
Getting started with smart home lighting based on HVLED815PF and SPSGRF

Introduction

The STEVAL-ILL082V1 evaluation board is an offline LED driver based on the HVLED815PF, coupled with Sub-GHz connectivity based on the SPSGRF-868 low power programmable RF transceiver module. The interface between the HVLED815PF and the SPSGRF is managed by an STM32L0 ultra-low-power ARM® Cortex®-M0+ MCU. The microcontroller and connectivity module are supplied by the LED driver through an auxiliary winding.

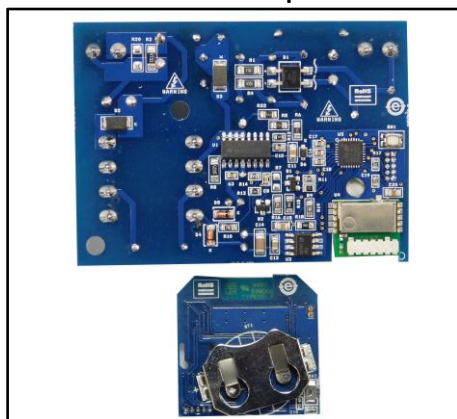
The LED driver evaluation board can operate in standalone mode in communication with the bundled STEVAL-ILL082V1_Remote controller based on SP1ML to help to reduce development and certification time.

The board can also be rendered visible to cloud applications with the addition of a wireless bridge.

Figure 1: STEVAL-ILL082V1 evaluation board plus remote controller (top view)



Figure 2: STEVAL-ILL082V1 evaluation board plus remote controller (bottom view)



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1 Overview

The STEVAL-ILL082V1 features:

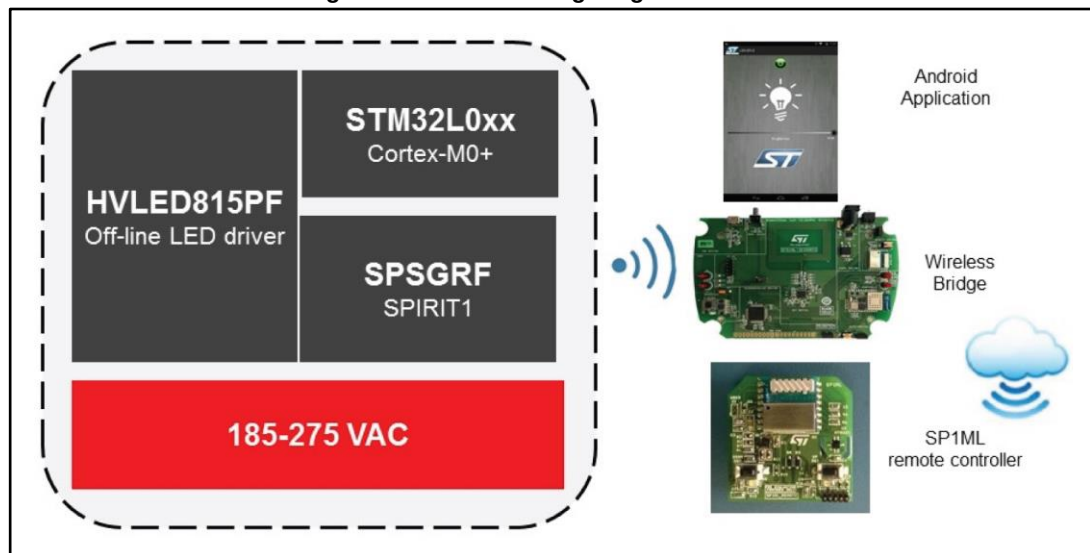
- LED driver features:
 - 10 W flyback converter with quasi-resonant operation
 - Primary side regulation, no optocoupler required
 - High power factor and low THD
 - Open circuit and short-circuit LED management
 - $\pm 1\%$ LED current regulation
 - Dimming range: 2.5% to 100%
- Sub-GHz connectivity features:
 - Works with the bundled STEVAL-ILL082V1_remote controller based on SP1ML-868 sub-GHz module
 - Allows remote lamp powering on and off
 - Allows lamp remote dimming
 - Standby power consumption: $< 0.5\text{ W}$
- RoHS compliant

1.1 Smart home lighting architecture

The architecture behind this smart home lighting system involves an LED driver (HVLED815PF) to supply and monitor the LED load, an STM32L05x microcontroller to manage the board, a low power sub-GHz module based on the SPIRIT1 RF transceiver (SPSGRF) for external communication and a remote application running on an Android® mobile device to display status information and generate remote commands.

Cloud-based IoT functionality is supported with the introduction of a separate ST wireless bridge (STEVAL-IDI004V2) or through a remote controller (SP1ML).

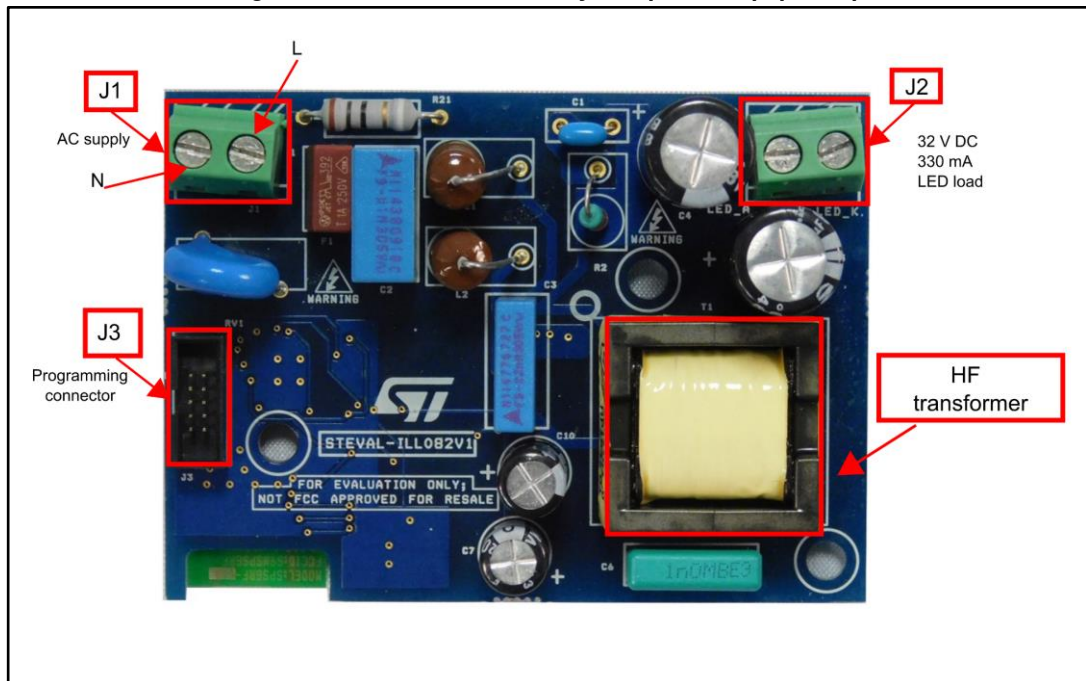
Figure 3: Smart home lighting architecture



1.2 Hardware description

The top side of the STEVAL-ILL082V1 board is figured below.

