
**EVAL6474H-DISC: fully integrated microstepping motor driver
based on the L6474 and STM32™**

Introduction

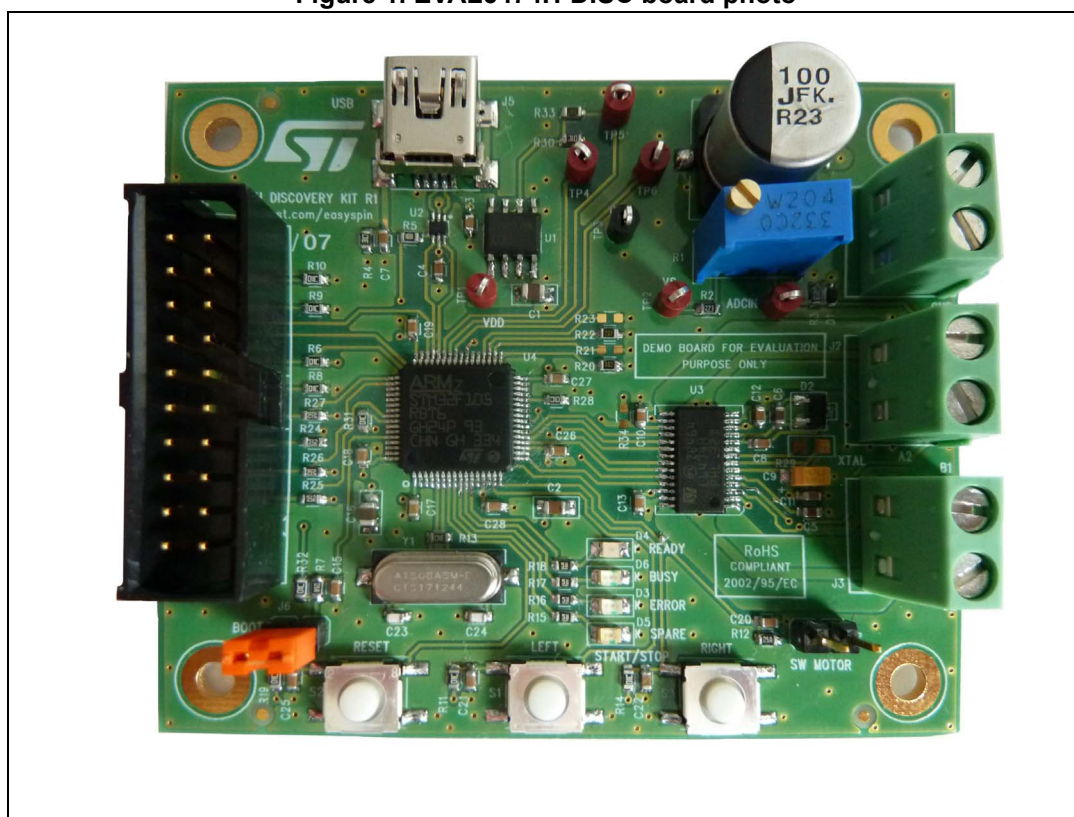
The EVAL6474H-DISC is a low cost development tool based on the L6474 and STM32™.

It is an ideal starter kit for both beginners and experienced users, it is autonomous and can be used with a software interface, or it can be used with custom firmware thanks to the embedded microcontroller with the 128 kB Flash memory and 64 kB RAM.

Through the available GUI the user can easily set the full configuration of application parameters.

There are “Plug and Play” tools suitable for high power solutions thanks to the wide operating voltage range from 8 V to 45 V and the current capability up to 3 A_{r.m.s.}

Figure 1. EVAL6474H-DISC board photo



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1 Main features

The characteristics of the EVAL6474H-DISC are the following:

- DC voltage range from 8 V to 45 V
- Maximum load phase current at 3 A_{r.m.s.}
- Footprint for external resonator or crystal
- Control interface through trimmer - user keys and switch motor input
- Control through LED indicators
- Interface control by USB and debug outputs
- Compatible with SPINFamily evaluation tool
- Autonomous board due to an embedded firmware
- Up to 1/16 microstepping
- Optimized layout on 2 layers board - low cost and high thermal performance

The possibility with these boards is double:

- Adapt the settings with your specific setup (motor - voltage) by using the dedicated PC application.
 - The user is able to save inside the board the specific parameters depending on user setup
- Using the board (with user parameters) directly on site - without a connected PC.

2 Board specifications

Table 1. Electrical specifications

Name	Value
Supply voltage (V_S)	8 to 45 V
Maximum output current (each phase)	3 A _{r.m.s}
Logic supply voltage (V_{REG})	3 V (L6474 regulator supply)
Logic interface voltage (V_{DD})	3.3 V (USB supply)
Low level logic inputs voltage	0 V
High level logic input voltage	V_{DD}
Stepping	Up to 1/16 microstepping
Operating temperature	0 to 85 °C

Figure 2. Schematic (power supply part)

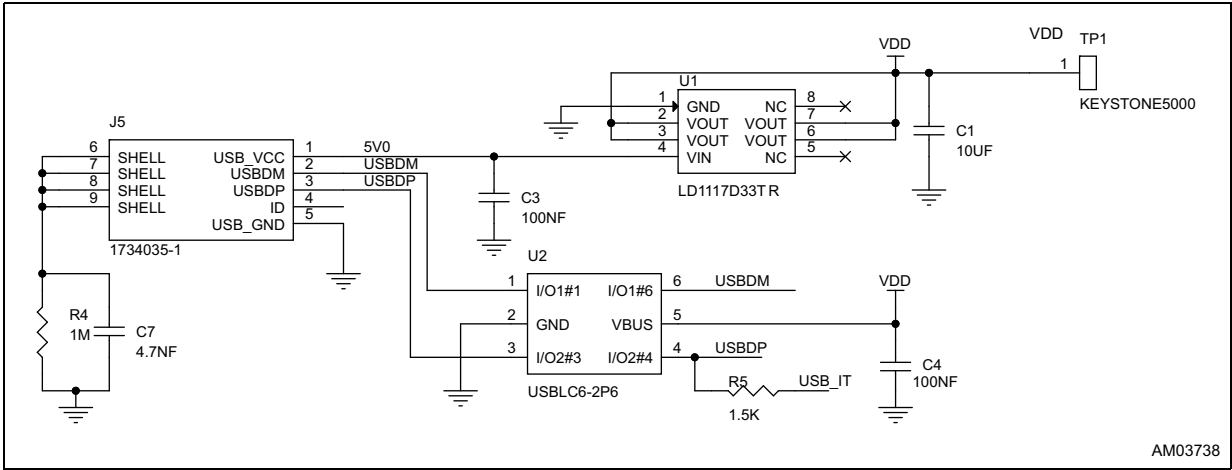
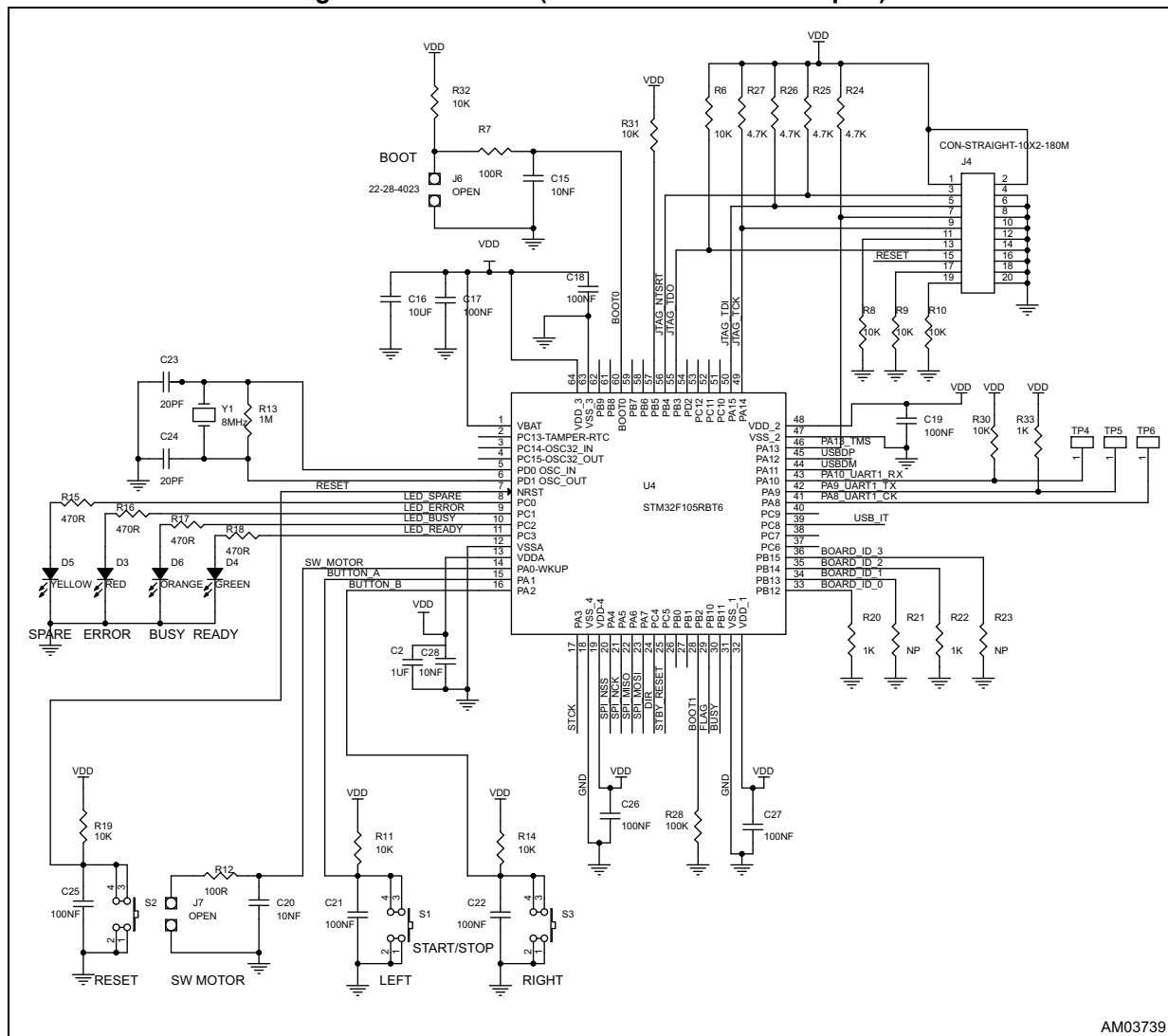
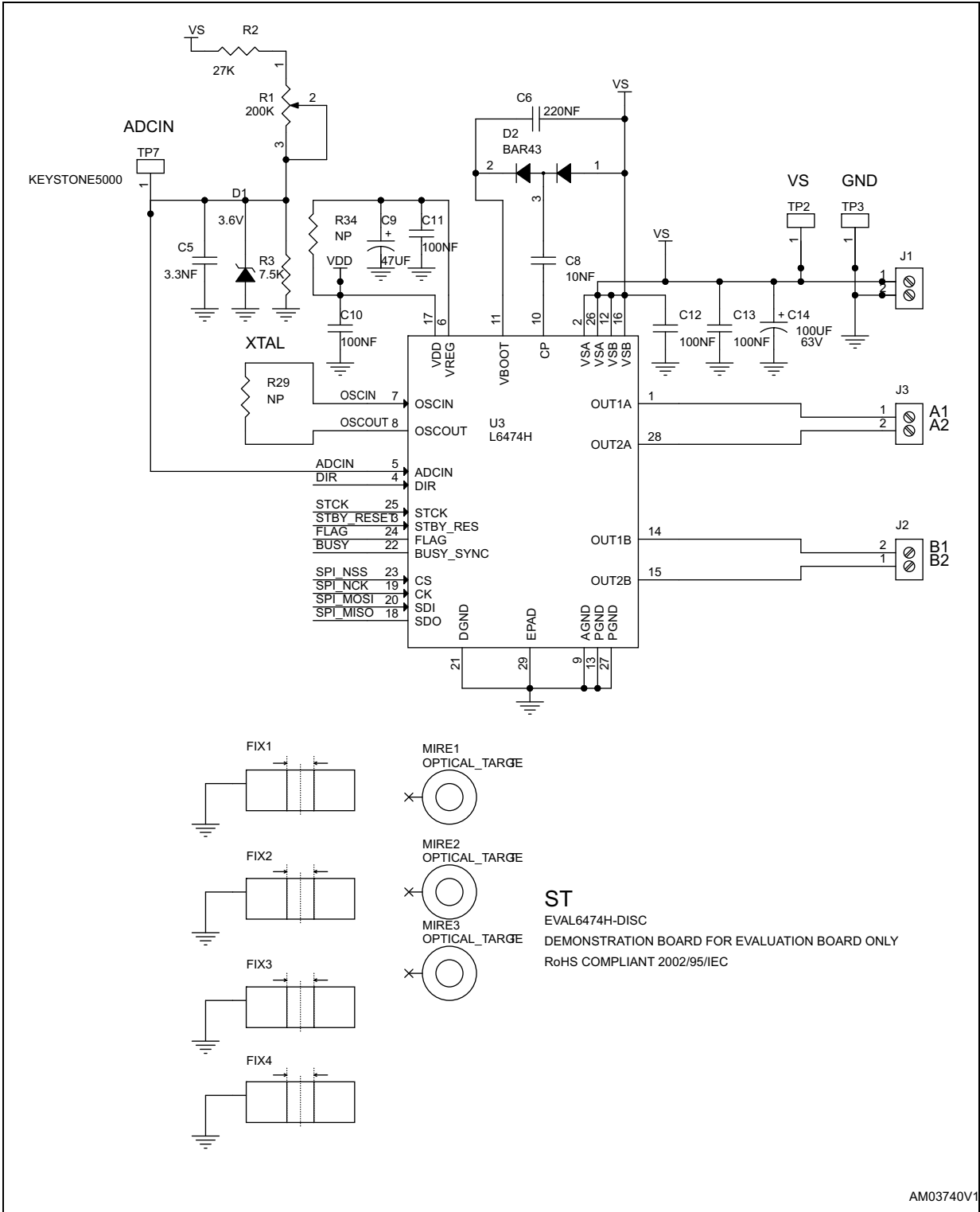


