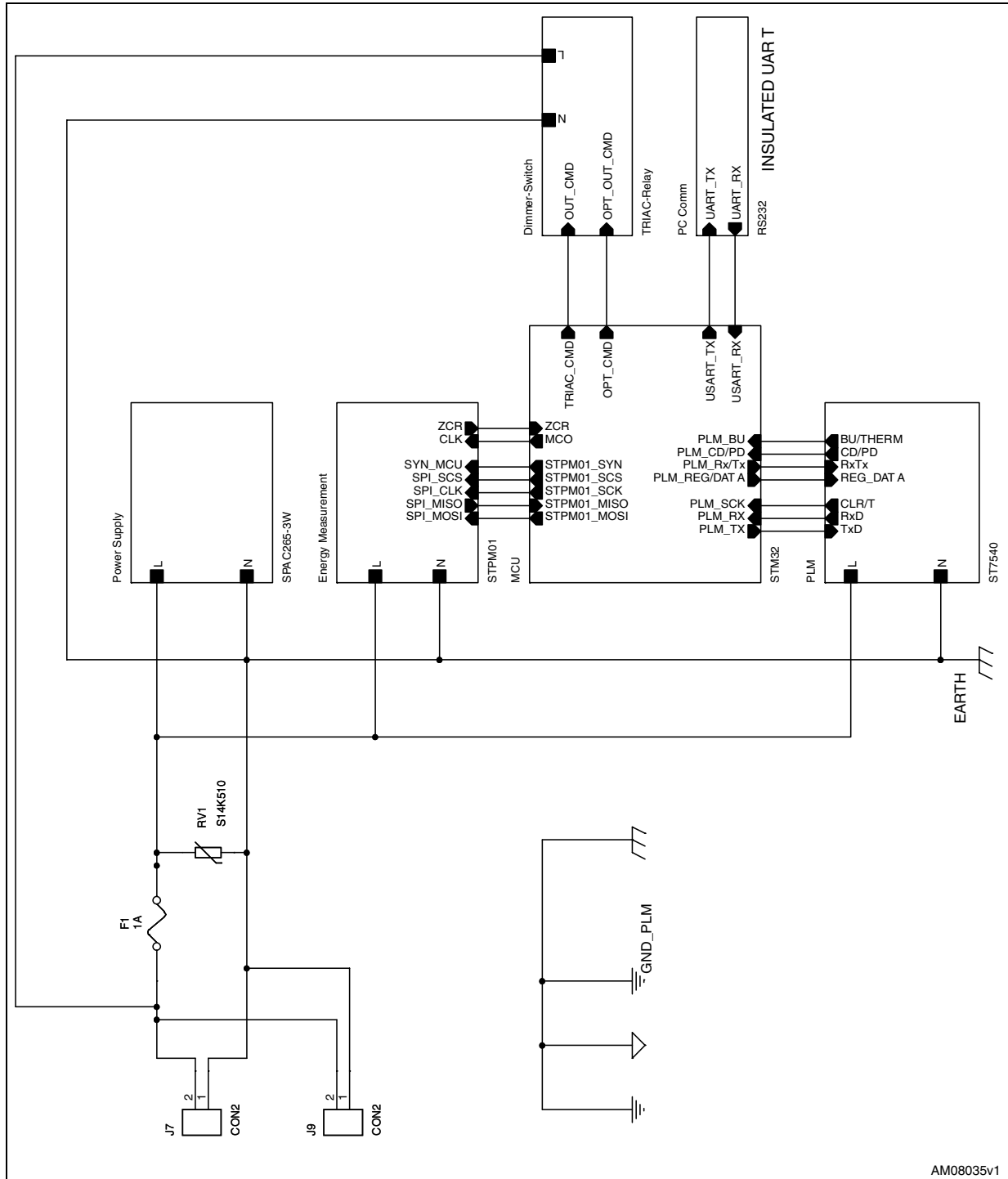


AM08035v1

**Figure 7.    RS232 communication section**
