STM32 PMSM SDK 5.2 training

T.O.M.A.S. team

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Hands-On section

Motor Control Kit – IHM001/002

Contents

- NUCLEO-F302R8
  - Control board based on the STM32F302
- X-NUCLEO-IHM07
  - Power board based on the L6230
- 3 Phase Motor
  - BR2804-1700kv
- AC/DC Converter
  - 3VDC - 12VDC @ 2.5A

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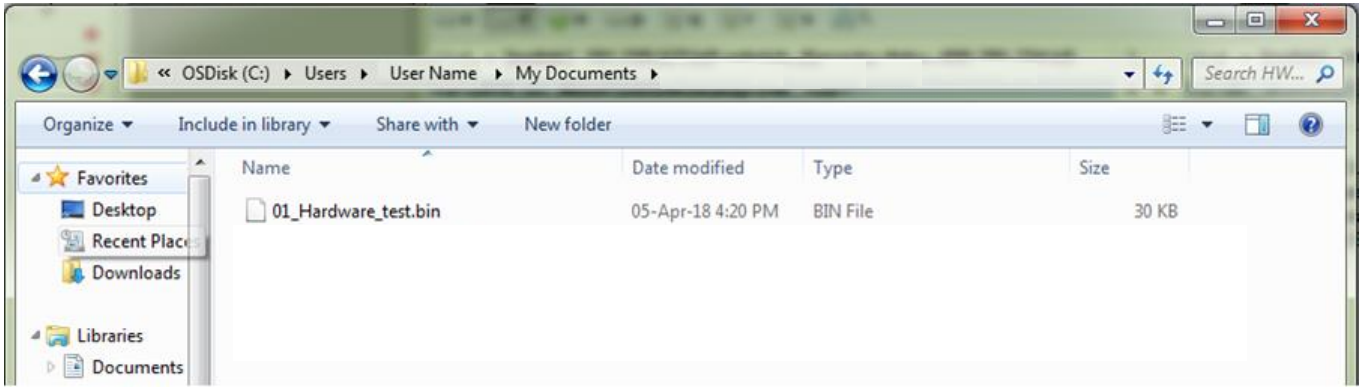
Where to find necessary files

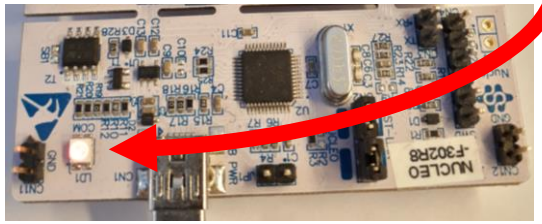
- Files location for 1st Hardware test
  - Binary file
    (distributed on USB stick)

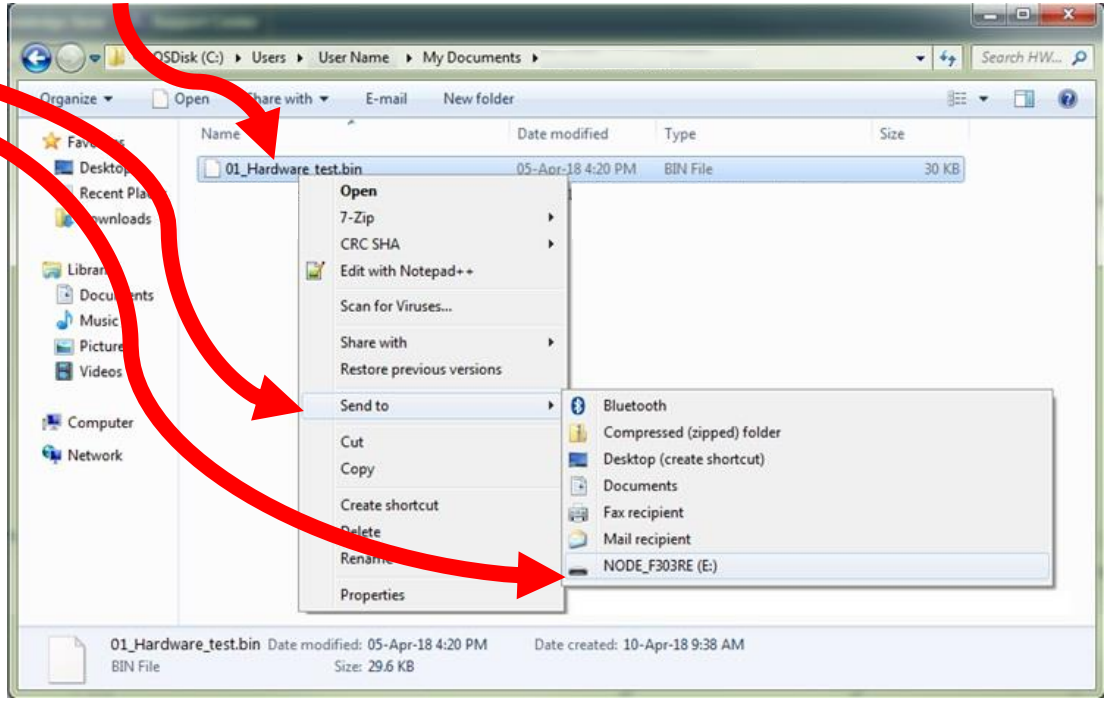


Hands-On section

ST Link virtual drive binary upload

- Upload testing Firmware to MCU by “Send to” feature
  - **Right click** on *01_Hardware_test.bin*
  - Select **Send to**
  - Select **NODE_F302R8**
  - ST Link – LED indication





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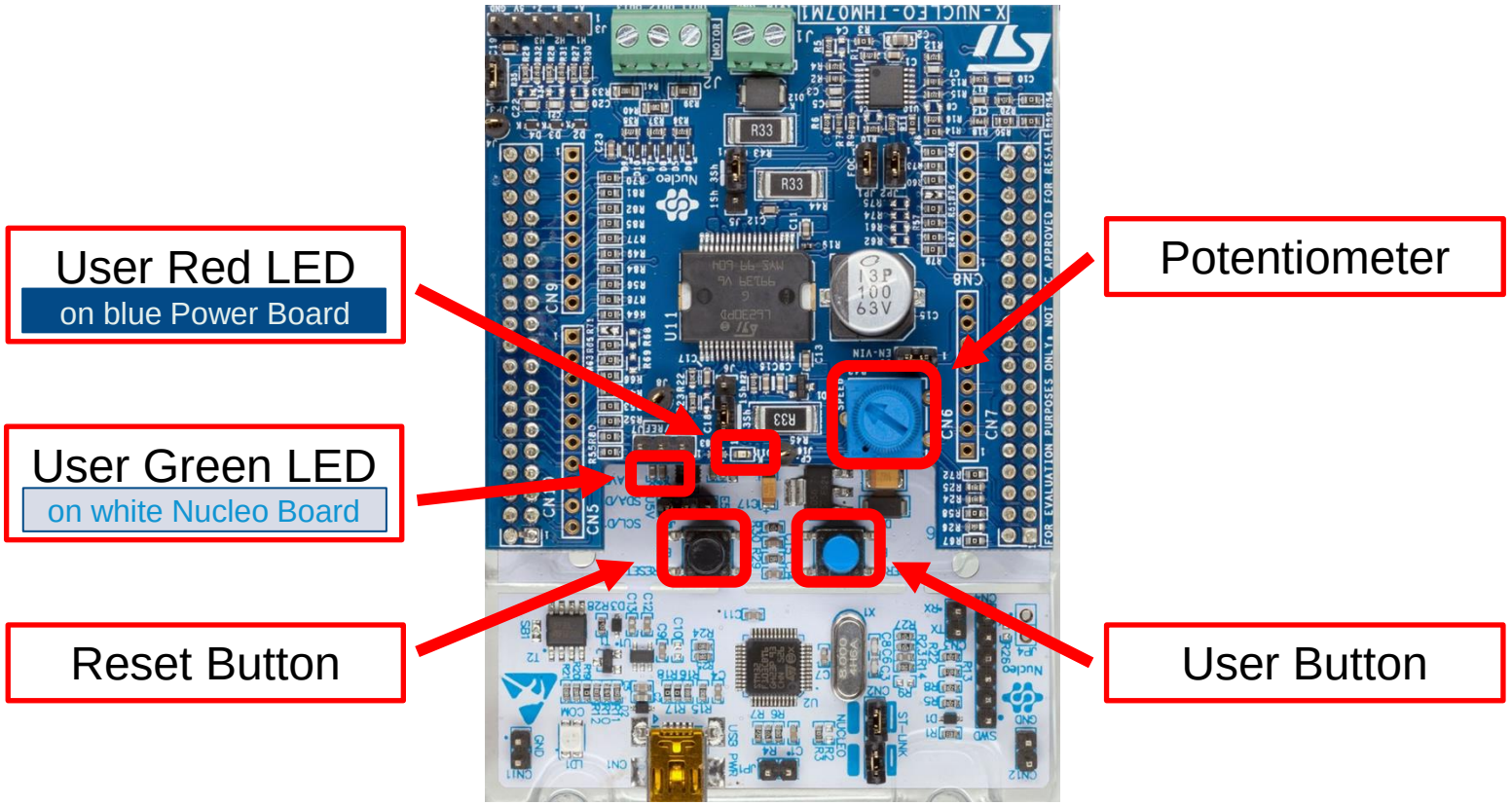
Hands-On section

Testing MC firmware – description



Testing MC firmware – description

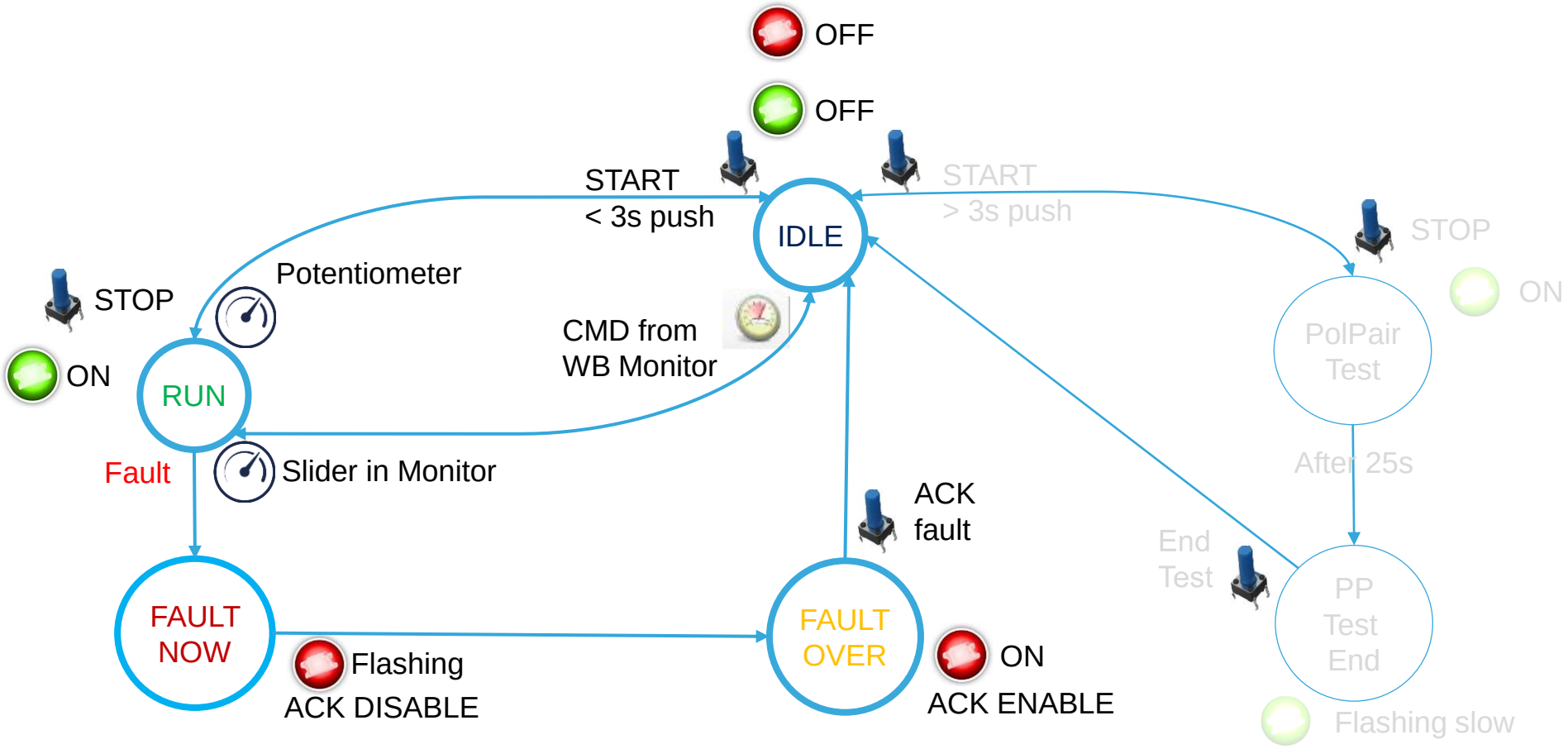
- User button function
  - Start
  - Stop
  - Acknowledge a fault

- Green LED diode indication
  - OFF - IDLE
  - ON – RUN

- Red LED diode indication
  - Flashing – FAULT NOW
  - ON - FAULT OVER

- Potentiometer
  - Regulation of the speed

Testing MC firmware – description



STM32 PMSM FOC SDK 5.x

Hands-on and Hardware tools

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Objectives

The purpose of this document is to:

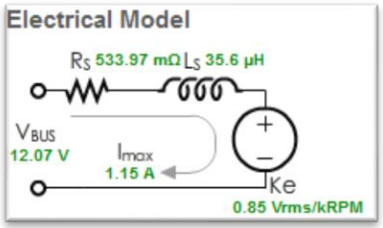
- Help developers get started with the STM32 PMSM FOC SDK using the ST MC Workbench with the final purpose of running a Permanent Magnet Synchronous Motor (PMSM) with ST Evaluation boards.
- Show where to find technical documentation, firmware libraries and other related materials.
- How to obtain additional technical support

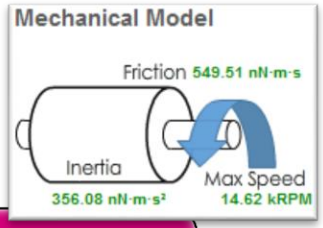
Systems check

- What is needed:
  - Windows laptop (Win 7)
  - ST-LINK dongle (optional)
  - USB to RS-232 dongle and a null modem cable (optional)
  - A permanent magnet motor
  - Multimeter (optional)
  - An oscilloscope with current probe (optional)
  - An insulated DC and or AC power supply

