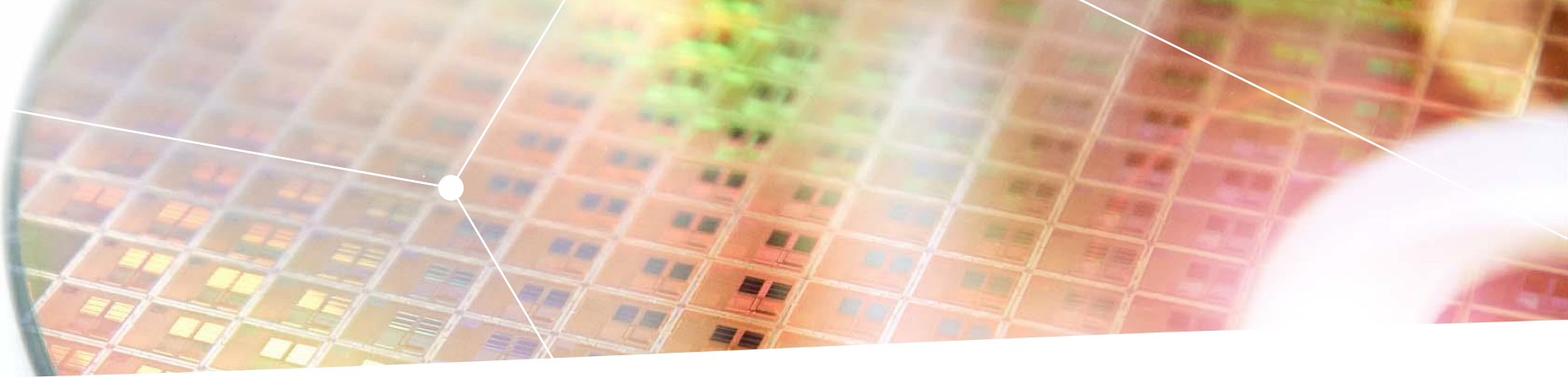


EVAL_FAN_XMC_PFD7

Information and user guide

www.Infineon.com/eval-fan-xmc-pfd7

Agenda

1. Introduction to fan driver evaluation board
2. Hardware and software
3. Tools
4. Getting started
5. Resources

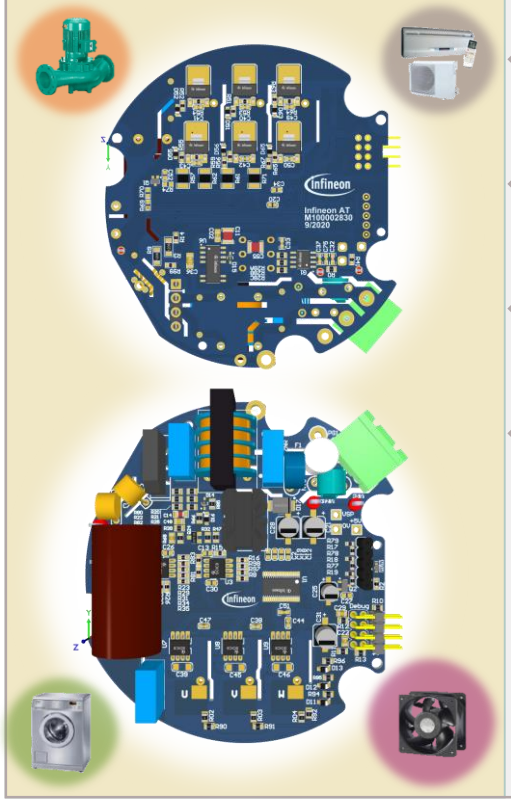
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Agenda

1. Introduction to fan driver evaluation board
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Introduction



Compact 3-phase motor drive system solution up to 100 W

Designed for **sensor less or sensored** motor control

Spin your motor with easy-to-use GUI for tuning of motor

The hardware board and motor control software provides:

- Sensorless speed controlled direct FOC startup
- 7-segment / 5-segment SVM
- Over-current protection by CTRAP
- Speed controlled using µC/Probe™ GUI's slider

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Agenda

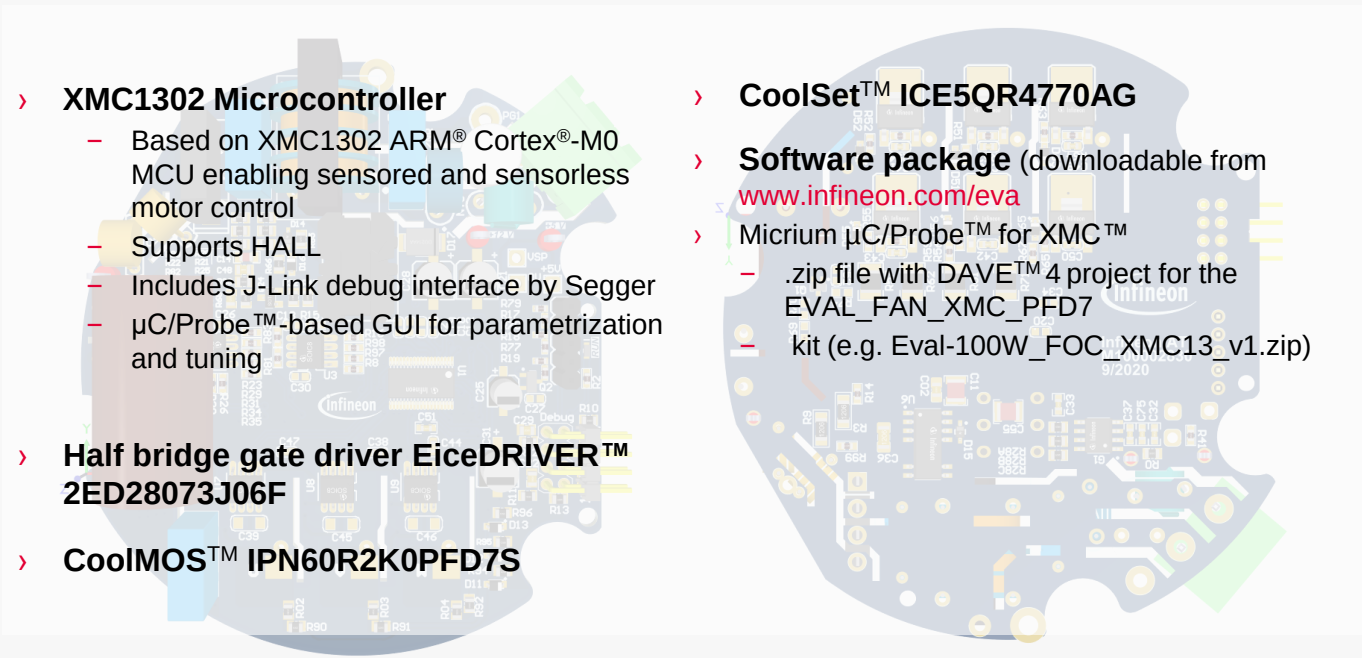
1. Introduction to fan driver evaluation board
2. Hardware and software
3. Tools
4. Getting started
5. Resources

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System overview

Components

- **XMC1302 Microcontroller**
  - Based on XMC1302 ARM® Cortex®-M0 MCU enabling sensored and sensorless motor control
  - Supports HALL
  - Includes J-Link debug interface by Segger
  - µC/Probe™-based GUI for parametrization and tuning
- **Half bridge gate driver EiceDRIVER™ 2ED28073J06F**
- **CoolMOS™ IPN60R2K0PFD7S**
- **CoolSet™ ICE5QR4770AG**
- **Software package** (downloadable from www.infineon.com/eva
- Micrium µC/Probe™ for XMC™
  - .zip file with DAVE™ 4 project for the EVAL_FAN_XMC_PFD7
  - kit (e.g. Eval-100W_FOC_XMC13_v1.zip)



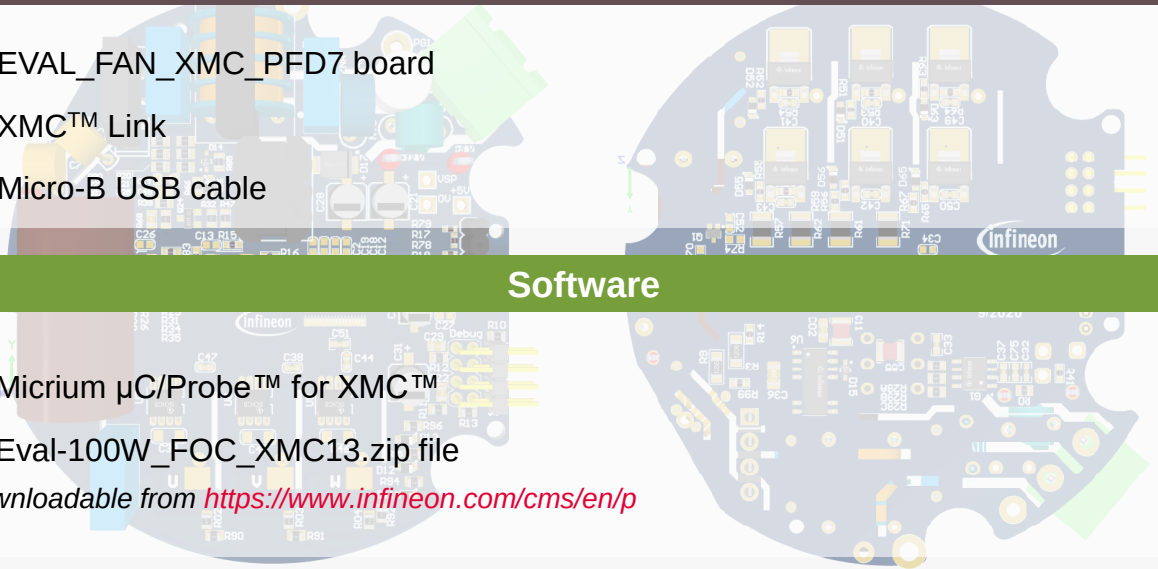
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System overview

For example the EVAL_FAN_XMC_PFD7 Kit consists of:

Hardware

- EVAL_FAN_XMC_PFD7 board
- XMC™ Link
- Micro-B USB cable



Software

- Micrium µC/Probe™ for XMC™
- Eval-100W_FOC_XMC13.zip file

(downloadable from https://www.infineon.com/cms/en/p

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System overview

Software package content description:

- **Eval-100W_FOC_XMC13**

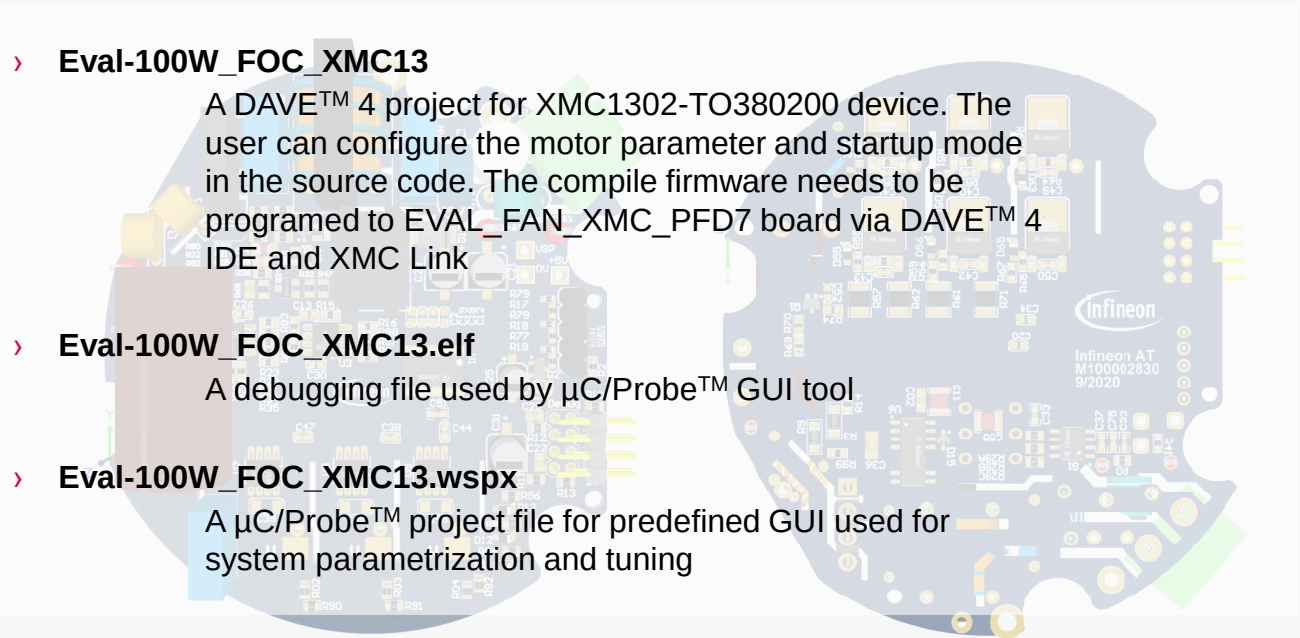
  A DAVE™ 4 project for XMC1302-TO380200 device. The user can configure the motor parameter and startup mode in the source code. The compile firmware needs to be programed to EVAL_FAN_XMC_PFD7 board via DAVE™ 4 IDE and XMC Link

- **Eval-100W_FOC_XMC13.elf**

  A debugging file used by µC/Probe™ GUI tool

- **Eval-100W_FOC_XMC13.wspx**

  A µC/Probe™ project file for predefined GUI used for system parametrization and tuning

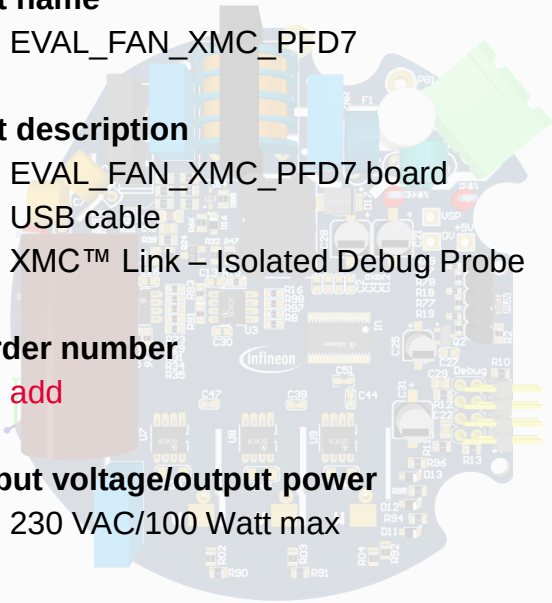


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Hardware overview

Hardware

- **Kit name**
  - EVAL_FAN_XMC_PFD7
- **Kit description**
  - EVAL_FAN_XMC_PFD7 board
  - USB cable
  - XMC™ Link – Isolated Debug Probe
- **Order number**
  - add
- **Input voltage/output power**
  - 230 VAC/100 Watt max

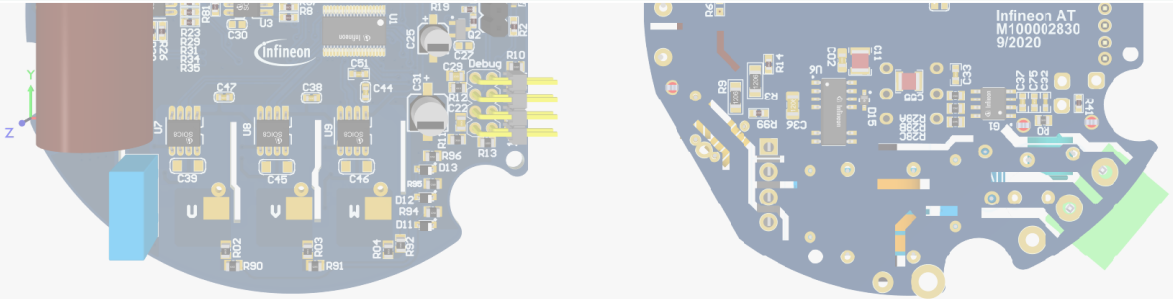


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Hardware overview

Infineon parts utilized on EVAL_FAN_XMC_PFD7 board:

