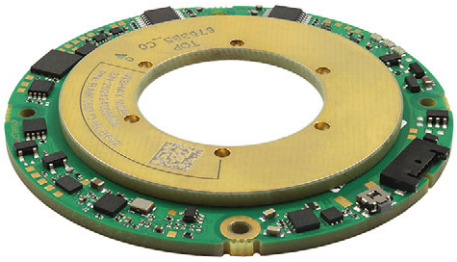
Rotational Absolute Inductive Kit Encoder Version 60 mm Position Sensor



FEATURES

- Off-axis rotational absolute inductive encoder
- Especially dedicated to motor drive, to robot's position and industrial motion control with accurate positioning
- Rotation speed up to 10 000 rpm
- High repeatability, high precision, high resolution, single or multi-turns variant
- Embedded self-calibration
- Easy assembly with status LED colors
- Memorization of last position before power off
- Not sensitive to external magnetic fields (no hall effect cells), electrical fields and temperature
- Not sensitive to moisture and pollution
- Especially dedicated for harsh conditions (vibrations, shocks, EMC…)
- Built-in self-monitoring
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

Pb-free

RoHS COMPLIANT

LINKS TO ADDITIONAL RESOURCES

3D Models | Infographics | Did You Know?

QUICK REFERENCE DATA	
Sensor type	ROTATIONAL, inductive technology
Output type	Connector Molex 5037630691
Market appliance	Industrial
Dimensions	Diameter 60 mm

ELECTRICAL SPECIFICATIONS	
PARAMETER	**RAIK060I11318**
Voltage power supply (on sensor connector)	5 V_{DC} ± 0.25 V_{DC}
Supply current at 5 V_{DC}	≤ 100 mA
Output format	BiSS-C, SSI, or SPI
Useful electrical angle	360°
Accuracy at 25 °C	≥ 13 bits (0.044°)
Repeatability	≥ 17 bits
Output noise (at 25 °C with airgap 0.4 mm)	± 1 LSB
Resolution	262 144 points (18 bits, ≈ 0.0014°)
Startup time	≤ 5 ms
Data latency time	≤ 5 µs
Maximum sampling rate	33 kHz (BiSS-C multi-turn version, MA 10 MHz)
Variant multi-turn counter	65 536 turns (16 bits, two's complement, -32 768 to +32 767)
For multi-turns options	Memorization of the position and the multi-turn counter values at power-off

MECHANICAL SPECIFICATIONS (All Versions)	
PARAMETER	
Mechanical angle	360°
Maximum rotation speed	10 000 rpm (more on request)
Rotor weight	≤ 5.5 g
Stator weight	< 10 g

For technical questions, contact: mcbprecisionpot@vishay.com

SAP PART NUMBERING GUIDELINES (CORRESPONDING TO ASSEMBLY CASE 1 - ROTOR 4 HOLES) [1]										
TYPE	MODEL	DESIGN	SIZE (mm)	TYPE	FUNCTION	ACCURACY (BITS)	RESOLUTION (BITS)	OUTPUT	PACKAGING	OPTION
R = rotational	AI	K = kit	060	I	1	13	18	F = SPI CCW	B = box	713 = option single-turn
								J = SSI CCW	B = box	714 = option single-turn
								L = BiSS-C	B = box	715 = option single-turn
								F = SPI CCW	B = box	717 = option multi-turn counting
								J = SSI CCW	B = box	718 = option multi-turn counting
								L = BiSS-C	B = box	716 = option multi-turn counting

SAP PART NUMBERING GUIDELINES (CORRESPONDING TO ASSEMBLY CASE 2 - ROTOR 6 HOLES) [1]										
TYPE	MODEL	DESIGN	SIZE (mm)	TYPE	FUNCTION	ACCURACY (BITS)	RESOLUTION (BITS)	OUTPUT	PACKAGING	OPTION
R = rotational	AI	K = kit	060	I	1	13	18	F = SPI CCW J = SSI CCW L = BiSS-C CCW	B = box	Single-turn
								F = SPI CCW		693 = multi-turn counting
								J = SSI CCW		694 = multi-turn counting
								L = BiSS-C CCW		692 = multi-turn counting

Note

[1] See section “Mounting and Electrical Connection Procedure” for details of assembly

ACCESSORY	
External connector equipped with wires to obtain a wires output (see section “Accessories on Request”)	ACCSRAIKWIRESOB073

PERFORMANCE	
PARAMETER	
Standard operating temperature range	-40 °C to +105 °C
Storage temperature range	-55 °C to +125 °C
Humidity	≤ 80 % no condensing
Environmental protection	Coating on PCB components side (on request)
Vibrations	0.05 g^2/Hz, 20 Hz to 2000 Hz for 1 hour along three major axis
Shocks	100 g, 6 ms, ½ sine (one on each axis)

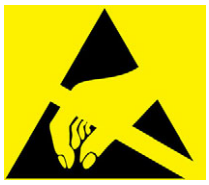
EMC PARAMETERS		
PARAMETER	**STANDARD**	**LEVEL**
Electrostatic discharge immunity (ESD)	61000-4-2 :2008	Level 4 (8 kV) - contact discharge (important: valid only on the connector interface)
Immunity of radiated radio-frequency electromagnetic field (80 MHz to 6 GHz)	EN 61000-4-3:2020	Level 3 (10 V/m)
Immunity to conducted disturbances induced by radio-frequency fields (150 kHz to 80 GHz)	EN 61000-4-6:2014	Level 3 (10 V)
Immunity to power frequency magnetic field (at 50 Hz)	EN 61000-4-8:2010	Level X (1500 A/m, 2 mT)
Radiated emission (30 MHz to 1 GHz)	EN 55011	Class A Group 1 (Industrial [1])

Notes

- Levels compliant with EN IEC 61326-1, industrial
- The sensor does not integrate protection against surges caused by overvoltages from switching and lightning transients (61000-4-5). It is recommended to use external protection if this standard is to be applied. To minimize the risk, we recommend that the power supply cable does not exceed 3 meters, and the data line does not exceed 30 meters

(1) This equipment is not intended for use in residential environments and may not provide adequate protection to radio reception in such environments

OTHER INFORMATION

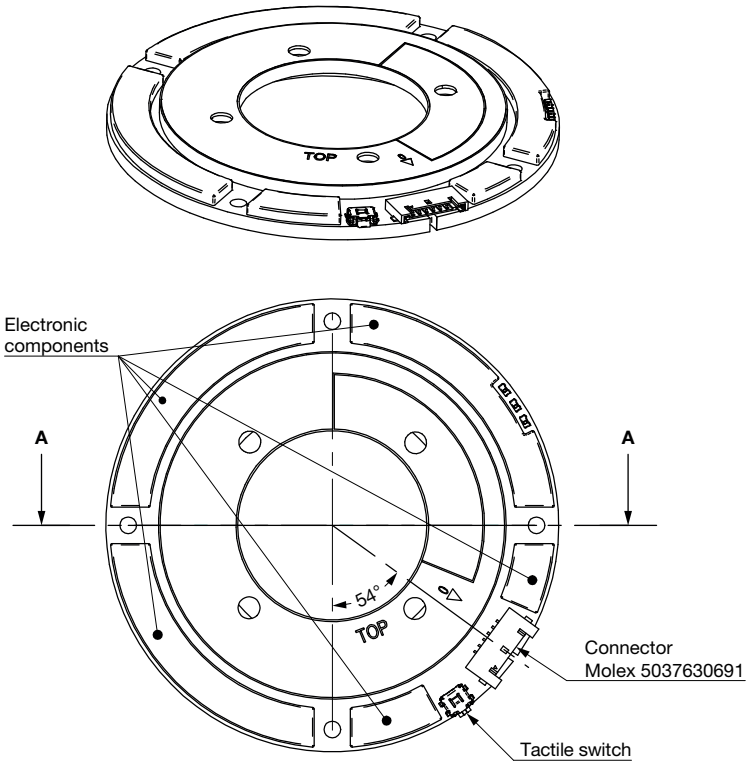


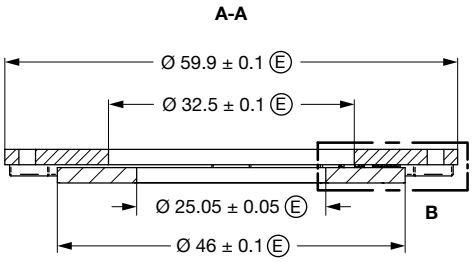
ATTENTION!
Observe Precautions for Handling Electrostatic Sensitive Devices!

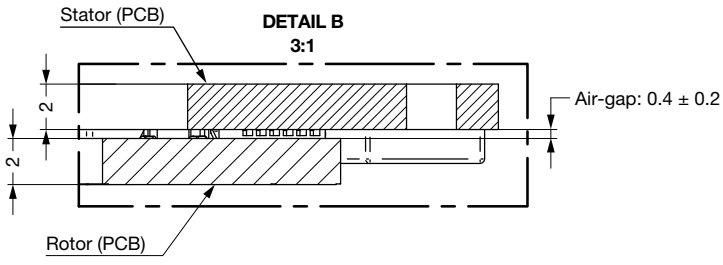
Warning: the rotor and the stator must have the same serial number!

- The sensor is delivered in an ESD packaging. To ensure safe handling, remove the sensor from its ESD bag only in an Electrostatic Protected Area (EPA)
- Do not damage the rotor disk surface
- Do not use cleaning product or chemical product
- Environmental protection: conformal coating or potting on request for use in heavy-duty environments (metallic particles, oils, greases, salt spray, moisture, corrosion...)

