UM1774
User manual

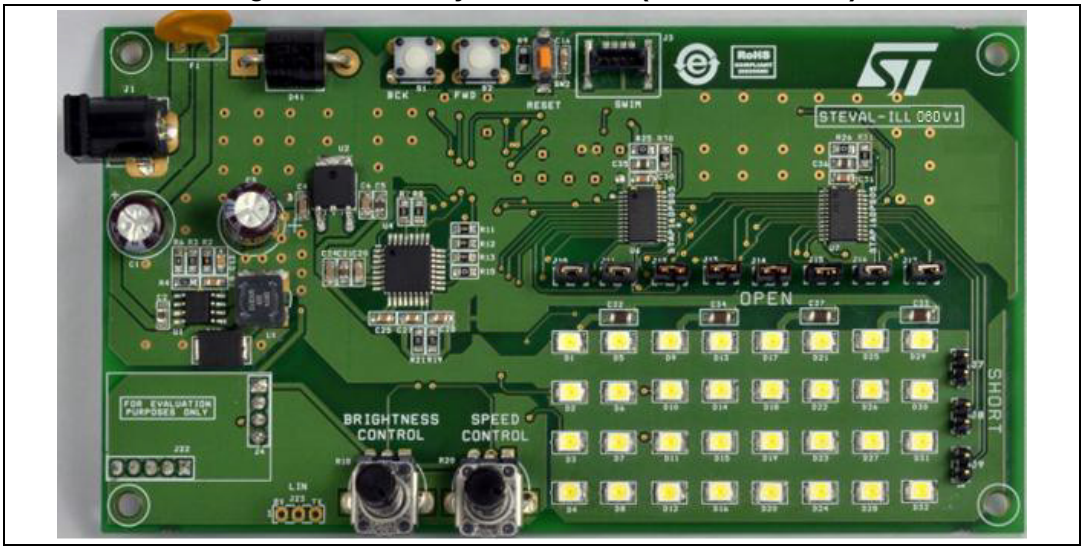
High brightness LED array driver with diagnostics for automotive applications based on STAP16DPPS05 and STM8A

Introduction

This user manual describes how to use the STEVAL-ILL060V1 high brightness LED array driver with diagnostics based on automotive grade low voltage 16-bit constant current LED sink driver STAP16DPPS05 from STMicroelectronics. The LED driver is configured and controlled through 8-bit automotive grade STM8AF6266 microcontroller via SPI interface. The automotive grade A5974D DC-DC converter provides the voltages/power for the overall functioning of the board.

This manual explains the operating procedures for the evaluation board, in terms of hardware setup, demonstration firmware functions, interconnection with PC, graphical user interface to show the driver's features and evaluation of the STAP16DPPS05.

Figure 1. LED array driver board (STAP16DPPS05)



This evaluation board can be used for demonstration purposes to show the LED driver features and also for user application development.

Software applications can be written, downloaded and debugged using on board SWIM connector.

Contents

1 Getting started 5

1.1 Package contents 5

1.2 Hardware description 5

1.2.1 Main board 5

1.2.2 Daughterboard 7

1.3 Block diagram of STAP16DPPS05 evaluation board 7

1.4 Modes of operation 8

2 Evaluation board function overview 9

2.1 Evaluation board controls 9

2.1.1 Power supply 9

2.1.2 Microcontroller SWIM 9

2.1.3 Jumpers for LED failure simulation 9

2.2 Board features 9

2.2.1 Features of evaluation board in stand-alone mode 9

2.2.2 Features of evaluation board in GUI mode 9

2.3 Key devices on the evaluation board 10

2.4 Daughterboard 10

3 Stand-alone demonstration 11

3.1 Normal mode 11

3.2 Error detection mode 14

4 GUI demonstration 15

4.1 Graphical user interface setup 15

4.2 Basic mode 16

4.2.1 Button control 17

4.2.2 Error detection 17

4.2.3 Brightness control for all channel 17

4.3 Frame programming 17

4.3.1 Designing of frames 18

4.3.2 Using preconfigured frame pattern 18

5 Thermal behavior 21

6 Schematics 22

7 Bill of material 26

8 Revision history 27

List of figures

Figure 1. LED array driver board (STAP16DPPS05) . . . 1
Figure 2. Setup of the board (top) . . . 5
Figure 3. Setup of the board (bottom) . . . 6
Figure 4. USB-UART bridge (top) . . . 7
Figure 5. USB-UART bridge (bottom) . . . 7
Figure 6. Block diagram of STAP16DPPS05 evaluation board . . . 7
Figure 7. ST flashing mode . . . 12
Figure 8. Random pattern 1 . . . 12
Figure 9. Random pattern 2 . . . 12
Figure 10. Random pattern 3 . . . 13
Figure 11. Random pattern 4 . . . 13
Figure 12. All LEDs ON during curtain pattern . . . 13
Figure 13. Error detection mode . . . 14
Figure 14. Graphical user interface . . . 16
Figure 15. GUI basic mode . . . 16
Figure 16. Error representation in GUI . . . 17
Figure 17. GUI frame programming . . . 18
Figure 18. Preset buttons to load preconfigured frame patterns . . . 19
Figure 19. Preset 1 . . . 19
Figure 20. Preset 2 . . . 19
Figure 21. Preset 3 . . . 20
Figure 22. Preset 4 . . . 20
Figure 23. STEVAL-ILL060V1 . . . 21
Figure 24. STEVAL- ILL060V1 thermal image . . . 21
Figure 25. Power section . . . 22
Figure 26. Microcontroller . . . 22
Figure 27. LED drivers . . . 23
Figure 28. Connectors . . . 23
Figure 29. High brightness LEDs, open/short-circuit jumpers . . . 24
Figure 30. USB -UART connector: microcontroller section . . . 24
Figure 31. USB section . . . 24
Figure 32. USB-UART connector . . . 25
Figure 33. BOM (part 1) . . . 26
Figure 34. BOM (part 2) . . . 26

1 Getting started

1.1 Package contents

Board package consists of:

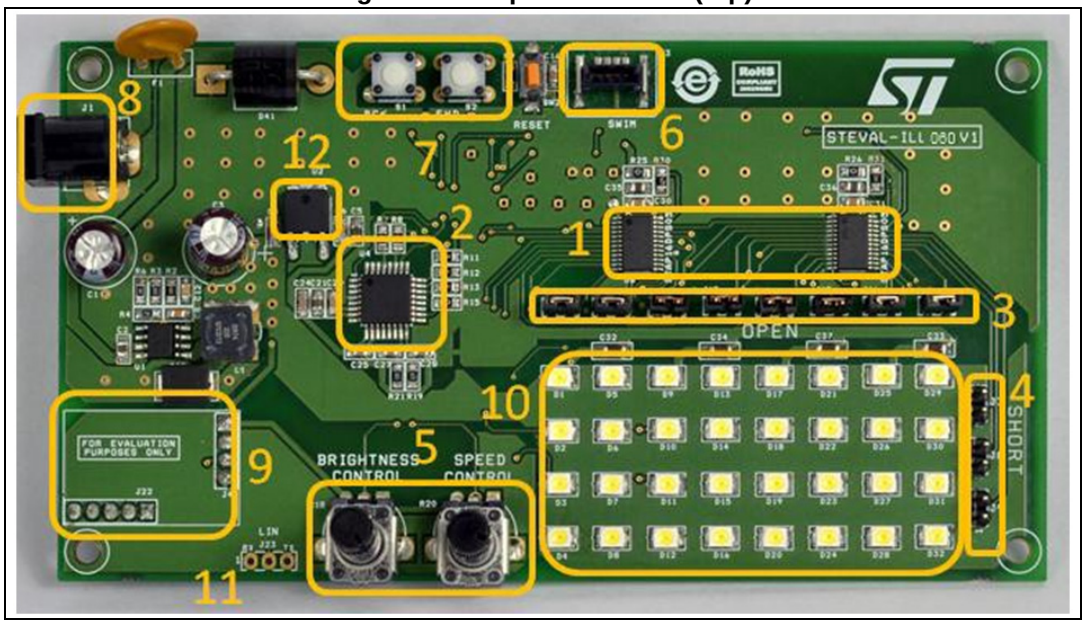
- Hardware: One evaluation board, One USB-UART bridge
- Software: graphical user interface
- Document: user manual

