NUMERIK JENA

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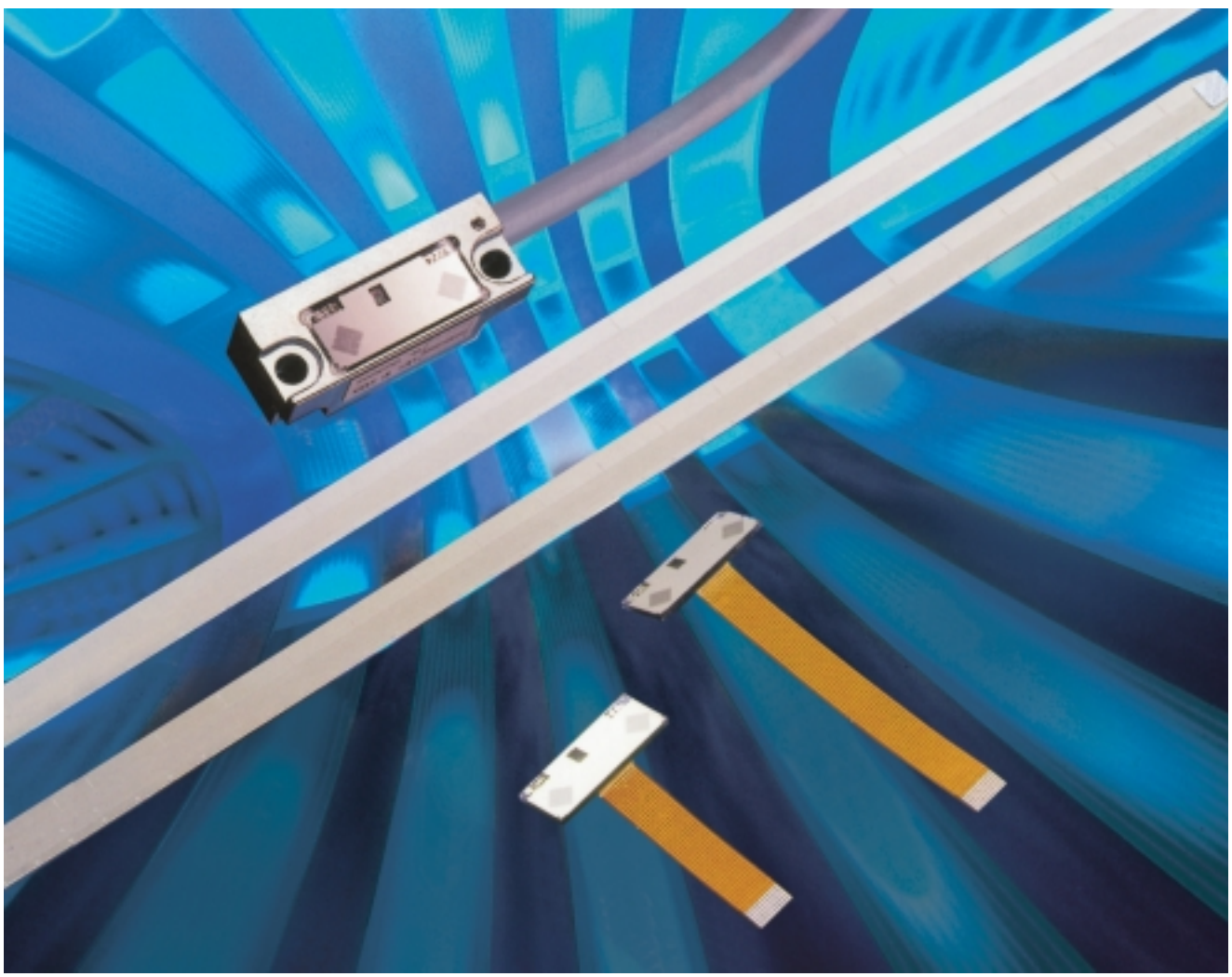


Linear Encoders

Contents

TYPES OF ENCODERS
Exposed Linear Encoders

Applications

Exposed linear encoders are designed for applications requiring measurement of length with very high accuracy and resolution without mechanical influence on the measuring device.

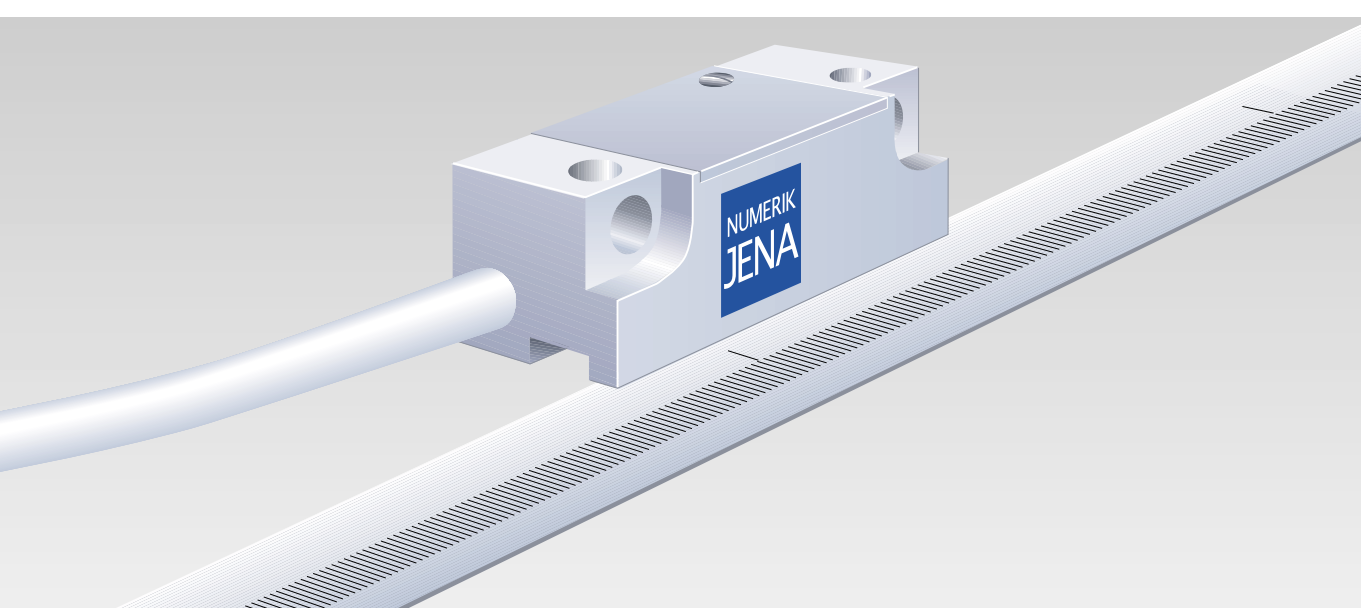
Typical areas of application:

- Coordinate measuring machines
- Measuring machines
- Coordinate tables
- Automatic component placement machines for PCBs
- Production and measuring equipment in the electronics industry
- Precision devices in reproduction graphics
- Precision processing machines
- Positioning and measuring equipment in medical technology
- Linear units/linear drives
- Linear guides

Primary characteristics

- Contact-free optical scanning of the scale by the measuring head.
- No mechanical effect on the slide system.
- The customer's slide system serves as guide between the measuring head and scale.
- High measuring velocity has no mechanical limits. It is limited only by the cutoff frequency of the optoelectronic scanning or by the subsequent counter.
- High accuracy.
- High resolution.
- Large mounting tolerances with respect to the attainable resolution.
- Small space requirement.
- Exact measurement in large temperature ranges thanks to thermally defined behavior.
- Scale and scanning head must be protected against contamination from dust, swarf, oil, water etc.

Scale / Measuring Head (LIE 5)



Sealed Linear Encoders

Applications

Sealed linear encoders are ideal for applications requiring measurement of length with high accuracy and resolution in harsh environments with airborne liquids and particles such as coolants, lubricants, chips and swarf.

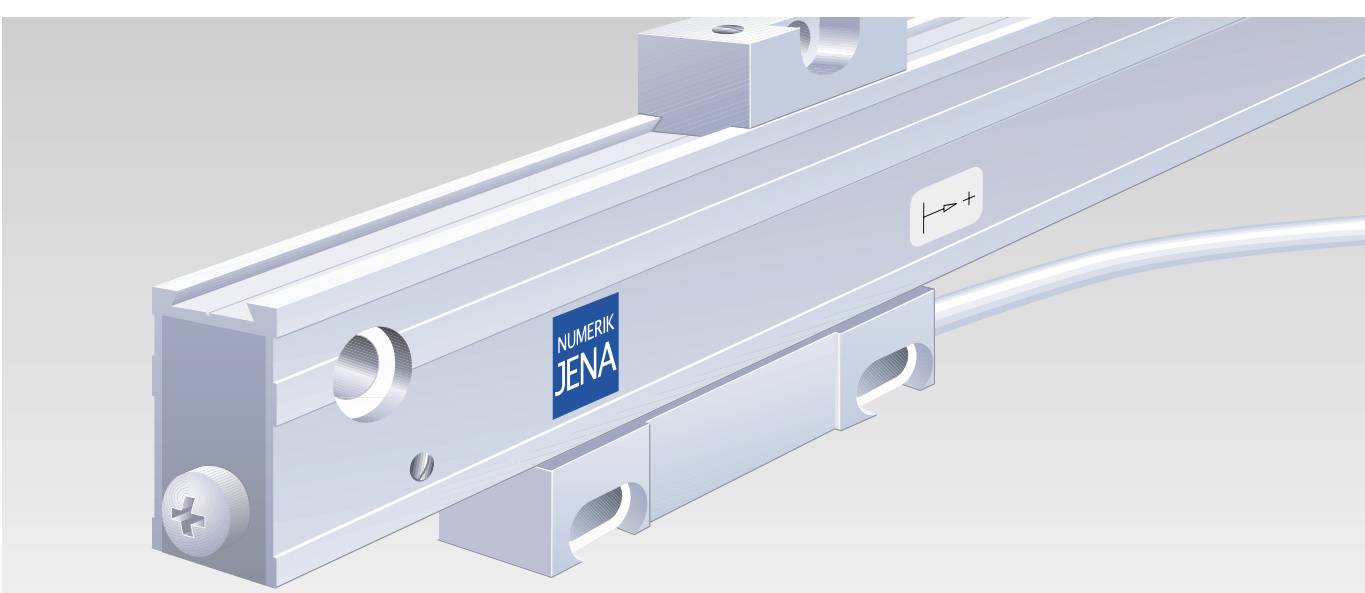
Typical areas of application:

- Machining centers
- Lathes
- Milling machines
- Drilling machines
- Grinding machines
- Electrical discharge machines
- Sheet metal working machines
- Welding machines
- Robotics/materials handling
- Measuring machines installed near production equipment
- Linear units/linear drives
- Linear guides

Primary characteristics

- The encoder forms a compact unit.
- The scanning unit is guided within the housing along scale.
- The scale, scanning unit and guide are protected against contamination by an aluminum extrusion and elastic sealing lips.
- The coupling elements between the scanning carriage and transfer web are designed to transfer motion in the measuring direction only.
- Pitch or other motion of the connecting web in a direction perpendicular to measurement is compensated without affecting accuracy.