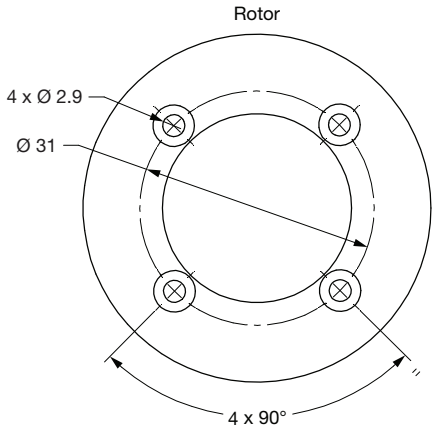
SENSOR DIMENSIONS CASE 1

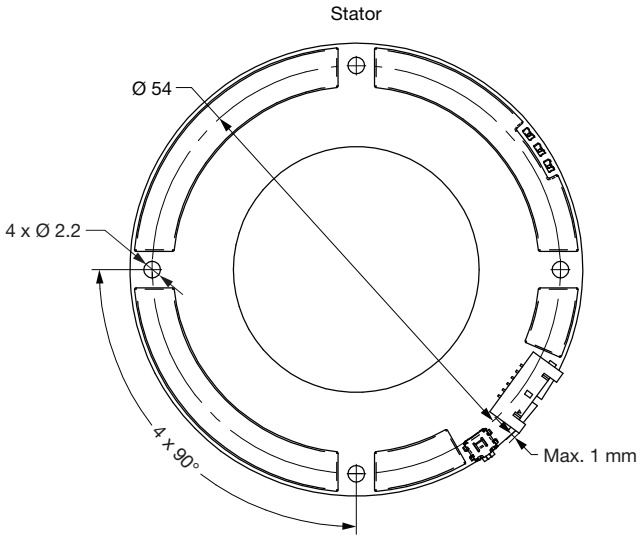


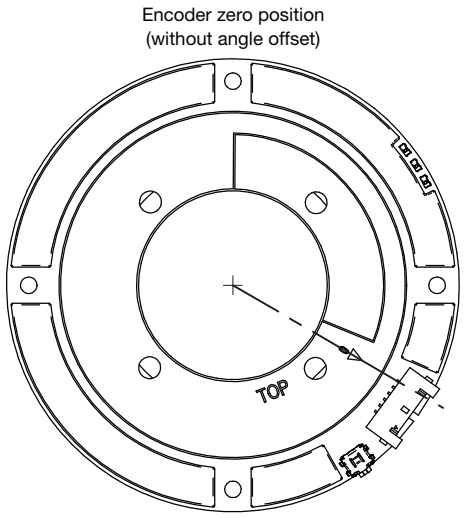




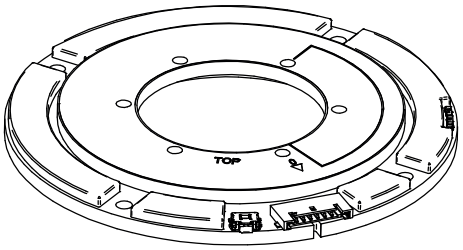
FASTENING POINTS CASE 1

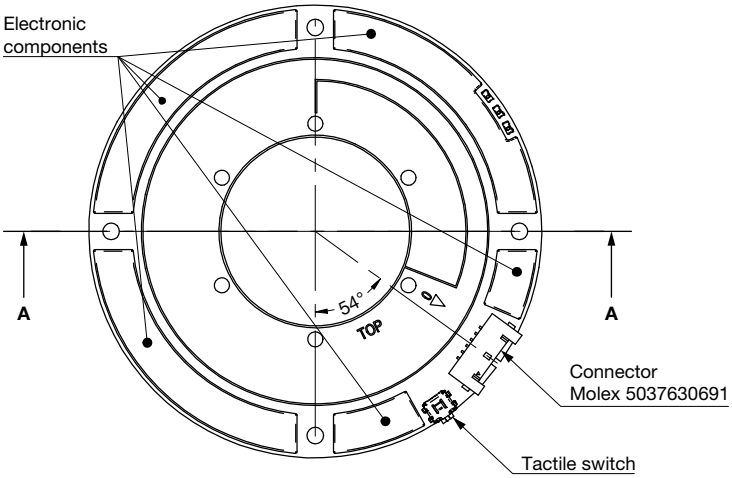




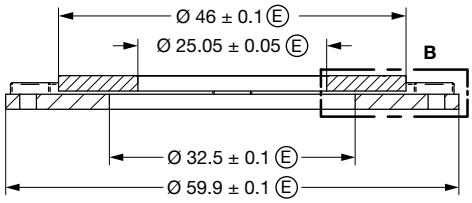


SENSOR DIMENSIONS CASE 2

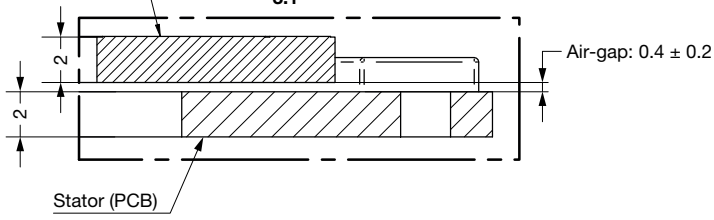




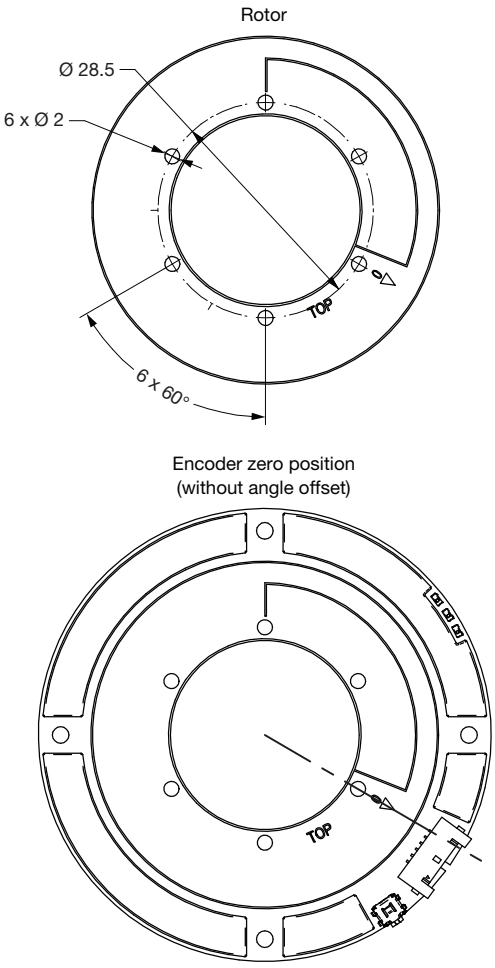
A-A



DETAIL B
3:1



FASTENING POINTS CASE 2



MOUNTING CONDITIONS

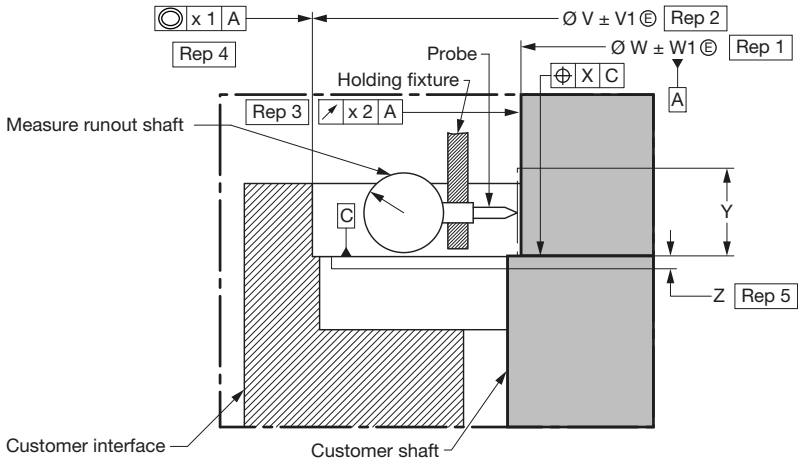


Fig. 1 - Mounting Detail

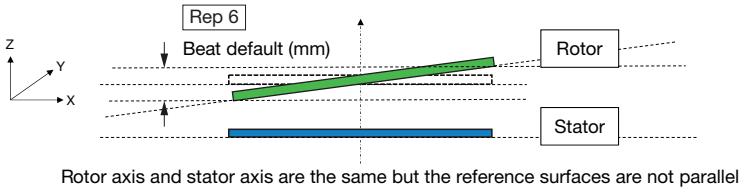


Fig. 2 - Beat

RECOMMENDED DIMENSIONS AND TOLERANCES OF CUSTOMER INTERFACES TO USE THE SELF-CALIBRATION		
Rep 1	Customer shaft diameter for centering of the rotor (see Fig. 1)	Diameter Ø 25 g6 (25 mm - 0.007 mm - 0.020 mm)
Rep 2	Customer interface diameter for centering of the stator (see Fig. 1)	Diameter Ø 60 H7 (60 mm + 0.030 mm - 0.000 mm)
Rep 3	Diameter runout of the customer shaft for the rotor centering (included gap between customer shaft and inner rotor diameter) (see Fig. 1)	< 0.120 mm
Rep 4	Misalignment: concentricity of the stator centering diameter versus shaft centering diameter (included tolerances of customer holder and stator interface) (see Fig. 1)	< 0.250 mm
Rep 5	Position of the stator reference upper surface versus rotor reference bottom surface (see Fig. 1) (air-gap: the condition of previous line avoids to measure the air-gap)	0.4 mm ± 0.2 mm
Rep 6	Total beat included in the air-gap between ref. C (rotor) and ref. D (stator) (see Fig. 2)	< 0.2 mm

Note

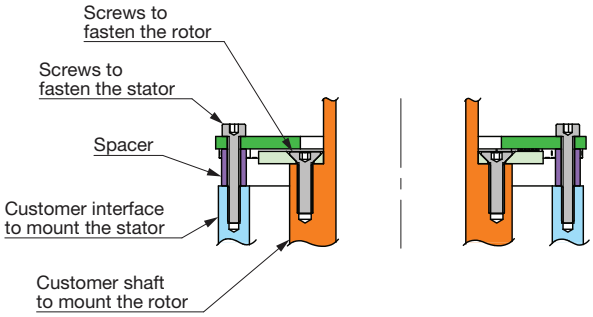
- Values at room temperature

MOUNTING AND ELECTRICAL CONNECTION PROCEDURE

1. Observe precautions for handling electrostatic sensitive devices.

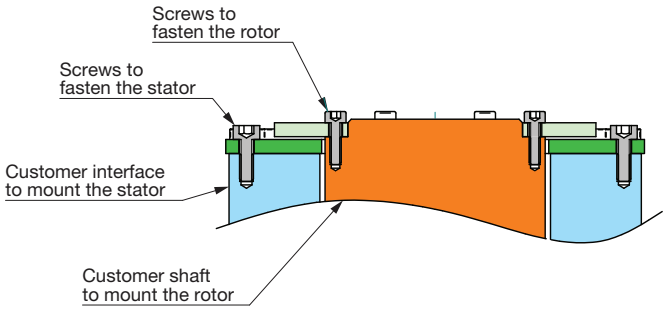
Case 1: Rotor Below to the Stator

2. Mount the rotor with recommended screws: M2 according to ISO 10642 (stainless steel A4 with recommended torque = 0.3 Nm ± 10 %) on the customer interface according to recommended mounting conditions. It is recommended to threadlocker on screws threads in function of environmental and use conditions. Its marking “TOP” shall be on the opposite side of the stator.
3. Mount the stator with recommended screws: M2 according to ISO 4762 (stainless steel A4 with recommended torque = 0.3 Nm ± 10 %) on the customer interface according to recommended mounting conditions. It is recommended to threadlocker on screws threads in function of environmental and use conditions. The electronic components side of the stator shall be in front of the rotor.



