

Quick Start Guide

Motor Control ToolKit for SPC5Studio

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



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

Motor control ToolKit

3

1

Introduction to the Motor Control Toolkit

2

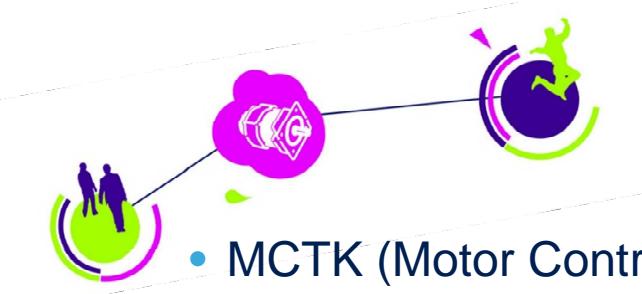
Setup and configure HW parts

3

Setup, configure SW and run demo example

4

Documents & Related Resources



What is MCTK

4

- MCTK (Motor Control Tool Kit) 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 HW demo
 - with SPC560P-DISP discovery Platform and L9907-EVAL kit
 - With SPC56EL70L5-DISP discovery Platform and L9907-EVAL kit
- Firmware Library Based on Field Oriented Control (FOC)
 - Sensored and Sensorless support
 - 2 shunt topology

Supported Features

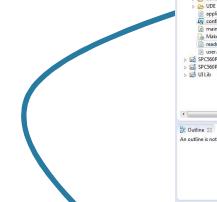
- Demo Kit with P-Line + L9907
- Demo kit with L-Line + L9907
 - Equipped with Maxon EC 40 motor
 - Validated with several others motors
- Supported microcontroller
 - SPC560P, SPC56EL
- Supported Sensors
 - Hall sensors
 - Encoder
 - Resolver
 - Sensor-less
- Control Algorithms
 - Single Vector FOC algorithm
 - Torque and Speed control
 - MTPA, Flux Weakening and Feed Forward techniques
- Library deployed as SPC5Studio component
 - Library Configuration tool available into Motor Control Component
 - Dedicated SPC5Studio component for L9907
 - Update site with Motor control component can made available
- SPC5 MCU initialization provided via SPC5Studio
 - drivers/pin wizard/clock tree initialization
- Supported Compiler:
 - Green Hills
 - HighTec
 - Free GCC
- Current Sensing
 - 2 shunts current measurements on motor phases and inverter legs
- Configuration/UI
 - SPC5Studio motor control component configuration to adapt library to customer motor, topology and application
- Power stage configuration
 - SPC5Studio L9907 component to Decoupling uC and Power
 - L9907 Fault management configuration
 - L99ASC03 smart driver support
 - STGAP1AS for High voltage applications



Hardware Demo Kit

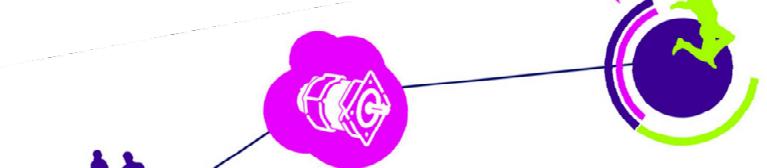


SPC5Studio configuration component

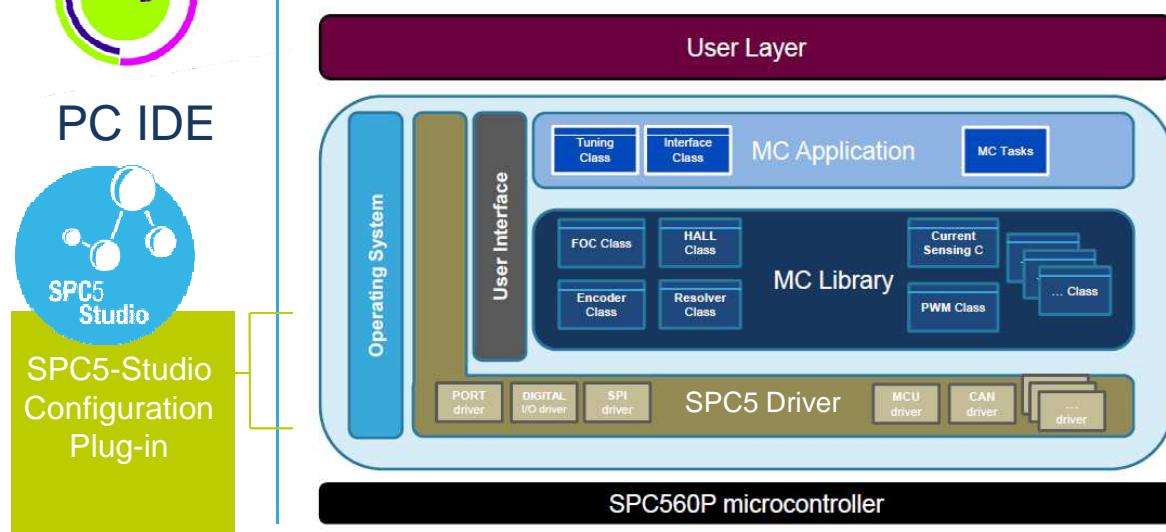


SPC5 Live Monitor

SPC5 MC ToolKit at Glance

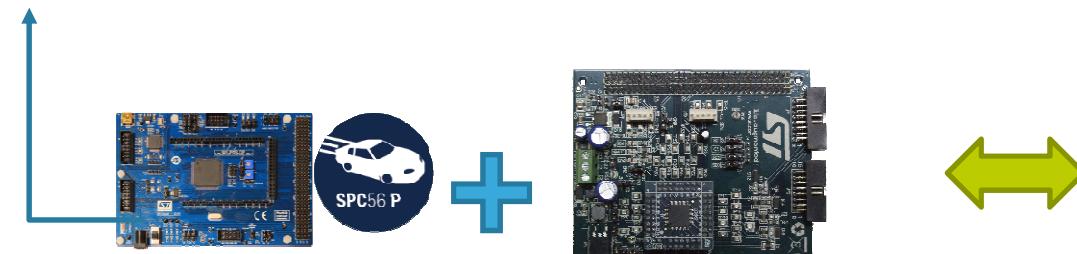


Embedded software



• Motor Control Tool Kit key elements

- SPC5 FOC Lib Configuration (SPC5Studio plug-in)
- Embedded Software Library (MC Lib)
- Live Monitor
- SPC5Studio (IDE and code gen)
- Micro and Power Boards

