

MANUAL
IXARC KIT ENCODERS WITH BISS LINE INTERFACE



- Absolute singleturn and multiturn on one PCB
- Kit solution – no ball bearing, no tether, very compact: 36 mm diameter
- Digital asynchronous serial interface: BiSS Line
- Designed for 2-wire / 4-wire communication
- Electrical resolution: Up to 17 bit singleturn and 32 bit multiturn
- Operating temperature:
-40 to +105 °C / -40 to 221 °F
- Very robust, insensitive to dust or humidity
- Easy installation, no manual alignment due to electronic calibration, relaxed mechanical tolerances
- In comparison to resolvers, full digital interface, no signal processing on motor controller required, no additional expensive voltage generator needed
- Additional functionality like electronic datasheet (EDS), up to 4 Kbyte OEM memory
- Integrated temperature sensor on board
- Kit design includes shielding concept against external fields e.g. from magnetic brake



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IXARC Encoder Kit Type	Firmware version
KCD-B203B-2417-U01C-JAN	≥ 1.9.0
KCD-B403B-2417-U01C-JAN	≥ 1.9.0

User Annotation

Please note, that no responsibility is assumed by POSITAL for any consequences arising out of the use of this material. This document is not intended as an instruction manual for untrained people.

POSITAL welcomes all readers to send us feedback and comments about this document.

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Safety

- The encoder must be installed by qualified personnel only, exhibiting knowledge in electronics and mechanics.
- Consider all safety and accident regulations valid for your country.
- Switch off the supply voltage of all devices connected to the encoder before installation.
- Avoid an electrical supply voltage while connecting the encoder.
- Avoid exerting shocks on motor shaft and mounting flange to prevent the encoder from being mechanically damaged.
- Rotary machine shafts may catch hair and cloths and cause injury.
- Mount the encoder in an ESD-conform fashion, avoid high voltages, e.g. static electricity discharged from a human body.
- Consider the specifications of the encoder. The device must be operated in the specified range.
- Metal filings or metal dust must be kept away from kit encoder parts and also during the assembly process.

EMC

- Kit encoder is a sub-assembly and not considered to be an independent system, therefore compliance with CE requirements has to be ensured by the integrator for the overall set-up.



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1. Introduction

With a combination of accuracy, reliability, robustness and cost efficiency POSITAL's magnetic kit encoders provide a unique variety of functionalities. An electrical resolution of up to 17 bit offers an accurate singleturn measurement. The multiturn range covers more than one million revolutions (32 bit). A large temperature range between -40 °C and +105 °C makes the kit encoders applicable in lots of environmental conditions. The kit encoder components include an electronics package mounted on a compact 35 mm diameter PCB and a small permanent magnet, designed to be mounted on the end of a motor shaft. The electronics package includes four Hall sensors, a powerful 32-bit microprocessor and a rotation counter based on POSITAL's Wiegand energy harvesting system. The BiSS Line interface enables a direct digital sensor data transmission over a 2-wire interface which is therefore suitable for one cable motor applications. Access to device and customer related register data, stored in the encoders internal memory is possible.

The multiturn counting is realized by POSITAL's energy harvesting system, based on the Wiegand effect. At any revolution, a voltage pulse is generated, which triggers the increment of an internal multiturn counter. This Wiegand pulse counting requires no external energy source. Therefore, a backup battery or complex gear systems can be eliminated.

In contrast to optical encoders, the installation of POSITAL's magnetic kit encoders requires no clean room similar conditions and can be performed under normal factory conditions. The integrated electronic autocalibration function corrects position errors due to minor misalignments between motor shaft and electronics package and makes a manual alignment procedure obsolete. In addition, a software integrated Wiegand sensor test determines the performance of the multiturn counter system. The kit encoder's embedded software monitors the system and provides associated error codes, that are transmitted during normal sensor operation. Furthermore, status and error information can be read out from the memory register.

In this manual, an overview of our BiSS Line kit encoder is presented. The electrical connection and characteristics of the device is provided in chapter 2, a brief description of the BiSS Line protocol is given in chapter 3 and an overview to the memory allocation is presented in chapter 4. The integrated hardware and software features of the kit encoder are described in chapter 5.

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2. Electrical Data

2.1 Connector Interface

Connector Type: JST BM04B-GHS-TBT

BiSS Line 2-wire, Kit Encoder Type KCD-B2...

Pin No.	Color	Symbol	Description
1	-	-	Do not connect
2	Blue	Data - GND	Negative data line Ground reference voltage
3	Red	Data + VCC	Positive data line Supply voltage with respect to GND
4	-	-	Do not connect

Table 1: Main Connector Allocation, BiSS Line 2-wire.

BiSS Line 4-wire, Kit Encoder Type KCD-B4...

Pin No.	Color	Symbol	Description
1	Blue	GND	Ground reference voltage
2	Green	Data -	Negative data line
3	Yellow	Data +	Positive data line
4	Red	VCC	Supply voltage with respect to GND

Table 2: Main Connector Allocation, BiSS Line 4-wire.

2.2 Connector External Temperature Sensor

Connector Type: JST BM02B-GHS-TBT

Pin No.	Color	Symbol	Description
1	Pink	R_ext Terminal 1	Sensor signal for temperature resistor
2	Gray	R_ext Terminal 2	Sensor signal for temperature resistor

Table 3: External Temperature Sensor Connector Allocation.

