UM1569
Application note

STEVAL-IHP004V1: SmartPlugW demonstration board

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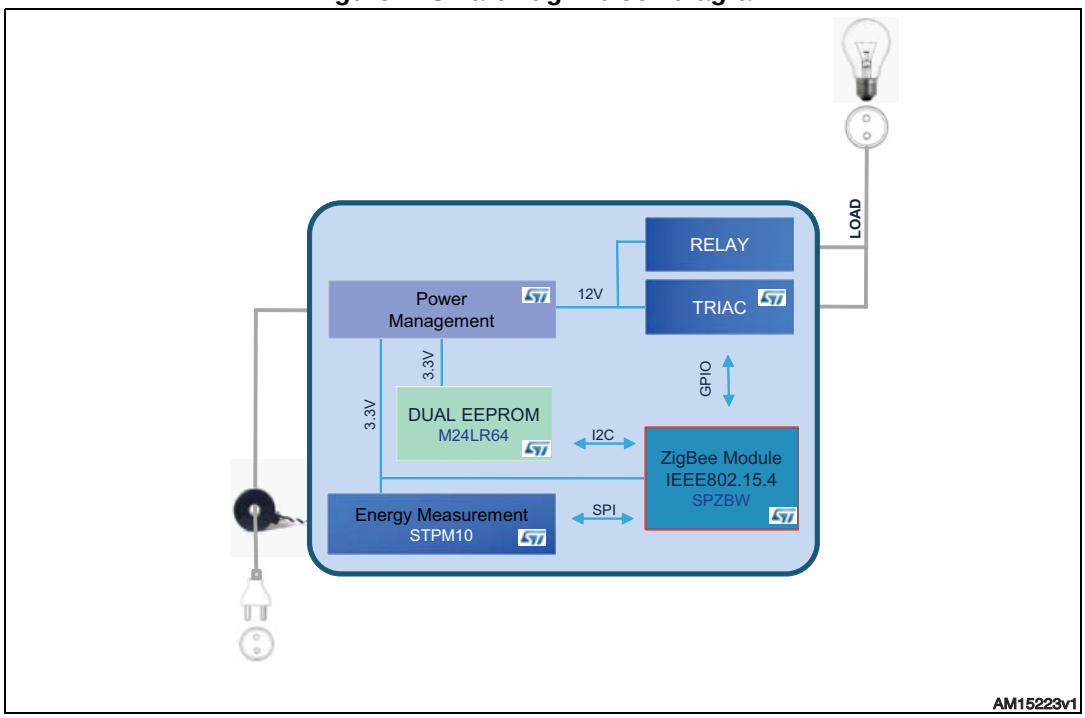
Introduction

This demonstration board is a smartplug based on the STM32W108CB microcontroller integrated into the SPZB32W1A2.1 module, the STPM10 energy metering IC, and the T2035H Triac. The board is a node of an IEEE-802.15.4 network which allows the final user to monitor and manage the energy consumption of the load connected to the SmartPlugW.

The board has been developed to provide a guideline to build an automation subsystem for energy management and is designed to fit the dimensions of a standard box for wall installation and easy integration into the electrical systems of homes or commercial buildings. The current, power, energy and other information related to the electrical load connected to the SmartPlugW board are sent to a data concentrator through the wireless network of a home or building. The board includes the following sections shown in the block diagram of *Figure 1*:

- Energy measurement by the STPM10 IC
- Wireless communication up to 250 kbps by the SPZB32W1A2.1 module
- Data storage by the M24LR64 dual-interface EEPROM
- Power supply by VIPer16
- Load driver with soft-start/stop by T2035H TRIAC and relay

Figure 1. SmartPlugW block diagram



Contents

1 Overview

1.1 Recommended reading

This document describes how to configure and use the SmartPlugW demonstration board. Additional information can be found in the following documents:

- ST device datasheets referenced in this document
- Third-party device datasheets
- AN4139

1.2 Safety precautions

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 tests on the board in which test instruments such as 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.

Warning: STMicroelectronics assumes no responsibility for any consequences which may result from the improper use of this tool

1.3 Getting technical support

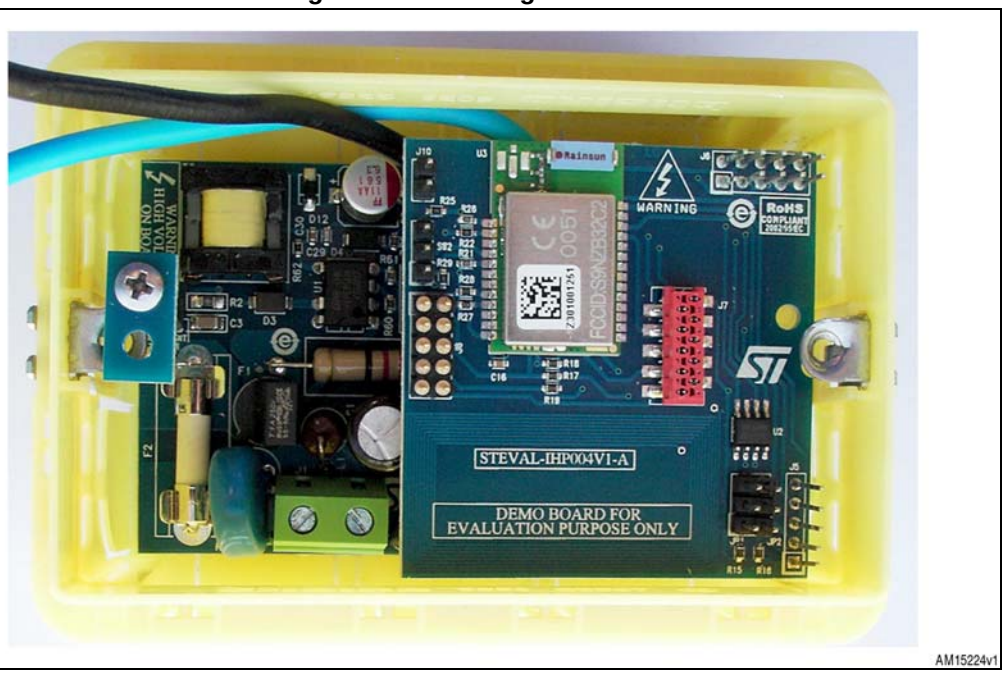
Technical assistance is provided free to all customers. For technical assistance, documentation, upgrades and information about products and services, please contact your local ST distributor/office.

