Support of Third Party BLDC motors

Summary

Overview of supported / required characteristics of third party BLDC motors.

Step by step instruction of setting up:
- a **third party** BLDC motor with **digital hall** sensors (+ incremental encoder)
- to operate with a MC3 Motion Controller
- using Motion Manager 6.3

Applies To

Faulhaber Motion Controller MC5004, MC5005 and MC5010

Description: Specification of third party BLDC motor / controller combination

Supply voltage	up to 50	V
Electrical time constant L / R	up to 2.5	ms
# of pole pairs	up to 12 (= 24 poles)	
Torque constant	up to 200	mNm / A
Commutation sources	Digital hall sensors (+ incremental encoder): • Block commutation or • Sinusoidal commutation in combination with incremental encoder, only	
Actual Sources of Velocity and Position	• Digital hall sensors (not as positon source) • Incremental encoder (recommended as postion and velocity source) • for absolute encoder, see also AppNote 158	
Total inertia $J_{Motor} + J_{Load}$ (J_{Load} reduced to motor-side)	• up to approx. 4000 = 0.0004 • with kJ = ((J_{Motor} + J_{Load}) / J_{Motor}) ideally <= 4	gcm² kgm²
Hall sensor phasing	120	°
Alignment of hall sensors with EMF	• Supported: - Hall sensors / EMF shifted by 60° (default) - Hall sensors / EMF shifted by 240° (inverted) • Other alignments in combination with sinusoidal commutation, only. (Adjusment of phase anlge offstet parameter required, which is not explained here)	
Commutation Sequence	• Supported sequences for clockwise rotation: - C-B-A (default) - A-B-C	
Lead labels	• usually: A = U = 1 | B = V = 2 | C = W = 3	

Step by Step instruction

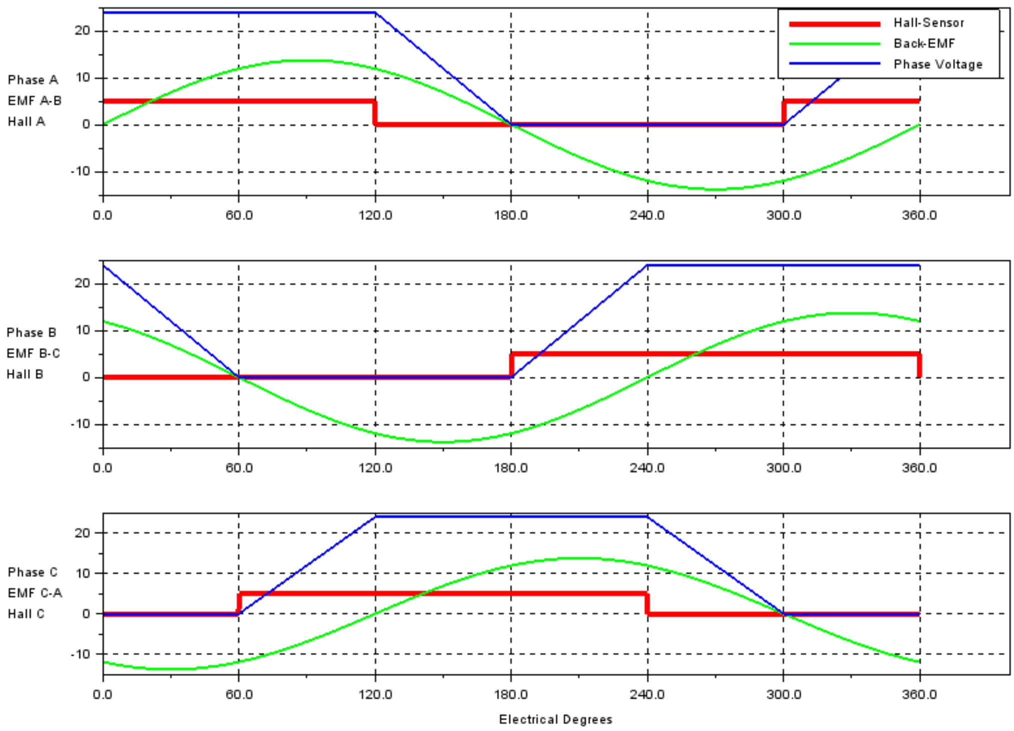
1. **Carefully compare the motor datasheet** with the specification on page 2 and the following tables and diagrams to identify if your third party motor is supported and which use case applies. Contact your motor supplier if the datasheet does not provide any comparable information.

Excitation sequences and hall sensor output tables of major use cases for clockwise (cw) rotation:

(1) Default settings for FAULHABER motors
Commutation Sequence: **C-B-A**
Alignment of hall sensors with EMF - **shifted by +60°**

	Sensors			Phases		
Electrical Degrees	A	B	C	A	B	C
0 - 60°	1	0	0	High	x	Low
60 - 120°	1	0	1	High	Low	x
120 - 180°	0	0	1	x	Low	High
180 - 240°	0	1	1	Low	x	High
240 - 300°	0	1	0	Low	High	x
300 - 360°	1	1	0	x	High	Low

