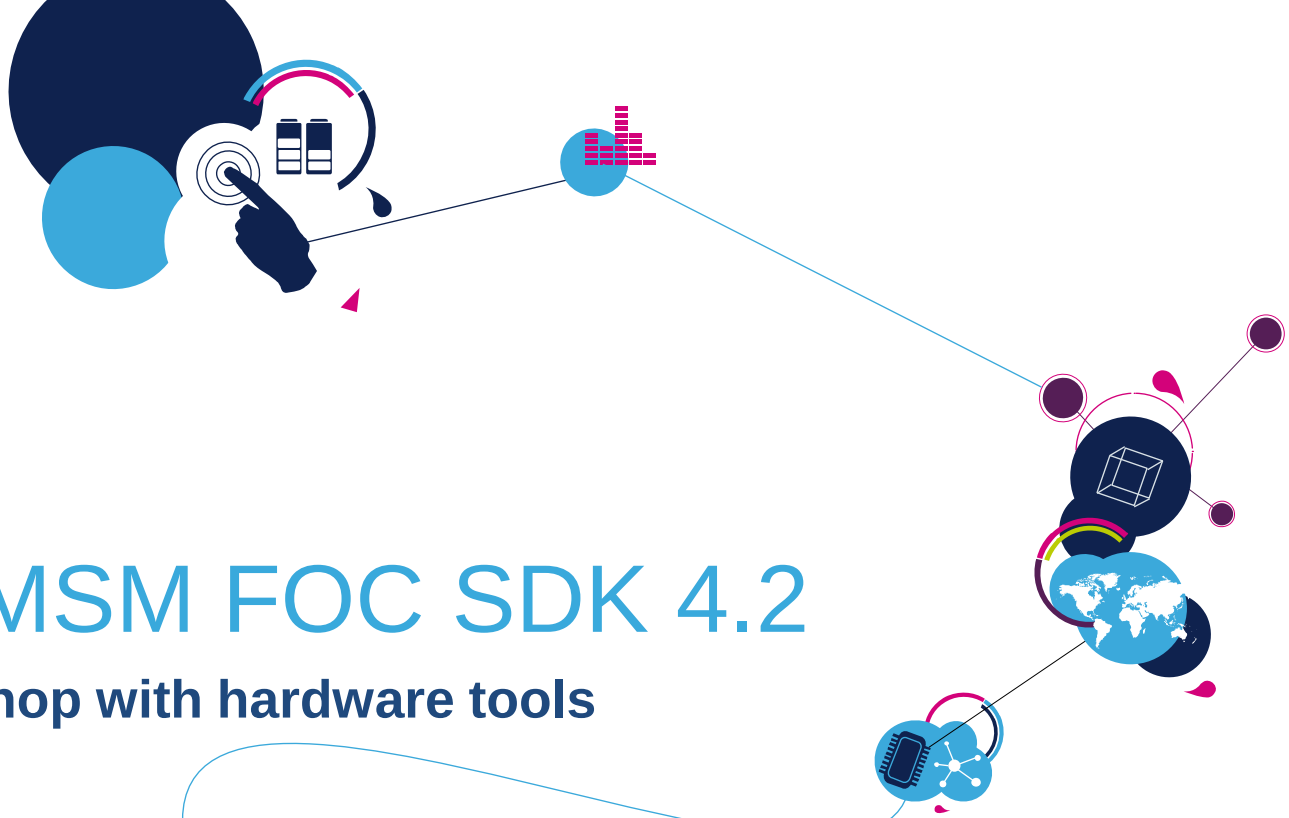

STM32 PMSM FOC SDK 4.2

Hands-on workshop with hardware tools

Rev 1.5

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Objectives

The purpose of this hands-on workshop is to:

- Get you up and running with the STM32 PMSM FOC SDK using the ST MC Workbench with the final purpose of running a PM synchronous motor with STEVAL boards.
- Show you where to go for documentation, firmware libraries and application notes and additional ecosystem support
- Help you obtain additional technical support

Systems check

- Everyone should have:
  - A Windows laptop (XP, Vista or Win 7, Win 8)
  - A ST-LINK dongle (optional)
  - USB to RS-232 dongle and a null modem cable (optional)
  - The permanent magnet motor you want to run
  - A multimeter (optional)
  - An oscilloscope with current probe (optional)
  - An insulated DC and or AC power supply
- Ready to begin?

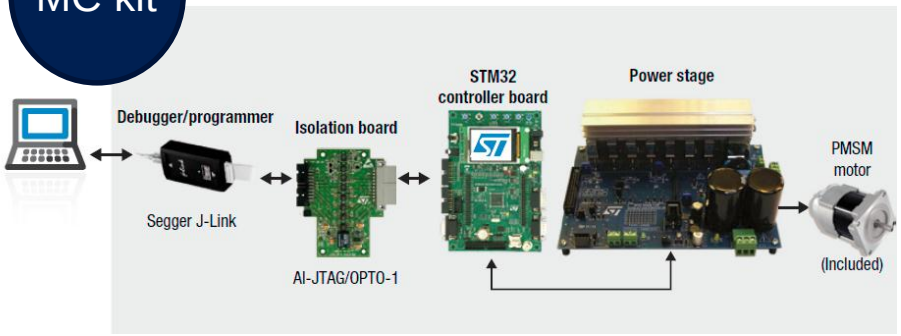
Hardware setup

Step #1 – Hardware setup

- It is possible to choose one of the following offers:
  - Complete Motor Control Kit.
  - One of the complete inverters currently in stock.
  - Any STM32 evaluation board combined with one of the ST evaluation power stages both including the MC connector.
- The following slides report all available boards present in the ST stock that can be used to arrange a motor control system.
  - Follow the instructions in the related user manual to set up each board.

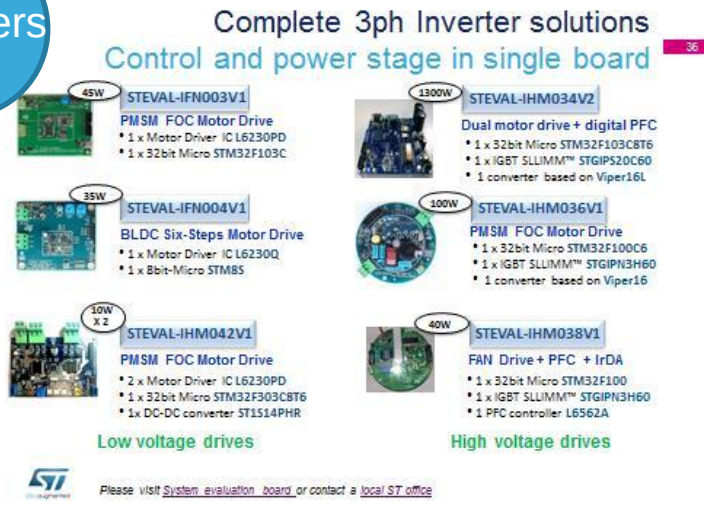
Motor control board offer

MC kit

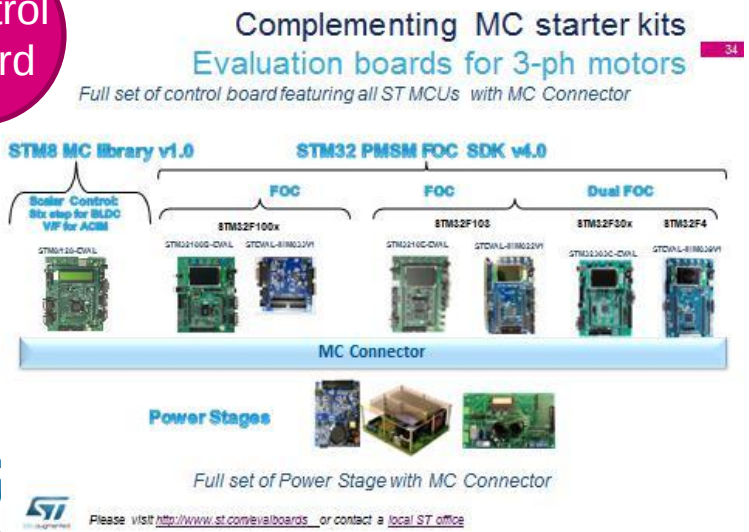


Kit: from isolated debug probe to motor

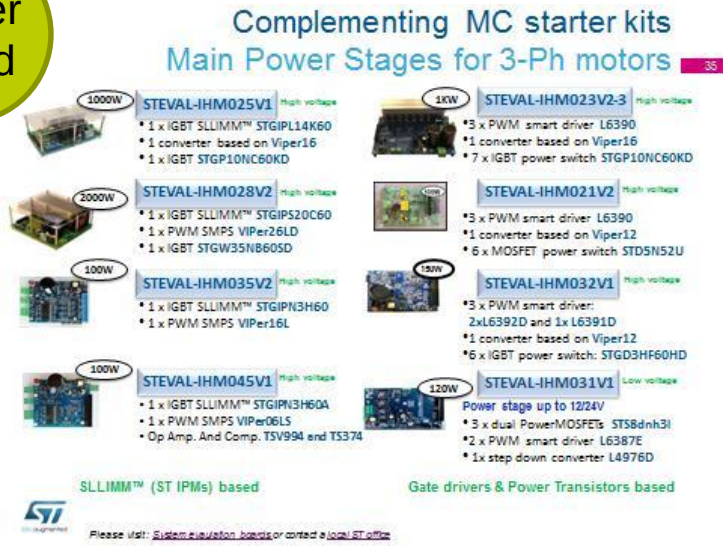
Inverters



Control board



Power board



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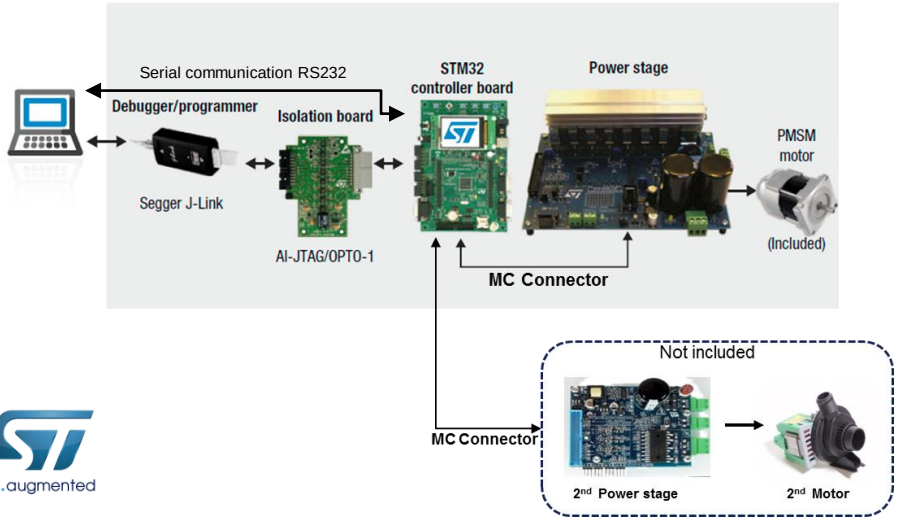
Motor control kits

Part Number	Description	ST Link on-board	Type
STM32100B-MCKIT	Motor control starter kit for STM32F100 (128KB Flash) Value Line MCUs	Yes	Single drive
STM3210B-MCKIT	Motor control starter kit for STM32 (128KB flash) Performance and Access Line microcontrollers	No	Single drive
P-NUCLEO-IHM001	STM32 Nucleo Pack FOC and 6-step control for Low voltage 3-ph motors	Yes (embedded)	Single drive

The motor control kit connections represented below can also be applied when combining STM32 control boards and evaluation power boards.

STM3210B-MCKIT STM32100B-MCKIT



P-NUCLEO-IHM001

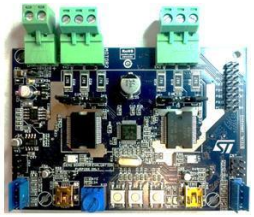
ST complete inverters

Part Number	Description	ST Link on-board	Type
STEVAL-IHM034V2	Dual motor control and PFC demonstration board featuring the STM32F103 and STGIPS20C60	No	Single/Dual drive
STEVAL-IHM036V1	Low power motor control board featuring the SLLIMM™ STGIPN3H60 and MCU STM32F100C6T6B	No	Single drive
STEVAL-IHM038V1	BLDC ceiling fan controller based on STM32 and SLLIMM-nano	No	Single drive
STEVAL-IHM040V1	BLDC/PMSM driver demonstration board based on STM32 and the SLLIMM nano™	No	Single drive
STEVAL-IHM042V1	Compact, low-voltage dual motor control board based on the STM32F303 and L6230	Yes	Single/Dual drive
STEVAL-IHM043V1	6-Step BLDC sensorless driver board based on the STM32F051 and L6234	No	Single drive
STEVAL-IFN003V1	DC PMSM FOC motor drive	No	Single drive

STEVAL-IHM034V2

STEVAL-IHM036V1

STEVAL-IHM042V1



STEVAL-IHM043V1

STEVAL-IFN003V1

STEVAL-IHM038V1

STEVAL-IHM040V1

Control board

STM32 evaluation boards with MC connector

Part Number	Description	ST Link on-board	Type
STM32072B-EVAL	Evaluation board with STM32F072VB MCU	Yes	Single drive
STM3210E-EVAL	Evaluation board for STM32 F1 series - with STM32F103 MCU	No	Single drive
STM3220G-EVAL	Evaluation board for STM32 F2 series - with STM32F207IG MCU	Yes	Single drive
STM32303E-EVAL	Evaluation board for STM32F303xx microcontrollers	Yes	Single/Dual drive
STM3240G-EVAL	Evaluation board for STM32F407 line - with STM32F407IG MCU	Yes	Single drive
STEVAL-IHM022V1	High density dual motor control demonstration board based on the STM32F103ZE microcontroller	No	Single/Dual drive
STEVAL-IHM039V1	Dual motor drive control stage based on the STM32F415ZG microcontroller	No	Single/Dual drive

STM32072B-EVAL

STM3220G-EVAL

STM3240G-EVAL

STM3210E-EVAL

STEVAL-IHM022V1

STM32303E-EVAL

STEVAL-IHM039V1

(1) Only necessary for high-voltage applications or if not included with the evaluation board:

In-circuit debugger/programmer..

- ST-LINK/V2
- ST-LINK/V2-ISOL (2500 VRMS high isolation voltage)

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Power board

ST evaluation power boards with MC connector

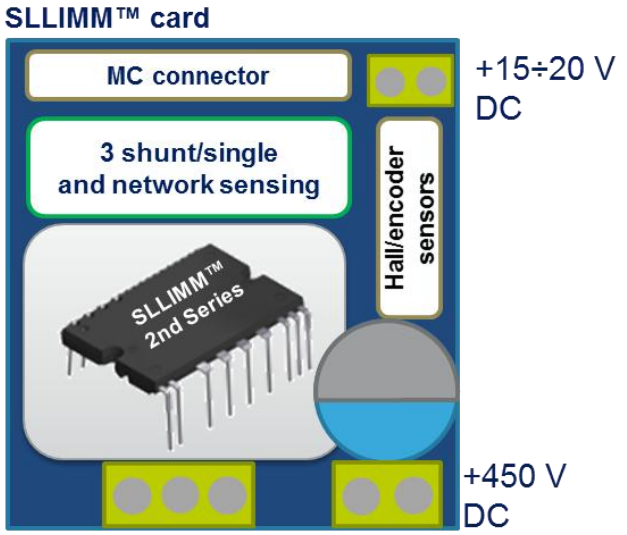
Part Number	Description
STEVAL-IHM021V2	100 W, 3-phase inverter based on L6390 and UltraFASTmesh™ MOSFET for speed FOC of 3-phase PMSM motor drive
STEVAL-IHM023V3	1 kW 3-phase motor control evaluation board featuring L6390 drivers and new IGBT STGP10H60DF
STEVAL-IHM025V1	1 kW 3-phase motor control demonstration board featuring the IGBT SLLIMM™ STGIPL14K60
STEVAL-IHM028V2	2 kW 3-phase motor control demonstration board featuring the IGBT intelligent power module STGIPS20C60
STEVAL-IHM032V1	150 W inverter featuring the L639x and STGD3HF60HD for 1-shunt based sinusoidal vector control and trapezoidal scalar control
STEVAL-IHM035V2	3-phase high voltage inverter power board for FOC and scalar motor control based on the STGIPN3H60 (SLLIMM™-nano)
STEVAL-IHM045V1	3-phase high voltage inverter power board for FOC based on the STGIPN3H60A (SLLIMM™-nano)
STEVAL-IPM05F(1)	3-phase motor control power board featuring STGIF5CH60TS-L
STEVAL-IPM07F(1)	3-phase motor control power board featuring STGIF7CH60TS-L
STEVAL-IPM10F(1)	3-phase motor control power board featuring STGIF10CH60TS-L
STEVAL-IPM10B(1)	3-phase motor control power board featuring STGIB10CH60TS-L
STEVAL-IPM15B(1)	3-phase motor control demonstration board featuring STGIB15CH60TS-L

Note 1: Available Q4/15

In development
Available
in Q4

Flexible approach: STEVAL-IPMxx

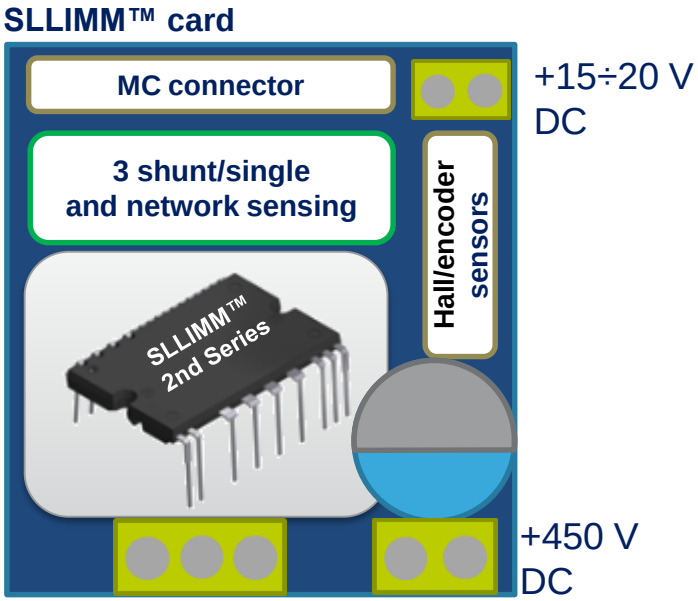
- The STEVAL-IPMnmx evaluation board is a universal, fully-tested and populated-design consisting of a 3-phase inverter bridge based on the SLLIMM™ 2nd series IPM.
- The main characteristics are small size, minimal BOM and high efficiency. It consists of an interface circuit (bus and V_{CC} connectors), bootstrap capacitors, snubber capacitor, short-circuit protection, fault event circuit, temperature monitoring, single/three shunt resistors and filters for input signals.
- A double current sensing option is provided: three dedicated on-board op amps or by using the op amps embedded on MCU.
- Hall/encoder part completes the circuit.



