

cyber[®] reaction wheel 2

Project planning guide



Revision history

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01	12/08/2021	New Version	All

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1 About this manual

These instructions contain information required for the safe use of the **cyber[®] reaction wheel 2** system, also referred to as the reaction wheel and the **cyber[®] reaction wheel starter kit**, also referred to as starter kit.

The document must always be used in connection with the cyber[®] reaction wheel 2 operating manual.

Each drive system is clearly described by its serial number (SN).

In case of conflict between this general operating manual and the material-specific documentation, the material-specific documentation applies. This project planning guide is valid for the product (drive system) unless another, material-specific documentation exists.

If this manual is supplied with amendment sheets (e.g. for special applications), then the information in the amendment is valid. Contradictory specifications in this manual are therefore void.

The operator must ensure that this operating manual is read through by all persons assigned to install, operate, or maintain the drive system, and that they fully comprehend its content.

Store this manual within reach of the drive system.

Inform colleagues who work in the area around the machine about the **safety instructions** so that no one sustains injuries.

The original was prepared in German, all other language versions are translations of the original manual.





1.1 Signal words

The following signal words are used to indicate hazards, things that are forbidden and important information:

	⚠ DANGER
	This signal word indicates an imminent danger that will cause serious injuries or even death.
	⚠ WARNING
	This signal word indicates a potential hazard that could cause serious injuries and even death.
	⚠ CAUTION
	This signal word indicates a potential hazard that could cause minor or serious injuries.
	NOTICE
	This signal word indicates a potential hazard that could lead to property damage.
	A note without a signal word indicates application tips or especially important information for handling the drive system.


1.2 Safety symbols

The following safety symbols are used to indicate hazards, things that are forbidden and important information:

			
General danger	Hot surface	Electric voltage	Electrostatically sensitive device

1.3 Structure of the safety information

Safety information in this manual has been structured according to the following template:

	⚠ CAUTION
	<p>Explanatory text shows the consequences of disregarding this information.</p> <ul style="list-style-type: none"> Instructive text uses direct address to indicate what to do.

1.4 Information symbols

The following information symbols are used:

- Indicates an action to be performed
- ➞ Indicates the results of an action
- ⓘ Provides additional handling information

2 Product characteristics

The reaction wheel with integrated servo controller provides a defined angular momentum. It is used to exchange an adjustable angular momentum with a satellite body. This induced angular momentum can be used for alignment of the satellite body or for compensation of interferences from the environment. The reaction wheel can be used in satellites with high demands for alignment accuracy.

This document is intended to familiarize the user with the use of the cyber[®] reaction wheel 2. Following the product specifications of the cyber[®] reaction wheel 2, the cyber[®] reaction wheel starter kit and the cyber[®] reaction wheel assistant are the chapter on startup working with the reaction wheel as well as prototypical integration into ADCS including a description of the available interfaces SPI, I2C and UART.

In the end, integration into an ADCS is explained.

In addition, the software interface of the cyber[®] reaction wheel 2 is explained in the interface control document.

The following table provides an initial overview of the cyber[®] reaction wheel 2

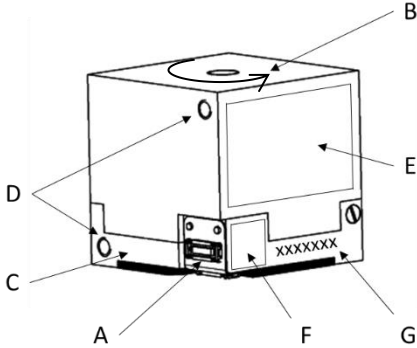
		Designation
	A	Power and signal connector
	B	Housing
	C	Base plate
	D	Fastening screw thread
	E	Name plate
	F	Data Matrix code with link to service portal
	G	Serial number

Table 1: Overview of the cyber[®] reaction wheel 2

2.1 cyber[®] reaction wheel 2

The **WITTENSTEIN cyber[®] reaction wheel 2** is an intelligent drive system with a maximum angular momentum of 2 mNm.

Possible communication interfaces are SPI, I2C and UART.

The intelligence is reflected in an encoderless control system with a high diagnostic depth and the range of functions of industrial drive technology. The sign change of the angular momentum as well as the operation throughout the angular momentum range can be done without any limitations.

Intuitive startup and integration of the drive system is made possible by the cyber[®] reaction wheel starter kit with the PC-based, graphical user interface cyber[®] reaction wheel assistant. It includes a wide range of options for parameterization, diagnostics and control. The CHM help is also part of the cyber[®] reaction wheel assistant.

Alternatively, the reaction wheel can be easily started up with a microcontroller using the cyber[®] reaction wheel starter kit. For this, WITTENSTEIN cyber[®] motor offers a communication stack that ensures easy integration into an ADCS.

Both possibilities for startup are described in sections 3.3 and 3.4.

2.1.1 Type code

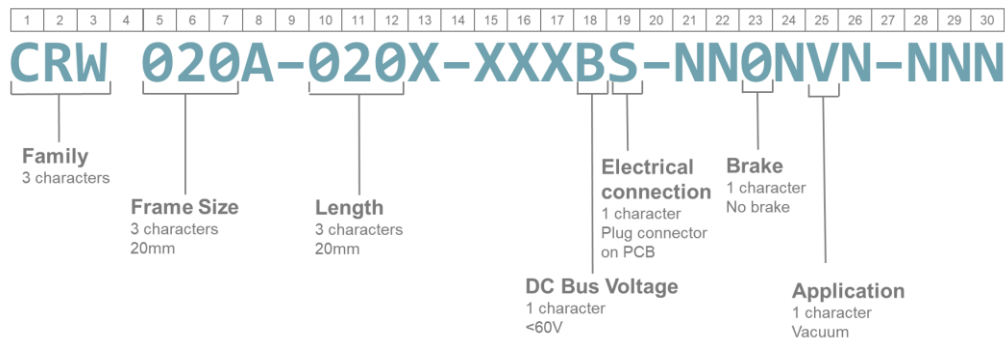


Figure 1.1: crw type code

2.1.2 Name plate

The name plate consists of a laser inscription on the motor housing.

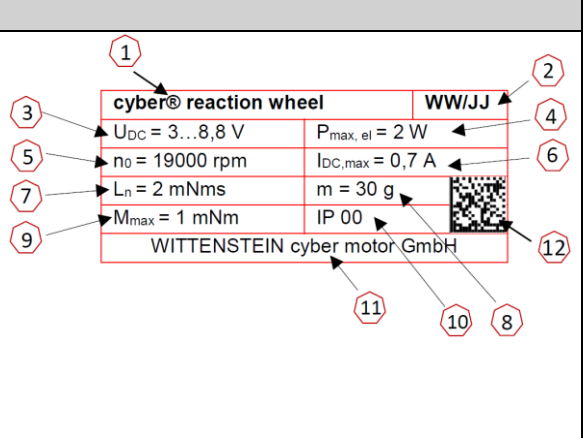
		Designation
	1	Product designation
	2	Calendar week and year of production
	3	DC bus voltage U_{DC}
	4	Maximum power $P_{max, el}$
	5	No-load speed n_0
	6	DC bus current I_{DC}
	7	Angular momentum L_n
	8	Mass m
	9	Maximum torque M_{max}
	10	Protection class
	11	Manufacturer
	12	Data Matrix code: Serial number

Table 2: Name plate of cyber[®] reaction wheel 2

Customized deviations are permissible.

The Data Matrix code (DMC) under the name plate is in the format C18x18 according to ECC200. It contains the Service Portal Address including the Service Portal Code.

2.1.3 Packaging and scope of delivery

The drive system is delivered packed in foil and/or cardboard boxes.

- Dispose of the packaging materials at the recycling sites intended for this purpose. Please observe the valid national regulations for waste disposal.
- Check the completeness of the delivery against the delivery note.
 - ① Immediately notify the carrier, the insurance company, or **WITTENSTEIN cyber motor GmbH** in writing of any missing parts or damage.

2.1.4 System characteristics

The maximum admissible technical data is described in the following table 3
 For additional information, please contact our sales department. Always state the serial number (SN) when doing so.

System data	Unit	Value
Angular momentum at 18000 rpm	mNms	2
Max. speed	rpm	19000
Nominal speed	rpm	18000
Nominal power ¹	W	0.2
Max. acceleration time to 18000 rpm	s	7
Max. acceleration	rev/s ²	60
Max. deceleration with recuperation	rev/s ²	60
Max. deceleration without recuperation	rev/s ²	30
Weight	g	30
Max. static imbalance	gmm	0.02
Max. dynamic imbalance	gmm ²	0.2

Table 3: System characteristics of cyber[®] reaction wheel 2

2.1.4.1 DC power, torque and speed

The following figure shows the DC power and torque against the speed at different accelerations.

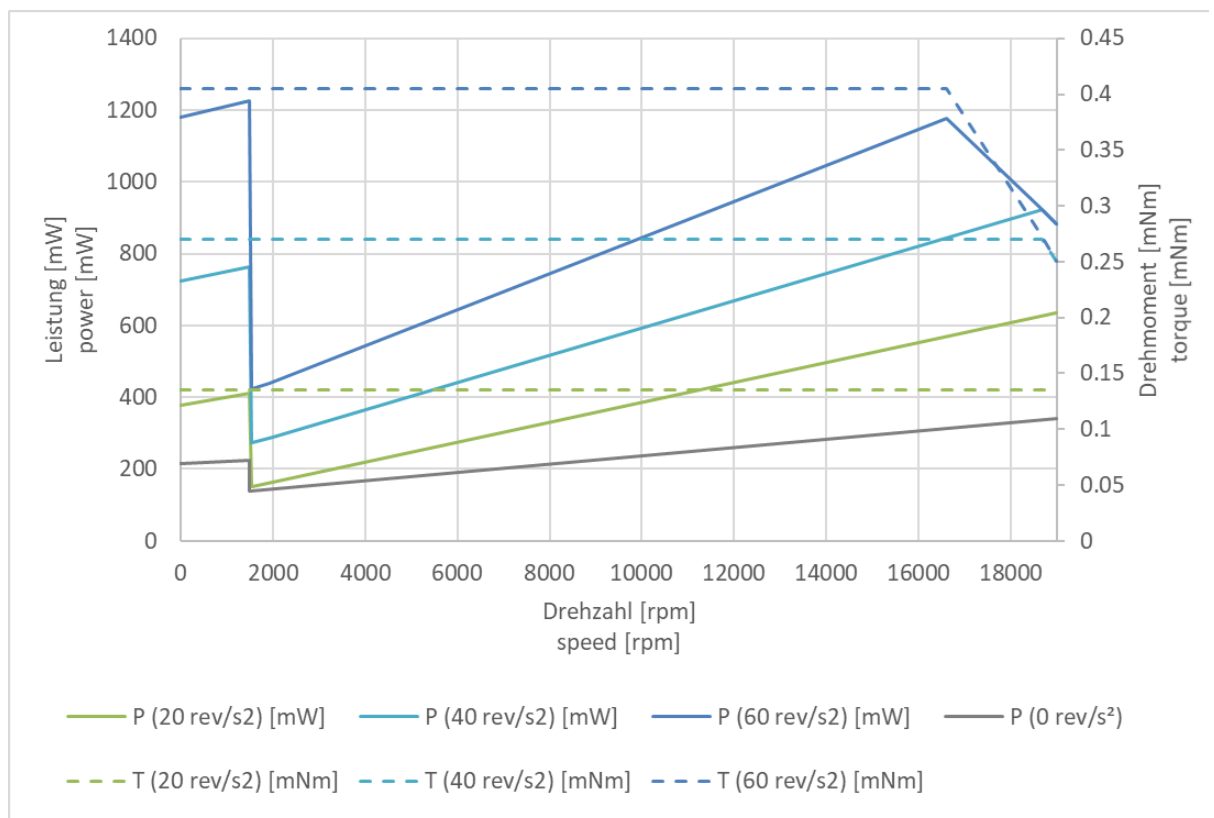


Figure 1.2: DC power and torque profiles against the velocity at accelerations of the cyber[®] reaction wheel 2 from 0 rev/s² to 60 rev/s² at UDC = 5 V

¹ The rated connection power refers to operation at a stationary velocity of 8000 rpm with run-in bearings and an intermediate circuit voltage of 5 V. After an extended standstill, power consumption may be temporarily increased.

2.1.4.2 Control characteristics

According to the following figure, the cyber[®] reaction wheel 2 can be approximated as a first or second order system.

