HEIDENHAIN

MULTI-DOF

Measurement technology for multiple degrees of freedom

www.heidenhain.com/multi-dof

02/2026

D*plus* encoders for perfect motion systems

Linear encoders measure the position of linear axes unmediated by other mechanical elements, thereby eliminating multiple sources of error:
- Positioning error due to thermal changes in the recirculating ball screw
- Reversal error
- Kinematic error due to the ball-screw pitch error

As a result, linear encoders are essential components on machines that require high **positioning accuracy** and **machining speed**.

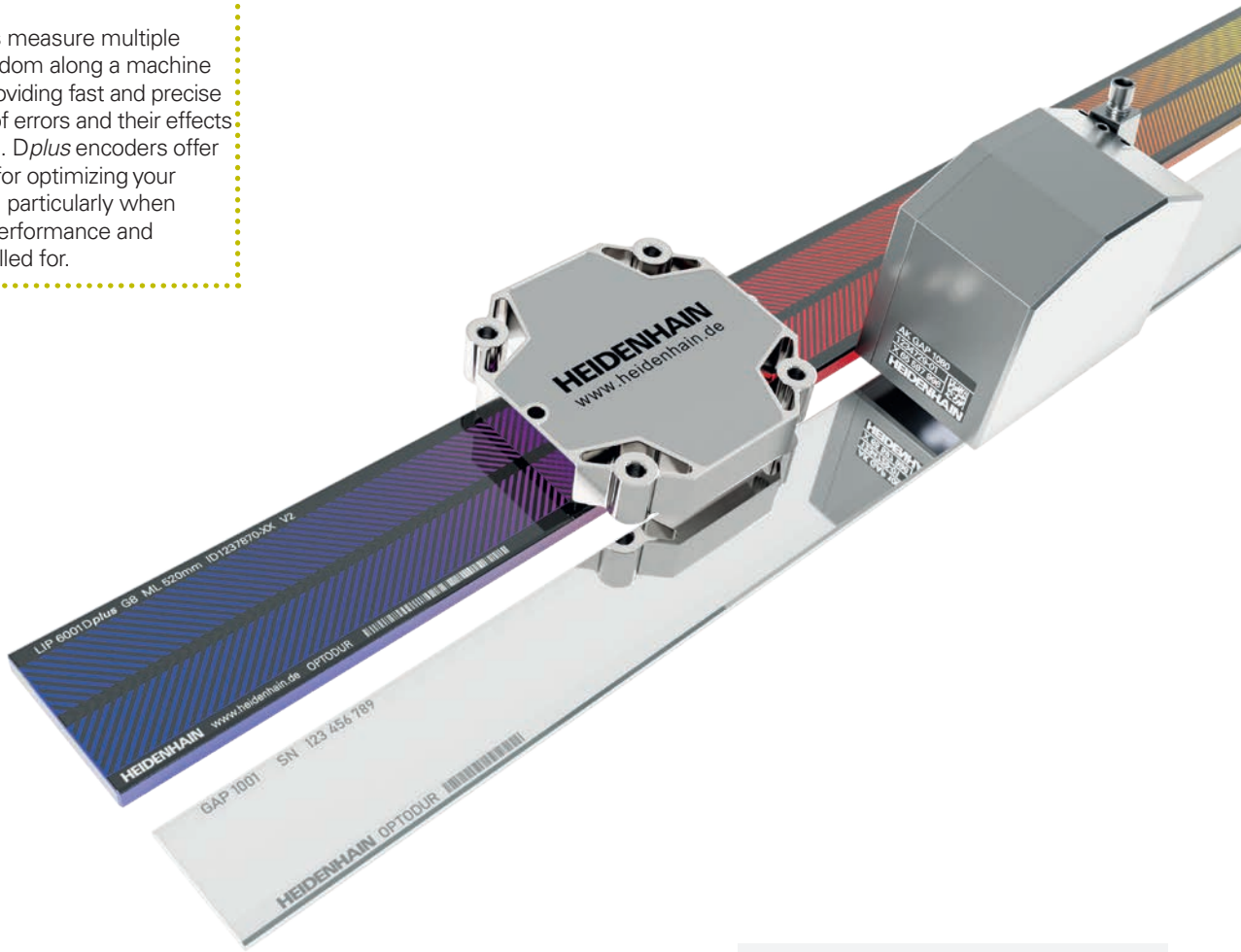
D*plus* encoders

D*plus* encoders measure multiple degrees of freedom along a machine axis, thereby providing fast and precise measurement of errors and their effects on the machine. D*plus* encoders offer great potential for optimizing your motion system, particularly when high dynamic performance and accuracy are called for.

Exposed linear encoders and **modular angle encoders with a circular scale** are used on machines that require high-accuracy position feedback. Typical applications include the following:
- Production and measurement equipment in the semiconductor industry
- PCB assembly machines
- Ultra-precision equipment such as diamond lathes for optical components, facing lathes for magnetic storage disks, and grinding machines for ferrite parts
- High-accuracy machine tools
- Measuring machines, comparators, measuring microscopes, and other precision measuring devices
- Direct-drive motors

Mechanical design of linear encoders
Exposed linear encoders consist of a scale or scale tape read by a non-contact scanning head. Because the scale of an exposed linear encoder is fastened to a mounting surface, achieving high linear encoder accuracy requires a mounting surface with high flatness.

Mechanical design of angle encoders
Modular angle encoders consist of a circular scale and a non-contact scanning head. With these encoders, the circular scale is attached to a mounting surface. A highly flat mounting surface is therefore essential for ensuring the high accuracy of these angle encoders.



To learn more about the following topics, visit www.heidenhain.com:
- Angle encoders with an integral bearing
- Angle encoders with a circular scale
- Modular angle encoders with scale drum or scale tape
- Rotary encoders
- Encoders for servomotors
- Linear encoders for numerically controlled machine tools
- Signal converters
- HEIDENHAIN controls

This brochure supersedes all previous editions, which thereby become invalid. The basis for ordering from HEIDENHAIN is always the brochure edition valid when the order is placed.

Standards (ISO, EN, etc.) apply only where explicitly stated in the brochure.

Find out more:

For a detailed description of all available interfaces, along with general electrical information, view the Interfaces of HEIDENHAIN Encoders brochure (ID 1078628-xx).

