# UM2161
# User manual

## Getting started with the X-CUBE-SPN13, low voltage brush DC motor driver software expansion for STM32Cube

## Introduction

The X-CUBE-SPN13 software expansion for STM32Cube allows complete management of the STSPIN250 for control of brush DC motors. It is built on STM32Cube software technology for easy portability across different STM32 microcontrollers.

The software comes with a sample implementation to drive a bidirectional brush DC motor with a NUCLEO-F401RE, NUCLEO-F334R8, NUCLEO-F030R8 or NUCLEO-L053R8 development board connected to an X-NUCLEO-IHM13A1 expansion board.

# Contents

# List of tables

# List of figures

# 1 Acronyms and abbreviations

Table 1: List of acronyms

| Acronym | Description |
|---|---|
| API | application programming interface |
| BSP | board support package |
| CMSIS | Cortex® microcontroller software interface standard |
| HAL | hardware abstraction layer |
| SPI | serial port interface |
| IDE | integrated development environment |
| LED | light emitting diode |

# 2 What is STM32Cube?

STMCube™ represents the STMicroelectronics initiative to make developers' lives easier by reducing development effort, time and cost. STM32Cube covers the STM32 portfolio.

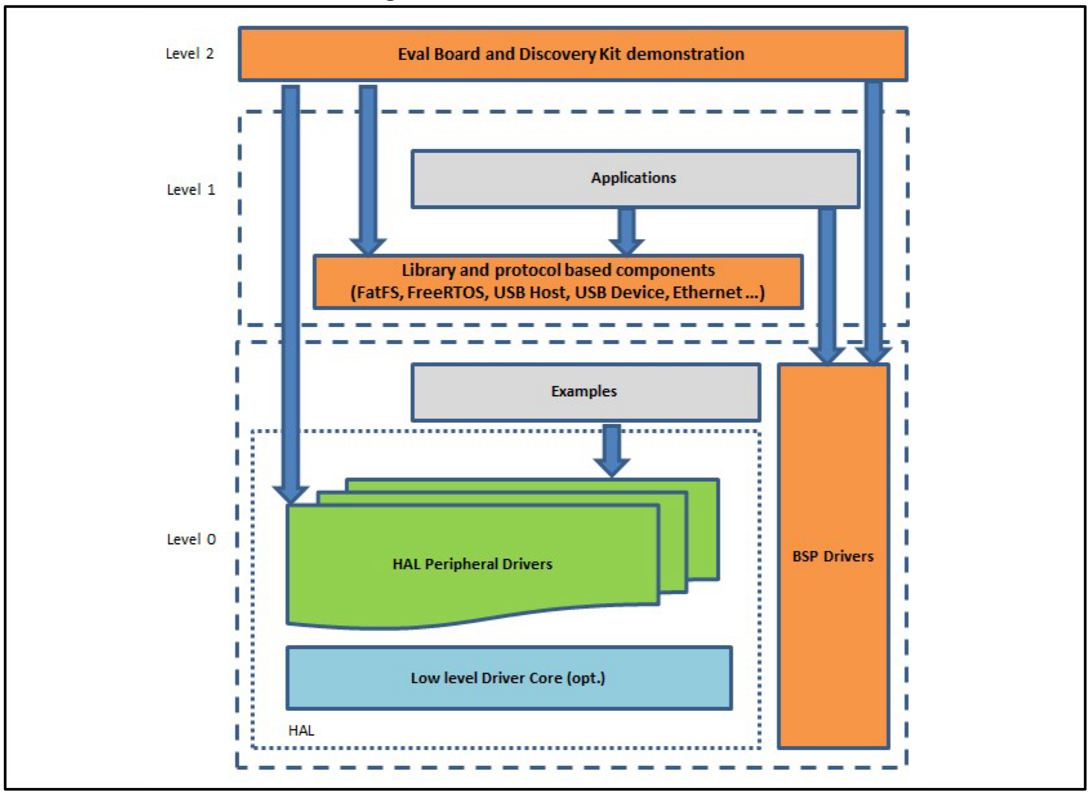
STM32Cube version 1.x includes:

- STM32CubeMX, a graphical software configuration tool that allows the generation of C initialization code using graphical wizards.
- A comprehensive embedded software platform specific to each series (such as the STM32CubeF4 for the STM32F4 series), which includes:
  - the STM32Cube HAL embedded abstraction-layer software, ensuring maximized portability across the STM32 portfolio
  - a consistent set of middleware components such as RTOS, USB, TCP/IP and graphics
  - all embedded software utilities with a full set of examples

## 2.1 STM32Cube architecture

The STM32Cube firmware solution is built around three independent levels that can easily interact with one another, as described in the diagram below.