1.4 Package list

The SmartPlugW demonstration kit includes the following items:

- The SmartPlugW demonstration board (*Figure 2*)
- A CD-ROM with software and documentation

Figure 2. SmartPlugW board



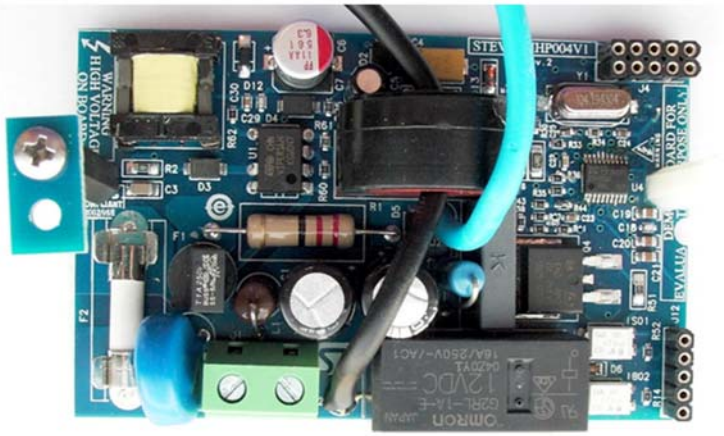
2 SmartPlugW demonstration board components

The SmartPlugW board is composed of three PCB layers as described in the following figures. The bottom layer includes the power supply section, a non-insulated flyback AC/DC based on the VIPer16 controller, the AC load driver, which includes the 16 A relay and the T2035H Triac, and the metrology section based on the STPM10 IC. The middle layer is the digital section including the SPZB32W1A2.1 module and the M24LR64 memory with its antenna. The top layer includes the LEDs and the user buttons and is integrated into the plastic front cover of the wall box. The LEDs are entitled LED1, LED2, LED3 and PWR; the buttons are RST, B1 and B2.

Figure 3. SmartPlugW top

Figure 4. SmartPlugW middle

Figure 5. SmartPlugW bottom



2.1 Microcontroller

The system is managed by the STM32W108CB microcontroller which is embedded in the SPZB32W1A2.1 wireless module. It is based on the 32-bit ARM Cortex -M3 core with 24 MHz maximum frequency, 128 KB flash and 8 KB SRAM embedded memories. It embeds standard peripherals and one dedicated IEEE-802.15.4 2.4 GHz radio peripheral. For further details please refer to the datasheets of the STM32W108CB family. The microcontroller is embedded in the SPZB32W1A2.1 wireless module which includes the 24 MHz crystal for the high-speed STM32W108CB main clock, the 32 kHz crystal to drive the STM32W108CB RTC, all the RF parts and the antenna. The wireless module is already FCC and CE compliant. For detailed information please refer to the datasheets of the SPZB32W1A2.1 family. Some jumpers are connected to the microcontroller GPIOs in order to allow firmware configuration.

2.2 Debugging

Software debugging is via a 10-pin JTAG connection. It is possible to use a 10-pin to 20-pin adapter to use standard 20-pin JTAG tools. The JTAG connector is not insulated, so for debugging use the JTAG opto-insulation board (order code: AIJTAG/OPTO-1/A), a battery-supplied notebook, or supply the board through an insulated AC source. The JTAG connector is shown in *Figure 6*.

Figure 6. JTAG connector

Table 1 shows the pinout of the JTAG connector.

Table 1. JTAG pinout

Pin number	Function
1	3.3 V
2	TMS
3	GND
4	TCK
5	GND
6	TDO
7	N.C.
8	TDI
9	GND
10	nRESET

2.3 Reset

The reset sources are:

- Power-on reset
- JTAG reset from an in-circuit emulator

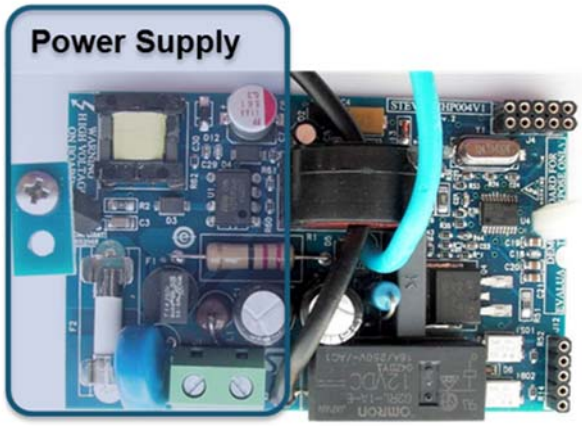
The RST button on the front cover is not connected to the system reset of the board.

2.4 Power supply

The board is powered directly by the mains. It includes a non-insulated extended range power supply and both 50 Hz and 60 Hz frequencies.

The power supply is based on the VIPer16 controller for AC/DC converter; it provides -12 Vdc and 3.3 V supply voltages. The minus 12 V is used to drive the relay and the TRIAC. Using -12 V allows driving the Triac gate without the need of derivative network-reducing noise. The 3.3 V voltage is the regulated output and supplies all the digital parts of the system. Both outputs can provide 150 mA maximum. *Figure 7* highlights the power supply section of the board. The mains can be connected using a screw connector.