Case 2: Stator Below to the Rotor

2. Mount the stator with recommended screws: M2 according to ISO 4762 (stainless steel A4 with recommended torque = 0.3 Nm ± 10 %) on the customer interface according to recommended mounting conditions. It is recommended to threadlocker on screws threads in function of environmental and use conditions. The electronic components side of the stator shall be in front of the rotor.
3. Mount the rotor with recommended screws: M1.6 according to ISO 4762 (stainless steel A4 with recommended torque = 0.1 Nm ± 10 %) on the customer interface according to recommended mounting conditions. It is recommended to threadlocker on screws threads in function of environmental and use conditions. Its marking “TOP” shall be on the opposite side of the stator; the word “TOP” can be read after mounting!
4. Plug the “wires user connector” in the encoder according to Fig. 4 and “Encoder pinout” (see “BiSS-C Compatible Connector” table).



COMMUNICATION INTERFACES

Three protocols are possible: SSI protocol, BiSS-C protocol, or SPI protocol.

SSI and BiSS-C signals comply with the RS-422 standard, employing Low Voltage Differential Signal (LVDS). To ensure robust EMC immunity, it is highly recommended to use twisted pair wire:

- **BiSS-C:** MA+ twisted with MA- / SLO+ twisted with SLO-
- **SSI:** CLK+ twisted with CLK- / DATA+ twisted with DATA-

Power supply signal (VCC, GND) does not need to be twisted pair.

The typical impedance of signal lines is 120 Ω. The requirement for termination resistors depends on the total length of the communication bus and the communication speed employed.

The SPI (Serial Peripheral Interface) is a four-wire bidirectional synchronous serial communications interface used for short-distance communications (≤ 30 cm). This protocol is full duplex (communication in both directions simultaneously) and signals are 3.3 V LVTTL (5 V tolerant). The master controller selects the slave with the nCS line, generates a clock signal on the SCLK line, sends commands on the MOSI line and receives data on the MISO line.

CONNECTOR TYPES:

Output connector mounted on the RAIK060: Molex 5037630691
Customer connector equipped of wires gauge 28 to plug:

- Female connector Molex 503764-0601
- Contacts Molex 503765-0098

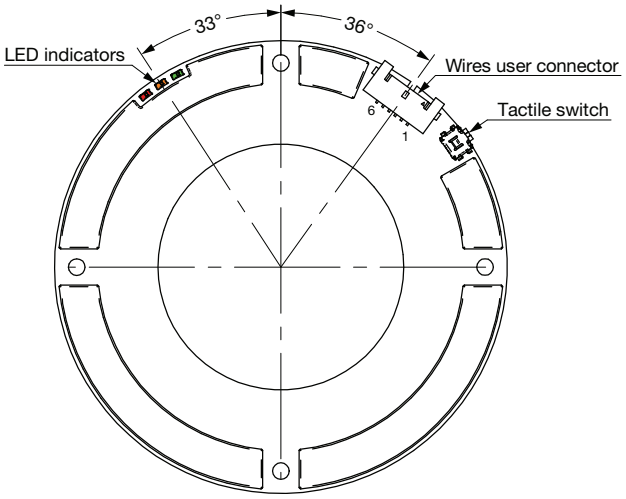


Fig. 3 - User Connector

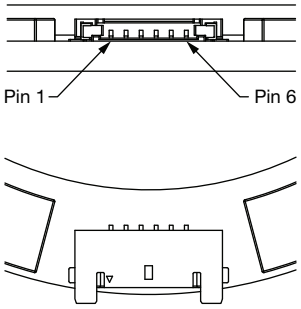


Fig. 4

BISS-C / SSI PINOUT				
PIN NO.	NAME (BiSS-C / SSI)	DESCRIPTION	TYPE	OPTIONAL: WIRE EQUIPED CONNECTOR (P/N: ACCSRAIKWIRESOB073)
1	VCC	Power supply input	Power	Red
2	MA+ / CLK+	Positive clock input	Input	Orange
3	MA- / CLK-	Negative clock input	Input	Yellow
4	SLO- / DATA-	Negative data output	Output	White
5	SLO+ / DATA+	Positive data output	Output	Green
6	GND	Ground	Power	Black

SPI PINOUT				
PIN NO.	NAME	DESCRIPTION	TYPE	OPTIONAL: WIRE EQUIPED CONNECTOR (P/N: ACCSRAIKWIRESOB073)
1	VCC	Power supply input	Power	Red
2	SCLK	SPI clock input	Input	Orange
3	/CS	SPI chip select input (active low)	Input	Yellow
4	MOSI	SPI data input (from master to slave)	Input	White
5	MISO	SPI data output (from slave to master)	Output	Green
6	GND	Ground	Power	Black

Note

- See section “Accessories on Request” for details on the wire equipped connector

SELF-CALIBRATION PROCEDURE

GENERAL

After each sensor assembly or mechanical mounting change, a self-calibration must be performed to ensure that the sensor reaches its maximum performance. Self-calibration consists of two steps:

- **Step 1:** automatic control of the airgap (distance between the lower part of the rotor and the upper part of the stator). If the airgap is out of range, it is not possible to move on to the next step. During this step, angle position is still available from interface communication; the accuracy is reduced to 13 bits (instead of 18 bits).

LED INDICATORS	DESCRIPTION	RECOMMENDED ACTION
 FAST BLINKING	Valid airgap. The airgap is in the correct range (0.4 mm ± 0.2 mm).	Go to the self-calibration Step 2.
 FAST BLINKING	Airgap is too low (< 0.2 mm).	Increase the distance between the rotor and stator.
 FAST BLINKING	Airgap is too high (> 0.6 mm) or missing rotor.	Check the presence of the rotor and decrease the airgap between the rotor and stator.

- **Step 2:** calculation of the angle correction table. During this step, the rotor must rotate at a speed between 100 rpm and 500 rpm and the communication master must provide clocks on the line to scan the angle data.

LED INDICATORS	DESCRIPTION	RECOMMENDED ACTION
 FAST BLINKING	Waiting for rotor rotation and clock on communication interface. If no rotation is detected after 30 seconds, the sensor automatically return to “Customer Mode”.	Start motor rotation (100 rpm to 500 rpm) and provide clocks on communication interface.
 FAST BLINKING	Computation and recording of the self-calibration parameters (typically 2 seconds at 100 rpm). The sensor automatically return to “Customer Mode” after calibration is complete.	Keep motor rotation to a fix speed (100 rpm to 500 rpm).

There are two methods of initiating this procedure:

- Using Push-Button
- Using BiSS-C or SPI commands

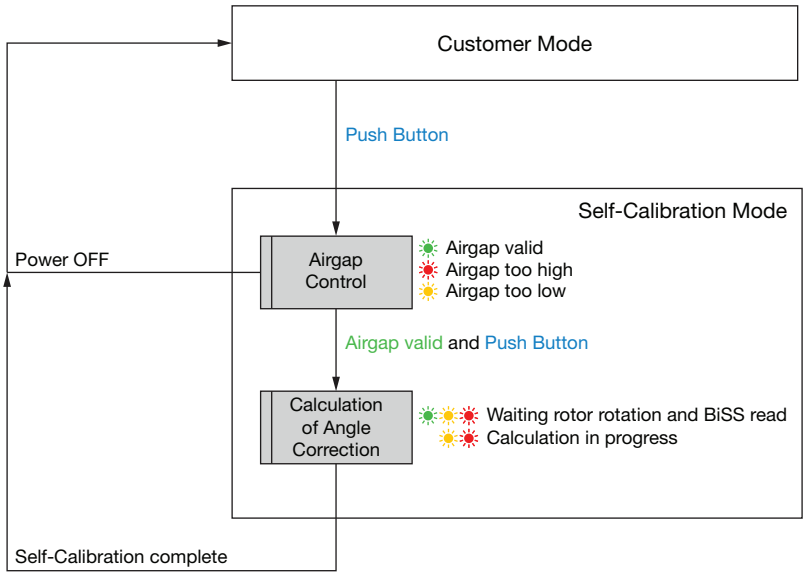
These two methods are described below.

USING PUSH-BUTTON

The self-calibration can be launched using the mechanical push-button on the sensor.

Important: use a soft non-metallic tool (wood, plastic, …) to press the button to not damage the sensor with ElectroStatic Discharges.

