

ENCODER INTERFACE MODULE V3

BiSS-C



Figure 1. ENCODER INTERFACE MODULE

SmarAct Metrology provides the **ENCODER INTERFACE - MODULE** as an accessory for the **METIRIO Encoder**. It is a compact interpolator device that directly converts sine-cosine and reference signals, provided by the **METIRIO** encoder into a position. Instead of interpreting analog signals, the digitized position can be read through BiSS-C, a widely used industrial standard interface. The **ENCODER INTERFACE MODULE** features a high-resolution data acquisition, low noise, and a compensation function for offset-, amplitude-, and phase errors. The module can directly be connected to the **METIRIO** D-Sub 15 connector.

FEATURES AND APPLICATION

Features

- Digitizes the analog encoder signals into a position
- Outputs data via BiSS-C protocol (BiSS BP3: Standard Encoder Profile)
- Input calibration using a single push button
- Dynamic input signal correction
- LED indicator for flagging degraded signal quality
- Reset button for resetting the interpolator
- Selectable output resolution (multiturn and singleturn bit width)
- Feed through of encoder I²C signals in both directions
- Access to any button-function and LED indication via host interface.

Working principle

Standard analog encoders provide analog position signals which need to be processed by a controller comprising ADCs to digitize the input signals and calculate the position via the arctan function. However, a standard interface is often beneficial for a quick and straightforward commissioning process.

For this reason, the position calculation is performed within the **ENCODER INTERFACE MODULE** and is output via BiSS-C using the standard encoder profile BP3.

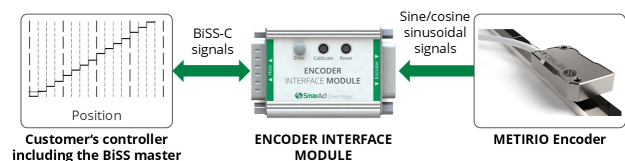


Figure 2. Typical application of the **ENCODER INTERFACE - MODULE** within a position measurement set-up

BiSS-C enables continuous process data transmission, making the communication real-time capable and deterministic. The customer's BiSS master controls the communication by applying the clock (MA). With each clock pulse, one bit of the BiSS frame is transmitted by the interface module over the SL line. Each BiSS frame includes:

- **Singleturn Data:** Represents the current position within a single period of the sine/cosine signal.
- **Multiturn Data:** Represents the accumulated count of complete sine/cosine wave cycles, including both positive and negative values.
- **Status Bits:** Provides information about the status of the encoder (e.g. warning, readiness).
- **CRC:** Used for error checking to ensure data integrity.

For a quick setup, the electronic data sheet EDS SE is provided. For further information on the BiSS-C protocol, please refer to the official documents.¹

¹<https://biss-interface.com/downloads/>

TECHNICAL DATA

General parameters

Parameter	Value	Unit
Input signal type	Sine, cosine, reference	
Output signal type	BiSS-C	
Profile	BP3	
Interpolator resolution multiturn	16, 20	bit
Interpolator resolution singleturn	4 to 16	bit
Filter and interpolator latency	5	µs
DC supply voltage (via host interface)	5 (± 5%)	V _{DC}
Input current (with METIRIO encoder and RS-422 termination)	180	mA

Table 1. General parameters

Dimensions and conditions

Parameter	Value	Unit
Encoder interface connector	D-Sub 15 female	
Host interface connector	D-Sub 15 male	
Dimensions (L x W x H)	64.0 x 41.5 x 16.6	mm
Weight	50	g
Operating temperature	0 to +50	°C
Relative humidity (non-condensing)	20 to 80	% RH