Infineon Parts	Order Number
XMC1300 Microcontroller	XMC1302-T038F0200
600 V half bridge gate driver	2ED28073J06F
600 V CoolMOS™	IPN60R2K0PFD7S
Quasi-resonant CoolSET™	ICE5QR4770AG
5 V LDO regulator	IFX1763XEJV50



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Hardware overview

To properly setup the board, follow these steps:

1. Connect 3-phase motor wiring to ‘U V W’ connector

2a. Connect XMC™ Link’s ribbon cable to pin 1 of Debug connector

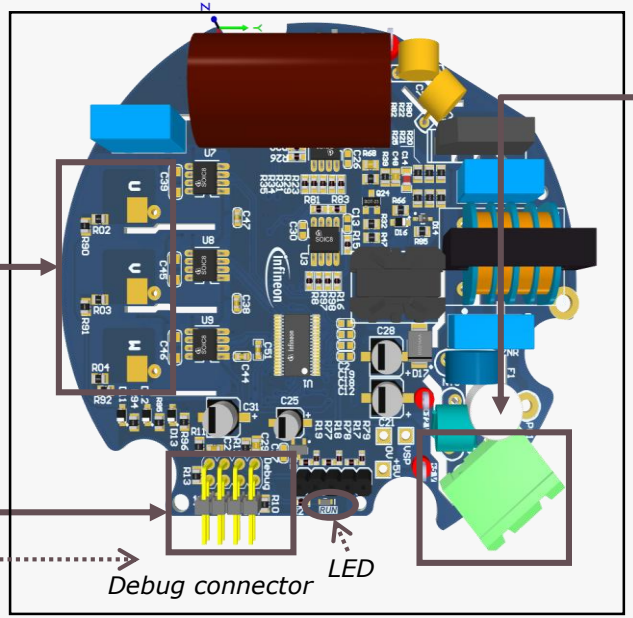
3. Connect AC source to EVAL_FAN_XMC_PFD7 board

AC power input 230 VAC

2b. Connect to PC via micro-B USB cable



XMC™ link for debugging the source code in DAVE™ 4 IDE



USB port of PC host

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Agenda

1. Introduction to fan driver evaluation board
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DAVE™ 4 setup



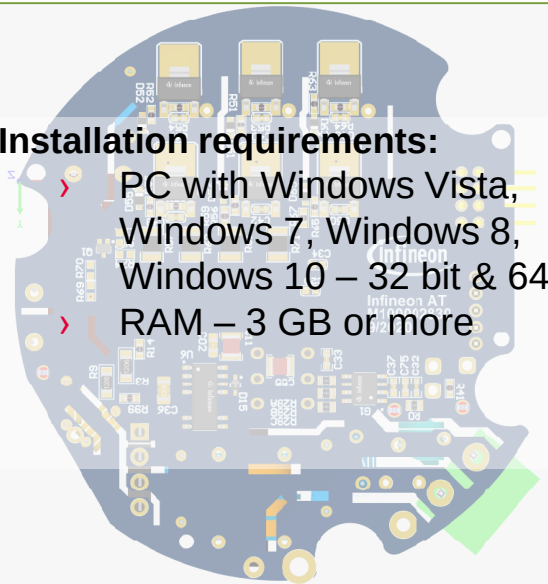
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Micrium µC/Probe™

Download Micrium µC/Probe™ for XMC™ installer package from:

www.infineon.com/ucprobexmc





Installation requirements:

- PC with Windows Vista, Windows 7, Windows 8, Windows 10 – 32 bit & 64 bit
- RAM – 3 GB or more

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Agenda

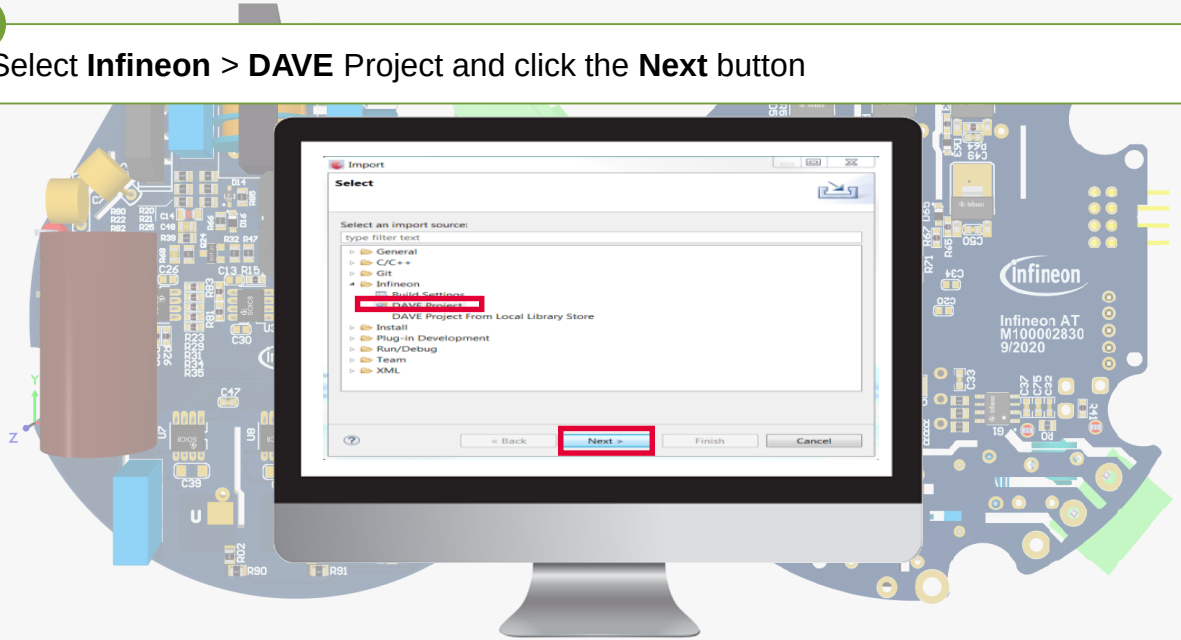
1. Introduction to fan driver evaluation board
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Import the *.zip project

1. Import the *.zip file into DAVE™ 4 IDE by clicking on **File** > **Import**

2. Select **Infineon** > **DAVE** Project and click the **Next** button

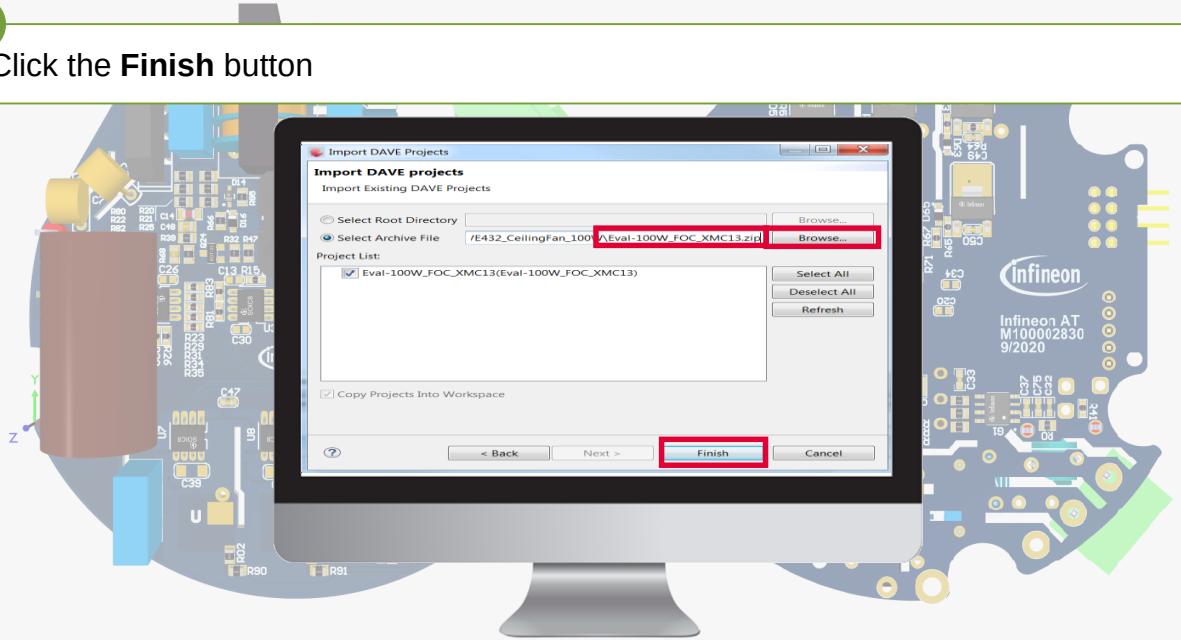


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Import the *.zip project

3. Click **Browse** and navigate to the *.zip file location

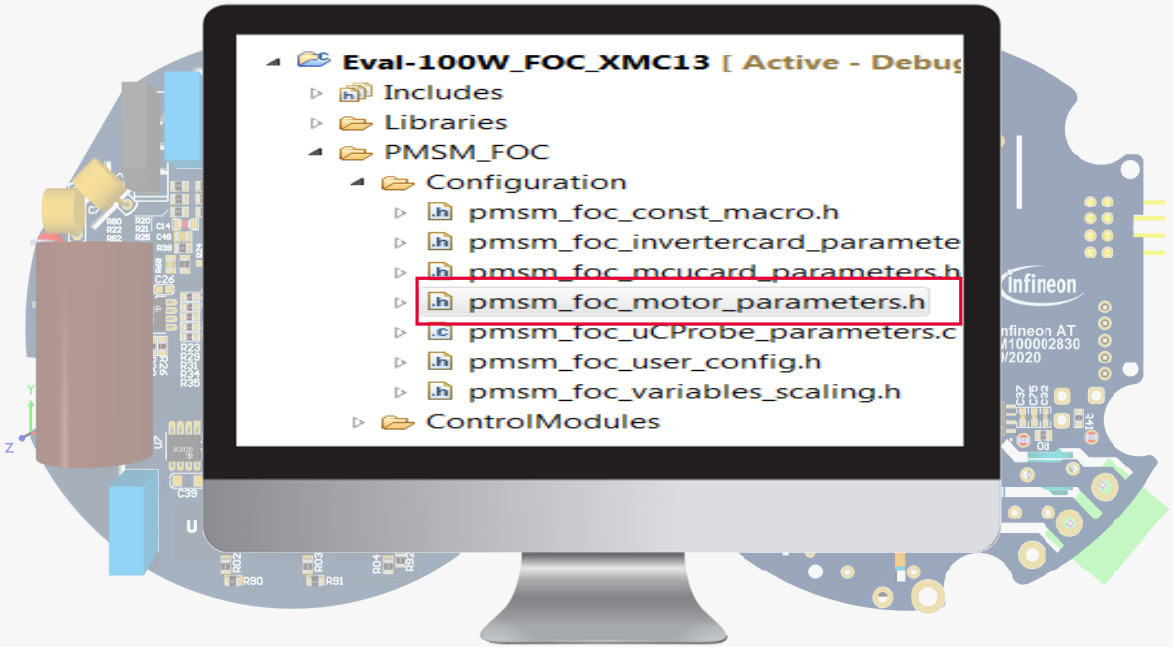
4. Click the **Finish** button



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Input motor parameters

1. Double click on **pmsm_foc_motor_parameters.h**

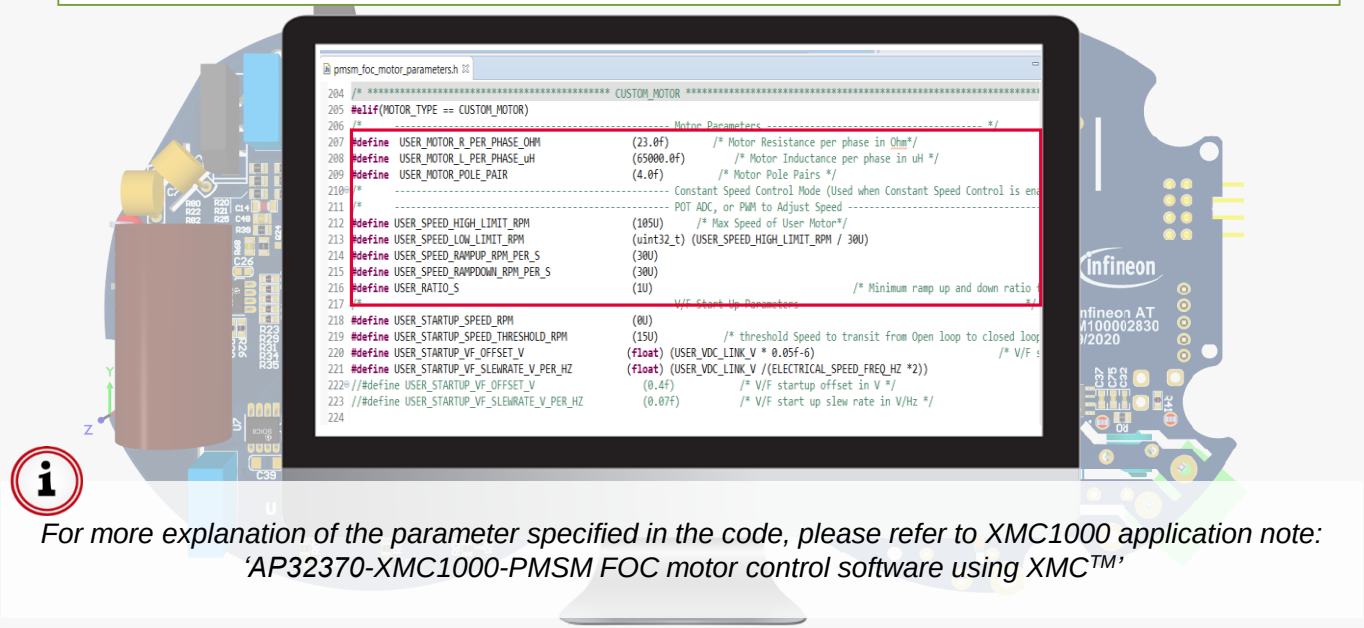


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Input motor parameters

2

Scroll to **(MOTOR_TYPE == CUSTOM_MOTOR)** and update the parameters in the red box with your motor's data

