MOTIX™ TLE987x Motor Control FOC

Getting started Application Note

About this document

Scope and purpose

This document provides the first steps to control a 12 [V] BLDC motor using the Motor Control Software Libraries for TLE987x on the TLE987x Evalkit hardware.

Product information

Release number and version:	2.1.0
Type of release:	Productive
Compiler:	Developed on Keil Arm® Compiler v6.22
Processor platform:	Arm® Cortex®-M3
Date:	2025-07-21
Previous release number and version:	1.3.0

Target devices

TLE9877QXA40 TLE9877QXW40 TLE9877QTW40	TLE9879QXA40 TLE9879-2QXA40 TLE9879QXW40 TLE9879QTW40	TLE9872QXA40 TLE9872-2QXA40 TLE9872QTW40

Intended audience

This Application Note is addressed to embedded software developers, who are going to use the TLE987x devices for BLDC motor control applications. The technical staff must be qualified for laboratory usage, sufficient to identify and control any hazard that arise from the usage of an evaluation board connected to an electrical motor.

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1 Introduction

1.1 TLE987x Motor Control FOC

The getting started steps are based on an application software example available in Infineon Developer Center (IDC), named MOTIX™ Motor Control Library Demo. This application example integrates the relevant software components of the Motor Control Software Libraries for TLE987x and the low-level driver to run on the TLE987x Eval Kit in a Keil® µVision®5 software project.

This software example is designed to drive a motor in two configurable control modes:

- Sensorless FOC mode
- V-to-F (voltage to frequency) mode

1.2 Overview of the MOTIX™ Software

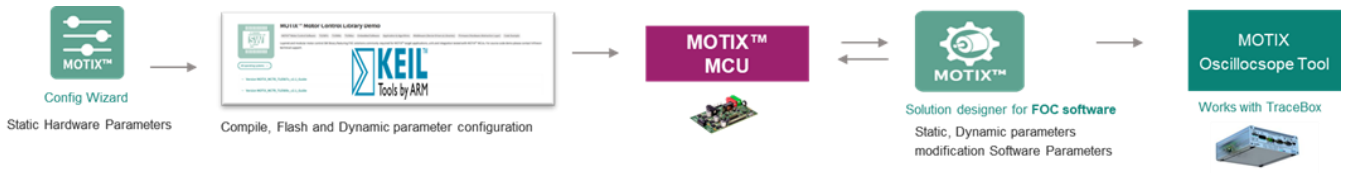
MOTIX™ Software is a modular and highly scalable platform of software and tools reducing efforts for automotive motor control system development. It features a common motor control middleware components and low-level device drivers, all optimized for the use across Infineon device families and designed to meet most stringent system safety requirements.

Table 1 The comparison table of MOTIX™ FOC Software v1.3 to v2.1

	MOTIX™ FOC Software	v1.3	v2.1
Software Features	Single Shunt FOC	yes	yes
	Open loop	I to F, V to F	I to F, V to F, CWA
	Closed loop	FOC	FOC
	Transition	I to F to FOC	I to F/ CWA to FOC
	Field Weakening	NA	Yes
	MTPA	NA	Yes
	Windmill Catch	NA	Yes
	Advanced Modulator	NA	Added Hysteresis (low inductance motor)
	Tracebox software Integrated	NA	Yes
Software Qualification	ASPICE L1	Yes	Yes
	MISRA C:2012 compliant	Yes	Yes
Parameter Configuration	Hardware	Infineon MCU Configuration Wizard	Infineon MCU Configuration Wizard
	Software	Infineon MCU Configuration Wizard	MOTIX ™ Solution Designer
IDE	Keil	Yes	Yes
	IAR	Yes	NA
Release Status	Infineon Developer Center	Obsolete	Getting started available with Solution Designer Source code visible on request in IDC

1.3 Overview of the Ecosystem

Our Eco system helps in particular support for MOTIX™ Hardware configuration and Motor control software configuration.



Note:
Static parameters: The parameters defined at compile-time or initialization, Stored in non-volatile memory (e.g., flash, EEPROM).
For Example:
Hardware static parameters: Clock frequency, pinout configuration, communication protocol settings.
Software static parameters: FOC software parameters such as: resistance, inductance, rated speed, pole pairs of the motor, base voltage, base current etc.

