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

Kit: from isolated debug probe to motor

Inverters

Complete 3ph Inverter solutions

Control and power stage in single board

Low voltage drives

- STEVAL-FMC03V1
  - PM SM FOC Motor Drive
  - 1x Motor Drive 1CL632DPD
  - 1x 3PH Micro STM32F070B6C

- STEVAL-HM034V1
  - BLDC 6-Steps Motor Drive
  - 1x Motor Drive 2CL623DPD
  - 1x 8 pin Micro STM32

- STEVAL-HM042V1
  - PM SM FOC Motor Drive
  - 1x Motor Drive 1CL623DPD
  - 1x 3 pin Micro STM32F116B6T6
  - 1x DC-DC converter ST1134FH

High voltage drives

- STEVAL-FMC04V1
  - Dual motor drive + digital PFC
  - 1x 225W Micro STM32F070C876
  - 1x 450W LUMINUS SEG450AC0
  - 1 converter based on Viper16L

- STEVAL-HM034V1
  - PM SM FOC Motor Drive
  - 1x 225W Micro STM32F070C876
  - 1x 450W LUMINUS SEG450AC0
  - 1 converter based on Viper16L

- STEVAL-HM036V1
  - PM SM FOC Motor Drive
  - 1x 312W Micro STM32F116B6T6
  - 1x PFC controller L6562A

Complementing MC starter kits

Evaluation boards for 3-ph motors

- STM32 MC library v1.0
- STM32 PMSM FOC SDK v2.0

Power Stages

- STM32F070R7
- STM32F070B6
- STM32F116T6
- STM32F116B6
- STM32F070C8
- STM32F116B6
- STM32F070C8
- STM32F070C8

- STM32F070C8
- STM32F070C8
- STM32F070C8
- STM32F070C8
- STM32F070C8

Power Stage based

- STM32F070C8
- STM32F070C8
- STM32F070C8
- STM32F070C8
- STM32F070C8

Low voltage drives

- STEVAL-HM023V1
  - FOC
  - 1x VDM smart driver 16390
  - 1x converter based on Viper16
  - 1x VST 3PH 20890

- STEVAL-HM032V1
  - PM SM FOC Motor Drive
  - 1x 16390
  - 1x converter based on Viper16
  - 1x VST 3PH 20890

- STEVAL-HM033V1
  - PM SM FOC Motor Drive
  - 1x 16390
  - 1x converter based on Viper16
  - 1x VST 3PH 20890

- STEVAL-HM034V1
  - PM SM FOC Motor Drive
  - 1x 16390
  - 1x converter based on Viper16
  - 1x VST 3PH 20890

- STEVAL-HM035V1
  - PM SM FOC Motor Drive
  - 1x 16390
  - 1x converter based on Viper16
  - 1x VST 3PH 20890

- STEVAL-HM036V1
  - PM SM FOC Motor Drive
  - 1x 16390
  - 1x converter based on Viper16
  - 1x VST 3PH 20890

Life.augment

Please visit www.st.com/st_products or contact a local ST office.
<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
<th>ST Link onboard</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>STM32100B-MCKIT</td>
<td>Motor control starter kit for STM32F100 (128KB Flash) Value Line MCUs</td>
<td>Yes</td>
<td>Single drive</td>
</tr>
<tr>
<td>STM3210B-MCKIT</td>
<td>Motor control starter kit for STM32 (128KB flash) Performance and Access Line microcontrollers</td>
<td>No</td>
<td>Single drive</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
<th>ST Link onboard</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEVAL-IHM034V2</td>
<td>Dual motor control and PFC demonstration board featuring the STM32F103 and STGIPS20C60</td>
<td>No</td>
<td>Single/Dual drive</td>
</tr>
<tr>
<td>STEVAL-IHM036V1</td>
<td>Low power motor control board featuring the SLLIMM™ STGI PN3H60 and MCU STM32F100C6T6B</td>
<td>No</td>
<td>Single drive</td>
</tr>
<tr>
<td>STEVAL-IHM038V1</td>
<td>BLDC ceiling fan controller based on STM32 and SLLIMM-nano</td>
<td>No</td>
<td>Single drive</td>
</tr>
<tr>
<td>STEVAL-IHM040V1</td>
<td>BLDC/PMSM driver demonstration board based on STM32 and the SLLIMM nano™</td>
<td>No</td>
<td>Single drive</td>
</tr>
<tr>
<td>STEVAL-IHM042V1</td>
<td>Compact, low-voltage dual motor control board based on the STM32F303 and L6230</td>
<td>Yes</td>
<td>Single/Dual drive</td>
</tr>
<tr>
<td>STEVAL-IHM043V1</td>
<td>6-Step BLDC sensorless driver board based on the STM32F051 and L6234</td>
<td>No</td>
<td>Single drive</td>
</tr>
<tr>
<td>STEVAL-IFN003V1</td>
<td>DC PMSM FOC motor drive</td>
<td>No</td>
<td>Single drive</td>
</tr>
</tbody>
</table>