Figure 3. Schematic (microcontroller control part)



AM03739

Figure 4. Schematic (motion control part)



AM03740V1

Figure 5. Layout top layer and bottom layer

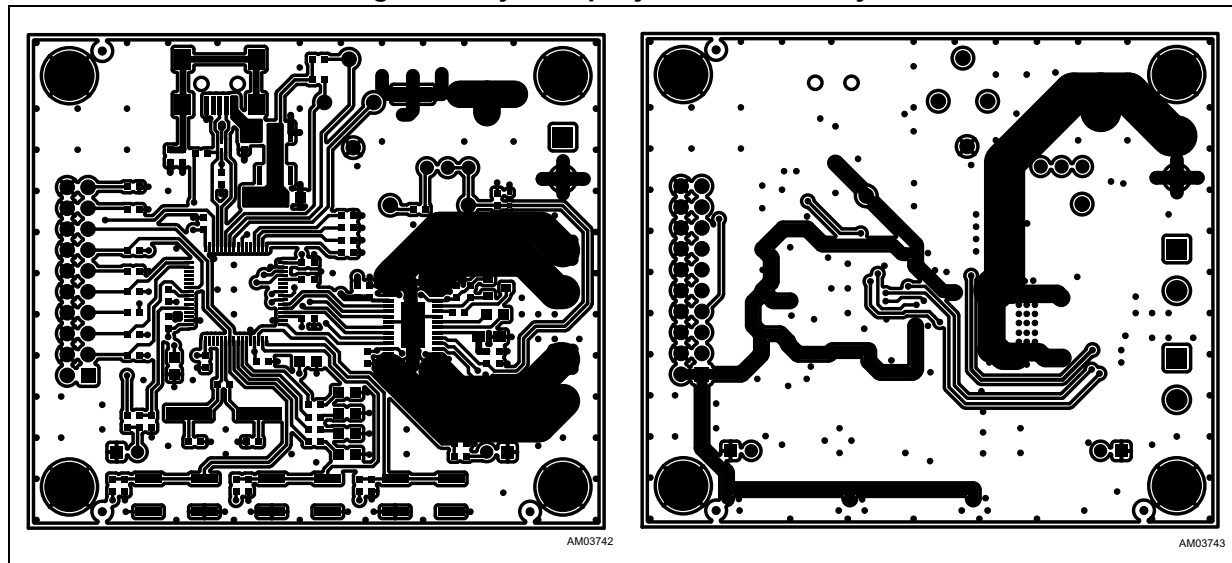


Table 2. Bill of material

Item	Qty.	Reference	Value	Package
C1, C16	2	Cap. cer. 10 μ F 10 V X7R 0805	10 μ F	0805
C2	1	Cap. cer. 1 μ F 10 V X7R 0805	1 μ F	0805
C3, C4, C10 - C13, C17 - C19, C21, C22, C25 - C27	14	Cap. cer. 100 nF 50 V X7R 0603	100 nF	0603
C5	1	Cap. cer. 3.3 nF 50 V X7R 0603	3.3 nF	0603
C6	1	Cap. cer. 220 nF 35 V X7R 0603	220 nF	0603
C7	1	Cap. cer. 4.7 nF 50 V X7R 0603	4.7 nF	0603
C8, C15, C20, C28	4	Cap. cer. 10 nF 50 V X7R 0603	10 nF	0603
C9	1	Cap. tant. 47 μ F 6.3 V 10% PACK-A	47 μ F	3216
C14	1	Cap. elect. 100 μ F 63 V	100 μ F	CAPES-R10HXX
C23, C24	2	Cap. cer. 20 pF 50 V COG 0603	20 pF	0603
D1	1	Zener regulator	3.6 V	SOD 523
D2	1	Double diode high speed switching diode	BAR43	SOT 23
D3	1	LED red - 0805 - 2 mcd - 621 nm	Red	0805
D4	1	LED green - 0805 - 6 mcd - 569 nm	Green	0805
D5	1	LED yellow - 0805 - 6 mcd - 588 nm	Yellow	0805
D6	1	LED orange - 0805 - 2 mcd - 602 nm	Orange	0805
FIX1 - FIX4	4	Hole	3 mn	-
J1 - J3	3	Screw connector 2 poles MKDSN 1.5 /2 - 5.08	MKDSN1.5 /2 - 5.08	MKDSN1.5 /2 - 5.08

Table 2. Bill of material (continued)

Item	Qty.	Reference	Value	Package
J4	1	JTAG CON-FLAT-10 x 2 - 180 M	CON-FLAT - 10 x 2 - 180 M	CON-FLAT - 10 x 2 - 180M
J5	1	USB_B_MINI_AMP_1734035-1	CN-USB	CMS mini-USB
J6, J7	2	JUMP254P-M-2	OPEN	Strip 2 x 2.54
MIRE1 - MIRE3	3	OPTICAL_TARGET	OPTICAL_TARGET	Diam. 1 mn
R1	1	Trimmer 200 K Ω	200 K Ω	Trimm. 100 x 50 x 110
R2	1	27 K Ω 5% 1/10 W	27 K Ω	0603
R3	1	Res. 7.5 K Ω 5% 1/10 W 0603 SMD	7.5 K Ω	0603
R4, R13	2	Res. 1 M Ω 1/10 W 5% 0603 SMD	1 M Ω	0603
R5	1	Res. 1.5 K Ω 1/10 W 5% 0603 SMD	1.5 K Ω	0603
R6, R8 - R11, R14, R19, R30 - R32	10	Res. 10 K Ω 5% 1/10 W 0603 SMD	10 K Ω	0603
R7, R12	2	Res. 100 Ω 5% 1/10 W	100 Ω	0603
R15 - R18	4	Res. 470 Ω 5% 1/10 W 0603	470 Ω	0603
R20, R22, R33	3	Res. 1 K Ω 5% 1/10 W 0603 SMD	1 K Ω	0603
R21, R23, R34	3	Res. NP 0603	NP	0603
R24 - R27	4	Res. 4.7 K Ω 5% 1/10 W 0603 SMD	4.7 K Ω	0603
R28	1	Res. 100 K Ω 5% 1/10 W 0603 SMD	100 K Ω	0603
R29	1	Res. NP 0805	NP	0805
S1 - S3	3	Switch button SMD	EVQQ2D03W	CMS 6.5 x 6 x 3.1
TP1, TP2, TP4 - TP7	6	Test point red	Keystone-5000	TH
TP3	1	Test point black	Keystone-5001	TH
U1	1	IC REG 1300 MA LN 3.3 V	LD1117D33TR	SO8
U2	1	UBSLC6-2P6 - ESD protection low capacitance	USBLC6-2P6	SOT 666
U3	1	L6474 microstepping motor driven	L6474	HTSSOP28
U4	1	IC, MCU, RISC, 72 MHz, 3.6 V, 32-bit, 64-pin, LQFP	STM32F105RBT6	LQFP64 10 x 10
Y1	1	Xtal 8 MHz - 30 PPM - 20 pF	8 MHz	HC49/US-SM

3 General description

3.1 Power supply

The EVAL6474H-DISC board is designed to be powered via:

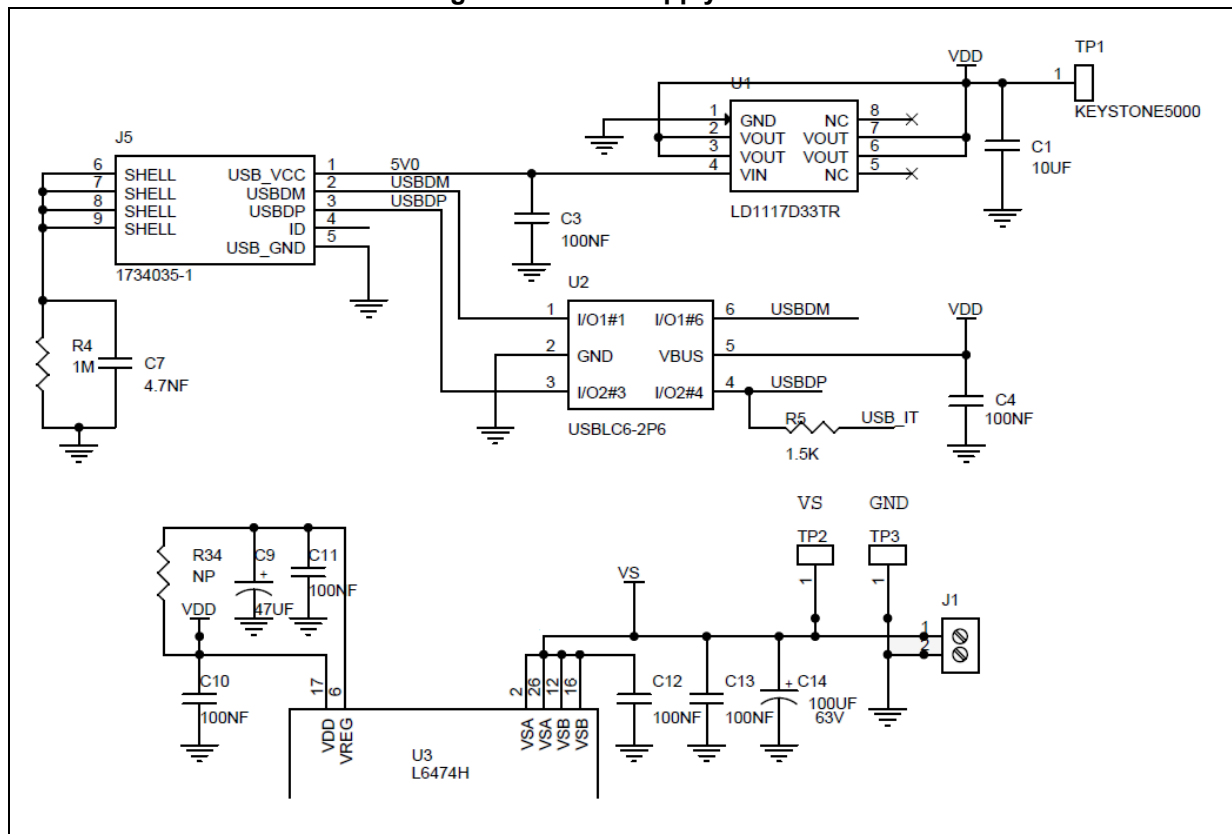
- Connector J1: power of the motor and also motor control driver
- USB connector J5: power of microcontroller and logic control

The USB cable supplies the digital part through a dedicated LDO (U1) providing 3.3 V.

