UM2166
User manual

Getting started with smart home lighting based on HVLED815PF and SPBTLE-RF

Introduction

The STEVAL-ILL083V1 evaluation board consists of a LED driver board based on HVLED815PF with the connectivity module SPBTLE-RF and the STM32L0 microcontroller which manages wireless communication and LED brightness control. The microcontroller and the connectivity module are supplied by the LED driver through the primary side auxiliary winding.

The embedded SPBTLE-RF Bluetooth v4.1 module lets you control the STEVAL-ILL083V1 board through the Smart Home Lighting Android™ application and can help 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-ILL083V1 evaluation board (top view)

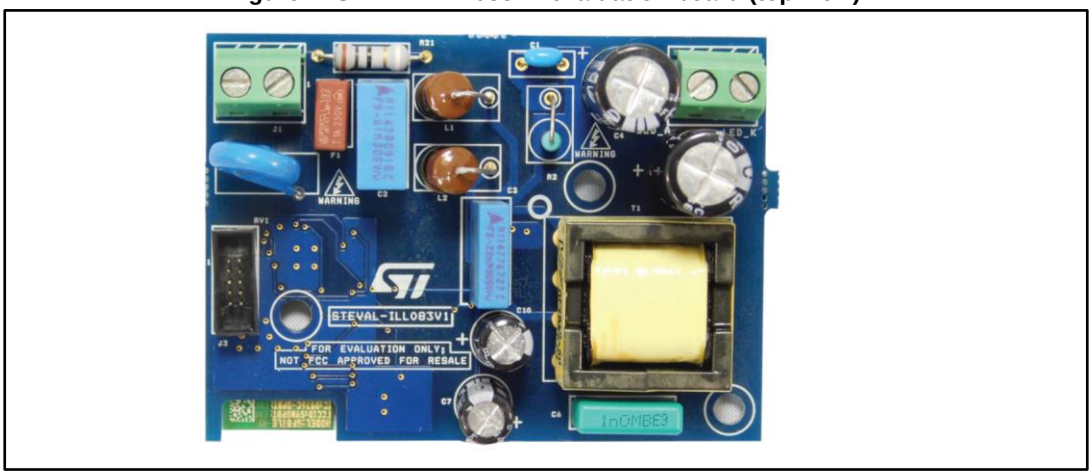
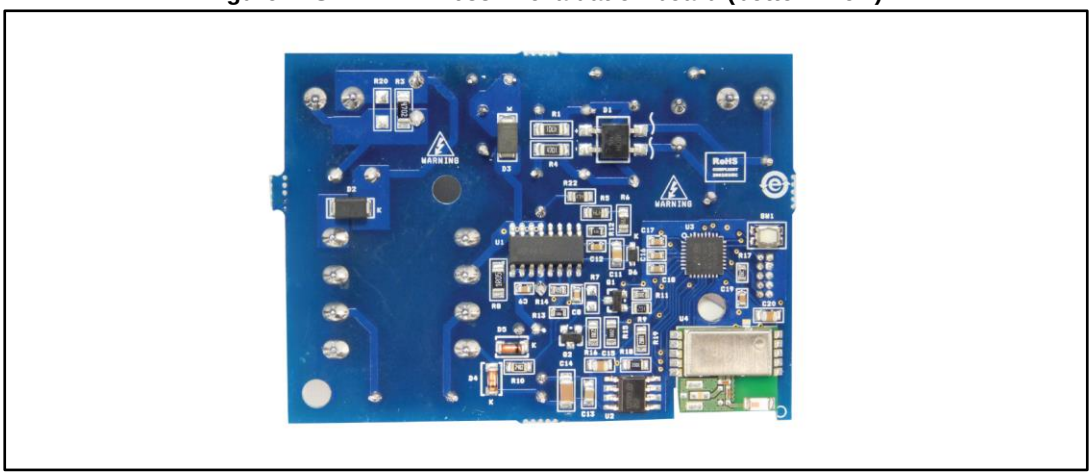


Figure 2: STEVAL-ILL083V1 evaluation board (bottom view)



Contents

List of tables

List of figures

1 Overview

The STEVAL-ILL083V1 features:

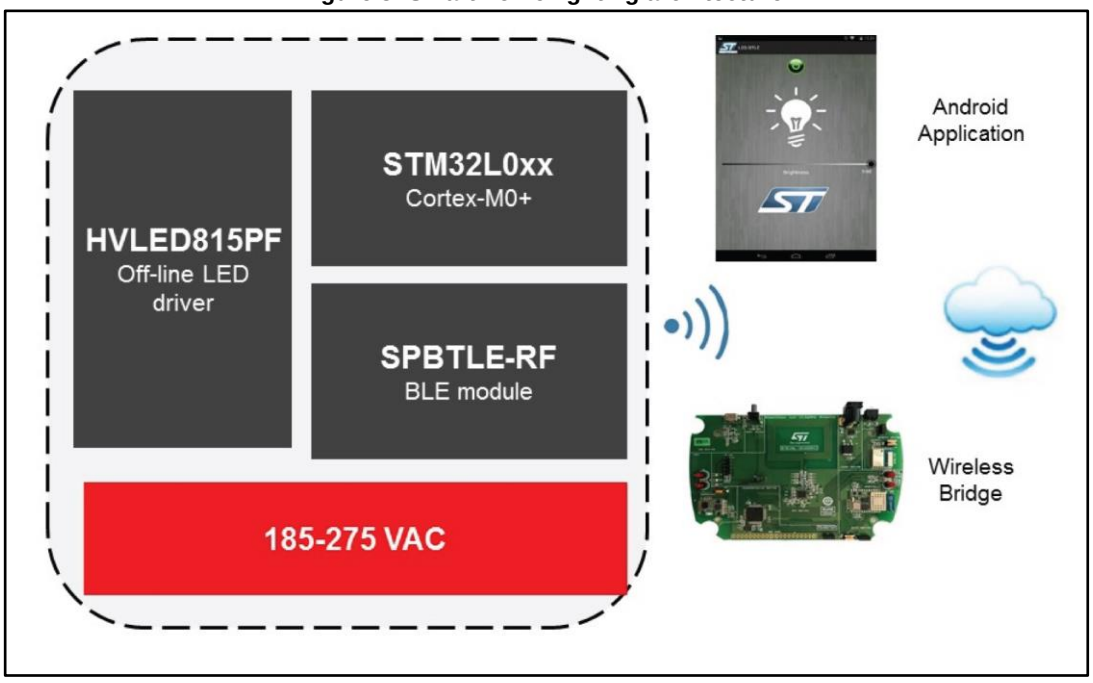
- LED driver main features
  - 10 W flyback converter with quasi-resonant operation
  - Primary side regulation, no optocoupler required
  - High power factor and low THD
  - Open/short LED management
  - ±1% Led current regulation
  - Dimming range: 2.5% to 100%
- BLE connectivity main features
  - Works with Android App - Smart Home Lighting
  - Allows lamp remote power-on / power-off
  - Allows lamp remote dimming
- 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 Bluetooth interface (SPBTLE-RF) for external communication and a remote application 'Smart Home Lighting' 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).

