UM1694
User manual

STEVAL-ILH007V1: 150W HID digital ballast based on STLUX385A

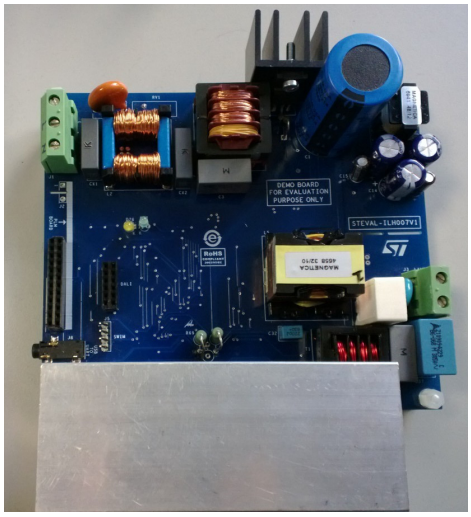
Introduction

This document describes 150 W high intensity discharge (HID) digital ballasts driven by STLUX385A devices. This platform is a solution to drive HID lamps (sodium and metal halide). The board is composed of two stages:

1. Power factor corrector (PFC), based on boost topology to correct the AC input current in phase with AC voltage mains.
2. Inverter, based on full bridge topology to drive the lamps.

The STLUX385A digital controller drives both stages.

Figure 1. STEVAL-ILH007V1



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1 Features

The STEVAL-ILH007V1 board has the following features:

- GREEN LED: indicates the normal operation of the board
- RED LED: indicates the fault condition of the board
- UART: connector for serial data communication to a PC to monitor the system parameters.

Table 1. Features

Parameter		Notes and conditions	Min.	Typ.	Max.	Unit
Input characteristics						
V_{in}	input voltage		185	230	265	V
Eff	efficiency	V_{in} = 230 V, load = 150 W	90			%
PF	power factor	V_{in} =185 V; load = 150 W	0.98			
THD%	input current THD	V_{in} =185 V; load = 150 W	10			%
Load characteristics						
Load	lamp type	sodium or metal halide				
Pout	lamp power			150		W
Iout	lamp current			1.6		A

2 Connectors

With reference to the schematic in *Appendix A*:

Figure 2. Top layout

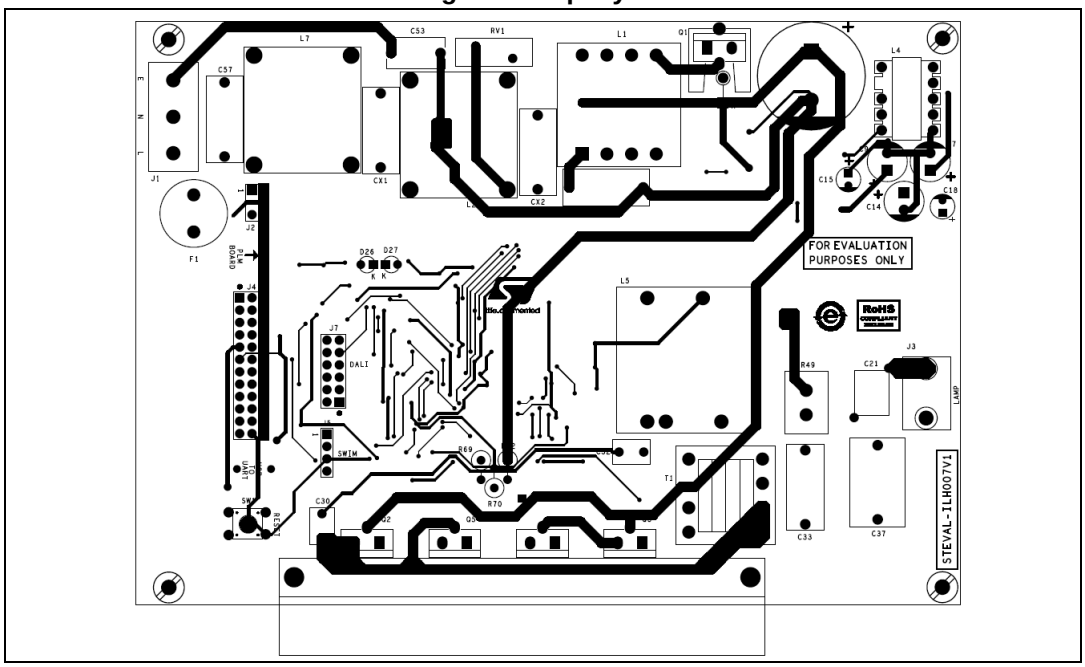


Figure 3. Bottom layout

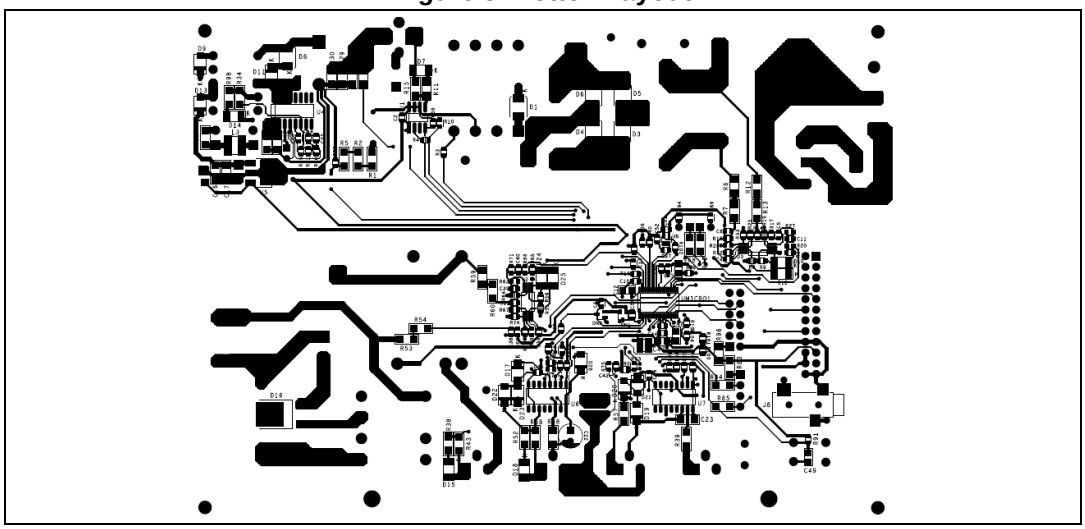


Table 2. Connectors

Pin	Description
J1	Power supply connector / 230Vac – 3 way screw terminal
J2	Power connector for power line modem / 230V - 2 way screw terminal
J3	Output connector for lamp connection - 2 way screw terminal
J4	Connector for UART output- 24 way terminals
J5	SWIM Connector to FW download and debug
J7	DALI Connector 12 way terminals
J8	UART output - stereo jack connector 3.5mm

3 Firmware

The MCU used is an STLUX385A, which is part of the MASTERLUX™ family of ST digital devices tailored for lighting and power conversion. The STLUX385A has been successfully integrated in a wide range of architectures and applications, including simple buck converters for LED driving, boosts for power factor correction, half-bridge resonant converters for dimmable LED strings, full-bridge control in HID lamp ballasts, wireless power chargers and TV power supplies.

This MCU has 16 MHZ CPU frequency, 32 Kbyte program memory and 2 Kbyte of RAM.

The firmware is organized as a collection of files inside a project for Raisonance RIDE7, a fully-featured Integrated Development Environment (IDE) that provides 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.

The firmware is released as an Intel HEX file (Rev01.HEX).

3.1 STEVAL-ILH007V1 firmware

The firmware running the STLUX385A of the STEVAL-ILH007V1 allows the MCU to manage the PFC and full-bridge of the board.

STEVAL-ILH007V1 is also able to manage UART communication with a PC to show system status information.

Following CPU clock and peripheral configuration, the MCU manages the board as a finite state machine, as shown below.

