Application Note

FESTO

CMMT-AS-MP Position sensor difference monitoring with linear encoder

This Application Note describes how to configure and run the CMMT-AS-MP with servomotor, linear toothed belt axis with 2nd linear encoder to monitor the position difference between the motor encoder 1 [X2] and linear encoder 2 [X3] of the linear toothed belt drive.

CMMT-AS-MP

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1   Components/Software used

1.1   Software Used

Type/Name	Software Version
FAS…Festo Automation Suite	V2.8.0.417
CMMT-AS Plug-in (FAS)	2.8.2.0

Table 1.1: Software used

1.2   Hardware Used

Type/Name	Firmware Version
CMMT-AS-MP	FW V352 (35.9.2.5078)
EGC-80-250-TB-KF-0H-GK-M2	Toothed belt drive with displacement encoder (M2: resolution 10 µm with 4-fold evaluation)

Table 1.2: Hardware used

2   APPLICATION DESCRIPTION

2.1   Use Case example

A target for this system is e.g. to brake and block the movement of the linear toothed belt axis in vertical mounting position in case of toothed belt break (i.e. due to wear/overload) by activating an additional clamping unit, which is holding the linear movement of the toothed belt drive, mechanically connected to the carriage of the axis.

2.2   Realization

To achieve the defined target, we are using here a 2nd linear encoder attached to the toothed belt drive to monitor the movement of the carriage and an additional clamping unit for the carriage of the axis. This additional clamping unit can come e.g. with the Festo toothed belt axes of type EGC-TB-KF with any of the possible variants for clamping unit

- 1HL Holding function, 1-channel, left
- 1HR Single-channel holding function, right
- 2H Holding function, 2-channel

or with any other clamping units from the market.
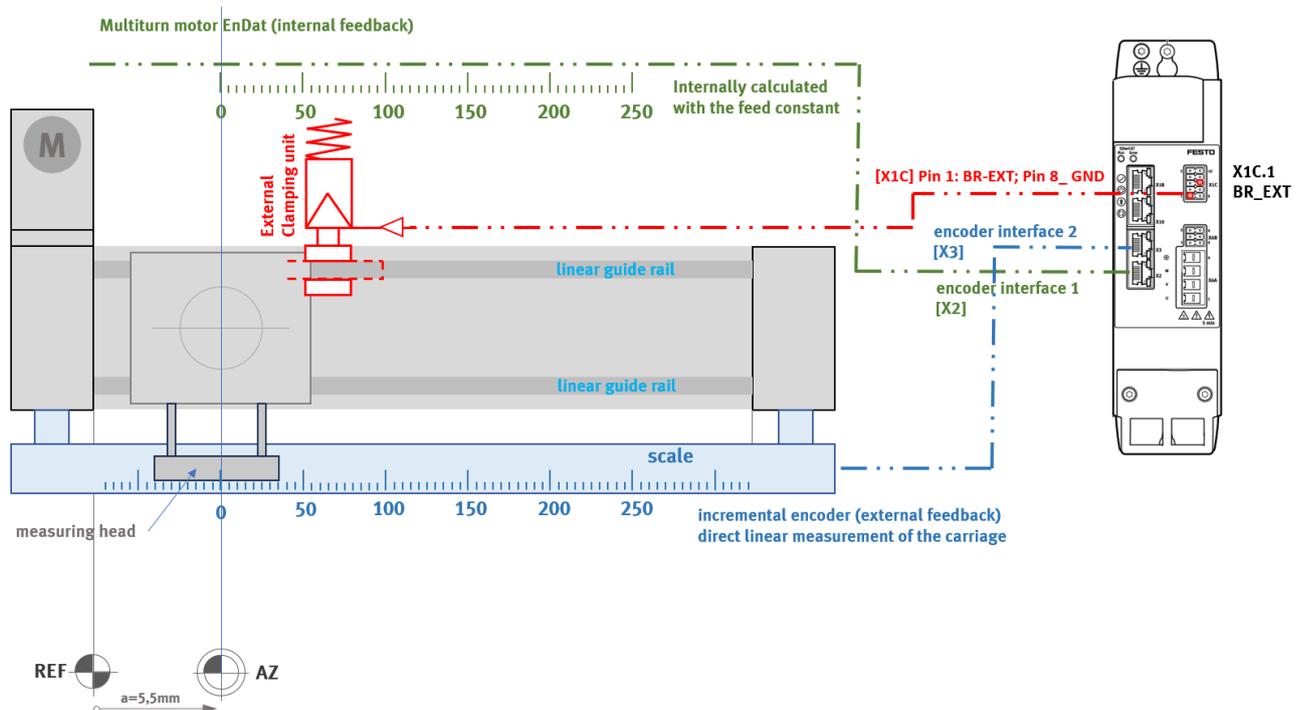
Fig. 1:   principal schematic (REF…reference point; AZ…Axis Zero Point Offset)