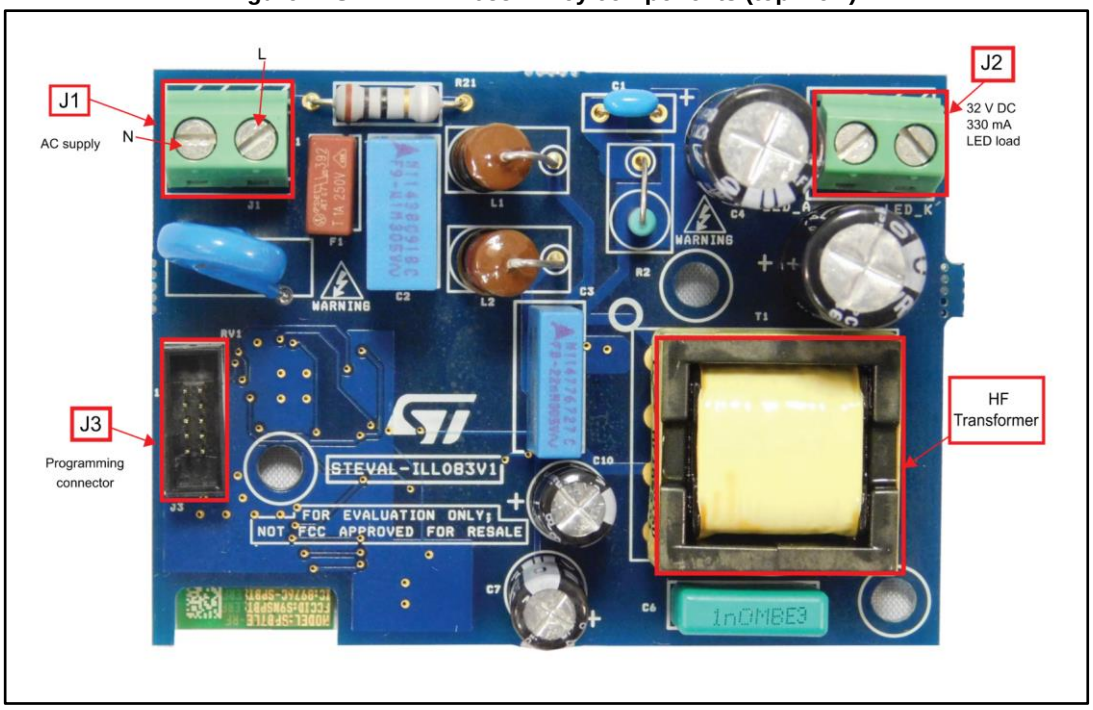
Figure 3: Smart home lighting architecture



1.2 Hardware description

The top side of the STEVAL-ILL083V1 board is figured below.

Figure 4: STEVAL-ILL083V1 key components (top view)

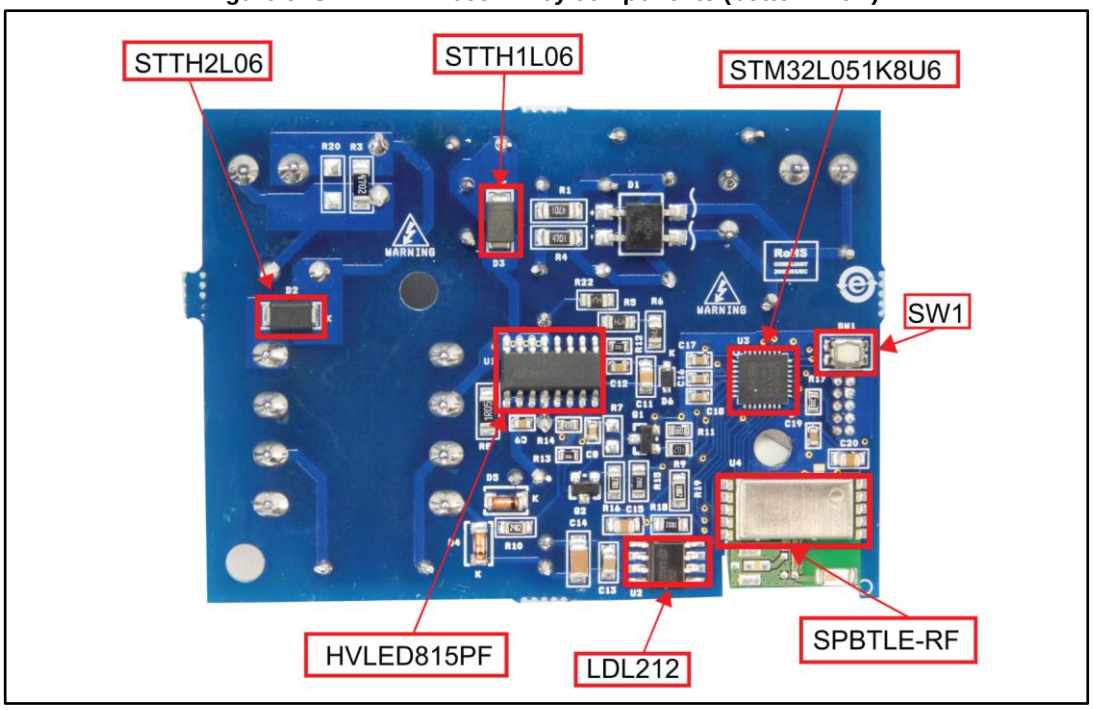


Key top side components include:

- **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-ILL083V1 board is figured below.

