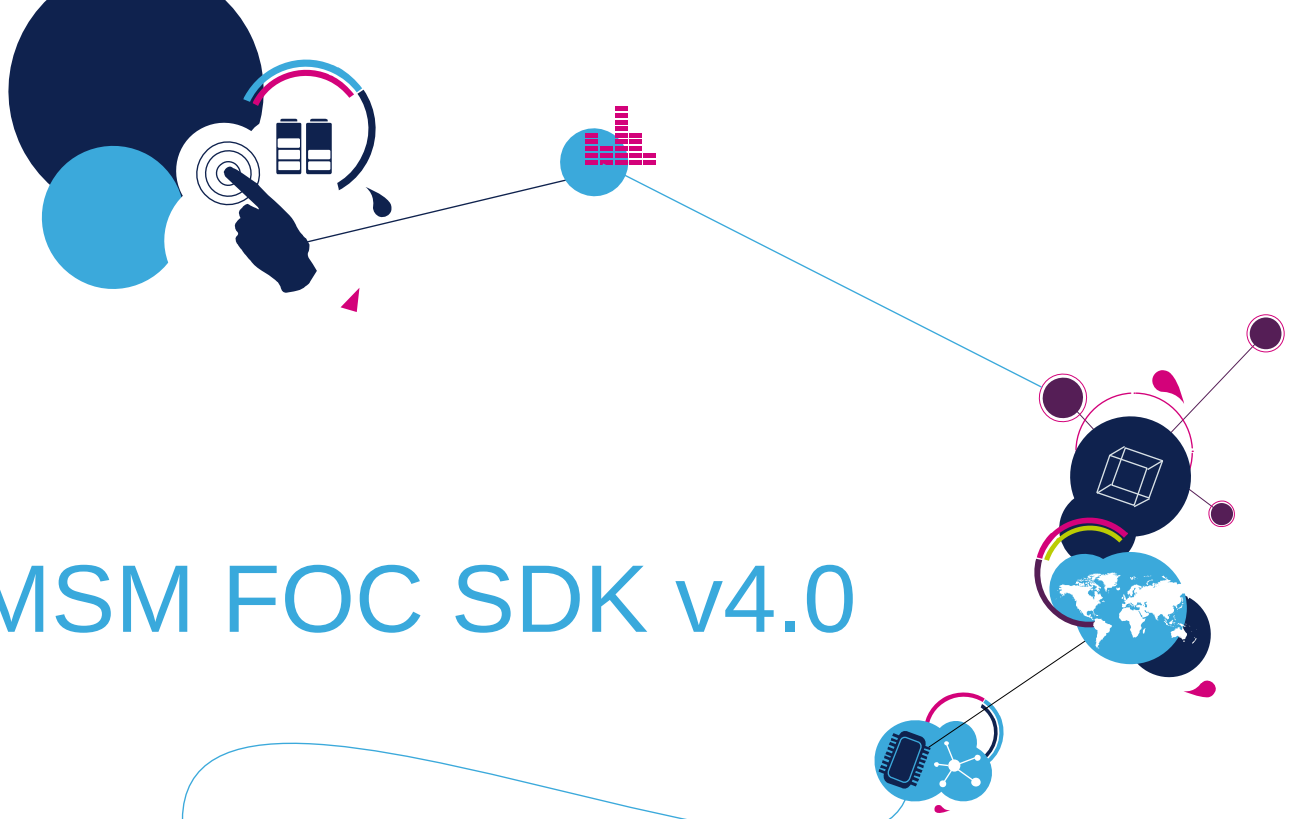

STM32 PMSM FOC SDK v4.0

Hands On

Rev 1.3

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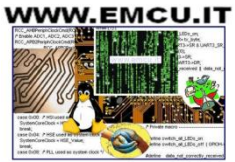
Objectives

- Hands-on workshop to show you the steps needed to quickly get 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.
- Know where to go for documentation, firmware libraries and application notes and additional ecosystem support
- Know where to 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 RS232 dongle and a null modem cable (optional)
  - The permanent magnet motor you want to run
  - A multimeter
  - An oscilloscope with current probe
  - An Insulated DC and or AC power supply
- Ready to begin?



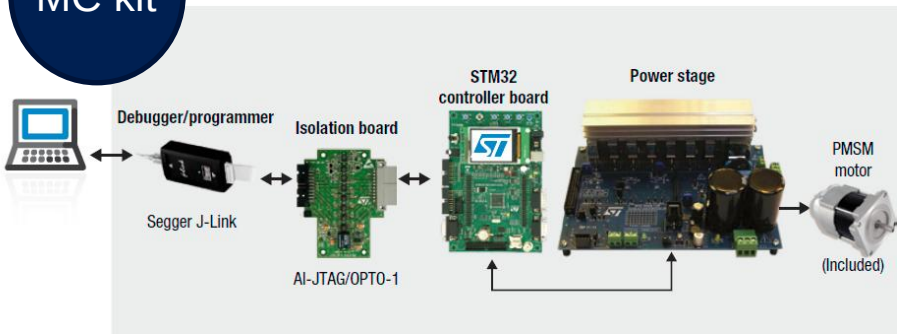
Hardware setup

Step #1 – Hardware setup

- It is possible to choose one of the following offers:
  - Complete Motor Control Kit.
  - One of the complete inverters present at 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 UM to setup each board.

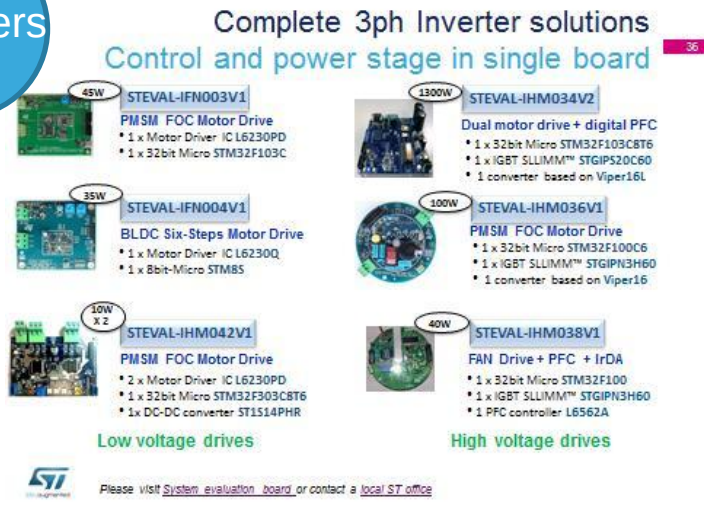
MC boards offer

MC kit

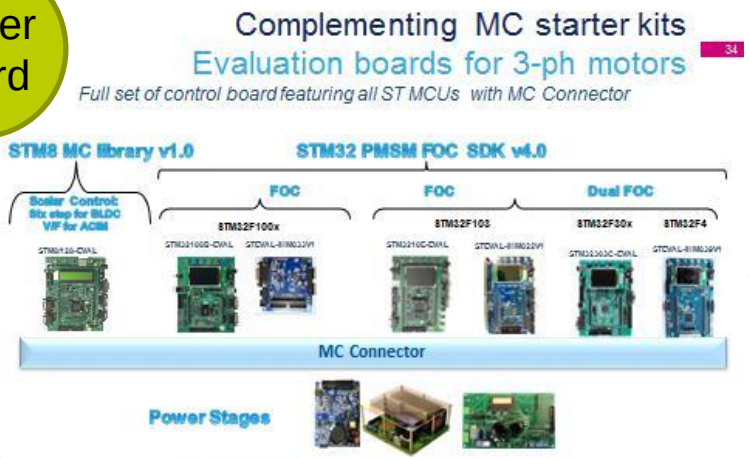


Kit: from isolated debug probe to motor

Inverters



Power board



Control board

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MC kit

Motor control kits

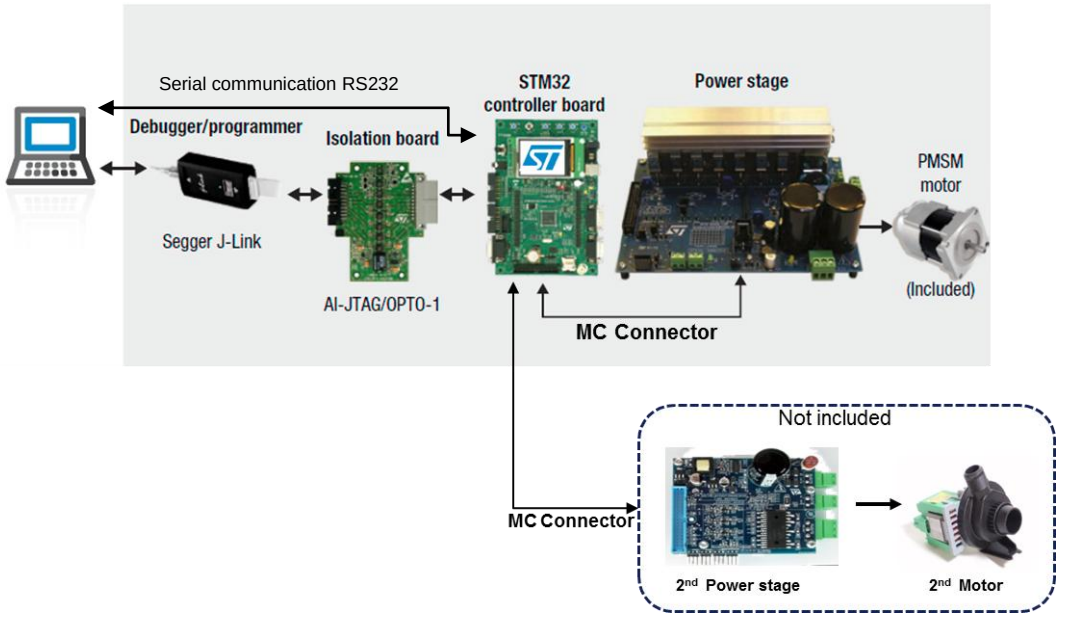
Part Number	Description	ST Link onboard	Type
STM32100B-MCKIT	Motor control starter kit for STM32F100 (128KB Flash) Value Line MCUs	Yes	Single drive
STM3210B-MCKIT	Motor control starter kit for STM32 (128KB flash) Performance and Access Line microcontrollers	No	Single drive

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

Motor control kits

STM32100B-MCKIT

STM3210B-MCKIT



Inverters

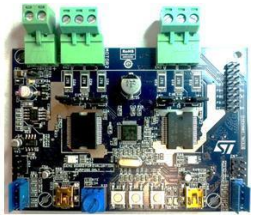
ST complete inverters

Part Number	Description	ST Link onboard	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

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Control board

STM32 evaluation boards with MC connector

Part Number	Description	ST Link onboard(1)	Type
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
STM32303C-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

STM3220G-EVAL

STM3240G-EVAL

STM3210E-EVAL

STEVAL-IHM022V1

STM32303C-EVAL

STEVAL-IHM039V1

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

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In-circuit debugger/programmer..