![Image of inverters](image-url)
# STM32 evaluation boards with MC connector

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
<th>ST Link onboard(^{(1)})</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>STM3210E-EVAL</td>
<td>Evaluation board for STM32 F1 series - with STM32F103 MCU</td>
<td>No</td>
<td>Single drive</td>
</tr>
<tr>
<td>STM3220G-EVAL</td>
<td>Evaluation board for STM32 F2 series - with STM32F2071G MCU</td>
<td>Yes</td>
<td>Single drive</td>
</tr>
<tr>
<td>STM32303C-EVAL</td>
<td>Evaluation board for STM32F303xx microcontrollers</td>
<td>Yes</td>
<td>Single/Dual drive</td>
</tr>
<tr>
<td>STM3240G-EVAL</td>
<td>Evaluation board for STM32F407 line - with STM32F407IG MCU</td>
<td>Yes</td>
<td>Single drive</td>
</tr>
<tr>
<td>STEVAL-IHM022V1</td>
<td>High density dual motor control demonstration board based on the STM32F103ZE microcontroller</td>
<td>No</td>
<td>Single/Dual drive</td>
</tr>
<tr>
<td>STEVAL-IHM039V1</td>
<td>Dual motor drive control stage based on the STM32F415ZG microcontroller</td>
<td>No</td>
<td>Single/Dual drive</td>
</tr>
</tbody>
</table>

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

- ST-LINK/V2
- ST-LINK/V2-ISOL (2500 VRMS high isolation voltage)
## ST evaluation power boards with MC connector

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEVAL-IHM021V2</td>
<td>100 W, 3-phase inverter based on L6390 and UltraFASTmesh™ MOSFET for speed FOC of 3-phase PMSM motor drive</td>
</tr>
<tr>
<td>STEVAL-IHM023V3</td>
<td>1 kW 3-phase motor control evaluation board featuring L6390 drivers and new IGBT STGP10H60DF</td>
</tr>
<tr>
<td>STEVAL-IHM025V1</td>
<td>1 kW 3-phase motor control demonstration board featuring the IGBT SLLIMM™ STGIPL14K60</td>
</tr>
<tr>
<td>STEVAL-IHM028V2</td>
<td>2 kW 3-phase motor control demonstration board featuring the IGBT intelligent power module STGIPS20C60</td>
</tr>
<tr>
<td>STEVAL-IHM032V1</td>
<td>150 W inverter featuring the L639x and STGD3HF60HD for 1-shunt based sinusoidal vector control and trapezoidal scalar control</td>
</tr>
<tr>
<td>STEVAL-IHM035V2</td>
<td>3-phase high voltage inverter power board for FOC and scalar motor control based on the STGIPN3H60 (SLLIMM™-nano)</td>
</tr>
<tr>
<td>STEVAL-IHM045V1</td>
<td>3-phase high voltage inverter power board for FOC based on the STGIPN3H60A (SLLIMM™-nano)</td>
</tr>
</tbody>
</table>

![Images of the power boards](image)
<table>
<thead>
<tr>
<th>Reference / Bundle</th>
<th>Voltage</th>
<th>Power</th>
<th>Motor Type / Control Type *</th>
<th>ST Parts</th>
<th>Application focus</th>
</tr>
</thead>
</table>
| 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 L6652A        | 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        |
<table>
<thead>
<tr>
<th>Reference / Bundle</th>
<th>Voltage</th>
<th>Power</th>
<th>Motor Type / Control Type *</th>
<th>ST Parts</th>
<th>Application focus</th>
</tr>
</thead>
</table>
| 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 STGIEL4K60  
• 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

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>STSW-STM32100</td>
<td>Active</td>
<td>STM32 PMSM FOC SDK motor control firmware library (UM1052)</td>
</tr>
</tbody>
</table>

• 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.