Figure 5: STEVAL-ILL083V1 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.
- **SPBTLE-RF**: the easy-to-use Bluetooth smart master/slave network processor module can act as a Bluetooth smart sensor and hub device at the same time. It provides a complete RF platform with integrated radio, antenna, high frequency and LPO oscillators in a certified solution which optimizes time-to-market of final applications. It can be powered by a 3 V cell battery.
- **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

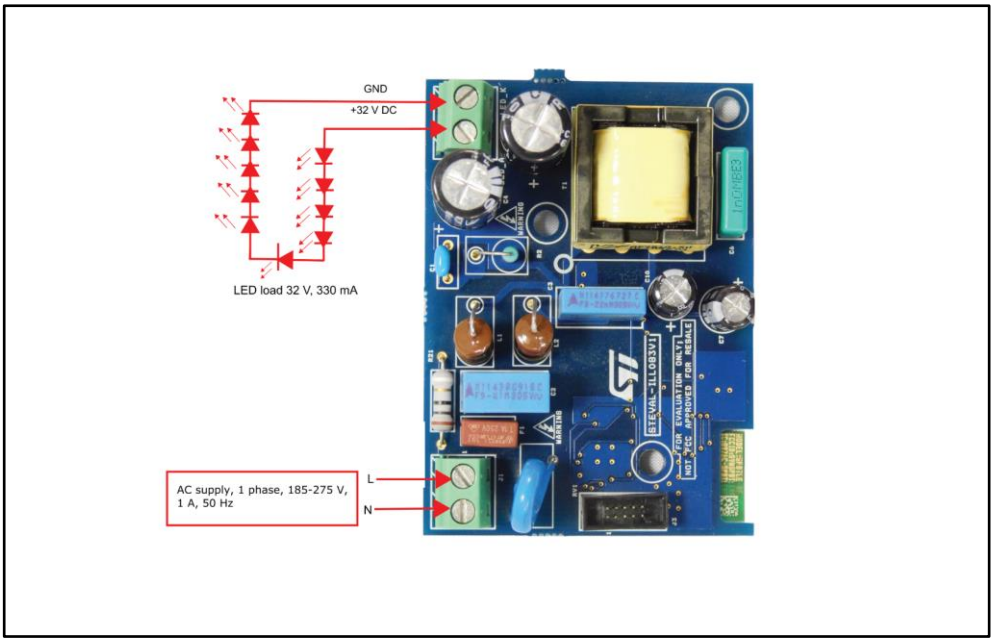
2.1 Powering the board

Smart home lighting board works on 185– 275 V_{AC} input voltage to control 32 V, 322±1% mA LED load.It contains one off-line LED driver for lighting and housekeeping power supply, one low drop regulator, 32-bit low power microcontroller and one module for wireless connectivity.

2.2 Smart home lighting board used with SPBTLE-RF and Android app

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 Android app 'Smart Home Lighting' to control the LED brightness from 2.5% to 100% or to switch LEDs on or off.

Figure 7: Android application for smart home lighting

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 LED load: 32 V, 322 mA±1%	AC source: Agilent 6812B Power analyzer: Yokogaba -WT310

Figure 8: STEVAL-ILL083V1 test setup

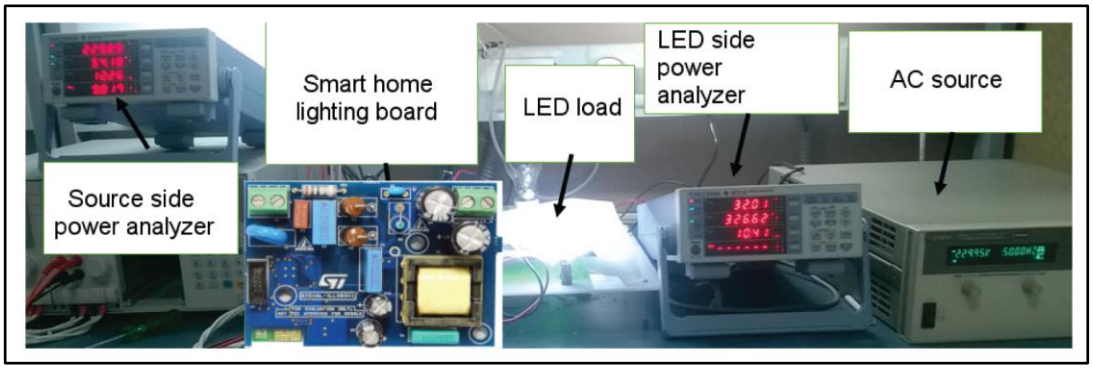


Table 2: Test results

Vin (V)	Pin (W)	Po (W)	Efficiency (%)	PF	THD (%)	LED current	Current regulation (%)
185	12.13	10.30	84.91	0.99	7.82	324.00	0.72
200	12.03	10.22	84.95	0.99	3.88	323.00	0.41
205	12.00	10.19	84.92	0.99	4.90	322.63	0.30
210	11.97	10.17	84.95	0.99	6.23	321.78	0.03
220	11.94	10.15	84.97	0.98	8.90	321.32	-0.11
230	11.95	10.14	84.83	0.98	11.96	321.04	-0.20
250	11.94	10.08	84.42	0.97	15.64	319.36	-0.72
275	12.03	10.12	84.09	0.97	19.50	320.31	-0.43

