UM2017
User manual

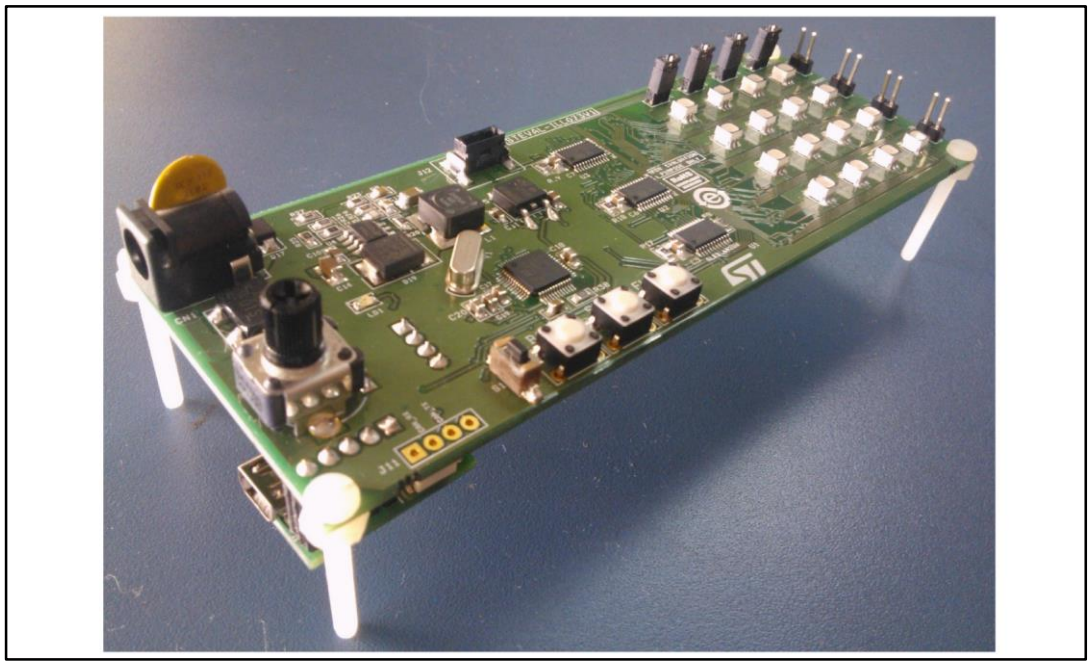
STEVAL-ILL073V1 RGB LED driver for automotive lighting based on ALED1642GW and STM8

Introduction

This evaluation board is based on the STMicroelectronics ALED1642GW independent PWM LED driver controlled through STM8 microcontroller SPI interface. An A7986A DC-DC converter supplies the necessary voltages and power for overall board operation.

Board hardware setup, demonstration firmware functions, PC interconnection and the graphical user interface for ALED1642GW evaluation are described.

Figure 1: STEVAL-ILL073V1: ALED1642GW evaluation board



Contents

1 Getting started

1.1 Package contents

The constant current LED driver ALED1642GW-based evaluation board includes:

- Hardware: a demonstration board and a USB-UART bridge
- Software: graphical user interface
- Document: user manual

1.2 Hardware description

The ALED1642GW evaluation board has on-board DC input power supply, 8-bit microcontroller, SWIM connector to program the microcontroller, 16 RGB LEDs and buttons to control the driver, and three ALED1642GW LED drivers (one for each channel - red, green and blue as per the block diagram in *Figure 4: "Block diagram of STEVAL-ILL073V1 evaluation board"*).

Figure 2: Setup of the board (Top)

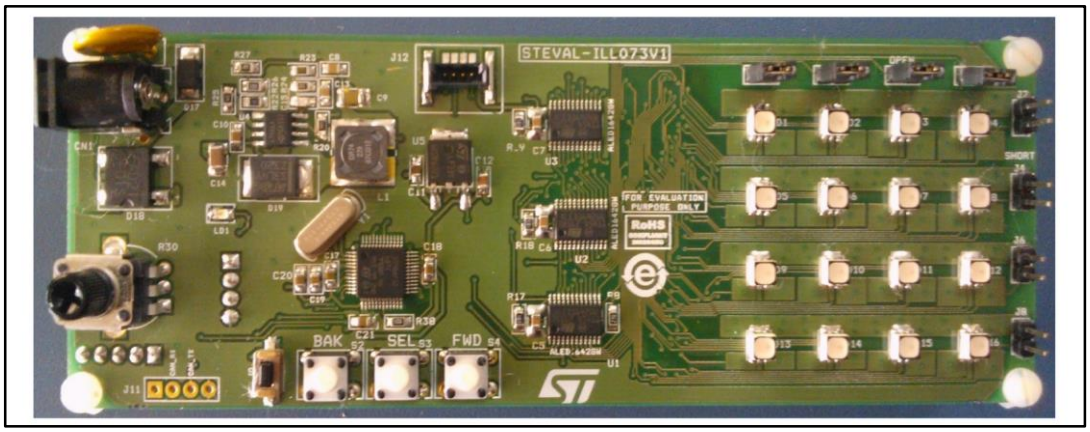
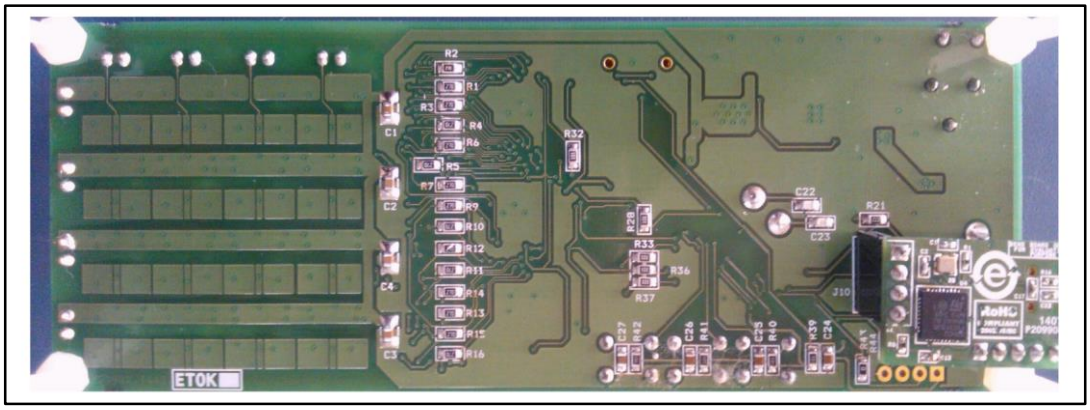


Figure 3: Setup of the board (Bottom)



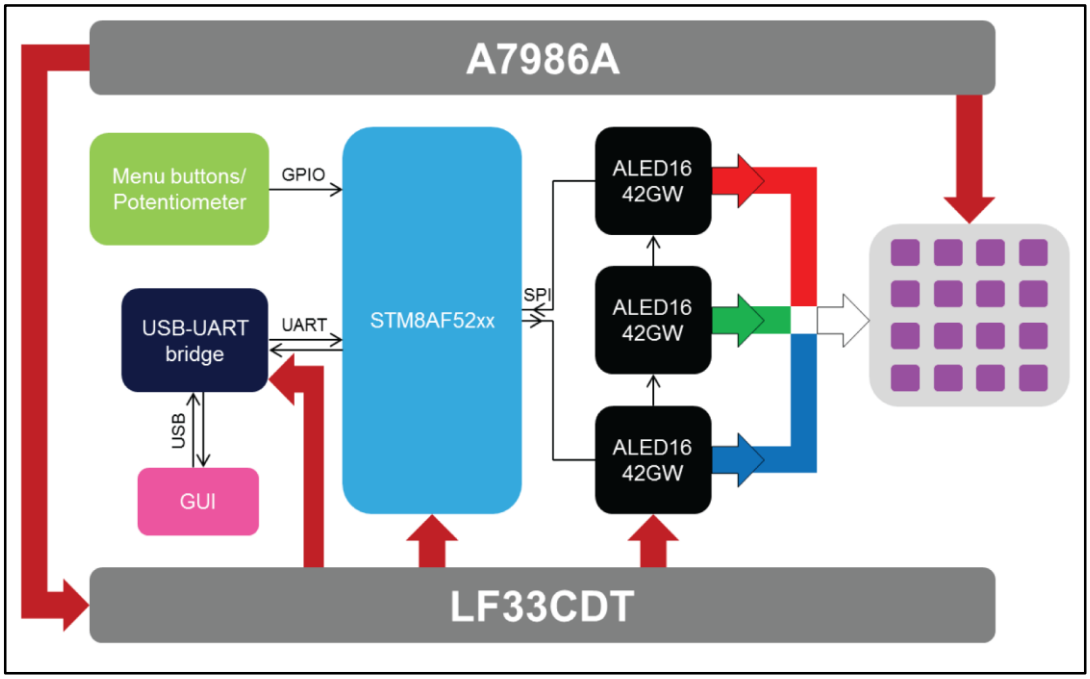
The STEVAL-ILL073V1 board contains the following sections:

1. 6 - 28 V DC power supply with polarity and overvoltage protection, standard DC jack input
2. Diode bridge
3. A7986A: High efficiency switching regulator
4. LF33: 3.3 Volts linear voltage regulator

5. ALED1642GW (TSSOP24 - exposed pad) LED driver
6. SWIM connector to program microcontroller
7. Potentiometer/knob
8. Back/Reset switches
9. STM8AF52xx microcontroller
10. Menu buttons
11. USB-UART bridge
12. 16 RGB (PLCC - 4) LEDs
13. 4 jumpers to simulate open-circuit errors
14. 4 jumpers to simulate short-circuit errors

2 Schematic diagram of STEVAL-ILL073V1 evaluation board

Figure 4: Block diagram of STEVAL-ILL073V1 evaluation board



2.1 Modes of operation

Evaluation board has two modes of operation:

- Stand-alone mode: the board is controlled via on-board push buttons and potentiometer
- GUI mode: if connected to PC, the board operates under the control of the GUI

3 Board function overview

3.1 Board controls

3.1.1 Power supply

The board is powered by a 6 to 28 V DC power supply. The power source must be able to deliver sufficient current depending on the input voltage. Since the board has a built-in diode bridge, the polarity of the input voltage is not specified.

