FAGOR

FAGOR AUTOMATION

Linear and angular encoders

standard series

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

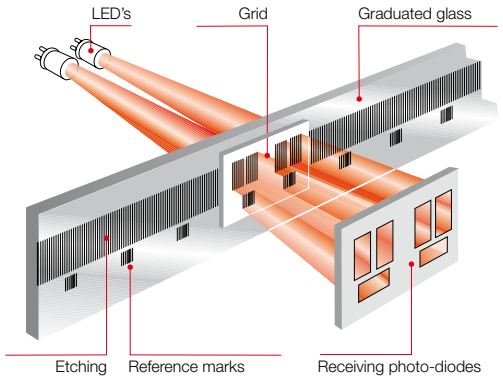
Fagor uses two measuring methods in their incremental encoders:

- **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.

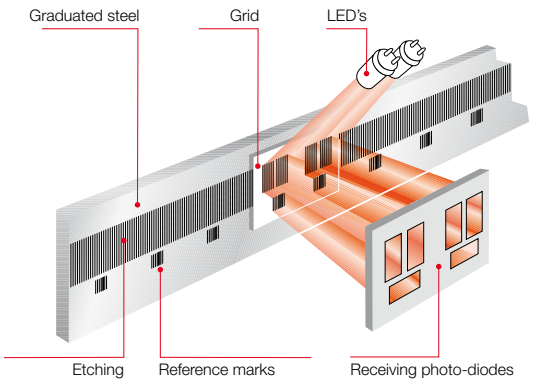
Types of incremental encoders

- **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.

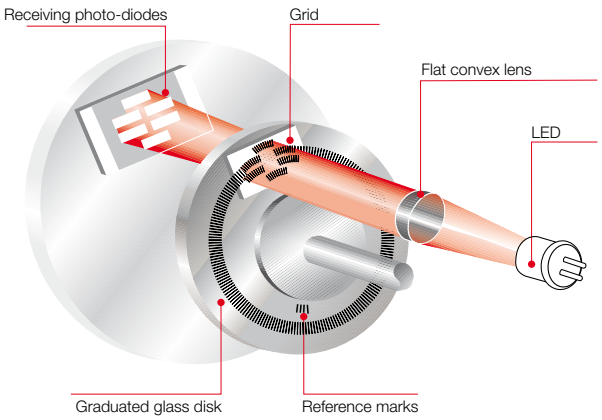
Graduated glass linear encoder

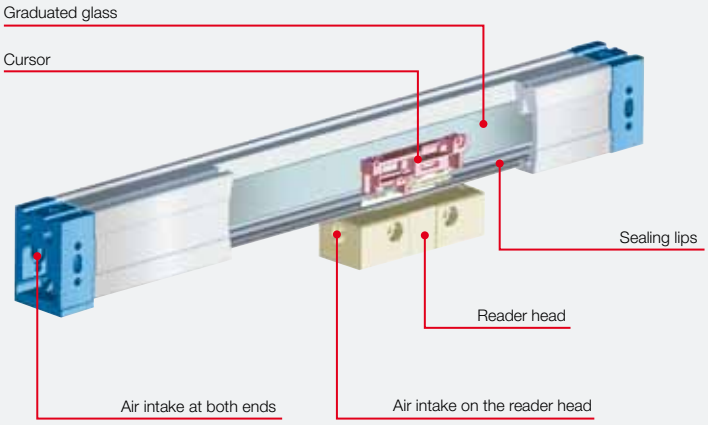


Graduated steel linear encoder

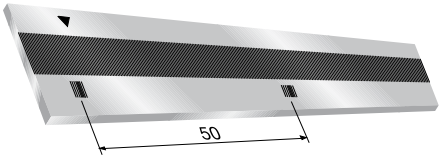


Graduated glass rotary encoder

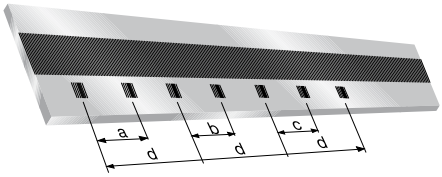




Linear encoder



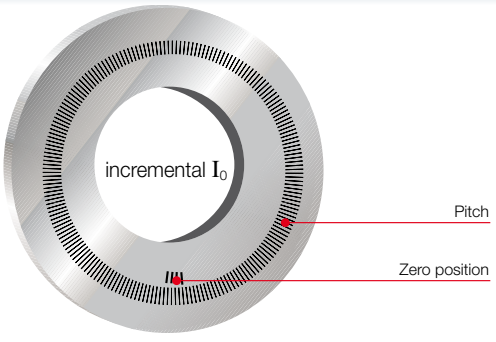
Incremental



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.

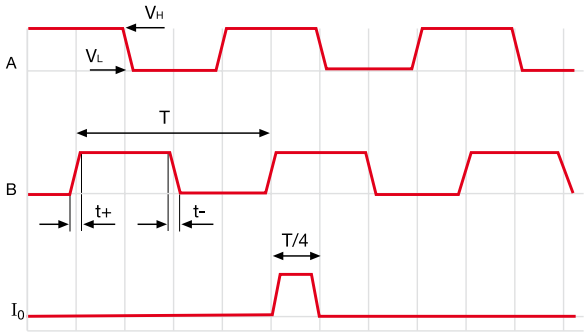
  Linear: One every 50 mm of travel.
  Rotary: One signal per turn.

- **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

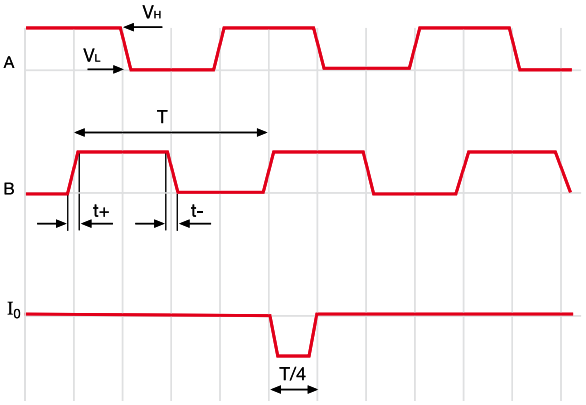
These are complementary signals in compliance with the EIA standard RS-422. This characteristic together with a line termination of 120 Ω, twisted pair, and an overall shield provide greater immunity to electromagnetic noise caused by the surrounding environment.



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
90° 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	$Z_o = 120\ \Omega$ between differential

No differential TTL



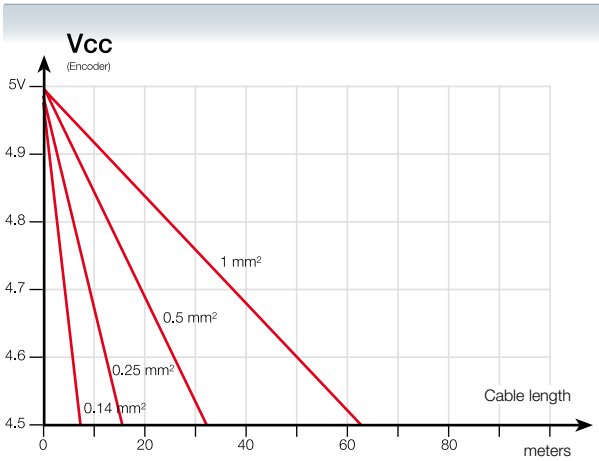
Characteristics

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
90° 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

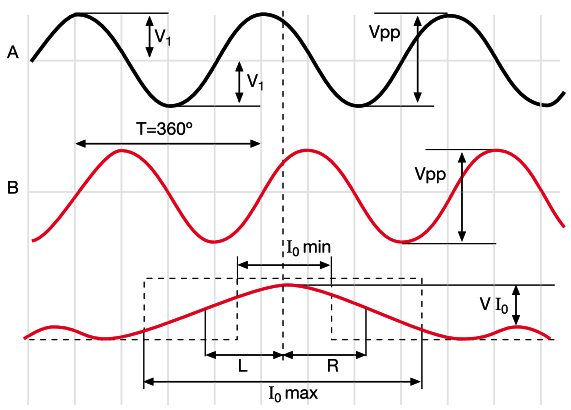
The voltage requirements for a TTL encoder are 5V ±5%. A simple formula described below, may be used to calculate the maximum cable length depending on the cross section diameter of the supply cable:

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



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)**

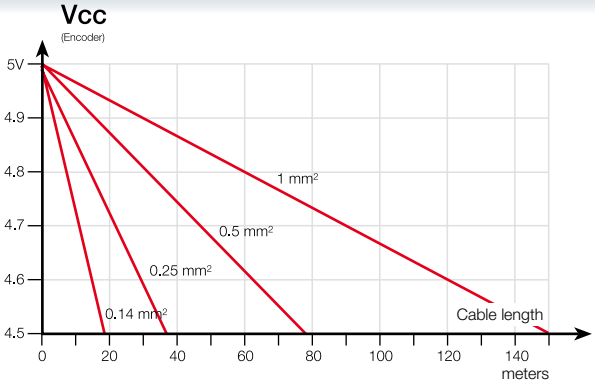


Differential 1 Vpp

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: $\|V_1-V_2\| / 2\ V_{pp}$	≤ 0.065
A&B relationship V_{App} / V_{Bpp}	0.8 ÷ 1.25
A&B phase shift:	90° ± 10°
I_0 amplitude: V_{I0}	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°



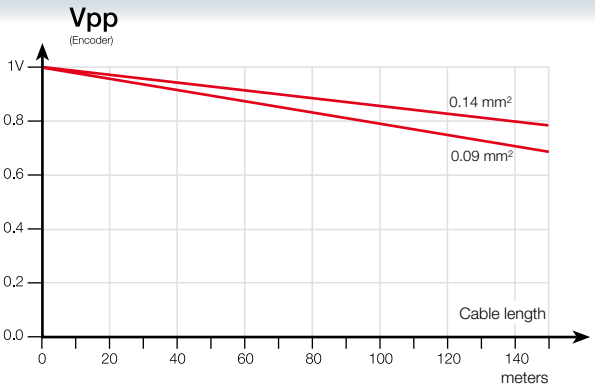
Voltage drop across cable

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.

F series

LINEAR

General specification

Measurement	By means of stainless steel linear encoder with 100 µm etching pitch
Steel tape accuracy	± 5 µm
Maximum speed	120 m/min.
Maximum vibration	10 g
Moving thrust	< 5 N
Operating temperature	0 ºC...50 ºC
Storage temperature	-20 ºC...70 ºC
Weight	1.50 kg + 4 kg/m
Relative humidity	20...80%
Protection	IP 53 (standard) IP 64 (DIN 40050) using pressurized air in linear encoders at 0.8 ± 0.2 bar
Reader head	With detachable cable connector

Especially designed for machines with longer travels and they are available up to 30 m in length. In the incremental model the reference marks are 50 mm apart and distance coded model is also available. Both models come with a detachable cable connectors in the reader head. The steel tape graduation pitch is 100 µm. For measuring lengths over 4040 mm the encoder is supplied in multiple sections and is assembled together at the time of installation.

Measuring lengths in millimeters

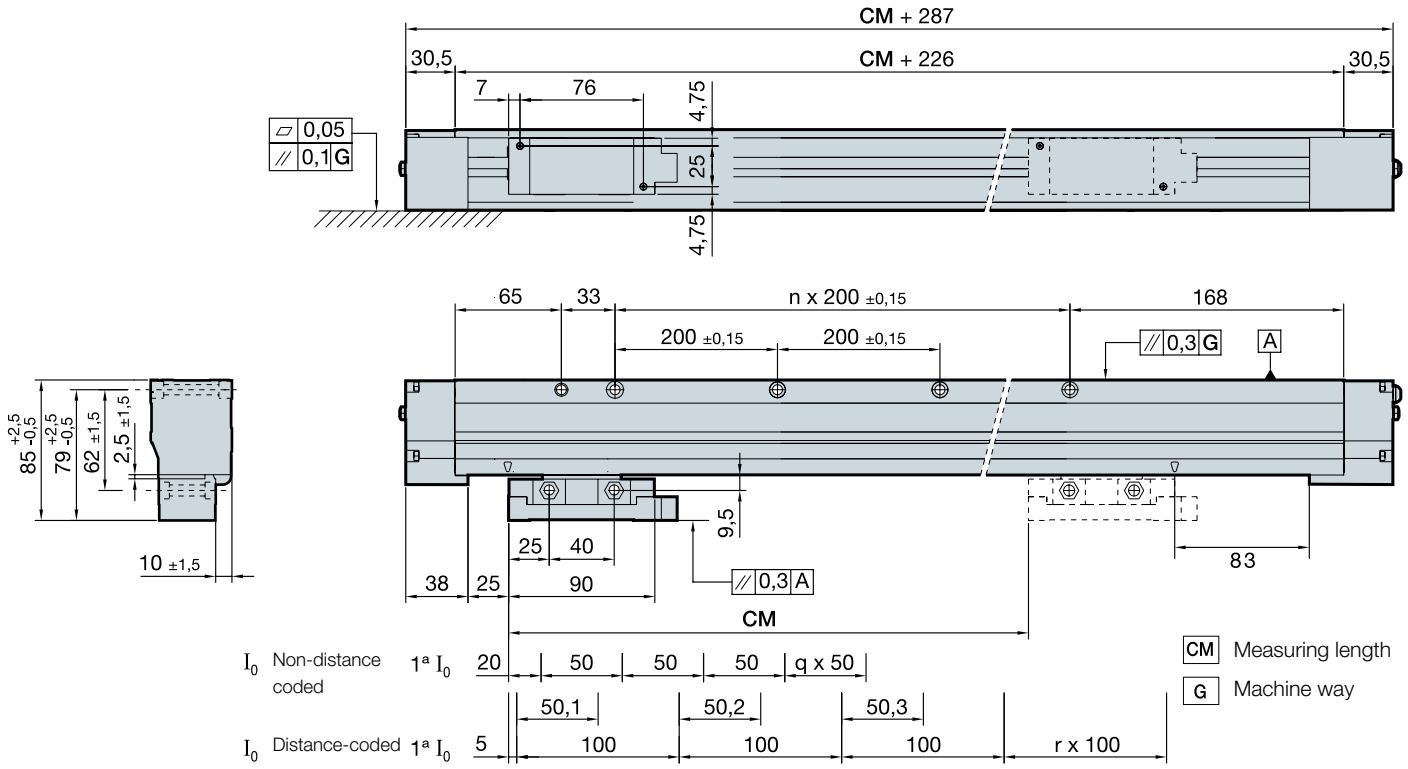
- Measuring lengths from 440 mm to 30 m in 200 mm increments. Contact Fagor Automation for custom length scales over 30 m.

