SR5E1-MCTK-01 motor control toolkit

Introduction

The SR5E1 Stellar E motor control toolkit provides a motor control solution for low voltage, three-phase motors, either DC brushless or PMSM motors.

This kit is composed of the SR5E1-EVBE3000D board and the X-NUCLEO-IHM08M1 board together with the Field oriented control library (SR5E1 motor control library) and monitoring tool (live monitor). The kit includes a 24 V, 64-Watt motor to simplify the set-up time.

The SR5E1-EVBE3000D discovery board is an evaluation board supporting STMicroelectronics SR5E1, a high-performance 32-bit Arm® Cortex®-M7 automotive MCU 2x cores, 2 MB flash, rich analog, high-resolution timer, HSM, ASIL-D in an eTQFP100 package.

The board integrates a programmer/debugger that allows debugging and programming the microcontroller via USB cable. In addition, it allows enabling a UART communication channel (USB virtual COM port). Dedicated connectors allow plugging shields Arduino® UNO-compatible; this feature makes it easy to expand the functionality of the SR5E1-EVBE3000D. A mipi-10 JTAG connector is available to program and debug the microcontroller by using an external tool.

The power board X-NUCLEO-IHM08M1 is a three-phase brushless DC motor driver expansion board based on STripFET F7 power MOSFET STL220N6F7. It provides an affordable and easy-to-use solution for driving a three-phase brushless DC motor in your SR5 E1 project.

The IC driver used on this expansion board is the L6398 single-chip half bridge gate driver for the N-channel power MOSFET.

This document describes the procedure to configure the SR5E1 motor control toolkit to run the motor included in the package.

Figure 1. SR5E1-MCTK-01 motor control toolkit

1 Preface

Stellar SR5 devices embed the Arm® Cortex®-M7+ and Cortex®-M0+ cores.

For information on the Arm® Cortex®-M7+ and Cortex®-M0+ cores, refer to the technical reference manuals, available from the www.arm.com website.

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2 Features

The information listed below shows the main board specification data and parameters set for the SR5E1-EVBE3000D board, X-NUCLEO-IHM08M1 expansion board included in the kit and SR5E1 motor control library.

SR5E1-EVBE3000D board

Discovery board based on the SR5E1E3 microcontroller.

The board integrates a programmer/debugger that allows debugging and programming the microcontroller via USB cable. In addition, it allows enabling a UART communication channel (USB virtual COM port)

Dedicated connectors allow plugging shields ARDUINO® UNO-compatible.

SR5E1 main features:

- AEC-Q100 automotive qualified
- SR5 high-performance analog MCUs offer:
  - Digital and analog high-frequency control requested by new wide-bandgap technologies (silicon carbide and gallium nitride)
  - Superior real-time and functional safety performance (ASIL-D capability)
  - Built-in fast and cost-optimized OTA (over-the-air) reprogramming capability (with built-in dual-image storage)
  - High-speed security cryptographic services (HSM)
- Cores
  - 2× 32-bit Arm® Cortex®-M7 with double-precision FPU, L1 cache and DSP instructions running at up to 306.7 MHz to reach 1284 DMIPS/2.14 DMIPS/MHz/core (Dhrystone 2.1)
  - Split-lock configuration, allowing either 2 cores in parallel or 1 core in lockstep configuration
  - 2 DMA engines in lockstep configuration
- Memories
  - Up to 2 MB on-chip flash memory with read while write support
  - 1920 KB code flash memory split in two banks allowing 960 KB OTA reprogramming
  - 160 KB HSM dedicated code flash memory
  - 96 KB data flash memory (64 KB + 32 KB dedicated to HSM)
  - 488 KB on-chip general-purpose SRAM:
  - 2× 32 KB instruction TCM + 2× 64 KB data TCM
  - 256 KB system RAM
  - 40 KB HSM dedicated system RAM
- Security: hardware security module (HSM)
  - Cybersecurity ISO/SAE 21434 compliance (refer to the cybersecurity reference manual for details)
  - On-chip high-performance security module with EVITA medium support with dedicated RAM and flash memory
  - Based on a Cortex®-M0+ core running at up to 150 MHz
  - Hardware accelerator for symmetric cryptography
- Safety: comprehensive new generation ASIL-D safety concept
  - State-of-the-art safety measures at all levels of the architecture for the most efficient implementation of ISO26262 ASIL-D functionalities
  - FCCU for collection and reaction to failure notifications with enhanced configurability
  - Memory error management unit (MEMU) for collection and reporting of error events in memories
  - Cyclic redundancy check (CRC) unit