Figure 4. STEVAL-ILH007V1 block diagram of the firmware

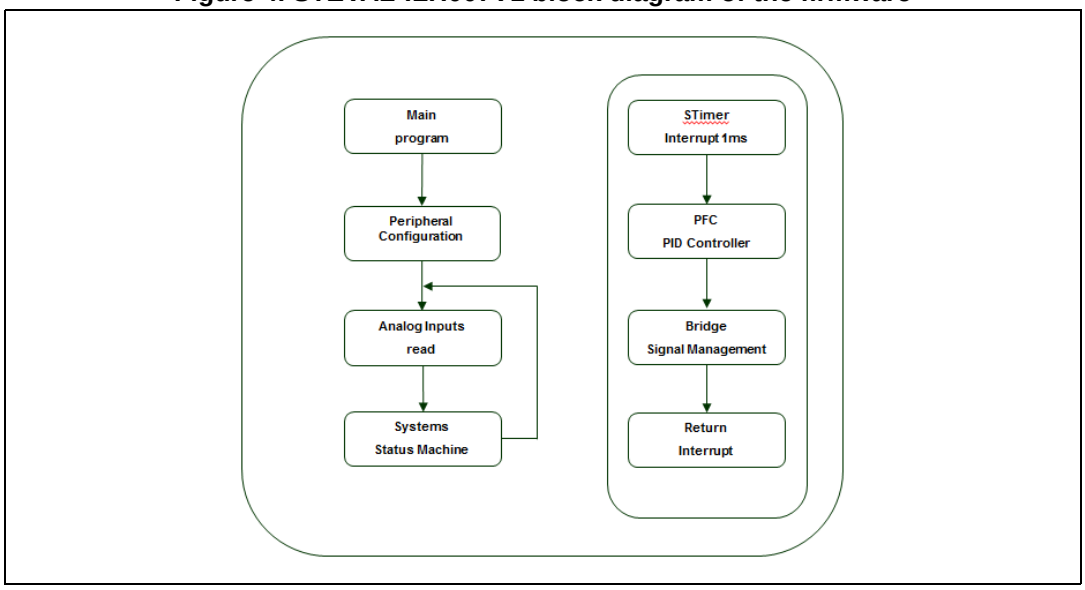
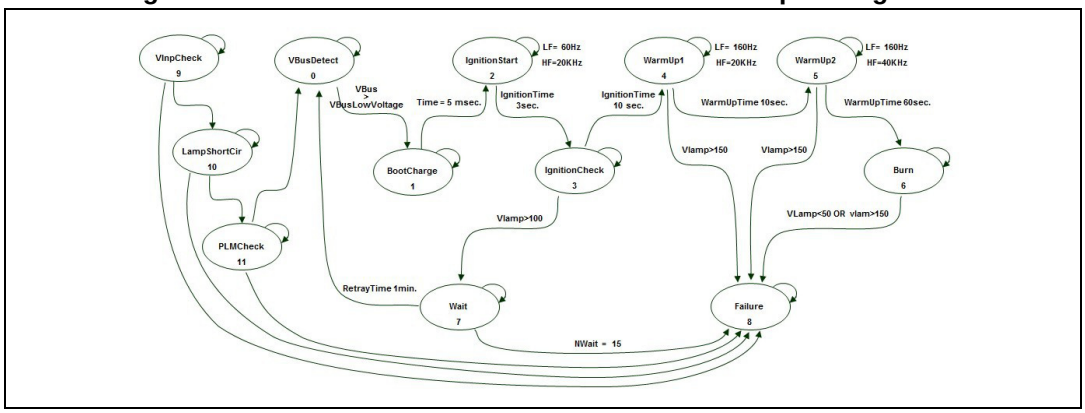


Figure 5. STEVAL-ILH007V1 finite state machine lamp management



The following table lists the user source.c files for the STEVAL-ILH007V1.

Table 3. HID FW user source file list

File	Brief descriptions
main.c	Main module
adc.c	ADC peripheral configuration
stlux_smed.c	Automatically generated by SMED_Configurator, a PC software application
stlux_it.c	Manages the IRQ functions
stmr.c	Manage the requested timing
uart.c	

3.1.1 Implemented peripherals

Analog to Digital Converter (ADC)

- ADC0 VIN Measures the main input voltage
- ADC1 VBUS Measures the output voltage of the PFC stage
- ADC2 PFC_ISENS Currently not used
- ADC3 PFC_OK Currently not used
- ADC4 VLAMP Measures of the voltage across the lamp
- ADC5 VOUT33 Checks the presence of the 3.3 V voltage regulator
- ADC6 VTEMP Measures the temperature of the board; the sensor is currently not calibrated

Analog comparators

CPP0 Currently not used

CPP1 Currently not used

CPP2 Currently not used

CPP3 Sets the bridge peak current value

16-bit system timer

STMR Sets the correct timing of all events for the application:
- PID controller
- drive signals of the bridge
- systems state machine

State machine event driven

SMED0 Provides for the high frequency signal generation of the bridge; it is also used for ZCD signal synchronization and bridge peak current control

SMED1 Provides for the high frequency signal generation of the bridge; it is also used for ZCD signal synchronization and bridge peak current control

SMED2 Currently not used

SMED3 Currently not used

SMED4 Generates the signals for the PFC switch

SMED5 Generates the reference voltage for CPP3 comparator

3.1.2 Used pins

Table 4. Used pins

PIN	Function	NetName	Description
PIN1	PWM0	PWM0	Generates the high frequency signal to drive the bridge low side
PIN2	DIGIN0		Digital input used to detect the PFC ZCD
PIN3	DIGIN1		Digital input used to detect the Bridge ZCD
PIN4	PWM1	PWM1	Generates the high frequency signal to drive the bridge high side
PIN5	GPIO1[2]	PWM2	Generates the low frequency signal to drive the bridge low side
PIN6	DIGIN2		Currently not used
PIN7	DIGIN3		Currently not used
PIN8	PWM5	PWM5	PWM to voltage generator used as a reference for the analog comparator CPP[3]
PIN9	SWIM		SWIM data interface
PIN10	NRST		Reset
PIN11	VDDIO		Digital and I/O power supply
PIN12	GNDIO		Digital and I/O ground
PIN13	VOUT		1.8 V regulator capacitor
PIN14	GPIO0/4		Red LED
PIN15	GPIO0/5		Green LED
PIN16	PWM4		Generate the signal to drive the PFC switch.
PIN17	DIGIN4		Currently not used
PIN18	DIGIN5		Currently not used
PIN19	GPIO1[3]	PWM3	Generates the low frequency signal to drive the bridge high side
PIN20	GPIO0/2	GPIO2	U6 L6390 output enable
PIN21	GPIO0/3	GPIO3	U7 L6390 output enable
PIN22	UART_TX		Currently not used
PIN23	UART_RX		Currently not used
PIN24	CPP3	IPEAK_OUT	Analog comparator input used to detect the bridge peak current control
PIN25	CPP2		Currently not used
PIN26	CPM3		CPP3 analog comparator input external reference voltage
PIN27	CPP1		Currently not used
PIN28	CPP0		Currently not used
PIN29	VDDA		Analog power supply
PIN30	GNDA		Analog ground
PIN31	ADCIN7		Currently not used
PIN32	ADCIN6	VTEMP	Measures the output voltage of the board temperature sensor

Table 4. Used pins (continued)

PIN	Function	NetName	Description
PIN33	ADCIN5	VOUT3.3	Measures the output voltage of 3.3 V regulator used to power the micro
PIN34	ADCIN4	VLAMP	Measures the voltage across the lamp
PIN35	ADCIN3	PFC_OK	Currently not used
PIN36	ADCIN2	PFC_ISENS	Currently not used
PIN37	ADCIN1	VBUS	Measures the output voltage of the PFC stage.
PIN38	ADCIN0	VIN	Measures the main input voltage