**Figure 1: Firmware architecture**


Level 2
Eval Board and Discovery Kit demonstration
Level 1
Applications
Library and protocol based components
(FatFS, FreeRTOS, USB Host, USB Device, Ethernet…)
Examples
Level 0
HAL Peripheral Drivers
BSP Drivers
Low level Driver Core (opt.)
HAL

**Level 0**: This level is divided into three sub-layers:

- Board Support Package (BSP): this layer offers a set of APIs relative to the hardware components in the hardware boards (Audio codec, IO expander, Touchscreen, SRAM driver, LCD drivers. etc…); it is based on modular architecture allowing it to be easily ported on any hardware by just implementing the low level routines. It is composed of two parts:

  - Component: is the driver relative to the external device on the board and not related to the STM32, the component driver provides specific APIs to the external components of the BSP driver, and can be ported on any other board.
  - BSP driver: links the component driver to a specific board and provides a set of easy to use APIs. The API naming convention is BSP_FUNCT_Action(): e.g., BSP_LED_Init(), BSP_LED_On().

- Hardware Abstraction Layer (HAL): this layer provides the low level drivers and the hardware interfacing methods to interact with the upper layers (application, libraries and stacks). It provides generic, multi-instance and function-oriented APIs to help offload user application development time by providing ready to use processes. For example, for the communication peripherals (I²C, UART, etc.) it provides APIs for peripheral initialization and configuration, data transfer management based on polling, interrupt or DMA processes, and communication error management. The HAL Drivers APIs are split in two categories: generic APIs providing common, generic functions to all the STM32 series and extension APIs which provide special, customized functions for a specific family or a specific part number.
- Basic peripheral usage examples: this layer houses the examples built around the STM32 peripherals using the HAL and BSP resources only.

**Level 1**: This level is divided into two sub-layers:

- Middleware components: set of libraries covering USB Host and Device Libraries, STemWin, FreeRTOS, FatFS, LwIP, and PolarSSL. Horizontal interaction among the components in this layer is performed directly by calling the feature APIs, while vertical interaction with low-level drivers is managed by specific callbacks and static macros implemented in the library system call interface. For example, FatFs implements the disk I/O driver to access a microSD drive or USB Mass Storage Class.
- Examples based on the middleware components: each middleware component comes with one or more examples (or applications) showing how to use it. Integration examples that use several middleware components are provided as well.

**Level 2**: This level is a single layer with a global, real-time and graphical demonstration based on the middleware service layer, the low level abstraction layer and basic peripheral usage applications for board-based functions.

# 3 X-CUBE-SPN13 software expansion for STM32Cube

## 3.1 Overview

The X-CUBE-SPN13 software package expands STM32Cube functionality, and features:

- STSPIN250 configuration (bridge input and enabling signals)
- flag interrupt handling (overcurrent and thermal alarm reporting)
- handling of one bidirectional brush DC motor
- STM32 Nucleo and expansion board configuration (GPIOs, PWMs, IRQs, etc.)

To use the STSPIN250 driver library, first call its initialization function to:

- set up the required GPIOs to handle the bridge enabling pins and the FLAG interupt which reports overcurrent detection or thermal protection
- set up the drivers
- load the driver parameters with the values in "stspin240_250_target_config.h", in order to program the PWM frequency of the bridge inputs.

Once the initialization is done, you can modify the driver parameters by calling specific functions to change the PWMs frequency bridge configuration.

You can also use callback functions with:

- the flag interrupt handler, when an overcurrent or a thermal alarm occur;
- the error handler, called by the library when it reports an error.

Then, you can drive the brush DC motors by setting a specified running direction and by changing the maximum speed. When a motor is requested to run, the related bridge is automatically enabled.

