ENCODER INTERFACE MODULE

SmarAct | metrology

Figure 1. ***ENCODER*** *INTERFACE* ***MODULE***

SmarAct Metrology provides the **ENCODER** INTERFACE **MODULE** (**IM**) as an accessory for the **METIRIO** Encoder.

The **ENCODER** INTERFACE **MODULE** is a compact 2-port I/O device that converts sine-cosine and reference signals, provided by the **METIRIO** encoder into a differential quadrature output, so called ABZ signals. This is useful, if the customer's controller is incapable to interpret the analog signals. It features a high-resolution data acquisition, low noise, and user preset compensation function for offset-, amplitude-, and phase errors. The module can directly be connected to the **METIRIO** A1 D-Sub 15 connector.

FEATURES AND APPLICATION

Features

- Converts analog encoder signals into ABZ
- Input calibration using a single push button
- Dynamic input signal correction
- LED indicator for flagging operational failure
- Selectable output resolution
- AB output frequency up to 12.5 MHz
- Feed through of encoder I^2C signals in both directions

Working principle

Standard analog encoders provide analog position signals which need to be processed by a controller comprising ADCs to digitizes the input signals and calculate the position via the arctan function. However, a lot of controllers are designed to interpret standardized quadrature signals (ABZ), instead.

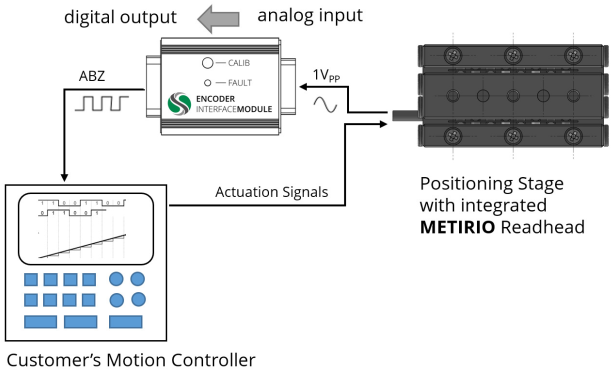

Figure 2. *Block diagram of a closed-loop control setup*

The **ENCODER** INTERFACE **MODULE** is can be used as an adapter for signal conversion. The input D-Sub 15 connector is matched to the pin-assignment of the **METIRIO** A1 variant. Figure 2 shows an exemplary connection setup of a closed loop motion control unit for customer controllers which only accept ABZ as input signals. In this case the customer's controller calculates the position by counting the increments of state-changes.

The period of the input signals corresponds to one period of the measuring scale, which is 20 µm for **METIRIO** encoders. Depending on the pre-programmed interpolation factor I, the ABZ output signals can have many more periods per scale-period. The A and B outputs are rectangular signals shifted by $\pi/4$. One period of the rectangular signal can be divided into 4 signal states as shown in figure 3. The number of signal states per scale-period is then $n = 2^I$. For instance with an interpolation of 4 bit, the position increment is 16 times smaller than one scale-period. A state change indicates a displacement by one increment. The direction of the state changes indicates the direction of motion.

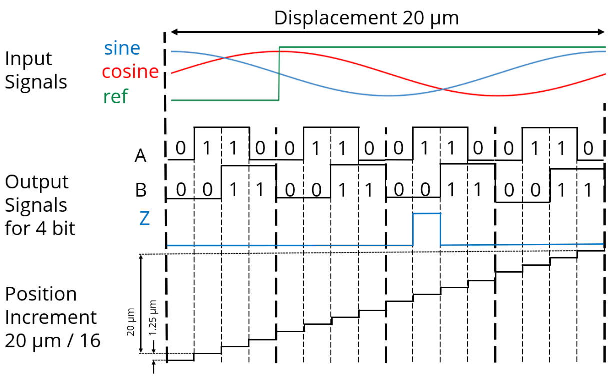

Figure 3. *Input and output signals for 4 bit interpolation*

TECHNICAL DATA

The **ENCODER** INTERFACE **MODULE** is precisely tuned to the input levels of the **METIRIO** output signals. If other input levels are applied, the corresponding functionality cannot be guaranteed.