LIS 73-3



Encoder Kit L

Applications

The Encoder Kit L was conceived for applications requiring measurement of length with very high accuracy and resolution without mechanical effect on the measuring device, and where space is a critical factor (applications for which even the very small measuring head of the LIE 4/LIE 5 is too large).

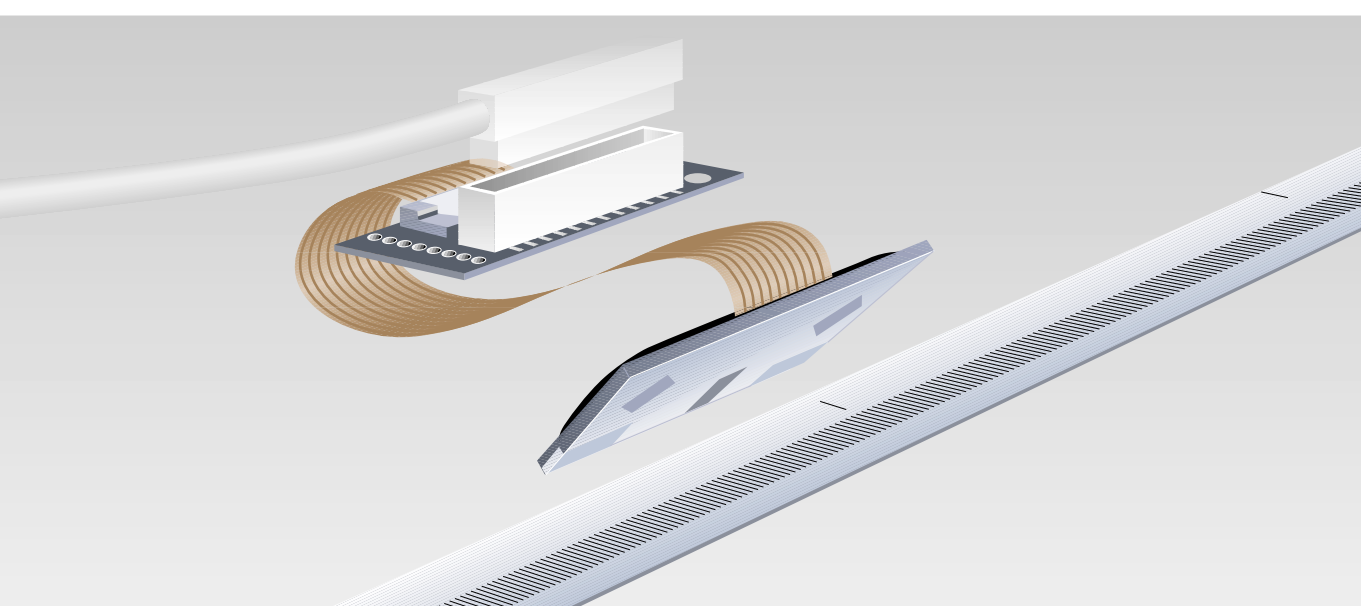
Typical areas of application:

- Plotters
- Printers
- Reprographic devices
- Probes
- Robots
- Coordinate tables
- Medical equipment

Primary characteristics

- The Encoder Kit L is a slimmed-down linear encoder consisting of a measuring standard, measuring module, interface PCB, and connecting cable.
- Contact-free optical scanning of the scale by the measuring module.
- High accuracy.
- High resolution.
- Very little space required.
- The components must be protected against contamination from dust, swarf, oil, water etc.
- The electromagnetic compatibility of the functional groups must be realized through an appropriate housing.

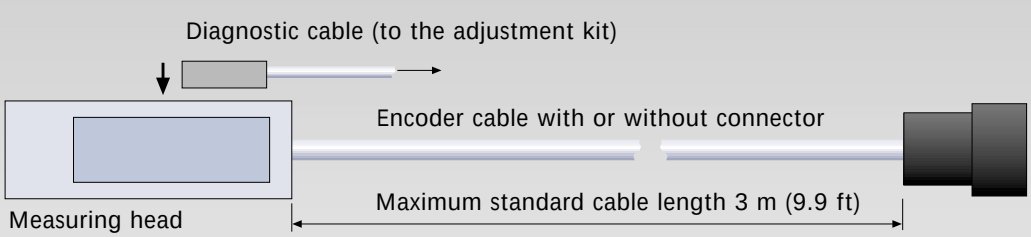
Encoder Kit L



Model Overview

Model	Resolution	Accuracy grade	Measuring length	Scale length/ total length	Mount. dim. W x H mm
Exposed linear encoders					
LIE 4 with	5; 1; 0.5; 0.2; 0.1 µm				
SINGLEFLEX scale tape		± 5 µm	Up to 10 m	Meas. length +21 mm	13.2 x 13.5
DOUBLEFLEX scale tape		± 2; 3; 5 µm	Up to 7 m	Meas. length +21 mm	13.2 x 13.7
		± 1 µm	Up to 1 m		
LIE 5 with	5; 1; 0.5; 0.2; 0.1 µm				
SINGLEFLEX scale tape		± 5 µm	Up to 10 m	Meas. length +30 mm	13.2 x 13.5
DOUBLEFLEX scale tape		± 2; 3; 5 µm	Up to 7 m	Meas. length +30 mm	13.2 x 13.7
		± 1 µm	Up to 1 m		
Encoder Kit L with double-field sensor	5; 1; 0.5; 0.2; 0.1 µm				
SINGLEFLEX scale tape		± 5 µm	Up to 10 m	Meas. length +30 mm	8.2 x 3.7
DOUBLEFLEX scale tape		± 2; 3; 5 µm	Up to 7 m	Meas. length +30 mm	8.2 x 3.9
		± 1 µm	Up to 1 m		
Encoder Kit L with single-field sensor	5; 1; 0.5; 0.2; 0.1 µm				
SINGLEFLEX scale tape		± 5 µm	Up to 10 m	Meas. length +21 mm	8.2 x 3.7
DOUBLEFLEX scale tape		± 2; 3; 5 µm	Up to 7 m	Meas. length +21 mm	8.2 x 3.9
		± 1 µm	Up to 1 m		
Sealed linear encoders					
LIS 73-1	5; 1; 0.5; 0.2; 0.1 µm	± 2; 3; 5 µm	Up to 3.51 m	Meas. length +105 mm	18 x 46.2
LIS 73-3	5; 1; 0.5; 0.2; 0.1 µm	± 2; 3; 5 µm	Up to 3.45 m	Meas. length +115 mm	17.6 x 46.2
LIS 75-1	5; 1; 0.5; 0.2; 0.1 µm	± 2; 3; 5 µm	Up to 3.48 m	Meas. length +119 mm	37 x 85

LIE / electronics in the measuring head

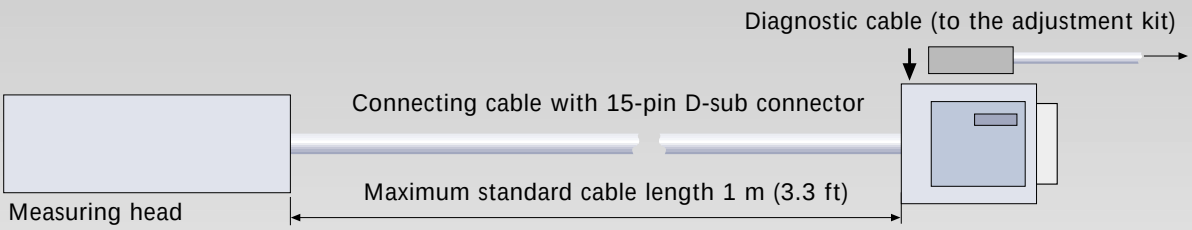


Output of measuring head = output of cable / connector

sin 1 V_{PP}	RS 422 square-wave signal;	***without*** interpolation
sin 11 μA_{PP}	RS 422 square-wave signal;	***with*** interpolation
		Fixed interpolation factor
		Fixed max. output frequency

Model Overview

LIE / electronics in the connector



Output of measuring head = Input of cable / connector

sin 1 V_{PP}

sin 1 V_{PP}

Output of connector

sin 1 V_{PP} (for 9-pin and 15-pin D-sub)

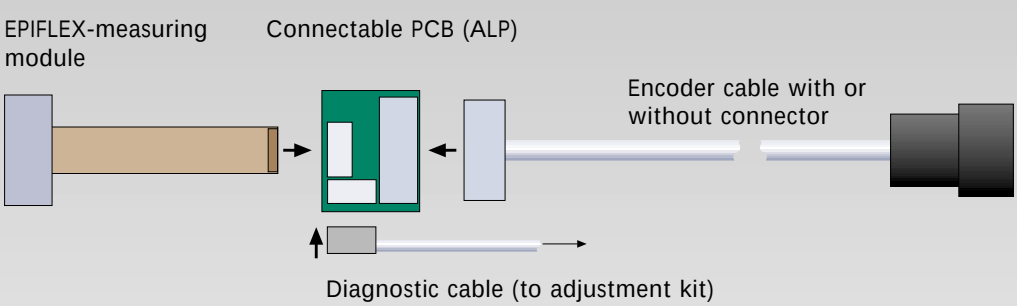
square-wave signal; 15-pin D-sub

With interpolation

Fixed interpolation factor

Maximum output frequency switchable

Encoder Kit L



Output of measuring module = input of connectable PCB

sin 1 V_{PP}

sin 1 V_{PP}

sin 11 μA_{PP}

sin 11 μA_{PP}

Output of connectable PCB (ALP) = Output of cable / connector

sin 1 V_{PP}

RS 422 square-wave signal; ***Without*** interpolation

sin 11 µA

RS 422 square-wave signal; ***With*** interpolation

Fixed interpolation factor

Fixed max. output frequency

Encoder Kit L is also available with the electronics in the connector, as with the LIE.

Functional Principle

Optoelectronic Scanning

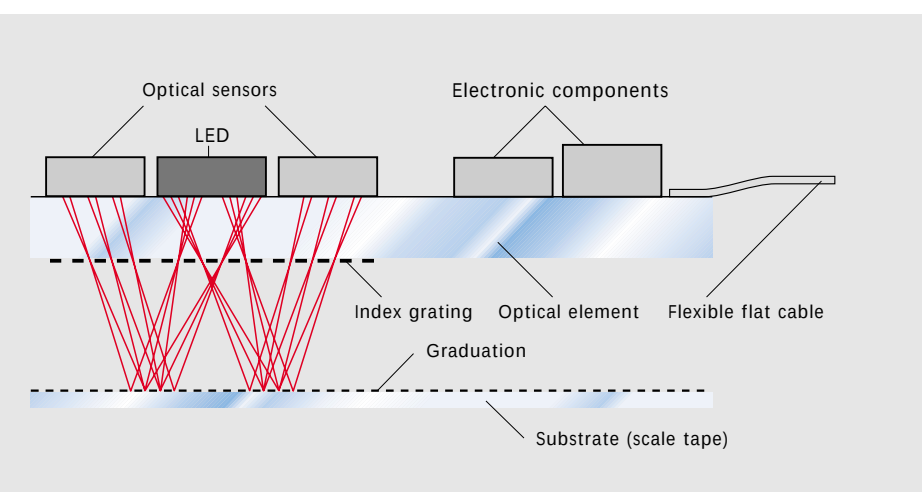
The core of all optoelectronic encoders from NUMERIK JENA is the Epiflex measuring module-a compact, miniaturized, and multifunctional component. It is based on a new scanning principle for reflected light and a completely new generation of integration design technology using the latest and most powerful microelectronic developments. The scanning principle exploits the diffraction of light in a triple-grating system. The light source is an LED chip with diffused radiation. Its light penetrates an index grating, then strikes and is reflected by the scale. This reflected light again penetrates the index grating and reaches a pin (p-intrinsic-n) photodiode array. The index grating differs in its period from the scale grating and is slightly rotated with respect to it. When the gratings move with respect to each other, the angular offset between the gratings produces moiré fringes that move perpendicularly to the measuring direction over the pin photodiode array. The receiver fields in the pin photodiode array are arranged geometrically to generate phase-shifted signals when they detect the moiré fringes.