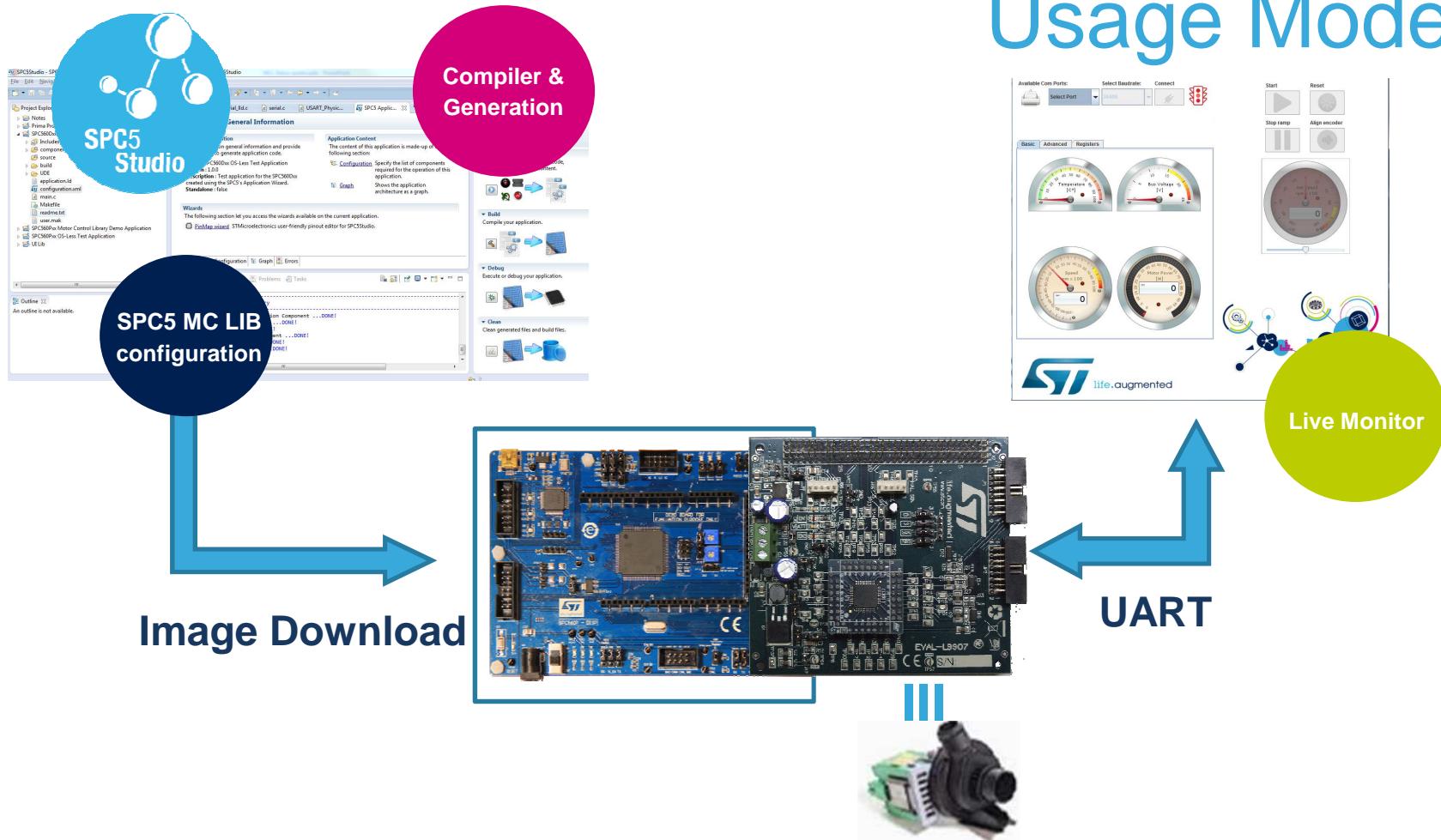


Micro and Power board



SPC5 Live Monitor

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

8

1

Introduction to the Motor Control Toolkit

2

Setup and configure HW parts

3

Setup, configure SW and run demo example

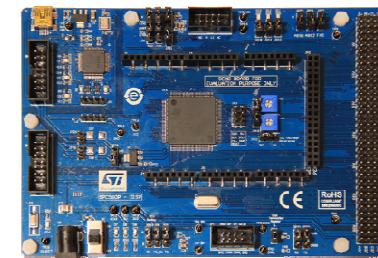
4

Documents & Related Resources

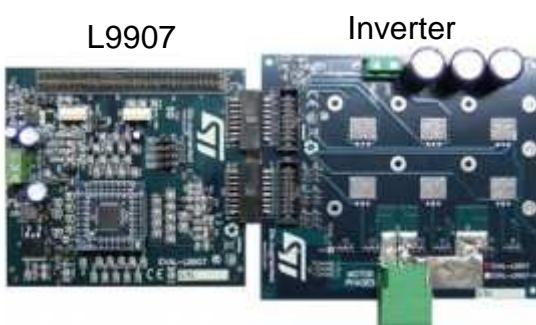
HW Prerequisites

9

- Get SPC560P Discovery platform ([SPC560P-DISP](#)) or [SPC56EL70L5-DISP](#)
- Get L9907 evaluation board for 3-phase BLDC motor pre-driver ([EVAL-L9907](#))
- 3-phase BLDC motor (e.g. MAXON EC40 or similar)
- Power supply accordingly with application
- 1 x mini USB cable
- Windows 8/7 - Laptop/PC



