Technical information

LEINE LINDE

Quality

Quality and the environment have for a long time been critical priorities at Leine & Linde. The company has been certified according to ISO 9001 since 1995. This includes the continuous follow-up and evaluation of our internal processes as well as the complete analysis and appraisal of all related data; to produce fact-based improvement measures.

All activities at Leine & Linde are characterized by an awareness of our environment and the impact our activities cause. This impact is regulated through well thought-out choices when introducing new products, equipment and materials as well as through a carefully prepared program for waste disposal. Leine & Linde is certified according to ISO 14001 since 2002. Leine & Linde consider this environmental work as strategically important and it is demonstrated by the environmental policy.

QUALITY POLICY

One of Leine & Linde's most important competitive advantages is quality. Superior quality results in a strong commitment with our customers.

This is achieved through:

- Measurable targets and plans of action
- Follow-up and continuous improvement
- Well defined internal communication
- Participation and input from all business units
- A continuous process of improving the management system

Contributing to our ambition "quality at the appointed time".

For our customers this can be interpreted as the mutual co-operation in the transformation from their requirements to the development of specific product features and continuous dialogue after the delivery and installation of the product.

Internally the policy is translated as an active co-operation with our suppliers, ongoing efforts to improve our internal processes and involvement of all parts of the company.

ENVIRONMENTAL POLICY

Actively working to minimize the environmental impact on our surroundings is considered a strategically important position for Leine & Linde.

This work involves:

- economizing on energy, water and other natural resources
- following existing environmental legislation
- continuously increasing employees' environmental knowledge and promoting their commitment
- selecting the best technology and materials from an environmental standpoint
- minimizing the amount of waste and emissions from operations
- continuously improving our environmental work through defined environmental goals and follow-up evaluation

This results in a working climate that favors both people and the environment.

ATEX / IECEx

Some encoder models are available as explosion proof versions, either approved in accordance with ATEX or IECEx directives. Flameproof enclosure according to Ex d or intrinsically safe encoders, i.e. Eex ia can be provided upon request.

UL listing

All rotary encoders in the 300, 500, 600 and 800 Series mentioned in this brochure comply with the UL safety regulations for the US. They also comply with the CSA safety regulations for Canada. They are listed under file number E223832.

CE marking and Declaration of Conformity

Leine & Linde products in the 300, 500, 600 and 800 Series, including the accessories conform with the protection requirements of Council Directive 2004/108/EC related to EMC when applicable. Please contact Leine & Linde to obtain Declaration of Conformity for unique encoder variants.

Use of encoders

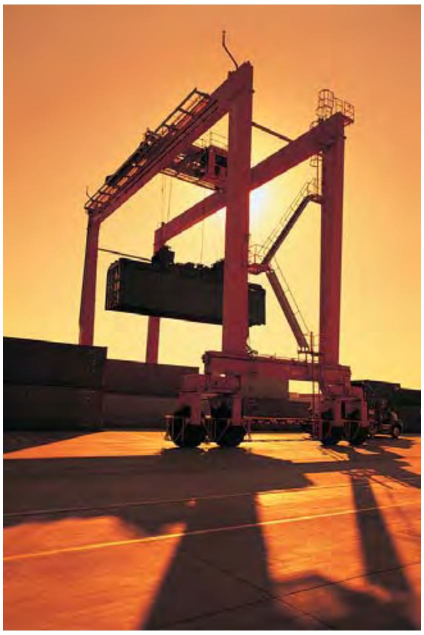
INCREMENTAL ENCODERS FOR VELOCITY FEEDBACK OR RELATIVE POSITIONING

An encoder can be either of two types, incremental or absolute. An incremental encoder usually generates a series of pulses in response to a linear or rotary motion. These pulses can be used to measure speed or be fed to a PLC or counter to keep track of a relative position. The output signal of an incremental encoder is normally an electrical square wave signal with a certain frequency related to the velocity of the encoder shaft.

ABSOLUTE ENCODERS FOR POSITIONING OR DIGITAL SPEED

Absolute rotary encoders generate a position value that indicates the actual position of the encoder shaft directly. A major benefit of absolute encoders is that if the application loses power, the encoder is able to keep track of its position also if the shaft is turned during the power loss. This is due to the genuine absolute scanning principle. An absolute encoder can also be used to calculate a digital speed value. By internally dividing the difference in position with a small delta time an accurate speed value can be calculated and transmitted to the subsequent electronics.

Other types of encoders such as tachometers, i.e. an encoder with analog current outputs (0-20 mA or 4-20 mA) or voltage (0-10 V or -10 V...+10 V) related to the speed or position of its shaft, may also be offered from Leine & Linde. Thus the principle function of the encoder is always the same, i.e. an encoder converts a mechanical movement of its shaft into an electrical measurable unit representing the shaft's velocity or position.



Encoders are often used on electrical motors in the paper and steel industries, cranes, robots and material handling systems as well as various types of measurement, testing and inspection systems.
These pictures show some of the applications.

Standard products

PRODUCT INFORMATION

Encoders are often used on electrical motors in the paper and steel industries, cranes, robots and material handling systems as well as in various types of measurement, testing and inspection systems. Leine & Linde offer standard encoder solutions suitable for many different kinds of applications. Where the applications demand specific requirements, Leine & Linde is also the right partner for customized encoder design. The standard series of encoders are described below and in this product catalogue, for information related to customized encoders you are welcome to contact us for more information.

Model 300 Series (Miniature)

The Model 300 Series consists of robust and extremely reliable miniature encoders, 30 mm in diameter and designed for installation in applications where limited space is at a premium. Various types of incremental electrical interfaces including TTL, HTL and RS-422 are supported by the series. Some typical applications are in wood harvesting apparatus and industrial high-pressure washing equipment. The series' high encapsulation level, IP67 and its shock and vibration resistant design, guarantees long life and ensures a durable sensor solution with high dependability.

Model 500 Series (Robust)

"Versatile" and "modular" are catchwords that differentiate the incremental and absolute encoders in the Model 500 Series. Used in a variety of different industrial applications such as on electric motors, cranes, elevators or in general automation, the series' mechanical, optical and electrical interfaces have become industry standard. If the standard selection of interfaces does not suit the application's particular requirements, customized and cost-effective solutions may be provided with very short lead times.

Model 600 Series (Industrial)

Fieldbus interfaces based on Ethernet, PROFIBUS or CAN are examples of communication protocols used in automation. These interfaces are available on the 600 Series of absolute coded singleturn or multiturn encoders. A robust mechanical design in shaft or hollow shaft design ensures that installation and commissioning of these encoders are reduced to a minimum. Serial point-to-point interfaces such as EnDat or the popular SSI interface are other examples of other communication protocols used for position feedback from an absolute coded encoder in the 600 Series.