Figure 9: Input voltage versus LED current

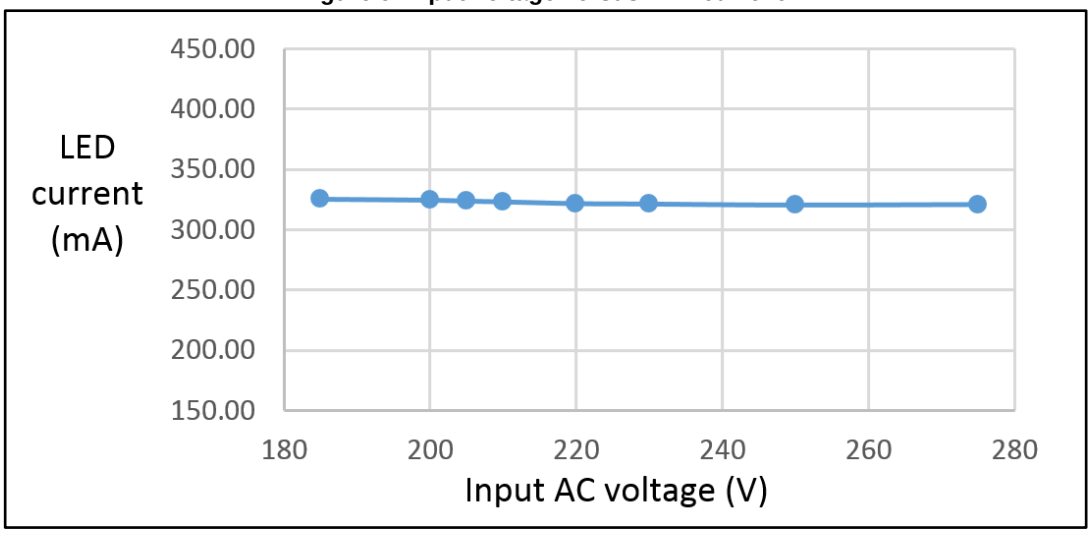


Figure 10: Input voltage versus PF

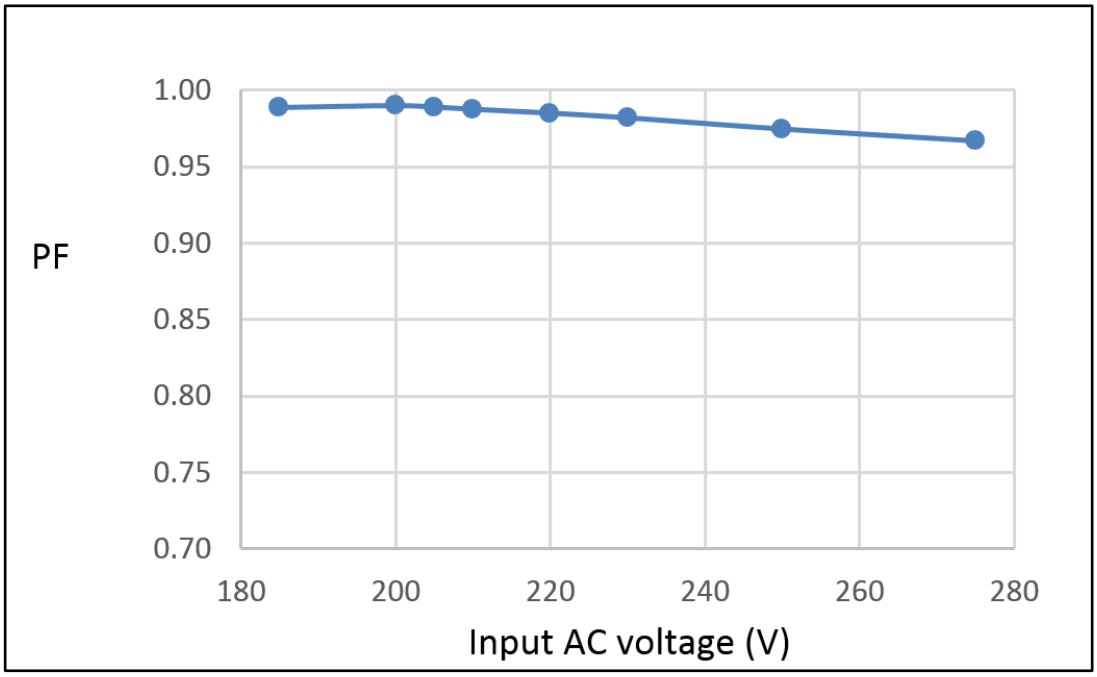