Figure 7. Power supply section



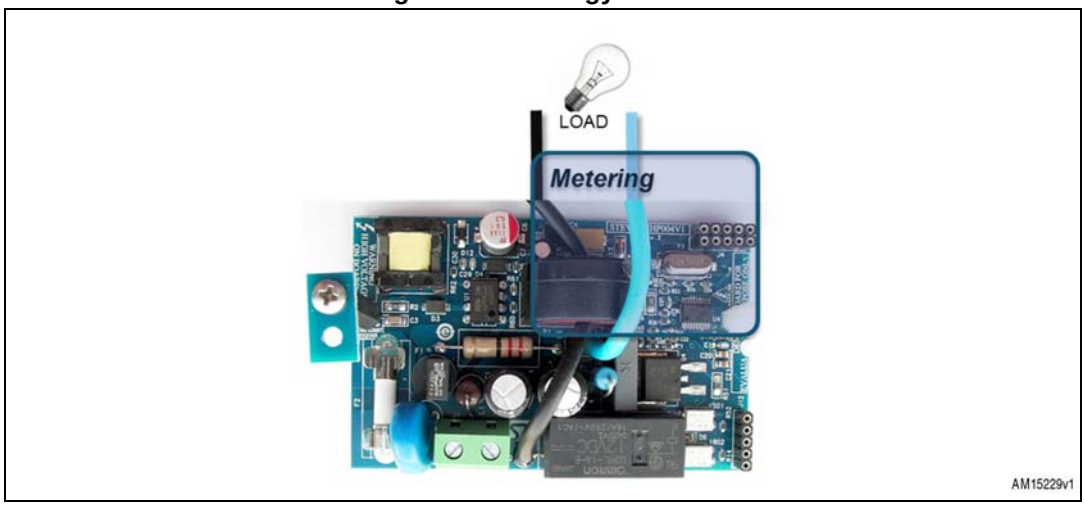
2.5 Wireless communication

The board allows digital data communication through the embedded IEEE802.15.4 2.4 GHz radio of the STM32W108CB microcontroller supporting encryption communication using the AES-128 algorithm. The module is designed to have 3 dBm output power (8 dBm in boost mode) and -99 dBm receiver sensitivity. Moreover, it has a robust coexistence with Bluetooth and WiFi.

2.6 Energy measurement

The energy metering section is based on the STPM10 programmable single-phase energy meter IC. The STPM10 supports 50 to 60 Hz - IEC62052-11, IEC62053-2X specifications with less than 0.1 % error. It is able to measure voltage, current (both instantaneous and RMS), active and reactive energy and voltage frequency. For further details please refer to the STPM10 datasheet. The current sensing is done by the current transformer. The image in *Figure 8* highlights the metrology section of the bottom board and shows the wiring diagram of the AC load.

Figure 8. Metrology section



The STPM10 is controlled by the MCU with an SPI communication bus and digital control line. *Table 2* shows the MCU resource mapping for energy metering IC management.

Table 2. STM32W108CB resources - STPM10 function mapping

STM32W108CB resource	Energy meter function
PC1	SYN
SC1-MISO (PB2)	SDA
SC1-SCLK (PB3)	SCL
PB4	SCS

2.7 Load driver

The board can supply one AC load up to 16 A. The AC load socket is available in the front panel. Please consider that the earth (ground) connector is not wired by default but it can be easily added. The load is driven by both a 16 A relay and a T2035H TRIAC connected in parallel. The Triac is assembled with no heatsink so it can be used for low power (up to 1.5 A) at a maximum temperature of 60 °C, for resistive load dimming, maintaining the relay opened, or for soft on/off when driven together with the relay by a soft on/off algorithm. *Figure 9* highlights the AC load driver section.

Figure 9. TRIAC plus relay section

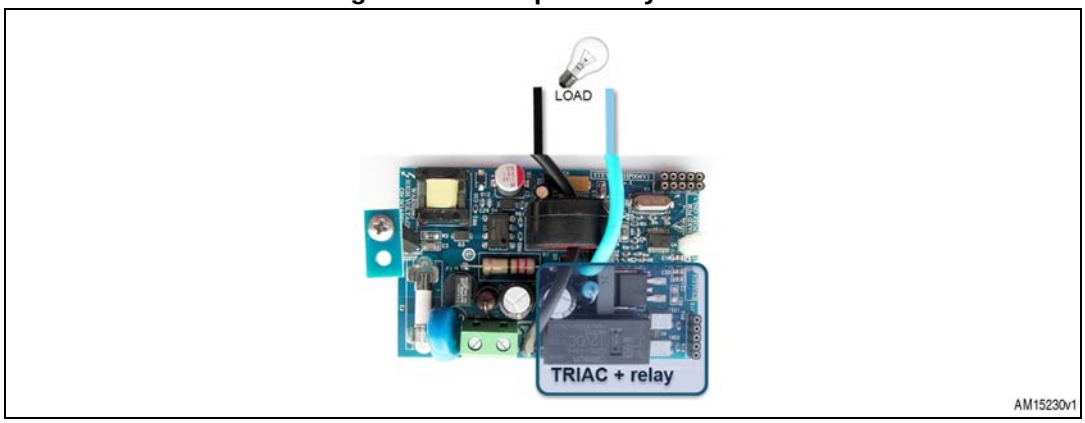


Table 3 shows the STM32W108CB resource mapping to drive the relay and the Triac.

Table 3. STM32W108CB resources - STPM10 function mapping

STM32W108CB resource	Load driver function
PC5	Relay command
PA6	TRIAC gate command
IRQA (PB0)	Zero-crossing

2.8 Local storage

The board includes a M24LR64 dual-interface 64-Kbit EEPROM which can be used for local storage. The EEPROM user memory can be accessed by both the standard I^2C bus (from the MCU) and using one 13.56 MHz ISO-15693 compliant RF reader. Thanks to this technology, the EEPROM can be accessed by the RF interface even if the board is not powered. *Table 4* shows the MCU resource mapping to drive the EEPROM from the I^2C bus side.