Table 2. Dimensions and conditions

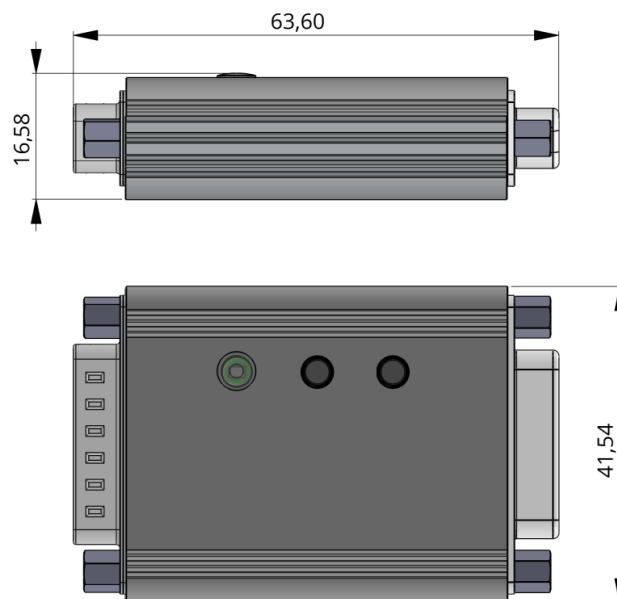


Figure 3. ENCODER INTERFACE MODULE Dimensions

Host interface specifications

The differential BiSS-C signals should be connected with twisted pair cables to ensure best signal integrity. The differential signal SL should be terminated with 120 Ω at the BiSS master's differential line receiver.

Parameter	Value (typ)	Unit	Comment
BiSS-C output signal type	RS-422		
BiSS-C differential output voltage $ V_{DD} $	3.3	V	
BiSS-C maximum input frequency f_{MA_max}	10	MHz	
RESET, CALIBRATE low level input voltage	0 to 0.5	V	
RESET, CALIBRATE high level input voltage	1.6 to 5.0	V	
RESET, CALIBRATE input pull-down resistor	1	M Ω	
$\overline{ERROR}$ output type	Open Drain		This flag corresponds to the warning flag of the BiSS-C frame.
$\overline{ERROR}$ output pull-up resistor	10	k Ω	Pull-up voltage level 3.3V
TWI SDA/SCL low level input voltage	0 to 0.9	V	
TWI SDA/SCL high level input voltage	1.5 to 5.0	V	
TWI SDA low level output voltage	< 0.3	V	
TWI SDA/SCL pull-up resistor	3.3	k Ω	Pull-up voltage level 3.3V

Table 3. Host interface specifications**Encoder interface specifications**

The **ENCODER INTERFACE MODULE** is optimized for the electrical interface of the **METIRIO** encoder. If other encoders are applied, the corresponding functionality cannot be guaranteed.

Parameter	Value (typ)	Unit
Encoder power supply voltage	3.3	V_{DC}
Sine/Cosine - differential input voltage amplitude $ V_{Diff} $	1	V
Sine/Cosine - common mode input voltage $ V_{CM} $	1.25	V
Sine/Cosine - maximum input frequency f_{max}	500	kHz
Reference - permissible input voltage V_{in} range	0 to 3.3	V
Reference - common mode input voltage $ V_{CM} $	1.65	V

Table 4. Encoder interface specifications

Host interface pinout

The host device is connected with a D-SUB 15 connector to the **ENCODER INTERFACE MODULE**. This interface outputs the BiSS-C data and provides a control interface to the module and the **METIRIO** encoder. The **ENCODER - INTERFACE MODULE** power supply is also provided through this interface. The pin assignment is shown in figure 4 and specified in table 5.

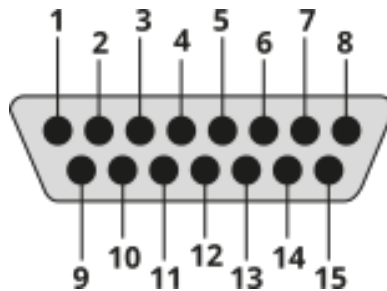


Figure 4. Pin assignment of the host interface (D-SUB 15 male connector)

Pin-number	Signal	Direction	Description
1	CALIBRATE	IN	The ENCODER INTERFACE MODULE is hold in calibration-mode during a high signal on the calibrate input pin.
2	RESET	IN	The ENCODER INTERFACE MODULE is hold in reset-state during a high signal on the reset input pin.
3	—	—	Not connected
4	GND	Power	Ground
5	MA+	In	BiSS-C input clock+
6	SL+	Out	BiSS-C slave output data+
7	—	—	Do not connect.
8	PD	In	Do not connect.
9	$\overline{\text{ERROR}}$	Out	Degraded analog sensor signals are indicated by a low signal on the error output pin. The error state is additionally signaled by the error LED. For more details see section Fault Indication.
10	SCL	In	METIRIO encoder TWI clock signal. The signal is buffered and passed to the encoder interface.
11	SDA	I/O	METIRIO encoder TWI data signal. The signal is buffered and passed to the encoder interface.
12	MA-	In	BiSS-C input clock -
13	SL-	Out	BiSS-C slave output data -
14	—	—	Do not connect.
15	V_{in}	Power	ENCODER INTERFACE MODULE DC power supply

Table 5. Pin assignment of the host interface (D-SUB 15 male connector)

Encoder interface pin description

The optical encoder is connected with a D-SUB 15 connector to the **ENCODER INTERFACE MODULE**. The pin assignment is shown in figure 5 and specified in table 6.