The motor power must be set according the voltage required by the user motor.

Note: *Both the supply sources (USB connector and J1 connector) must be present to make the board operative.*

Figure 6. Power supply section



3.2 L6474 stepper motor controller

Features

- Operating voltage: 8 - 45 V
- 7.0 A out peak current (3.0 A $r.m.s.$)
- Low $R_{DS(on)}$ power MOSFETs
- Programmable power MOS slew-rate
- Up to 1/16 microstepping
- Current control with adaptive decay
- Non-dissipative current sensing
- Integrated voltage regulators
- SPI interface
- Low quiescent standby currents
- Programmable non-dissipative overcurrent
- Overtemperature protection

Figure 7. L6474 block diagram

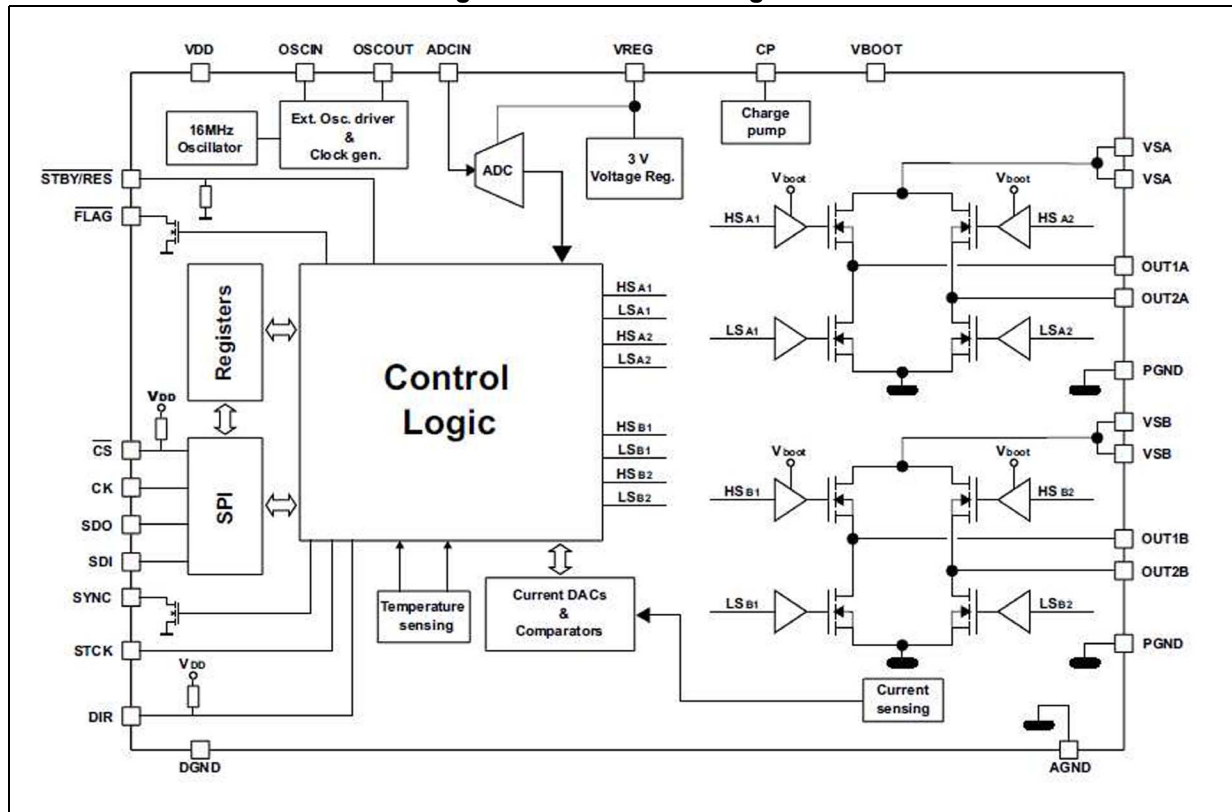


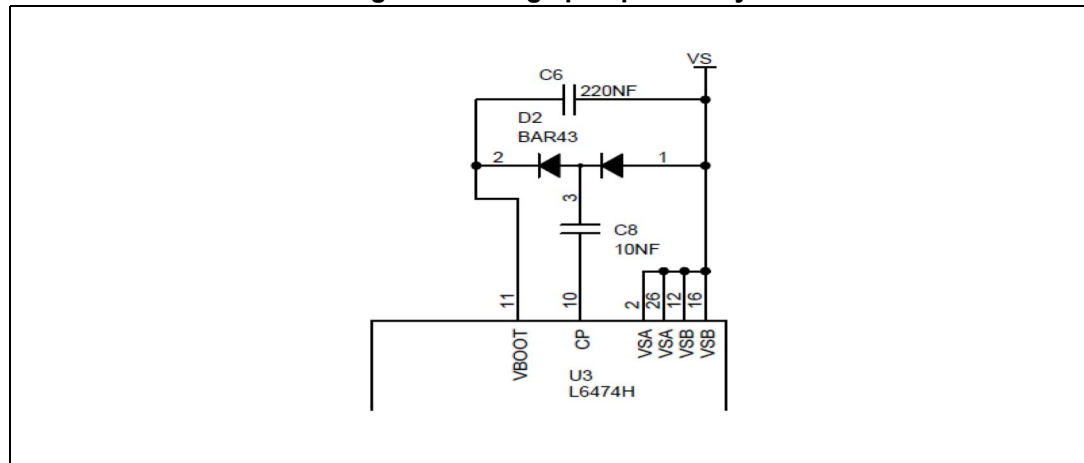
Table 3. Recommended operating conditions

Symbol	Parameter	Test condition	Value	Unit
V_{DD}	Logic Interface supply voltage		3.3	V
V_S	Motor supply voltage	$V_{SA} = V_{SB} = V_S$	$8 \div 45$	V
V_{OUT_diff}	Differential voltage between V_{SA} , OUT1 _A , OUT2 _A , PGND and V_{SB} , OUT1 _B , OUT2 _B , PGND pins	$V_{SA} = V_{SB} = V_S$	Up to 45	V
$V_{REG\ in}$	Logic supply voltage	V_{REG} internal	3	V
V_{ADC}	Integrated ADC input voltage range (ADCIN pin)		$0 \div V_{REG}$	V

3.3 Charge pump

The L6474 device uses an internal charge pump for driving correctly the integrated MOSFETs, a voltage higher than the motor power supply. The charge pump is obtained through an oscillator and few external components.

Figure 8. Charge pump circuitry



4 Device configuration

This section offers an overview of the basic configuration steps which are required to make the demonstration board operative.

Warning: Important - the device configuration is mandatory. The default configuration is not operative. Before changing the device configuration verify that the device is in high impedance status (power stage is disabled).

4.1 Advanced current control

The following configuration gives good results with most of motors:

Table 4. Phase current control

Parameter	Value	Unit
Minimum ON time	4	μs
Minimum OFF time	21	μs
Maximum fast decay (TOFF_FAST)	10	μs
Maximum fast decay at step change (FAST_STEP)	16	μs
Target switching time	48	μs

The impacts of the timing parameters are explained in the application note AN4158- "Peak current control with automatic decay adjustment and predictive current control: basics and setup".

4.2 Overcurrent protection

The overcurrent protection detection is implemented by measuring the current flowing into each integrated MOSFET.

The overcurrent protection threshold should be set just above the current rating of the motor:

$$I_{\text{OCDth}} > I_{\text{max,r.m.s.}} \times \sqrt{2}$$

For example: if the maximum phase current of the motor is 2 A_{r.m.s.}, the overcurrent protection should be set to about 3 A.

Warning: Important - it is strongly discouraged to disable the overcurrent shutdown. It may result in critical failures.

Figure 9. Overcurrent protection

Overcurrent threshold

Over-current shutdown ☒

Alarm enabled:

- ☒ Over-current detection
- ☒ Thermal shutdown
- ☒ Thermal warning
- ☒ Under voltage lock out
- ☐ UNUSED
- ☐ UNUSED
- ☒ Switch turn-on event (SW falling edge)
- ☒ Wrong or not performable command

4.3 Speed profile

The max. speed parameter is the maximum speed the motor will run. By default, it is about 1000 steps. That means, if you send a command to run at 2000 steps, the motor speed is limited at 1000 steps.

This is an important safety feature in the final application, but not necessarily useful to evaluate the device performances. Setting the parameter to high values (e.g. 6000 steps) allows evaluating the maximum speed which can be achieved by the application under test through the speed tracking command (Run), but it probably limits the possibility to use positioning commands ("Move", "GoTo", etc.).

The "Full step" speed parameter indicates the speed at which the system switches from microstepping to full step operation.

5 Programming section

5.1 STM32F105RB microcontroller

The STM32F105xx device incorporates the high-performance ARM®Cortex™-M3 32-bit RISC core operating at a 72 MHz frequency, high-speed embedded memories (Flash memory up to 256 Kbytes and SRAM 64 Kbytes), and an extensive range of enhanced I/O and peripherals connected to two APB buses. All devices offer two 12-bit ADCs, four general-purpose 16-bit timers plus a PWM timer, as well as standard and advanced communication interfaces: up to two I²Cs, three SPIs, two I2Ss, five USARTs, a USB OTG FS and two CANs.

The STM32F105xx operates in the -40 to +105 °C temperature range, from a 2.0 to 3.6 V power supply. A comprehensive set of power-saving mode allows the design of low-power applications.

The STM32F105xx offers devices in three different package types: from 64 pins to 100 pins. Depending on the device chosen, different sets of peripherals are included.

These features make the STM32F105xx and STM32F107xx connectivity line microcontroller family suitable for a wide range of applications such as motor drives and application control, medical and handheld equipment, industrial applications, PLCs, inverters, printers, and scanners, alarm systems, video intercom, HVAC and home audio equipment.