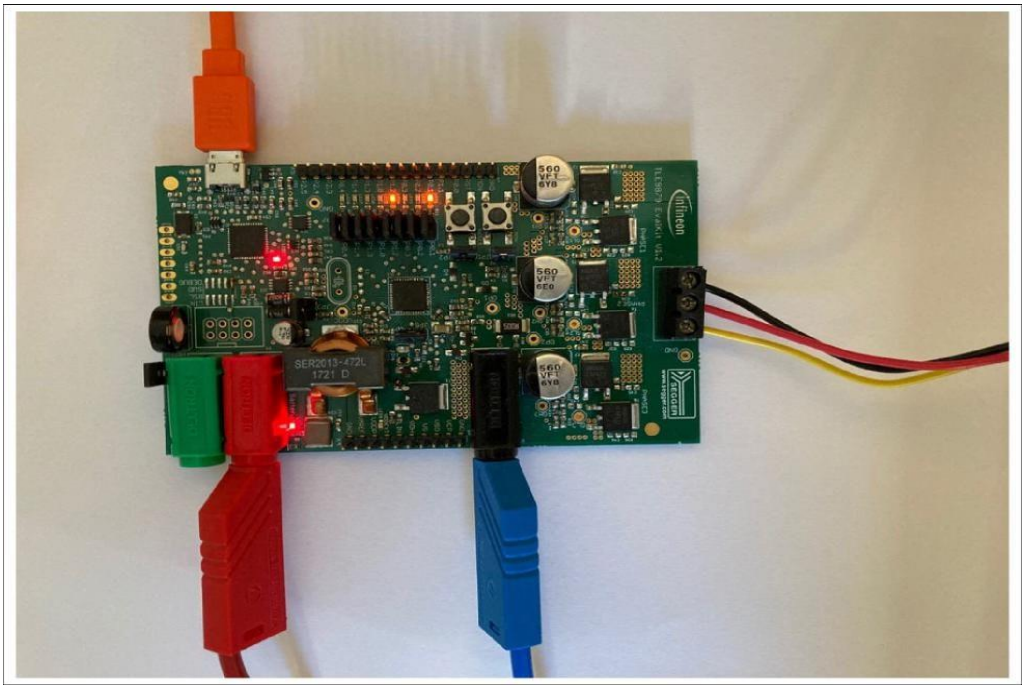
Dynamic parameters: Can be changed during operation (run time), stored in volatile memory (e.g., RAM).
For example:
Software dynamic parameters: reference speed, enable power stage, clearing software faults, PI controller etc.

2 Prerequisites

2.1 Hardware requirements

For the evaluation of the TLE987x-eSL-BAS Motor Control Library using the demo software example, the following hardware is necessary:

- A 12 [V] bipolar (4Q) power supply with adjustable output voltage that is capable to back supply (in generator mode) and to deliver a current sufficient for turning the designed motor
- The TLE987x Eval Kit connected to the power supply and connected to the PC via J-LINK / J-TRACE debug Cortex interface as shown, for example, in the following figure:



- A 12 [V] BLDC motor designed for the target application with the three phases connected to the TLE987x Eval Kit and the Eval Kit is powered up
- An oscilloscope or scope capable of measuring the phase currents with three current probes connected to measure the currents on each motor phase

***Note**: The provided example project is configured for the reference application motor, which is the Nanotec DB42S03 - brushless DC motor or QBL4208-61-04-013. Refer to the datasheet of this motor and in the Solution Designer (psxml) to understand how to enter the parameters from the datasheet in the Solution Designer.*

2.2 Software requirements

For the evaluation of the TLE987x-eSL-BAS Motor Control Library using the demo software example, the following software tool chain in MS Windows is required:

- Arm® Keil® µVision®5, an integrated development environment (IDE)
- Infineon MCU Configuration installed from Infineon Developer Center (IDC)
- Infineon Solution Designer installed from Infineon Developer Center (IDC)
- Latest Segger J-Link Driver
- Infineon MOTIX™ MCU low level drivers (LLD) integrated in Keil® µVision®5 and FOC software from Infineon Developer Center (IDC)

How to achieve the software prerequisites is described in Appendix A.3.

3 Steps to get a motor running in FOC mode

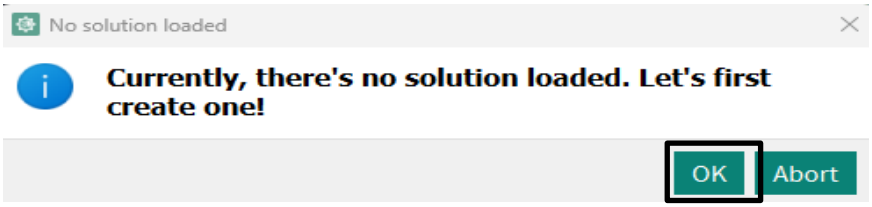
3.1 Getting started

Getting started does require to directly use µVision Keil, the Solution Designer tool contains already predefined hex file configured for Nanotec Motor DB42S03

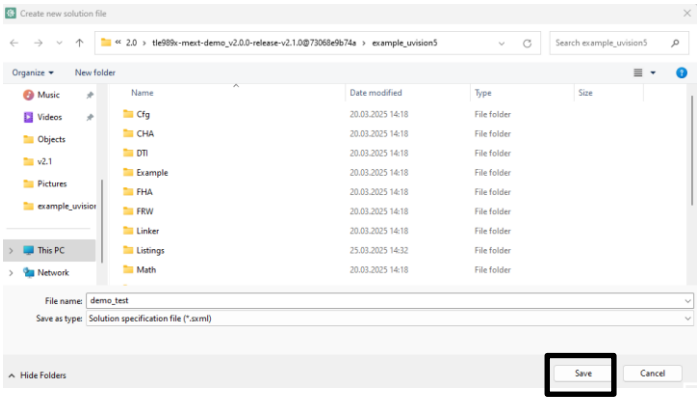
1. Open the Solution Designer and click on Getting started of the respective Board in the Solution designer tool