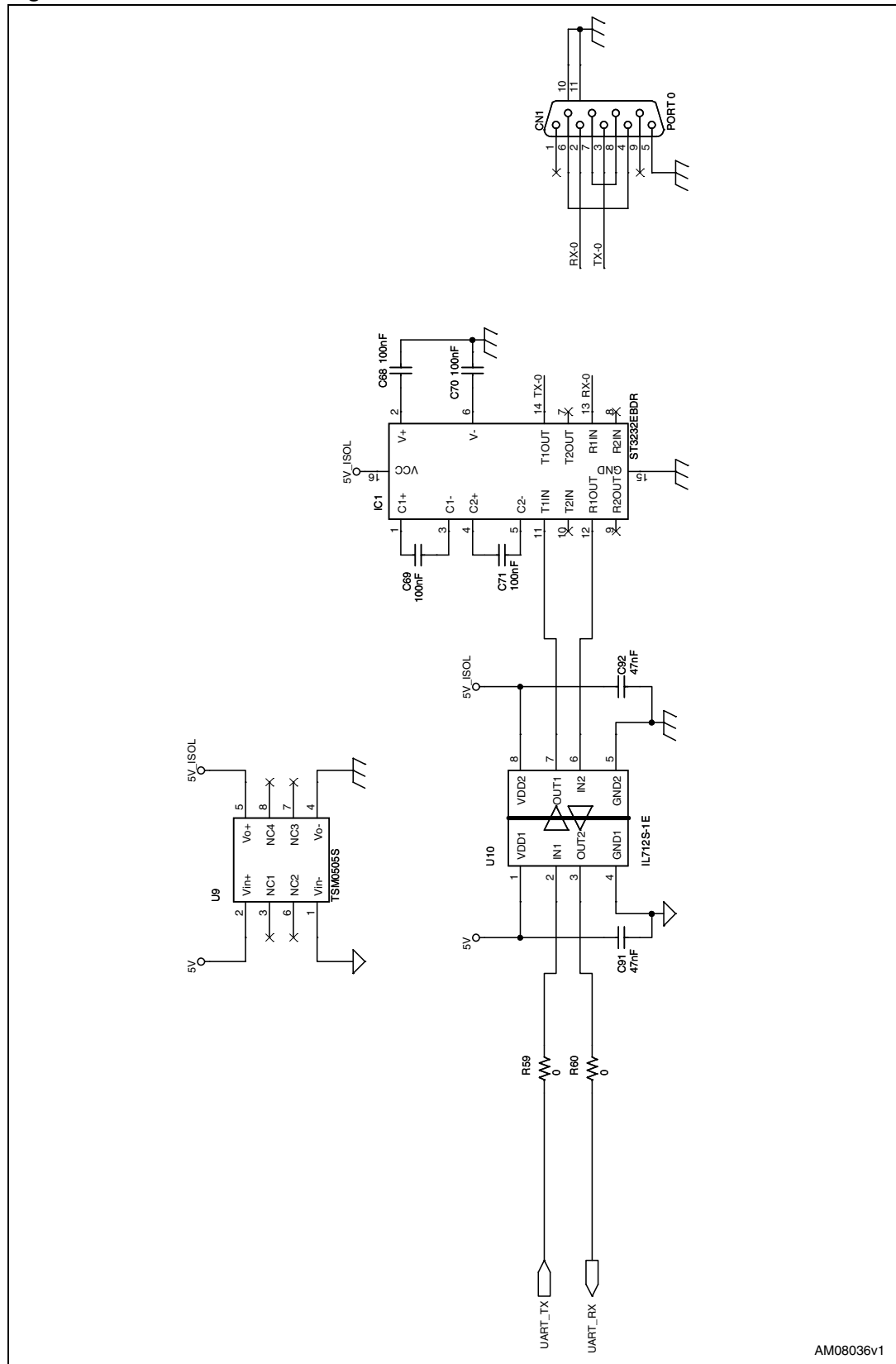


AM08036v1

**Figure 8. Power supply section**
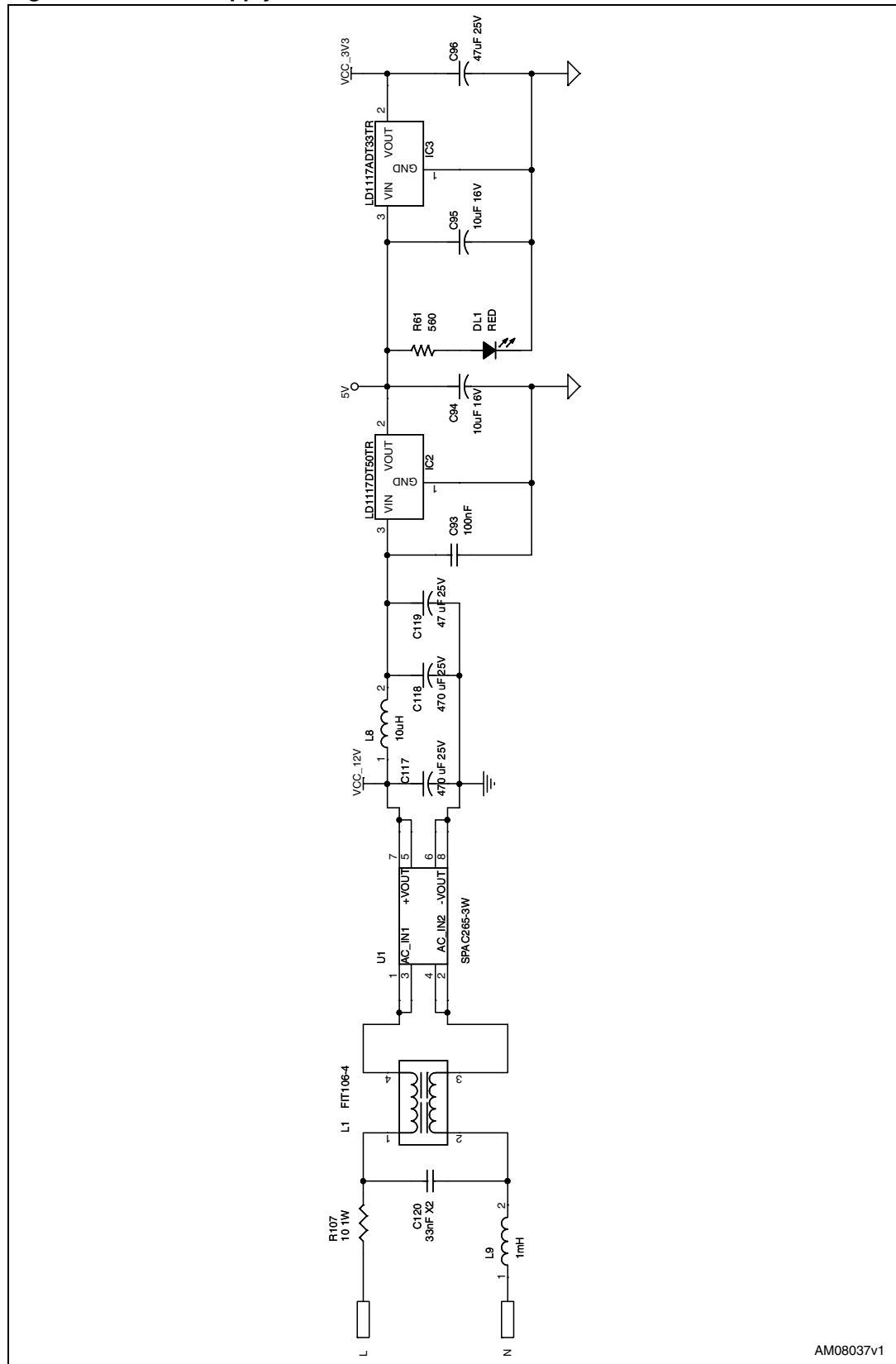


