Netzer

DS-25
PRODUCT GUIDE

Absolute
Rotary Encoder

Hollow Shaft
Three-plate

HARSH ENVIRONMENT

INDUSTRIAL AUTOMATION

MEDICAL ROBOTICS

SPACE


Netzer

Table of Contents

1. DS Encoders Introduction

Designed to meet the requirements of the most demanding applications

The DS series of Electric Encoders™ are a line of encoders designed for harsh environment applications.

These encoders are based on capacitive technology which have been developed and improved for over 20 years by Netzer Precision Position Sensors.

The DS encoders are characterized by the following features that sets them apart from other similar encoders:

- Low profile (<7 mm)
- Hollow shaft (Stator / Rotor)
- No bearings or other contact elements
- High resolution and excellent precision
- Immunity to magnetic fields
- High tolerance to shock, moisture, EMI, RFI
- Very low weight
- Holistic signal generation and sensing
- Digital interfaces for absolute position

The holistic structure of the DS Electric Encoder™ makes it unique. Its output reading is the averaged outcome of the entire circumference area of the sensor. This inherent design characteristic provides the DS encoder with outstanding precision and accuracy.

The absence of components such as ball bearings, flexible couplers, glass discs, light sources & detectors, along with very low power consumption, enables the DS encoders to deliver virtually failure-free performance.

2. Technical Specifications

General

Angular resolution	17-21 bit
Nominal position accuracy	±0.020°
Nominal position extended accuracy (EA)	±0.010°
Repeatability	±0.001°
Maximum operational speed	4,000 rpm
Measurement range	Single turn absolute position
Build In Test BIT	Optional
Rotation direction	Adjustable CW/CCW

* Default same direction from bottom side of the encoder

Mechanical

Allowable mounting eccentricity	±0.1 mm
Allowable axial mounting tolerance	±0.1 mm
Rotor inertia	11 gr · mm^2
Total weight	10 gr
Outer Ø /Inner Ø/ Height	25 / 6 / 7 mm
Material (stator, rotor)	Ultem™ polymer / TRVX-50

Electrical

Supply voltage	5V ± 5%
Current consumption	~90 mA
Interconnection	#30 shielded cable
Communication	SSi, BiSS-C
Output code	Binary
Serial output	Differential RS-422
Clock frequency	0.1 ÷ 5.0 MHz
Position update rate	35 kHz (Optional - up to 375 kHz)

Environmental

EMC	IEC 6100-6-2, IEC 6100-6-4
Operating temperature	-40°C to +85°C
Storage temperature	-40°C to +125°C
Relative humidity	98% Non condensing
Shock endurance / functional	100 g for 11 ms / 40g 11ms (per MIL-STD-810G)
Vibration functional	20 g 10 – 2000 Hz (per MIL-STD-810G)
Protection	IP 40

3. Ordering Code

DS - XXX - S G [ ] - S 0 - n n n

DS Product Line

Outer Diameter
16, 25, 37, 40, 58, 70, 90, 130

Output	
S	SSi
I	BiSS

Resolution		
Code	bit	CPR
E	16	65,536
F	17	131,072
G	18	262,144
H	19	524,288
I	20	1,048,576
J	21*	2,097,152
K	22*	4,194,304
L	23*	8,388,608

DS-16	16-17 bit
DS-25, 37, 40	17-21 bit
DS-58	18-22 bit
DS-70, 90, 130	19-23 bit
* SSi only	

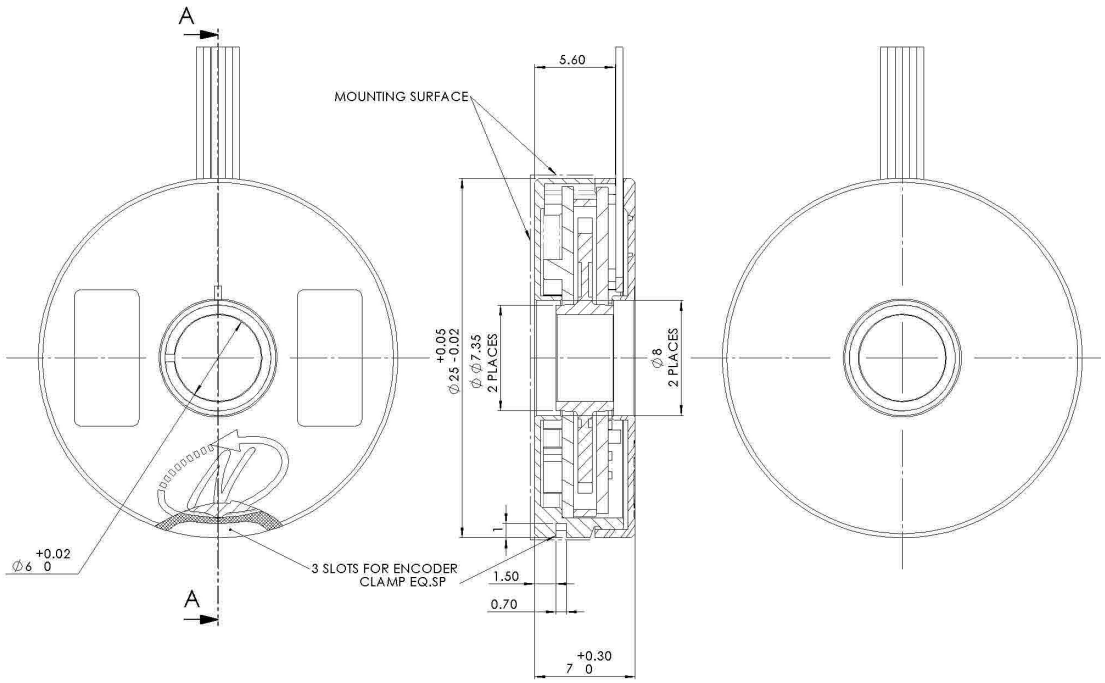
BIT (Built In Test): Optional	
[ ]	None
B	BIT

EA	Extended Accuracy
nnn	Custom

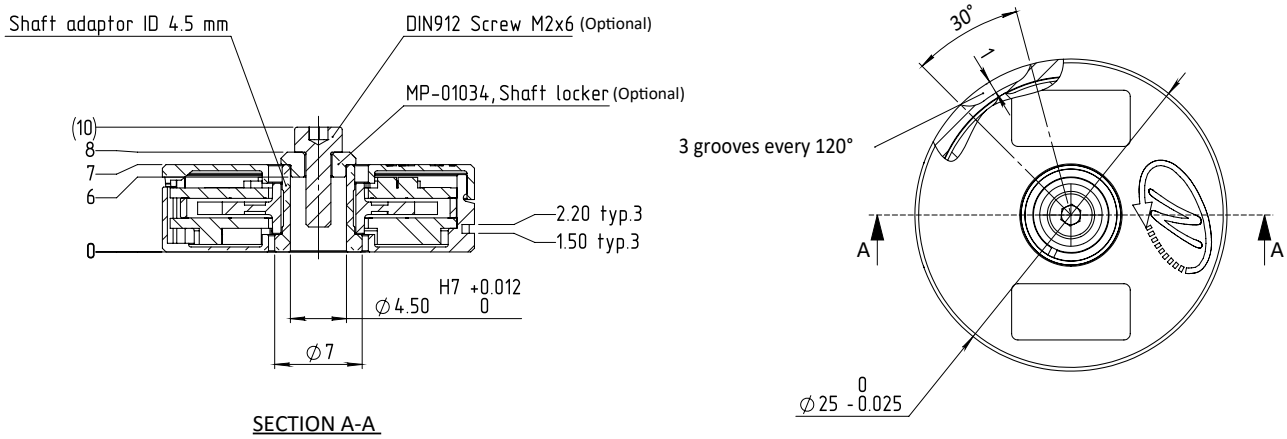
Cable Length	
0	250 mm Flying leads - 30AWG
1	500 mm Flying leads - 30AWG
2	750 mm Flying leads - 30AWG
3	1000 mm Flying leads - 30AWG
4	250 mm Flying leads - 28AWG
5	500 mm Flying leads - 28AWG
6	750 mm Flying leads - 28AWG
7	1000 mm Flying leads - 28AWG
To add a connector contact us	

Cable Options	
S	Jacket and shielded cable
B	Shielded cable
W	Wires only
Cable Options for DS-16	
FC	Connector DF-13-6P-1, 25-H
F0	Without connector