Specific characteristics

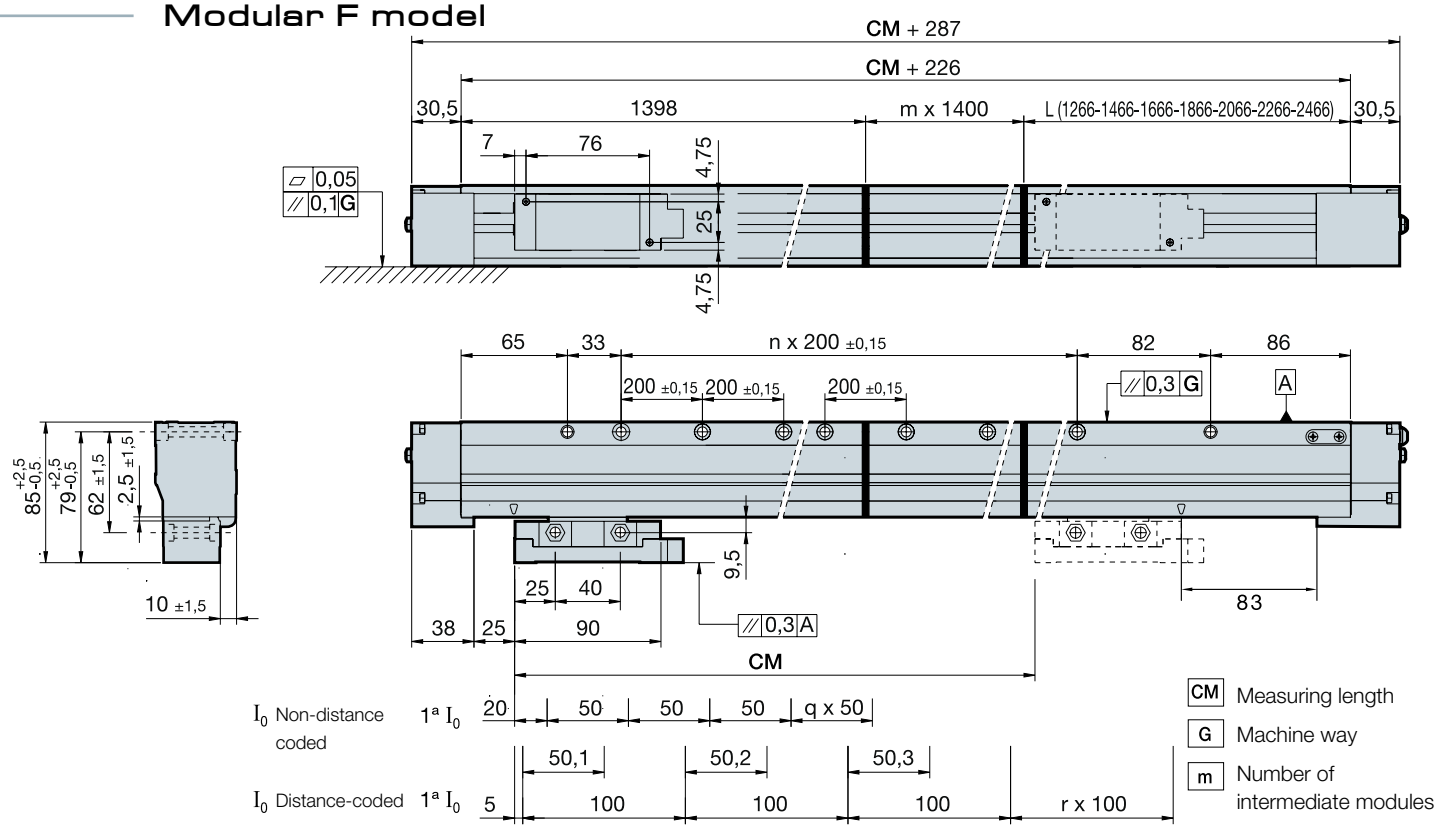
	FT FOT	FX FOX	FP FOP
Resolution	5 µm	1 µm	Up to 0.1 µm
Reference marks (I_0)	FT, FX, FP: every 50 mm FOT, FOX, FOP: Distance-coded I_0		
Output signals	⊔⊓ TTL	⊔⊓ TTL differential	∿ 1 Vpp
T period of output signals	20 µm	4 µm	100 µm
Limit frequency	100 kHz	500 kHz	20 kHz
Maximum cable length	20 m	50 m	150 m
Supply voltage	5V ±5% ,100 mA (without load)		5V ±10%, <100 mA (without load)

Single F model

Dimensions in mm



Modular F model



Order identification

Example for an incremental encoder : **FX - 36**

F		X	36
Type of profile: **F: for long distances**	***Type of reference mark*** I_0**:** • **Blank space: Incremental, one mark every 50 mm** • O: Distance-coded marks	***Type of signal:*** • T: 5 µm resolution TTL • **X: 1 µm resolution differential TTL** • P: 1 Vpp sinusoidal	***Ordering length code:*** In the example (36) = 3640 mm

C series

LINEAR

General specification

Measurement	By means of graduated glass scale, with 20 µm etching pitch
Maximum speed	60 m/min.
Maximum vibration	3 g
Moving thrust	< 5 N
Operating temperature	0 °C...50 °C
Storage temperature	-20 °C...70 °C
Weight	1.2 kg + 2.5 kg/m
Relative humidity	20...80%
Protection	IP 53 (standard) IP 64 (DIN 40050) using pressurized air in linear encoders at 0.8 ± 0.2 bar
Reader head	With detachable cable connector

Designed for applications on standard machines with travels up to 3040 mm. With reference marks every 50 mm or distance-coded and detachable cable connector built into the reader head.

Measuring lengths in millimeters

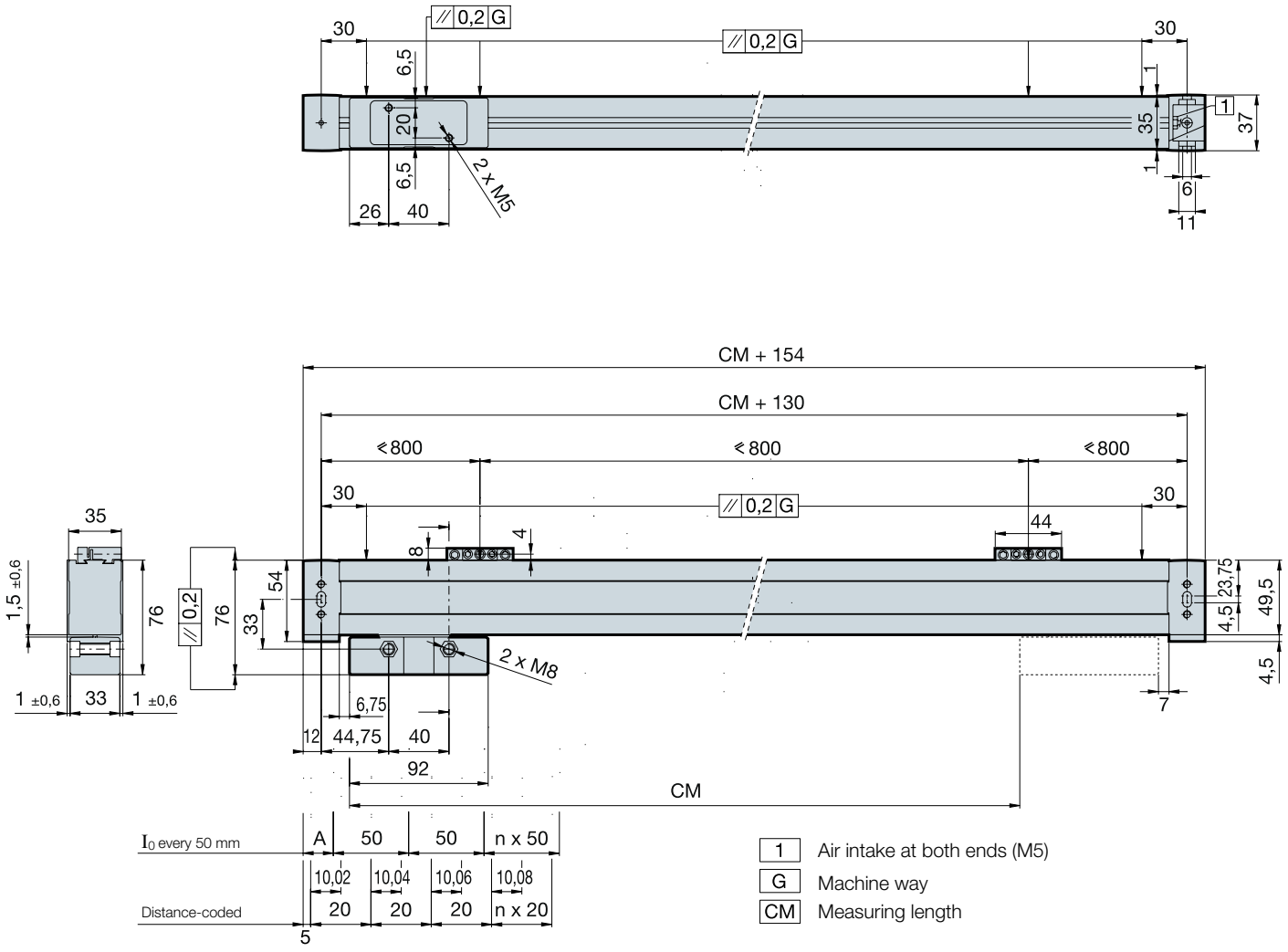
220 • 270 • 320 • 370 • 420 • 470 • 520 • 620 • 720 • 770
820 • 920 • 1020 • 1140 • 1240 • 1340 • 1440 • 1540
1640 • 1740 • 1840 • 1940 • 2040 • 2240 • 2440 • 2640
2840 • 3040

