UM1696
User manual

5 W A1-Type wireless power transmitter based on STLUX385A

Introduction

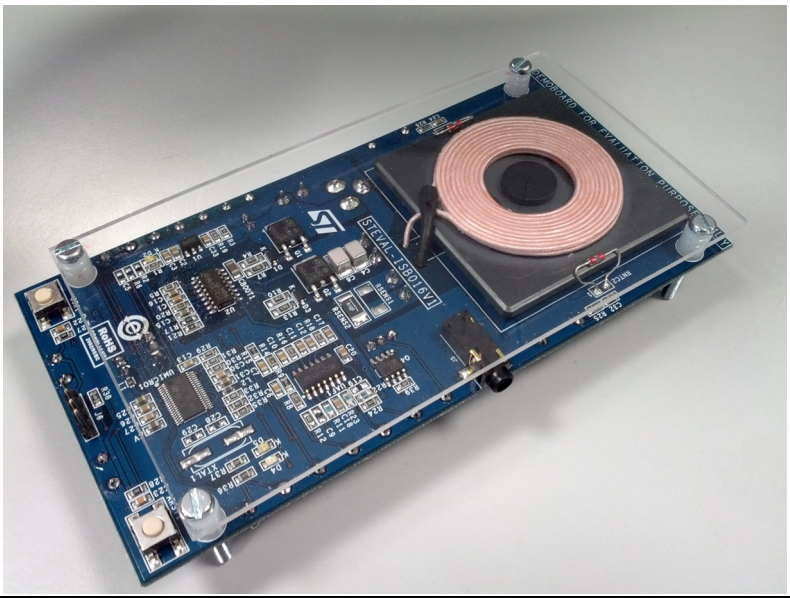
The ST wireless battery charger transmitter is a system to demonstrate and help engineers to start designing 5 watt wireless power solutions.

The wireless power transmitter provides the basic functions of the wireless power consortium 1.1.1 standard and is intended to allow designers and advanced users to explore and develop proprietary standards and solutions by simply modifying the associated firmware.

The power transmitter unit is connected via the printed circuit board with the power transmitter coil and electronics, LED indicators and user buttons. The main IC of the system is the STLUX385A digital controller.

It requires a 19 VDC, 1 A power supply to operate and control a wireless power transfer to any WPC compliant power receiver.

Figure 1. STEVAL-ISB016V1



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1 Features

The ST WBC power transmitter evaluation board has the following features:

- WPC 1.1.1 compliant
- Standard A1-type transmitter architecture
- Standard A1-type transmitter coil
- LED over current indicator (RED fixed)
- LED FOD indicator (RED blinking)
- LED communication indicator with the power receiver (BLUE)
- LED system on indicator (GREEN)

A UART connector for serial data communication to a PC monitors the system parameters such as working frequency, power transmitted, power received, efficiency, etc.

Table 1. Electrical parameters

Parameter		Notes and conditions	Min.	Typ.	Max.	Unit
Input characteristics						
V_{in}	Input voltage	DC voltage	18	19	20	V
I_{in}	Input current	V_{in}= 19 V, I_{out}= Max		0.35		A
System characteristics						
F_S	Switching frequency	50% duty cycle	110		205	kHz
dc@205	Duty cycle modulation	Only for F_S= 205 kHz	10		50	%
Eff.	Efficiency	V_{in}= 19, RX_Power= 5 W		70		%

2 Connectors, jumpers and test points

With reference to the schematic in *Appendix A: WBC power TX evaluation board*.