4. Mechanical Drawings



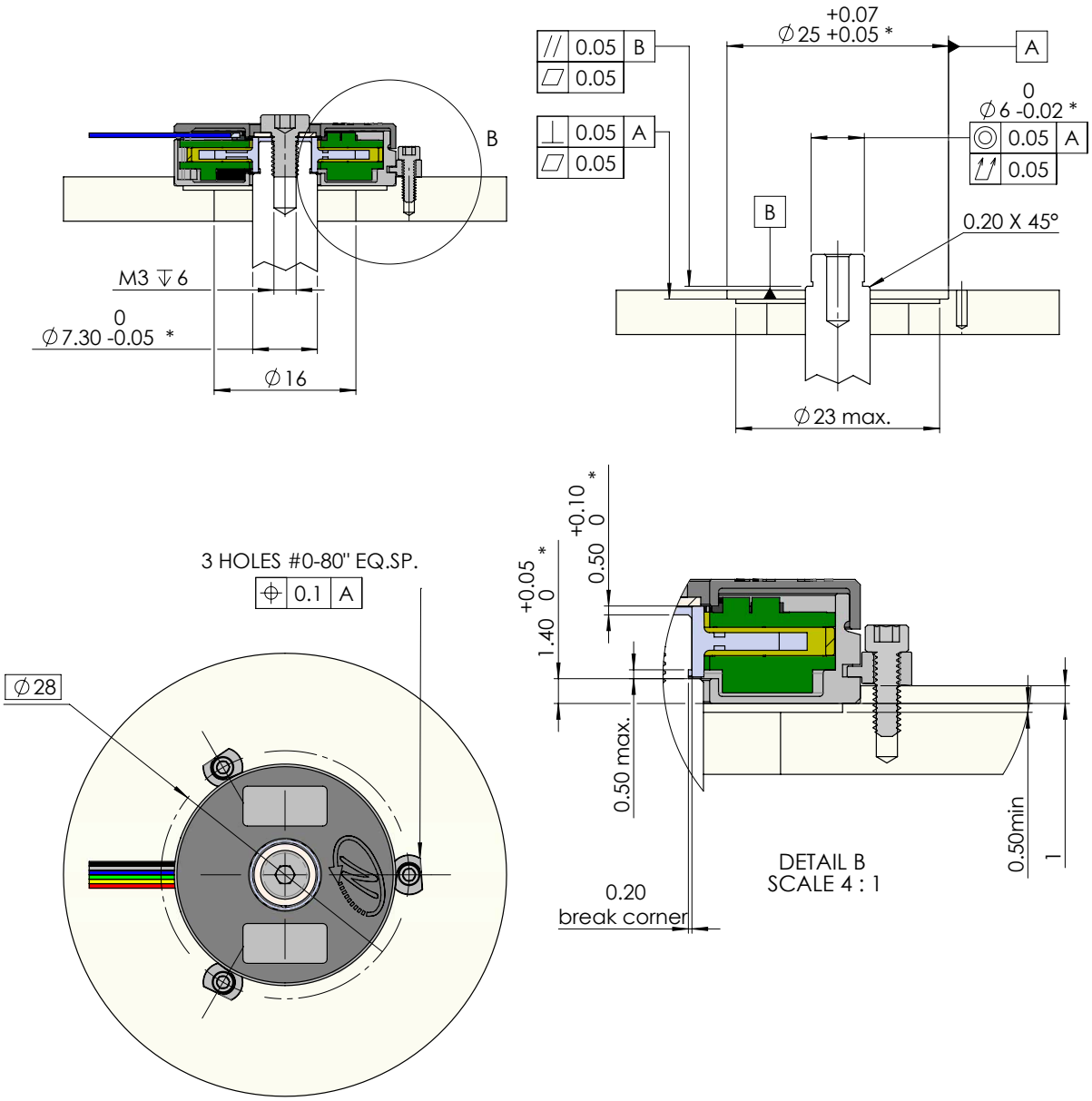
DS-25 with rotor metal sleeve



Unless otherwise specified	
Dimensions are in: mm	Surface finish: N6
Linear tolerances	
0.5-4.9: ±0.05 mm	5-30: ±0.1 mm
31-120: ±0.15 mm	121-400: ±0.2 mm

5. Mechanical Interface Control Drawing

Shaft - End installation (step)



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Dimensions are in: mm	Surface finish: N6
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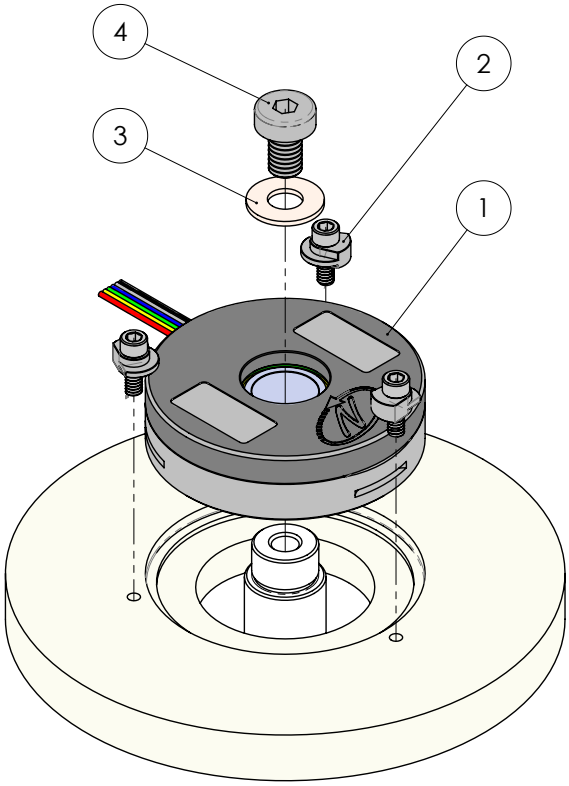


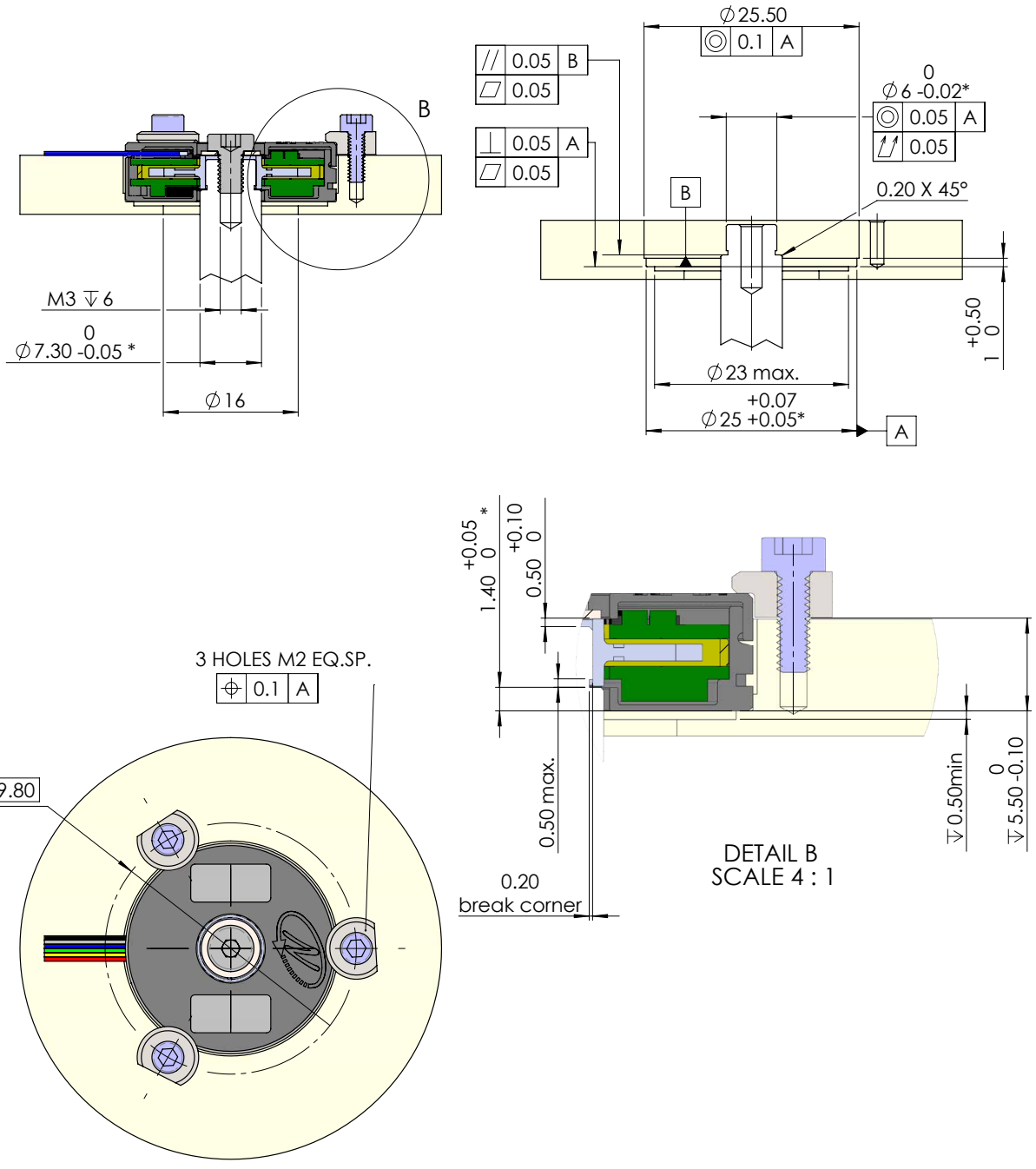
No	Part			Description	QTY.
1	DS-25	Included		DS-25 encoder	1
2	EAPK004	Included	Kit 0-80"	3 x encoder clamps nylon	1
3	MA-DS25-004	Optional	Shaft end installation kit	Washer DIN125-A3.2	1
4				Screw DIN 7984 M3x5	1

Critical dimensions marked with "*"

WARNING

Do not use Loctite or other glues containing Cyanoacrylate.
We recommend to use 3M glue - Scotch-Weld™ Epoxy Adhesive EC-2216 B/A.

Deep, Shaft - End installation (step)



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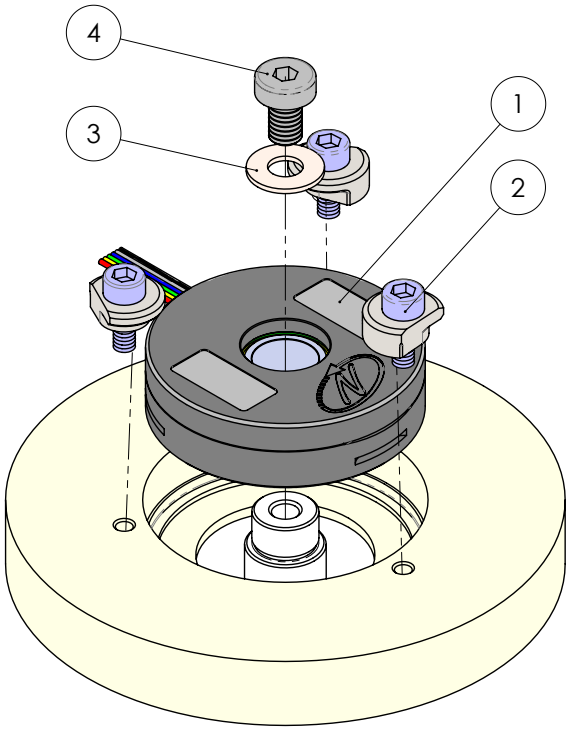


No	Part			Description	QTY.
1	DS-25	Included		DS-25 encoder	1
2	EAPK005	Optional	Kit	3 x M2 encoder clamps	1
3	MA-DS25-004	Optional	Shaft end installation kit	Washer DIN125-A3.2	1
4				Screw DIN 7984 M3x5	1

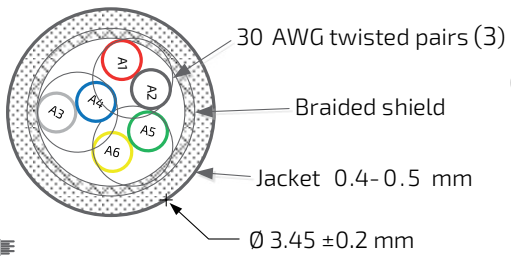
Critical dimensions marked with "*"

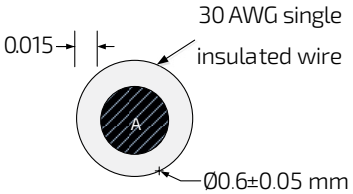
Cable Information

Cable: 30 AWG twisted pair (3)

(30 AWG 25/0.05 tinned copper, Insulation: ETFE Ø 0.12-0.15 to Ø 0.6 ± 0.05 OD)
Temperature rating: -60° to +150° C
Braided shield: Thinned copper braided 95% min. coverage
Jacket: 0.4-0.5 silicon rubber Ø3.45 ±0.2 OD

Pair #	Color
A1-A2	Red / Black
A3-A4	Gray / Blue
A5-A6	Green / Yellow





6. Storage and Handling

Storage temperature: -40 °C to +105 °C

Humidity: Up to 70 % non-condensing

7. ESD Protection

As usual for electronic circuits, during product handling do not touch electronic circuits, wires, connectors or sensors without suitable ESD protection. The integrator / operator shall use ESD equipment to avoid the risk of circuit damage.