Figure 11: THD versus line variation

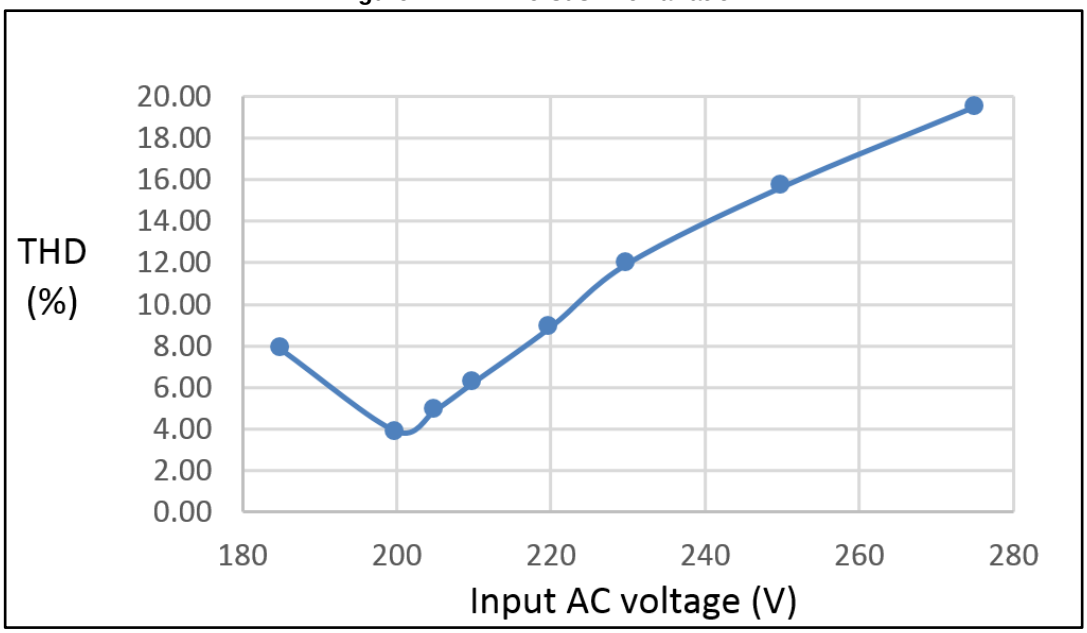


Figure 12: Current regulation

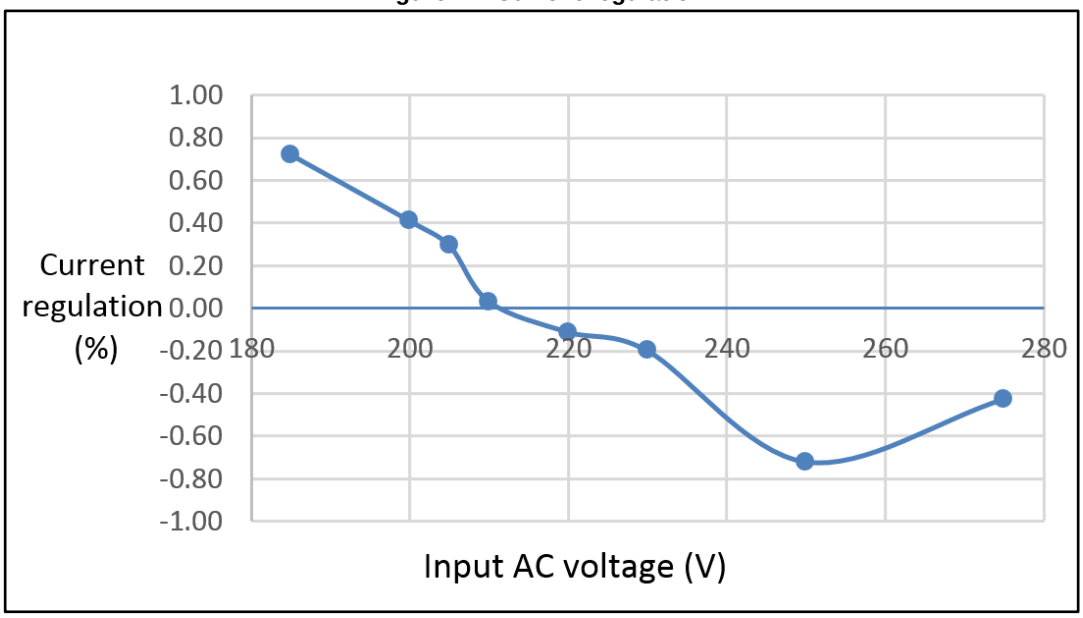
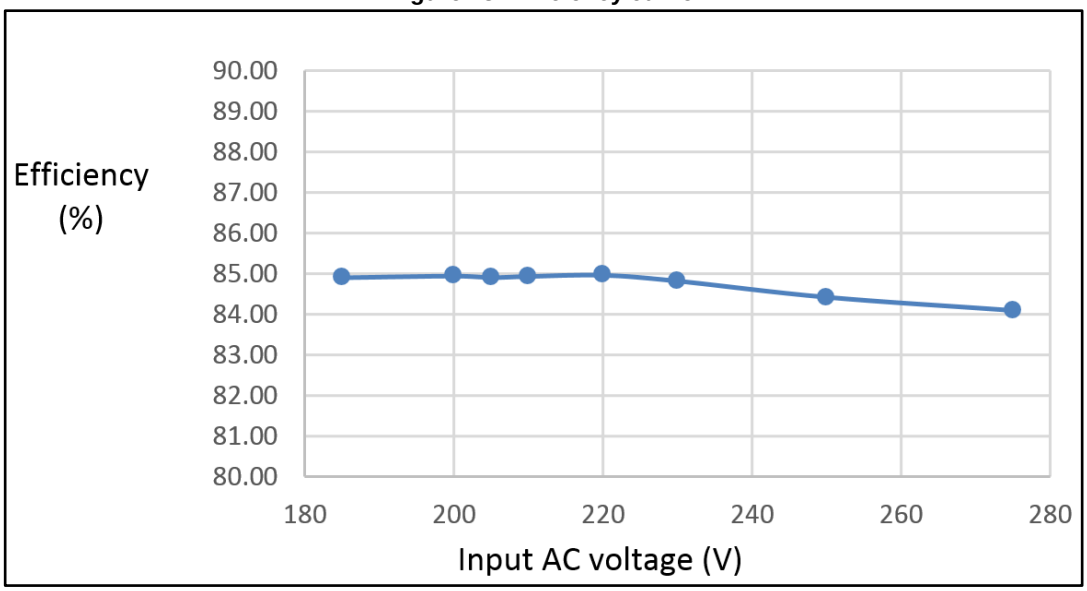