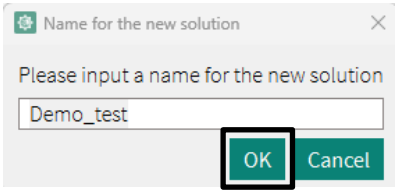
2. Click on OK in the pop-up that shows up



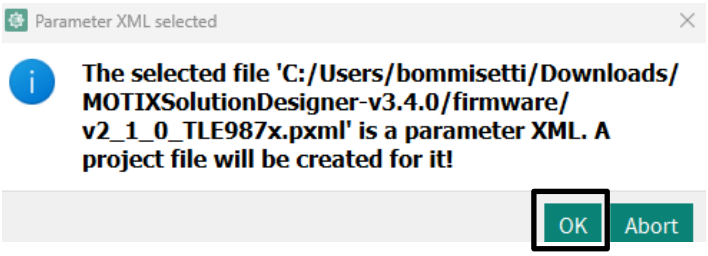
3. Create a solution in your Keil folder location (for example: Demo_test) and click on Save



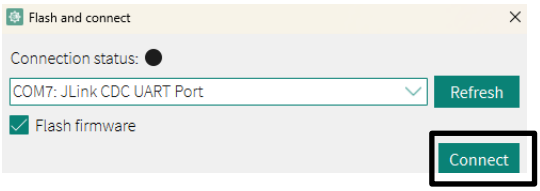
4. Click OK after writing a name for your solution, then the Solution Designer UI will open

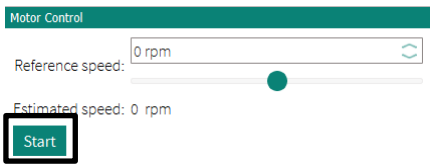


5. A project file will be created, click OK



6. Click on connect and Click on Start (Power stage and control will be enabled), set Reference speed after the connection.





3.2 Run your own motor

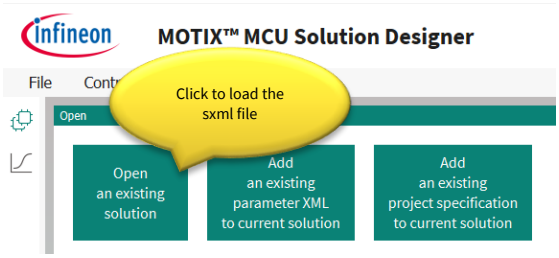
Before you begin

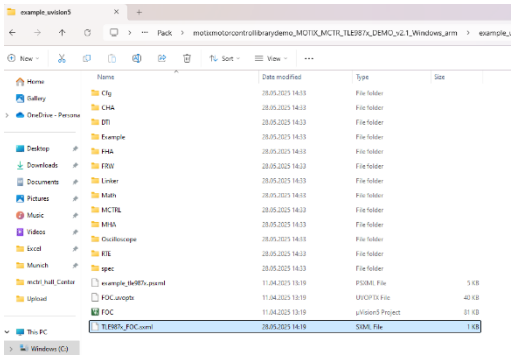
Request the source code from your Infineon support contact.

Steps

1. Load the provided FOC application software example project FOC.uvprojx in Keil® µVision® 5: click **Project > Open Project** and select `FOC.uvprojx`.

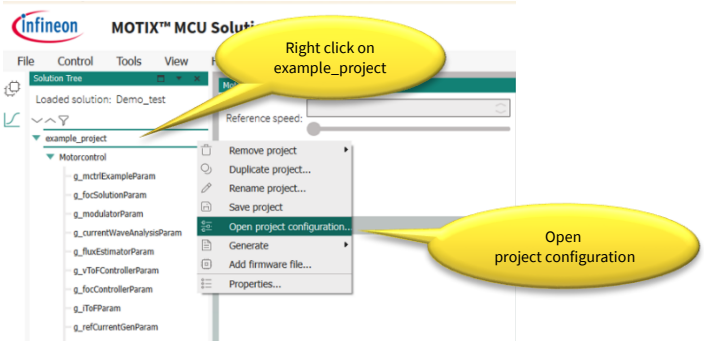
2. User can directly load the solution file (sxml) from the Keil project folder.





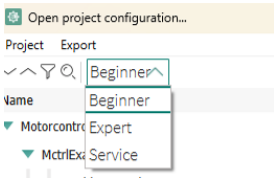
3. Configure the software parameters in the Solution Designer:

a. Software static parameters modifications can be done in project configuration



There different modes available for the user, Beginner, Expert and Service.

Beginner mode will display a limited number of variables to the user.
In Expert and Service mode all variables will be displayed to the user (for example: Look up table size).