2.3   Main principle

The CMMT-AS-MP is monitoring continuously the position difference between the actual position of the motor encoder 1 (encoder interface [X2]) and the actual position of the linear encoder 2 (encoder interface [X3]).

The monitoring of the position difference between encoders are active when

- Two encoders are parameterised
- AND the synchronisation of both encoders is activated
- AND both encoders are homed.

The linear encoder is attached to the toothed belt axis and is connected to the carriage, allowing for a direct measurement of the actual position of the moving carriage. Whenever, for example, the toothed belt breaks, the carriage immediately starts to move downwards due to gravitational force, and the value of the position difference increases.

2.3.1 Actual position difference

The actual value position difference encoder monitoring is offered by the parameter P1.4644.0.0.
/Axis1/Movement monitoring group[0]
ID Px. 4644 Specifies the actual position difference between encoder 1 and encoder 2.

▼ /Axis1/Movement monitoring group[0] (94) ⟳		
P1.4644.0.0	Actual value position difference encoder monitoring	-0,0004563 m

Fig. 2: FAS‹‹Parameter list. P1.4644.0.0 Specifies the actual position difference between encoder 1 and encoder 2.

2.3.2 Actual positions 1 and 2

The actual positions from encoder 1 and encoder 2 you can get from these two following signals
/System/Encoder interface group[0]
P0.11601.0.0 Absolute Position in user units [X2] (multiturn encoder motor)
/System/Encoder interface group[1]
P0.11601.1.0 Absolute Position in user units [X3] (incremental encoder)

▼ /System/Encoder interface group[0] (35) ⟳		
P0.11601.0.0	Absolute position in user units	192,6695914 mm
▼ /System/Encoder interface group[1] (35) ⟳		
P0.11601.1.0	Absolute position in user units	193,1258651 mm

Fig. 3: FAS‹‹Parameter list. P0.11601.0.0 and P0.11601.1.0
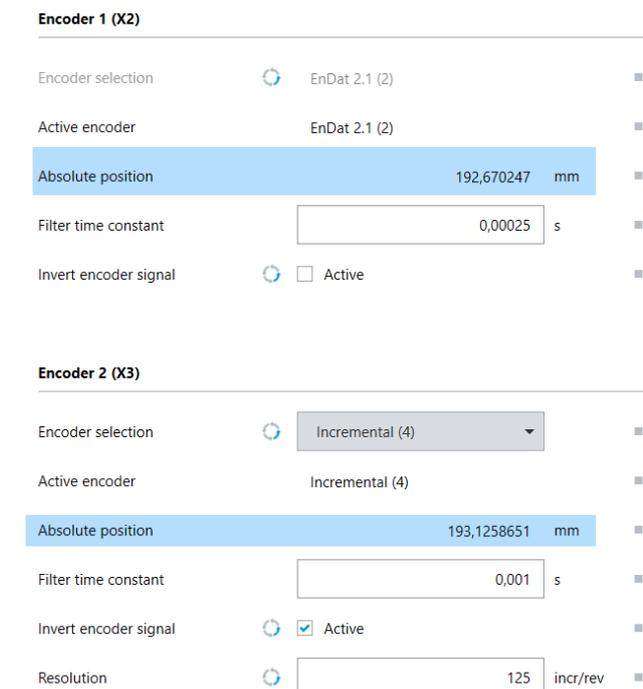
Encoder 1 (X2)

Encoder selection	⟳	EnDat 2.1 (2)	▪
Active encoder		EnDat 2.1 (2)	▪
Absolute position		192,670247 mm	▪
Filter time constant		0,00025 s	▪
Invert encoder signal	⟳	☐ Active	▪

Encoder 2 (X3)

Encoder selection	⟳	Incremental (4) ▼	▪
Active encoder		Incremental (4)	▪
Absolute position		193,1258651 mm	▪
Filter time constant		0,001 s	▪
Invert encoder signal	⟳	☑ Active	▪
Resolution	⟳	125 incr/rev	▪

Fig. 4: FAS‹‹Encoder Interface

2.3.3   The following error (position difference)

The following error (position difference) between the encoders is generated when the position difference is outside the set comparator. The comparator is defined by a monitoring window and a damping time.

