Drive Engineering – Practical Implementation

Encoder Systems from SEW-EURODRIVE

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Contents

1 Introduction

SEW-EURODRIVE is one of the leading companies in the world market for electrical drive engineering. The company headquarters are in Bruchsal, Germany. Components for the SEW-EURODRIVE modular drive system are manufactured to the highest quality standards in production plants sited in Germany, France, Finland, the United States, Brazil and China. The individual drive systems are assembled with a consistently high quality standard and very short delivery times from stocked components in 67 assembly plants located in 47 industrialized countries all over the world. SEW-EURODRIVE sales, consulting, customer and spare parts services are available in more than 60 countries around the world.

Its global presence, extensive product range and broad spectrum of services make SEW-EURODRIVE the ideal partner for demanding automation solutions.

The volume before you from the series "Drive Engineering - Practical Implementation" is aimed at technical specialists and provides clear information on the design and theory of operation of common components of encoder technology as well as their applications and project planning.

SEW-EURODRIVE – driving the world.

Bruchsal, November 2009

1.1 Product names and trademarks

The brands and product names contained within this issue are trademarks or registered trademarks of the titleholders.

2 What Are Encoder Systems?

2.1 What are the tasks of encoder systems?

Depending on the respective requirements, encoder systems have to perform different tasks in drive systems.

One of the most common task is to allow for a positioning of the drive system. This positioning can be incremental or absolute. The encoder can be mounted to the motor or to the track. Encoder systems can also be used for speed control purposes. With a direct motor feedback, you can significantly improve the speed quality and the control response even with major load changes. With synchronous motors, the feedback of the rotor position is required in order to set the rotating field for the dynamic control with varying load conditions.

With the suitable encoder and the ideal combination of the signals for control processes and positioning, you can implement an optimized drive system.

2.2 Which types of encoder systems are there?

2.2.1 Overview of conventional encoder systems with respect to electrical interfaces

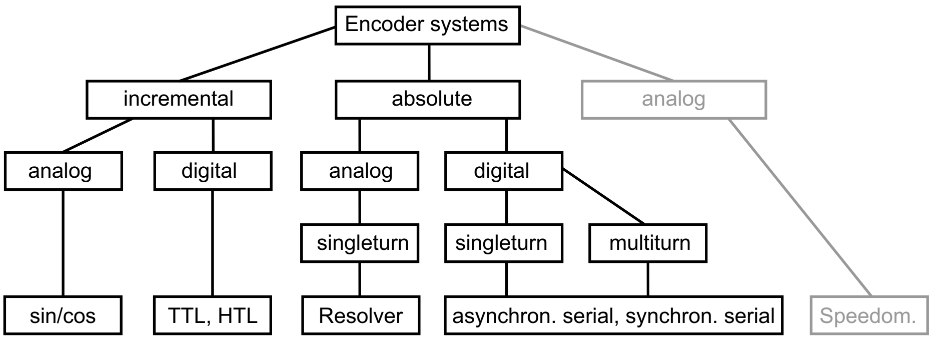

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Fig. 1: Overview of conventional encoder systems

The different encoders provide the following data:

Encoder system	Data		
	Rotor angle	Position	Speed
Single-turn absolute encoder	x	x	(x)
Multi-turn absolute encoder	x	x	(x)
Incremental encoder	(x)	(x)	(x)
Resolver	x	(x)	x
Tacho generator	-	-	x

x direct evaluation, (x) available with additional evaluation

The robustness of an encoder system is a crucial criterion for the encoder selection. As some encoders are installed directly on the motor, they have to be temperature- and vibration-resistant, as they could get damaged otherwise. The encoder system's susceptibility to interference is another crucial factor as well In the event of a power failure, the absolute encoder keeps the latest track information whereas the incremental encoder loses it. This is why the absolute encoder is susceptible to external interference. Once the interference has decayed, the absolute encoder resumes working flawlessly as the track information has been stored. With an incremental encoder, a lost or redundant counting pulse is not registered and results in a permanent measuring error.

2.2.2 Benefits and drawbacks of the most important encoder systems

Encoder system	Benefits	Drawbacks
Incremental encoder	• Relatively robust design is possible • Broad range regarding resolution, mounting positions and interfaces • Very high resolution is possible • Can be installed in the motor	• Position information is lost in the event of a power failure
Absolute encoder	• Position information is stored in the event of a power failure • Explicit assignment of a position to an output value • Very high resolution is possible • Rotary encoders can even image a position over several revolutions • Can be installed in the motor	• High costs
Resolver	• Robust design • Not affected by vibration and temperature fluctuations • Can be installed in the motor	• High evaluation efforts • only single-turn position information

2.3 How do encoder systems work?

2.3.1 Rotary encoder systems

Incremental encoder

Optical system

Incremental encoders convert the speed into a direct number of electrical impulses. This is performed via a code disk with radial transparent slits that is scanned optoelectronically. The resolution is determined by the number of slits.

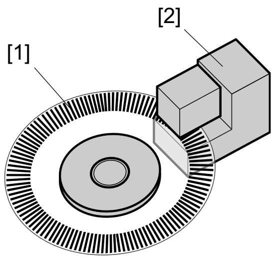

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Fig. 2: Incremental encoder

[1] Incremental disk
[2] Scanning device

Magnetic system

Sensors scan rotating magnets or ferromagnetic material measures and generate a signal. Those systems tend to be more robust than optical systems. There can also be deviations from the classic design, e.g. with the DR built-in encoder, there are magnets in the fan wheel. Those magnets are tracked by magnetic field sensors on an encoder module mounted to the stud. The measured values are interpolated to generate the corresponding incremental signals.

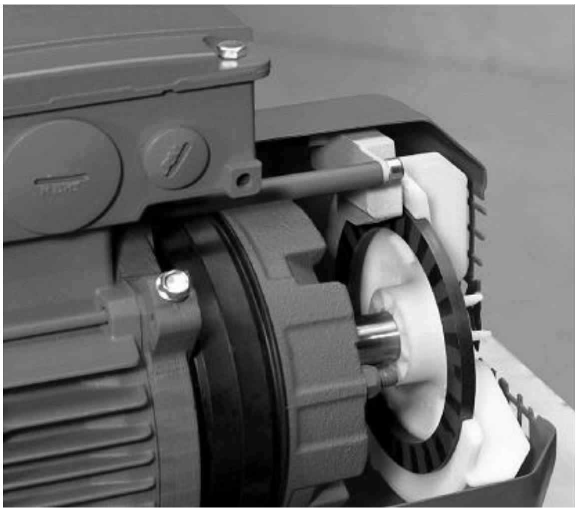

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Fig. 3: DR built-in encoder

Structure and functional principle

Usually, incremental encoders have 2 tracks and one index signal track. Inverting the signals results in a total of six tracks. Two scanning elements in the incremental encoder, arranged at a 90° angle to each other, provide 2 signal tracks A (K1) and B (K2). Track A (K1) is 90° ahead of B (K2) as viewed onto the motor shaft This phase shift is used for determining the direction of rotation of the motor. The zero pulse (one pulse per revolution) is registered by a third scanning device and made available on track C (K0) as a reference signal.

The signals A (K1), B (K2) and C (K0) are inverted in the encoder and provided as signals $\overline{A}$ ($\overline{K1}$), $\overline{B}$ ($\overline{K2}$) and $\overline{C}$ ($\overline{K0}$).

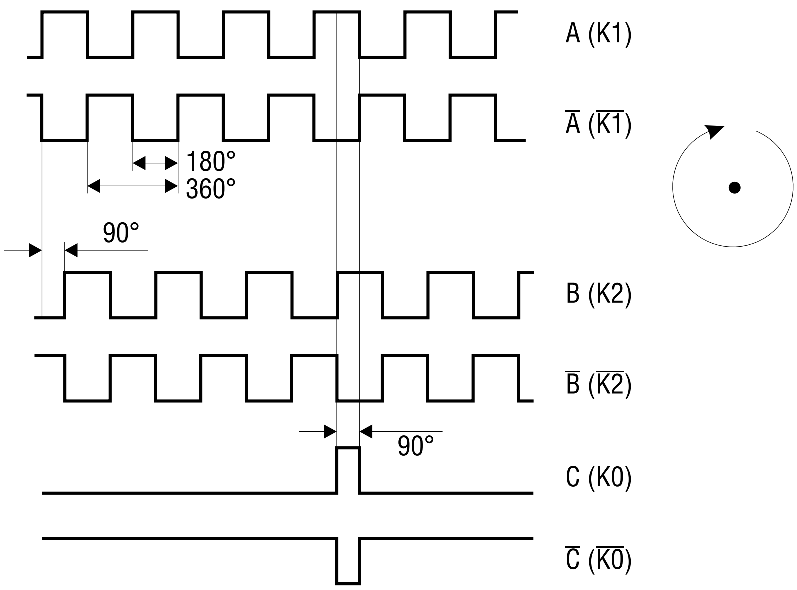

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Fig. 4: TTL signals with zero track, with inverted signals
HTL signals with zero track, without inverted signals

Signal level

There are two kinds of signal levels for incremental digital encoders:

- TTL (**T**ransistor-**T**ransistor-**L**ogic)
- TTL (**H**igh-voltage-**T**ransistor **L**ogic)

*TTL (**T**ransistor-**T**ransistor-**L**ogic)*

The signal levels are $V_{low} \leq 0.5$ V and $V_{high} \geq 2.5$ V. A positive and a negative signal (e.g. A, $\overline{A}$) each is transmitted between the sender and the receiver and evaluated differentially. This symmetrical signal transmission and the differential evaluation can minimize common-mode interference and increase the data rate.

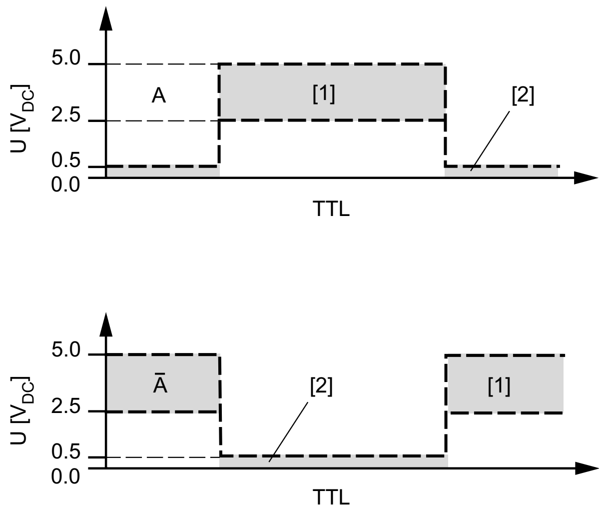

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Fig. 5: TTL signal level

[1] "1" area
[2] "0" area

*TTL (**H**igh-voltage-**T**ransistor **L**ogic)*

The signal levels are $V_{low} \leq 3$ V and $V_{high} \geq V_B$-3.5 V. The signals are transmitted symmetrically and are evaluated differentially. This and the high voltage level of the HTL encoders result in very favorable EMC properties.

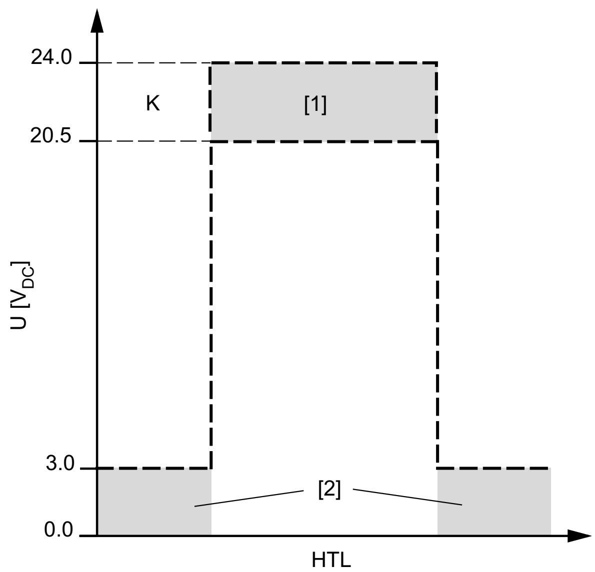

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Fig. 6: HTL signal level

[1] "1" area
[2] "0" area

Inverted HTL signals must usually not be directly connected to the encoder input of the inverter as this might overload and damage the input stages.

Incremental rotary encoders with sin/cos tracks

Structure and functional principle

Sin/cos encoders, also called sinusoidal encoders, supply two sinusoidal signals, offset by 90°. The number and progress of the sine waves (interpolation and arctangent) is evaluated. Using these values, the speed can be determined with a very high resolution. This is especially advantageous if a large setting range and small speeds must be exactly met. Further, there is a very high control stiffness.

Usually, sin/cos encoders have 2 tracks and one index signal track. Inverting the signals results in a total of six tracks. The 90° offset signals are on tracks A (K1) and B (K2). One sine half-wave per revolution is provided at channel track C (K0) as the zero pulse. The tracks A (K1), B (K2) and C (K0) are inverted in the encoder and provided inverted as signals on tracks $\overline{A}$ ($\overline{K1}$), $\overline{B}$ ($\overline{K2}$) and $\overline{C}$ ($\overline{K0}$).

Track A = Cos
Track B = Sin

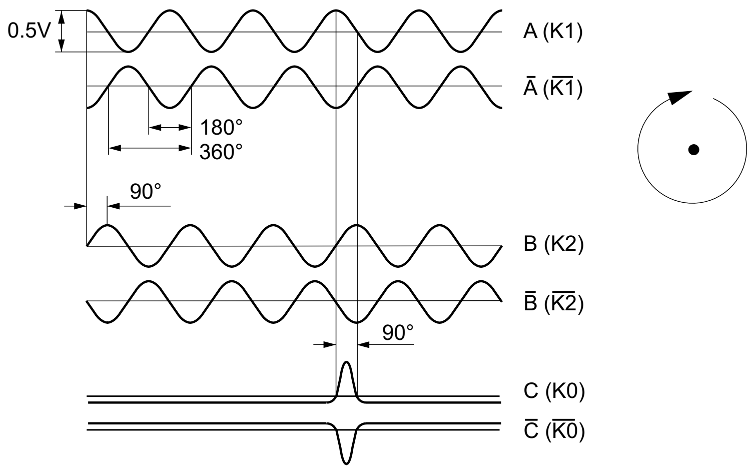

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Fig. 7: Sin/cos signals with zero track and inverted signal

Signal level

The sin/cos signals are usually superimposed on a DC voltage of 2.5 V. As the sin/cos signals are transferred symmetrically and evaluated differentially (V_{SS} = 1 V), they are not sensitive to asymmetric interference and have a good EMC behavior.