3.1.2 Microcontroller SWIM

The board is equipped with a standard 4-pin SWIM connector allowing debugging and development of the STM8 microcontroller firmware.

3.1.3 USB-UART Bridge

STEVAL-ILL073V1 communicates with PC GUI via the USB-UART board, which acts as the bridge between STM8 and your PC. It communicates with the main board via UART interface and via USB with the PC.

3.1.4 Jumpers for LED failure simulation

LED defects can be simulated by using J1 to J8 jumpers:

- Removing a jumper on J1, J3, J5 and J7 causes green LED open-circuit error in D1, D2, D3 and D4 respectively (refer to *Section 4.7: "Open error detection"*).
- Placing a jumper on J2, J4, J6 and J8 causes red LED short-circuit error in D4, D8, D12 and D16 respectively (refer to *Section 4.8: "Short error detection"*).

These simulated defects can be detected during error detection mode. The defect LED is signaled by lighting the corresponding blue LED on the board in standalone mode, and by flashing the corresponding light in the LED map in GUI mode.

3.2 Board features

3.2.1 Features of evaluation board in stand-alone mode

- Demonstrates preconfigured patterns (with adjustable brightness/speed) like random color, wave and color transition demo
- On-board buttons to switch between the demos
- Potentiometer as a slider to control speed or brightness of the pattern
- Error detection simulation for open circuit, short circuit and and a combination of both using specific jumpers

3.2.2 Features of evaluation board in GUI mode

- All the features present in standalone mode can be controlled via the GUI
- Global brightness control to change the brightness of all the channels
- 4 individual channel brightness control to control individual brightness of each LED
- Reference PWCLK control from 250 kHz to 12 MHz
- Frame programming mode and 4 predefined presets with variable transition time between frames
- Error detection selection and representation on GUI for open circuit, short circuit and combinations of both
- Error detection in "no loop" and in 0.5 s and 1 s (approx.) loops
- Read/write configuration register

3.3 Key devices on evaluation board

The main devices on the board are:

A7986A: A7986A is a high efficiency step down 250 kHz (programmable up to 1 MHz) switching regulator with max. 3 A DC output current. Input voltage varies from 4.5 to 38 V and also depends on the required output. It supports low dropout operation along with zero load current operation. Overcurrent and thermal protection are provided for safe operation of the device. It powers the LF33 and RGB LEDs.

LF33CDT: LF33 is a fixed 3.3 V output, very low-dropout voltage (0.45 V) regulator which is able to provide up to 500 mA. It powers the microcontroller and LED drivers.

STM8AF52xx: STM8AF52xx is an 8-bit Harvard architecture microcontroller. It has an ADC, Timer, I²C, SPI, USART, etc. The option byte has been modified for suitable STEVAL-ILL073V1 operation as follows:

- AFR5 to "Port B3 Alternate Function = TIM1_ETR" (TIM1 is used for the LE command of the ALED1642GW)
- WAITESTATE to "1 wait state" to support a 24 MHz external clock (for clock frequencies above 16 MHz, flash/data EEPROM access must be configured for 1 wait state)

Diode Bridge: the diode bridge at the power supply input ensures board operation regardless of the input voltage polarity.

RGB LED: 16 high performance tricolor (red, green & blue) SMD LEDs with wide viewing angle and high brightness are mounted in 4x4 fashion on the board. The features listed in the table below render these LEDs suitable for video signals.

Table 1: List of external components

Channel	Dominant wavelength	Luminous intensity	Viewing angle
Red	619 - 624 nm	450 - 1120 nm	120°
Green	520 - 540 nm	990 - 2240 nm	
Blue	460 - 480 nm	224 - 560 nm	

4 Stand-alone mode

If the ALED1642GW evaluation board is not connected to a PC, it runs in standalone mode. The main features of standalone mode are:

- Brightness control for each LED in preconfigured patterns
- Speed and brightness control of the patterns
- Open error, short error and combined error detection to detect LED failure

When connected to a DC supply, the 4x4 RGB LED matrix flashes with a brief animation followed by a sequence where one row is brighter than the others. The speed of this sequence can be altered via the potentiometer knob.

Pressing the on-board SEL button activates another function where all the LEDs become white and the brightness of the LEDs can be altered via the potentiometer.

Hence, there are nine different patterns in standalone mode which you can control using the on-board SEL, BAK, and FWD buttons.

4.1 Pot function demo

Following power on, pressing the on-board SEL button activates the pot function demo mode. In this mode, the color of all LEDs is white and their is controlled via the potentiometer knob.

4.2 Random color speed

When the pot function dempo is active, pressing the FWD button one causes all the LEDs to change color randomly.

4.3 Wave of colors

When random color speed mode is active, pressing the FWD button causes all the LEDs to change color randomly and the speed and the speed at which the colors change is controlled via the potentiometer knob.

4.4 Solid color brightness

When wave of colors mode is active, pressing the FWD button one causes all the LEDs to show the same color, which changes over time.

4.5 Color change with pot

When solid color brightness mode is active, pressing the FWD button causes all the LEDs to retain the same color, which can be changed by rotating the potentiometer knob.

4.6 One row brighter than other

When color change with pot is active, pressing the FWD button causes a sequence where each row illuminates in one of the three color wavelengths, but the last row remains white. The speed of the sequence is changed with the potentiometer knob.

4.7 Open error detection

In this mode, drivers perform open circuit error detection and display the error. A defective LED is signaled by lighting the corresponding blue LED. D1, D2, D3 and D4 green channel open-circuits can be simulated by opening the J1, J3, J5, J7 jumpers, respectively.

4.8 Short error detection

In this mode, drivers perform short circuit error detection and display the error. A defective LED is signaled by lighting the corresponding blue LED. D4, D8, D10 and D12 red channel short-circuits can be simulated by closing the J2, J4, J6, J8 jumpers, respectively.

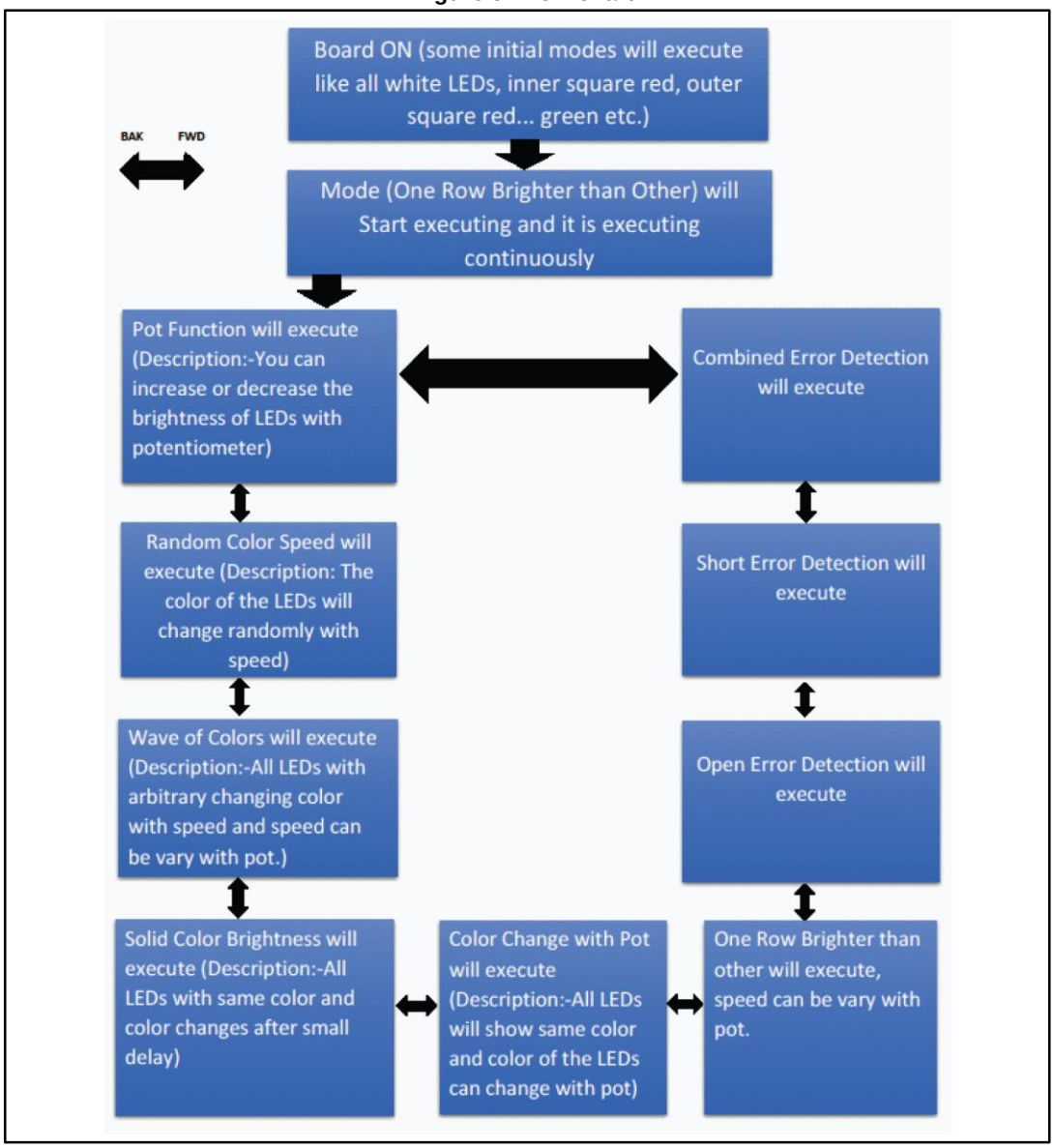
4.9 Combined error detection

In this mode, drivers perform both open circuit and short circuit error detection simultaneously. A defective LED is signaled by lighting the corresponding blue LED. Simulation of both types of error is described in the preceding sections.