Figure 6. SMED4 PFC state machine

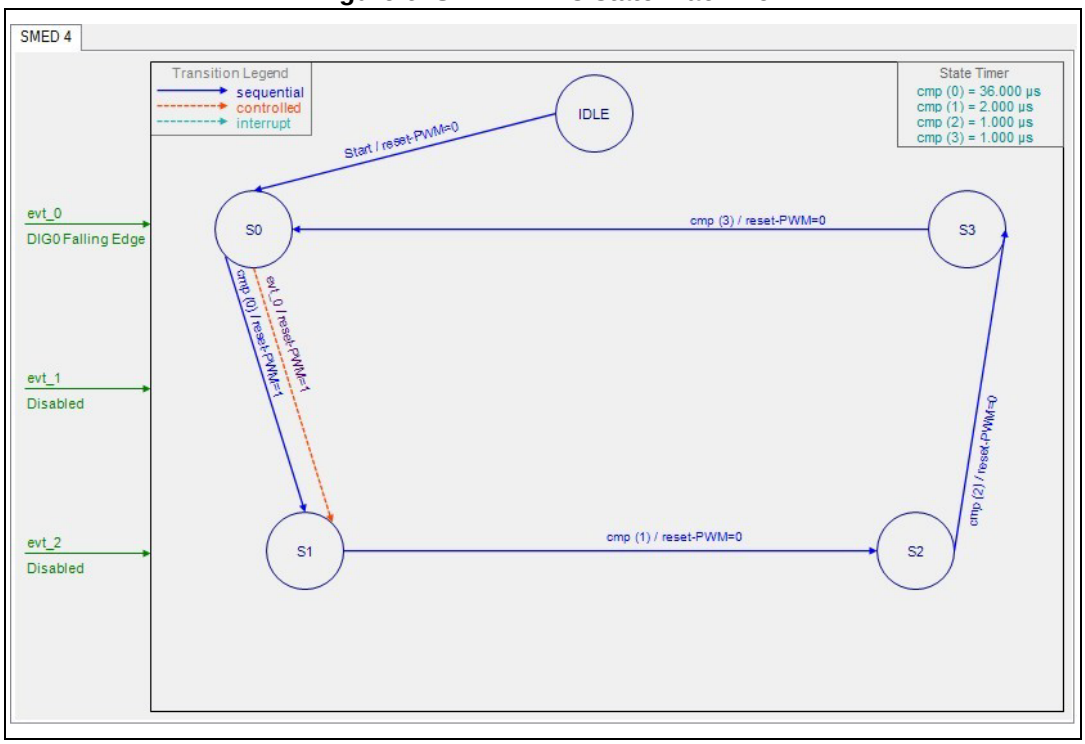


Figure 7. SMED0 bridge low side drive

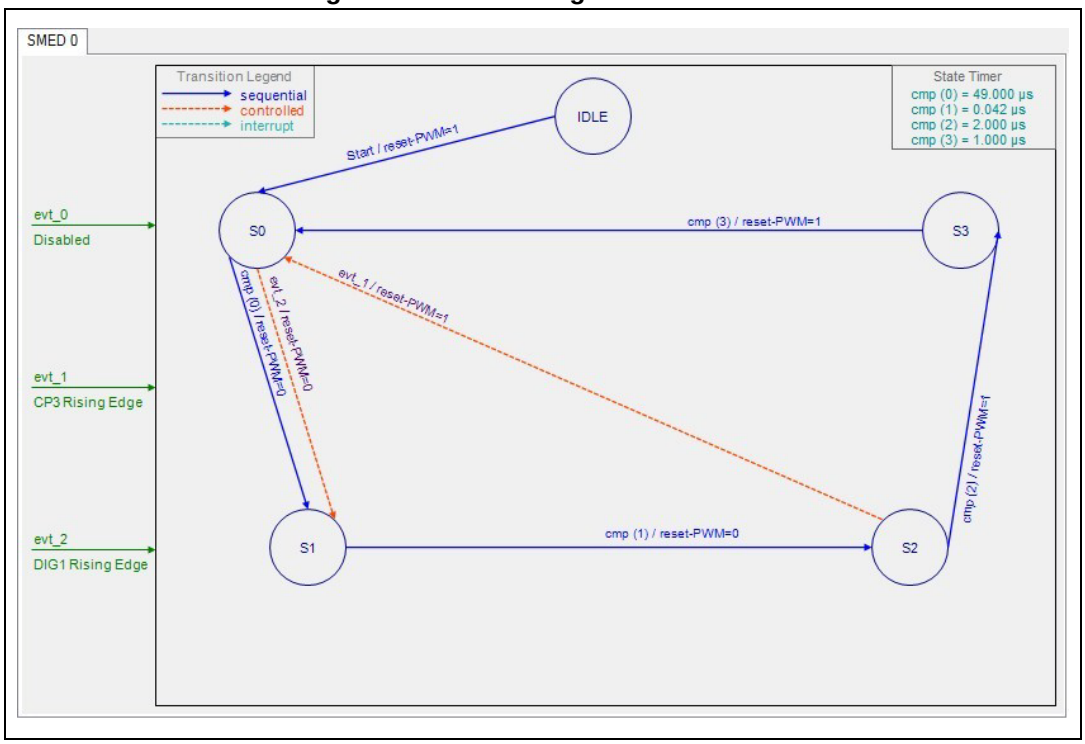


Figure 8. SMED1 bridge high side drive

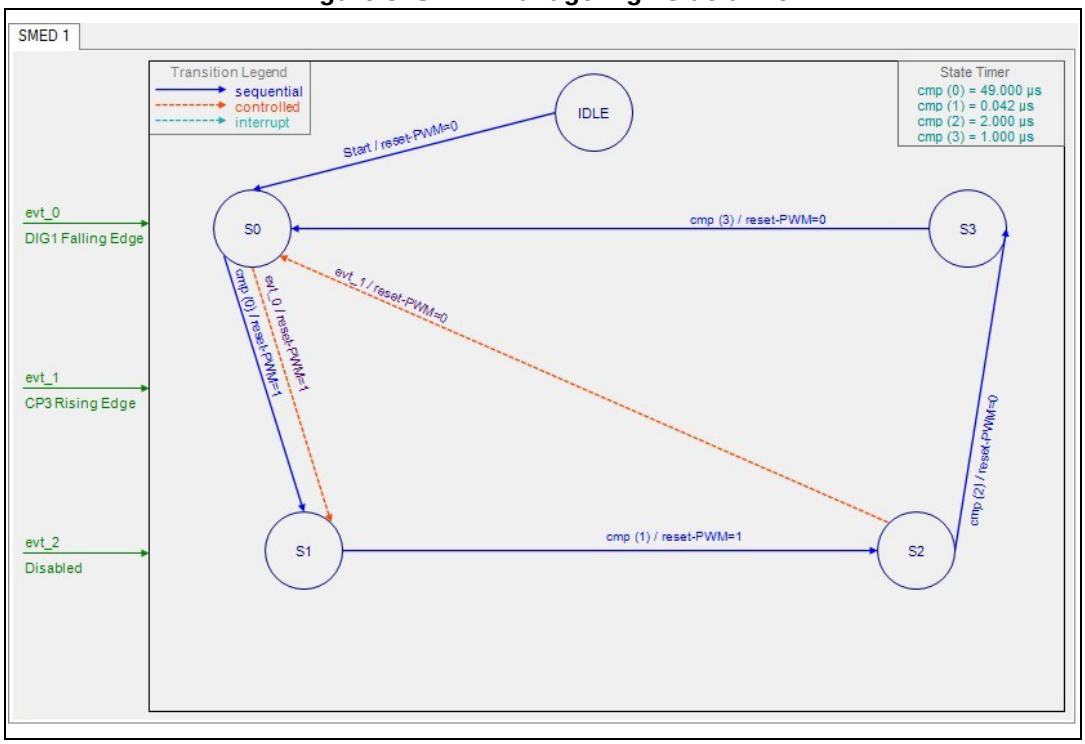
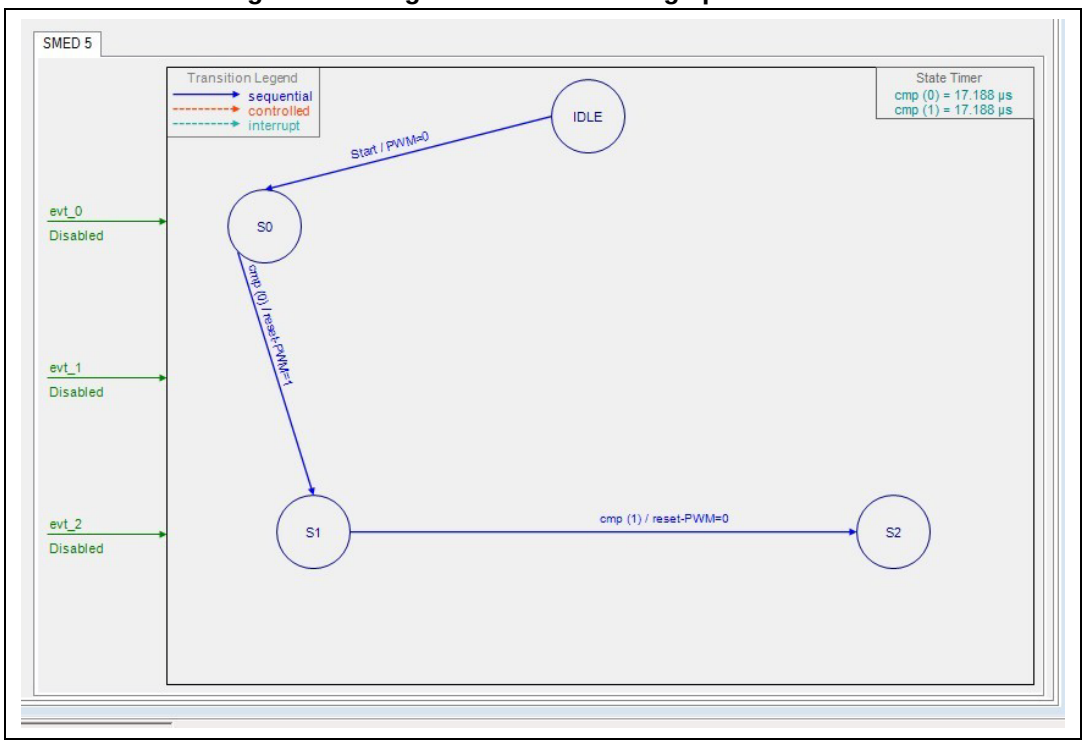


Figure 9. Voltage reference for bridge peak current



3.1.3 Module summary

Table 5. Module information

Module	Code size		Constant size		Data size		Page0 size		Bit size	
	Static	Overlayable	Static	Overlayable	Static	Overlayable	Static	Overlayable	Static	Overlayable
Main	1014		73							
Stlux_config	1014		73							
Stlux_it	510		76				1			
Stmr	145									
Uart	412						24			
ADC	604									

Table 6. Executable summary

Total EEPROM storage requirement	0000H (0)
Total DATA storage requirement	02C9H (713)
Total CODE storage requirement	11BCH (4540)

4 Firmware download into the STLUX MCU

4.1 Setup

To download the firmware to the STLUX on the board, you need:

Hardware