ATTENTION OBSERVE PRECAUTIONS FOR HANDLING ELECTROSTATIC SENSITIVE DEVICES

8. Product Overview

8.1 Overview

The DS-25 absolute position Electric Encoder™ is a rotary position sensor originally developed for harsh environment applications. Currently it performs in a broad range of applications, including defense, homeland security, medical robotics and industrial automation.

The Electric Encoder™ non-contact technology provides accurate position measurement through the modulation of an electric field.

The DS-25 Electric Encoder™ is semi-modular, i.e., its rotor and stator are separate, with the stator securely housing the rotor.

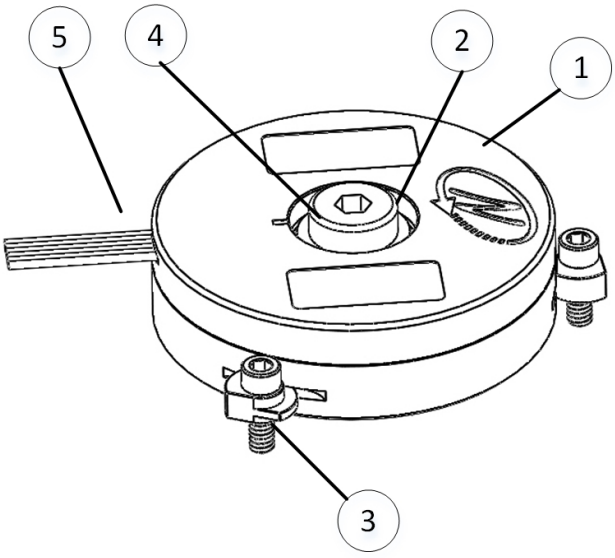
(1) Encoder stator

(2) Encoder rotor

(3) Encoder mounting clamps

(4) Rotor fastner

(5) Cable interface



8.2 Unpacking - Standard order

The package of the standard DS-25 contains the encoder with 250 mm shielded cable AWG30 and EAPK004 kit encoder mounting clamps, (3 clamps, 0-80 UNF HEX Socket screw L 3/16", S.S)

Optional accessories:

(1) DS-25-R-00, Rotor shims kit (x10 stainless steel shims, 50um each)

(2) MA-DS25-004, Shaft end installation kit (M3x5 screw + washer)

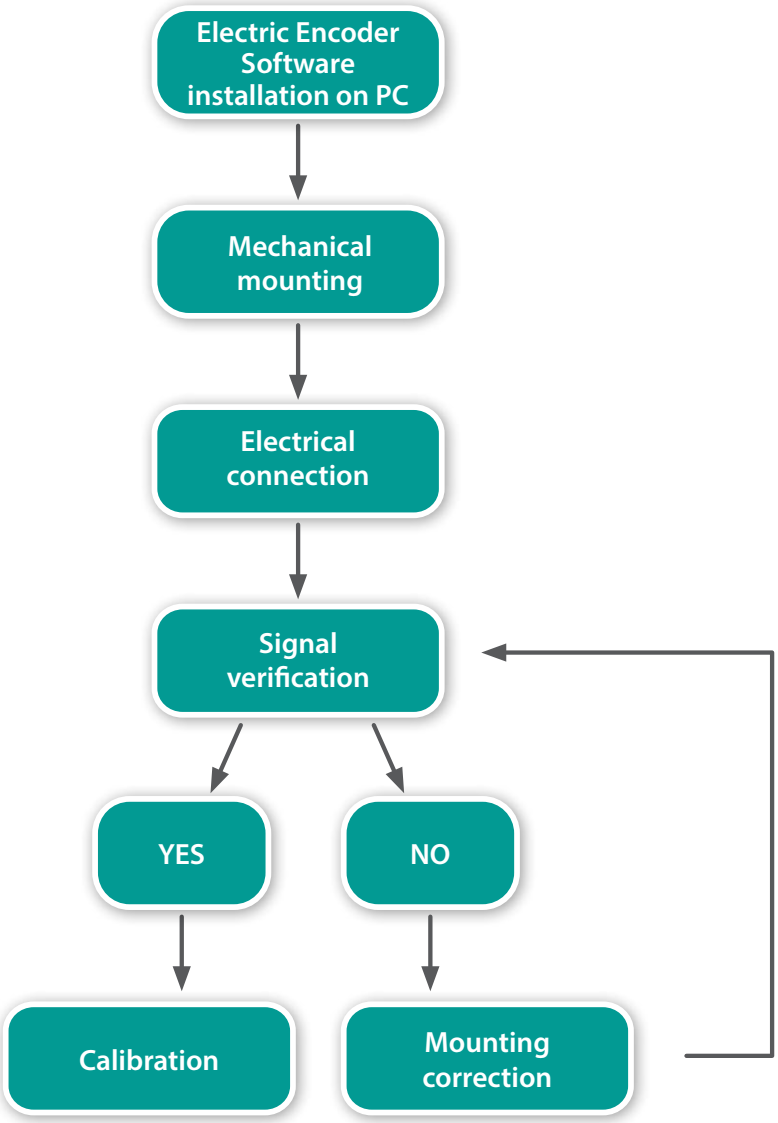
(3) CNV-00003, RS-422 to USB converter (Setup Mode)

(4) NanoMIC-KIT-01, RS-422 to USB converter. Setup & Operational modes via SSi /BiSS interface

(5) DKIT-DS-25-SF-S0, Mounted SSi encoder on rotary jig, RS-422 to USB converter and cables

(6) DKIT-DS-25-IF-S0, Mounted BiSS encoder on rotary jig, RS-422 to USB converter and cables

8.3 Installation flow chart



9. Electric Encoder Software Installation

The Electric Encoder Explorer (EEE) software:

- Verifies correct mounting for an adequate signal amplitude
- Calibration of offsets
- General set up and signal analysis

This section describes the steps associated with installing the EEE software application.

9.1 Minimum requirements

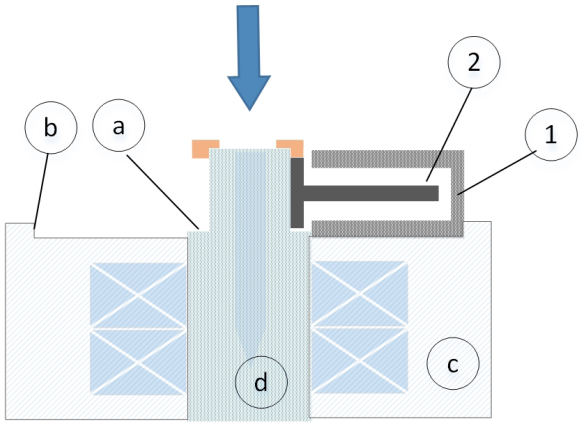
- Operating system: MS windows 7/ 10, (32 / 64 bit)
- Memory: 4MB minimum
- Communication ports: USB 2
- Windows .NET Framework, V4 minimum

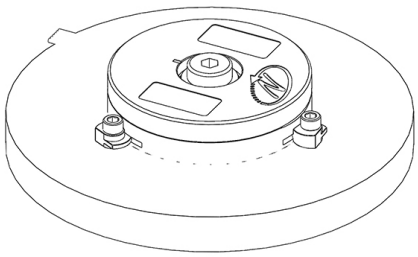
9.2 Installing the software

- Run the Electric Encoder™ Explorer file found on Netzer website: **Encoder Explorer Software Tools**
- After the installation you will see **Electric Encoder Explorer software icon** on the computer desktop.
- Click on the Electric Encoder Explorer software **icon** to start.

10. Mechanical Mounting

10.1 Encoder mounting - End-of-Shaft Installation





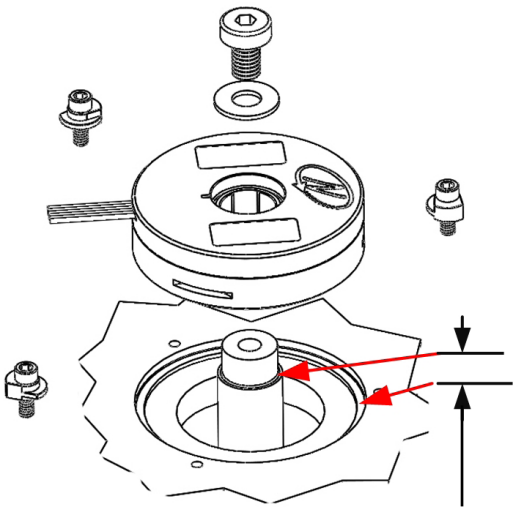
The encoder rotor **(2)** is attached to the host shaft **(d)** by pressing it against a dedicated shoulder **(a)**, while using screw and a washer, or a circular spring and a washer, at the top of the shoulder to maintain downward pressure. Recommended torque of 0.3 Nm with M3 screw.

The encoder stator **(1)** is centered by circumferential step **(b)** and is mounted to the host stator **(c)** by using three dedicated encoder clamps. Recommended torque of 0.3 Nm with the supplied encoder clamps.

Note that Netzer strongly recommends using the clamps. If not using the dedicated clamps, avoid applying pressure to the entire top surface of the encoder's housing, but only to the outer circumference perimeter of the cover.

Stator / rotor relative position

As the rotor is floating, a nominal axial mounting distance of 1.4 mm between the shaft shoulder **(b)** and stator mounting recess **(a)** is required.
The mounting can be assisted by rotor shims, in order to ensure that the mounting distance is 1.4mm with -/+ 0.05 mm tolerance.



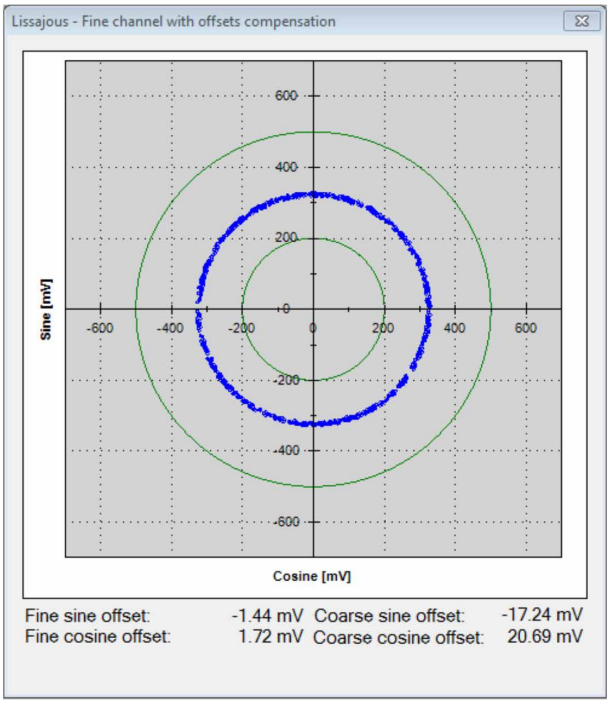
H 1.4mm +0/-0.05

In an optimal mounting, the signal amplitude values generated by the encoder, would be in the middle of the range of the signal plot shown in the Encoder Explorer software (see plot below). This may vary according to the encoder type.

