User Manual for the FAULHABER SIMULINK® Library

Introduction

The FAULHABER SIMULINK library allows the dynamic simulation of FAULHABER drive systems. It contains a motor model that can be parameterized to FAULHABER BLDC motors with a corresponding sensor/encoder system. Different controller models represent the functionality of a FAULHABER Motion Controller V3.0. As with the real start-up of FAULHABER drives using the Motion Manager, the controller parameters are determined based on the selected motor, encoder and attached load. No matter if you are a beginner or an advanced SIMULINK user, the FAULHABER SIMULINK library is a user-friendly tool for simulating the dynamic behavior of a drive system.

It should be noted that models are always a simplification of reality and, despite careful validation, there may be differences between simulation results and real motor behavior.

The simulation models do not consider any thermal influence like heating of the winding. To ensure that a simulated movement is also possible in real operation, additional thermal simulations are necessary.

Furthermore, the simulation models do not consider any properties of the power supply. When decelerating high inertias, energy is fed back and the the usage of a braking chopper might be necessary.

Content

Installation of the toolbox

With the download, two files are provided. The user manual gives a brief overview of the handling of the model blocks, while the second file represents the actual MATLAB Toolbox. In the download-folder, right click on the Toolbox-file and select “Install”. The MATLAB Add-On Manager opens up and reports the successful installation of the library.

In the Library Browser of a Simulink-Model, the FAULHABER SIMULINK Library now should be displayed. If this is not the case, it might be necessary to refresh your Library Browser. Therefore, right click and select “Refresh Library Browser”. If the library still is not displayed, please check the troubleshooting section.

Model overview

Brushless DC-Motor models:

There are two different models of a FAULHABER BLDC-Motor available. In most cases, it is recommended to use the single-phase model which represents a BLDC-motor as a DC-motor. If you want to simulate voltages and currents of the three single motor-phases (A,B,C) or combine the motor model with a custom field-oriented controller, the three-phase model would be the right choice. The structure of the models can be seen by clicking the “Help”-button on each model block.

Controller models:

The library offers different controller models, depending on the desired control variable. The choice can be made between current control, velocity control and position control. How the detailed controller structure looks like, can be seen by clicking the “Help”-button on each controller block.

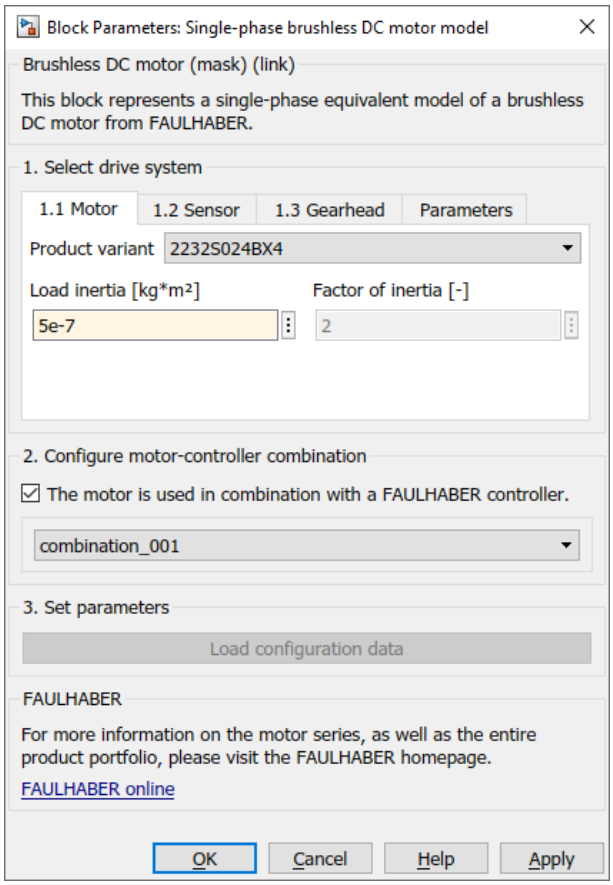
Profile Generator:

FAULHABER Motion Controller of generation V3.0 can be operated in many different operating modes, depending on how the target value is specified. For position- and speed-controlled applications, there are profile-based operating modes, among others. Here, the Motion Controller calculates a speed or position profile in order to reach the target value. This calculation is performed by the profile generator model. The basic calculations of the model correspond to the “Linear ramp”-profile generator in FAULHABER Motion controllers. In contrast to the real profile generator, the motion profil must be calculated before running the simulation.