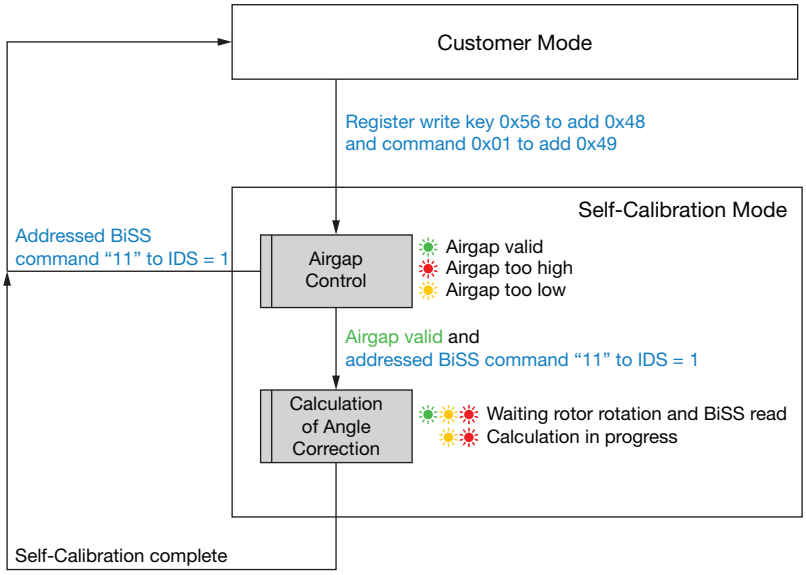
1. Press the Push-Button to enter the Self-Calibration Mode (the sensor will restart in Self-Calibration Mode).
2. In the self-calibration **Step 1** (Airgap Control), the green LED should blink fastly if airgap is valid. If orange or red LED are blinking, the sensor detects an incorrect airgap. Refer to the “Self-Calibration Procedure” section for details.
3. When airgap is valid, press the push button to go to **Step 2** (Correction Calculation). At this step, the only way to return in Customer Mode is to reboot the sensor.
4. In the self-calibration **Step 2** (Correction Calculation), the sensor start calculates only if the rotor is in rotation and the BiSS master send clocks to read data.
5. When the calculation is complete, the sensor return automatically in Customer Mode and the LED stop blinking.
   a. A fix green LED indicates a valid calibration.
   b. A fix orange LED indicates a valid calibration, with a power-off motion warning (multi-turn value change during self-calibration procedure).
   c. A fix red LED indicates that a calibration error.



USING BiSS-C COMMAND

The self-calibration can be launched using BiSS-C commands:

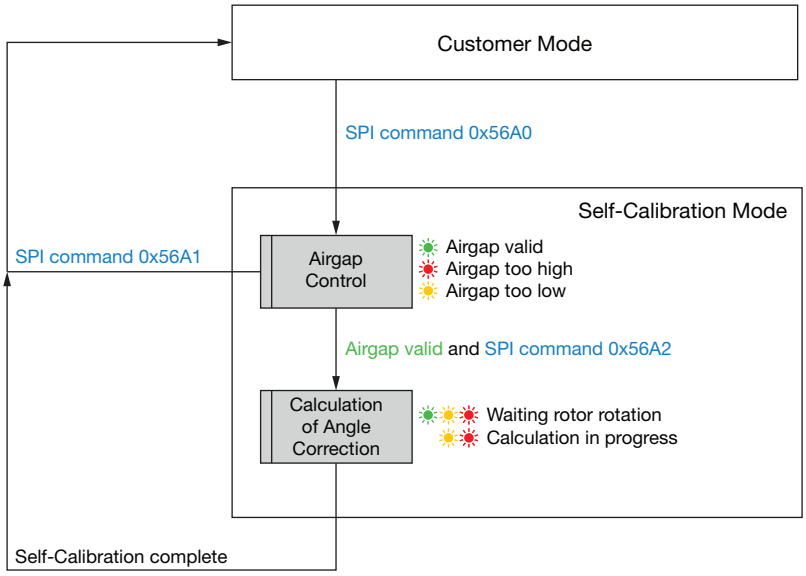
1. Unlock the command by writing **key code 0x56** to address **0x48**.
2. Write **command code 0x01** to address **0x49** to enter the Self-Calibration Mode (the sensor will restart in Self-Calibration Mode).
3. In the self-calibration **Step 1** (Airgap Control), the green LED should blink fastly if airgap is valid. If orange or red LED are blinking, the sensor detects an incorrect airgap. Refer to the “Self-Calibration Procedure” section for details.
4. When airgap is valid, there are two possibilities:
   a. Return in Customer Mode: **write addressed BiSS command “10” to IDS = 1**.
   b. Start calculation of angle correction table: **write addressed BiSS command “11” to IDS = 1**.
5. In the self-calibration **Step 2** (Correction Calculation), the sensor start calculates only if the rotor is in rotation and the BiSS master send clocks to read data.
6. When the calculation is complete, the sensor return automatically in Customer Mode and the LED stop blinking.
   a. A fix green LED indicates a valid calibration.
   b. A fix orange LED indicates a valid calibration, with a power-off motion warning (multi-turn value change during self-calibration procedure).
   c. A fix red LED indicates that a calibration error occurs (need to restart the self-calibration procedure).



USING SPI COMMAND

The self-calibration can be launched using SPI commands:

1. Write command **0x56A0** on MOSI line to enter the Self-Calibration Mode (the sensor will restart in Self-Calibration Mode).
2. In the self-calibration **Step 1** (Airgap Control), the green LED should blink fastly if airgap is valid. If orange or red LED are blinking, the sensor detects an incorrect airgap. Refer to the “Self-Calibration Procedure” section for details.
3. When airgap is valid, there are two possibilities:
   a. Return in Customer Mode: write command **0x56A1**
   b. Start calculation of angle correction table: command **0x56A2**
4. In the self-calibration **Step 2** (Correction Calculation), the sensor starts to calculate only if the rotor is in rotation (100 rpm to 500 rpm).
5. When the calculation is complete, the sensor returns automatically in Customer Mode and the LED stop blinking.
   a. A fix green LED indicates a valid calibration.
   b. A fix orange LED indicates a valid calibration, with a power-off motion warning (angle change more than ± 90° during self-calibration procedure).
   c. A fix red LED indicates that a calibration error occurs (need to restart the self-calibration procedure).



VARIANT MULTI-TURNS COUNTER

First Possible Option: Counting of Turns Without Battery Backup Connector and Memorization of Last Position Before Power-Off!

In normal operation, when the power is on, the counting of the turns is made in both directions (clockwise and anticlockwise). The counter value is sent in the output frame in two’s complement. The maximum value of the counter is +32 767, the minimum is -32 768: once the counter has reached the maximum value (+32 767), the next counter value is automatically set to -32 768. Once the counter has reached the minimum value (-32 768), the next value is set to +32 767.

Please note that no counting operations are performed during power-off. When the power is turn off, the last position before power cutting (multi-turn counter and position value) is stored in a non-volatile memory. This allows the encoder to accept a movement of up to ± 90° during power off, which is then calculated and released as soon as the power comes back. Upon power-on, if the angle variation exceeds ± 90°, the frame warning flag is set. This warning is reset at the next power-on or after 50 frames have been read on the communication port. The orange LED is “ON” when the warning is active.

The number of non-volatile memory write-in cycles is unlimited.

The multi-turn counter is reset when the sensor performs a self-calibration.

BiSS-C OUTPUT FORMAT

BiSS-C Frame Timing Diagram (Multi-Turn Version)

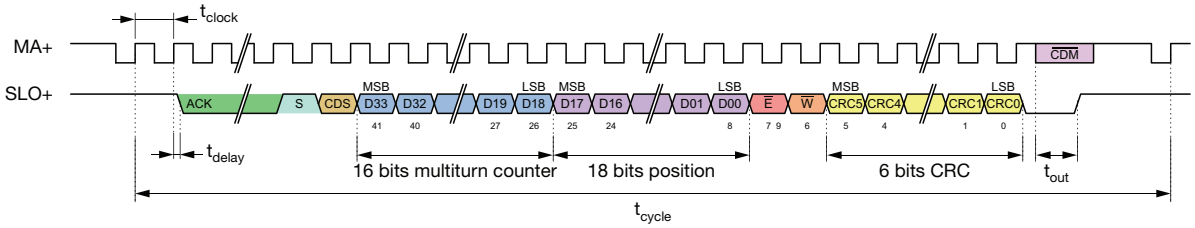


Fig. 5

BiSS-C Frame Timing Diagram (Multi-Turn Version) in Self-Calibration Mode

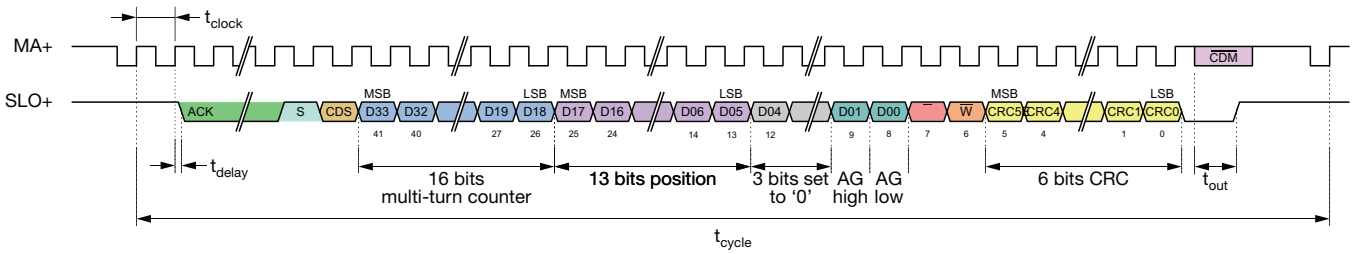


Fig. 6

BiSS-C Frame Timing Diagram (Single-Turn Version)

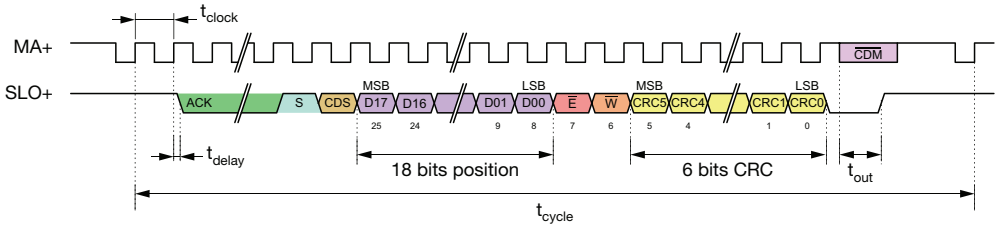


Fig. 7

BiSS-C Frame Timing Diagram (Single-Turn Version) in Self-Calibration Mode

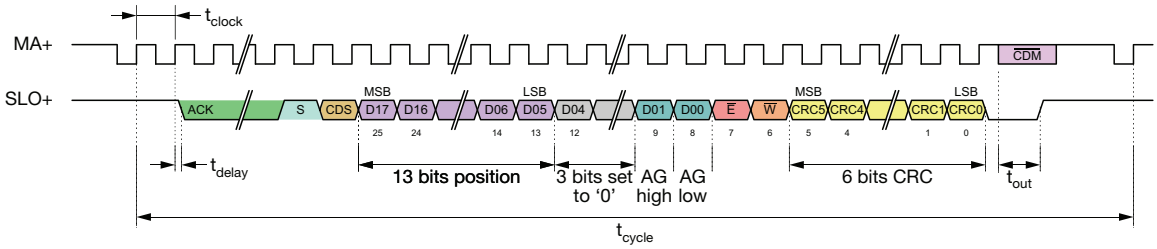


Fig. 8

Note

- The total number of clock period after the CDS bit can be higher than the number of data bits, depending on propagation delays and processing timing. Tests must be carried out depending on the specific installation

