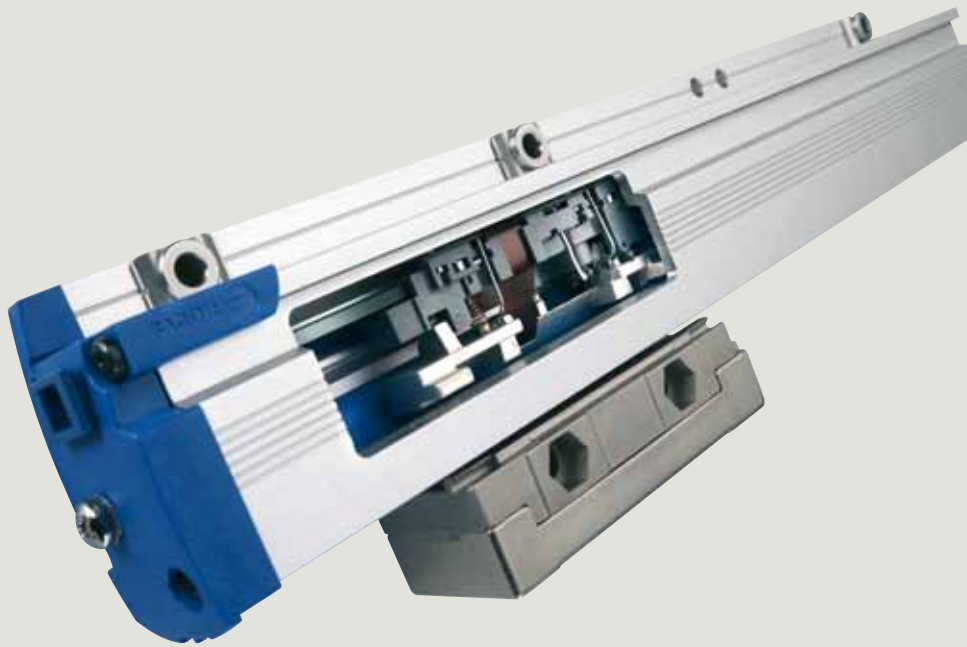


# Linear, angular and rotary encoders

Over 30 years of continuous evolution





Fagor Automation has been manufacturing high quality linear and rotary encoders using precision optical technology for more than 30 years.

Over the years Fagor has created, developed and patented systems, components and technologies that allow us to offer best quality and features over the complete range of product utilizing innovative production methods.

Hence making Fagor Automation the most efficient alternative in the world of feedback systems.

## Modern facilities and innovative processes

In order to ensure quality and reliability in all its products Fagor Automation utilizes the most advanced technology and testing and manufacturing facilities. From centralized computer control temperature monitoring, cleanliness and relative humidity control, a must for the feedback system manufacturing process, to laboratories for climate, vibration and EMC testing to certify the designs.

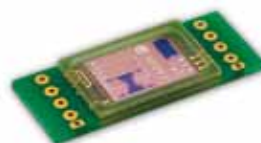


## With state-of-the-art technology

Fagor Automation's commitment to this technology and quality is evident by creation of **Aotek** in 2002, a dedicated research center providing various technological breakthroughs. This investment has resulted in large number of patents and customized solutions in electrical, optical and mechanical fields.



Steel-tape tensioner



Fringe scanning



# Superior technology and innovative design

Fagor Automation develops with maximum professionalism the three cornerstones in encoder design: optical design, electronic design and mechanical design that result in a state-of-the-art product.

## Optical design

Leader in measurement technologies, Fagor Automation uses transmissive and reflective optics in its range of encoders.

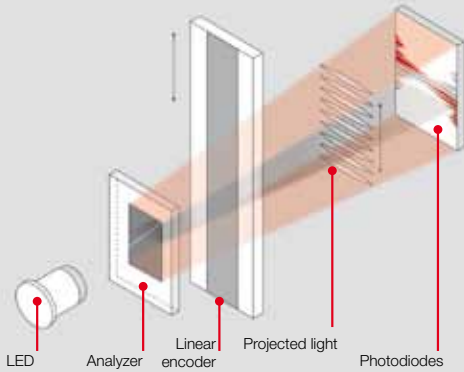
With new scanning techniques such as single field and three-phase scanning that provide high quality signals that minimize interpolation errors.