Specific characteristics

	CT COT	CX COX	CP COP
Accuracy	± 10 µm	± 5 µm	
Resolution	5 µm	1 µm	Up to 0.1 µm
Reference marks (I_0)	CT, CX, CP: every 50 mm COT, COX, COP: Distance-coded I_0		
Output signals	⊔⊓ TTL	⊔⊓ TTL differential	∿ 1 Vpp
T period of output signals	20 µm	4 µm	20 µm
Limit frequency	50 kHz	250 kHz	50 kHz
Maximum cable length	20 m	50 m	150 m
Supply voltage	5 V ± 5%,100 mA (without load)		5V ±10%, <100 mA (without load)

C model

Dimensions in mm



Measuring lengths (CM)	
For CM ending in 20	A= 10
For CM ending in 40	A= 20
For CM ending in 70	A= 35

Order identification

Example for an incremental encoder : **COP - 425**

C	O	P	42	5
Type of profile: **C for wide spaces**	***Type of reference mark*** I_0**:** • Blank space: Incremental, one mark every 50 mm • **O: Distance-coded marks**	***Type of signal:*** • T: 5 µm Resolution TTL • X: 1 µm Resolution differential TTL • **P: 1 Vpp sinusoidal**	***Measuring length in cm:*** In the example (42) = 42 cm = 420 mm	***Accuracy of the linear encoder:*** • **5: ± 5 µm** • Blank space: ± 10 µm

M series

LINEAR

General specification

Measurement	By means of graduated glass scale, with 20 µm etching pitch
Maximum speed	60 m/min
Maximum vibration	3 g
Moving thrust	< 5 N
Operating temperature	0 ºC...50 ºC
Storage temperature	-20 ºC...70 ºC
Weight	0.58 kg + 0.6 kg/m
Relative humidity	20...80%
Protection	IP 53 (standard) IP 64 (DIN 40050) using pressurized air in linear encoders at 0.8 ± 0.2 bar
Reader head	With detachable cable connector (except MKT and MKX)

Designed for applications on standard machines with travels up to 1540 mm. With reference marks every 50 mm or distance-coded and detachable cable connector built into the reader head (except the MK series where the reader head comes standard with a 3-meter attached cable).

Measuring lengths in millimeters

40 (*) • 70 • 120 • 140 • 170 • 220 • 270 • 320 • 370
420 • 470 • 520 • 620 • 720 • 770 • 820 • 920 • 1020
1140 • 1240 • 1340 • 1440 • 1540

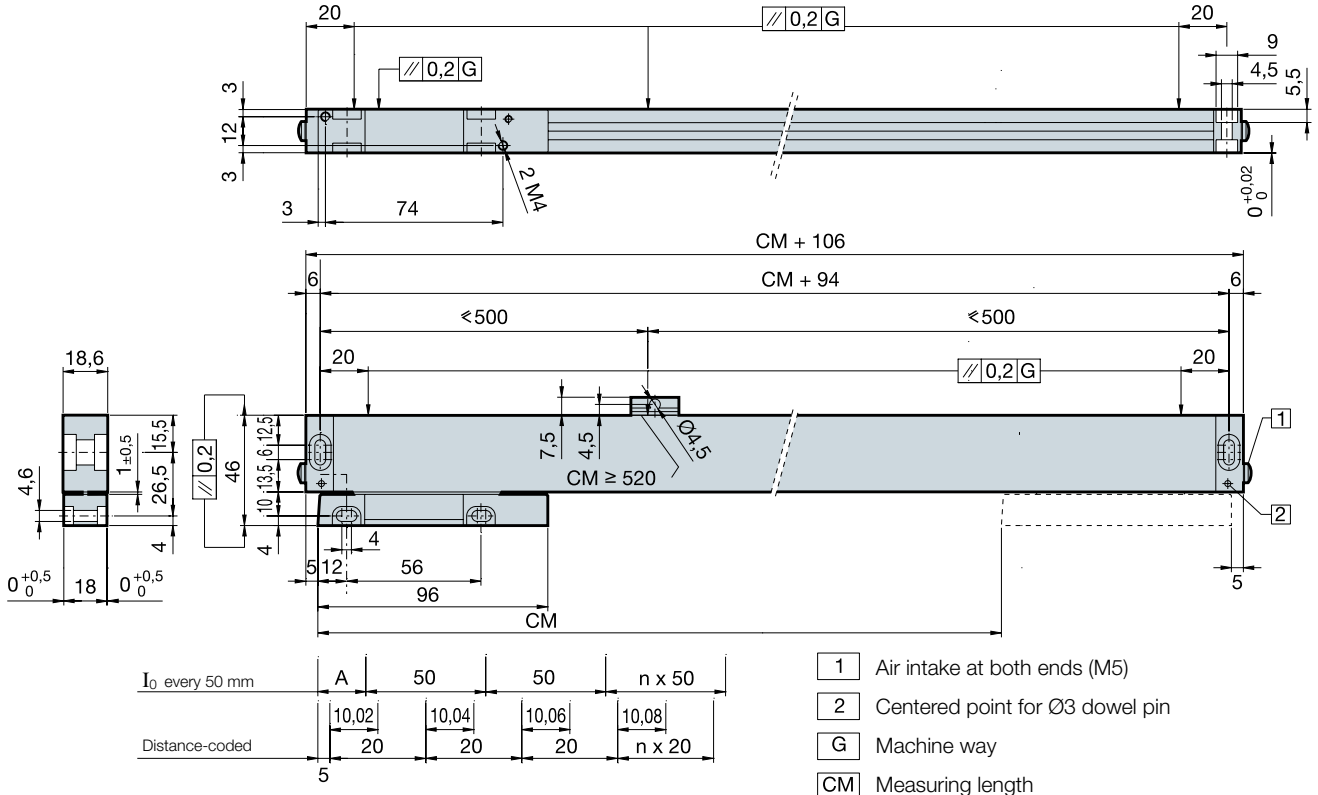
(*) On MT and MX models.