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2.3 Electrical Characteristics

No.	Parameter	Symbol	Type	Min.	Typ.	Max.	Unit	Remark
201	Supply Voltage	VCC	KCD-B203B (2-wire)	7.0		12.5	V	At 25 °C, DC
			KCD-B403B (4-wire)	4.75	5.0	12.5		
202	Power Consumption	PC			0.25	0.3	W	-
203	Reverse Polarity Protection					-12.5	V	-

Table 4: Kit Encoder Electrical Characteristics.

2.3 Communication Parameters

The communication parameters are listed below and can also be found in the memory of the kit encoder. The corresponding entries can be accessed by the registers in the EDS banks.

No.	Parameter	Symbol	Min.	Typ.	Max.	Unit	Remark
301	Serial Communication Format	BiSS Line (point to point)					-
302	Data Transmission	Bidirectional, asynchronous					-
303	Output Driver	RS-485					-
304	SCD	Multiturn (MT) Singleturn (ST) Fill bits (Zero) Error (nE) Warning (nW) CRC			24 bit 17 bit 7 bit 1 bit 1 bit 6 bit		Default
305	CRC	Length Start value Polynomial Transmission			6 bit 0x00 0x43 inverted		Default
306	FEC	Length			64 bit		-
307	Interface Cycle Time	CT	62.5			µs	-

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No.	Parameter	Symbol	Min.	Typ.	Max.	Unit	Remark
308	Bit Rate	BR	12.49875	12.5	12.50125	MHz	Limit depends on line driver and length of line
309	Length of transmission line		0		100	m	-
310	Maximum Response Time				10	μs	Measured at master
311	Minimum Idle Time (slave)		8			μs	-
312	Release time between master sending and slave sending				600	ns	keep as short as possible

Table 5: BISS Communication Parameters.

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3. BiSS Line Interface

The BiSS Line interface provides a communication connection between a master device, representing the motor control unit and its connected slave device, representing the encoder. There are two wiring options available: The connection between the master and the slave can be realized using a 4-wire configuration or a 2-wire configuration. The 4-wire configuration uses two wires for data transmission and two separate power lines, see Figure 1. The 2-wire configuration uses only two wires for data transmission and power supply, see Figure 2.

For both configurations, the data transmission is based on the industrial standard RS-485 using half-duplex asynchronous transmission. All communication is encoded in 8b10b to achieve DC-balance and allow reasonable clock recovery.

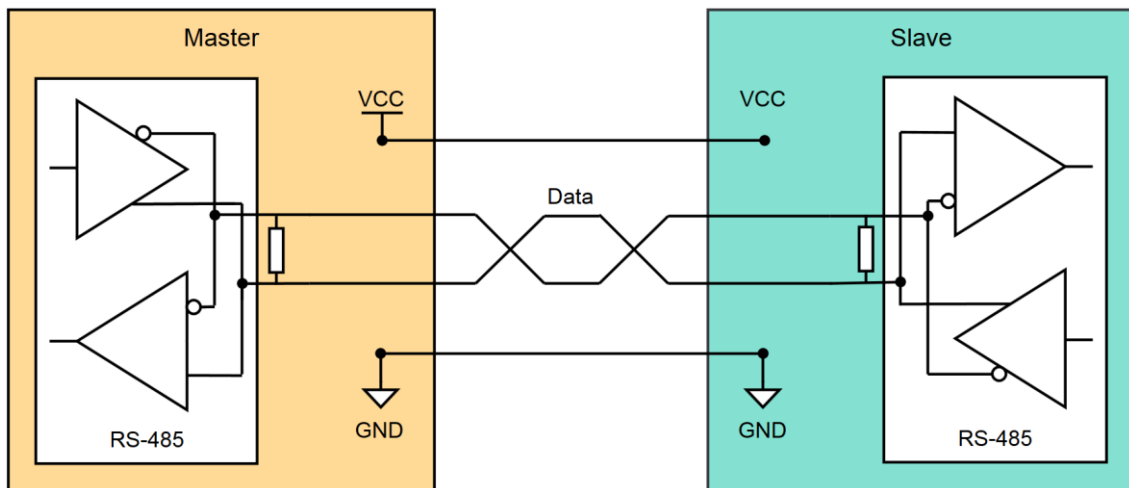


Figure 1: Simplified BiSS Line Interface (4-wire configuration).

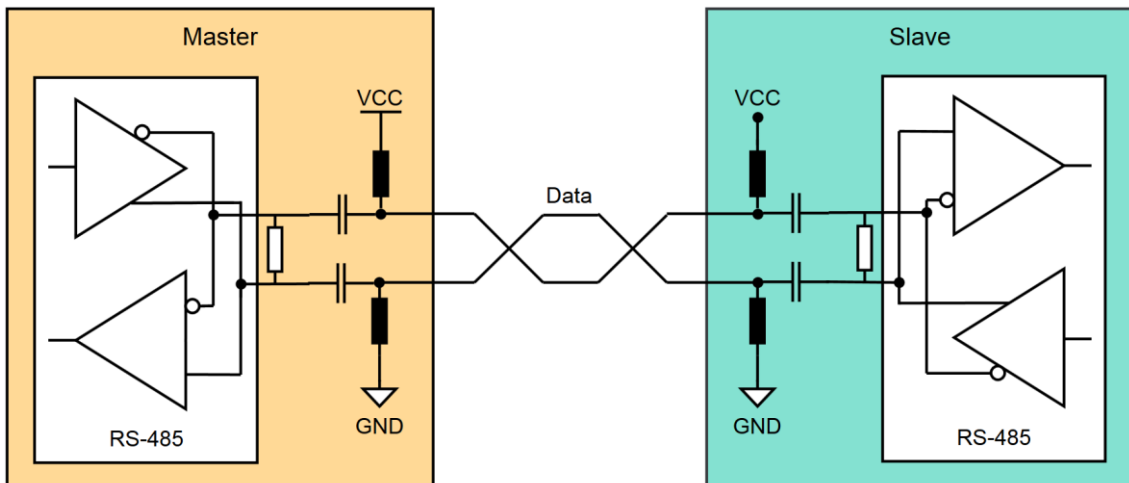


Figure 2: Simplified BiSS Line Interface (2-wire configuration).

