Quick Start Guide
Motor Control ToolKit for SPC5Studio

Quick guide to set up HW and SW kit and run demo application

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Overview

1. Introduction to the Motor Control Toolkit
2. Unbox the SPC5 Motor Control ToolKit SPC5-MCTK-01
3. Setup, configure SW and run demo example
4. Documents & Related Resources

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Motor control ToolKit

1 Introduction to the Motor Control Toolkit

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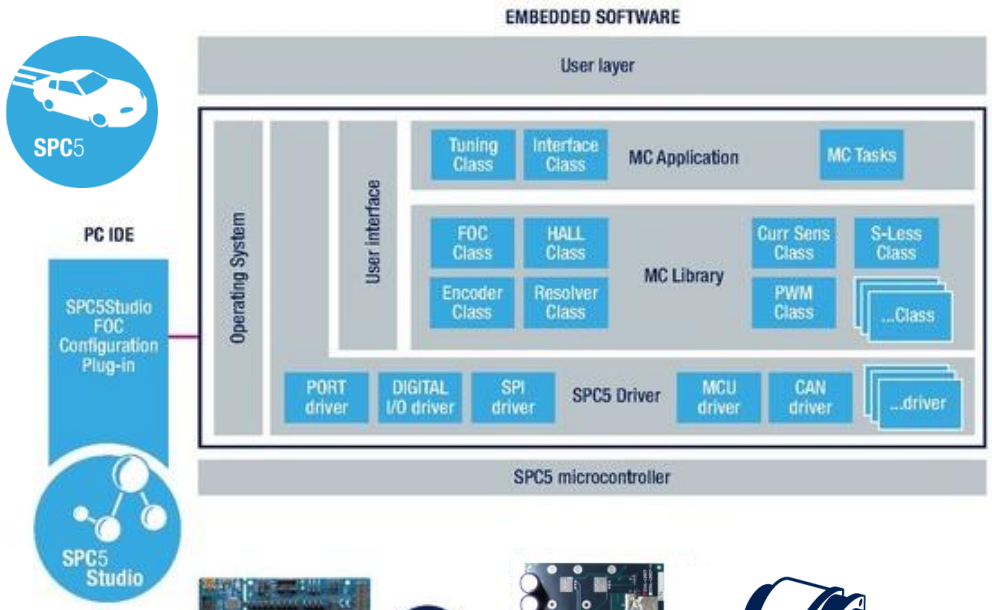
What is SPC5-MCTK

- It is a development kit based on automotive Grade SPC5 microcontroller, to control 3-phase Permanent Magnet Synchronous Motors:
  - Easy to configure and monitor
  - Very flexible and customizable
  - Minimize the customer support effort
  - Reduced FW re-work time when moving from evaluation kits to final customer's production HW
  - FW structure easy to be ported on different SPC5 microcontroller
  - Integrated into a SPC5Studio software development environment ready for further customer improvement

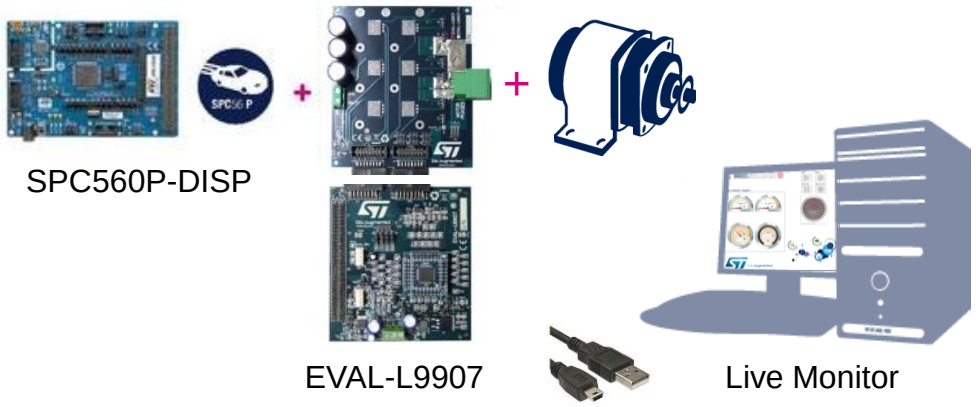
- Available kit
  - with SPC560P-DISP discovery Platform and L9907-EVAL kit

- Firmware Library Based on Field Oriented Control (FOC)
  - Sensored and Sensorless support
  - Two shunt / ICS and one shunt topologies

SPC5-MCTK at the glance



- **Motor Control Tool Kit key elements**
  - SPC5 FOC Lib Configuration through SPC5Studio plug-in
  - Embedded Software Library (SPC5-MCTK-LIB) implementing FOC control
  - SPC560P-DISP Micro board
  - EVAL-L9907 Power Board
  - BLDC Motor with HALL sensors
  - Wizard for Demo application project
  - External Live Monitor running on PC using serial and Can (additional HW required)



Supported Features

- Demo Kit with P-Line + L9907
  - Equipped with Nanotec DF45 BLDC motor
    - Validated with several others motors

- Supported Sensors
  - Hall sensors
  - Encoder
  - Resolver (alpha)
  - Sensor-less

- Control Algorithms
  - Single Vector FOC algorithm
  - Torque and Speed control
  - MTPA, Flux Weakening and Feed Forward technics

- Library is deployed as SPC5Studio component
  - Library Configuration tool available into Motor Control Component
  - Dedicated SPC5Studio components for L9907, L99ASC03 and STGAP1AS
  - Update site with Motor control component available

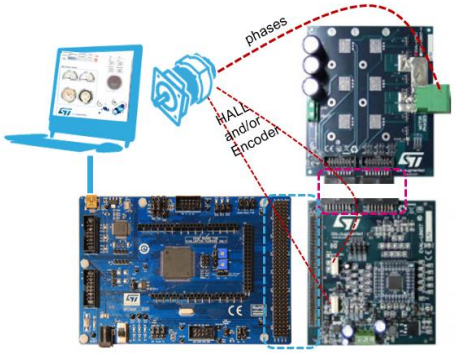
- SPC5 MCU initialization provided via SPC5Studio
  - drivers/pin wizard/clock tree/IRQ initialization

- Supported Compiler:
  - Green Hills
  - HighTec
  - Free GCC

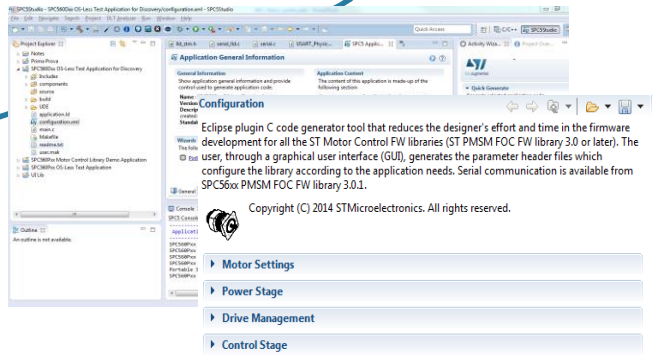
- Current Sensing
  - Two shunts current measurements on motor phases or inverter legs
  - One shunt

- Configuration/UI
  - SPC5Studio motor control component configuration to adapt library to customer motor, topology and application
  - SPC5 motor control live monitor tool to tune on fly library parameters

- Power stage configuration
  - SPC5Studio L9907 component to Decoupling uC and Power
  - L9907 Fault management configuration
  - L99ASC03 smart driver support
  - STGAP1AS insulated gap driver support