BiSS-C COMPATIBLE PARAMETERS	
PARAMETER	**INFORMATION**
BiSS-C compatible configuration	Point to point (multi-slave not supported)
Clock and data differential interface	RS422 according to the EIA-RS422
Acknowledgment (ACK) duration	10 x t_{clock} for 100 kHz ≤ f_{clock} ≤ 2.5 MHz or 4.2 µs typ. for 2.5 MHz < f_{clock} ≤ 10 MHz
Start (S)	1 bit always to “1”
Control data slave (CDS)	1 bit
Multi-turn counter data (D33 to D18)	16 bits two’s complement binary code (-32 768 to +32 767)
Position data (D17 to D00)	18 bits binary code (0 to 262 143)
Error bit (E)	1 bit (active low)
Warning bit (W)	1 bit (active low)
Cyclic redundancy check data (CRC5 to CRC0)	CRC polynomial X6 + X1 + X0 = 0 x 43 - CRC bit length 6 bits; inverted; CRC start value = “0”
Inverted control data master data (/CDM)	Generated by master on clock signal
Clock frequency (f_{clock} = 1/t_{clock})	≤ 10 MHz
Request rate (f_{cycle} = 1/t_{cycle})	≤ 33 kHz (t_{req} = 30 µs) (1)
Propagation delay (t_{delay})	20 ns to 50 ns
BiSS-C compatible timeout (t_{out})	15 µs

Note

(1) With 10 MHz master clock frequency and multi-turn version

Position Offset Command (Encoder Zero Position)

ADDR 0x4A								ADDR 0x4B								ADDR 0x4C							
7	**6**	**5**	**4**	**3**	**2**	**1**	**0**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
						OFF [17]	OFF [16]	OFF [15]	OFF [14]	OFF [13]	OFF [12]	OFF [11]	OFF [10]	OFF [9]	OFF [8]	OFF [7]	OFF [6]	OFF [5]	OFF [4]	OFF [3]	OFF [2]	OFF [1]	OFF [0]

Note

- The position offset OFFSET_ANGLE [17:0] is mapped to registers 0x4A, 0x4B, and 0x4C of the direct access memory in a big-endian format

There is two ways to apply a zero position:

A. Using command:
   1. Unlock the command by writing **key code 0x56** to address **0x48**
   2. Write **command code 0x12** to address **0x49** to apply the position offset. The position is then automatically shifted by the value of the current position
   3. It is also possible to **cancel** the position offset with the command **code 0x13** to address **0x49**

B. Using register access:

   It is also possible to set the offset position directly by writing to registers 0x4A, 0x4B and 0x4C. To do so, user must write independently to the registers. Note that register 0x4A stores the two MSB OFFSET_ANGLE[17] and OFFSET_ANGLE[16] of the 18 bits offset position, and ignores the 6 other bits.

The position offset is saved in non-volatile memory and will not change after the sensor is restarted.

Applying a new position offset change the multi-turn counter origin to the new zero position (if present).

Multi-turn Counter Reset Command

The Multi-turn counter can be reset using a BiSS command:

1. Unlock the command by writing **key code 0x56** to address **0x48**
2. Write **command code 0x11** to address **0x49** to reset the counter. The counter will then be automatically reset

Note that the multi-turn counter is only available on the MT version of the sensor. Applying this command to a ST sensor will have no effect.

BiSS-C MEMORY ORGANIZATION

1. LEXICON

TYPE	DESCRIPTION	COMMENT
ST	Single-turn sensor version	For example, RAIK060I11318LB (BiSS-C Single-turn)
MT	Multi-turn sensor version	For example, RAIK060I11318LB692 (BiSS-C Multi-turn)
R	“Read only” access	Register readable but not writable. Read access also support sequential reading method.
R/W	“Read and Write” access	Register readable and writable. Write access also support sequential writing method.
U8	Unsigned 8 bits	Values are saved as a Big Endian, i.e. with the highest-value byte at the lowest-value address
U16	Unsigned 16 bits	
U24	Unsigned 24 bits	
U32	Unsigned 32 bits	
U48	Unsigned 48 bits	

2. BANKS

BANK N°	ADDRESS	DETAIL	R / W
0	0x00 to 0x3F	Device configuration	R
1	0x00 to 0x3F	EDS common part	R
2	0x00 to 0x3F	EDS BiSS profil 3	R
3 to 7	0x00 to 0x3F	User bank	R / W

Note for user bank memory: five user banks of 64 bytes are available in banks 3 to 7 for free R / W access by the user, representing 320 bytes of non-volatile memory read and write access supports sequential read / write method.

3. BiSS-C DIRECT ACCESS

ADDR	R / W	SYMBOL	DESCRIPTION	FORMAT	VALUES
0x40	R / W	BSEL	Blank selection	U8	-
0x41	R	EDS_BANK	Point to EDS bank	U8	0x01
0x42	R	BP_ID [15:8]	BiSS profile ID	U16	0x62
0x43	R	BP_ID [7:0]			0x24 for MT version, 0x14 for ST version
0x44	R	DEV_SN [31:24]	Device serial number	U32	Unique number for each sensor
0x45	R	DEV_SN [23:16]			
0x46	R	DEV_SN [15:8]			
0x47	R	DEV_SN [7:0]			
0x48	R / W	KEY	Key register (1)	U8	-
0x49	R / W	CMD	Command register	U8	-
0x4A	R / W	“0000 00” and OFFSET_ANGLE [17:16]	Offset angle register	U24	-
0x4B	R / W	OFFSET_ANGLE [15:8]			
0x4C	R / W	OFFSET_ANGLE [7:0]			
0x4D to 0x77	R / W	Free registers	Free registers	U8	-
0x78	R	DEV_ID [47:40]	Device ID	U48	= 0x343137363932 for MT version = 0x343137363931 for ST version
0x79	R	DEV_ID [39:32]			
0x7A	R	DEV_ID [31:24]			
0x7B	R	DEV_ID [23:16]			
0x7C	R	DEV_ID [15:8]			
0x7D	R	DEV_ID [7:0]			
0x7E	R	MFR_ID [15:8]	Manufacturer ID (2)	U16	0x56
0x7F	R	MFR_ID [7:0]			0x59

Notes

(1) Vishay key code: 0x56

(2) Vishay manufacturer ID: 0x5659

4. BiSS-C BANK N° 0 - DEVICE CONFIGURATION					
ADDR	SYMBOL	DESCRIPTION	FORMAT	VALUES	COMMENT
0x00	FW_MAJOR_VERS	Major firmware version	U8	-	Example for firmware version A4: FW_MAJOR_VERS = 0x41 FW_MINOR_VERS = 0x34
0x01	FW_MINOR_VERS	Minor firmware version	U8	-	
0x02 to 003F	Reserved	-	U8	0x00	-

5. BiSS-C BANK N° 1 - EDS COMMON PART						
ADDR	SYMBOL	DESCRIPTION	FORMAT	UNIT	VALUES	COMMENT
0x00	EDS_VER	EDS version (continuous number)	U8		0x01	
0x01	EDS_LEN	EDS length (bank count completely)	U8	BANKS	0x02	
0x02	USR_STA	Bank address USER start (bank selection in address 64, 255= not available)	U8		0x03	
0x03	USR_END	Bank address USER end (bank selection address 64)	U8		0x07	
0x04	TMA	Minimum permitted clock period on MA (TMA)	U8	1 ns	0xC8	200 ns
0x05	TO_MIN	Minimum BiSS timeout (0= adaptive)	U8	250 ns	0x3C	15 µs
0x06	TO_MAX	Maximum BiSS timeout (0= adaptive)	U8	250 ns	0x4C	19 µs
0x07	TOS_MIN	Minimum BiSS timeout_S (0= adaptive)	U8	25 ns	0x3C	15 µs
0x08	TOS_MAX	Maximum BiSS timeout_S (0= adaptive)	U8	25 ns	0x4C	19 µs
0x09	TCLK_MIN	Minimum sampling period adaptive timeout (0= adaptives timeout not available)	U8	25 ns	0x00	
0x0A	TCLK_MAX	Maximum sampling period adaptive timeout (0= adaptives timeout not available)	U8	25 ns	0x00	
0x0B	TCYC	Minimum cycle time (0= no limitation)	U8	250 ns	0x00	
0x0C	TBUSY_S	Maximum processing time SCD	U8	250 ns	0x12	4.5 µs
0x0D	BUSY_S	Additional processing time SCD in clocks	U8	TMA	0x00	
0x0E	PON_DLY [15:8]	Maximum “power on delay” until control communication is available	U16	1 ms	0x00	5 ms
0x0F	PON_DLY [7:0]				0x05	
0x10	DC_NUM	Number of data channel in this device (number of words)	U8	-	0x01	
0x11	SL_NUM	Area of validity for this EDS (number of slave addresses)	U8	-	0x01	
0x12	SL_OFF	Memory location for this EDS (slave ID within this device)	U8	-	0x00	
0x13	Reserved	-				
0x14	BANK1	Bank address for content description data channel 1 (profile EDS)	U8		0x02	
0x15	DLEN1	Data length data channel 1	U8	Bit	0x24 0x14	36b for MT version 20b for ST version
0x16	FORMAT1	Data format data channel 1	U8	Bit	0x00	
0x17	CPOLY1	CRC polynome [8:1] for data channel 1	U8	-	0x21	= 0x43 polynome
0x18	BANK2	Bank address for content description data channel 2 (profile EDS)	U8	-	0x00	
0x19	DLEN2	Data length data channel 2	U8	Bit	0x00	
0x1A	FORMAT2	Data format data channel 2	U8	Bit	0x00	
0x1B	CPOLY2	CRC polynome [8:1] for data channel 2	U8	-	0x00	
0x1C	BANK3	Bank address for content description data channel 3 (profile EDS)	U8	-	0x00	
0x1D	DLEN3	Data length data channel 3	U8	Bit	0x00	
0x1E	FORMAT3	Data format data channel 3	U8	Bit	0x00	
0x1F	CPOLY3	CRC polynome(8:1) for data channel 3	U8	-	0x00	