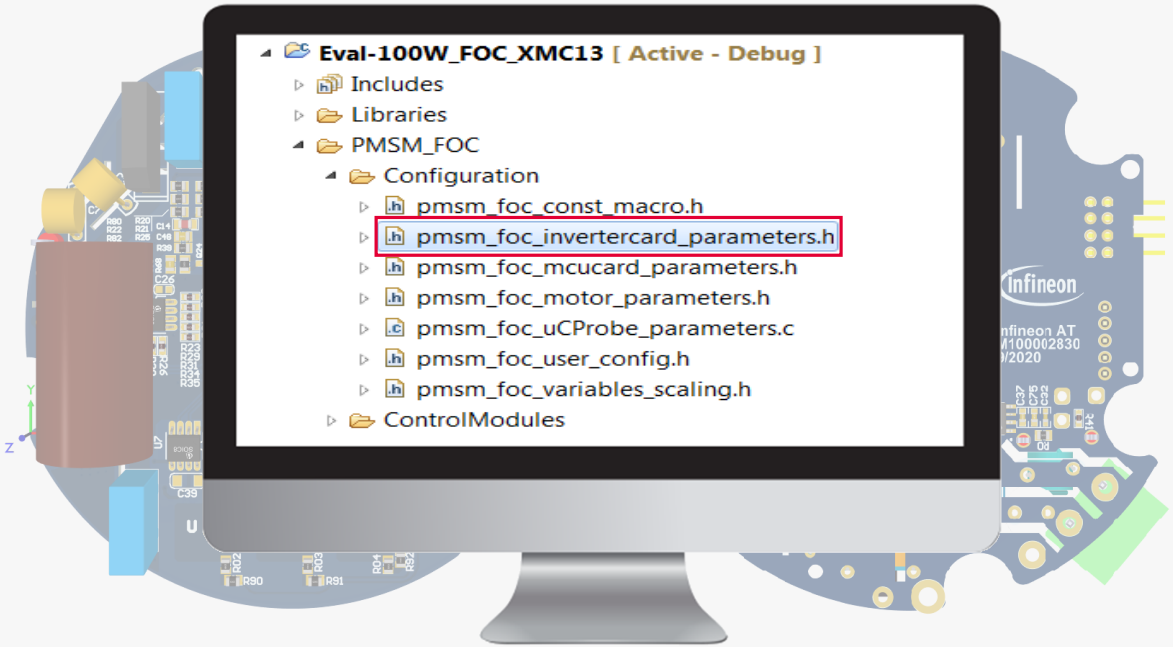


For more explanation of the parameter specified in the code, please refer to XMC1000 application note: 'AP32370-XMC1000-PMSM FOC motor control software using XMC™'

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Input inverter circuitry parameters

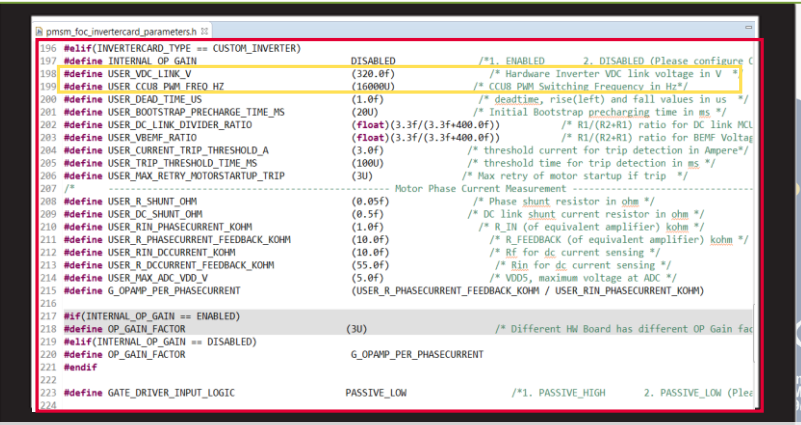
1. Double click on **pmsm_foc_invertercard_parameters.h**



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Input inverter circuitry parameters

2 Scroll to **(INVERTERCARD_TYPE == CUSTOM_INVERTER)**



*The inverter parameters is already preset to the EVAL_FAN_XMC_PFD7 board's value, e.g. USER_VDC_LINK_V is 320 V (√2*230 V) with the assumption that AC input voltage is 230 V*

The PWM frequency driving the power MOSFET is set to 16 kHz

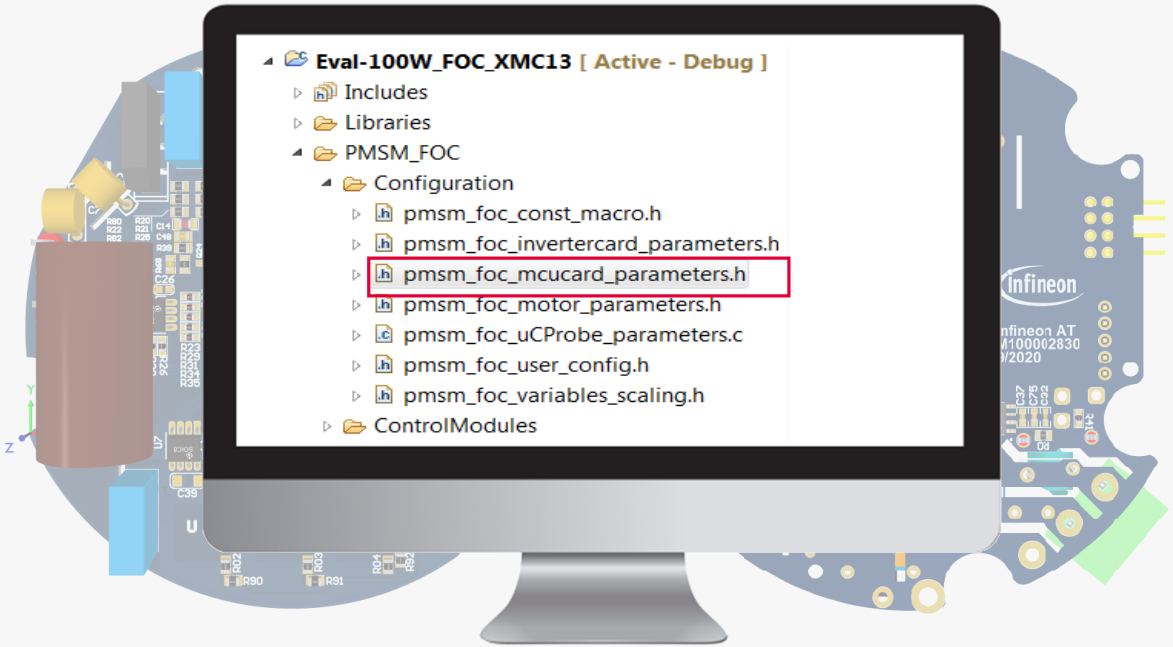
The minimum PWM frequency can be set is 6.6 kHz

The user does NOT need to change the value here if AC input voltage to EVAL_FAN_XMC_PFD7 board is 230 V

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Input XMC1302 pin setting

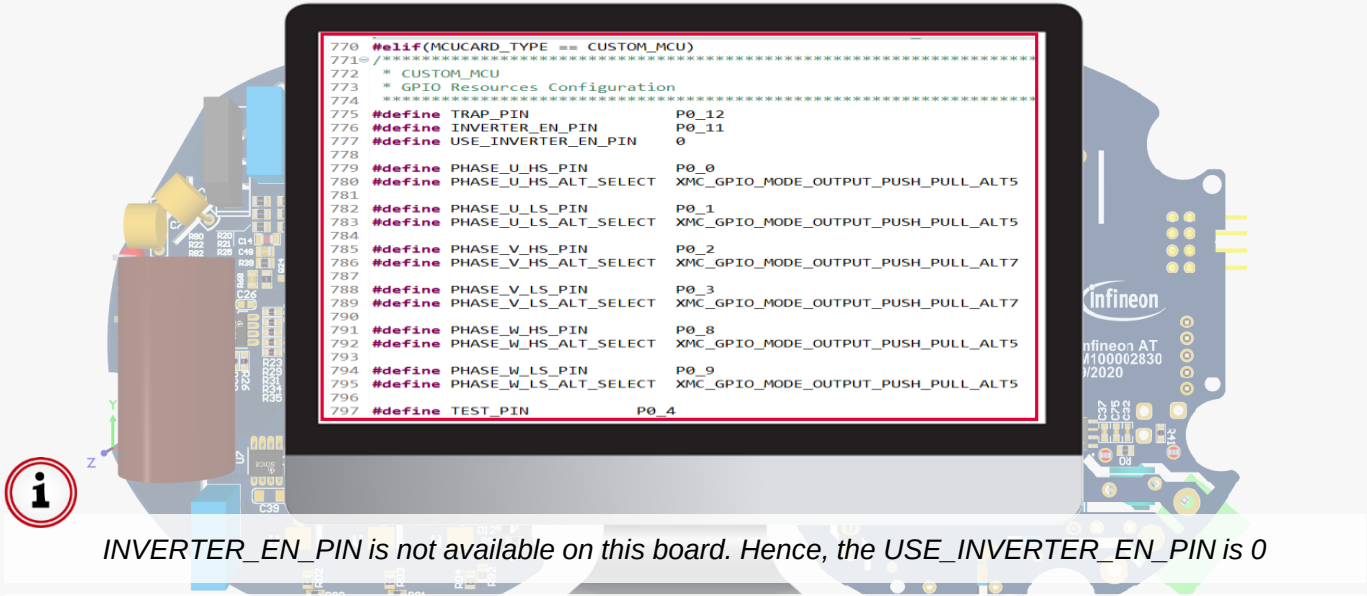
1. Double click on **pmsm_foc_mcucard_parameters.h**



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Input XMC1302 pin setting

2 Scroll to **(MCUCARD_TYPE == CUSTOM_MCU)**



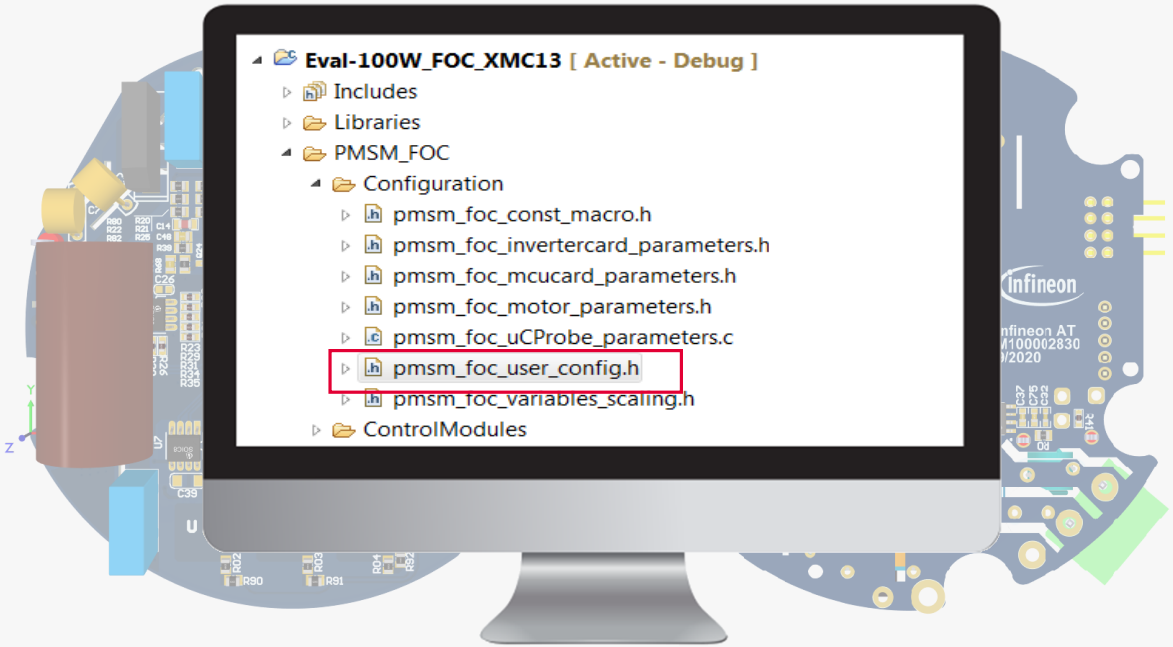
INVERTER_EN_PIN is not available on this board. Hence, the USE_INVERTER_EN_PIN is 0

The MCU pinout setting is already set according to the EVAL_FAN_XMC_PFD7 board.
The user does NOT need to change it!

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Input motor startup: current sensing setting

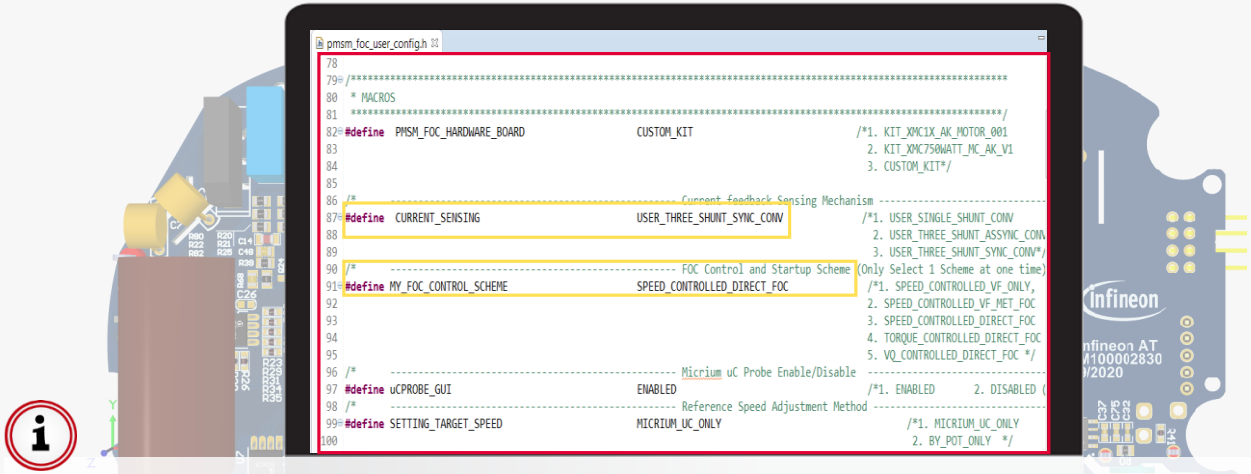
1. Double click on **pmsm_foc_user_config.h**



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Input motor startup: current sensing setting

2 Scroll to **(MCUCARD_TYPE == CUSTOM_MCU)**



The user can select 3 types of current sensing methods (as shown in green comment lines)

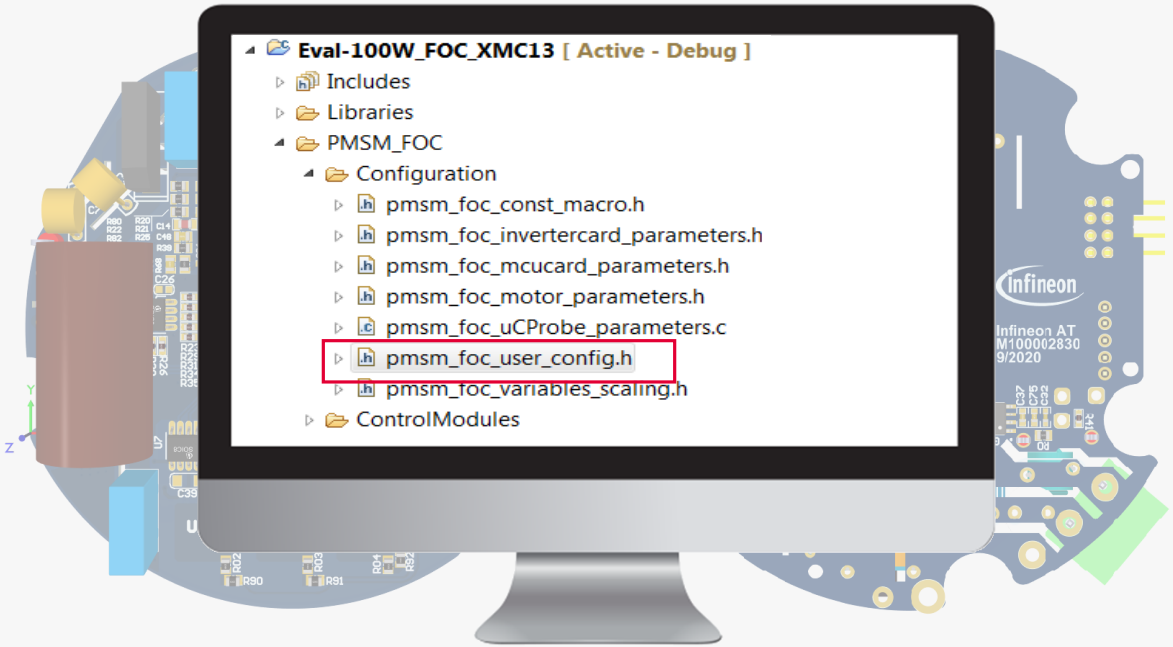
The user can select 5 types of motor control schemes (as shown in green comment lines)

3 shunt synchronous current sensing and speed controlled direct FOC startups have been selected by default. The user does NOT need to change these!