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3.1 BiSS Line Frame

The BiSS Line communication is realized with frames, in which the data exchange between the master and the slave is performed. A simplified overview of the BiSS Line Frame is given in Figure 3: BiSS Line Frame overview. Line driver: master (orange), slave (green). **Error! Reference source not found..** The color of the bit stream indicates whether the master (orange) or the slave (green) is driving the line.

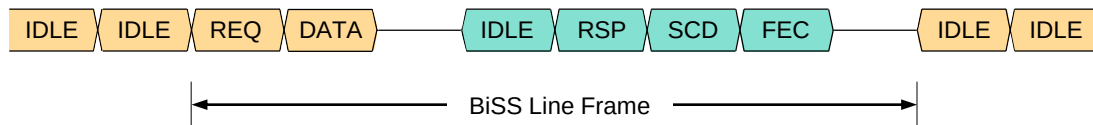


Figure 3: BiSS Line Frame overview. Line driver: master (orange), slave (green).

In between frames the master is sending “IDLE” symbols on the line to maintain DC balance and ensure a signal for clock recovery on the slave side. The “IDLE” symbol consists of alternating bits, see Table 6.

The BiSS Line Frame is initiated by the master by sending the symbol “REQ” followed by “DATA”. Afterwards the master waits for the slave to drive the line. The slave starts sending “IDLE” symbols on the data line, until the current position calculation is ready to output a value. The idle is then interrupted by responding with the “RSP” symbol (either RSP0 or RSP1), which includes the Control Data Slave (CDS) bit, followed by the Single Cycle Data (SCD) see Table 7 and the Forward Error Correction (FEC) bytes, see Table 6. The MSB is transmitted first. At the end of the transmission, the slave releases the line and the master sends “IDLE” symbols again until the next BiSS Line Frame begins.

For more information on the CRC calculation, see [2].

Symbol	Description	8b10b	Binary
IDLE	Symbol during idle state	21.5	1010101010
Start Symbols	Description	8b10b	Binary
REQ	Position request for slave	26.7	0101101110
RSP0	Response of slave with CDS = 0	29.4	0100011101
RSP1	Response of slave with CDS = 1	26.7	0101101110

Table 6: Symbols used in the BiSS Line Frame.

Multiturn value (MT)	Singleturn value (ST)	Fill bits (Zero)	Error (nE)	Warning (nW)	CRC
24 bit	17 bit	7 bit	1 bit	1 bit	6 bit

Table 7: Single Cycle Data (SCD).



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3.2 Register Communication

By using register communication, the slave registers can be accessed. This allows the execution of encoder functions like the sensor calibration, the Wiegand sensor test and the query of status and device information. Therefore, the slave registers are accessed with their corresponding addresses. To establish a register communication with the kit encoder a communication master device supporting BiSS Line is needed.

Register communication is performed via the Control Data Frame. The Control Data Frame composes from consecutive BiSS Line Frames, which inhere the Control Data (Control Data Master "CDM" and Control Data Slave "CDS") with one bit each in every BiSS Line Frame. The CDM bit is included in "DATA " sent by the master in the highest bit. The CDS bit is included in the slave response symbol "RSP", see Table 6.

More information about the Control Data Frame can be found in the BiSS C protocol description, see [1].

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4. Registers

Due to the limited number of 7 bits for addressing, the accessible memory is partitioned into two 64 byte sections. The first section is defined from address 0x00 to 0x3F and is called bank section. The content of these registers depends on the selected bank. The active bank is selected by the bank selection register (address 0x40). The second section is fixed and always directly accessible from address 0x40 to 0x7F, called direct register.

The kit encoder has 68 banks, which are used e.g. for encoder functions, to save electronic datasheets (Encoder Data, Motor Data) and OEM Data. Banks 0x00 and 0x01 are used to execute special encoder functions such as the Wiegand sensor test. Banks 0x02 and 0x03 contain the electronic datasheets (EDS). Banks 0x04 to 0x43 are empty upon delivery and can be used to save data for your own needs. A detailed overview of the registers and the register entries is provided in the appendix, see 8.1 Register Overview.

4.1 Register Accessing

Registers can be addressed by using the BiSS register communication. The direct registers (second section) can be addressed directly. To access a specific bank register, write the bank number into the bank select register (address 0x40).

Register Address	Size	Bank 0x00...0x01	Bank 0x02...0x03	Bank 0x04...0x23	Bank 0x24...0x43
0x00 ... 0x3F	64 byte	Special Encoder Functions	EDS Encoder Data	EDS Motor Data	OEM Data
0x40 ... 0x7F	64 byte	Direct Registers			

Figure 4: Register Map.

