AN4549
Application note

Single-channel boost LED driver using the ALED6001 with graphic user interface for quick evaluation

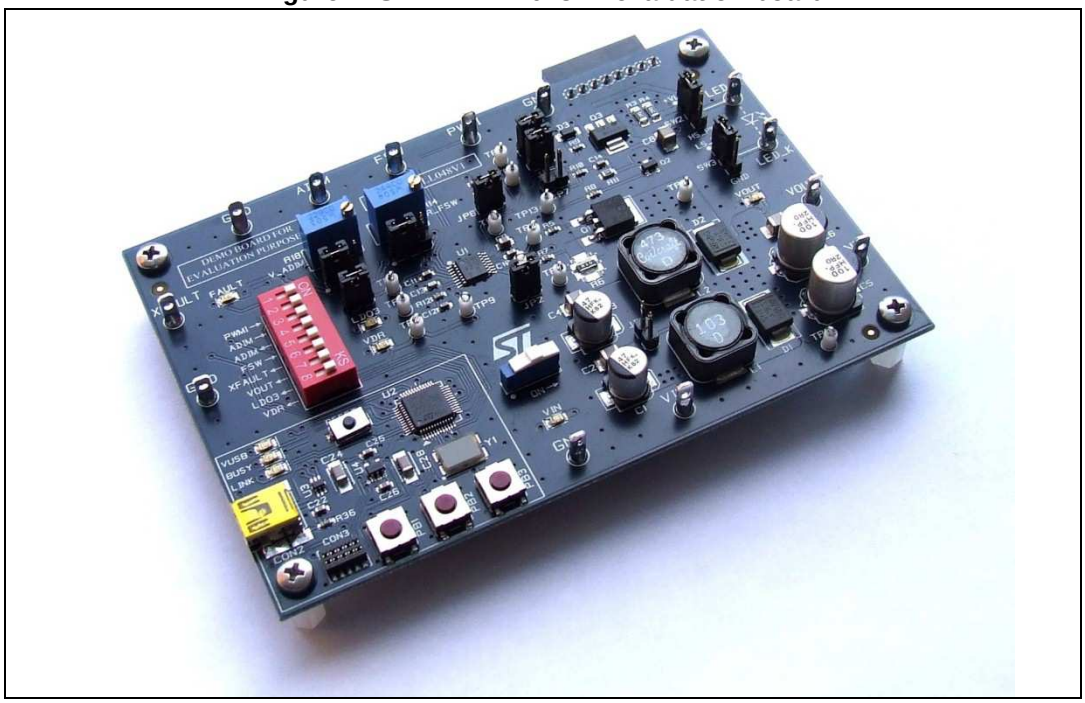
Introduction

The ALED6001 is an automotive-grade LED driver that combines a boost controller and high-side current sensing circuitry optimized for driving a string of high brightness LEDs. The device is compatible with multiple topologies such as boost, SEPIC and floating load buck-boost. PWM dimming of the LED brightness is achieved via an external MOSFET in series with the LED string, directly driven by a dedicated pin. Another pin allows analog control of the LED current (10:1 analog dimming) and can also be used to limit the temperature of the LED string (thermal feedback) by means of an NTC thermistor.

High-side current sensing in combination with a P-channel MOSFET provides effective protection in cases where the positive terminal of the LED string shorts to ground. The high precision current sensing circuitry allows a LED current regulation reference within +/-4% accuracy over the whole temperature range and production spread.

A fault output (open drain) informs the host system of device over-temperature, output over-voltage (disconnected LED string) or LED overcurrent fault conditions.

Figure 1. STEVAL-ILL048V1 evaluation board



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1 STEVAL-ILL048V1 evaluation board

The STEVAL-ILL048V1 evaluation board is based on the ALED6001 in boost configuration and is designed to drive a string of high-brightness LEDs in series, starting from a single supply rail.

The board integrates a micro controller section that allows the user to quickly evaluate all the ALED6001 functions through a graphic user interface (GUI) running on a PC.

Table 1 summarizes the main features of the STEVAL-ILL048V1 board.

Table 1. STEVAL-ILL048V1 board specifications summary

Parameter	Conditions	Value
Minimum input voltage		6 V
Maximum input voltage		24 V
Output voltage		24 V÷40 V
Output OVP threshold		48 V
Boost section switching frequency	FSW high (LDO3)	630 kHz
	FSW pin to R14 trimmer	100 kHz-1 MHz
Minimum dimming on-time	100Hz<FDIM<20kHz	10 µs
Output (LED) current	ADIM to LDO3	350 mA
Output current accuracy (respect to nominal value)		±4% max (<±2% typ.)

This document is intended as a reference guide to start working with the ALED6001 LED driver only using the STEVAL-ILL048V1 board, a DC power supply and a PC.

1.1 Board connectors and test-points

The STEVAL-ILL048V1 board has a set of connectors and test points that facilitate interfacing it with the measurement equipment. The following tables summarize the function of each terminal and test-point on the board.

Table 2. STEVAL-ILL048V1 board terminals description

Connector	Description
VIN	Input voltage, positive terminal
GND	Reference ground
LED_A	Positive terminal of the LED string (anode)
LED_K	Negative terminal of the LED string (cathode)
VOUT	Boost regulator output voltage
ADIM	Analog dimming control
PWMI	Enable/PWM dimming control
FSW	Boost converter synchronization input
XFAULT	Fault signal, active low

Table 3. STEVAL-ILL048V1 board test-points description

Connector	Description
TP1	VIN pin
TP2	VDR pin
TP3	LDO3 pin
TP4	GATE pin
TP5	Switching node
TP6	R6 sensing resistor, hot terminal
TP7	CSNS pin
TP8	Boost converter output voltage
TP9	OVFB pin
TP10	VFBP pin
TP11	VFBN pin
TP12	COMP pin
TP13	PWMO pin

2 Recommended equipment

The on-board MCU section controls all the functions of the ALED6001 by applying the required signals and reading back certain voltages.

Rapid evaluation of the ALED6001 can be performed with just a DC power supply and a PC with USB connectivity; more detailed performance analyses require conventional lab equipment (digital multi-meters, oscilloscope, etc.).

3 Configuration

The STEVAL-ILL048V1 board allows the user to select different options by acting on a set of jumpers and switches (see *Table 4* and *Table 5*).