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Input SVM scheme

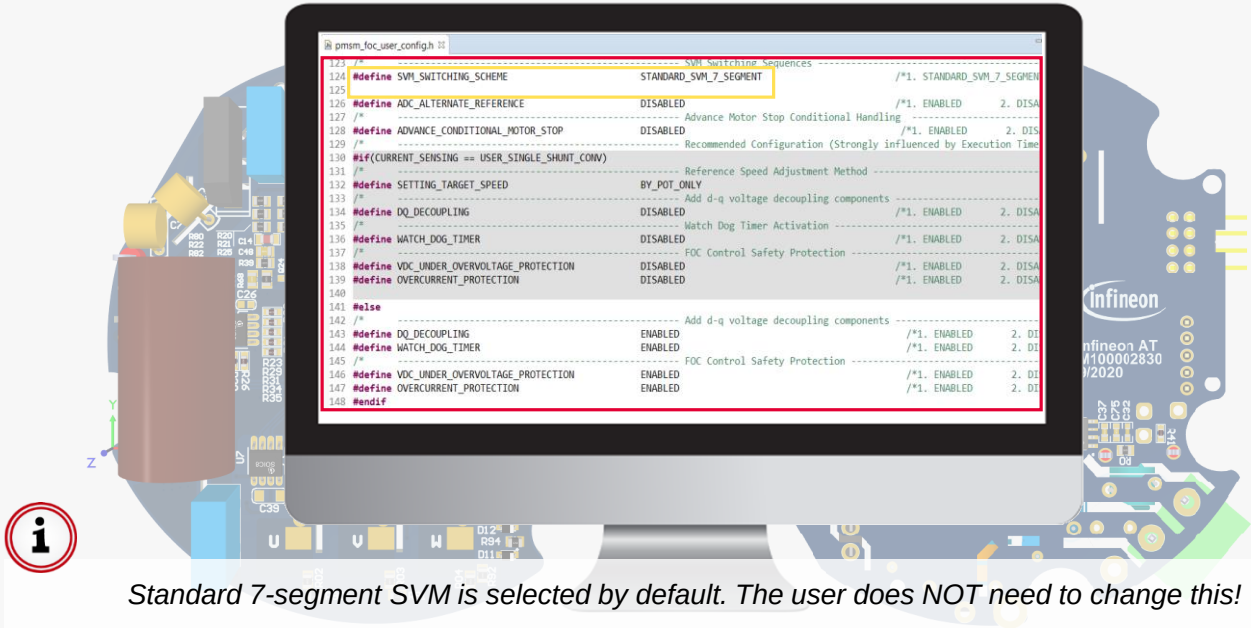
1. Double click on **pmsm_foc_user_config.h**



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Input SVM scheme

2 The user can select 2 types of SVM scheme: 7-segment or 5-segment SVM (as shown in green comment lines)

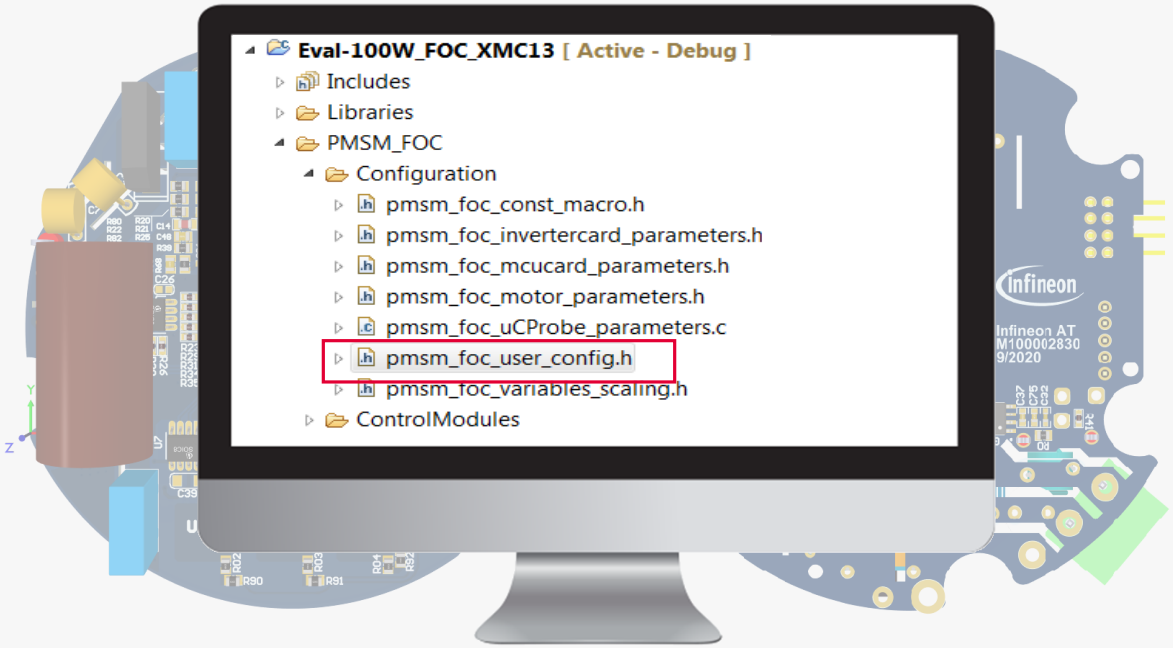


Standard 7-segment SVM is selected by default. The user does NOT need to change this!

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Input current and voltage protection setting

1. Double click on **pmsm_foc_user_config.h**

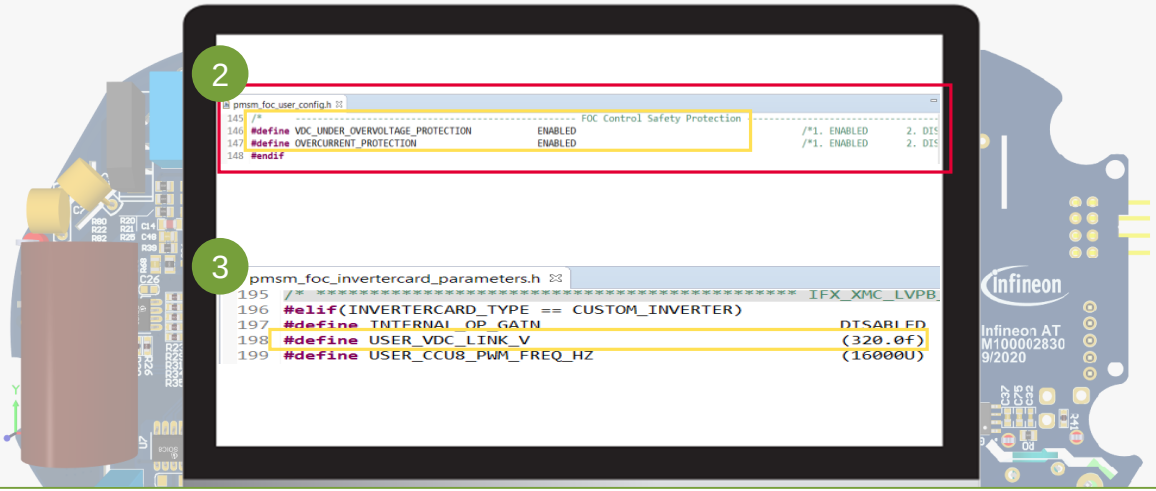


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Input current and voltage protection setting

2

User can enable over-current and under-voltage protection (as shown in the green comment lines)



3

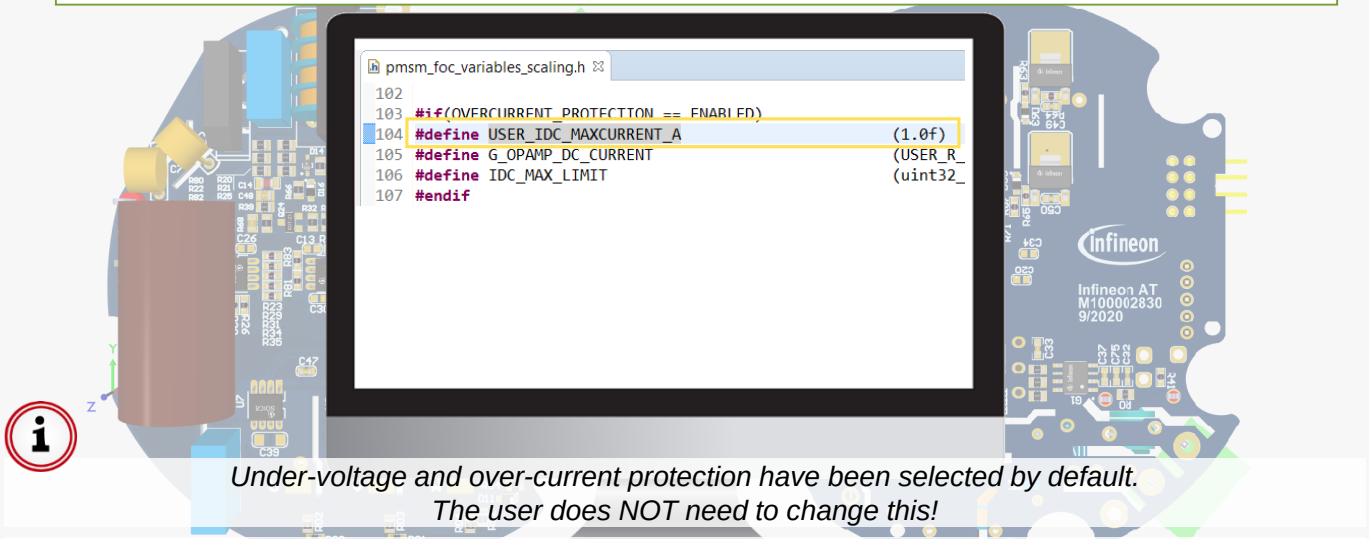
If the DC link voltage is <0.8 or >1.2 of USER_VDC_LINK_V, the PWM signal input to gate driver will go into high impedance and the motor will slowly stop

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Input current and voltage protection setting

4

If the average current flow through the DC link shunt resistor R57 is > USER_IDC_MAXCURRENT_A, the reference speed will reduce until the current is < USER_IDC_MAXCURRENT_A



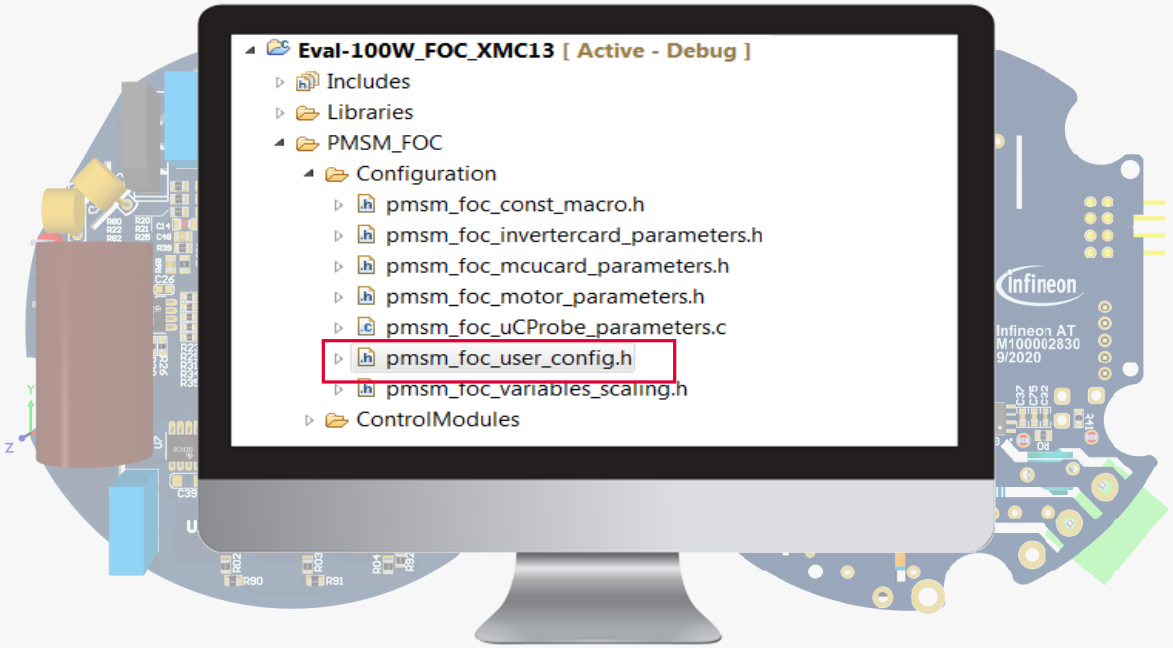
Under-voltage and over-current protection have been selected by default.
The user does NOT need to change this!

USER_VDC_LINK_V and USER_IDC_MAXCURRENT_A values might need to change depending on user motor setting

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Input speed control setting

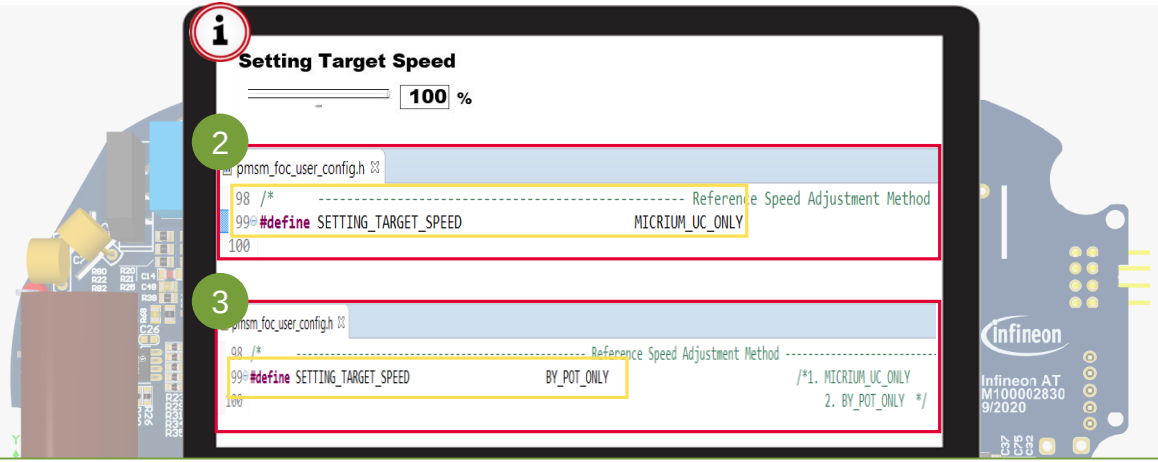
1. Double click on **pmsm_foc_user_config.h**



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Input speed control setting

By default, the speed control method is using µC/Probe™ GUI's speed slider



2 The user can choose to use an external 10 kohm potentiometer as speed control method but he has to solder the potentiometer on the EVAL_FAN_XMC_PFD7 board