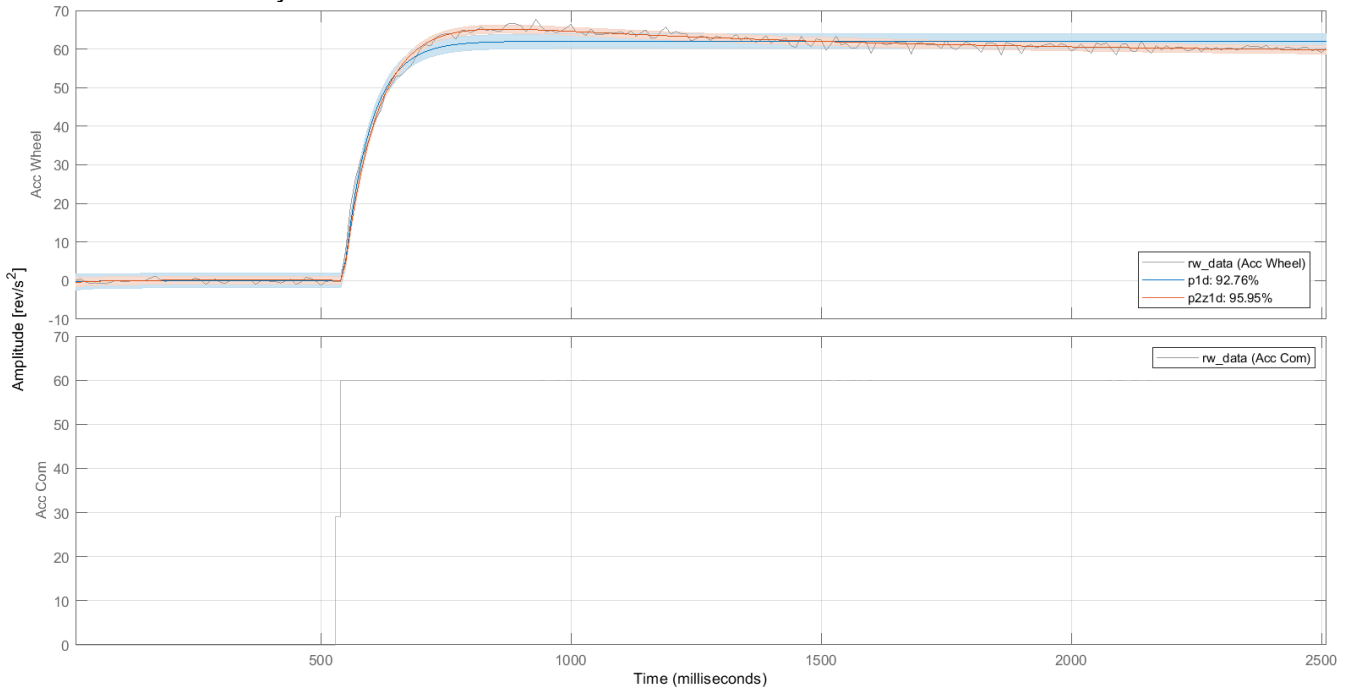


Figure 1.3: Illustration of the step response of the cyber[®] reaction wheel 2 at an acceleration jump from 0 rev/s² to 60 rev/s²

Wittenstein recommends using a transfer function second order with the following parameters for simulation to better map the settling time:

$$G(s) = K_p * \frac{1+T_z*s}{1+2*Zeta*Tw*s+(Tw*s)^2} * exp(-T_d*s)$$

- Kp = 0.983
- Tw = 0.228
- Zeta = 1.867
- Td = 0.01
- Tz = 0.908
- SettlingTime: ~1.7
- Overshoot: ~10 %

2.1.5 Electrical data

Electrical data	Unit	Value
Nominal supply voltage	V DC	5
Supply voltage range	V DC	3.0...8.8
Max. power input (configurable)	mW	<2000
Inrush current power off/on	mA	480
Inrush current disable/enable	mA	560
Plug-in cycles for connector A	number	max. 30

Table 4: Overview of electrical data of the cyber[®] reaction wheel 2

2.1.5.1 Pin assignment of connector A

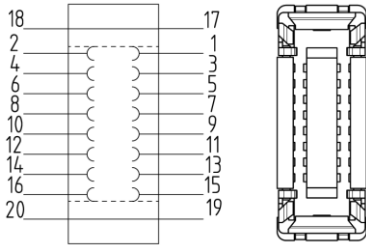
Figure	Pin no.	Signal name	Function
	17	GND	Ground reference
	18	GND	Ground reference
	1	Chopper_Ena	Output signal, underclocking
	2	I2C_SCL	I2C bus SCL
	3	IO_1	User Output 1
	4	I2C_SDA	I2C bus SDA
	5	CAN_Rx	Reserved for CAN Rx
	6	SPI_MOSI	SPI Bus MOSI
	7	CAN_Tx	Reserved for CAN Tx
	8	SPI_MISO	SPI Bus MISO
	9	UART_Tx	UART Tx
	10	SPI_nCS	SPI Bus Chip-Select
	11	UART_Rx	UART Rx
	12	SPI_CLK	SPI Bus Clock
	13	USB_M	Reserved for USB D-
	14	USB_P	Reserved for USB D+
	15	IO_2	User Output 2
	16	IO_3	User Input 1
	19	VDD	Supply voltage
	20	VDD	Supply voltage
<p>Connector type for connection of cyber[®] reaction wheel 2: MOLEX SlimStack PCB connector (16+2) 505070-1622</p> <p>For alignment of the connector on the drive system, see dimensional drawing, document number 5007-D060499.</p>			

Table 5: Pin assignment of connector A at the cyber[®] reaction wheel 2

2.1.5.2 Pin characteristics of connector A

Direction	Size	Value	Affected pins	General limits
Input	Maximum voltage for low level	1.2 V	2, 4, 5, 6, 10, 11, 12, 13, 14	Permitted voltage range of inputs: 0 V - 3.6 V
	Minimum voltage for high level	1.9 V		
Output	Maximum voltage at low level	0.4 V	1, 3, 4, 7, 8, 9, 15	Permitted maximum current of outputs: ±4 mA each
	Minimum voltage at high level	2.4 V		

Table 6: Pin characteristics of connector A at the cyber[®] reaction wheel 2

2.1.5.3 Use of digital IOs

The digital IOs user output 1, user output 2 and user input 1 specified in the tables 5 and 6 can be functionally configured by the user. The configuration options are documented in the CHM help in the cyber[®] reaction wheel assistant.

To do so, simply tap digital IO help and configure the digital IOs within the digital IO tile (1).

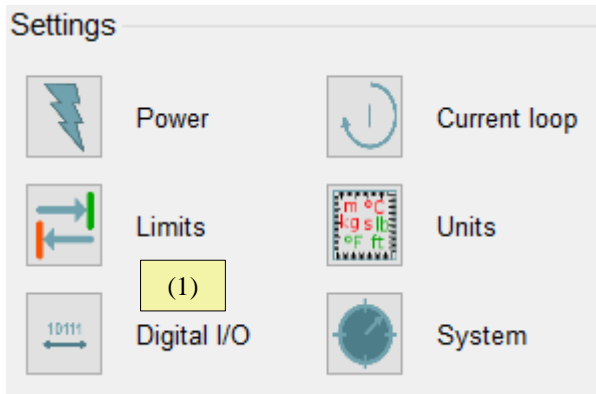


Figure 1.4: Display and application of the configuration options of the digital IOs for the cyber[®] reaction wheel 2

For information on how the digital IOs can best be integrated into the application, please refer to section 2.2.7.3.

The configuration example below describes use of the reaction wheel with the cyber[®] reaction wheel starter kit:

As described in table 17,

- User output 1 is wired to a red LED
- User output 2 is wired to a green LED on the cyber[®] reaction wheel starter kit.

In this configuration example, the red LED lights up in case of a fault in the drive and the green LED as soon as the setpoint velocity is reached:

OUT1	<input type="radio"/>	<input type="checkbox"/>	0 - High ▾			5-Fault ▾
OUT2	<input type="radio"/>	<input type="checkbox"/>	0 - High ▾			2-In velocity ▾

Figure 1.5: Configuration example of user output 1 and 2 for the cyber[®] reaction wheel 2 for displaying an error with the red LED and displaying the velocity status with the green LED during operation with the cyber[®] reaction wheel starter kit

2.1.6 Control and setpoint selection of the reaction wheel

The software of the reaction wheel offers numerous options for control and diagnostics.

For this purpose, the reaction wheel is operated in velocity control mode.

For specification of the angular momentum, acceleration, deceleration and a velocity setpoint are specified. The velocity setpoint is then approached with the set gradients. Changing the velocity of the rotating inertia causes an angular momentum of the required value and in the required direction.

A positive value of the velocity results in revolution of the rotor in counterclockwise direction when viewing the housing from above (see table 1). Respectively, entering of a positive acceleration results in a clockwise reaction torque to the application.

The change velocity (acceleration/deceleration) of the angular momentum as well as the velocity setpoint can be set as required within the limits defined in table 3.

Chapters 3 and 4 describe in detail the options for initial startup and integration of the reaction wheel:

- Initial startup with the cyber[®] reaction wheel assistant (see section 2.3) and the cyber[®] reaction wheel starter kit (see section 2.2) within a few minutes: Section 3.3
- Startup with the cyber[®] reaction wheel starter kit and a microcontroller for prototypical integration into an ADCS: Section 3.4.
- Integration of the cyber[®] reaction wheel 2 into an ADCS: Chapter 4

Installation of the cyber[®] reaction wheel assistant (see section 2.3) provides automatic access to the CHM help in addition to the options for easy startup and diagnostics.

2.1.7 Ensuring availability of the reaction wheel

The reaction wheel has implemented numerous mechanisms to maximize availability.

These include:

- Temperature, current and voltage monitoring
 - Monitoring of internal voltage references and power supply units
 - Monitoring of FLASH and RAM memory as well as correction of corrupt addresses
 - Fault memory for detailed diagnostics, see CHM help of the cyber[®] reaction wheel assistant
- ➡ Wittenstein strongly recommends maintaining the voltage supply to the reaction wheels at all times. This is the only way to ensure that the monitoring and repair mechanisms mentioned above are functional and that the availability of the reaction wheel is maximized. Energy consumption is therefore reduced to a minimum during no-load operation of the reaction wheels.

2.1.8 Environmental conditions

The cyber[®] reaction wheel 2 can be stored on the ground for 2 years before use.

Environmental conditions	Unit	Value
Operating ambient temperature range	°C	-40 ... 85 ²
Survival ambient temperature range	°C	-40 ... 100
Nominal ambient temperature range ³	°C	0 ... 55
Max. radiation dose	Gy	200
Minimum ambient pressure	mbar	10 ⁻⁸

Table 7: permitted ambient conditions

2.1.9 Vibration/shock

The drive system fulfills the following specifications:

- Vibration according to DIN EN 60068-2-6:2008
 - Frequency range 5 Hz – 2000 Hz
 - Acceleration: 1 g – 8 g
- Broadband noise according to DIN EN 60068-2-64:2008
 - Frequency range 20 Hz – 2000 Hz
 - Acceleration RMS: 7.5 g
- Shock according to DIN EN 60068-2-27:2009
 - Shock form: semi-sinusoidal
 - Acceleration: 40 g
 - Shock duration: 3 ms

2.1.10 Electromagnetic Compatibility (EMC)

The system meets the requirements for interference immunity according to EN 61000-4-3 (electromagnetic HF field) and EN 61000-4-4 (fast transients) as well as interference emissions according to EN 55011 (interference voltage at the power supply connection and radiated interference emission).

² At 85 °C, a permanent acceleration and deceleration of 10 rev/s² is possible for the speed range from -1500 rpm to 1500 rpm. Between 1500 rpm and 10000 rpm, a permanent acceleration and deceleration of 60 rev/s² is possible.

³ In this temperature range, the crw can be operated continuously over the complete speed range with the maximum acceleration of 60 rev/s² if the thermal connection is sufficient.

2.2 cyber[®] reaction wheel starter kit

The WITTENSTEIN cyber[®] reaction wheel starter kit is a startup platform for the cyber[®] reaction wheel 2. This platform makes it very easy to start up the reaction wheel via USB and the cyber[®] reaction wheel assistant. The voltage can be supplied via USB port or alternatively via an external power supply unit.

For connection of the cyber[®] reaction wheel 2 to a microcontroller (e.g. an ADCS), all signals at connector B are routed to the outside (see table 9).