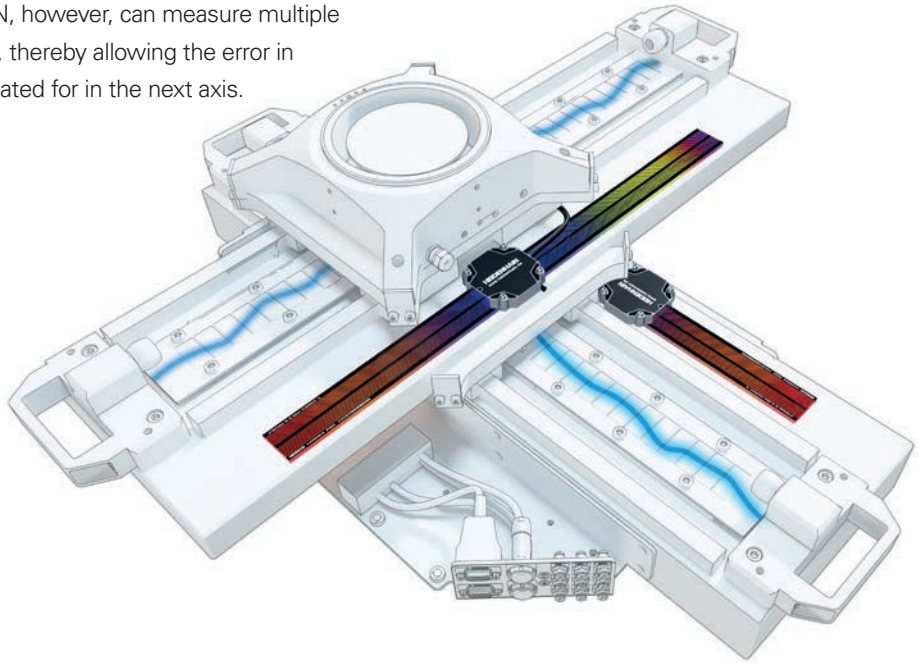
For the required connecting cable, read our Cables and Connectors *brochure* (ID 1206103-xx).

Contents

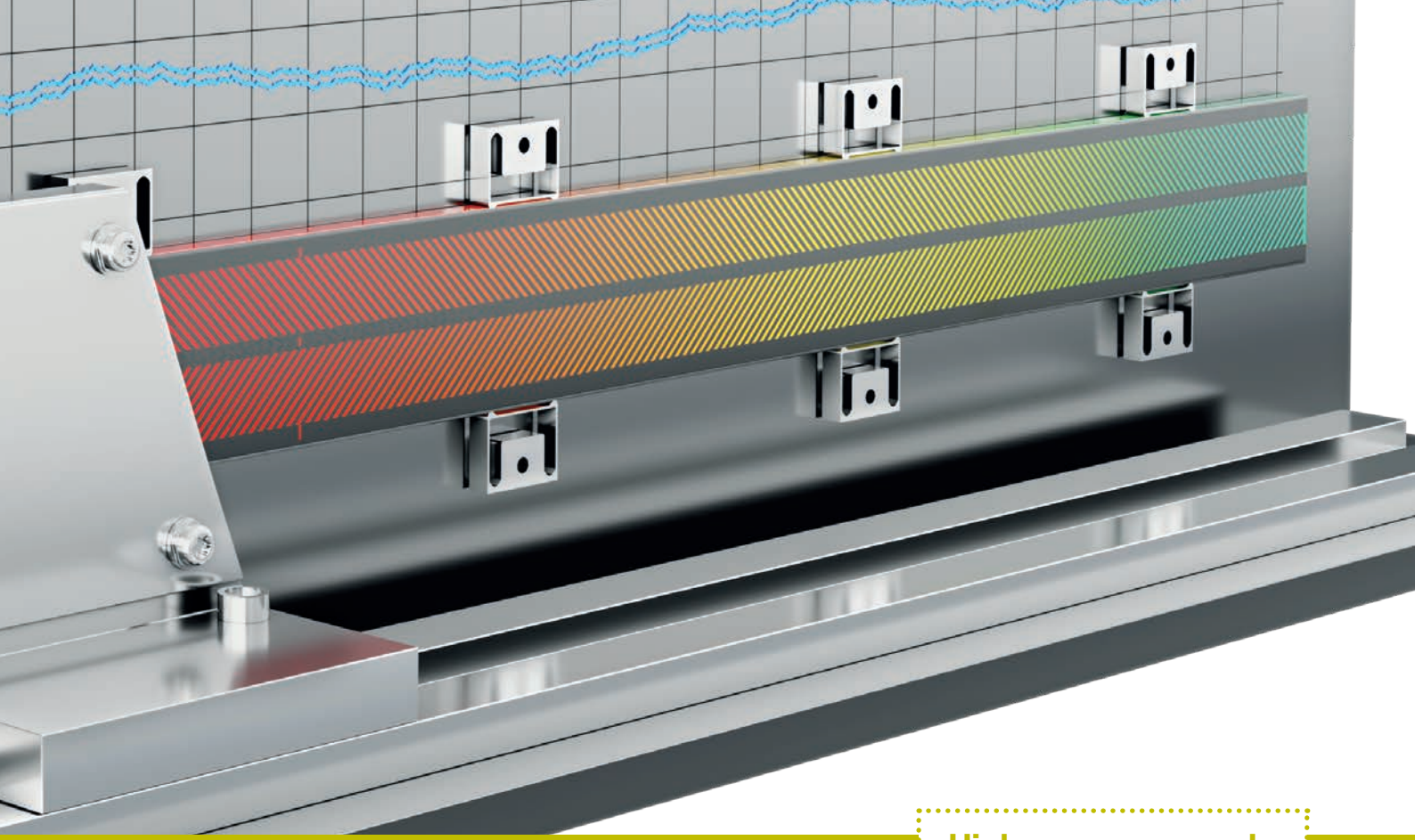
Multi-dimensional measurement technology

Conventional encoders can measure only one degree of freedom, rendering them blind to unavoidable errors in the other direction of measurement. In multi-axis systems, errors along one axis carry over onto the other axes, thereby affecting the entire motion system. Errors in the first axis change the position of the encoder on the second axis, and so on. Yet these errors are not normally measured.

The D*plus* encoders from HEIDENHAIN, however, can measure multiple degrees of freedom along a single axis, thereby allowing the error in one axis to be measured and compensated for in the next axis.