The DS-25 amplitudes compensation

If as part of the signal validation process (section 7.2) the signal amplitudes are not optimal, it is possible to improve/correct the mounting, by using 50 um shims below the rotor (available as DS-25-R-00 kit). Each will increase the amplitude level by ~ 50mV.

Verify that the rotor mounting provides a good signal amplitude, by using the "Signal analyzer" or "Signal verification process", of the Encoder Explorer tool, as part of the procedure the described in section 7.



11. Electrical Connection

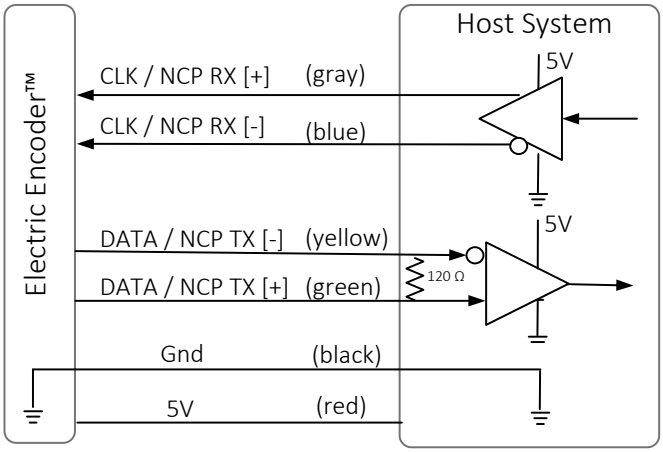
This chapter reviews the steps required to electrically connect the encoder with digital interface (SSi or BiSS-C).

Connecting the encoder

The encoder has two operational modes:

11.1 Absolute position over SSi or BiSS-C

This is the power-up default mode



SSi / BiSS interface wires color code

Clock +	Grey	Clock
Clock -	Blue	
Data -	Yellow	Data
Data +	Green	
GND	Black	Ground
+5V	Red	Power supply

SSi / BiSS output signal parameters

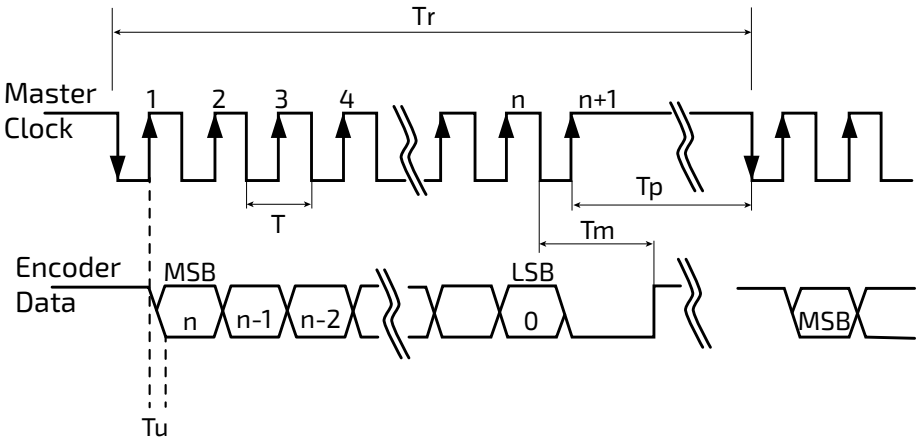
Output code	Binary
Serial output	Differential RS-422
Clock	Differential RS-422
Clock frequency	0.1 ÷ 5.0 MHz
Position update rate	35 kHz (Optional - up to 375 kHz)

SSi / BiSS interface wires color code

Clock + / NCP RX +	Grey	Clock
Clock - / NCP RX -	Blue	
Data - / NCP TX -	Yellow	Data
Data + / NCP TX +	Green	
GND	Black	Ground
+5V	Red	Power supply

11.2 Digital SSi Interface

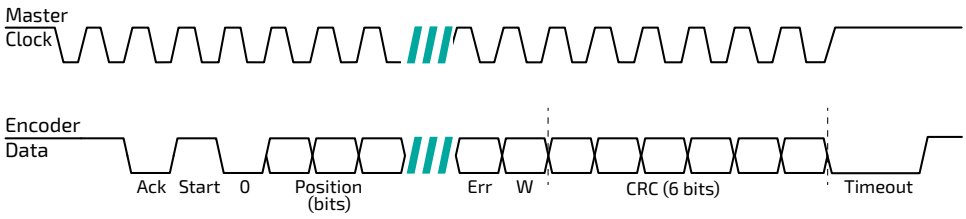
Synchronous Serial Interface **(SSi)** is a point to point serial interface standard between a master (e.g. controller) and a slave (e.g. sensor) for digital data transmission.



	Description	Recommendations
n	Total number of data bits	12 - 20
T	Clock period	
f= 1/T	Clock frequency	0.1 - 5.0 MHz
Tu	Bit update time	90 nsec
Tp	Pause time	26 - ∞ µsec
Tm	Monoflop time	>25 µsec
Tr	Time between 2 adjacent requests	Tr > n*T+26 µsec
fr=1/Tr	Data request frequency	

11.3 Digital BiSS-C Interface

BiSS – C Interface is unidirectional serial synchronous protocol for digital data transmission where the Encoder acts as "slave" transmits data according to "Master" clock. The BiSS protocol is designed in B mode and C mode (continuous mode). The BiSS-C interface as the SSi is based on RS-422 standards.



Bit #		Description	Default	Length
27	Ack	Period during which the encoder calculates the absolute position, one clock cycle	0	1/clock
26	Start	Encoder signal for "start" data transmit	1	1 bit
25	"0"	"Start" bit follower	0	1 bit
8...24	AP	Absolute Position encoder data		
7	Error	Error (amplitude levels)	1	1 bit
6	Warn.	Warning (non active)	1	1 bit
0...5	CRC	The CRC polynomial for position, error and warning data is: $x^6 + x^1 + x^0$. It is transmitted MSB first and inverted. The start bit and "0" bit are omitted from the CRC calculation.		6 bits
	Timeout	Elapse between the sequential "start" request cycle's.		25 µs

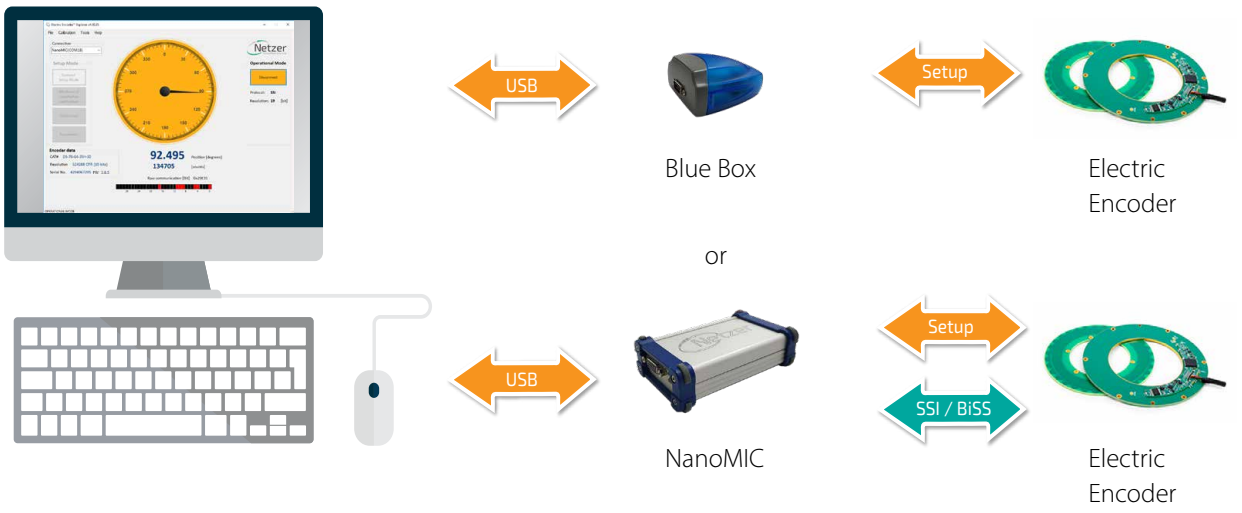
11.4 Setup mode over NCP (Netzer Communication Protocol)

This service mode provides access via USB to a PC running Netzer Encoder Explorer application (on MS Windows 7/10). Communication is via Netzer Communication Protocol (NCP) over RS-422 using the same set of wires.

Use the following pin assignment to connect the encoder to a 9-pin D-type connector to the RS-422/USB converter CNV-0003 or the NanoMIC.

Electric encoder interface, D Type 9 pin Female

Description	Color	Function	Pin No
SSi Clock / NCP RX	Gray	Clock / RX +	2
	Blue	Clock / RX -	1
SSi Data / NCP TX	Yellow	Data / TX -	4
	Green	Data / TX +	3
Ground	Black	GND	5
Power supply	Red	+5V	8



Connect Netzer encoder to the converter, connect the converter to the computer and run the Electric Encoder Explorer Software Tool

11.5 Electrical connection and grounding

The encoder does NOT come with specified cable and connector, however, do observe grounding consideration:

[1] The cable shield does not connect to the power supply return line.

[2] Ground the host shaft to avoid interference from the host system, which could result in encoder internal noise.

Note: 4.75 to 5.25 VDC power supply required

12. Signal Verification

12.1 Starting the Encoder Explorer

Make sure to complete the following tasks successfully:

- Mechanical Mounting
- Electrical Connection to the encoder
- Encoder Explore Software Installation

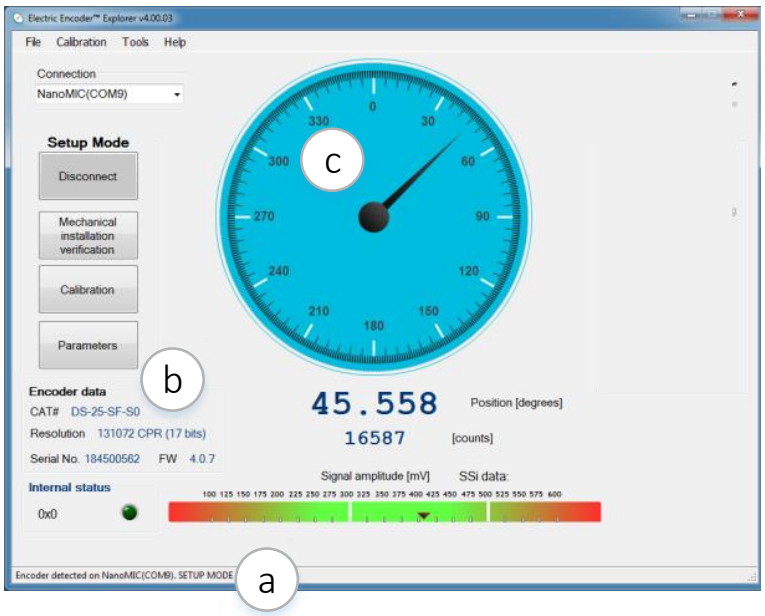
Run the Electric Encoder Explorer tool (EEE)

Ensure proper communication with the encoder: (Setup mode by default).

