Technology

An encoder measures the actual machine position without the effect of any mechanical inaccuracies. Machine errors induced due to mechanical inaccuracies are eliminated as the encoder is attached to the machine guide ways and hence provides the actual machine position to the controller. Some of the potential sources of such errors in a machine tool such as lead screw pitch, certain amount of backlash and thermal behavior can be minimized using these encoders.

Enclosed design

The graduated scale in a linear encoder is protected by the enclosed aluminum profile. The highly durable sealing lips protect the encoder from industrial contaminants and liquid splashes as the reader head moves along the profile. The reader head movement in complete synchronization captures and transmits the position and movement of the machine. The reader head moves along the graduated scale on linear bearings minimizing the friction. For enhanced protection against contamination both ends of the encoder and also the reader head can be connected to pressurized air.

Measuring methods

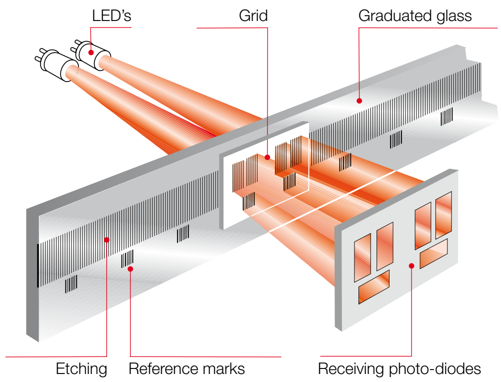
Fagor uses two measuring methods in their incremental encoders:

- **Graduated glass:** Linear encoders with a measuring length of up to 3 040 mm use optical transmission. The light from the LED goes through an engraved glass and a reticule before reaching the receiving photo diodes. The period of the generated electrical signals is the same as the graduation pitch.
- **Graduated steel:** Linear encoders with a measuring length over 3 040 mm use auto imaging principle which uses diffuse light reflected from the graduated steel tape. This optical reading system consists of a LED as a light source, a mesh that creates the image and a monolithic photo detector element in the image plane, which is specially designed and patented by Fagor.

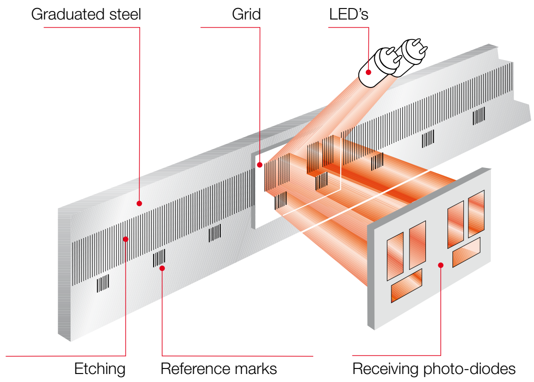
Types of incremental encoders

- **Linear encoder:** Suitable for applications on milling, turning, boring mills, grinding machines for feedrates of up to 120 m/min and vibration levels up to 10 g.
- **Rotary encoder:** Used as measurement device for rotary axis, angular speed and also for linear movements for mechanisms like lead screws etc. They are widely used in machine tools, wood working equipment, robots and material handlers etc.