Hall sensor outputs and excitation sequence

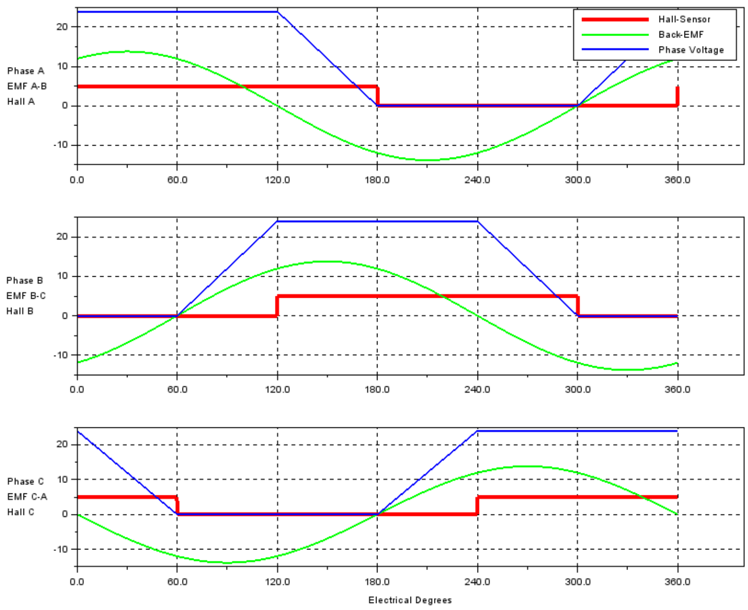


Phase-Voltages, Back-EMF and Hall-Sensor-Signals

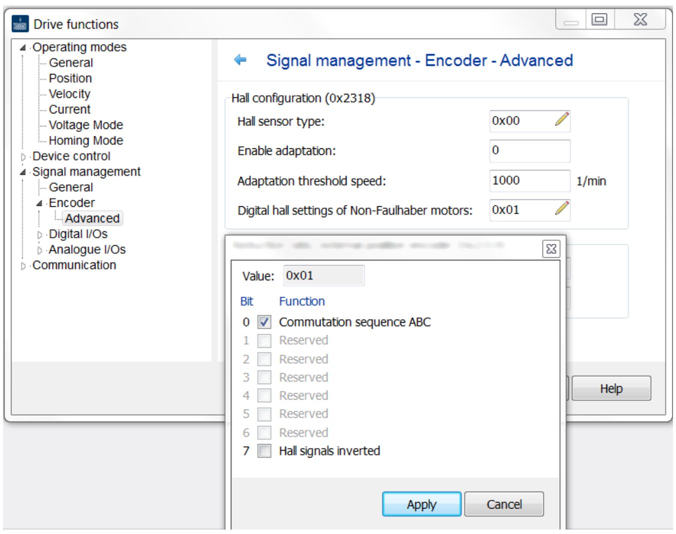
(2) Commutation Sequence **A-B-C**
Alignment of hall sensors with EMF - **shifted by -60°**

	Sensors			Phases		
Electrical Degrees	A	B	C	A	B	C
0 - 60°	1	0	1	High	Low	x
60 - 120°	1	0	0	High	x	Low
120 - 180°	1	1	0	x	High	Low
180 - 240°	0	1	0	Low	High	x
240 - 300°	0	1	1	Low	x	High
300 - 360°	0	0	1	x	Low	High