/Axis1/Movement monitoring group[0]
ID Px. 4642 Damping time encoder monitoring position

> Specifies the damping time for encoder monitoring. The signal is set if the position difference for the specified duration is outside the monitoring window. If the position difference is within the monitoring window, the required damping time re-starts when the difference is outside the window again.

/Axis1/Movement monitoring group[0]
ID Px. 4643 Monitoring window encoder position

> Specifies the monitoring window for the position difference. The monitoring window is set symmetrically to the setpoint value pattern (window width = 2x parameter).

When the position difference between encoder 1 and encoder 2 is outside the monitoring window for the specified duration the error reaction of the generated diagnosis message ID Dx. 00133 'Position difference encoder 1 to encoder 2 too large' is being triggered.
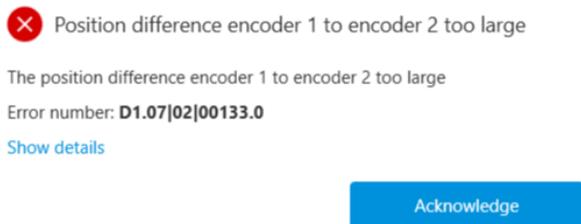
Fig. 5:   Error message in FAS

2.3.4   Error Classification

To use this error we have to parameterized the error reaction before, because it set per default to 'do not save (0)'. A typical setting is 'Stop category 0 (4096)'. With this stop category the power stage is being switched off immediately and as well the brake are being closed immediately. This is the advantage of this stop category 0 to close the brakes as fast as possible in comparison between stop category 1 and 2. With this stop category, the power stage is switched off immediately, and the brakes are also closed immediately.

Error Messages		
ID	**Name**	**Category (actual configured)**
D1.07|02|00133.0	Position difference encoder 1 to encoder 2 too large	Stop category 0 (4096) ▾

Fig. 6:   FAS‹‹Diagnosis ‹‹ Error Classification

or

ID ▼	Name ▼	Value ▼	Unit ▼	▼
▼ **/Axis1/Movement monitoring group[0] (94)** ⟳				
P1.4645.0.0	Diagnostic category: Position difference encoder 1 to encoder 2 too large	Stop category 0 (4096) ▾		▪

Fig. 7:   FAS‹‹Parameterization‹‹Parameter List ‹‹ P1.4645.0.0 Diagnostic category

2.3.5 Error, stop category 0

The output stage is switched off immediately after the error has occurred. The brake locks on drives with brake.

When this error event is then coming up, the external brake is as well engaged and block/brake then finally the movement of the linear axis.

3 Commissioning with FAS (Festo Automation Suite)

3.1 Parameterization of the 2nd encoder

3.1.1 Encoder interface ›› Encoder selection of position control

When you want to have the 2nd linear encoder only for monitoring e.g. a toothed belt break, then you can keep the default setting of the encoder selection of the position control to 'Encoder interface 1 (0) [X3]'. This means, we use the actual position from the servo motor encoder for position control.

Encoder Selection of Position Control

Encoder channel   Encoder interface 1 (0) ▼

Fig. 8:   Encoder Interface ‹‹ Encoder Selection of position Control. Parameter P1.122.0.0 Encoder Channel

When you use the 2nd linear encoder additionally to improve the positioning accuracy, then you can set the encoder channel to 'Encoder interface 2 (1) [X3]' to evaluate the actual position information from the 2nd encoder for the position controller (direct position measuring of the carriage).