Specific characteristics

	MT MOT	MTD	MKT	MX MOX	MKX	MP MOP
Accuracy	± 10 µm			± 5 µm	± 10 µm	± 5 µm
Resolution	5 µm			1 µm		Up to 0.1 µm
Reference marks (I_0)	MKT and MKX: I_0 every 50 mm MT, MTD, MX and MP: I_0 every 50 mm MOT, MOX and MOP: Distance-coded I_0					
Output signals	⊓⊓ TTL			⊓⊓ TTL differential		∿ 1 Vpp
T period of output signals	20 µm			4 µm		20 µm
Limit frequency	50 kHz			250 kHz		50 kHz
Maximum cable length	20 m	50 m	20 m	50 m		150 m
Supply voltage	5V ±5% ,100 mA (without load)					5V ±10%, <100 mA (without load)

M model

Dimensions in mm



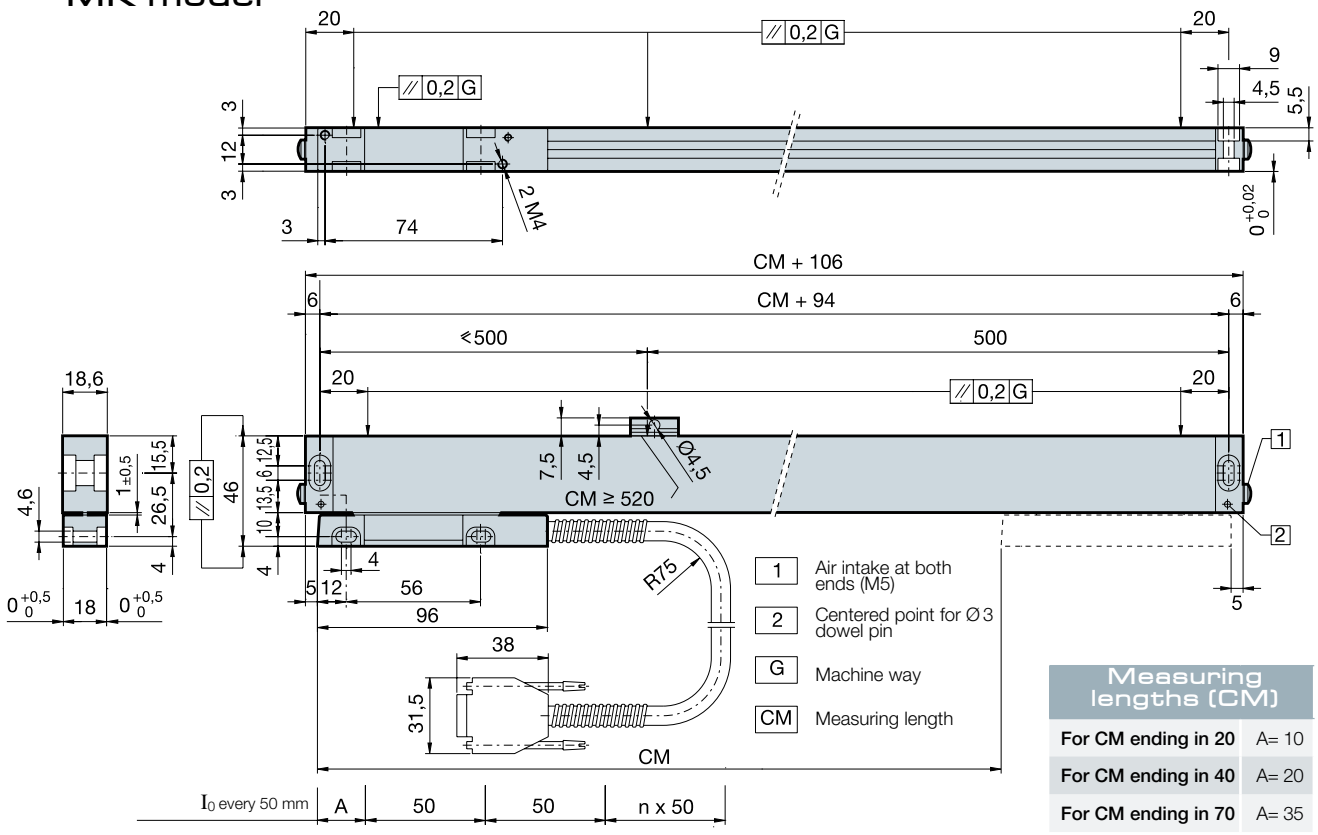
1 Air intake at both ends (M5)

2 Centered point for Ø3 dowel pin

G Machine way

CM Measuring length

MK model



1 Air intake at both ends (M5)

2 Centered point for Ø 3 dowel pin

G Machine way

CM Measuring length

Measuring lengths (CM)	
For CM ending in 20	A= 10
For CM ending in 40	A= 20
For CM ending in 70	A= 35

Order identification

Example for an incremental encoder : **MOP - 425**

M	O	P	42	5
Type of profile: **M: for limited spaces**	***Type of reference mark*** I_0**:** • Blank space: Incremental, one mark every 50 mm • **O: Absolute distance-coded marks**	***Type of signal:*** • T: 5 µm resolution TTL • TD: 5 µm resolution differential TTL • X: 1 µm resolution differential TTL • **P: 1 Vpp sinusoidal**	***Measuring lengths in cm:*** In the example (42) = 42 cm = 420 mm	***Accuracy of the linear encoder:*** • **5: ± 5 µm** • Blank space: ± 10 µm

MM series

LINEAR

General specification

Measurement	By means of graduated glass scale, with 20 µm etching pitch
Maximum speed	60 m/min.
Maximum vibration	3 g
Moving thrust	< 5 N
Operating temperature	0 ºC...50 ºC
Storage temperature	-20 ºC...70 ºC
Weight	0.58 kg + 0.5 kg/m
Relative humidity	20...80%
Protection	IP 53 (standard) IP64 (DIN 40050) using pressurized air in linear encoders at 0.8 ± 0.2 bar
Reader head	With detachable cable connector (except MMKT and MMKX)

Designed for applications on standard machines with travels up to 520 mm. With reference marks every 50 mm and detachable cable connector built into the reader head (except the MMK series where the reader head comes standard with a 3-meter attached cable). With very small profile, 5 mm less than the M series they are ideal for tight spaces.

Measuring lengths in millimeters

40 (*) • 70 (*) • 120 • 140 • 170 • 220 • 270 • 320 • 370 420 • 470 • 520

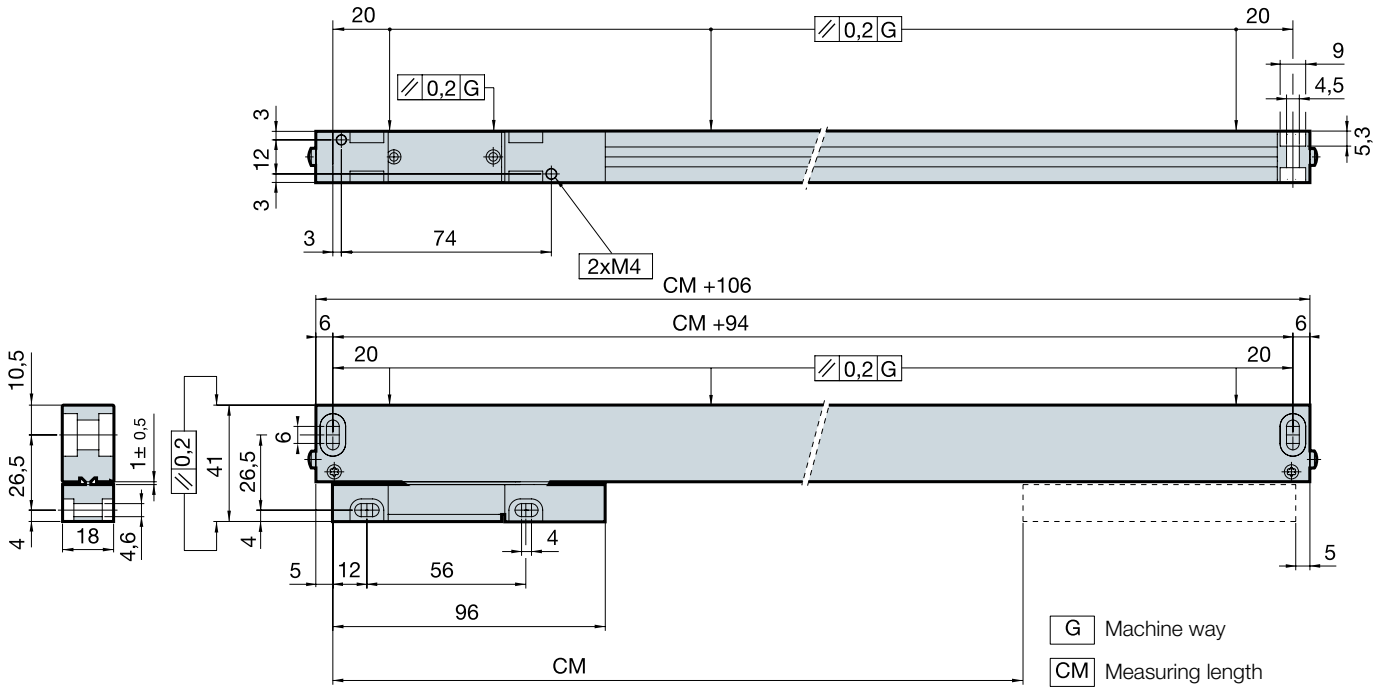
(*) On MMT and MMX models.