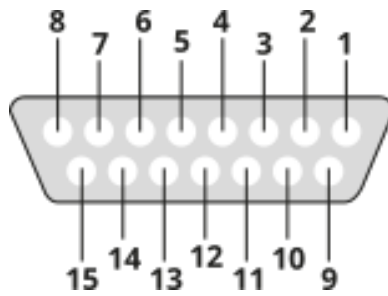


Figure 5. Pin assignment of the METIRIO encoder interface (D-SUB 15 female connector)

Pin-number	Signal	Direction	Comment
1	—	—	not connected
2	—	—	not connected
3	—	—	not connected
4	GND	Power	Encoder ground
5	Sin+	In	Encoder output SIN+
6	Cos+	In	Encoder output COS+
7	Ref+	In	Encoder output REF+
8	PD	Out	Encoder power down
9	—	—	not connected
10	SCL	Out	Encoder TWI clock
11	SDA	I/O	Encoder TWI data
12	Sin-	In	Encoder output SIN-
13	Cos-	In	Encoder output COS-
14	Ref-	In	Encoder output REF-
15	V _{Sensor}	Power	Encoder DC power supply

Table 6. Pin assignment of the METIRIO encoder interface (D-SUB 15 female connector)

Measurement range

The number of multiturn bits determines the measurement range of the sensor. The higher the number of multiturn bits, the greater the measurement range. Ideally, the number of bits should be chosen such that the required measurement range is accurately represented. For example, on a linear sensor strip, one period typically corresponds to 20 µm, which leads to the following measurement ranges:

Multiturn bits	Distance range [m]
16	-0.65 .. 0.65
20	-10.4 .. 10.4

Table 7. Multiturn resolution

By default, 16 or 20 bits are sufficient to meet the requirements of most applications.

Resolution

The number of singleturn bits determines the resolution of the position measurement. As the number of bits increases, the resolution becomes finer, leading to smaller step sizes during the digitization of the analog sine/cosine values into a digital position. For example, with a 16-bit resolution, the step size is $20\text{ }\mu\text{m} / 2^{16}$, defining the precision within a single turn. Going beyond 16-bit will not increase the resolution further because the resolution limit of the **METIRIO** is reached.

Singleturn bits	Resolution [nm]
4	1250
5	625.0
6	312.5
7	156.3
8	78.13
9	39.06
10	19.53
11	9.766
12	4.883
13	2.441
14	1.221
15	0.610
16	0.305

Table 8. Singleturn resolution

Data rate

BiSS-C allows transmission speeds of up to 10 MHz. The maximum data rate depends on the master's clock frequency and the payload per frame. The payload corresponds to the total number of bits per frame, including multibit and singleturn data, status, and CRC bits. The maximum data rate $f_{\max}$ can be estimated using the following formula. The derivation of the formula is explained in the official protocol description of the BiSS Association.

$$f_{\max} = 1 / (T_{MA} \cdot (6.5 + \text{MultiturnBits} + \text{SingleturnBits} + \text{StatusBits} + \text{CRCBits}))$$

Where T_{MA} is the master's clock period, MultiturnBits and SingleturnBits are selectable, StatusBits are fixed at 2, and CRCBits are 6 bits. In Table 9 a few examples are given.

Clock $f_{MA} = (1/T_{MA})$	MultiturnBits	SingleturnBits	StatusBits	CRCBits	Data rate
10 MHz	20	16	2	6	198 kHz
10 MHz	16	16	2	6	215 kHz
10 MHz	16	4	2	6	289 kHz
2 MHz	16	16	2	6	43 kHz
..	...	...	2	6	...

Table 9. Setting examples

BiSS-C status

Warning: The warning status is transmitted via the BiSS-C warning bit according to BiSS Profile BP3 and is based on the active-low nW signal. Consequently:

- Warning bit = 1: No warning is present (nW = High).
- Warning bit = 0: Warning is active (nW = Low).

