Technology

The incremental encoders provide direct measure of machine position without using any intermediate device. The positioning errors originating from machine mechanics are minimized as the encoder is directly mounted to the machine surface and the guide ways. The encoder sends the real machine movement data to the CNC and mechanical errors caused due to thermal behavior of the machine, pitch error compensation and backlash etc. are minimized.

Measuring Methods

Fagor Automation uses two measuring methods in their incremental encoders:

- **Graduated glass:** Linear encoders with a measuring length of up to 3040 mm use optical transmission. The light from the LED goes through a graduated 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 over 3040 mm measuring length use graduated steel tape and image captured through diffused light as a measuring principle. The reading system consists of an LED as a light source, a mesh to make the image and a monolithic photo detector element in the plane of the image specially designed and patented by Fagor Automation.

Types of incremental encoders

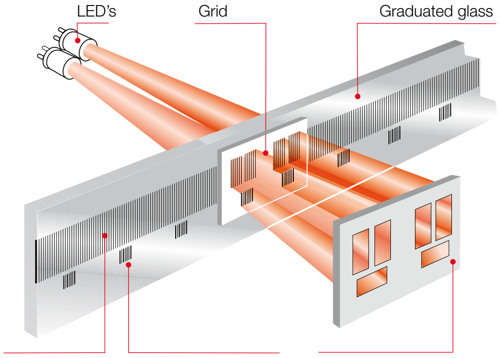
- **Linear encoder:** Ideal for milling, grinding, lathe and boring mill applications requiring federates of up to 120 m/min and vibrations of up to 20 g.
- **Angular encoder:** Used as an angular movement sensor on machines/devices requiring high resolution and accuracy. Fagor Angular encoders offer from 18000 to 360000 pulses/turn and accuracy levels of ± 5”, ± 2.5” and ± 2” depending on the model.
- **Rotary encoder:** Used as a measuring sensor for rotary movements, angular speeds and also linear movement when connected to a mechanical device like ball screw. They are also used on various types of machine tools and robotic applications.

Enclosed design

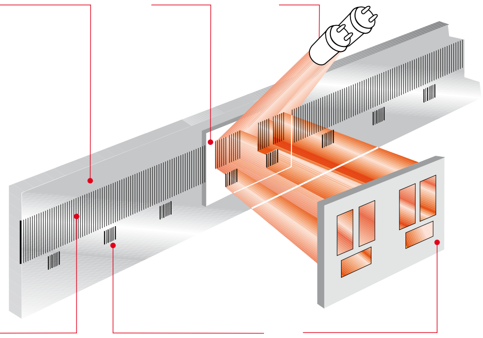
The robust aluminum profile encasing the graduated glass provides the primary protection. The sealing lips provides protection against contaminants and liquids as the reader head travels along the profile. The reader head movement along the graduated glass provides a perfectly balanced system accurately capturing the machine movement. The reader heard travels on precision bearings with minimum contact with the profile hence minimizing the friction.

The optional air inlet at both ends of the encoder and at the reader head provides increased protection levels against contaminants and liquids.