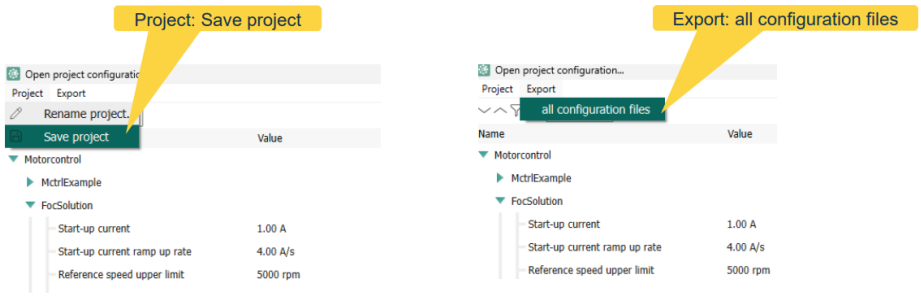


b. Provide the following parameters with values according to the connected motor. The most important parameters are:

- **Base voltage**: the maximum voltage that can be represented in the software
- **Base current**: the maximum current that can be represented in the software
- **Base mechanical speed**: the maximum motor rotation speed that can be represented in the software
- **Phase resistance**: phase resistance is equal to half of the line-to-line resistance, no matter if it is delta connection or star connection
- **Phase inductance**: phase inductance in d axis and in q axis
- **Number of pole pairs**: the number of motor pole pairs
- **Start-up current**: the current required for the motor to start turning



c. Click on file -> Save Project and click on Export -> all configuration files, this will generate all the files which needed for the Keil project, close the tab



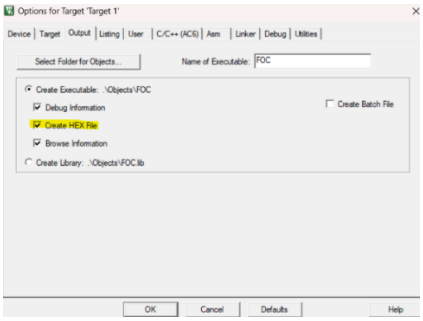
d. Configure the Current Sense amplifier (CSA) gain. If the power class of the motor used in the application differs from the standard motor, then the maximum current is different. In this case the CSA gain needs to be configured in order to achieve measurement of the maximum phase current with sufficient reSolution. For information on how to adjust the CSA gain, see the user manual of the TLE987x family. CSA gain needs to be changed in the Infineon MCU Configuration Wizard.

4. Dynamic parameters can be handled in two ways:

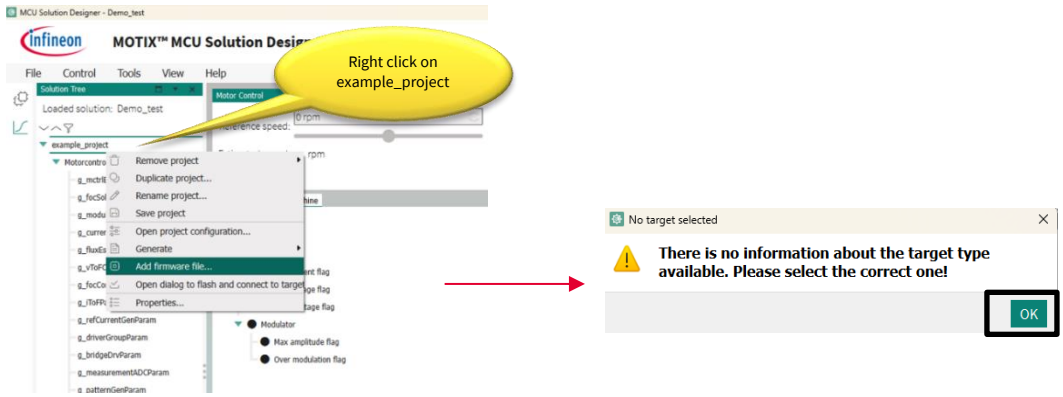
- In the Solution Designer.
- In the Keil debugger watch window.

a. To handle the dynamic parameters in the Solution Designer:

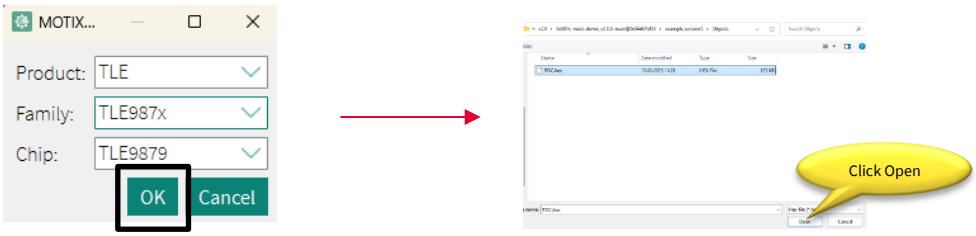
- Select the output file as HEX file in Keil project