STEVAL-IPMxx
Features and architecture

- **Inverter evaluation board based on 2nd series of ST's SLLIMM™ IPM trench-gate field-stop technology IGBT STGIxxCH60x full-molded or DBC package**

- Input bus voltage: 125 ÷ 450 V_{DC}
- Nominal power: from 300 W to 3 kW
- Current capability: from 5 to 30 A (nominal)
- Hardware overcurrent protection using SLLIMM's Smart Shut Down
- Motor current sensing: single or three shunt configuration
- ST's MC connector compatible
- Two options for sensing: on-board op amps or the MCU's
- DC bus voltage sensing to MCU
- Hall sensors (3.3/5 V) / encoder inputs (3.3/5 V) to MCU
- Testing pins for all IPM signals
- Very compact size



STEVAL-IPMnmx
SLLIMM™ "cards"

n	0	1	2	3
m	0	3	5	7

x	F	B

IPM current capability:
- 05= 5A
- 07= 7A
- 10= 10A
- 15= 15A
- 20= 20A
- 30= 30A

F = Full molded package
B = DBC package

Example of codes:
- STEVAL-IPM05F
- STEVAL-IPM20B

→ SLLIMM Gen 2 Full Molded 5A
→ SLLIMM Gen 2 DBC 20A

Hardware key features 1/3

Reference / bundle	Voltage	Power	Motor type / control type *	ST parts	Application focus
STEVAL-IHM034V2	230 V_{AC} Nominal	Up to 1.3k W	PMSM, Dual Motor (FOC) + digital PFC	• 1x **STM32F103C8T6** • 1x **STGIPS20C60** • 1x **Viper16L**	Complete drive: compressors, room air conditioning,
STEVAL-IHM036V1	90 – 285 V_{AC} 125 – 400 V_{DC}	Up to 100 W	PMSM, FOC	• 1x **STM32F100C6** • 1x **STGIPN3H60** • 1x **Viper16**	Water pumps, dish washers, washing machines
STEVAL-IHM038V1	90 – 265 V_{AC}	Up to 40 W	PMSM, FOC	• 1x **STM32100** • 1x **STGIPN3H60** • 1x **L6562A**	Complete drive: fans, ceiling fans, pumps.
STEVAL-IHM040V1	120/230 V_{AC} nominal (60/50 Hz)	Up to 100 W	PMSM/BLDC FOC/Six step	• 1x **STGIPN3H60** • 1x **STM32F100C8T6** • 1x **VIPer16**	Complete drive: pumps, fans
STEVAL-IHM042V1	8 - 48 V	Up to 10 W	PMSM, FOC Single/3 shunt	• 2x **L6230** • 1x **STM32F303** • 1x **ST1S14**	Complete drive: fans, blowers, toys
STEVAL-IHM043V1	7 to 42 V_{DC}	Up to 35 W	BLDC Six-step motor control	• 1x **L6234** • 1x **STM32F051C6T6** • 1x **L78L33ACD**	Complete drive: pumps, security systems, ATMs.
STEVAL-IFN003V1	8 - 48 V	Up to 45 W	PMSM, FOC	• 1x **STM32F103C** • 1x **L6230PD**	Complete drive: pumps, security systems, ATMs
STEVAL-IFN004V1	8 - 48 V	Up to 35 W	BLDC Six-step motor control	• 1x **STM8S** • 1x **L6230Q**	Complete drive: pumps, security systems, ATMs

Hardware key features 2/3

Reference / bundle	Voltage	Power	Motor type / control type *	ST parts	Application focus
STEVAL-IHM021V2	120/230 V_{AC} nominal (60/50 Hz)	Up to 100 W	PMSM/BLDC FOC/Six step 3 shunts	• 3x **L6390** • 1x **Viper12** • 6x **STD5N52U**	Power board: water pumps, fans, dish washers, washing machines
STEVAL-IHM023V3	90 – 285 V_{AC} 125 – 400 V_{DC}	Up to 1 kW	PMSM/BLDC FOC/Six step Single/3 shunts	• 3x **L6390** • 1x **Viper16** • 7x **STGP10H60DF**	Power board: pumps, compressors, washing machines and more
STEVAL-IHM025V1	90 – 285 V_{AC} 125 – 400 V_{DC}	Up to 1 kW	PMSM/BLDC FOC/Six step	• 1x **STGIPL14K60** • 1x **Viper16** • 1x **STGP10NC60KD**	Power board: pumps, compressors, washing machines and more
STEVAL-IHM028V2	90 – 285 V_{AC} 125 – 400 V_{DC}	Up to 2 kW	PMSM/BLDC FOC/Six step single/3-shunt	•1x **STGIPS20C60** • 1x **VIPer26LD** • 1x **STGW35NB60SD**	Power board: pumps, compressors, air conditioning and more
STEVAL-IHM032V1	230 V_{AC} nominal 86 to 260 V_{AC}	Up to 150 W	PMSM/BLDC FOC/Six step single/3-shunt	• 2x **L6392D** • 1x **L6391D** • 1x **Viper12** • 6 x **STGD3HF60HD**	Power board: pumps, compressors, fans, dish washers and more
STEVAL-IHM035V2	120/230 V_{AC} nominal	Up to 100 W	PMSM/BLDC FOC/Six step single-shunt	• 1x **STGIPN3H60** • 1x **VIPer16L**	Power board: pumps, compressors, fans, dish washers and more
STEVAL-IHM045V1	30 – 270 V_{AC} 40 – 400 V_{DC}	Up to 100 W	PMSM FOC Single/3-shunt	• 1x **STGIPN3H60A** • 1x **VIPer06L** • 1x **TSV994**	Power board: pumps, compressors, fans, dish washers and more

NEW

Hardware key features 3/3

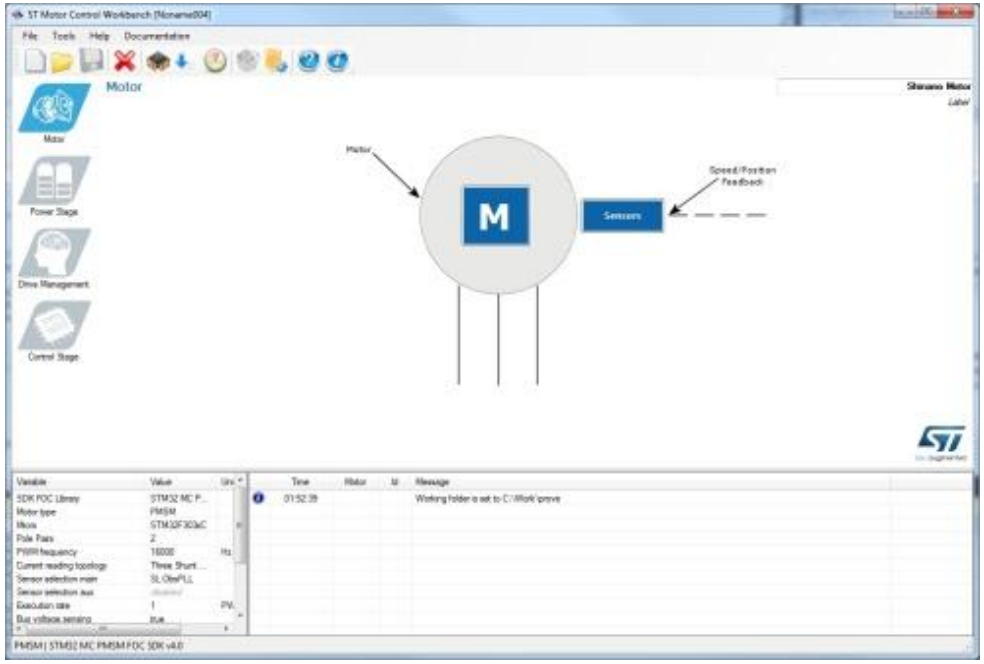
Reference / bundle	Voltage	Power	Motor type / control type *	ST Parts	Application focus
STEVAL-IPM05F(1)	125 – 450 V_{DC}	Up to 500 W	PMSM/BLDC FOC/Six step 3shunts	• 1 x **STGIF5CH60TS-L** • 1x **TSV994**	Power board: water pumps, fans, dish washers and more
STEVAL-IPM07F(1)	125 – 450 V_{DC}	Up to 700 W	PMSM/BLDC FOC/Six step Single/3 shunts	• 1 x **STGIF7CH60TS-L** • 1x **TSV994**	Power board: water pumps, fans and more
STEVAL-IPM10F(1)	125 – 450 V_{DC}	Up to 1 kW	PMSM/BLDC FOC/Six step	• 1 x **STGIF10CH60TS-L** • 1x **TSV994**	Power board: pumps, compressors, washing machines and more
STEVAL-IPM10B(1)	125 – 450 V_{DC}	Up to 1.5 kW	PMSM/BLDC FOC/Six step single/3-shunt	• 1 x **STGIB10CH60TS-L** • 1x **TSV994**	Power board: pumps, compressors, air conditioning and more
STEVAL-IPM15B(1)	125 – 450 V_{DC}	Up to 2 W	PMSM/BLDC FOC/Six step single/3-shunt	• 1 x **STGIB15CH60TS-L** • 1x **TSV994**	Power board: pumps, compressors, fans, dish washers and more

Note 1: Available Q4'15

SDK workflow

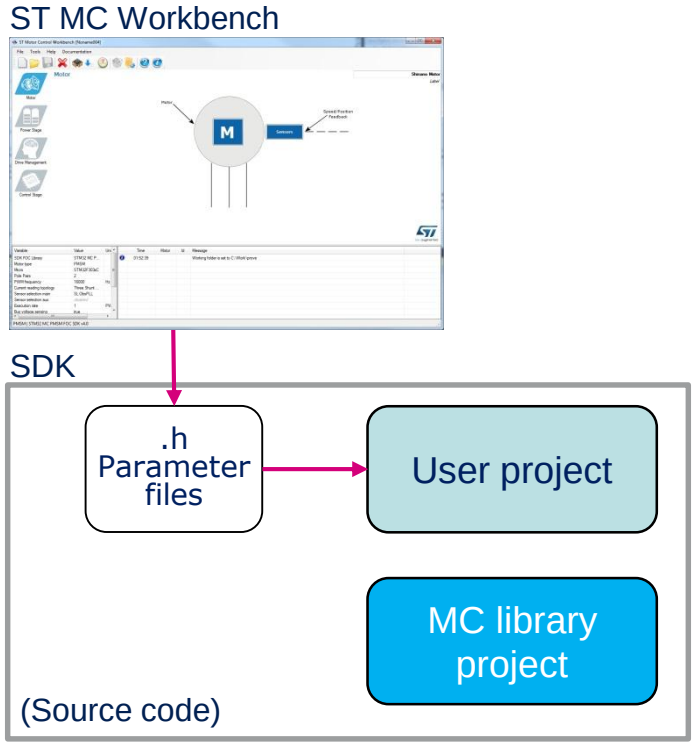
SDK workflow 1/5

ST MC Workbench



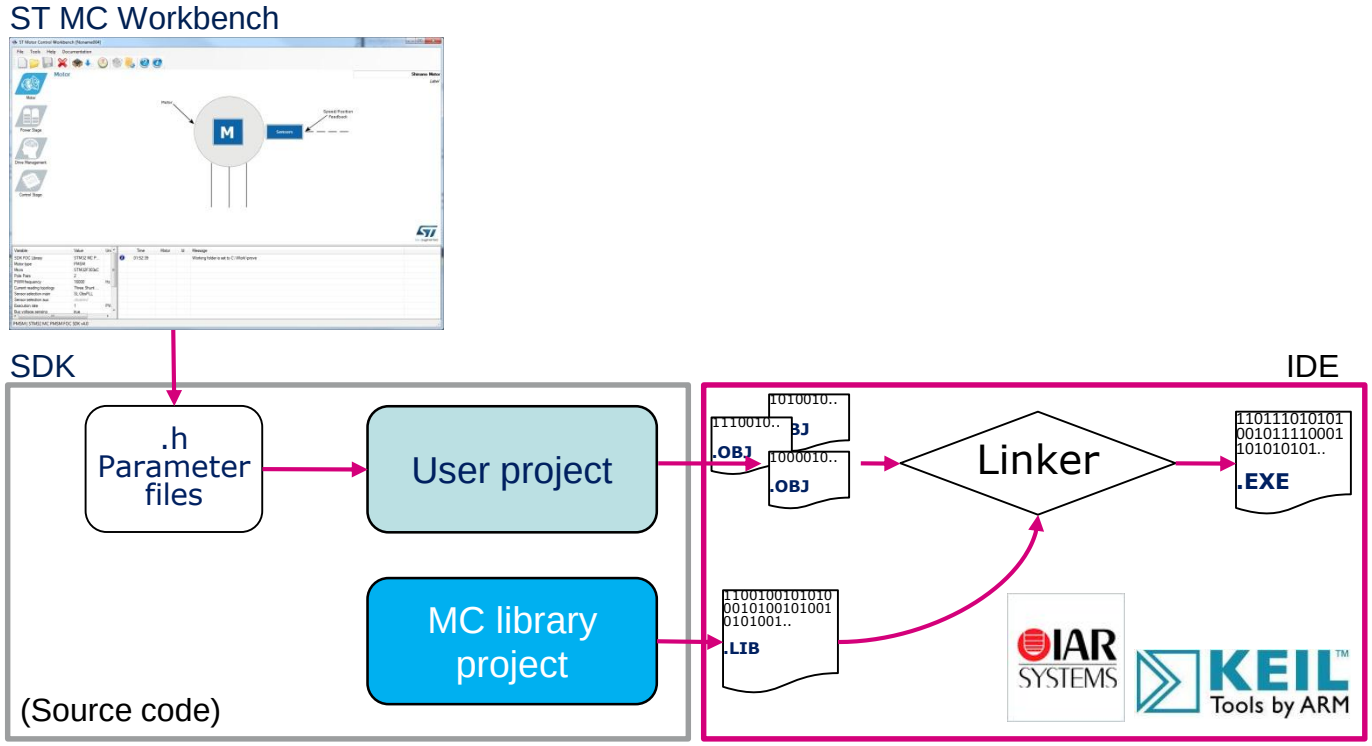
- Open the ST MC Workbench and create a new project (see Step #6).

SDK workflow 2/5



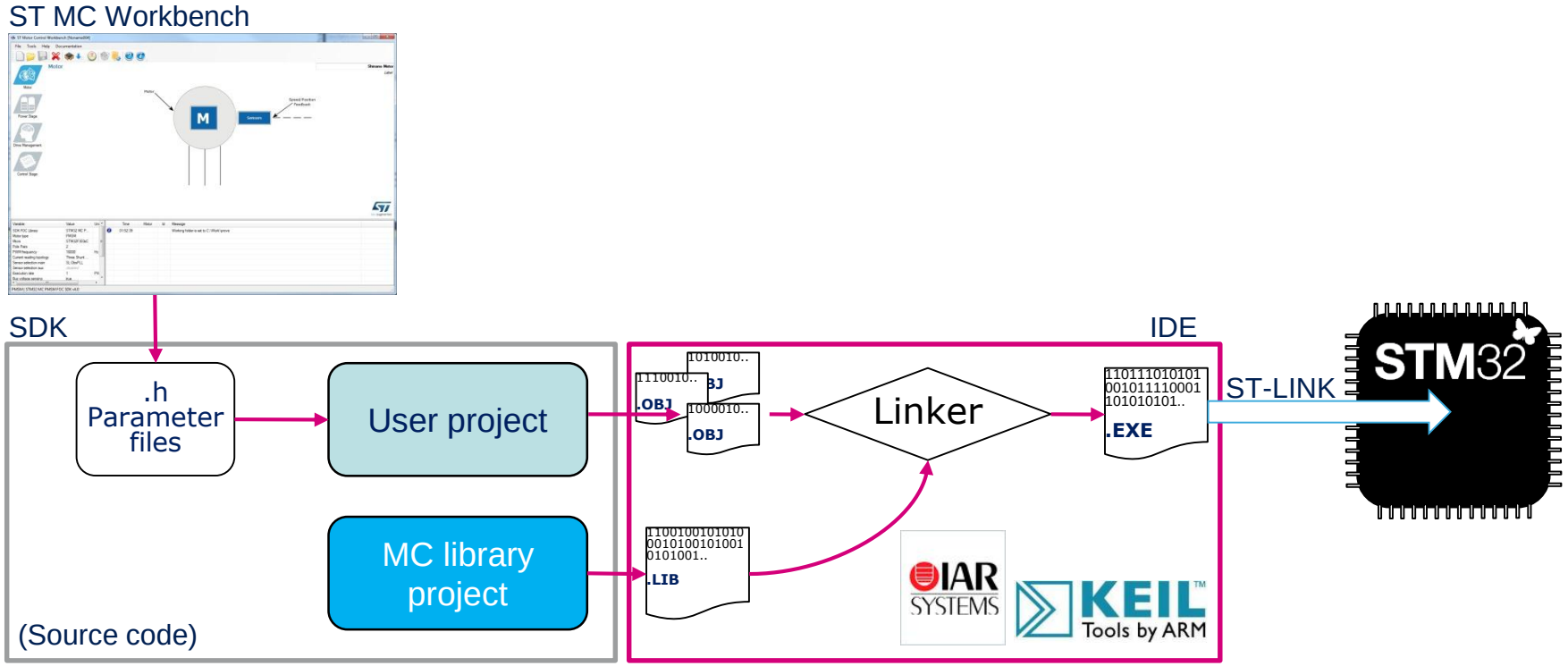
- Generate the configuration (.h) files for the firmware library (see Step #9).

SDK workflow 3/5



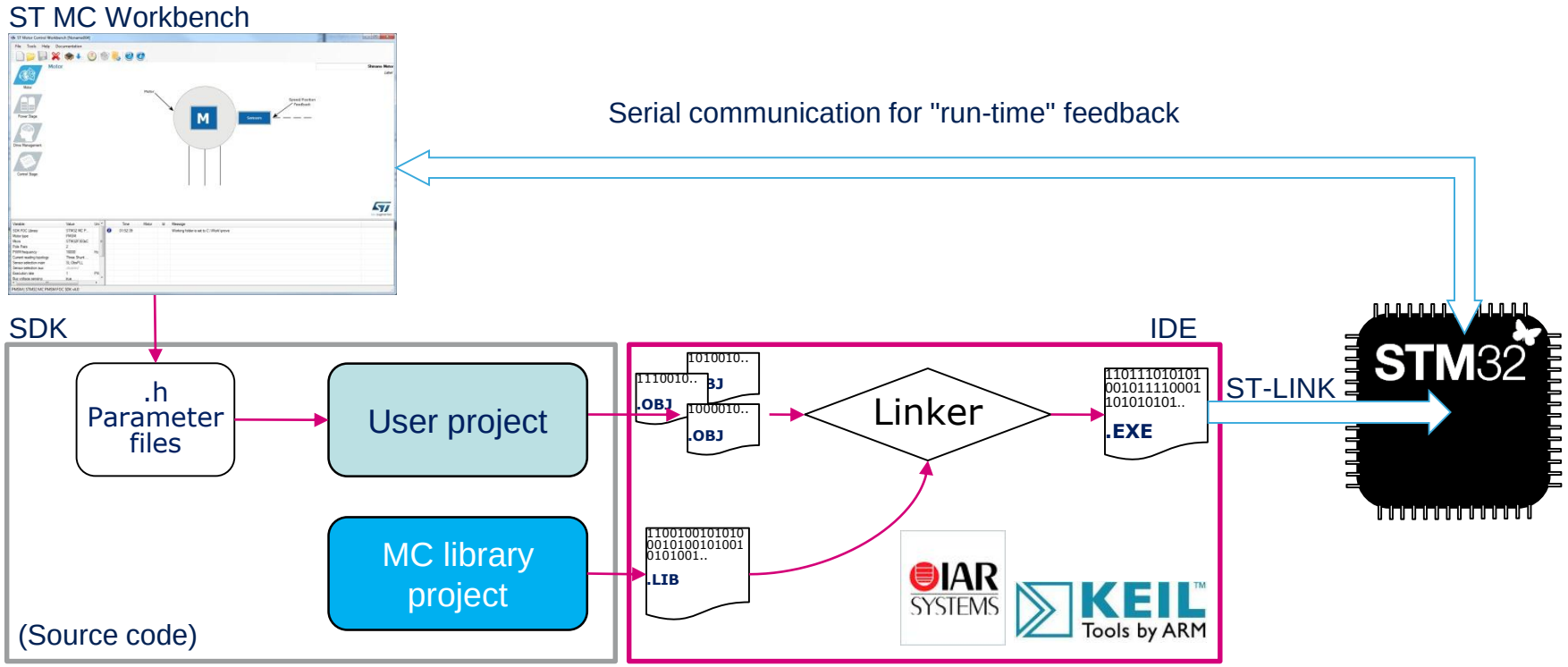
- Compile the FW library using available IDE (IAR, Keil) (see step #10).

SDK workflow 4/5



- Flash the executable into the microcontroller using ST-LINK (see Step #10).

SDK workflow 5/5



- Establish a real-time communication with the firmware using the monitor feature of ST MC Workbench to start the motor, set the speed and get feedback (see Step #12).

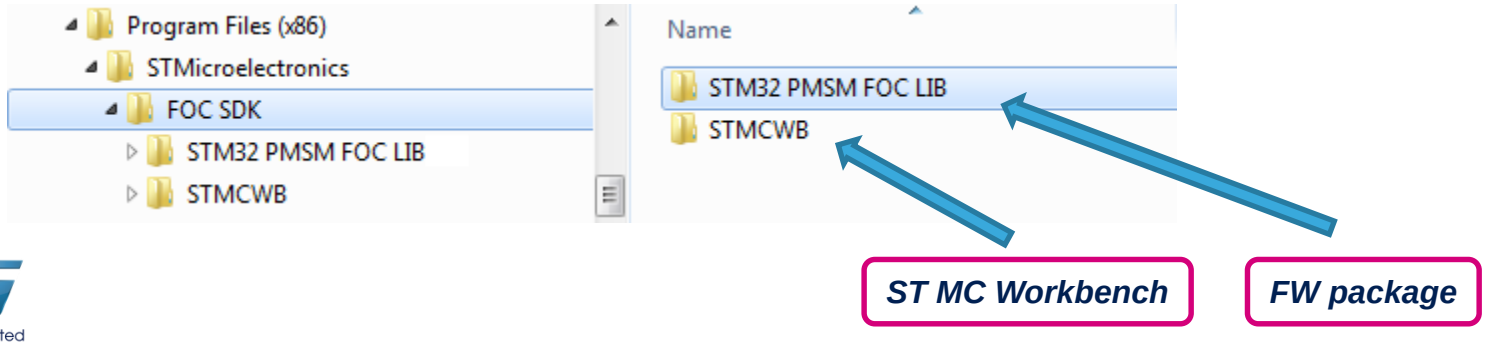
Software setup

Step #2 – Software setup

- Download and install the STM32 PMSM FOC SDK
- You can find it at www.st.com and searching for part number STSW-STM32100

Part Number	Status	Description
STSW-STM32100	Active	STM32 PMSM FOC SDK motor control firmware library (UM1052)

- It contains both the firmware package and the ST MC Workbench (PC GUI)
- After installation, you will have the following new folders:



Step #3 – IDE setup

- An IDE (Integrated development environment) is required to compile, flash and debug the application.
- Two IDEs are supported: IAR EWARM and KEIL µVision.
- They are available at the following addresses:
  - *IAR* Embedded Workbench for ARM - *IAR* Systems (http://www.iar.com/)
  - *Keil* Embedded Development Tools for ARM, Cortex-M **...** (**http://www.keil.com/**)

Step #4 – ST-LINK installation

- If the control board or the complete system doesn't embed the ST-LINK, a stand-alone dongle is required.