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5. Hardware and Software Features

5.1 Function Overview

The kit encoder provides a set of additional features aside the actual angle measurement:

- Temperature Readout
- Singleturn Calibration
- Wiegand Sensor Test
- OEM Data Storage
- Electronic Datasheets
- Filter Selection
- Preset Function
- FEC Setting
- Diagnostics

The activation of a feature requires the activation of the corresponding device mode, except for the temperature readout. The change of the device mode is password secured. To enable the device mode configuration, the password "0x2A" must be written to register 0x6B. Next, the desired register value is written to the device mode register 0x6A.

Command Register	Register Address (direct)
Password register (password: 0x2A)	0x6B
Device mode register	0x6A

The following device modes are available:

Device Mode Register	Register Value
Operation mode	0x00
Calibration mode	0x01
Wiegand Sensor Test mode	0x02
OEM/EDS Motor Data Write	0x04
Filter Selection mode	0x05
Preset mode	0x07
FEC setting mode	0x08

Note

- All listed device features perform write cycles in the flash memory. Due to flash endurance, 1000 write cycles should not be exceeded.

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- The device must be set back to operation mode, after carrying out a feature!
The password register is not reset by changing the mode back to operation mode.

5.2 Temperature Readout

5.2.1 Internal Temperature Sensor

The kit encoder has an internal temperature sensor, used to monitor the encoder temperature. The measured temperature value T_{reg} is stored in the direct register 0x66. The register value T_{reg} can be converted to °C with equation:

$$T[^{\circ}C] = T_{reg} - 50$$

and to °F with equation:

$$T[^{\circ}F] = 1.8 * T_{reg} + 32$$

The specifications of the integrated temperature sensor can be found in Table 8. A change of the device mode is not necessary for this encoder feature.

Attention: The sensor measures the encoder temperature and is not intended to substitute a motor temperature sensor!

No.	Register Address	Value	OP	Remark
1	0x66 (direct register)	T_{reg}	R	Read out temperature register.

Parameter	Symbol	Remark
Interface	TSI	BiSS register entry, size: 8 bit
Temperature Accuracy	TSA	5 °C
Temperature Range	TSR	-40 to 130 °C

Table 8: Temperature Sensor Properties.

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5.2.1 External Temperature Sensor

A resistance thermometer can be connected to the kit encoder, e.g. to monitor motor temperature.

No.	Register Address	OP	Remark
1	0x64 (direct register) 0x65 (direct register)	R	Resistance in Ohm. No connect register values is 0xFF.

Parameter	Symbol	Remark
Compatible Sensors		PT1000, KTY84-151
Interface		BiSS register entry, size: 16 bit (big-endian format).
Resistance Accuracy		15 Ohm
Resistance Range		350 - 1800 Ohm

Table 9: External Temperature Sensor Measurement Properties.

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5.3 Wiegand Sensor Test

The BiSS Line kit encoder uses a magnetic Wiegand counter to provide absolute multiturn values. The software integrated Wiegand sensor test measures the Wiegand sensor properties, by analyzing Wiegand pulses for 515 motor shaft revolutions. The test must be carried out for both clockwise (CW) and counter clockwise (CCW) rotations and can be performed by the following sequence. Carry out the sequence for CW first and afterwards for CCW direction.

▶ VIDEO INSTRUCTION

No.	Register Address	Value	OP	Remark
1	-	-	-	Run the motor at constant rotation speed in CW direction. A rotation speed of 500-2000 rpm is recommended.
2	0x6B (direct register)	0x2A	W	Enable device mode configuration: Write password 0x2A to register.
3	0x6A (direct register)	0x02	W	Change device mode to Wiegand sensor test mode.
4	0x40 (direct register)	0x00	W	Select bank 0: Write value 0x00 to the bank selection register.
5	0x06 (bank 0)	0x01	W	Start Wiegand sensor test, CW direction. The duration of the test routine depends on the rotation speed of the motor. The test must run for at least 515 motor revolutions.
6	0x07 (bank 0)		R	Check the result of the test by reading the Wiegand sensor test status register. If the pulse collection in CW direction is active, the register value is 0x01. If the pulse collection in CW direction is finished, the routine waits for the change of motor direction to CCW (value 0x03).
7	-	-	-	Run the motor in CCW direction.
8	0x06 (bank 0)	0x02	W	Start Wiegand sensor test, CCW direction.
9	0x07 (bank 0)		R	Check the result of the test by reading the Wiegand sensor test status register. If the pulse collection in CCW direction is active, the register value is 0x04. If the pulse collection in CCW direction is finished, the test is completed (value 0x06).
10	0x06 (bank 0)	0x05	W	Save the acquired result data permanently. The saved data is not visible until an encoder reboot.
11	0x06 (bank 0)	0x03	W	Finish test.
12	0x6A (direct register)	0x00	W	Change device mode back to operation mode.

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The saved result data can be checked at any time, if step 10 was executed. The average pulse height of the analyzed pulses and its standard deviation is saved for CW and CCW direction. A Wiegand pulse height average minus 4x standard deviation greater than 5.3 V is recommended for operation.