Table 4. STEVAL-ILL048V1 jumpers' description

Jumper	Function	Default position
JP1	The input filter consists of C1, C2, L1, C2 and C3 and it has been added to reduce EMI emission. In the default setting, JP1 is closed and L1 is shorted so that its DC resistance does not affect the overall efficiency.	Closed
JP2	The JP2 jumper is used to measure the real current consumption of the ALED6001. Once JP1 is removed, a current meter can be connected in series with the VIN pin of the device.	Closed
JP3	The JP3 jumper is used to measure the current consumption of the external circuitry connected to the 3.3V LDO of the ALED6001. Once JP3 is removed, a current meter can be connected in series with the LDO3 pin of the device.	Closed
JP4	If this jumper is removed, the VFBP pin is disconnected from the sensing resistor and the ALED6001 returns a fault condition (XFAULT pin low)	Closed
JP5	If this jumper is removed, the VFBP pin is disconnected from the sensing resistor and the ALED6001 returns a fault condition (XFAULT pin low)	Closed
JP6	If this jumper is removed, the VFBP pin is disconnected from the sensing resistor and the ALED6001 returns a fault condition (XFAULT pin low)	Closed
JP7	This jumper enables high-side PMOS driving. When a simple low-side dimming NMOS is used, this jumper should be open to avoid undesired power dissipation.	Open
JP8	This jumper connects the FSW pin of the ALED6001 to LDO3 (630 kHz default switching frequency, dot position) or to the R14 trimmer (100 kHz–1 MHz adjustable switching frequency.	Left (dot)
JP9	This jumper connects the ADIM pin of the ALED6001 to LDO3 (full-scale LED current) or to the R18 trimmer (adjustable 30 mV–300 mV feedback reference for analog dimming)	Left (dot)
JP10	"VIN" LED disconnection	Closed
JP11	"VOUT" LED disconnection	Closed

Table 4. STEVAL-ILL048V1 jumpers' description (continued)

Jumper	Function	Default position
JP12	"LDO3" LED disconnection	Closed
JP13	"VDR" LED disconnection	Closed
JP14	This jumper powers the MCU from the LDO3 pin of the ALED6001. The SW1 switch must be in the "ON" position to ensure the MCU is powered when the input voltage is applied.	Open
JP15	If this jumper is closed, the R43-C39 snubber is connected in parallel to the Q3 low-side switch in order to damp undesired oscillations that may occur in long wiring between the board and the LED string (parasitic inductance)	Open

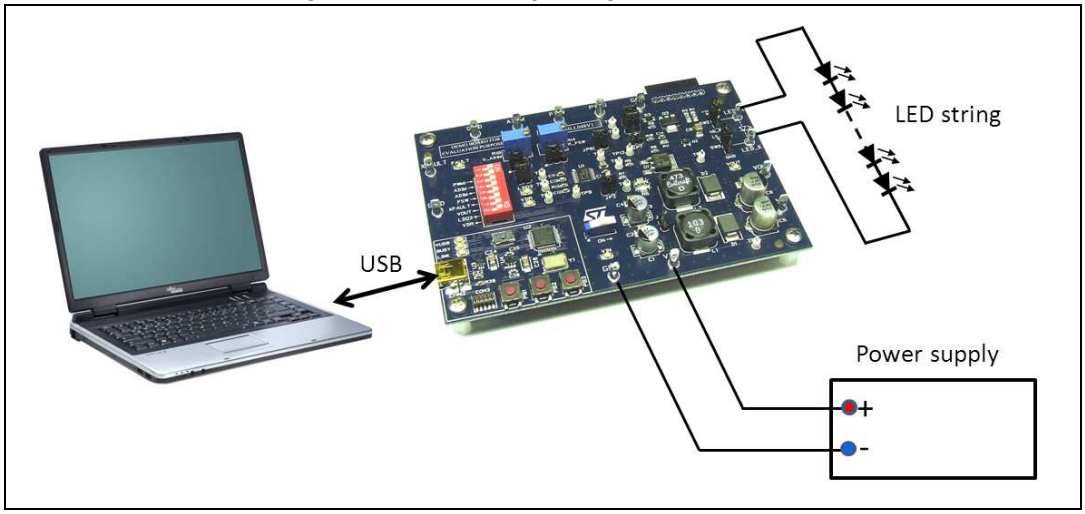
Table 5. STEVAL-ILL048V1 switches' description

Jumper	Function	Default position
SW1	If this switch is in the default position (left, dot), the PWMI pin of the ALED6001 is left floating, i.e. tied to ground by the internal pull-down resistor. If moved to the right position, the PWMI pin is pulled-up by the input rail and the device turns-on.	Left (dot)
SW2	This jumper is used to assign the LED_A connector according to the selected dimming MOSFET (low-side or high-side). If the low-side dimming MOSFET is used, this jumper must be in the upper position (dot).	Upper (dot)
SW3	This jumper is used to assign the LED_A connector according to the selected dimming MOSFET (low-side or high-side). If the low-side dimming MOSFET is used, this jumper must be in the upper position (dot).	Upper (dot)
SW4	This switch array is used to connect the ALED6001 to the on-board MCU, allowing the latter to control the device. If external signals have to be applied to specific pins of the ALED6001, the related switch must be opened to avoid conflict with the MCU.	Right (all ON)

4 Getting started with STEVAL-ILL048V1 board

Figure 2 shows how to connect the STEVAL-ILL048V1 board to the DC power supply and the LED string. Alternatively, an OSLON_DTRL_x board (see *Appendix B*) can be directly connected to CON1 on the STEVAL-ILL048V1 board.

Figure 2. Basic setup for quick evaluation

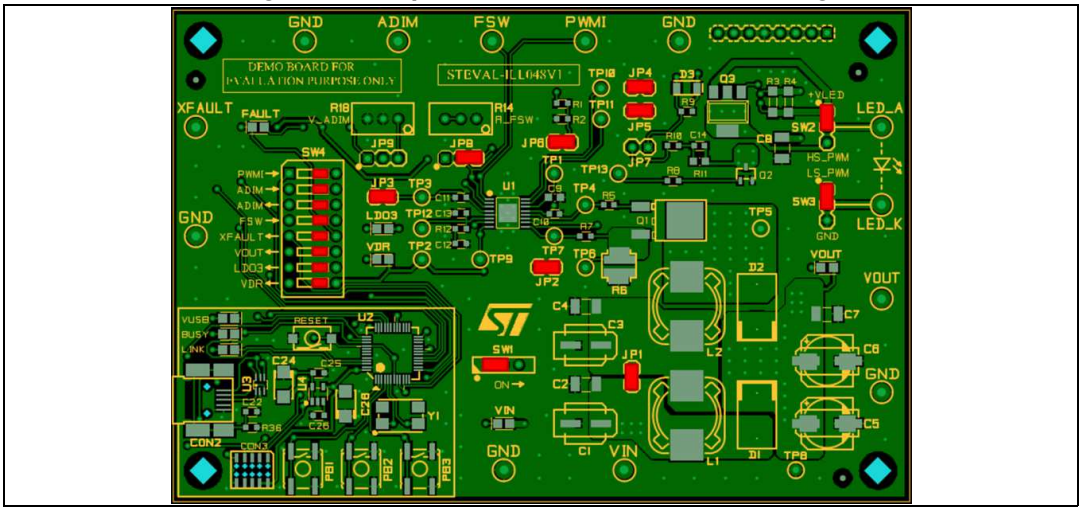


4.1 Quick startup

The following step-by-step sequences provide a guideline to quickly connect the STEVAL-ILL048V1 board to the PC and evaluate the ALED6001 performance.