Hardware Demo Kit



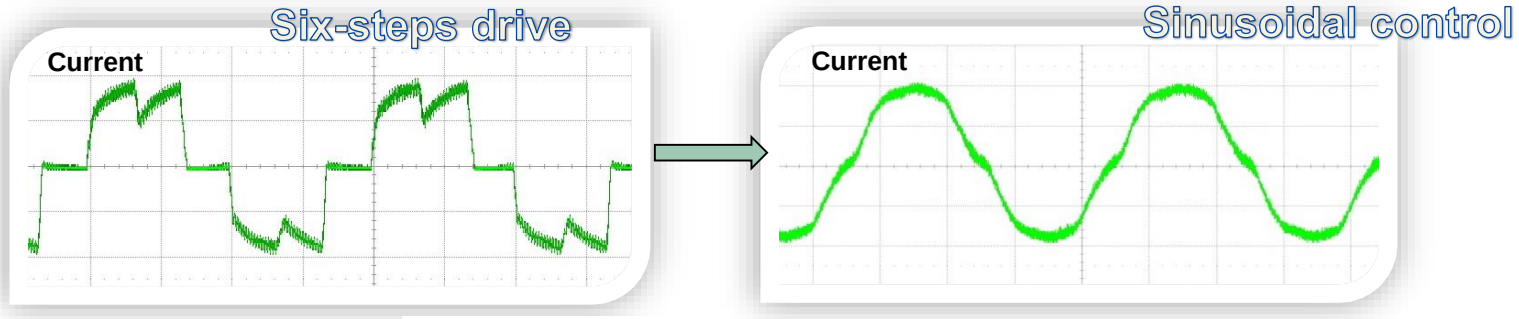
SPC5Studio configuration component

SPC5 Motor Control Live Monitor

FOC single/dual motor for automotive applications

- **Target applications:**
  - All those low voltage automotive applications where:
    - Automotive requirements
    - Accurate and quick regulation of motor speed and/or torque is required
    - CPU load granted to motor control must be low, due to other duties
    - Quietness of sinusoidal current control (vs six steps drive) is valuable
    - Extended speed range is required
  - Particularly suitable for **traction**, **pumps, HVAC,..**

SPC560P
SPC56EL



- More silent
- Lower torque ripple
- Extended speed range easier to be achieved

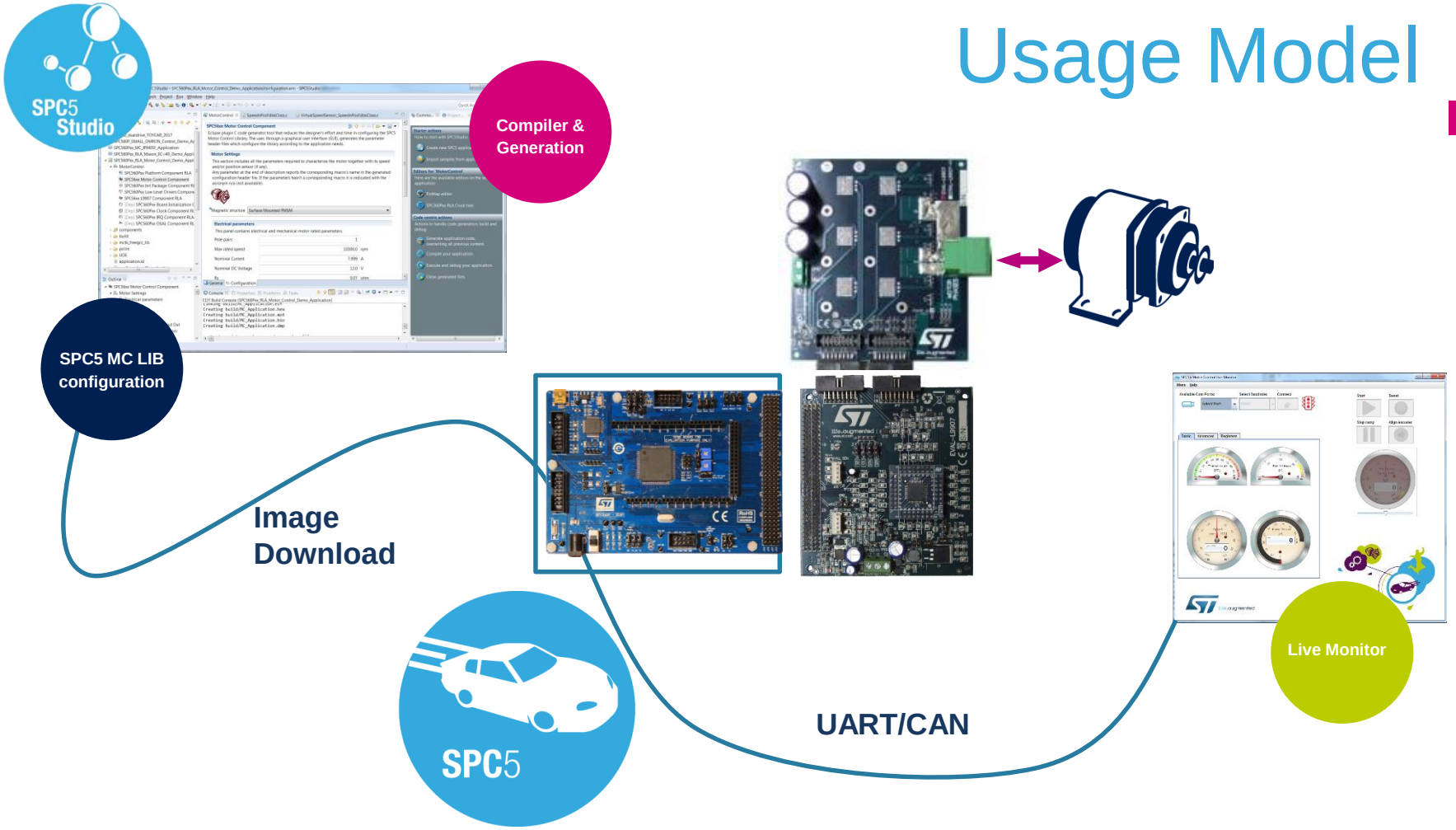
What you'll find on st.com page

- Software:
  - SPC5 Motor Control Live Monitor
    - Executable installation file
  - Motor Control Binary Image
    - the same/update provided built in with kit
  - Web Motor Control Update Site for SPC5Studio
    - It installs the SPC5Studio Web Motor Control component
    - This provides configuration plugin with binary of the library
    - That's allow customer to configure the library and change the motor
  - Demo Application for SPC5Studio
    - Based on the SPC5Studio Web Motor Control component

- Documentation:
  - Data brief
  - Quick Start Guide
  - Video Tutorial
  - User Manual (inside the SPC5Studio plugin)
  - General Presentation

Source code delivered on via FTP upon request to ST regional representative

Usage Model



- Once the HW and SW are configured, use the SPC5Studio motor control configuration component for a complete and easy customization of the Motor Control library
- Generate, compile and program the binary image on the HW board
- Connect live Monitor via UART, to interact with the motor control library running on MCU, to start, stop, change reference speed, …