Wiegand Sensor Test Register	Register Address (bank 0)
Command register	0x06
Status register	0x07

Wiegand Sensor Test Status Register	Register Value
Test stopped	0x00
Pulse Collection active (CW)	0x01
Wait for change of motor rotation direction	0x03
Wrong motor rotation direction	0x30
Pulse Collection active (CCW)	0x04
Test complete	0x06
Test failed	0x07

Result Data (last test)	Register Address (bank 0)
Average Pulses (CW)	0x09
Average minus 4x Standard Deviation (CW)	0x0A
Average Pulses (CCW)	0x0B
Average minus 4x Standard Deviation (CCW)	0x0C

Result Data (saved)	Register Address (bank 0)
Average Pulses (CW)	0x11
Average minus 4x Standard Deviation (CW)	0x12
Average Pulses (CCW)	0x13
Average minus 4x Standard Deviation (CCW)	0x14

Note

- The result data values must be divided by 10 to get the value in volts.
- The Wiegand sensor test can be stopped at any time by writing value 0x03 to the pulse testing command register (0x06, bank 0).
- The measured pulses are not depended on rotation speed, but low rotation speeds can lead to long test times.

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Attention

- The encoder cannot be used as a feedback system during the test!
- It is mandatory to run the Wiegand sensor test once after installation is finished.
- The encoder is not able to identify the rotation direction of the motor during the test, so make sure rotation and test direction match.

5.4 Calibration

The electronic calibration of the kit encoder is required to improve the measurement accuracy of the kit encoder after installation.

The device is delivered in a pre-calibrated state. In factory state the accuracy of the encoder after installation is limited to an angle error below $\pm 0.3^\circ$ typically. This is caused by mechanical tolerances during the mounting of the kit encoder onto the motor shaft (static or build-up tolerances). By using the offered electronic calibration procedure, the impact of the static mounting tolerances on the kit encoder accuracy can be cancelled out and the system angle error will be improved towards the specified accuracy. Existing calibration is not lost when starting new calibration.

Please note, that after the electronic calibration further movements of the mounted magnet on the shaft towards the kit encoder (due to dynamic tolerances e.g. thermal expansion of the shaft or play of the ball bearing) should be minimized as these tolerances have a negative impact on the total system accuracy. To achieve the specified accuracy, it is recommended to keep the dynamic tolerance below ± 0.1 mm. The sum of static and dynamic tolerances must always be below ± 0.3 mm.

External Conditions for Calibration

To successfully calibrate the kit encoder several external conditions must be fulfilled. The sensor must be completely mounted (including housing for magnetic shielding) and fixed in the final position before the calibration is started. All external conditions should match the normal operation conditions as far as possible. The operating temperature of the kit encoder must be in the range of 25°C to 40°C (77°F to 104°F).

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Calibration Register	Register Address (bank 0)
Command register	0x00
Status register	0x01

Calibration Status Register	Register Value
Calibration running	0x01
Calibration finished (CCW)	0x02
Calibration finished (CW)	0x22
Wrong rotation direction	0x30
Temperature out of range	0x31
Motor speed out of range	0x32
Calibration failure	0x33

Calibration Procedure

Description of recommended motor speed settings:

- Applicable speed range 300 rpm to 700 rpm
- Assure synchronized speed with max. fluctuation of ± 2 rpm
- Recommended motor speed = 500rpm, synchronized speed ± 2 rpm

Note:

- resulting angular accuracy is directly dependent on the rotational speed uniformity
- filter setting V3B (default) has to be active, when calibration is performed

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The calibration procedure is performed by carrying out the following sequence:

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No.	Register Address	Value	OP	Remark
1	-	-	-	Run the motor in CCW direction at constant rotation speed of 500 rpm $< \pm 2$ rpm.
2	0x6B (direct register)	0x2A	W	Unlock device mode configuration: Write password 0x2A to register.
3	0x6A (direct register)	0x01	W	Change the device mode to calibration mode.
4	0x40 (direct register)	0x00	W	Select bank 0: Write value 0x00 to the bank selection register.
5	0x00 (bank 0)	0x01	W	Start the calibration routine, CCW direction: Write value 0x01 to the calibration command register. The execution of the calibration routine takes about 5 seconds and stops automatically.
6	0x01 (bank 0)		R	Read the calibration status until the register value is 0x02, then the calibration in CCW direction is finished. Note that while the encoder is performing the calibration, it may not respond.
7	-	-	-	Run the motor in CW direction.
8	0x00 (bank 0)	0x02	W	Start the calibration routine, CW direction: Write value 0x02 to the calibration command register.
9	0x01 (bank 0)		R	Read the calibration status register until the register value is 0x22, then the calibration in CW direction is finished. The calibration data is saved automatically.
10	0x6A (direct register)	0x00	W	Change the device mode back to operation mode. Restart the encoder for consistent position value!

Note, that If calibration fails in CW direction the calibration table is lost, which leads to an increase of the angle error.

Attention:

The encoder cannot be used as a feedback system during calibration!
Restart the encoder after calibration for a consistent position value!

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5.5 Data Storage

The kit encoder offers the capability to access two different internal memory regions to store data: The EDS-Motor-Data and the OEM-Data. The corresponding memory addresses are given in Table 10. The accessibility of the specific memory depends on the access rights.

Memory	Start-Addr.	End-Addr.	Access	Remark
EDS Encoder Data	Bank 0x02	Bank 0x03	R	We support the BiSS Profile 3 as Standard Encoder Profile.
EDS-Motor-Data	Bank 0x04	Bank 0x23	R/W	2 Kbyte Motor Data: customer specific motor data
OEM-Data	Bank 0x24	Bank 0x43	R/W	2 Kbyte OEM Memory: open access for customer use

Table 10: Data Storage Overview.