For demonstrative purposes, open circuit error is managed in the green channels and short circuit error in the red channels. However, the LED1642GW can perform error detection on any channel and any LED.

5 Flow chart for transition between modes

Figure 5: Flow chart

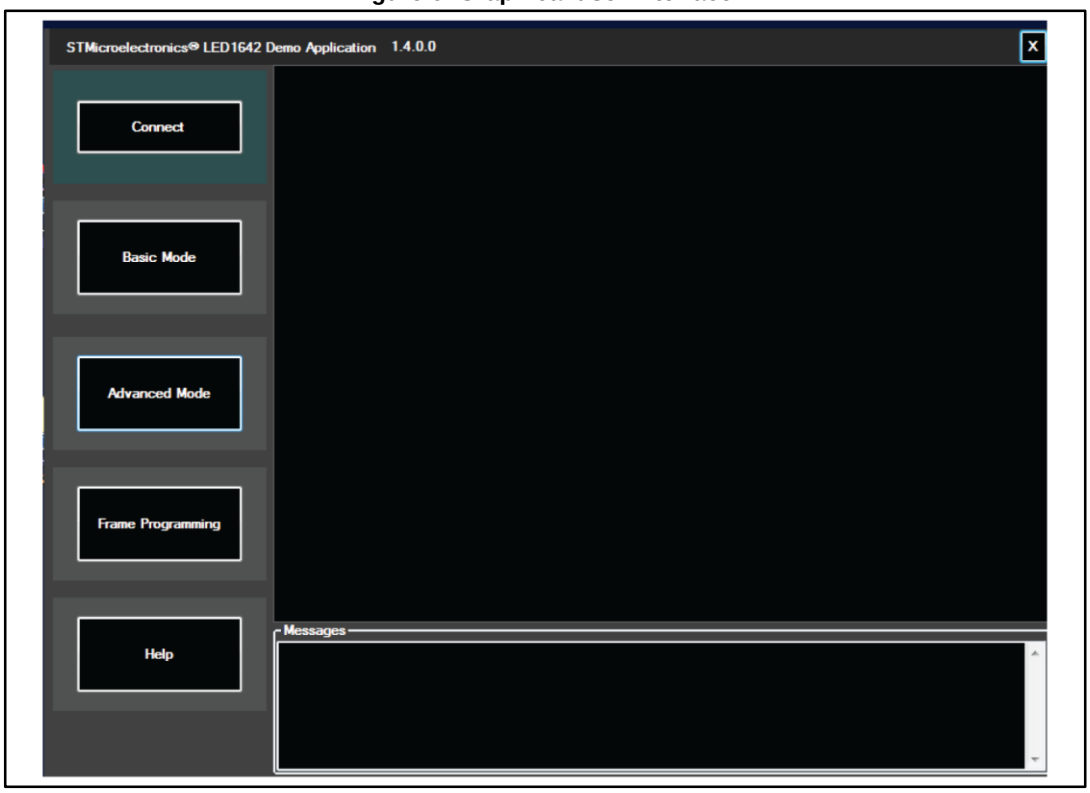


6 GUI mode

The STEVAL-ILL073V1 GUI has the following modes, as well as a help section:

- Basic mode
- Advanced mode
- Frame programming mode

Figure 6: Graphical user interface



The main features of the GUI mode are:

- Replication of on-board control buttons for mode selection from the GUI
- Option to select type and frequency of error detection and signaling on 4x4 LED (mapped to 4x4 LEDs on evaluation board) map
- Adjustable global brightness for all the channels
- Adjustable individual brightness 16 LEDs
- Bitwise access (read and write) of configuration register with a preconfigured default setting
- PWCLK reference clock control from 250 kHz to 12 MHz in 50 steps (frequency intervals are not equally spaced see *Section 6.3: "Advanced mode"*)
- Frame programming to display any arbitrary pattern consisting of up to 10 frames with variable transition speed
- 4 preconfigured patterns for quick visualization of frame programming mode on the evaluation board

6.1 Graphical user interface setup

The Virtual Com Port driver from ST needs to be installed on your PC/laptop in order to use the STEVAL-ILL073V1 GUI.

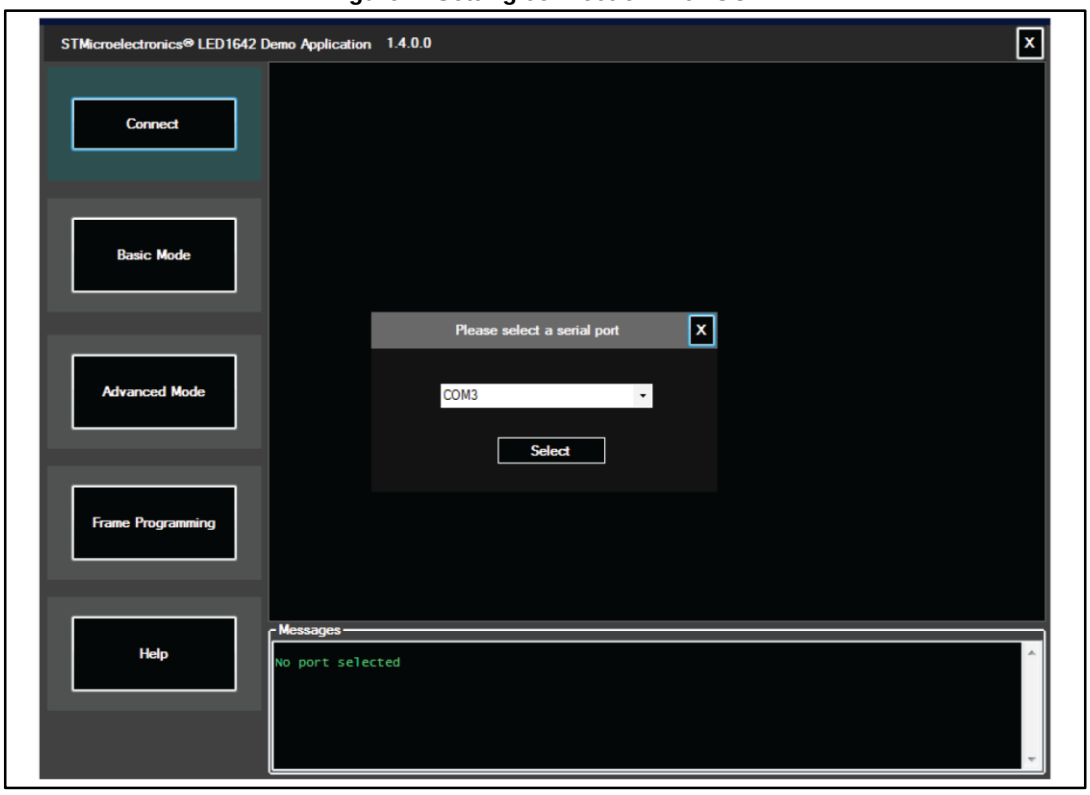
First install the setup (.exe) file on your Windows machine. The GUI appears as "ALED1642 Demo" in programs list. If not already installed, install the VCP driver from …\\Program Files\\ STMicroelectronics\\LED1642Demo\\ST VCP Driver. Both 32-bit version and 64-bit versions are included in the setup.

Launch the GUI; the page shown in *Figure 17: "STEVAL-ILL073V1 evaluation board thermal image"* appears. Then connect the evaluation board to the PC and power it up. After the start sequence, the evaluation board displays a "U" in green (see *Figure 5: "Flow chart"*).

Now press "Connect".

If the GUI identifies the board, it automatically establishes connection, otherwise it prompts the user to select the port where the board is connected, as shown in figure below. Choose the port manually and press "Select". When the GUI is able to interact with the board, the "Port is open" message appears.

Figure 7: Setting connection with GUI



To use the GUI, your Windows machine should have the virtual COM port driver installed. In the picture above, COM3 is given as an example. On connecting the USB to the PC, VCOM is established on an arbitrary port, which has to be identified manually if the GUI doesn't recognize the board automatically.