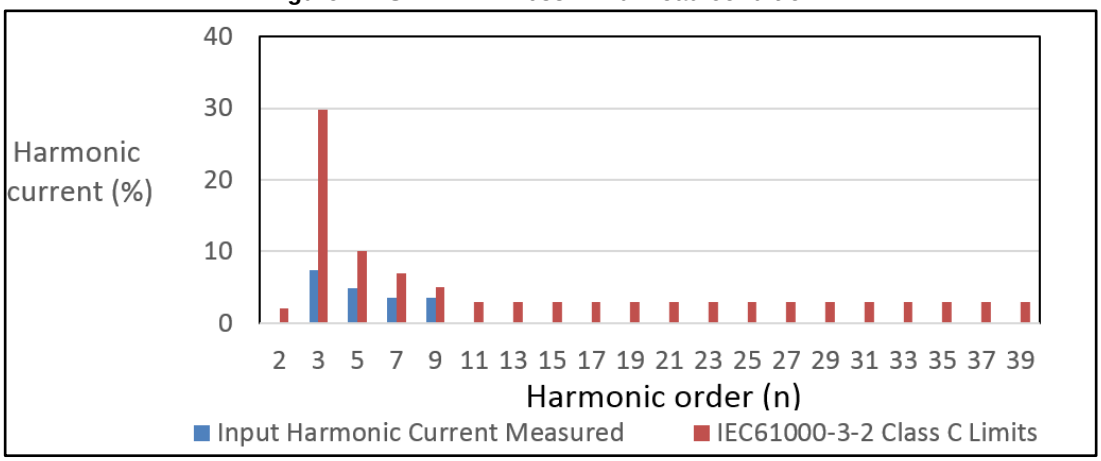
Figure 13: Efficiency curve



3.2 IEC61000-3-2 class C harmonic measurement

The STEVAL-ILL083V1 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.

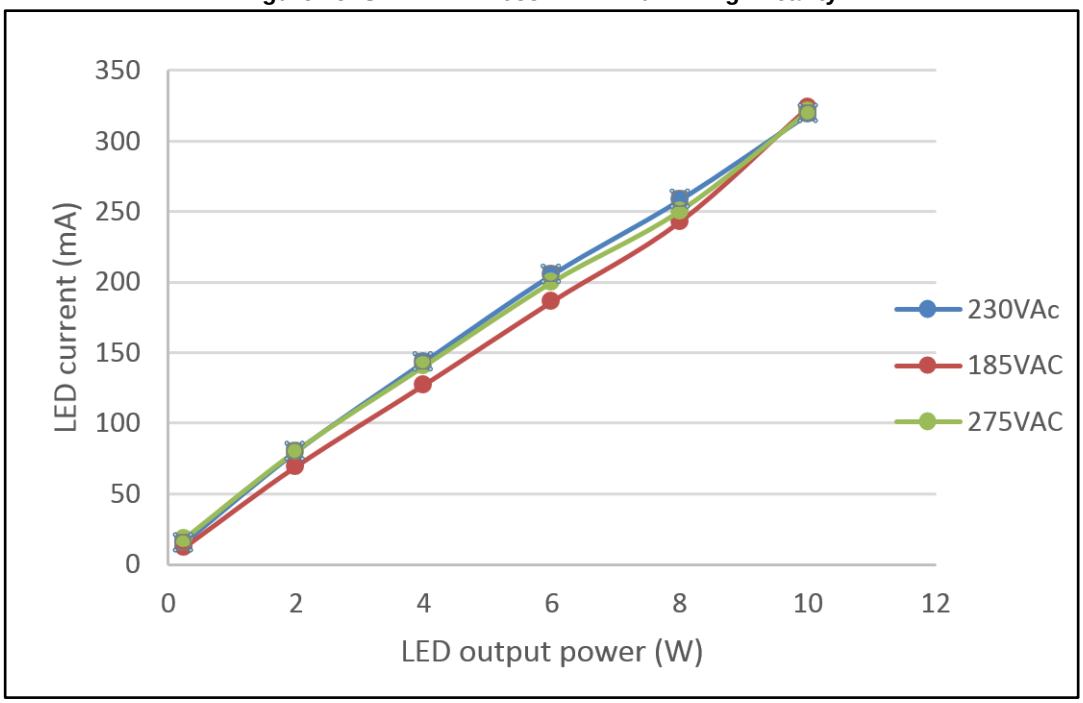
Figure 14: STEVAL-ILL083V1: full load condition



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-ILL083V1: LED dimming linearity

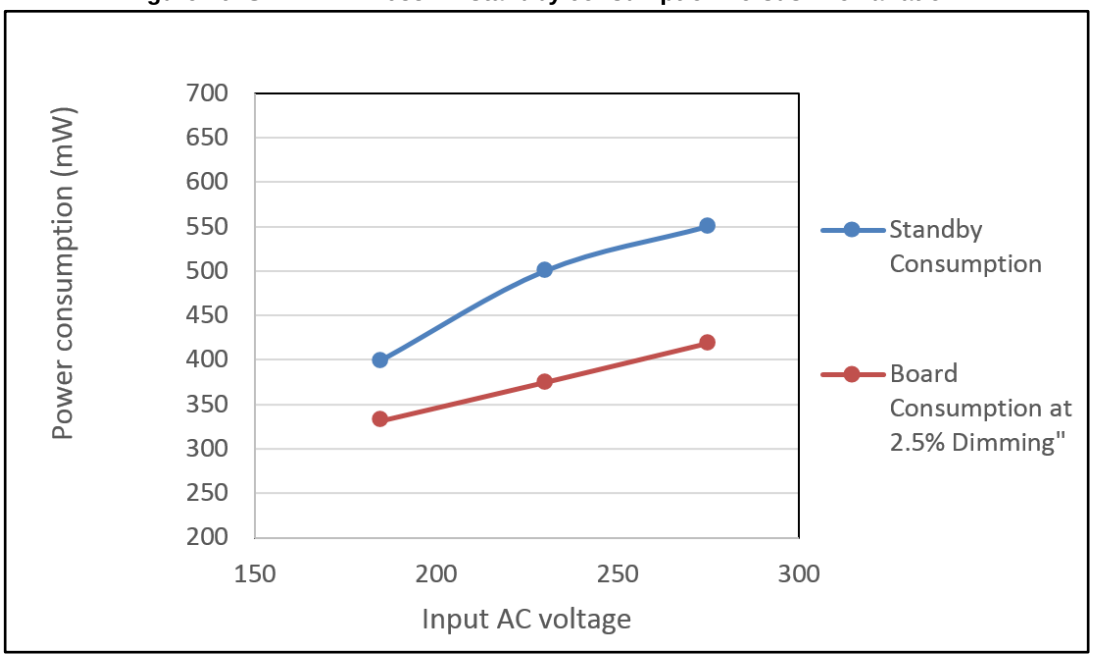


3.4 Standby power consumption

The STEVAL-ILL083V1 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-ILL083V1: standby consumption versus line variation