Figure 4: STEVAL-ILL082V1 key components (top view)

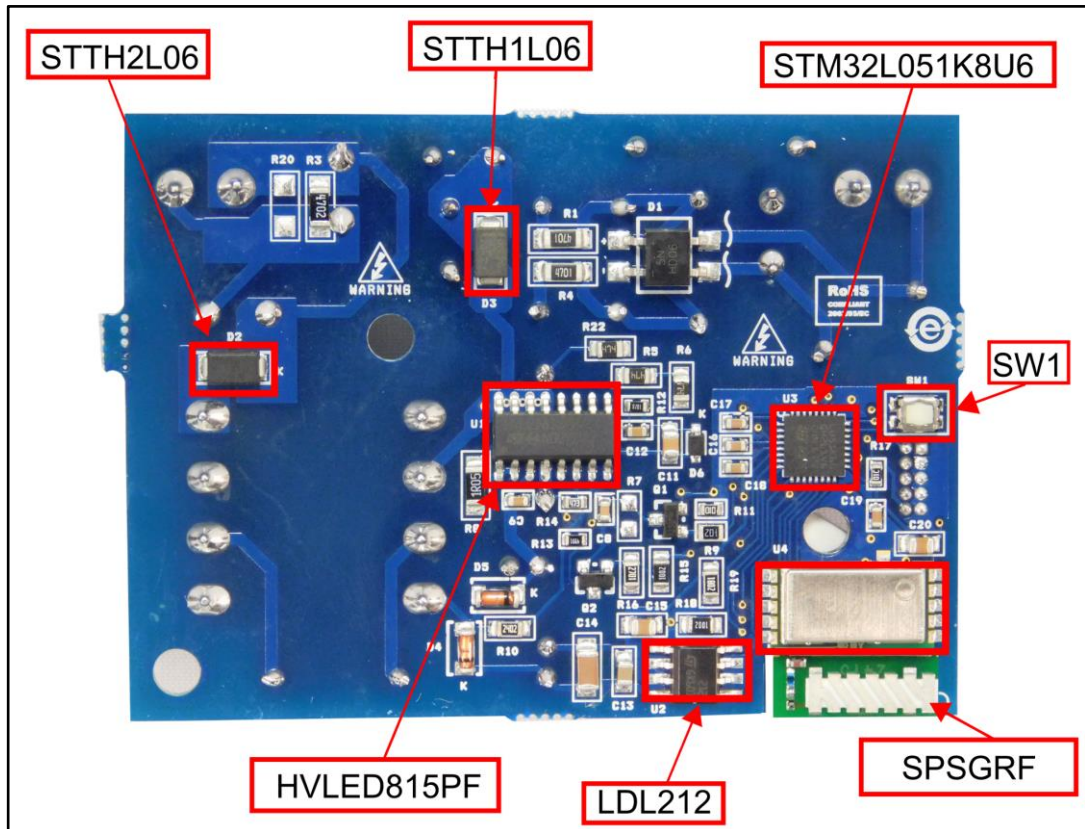


Key top side components include:

- **J1:** the input connector for AC voltage input.
- **J2:** the output connector for the LED load.
- **J3:** the 10-pin/10-position shrouded connector for STM32 microcontroller firmware development and debugging.
- **HF transformer.**

The bottom side of the STEVAL-ILL082V1 board is figured below.

Figure 5: STEVAL-ILL082V1 key components (bottom view)



Key bottom side components include:

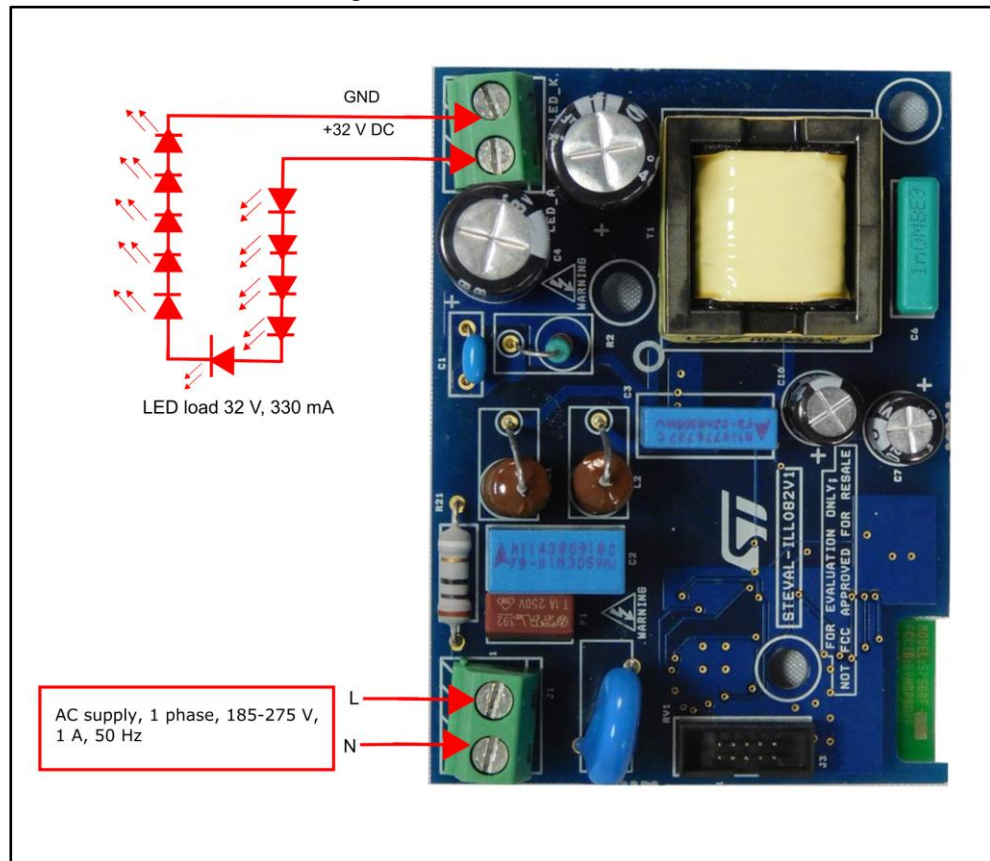
- **HVLED815PF**: offline constant current LED driver with primary-sensing, integrated MOSFET, high power factor, low THD and ability to supply 15 W controlled power.
- **SPSGRF**: low power sub-GHz module based on SPIRIT1 RF transceiver and BALUN. It enables wireless connectivity requiring no RF experience or expertise for integration. It has a programmable radio which supports different modulation schemes (e.g. FSK, GFSK, MSK, GMSK, OOK and ASK). The output power can vary up to 11.6 dBm and the receiver sensitivity is -118 dBm. Four GPIOs are available and can be programmed for 32 different input/output functions. SPSGRF is FCC, IC and CE certified. It is available in two different carrier frequency versions to cater 868 MHz SRD and 915 MHz ISM bands.
- **STM32L05x**: ultra-low power 32-bit RISC microcontroller based on the ARM® Cortex®-M0+ core, featuring an advanced APB bus, ADC, timer, I²C, SPI and USART.
- **STTH1L06** and **STTH2L06**: ultra-fast high voltage rectifiers, with low reverse recovery current and low thermal resistance.
- **LDL212**: a 3.3 V low dropout regulator (LDO) to supply the MCU and SPSGRF.
- **SW1**: reset switch for the microcontroller and connectivity module.