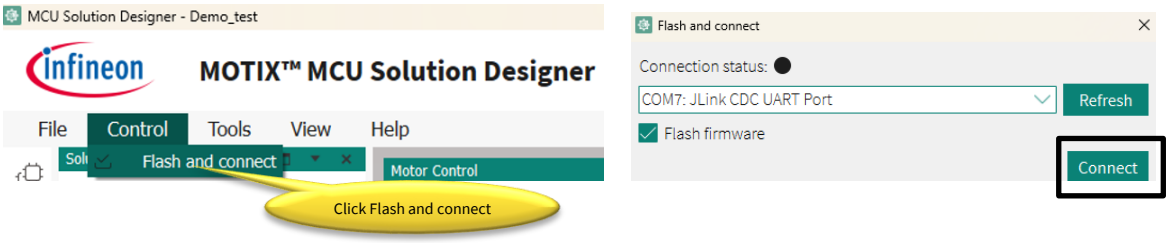
- Build the Keil® µVision® 5 project: click **Project** > **Build Target / Rebuild all target values**.
- Add firmware from the Keil folder object section in Solution Designer and select the target



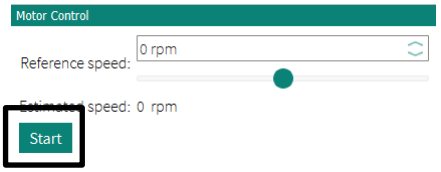
Steps to get a motor running in FOC mode



- Open **Control** -> **Flash and connect.**

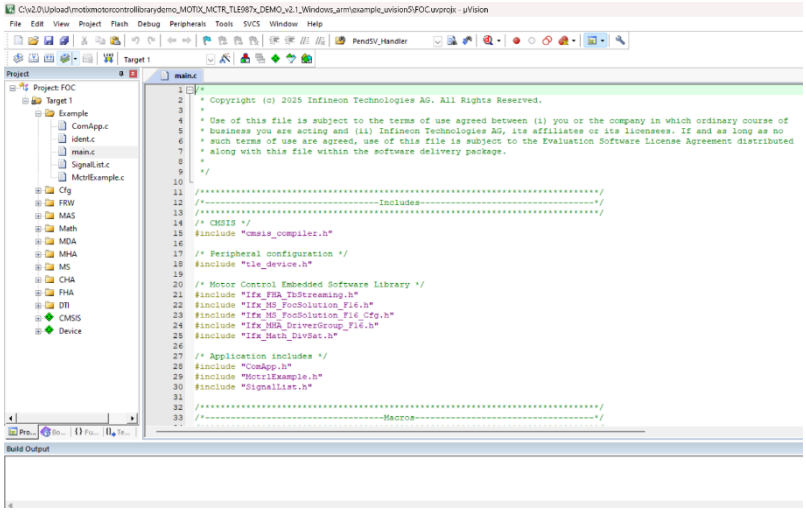


- Click on **Start** (power stage and control will be enabled), set reference speed after the connection.



b. To handle the dynamic parameters in the Keil debugger watch window:

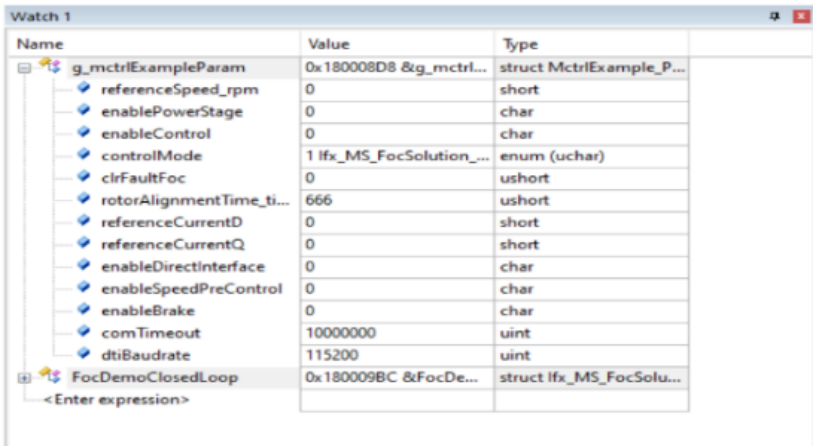
- Build the Keil® µVision® 5 project: Click **Project** > **Build Target / Rebuild all target values**. The project compiles successfully (0 errors, 0 warnings).



- In Keil® µVision® 5, download the compiled code to the target flash memory: **Flash** > **Download (F8)**.

Steps to get a motor running in FOC mode

- Open Debugger (View -> Watch Window -> watch 1), Change the dynamic parameters in the watch window
  - Click **Enable power stage** to change it to **1**.
  - Set the control mode: **1** for FOC, **0** for V-to-F mode.
  - Click **Enable Control** to change it to **1**.
  - Set the reference speed.



Results

The motor will start turning, controlled by the compiled motor control software library software in FOC mode.

If the motor does not start or does not turn as expected, see Troubleshooting.

