UM0608
User manual

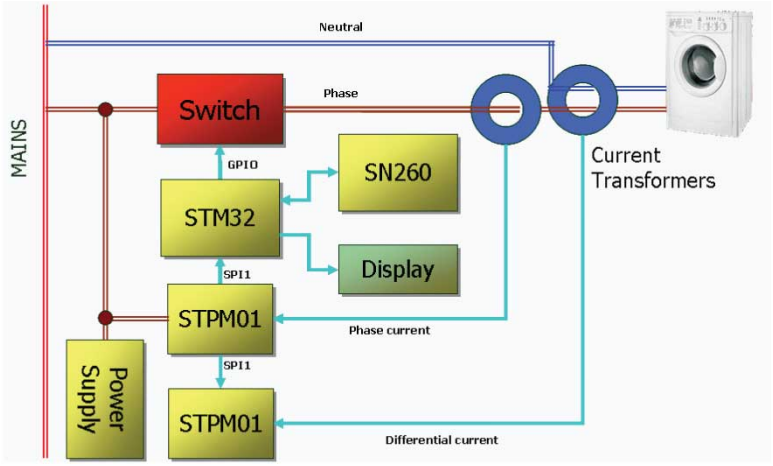
ZigBee® smartplug board STEVAL-IHP001V2

Introduction

The ZigBee® smartplug board can be used as a guide to build a home/building automation subsystem for energy management. In a typical application, the board is plugged into an electrical wall socket and supplies an electrical load, monitoring the energy consumption; using several smartplugs it is possible to monitor and control the home/building energy consumption socket by socket. The board includes the following functions shown in the block diagram of *Figure 1*:

- Energy measurement
- Load differential current
- Load driving by relay or TRIAC (dimming)
- ZigBee® communication capability

Figure 1. Block diagram



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1 Overview

1.1 Recommended reading

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

- STMicroelectronics device datasheet
- third party device datasheet
- dedicated application notes
- ZigBee® smartplug firmware user manual

1.2 Safety precautions

The ZigBee® smartplug board must only be used by expert technicians. Due to the high voltage (220 Vac) special care should be taken in regard to human safety.

There is no protection against accidental high voltage contact.

After disconnecting 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 like 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: ST assumes no responsibility for any consequences which may result from the improper use of this device.

1.3 Getting technical support

Technical assistance is provided free of charge to all our customers. For technical assistance, documentation, information and upgrades for products and services, please refer to your local STMicroelectronics distributor/office.

1.4 Package checklist

The ZigBee® smartplug kit includes the following items:

- the ZigBee® smartplug board
- CD-ROM with software and documentation

2 ZigBee® smartplug components

2.1 Microcontroller

The system is managed by the STM32F103Rx microcontroller. It is based on the 32-bit ARM Cortex M3 core with a 72 MHz maximum frequency, 128 KB flash and 20 KB SRAM embedded memories. For further details please refer to the STM32F103xx performance-line datasheet.

2.2 Debug

Software debug is via a standard 20-pin JTAG connection. The JTAG connector is not isolated, so for debugging use the JTAG opto-isolation board (order code: AI-JTAG/OPTO-1/A) or a battery supplied notebook.

2.3 Reset

The reset sources are:

- power on reset
- push button reset
- JTAG reset from an in-circuit emulator.

2.4 Power supplies

The board is powered directly by the mains. It includes a not-isolated extended range power supply validated in the 88 - 256 Vac range and both 50 Hz and 60 Hz frequencies.

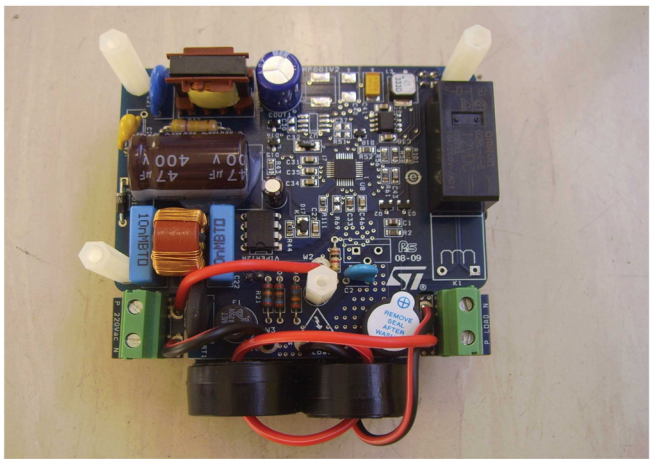
The power supply consists of an AC-DC and a DC-DC stage. The AC-DC is based on a VIPer12 and provides 12 Vdc with a 70 mA maximum current. The DC-DC stage is based on a PM6680 and provides both 5 Vdc and 3.3 Vdc with a 250 mA maximum current for each output. The 5 Vdc voltage is not necessary for board functionality (it is added only as reference and all components related to this output are not fitted in the default configuration).

2.5 Energy meters

The energy meter section is based on two STPM01 programmable single phase energy meter ICs. The STPM01 supports 50-60 Hz - IEC62052-11 and IEC62053-2X specifications with less than 0.1% error. For further details please refer to the STPM01 datasheet. The current sensing for each STPM01 is done by current transformers.

One STMP01 is used for load energy consumption monitoring by the measurement of the phase current: only the phase wire goes through the current transformer hole. The second STPM01 is used for load differential monitoring: this is possible if both phase and neutral wires go through the second current transformer. Both STPM01s must, of course, measure the mains voltage. The wiring diagram is shown in *Figure 2*.

Figure 2. Load wiring diagram



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2.6 Load drivers

The smartplug can supply 110/230 Vac - 50/60 Hz mono-phase resistive load with 16 A maximum current. It offers two different options to drive the load:

- ON/OFF by a relay
- dimming by TRIAC.

ON/OFF is the default configuration. The choosing of the configuration is done by changing the fitted component into the output section of the board as described in the following:

- ON/OFF configuration: fit only R5, Q2, D1, k1, C2, R3
- dimming configuration: fit only R5, Q2, R1, C1, R2, Q1, C2, R3

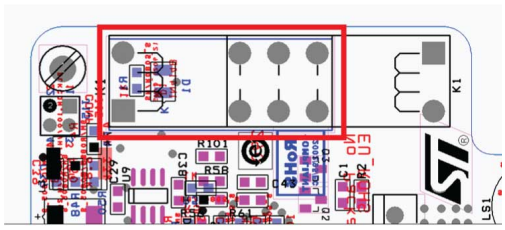
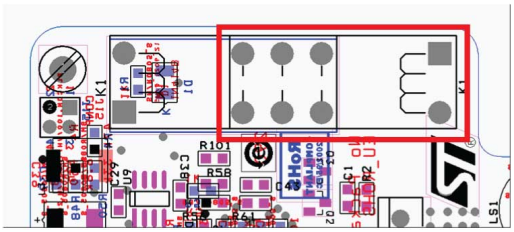
Moreover, as far as the ON/OFF configuration is concerned, depending on whether R4 is fitted or not and the fitting orientation of the relay, it is possible to have the output contacts as:

- normally opened (N.O.)
- normally closed (N.C.)