The form and arrangement of photoelectric transducer fields (distribution of one channel into two or more) largely compensate pitch and planar misalignment of the measuring head with respect to the scale. Furthermore, they provide good harmonic filtering of the measuring signals to guarantee their quality and permit high interpolation factors.

The signals are processed in the measuring module by an ASIC with the following functions:

- Amplification of the photodiode signals in three channels
- Adjustment of signal amplitude, balance and offset
- Output of sensor signals as voltage, current, or square-wave signals
- Line drivers for up to 100 meters cable length for voltage signals
- Input signal level monitoring with generation of a fault detection signal
- Stabilization of the LED current
- Compensation of LED temperature variation

Optical path



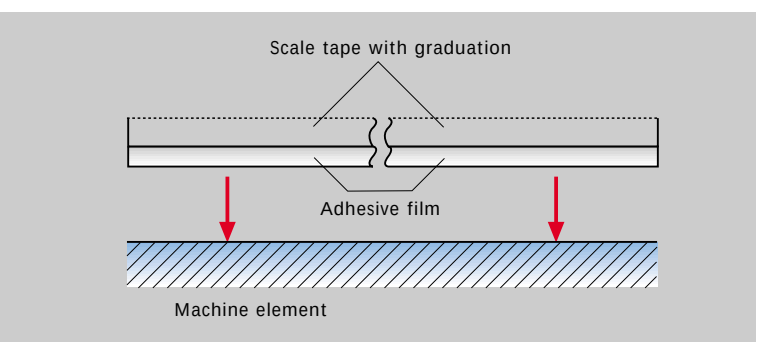
Measuring Standard

The component responsible for the accuracy of a linear encoder is its measuring standard. The measuring standard for NUMERIK linear encoders is a graduated scale on a steel strip. The graduation is etched into the polished steel surface, which makes it resistant to wiping and abrasion.

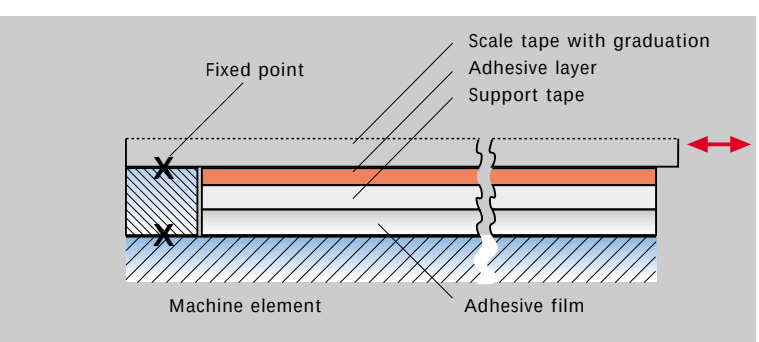
Depending on the requirements of the application, exposed linear encoders are available with SINGLEFLEX or DOUBLEFLEX scales. Sealed linear encoders are provided with DOUBLEFLEX scales (see "Thermal Behavior")

SINGLEFLEX scale tape
Scale tape with adhesive film on back. Used primarily for:

- Accuracy grade of ±5 µm
- Machine elements with linear expansion coefficient equal to that of steel (approx. 10.5 ppm/K)



SINGLEFLEX scale tape



DOUBLEFLEX scale tape

DOUBLEFLEX scale tape
Scale tape with support tape and adhesive film on back. Used primarily for:

- Measuring lengths beyond 100 mm
- Accuracy grades of ±3 µm and better
- Machine elements with linear coefficient of expansion different from steel

The outstanding characteristics of the **DOUBLEFLEX scale tape** are:

- Defined linear coefficient of expansion of a ≈ 10.5 ppm/K when installed
- No thermally induced stress of the DOUBLEFLEX scale in function. Even with large temperature changes or at great difference from the expansion coefficient of the machine element (e.g., aluminum) the scale expands without stress.
- No mechanically induced deformation of the DOUBLEFLEX scale tape during mounting. The scale tape assembly distributes the stress so that the graduation remains accurate.
- Significant reduction of the flectional error component of the mounted DOUBLEFLEX scale tape and therefore higher accuracy compared with conventional scales or simple tape scales.

Design of the DOUBLEFLEX scale tape
Two bendable steel strips are connected by an intermediate adhesive layer that provides a flexible mechanical separation:

- One steel strip carries the graduation and serves as the scale.
- One steel strip serves as a support for the scale tape.

The intermediate layer connects the two strips and forms a stable bond, by which the scale can expand and contract in the measuring direction in a defined manner with respect to a fixed point, which is connected with the scale carrier (machine element).

Mechanical Design

Exposed Linear Encoders

Exposed linear encoders consist of a measuring head and a scale. The two are connected over the guideway of the slide system. The scale tape is fastened by a self-adhesive tape on its back.

The fixed point of the DOUBLEFLEX scale tape is to be connected with the machine element. Optional guide bands can be used to facilitate mounting of both the SINGLEFLEX and DOUBLEFLEX scale tape and to provide additional protection against lateral motion of the DOUBLEFLEX scale tape. With the aid of a special device (FAV) that can be connected in place of the measuring head, these self-adhesive guide bands are applied in the correct position relative to the measuring head and parallel to direction of slide traverse. The scale tape is then applied in the resulting „slot."

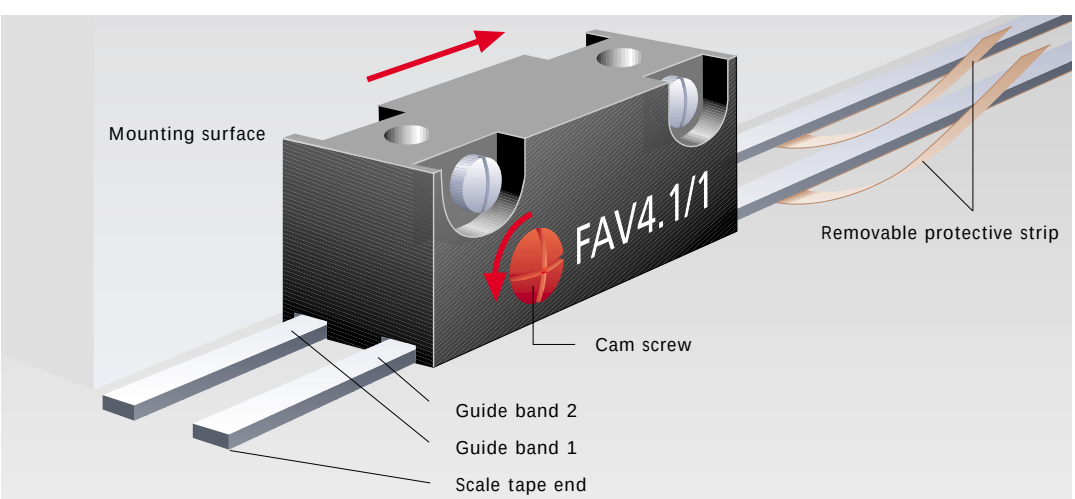
Sealed Linear Encoders

In sealed linear encoders, the scale tape and scanning system are protected in an aluminum housing against dust, chips, oil and water.

The scanning head is guided along the scale by an internal, low-friction ball bearing, so that relatively generous mounting tolerances are possible.

The scale tape and the scanning carriage with the scanning system are completely separated from each other.

Between the measuring carriage and the connecting web, a special coupling that is very stiff in the measuring direction compensates other motion between the connecting web and scale without reducing measuring accuracy.



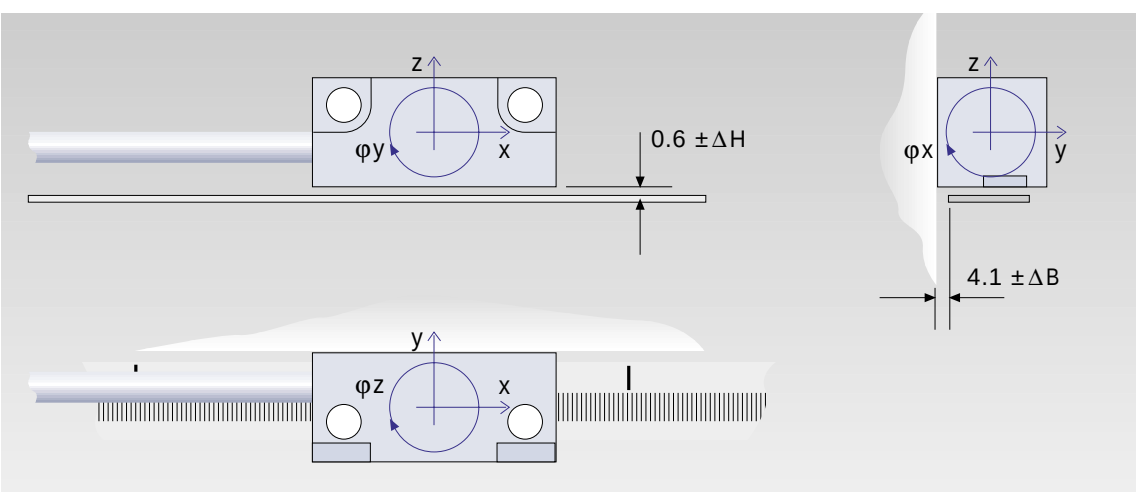
Application of the guide band with FAV

LIE 5 - Mounting Tolerances

Overview of permissible position deviation between measuring head and scale tape: The values represent the sum of mounting tolerances and dynamic error during operation. The additional tolerances shown in the mounting instructions must be observed.

		With use of reference pulse	Without use of reference pulse
φy	Rotation about the Y axis (pitch angle)	±3' or ±0.05° or 0.04/50	±6' or ±0.1° or 0.08/50
φz	Rotation about the Z axis (yaw angle)	±6' or ±0.1° or 0.08/50	±6' or ±0.1° or 0.08/50
φx	Rotation about the X axis (roll angle)	±30' or ±0.5° or 0.4/50	±30' or ±0.05° or 0.4/50
ΔH	Gap tolerance of measuring head to scale tape	± 0.1	± 0.1
ΔB	Gap tolerance of measuring head mounting surface to the scale tape	± 0.1	± 0.3

The tolerances φy and φz are particularly critical for the LIE 5 with reference signal!