Setup and Configure HW parts

1 Introduction to the Motor Control Toolkit

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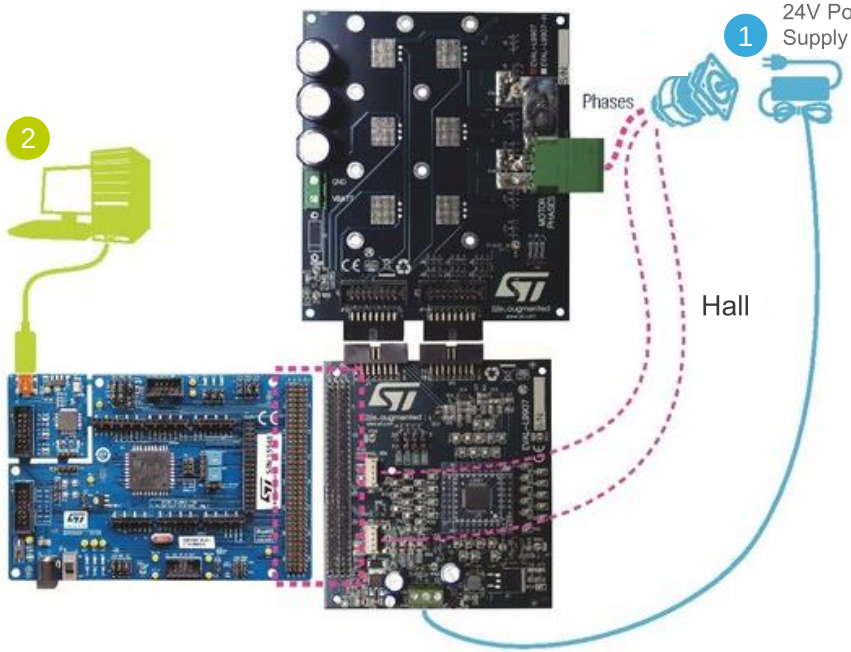
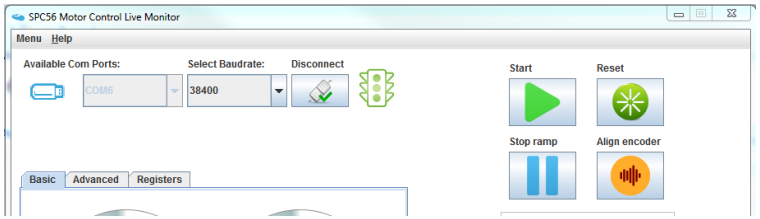
Unbox and run the MCTK

Windows Laptop/PC 24V, 3A Power Supply



1. Connect the power supply to EVAL-L9907 board and check the LEDS on it are ON
2. Connect the microcontroller board to a PC or USB charger via USB cable provided with the Kit.
3. Get SPC5 Live Monitor binary installer package from st.com and Install SPC5 Live Monitor on a Windows PC. Install JtagUsbDriver to enable virtual COM over USB



The kit is provided with a built in software image, so customer can power up the system and see the motor spinning

Software Setup and Demo example

1 Introduction to the Motor Control Toolkit

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Software Setup in 6 steps

1

Get SPC5Studio and documentation from
www.st.com/spc5studio or
www.spc5studio.com

Install SPC5Studio by
reading carefully installation procedure
and additional document and tutorials

2

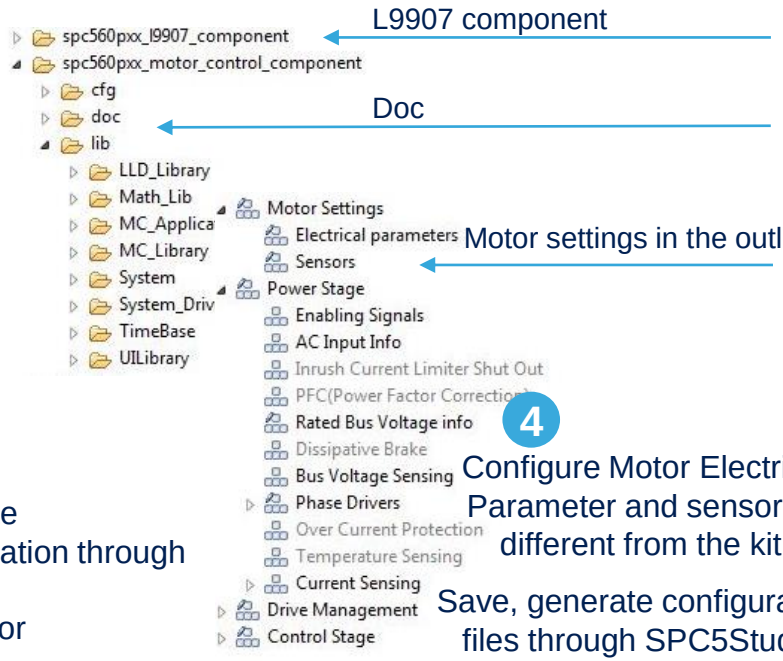
Get Motor Control SW package
(ask ST regional office):

- **MotorControlUpdateSite**
- **Live Monitor Installer**

3

1) Install Motor Update Site
2) Import the Demo Application through the SPC5Studio wizard
3) Install SPC5 Live Monitor

Motor Control Component Structure



4

Configure Motor Electrical Parameter and sensors if different from the kit.

Save, generate configuration files through SPC5Studio activity wizard

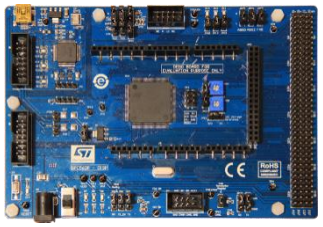
Compile through SPC5Studio activity wizard

5

Download binary to target board via Debug tool
(UDE 4.8 or Lauterbach)

6

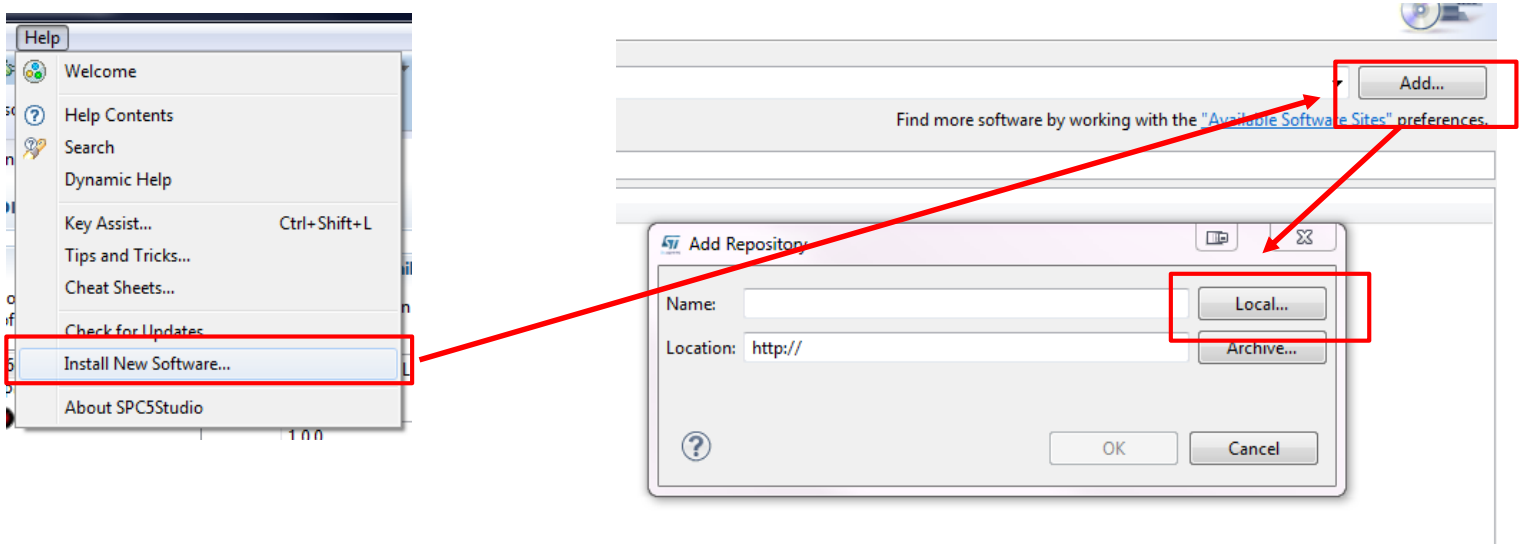
Connect Live Monitor (set baud rate to 38400) and play with motor
Alternatively SPC5-CONNECT converter can be used in case of CAN communication*



