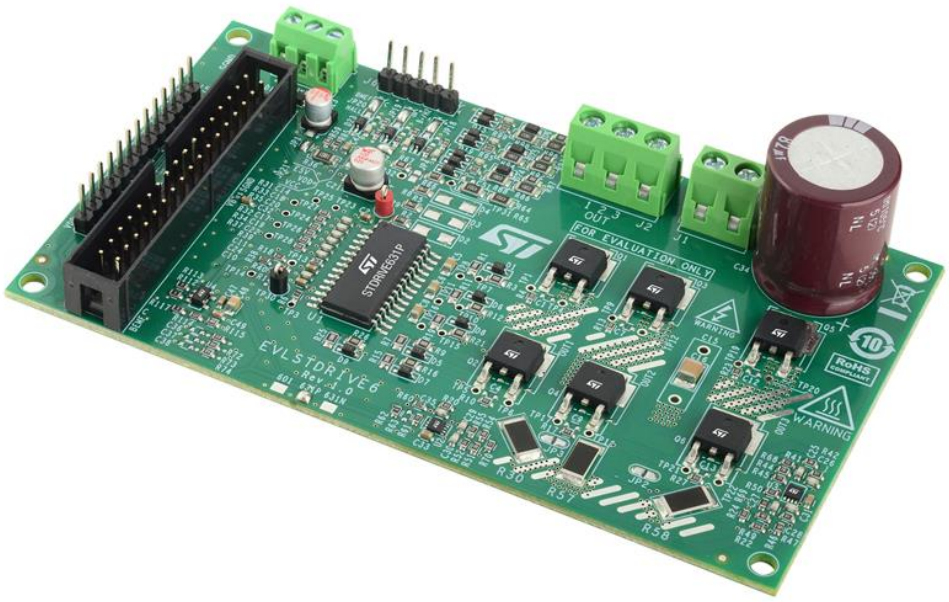
Getting started with EVLSTDRIVE631P/N: a 3-phase inverter platform for fast motor drive prototyping

Introduction

The EVLSTDRIVE631P and EVLSTDRIVE631N demonstration boards are complete 3-phase inverters that allow evaluating the STDRIVE631P or STDRIVE631N features. The power stage features STGD6M65DF2 IGBTs, but can be populated with any IGBT or power MOSFET in DPAK or PowerFLAT 8x8 HV package. The board is designed to support a three-shunts or a single-shunt current sensing topology. A strip connector allows an easy interfacing with MCU control.

The STDRIVE631P and STDRIVE631N are a 600 V gate drivers. The device is a single chip with three half-bridge gate drivers for N-channel power MOSFETs or IGBTs, suitable for three-phase applications. It integrates three bootstrap diodes and a smart shutdown feature that detects very fast overcurrent conditions. This feature minimizes the propagation delay between the overcurrent event and the output switch-off.

Figure 1. EVLSTDRIVE631P - Evaluation board



1 Main features

The EVLSTDRIVE6xx has the following features:

- Input voltage VCC from 9.5 V_{DC} to 20 V_{DC}
- High voltage rail up to 400 V (limited by input components)
- STGD6M65DF2 IGBTs power stage featuring:
  - $V_{(BR)CES}$ = 650 V
  - $V_{CE(sat)}$ = 1.55 V @ I_C = 6 A
- Dual footprint for IGBT/MOSFET package:
  - PowerFlat 8x8
  - DPAK
- Configurable overcurrent protection threshold (5.5 A_{peak} default)
- Selectable single or 3-shunt current sensing topology, suitable for:
  - Single-shunt/3-shunt vector (FOC) algorithm and 6-Step algorithm
- Digital Hall sensors and encoder input for sensored control algorithm
- BEMF detection network for sensorless control algorithm
- Smart shutdown Overcurrent protection
- Bus voltage sensing
- 450 V bulk capacitor
- 34-pins connector for MCU interfacing
- RoHS compliant

1.1 Target applications

- Three-phase motor drives
- Fans
- Pumps
- Refrigerator compressors
- Industrial inverters

2 Safety and operating instructions

2.1 General terms

Warning: *During assembly, testing, and operation, the evaluation board poses several inherent hazards, including bare wires, moving or rotating parts, and hot surfaces.*

Danger: *There is a danger of serious personal injury, property damage, or death due to electrical shock and burn hazards if the kit or components are improperly used or installed incorrectly.*

Danger: *The kit is not electrically isolated from the high-voltage supply AC/DC input. The evaluation board is directly linked to the mains voltage. No insulation is ensured between the accessible parts and the high voltage. All measuring equipment must use adequately insulated probes, clamps, and connecting wires; use adequate protective shields and use personal protective equipment.*

Never touch the evaluation board while it is energized as it is capable of causing an electrical shock hazard. After supply disconnection, wait and ensure that the onboard capacitors are fully discharged before touching or working on the board.

Danger: ***Board supplied with isolated AC source.***

When using an oscilloscope with single ended probes or when connecting a PC to the board as for programming the µC with a standard programmer, the board AC input shall be provided from an isolated or floating AC source. Floating AC supply is required to avoid shorting AC mains to earth ground through oscilloscope or PC with the risk of death, injury, and equipment damage. However, touching a single high-voltage point of the board could still result in an electrical shock hazard, even when supplying the board with an AC isolated source, isolation transformer, or high-voltage DC source.