Model 800 Series (Heavy duty)

When the most robust, maintenance-free and cost-effective encoder solution is required, the Model 800 Series is the first choice of most engineers. The optional ADS™ (Advanced Diagnostic System) is a built-in system used for condition-based or preventive maintenance, guaranteeing the reliability of the application. Demanding environments and electrically or mechanically stressful installations are circumstances the encoders in the Model 800 Series often are exposed to, and against which they are protected. Accessories and ready-made design solutions meant to guarantee operation and increase service life which reduce the total cost of the application are also offered as accessories to the encoder series.

Accessories

Connectors, shaft couplings, draw-wire units and measuring wheels are just some parts in Leine & Linde's line of accessories. Accessory cables, connectors and all the other accessories that may be used in an application should always maintain the same high quality as the encoders Leine & Linde deliver. The best way to guarantee that the accessories are of this quality is to only use original accessories that have been verified regarding function and performance, and offered as Leine & Linde accessories.

Encoder technology

MEASURING PRINCIPLES

Leine & Linde encoders based on optical scanning incorporate measuring standards of periodic structures known as graduations. These graduations are applied to a carrier substrate of glass, unbreakable plastic or other materials. These precision graduations are manufactured in photolithographic processes.

The photolithographic processes permit very fine grating periods and are characterized by a high definition and homogeneity of the line edges. Together with the photoelectric scanning method, this high edge definition is a precondition for the high quality and accuracy of the output signals. The unique way of producing the graduations on unbreakable plastic discs enables Leine & Linde to offer any arbitrary resolution or line count on the encoders.

ABSOLUTE ENCODERS MEASURING PRINCIPLE

With the absolute measuring principle, the position value is available from the encoder immediately upon switch-on and can be called at any time by the subsequent electronics. There is no need to move the axis to find a reference position. The absolute position information is read from the disk graduation, which consists of several parallel graduation tracks.

Absolute graduated code disc

On singleturn encoders the absolute position information repeats itself with every revolution. Multiturn encoders can also distinguish between the numbers of absolute revolutions by the use of an internal gearbox.

INCREMENTAL ENCODERS MEASURING PRINCIPLE

With the incremental measuring principle, the graduation consists of a periodic grating structure producing a defined number of sinusodial signals when the encoder shaft is rotated. These sinusodial signals can be converted into other signal formats and used in two different ways. Either for relative positioning or more commonly as velocity feedback devices. Relative position information can be obtained by counting the individual increments (measuring steps) from some point of origin. When such a semi-absolute reference is required to ascertain positions, the graduated disks are provided with an additional track that bears a reference mark.

Incremental graduated code disc

The rotational velocity of the encoder shaft can be determined by calculating the frequency of the sinusodial signals. Incremental encoders are normally used in closed loop velocity control loops or as speed feedback devices.

Photoelectric scanning

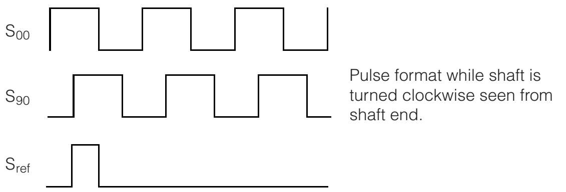
Most Leine & Linde encoders operate using the principle of photoelectric scanning. The photoelectric scanning of a graduated code disc is contact-free, and therefore without wear. This method detects very fine lines, no more than a few micrometers wide, and generates output signals with very accurate signal periods.

Put simply, the photoelectric scanning principle functions by means of projected-light signal generation: The output signal is generated when two graduations with equal grating periods are moved relative to each other, the graduated code disc and the scanning reticle.

The carrier material of the scanning reticle and code disc is transparent, whereas the graduation may be transparent or reflective. When parallel light passes through a grating, light and dark surfaces are projected at a certain distance and when the two gratings move relative to each other, the incident light is modulated. If the gaps in the gratings are aligned, light passes through. If the lines of one grating coincide with the gaps of the other, no light passes through. Photovoltaic cells convert these variations in light intensity into nearly sinusoidal electrical signals.

Resolution, Line count and Pulse rate

The resolution, line count or pulse rate are just different designations of the number of signal periods per channel and per revolution of an incremental encoder. Denominations of these signals vary between encoder manufacturers but Leine & Linde constantly use S00, S90 and Sref. The signals S00 and S90 are 90 el° displaced from each other. S00 appear 90 el° before S90 when the encoder shaft is turned clockwise. A, B and N or K1, K2 and K0 are other examples of denominations used on incremental signals.

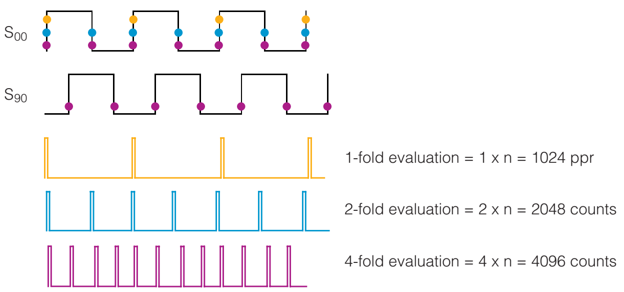


Output signals from an incremental encoder.

For absolute encoders, resolution is stated as the number of bits. The number of bits (or unique positions per revolution) is calculated as 2^n where n equals the number of bits. The total resolution of multiturn encoders also includes the number of distinguishable revolutions.

Measuring steps

In order to obtain higher resolutions from an incremental encoder, evaluation of all raising and falling pulse edges may be monitored. This is normally done by subsequent electronics as a quadruple, double or single evaluation. A measuring step is the definition of maximal number of edges as acquired when the subsequent electronics support quadruple evaluation, i.e. maximal measuring steps = 4 x line count. The example below indicates what different measuring step evaluation results in as seen by the subsequent electronics. In the example a 1024 ppr line count disc is used.



Edge evaluation of incremental signals.

Accuracy

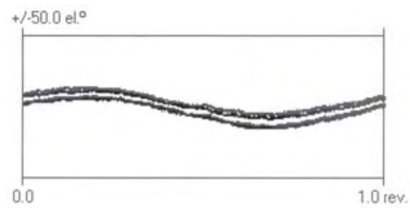
The accuracy of measurements with encoders is mainly determined by:

- Directional deviation of the radial grating
- Eccentricity of the graduated disk to the bearing
- Radial deviation of the bearing
- Error resulting from the mechanical installation
- Interpolation error during signal processing in the integrated or external interpolation and digitizing electronics.

When speaking about accuracy of incremental encoders, the unit el° (electrical degrees) is normally used. For one signal period of the output signal is the equivalent of 360 el°. One revolution of the encoder equals 360 * N el°, where N is equal to the number of lines on the graduated disc (ppr).