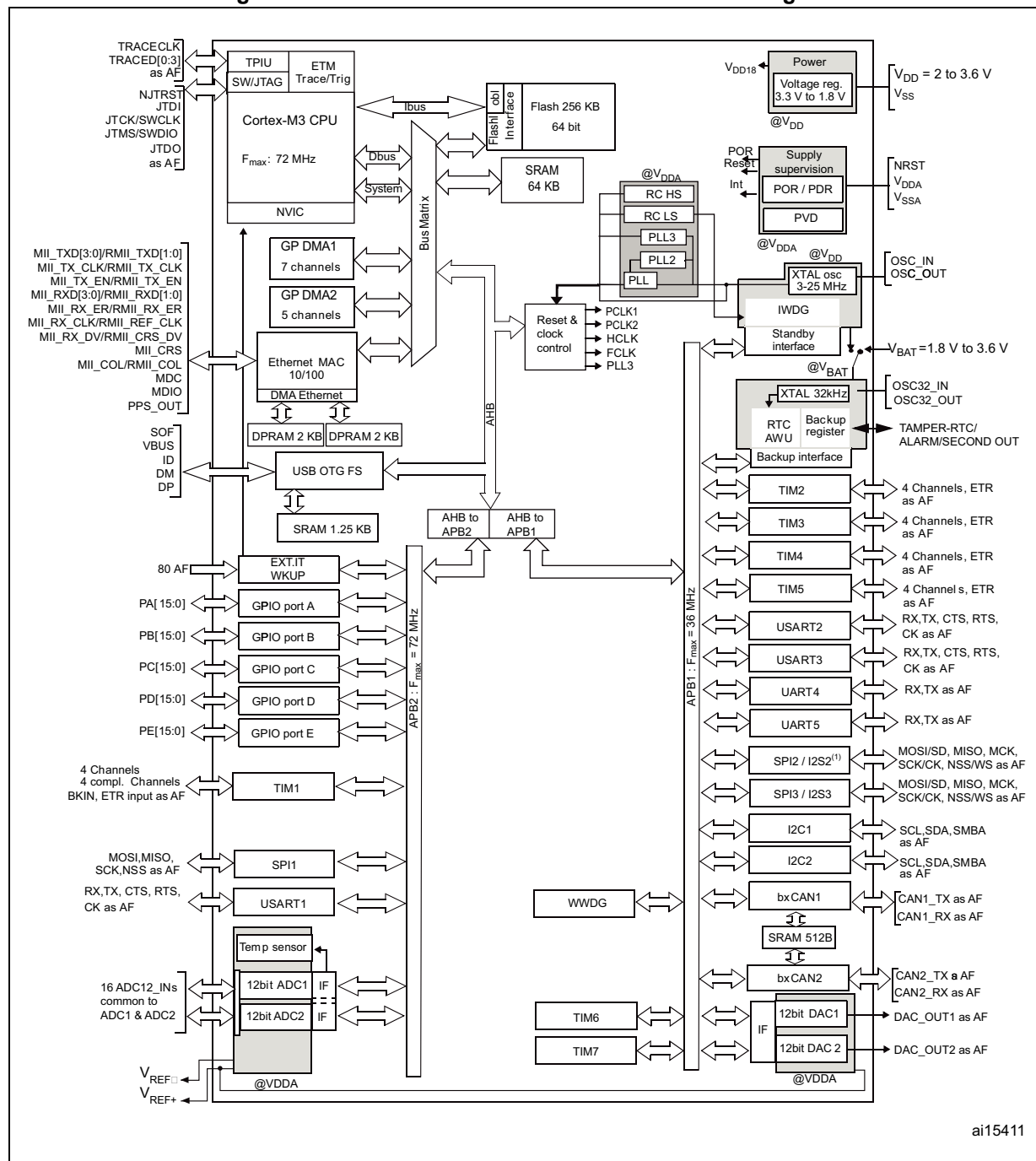
Please refer to the STM32F105xx datasheet for an overview of the complete range of peripherals proposed in this family.

Please refer to the STM32F105xx reference manual RM0008 to get more information on the microcontroller operation.

The STM32F105RBT6 has a 64-pin LQFP package with 128 KBytes Flash memory and operates in the -40 to +85 °C temperature range.

Figure 10 shows the general block diagram of the STM32F105xx and STM32F107xx family.

Figure 10. STM32F105xx and STM32F107xx block diagram



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5.2 Firmware loading

This section describes how to load firmware into the board by using the DfuSe demonstration software.

5.2.1 DfuSe installation

You need first to download the DfuSe demonstration software from www.st.com.

The DfuSe tool is referenced under the development suite STSW-STM32080.

Once downloaded, run the setup.exe file.

More details on the DfuSe are given in the UM0412 - “Getting started with DfuSe USB device firmware upgrade STMicroelectronics extension” user manual.

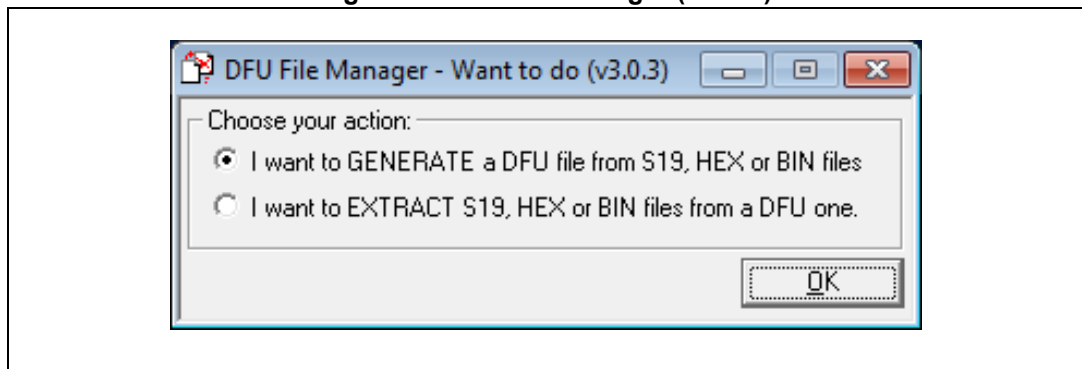
5.2.2 Generate a DFU file from an HEX file

If the file you want to download to the discovery board is not a DFU file but an HEX file, you will need first to convert it.

In this purpose,

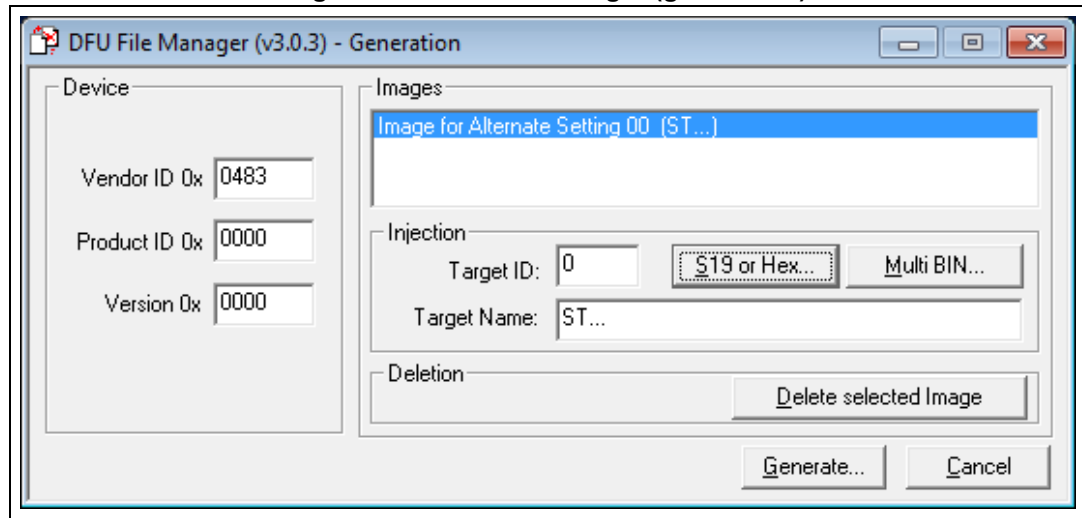
- Start the DFU file manager (V3.0.3 or greater) which has been installed with the DfuSe.
- Choose “I want to GENERATE a DFU file from S19, HEX or BIN files”.

Figure 11. DFU file Manager (action)



- Click “S19 or Hex”... button
- Select in the open dialog box the file of type “hex Files”, select the HEX file and click “OK”.
- Click on the “Generate...” button
- Give a name to the *.DFU file and click on the “Save” button.

Figure 12. DFU File Manager (generation)



5.2.3 Board settings

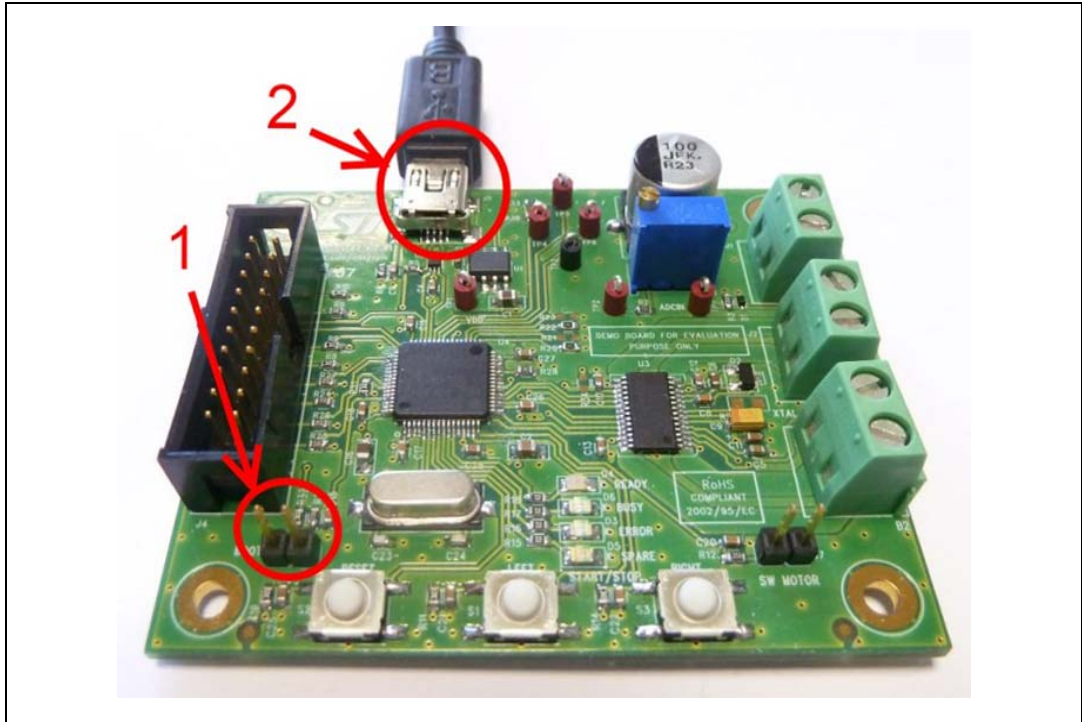
To be able to download firmware, the discovery board should be started in the “DFU” mode.

In this purpose:

1. Remove the jumper from the BOOT pins.
2. Plug a USB cable between the discovery board and the PC.

It does not matter if the discovery board is plugged or not to a 5 - 45 V DC supply.