A motion command can be stopped at any moment:

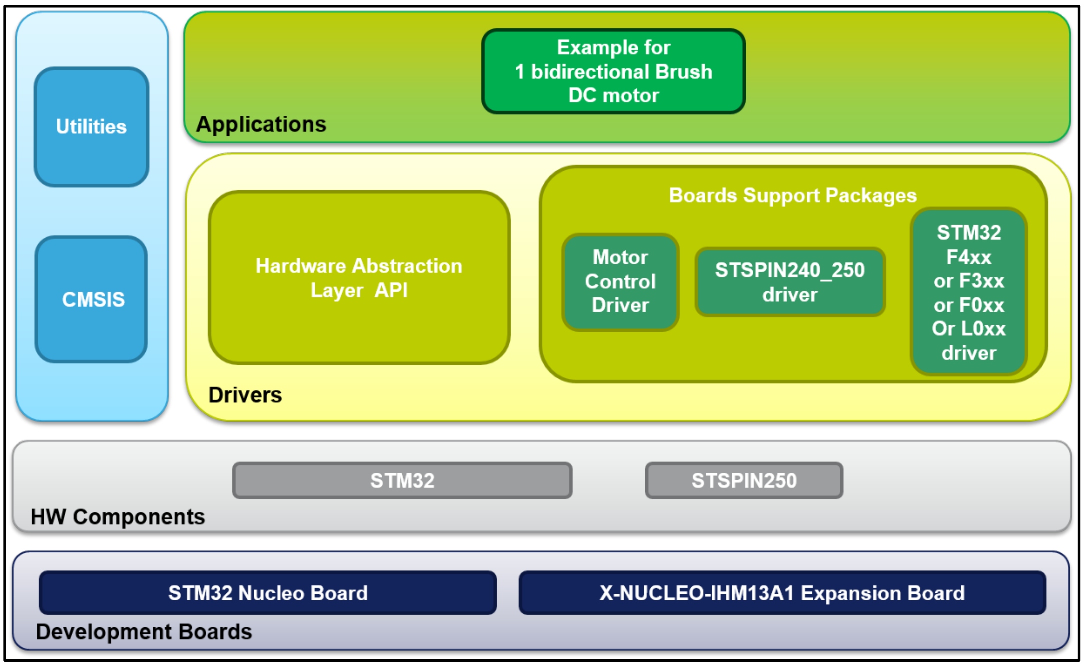
- by a hard stop which immediately stops the motor
- or by a hardHiz command which immediately stops the motor and disables the bridge it uses.

The library also provides functions to disable or enable the bridges independently of the run or stop commands.

## 3.2 Architecture

This fully compliant STM32Cube software expansion enables development of applications using brush DC motor drivers based on STPIN250.

**Figure 2: X-CUBE-SPN13 architecture**



The software is based on the STM32CubeHAL hardware abstraction layer for the STM32 microcontroller and extends STM32Cube with a board support package (BSP) for the low voltage brush DC motor driver expansion board (X-NUCLEO-IHM13A1) and a BSP component driver for STSPIN250 motor driver.

The software layers used by the application software to access and use the brush DC motor driver expansion board are:

- STM32Cube HAL layer: provides a generic, multi-instance set of simple APIs (application programming interfaces) to interact with the upper layers (application, libraries and stacks). These generic and extension APIs are based on a common architecture and the layers above them like the middleware layer can function without requiring specific hardware configuration data for a given microcontroller unit (MCU). This structure improves the library code reusability and guarantees easy portability across other devices.
- Board support package (BSP) layer: supports the peripherals on the STM32 Nucleo board, except for the MCU. This limited set of APIs provides a programming interface for certain board specific peripherals like the user button, the LED, etc, and helps in identifying the specific board version. In case of motor control expansion boards, the motor control BSP provides a programming interface for various motor driver components. The BSP in the X-CUBE-SPN13 software provides the drivers to manage the STSPIN250 motor driver.