Incremental encoders from Leine & Linde have a maximal permissible accuracy of ±50 el° (dividing error) which means that each pulse edge of the encoder signal has a deviation from its theoretical angle position of a maximum of 50/N °. As an example, for an encoder with 5000 ppr, ±50 el° corresponds to 0.01° maximum mechanical angle deviation from the theoretical position for each of the 20,000 pulse edges. (The encoder's highest resolution is in this case 360/(5000*4) or 0.018°).

The dividing error is always sinus-shaped. One half of the revolution the pulses will have a shorter signal period where as the signal period will be a little longer for the other half of the revolution. If an incremental encoder is used in a velocity control loop and has a high dividing error, may this be seen as a speed ripple.



Dividing error of an incremental encoder.

For absolute encoders the term accuracy relates to the deviation from the absolute encoders optimal theoretical position. The unit used for accuracy of an absolute encoder is LSB, Least Significant Bit. On an absolute encoder with 13 bit singleturn resolution (2^{13} = 8192 position) the accuracy is ±1LSB which implies that the maximal mechanical angle deviation is:

360° / 8192 = ±0.04°

Accuracy and calibration charts for each delivered encoder can be provided upon request.

Encoder technology

Channel separation on incremental encoders

The specification of accuracy also includes the term channel separation, which is the distance between adjacent pulse edges of the S_{00} and S_{90} output signals. During final adjustments this is tuned to 90 el° and should lie within 90 ±25 el° for standard encoders. This means that the distance between adjacent pulse edges can vary between 65 el° and 115 el° for an approved encoder. Channel separation error is included in the dividing error.

The duty cycles of all incremental encoders are 180 el° or 1:1 unless stated otherwise.

Every delivered encoder is verified with respect to their accuracy, channel separation and duty cycle accomplished by monitoring that all pulse edges lies within approved limits. The measured values for maximum deviations from the encoder specifications are referred to the encoder's serial number and collected in a database for statistical follow-up and future reference.

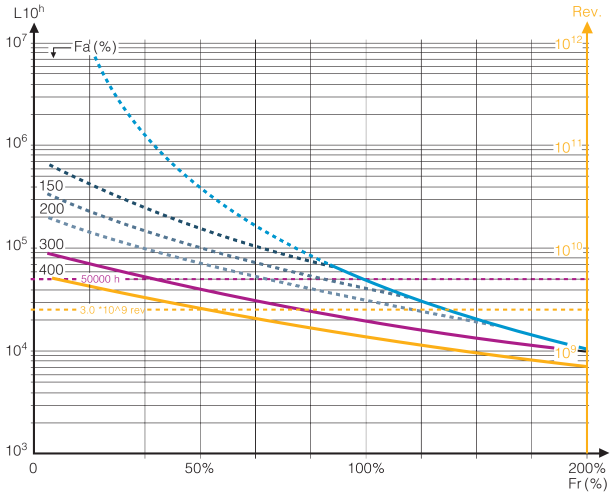
All accuracy data refer to measuring signals at an ambient temperature of 20°C, and with controlled subsequent electronics and transmission lines.

Bearing lifetime / Shaft load

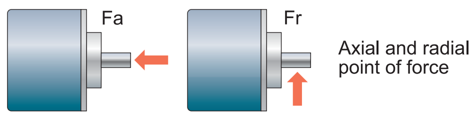
The lifetime of an encoder depends partially on its shaft bearings. Several other environmental parameters influence the lifetime such as shaft load, shaft speed, point of force and ambient temperature, among other things. The bearings used within Leine & Linde encoders are always utilized by high-quality permanent lubricated bearings. The encoder has a defined lifetime and need to be replaced at certain time intervals to ensure proper function. If the bearings are subjected to considerable static or dynamic load, the limiting factor will be normal bearing wear, i.e. surface fatigue of the ball race rather than lack of lubrication. The permissible nominal dynamic shaft loads are given in each model's datasheet - these value are based on a recommended service life of approximately 50,000 hours calculated at 1500 rpm nominal velocity.

The simplified diagram below shows an example of how the bearing lifetime is affected at various loads for the different encoder series.

The F_r and F_a values for each encoder series can be found in its respective datasheet. Example, a 503 Series encoder has a permissible radial force F_r equal to 60 N. This corresponds to 100% in the graph. If the force is reduced to 30 N the F_r = 50% in the graph. See next column.



Permissible shaft load and lifetime relation.



Note: High-quality shaft-coupling shall always be used on solid shaft encoders in order to reduce shaft loads and optimize the lifetime of the encoder. When measuring wheels are used or if shaft loads are unavoidable, separate bearing boxes should be used to minimize the shaft load. Bearing boxes are offered as accessories to complement the Leine & Linde encoder. Never exceed twice the specified maximum shaft load.

Vibration

Encoders are subject to various types of vibrations during operation and mounting. The indicated maximum values for vibration apply for frequencies between 55 to 2000 Hz (IEC 60 068-2-6). Any vibrations exceeding the permissible values, for example due to resonance depending on the application and mounting, might damage the encoder.

The permissible angular acceleration for all encoders is over 10^5 rad/s^2. The maximum values for vibration and shock indicate the limits up to which the encoder can be operated without failure.

In order to achieve the highest potential accuracy of an encoder, the environmental and operating conditions need to be optimized.

Shock

Comprehensive tests of the entire system are often required. The maximum permissible vibrations values (semi-sinusoidal shock) for shock and impact are valid for 6 ms (IEC 60 068-2-27). Under no circumstances should a hammer or similar device be used to adjust or position the encoder.

If the application includes increased shock and vibration loads, please ask for assistance from Leine & Linde.

Humidity

The maximal permissible relative humidity is 75%. 95% is permissible temporarily. Condensation is not permissible. Measures to permit higher humidity are available upon request.

Starting torque

The starting torque of the encoders in the different series are in accordance with the table below. The values are measured at room temperature (20°C). Note that the values may vary slightly from unit to unit. In order to reduce the starting torque special measures may be performed.

Encoder series	Torque[Ncm]
300	0.5
500	1
600	1.2
800	2

Natural frequencies

Hollow shaft encoders with their stator couplings form a vibrating spring mass system whose natural frequency f_n should be as high as possible.

A prerequisite for the highest possible natural frequency on shaft encoders is to use a coupling with a high torsional rigidity.

The natural frequency can be calculated as:

$$f_n = \frac{1}{2\pi} \cdot \sqrt{\frac{C}{I}}$$

f_n: Natural frequency of coupling in Hz
C: Torsional rigidity of the coupling in Nm/rad
I: Moment of inertia of the rotor in kgm^2

If radial and/or axial acceleration forces are added, the stiffness of the encoder bearings and the encoder stators are also significant. If such loads occur in the application, please consult Leine & Linde.

Magnetic fields

Magnetic fields > 30 mT can impair the proper function of encoders. If required, please contact Leine & Linde.