## Electronic design

Fagor Automation uses latest generation integrated electronic components in their design hence achieving accurate signal optimization at high speeds and nano resolution.

## Mechanical design

Fagor Automation designs and manufactures the most innovative and reliable measuring systems using its advanced mechanical designs. These designs using titanium and stainless steel materials provide the encoders with optimum robustness ensuring best performance in machine tool applications.



# Thermal performance

When designing the encoders Fagor Automation has taken into account the effect of temperature change on their performance.

Most machine shops do not operate in temperature controlled environment hence affecting the accuracy of finished part. Using the TDMS™ system, **Thermal Determined Mounting System** which controls expansion/contraction, Fagor linear encoders can deliver consistent accuracy and repeatability.

For linear encoders more than three meters long, Fagor guarantees a thermal behavior identical to that of the machine surface it is mounted on thanks to the special mounting system at the end of the linear encoders.



The TDMS™ system is only available on G and SV series linear encoders.

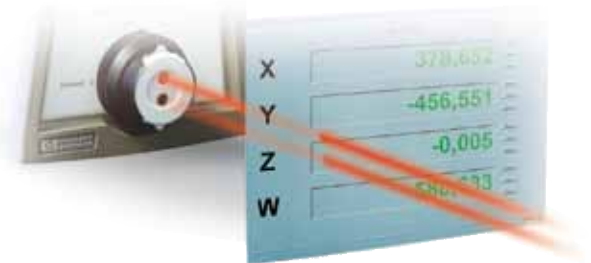
## Quality

### Accuracy certificate

Every single Fagor encoder is subjected to an extensive final accuracy check. This control is carried out on a computerized measuring bench equipped with a laser interferometer located inside a climate controlled chamber at 20 °C. The resulting final accuracy graph is supplied with every Fagor encoder.

**The quality of the measurement is mainly determined by:**

- Etching quality
- The quality of the scanning process
- The quality of the electronics that processes the signals







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# Technology

**The absolute measurement system is a direct digital measure of machine position. It is fast, accurate and does not require homing of the machine. The position value is available from the moment the machine is turned on and may be requested by the connected device (CNC) at any time.**

The absolute 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.

## Linear encoders

Fagor Automation uses two measuring methods in their absolute linear 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 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 with a measuring length over 3040 mm use the autoimage principle by means of diffuse light reflected on the graduated steel tape. The reading system consists of one LED, as the light source of the linear encoder; a mesh that makes the image and a monolithic photo detector element in the plane of the image specially designed and patented by Fagor Automation.

Both measuring methods have two different etchings:

- Incremental graduation:** Used to generate incremental signals that are counted inside the reader head. The incremental graduation also provides the 1 Vpp analog signals except in systems that only use digital signals.
- Absolute graduation:** It is a unique binary code which is imprinted along the measuring length of encoder.

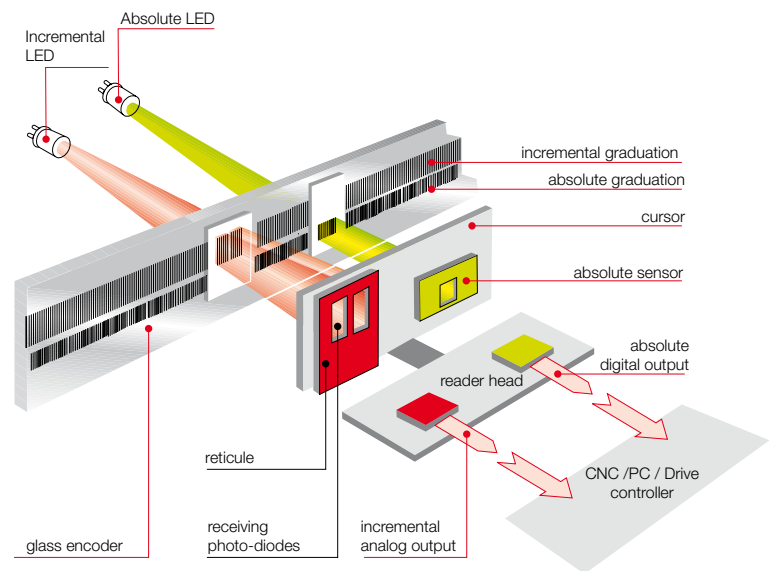
Fagor encoders calculate the absolute position by reading the unique binary code using a high precision optical sensor.