= *Guideway error*



Higher accuracy and greater dynamic performance

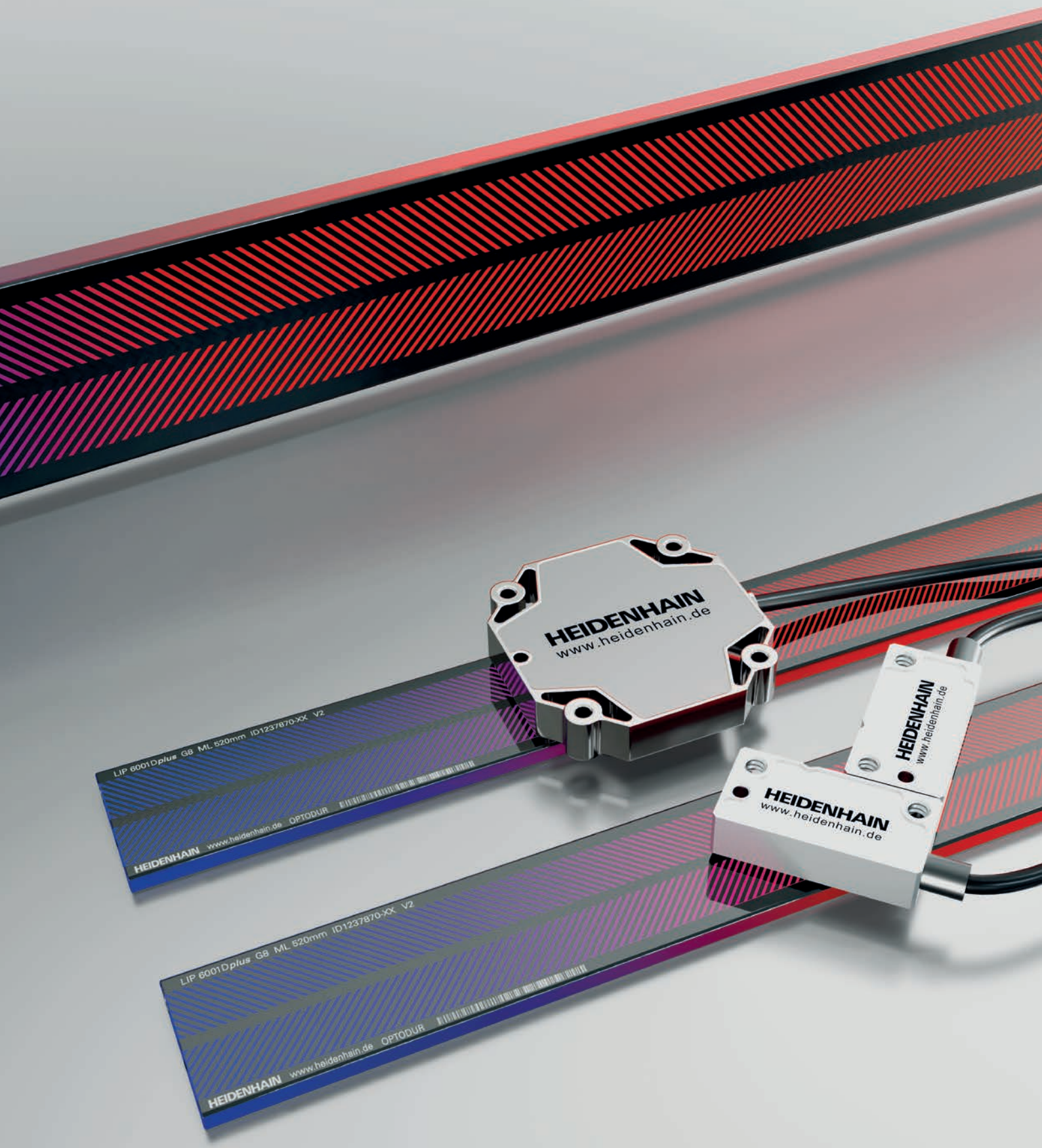
More than ever, productivity and accuracy are key competitive advantages. But faster and more precise production processes are only part of the equation: reproducibility and stable quality are essential as well. Attaining reliably high accuracy greatly expands your manufacturing capabilities, particularly in the high-end spectrum.

The accuracy of a motion system depends on multiple factors:

- Non-linear guideway errors
- Vertical flatness and horizontal straightness
- Pitch, yaw, and roll
- Squareness error
- Kinematics error
- Thermal expansion and other thermal effects
- Hysteresis

The challenge of perfecting position measurement in the primary axis is significant. Simply optimizing the scale and scanning head is not sufficient for maximizing a motion system's precision and dynamic performance. Machine design factors and thermal changes are playing an ever greater role as accuracy and dynamic-performance requirements grow. Thanks to multi-dimensional encoders such as the LIP 6000 D*plus*, these factors can be directly measured and compensated for.

Innovative graduation structures



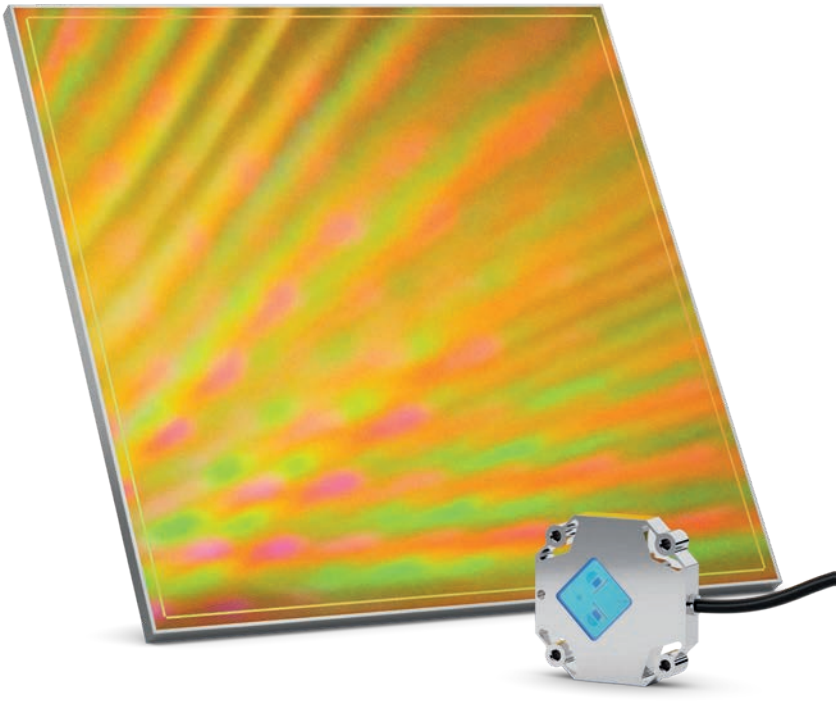
Precise measurement for optimal performance

The interferential measuring principle generates signals by utilizing the refraction and interference of light on finely divided gratings. The measuring standard consists of a flat surface with 0.2 µm-high reflecting lines. These lines are read by a scanning reticle featuring a light-permeable phase grating with an identical graduation period.

Interferential encoders use signal periods of 4 µm or less with harmonics-free scanning signals that can be highly interpolated. As a result, these encoders are ideal when high resolution and accuracy are needed.