- In any case, you must install the ST-LINK driver that can be found in the ST website searching for part number ST-LINK/V2 or ST-LINK/V2-ISOL

Part Number	Status	Description
ST-LINK/V2	Active	ST-LINK/V2 in-circuit debugger/programmer for STM8 and STM32

- Click on Design Resources, download and install the STSW-LINK009

Related Tools and Software

Related Tools and Software	
Part Number	Description
STSW-LINK004	STM32 ST-LINK utility
STSW-LINK005	ST-LINK/V2 firmware upgrade
STSW-LINK009	ST-Link, ST-Link/V2, ST-Link/V2-1 USB driver signed for XP, Windows7, Windows8

Step #4 – ST-LINK installation

- On the same page, download and install also the STSW-LINK004 – STM32 ST-LINK utility

  (This will be required to flash the LCD FW code into the MCU).

Related Tools and Software

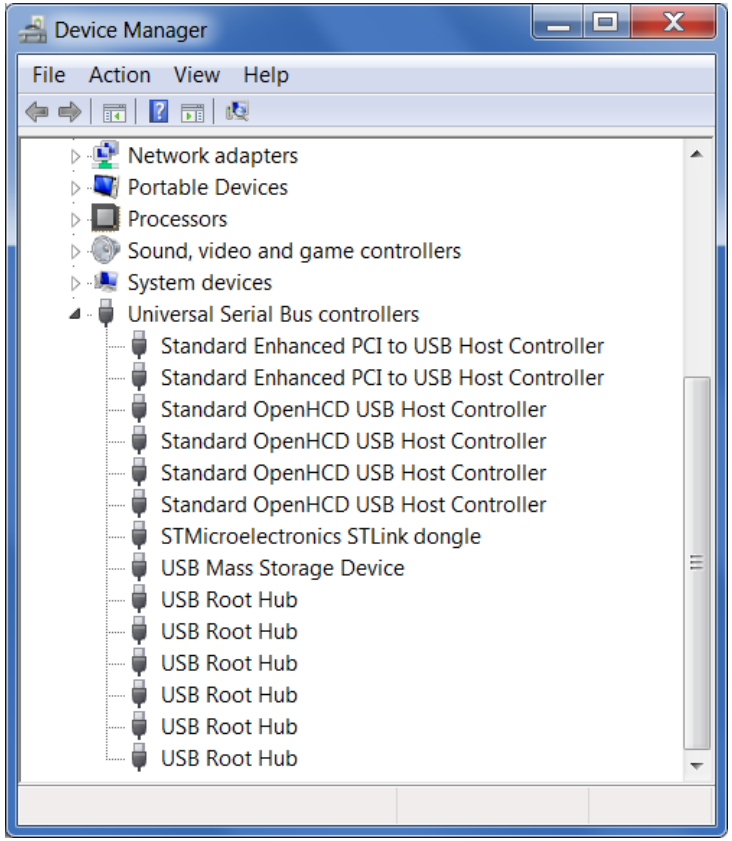
Related Tools and Software	
Part Number	Description
STSW-LINK003	ST-LINK/V2 USB driver for Windows 7, Vista and XP
STSW-LINK004	STM32 ST-LINK utility
STSW-LINK005	ST-LINK/V2 firmware upgrade
STSW-LINK006	ST-LINK/V2 USB driver for Windows 8

Step #5 – Connect ST-LINK

- Using the USB cable, connect the control board with ST-LINK embedded (or the ST-LINK dongle) to the A male connector into your laptop.

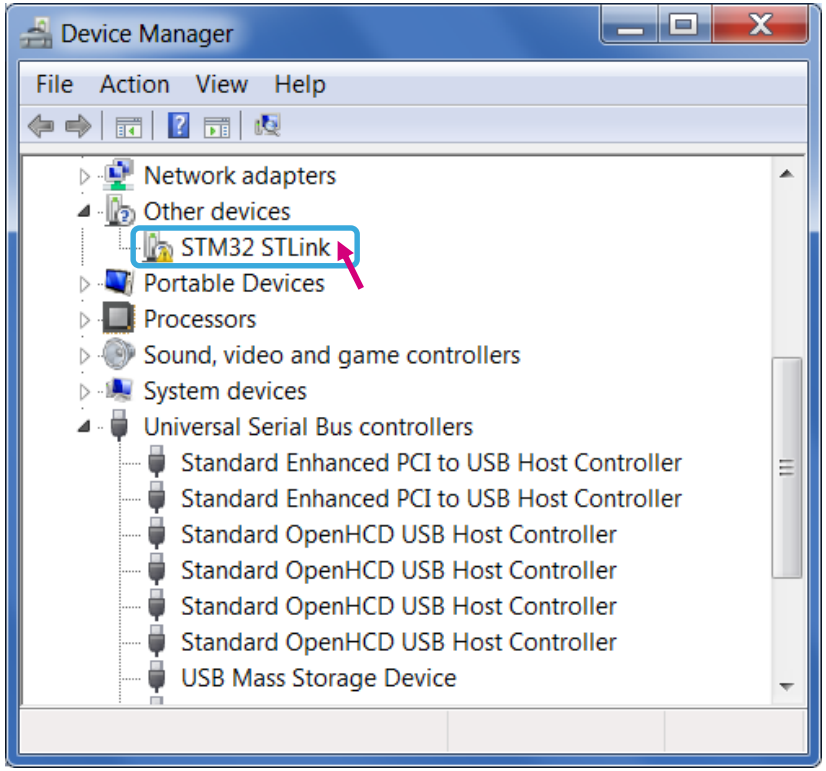
- Wait for Windows to recognize the ST-Link device and follow any steps required to install the driver.

- Upon successful driver recognition, the ST-Link device should be fully enumerated in the Windows Device Manager as shown:



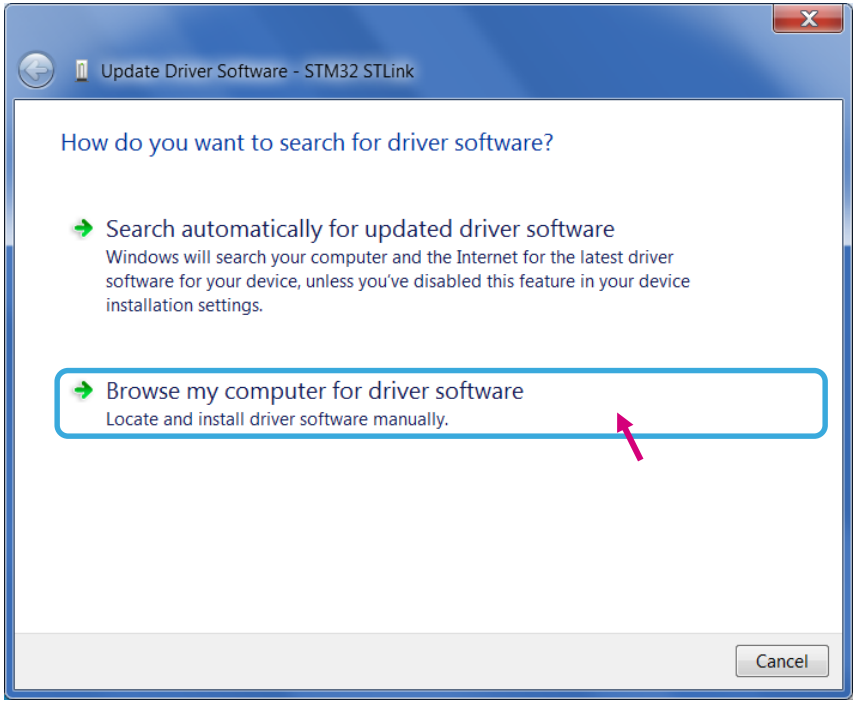
Step #5 – Driver trouble-shooting

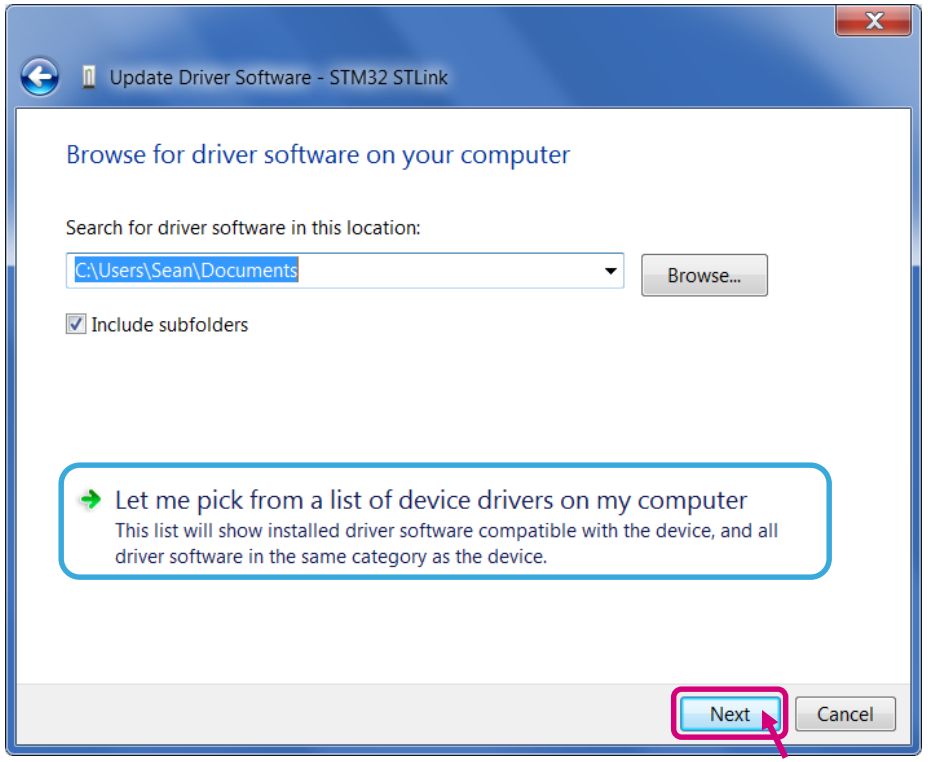
1. Open Device Manager.
2. Right-click on the “**STM32 STLink**” Driver icon.
3. Select “**Update Driver Software**”.



Step #5 – Driver trouble-shooting

4. Select “**Browse my computer for driver software**”.





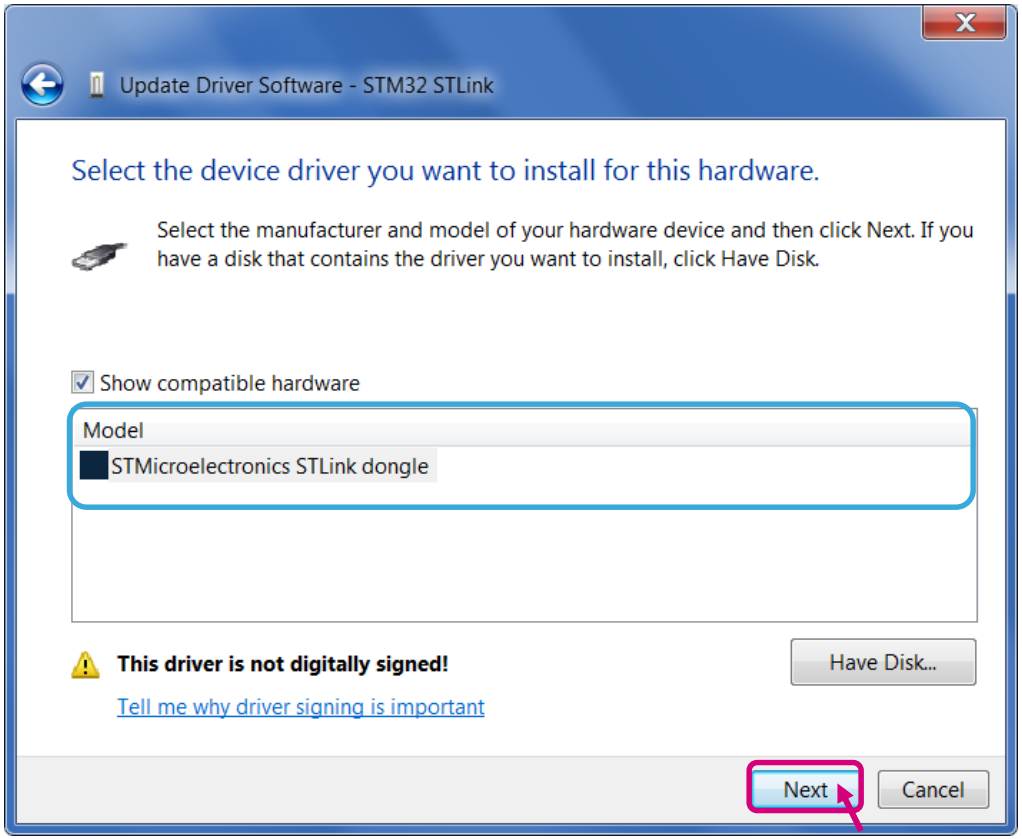
5. Select “Let me pick from a list of device drivers of my computer”.

6. Click “Next”.

Step #5 – Driver trouble-shooting

- The “**STMicroelectronics ST-Link dongle**” should be listed.

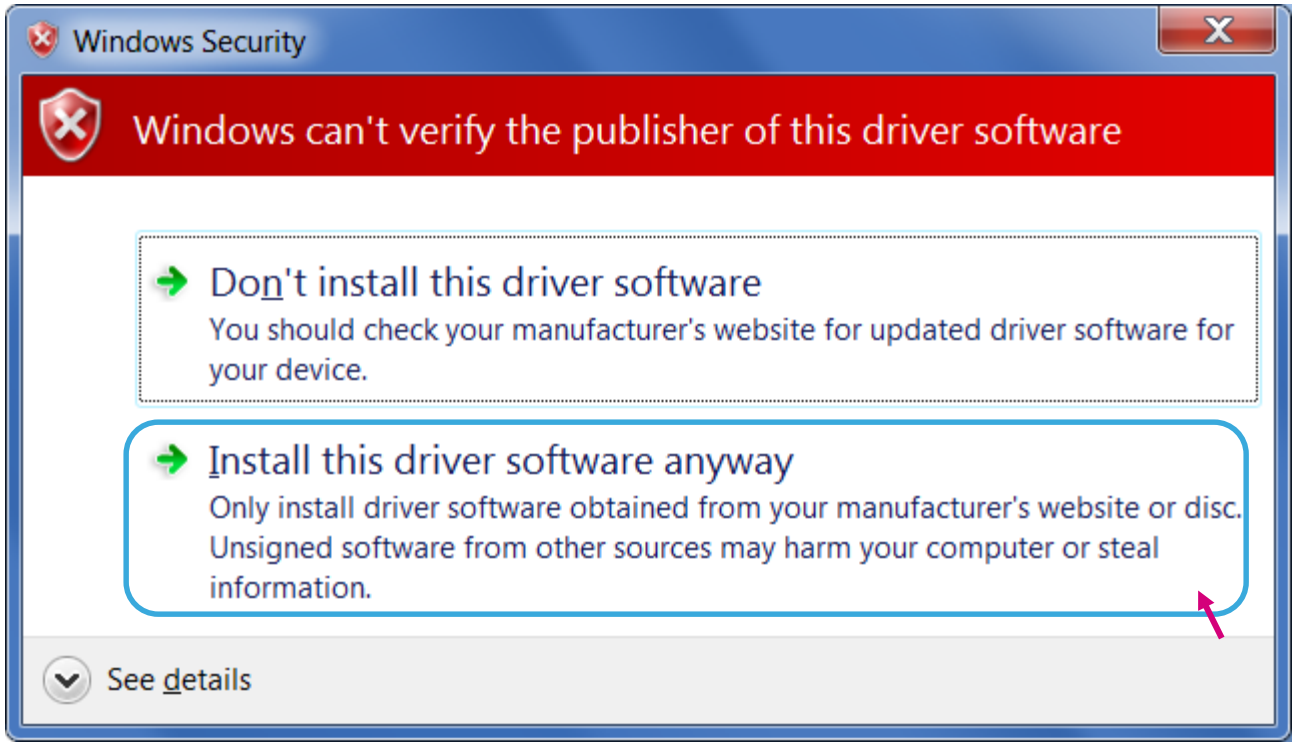
7. Click “Next”.



Step #5 – Driver trouble-shooting

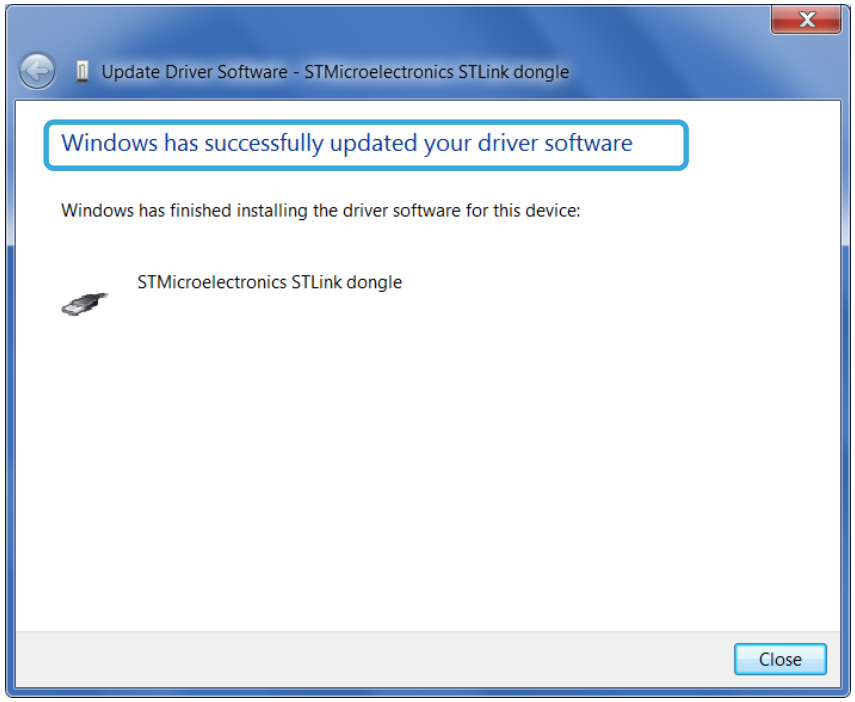
- A warning message may appear.

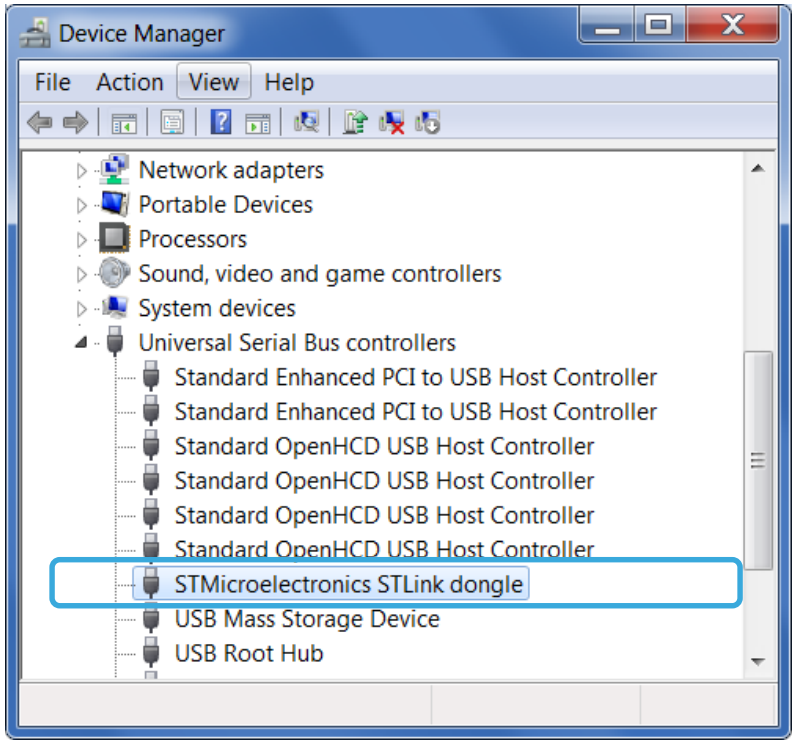
8. Select “**Install this driver software anyway**”.