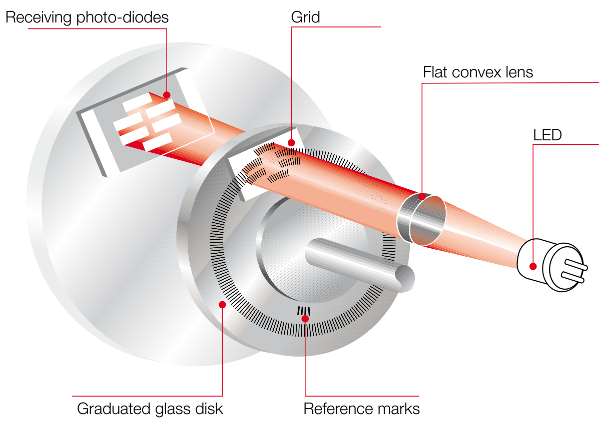
Graduated glass linear encoder

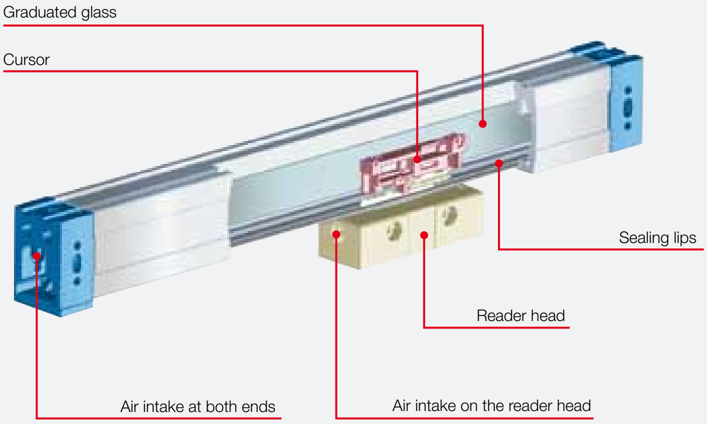


Graduated steel linear encoder

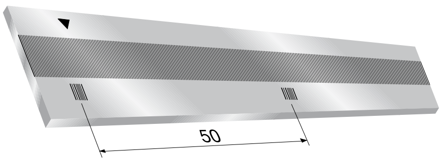


Graduated glass rotary encoder

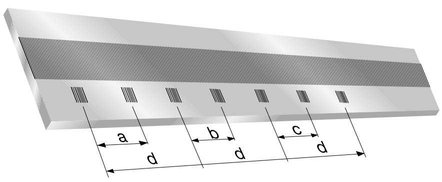




Linear encoder



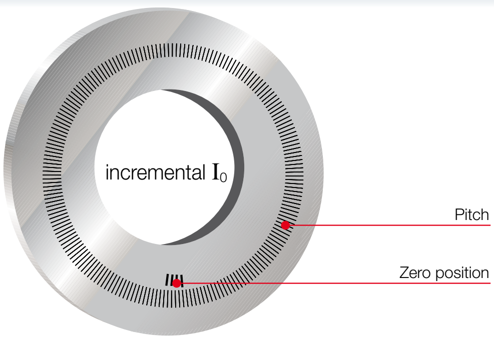
Incremental



Series	Distances			
	a	b	c	d
F	50.1	50.2	50.3	100
C, M	10.02	10.04	10.06	20

Distance-coded

Rotary encoder



Reference signals (I_0)

The reference signal is a specially etched mark along the graduated glass, which when scanned generates a pulse signal. They are used to set/recover the machine zero position and avoid possible errors after powering up the DRO or CNC system.

Fagor provides two different types of reference marks I_0:

- **Incremental:** The reference signal is synchronized with the feedback pulses to ensure perfect measuring repeatability.

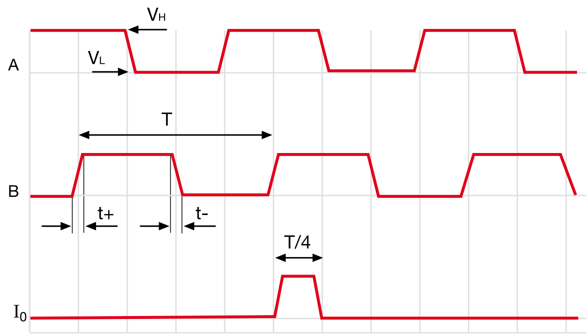
  Linear: One every 50 mm of travel.
  Rotary: One signal per turn.

- **Distance-coded:** Each distance coded reference signal is separated from the next signal a different distance according to predefined mathematical function. The actual position value after power up is restored by moving through two consecutive reference signals. This is very useful for long travel axes as the movement needed to recover actual position is minimum.