4 Troubleshooting

Table 3 Toubleshooting

Trouble	Possible root cause	Solution
Project does not build successfully	Older version of the Infineon MCU Configuration Wizard	Use Infineon MCU Configuration Wizard v2.7.3
	Older version of Keil Compiler	Use the Keil compiler v6.22
Motor does not turn at all or motor does not turn as expected	The motor parameters are not configured optimally	Make sure that the motor parameters are correct (especially if the motor parameters were not updated, the per defaults used according to the reference motor may not fit). Ideally the motor phase resistance, motor phase inductance should be measured, the motor start-up current should be identified, and the measured and identified motor parameters should be updated in the configuration
	The connection between Evalkit and motor might be faulty or the current sensing might be faulty	In order to check the HW setup, the reference application motor QBL4208-61-04-013 or Nanotec DB42S03 - brushless DC motor can be used
		Alternatively, switch to V-to-F mode, check the phase currents with the oscilloscope and compare with the measured currents by CSA module. Details are provided in Appendix A.2

A Appendix

A.1 Steps to get a Nanotec motor running with FOC mode

The motor used in this example software is the Nanotec DB42S03. The parameters have been already configured in the Solution Designer -> Project configuration) to run the motor, without an additional load connected.

The details of the Nanotec motor can be found in the Nanotec DB42S03 datasheet.

SPECIFICATION / CONNECTION	DELTA
NO. OF POL./PHASE	8/3
VOLTAGE RATED (VDC)	24
CURRENT NO LOAD/RATED/PEAK (AMP)	0.2/1.79/5.4
RESISTANCE/PHASE TO PHASE (Ohms) @25°C	1.5±15%
INDUCTANCE/PHASE TO PHASE (mH) @1KHz	2.1±20%
TORQUE RATED/PEAK (Nm) [lb-in]	0.0625/0.19 [0.553/1.68]
TORQUE CONSTANT (Nm/A)	0.035 ⚠1 ⚠4
POWER RATED (W)	26
SPEED RATED/NO LOAD (RPM) ⚠4	4000/6200
ROTOR INERTIA (Kg-m²) [lb-in²]	2.4×10^{-6} [8.2×10^{-3}]
WEIGHT (Kg) [lb]	0.3 [0.661]
TEMPERATURE RISE: MAX.80°C	
AMBIENT TEMPERATURE -10°~ 50°C [14°F ~ 122°F]	
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)	

Mandatory static parameters (Solution Designer -> Project Configuration):

- **System base voltage**: 24 V
  The maximum voltage for scaling, higher than the supply voltage.
- **System base current:** 5 A
  The maximum current for scaling, higher than the rated current.
- **System base mechanical speed:** 4000 rpm
- **Phase resistance:** 0.75000 Ω ($\frac{1.5\ \Omega}{2}$)
- **Phase inductance:** 1.05000 mH ($\frac{2.1\ mH}{2}$)
- **Number of pole pairs:** 4
- **Startup current:** 1 A
  The start-up current amplitude should be big enough to start the motor, it can be adjusted depending on the load. It has to be checked at which current the motor starts rotating in IToF open loop. At no load, 1A is good enough as a startup current for this Nanotec motor.
- **Startup current ramp up:** 4 A/s (default)
- **Shunt resistance:** 0.005 Ω

Mandatory dynamic parameters (Keil or Solution Designer):

- **Enable power stage:** 1
- **Enable control:** 1
- **Reference speed:** 0 to 2000 rpm
- **Control mode:** 1

A.2 Steps to get a motor running in V-to-F mode

The V-to-F mode can be used in order to simplify the use case when a motor in FOC is not running:

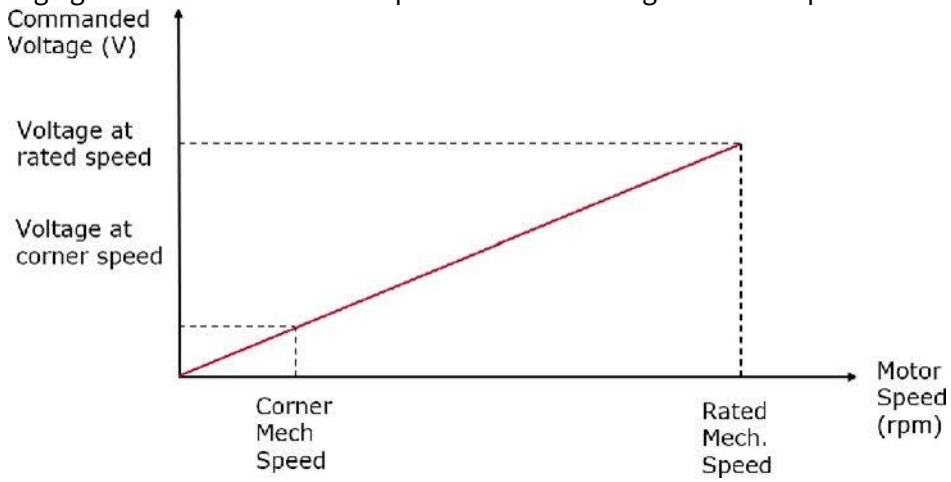
- Generate sinusoidal phase currents of constant amplitude at desired constant rotation speed in order to measure them on the oscilloscope
- Check that the phase currents measured by the CSA and available in the software variables are consistent or it can be used as simpler method to turn a motor

The switch to V-to-F can be done without any re-flash of the target, but if the V-to-F characteristic parameters do not match to the motor, then these parameters must be configured in the Solution Designer -> Project configuration, saved, and the code must be rebuilt and the target must be re-flashed.