This chapter describes the detailed structure of the starter kit and its intended use. Chapter 3 describes the various options for startup and integration of the cyber[®] reaction wheel 2 with the cyber[®] reaction wheel starter kit.

Section 2.2.7 presents application examples for implementation and verification with the starter kit.

2.2.1 Type code

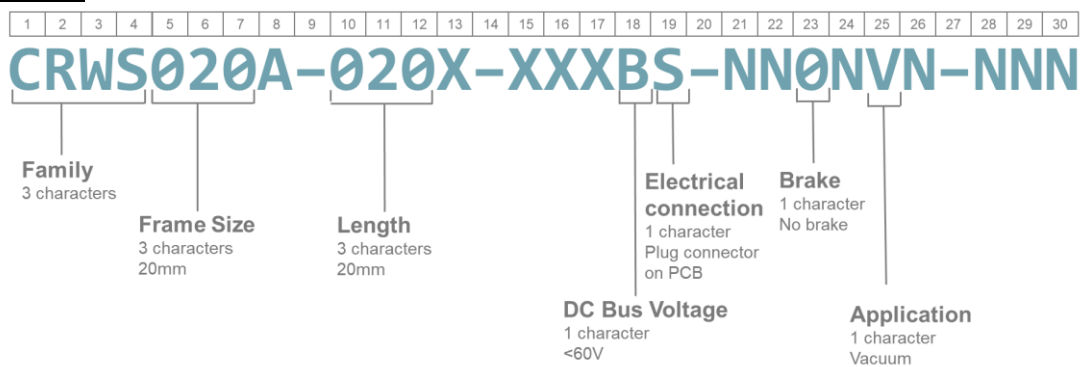


Figure 1.6: crws type code

2.2.2 Intended use

The cyber[®] reaction wheel starter kit is intended exclusively for startup of the cyber[®] reaction wheel 2. Integration of the cyber[®] reaction wheel starter kit into any commercially available products is not permitted.

2.2.3 Packaging and scope of delivery

On delivery, the cyber[®] reaction wheel starter kit is packaged in foil and/or cardboard.

- Dispose of the packaging materials at the recycling sites intended for this purpose. Please observe the valid national regulations for waste disposal.
- Check the completeness of the delivery against the delivery note.
- ① Immediately notify the carrier, the insurance company, or **WITTENSTEIN cyber motor GmbH** in writing of any missing parts or damage.

cyber[®] reaction wheel starter kit

- 1 PCB for startup
- 1 USB cable
- 2 screws, DIN 912 M2x4, for mounting the cyber[®] reaction wheel 2

2.2.4 Structure

Table 8 and figure 1.7 provide an overview of the starter kit and its interfaces.

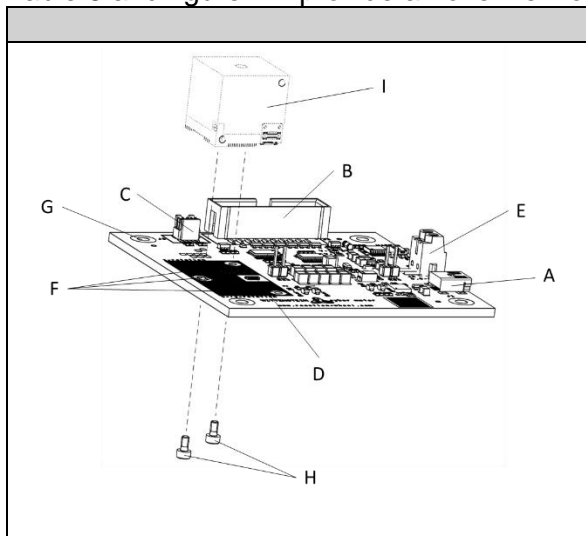
	Designation	
	A	USB port
	B	Application interface
	C	Only for manufacturer
	D	Interface to reaction wheel
	E	Supply voltage
	F	Slot for reaction wheel
	G	Fixing bores for starter kit
	H	Screws DIN 912 M2x4
	I	Reaction wheel (not included in the scope of delivery of the cyber [®] reaction wheel starter kit)

Table 8: Overview of external interfaces of the starter kit

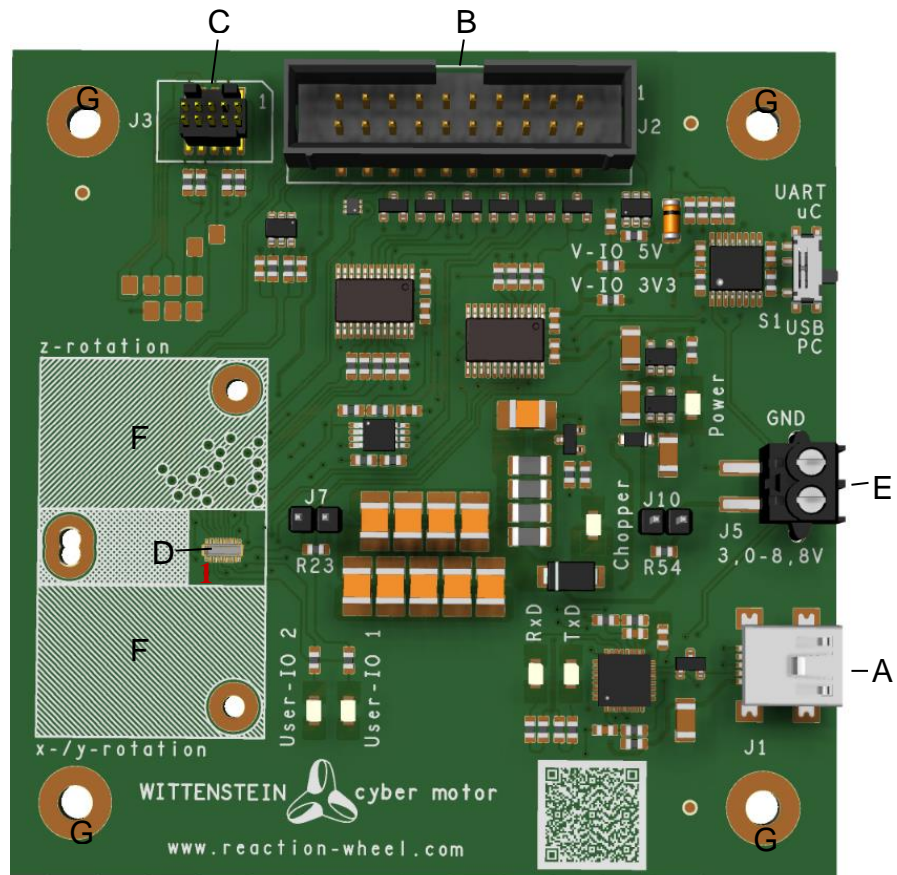


Figure 1.7: Illustration of the external interfaces of the cyber[®] reaction wheel starter kit

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 2.2.5 Electrical interfaces

The following section describes the electrical interfaces as shown in figure 1.7 at the starter kit as well as their properties.

Connector	Function	Plug connector type crws	Plug connector type remote end
A	USB port	Mini-USB B socket	Mini USB connector
B	Application interface	Pin connector, 20-pin, male, grid 2.54 mm	Socket strip, 20-pin, female, grid 2.54 mm
C	Programming interface	Only for manufacturer	Only for manufacturer
D	Interface to reaction wheel	MOLEX SlimStack PCB connector (16+2) 5050701622	MOLEX SlimStack PCB connector (16+2) 5050661622
E	Supply voltage	2-pin screw terminal	Open cable

Table 9: Overview of starter kit plug connectors

 2.2.5.1 A: USB port

The USB port is used for easy startup,

- for communication with the cyber[®] reaction wheel assistant, see section 3.3,
- as well as for voltage supply (if necessary, derating the reaction wheel due to available power of the USB voltage source)
- and for diagnosis of the reaction wheel during integration, see section 3.5

The USB interface is based on a FT232R *USB-to-serial UART interface* from FTDI.

In the customer application, the pins UART Rx/Tx can be controlled directly, see section 2.2.7.4.

Connection	Property	Unit	Minimum value	Nominal value	Maximum value
USB 2.0	Voltage supply and/or communication interface for startup tool	V		5.0	

 Table 10: Electrical properties of application interface, connector B, at the cyber[®] reaction wheel starter kit

2.2.5.2 B: Application interface

Application interface B, see figure 1.7, is intended for fast and prototypical integration of the reaction wheel into the target application. Section 3.4 describes how this is to be done.

All signals listed below have an ESD protection diode.

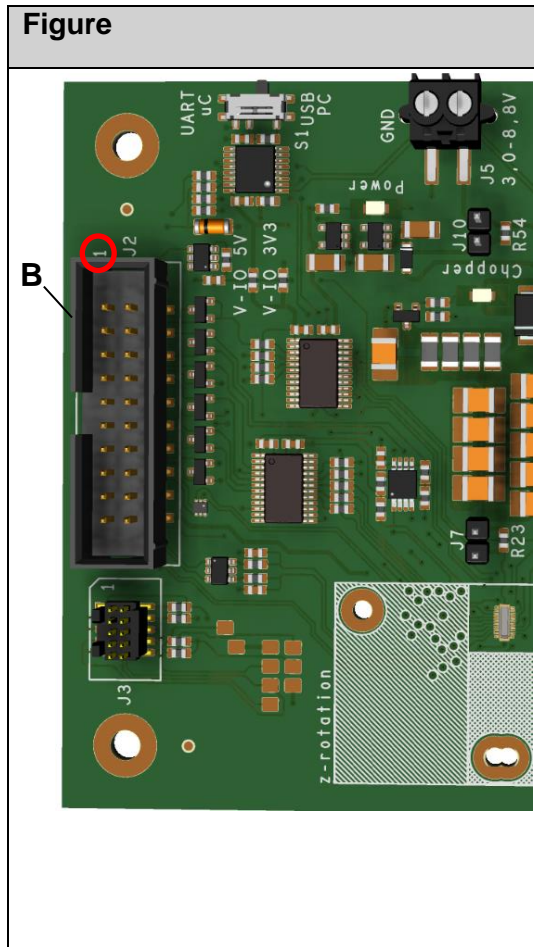
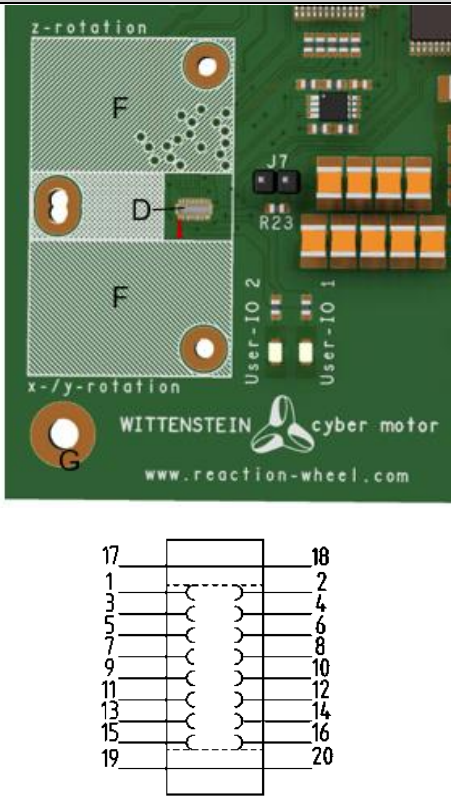
Figure	Pin no.	Signal name	Function
	1	GND	Ground reference
	2	GND	Ground reference
	3	Chopper_Ena	Activation of underclocking (Out)
	4	I2C_SCL	I ² C Bus SCL (In)
	5	IO_1	User Ouput 1
	6	I2C_SDA	I ² C Bus SDA (Bi)
	7	Reserved	Reserved for CAN Rx (In)
	8	SPI_MOSI	SPI Bus MOSI (In)
	9	Reserved	Reserved for CAN Tx (Out)
	10	SPI_MISO	SPI Bus MISO (Out)
	11	UART_Tx	Serial interface (Out)
	12	SPI_nCS	SPI Bus Chip-Select (In)
	13	UART_Rx	Serial interface (In)
	14	SPI_CLK	SPI Bus Clock (In)
	15	Reserved	Reserved for USB D- (Bi)
	16	Reserved	Reserved for USB D+ (Bi)
	17	IO_2	User Ouput 2
	18	IO_3	User Input 1
	19	V-IO	Logic supply
	20	VDD	Reaction wheel supply

Table 11: Pin assignment of application interface, connector B, at the cyber[®] reaction wheel starter kit