2 Getting started

2.1 Smart home lighting board used with SPSGRF and SP1ML

- 1 Connect LED load (10 LED/32 V 322 mA) to J2.
- 2 Connect mains voltage (185 – 275 V_{AC}) through input connector J1.

Figure 6: LED load connection

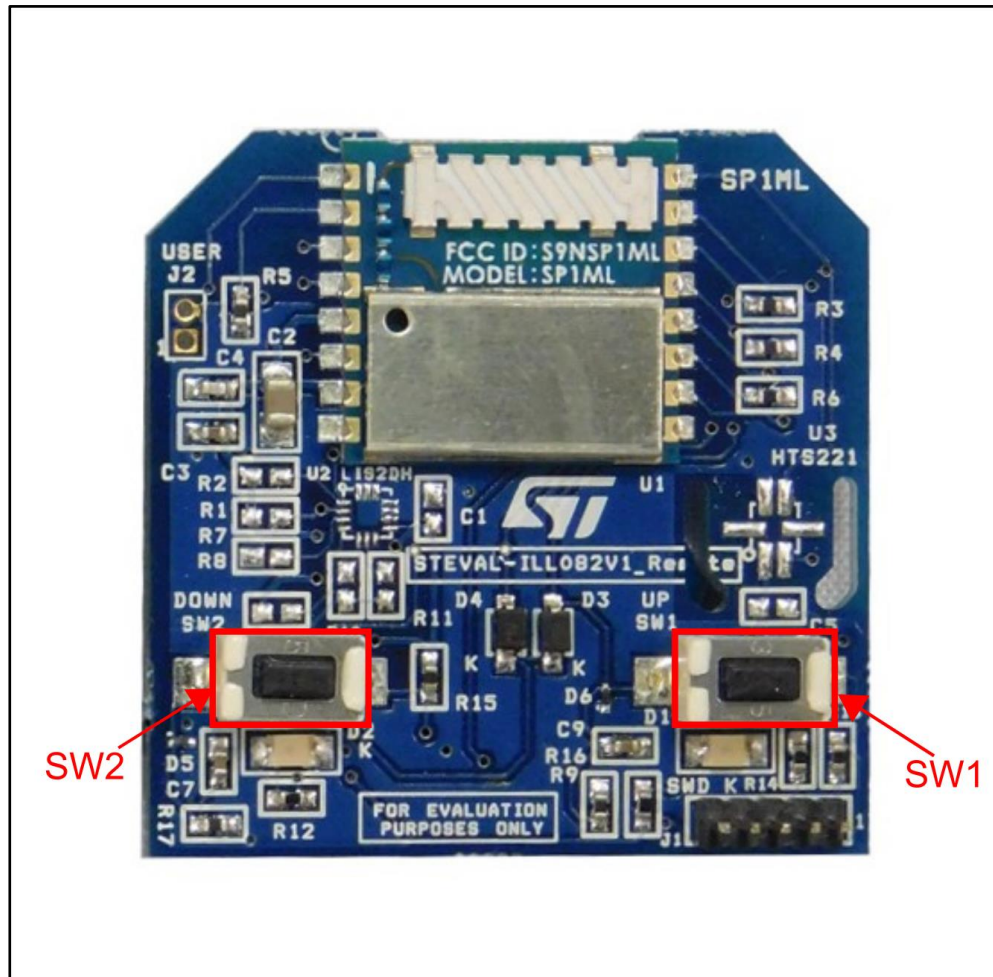


- 3 Use SP1ML (STEVAL-ILL082V1_Remote) to control the LED brightness from 2.5% to 100% or to switch LEDs on or off.

SW1 decreases output current and switches LEDs off.

SW2 increases output current and switches LEDs on.

Figure 7: SP1ML (STEVAL-ILL082V1_Remote) remote controller



3 Efficiency testing and measurements

3.1 Efficiency, power factor, THD, LED current and current regulation

Table 1: Test conditions

Test conditions	Devices
Input voltage: 185-275 V _{AC} , 50 Hz	AC source: Agilent 6812B
LED load: 32 V, 322 mA±1%	Power analyzer: Yokogawa -WT310

Figure 8: STEVAL-ILL082V1 test setup

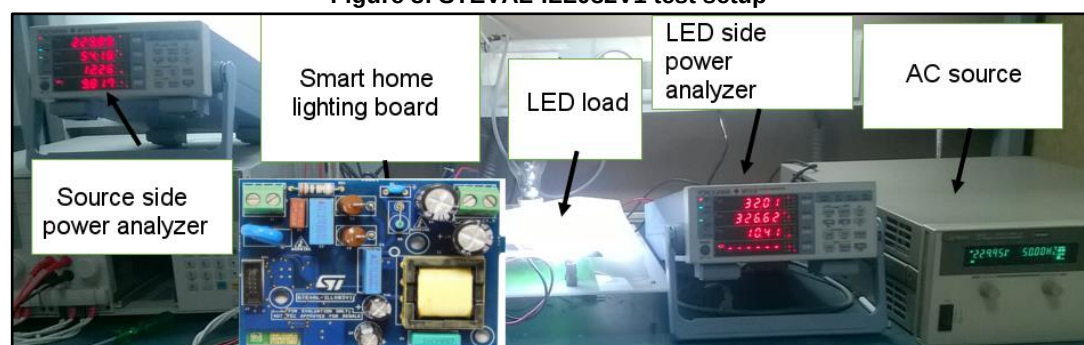


Table 2: Test results

V _{in} (V)	P _{in} (W)	P _o (W)	Efficiency (%)	PF	THD (%)	LED current	Current regulation (%)
185	12.19	10.28	84.35	0.98	11.50	325.00	0.87
200	12.13	10.24	84.42	0.99	5.10	324.18	0.61
205	12.10	10.21	84.38	0.99	4.00	323.46	0.39
210	12.08	10.19	84.34	0.99	4.20	322.80	0.18
220	12.03	10.15	84.34	0.99	6.00	321.40	-0.25
230	12.04	10.14	84.24	0.99	8.60	321.00	-0.37
250	12.03	10.10	83.97	0.98	13.00	320.19	-0.63
275	12.11	10.12	83.57	0.97	17.30	320.65	-0.48