Step #5 – Driver trouble-shooting

- You should receive a message: “**Windows has successfully updated your driver software**”.



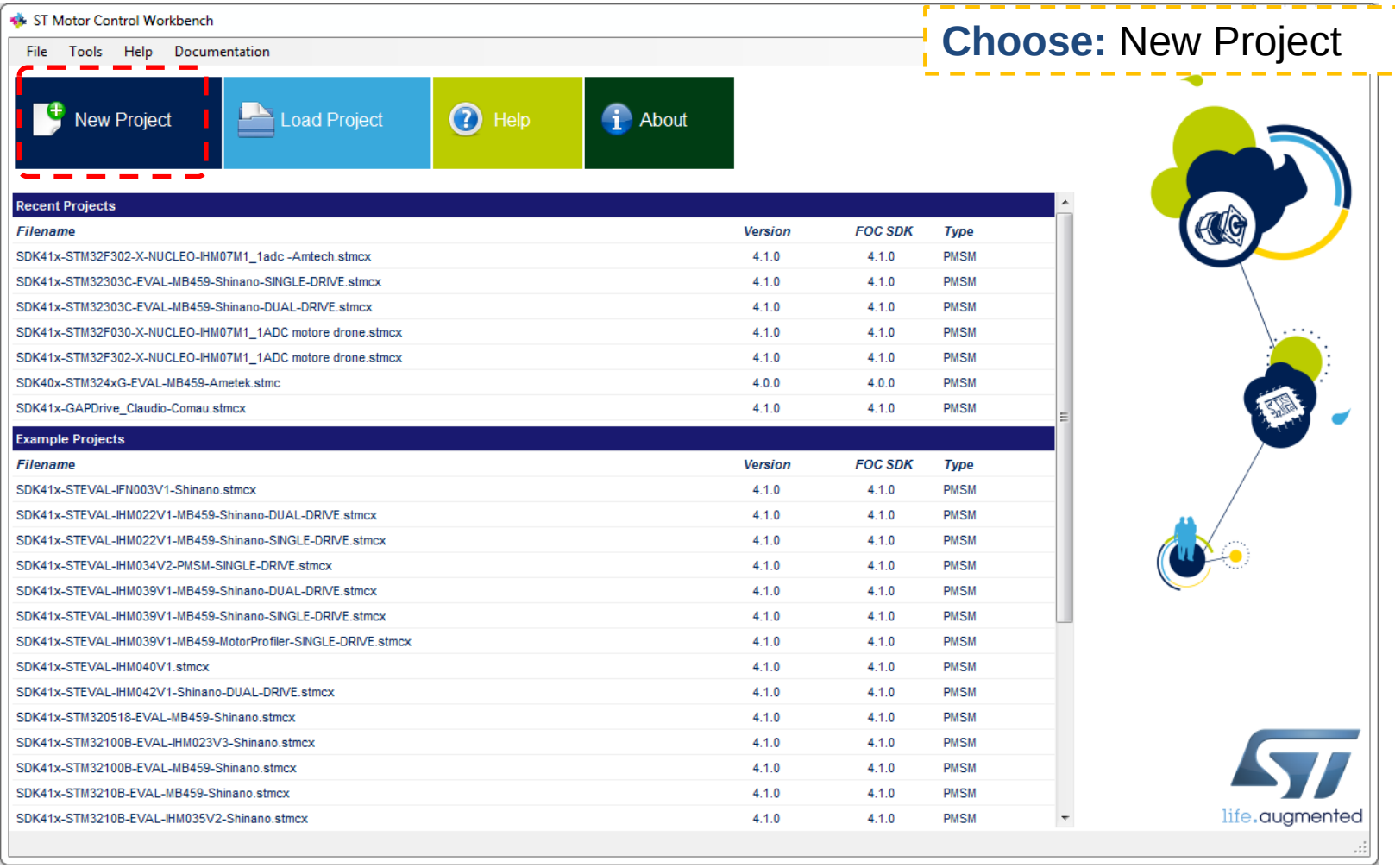


- Re-check Device Manager to ensure “**STMicroelectronics STLink dongle**” is functioning normally.

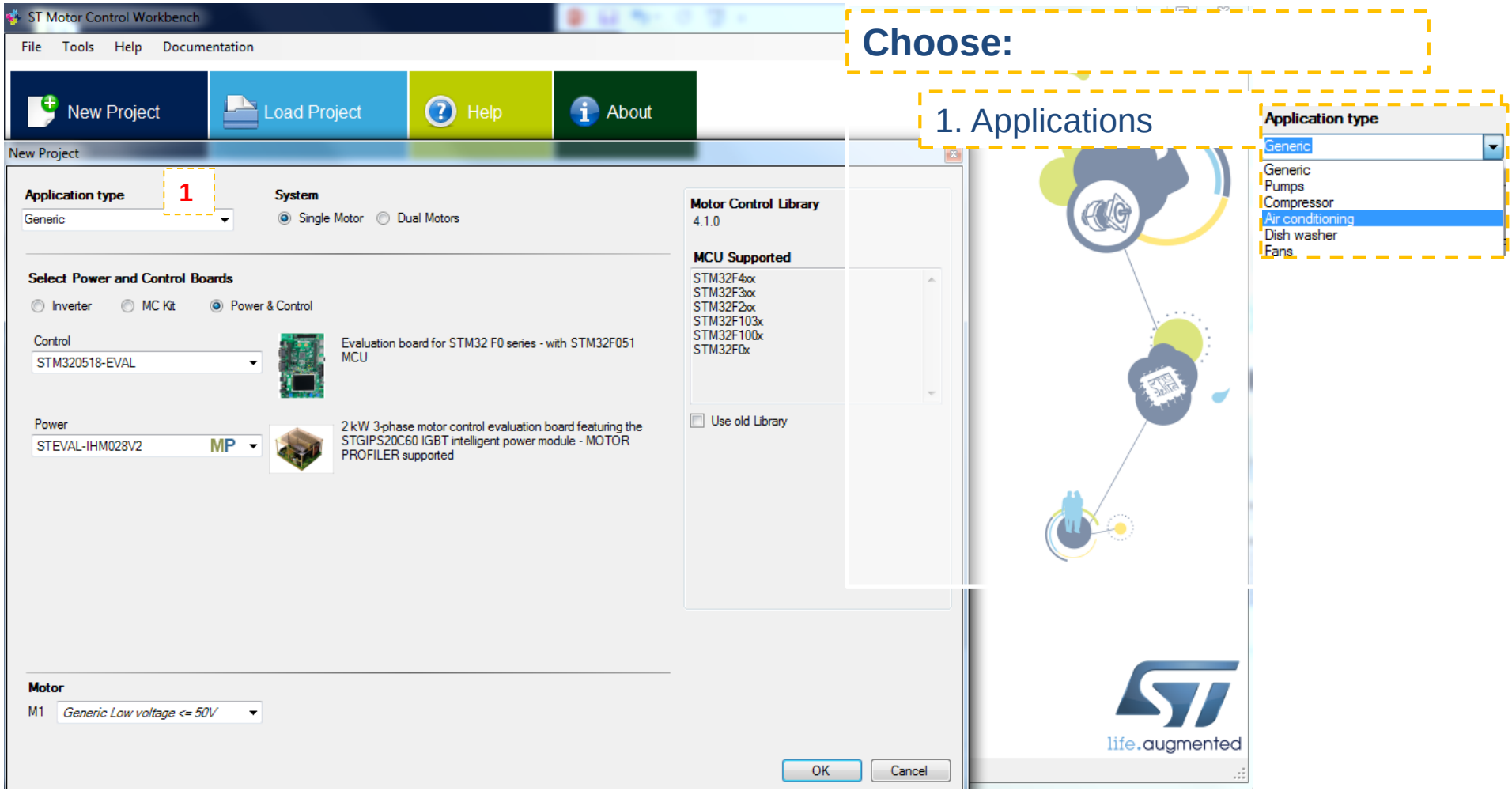
Set up workbench project

Step #6 – Create a new WB project based on the ST evaluation board

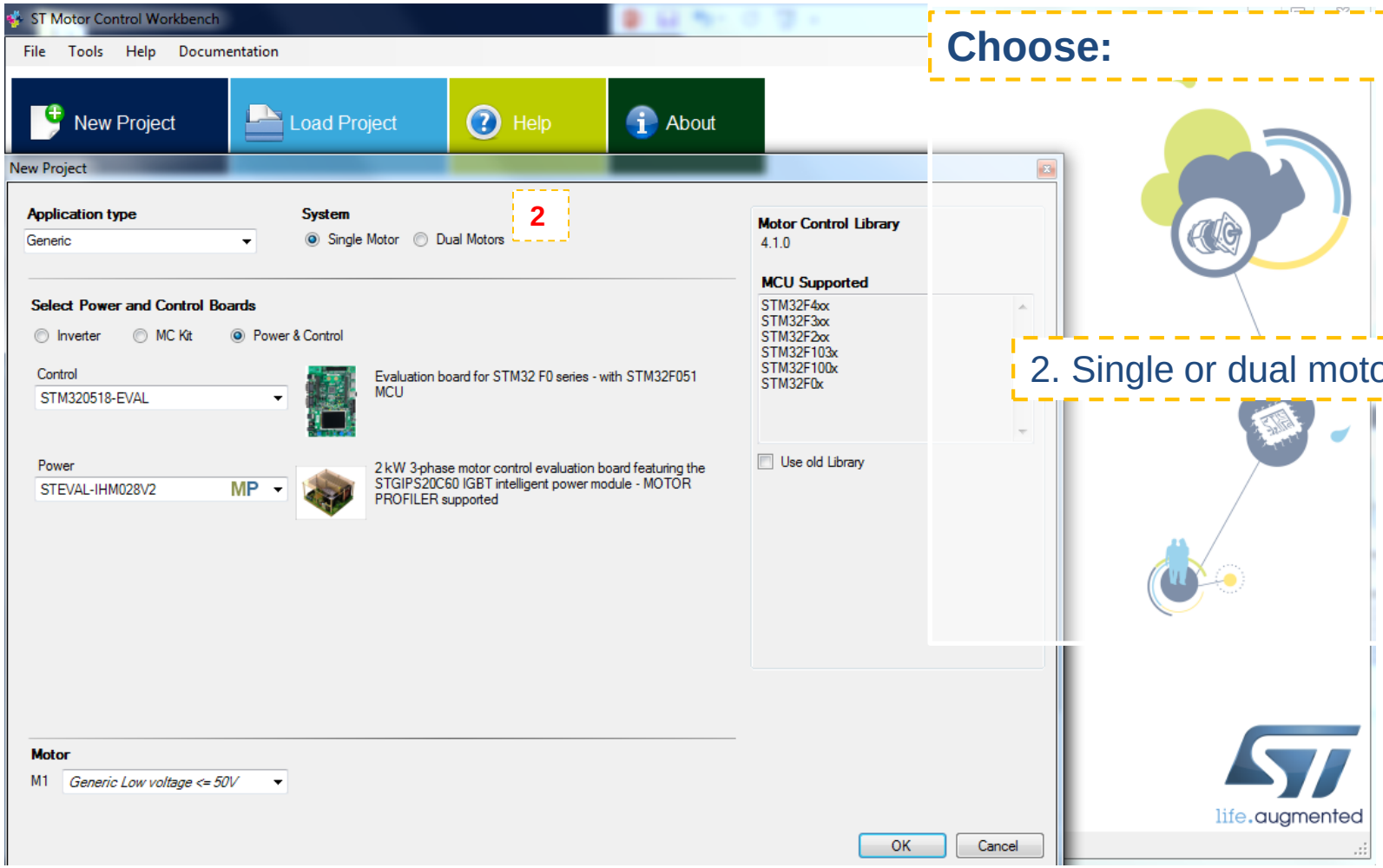
Choose: New Project



Step #6 – Create a new WB project based on the ST evaluation board



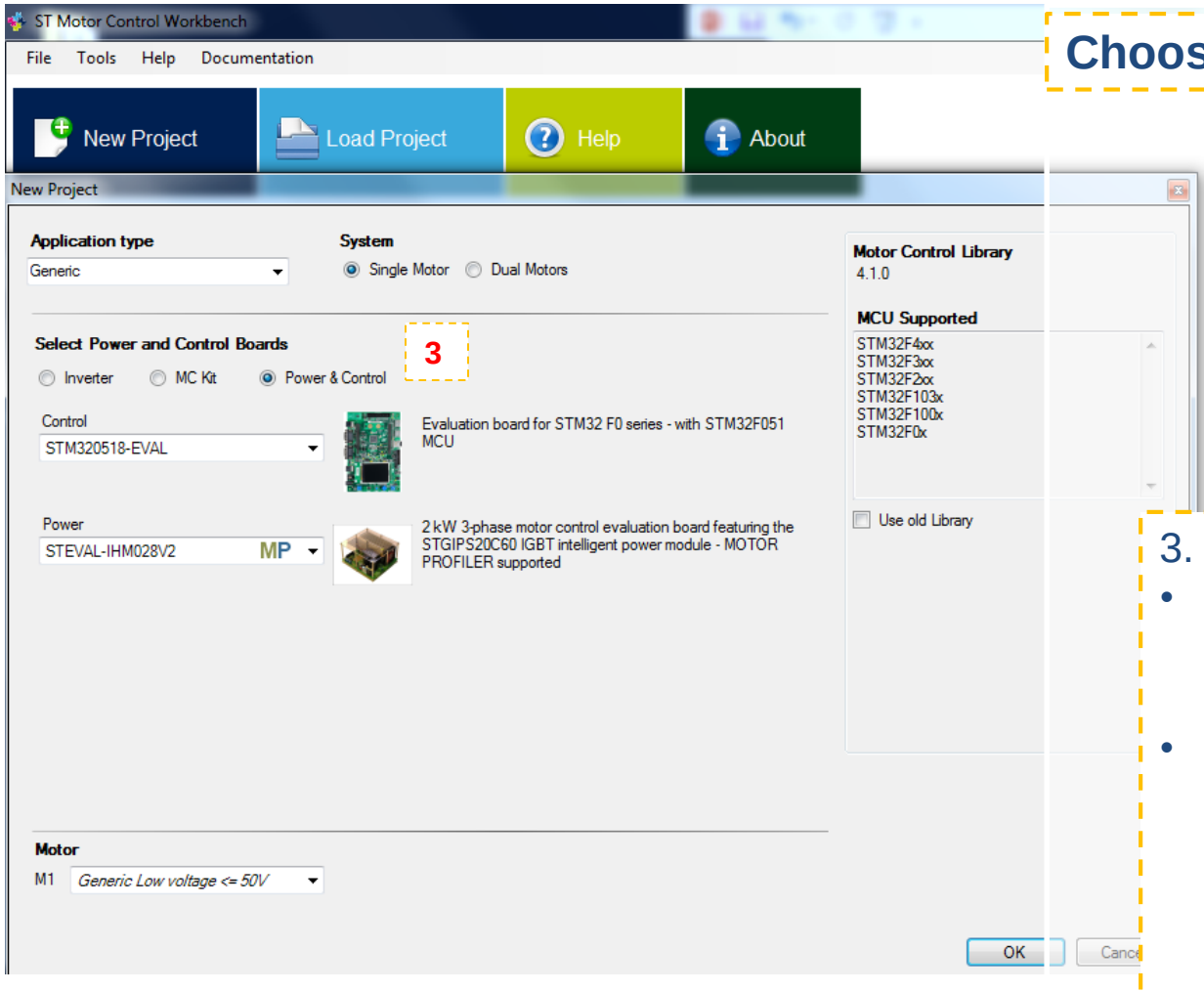
Step #6 – Create a new WB project based on the ST evaluation board



Choose:

2. Single or dual motor

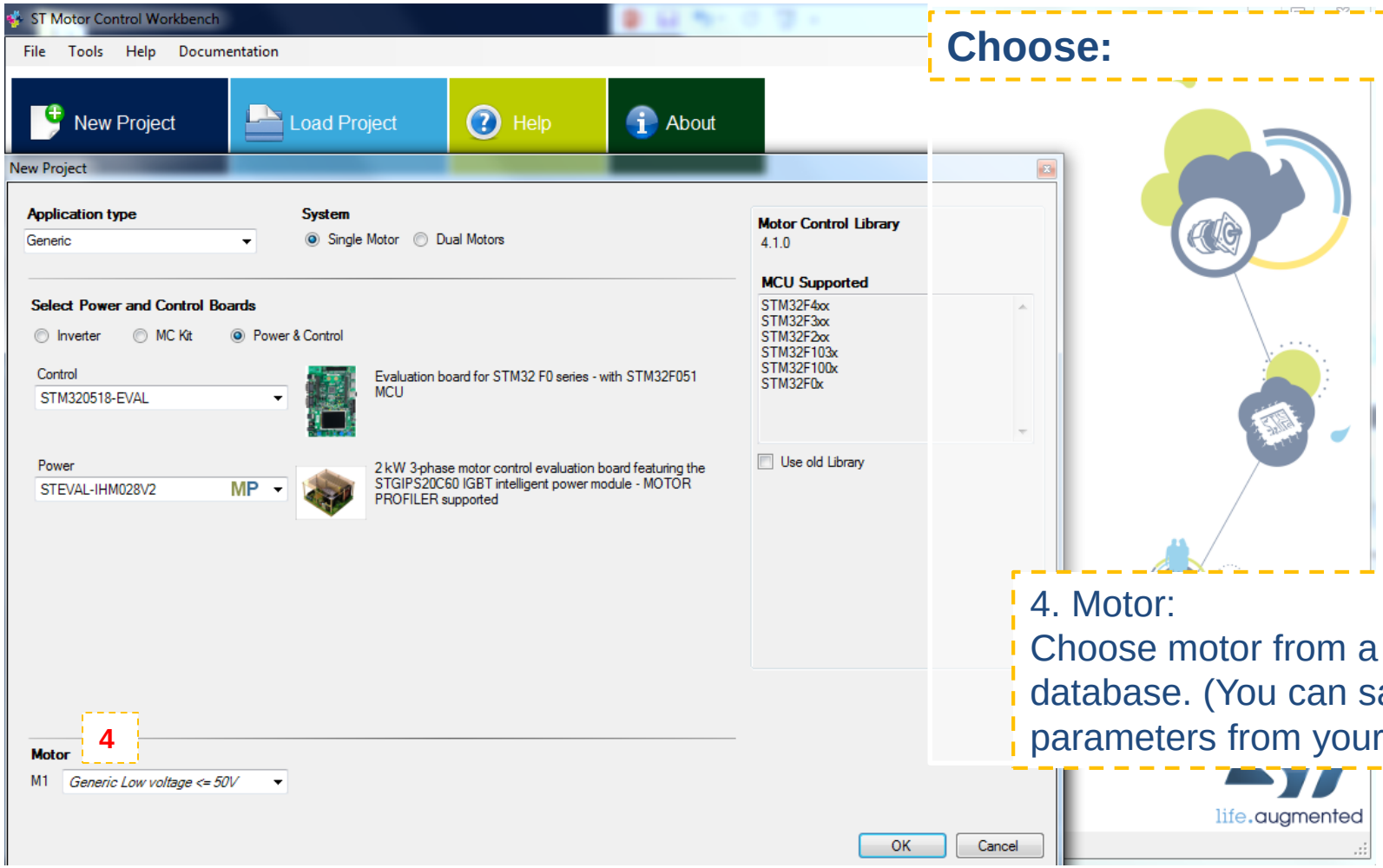
Step #6 – Create a new WB project based on the ST evaluation board



Choose:

3. Board approach:
   - Choose if you are using Inverter, MC Kit or Power plus Control boards.
   - Select the board used or create your own custom board.