Step-by-step instructions

To build a simulation model with components from the FAULHABER library, the desired blocks must first be inserted by using the Library Browser. The subsequent parameterization must start with the motor model.

Motor model:



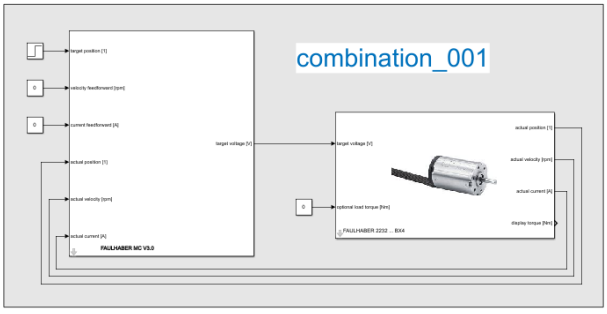
1. After double-clicking on the motor block, a mask opens. In the "Select drive system" panel, the desired model is first selected in the " Motor" tab. The inertia of the simulated load must then be entered in the "Load inertia" field.

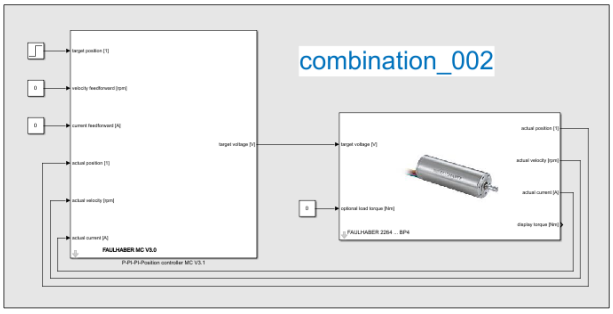
2. The "Sensor" tab now displays the sensor systems that are available for the selected motor model. According to this information, the desired system can be chosen. For incremental encoders, the number of pulses per revolution must be specified. In addition, it is possible to select whether the typical position error of the sensor system should be taken into account. The amount of the position error for incremental encoders can be found in the data sheet and amounts 0.5 °m by default.

3. (Optional) In a third step, a gearhead can be parameterized in the "Gearhead" tab. To do this, check the corresponding box and enter the parameters of the gearbox.

4. If the motor model is used in combination with a controller model from the FAULHABER library, a combination parameter must be defined. This parameter is necessary in order to transfer the correct motor data to the controller model for the calculation of the controller parameters. The parameter must be unique, that means every motor-controller combination in a Simulink-model must be defined by a different combination parameter.

5. After all the necessary settings have been made, the “Load configuration data“ button in the “Set parameters” panel can be pressed.





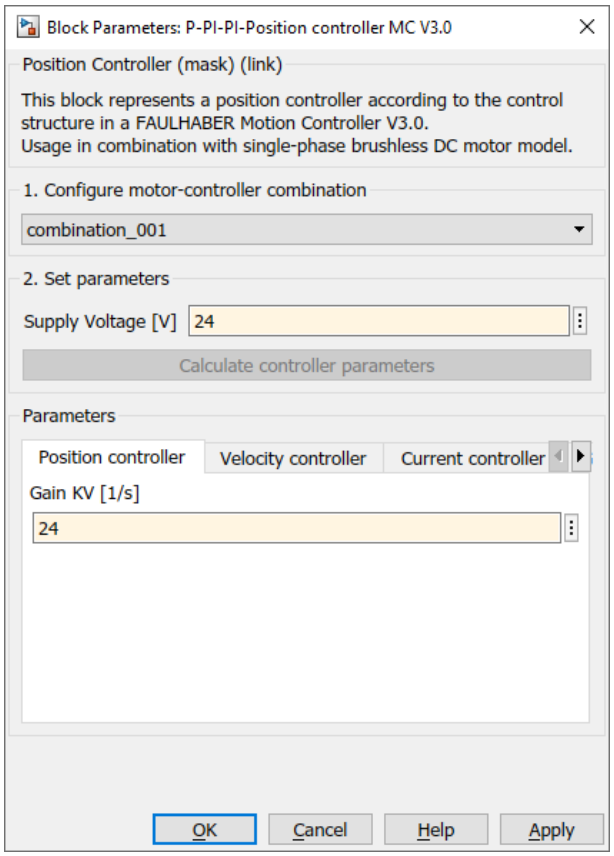
Controller model:

