Intelligent matrix LED display driver based on STLED524 in a CSP package
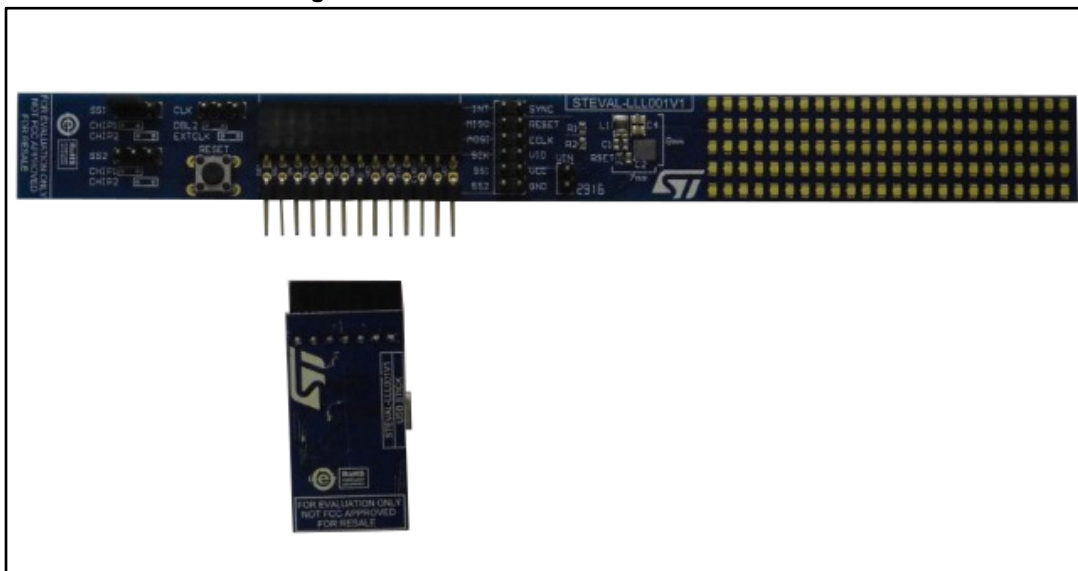
Introduction

The STEVAL-LLL001V1 board is designed to demonstrate the features of the STLED524 intelligent matrix LED display driver with a 5 x 24 matrix of SMD white LEDs incorporated on the board.

Two boards can also be joined using the on-board connectors to drive a 10 x 24 LED matrix.

The board is driven by the USB control board for interface with the graphical user interface (GUI), but there is also an SPI interface connector on the STEVAL-LLL001V1 which can be used for customized control.

This user manual is dedicated to the configuration of the STLED524 STEVAL-LLL001V1 evaluation board in a CSP package.

Figure 1: STEVAL-LLL01V1 evaluation board

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1 Overview

The STLED524 is a 5x24 dot matrix LED display driver. It is capable of driving each dot with a maximum 20 mA current. The matrix rows are multiplexed. Each LED in a row is driven by a separate low side current mirror.

The current regulators are supplied through an integrated boost DC-DC converter. The output voltage can be adjusted by an internal register to optimize the efficiency according to the type of LED (with reference to the forward voltage). This helps to reduce the current mirror power dissipation, improving the overall efficiency.

STLED524 also contains an internal LDO regulator, which can provide a supply voltage for additional circuitry.

The maximum current provided by each current mirror can be adjusted by the RSET resistor and the current of each LED (dot) can be dimmed in 255 steps by the internal register settings.

The STLED524 is also capable of PWM dimming in 255 steps.

The automatic slope function is also supported. Cycle and slope time can be separately adjusted for each LED (dot).

Two patterns can be stored in the internal registers; four-way automatic scrolling is also possible.

The STEVAL-LLL001V1 evaluation board for the STLED524 dot matrix LED display driver features:

- Operating input voltage from 2.7 V to 5.5 V
- Drives 5 x 24 LED matrix
- Luminance separately adjustable for each LED by internal registers in 255 steps
- Internal registers capable of storing two patterns
- 4-way scroll function with a possibility to lock column data
- 255-step PWM dimming
- SPI interface
- Integrated step-up converter with adjustable output voltage
- Integrated LDO with 3.1 V output at 80 mA
- CSP 56 bumps 0.4 mm pitch 3.4 x 3.0 mm
- RoHS compliant

2 Applications

- Appliance user interfaces;
- Display driver for handheld units.

Figure 2: CSP package: 3.4x3.0mm, 0.4mm pitch, 56 bumps
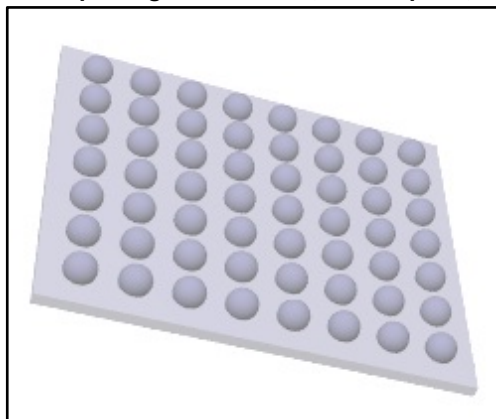
3 Connectors

Figure 3: STLED524 connectors
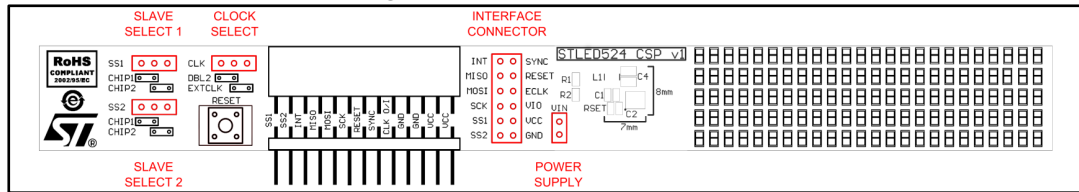
Table 1: Slave select 1 (SS1)

Connector	Description
CHIP1	the jumper is on the left side: the SS1 signal is assigned to the device
CHIP2	the jumper is on the right side: the SS2 signal is assigned to the device
-	the jumper is not in use: the SS signal is not selected

Table 2: Slave select 2 (SS2)

Connector	Description
CHIP1	the jumper is on the left side: the SS1 signal is assigned to the device
CHIP2	the jumper is on the right side: the SS2 signal is assigned to the device
-	the jumper is not in use: the SS signal is not selected

The SS2 setting is mainly used for double connection

Table 3: Clock select (CLK)

Connector	Description
DBL2	the jumper is on the left side: the clock signal for display timing is taken from the first chip [1]
EXTCLK	the jumper is on the right side: the external clock signal is used to display timing

Notes:

[1]This setting is mainly used for double connection

Table 4: Power supply (VIN)

Connector	Description
VIN	power supply positive terminal
-	power supply negative terminal

Table 5: Interface connector

Connector	Description
INT	interrupt pin
MISO	master in, slave out -SPI bus
MOSI	master out, slave in - SPI bus
SCK	SPI bus clock
SS1	slave select 1 - SPI bus
SS2	slave select 2 - SPI bus
SYNC	synchronization pin (by an external signal)
RESET	reset input: when low, the device is in shutdown mode
ECLK	external clock signal used to display timing
VIO	positive terminal of the I/O pins and logic supply voltage (internal LDO output voltage = 3.1 V)
VCC	supply voltage positive terminal
GND	supply voltage negative terminal

4   Connecting the evaluation board

To connect STLED524 devices, you can use a single device or two or more connected
devices to be cascaded to increase the display size (see figure below).

Figure 4: STLED524 cascade
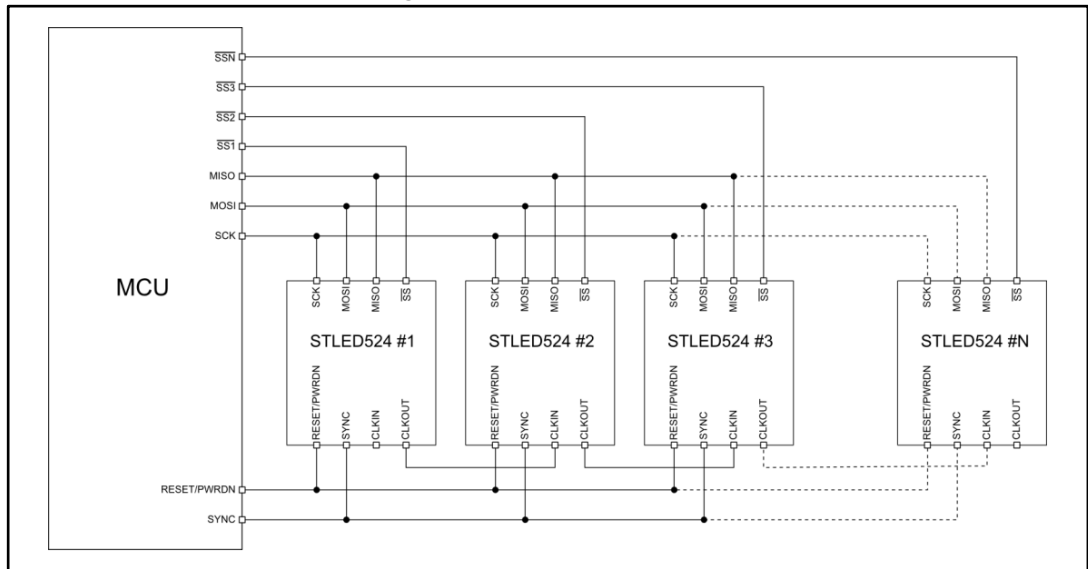
4.1   Single connection

In single connections, the display is standard size (5x24, 120 LEDs).

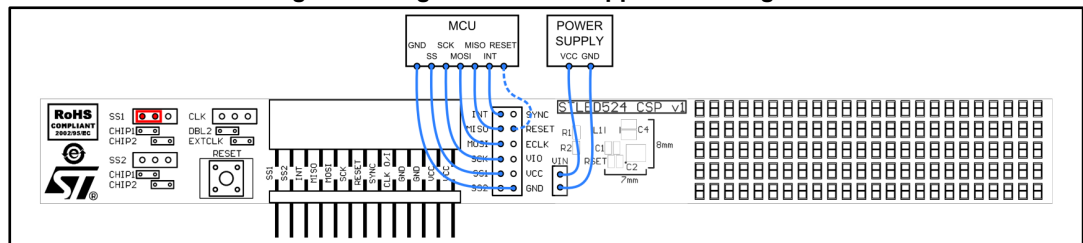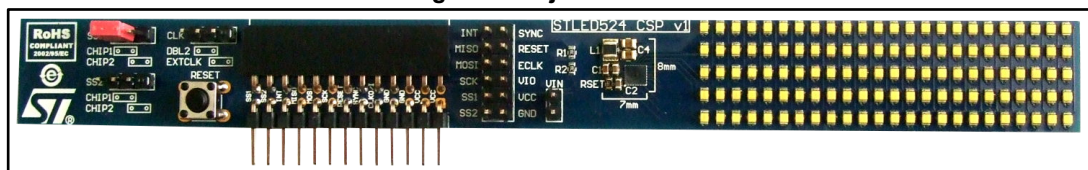**Figure 5: Single connection application diagram**

Figure 6: Adjusted PCB

4.2 Double connection

In double connections, the display is double size (10x24, 240 LEDs).