Step #6 – Create a new WB project based on the ST evaluation board

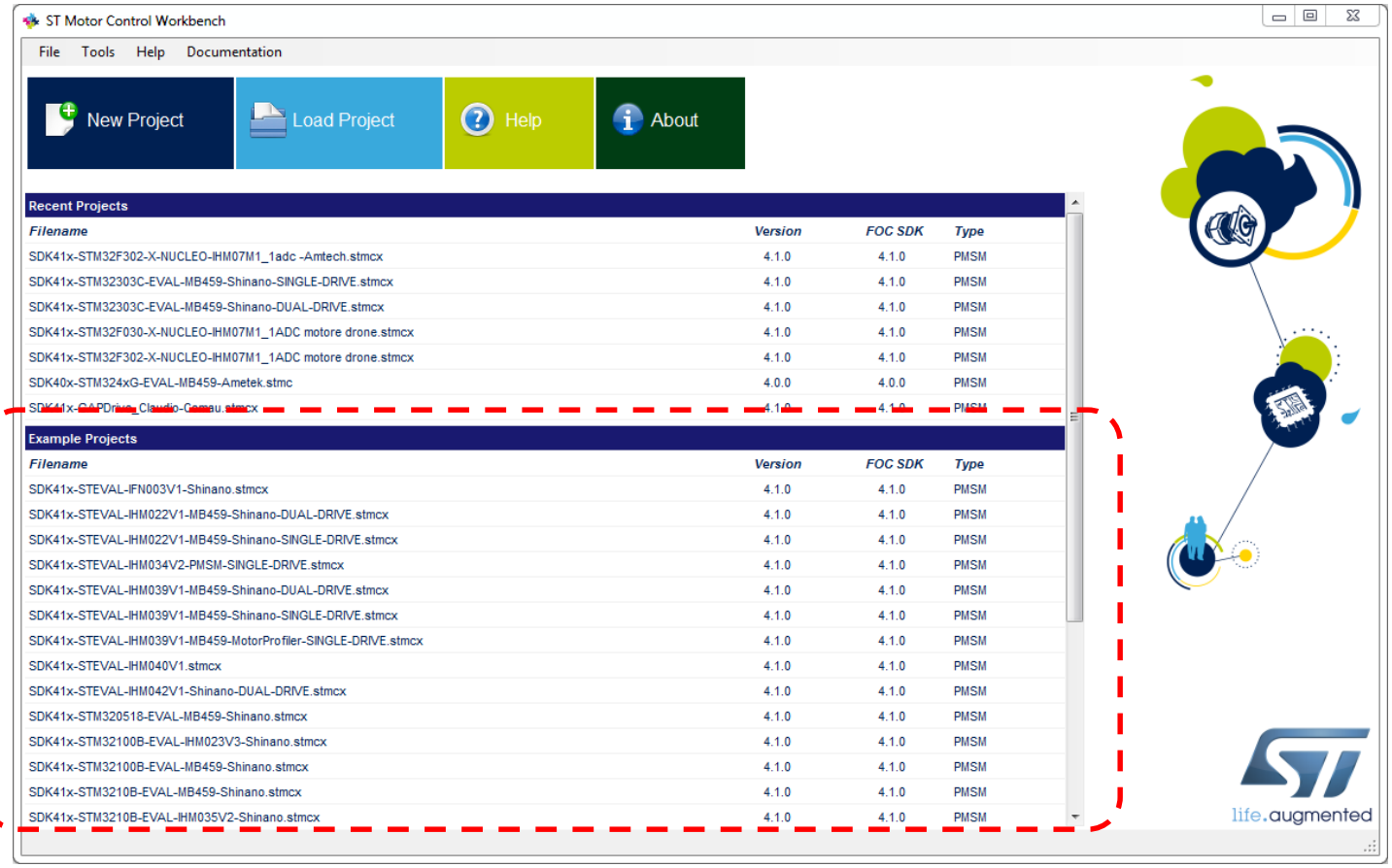


Choose:

4. Motor:
Choose motor from a motor database. (You can save your motor parameters from your project.)

Step #6 – or Create a new WB project based on an example project

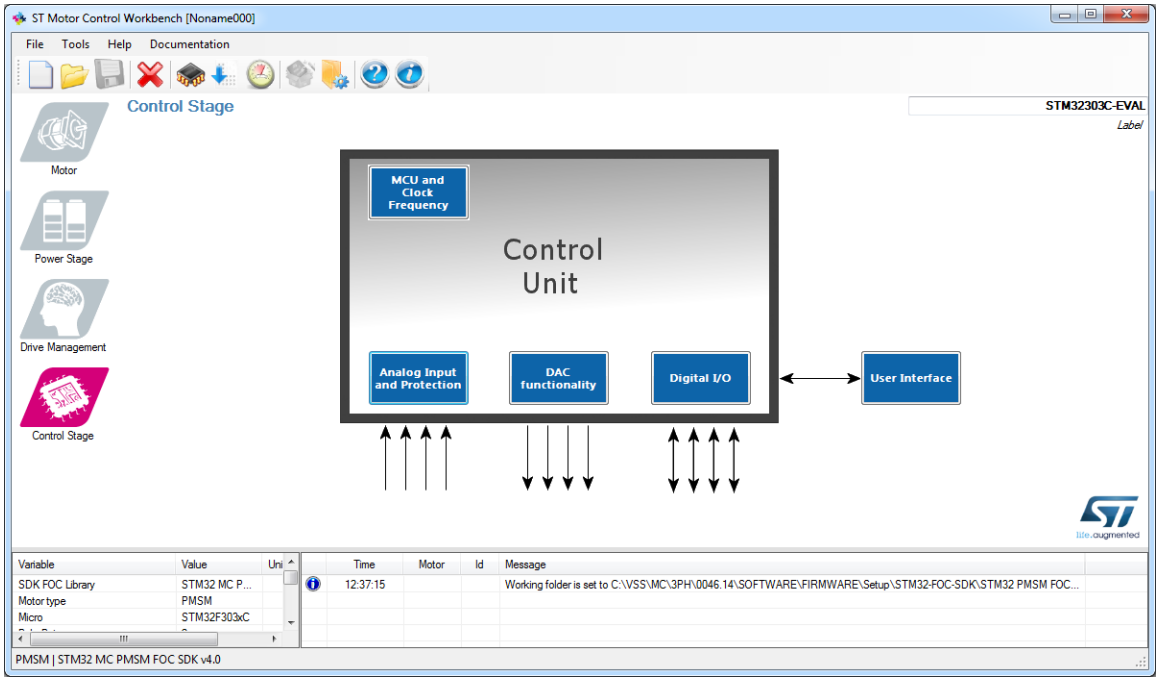
- Choose the WB example project that best fits your needs.
  - Choose the one with the same name of the ST evaluation board you are using, or
  - choose the one with the same microcontroller you are using.



Step #6 – Create a new WB project

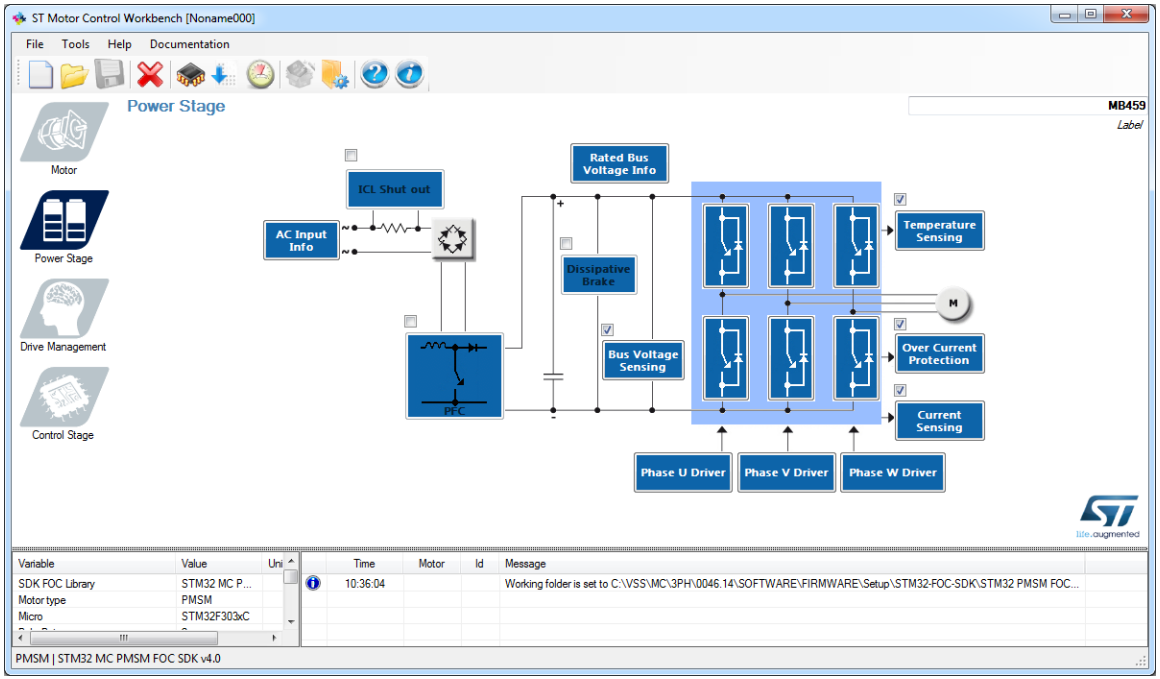
- Starting from the board selection or example project, the control stage parameters will be populated with the correct values.
- For a custom project, the user can set all the parameters.

STM32303C-EVAL



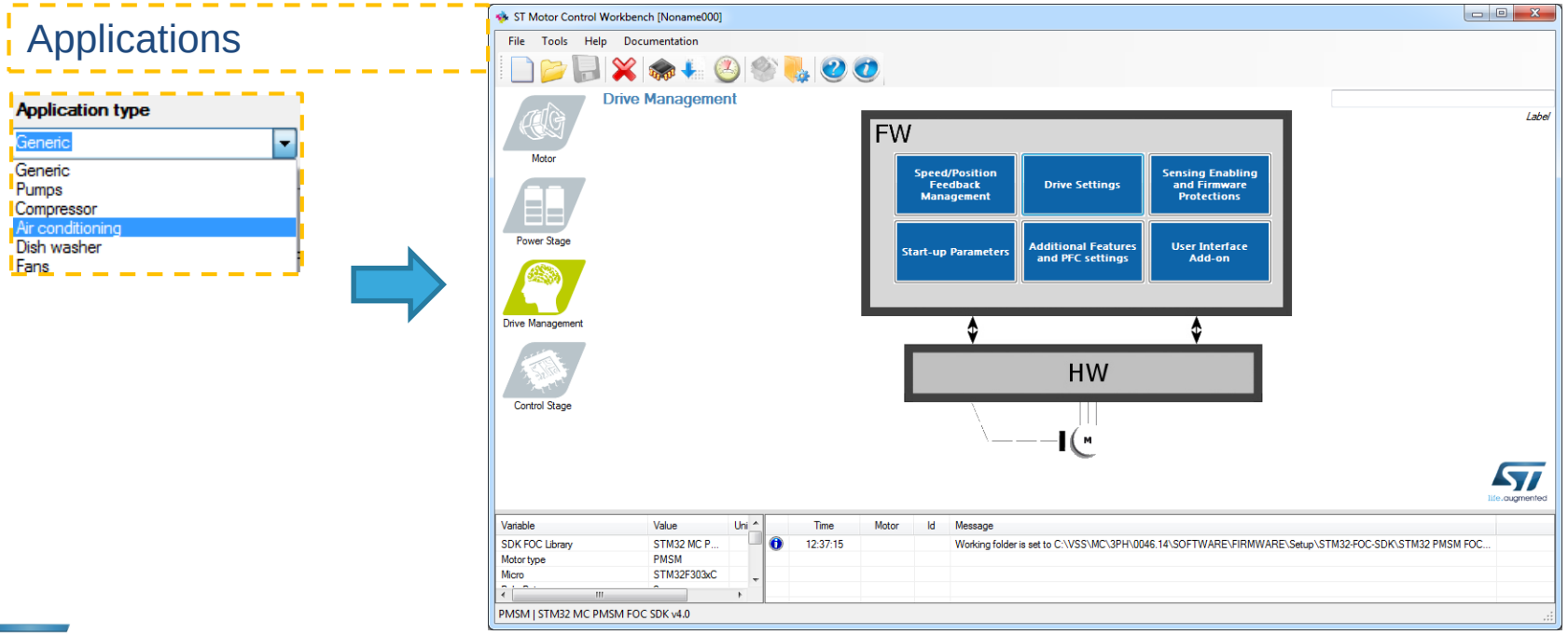
Step #6 – Set up power stage

- Starting from the board selection or example project, the power stage parameters will be populated with the correct values.
- For a custom project, the user can set all the parameters.



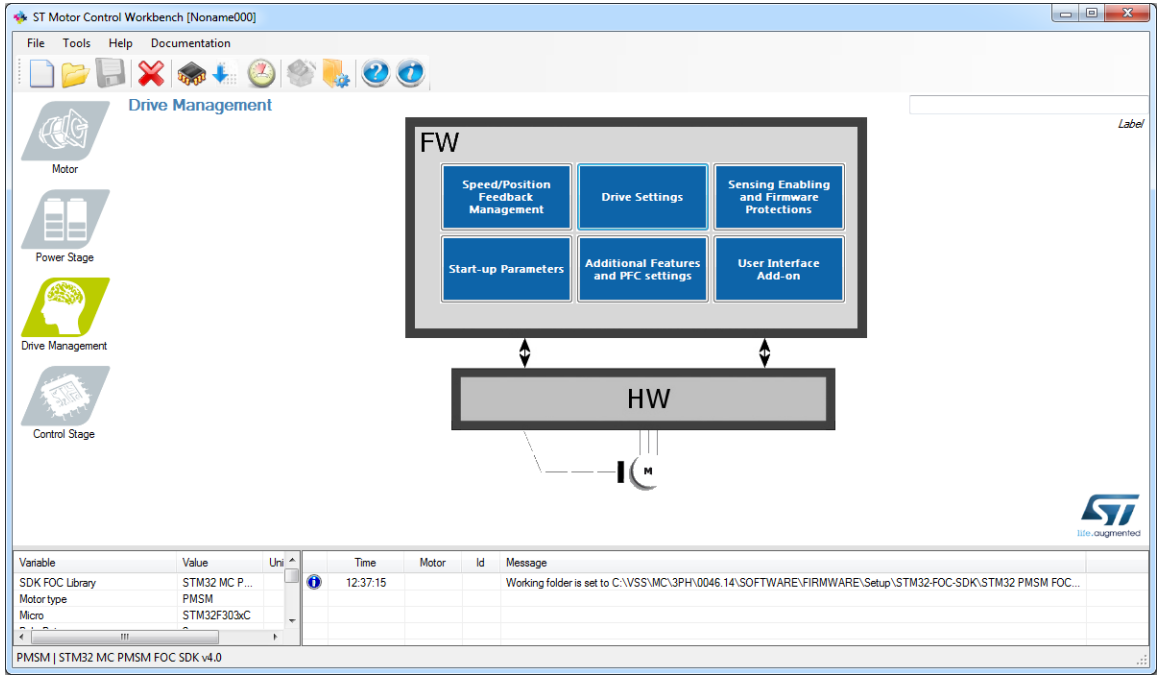
Step #6 – Set up drive parameters

- Starting from the board selection according to the chosen application, drive parameters will be populated with the correct values.
- For a custom project, the user can set all the parameters.



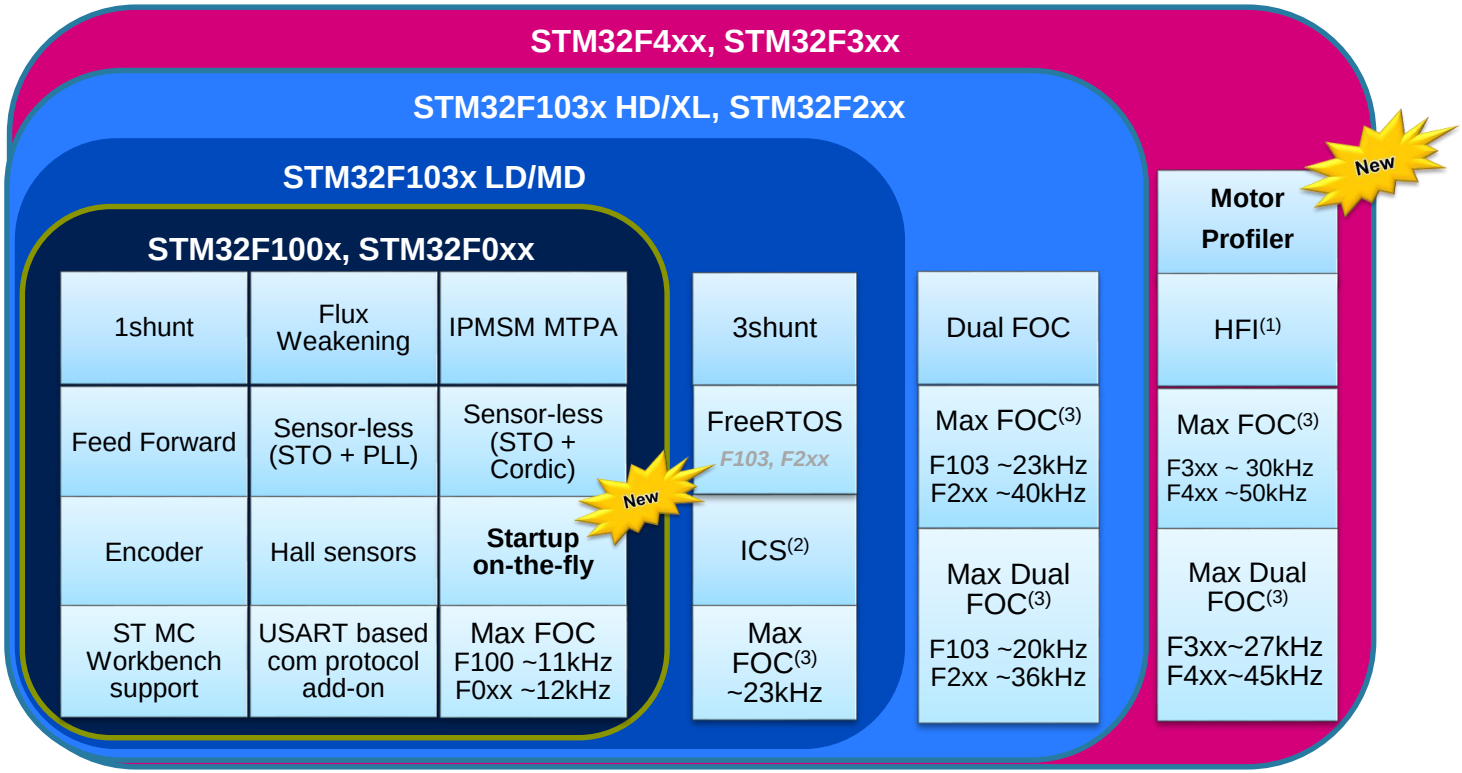
Step #6 – Drive parameter tricks

- In Drive settings, decrease cut-off frequency of torque and flux regulator down to 2000 rad/s if power stage → current reading topology is single shunt.
- In Sensing enabling and FW protections, uncheck the sensing options not supported by power stage and check any “Set intervention threshold to power stage xxx” buttons.
- In Drive settings, initially set default target speed to at least 20% of maximum application speed.
- In additional features, start without any additional method (possible to add them later).



Step #6 – Drive parameter tricks

- In Drive settings, choose a correct PWM frequency and torque and flux execution rate in such a way that the $FOC\ rate = \frac{PWM\ freq}{Execution\ rate}$ is compatible with the maximum FOC rate according to the microcontroller used.