(a) The status bar indicates successful communication.

(b) Encoder data displays in the encoder data area. (CAT No., Serial No.)

(c) The position dial display responds to shaft rotation.



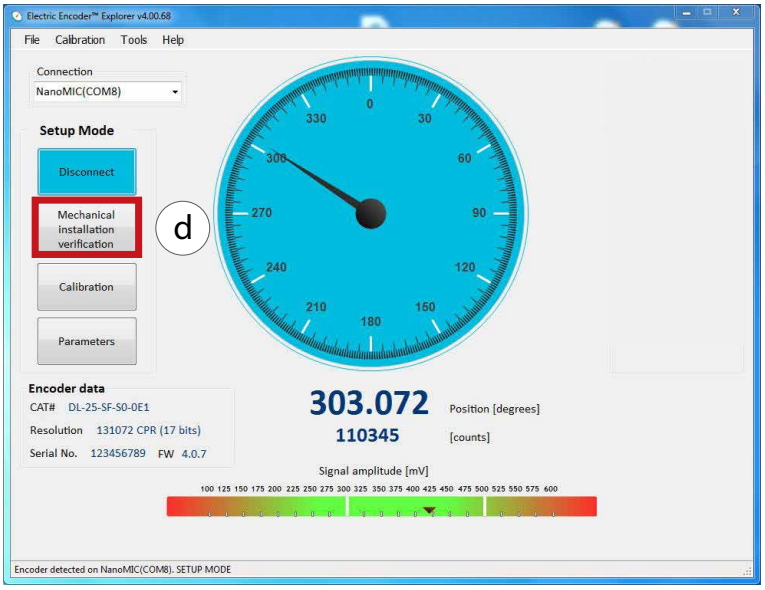
Perform mounting verification & rotation direction selection before calibration to ensure optimal performance.

It is also recommended to observe the installation at the [Tools - Signal Analyzer] window.

12.2 Signal verification process

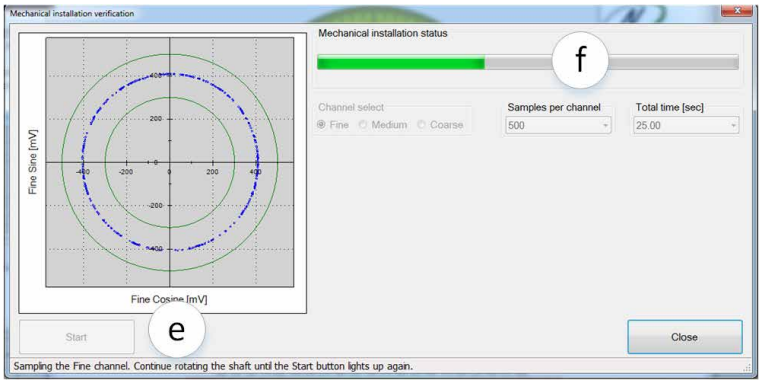
The Signal verification process provides a procedure that will ensure the mechanical mounting provides good signal amplitudes. This is performed by collecting raw data of the fine and coarse channels during rotation.

(d) Select [Signal Verification] on the main screen.

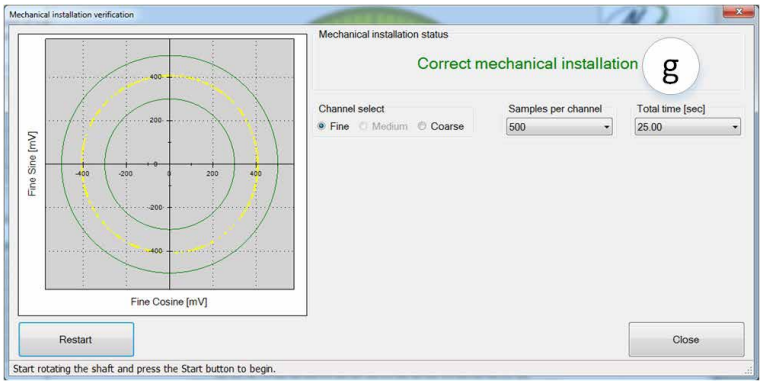


(e) Select [Start] to initiate the data collection.

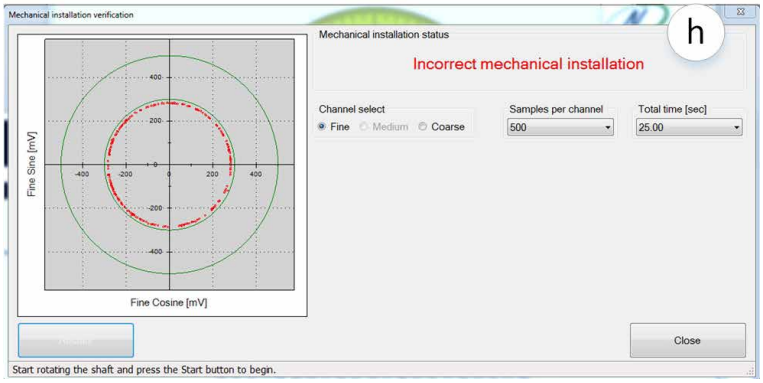
(f) Rotate the shaft in order to collect the fine and coarse channels data.



(g) At the end of a successful verification, the SW will show "good mounting".



(h) If the SW indicates "Incorrect Mounting," correct the mechanical position of the rotor, as presented in paragraph 5.1 - "Encoder stator / Rotor relative position".



The Signal Analyzer window [Tools - Signal Analyzer] can also be used to verify the signals are good for an installed encoder.

13. Calibration

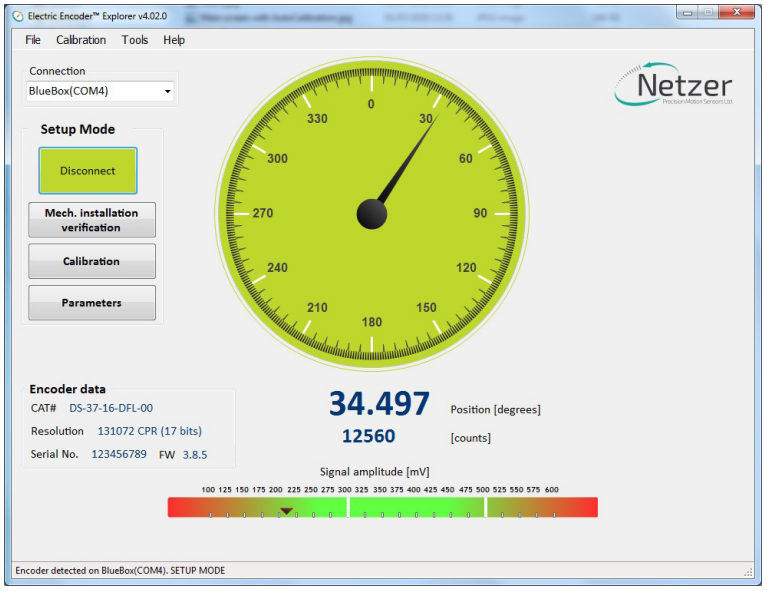
13.1 Auto-calibration

Auto-calibration is a new feature for easy and quick calibration. It is supported by encoders with FW 4 version 4.1.3 or higher.

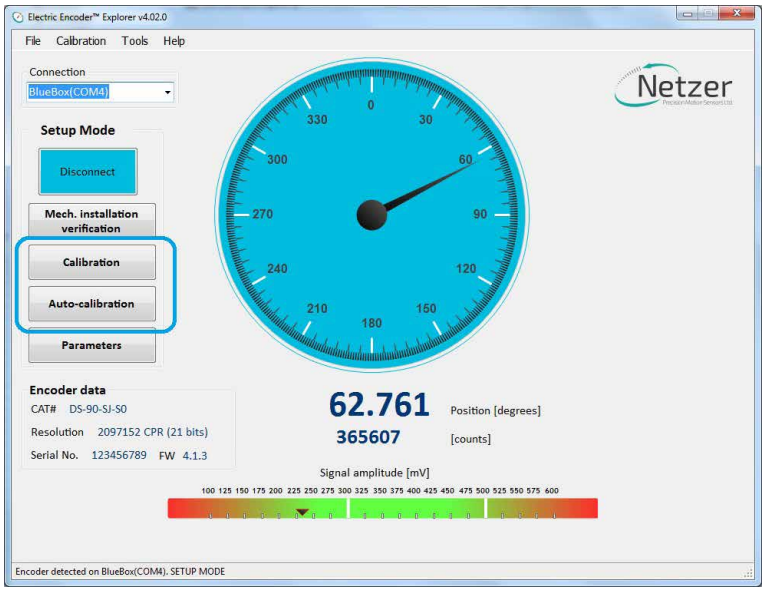
For encoders that support auto-calibration, under the "**Calibration**" button, additional "**Auto-calibration**" button will be displayed.

13.1.1 Main screen

Main screen for encoders **without** auto-calibration support



Main screen for encoders **with** auto-calibration support



13.1.2 Auto-calibration process

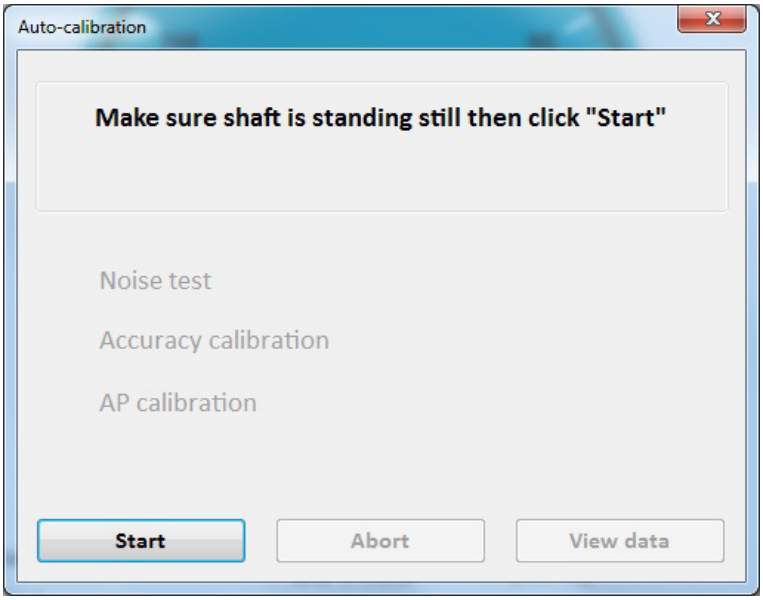
The Auto-calibration process consists of three stages:

1. **Noise test** - This stage runs a jitter test for the Fine, Medium, and Coarse encoder channels. During the Noise test, the shaft must be stationary.
2. **Accuracy calibration** - During Accuracy calibration, the shaft must rotate continuously. The accuracy calibration of Fine, Medium, and Coarse encoder channels includes:
   - Amplitude test
   - Offsets calibration
3. **AP (Absolute Position) calibration**
   - At this stage, CAA and MAA are calculated

13.1.3 Performing Auto-calibration

- Press the "**Auto-calibration**" button.
- The main auto-calibration window opens.