- Enhanced peripherals for fast control loop capability
  - 12 timers:
    - 2 × HRTIM (high-resolution and complex waveform builder) in total: 12× 16-bit counters, up to 102 ps resolution, 24 PWM
    - 2 × 16-bit 6-channel advanced control timers in total, with up to 12× PWM
    - 2 × 32-bit general-purpose timers in total, with up to 8× IC/OC/PWM or pulse counter and quadrature encoder input
    - 4 × 16-bit general-purpose timers in total, with up to 11× PWM, 2 of which paired
    - 2 × 16-bit basic timers
  - Enhanced analog-to-digital converter system with:
    - 5 separate 12-bit SAR analog converters, 8 channels each. Sampling rate up to 2.5 MSPS in single mode, 5 MSPS in dual mode
    - 2 separate 16-bit sigma-delta analog converters
  - 12-bit digital-to-analog converters (DAC)
    - 2 buffered external channels 1 MSPS
    - 8 unbuffered internal channels 15 MSPS
  - 8 rail-to-rail analog comparators, 50 ns propagation delay
  - Hardware accelerator
    - 1× CORDIC for trigonometric functions acceleration
  - Communication interfaces
    - 4 modular controller area network (MCAN) modules, all supporting flexible data rate (ISO CAN-FD)
    - 3 UART modules with LIN functionality
    - 4 serial peripheral interface (SPI) modules, 2 multiplexed with I²S interfaces
    - 2 I²C modules
  - Advanced debug and trace for high-performance automotive application development
    - Built around Arm® Core® Sight™-600
    - Debug interface: Arm® Core® Sight™ JTAG (IEEE 1149.1) or SWD
    - 4 KB embedded trace FIFO for both on- and off-chip tracing
    - Trace port for off-chip tracing: parallel trace port configurable from 1 to 8 data lines

X-NUCLEO-IHM08M1 expansion board

The information listed below shows the board specification data and parameters set for the X-NUCLEO-IHM08M1 expansion board:

- 3-phase driver board for BLDC/PMSM motors
- The nominal operating voltage ranges from 10 V to 48 V DC
- 15 ARMS output current
- Operating frequency selectable by firmware
- Overcurrent detection and protection (30 a_{peak})
- Thermal monitoring and overheating protection
- Equipped with ST morpho connectors
- 3-Shunt and 1-Shunt configurable jumpers for motor current sensing
- Hall/Encoder motor sensor connector and circuit
- Debug connector for DAC, GPIOs, etc.
- Potentiometer available for speed regulation
- User LED
- RoHS compliant

SR5E1-MCTK-LIB

The SR5E1 motor control library provides developers with the configuration tool (integrated in the Stellar studio tool) and libraries needed to build a complete FOC software subsystem for SR5 E1 MCU.

Features:

- Single motor vector control (FOC)
- Control algorithm
  - Single vector FOC algorithm
  - Torque and speed control
- Current reading topologies supported:
  - 2 shunt current sensing on motor legs
  - 2 ICS in inverter phase
- Supported sensors
  - Hall sensor
  - Quadrature encoder
  - Resolver
  - Sensor-less
- Fault conditions management
  - Overcurrent (only from external sensor)
  - Over and undervoltage
  - Overtemperature
  - Speed feedback reliability error
  - FOC algorithm execution overrun
- Motor control library fully integrated into the Stellar studio software development environment with graphic configuration
- A set of demo is already available for the Stellar studio
- Compiler supported
  - Free GCC
  - IAR
  - HighTec
- Communication with motor control live monitor (LM) to real-time live monitoring of the motor control library variables

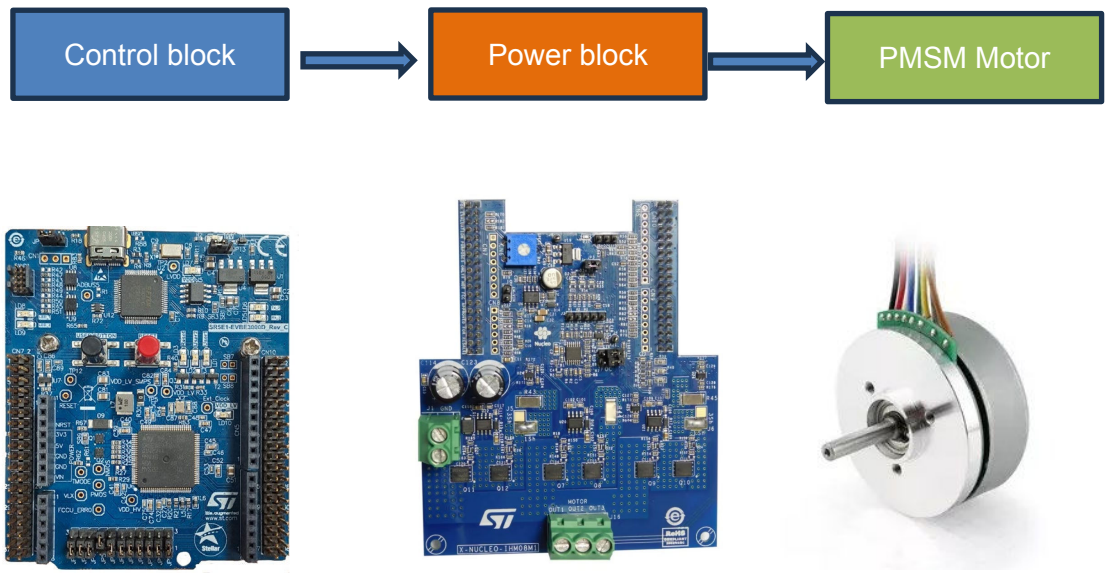
3 Getting started as a basic user

3.1 System architecture

A generic motor control system such as SR5E1 MCTK can be basically schematized as the arrangement of three main blocks (see Figure 2. SR5E1-MCTK-01 main blocks):

- **Control block**: its main task is to accept user commands and configuration parameters to drive a motor. The SR5E1-MCTK-01 is based on the SR5E1-EVBE3000D board that provides all digital signals to perform the proper motor driving control algorithm (FOC).
- **Power block**: the X-NUCLEO-IHM08M1 is based on a 3-phase inverter topology. The L6398 gate driver plus STL220N6F7 power MOSFET combination contains all the necessary active power and analog components to perform a low-voltage PMSM motor control.
- **PMSM motor:** low-voltage, 3-phase, brush less motor.