Motor control – SDK workflow

Motor control – SDK – Workflow





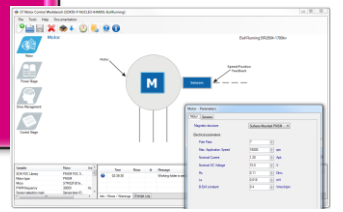
Hardware Setup

Motor Characterization

Motor Profiler
Motion Control Suite

System Configuration

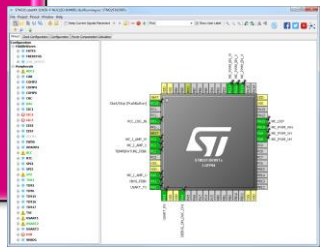
Motor Control Workbench



Project Configuration

CubeMX & IDE

STM32 CubeMX



Motor Drive Tuning

Tune MC part

Final Application Development

User code

```
#include "MC.h"
{
    CMCI oMCI = GetMCI(M1);
    MCI_ExecSpeedRamp(oMCI, final speed, ramp
duration);
    MCI_StartMotor(oMCI);
}
```

KEIL Tools by ARM

AC6 Assistance Conseil Systèmes

TrueSTUDIO for STM32

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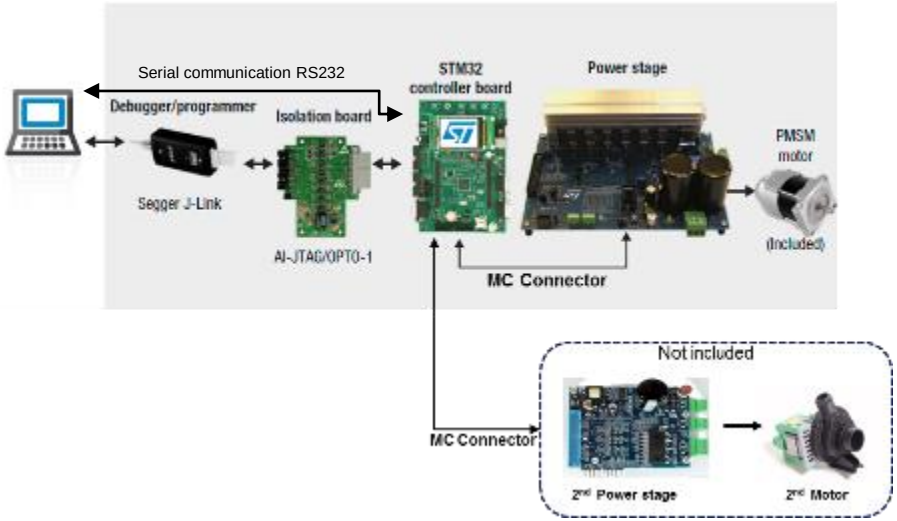
Motor control – SDK – Workflow 1/4

- First step → ***Set up the hardware.*** Depending on the targeted application, it is possible to choose the most suitable hardware configuration from among the different “ready-to-start” ST evaluation boards presented in *Steps 1 to 5*.

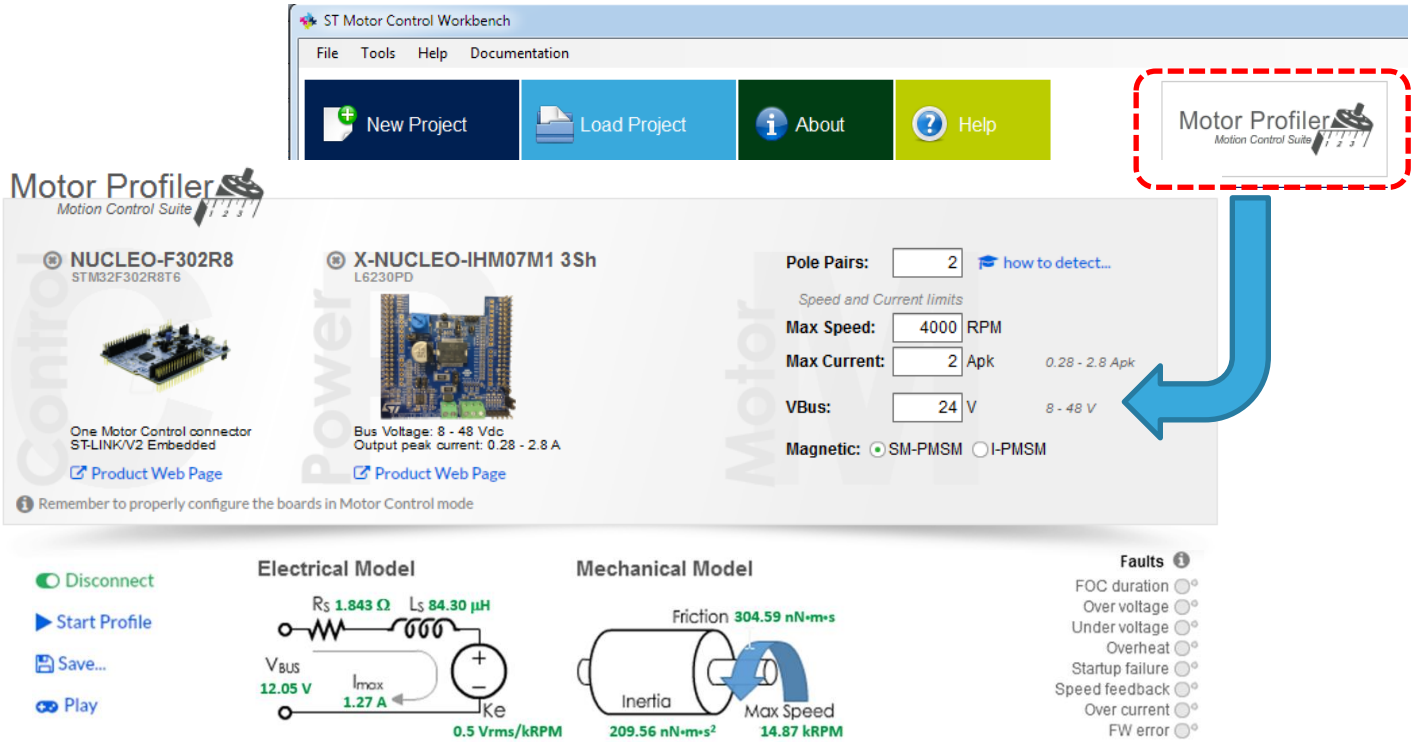
- Set up the selected board according the specification stated in each of the related user manuals.

- Connect the board (if required) to the power supply and your motor.



Motor control – SDK – Workflow 2/4

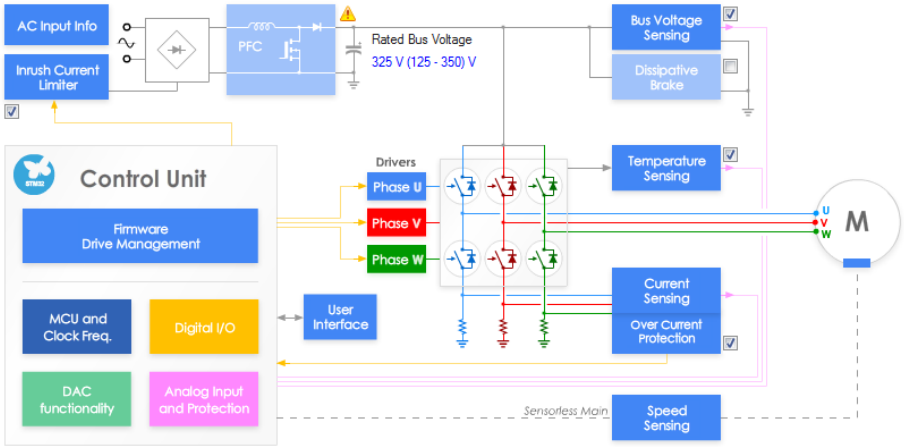
- When the hardware is ready, if the user does not know the motor parameters, he can identify the motor.
- How? Using the ***Motor Profiler***!!
  - Follow the instruction in Step 6.
- If want to measure the Motor parameter in the lab Step 8



Motor control – SDK – Workflow 3/4

- When using the Motor Profiler, the motor is running but the user can develop his own code!
- **Finalize the MC project** using Workbench according to the instructions in Step 7.
- Use your favorite IDE to develop your code.

MC Workbench



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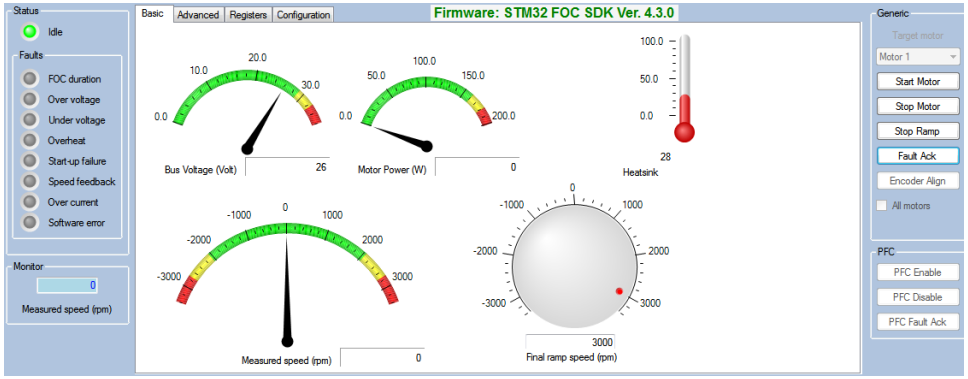
Motor control – SDK – Workflow 4/4

- Finally, the user can **send commands** (e.g. start, stop, execRamp, …) via serial communication.

- Use the Workbench as explained in Step 13.



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 which include the MC connector.
- The following slides cover the boards in the *ST Evaluation Tools Portfolio* 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 HW boards

Various offer

Control + Power

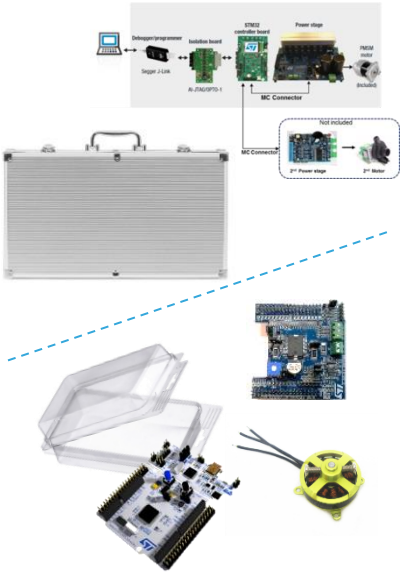
Eval/Nucleo + Power/Expension

Control stages

Power stages

Inverter (Complete Drive)

MC Kits



SDK5.x Reference Boards

SDK5.x Control Boards (1)

Family	MCU	Board	SDK4.3	SDK5.x	Description
F0	F030R8	NUCLEO-F030R8	SDK4.3	SDK5.0	F0 Nucleo Board
F0	F072RB	NUCLEO-F072RB	SDK4.3	SDK5.0	F0 Nucleo Board
F0	F072VB	STM32072B-EVAL	SDK4.3	SDK5.0	F0 Evaluation Board
F1	F103RB	NUCLEOF103RB	-	SDK5.1.2	F1 Nucleo Board (MD)
F1		STM3210E_EVAL	SDK4.3	SDK5.1	F1 Evaluation Board
F3	F302R8	NUCLEO-F302R8	SDK4.3	SDK5.0	F3 Nucleo Board
F3	F303RE	NUCLEO-F303RE	SDK4.3	SDK5.0	F3 Nucleo Board
F3	F303VE	STM32303E-EVAL	SDK4.3	SDK5.0	F3 Evaluation Board

SDK5.x Control Boards (2)

Family	MCU	Board	SDK4.3	SDK5.x	Description
F4	F446RE	NUCLEO-F446RE	SDK4.3	SDK5.0	F4 Nucleo Board
F4	F407IG	STM3240G-EVAL	SDK4.3	SDK5.0	F4 Evaluation Board
F4	F417IG	STM3241G-EVAL	SDK4.3	SDK5.0	F4 Evaluation Board
F4	F446ZET	STM32446E-EVAL	SDK4.3	SDK5.0	F4 Evaluation Board
F4	F415ZGT8	STEVAL-IHM039V1	SDK4.3	SDK5.0	F4 Evaluation Board
F4	F401RE	STM32F401RE	-	SDK5.2	F4 Nucleo Board
F7	F746ZG	NUCLEO-F746ZG	-	SDK5.2	F7 Nucleo Board
F7	F769I	STM32F769I-EVAL	-	SDK5.2	F7 Evaluation Board
L4	L452RE	NUCLEO-L452RE	-	SDK5.2	L4 Nucleo Board
L4	L476G	STM32L476G-EVAL	-	SDK5.2	L4 Evaluation Board

SDK5.x Inverters

Family	MCU	Board	SDK4.3	SDK5.x	Description
F0	F031	STEVAL_SPIN3201	SDK4.3	SDK5.1	STSPIN32F0 3-shunt
F0	F031	STEVAL_SPIN3202	-	SDK5.1	STSPIN32F0A 1-shunt
F1	F103RC	STEVAL_IHM034V2	SDK4.3	SDK5.1	Used for PFC
F3	F303RE	X-Nucleo_IHM16 + Nucleo-F303RE	-	SDK5.1	Bundle used for EMEA workshop
F3	F303	STEVAL-ESC001V1	-	SDK5.1.2	F3 ESC board

SDK5.x Power Boards (1)

Board	SDK4.3	SDK5.x	Description
STEVAL-IHM023V3	SDK4.3	SDK5.0	1 kW 3-phase motor control evaluation board featuring L6390 drivers and STGP10H60DF IGBT
STEVAL-IHM025V1	SDK4.3	SDK5.0	Obsolete – but still part of the list in SDK5.0
STEVAL-IHM028V2	SDK4.3	SDK5.0	2 kW 3-phase motor control evaluation board featuring the STGIPS20C60 IGBT intelligent power module
STEVAL-IHM045V1	SDK4.3	SDK5.0	3-phase high voltage inverter power board for FOC based on the STGIPN3H60A (SLLIMM-nano)
X-NUCLEO-IHM07M1	SDK4.3	SDK5.0	Three-phase brushless DC motor driver expansion board based on L6230 for STM32 Nucleo
X-NUCLEO-IHM08M1	SDK4.3	SDK5.0	Low-Voltage BLDC motor driver expansion board based on STL220N6F7 for STM32 Nucleo
X-NUCLEO-IHM11M1	SDK4.3	SDK5.0	Low voltage three-phase brushless DC motor driver expansion board based on STSPIN230 for STM32 Nucleo
STEVAL-IPM10F	SDK4.3	SDK5.0	Motor control power board based on the SLLIMM™ 2nd series of IGBT IPMs
STEVAL-IPM15B	SDK4.3	SDK5.0	Motor control power board based on the SLLIMM™ 2nd series of IGBT IPMs

SDK5.x Power Boards (2)