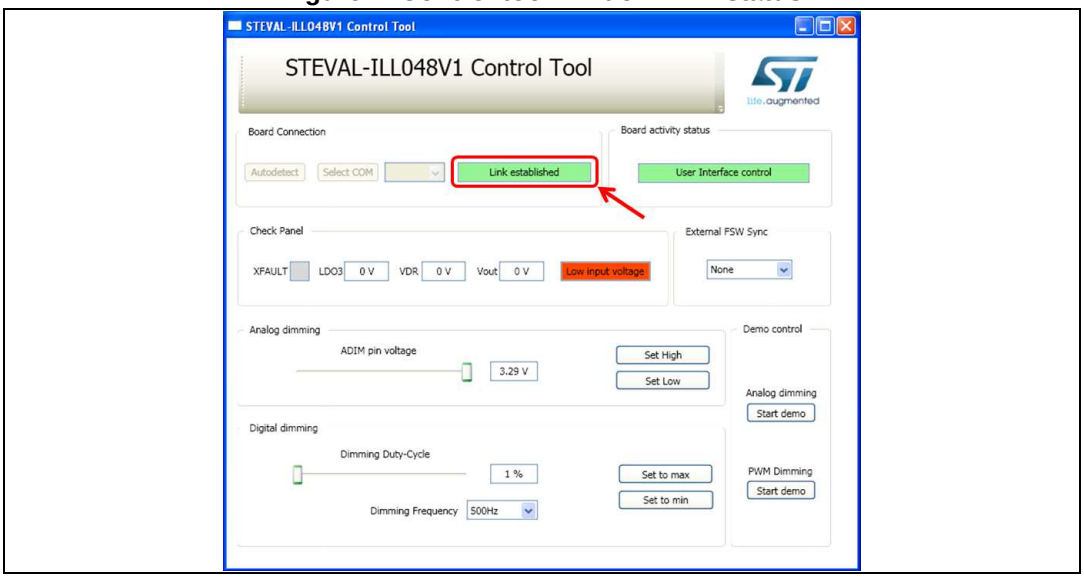
1. Working in an ESD-protected environment is highly recommended. Check all wrist straps and mat earth connections before handling the STEVAL-ILL048V1 board.
2. Check all the jumpers are set according to *Figure 3*. Note that JP9 is removed to give the MCU full control of the ADIM pin.

Figure 3. Jumpers and switches default settings



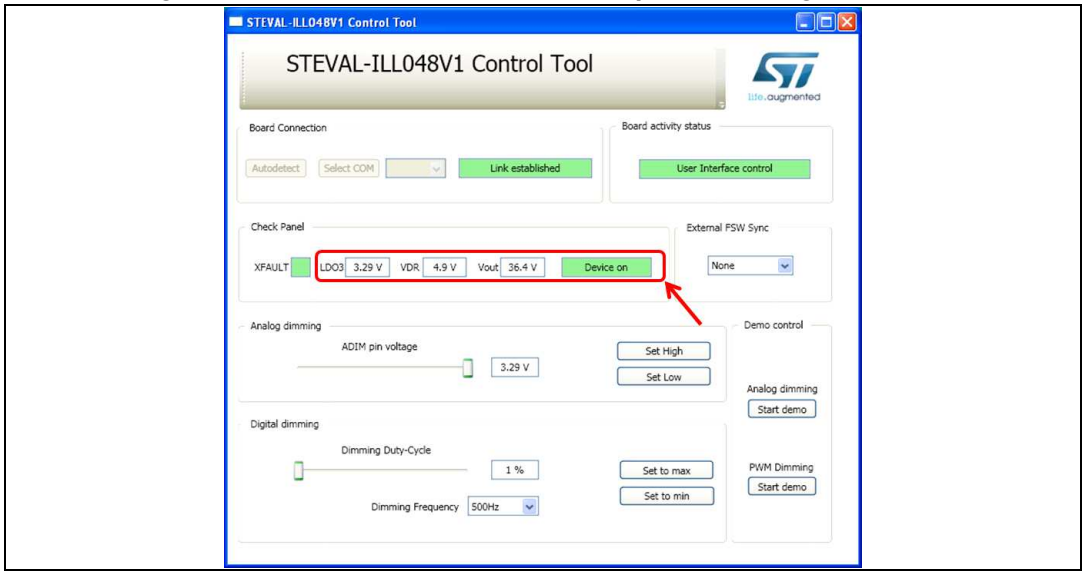
3. Connect a 12 V±10% (3 A current capability) power supply to the STEVAL-ILL048V1 board (VIN and GND terminals).
4. Connect a suitable LED string (8-12 high-brightness White LEDs capable of handling at least 350 mA) between LED-A & LED-K terminals. If the OSLON_DTRL_x board is used, connect it to CON1 of the STEVAL-ILL048V1 board.
5. Connect the STEVAL-ILL048V1 board to the PC via a USB cable. The yellow “LINK” LED should light after a while. You may need to install the STM32 Virtual COM Port Driver on the PC beforehand.
6. Launch the STEVAL-ILL048V1 Control Tool and click on “Autodetect” for the tool to locate the evaluation board port. Manual assignment of the COM port is also possible via the “Select COM” button.

Figure 4. Control tool window: link status



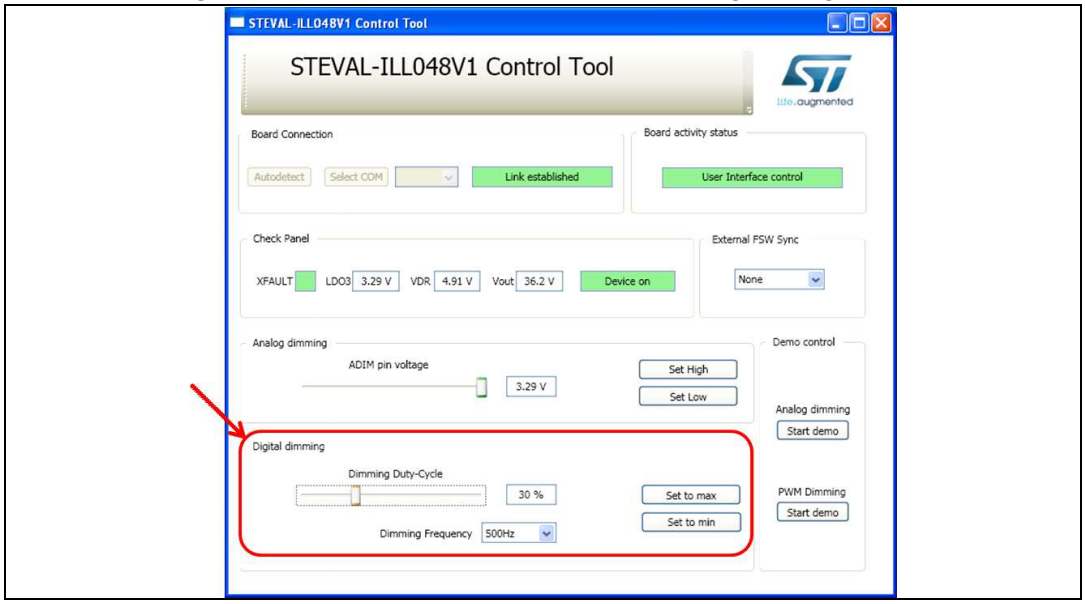
7. Turn on the power supply. The LED string should turn on at 3% PWM dimming. Check the voltage of the LDOs (LDO3 and VDR pins) and the output voltage of the boost converter.