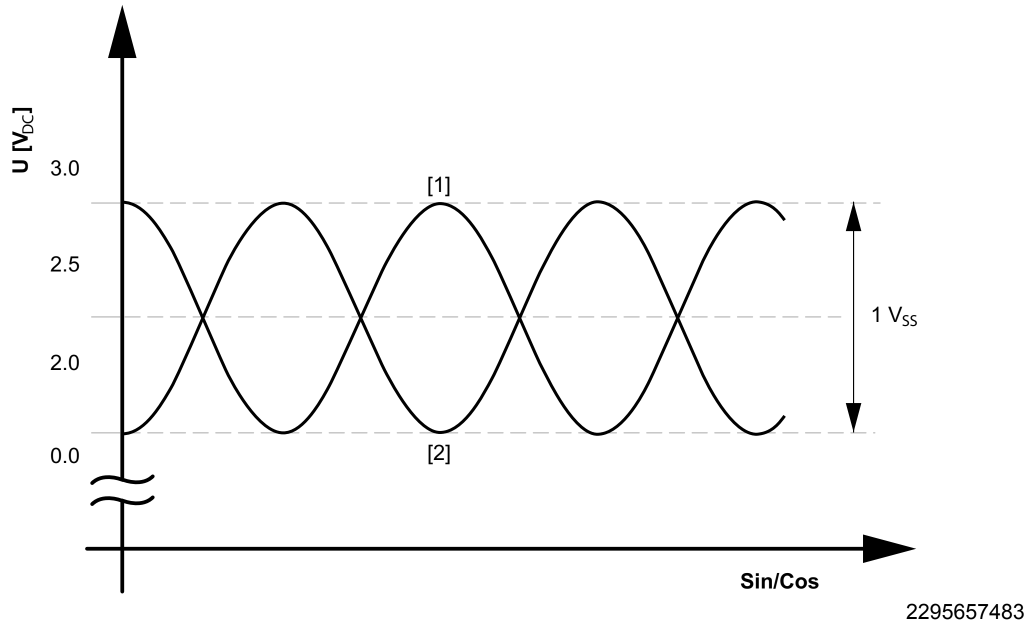

Fig. 8: Signal level of an incremental rotary encoder with sin/cos tracks

[1] B - $\overline{B}$
[2] A - $\overline{A}$

Absolute encoder

Absolute encoder with asynchronous-serial interface

In the past few years, so-called combination encoders have established on the marked. Those encoders are sin/cos encoders with absolute value information. In addition to the current speed of the motor, they provide absolute value information and offer technical and financial advantages if an absolute value encoder is required.

Structure

The absolute encoder with an asynchronous interface is a typical combination encoder. In addition to a sin/cos signal for speed recording and absolute value information, these encoders also have an electronic nameplate in which data such as drive data can be stored. This makes startup easier and reduces possible user input errors, as the user does not need to input any drive data.

Absolute encoders with asynchronous interface are available as:

1. Add-on encoder s for asynchronous motors and synchronous servomotors
2. Built-in encoders for synchronous servomotors

Both designs are available as single-turn and multi-turn variant.

Functional principle

At the beginning of the startup process, the absolute value encoder component determines the absolute position. For synchronous motors, the inverter can use this value to calculate the commutation information. The inverter reads this position information via an RS-485 connection (parameter channel) and sets a counter status. Based on this absolute value, the position changes are recorded using the tracks of the sin/cos encoder. These changes are transmitted over the process data channel to the inverter in analog form. Additional absolute position queries are only performed periodically to check validity.

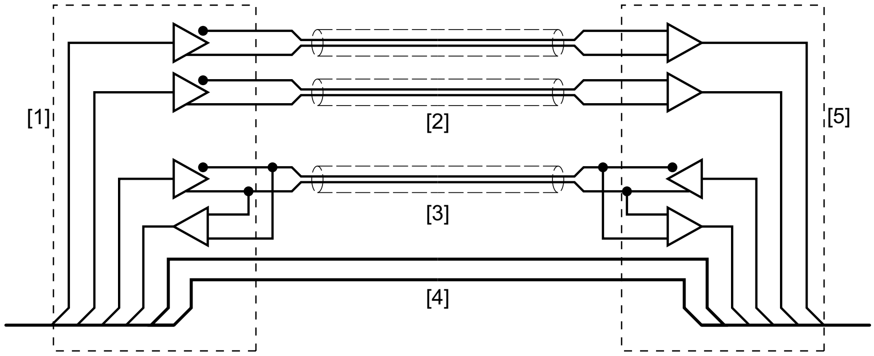

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Fig. 9: Information flow

[1] Motor feedback systems
[2] Sin/cos signals
[3] RS485 parameter channel
[4] Supply voltage
[5] Inverter

An inverter with an asynchronous-serial interface receives position information as well as the time for which the position is valid via the parameter channel. At the same time, the process data channel continuously receives and counts the incoming analog (sin/cos) signals.

The encoder is available in single-turn or multi-turn versions. Single-turn means that the absolute position information always relates to one revolution only. In addition, the multi-turn variant of the encoder can provide information regarding the number of revolutions (typically e.g. 4096) via downstream scaled code disks or an electronic revolution counter. Thus, depending on the inverter, after the maximum number of revolutions, there will be an encoder overflow that is counted in the non-volatile SRAM (NVS) of the inverter. Up to 256 encoder overflows are saved (at 4096 revolutions). If the voltage at the supply pins drops below a threshold (e.g. power failure), the NVSRAM detects this and saves the data in a retentive way.

Overflow example:

At restart, the EEPROM in the inverter provides the following values:

- The absolute value within an overflow (typically 4096 x 4096)
- The number of overflows (0 – 255)

If the drive that is close to an overflow is moved beyond the encoder overflow point when the supply voltage is removed, a discrepancy exists at restart between the recorded and the stored absolute values. The encoder electronics then corrects the stored values automatically with the recorded ones.

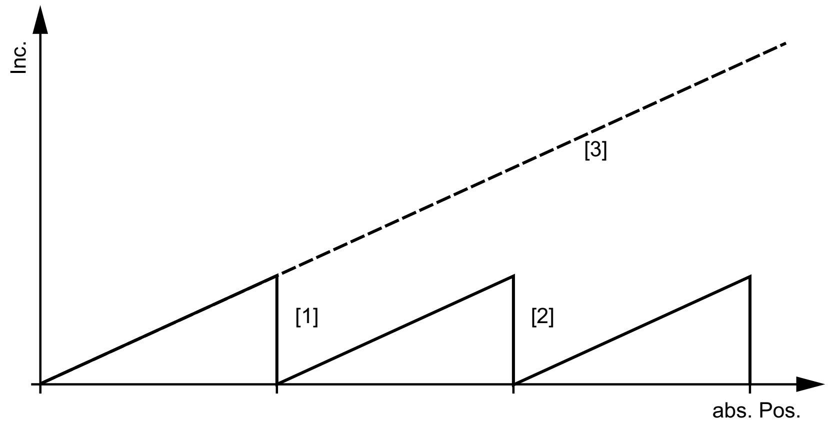

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Fig. 10: Encoder overflow

[1] 1. Encoder overflow
[2] 2. Encoder overflow
[3] Absolute value seen by user

The encoder overflows are counted in the inverter and thus the absolute position can be determined.

The user does not see the actual encoder overflows; they are saved in the inverter. Hence, the encoder with asynchronous-serial interface is a genuine absolute encoder.

Absolute encoder with SSI (synchronous-serial interface)

Single-turn encoder

The absolute value information is generated by a code disk with Gray Code that is generally scanned optically. Every angle position is assigned a unique code pattern. Thus the absolute position of the motor shaft can be determined. As opposed to the binary code, only 1 bit changes at a time. Thus, with the single-step Gray Code, an incorrect scanning is detected immediately.

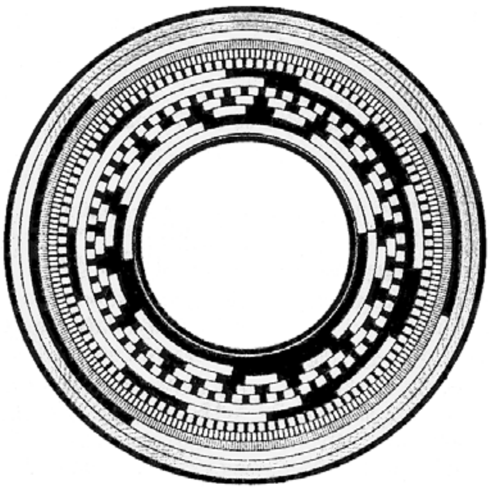

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Fig. 11: Code disk with Gray Code

Decimal	Gray code	Binary code
0	0000	0000
1	0001	0001
2	0011	0010
3	0010	0011
4	0110	0100
5	0111	0101
6	0101	0110
7	0100	0111
8	1100	1000
9	1101	1001
10	1111	1010
11	1110	1011
12	1010	1100
13	1011	1101
14	1001	1110
15	1000	1111

This kind of encoder is a single-turn encoder because the absolute position of the motor shaft can only be determined with one revolution.

Multi-turn encoder

In addition to single-turn designs, there are also multi-turn encoders that determine the absolute position with multiple revolutions.

Different technological solutions are available for the revolution detection. Micro gear unit stages that are scanned magnetically or optically via code disks are one of the more common solutions.

The multi-turn unit is also available as a storing electronic counter.

With an optical rotary encoder, the code disks are decoupled from each other with gear unit stages with a ratio of i = 16. With three additional code disks (usual value), 16 x 16 x 16 = 4096 revolutions can be absolutely resolved.

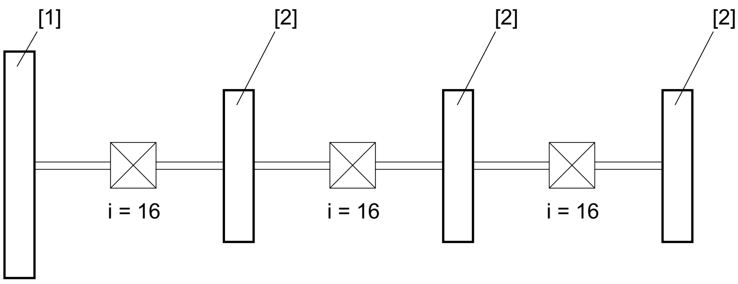

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Fig. 12: Arrangement of the code disks

[1] Code disk for angle position detection
[2] Code disk for detecting the number of revolutions

Resolver

The resolver is the most commonly used encoder system for synchronous servomotors. A resolver can determine the absolute position of the motor shaft within one motor revolution. The speed and the absolute position are derived from the resolver signal each revolution.

Structure

The resolver consists of two function units, the stator and the rotor.

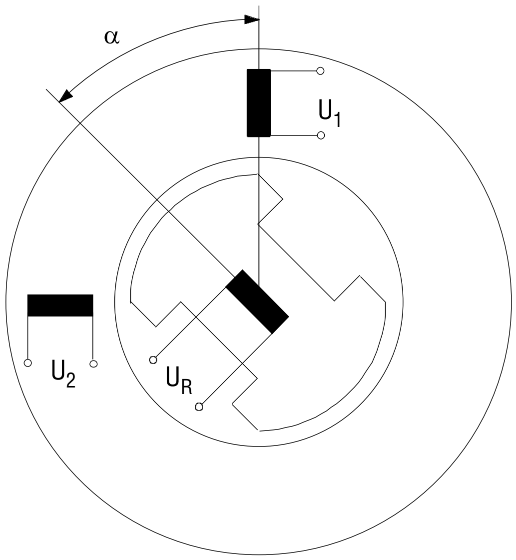

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Fig. 13: Schematic structure of the resolver

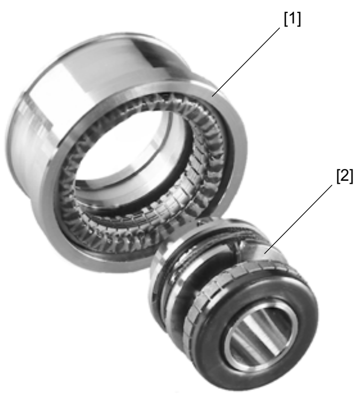

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Fig. 14: Resolver

[1] Stator of the resolver
[2] Rotor of the resolver

Functional principle

The inverter supplies a high-frequency excitation signal with a constant amplitude and frequency. This high-frequency signal is transferred to the rotor of the resolver via the stator.

The rotation of the resolver rotor induces the rotor-position-dependent voltages into the stator winding of the rotary transformer.

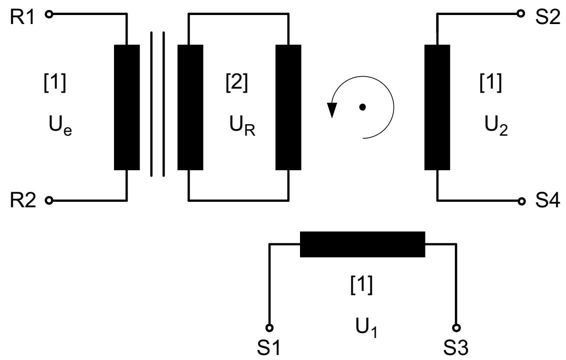

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Fig. 15: Equivalent circuit diagram of a resolver

[1] Stator
[2] Rotor

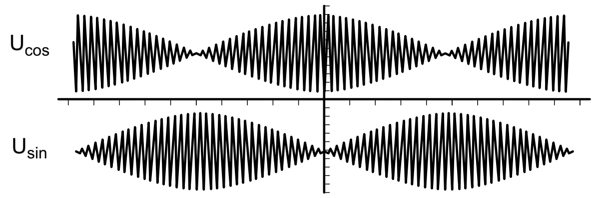

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Fig. 16: Output voltage V_{cos} and V_{sin} of the resolver

Signal characteristics

The characteristics of the signals are calculated as follows:

$$V_{ref} = A \times \sin(\omega_{excitation} \times t)$$
$$V_{cos}(t) = A \times ü \times \sin(\omega_{excitation} \times t) \times \cos(p \times \alpha)$$
$$V_{sin}(t) = A \times ü \times \sin(\omega_{excitation} \times t) \times \sin(p \times \alpha)$$
$$p \times \alpha = \arctan(V_{sin} / V_{cos})$$

V_{ref}	Reference voltage
V_{cos}	Output voltage 1 of the stator
V_{sin}	Output voltage 2 of the stator
A	Peak value of the input voltage
$\omega_{Excitation}$	Angle frequency of V_e
α	Rotor angle
ü	Gear ratio
p	Number of pole pairs of the resolver

Depending on the rotor position, the amplitudes of the voltages V_{sin} and V_{cos} change and are fed to the evaluation via a differential amplifier each. The differential amplifiers filter interference signals (common mode interference) on the isolated track signals V_{sin} and V_{cos}.