Encoder Selection of Position Control

Encoder channel   Encoder interface 2 (1) ▼
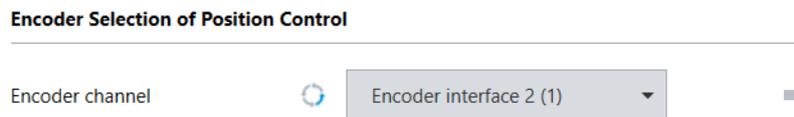
Fig. 9:   Encoder Interface ‹‹ Encoder Selection of position Control. Parameter P1.122.0.0 Encoder Channel

3.1.2 Encoder interface ›› Feed constant

Set 'Encoder interface 2' to 5,0 mm/r (please see appendix 'Displacement encoder EGC-M1/2')

Feed constant

Encoder interface 1		90,00	mm/r
Encoder interface 2 (user defined)		5,00	mm/r

Fig. 10: Encoder Interface ‹‹ Feed Constant ‹‹ Encoder interface 2 (user defined)

3.1.3 Encoder interface ›› Encoder 2 [X3]

- Set parameter P0.11616.1.0 (Encoder selection) to 'Incremental (4)'
- If needed, invert the encoder signal with parameter P1.1171.0.1 (Invert encoder signal)
- Set parameter P0.10040.1.0 (resolution) to 125 inc/rev (please see appendix 'Displacement encoder EGC-M1/2')

Encoder 2 (X3)

Encoder selection	Incremental (4) ▼	
Active encoder	Incremental (4)	
Absolute position	131,8614095	mm
Filter time constant	0,001	s
Invert encoder signal	☑ Active	
Resolution	125	incr/rev
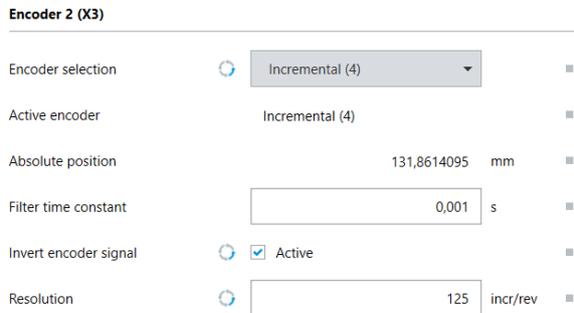
Fig. 11: Encoder Interface ‹‹ Encoder 2 (X3)

3.1.4 Parameterization of the position difference behavior

Please set the damping time and monitoring window position which fits to your application needs to trigger the error not in a normal operation cycle and not too late in case e.g. of the event when the toothed belt is breaking.

ID Px. 4642 Damping time encoder monitoring position
ID Px. 4643 Monitoring window encoder position

Note:
> A linear toothed belt drive with their nominal specified feed constant has in principle deviations from the specified nominal value.

3.1.5 Practical example

EGC-80-220-TB-KF-0H-GK-M2

The feed constant is specified as a nominal value of 90 mm/rev. The nominal feed constant differs from reality and must be considered when setting the monitoring window for the encoder position.

- The encoder selection of the position control to 'Encoder interface 1 (0) [X3]
  - ⇨ multiturn encoder motor

- P0.11601.0.0 Absolute Position in user units [X2] (multiturn encoder motor)
  - ⇨ 180,00 mm = 2 motor revolutions

- P0.11601.1.0 Absolute Position in user units [X3] (incremental encoder)
  - ⇨ 180,40 mm

0.4 mm position difference after 180 mm stroke (180 mm / 90 mm/rev = 2.0 rev => 0.2 mm/rev). Such deviations must be considered when setting the monitoring window for the encoder position; otherwise, an error is triggered during normal operation.
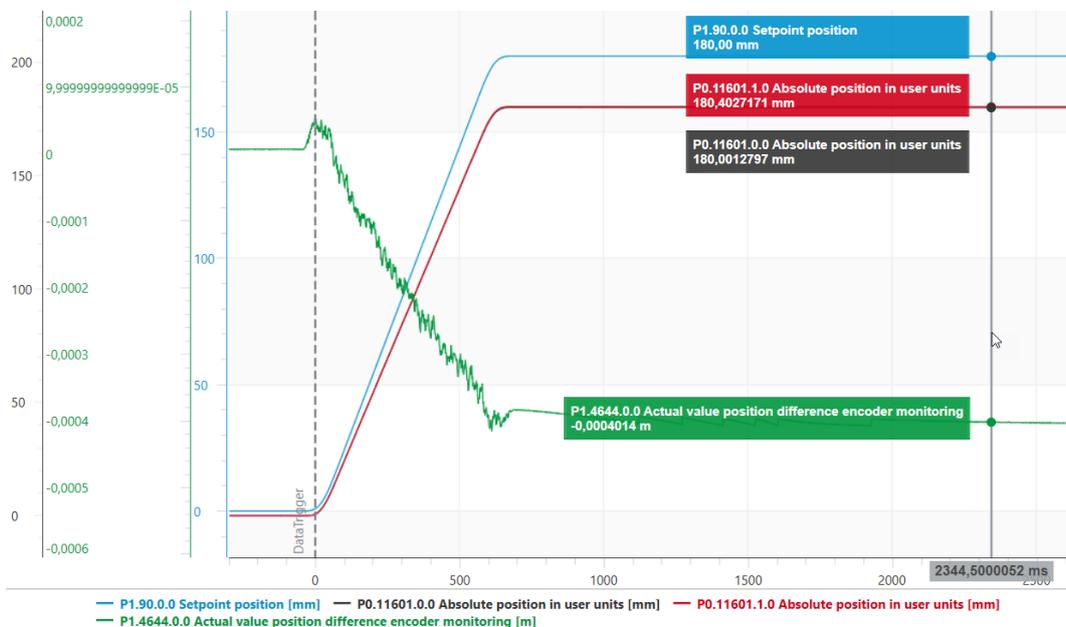