Encapsulation

After a completed encoder installation, all rotating parts must be protected against accidental contact during operation.

Unless otherwise indicated, all encoders meet protection standard IP 67 according to IEC 60 529. This includes housings, cable outlets and flange sockets when the connector is fastened.

The shaft inlet provides protection to up to IP67 but may be subject to reduction due to aging of sealing and environmental aspects. Splash water should not contain any substances that would have harmful effects on the encoder parts. If the standard protection of the shaft inlet is not sufficient (such as when the encoders are mounted vertically), additional labyrinth seals should be provided. The sealing rings used to seal the shaft are subject to wear due to friction, the amount of which depends on the specific application. Please contact Leine & Linde if solutions with higher protection are required.

Surface treatment

The normal surface treatment used on all encoder parts is either paint or anodization. Most variants can also be offered in stainless-steel versions upon request. The encoder shaft is always manufactured in stainless steel. Connecting elements may be utilized by other surface treatments.

System tests

Encoders from Leine & Linde are usually integrated as components in larger systems. Such applications require comprehensive tests of the entire system regardless of the specifications of the encoder.

The specifications given in the catalog apply to the specific encoder, not to the complete system. Any operation of the encoder outside of the specified range or for any other than the intended applications is at the user's own risk.

Assembly

Work steps to be performed and dimensions to be maintained during mounting are specified solely in the mounting instructions supplied with the unit. All data in this catalog regarding mounting are therefore provisional and not binding.

Temperature ranges

For the encoder in its packaging, the storage temperature range is –30°C to +70°C. The operating temperature range indicates the temperature the encoder may reach during operation in the actual installation environment. The function of the encoder is guaranteed within this range (DIN 32878). The operating temperature is measured on the face of the encoder flange and must not be confused with the ambient temperature. The temperature of the encoder is influenced by:

- Mounting conditions, i.e. friction
- The ambient temperature
- Self-heating of the encoder, i.e. cable length, supply voltage, etc.

The self-heating of an encoder depends both on its design characteristics (stator coupling/solid shaft, shaft sealing ring, etc.) and on the operating parameters (rotational speed, power supply). Higher heat generation in the encoder means that a lower ambient temperature is required to keep the encoder within its permissible operating temperature range. In the worst case, a combination of operating parameters can exacerbate self-heating, for example a 30 Vdc power supply and maximum rotational speed. Therefore, the actual operating temperature should be measured directly at the encoder if the encoder is operated near the limits of permissible parameters. Then suitable measures should be taken (fan, heat sinks, etc.) to reduce the ambient temperature far enough so that the maximum permissible operating temperature will not be exceeded during continuous operation.

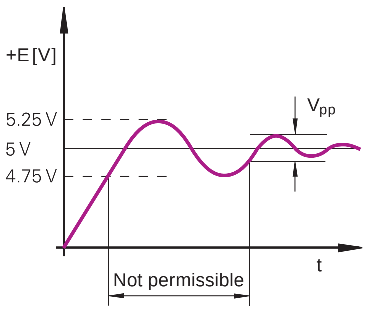
For high speeds at maximum permissible ambient temperature, special encoder versions are available on request with reduced degree of protection.

Power supply

All encoders require a stabilized dc voltage +EV as power supply. Most encoders have a polarity-protected power supply. For encoders with 5 V power supply the permissible ripple content of the dc voltage is:

High-frequency interference
V_{pp} < 250 mV with dV/dt > 5 V/µs.

Low-frequency fundamental ripple
V_{pp} < 100 mV



Permissible power supply ripple.

The values apply as measured at the encoder, i.e., without cable influences.

The voltage should be monitored and adjusted to ensure proper power supply at the encoder.

The voltage drop in the power supply lines can be calculated as:

$$\Delta U = \frac{\rho \cdot l \cdot I}{A}$$

where

ΔU: Voltage drop
ρ : Resestivity in copper 0.0175 ohm mm²/m at 15°C
l : Cable length in meter
I : Current consumption in Ampere
A : Cross section area of conductor in mm²

The encoder housings are isolated against their internal circuits. Rated surge voltage: 500 V (preferred value as per VDE 0110 Part 1, overvoltage category II, contamination level 2)

Electrically Permissible Speed / Traversing Speed

The maximum permissible shaft speed or traversing velocity of an encoder is derived from the mechanically permissible shaft speed/traversing velocity (if listed in the datasheet) and the electrically permissible shaft speed or traversing velocity. For encoders with square-wave signals, the electrically permissible shaft speed/traversing velocity is limited by the maximum permissible scanning frequency, fmax, of the encoder.

Electromagnetic compatibility / CE compliance

When properly installed and when Leine & Linde connecting cables and cable assemblies are used, Leine & Linde encoders fulfill the requirements for electromagnetic compatibility according to 2004/108/EC with respect to the generic standards for industrial environment:

- Immunity IEC 61000-6-2
- Emission IEC 61000-6-4

Noise voltages arise mainly through capacitive or inductive transfer. Electrical noise can be introduced into the system over signal lines and input or output terminals and should always be avoided. Possible sources of noise are:

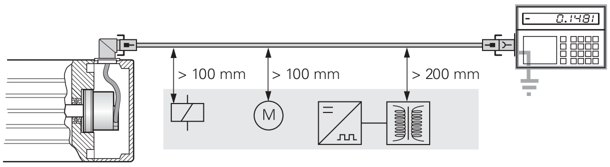
- Strong magnetic fields from transformers and electric motors
- Relays, contactors and solenoid valves
- High-frequency equipment, pulse devices, and stray magnetic fields from switch-mode power supplies
- AC power lines and supply lines to the above devices

Protection against electrical noise

The following measures must be taken to ensure disturbance-free operation:

- Use only Leine & Linde cables.
- Use connectors or terminal boxes with metal housings.
- Do not conduct any extraneous signals.
- Connect the housings of the encoder, connector, terminal box and evaluation electronics through the shield of the cable.
- Connect the shielding in the area of the cable inlets to be as induction-free as possible (short, full-surface contact).
- Connect the entire shielding system with the protective ground.
- Prevent contact of loose connector housings with other metal surfaces.
- The cable shielding has the function of an equipotential bonding conductor.

Sufficient decoupling from interference signal-conducting cables can usually be achieved by an air clearance of 100 mm or, when cables are in metal ducts, by a grounded partition. A minimum spacing of 200 mm to inductors in switch-mode power supplies is required.



Potential sources causing interference.

When using multiturn encoders in electromagnetic fields greater than 30 mT, please consult Leine & Linde.

Both the cable shielding, the metal housings of encoders and subsequent electronics have a shielding function. It is recommended that the housings have the same potential and are connected to the main signal ground over the machine chassis or by means of a separate potential compensating line. Potential compensating lines should have a minimum cross section of 6 mm^2 (Cu).