Electrical output signals

Differential TTL

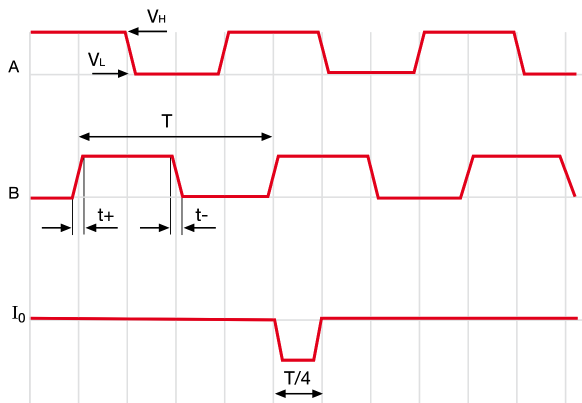
These are complementary signals in compliance with the EIA standard RS-422. This characteristic together with a line termination of 120 Ω, twisted pair, and an overall shield provide greater immunity to electromagnetic noise caused by the surrounding environment.



Characteristics

Signals	A, /A, B, /B, I_0, / I_0
Signal level	$V_H \geq$ 2.5V I_H= 20 mA $V_L \leq$ 0.5V I_L= 20 mA With 1 m cable
90º reference signal (I_0)	Synchronized with A and B
Switching time	t+/t-< 30ns With 1 m cable
T period	according to model
Max. cable length	50 meters
Load impedance	Z_o= 120 Ω between differential

No differential TTL



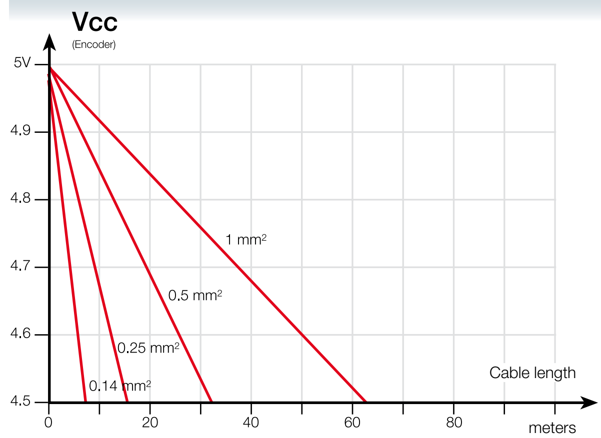
Characteristics

Signals	A, B, /I_0
Signal level A, B, I_0	$V_H \geq$ 3.5 V I_H = 4 mA $V_L \leq$ 0.4 V I_L = 4 mA with 1 m cable
90º reference signal (I_0)	Synchronized with A and B
Switching time	t+/t-< 30ns with 1 m cable
T period	according to model
Max. cable length	20 meters

Voltage drop across cable

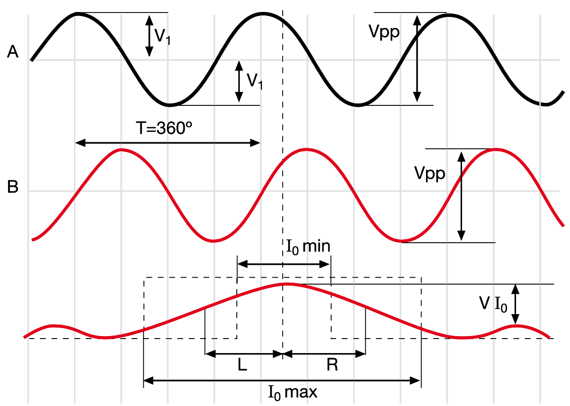
The voltage requirements for a TTL encoder are 5V ±5%.
A simple formula described below, may be used to calculate the maximum cable length depending on the cross section diameter of the supply cable:

$$L_{max} = (V_{CC}-4{,}5) * 500 / (Z_{CABLE/Km} * I_{MAX})$$



Example

V_{CC} = 5V, IMAX	=	0.2 Amp (with 120 Ω load)	
Z (1 mm²)	=	16.6 Ω/Km	**(L_{max}= 75 m)**
Z (0.5 mm²)	=	32 Ω/Km	**(L_{max}= 39 m)**
Z (0.25 mm²)	=	66 Ω/Km	**(L_{max}= 19 m)**
Z (0.14 mm²)	=	132 Ω/Km	**(L_{max}= 9 m)**