Figure 2. Top layout

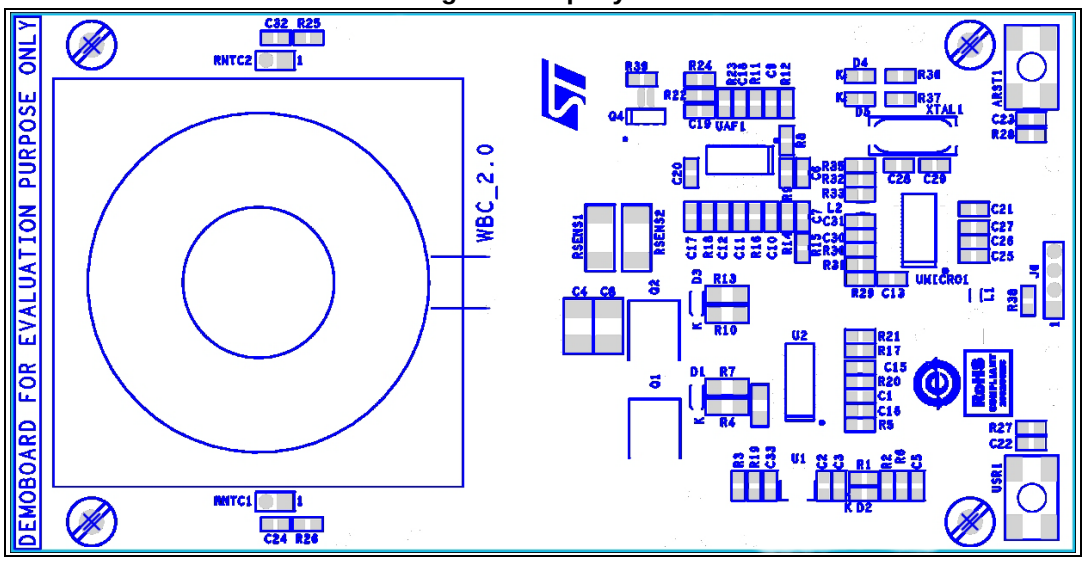


Figure 3. Bottom layout

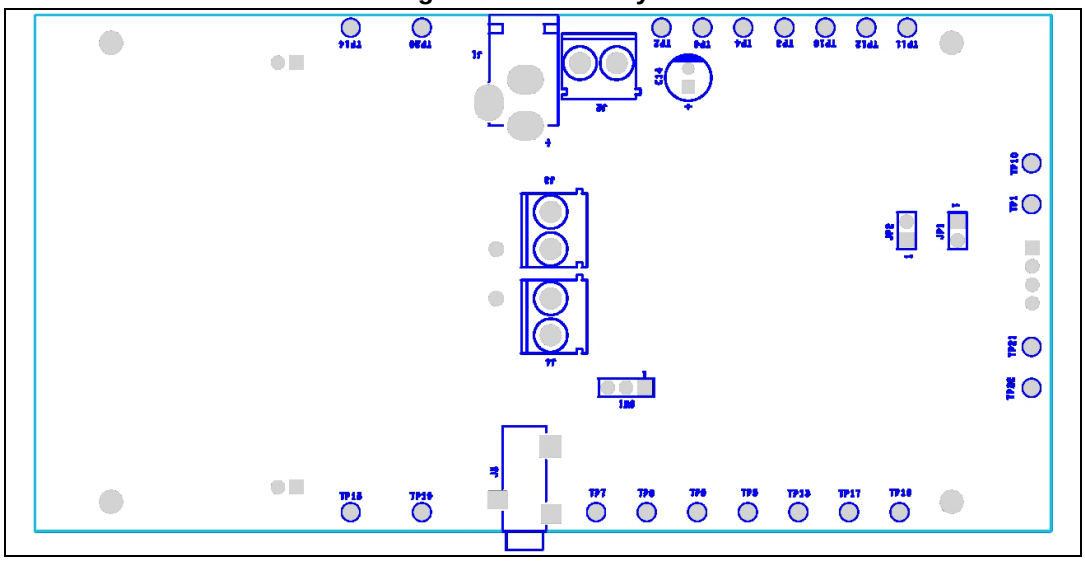


Table 2. Connectors

Connector	Description
J1	Power supply connector / 19 V DC-DC power socket 2.5 mm
J2	Power supply connector / 19 V DC-2 way screw terminal
J3	Connection between half bridge central point and TX coil - 2 way screw terminal Connect a wire of the coil to terminal 1
J4	Connection between TX coil and current sense resistor - 2 way screw terminal Connect a wire of the coil to terminal 1
J5	UART output - stereo jack connector 3.5 mm
J6	SWIM connector to FW download and debug

Table 3. Jumpers

Jumper	Description
JP1	Enables/disables the power supply to STLUX385A digital controller. Default is short.
JP2	For factory service. Default is open (both).
SW1	For factory service. To select the appropriate current sense resistor. Default is: short between 1 and 2 and open between 2 and 3.

Table 4. Test points

Test point	Description	Test point	Description
TP1	V_{DD} (3.3 V DC regulated voltage)	TP12	Digital controller high side power MOSFET gate driver
TP2	HVG (half bridge power MOSFET high side gate)	TP13	CURR (analog signal to monitor the DC current through the coil)
TP3	Vth (not used)	TP14	COIL TEMP 1 (analog signal to monitor the temperature of the coil)
TP4	VBUS (19 V DC voltage V_{in} divided)	TP15	COIL TEMP 2 (analog signal to monitor the temperature of the coil)
TP5	AV1 (amplified V_{SENSE})	TP16	LED Blue
TP6	LVG (half bridge power MOSFET low side gate)	TP17	LED Red
TP7	V_{SENSE} (voltage to sense the current through the power coil)	TP18	FAULT IN (To monitor the over current event on the coil, goes down if the overcurrent happens)
TP8	AV2 (demodulated power receiver signal)	TP19	PWR GND
TP9	HPF	TP20	Digital controller GND
TP10	V_{DD} digital controller (3.3 V DC regulated voltage to the STLUX385A digital controller)	TP21	Digital controller GND
TP11	Digital controller low side power MOSFET gate driver	TP22	AGC

3 Firmware

The digital controller is the STLUX385A. The STLUX385A is part of the MASTERLUX™ family of ST's digital devices tailored for lighting and power conversion. The STLUX385A has been successfully integrated into a wide range of architectures and applications, starting from simple buck converters for LED driving, boost for power factor correction, half-bridge resonant converters for dimmable LED strings, up to full-bridge control in HID lamp ballasts, wireless power chargers and TV power supplies.

This digital controller has a CPU frequency of 16 MHZ, 32 Kb of program memory and 2 Kb of RAM.

The firmware is organized as a collection of files organized in a project for RAISONANCE RIDE7, a full-featured integrated development environment (IDE) that provides users with seamless integration and easy access to the complete range of RAISONANCE tools and features for writing, compiling and debugging application code from a single user interface.

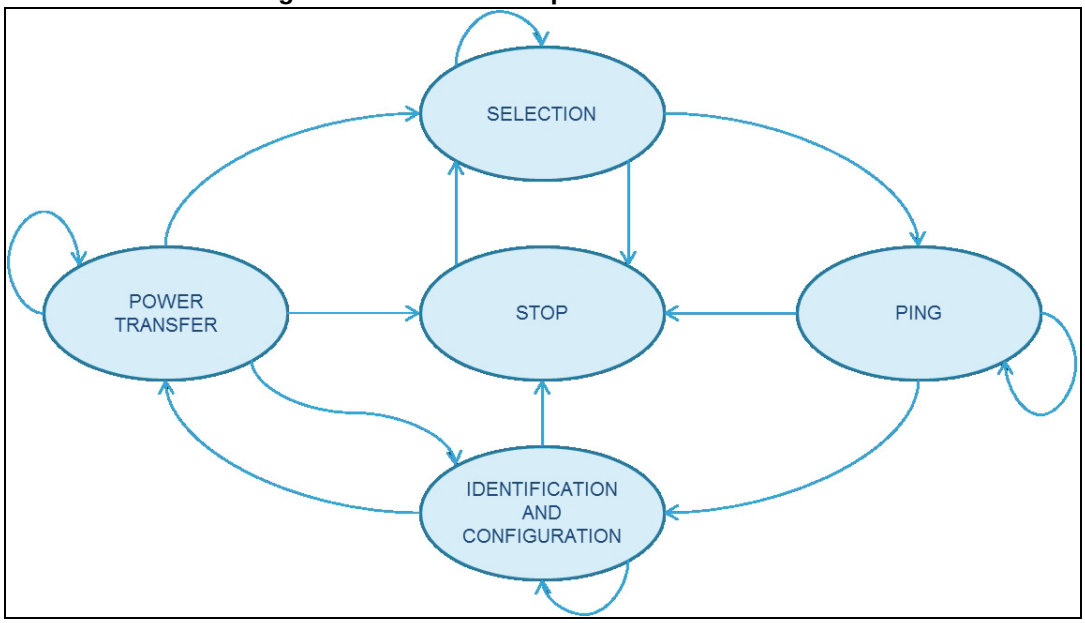
3.1 STEVAL-ISB016V1 firmware

The firmware allows the digital controller to manage the WPC communication protocol while controlling the power transmitted to any WPC power receiver unit.