*) to use Live Monitor make sure to have selected UI enabled into Drive Setting -> User Interface

Step 3 - Install update site into SPC5Studio

- Unzip the content of the update site in one directory of your choice
- ***Go to Help → Install New Software → Add → Local… →***
- Select the directory where you un-zipped the update site and press OK
- Follow the on-screen instructions
  - Select Motor Control ToolKit
  - Read License Agreement and Accept

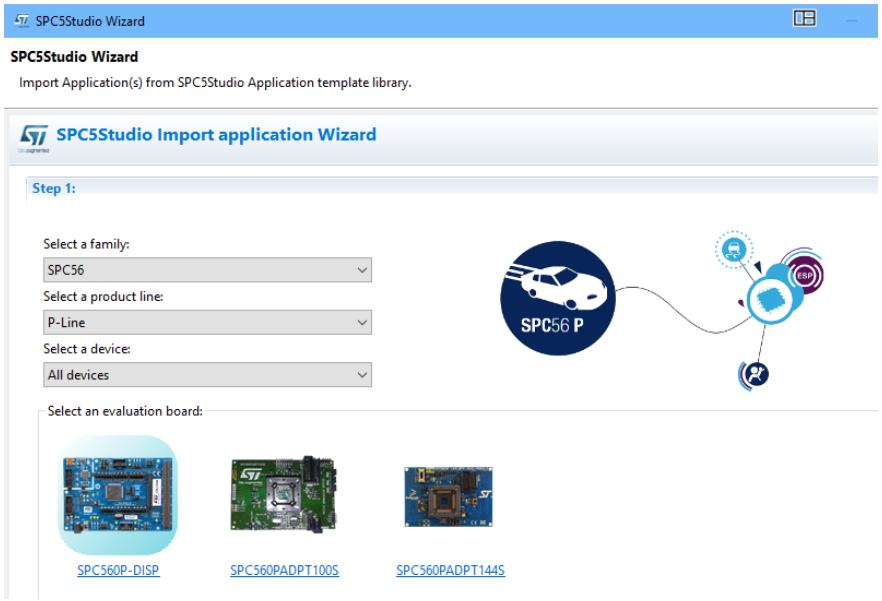


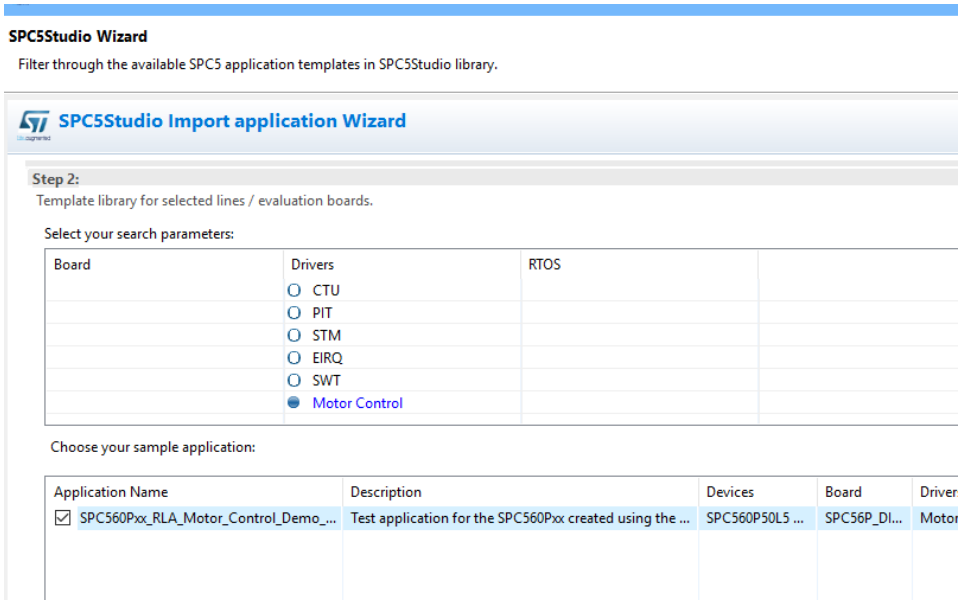
- Exit from SPC5Studio and Start it again

Step 3 - Import the demo application though SPC5Studio wizard

- Click on “SPC5Studio wizard” button on main bar menu

- Select **SPC56** as family, P-Line as product line, and then select SPC560P-DISP as evaluation board
- select “Motor Control” in search parameter and then “SPC560Pxx_RLA_Motor_Contr…” Demo application and click finish