The current mechanical position can be determined from the scanned track signals:

$$p\,x\,\alpha = \arctan(U_{\sin} / U_{\cos})$$

The following figure gives a overview of the principle hardware structure of a resolver evaluation that works according to the scanning method.

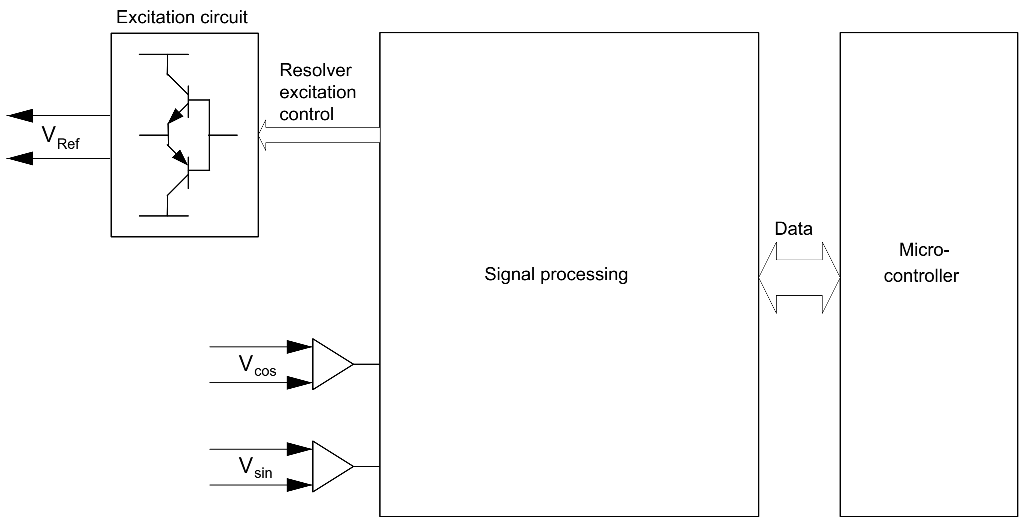

Fig. 17: Hardware resolver evaluation (simplified representation)

2.3.2 Linear encoder systems

Laser encoder

Laser distance measuring instruments are often used in drive engineering to measure distances of up to 250 m. The laser diodes send a modulated beam as pulse or with a certain frequency. This beam is reflected by a reflector and received by a photo diode system in the device. The propagation speed is 30 ns/m. The distance to the reflector surface is determined based on the delay between the sent and the received beam.

For distances of up to about 50 m, you can use laser diodes without reflector and the triangulation method for distance measuring.

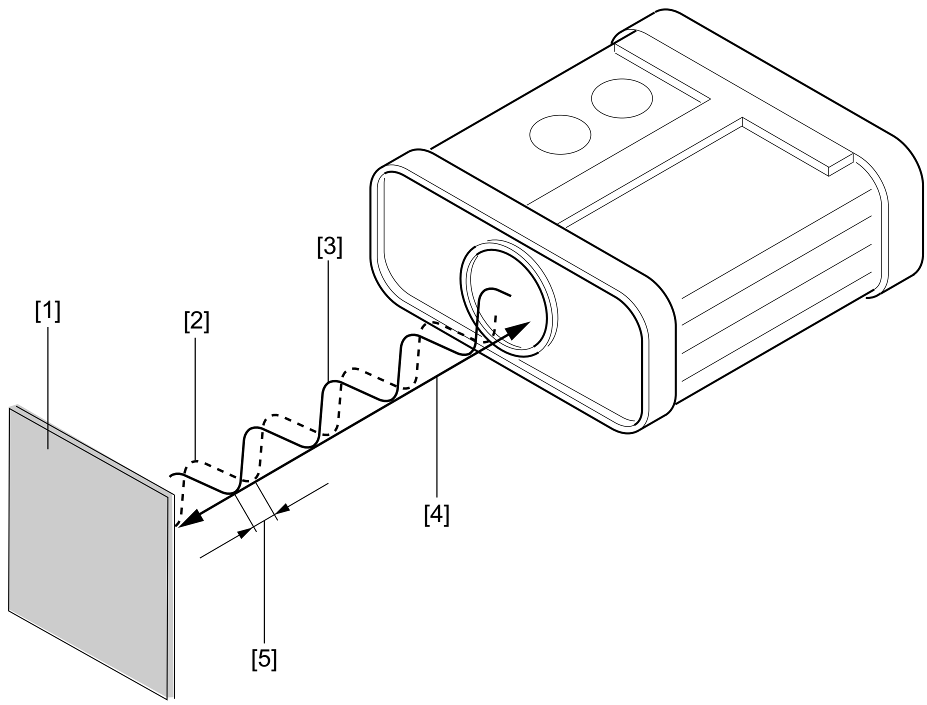

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Fig. 18: Laser distance measuring instruments

[1] Reflector or plain surface
[2] reflected signal
[3] sent signal
[4] Distance
[5] Phase shift

Barcode encoder

A barcode strip is installed along the track and is read by a barcode encoder. With a visible red-light laser, the barcode encoder determines its position in relation to the barcode strip. This is basically carried out in 3 steps:

1. Reading the code on the barcode strip.
2. Determining the position of the read code within the scan range of the laser beam.
3. Millimeter-precise position detection based on code information/position.

Then the position value is transmitted to the drive system of the respective vehicle via the standardized interface (e.g. SSI interface). The benefit of this system is the very accurate positioning over long distances. Further, it eliminates disturbances such as air pressure and temperature, that have effects on conventional laser distance measuring devices. This system can even handle curved tracks.

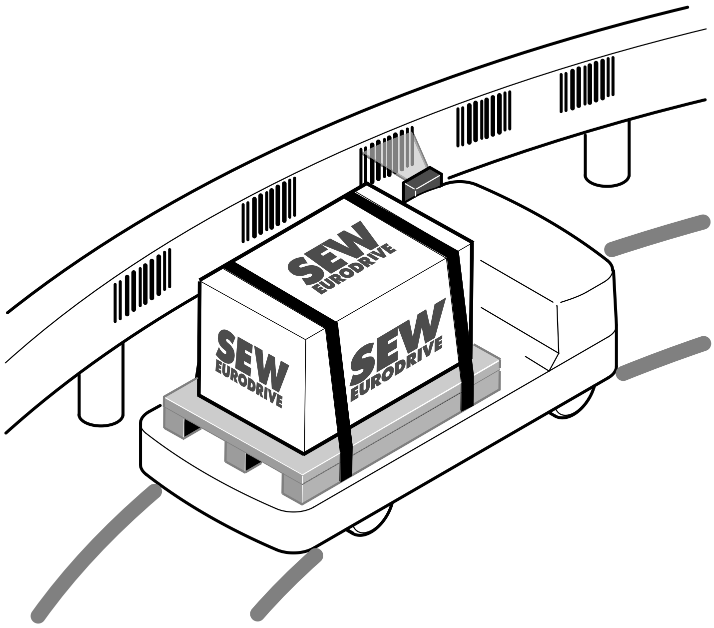

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Fig. 19: Barcode encoder

Code rail

For positioning purposes with long travel distances, there is the WCS distance coding system. It is especially suited for plants with curves, switches and inclining/declining sections. With measuring lengths of up to 327 meters it is also suitable for position detection in the following fields:

- Storage and materials handling systems
- Film studio technology
- Crane positioning
- Electroplating plants
- Elevators

Further, the WCS is suitable for the vehicle identification in materials handling systems with millimeter-precise positioning of the respective vehicle.

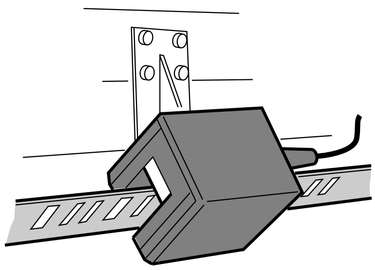

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Fig. 20: WCS distance coding system

Rulers

A measuring system is required for the operation of a synchronous linear motor in order to determine the position of the primary. In the inverter, the velocity is derived from this value and the positioning is carried out.

There are different criteria for the selection of the appropriate encoder system depending on the application:

- Maximum speed
- Maximum travel distance
- Resolution (accuracy requirements)
- Contamination level
- EMC conditions

Structure and functional principle of optical travel distance measuring systems

An optical travel distance measuring system consists of a measuring gauge made of glass or steel mounted on the track and a scanning unit that travels over the track. The scanning unit contains a light source, photo elements and optical filters for better recording. The light emitted by the light source hits the measuring gauge and is reflected according to the applied pitch and detected by the photo elements. An electronic evaluation device generates an incremental signal.

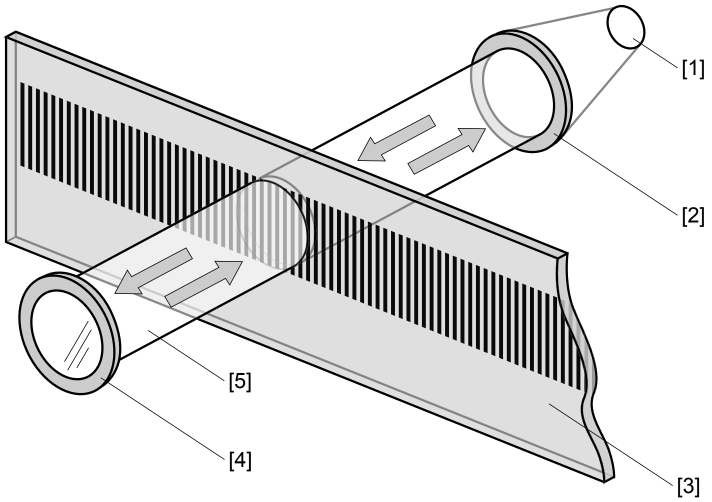

Fig. 21: Schematic representation an optical travel distance measuring system

[1] Light source and photo element
[2] Lens
[3] Scanning plate
[4] Reflector
[5] Light waves

Depending on the resolution, there are two different operating principles:

- Display principle with a line graduation of 20-100 µm
- Interference principle with a line graduation of 4-8 µm

Depending on the usage conditions and environmental conditions, different optical systems designs are used.

Closed systems

- Maximum traveling velocity about 2 m/s
- Good protection from environmental conditions
- With mechanical control

Open systems

The system works without mechanical control.

- The scanning unit is attached to the movable part and virtually "floats" above the track, thus the maximum traveling velocity is about 8 m/s.
- Almost no protection from environmental conditions.

Structure and functional principle of magnetic travel distance measuring systems

Magnetic travel distance measuring systems comprise a magnet strip and a sensor.

The magnetic tape is attached to the track as a measuring tape. The sensor that is attached to the primary travels over this measuring tape.

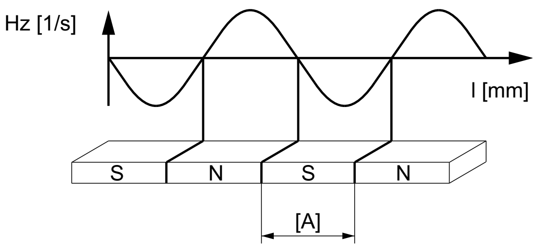

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Fig. 22: Magnetic travel distance measuring system

[A] Resolution

The sensor measures the changes of the magnetic field strength via a travel motion, which an electronic evaluation device uses to generate a sinusoidal signal. The phase-shifted configuration of the two sampling units within a sensor generates sine or cosine signals.

The sine signals of the sampling element can be resolved higher using interpolation (D/A converter). Optional electronic switches integrated in the encoders can convert these sine signals into commonly used interface signals such as TTL.

These measuring tapes are also available with a magnetized code for the absolute value. Reference travel is not required after startup for encoder systems with absolute value information. With linear absolute encoders, the position signal is converted to a digital protocol.

Structure and functional principle of inductive travel distance measuring systems

Inductive travel distance measuring systems work according to the principle of variable reluctance. Markings on a metallic measuring tape deflect a magnetic field generated by a control unit. The electronic evaluation device detects those field changes and converts them to sinusoidal signals. The phase-shifted configuration of the two sampling units within a sensor generates sine or cosine signals.

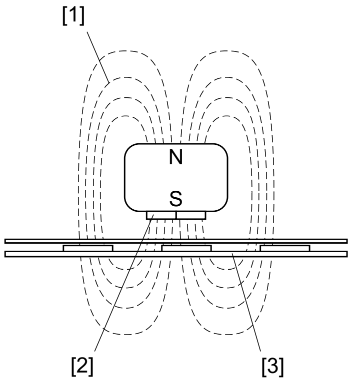

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Fig. 23: Schematic representation an inductive travel distance measuring system

[1] Magnetic field lines
[2] Magnetic sensors
[3] Measuring tape cross-section

The measuring tape on the track is crucial to the accuracy of the measurement. It consists of several layers: The core is a metal strip in which the markings are etched very precisely. These measuring tapes are also available with a reference mark. Depending on the design of the length-measuring system, the reference signal is partially recorded by a separate sensor. This metal strip is embedded between the carrier and cover tape.

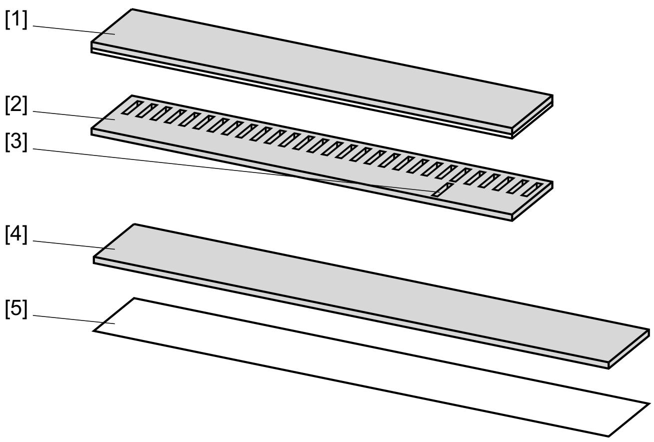

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Fig. 24: Structure of a measuring tape in layers

[1] Masking tape
[2] Partition
[3] Reference marks
[4] Steel carrier tape
[5] Adhesive layer

Optional evaluation electronics are available for inductive measuring systems for converting the sine and cosine signals into a TTL signal.