Important: *All operations involving transportation, installation and use, and maintenance must be performed by skilled technical personnel able to understand and implement national accident prevention regulations. For the purposes of these basic safety instructions, “skilled technical personnel” are suitably qualified people who are familiar with the installation, use, and maintenance of power electronic systems.*

2.2 Intended use of evaluation board

The evaluation board is designed for demonstration purposes only, and must not be used for electrical installations or machinery. Technical data and information concerning the power supply conditions are detailed in the documentation and should be strictly observed.

2.3 Installing the evaluation board

- The installation and cooling of the evaluation board must be in accordance with the specifications and target application.
- The board must be protected against excessive strain. In particular, components should not be bent nor should isolating distances be altered during transportation or handling.
- No contact must be made with other electronic components and contacts.
- The board contains electrostatically sensitive components that are prone to damage if used incorrectly. Do not mechanically damage or destroy the electrical components (potential health risks).

2.4 Operating the evaluation board

To properly operate the board, follow these safety rules.

1. Work area safety:
   - The work area must be clean and tidy.
   - Do not work alone when boards are energized.
   - Protect against inadvertent access to the area where the board is energized using suitable barriers and signs.
   - A system architecture that supplies power to the evaluation board must be equipped with additional control and protective devices in accordance with the applicable safety requirements (that is, compliance with technical equipment and accident prevention rules).
   - Use a non-conductive and stable work surface.
   - Use adequately insulated clamps and wires to attach measurement probes and instruments.
2. Electrical safety:
   - Remove the power supply from the board and electrical loads before taking any electrical measurements.
   - Proceed with the arrangement of measurement setup, wiring, or configuration paying attention to high-voltage sections.
   - Once the setup is complete, energize the board.

Danger: *Do not touch the board when it is energized or immediately after it has been disconnected from the voltage supply as several parts and power terminals containing potentially energized capacitors need time to discharge.*
Do not touch the board after disconnection from the voltage supply as several parts, including the PCB, may still be very hot.
The kit is not electrically isolated from AC/DC input.

3. Personal safety
   - Always wear suitable personal protective equipment such as insulating gloves and safety glasses.
   - Take adequate precautions and install the board in such a way to prevent accidental touch. Use protective shields such as an insulating box with interlocks if necessary.

3 Hardware and software requirements

Using the EVLSTDRIVE6xx demonstration board requires the following software and hardware:

- A windows PC (Win 10, Win 11) to install the software package
- An STM32 nucleo board with related USB cable to be connected to a PC
- X-NUCLEO-IHM09M2: Motor control connector expansion board for STM32 Nucleo and related motor control connector, to easily connect the EVLSTDRIVE6xx board to the nucleo board via ST morpho connector
- A 6-step firmware package or the STM32 PMSM FOC Software Development Kit (available on www.st.com)
- A 3 phase BLDC or PMSM motor with compatible voltage and current ratings
- AC Mains power supply or external DC power supply

Warning: *The kit is not electrically isolated from the AC/DC input. The USB interface of the board does not insulate host computer from high voltage. When the board is supplied at a voltage outside the ELV range, a proper insulation method such as an USB isolator must be used to operate the board.*

4 Getting started

The maximum ratings of the board are the following:

- Power stage supply voltage up to 400 V_{DC} (limited by onboard bulk capacitor)
- Overcurrent protection threshold set to 5.5 A_{peak} (configurable)

To start your project with the board:

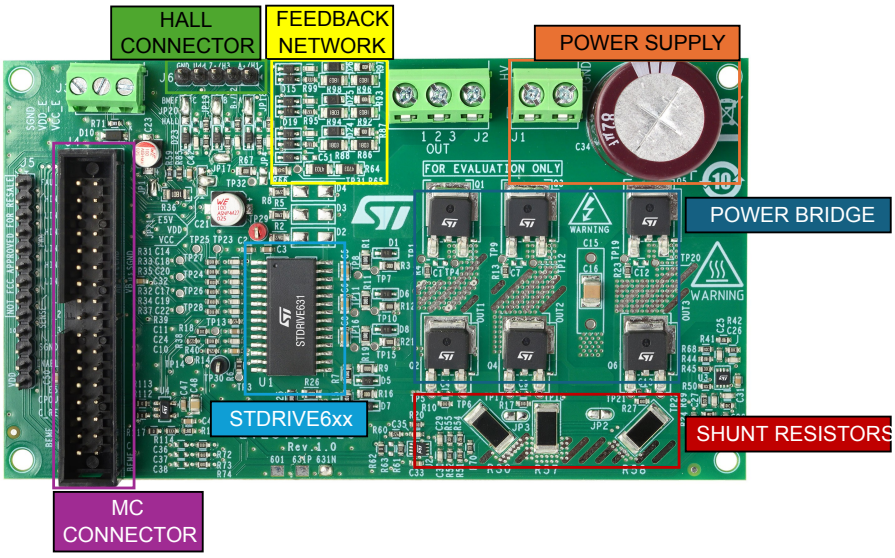
- Check the jumper position according to the target configuration (see Section 5).
- Connect the nucleo board to the EVLSTDRIVE6xx board through the expansion board
- Connect the motor phases to terminals J2.1, J2.2, J2.3 taking care of the motor phases' sequence.
- Supply the board through connector J1 (HV) and J3 (VCC), taking care of correct polarity

Develop your application using code examples provided or the STM32 FOC MC Library.
Please refer to the respective user manual for details.