Connection	Property	Unit	Minimum value	Nominal value	Maximum value
V-IO	Voltage	V	3.0	3.3 / 5.0	5.5
VDD	Voltage	V	3.0	5.0	8.8
Chop_Ena	Voltage	V		Corr. to V-IO	
I2C_xx	Voltage	V		Corr. to V-IO	
User_IO_x	Voltage	V	3.0	3.3	3.6
CAN_xx	Voltage	V		Corr. to V-IO	
SPI_xxx	Voltage	V		Corr. to V-IO	
UART_xx	Voltage	V		Corr. to V-IO	
USB	Voltage	V		typ. USB	

Table 12: Electrical properties of application interface, connector B, at the cyber[®] reaction wheel starter kit

2.2.5.3 **D: Interface to reaction wheel**

Figure	Pin no.	Signal name	Function
	17	GND	Ground reference
	18	GND	Ground reference
	1	Chopper_Ena	Activation of underclocking
	2	I2C_SCL	I ² C Bus SCL
	3	IO_1	User Ouput 1: red LED on starter kit
	4	I2C_SDA	I ² C Bus SDA
	5	Reserved	Reserved for CAN Rx
	6	SPI_MOSI	SPI Bus MOSI
	7	Reserved	Reserved for CAN Tx
	8	SPI_MISO	SPI Bus MISO
	9	UART_Tx	Serial interface
	10	SPI_nCS	SPI Bus Chip-Select
	11	UART_Rx	Serial interface
	12	SPI_CLK	SPI Bus Clock
	13	Reserved	Reserved for USB D-
	14	Reserved	Reserved for USB D+
	15	IO_2	User Ouput 2: green LED on starter kit
	16	IO_3	User Input 1
	19	VDD	Reaction wheel supply
	20	VDD	Reaction wheel supply

Connector type at starter kit: MOLEX SlimStack PCB connector (16+2) 5050701622

Table 13: Pin assignment of interface to reaction wheel, connector D, at the cyber[®] reaction wheel starter kit

- Observe the maximum number of 30 plug-in cycles for the interface to the reaction wheel.

Connection	Property	Unit	Minimum value	Nominal value	Maximum value
Signals 1-16	Voltage	[V]	3.0	3.3	3.6
VDD	Voltage	[V]	3.0		8.8

Table 14: Electrical properties of application interface, connector D, at the cyber[®] reaction wheel starter kit

2.2.5.4 **E: Supply voltage**

Besides voltage supply via USB port (A), see section 2.2.5.1, a power supply unit can also be used directly. This is recommended if the reaction wheel is operated very dynamically, as the power supplied from the USB port is not sufficient for stable supply of the reaction wheel at every operating point.


Figure	Pin no.	Signal	Function
	1	VDD	Supply
	2	GND	Ground reference
Connector type at starter kit: 2-pin screw terminal			

Table 15: Pin assignment of supply voltage, connector E, at the cyber[®] reaction wheel starter kit

Connection	Property	Unit	Minimum value	Nominal value	Maximum value
VDD	Voltage	[V]	3.0	5.0	8.8

Table 16: Electrical properties of supply voltage, connector E, at the cyber[®] reaction wheel starter kit

2.2.6 LEDs

The starter kit has a total of 6 LEDs, the functions of which are described in the following table:

Ref	Color	Signal	Notice
D4	green	Supply voltage	<i>Power</i> label on starter kit;
D8	red	USB Rx/Tx	<i>TxD</i> label on starter kit;
D9	green	USB Rx/Tx	<i>RxD</i> label on starter kit;
D13	red	Chopper active	<i>Chopper</i> label on starter kit;
D22	red	User_IO_1	<i>User_IO_1</i> label on starter kit; Output controls the red LED, see section 2.1.5.3
D23	green	User_IO_2	<i>User_IO_2</i> label on starter kit; Output controls the green LED, see section 2.1.5.3

Table 17: function of the LEDs at the cyber[®] reaction wheel starter kit

2.2.7 Application notes

This section on the starter kit deals with the implemented circuit modules, which are illustrated in figure 1.8. In the following, application examples are derived and explained based on these circuit modules.

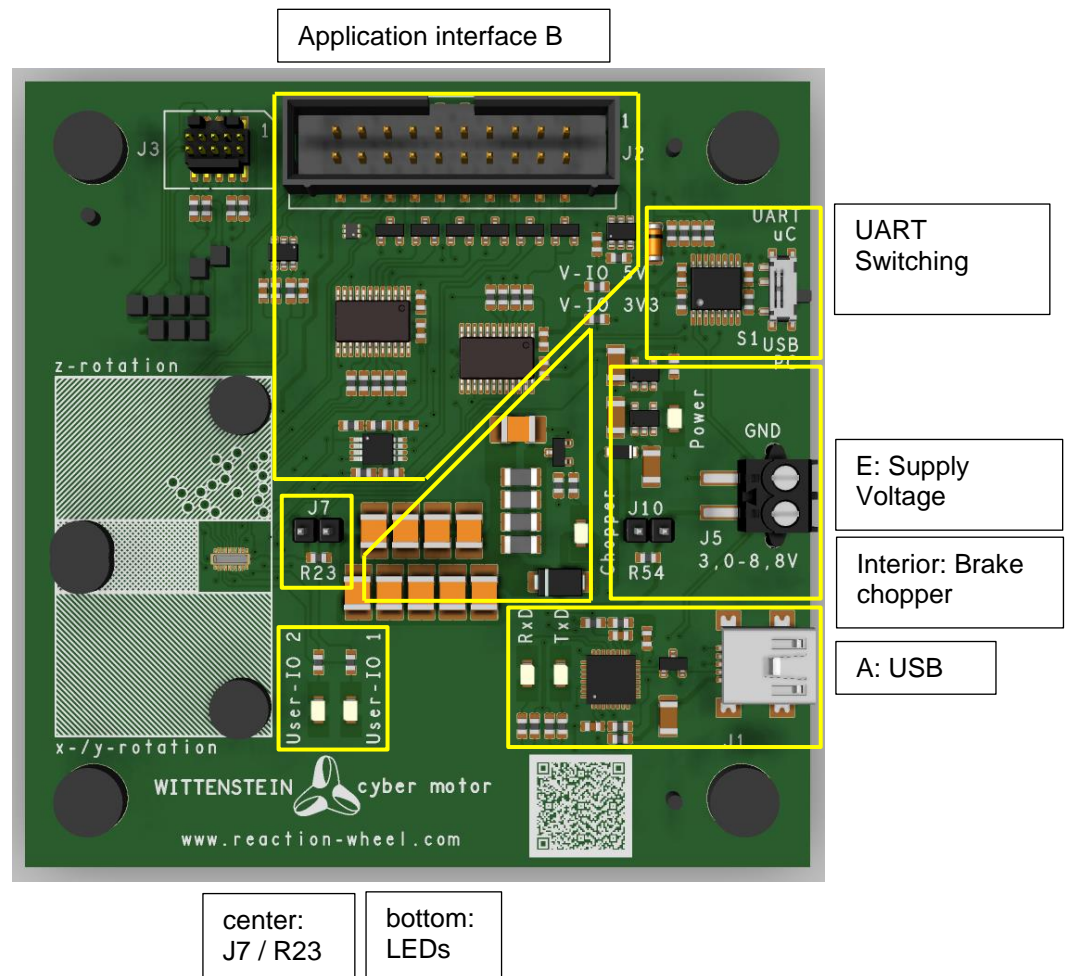


Figure 1.8: Illustration of function blocks on the cyber[®] reaction wheel starter kit

Project planning guide

2.2.7.1 Setting the supply voltage

Option 1:

Connect USB port A to a remote end using the provided USB cable.

Option 2:

With the USB cable not connected, a supply voltage can be set within the specified limits via screw terminal E.

To be able to supply a supply voltage lower than the USB voltage via screw terminal E while the USB cable is connected, the 0 Ω resistor, R54, must be removed as illustrated in figure 1.8, block E. In case of frequent changes, a jumper can be refitted for J10.

2.2.7.2 Provision of V-IO for the logic blocks on the starter kit

Except for the signals IO_1 (pin 5, connector B), IO_2 (pin 17, connector B) and IO_3 (pin 18, connector B), as well as the reserved pins 15 and 16 on connector B, all signals refer to V-IO, pin 19, connector B. The assignment of connector B is described in section 2.2.5.2.

This voltage must be supplied externally at pin 19 at the external plug connector B. Alternatively, a connection to the internal 3.3 or 5 V must be established with a 0 Ω resistor:

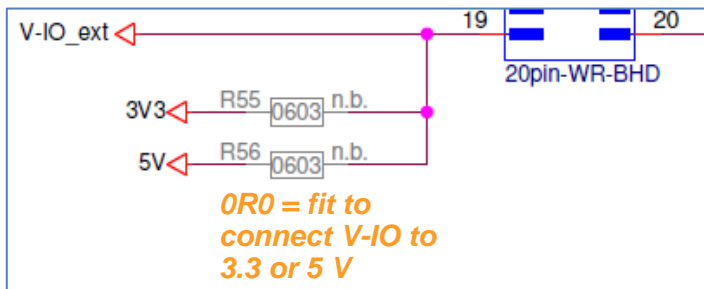


Figure 1.9: Illustration of the circuit diagram section for supplying the logic blocks on the cyber[®] reaction wheel starter kit

Notice: The internally generated 3.3 V and 5 V are not intended for supplying external consumers via pin V-IO_ext.

2.2.7.3 Integration of digital IOs

The digital IOs are decoupled via a series resistance of 100 Ω. The 3.3 V level must always be complied with:

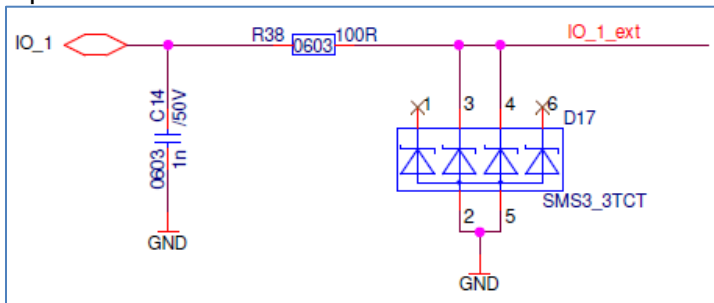


Figure 1.10: Illustration of the circuit diagram section for the user IOs on the cyber[®] reaction wheel starter kit

The two signals IO_1 and IO_2, see section 2.2.5.3, additionally have a red and/or green LED against GND (high-active) to indicate the status of the reaction wheel. The configuration options for these two outputs are described in section 2.1.5.3.

2.2.7.4 UART switching

The reaction wheel provides a UART interface as described in section 3.4.3.3. It can be patched on the starter kit by means of S1 UART switch either to the USB-UART converter for startup with the cyber[®] reaction wheel assistant as described in section 3.3 or alternatively on the application interface for integration into the target application as described in chapter 4 or section 3.4 by switching to position UART uC.

When it comes to integration into the target environment according to chapter 4, the two Rx/Tx signals can be controlled directly with 3.3 V. A serial protection and termination resistor in the range of 1 kΩ ... 3.3 kΩ is recommended as close to the signal source as possible:

Signal	Level	Signal source	Signal target	Series resistance
UART_Tx	3.3 V	Reaction wheel	Customer	Near reaction wheel
UART_Rx	3.3 V	Customer	Reaction wheel	Near customer

Table 18: UART switching

2.2.7.5 Brake chopper: Dissipation of recuperation energy

The reaction wheel was designed for dynamic deceleration and acceleration processes. In case of decelerations as of 30 rev/s², see table 3, the feedback energy may exceed the energy consumption of the reaction wheel.

If no other "consumer" is connected or the energy can be fed back, the supply voltage increases. This behavior can be easily adjusted, for example, if the reaction wheel is supplied via USB and decelerated at max. deceleration. In this case, the supply voltage increases, exceeding the default limit of 7 V. The reaction wheel switches down to the limit and indicates this as an error. For this reason, the circuit on the starter kit is designed and implemented as illustrated in figure 1.11.