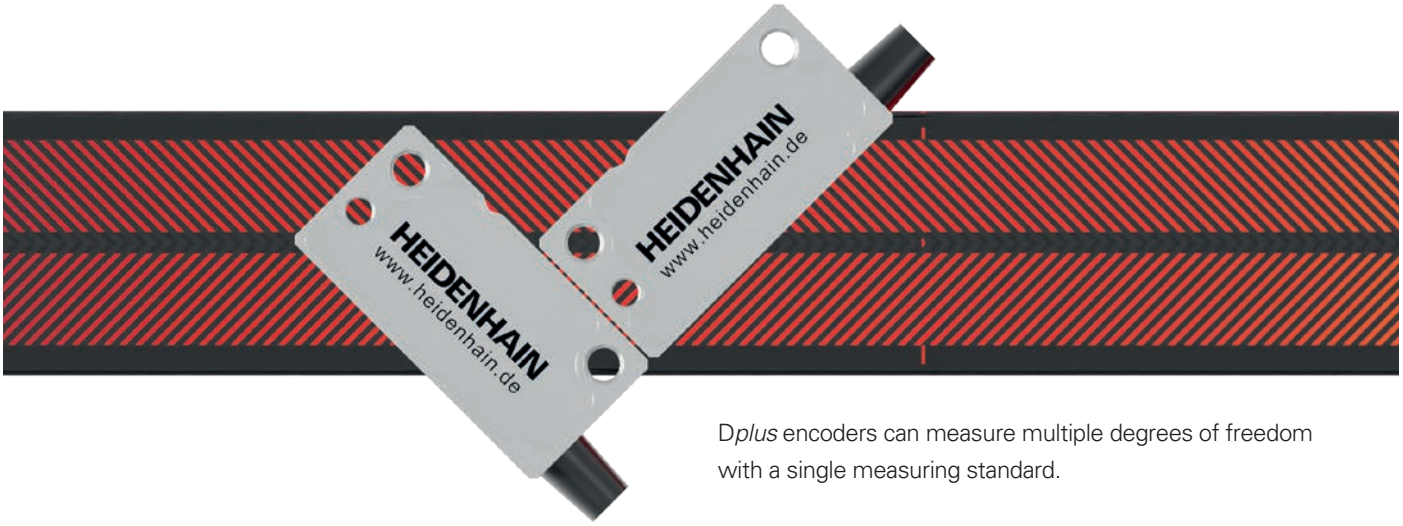
The D*plus* encoders, such as the LIP 6000 D*plus*, feature a carrier with two separate graduation tracks containing diagonal graduations (±45°), thus permitting direct, high-accuracy measurement of the primary and secondary directions along the entire measuring length.

HEIDENHAIN also offers an incremental two-coordinate encoder for feedback in two directions of measurement, with neither direction being primary or secondary. In this case, the carrier is itself a high-accuracy grid graduation.



The PP 6000 two-coordinate incremental encoder

Multiple degrees of freedom in one encoder



D*plus* encoders can measure multiple degrees of freedom with a single measuring standard.

Measuring multiple degrees of freedom

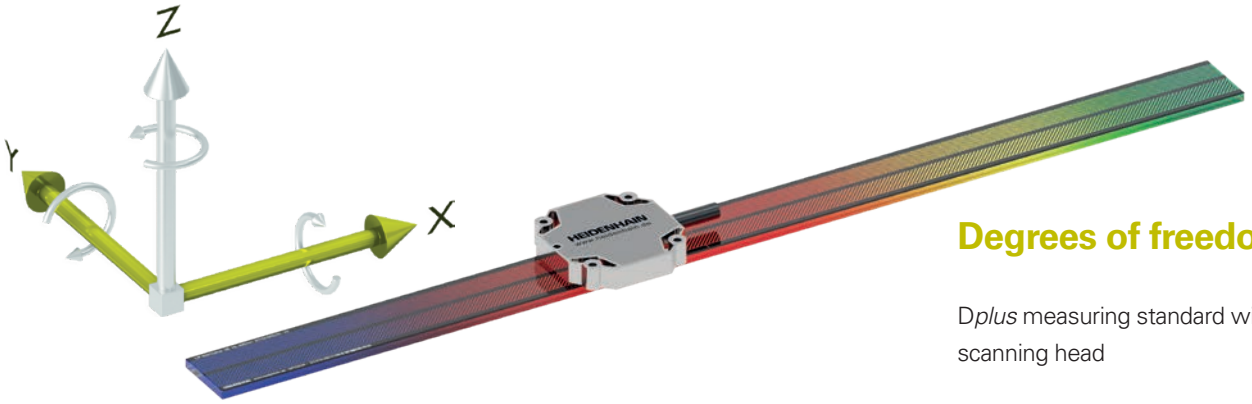
A body in space can move in six degrees of freedom, which are divided into translational degrees of freedom (X, Y, Z) and rotational degrees of freedom (R_X, R_Y, R_Z).

Normally, measuring motion in multiple degrees of freedom requires numerous components, with conventional encoders requiring one scanning head and one measuring standard for each degree of freedom. The D*plus* encoders from HEIDENHAIN, however, can significantly reduce the number of components required.

A D*plus* scale with two separate graduation tracks and three scanning heads on the same scale, for example, can measure up to three degrees of freedom. This technology makes it possible to implement complex measuring tasks in a simple and compact design.