Figure 9: Input voltage versus LED current

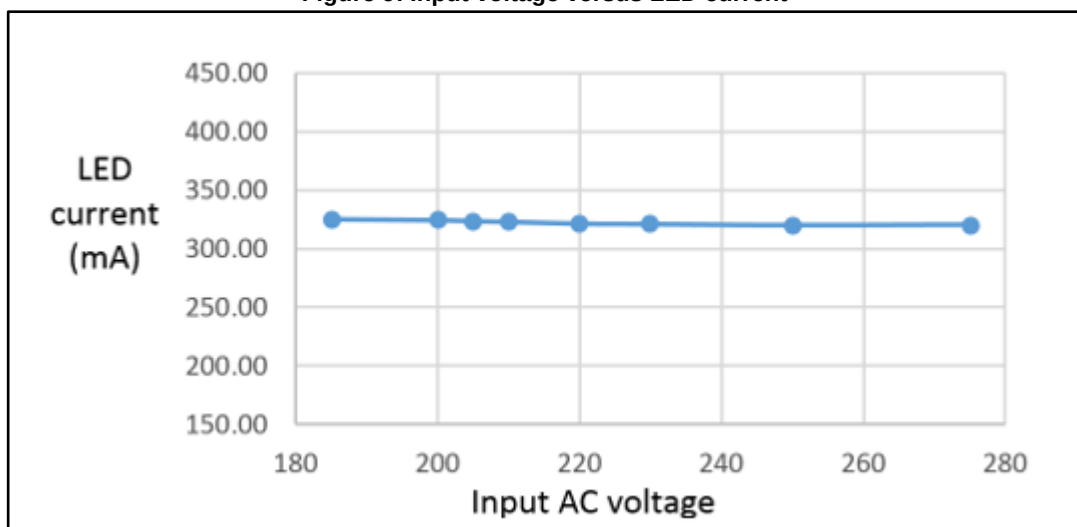


Figure 10: Input voltage versus PF at full load

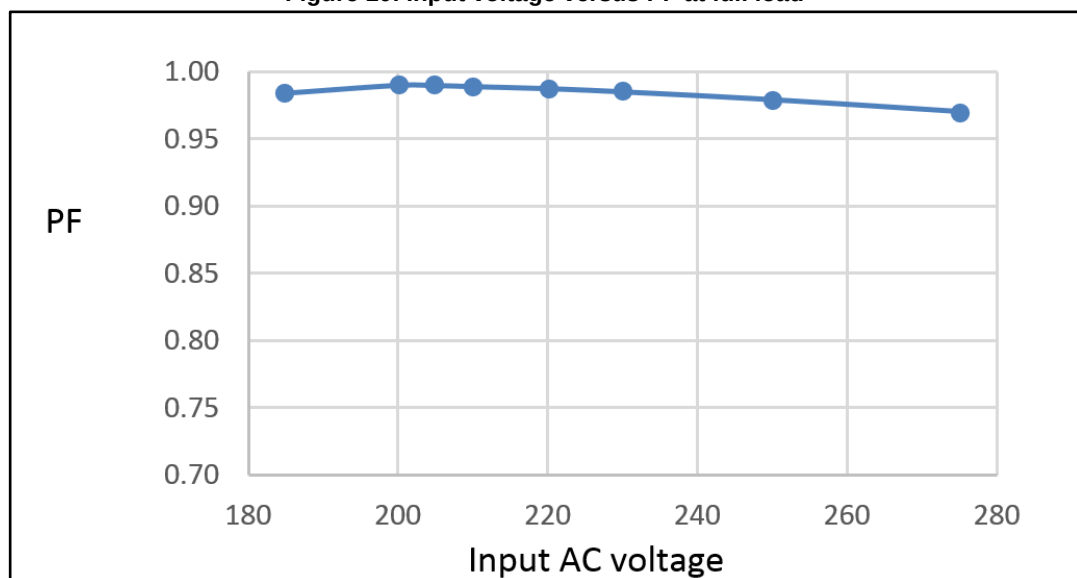


Figure 11: THD versus line variation

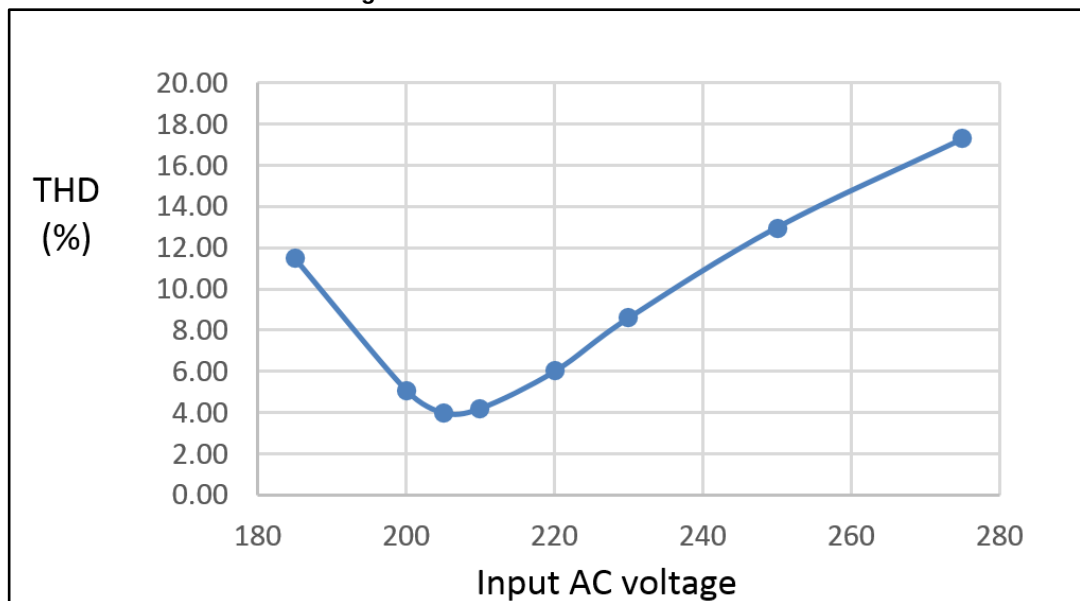


Figure 12: Current regulation

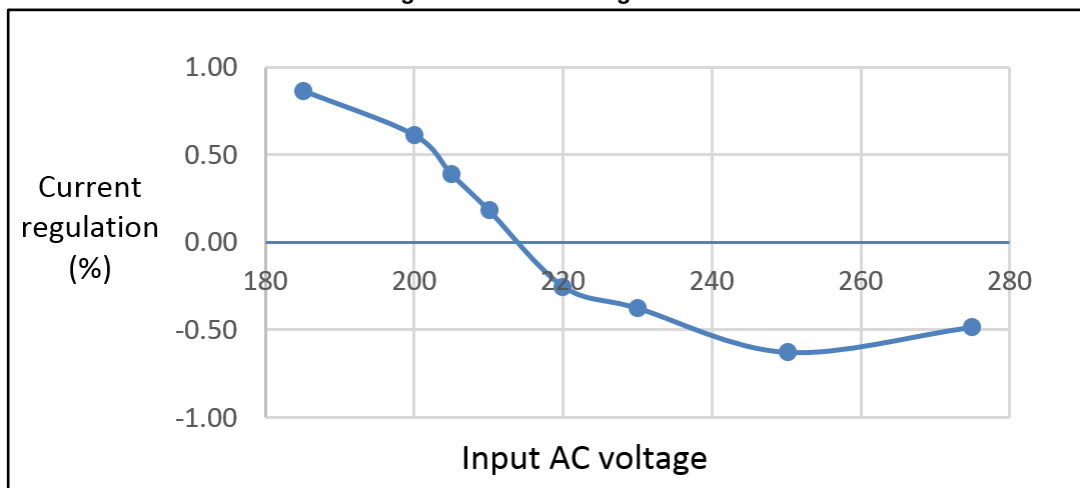
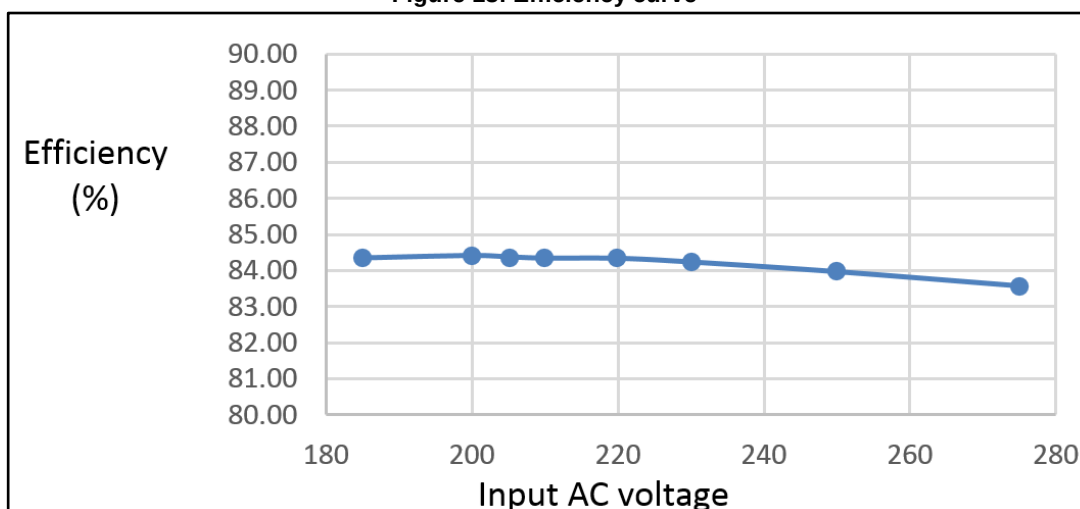


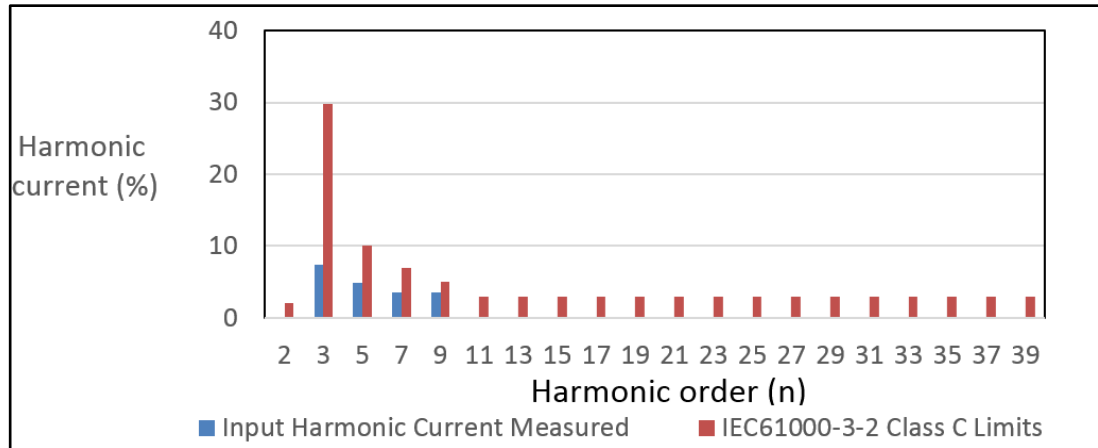
Figure 13: Efficiency curve



3.2 IEC61000-3-2 class C harmonic measurement