Specific characteristics

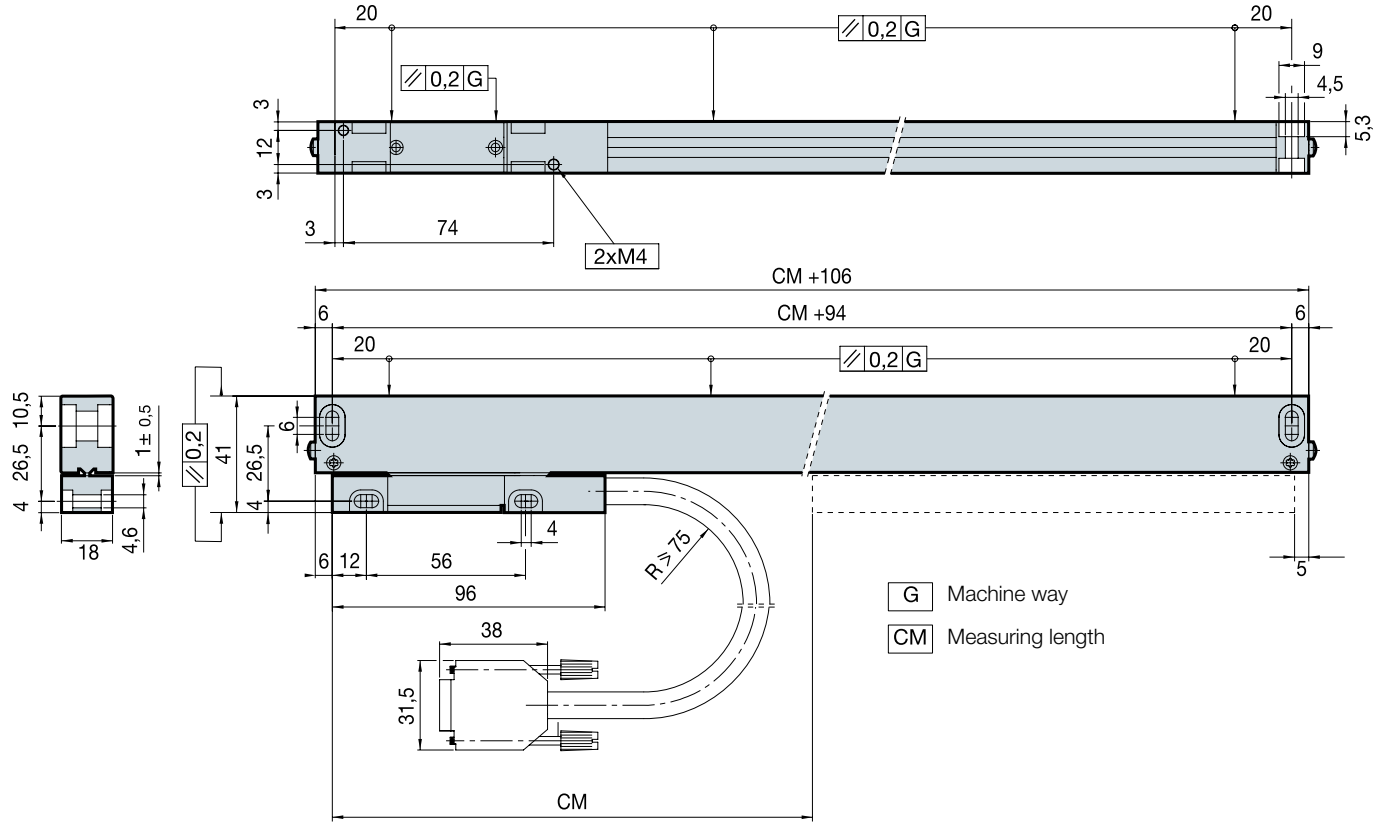
	MMT	MMKT	MMX	MMKX	MMP
Accuracy	± 10 µm		± 5 µm	± 10 µm	± 5 µm
Resolution	5 µm		1 µm		0.1 µm
Reference marks I_0	I_0 every 50 mm				
Output signals	⊔⊓ TTL		⊔⊓ TTL differential		⌒ 1 Vpp
T period of output signals	20 µm		4 µm		20 µm
Limit frequency	50 kHz		250 kHz		50 kHz
Maximum cable length	20 m		50 m		150 m
Supply voltage	5V ± 5%,100 mA (without load)				5V ±10%, <100 mA (without load)

MM model

Dimensions in mm



MMK model



Order identification

Example for an incremental encoder : **MMT-27**

MM	T	27
Type of profile:	***Type of signal:***	***Measuring lengths in cm:***
MM: for very limited space	• **T: 5 µm resolution TTL** • X: 1 µm resolution differential TTL • P: 1 Vpp sinusoidal	In the example (27) = 27 cm = 270 mm

MTD-P-2R series

LINEAR

General specification

Measurement	By means of graduated glass scale, with 20 µm etching pitch
Maximum speed	60 m/min.
Maximum vibration	3 g
Moving thrust	< 5 N
Operating temperature	0 °C...50 °C
Storage temperature	-20 °C...70 °C
Weight	0.58 kg + 2.43 kg/m
Relative humidity	20...80%
Protection	IP 53 (standard) IP64 (DIN 40050) using pressurized air in linear encoders at 0.8 ± 0.2 bar
Reader head	With detachable cable connector

Designed for applications on press brakes with strokes up to 1540 mm. The linear encoder comes with a universal joint for reader head movement and an aluminum support that is mounted directly on the machine.

Measuring lengths in millimeters

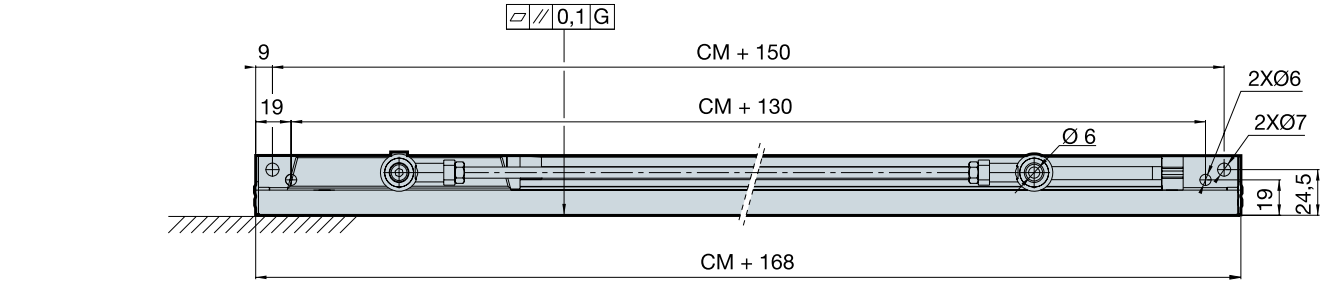
40 • 70 • 120 • 140 • 170 • 220 • 270 • 320 • 370 • 420
470 • 520 • 620 • 720 • 770 • 820 • 920 • 1020 • 1140
1240 • 1340 • 1440 • 1540