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

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-IHM021V2

STEVAL-IHM023V3

STEVAL-IHM025V1

STEVAL-IHM032V1

STEVAL-IHM035V2

STEVAL-IHM045V1

STEVAL-IHM028V2

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HW key features 1/2

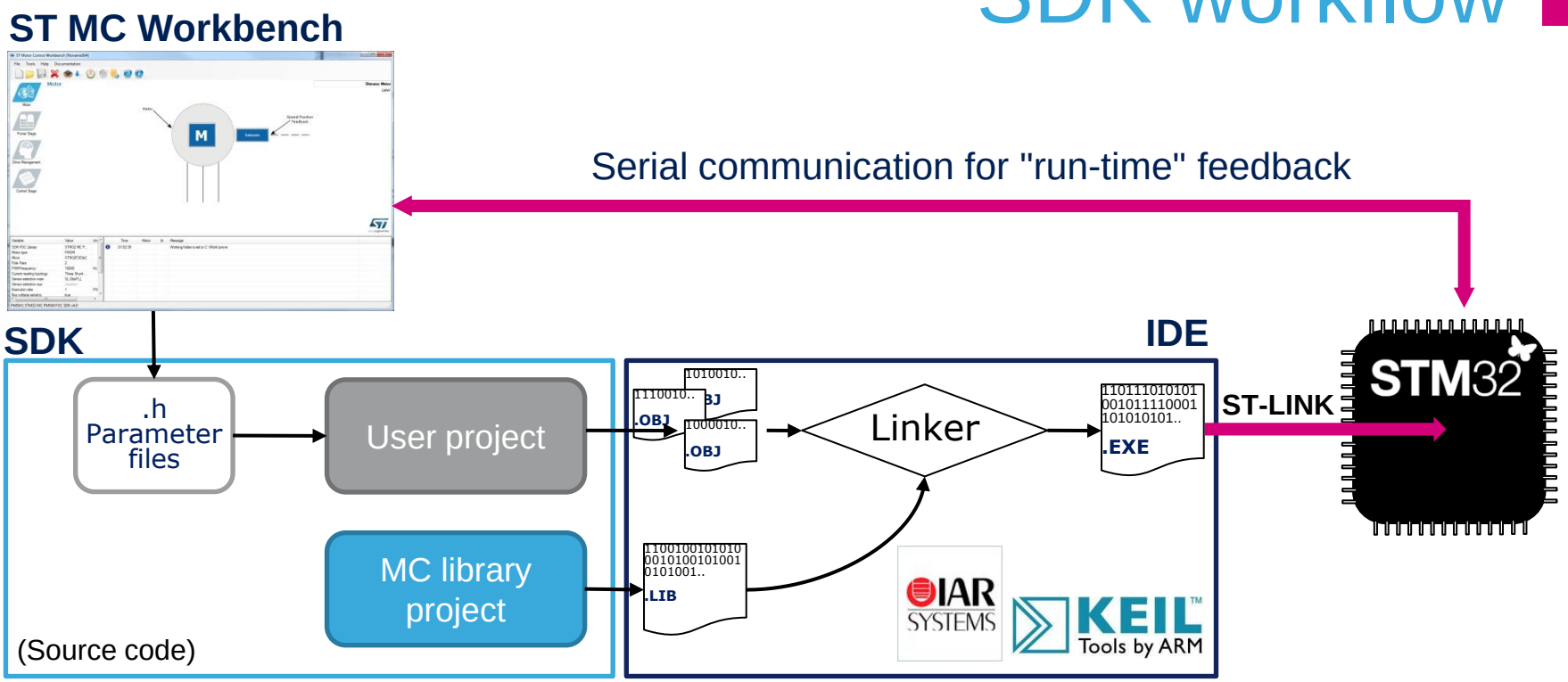
Reference / Bundle	Voltage	Power	Motor Type / Control Type *	ST Parts	Application focus
STEVAL-IHM034V2	230VAC Nominal	Up to 1.3kW	PMSM, Dual Motor (FOC) + digital PFC	• 1x **STM32F103C8T6** • 1x **STGIPS20C60** • 1x **Viper16L**	Complete drive: Compressors, room air conditioning,
STEVAL-IHM036V1	90VAC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

HW key features 2/2

Reference / Bundle	Voltage	Power	Motor Type / Control Type *	ST Parts	Application focus
STEVAL-IHM021V2	120/230 VAC nominal (60/50Hz)	Up to 100W	PMSM/BLDC FOC/Six step 3shunts	• 3x **L6390** • 1x **Viper12** • 6x **STD5N52U**	Power Board: Water pumps, fans, dish washers, washing machines
STEVAL-IHM023V3	90VAC - 285VAC 125VDC - 400VDC	Up to 1kW	PMSM/BLDC FOC/Six step Single/3 shunts	• 3x **L6390** • 1x **Viper16** • 7x **STGP10H60DF**	Power Board: Pumps, compressors, washing machines and more
STEVAL-IHM025V1	90VAC - 285VAC 125VDC - 400VDC	Up to 1kW	PMSM/BLDC FOC/Six step	• 1x **STGIPL14K60** • 1x **Viper16** • 1x **STGP10NC60KD**	Power Board: Pumps, compressors, washing machines and more
STEVAL-IHM028V2	90VAC - 285VAC 125VDC - 400VDC	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	230VAC nominal 86 to 260 VAC	Up to 150W	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 VAC nominal	Up to 100W	PMSM/BLDC FOC/Six step single-shunt	• 1x **STGIPN3H60** • 1x **VIPer16L**	Power Board: Pumps, compressors, fans, dish washers and more
STEVAL-IHM045V1	30VAC - 270VAC 40VDC - 400VDC	Up to 100W	PMSM FOC Single/3-shunt	• 1x **STGIPN3H60A** • 1x **VIPer06L** • 1x **TSV994**	Power Board: Pumps, compressors, fans, dish washers and more

Software setup

SDK workflow



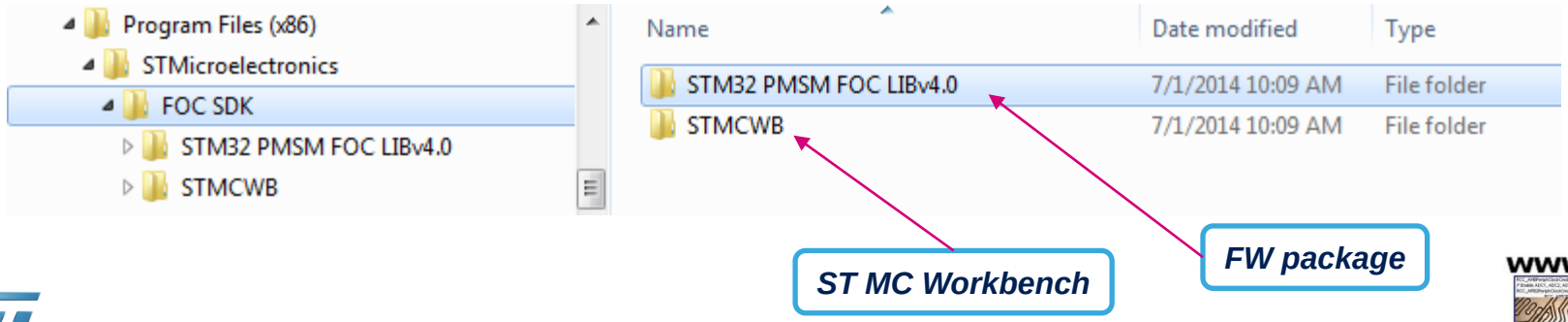
- Parameter files, generated by the ST MC Workbench GUI, are used to configure the SDK.
- The IDE builds the projects, links and creates the executable.
- The ST-LINK dongle (or equivalent) is used to download and debug the executable into the MCU.
- Serial communication between the ST MC Workbench and the FW can be established to send commands or get feedback.

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/**)
- Ask for assistance if you have an issue.

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-ISO

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-LINK003

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 #4 – ST-LINK installation

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

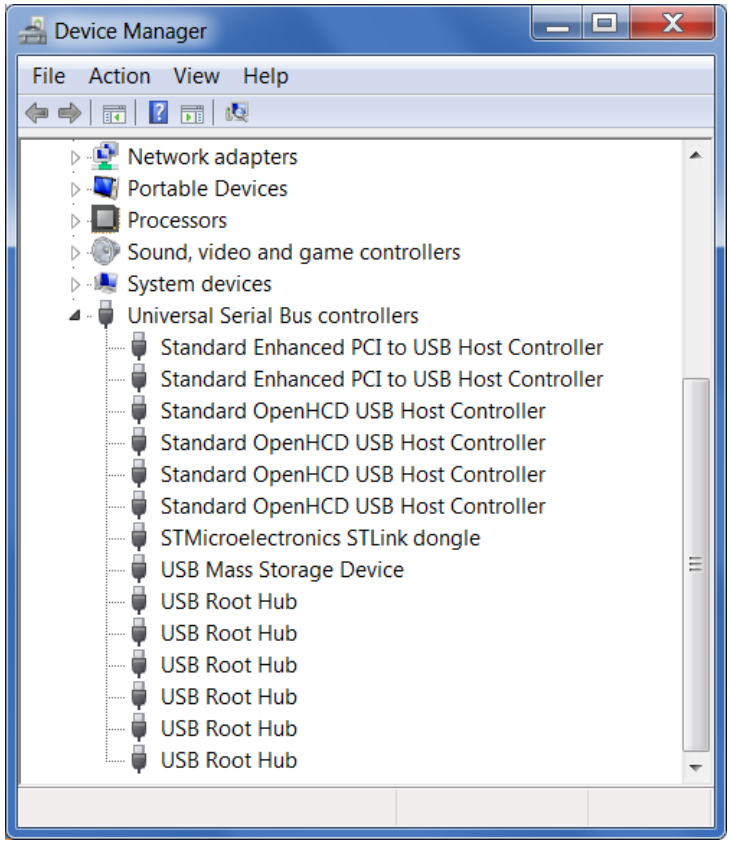
(This will be required to flash the LCD FW code into the MCU).