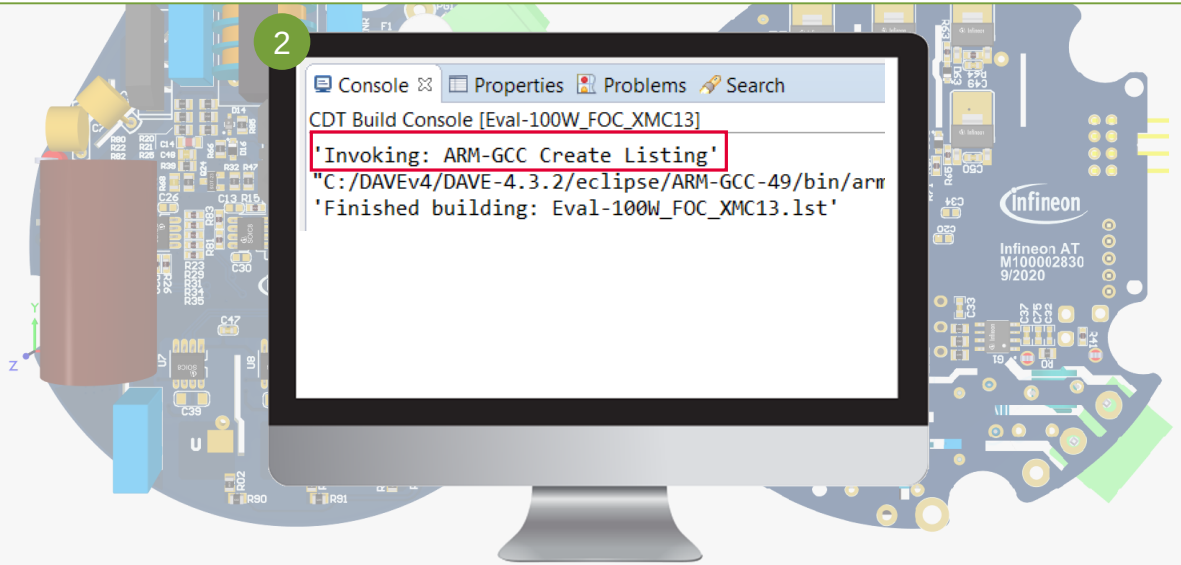
3 Change the speed control method to BY_POT_ONLY

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Compile and download the code

1. Click **Build Active Project**

2. Check **Eval-100W_FOC_XMC13.lst** created

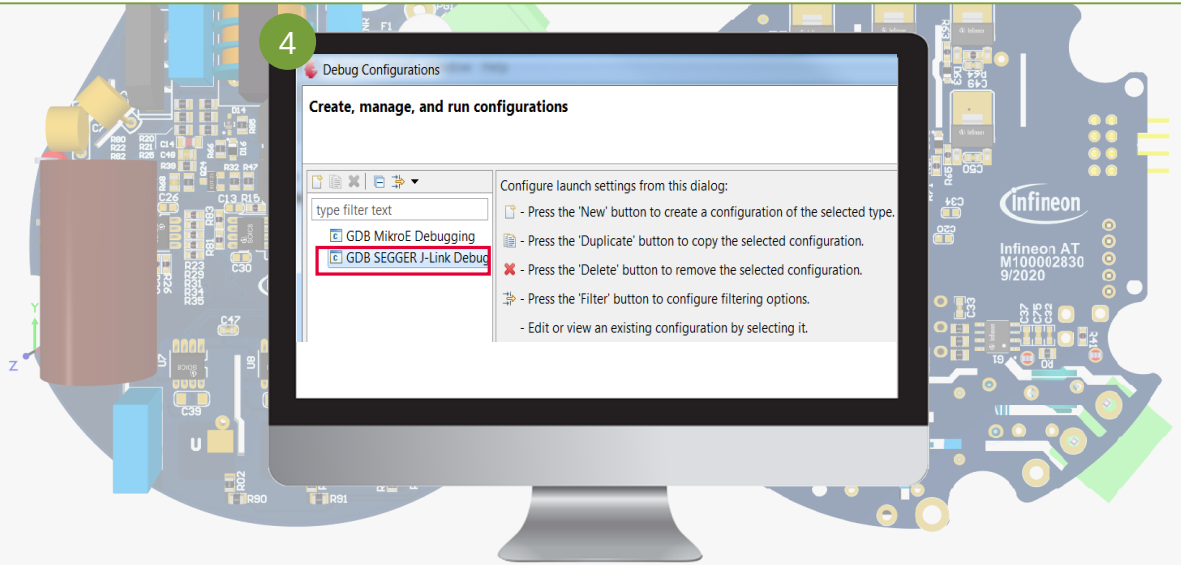


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Compile and download the code

3 Click **Debug Configuration** 

4 Select **GDB SEGGER J-Link Debugging**

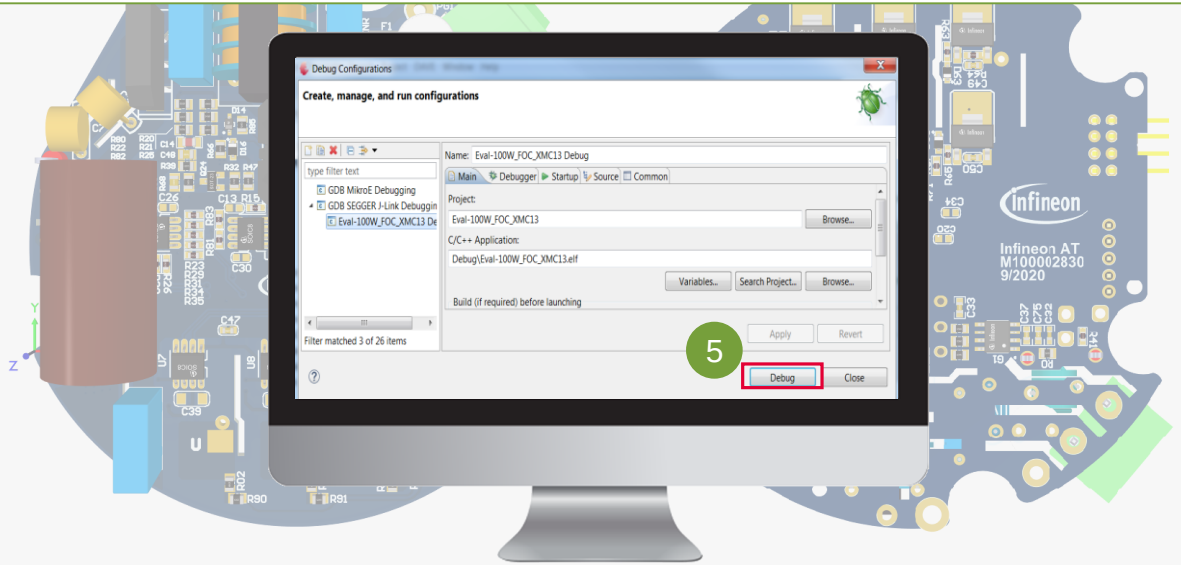


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Compile and download the code

5 Click the **Debug** button to download the code

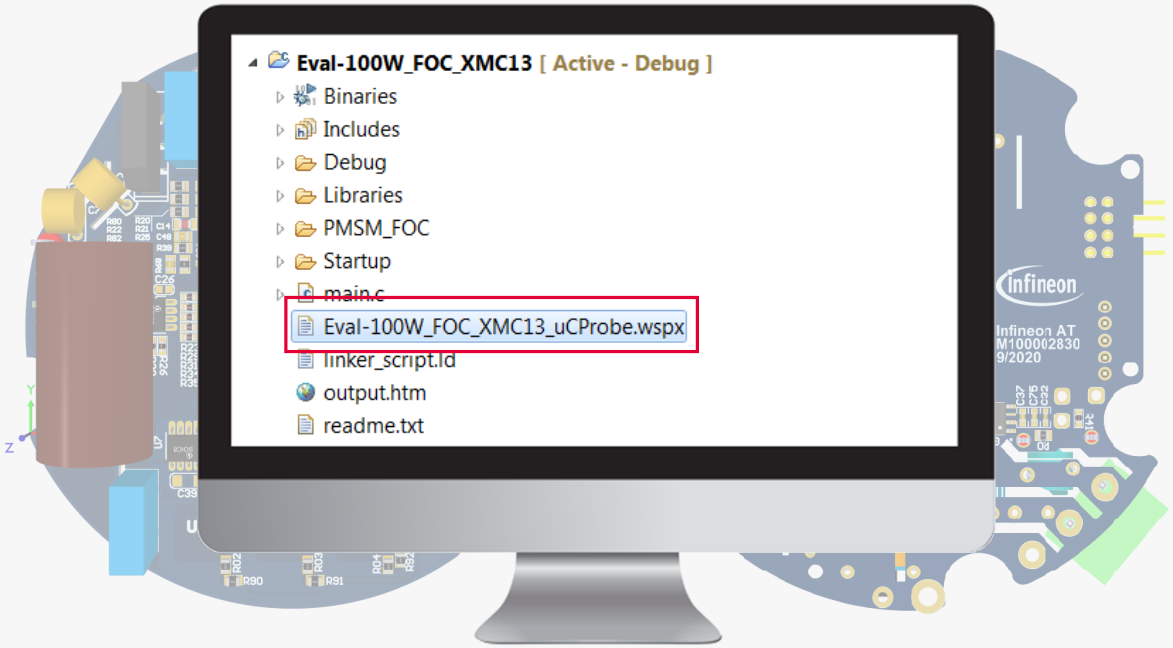
6 Click the **Resume** button to start the application



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Using µC/Probe™ GUI

1. Open the ***.wspx µC/Probe™** project by double click on the ***.wspx** file

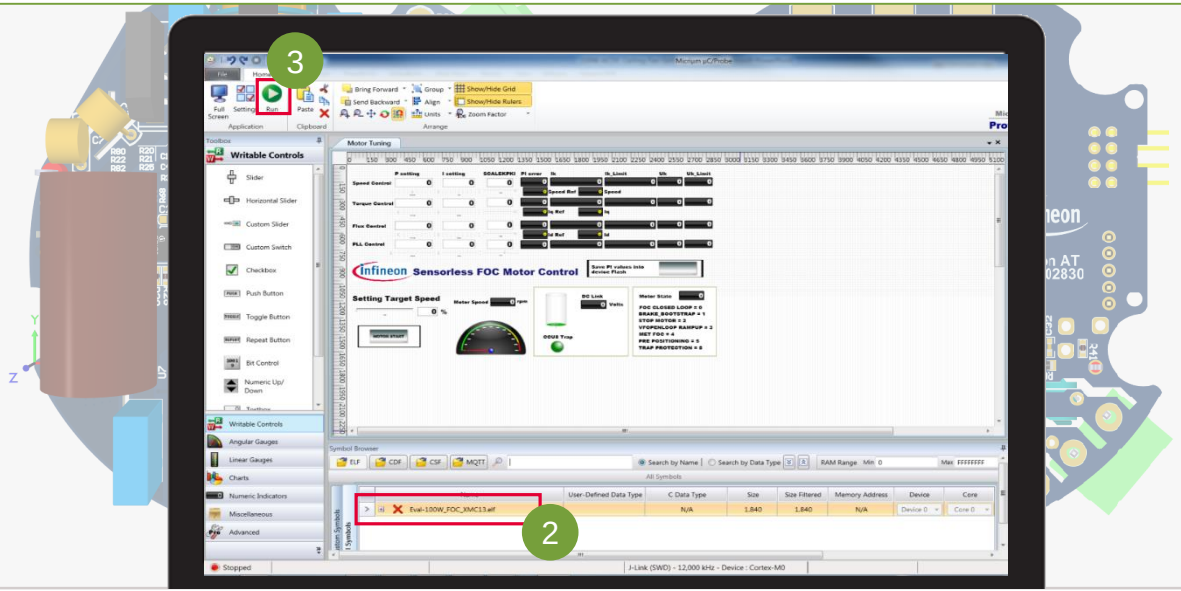


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Using µC/Probe™ GUI

2 Check the ***.elf** file is attached to µC/Probe™ project

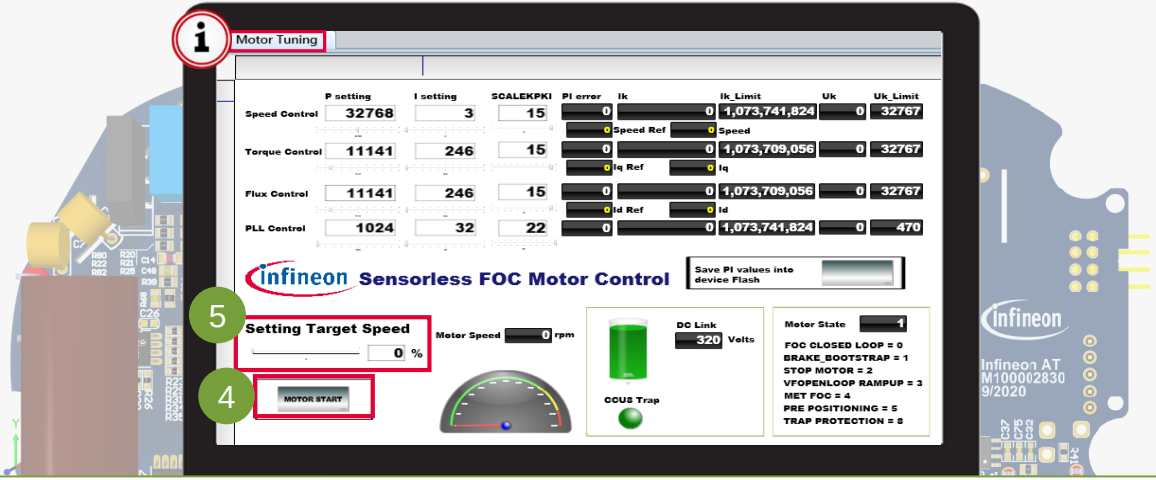
3 Click the **Run** button



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Using µC/Probe™ GUI

The default K_P, K_I values from the pmsm_foc_motor_parameters.h file are automatically displayed in the Motor Tuning page

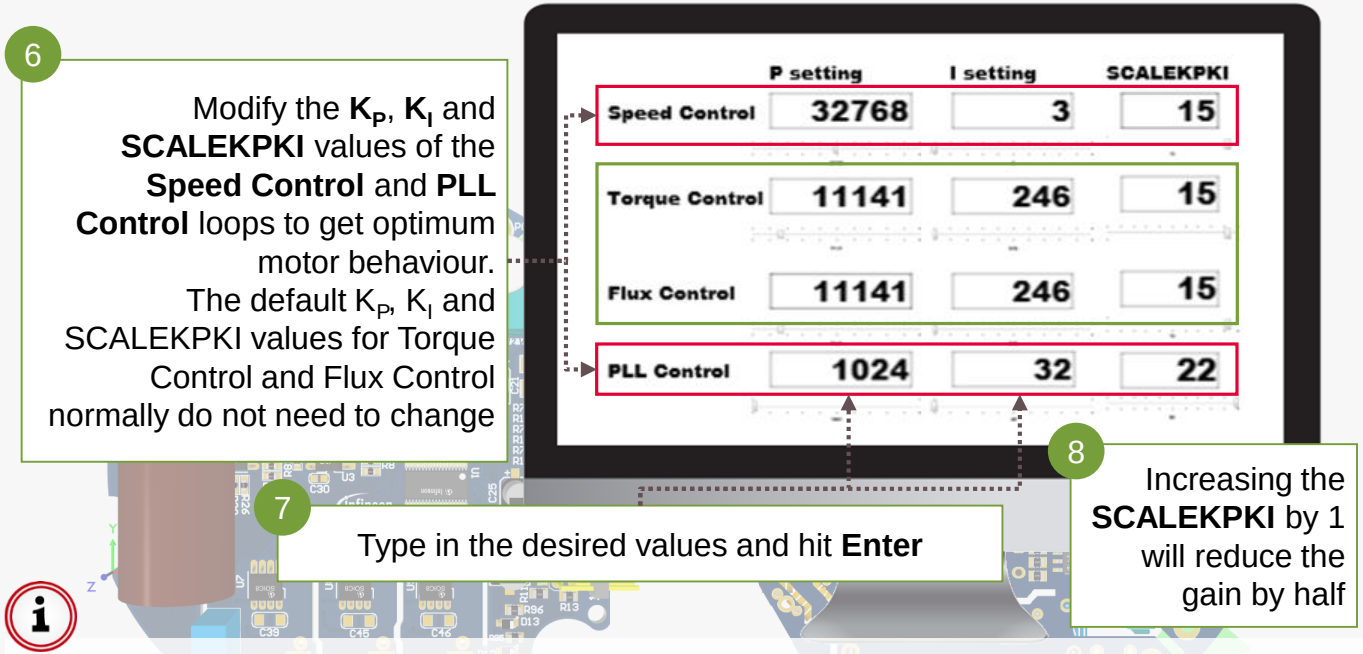


4 Click the **MOTOR START** button

5 Then use the target speed slider or key in directly to set the percentage of maximum speed desired. The motor will start to spin