5 Hardware description and configuration

Figure 2 shows the position of the main circuitry blocks of the board.

Figure 2. EVLSTDRIVE6xx – Board function description – TOP view



The Figure 3 shows the position of the connectors and jumpers of the board.

Figure 3. EVLSTDRIVE6xx – Main components and connectors position

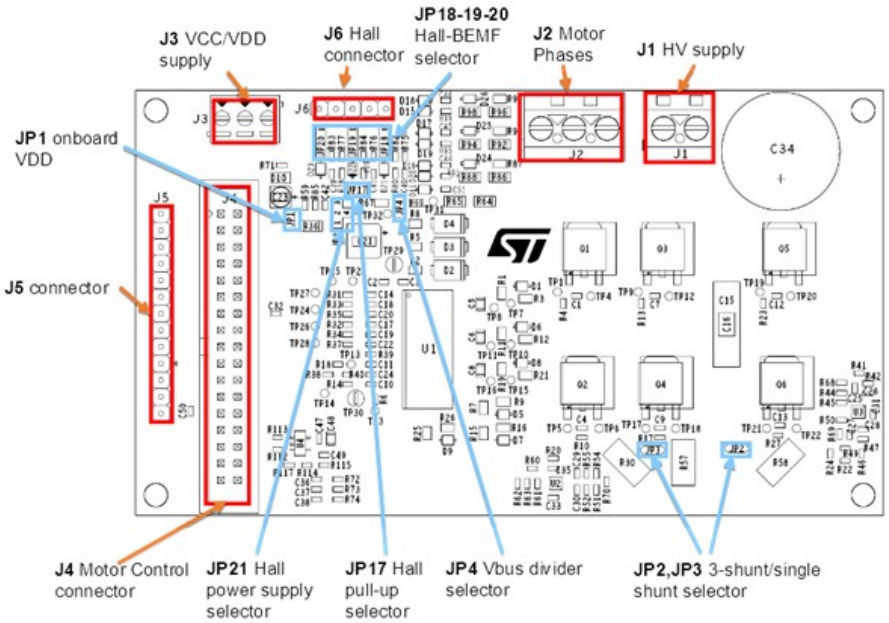


Table 1. Jumpers Hardware setting

Jumper	Description	Default Condition
JP1	Onboard VDD generation	CLOSED
JP2	SENSE 2-3 connection	OPEN
JP3	SENSE 1-2 connection	OPEN
JP4	HV divider selection: 126.5 (OPEN) or 145.8 (CLOSED)	OPEN
JP17	Power supply for hall sensors pull-up	CLOSED
JP18	Selection MCU input connected to BEMF phase 1 (1-2 CLOSED) or Hall A (2-3 CLOSED)	1-2 CLOSED
JP19	Selection MCU input connected to BEMF phase 2 (1-2 CLOSED) or Hall B (2-3 CLOSED)	1-2 CLOSED
JP20	Selection MCU input connected to BEMF phase 3 (1-2 CLOSED) or Hall C (2-3 CLOSED)	1-2 CLOSED
JP21	Hall sensors'power selection to VCC (1-2 CLOSED), VDD (2-4 CLOSED) or 5 V (2-3 CLOSED)	2-4 CLOSED

Table 2. Connectors and test points description

Name	Pin	Label	Description
J1	1-2	HV-PGND	External high voltage supply terminal block
J2	1	OUT 1	motor phases connections
	2	OUT 2	
	3	OUT 3	
J3	1	VCC_E	Driver power supply
	2	VDD_E	MCU/Logic power supply
	3	SGND	Driver ground
J4	1	FAULT	Driver FAULT signal
	2, 4, 6, 8, 10, 12, 16, 18 20, 22, 24, 30, 32	SGND	GND
	3	HIN1	Driver HIN1
	5	LIN1	Driver LIN1
	7	HIN2	Driver HIN2
	9	LIN2	Driver LIN2
	11	HIN3	Driver HIN3
	13	LIN3	Driver LIN3
	14	VBus	Vbus feedback to MCU
	15	SENSE_1	Sense_1 to MCU
	17	SENSE_2	Sense_2 to MCU
	19	SENSE_3	Sense_3 to MCU
	21		GPIO_BEMF divider enable from MCU
	23	ENABLE	Driver enable signal from MCU
	25	E5V	External 5V for hall power supply
	26		NC
	27	CPOUT	Current Comparator output (CPOUT) signal to MCU
	28		VDD
	29	C_REF	Current Reference signal from MCU
	31	BEMF A	BEMF OUT1 or Hall A signal to MCU
	33	BEMF B	BEMF OUT2 or Hall B signal to MCU

Name	Pin	Label	Description
J4	34	BEMF C	BEMF OUT3 or Hall C signal to MCU
J5	1	J5	Driver FAULT signal
	2		Driver HIN1
	3		Driver LIN1
	4		Driver HIN2
	5		Driver LIN2
	6		Driver HIN3
	7		Driver LIN3
	8		Sense_1 to MCU
	9		Sense_2 to MCU
	10		Sense_3 to MCU
	11		GND
	12		Driver enable signal from MCU
	13		VDD
J6	1	A+/H1	Hall/encoder sensors connector
	2	B+/H2	
	3	Z+/H3	
	4	Udd	Hall sensors/encoder supply
	5	GND	