Board	SDK4.3	SDK5.x	Description
STEVAL-IPM05F	SDK4.3	SDK5.0	Motor control power board based on the SLLIMM™ 2nd series of IGBT IPMs
STEVAL-IPM07F	SDK4.3	SDK5.0	Motor control power board based on the SLLIMM™ 2nd series of IGBT IPMs
STEVAL-IPM10B	SDK4.3	SDK5.0	Motor control power board based on the SLLIMM™ 2nd series of IGBT IPMs
STEVAL-IPM08B	-	SDK5.1	in one shunt and three shunt topology-
STEVAL-IPM10F	SDK4.3	SDK5.0	Motor control power board based on the SLLIMM™ 2nd series of IGBT IPMs
STEVAL-IPM15B	SDK4.3	SDK5.0	Motor control power board based on the SLLIMM™ 2nd series of IGBT IPMs
STEVAL-IPMNG3Q	-	SDK5.1	in one shunt and three shunt topology-
STEVAL-IPMNG5Q	-	SDK5.1	in one shunt and three shunt topology-
STEVAL-IPMNG8Q	-	SDK5.1	in one shunt and three shunt topology-
STEVAL-IPMNM1N	-	SDK5.1	in one shunt and three shunt topology-
STEVAL-IPMNM2N	-	SDK5.1	in one shunt and three shunt topology-

Software setup

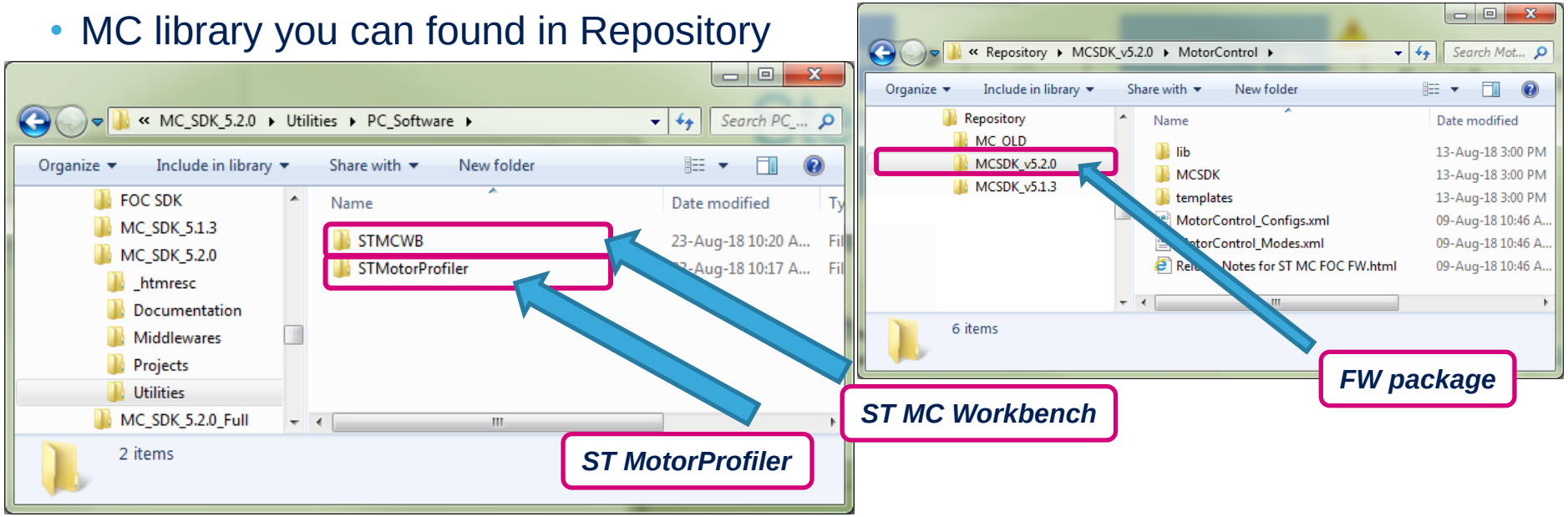
Step #2 – Software setup

Download and install the X-CUBE-MCSDK from www.st.com.

It contains the firmware package, the ST MC Workbench (GUI) and Motor profiler.

- ST MC WB and MotorProfiler you can found in installed folder
  (c:\Program Files (x86)\STMicroelectronics\MC_SDK_5.x.x\)

- MC library you can found in Repository



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Step #3 – IDE setup

- An IDE (Integrated development environment) is required to compile, flash and debug the application.

- Several IDEs are supported:
  - *IAR* Embedded Workbench for ARM - *IAR* Systems (http://www.iar.com/)
  - *Keil* Embedded Development Tools for ARM, Cortex-M **...** (**http://www.keil.com/**)
  - TrueSTUDIO : free IDE for STM32 on Windows (https://atollic.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

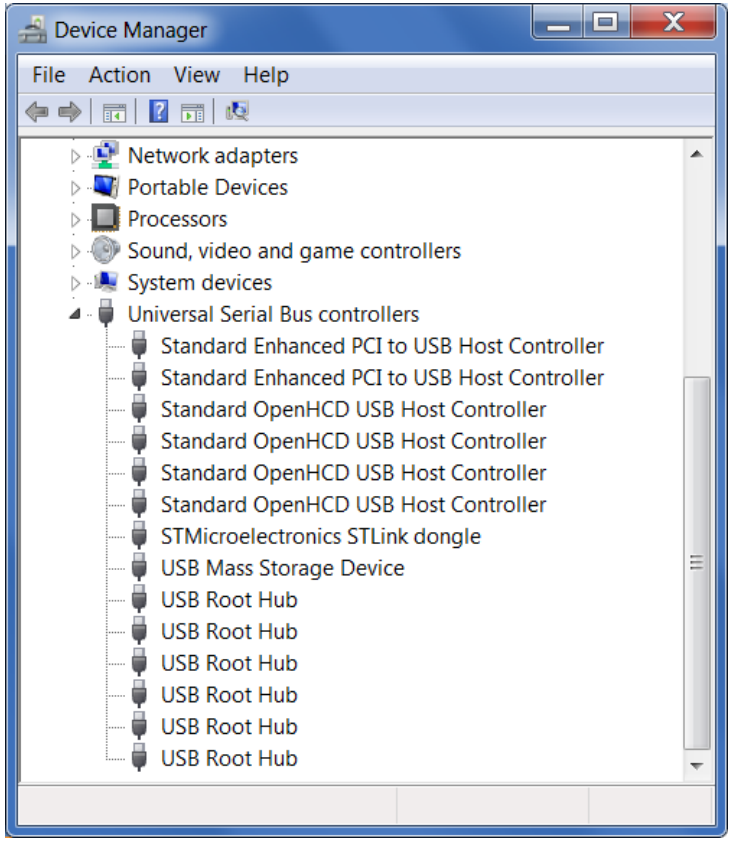
Related Tools and Software	
Part Number	Description
STSW-LINK003	ST-LINK/V2 USB driver for Windows 7, Vista and XP
STSW-LINK004	STM32 ST-LINK utility
STSW-LINK005	ST-LINK/V2 firmware upgrade
STSW-LINK006	ST-LINK/V2 USB driver for Windows 8

Step #5 – Connect ST-LINK (1/6)

- 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.

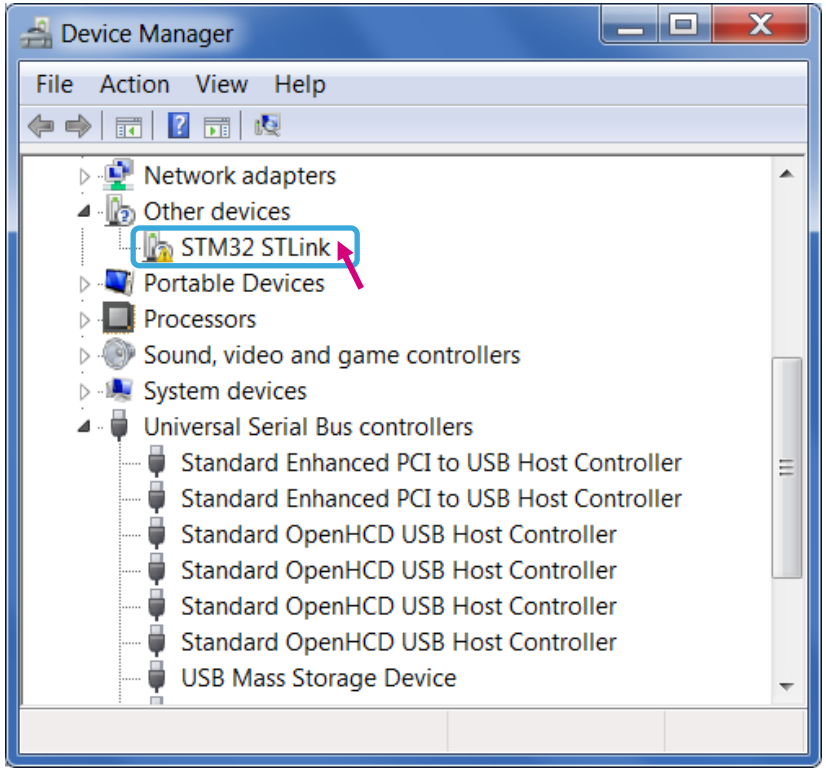
- Wait for Windows to recognize the ST-Link device and follow any steps required to install the driver.

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



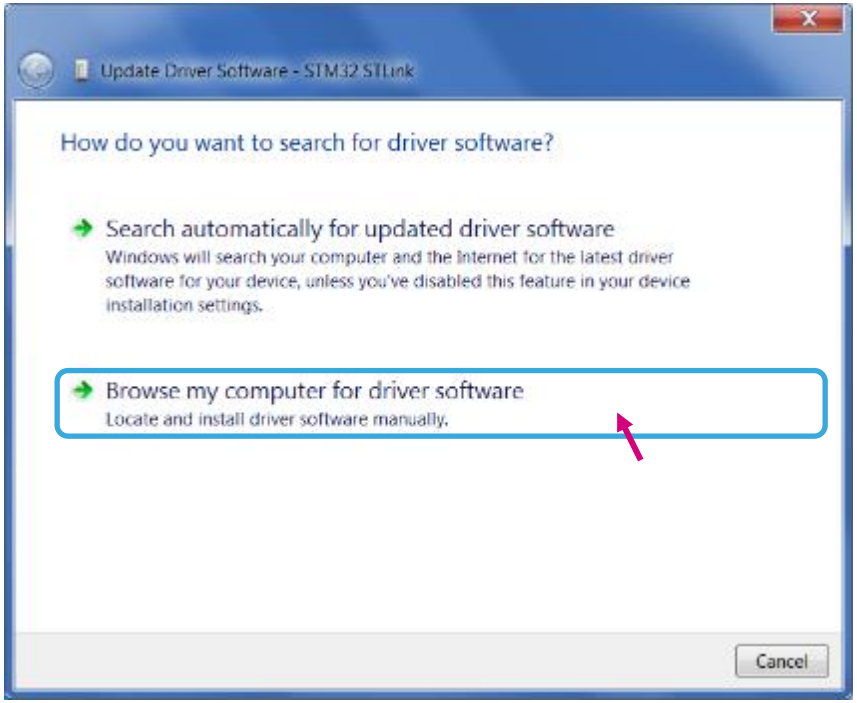
Step #5 – Driver trouble-shooting (2/6)

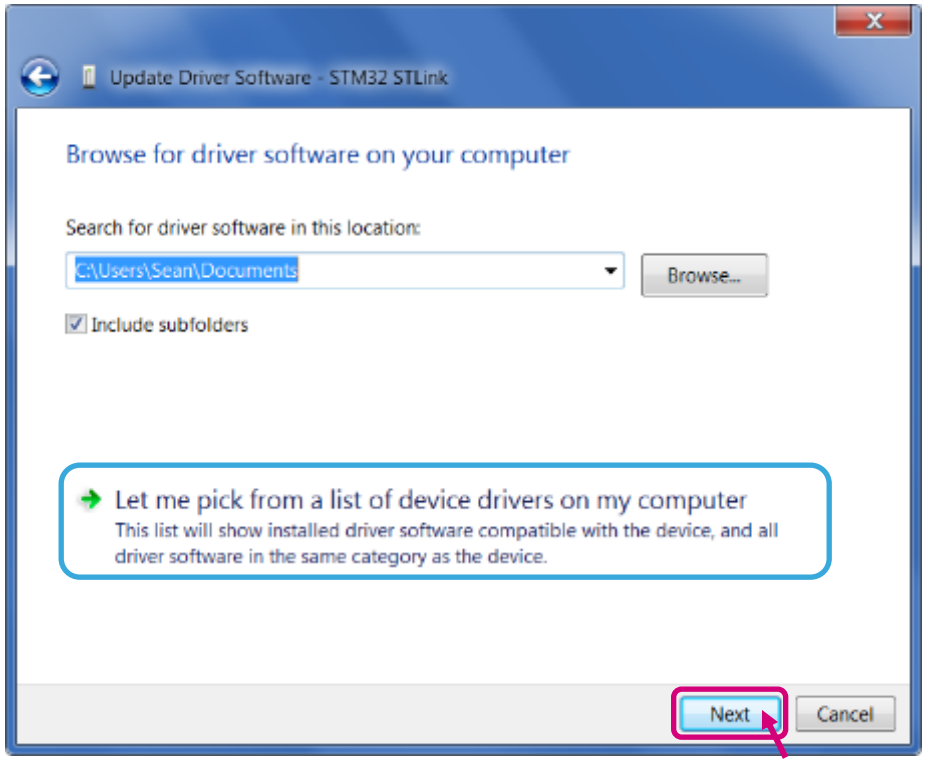
1. Open Device Manager.
2. Right-click on the “**STM32 STLink**” Driver icon.
3. Select “**Update Driver Software**”.