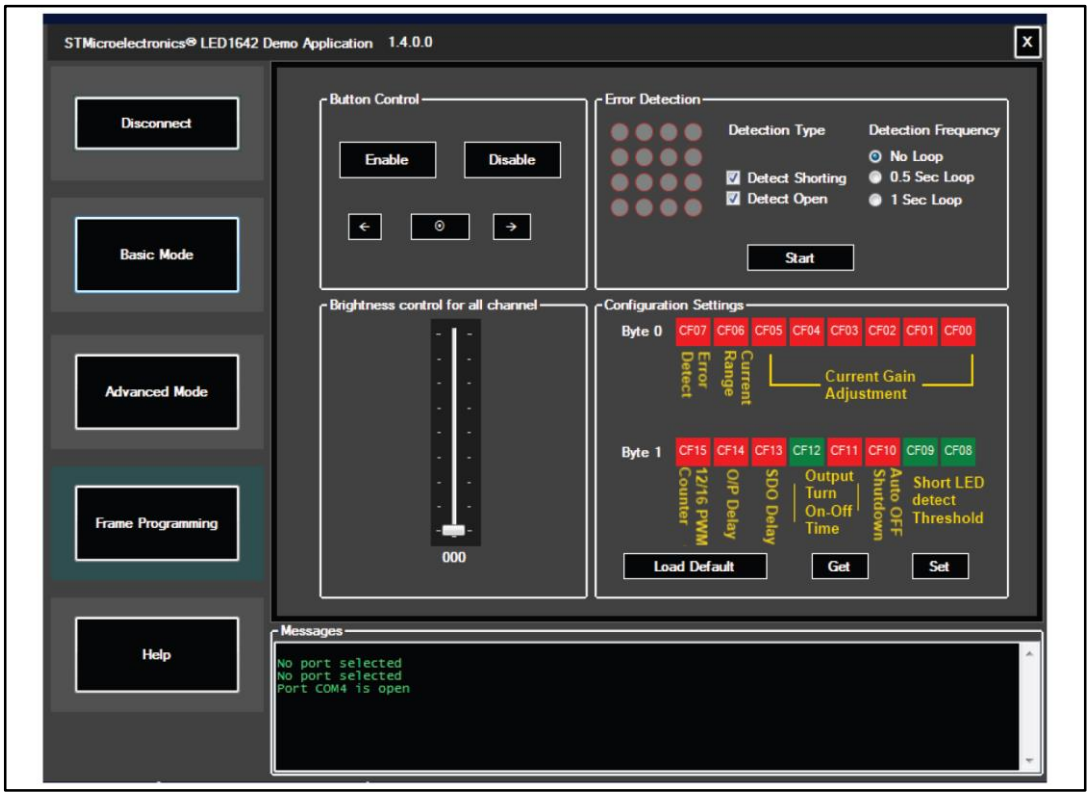
6.2 Basic Mode

Basic mode has the following sections:

- Button control
- Error detection
- Brightness control for all channels

- Configuration of settings

Figure 8: GUI basic mode



6.2.1 Button control

In GUI mode, the buttons in this section toggle between the preconfigured demos; these bottons represent the on-board BAK, SEL and FWD buttons.

By default, the GUI disables the on-board buttons, but they can be enabled or disabled manually by pressing Enable or Disable buttons, respectively.

6.2.2 Error detection

The error detection section signals any errors in the LEDs on the 4x4 LED matrix. Error detection frequency can be selected from three options:

- No loop (Error detection is performed once and the results are displayed),
- 0.5 second loop (error detection is performed every 0.5s by the drivers and the results get update in real time)
- similar 1 second loop.

The error type can be chosen by checking the appropriate box. Check both boxes for combined error detection; uncheck both boxes to disable error detection.

6.2.3 Brightness control for all channel

The brightness of all the channels is simultaneously varied by moving the all-channel slider control. Brightness can be varied in 256 steps (0% to 100%) using the slider.

6.2.4 Configuration settings

The configuration settings section represents a 16-bit configuration register for the ALED1642GW driver. You can set/reset bits by clicking on them.

- The Load Default button loads the default value of setting on the GUI
- The Set button configures the drivers for the value shown on the GUI
- The Get button reads the configuration register value from the driver

All three drivers always have the same configuration register value.

6.3 Advanced mode

Advanced mode has two sections: Channel Brightness Control for individual adjustment of each LED brightness and PWCLK slider to control the reference PWCLK clock.

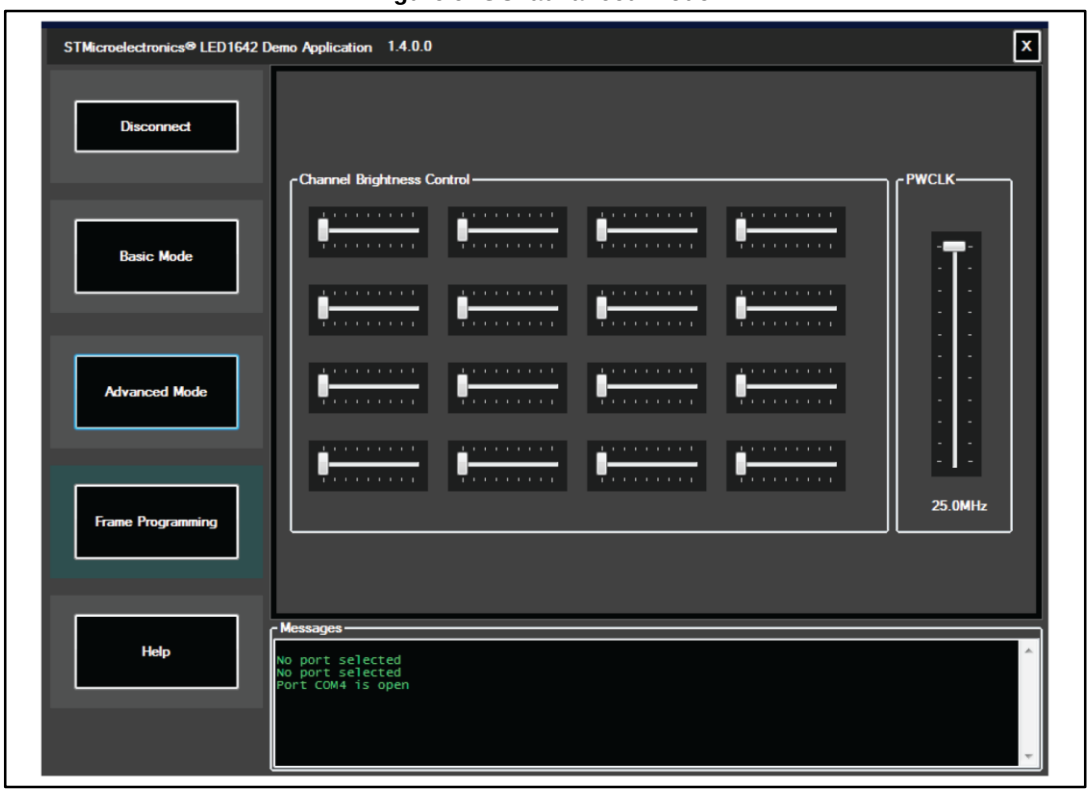
Similar to the overall brightness control in basic mode (see *Section 6.2.3: "Brightness control for all channel"*), a brightness control slider is available for each LED here.

Thye PWCLK slider controls the reference clock from 250 kHz to 12 MHz in 50 steps according to the formula:

PWCLK frequency = SYSTEM CLOCK / 1 + (101 - 2 * PWCLK slider)

where, SYSTEM clock is equal to 24 MHz and the initial value of PWCLK frequency is 12 MHz.

Figure 9: GUI advanced mode

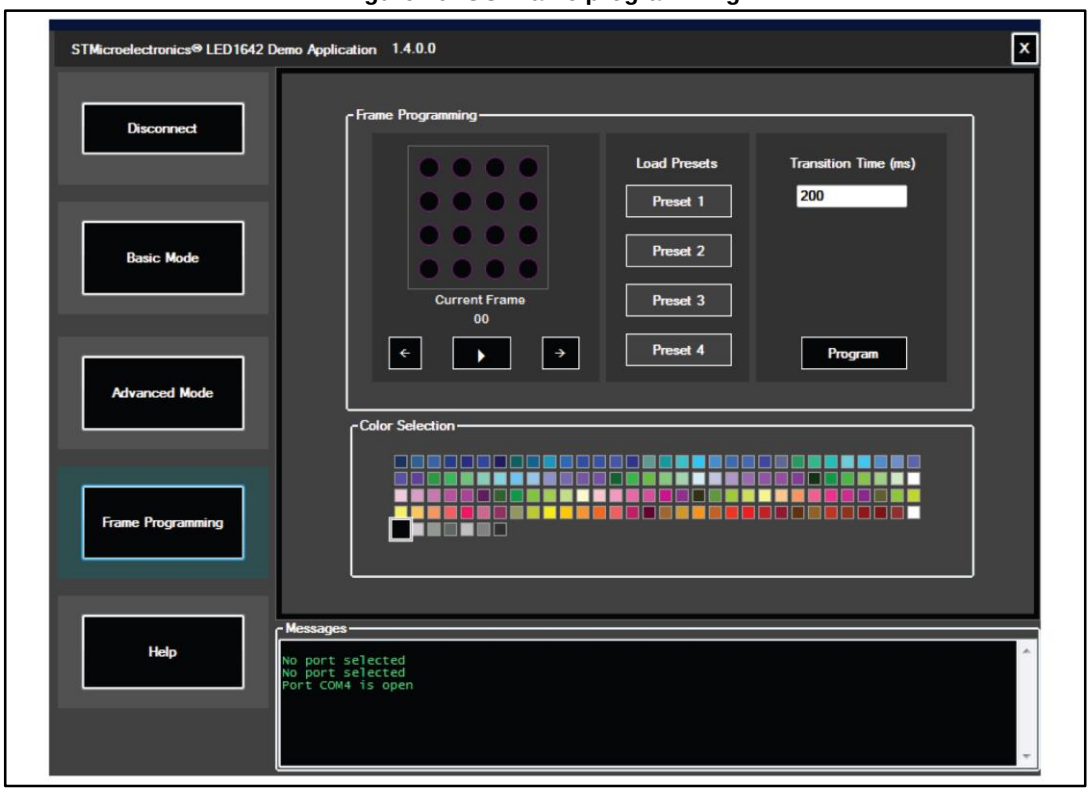


6.4 Frame programming

Frame programming manages user-defined RGB round robin sequence patterns on the evaluation board. This mode contains a set of 10 independent frames and each frame represents one LED color sequence on the board.

In this mode, the frames can be set by the user or preconfigured patterns can be selected using Presets. The approximate transition time between the frames (in milliseconds) is set by the value in the Transition Time text box.