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Using µC/Probe™ GUI

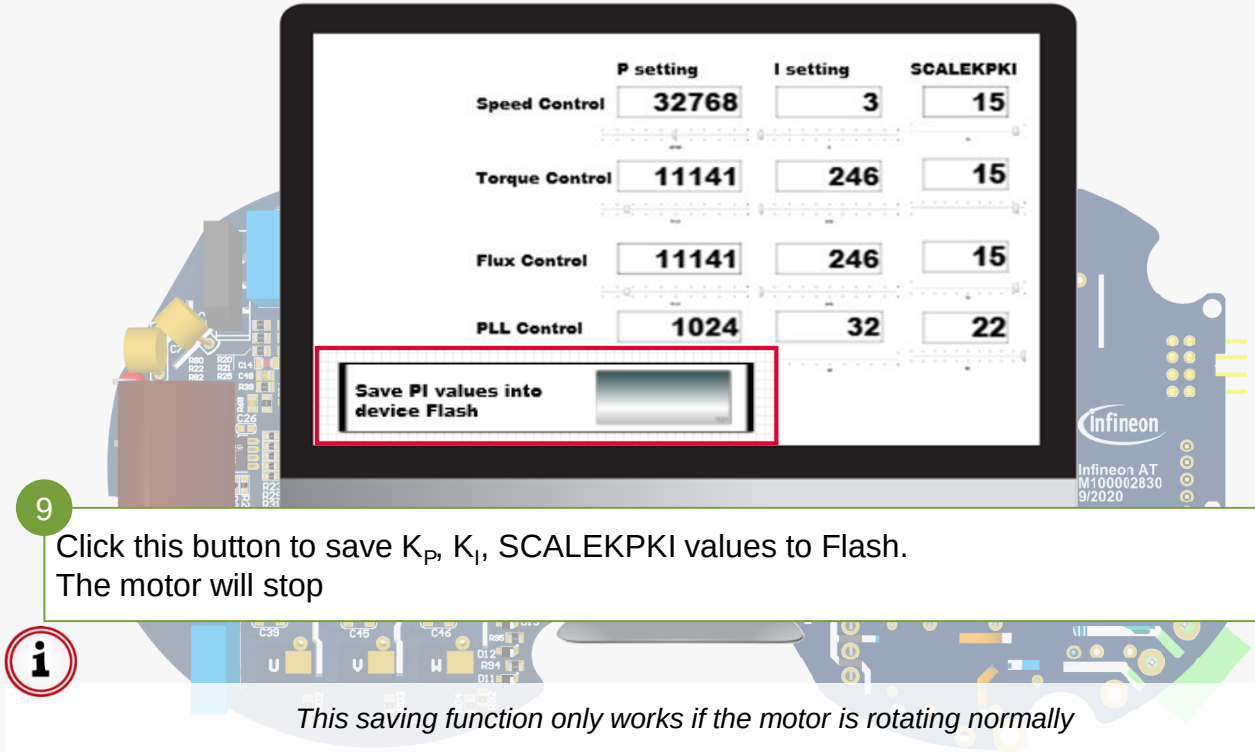


*Under the **P setting** column are the K_P value for the 4 control loops*

*Under the **I setting** column are the K_I value for the 4 control loops*

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Using µC/Probe™ GUI



9

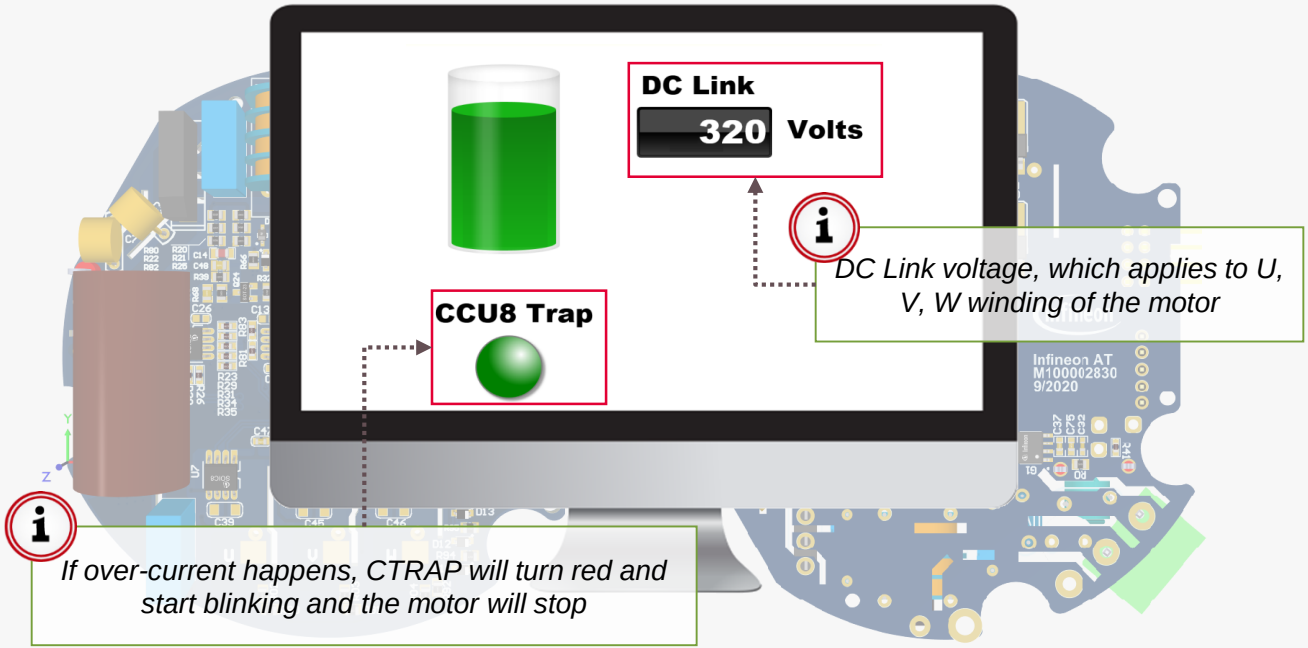
Click this button to save K_P, K_I, SCALEKPKI values to Flash.
The motor will stop

This saving function only works if the motor is rotating normally

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Using µC/Probe™ GUI

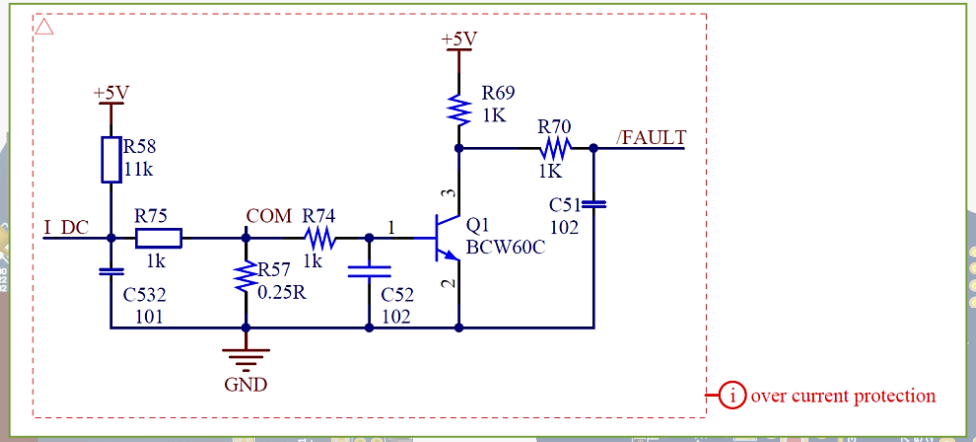
Over-current and under-voltage protections



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Using µC/Probe™ GUI

Over-current and under-voltage protections



On the Eval-100W_FOC board, the VBE(th) of BCW60C is 0.7 V

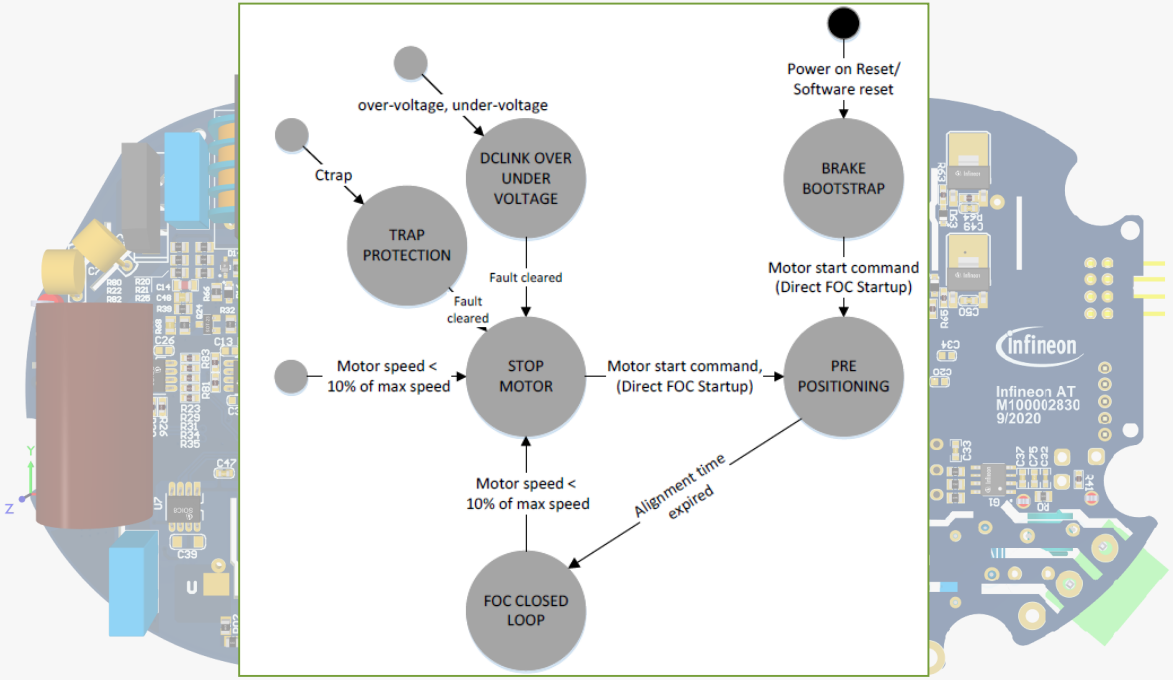
The trip current Itrip is 0.7/0.25=2.8 A

When the 3-phase motor currents exceed its trip current, the CTRAP signal is activated and over-current detected

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Using µC/Probe™ GUI

PMSM FOC state machine panel

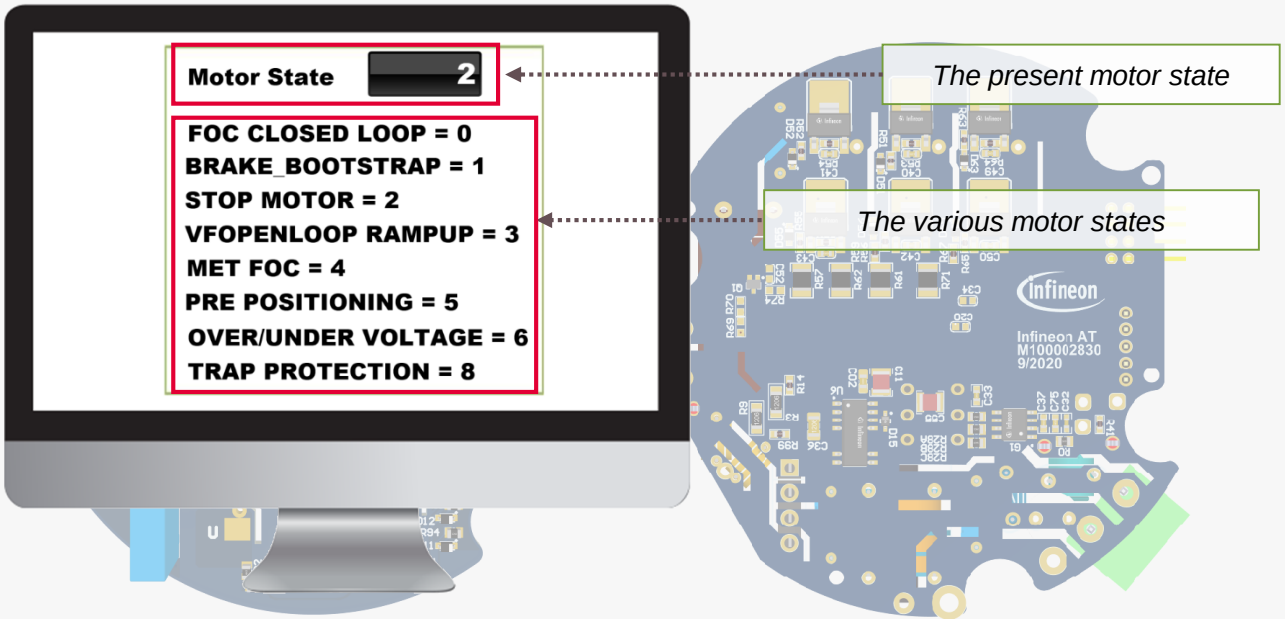


Direct FOC startup state machine diagram

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Using µC/Probe™ GUI

PMSM FOC state machine panel

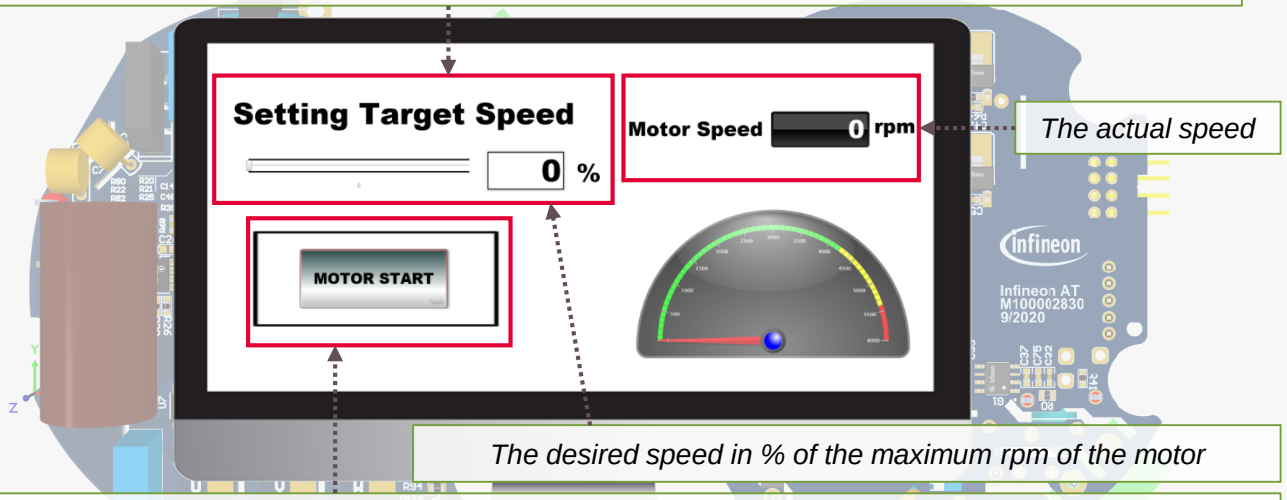


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Using µC/Probe™ GUI

Motor speed, motor start/stop control panel

Use the slider to set the desired speed (% of motor maximum speed in rpm).
*The motor should start to run if **MOTOR START** is clicked*