(1) High Frequency Injection

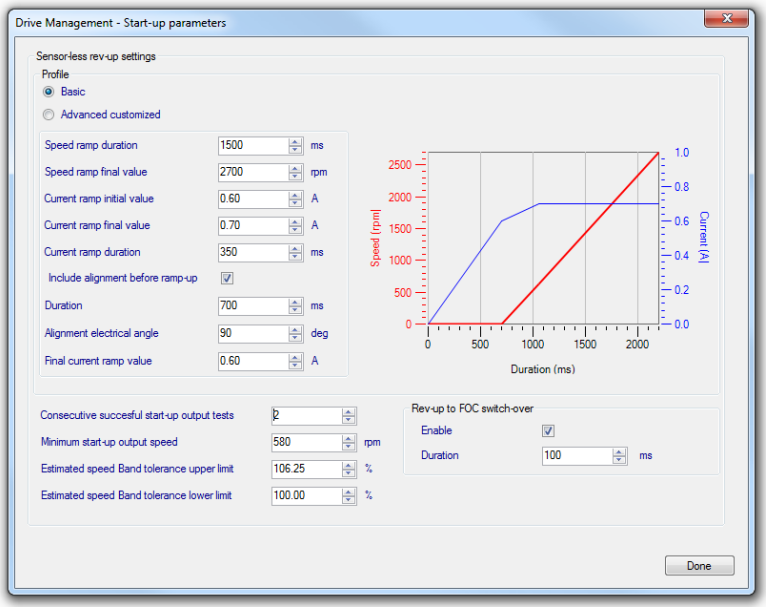
(2) Supported only for STM32F103, STM32F2, STM32F4

(3) Max FOC estimated in sensorless mode

Step #6 – Drive parameter tricks

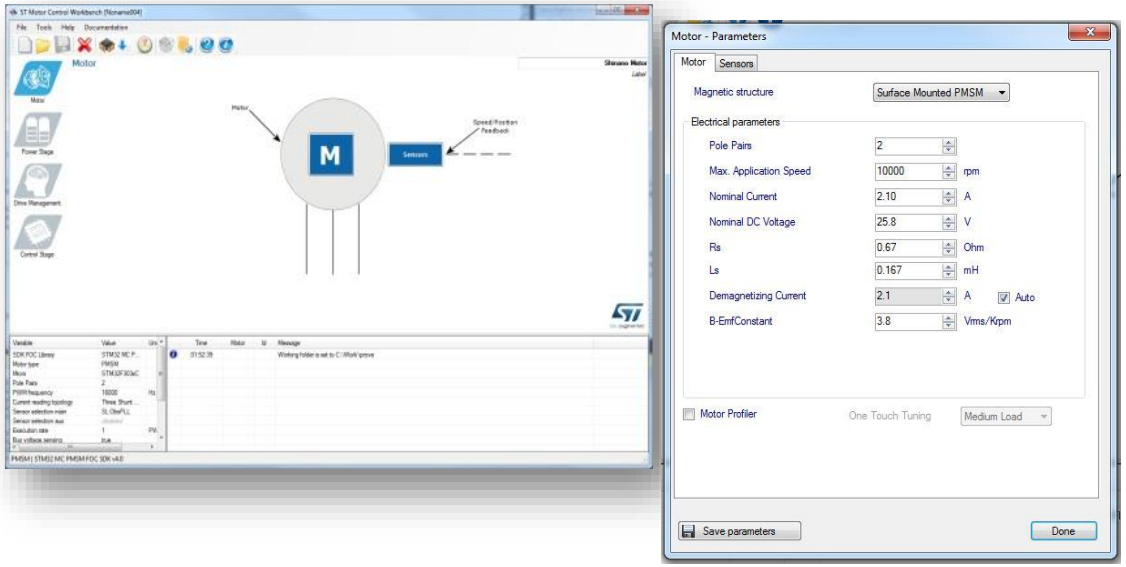
- ***If motor profiler is not used***, in start-up parameters, select the *basic* profile.
- Set *current ramp initial and final values* equal to motor nominal current value / 2 (if load is low at low speed, otherwise it can be set up to 0.8-1.0 times nominal current value).
- Set *speed ramp final value* to around 30% of maximum application speed.
- According to motor inertia it may be required to increase the *speed ramp duration*.
- Set *minimum start-up output speed* to 15% of maximum application speed (if required, decreased it later).
- Set *estimated speed band tolerance lower limit* to 93.75%
- Enable the alignment at the beginning of your development (duration 2000 ms, final current ramp value from 0.5 to 1 times motor nominal current according to load)

Basic



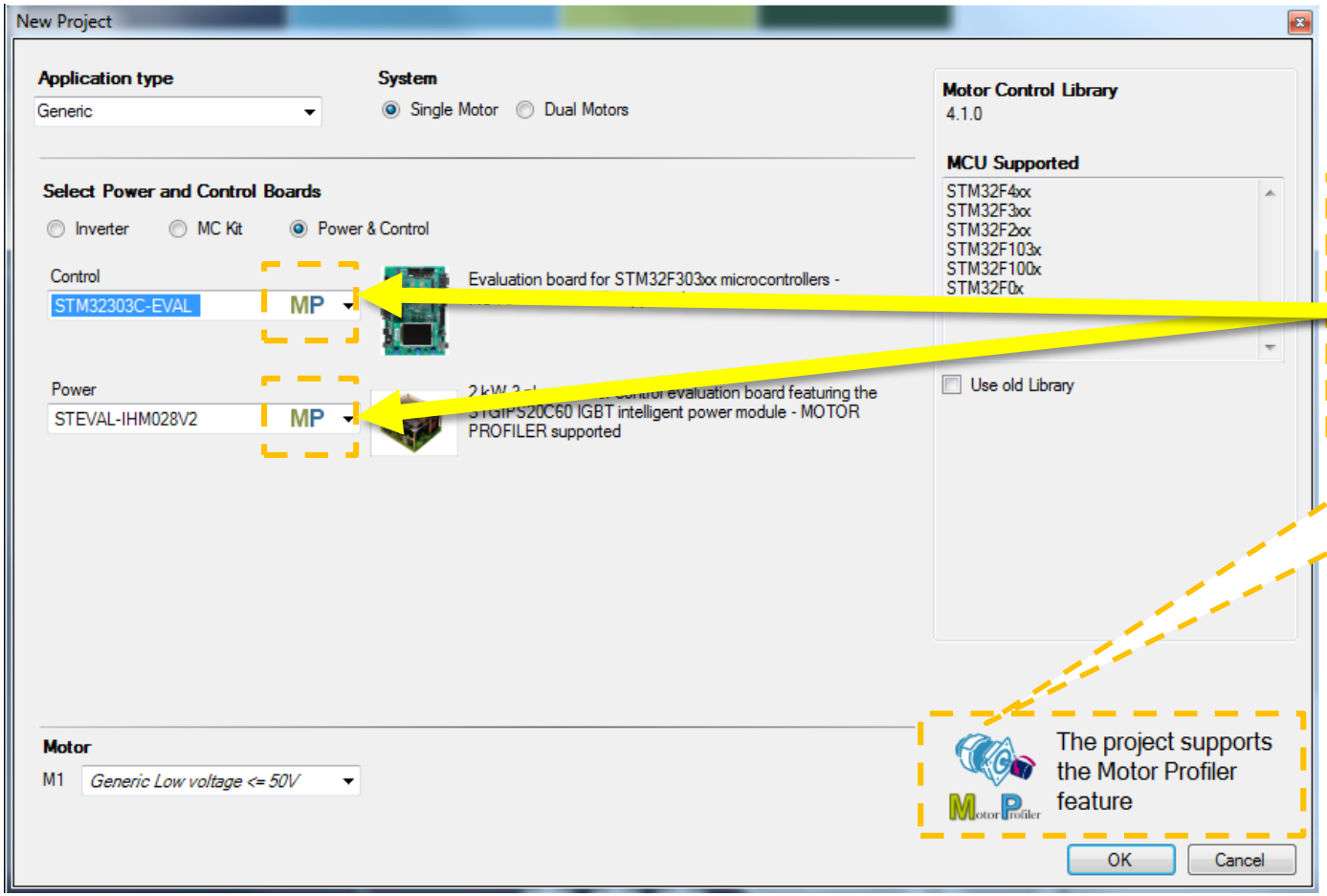
Step #7 – Set up motor parameters

- ST MC Workbench – Motor section contains:
  - Electrical motor parameters
  - Motor sensor parameters
- In this hands-on session, we will configure the system for sensor-less control using a motor with a surface-mounted magnet.
- For a custom project, the user can set all the parameters.



Step #7 – Set up motor parameters

- If motor parameters are unknown (or instrumentation to measure them are missing), and if supported by the hardware, it is possible to use the new Motor Profiler feature.

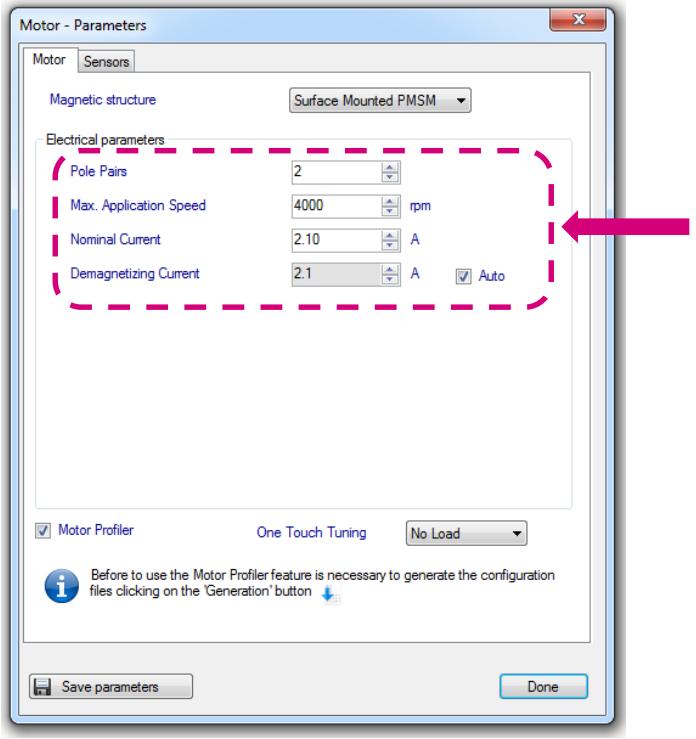


Example
Hardware supporting the Motor Profiler (M.P.)

Step #7 – Setup Motor Profiler

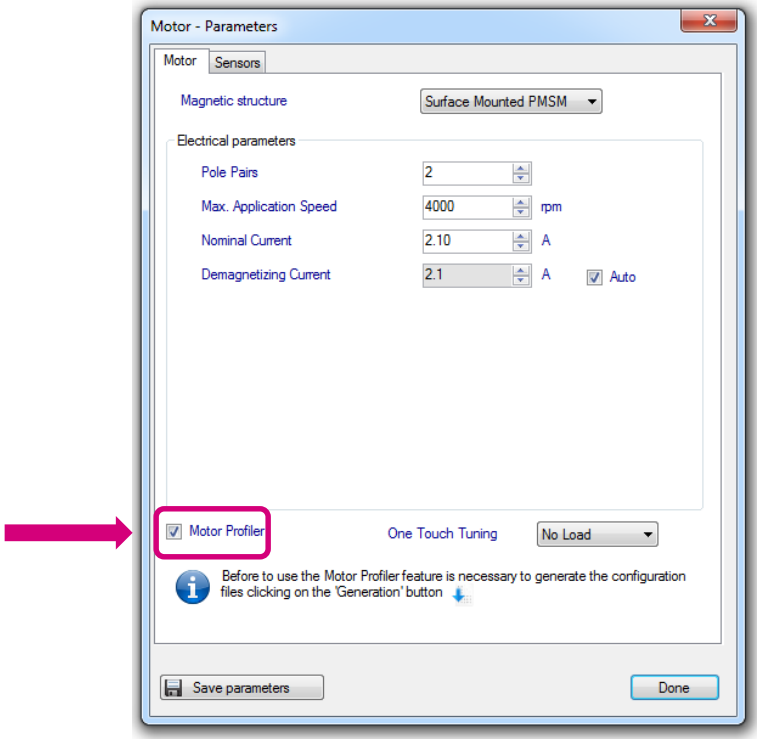
These parameters must be set by the user

- Motor pole pairs
- Maximum application speed
  - Nominal speed of the motor will be computed and used to validate the maximum application speed selected by the user.
- Nominal current



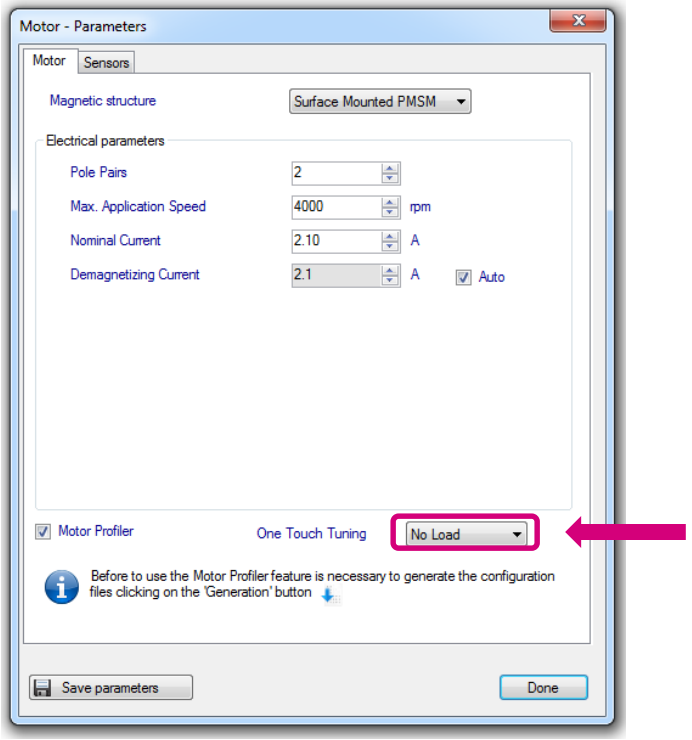
Step #7 – Setup Motor Profiler

- Verify that the Motor Profiler check box is selected.



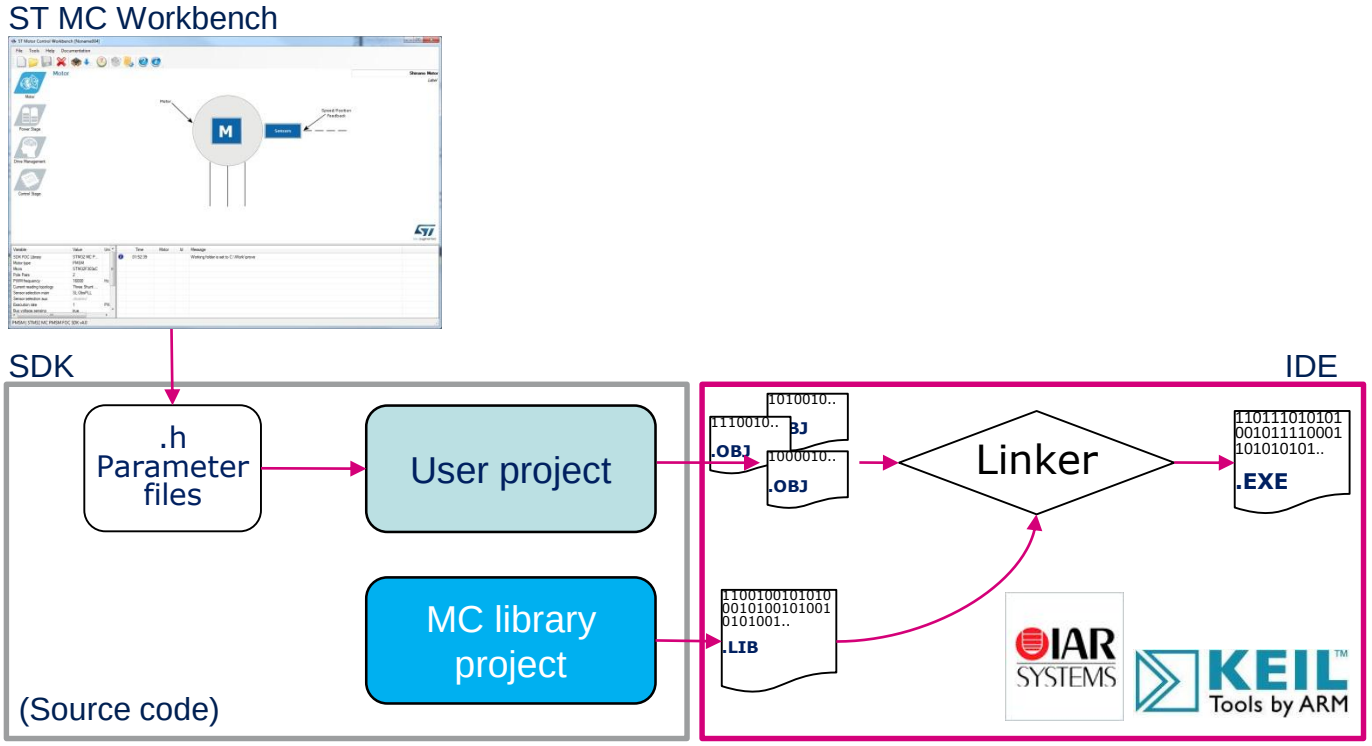
Step #7 – Setup Motor Profiler

- Choose the kind of load.



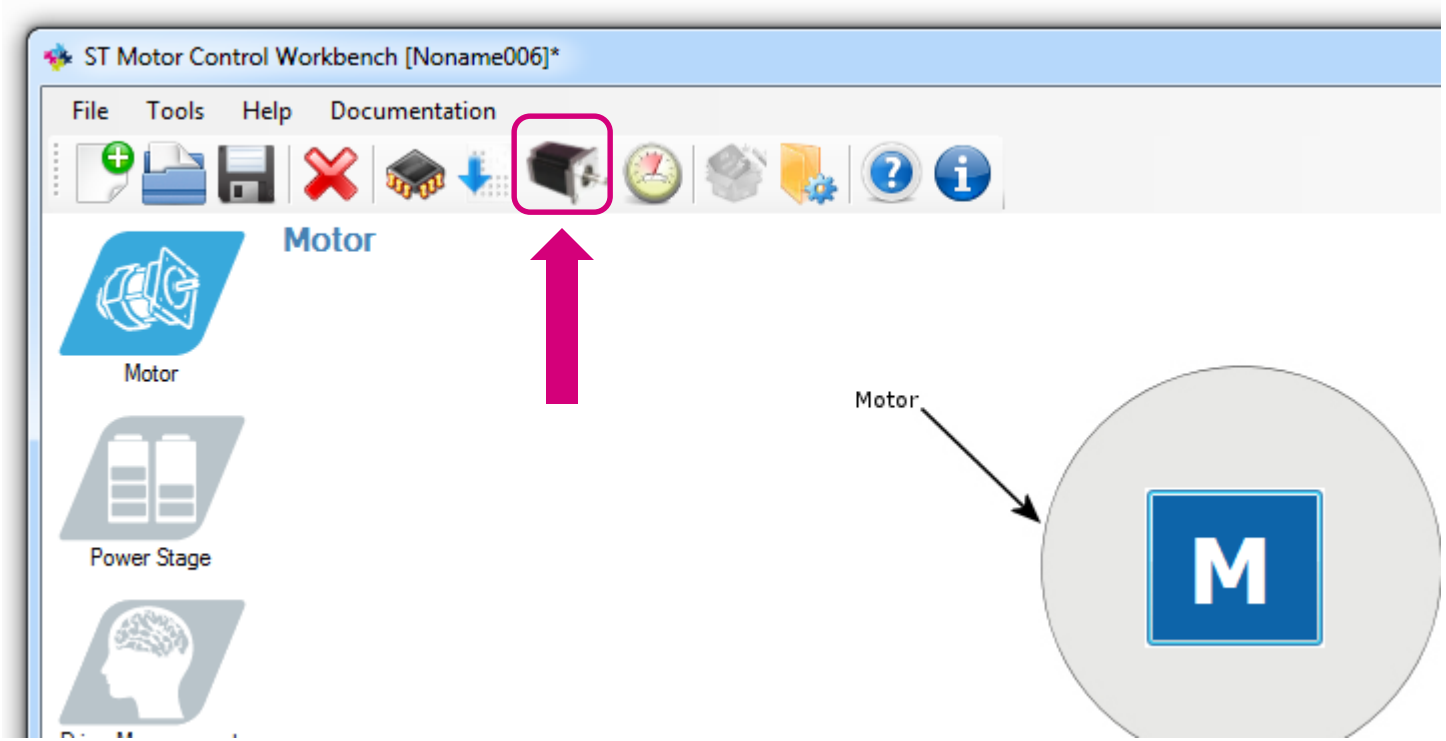
Step #7 – Generate and compile the FW

- Before running the Motor Profiler, execute Steps #9, #10 and #11 (#11 only if LCD is present in the board) to generate and compile the firmware.



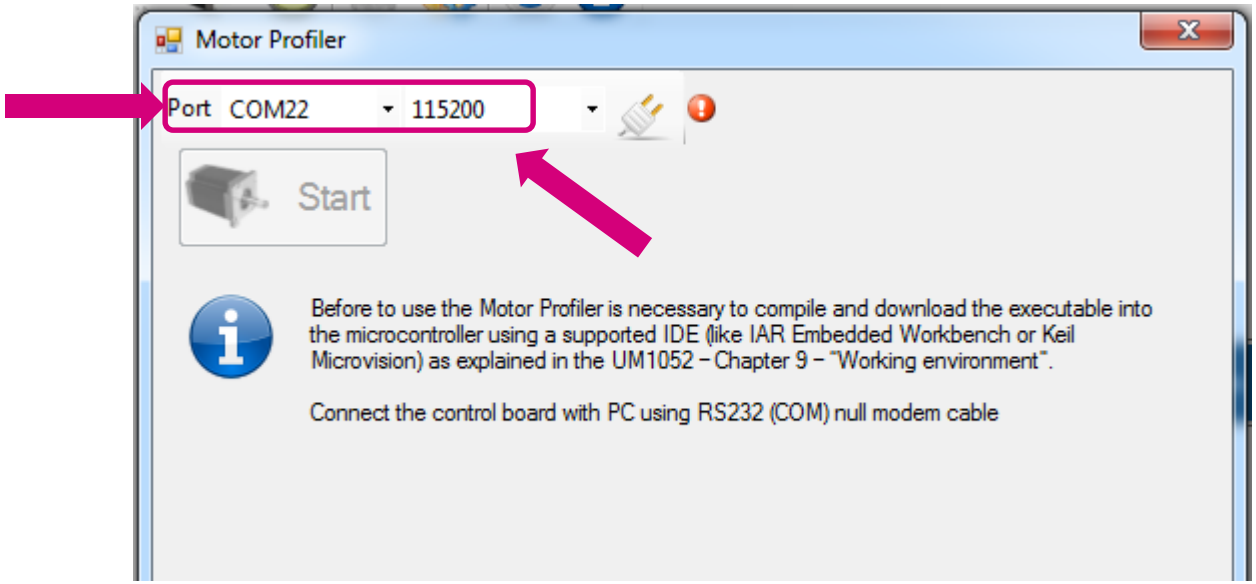
Step #7 – Run Motor Profiler

- Using the ST MC Workbench, run the Motor Profiler procedure.