1.2 Hardware description

1.2.1 Main board

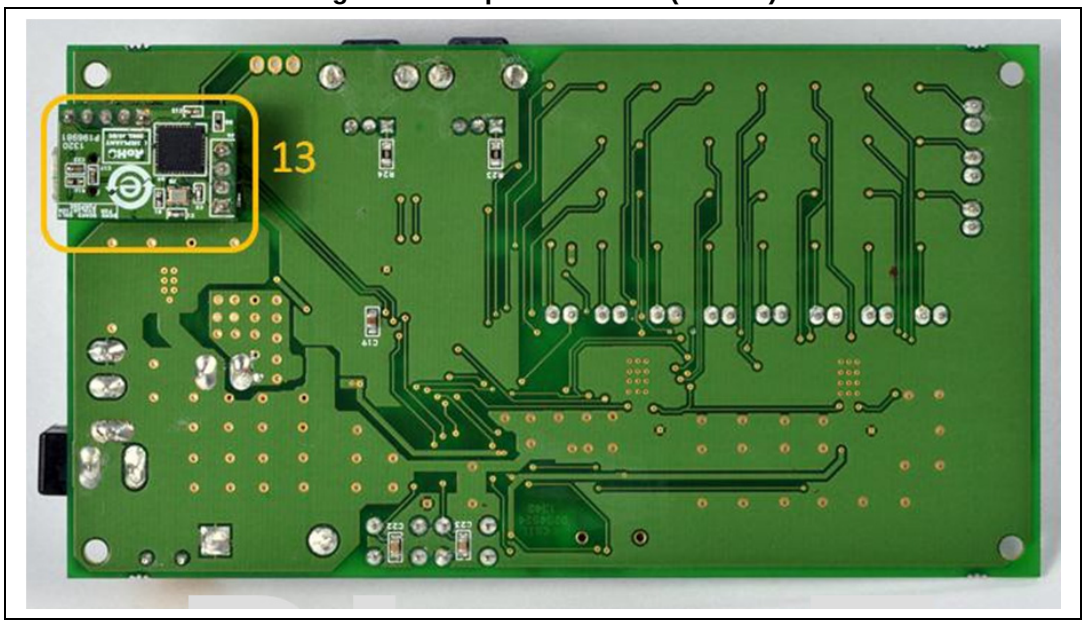
STAP16DPPS05 evaluation board has on board DC input power supply, 8-bit microcontroller, SWIM connector to program the microcontroller, 32 white LEDs and buttons and potentiometer to change modes and to control brightness and speed, two STAP16DPPS05 LED driver.

Figure 2. Setup of the board (top)



1. STAP16DPPS05 LED driver
2. STM8AF6266 microcontroller
3. Jumpers to simulate open-circuit error detection
4. Jumpers to simulate short-circuit error detection
5. Potentiometer to change brightness and speed
6. SWIM connector: to program microcontroller
7. Push buttons (BCK & FWD): to change different modes
8. DC supply connector: 6-24 V
9. USB-UART bridge: for interfacing board with GUI
10. 32 white LEDs (PLCC 4 ' package)
11. Connector for LIN development and evaluation
12. LF33CDT (low drop out regulator)

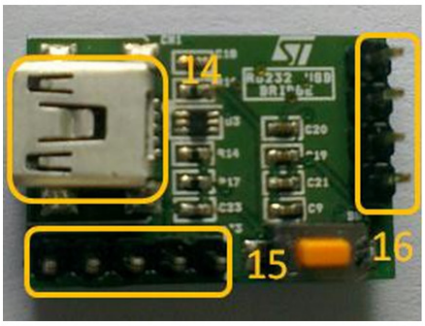
Figure 3. Setup of the board (bottom)



13. Daughterboard (USB-UART bridge connector)

1.2.2 Daughterboard

Figure 4. USB-UART bridge (top)



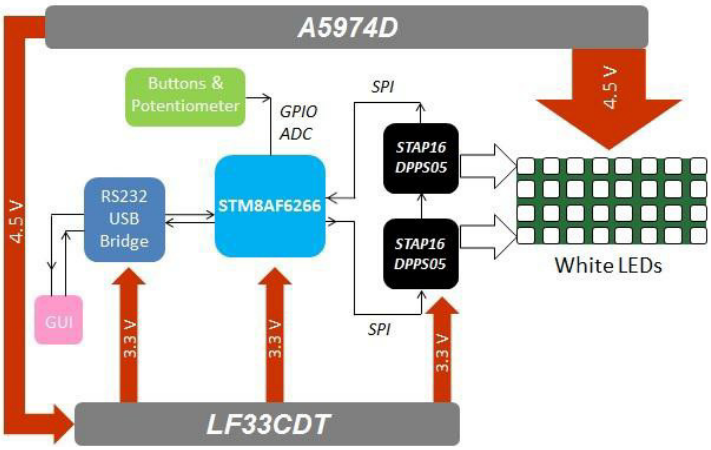
14. USB connector
15. SWD connector (for programming daughter card)
16. UART connector

Figure 5. USB-UART bridge (bottom)

17. STM32F103xx microcontroller

1.3 Block diagram of STAP16DPPS05 evaluation board

Figure 6. Block diagram of STAP16DPPS05 evaluation board



1.4 Modes of operation

The evaluation board has two modes of operation:

- Stand-alone mode: In this mode, the board is controlled via on-board push buttons and potentiometer
- GUI mode: If connected to PC, board is in GUI mode and GUI has the control of board

2 Evaluation board function overview

2.1 Evaluation board controls

2.1.1 Power supply

The evaluation board is powered by standard 6 to 24 V DC adapter. The power source must be able to deliver sufficient current depending on the input voltage for the proper functioning. Reverse voltage protection and input surge protection is provided to avoid any damage because of improper handling on the input.

2.1.2 Microcontroller SWIM

The board is equipped with a standard 4-pin SWIM connector allowing to debug and develop the STM8AF6266 microcontroller firmware.

2.1.3 Jumpers for LED failure simulation

LED defects can be simulated by using J6 to J17 jumpers:

- J10-J17 is used to demonstrate open-circuit error detection of LEDs (D4, D8, D12, D16, D20, D24, D28, D32).
- J7-J9 is used to demonstrate short-circuit error detection of LEDs (D30-D32, refer to *Section 4.3*).

These simulated defects can be detected during the activation of the error detection mode (see *Section 3.2*). The defective LED is highlighted by switching on another LED in stand-alone mode (see mapping table) and by flashing corresponding circle in LED map in GUI mode.

2.2 Board features

2.2.1 Features of evaluation board in stand-alone mode

- Demonstrates pre-configured patterns (with adjustable brightness/speed) like rolling text, wave effect, dot sequence, etc.
- On-board buttons to switch between the demos.
- Potentiometer as a slider to control speed or brightness of the pattern.
- Open-circuit, short-circuit using open-circuit/short-circuit jumpers.

2.2.2 Features of evaluation board in GUI mode

- All the features present in stand-alone mode can be controlled using GUI.
- Global brightness control to change the brightness of all the channels.
- Frame programming mode and 4 predefined presets with variable transition time between frames.
- Open, short error detection and representation on GUI.
- Error detection in “no loop” and in loop of 0.5 s and 1 s.

2.3 Key devices on the evaluation board

The following are the major devices responsible for the board's functionality:

A5974D: An automotive grade step-down 250 kHz switching regulator with up to 2.5 A (internally limited) current to the load. Device accepts input voltage from 4 to 36 V. However, the specified input voltage to the board is 6 to 24 volts. It supports low dropout operation along with zero load current operation. Overcurrent and thermal protection are provided for safe operation of the device.

LF33C: An automotive grade fixed output 3.3 V, very low drop voltage regulator able to provide current up to 500 mA. It powers up all the devices as well as daughter card.

STM8AF6266: An automotive grade 8-bit microcontroller. It features 10 MIPS at 16 MHz fCPU, advance timers, LINUART, ADC, robust I/O's, nested interrupt controller and several other supporting features. It conforms to AEC-Q100 norms.

BZW50: A transient voltage surge suppressor (TVS) with fast response time. It provides high overvoltage protection by clamping. It is capable of dissipating up to 5000 W (10/1000 us) pulses

White LED: 32 white SMD LEDs are used. LEDs are mounted in 8x4 matrix on the board to display different patterns. Minimum luminous intensity of an LED is around 280 mcd with wide viewing angle of 120º.

2.4 Daughterboard

The STEVAL-ILL060V1 is available with daughterboard which enables it to communicate with the PC GUI via USB. The daughterboard acts as a bridge between PC and the main board.

The daughterboard supports full-duplex communication between USB and UART and derive power from the main board for its operation.It is mounted on the main board with the help of UART and SWD connectors.

3 Stand-alone demonstration

STAP16DPPS05 evaluation board while not connected to PC runs in stand-alone mode. The main features of the stand-alone mode are:

- Buttons for transition between different modes
- Speed and brightness control of the patterns
- Error detection to detect LED failure

Note: After DC input is applied, it starts with brief animation on 4x8 White LED matrix. User can have control over the board only after brief animation.

After brief animation LED matrix will show “ST” flashing. After which user can select different patterns and modes with the help of BCK and FWD button present on the board.

BCK Button: On pressing this button user will switch on to previous pattern or mode.