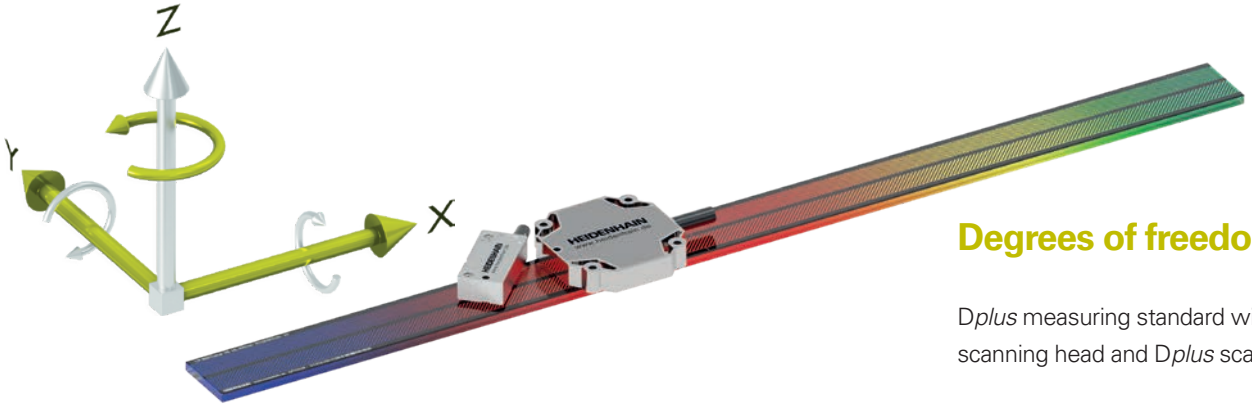
Degrees of freedom: X, Y

D*plus* measuring standard
with two scanning heads



Degrees of freedom: X, Y

D*plus* measuring standard with D*plus*
scanning head



Degrees of freedom: X, Y, R_Z

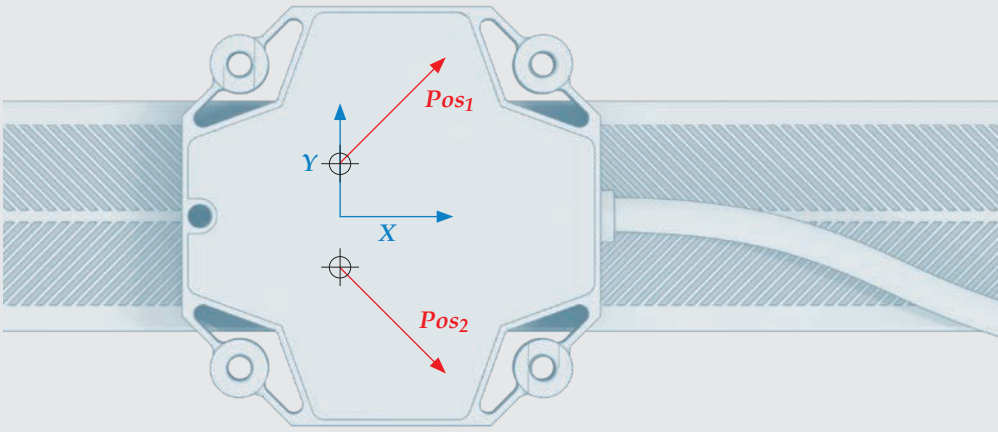
D*plus* measuring standard with standard
scanning head and D*plus* scanning head

Diagonal graduations

Position value calculation

$$x = \frac{1}{\sqrt{2}} (Pos_1 + Pos_2)$$

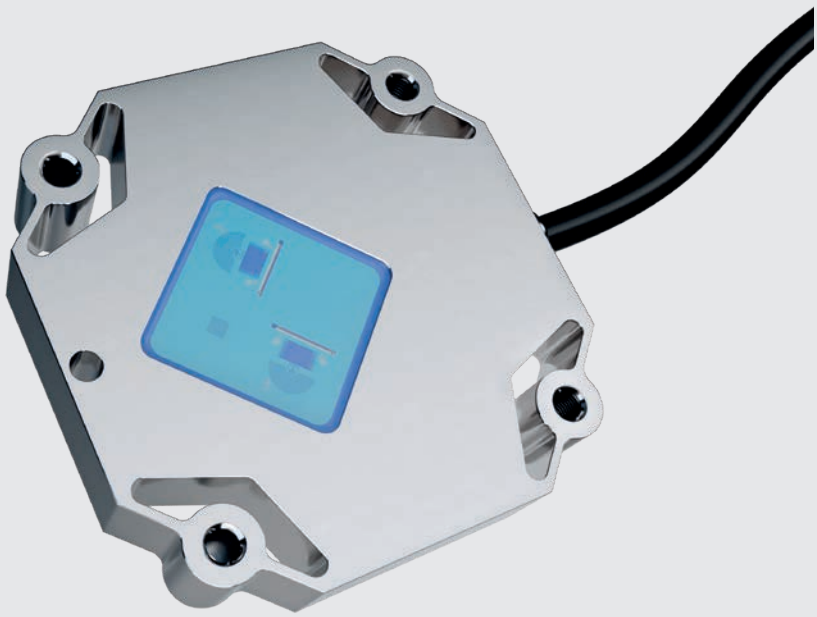
$$y = \frac{1}{\sqrt{2}} (Pos_1 - Pos_2)$$



D*plus* scanning head

The D*plus* scanning head developed by HEIDENHAIN can measure two degrees of freedom at the same time. These two position values are then forwarded to the control over a single cable using the EnDat 3 interface.

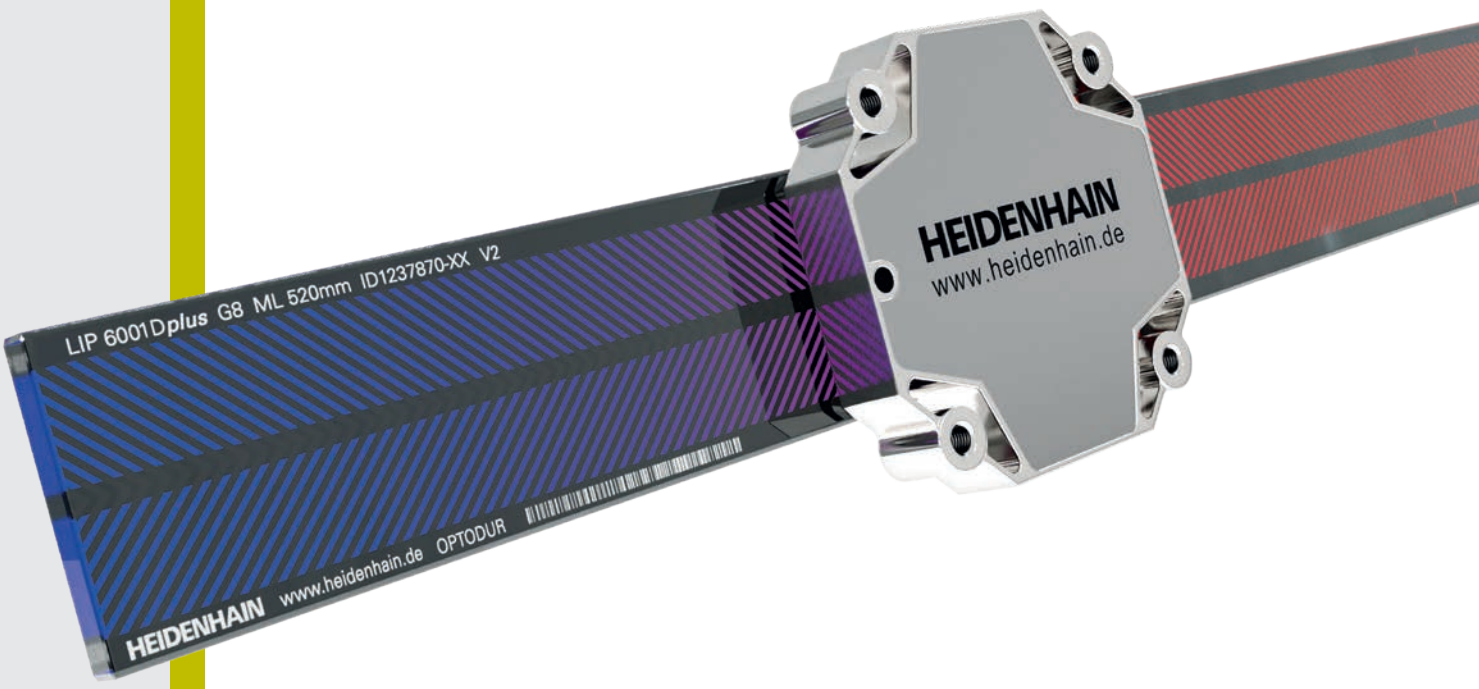
The resulting reduction in cabling not only simplifies installation but also optimizes the dynamic behavior of the motion system.