Writing the EDS-Motor-Data or OEM-Data is permitted by default. The write access is protected by a password. To write an EDS-Motor or OEM-Data register, carry out the following sequence:

No.	Register Address	Value	OP	Remark
1	0x6B (direct register)	0x2A	W	Unlock device mode configuration: Write password 0x2A to register.
2	0x6A (direct register)	0x04	W	Change the device mode to OEM / EDS Motor Data Write.
3	0x40 (direct register)	0x00	W	Select bank 0: Write value 0x00 to the bank selection register.
4	0x1B (bank 0)		R	Get write access: Read OEM / EDS-Motor Data Write status register until a value of 0x00 indicates permission to get write access to the EDS-Motor Data.
5	0x1A (bank 0)	0x01 or 0x02	W	Write the value to the OEM / EDS-Motor Data Write command register. 0x01: access EDS-Motor Data 0x02: access OEM-Data
6			W	Write data to the desired register, by using the BiSS register communication.
7	0x1B (bank 0)		R	Get save access: Read the OEM / EDS-Motor Data Write status register until a value of 0x01 indicates permission to get save access to the EDS-Motor Data.
8	0x1A (bank 0)	0x03	W	Write data to flash memory: Write the value 0x03 to the OEM / EDS-Motor Data Write command register.

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No.	Register Address	Value	OP	Remark
9	0x1A (bank 0)	0x04	W	(Optional) Cancel write access: Write the value 0x04 to the OEM / EDS-Motor Data Write command register.
10	0x6A (direct register)	0x00	W	Change the device mode back to operation mode.

OEM / EDS-Motor Data Register	Register Address (bank 0)
Command register	0x1A
Status register	0x1B

OEM / EDS-Motor Data - Command Register	Register Value
Get write access EDS-Motor Data	0x01
Get write access OEM-Data	0x02
Save data	0x03
Cancel write access	0x04

OEM / EDS-Motor Data - Status Register	Register Value
Wait for write access	0x00
Wait for save command	0x01

Attention: Reading and writing data during motor operation is not allowed.

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5.6 Filter Selection

The kit encoder offers two different filter options:

- **Balanced (default)**
This filter provides a very well-balanced relation of signal noise and dynamic behavior.
- **Dynamic**
This filter provides position values with short latency, but increased signal noise. Therefore, this filter is suitable for very fast and dynamic motor control loops.

To check which filter is currently active, read direct register 0x6E (balanced: 0x03, dynamic: 0x04). To activate a filter setting, carry out the following sequence:

No.	Register Address	Value	OP	Remark
1	0x6B (direct register)	0x2A	W	Enable device mode configuration: Write password 0x2A to register.
2	0x6A (direct register)	0x05	W	Change device mode to filter selection mode.
3	0x40 (direct register)	0x00	W	Select bank 0: Write value 0x00 to the bank selection register.
4	0x25 (bank 0)		R	Get write access: Read filter status register. A value of 0x00 indicates permission to get write access.
5	0x24 (bank 0)	0x01	W	Write value 0x01 to the filter command register.
6	0x25 (bank 0)		R	Read filter status register. A value of 0x02 indicates waiting for value.
7	0x24 (bank 0)		W	Set filter: <ul style="list-style-type: none"> ▪ Balanced filter, value 0x03 ▪ Dynamic filter, value 0x04
8	0x25 (bank 0)		R	Save filter selection: Read filter status register. A value of 0x01 indicates permission to save filter settings.
9	0x24 (bank 0)	0x02	W	Write value to filter command register. Encoder reboots with new filter setting.
10	0x6A (direct register)	0x00	W	Change the device mode back to operation mode.

Filter Selection Register	Register Address (bank 0)
Command register	0x24
Status register	0x25



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Commands	Register Value
Get write access	0x01
Save filter selection	0x02
Balanced filter	0x03
Dynamic filter	0x04

Attention: The encoder cannot be used as a feedback system during the filter change!

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5.7 Preset Function

The preset function can be used to adapt the encoder position to the mechanical alignment of the system. By performing a preset, the actual position value of the encoder is set to the desired preset value. The preset value is specified in registers 0x02 to 0x07 (bank 1). In registers 0x02 to 0x04 (bank 1) the singleturn preset value is saved in little endian format. In registers 0x05 to 0x07 (bank 1) the multiturn preset value is saved in little endian format. The preset can only be triggered by software.

Preset Value	Singleturn preset value			Multiturn preset value		
Register Address (bank 1)	0x02	0x03	0x04	0x05	0x06	0x07
Endianness	LSB		MSB	LSB		MSB

Table 11: Preset value register.

Software Preset

To change the preset value and perform a preset via software, follow the steps below:

No.	Register Address	Value	OP	Remark
1	0x6B (direct register)	0x2A	W	Enable device mode configuration: Write password 0x2A to register.
2	0x6A (direct register)	0x07	W	Change device mode to preset mode.
3	0x40 (direct register)	0x01	W	Select bank 1: Write value 0x01 to the bank selection register.
				To set the target preset value or configure the hardware preset, continue with step 4. To directly perform a preset, continue with step 11.
4	0x00 (bank 1)	0x02	W	Enable preset value edit.
5	0x01 (bank 1)		R	Read status register, a value of 0x01 indicates waiting for value to enter.
6	0x02 – 0x04 (bank 1)		W	Enter singleturn preset value.
7	0x05 – 0x07 (bank 1)		W	Enter multiturn preset value.
8	0x00 (bank 1)	0x03	W	Save preset value. Encoder restarts.
9				Repeat steps 1, 2, 3 to enter preset mode again.
10	0x00 (bank 1)	0x01 0x04 0x05	W	Perform preset: <ul style="list-style-type: none"> ▪ ST + MT, 0x01 ▪ ST, 0x04 ▪ MT, 0x05 Encoder restarts with preset value.