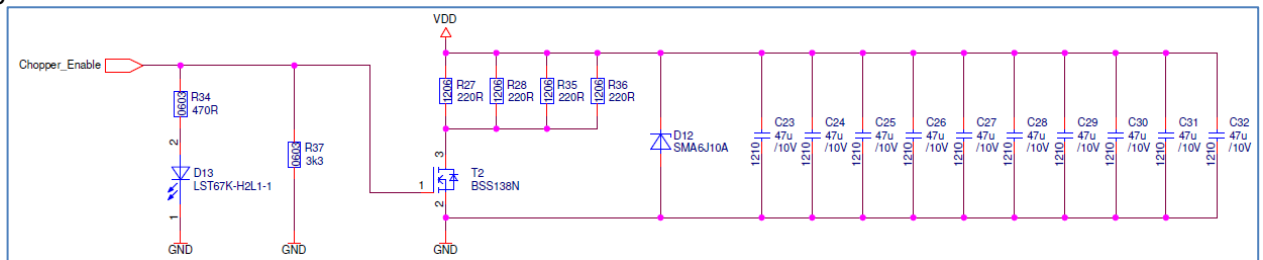


Figure 1.11: Illustration of the circuit diagram section for implementing a brake chopper for dissipation of recuperation energy

This circuit module interacts with pin 1, Chopper_Ena, of the reaction wheel according to table 5 and can be configured in the cyber[®] reaction wheel assistant in the power screen, see figure 1.13.

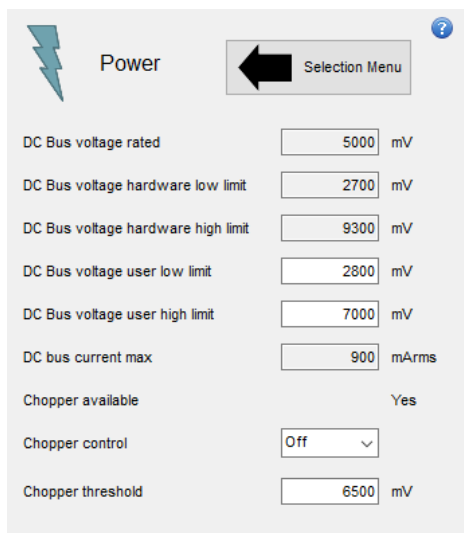


Figure 1.12: Configuration of the pin for dissipation of recuperation energy during braking

To activate the circuit module, the chopper control field must be set to "On". Afterwards, carry out the voltage settings required for the application. Do you want to save the setting permanently? In this case, click the button Save to EEPROM to maintain the settings even after a power failure. The settings presented above causes switch T2 to be switched on by the Chopper_Enable signal from the reaction wheel when the voltage threshold of 6.5 V is exceeded and be switched off when the voltage falls below that threshold.

As soon as T2 is switched on, the energy feedback is converted into heat via resistors R27, R28, R35 and R36.

For the target application, we recommend adopting the circuit module as long as no consumers are connected to the supply system of the reaction wheels that can absorb the energy feedback.

- Notice: The pin Chopper_Ena is activated in the example as of 6.5 V. For this reason, it must be ensured that the supply voltage is always below the set threshold voltage while this module is being used. Otherwise, the module or T2 is permanently activated, which generates power loss and heating.

2.2.8 Environmental conditions

Environmental conditions	Unit	Value
Operating ambient temperature range	°C	0 ... 40
Operating air humidity	%	< 95, non-condensing

Table 19: Ambient conditions of the cyber[®] reaction wheel starter kit

2.3 Graphical user interface cyber[®] reaction wheel assistant

The graphical user interface cyber[®] reaction wheel assistant allows a very fast, easy and comprehensive startup and diagnosis of the reaction wheel. The assistant uses UART to establish a connection to the reaction wheel and allows startup as stand-alone module as described in section 3.3. Furthermore, the cyber[®] reaction wheel assistant can be used very well for diagnostics when integrating the reaction wheels into the target application. The options for this are explained in section 3.5.

With the cyber[®] reaction wheel assistant, the user can also set the I2C address and the baud rate of the reaction wheels for the target application, for example. Information and assistance can be found in the CHM-Help of the cyber[®] reaction wheel assistant.

2.3.1 Installation of the cyber[®] reaction wheel assistant

The cyber[®] reaction wheel assistant is required to be able to easily control the reaction wheel.


System requirements:

Operating system	Windows XP SP3 Windows Vista SP1 Windows 7 Windows 10
Software requirements	<ul style="list-style-type: none"> • .NET framework 4 client profile or higher • Windows installer 3.1 or higher • Internet Explorer 5.01 or higher • FTDI VCP/D2XX driver Download here
Supported Hardware architecture	<ul style="list-style-type: none"> • x86 • x64
Hardware requirements	<p>Minimum requirements</p> <ul style="list-style-type: none"> • Pentium processor 1 GHz 512 MB Ram • Minimum required hard disk space: x86: 600MB x64: 1.5 GB • Screen resolution 1024x768. Higher resolutions are recommended to ease working.

Figure 1.13: System requirements for installation of the cyber[®] reaction wheel assistant


2.3.2 CHM-Help

CHM-Help is an integral part of the cyber[®] reaction wheel assistant. This integrated help tool provides information on all parameters and screens and detailed descriptions.

The CHM-Help can be accessed best by pressing F1 when the cyber[®] reaction wheel assistant is open. More targeted help is provided by clicking on the question mark  in the respective context menu.

2.3.3 Oscilloscope

The oscilloscope is a very helpful diagnostics tool for the reaction wheel. The feature is located directly in the main menu of the cyber[®] reaction wheel assistant by clicking the Scope menu item. With its eight freely configurable channels, many states can be recorded, analyzed, exported and imported.

The scope of functions of the oscilloscope is also described in the CHM-Help. To access it, simply click on  in the Scope menu.

2.3.4 Setting of communication parameters

2.3.4.1 Setting the I2C address

- 1) Open the CHM-Help
- 2) Search index 3E06
- 3) Set the required address according to the parameter description in CHM-Help or the figure below

Index	3E06:0 Communication I2C Slave Address							CAN
Properties	Data Type	Unsigned8	Access Type	ReadWrite	Default Value	119	High Limit	119
	Unit		from Version	2.2.0	PDO Mapping	no	Low Limit	8
	Restrictions							
Parameter description	<p>Parameter to set the I2C address of the slave. The valid address area is from 0x8 to 0x77. All other addresses are reserved by I2C bus specification.</p> <p>After changing the I2C slave address, store all parameters to EEPROM and restart drive.</p> <p>Note: Do NOT use the default I2C address of 0x77 for any reaction wheel. When a firmware update is done the default I2C address is set. So when updating more than one reaction wheel there are two reaction wheels with the same I2C address. The firmware update process should be: 1. Select first reaction wheel and do the firmware update 2. Set the I2C address of the first reaction wheel back to previous selected one and store the parameters to EEPROM 3. Do step 1 and 2 for all other reaction wheels</p>							
Related topics	3B12:1 Setup NVM Access Command							

Figure 1.14: Example of the 0x3E06 parameter for setting the I2C address in the CHM-Help of the cyber[®] reaction wheel assistant

- 4) Save to EEPROM: This saves the address permanently in the reaction wheel.
- 5) Restart Drive: The reaction wheel starts with the new address.

2.3.5 Changing important system parameters

2.3.5.1 Setting the voltage limits

The necessary parameters are listed in the Power screen of the cyber[®] reaction wheel assistant. The CHM-Help for the parameter can be accessed by clicking on the corresponding field and pressing F1 or clicking the question mark circled in blue.

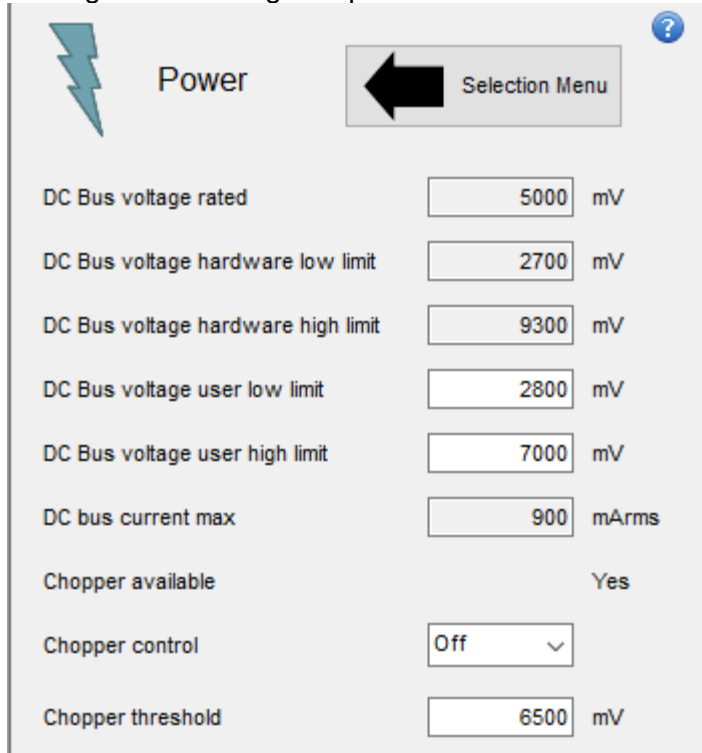


Figure 1.15: Screen for setting the voltage limits

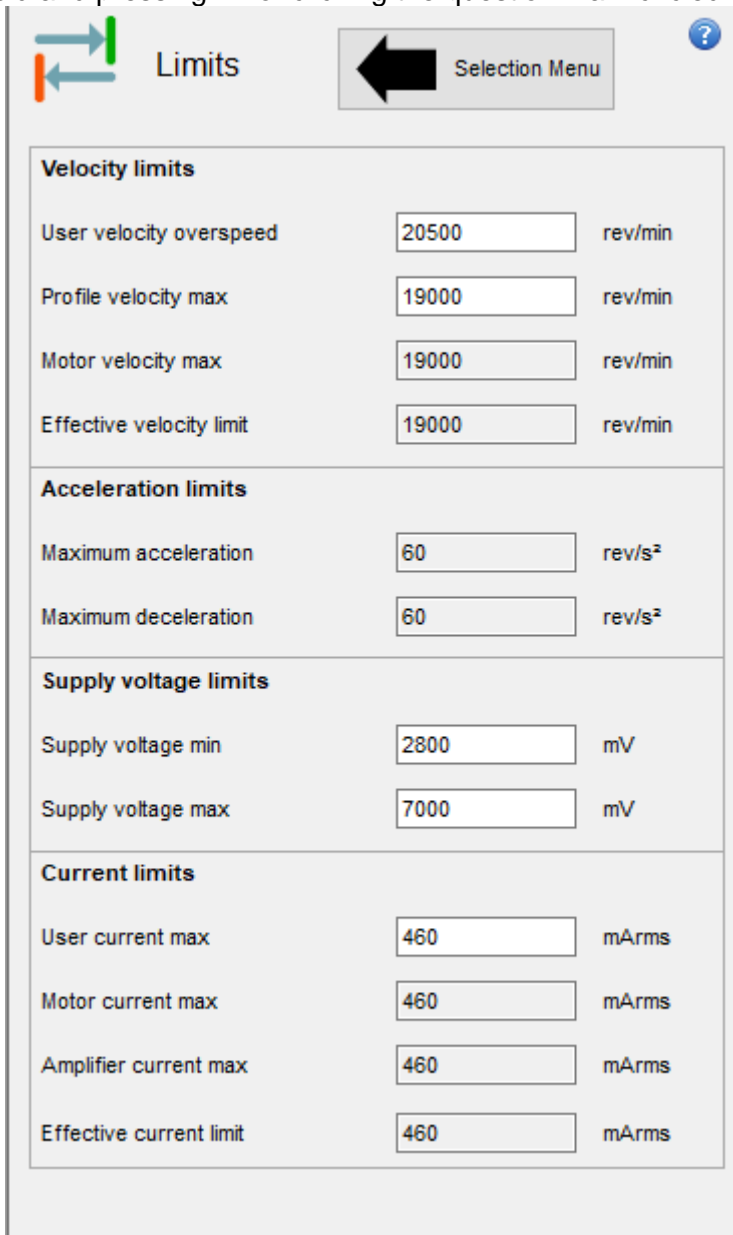
Click on *Save to EEPROM* in the upper menu ribbon to permanently save the changes in the reaction wheel. Otherwise, the previously set values will be loaded again after the next restart.

Index	Description	upper limit	lower limit	Default	Access
0x3A05	Nominal voltage	5 V	5 V	5 V	ro
0x3A06	Lower hardware voltage limit	2.7 V	2.7 V	2.7 V	ro
0x3A07	Upper hardware voltage limit	9.3 V	9.3 V	9.4 V	ro
0x3A1C	Lower user voltage limit	0x3A07	0x3A06	2.8 V	r/w
0x3A1D	Upper user voltage limit	0x3A07	0x3A06	7.0 V	r/w
0x3A19	Brake chopper threshold voltage	0x3A07	0x3A06	6.5 V	r/w

Table 20: Parameters for setting the voltage limits

2.3.5.2 Setting speed and current limits

The necessary parameters are listed in the Limits and Power screen of the cyber[®] reaction wheel assistant. The CHM-Help for the parameter can be accessed by clicking on the corresponding field and pressing F1 or clicking the question mark circled in blue.