Table 4. STM32W108CB resources - EEPROM function mapping

STM32W108CB resource	EEPROM function
SC2-SDA (PA1)	SDA
SC2-SCLK (PA2)	SCL
PA0	Vcc

Since the EEPROM power consumption is compatible with current capability of the STM32W108CB GPIO, it is powered by one GPIO which allows easy reset of the device. The I^2C address is set by two jumpers described in *Section 2.10* connected to the E0 and E1 pin of the EEPROM. The complete address is shown in *Table 5* where E2 must be properly set as described in the M24LR64 datasheet.

Table 5. M24LR64 I^2C address configuration

	Device type identifier				Chip Enable address			$\overline{RW}$
	b7	b6	b5	b4	b3	b2	b1	b0
Device select code	1	0	1	0	E2	E1	E0	$\overline{RW}$

2.9 Status LEDs

Table 6. LED description and STM32W108CB mapping

LED	Description (MCU mapping)
DL1 (green)	3.3 V power supply
D7 (yellow)	General purpose (PA5)
D8 (red)	General purpose (PA7)
D11 (blue)	General purpose (PB6)

2.10 Jumpers

Figure 10. Placement of jumpers

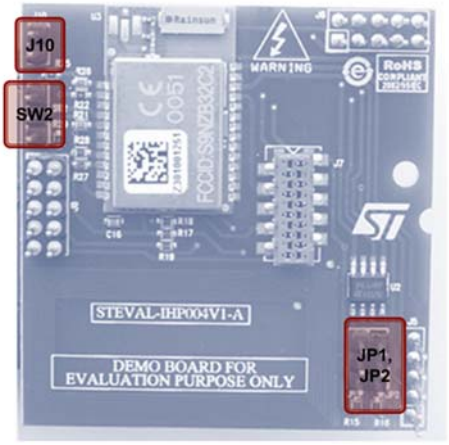


Figure 11. Position of jumpers

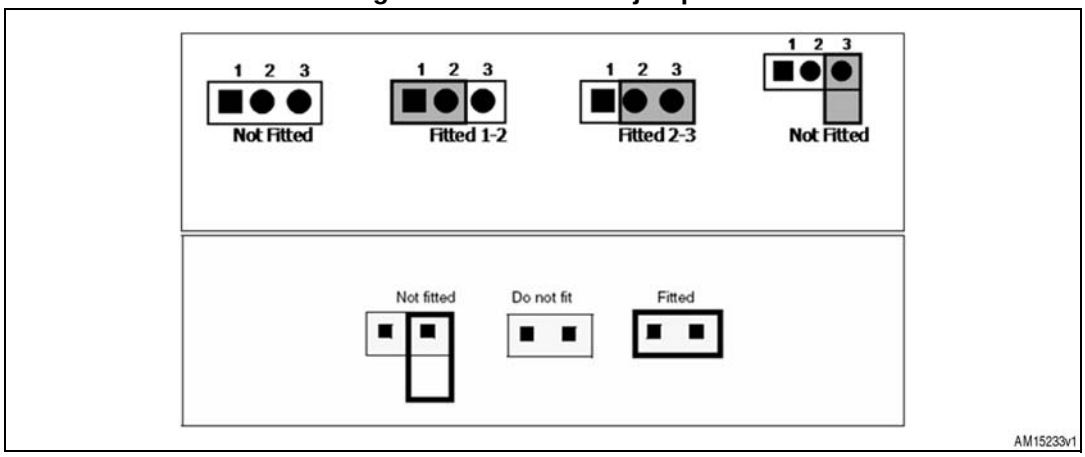
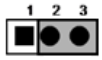


Table 7. Jumper description and default position

Jumper	Description	Default
J10	Boot mode: – Fitted: SRAM boot mode – Not fitted: Flash boot mode	Not fitted 
SW2	General-purpose configuration	Not fitted 
JP1	E0 EEPROM address	Fitted (2-3) 
JP2	E1 EEPROM address	Fitted (2-3) 

2.11 Pushbuttons

Table 8. Pushbutton description

Button	Description (MCU mapping)
SW1 (RST)	Not connected
SW3 (B1)	General purpose (PB5)
SW4 (B2)	General purpose (PB7)

2.12 Connectors

Figure 12. Placement of connectors

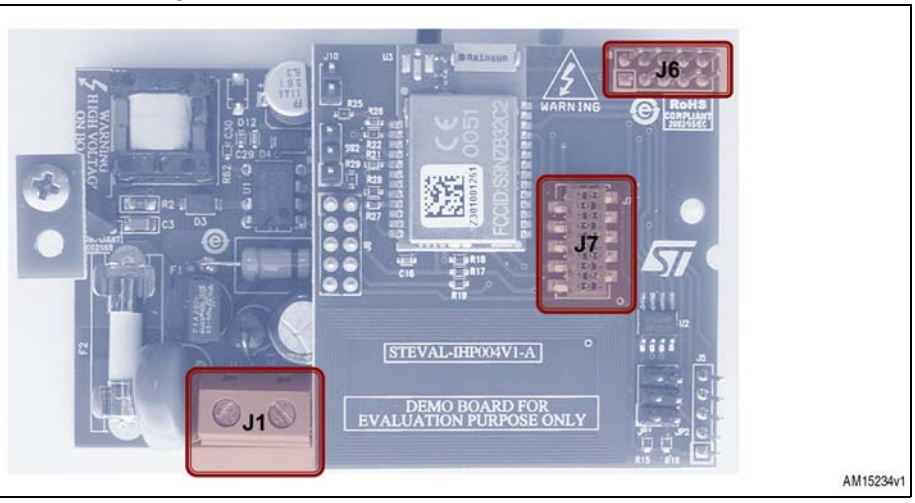


Table 9. Connector description

Connector	Description
J7	Connector to the front panel
J6	STPM10 calibration connector
J1	AC input