AM08037v1

**Figure 9.    Power line communication section**
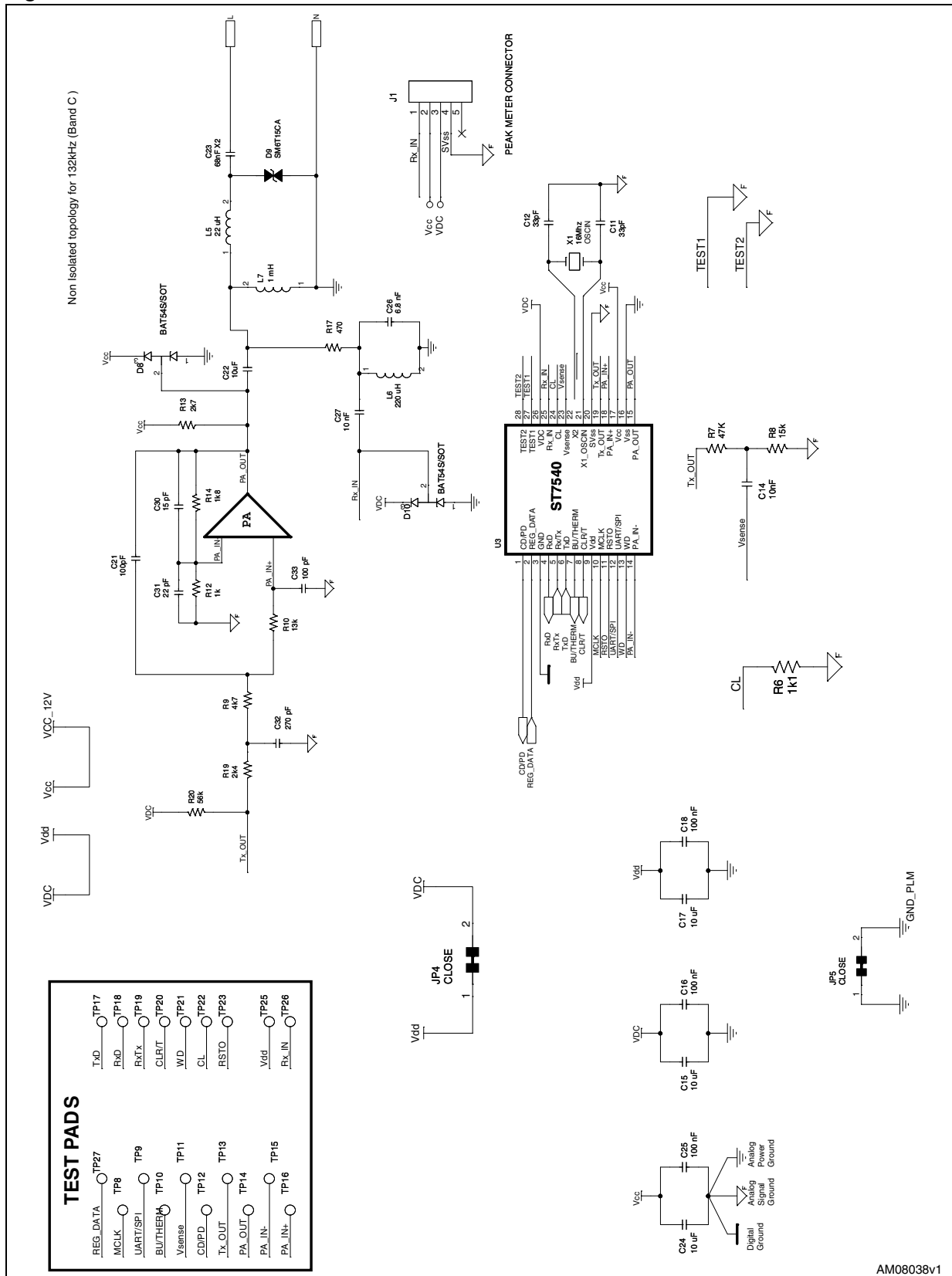


AM08038v1