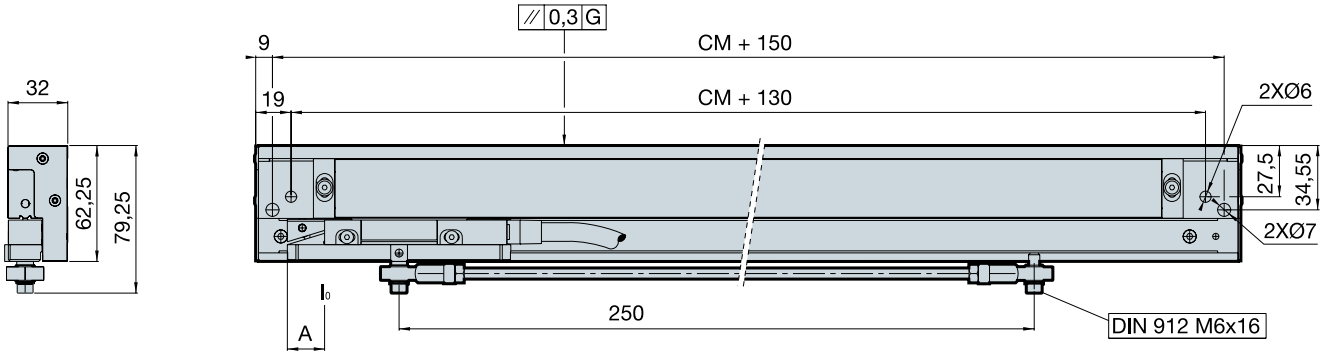
Specific characteristics

	MTD-P-2R
Accuracy	± 10 µm
Resolution	5 µm
Reference marks (I_0)	Two I_0 at the ends
Output signals	⊔⊓ TTL differential
T period of output signals	20 µm
Limit frequency	50 kHz
Maximum cable length	50 m
Supply voltage	5V ±5% ,100 mA (without load)

MTD-P-2R model

Dimensions in mm





G Machine way

CM Measuring length

Measuring lengths (CM)	
For CM ending in 20	A= 10
For CM ending in 70	A= 35

Order identification

Example for an incremental encoder: **MTD-77 P-2R**

M	TD	77	P2R
Type of profile: **M: for limited space**	***Type of signal:*** **TD: 5 µm resolution differential TTL**	***Measuring lengths in cm:*** In the example (77) = 77 cm = 770 mm	***Reference mark I_0:*** **Two I_0 at both ends**

H, S series

ROTARY

General specification

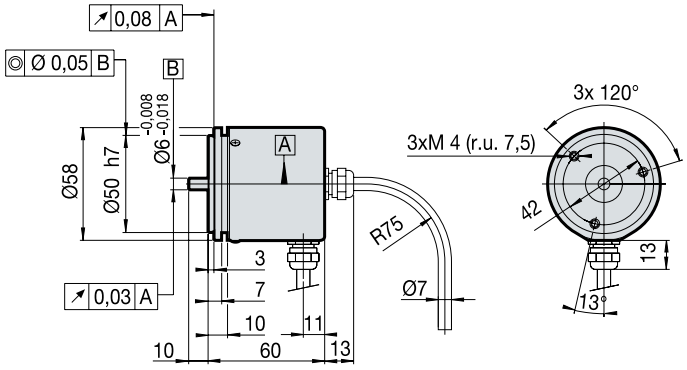
	S	SP	H / HA	HP
Measurement	With graduated disk			
Accuracy	± 1/10 of the pitch			
Maximum speed	12000 rpm			
Vibration	100 m/s² (10 ÷ 2000 Hz)			
Shock	300 m/s² (11 m/s)			
Inertia	16 gr/cm²			
Turning torque	0.003 Nm (30 gr/cm) max. at 20 °C			
Type of shaft	Solid shaft		Hollow shaft	
Maximum load on the shaft	Axial: 10 N Radial: 20 N		–	
Weight	0.3 kg			
Ambient characteristics:				
Running temperature	0 °C…+70 °C			
Storage temperature	-30 °C…+80 °C			
Relative humidity	98% non-condensing			
Protection	IP 64 (DIN 40050). On S and SP models: Optional IP 66			
Light source	IRED (InfraRed Emitting Diode)			
Maximum frequency	200 kHz			
Reference signal I_0	One reference signal per encoder turn			
Supply voltage	5 V ± 5% (TTL)	5 V ± 10% (1 Vpp)	5 V ± 5% (TTL)	5 V ± 10% (1 Vpp)
Consumption	70 mA typical, 100 mA max. (without load)			
Output signals	⊓⊔ TTL differential	∿ 1 Vpp	⊓⊔ TTL differential	∿ 1 Vpp
Maximum cable length	50 m	150 m	50 m	150 m

Number of pulses/turn

S	SP	H	HA	HP
50	–	50	–	–
100	–	100	–	–
200	–	200	–	–
250	–	250	–	–
400	–	400	–	–
500	–	500	–	–
600	–	600	–	–
635	–	635	–	–
1 000	1 000	1 000	–	1 000
1 024	1 024	1 024	1 024	1 024
1 250	1 250	1 250	1 800	1 250
1 270	1 270	1 270	2 000	1 270
1 500	1 500	1 500	2 048	1 500
2 000	2 000	2 000	2 500	2 000
2 500	2 500	2 500	3 000	2 500
3 000	3 000	3 000	3 600	3 000
–	3 600	–	4 000	–
–	4 320	–	4 096	–
5 000	5 000	–	5 000	–
–	–	–	10 000	–

S, SP model

Dimensions in mm

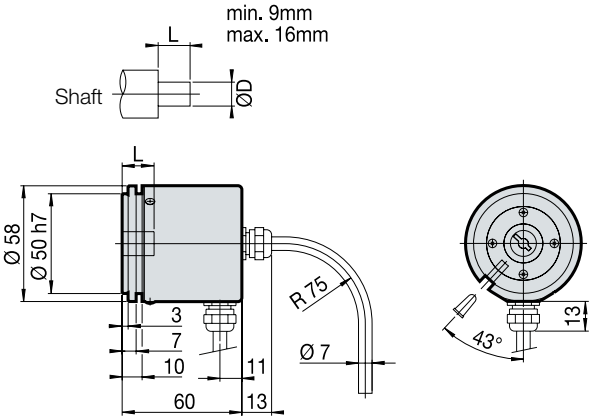


A Roller bearings

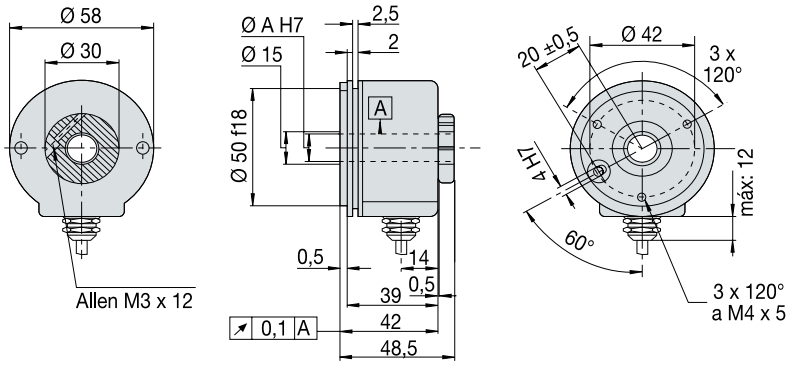
H, HP model

L: Min. 9 mm, max. 16 mm

ØD g7 mm
3
4
6
6.35
7
8
9.53
10



HA model



Order identification - models H, HP, S and SP

Example for a Rotary Encoder: **SP-1024-C5-R-12-IP 66**

S	P	1024	C5	R	12	IP 66
Model: • **S: Solid shaft** • H: Hollow shaft	**Type of signal:** • Blank space: square signal (TTL or HTL) • **P: 1 Vpp sinusoidal signal**	***Number of pulses/turn:*** (See table page 16)	***Type of connector:*** • Blank space: 1 m cable without connector • C: Flange socket CONNEI 12 • **C5: 1 m cable with CONNEI 12 connector**	***Cable exit:*** • **R: Radial** • A: Axial Blank space: Axial	***Voltage:*** • Blank space: Standard 5 V supply • **12: Optional 12 V supply (only for HTL signal)**	***Protection:*** • Blank space: Standard protection (IP 64) • **IP 66: Protection IP 66**