Step #5 – Driver trouble-shooting (3/6)

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





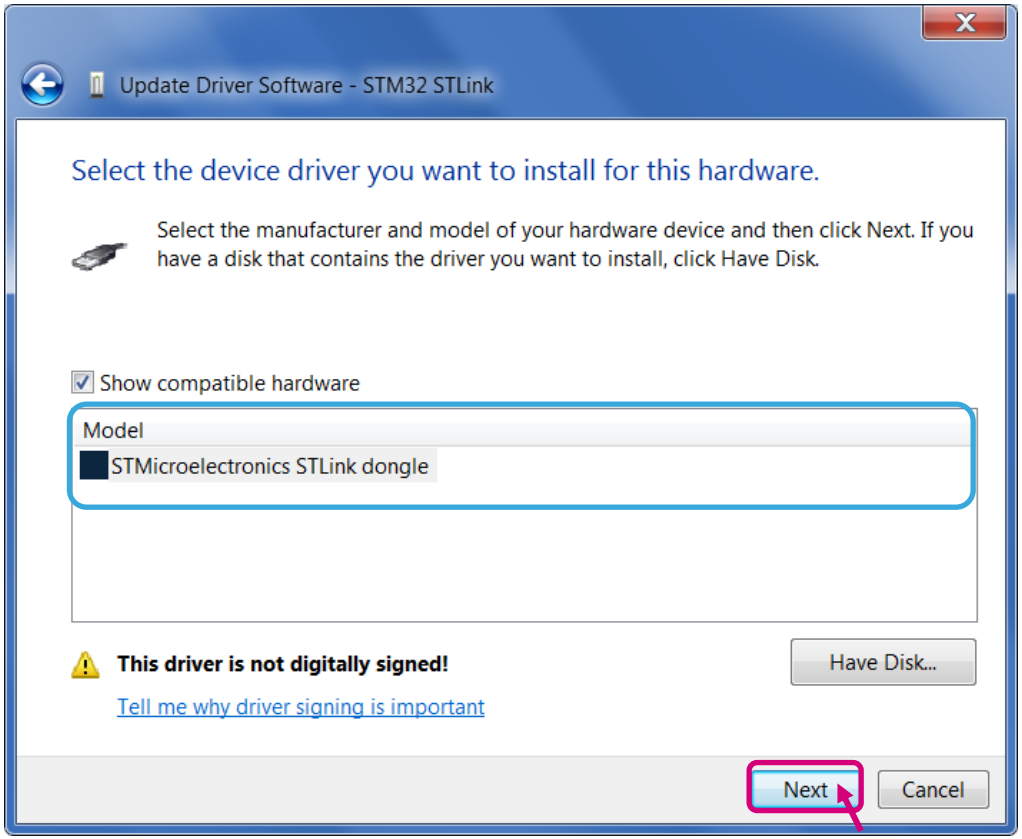
5. Select “Let me pick from a list of device drivers of my computer”.

6. Click “Next”.

Step #5 – Driver trouble-shooting (4/6)

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

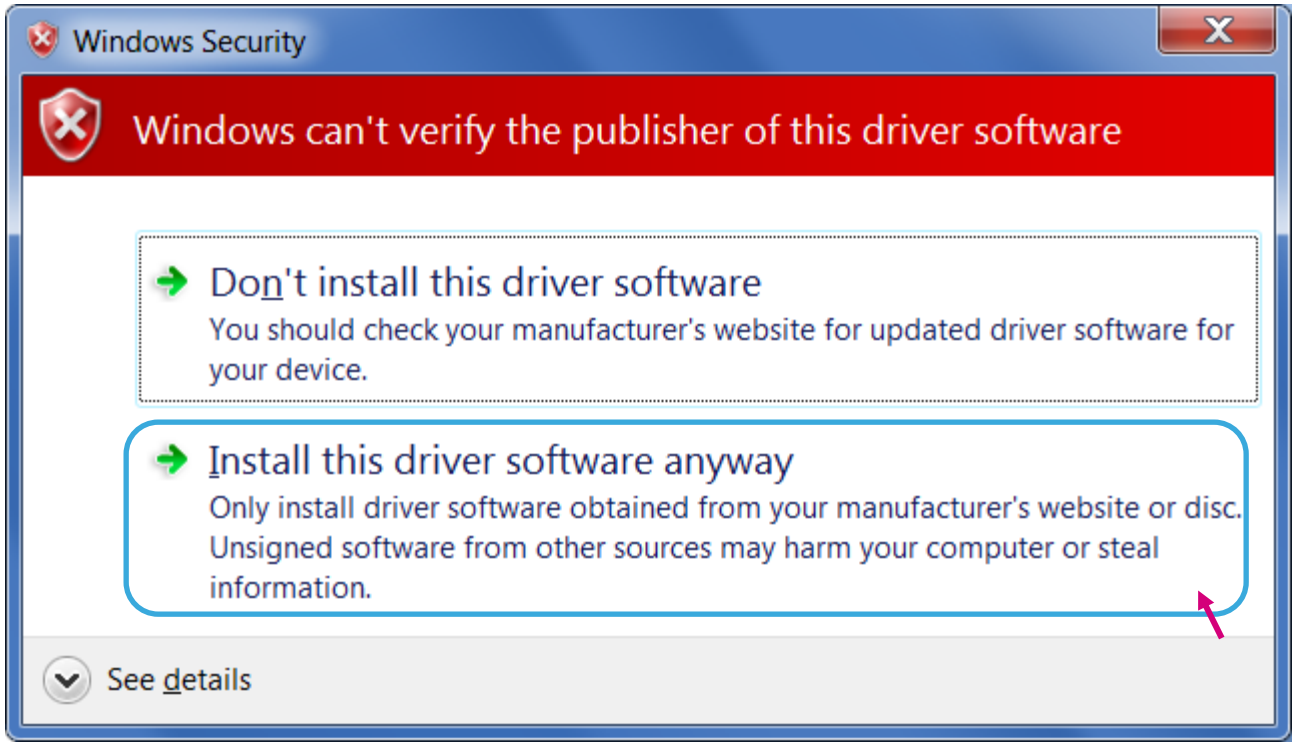
7. Click “Next”.



Step #5 – Driver trouble-shooting (5/6)

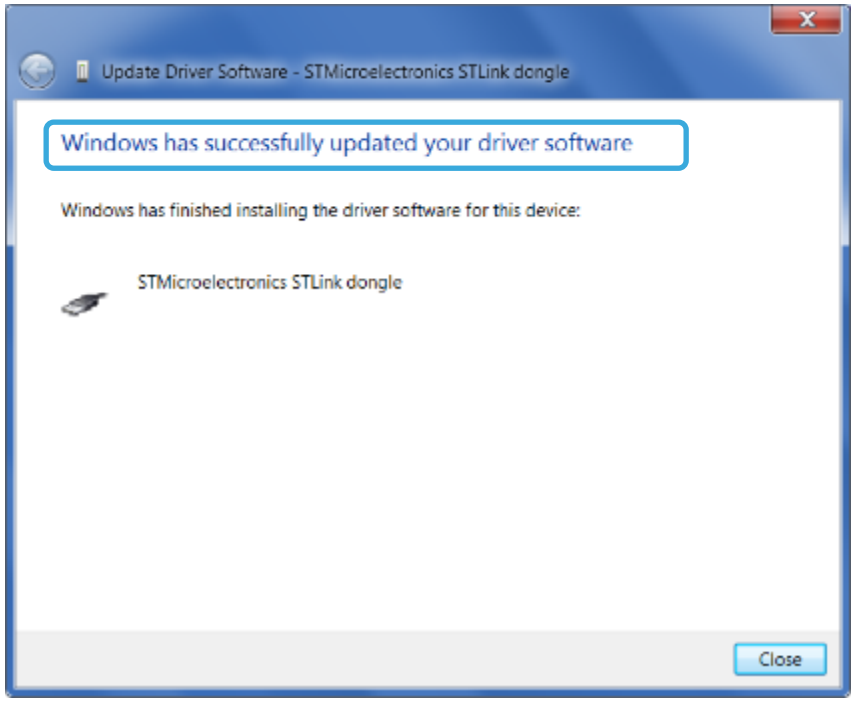
- A warning message may appear.

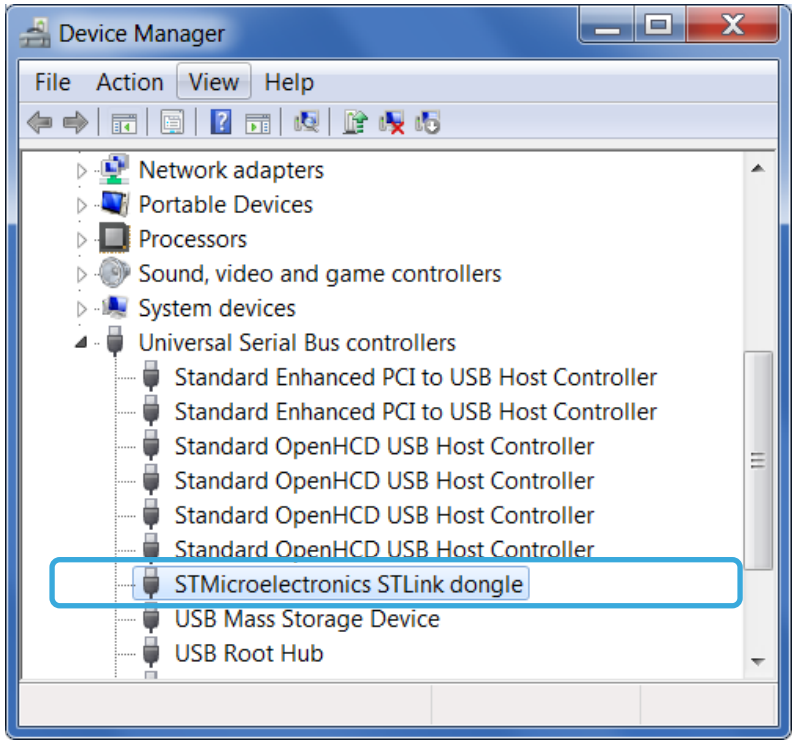
8. Select “**Install this driver software anyway**”.



Step #5 – Driver trouble-shooting (6/6)

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





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

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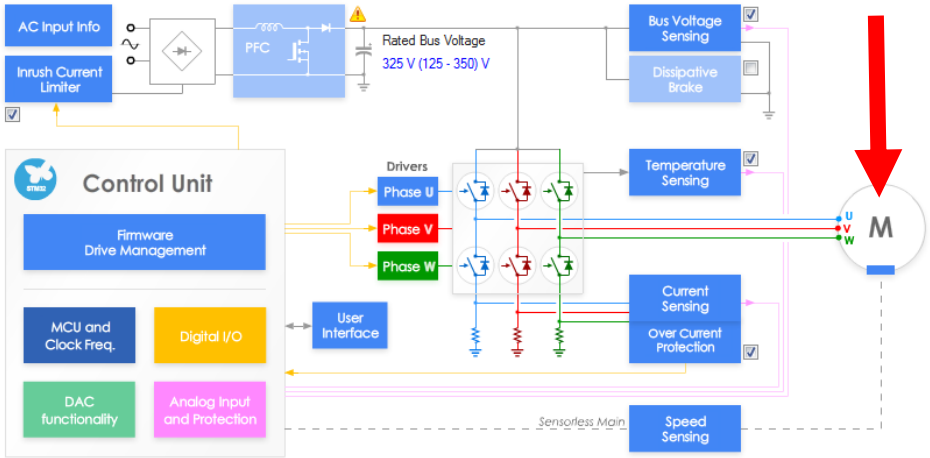
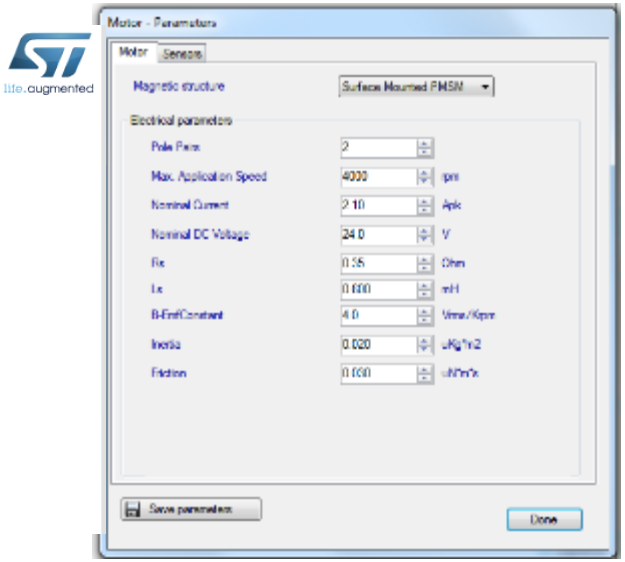
Step #6 – Set up motor parameters

- ST MC Workbench – Motor section contains:
  - 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 individually.





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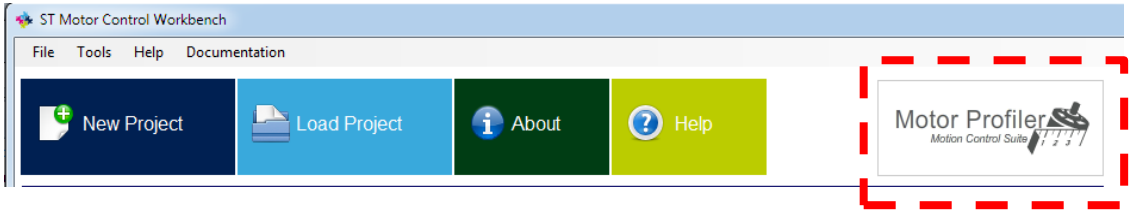
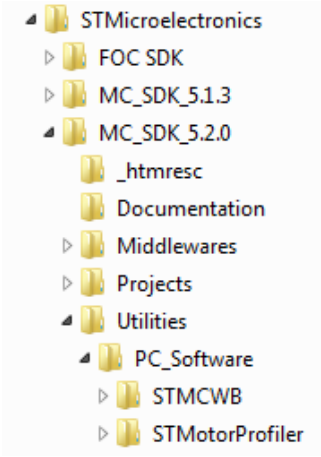
Step #6 – Set up motor parameters

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

- Two ways to open the Motor Profiler:
  - From the Home page of the ST Motor Control Workbench