Table 3. Test points description

Name	Pin	Label	Description
TP1	-		Phase 1 high side gate
TP2	-		W phase
TP3	-	PGND	Power GND
TP4	-		Phase 1
TP5	-		Phase 1 low side gate
TP6	-		SENSE 1
TP7	-		HVG1
TP8	-		OUT1
TP9	-		Phase 2 high side gate
TP10	-		HVG2
TP11	-		OU2
TP12	-		Phase 2
TP13	-	CIN	CIN– comparator positive input
TP14	-	OD	OD – SmartSD Open Drain output, unlatch and restart input
TP15	-		HVG3
TP16	-		OUT3
TP17	-		Phase 2 low side gate
TP18	-		SENSE 2
TP19	-		Phase 3 high side gate
TP20	-		Phase 3
TP21	-		Phase 3 low side gate
TP22	-		SENSE3
TP23			HIN1
TP24			LIN1
TP25			HIN2
TP26			LIN2
TP27			HIN3
TP28			LIN3
TP29			VCC
TP30		SGND	Signal GND
TP31			Vbus feedback
TP32			Signal GND

6 Board description

6.1 Sensorless

To configure the evaluation board for 6 STEP sensorless mode, the BEMF detection network must be enabled. Jumpers have to be set in the following way:

- JP18 pins 1-2 CLOSED, MCU ADC channel connected to Bemf phase 1
- JP19 pins 1-2 CLOSED, MCU ADC channel connected to Bemf phase 2
- JP20 pins 1-2 CLOSED, MCU ADC channel connected to Bemf phase 3

6.2 Hall/Encoder motor speed sensor

The EVLSTDRIVE6xx evaluation board supports the digital Hall and quadrature encoder sensors for motor position feedback.

Sensors can be connected through the J6 connector as listed in following table.

Table 4. Hall/Encoder connector (J6)

Name	Pin	Description
Hall1/A+	1	Hall sensor 1/Encoder out A+
Hall2/B+	2	Hall sensor 2/Encoder out B+
Hall3/Z+	3	Hall sensor 3/Encoder Zero feedback
Udd	4	Sensors supply voltage (default VDD)
GND	5	Ground

A protection series resistor of 1.8 kΩ is mounted in series with sensor outputs.

For sensors requiring external pull-up, three 10 kΩ resistors are already mounted on the output lines and connected to VDD voltage by means of jumper JP17.

Jumper JP21 selects the power supply for sensor supply voltage:

- JP21 pins 2-4 CLOSED (default) : Hall sensors powered by VDD (3.3V)
- JP21 pins 2-1 CLOSED : Hall sensors powered by VCC
- JP21 pins 2-3 CLOSED : Hall sensors powered by external 5 V

The external MCU can decode Hall/Encoder sensor outputs configuring jumpers as follows:

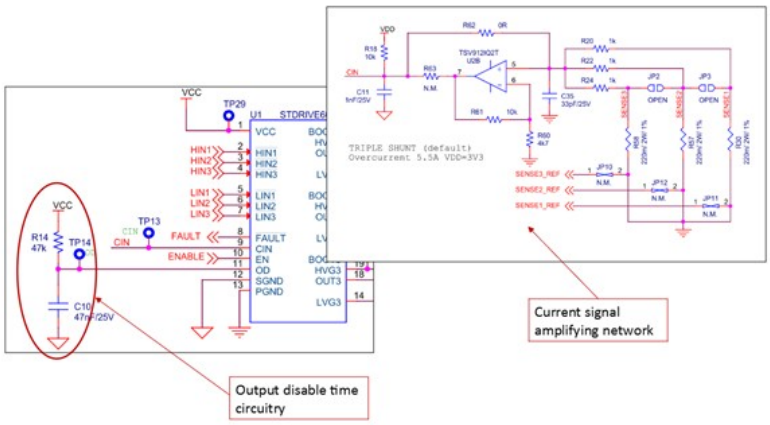
- JP18 pins 2-3 CLOSED, MCU ADC channel connected to Hall1
- JP19 pins 2-3 CLOSED, MCU ADC channel connected to Hall2
- JP20 pins 2-3 CLOSED, MCU ADC channel connected to Hall3

6.3 Overcurrent detection and current sensing measurement

The EVLSTDRIVE6xx evaluation board implements overcurrent protection based on the STDRIVE631P or STDRIVE631N integrated comparator. The single shunt resistors measure the load current bringing the voltage signal associated to load current and amplified by U2B OpAmp to CIN pin (TP13).

By default the amplifying network is disabled and the signal brought directly from shunts to CIN pin through R62 resistor. When the peak current in the phases exceeds the selected threshold, the integrated comparator is triggered and all the power switches are disabled. Power switches are enabled again when the current falls below the threshold and the *output disable time* expires, thus implementing a current limitation control.

Figure 4. EVLSTDRIVE6xx Current sensing and disable time circuitry



By default, evaluation board has an overcurrent threshold set to I_{OC_typ}= 5.5 A and a restart time after fault detection of ~735 us for VCC=12 V.