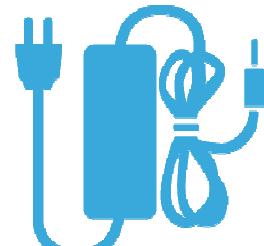
SPC560P-DISP



EVAL-L9907



Laptop/PC



Power Supply

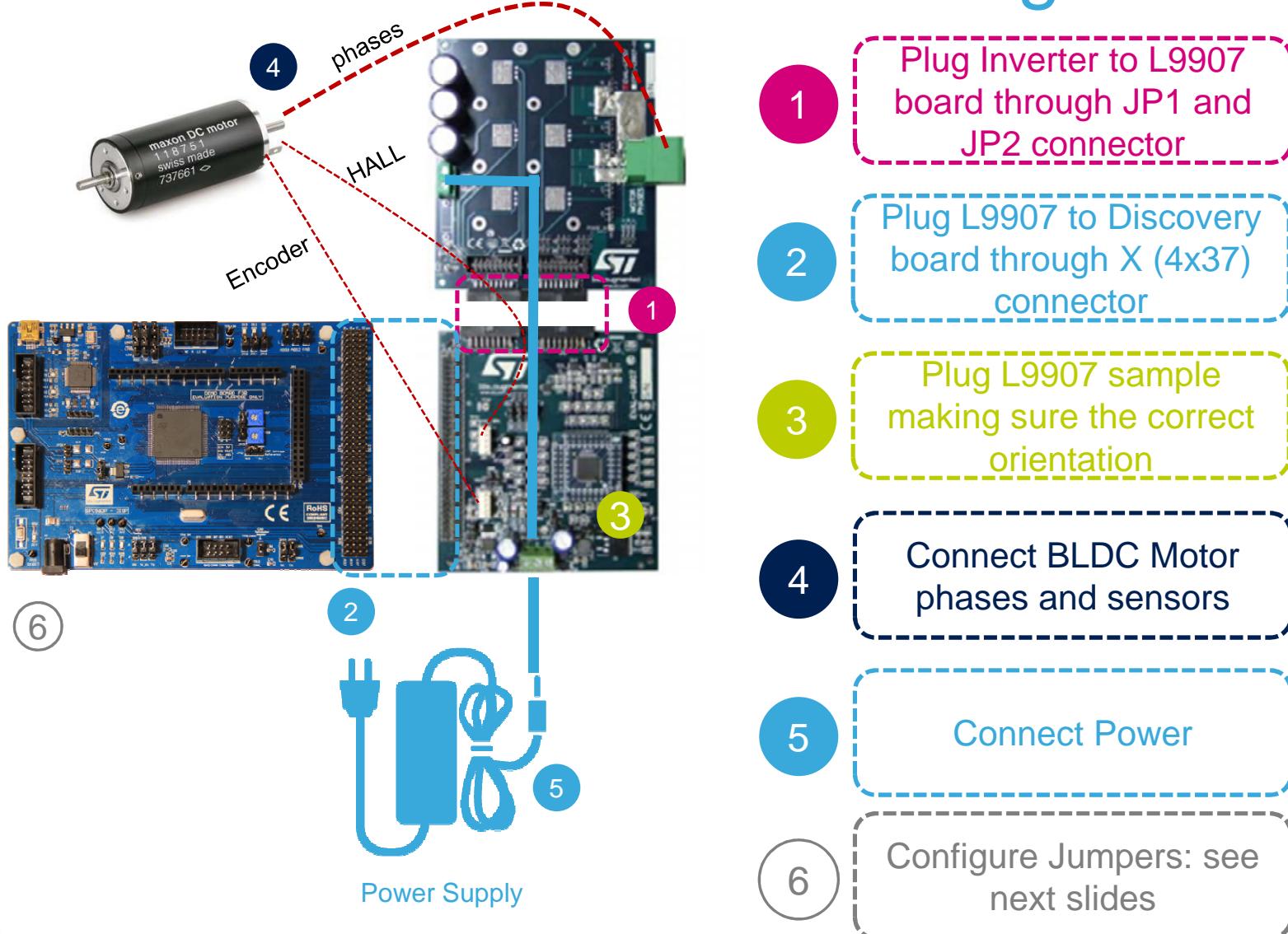


Mini USB



BLDC Motor

Assembling HW kit

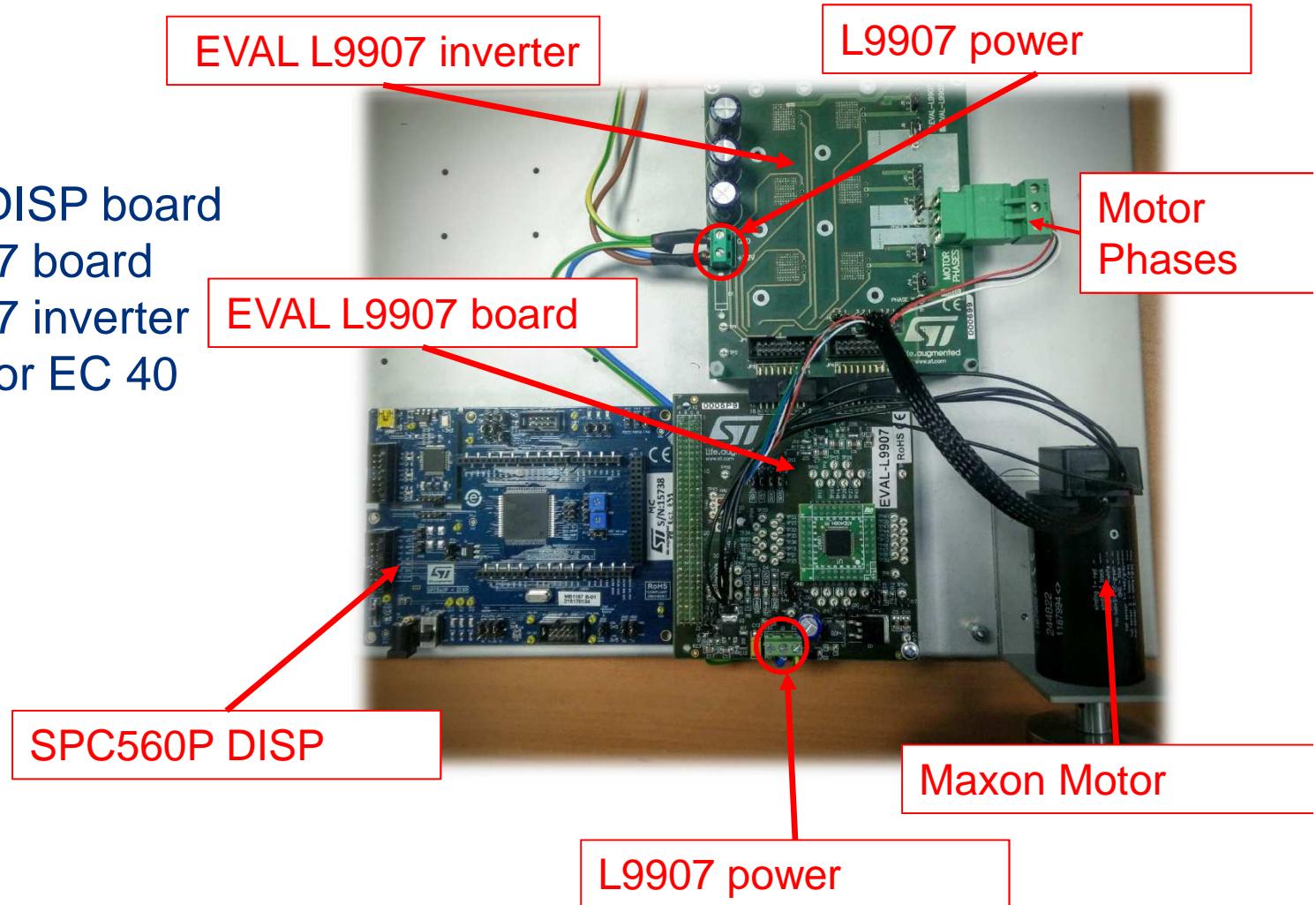


Assembled Kit available

11

• HW

- SPC560P DISP board
- EVAL L9907 board
- EVAL L9907 inverter
- Maxon motor EC 40