The following table summarizes the several options:

The red rectangle indicates the relay position related to the picture of the board detail where the relay is fitted.

Table 1. Relay position

Relay position	Figure	R4 fitted	R4 not fitted
Relay position 1	 AM01800v1	N.O.	N.C.
Relay position 2	 AM01815v1	N.C.	N.O.

2.7 ZigBee® module

The ZigBee® smartplug communication is based on the SPZB260 module with the DIL adapter. The module is FCC compliant (FCC ID:S9NZB260A). The module is based on the SN260 ZigBee® network processor which integrates a 2.4 GHz, IEEE 802.15.4 compliant transceiver as well as IEEE 802.15.4 PHY and MAC. The main features are:

- 0dBm nominal TX output power
- -92dBm RX sensitivity
- +2dBm TX output power in boost mode
- RX filtering for co-existence with IEEE 802.11g and Bluetooth devices

For further details please refer to the SPZB260 module and the SN260 network processor datasheet.

2.8 Temperature sensor

The board includes a temperature sensing section based on the STLM75 IC. It can measure temperatures in the range of -55 °C to +125 °C with ±2 °C accuracy in the range -25 °C to +100 °C. It is managed by an I^2C communication bus For detailed information please refer to the STLM75 datasheet.

2.9 Buzzer

The board includes a buzzer with a 4 kHz frequency and an 85 dB sound level.

2.10 Display

The board includes connectors (J5 and J7) to optionally fit a 2.4" 240x320 RGB TFT LCD display which is not included in the package but can be ordered as a spare part for the STM32-EVAL board with the following order code; MB542.

2.11 Status LEDs

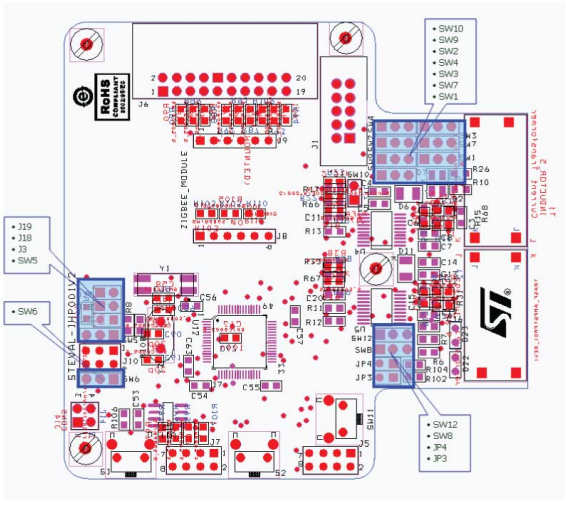
Table 2. LED description

LED	Description
D2	Energy measurement STPM01 status LED
D22	General purpose
D23	General purpose
D7	Differential current measurement STPM01 status LED

2.12 Jumpers

2.12.1 Jumper placement

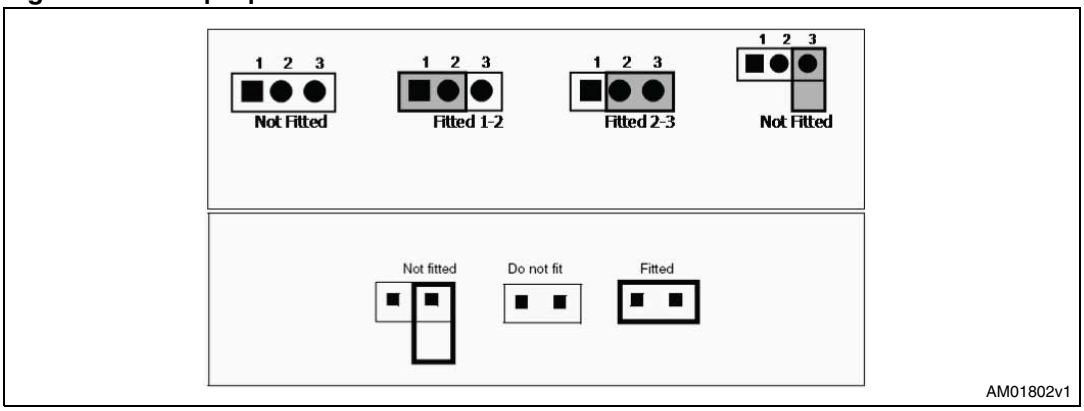
Figure 3. Jumper placement



AM01801v1

2.12.2 Jumper positions

Figure 4. Jumper positions



2.12.3 Jumper description and default value

Table 3. Jumper description

Jumper	Description	Default
J18	Software configuration – Fitted: LCD used – Not fitted: LCD not used	Fitted
J19	Software configuration – Fitted: DIMMING configuration – Not fitted: ON/OFF configuration	Not fitted
J3	Enable running mode (normal/calibration) – Fitted: running mode enabled – Not fitted: running mode disabled	Fitted
SW5, SW6, SW4, SW9, SW7, SW8	Running-mode configuration – Fitted (1-2): normal mode – Fitted (2-3): calibration mode	Fitted (1-2)
SW10, SW1, SW2, SW3	STPM01 meter selection for calibration – Fitted (1-2): energy meter – Fitted (2-3): differential current meter	Fitted (1-2)
SW12	SPI communication option – Fitted (1-2): MISO used for data – Reading managed by SPI peripheral – Writing emulated by GPIO – Fitted (2-3): MOSI used for data – SPI in simplex mode	Fitted (1-2)

Table 3. Jumper description (continued)

Jumper	Description	Default
JP3	Enable LED D22 – Fitted: enabled – Not Fitted: disabled	Fitted
JP4	Enable LED D23 – Fitted: enabled – Not fitted: disabled	Fitted

3 Push-button description

Table 4. Push-button description

Switch	Description
S1	General purpose button
S2	General purpose button
SW11	Reset button: – when pushed force MCU reset

3.1 Connector description

Figure 5. Connector position

Table 5. Connector description

Connector	Description
J6	JTAG connector for debugging
J5, J7	TFT LCD connector
J1	SPI ISKRA EMECO connector for STPM01 meters calibration
J10	Optional 6 analog channel connector

3.2 Mains and AC load connection

Both AC supply from mains and AC load are connected directly by wire to easily connect a standard mains plug and socket. *Figure 6* shows the AC mains and AC load connection points.