FWD Button: On pressing this button user will switch on to next pattern or mode. Following are the patterns and modes:

1. ST flashing pattern
2. Dot sequence pattern
3. ST rolling pattern
4. Wave or curtain pattern
5. Error detection mode
6. Random pattern
7. ST curtain pattern

User with the help of speed and brightness control potentiometer present on board can control the brightness of LEDs and speed between transitions.

Brightness and speed control: On rotating potentiometer clockwise brightness/speed between transition will increase and vise-versa.

Note: In ST flashing pattern user can control only speed.

3.1 Normal mode

All patterns which are mentioned above will be operating under normal mode. In this mode data to be displayed is sent to STAP16DPPS05 through SPI by microcontroller. And by using potentiometer user can change speed and brightness of the pattern.

Figure 7. ST flashing mode

Figure 8. Random pattern 1

Figure 9. Random pattern 2

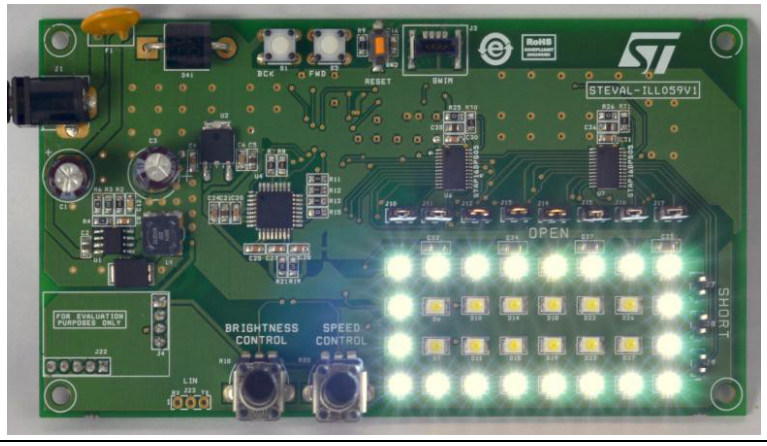


Figure 10. Random pattern 3

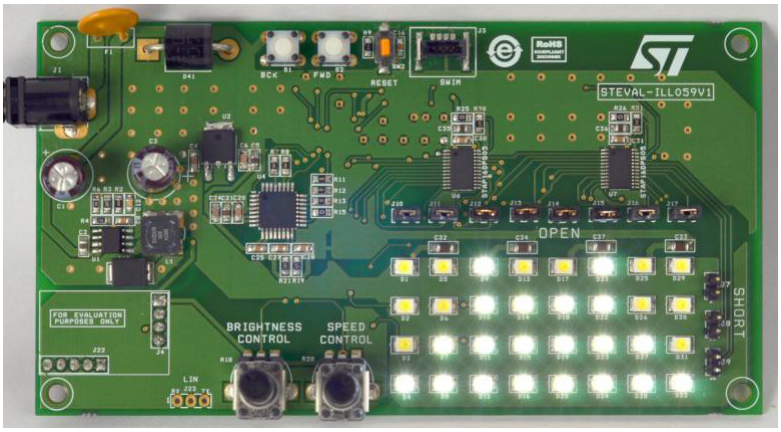


Figure 11. Random pattern 4

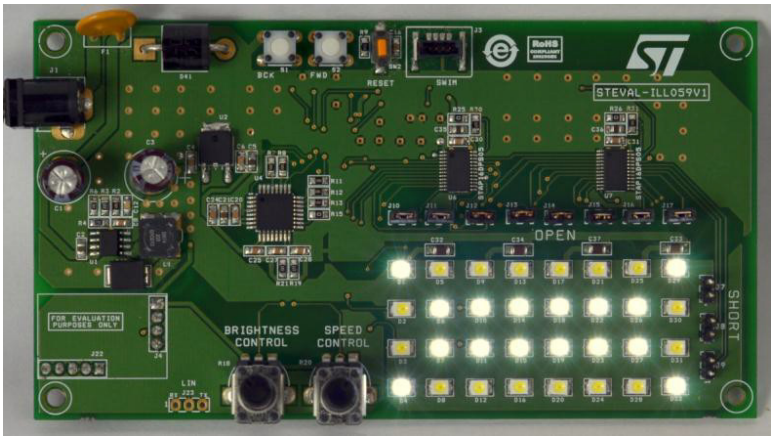
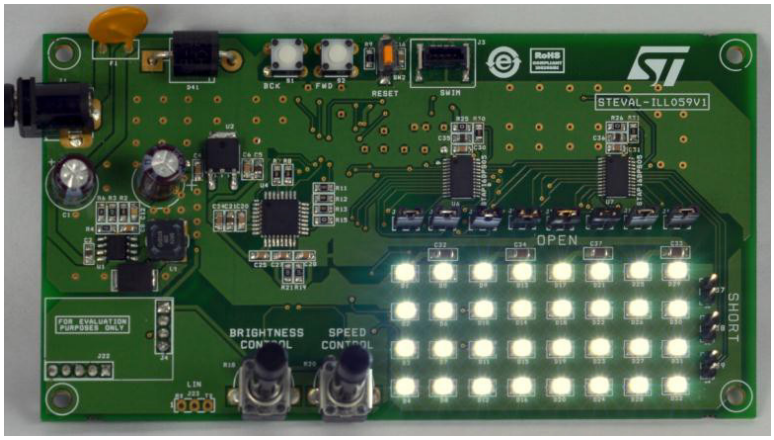


Figure 12. All LEDs ON during curtain pattern



3.2 Error detection mode

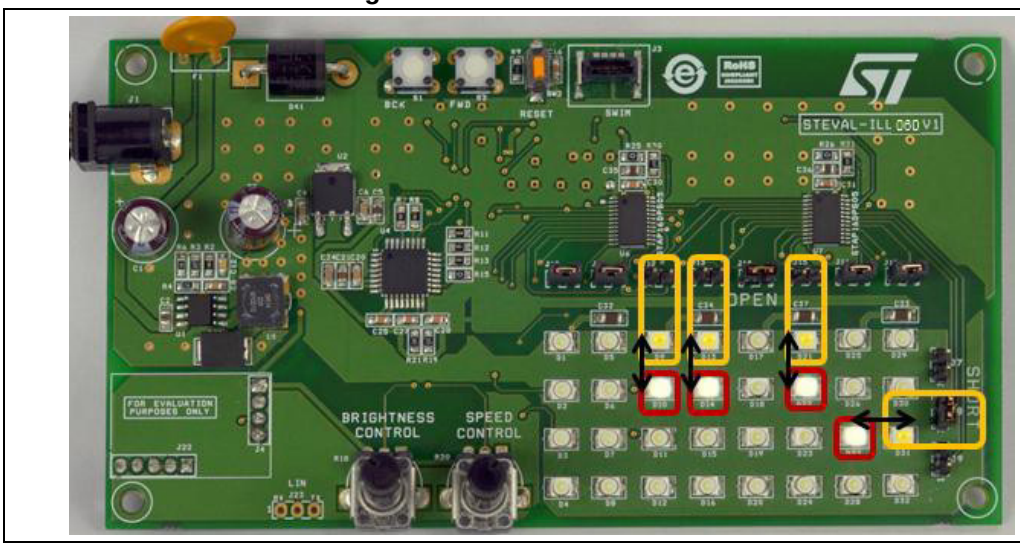
STAP16DPPS05 driver is capable of error detection, such as open-circuit and short-circuit. Evaluation board provides the option to simulate and detect these errors. In this mode drivers perform open-circuit and short-circuit error detection and display the error. If a defective LED is found, it is signaled by switching on the adjacent LED as mentioned in the table below.

Table 1. Error detection and representation

Open			Short		
Jumper	**Error in LED**	**Shown on LED**	**Jumper**	**Error in LED**	**Shown on LED**
J10	D4	D2	J7	D30	D26
J11	D8	D6	J8	D31	D27
J12	D12	D10	J9	D32	D28
J13	D16	D14			
J14	D20	D18			
J15	D24	D22			
J16	D28	D26			
J17	D32	D30			

Error detection simulation: Jumper (J12, J13 & J15) are removed to evaluate open-circuit error detection mode and jumper (J8) is placed to evaluate short-circuit error detection as shown in figure 13. While operating error detection mode the defective LED is signaled by switching on corresponding LED (as mentioned in the above table).