2.12.1 STM32 JTAG connector

Figure 13. STM32 10-pin JTAG connector

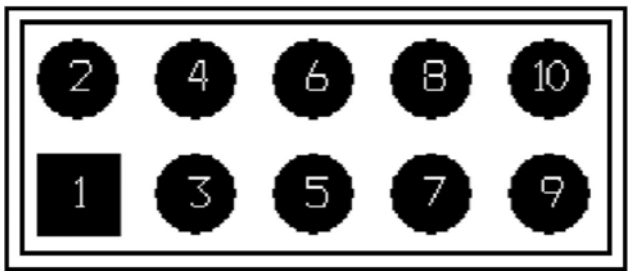


Table 10. JTAG connector - pin description

Pin	Description	Pin	Description
1	VCC	6	TDO
2	TMS	7	N.C.
3	GND	8	TDI

Table 10. JTAG connector - pin description (continued)

Pin	Description	Pin	Description
4	TCK	9	GND
5	GND	10	Reset

2.12.2 Energy meter IC calibration connector

Figure 14. Energy meter calibration connector

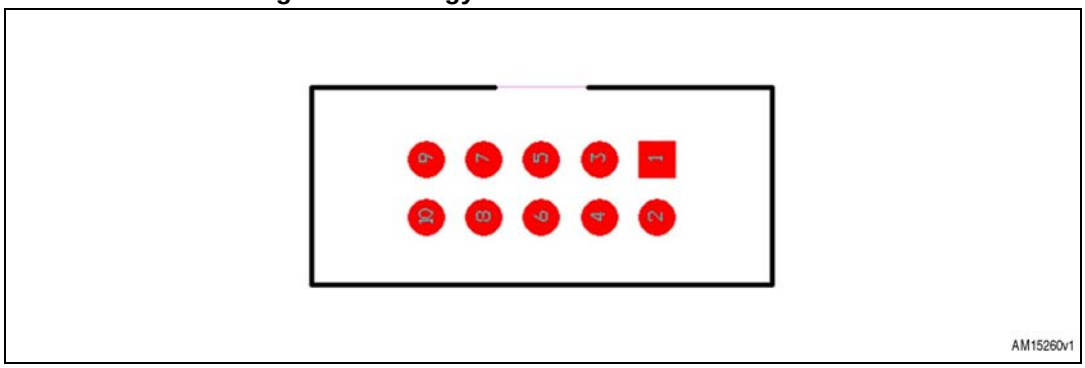


Table 11. Energy meter calibration connector - pin description

Pin	Description	Pin	Description
1	VCC	6	TDO
2	TMS	7	N.C.
3	GND	8	SYN_CAL
4	TCK	9	SBG
5	GND	10	Not connected