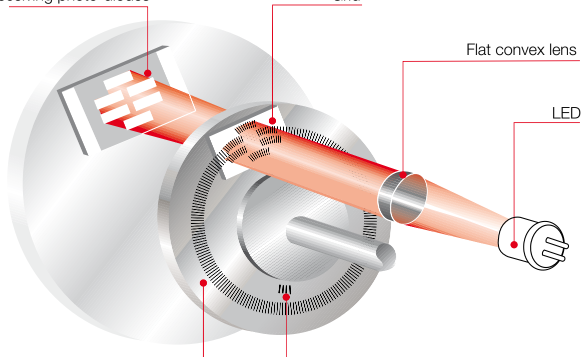
Graduated glass encoder

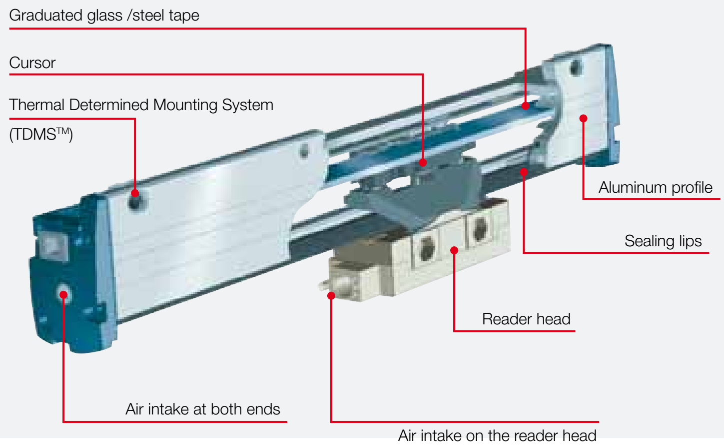


Graduated steel encoder



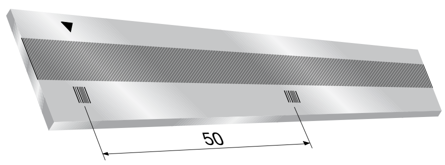
Graduated glass disk



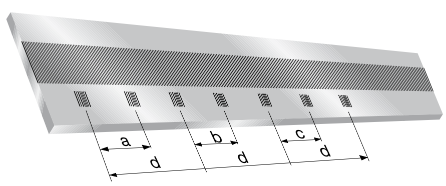


Linear encoder

Incremental

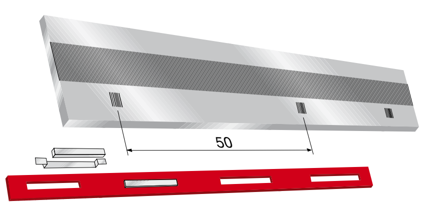


Distance-coded



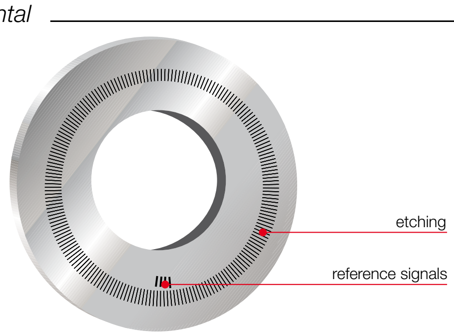
Series	Distances			
	a	b	c	d
L	40.04	40.08	40.12	80
G and S	10.02	10.04	10.06	20

Selectable

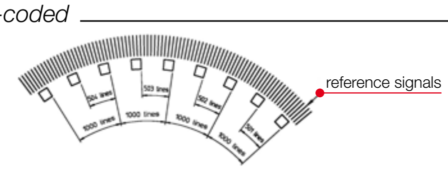


Angular encoder

Incremental



Distance-coded



Reference signals (I_0)

It is a reference signal etched on a graduation and when scanned by the measuring system generates a pulse. Reference marks are used to validate and restore the machine zero position specially after turning on the machine power.

Fagor Automation encoders have three types of reference marks I_0:

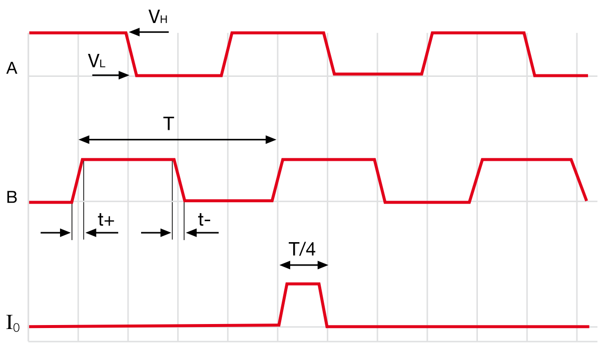
- **Incremental:** The reference signal obtained is synchronized with the feedback signals to ensure perfect measuring repeatability.
  Linear: One every 50 mm of travel.
  Angular and rotary: One signal per turn
- **Distance-coded:** Both on linear and angular encoders each distance coded reference signal is graduated in a non linear way based on the predefined mathematical function. The machine position value can be restored by moving through two consecutive reference signals. The machine movement needed to know the real position is always very small and this is a very useful feature for large travel machines.
- **Selectable:** With selectable linear encoders the customer can select one or more reference points and ignore the rest by simply inserting a magnet at the selected point or points.

Series	Nr. of lines	Nr. of references	Angle
H-D90	18 000	36	20º
S-D90			
S-D170			
H-D200			
H-D200	36 000	72	10º

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 their environment.