## 3.3 Folder structure

The software is packaged in the following main folders:

- **Drivers**:
  - STM32Cube HAL driver files located in the STM32F4xx_HAL_Driver, STM32F3xx_HAL_Driver, STM32F0xx_HAL_Driver or STM32L0xx_HAL_Driver subdirectories. These files are not described here as they are not specific for the X-CUBE-SPN13 software but derive directly from the STM32Cube framework.
  - CMSIS folder with the CMSIS (Cortex® microcontroller software interface standard) files from ARM. These files form a vendor-independent hardware abstraction layer for the Cortex-M processor series. This folder is also unchanged from the STM32Cube framework.
  - BSP folder with code files required for X-NUCLEO-IHM13A1 configuration, the STSPIN250 driver and the motor control API.
- **Projects**: contains a sample STSPIN250 application using a bidirectional brush DC motor.

### 3.3.1 BSP folder

#### 3.3.1.1 STM32F4XX-Nucleo/STM32F3XX-Nucleo/STM32F0XX-Nucleo/STM32L0XX-Nucleo BSPs

Depending on the STM32 Nucleo development board, these BSPs provide an interface to configure and use the development board peripherals with the X-NUCLEO-IHM13A1 expansion board.

Each subfolder (STM32F4XX-Nucleo/STM32F3XX-Nucleo/STM32F0XX-Nucleo/STM32L0XX-Nucleo) contains two couples of .c/.h files:

- **stm32XXxx_nucleo.c/h**: these files derive from the STM32Cube framework (with no modification) and provide the functions to handle the related STM32 Nucleo board user button and LEDs.
- **stm32XXxx_nucleo_IHM13a1.c/h**: these files are dedicated to the configuration of the PWMs, the GPIOs and the interrupt enabling/disabling.

#### 3.3.1.2 Motor control BSP

This BSP provides a common interface to access the driver functions of various motor drivers like L6206, L6474, powerSTEP01, STSPIN240, etc. This is done via a couple of c/h files: MotorControl/motorcontrol.c/h, which defines all the functions to configure and control the motor driver. These functions are then mapped to the functions of the motor driver component used on the given expansion board via the structure file: motorDrv_t (defined in Components\Common\motor.h).

This structure defines a list of function pointers filled during its instantiation in the corresponding motor driver component.

For X-CUBE-SPN13, the structure instance is called stspin240_250Drv (see file BSP\Components\stspin240_250\stspin240_250.c).

As the motor control BSP is common for all motor driver expansion boards, some functions are not available for all expansion boards. In this case, during the instantiation of the motorDrv_t structure in the driver component, the unavailable functions are replaced by a null pointer.

#### 3.3.1.3 Stspin240_250 BSP component

The stspin240_250 BSP component provides the driver functions of the STSPIN250 low voltage brush DC motor driver in the folder stm32_cube\Drivers\BSP\Components\stspin240_250, which contains:

- **stspin240_250.c:** Stspin240_250 driver core functions
- **stspin240_250.h:** declaration of the Stspin240_250 driver functions and their associated definitions
- **stspin240_250_target_config.h:** parameter value setup for the STSPIN240 or the STSPIN250 (bridge configuration, bridge input PWMs frequency)

When used with an STSPIN250 driver as in the case of the X-NUCLEO-IHM13A1 expansion board, this component requires the compilation flag declaration: STSPIN_250.

### 3.3.2 Project folder

For each STM32 Nucleo board, the example projects are in the folder stm32_cube\Projects\Multi\Examples\MotionControl\:

IHM13A1_ExampleFor1BiDirMotors (examples of control functions for one bidirectional brush DC motor driving).

There is a dedicated folder for the target IDE:

- **EWARM** containing the project files for IAR
- **MDK-ARM** containing the project files for Keil
- **SW4STM32** containing the project files for OpenSTM32

Each example also has the following code files:

- **inc\main.h**: main header file
- **inc\ stm32xxxx_hal_conf.h**: HAL configuration file
- **inc\stm32xxxx_it.h** : header for the interrupt handler
- **src\main.c:** main program (code of the example which is based on the motor control library for Stspin250)
- **src\stm32xxxx_hal_msp.c**: HAL initialization routines
- **src\stm32xxxx_it.c**: interrupt handler
- **src\system_stm32xxxx.c**: system initialization
- **src\clock_xx.c**: clock initialization

## 3.4 Software required resources

STSPIN250 and the MCU communicate through GPIOs, using:

- 1 common GPIO for the flag interrupt (overcurrent detection or overtemperature protection) and the enable pin
- 1 GPIO to generate a PWM for the bridge input (PWM)
- 1 GPIO for the bridge input phase and to set the motor direction (PHA/DIR_A)
- 1 GPIO to generate a PWM for REF level setup
- 1 GPIO to set/reset the reset pin

**Table 2: Required resources for the X-CUBE-SPN13 software**

| Resources for F4xx/F3xx | Resources for L0xx | Resources for F0xx | Pin | Features |
|---|---|---|---|---|
| ext. line 10<br>GPIO PA10 | | | D2 | flag interrupt and enable pin |
| GPIO PB4<br>TIM3 CH1 | | GPIO PB4<br>TIM22 CH1 | D5 | PWM for bridge |
| GPIO PB10 | | | D6 | direction for PHA/DIR_A bridge |
| GPIO PA0<br>TIM2 CH1 | GPIO PA9<br>TIM1 CH2 | GPIO PA0<br>TIM2 CH1 | A0 (or D8 for F0) | REF |
| GPIO PC7 | | | D9 | reset |

## 3.5 APIs

Detailed function and parameter descriptions for the user-APIs are compiled in an HTML file in the software package **Documentation** folder.

X-CUBE-SPN13 software API is defined in the BSP motor control (functions predefined through BSP_MotorControl_).

Not all the functions of this module are available for the STSPIN250 and, consequently, for the X-NUCLEO-IHM13A1 expansion board.

# 4 System setup guide

## 4.1 Hardware description

This section describes the hardware components which are required to execute the X-CUBE-SPN13 software and successfully drive one brush DC motor.

### 4.1.1 STM32 Nucleo platform

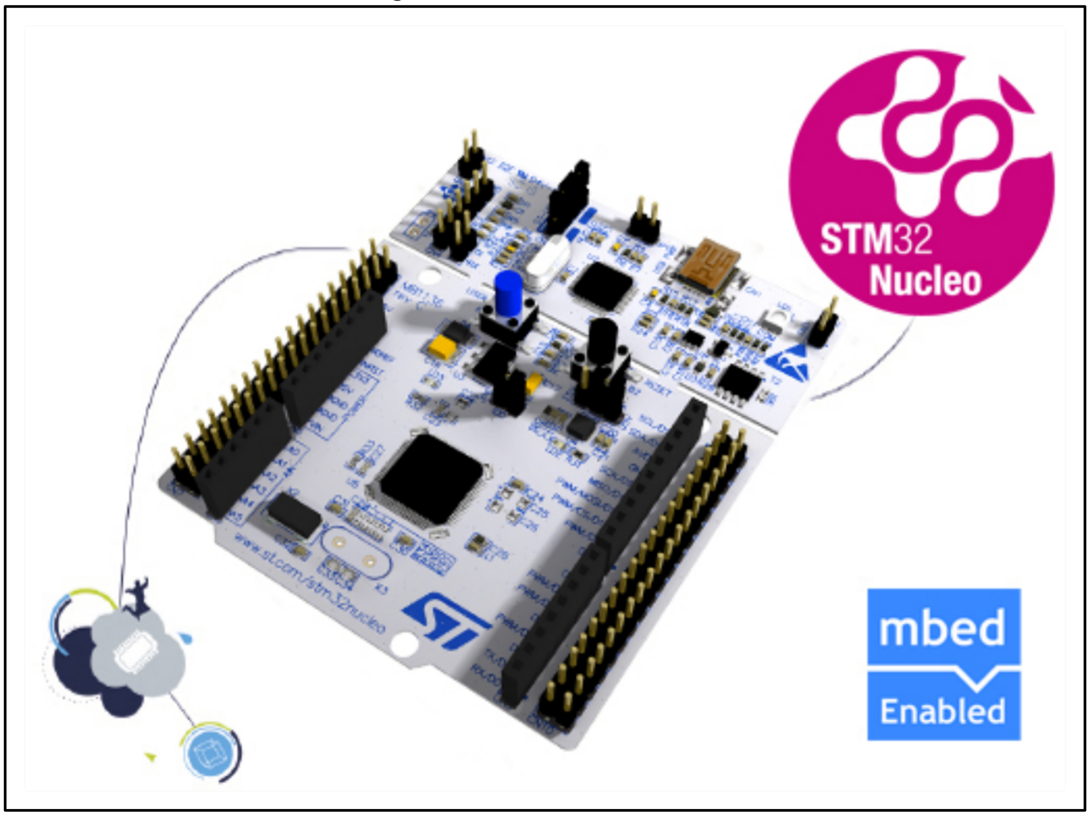
STM32 Nucleo development boards provide an affordable and flexible way for users to test solutions and build prototypes with any STM32 microcontroller line.