Fig. 12: Trace from FAS without adaption the feed constant

Another option is to adapt the determined feed constant in the parameterization. This would be then from our practical example 0,2 mm/rev => 90,2 mm.

Fig. 13: Encoder Interface‹‹Feed Constant‹‹Encoder interface 1

With this adaption we reach then in the normal operation an insignificant position difference of 7,2 μm in stand-still after two motor revolutions = 180 mm linear.
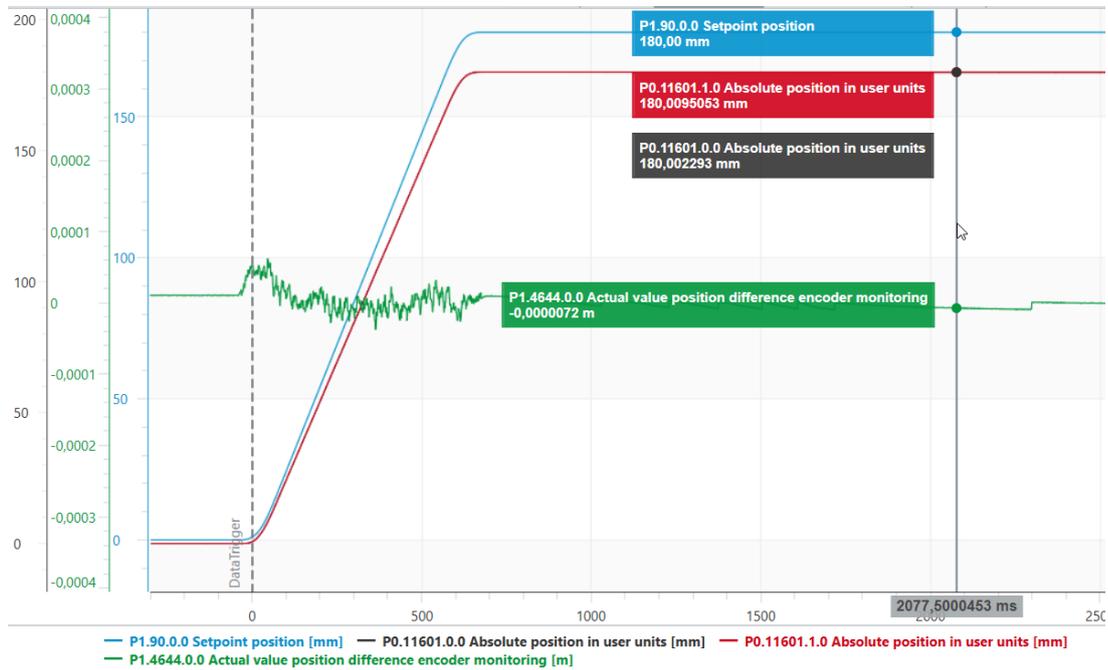

Fig. 14:   Trace from FAS with adaption the feed constant

4   Example: Demonstration of the position shift between encoder 1/2

ID Px. 4642 Damping time encoder monitoring position

⇨   1 ms

ID Px. 4643 Monitoring window encoder position

⇨   0,4 mm

ID Px. 4645 Diagnostic category: Position difference encoder 1 to encoder 2 too large