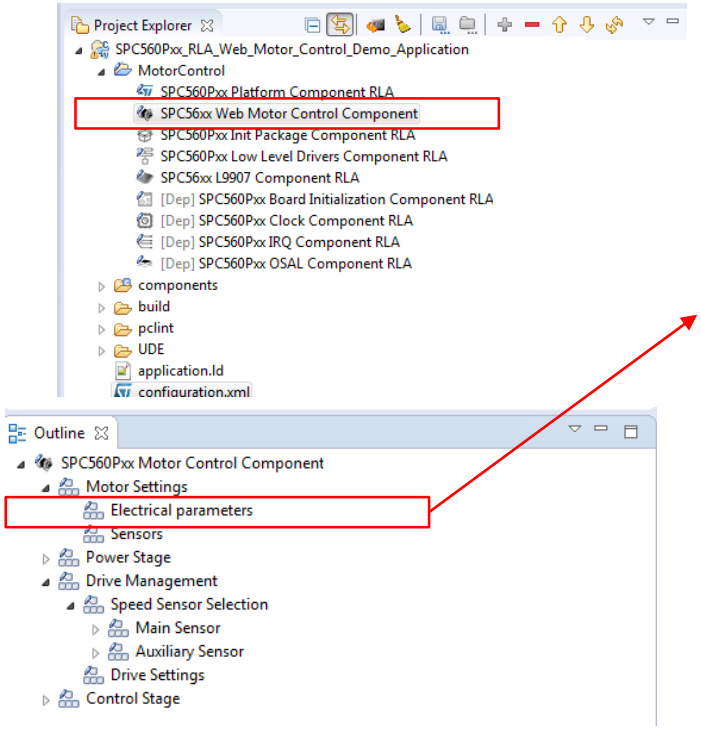


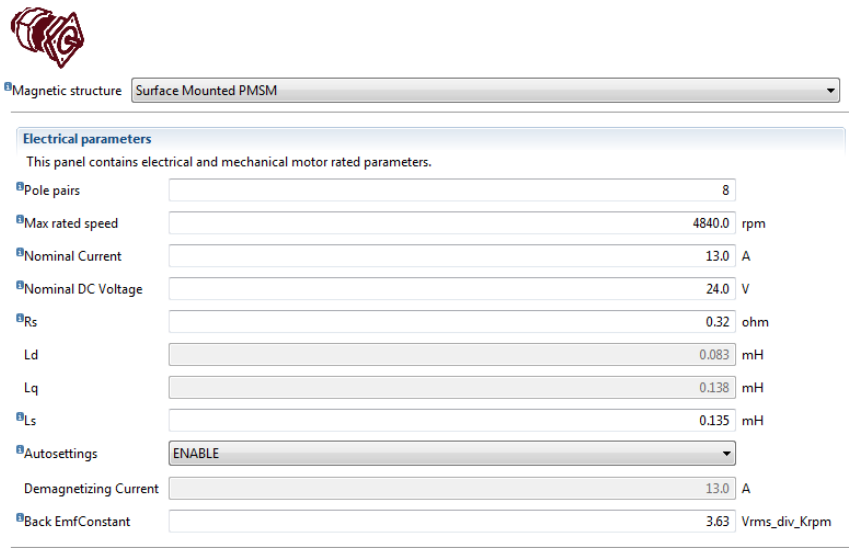


Step 4 - Configure Motor Control Component: Electrical Parameter

Demo Application is preconfigured to run on Nanotec DF45. Configuration can be customized to fit customer application.

- select “Web Motor Control Component” down to the Application name in the demo application.
- configure **Motor Settings** tabs from Outline box (down left SPC5Studio tool corner) to configure the library





Step 4 - Motor configuration example for the Nanotec DF45L024048-A2 starting from the motor datasheet

SPECIFICATION \ CONNECTION	STAR
NO. OF POL./PHASE	16/3
VOLTAGE RATED (VDC)	24
NO LOAD CURRENT (A)	<0.5
CURRENT RATED/PEAK (A)	3.26/9.5
RESISTANCE/PHASE TO PHASE (Ohms) @20°C	0.64 ±10% ⚠
INDUCTANCE/PHASE TO PHASE (mH) @1KHz	0.27 ±20% ⚠
TORQUE RATED/PEAK (Nm) [lb-in]	0.13/0.39 [1.15/3.45]
TORQUE CONSTANT (Nm/A)	0.0369 ⚠
POWER RATED (W)	65
SPEED RATED/NO LOAD (RPM)	4840/6100
ROTOR INERTIA (Kg-m²) [lb-in²]	1.81x10⁻⁵ [0.0618]
WEIGHT (Kg) [lb]	0.15 [0.33]
TEMPERATURE RISE: MAX.80°C	
AMBIENT TEMPERATURE -20°~ 50°C ⚠	
INSULATION RESISTANCE 100 MOhm (UNDER NORMAL TEMPERATURE AND HUMIDITY	
INSULATION CLASS B 130° [266°F]	
DIELECTRIC STRENGTH 500VAC FOR 1 MIN. (BETWEEN THE MOTOR COILS AND THE MOTOR CASE	
AMBIENT HUMIDITY MAX. 85% (NO CONDENSATION)	

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Step 4 - Motor configuration example for the Maxon Motor EC 40 starting from the motor datasheet

Motor Datasheet

			167176
Motor Data			
	Values at nominal voltage		
1	Nominal voltage	V	12
2	No load speed	rpm	10300
3	No load current	mA	886
4	Nominal speed	rpm	9050
5	Nominal torque (max. continuous torque)	mNm	107
6	Nominal current (max. continuous current)	A	10.4
7	Stall torque	mNm	985
8	Starting current	A	89.2
9	Max. efficiency	%	81
	Characteristics		
10	Terminal resistance phase to phase	Ω	0.134
11	Terminal inductance phase to phase	mH	0.0266
12	Torque constant	mNm/A	11.0
13	Speed constant	rpm/V	865
14	Speed/torque gradient	rpm/mNm	10.5
15	Mechanical time constant	ms	9.39
16	Rotor inertia	gcm²	85.0

Specifications			**Opera**
	Thermal data		n [rpm]
17	Thermal resistance housing-ambient	3.2 K/W	
18	Thermal resistance winding-housing	1.2 K/W	
19	Thermal time constant winding	17.1 s	
20	Thermal time constant motor	1050 s	
21	Ambient temperature	-20…+100°C	
22	Max. permissible winding temperature	+125°C	
	Mechanical data (preloaded ball bearings)		
23	Max. permissible speed	18000 rpm	
24	Axial play at axial load < 8 N	0 mm	
	> 8 N	max. 0.14 mm	
25	Radial play	preloaded	
26	Max. axial load (dynamic)	7 N	
27	Max. force for press fits (static)	133 N	
	(static, shaft supported)	5000 N	
28	Max. radial loading, 5 mm from flange	70 N	
	Other specifications		
29	Number of pole pairs	1	Planet
30	Number of phases	3	Ø42 m
31	Weight of motor	390 g	3 - 15 N

18000
12000
6000

SPC5Studio

Application/configuration.xml - SPC5Studio

Plug-in Manifest Editor | IpWay_Cfg.h.ftl | *MotorControl

Any parameter at the end of description reports the corresponding macro's name in the generated configuration header file. If the parameters hasn't a corresponding macro it is indicated with the acronym n/a (not available).

Select "Surface Mounted PMSM" if only a value of inductance is reported in the datasheet

Magnetic structure: Surface Mounted PMSM

Electrical parameters

This panel contains electrical and mechanical motor rated parameters.

Pole pairs	1	
Max rated speed	10300.0	rpm
Nominal Current	10.4	A
Nominal DC Voltage	12.0	V
Rs	0.07	ohm
Ld	0.6	mH
Lq	0.013	mH
Ls	0.013	mH
Autosettings	ENABLE	
Demagnetizing Current	7.999	A
Back EmfConstant	1.2	Vrms_div_Krpm

phase to phase value divided by 2

phase to phase value divided by 2

1000/(rpm/V value)

Sensors

This panel contains electrical and mechanical motor related parameters.