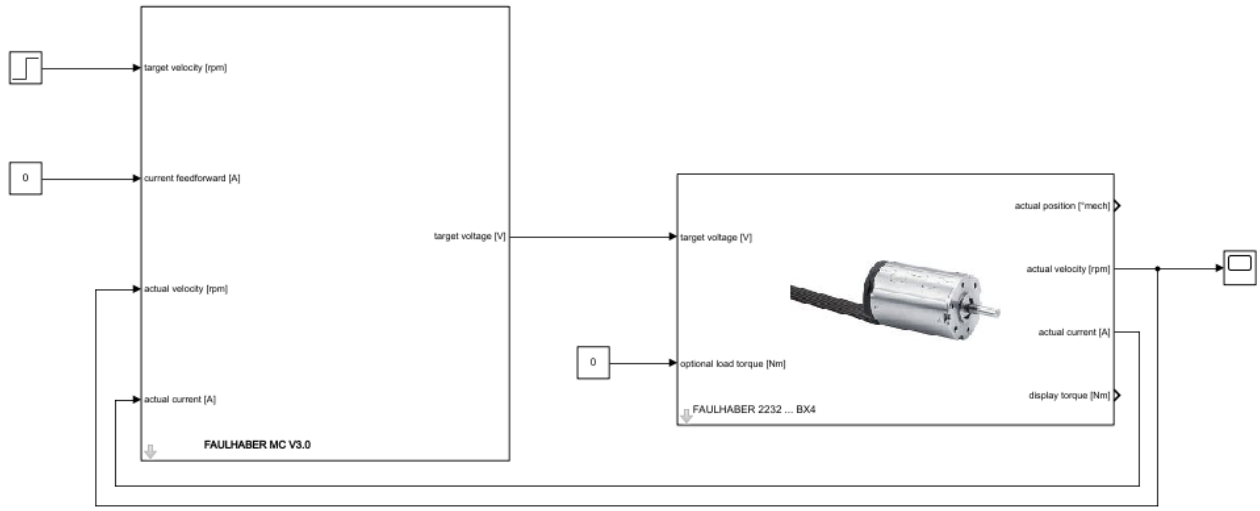
1. Now, the mask of the controller model can be opened by double-clicking on the block. First of all, in the “Configure motor-controller combination“ panel the combination parameter has to be selected, which belongs to the corresponding motor model.

2. In the “Set parameters” panel, a supply voltage must be inserted. After that, by pressing the “Calculate controller parameters“ button, the controller parameters are calculated and load into the model.

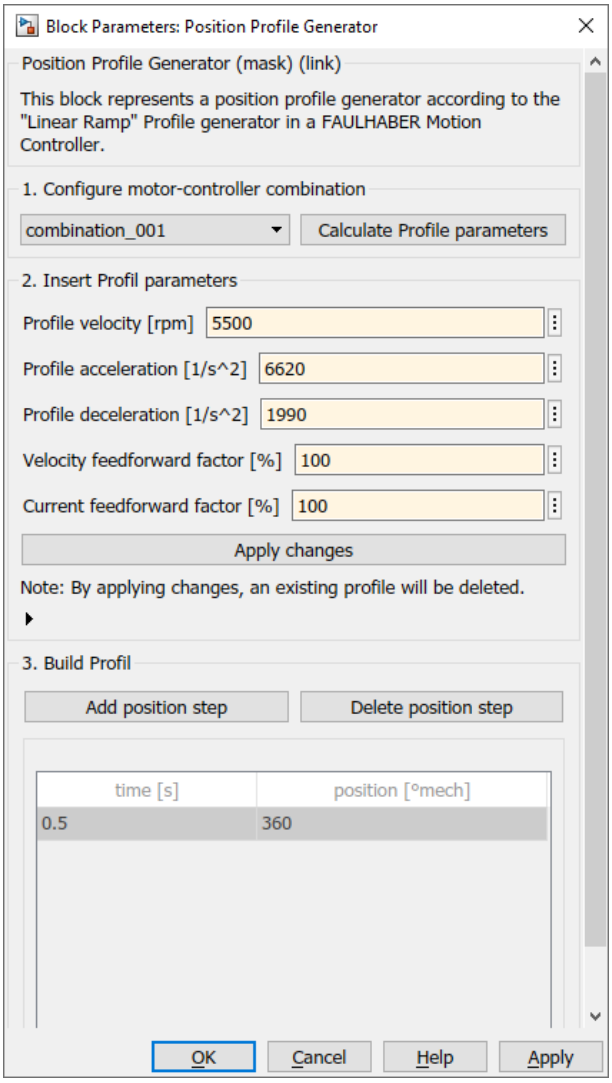
3. The editable controller parameters are highlighted in white in the “Parameters” panel. A change in the parameters results in a change of the dynamic behavior of the drive system.