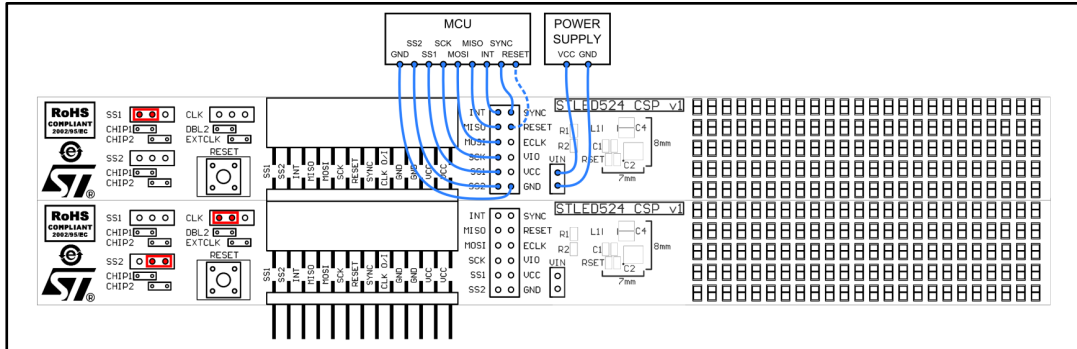**Figure 7: Double connection application diagram**

Figure 8: Adjusted PCBs
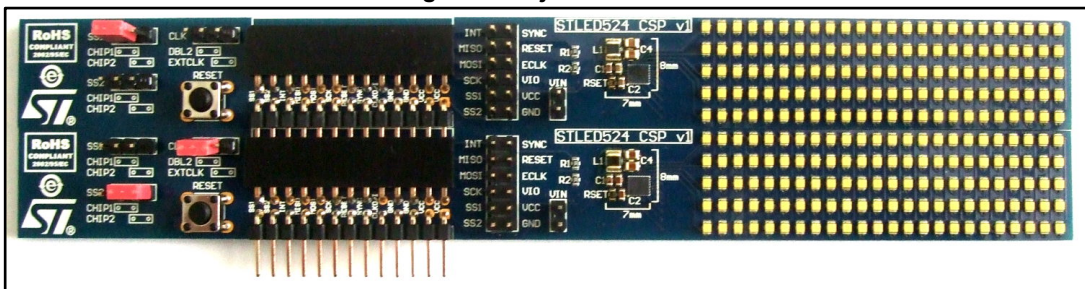
5 How to use the board

This section shows how to use the board in single or double connections via an STM32 MCU connected to a PC through a USB cable using the human interface device class, so no driver installation is necessary.

The evaluation boards are powered by a DC power supply from 2.7 to 5.5 V.

Running the evaluation boards with boosts at 2.7 V maximum load (all 120/240 LEDs are on at maximum current) require a power supply which can provide at least 3 A.

If the evaluation boards run with disabled boosts, a 4 V / 1 A power supply is sufficient.

Figure 9: Single STLED524 connected to a USB control board

Figure 10: Double STLED524 connected to a USB control board

5.1 Single board

5.1.1 How to get started

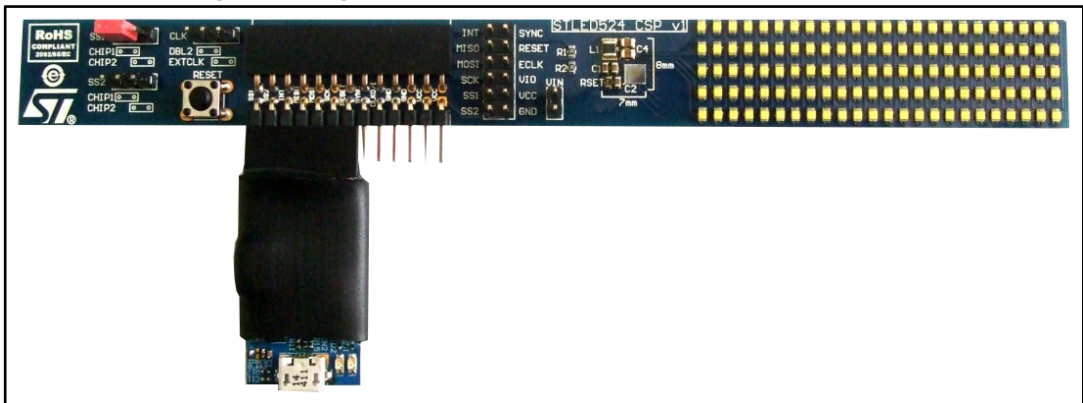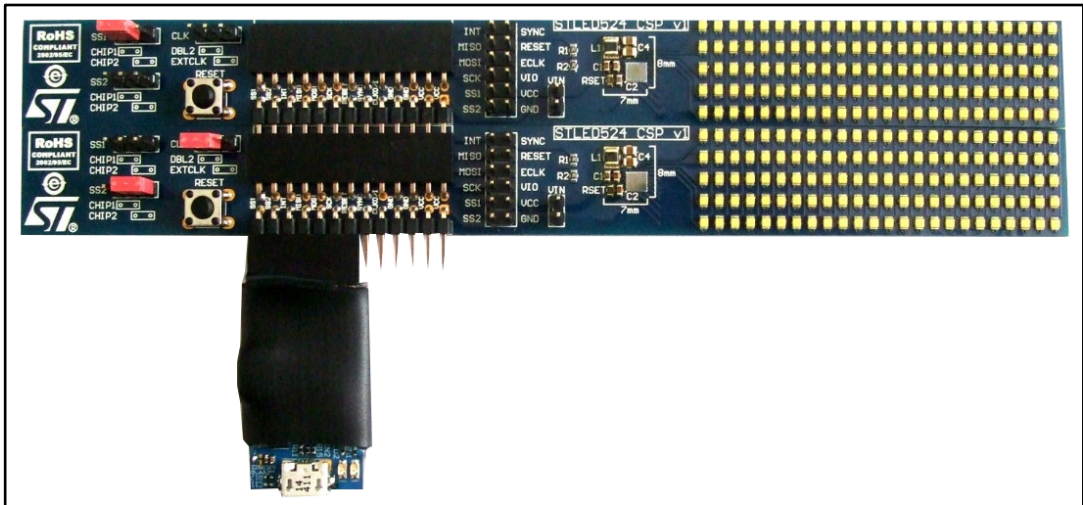1 Connect the power supply and adjust jumpers according to *Figure 5: "Single connection application diagram"*

2 Connect the USB control board to the single evaluation board according to *Figure 9: "Single STLED524 connected to a USB control board"*

3 Connect the USB control board to a PC by a USB cable (A-B mini type)

4 Wait until your computer enumerates the control board and displays the message that a new hardware has been found and is ready to use. This message is displayed only once, when the board is connected for the first time. Then run the STLED524_v1.44.exe (or higher). The GUI main window is shown: most buttons are disabled as the "Connect ARM board" button has not been clicked yet.

Figure 11: STLED524 GUI main window
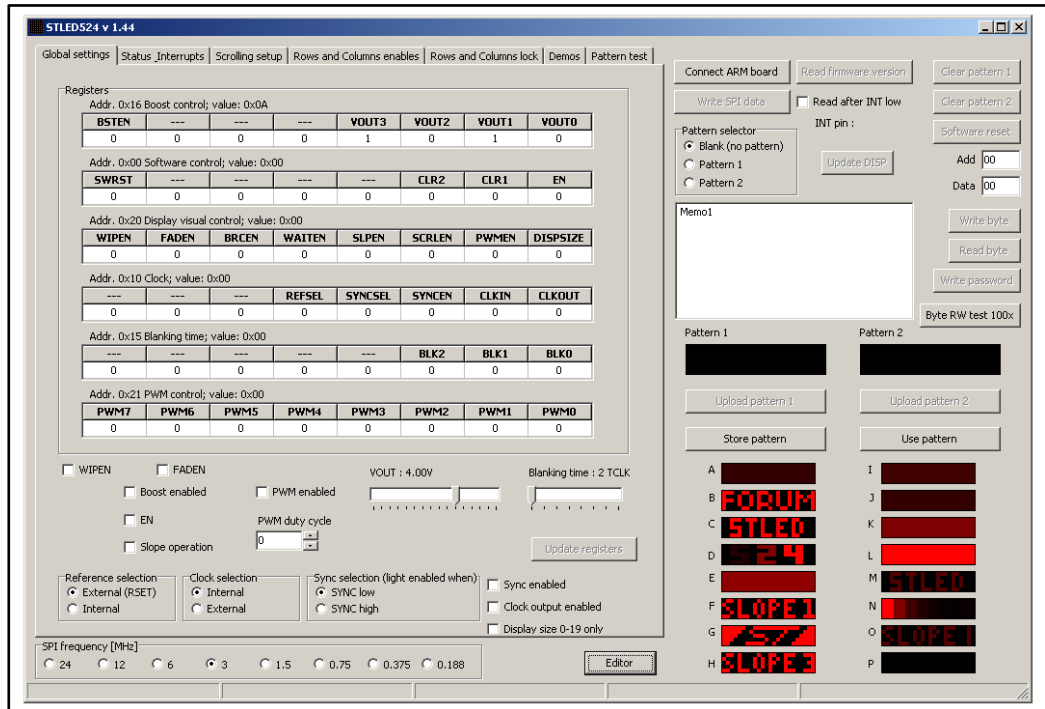
5   If the STM32 evaluation board is connected and "Connect ARM board" button is
     clicked, the GUI starts communicating with the USB control board and the disabled
     buttons are enabled.

**Figure 12: STLED524 GUI main window: successful communication with USB control
board**
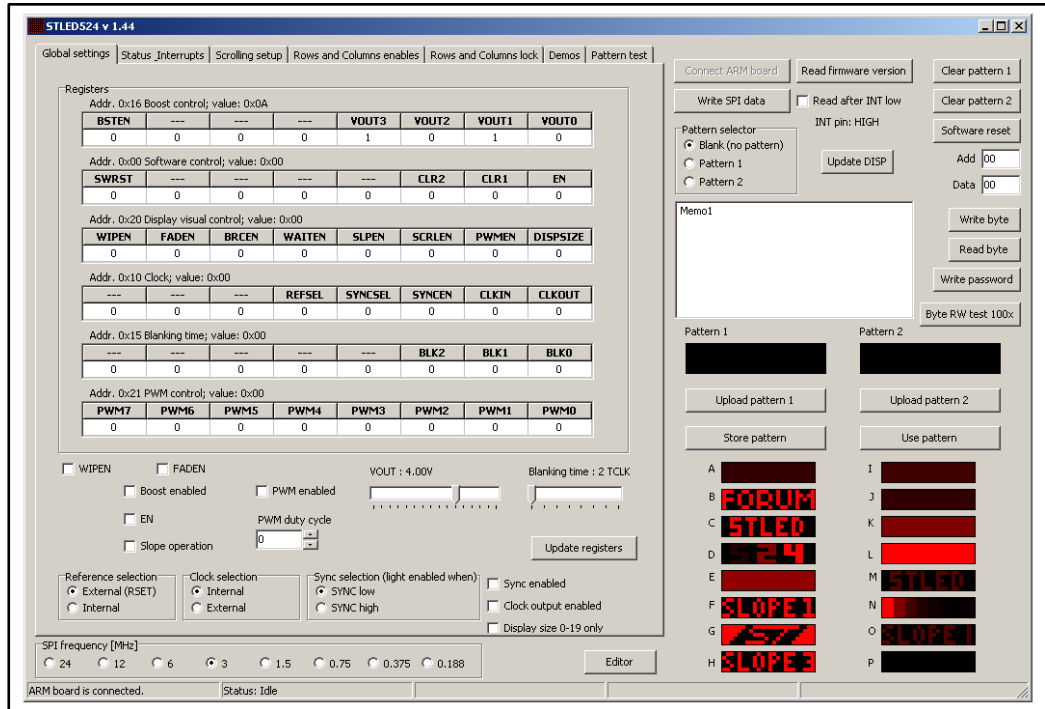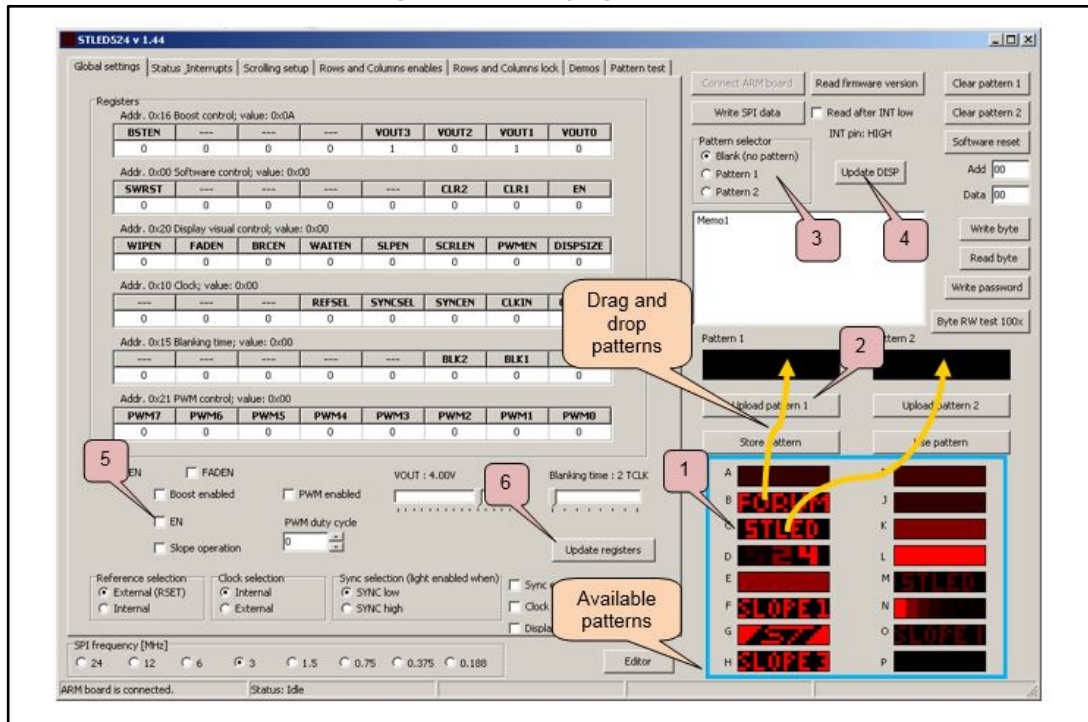
5.1.2 How to display a pattern

All the available patterns that can be displayed are shown in *Figure 13: "Displaying patterns"*.