Steps

1. Configuring the V – to - F parameters to fit to the target motor: In Solution Designer -> Project configuration, adjust the parameters:
   a. **Rated mechanical speed**: this parameter should be chosen according to the motor's datasheet.
   b. **Rated voltage**: this parameter should be chosen according to the motor's datasheet.
   c. **Corner mechanical speed**: this parameter can be estimated and set as approximately 10% of the of the rated speed.
   d. **Corner voltage**: This parameter can be calculated by linear interpolation using rated speed and rated voltage as pictured by the figure. This figure illustrates the linear interpolation of the voltage at corner speed.

      The following figure shows the linear interpolation of the voltage at corner speed:



   e. **Voltage at minimum speed**: This parameter helps increasing the amplitude of the phase current at low motor speeds, in addition to the corner voltage and corner speed. A bit higher current is sometimes necessary in order to start the motor, which would require a higher voltage at a low speed, starting with 0 rpm.
2. Once the parameters are configured in the Solution Designer, update the parameters on the target:
   a. Press **Save** (in the Solution Designer) and click on generate the new configuration files.
   b. Rebuild the project in Keil® µVision® 5.
   c. Download the code to target and start debug session (in Keil® µVision® 5).
3. Switching to V-to-F control mode in the Keil debugger window:
   a. The software runs in debug mode on the target evaluation board.
   b. Switch **Enable Control** to **1**.
   c. Click on the button **Control Mode** The indicator changes to **0**

A Appendix

d. Switch **Enable Control** to **1**.

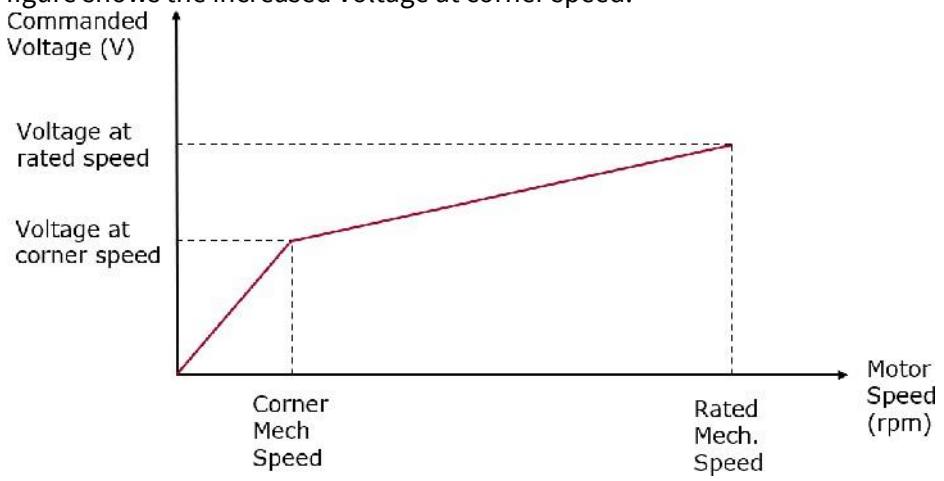
e. Set the reference speed (rpm).

Then the

- Motor starts turning
- Phase currents measured by the current probes should have a sinusoidal shape (as much as permitted by the disturbance due to the induced currents by a turning rotor) on the scope
- DC current consumption on the DC power supply should not be too high, that means according to the characteristics of the motor used

If the motor does not start turning, check if the phase currents amplitude is sufficient to start the motor. If this amplitude is not sufficient, it can be increased by increasing the voltage at minimum speed and the voltage at corner speed.

The following figure shows the increased voltage at corner speed:



If the currents are not sufficient, increase the voltage at corner speed and return to Step 2.

If the currents have a sufficient sinusoidal shape and the amplitude of the currents is sufficient to start the motor and the motor still does not turn as expected, then the connection to the motor is the cause and it should be debugged. Otherwise, if the currents are not generated as expected, then the configuration of the bridge driver, the pattern generator and the modulator have to be debugged.

A.3 Toolchain installation

A.3.1 Overview of the toolchain installation

Table 4 Toolchain installation overview

Toolchain installation steps		Supplier	Description
Step 1	Download and install Keil® µVision® 5		Arm® Keil® µVision® 5 is an integrated development environment which consists of code editor, compiler and debugger. The evaluation version can handle up to 32 kB code size
Step 2	Download and install IDC launcher		The Infineon Developer Center Launcher tools and configuration programs to use Infineon devices
Step 3	Install the Infineon MCU Configuration Wizard		Configuration tool for static configuration of the hardware
Step 4	Install the Solution Designer		Configuration tool for static configuration of the software
Step 5	Download and install Segger JLink Driver J-Link Driver		Driver for on-board or stand-alone debugger
Step 6	Download the SDK via Keil® µVision® 5 PackInstaller (See step 1)		Device database for TLE987x: Device support for flashing/erasing SFR description for register debugging. Device description for the Config Wizard. Includes SDK (Software Development Kit). Example code included
Step 7	Download the Latest MOTIX™ FOC software from Infineon Developer center		Download the latest Motor Control software from the Infineon Developer Center (IDC) webpage. (Visible on request in IDC)

A detailed guide for toolchain installation steps is provided in the following chapter.