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

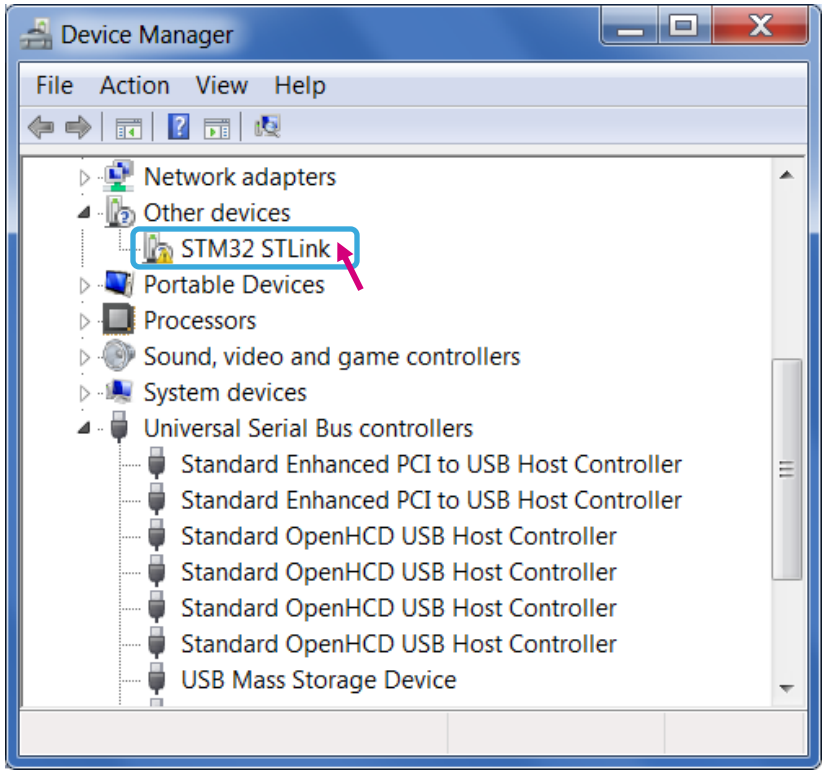
Step #5 – Connect ST-LINK

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



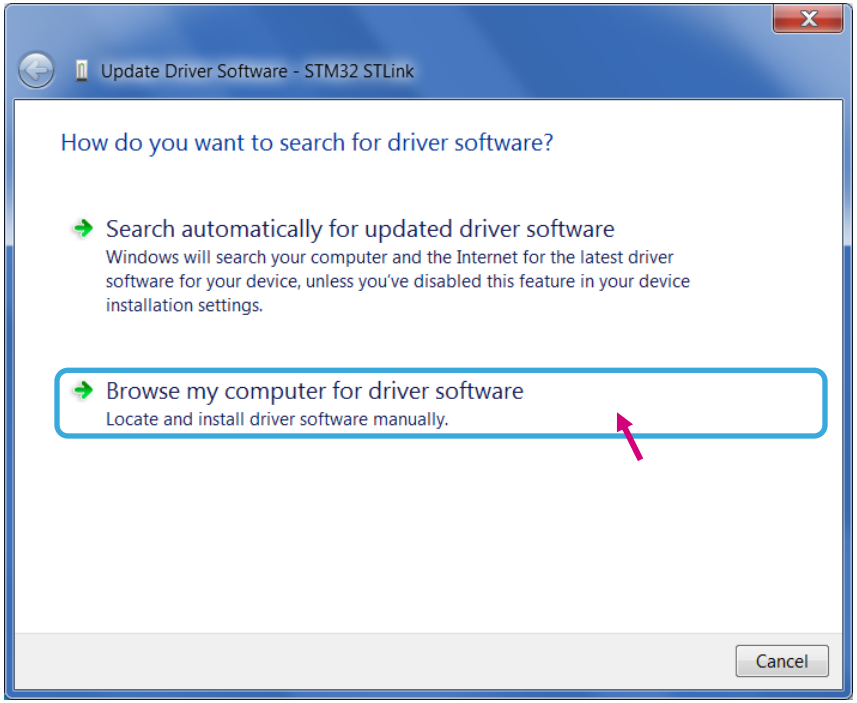
Step #5 – Driver Trouble Shooting

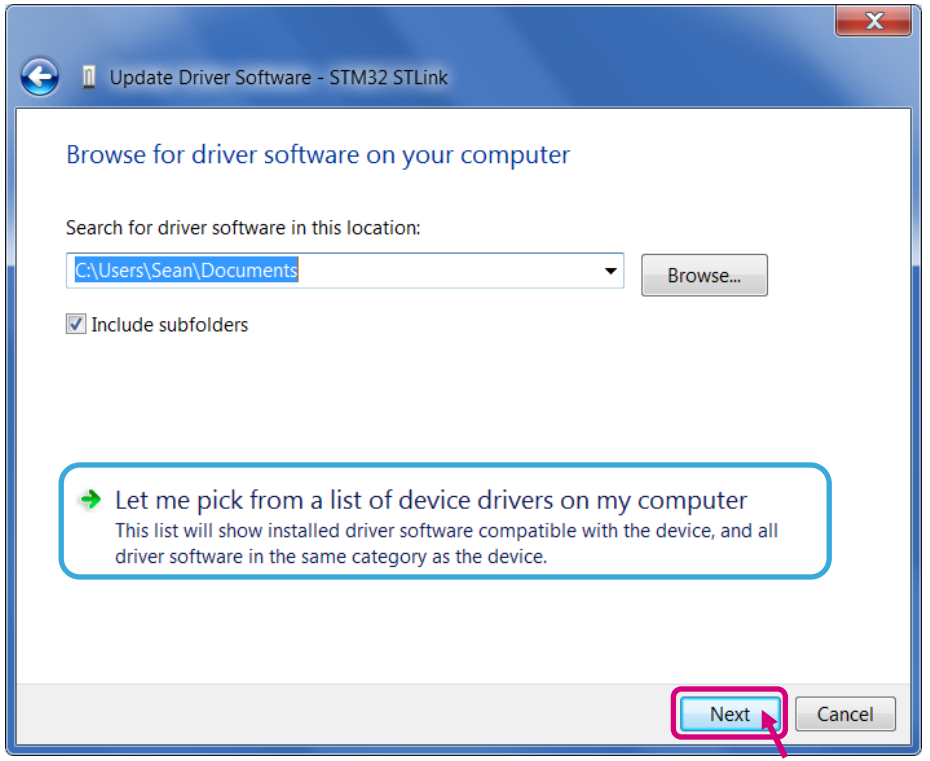
1. Open Device Manager
2. Right-click on the "**STM32 STLink**" Driver icon
3. Select "**Update Driver Software**"



Step #5 – Driver Trouble Shooting

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





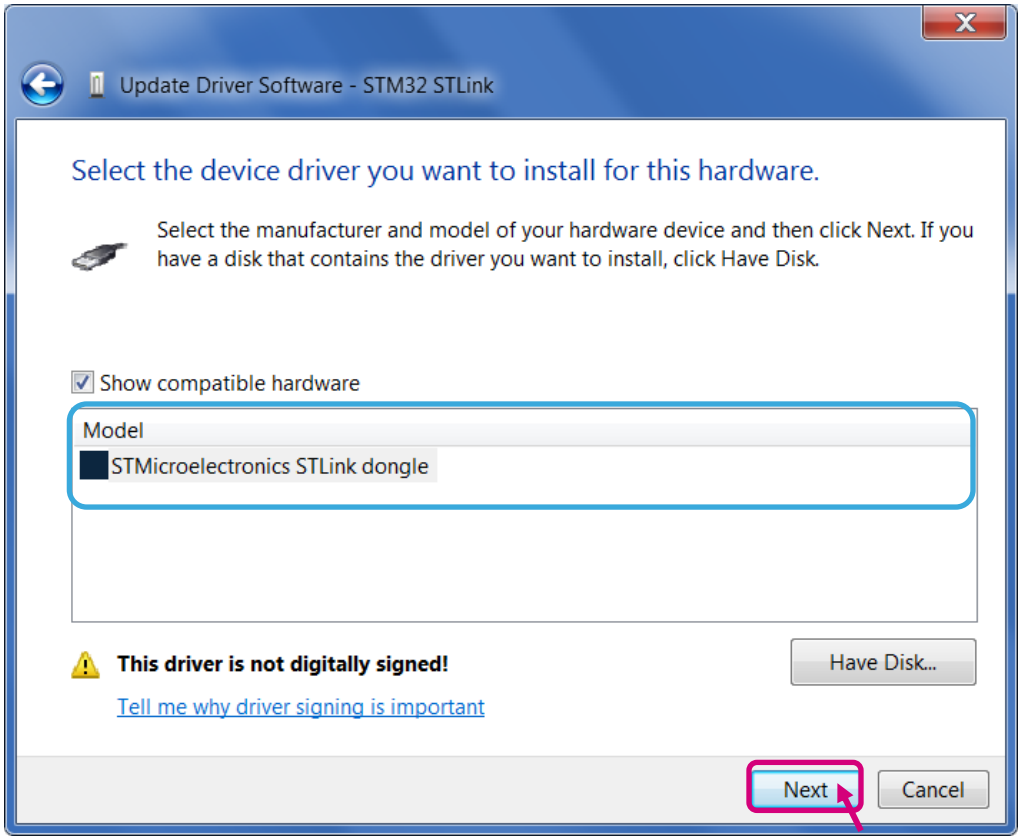
5. Select “Let me pick from a list of device drivers of my computer”

6. Click “Next”

Step #5 – Driver Trouble Shooting

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

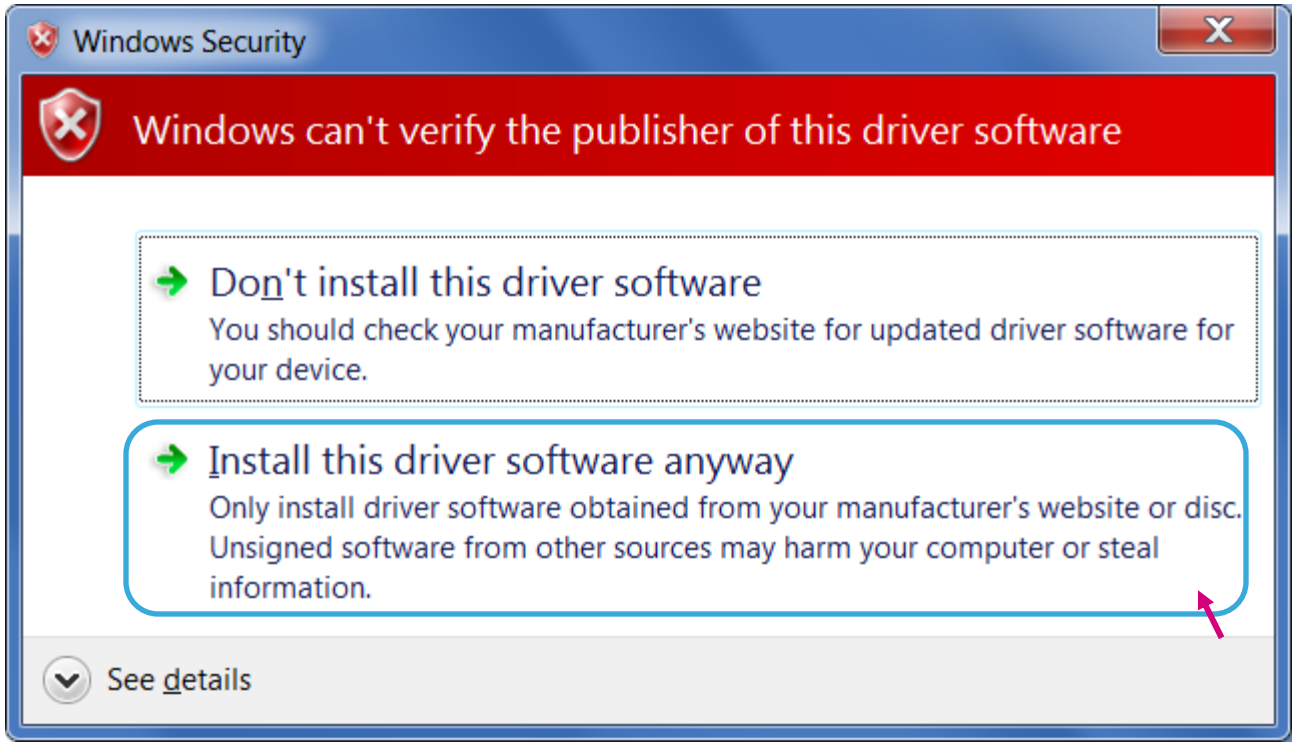
7. Click “Next”



Step #5 – Driver Trouble Shooting

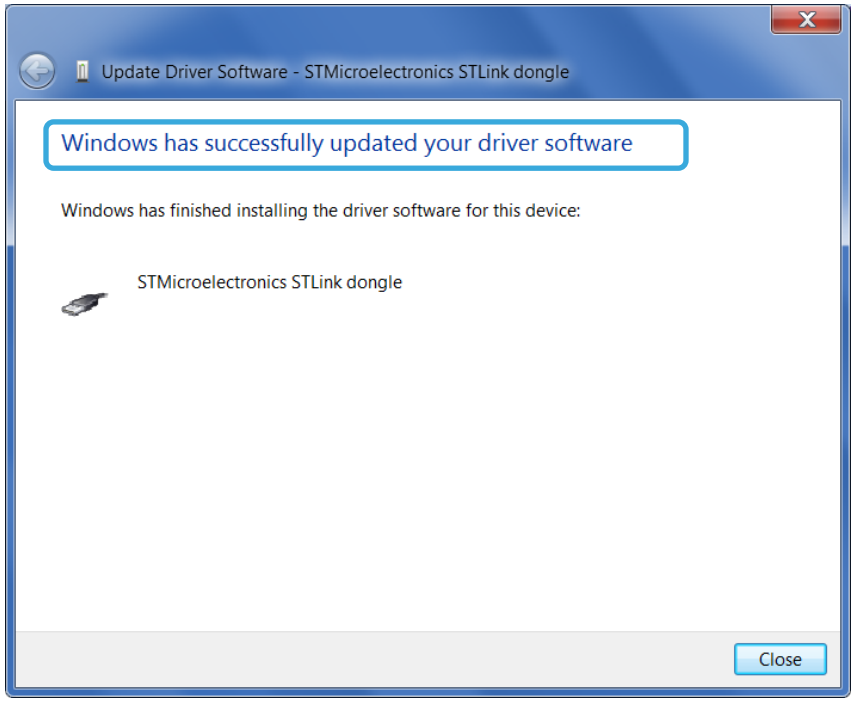
- A warning message may appear

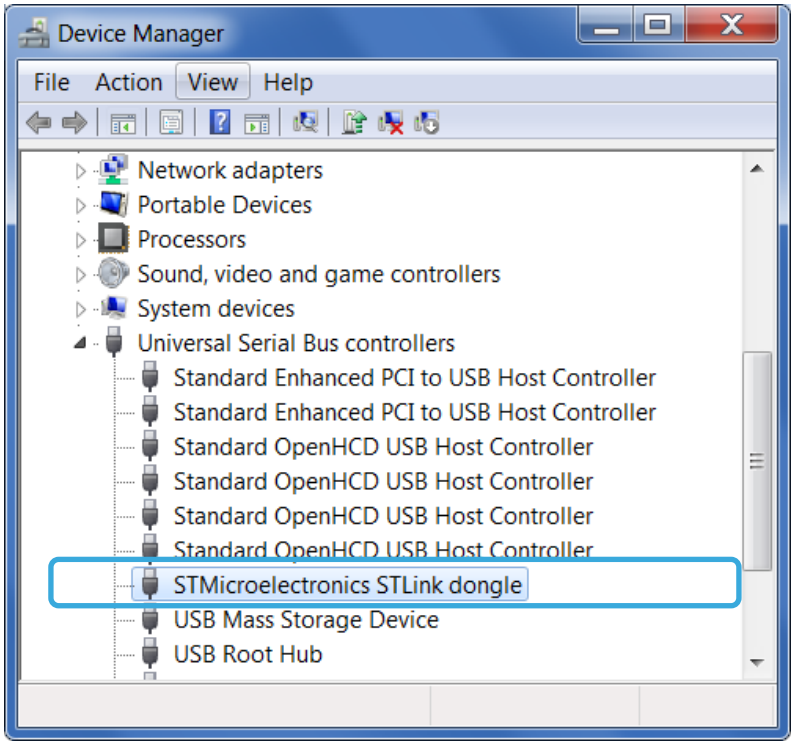
8. Select "**Install this driver software anyway**"