STLED524 internal memory incorporates two patterns.

The procedure to upload patterns is:

1. Drag and drop patterns into 1 or 2 pattern boxes
2. Upload the patterns into STLED524
3. Choose the pattern to display
4. Confirm choice by the "Update DISP" button
5. Tick the EN bit
6. Press the "Update registers" button

Figure 13: Displaying patterns

If you want to switch the display to the second pattern, simply choose it in the pattern selector and click the "Update DISP" button. The change is immediate.

The content of any pattern (1 or 2) can be changed anytime, even if the display driver is enabled.

Suppose pattern 2 is displayed. If a new pattern is dragged and dropped into the pattern 2 box and the "Upload pattern 2" button is clicked, the content of pattern 2 is immediately changed.

The display can be turned off in three ways:

1. Set the EN bit to zero and press the "Update registers" button.
2. Choose the blank pattern in the pattern selector and click the "Update DISP" button.
3. Clear the pattern by clicking the "Clear pattern 1" or "Clear pattern 2" buttons.
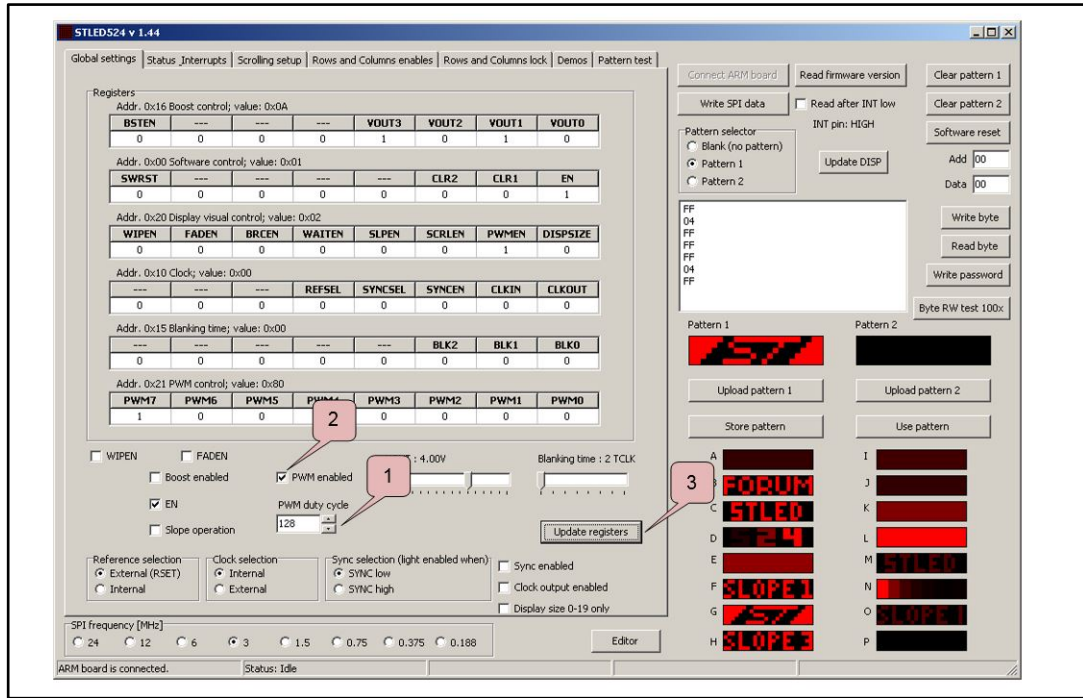
5.1.3   Controlling PWM

STLED524 is able to control display brightness by PWM, that can be set in a range from 0 to 255/255.

To set the PWM duty cycle and enable PWM operation:

1.   Set the PWM duty by typing the nominator of the x/255 duty cycle value.
2.   Check the "PWM enabled" checkbox.
3.   Click the "Update registers" button.

Figure 14: PWM settings

If the PWM is already enabled, the duty cycle can be changed by steps 1 – 2 only.

1.   Uncheck the "PWM enabled" checkbox.
2.   Press the "Update registers" button.

5.1.4 Enabling slope operation

The slope operation works only if the displayed pattern contains non-zero values of slope bits. If a pattern that supports the slope operation is already displayed, you can start the slope operation by:

1. Checking the "Slope operation" checkbox.
2. Pressing the "Update registers" button.

Figure 15: Slope operation
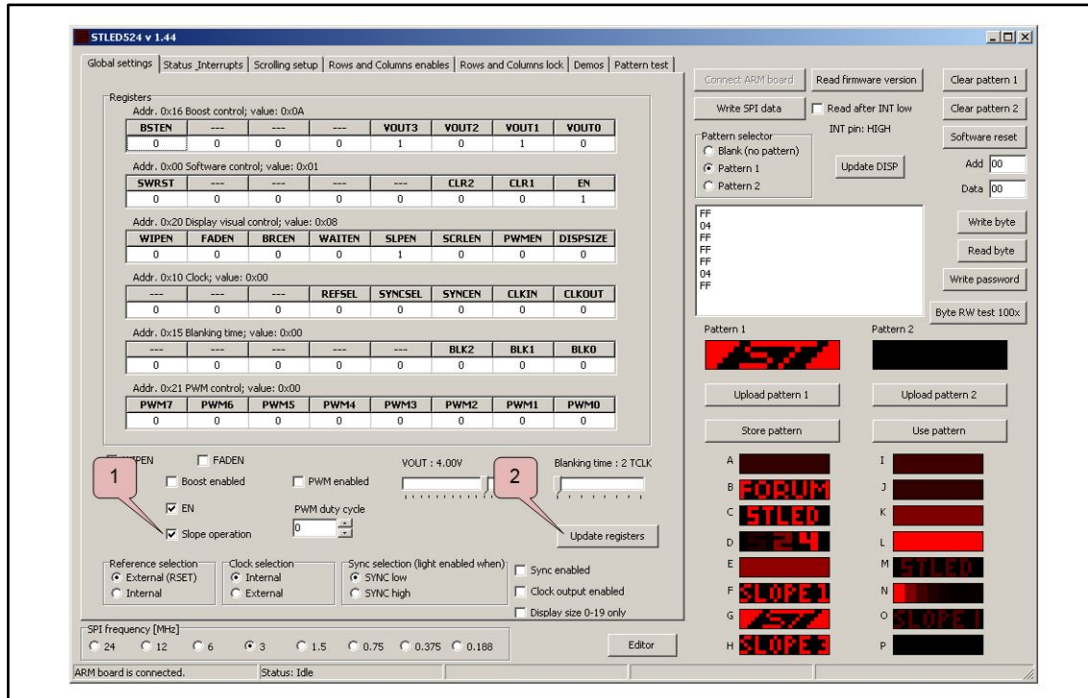
To stop the slope operation:

1. Uncheck the "Slope operation" checkbox.
2. Press the "Update registers" button.

5.1.5 Scrolling feature

The scrolling feature is active, only after checking the "Scroll enabled" checkbox, choosing the"Scrolling setup" tab and clicking the "Update DISP" button.

Before enabling the scrolling feature, it is recommended to set up its parameters in the scroll setup section.

Any change in the "Scrolling setup" section takes effect only after clicking the "Update scroll setup" button and after the setup modification.

Scrolling direction: STLED524 supports a four-way scrolling without any microcontroller support.

Scrolling speed: the scrolling speed is adjusted by the "Scroll speed" track bar.

Blank columns and rows: in some cases the display content is easier to read, if some blank columns are inserted between patterns.To insert blank columns click the "Blank rows/cols enable" checkbox. Then, adjust the number of blank columns and rows by the "Blank columns" and "Blank rows" track bars.

Waiting time: the waiting time has no visual effect. It only delays the "end of scroll" interrupt.The display content scrolling starts when the target pattern is selected in the "Pattern selector" and the "Update DISP" button is clicked.

Figure 16: Scrolling setup
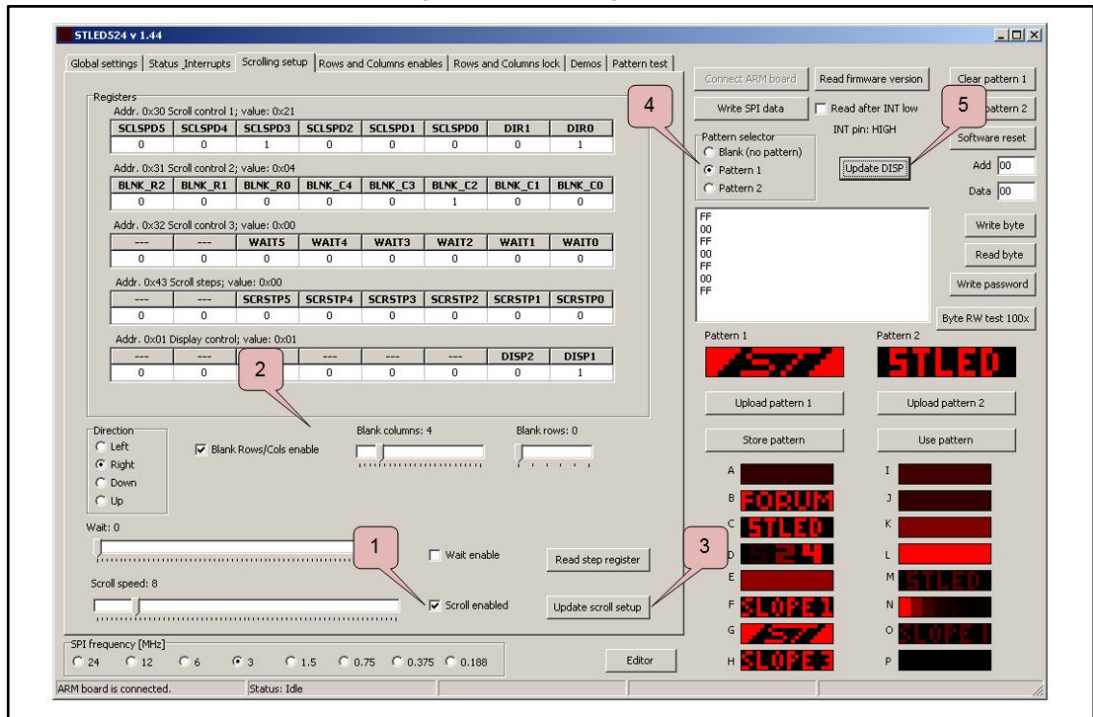
5.1.6 Wipe feature

The wipe feature is active, only after checking the "WIPEN" checkbox and clicking the "Update registers" button.