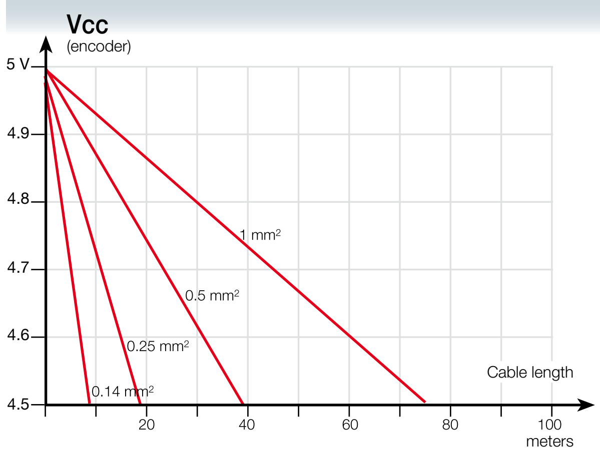
Characteristics

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-< 30 ns With 1 m cable
Supply voltage and consumption	5 V ± 5%, 100 mA
T period	4, 2, 0.4, 0.2 µm
Max. cable length	50 meters
Load impedance	Zo= 120 Ω between differential

Voltage drop across cable

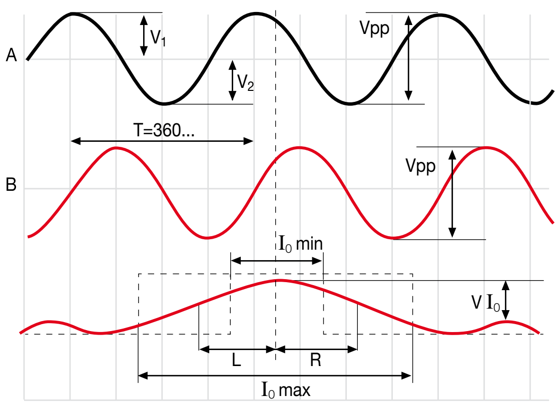
The voltage required for a TTL encoder must be 5V ± 5%. A simple formula may be used to calculate the maximum cable length depending on the section of the supply cables.

L_{max} = (V_{CC}-4.5)* 500 / ($Z_{CABLE/Km}$* I_{MAX})



Example

Vcc = 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)**

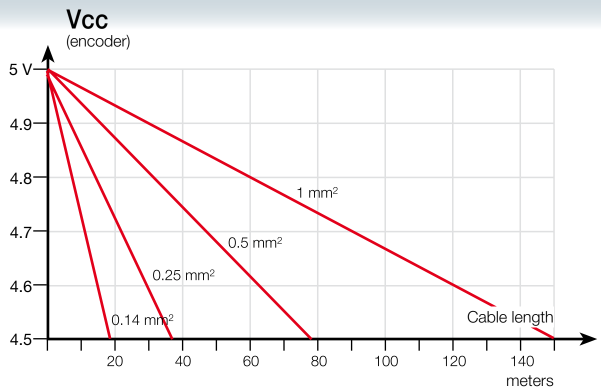


Differential 1 Vpp

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 to electromagnetic noise caused by their 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	20 µm, 40 µm
Supply V	5 V ± 10%
Max. cable length	150 meters
A, B centered: $\|V_1-V_2\|$ / 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: VI_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°



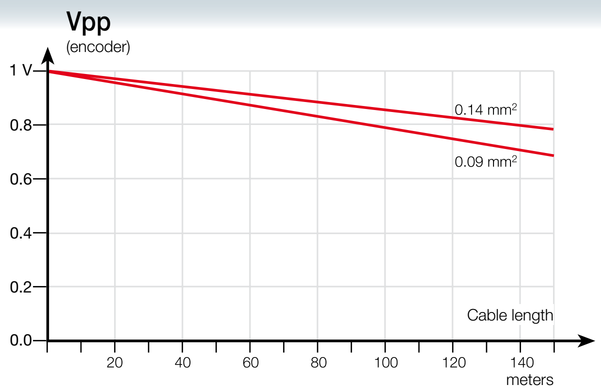
Voltage drop across cable

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

$L_{max} = (V_{CC}-4.5) * 500 / (Z_{CABLE/Km} * I_{MAX})$

Example

Vcc	=	5V, IMAX= 0.1Amp	
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.

I