Figure 10: GUI frame programming



For frame programming, the RGB color levels are rendered directly from the color selected in GUI, actual perception might be different compared to the selection because of different luminous intensity of red, green and blue channels. Fine tuning might be required for proper visualization.

6.4.1 Designing of frames

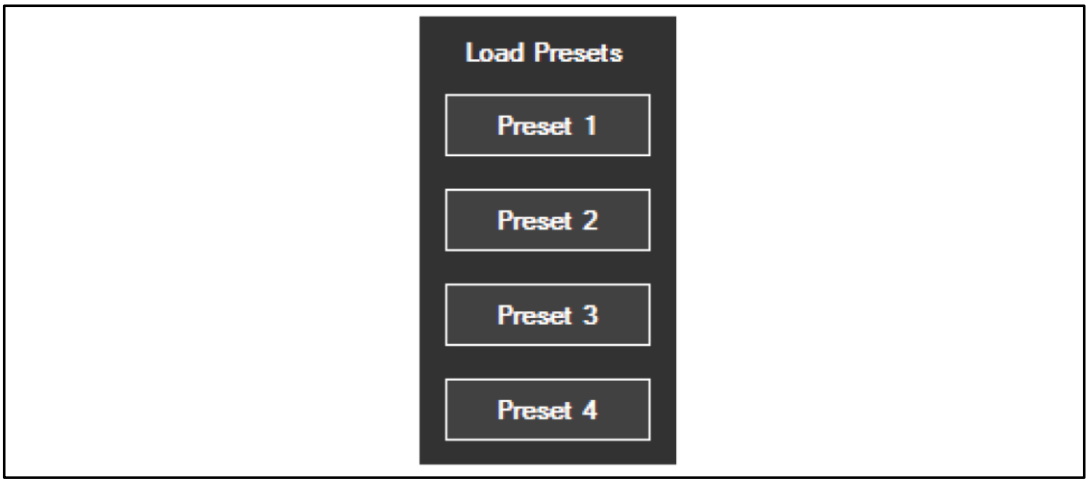
A frame on the GUI represents LEDs on the evaluation board. Each LED representation is configurable for various RGB color values given in the Color Selection pane. Below are the steps for designing the frames and displaying them on the evaluation board:

- Choose a color from the pane and click on the LEDs to configure them for the selected color
- There can be maximum of 10 frames (00 to 09), the right arrow button increments the frame number and left arrow button decrements it
- Each frame is designed separately for the required color pattern in a similar way
- The Play button plays the sequence of frames in the GUI to visualize the whole pattern to be displayed on the board
- Set required transition time between the frames and press "Program"

6.4.2 Using preconfigured frame pattern

In frame programming mode, four "Preset" frame patterns are provided for quick demonstration of this feature.

Figure 11: Load preconfigured frame patterns



Preset1, Preset2, Preset3 and Preset4 can be loaded by clicking on the corresponding preset button. The figures below show the frame configurations in different presets. Choosing any one of them configures frames as shown below:

Figure 12: Preset 1

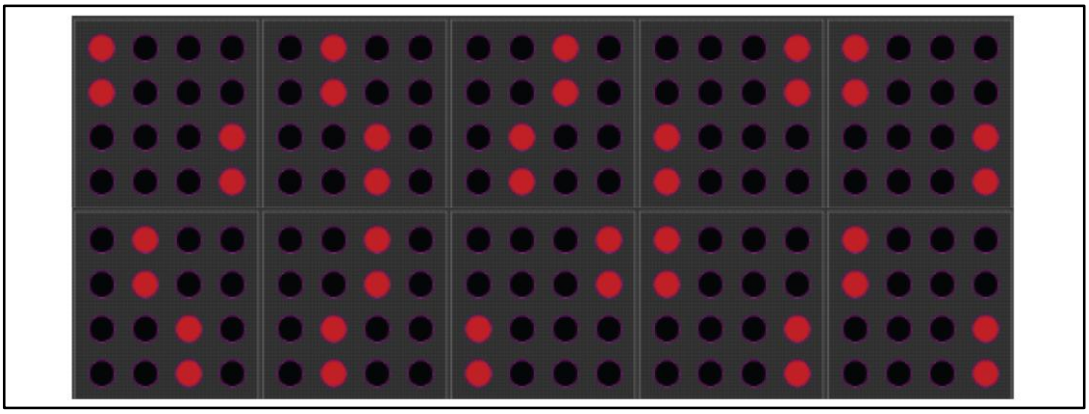


Figure 13: Preset 2

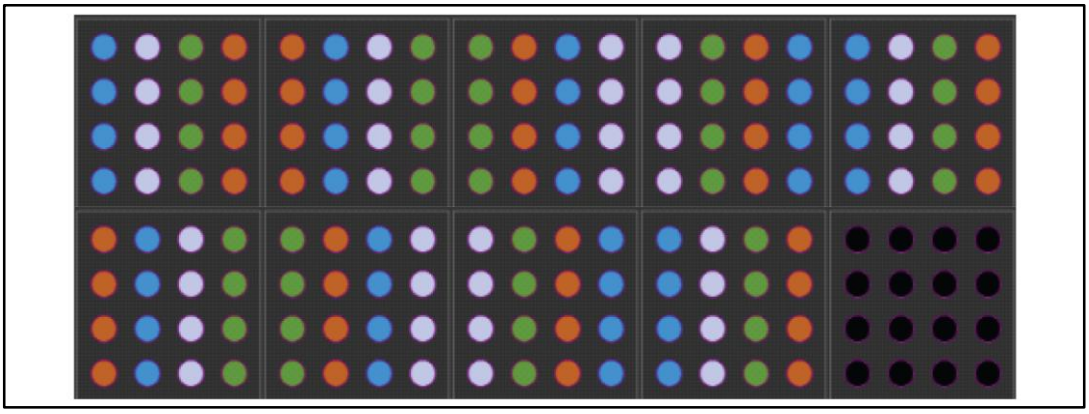


Figure 14: Preset 3

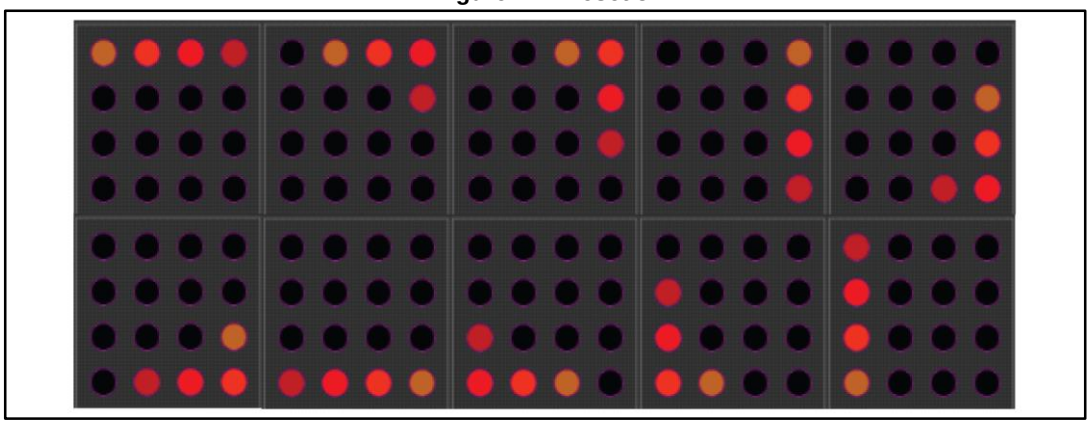
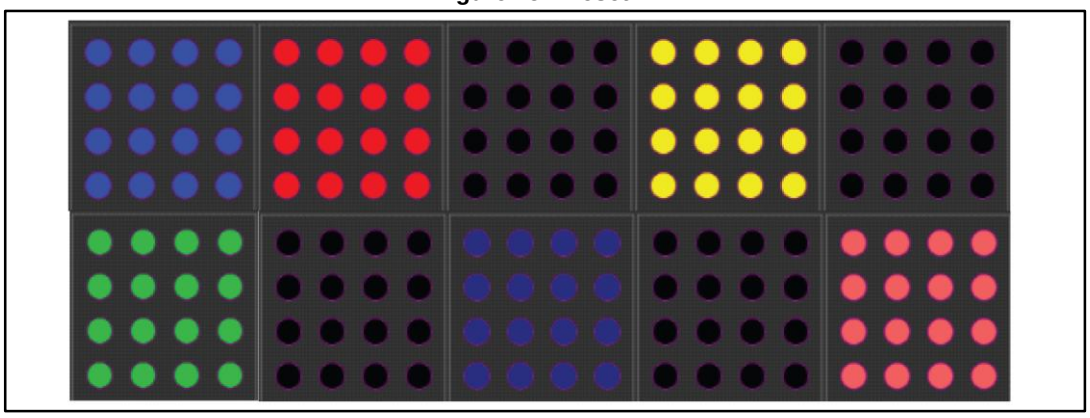


Figure 15: Preset 4



7 Thermal behavior

The ALED1642GW is available in a TSSOP24-EP package, with 37.5 °C/W thermal resistance. The average forward voltage drop of red, green and blue channels are 2, 3.2 and 3.2 V respectively. The maximum channel current is configured for 24 mA. Red channels have series resistance of 27E for limited dissipation in the red channel driver because forward voltage drop of red channel is less than that of blue channel of green channel driver. The evaluation board and the corresponding thermal image at the maximum current in all the channels (TSSOP24-EP package is mounted on the evaluation board) are shown below.