The following properties of inductive travel distance measuring systems must be taken into account during project planning:

- Maximum traveling velocity about 20 m/s
- Resolution: 1000 µm/sine cycle (sin/cos signal)
  5 - 50 µm (TTL signal)
- Accuracy about 10 µm/m
- Usually in IP66 design
- Dirt resistant

Wire-actuated encoder

A wire-actuated encoder basically consists of a measuring drum, a spring return and an unwind mechanism. A conventional encoder is connected to this unwind mechanism via a coupling. Wire-actuated encoders are especially suitable for vertical applications in storage and logistics applications as well as in stage technology.

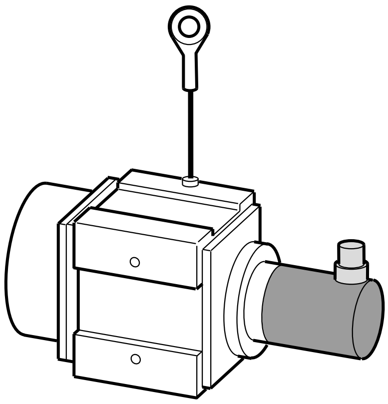

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Fig. 25: Wire-actuated encoder

2.4 Which encoder with which motor?

2.4.1 Encoder systems for asynchronous AC or servomotors

Usually, there are two reasons for using encoder systems with asynchronous motors:

– Speed control (in order to achieve a high speed quality and to optimize the response to load changes)
– Positioning

Usually, the following encoders are used:

- Incremental encoders with low resolution
  - can only be used for positioning rather than for speed control
  - only simple positioning (rapid/creep speed)
  - thus less dynamic system
  - reference travel required

- Incremental encoders
  - for speed control
  - for positioning
  - reference travel required

- Absolute encoder
  - for positioning
  - no reference travel required.
  - an additional encoder system is required for speed control if there is no realtime channel (combination encoder with either sin/cos, TTL, or HTL signal)

2.4.2 Encoder systems for synchronous servomotors

With synchronous motors, the control system additionally requires the rotor position for dynamic control. Usually, with synchronous servomotors, there are two systems for the rotor position detection:

- Resolver
  - for rotor position detection
  - for speed control
  - for positioning
  - reference travel required

- Absolute encoder
  - for rotor position detection
  - Absolute encoders for servomotors are usually combination encoders with a realtime channel (sin/cos) for speed control
  - for positioning
  - single-turn encoders usually require a reference travel
  - multi-turn encoders do not require a reference travel

2.4.3 Encoder systems for linear servo systems

- Rulers
  - for positioning
  - with absolute value information on the measuring tape, a reference travel is not required
  - with mere incremental information on the measuring tape, a reference travel is required

2.4.4 Encoder systems for linear position detection

For an exact positioning with systems subject to slip, a measuring system is required on the track in addition to the encoders mounted to the motor.

- Laser encoder
  - for measuring distances of up to about 250 m
  - Cannot handle curves

- Barcode encoder
  - can be used for measuring very long distances
  - Curves and switches are possible

- Code rail
  - can be used for measuring distances of up to about 320 m
  - very robust system
  - Curves and switches are possible

- Wire-actuated encoder
  - robust system
  - ideal for vertical applications

3 How Are Encoder Systems Used At SEW-EURODRIVE?

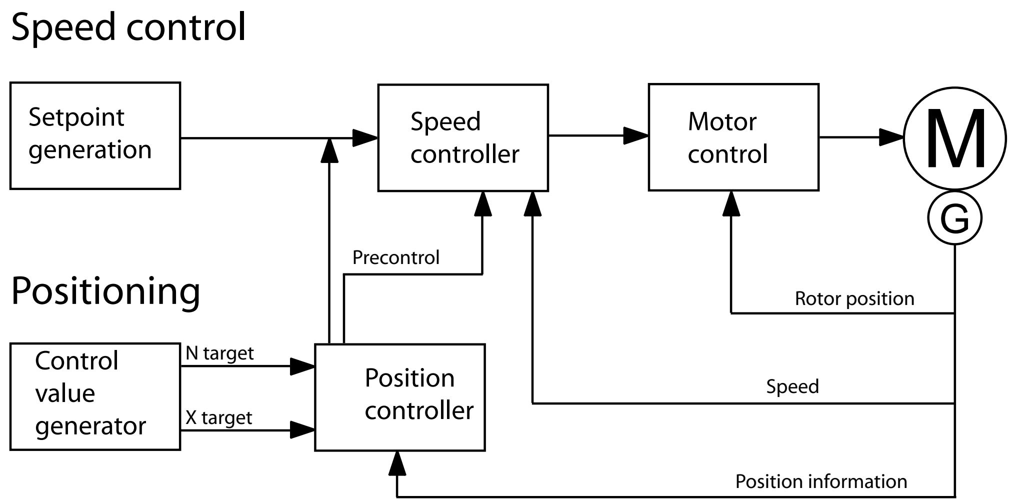

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Fig. 26: Speed and position control circuit of a drive system

3.1 Which encoder systems does SEW-EURODRIVE use?

3.1.1 Incremental encoders with a low resolution NV.. / EI.. / ES12/16/22/26

With incremental encoders with a low resolution, you can realize simple non-dynamic positioning tasks Further, those encoders allow you to inexpensively check whether the motor is turning. If a two-track encoder is used, the direction of rotation of the motor can also be detected.

3.1.2 Incremental encoder E..T / E..C / E..S / E..R

Incremental encoders are suitable for speed control and positioning. They have 2 signal tracks and one index signal track. Incremental encoders are available as hollow shaft encoders, spread shaft encoders, plug-in shaft with end thread, or solid shaft encoders with coupling. Signal output: TTL, HTL or sin/cos.

3.1.3 Single-turn combination encoders E..H / E..W

The E..H and E..W absolute encoders are combination encoders. They contain a single-turn absolute encoder and a high-resolution sinusoidal encoder. An asynchronous-serial interface is available for the data transfer of the absolute values. They are suitable for the use with synchronous motors. They can be used for speed control or for positioning within one revolution. Further, the E..H and E..W absolute encoders are equipped with an electronic nameplate.

3.1.4 A..Y / A..H / A..W absolute encoders

The A..Y, A..H and A..W absolute encoders are combination encoders. They contain a multi-turn absolute encoder and a high-resolution sinusoidal encoder. You can choose between an SSI interface or an asynchronous-serial interface for data transmission of absolute values. Further, the A..H and AS7W absolute encoders are equipped with an electronic nameplate.

3.2 What is the structure of the type designation of those encoder systems?

E S 7 S

Signal type (4th character: S)

T	V_B = DC 5 V, TTL
A	Mounting device design
C	V_B = DC 4,75 (9) – 30 V, HTL or TTL
H	HIPERFACE®
R	V_B = DC 7 (9) – 30 V, TTL
S	V_B = DC 7 (9) – 30 V, Sin/Cos 1 V_{SS}
W	V_B = DC 7 – 30 V, RS485, sin/cos 1 V_{SS}
Y	SSI [synchronous serial interface]
1 ... 6	Periods per revolution
M	Resolver signal
L	Resolver signal

Design (3rd character: 7)

1	0 – 7

Mounting/shaft (2nd character: S)

F	positive, secured with bolts
S	shaft centered, spread shaft
G	shaft-centered, plug-in shaft
I	Integrated
V	flange-centered, solid shaft
H	shaft-centered, hollow shaft
K	shaft-centered, cone shaft
L	Linear encoder

Encoder type (1st character: E)

E	Encoder (incremental encoder or single-turn combination encoder)
A	Absolute encoder
N	Proximity sensor
X	Mounting device for non-sew encoders
R	Resolver

3.3 Which products are the encoder systems used with?

3.3.1 Rotary encoders for AC motors and asynchronous servomotors

Incremental encoders for DR motors

Encoder type	Mounting type	Installed to	Electrical interface	Resolution	Supply [V_{DC}]
EH1T	Add-on encoder with hollow shaft	• DR63	TTL	1024	5
EH1S			Sin/cos		9 – 26
EH1R			TTL		
EH1C			HTL		
EI7C / EI76 / EI72 / EI71	Built-in encoder	• DR71 – 132	HTL	24 / 6 / 2 / 1	9 – 30
ES7S	Add-on encoder with spread shaft	• DR71 – 132	Sin/cos	1024	7 – 30
ES7R			TTL		
ES7C			TTL to HTL, depending on supply		4.75 – 30
EG7S	Add-on encoder with plug-in shaft	• DR160 – 225	Sin/cos	1024	7 – 30
EG7R			TTL		
EG7C			TTL to HTL, depending on supply		4.75 – 30
EV7S	Add-on encoders with coupling	• DR71 – 225	Sin/cos	1024	7 – 30
EV7R			TTL		
EV7C			TTL to HTL, depending on supply		4.75 – 30
EH7T	Add-on encoder with hollow shaft	• DR315	TTL	1024	5
EH7S			Sin/cos		10 – 30
EH7R			TTL		
EH7C			HTL		

Incremental encoders for DT/DV motors

Encoder type	Mounting type	Installed to	Electrical interface	Resolution	Supply [V_{DC}]
ES1T / ES2T	Add-on encoder with spread shaft	• DT71 – DV225 • CT71 – CV200	TTL	1024	5
ES1S / ES2S			Sin/cos		9 – 26
ES1R / ES2R			TTL		
ES1C / ES2C			HTL		
EV1T / EV2T*	Add-on encoders with coupling	• DT71 – DV225 • CT71 – CV200	TTL	1024	5
EV1S			Sin/cos		10 – 30
EV1R:			TTL		
EV1C			HTL		
ES12	Add-on encoder with spread shaft	• DT71 – DV100	HTL	1 / 2	9 – 26
ES16			HTL	6	
ES22		• DV112 – DV132S	HTL	1 / 2	
ES26			HTL	6	

* Encoder with Ex design

Single-turn/multi-turn absolute encoder

Encoder type	Mounting type	Installed to	Electrical interface	Resolu-tion	Supply [V_{DC}]
AS7W	Add-on encoder with spread shaft	• DR71- 132	RS485 (multi-turn) + 1 V sin/cos	2048	7 – 30
AG7W	Add-on encoder with plug-in shaft	• DR160 - 225:	RS485 (multi-turn) + 1 V sin/cos	2048	7 – 30
AS7Y	Add-on encoder with spread shaft	• DR71- 132	M-SSI (multi-turn) + 1 V sin/cos	2048	7 – 30
AG7Y	Add-on encoder with plug-in shaft	• DR160 - 225:	M-SSI (multi-turn) + 1 V sin/cos	2048	7 – 30
AH7Y	Add-on encoder with hollow shaft	• DR315	M-SSI (multi-turn) + TTL	2048	7 – 30
AV7Y	Add-on encoders with coupling	• DR71 – 225	M-SSI (multi-turn) + 1 V sin/cos	2048	7 – 30
AV7W	Add-on encoders with coupling	• DR71 – 225	RS485 (multi-turn) + 1 V sin/cos	2048	7 – 30
AS3H / AS4H	Add-on encoder with spread shaft	• DT71 – DV132S • CT71 – CV132S	HIPERFACE® (multi-turn) + 1 V sin/cos	4096	7 – 12
AV1H / AV6H	Add-on encoders with coupling	• DT71 – DV225 • CT71 – CV200L	HIPERFACE® (multi-turn) + 1 V sin/cos	1024	7 – 12
AV1Y	Add-on encoders with coupling	• DT71 – DV225 • CT71 – CV200L	M-SSI (multi-turn) + 1 V sin/cos	512	10 – 30

M-SSI: Multi-turn synchronous-serial interface

Proximity sensor

Encoder type	Mounting type	Installed to	Electrical interface	Resolu-tion	Supply [V_{DC}]
NV11	Radial on fan guard	• DT71 – DV132S	HTL	1	10 – 30
NV21				1	
NV12				2	
NV22				2	
NV16				6	
NV26				6	

3.3.2 Rotary encoders for synchronous servomotors

Single-turn/multi-turn absolute encoder

Encoder type	Mounting type	Installed to	Electrical interface	Resolution	Supply $[V_{DC}]$
AK0H	Built-in encoder with conical shaft	• CMP40 • CMD55, 70	HIPERFACE® (multi-turn) + 1 V sin/cos	128	7 – 12
EK0H	Built-in encoder with conical shaft	• CMP40 • CMD55, 70	HIPERFACE® (single-turn) + 1 V sin/cos		7 – 12
AS1H	Built-in encoder with spread shaft	• CMP50, 63 • CMD93, 138 • DS/CM	HIPERFACE® (multi-turn) + 1 V sin/cos	1024	7 – 12
ES1H	Built-in encoder with spread shaft	• CMP50, 63 • CMD93, 138 • DS/CM	HIPERFACE® (single-turn) + 1 V sin/cos		7 – 12
AK1H	Built-in encoder with conical shaft	• CMP71 – 160 • CMD93 – 162	HIPERFACE® (multi-turn) + 1 V sin/cos	1024	7 – 12
EK1H	Built-in encoder with conical shaft	• CMP71 – 160 • CMD93 – 162	HIPERFACE® (single-turn) + 1 V sin/cos		7 – 12
AV1H	Add-on encoders with coupling	• DS/CM	HIPERFACE® (multi-turn) + 1 V sin/cos	1024	7 – 12
AV1Y	Add-on encoders with coupling	• DS/CM	M-SSI (multi-turn) + 1 V sin/cos	512	10 – 30
AF1H	Built-in encoder with spread shaft, positive connection at the shaft connection	• CM71 – CM112	HIPERFACE® (multi-turn) + 1 V sin/cos	1024	7 – 12
EF1H	Built-in encoder with spread shaft, positive connection at the shaft connection	• CM71 – CM112	HIPERFACE® (single-turn) + 1 V sin/cos		7 – 12

M-SSI: Multi-turn synchronous-serial interface

Resolver

Resolver type	Mounting type	Installed to	Electrical interface	Resolution	Supply [V_{AC}]
RH1M	Built-in encoder with hollow shaft	DS / CM / CMP / CMD synchronous servomotors	Resolver signals, 2-pole	-	7
RH1L		CM Synchronous servo brakemotors			
RH3M	Built-in encoder with hollow shaft for the second shaft end	DS / CM / CMP / CMD synchronous servomotors			
RH3L		CM Synchronous servo brakemotors			
RH4M / RH4L	Special design				
RH5M / RH5L	Special design				
RH6M / RH6L	Special design				

Linear absolute encoders

Encoder type	Mounting type	Installed to	Electrical interface	Resolution	Supply [V_{DC}]
AL1H	Add-on encoders for synchronous linear motors	SL2 synchronous linear motors	HIPERFACE® (multi-turn) + 1 V sin/cos	0,5/100 mm	7 – 12

Linear hall sensor encoders

Encoder type	Mounting type	Installed to	Electrical interface	Resolution	Supply [V_{DC}]
NL16	Add-on encoders for synchronous linear motors	SLC	3 TTL signals with an 120° offset	6/100 mm	24

3.4 How do you perform the project planning for encoder systems?

The use of a certain encoder depends on the application requirements. If the application is not very dynamic, rapid/creep speed positioning via a low-resolution incremental encoder might be sufficient. However, speed control is required for dynamic positioning. A high resolution is required for a high speed control quality. This is why SEW-EURODRIVE recommends sin/cos encoders. The signals are scanned with an A/D converter that achieves a higher resolution than the typical 1024 (4096 due to quadruple evaluation) increments of a TTL or HTL incremental encoder. Linear systems are often used the track for travel distance positioning. The advantage is that those systems measure directly at the track and are thus independent from the slip of the drive system.