5. BiSS-C BANK N° 1 - EDS COMMON PART

ADDR	SYMBOL	DESCRIPTION	FORMAT	UNIT	VALUES	COMMENT
0x20	BANK4	Bank address for content description data channel 4 (profile EDS)	U8	-	0x00	
0x21	DLEN4	Data length data channel 4	U8	Bit	0x00	
0x22	FORMAT4	Data format data channel 4	U8	Bit	0x00	
0x23	CPOLY4	CRC polynome [8:1] for data channel 4	U8	-	0x00	
0x24	BANK5	Bank address for content description data channel 5 (profile EDS)	U8	-	0x00	
0x25	DLEN5	Data length data channel 5	U8	Bit	0x00	
0x26	FORMAT5	Data format data channel 5	U8	Bit	0x00	
0x27	CPOLY5	CRC polynome [8:1] for data channel 5	U8	-	0x00	
0x28	BANK6	Bank address for content description data channel 6 (profile EDS)	U8	-	0x00	
0x29	DLEN6	Data length data channel 6	U8	Bit	0x00	
0x2A	FORMAT6	Data format data channel 6	U8	Bit	0x00	
0x2B	CPOLY6	CRC polynome [8:1] for data channel 6	U8	-	0x00	
0x2C	BANK7	Bank address for content description data channel 7 (profile EDS)	U8	-	0x00	
0x2D	DLEN7	Data length data channel 7	U8	Bit	0x00	
0x2E	FORMAT7	Data format data channel 7	U8	Bit	0x00	
0x2F	CPOLY7	CRC polynome [8:1] for data channel 7	U8	-	0x00	
0x30	BANK8	Bank address for content description data channel 8 (profile EDS)	U8	-	0x00	
0x31	DLEN8	Data length data channel 8	U8	Bit	0x00	
0x32	FORMAT8	Data format data channel 8	U8	Bit	0x00	
0x33	CPOLY8	CRC polynome [8:1] for data channel 8	U8	-	0x00	
0x34	BC_OFF	Bus coupler control location for this device (slave ID within this device)	U8	-	0x00	
0x35 to 0x3E	Reserved	-	U8	-	0x00	
0x3F	CHKSUM	Check sum (addition of all bytes within this bank)	U8	-	-	

Note

- Bank N° 1 store the electronic datasheet (EDS) parameters

6. BiSS-C BANK N° 2 - BiSS PROFIL 3

ADDR	SYMBOL	DESCRIPTION	FORMAT	UNIT	VALUES	COMMENT
0x00	BP_VER	BiSS profile 3 version	U8	-	0x01	
0x01	BP_LEN	Length of this profile	U8	Banks	0x01	
0x02	BP_ID	Profile identification BP3 (content also available in address 0x42 and 0x43)	U8	-	0x62	
0x03			U8	-	0x24 0x14	Data length = 36b for MT version = 20b for ST version
0x04	FB1	Feedback bit 1 low active error status nE	U8	Table B	0x01	Error bit low active
0x05	FB2	Feedback bit 2 low active warning status nW	U8	Table B	0x02	Warning bit low active
0x06	PON_PDL	Maximum “power on delay” until position data are available	U8	ms	0x05	5 ms
0x07	Reserved	Reserved	-	-	-	
0x08	EN_TYP	Encoder type	U8	-	0x00	Rotary encoder
0x09	POS_NUM	Position value	U8	Table N	0x01	Position value 1
0x0A	MT_LEN	Data length MULTI-TURN	U8	Bit	0x10 0x00	= 16b for MT version = n/a for ST version
0x0B	MT_FMT	Data format MULTI-TURN	U8	Table F	0x00	Right aligned
0x0C	CO_LEN	Data length COARSE	U8	Bit	0x00	

6. BiSS-C BANK N° 2 - BiSS PROFIL 3						
ADDR	**SYMBOL**	**DESCRIPTION**	**FORMAT**	**UNIT**	**VALUES**	**COMMENT**
0x0D	CO_FMT	Data format COARSE	U8	Table F	0x00	
0x0E	FI_LEN	Data length FINE	U8	Bit	0x12	0x12 = 18 bits position
0x0F	FI_FMT	Data format FINE	U8	Table F	0x01	Left-aligned
0x10	MT_CNT	Number of distinguishable revolutions/periods	U32	-	0x00	= 65 536 for MT version = n/a for ST version
0x11					0x01	
0x12					0x00	
0x13					0x00	
0x14	SIP_CNT	Number of signal periods per revolution / length of signal period	U32	PPR (rotary) nm (linear)	0x00	0x01=1period per revolution
0x15					0x00	
0x16					0x00	
0x17					0x01	
0x18	SIP_RES	resolution factor per signal period (LSB of the interpolation)	U32	LSB	0x00	0x40000 = 262 144
0x19					0x04	
0x1A					0x00	
0x1B					0x00	
0x1C	CPOLY	CRC polynomial (32:1) of 0x43 = 0x21	U32	-	0x00	= 0x43 polynome
0x1D					0x00	
0x1E					0x00	
0x1F					0x21	
0x20	CSTART	CRC start value	U32	-	0x00	
0x21					0x00	
0x22					0x00	
0x23					0x00	
0x24	ABS_ACU	Absolute accuracy	U16	LSB/2	0x00	
0x25					0x00	
0x26	REL_ACU	Repeat accuracy	U16	LSB/2	0x00	
0x27					0x00	
0x28	SPD_ACU	Angular speed / speed depending accuracy	U16	LSB/2	0x00	
0x29					0x00	
0x2A	HYST	Hysteresis	U16	LSB/2	0x00	
0x2B					0x00	
0x2C	SPD_MAX	Maximum revolution speed / maximum speed	U16	1/min m/min	0x27	10 000 rpm
0x2D					0x10	
0x2E	ACC_MAX	Maximum angular acceleration / maximum acceleration	U16	1/min² m/min²	0x00	
0x2F					0x00	
0x30	TMP_MIN	Minimum operating temperature	U16	K	0x00	233 K / -40 °C
0x31					0xE9	
0x32	TMP_MAX	Maximum operating temperature	U16	K	0x01	378 K / +105 °C
0x33					0x7A	
0x34	VLT_MIN	Minimum operating voltage	U16	mV	0x12	4.75 V
0x35					0x8E	
0x36	VLT_MAX	Maximum operating voltage	U16	mV	0x14	5.25 V
0x37					0x82	
0x38	CUR_MAX	Maximum current consumption	U16	mA	0x00	120 mA
0x39					0x78	
0x3A to 0x3E	Reserved	Reserved	-	-	0x00	
0x3F	CHKSUM	Checksum (sum of bytes in 0x00 to 0x3E)	U8	-		

Note

- Bank N° 2 store the encoder profile BP3 parameters

BiSS-C CUSTOMER MODE							
STATUS BIT		STATUS	INFORMATION	ACTION	LED INDICATOR		
$\overline{E}$	$\overline{W}$				GREEN	ORANGE	RED
1	1	Normal operation	Frame and datas are valid with full accuracy / resolution	No action required			
1	0	Power-off motion warning	This warning occurs at power up if the sensor has detected an excessive displacement (> ± 90°) during power-off; this warning is reset at the next power-on or after 50 frames have been read on the communication port; the orange LED is “on” when the warning is active	Take decision according to the warning			
0	1	Self-calibration error	This error occurs if self-calibration is not completed correctly	The self-calibration shall be restarted			
1	1	Airgap valid (only in self-calibration mode, STEP 1)	Valid airgap; the airgap is in the correct range (0.4 mm ± 0.2 mm); the two LSB of the position indicates the “airgap valid” state: D01 = low / D00 = low	Go to the self-calibration STEP 2			
0	1	Airgap too low (only in self-calibration mode, STEP 1)	Airgap is too low (< 0.2 mm); the two LSB of the position indicates the “airgap too low” state: D01 = low / D00 = high	Increase the distance between the rotor and stator			
0	1	Airgap too high (only in self-calibration mode, STEP 1)	Airgap is too high (> 0.6 mm) or the rotor is missing; the two LSB of the position indicates the “airgap too high” state: D01 = high / D00 = low	Check the presence of the rotor and / or reduce the distance between the rotor and stator			
0	1	Waiting rotor rotation and communication read (only in self-calibration mode, STEP 2)	Waiting for rotor rotation and clock on communication interface; if no rotation is detected after 30 s, the sensor automatically return to “Customer Mode”	Start motor rotation (from 100 to 1000 rpm) and provide clocks on communication interface			
0	1	Angle correction calculation in progress (only in self-calibration mode, STEP 2)	Computation and recording of the self-calibration parameters (typically 2 s at 100 rpm); the sensor automatically return to “Customer Mode” after calibration is complete	Keep motor rotation speed to a fix value			

Note

- **MANDATORY: a self-calibration shall be performed after the initial mounting and after each change of mechanical assembly of the encoder**

SSI OUTPUT FORMAT

SSI Frame Timing Diagram (Multi-Turn Version)

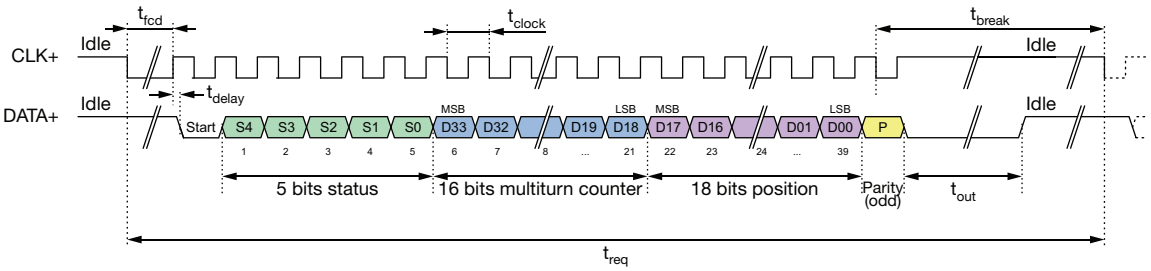


Fig. 9

SSI Frame Timing Diagram (Multi-Turn Version) in Self-Calibration Mode

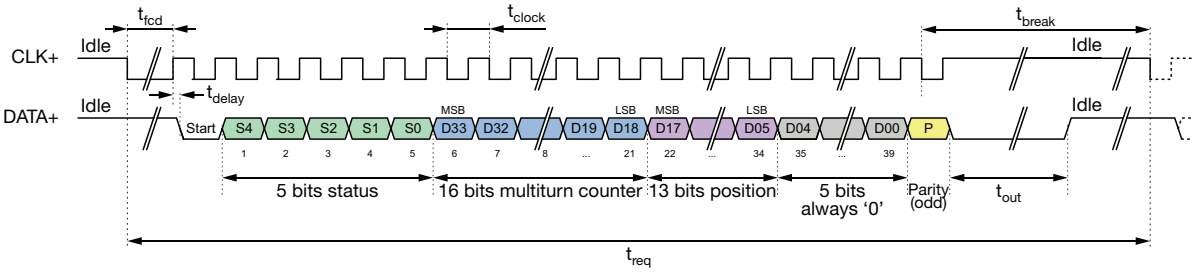


Fig. 10

SSI Frame Timing Diagram (Single-Turn Version)