Figure 13. Board settings

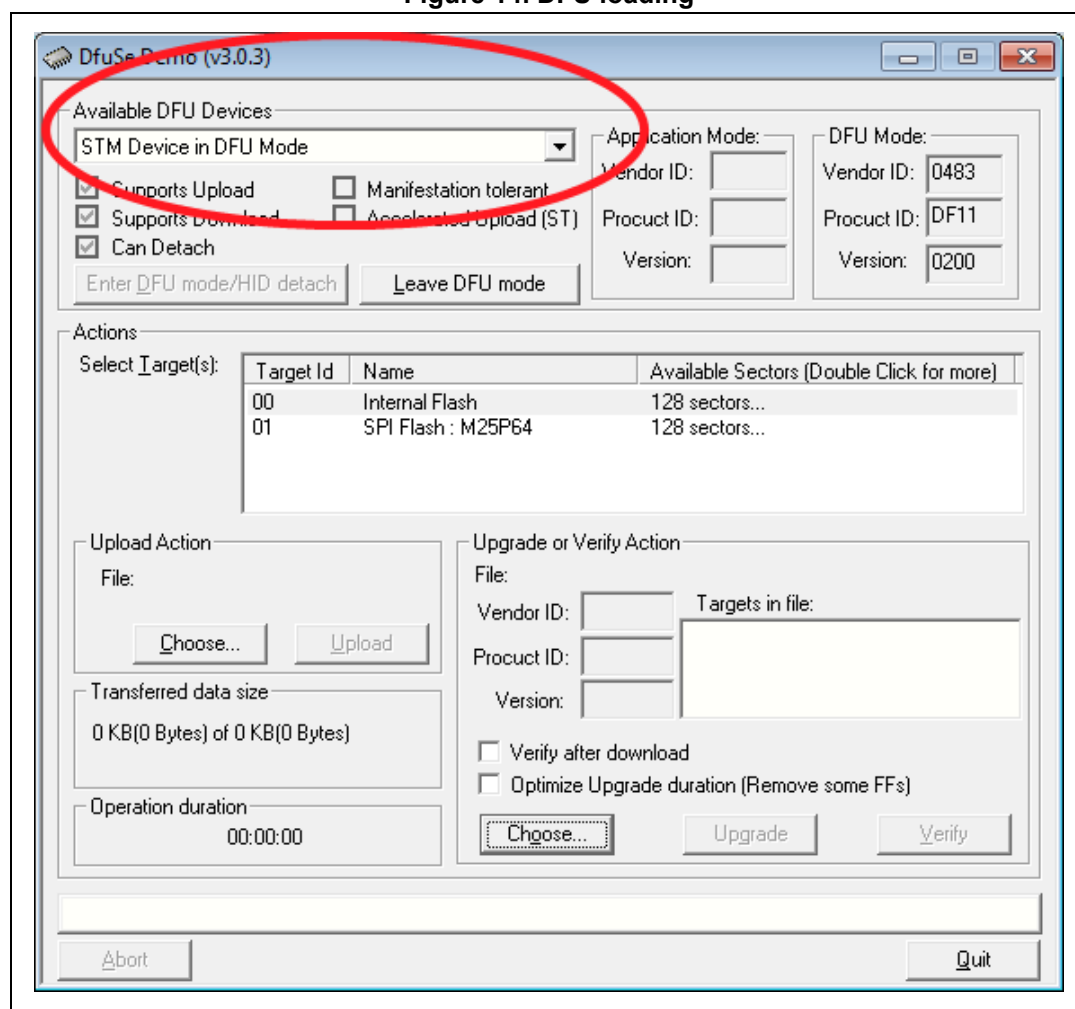


5.2.4 DFU loading

At this step, you are now ready to perform the firmware upgrade.

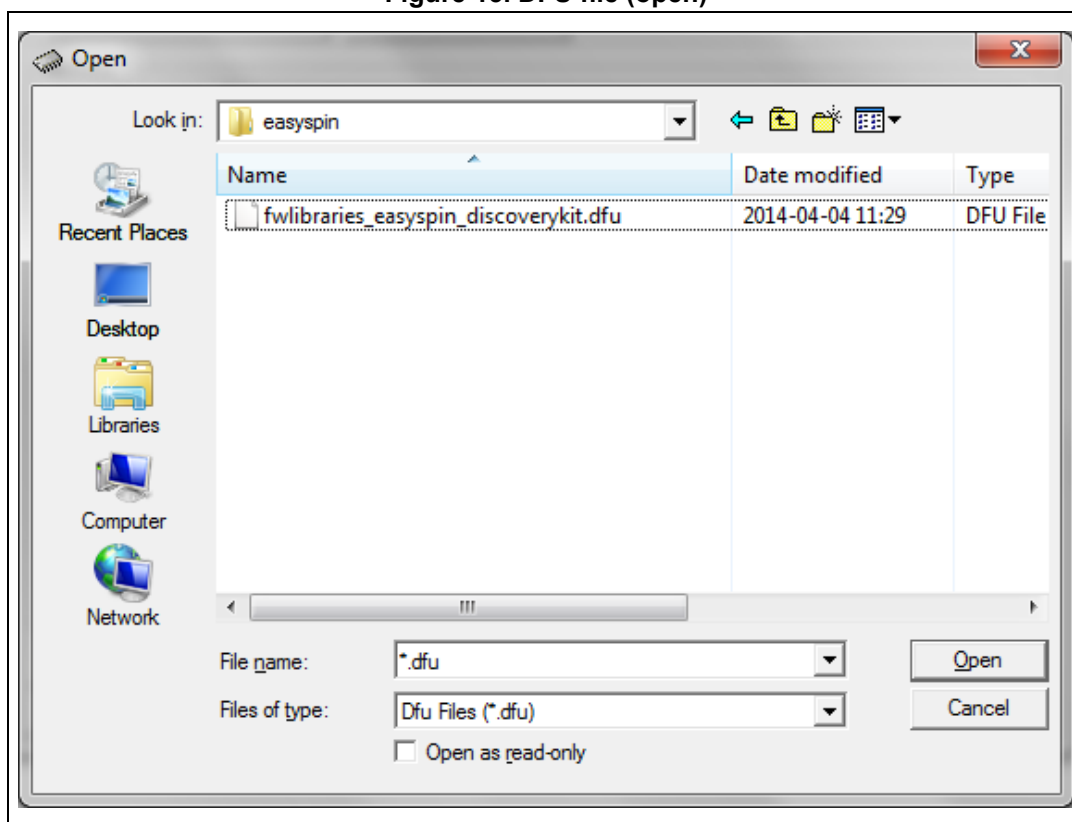
1. Start the “DfuSeDemo.exe”.
2. You must have an “STM Device in DFU Mode” in the list of the “Available DFU Devices”. Else, it means that your board is not correctly configured or not connected to the PC.

Figure 14. DFU loading



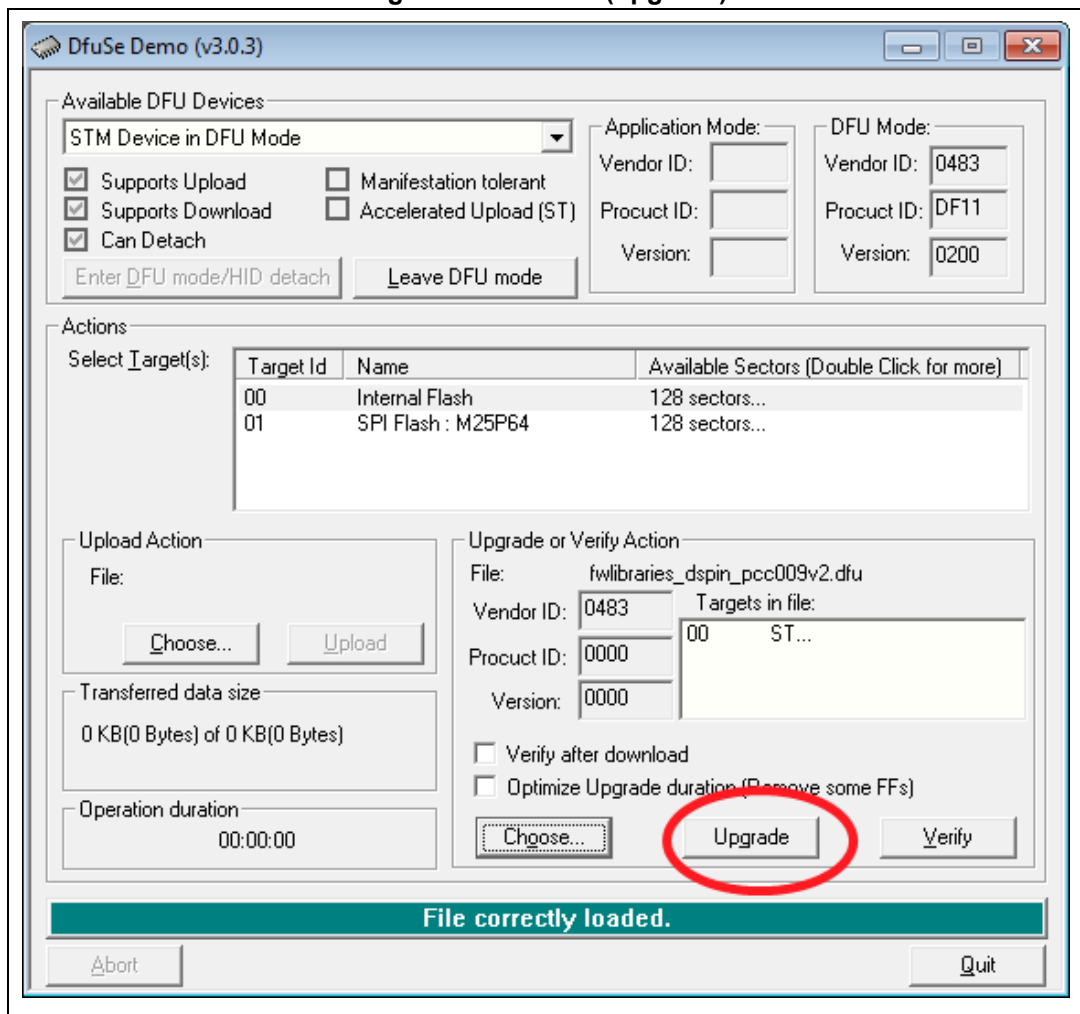
3. In the “Upgrade or Verify Action” group, click the “Choose...” button.

4. Select the *.dfu file of your choice in the “Open” dialog box and click on the “Open” button.

Figure 15. DFU file (open)

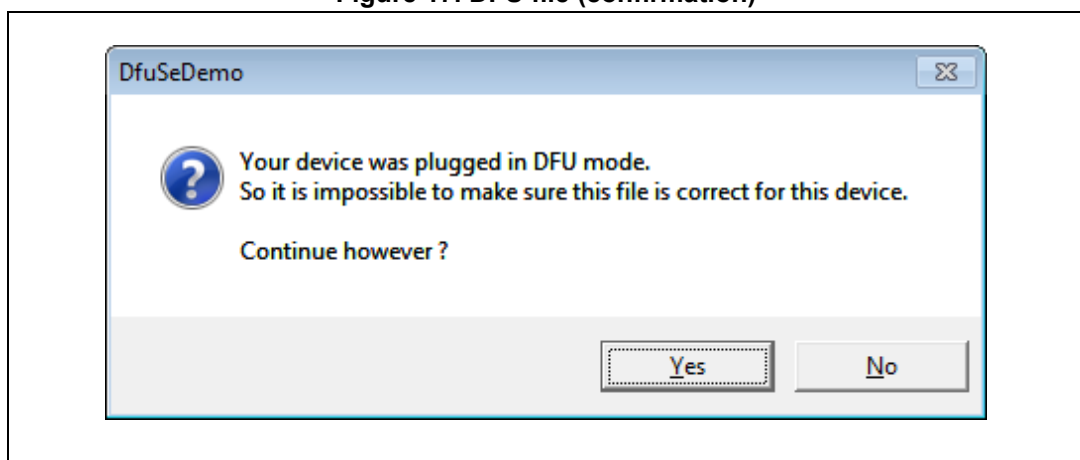
- Click on the “Upgrade” button.

