Getting started with X-CUBE-SPN6 low voltage stepper motor driver software expansion for STM32Cube

Introduction

The X-CUBE-SPN6 expansion package for STM32Cube gives you full control of the STSPIN220 stepper motor driver.

It is built on top of STM32Cube software technology for easy portability across different STM32 microcontrollers.

When combined with one or more X-NUCLEO-IHM06A1 expansion boards, this software allows a compatible STM32 Nucleo development board to control one or more stepper motors.

The software comes with a sample implementation for one low voltage stepper motor. It is compatible with NUCLEO-F401RE, NUCLEO-F334R8, NUCLEO-F030R8 or NUCLEO-L053R8 development boards with an X-NUCLEO-IHM06A1 expansion board mounted on top.

RELATED LINKS

Visit the STM32Cube ecosystem web page on www.st.com for further information

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
IDE	Integrated development environment
LED	Light emitting diode

2 X-CUBE-SPN6 software expansion for STM32Cube

2.1 Overview

The X-CUBE-SPN6 software package expands the functionality of STM32Cube. It's key features include:

- Driver layer for complete management of the STSPIN220 low voltage stepper motor driver mounted on the X-NUCLEO-IHM06A1 expansion board
- Speed profile and step resolution management
- Fault interrupt handling
- Application example for a single stepper motor driving
- Easy portability across different MCU families, thanks to STM32Cube
- Free, user-friendly license terms

The software implements pseudo registers and motion commands by:

- configuring timers that are used to generate step clock and voltage reference
- managing device parameters like acceleration, deceleration, min. and max. speed, positions at speed profile boundaries, mark position, micro-stepping mode, direction, motion state etc

At each tick timer pulse end, a callback is executed to call the step clock handler which controls the motor motion by managing:

- motion status (e.g., stop motor at target destination)
- motor direction via GPIO level
- relative and absolute motor position in microsteps
- the speed through zero, positive and negative acceleration

The speed is set by varying the step clock frequency and, optionally, the step mode when the automatic full step switch feature is enabled. The timer used for the step clock is configured in output compare mode. A new capture compare register value is calculated at each step clock handler call to achieve frequency control.

The speed is a linear function of the step clock frequency for a given micro-stepping mode, which can be varied by the software from full to 1/256 step.

To use the STSPIN220 driver library, you must run the initialization function which:

- Sets up the required GPIOs to enable the bridges and manage fault pin EN\FAULT, dedicated MODE1 and MODE2 step mode selection pins, the DIR\MODE4 pin for motor direction or step mode selection, the STCK\MODE3 pin for the step clock or the step mode selection and the standby reset pin STBY\RESET.
- Sets up the timer in output compare mode for the STCK pin and the timer reference voltage generation in PWM mode for REF pin.
- Loads the driver parameters with values from stspin220_target_config.h or defined in the main function using a dedicated initialization structure.

Driver parameters can be modified after initialization by calling specific functions. You can also write callback functions and attach them to:

- the flag interrupt handler to perform certain actions when a failure is reported by the STSPIN220
- the error handler which is called by the library when it reports an error

Subsequent motion commands include:

- `BSP_MotorControl_Move` to move a given number of steps in a specific direction
- `BSP_MotorControl_GoTo`, `BSP_MotorControl_GoHome`, `BSP_MotorControl_GoMark` to go to a specific position using the shortest path
- `BSP_MotorControl_CmdGoToDir` to go in a specific direction to a specific position
- `BSP_MotorControl_Run` to run indefinitely

The speed profile is completely handled by the microcontroller. The motor starts moving at the `BSP_MotorControl_SetMinSpeed` minimum speed setting, which is then altered at each step by the `BSP_MotorControl_SetAcceleration` acceleration value.

If the target position of a motion command is far enough, the motor performs a trapezoidal move by:

- accelerating with the device acceleration parameter
- remaining steady at `BSP_MotorControl_SetMaxSpeed` maximum speed
- decelerating by `BSP_MotorControl_SetDeceleration`
- stopping at the target destination

If the target position is too close for the motor to reach maximum speed, it performs a triangular move involving:

- acceleration
- deceleration
- stopping at the target destination

A motion command can be stopped at any time with `BSP_MotorControl_SoftStop` progressively decreasing the speed using the deceleration parameter or the `BSP_MotorControl_HardStop` command which immediately stops the motor. The power bridge is automatically disabled when the motor stops if the `HIZ_MODE` stop mode was previously set (`BSP_MotorControl_SetStopMode`).

Direction, speed, acceleration and deceleration can be changed either when the motor is stopped or when the motion is requested via `BSP_MotorControl_Run`.