4. Motor and controller block must be connected via the corresponding interfaces. The external specification of target value or optional load torque like friction can be done e.g. via constant or step blocks from the Simulink sources library.

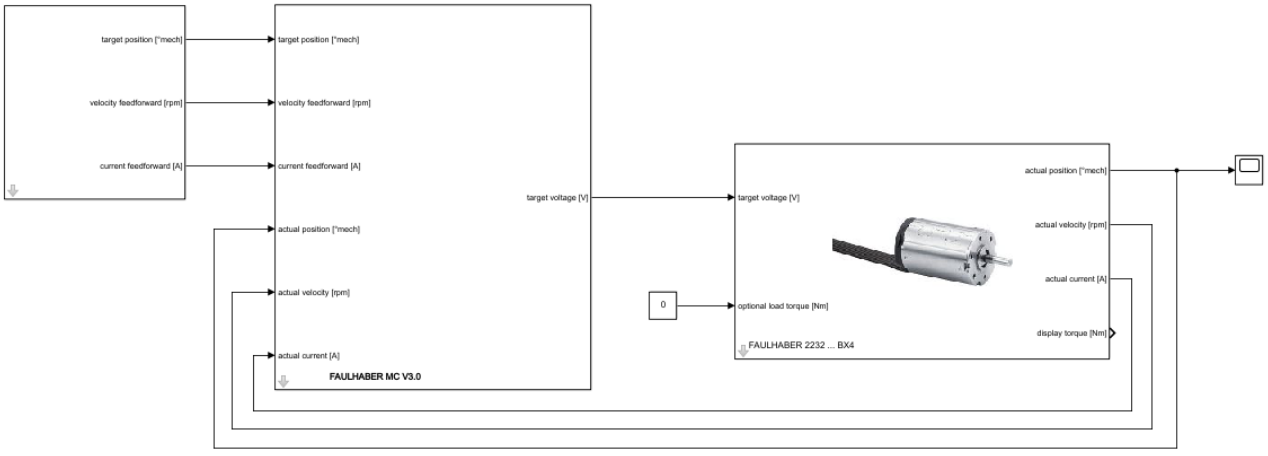




Profile generator model:



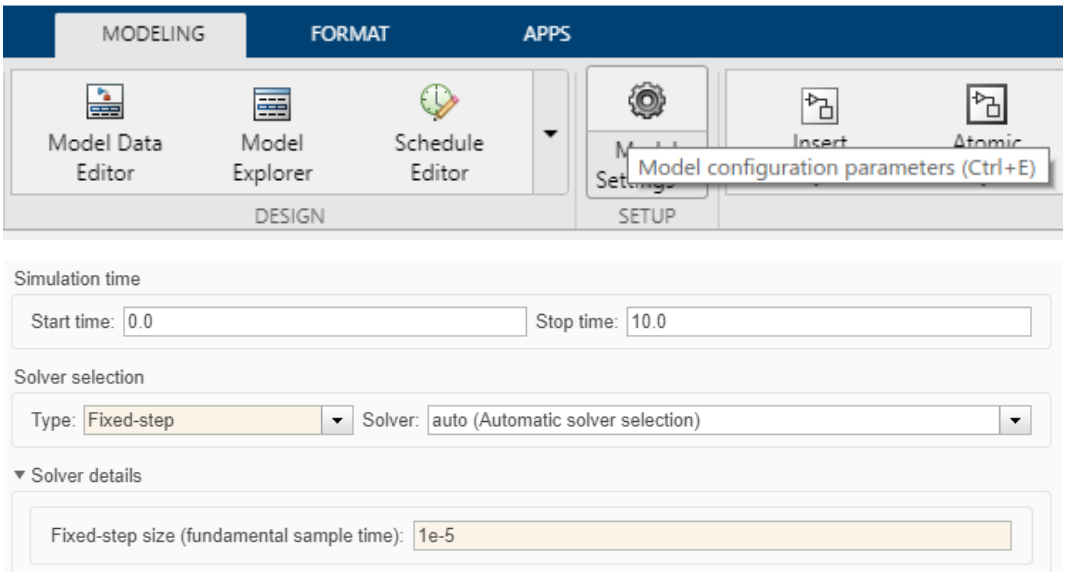
1. The profile generator model also must be assigned to the motor-controller combination by selecting the correct combination parameter.
2. Afterwards, the profile parameters can be calculated. The calculation rules consider the selected motor and the load inertia.
3. The values for profile velocity, acceleration and deceleration can be adapted. It is also possible to activate velocity and current feedforward. The feedforward structure allows to improve the dynamic behavior of a drive system and reduce the position error during acceleration or deceleration.
4. A motion profile can consist of a single step or several steps after eachother. Each position step is added by clicking the “Add position step” button. A time stamp and a position value must be defined. The motion profile is calculated considering the values for profile velocity, acceleration and deceleration.
5. The restriction for the building of a motion profile with several position steps is, that the time stamp of position step “n+1” must be greater than the endpoint of position step “n”. This means that a new position step can only be specified when the target position of the previous profile has been reached.
6. Controller and profile generator block must be connected via the corresponding interfaces.



Solver configuration

Due to the configuration of the referenced subsystems, it is necessary to specify a certain solver configuration in each Simulink model with components from the FAULHABER library. The following two settings must be made within the Model configuration parameters:

- Type: Fixed-step
- Fixed-step size (fundamental sample time): 1e-5



Troubleshooting

In case of issues with the usage of the FAULHABER Simulink Library, there might be an issue with your MATLAB path. By evaluating the “path”-command in the MATLAB Command Window, the search path is displayed. In case of a successful installation, one folder is added here.

[redacted]\MATLAB Add-Ons\Toolboxes\FAULHABER_Toolbox

If this path is deleted from the search path, the FAULHABER Simulink Library will not work. In this case, you must add the search path manually.

Type “addpath(‘<installation path>\FAULHABER_Toolbox’)” in the command window and evaluate the command. The necessary installation path of the library can be found in the MATLAB Add-On Manager by right clicking on the toolbox and selecting the option “Open Folder”. Now the library should work without any issues. If not, try to install the toolbox again.

Rechtliche Hinweise

Urheberrechte. Alle Rechte vorbehalten. Ohne vorherige ausdrückliche schriftliche Zustimmung der Dr. Fritz Faulhaber GmbH & Co. KG darf diese Application Note oder Teile dieser unabhängig von dem Zweck insbesondere nicht vervielfältigt, reproduziert, gespeichert (z.B. in einem Informationssystem) oder be- oder verarbeitet werden.

Gewerbliche Schutzrechte. Mit der Veröffentlichung, Übergabe/Übersendung oder sonstigen Zur-Verfügung-Stellung dieser Application Note werden weder ausdrücklich noch konkludent Rechte an gewerblichen Schutzrechten, übertragen noch Nutzungsrechte oder sonstige Rechte an diesen eingeräumt. Dies gilt insbesondere für gewerbliche Schutzrechte, die mittelbar oder unmittelbar den beschriebenen Anwendungen und/oder Funktionen dieser Application Note zugrunde liegen oder mit diesen in Zusammenhang stehen.