The following table lists the most important benefits of the encoder systems.

Encoder system [SEW type] **Characteristics**	**Sin/cos encoder**	**Incremental encoder**	**Incremental encoder with low resolution**
Output signal	1024 sin/cos periods	1024 periods/revolution (HTL/ TTL level)	1 to 24 periods
Accuracy	< 2 angular minutes	< 7 angular minutes	< 300 angular minutes (EI7C)
Maximum useable resolution	< 22 bits	< 14 bits	< 5 bits (EI7C)
Operating temperature	-30 °C to +100 °C	-30 °C to +85 °C	-30 °C to +60 °C
Mechanical influences	– Shock 200 g / 1 ms – Vibration 10 g / 10 - 2000 Hz	– Shock 200 g / 6 ms – Vibration 10 g / 10 - 2000 Hz	-
Use	For speed control and "incremental" positioning	For speed control and "incremental" positioning	For simple "incremental" positioning
Suitable for	Asynchronous servomotors	Asynchronous AC motors	Asynchronous AC motors
Speed control	Suitable for dynamic applications	Suitable for dynamic applications with restrictions in the lower speed range	-
Other features	Simple startup due to electronic nameplate	Simple encoder system for standard applications	-

Encoder system [SEW type] Characteristics	Resolver	Absolute encoder with asyn-chronous-serial interface (sin/cos encoder with absolute value)	SSI absolute encoder
Output signal	Amplitude-modulated sin/cos signal, 2-pole	– up to 2048 sin/cos periods – up to 32768 increments/rev-olution (absolute) – up to 65536 revolutions (absolute)	– up to 2048 sin/cos periods – up to 4096 increments/revo-lution (absolute) – up to 4096 revolutions (abso-lute)
Maximum useable resolu-tion	< 16 bits	< 22 bits	< 22 bits
Accuracy	< 40 angular minutes	< 2 angular minutes	< 2 angular minutes
Operating temperature	-55 °C to +125 °C	-20 °C to +115 °C	-40 °C to +100 °C
Mechanical influences	– Shock 100 g / 11 ms – Vibration 20 g / 10 - 50 Hz	– Shock 100 g / 10 ms – Vibration 20 g / 10 - 2000 Hz	– Shock 100 g / 10 ms – Vibration 20 g / 10 - 2000 Hz
Use	For speed control and determin-ing the rotor position within one motor revolution as well as "incremental" positioning	For speed control and determin-ing the rotor position and abso-lute position	For speed control and determin-ing the rotor position and abso-lute position
Suitable for	– Synchronous servomotors	– Synchronous servomotors – Asynchronous servomotors – AC motors	– Synchronous servomotors – Asynchronous servomotors – AC motors
Speed control	Suitable for dynamic applications	Suitable for highly-dynamic and dynamic applications	Suitable for highly-dynamic and dynamic applications
Other features	Mechanically very robust	Simple startup due to electronic nameplate	-

4 What Are The Technical Data Of These Encoder Systems?

4.1 Incremental rotary encoders with spread and plug-in shaft

Encoder type		ES7S	EG7S
For motors		DR71 – 132	DR160 – 225
Supply voltage	V_B	DC 7 V – 30 V	
Max. current consumption	I_{in}	140 mA_{RMS}	
Max. pulse frequency	f_{max}	150 kHz	
Periods per revolution	A, B	1024	
	C	1	
Output amplitude per track	V_{high}	1 V_{SS}	
	V_{low}		
Signal output		Sin/cos	
Output current per track	I_{out}	10 mA_{RMS}	
Mark space ratio		Sin/cos	
Phase angle A : B		90 ° ± 3 °	
Data memory		1920 bytes	
Vibration resistance		≤ 100 m/s²	
Shock resistance		≤ 1000 m/s²	≤ 2000 m/s²
Maximum speed	n_{max}	6000 min^{-1}	
Mass	m	0.35 kg	0.65 kg
Degree of protection		IP66	
Ambient temperature	ϑ_A	-30 °C to +60 °C	
Connection		Terminal box on incremental encoder	

Encoder type		ES7R	EG7R
For motors		DR71 – 132	DR160 – 225
Supply voltage	V_B	DC 7 – 30 V	
Max. current consumption	I_{in}	160 mA_{RMS}	
Max. pulse frequency	f_{max}	120 kHz	
Periods per revolution	A, B	1024	
	C	1	
Output amplitude per track	V_{high}	≥ DC 2.5 V	
	V_{low}	≤ DC 0.5 V	
Signal output		TTL	
Output current per track	I_{out}	25 mA_{RMS}	
Mark space ratio		1 : 1 ± 10 %	
Phase angle A : B		90 ° ± 20 °	
Data memory		-	
Vibration resistance		≤ 100 m/s²	≤ 200 m/s²
Shock resistance		≤ 1000 m/s²	≤ 2000 m/s²
Maximum speed	n_{max}	6000 rpm	
Mass	m	0.35 kg	0.65 kg
Degree of protection		IP66	
Ambient temperature	ϑ_A	-30 °C to +60 °C	
Connection		Terminal box on incremental encoder	

Encoder type		ES7C	EG7C
For motors		DR71 – 132	DR160 – 225
Supply voltage	V_B	DC 4.75 – 30 V	
Max. current consumption	I_{in}	240 mA_{RMS}	
Max. pulse frequency	f_{max}	120 kHz	
Periods per revolution	A, B	1024	
	C	1	
Output amplitude per track	V_{high}	≥ DC 2.5 V	
	V_{low}	≤ DC 1.1 V	
Signal output		HTL	
Output current per track	I_{out}	60 mA_{RMS}	
Mark space ratio		1 : 1 ± 10 %	
Phase angle A : B		90 ° ± 20 °	
Data memory		-	
Vibration resistance		≤ 100 m/s²	
Shock resistance		≤ 1000 m/s²	≤ 2000 m/s²
Maximum speed	n_{max}	6000 rpm	
Mass	m	0.35 kg	0.65 kg
Degree of protection		IP66	
Ambient temperature	ϑ_A	-30 °C to +60 °C	
Connection		Terminal box on incremental encoder	

Encoder type		ES1T ES2T	ES1S ES2S	ES1R ES2R	ES1C ES2C
For motors		DT71 – DV225, CT71 – 200CV			
Supply voltage	V_B	DC 5 V	DC 9 – 26 V		
Max. current consumption	I_{in}	180 mA_{RMS}	160 mA_{RMS}	180 mA_{RMS}	340 mA_{RMS}
Max. pulse frequency	f_{max}	120 kHz			
Periods per revolution	A, B	1024			
	C	1			
Output amplitude per track	V_{high}	≤ DC 2.5 V	1 V_{SS}	≤ 2.5 VDC	≤ V_B DC - 3.5 V
	V_{low}	≤ DC 0.5 V		≤ DC 0.5 V	≤ 1.5 VDC
Signal output		TTL	Sin/cos	TTL	HTL
Output current per track	I_{out}	20 mA_{RMS}	40 mA_{RMS}	20 mA_{RMS}	60 mA_{RMS}
Mark space ratio		1 : 1 ± 20 %	Sin/cos	1 : 1 ± 20 %	
Phase angle A : B		90 ° ± 20 °	90 °	90 ° ± 20 °	
Data memory		-			
Vibration resistance		≤ 100 m/s²			
Shock resistance		≤ 1000 m/s²			
Maximum speed	n_{max}	10000 rpm			
Mass	m	0.38 kg			
Degree of protection		IP66			
Ambient temperature	ϑ_A	-30 °C to +60 °C			
Connection		Terminal box on incremental encoder			

Encoder type		**EH7S**
For motors		DR315
Supply voltage	V_B	DC 10 V – 30 V
Max. current consumption	I_{in}	140 mA_{RMS}
Max. pulse frequency	f_{max}	180 kHz
Periods per revolution	A, B	1024
	C	1
Output amplitude per track	V_{high}	1 V_{SS}
	V_{low}	
Signal output		Sin/cos
Output current per track	I_{out}	10 mA_{RMS}
Mark space ratio		Sin/cos
Phase angle A : B		90 ° ± 10 °
Data memory		-
Vibration resistance		≤ 100 m/s²
Shock resistance		≤ 2000 m/s²
Maximum speed	n_{max}	6000 rpm at 70 °C / 3500 rpm at 80 °C
Mass	m	0.8 kg
Degree of protection		IP65
Ambient temperature	ϑ_A	-20 °C to +60 °C
Connection		12-pin plug connector

4.2 Incremental rotary encoders with solid shaft

Encoder type		**EV1T**	**EV1S**	**EV1R:**	**EV1C**	**EV7S**
For motors		DT71 – DV225, CT71 – 200CV				DR71 – 225
Supply voltage	V_B	DC 5 V	DC 10 V – 30 V			DC 7 V – 30 V
Max. current consumption	I_{in}	180 mA_{RMS}	160 mA_{RMS}	180 mA_{RMS}	340 mA_{RMS}	140 mA_{RMS}
Max. pulse frequency	f_{max}	120 kHz				150 kHz
Periods per revolution	A, B	1024				
	C	1				
Output amplitude per track	V_{high}	≤ DC 2.5 V	1 V_{SS}	≤ 2.5 VDC	≤ V_B DC - 3.5 V	1 V_{SS}
	V_{low}	≤ DC 0.5 V		≤ DC 0.5 V	≤ 1.5 VDC	
Signal output		TTL	Sin/cos	TTL	HTL	Sin/cos
Output current per track	I_{out}	20 mA_{RMS}	40 mA_{RMS}	20 mA_{RMS}	60 mA_{RMS}	10 mA_{RMS}
Mark space ratio		1 : 1 ± 20 %	Sin/cos	1 : 1 ± 20 %		Sin/cos
Phase angle A : B		90 ° ± 20 °	90 °	90 ° ± 20 °		90 ° ± 3 °
Data memory		-				
Vibration resistance		≤ 300 m/s²				
Shock resistance		≤ 1000 m/s²				
Maximum speed	n_{max}	6000 rpm				
Mass	m	0.3 kg				
Degree of protection		IP66				
Ambient temperature	ϑ_A	-30 °C to +60 °C				
Connection		Terminal box on incremental encoder				

4.3 SSI absolute encoder

Encoder type		AS7Y	AG7Y
For motors		DR71 – 132	DR160 – 225
Supply voltage	V_B	DC 7 – 30 V	
Max. current consumption	I_{in}	140 mA_{RMS}	
Max. pulse frequency	f_{max}	200 kHz	
Periods per revolution	A, B	2048	
	C	-	
Output amplitude per track	V_{high}	1 V_{SS}	
	V_{low}		
Signal output		Sin/cos	
Output current per track	I_{out}	10 mA_{RMS}	
Mark space ratio		Sin/cos	
Phase angle A : B		90 ° ± 3 °	
Scanning code		Gray code	
Single-turn resolution		4096 increments / revolution	
Multi-turn resolution		4096 revolutions	
Data transfer		synchronous-serial	
Serial data output		Driver according to EIA RS-485	
Serial clock input		Optocoupler, recommended driver to EIA RS-485	
Clock rate		Permitted range: 100 – 2000 kHz (max. 100 m cable length with 300 kHz)	
Clock-pulse space period		12 – 30 µs	
Data memory		1920 bytes	
Vibration resistance		≤ 100 m/s²	
Shock resistance		≤ 1000 m/s²	≤ 2000 m/s²
Maximum speed	n_{max}	6000 rpm	
Mass	m	0.4 kg	0.7 kg
Degree of protection		IP66	
Ambient temperature	ϑ_B	-20 °C to +60 °C	
Connection		Terminal strip in pluggable connection cover	

Encoder type		AV1Y
For motors		CT71 – DV200L, DT71 – DV225, DS/CM
Supply voltage	V_B	DC 10 – 30 V
Max. current consumption	I_{in}	250 mA_{RMS}
Max. pulse frequency	f_{max}	100 kHz
Periods per revolution	A, B	512
	C	-
Output amplitude per track	V_{high}	1 V_{SS}
	V_{low}	
Signal output		Sin/cos
Output current per track	I_{out}	10 mA_{RMS}
Mark space ratio		Sin/cos
Phase angle A : B		90 °
Scanning code		Gray code
Single-turn resolution		4096 increments / revolution
Multi-turn resolution		4096 revolutions
Data transfer		synchronous-serial
Serial data output		Driver according to EIA RS-485
Serial clock input		Optocoupler, recommended driver to EIA RS-485
Clock rate		Permitted range: 90 – **300** – 1100 kHz (max. 100 m cable length with 300 kHz)
Clock-pulse space period		12 – 35 µs
Data memory		-
Vibration resistance		≤ 300 m/s²
Shock resistance		≤ 1000 m/s²
Maximum speed	n_{max}	6000 rpm
Mass	m	0.3 kg
Degree of protection		IP64/67
Ambient temperature	ϑ_B	-40 °C to +60 °C fixed cable installation; -10 °C to +60 °C flexible cable installation
Connection		1 m (3.3 ft) cable with 17-pin round connector