Figure 6. Mains and AC load connection positions

4 Connectors

4.1 Debug connector

Figure 7. Debug connector

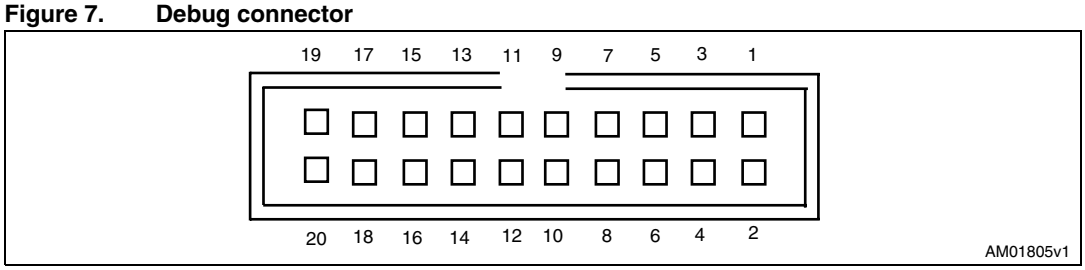


Table 6. Debug connector description

Pin	Description	Pin	Description	Pin	Description
Even pins	Ground	5	TDI	13	TD0
1	VTref + 3.3 V	7	TMS	15	Not reset
2	Vsupply +3.3 V	9	TCK	17	DBGRQS - pulled down
3	Not TRST	11	RTCK (ground)	19	Pulled down

4.2 ISKRA EMECO calibration connector

Figure 8. ISKRA EMECO connector

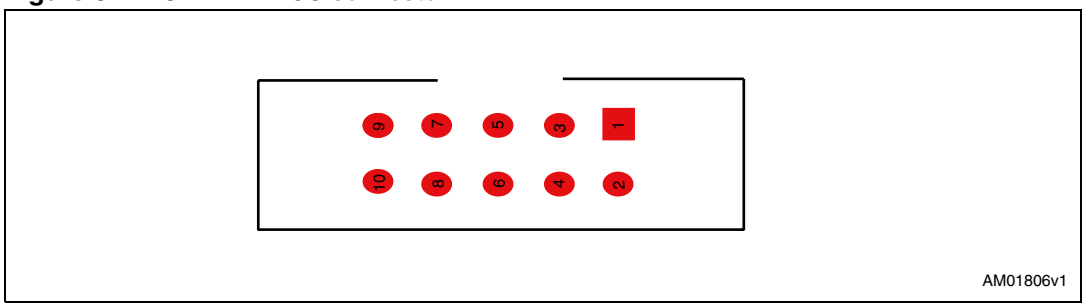


Table 7. ISKRA EMECO connector description

Pin	Description	Pin	Description
1	VOTP	6	SCLK
2	SBG	7	LED
3	GND	8	SYN
4	SDA	9	SBG
5	SCS	10	N.C.

5 STPM01 meter calibration

5.1 Board setup

The board must be properly configured before starting meter-calibration operations. The STPM01 must be calibrated separately, configuring the jumpers in such a way to select the board calibration mode and the right meter to calibrate, according to *Table 3*.

5.2 Procedure

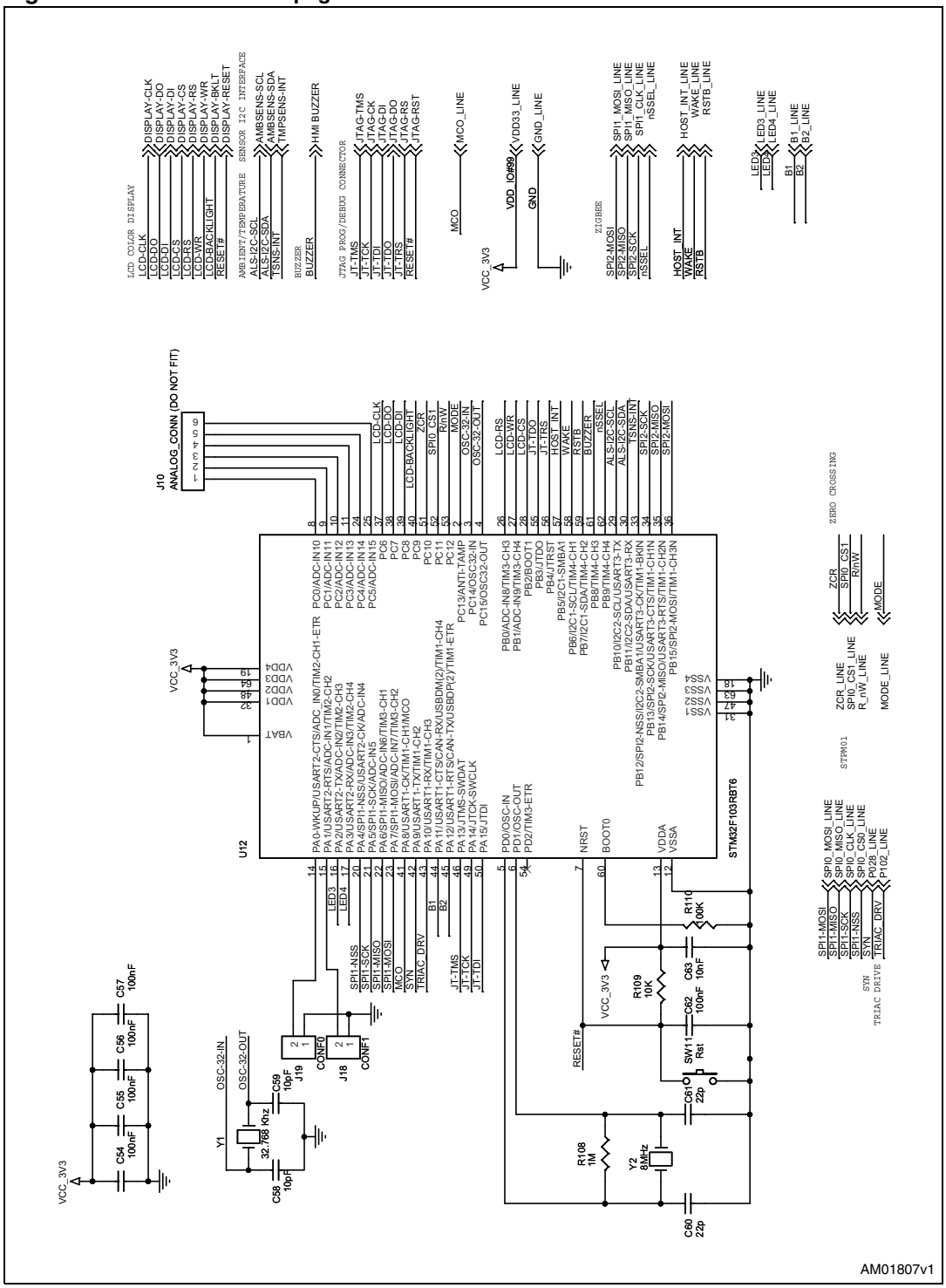
For detailed information about the STPM01 calibration procedure, please refer to STPM01 specific documentation and the following documents for operation theory:

- AN2299 - fast digital calibration procedure for STPM01 based energy meters

6 Smartplug board schematics and bill of material

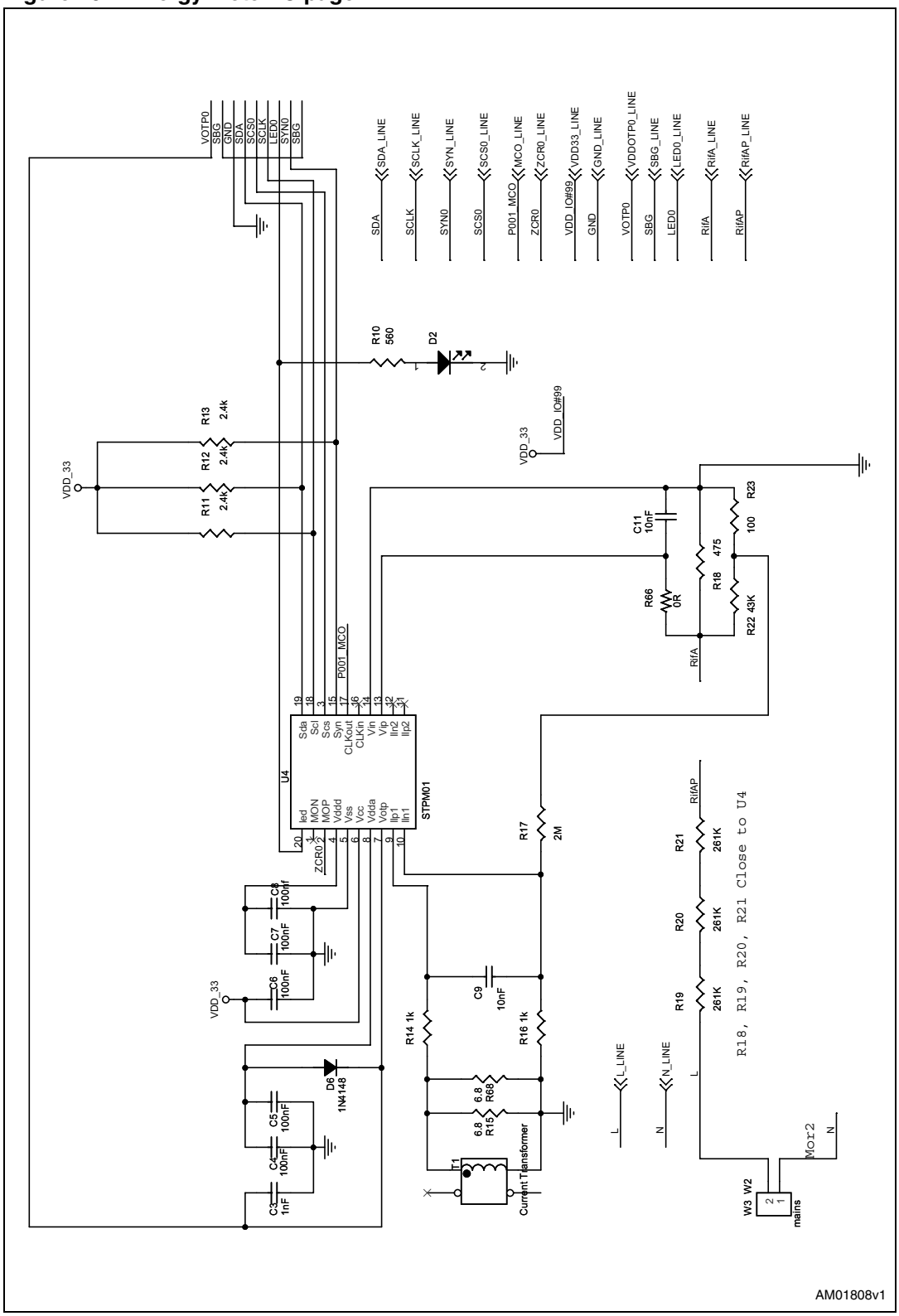
6.1 Microcontroller

Figure 9. Microcontroller page



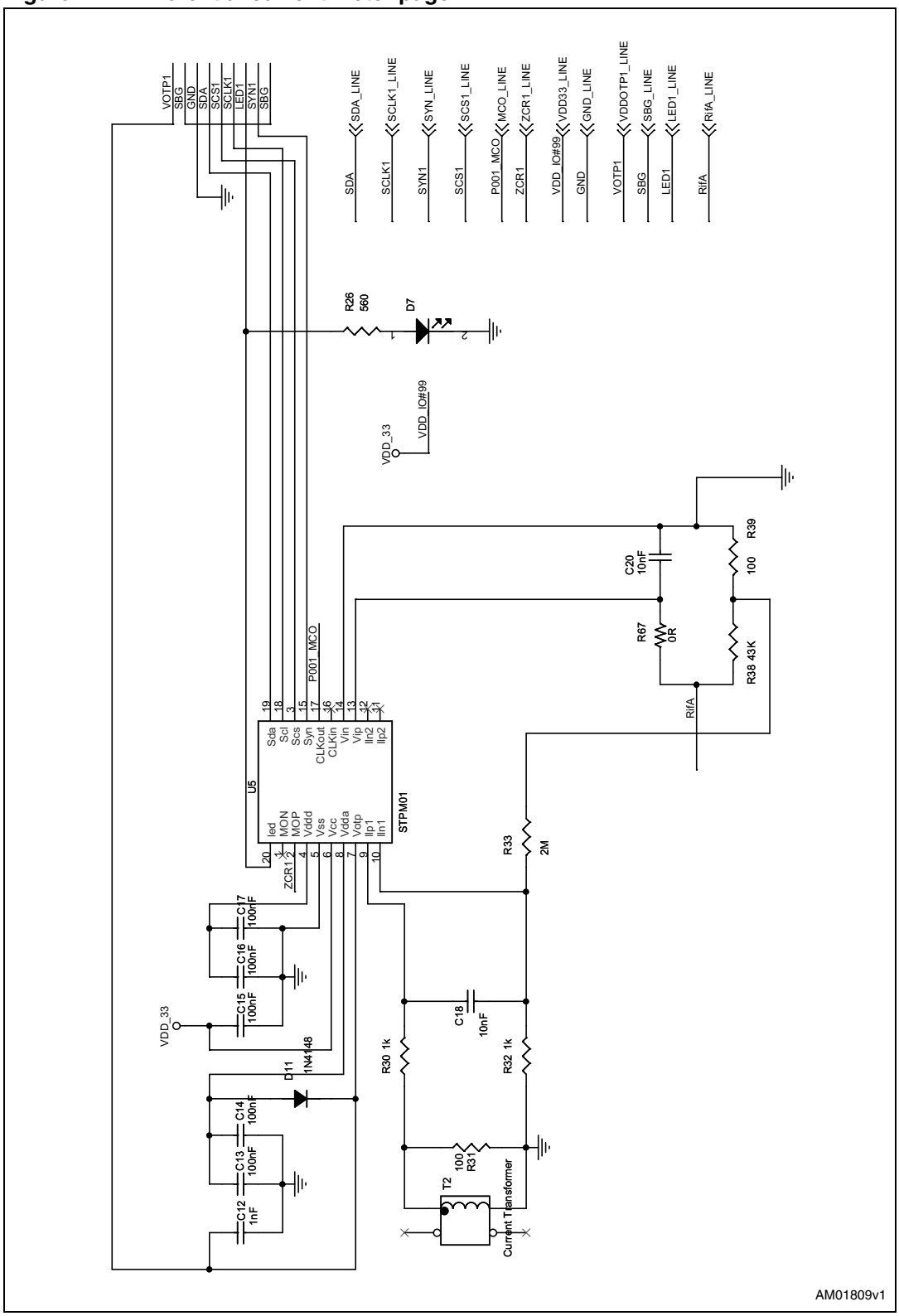
6.2 Energy consumption meter

Figure 10. Energy meter IC page



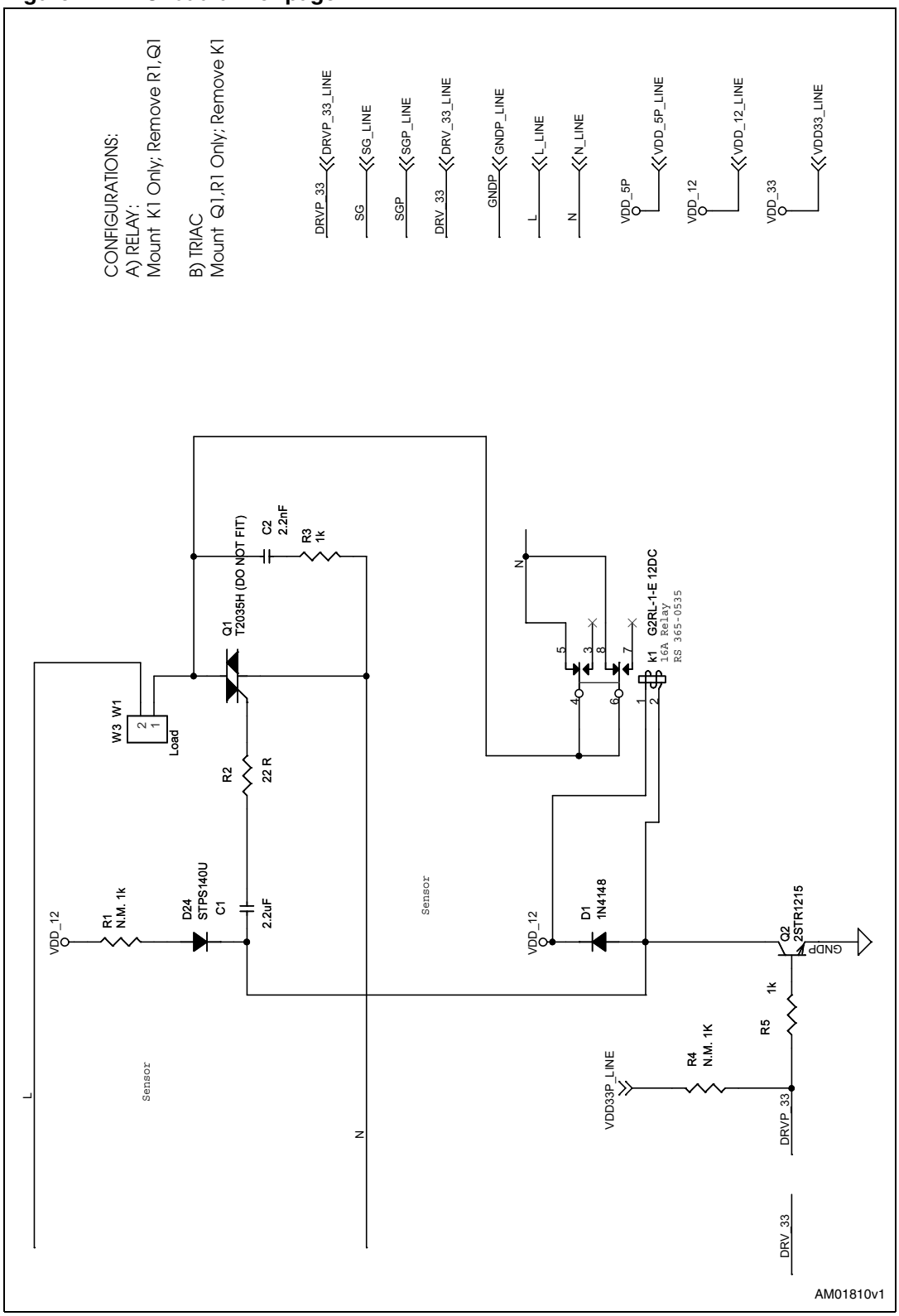
6.3 Differential current meter

Figure 11. Differential current meter page



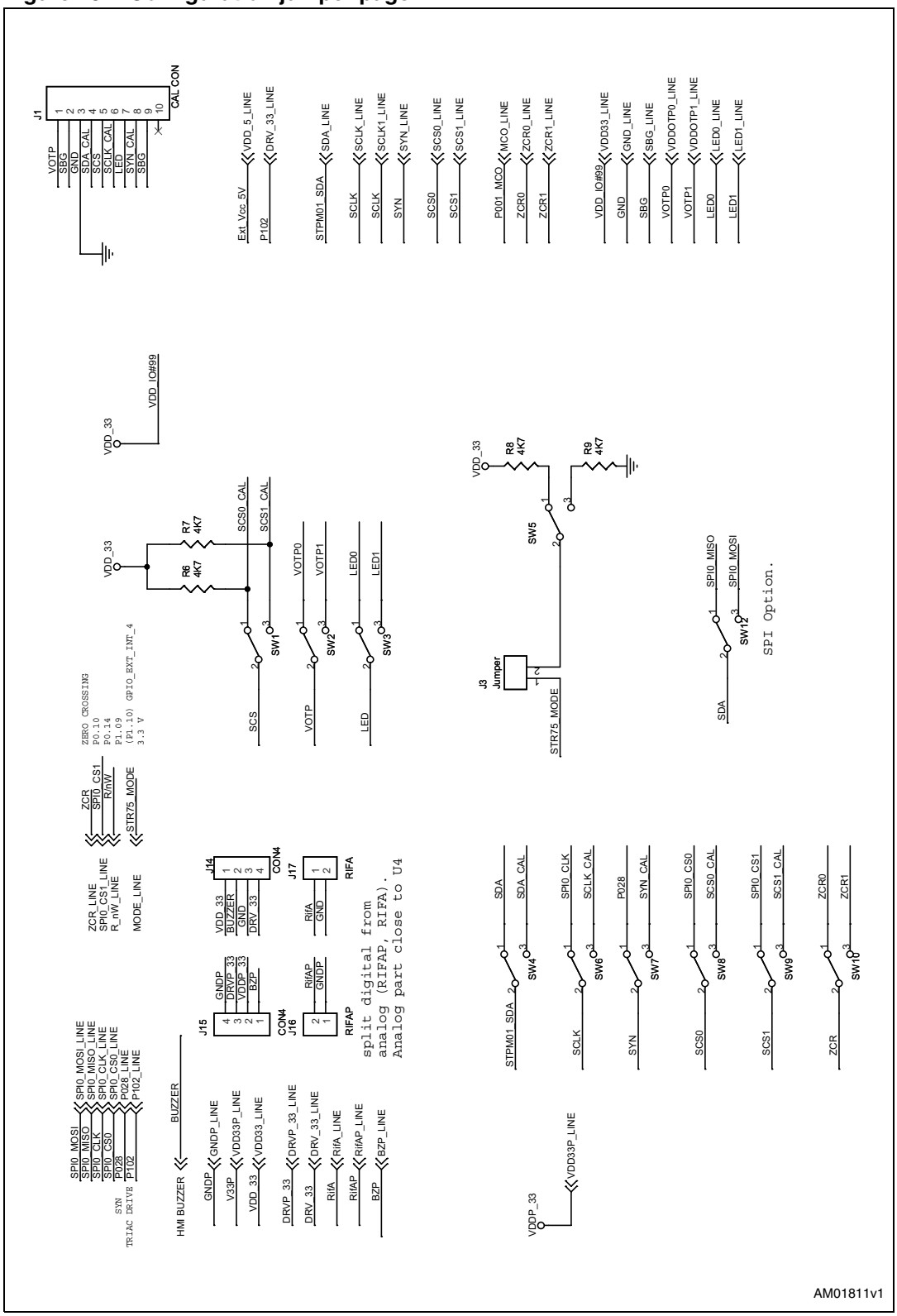
6.4 Load driver