- an HID evaluation board
- a RAISONANCE RLink
- a RAISONANCE RLink connection adapter for STM8 and ST7
- a PC with Microsoft Windows™
- a 3.3 V power supply

Software

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

4.2 Installation

Begin with the connections:

- link the RAISONANCE RLink to the PC with 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 with a 4-wire SWIM cable for the RAISONANCE RLink connection adapter for STM8 and ST7 and for the board that you are going to program
- connect the 3.3 V to supply the STLUX

Figure 10. RLink

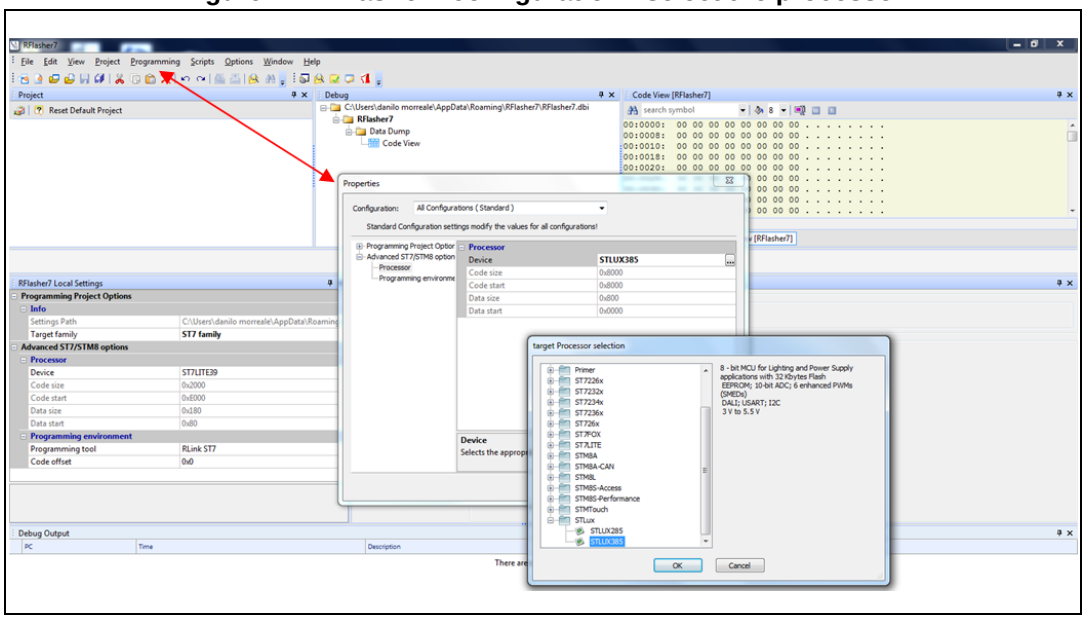
Figure 11. RLink-ADP-ST7-STM8-V1.2

On the PC, open the RFlasher7 software interface for programming the STLUX microcontroller; it provides an easy-to-use and efficient environment for reading, writing to and verifying device memory and option bytes.

Follow these steps:

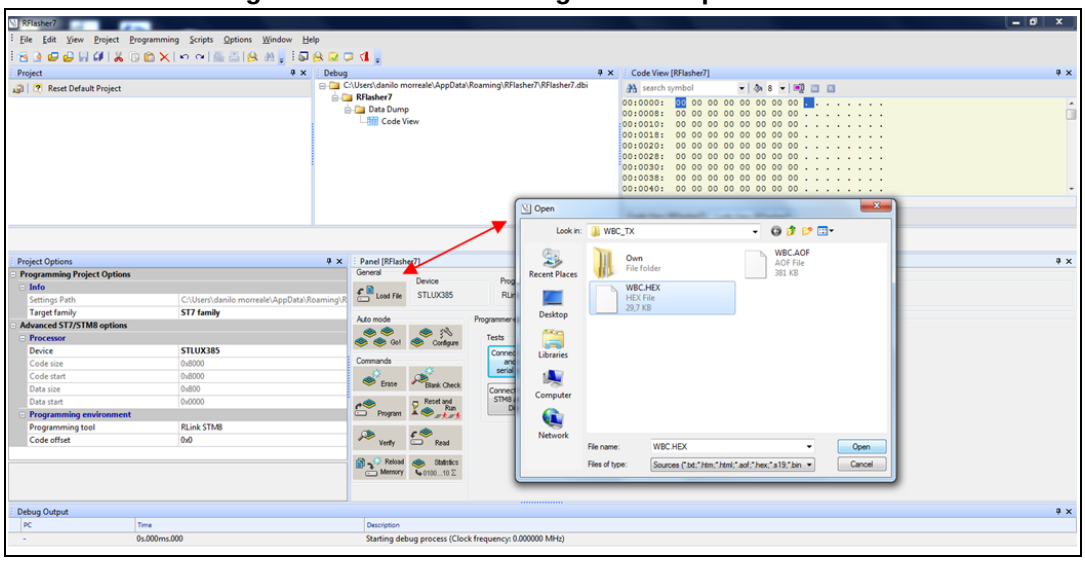
1. configure the RFlasher7 project properties to work with the STLUX385