4 Schematic diagrams

Figure 17: STEVAL-ILL083V1 circuit schematic (1 of 3)

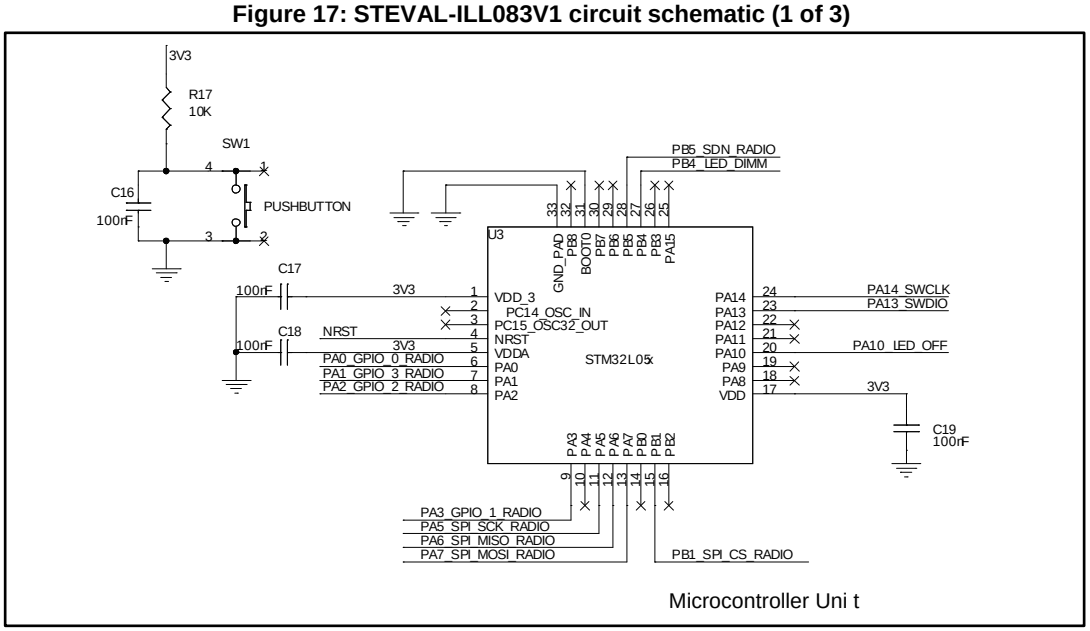


Figure 18: STEVAL-ILL083V1 circuit schematic (2 of 3)

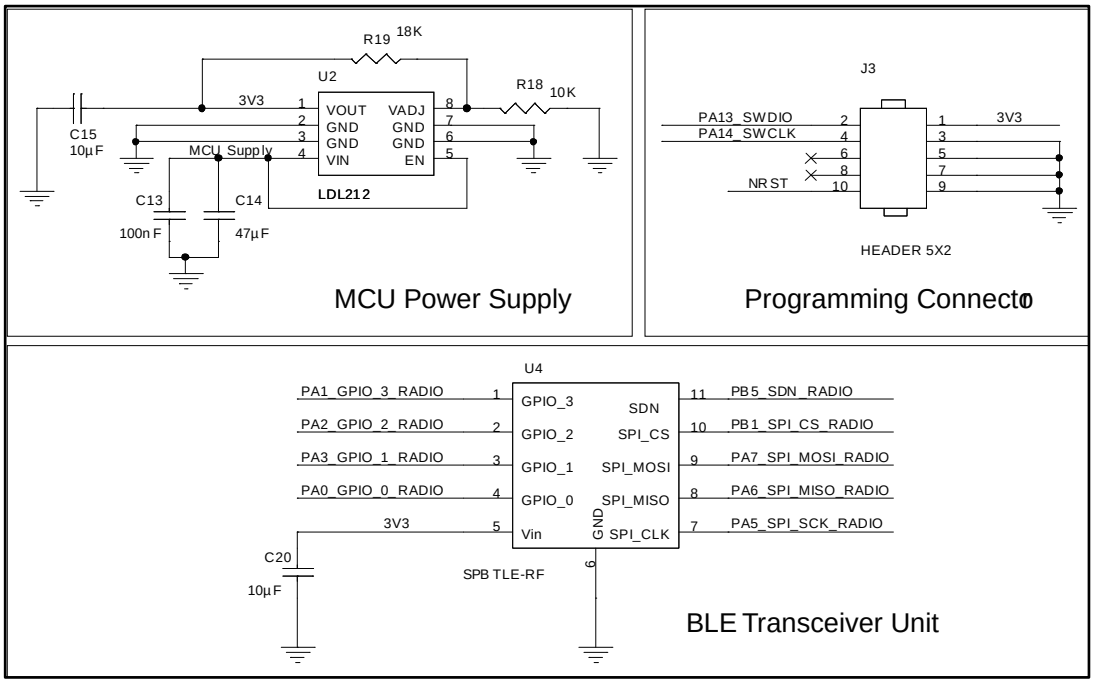
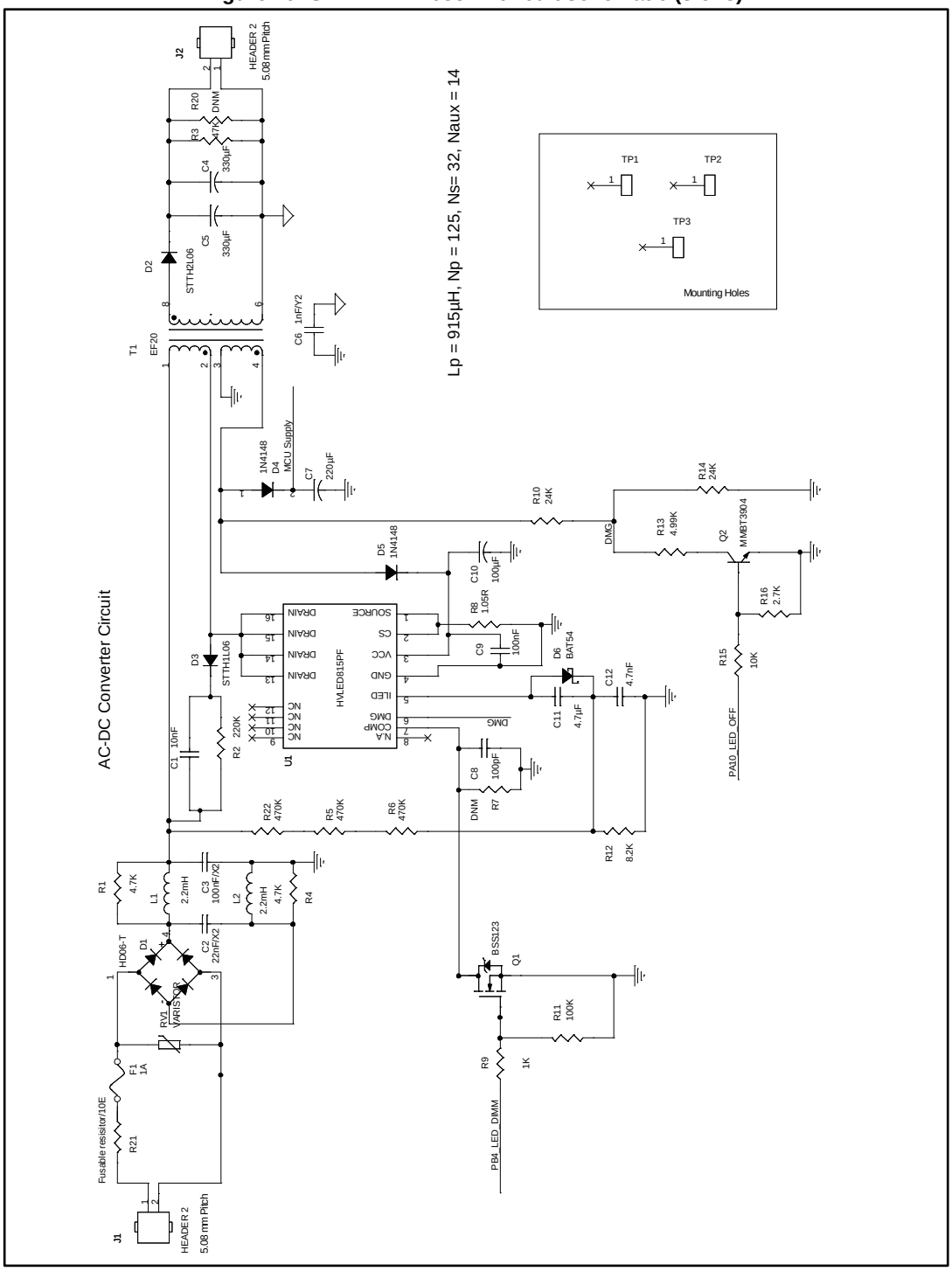