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Example

Assuming it is desired to preset the singleturn position of a kit encoder with 17 bit singleturn resolution.

Desired singleturn position: 270°
 Corresponding decimal value in digits: 98304
 Expressed as a hex value: 0x18000

For this configuration, the register entries must be set as follows:

Register Address (bank 1)	0x02	0x03	0x04
Register Value	0x00	0x80	0x01

Table 12: Example preset register.

Preset Registers	Register Address (bank 1)
Command register	0x00
Status register	0x01
Singleturn preset value register	0x02 – 0x04
Multiturn preset value register	0x05 – 0x07

Commands	Register Value
Perform preset (ST + MT)	0x01
Perform preset (ST)	0x04
Perform preset (MT)	0x05
Enable preset value edit	0x02
Save preset value	0x03

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5.8 Diagnostics

The BiSS Interface provides 2 status bits which are part of the SCD:

- nE (error bit)
- nW (warning bit)

The bit value has an inverted logic, i.e. a value of “nE = 0” means an active error state.

The cause of the error/warning can be determined by reading out the error/warning register. The register addresses are defined in the register tables (appendix).

Error Register Bit	Name	Description
0	FRAM Error	Error detected in FRAM
1	Multiturn Error	Synchronization error
2	Singleturn Error	Position sensor error (e.g. voltage dump)
3	Temperature Sensor Error	Temperature sensor error
4	Magnetic Field too low	e.g. detect missing magnet
5-7	Not used	

Warning Register Bit	Name	Description
0	Temperature Warning	Temperature too high. Set at $T \geq 125^{\circ}\text{C}$, clear warning at $T < 123^{\circ}\text{C}$
1-7	Not used	

Registers	Register Address (direct)
Error Register	0x68
Warning register	0x69

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5.9 FEC Setting

The forward error correction (FEC) is a mechanism to protect the data transmission. It is calculated on the RSP symbol and Single Cycle Data and can repair up to 4 corrupted bytes of data.

FEC is enabled by default and recommended to keep enabled. To check if the FEC is active, read direct register 0x6F (FEC enabled: 0x01, FEC disabled: 0x00). To change the FEC setting, carry out the following sequence:

No.	Register Address	Value	OP	Remark
1	0x6B (direct register)	0x2A	W	Enable device mode configuration: Write password 0x2A to register.
2	0x6A (direct register)	0x08	W	Change device mode to FEC setting mode.
3	0x40 (direct register)	0x00	W	Select bank 0: Write value 0x00 to the bank selection register.
4	0x2B (bank 0)		R	Get write access: Read status register. A value of 0x00 indicates permission to get write access.
5	0x2A (bank 0)	0x01	W	Write value 0x01 to the command register.
6	0x2B (bank 0)		R	Read filter status register. A value of 0x02 indicates waiting for value.
7	0x2A (bank 0)	0x02 or 0x03	W	Change FEC setting: <ul style="list-style-type: none"> ▪ Enable, value 0x02 ▪ Disable, value 0x03 The encoder restarts after input.

FEC Setting Register	Register Address (bank 0)
Command register	0x2A
Status register	0x2B

Commands	Register Value
Get write access	0x01
Enable FEC	0x02
Disable FEC	0x03
Cancel	0x04

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6. BiSS Line Master Products

Regarding the BiSS Line interface, the following two products from manufacturer iC-Haus can be used to realize a BiSS Line communication with the corresponding IP core:

- iC-BL EVAL BL1M + BL2M, Evaluation board based on FPGA solution
- MB3U, MB3U-I2C adapter

There is a “Getting Started” document for the BL1M + BL2M + MB3U Evaluation board setup available on request.

You can also request just the IP core for BiSS Line for direct implementation on your FPGA without using above hardware.

For more details about the master implementation please contact the manufacturer iC-Haus.

iC-Haus GmbH - Am Kuemmerling 18 - 55294 Bodenheim - Germany,

Phone: +49 6135 9292-0, email: info@ichaus.de

7. References

- [1] iC-Haus GmbH: BiSS Interface - PROTOCOL DESCRIPTION (C-Mode). Rev C5, 2008.
- [2] iC-Haus GmbH: BiSS Interface AN3: CYCLIC REDUNDANCY CODES. Rev E1, 2012.
- [3] iC-Haus GmbH: BiSS Interface: BiSS Line Concept. Rev A1, 2016.

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8. Appendix

8.1 Register Overview

8.1.1 Direct Registers

Register Address	Description / Symbol	Access
0x40	BANK Select	R/W
0x41	EDS Start Bank	R
0x42	Profile ID	R
0x43		R
0x44	Serial Number, U32	R
0x45		R
0x46		R
0x47		R
0x64	Temperature Extern, U16	R
0x65		R
0x66	Temperature Intern	R
0x68	Error Register	R
0x69	Warning Register	R
0x6A	Device Mode	R/W
0x6B	Protection	R/W
0x6E	Selected Filter	R
0x6F	FEC Enabled Register (Status)	R
0x74	Major Firmware Release	R
0x75	Minor Firmware Release	R
0x76	Firmware Patch Level	R
0x78	Device ID	R
0x79		R
0x7A		R

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Register Address	Description / Symbol	Access
0x7B		R
0x7C		R
0x7D		R
0x7E	Manufacturer Coder	R
0x7F		R

Table 13: Direct Registers.