Hall sensor outputs and excitation sequence



Phase-Voltages, Back-EMF and Hall-Sensor-Signals



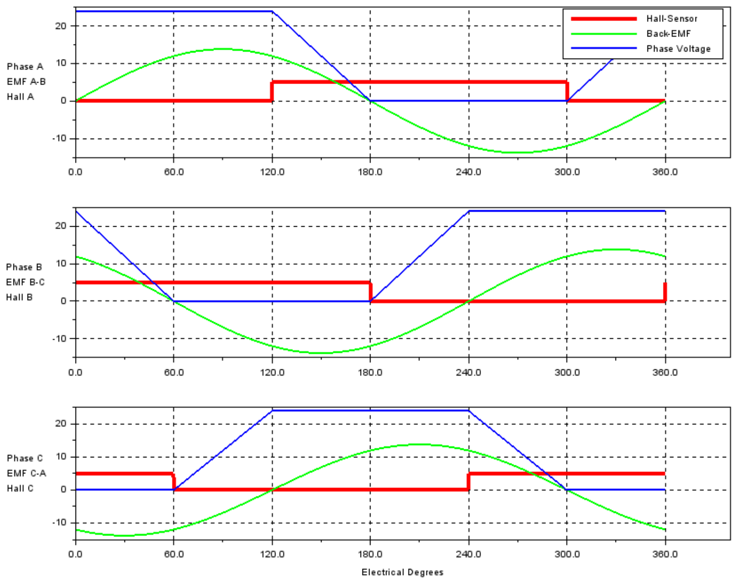
Motion Manager Settings

(3) Commutation Sequence C-B-A

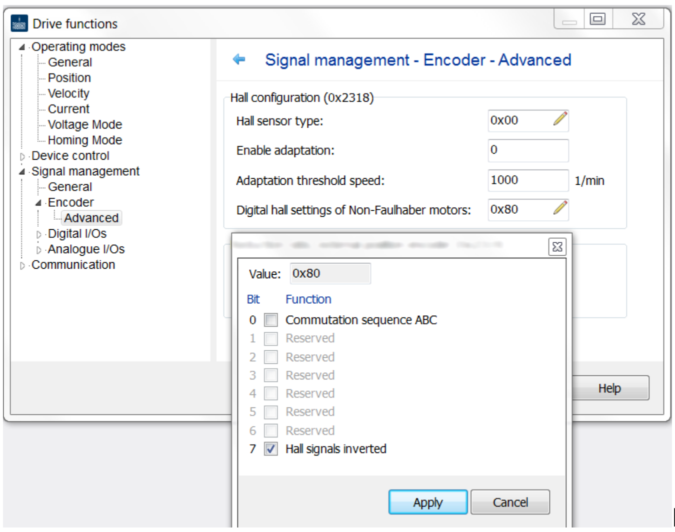
Alignment of hall sensors with EMF - **shifted by +240°** (= **inverted** to use case 1)

	Sensors			Phases		
Electrical Degrees	A	B	C	A	B	C
0 - 60°	0	1	1	High	x	Low
60 - 120°	0	1	0	High	Low	x
120 - 180°	1	1	0	x	Low	High
180 - 240°	1	0	0	Low	x	High
240 - 300°	1	0	1	Low	High	x
300 - 360°	0	0	1	x	High	Low

Hall sensor outputs and excitation sequence



Phase-Voltages, Back-EMF and Hall-Sensor-Signals



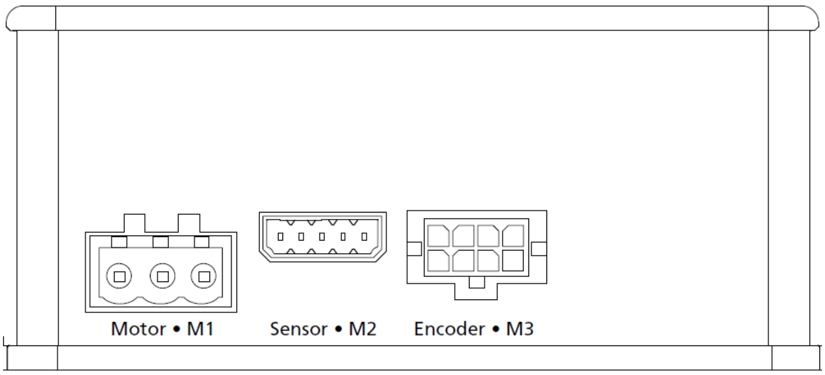
Motion Manager Settings

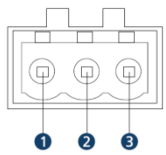
2. **Connect the motor phases and sensor wires**.
Faulhaber Controllers use the labels A, B and C.
Usually this can be directly transferred to:

	Phases			Hall Sensors		
Controller	Mot-A	Mot-B	Mot-C	Sens-A	Sens-B	Sens-C
Motor	Phase_U	Phase_V	Phase_W	Hall_U	Hall_V	Hall_W
or						
Motor	Phase_1	Phase_2	Phase_3	Hall_1	Hall_2	Hall_3

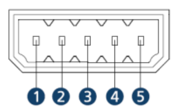
- Some motors offer positive and negative digital hall sensor signals. Connect the positive ones to the controller, the negative ones are not used.
- It is likely that the motor will have an additional incremental encoder. Connect it to the Encoder input M3, making sure that Channel_A and Channel_B are not mixed up. (Using an encoder index or a line driver is optional.)

Naming of the controller connectors (MC5005 + MC5010)