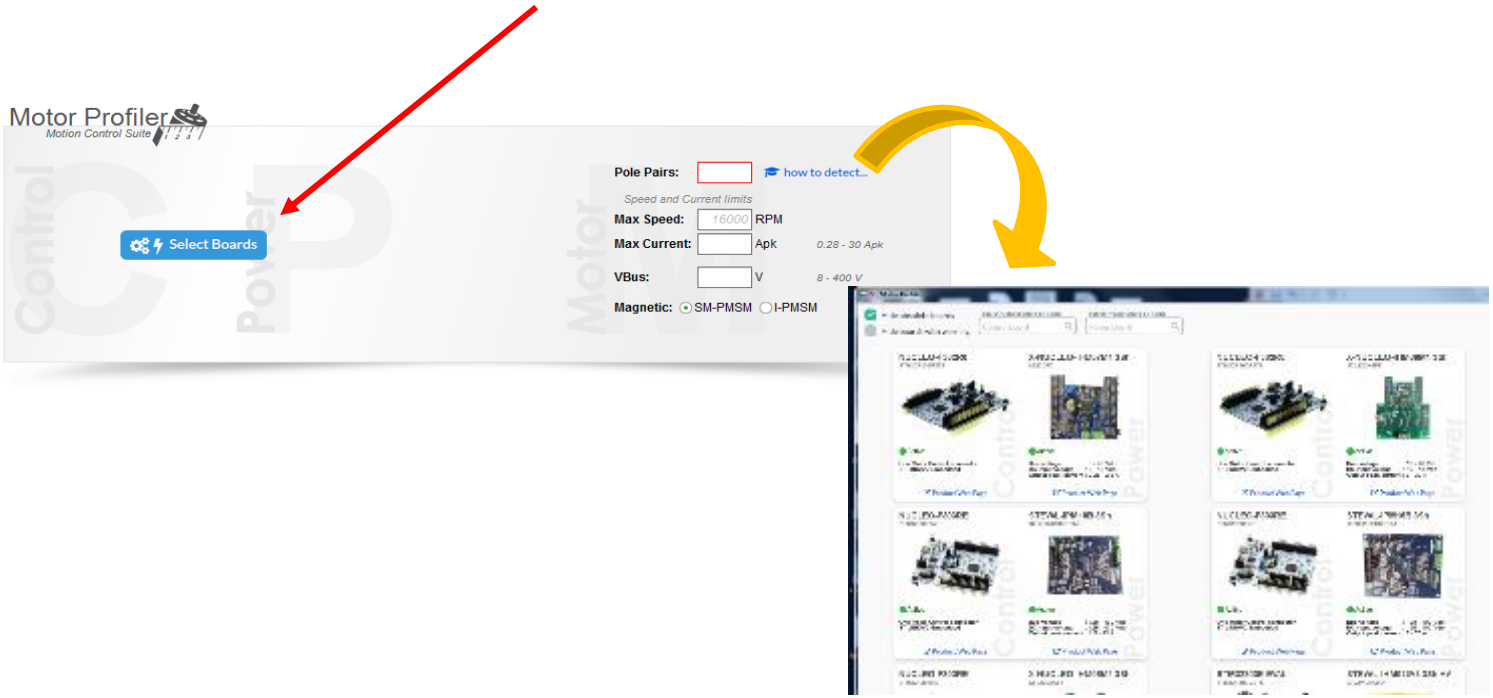


  - From the "STMotorProfiler" installation folder



Step #6 – Set up the Motor Profiler

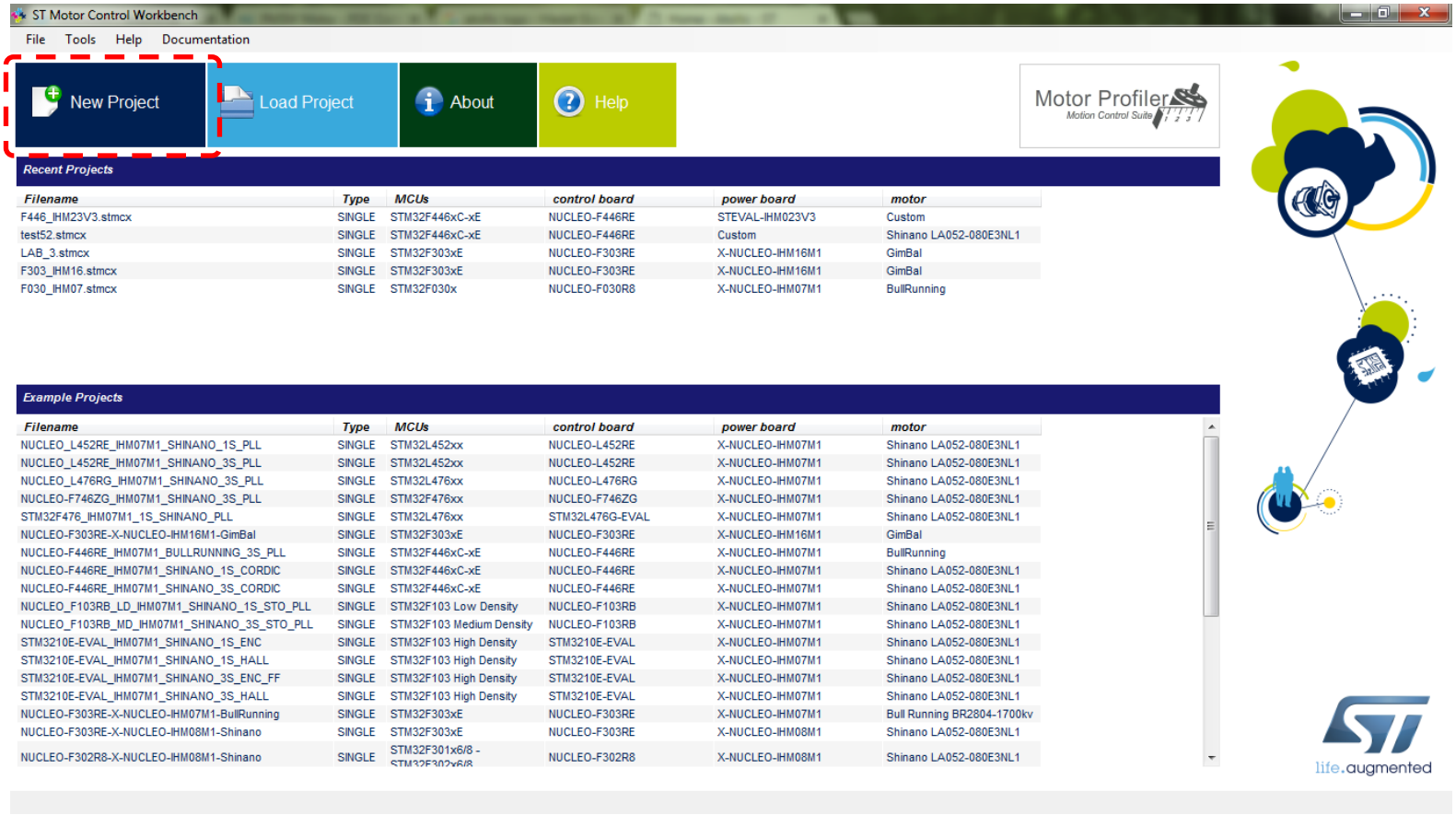
- Click “Select Boards” to display a list of supported boards. The Motor Profiler feature can be used only in the systems listed.



Set up workbench project

Step #7 – Create a new Workbench project based on the ST evaluation board

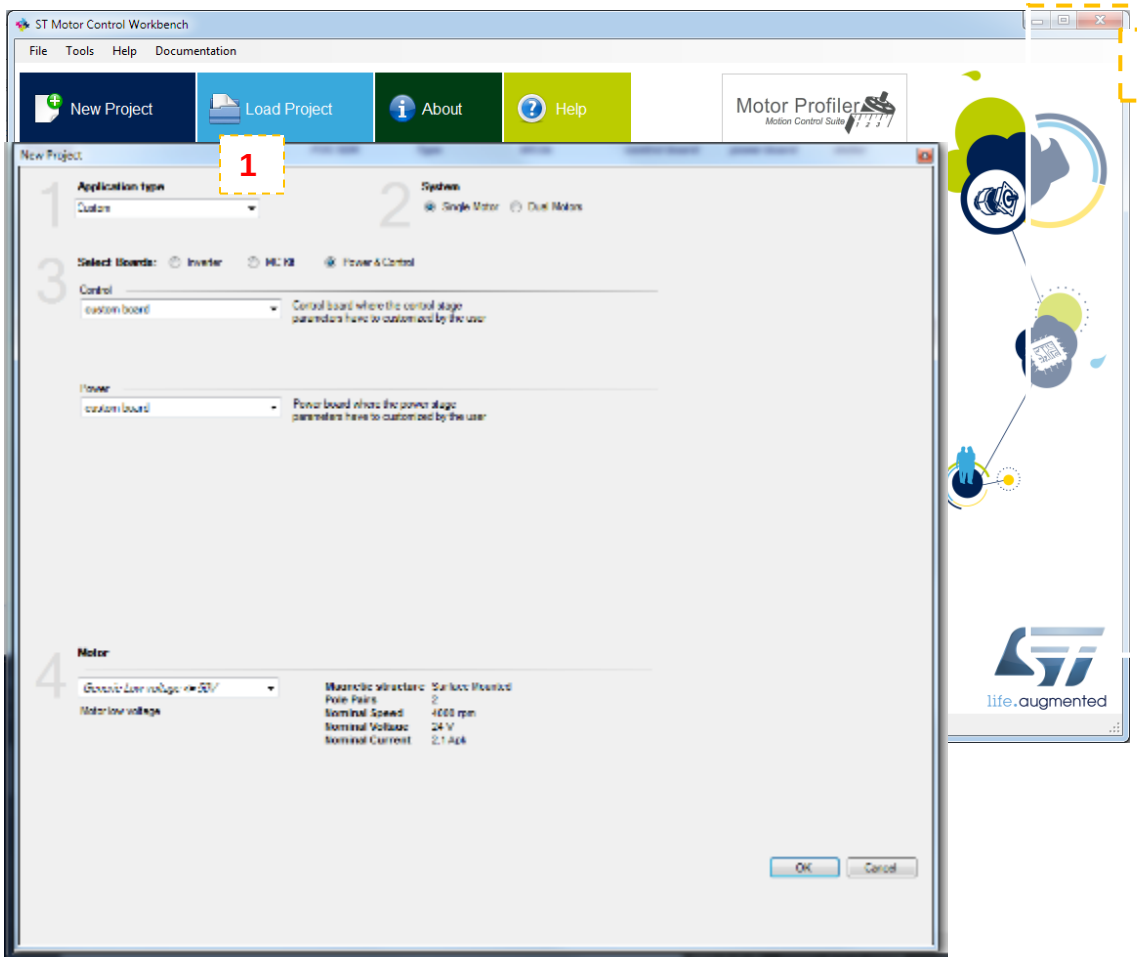
Choose: New Project

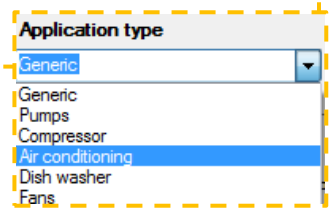


Step #7 – Create a new Workbench project based on the ST evaluation board

Choose:

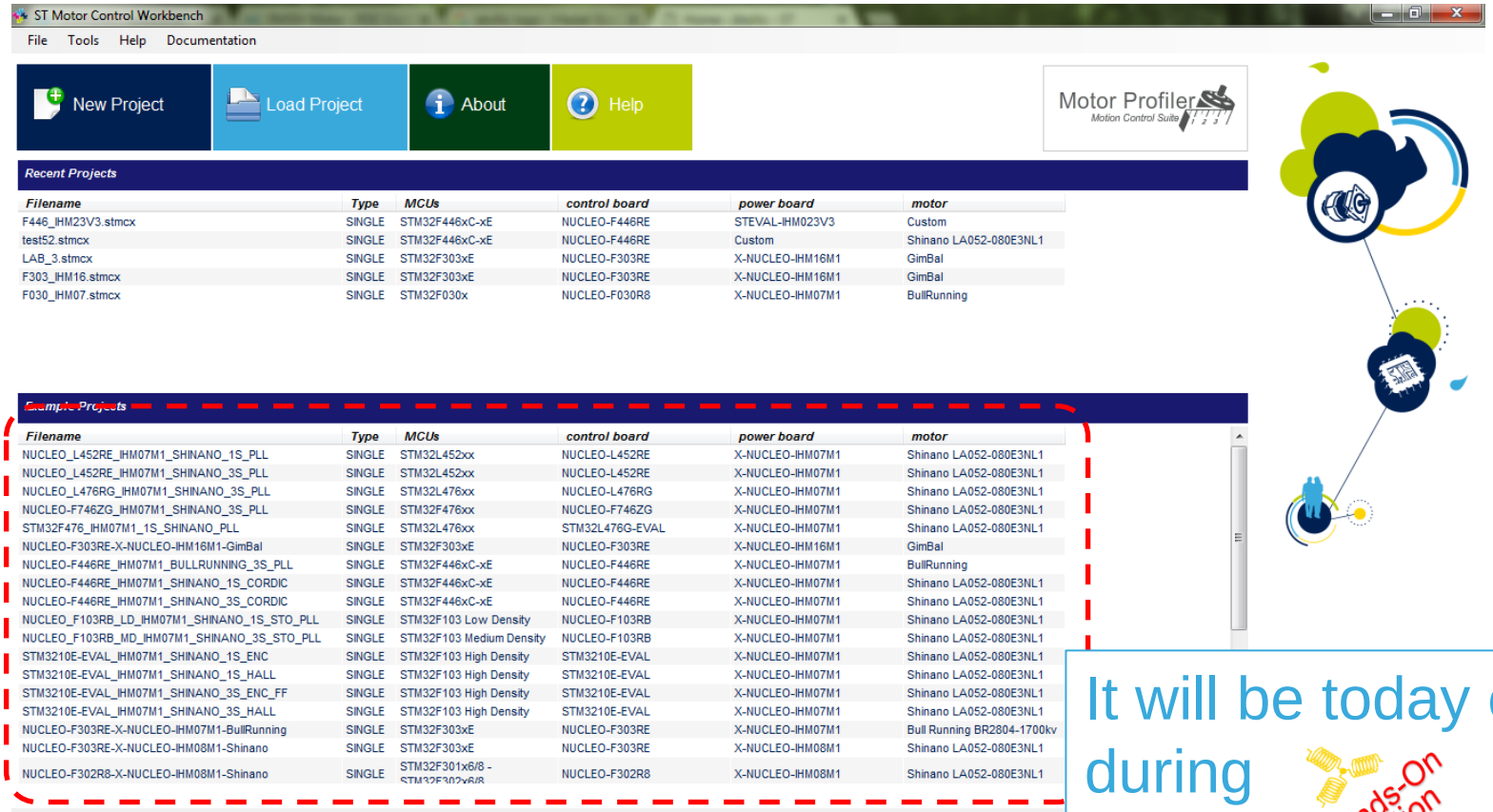
1. Applications





Step #7 – Create a new Workbench project based on the ST evaluation board

- Choose the example Workbench 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.

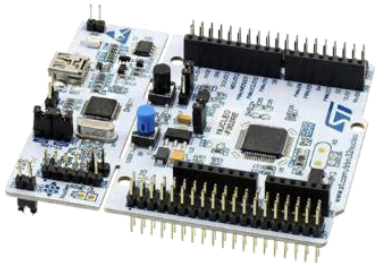


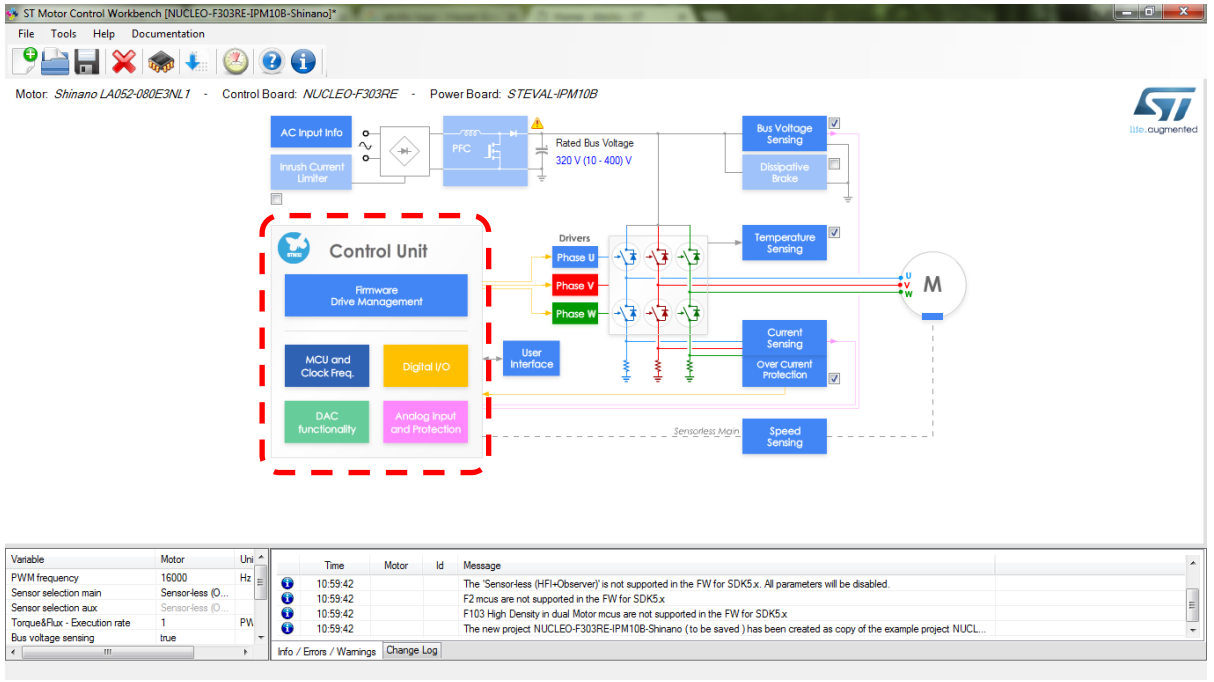
It will be today case during Hands-On section

Step #7 – Create a new Workbench 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.