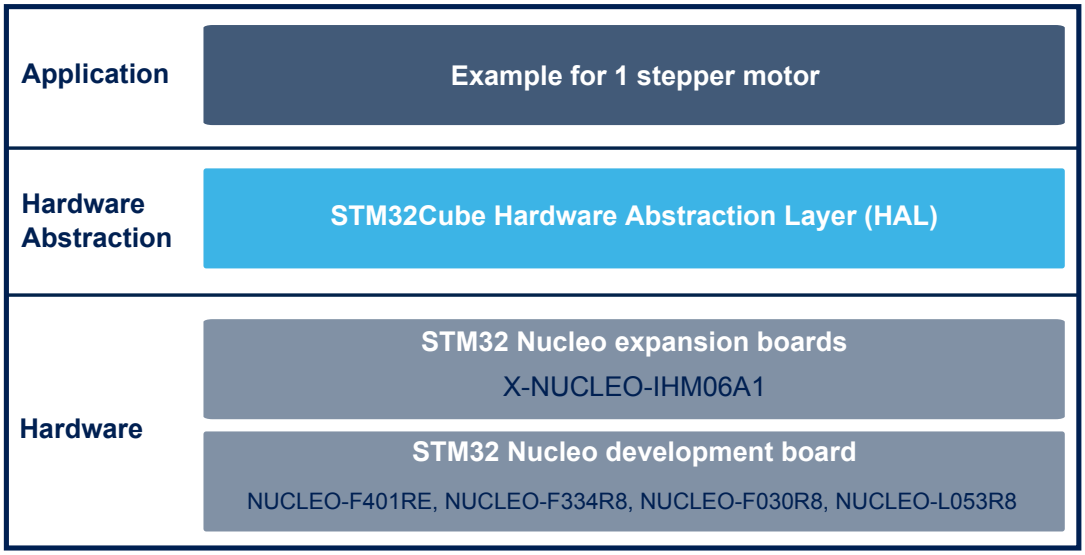
To block new commands before the completion of previous ones, `BSP_MotorControl_WaitWhileActive` locks program execution until the motor stops.

`BSP_MotorControl_SelectStepMode` can change the step mode from full to 1/256 step. When step mode is changed, the device and the current position and speed are reset.

2.2 Architecture

This software expansion complies with STM32Cube architecture and expands it to enable the development of applications using stepper motor drivers.

Figure 1. X-CUBE-SPN6 software architecture



The software is based on the STM32CubeHAL hardware abstraction layer for the STM32 microcontroller. The package extends STM32Cube with a board support package (BSP) for the motor control expansion board and a BSP component driver for the STSPIN220 low voltage stepper motor driver.

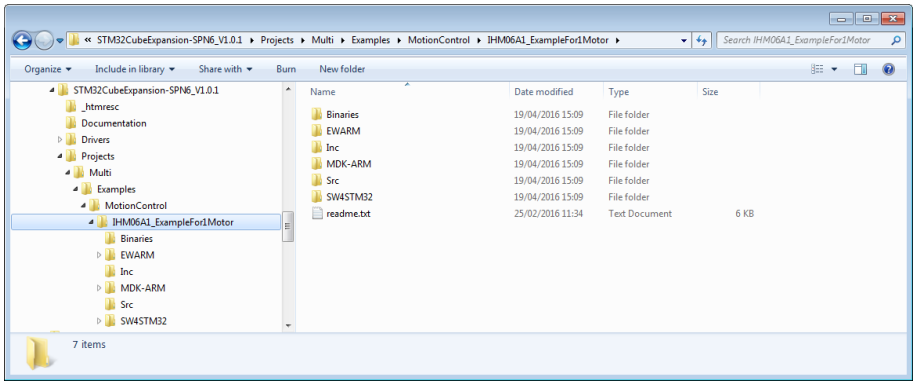
The software layers used by the application software are:

STM32Cube HAL layer: a simple, generic and multi-instance set of APIs (application programming interfaces) to interact with upper application, library and stack layers. It is composed of generic and extension APIs based on a common architecture so that layers built on it, such as the middleware layer, can function without requiring specific microcontroller Unit (MCU) hardware configurations. This structure improves library code reusability and guarantees an easy portability on 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 LED and the user button, and helps in identifying the specific board version. The motor control BSP provides the programming interface for various motor driver components. It is associated with the BSP component for the STSPIN220 motor driver in the X-CUBE-SPN6 software.