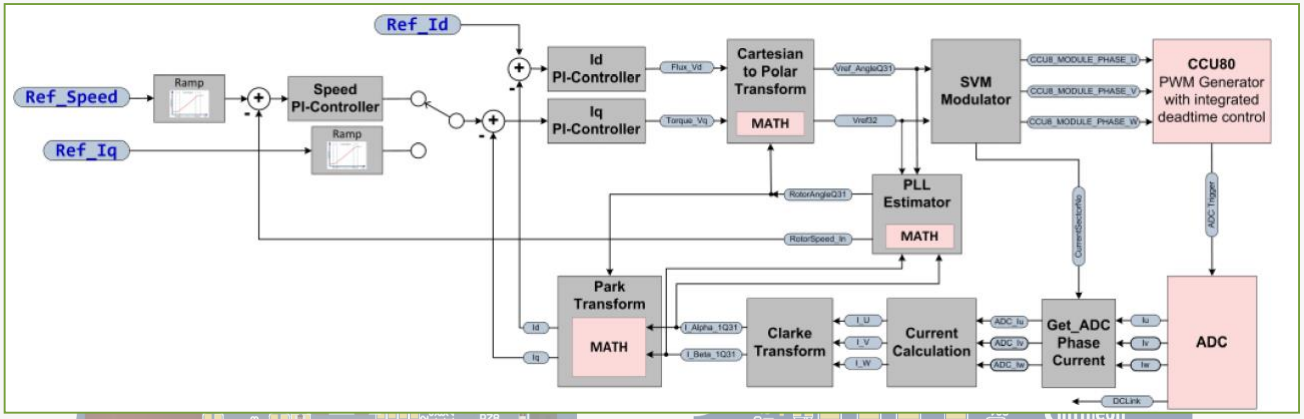
The actual speed

The desired speed in % of the maximum rpm of the motor

*1) Click this **MOTOR START** button. 2) Then, set the desired speed for the motor to start. The wording on the button will change to **MOTOR STOP**. 3) Click this button to stop the motor*

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Tuning of K_P, K_I value using the µC/Probe™

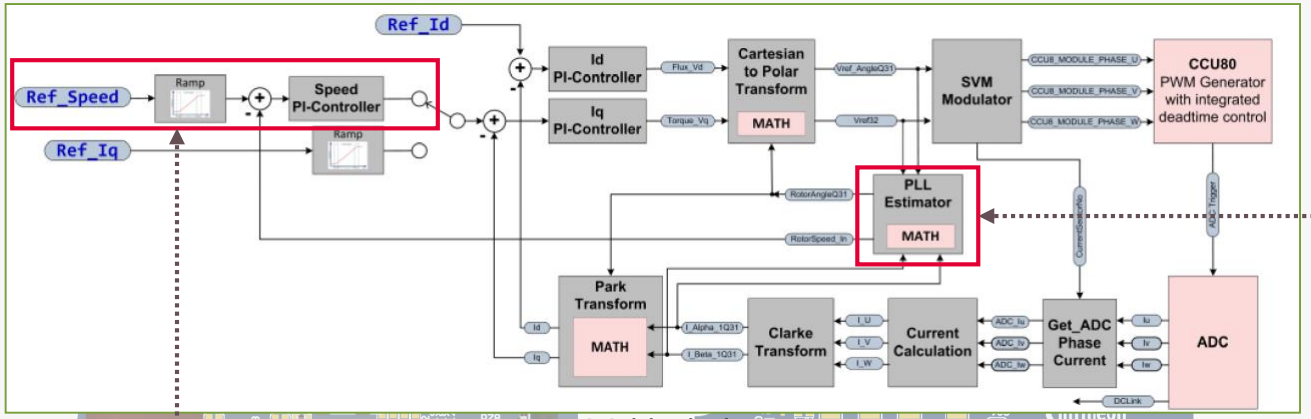


PMSM FOC block diagram

*The FOC software starts the motor directly with **Speed Control Direct FOC control** scheme (by default setting)*

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Tuning of K_P, K_I value using the µC/Probe™



PMSM FOC block diagram

Remove the Speed control here if using TORQUE_CONTROLLED_DIRECT_FOC scheme

Tune the PLL control loop here

*If the **MOTOR START** button was clicked and the motor does not spin after the desired speed slider is set to 30%, for example, the user should change the **My_FOC_CONTROL_SCHEME** in pmsm_foc_user_config.h to **TORQUE_CONTROLLED_DIRECT_FOC**, re-compile and reload*

So that the user can tune the K_P, K_I and SCALEKPKI of PLL, control loop first

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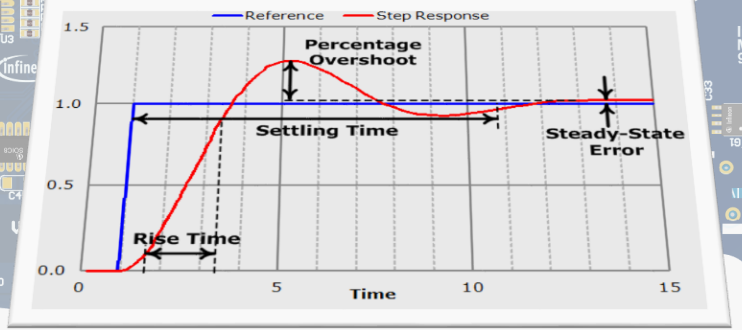
Tuning of K_P, K_I value using the µC/Probe™

Effects of increasing proportional gain K_P or integral gain K_I of PI controller independently

	Gain change	Effects on step response characteristics			
		Rise time	Overshoot	Settling time	Steady-state error
1	K_P ↑ K_I unchanged	↓ ☺	↑ ☹	Minor Change 😐	↓ ☺
2	K_I ↑ K_P unchanged	↓ ☺	↑ ☹	↑ ☹	Eliminate ☺

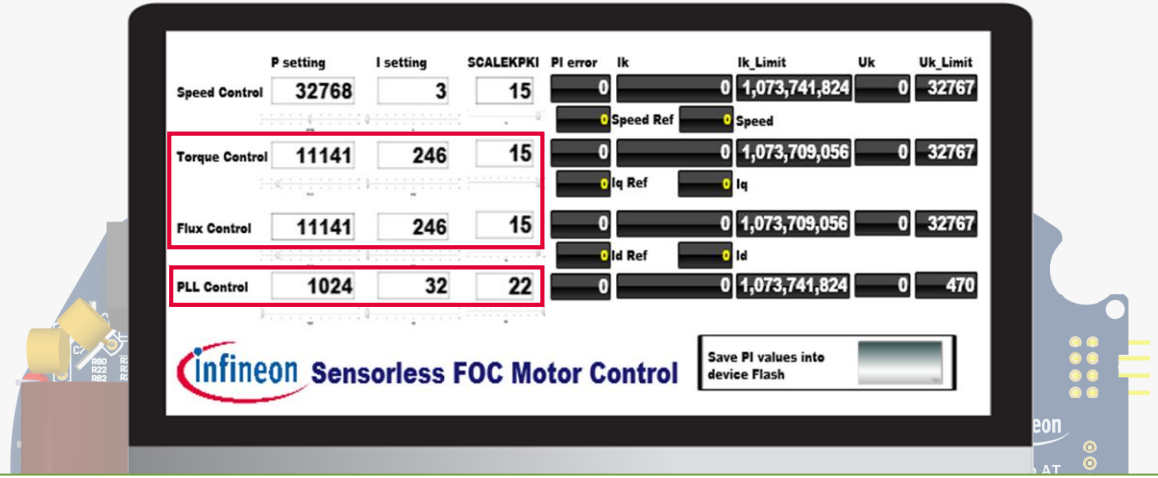
↑ Increase

↓ Decrease



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Tuning of K_P, K_I value using the µC/Probe™

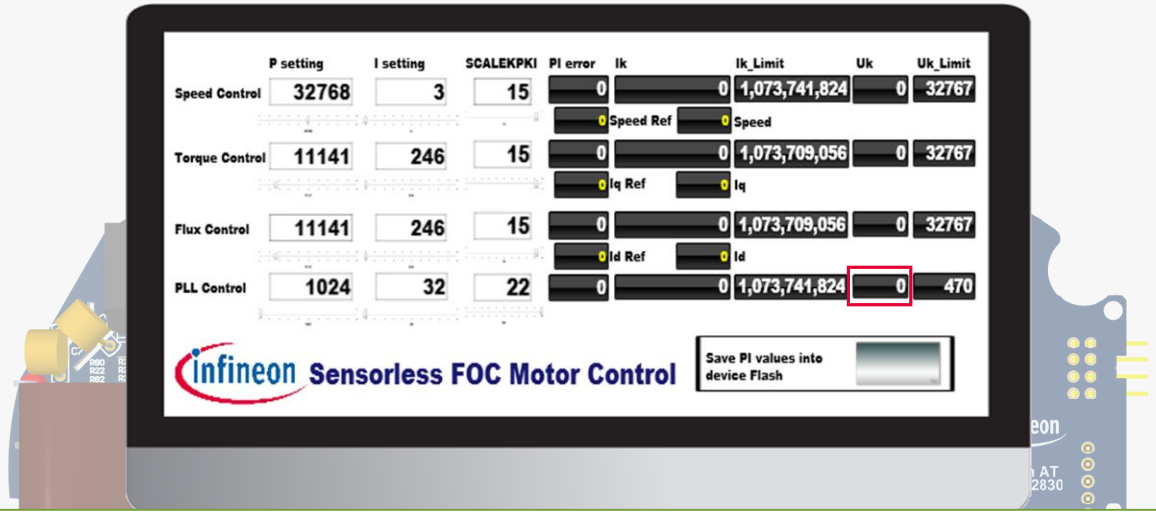


1. The P setting, I setting and SCALEKPKI values for Torque and Flux PI Controllers are calculated from the physical motor and system parameters, and typically don't need to be tuned in the first iteration

2. The PLL Control parameters K_P, K_I, SCALEKPKI should start to be modified if the motor cannot startup in FOC closed-loop smoothly

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Tuning of K_P, K_I value using the µC/Probe™

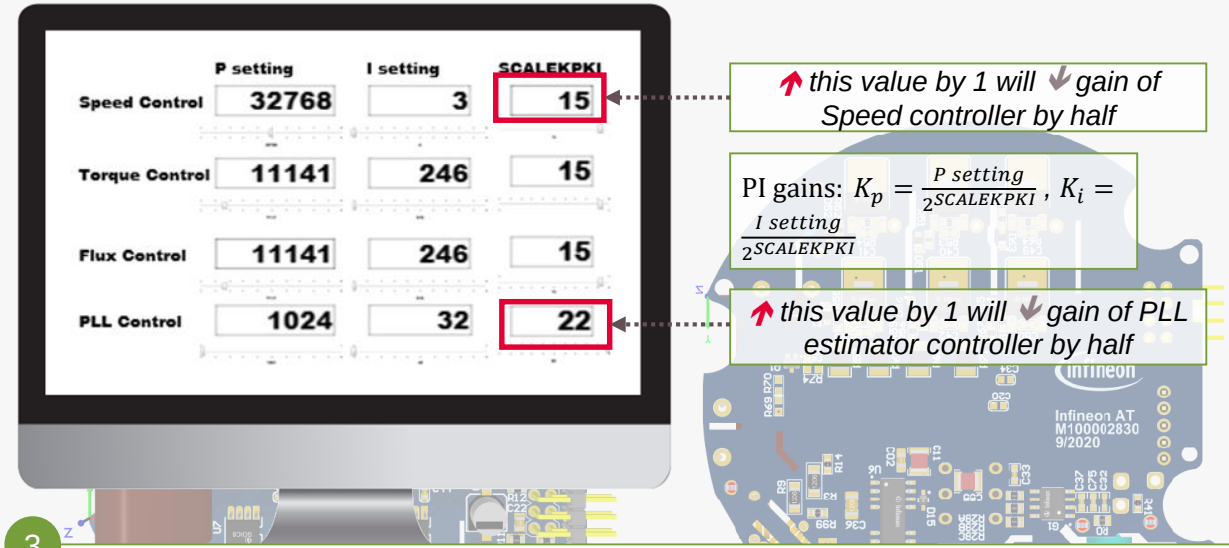


3 The target speed slider becomes the target torque slider under TORQUE_CONTROLLED_DIRECT_FOC mode

4 Make sure the Uk value of PLL control does not hit its Uk_Limit while tuning the PLL control parameters

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Tuning of K_P, K_I value using the µC/Probe™

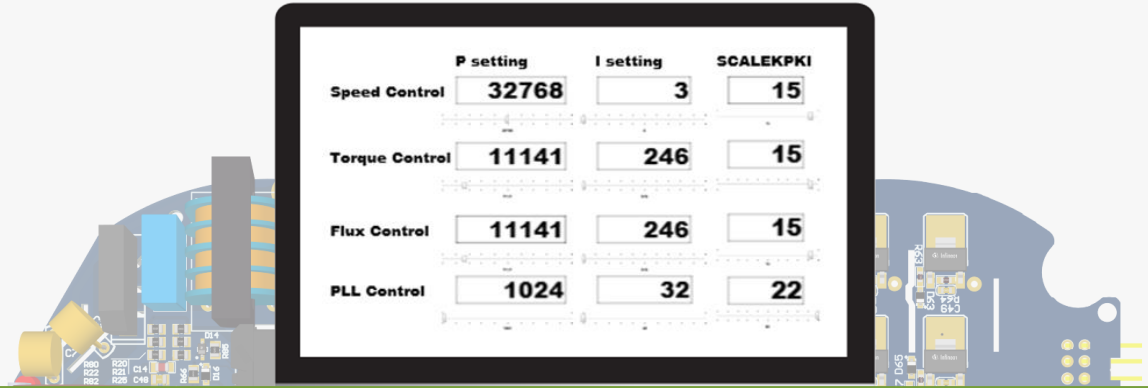


3

If the motor does not spin in FOC close loop, ↑ the SCALEKPKI of PLL Control and check the motor behavior. If the motor starts to move slowly, ↑ the SCALEKPKI further. Else, ↓ the SCALEKPKI.