Figure 5. Control tool window: XFAULT pin and voltages monitor



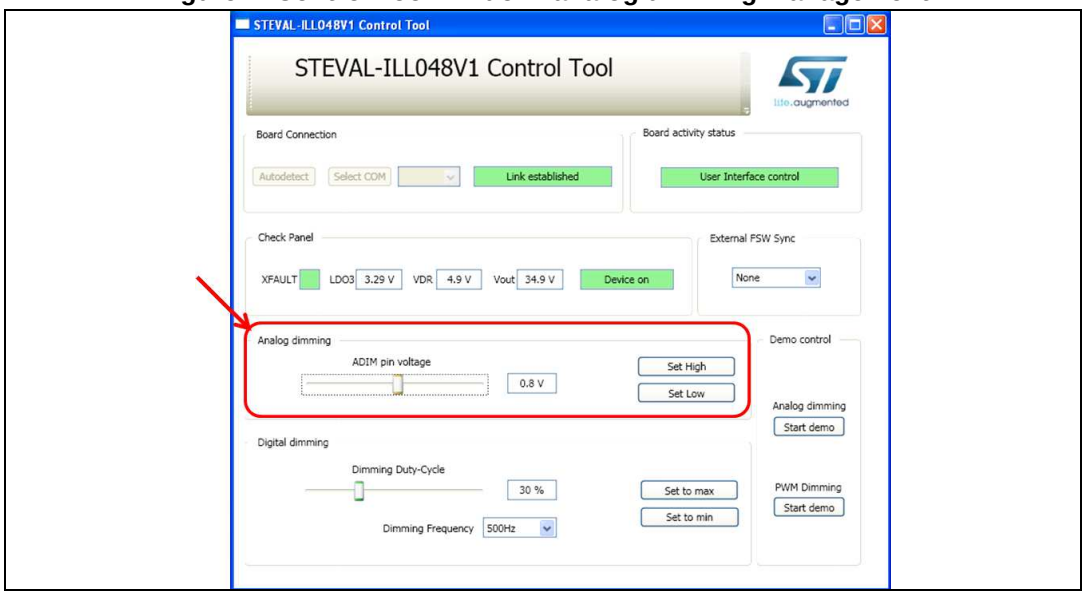
8. In the “digital dimming” section, change the frequency and duty-cycle of the PWM signal applied to the PWMI pin of the device. If the duty-cycle is set to zero, the device shuts-down.

Figure 6. Control tool window: PWM dimming management



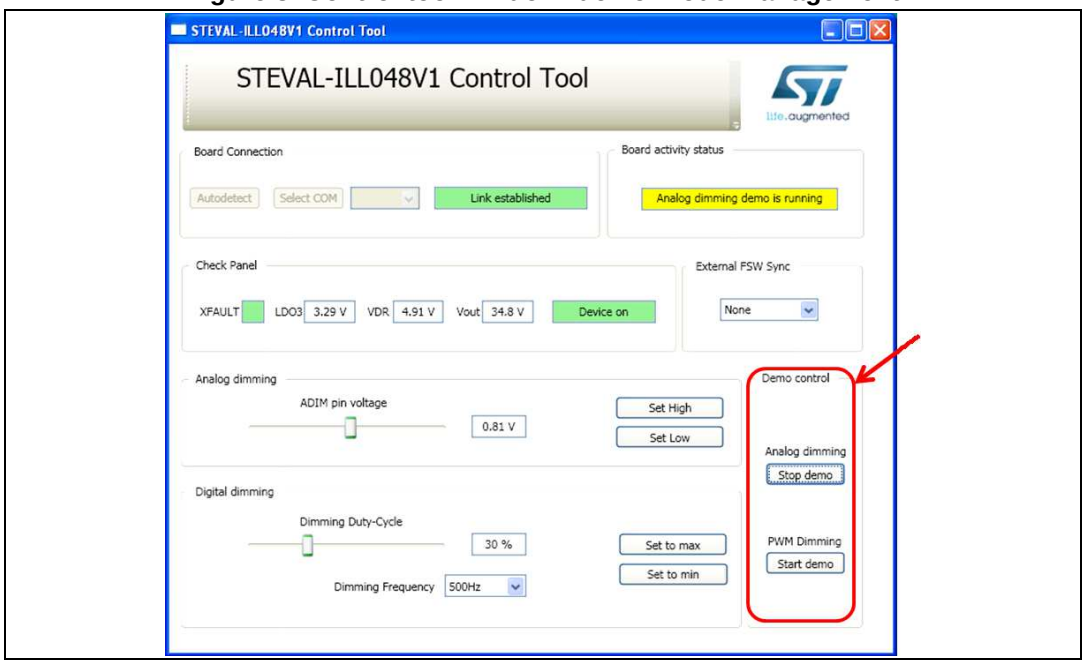
9. In the analog dimming section, change the DC level at the ADIM pin of the device. The real value is read back by the on-board MCU.

Figure 7. Control Tool window: analog dimming management



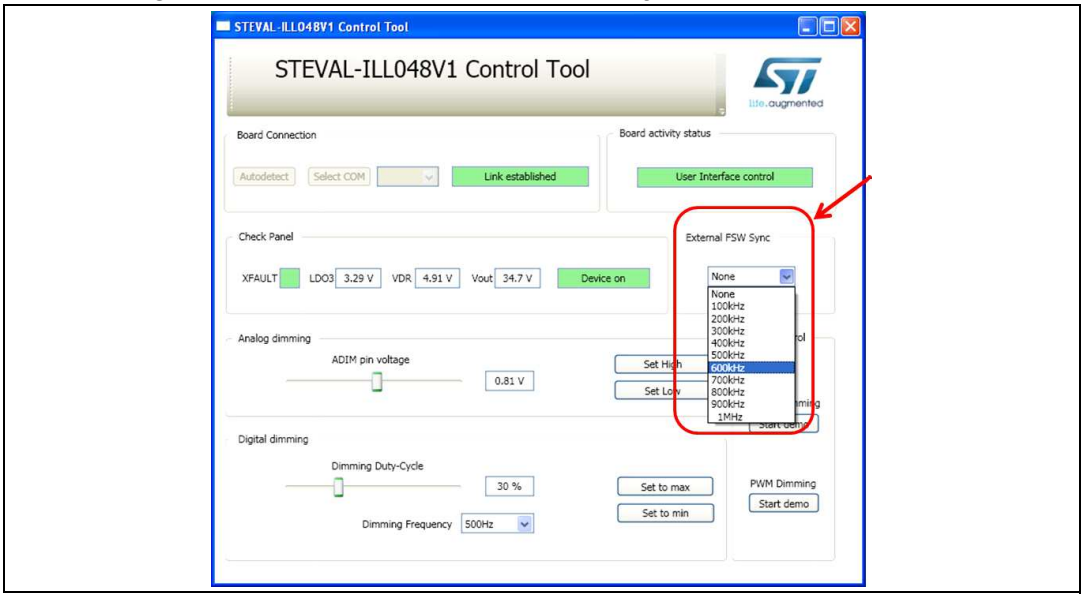
10. Digital and analog dimming controls can operate at the same time. A “Start demo” button for each dimming mode runs the respective demo.