Note: Color of the board may be different

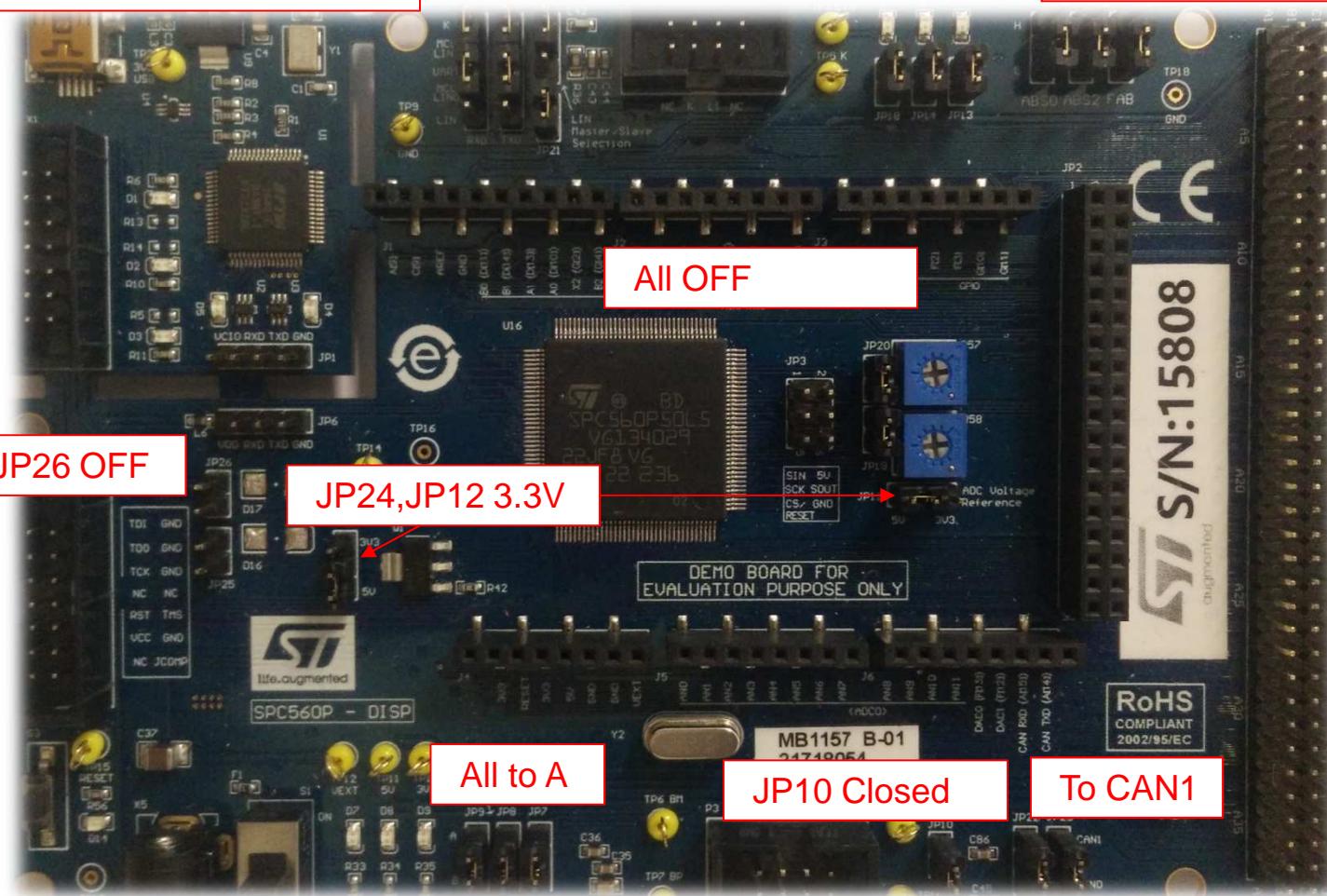
Jumper Configuration for SPC560P-DISP

12

JP4,JP5 Uart-MCULin0
JP11, K-MCULin1
JP21 ON

JP13,JP14,JP18 ON

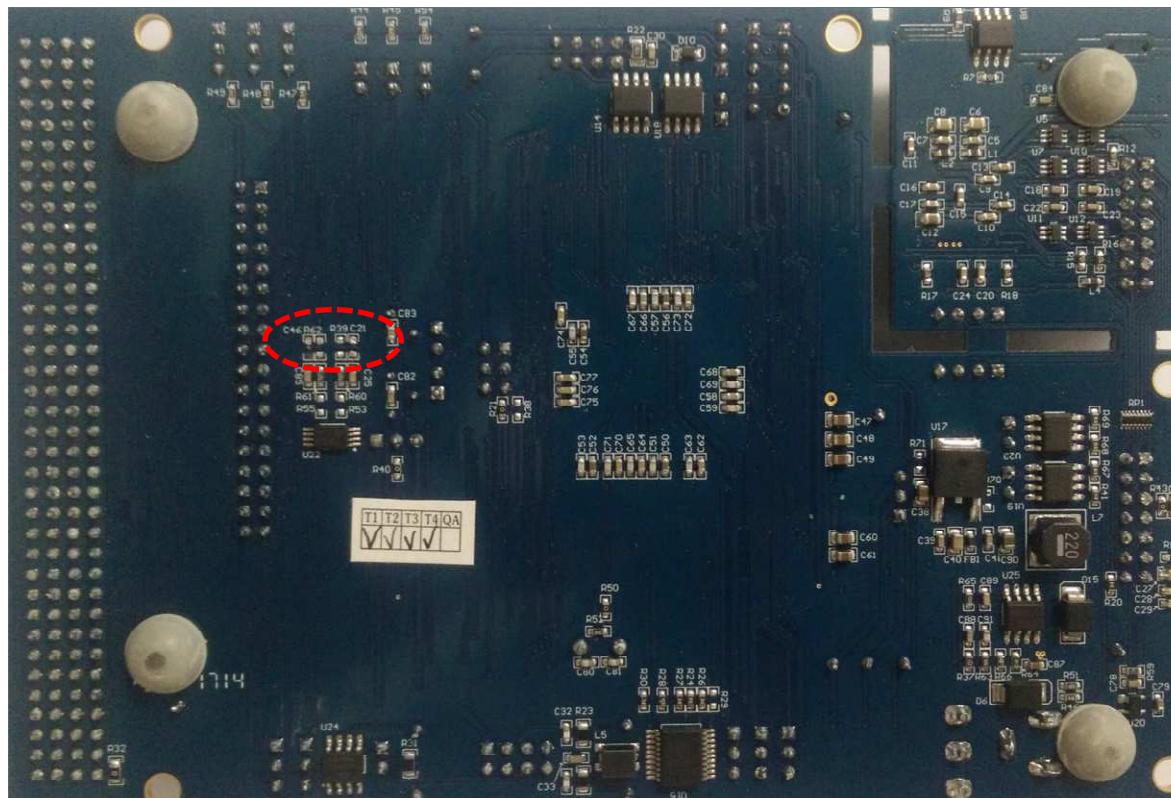
JP15,JP16 OFF
JP17 L



Modification to using Encoder

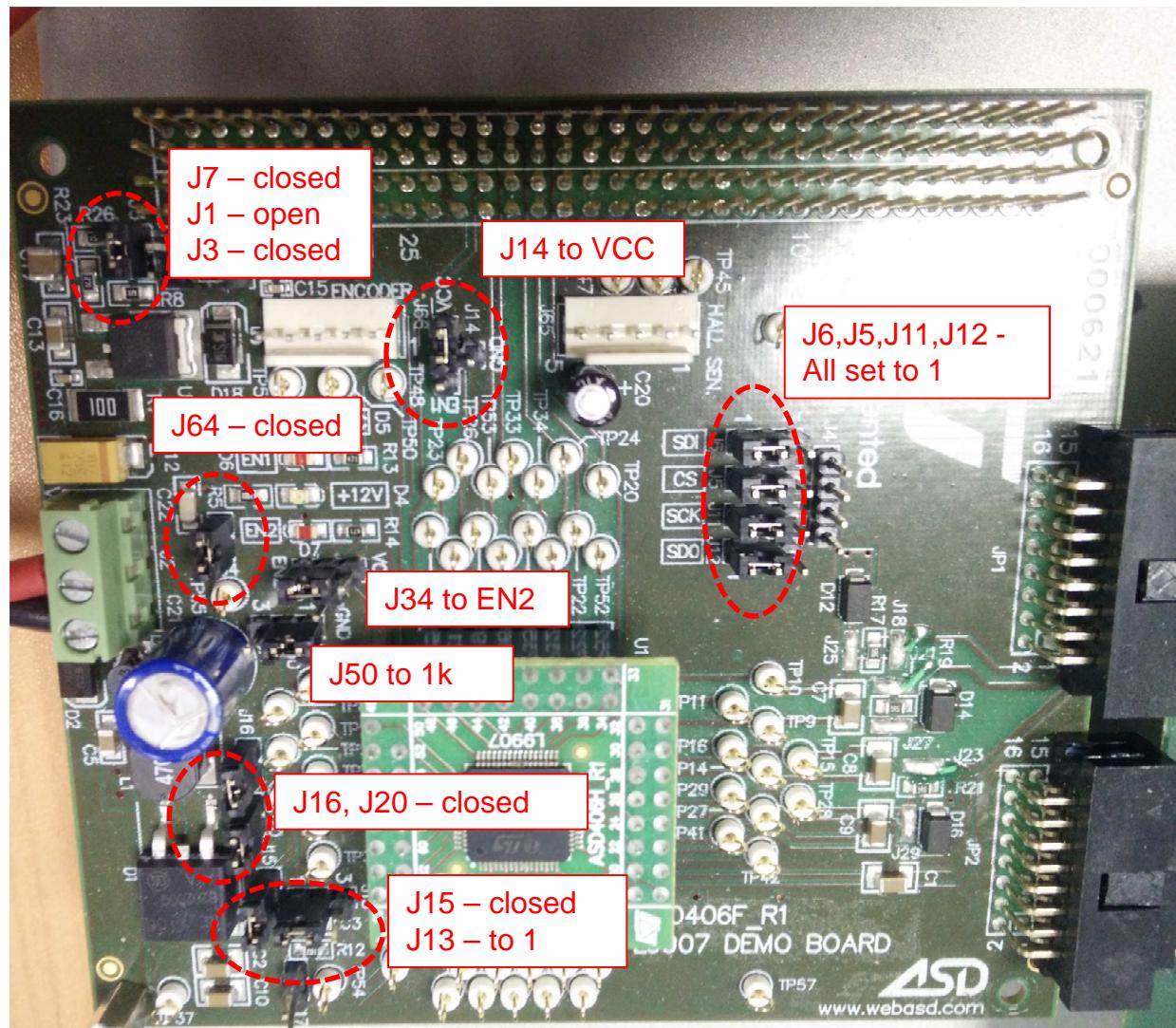
13

2 resistors (R39 and R62) and 2 capacitors (C21 and C46) on back side of the SPC560P-DISP must be removed to use ENCODER due to an incompatibility on pins. After this modification DAC0 and DAC1 will not work properly. Those modification are not needed if either HALL or Sensor-less are used