Step #5 – Driver Trouble Shooting

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



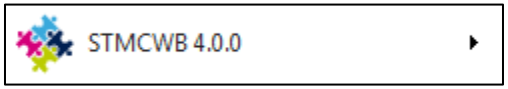


- Re-check Device Manager to ensure “**STMicroelectronics STLink dongle**” is functioning normally

Setup Workbench Project

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

- Starting point of new design is to create the WB project.
- Execute the **STMCWB 4.0.0**



- Choose the WB example project that best fits your need.
  - 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

Example projects

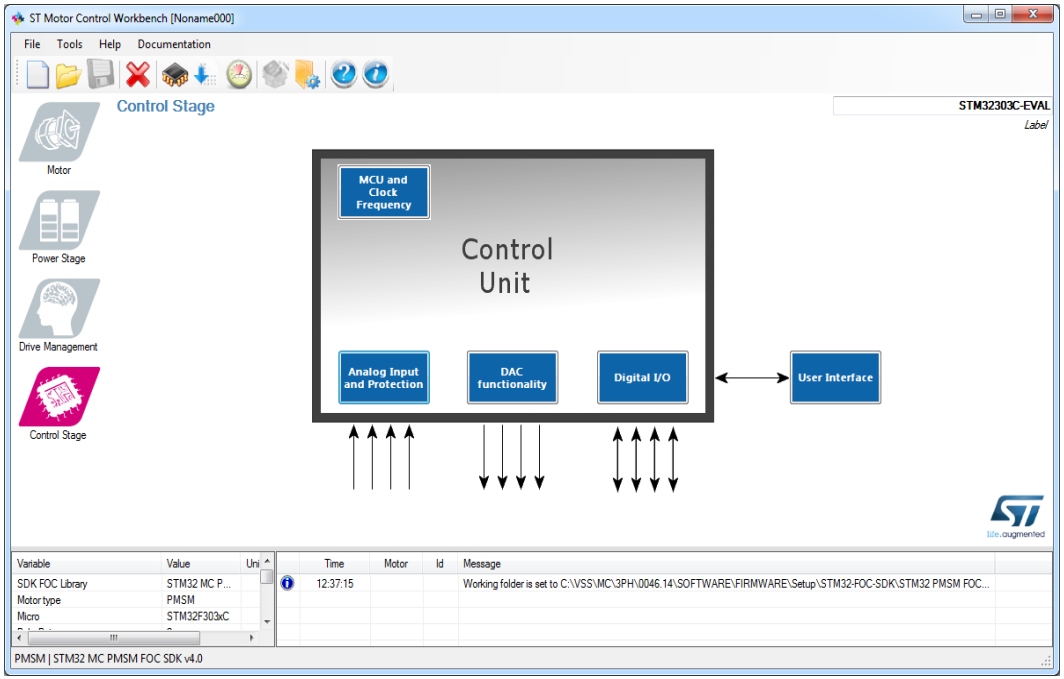
Filename
SDK40x-STEVAL-IFN003V1-Shinano.stmc
SDK40x-STEVAL-IHM022V1-MB459-Shinano-DUAL-
SDK40x-STEVAL-IHM022V1-MB459-Shinano-SINGL
SDK40x-STEVAL-IHM034V2-PMSM-SINGLE-DRIVE.
SDK40x-STEVAL-IHM039V1-MB459-Shinano-DUAL-
SDK40x-STEVAL-IHM039V1-MB459-Shinano-SINGL
SDK40x-STEVAL-IHM042V1-Shinano-DUAL-DRIVE.s
SDK40x-STM320518-EVAL-MB459-Shinano.stmc
SDK40x-STM32100B-EVAL-IHM023V2-Shinano.stm
SDK40x-STM32100B-EVAL-MB459-Shinano.stmc
SDK40x-STM3210B-EVAL-MB459-Shinano.stmc
SDK40x-STM3210E-EVAL-MB459-Shinano.stmc
SDK40x-STM322xG-EVAL-MB459-Shinano.stmc
SDK40x-STM32303C-EVAL-IHM045V1-Shinano-DU
SDK40x-STM32303C-EVAL-IHM045V1-Shinano-SIN
SDK40x-STM32303C-EVAL-MB459-Shinano-DUAL-[
SDK40x-STM32303C-EVAL-MB459-Shinano-SINGLI
SDK40x-STM324xG-EVAL-MB459-Shinano.stmc

Microcontroller family	WB project
Single drive	
STM32F0x	SDK40x-STM320518-EVAL-MB459-Shinano.stmc
STM32F100	SDK40x-STM32100B-EVAL-MB459-Shinano.stmc
STM32F103 LD/MD	SDK40x-STM3210B-EVAL-MB459-Shinano.stmc
STM32F103 HD	SDK40x-STM3210E-EVAL-MB459-Shinano.stmc
STM32F2x	SDK40x-STM322xG-EVAL-MB459-Shinano.stmc
STM32F3x	SDK40x-STM32303C-EVAL-MB459-Shinano-SINGLE-DRIVE.stmc
STM32F4x	SDK40x-STM324xG-EVAL-MB459-Shinano.stmc
Dual drive	
STM32F103 HD	SDK40x-STEVAL-IHM022V1-MB459-Shinano-DUAL-DRIVE.stmc
STM32F2x	No board available at stock
STM32F3x	SDK40x-STM32303C-EVAL-MB459-Shinano-DUAL-DRIVE.stmc
STM32F4x	SDK40x-STEVAL-IHM039V1-MB459-Shinano-DUAL-DRIVE.stmc

Step #6 – Create a new WB project

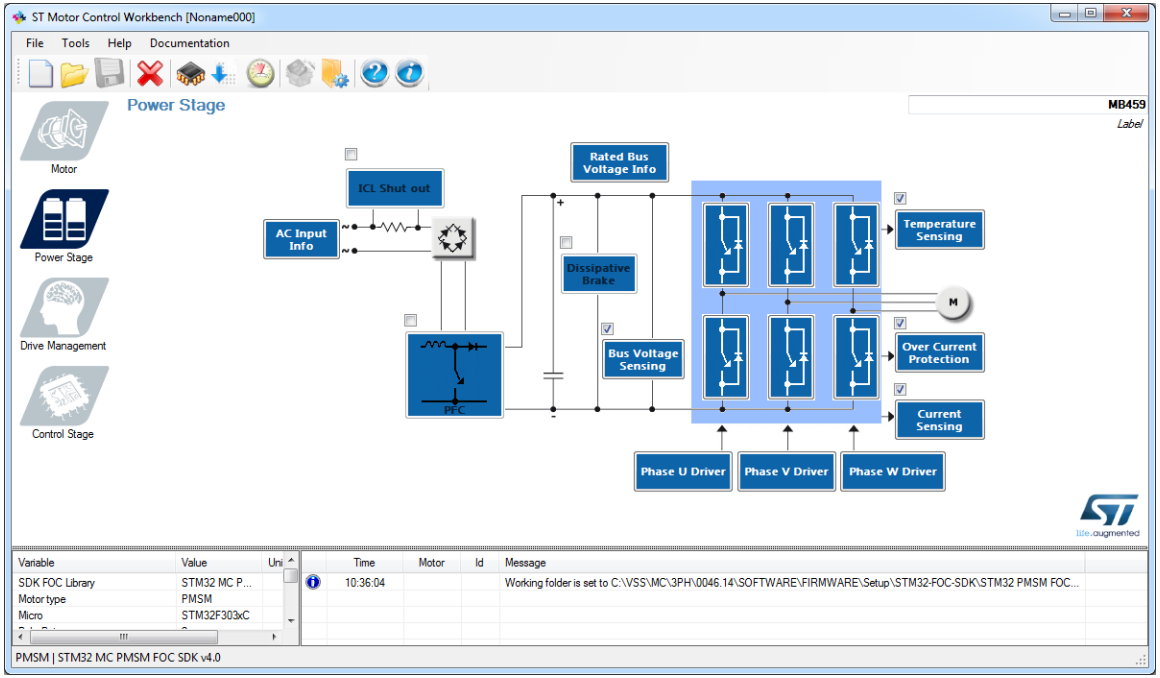
- You will be asked to choose where to save the new project.
- Save in a working folder and rename it accordingly.
- This way, all the control stage parameters will be populated with the correct values.

STM32303C-EVAL



Step #7 – Setup power stage

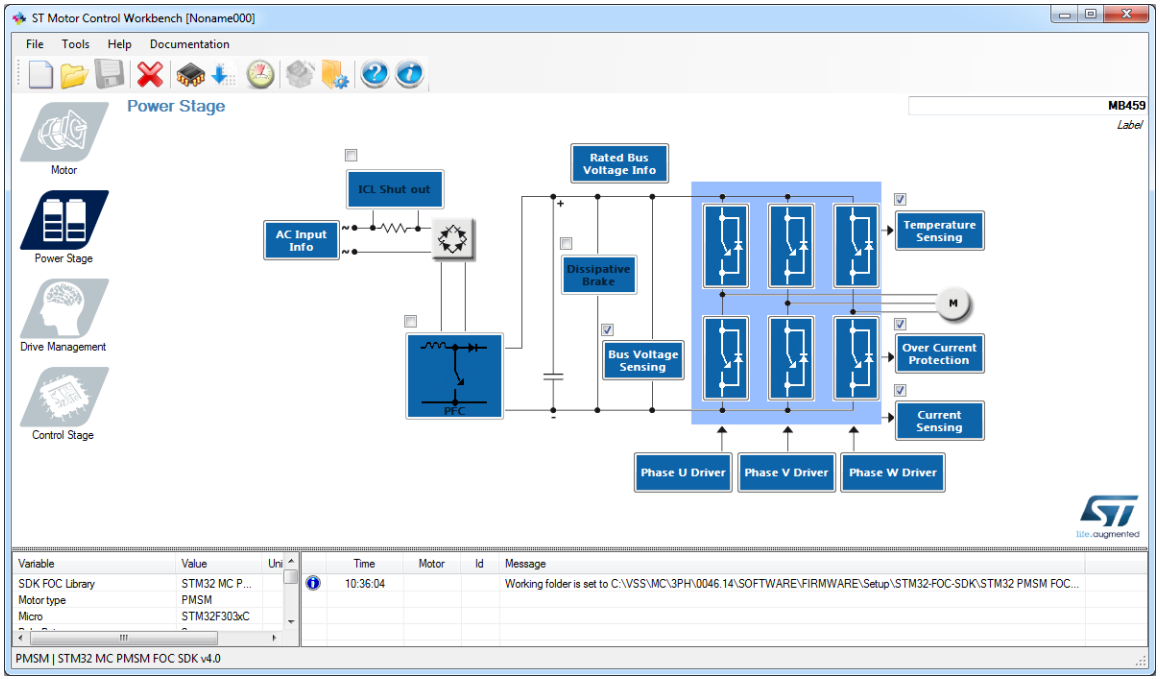
- Setup the power stage parameters according to schematic, data sheet, UM, and/or measurements.



(1) User can refer to tables of slides 11-12 for direct link on st.com.