The STEVAL-ILL082V1 is IEC61000-3-2 compliant. The harmonic current is measured from the 2nd to the 39th harmonic order as required by IEC61000-3-2 class C for lighting equipment. The measured value at 230 V_{AC} is well behind the specified harmonic limits.

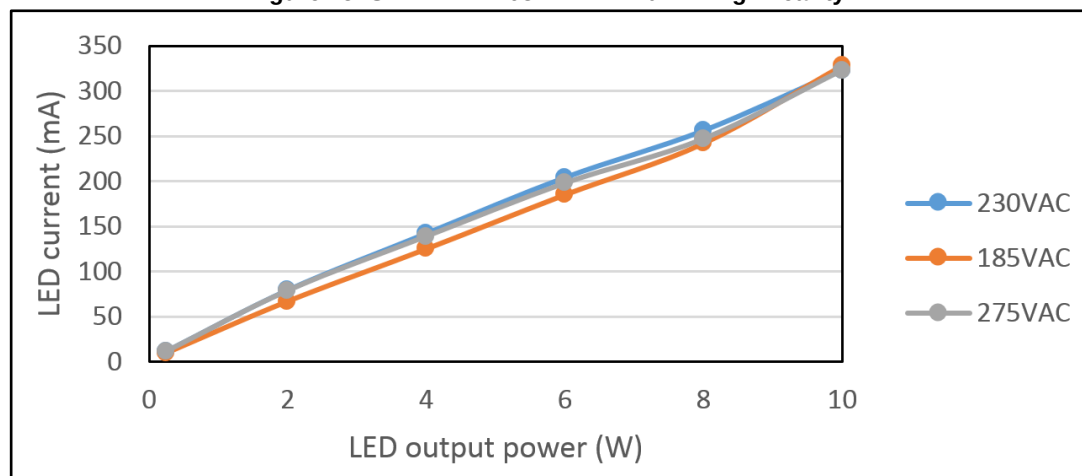
Figure 14: STEVAL-ILL082V1: full load condition



3.3 LED dimming versus output power and LED current

The LED dimming is implemented in 5 steps: 2.5, 20, 40, 60 and 80% of the LED power output. It is linear for the entire EU line voltage range and almost independent from line voltage variations.