Kein Vertragsbestandteil; Unverbindlichkeit der Application Note. Die Application Note ist nicht Vertragsbestandteil von Verträgen, die die Dr. Fritz Faulhaber GmbH & Co. KG abschließt, und der Inhalt der Application Note stellt auch keine Beschaffenheitsangabe für Vertragsprodukte dar, soweit in den jeweiligen Verträgen nicht ausdrücklich etwas anderes vereinbart ist. Die Application Note beschreibt unverbindlich ein mögliches Anwendungsbeispiel. Die Dr. Fritz Faulhaber GmbH & Co. KG übernimmt insbesondere keine Gewährleistung oder Garantie dafür und steht auch insbesondere nicht dafür ein, dass die in der Application Note illustrierten Abläufe und Funktionen stets wie beschrieben aus- und durchgeführt werden können und dass die in der Application Note beschriebenen Abläufe und Funktionen in anderen Zusammenhängen und Umgebungen ohne zusätzliche Tests oder Modifikationen mit demselben Ergebnis umgesetzt werden können. Der Kunde und ein sonstiger Anwender müssen sich jeweils im Einzelfall vor Vertragsabschluss informieren, ob die Abläufe und Funktionen in ihrem Bereich anwendbar und umsetzbar sind.

Keine Haftung. Die Dr. Fritz Faulhaber GmbH & Co. KG weist darauf hin, dass aufgrund der Unverbindlichkeit der Application Note keine Haftung für Schäden übernommen wird, die auf die Application Note und deren Anwendung durch den Kunden oder sonstigen Anwender zurückgehen. Insbesondere können aus dieser Application Note und deren Anwendung keine Ansprüche aufgrund von Verletzungen von Schutzrechten Dritter, aufgrund von Mängeln oder sonstigen Problemen gegenüber der Dr. Fritz Faulhaber GmbH & Co. KG hergeleitet werden.

Änderungen der Application Note. Änderungen der Application Note sind vorbehalten. Die jeweils aktuelle Version dieser Application Note erhalten Sie von Dr. Fritz Faulhaber GmbH & Co. KG unter der Telefonnummer +49 7031 638 688 oder per Mail von mcsupport@faulhaber.de.

Legal notices

Copyrights. All rights reserved. This Application Note and parts thereof may in particular not be copied, reproduced, saved (e.g. in an information system), altered or processed in any way irrespective of the purpose without the express prior written consent of Dr. Fritz Faulhaber GmbH & Co. KG.

Industrial property rights. In publishing, handing over/dispatching or otherwise making available this Application Note Dr. Fritz Faulhaber GmbH & Co. KG does not expressly or implicitly grant any rights in industrial property rights nor does it transfer rights of use or other rights in such industrial property rights. This applies in particular to industrial property rights on which the applications and/or functions of this Application Note are directly or indirectly based or with which they are connected.

No part of contract; non-binding character of the Application Note. The Application Note is not a constituent part of contracts concluded by Dr. Fritz Faulhaber GmbH & Co. KG and the content of the Application Note does not constitute any contractual quality statement for products, unless expressly set out otherwise in the respective

contracts. The Application Note is a non-binding description of a possible application. In particular Dr. Fritz Faulhaber GmbH & Co. KG does not warrant or guarantee and also makes no representation that the processes and functions illustrated in the Application Note can always be executed and implemented as described and that they can be used in other contexts and environments with the same result without additional tests or modifications. The customer and any user must inform themselves in each case before concluding a contract concerning a product whether the processes and functions are applicable and can be implemented in their scope and environment.

No liability. Owing to the non-binding character of the Application Note Dr. Fritz Faulhaber GmbH & Co. KG will not accept any liability for losses arising from its application by customers and other users. In particular, this Application Note and its use cannot give rise to any claims based on infringements of industrial property rights of third parties, due to defects or other problems as against Dr. Fritz Faulhaber GmbH & Co. KG.

Amendments to the Application Note. Dr. Fritz Faulhaber GmbH & Co. KG reserves the right to amend Application Notes. The current version of this Application Note may be obtained from Dr. Fritz Faulhaber GmbH & Co. KG by calling +49 7031 638 688 or sending an e-mail to mcsupport@faulhaber.de.