General

Parameter	Specification	Unit
Encoder interface connector	D-Sub 15 female	
Output connector	D-Sub 15 male	
Dimensions (L X W x H)	64 x 41 x 16	mm
Operating Temperature	0 to +50	°C

Table 1. *General parameters*

Power supply requirements

Parameter	Specification	Unit
DC supply voltage	4.75 – 5.25	V_{DC}
Input current (with **METIRIO** encoder and RS422 termination)	200	mA

Table 2. *Power supply requirements*

Encoder interface specification

Parameter	Specification	Unit
Encoder supply voltage (internal)	3.3	V
Sine/Cosine - differential input voltage amplitude range $\|V_{Diff}\|$	20 – 700	mV
Sine/Cosine - common mode input voltage range $\|V_{CM}\|$	0.7 – 1.85	V
Sine/Cosine - maximum input frequency f_{max}	700	kHz
Reference - permissible input voltage range V_{in}	0 – 3.3	V
Reference - common mode input voltage range $\|V_{CM}\|$	0.7 – 1.85	V

Table 3. *Interface specifications*

ABZ quadrature output interface specifications

Parameter	Specification	Unit
ABZ output Signal Type	RS-422	
ABZ differential output voltage $\|V_{DD}\|$	5	V
Maximum ABZ output frequency $f_{max,ABZ}$	12.5	MHz

Table 4. *ABZ interface specifications*

Encoder interface pin description

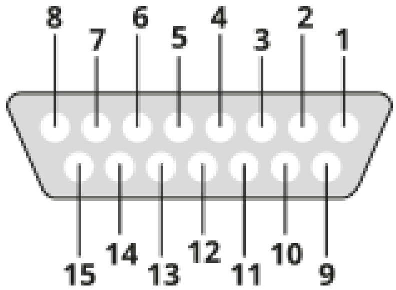

Figure 4. *D-Sub 15 female*

Pin-number	Description	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 input
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_{sen}	Power	Encoder V_{DD}

Table 5. *D-Sub 15 Female Pin description*

ABZ quadrature output interface pinout

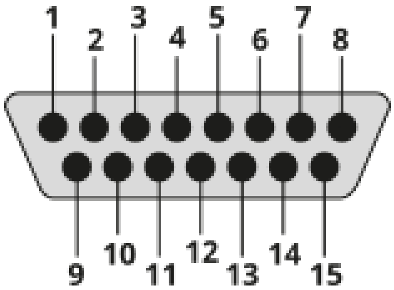

Figure 5. *D-Sub 15 male*

Pin-number	Description	Direction	Comment
1	—	—	not connected
2	IRQ	Out	Fault Indicator (3.3 V push-pull, low active). Additionally the fault indicator drives the integrated fault LED.
3	CALIB	I/O	Device enters calibration mode on falling edge of CALIB Can be triggered by the button or via an open collector signal on the connector.
4	EXT-GND	Power	ground
5	A+	Out	ABZ output A+
6	B+	Out	ABZ output B+
7	Z+	Out	ABZ output Z+
8	PD	IN	encoder power down. Signal through the **IM** to the encoder.
9	—	—	not connected
10	SCL	In	TWI clock. Signal through **IM** to the encoder.
11	SDA	I/O	TWI Data. Signal through **IM** to the encoder.
12	A-	Out	ABZ output A-
13	B-	Out	ABZ output B-
14	Z-	Out	ABZ output Z-
15	V_{in}	Power	+5V DC supply voltage of the interface module

Table 6. *D-Sub 15 Male Pin description*

Factory Configuration
The **ENCODER** INTERFACE **MODULE** is configurable to meet the output resolution as desired for the individual application. The interpolation factor I is programmed during factory calibration. Values between 2 and 20 bit can be chosen. When a measuring scale with P = 20 µm pitch is used, which is the standard for **METIRIO** encoders, then the resolution is given by

$$R = \frac{20\ \mu\text{m}}{2^{I}}, \tag{1}$$

which is the smallest detectable displacement increment.

> In any case, to avoid rounding errors, be sure to process the increments R with a sufficient number of decimal places within your controller. Otherwise, large position errors can occur when processing large distances.

Because the maximum output frequency is limited to 12.5 MHz, the input frequency needs to be limited according to the chosen interpolation. Theoretically the maximum input limit is

$$f_{in,max} \leqslant \frac{4 \cdot 12.5\,\text{MHz}}{2^I}, \qquad (2)$$

but the actual maximum input bandwidth is smaller than the theoretical value, because of the filtering and correction algorithms. The tested values are given in table 7.
For this reason, the maximum resolution which can be chosen depends on the maximum displacement velocity in your application: $v_{max} = P \cdot f_{in,max}$, where P = 20 µm is the scale periodicity. If, on the other hand, a certain velocity is required, the interpolation should be limited.

> Please limit the displacement velocity in your measurement setup to the values given in table 7, depending on the chosen resolution. Exceeding these values leads to the loss of counting pulses and thus to noticeable position errors.