## Enclosed design

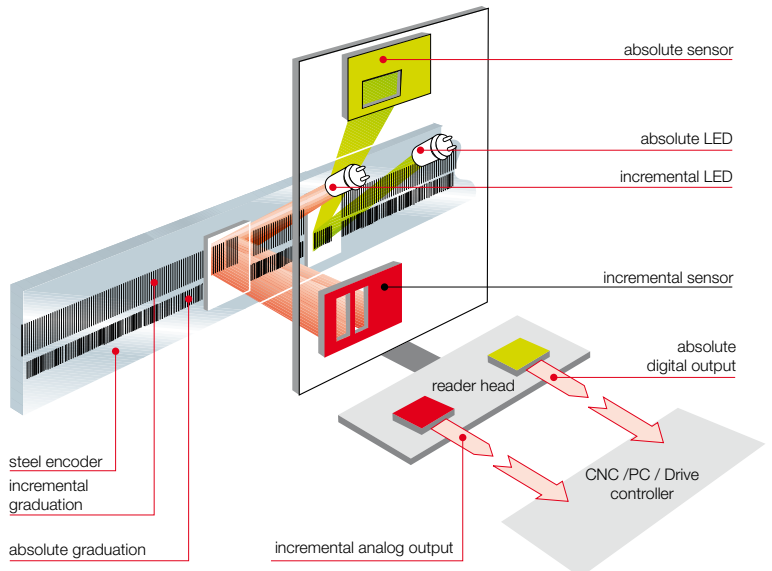
The robust aluminum profile encasing the graduated glass provides the primary protection. The sealing lips provides protection against contaminants and liquids as the reader head travels along the profile. The reader head movement along the graduated glass provides a perfectly balanced system accurately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

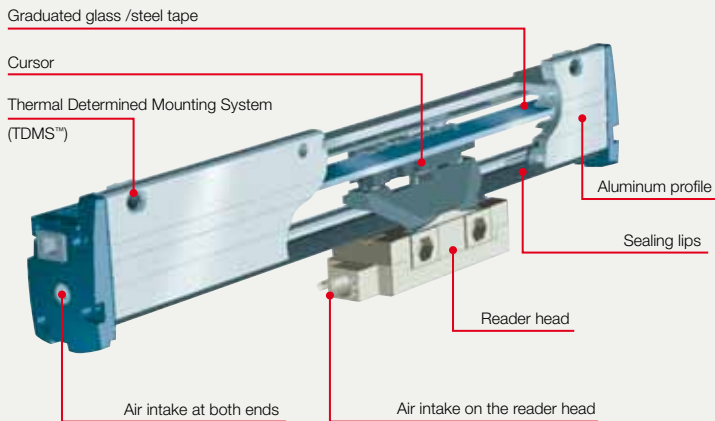
The optional air inlet at both ends of the encoder and at the reader head provides increased protection levels against contaminants and liquids.