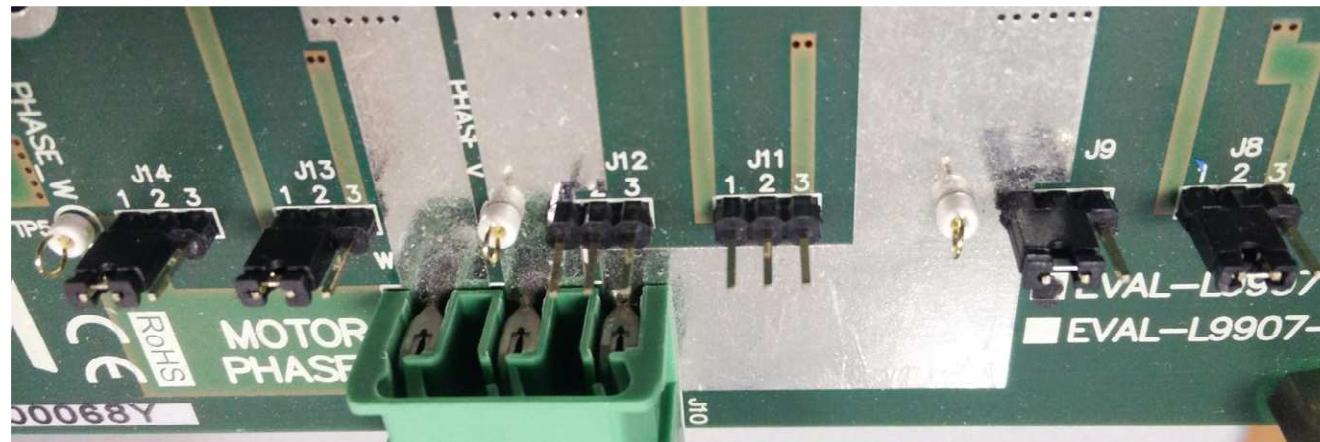
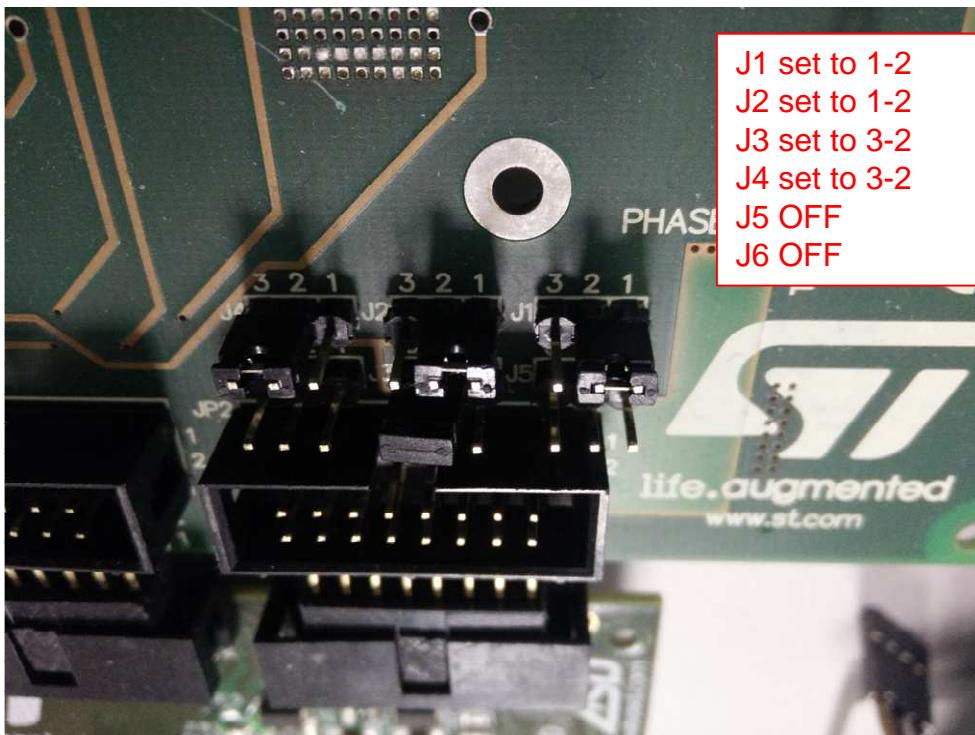
Jumper Configuration for L9907-Eval board

14



Jumper Configuration for L9907-Inverter board (configured for 2ICS)

15



Software Setup and Demo example

16

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

Software Setup in 6 steps

17



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

1
Install SPC5Studio by
reading carefully installation procedure
and additional document and tutorials

2

Get Motor Control SW package
(ask ST regional office):
- **MotorControlUpdateSite**
- **SPC56xx Demo Application**
- **Live Monitor Installer**



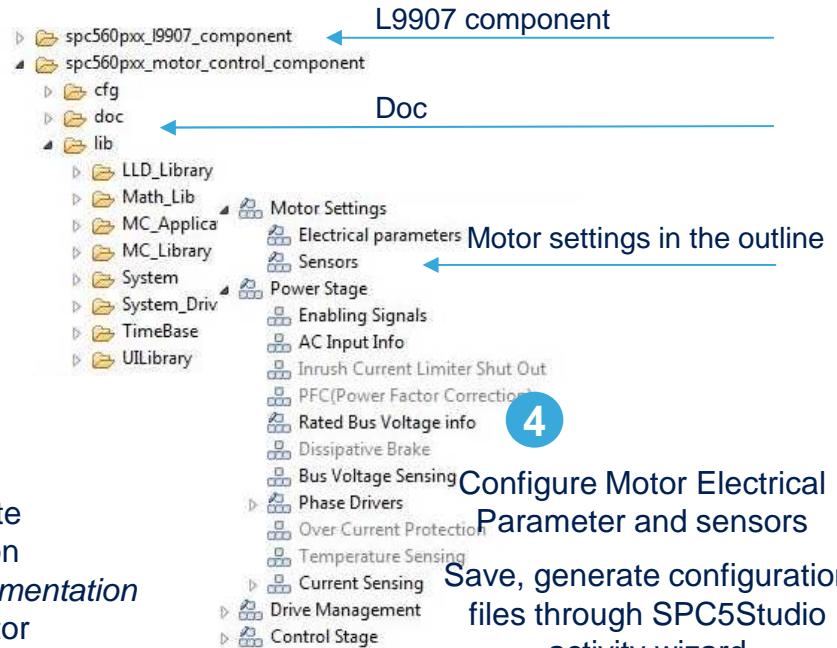
3

- 1) Install Motor Update Site
- 2) Import Demo Application
... see *SPC5Studio documentation*
- 3) Install SPC5 Live Monitor

6

Connect Live Monitor (set
baud rate to 38400) and
play with motor
Alternatively USB2CAN
converter can be used in
case of CAN
communication

Motor Control Component Structure



4

Configure Motor Electrical
Parameter and sensors

Save, generate configuration
files through SPC5Studio
activity wizard

Compile through SPC5Studio
activity wizard

5

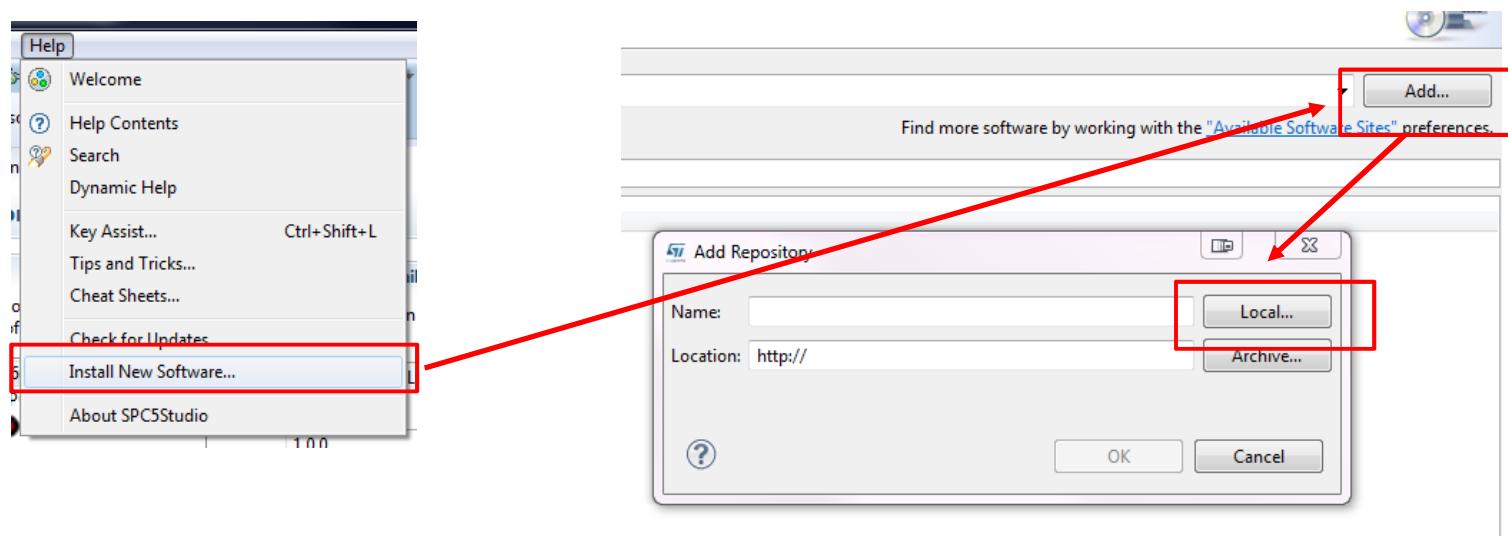
Download binary to target board
via Debug tool
(UDE 4.8 or Lauterbach)