Figure 8. Control tool window: demo-mode management



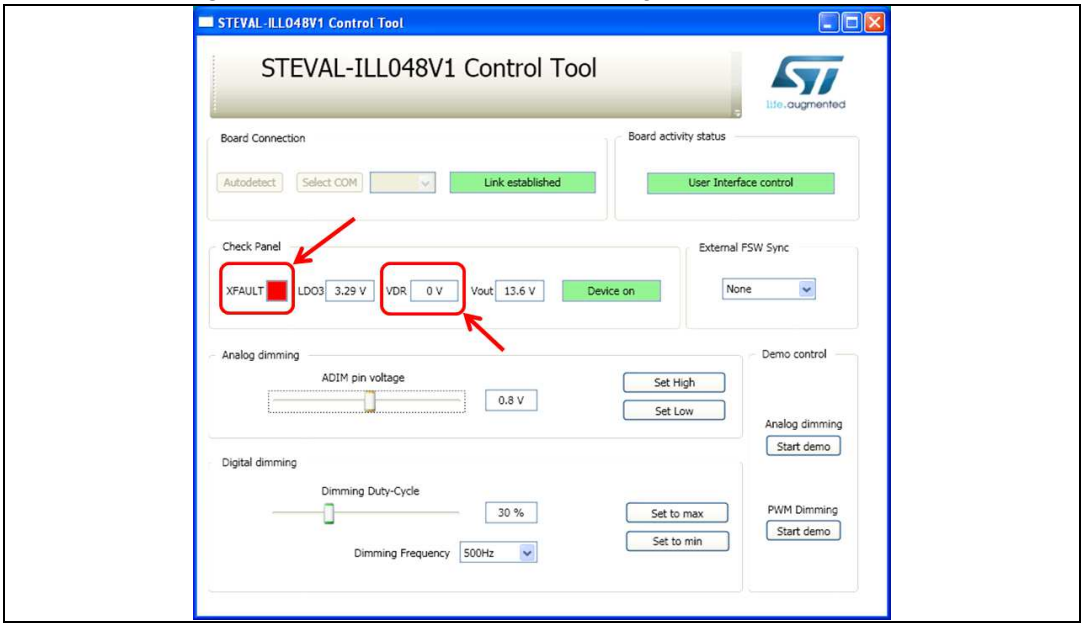
11. The switching frequency of the boost converter can be changed during runtime by applying a synchronization signal at the FSW pin of the device. Preset values can be selected through the dedicated section of the control tool.

Figure 9. Control tool window: external synchronization selection



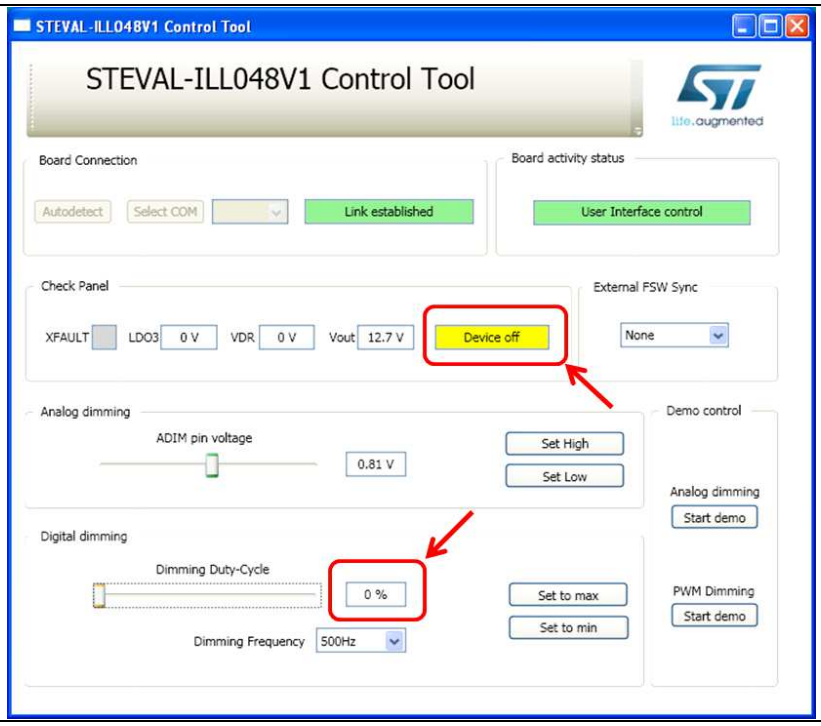
12. The XFAULT pin of the device is monitored in real-time. To simulate a fault condition, remove any of SW2, SW3, JP4, JP5 or JP6: the XFAULT pin goes low and the +5V LDO is disabled.

Figure 10. Control tool window: faulty condition detected



13. Normal operation can resume once the fault condition is cleared and the device is reset by toggling the PWMI pin (digital dimming to zero for more than 10ms and then high again).

Figure 11. Control tool window: device turned-off at zero PWM dimming



Appendix A STEVAL-ILL048V1 board

Figure 12. STEVAL-ILL048V1 board schematic (LED driver section)