Figure 2. SR5E1-MCTK-01 main blocks



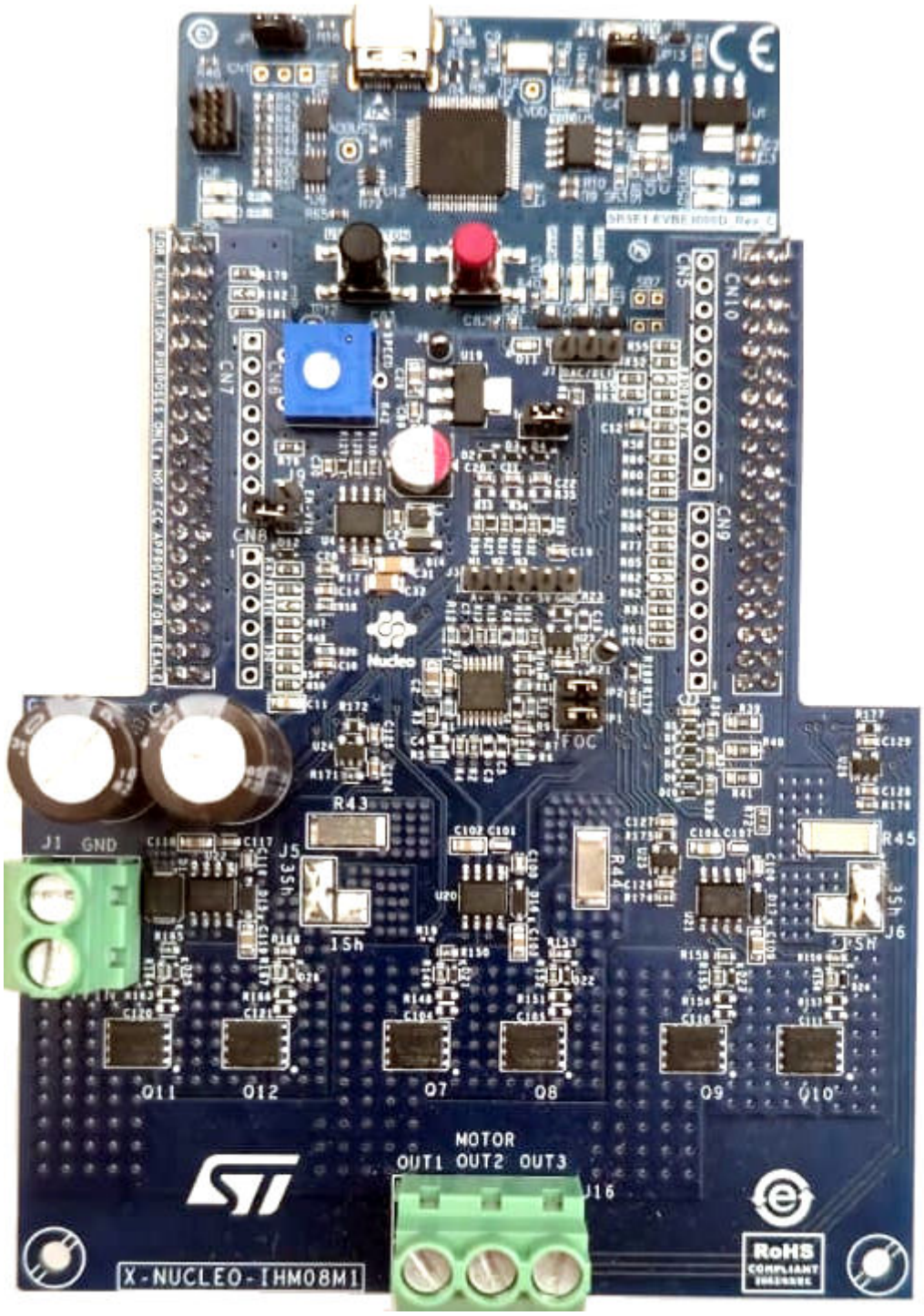
3.2 Building and runt the motor control

The SR5E1-MCTK-01 is a complete hardware development platform for the Stellar E1 ecosystem to evaluate a motor control solution with a single motor.

For a regular board operating, follow the hardware configuration explained below:

1. The X-NUCLEO-IHM08M1 must be stacked on the SR5E1-EVBE3000D board through the extended CN7 and CN10 connectors. There is only one position allowed for this connection, in particular the user button and reset button on the SR5E1-EVBE3000D board must be kept out, as shown in the following figure.

Figure 3. X-NUCLEO-IHM08M1 and SR5E1-EVBE3000D assembled



2. Connect the three-motor wires U, V, W at J16 connector; it is mandatory to connect the phase U wire to OUT1, the phase V to OUT2 and the phase W to OUT3, to respect clockwise and counterclockwise the motor rotation, according to the firmware implementation.

3. Select the jumper configuration on the power board to select the FOC control algorithm as described below:
   a. On the SR5E1-EVBE3000D board, check the jumper settings: JP13 on 1-2 (+5 V connected to U5V on E5V), JP1-JP4 on 1-2, JP5 on 2-3 (VBUS) and JP6-JP13 on 1-2.
   b. On X-NUCLEO-IHM08M1 expansion board:
      - Check jumper settings: J9 open, JP3 closed, J7 open
      - For FOC control, set jumpers: JP1 and JP2 closed, J5&J6 on the 3-Sh side. Remove capacitors C3, C5, and C7

Note: When using a different motor rated greater than 12 V, keep jumper J9 on the power board open before applying power-on voltage at J1 to avoid damaging the SR5E1-EVBE3000D control board.