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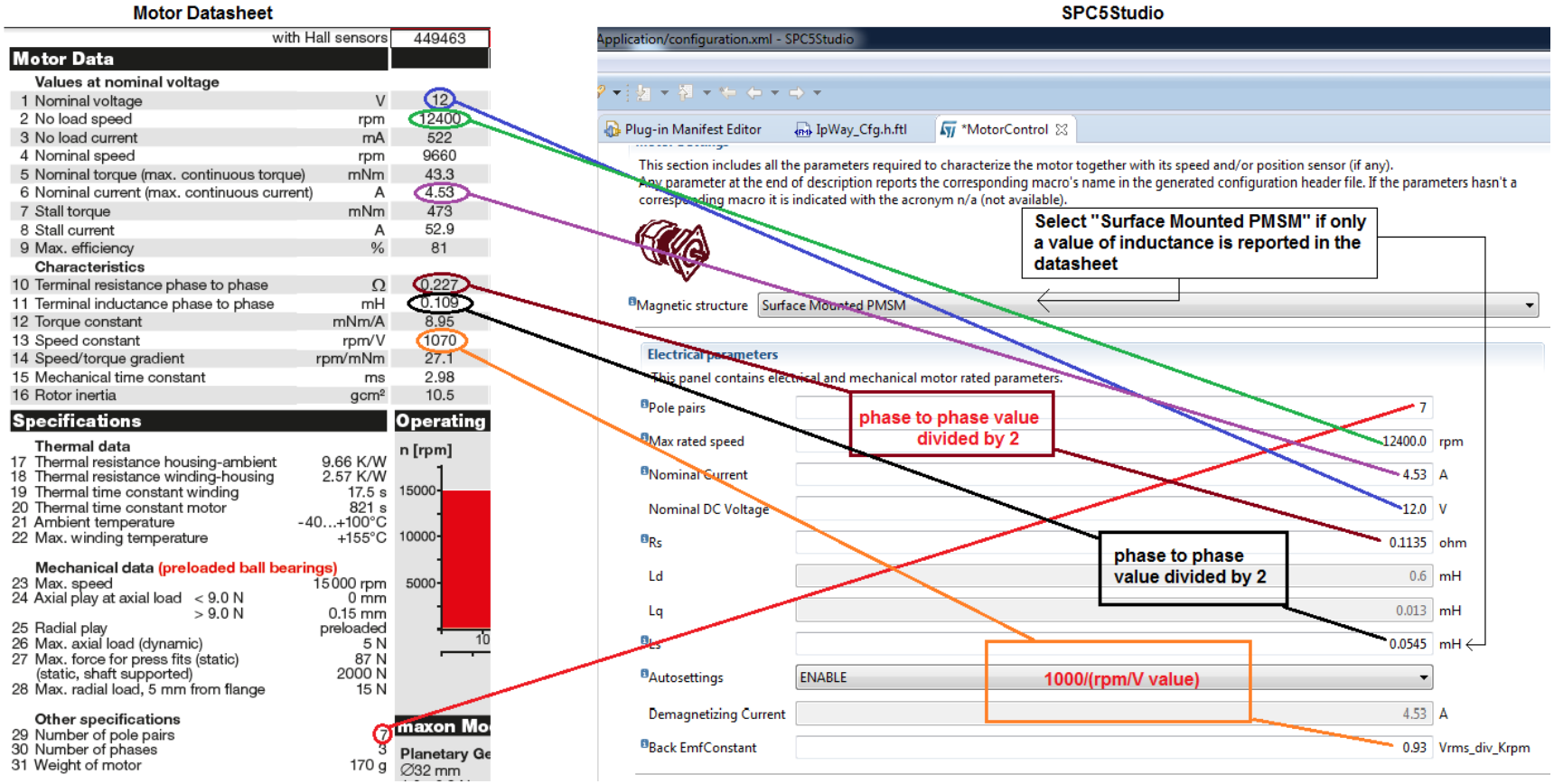
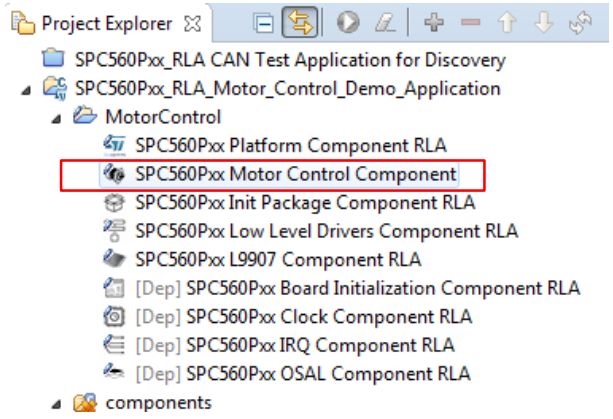
Step 4 - Motor configuration example for the Maxon Motor EC-i 40 starting from the motor datasheet

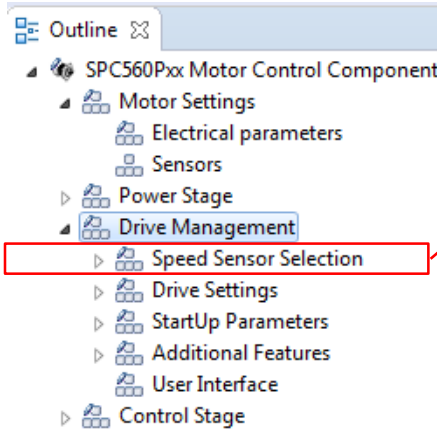


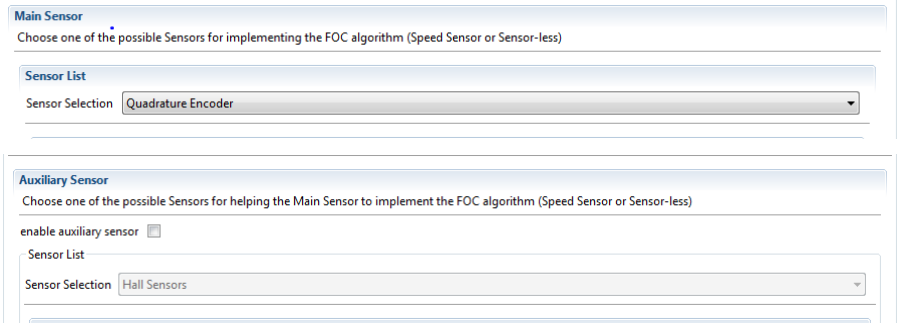
Step 4 - Configure Motor Control Component: Speed Sensor Selection

Demo Application is preconfigured to run on Nanotec DF45 motor. Configuration can be customized to fit customer application.

- configure **Drive Management** tabs from Outline box (down left SPC5Studio tool corner) to configure Speed sensor to be used by the library







- Select Main Sensor between:
  - Sensorless + PLL
  - Hall Sensor
  - Quadrature Encode
  - Resolver (Need additional HW)
- “Enable Auxiliary Sensor” checkbox is used for debugging only.
- Quadrature Encode is the most reliable sensor and it is encouraged to use this mode.

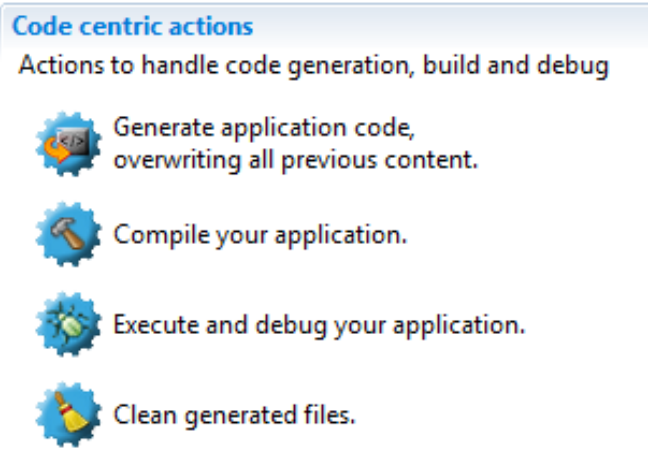
Note: two resistors need to be removed from Pictus Discovery, kit is already fixed