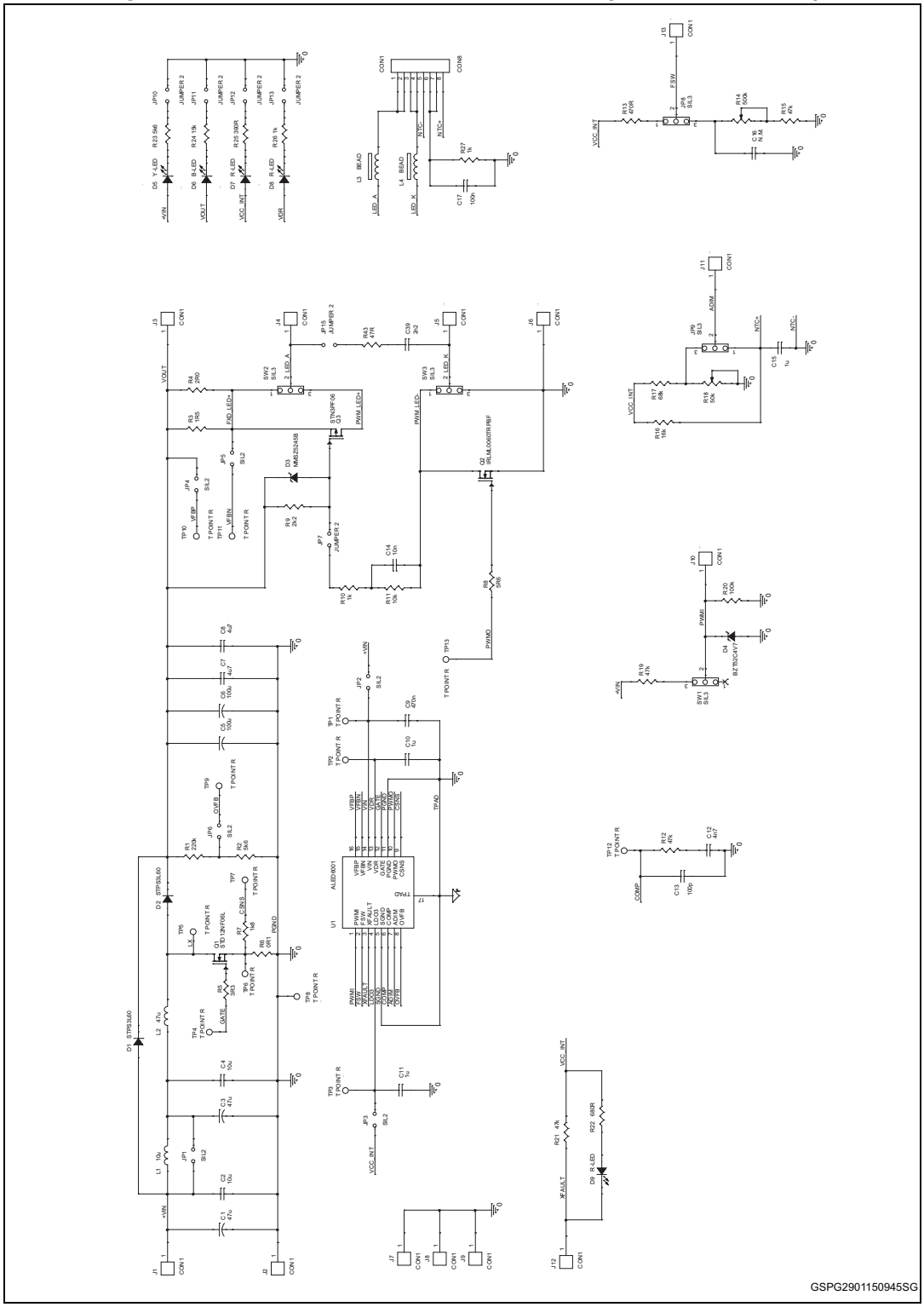


Figure 13. STEVAL-ILL048V1 board schematic (MCU section)