Figure 13. Error detection mode



4 GUI demonstration

STAP16DPPS05 GUI has two modes. Modes are classified as:

- Basic mode
- Frame programming mode

The main features of the GUI mode are:

- Replication of on-board control buttons to select mode itself from the GUI
- Error detection, frequency of performing error detection and error detection representation on 4x8 LED (mapped to 4x8 LEDs on evaluation board) map
- Adjustable global brightness for all the channels
- Frame programming to display any arbitrary pattern consists of up to 20 frames with variable transition speed
- 4 preconfigured patterns for quick visualization of frame programming mode on the evaluation board

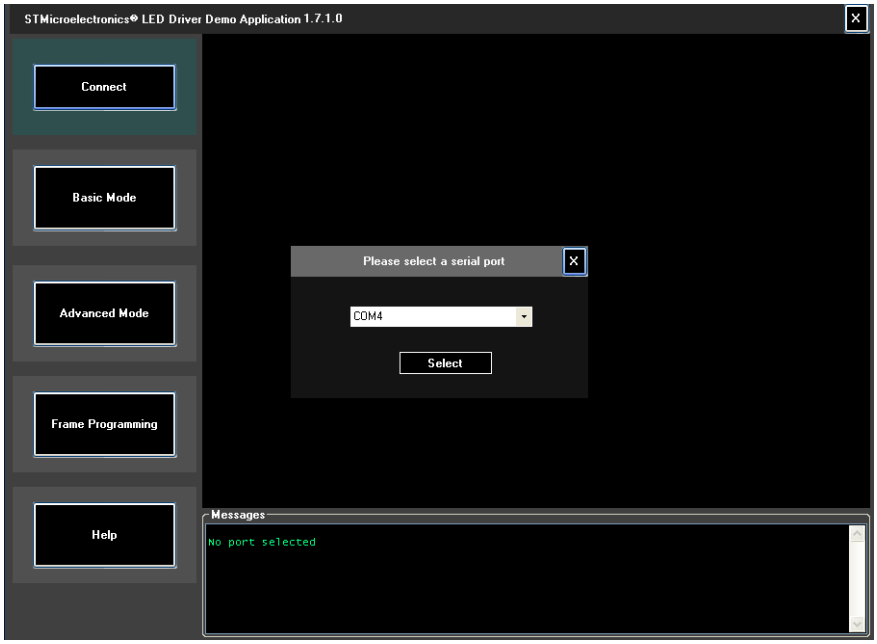
4.1 Graphical user interface setup

The Virtual Com Port driver from ST needs to be installed on the PC/laptop for using the STAP16DPPS05 evaluation board GUI. Please follow the procedure below:

First install the setup (.exe) file on Windows machine. After installing, GUI appears as “LED Driver Demo” in programs list. Now, if VCP driver is not installed, it can be installed from …\Program Files\ STMicroelectronics\LED Driver Demo\ST VCP Driver. Both 32-bit version and 64-bit version are included in the setup.

Now, on launching the GUI, first page appears as shown in *Figure 14*. At this point connect evaluation board to the PC and power it up. Now press “Connect”. If GUI identifies the board, it automatically establishes the connection with the board else GUI prompts the user to select the port to which 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, message shown is “Port is open”.

Figure 14. Graphical user interface



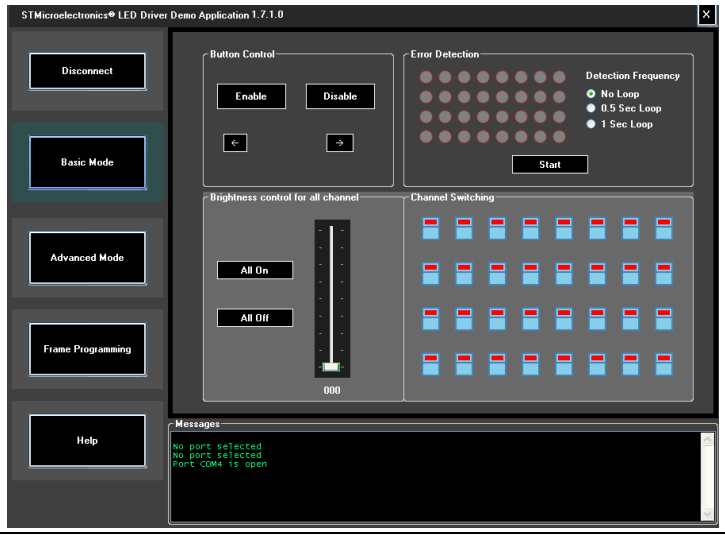
Note: To use the GUI, a Windows machine should have Virtual Com Port driver installed. In the picture shown above, COM4 is shown as an example, on connecting USB to the PC, VCOM establishes on any arbitrary port which has to be identified manually if GUI does not recognize the board automatically.

4.2 Basic mode

Basic mode has three sections to address different requirements as follows:

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

Figure 15. GUI basic mode



4.2.1 Button control

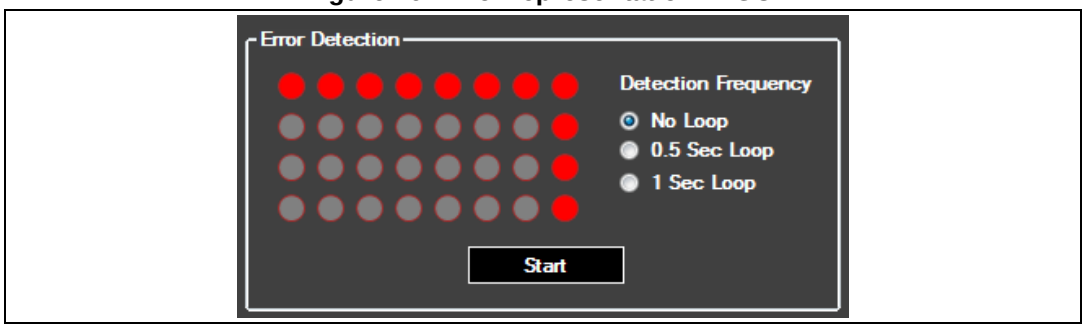
While in GUI mode, toggling between preconfigured demos can be handled by buttons in this section. These controls buttons are replication of on board BCK & FWD button.

By the help of GUI buttons on board can be enabled or disabled by pressing Enable or Disable buttons respectively.

4.2.2 Error detection

Error detection section demonstrates error (if any) present in the LEDs on 4x8 LED matrix. Error detection frequency can be selected from three options such as No loop (Error detection is performed once and the results are displayed till any other button is pressed), 0.5 second loop (error detection is performed every 0.5 s by the drivers and the results get updated in real time) and similarly a 1 second loop.

Figure 16. Error representation in GUI



4.2.3 Brightness control for all channel

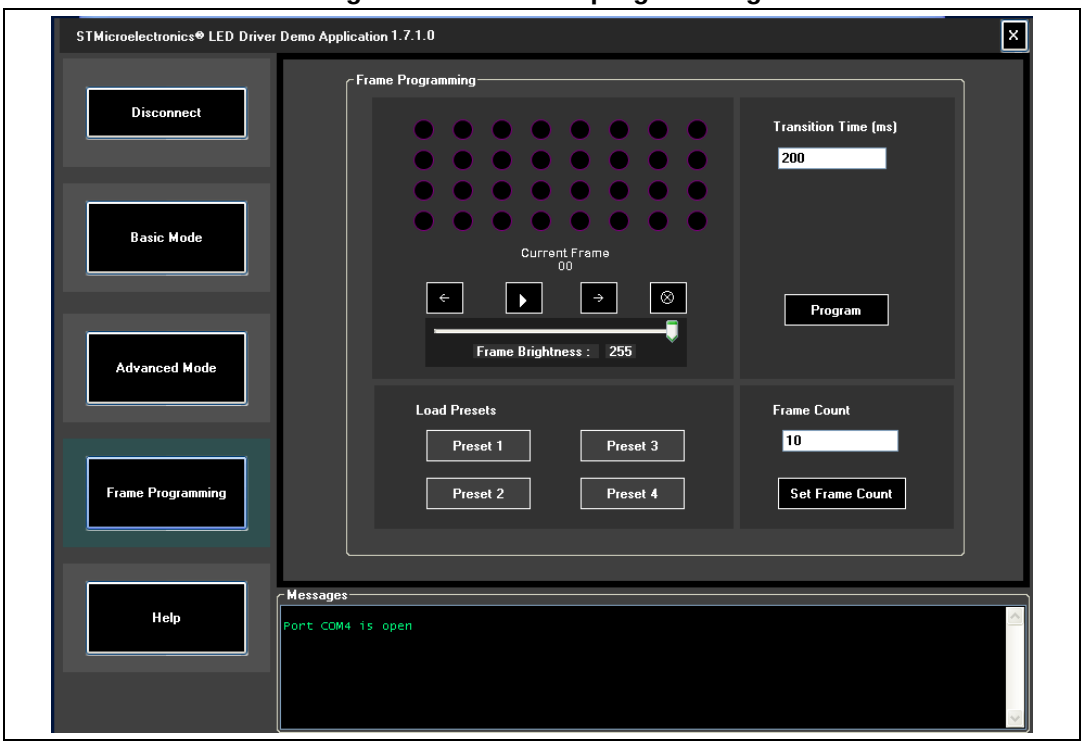
Brightness of all the channels is simultaneously varied by varying brightness control for all channel slider. Brightness can be varied in 256 steps (15% to 90%) using the slider.