2.3 Folder structure

Figure 2. Folder structure



The software is located in two main folders:

- the **Drivers** folder which contains:
  - the STM32Cube HAL files, taken directly from the STM32Cube framework and only include those required to run the motor driver examples;
  - the CMSIS (Cortex® microcontroller software interface standard), vendor-independent hardware abstraction layer for the Cortex-M processor series from ARM. This folder is also unchanged from the STM32Cube framework.
  - a BSP folder with the code files for X-NUCLEO-IHM06A1 configuration, the STSPIN220 driver and the motor control API.
- the **Projects** folder which contains several use examples of the STSPIN220 motor driver for different STM32 Nucleo platforms.

2.3.1 BSP folder

The X-CUBE-SPN6 software includes the BSPs described in the following sections.

2.3.1.1 STM32L0XX-Nucleo/STM32F0XX-Nucleo/STM32F3XX-Nucleo/STM32F4XX-Nucleo BSPs

These BSPs provide an interface for each compatible STM32 Nucleo development board to configure and use its peripherals with the X-NUCLEO-IHM06A1 expansion board. Each subfolder has two.c/.h file pairs:

- **stm32XXxx_nucleo.c/h**: these unmodified STM32Cube framework files provide the user button and LED functions for the specific STM32 Nucleo development board.
- **stm32XXxx_nucleo_ihm06a1.c/h**: these files are dedicated to the configuration of the PWMs, the GPIOs, and interrupt enabling/disabling required for X-NUCLEO-IHM06A1 expansion board operation.

2.3.1.2 Motor control BSP

This BSP provides a common interface to access the driver functions of various motor drivers, such as L6474, powerSTEP01, L6208 and STSPIN220, via MotorControl/motorcontrol.c/h file pair. These files define all the driver configuration and control functions, which are then mapped to the functions of the motor driver component used on the given expansion board via motorDrv_t structure file (defined in Components\Common\motor.h.). This structure defines a list of function pointers which are filled during its instantiation in the corresponding motor driver component. For X-CUBE-SPN6, the structure is called stspin220Drv (see file: BSP\Components\stspin220\stspin220.c).

As the motor control BSP is common for all motor driver expansion boards, all its functions may not be available for a given expansion board. Unavailable functions are replaced by null pointers during the instantiation of the motorDrv_t structure in the driver component.

2.3.1.3 *STSPIN220 BSP component*

The STSPIN20 BSP component provides the driver functions of the STSPIN220 motor driver in the folder stm32_cube\Drivers\BSP\Components\STSPIN220.

This folder has 3 files:

- **stspin220.c**: core functions of the STSPIN220 driver
- **stspin220.h**: declaration of the STSPIN220 driver functions and their associated definitions
- **stspin220_target_config.h**: predefined values for the STSPIN220 parameters and for the motor devices context

2.3.2 Projects folder

For each STM32 Nucleo platform, one example project is available in stm32_cube\Projects\Multi\Examples\MotionControl\:

- **IHM06A1_ExampleFor1Motor** examples of control functions for single-motor configurations

The example has a folder for each compatible IDE:

- **EWARM** for IAR
- **MDK-ARM** for Keil
- **STM32CubeIDE**

The following code files are also included:

- **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 based on the motor control library for STSPIN220)
- **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

2.4 Software required resources

MCU control of a single STSPIN220 (one X-NUCLEO-IHM06A1 expansion board) and communication between the two is handled through six GPIOs (STBY\RESET, EN\FAULT, MODE1, MODE2, STCK\MODE3, DIR\MODE4 pins) and a PWM for REF pin. The GPIO for the STCK\MODE3 pin is reconfigured dynamically to be used as a TIMER OUTPUT COMPARE alternate function signal for the STCK pin.

For the handling of overcurrent and the overtemperature alarms, the X-CUBE-SPN6 software uses an external interrupt configured on the GPIO used for the EN\FAULT pin, after it has enabled or disabled the power bridges.

Table 2. Required resources for the X-CUBE-SPN6 software

Resources F4xx	Resources F3xx	Resources F0xx	Resources L0xx	Pin	Features (board)
Port A GPIO 10 EXTI15_10_IRQn	Port A GPIO 10 EXTI15_10_IRQn	Port A GPIO 10 EXTI4_15_IRQn	Port A GPIO 10 EXTI4_15_IRQn	D2	EN\FAULT (EN)
Port B GPIO 3 Timer2 Ch2	Port B GPIO 3 Timer2 Ch2	Port B GPIO 3 Timer15 Ch1	Port B GPIO 3 Timer2 Ch2	D3	STCK\MODE3 (PWM1)
Port B GPIO 4				D5	MODE1 (M1)
Port A GPIO 8				D7	DIR\MODE4 (DIR1)
Port A GPIO 9				D8	STBY\RESET (RST)
Port C GPIO 7 Timer3 Ch2	Port C GPIO 7 Timer3 Ch2	Port C GPIO 7 Timer3 Ch2	Port C GPIO 7 Timer22 Ch2	D9	PWM REF (REF)
Port B GPIO 6				D10	MODE2 (M2)

2.5 APIs

X-CUBE-SPN6 software APIs are defined in the motor control BSP. The related functions contain the “BSP_MotorControl_” prefix.