Overcurrent threshold can be modified changing R18 bias resistor, R20, R22, R24 loop resistors and R30, R57 and R58 shunt resistors according to the following formulas:

V_{REF_typ} = 460 mV, VDD = 3.3 V, R_{SHUNT} = R30=R57=R58 = 220 mΩ, R_{PU} = 10 kΩ, R_{LOOP} = R20=R22=R24= 1 kΩ

If R_{SHUNT} << R_{LOOP}

Equation 1

$$I_{OC_{typ}} \cong V_{REF_{typ}} \cdot \frac{(3R_{PU} + R_{LOOP})}{R_{SHUNT} \cdot R_{PU}} - VDD \cdot \frac{R_{LOOP}}{R_{SHUNT} \cdot R_{PU}} \quad (1)$$

The *output disable time* can be monitored on OD pin (TP14) and is determined mainly by the time required to recharge C10 capacitor up to V_{SSDh} threshold, according to the formula :

V_{SSDh}=3.8 V, V_{SSDl}=0.56 V, V_{OD}=VCC

Equation 2

$$t_2 \cong C10 \cdot R14 \cdot ln\frac{(VSSDl - VOD)}{(VSSDh - VOD)} \quad (2)$$

6.4 Bus voltage circuit

The EVLSTDRIVE6xx evaluation board provides the bus voltage sensing. This signal is set through a voltage divider (R64 to R67) from motor supply voltage (HV) and sent to the corresponding MCU ADC channel. The default voltage divider is set to 126.5 and can be configured through JP4.

6.5 Debug

The EVLSTDRIVE6xx evaluation board can be connected to an external Nucleo board with embedded ST-LINK/V2-1 debugger/programmer. The features supported by ST-LINK are:

- USB software re-enumeration
- Virtual com port interface on USB connected to the UART pins of the ST-LINK MCU (UART1)
- Mass storage interface on USB

The power supply for ST-LINK is provided by the host PC.

The programming/debugging phase of the MCU can be performed through Serial Wire interface available on Nucleo Board. Please refer to the relevant Nucleo board user manual for additional details.

7 Motor Control Workbench firmware generation

7.1 Introduction

To generate a functional example, you need the following components:

- STM32 Nucleo board (NUCLEO-G431RB is used as reference)
- X-NUCLEO-IHM09M2 adapter board
- EVLSTDRIVE6xx evaluation board

The firmware can be generated with Motor Control Workbench using the MCSDK-PKG007 package.

To generate the firmware, update STM32CubeMX libraries before starting the process.

The package describes the EVLSTDRIVE6xx evaluation board and must be imported into MCSDK to generate the firmware code. You can extend the package to other STM32 Nucleo boards.

7.2 STM32CubeMX libraries install and update

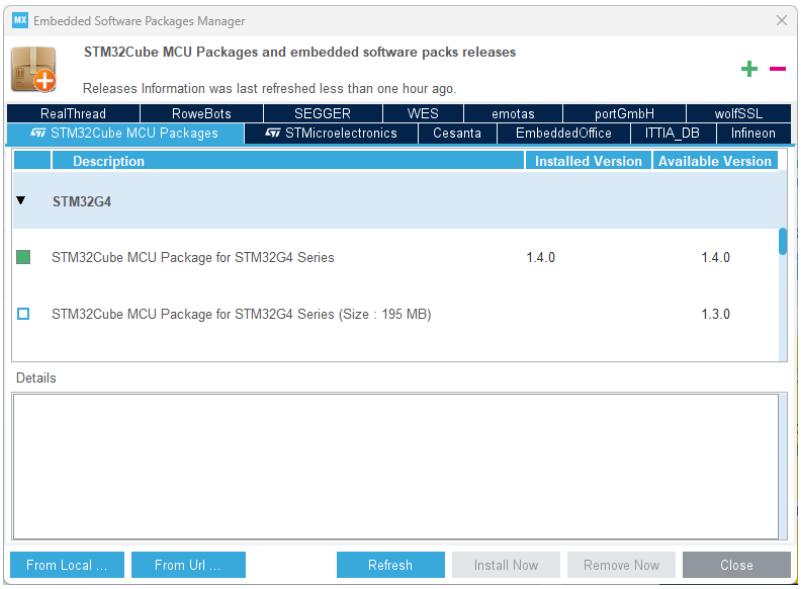
To generate board firmware for the EVLSTDRIVE6xx, update the tool and install the required additional packages.

Run STM32CubeMX and click **CHECK FOR UPDATES**.

Then click **INSTALL / REMOVE** to add the required STM32G4 software packages.

In the **STM32Cube MCU packages** tab, search and install S**TM32Cube MCU Package for STM32G4 Series** (or the one related to your Nucleo board).