### Figure 10. MCU section
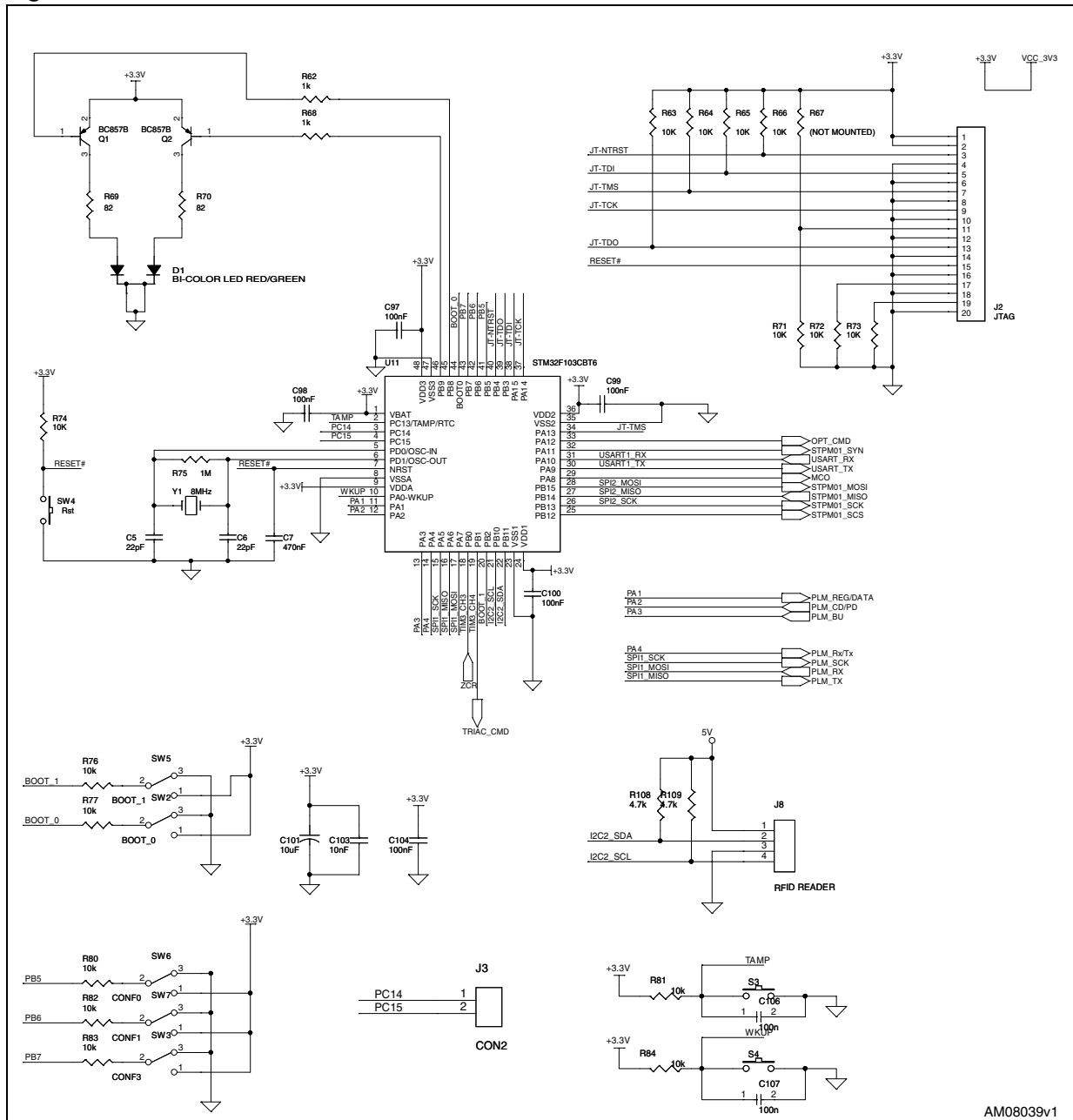


AM08039v1

**Figure 11.   