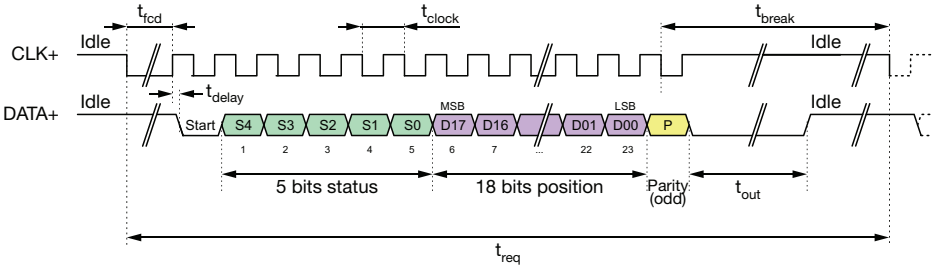


Fig. 11

SSI Frame Timing Diagram (Single-Turn Version) in Self-Calibration Mode

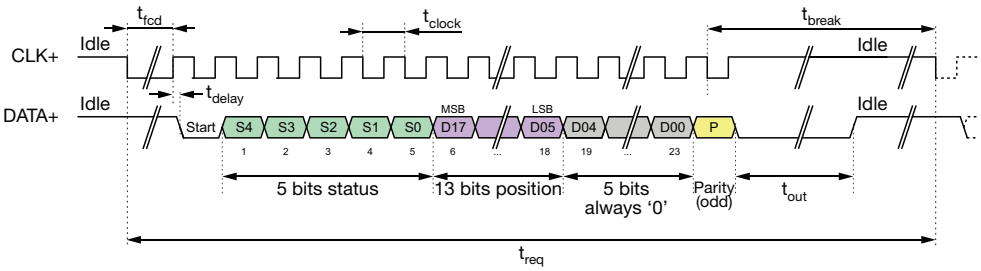


Fig. 12

SSI COMPATIBLE PARAMETERS		
PARAMETER	**INFORMATION**	
	MIN.	**MAX.**
SSI configuration	SLAVE mode only	
Clock and data differential interface	RS422 according to the EIA-RS422	
Multi-turn counter data (D33 to D18)	16 bits two's complement binary code (-32 768 to +32 767)	
Position data (D17 to D00)	18 bits binary code (0 to 262 143)	
Parity bit	Odd parity (does not include the start bit)	
First clock delay period (t_{fcd}) (1)	4.2 µs	14 µs
Propagation delay (t_{delay}) (2)	20 ns	50 ns
Transfer time-out period - monoflop time (t_{out})	15 µs	
Time period between two consecutive clock sequences (t_{break})	20 µs	-
Master clock frequency ($f_{clk} = 1/t_{clock}$)	100 kHz	3 MHz
Master request frequency ($f_{req} = 1/t_{req}$)	-	20 kHz (t_{req} = 50 µs) (3)

Notes

(1) Position acquisition is synchronized with the first falling edge of CLK. The first clock delay period is required for data acquisition, calculation, and storage in the communication buffer

(2) Measured with ACCSRAIKWIRESOB073 cord (20 cm) at 25 °C ambient temperature

(3) With 3 MHz master clock frequency and multi-turn frame

SSI CUSTOMER MODE										
STATUS BIT					STATUS	INORMATION	ACTION	LED INDICATOR		
S4	S3	S2	S1	S0				GREEN	ORANGE	RED
0	0	0	0	0	Normal operation	Frame and datas are valid with full accuracy / resolution	No action required			
0	0	0	0	1	Power-off motion warning	This warning occurs at power up if the sensor has detected an excessive displacement (> ± 90°) during power-off; this warning is reset at the next power-on or after 50 frames have been read on the communication port; the orange LED is “on” when the warning is active	Take decision according to the warning			
0	0	0	1	0	Self-calibration error	This error occurs if self-calibration is not completed correctly	The self-calibration shall be restarted			
1	1	0	0	0	Airgap valid (only in self-calibration mode, STEP 1)	Valid airgap; the airgap is in the correct range (0.4 mm ± 0.2 mm)	Go to the self-calibration STEP 2			
1	1	0	0	1	Airgap too low (only in self-calibration mode, STEP 1)	Airgap is too low (< 0.2 mm)	Increase the distance between the rotor and stator			
1	1	0	1	0	Airgap too high (only in self-calibration mode, STEP 1)	Airgap is too high (> 0.6 mm) or the rotor is missing	Check the presence of the rotor and / or reduce the distance between the rotor and stator			
1	1	1	0	0	Waiting rotor rotation and communication read (only in self-calibration mode, STEP 2)	Waiting for rotor rotation and clock on communication interface; if no rotation is detected after 30 s, the sensor automatically return to “Customer Mode”	Start motor rotation (from 100 to 1000 rpm) and provide clocks on communication interface			
1	1	1	0	1	Angle correction calculation in progress (only in self-calibration mode, STEP 2)	Computation and recording of the self-calibration parameters (typically 2 s at 100 rpm); the sensor automatically return to “Customer Mode” after calibration is complete	Keep motor rotation speed to a fix value			
Others					RFU (reserved for future use)					

Note

- **MANDATORY: a self-calibration shall be performed after the initial mounting and after each change of mechanical assembly of the encoder**

SPI OUTPUT FORMAT

SPI Timing Diagram, Customer Mode, Simple Frame (Multi-Turn Version)

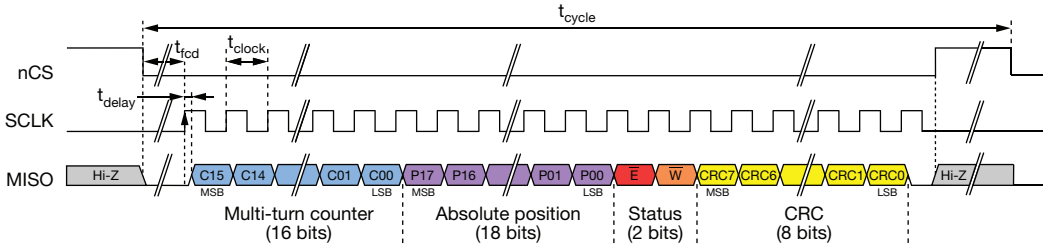


Fig. 13

SPI Timing Diagram, Customer Mode, Simple Frame (Single-Turn Version)

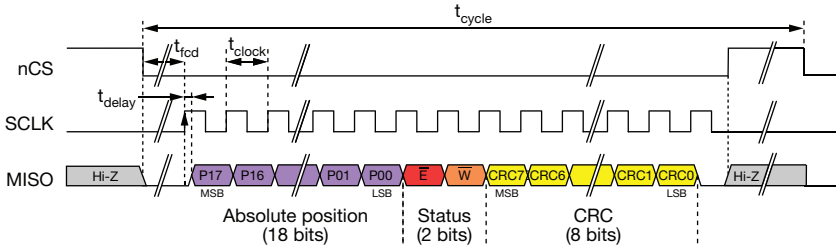


Fig. 14

SPI Timing Diagram, Self-Calibration Mode, Simple Frame (Multi-Turn Version)

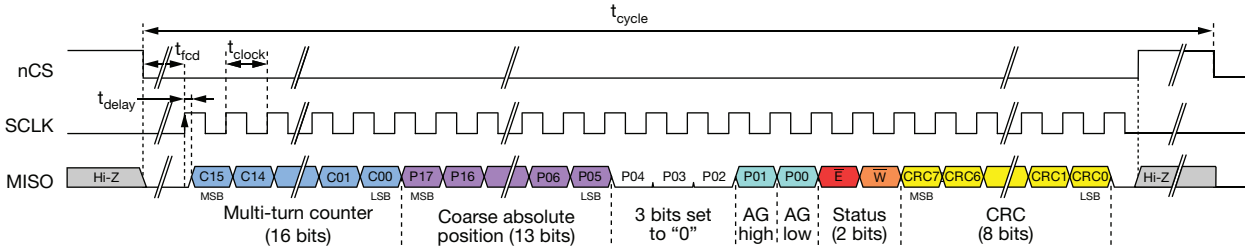


Fig. 15

SPI Timing Diagram, Self-Calibration Mode, Simple Frame (Multi-Turn Version)