Figure 16: STEVAL-ILL073V1 evaluation board

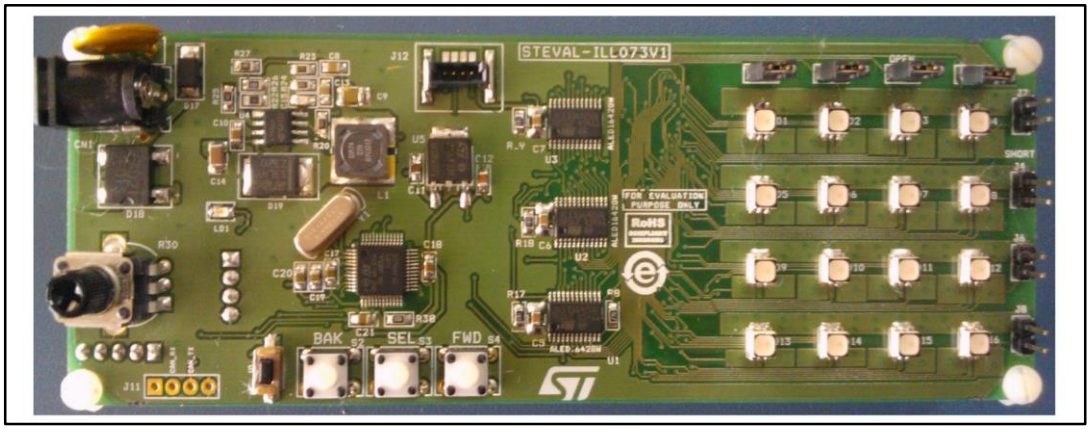
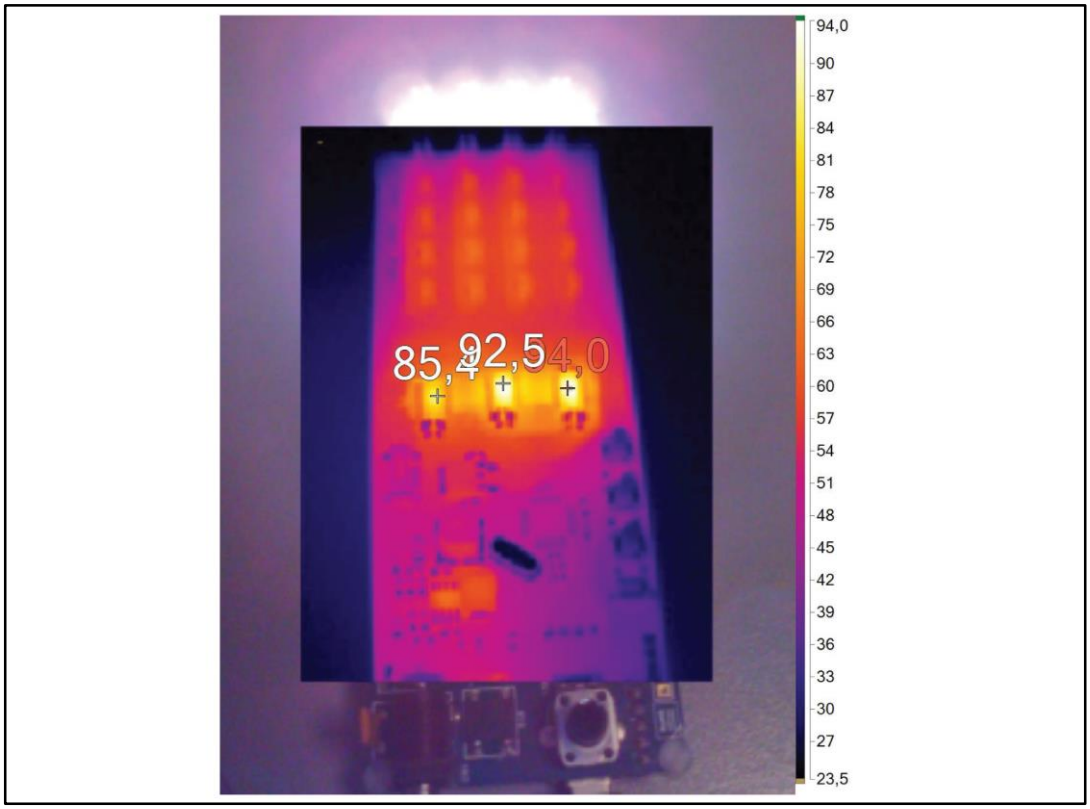


Figure 17: STEVAL-ILL073V1 evaluation board thermal image



8 Schematic diagram

Figure 18: STEVAL-ILL073V1 circuit schematic (1/9)

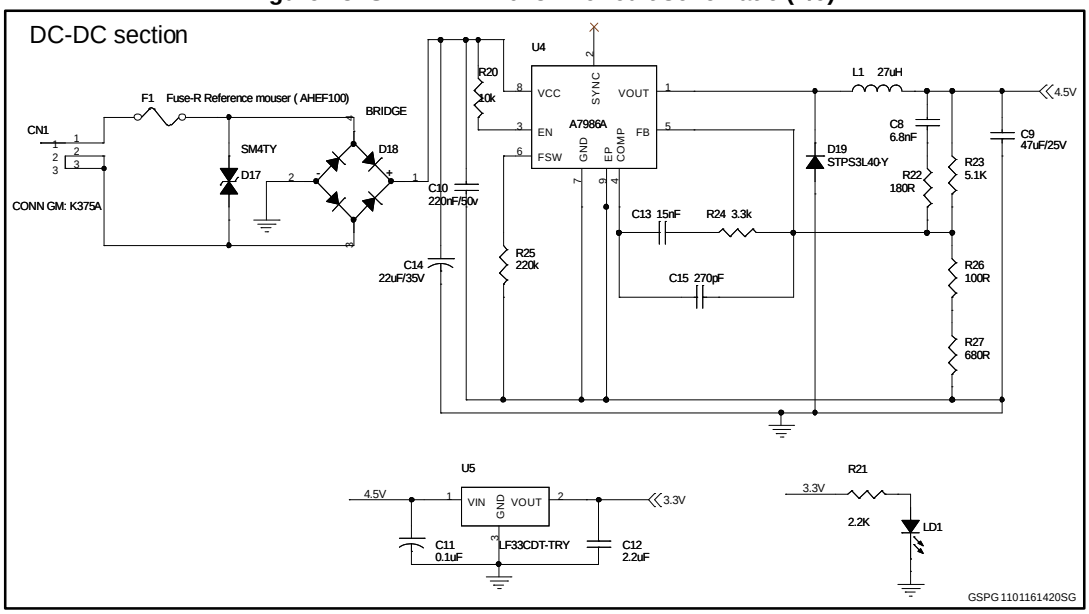


Figure 19: STEVAL-ILL073V1 circuit schematic (2/9)

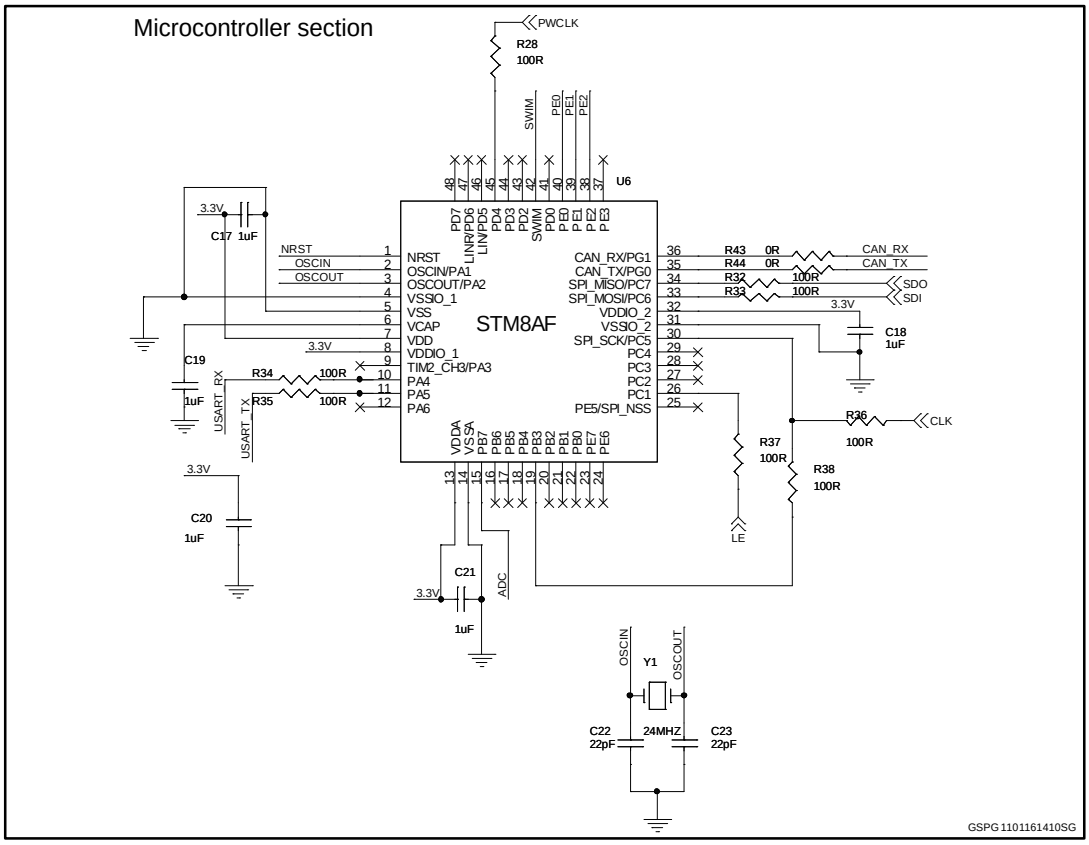


Figure 20: STEVAL-ILL073V1 circuit schematic (3/9)