⇨   Stop category 0 (4096)

The error Dx. 00133 'Position difference encoder 1 to encoder 2 too large' is being triggered when the position difference is bigger than 0,4 mm for min. 1 ms. As well the Bit 5 (FEE… Following error position discrepancy between encoder 1 and encoder 2) changed to TRUE in parameter Px. 460 Movement monitoring status.
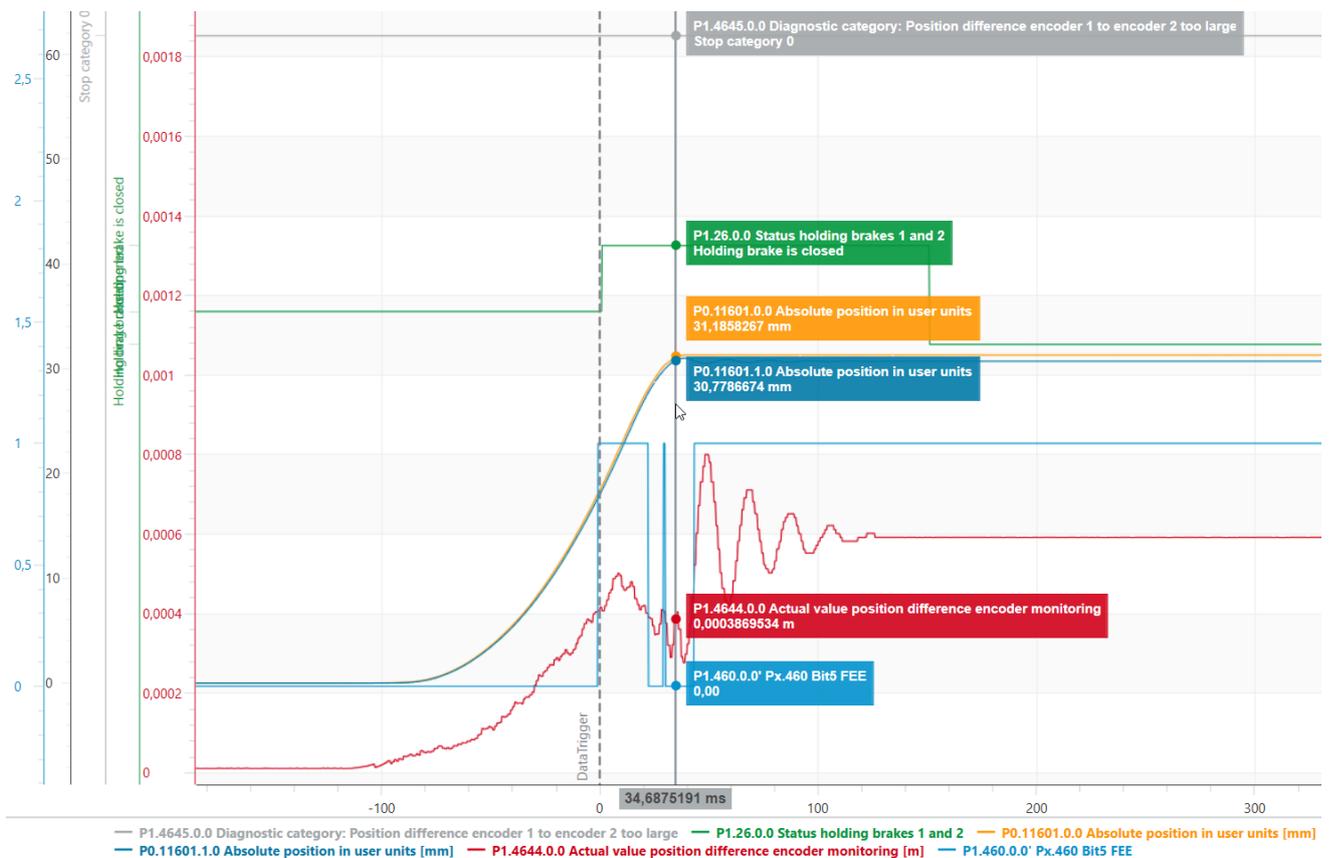

Fig. 15:   Trace with DataTrigger to Dx. 00133 'Position difference encoder 1 to encoder 2 too large'

5 Displacement encoder EGC-M1/2

In general, the value for the feed constant and resolution depends on the encoder type used. The feed constant for a linear encoder type refers to the length between 2 zero pulses or the pole pitch.