Graduated glass encoder

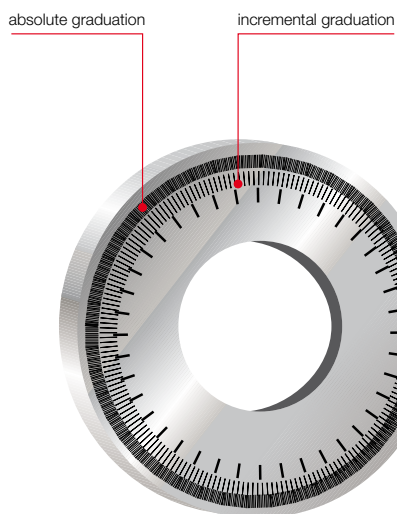
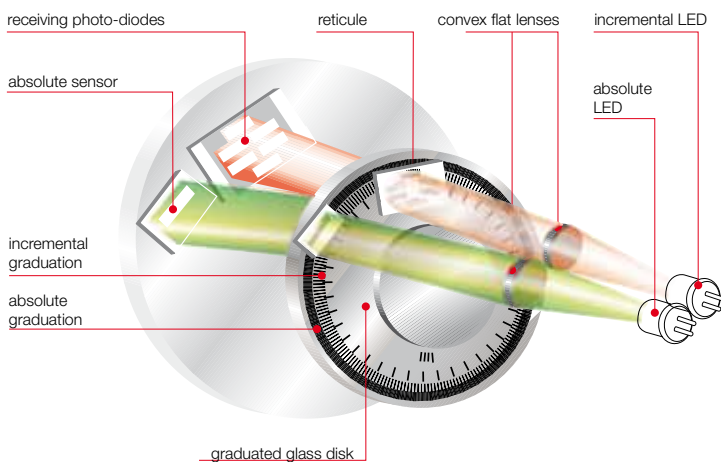


Graduated steel encoder





### Graduated glass disk



## Angular and rotary encoders

Angular encoders are used as angular movement sensors on machines that require high resolution and high accuracy.

Fagor angular encoders reach 23 and 27-bit angular resolution equivalent to 8 388 608 and 134 217 728 positions respectively and accuracy levels of  $\pm 5''$ ,  $\pm 2.5''$ ,  $\pm 2''$  and  $\pm 1''$  depending on the model. In them, the graduated disk of the measuring system is attached directly to the shaft. They have bearings and couplings that serve as guide and adjustment.

Couplings, besides minimizing the static and dynamic deviations, compensate for axial movements of the shaft providing easier mounting, smaller size and the possibility of hollow shafts.

Fagor Automation uses the **graduated glass** measuring method in their absolute angular and rotary encoders.

The measurement is based on the pitch determined by the number of pulses/turn. Like graduated glass linear encoders, they are based on optical transmission.

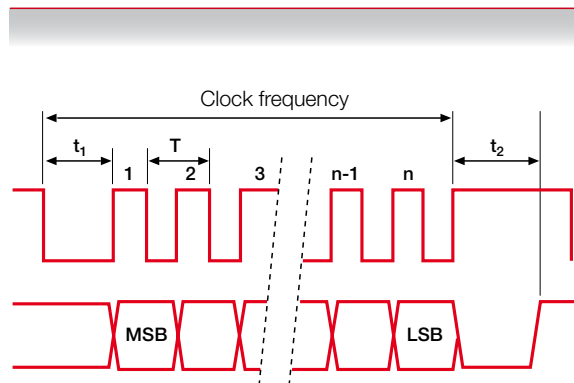
This measuring method has two different graduations: An **incremental** one and an **absolute** one, like linear encoders as described in the previous page.



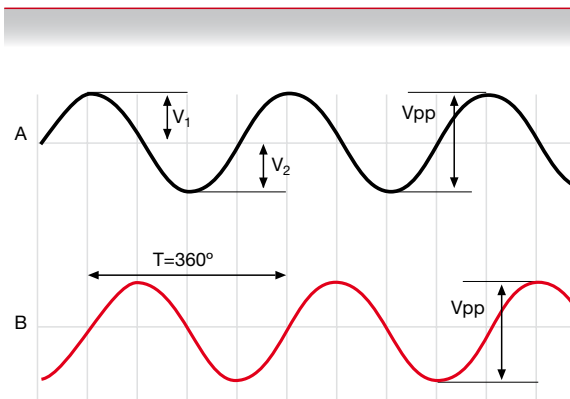
# Electrical output signals

They are defined according to the communication protocol. Protocols are specific communication languages used by linear or angular encoders to communicate with the machine controller (CNC, drive, PLC, etc.). There are different communication protocols depending on the CNC manufacturer. Fagor Automation offers absolute encoders with different communication protocols compatible with the main CNC manufacturers on the market such as FAGOR, FANUC®, SIEMENS®, MITSUBISHI®, PANASONIC® and others.

## absolute



## 1 Vpp differential



### FAGOR systems

They may be connected to Fagor systems via:

#### 1. Serial Synchronous Interface - SSI

These systems synchronize the SSI interface with the sinusoidal 1 Vpp signals. Once the absolute position has been obtained through the SSI interface, the encoders keep operating with incremental 1 Vpp signals.