The wipe feature has some settings in common with the scrolling feature: "Direction" and "Scroll speed". The direction is limited to left/right only. Setting the direction to up or down leads to wipe feature wrong functionality. The "Scroll speed" determines the speed of the wipe feature. After this settings, click the "Update scroll setup" button.

Similarly to the scrolling, the wipe operation is started by choosing a pattern in the pattern selector and clicking the "Update DISP" button.
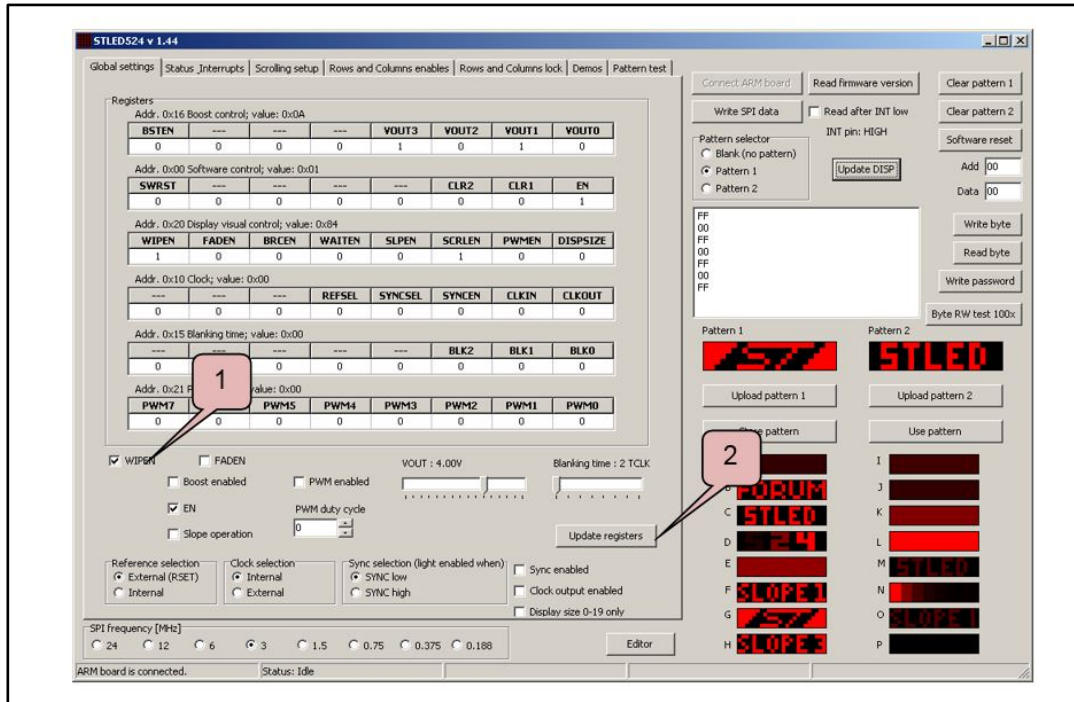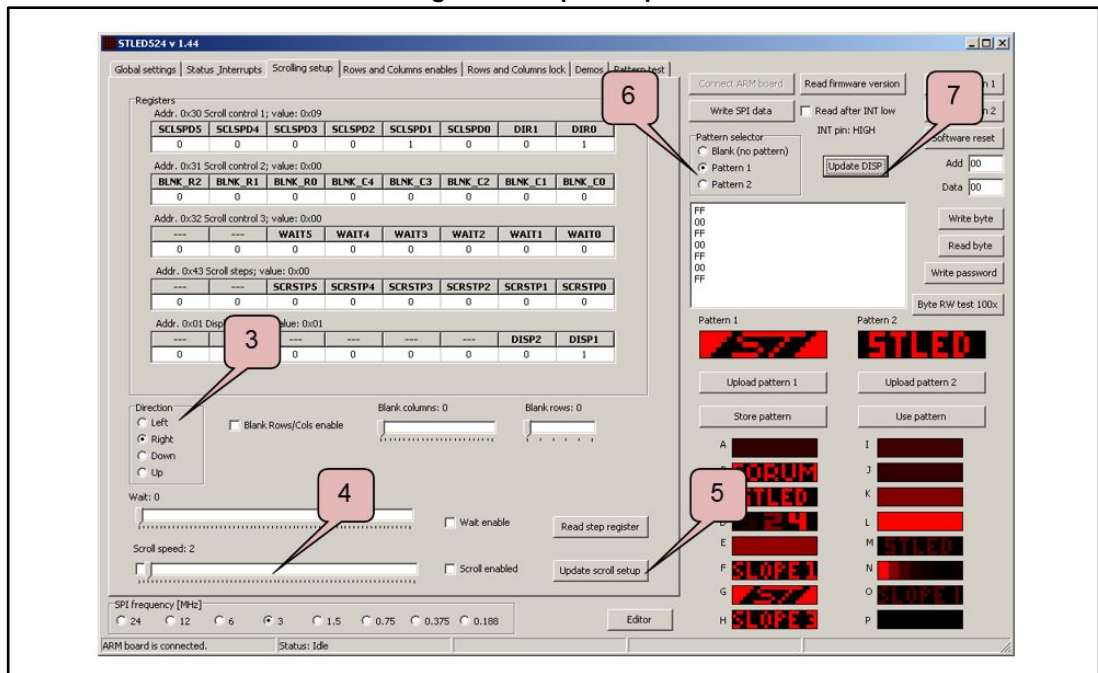
Figure 17: Wipe setup 1
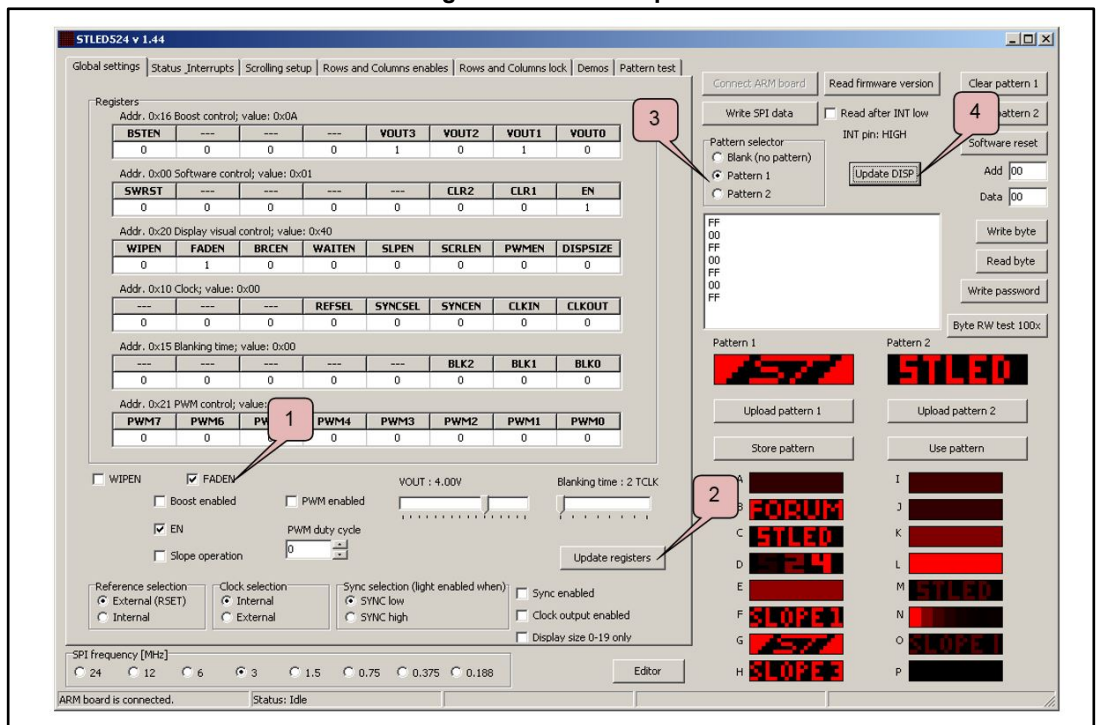
Figure 18: Wipe setup 2

5.1.7 Fade feature

The fade feature is active, only after checking the "FADEN" checkbox and clicking the "Update registers" button. No other setting is required.

The fade feature starts when the displayed pattern is changed clicking the "Update DISP" button.
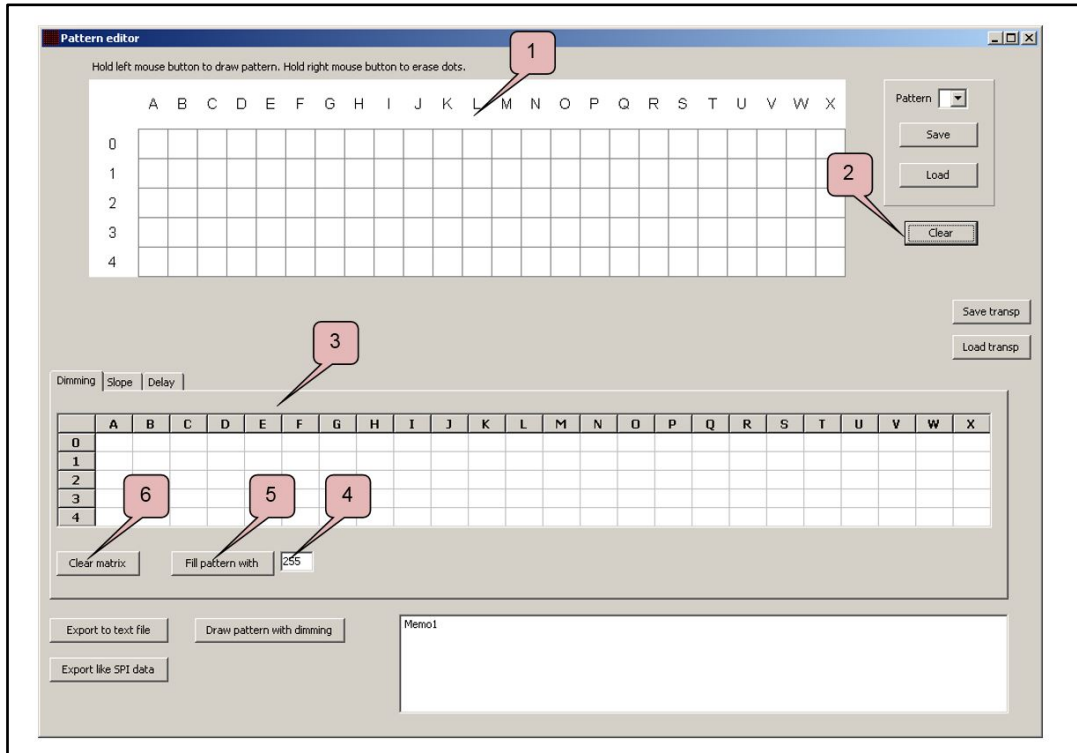
Figure 19: Fade setup

5.1.8   Pattern editor

You can open the pattern editor by clicking the "Editor" button on the "Global settings" tab. It is possible to create new patterns or edit existing patterns.

Figure 20: Pattern editor

Creating new pattern:

- draw the pattern in the grid on top of the window (1); you can draw a dot by clicking the left mouse button and erase it by clicking the right mouse button. It is also possible to press and hold the mouse buttons while moving the cursor;
- erase drawing grid content by clicking the "Clear" button whenever necessary;
- apply the drawn pattern to the dimming, slope or delay matrix in the bottom part of the window (3);
- fill in the value in the matrix (4) by clicking the "Fill pattern with" button (5);
- clear the matrix by pressing the "Clear matrix" button (6).