Figure 12. RFlasher7 configuration - select the processor



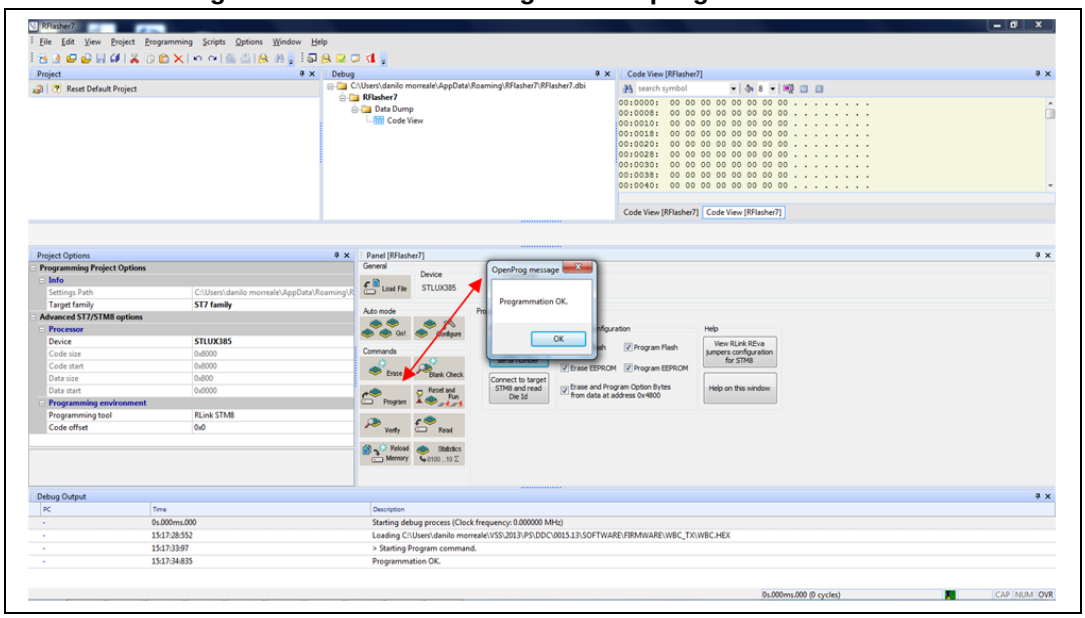
2. load the Intel HEX file for download (REV01.HEX)

Figure 13. RFlasher7 configuration - open .HEX file



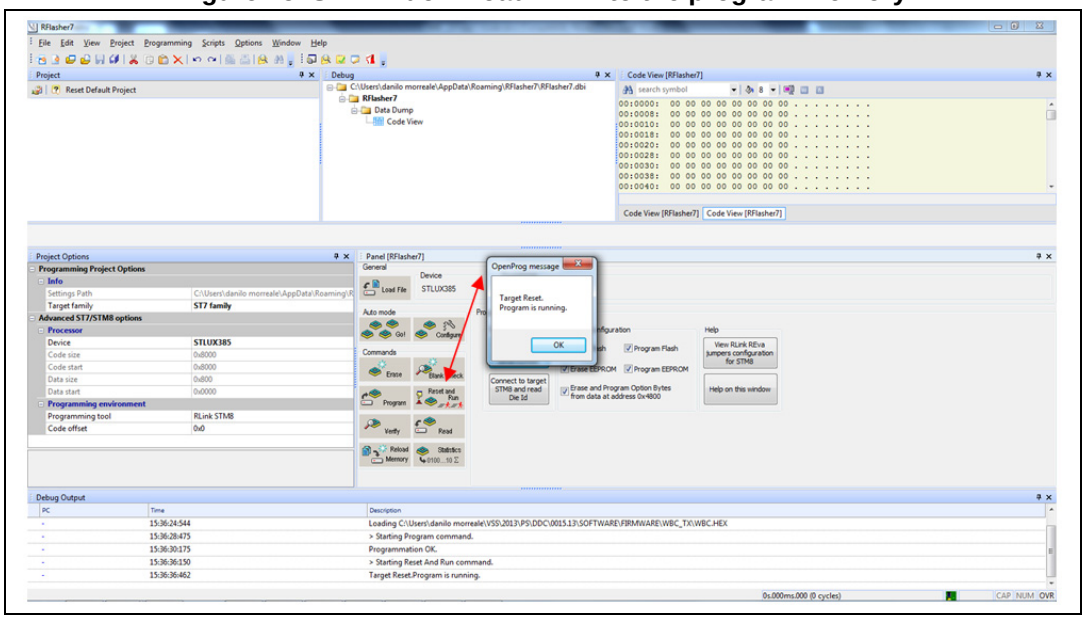
3. program the STLUX microcontroller

Figure 14. RFlasher7 configuration - program the STLUX



4. reset and run

Figure 15. STVP - download FW into the program memory



5 STEVAL-ILH007V1 evaluation board operation

Once the STLUX has been programmed with the right firmware, you can commence evaluation board operation.

5.1 Setup

To run the evaluation board, you need:

Hardware

- a STEVAL-ILL007V1 evaluation board
- an AC power supply able to provide 230V
- a 150 W sodium or metal halide lamp

5.2 Operation

- connect the lamp to the J3 terminal
- connect the AC source to the J1 terminal
- switch the AC source on and wait a few minutes for the lamp to reach the nominal power