Encoder type		AH7Y
For motors		DR315
Supply voltage	V_B	DC 9 – 30 V
Max. current consumption	I_{in}	150 mA_{RMS}
Max. pulse frequency	f_{max}	120 kHz
Periods per revolution	A, B	2048
	C	-
Output amplitude per track	V_{high}	≥ 2.5 V_{SS}
	V_{low}	≤ 0.5 V_{SS}
Signal output		TTL
Output current per track	I_{out}	20 mA_{RMS}
Mark space ratio		1 : 1 ± 20 %
Phase angle A : B		90 ° ± 20 °
Scanning code		Gray code
Single-turn resolution		4096 increments / revolution
Multi-turn resolution		4096 revolutions
Data transfer		synchronous-serial
Serial data output		Driver according to EIA RS-485
Serial clock input		Optocoupler, recommended driver to EIA RS-485
Clock rate		Permitted range: 100 – 800 kHz (max. 100 m cable length with 300 kHz)
Clock-pulse space period		12 – 30 µs
Data memory		-
Vibration resistance		≤ 100 m/s²
Shock resistance		≤ 2000 m/s²
Maximum speed	n_{max}	3500 rpm
Mass	m	< 3 kg
Degree of protection		IP56
Ambient temperature	ϑ_B	-20 °C to +60 °C
Connection		Terminal strip on encoder

4.4 Resolver

Encoder type		RH1M / RH1L
For motors		DS / CM / CMP / CMD synchronous servomotors
Supply voltage	V_{12}	7 V_{AC_eff} / 7 kHz
Number of poles		2
Gear ratio	ü	0.5 ± 10%
Output impedance	Z_{SS}	200 to 330 Ω
Ambient temperature	ϑ_B	-40 °C to +60 °C
Connection		12 pole circular connector (Intercontec) or terminal box connection

4.5 Absolute encoder with asynchronous-serial interface

Encoder type		AS7W	AG7W
For motors		DR71 – 132	DR160 – 225
Supply voltage	V_B	DC 7 – 30 V	
Max. current consumption	I_{in}	150 mA_{RMS}	
Max. pulse frequency	f_{max}	200 kHz	
Periods per revolution	A, B	2048	
	C	-	
Output amplitude per track	V_{high}	1 V_{SS}	
	V_{low}		
Signal output		Sin/cos	
Output current per track	I_{out}	10 mA_{RMS}	
Mark space ratio		Sin/cos	
Phase angle A : B		90° ± 3°	
Scanning code		Binary code	
Single-turn resolution		8192 increments / revolution	
Multi-turn resolution		65536 revolutions	
Data transfer		RS485	
Serial data output		Driver according to EIA RS-485	
Serial clock input		Optocoupler, recommended driver to EIA RS-485	
Clock rate		9600 baud	
Clock-pulse space period		-	-
Data memory		1920 bytes	
Vibration resistance		≤ 100 m/s²	≤ 200 m/s²
Shock resistance		≤ 1000 m/s²	≤ 2000 m/s²
Maximum speed	n_{max}	6000 rpm	
Mass	m	0.4 kg	0.7 kg
Degree of protection		IP66	
Ambient temperature	ϑ_A	-20 °C to +60 °C	
Connection		Terminal strip in pluggable connection cover	

Encoder type		ES1H	AS1H	EK1H	AK1H
For motors		CMP50 / 63, CDM93 / 138, DS/CM		CMP40, CMD55 / 70	
Supply voltage	V_B	DC 7 – 12 V			
Max. current consumption	I_{in}	130 mA_{RMS}			
Max. pulse frequency	f_{max}	200 kHz			
Periods per revolution	A, B	1024			
	C	-			
Output amplitude per track	V_{high}	1 V_{SS}			
	V_{low}				
Signal output		Sin/cos			
Output current per track	I_{out}	10 mA_{RMS}			
Mark space ratio		Sin/cos			
Phase angle A : B		90°			
Scanning code		Binary code			
Single-turn resolution		32768 increments / revolution			
Multi-turn resolution		-	4096 revolutions	-	4096 revolutions
Data transfer		RS485			
Serial data output		Driver according to EIA RS-485			
Serial clock input		-			
Clock rate		9600 baud			
Clock-pulse space period		-			
Data memory		1792 bytes			
Vibration resistance		≤ 200 m/s²			
Shock resistance		≤ 1000 m/s²			
Maximum speed	n_{max}	6000 rpm			
Mass	m	0.2 kg			
Degree of protection		IP40			
Ambient temperature	ϑ_A	-20 °C to +60 °C			
Connection		12 pole circular connector (Intercontec) or terminal box connection			

Encoder type		AS3H	AS4H
For motors		DT71 – DV132S, CT71 – CV132S	
Supply voltage	V_B	DC 7 – 12 V	
Max. current consumption	I_{in}	130 mA_{RMS}	
Max. pulse frequency	f_{max}	200 kHz	
Periods per revolution	A, B	1024	
	C	-	
Output amplitude per track	V_{high}	1 V_{SS}	
	V_{low}		
Signal output		Sin/cos	
Output current per track	I_{out}	10 mA_{RMS}	
Mark space ratio		Sin/cos	
Phase angle A : B		90°	
Scanning code		Binary code	
Single-turn resolution		32768 increments / revolution	
Multi-turn resolution		4096 revolutions	
Data transfer		RS485	
Serial data output		Driver according to EIA RS-485	
Serial clock input		Optocoupler, recommended driver to EIA RS-485	
Clock rate		-	
Clock-pulse space period		-	
Data memory		1792 bytes	
Vibration resistance		≤ 200 m/s²	
Shock resistance		≤ 1000 m/s²	
Maximum speed	n_{max}	6000 rpm	
Mass	m	0.3 kg	
Degree of protection		IP65	
Ambient temperature	ϑ_A	-20 °C to +60 °C	
Connection		M23 12-pole	

Encoder type		AV1H
For motors		DT71 – DV225, CT71 – DV200L, DS/CM
Supply voltage	V_B	DC 7 – 12 V
Max. current consumption	I_{in}	130 mA_{RMS}
Max. pulse frequency	f_{max}	200 kHz
Periods per revolution	A, B	1024
	C	-
Output amplitude per track	V_{high}	1 V_{SS}
	V_{low}	
Signal output		Sin/cos
Output current per track	I_{out}	10 mA_{RMS}
Mark space ratio		Sin/cos
Phase angle A : B		90°
Scanning code		Binary code
Single-turn resolution		32768 increments / revolution
Multi-turn resolution		4096 revolutions
Data transfer		RS485
Serial data output		Driver according to EIA RS-485
Serial clock input		Optocoupler, recommended driver to EIA RS-485
Clock rate		-
Clock-pulse space period		-
Data memory		1792 bytes
Vibration resistance		≤ 200 m/s²
Shock resistance		≤ 1000 m/s²
Maximum speed	n_{max}	6000 rpm
Mass	m	0.55 kg
Degree of protection		IP65
Ambient temperature	ϑ_A	-20 °C to +60 °C
Connection		M23 12-pole

Encoder type		EK0H	AK0H
For motors		CMP40, CMD55 / 70	
Supply voltage	V_B	DC 7 – 12 V	
Max. current consumption	I_{max}	110 mA_{RMS}	
Max. pulse frequency	f_{max}	65 kHz	
Periods per revolution	A, B	128	
	C	-	
Output amplitude per track	V_{high}	1 V_{SS}	
	V_{low}		
Signal output		Sin/cos	
Output current per track	I_{out}	10 mA_{RMS}	
Mark space ratio		Sin/cos	
Phase angle A : B		90°	
Scanning code		Binary code	
Single-turn resolution		4096 increments / revolution	
Multi-turn resolution		-	4096 revolutions
Data transfer		RS485	
Serial data output		Driver to EIA RS485	
Serial clock input		-	
Clock rate		-	
Clock-pulse space period		-	
Data memory		1792 bytes	
Vibration resistance		≤ 500 m/s²	
Shock resistance		≤ 1000 m/s²	
Maximum speed	n_{max}	12000 rpm	9000 rpm
Mass	m	0,065 kg	
Degree of protection		IP50	
Ambient temperature	ϑ_A	-20 °C to +110 °C	
Connection		12-pin round connector	

4.6 Built-in encoder

Encoder type		EI7C	EI76 / EI72 / EI71
For motors		DR71 – 132	
Supply voltage	V_B	DC 9 – 30 V	
Max. current consumption	I_{max}	120 mA_{RMS}	
Max. pulse frequency	f_{max}	1,54 kHz	
Periods per revolution	A, B	24	6, 2, 1
	C	-	-
Output amplitude per track	V_{high}	$\geq V_B$ -2.5 V_{SS}	
	V_{low}	$\leq$ 0.5 V_{SS}	
Signal output		HTL	
Output current per track	I_{out}	60 mA_{RMS}	
Mark space ratio		1 : 1 ± 20 %	
Phase angle A : B		90 ° ± 20 °	
Data memory		-	
Vibration resistance		≤ 100 m/s²	
Shock resistance		≤ 1000 m/s²	
Maximum speed	n_{max}	3600 rpm	
Mass	m	0.2 kg	
Degree of protection		IP65	
Ambient temperature	ϑ_A	-30 °C to +60 °C	
Connection		Terminal strip in the terminal box or M12 (8-pin)	

4.7 Proximity sensor

Encoder type		NV11	NV12	NV16	NV21	NV22	NV26
for motors/brakemotors		DT71 – DV132S					
Supply voltage	V_B	DC 10 – 30 V					
Max. current consumption	I_{max}	200 mA_{RMS}					
Max. pulse frequency	f_{max}	1.5 kHz					
Periods per revolution		1 A track	2 A track	6 A track	1 A+B tracks	2 A+B tracks	6 A+B tracks
Output		NO contact (pnp)					
Mark space ratio		1 : 1 ± 20 %					
Phase angle A : B		90 ° ± 45 %					
Degree of protection		IP67					
Ambient temperature	ϑ_A	0 °C to +60 °C					
Connection		M12 1 connector, e.g. RKWT4 (Lumberg)					

4.8 Mounting device

Mounting device	ES7A	EG7A	EH7A
For motors	DR71–132	DR160 – 225	DR315
Mounting type of encoder	Shaft centered		Hollow shaft
Motor shaft type	10 mm bore	14 mm bore with M6 end thread	Shaft end 38 mm × 116 mm
Suitable for encoder	ES7S ES7R AS7Y AS7W	EG7S EG7R AG7Y AG7W	EH7S - AH7Y -

Mounting device		XV0A	XV1A	XV2A	XV3A	XV4A
For motors		DR71 – 225				
Mounting type of encoder		Flange centered with coupling				
Type	Encoder shaft	Any	6 mm	10 mm	12 mm	11 mm
	Centering	Any	50 mm	50 mm	80 mm	85 mm
Suitable for encoder		Provided by the customer or by SEW-EURODRIVE on behalf of the customer.				

Mounting device	ES1A	ES2A
For motors	DT71 – 100	DV112 – 132S
For encoder	Spreadshaft encoders with 8 mm center bore	Spreadshaft encoders with 10 mm center bore

Mounting device	EV1A	AV1A
For motors	DT71 – DV225	DY71 – 112
For encoder	Solid shaft encoder (synchronous flange)	
Flange diameter	58 mm	
Center bore diameter	50 mm	
Shaft end diameter	6 mm	
Length of shaft end	10 mm	
Fastening	3 fixing clamps (screws with eccentric disks) for 3 mm flanges	

5 How Is The Encoder Mounted Mechanically?

5.1 Spread-shaft encoder (DR and DT/DV motors)

When the encoder is mounted with a spread ahsft, there is a non-positive connection between the motor shaft and the encoder shaft. Tightening the screw in the encoder shaft pulls up a cone that spreads the notched encoder shaft. Thus the encoder shaft is jammed inside the mottor shaft and transmits the rotating motion. The resulting encoder torque is supported on the fan guard.

DR 71 – 132

DT 71 – 90

DV 100 – 132S

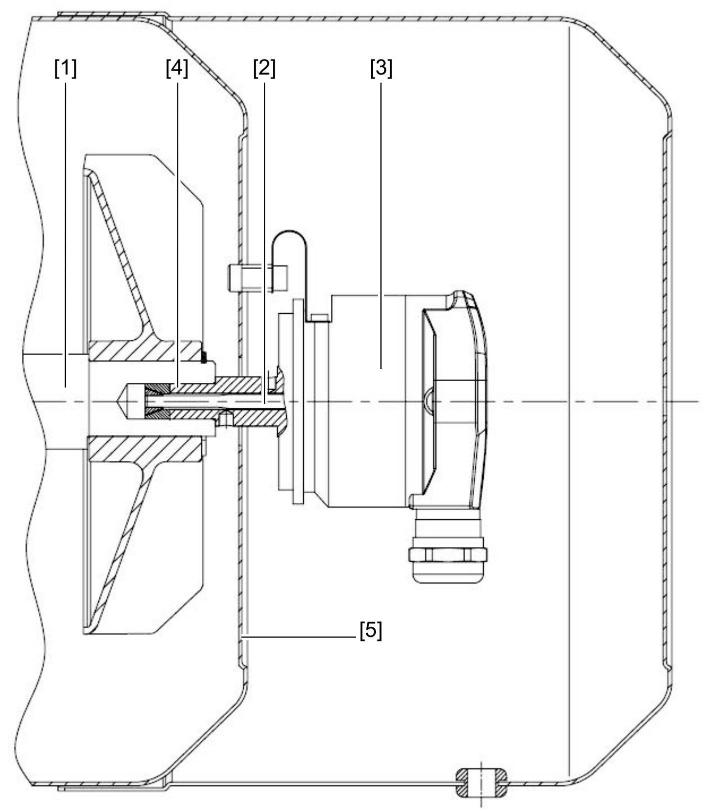

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Fig. 27: Spread-shaft encoder

[1] Motor shaft
[2] Encoder shaft
[3] Screw within the encoder shaft
[4] COne
[5] Fan guard

5.2 Plug-in shaft with end thread (DR motors only)

The encoder is fixed via a combination of interference fit and thread clamping. The diameter at the end of the larger bore of the motor shaft is smaller than at the guide. If you tighten the screw in the encoder shaft, it pulls the encoder into this smaller diameter, resulting in an interference fit. In addition, the thread is braced against the encoder that is completely pulled in. Thus the encoder shaft is jammed inside the mottor shaft and transmits the rotating motion. The resulting encoder torque is supported on the fan guard.