After pressing the "**Auto-calibration**" button on the Encoder Explorer main screen, the following window will open:



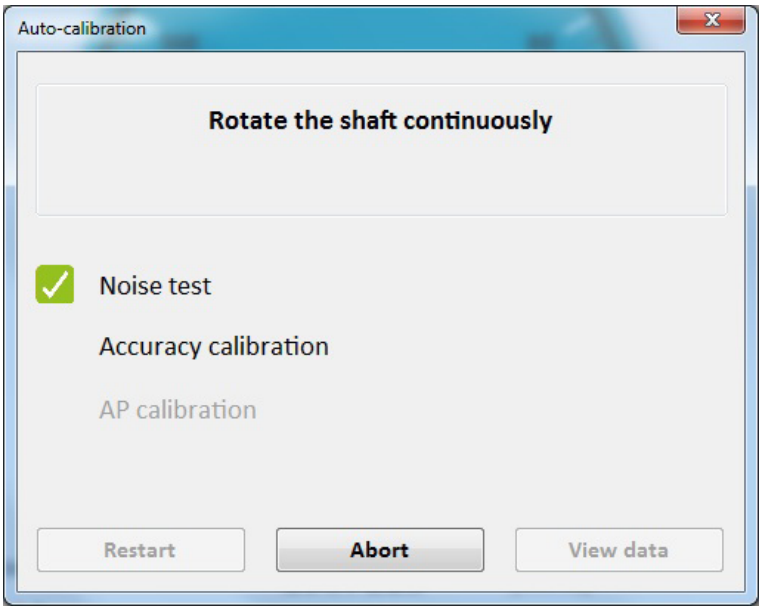
1. **Make sure the shaft is at standstill**
2. **Press the "Start"**

Noise test - The encoder should stay standstill at this stage.

The Auto-calibration process starts the Noise test.

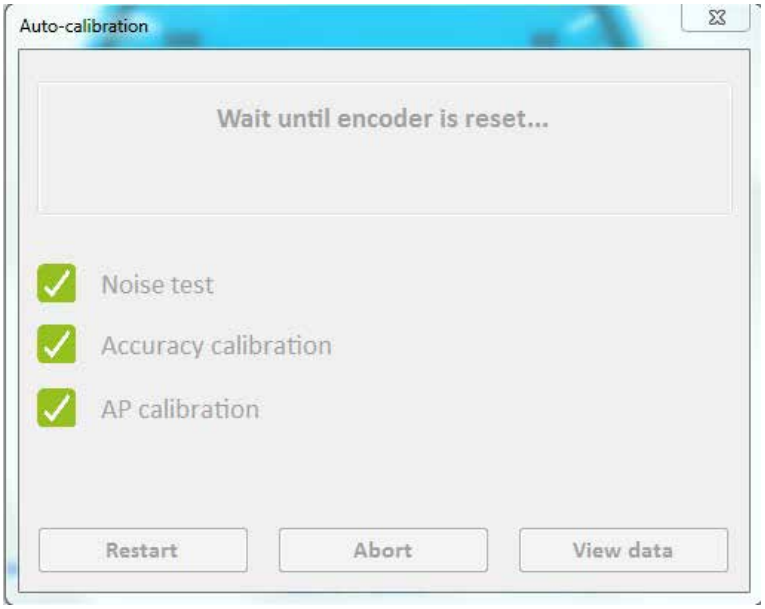
If the Noise test completes successfully:

- The "Noise test" label will be marked with a green check mark.
- The Auto-calibration process will start the Accuracy calibration.

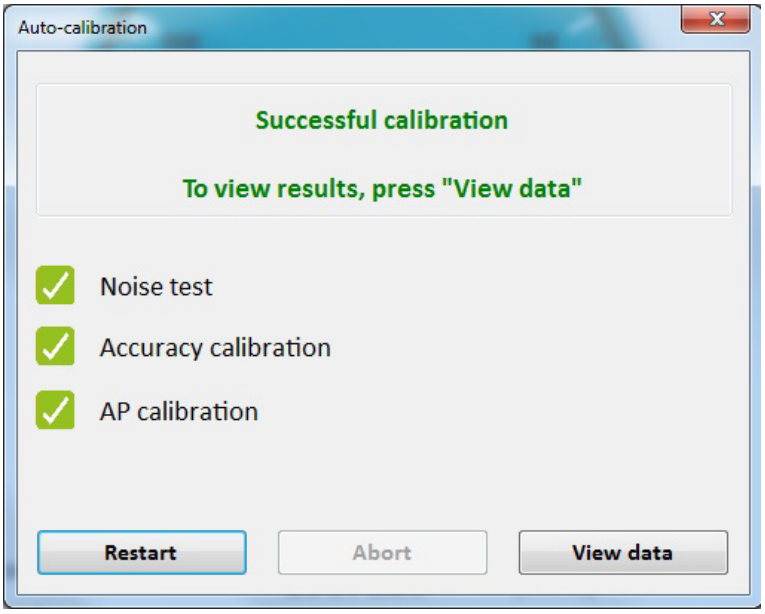


Once the noise test is successful, start rotating the shaft continuously until the auto-calibration process ends.

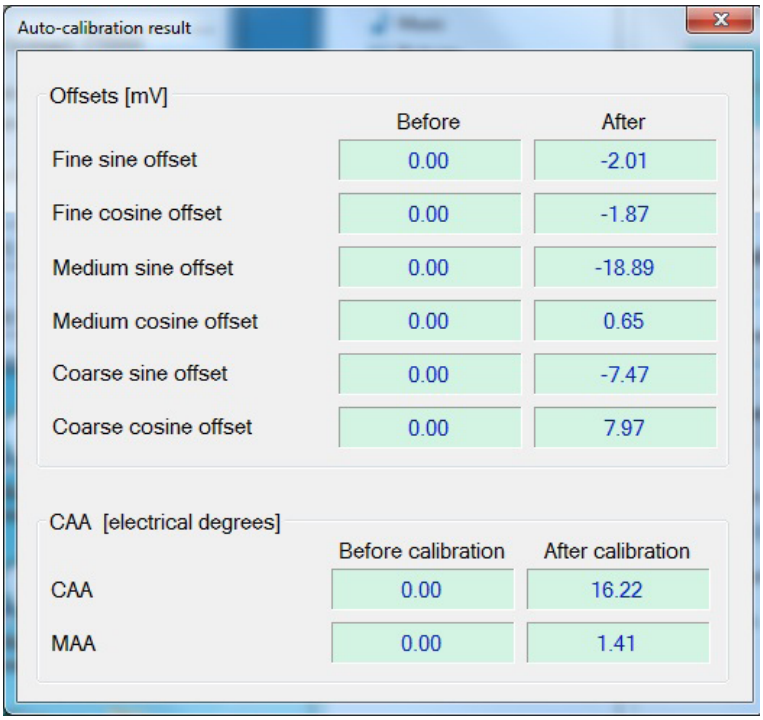
3. Wait until encoder is reset.



4. The Auto-calibration process is successfully finished.



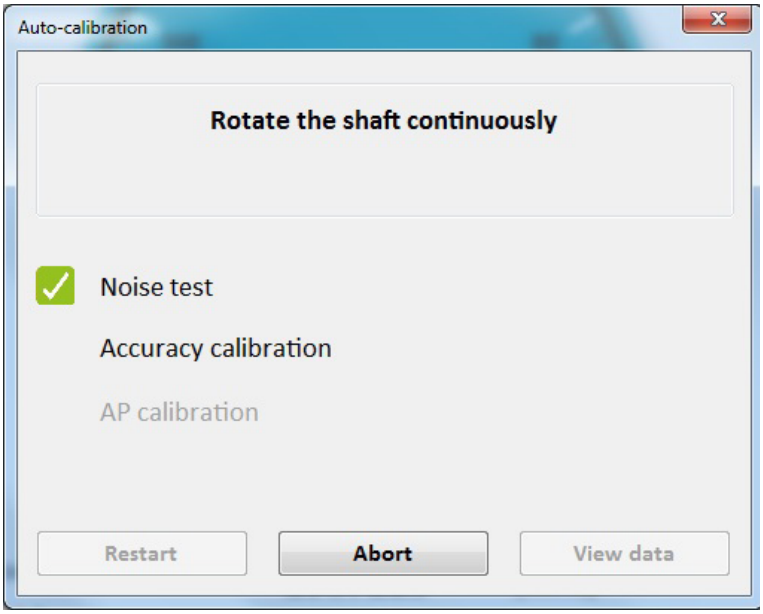
5. (Optionally) press the "View data" button to review the calibration results.



6. Close the Auto-calibration window

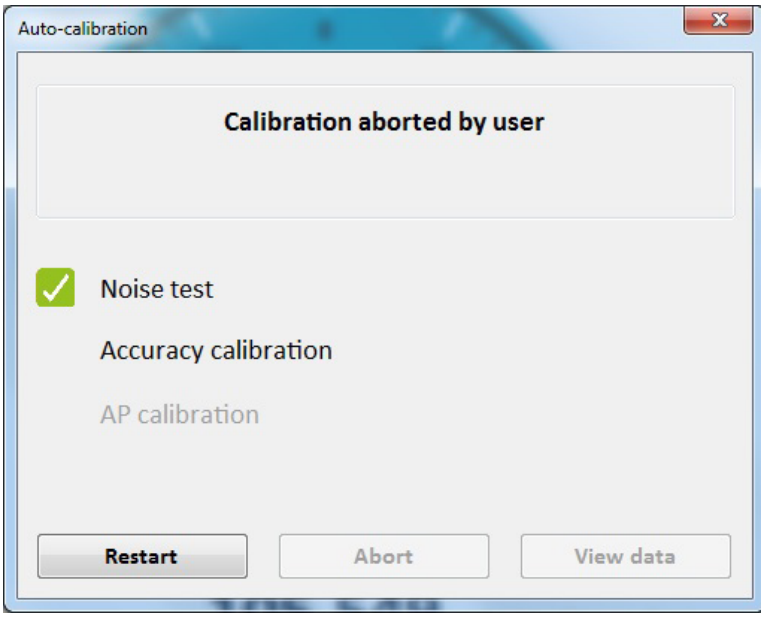
13.1.4 Aborting auto-calibration process

At any stage, it is possible to abort the auto-calibration process by pressing the "**Abort**" button.