Figure 5. STM32CubeMX – Packages Manager window

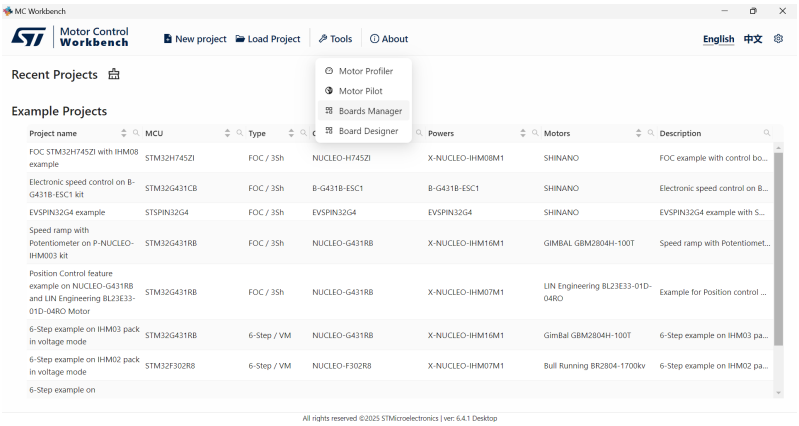


7.3 Motor Control Workbench FW generation

Run **Motor Control Workbench 6.4.1**.

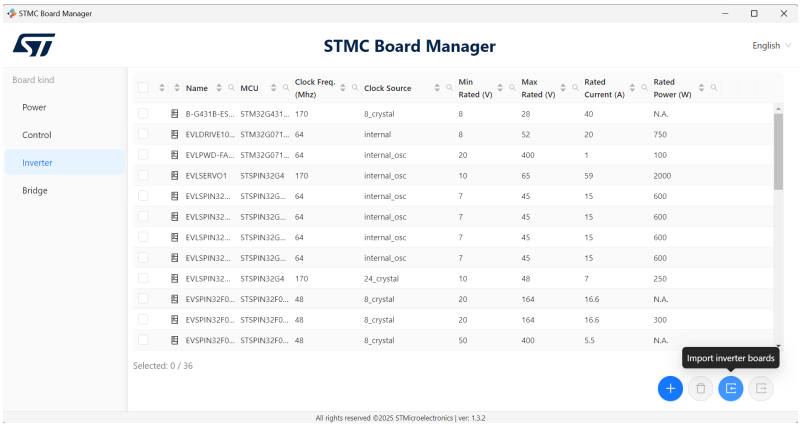
Click on **Boards Manager** in the **Tools** dropdown menu.

Figure 6. Motor Control Workbench – Start window



Select **Inverter** and click on **Import inverter boards**.

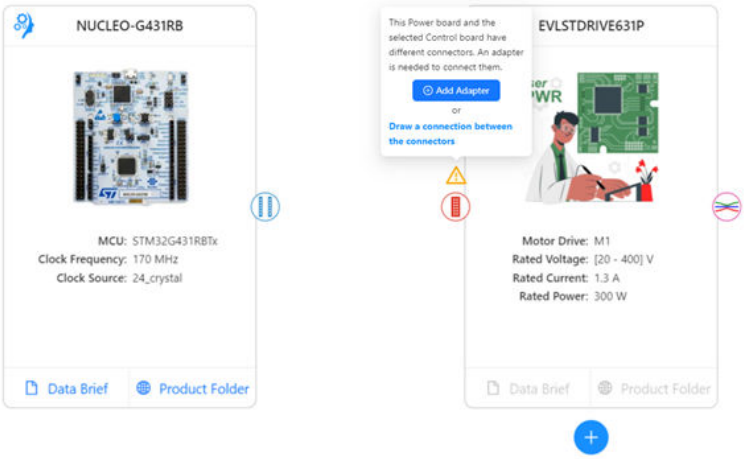
Figure 7. Motor Control Workbench – Board manager window



Select the file **EVLSTDRV631P.json** or **EVLSTDRV631N.json** or provided in the folder EVLSTDRIVE6 located inside the MCSDK-PKG007 package.

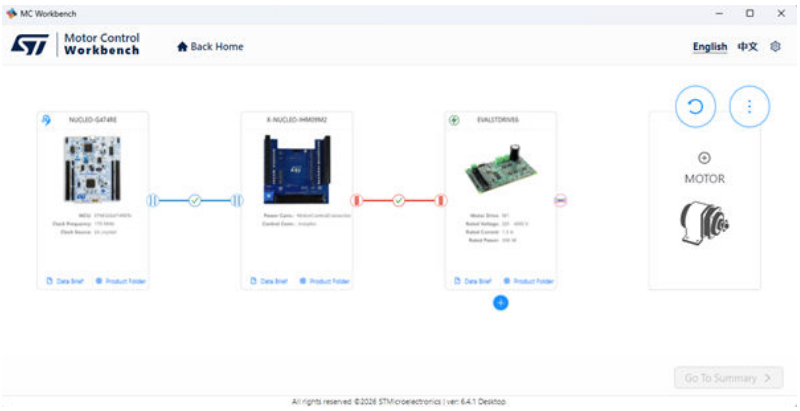
It is now possible to create a **New project** in the starting window.

Figure 8. **Motor Control Workbench – New project window**



Click on **New project**, then add EVLSTDRIVE631P or EVLSTDRIVE631N according to your board. Then add your STM32 Nucleo board.