The STEVAL-ISB016V1 is also able to manage the UART communication with a PC to show information about the system status, such as transmitted power, received power, efficiency, FOD, etc.

The digital controller performs the WPC standard protocol (ver. 1.1.1) acting as the finite state machine described in *Figure 4*.

Figure 4. WBC FSM for power transmitter unit



The file params.h allows to the user to make some customization about key system parameters.

```
/* Define to prevent recursive inclusion -----------------------------------
---*/
#ifndef __PARAMS_H
#define __PARAMS_H

#define FW_VER  "Firmware Version X.Y"

#define USE_CHECK_COIL_TEMPERATURE// comment to check no coil temperature
#define USE_CHECK_FOD// comment to check no Foreign Object Detection

/* Includes ----------------------------------------------------------------
---*/
#include "stlux385.h"

/* Exported constants --------------------------------------*/
#define BRIDGE_MIN_FREQUENCY((u32)110000)
   // min WPC Operating Frequency in Hz
#define BRIDGE_MAX_FREQUENCY((u32)205000)
   // max WPC Operating Frequency in Hz
#define BRIDGE_INIT_FREQUENCY((u32)175000)
   // initial WPC Operating Frequency
#define BRIDGE_MAX_DUTY_CYCLE_E1((u16)500)
   // max Duty Cycle percentage (multiplied by 10) for WPC Operating
Frequency
#define BRIDGE_MIN_DUTY_CYCLE_E1((u16)100)
   // min Duty Cycle percentage (multiplied by 10) for WPC Operating
Frequency
#define BRIDGE_INIT_DUTY_CYCLE_E1BRIDGE_MAX_DUTY_CYCLE_E1
   // initial Duty Cycle of WPC Operating Frequency
#define BRIDGE_DEAD_TIME((u16)110)
   // Dead Time for Half-Bridge Inverter in ns

#define ADC_Vref_mV1250
   // STLUX ADC reference voltage in mV
#define ADC_DIG_OVF1023
   // STLUX ADC maximum digital value

#define RSENSE0.150
   // RSENS1 ohm value
#define AV1_Rup62000
   // R12 ohm value
#define AV1_Rdown3300
   // R11 ohm value

#define VBUS_Rup((u32)390000)
   // R3 ohm value
```

```
#define VBUS_Rdown((u32)22000)
   // R19 ohm value

#define R_NTC_UP120000
   // R25 and R26 ohm value
#define R_NTC_30C(50000*0.8066)
   // NTC ohm value for 30°C
#define R_NTC_50C(50000*0.3620)
   // NTC ohm value for 50°C
#define R_NTC_55C(50000*0.3003)
   // NTC ohm value for 55°C
#define R_NTC_60C(50000*0.2504)
   // NTC ohm value for 60°C
#define R_NTC_THRESHOLDR_NTC_50C
   // NTC Chosen Threshold

#define OVER_CURRENT_STOP_LED_BLINKING_DELAY500
   // Red LED blinking delay (in ms) after an Over Current detection
#define OVER_CURRENT_STOP_LED_BLINKING_NR7
   // Red LED blinking times after an Over Current detection
#define FOD_DETECTED_STOP_LED_BLINKING_DELAY500
   // Red LED blinking delay (in ms) after a Foreign Object Detection (FOD)
#define FOD_DETECTED_STOP_LED_BLINKING_NR5
   // Red LED blinking times after a Foreign Object Detection (FOD)
#define COIL_OVER_TEMPERATURE_STOP_LED_BLINKING_DELAY500
   // Red LED blinking delay (in ms) after an Over Temperature detection
#define COIL_OVER_TEMPERATURE_STOP_LED_BLINKING_NR3
   // Red LED blinking times after an Over Temperature detection
#define GENERAL_STOP_LED_BLINKING_DELAY250
   // Red LED blinking delay (in ms) after a generic stop cause
#define GENERAL_STOP_LED_BLINKING_NR1
   // Red LED blinking times after a generic stop cause

/* Exported variables ------------------------------------*/
extern u32 bridge_min_frequency;
extern u32 bridge_max_frequency;
extern u32 bridge_init_frequency;
extern u16 bridge_max_duty_cycle_e1;
extern u16 bridge_min_duty_cycle_e1;
extern u16 bridge_init_duty_cycle_e1;
extern u16 bridge_dead_time;
extern u16 Vd2ImA_e3;
extern u16 Vd2VmV_e3;
extern u16 Vd_NTC_th;
extern u16 oc_led_blnk_dly;
```

```
extern u8 oc_led_blnk_nr;
extern u16 fod_led_blnk_dly;
extern u8 fod_led_blnk_nr;
extern u16 cot_led_blnk_dly;
extern u8 cot_led_blnk_nr;
extern u16 gnrl_led_blnk_dly;
extern u8 gnrl_led_blnk_nr;
extern bool use_check_coil_temperature;
extern bool use_check_fod;

/* Exported functions ------------------------------------------------------
-- */
void Init_Config(void);
void blinking_all_leds(u16 delay_ms, u8 times);
void wbc_fsm(void);

#endif /* __PARAMS_H */

/****************** (C) COPYRIGHT STMicroelectronics ********* END OF FILE
***/
```

3.1.1 Used peripherals

The peripherals that are used by this unit are the following:

- ADC
  - CH0: 19 V DC V_{IN} voltage measurement
  - CH1: coil current measurement
  - CH2: coil temperature 1 measurement
  - CH3: coil temperature 2 measurement
- SMED0
  - Half bridge high side power MOSFET gate driver
- SMED1
  - Half bridge low side power MOSFET gate driver
- SMED5

Analog comparator 3

DAC 3

  - WPC communication signal decode
- STMR
  - Time base
- UART
  - To send information to PC

Note: SMED0 and SMED1 are synchronous coupled.