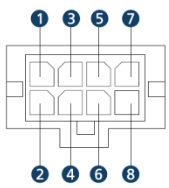




Pin	Designation
1	Motor A
2	Motor B
3	Motor C



Pin	Designation
1	U_{DD}
2	GND
3	Sensor A
4	Sensor B
5	Sensor C

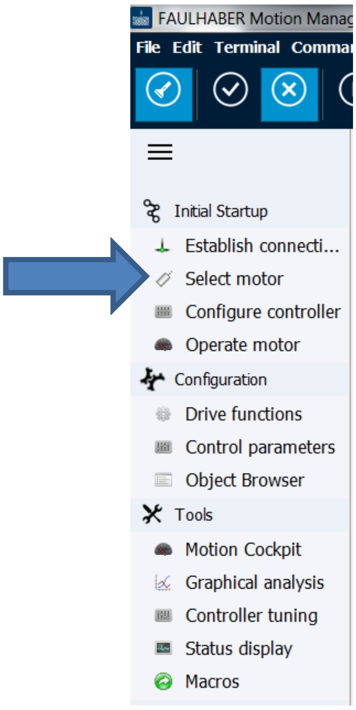


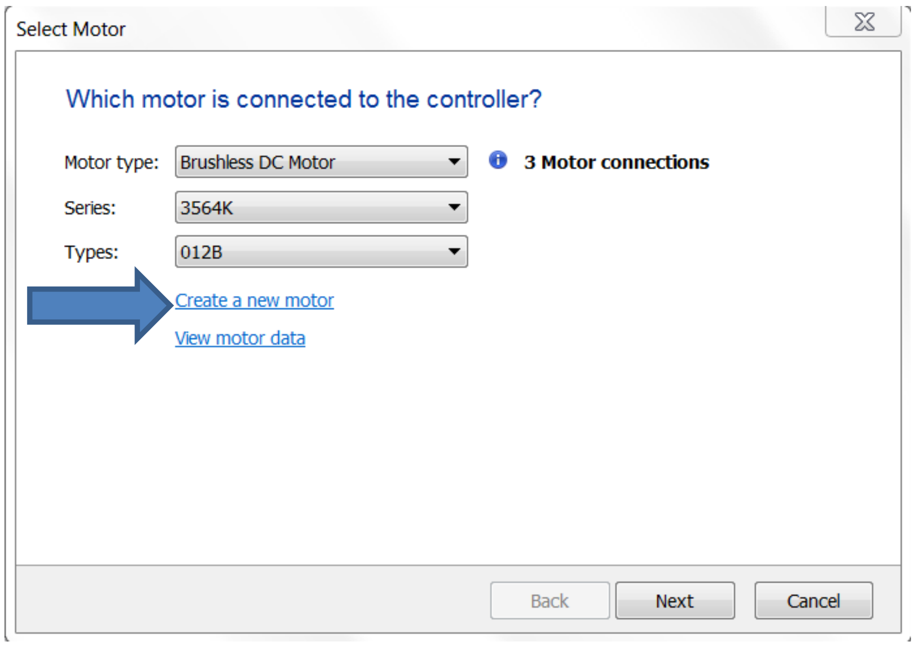
Pin	Designation	Meaning
1	U_{DD}	Power supply for the incremental encoder
2	GND	Ground
3	$\overline{\text{Channel A}}$	Encoder channel A (logically inverted signal)
4	Channel A	Encoder channel A
5	$\overline{\text{Channel B}}$	Encoder channel B (logically inverted signal)
6	Channel B	Encoder channel B
7	$\overline{\text{Index}}$	Encoder index (logically inverted signal)
8	Index	Encoder Index

3. **Connect** the **power supply** to the controller (Up and Umot)

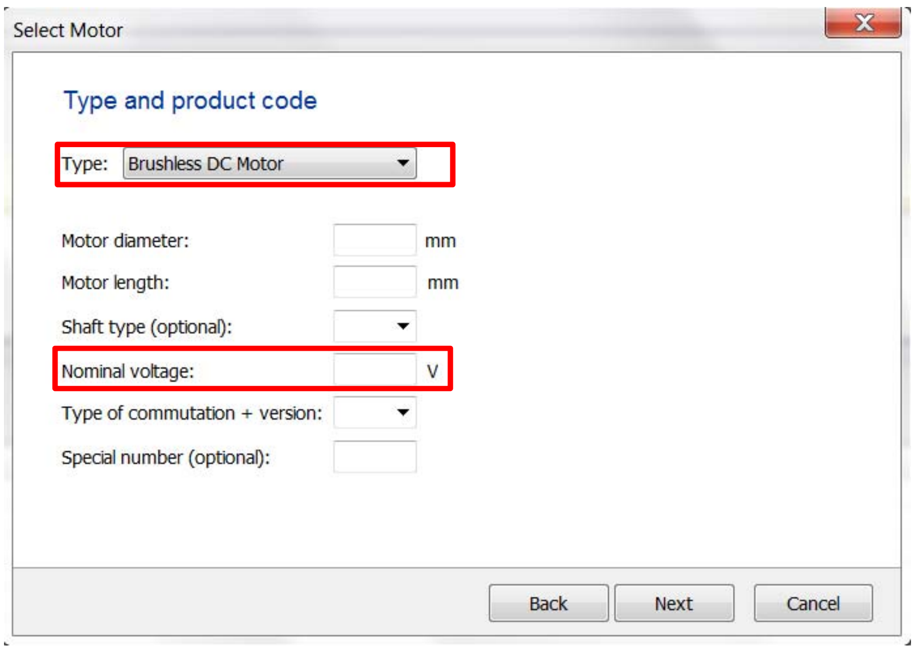
and establish communication

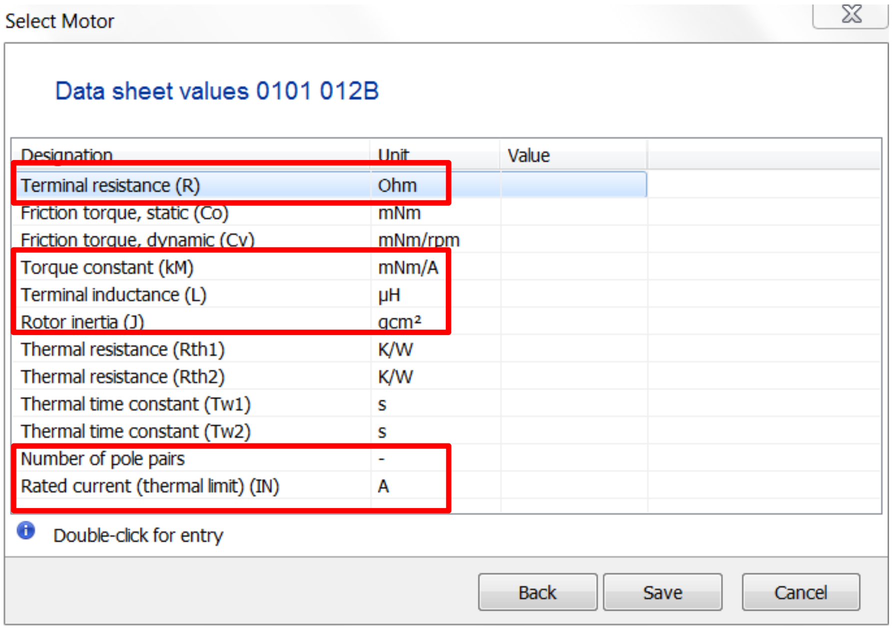
4. Create a **new motor** using the motor select wizard of Motion Manager 6.3





When creating the motor make sure that especially the red marked parameters are correctly entered.