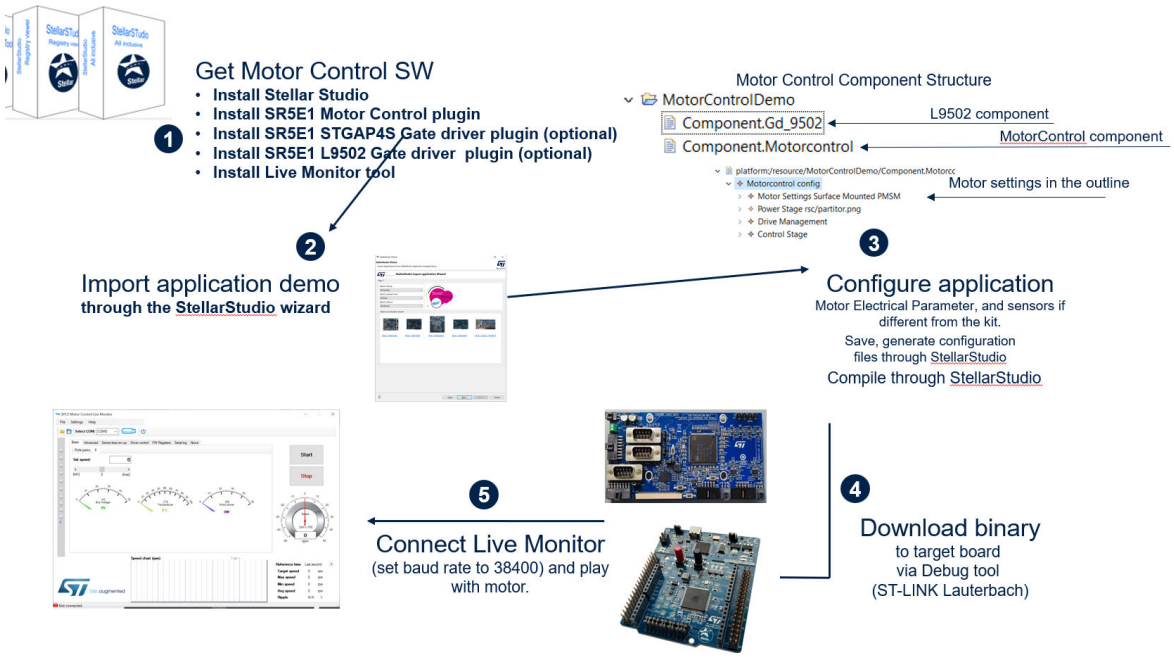
4. Connect the DC power supply on J1 connector and power-on. An external power supply is required to power up the power board.
5. The SR5E1-EVBE3000D board must be supplied by using the host through the USB cable (5 V). After the power on, the system is ready to start:
6. Press the user button on SR5E1-EVBE3000D and the motor starts spinning.
7. Press again the user button on SR5E1-EVBE3000D to stop the motor.
8. Connect to a live monitor tool to drive the motor.

3.3 SR5 E1 motor control library

To develop a motor control application using the SR5E1 motor control library, you need to follow these five steps:

1. The first step is to install the necessary software, StellarStudio, the motor control plugin, and the live monitor tool.
2. The second step is to import the demo, for the kit, into the development environment using StellarStudio wizard.
3. The third step is to configure the library, for example by changing the parameters for a new motor or configuring a different position sensor. Once the configuration is completed, it is necessary to save to generate the configuration code. Finally, it is possible to compile the application.
4. The fourth step is to download the application onto the control board using the integrated STELLARLINK debugger.
5. Finally, as the last step, connect the control board to the live monitor to play with the motor.

Figure 4. SR5 E1 motor control toolkit usage model



3.3.1 Get motor control software

The StellarStudio tool is the software environment dedicated to the Stellar microcontrollers family. It helps develop applications on the Stellar microcontrollers with useful interfaces to configure communication peripherals, clock distribution, pin mapping and so on.

StellarStudio is online and downloadable at:

https://www.st.com/en/development-tools/stellarstudio.html

A dedicated interface, the SR5E1 motor control plugin, can help you with your developments in the motor control library:

- Give immediate access to all the configuration parameters,
- Quickly develop your own motor control application with different requirements (for example a different motor to drive) and avoid direct modifications on motor control library code.

The SR5E1 motor control plugin is composed by the following components:

- Motor control FOC firmware library
- Motor control configuration GUI
- Gate driver configuration GUI: SR5E1 L9502 and STGAP4S gate driver feature (optional)
- Live monitor version 1.6.0

The latest version of the SR5E1 motor control library is automatically installed during the installation of the StellarStudio tool.