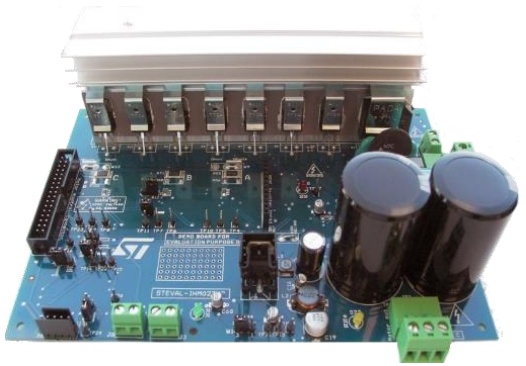
Nucleo STM32F303RE

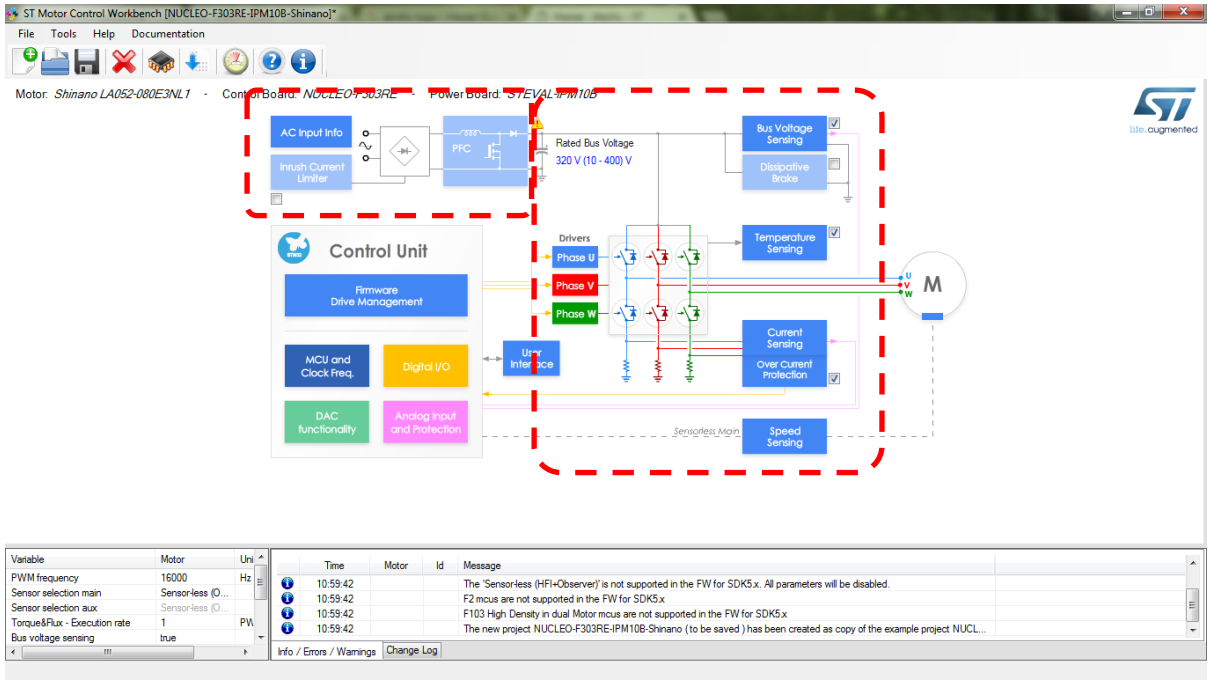




Step #7 – Set up power stage

- 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.

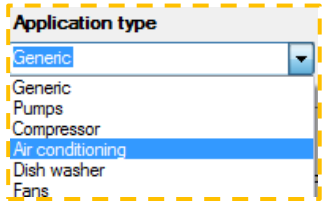


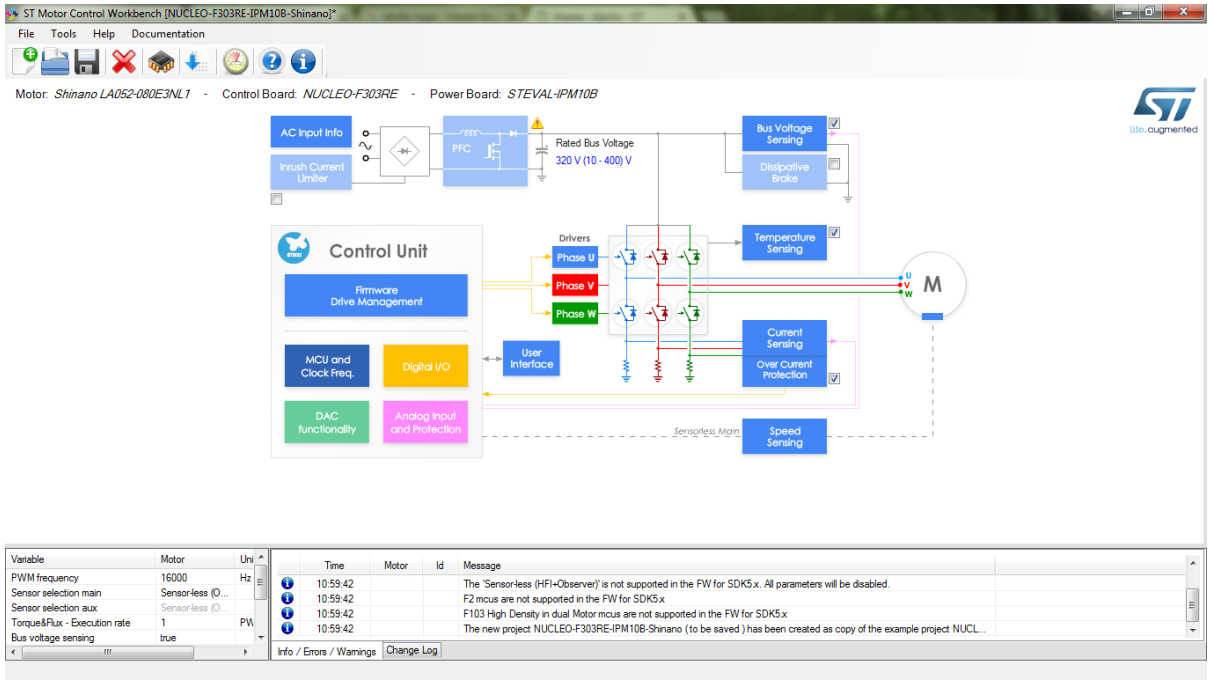


Step #7 – Set up drive parameters

- 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.

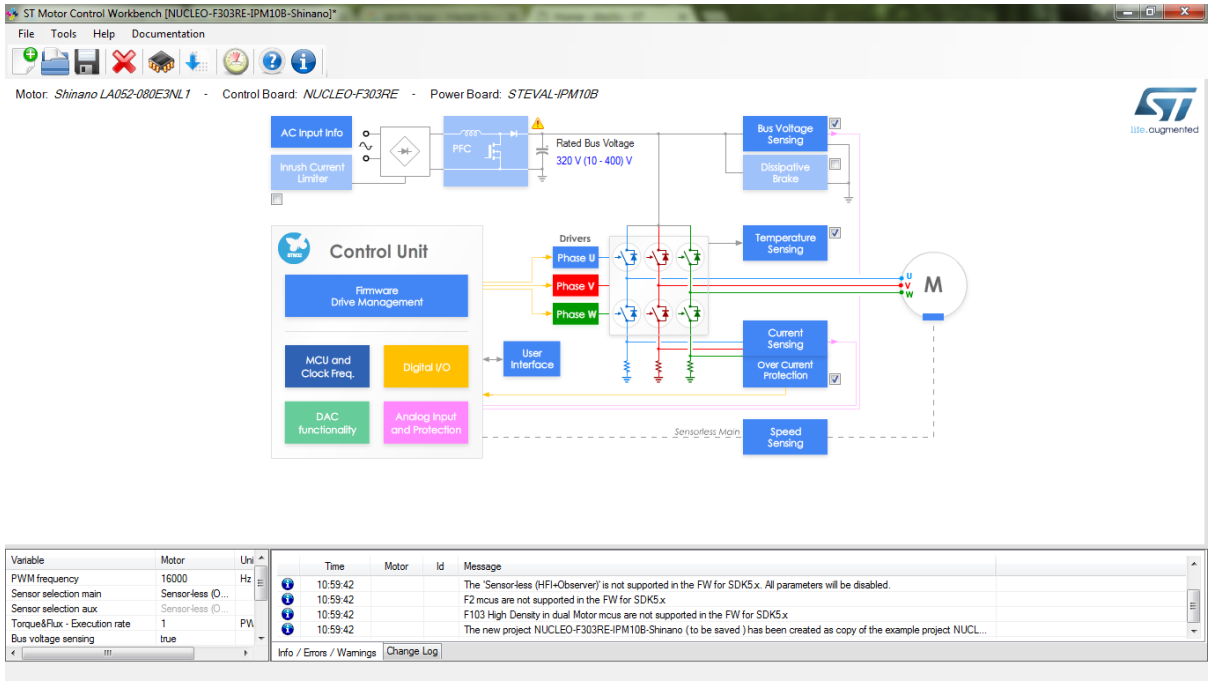
Applications





Step #7 Finalizing the firmware 1/5

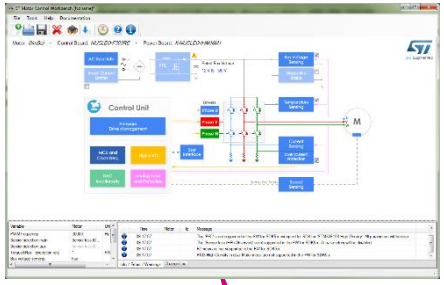
ST MC Workbench



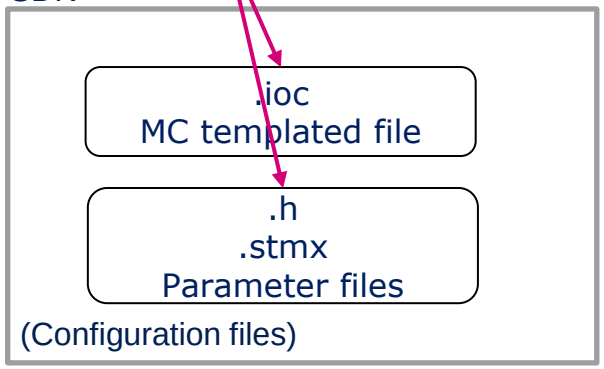
- Open the ST MC Workbench and create a new project.