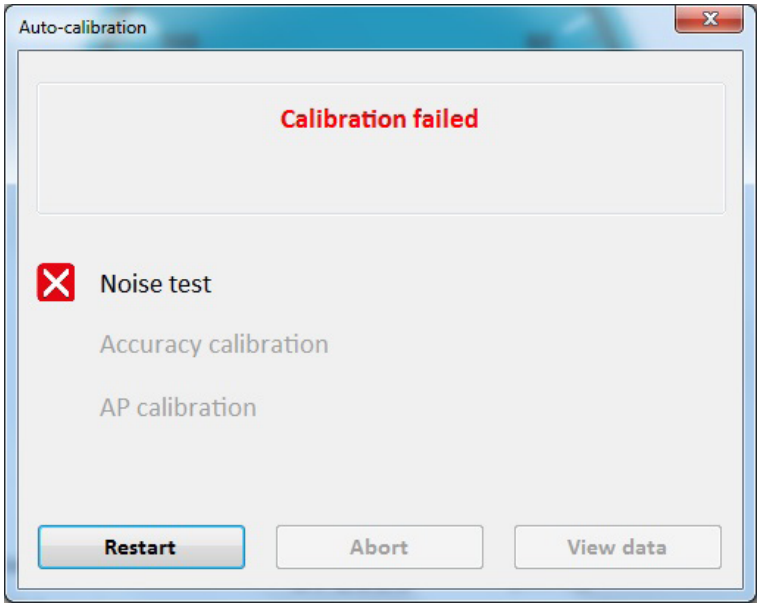
13.1.5 Restart auto-calibration process

It is possible to restart the auto-calibration process by pressing the "**Restart**" button.

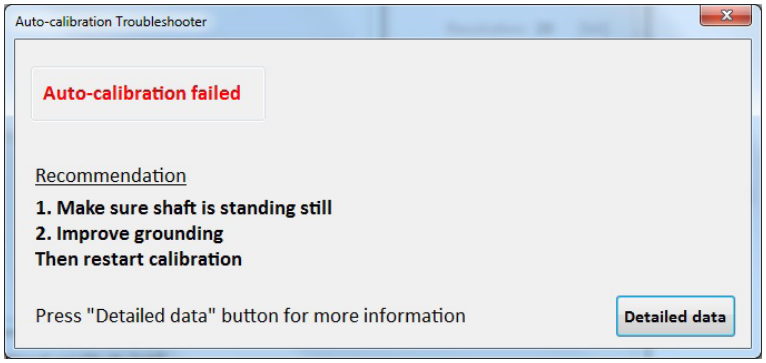


13.1.6 Auto-calibration failures

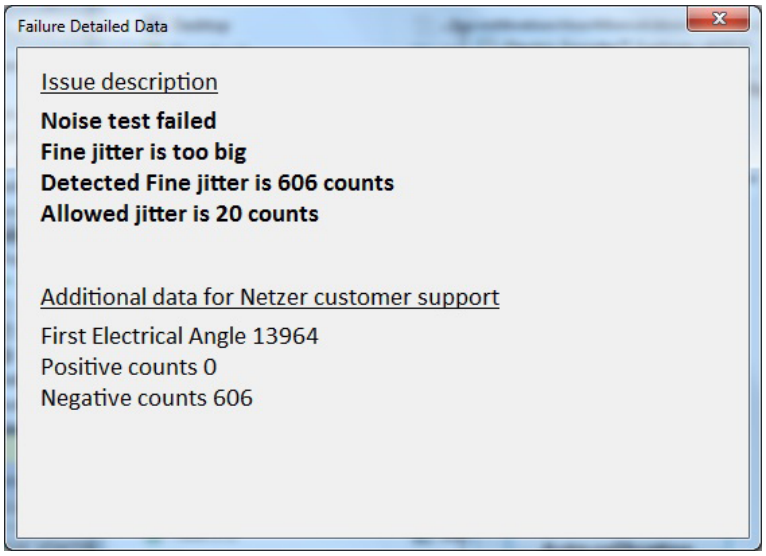
If a test fails (for example the Noise test) – the result will be marked with in red X.



In the event of an auto-calibration failure, corrective recommendations will be displayed.



Pressing the "**Detailed data**" button, will display detailed information regarding the failure.

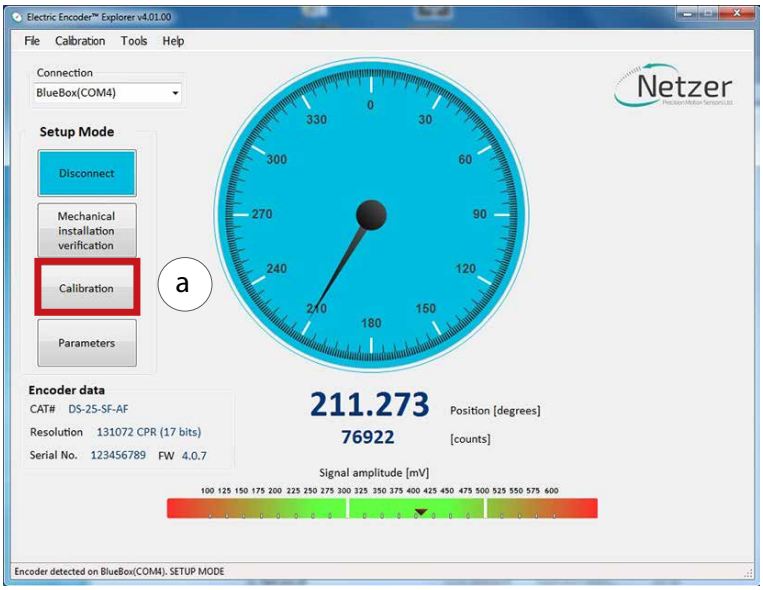


13.2 Manual calibration

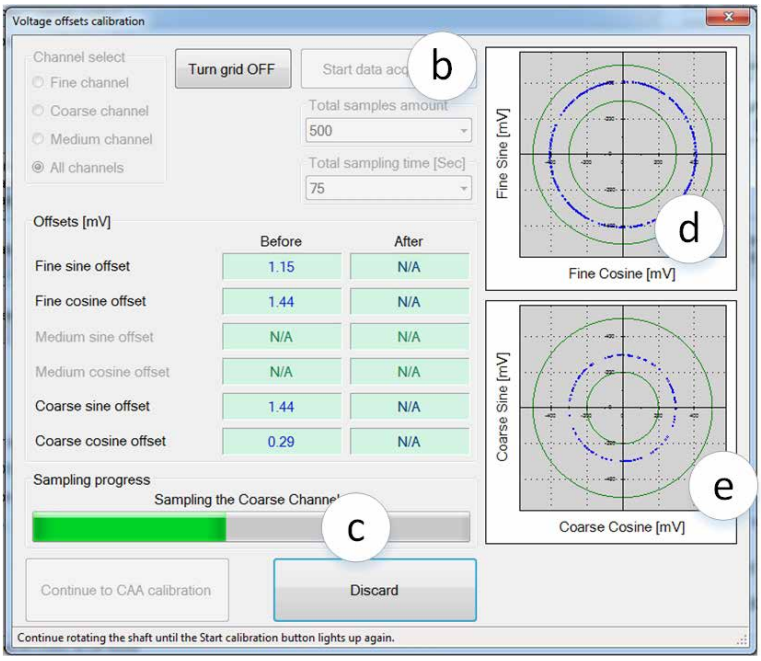
13.2.1 Offset calibration

For optimal performance of the Electric Encoders, the DC offset of the sine and cosine signals are compensated over the operational sector. After successfully completing the Signal Verification process:

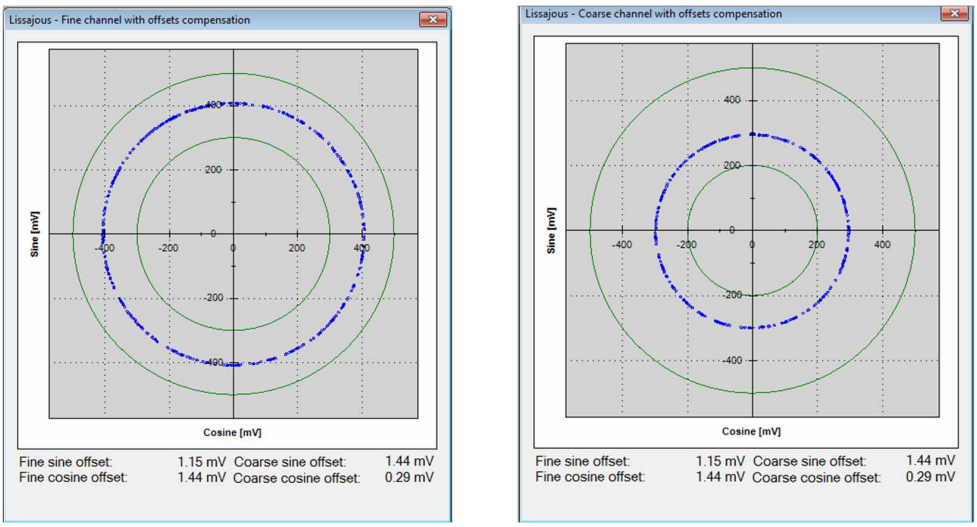
(a) Select [Calibration] on the main screen.



(b) Start the data acquisition while rotating the shaft. The progress bar **(c)** indicates the progress of the data collection. Rotate the axis consistently during data collection, covering the working sector of the application end to end. By default the procedure collects 500 points over 75 seconds. Rotation speed is not a parameter during data collection. The collected data for the fine / coarse channels, should be a clear "thin" circle which appears in the center of the plots **(d)** **(e)** with some offset.