Saving patterns:

1. Choose the pattern slot (A-X) where the pattern will be saved.
2. Click the "Save" button.

If a pattern already exists in the chosen slot, it is overwritten without any warning.
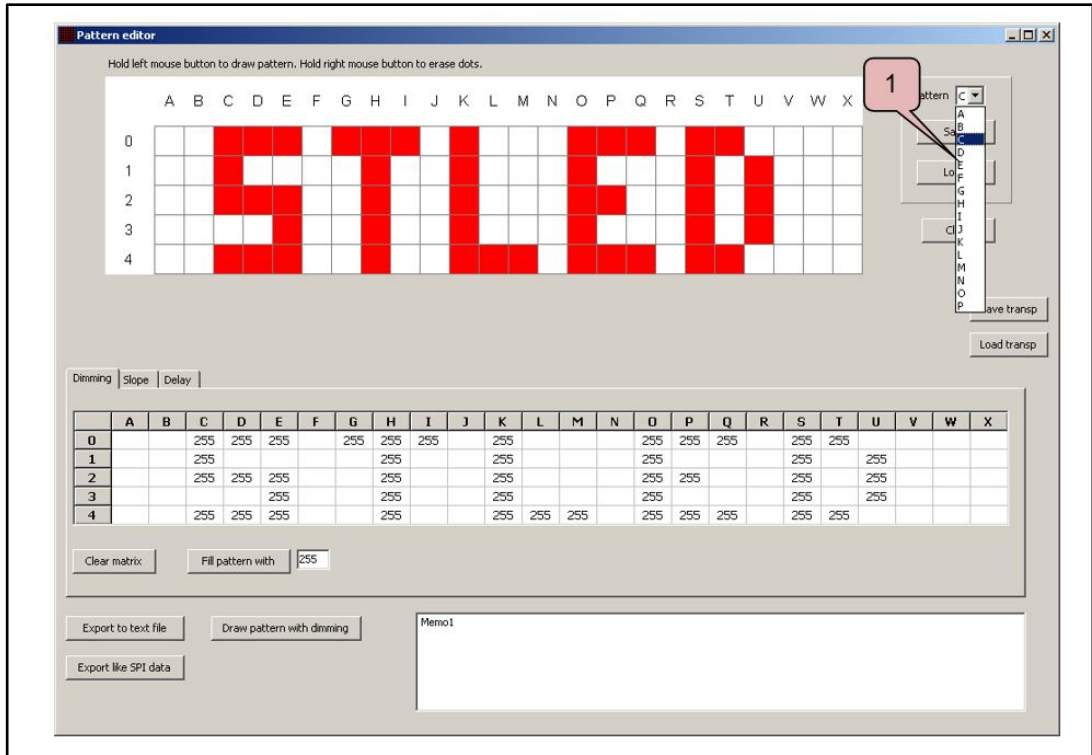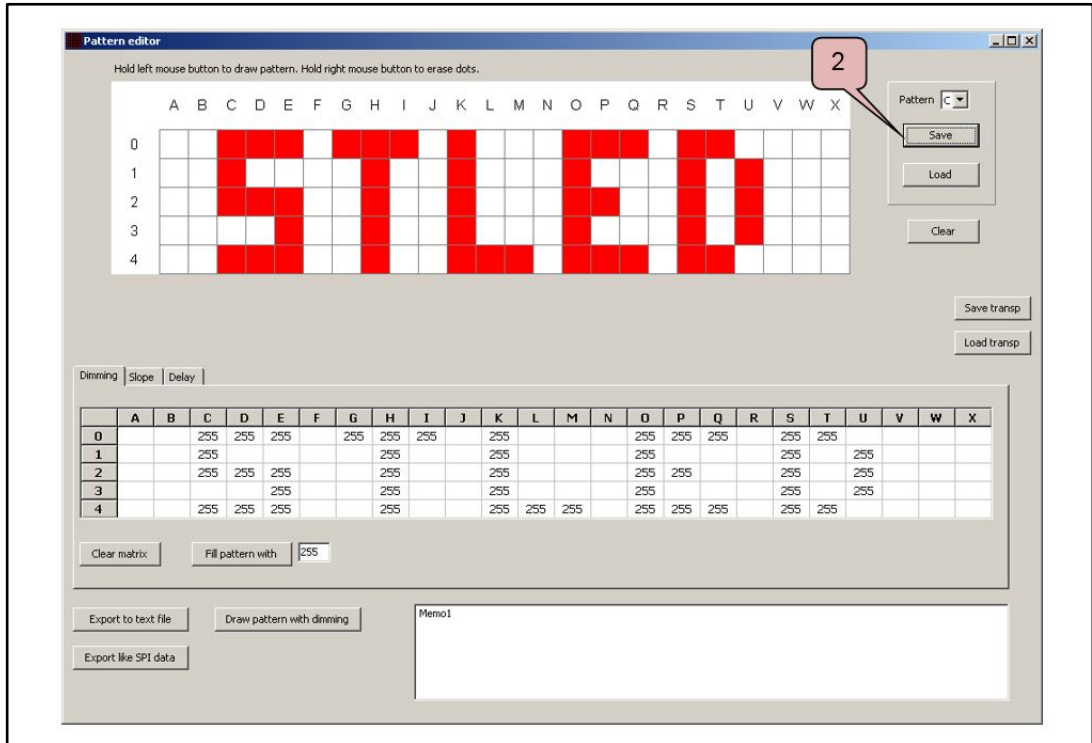
Figure 21: Saving patterns 1

Figure 22: Saving patterns 2

Loading patterns:

1.   Choose the slot (A-X) from which the pattern will be loaded.
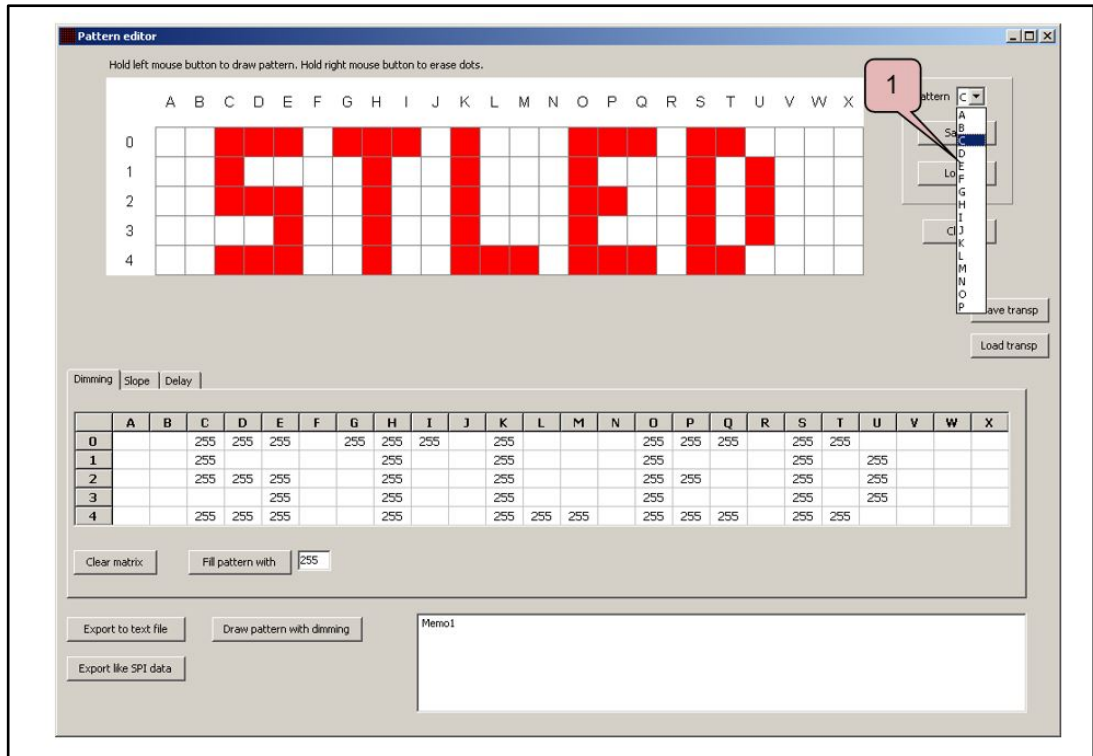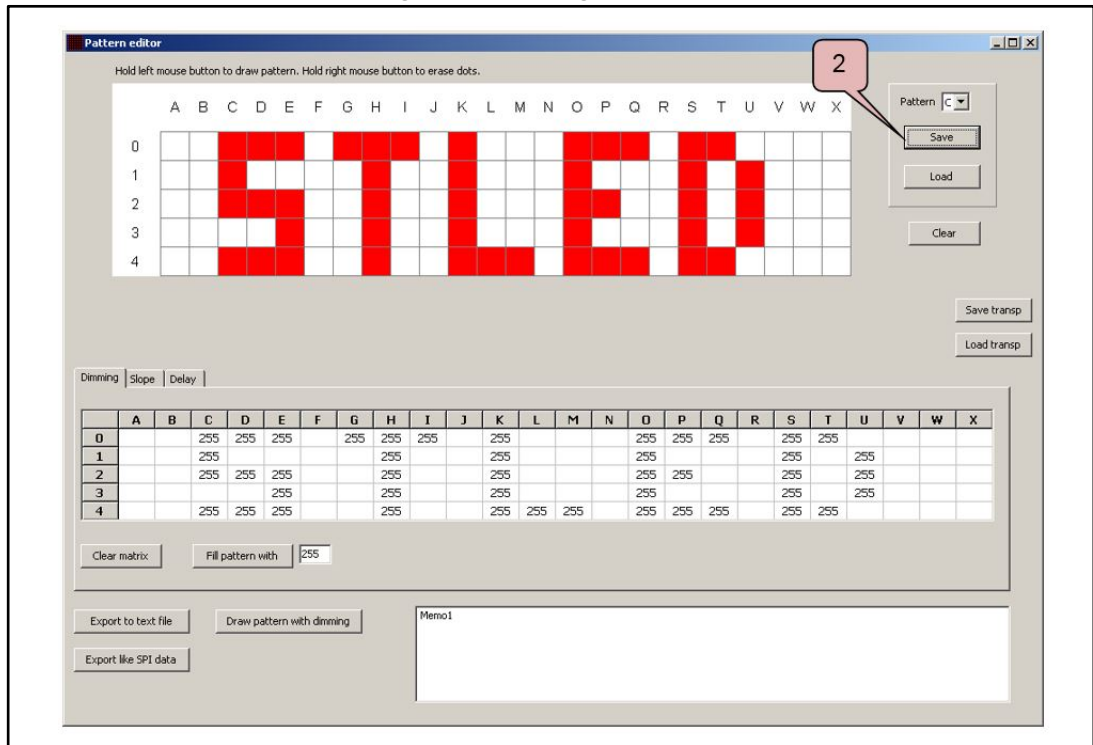2.   Click the "Load" button.

Figure 23: Loading patterns 1


Figure 24: Loading patterns 2

5.2 Double board

5.2.1 How to get started

1 Connect the power supply and adjust jumpers according to *Figure 5: "Single connection application diagram"*

2 Connect the USB control board to the single evaluation board according to *Figure 9: "Single STLED524 connected to a USB control board"*

3 Connect the USB control board to a PC by a USB cable (A-B mini type)

4 Wait until your computer enumerates the control board and displays the message that a new hardware has been found and is ready to use. This message is displayed only once, when the board is connected for the first time. Then run the STLED524_D_v1.01 (or higher). The GUI main window is shown: most buttons are disabled as the "Connect ARM board" button has not been clicked yet.