8.1.2 Bank 0 / Special Encoder Functions

Register Address	Description / Symbol	Access
0x00	Calibration Command	R/W
0x01	Calibration Status	R
0x06	Wiegand Sensor Test, Command Register	R/W
0x07	Wiegand Sensor Test, Status Register	R
0x08	Wiegand Sensor Test, Error Code	R
0x09	Wiegand Sensor Test, average pulses CW (last test result)	R
0x0A	Wiegand Sensor Test, average minus 4x standard deviation CW (last test result)	R
0x0B	Wiegand Sensor Test, average pulses CCW (last test result)	R
0x0C	Wiegand Sensor Test, average minus 4x standard deviation CCW (last test result)	R
0x0D	Wiegand Sensor Test, average pulses CW (FRABA Production)	R
0x0E	Wiegand Sensor Test, average minus 4x standard deviation CW (FRABA Production)	R
0x0F	Wiegand Sensor Test, average pulses CCW (FRABA Production)	R
0x10	Wiegand Sensor Test, average minus 4x standard deviation CCW (FRABA Production)	R
0x11	Wiegand Sensor Test, average pulses CW (saved test result)	R
0x12	Wiegand Sensor Test, Average minus 4x Standard Deviation CW (saved test result)	R

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Register Address	Description / Symbol	Access
0x13	Wiegand Sensor Test, average pulses CCW (saved test result)	R
0x14	Wiegand Sensor Test, average minus 4x standard deviation CCW (saved test result)	R
0x1A	OEM / EDS-Motor Data Write, Command Register	R/W
0x1B	OEM / EDS-Motor Data Write, Status Register	R
0x24	Filter Selection, Command Register	R/W
0x25	Filter Selection, Status Register	R
0x2A	FEC Setting, Command Register	R/W
0x2B	FEC Setting, Status Register	R

Table 14: Bank 0 / Special Encoder Functions.

8.1.3 Bank 1 / Special Encoder Functions

Register Address	Description / Symbol	Access
0x00	Preset, Command Register	R/W
0x01	Preset, Status Register	R
0x02	Preset singleturn value, byte 0	R/W
0x03	Preset singleturn value, byte 1	R/W
0x04	Preset singleturn value, byte 2	R/W
0x05	Preset multiturn value, byte 0	R/W
0x06	Preset multiturn value, byte 1	R/W
0x07	Preset multiturn value, byte 2	R/W

Table 15: Bank 1 / Special Encoder Functions.

9.1.4 Bank 2 / EDS Encoder Data

We support the BiSS Profile 3 as Standard Encoder Profile.

Register Address	Description / Symbol	Access
0x00	EDS Version (continuous number)	R
0x01	EDS Length (bank count completely)	R

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Register Address	Description / Symbol	Access
0x02	Bank Address USER Start (bank selection in address 64, 255 = not available)	R
0x03	Bank Address USER End (bank selection address 64)	R
0x05	Minimum BiSS Timeout (0 = adaptive)	R
0x06	Maximum BiSS Timeout (0 = adaptive)	R
0x0B	Minimum Cycle Time (0 = no limitation)	R
0x0C	Maximum Processing Time SCD	R
0x0E	Maximum "power on delay" until control communication is available	R
0x0F		R
0x10	Number of data channel in this device (number of words)	R
0x11	Area of validity for this EDS (number of slave addresses)	R
0x14	Bank Address for content description data channel 1 (profile EDS)	R
0x15	Data Length, Data Channel 1	R
0x16	Data Format, Data Channel 1	R
0x17	CRC Polynomial (8:1) for Data Channel 1	R
0x3F	Checksum (addition of all bytes in this bank)	R

Table 16: Bank 2 / Electronic Data Sheet, Encoder Data.

9.1.5 Bank 3 / EDS Encoder Data

We support the BiSS Profile 3 as Standard Encoder Profile.

Register Address	Description / Symbol	Access
0x00	BiSS Profile 3 Version	R
0x01	Length of this profile	R
0x02	Profile Identification BP3 (content also available in addresses 0x42 and 0x43)	R
0x03		R
0x04	Feedback bit 1	R
0x05	Feedback bit 2	R
0x06	Maximum "power on delay" until position data is available	R
0x08	Encoder Type	R
0x0A	Data Length MULTITURN	R

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Register Address	Description / Symbol	Access
0x0C	Data Length COARSE	R
0x1C	CRC Polynomial (32:1)	R
0x1D		R
0x1E		R
0x1F		R
0x20	CRC Start Value	R
0x21		R
0x22		R
0x23		R
0x2C	Maximum revolution speed/maximum speed [1/min]	R
0x2D		R
0x30	Minimum operating temperature [K]	R
0x31		R
0x32	Maximum operating temperature [K]	R
0x33		R
0x34	Minimum operating voltage [mV]	R
0x35		R
0x36	Maximum operating voltage [mV]	R
0x37		R
0x38	Maximum current consumption [mA]	R
0x39		R
0x3F	Checksum (addition of all bytes in this bank)	R

Table 17: Bank 3 / Electronic Data Sheet, Encoder Data.