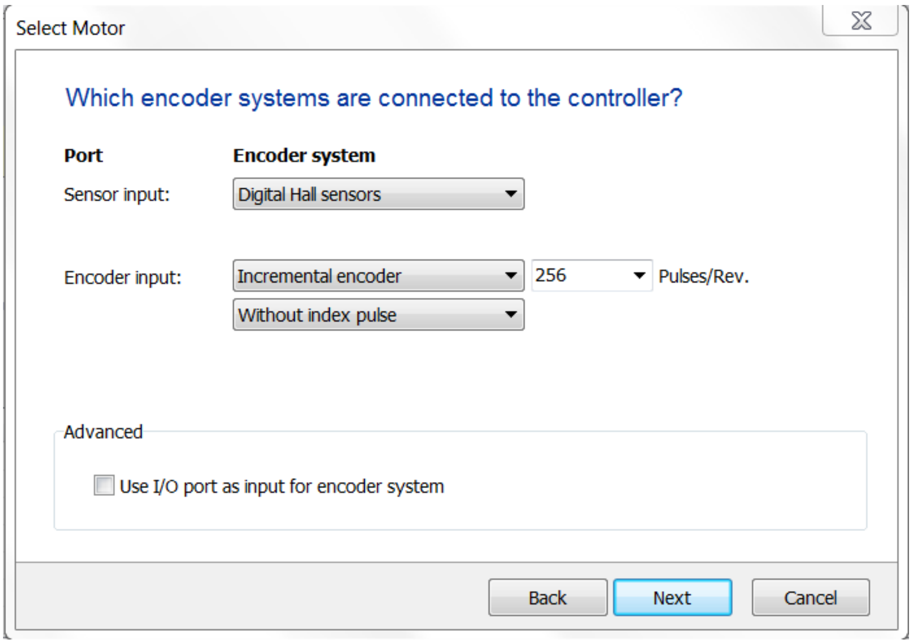




If the values for friction and thermal parameters are not available, choose the values of a similar Faulhaber motor instead (of course the thermal motor model will not be precise in this case). Then click save.

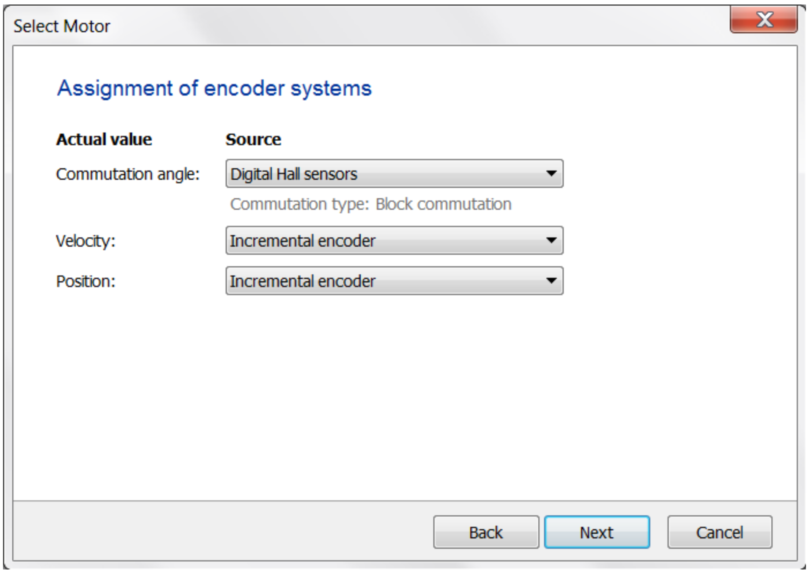
5. **Choose** the newly created **motor** by clicking next.

6. **Configure the sensors**, following the “select motor wizard”
Choose Digital Hall sensors as Sensor input. If present enter an Incremental Encoder as encoder input, as well as the number of Pulses/Rev. (The value entered here will be internally multiplied by 4 to reflect the 4-edge evaluation of the controller).