The Arduino™ connectivity support and ST morpho connectors make it easy to expand the functionality of the STM32 Nucleo open development platform with a wide range of specialized expansion boards to choose from.

The STM32 Nucleo board does not require separate probes as it integrates the ST-LINK/V2-1 debugger/programmer.

The STM32 Nucleo board comes with the comprehensive STM32 software HAL library together with various packaged software examples.

**Figure 3: STM32 Nucleo board**



Information regarding the STM32 Nucleo board is available at *www.st.com/stm32nucleo*

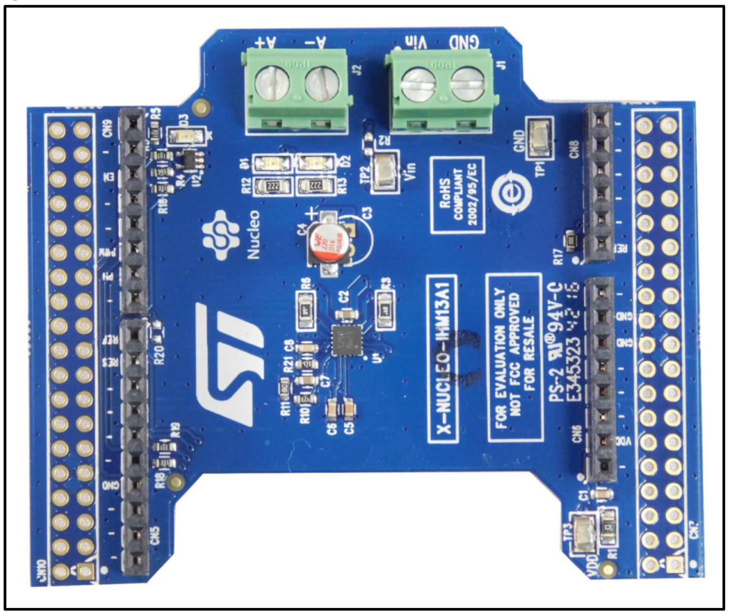
### 4.1.2 X-NUCLEO-IHM13A1 low voltage brush DC motor driver expansion board

The X-NUCLEO-IHM13A1 expansion board for STM32 Nucleo is based on the STSPIN250 low voltage brush DC motor driver.

It provides an affordable and easy-to-use solution for the implementation of portable motor driving applications such as thermal printers, robotics and toys.

The X-NUCLEO-IHM13A1 is compatible with the Arduino UNO R3 connector and most STM32 Nucleo boards.

**Figure 4: X-NUCLEO-IHM13A1 expansion board for STM32 Nucleo**



### 4.1.3 Miscellaneous hardware components

To complete the hardware setup, you need:

- one low voltage brush DC motor
- an external DC power supply with two electric cables
- a USB type A to mini-B USB cable to connect the STM32 Nucleo to a PC

## 4.2 Software description

The following software components are needed for a suitable development environment for applications based on the motor driver expansion board:

- X-CUBE-SPN13 expansion for STM32Cube dedicated to STSPIN250 low voltage brush motor driver application development. The X-CUBE-SPN13 firmware and related documentation are available on www.st.com.
- One of the following development tool-chain and compilers:
  - Keil RealView Microcontroller Development Kit (MDK-ARM) toolchain V5.12
  - IAR Embedded Workbench for ARM (EWARM) toolchain V7.20
  - OpenSTM32 System Workbench for STM32 (SW4STM32)

## 4.3 Hardware and software setup

This section describes the hardware and software setup procedure for executing the provided examples and to develop new applications based on the motor driver expansion board.

### 4.3.1 Common setup for all configurations

The STM32 Nucleo board has to be configured with the following jumper position:

- JP1 off
- JP5 (PWR) on UV5 side
- JP6 (IDD) on

### 4.3.2 REF pin setup on X-NUCLEO-IHM13A1 expansion board

Depending on the nucleo board, the REF pin setup has to be adapted to the X-NUCLEO-IHM13A1 expansion board.