Figure 19: STEVAL-ILL083V1 circuit schematic (3 of 3)



5 Bill of materials

Table 3: STEVAL-ILL083V1 bill of materials

Item	Q.ty	Ref.	Part / Value	Description	Manufacturer	Order code
1	1	C1	10 nF, 630 V±0.1	Capacitor	Murata	RDER72J103K2M1H03A
2	1	C2	100 nF, 305 V, X2±0.2	Capacitor	EPCOS	B32921C3104M
3	1	C3	22 nF, 305 V, X2±0.2	Capacitor	EPCOS	B32921C3223M
4	2	C4, C5	330 µF, 63 V	Capacitors	Nichion	UVR1J331MPD
5	1	C6	1 nF, 250 V_{AC}, Y2±0.2	Capacitor	Kemet	PHE850EA4100MA01R17
6	1	C7	220 µF, 25 V±0.2	Capacitor	Nichion	UVK1E221MED1TD
7	1	C8	100 pF, 25 V, X7R±0.05	Capacitor	Wurtz	885012206053
8	1	C13	100 nF, 25 V, X7R±0.1	Capacitor	Murata	GRM21BR71E104KA01L
9	5	C9, C16, C17, C18, C19	100 nF, 25 V, X7R±0.1	Capacitors	TDK	C1608X7R1E104K080AA
10	1	C10	100 µF, 35 V±0.2	Capacitor	Nichion	UVR1V101MED1TD
11	1	C11	4.7 µF, 16 V, X7R±0.1	Capacitor	Murata	GRM21BR71C475KA73L
12	1	C12	4.7 nF, 25 V, X7R±0.1	Capacitor	Murata	GRM188R71H472KA01D
13	1	C14	47 µF, 25 V, X5R±0.2	Capacitor	TDK	C3216X5R1E476M160AC
14	2	C15, C20	10 µF, 10 V, X7R±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	Wurth	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	SPBTLE-RF	BLE module-RF platform	ST	SPBTLE-RF

6 Revision history

Table 4: Document revision history

Date	Version	Changes
30-Jan-2017	1	Initial release.
28-Mar-2017	2	Updated *Section "Introduction"* and *Section 1: "Overview"*.
26-Sep-2017	3	Updated *Section 1.1: "Smart home lighting architecture"*

IMPORTANT NOTICE – PLEASE READ CAREFULLY

STMicroelectronics NV and its subsidiaries (“ST”) reserve the right to make changes, corrections, enhancements, modifications, and improvements to ST products and/or to this document at any time without notice. Purchasers should obtain the latest relevant information on ST products before placing orders. ST products are sold pursuant to ST’s terms and conditions of sale in place at the time of order acknowledgement.

Purchasers are solely responsible for the choice, selection, and use of ST products and ST assumes no liability for application assistance or the design of Purchasers’ products.

No license, express or implied, to any intellectual property right is granted by ST herein.

Resale of ST products with provisions different from the information set forth herein shall void any warranty granted by ST for such product.

ST and the ST logo are trademarks of ST. All other product or service names are the property of their respective owners.

Information in this document supersedes and replaces information previously supplied in any prior versions of this document.