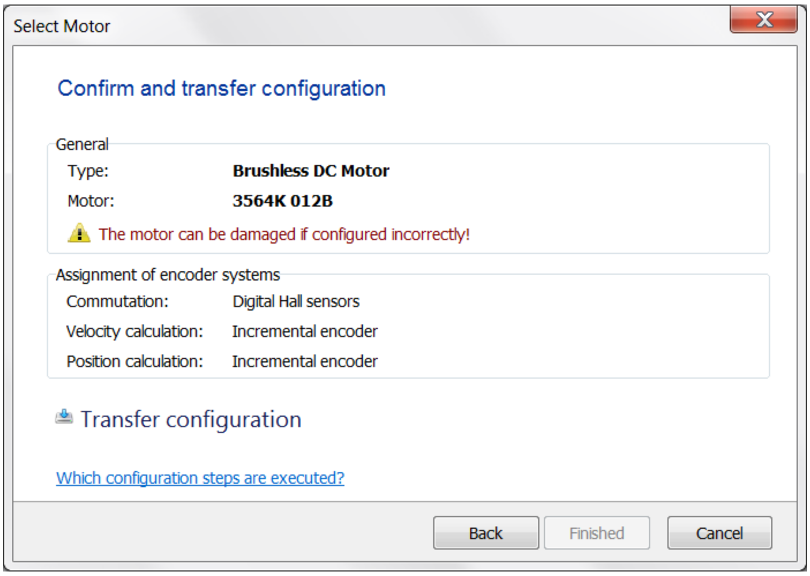


7. **Choose block commutation** by assigning digital hall sensors for commutation. If present select an incremental encoder as source for velocity and position.

Even if **sinusoidal commutation** shall be used in the application it is highly recommended to first select block commutation. Then follow the steps 8..11 for configuration and verification, and only afterwards come back to the "motor selection wizard" and choose sinusoidal commutation by assigning "digital hall sensors + incremental encoder" to the commutation angle. (Otherwise verification of the correct settings gets difficult).



8. **Transfer** the **configuration** to the controller and save it.

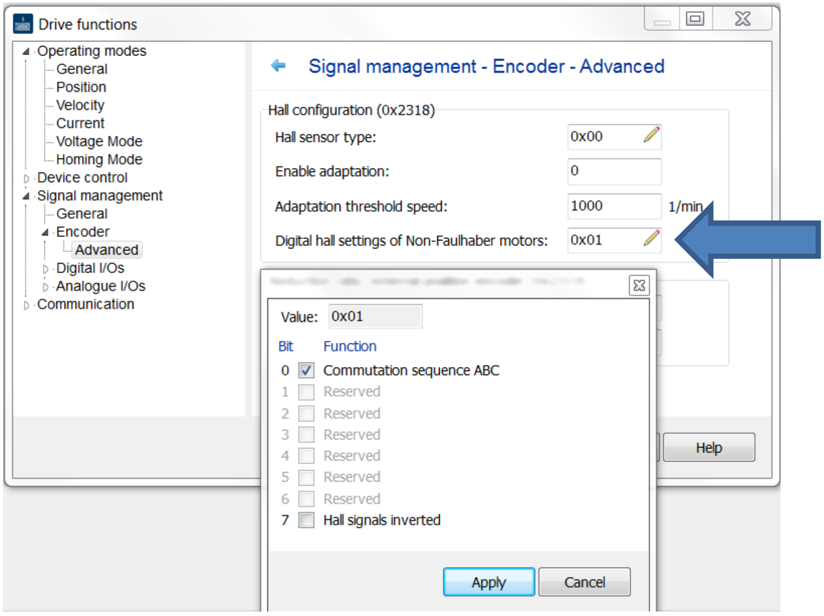


If the configuration cannot be transferred, contact your FAULHABER sales partner and provide the data which was entered during motor creation, so FAULHABER can check for compatibility with the controller.

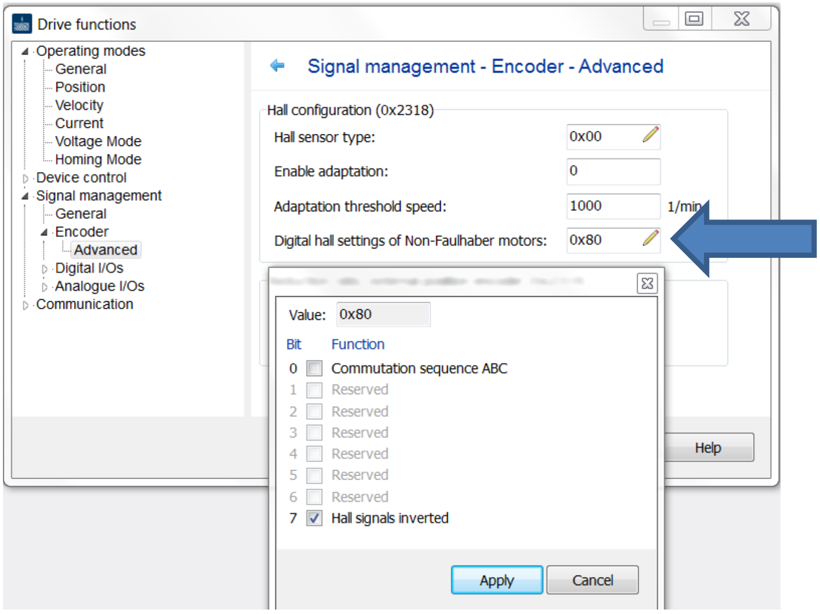
9. **Recall the use case** which was identified in step 1 on by examining the tables and diagrams.
If **use case 2 (commutation sequence A-B-C) or 3 (inverted hall signals)** applies to the motor the hall configuration 2318.04 has to be modified accordingly.