Step #7 – Setup power stage

- What are the power stage parameters?
  - Inverter power devices: max switching frequency, min dead time.
  - Gate drivers: signal polarity, enabling signal
  - Current sensing and protection: topology, Rshunt, AOP, noise parameters
  - Bus voltage sensing: partitioning, range
  - Temperature sensing: V/T curve, range
  - AC input & PFC



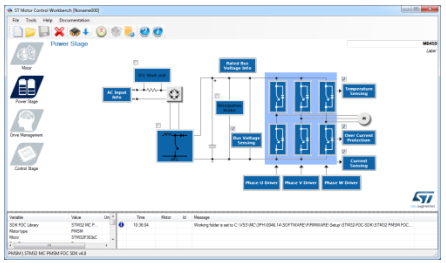
Step #7 – Setup power stage

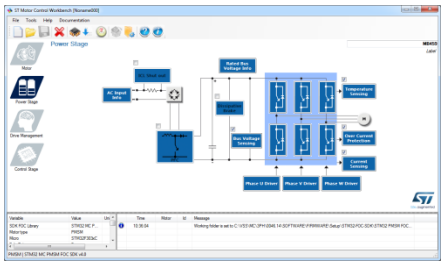
- Some power stages are already present in the WB examples, open them, create a dummy project and copy the power stage parameters from it.

Example projects

Filename
SDK40x-STEVAL-IFN003V1-Shinano.stmc
SDK40x-STEVAL-IHM022V1-MB459-Shinano-DUAL-DRIVE.stmc
SDK40x-STEVAL-IHM022V1-MB459-Shinano-SINGLE-DRIVE.stmc
SDK40x-STEVAL-IHM034V2-FMSM-SINGLE-DRIVE.stmc
SDK40x-STEVAL-IHM039V1-MB459-Shinano-DUAL-DRIVE.stmc
SDK40x-STEVAL-IHM039V1-MB459-Shinano-SINGLE-DRIVE.stmc
SDK40x-STEVAL-IHM042V1-Shinano-DUAL-DRIVE.stmc
SDK40x-STM320518-EVAL-MB459-Shinano.stmc
SDK40x-STM32100B-EVAL-IHM023V2-Shinano.stmc
SDK40x-STM32100B-EVAL-MB459-Shinano.stmc
SDK40x-STM3210B-EVAL-MB459-Shinano.stmc
SDK40x-STM3210E-EVAL-MB459-Shinano.stmc
SDK40x-STM322xG-EVAL-MB459-Shinano.stmc
SDK40x-STM32303C-EVAL-IHM045V1-Shinano-DUAL-DRIVE.stmc
SDK40x-STM32303C-EVAL-IHM045V1-Shinano-SINGLE-DRIVE.stmc
SDK40x-STM32303C-EVAL-MB459-Shinano-DUAL-DRIVE.stmc
SDK40x-STM32303C-EVAL-MB459-Shinano-SINGLE-DRIVE.stmc
SDK40x-STM324xG-EVAL-MB459-Shinano.stmc

Power stage	Picture
STEVAL-IFN003V1	
STEVAL-IHM034V2	
STEVAL-IHM042V1	
STEVAL-IHM045V1	
MB459	





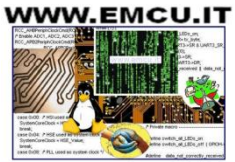
Step #7 – Setup power stage

- Other power stage data can be found here

	IHM021v2	IHM032v1	IHM025v1
Rated Bus Voltage Info			
Min rated voltage (V)	60	60	45
Max rated voltage (V)	380	450	450
Nominal voltage (V)	325	325	
Bus voltage sensing			
Bus voltage divider 1/...	125	125	136
Dissipative brake			W3 R_{brake} W3 OCPoff
Polarity			Active high
Driving signals			
Phases U, V, W High side polarity	Active high	Active hgh	Active high
Phases U, V, W Low side polarity	Active low	Active low	Active low
Temperature sensing			
V0 (mV)	1055	1055	1020
T0 (°C)	25	25	25
ΔV/ΔT (mV/°C)	22	22	23.6
Max working temperature on sensor (°C)	70	70	70

Step #7 – Setup power stage

Over current protection	IHM021v2	IHM032V1	IHM025v1
Comparator threshold (V)	0.5	0.55	0.5
Over-current network gain (V/A)	0.45	0.45	0.075
Expected over-current threshold (A)	1.11	1.22	6.25
Over-current feedback signal polarity	Active low	Active low	Active low
Over-current protection disabling network			
Over-current protection disabling network polarity	Active high		Active low
Current sensing			
Current reading topology	Three shunt	One shunt	Configurable
Shunt resistor(s) value (ohm)	0.45	0.45	0.15
Amplifying network gain	2.9	2.92	1.7
T-noise (ns)	1250	-	
T-rise (ns)	1250	1000	
Power switches			
Min dead-time	500	500	
Max switching frequency	50kHz	50kHz	



Step #7 – Setup power stage

- Other parameters can be found in the user manual of the relative power boards.
- Search the ST website for the part number of the board(1) (ex. STEVAL-IHM035V2)

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UM1517
User manual

3-phase high voltage inverter power board for FOC and scalar motor control based on the STGIPN3H60 (SLLIMM™-nano)

Introduction

The 3-phase high voltage inverter power board features the STGIPN3H60 (SLLIMM™-nano) for both field-oriented control (FOC) of permanent magnet synchronous motors (PMSM) and trapezoidal scalar control of brushless DC (BLDC) motors. Also referred to by the order code STEVAL-IHM035V2, this 3-phase inverter is designed to perform both the FOC of sinusoidal-shaped back-EMF PMSMs and trapezoidal control of BLDC m or without sensors, with nominal power up to 100 W. The flexible, open, high-perf design consists of a 3-phase inverter bridge based on:

- The STGIPN3H60 SLLIMM™-nano (small low-loss intelligent molded module) 600 V 3-phase IGBT inverter bridge
- The VIPer16 fixed frequency VIPer™ plus family

The system is specifically designed to achieve fast and accurate conditioning of t feedback, thereby matching the requirements typical of high-end applications suc oriented motor control.

The board is compatible with 110 and 230 Vac mains, and includes a power supp with the VIPer16 to generate the +15 V and the +3.3 V (or optionally the +5 V) su voltage required by the application. Finally, the board can be interfaced with the STM3210xx-EVAL (STM32 microcontroller evaluation board), STEVAL-IHM022V density dual motor control evaluation board based on the STM32F103ZE microc and with the STEVAL-IHM033V1 (control stage based on the STM32F100CB microcontroller suitable for motor control), through a dedicated connector.

Figure 1. STEVAL-IHM035V2 evaluation board

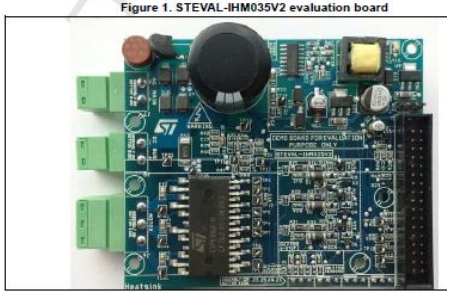

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Table 4. STEVAL-IHM035V2 motor control workbench parameters

Parameter	STEVAL-IHM035V2 default value	Unit	Parameter
ICL shut-out	Disabled		ICL shut-out
Dissipative brake	Disabled		Dissipative brake
Bus voltage sensing	Enabled		Bus voltage sensing
Bus voltage divider	125		Bus voltage divider
Min. rated voltage	40	V	Min. rated voltage
Max. rated voltage	380	V	Max. rated voltage
Nominal voltage	325	V	Nominal voltage
Temperature sensing	Enabled		Temperature sensing
V0(1)	1055	mV	V0
T0	25	°C	T0

Table 4. STEVAL-IHM035V2 motor control workbench parameters (continued)

Parameter	STEVAL-IHM035V2 default value	Unit	Parameter
ΔV/ΔT(1)	22	mV/°C	ΔV/ΔT
Max. working temperature on sensor	70	°C	Max. working temperature on sensor
Overcurrent protection	Enabled		Overcurrent protection
Comparator threshold	0.50	V	Comparator threshold
Overcurrent network gain	0.47	V/A	Overcurrent network gain
Expected overcurrent threshold	1.0638	A	Expected overcurrent threshold
Overcurrent feedback signal polarity	Active low		Overcurrent feedback signal polarity
Overcurrent protection disabling network polarity	Active low		Overcurrent protection disabling network polarity
Current reading topology	One shunt resistor		Current reading topology
Shunt resistor(s) value	0.47	Ω	Shunt resistor(s) value
Amplifying network gain(2)	2.91		Amplifying network gain
T-rise	1000	ns	T-rise
Power switches min. deadtime	1500	ns	Power switches min. deadtime
Power switches max. switching frequency	50	kHz	Power switches max. switching frequency
U,V,W driver high-side driving signal	Active high		U,V,W driver high-side driving signal
U,V,W driver low-side driving signal complemented from high-side	Disabled		U,V,W driver low-side driving signal complemented from high-side
U,V,W driver low-side driving signal polarity	Active low		U,V,W driver low-side driving signal polarity
Overcurrent protection disabling network polarity	Active low		Overcurrent protection disabling network polarity
Current reading topology	One shunt resistor		Current reading topology

1. These values are computed for V_{st_micro} = 3.3 V. If the V_{st_micro} = 5 V, the values are V0 = 1600 m V, ΔV/ΔT= 34 mV/°C.
2. Amplifying network gain = 12 for trapezoidal drive. See Section 8.4.1.

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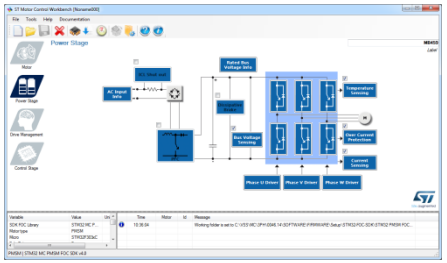
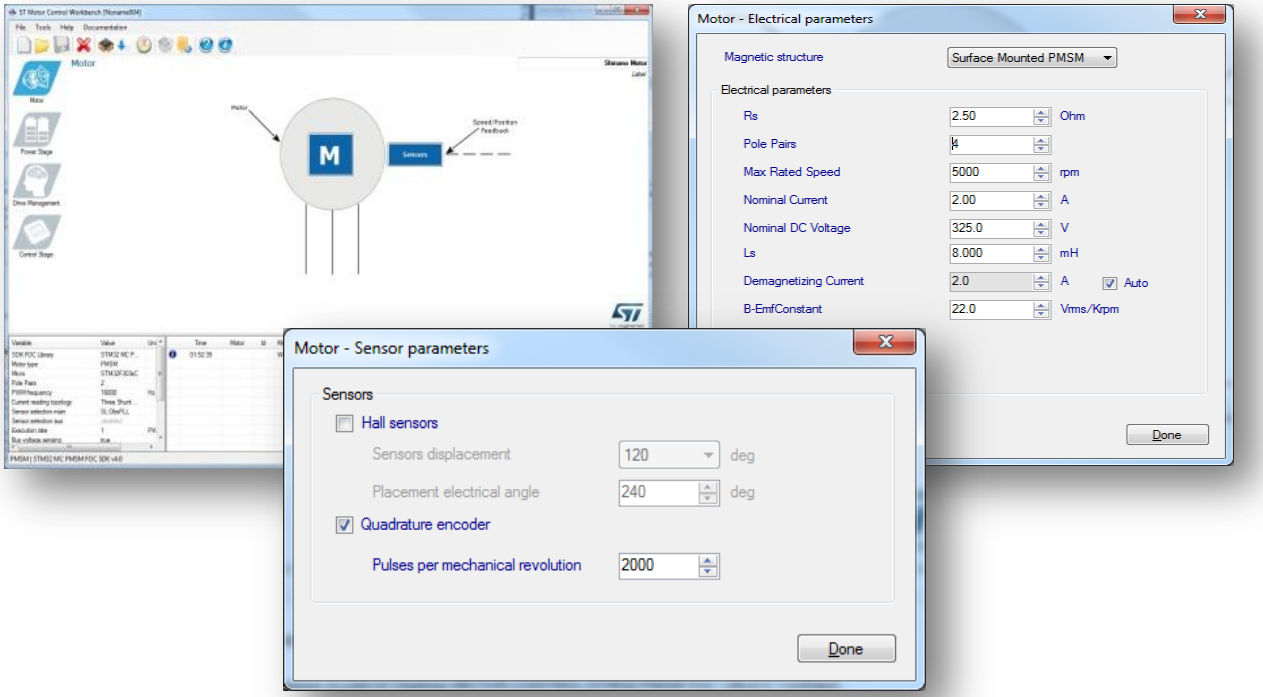


(1) User can refer to tables of slides 11-12 for direct link on st.com.