Section	Parameter	Value	Unit
Velocity limits	User velocity overspeed	20500	rev/min
	Profile velocity max	19000	rev/min
	Motor velocity max	19000	rev/min
	Effective velocity limit	19000	rev/min
Acceleration limits	Maximum acceleration	60	rev/s ²
	Maximum deceleration	60	rev/s ²
Supply voltage limits	Supply voltage min	2800	mV
	Supply voltage max	7000	mV
Current limits	User current max	460	mArms
	Motor current max	460	mArms
	Amplifier current max	460	mArms
	Effective current limit	460	mArms

Figure 1.16: Screen for setting system limits, e.g., current limits


Index	Description	upper limit	lower limit	Default	Access
0x3A0B	Max. DC current	0.9 A	0.9 A	0.9 A	ro
0x6073	Maximum motor current	0.46 A	0.46 A	0.46 A	ro
0x3A04	Maximum power electronics current	0.46 A	0.46 A	0.46 A	ro
0x3A45	Maximum user phase current	0.46 A	0 A	0.46 A	r/w
0x3610	Used current limit	-	-	Min(0x6073,0x3A04,0x3A45)	ro

Table 21: Parameters for setting the system limits


3 Startup of the cyber[®] reaction wheel 2

3.1 Safety instructions

- For mechanical installation, the ESD information must be observed.
- The drive system must be checked for mechanical damage before installation. Only install reaction wheels that are in perfect working condition.
- Operation of reaction wheels with condensation on them is not permitted.


	⚠ CAUTION
	<ul style="list-style-type: none"> • The drive system may only be assembled with the power disconnected. • Installation may only be performed by trained personnel.

3.2 Preparations

	NOTICE
	<p>Compressed air can damage the drive system.</p> <ul style="list-style-type: none"> • Do not use compressed air to clean the drive system.

	NOTICE
	<p>The system can be damaged by electrostatic discharge.</p> <ul style="list-style-type: none"> • Observe the directives concerning ESD protection.

	NOTICE
	<p>Dirt particles may cause damage to the system.</p> <ul style="list-style-type: none"> • Ensure cleanliness.

	NOTICE
	<p>Incorrect handling may result in damage to the system.</p> <ul style="list-style-type: none"> • Proceed with utmost caution.

- In addition, check the fitting surfaces for damage and impurities.
- For drive systems, use screws of property class A2-70 or titanium grade 5.
- Do **not** use any washers.
- Installation of the cyber[®] reaction wheel assistant (see section 2.3.1)

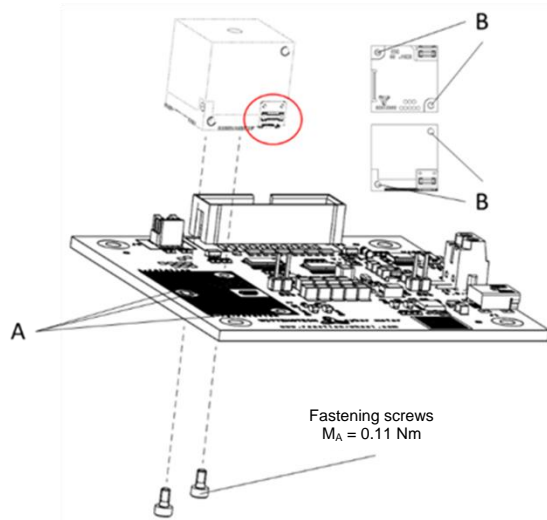
3.3 Startup with the cyber[®] reaction wheel assistant

The following section describes startup of the reaction wheel with the cyber[®] reaction wheel starter kit and the cyber[®] reaction wheel assistant.

3.3.1 Installation at cyber[®] reaction wheel starter kit

To do this, perform the following steps:

Secure the reaction wheel (I) in the required axis configuration to the starter kit (G) using screws (H).



- If the cyber[®] reaction wheel is to be detached from the starter kit again, do **not** use threadlocker.
- Fasten the reaction wheel to the starter kit using the fastening screws H.
- Make sure the unused second connector (red marking) is protected against contact with conductive components.

3.3.2 Establishing the power supply

1. Connect the USB cable included with the starter kit to the PC on which the cyber[®] reaction wheel assistant has been installed and to the USB port A (see section 2.2.5.1) on the starter kit. The reaction wheel is then already supplied with voltage via the USB port.
2. Set the UART uC / USB PC switch at the starter kit to USB PC
3. There is also the option of connecting an external supply voltage to screw terminals E in addition to the USB voltage as described in section 2.2.5.4. This allows operation under all load conditions. Observe the maximum permitted input voltage according to section 2.1.5.

3.3.3 Establishing a connection

1. Open the cyber[®] reaction wheel assistant with a double-click
2. Select Device ReactionWheel[...]
3. Press "Connect" to establish a connection

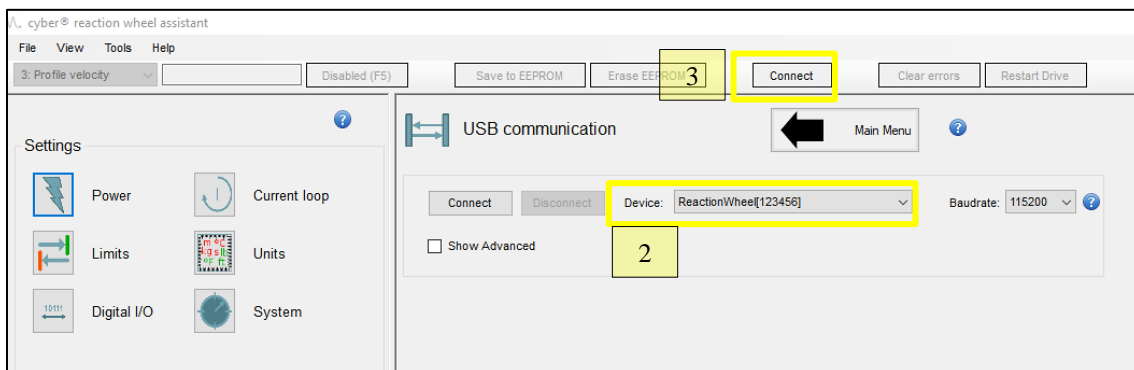


Figure 1.17: Establishing a connection to the cyber[®] reaction wheel 2

3.3.4 Speed setting

1. Open Service motion

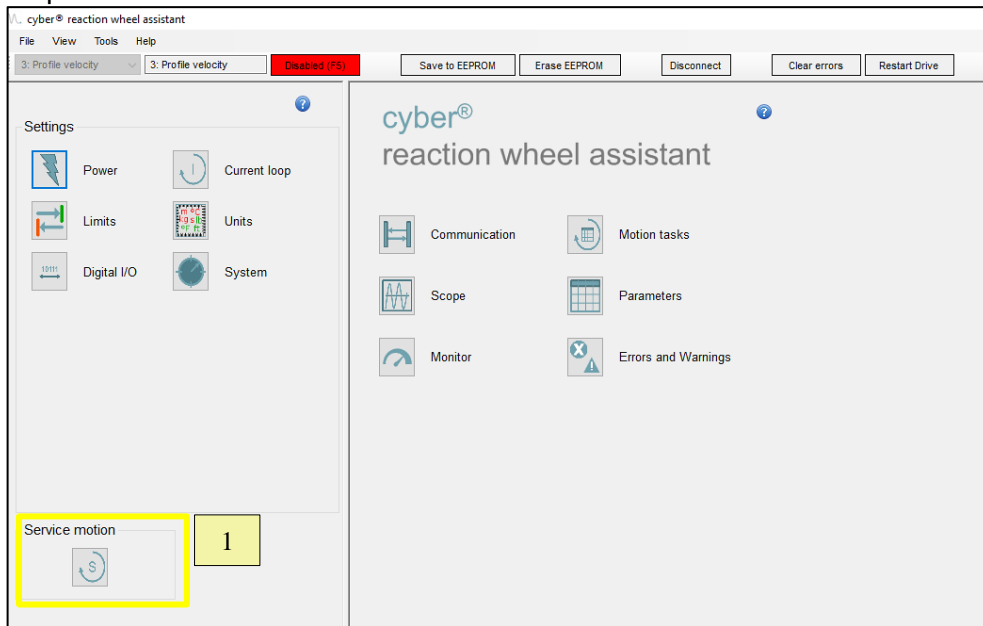


Figure 1.18: Open the screen for specifying the velocity in the cyber[®] reaction wheel assistant

2. Select "Continuous" mode
3. Enter the velocity specification under "Target velocity 1" with the desired acceleration in the "Acceleration" field and deceleration in the "Deceleration" field.
4. Confirm the entry by pressing "Disabled" or F5 (button changes to green and Enabled)
5. Start the rotation of the rotor with "PLAY"
6. The status variables of the reaction wheel can be viewed and/or recorded in the Monitor 6a or Scope 6b screen.

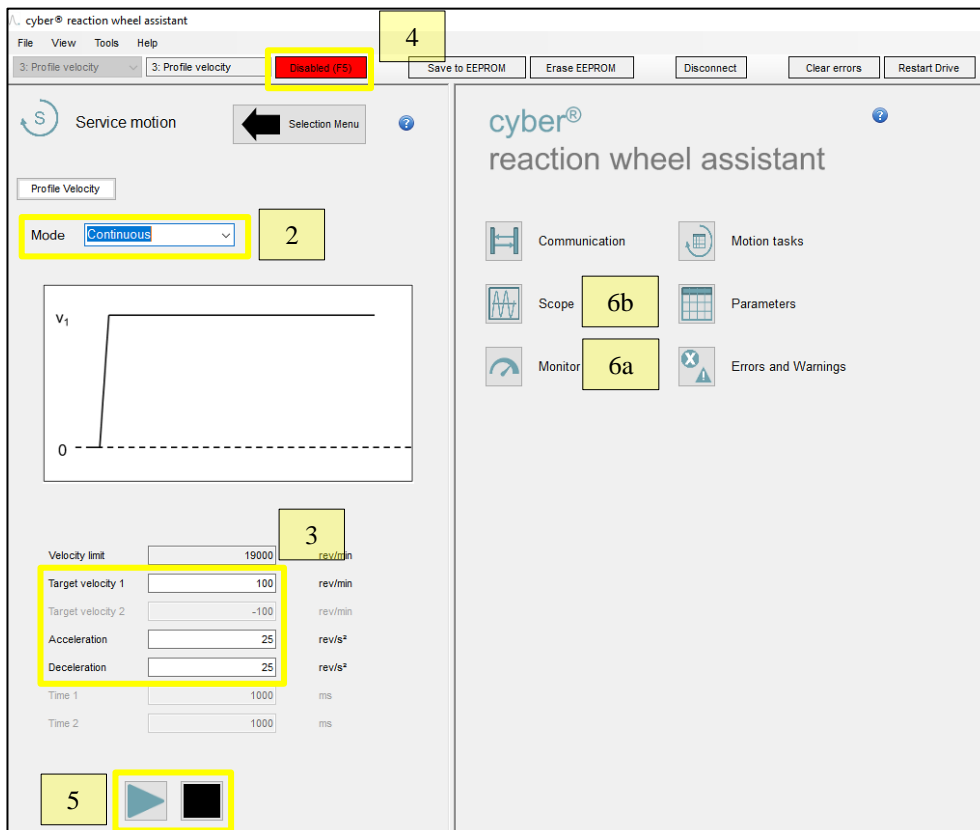


Figure 1.19: specifying the velocity in the cyber[®] reaction wheel assistant

3.4 Prototypical integration of the cyber[®] reaction wheel 2 into an ADCS environment

For control and diagnosis of the reaction wheel with a microcontroller, e.g. an ADCS, the interfaces I2C, SPI and UART as well as a Wittenstein communication stack are provided as a C code. All relevant functions for control and diagnostics of the reaction wheel are implemented in the stack provided. A documentation can be found in the download portal of the cyber[®] reaction wheel 2 in the Interface Control Document (<https://cyber-motor.wittenstein.de/de-de/download-reactionwheel/>).

Basic control of the drive system with a microcontroller platform is explained below.