Go to Configuration / Drive functions / Signal management / Encoder / Advanced:

Configuration of use case 2:

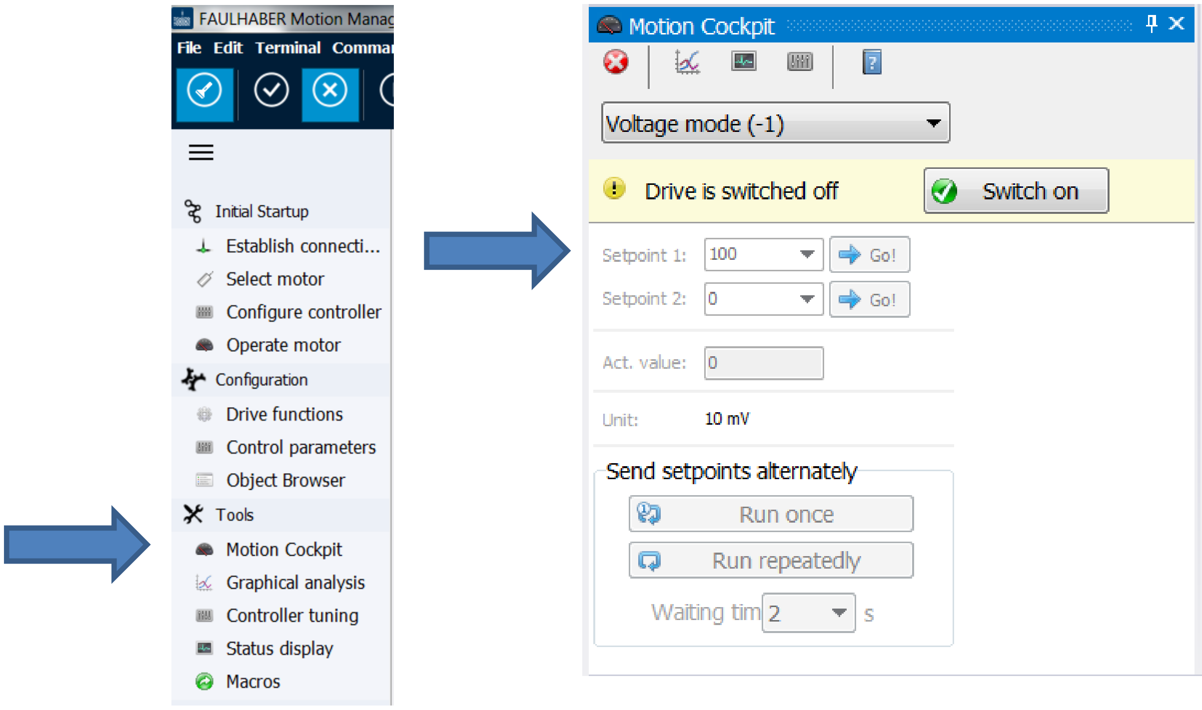


Configuration of use case 3:



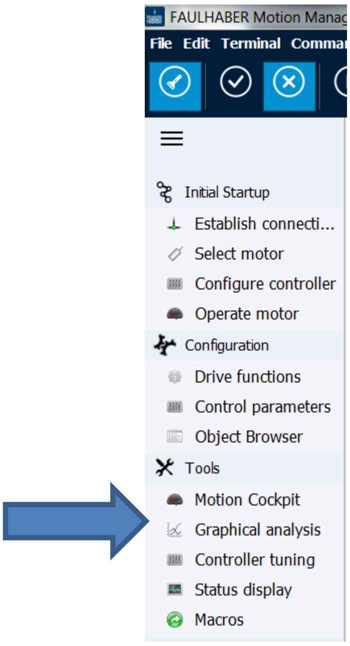
If use case 1 applies the value of object 2318.04 must be 0x00.

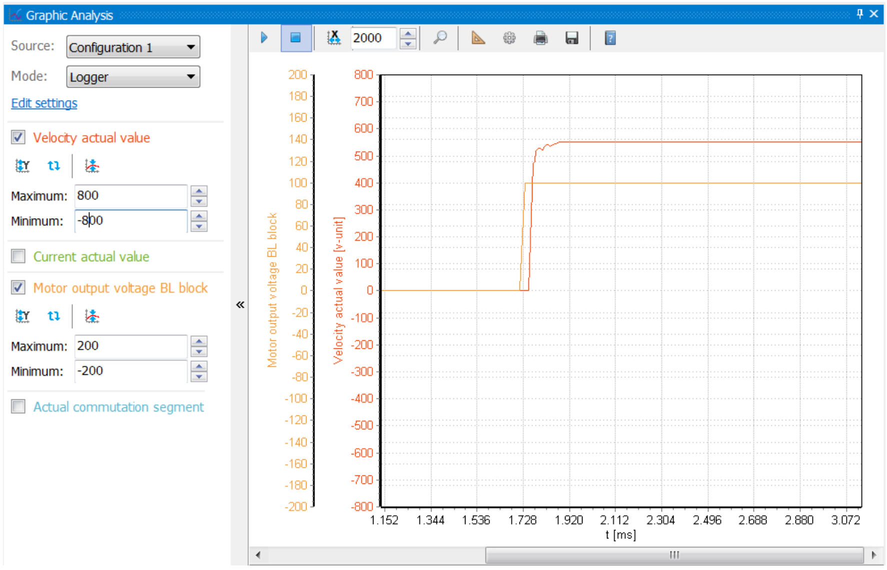
10. Testing the configuration - in voltage mode, via graphical analysis



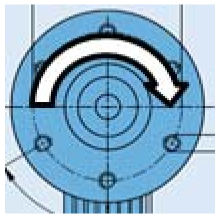
- Open the Motion Cockpit
- Choose the voltage mode and switch the power stage on.
- Command a voltage of 1 V by tipping 100 into the “Setpoint 1” field.
- Then push the Motion Cockpit button “Go!”