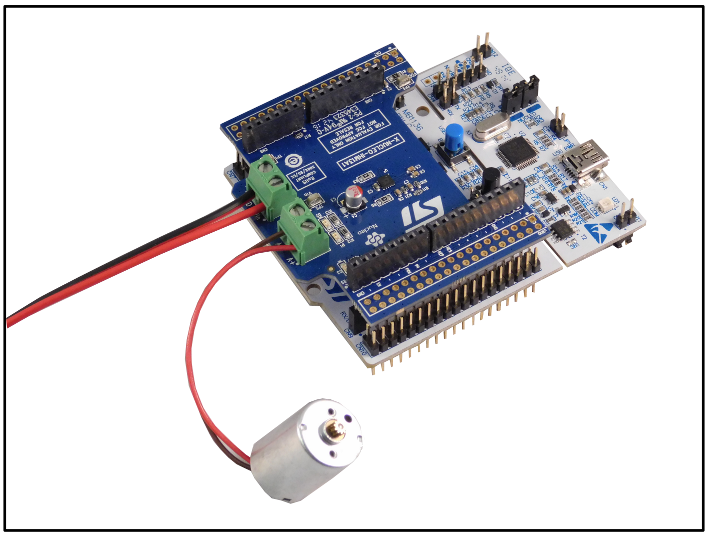
With NUCLEO-F401RE, NUCLEO-F334R8 or NUCLEO-L053R8, the default configuration of the board is: R22 (200 kΩ) mounted and R23 not mounted.

With NUCLEO-F030R8, R23 (200 kΩ) has to be mounted and R22 not mounted. If you want to keep the default board configuration, you can simply put a wire between the Arduino UNO R3 CN5-1 and CN8-1 connector pins.

### 4.3.3 Setup to drive one bidirectional brush DC motor

1. Plug the X-NUCLEO-IHM13A1 expansion board on top of the STM32 Nucleo board via the Arduino UNO connectors.
2. Connect the STM32 Nucleo board to a PC with the USB cable through USB connector CN1 to power the board
3. Connect the leads of the brush DC motor to the X-NUCLEO-IHM13A1 bridge output connector A+/A-.
4. Power on the X-NUCLEO-IHM13A1 expansion board by connecting its connectors Vin and Gnd to the DC power supply. The DC supply must be set to deliver the required voltage to the brush DC motor.

**Figure 5: STM32 Nucleo and X-NUCLEO-IHM13A1 connection to drive a bidirectional brush DC motor**



5. Open your preferred toolchain (MDK-ARM from Keil, EWARM from IAR, or SW4STM32 from OpenSTM32)
6. Depending on the used STM32 Nucleo board, open the software project from:
   – \stm32_cube\Projects\Multi\Examples\MotionControl\IHM13A1_ExampleFor1BiDirMotor\*YourToolChainName*\STM32F401RE-Nucleo for NUCLEO-F401
   – \stm32_cube\Projects\Multi\Examples\MotionControl\IHM13A1_ExampleForBiDirMotor\*YourToolChainName*\STM32F334R8-Nucleo for NUCLEO-F334R8
   – \stm32_cube\Projects\Multi\Examples\MotionControl\IHM13A1_ExampleFor1BiDirMotor\*YourToolChainName*\STM32F030R8-Nucleo for NUCLEO-F030R8
   – \stm32_cube\Projects\Multi\Examples\MotionControl\IHM13A1_ExampleFor1BiDirMotor*YourToolChainName*\STM32L053R8-Nucleo for NUCLEO-L053R8
7. Adapt the default parameters used by the STSPIN250 to your motor characteristics by modifying the parameters in stm32_cube\Drivers\BSP\Components\stspin240_250\stspin240_250_target_config.h.
8. Rebuild all files and load your image into target memory.
9. Run the sample application.
10. Push the user button to start the motor.
11. Open main.c to watch the detailed demo sequence. Each time you press the user button, a different demo sequence step appears.

# 5 Revision history

Table 3: Document revision history

| Date | Version | Changes |
|---|---|---|
| 09-Jan-2017 | 1 | Initial release |