3.3.2 Software architecture

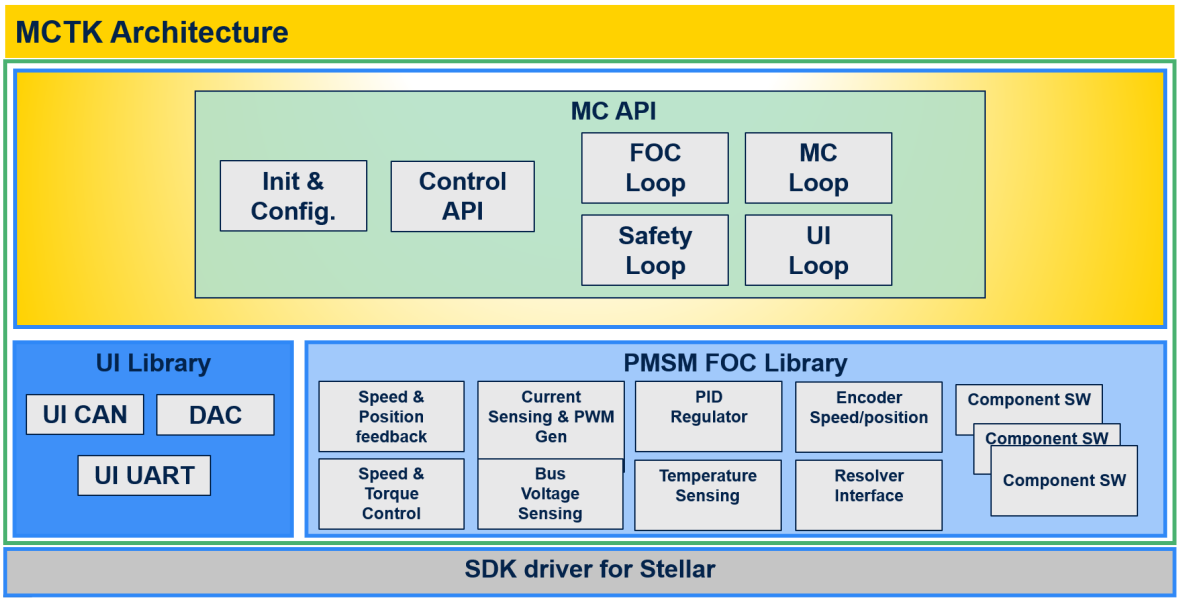
SR5E1 motor control firmware uses the SDK for SR5E1 and low layer drivers (LL) for interfacing with the peripherals. In some places of the code of the PMSM FOC library, direct accesses to hardware registers have been used, for performance reasons.

The firmware consists of the three following functional sets:

- The PMSM FOC library contains software components that implement the motor control features; each component implements a feature involved in MC such as, for instance, the speed and position sensing, the current sensing, or motor control algorithms
- The UI library contains software components that deal with the communication between the motor control firmware subsystem and either the user or an offloaded application; This library is used to allow the SR5E1 motor control firmware to connect to the live monitor application
- The MC API integrates all these software components into a motor control firmware subsystem and implements the regulation loops.

Motor controls live monitor tool running on PC used to monitor and to tune on fly library parameters.

Figure 5. SR5E1 motor control architecture



3.3.3 Live monitor

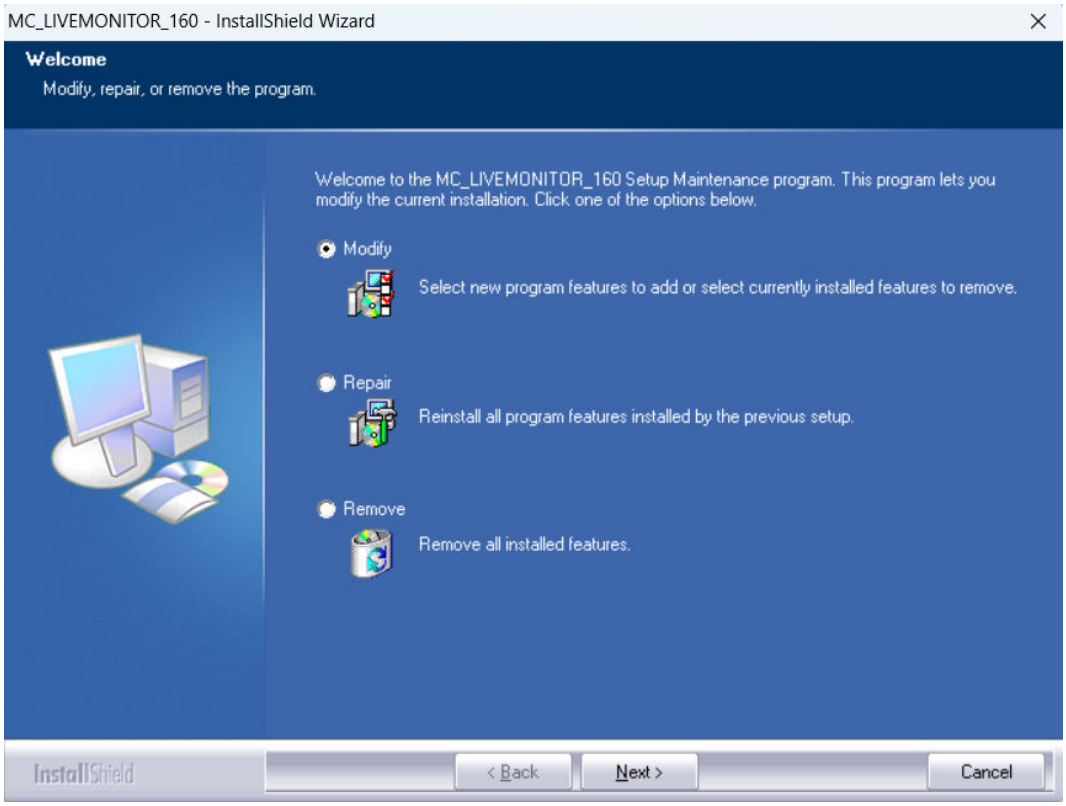
The live monitor tool is a very configurable monitor for all the variable exported by the motor control library (bus voltage, Speed, motor power as first) It provides a way to tune motor control and driver parameters and can be used for diagnostic purpose, as it integrates some commands to read/clear diagnostic variables of the driver of the complete motor control system.