General Mounting Information

The measuring or positioning error of a machine are influenced essentially by the dynamic accuracy of the table slide system. To minimize the Abbe comparator error resulting from this system, the encoder should be mounted as closely as possible to the measuring or working plane or in close proximity to the guideway. If the machine has dual guideways, the best position for the encoder is between them.

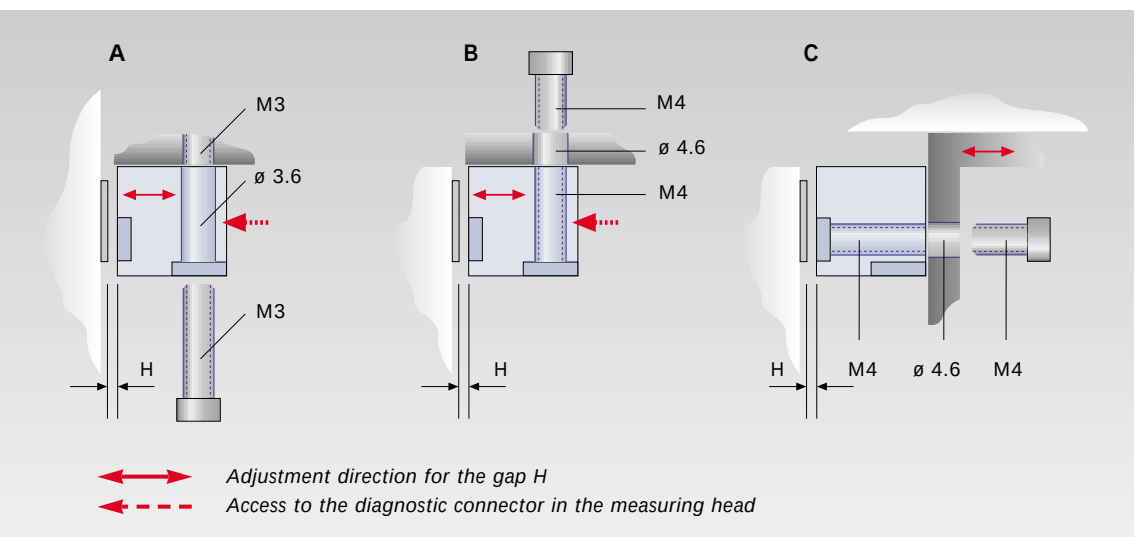
The gap between measuring head and scale tape in exposed linear encoders is adjusted with the aid of a provided feeler gauge. For sealed linear encoders, the shipping brace serves to set the gap between the housing and the connecting web.

Improper adjustment of the head-to-scale gap on exposed linear encoders can result in signals that are out of tolerance. A signal monitor from NUMERIK JENA is available for checking proper installation and/or for adjusting of the output signals.

The scale or housing are to be aligned parallel with the machine guideway.

To prevent frequent flexing of the cable, the measuring head or connecting web should be fixed to the stationary machine element. If possible, the encoders should be mounted on machine parts that are rigid or low in vibration (or at the vibration nodes).

LIE - Fastening Conditions



A Standard mounting LIE 5 1 (through hole in measuring head)

B Mounting option LIE 5 1 (M4 thread in measuring head)
Diagnostic connector in measuring head is accessible after mounting.

C Mounting option LIE 5 1 (M4 thread in measuring head)
Measuring head holder must be movable to adjust the gap H.
*Diagnostic connector in measuring head is **not** accessible after mounting.*

Protection against Contamination

Exposed encoders have no integral protection against contamination. The selected scanning principle (double-field sensor, two or more photoreceivers per channel) provides high redundancy, so that small amounts of contamination have no influence on measuring accuracy.

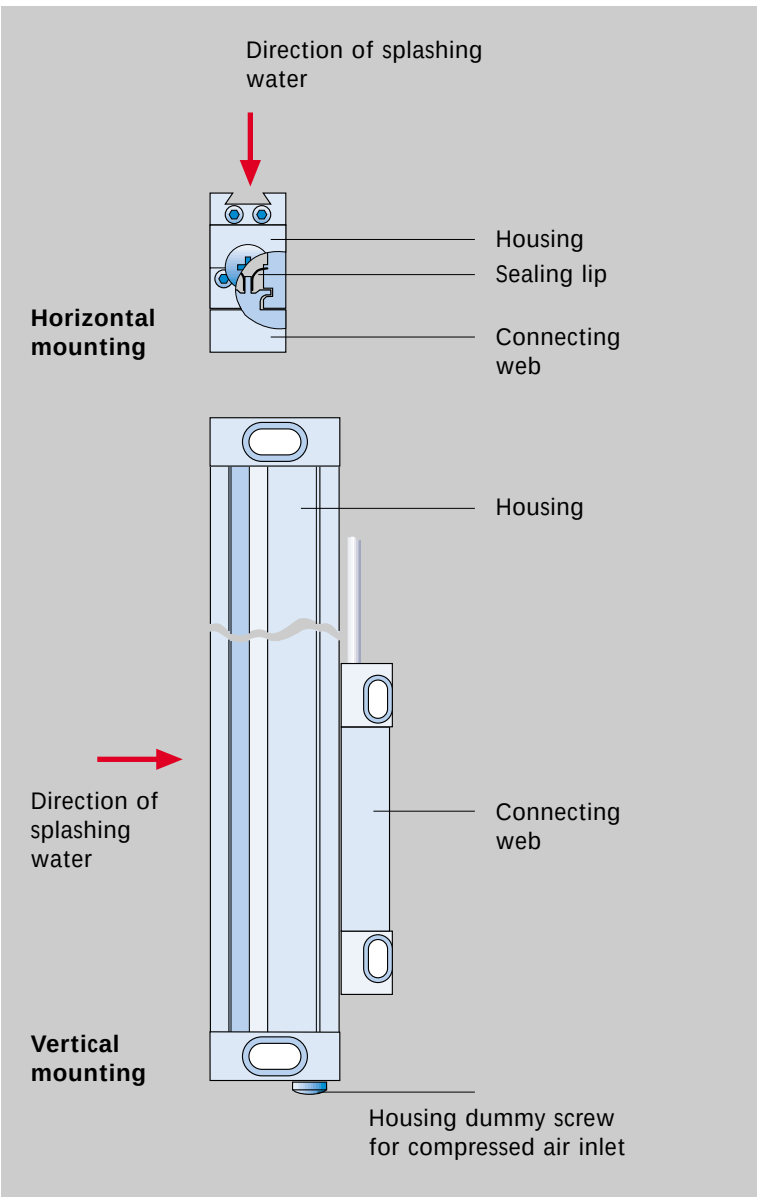
If the encoder is exposed to heavy contamination, appropriate protective measures must be taken, or the encoder must be mounted where it can be easily accessed for cleaning. Frequent cleaning, even with solvents, will not damage the scale tape.

Sealed encoders are designed to protect the scale against dust and splashwater in accordance with IEC 529 or EN 60 529.

In order to achieve the rated degree of protection, the encoder must be mounted with the connecting web showing downward and the sealing lips oriented away from the water. Otherwise the encoder must be protected through corresponding mechanical design measures.

If the encoder is subjected to coolant or lubricant mist, the encoder can be protected additionally through the introduction of compressed air (air purging). An air inlet with integrated throttle for the housing is available as an option. The compressed air must be free of water, oil and dust (course and fine filters). The recommended flow is 3 to 6 liters per minute at a pressure of 0.6 to 1 bar (9 to 14 psi).

Impermissible contamination or other problems can be detected through the electronic encoder monitoring function and from the error signal (AS or NAS) and transmitted to the evaluation electronics.



Thermal Behavior

Exposed Linear Encoders

Wherever DOUBLEFLEX scale tape is used, the measuring standard behaves like steel with a linear expansion coefficient of $\alpha \approx 10.5$ ppm/K, regardless of the temperature and expansion coefficient of the machine element to which it is connected. The thermal reference point lies at the beginning of the measuring length (fixed point).

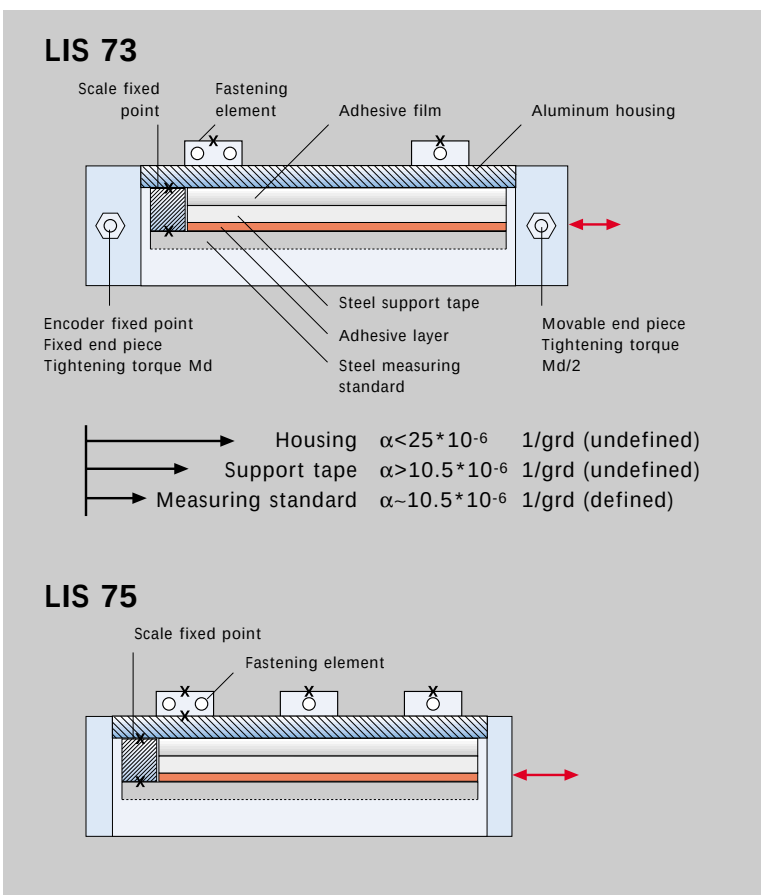
Benefit:
If the scale tape and a steel workpiece have the same temperature, then even when the temperature deviates from 20° C (68 °F) there will be no resulting measuring or machining error.
If the coefficient of expansion of the measured object (e.g., a workpiece) is other than a ≈ 10.5 ppm/K, and/or if the temperature of the scale tape differs from that of the measured object, then the difference can be exactly compensated numerically, provided that the temperatures of the scale tape and measured object are known.

Sealed Linear Encoders

Sealed NUMERIK JENA linear encoders feature DOUBLEFLEX scale tape. Sealed linear encoders from NUMERIK JENA therefore have a defined linear coefficient of expansion of $\alpha \approx 10.5$ ppm/K. The fixed point of the DOUBLEFLEX scale tape is located near the fixed point of the housing and serves simultaneously as the fixed point of the entire linear encoder.