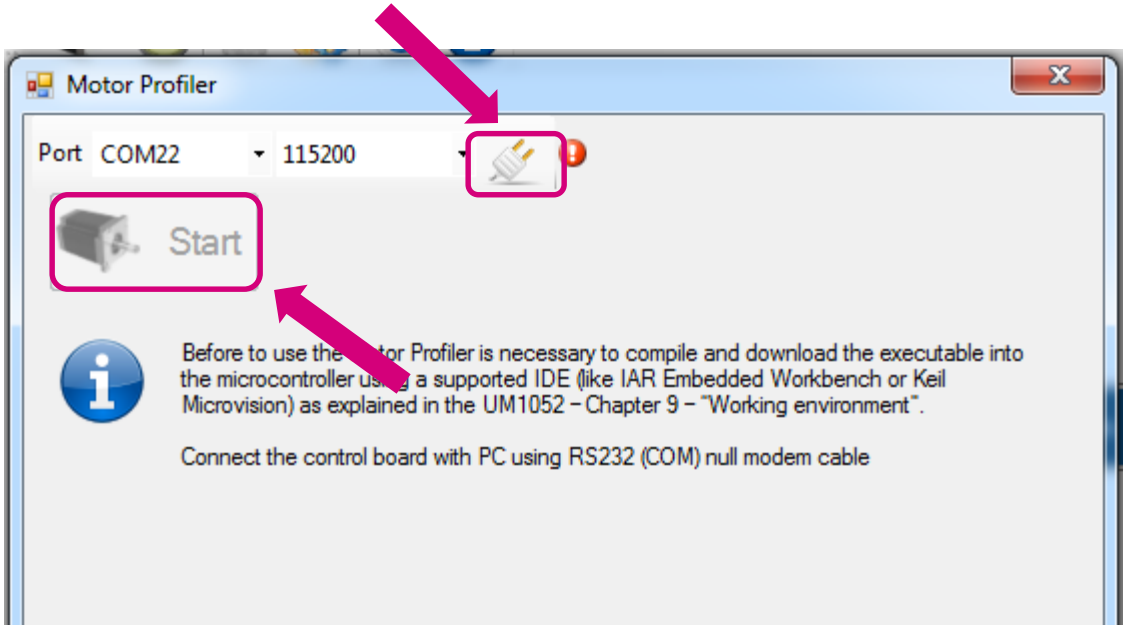
Step #7 – Run Motor Profiler

- To execute the Motor Profiler procedure, connect the PC to the microcontroller board via the USART connection.
- Connect the PC to the control board with the USB to RS-232 dongle (and a null modem cable).
- Select COM port and communication speed (as set in the Control Stage -> Digital I/O).



Step #7 – Run Motor Profiler

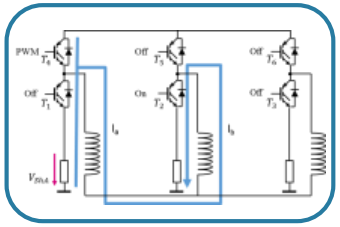
- Press Connect.
- Press Start.



Step #7 – Run Motor Profiler

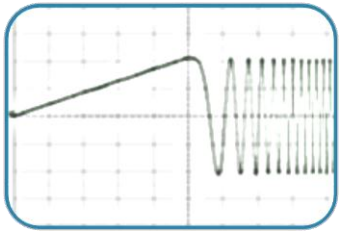
- Procedure will end in about 60 seconds.

Motor stopped
- Rs measurement
- Ls measurement
- Current regulators set-up



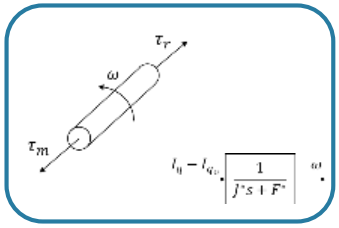
10 sec

Open loop
- Ke measurement
- Sensorless state observer set-up
- Switch over



5 sec

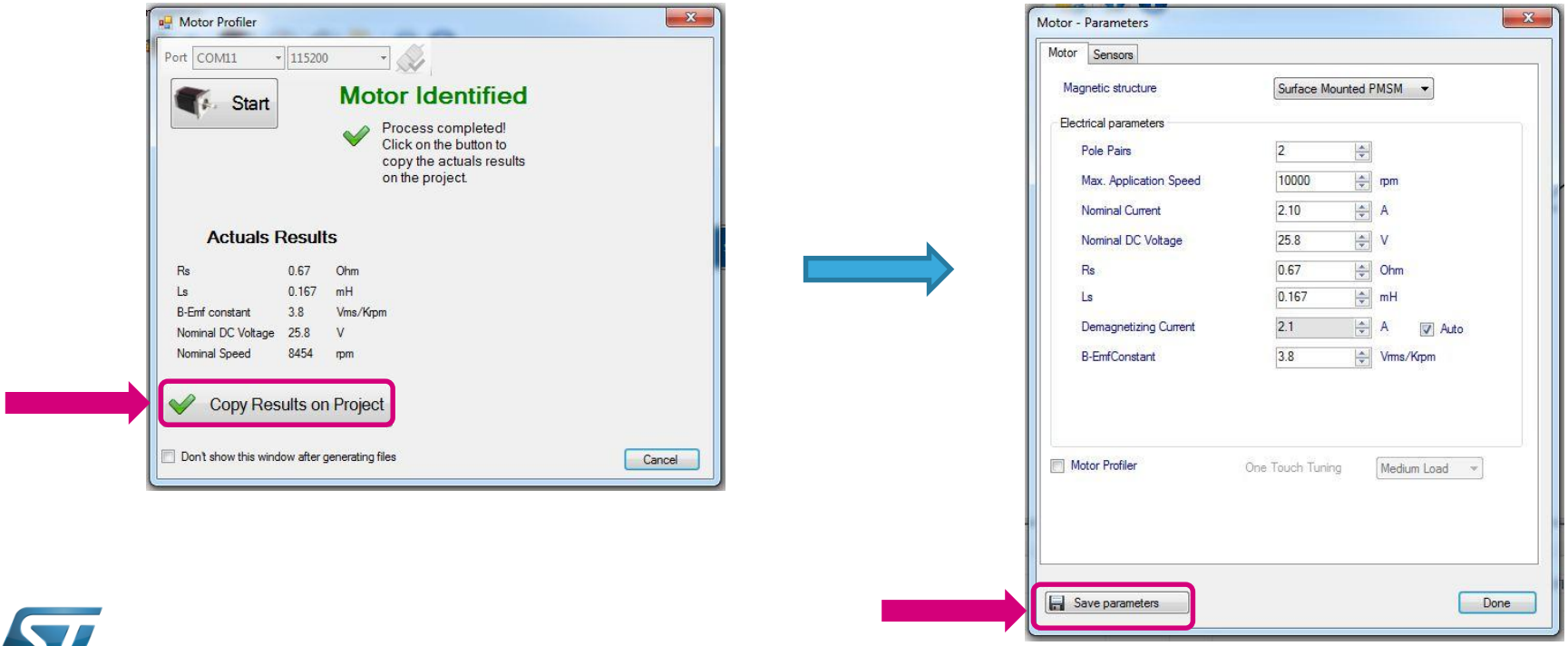
Closed loop
- Friction coefficient measurement
- Moment of inertia measurement
- Speed regulator set-up



45 sec

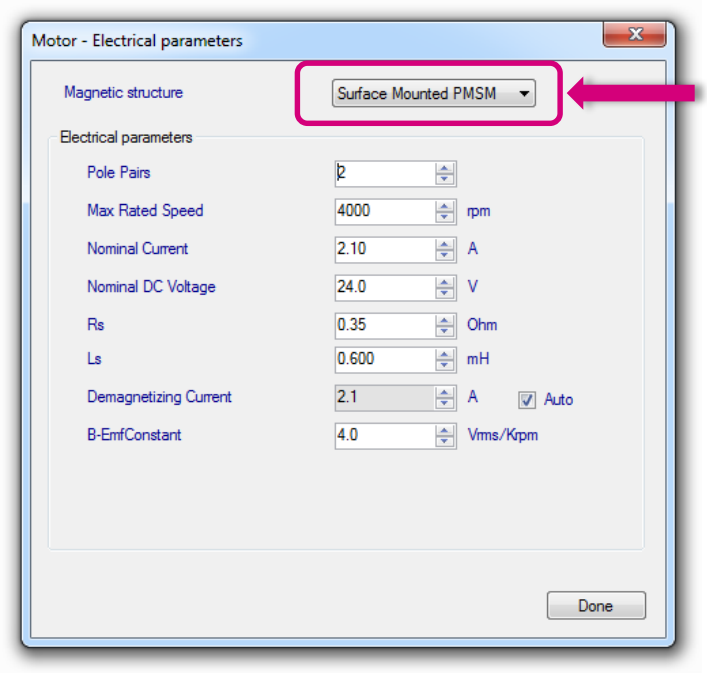
Step #7 – Motor Profiler complete

- At the end of the procedure, the measured parameters will be shown on a dedicated window.
- It is possible to import them on the workbench project and save them for later use.



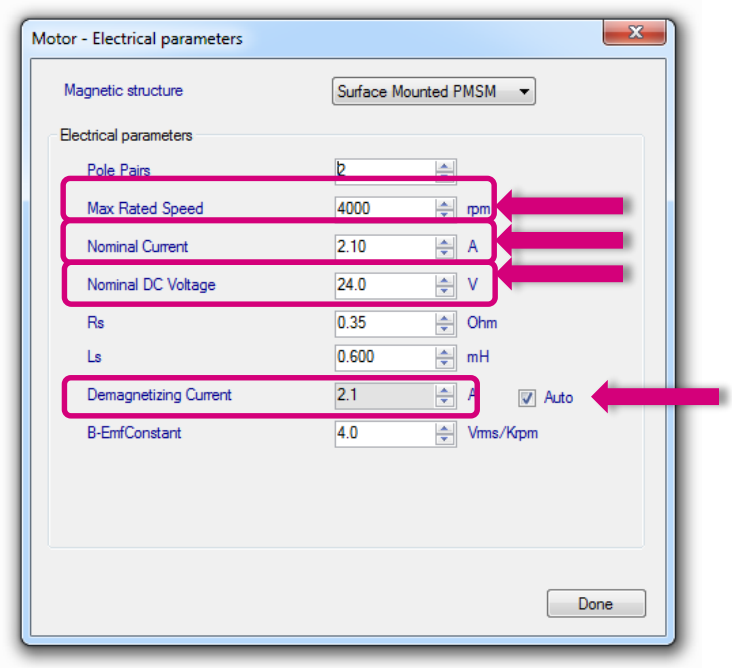
Step #8 – Set up motor parameters manually

- Select Surface Mounted PMSM in Motor → Electrical parameters → Magnetic structure.



Step #8 – Set up motor parameters manually

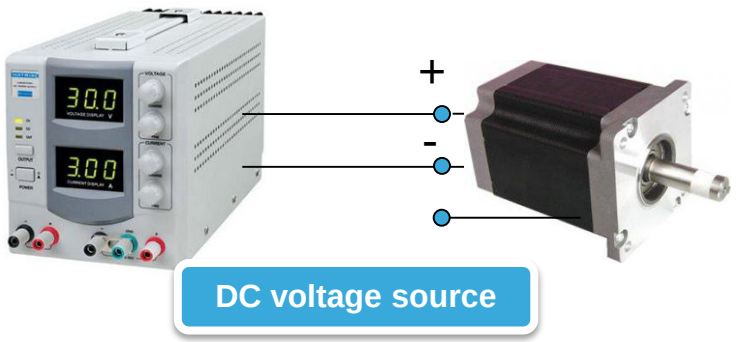
- Set ***Max Rated Speed*** with the maximum motor speed according the application specs.
- Set ***Nominal Current*** with maximum peak current provided to each of the motor phases according the motor specs.
- Set ***Nominal DC Voltage*** with value of DC bus provided to the inverter or the rectified value of AC input.
- Keep checked the “Auto” button near “Demagnetizing Current”.



Step #8 – Set up motor parameters manually

Pole pair number

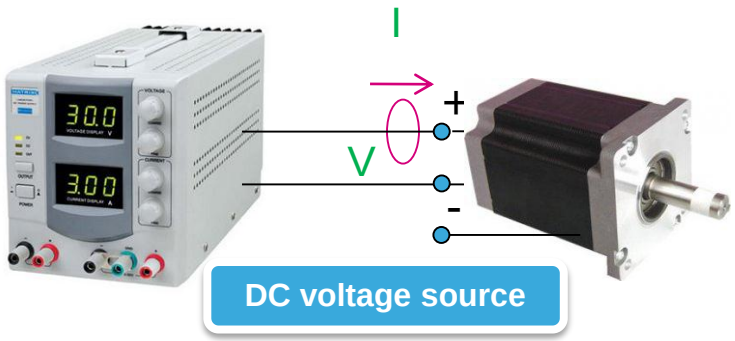
- The number of pole pairs is usually provided by the motor supplier, but in case it's not or if you'd like to double check it:
  - Connect a DC power supply between two (of the three) motor phases and provide up to 5% of the expected nominal DC bus voltage. (You may also set current protection to nominal motor current.)
  - Rotate the motor with your hands, you should notice a little resistance, otherwise:
    - If you are not able to rotate the motor, decrease the applied voltage.
    - If the motor does not generate any resistance, gradually increase the applied voltage.
  - The number of rotor stable positions in one mechanical turn represents the number of pole pairs.



Step #8 – Set up motor parameters manually

Stator resistance and inductance

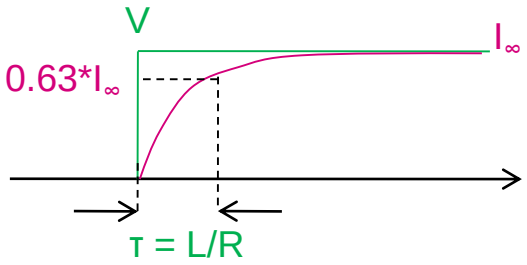
- Using the multimeter, measure the DC stator resistance phase-to-phase (Rs) and divide it by two.
- Connect the DC voltage between two motor phases.
- Connect the oscilloscope voltage and current probes as shown in the figure.
- Increase the voltage up to the value where the current equals the nominal value, rotor with align.
- Don’t move the rotor anymore.

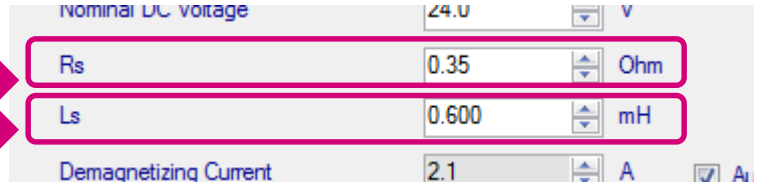


Step #8 – Set up motor parameters manually

Stator resistance and inductance

- Disable the current protection of DC voltage source.
- Unplug one terminal of the voltage source cable without switching it off.
- Plug the voltage source rapidly and monitor on the scope the voltage and current waveform until you get something like the one shown in the figure.
- The measurement is good if the voltage can be assimilated to a step and the current increase such as $I_\infty * (1-e^{-t*L/R})$.
- Measure the time required to current waveform to rise up to 63%.
- This time is Ld/Rs constant. Multiply it by Rs and you'll get Ld value.





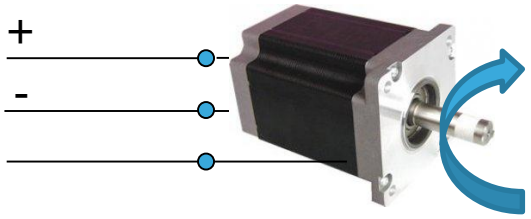
Step #8 – Set up motor parameters manually

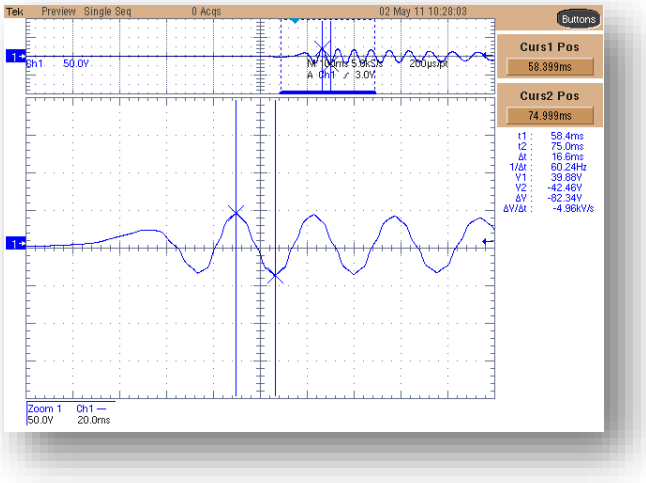
Back EMF constant Ke

- The Back-EMF constant represents the proportionality constant between the mechanical motor speed and the amplitude of the B-EMF induced into the motor phases:

$$V_{Bemf} = K_e \cdot \omega_{mec}$$

- To measure Ke, it usually suffices to turn the motor with your hands (or using a drill or another motor mechanically coupled) and use an oscilloscope to look for the phase-to-phase induced voltage (V_{Bemf})



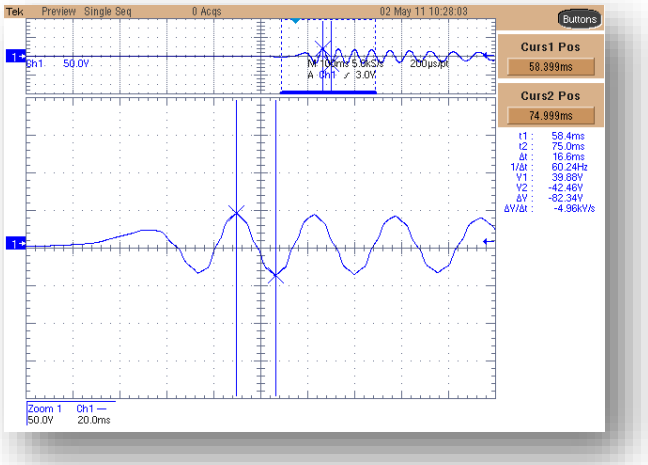


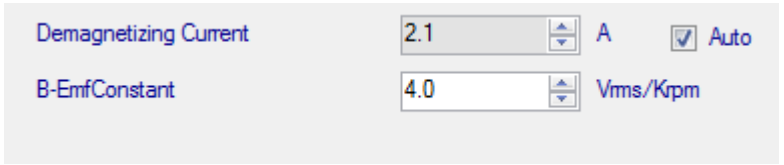
Step #8 – Set up motor parameters manually

Back EMF constant Ke

- Measure the V_{Bemf} frequency (f_{Bemf}) and the peak-to-peak amplitude (V_{Bemf-A})
- Compute Ke in V_{RMS} / K_{RPM}:

$$K_e = \frac{V_{Bemf-A}\ [V\ peak-to-peak] \cdot pole\ pairs\ number \cdot 1000}{2 \cdot \sqrt{2} \cdot f_{Bemf}\ [Hz] \cdot 60}$$

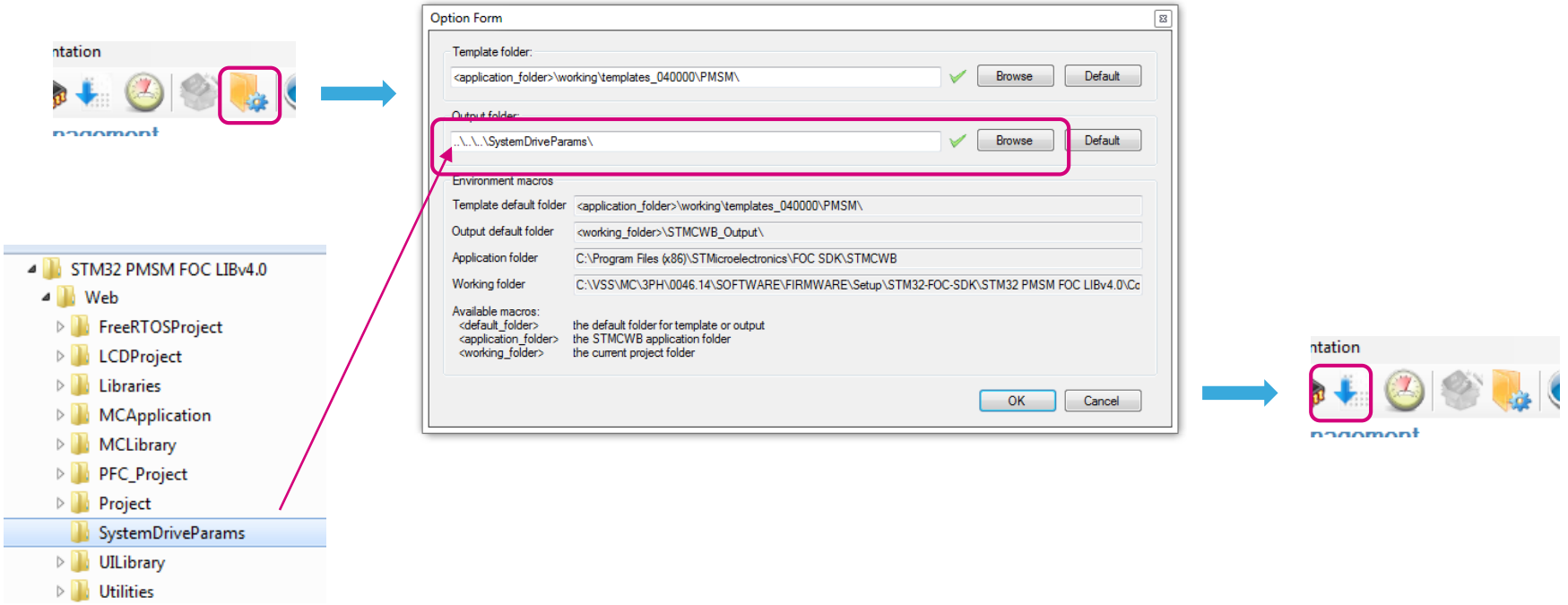




Generate, compile, debug and run

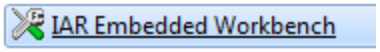
Step #10 – Parameter generation

- Once all the parameters have been entered in the ST MC Workbench, select the output path in the option form and choose '**SystemDriveParams**' present in the FW working folder.
- Click on the '**Generation**' button to configure the project.