4.3 Frame programming

Frame programming displays the feature of demonstrating user-defined patterns in round robin sequence on the evaluation board. This mode contains the set of 20 (maximum) independent frames and each frame represents one instance of representation of LEDs on the board.

In this mode, either the frames can be designed by the user or preconfigured frame patterns can be selected using presets. Transition time between the frames in milliseconds is set by the value in the transition time text box.

Figure 17. GUI frame programming



4.3.1 Designing of frames

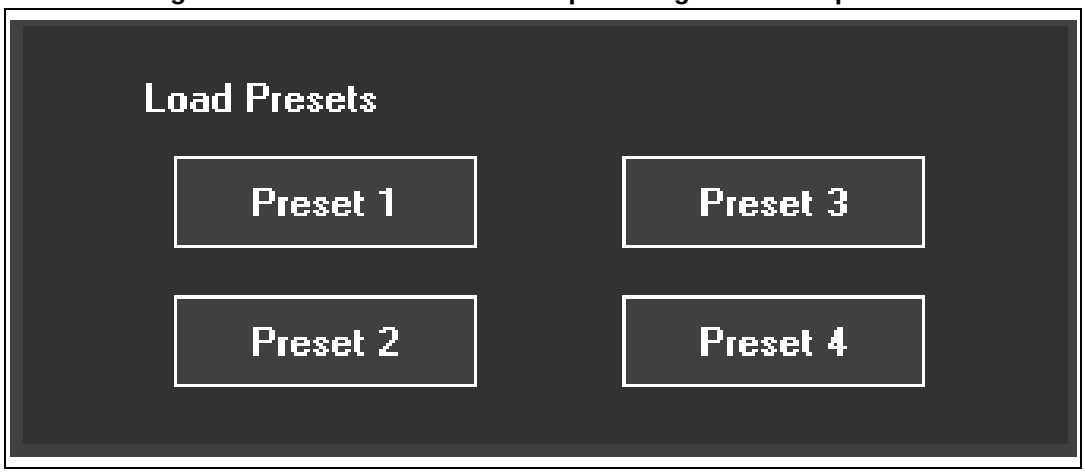
A frame on the GUI represents LEDs on the evaluation board in a similar fashion. Below are the steps for designing the frames and demonstrating it on the evaluation board:

- There can be maximum 20 frames (00 to 19) which can be set using “Set Frame Count”.
- To design a frame, click on the LED(s) to configure them
- Each frame can be set for different brightness using “Frame Brightness”
- 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”

4.3.2 Using preconfigured frame pattern

In frame programming mode, four preconfigured frame patterns called Presets are provided for quick demonstration of this feature.

Figure 18. Preset buttons to load preconfigured frame patterns



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

Figure 19. Preset 1

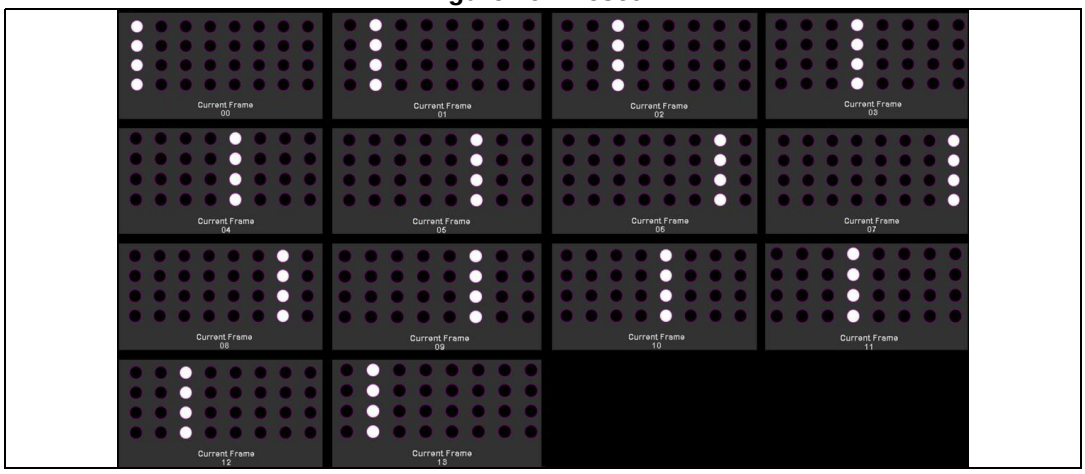


Figure 20. Preset 2

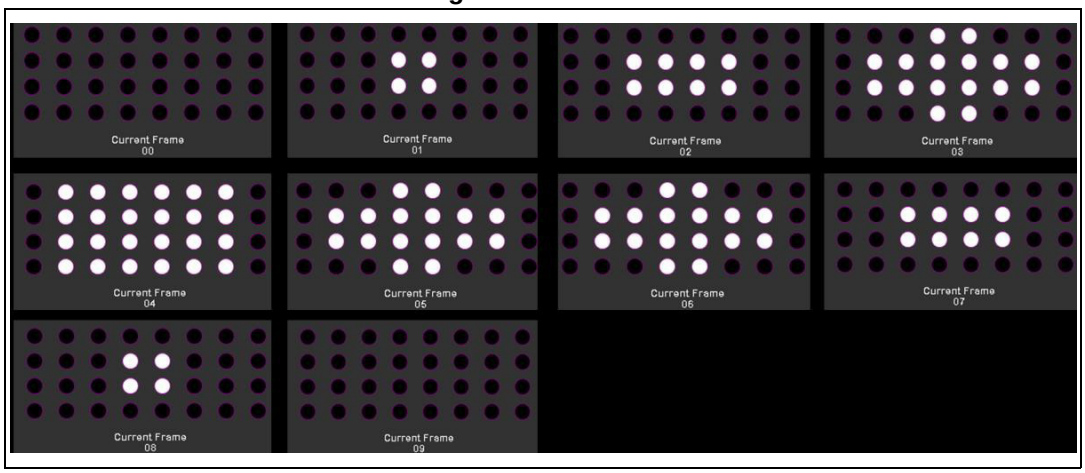


Figure 21. Preset 3

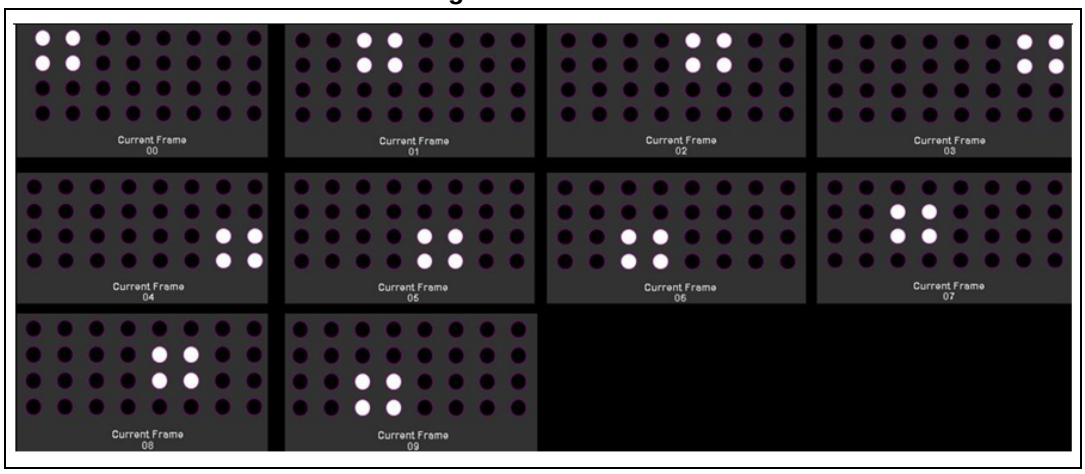
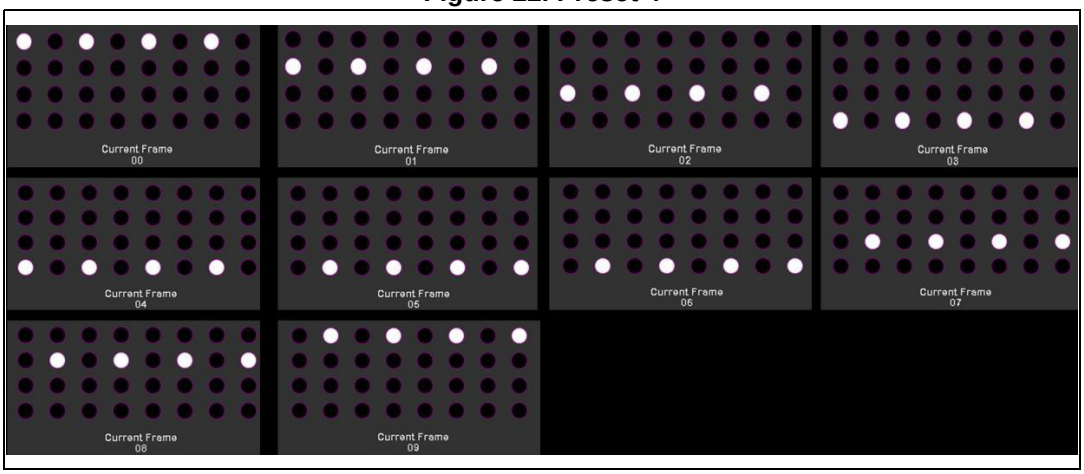