3.4.1 Preparations at the cyber[®] reaction wheel starter kit

Communication with the cyber[®] reaction wheel 2 via the cyber[®] reaction wheel starter kit is realized via application interface B with pin assignment according to table 11 in section 2.2.5.22.2. Depending on the required communication interface, the corresponding pins must be connected to the pins of a suitable microcontroller.

In addition, the logic voltage (3.3 V or 5 V) must either be supplied externally at pin 19, connector B or a connection must be established to the internal 3.3 V or 5 V via a 0 Ω resistor (see section 2.2.7.2).

3.4.2 Example of an integration of a reaction wheel for startup via SPI with a Nucleo board from ST

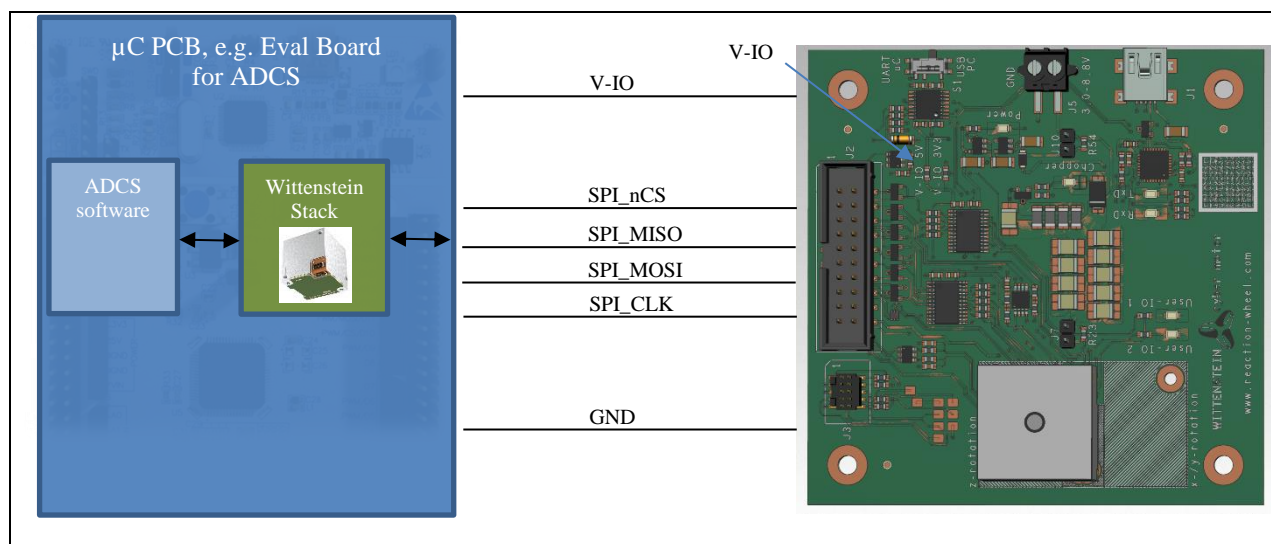


Figure 1.20: Schematic integration of the starter kit with reaction wheel for initial startup using SPI

Depending on the interface used, the following connections must be established between the Nucleo Board and one or more starter kits:

Nucleo Board (general)		Communication master (specific)			reaction wheel starter kit J2 (all axes)		Comment
CN	Pin	Axis	Interface	Name	Pin	Name	
7	18	-	-	5 V	20	VDD	Supply (optional), alternatively via USB or screw terminal
					19	V IO	Supply IO (optional), see 3.4.1
	19	-	-	GND	1, 2	GND	Reference
	28	X	SPI	SPI_nCS_X	12	SPI_nCS	
	30	Y	SPI	SPI_nCS_Y	12	SPI_nCS	
10	32	Z	SPI	SPI_nCS_Z	12	SPI_nCS	
	3	All	I2C	I2C_SCL	4	I2C_SCL	
	5	All	I2C	I2C_SDA	6	I2C_SDA	
	9	-	-	GND	1, 2	GND	Reference
	18	Z	UART	UART_RX_Z	11	UART_TX	RX/TX crossing
	20	-	-	GND	1, 2	GND	Reference
	21	X	UART	UART_TX_X	13	UART_RX	RX/TX crossing
	25	All	SPI	SPI_CLK	14	SPI_CLK	
	26	All	SPI	SPI_MOSI	8	SPI_MOSI	
	28	All	SPI	SPI_MISO	10	SPI_MISO	
	33	X	UART	UART_RX_X	11	UART_TX	RX/TX crossing
	34	Z	UART	UART_TX_Z	13	UART_RX	RX/TX crossing
	35	Y	UART	UART_TX_Y	13	UART_RX	RX/TX crossing
37	Y	UART	UART_RX_Y	11	UART_TX	RX/TX crossing	

Table 22: Specification of pin assignment during a prototypical startup of the reaction wheel with an STM32 Nucleo Board

Further information on the required integration of the Wittenstein stack is described in section 3.4.4.

3.4.3 Communication interfaces

The cyber[®] reaction wheel 2 offers the following communication interfaces as an interface to a higher-level system:

- I2C
- SPI
- UART

All three interfaces can be used in parallel. A precondition for this is that the interface is switched after the last command has been completed. The reaction wheel always switches to the interface which has at last received a signal.

Redundant provision of several interfaces can make sense to increase the availability of the cyber[®] reaction wheel 2. With a simple structure, several reaction wheels can be integrated in parallel by using all available communication interfaces as schematically illustrated in figure 1.21. The special features of the interface are explained in the sections 3.4.3.1 - 3.4.3.3. Integration of the Wittenstein communication stack is described in section 3.4.4.

I2C and SPI can be used to transmit the setpoint values for velocity, acceleration and deceleration either synchronously or asynchronously to the reaction wheels. For the normally prioritized synchronous setpoint transmission, the reaction wheel uses the broadcast message at address 0x0 at the I2C bus.

- When this combination is used, it must be ensured that this message does not interfere with other I2C participants or that they do not interfere with it.

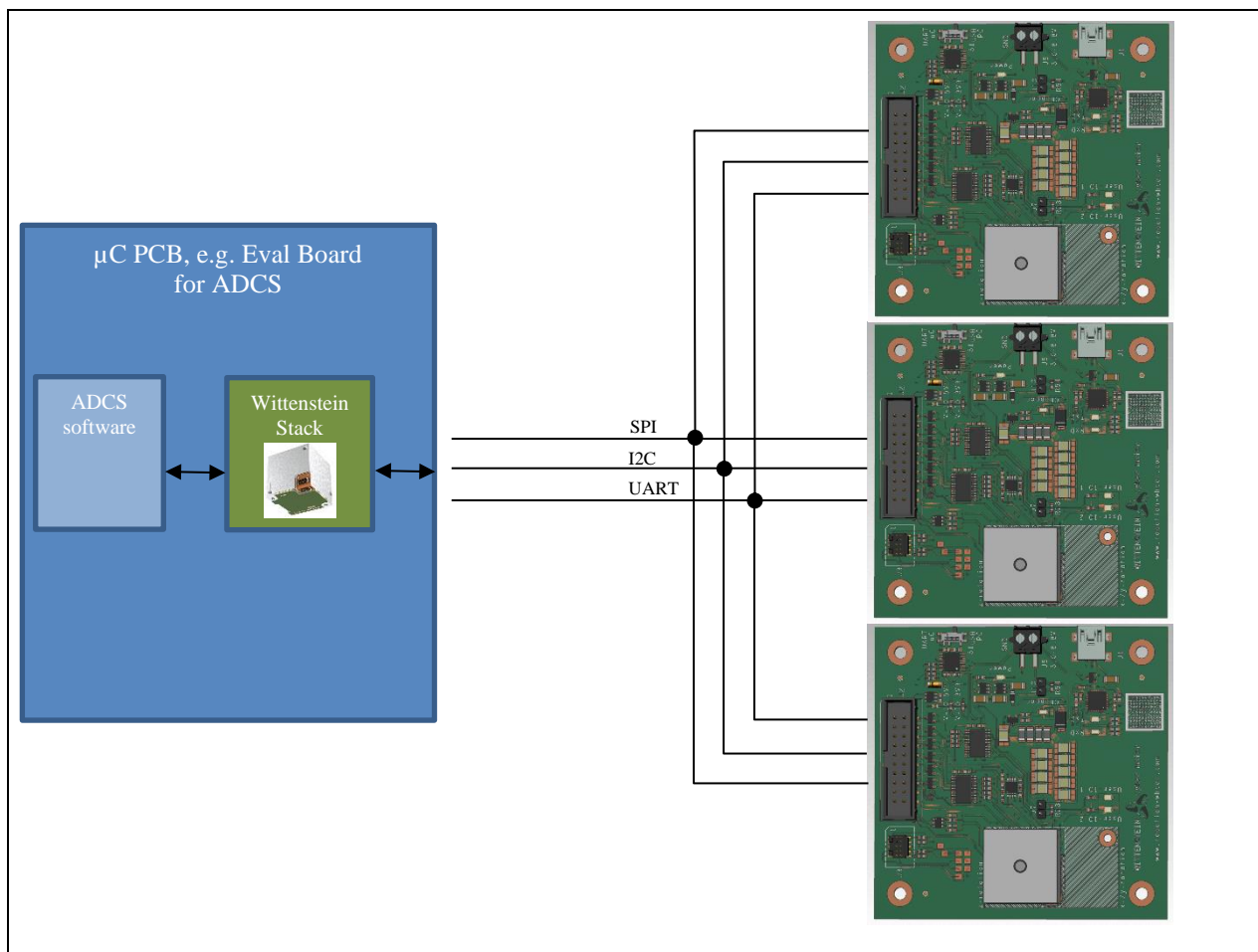


Figure 1.21: Schematic integration of several starter kits with reaction wheels for startup of all interfaces with multiple axes

3.4.3.1 I2C interface

The I2C bus is a master/slave bus system. The controlling microcontroller acts as the master, the different cyber[®] reaction wheels 2 as slaves.

The I2C interface is based on two lines. The clock line (SCL) and the data line (SDA) of the master are connected with all cyber[®] reaction wheel 2 to I2C_SCL or I2C_SDA of customer interface B (see table 11) of the starter kit or the interface for reaction wheel D, see table 13.

I2C clock frequency:

The I2C master can be used in standard mode (= 100 kHz) and in fast mode (= 400 kHz).

I2C addressing:

The cyber[®] reaction wheel 2 uses 7 bits for addressing. The default address is 0x77 (119 dec).

This must be changed by the user during startup with the help of the cyber[®] reaction wheel assistant as described in section 2.3.4.1 so that, for example, after a firmware update (see section 3.6), no address is used twice in the network. The address can also be changed with the Wittenstein software stack with ADCS without any problems. For synchronous setpoint transmission, please observe the information in the introduction of this chapter.

3.4.3.2 SPI interface

The SPI bus is a master/slave bus system. The controlling microcontroller acts as the master, the different cyber[®] reaction wheels 2 as slaves.

The SPI interface is based on four lines. The two data lines (MOSI, MISO) and the clock line (SCK) are star-wired to the various reaction wheels 2 to SPI_MOSI, SPI_MISO and SPI_SCK at customer interface B, table 11, of the starter kit or the interface to reaction wheel D, table 13.

The chip select line (nCS) is used for data transmission by the microcontroller of the selected cyber[®] reaction wheel 2. This is why each cyber[®] reaction wheel 2 has its own chip select line. This line is connected to SPI_nCS of the customer interface B, table 11, the starter kit or the interface to reaction wheel D, table 13.

SPI clock frequency:

The SPI should use a clock frequency of at least 1 MHz. The maximum permitted clock frequency is 10 MHz.