Order identification - HA model

Example for a Rotary Encoder: **HA - 22132 - 2500**

HA	2	2	1	3	2	2500
In all cases	***Type of clamp:*** • 1: Rear clamp • **2: Front clamp**	***Size of the hollow shaft (ØA):*** • 1: 10 mm • **2: 12 mm**	***Output signals:*** • **1: A, B, I_0 plus their inverted**	***Type of connection:*** • 1: Radial cable (2 m) • 2: CONNEI 12 radial connector built into it • **3: Radial cable (1 m) with CONNEI 12 connector**	***Supply voltage:*** • 1: Push-Pull (11-30 V) • **2: RS-422 (5 V)**	***Number of pulses/turn:*** (See table page 16)

Connection cables

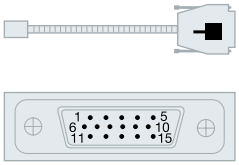
Connection to FAGOR

EC...T-D

Lengths: 1, 3, 6, 9 and 12 meters

SUB D 15 HD connector (male Pin)

Pin	Signal	Color
1	A	Green
3	B	Brown
5	I_0	Grey
9	+5 V	Yellow
11	0 V	White
15	Ground	Shield
Housing	Ground	Shield

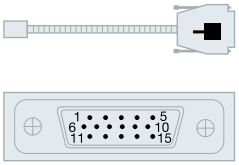


EC...P-D

Lengths: 1, 3, 6, 9 and 12 meters

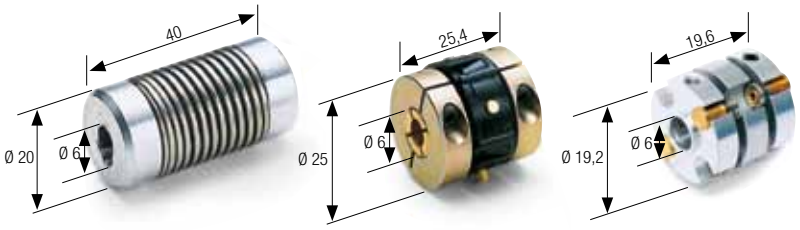
SUB D 15 HD connector (male Pin)

Pin	Signal	Color
1	A	Green
2	/A	Yellow
3	B	Blue
4	/B	Red
5	I_0	Grey
6	I_0	Pink
9	+5 V	Brown
11	0 V	White
15	Ground	Shield
Housing	Ground	Shield



Coupling for rotary encoders

For solid shaft encoders



AF model AC model AL model

Specific characteristics

	AF	AC	AL
Maximum radial misalignment permitted	2 mm	1 mm	0.2 mm
Maximum angular misalignment permitted	8°	5°	4°
Maximum axial misalignment permitted	± 1.5 mm	—	± 0.2 mm
Maximum torque that may be transmitted	2 Nm	1.7 Nm	0.9 Nm
Torsion rigidity	1.7 Nm/rad.	50 Nm/rad.	150 Nm/rad.
Maximum rotating speed	12 000 rpm		

AH couplings

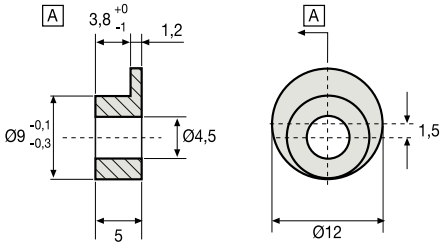
Couplings for hollow shaft encoders

The hollow shaft encoders are accompanied by a standard 6 mm cap diameter (Ø 6).

Can also be supplied in the following diameters:
Ø 3, Ø 4, Ø 6, Ø 7, Ø 8 and Ø 10 mm, 1/4" and 3/8".

AD washer

Washer for mounting rotary encoder models H, HP, S, SP.



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FAGOR AUTOMATION

Fagor Automation, S. Coop.
Bº San Andrés, 19
E-20500 Arrasate - Mondragón
SPAIN
Tel.: +34 943 719 200
Fax.: +34 943 791 712
E-mail: info@fagorautomation.es

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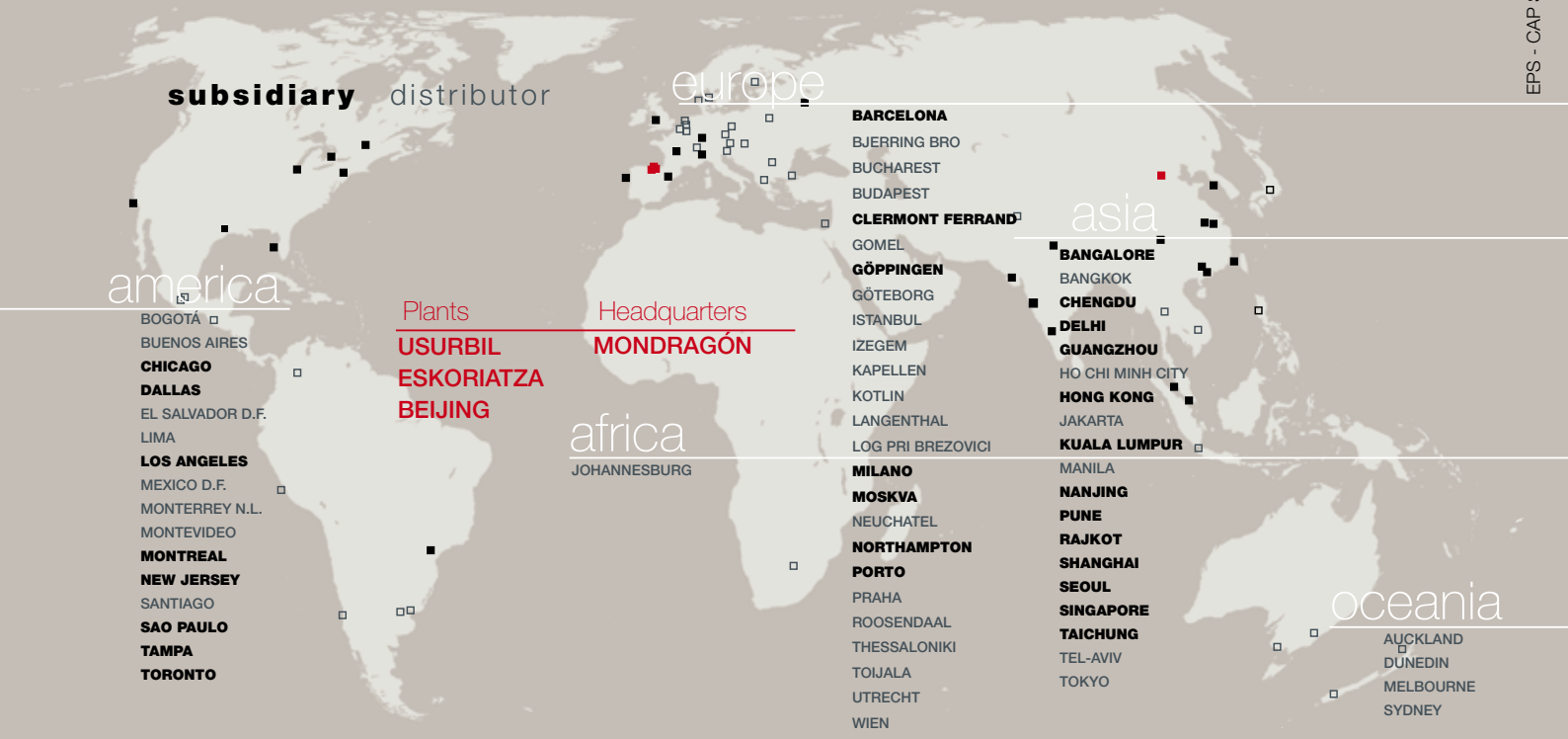

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