Note: Not all the functions of this module are available for the STSPIN220 and hence the X-NUCLEO-IHM06A1 expansion board.

Full user API function and parameter descriptions are compiled in an HTML file in the software Documentation folder.

2.6 Sample application description

An example application using the X-NUCLEO-IHM06A1 expansion board with a compatible STM32 Nucleo development board is provided in the Projects directory, with ready-to-build projects for multiple IDEs (see Section 2.3.2 Projects folder).

3 System setup guide

3.1 Hardware description

This section describes the hardware components needed to develop a low voltage stepper motor driver-based application using X-CUBE-SPN6.

The following sub-sections describe the individual components.

3.1.1 STM32 Nucleo

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

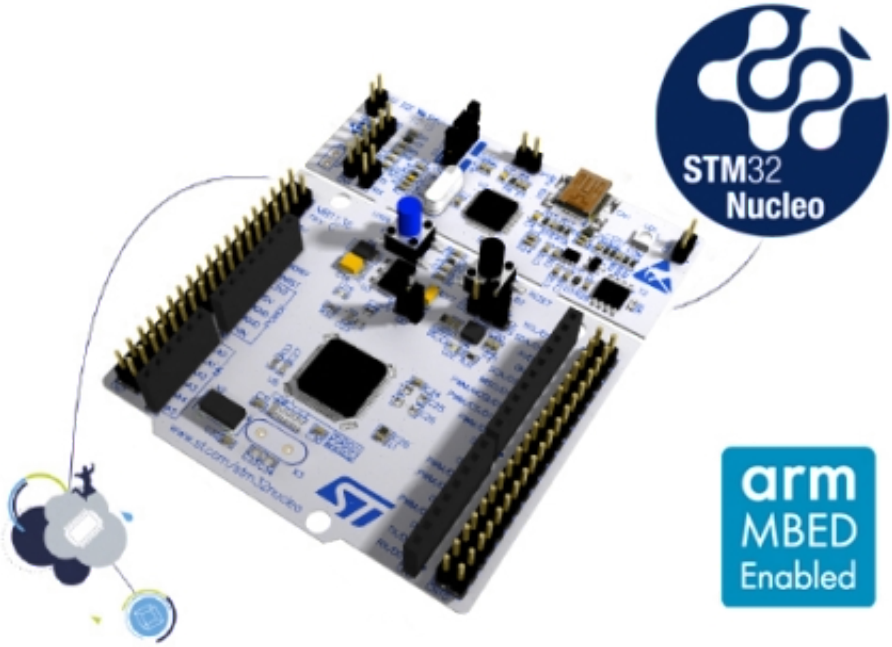
The Arduino connectivity support and ST morpho connectors make it easy to expand the functionality of the STM32 Nucleo open development platform with a wide range of specialized expansion boards to choose from.

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 for different IDEs (IAR EWARM, Keil MDK-ARM, STM32CubeIDE, mbed and GCC/ LLVM).

All STM32 Nucleo users have free access to the mbed online resources (compiler, C/C++ SDK and developer community) at www.mbed.org to easily build complete applications.

Figure 3. STM32 Nucleo board

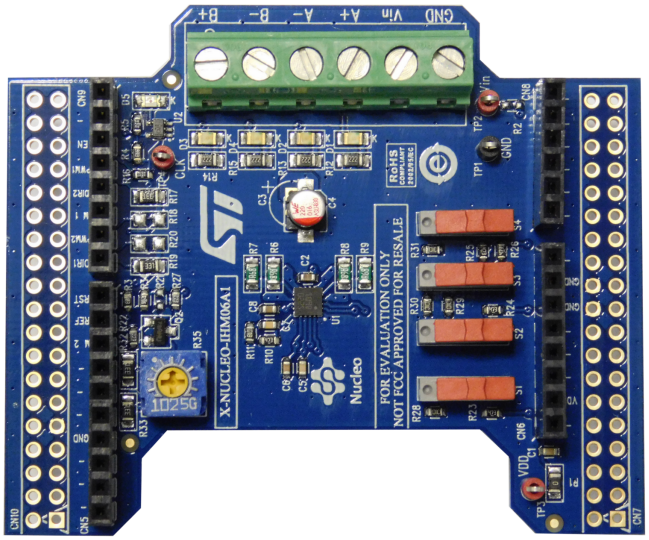


3.1.2 X-NUCLEO-IHM06A1 low voltage stepper motor driver expansion board

The X-NUCLEO-IHM06A1 is a low voltage stepper motor driver expansion board based on the STSPIN220. It provides an affordable and easy-to-use solution for driving a stepper motor in your STM32 Nucleo project.