3.1.2 Module summary

Module information

```
*******************************************************************************
*****
*** MODULE SUMMARY
***

    Module                ro code  ro data  rw data
    ------                -------  -------  -------
Debug\Obj: [1]
    STEVAL-ISB016V1.o         517
    adc.o                     488
    main.o                     16
    params.o                              40       40
    stlux_it.o                245
    stmr.o                     85                  6
    uart.o                    598      340       20
    wbc.o                   6 659    1 511      138
    ----------------------------------------------
    Total:                  8 608    1 891      204

command line: [2]
    ----------------------------------------------
    Total:

dbgstm8smd.a: [3]
    __dbg_break.o              1
    __dbg_xxexit.o            20
    ----------------------------------------------
    Total:                    21

dlstm8smn.a: [4]
    cexit.o                    5
    char.o                     6
    cstartup.o                19
    dc_util.o                 44
    exit.o                     3
    float.o                  761
    init.o                    23
    init_small.o              70
    interrupt.o                3      128
    long.o                   607
    long_util.o               50
    low_level_init.o           3
```

```
    short.o                      53
    switch.o                     12
    unhandled_exception.o         3
    vreg_util.o                 316
    vregs.o                                                16
    ------------------------------------------------------------
    Total:                    1 978       128        16

    Linker created                         18       256
--------------------------------------------------------------------
    Grand Total:             10 607     2 037       476
```

4 Programming the STLUX385A digital controller

4.1 Preliminary

Downloading the firmware into the STLUX385A digital controller requires:

Hardware

- WBC evaluation board
- RAISONANCE RLink
- RAISONANCE RLink connection adapter for STM8 and ST7
- PC with MS windows OS

Software

- Ride7 application development software
- RFlasher7 (to download the compiled FW code only)

4.2 Step by step instructions

Begin with the connections:

- Link the RAISONANCE RLink to the PC by means of a USB cable (type A male / type B male).
- Link the 24-pin flat cable of the RAISONANCE RLink to the RLink connection adapter for STM8 and ST7
- Link the two SWIM connectors, both for the RAISONANCE RLink connection adapter for STM8 and ST7 and for the board to be programed, by means of a 4-wire SWIM cable.
- Turn on the power supply for the WBC evaluation board

Figure 5. RLink

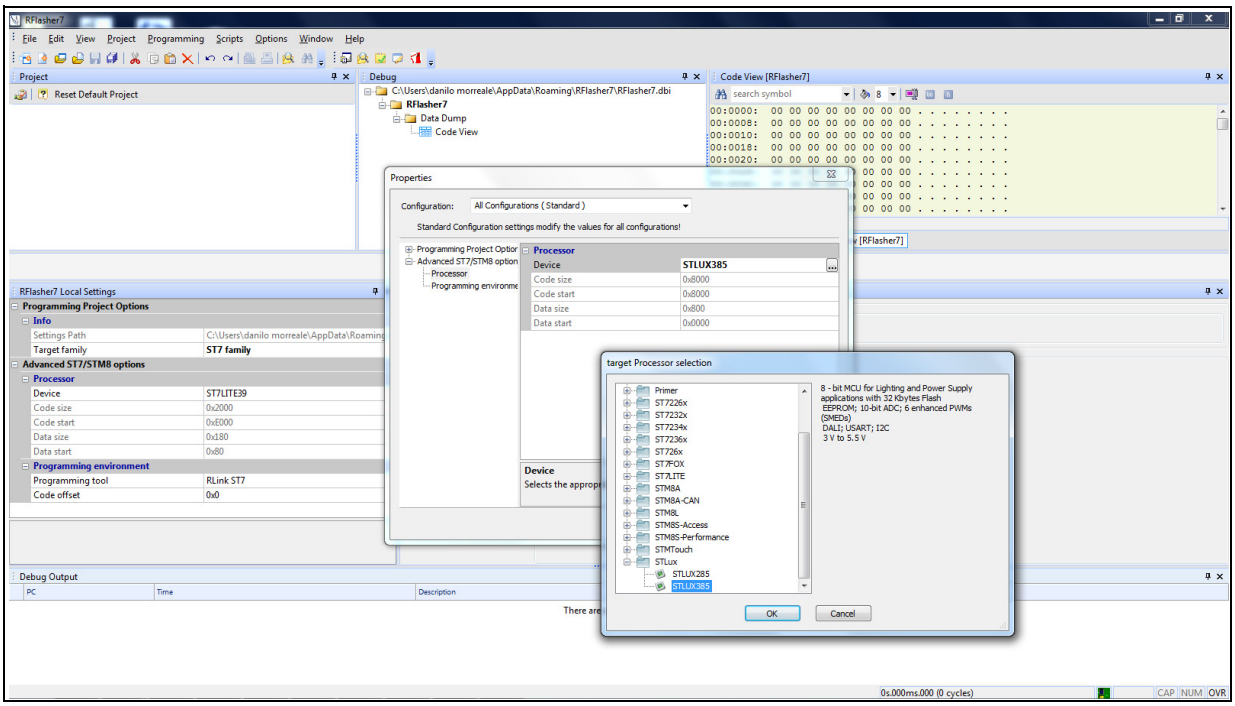
Figure 6. RLink-ADP-ST7-STM8-V1.2

On PC side, open the RFlasher7, which is a software interface for programming the STLUX385A digital controller. It provides an easy-to-use and efficient environment for reading from, writing to and verifying device memory and option bytes.

Follow these steps:

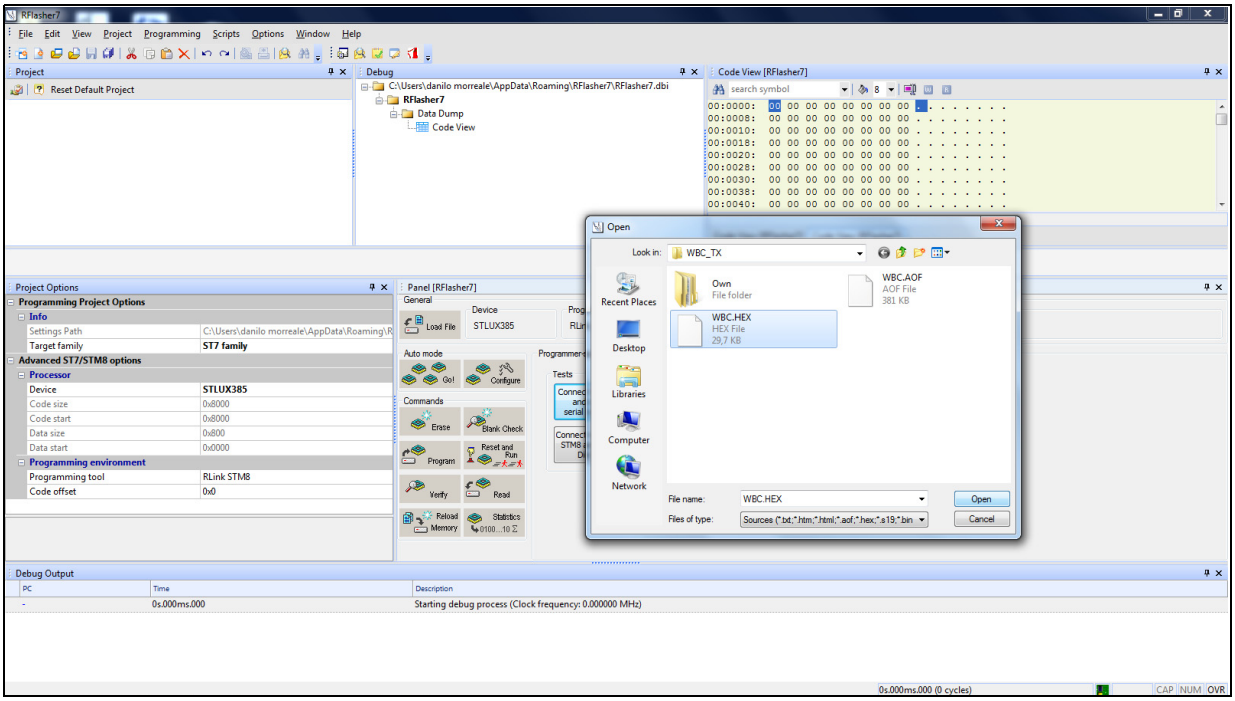
1. Configure the RFlasher7 to work with STLUX385A by means of the project properties.

Figure 7. RFlasher7 configuration - select the processor



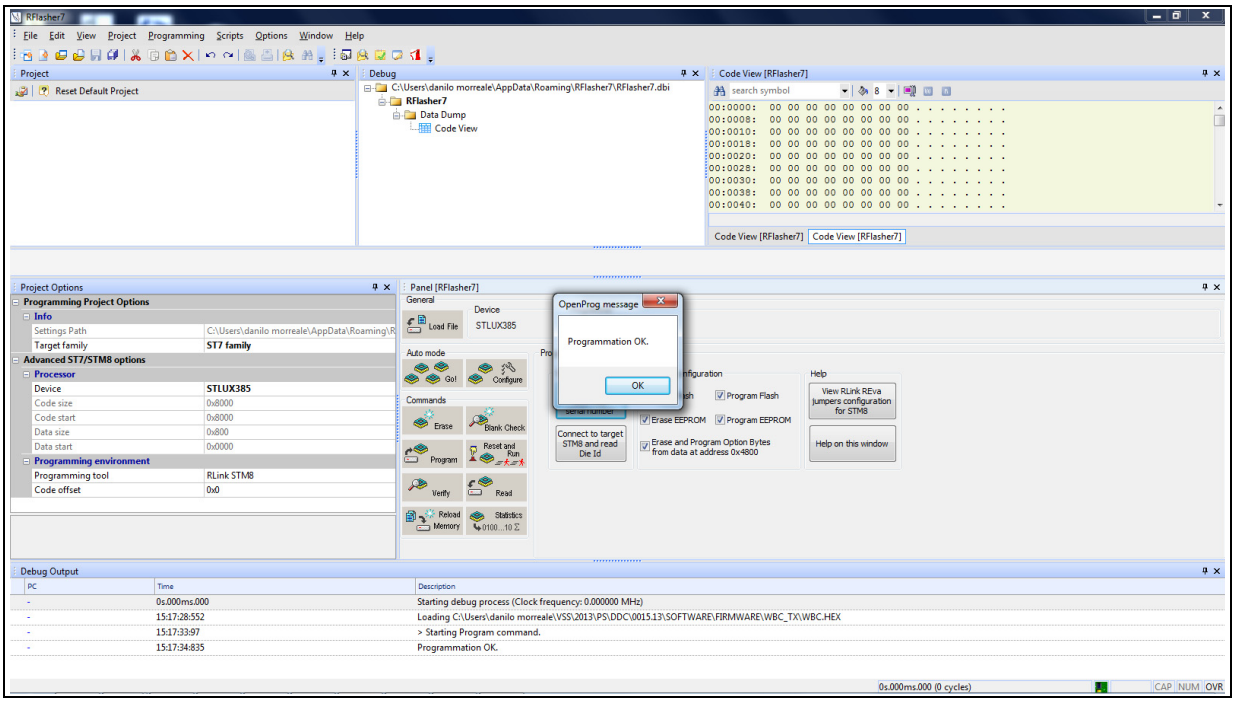
2. Load the Intel HEX file that you are going to download (WBC.HEX)

Figure 8. RFlasher7 configuration - .HEX file open



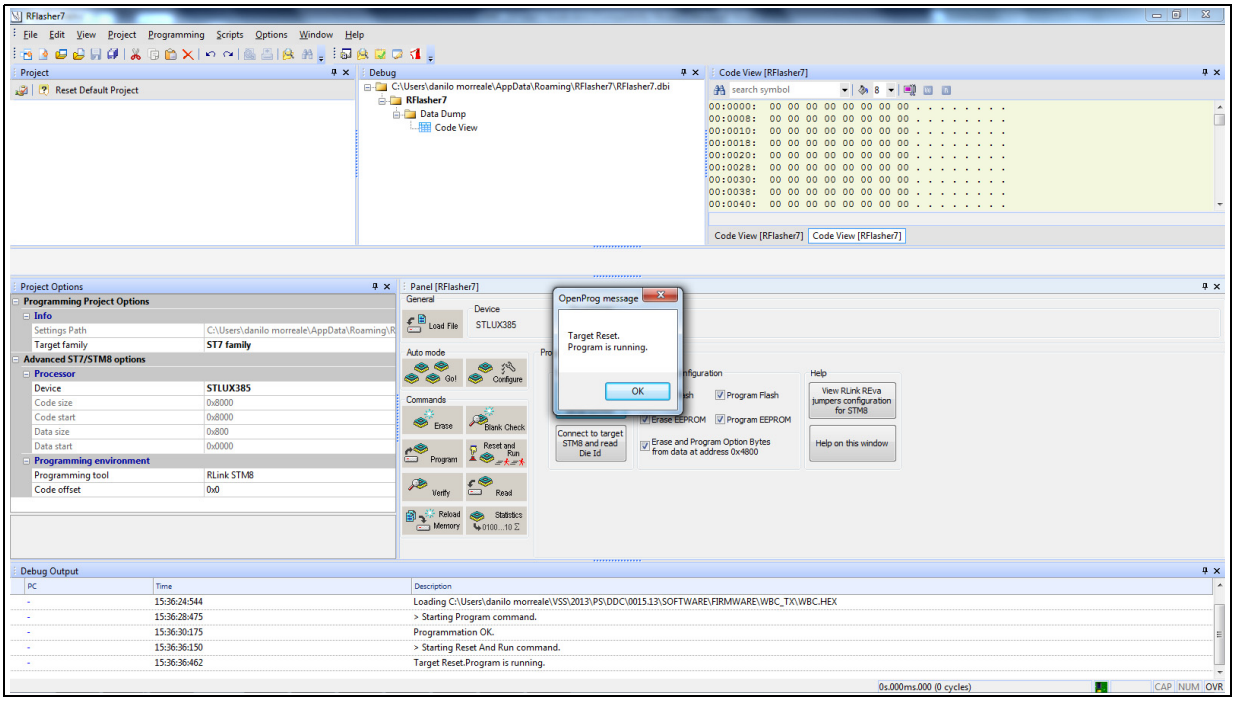
3. Now you can program the STLUX385A digital controller.