#### ABSOLUTE signals

Transmission	SSI synchronous serial transfer via RS 485
Levels	EIA RS 485
Clock frequency	100 kHz - 500 kHz
Max. bit (n)	32
T	1 $\mu$ s + 10 $\mu$ s
$t_1$	> 1 $\mu$ s
$t_2$	20 $\mu$ s - 35 $\mu$ s
SSI	Binary
Parity	No

#### 1 Vpp DIFFERENTIAL signals

Signals	A, /A, B, /B
$V_{App}$	1 V +20%, -40%
$V_{Bpp}$	1 V +20%, -40%
DC offset	2.5 V $\pm$ 0.5 V
Signal period	20, 40 $\mu$ m
Supply V	5 V $\pm$ 10%
Max. cable length	100 meters
A, B centered: $ V_1 - V_2  / 2 V_{pp}$	< 0.065
A&B relationship $V_{App} / V_{Bpp}$	0.8 $\div$ 1.25
A&B phase shift	90 $\pm$ 10°

#### 2. Fagor FeeDat Serial Interface

These systems only use digital signals. The absolute encoder is connected via the SERCOS board. A high communication speed of 10 MHz provides a loop time of 10 microseconds. Communication also includes alarms, analog signal values and other encoder parameters. Fagor FeeDat is an open communication protocol that is also used to communicate with other CNC system manufacturers.

SERCOS counter board



## SIEMENS® systems

They may be connected to Siemens® systems via:

### 1. Serial Synchronous Interface - SSI

These systems synchronize the SSI interface with sinusoidal 1 Vpp signals. Once the absolute position has been obtained through the SSI interface, the encoders keep operating with incremental 1 Vpp signals. These encoders are only valid to connect to SME 25 or SMC 20 modules of the Solution Line family.

#### ABSOLUTE signals

Transmission	SSI synchronous serial transfer via RS 485
Levels	EIA RS 485
Clock frequency	100 kHz - 500 kHz
Max. bit (n)	28
$T$	1 $\mu$ s + 10 $\mu$ s
$t_1$	> 1 $\mu$ s
$t_2$	20 $\mu$ s - 35 $\mu$ s
SSI	Gray
Parity	Yes

### 2. DRIVE-CLiQ® Interface

These systems only use digital signals.

The absolute encoder is connected through a cable having the electronics integrated into the connector and it is connected to the "Solution Line" family without the need for intermediate modules.

## Sistemas FANUC® Serial Interface for position feedback encoder

These systems only use digital signals. The absolute encoder is connected through the SDU (Separate Detector Unit) device and is valid for communication protocol versions FANUC® 01 and 02 serial interface.

## MITSUBISHI® systems High Speed Serial Interface - HSSI

These systems only use digital signals. The absolute encoder is connected through the MDS Series drive and it is valid for MITSUBISHI® communication protocol versions Mit 03-2/4.

#### 1 Vpp DIFFERENTIAL signals

Signals	A, /A, B, /B
$V_{App}$	1 V +20%, -40%
$V_{Bpp}$	1 V +20%, -40%
DC offset	2.5 V $\pm$ 0.5 V
Signal period	20, 40 $\mu$ m
Supply V	5 V $\pm$ 10%
Max. cable length	100 meters
A, B centered: $ V_1 - V_2  / 2 V_{pp}$	< 0.065
A&B relationship $V_{App} / V_{Bpp}$	0.8 $\div$ 1.25
A&B phase shift	90° $\pm$ 10°

## PANASONIC® systems Serial Communication

These systems only use digital signals. The absolute encoder is connected through the MINAS series drive.

As an example, here is the photo and characteristics of the Panasonic® MINAS A5L drive.

These systems use Analogue / Pulse signals.

- Systems can be connected to linear motors, shaft motors, DD motors
- Automatic drive/motor matching software available
- Vibration, resonance suppression filters available with setting done automatically / manually
- Drive range from 50 W to 15 kW at AC 100 V / 200 V / 400 V
- Safety Torque Off feature available



PANASONIC® A5L systems