Appendix A STEVAL-ILH007V1 schematic

Figure 16. Auxiliary power supply scheme

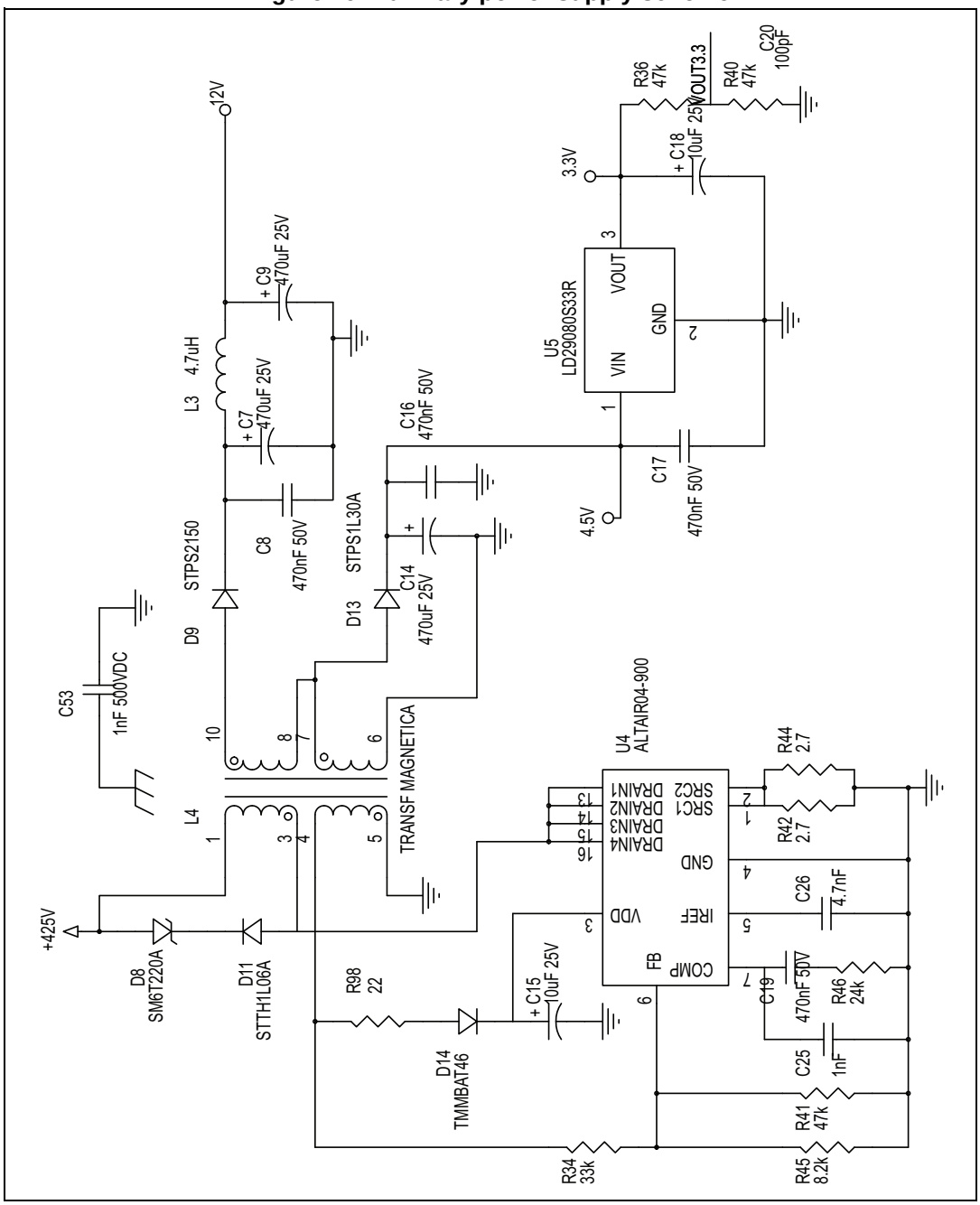


Figure 17. PFC and input section

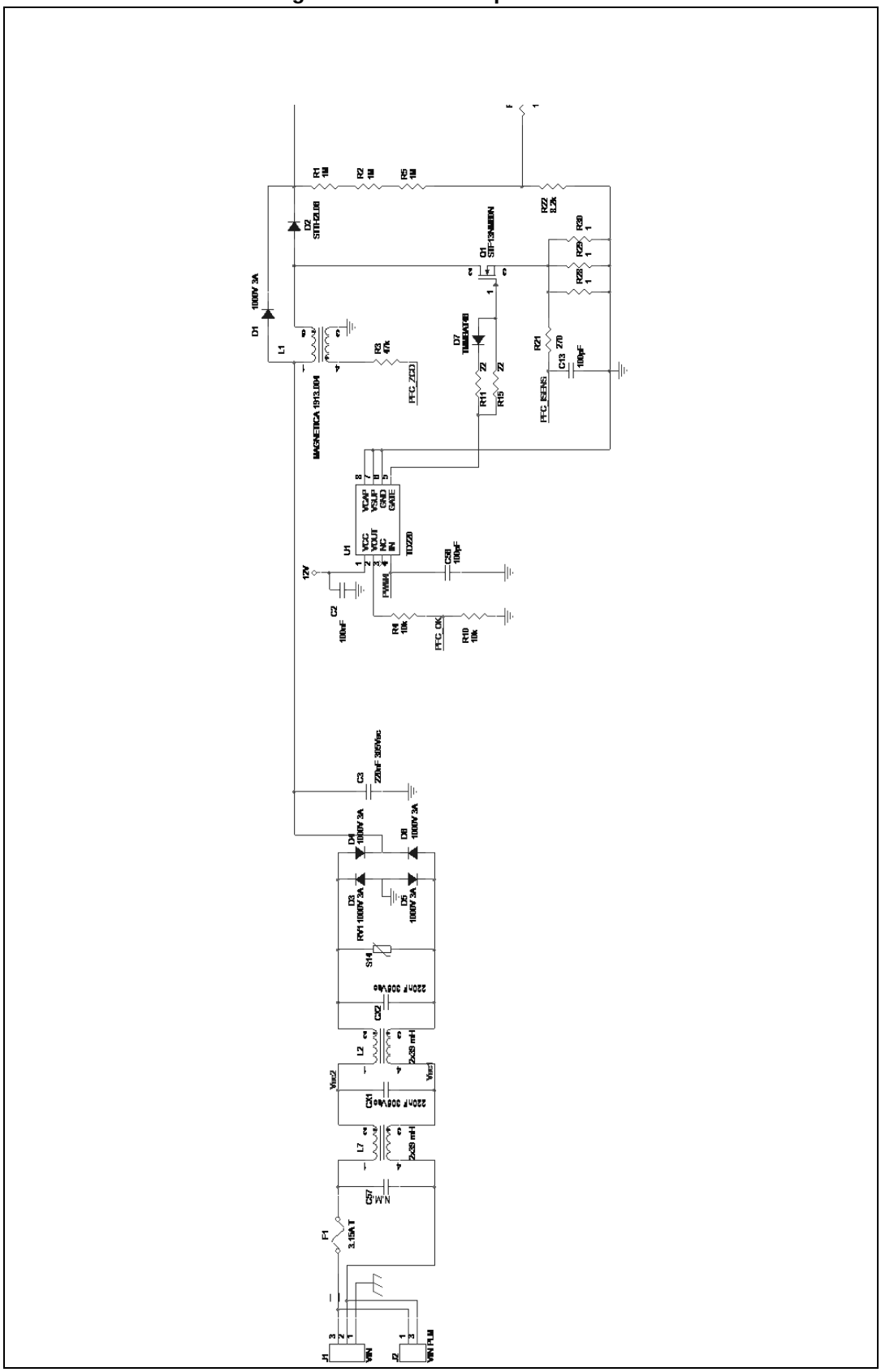


Figure 18. Full-bridge scheme

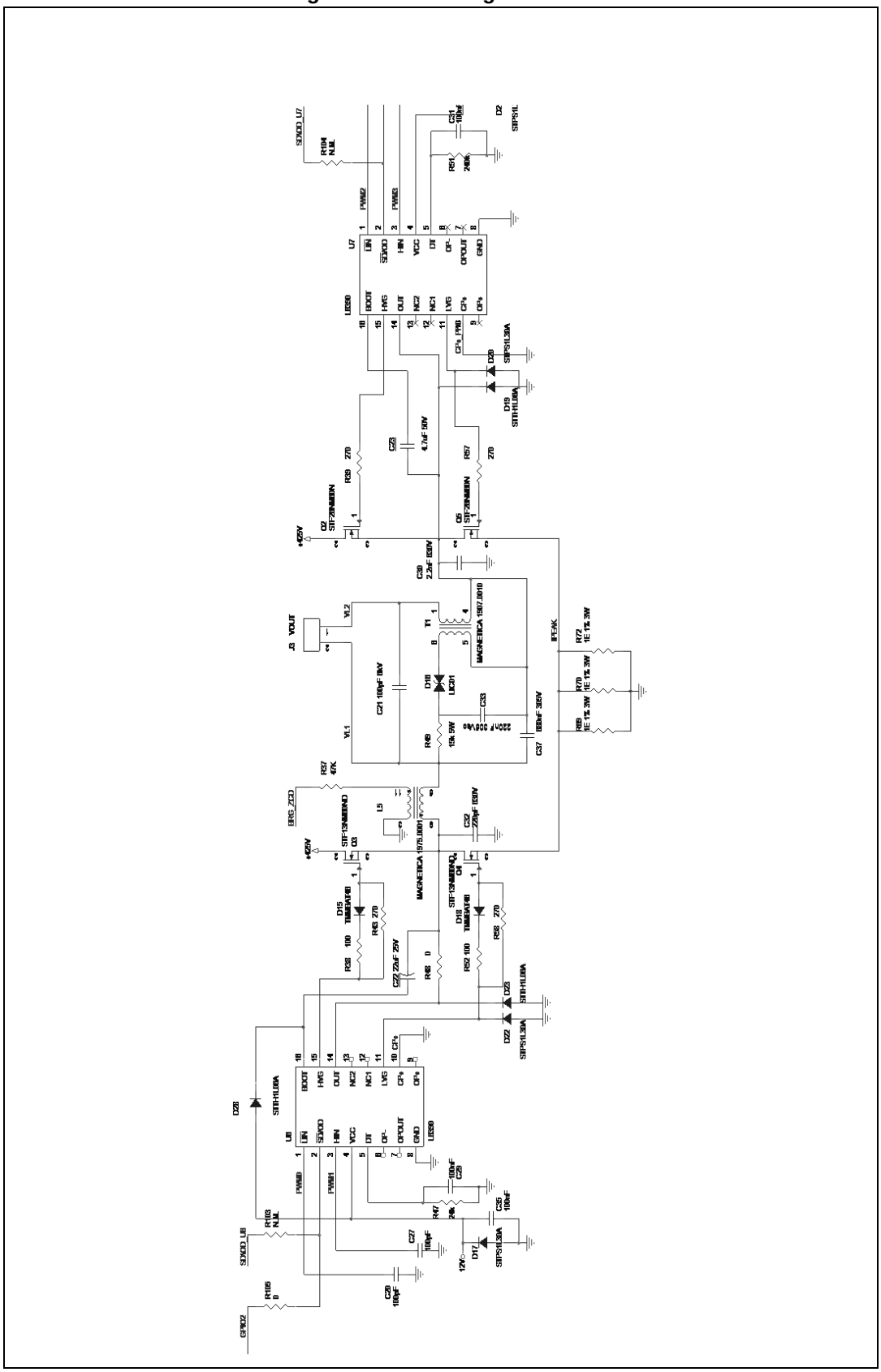
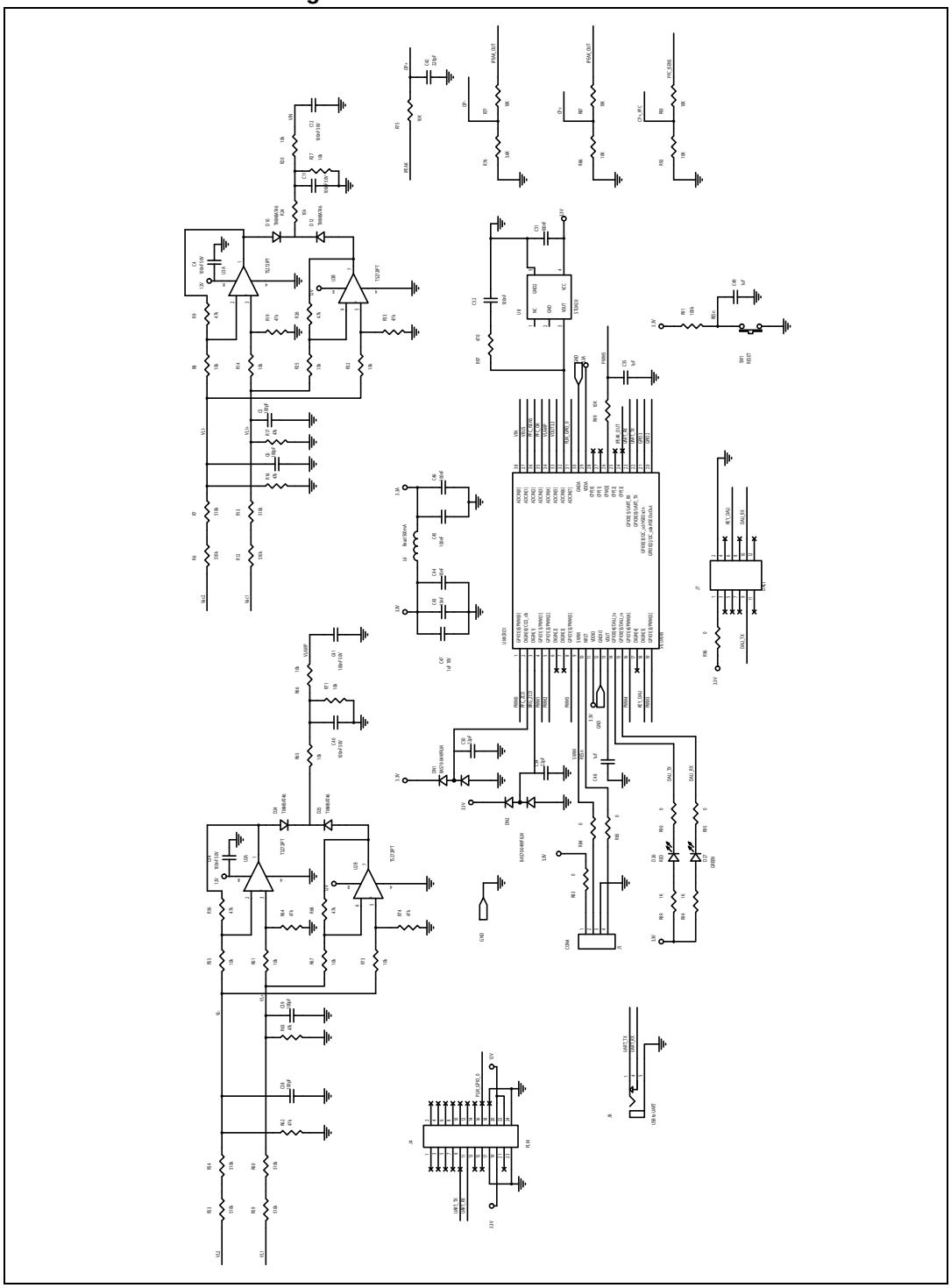


Figure 19. Control section scheme



6 Bill of material

Table 7. Bill of material (BOM)

Item	Quantity	Reference	Value	Rated	Type	Package	Manufacturer
1	3	CX1,CX2,C3, C33	220 nF,10%	520 V	polypropylene film capacitor	through hole lead spacing 15 mm	
2	1	C1	100 µF,20%	500 Vdc	electrolytic capacitor	through hole lead spacing 10 mm	
3	14	C2,C4,C11,C29, C31,C34,C35, C36,C40,C41, C45,C46,C51, C52	100 nF,10%	50 V	X7R ceramic capacitor	SMD 0603	
4	1	C3	220 nF,10%	520 V	polypropylene film capacitor	through hole lead spacing 15 mm	