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST-LINK/V2</td>
<td>Active</td>
<td>ST-LINK/V2 in-circuit debugger/programmer for STM8 and STM32</td>
</tr>
</tbody>
</table>

- Click on Design Resources, download and install the STSW-LINK003.
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).
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

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

<table>
<thead>
<tr>
<th>Power stage</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEVAL-IFN003V1</td>
<td></td>
</tr>
<tr>
<td>STEVAL-IHM034V2</td>
<td></td>
</tr>
<tr>
<td>STEVAL-IHM042V1</td>
<td></td>
</tr>
<tr>
<td>STEVAL-IHM045V1</td>
<td></td>
</tr>
<tr>
<td>MB459</td>
<td></td>
</tr>
</tbody>
</table>
Step #7 – Setup power stage

- Other power stage data can be found here

<table>
<thead>
<tr>
<th></th>
<th>IHM021v2</th>
<th>IHM032v1</th>
<th>IHM025v1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rated Bus Voltage Info</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min rated voltage (V)</td>
<td>60</td>
<td>60</td>
<td>45</td>
</tr>
<tr>
<td>Max rated voltage (V)</td>
<td>380</td>
<td>450</td>
<td>450</td>
</tr>
<tr>
<td>Nominal voltage (V)</td>
<td>325</td>
<td>325</td>
<td></td>
</tr>
<tr>
<td><strong>Bus voltage sensing</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bus voltage divider 1/...</td>
<td>125</td>
<td>125</td>
<td>136</td>
</tr>
<tr>
<td><strong>Dissipative brake</strong></td>
<td></td>
<td>W3 R_{brake}</td>
<td>W3 OCPoff</td>
</tr>
<tr>
<td>Polarity</td>
<td></td>
<td></td>
<td>Active high</td>
</tr>
<tr>
<td><strong>Driving signals</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phases U, V, W High side polarity</td>
<td>Active high</td>
<td>Active hgh</td>
<td>Active high</td>
</tr>
<tr>
<td>Phases U, V, W Low side polarity</td>
<td>Active low</td>
<td>Active low</td>
<td>Active low</td>
</tr>
<tr>
<td><strong>Temperature sensing</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V0 (mV)</td>
<td>1055</td>
<td>1055</td>
<td>1020</td>
</tr>
<tr>
<td>T0 (°C)</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>ΔV/ΔT (mV/°C)</td>
<td>22</td>
<td>22</td>
<td>23.6</td>
</tr>
<tr>
<td>Max working temperature on sensor (°C)</td>
<td>70</td>
<td>70</td>
<td>70</td>
</tr>
</tbody>
</table>
### Step #7 – Setup power stage

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>STEVAL-IHM035V2 default value</th>
<th>Unit</th>
<th>Parameter</th>
<th>STEVAL-IHM035V2 default value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>VREF</td>
<td>1055 mV</td>
<td></td>
<td>VREF</td>
<td>1055 mV</td>
<td></td>
</tr>
<tr>
<td>T0</td>
<td>25°C</td>
<td></td>
<td>T0</td>
<td>25°C</td>
<td></td>
</tr>
</tbody>
</table>

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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 to the specs of the application.

- Set Nominal Current with max peak current provided to each of the motor phases according to the specs of the motor.

- Set Nominal DC Voltage with the value of DC bus provided to the inverter or the rectified value of AC input.

- Keep the 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.

![DC voltage source image]
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 \( I_\infty \times (1 - e^{-t \cdot L/R}) \).
- 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 $K_e$

- Measure the $V_{Bemf}$ frequency ($f_{Bemf}$) and the peak-to-peak amplitude ($V_{Bemf-A}$)

- Compute $K_e$ in Vrms / Krpm:

$$K_e = \frac{V_{Bemf-A} \cdot \text{[V peak-to-peak]} \cdot \text{pole pairs number} \cdot 1000}{2 \cdot \sqrt{2} \cdot f_{Bemf} \cdot [\text{Hz}] \cdot 60}$$
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.
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)
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 establishes the communication with the firmware.
- To clear the fault, click Fault Ack and then Start Motor button to run the motor.
Releasing your creativity with the STM32

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