Step 4 and 5 - Configure Motor Control Component: Generate Build and Debug

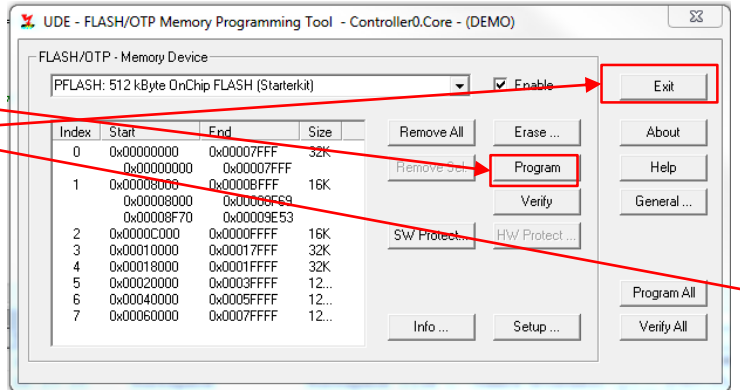
After the configuration phase you need to generate configuration file:

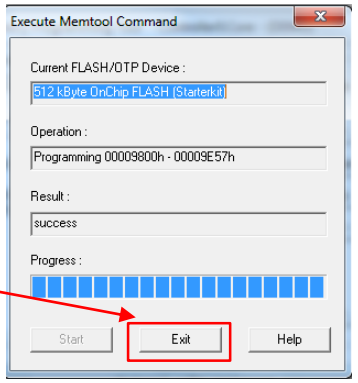
- PMSM motor parameters.h
- Power stage parameters.h
- Drive parameters.h
- Control stage parameters.h

They will be available under:
components/spc560pxx_motor_control_component/cfg



- Click on "*Generate application code, …*"
  - to create configuration file based on your settings
- Click on "*Compile your application*"
  - to build your application
- Click on "*Execute and debug your application*"
  - to use Pls for downloading your code on Pictus
  - The UDE Visual Platform will be opened
  - Press Load in "Load binary target file" to open the programming tool
  - Press Program
  - Than Press Exit 2 times
  - Than Start Program or F5





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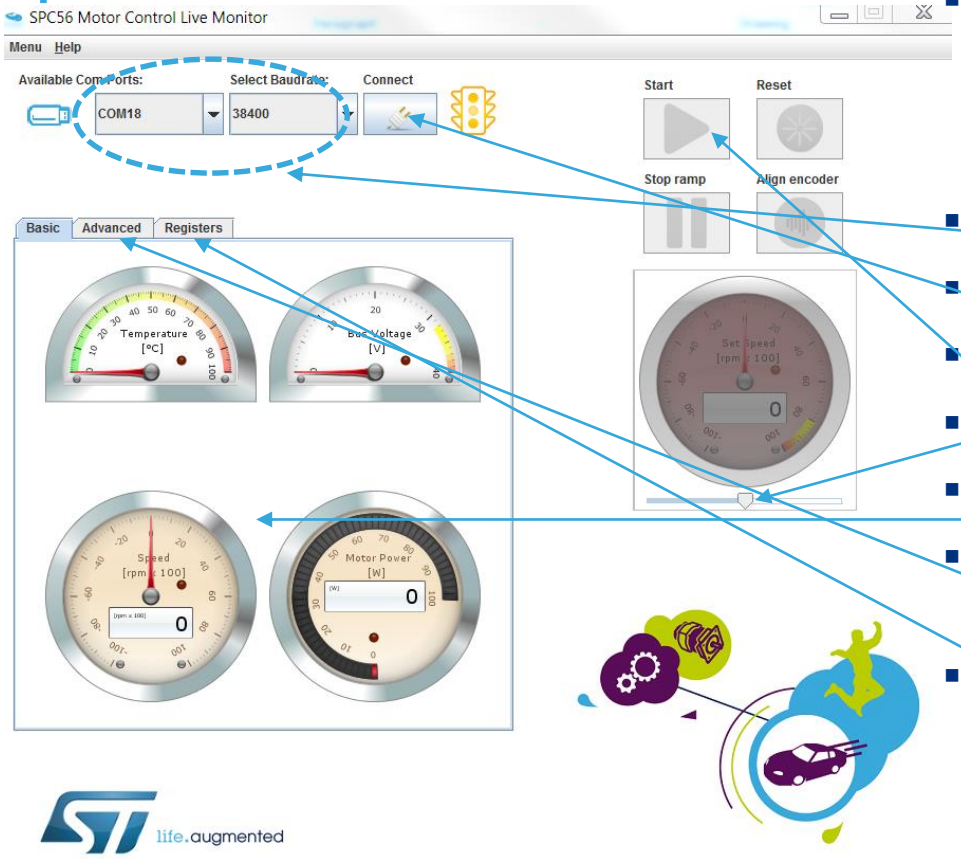
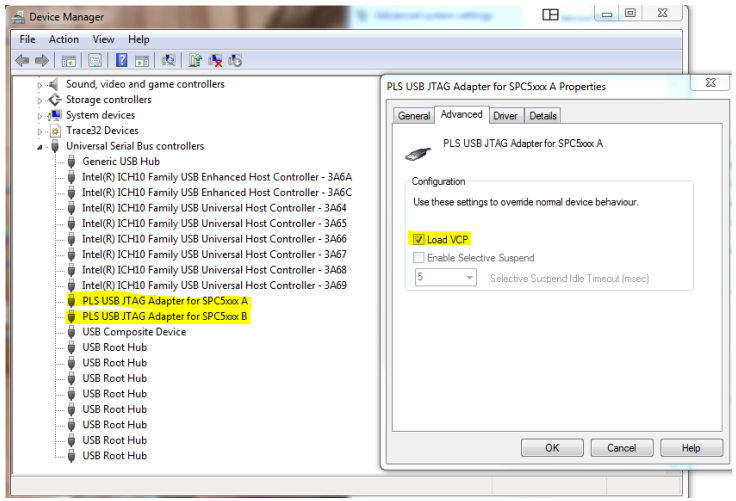
Step 6 - Connect Live Monitor



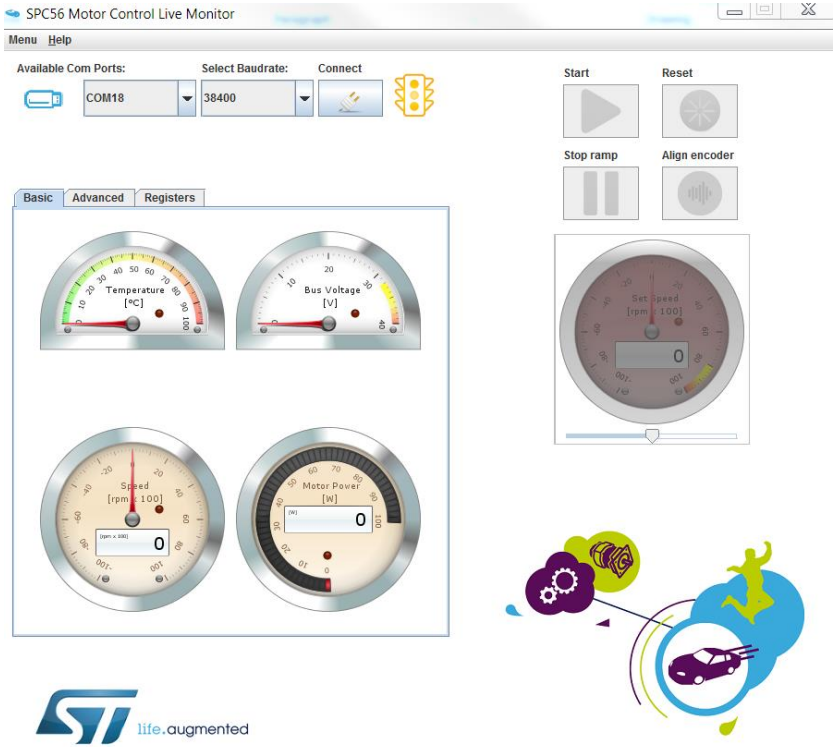
- Install and Open SPC5 MC Live Monitor
- Make sure to have selected SERIAL into Drive Setting -> User Interface of the motor control component into SPC5studio
- Select virtual COM* and set baud rate
- Click on Connect Button
- Start the Motor
- Change the reference speed
- Monitor actual speed, voltage and power
- Go the advanced option to change amplification gain or set ramp speed
- Go to register view to check all library parameters