5	12	C5,C6,C10,C13, C20,C24,C27, C28,C38,C39, C42,C56	100 pF,5%	50 Vdc	C0G ceramic capacitor	SMD 0603	
6	3	C7,C9,C14	470 µF,20%	25 V	electrolytic capacitor	through hole lead spacing 3.5 mm	
7	4	C8,C16,C17, C19	470 nF,10%	50 V	X7R ceramic capacitor	SMD 1206	
8	5	C12,C47,C48, C49,C55	1 µF,10%	25 Vdc	X7R ceramic capacitor	SMD 0805	
9	2	C15,C18	10 µF,20%	50 V	electrolytic capacitor	through hole lead spacing 2.5 mm	
10	1	C21	100 pF10%	6.3 kV	high voltage ceramic capacitor	through hole Lead spacing 10 mm	
11	1	C22	22 µF,20%	25 V	electrolytic capacitor	through hole lead spacing 2 mm	
12	1	C23	4.7 µF,10%	50 V	X7R ceramic capacitor	SMD 1206	not mounted
13	1	C19	470 nF,10%	50 V	X7R ceramic capacitor	SMD 0603	
14	1	C25	1 nF,10%	50 V	X7R ceramic capacitor	SMD 0603	

Table 7. Bill of material (BOM) (continued)