Setup

The tool must be installed by the user. The installation file is in the following StellarStudio folder:

StellarStudio/contrib/LiveMonitorSetup/MC-LIVEMONITOR-1.6.0-Setup.exe

Figure 6. Live monitor setup tool

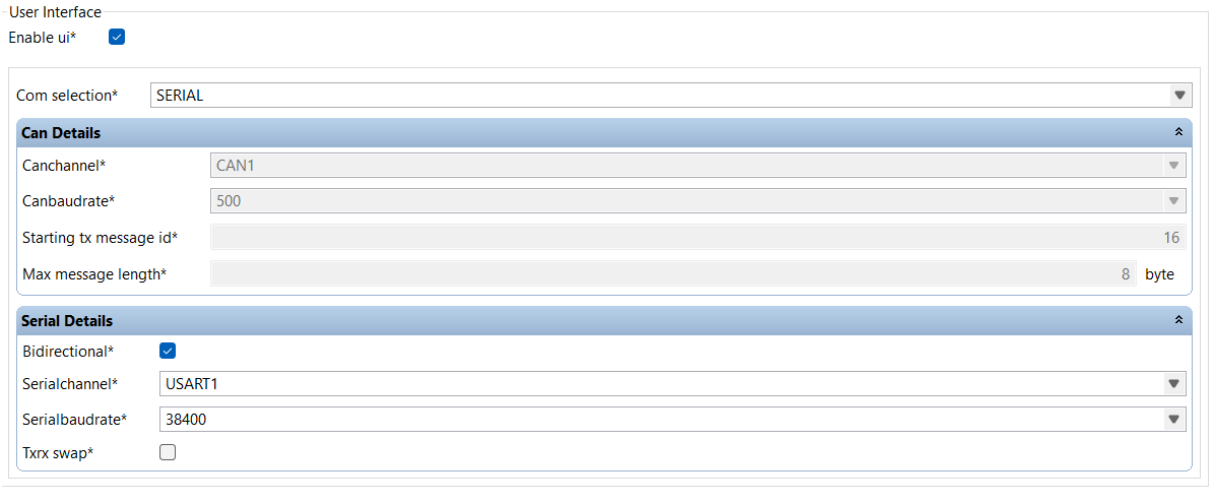


Live monitor configuration

Perform the following steps:

- Make sure to have selected SERIAL into drive setting → user interface of the motor control component into the StellarStudio tool

Figure 7. **User iInterface configuration**



- Select virtual COM and set the baud rate
- Click on the connect button
- Start the motor
- Change the reference speed
- Monitor actual speed, voltage, and power
- Go to the advanced option to change amplification gain or set ramp speed
- Go to the register view to check all library parameters

3.3.4 Upload the firmware example

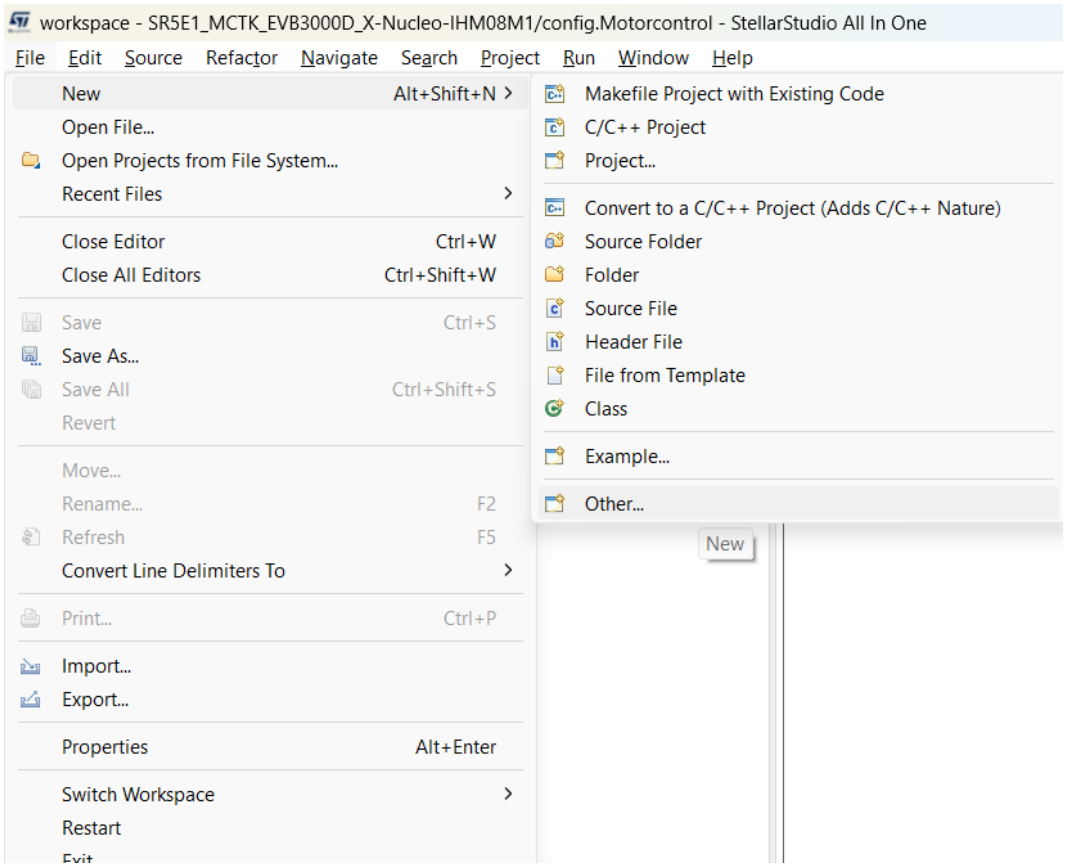
The example for the motor-control firmware of the SR5E1 motor control toolkit is preloaded in the SR5E1-EVBE3000D board. This chapter describes the procedure to reload the firmware demonstration inside the SR5E1-EVBE3000D board, to restart by the default condition.