Energy meter**
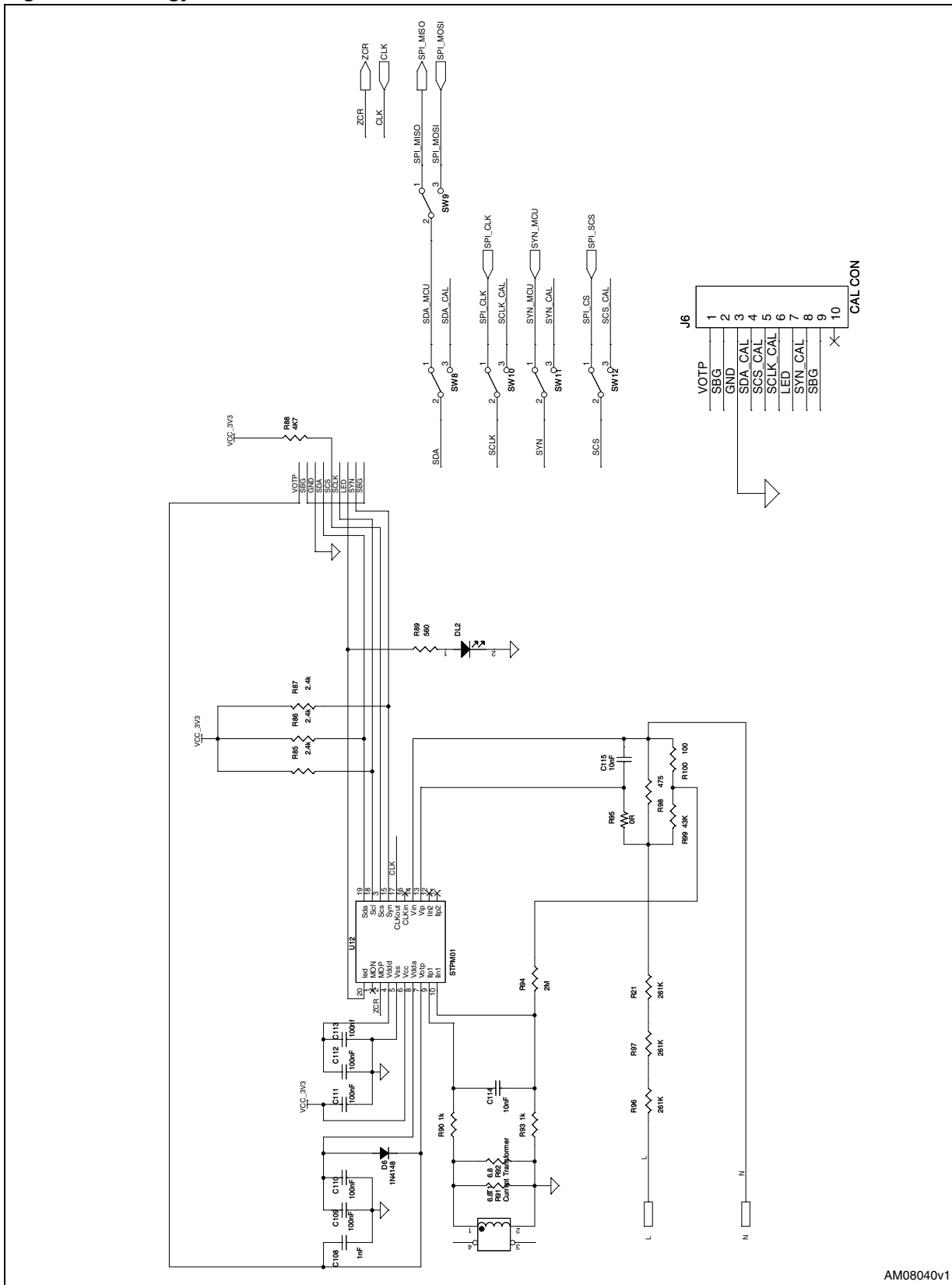


AM08040v1

# Figure 12. Output drivers
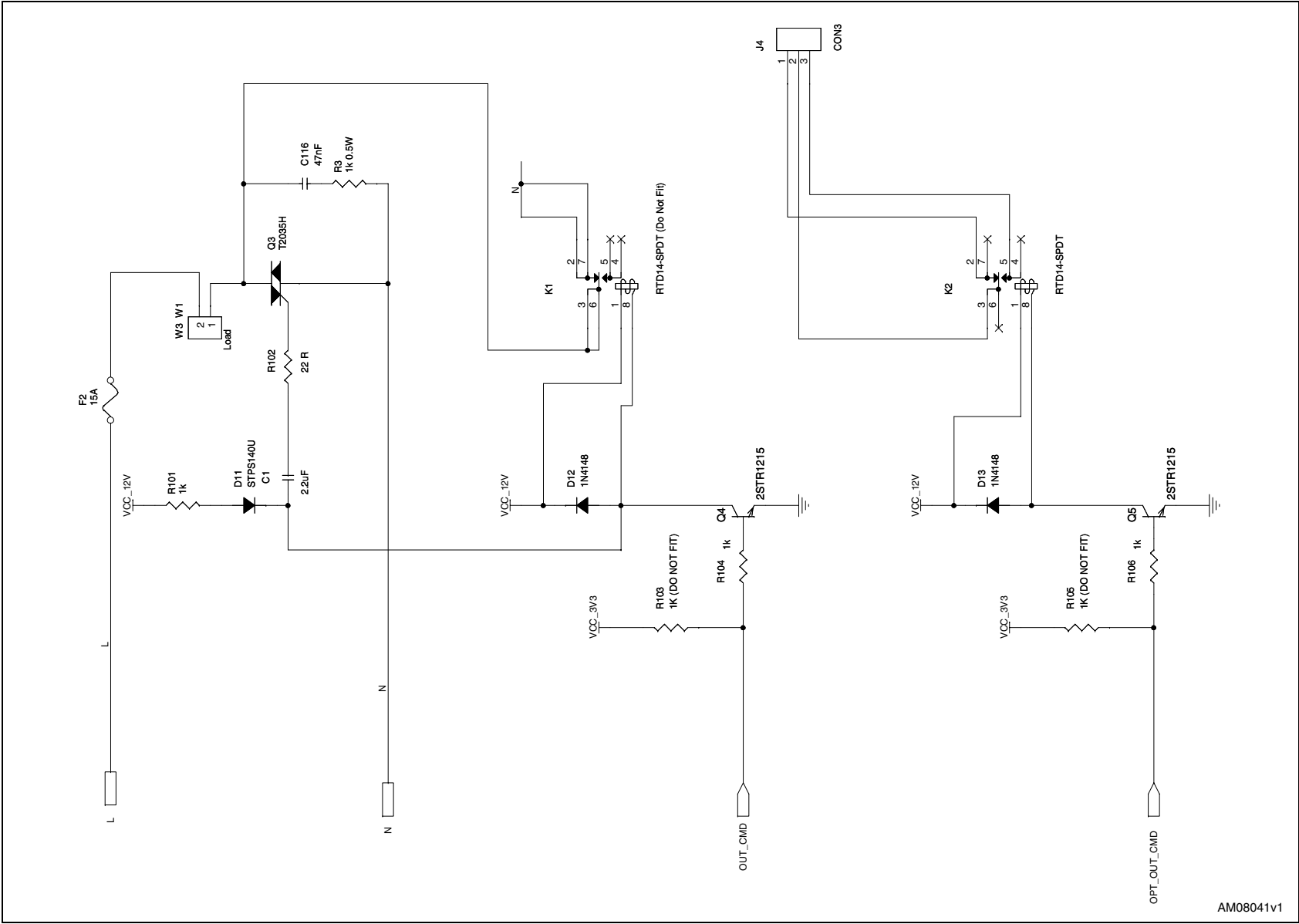
AM08041v1

# 6 Revision history

**Table 7.    Document revision history**

| Date | Revision | Changes |
|------|----------|---------|
| 10-Dec-2010 | 1 | Initial release. |

**Please Read Carefully:**

Doc ID 18008 Rev 1