Figure 15: STEVAL-ILL082V1: LED dimming linearity

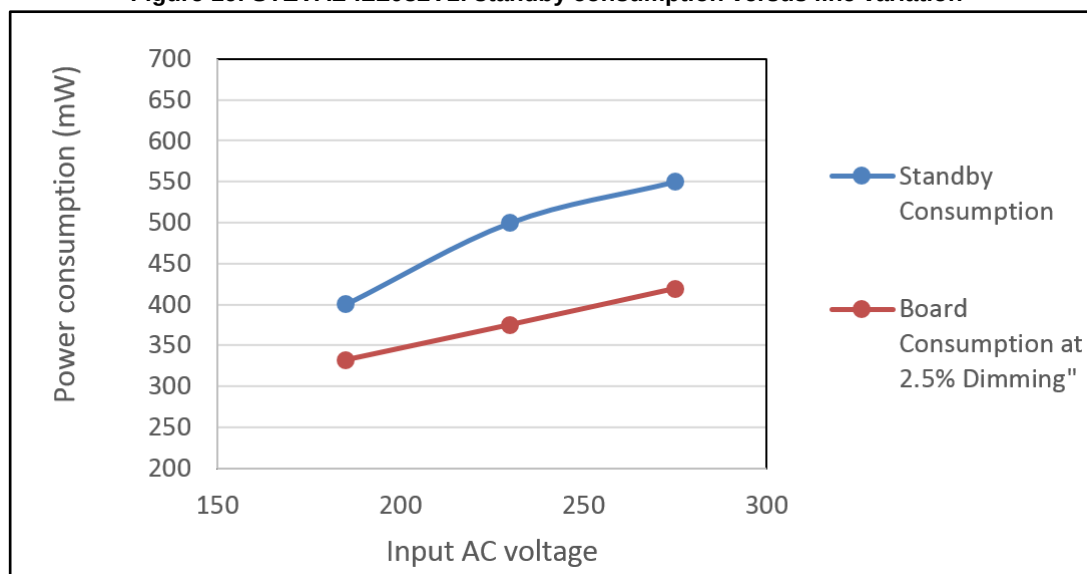


3.4 Standby power consumption

The STEVAL-ILL082V1 evaluation board standby power consumption is between 0.4 and 0.6 W for the entire line voltage variation.

At the lowest dimming condition, the power consumption is less than standby thanks to the fact that HVLED815 PF IC is working in high voltage startup mode to generate 3.3 V housekeeping power supply.

Figure 16: STEVAL-ILL082V1: standby consumption versus line variation



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Figure 17: STEVAL-ILL082V1 circuit schematic (1 of 2)

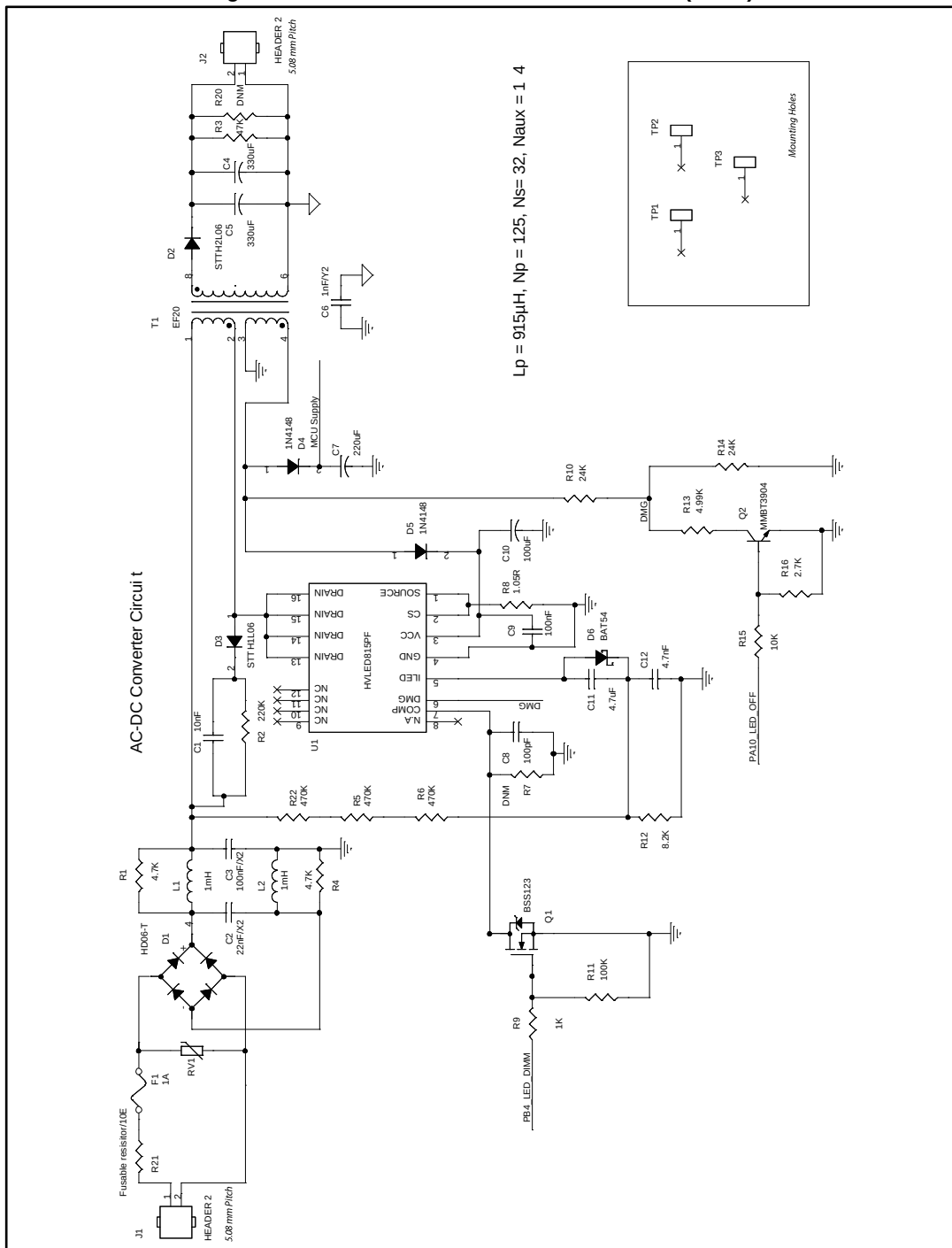


Figure 18: STEVAL-ILL082V1 circuit schematic (2 of 2)