Figure 9. RFlasher7 configuration - program the STLUX385A



4. Reset and run.

Figure 10. STVP - Ready to download FW into the program memory



5 STEVAL-ISB016V1 usage

After the STLUX385A has been programmed, let us try the demo.

5.1 Preliminary

Running the demo requires the following:

Hardware

- WBC evaluation board
- 19 V DC power supply capable of providing at least 0.35 A

Optional (to obtain information on power transmitter status and working parameters)**:**

- Personal computer
- TTL-to-USB serial converter cable (FTDI Chip TTL-232R-3V3-AJ)

Software

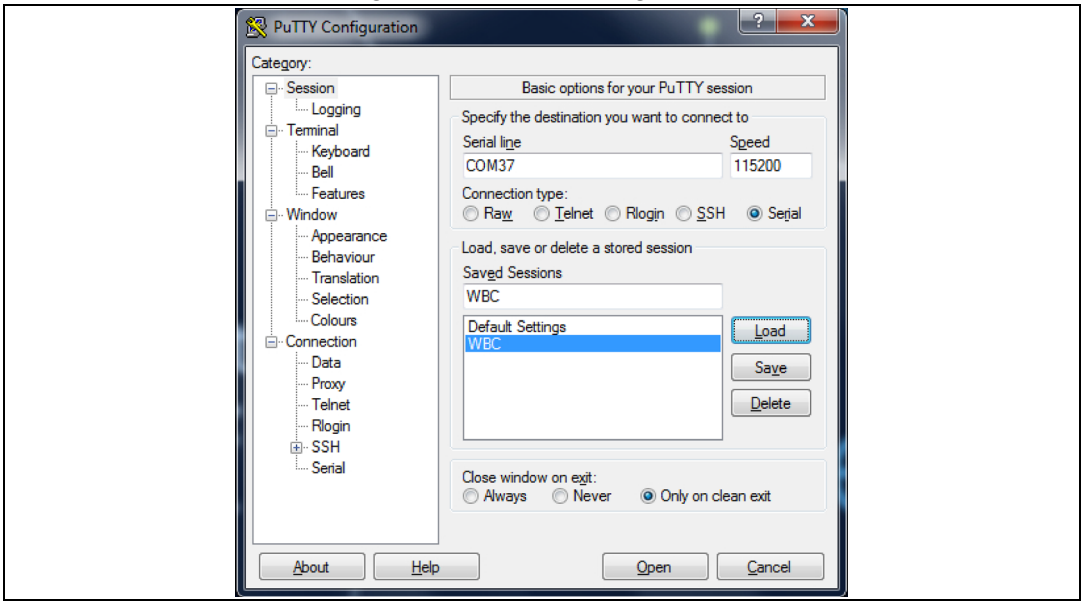
- Any terminal emulator software for communication by serial ports (ex. PuTTY)

5.2 Step by step instructions

- Connect the jack terminal of the TTL to USB serial converter cable to J5 connector of the WBC evaluation board.
- Connect to the USB terminal of the TTL-to-USB serial converter cable to any USB port of the PC

Start PuTTY and set it for serial communication with a 115200 baud rate. The serial line depends on the PC configuration.

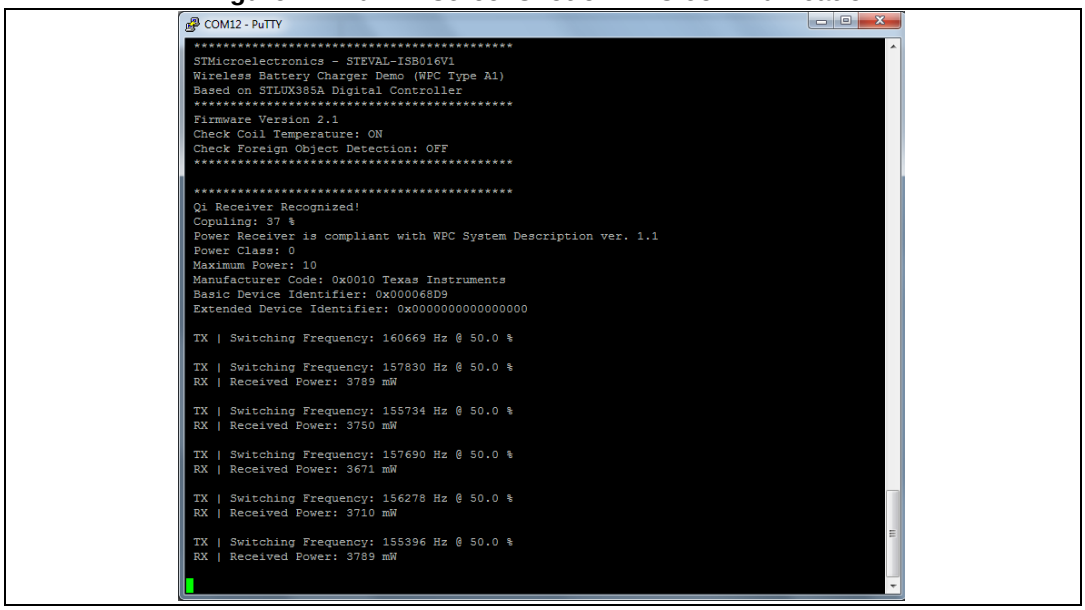
Figure 11. PuTTY configuration



- Connect the 19 V power supply to J1 or J2 connector and switch it on
- Put on the WBC evaluation board any WPC RX device ensuring that their coils overlap as much as possible.
- If the system (power transmitter plus power receiver) is working, the blue LED will start blinking.
- If a stop cause should be happend the red LED will start blinking according the parameters fixed by the module "params.h".