Figure 12. AC load driver page



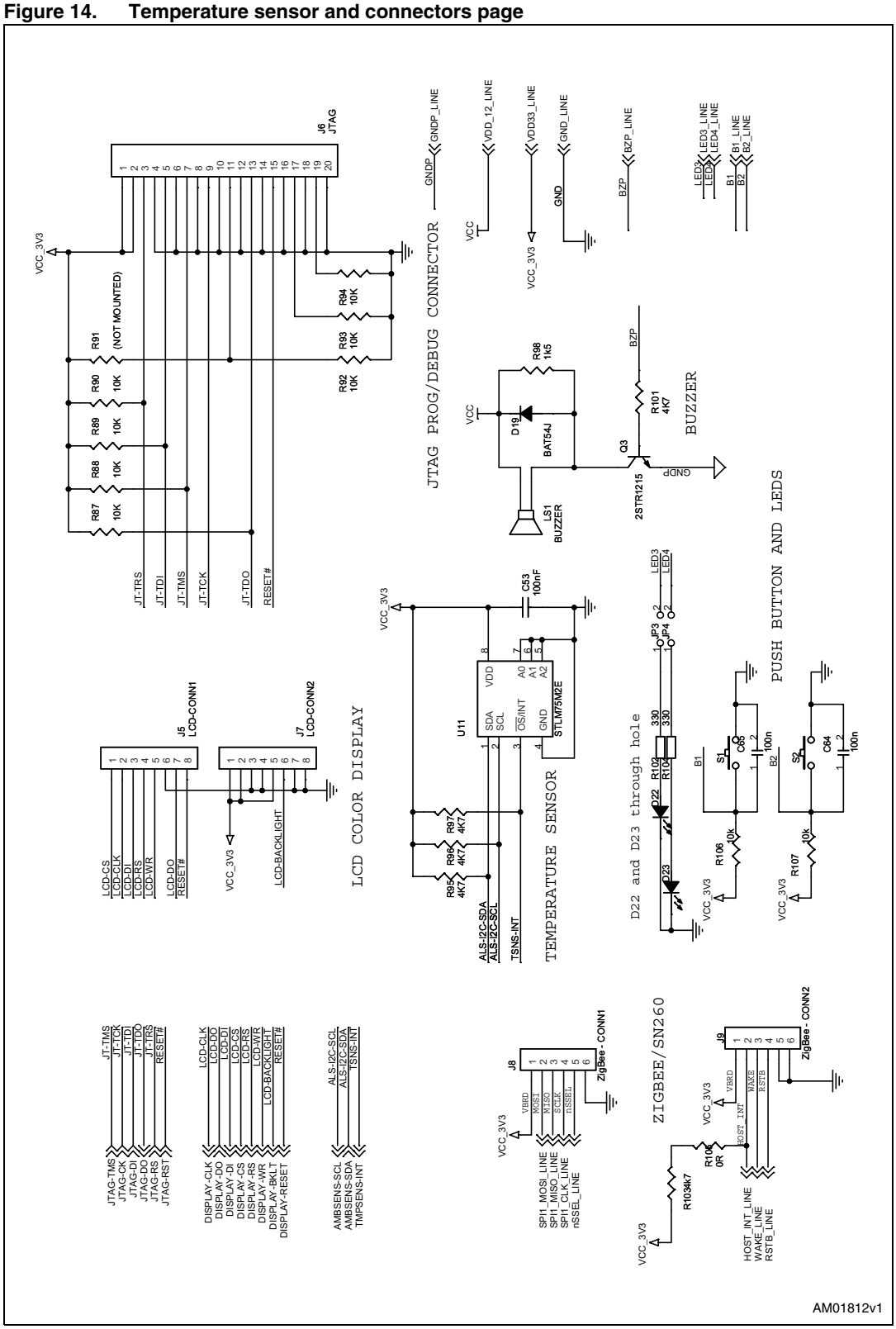
6.5 Configuration jumpers

Figure 13. Configuration jumper page



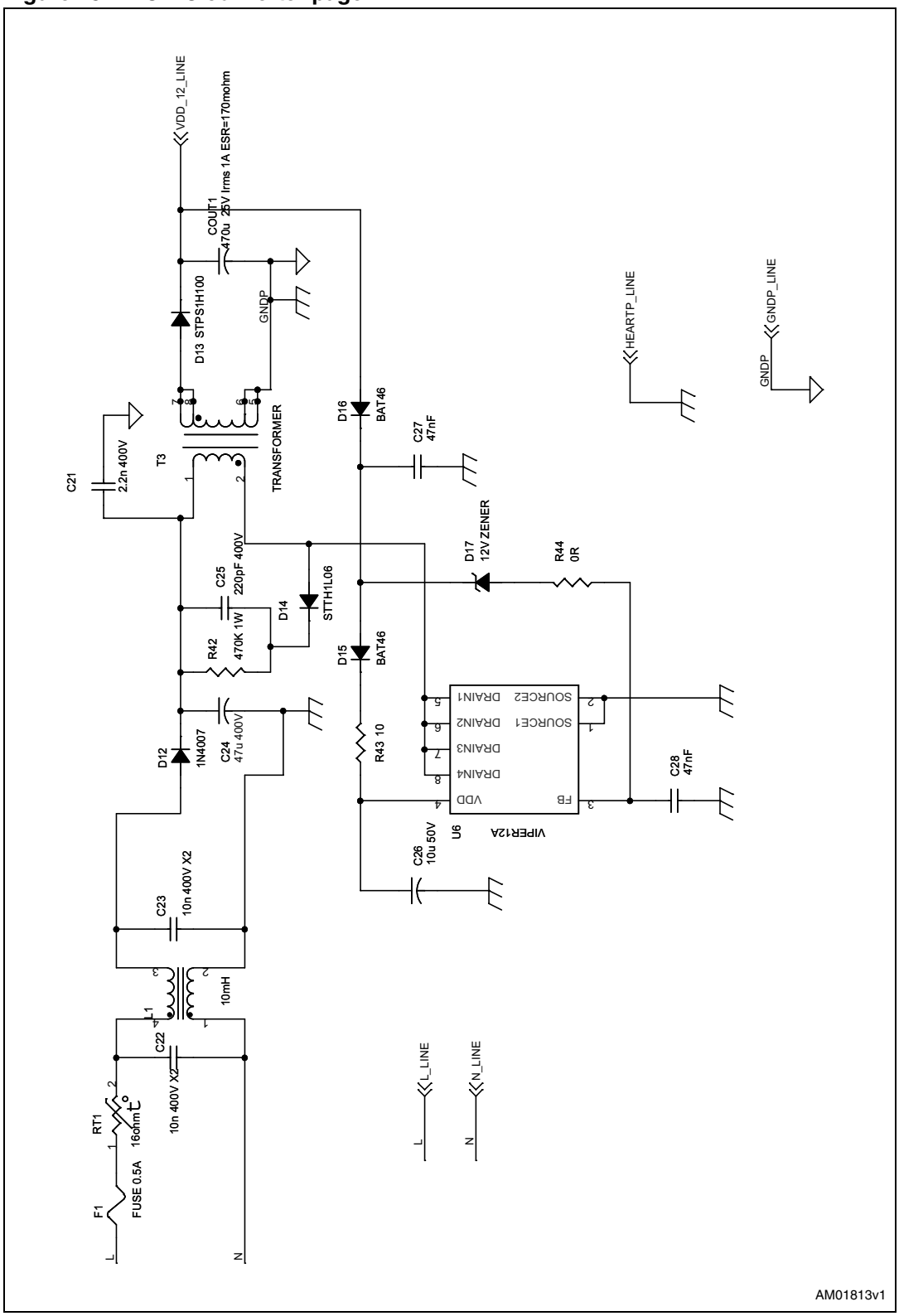
6.6 Temperature sensor and connectors

Figure 14. Temperature sensor and connectors page



6.7 Power supply - AC-DC converter

Figure 15. AC-DC converter page



6.8 Power supply DC-DC converter

Figure 16. DC-DC converter page

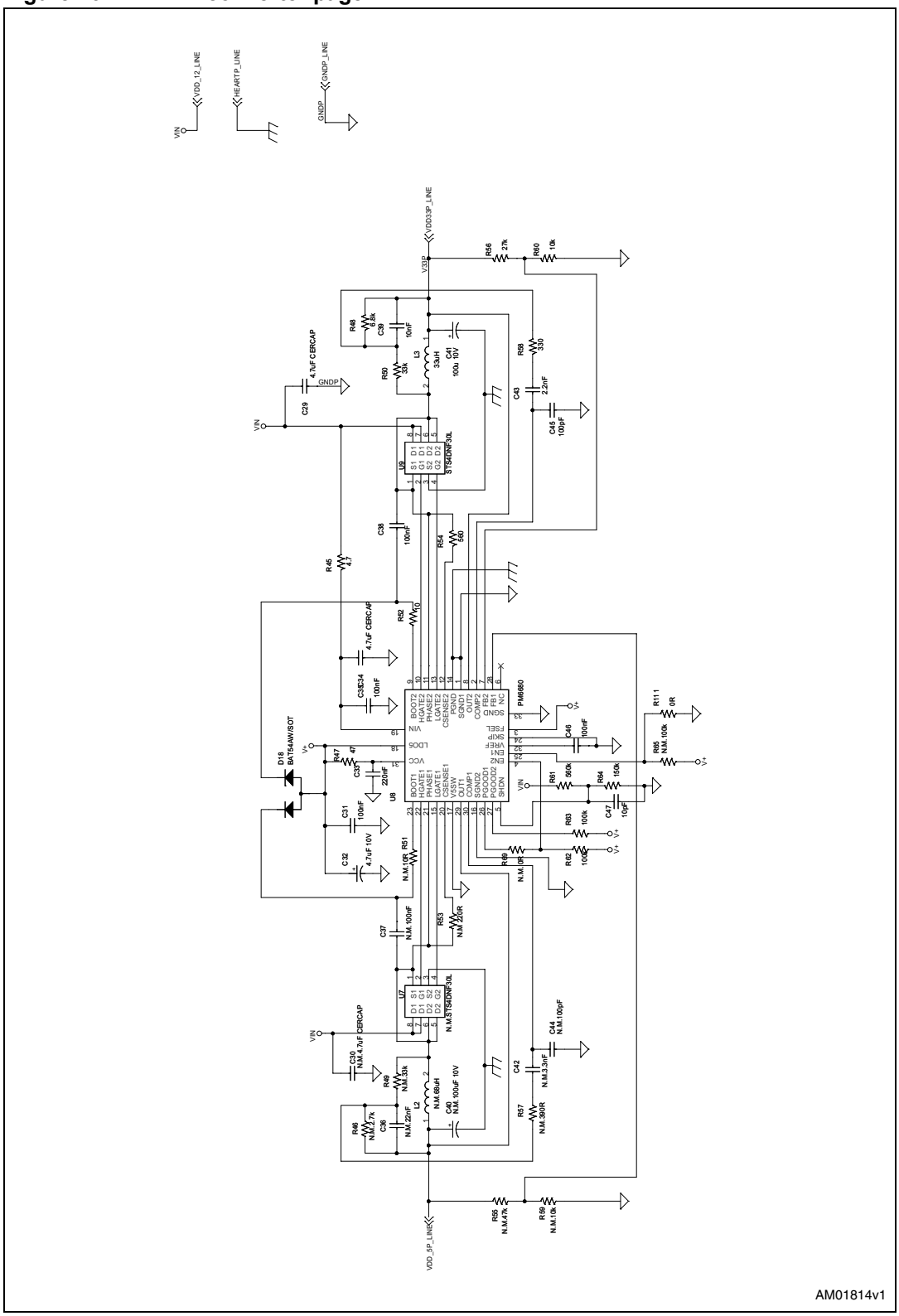


Table 8. BOM list