Harness the advantages of precise error measurement

It would be impossible to home the secondary direction of measurement if the graduations were positioned at right angles (0° and 90°). But with a diagonal configuration, the primary and secondary directions of motion can be homed at the same time.

As a result, absolute feedback from the main axis and auxiliary axis is made available. The resulting absolute measurement of position changes within the machine enables more accurate positioning along with insight into possible sources of error.

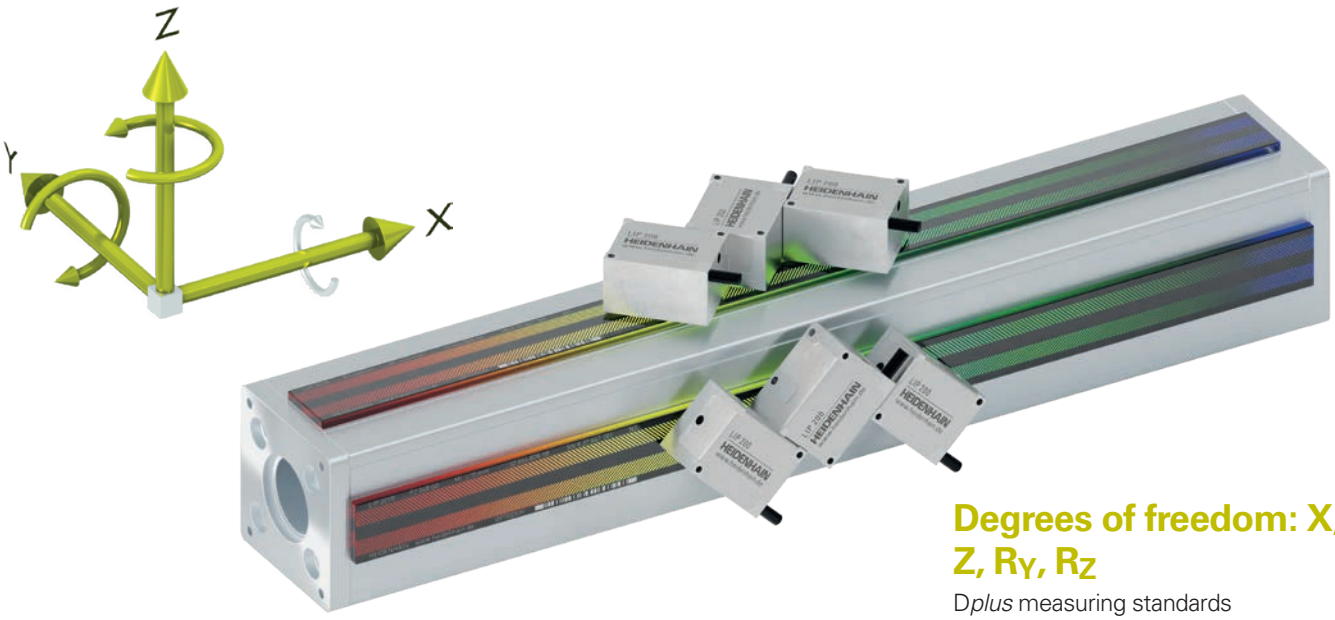


Out-of-plane gap measurement

Conventional encoders can measure only one degree of freedom per encoder. D*plus* encoders, however, can measure up to three degrees of freedom within the encoder's plane (e.g., X, Y, and R_Z). Additional measurements in a different plane would require more encoders and higher system complexity.

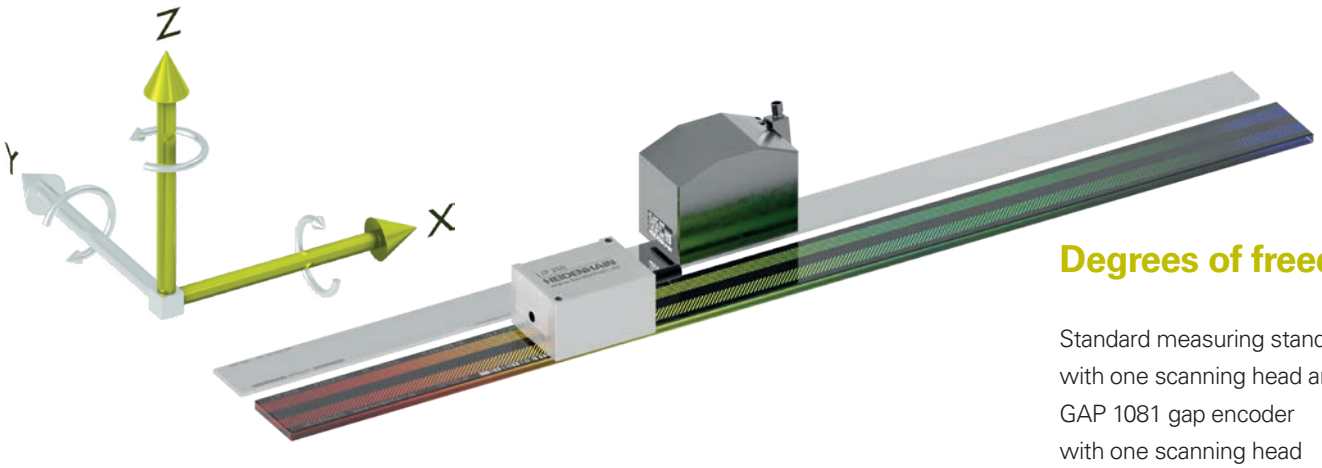
Through vertical measurement, the GAP 1081 gap encoder is a convenient and space-saving solution for expanding the system to include additional directions of measurement. Because its components are mounted within the encoder's main plane, the GAP 1081 delivers especially direct feedback.

The GAP 1081 can be used for purely vertical positioning tasks or to track changes in vertical position across a linear plane. It is even possible to measure pitch and yaw when two scanning heads are used on the same mirror. The result is significantly simpler installation and reduced complexity within the metrology design.