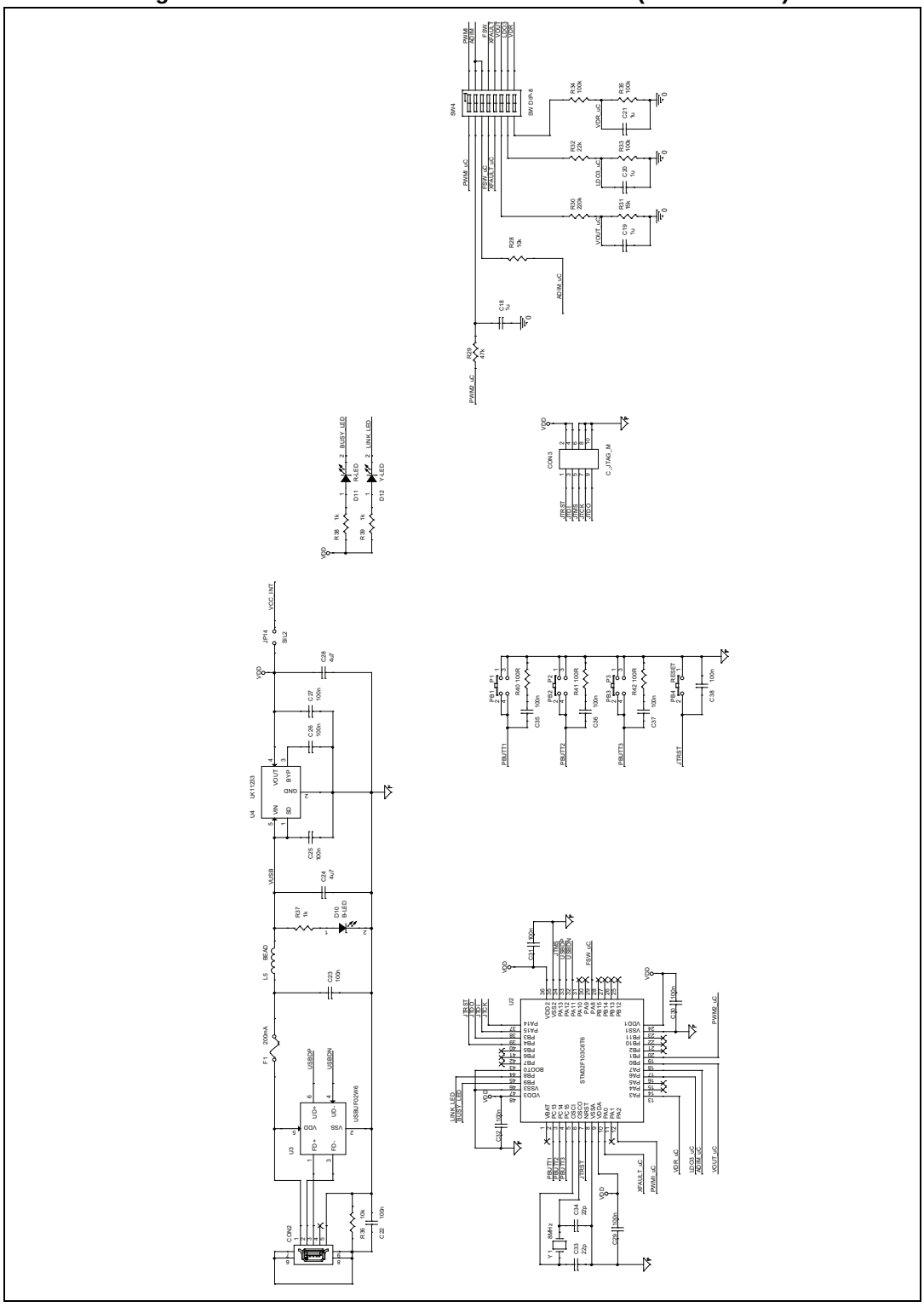


Table 6. BOM

Qty	Component	Description	Package	Part-Number	MFR	Value
1	CON1	8 pin female header	SIL8	613-008-143-121	Wurth Elektronik	
1	CON2	Mini USB connector		6510-0516121		
1	CON3	5x2 female connector		6233-10235321		
2	C1,C3	Aluminum, 50V	D8	EEEFK1H470XP	Panasonic	47u
2	C5,C6	Aluminum, 50V	F	EEEFP1H101AP	Panasonic	100u
4	C2,C4,C7, C8	MLCC, 50V, X7R, 10%	1210	GCM32ER71H475KA40	Murata	4.7u
1	C9	MLCC, 50V, X7R, 10%	0805	GCM21BR71H474KA40		470n
7	C10,C11, C15 C18,C19, C20, C21	MLCC, 25V, X7R, 5%	0603	GCM188R71E105KA64		1u
1	C39	MLCC, 50V, X7R, 10%		GCM188R71H222KA37		2n2
1	C12	MLCC, 50V, X7R, 10%		GCM188R71H103JA37		10n
1	C13	MLCC, 50V, C0G, 5%		GCM1885C1H101JA16		100p
1	C14	MLCC, 50V, X7R, 10%		GCM188R71H103KA37		10n
	C16					N.M.
14	C17,C22, C23,C25, C26,C27 C29,C30, C31,C32, C35,C36 C37,C38	MLCC, 50V, X7R, 10%		GCM188R71H104KA57		100n
2	C24,C28	MLCC, 10V, X7R, 10%	1206	GCM31CR71A106KA64		10u
2	C33,C34	MLCC, 50V, C0G, 5%	0603	GCM1885C1H220JA16		22p
2	D1,D2	Schottky, 60V, 3A	SMB	STPS3L60SY	ST	
1	D3	Zener 15V 400mW	SOD123	MMSZ5245B	Zetex	
1	D4	Zener 4.7V1 400mW		BZT52C4V7S	Zetex	
2	D6,D10	Blue LED	0805	KP-2012PBC-A	Kingbright	
4	D7,D8,D9 D11	Red LED		KP-2012SRC-PRV		
2	D5,D12	Yellow LED		KP-2012SYC		
1	F1	Fuse	1206	0466.200NR	Littelfuse	200mA

Table 6. BOM (continued)

Qty	Component	Description	Package	Part-Number	MFR	Value
13	J1,J2,J3, J4,J5 J6,J7,J8,J9, J10,J11,J12, J13	Faston terminal	hole 1.2mm			
11	JP1,JP2, JP3,JP4, JP5,JP6 JP7,JP10, JP11,JP12, JP13	jumper	SIL2			
2	JP8,JP9	jumper selector	SIL3			
	JP14,JP15	jumper	tin-drop			
1	L1	custom	custom	MSS1260T-103	Coilcraft	10u
1	L2	custom	custom	MSS1260T-473		47u
3	L3,L4,L5	Ferrite bead, 600Ω, 0.6A	0805	BLM21AG601SN1	Murata	0R
3	PB1,PB2, PB3	Pushbutton		430453031836	Wurth Elektronik	
1	PB4			434123025816		
1	Q1	NMOS 60V 12A	DPAK	STD12NF06L	ST	
1	Q2	NMOS 60V 2.5A	SOT23	IRLML0060TRPBF	IR	
1	Q3	PMOS 60V 2.5A	SO8	STN3PF06	ST	
2	R1,R30	Resistor, 1%, 0.125W	0603			220k
2	R2,R23					5k6
1	R3	Sensing resistor 1%, 0.5W	1206	ERJ8BQF1R5V	Panasonic	1R5
1	R4			ERJ8BQF2R0V		2R0
1	R5	Resistor, 1%, 0.125W	0603			3R3
1	R6	Sensing resistor	1020	ERJB2CFR10V	Panasonic	R100

Table 6. BOM (continued)

Qty	Component	Description	Package	Part-Number	MFR	Value
1	R7	Resistor, 1%, 0.125W	0603			1k8
1	R8					5R6
1	R9					2k2
6	R10,R26 R27,R37 R38,R39					1k
1	R11		0805			10k
1	R12		0603			39k
1	R16					16k
2	R28,R36					10k
1	R13					470R
1	R14	Through-hole trimmer	SIL3			500k
1	R18					50k
1	R17	Resistor, 1%, 0.125W	0603			68k
4	R20,R33 R34,R35					100k
4	R15,R19 R21,R29					47k
1	R22					680R
2	R24,R31					15k
1	R25					390R
1	R32					22k
3	R40,R41,R42					100R
1	R43		0805			47R
1	SW1	switch selector	SIL3	MMP1010D	Knitter	
2	SW2,SW3	jumper selector	SIL3			
1	SW4	DIP switch	DIL8	DBS3108	Knitter	
13	TP1,TP2, TP3,TP4, TP5, TP6 TP7,TP8, TP9,TP10, TP11,TP12, TP13	Test point (white)	hole 1mm	200-202	RS	

Table 6. BOM (continued)

Qty	Component	Description	Package	Part-Number	MFR	Value
1	U1	LED driver	TSSOP 16	ALED6001	ST	ALED6001
1	U2	Microcontroller	LQFP-48	STM32F103C6T6		STM32F103 C6T6
1	U3	USB protector	SOTT-123	USBUF02W6		USBUF02W6
1	U4	3V3 Linear regulator	SOT-23	LK112M33TR		LK11233
1	Y1	Crystal resonator	FQ7050B	FQ7050B-8.000	FOX	8MHz

Figure 14. Top side components placement

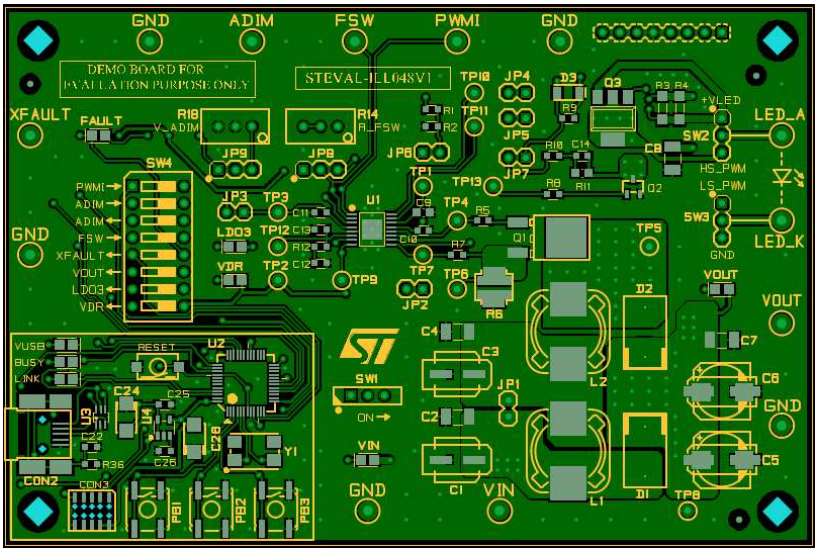
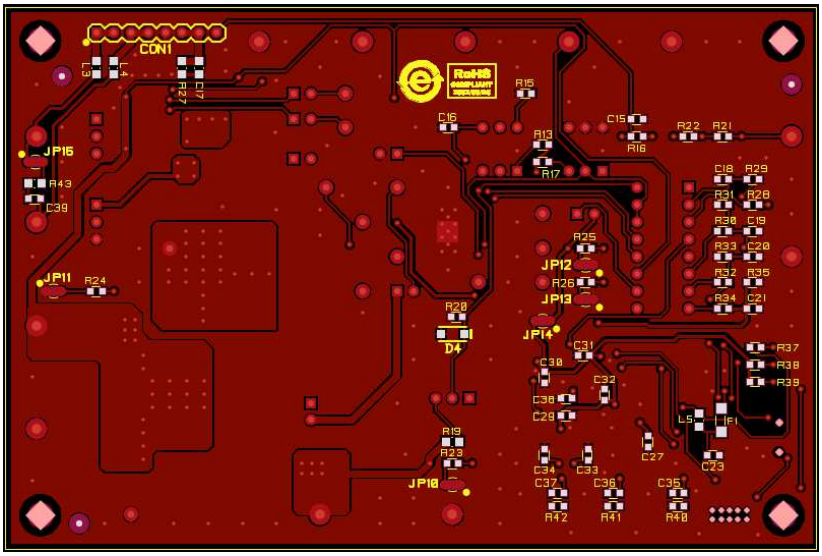