***Note**: We recommend having the Keil® license to use the V2.1 software (by default the code is larger than 32 kB). The Keil® Community Edition allows code with more than 32 kB.*

To improve performance:

- *Use O3 optimization and*
- *Enable link-time optimization (LTO) (only possible if you have a Keil® license)*

A.3.2 Steps to install the toolchain

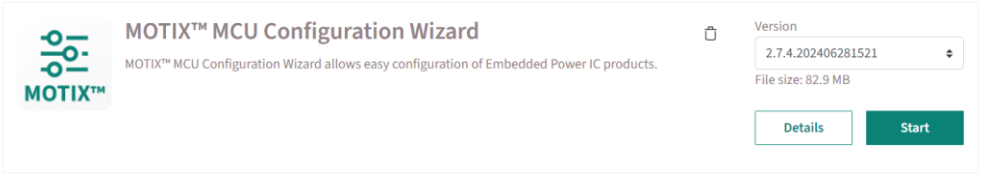
The toolchain must be installed on a Windows computer.

Steps

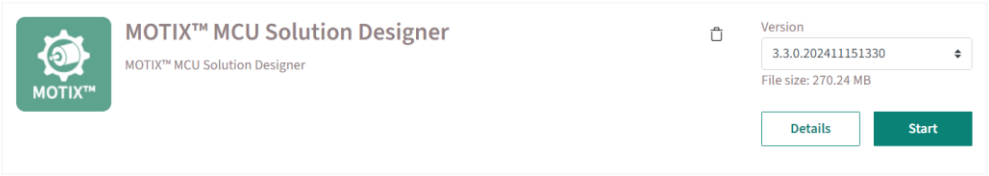
1. Download Keil® µVision®5.
   Download it from: https://www.keil.com/demo/eval/arm.htm.



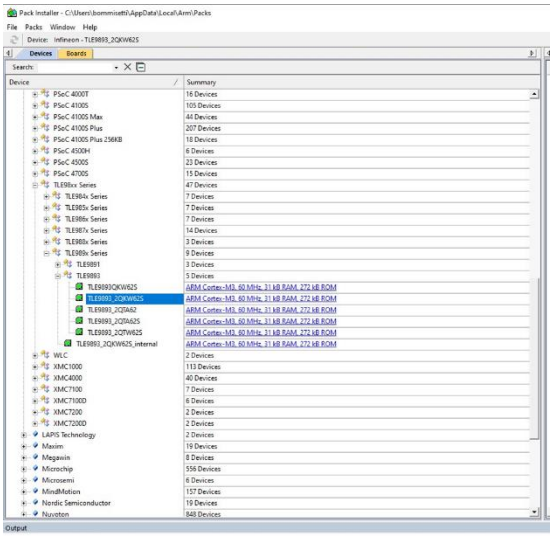
2. Login to the the Infineon Developer center (IDC) webpage or Infineon Developer Center (IDC) Launcher.
3. Search for **Configuration Wizard for MOTIX™ MCU** and install the Config Wizard.



4. Start the Config Wizard once to integrate into Keil® Vision®5.
5. Search for **MOTIX™ MCU Solution Designer** and install latest version

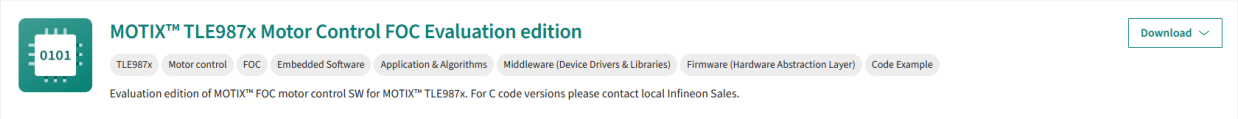


6. Install the Segger J-Link LITE driver. Download it from: https://www.segger.com/downloads/jlink/JLink_Windows.exe
7. In Keil® µVision®5, download the sdk pack from the pack installer.



A Appendix

8. Download the latest Motor control software from the Infineon Developer Center webpage.



***Note**:*

Request the Motor control software source code from the Infineon customer support or Regional FAE's to download the source code from evaluation edition

***Software** - can be downloaded from Infineon Developer Center (IDC) webpage*

***Tools** - can be downloaded from the Infineon Developer Center (IDC) webpage or IDC launcher app*

A Appendix

References

[1] Evaluation Board and Evaluation Kit, Getting Started for MOTIX™ TLE986x/7x
[2] MOTIX™ TLE987x, User manual
[3] MOTIX™ TLE987x Motor Control FOC Demo application note (Old)
[4] MOTIX™ Solution Designer Help section

Revision history

Document revision	Date	Description of changes
Rev. 1.0	2025-07-21	Initial version for MOTIX™ FOC v2.1 software

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