To avoid excessive thermal stress between the encoder housing (aluminum) and the machine element (steel or gray cast iron) under large changes of temperature, the housing is rigidly connected to the machine element only at the fixed point. The housing is movable in its flexible fastening elements and can avert stress resulting from expansion.

With the LIS 73, the end piece opposite from the fixed end piece is fastened with less torque, so that it can also move to avert stress.



Thermal behavior of sealed linear encoders

Resolution

A distinction must be made between the resolution and accuracy of an encoder. The two have no immediate relationship and may differ.

The resolution of an encoder is the smallest distance of measuring head movement relative to the scale that can be distinguished by the evaluation electronics (display unit, control).

Resolution depends on:

- The grating period of the scale
- The factor of the signal interpolation (internally or in the subsequent electronics)
- Type of evaluation in the counter

Grating period (GP) the of scale	Signal period of the sinusoidal signal	Interpolation factor	Signal period after interpolation	Resolution after evaluation in the counter		
				1-fold	2-fold	3-fold
20 µm	20 µm	None	20 µm	20 µm	10 µm	5 µm
		5-fold	4 µm		2 µm	1 µm
		10-fold	2 µm	2 µm	1 µm	0.5 µm
		25-fold	0.8 µm			0.2 µm
		50-fold	0.4 µm		0.2 µm	0.1 µm
				1-fold	2-fold	4-fold
100 µm	100 µm	None	100 µm	100 µm	50 µm	
		5-fold	20 µm	20 µm	10 µm	5 µm
		10-fold	10 µm	10 µm	5 µm	
		25-fold	4 µm		2 µm	1 µm
		50-fold	2 µm	2 µm	1 µm	0.5 µm

Accuracy

The accuracy of linear encoders is expressed in terms of accuracy grades. The extreme values of error with reference to their mean value lie within ± a µm for a position within any maximum one-meter section of the measuring length.

For measuring lengths below one meter, the tolerance (± a) refers to the respective measuring length. The accuracy values apply for a reference temperature of 20 °C (68 °F).

For exposed linear encoders, the above definition of accuracy applies only to the scale. In this case, it is referred to as the scale accuracy. The system accuracy is determined by the following factors:

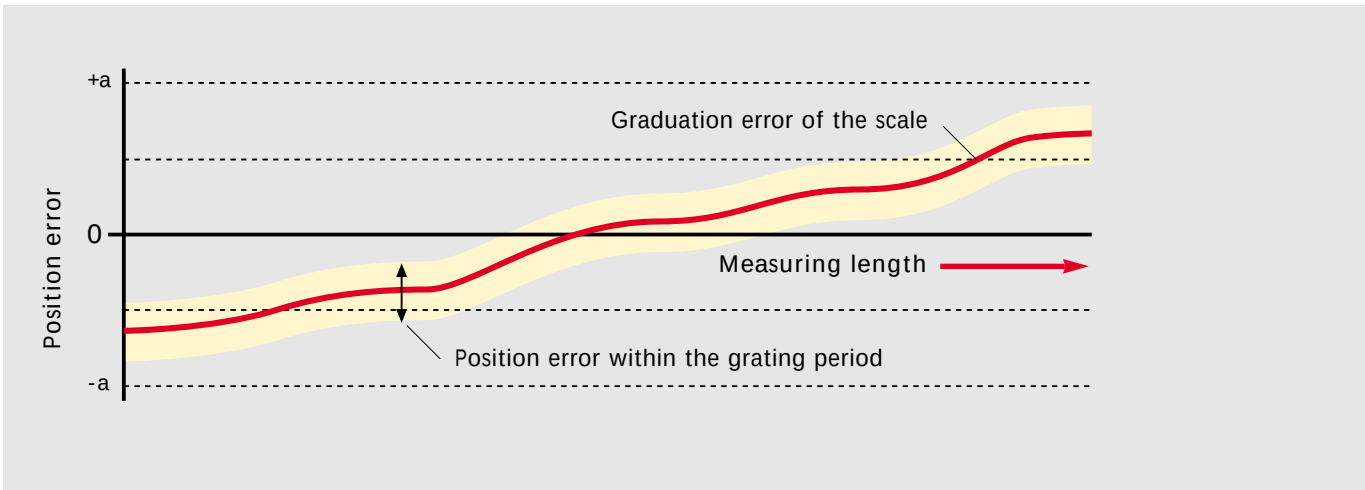
- Scale accuracy
- Influences of photoelectrical scanning and signal processing
- Influences of the guide between the measuring head and scale, and of the mounting tolerances

The last two influencing variables affect the position error within one signal period. This error is random in character and is superimposed as an envelope curve on the scale error.

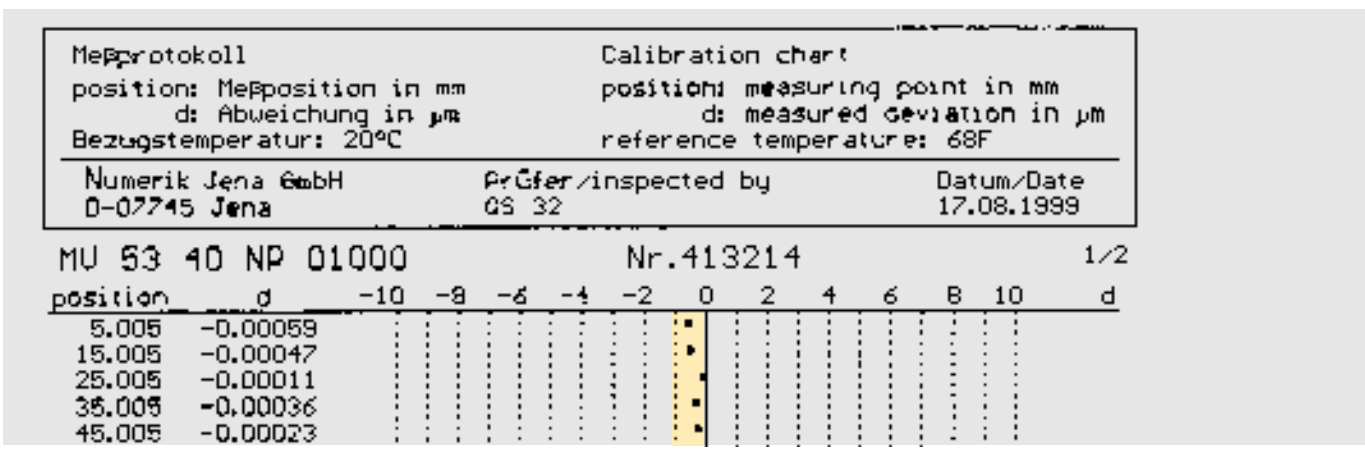
If the encoder is optimally mounted, the position error within one signal period is ± 1 to 2% of the grating period.

In exposed linear encoders, the accuracy of the mounting and the quality of the guide influence this error substantially. If the sinusoidal signals are interpolated, NUMERIK JENA recommends an electronic fine adjustment.

The accuracy of the scale tapes and of the complete sealed linear encoders is measured by a laser interferometer and recorded.



Position error


Meßprotokoll
position: Meßposition in mm
d: Abweichung in µm
Bezugstemperatur: 20°C

Calibration chart
position: measuring point in mm
d: measured deviation in µm
reference temperature: 68F

Numerik Jena GmbH
D-07745 Jena

Prüfer/inspected by
GS 32

Datum/Date
17.08.1999

MU 53 40 NP 01000 Nr.413214 1/2

position	d	-10	-8	-6	-4	-2	0	2	4	6	8	10	d
5.005	-0.00059												
15.005	-0.00047												
25.005	-0.00011												
35.005	-0.00036												
45.005	-0.00023												

Calibration chart

Reference Marks

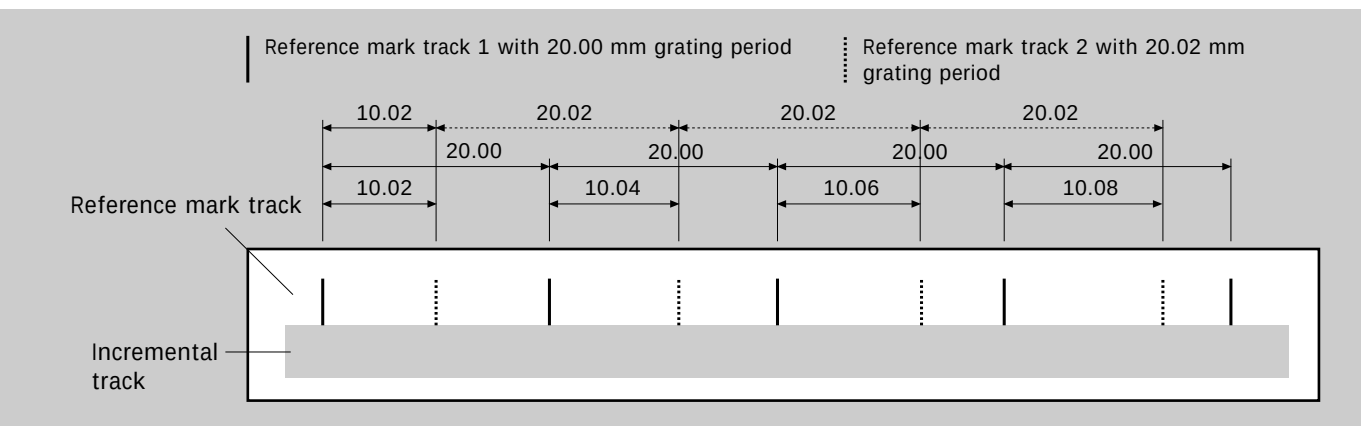
Reference marks at defined points on the scale serve to establish the assignment of incremental encoder positions to positions in the absolute coordinate system of a machine or other device.
When the measuring head moves over the scale, a reference mark signal is generated at each of these reference marks. After the machine is switched on, or after a power interruption, these signals make it possible to establish an exact assignment of encoder positions (corresponding to the resolution of the counting signals) to the absolute coordinates of the machine or device.

Possible configuration

- Reference marks spaced 50 mm apart; the user can activate one or more of them, e.g., through additional switches
- Reference marks at midpoint of measuring length
- Reference mark position as requested by customer
- Distance-coded reference marks:
  Two reference mark tracks are arranged so that the absolute position of the encoder can be re-established after traverse of two successive reference marks (after max. 20-mm traverse for a 20-µm graduation period).

Reference mark track 1:
Grating period 1000 GP of the incremental track (20 µm)*
Reference mark track 2:
Grating period 1001 GP of the incremental track (20 µm)*

The distance between adjacent reference marks therefore changes in increments of 1 GP (20 µm). In this way, every reference mark is assigned to a defined position in the slide.*
The evaluation of distance-coded reference marks must be implemented with special software in the NC or CNC.