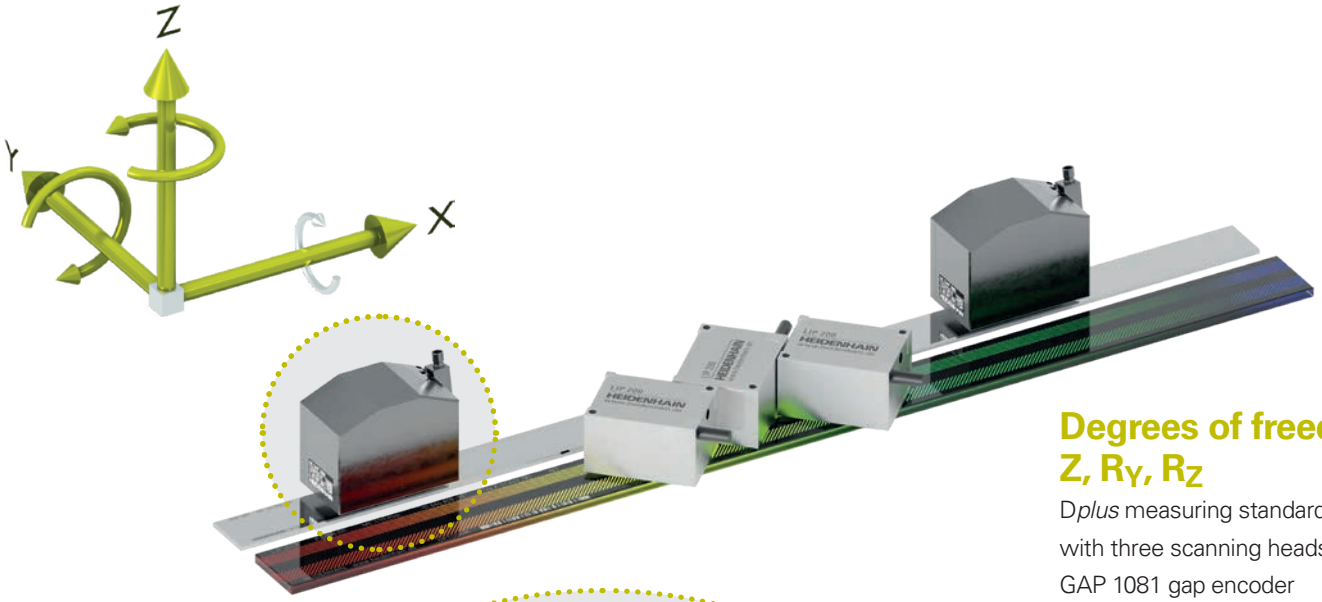
Degrees of freedom: X, Y, Z, R_Y, R_Z

D*plus* measuring standards with three scanning heads each (without the GAP 1081)



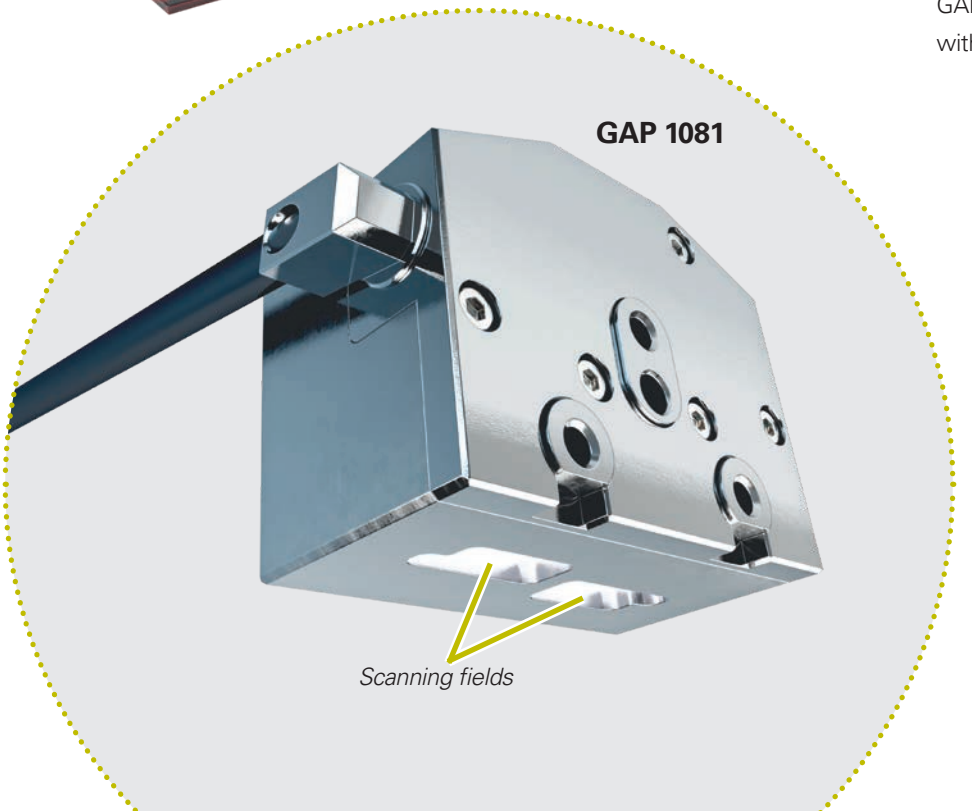
Degrees of freedom:X, Z

Standard measuring standard
with one scanning head and the
GAP 1081 gap encoder
with one scanning head

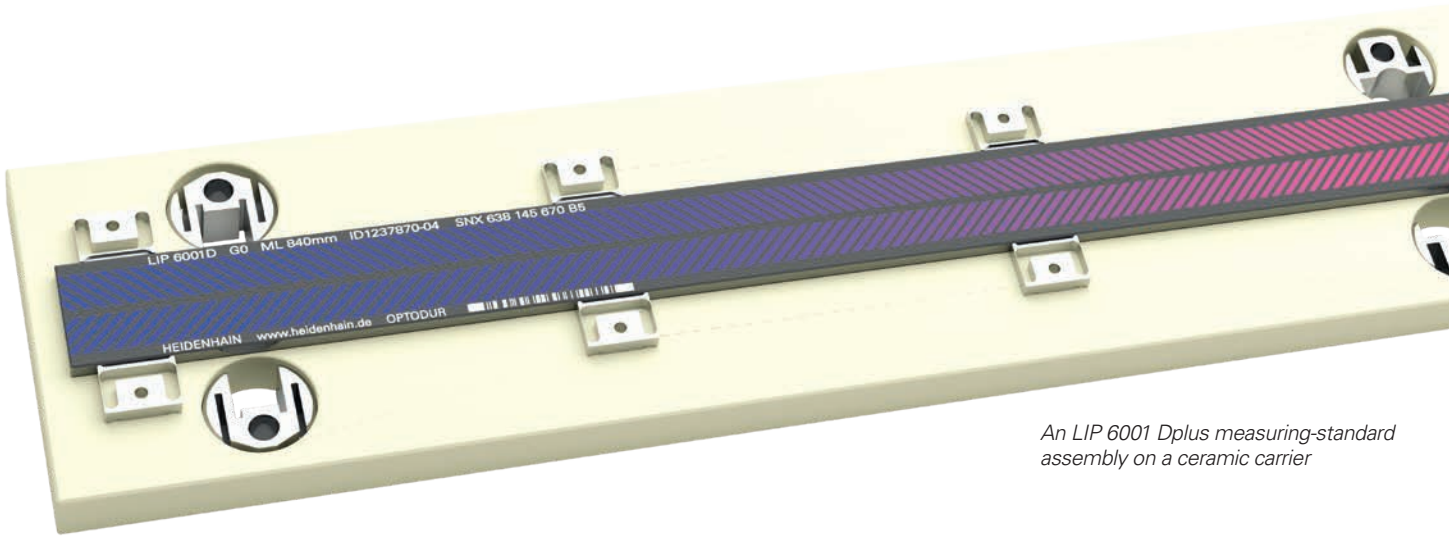


Degrees of freedom: X, Y, Z, R_Y, R_Z

D*plus* measuring standard
with three scanning heads and the
GAP 1081 gap encoder
with two scanning heads