Figure 16. DFU file (upgrade)



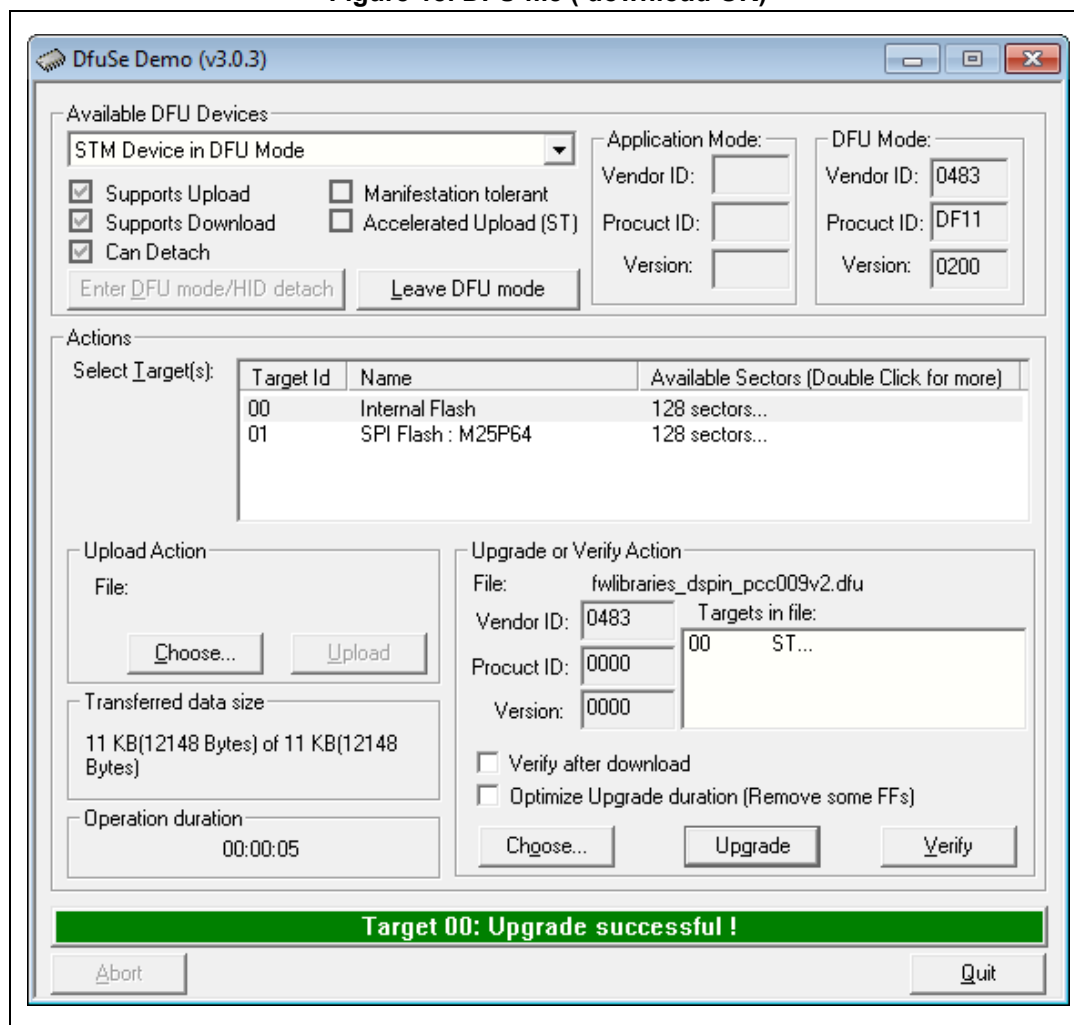
- If this dialog box appears, click “Yes”.

Figure 17. DFU file (confirmation)



7. Once the download is performed, you should have:

Figure 18. DFU file (download OK)



8. Do not forget to put the jumper back on the BOOT pins in order to restart the discovery board to the normal mode!

5.3 Using the EVAL6474H-DISC with the firmware for the GUI (FWGUI)

By default the discovery board is loaded with the FWGUI. This firmware offers the capability to connect the board with a GUI: the SPINFamily evaluation tool. This GUI provides direct access to all L6474 registers and allows sending application commands.

Both the FWGUI and the GUI can be downloaded on the “Design Resources” page of the L6474.

The FWGUI can be downloaded to the discovery board as detailed in [Section 5.2](#).

The behavior of the GUI is detailed in the “Help.chm” file which is provided with the setup file of the GUI.

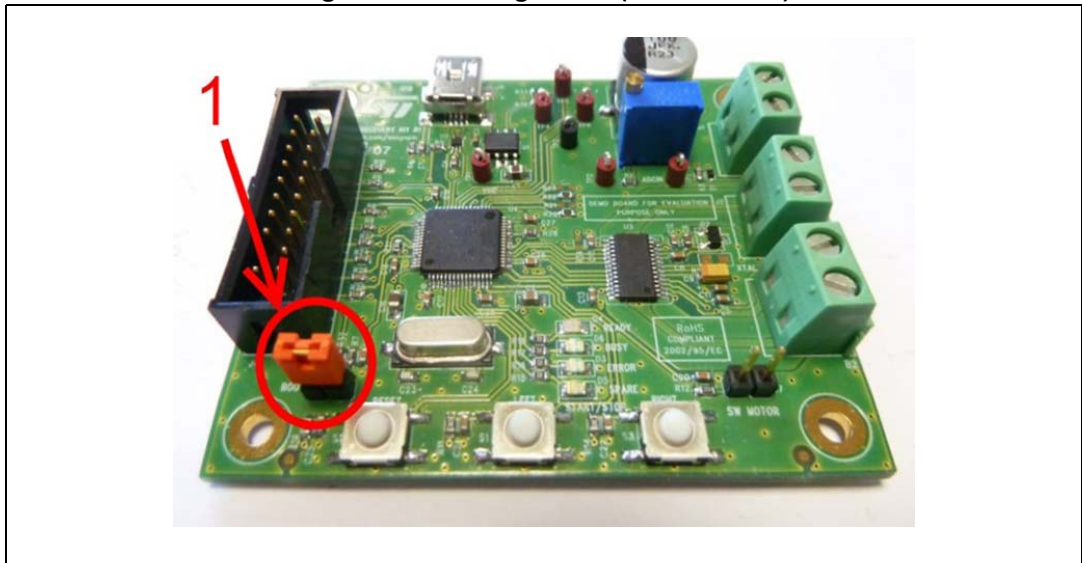
5.3.1 Sanity check of the board with the firmware for the GUI (FWGUI)

At the startup of the FWGUI, a sanity check is performed to confirm the discovery board is working correctly. The status is returned via the board LEDs.

To have a correct execution of the sanity check, please follow the steps below:

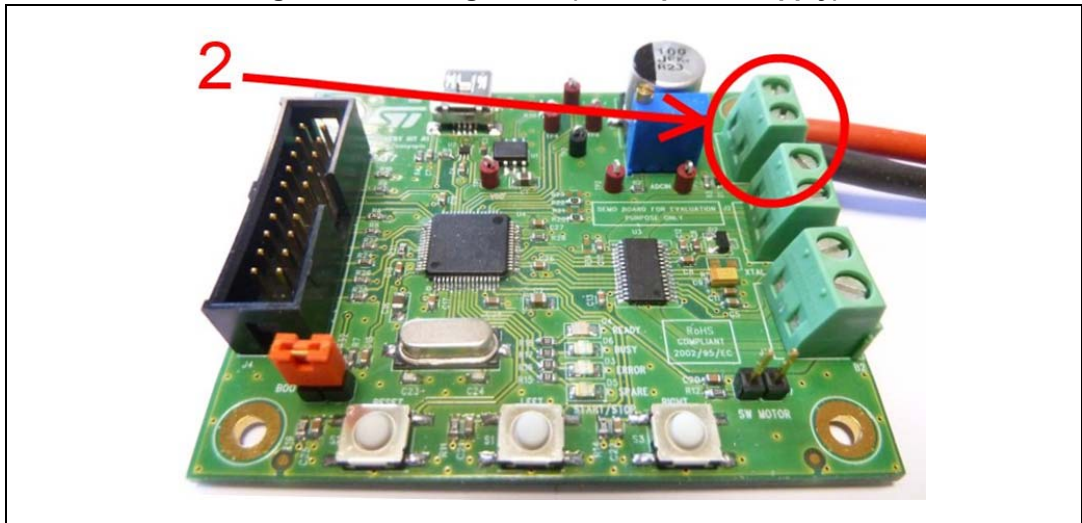
1. Place a jumper on the BOOT pins (bottom left corner of the board):

Figure 19. Starting board (BOOT mode)



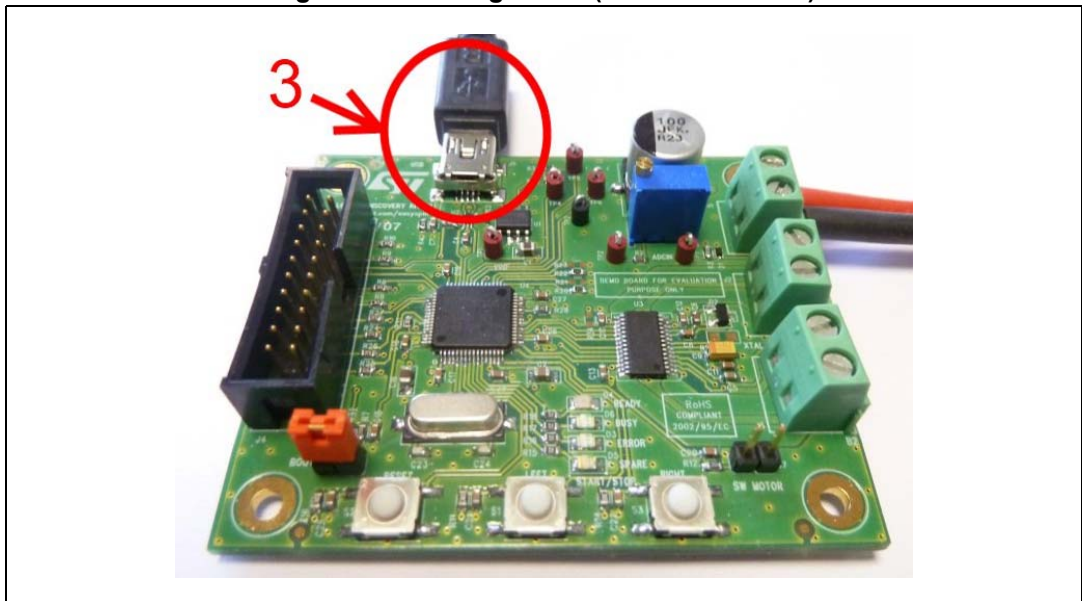
2. Connect the board to a 5 V - 45 V DC power supply:

Figure 20. Starting board (motor power supply)



3. Plug a USB cable (which must at least provide a power supply).

Figure 21. Starting board (USB connection)



4. The board should switch on automatically.

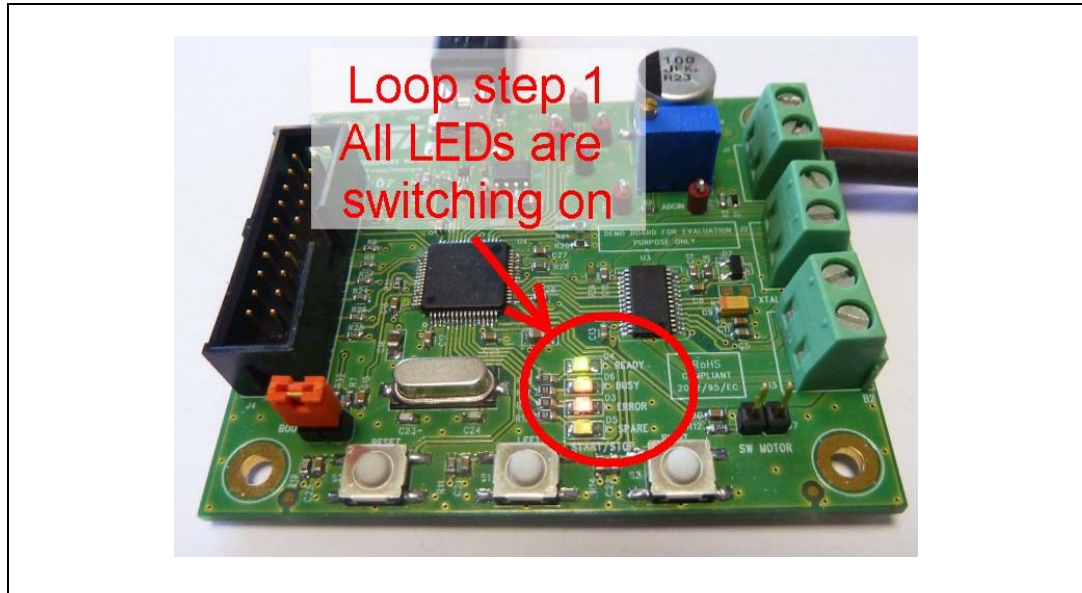
5. At this step:
- a) **If a problem is detected**, the “ready” LED (green) and the “error” LED (red) will switch on without blinking. This means that:
- Either the board Id is not recognized by the FW (bad FW versions used).
 - Or there is a problem with the SPI (no connection between the MCU and the L6474 via the SPI).
 - Or there is no 5 V - 45 V DC power supply.