Step 3 - Install update site into SPC5Studio

18

- 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

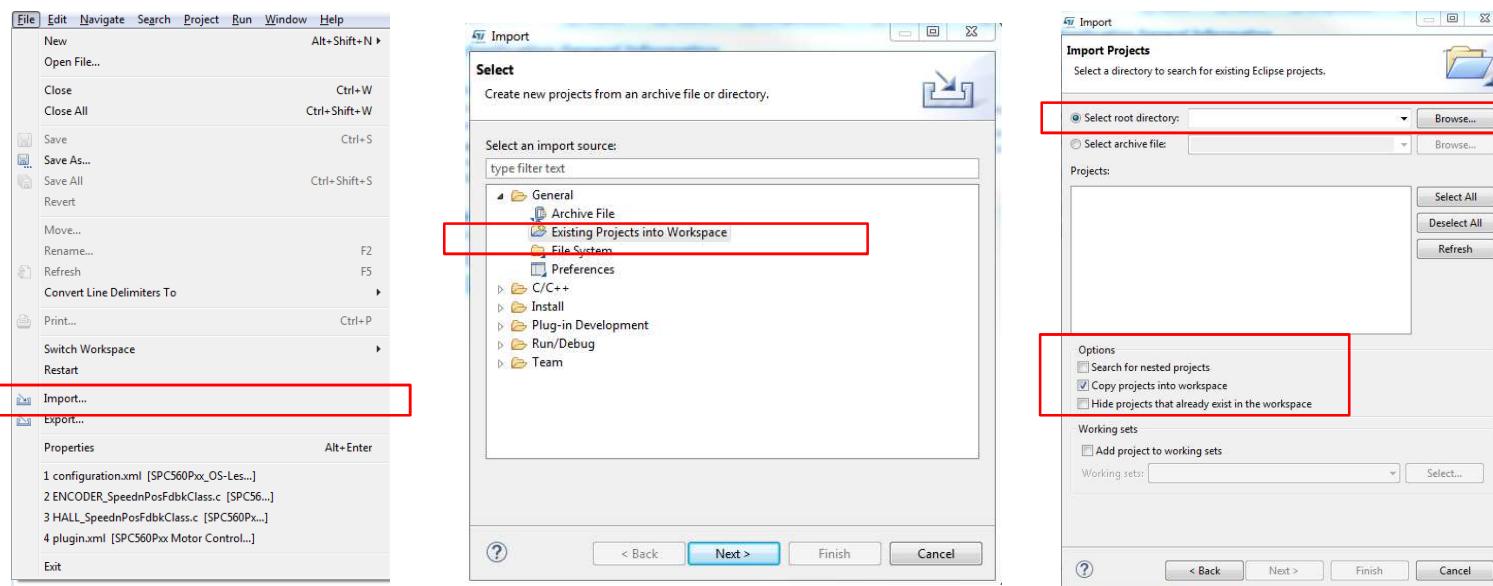


- Exit from SPC5Studio and Start it again

Step 3 - Import demo application into SPC5Studio

19

- Unzip the content of the demo application in one directory of your choice
- **Go to File → Import**
- select “Existing Project into Workspace” and click next
- Select the directory where you un-zipped the demo application
- It is strongly advised to select the option “Copy projects into workspace”, In this way the original version of the demo is not changed as you have created a copy into your default workspace)

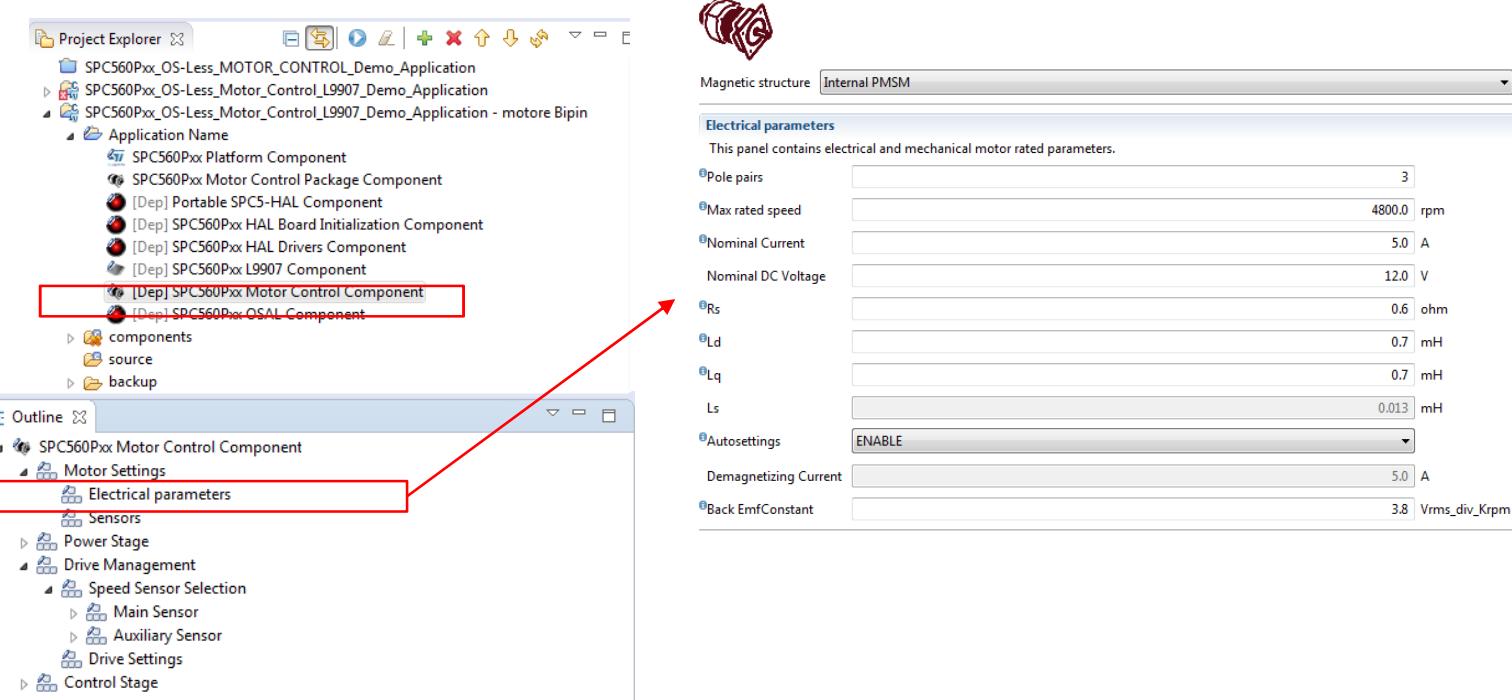


Step 4 - Configure Motor Control Component: Electrical Parameter

20

Demo Application is preconfigured to run on Maxon EC40 motor. Configuration can be customized to fit customer application.