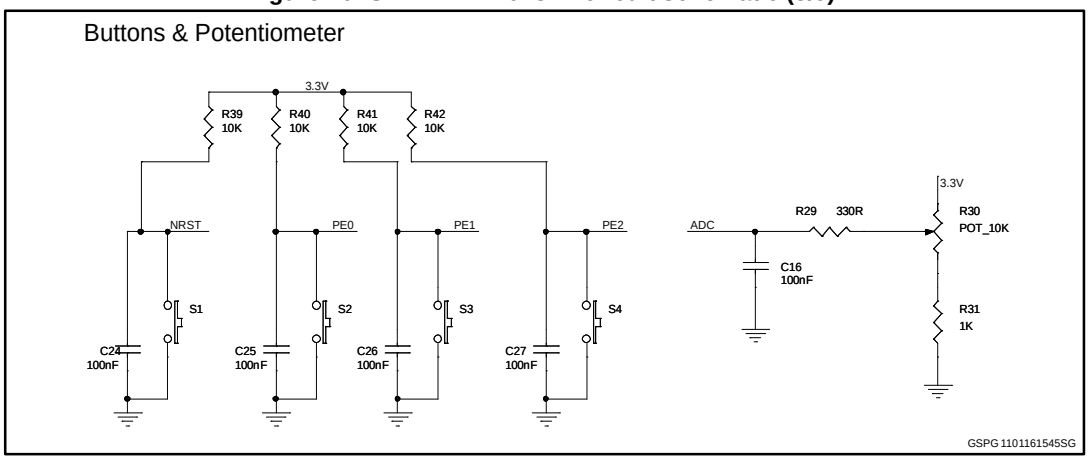


Figure 21: STEVAL-ILL073V1 circuit schematic (4/9)

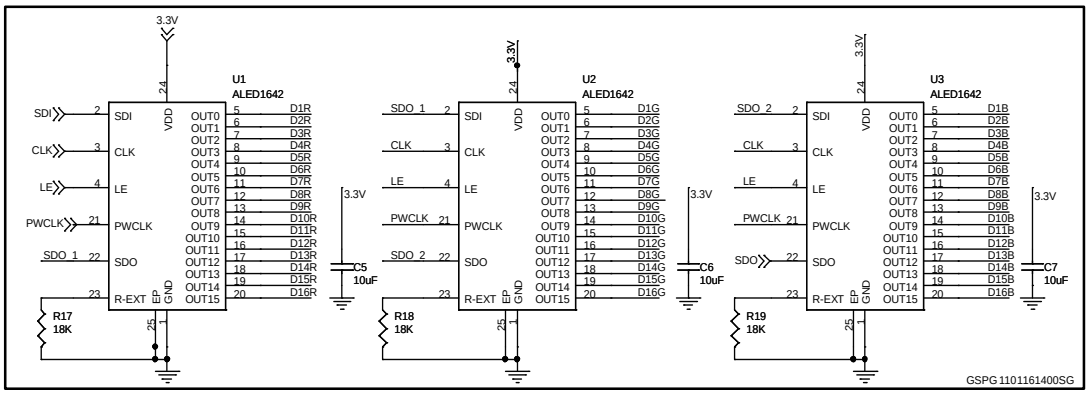


Figure 22: STEVAL-ILL073V1 circuit schematic (5/9)

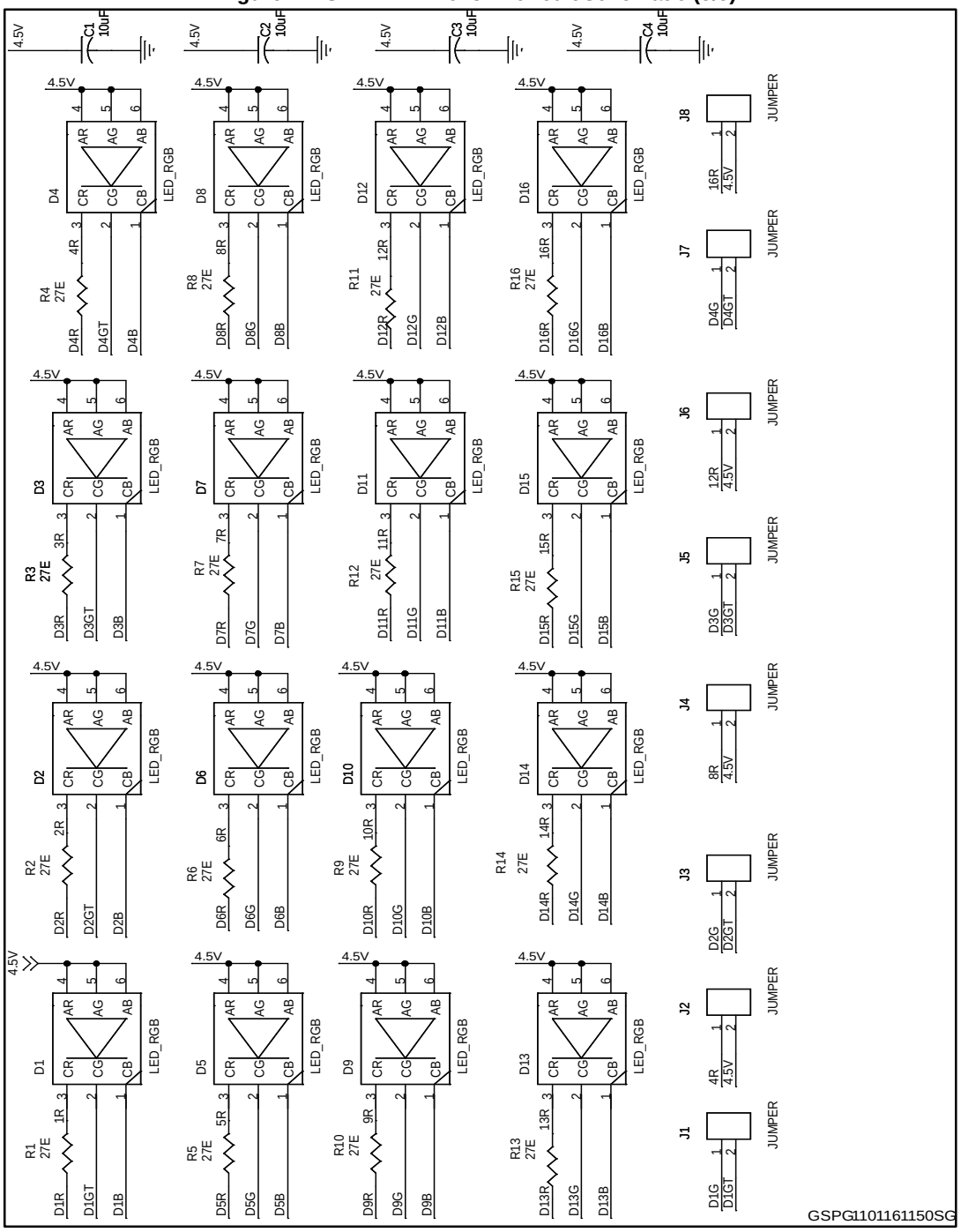


Figure 23: STEVAL-ILL073V1 circuit schematic (6/9)

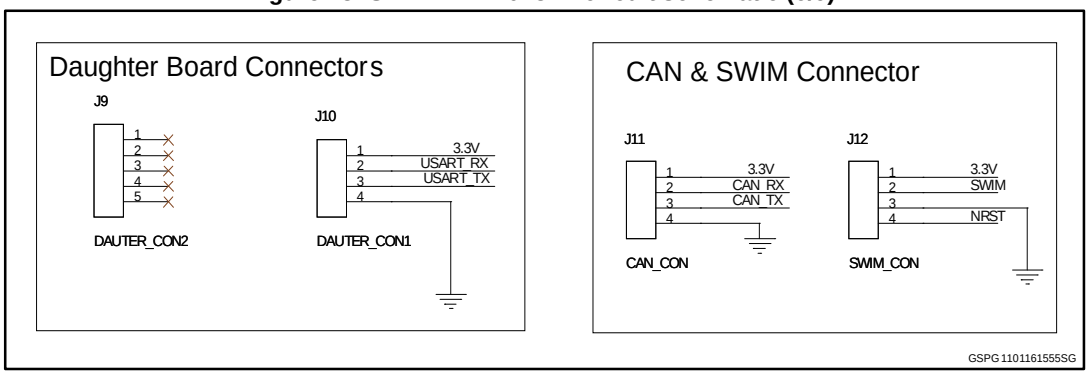


Figure 24: STEVAL-ILL073V1 circuit schematic (7/9)