Item	Quantity	Reference	Value	Rated	Type	Package	Manufacturer
15	1	C26	4,7 nF,5%	50V	COG ceramic capacitor	SMD 0603	
16	1	C30	2.2 nF,10%	630 Vdc	polypropylene film capacitor	through hole lead spacing 5 mm	
17	1	C32	220 pF,10%	630 Vdc	polypropylene film capacitor	through hole lead spacing 5 mm	
18	1	C37	680 nF,10%	305 Vac	polypropylene film capacitor	through hole lead spacing 15 mm	
19	2	C43,C44	10 nF,10%	50 Vdc	X7R ceramic capacitor	SMD 0603	
20	2	C50,C54	22 pF,10%	50 V	C0G ceramic capacitor	SMD 0603	
21	1	C53	1 nF,20%	250 Vac	Y1 capacitor	through hole lead spacing 9.5 mm	
22	1	C57	220 nF,10%	520 V	polypropylene film capacitor	through hole lead spacing 15 mm	
23	5	D1,D3,D4,D5, D6	100 0V 3 A	1000 V/ 3 A	standard rectifier diode 1000 V 3 A	SMD SMB	
24	2	DN1,DN2	70 V, 70 mA	70 V,70 mA	small signal Schottky diode	SOT23	ST
25	1	D2	STTH2L06	2 A/600 V	ultrafast high voltage rectifier	through hole DO41	ST
26	8	D7,D10, D12,D14,D15, D18,D24,D25	TMMBAT46	100 V/150 mA	Small signal Schottky diode	SMD minimelf	ST
27	1	D8	SM6T220A	220 V/600 W	TRANSIL	SMD SMB	ST
28	1	D9	STPS2150	150 V/2 A	power Schottky diode	SMD SMA	ST
29	3	D11,D19,D23, D28	STTH1L06A	1 A/600 V	ultrafast high voltage rectifier	SMD SMA	ST
30	5	D13,D17,D20, D21,D22	STPS1L30A	30 V/1 A	power Schottky diode	SMD SMA	ST
31	1	D16	LIC01	255 V	light ignition circuit	SMD Dpak	ST

Table 7. Bill of material (BOM) (continued)

Item	Quantity	Reference	Value	Rated	Type	Package	Manufacturer
32	1	D26	red LED	2 mA	high efficiency Red diffused LED 2 mA 3 mm	through hole 3 mm	
33	1	D27	green LED	2 mA	high efficiency green diffused LED 2 mA 3 mm	through hole 3 mm	
34	1	F1	3.15 A T	250Vac/3.15A	fuse	through hole 5 mm	
35	1	J1	VIN		not mounted	through hole	
36	1	J2	VIN PLM		low profile female strip line connector	through hole	
37	1	J3	VOUT		not mounted	through hole	
38	1	J4	PLM		low profile 24 way (2 x 12) female stripline connector	through hole	
39	1	J5	CON4		low profile female strip line connector	through hole	
40	1	J7	DALI		12 pin male double strip line connector		
41	1	J8	USB TO UART		jack stereo connector	SMD	
42	1	L1	600 µH	2.8A	PFC Inductor	through hole	MAGNETICA 1913.0004
43	2	L2,L7	2x39 mH	1.2 A	power line choke	through hole	

Table 7. Bill of material (BOM) (continued)

Item	Quantity	Reference	Value	Rated	Type	Package	Manufacturer
44	1	L3	4.7 µH,20%	1,9A	power inductor	SMD 4X4.5X3.2	
45	1	L4	2.2 mH,10%			through hole	MAGNETICA 2198.0008
46	1	L5	520 µH	1.8A	bridge Inductor	through hole	MAGNETICA 1975.0001
47	1	L6	4.7 µH,30%	740 mA	ferrite filter	SMD 3x3x1,2	
48	1	Q1	STF13NM60N	600V	Power MOSFET	TO220FP	ST
49	2	Q3,Q4	STF13NM60N D	600V	Power MOSFET	TO220FP	ST
50	2	Q2,Q5	STF26NM60N	600V/10A	power MOSFET	TO220FP	ST
51	1	RV1	S14K275	275 Vac	Varistor	through hole	
52	3	R1,R2,R5	1 M,1%	1/4W	metal film resistor	SMD 1206	
53	16	R3,R9,R16,R17, R19,R26,R33, R36,R37,R40, R56,R62,R63, R64,R68,R74	47 k,1%	1/10W	metal film resistor	SMD 0603	
54	19	R4,R8,R10,R14, R18,R20,R24, R25,R32,R55, R61,R65,R66, R67,R73,R75, R92,R93, R99	10 k,1%	1/10W	metal film resistor	SMD 0603	
55	4	R6,R7,R12,R13, R53,R54,R59, R60	510 k,1%	1/4W	metal film resistor	SMD 1206	
56	3	R11,R15,R98	22,1%	1/4W	metal film resistor	SMD 1206	
57	5	R21,R39,R43, R57,R58	220,1%	1/4W	metal film resistor	SMD 1206	
58	2	R22,R45	8.2 k,1%	1/10W	metal film resistor	SMD 0603	
59	2	R27,R71	5.6 k,1%	1/10W	metal film resistor	SMD 0603	
60	3	R28,R29,R30	1,1%	1/4W	metal film resistor	SMD MELF 0204	
61	1	R34	33 k,1%	1/4W	metal film resistor	SMD 1206	

Table 7. Bill of material (BOM) (continued)

Item	Quantity	Reference	Value	Rated	Type	Package	Manufacturer
62	2	R38,R52	100,1%	1/4W	metal film resistor	SMD 1206	
63	1	R41	33k,1%	1/10W	metal film resistor	SMD 0603	
64	2	R42,R44	2.7,1%	1/4W	metal film resistor	SMD 1206	
65	2	R46,R47	24 k,1%	1/10W	metal film resistor	SMD 0603	
66	7	R48,R83,R84, R85,R90,R95, R96	0	1/4W	metal film resistor	SMD 1206	
67	1	R49	15 k ,5%	5W	ceramic resistor	through hole	
68	1	R51	240 k,1%	1/10W	metal film resistor	SMD 0603	
69	3	R69,R70,R72	1,1%	3W	metal film resistor	through hole	
70	2	R89,R94	1 k,1%	1/10W	metal film resistor	SMD 0603	
71	2	R91,R102	100 k,1%	1/10W	metal film resistor	SMD 0603	
72	1	R97	470,1%	1/10W	metal film resistor	SMD 0603	
73	2	R100,R101	0	1/10W	metal film resistor	SMD 0603	not mounted
74	2	R103,R104	0	1/10W	metal film resistor	SMD 0603	not mounted
75	2	R105,R106	0	1/10W	metal film resistor	SMD 0604	
76	1	SW1	RESET		Tactile Switches	through hole	
77	1	T1	Magnetica		Igniter	through hole	MAGNETICA 1907.0010
78	1	UMICRO1	STLUX385A			SMD TSSOP38	ST
79	1	U1	TD220		gate driver with VREG and two-point regulator	SMD SO8	ST
80	1	U2,U3	TS272		dual operation amplifiers	SMD TSSOP8	ST

Table 7. Bill of material (BOM) (continued)

Item	Quantity	Reference	Value	Rated	Type	Package	Manufacturer
81	1	U4	ALTAIR04-900		off-line all-primary-sensing switching regulator	SMD SO16N	ST
82	1	U5	LD29080S33R		low drop voltage regulators	SMD SOT223	ST
83	1	U6,U7	L6390		high-voltage high/low-side driver	SO16	ST
84	1	U8	STLM20		analog temperature sensor	SOT323-5L	ST
85	1		20°K/W		heat sink	through hole 13 x 12.7 x 19.5mm	
86	1		3.32 °K/W		heat sink	100 x 27 x 50 mm	

7 Revision history

Table 8. Document revision history

Date	Revision	Changes
12-Jun-2015	1	Initial release.