Figure 25: STLED524_D application main window
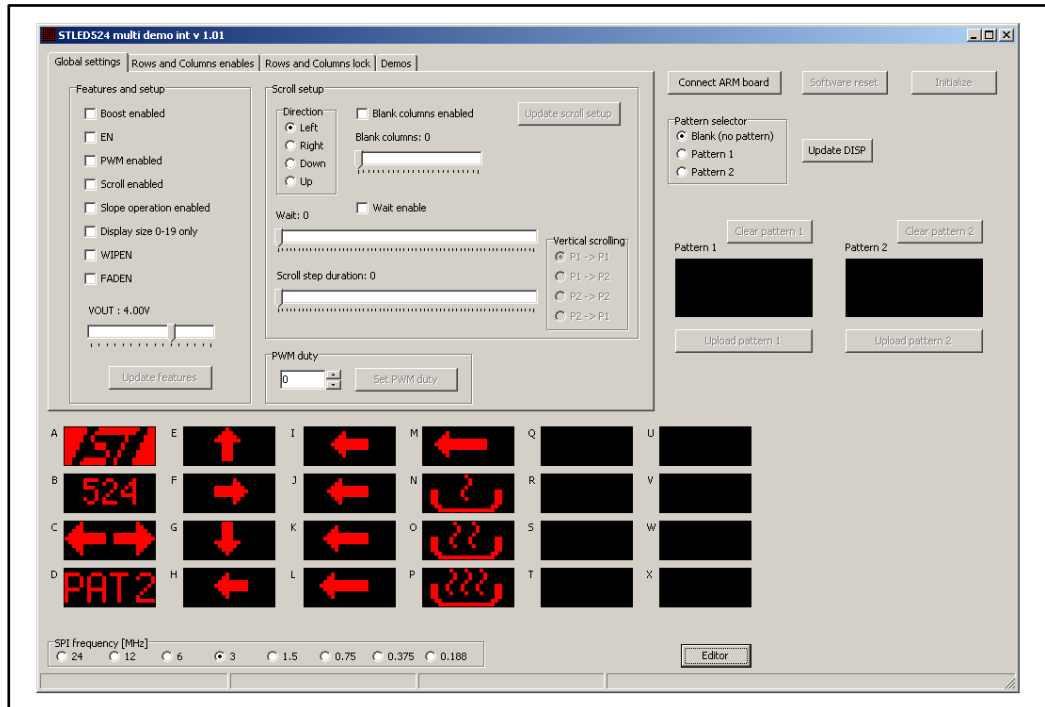
5   If the STM32 evaluation board is connected and "Connect ARM board" button is clicked, the GUI starts communicating with the USB control board and the disabled buttons are enabled.

Figure 26: STLED524_D application window: USB control board successful communication
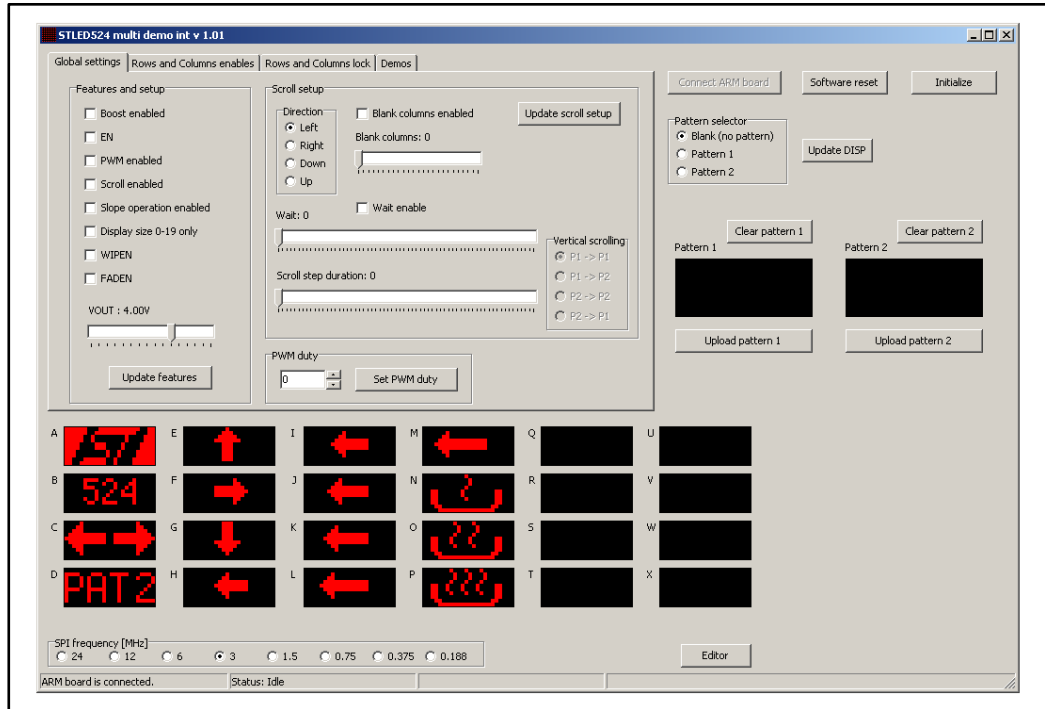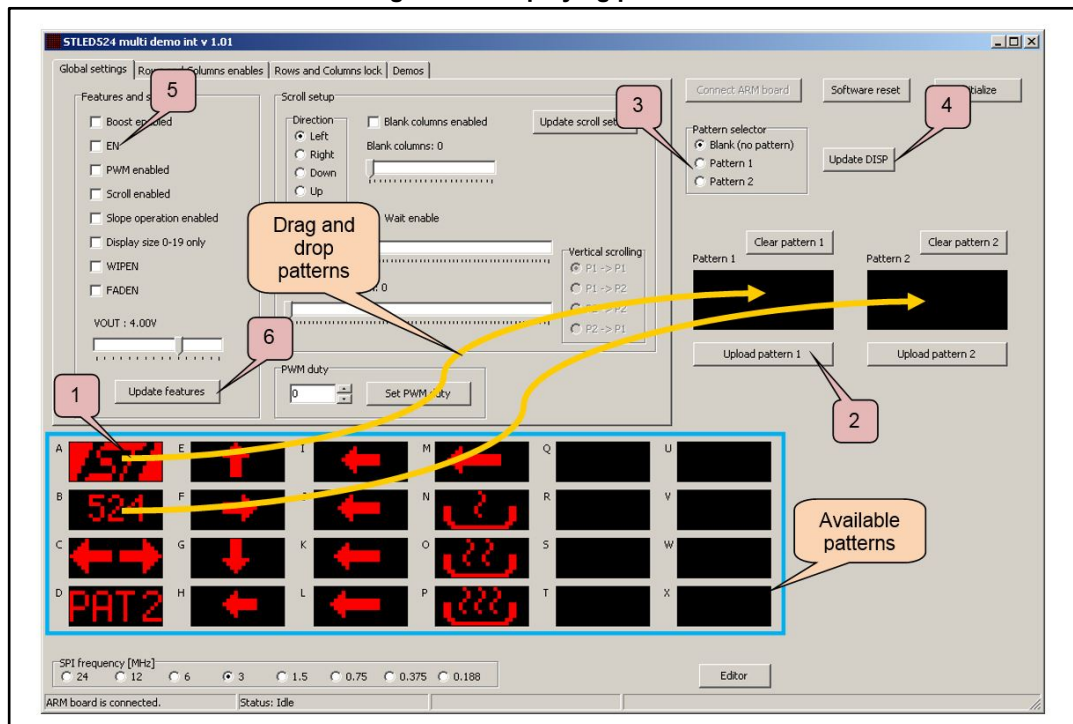
5.2.2 How to display a pattern

All the available patterns that can be displayed are shown in *Figure 27: "Displaying patterns"*.

STLED524 internal memory incorporates two patterns.

The procedure to upload patterns is:

1. Drag and drop patterns into 1 or 2 pattern boxes
2. Upload the patterns into STLED524
3. Choose the pattern to display
4. Confirm choice by the "Update DISP" button
5. Tick the EN bit
6. Press the "Update features" button

Figure 27: Displaying patterns

If you want to switch the display to the second pattern, simply choose it in the pattern selector and click the "Update DISP" button. The change is immediate.

The content of any pattern (1 or 2) can be changed anytime, even if the display driver is enabled.

Suppose pattern 2 is displayed. If a new pattern is dragged and dropped into the pattern 2 box and the "Upload pattern 2" button is clicked, the content of pattern 2 is immediately changed.

The display can be turned off in three ways:

1. Set the EN bit to zero and press the "Update registers" button.
2. Choose the blank pattern in the pattern selector and click the "Update DISP" button.
3. Clear the pattern by clicking the "Clear pattern 1" or "Clear pattern 2" buttons.
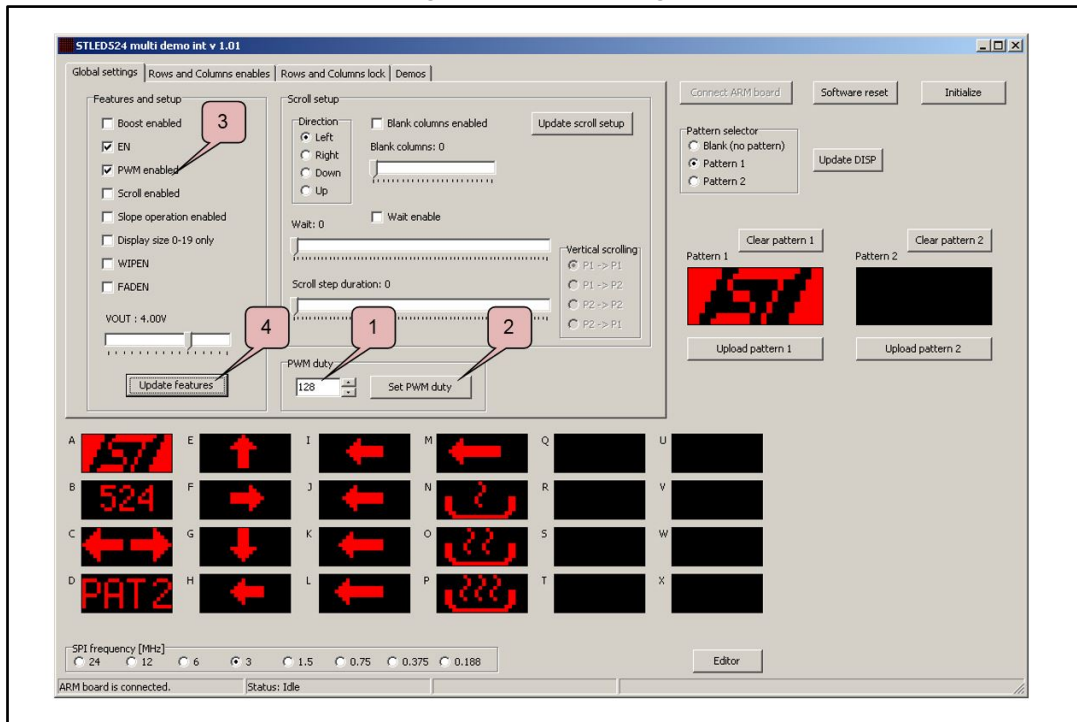
5.2.3 Controlling PWM

STLED524 is able to control display brightness by PWM, that can be set in a range from 0 to 255/255.

To set the PWM duty cycle and enable PWM operation:

1. Set the PWM duty by typing the nominator of the x/255 duty cycle value.
2. Check the "PWM enabled" checkbox.
3. Click the "Update registers" button.

Figure 28: PWM settings

If the PWM is already enabled, the duty cycle can be changed by steps 1 – 2 only.