Figure 22. Preset 4



5 Thermal behavior

The STAP16DPPS05 is available in TSSOP24 (exposed pad) package. TSSOP24 exposed pad has a thermal resistance of 37.5 °C/W. Below is the image of 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):

Figure 23. STEVAL-ILL060V1

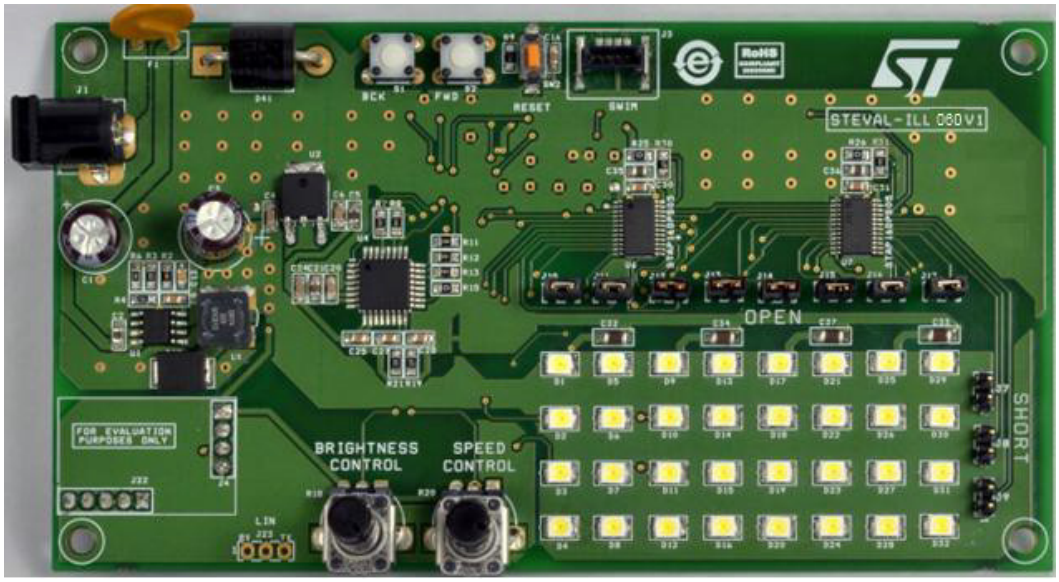
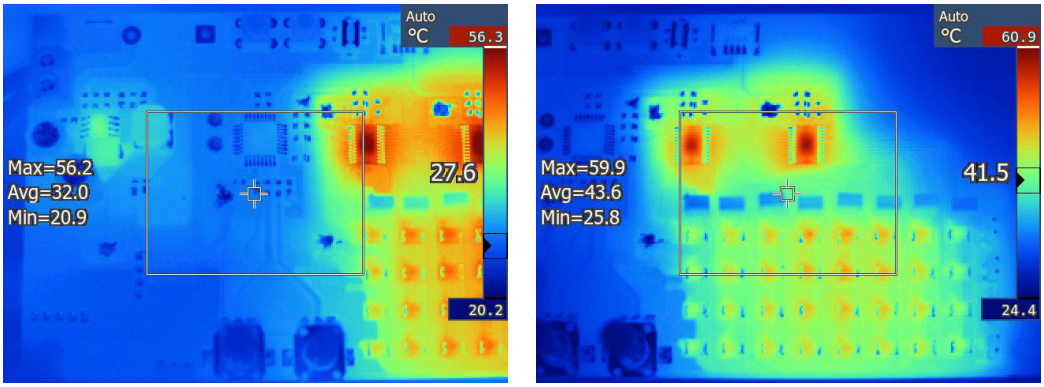