The warning flag indicates either a missing calibration or degraded analog sensor signals, potentially caused by dirty or scratched sensor strips, or improper optomechanical alignment. In such cases, the position accuracy may be compromised and exceed the expected system accuracy. Users are advised to inspect the raw analog encoder signals and the measurement scale. This warning is non-latching and resets after each BiSS-C frame. An active warning is also indicated by the warning LED. When the LED is illuminated, the warning condition is active.

Error: The error status is transmitted via the BiSS-C error bit according to BiSS Profile BP3 and is based on the active-low nE signal. Consequently:

- Error bit = 1: No error is present (nE = High).
- Error bit = 0: Error is active (nE = Low).

The error flag indicates whether a reference mark has been detected (see Startup behaviour).

Startup behaviour

After power-up, the **ENCODER INTERFACE MODULE** immediately provides relative position data. The error flag remains active until a reference mark is detected. Once the first reference mark is detected, the position resets to 0, and the absolute position becomes valid.

The use of distance-coded sensor strips is not generally supported. Please contact our Sales team for further information.

Custom settings

The factory configuration is designed to cover most applications. However, the configuration can also be adjusted via a BiSS-C master device. For further information, please contact our Sales team.

Please be aware that changing any settings is happening at your own risk and can lead to failure of the device!

Order code

EC-IM-V3.0-BiSS-MT16-ST16

The MT-value indicates the length of the multiturn portion of the position data in bits. Valid values: 16, 20

The ST-value indicates the length of the singleturn portion of the position data in bits Valid range: 4 - 16

Contact

Germany

**SmarAct Metrology
GmbH & Co. KG**

August-Wilhelm-Kuehnholz-Str. 1
D-26135 Oldenburg
Germany

T: +49 441 - 800 879 0
Email: metrology@smaract.com
www.smaract.com

France

SmarAct GmbH

Schuetten-Lanz-Strasse 9
26135 Oldenburg
Germany

T: +49 441 - 800 879 956
Email: info-fr@smaract.com
www.smaract.com

USA

SmarAct Inc.

2140 Shattuck Ave. Suite 302
Berkeley, CA 94704
United States of America

T: +1 415 - 766 9006
Email: info-us@smaract.com
www.smaract.com

China

Dynasense Photonics

6 Taiping Street
Xi Cheng District,
Beijing, China

T: +86 10 - 835 038 53
Email: info@dyna-sense.com
www.dyna-sense.com

Natsu Precision Tech

Room 515, Floor 5, Building 7,
No.18 East Qinghe Anning
Zhuang Road,
Haidian District
Beijing, China

T: +86 18 - 616 715 058
Email: chenye@nano-stage.com
www.nano-stage.com

**Shanghai Kingway Optech
Co.Ltd**

Room 1212, T1 Building
Zhonggong Global Creative Center
Lane 166, Yuhong Road
Minhang District
Shanghai, China

Tel: +86 21 - 548 469 66
Email: sales@kingway-optech.com
www.kingway-optech.com

Japan

Physix Technology Inc.

Ichikawa-Business-Plaza
4-2-5 Minami-yawata,
Ichikawa-shi
272-0023 Chiba
Japan

T/F: +81 47 - 370 86 00
Email: info-jp@smaract.com
www.physix-tech.com

South Korea

SEUM Tronics

1109, 1, Gasan digital 1-ro
Geumcheon-gu
Seoul, 08594,
Korea

T: +82 2 - 868 10 02
Email: info-kr@smaract.com
www.seumtronics.com

SmarAct Metrology GmbH & Co. KG develops sophisticated equipment to serve high accuracy positioning and metrology applications in research and industry within fields such as optics, semiconductors and life sciences. Our broad product portfolio – from miniaturized interferometers and optical encoders for displacement measurements to powerful electrical nanoprobe for the characterization of smallest semiconductor technology nodes – is completed by turnkey scanning microscopes which can be used in vacuum, cryogenic or other harsh environments.

We maintain the complete production in house for a high level of customization so that we can always provide you the optimal individual or OEM solution. We also offer feasibility studies, measurement services and comprehensive support to accompany you along your projects.

Headquarters

SmarAct GmbH

Schuetten-Lanz-Strasse 9
26135 Oldenburg
Germany

T: +49 441 - 800 879 0
Email: info-de@smaract.com
www.smaract.com

USA

SmarAct Inc.

2140 Shattuck Ave. Suite 302
Berkeley, CA 94704
United States of America

T: +1 415 - 766 9006
Email: info-us@smaract.com
www.smaract.com