DR 160 – 225

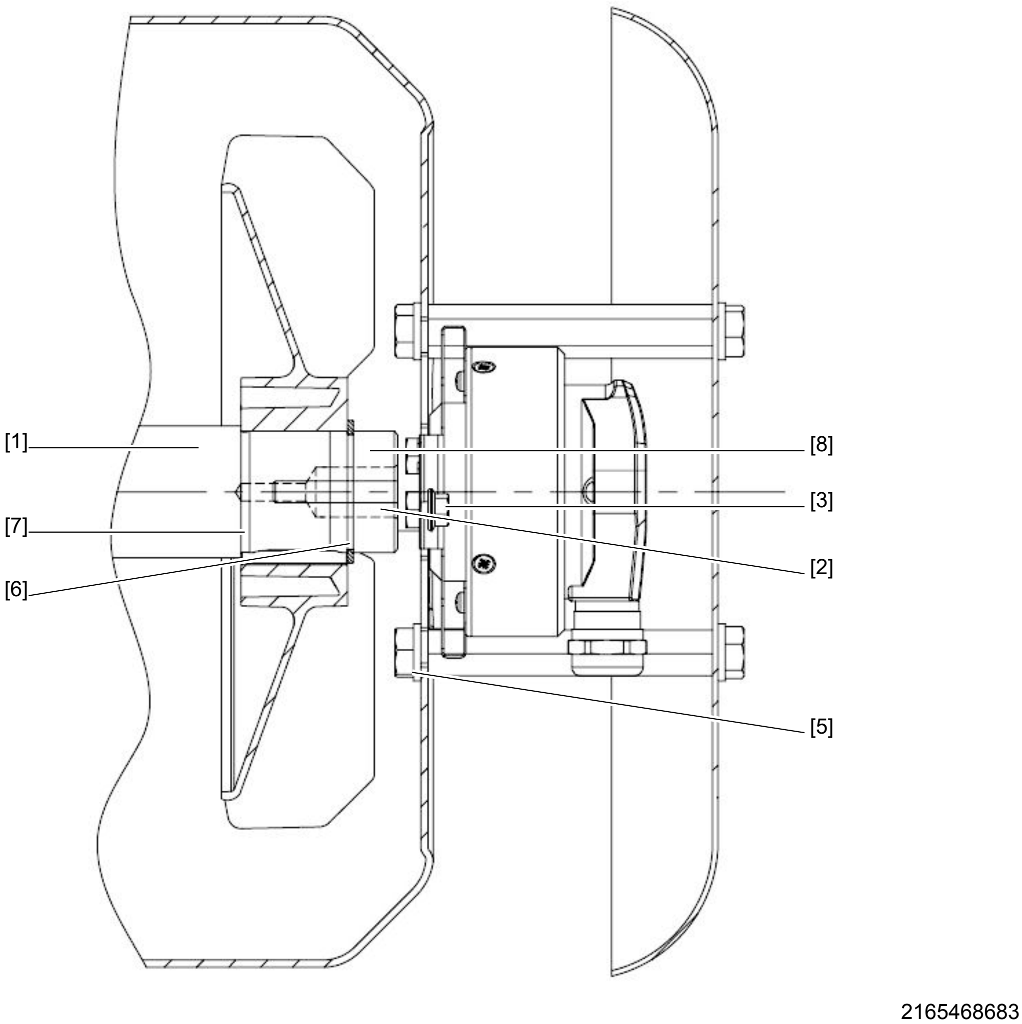

Fig. 28: Mounting on DR motor

[1] Motor shaft
[2] Encoder shaft
[3] Screw within the encoder shaft
[5] Fan guard
[6] Interference fit
[7] Thread clamping
[8] Large bore on the motor shaft

5.3 Built-in encoder (only DR-motors)

With this variant, the encoder does not have to be directly connected to the motor shaft. The encoder module is screwed on the endshield. Cylinder head screws and distance bushing are required for brakemotors. An additional support plate is required for size DR 112/132. In addition, a special fan with integrated magnets must be installed on the motor shaft.

DR 71 – 132

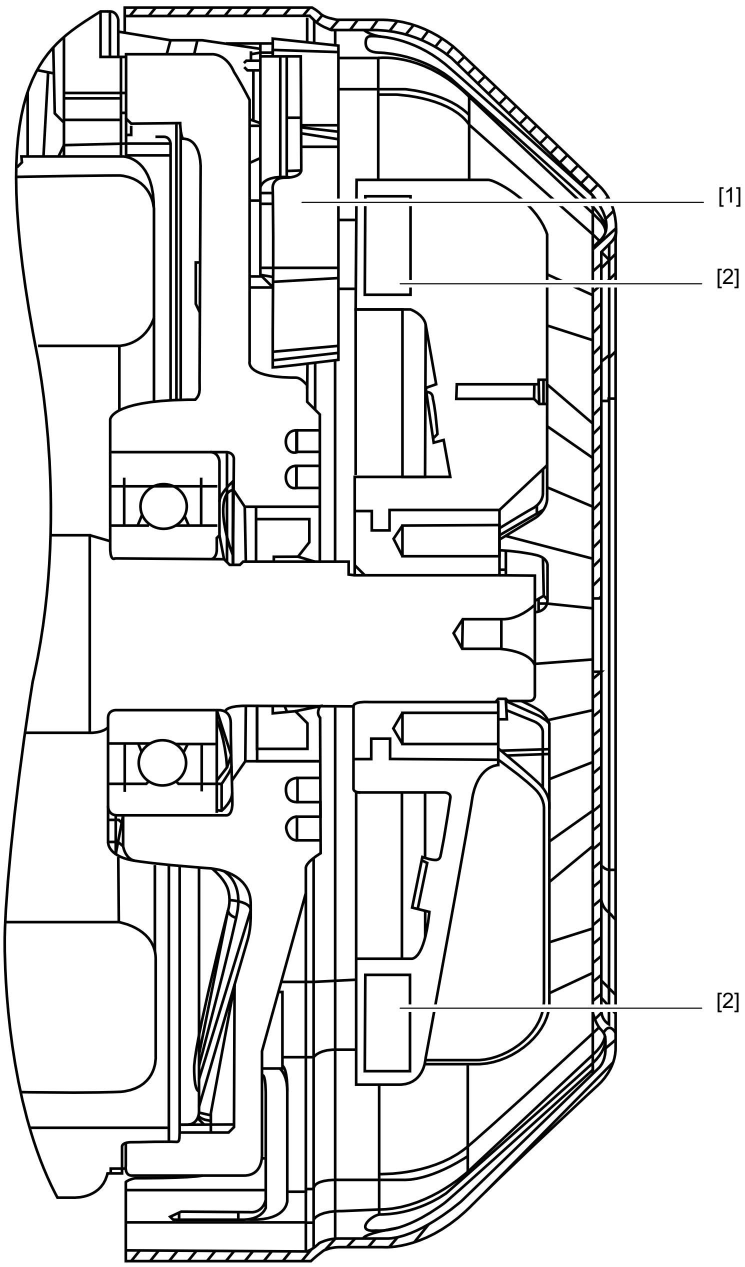

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Fig. 29: Built-in encoder

[1] Encoder module
[2] Magnet

5.4 Mounting device (DR and DT/DV motors)

Instead of being connected directly to the motor shaft, the encoder is connected via a coupling. The coupling in the motor shaft (here brakemotor) hase the same dimensions as the conventional encoder connection (spread shaft or thread bore). The coupling half on the encoder end is adapted to the dimensions of hte required enccoder shaft. Thus you can install any encoder. The torque is balanced via the fan guard.

DR 71 – 225 for non-SEW encoders

DR 71 – 225 for EV7A

DV 132M – 225 for all encoders

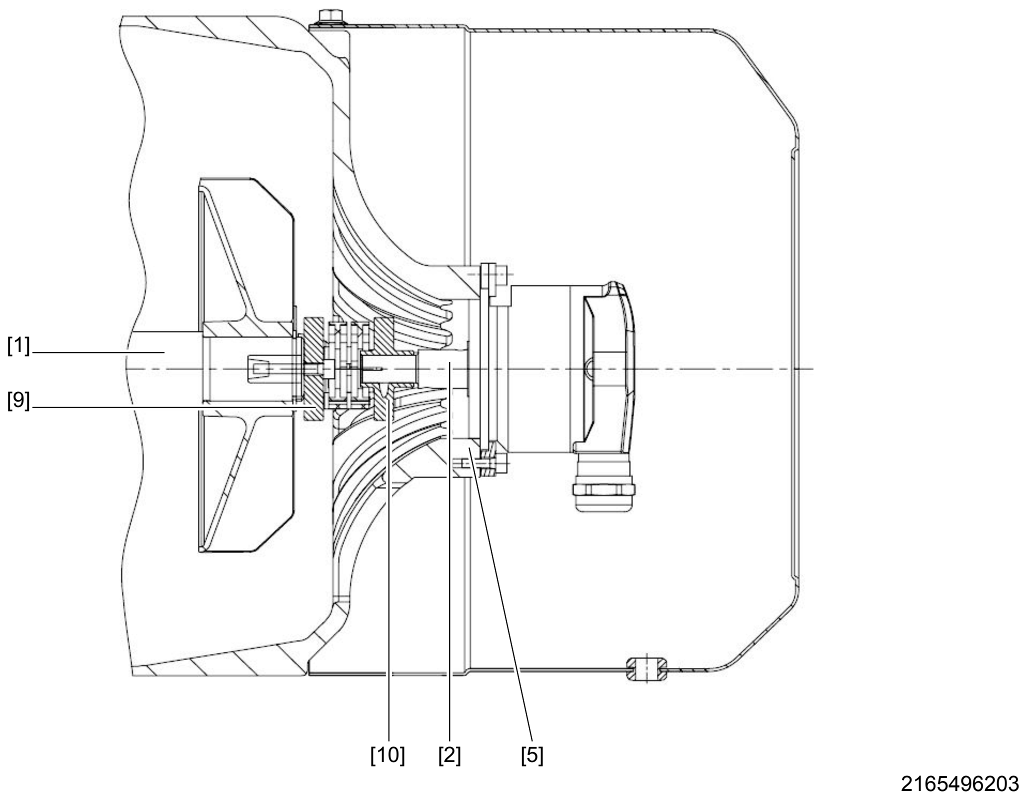
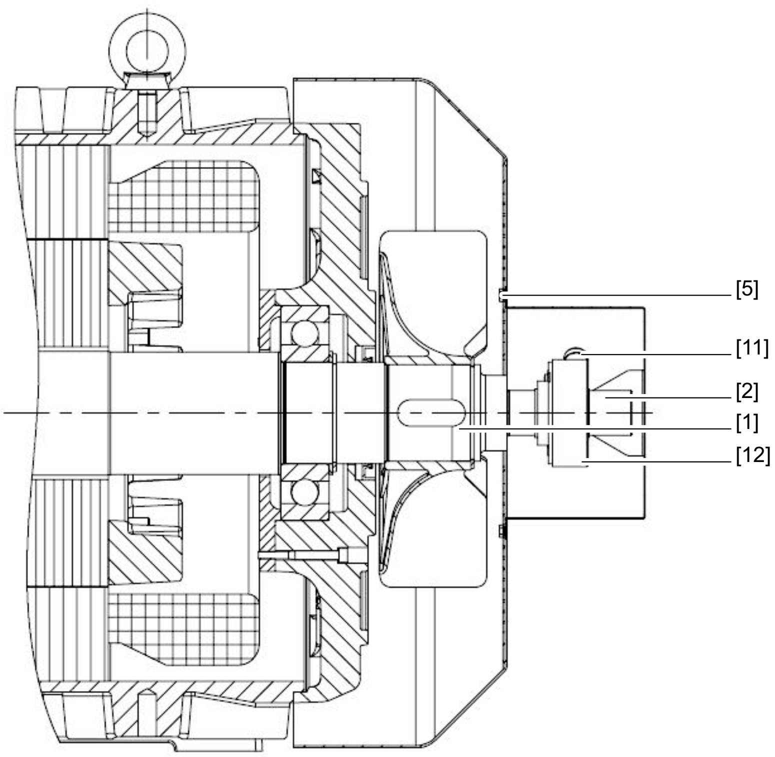


Fig. 30: Non-SEW encoder mounting device

[1] Motor shaft
[2] Encoder shaft
[5] Fan guard with encoder mount
[9] Coupling within the motor shaft
[10] Coupling half on the encoder end

5.5 Hollow-shaft encoder (only DR 315)

When the encoder is connected with via a hollow shaft, the motor shaft is not equipped with a bore. The encoder shaft is equipped with a through hole and is pushed on the motor shaft. Depending on the encoder variant (pulse or absolute value), with or without a sleeve. In both cases, the torque is supported via the fan guard. The figure shows both encoder variants.



2165464843

Fig. 31: Hollow-shaft encoder

[1] Motor shaft
[2] Encoder shaft
[5] Fan guard
[11] Pulse
[12] Absolute value

5.6 *Cone shaft enccoder (CMP motors)*

5.6.1 Connection variant 1 (AK0H)

For mounting a cone shaft encoder, the motor shaft must be equipped with a tapped hole and a suitable cone hole. The output shaft must be blocked for the assembly of the cone shaft enccoder. Then the encoder shaft can be screwed into the motor shaft with a special assembly device. The screws must not hook into the retaining holes of the motor. The output shaft must be released before the torque can be supported. Then the encoder must be turned until the screws in the mounting plate are above the retaining holes of the motor. Then the screws must be tightened alternately. This wil release the encoder shaft.

CMP 40 – 63

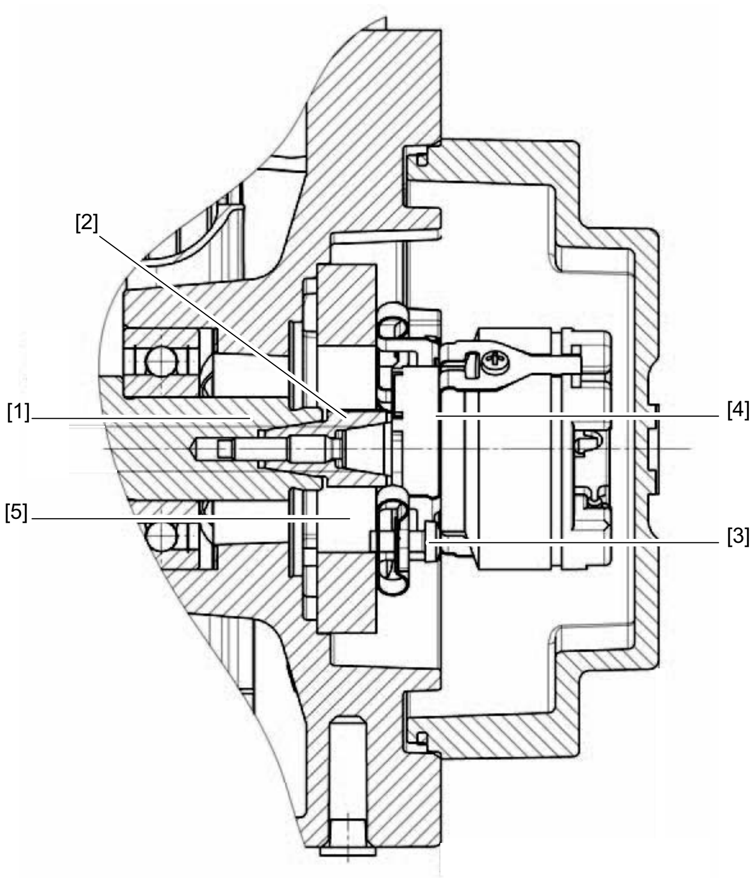


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Fig. 32: Cone shaft encoder – variant 1 (AK0H)

[1] Tapped hole
[2] Cone hole
[3] Screw
[4] Mounting plate
[5] Retaining holes

5.6.2 Connection variant 2 (EK1H, AK1H)

For mounting a cone shaft encoder, the motor shaft must be equipped with a tapped hole and a suitable cone hole. The output shaft must bee blocked for the assembly. Then the encoder is pushed on the motor shaft. Tightening the screw will press the cone of hte encoder shaft into the motor shaft. The spring plate of the torque arm is attachedd to the endshield with 2 screws.