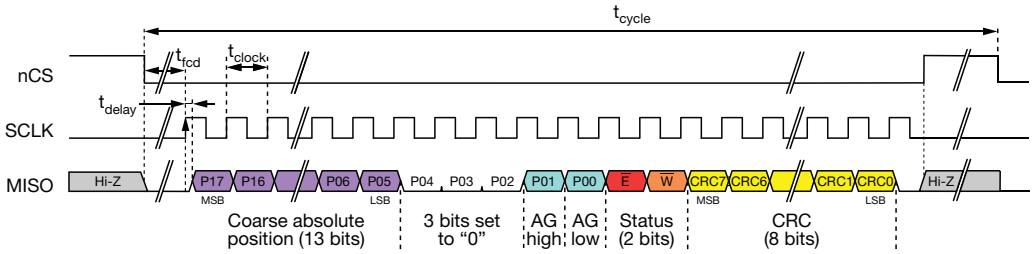


Fig. 16

SPI Timing Diagram, Customer Mode, Bidirectional Frame

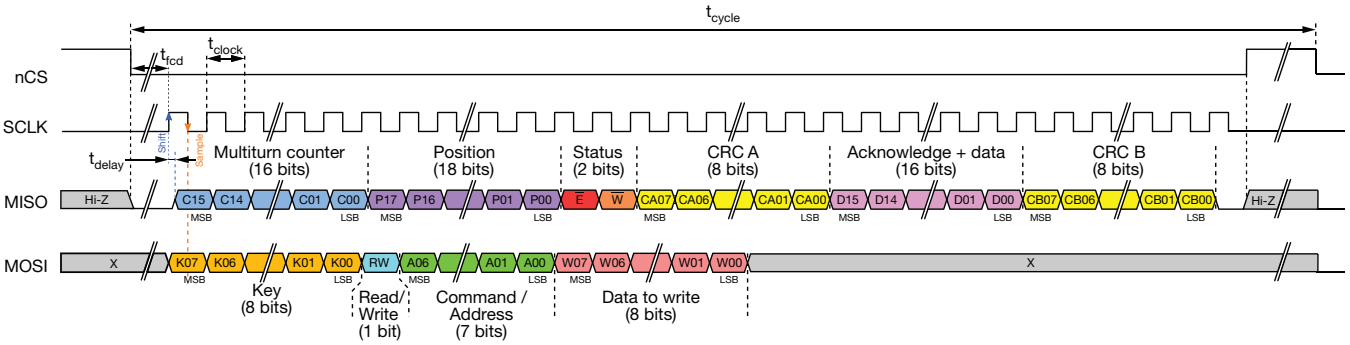


Fig. 17

SPI PARAMETERS		
PARAMETER	**INFORMATION**	
	SINGLE-TURN	**MULTI-TURN**
SPI compatible configuration	Direct connection (no daisy chain), single master, multiple slaves	
SPI interface	3.3 V LVTTL (inputs are 5 V tolerant)	
SPI mode	Mode 1 (CPOL0, CPHA1) SCLK idle state = low MISO data are shifted out on the rising edge of SCLK MOSI data are sampled on the falling edge of SCLK	
Processing time (t_{fcd})	≥ 5 µs (CS falling edge to SCLK first rising edge) (1)	
Clock frequency ($f_{clock} = 1/t_{clock}$)	100 kHz ≤ f_{clock} ≤ 3 MHz	
Request rate ($f_{cycle} = 1/t_{cycle}$)	≤ 33 kHz (treq = 30 µs) (2)	
Propagation delay (t_{delay})	70 ns (typ.) (3)	
Total number of bit (simple frame)	28	44
Total number of bit (advanced frame)	52	68
Multi-turn counter data (C15 to C00)	-	16 bits, two's complement (-32 768 to +32 767)
Absolute position data (P17 to P00)	18 bits, binary code, MSB first (0 to 262 143)	
Error bit (nE)	1 bit, active low In Customer Mode: high during normal operation / low when self-calibration failed In Airgap-Check Mode: high when airgap is valid / low when airgap is too low or too high	
Warning bit (nW)	1 bit, active low (high during normal operation / low when the encoder position moves more than ± 90° during power-off)	
Airgap status bits (AG high / AG low)	2 bits, active high "AG High" bit: high when airgap is too high, low when airgap is valid "AG Low" bit: high when airgap is too low, low when airgap is valid	
Simple frame error detection (CA07 to CA00)	CRC, 8 bits, inverted polynomial: 0x97 (X8 + X7 + X4 + X2 + X + 1) CRC start value = "0"	
CRC A data input	20 bits (P17 to nW)	36 bits (C15 to nW)
MOSI frame: key (K07 to K00)	8 bits, 0x56	
MOSI frame: read/write bit (RW)	0 = read operation 1 = write or command operation	
MOSI frame: address (A06 to A00)	7 bits (64 bytes of free user bank, from 0x40 to 0x7F)	

SPI PARAMETERS		
PARAMETER	INFORMATION	
	SINGLE-TURN	MULTI-TURN
MOSI frame: data to write (W07 to W00)	8 bits, MSB first Note: for read and command operations, the 8 bits [W07:W00] are ignored (can be 0 or any other value).	
Acknowledge + data (D15 to D00)	Read operation: D15 to D08: RW bit + address acknowledgment D07 to D00: data read from memory Write operation: D15 to D08: RW bit + address acknowledgment D07 to D00: data to write acknowledgment Command operation: D15 to D08: command acknowledgment D07 to D00: 0x00 (no data, low level)	
Error detection (CB07 to CB00)	CRC, 8 bits, inverted polynomial: 0x97 (X8 + X7 + X4 + X2 + X + 1) CRC start value = “0”	
CRC B data input	16 bits (D15 to D00)	

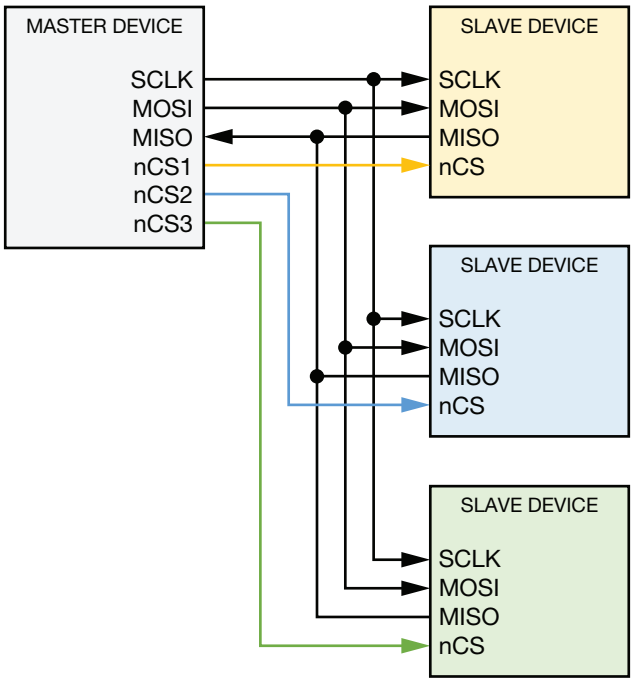
Notes

(1) Position acquisition is synchronized with the first falling edge of CLK. The first clock delay period is required for data acquisition, calculation, and storage in the communication buffer

(2) With 3 MHz master clock frequency and multi-turn version

(3) Measured with ACCSRAIKWIRESOB073 cord (20 cm) at 25 °C ambient temperature

SPI CONNECTION



SPI COMMANDS AND MEMORY REGISTERS

SPI REGISTER ACCESS			
R/W	**ADDR (HEX)**	**REGISTER**	**DEFAULT VALUES**
R	0x00	Reserved for future use	0x00
R	0x01	Reserved for future use	0x00
R	0x02	DEV_SN[31:24]	32-bits serial number
R	0x03	DEV_SN[23:16]	
R	0x04	DEV_SN[15:8]	
R	0x05	DEV_SN[7:0]	
R	0x06	DEV_ID[47:40]	48-bits device identification: RAIK060I11318FB713: 0x343137373133 RAIK060I11318FB717: 0x343137373137 RAIK060I11318FB: 0x343137363839 RAIK060I11318FB693: 0x343137363933
R	0x07	DEV_ID[39:32]	
R	0x08	DEV_ID[31:24]	
R	0x09	DEV_ID[23:16]	
R	0x0A	DEV_ID[15:8]	
R	0x0B	DEV_ID[7:0]	
R	0x0C	MFR_ID[15:8]	0x56
R	0x0D	MFR_ID[7:0]	0x59
R	0x0E	FW_MAJOR_VERSION[7:0]	Depends on the coder's embedded firmware version.
R	0x0F	FW_MINOR_VERSION[7:0]	
R/W	0x10	"0000 00" and OFFSET_ANGLE[17:16]	0x00
R/W	0x11	OFFSET_ANGLE[15:8]	0x00
R/W	0x12	OFFSET_ANGLE[7:0]	0x00
R/W	0x40 to 0x7F	Free register user bank	0x00

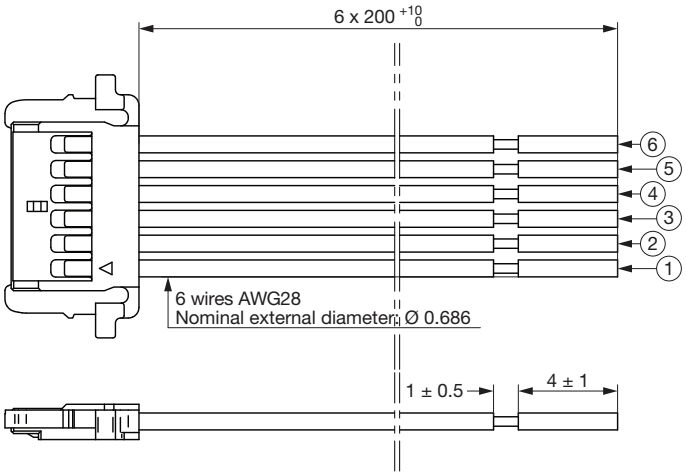
SPI COMMANDS			
R/W	**CODE (HEX)**	**COMMAND**	**DETAILS**
W	0x20	Airgap-Check	This command is only available in Customer Mode.
W	0x21	Return to Customer Mode	This command is only available in Airgap-Check state (self-calibration mode).
W	0x22	Start self-calibration process	This command is only available in Airgap-Check state (self-calibration mode).
W	0x23	Reset multi-turn counter	This command is only available in Customer Mode.
W	0x24	Apply "Zero position" offset	This command is only available in Customer Mode.
W	0x25	Reset "Zero position" offset	This command is only available in Customer Mode.

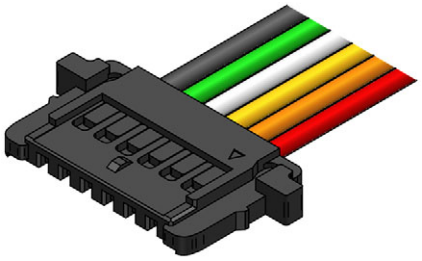
Note

- The RW bit must be set to 1 for all command operations

ACCESSORIES ON REQUEST

EXTERNAL CONNECTOR EQUIPPED OF WIRES TO OBTAIN A WIRES OUTPUT (ACCSRAIKWIRESOB073)





Note

- General tolerancing according to ISO 8015

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