Reference	Part / value	Voltage / Watt	Foot-Print	Manuf.	Manuf. code	RS code	More info
COUT1	470 µF 25 V Irms 1 A ESR=170 mΩ	25 V electrolytic	Radial			315-0574	height 16 mm
C1	2.2 µF	16 V ceramic	SMD/ 0805				
C2,C43	2.2 nF	16 V ceramic	SMD/ 0805				
C3,C12	1 nF	16 V ceramic	SMD/ 0805				
C4,C5,C6,C7,C8,C13,C14, C15,C16,C17,C31,C35,C38, C46,C53,C54,C55,C56,C57, C62	100 nF	16 V ceramic	SMD/ 0805				
C9,C11,C18,C20,C39,C63	10 nF	16 V ceramic	SMD/ 0805				
C21	2.2 nF 400 V	400 V ceramic					
C22,C23	10 nF 400 V X2	400 V				441-9616	
C24	47 µF 400 V	400 V electrolytic	Radial			434-0330	
C25	220 pF 400 V	400 V ceramic					
C26	10 µF 50 V	electrolytic	Radial				
C27,C28	47 nF	16 V ceramic	SMD/0805				
C29,C34	4.7 µ CERCAP	16 V ceramic	SMD/ 0805				
C32	4.7 µ 10 V	10 V tantalum	SMD			533-9126	
C33	220 nF	16 V ceramic	SMD/0805				
C41	100 µF 10 V	10 V tantalum	SMD			464-7877	
C45	100 pF	16 V ceramic	SMD/0805				
C47,C58,C59	10 pF	16 V ceramic	SMD/0805				
C60,C61	22 pF	16 V ceramic	SMD/0805				
C64,C65	100 nF	16 V ceramic	SMD/0805				