Figure 22. Starting board (error case)



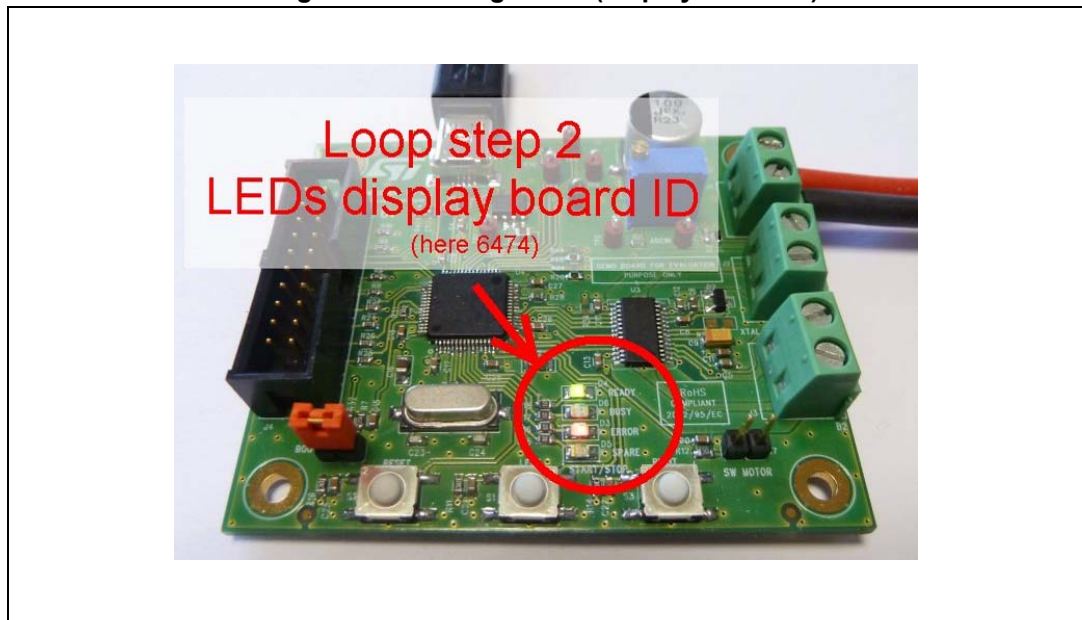
- b) **If no problem is detected**, the LEDs will start an infinite two-step loop:
- In the first step, the four LEDs will switch on one after the other by starting by the green one and ending by the yellow one.

Figure 23. Starting board (board OK)



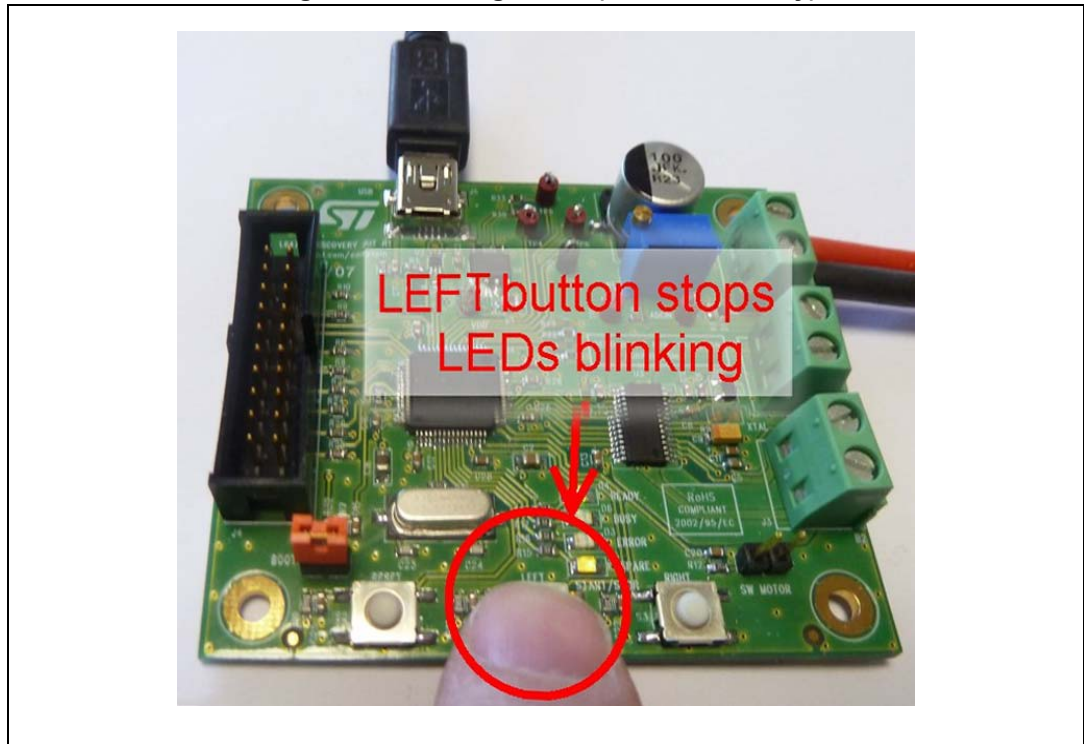
- In the second step, only the LEDs which correspond to the board ID are switched on all at the same time. For the L6474 device, there are the green and red LEDs.

Figure 24. Starting board (display board ID)



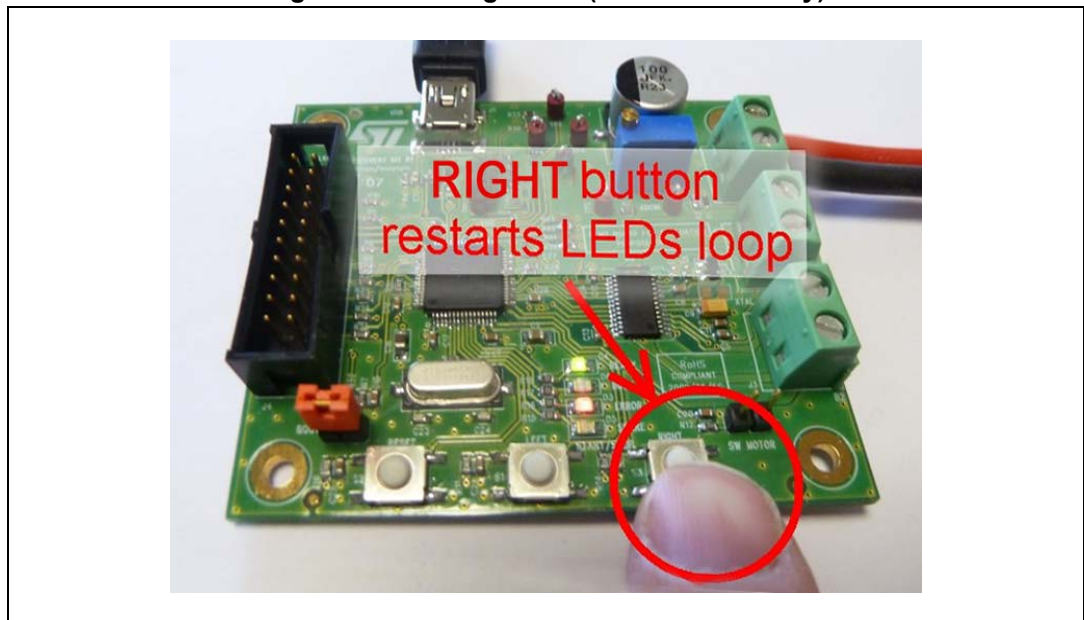
6. Press the LEFT button and check the two-step loop stops after a few seconds. Only the green LED remains switched on.

Figure 25. Starting board (action LEFT key)



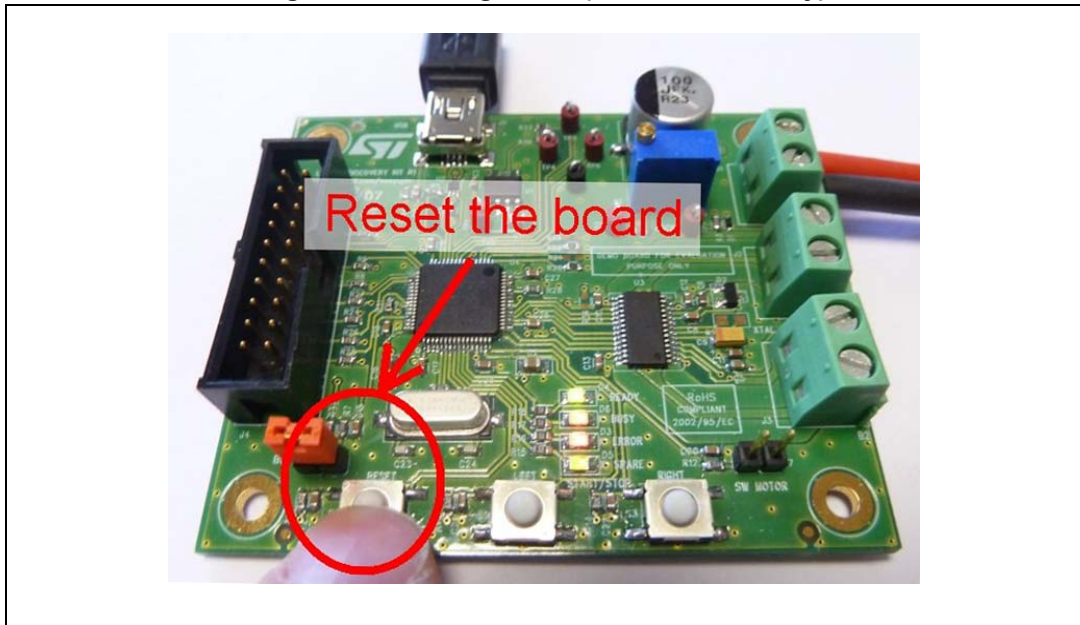
7. Press the RIGHT button and check the two-step loops restarts.

Figure 26. Starting board (action RIGHT key)



8. Press the RESET button and check that the LEDs restart there two-step loop after the board reset.

Figure 27. Starting board (action RESET key)



Note: Please note that once you have connected the discovery board to the GUI, the LEDs meaning is different. You then need to restart the board to perform a new auto-check and to have a valid status from the LEDs.