Import application Wizard

The following steps are needed to import the application demo for the SR5E1 motor control toolkit:

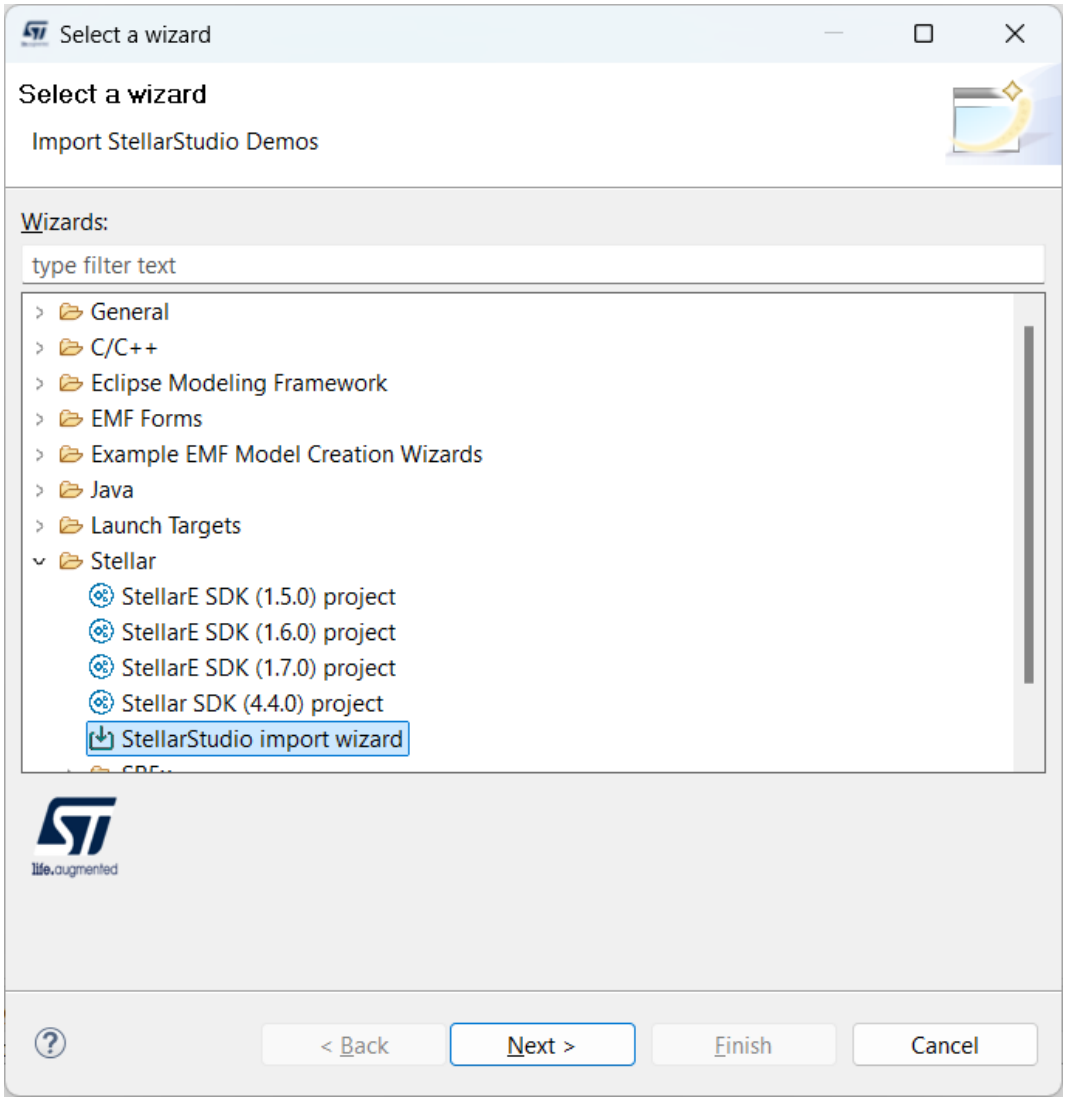
- Open StellarStudio tool
- Select file → New → Other…