- select “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 Maxon Motor EC 40 starting from the motor datasheet

Motor Datasheet

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	gcm ² 85.0
Specifications	
Thermal data	
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
30 Number of phases	3
31 Weight of motor	390 g

SPC5Studio

Application/configuration.xml - SPC5Studio

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

phase to phase value divided by 2

R_s: 0.07 ohm

L_d: 0.6 mH

L_q: 0.013 mH

phase to phase value divided by 2

L_s: 0.013 mH

Autosettings ENABLE

Demagnetizing Current: 7.999 A

Back Emf Constant: 1.2 Vrms_div_Krpm

Sensors

This panel contains electrical and mechanical motor related parameters.

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

Motor Datasheet

Motor Data		with Hall sensors	449463
Values at nominal voltage			
1 Nominal voltage	V	12	12400
2 No load speed	rpm	12400	12400
3 No load current	mA	522	522
4 Nominal speed	rpm	9660	9660
5 Nominal torque (max. continuous torque)	mNm	43.3	43.3
6 Nominal current (max. continuous current)	A	4.53	4.53
7 Stall torque	mNm	473	473
8 Stall current	A	52.9	52.9
9 Max. efficiency	%	81	81
Characteristics			
10 Terminal resistance phase to phase	Ω	0.227	0.227
11 Terminal inductance phase to phase	mH	0.109	0.109
12 Torque constant	mNm/A	8.95	8.95
13 Speed constant	rpm/V	1070	1070
14 Speed/torque gradient	rpm/mNm	27.1	27.1
15 Mechanical time constant	ms	2.98	2.98
16 Rotor inertia	gcm^2	10.5	10.5
Specifications			
Thermal data			
17 Thermal resistance housing-ambient	K/W	9.66	9.66
18 Thermal resistance winding-housing	K/W	2.57	2.57
19 Thermal time constant winding	s	17.5	17.5
20 Thermal time constant motor	s	821	821
21 Ambient temperature	-40...+100°C	+100°C	+100°C
22 Max. winding temperature	+155°C	+155°C	+155°C
Mechanical data (preloaded ball bearings)			
23 Max. speed	rpm	15000	15000
24 Axial play at axial load < 9.0 N	mm	0 mm	0 mm
> 9.0 N	mm	0.15 mm	0.15 mm
25 Radial play	N	5 N	5 N
26 Max. axial load (dynamic)	N	87 N	87 N
27 Max. force for press fits (static)	N	2000 N	2000 N
(static, shaft supported)	N	15 N	15 N
28 Max. radial load, 5 mm from flange			
Other specifications			
29 Number of pole pairs			
30 Number of phases			
31 Weight of motor	g	170 g	170 g

SPC5Studio

Application/configuration.xml - SPC5Studio

This section includes all the parameters required to characterize the motor together with its speed and/or position sensor (if any). 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: 7

Max rated speed: 12400.0 rpm

Nominal Current: 4.53 A

Nominal DC Voltage: 12.0 V

R_s : 0.1135 ohm

L_d : 0.6 mH

L_q : 0.013 mH

L_s : 0.0545 mH

Autosettings: ENABLE

Demagnetizing Current: 4.53 A

1000/(rpm/V value): 0.93 Vrms_div_Krpm

Back EmfConstant: 0.93 Vrms_div_Krpm

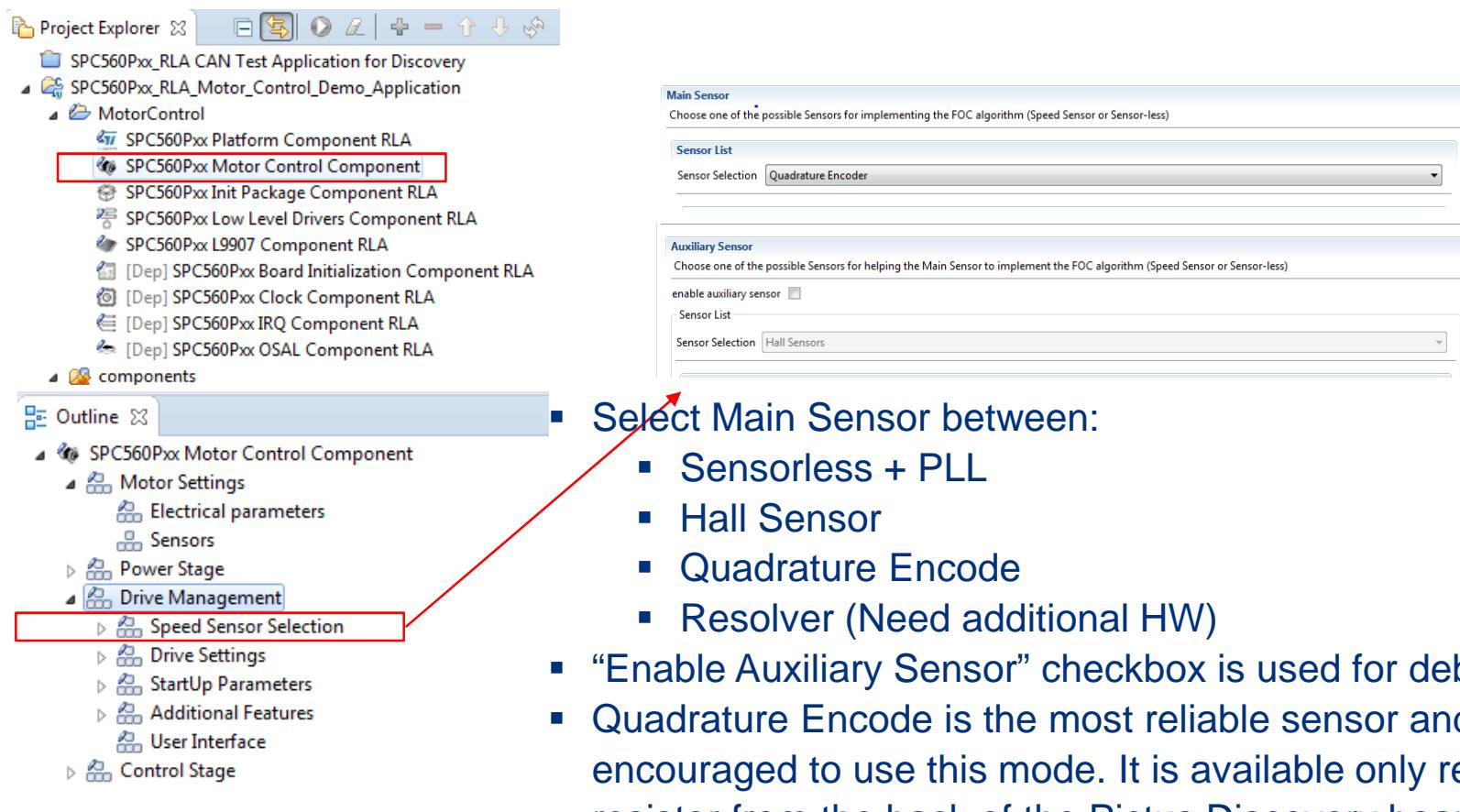
phase to phase value divided by 2

phase to phase value divided by 2

Step 4 - Configure Motor Control Component: Speed Sensor Selection

Demo Application is preconfigured to run on Maxon EC40 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. It is available only removing resistor from the back of the Pictus Discovery board