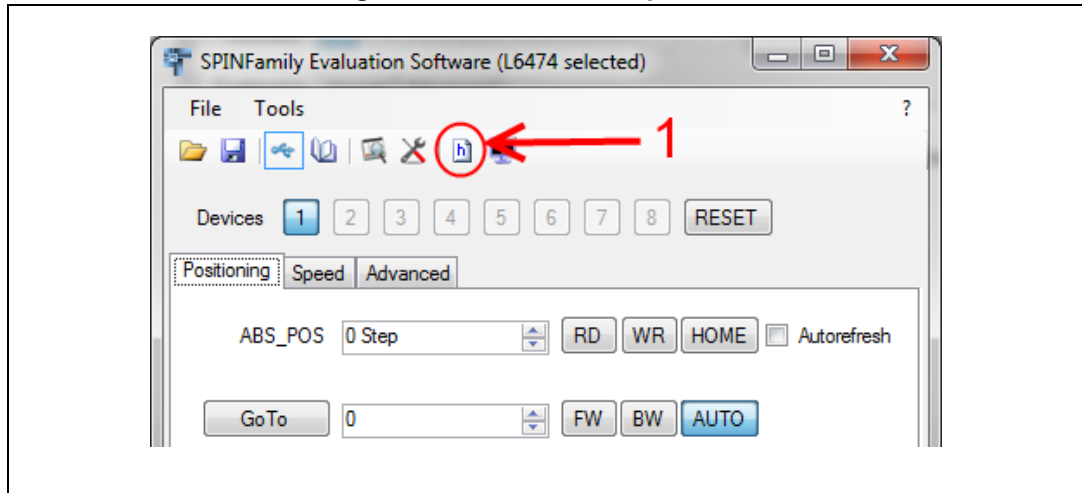
5.3.2 Parameters exportation from the GUI to the FW library

Once you have customized the L6474 parameters with the GUI, you can export them to a header file in order to use it with the FW demonstration library.

In this purpose:

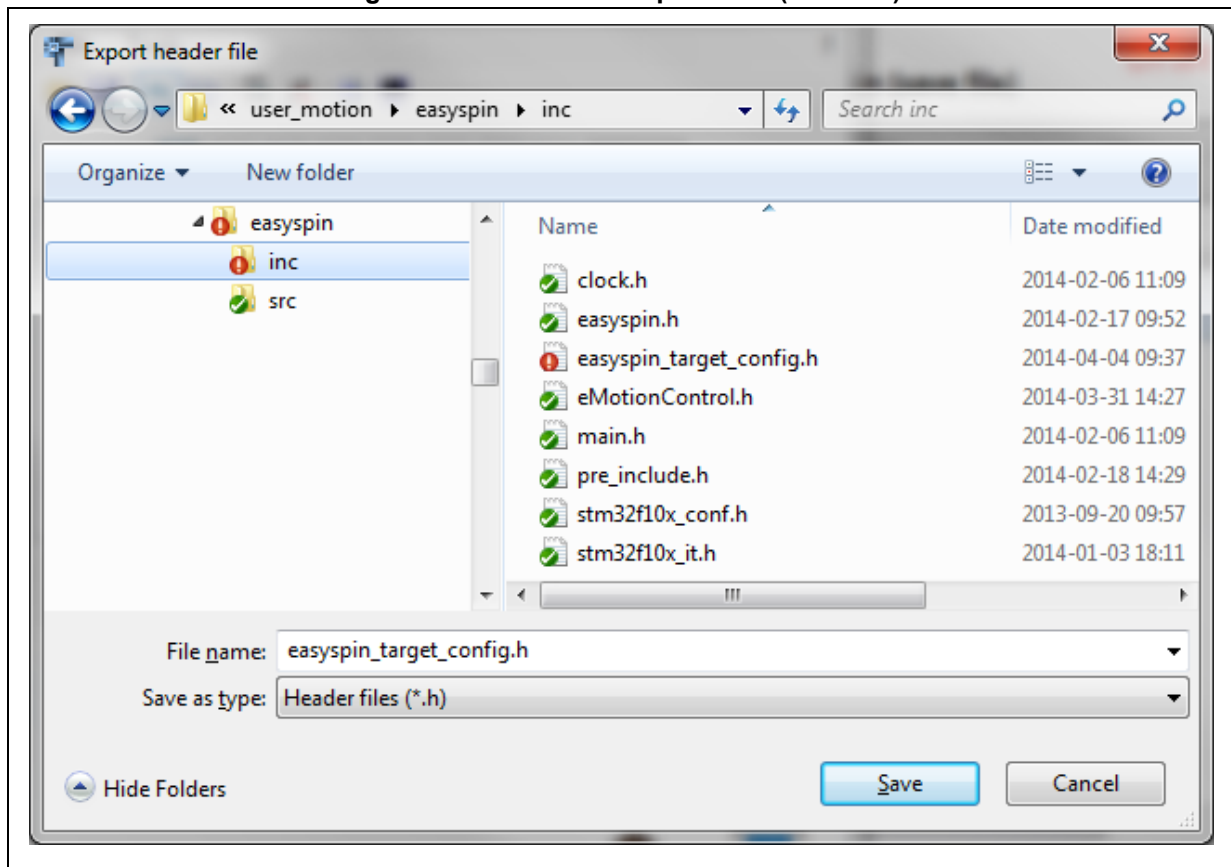
1. Press the “header file” button on the main window of the GUI.

Figure 28. Parameters exportation



2. Replace the existing “easyspin_target_config.h” of your current demonstration FW library by the new one.

Figure 29. Parameters exportation (save file)



3. Then you only need to recompile your project “demo FW library” as usual to use the exported parameters.

5.4 Using the EVAL6474H-DISC with the firmware library (FW L6474)

The L6474 firmware library is supplied as an IAR workspace with a source, including project files. If you are using the IAR design environment, you just need to load the “easyspin.eww” file and use the “fwlibraries_easyspin_discoverykit” project which is already active.

If you are using a different design environment, you will find instructions in this user manual to build a new project on your preferred IDE.

The L6474 firmware library is also supplied as an executable in the HEX and in DFU format. It can be loaded into the EVAL6474H-DISC board as explained in [Section 5.2](#).

5.4.1 FW library package contents

- FW L6474 library
 - Described in [Section 5.4.2](#).
- CMSIS library
 - /stm32f10x/CMSIS Library used by the L6474 FW library
- STM32F10x Standard Peripherals Library Drivers
 - /stm32f10x/STM32F10x_StdPeriph_Driver Library used by the L6474 FW library
- IAR workspace files
 - /user_motion/project/ewarm6/fwlibraries/easyspin/easyspin.eww
 - workspace file
 - /user_motion/project/ewarm6/fwlibraries/easyspin/settings/easyspin.wsdtd
 - workspace settings file
 - /user_motion/project/ewarm6/fwlibraries/easyspin/discoverykit
 - directory containing easySPIN discovery board project files and subdirectories
 - /user_motion/project/ewarm6/fwlibraries/easyspin/discoverykit/Debug/Exe/
 - directory containing the *.HEX and *.DFU executable files
 - /user_motion/project/ewarm6/fwlibraries/easyspin/pcc009v2
 - directory containing PCC009V2 board project files and subdirectories

5.4.2 FW L6474 library description

The FW L6474 library has the following features:

- Register read, write and check
- Register values conversion
- Device configuration
- Motion commands
- FLAG interrupts management
- Button interrupts management
- “Daisy Chain” mode

The FW L6474 library has been tested on the L6474H Discovery board. The main program contains a commented demonstration sequence which uses most of the FW L6474 library supported features.

At the end of the demonstration sequence, the GPIO connected to LEFT and RIGHT buttons are configured to trigger interrupts on the microcontroller:

- On a LEFT button press, the microcontroller starts the motor which will accelerate up to max. speed.
- On a RIGHT button press, the microcontroller performs a soft stop of the motor.

Even if the “Daisy Chain” mode is supported in the L6474 FW library, the L6474 Discovery board HW does not allow it. Please contact ST support if you want more information on the “Daisy Chain” mode testing or implementation.

The FW L6474 library consists of the following files:

- | | |
|---|--|
| • user_motion/easyspin/inc/stm32f10x_conf.h | Library configuration file |
| • user_motion/ easyspin /src/stm32f10x_it.c | Interrupt handlers |
| • user_motion/easyspin/inc/stm32f10x_it.h | Header for stm32f10x_it.c |
| • user_motion/easyspin/inc/clock.h | System clock setup related header |
| • user_motion/ easyspin/src/clock.c | System clock source file |
| • user_motion/easyspin/inc/easyspin.h | L6474 definitions header |
| • user_motion/easyspin/inc/eMotionControl.h | L6474 definitions header (for motion control routines) |
| • user_motion/easyspin/src/easyspin.c | L6474 routines source file |
| • user_motion/easyspin/src/ eMotionControl.c | L6474 routines source file (related to motion control) |
| • user_motion/easyspin/inc/easyspin_target_config.h | L6474 configuration parameters (this file can be generated by the GUI) |
| • user_motion/easyspin/inc/main.h | Main header file |
| • user_motion/easyspin/src/main.c | Main program |
| • user_motion/easyspin/inc/pre_include.h | First header file included by the preprocessor |
| • user_motion/easyspin/readme.txt | Information on the files |

5.4.3 Create a project using the FW library package

Using your preferred IDE, create a new project.

In project options, properties or settings:

- Select for the device, the ST STM32F105xB.
- Use the CMSIS library.

Edit the preprocessor defined symbols and add:

- STM32F10X_CL
- USE_STDPERIPH_DRIVER
- ST_EASYSPIN_6474H_DISC

Edit the preprocessor include directories and add:

- \$PROJ_DIR\$\..\..\..\stm32f10x\CMSIS\CM3\DeviceSupport\ST\STM32F10x
- \$PROJ_DIR\$\..\..\..\stm32f10x\STM32F10x_StdPeriph_Driver\inc
- \$PROJ_DIR\$\..\..\..\easyspin\inc

Edit the “Linker” configuration file:

- \$PROJ_DIR\$\config\stm32f10x_flash.icf

Where \$PROJ_DIR\$ is a variable containing the path to the project directory.

Add the required library source files:

- startup_stm32f10x_cl.s
- system_stm32f10x.c
- misc.c
- stm32f10x_exti.c
- stm32f10x_flash.c
- stm32f10x_gpio.c
- stm32f10x_rcc.c
- stm32f10x_spi.c
- stm32f10x_tim.c

For the debugger, for example, select the ST-LINK and configure it to run to main, to verify download, to use Flash loader and to override the “default *.board” file with the “FlashSTM32F105xB.board”.

6 References

This user manual provides information on the hardware features and use of the EVAL6474H-DISC board along with the demonstration firmware and software. For additional information, refer to the following:

1. STM32F105xx/STM32F107xx datasheet (CD00220364).
2. STM32F101xx, STM32F102xx, STM32F103xx, STM32F105xx and STM32F107xx advanced ARM®-based 32-bit MCUs reference manual (RM0008).
3. L647x, L648x and powerSTEP01 family communication protocol (AN4290).
4. Getting started with DfuSe USB device firmware upgrade STMicroelectronics extension (UM0412).

7 Revision history

Table 5. Document revision history

Date	Revision	Changes
02-Jul-2014	1	Initial release.
17-Apr-2015	2	<p>Replaced “easySPIN” by “L6474” and/or “motor” in the whole document.</p> <p>Updated Figure 4 on page 8 (removed web link).</p> <p>Removed Figure 5. Layout (silk screen) from page 9.</p> <p>Updated Table 2 on page 9 (replaced “L6474H” by “L6474”).</p> <p>Updated Table 3 on page 13 (minor modifications).</p> <p>Updated Section 4.2 on page 14 (added “r.m.s.” and subscripts).</p> <p>Updated Section 5.3 on page 25 (replaced “FWPSPIN” by “FWGUI”, removed web link).</p> <p>Updated from 1. to 3. in Section 6 on page 36.</p> <p>Minor modifications throughout document.</p>

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