Step #7 - Finalizing the firmware 2/5

ST MC Workbench

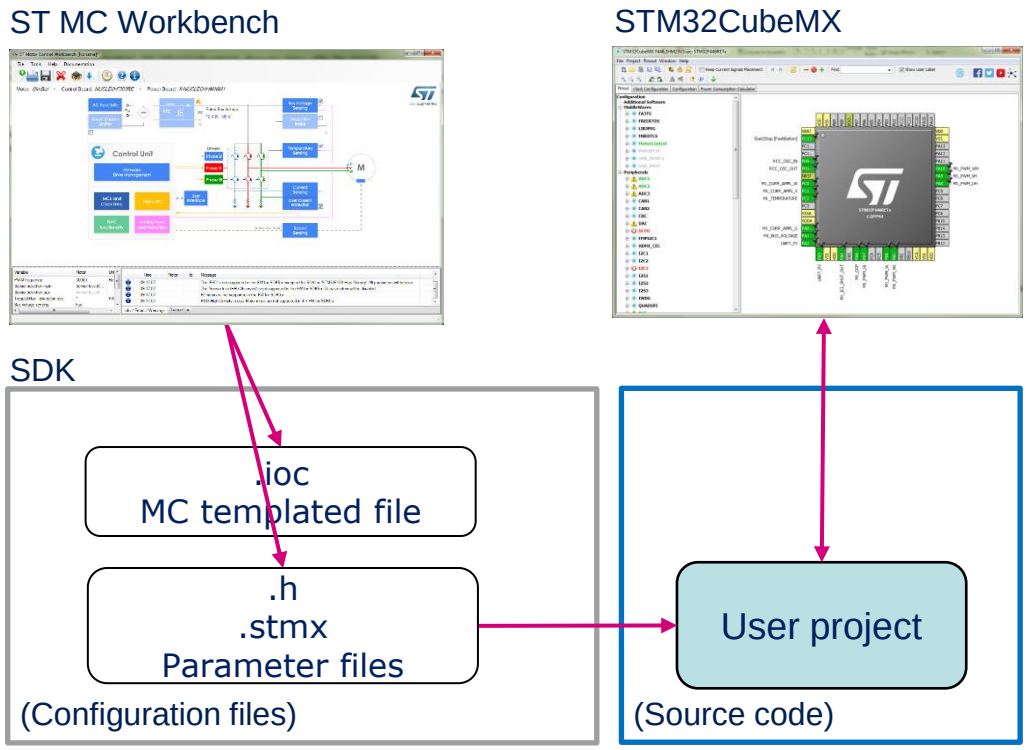


SDK



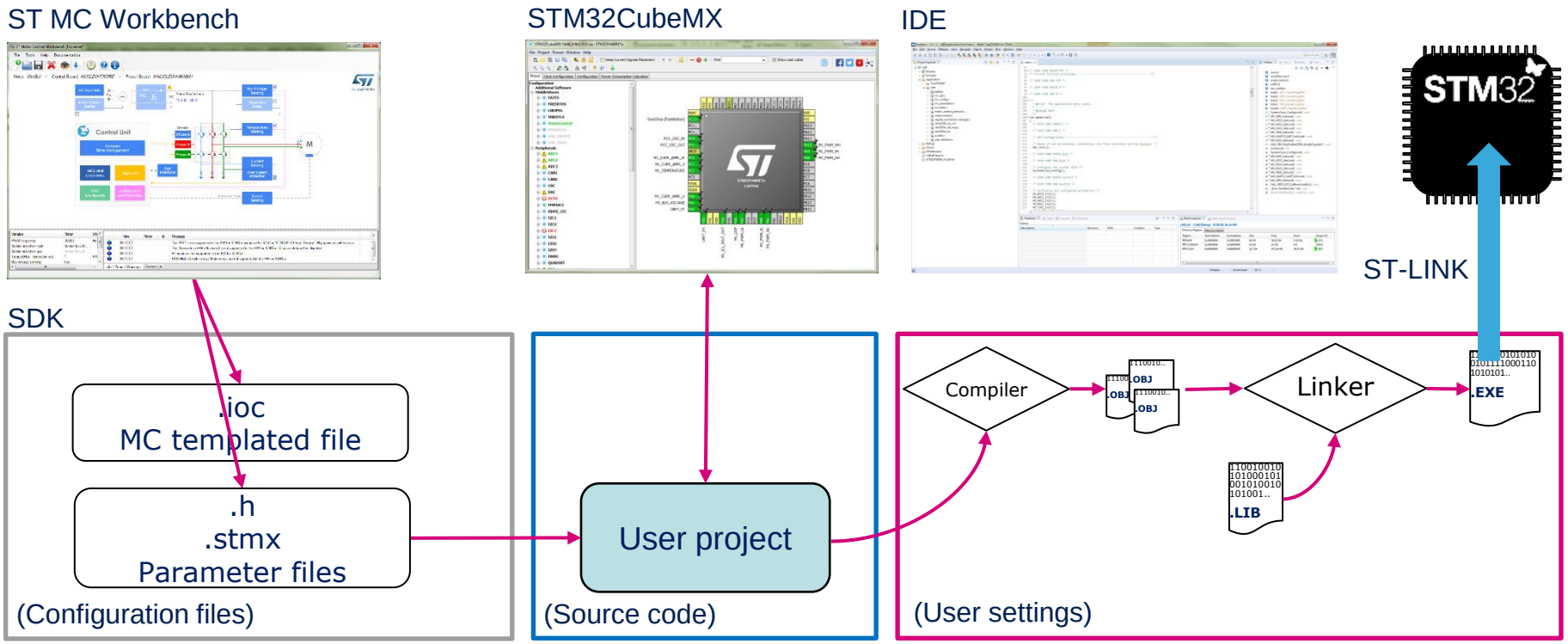
- Generate the configuration (.h) files, (.stmx) Project file and (.ioc) templated file for the firmware library.

Step #7 - Finalizing the firmware 3/5



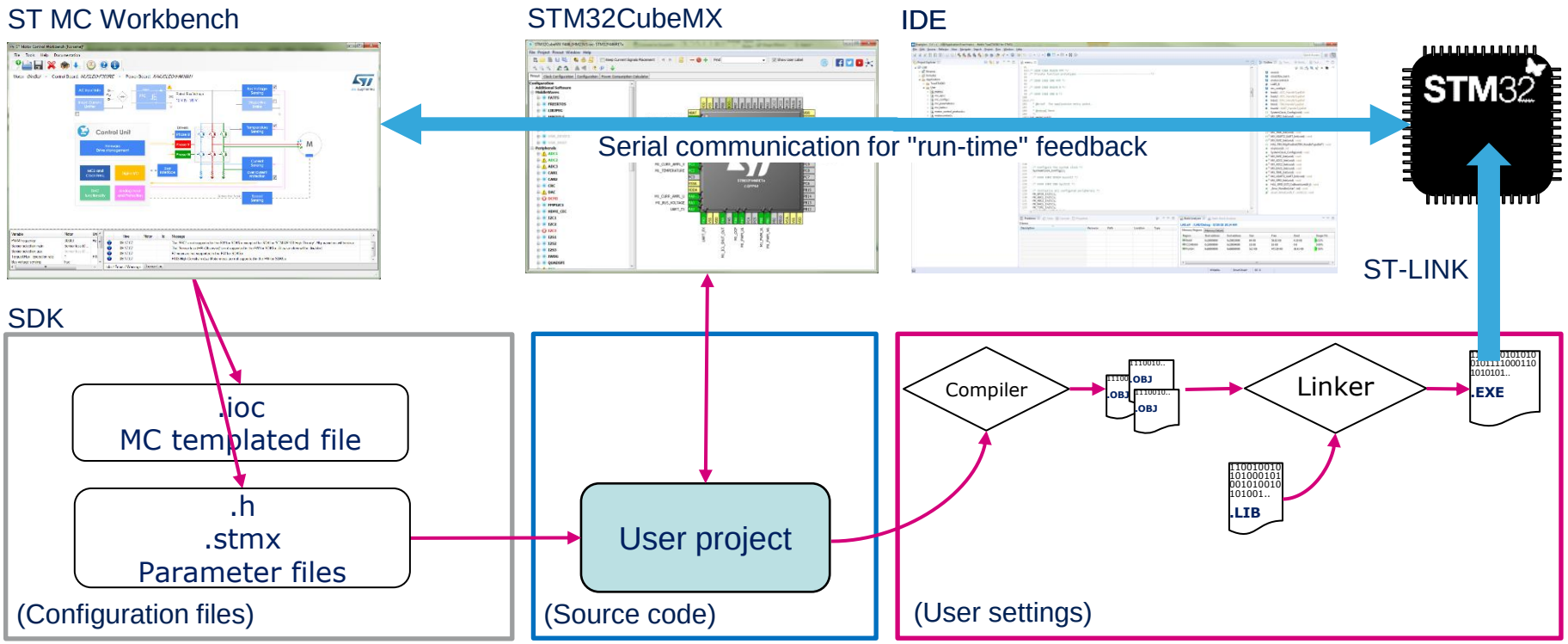
- The STM32CubeMX generated project with Motor Control library in selected IDE

Step #7 - Finalizing the firmware 4/5



- Compile and flash the executable into the microcontroller using ST-LINK (see Step #10).

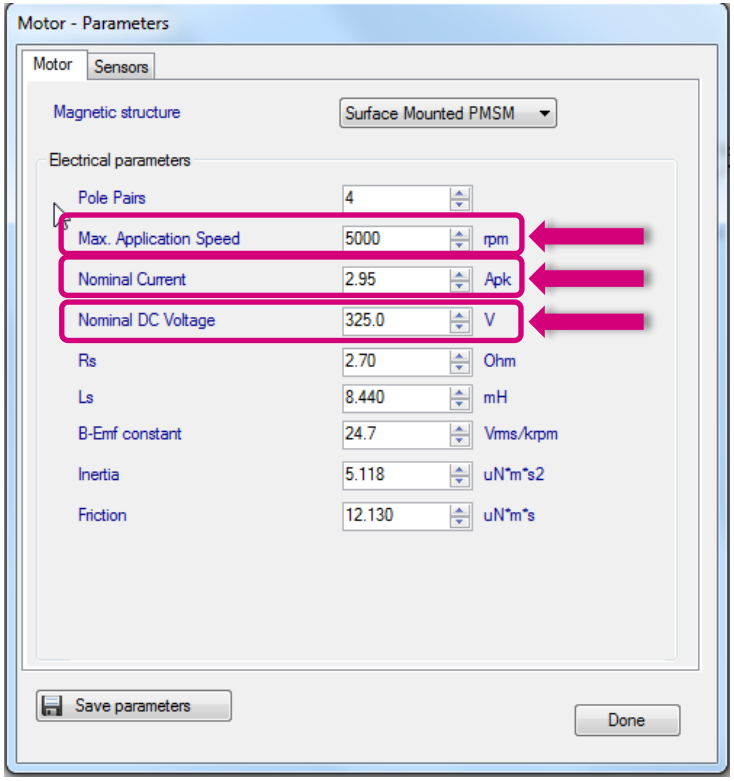
Step #7 - Finalizing the firmware 5/5



- 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).

Step #8 – Set up motor parameters manually

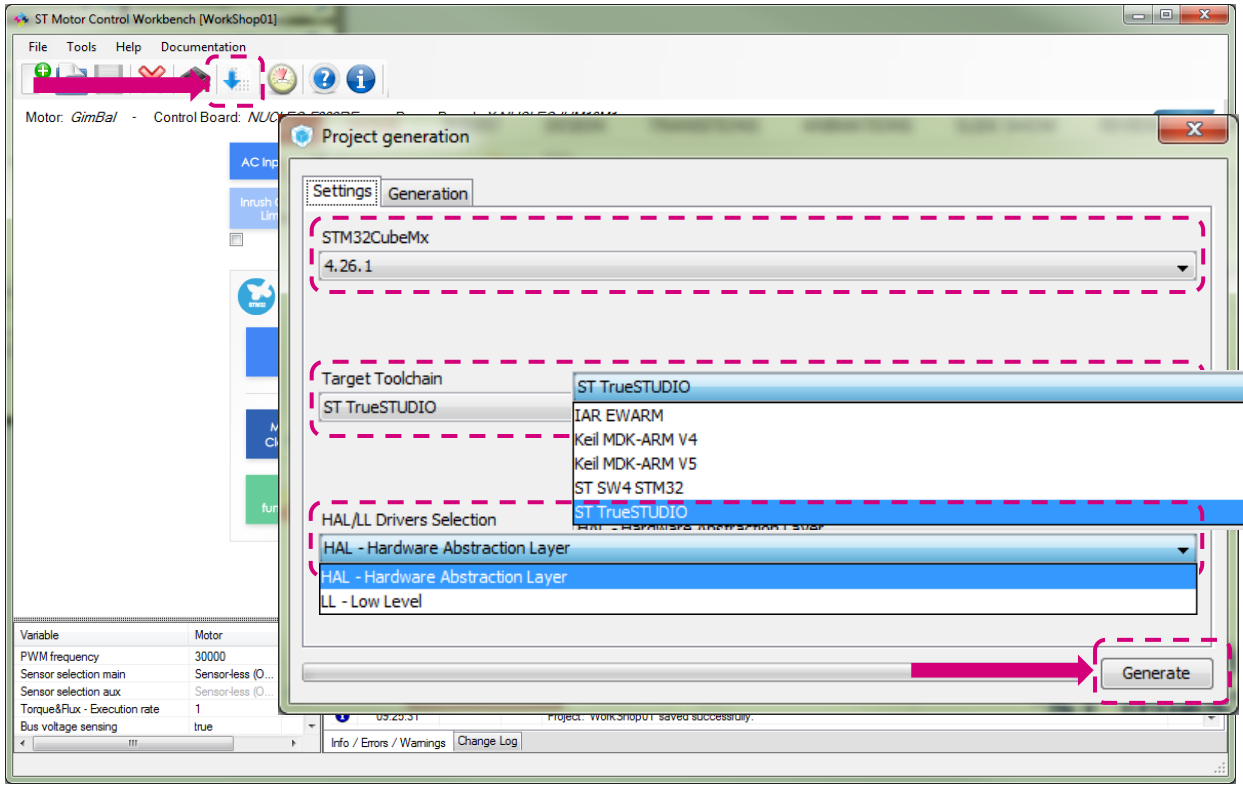
- Set ***Max Rated Speed*** with the maximum motor speed according to the application specs.
- Set ***Nominal Current*** with maximum peak current provided to each of the motor phases according to the motor specs.
- Set ***Nominal DC Voltage*** with value of DC bus provided to the inverter or the rectified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



Generate, compile, debug and run

Step #9 – Parameter generation

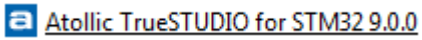
- Select the proper version of STMCubeMX - “**4.26.1**” or newer!
- Select Target toolchain “**ST TrueSTUDIO**”
- Select driver HAL/LL**“HAL”**
- Click on button **Generate**



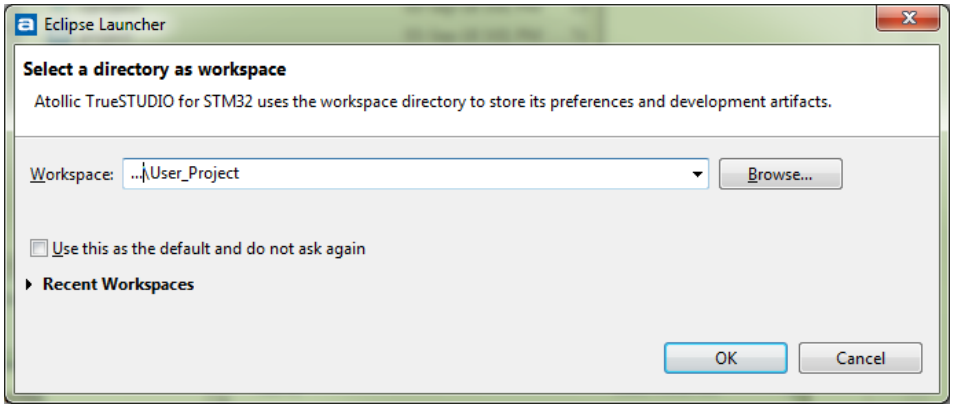
life.augmented

Step #10 – Compile and program the MCU TrueSTUDIO 1/2

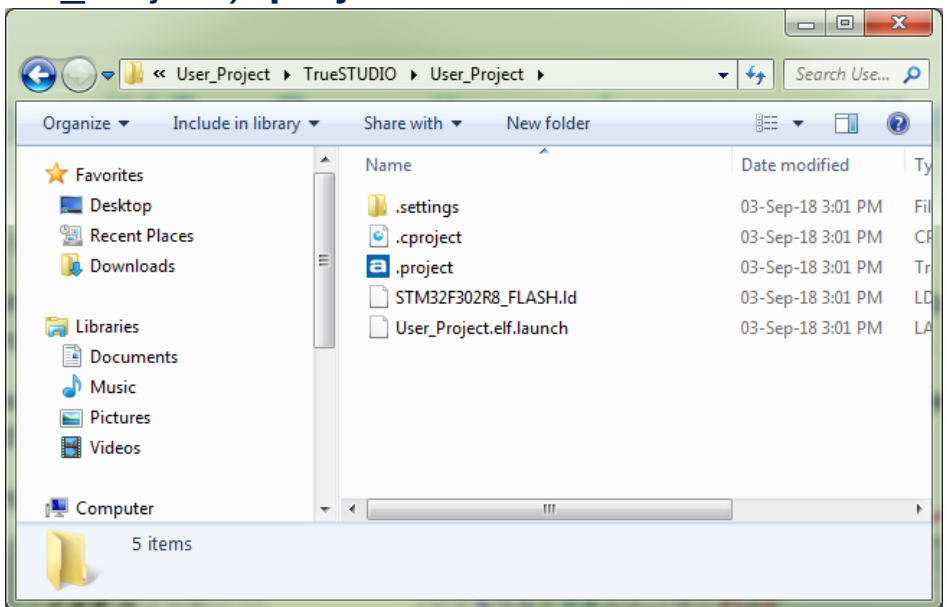
- Run the TrueSTUDIO



- Select your workspace



- Open the TrueSTUDIO workspace (located in User_Project\TrueSTUDIO\User_Project\) **.project**