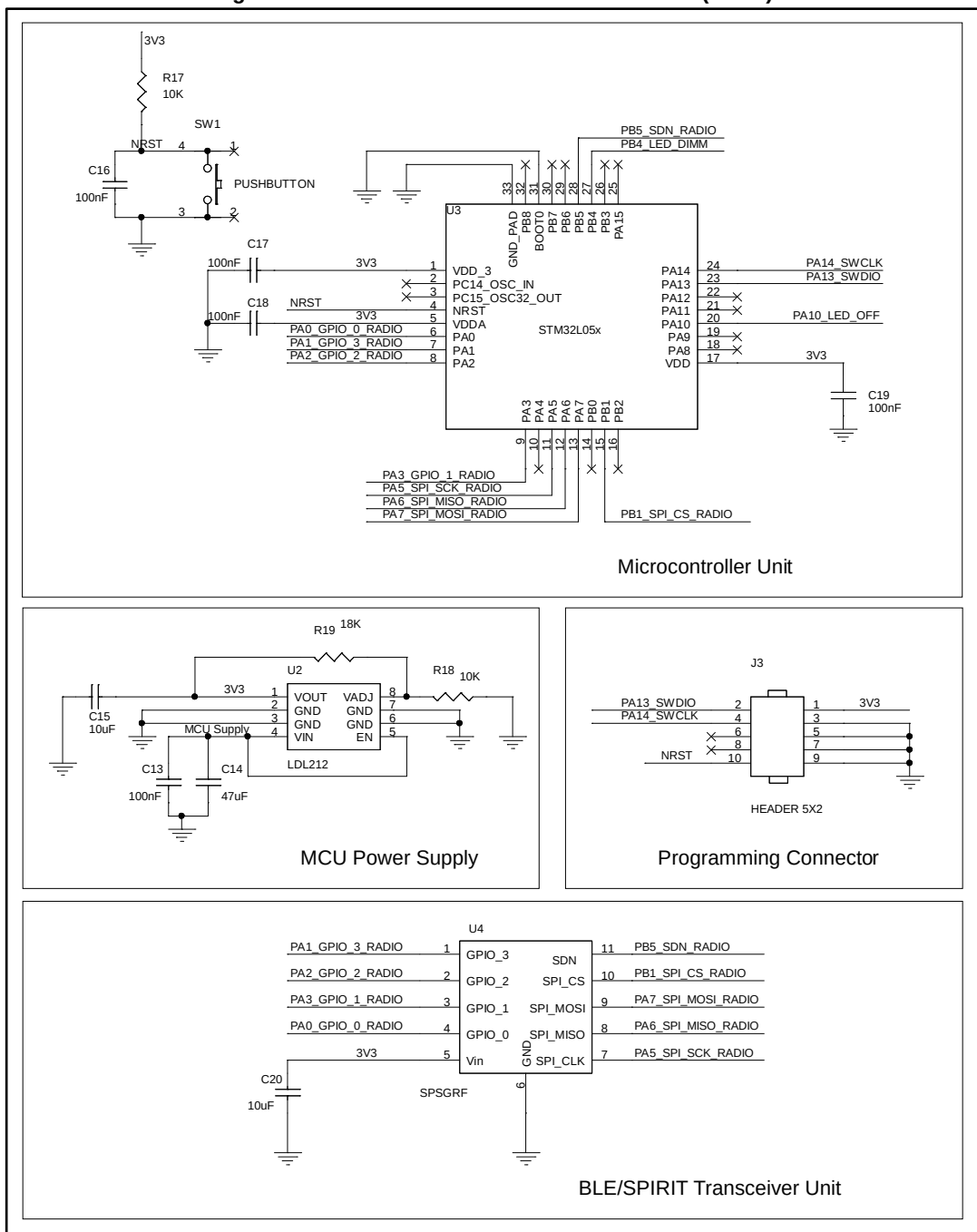
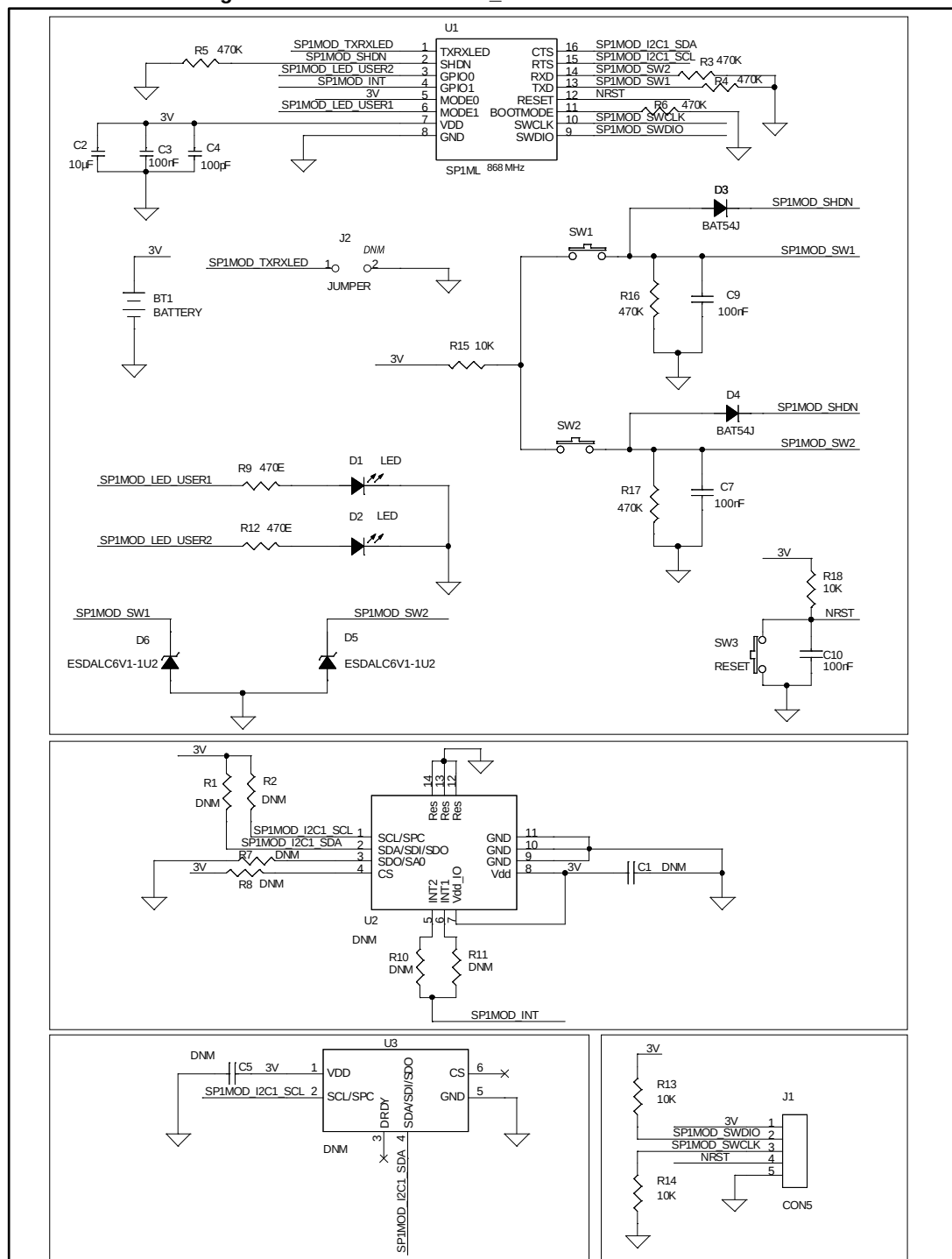