Figure 9. **Setup configuration**



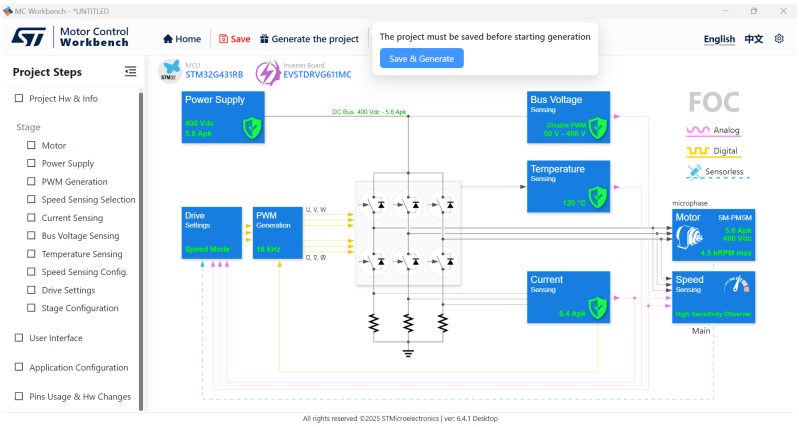
Click on **Add Adapter** and select the X-NUCLEO-IHM09M2.

On the **Motors** tab, import a motor (blue button on the right), selecting an appropriate JSON file if available, or select a motor similar the one to be used. Some motor parameters can be changed later before actual firmware code generation.

Click on the button **Go To Summary**, check that there are no issues and press the **Create** button.

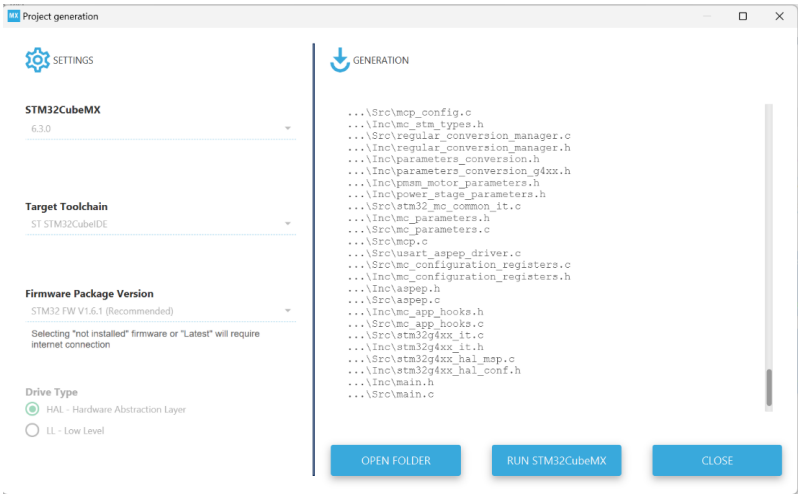
Once all the parameters are correctly set for the application (which depends on the motor and power supply used, please carefully check all **Project Steps** on the left before proceeding), it is possible to **Save & Generate** the project.

Figure 10. Motor Control Workbench – Project customization page



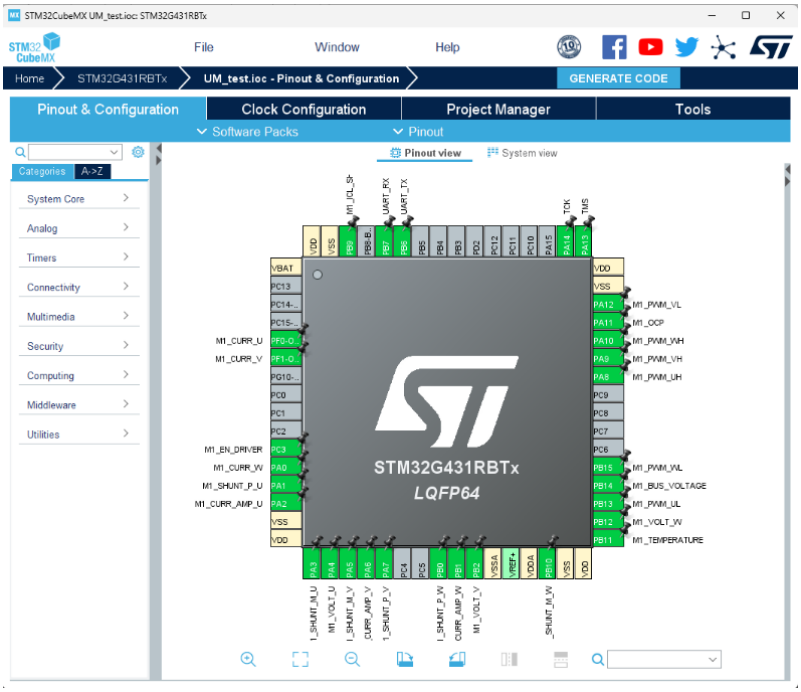
In the **Project generation** page you can decide the **STM32CubeMX** version for IOC file generation, the **Target Toolchain** to use (here STM32CubeIDE), the **Firmware Package Version** and the abstraction level for the autogenerated project. Depending on the environment settings, the user may get some warnings about the Nashorn engine and errors regarding the PDSC, which can be safely ignored.

Figure 11. Motor Control Workbench – Project generation page



Click on R**UN STM32CubeMX**. The project can be used as-is to start spinning the motor. All the required hardware is preconfigured by MCSDK. Open the project from the pop-up window in STM32CubeIDE.