Figure 15. Bottom side components placement



Appendix B OSLON_DTRL_R board

Figure 16. OSLON_DTRL_L and STEVAL-ILL048V1 assembly

The OSLON_DTRL_R board is a simple LED string involving 12 High-Brightness, OSRAM Opto white LEDs (OSLON series) and a few other components. It can be easily coupled to the STEVAL-ILL048V1 evaluation board via the 8-pin strip connector (CON1).

A negative temperature coefficient (NTC) thermistor is thermally coupled to the LED string in order to provide a feedback signal to the LED driver. As visible in the schematic of the STEVAL-ILL048V1 board (see *Appendix A*), the ADIM pin of the ALED6001 is connected to this signal and used for limiting the operating temperature of the LEDs through a closed loop. Optionally, if a LED current lower than the default 350 mA is desired, a fixed value resistor can be selected through the JP1 jumper (*Figure 17*).

Figure 17. OSLON_DTRL_R board schematic

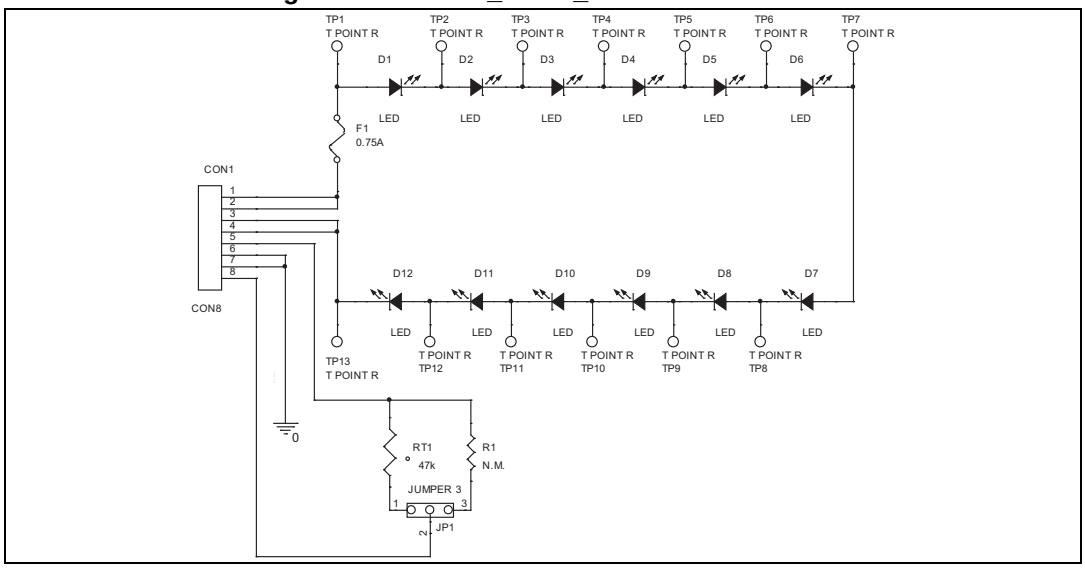


Table 7. OSLON_DTRL_R component list

Qty	Component	Description	Package	Part-Number	MFR
1	F1	fuse	1206	1206SFF075F/63-2	Littlefuse
1	R1	resistor	0603		
1	RT1	47k NTC	0603	NCP18WB473J03RB	Murata
1	CON1	Strip connector	SIL8 SMD		
12	D1…D12	White LEDs	custom	LUW H9QP	OSRAM Opto

Figure 18. OSLON_DTRL_R board layout and components placement (top)

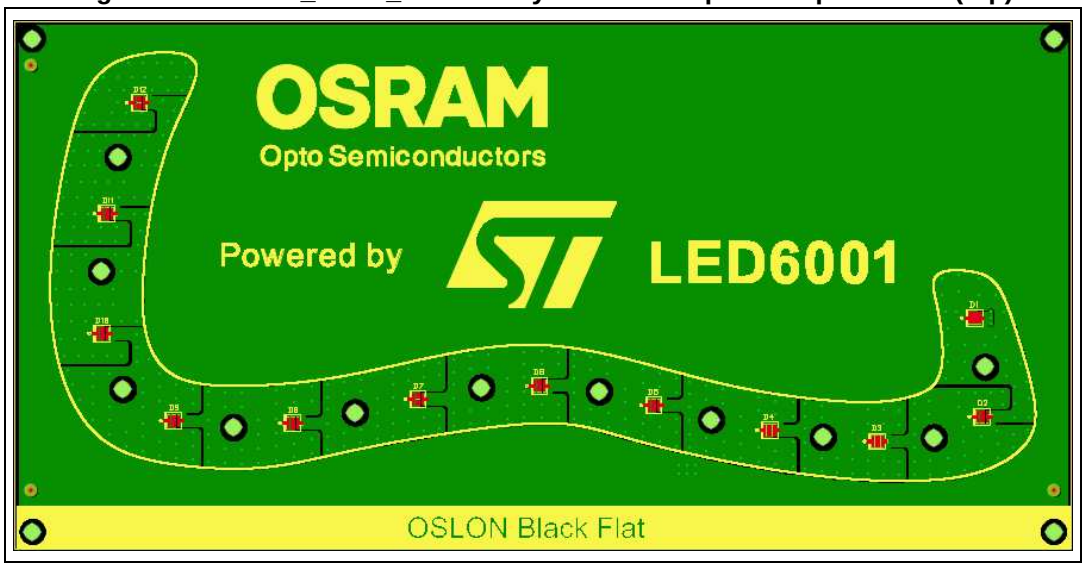


Figure 19. OSLON_DTRL_R board layout and components placement (bottom)

5 Revision history

Table 8. Document revision history

Date	Revision	Changes
11-Dec-2014	1	Initial release.
29-Jan-2015	2	Updated *Figure 12 on page 14*.