Cables

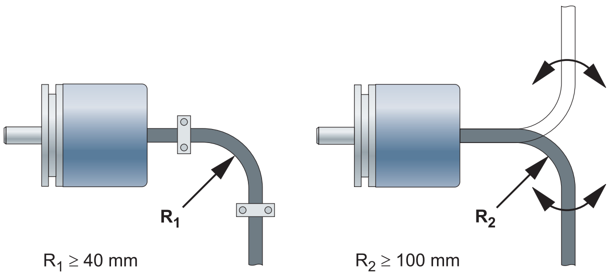
The permissible cable lengths listed apply only for Leine & Linde cables and the recommended input circuitry of the subsequent electronics.

The cable type is normally polyurethane, PUR cables or PVC depending on encoder model. PUR cables are resistant to oil, hydrolysis and microbes in accordance with VDE 0472 and most cables comply with UL safety directives.

Standard Leine & Linde cables can be used in a rigid configuration between –40 to 85°C and in frequent flexing between –10 to 85°C. High-temperature cables are available upon request and shall be used when the permissible temperature of the encoder exceed 85°C.

Bending radius

The permissible bending radius R depends on the cable type, the configuration (flexible or rigid installation) and surrounding temperature. Normative values for standard cables are shown in the picture below.



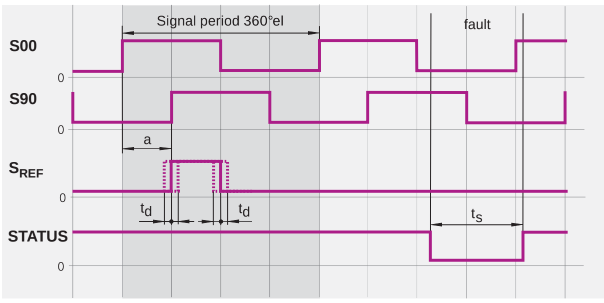
Permissible bending radius for standard cables.

Interfaces

INCREMENTAL INTERFACES

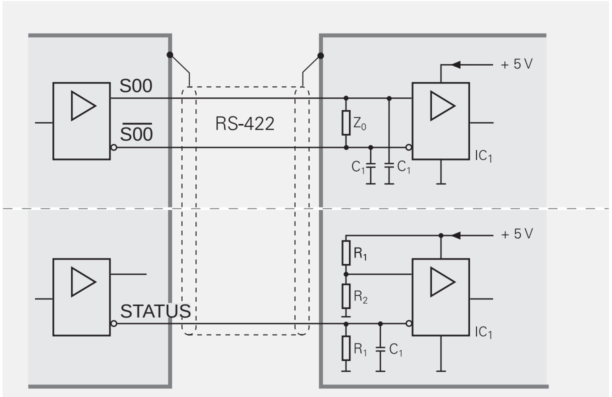
TTL electronics / RS-422

Incremental TTL-signals are transmitted as digital square-wave pulse trains S00 and S90, phase-shifted by 90 el°. The reference mark signal consists of one reference pulse denoted as Sref, which is gated with the incremental signals. As an option on TTL-encoders, the integrated electronics also produce inverse signals of S00 and S90 for noiseproof differential transmission. In this case the encoder signals comply with the RS-422 standard.



Output signals, TTL electronics.

Interface	Square-wave TTL or RS-422 (differential)
Incremental signals	S00, S90 (optional $\overline{S00}$, $\overline{S90}$)
Reference mark Pulse width Delay time	Sref (optional $\overline{Sref}$) 90 el° (other on request) $t_d < 50$ ns
STATUS (optional) Pulse width	Improper function: Low Proper function: High $t_s > 20$ µs
Signal level	Uh > 3 V with - Ih = 10 mA Ul < 0.4 V with Il= 10 mA
Permissible load	Z0 = 100 W Il < ±20 mA (per output) Cload < 1000 pF Outputs are short-circuit protected max. 1 min against 0 V and +EV
Switching times (10% to 90%)	t+/t- < 200 ns With 1m cable and recommended input circuitry



Recommended subsequent electronics, TTL/RS-422.

The permissible cable length for transmission of the TTL square-wave signals to the subsequent electronics depends on the edge separation and whether differential (6 channels) or single-ended transmission is used. Note that the permissible cable length is calculated as long as the power supply can be ensured at the encoder. Make sure to compensate for voltage drop in the power supply lines.

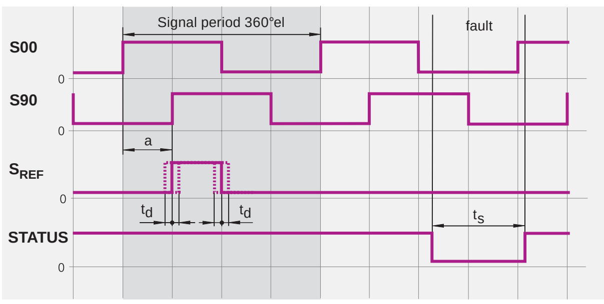
Note: Leine & Linde encoders equipped with TTL output comply to the RS-422 standard when differential signals (6 channels) are used.

HTL and HC-HTL Electronics

Leine & Linde encoders with HTL interface incorporate electronics that digitize sinusoidal scanning signals. The incremental signals are transmitted as digital square-wave pulse trains S00 and S90, phase-shifted by 90 el°. The reference mark signal consists of one reference pulse Sref, which is gated with the incremental signals. In addition, the integrated electronics produce inverse signals of S00 and S90 for noise proof differential transmission. The fault-detection signal STATUS indicates fault conditions such as under voltage of the power supply or failure of the light source. It can be used for such purposes as machine shut-off during automated production.

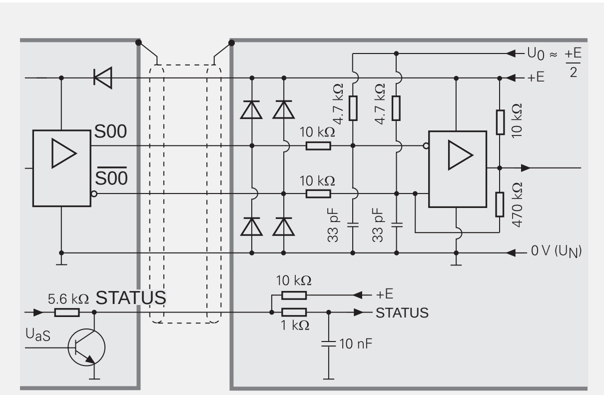
To prevent counting error, the subsequent electronics should be designed to process as little as 90% of the edge separation a. See diagram below.

The permissible cable length for incremental encoders with HTL signals depends on the scanning frequency, the effective power supply and the operating temperature of the encoder.