Figure 19: STEVAL-ILL082V1_Remote circuit schematic



5 Bill of materials

Table 3: STEVAL-ILL082V1 bill of materials

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
1	1	C1	10 nF, 630 V $\pm$ 0.1	Capacitor	Murata	RDER72J103K2M1H03A
2	1	C2	100 nF, 305 V, X2 $\pm$ 0.2	Capacitor	EPCOS	B32921C3104M
3	1	C3	22 nF, 305 V, X2 $\pm$ 0.2	Capacitor	EPCOS	B32921C3223M
4	2	C4, C5	330 μ F, 63 V	Capacitors	Nichion	UVR1J331MPD
5	1	C6	1 nF, 250 V _{AC} , Y2 $\pm$ 0.2	Capacitor	Kemet	PHE850EA4100MA01R17
6	1	C7	220 μ F, 25 V $\pm$ 0.2	Capacitor	Nichion	UVK1E221MED1TD
7	1	C8	100 pF, 25 V, X7R $\pm$ 0.05	Capacitor	Wurtz	885012206053
8	1	C13	100 nF, 25 V, X7R $\pm$ 0.1	Capacitor	Murata	GRM21BR71E104KA01L
9	5	C9, C16, C17, C18, C19	100 nF, 25 V, X7R $\pm$ 0.1	Capacitors	TDK	C1608X7R1E104K080AA
10	1	C10	100 μ F, 35 V $\pm$ 0.2	Capacitor	Nichion	UVR1V101MED1TD
11	1	C11	4.7 μ F, 16 V, X7R $\pm$ 0.1	Capacitor	Murata	GRM21BR71C475KA73L
12	1	C12	4.7 nF, 25 V, X7R $\pm$ 0.1	Capacitor	Murata	GRM188R71H472KA01D
13	1	C14	47 μ F, 25 V, X5R $\pm$ 0.2	Capacitor	TDK	C3216X5R1E476M160AC
14	2	C15, C20	10 μ F, 10 V, X7R $\pm$ 0.1	Capacitors	Murata	GRM21BR71A106KE51K
15	1	D1	HD06-T, 600 V, 0.8 A	Bridge rectifier	Diodes Inc.	HD06-T
16	1	D2	STTH2L06, 600 V, 2 A	Ultra-fast high voltage rectifier	ST	STTH2L06A
17	1	D3	STTH1L06, 600 V, 1 A	Ultra-fast high voltage rectifier	ST	STTH1L06A
18	2	D4, D5	1N4148, 75 V, 200 mA	Switching diode	NXP	PMLL4148L115
19	1	D6	BAT54	Schottky diode	ST	BAT54JFILM
20	1	F1	1 A, 250 V	Fuse	Littelfuse	39211000000
21	2	J1, J2	Header 2	I/O connectors	Phoenix	1729128
22	1	J3	HEADER 5x2	10-pin/10-position shrouded connector	CNC Tech	3220-10-0100-00
23	2	L1, L2	1 mH, 370 mA	Inductors	EPCOS	B82145A1105J
24	1	Q1	BSS123, 100 V, 0.17 A	Transistor	Fairchild	BSS123L

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
25	1	Q2	40 V, 0.2 A	Switching transistor	Fairchild	MMBT3904
26	1	RV1		Varistor	Bourns	MOV-10D471K
27	1	R21		10R Fusible	Yageo	FRM-50JR-52-10R
28	2	R1, R4	4.7 K, 0.25 W±0.05	Resistors	Panasonic	ERJ-8GEYJ472V
29	1	R2	220 K, 0.5 W±0.05	Resistor	Stackpole	CFM12JT220K
30	1	R3	47 K, 0.5 W±0.05	Resistor	Vishay	CRCW120647K0FKEAHP
31	1	R20	DNM	Resistor		
32	3	R5, R6, R22	470 K, 0.125 W±0.05	Resistor	Panasonic	ERJ-6GEYJ474V
33	1	R19	18 K, 0.125 W±0.01	Resistor	Panasonic	ERJ-6ENF1802V
34	2	R15, R18	10 K, 0.125 W±0.01	Resistors	Yageo	RC0805FR-0710KP
35	1	R9	1 K±0.05	Resistor	Panasonic	ERJ-6GEYJ102V
36	1	R17	10 K, 0.1 W±0.01	Resistor	Yageo	RC0603FR-0710KL
37	1	R11	100 K, 0.1 W±0.01	Resistor	Yageo	RC0603FR-07100KL
38	1	R7	0.125 W±0.01	Resistor	Yageo	RC0805FR-07100KL
39	1	R16	2.7 K, 0.125 W±0.01	Resistor	Stackpole	RMCF0805FT2K70
40	1	R8	1.05 R, 0.25 W±0.01	Resistor	Vishay	CRCW12061R05FKEA
41	1	R10	24 K, 0.125 W±0.01	Resistor	Yageo	RC0805FR-0724KL
42	1	R12	8.2 K, 0.063 W±0.05	Resistor	Yageo	RC0603JR-078K2L
43	1	R13	4.99 K, 0.1 W±0.01	Resistor	Yageo	RC0603FR-074K99L
44	1	R14	47 K, 0.1 W±0.05	Resistor	Yageo	RC0603JR-0747KL
45	1	SW1		Switch	Panasonic	EVP-AA402W
46	3	TP1, TP2, TP3		Mounting holes		
47	1	T1	EFD20	Transformer	Würth	750810150
48	1	U1	HVLED815PF	LED driver	ST	HVLED815PFTR
49	1	U2	LDL212	Low dropout regulator	ST	LDL212
50	1	U3	STM32L051K6U6	Microcontroller	ST	STM32L051K6U6
51	1	U4	SPSGRF, 868 MHz	Low power sub-GHz module	ST	SPSGRF-868

Table 4: STEVAL-ILL082V1 Remote bill of materials

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
1	1	U1	SMD	SPIRIT1 module	ST	SP1ML-868

Bill of materials
UM2170

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
2	1	U2 (DNM)	LGA-14	MEMS accelerometer	ST	DNM
3	1	U3 (DNM)	HLGA-6L	Humidity and temperature sensor	ST	DNM
4	2	D5, D6	ST0201	ESD protection	ST	ESDALC6V1-1U2
5	2	D3, D4	SOD-323	Schottky diode	ST	BAT54JFILM
6	1	J1	Single line 5 pin Berg stick (1.27 pitch)	Berg stick	Sullins	GRPB051VWVN-RC
7	1	J2 (DNM)	Single line 2 pin Berg stick (1.27 pitch)	Berg stick	Sullins	DNM
8	1	BT1	20 mm coin	CR2032 battery holder	Linx	BAT-HLD-001
9	4	C3, C7, C9, C10	100 nF, 10 V, X5R±10%	Capacitors	Murata	GRM155R61A104KA01J
10	2	C1, C5 (DNM)		Capacitors		DNM
11	1	C2	10 µF, 25 V, ±10%	Capacitor	Murata	GRM219R61E106KA12D
12	1	C4	100 pF, 50 V, ±5%	Capacitor	Yageo	CC0402JRNPO9BN101
13	2	R1, R2 (DNM)	47 µF, 25 V, X5R±0.2	Resistor	Yageo	DNM
14	6	R3, R4, R5, R6, R16, R17	470 K, 10 W, ±5%	Resistors	Panasonic	ERJ-2GEJ474X
15	2	R9, R12	470 ohms, 1-16 W±1%	Resistor	KOA Speer	RK73H1ETTP4700F
16	2	R10, R11 (DNM)		Resistor	Te Connectivity	6-1622826-4
17	4	R13, R14, R15, R18	10 K, ±5%	Resistors	Samsung	RC1005J103CS
18	2	R7, R8 (DNM)	10 K	Resistors		DNM
19	2	SW1, SW2	0.05 A, 12 V	Tactile switches	Panasonic	EVQ-5PN04K
20	1	SW3	0.05 A, 12 V	Tactile switch	Omron	B3U-3000P
21	2	D1, D2	CHIPLED 645NM RED DIFF 0805	LED	OSRAM Opto Semiconductors Inc	LH R974-LP-1

6 Revision history

Table 5: Document revision history

Date	Version	Changes
08-Feb-2017	1	Initial release.
21-Sep-2017	2	Updated: Figure 3

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