Table 8. BOM list (continued)

Reference	Part / value	Voltage / Watt	Foot-Print	Manuf.	Manuf. code	RS code	More info
C30,C36,C37,C40,C42,C44, J10, L2 R1,R4,R69,R46,R49,R51,R53 R55,R57,R59,R65,R69,R91, U7,	Not assembly						Not assembly
D2,D7	LED -LGR971		SMD/0805			654-5773	
D1,D6,D11	LL1N4148		SMD				
D12	1N4007		with terminal				
D13	STPS1H100		SMD	STMicroelectronics			
D14	STTH1L06		SMD	STMicroelectronics			
D15,D16	BAT46W		SOT/23	STMicroelectronics			
D17	12 V Zener 0.5 W		SMD				
D18	BAT54AW/ SOT		SOT/23	STMicroelectronics			
D19	BAT54J		SMD				
D22	Rectangular LED 2x5	Green	with terminal			171,6807	
D23	Rectangular LED 2x5	Yellow	with terminal			171-6784	
D24	STPS140U			STMicroelectronics			
F1	FUSE 0.5 A		with terminal			226-0591	
J1	Ampmode-10 pin					461-663	
J6	Male connector 90° 20 pin					461-691	
J5-J7	Female double STRIP line 8 pin						
J14	Male double STRIP line 4 pin						

Table 8. BOM list (continued)

Reference	Part / value	Voltage / Watt	Foot-Print	Manuf.	Manuf. code	RS code	More info
J15	Female double STRIP line 4 pin low profile			KONTEK		230-4950	
J3,J17,J18,J19,JP3,JP4	Male single STRIP line 2 pin						
J16	Female single STRIP line 2 pin low profile			KONTEK		230-4938	
LS1	Buzzer					511-7670	
L1	10 mH	Filter inductor				489-0245	
L3	33 µH 1.3 A		SMD	Coilcraft	LPS6235 -333ML		
Q1	Triac T2035H	With terminal	TO220	STMicroelectronics			Not assembly
Q2-Q3	2STR1215		SOT/23	STMicroelectronics			
RT1	NTC 16 Ω	With terminal				216-1393	
R3,R5,R14,R16,R30,R32,	1 kΩ 1/8 W 10%	1/8 W 10%	SMD/0805				
R2	22 kΩ 1/8 W 10%	1/8 W 10%	SMD/0805				
R4,R55	47 kΩ 1/8 W 10%	1/8 W 10%	SMD/0805				
R6,R7,R8,R9,R95,R96,R97, R101, R103	4.7 kΩ 1/8 W 10%	1/8 W 10%	SMD/0805				
R10,R26,R54,	560 Ω	1/8 W 10%	SMD/0805				
R11,R12,R13	2.4 kΩ 1/8 W 10%	1/8 W 10%	SMD/0805				
R15,R68	6.8 Ω 1/8 W 1%	1/8 W 1%	SMD/0805				
R17,R33	2 MΩ 1/8 W 10%	1/8 W 10%	SMD/0805				
R18	475 Ω 1/8 W 1%	1/8 W 1%	SMD/0805				
R19,R20,R21	261 kΩ 1/4 W 1%	1/8 W 1%	Axial with terminal				

Table 8. BOM list (continued)

Reference	Part / value	Voltage / Watt	Foot-Print	Manuf.	Manuf. code	RS code	More info
R22,R38	43 kΩ 1/8 W 10%	1/8 W 10%	SMD/0805				
R23,R39	100 Ω 1/8 W 1%	1/8 W 1%	SMD/0805				
R42	470 kΩ 1 W 10%	1 W 10%	Axial with terminal				
R43,R52	10 Ω 1/8 W 10%	1/8 W 10%	SMD/0805				
R44,R66,R67,R105,R111	0 Ω 1/8 W 10%	1/8 W 10%	SMD/0805				
R45	4.7 Ω 1/8 W 10%	1/8 W 10%	SMD/0805				
R47	47 Ω 1/8 W 10%	1/8 W 10%	SMD/0805				
R48	6.8 kΩ 1/8 W 10%	1/8 W 10%	SMD/0805				
R50	33 kΩ 1/8 W 10%	1/8 W 10%	SMD/0805				
R58,R102,R104	330 Ω 1/8 W 10%	1/8 W 10%	SMD/0805				
R56	27 kΩ 1/8W 10%	1/8 W 10%	SMD/0805				
R60,R87,R88,R89,R90,R92, R93, R94,R109, R106, R107	10 kΩ 1/8 W 10%	1/8 W 10%	SMD/0805				
R61	560 kΩ 1/8 W 10%	1/8 W 10%	SMD/0805				
R62,R63,R65,R110	100 kΩ 1/8 W 10%	1/8 W 10%	SMD/0805				
R31	100 Ω 1/8 W 10%	1/8 W 10%	SMD/0805				
R64	150 kΩ 1/8 W 10%	1/8 W 10%	SMD/0805				
R98	1.5 kΩ 1/8 W 10%	1/8 W 10%	SMD/0805				
R108	1 MΩ 1/8 W 10%	1/8 W 10%	SMD/0805				
SW1,SW2,SW3,SW4,SW5, SW6,SW7,SW8,SW9,SW10, SW12	Male strip line 3 pins						
SW11,S1,S2	Vertical reset push button			DISTRELEK	200862		5 mm button

Table 8. BOM list (continued)

Reference	Part / value	Voltage / Watt	Foot-Print	Manuf.	Manuf. code	RS code	More info
T1,T2	Current transformer		with terminal	VAC	4622-X503		
T3	Output transformer		with terminal	MAGNETICA	1155-0002		
U4,U5	STPM01			STMicroelectronics			
U6	VIPER12A			STMicroelectronics			
U9	STS4DNF30L			STMicroelectronics			
U8	PM6680			STMicroelectronics			
U11	STML75M2E			STMicroelectronics			
U12	STM32F103RBT6			STMicroelectronics			
Y1	SMD 32.768 kHz crystal		SMD			244-2018	
Y2	8 MHz HC49/4H crystal	Low profile	with terminal			226-1724	
K1	Relay 16 A 12 V	Low profile		OMRON		365-0535	

7 Revision history

Table 9. Document revision history

Date	Revision	Changes
28-Apr-2010	1	Initial release

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