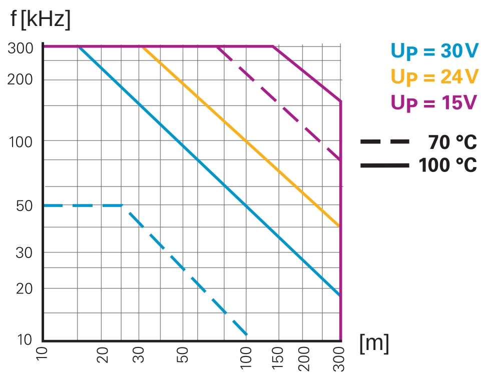


Output signals, HTL/HC-HTL electronics.

Interface	HTL or HC-HTL
Incremental signals	S00, S90 (optional $\overline{S00}$, $\overline{S90}$)
Reference mark Pulse width Delay time	Sref (optional $\overline{Sref}$) 90 el° (other on request) t_d < 50 ns
STATUS (optional) Pulse width	Improper function: Low Proper function: High t_s > 20 µs
Signal level	Uh > 21 V with - Ih = 20 mA Ul < 2.8 V with Il= 20 mA
Permissible load	Z0 = ±40 mA Il < ±100 mA (per output) Cload < 10 nF Outputs are short-circuit protected max. 1min against 0 V and +EV
Switching times (10% to 90%)	t+/t- < 200 ns With 1 m cable and recommended input circuitry



Recommended subsequent electronics, HTL.



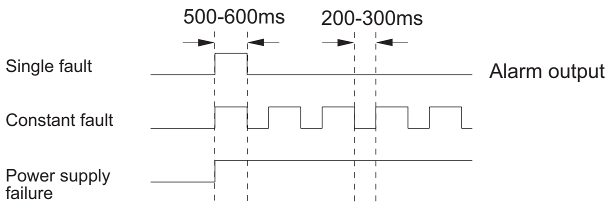
The graph shows the permissible cable length at various frequences for HTL and HC-HTL encoders.

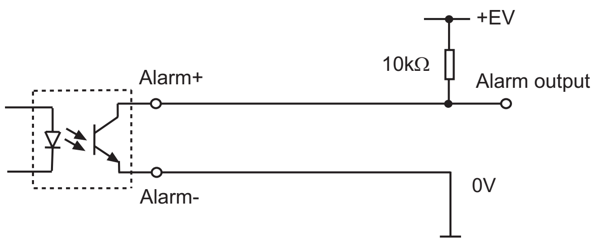
ADS

Leine & Linde's ADS system has been developed to permit the early detection of fault functions internally in rotating incremental pulse encoders on the 800 Series.

The system is based on a rapid logic in conjunction with a microprocessor which continuously monitors the encoder's functions and is thus able to detect a fault function at an early stage. This takes place at such an early stage that the encoder can continue to perform its function in the majority of cases, and replacement of the encoder can take place subsequently during a planned maintenance shutdown.

The main control system receives a message from the encoder about a detected fault function via a signal at the encoder's alarm output. This alarm signal is sent to the operator who, with the help of a PC and the analysis software of the diagnostic system, can communicate with the encoder and establish the cause of the indicated fault. The operator is also informed of the frequency, internal temperature and operating period at the time of the fault. External faults can also be detected. The internal signals in the encoder are compared with the signal that is generated in the cable. It is possible in this way, for example, to detect an overload of the output signals from the encoder. The analysis software can also be used to obtain information about the total operating time and the max./min. operating temperature.





Alarm output.

Interfaces

ABSOLUTE ELECTRICAL INTERFACES

Parallel interface

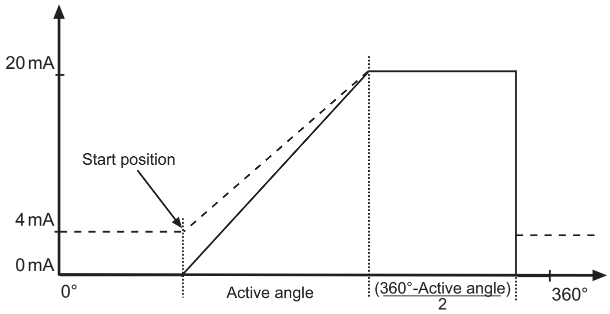
Parallel output provides an absolute position available simultaneously on the output. It may be provided as binary or transformed in gray code format. Gray code means a single-bit change between each position step, which can reduce transmission errors.

Parallel output encoders can also accept inputs, for example setting the counting direction.

The advantage of parallel output is that it is fast and all the data is available in real time, all the time.

Analog interface

The absolute position can also be represented as an analog current output. 0-20 mA or 4-20 mA for a full-scale output.



Output signal analog interface.

On special request an analogue output with a teach-in functionality can also be offered. The teach-in function implies that the encoders active angle can be configured at will. A maximal full-scale output 0 or 4-20 mA current value can therefore be distributed over the total measuring range, up to 10 revolutions. Note that the position value represented by the output is only absolute within one revolution.

BiLL-interface (RS-485 based)

BiLL is a bi-directional master/slave communication used on absolute encoders. The protocol can be used for RS-485 transmission standards or for a multi-drop bus system using the RS-485 standard. Data are sent in hexadecimal format and the addressed encoder answers only on a master request. The protocol includes position data in binary format, a checksum for transmission reliability, a hold command, a change of baud rate command and an error message.

Serial point-to-point interfaces

Serial transmission means that bit information is transmitted sequentially in the same pair of conductors rather than sending each bit in its own conductor as in parallel transmission.

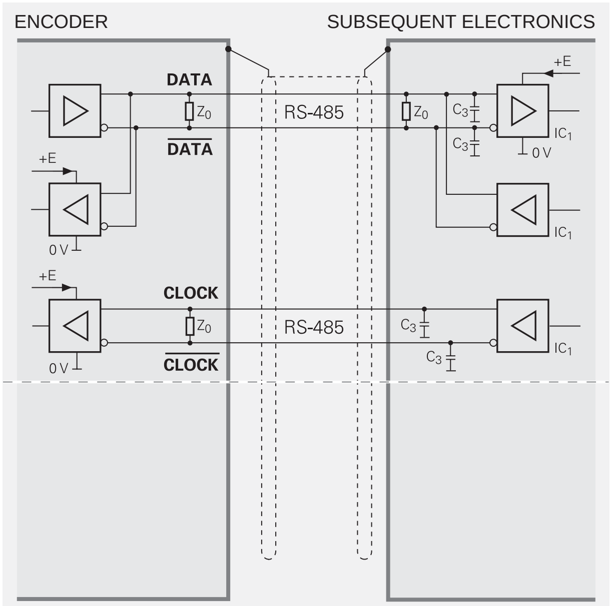
One of the advantages of serial transmission is that installation costs less; fewer wires means less work and less documentation.