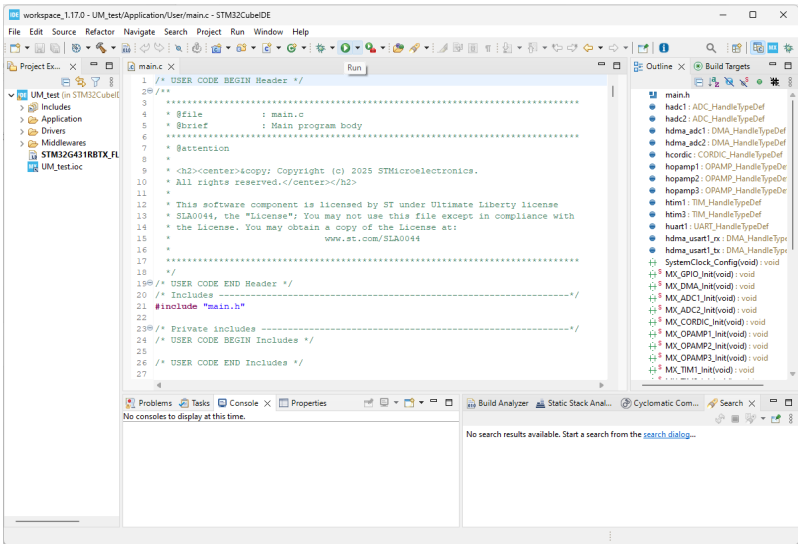
Figure 12. **STM32CubeMX – Project generation page**



8 Running firmware with STM32CubeIDE and Motor Pilot GUI

From the STM32CubeIDE, **Run** the application. By default, the ST-LINK programs the board to use the **Motor Pilot** GUI, accessible from **MC Workbench**.

Figure 13. STM32CubeIDE – Project generation page



The LD1 on ST-LINK lights depending on the target MCU operation:

- Red: ST-LINK connected to PC
- Green: target in stop mode
- Blinking green/red: target running.

8.1 Running the motor with the EVLSTDRIVE6xx and Motor Pilot GUI

Run **Motor Pilot 6.4.1**.

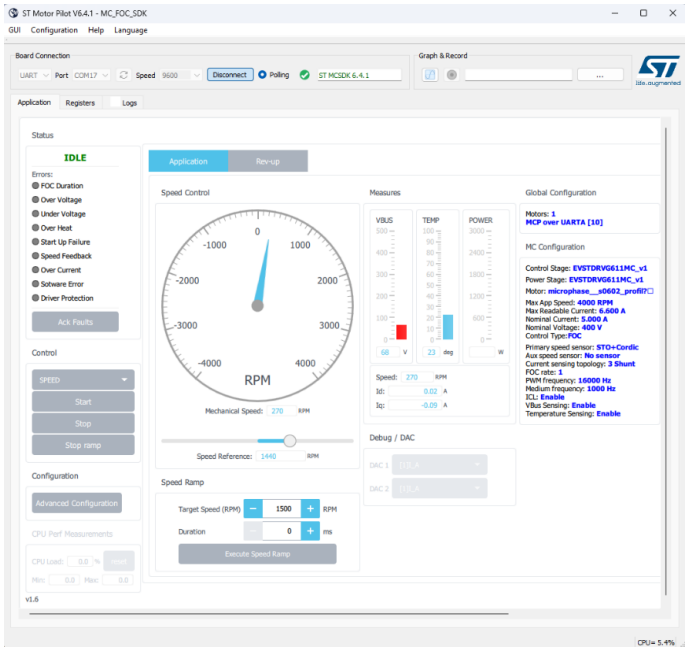
Supply the board with at least 45 V as described in paragraph Section 4.

On the GUI menu, click on **Reset GUI to Default** and then click on **Discover Board**. The correct serial port is connected, and the correct GUI is selected based on the firmware found on the MCU.

Figure 14. Motor Pilot - Discover board

Once connected, several board parameters are available such as bus voltage, speed, etc.
Ensure that the board is supplied with the proper voltage and sufficient current capability.

Figure 15. Motor Pilot - User interface



Now it is possible to start the motor clicking on **Start**.

If the startup and motor parameters are correct, the motor starts. Otherwise an error is likely to arise. It is recommended to monitor motor current and voltage for debugging purposes. MCSDK offers a convenient **Motor profile** application that can be used to extract motor parameters if unknown.

To clear any detected errors and try to start the motor again, click on the **Ack Faults** button before clicking on **Start** again.

The **Rev-up** tab can be used to test different startup sequences. It is recommended to first use a high-current, zero-speed phase to align the motor to the nearest magnetic pole, then a stable spinning status can be reached by a speed ramp-up phase. In case a sensorless observer is employed, once the motor is correctly spinning, the Back-EMF from the motor can be read and used in the closed feedback loop to control the motor speed.

9 References

This user manual provides information on the hardware features and use of the EVLSTDRIVE6xx evaluation boards. For additional information refer to:

- EVLSTDRIVE6xx data brief, schematic, bill of material, layout
- STDRIVE631P, STDRIVE631N, STGD6M65DF2 datasheet
- STM32 Nucleo board user manual.

Revision history

Table 5. **Document revision history**

Date	Version	Changes
20-May-2026	1	Initial release.

Contents

List of tables

List of figures