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Tuning of K_P, K_I value using the µC/Probe™

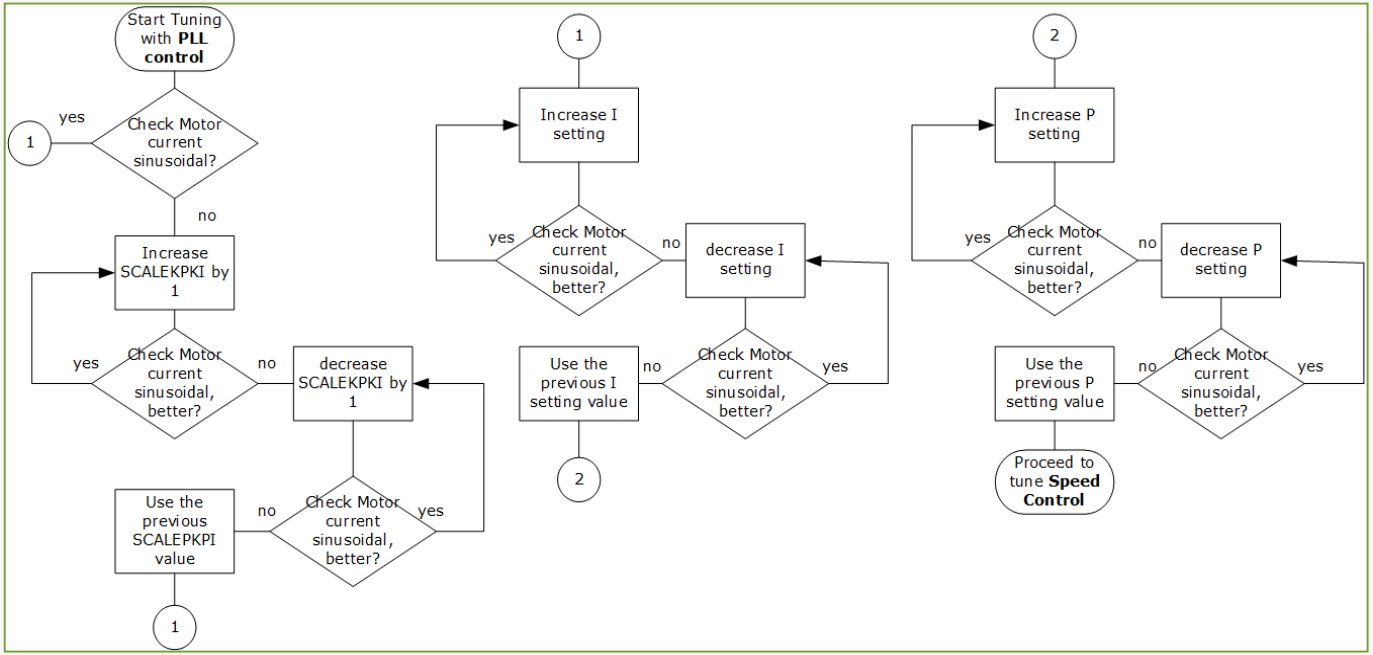


4. After the motor is able to rotate smoothly under TORQUE_CONTROLLED_DIRECT_FOC, remember to save the parameters by clicking the **Save PI** button
5. Change the My_FOC_CONTROL_SCHEME in pmsm_foc_user_config.h to SPEED_CONTROLLED_DIRECT_FOC, re-compile and reload the code
6. Use the same tactic to tune the Speed Control parameters. No need to modify the PLL control parameters

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General hints on tuning of SCALEKPKI, P, I value using the µC/Probe™

For the FOC control tuning, this is the procedure in form of an algorithm block diagram on how to tune the PLL loop for FOC control

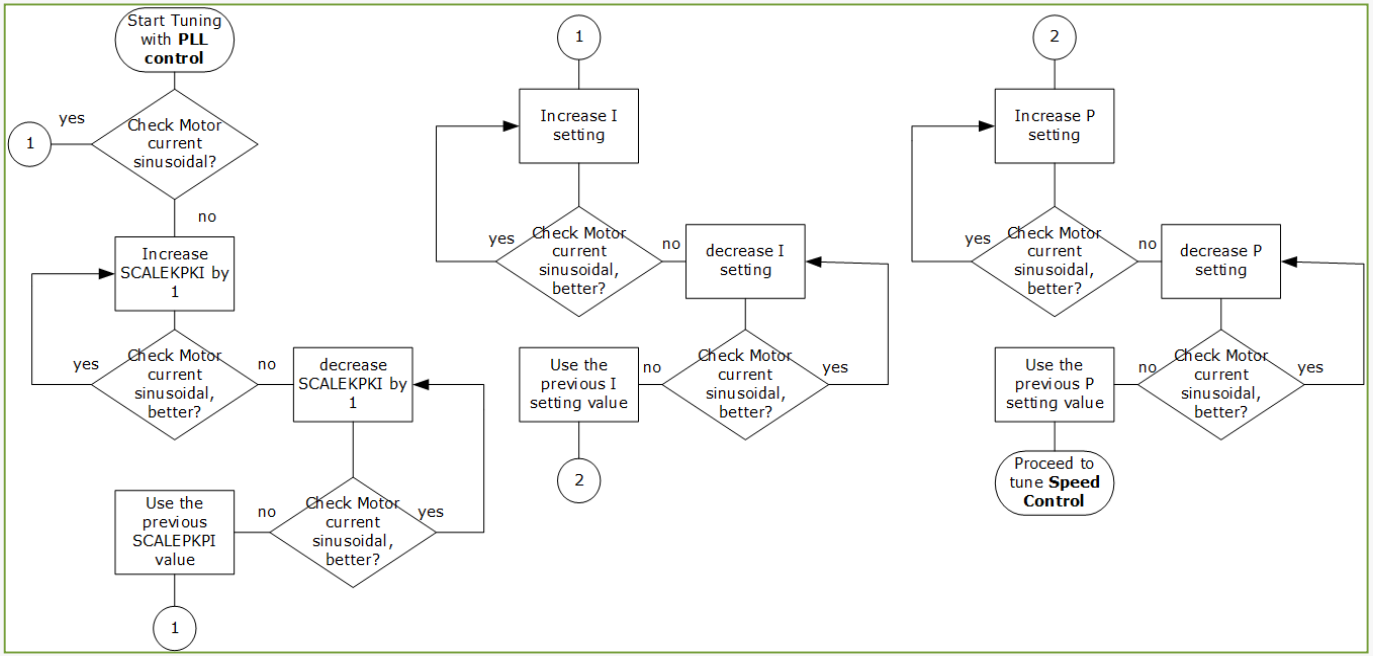


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General hints on tuning of SCALEKPKI, P, I value using the µC/Probe™

For Speed Control tuning the user should follow the same flow

Typically, only these 2 PI control loops need to be tuned with the FOC software for EVAL_FAN_XMC_PFD7 *kit*

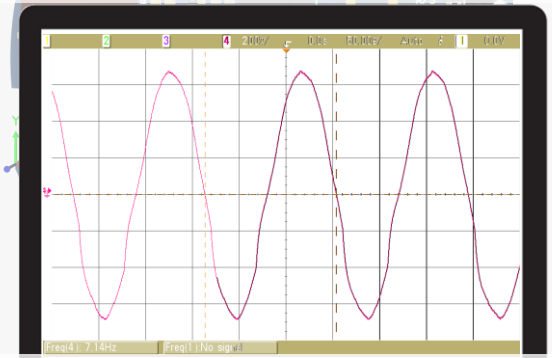


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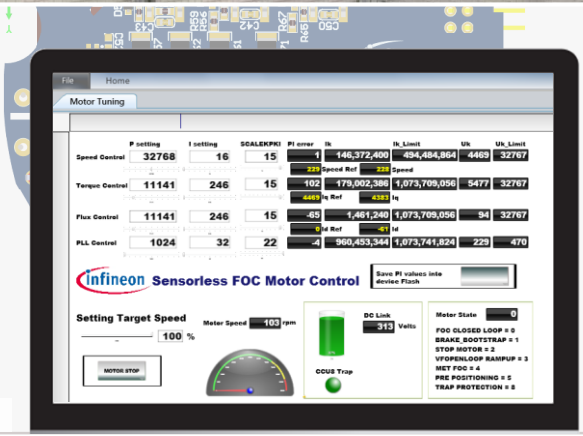
Testing result with a ceiling fan

- AC input: 230 V/50 Hz
- Ceiling Fan motor specification:
  - Resistance/phase: 23 ohms
  - Inductance/phase: 65 mH
  - Pole pairs: 4
  - Max. speed: 105 rpm
- Power consumption: 35 W @ 105 rpm





The current waveform of phase U at max. speed



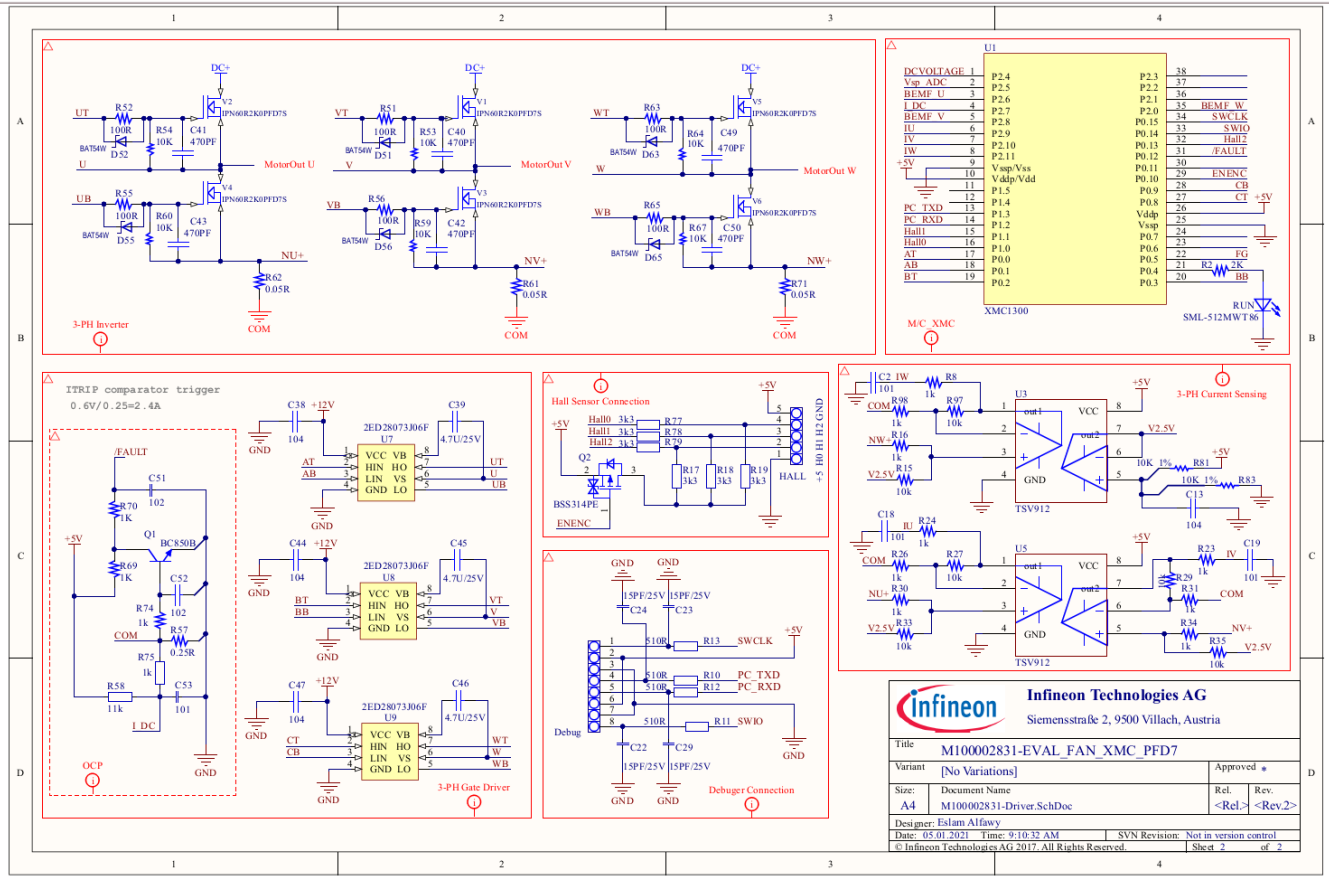
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Agenda

1. Introduction to fan driver evaluation board
2. Hardware and software
3. Tools
4. Getting started
5. Resources

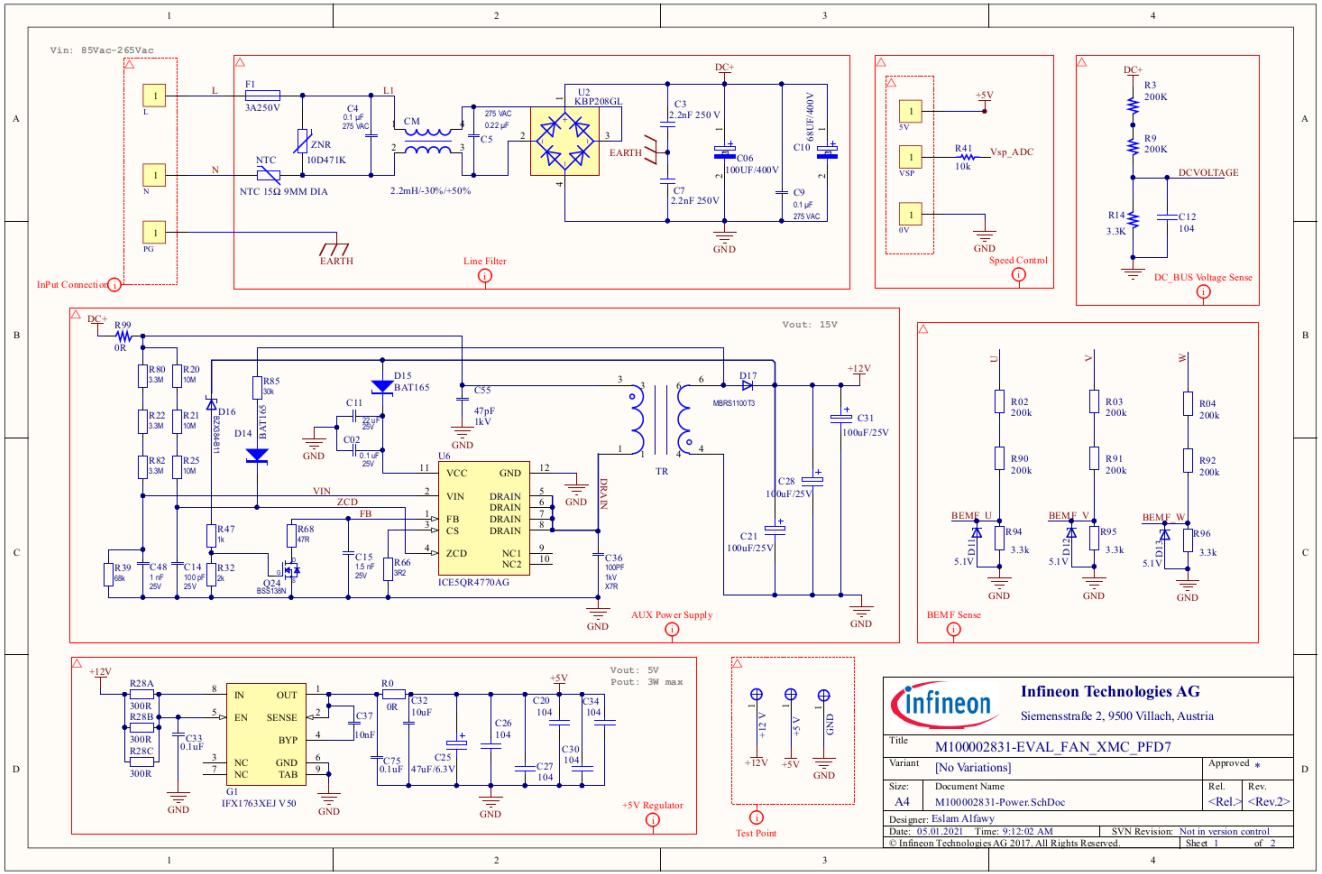
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Schematic of EVAL_FAN_XMC_PFD7 board



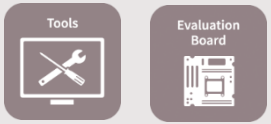
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Schematic of EVAL_FAN_XMC_PFD7 board



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Glossary abbreviations

Abbreviation	Full name
ADC	Analog-to-Digital Converter
FOC	Field-Oriented Control
PI Controller	Proportional–Integral Controller
PMSM	Permanent Magnet Synchronous Motor
PWM	Pulse Width Modulation
SVM	Space Vector Modulation
XMC™	Cross-Market Microcontrollers

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