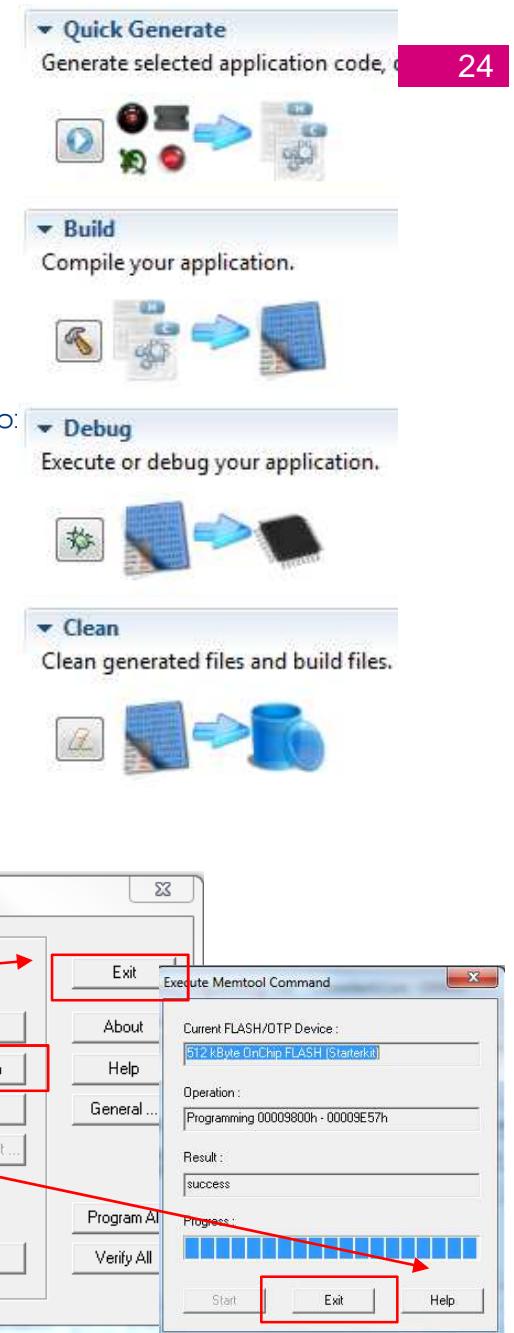
Step 4 - Configure Motor Control Component: Generate Build and Debug

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

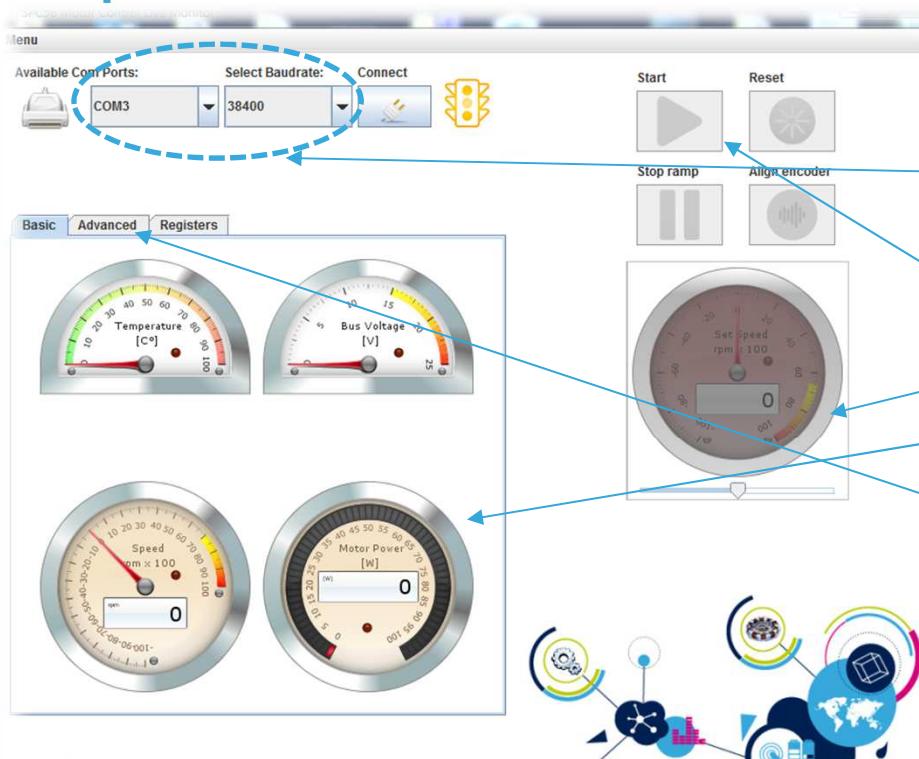
They will be available under `components/spc560pxx_motor_control_compo`:

- Click on Quick Generate to create configuration file based on your settings
- Click on Build to compile your application
- Click on Debug to use Pls for download 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

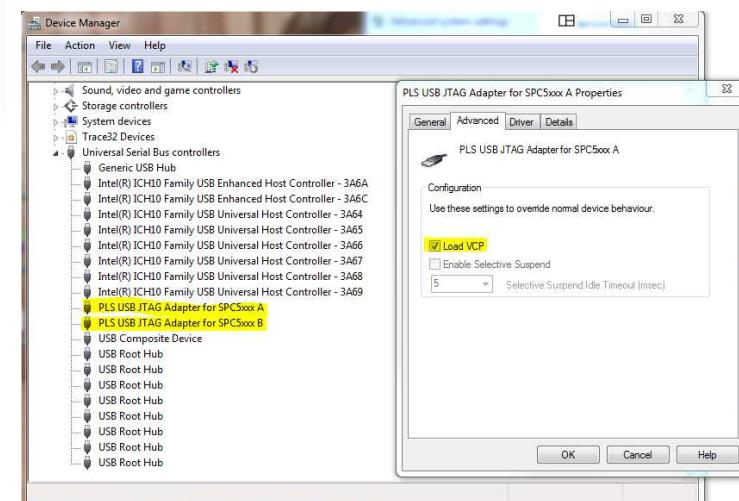


Step 6 - Connect Live Monitor

25



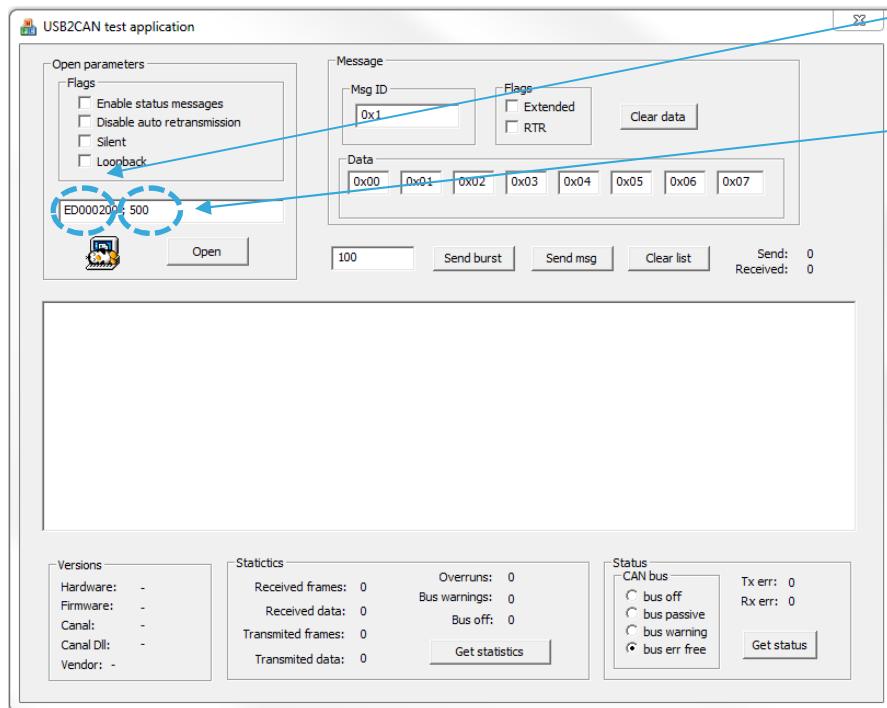
- Install and Open SPC5 Live Monitor
- Select virtual COM* and set baud rate
- Click on Connect Button
- Start the Motor
- Change the reference speed
- Monitor actual speed, temp and power
- Go the advanced option to change amplification gain or set ramp speed
- Go to register view to check all library 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 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

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

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