I [bit]	f_{in} [kHz]	v_{max} [mm/s]	R [nm]**
2	500.00*	10000*	5000.00
3	500.00*	10000*	2500.00
4	500.00*	10000*	1250.00
5	500.00*	10000*	625.00
6	500.00*	10000*	312.50
7	371.09	7422	156.25
8	185.55	3711	78.13
9	92.77	1855	39.06
10	46.38	928	19.53
11	23.19	464	9.77
12	11.59	232	4.88
13	5.79	116	2.44
14	2.89	58	1.22
15	1.45	29	0.61
16	0.72	14	0.31
17	0.36	7	0.15
18	0.18	4	0.08
19	0.09	2	0.04
20	0.04	1	0.02

Table 7. *Allowed maximum input frequencies for different resolutions.*
**** METIRIO*** *Encoders are limited to 500 kHz bandwidth and 10 m/s displacement velocity. Tests with higher frequencies have not yet been performed.*
******** *Values are rounded. To avoud rounding errors, use equation 1*

Auto calibration

The input signals can comprise different errors depending on the opto-mechanical and electrical setup of the connected encoder. Normally the input signals shall represent a perfect circle in the Lissajous-representation, but the **ENCODER** INTERFACE **MODULE** provides automatic calibration functions for the sensor signals, if these are not totally perfect.

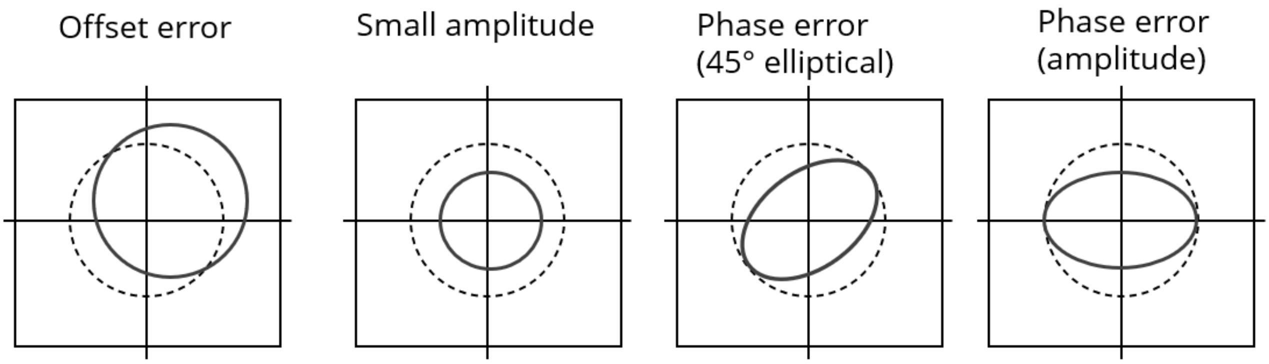

Figure 6. *Possible errors of analog input signals*

During calibration gain, offset, sine and cosine balance, as well as phase correction values are estimated. The calibration is performed by means of the **„Calib“-push-and-hold button**, or by pulling the **Calib-PIN** low when operating in an open collector configuration. During the calibration, the Interface Module anticipates at least ten sine / cosine and one reference pulse to optimize the signals in terms of lowest error and jitter. The calibration is finished when releasing the button or the Calib signal. The correction values are stored in an internal EEPROM and loaded after each power cycle. During operation the values are adjusted continuously.

Calibration Quickstart:

1. Connect the encoder to the Interface Module and make sure the supply voltage of the Interface Module (5V) is applied.
2. Press and hold the „Calib“-button or pull the Calib-PIN low.
3. Move the encoder over a distance of at least 10 scale-periods (200 μm). Make sure that also one reference mark is passed during movement. It is recommended to move even slower than given in table 7 during this procedure.
4. Release the „Calib“-push-and-hold button or set the Calib-PIN high again.
5. After calibration the Fault LED can be active.
6. Power-cycle the Interface Module. The Fault LED will stop shining.

The width of the output reference pulse Z is one state of the ABZ signals (as seen in figure 3. The width of the input reference pulse needs to be about one period of the analog signals (input signal condition). During calibration the position of the output reference pulse Z, which is therefore much narrower will be set to the center position of the input reference pulse. This position is stored to the memory of the **ENCODER** INTERFACE **MODULE** until a new calibration procedure is performed, even if the center position of the input reference pulse changes for some reason (for example due to hysteresis when moving forward and backward).

Fault Indication

The „Fault“ LED and the fault indication at pin 2, indicates that output quadrature pulses are missing because the frequency of the analog input signals was too high. This results in an incorrect position after evaluation of the quadrature pulses. The fault is latched until a power cycle.

Order code

EC-IM-V1.0-ABZ-R02 ... R15 The R-value *R02 ... R15* indicates the desired interpolation factor given in bit.

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