On terminal emulator running on PC they will be displayed information about the Qi Receiver as well as the half-bridge inverter switching frequency of the Qi Transmitter.

Figure 12. PuTTY screenshot of WPC communication



Appendix A WBC power TX evaluation board

Figure 13. STEVAL-ISB016V1 schematic

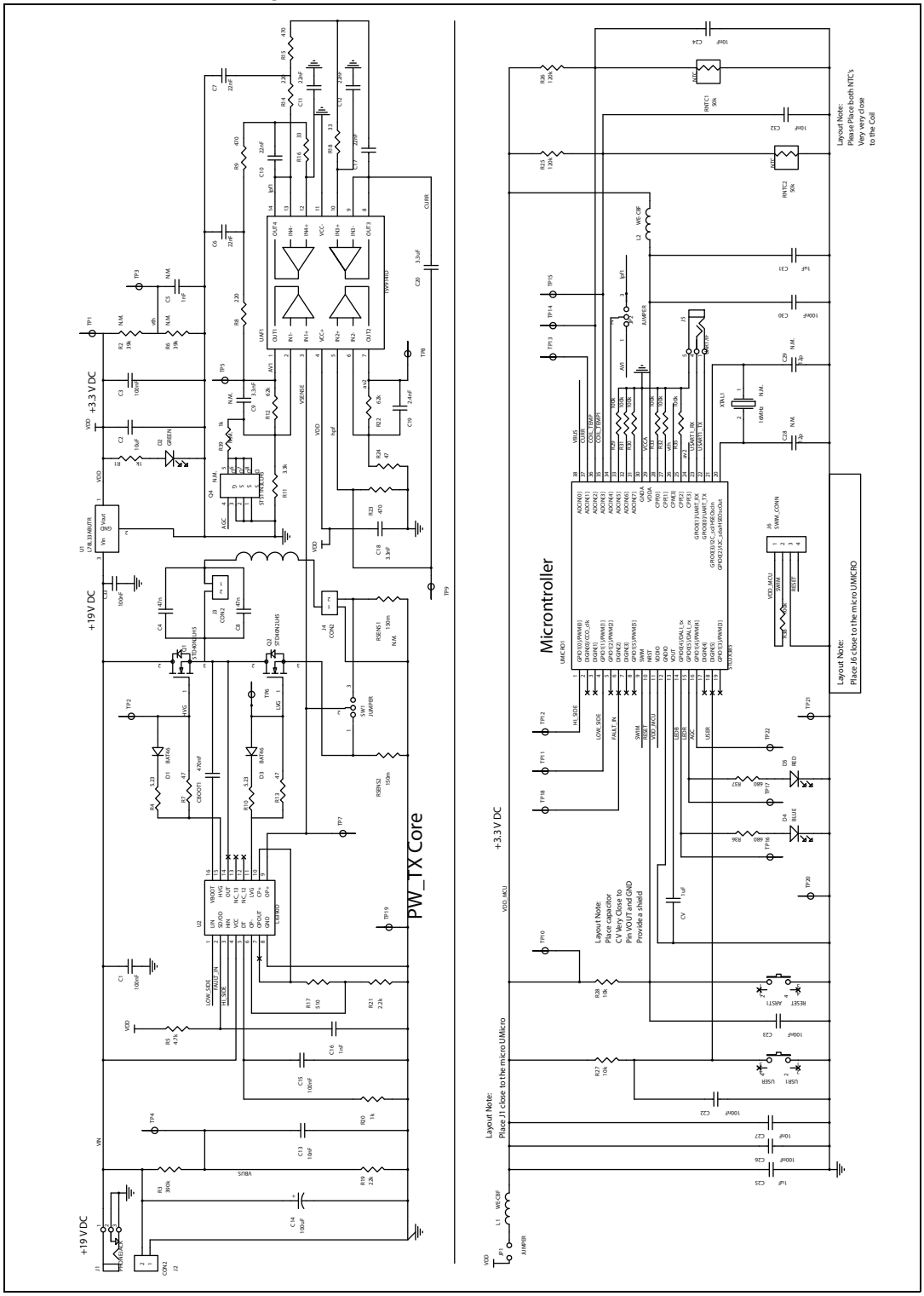


Table 5. Bill of material (BOM) part 1

Item	Qty.	Reference	Part/ value	Tolerance	Voltage/ Watt/ Ampere	Type/tech inf
1	1	ARST1	RESET			Surface mount tactile switch
2	8	C1, C3, C15, C22, C23, C26, C30, C33	100nF	+/-10%	25V	X7R ceramic capacitor
3	4	C13, C24, C27, C32	10nF	+/-10%	25V	X7R ceramic capacitor
4	1	C14	100uF	+/-20%	25V	Electrolitic aluminium capacitor
5	1	C16	1nF	+/-10%	10V	X7R ceramic capacitor
6	1	C18	3.3nF	+/-10%	10V	X7R ceramic capacitor
7	1	C19	2.4nF	+/-10%	10V	X7R ceramic capacitor
8	1	C2	10uF	+/-20%	10V	ceramic capacitor
9	1	C20	3.3uF	+/-10%	10V	X7R ceramic capacitor
10	3	C25, C31, CV	1uF	+/-10%	10V	X7R ceramic capacitor
11	2	C28, C29	12p	+/-5%	50V	COG ceramic capacitor
12	2	C4, C8	47n	+/-10%	250V	capacitor
13	1	C5	1nF	+/-10%	10V	capacitor
14	6	C6, C7, C10, C11, C12, C17	22nF	+/-10%	10V	X7R ceramic capacitor
15	1	C9	3.3nF	+/-10%	10V	X7R ceramic capacitor
16	1	CBOOT1	470nF	+/-10%	25V	X7R ceramic capacitor
17	2	D1, D3	BAT46			Small signal Schottky diode
18	1	D2	GREEN			Chip_led
19	1	D4	BLUE			Chip_led
20	1	D5	RED			Chip_led
21	1	J1	PHONEJACK			Mini DC power socket 2,5 mm
22	3	J2, J3, J4	CON2			2 way PCB srew terminal, 5,08 mm pitch
23	1	J5	UART/IF			UART I/F JACk-3_5-35RASMT2BHNTRX
24	1	J6	SWIM_CONN			4 ways single row strip line connector (male connector) 2,54mm pitch
25	1	JP1	JUMPER			2 ways single row strip line connector (male connector) 2,54mm pitch
26	2	L1, L2	WE-CBF			Ferrite
27	2	Q1, Q2	STD40N2LH5			Power MOSFET
28	1	Q4	STS11N3LLH5			