3 Schematics

Figure 15. Bottom board schematic

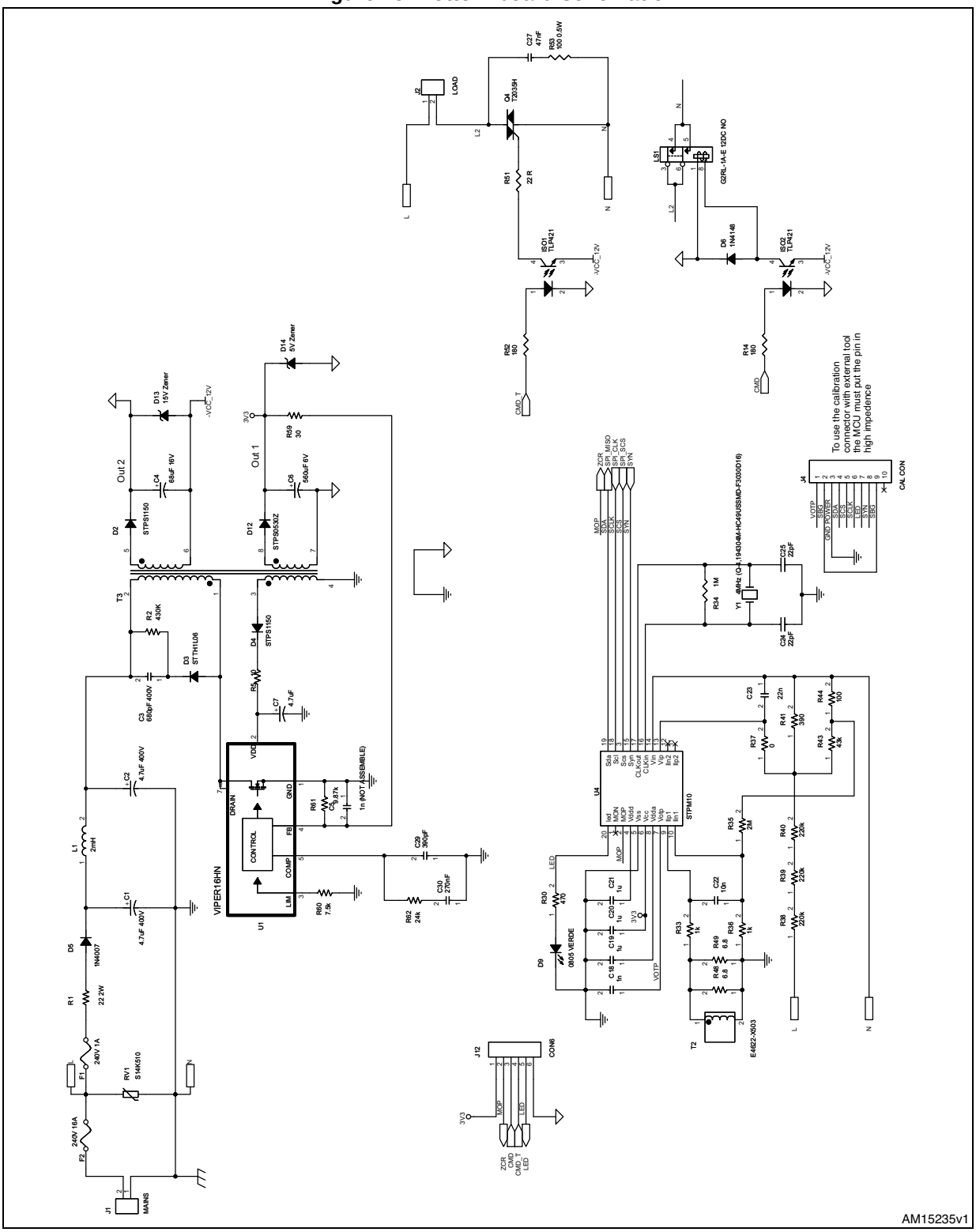


Figure 16. Middle board schematic

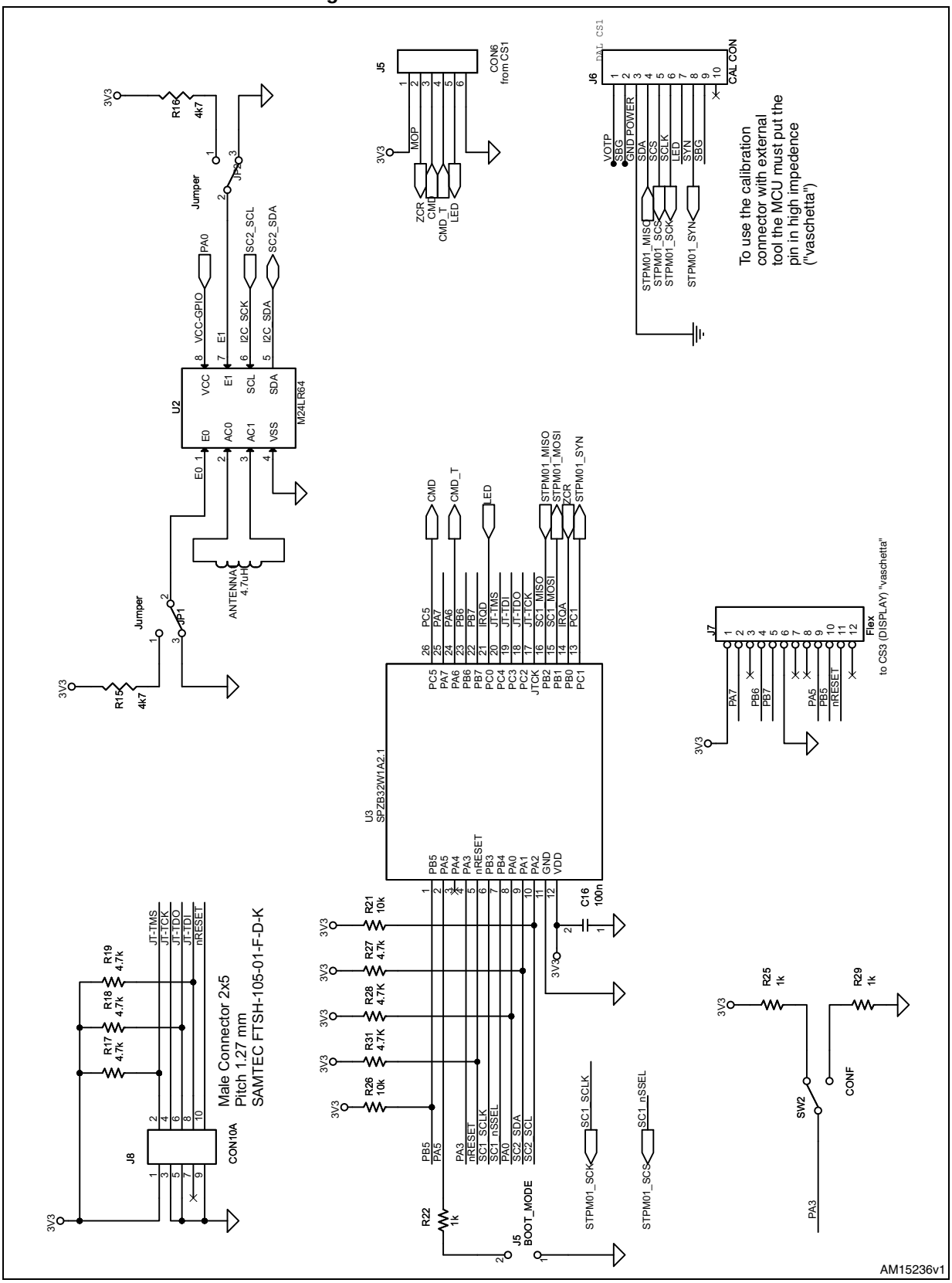


Figure 17. Front panel schematic

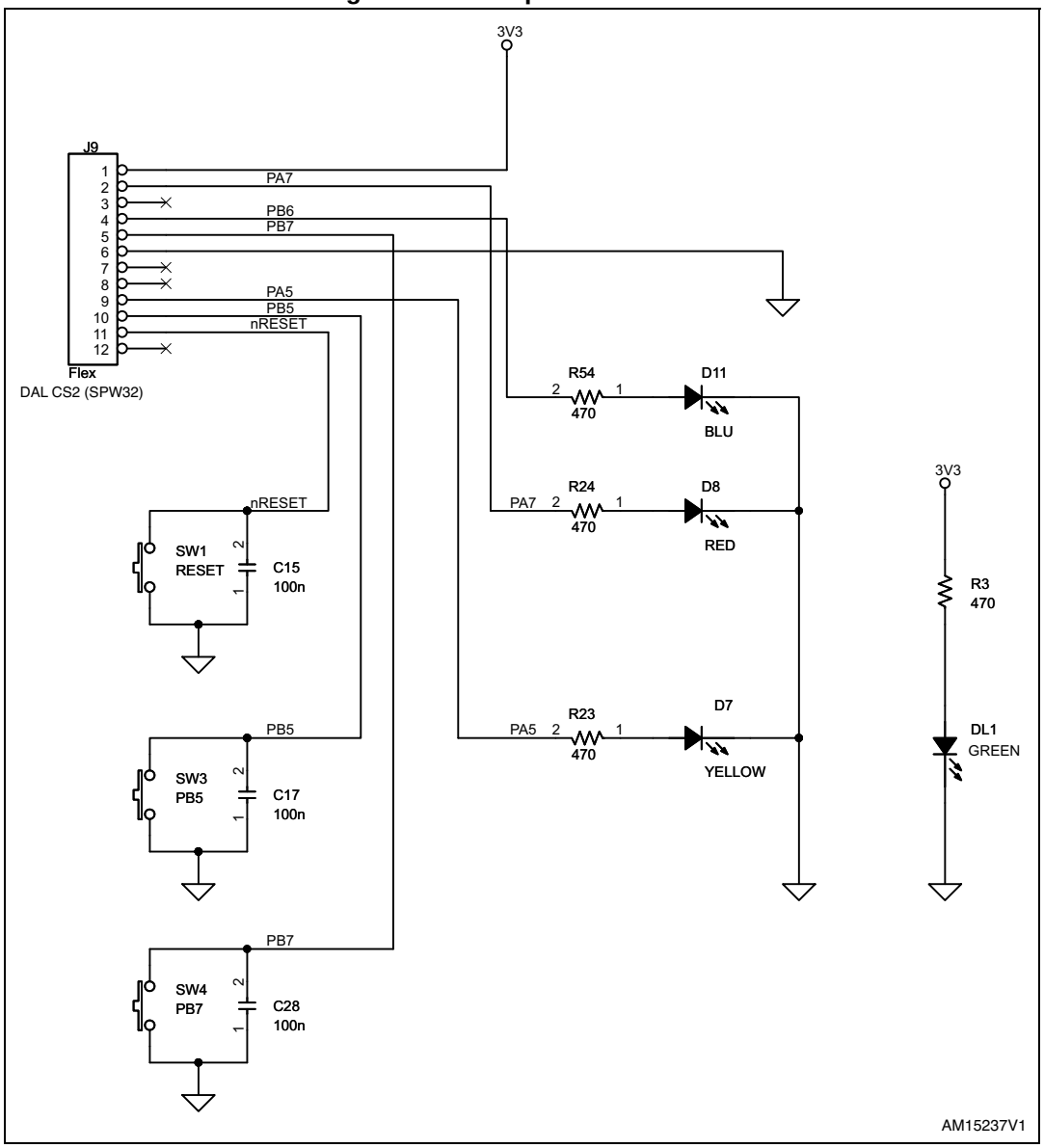
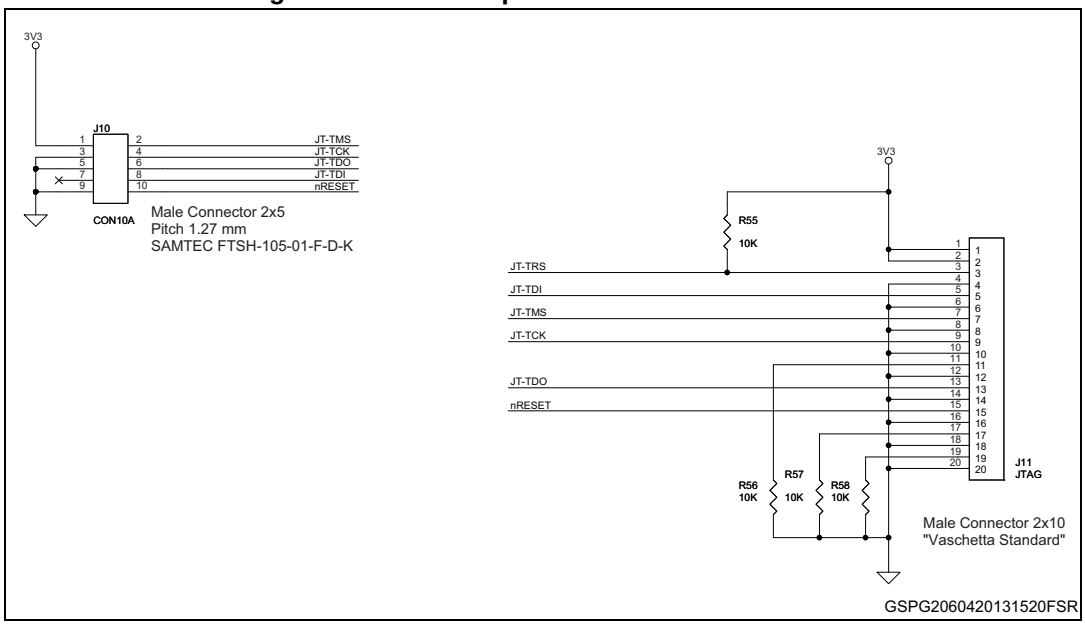


Figure 18. JTAG adapter connectors schematic



4 Bill of material

Table 12. BOM

Reference	Order code	Description	Retailer/dealer device code
D6	DH05-0192-A	D LL4148 MINIMELF	
D9	DH05-0313-A	DL HSMG-C170 0805 GREEN	
D5		D 1N4007 1A 1000V DO214BA	RS 629-2299
DL1		LED 3mm L934SGC green/transparent	RS 247-1606
D7		LED 3mm L934SYC yellow/transparent	RS 247-1612
D8		LED 3mm L934SRCG red/transparent	RS 247-1656
D11		LED 3mm L934MBC blu/transparent	RS 247-1628
D3		D STTH1L06A ST SMA	RS 485-8500
D2,D4		D STPS1150 ST SMA	RS 249-864
D12		D STPS0530Z ST SOD123	RS 250-268