CMP 71 – 100

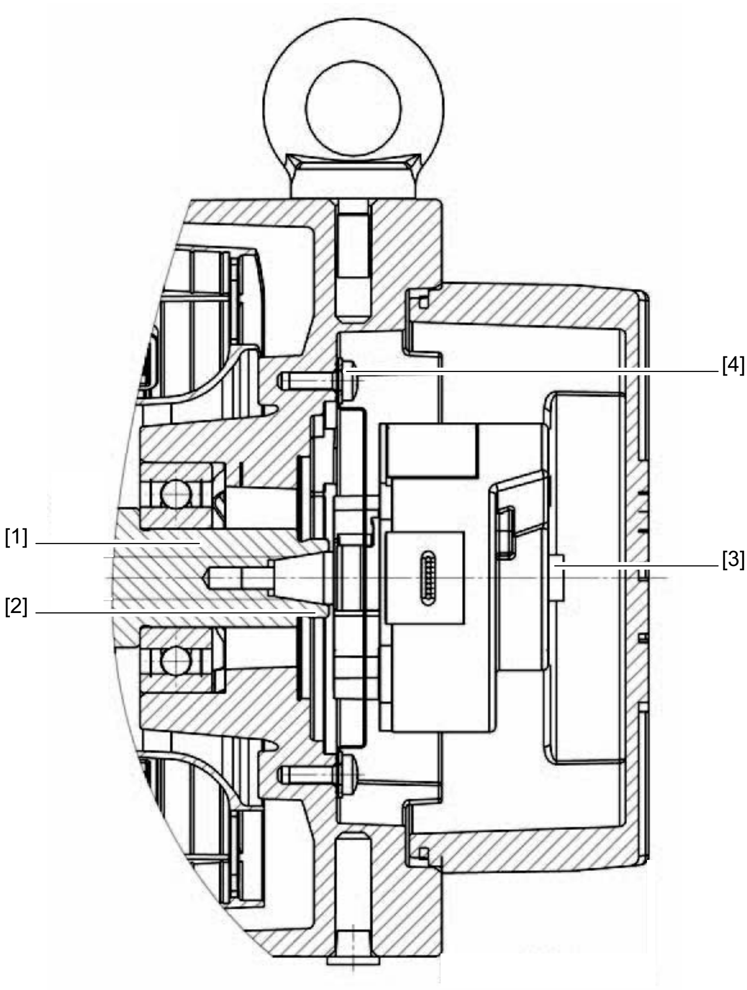

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Fig. 33: Cone shaft encoder – variant 2 (EK1H, AK1H)

[1] Tapped hole
[2] Cone hole
[3] Screw
[4] Screws on endshield

6 What Are The Setting Specifications For The Encoder Assembly?

Usually, synchronous servomotors are equipped with resolvers with sin/cos absolute encoders. With the data determined by the position encoders, the servo inverter ensures that the rotor displacement angle is 90°. However, the position encoders must be exactly aligned with the poles of the permanent magnets. Only then can the external magnetic field of the stator form with a 90° offset. This is also called commutation.

The commutation is performed at the end of the motor assembly. For motors with resolver, the stationary part is rotated mechanically accorrding to the setting specifications before it is fixed. For motors with sin/cos combination encoders, the absolute information is reset electrically within one motor revolution according to the setting specifications with the encoder already fixed in place.

6.1 Setting specifications for motors with HIPERFACE® encoders

Setting specification:

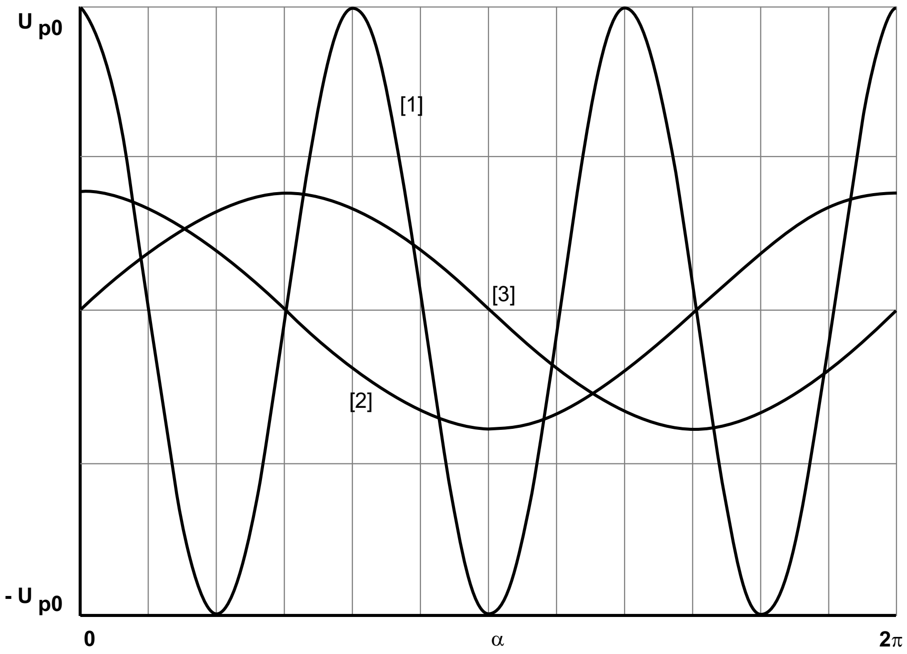
- Motor without load, brake released. Rotor can freely align in the stator field.
- Motor supplied with AC power (80% I_o):

Motor terminal	U	V	W
Supply	Open	minus	plus

Rotor alings in the field.

- Encoder angle reset in this rotor position.

6.2 Resolver setting specifications for SEW motors CM71 – 112



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[1] $V_p(\alpha)$
[2] $V_{cos}(\alpha)$
[3] $V_{sin}(\alpha)$

Number of pole pairs – motor: p_M = 3, number of pole pairs – resolver: p_R = 1

Setting specification (see figure):

Resolver zero position [V_{cos} (S1-S3) pos. max., V_{sin} (S2-S4) pos. zero passage] coincides with pos. maximum of the EMF Up in line U (with CW rotor rotation as viewed on the input shaft end).

Adjustment check:

Motor without load, brake released

The following applies to an AC power supply (motor terminal W+, terminal V-, terminal U open): S2-S4 (sin) pos. zero passage, S1-S3 (cos) pos. maximum

Direction of rotation check: The following applies to supply via terminals U, W+, V-: S1-S3 pos.↓, S2-S4 pos.↑

7 What General Installation Notes Must Be Observed?

When connecting the encoders to the inverters, always follow the operating instructions for the relevant inverter and the wiring diagrams supplied with the encoders.

- Maximum cable length (inverter – encoder): 100 m with a capacitance per unit length:
  - < 83 nF/km (core / core) according to DIN VDE 0472 part 504
  - < 110 nF/km (core / shield)
- Core cross section: 0,2 – 0,5 mm²
- Use shielded cable with twisted pair conductors and apply shield over large area on both ends:
  - to the encoder in the cable gland or in the encoder plug
  - To the inverter on the electronics shield clamp or to the housing of the D-sub connector
- Install the encoder cables separately from the power cables, maintaining a distance of at least 200 mm.
- Encoder with cable gland: Observe the permitted diameter of the encoder cable to ensure that the cable gland functions correctly.

7.1 Encoder line shield on inverter

Connect the shield of the encoder cable to the inverter over a large area.

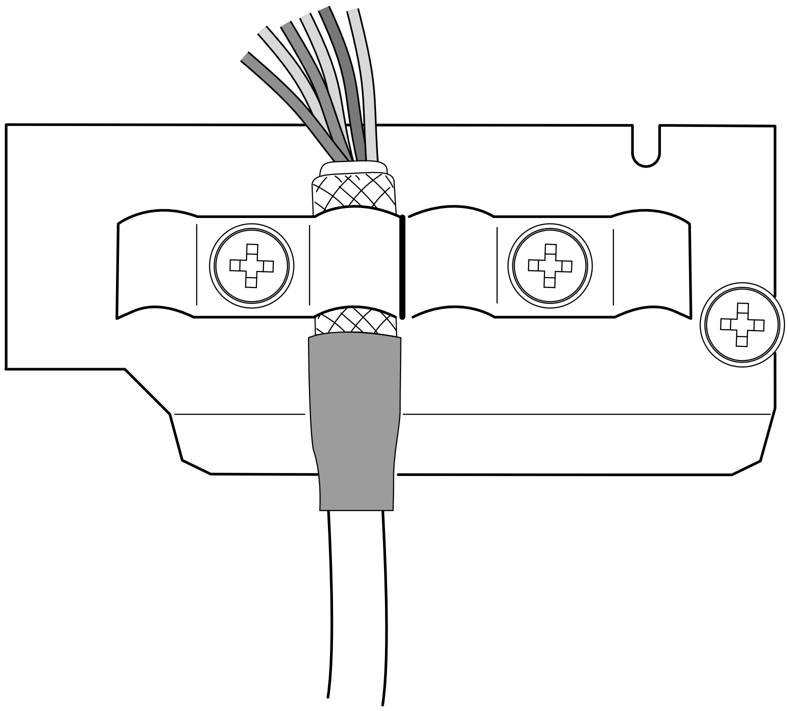

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Fig. 34: Applying the shield to the electronics shield clamp shield clamp

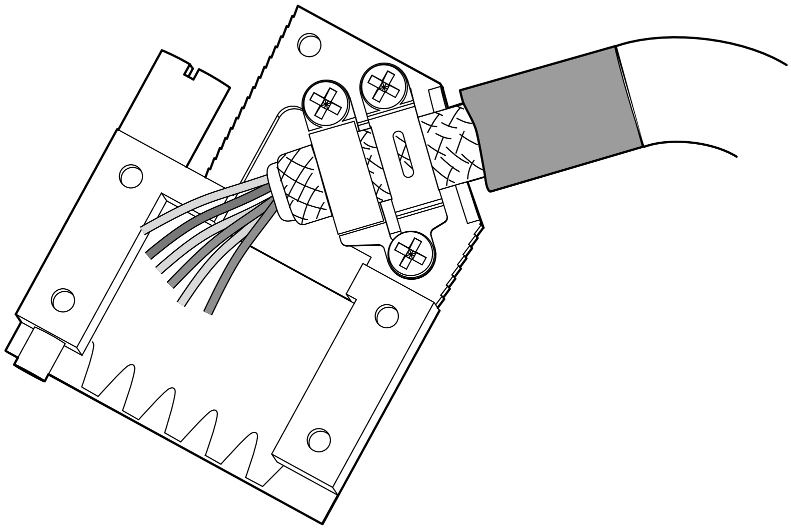

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Fig. 35: Shield in the sub D connector

7.2 Encoder line shield on encoder

Connect the shield of the encoder cable to the encoder over a large area.

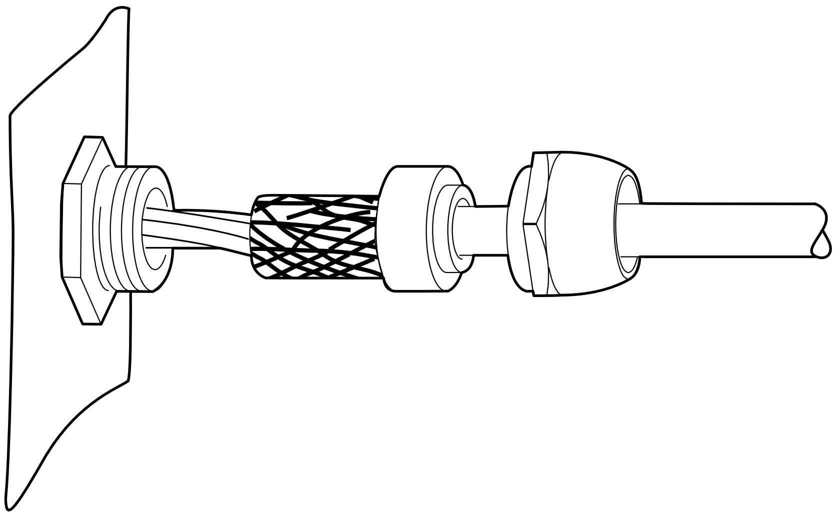

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Fig. 36: Connect the shield in the cable gland of the encoder

8 Terms And Definitions

Term/abbreviation	Definition/explanation
A/D converter	**A**nalog/**D**igital converter
DPR interface	**D**ual **P**ort **R**AM interface
DSP	**D**igital **S**ignal **P**rocessor
EEPROM	**E**lectrically **E**raseable **P**rogrammable **R**ead **O**nly **M**emory
EMC	**E**lectro **M**agnetic **C**ompatibility
HIPERFACE®	**Hi**gh **Per**formance Inter**face**. Registered trademark of the company Sick Stegmann GmbH.
HTL	**H**igh-voltage **T**ransistor-**L**ogics
Multi-turn encoder	Absolute position specification over multiple revolutions
NVSRAM	**N**on-**V**olatile **S**tatic **R**andom **A**ccess **M**emory
Reluctance	Magnetic resistance
Single-turn encoder	Absolute position specification over one revolution
SRAM	**S**tatic **R**andom **A**ccess **M**emory RAM
SSI	**S**erial **S**ynchronous **I**nterface
TTL	**T**ransistor-**T**ransistor-**L**ogics

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