- Open the Graphical Analysis and add the sources “Velocity actual value”, “Motor output voltage BL block”, “Current actual value” and “Actual commutation segment” (via Edit settings).





A correctly configured motor will:

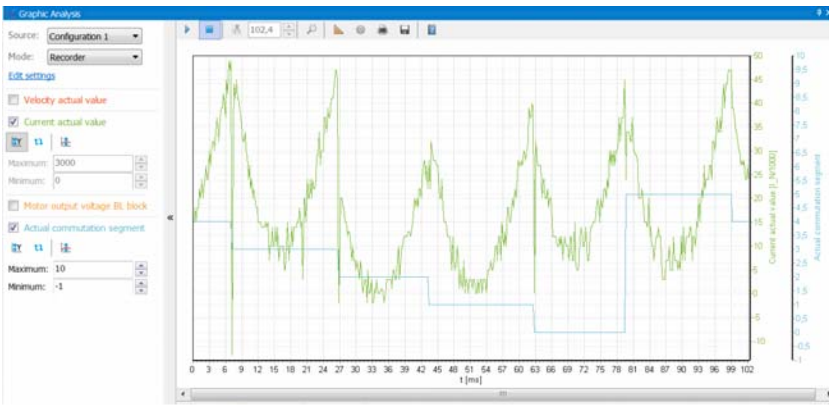


- run clockwise (when looking onto the shaft) ✓
- show a positive Velocity actual value as displayed in the above graph ✓

For block commutation only:

- show the typical current waveform with commutation “arcs” ✓
- show no current spikes, expect for spikes towards zero at the point of commutaion. ✓

Recorder view of a reasonable Torque actual value + Commutation segments:



11. Troubleshooting

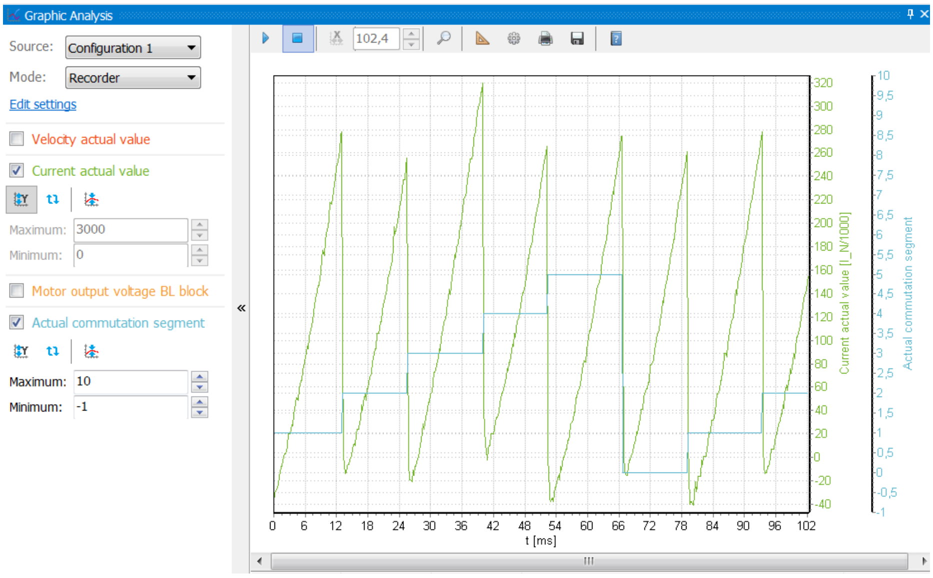
- The Velocity actual value is negative, when commanding a positive voltage
    - if an incremental encoder is used, swap the encoder channels A and B
    - if only digital hall sensors are used, it is likely that the hall sensor configuration is incorrect, see step 9, page 10.

- The motor is not running at all or not running smoothly
    - Check if the number of pole pairs (object 0x2329.07) was entered correctly (see object browser, or select motor → edit motor data)
    - Check if the correct hall sensor configuration was chosen (object 2318.04), see step 9, page 10.
    - Check the wiring, see step 2, page 6

For block commutation, only:

- The recorded graph of the torque actual value does not show the typical commutation waveform (see page 12)

  Example of an incorrect current waveform:



    - Check if the correct hall sensor configuration was chosen (object 2318.04), see step 9, page 10.
    - Check the wiring, see step 2, page 6

- The recorded graph of the torque actual value shows spikes which are not related to the point of commutation (= when a commutation segment changes)
    - Check if the correct hall sensor configuration was chosen (object 2318.04), see step 9, page 10.
    - Check the wiring, see step 2, page 6

12. Further Steps for starting up the system

Proceed with the controller configuration wizard.
There the parameters of the feedback control system will be set according to the inertia of the system. In order to identify the inertia, the complete system including the load must be available.
Be aware that the automatic system identification was designed for slotless motors; it might not work with some slotted motors.

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