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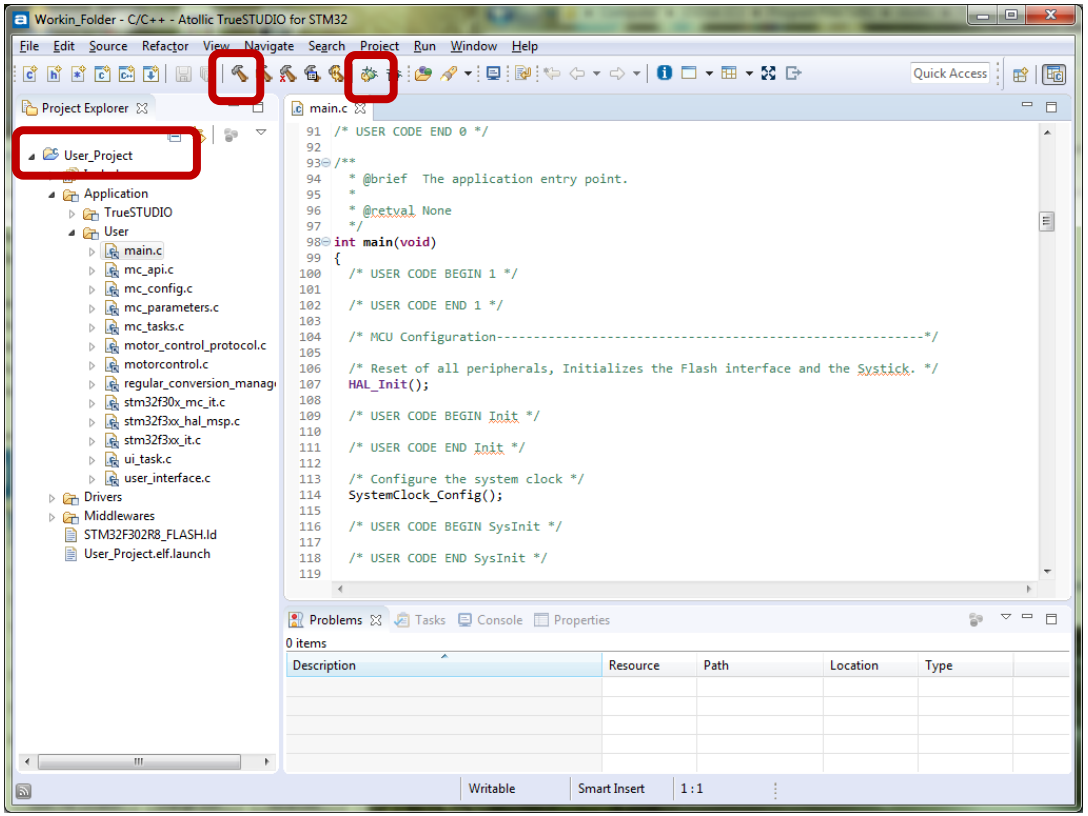
Step #10 – Compile and program the MCU TrueSTUDIO 2/2

- Select project WorkShop01 and click on the button **“Build”**  or **Ctlr+B**

- Click on the button **“Debug”**  or **F11**

- After downloaded click on the **“Terminate”**  or **Ctrl+F2**

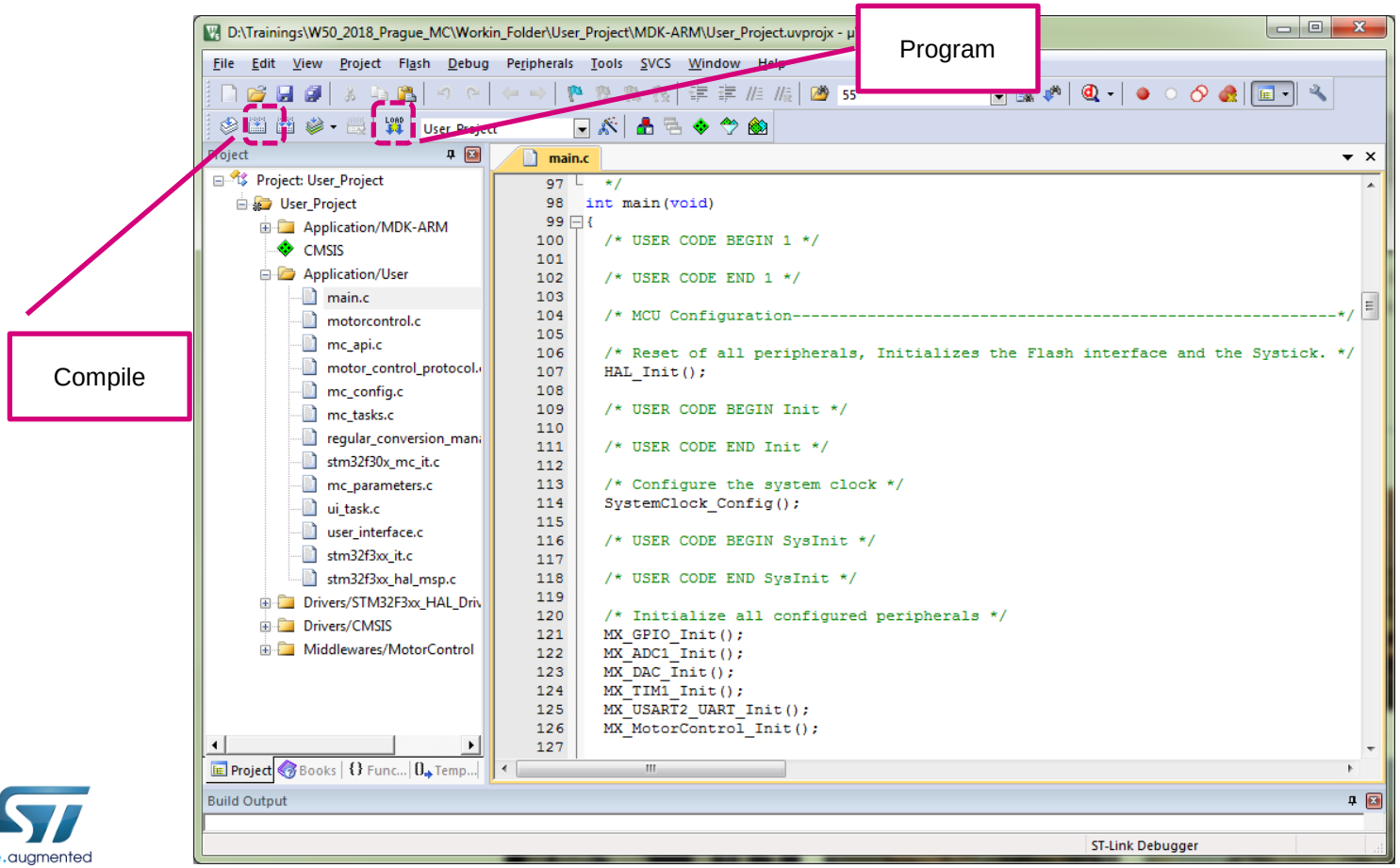


life.augmented

Step #10 – Compile and program the MCU

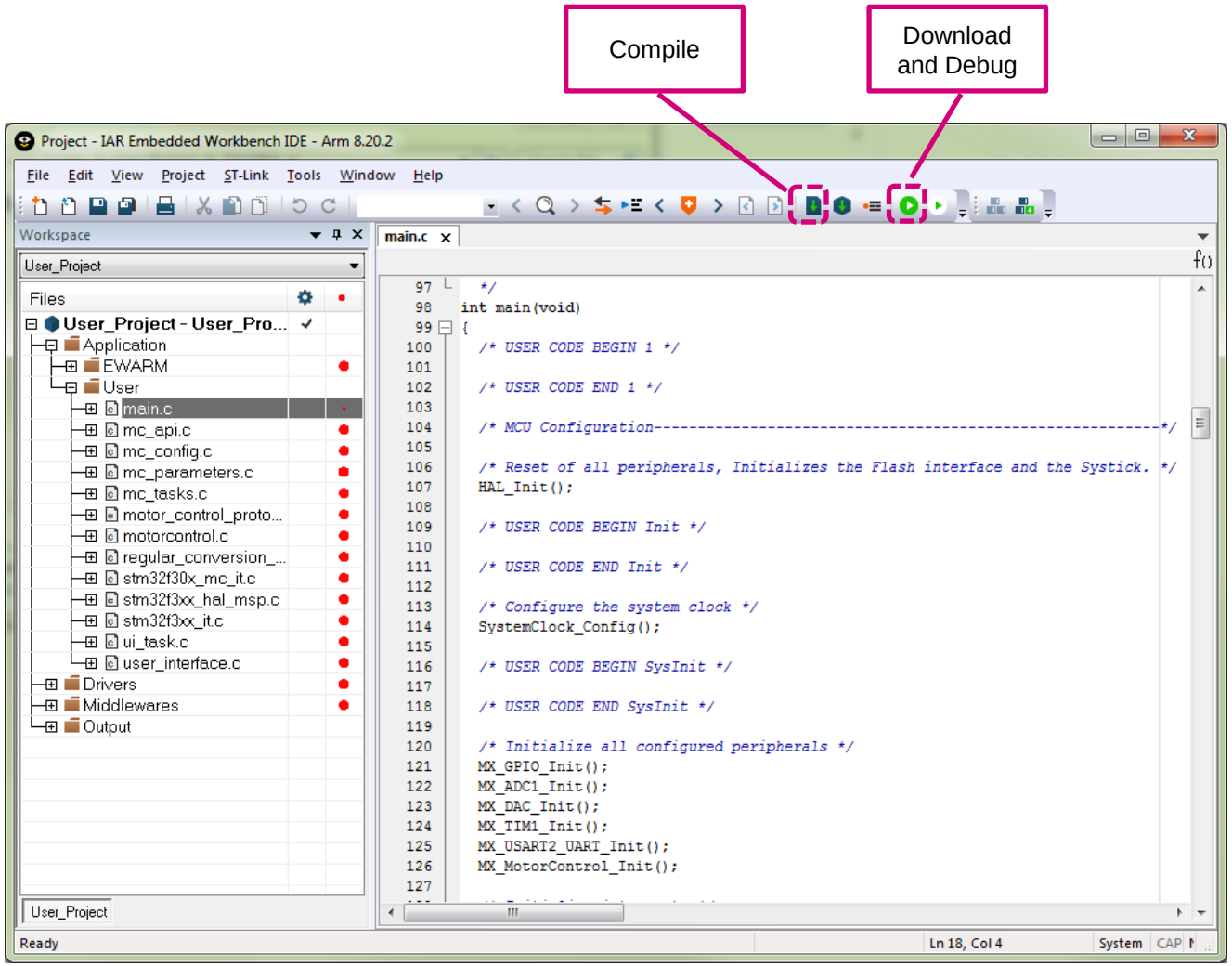
- Optionally, run Keil uVision. 

- Open the Keil workspace (located in User_Project\MDK-ARM) **User_Project.uvprojx**
- Compile and download.



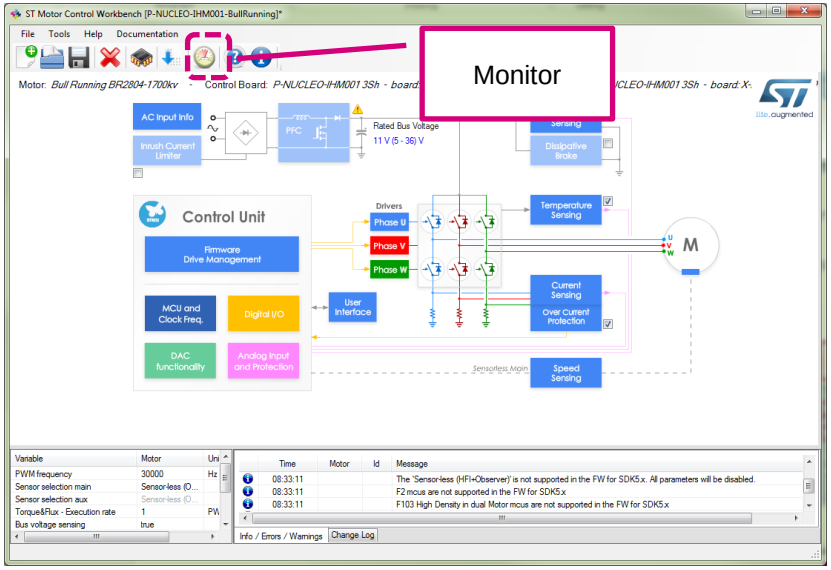
Step #10 – Compile and program the MCU

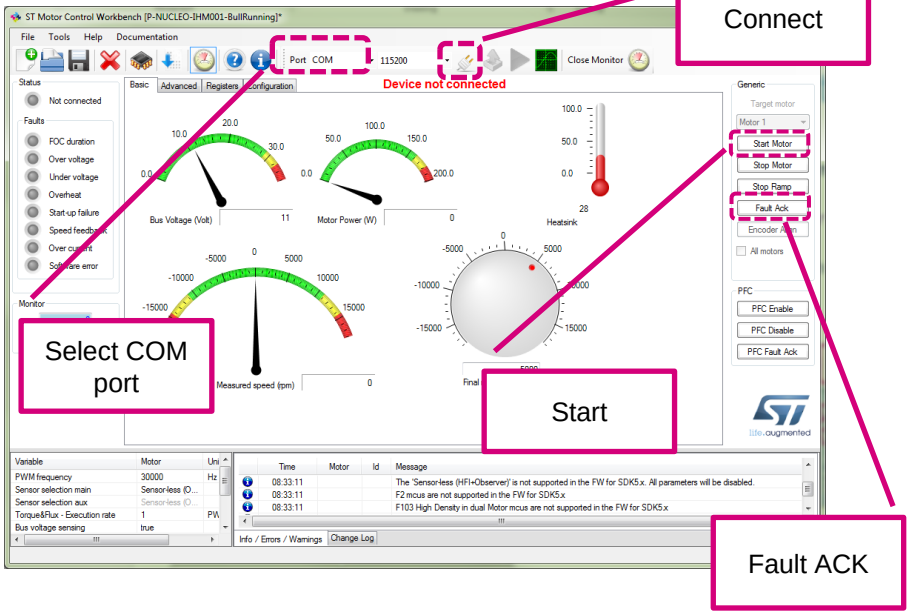
- Run the IAR Embedded Workbench. IAR Embedded Workbench
- Open the IAR workspace (located in User_Project\EWARM)
- Compile
- Download and Debug



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.





Thanks