Table 5. Bill of material (BOM) part 1 (continued)

Item	Qty.	Reference	Part/ value	Tolerance	Voltage/ Watt/ Ampere	Type/tech inf
29	2	R1, R20	1k	1%	0.125	Resistor
30	1	R11	3.3k	1%	0.125	Resistor
31	2	R12, R22	62k	1%	0.125	Resistor
32	2	R16, R18	33	1%	0.125	Resistor
33	1	R17	510	1%	0.125	Resistor
34	1	R19	22k	1%	0.125	Resistor
35	2	R2, R6	39k	1%	0.125	Resistor
36	1	R21	2.2k	1%	0.125	Resistor
37	1	R24	47	1%	0.125	Resistor
38	2	R25, R26	120k	1%	0.125	Resistor
39	2	R27, R28	10k	1%	0.125	Resistor
40	7	R29, R30, R31, R32, R33, R35, R38	100k	1%	0.125	Resistor
41	1	R3	390k	1%	0.125	Resistor
42	2	R36, R37	680	1%	0.125	Resistor
43	1	R39	1k	1%	0.125	Resistor
44	2	R4, R10	5.23	1%	0.25	Resistor
45	1	R5	4.7k	1%	0.125	Resistor
46	2	R7, R13	47	1%	0.25	Resistor
47	2	R8, R14	220	1%	0.125	Resistor
48	3	R9, R15, R23	470	1%	0.125	Resistor
49	2	RNTC1, RNTC2	50k			Temperature measurement probe assemblies
50	1	RSENS1	150m	1%	1W	Sense resistor
51	1	RSENS2	150m	1%	1W	Sense resistor
52	2	SW1, JP2	JUMPER			
53	22	TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12, TP13, TP14, TP15, TP16, TP17, TP18, TP19, TP20, TP21, TP22	TEST POINT			
54	1	U1	L78L33ABUTR			Positive voltage regulators
55	1	U2	L6390D			High-voltage high and low side driver
56	1	UAF1	TSV914ID			8 MHz operational amplifiers

Table 5. Bill of material (BOM) part 1 (continued)

Item	Qty.	Reference	Part/ value	Tolerance	Voltage/ Watt/ Ampere	Type/tech inf
57	1	UMICRO1	STLUX385			Digital controller for lighting and power supply applications
58	1	USR1	USER			Surface mount tactile switch
59	1	XTAL1	16MHz			HC49-4H

Table 6. Bill of material (BOM) part 2

Item	Package	MFR	MFR's ordering code/ Orderable part number	Supplier	Supplier's ordering code	Additional Notes
1	SMD			RS	183-701	
2	SMD 0805	Any				
3	SMD 0805	Any				
4	TH	Any		RS	526-1430	
5	SMD 0805	Any				
6	SMD 0805	Any				
7	SMD 0805	Any				
8	SMD 0805	Any				
9	SMD 0805	Any		RS	723-6073	
10	SMD 0805	Any		RS	653-0529	
11	SMD 0805	Any				N.M.
12	SMD 1812	TDK		TDK	C4532C0G2E 473K320KA	
13	SMD 0805	Any				N.M.
14	SMD 0805	Any				
15	SMD 0805	Any				N.M.
16	SMD 1206	Any				
17	SOD-123	ST	BAT46ZFILM			
18	SMD 0805	Any		RS	692-0935	
19	SMD 0805	Any		RS	665-9368	
20	SMD 0805	Any		RS	654-5818	
21	Through hole			RS	448-376	
22	Through hole	any		RS	408-7871	
23				Digi-Key	SC1489-1-ND	
24	Vertical through hole			RS	495-8470	

Table 6. Bill of material (BOM) part 2 (continued)

Item	Package	MFR	MFR's ordering code/ Orderable part number	Supplier	Supplier's ordering code	Additional Notes
25	Vertical through hole			RS	495-8470	
26	SMD 0603	Panasonic		RS	669-4005	
27	DPAK	ST	STD40N2LH5			
28	SO-8	ST				N.M.
29	SMD 0805	Any				
30	SMD 0805	Any				
31	SMD 0805	Any				
32	SMD 0805	Any				
33	SMD 0805	Any				
34	SMD 0805	Any				
35	SMD 0805	Any				N.M.
36	SMD 0805	Any				
37	SMD 0805	Any				
38	SMD 0805	Any				
39	SMD 0805	Any				
40	SMD 0805	Any				
41	SMD 0805	Any				
42	SMD 0805	Any				
43	SMD 0805	Any				N.M.
44	SMD 1206	Any				
45	SMD 0805	Any				
46	SMD 1206	Any				
47	SMD 0805	Any				
48	SMD 0805	Any				
49	Through hole	Any	DKF503B10	RS	198-955	
50	SMD 2512			RS	721-6205	N.M.
51	SMD 2512			RS	721-6205	
52				RS	495-8470	
53	Through hole	Vero Technologies		RS	101-2391	
54	SOT-89	ST	L78L33ABUTR			
55	SO16	ST	L6390D			
56	SO14	ST	TSV914ID			
57	TSSOP38	ST	STLUX385			

Table 6. Bill of material (BOM) part 2 (continued)

Item	Package	MFR	MFR's ordering code/ Orderable part number	Supplier	Supplier's ordering code	Additional Notes
58	SMD			RS	183-701	
59	HC-49 SMD			RS	693-8885	N.M.

6 References

- STLUX385A datasheet

7 Revision history

Table 7. Document revision history

Date	Revision	Changes
29-Jan-2014	1	Initial release.

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