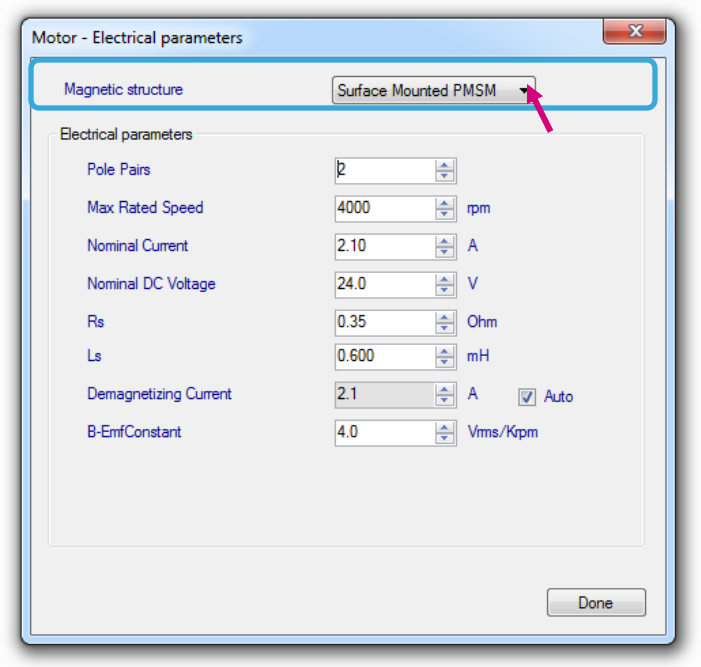
Step #8 – Setup motor parameters

- 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.



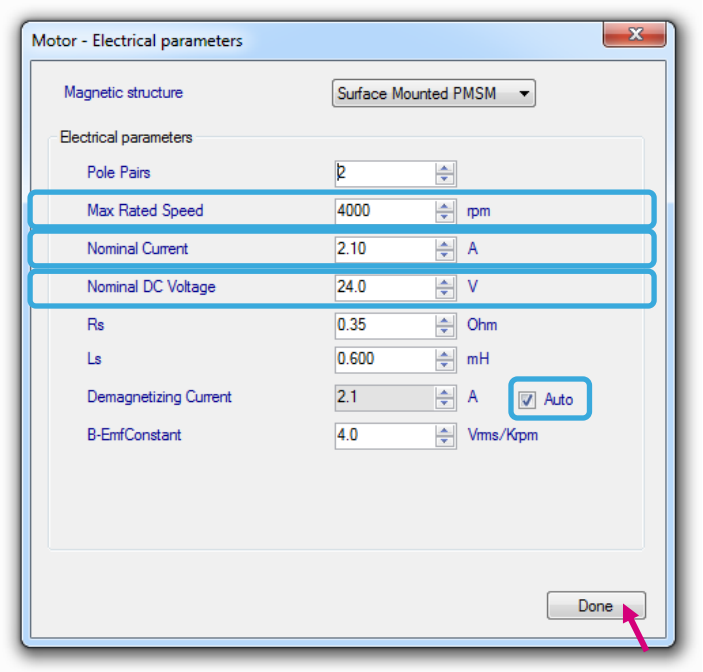
Step #8 – Setup motor parameters

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



Step #8 – Setup motor parameters

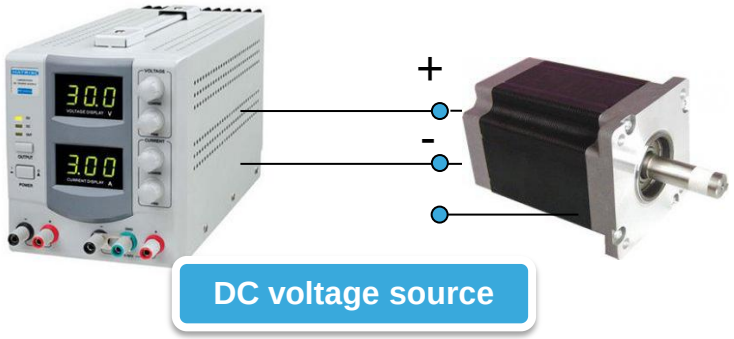
- Set *Max Rated Speed* with max speed of the motor according the specs of the application.
- Set *Nominal Current* with max peak current provided to each of the motor phases according the specs of the motor.
- Set *Nominal DC Voltage* with value of DC bus provided to the inverter or the rectified value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

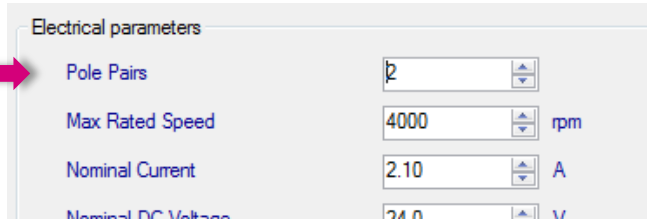


Step #8 – Setup motor parameters

Pole pairs 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.

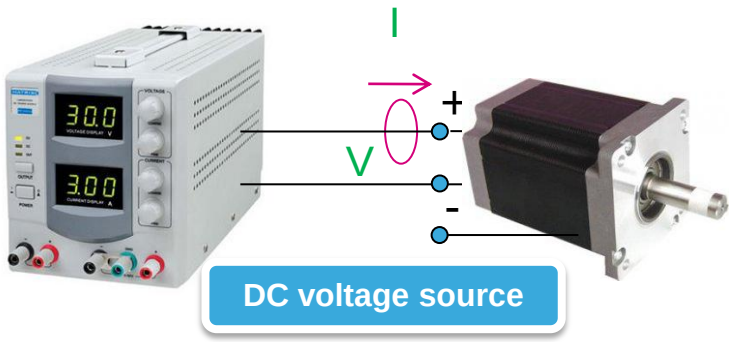




Step #8 – Setup motor parameters

Stator resistance and inductance

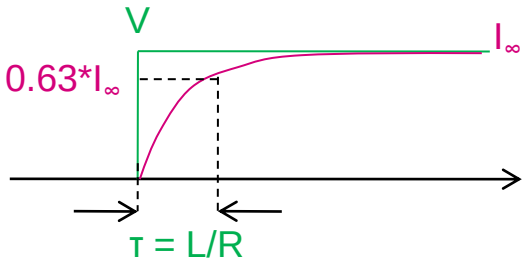
- Using the multimeter, measure the DC stator resistance phase-to-phase (Rs) and divide it by two.
- Connect DC voltage between two motor phases.
- Connect oscilloscope voltage and current probes as shown in the figure.
- Increase the voltage up to the value where the current equals the nominal value,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



Step #8 – Setup motor parameters

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 like $I_\infty * (1-e^{- t *L/R})$.
- 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.



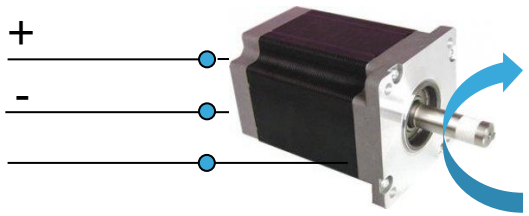
Step #8 – Setup motor parameters

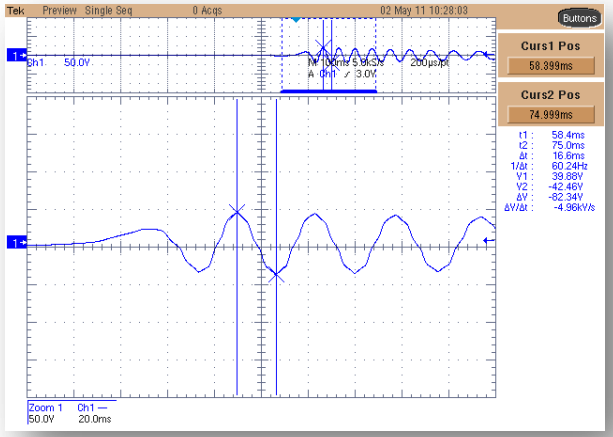
BEMF constant Ke

- The B-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})



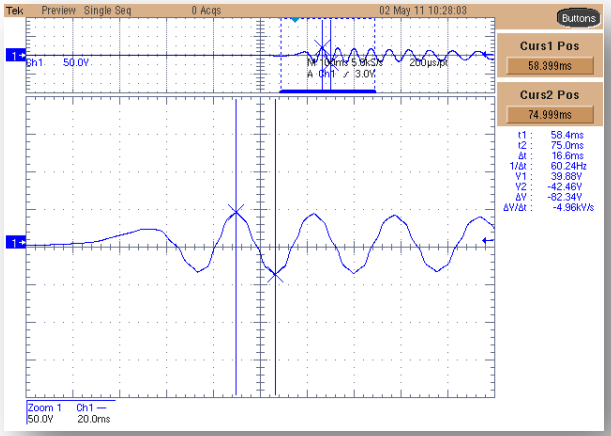


Step #8 – Setup motor parameters

BEMF constant Ke

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

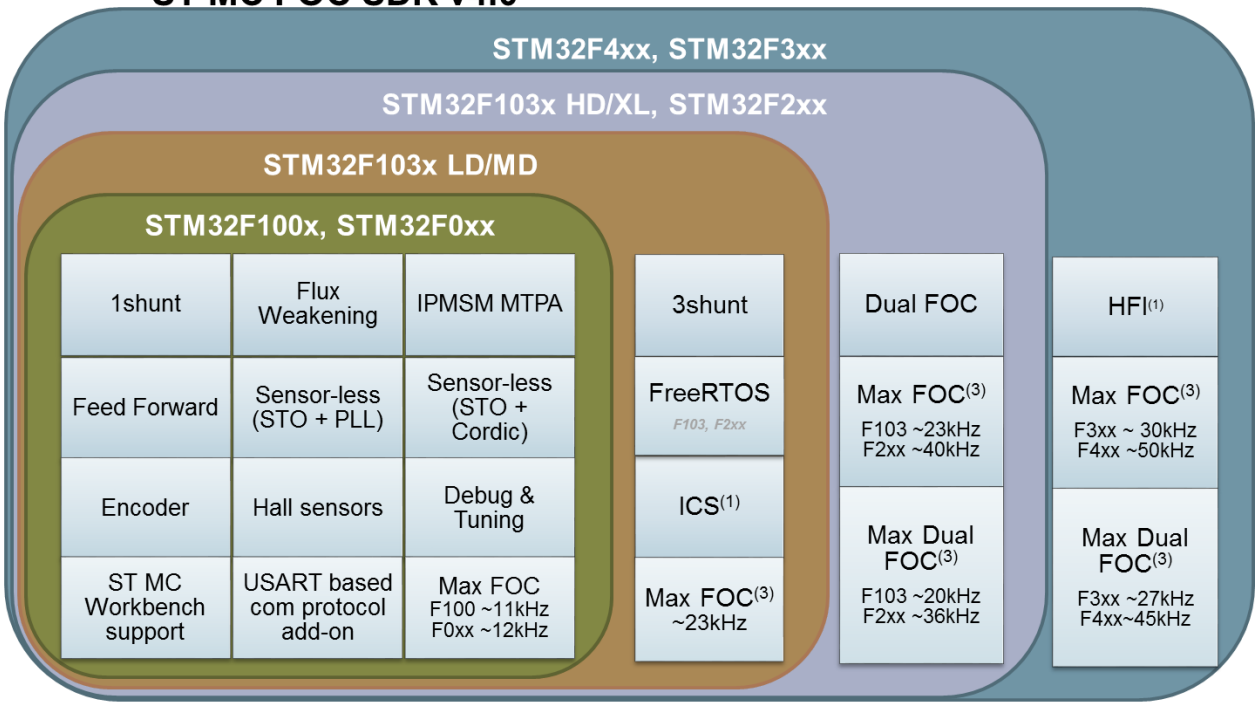
$$K_e = \frac{V_{Bemf-A}\ [V\ peak-to-peak] \cdot pole\ pairs\ number \cdot 1000}{2 \cdot \sqrt{2} \cdot f_{Bemf}\ [Hz] \cdot 60}$$



Step #9 – Setup drive parameters

- The list of initial settings should be as follows (leave default values unless otherwise specified here):
  - In Speed/position feedback management, select the main speed sensor to be used.
  - In Drive settings choose a proper 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 max FOC rate according to the microcontroller used.