SPI settings, see figure 1.22:

Mode:	Full-Duplex Master
Frame format:	Motorola
Data size:	8 bits
First bit:	MSB (=highest bit) first
Clock Polarity (CPOL):	0
Clock Phase (CPHA):	0

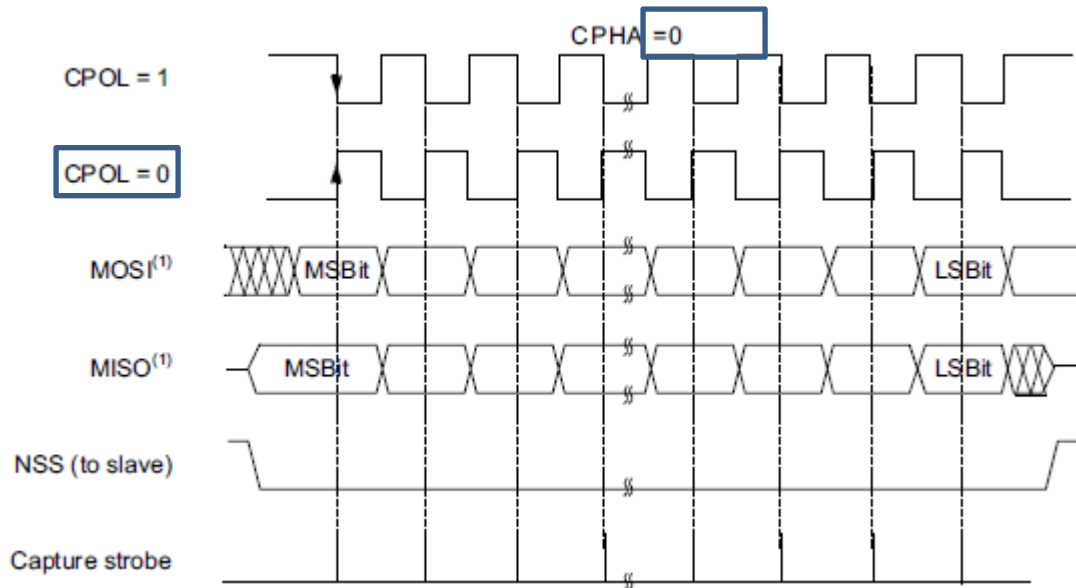


Figure 1.22: Illustration of SPI settings for CPHA and CPOL in the reaction wheel

3.4.3.3 UART interface

The UART bus is not a master/slave bus system but consists of equal stations.

The UART interface consists of two lines. The transmission line (Tx) of the controlling microcontroller is connected to UART_RX and UART_TX at customer interface B, table 11, of the starter kit or the interface to reaction wheel D, table 13.

Remember to set the "UART switching" selection switch, see figure 1.8, to UART uC.

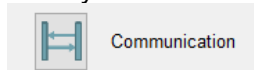
As UART is a point-to-point connection, a separate UART channel must be provided for each cyber[®] reaction wheel 2. Alternatively, a multiplexer switched by the microcontroller can be used.

UART settings:

Baud rate in Bits/s:	adjustable: 9600, 19200, 38400, 57600, 115200 (default)
Data size:	8 bits
Parity:	no
Stop bits:	1

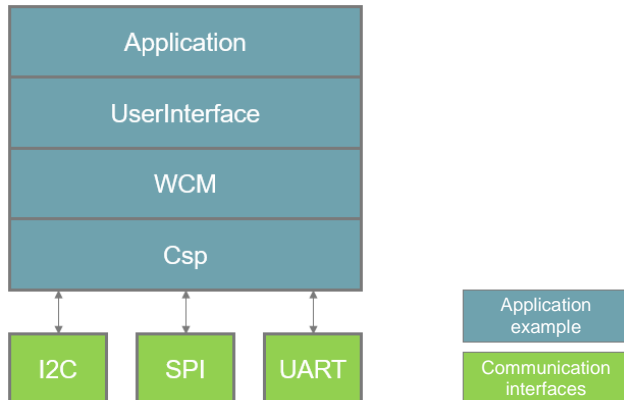
The default baud rate of 115200 bits/s is set on delivery and after a firmware update. Parameter 0x3E07 Communication UART Baud Rate can be used to change the baud rate. For a detailed description of the baud rate setting, refer to parameter 0x3E07 in the CHM help.

The cyber[®] reaction wheel assistant offers a good starting point in the menu item



3.4.4 Wittenstein software stack for integration of the reaction wheel

The example project provided in the download portal of the cyber[®] reaction wheel 2 for the controlling microcontroller consists of the following layers:



The communication interfaces are already described in section 3.4.3.

The example project itself is divided into different layers.

To successfully adapt the sample project to the desired microcontroller and create an application, some layers must be adapted to the target hardware.

All code points where adjustments are required are marked as follows:

```
/* BEGIN OF USER CODE ... */
```

```
/* END OF USER CODE ... */
```

The documentation for the stack can be found in the "Interface Control Document". (<https://cyber-motor.wittenstein.de/de-de/download-reactionwheel>)

3.5 Diagnostics using the cyber[®] reaction wheel assistant

In the case of a prototypical integration of the reaction wheel, see section 3.4, parallel diagnostics with the cyber[®] reaction wheel assistant can be of great use. In this way, the implemented source code lines in the prototypical ADCS setup can be verified using the oscilloscope, the monitor, or simply by querying parameters in the assistant.

This can be realized very easily.

Simply follow the steps described in sections 3.3.2 and 3.3.3. This establishes a parallel connection to the cyber[®] reaction wheel assistant. In this structure the cyber[®] reaction wheel assistant is only intended for diagnosis. Theoretically, setpoints can be written for active control of the reaction wheel. However, this may result in unwanted behavior.

- Parallel operation can cause a CPU load warning. This can be ignored in this case. This can be recognized by the *Warning* flashing in red in the bottom of the cyber[®] reaction wheel assistant.

Project planning guide

3.6 Firmware update

Download the required firmware package from the download portal.

3.6.1 Firmware update with the cyber[®] reaction wheel assistant

The update process is described in the CHM help.

For this purpose,

- open the cyber[®] reaction wheel assistant
- open the CHM-Help by pressing F1
- enter firmware update in the search screen

- Notice:

During the firmware update, the I2C address is reset to the default value 0x77. After the firmware update has been completed, the desired I2C address, see section 2.3.4.1, must be restored.

3.6.2 Firmware update with ADCS

The procedure for this is described in the Interface Control Document in the `UserInterface_FirmwareUpdate()` function.

4 Integration of the cyber[®] reaction wheel 2 into a satellite

4.1 Electrical integration of the cyber[®] reaction wheel 2

There are identical plug connectors on two sides of the reaction wheel. All three axes of rotation of a Cartesian coordinate system can be mapped on the carrier board with only two different mating connector arrangements (turned by 90°).

For positions of the connectors and the mounting threads, see dimensional drawing 5007-D060499. Connector type and pin assignment are described in section 2.1.5.1. The pin characteristic is explained in the following section 2.1.5.2.

The connecting lines to the plug connector (routing, vias, etc.) that accommodates the reaction wheel may only be implemented as closely as possible with the reaction wheel within a radius of approx. 2 mm in compliance with the constraints illustrated in figure 1.23. The red border in figure 1.23 is the connector on the reaction wheel. With its housing, it protrudes beyond the connector on the carrier board. For this reason, observe the information in the connector data sheet. The manufacturer designation is MOLEX SlimStack PCB connector (16+2) 505066-1622. There may not be any line on the outside of the carrier board in the remaining area below the reaction wheel (see figure 1.23, shaded area) as the solder resist does not serve as reliable insulation. A short circuit could occur at the housing or vias on the reaction wheel.

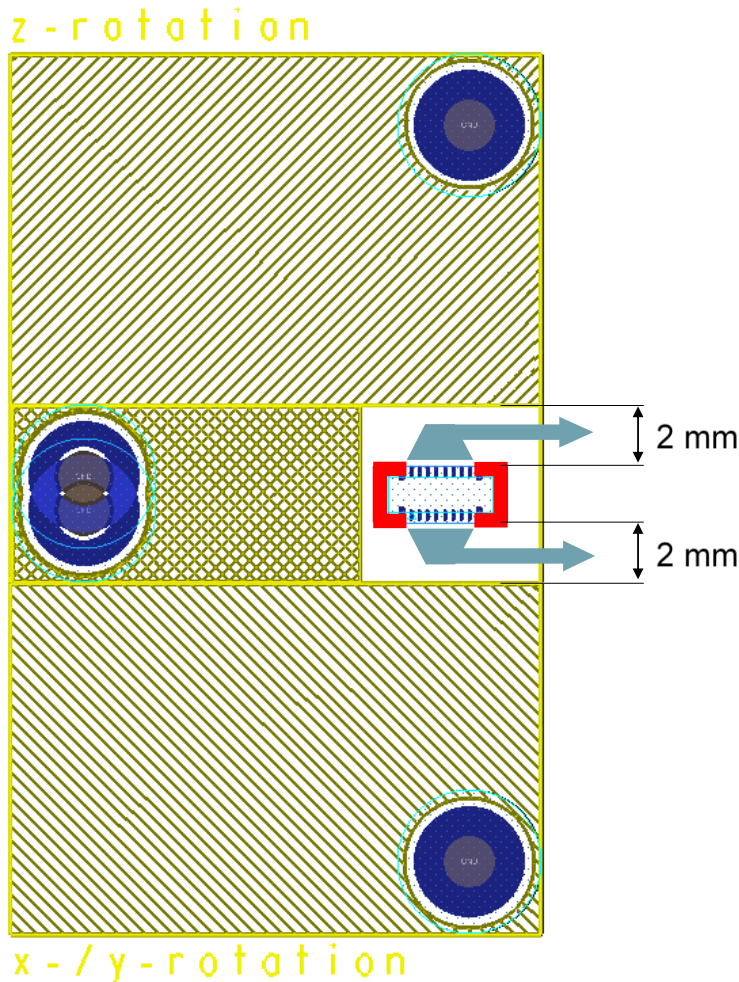


Figure 1.23: Illustration of constraints for integration of the cyber[®] reaction wheel 2 on a carrier board

The mounting bores for the reaction wheel are at GND potential for the cyber[®] reaction wheel starter kit as well as the 4 mounting bores at the corners. For integration into the satellites, the mounting bores for the reaction wheel and the entire housing of the reaction wheel can be on GND and chassis potential. This allows power to be supplied by a grounded or ground-free voltage source. The voltage difference between chassis and GND must not exceed 30 V.

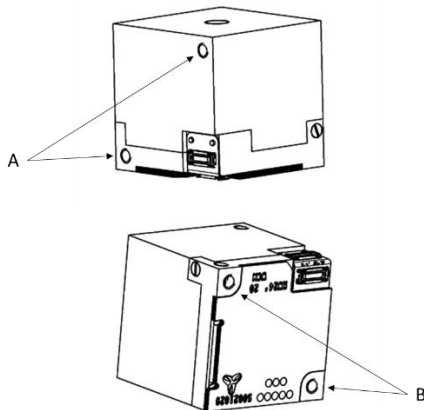
- Notice: Alternatively, the housing of the cyber[®] reaction wheel could be mounted isolated (connected neither to GND nor to chassis). However, we recommend connecting the mounting bores with a high resistance of 100 kΩ to 1 MΩ to GND to compensate for possible charges between GND and the housing to prevent the permitted 30 V from being exceeded.

4.2 Mechanical integration of the cyber[®] reaction wheel 2

The through holes for the M2 fastening screws must have a diameter of 2.6 mm. A position tolerance of 0.2 mm for compensation of any position and length deviations of the connectors must be observed.

4.3 Installation of the cyber[®] reaction wheel 2

- | | |
|--|---|
| | <ul style="list-style-type: none"> • Observe the safety and processing instructions for the threadlocker to be used. |
|--|---|



- Connect the connector of the mounting position used with the PCB connector on your attachment part. While doing so, make sure that the connector is engaged properly and not damaged.
- Coat the fastening screws with a threadlocker.
- Fasten the drive system with the fastening screws through the threaded bores (A or B). When tightening, ensure that the connector is not subject to any lateral loads.

- Use screws with property class A2-70 or titanium grade 5 and tighten them with a maximum torque of 0.11 Nm. Also observe the load capacity of the screw head.
- Use the maximum screw-in depth.
- Attach the drive system so that the name plate can still be read.
- Make sure that the unused second connector is protected against contact with conductive components.



NOTICE

Fastening screws that are screwed in too far can damage the drive system.

- Screw in the screws only up to their maximum depth.
- ① see dimensional drawing (5007-D060499).

4.4 Requirements for power adapters and supply voltage

When dimensioning the power supply units, observe the electrical characteristics specified in table 4. Also take into account operation of several reaction wheels at the same time.

4.5 Installation space

The installation size must be sufficiently large.

A minimum distance of 1 mm on all sides of the drive system must be observed.

4.6 Mounting position

Any mounting position can be selected.

4.7 Cooling

Sufficient thermal conduction for cooling of the drive system must be ensured at the installation location.

4.8 Maintenance

No maintenance is required.

4.9 Software-side integration in ADCS

For integration of the reaction wheel into an ADCS, Wittenstein provides a communication stack including a sample or reference project for download.

The procedure is described in detail in section 3.4. Information on integration of the software stack can be found in section 3.4.4.