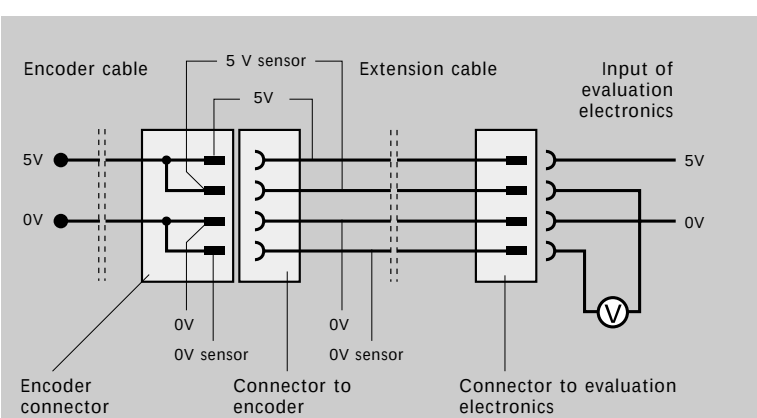


Power Supply

Linear encoders from NUMERIK JENA require a power supply of 5 V ±20% (±1 V). The maximum permissible ripple content of the power supply is U_{PP} < 250 mV with dU/dt > 5 V/µs (high frequency noise) and U_{PP} < 100 mV (low frequency noise).

These voltage values apply at the input of the encoder or the permanent encoder cable (without influence of an extension cable) and can be tested through the sensor lines. The sensor lines (0 V and 5 V) are non-loaded measuring lines through which the evaluation electronics (display unit or control) can measure the power supply of the encoder input or compensate it so that the required operating voltage of 5 V ±20% is present at the encoder.

The power line and associated sensor line are bridged in the encoder's connector.



Sensor line

Signal Interpolation

Internal signal interpolation up to a factor of 50 is available as an option with all NUMERIK JENA encoders. The interpolation electronics can be integrated in the

measuring head (LIE, LIS) or on the **printed circuit board (Encoder Kit)** or in the **sub-D connector (all encoders).**

In an internal resistor network and bridge circuit, n (= interpolation factor) signals are generated within one primary signal period. The interpolated signals are phase-shifted by 2Π/n. At the zero crossovers of these signals, a clocked trigger generates square-wave signals.

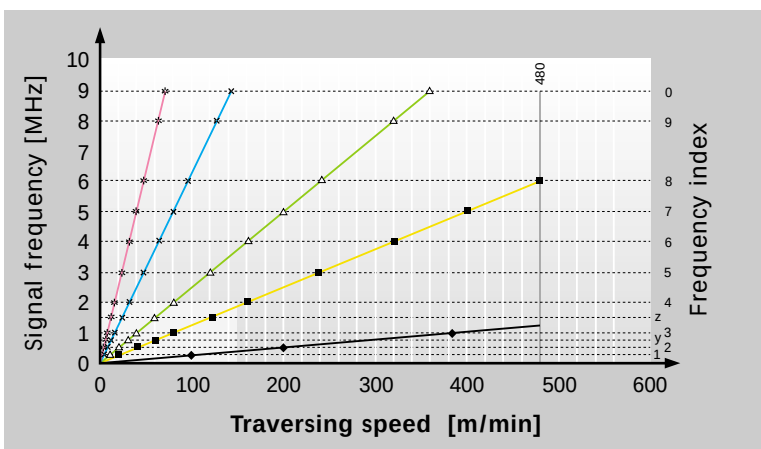
The signals are subdivided with a high internal nominal clock frequency. Due to component tolerances and deviations of the primary signals from an ideal sine wave, the signal output frequency can assume higher values independently from the traversing speed. If the maximum permissible input frequency of the evaluation electronics (CNC) is at least 9 MHz, the signal will be counted without error. If the input frequency is less than 9 MHz, the interpolator can be limited through external circuitry to this lower frequency.

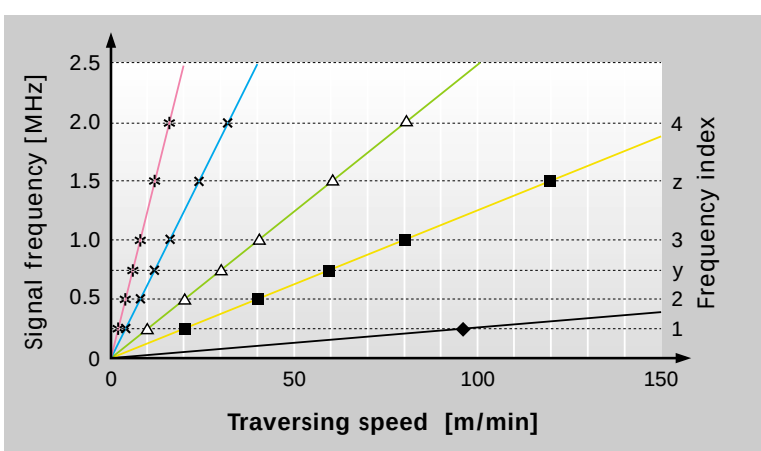
For this reason, orders for linear encoders should include the frequency index or the maximum signal input frequency of the CNC.

The diagram at right shows the signal frequency and the resulting traversing speeds for the available interpolation factors.

Example:

Max. signal input frequency of the CNC:	*2.0 MHz (8 MHz counting frequency with 4-fold evaluation)*
Desired interpolation factor:	*10 (resolution 0.5 µm with 20 µm grating period)*
Max. selectable frequency index:	*4 (signal frequency limited to 2 MHz; ≤ max. signal input frequency of the CNC)*
Resulting max. traversing speed:	*80 m/min (3150 ipm)*





50-fold
25-fold
10-fold
5-fold
None

Signal interpolation with 20 µm grating period

Output signals

Cutoff frequency
For outputs with sinusoidal signals:
The cutoff frequency indicates the maximum scanning frequency (with respect to the grating period of the measuring standard), at which the corresponding quasi static signal amplitude falls to 70% (–3 dB).

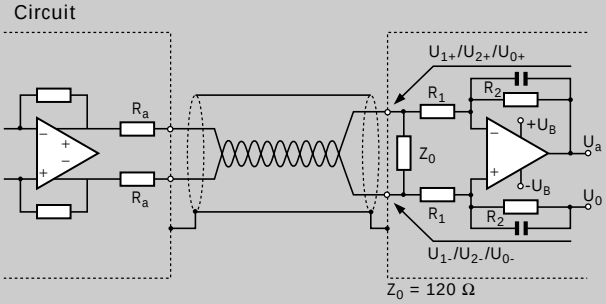
Edge separation
The edge separation a is defined for square-wave signals (linear encoders with integrated interpolation and digitizing electronics). It indicates the minimum difference of two successive signal edges between the counting signals Z_1 and Z_2 at the maximum permissible traversing speed under consideration of all unfavorable influences.

Monitoring signal
The proper function of the linear encoders is monitored through an internal circuit. If, for example, a weakening of the light source or photoelectric transducer, contamination, or deviations from signal levels cause a disruption of normal function, the encoder issues a signal (AS, high-active: NAS, low-active) that can be evaluated in the higher-level electronics and can, for example, be used to switch off the machine.

Symbols

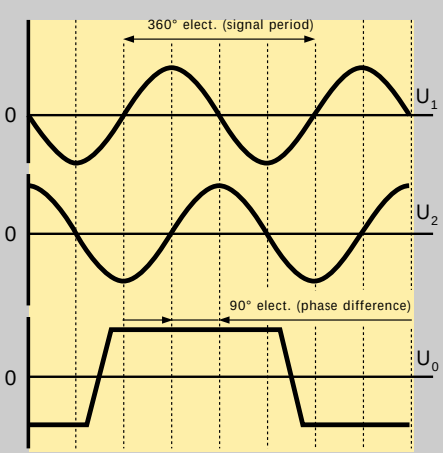
I_1 U_1	Sinus signal	Counting track
I_2 U_2	Cosine signal	Counting track
I_{1-} U_{1-}	Neg. sine signal	Counting track
I_{2-} U_{2-}	Neg. cosine signal	Counting track
I_0 U_0	Reference signal	
I_{0-} U_{0-}	Neg. reference signal	
U_B	Operating voltage (+5V)	
Z_1	Counting signal 0°	
Z_2	Counting signal 90°	
$\bar{Z}_1$	Neg. counting signal (180°)	
$\bar{Z}_2$	Neg. counting signal (270°)	
R	Reference signal	
$\bar{R}$	Neg. reference signal	
AS	Monitoring signal	
NAS	Neg. monitoring signal	
	NAS high: proper function. Input signal is within tolerance.	
	NAS low: improper function. Encoder is nonfunctional.	
a	*Minimum edge separation as a function of the interpolation factor and traversing speed*	
UM	Medium-high voltage (+2.5 V)	

Circuit



1 V_{PP} ~

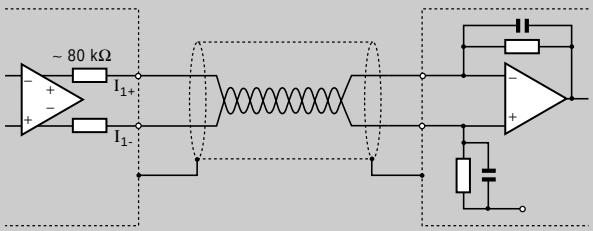
Phase diagram



Sinusoidal voltage signals

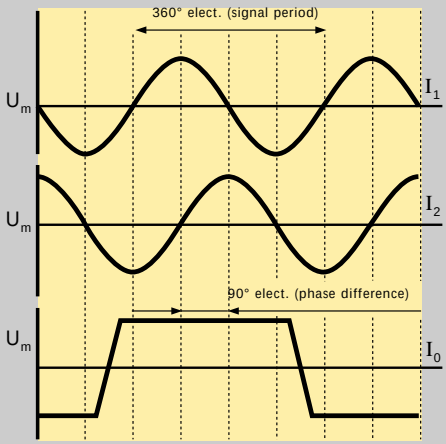
Differential signals measured at Z_0:
$U_1 = U_{1+} - U_{1-} = 0.6...1.2\ V_{PP}$ (nominal voltage 1 V_{PP})
$U_2 = U_{2+} - U_{2-} = 0.6...1.2\ V_{PP}$ (nominal voltage 1 V_{PP})
$U_0 = U_{0+} - U_{0-} = 0.5...1.2\ V_{PP}$ (nominal voltage 0.8 V)

Circuit



11 μA_{PP}

Phase diagram

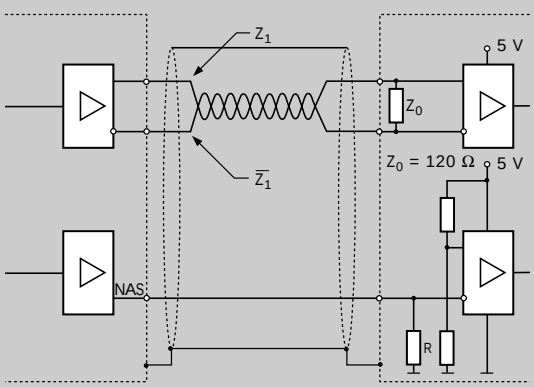


Sinusoidal current signals

U_m = 2.5 V ± 0.5 V

I_1 = 7.0...16 μA_{PP}
I_2 = 7.0...16 μA_{PP}
I_0 = 5.5...15 µA

Circuit

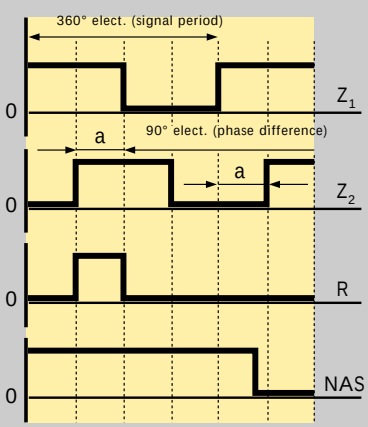


RS 422 line driver

RS 422 line receiver
(e.g. AM, 26 LS 32, MC 34 86)

RS 422 A

Phase diagram



a = edge separation

RS 422 square-wave signals

To prevent interference, the cable connection must be adjusted with the terminal resistor Z_0 = 120 Ω.