D14		D Zener 5 Volt minimelf	
D13		D Zener 15 Volt minimelf	
Q4		TRIAC T2535-600G D2PACK	RS 687-1025 Altern. PN: TRIAC T2035H TO220
U1		IC VIPER16HN ST DIP16	RS 686-8455
U2		IC M24LR64 SO8	FA 1794173 – DK 497-10486-1-ND
ISO1,ISO2		IC TLP421 DIP4	RS 505-7118
U4	CL	IC STPM10 TSSOP20 ST	
U3	CL	IC SPZB32W1A2.1	
C4		CCT 68µF 16V - SMD 2917 (7343)	FA 1219096 - DK 399-4703-1-ND
C3		CCC 680PF 500V X1206 501R18W681KV4E	FA 1886027 – DK 709-1282-1-ND
C1,C2	DH10	CEL 4.7uF 400V 20% D10 H16 P5 TH	RS 3654745
C6		CEL 560µF 6.3V 8x11 SMD	RS 714-9464
C7		CEL 4.7µF 35V 5X11 TH	RS 711-1223
C18	DH09-0444-A	CCC 1nF 50V 10% X0603	
C24,C25	DH09-0468-A	CCC 22pF 50V 5% N0603	FA 498543
C22	DH09-0508-AF	CCC 10nF 50V 10% X0603	
C15,C16,C17,C28	DH09-0516-A	CCC 100nF 50V 10% X0603	FA 1288255
C19,C20,C21	DH09-0533-A	CCC 1µF 25V 10% X0805	FA 1907348