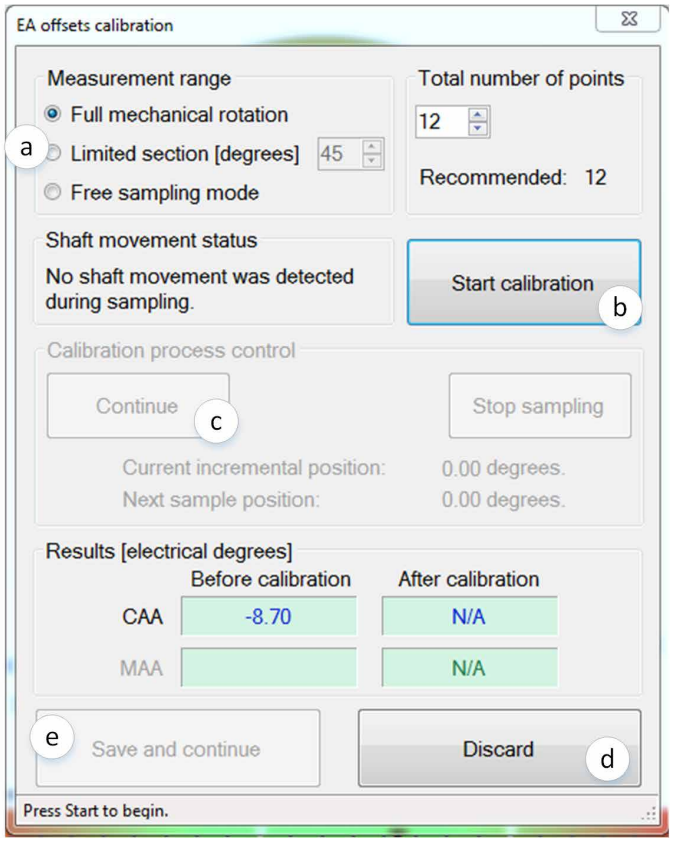
Fine / Coarse channel after compensation



13.2.2 Coarse Amplitude Alignment (CAA) calibration

The following calibration aligns the coarse channel with the fine channel by collecting data from each point of both channels. This is performed to make sure that every time the encoder is turned on, it would provide an accurate absolute position.

Select [Continue to CAA Calibration]



In the CAA angle calibration window, select the relevant option button from the measurement range options **(a)**:

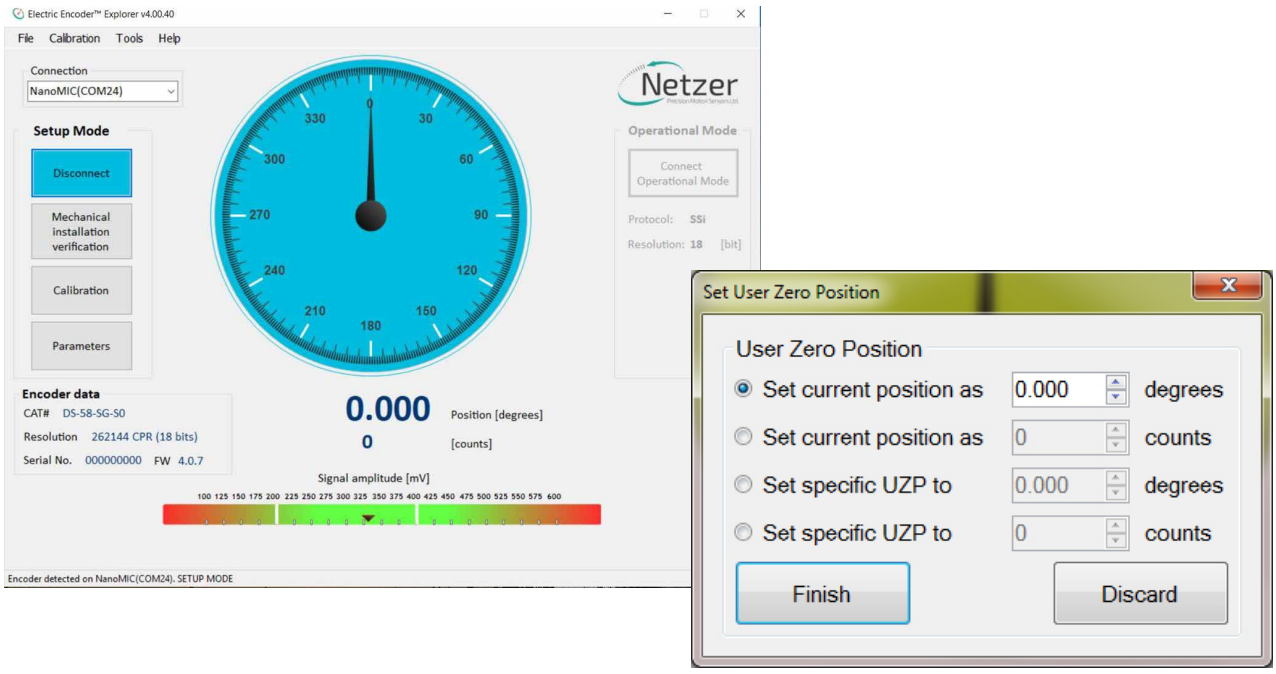
- Full mechanical rotation – shaft movement is over a full 360 degrees rotation – (that is the recommended calibration).
- Limited section – shaft has a limited rotation angle which is less than 360 degrees. In this mode you need to input the rotation range by degrees.
- Free sampling mode - sets the number of calibration points in accordance with the total number of points in the text box. The system displays the recommended number of points by default. Collect a minimum of nine points over the working sector.
- Click the [Start Calibration] button **(b)**
- The status **(c)** indicates the next required action; the shaft movement status; the current position, and the next target position to which the encoder should be rotated.
- Rotate the shaft/encoder to the next position and click the [Continue] button **(c)** - the shaft should be at STAND STILL during the data collection. Follow the indication/interactions during the following routine: positioning the shaft --> stand still --> reading calculation.
- Repeat the above step for all defined points. Finish **(d)**
- Click the [Save and Continue] button **(e)**.

13.3 Setting the encoder zero-position

The zero position can be defined anywhere in the working sector. Rotate the shaft to the desired zero mechanical zero position.

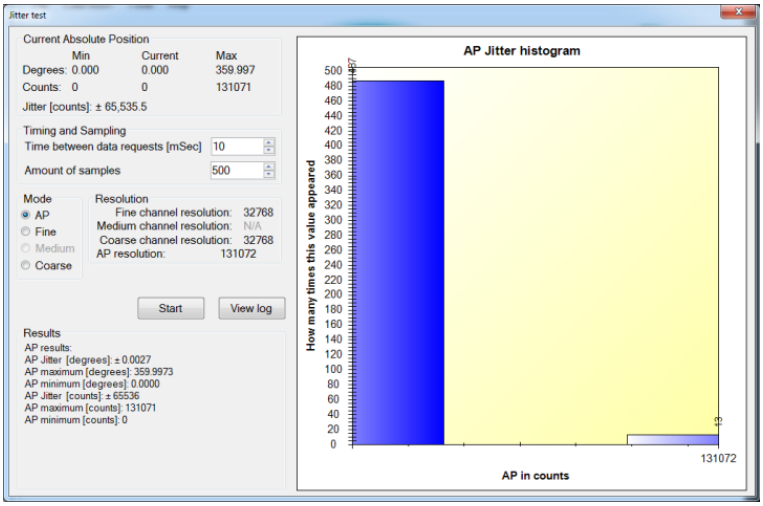
Selelct "Calibration" button at the top menu bar, and press "Set UZP".

Select one of the options for setting the zero point and click [Finish]. It is possible to set either current position or any other as the zero point.

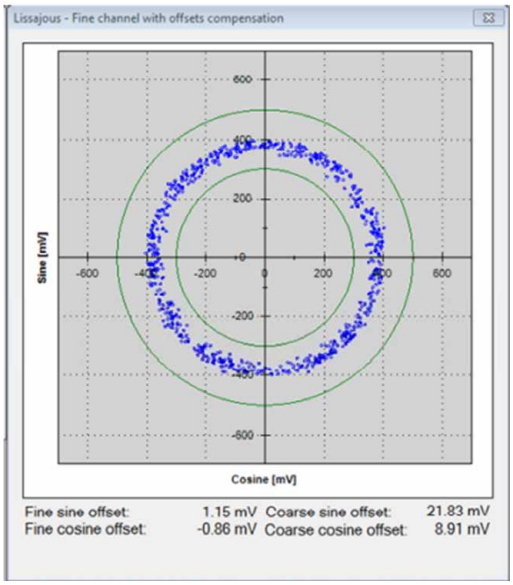


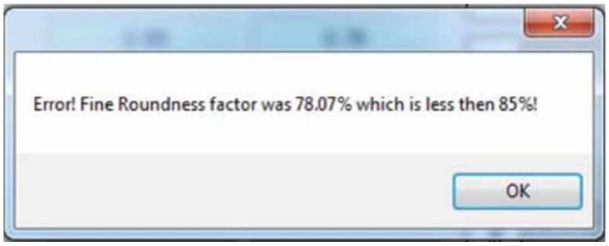
13.4 Jitter test

Perform a jitter test to evaluate the quality of the installation; the jitter test presents the reading statistics of absolute position readings (counts) over time. Common jitter should be up +/- 3 counts; higher jitter may indicate system noise.



In case the reading data (blue dots) are not evenly distributed on a thin circle, you may experience "noise" in your installation (check shaft/stator grounding).





14. Operational Mode

14.1 SSi / BiSS

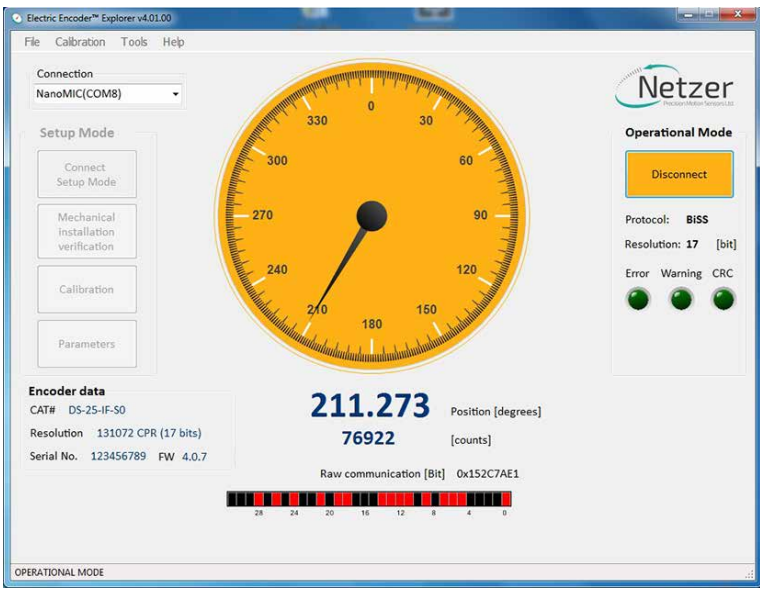
Operational mode indication of the SSi / BiSS Encoder interface available by using the NanoMIC.

[For more information read about NanoMIC on Netzer website]

The operational mode presents the "real" SSi / BiSS interface with 1MHz clock rate.

Protocol SSi

Protocol BiSS



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DS-25-PG-V02