EGC-M1
Zero pulse = cyclically every 5 mm
Resolution encoder 2 = Feed Constant Encoder 2 / graduation period each channel without quadric evaluation
= 5,00 mm / 0,01 mm = 500

EGC-M2
Zero pulse = cyclically every 5 mm
Resolution encoder 2 = Feed Constant Encoder 2 / graduation period each channel without quadric evaluation
= 5,00 mm / 0,04 mm = 125
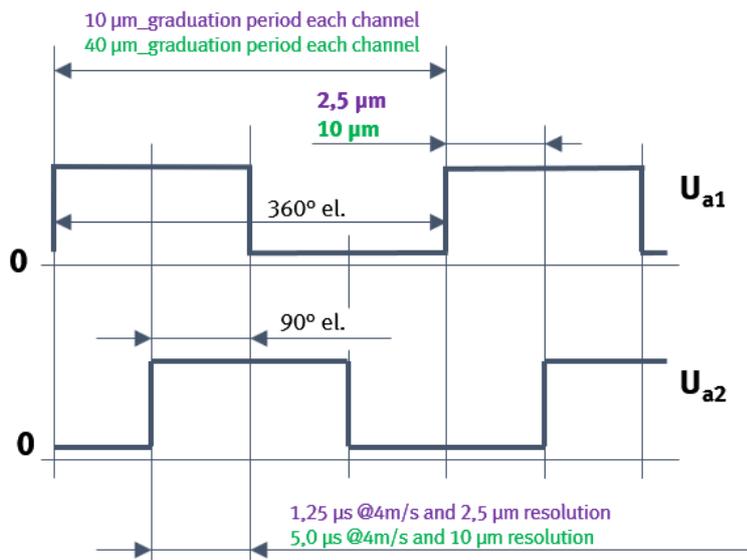
Fig. 16: Resolution
EGC-M1: 2,5 µm_4 fold evaluation
EGC-M2: 10 µm_4 fold evaluation
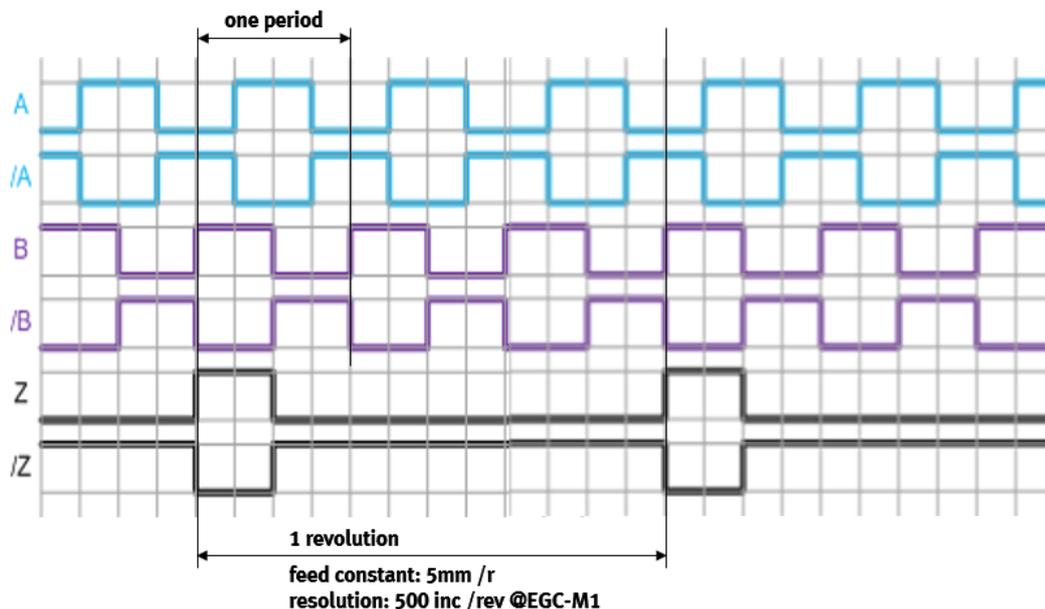
Fig. 17: zero pulse and feed constant