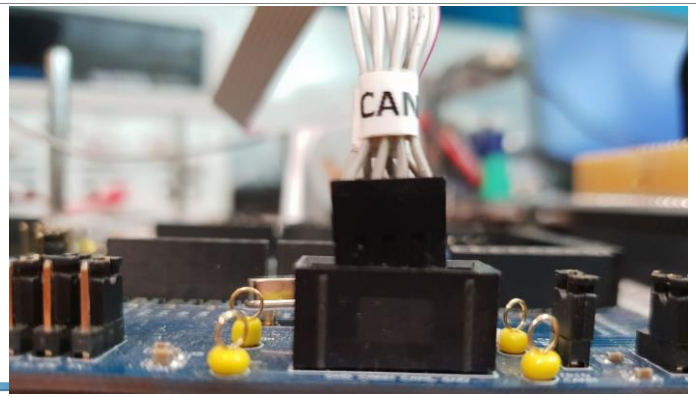
* Virtual COM should be enabled in:
Window Device Manager ->USB Controllers

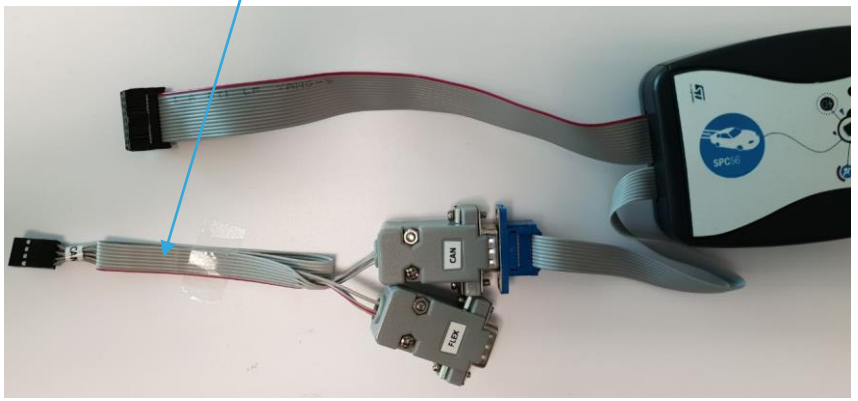
Note: in case there is no Advanced Tab
remove and insert again usb cable from
Pictus Discovery board

Step 6 - Using CAN with SPC5-CONNECT*



- From http://www.st.com
  - Buy SPC5-CONNECT
  - Download and Flash to SPC5-CONNECT the MCTK-Connect firmware upgrade (ask for binary)
- Connect SPC5-CONNECT to PC using USB and to SPC50P-DISP on P3 connector using CAN_TO_P3 cable
- Use SPC5 Live Monitor normally as in the Serial Virtual COM connection (slide 22)





*) Make sure to have selected CAN into Drive Setting -> User Interface of the motor control component into SPC5studio

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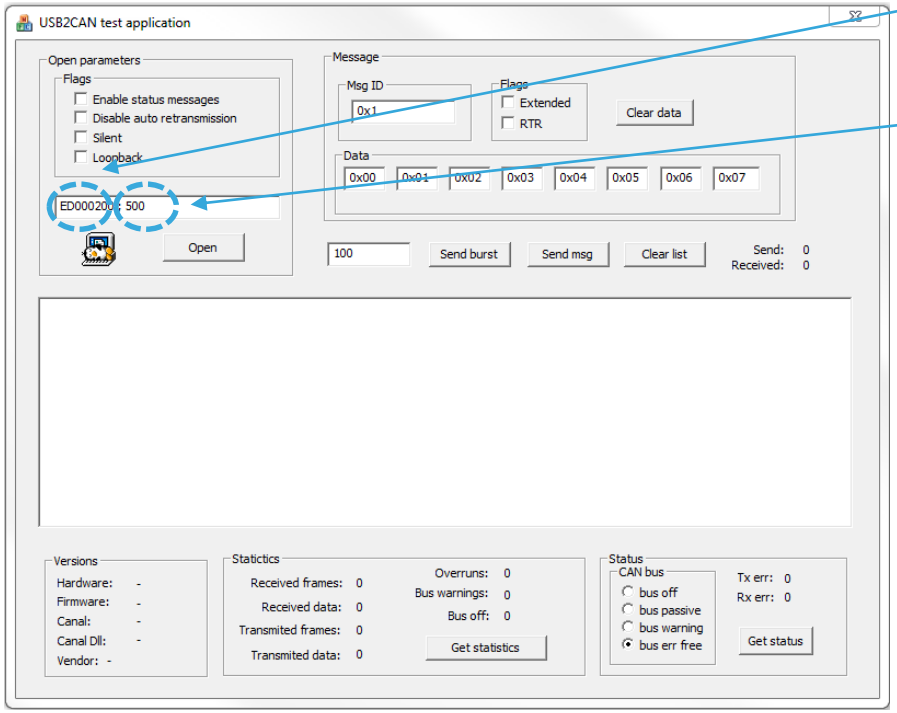
Step 6 - Using CAN with USB2CAN converter*



- From http://www.8devices.com
  - Buy USB2CAN converter
  - Download and Install USB driver
  - Download USB2CAN Test application v1.0
- Set the correct ED code from back of your USB2CAN converter
- Set baudrate according to motor control configuration (drive management -> user interface -> can details) component and Open the connection
- Set the CAN message as specified into the User Manual into the motor control component documentation folder:

Command	Can ID STD	Can Data
RAMP FINAL SPEED (2000 rpm)	01	05 5B D0 07 00 00 39
BUS VOLTAGE	02	01 19 1C
START/STOP MOTOR	03	01 06 0A
GET BOARD INFO	06	01 00 07
EXEC RAMP(1000,2000)	07	06 E8 03 00 00 D0 07 D0
GET REV UP	08	01 Stage CRC
SET REF	0A	04 Iq_LB Iq_HB Id_LB Id_HB CRC

Table 1: Can Frame Example

*) Make sure to have selected CAN into Drive Setting -> User Interface of the motor control component into SPC5studio

Overview

1 Introduction to the Motor Control Toolkit

2 Setup and configure HW parts

3 Setup, configure SW and run demo example

4 Documents & Related Resources

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Documents & related resources

All documents are available in the release package

- Release Note

  Content of the release package

- Data Brief

  One page description of the Motor Control ToolKit

- User Manual Chm

  Compressed chm manual available in the SPC5Studio motor control component doc folder

- Quick Start Guide

  Presentation to quickly configure HW and SW and run demo application

- MCTK SPC5Studio Motor Configuration Quick Guide

  Pdf doc describing how to configure HW and SW and run demo application

Consult www.st.com for the complete list

Thanks