The X-NUCLEO-IHM06A1 is compatible with the Arduino UNO R3 connector and supports additional boards.

Figure 4. X-NUCLEO-IHM06A1 low voltage stepper motor driver expansion board



3.2 Hardware requirements

To complete the hardware setup, you need:

- a bipolar low voltage (1.8 to 10 V) stepper motor
- an external DC power supply with two electric cables for the X-NUCLEO-IHM06A1 expansion board
- a USB type A to mini-B USB cable to connect the STM32 Nucleo development board to a PC/laptop

3.3 Software requirements

The following software components are required to set up the suitable development environment for creating applications based on the motor driver expansion board:

- X-CUBE-SPN6 STM32Cube expansion for STSPIN220 low voltage stepper motor driver application development. The X-CUBE-SPN6 firmware and related documentation is 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
  - Integrated Development Environment for STM32 (STM32CubeIDE)

3.4 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.

3.4.1 Setup to drive a single motor

Step 1. Configure the following jumpers on the STM32 Nucleo development board:
- JP1 off
- JP5 (PWR) on UV5 side
- JP6 (IDD) on

Step 2. Configure the X-NUCLEO-IHM06A1 expansion board as follows:

Step 2a. Tune R35 potentiometer to 1 kΩ.

Step 2b. Set S1, S2, S3 and S4 switches to the pull-down side as shown in Figure 4.

You can select the micro-stepping mode through the MODE1, MODE2, MODE3 and MODE4 levels controlled by the STM32 Nucleo development board.

Step 3. Plug the X-NUCLEO-IHM06A1 expansion board on top of the STM32 Nucleo development board via the Arduino UNO connectors.

Step 4. Connect the STM32 Nucleo to a PC/laptop with the USB cable through USB connector CN1 to power the board.

Step 5. Power the X-NUCLEO-IHM06A1 on by connecting Vin and Gnd connectors to a DC power supply set to deliver the required voltage by the stepper motor.

Step 6. Connect the stepper motor to the X-NUCLEO-IHM06A1 bridge connectors A+/- and B+/-.

Step 7. Open your preferred toolchain.

Depending on the STM32 Nucleo, open the software project from:
- \stm32_cube\Projects\Multi\Examples\MotionControl\IHM06A1_ExampleFor1Motor\YourToolChainName\STM32F401RE-Nucleo for Nucleo STM32F401
- \stm32_cube\Projects\Multi\Examples\MotionControl\IHM06A1_ExampleFor1Motor\YourToolChainName\STM32F030R8-Nucleo for Nucleo STM32F334
- \stm32_cube\Projects\Multi\Examples\MotionControl\IHM06A1_ExampleFor1Motor\YourToolChainName\STM32F030R8-Nucleo for Nucleo STM32F030
- \stm32_cube\Projects\Multi\Examples\MotionControl\IHM06A1_ExampleFor1Motor\YourToolChainName\STM32L053R8-Nucleo for Nucleo STM32L053

Step 8. To adapt the default STSPIN220 parameters to your low voltage stepper motor characteristics, either:
- use `BSP_MotorControl_Init` with the NULL pointer and open stm32_cube\ Drivers\ BSP\ Components\ STSPIN220\ STSPIN220_target_config.h to modify the parameters according to your needs;
- use `BSP_MotorControl_Init` with the address of the `initDevicesParameters` structure with appropriate values.

Step 9. Rebuild all files and load your image into target memory.

Step 10. Run the example.

The motor automatically starts (See main.c for demo sequence details).

Revision history

Table 3. **Document revision history**

Date	Version	Changes
01-Jul-2016	1	Initial release.
21-May-2021	2	Updated Introduction, Section 2.1 Overview, Section 2.2 Architecture, Section 2.3 Folder structure, Section 2.3.2 Projects folder, Section 3.2 Hardware requirements, Section 3.3 Software requirements and Section 3.4.1 Setup to drive a single motor. Removed Section 2. What is STM32Cube? and Section 2.1 STM32Cube architecture and replaced them by a link in the Introduction.

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