Table 12. BOM (continued)

Reference	Order code	Description	Retailer/dealer device code
C23	DH09-0511-A	CCC 22nF 50V 10% X0603	RS 624-2452
C29		CCC 390pF 50V 10% X0603	RS 723-5916
C30		CCC 270nF 16V 10% X0603	FA 1865526 – DK 399-4913-1-ND
C27		CPOL 47nF 300V 18x5x11 TH	RS 441-9600
RV1		VAR S14K510 510V D14 P7.5 EPC	DK S14K510-ND DK: 495-4298-ND
R2		CCR 430K 1% 0805	RS 6980283
R3 R23 R24 R30 R54		CCR 470R 1% 0603	RS 740-8868
R5		CCR 10R 1% 0603	RS 678-9695
R14 R52		CCR 180R 1% 0603	RS 678-9841
R15 R16 R17 R18 R19 R27 R28		CCR 4.7K 1% 0603	RS 740-8956
R21 R26 R55 R56 R57 R58		CCR 10k 1% 0603	RS 740-8892
R22 R25 R29 R33 R36		CCR 1k 1% 0603	RS 213-2266
R34		CCR 1M 1% 0603	RS 678-9932
R35		CCR 2M 1% 0603	RS 679-0169
R37		CCR 0R 1% 0603	RS 740-8870
R38 R39 R40		CCR 220k 1% 0603	RS 213-2581
R41		CCR 390 1% 0603	RS 213-2424 Avnet
R43		CCR 43k 1% 0603	RS 679-0386
R44		CCR 100R 1% 0603	RS 213-2143
R48,R49		CCR 6R8 1% 1206	RS 617-8698
R51		CCR 22R 1% 0603	RS 679-0018
R59		CCR 30R 1% 0805	RS 679-1260
R60		CCR 7.5K 1% 0603	RS 679-0702
R61		CCR 10K 1% 0603	RS 7408892
R62		CCR 24K 1% 0603	RS 679-0046
R1		RES 22R 5% 2W D3 L9 P12.5 TH	RS 131-946
R53		RES 100R 0.5W TH 5%	RS 707-8142
LS1		G2RL-1A-E 12DC NO	FA 1695877 - DK Z2924-ND
L1		IND 2mH 0.25A TH	FA 1644329
Y1		XTAL 4MHz Q-4,194304M-HC49USSMD-F3030D16	RS 226-1550 – Required 7x4 SMD

Table 12. BOM (continued)

Reference	Order code	Description	Retailer/dealer device code
T2		Transformer T60404-E4622-X002 SISRAM	SISRAM
T3		1801.004 REV1	MAGNETICA
F1		FUSE 240V 1A MST785210 OMEGA	OMEGA
F2		FUSE 240V 16A GT520316 OMEGA	OMEGA
PF2		PFUSE PZ1006 Omega Alt Farnell 146-123	OMEGA
PF1		Omega c7850	
JP1 JP2	DH29-0013-A	JMP L4.8W2.54H5.0 P2.54	
J4 J12	DH20-0117-B	CONN 801-83-050-10-001101 F H7MM PDIP	
J8 J10 SW2 JP1 JP2	DH20-0174-A	STRIP M 1X40PIN DIR P2.54 T6/2.5/B3.0 SN	
J1		CNN 750V 20A P7.5 FA 3882573	Wurth 691 217 910 002
J5 J6		Strip 50way Pcb Stacker 36.32mm (reduce the Hights)	RS 277-9758
J7 (CS2), J9 (CS3)		CNN 10P F P1.27 SMD 8-188275-0 AMP	FA 3784745 Wurth 690 367 281 076
Flex		CNN 10P M P1.27 FLEX 8-215083-0 AMP	FA 149081 Wurth 690 157 001 072
SW1 SW3 SW4		RESET	
	DH29-0030-A	Spacer M3 F/F h40mm Polyamide	
	DH29-0055A	Flate washer - Nylon 6.6 M3 Box 50	RS 525739
	DH29	Cylindrical screw - Nylon M3x12mm Box 100	RS 527-987
	DH29	Gauge M3x25mm Box 50	RS 325-716
	DH29	M-F NYLON SPACER,M3X10MM Box50	RS 325-687
	DH29	SCREW INOX 2,9X6,5MM TCTF	Ferramenta Ferrero Caselle
Bezel + Screws		Mask + Screws - Living Art L4803 BLACK BTicino	Veglio Aldo Elettricita' - Illuminazione
Chassis		Chassis - Living Art L4703 BTicino	Veglio Aldo Elettricita' - Illuminazione

5 References

- SPZB32W1A2.1 module datasheet
- STM32W datasheet
- T2035H datasheet
- STPM10 energy metering IC datasheet
- AN4139

6 Revision history

Table 13. Document revision history

Date	Revision	Changes
26-Mar-2013	1	Initial release.