1. Uncheck the "PWM enabled" checkbox.
2. Press the "Update features" button.

5.2.4 Enabling slope operation

The slope operation works only if the displayed pattern contains non-zero values of slope bits. If a pattern that supports the slope operation is already displayed, you can start the slope operation by:

1. Checking the "Slope operation" checkbox.
2. Pressing the "Update features" button.

Figure 29: Slope operation
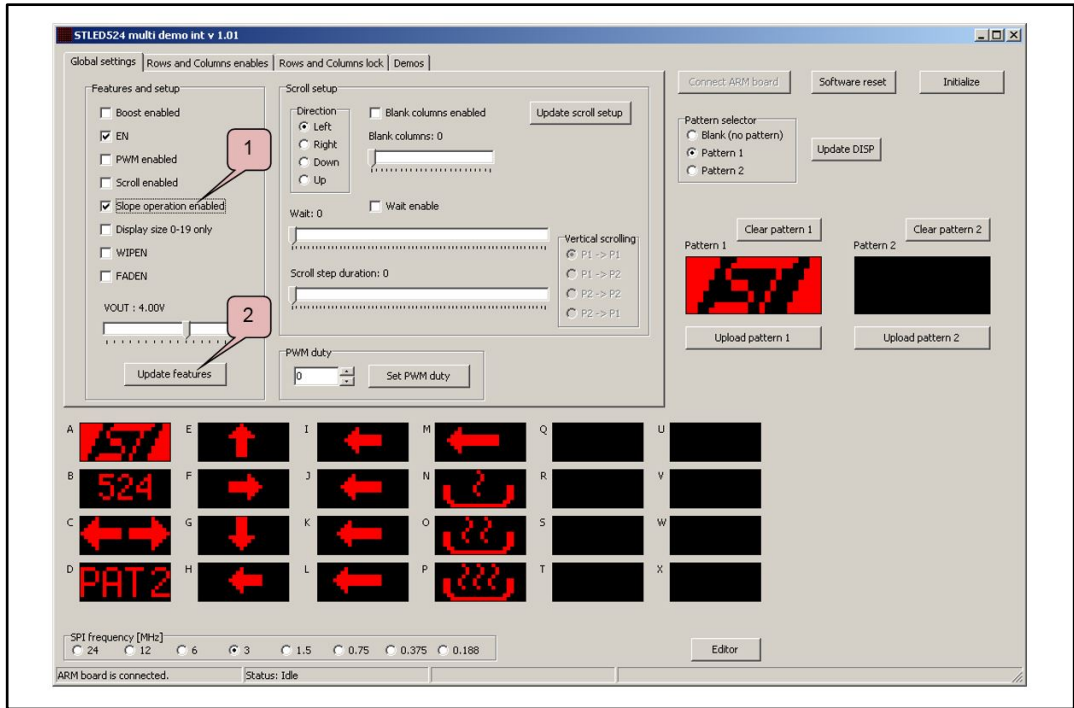
To stop the slope operation:

1. Uncheck the "Slope operation" checkbox.
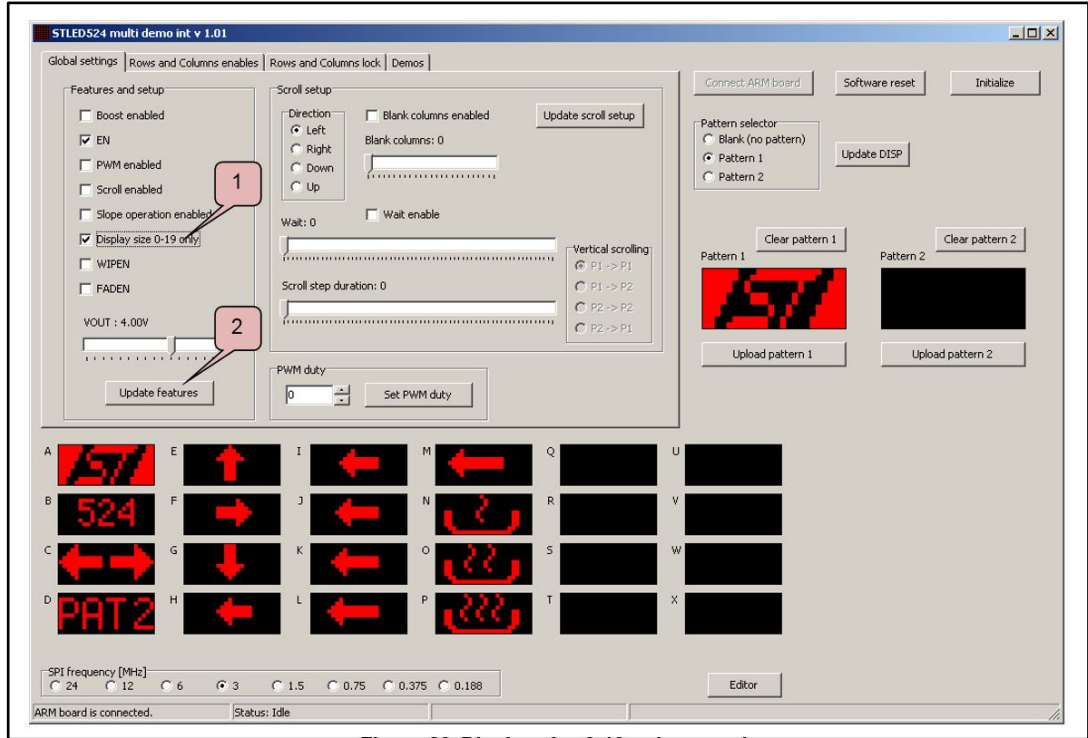2. Press the "Update features" button.

5.2.5 Display size columns 0-19 only

When enabling this feature, the display size is limited to 20 columns only. Columns 20-23 permanently display the content of pattern 1 regardless of the DISP bits settings.

To turn the "Display size 0-19" feature on:

1. Check the "Display size 0-19 only" checkbox.
2. Click the "Update features" button.

Figure 30: Slope operation

The display size is set back to 24 columns by the following steps:

1. Uncheck the "Display size 0-19 only" checkbox.
2. Click the "Update features" button.

5.2.6   Scrolling feature

The scrolling feature is active, only after checking the "Scroll enabled" checkbox, choosing the"Scrolling setup" tab and clicking the "Update DISP" button.

Before enabling the scrolling feature, it is recommended to setup its parameters in the scroll setup section.

Any change in the "Scrolling setup" section takes effect only after clicking the "Update scroll setup" button and after the setup modification.

Scrolling direction: STLED524 supports a four-way scrolling without any microcontroller support.

Scrolling speed: the scrolling speed is adjusted by the "Scroll speed" track bar.

Blank columns and rows: in some cases the display content is easier to read, if some blank columns are inserted between patterns. To insert blank columns click the "Blank rows/cols enable" checkbox. Then, adjust the number of blank columns and rows by the "Blank columns" and "Blank rows" track bars.

Waiting time: the waiting time has no visual effect. It only delays the "end of scroll" interrupt.The display content scrolling starts when the target pattern is selected in the "Pattern selector" and the "Update DISP" button is clicked.

**Figure 31: Scrolling setup**
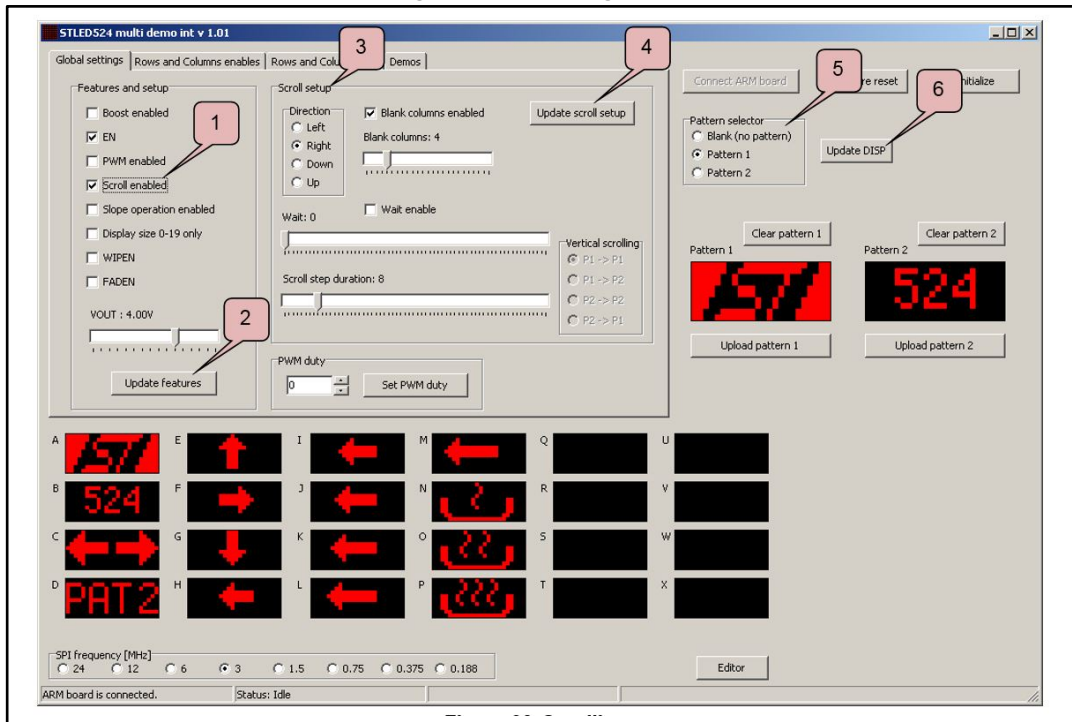
5.2.7 Wipe feature

The wipe feature is active, only after checking the "WIPEN" checkbox and clicking the "Update registers" button.

The wipe feature has some settings in common with the scrolling feature: "Direction" and "Scroll speed". The direction is limited to left/right only. Setting the direction to up or down leads to wipe feature wrong functionality. The "Scroll speed" determines the speed of the wipe feature. After this settings, click the "Update scroll setup" button.

Similarly to the scrolling, the wipe operation is started by choosing a pattern in the pattern selector and clicking the "Update DISP" button.

Figure 32: Wipe setup
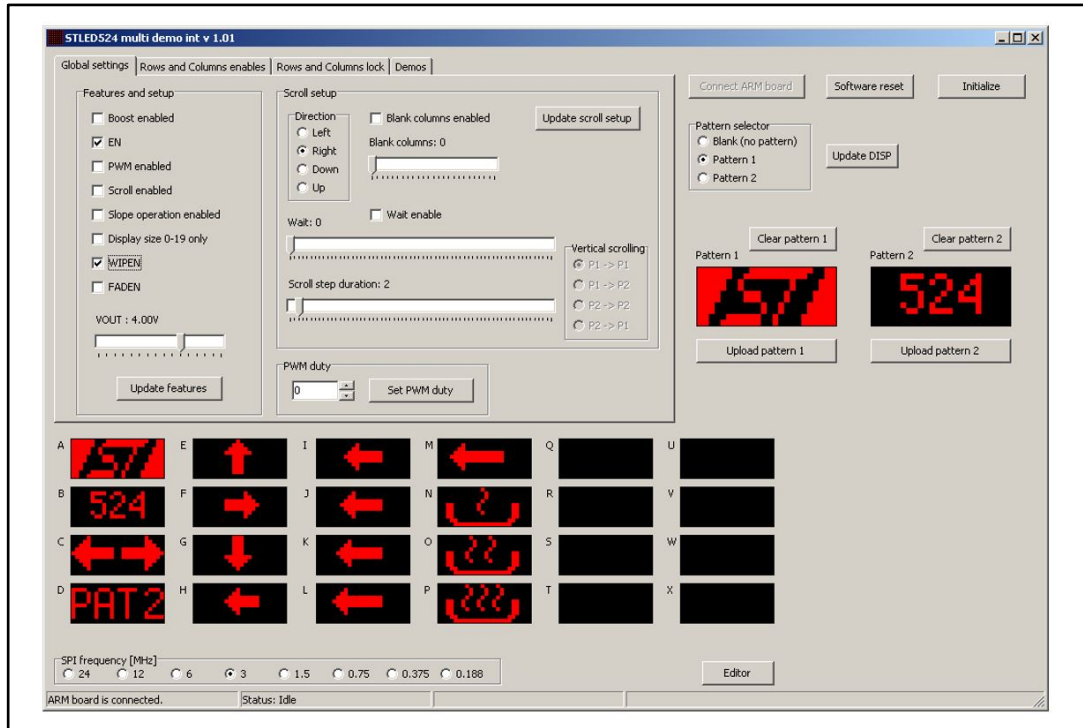
5.2.8 Fade feature

The fade feature is active, only after checking the "FADEN" checkbox and clicking the "Update registers" button. No other setting is required.

The fade feature starts when the displayed pattern is changed clicking the "Update DISP" button.

5.2.9 Pattern editor

You can open the pattern editor by clicking the "Editor" button. All the other settings are the same as the ones described in *Section 5.1.8: "Pattern editor"*.