Figure 8. Import application



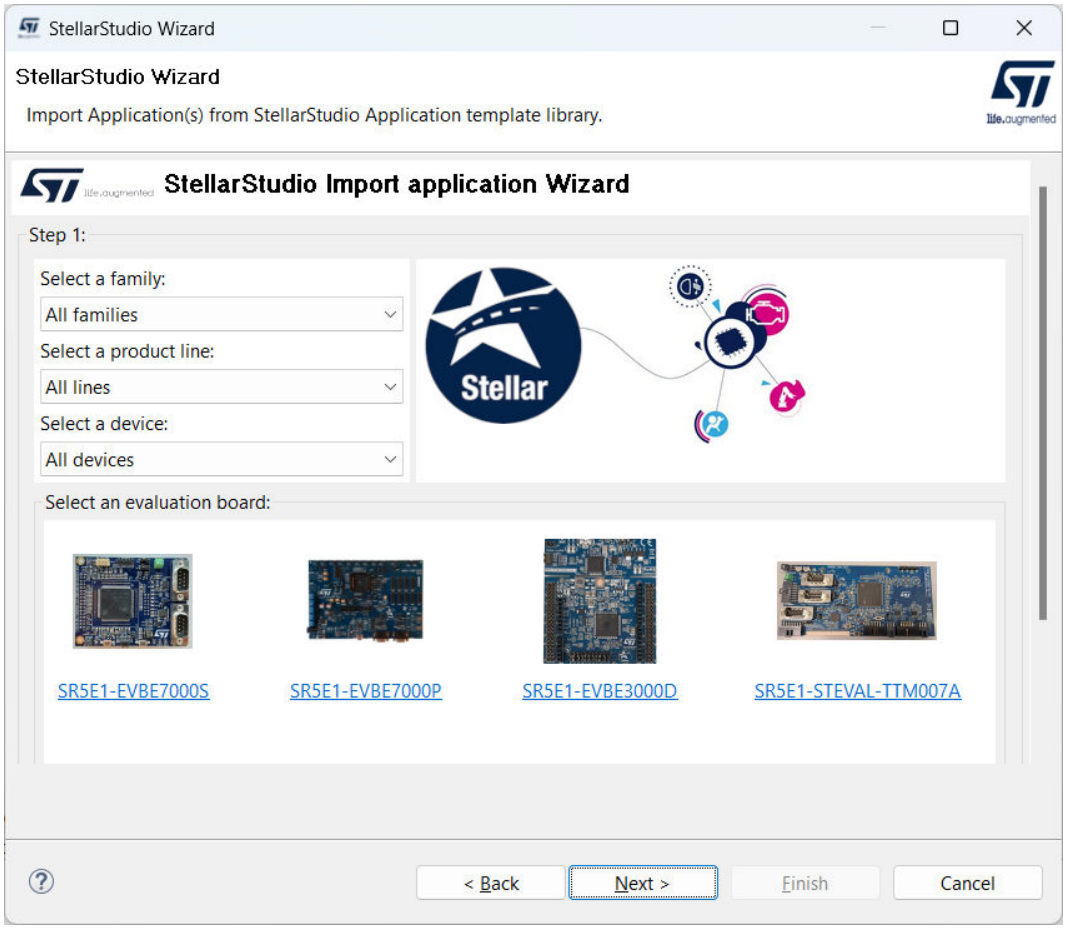
- Select in the Stellar/StellarStudio import wizard

Figure 9. **StellarStudio import wizard**



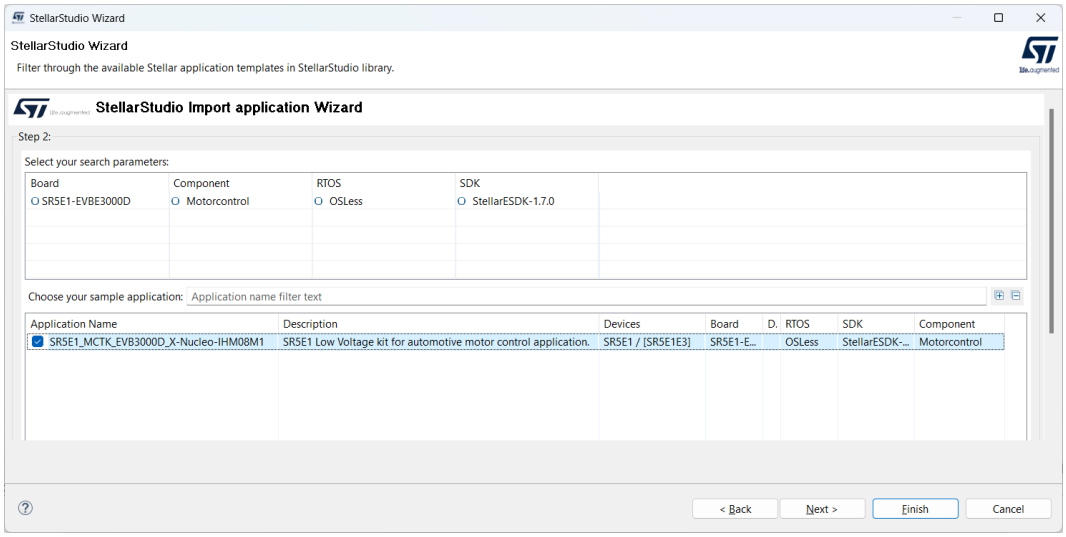
- Select the SR5E1-EVBE3000D control board and click on the next button

Figure 10. **Selection an evaluation board - StellarStudio**



- Select the SR5E1_MCTK_EVB3000D_X-Nucleo-IHM08M1 application

Figure 11. **Selection motor control application - StellarStudio**



Revision history

Table 1. **Document revision history**

Date	Revision	Changes
04-Dec-2025	1	Initial release.

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