If two or more parallel signal inputs are connected to one encoder output signal (e.g., for linear drives a parallel connection of position controller, velocity controller, and acceleration controller), please ensure that the resulting terminal resistance of these inputs is Z_{0res} ≈ 120 Ω.

Electromagnetic Compatibility

Strong electromagnetic fields can result in spurious pulses in the measuring signals and cause counting errors. Possible sources of noise include:

- *Strong magnetic fields from transformers or electric motors (particularly linear motors)*
- *Contactors, relays, solenoid valves*
- *High-frequency equipment, pulse generators, switch-mode power supplies, and frequency inverters*
- *Power supply units and power lines to the above devices*

To ensure maximum protection against noise fields:

- *Use only original NUMERIK JENA cable and connecting elements.*
- *Comply with the NUMERIK JENA shielding recommendations.*
- *Ensure that the encoder and evaluation electronics have the same electrical potential. They must be connected with the main signal ground through the machine chassis or through a separate potential compensating line (minimum cross section 6 mm² Cu).*
- *Connect the encoder with the machine such that electrically conductive contact is ensured (paint-free mounting surface, electrically conductive screw and hole threads).*
- *Maintain a minimum spacing of 100 mm between signal cables and sources of interference.*
- *Maintain a minimum spacing of 200 mm between signal cable and inductors (switching power supply).*
- *Connect the encoders only to devices whose power supplies comply with EN 50 178 (protective low voltage)*
- *Configure the signal lines for minimum length and use no unshielded connections.*
- *If signal lines are routed together with spurious signal transmitting cables, use a grounded partition to ensure sufficient decoupling.*

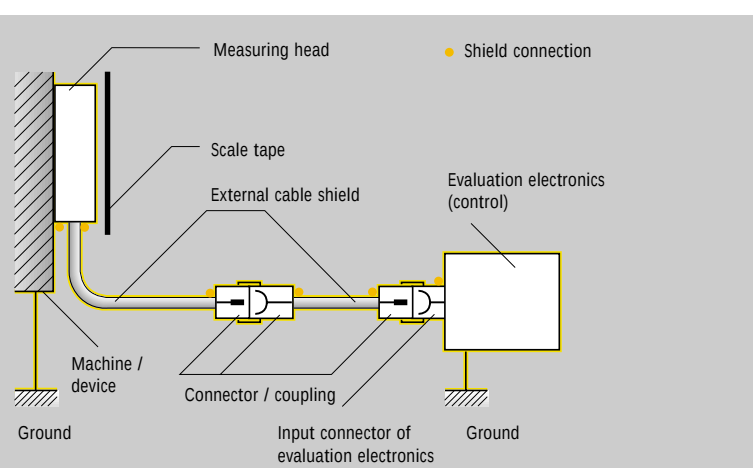
If contrary to these recommendations encoders are installed without cable connecting elements:

- *When connected directly with the evaluation electronics, ensure that the external shield of the cable is well grounded.*
- *If cable connectors, (e.g. terminal strips) are used, connect the external shields of the cables are connected with each other and with the shielding of the cable connector.*
- *If double-shielded cables are used, connect the internal shield with the 0 V conductor.*

Extensions cables

The use of original NUMERIK JENA extension cables guarantees optimum compatibility with the encoder and ensures maximum protection against interference.

Please consult the encoder manufacturer before using self-manufactured extension cables. The encoder cable must not include any additional signal lines or other electrical lines transmitting spurious signals. Encoders with NUMERIK JENA cable connecting elements fulfill the requirements of EN 50081-1 and EN 50082-1, provided that they are installed and operated in accordance with these recommendations and the above-described prerequisites.



Shielding configuration

Connecting Elements and Cable

Connecting elements

Connectors, couplings, and flange sockets are connecting elements with locking features. They can be either male or female.

A **connector** has a movable locking element (e.g., coupling ring).

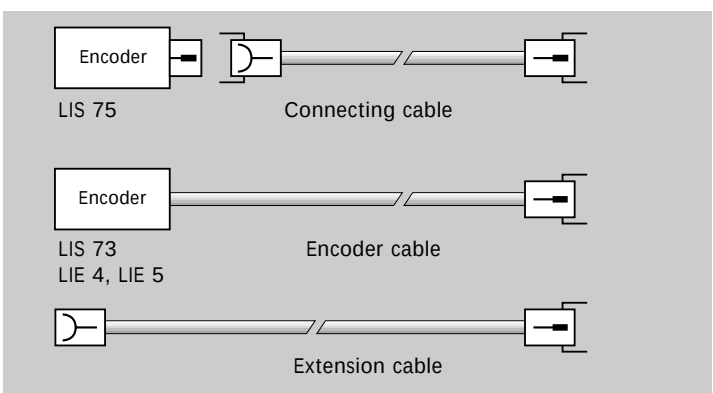
A **coupling** has a fixed locking element (outside thread).

A **flange socket** has a fixed locking element and is mounted directly on the encoder or on the housing of the subsequent electronics.

Cables

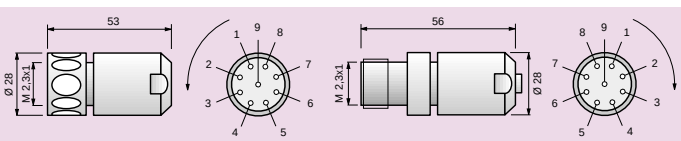
Cable type	Cable diameter	Bending radius in mm		
	[mm]	Rigid configuration	Occasional flexing	Frequent flexing
Encoder cable	5.3	11	26	50
Connecting cable	8	40	-	100
Extension cable	8	40	-	100

Cable lengths			
Output signal	**Encoder cable**		**Total cable length**
1V sinusoidal	Up to 3 m	(*1m with*	100 m
11 µA sinusoidal	Up to 3 m	*electronics in*	18 m
RS422 square-wave	Up to 3 m	*connector)*	100 m



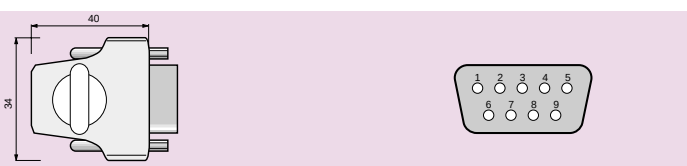
Connecting elements; pin layout

Current interface 11µA$_{PP}$
9-pin connector
9-pin coupling (male)



Pin	1	2	3	4	5	6	7	8	9	Housing
Signal	I_{1+}	I_{1-}	5 V	0 V	I_{2+}	I_{2-}	I_{0+}	I_{0-}	S_c*	External shield
Color	Green	Yellow	Brown	White	Blue	Red	Gray	Pink	White/Brown	–

Current interface 11µA$_{PP}$
9-pin sub-D connector (male)

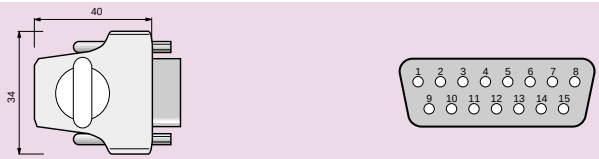


Pin	1	2	3	4	5	6	7	8	9	Housing
Signal	I_{1-}	0 V	I_{2-}	S_c*	I_{0-}	I_{1+}	5 V	I_{2+}	I_{0+}	External shield
Color	Yellow	White	Red	White/Brown	Pink	Green	Brown	Blue	Gray	–

** Internal shield for double-shielded cable*

Current interface 11µA$_{PP}$
15-pin sub-D connector (male)

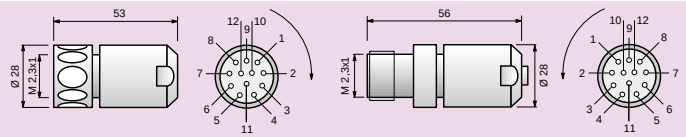
~ *11µA$_{PP}$*



Pin	1	2	3	4	5	6	7	10	12	Housing
Signal	5 V	0 V	I_{1+}	I_{1-}	S_c*	I_{2+}	I_{2-}	I_{0+}	I_{0-}	External shield
Color	Brown	White	Green	Yellow	White/Brown	Blue	Red	Gray	Pink	–

Voltage interface 1V$_{PP}$
12-pin connector
12-pin coupling (male)

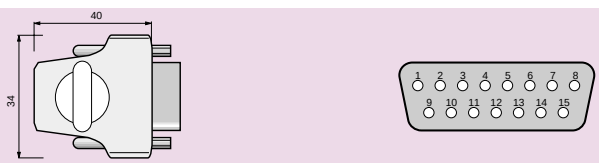
~ *1V$_{PP}$*



Pin	1	2	3	4	5	6	7	8	9	10	11	12	Housing
Signal	U_{2-}	Sensor 5 V	U_{0+}	U_{0-}	U_{1+}	U_{1-}	–	U_{2+}	–	0 V	Sensor 0 V	5 V	External shield
Color	Red	**	Gray	Pink	Green	Yellow	–	Blue	–	White	**	Brown	

Voltage interface 1V$_{PP}$
15-pin sub-D connector (male)
1 and 9 bridged
2 and 11 bridged

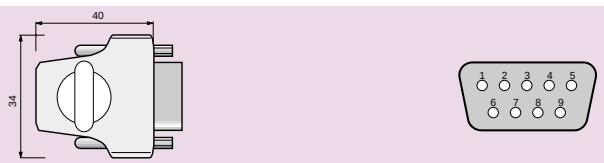
~ *1V$_{PP}$*



Pin	1	2	3	4	6	7	9	10	11	12	Housing
Signal	5 V	0 V	U_{1+}	U_{1-}	U_{2+}	U_{2-}	5 V	U_{0+}	0 V	U_{0-}	External shield
Color	Brown	White	Green	Yellow	Blue	Red	Brown	Gray	White	Pink	–

Voltage interface 1V$_{PP}$
Square-wave interface
9-pin sub-D connector (male)
NAS...negated monitoring signal

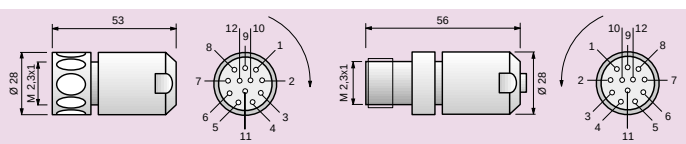
~ *1V$_{PP}$*
⊓ *RS 422*



Pin	1	2	3	4	5	6	7	8	9	Housing
Signal	U_{1-} $\bar{Z}_1$	0 V 0 V	U_{2-} $\bar{Z}_2$	– NAS	U_{0-} $\bar{R}$	U_{1+} Z_1	5 V 5 V	U_{2+} Z_2	U_{0+} R	External shield
Color	Yellow	White	Red	Violet	Pink	Green	Brown	Blue	Gray	–