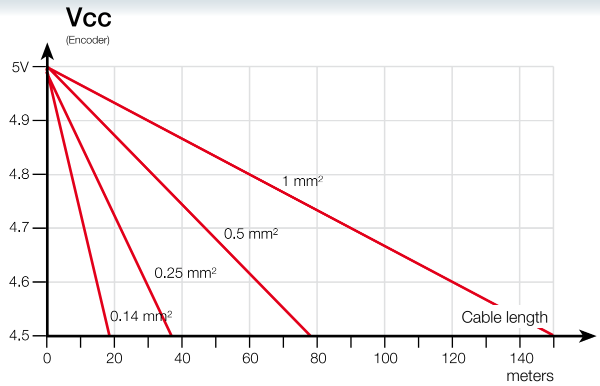


Differential 1 Vpp

They are complementary sinusoidal signals whose differential value is 1 Vpp centered on $V_{CC/2}$. This characteristic together with a line termination of 120 Ω, twisted pair, and an overall shield provide greater immunity against electromagnetic noise caused by their surrounding environment.

Characteristics

Signals	A, /A, B, /B, I_0, / I_0
V_{App}	1 V +20%, -40%
V_{Bpp}	1 V +20%, -40%
DC offset	2.5 V ± 0.5 V
Signal period	according to model
Max. cable length	150 meters
A, B centered: $\lvert V_1 - V_2 \rvert$ / 2 V_{pp}	≤ 0.065
A&B relationship V_{App} / V_{Bpp}	0.8 ÷ 1.25
A&B phase shift:	90° ± 10°
I_0 amplitude: V_{I_0}	0.2 ÷ 0.8 V
I_0 width: L + R	I_0_min: 180°
	I_0_typ: 360°
	I_0_max: 540°
I_0 synchronism: L, R	180° ± 90°



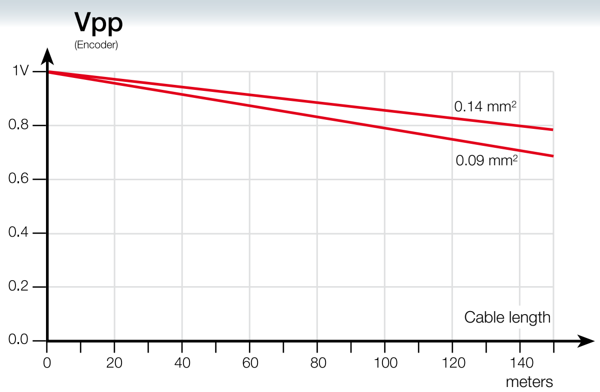
Voltage drop across cable

The voltage requirements for a 1 Vpp encoder are 5V ±10%. A simple formula may be used to calculate the maximum cable length depending on the cross section diameter of the supply cables.

L_{max} = (V_{CC}-4,5)* 500 / ($Z_{CABLE/Km}$* I_{MAX})

Example

V_{CC}	=	5V, IMAX= 0.1 Amp	
Z (1 mm²)	=	16.6 Ω/Km	**(L_{max}= 150 m)**
Z (0.5 mm²)	=	32 Ω/Km	**(L_{max}= 78 m)**
Z (0.25 mm²)	=	66 Ω/Km	**(L_{max}= 37 m)**
Z (0.14 mm²)	=	132 Ω/ Km	**(L_{max}= 18 m)**



1 Vpp signal damping due to the cable section

Besides attenuation due to signal frequency, there is another signal attenuation caused by the section of the cable connected to the encoder.