Figure 24. STEVAL- ILL060V1 thermal image



6 Schematics

Figure 25. Power section

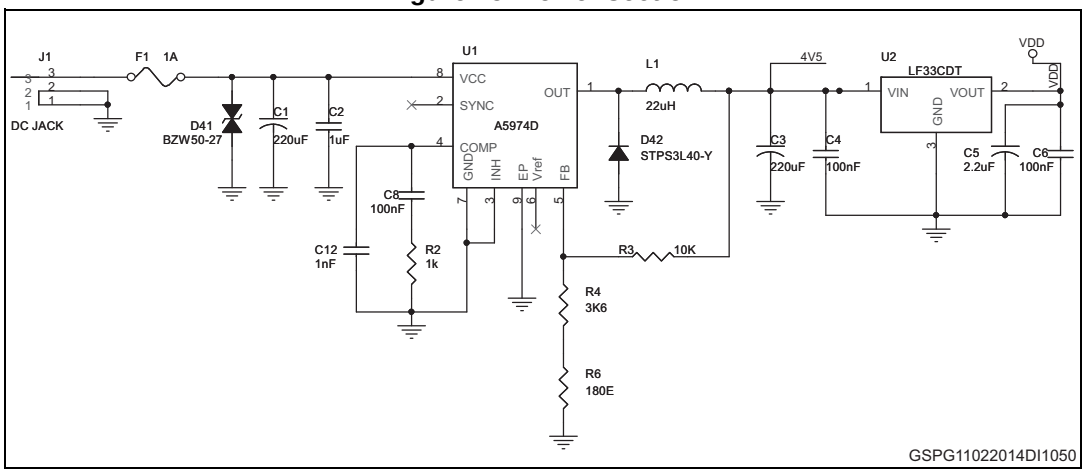


Figure 26. Microcontroller

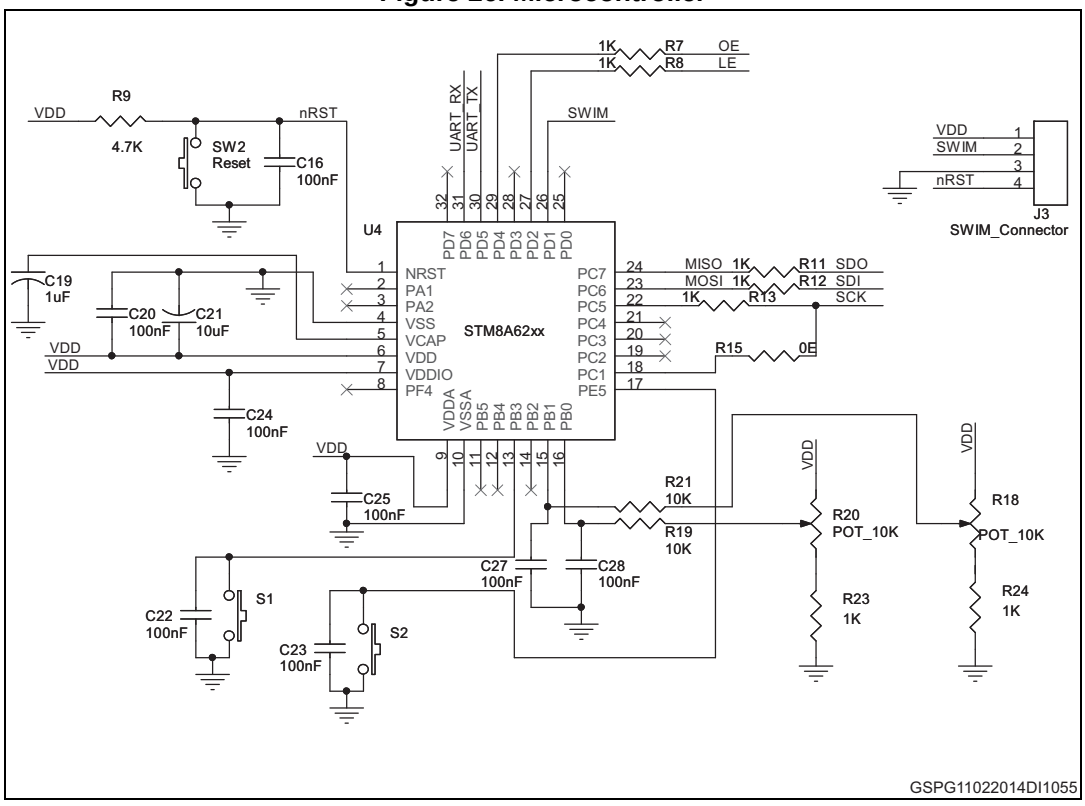


Figure 27. LED drivers

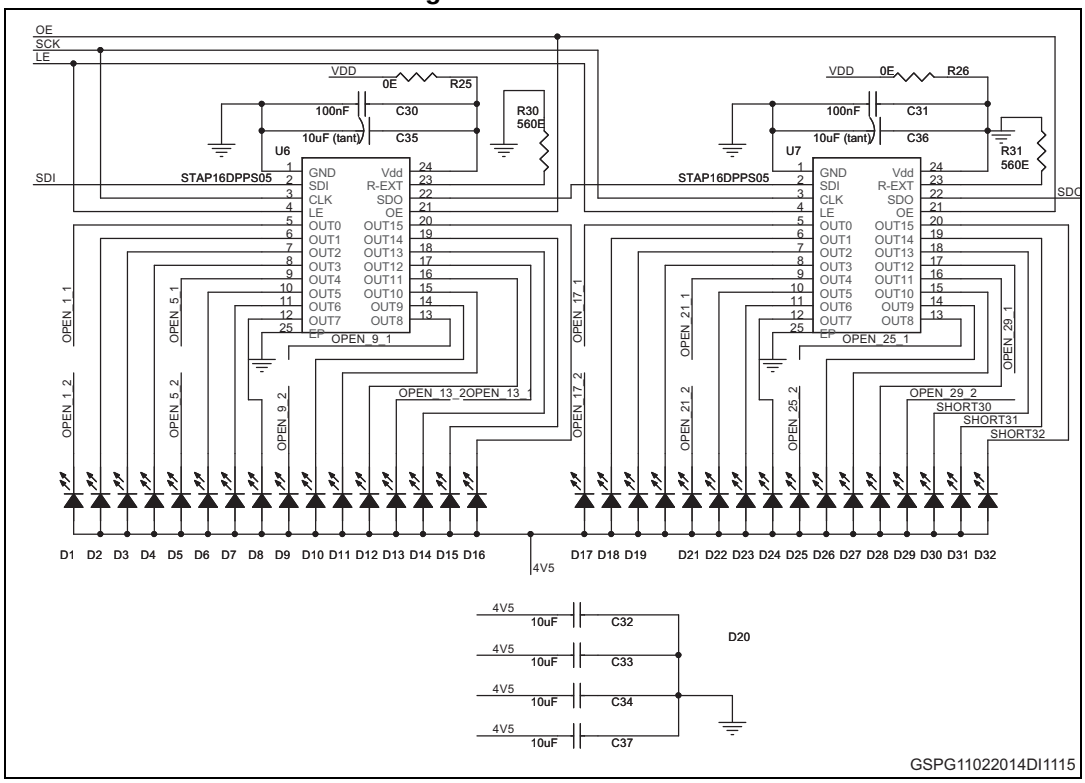


Figure 28. Connectors

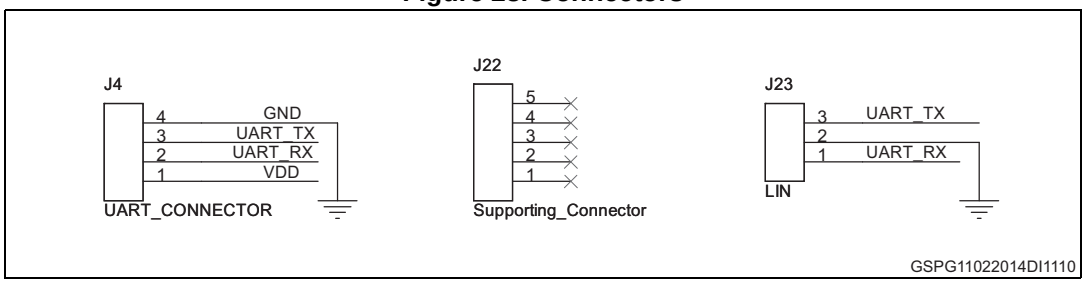


Figure 29. High brightness LEDs, open/short-circuit jumpers

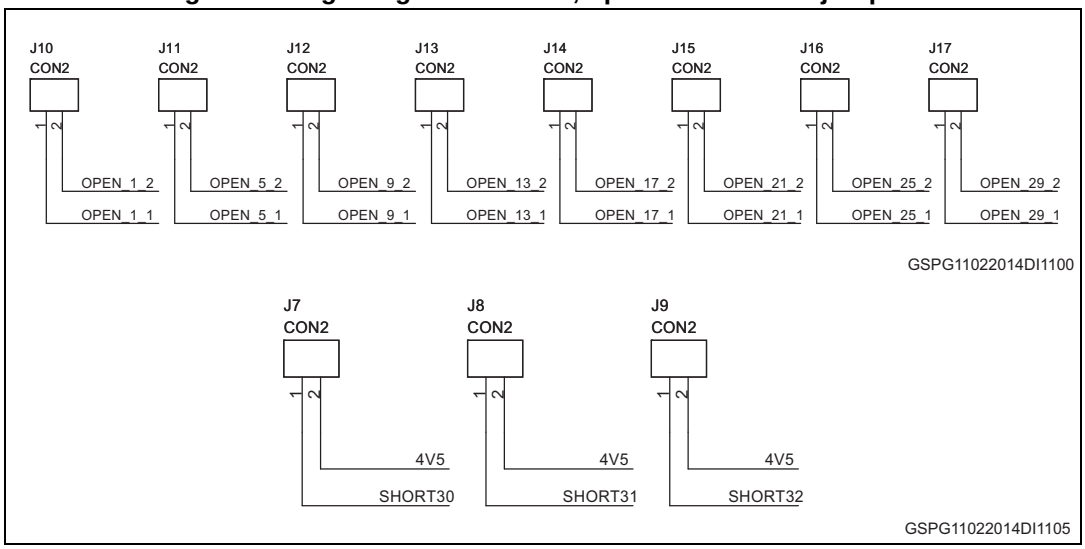


Figure 30. USB -UART connector: microcontroller section

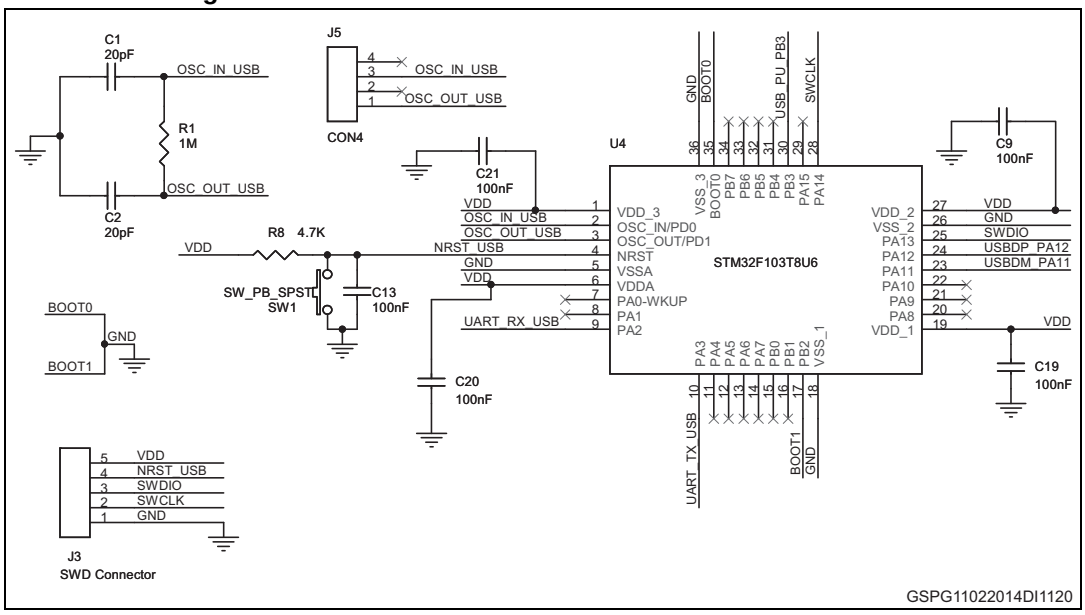


Figure 31. USB section

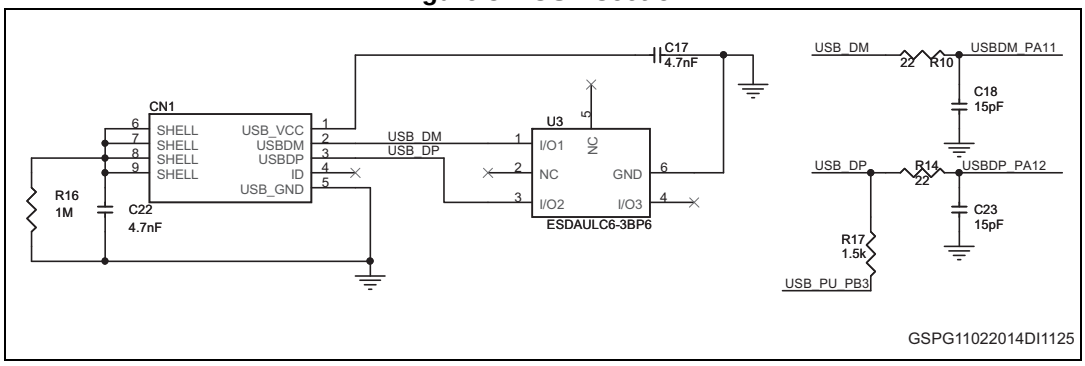
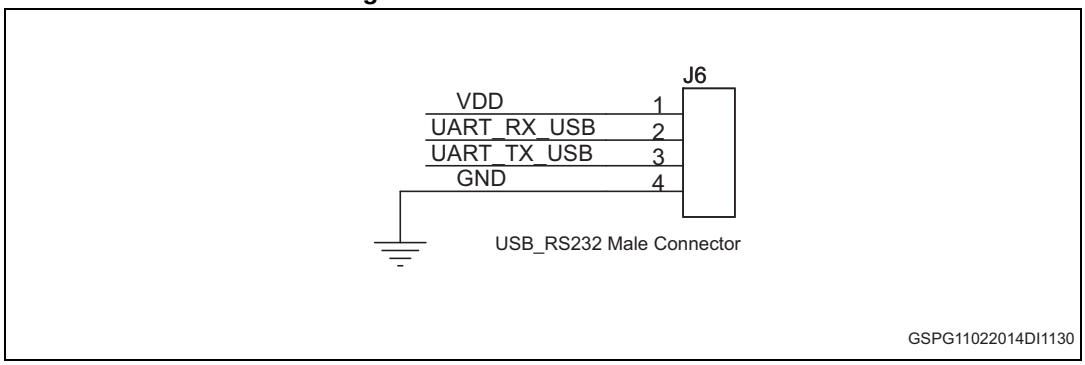


Figure 32. USB-UART connector



7 Bill of material

Figure 33. BOM (part 1)

Category	S. No.	Reference Designator	Component Description	Package	Manufacturer	Manufacturer's ordering code / Orderable Part Number or Equivalent	Supplier	Supplier Ordering Code	Quantity
ST Devices	1	U1	Switching Regulator	HSOP8	ST	A5974D	ST	A5974D	1
	2	U2	Voltage Regulator	DPAK	ST	LF33CDT	ST	LF33CDT	1
	3	U4	Microcontroller	LQFP 32	ST	STM8AF6266TD	ST	STM8AF6266TD	1
	4	U6,U7	LED Driver	HTSSOP24	ST	STAP16DPPS05	ST	STAP16DPPS05	2
	5	D41	Transil	R6	ST	BZW50-27	ST	BZW50-27	1
	6	D42	STPS3L40-Y	SMC	ST	STPS3L40SY	ST	STPS3L40SY	1
Resistances	7	R3,R19,R21	10K	SMD0805	Panasonic - ECG	ERJ-6GEYJ103V	Digikey	P10KACT-ND	3
	8	R4	3K6	SMD0805	Panasonic - ECG	ERJ-6ENF3601V	Digikey	P3.60KCCT-ND	1
	9	R6	180E	SMD0805	Panasonic - ECG	ERA-6AEB181V	Digikey	P180DACT-ND	1
	10	R15,R25,R26	0E	SMD0805	Panasonic - ECG	ERJ-6GEY0R00V	Digikey	P0.0ACT-ND	3
	11	R9	4.7K	SMD0805	Panasonic - ECG	ERJ-6GEYJ472V	Digikey	P4.7KACT-ND	1
	12	R18,R20	POT_10K	Through hole	ALPS	RK09K113004U	Mouser	688-RK09K113004U	2
	13	R2,R7,R8,R11,R12,R13,R23,R24,R30,R31	1K	SMD0805	Panasonic - ECG	ERJ-6GEYJ102V	Digikey	P1.0KACT-ND	10
Capacitors	14	C1,C3	220uF	RADIAL 8X11	Panasonic - ECG	EEU-FM1E221	Digikey	P12383-ND	2
	15	C4,C6,C8,C16,C20,C22,C23,C24,C25,C27,C28,C30,C31	100nF	SMD0805	TDK	CGA4F2X7R1H104K	Mouser	810-CGA4F2X7R1H104K	13
	16	C21,C32,C33,C34,C35,C36,C37	10uF	SMD0805	Panasonic - ECG	ECJ-2FB1A106K	Digikey	PCC2403CT-ND	7
	17	C5	2.2uF	SMD0805	Taiyo Yuden	LMK212B7225KG-T	Digikey	587-1286-1-ND	1
	18	C12	1nF	SMD0805	Kemet	C0805C102F4GACTU	Digikey	C0805C102F4GACTU-ND	1