Square-wave interface
12-pin connector
12-pin coupling (male)

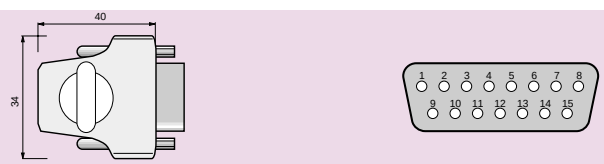
⊓ *RS 422*



Pin	1	2	3	4	5	6	7	8	9	10	11	12	Housing
Signal	$\bar{Z}_2$	Sensor 5 V	R	$\bar{R}$	Z_1	$\bar{Z}_1$	NAS	Z_2		0 V	Sensor 0 V	5 V	Shield
Color	Red	**	Gray	Pink	Green	Yellow	Violet	Blue	–	White	**	Brown	

Square-wave interface
15-pin sub-D connector (male)
AS...monitoring signal
NAS...negated monitoring signal

⊓ *RS 422*



Pin	3	4	5	6	7	8	9	10	11	12	13	14	Housing
Signal	NAS	$\bar{R}$	$\bar{Z}_2$	$\bar{Z}_1$	–	5 V	0 V	–	AS	R	Z_2	Z_1	External shield
Color	Violet	Pink	Red	Yellow	–	Brown	White	–	Black	Gray	Blue	Green	–

* *Internal shield for double-shielded cables*
** *Bridged with pin 12 or 10 (see page 16)*

Accessories for Inspection and Adjustment

FAV guide band application device for exposed linear encoders
This special device can be screwed on in place of the measuring head. It applies the guide bands in the correct position with respect to the measuring head and parallel to the direction of slide motion. The scale tape is then applied in the resulting „slot."

Signal adjustment kit, primarily for exposed linear encoders
The kit consists of a connection box, measuring and adjusting cable, and software on a floppy disk.

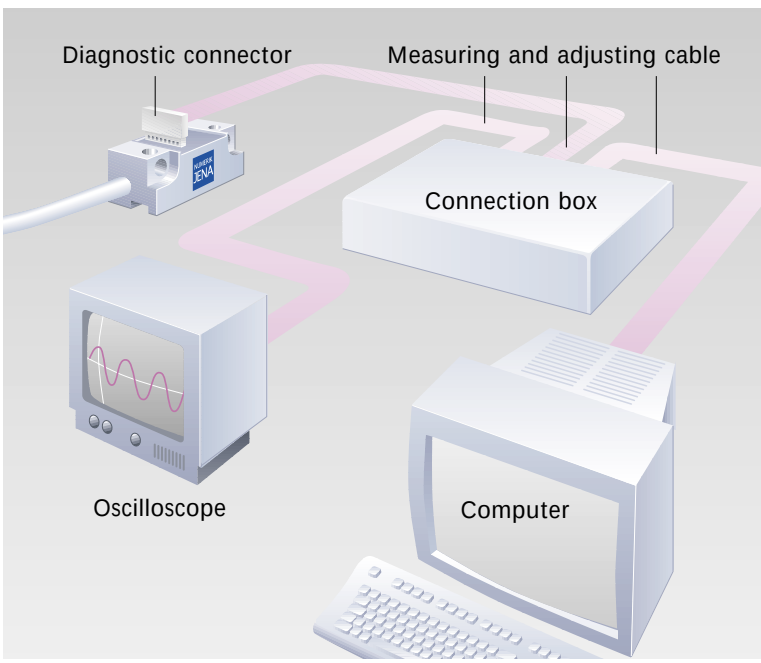
After the encoder has been mounted the encoder signals can be inspected with aid of an oscilloscope (or multimeter) and optimized through the PC by programming the EPIFLEX measuring module. A diagnosis cable is to connect with the diagnosis connector inside the scanning head (after removing the measuring head cover). If the electronics are inside the connector (option) the diagnosis connector will be accessible after opening the connector.

Signal monitor for exposed linear encoders
The signal monitor is an inspection device for inspecting signal quality in order to optimize the mechanical adjustment of the measuring head.

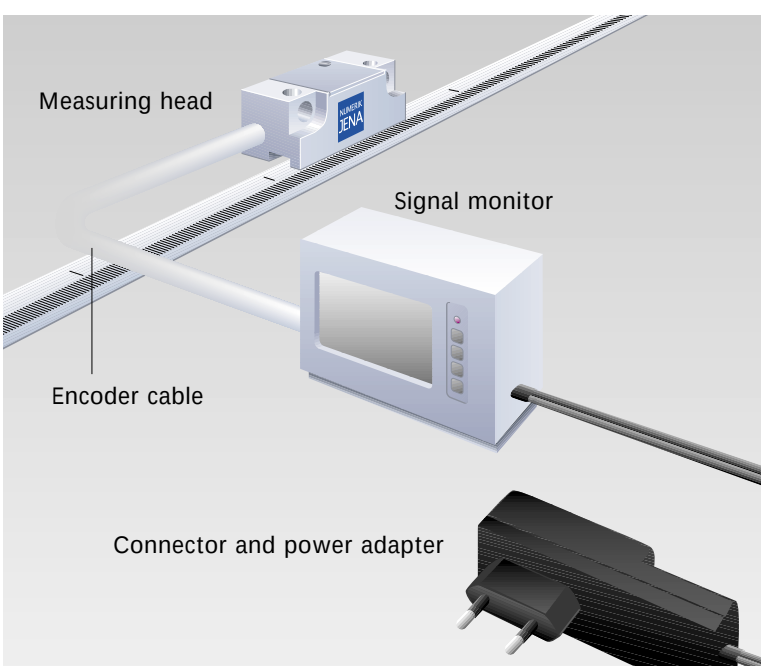
The signal monitor is connected to the encoder cable. It has its own power supply for the encoder, so that the encoder can be tested without connecting it with the control.

It is also possible to use the signal monitor to optimize the output signals of the EPIFLEX measuring module by programming. As when adjusting signals, an additional diagnostic cable is required. A PC or oscilloscope is not needed.

The signal monitor can evaluate the quality of sinusoidal and square-wave signals.



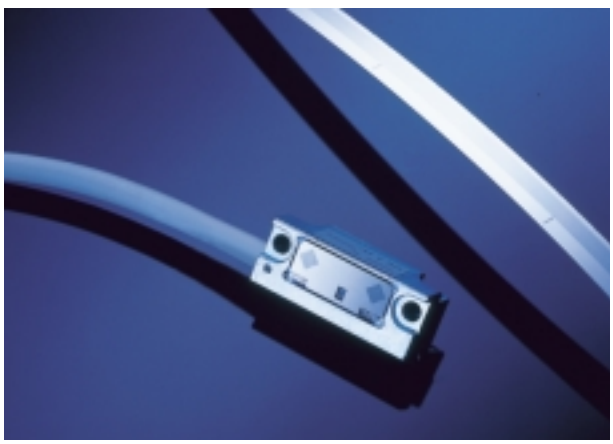
Signal adjustment kit



Signal monitor

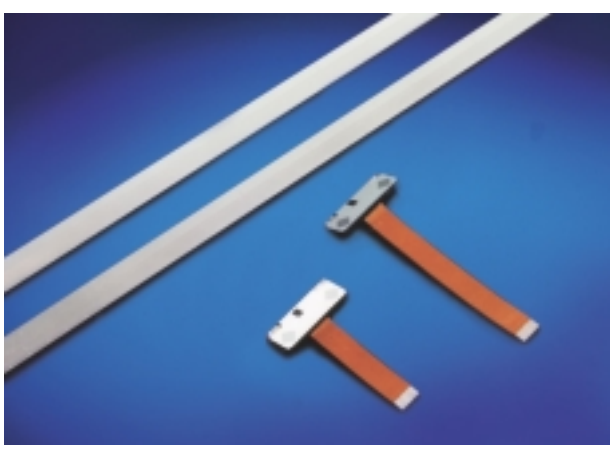
Product Overview

Product dimensions, required mating dimensions, and specifications are available in data sheets for the individual units.



LIE 4, LIE 5 Incremental Exposed Linear Encoders

- Very little space required
- Generous mounting tolerances
- Defined thermal behavior of the DOUBLEFLEX scale tape
- Mechanical decoupling of the DOUBLEFLEX scale tape from the scale carrier
- Up to 50-fold signal interpolation integrated in the measuring head
- High tolerance to contamination thanks to double-field scanning
- High resolution and accuracy
- Simple mounting of the self-adhesive scale tapes



Encoder Kit L

Component set for linear measurement consisting of
– EPIFLEX measuring module with interface PCB
– DOUBLEFLEX scale tape or
– SINGLEFLEX scale tape

- Very small dimensions of the EPIFLEX measuring module
- High resolution and accuracy
- Defined thermal behavior of the DOUBLEFLEX scale tape
- Variable interface, up to 50-fold signal interpolation

LIS 73-1, LIS 73-3, LIS 75-1
Incremental Sealed Linear Encoders

- Little space required
- High resolution and accuracy
- Mechanical decoupling of the DOUBLEFLEX scale tape from the housing
- Integrated interpolation up to 50-fold
- Defined thermal behavior (same as steel or gray cast iron)

Encoder Kit R

Component set for rotational measurement, consisting of:

– EPIFLEX measuring module, optionally with holder
– Interface PCB
– Graduated disk

- Minimal dimensions
- Extremely flat design
- Low mass moment of inertia of the aluminum graduated disks
- Variable signal interface, up to 50-fold signal interpolation

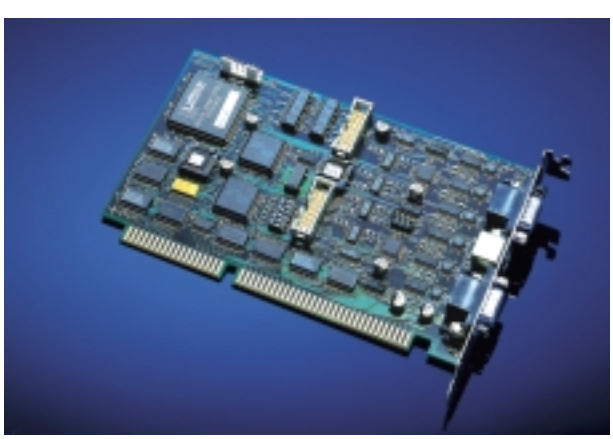
AXOflex Display Unit

Position display unit for two incremental linear encoders on:

- X-Y tables
- Coordinate measuring devices
- Workshop microscopes
- Measuring microscopes

IFK 200 Interface Board for PCs

- Two encoder inputs
- Suitable for IBM AT and compatible computers
- User-friendly operating and evaluation software for Windows
- Up to 200-fold signal interpolation
- Linear and/or angular measurement depending on connected encoders
- Measured value processing (for statistical analysis) and storage



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Linear-D-e 02/00 Subject to change without notice