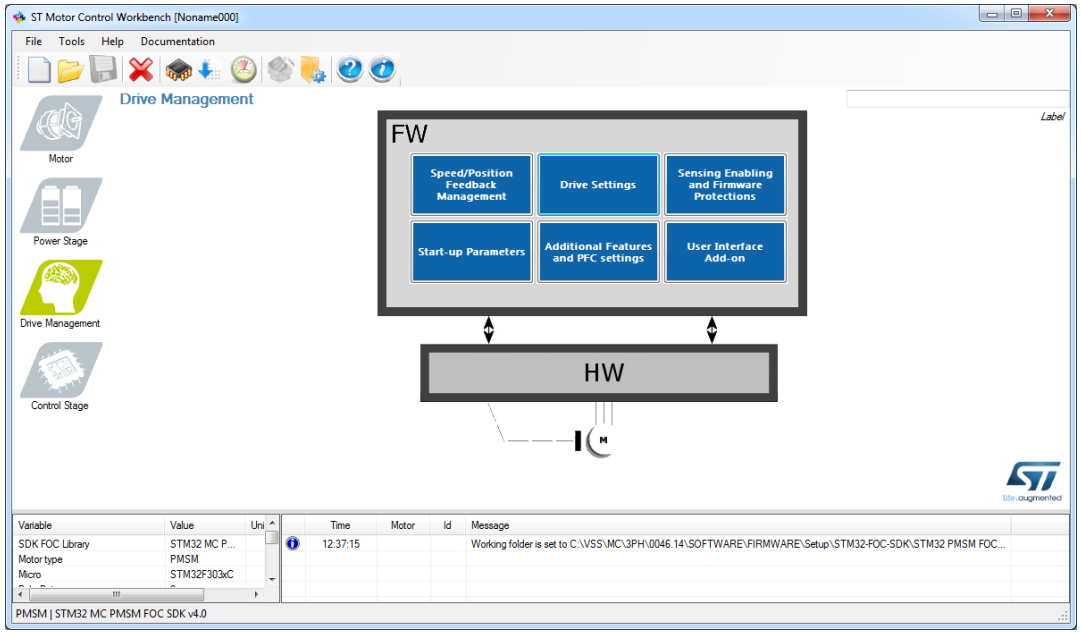
ST MC FOC SDK v4.0



(1) High Frequency Injection
(2) F1, F2, F4
(3) Max FOC estimated in sensorless mode

Step #9 – Setup drive parameters

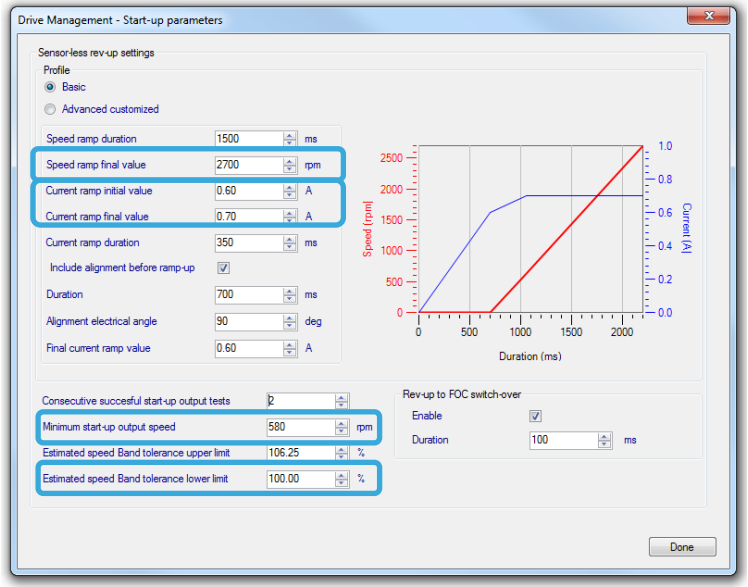
- In Drive settings, decrease Cut-off frequency of torque and flux regulator down to 2000 rad/s if power stage → current reading topology is single shunt.
- In Sensing enabling and FW protections, uncheck those sensing not supported by power stage and check any “Set intervention threshold to power stage 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 #9 – Setup drive parameters

- In start-up parameters, check 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)

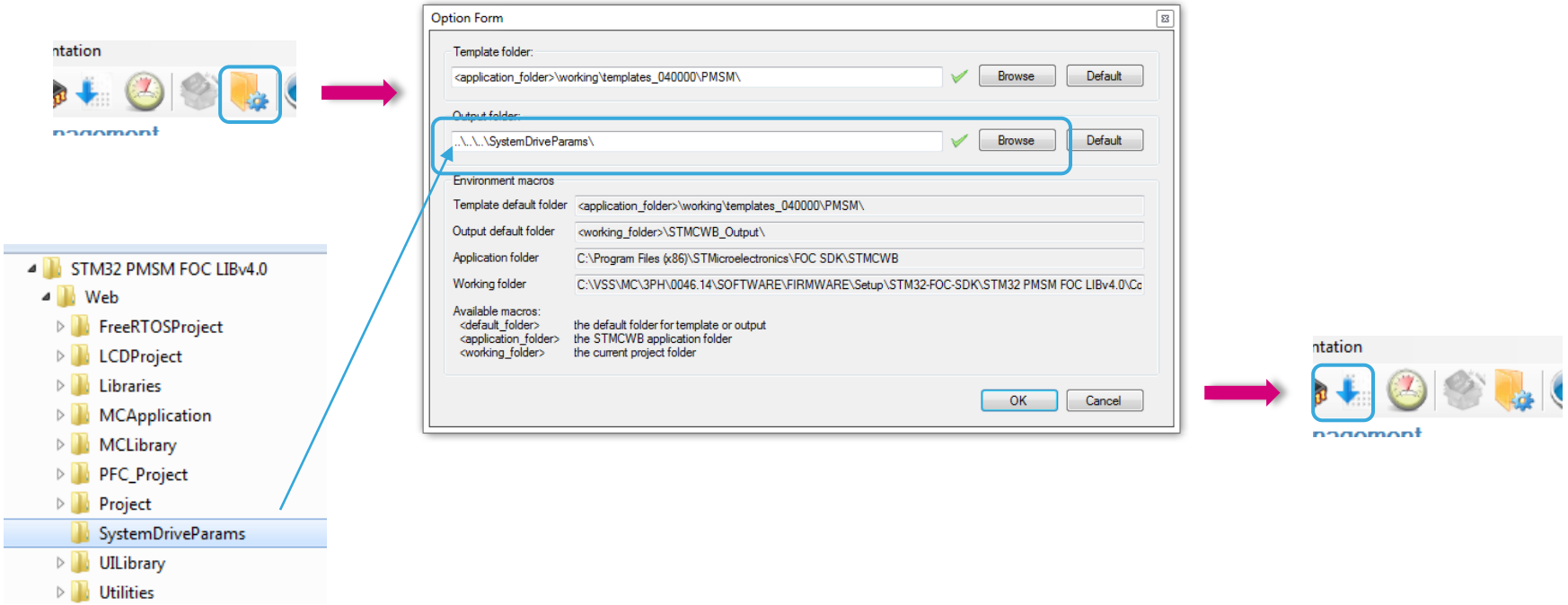
Basic



Generate, Compile, Debug and Run

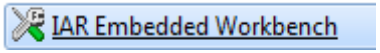
Step #10 – Parameter generation

- 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.

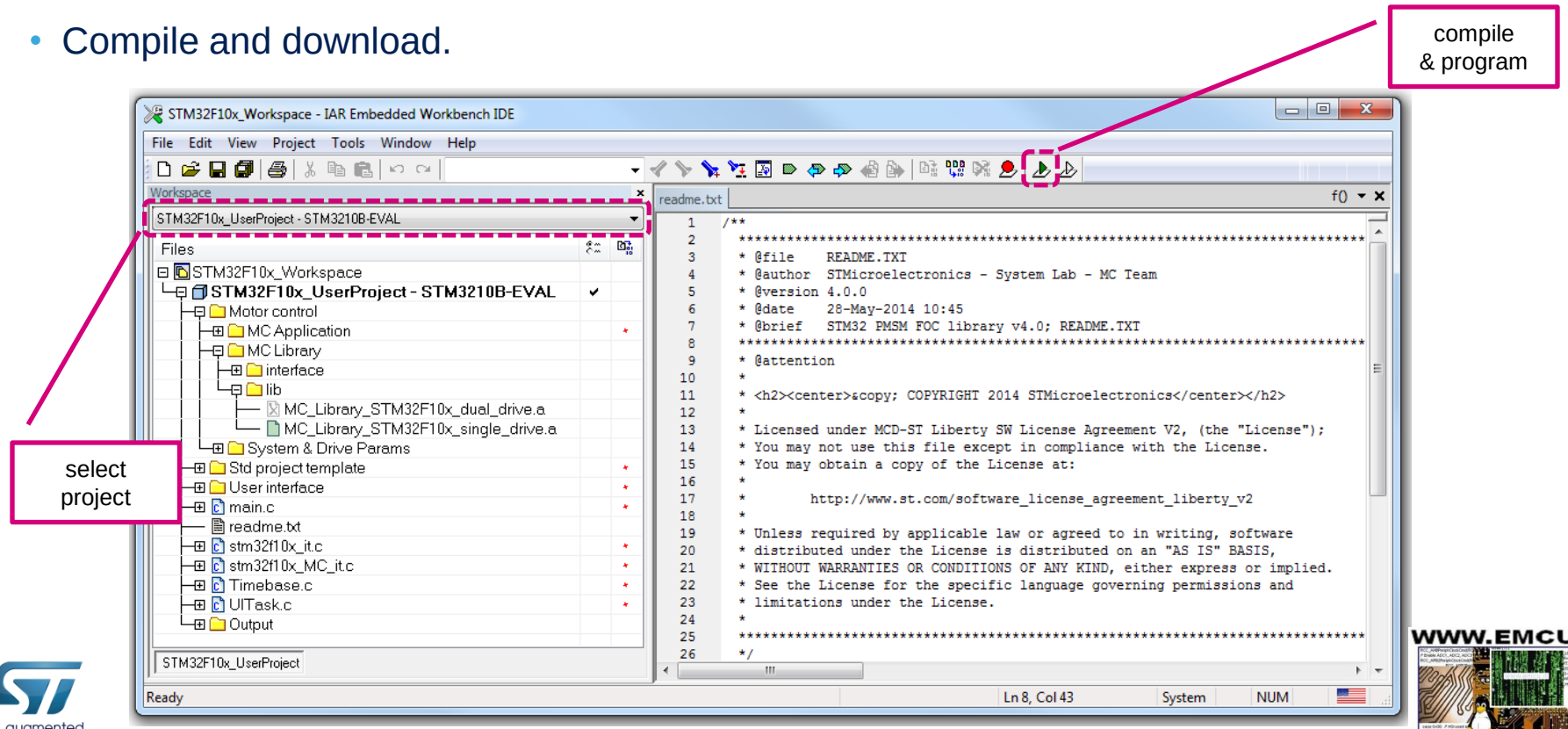


Step #11 – Compile and program the micro

- Run the IAR Embedded Workbench.