	19	C2,C19	1uF	SMD0805	Taiyo Yuden	EMK212B7105KG-T	Digikey	587-1283-1-ND	2
Diodes/Display/ Switches	20	D1-D32	LED	PLCC2	Lite-On	LTW-670DS	Mouser	859-LTW-670DS	32
	21	SW2	SPST Reset	Tactile & Jog Switches	MULTICOMP	DTSM-32S-B	Farnell	9471898	1
	22	S1,S2	PUSH BUTTON	Through hole	ALCOSWITCH	FSM2JH	Farnell	1555981	2
Miscellaneous	23	F1	Resettable Fuse	Through hole	TE connectivity	RXEF110	Mouser	650-RXEF110	1
	24	J1	Input power jack	Through hole	CUI Inc	PJ1-021 or equivalent	Digikey	CP1-021-ND	1
	25	J3	SWIM Connector	Through hole	ERNI	284697	ERNI	284697	1
	26	J4	4-pin female bergstick	Through hole					1
	27	J7,J8,J9,J10,J11,J12,J13,J14,J15,J16,J17	Jumpers - 2pin berg stick	Through hole					11
	28	L1	Inductor 22uH	Surface Mount	Coiltronics	DR74-220-R	Mouser	704-DR74-220-R	1
	29	J23	LIN Connector						

Figure 34. BOM (part 2)

	DAUGHTER CARD (USB-RS232 Bridge)								
ST DEVICES	30	U3	ESDAULC6-3BP6	SOT666	ST	ESDA ULC 6 - 3 B	ST	ESDA ULC 6 - 3 B	1
	31	U4	STM32F103T8U6	VFQFPN 36 6x6x1-0	ST	STM32F103C8T7TR	ST	STM32F103C8T7TR	1
SWITCES	32	SW1	SW_PB_SPST	SMD	MULTICOMP	DTSM-32S-B	Farnell	9471898	1
CONNECTOR AND JUMPERS	33	CN1	USB-B TYPE MINI CONNECTOR	SMD	Samtec Inc	MUSB-05-S-B-SM-A	Digikey	MUSB-05-S-B-SM-A-ND	1
	34	J3	SWD Connector	Through hole, 2.54 mm pitch					1
	35	J5	Crystal	4-SMD, (DFN, LCC)	ABRACON	ABM10-16.000MHZ-E20-T	Mouser	815-AM10-16-E20-T	1
	36	J6	Daughter Card to Main board connector	Through hole, 2.54 mm pitch					1
RESISTORS	37	R1,R16	1M	SMD0402	Panasonic	ERJ-2GEJ105X	Digikey	P1.0MJCT-ND	2
	38	R8	4.7K	SMD0402	Panasonic	ERA-2AEB472X	Digikey	P4.7KDCCT-ND	1
	39	R10,R14	22	SMD0402	Panasonic	ERJ-2GEJ220X	Digikey	P22JCT-ND	2
	40	R17	1.5k	SMD0402	Panasonic	ERJ-2GEJ152X	Digikey	P1.5KJCT-ND	1
CAPACITORS	41	C1,C2	20pF	SMD0402	TDK Corporation	C1005C0G1H200J	Digikey	445-4900-1-ND	2
	42	C9,C13,C19,C20,C21	100nF	SMD0402	TDK Corporation	C1005X5R1A104K	Digikey	445-1265-1-ND	5
	43	C17,C22	4.7nF	SMD0402	TDK Corporation	C1005X7R1E472K	Digikey	445-1259-1-ND	2
	44	C18,C23	15pF	SMD0402	TDK Corporation	C1005C0G1H150J	Digikey	445-1237-1-ND	2

8 Revision history

Table 2. Document revision history

Date	Revision	Changes
30-May-2014	1	Initial release.

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