6   Schematic diagrams

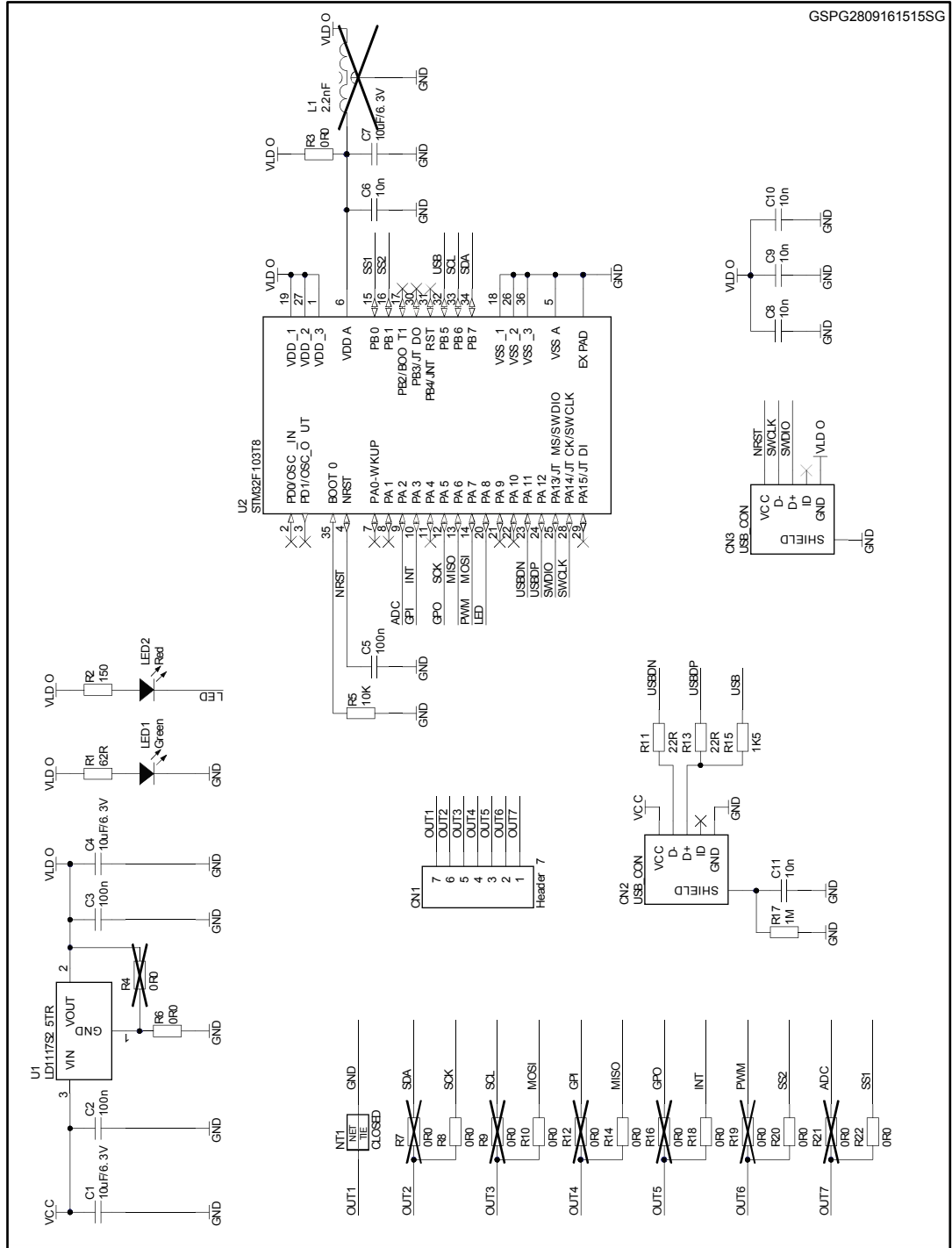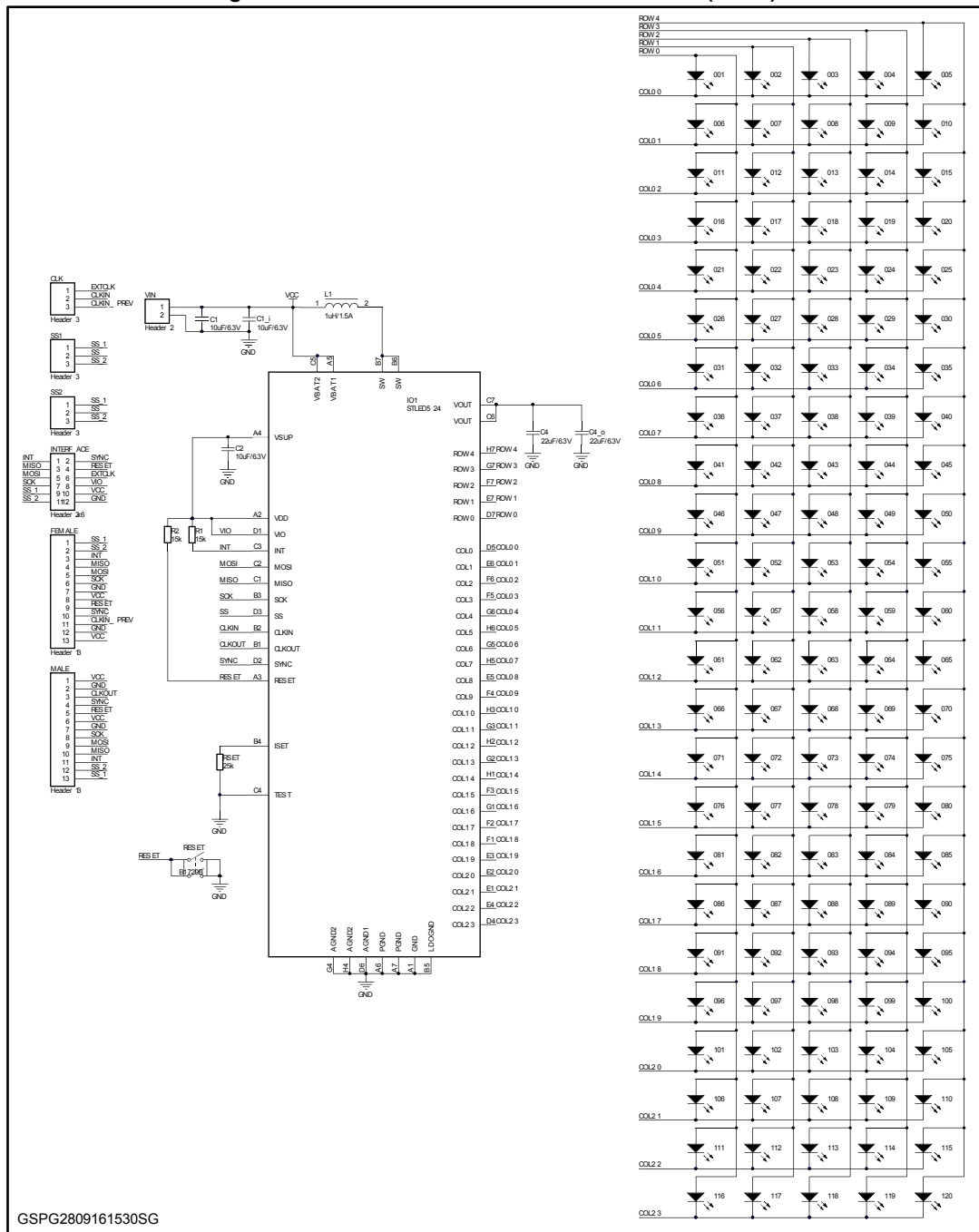**Figure 33: STEVAL-LLL001V1 circuit schematic (1 of 2)**

Figure 34: STEVAL-LLL001V1 circuit schematic (2 of 2)

GSPG2809161530SG

7   Bill of materials

Table 6: STEVAL-LLL001V1 evaluation board bill of materials

Item	Q.ty	Reference	Value	Description	Part number	Manufacturer
1	3	C1,C1_i,C2	10 µF, 6.3 V, ± 20%	MLCC, 0603	GRM188R60J106ME84D	Murata
2	2	C4,C4_o	22 µF, 6.3 V, ± 20%	MLCC, 0805	GRM21AR60J226ME47L	Murata
3	1	IO1	-	CSP 56 bumps, 3.4x3 mm	STLED524	ST
4	1	L1	1 µH, 1.5 A, ± 10%	Power inductor, 2.5x2x1.1 mm	LQM2HPN1R0MJC	Murata
5	120	001 – 120	20 mA	White LED, 0805	Any	Any
6	2	R1, R2	15 k	0603	Any	Any
7	1	RSET	25 k	0603	Any	Any
8	1	RESET	-	DPST switch	B1720B	Any
9	1	CLK,SS1,SS2	-	Header 2-pin, 2.54 mm, male	Any	Any
10	3	VIN	-	Header 3-pin, 2.54 mm, male	Any	Any
11	1	Male	-	Header 6-pin, 90°, 2.54 mm, male	Any	Any
12	1	Female	-	Header 6-pin, 90°, 2.54 mm, female	Any	Any
13	1	Interface	-	Header 2x6-pin, 2.54 mm, male	Any	Any

8   PCB layout

Figure 35: STEVAL-LLL001V1 evaluation board - top layer
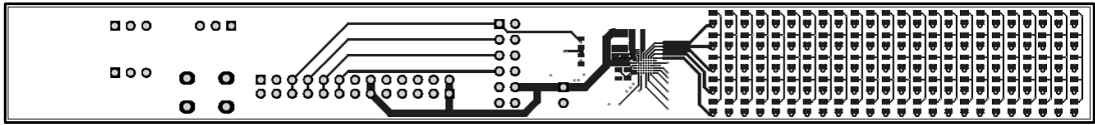
Figure 36: STEVAL-LLL001V1 evaluation board - mid layer 1
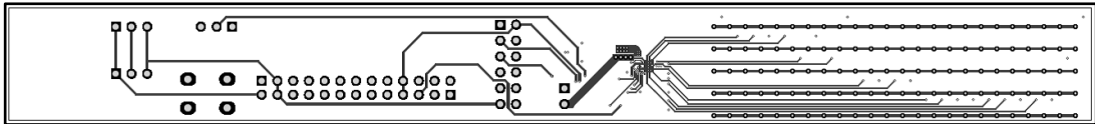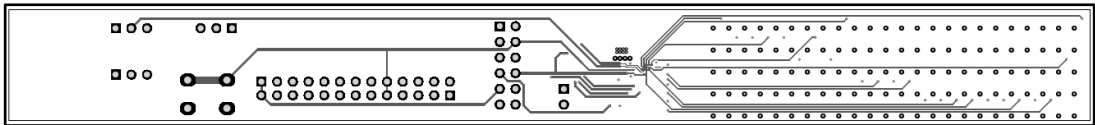

Figure 37: STEVAL-LLL001V1 evaluation board - mid layer 2

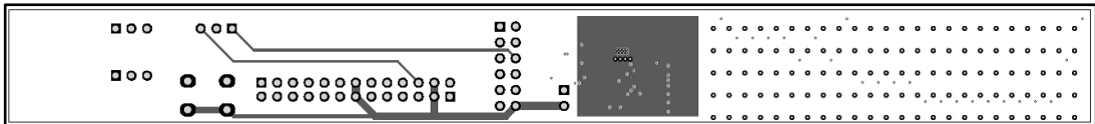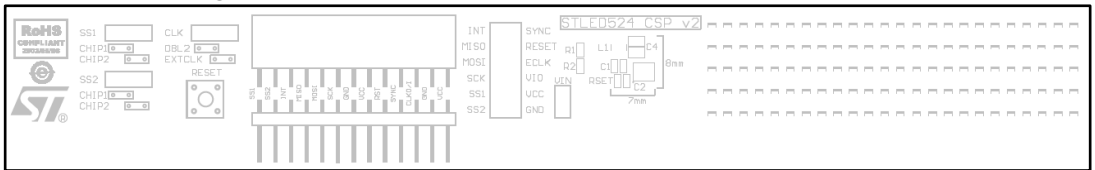**Figure 38: STEVAL-LLL001V1 evaluation board - bottom layer**

Figure 39: STEVAL-LLL001V1 evaluation board - components

9 Revision history

Table 7: Document revision history

Date	Version	Changes
14-Nov-2016	1	Initial release.

IMPORTANT NOTICE – PLEASE READ CAREFULLY