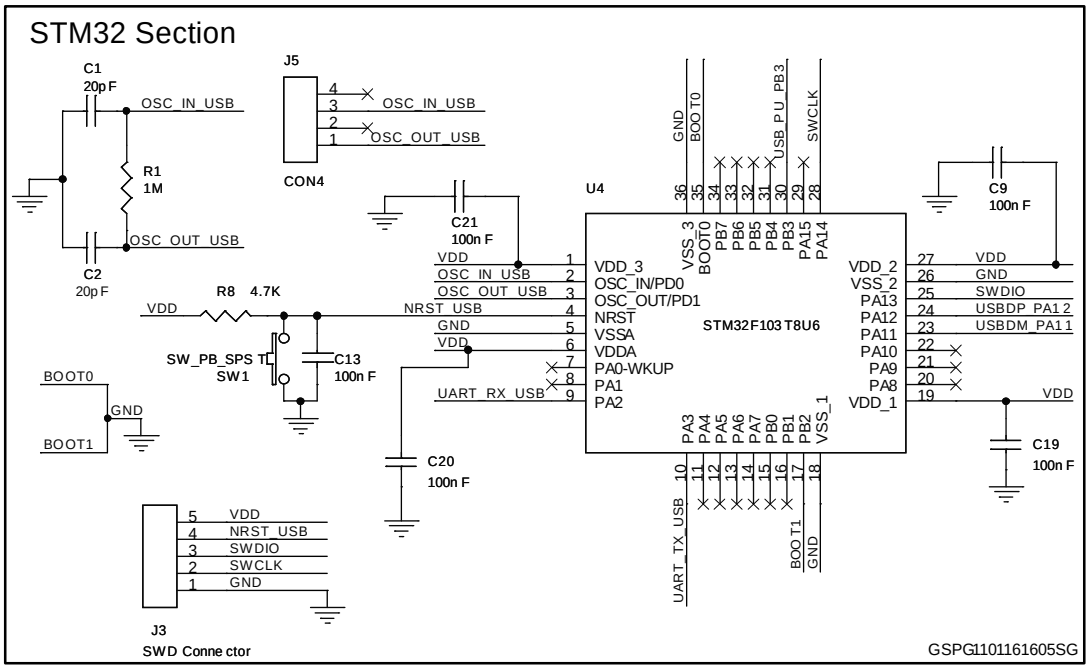


Figure 25: STEVAL-ILL073V1 circuit schematic (8/9)

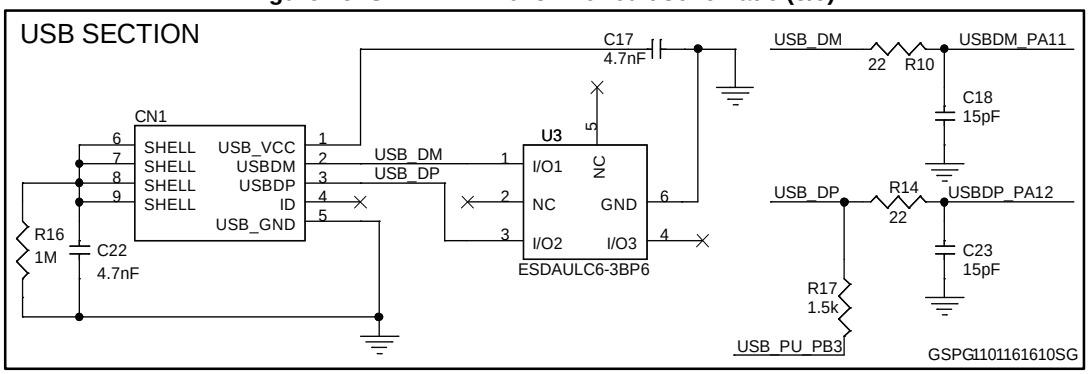
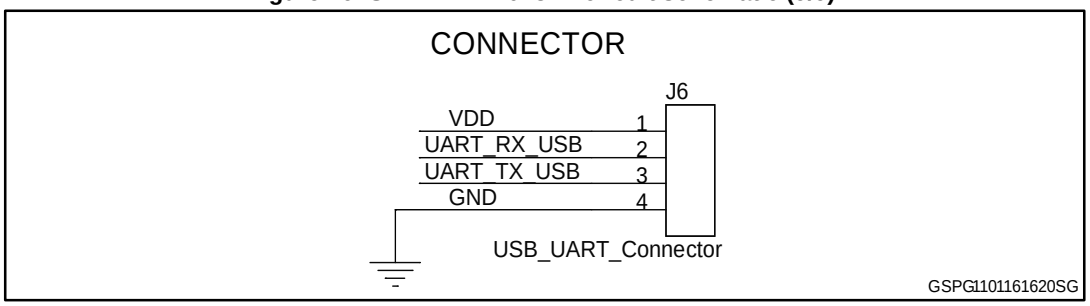


Figure 26: STEVAL-ILL073V1 circuit schematic (9/9)



9 Bill of materials

Table 2: List of external components

Item	Qty	Reference	Value	Description	Part number	Manufacturer
1	1	CN1	Power Jack		PJ1-021 or equivalent	CUI
2	7	C1, C2, C3, C4, C5, C6, C7	10 µF	CERAMIC X7R	C1206C106K4PACTU	Kemet
3	1	C8	6.8 nF	CERAMIC X7R	GRM2195C1H682JA01D	Murata
4	1	C9	47 µF	CERAMIC X5R	C3216X5R1E476M160AC	TDK
5	1	C10	220 nF	CERAMIC X7R	UMK212B7224KG-T	Taiyo Yuden
6	6	C11, C16, C24, C25, C26, C27	100 nF	CERAMIC X7R	C0805C104K5RAC7210	Kemet
7	1	C12	2.2 µF	CERAMIC X7R	C2012X7R1C225M125AB	TDK
8	1	C13	15 nF	CERAMIC X7R	GRM2195C1H153JA01D	Murata
9	1	C14	22 µF	JB	C3216JB1V226M160AC	TDK
10	1	C15	270 pF	CERAMIC X7R	C0805C271J5GACTU	Kemet
11	5	C17, C18, C19, C20, C21	1 µF	CERAMIC X7R	C2012X7R1C105M085AC	TDK
12	2	C22, C23	22 pF	CERAMIC X7R	C0805C220J5GACTU	Kemet
13	16	D1, D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12, D13, D14, D15, D16	LED_RGB		CLX6A-FKB-CJNNRFJBB7A363	CREE
14	1	D17	SM4TY		SM4T33CAY	ST
15	1	D18	DIODE_BRIDGE		DF01S	Fairchild
16	1	D19	STPS3L40-Y		STPS3L40SY	ST
17	1	F1	FUSE-R		RXEF110	TE Connectivity
18	8	J1, J2, J3, J4, J5, J6, J7, J8	JUMPER	Male	77311-101-14LF or equivalent	FCI
19	1	J9	CON	Female	77311-101-14LF or equivalent	FCI
20	1	J10	CON	Female	77311-101-14LF or equivalent	FCI
21	1	J11	CON	Male	77311-101-14LF or equivalent	FCI
22	1	J12	CON	SWIM	284697	ERNI
23	1	LD1	LED	Red	LTST-C170KRKT	Lite-On Inc
24	1	L1	22 µH		22R223MC	Murata

Item	Qty	Reference	Value	Description	Part number	Manufacturer
25	16	R1, R2, R3, R4, R5, R6, R7, R8, R9, R10, R11, R12, R13, R14, R15, R16	27 R	Thick film	ERJ-6ENF27R0V	Panasonic
26	3	R17,R18,R19	18 K	Thick film	ERJ-6ENF1802V	Panasonic
27	5	R20, R39, R40, R41, R42	10 K	Thick film	ERJ-6ENF1002V	Panasonic
28	1	R21	2.2 K	Thick film	ERJ-6ENF2201V	Panasonic
29	1	R22	180 R	Thick film	ERJ-6ENF1800V	Panasonic
30	1	R23	5.1 K	Thick film	ERJ-6ENF5101V	Panasonic
31	1	R24	3.3 K	Thick film	ERJ-6ENF3301V	Panasonic
32	1	R25	220 K	Thick film	ERJ-6ENF2203V	Panasonic
33	9	R26, R28, R32, R33, R34, R35, R36, R37, R38	100 R	Thick film	ERJ-6ENF1000V	Panasonic
34	1	R27	680 R	Thick film	ERJ-6ENF6800V	Panasonic
35	1	R29	330 R	Thick film	ERJ-6ENF3300V	Panasonic
36	1	R30	POT_10 K		RK09K1130A70	Alps
37	1	R31	1 K	Thick film	ERJ-6ENF1001V	Panasonic
38	2	R43, R44	0 R	Thick film	ERJ-6GEY0R00V	Panasonic
39	1	S1	Push button		DTSM-32S-B	Multicomp
40	3	S2, S3, S4	Tactile switch	4 pin	611-PTS645SM952	C&K
41	3	U1, U2, U3	ALED1642GW	LED driver	ALED1642GWXTTR	ST
42	1	U4	A7986A	DC-DC	A7986A	ST
43	1	U5	LF33CDT-TRY	LDO	LF33CDT-TRY	ST
44	1	U6	STM8AF5268	Microcontroller	STM8AF5268T	ST
45	1	Y1	24 MHz	Crystal	ATS24A-E	CTS Electronic
46	2	C1, C2	20 pF	CERAMIC X7R	C1005C0G1H200J	TDK
47	5	C9, C13, C19, C20, C21	100 nF	CERAMIC X7R	C1005X5R1A104K	TDK
48	2	C17, C22	4.7 nF	CERAMIC X7R	C1005X7R1E472K	TDK
49	2	C18, C23	15 pF	CERAMIC X7R	C1005C0G1H150J	TDK
50	1	CN1	USB-Mini B		MUSB-05-S-B-SM-A	Samtec Inc
51	1	J3	CON	Male	77311-101-14LF or equivalent	FCI
52	1	J5	Crystal		ABM10-16.000MHZ-E20-T	Abracon

Item	Qty	Reference	Value	Description	Part number	Manufacturer
53	1	J6	CON	Male	77311-101-14LF or equivalent	FCI
54	2	R1, R16	1 M	Thin film	MCS04020C1004FE000	Vishay
55	1	R8	4.7 K	Thin film	ERA-2AEB472X	Panasonic
56	2	R10, R14	22 R	Thin film	ERA-2AKD220X	Panasonic
57	1	R17	1.5 K	Thin film	ERA-2AED152X	Panasonic
58	1	SW1	SPST			
59	1	U3	ESDAULC6-3BP6	USB protection	ESDAULC6-3BP6	ST
60	1	U4	STM32F103T8U6	Microcontroller	STM32F103T8U6	ST

10 Revision history

Table 3: Document revision history

Date	Revision	Changes
16-Feb-2016	1	Initial release.

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