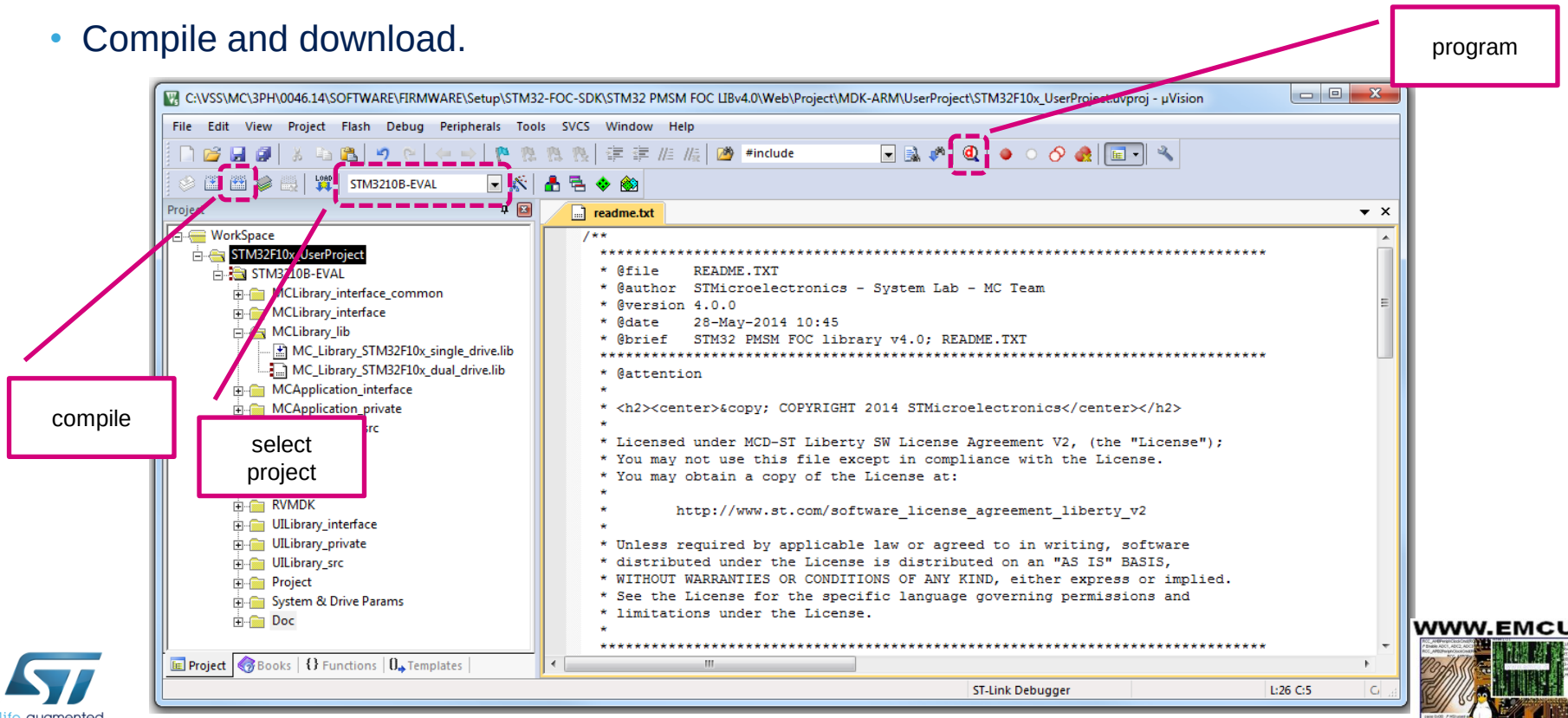
- Open the IAR workspace (located in Project\EWARM) folder according to the microcontroller family (e.g. STM32F10x_Workspace.eww for STM32F1).
- Select the correct user project from the drop-down menu according to the control stage used (e.g. STM32F10x_UserProject - STM3210B-EVAL).
- Compile and download.



Step #11 – Compile and program the micro

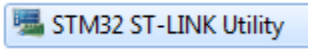
- Optionally, run Keil uVision.

- 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.

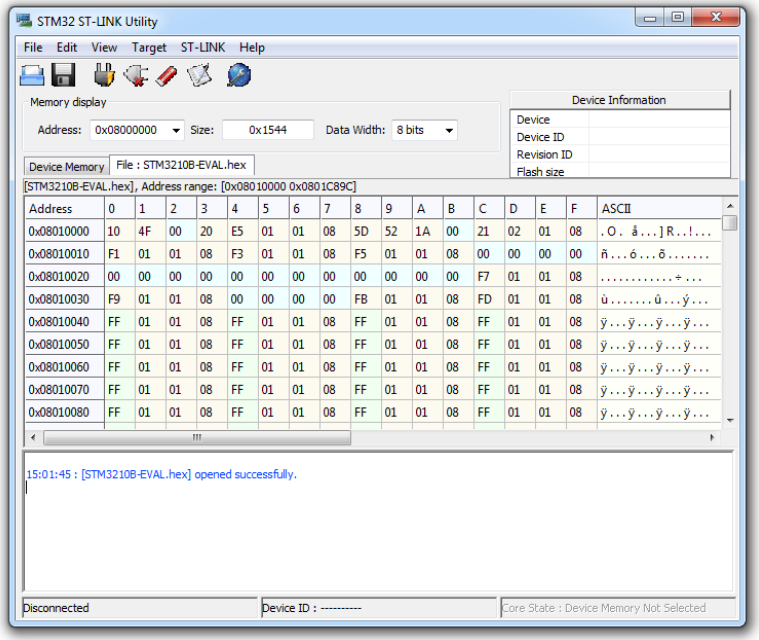


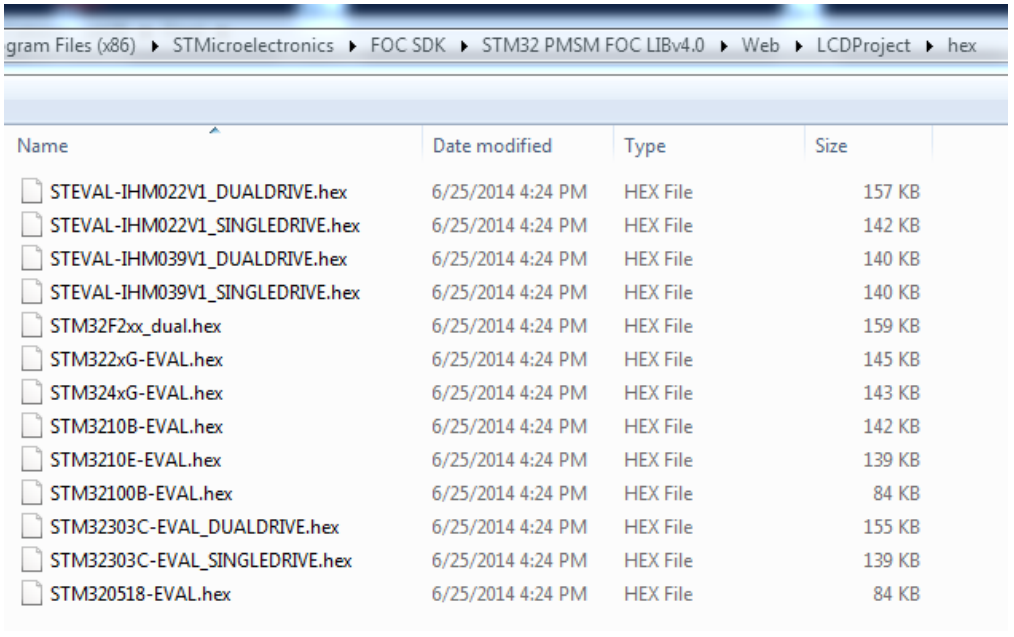
Step #12 – Program LCD FW

- Run the ST-LINK Utility.



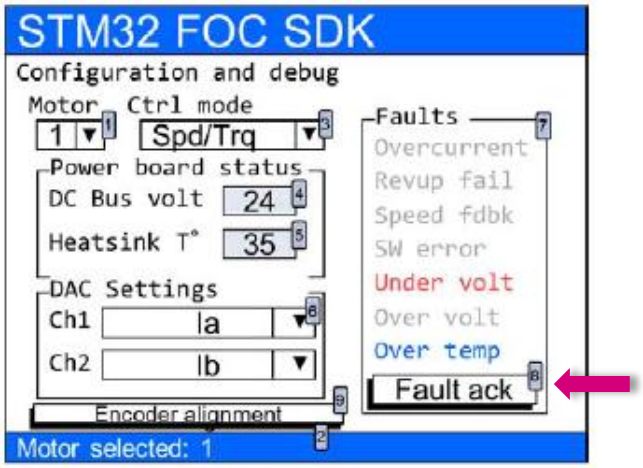
- File → Open file… and select the .hex file (located in LCDProject\hex) according to the control stage used (e.g. STM3210B-EVAL.hex).
- Target → Program…

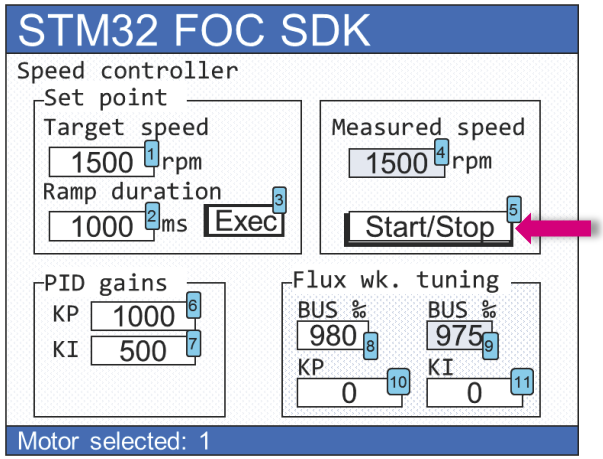




Step #13 – Run the motor

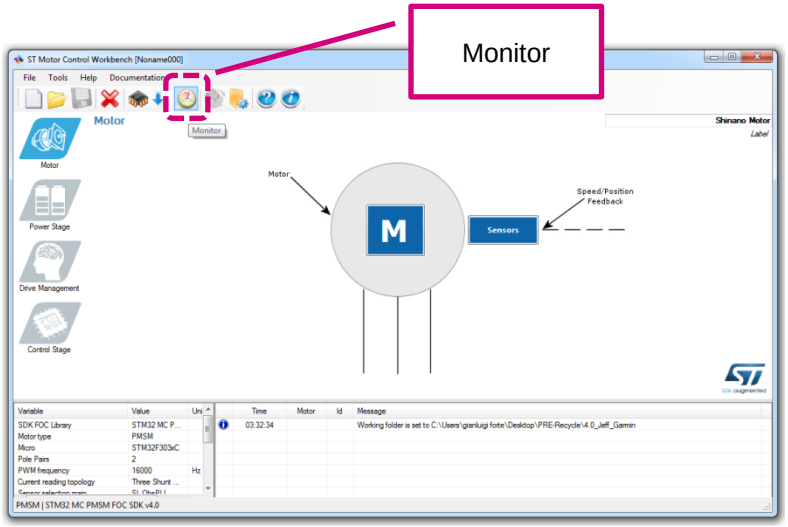
- Arrange the system for the run:
  - Connect the control board with the power board using the MC Cable.
  - Connect the motor to the power board.
  - Connect the power supply to the power board and turn on the bus.
- If the board is equipped with the LCD:
  - Press joystick center on *Fault Ack* button 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.

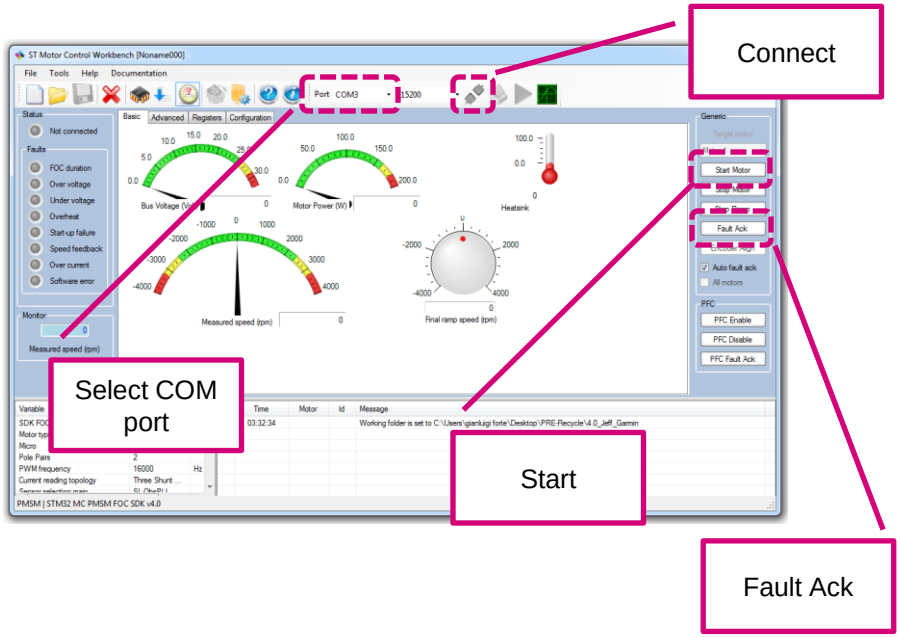




Step #13 – Run the motor

- Optionally you can start the motor using the ST MC Workbench.
- Connect the PC to the control board with the USB to RS232 dongle (and a null modem cable).
- Open the Workbench project used to configure the FW 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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STM32
STM32 Motor Control

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