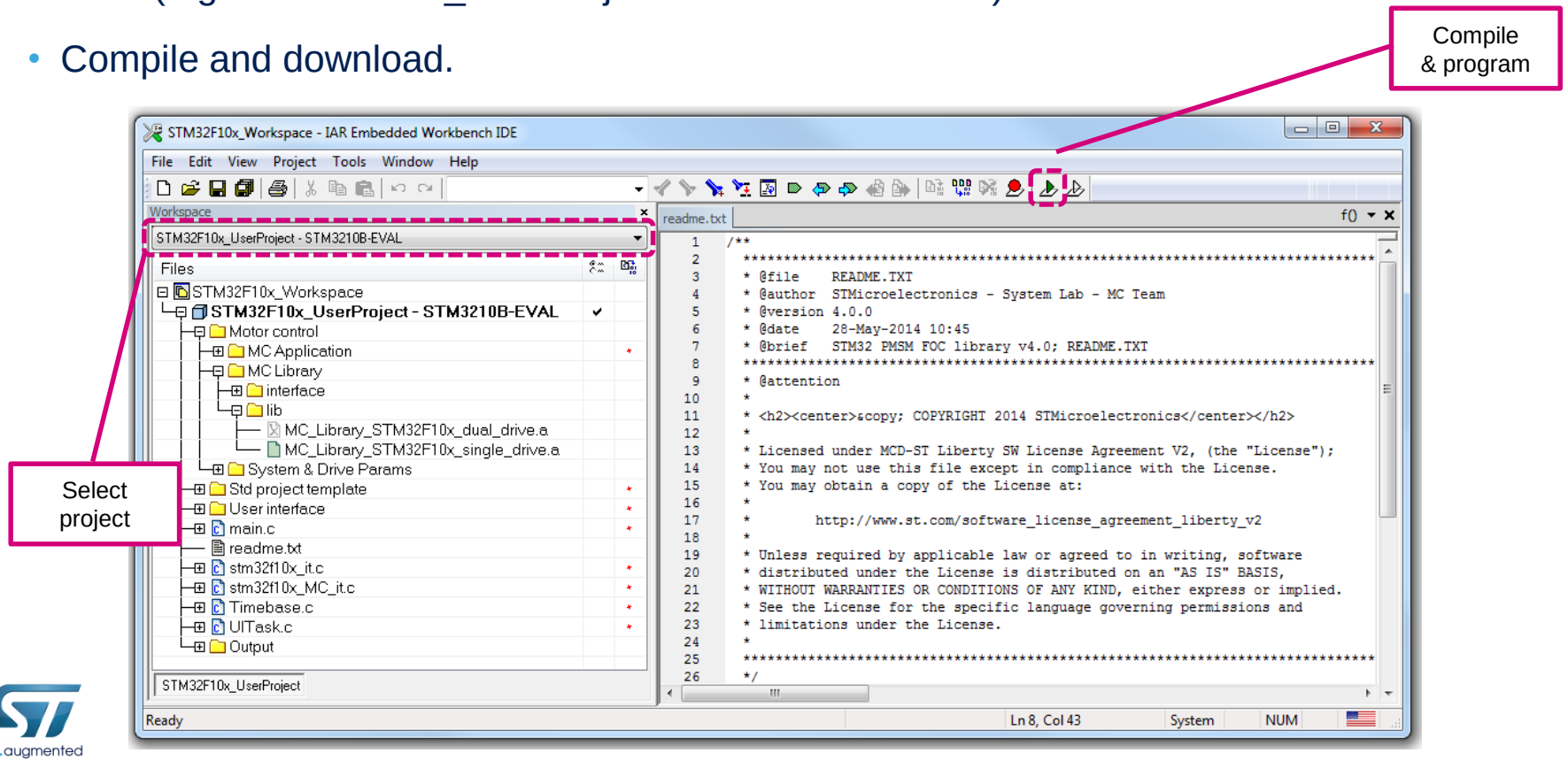


Step #11 – Compile and program the MCU

- Run the IAR Embedded Workbench.



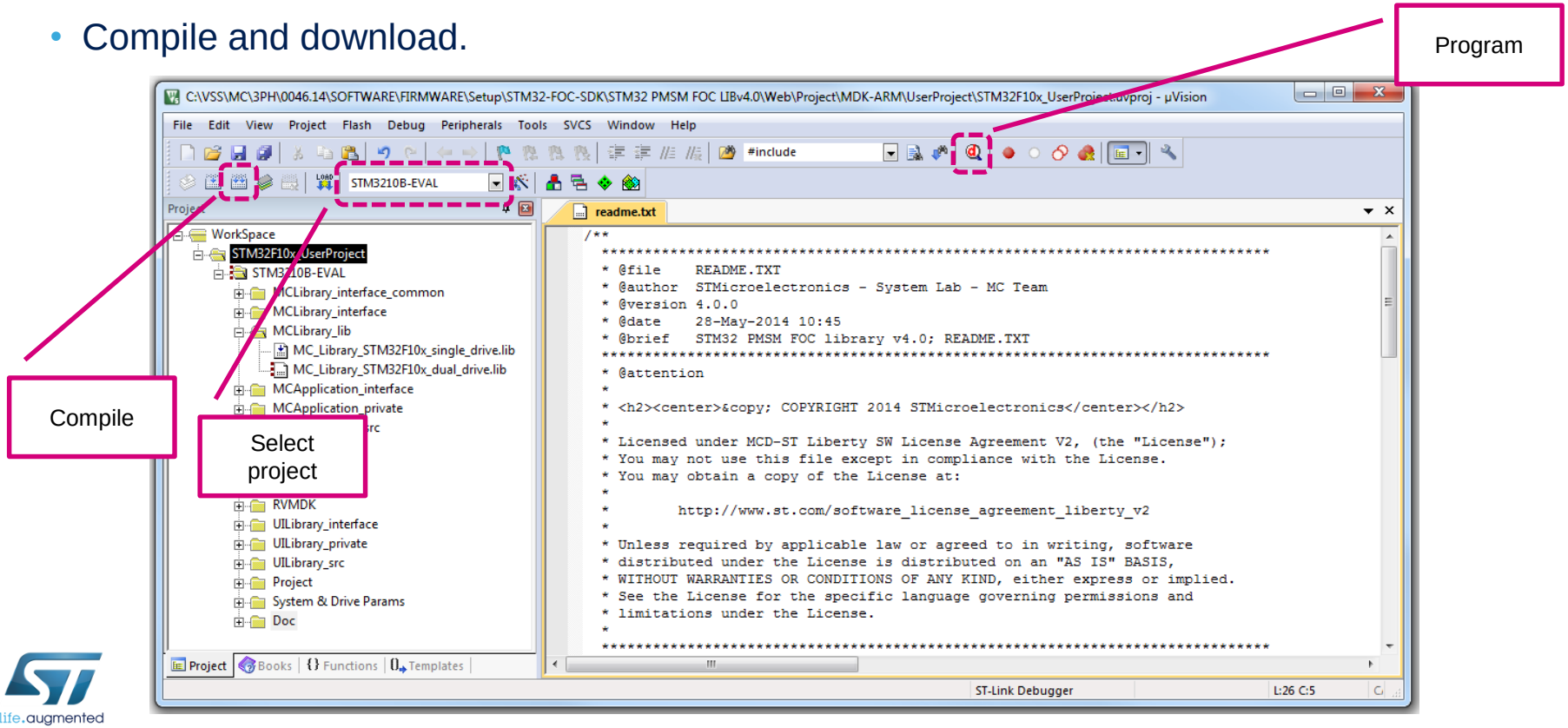
- Open the IAR workspace (located in Project\EWARM) folder according to the microcontroller family (e.g. STM32F10x_Workspace.eww for STM32F1).
- Select the correct user project from the drop-down menu according to the control stage used (e.g. STM32F10x_UserProject - STM3210B-EVAL).
- Compile and download.



Step #11 – Compile and program the MCU

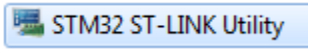
- Optionally, run Keil uVision.

- Open the Keil workspace (located in Project\MDK-ARM) folder according to the microcontroller family (e.g. STM32F10x_Workspace.uvmpw for STM32F1).
- Select the proper user project from the drop-down menu according to the control stage used (e.g. STM3210B-EVAL).
- Compile and download.

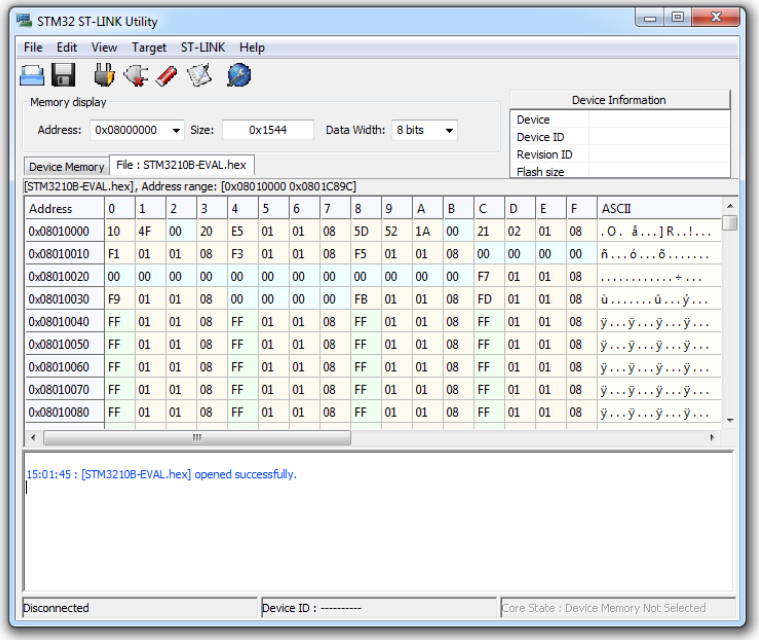


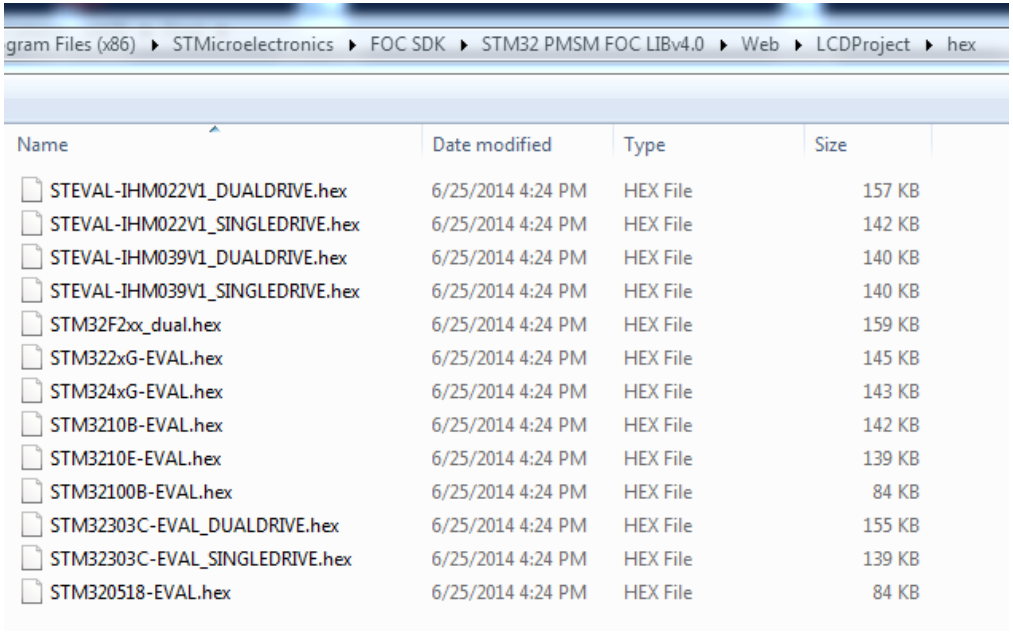
Step #12 – Program LCD firmware

- Run the ST-LINK Utility.



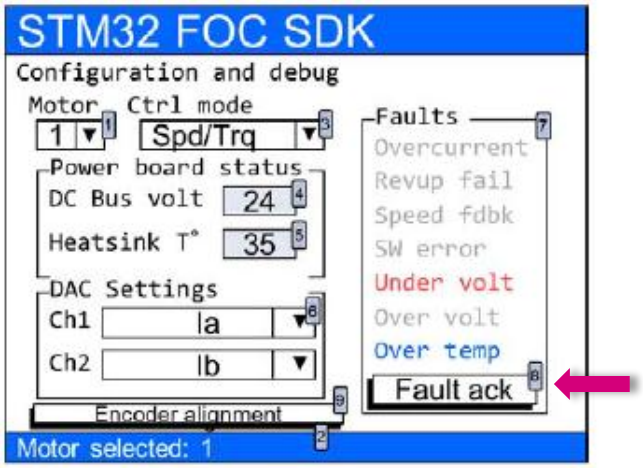
- File → Open file… and select the .hex file (located in LCDProject\hex) according to the control stage used (e.g. STM3210B-EVAL.hex).
- Target → Program…

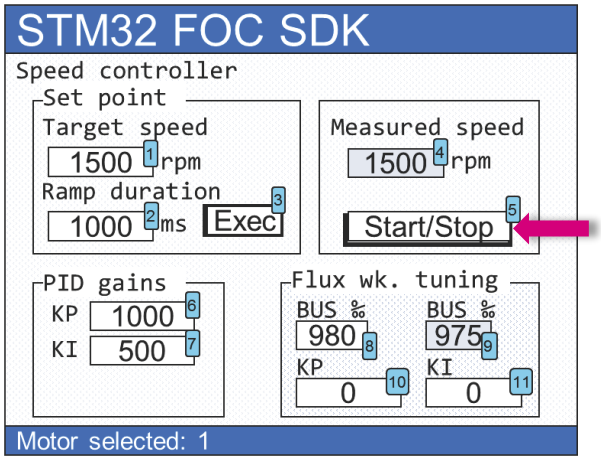




Step #13 – Run the motor

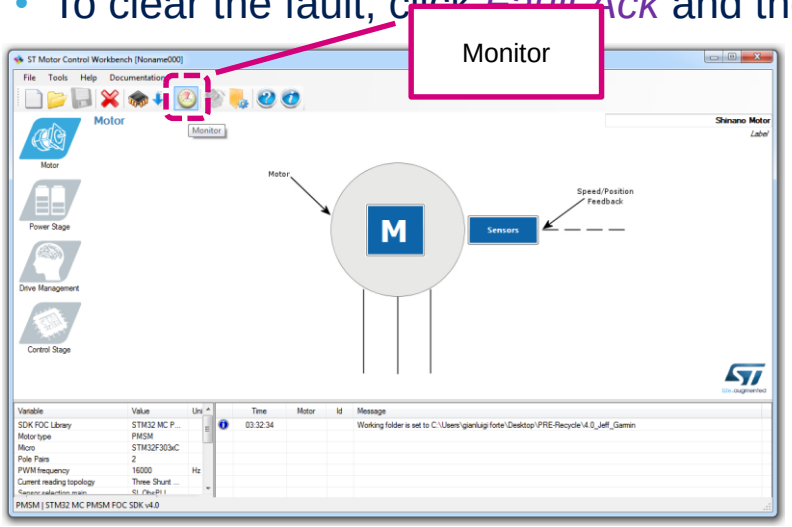
- Arrange the system for running the motor:
  - Connect the control board with the power board using the MC cable.
  - Connect the motor to the power board.
  - Connect the power supply to the power board and turn on the bus.
- If the board is equipped with the LCD:
  - Press joystick center on *Fault Ack* button to reset the faults.
  - Press joystick right until the *Speed controller* page is reached.
  - The press joystick down to reach the *Start/Stop* button.
  - Press the center of the joystick to run the motor.

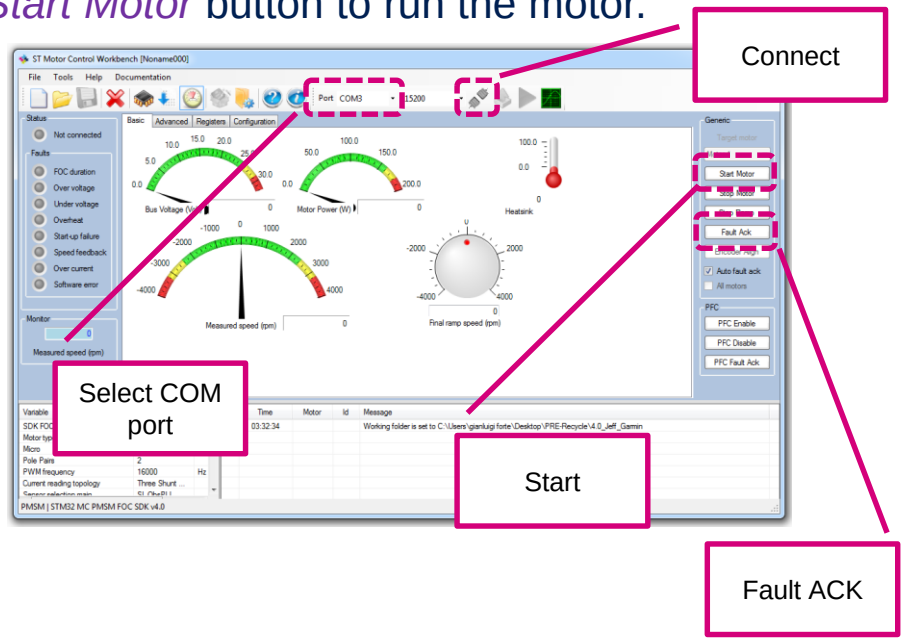




Step #13 – Run the motor

- Optionally you can start the motor using the ST MC Workbench.
- Connect the PC to the control board with the USB to RS-232 dongle (and a null modem cable).
- Open the Workbench project used to configure the firmware and click on *Monitor* button.
- Select the *COM port* and click *Connect* button. This establish the communication with the firmware.
- To clear the fault, click *Fault Ack* and then *Start Motor* button to run the motor.





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