There are several more or less standardized methods for serial transmission of data, all with their advantages and disadvantages. The following is a short description of the most common serial standards used for communication with encoders.

EnDat interface

The EnDat interface is a digital, bidirectional interface for encoders. It is capable of transmitting position values from absolute encoders, as well as reading and updating information stored in the encoder.

Thanks to the serial transmission method, only four signal lines are required. The absolute position data are transmitted in synchrony with the clock signal generated by the subsequent electronics. The type of transmission (position values, parameters, diagnostics, etc.) is selected by mode commands that the subsequent electronics send to the encoder.



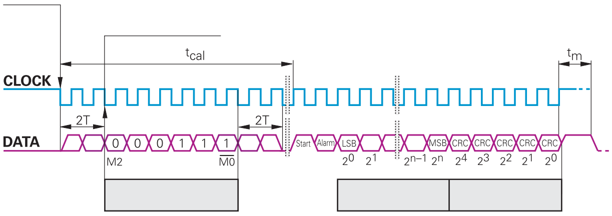
Recommended subsequent electronics.

A clock pulse (CLOCK) is transmitted by the subsequent electronics to synchronize data transmission. When not transmitting, the clock signal defaults to HIGH.

One data packet is sent in synchrony per data transmission. The transmission cycle begins with the first falling clock edge. The measured values are saved and the position value calculated. After two clock pulses (2T), the subsequent electronics transmit the mode command "Encoder transmit position value". After successful calculation of the absolute position value (tcal - see table), the start bit begins the data transmission from the encoder to the subsequent electronics.

Interface	EnDat
Clock frequency f_c	100 kHz … 2 MHz (optional up to 16 MHz)
Calculation time for Position value t_{cal}	< 5 µs
Recovery time t_m t_r	10 to 30 µs Max. 500 ns

The encoder then transmits the absolute position value, beginning with the LSB. Its length varies depending on which encoder is being used. The number of required clock pulses for transmission of a position value is saved in the parameters of the encoder manufacturer. The data transmission of the position value is completed with the Cyclic Redundancy Check (CRC).



Data transfer EnDat.

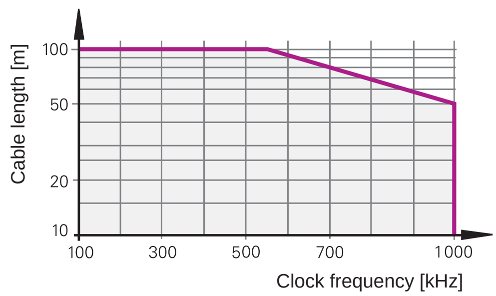
Note: Every Leine & Linde gateway for fieldbus communications communicates with the encoder via the EnDat interface.

For further information about the EnDat interface, please contact Leine & Linde.

SSI interface

SSI or Synchronous Serial Interface, is a digital point-to-point interface. It provides unidirectional communication at speeds up to 1.0 MHz by the use of only 4 wires.

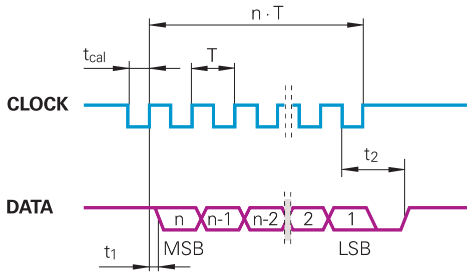
The absolute position value, beginning with the most significant bit, is transferred over the data lines (DATA) in synchrony with a CLOCK signal from the control. The SSI standard data word length for singleturn absolute encoders is 13 bits, and for multiturn absolute encoders 25 bits. The position value is transmitted in Gray or binary code format.



Permissible cable length SSI.

In the quiescent state the clock and data lines are on high level. The current position value is stored on the first falling edge of the clock. The stored data is then clocked out on the first rising edge.

After transmission of a complete data word, the data line remains low for a period of time (t_2) until the encoder is ready for interrogation of a new value. If another data-output request (CLOCK) is received within this time, the same data will be output once again. If the data output is interrupted (CLOCK = high for $t \geq t_2$), a new position value will be stored on the next falling edge of the clock, and on the subsequent rising edge clocked out to the subsequent electronics.



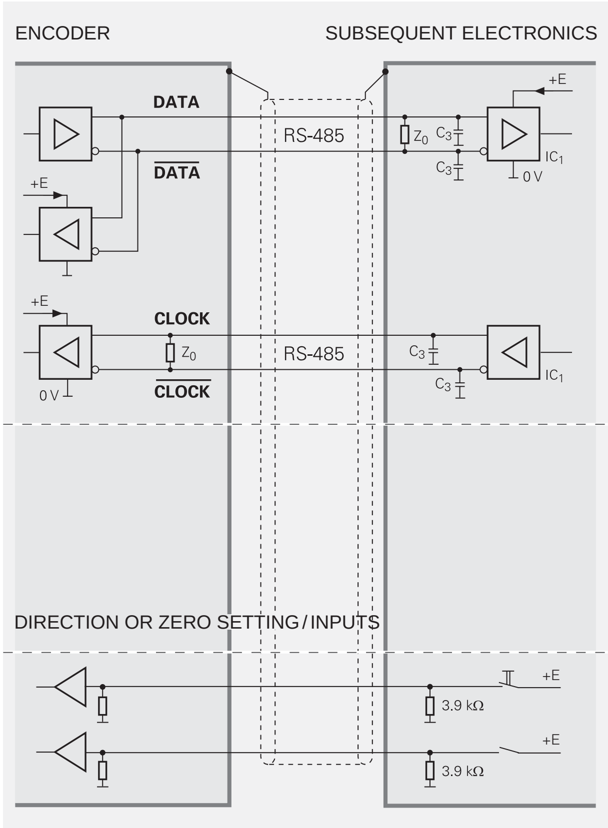
Data transfer SSI.

Interface	SSI
Clock frequency T	1… 10 µs
Calculation time for Position value t_{cal}	< 5 µs
Recovery time t_1 t_2	0.4 µs 12…30 µs
n	13…25 bit

For the RSA/RHA 60X Series of encoders, the following functions can be activated via the programming inputs of the interfaces by applying the input to a logic high level, i.e +EV:

Direction of rotation
Continuous application of a HIGH level reverses the direction of rotation for ascending position values.

Zero setting (setting position to zero)
Applying a positive edge (t_{min} > 1 µs) sets the current position to zero.



Recommended subsequent electronics.

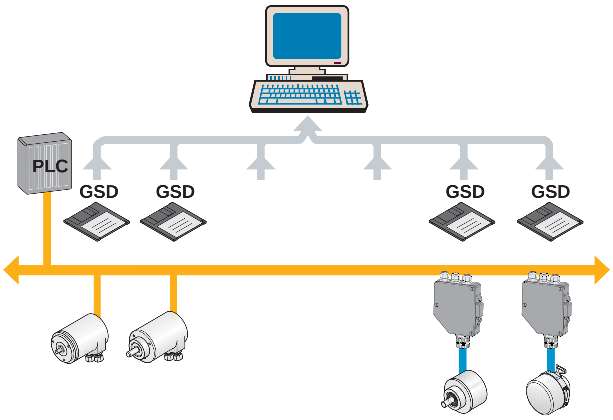
Note: The programming inputs must always be terminated with a resistor (see input circuitry of the subsequent electronics).

FIELDBUS INTERFACES

PROFIBUS DP

PROFIBUS is a powerful and versatile 2-wire non-proprietary open fieldbus standard defined by several international standards such as EN 50170, IEC 61158 together with different device profiles.

The encoder device profiles for PROFIBUS-DPV0, DPV1 and DPV2 define the functionality of encoders connected to a PROFIBUS-DP bus. There are two encoder profiles available 3.062 and 3.162 defining the functionality of encoder for the different versions of PROFIBUS DP.



Network and configuration of PROFIBUS.

Encoder Profile for DPV0, profile number 3.062

The operating functions in this profile are divided into two device classes. Class 1 encoders offer basic functions that all PROFIBUS-DP encoders must support. An encoder of class 1 can optionally support selected functions of class 2 but these functions must be implemented according to the profile.

Encoders of class 2 must support all functions of class 1 as well as the additional functionality of class 2.

Encoder Profile for DPV1 and DPV2, profile number 3.162

In addition to the functionality enabled in DPV0 and acyclic data exchange, expansions to the PROFIBUS were required to enable the interface in time-critical applications. As a result, DP-V2 functionality such as slave-to-slave communication and isosynchronous data exchange was added.

Slave-to-slave communication means, as the name implies, that slaves in a net can exchange information with each other via broadcast messages without communication being initiated by the master. This type of communication is very efficient and fast, which reduces the response time on the bus by up to 90%.

Isosynchronous data exchange implies that the master can reach several slaves simultaneously with for example set point values, or receives feedback values from different slaves. With the isosynchronous mode, a system can be set up where all slaves set their output values and read their input values at the same time with a very high accuracy. This functionally results in synchronization between many different slaves within 1 µs.

For further information regarding the Encoder functionality refer to the device profiles. These profiles and PROFIBUS technical information can be ordered at PNO in Karlsruhe, Germany (www.PROFIBUS.com).

To choose between the different profile versions different GSD files are available. The user can select the version that fits their hardware and software. The different GSD file can be ordered form Leine & Linde or downloaded from www.leinelinde.com.

Encoder functionality

The encoder can be configured as a class 1, 2 (DPV0) or class 3 or 4 (DPV2) PROFIBUS slave device. Class 2 configuration is extended to optionally access velocity information from the encoder.

In the basic class 1 or 3 configuration only output values/positions are available.

The following functions can be performed or programmed:

- Position read out
- Changed direction of counting
- Diagnostic data up to octet 16

The following functions are available in addition on the class 2 or 4 functions:

- Scaling function
- Preset Value Function
- Velocity read-out (class 2)
- Extended diagnostic data

CANopen

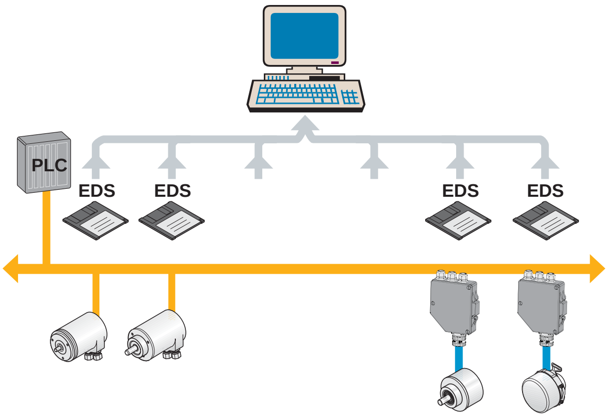
The CANopen communication profile is based on the CAN Application Layer (CAL) specification from the CiA (CAN in Automation). CANopen is regarded as a robust fieldbus with highly flexible configuration possibilities. It is used in many various applications all based on different application profiles.

CANopen comprises a concept to configure and communicate real-time data using both synchronous and asynchronous messages. Four types of messages (objects) are distinguished:

1. Administrative messages (Layer Management, Network Management, etc.)
2. Service Data Messages (SDO)
3. Process Data Messages (PDO)
4. Pre-defined Messages (Synchronization-, Time-stamp-, Emergency Messages)

For further information please view the CANopen specification available at www.can-cia.org

Interfaces



Network and configuration of CAN.

The Encoder Profile defines the functionality of encoders connected to CANopen. The operating functions are divided into two device classes:

Class 1, the Mandatory class with a basic range of functions that all Encoders must support. The class 1 encoder can optionally support selected class 2 functions, these functions must however be implemented according to the profile.

Class 2, where the Encoder must support all class 1 functions and all functions defined in class 2. The full class 2 functionality includes:

- Absolute position value transfer using either polled, cyclic or sync mode
- Velocity and acceleration output values
- Change of code sequence
- Preset value settings
- Scaling of the encoder resolution

Advanced diagnostics including:

- Encoder identification
- Operating status
- Operating time
- Alarms and warnings

All programming and diagnostic parameters are accessible through SDO's. The output position value from the encoder is presented in a binary format.

DeviceNet

DeviceNet is a low-level network that provides connections between simple industrial devices (sensors, actuators) and higher-level devices (controllers). DeviceNet provides Master/Slave and Peer-to-Peer capabilities over the CAN bus.

DeviceNet has two primary purposes:

- Transport of control-oriented information associated with low-level devices
- Transport of other information, which is indirectly related to the system being controlled, such as configuration parameters.

A DeviceNet node is modeled as a collection of Objects. An Object provides an abstract representation of a particular component within a product. The realization of this abstract object model within a product is implementation-dependent. In other words, a product internally maps this object model in a fashion specific to its implementation.

Like all other fieldbus interfaces, there is also an Encoder Profile which defines the functionality of encoders connected to a DeviceNet network. In the Encoder Profile are all Objects described that are used from DeviceNet Object library. Particular interesting is the Position Sensor Object (0x23 Hex). It describes the services that are available for fetching positions, scaling of position values and other useful information.

The full profile describes the encoder functionality which includes:

- Absolute position value transfer
- Velocity output values
- Change of code sequence
- Preset value settings
- Scaling of the encoder resolution

Advanced diagnostics including:

- Encoder identification
- Operating status
- Operating time
- Alarms and warnings

The Encoder Profile is a description of the objects and functions available to the user available upon request or downloadable on www.leinelinde.com.

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