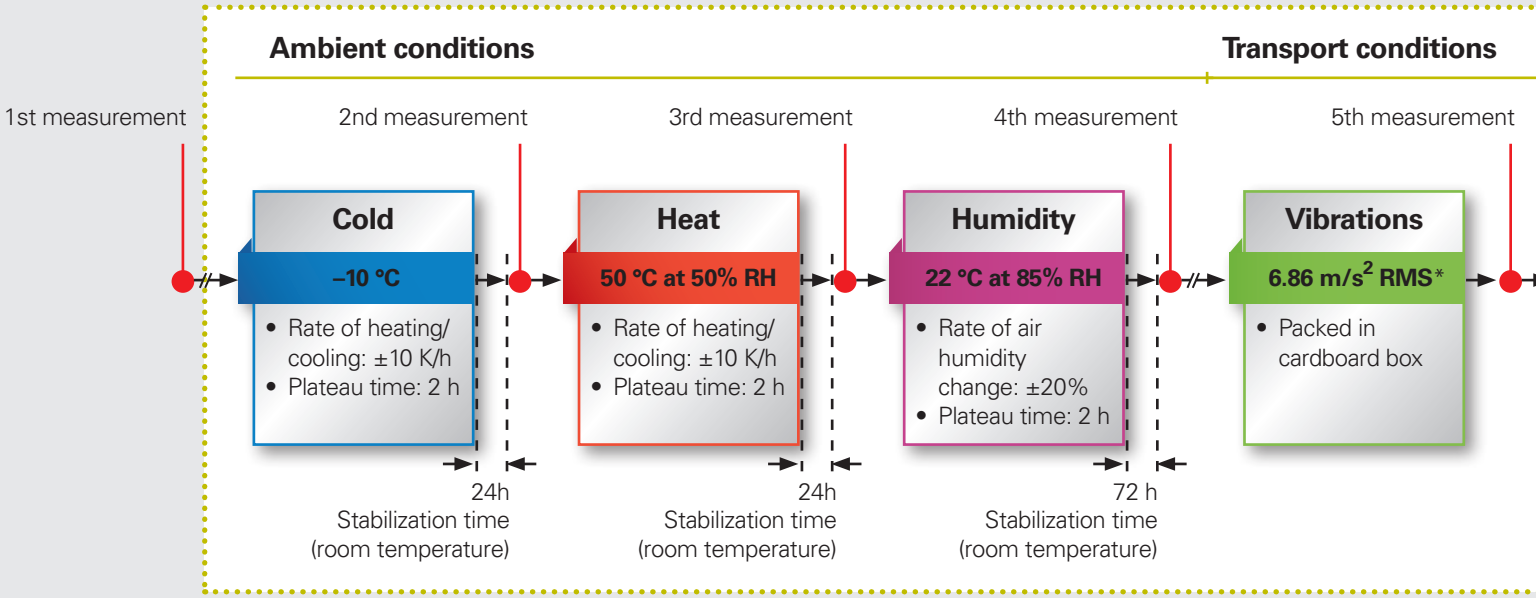


Transferable accuracy



An LIP 6001 Dplus measuring-standard assembly on a ceramic carrier

LIP 6001 D*plus*

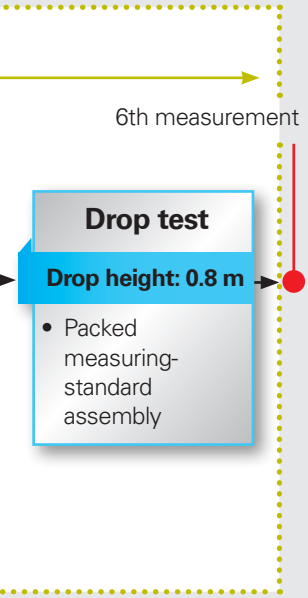


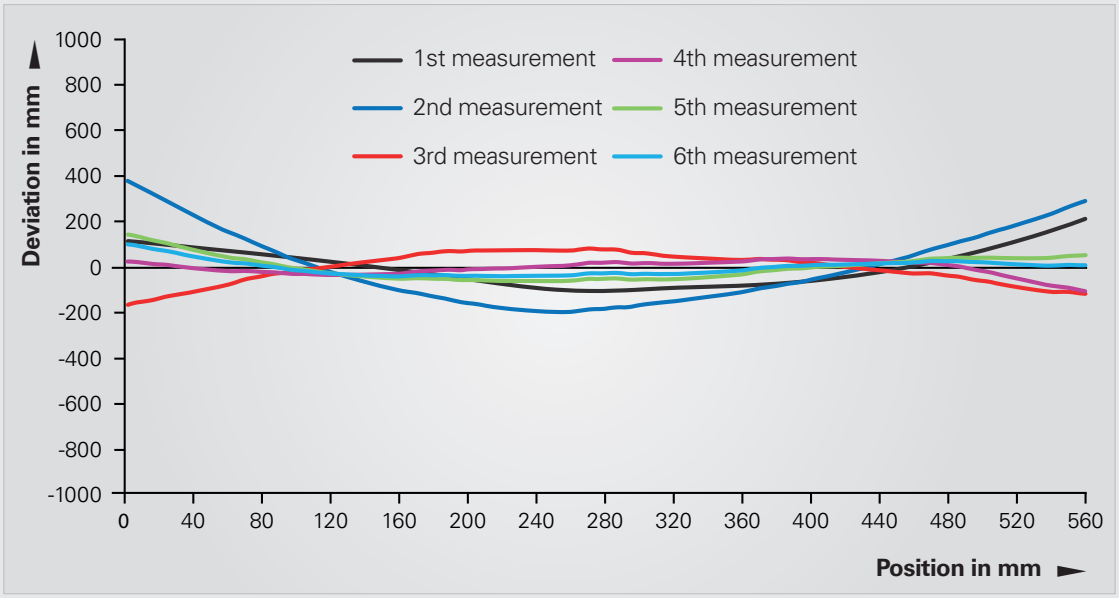
** 40 minutes: 3.92 m/s² RMS; 15 minutes: 5.29 m/s² RMS; 5 minutes: 6.86 m/s² RMS (ASTM D 4169)*

Robustness test for D*plus* measuring-standard assemblies

The system accuracy within an application depends not only on how well the encoder was installed but also on the ambient conditions during operation. Thanks to measuring-standard calibrations performed using measuring machines at HEIDENHAIN, the accuracy of the measuring system is increased, and complex on-site calibrations are not needed after installation.

Prior to shipment, the measuring standard is also mounted to a carrier and measured at HEIDENHAIN, thereby decoupling the measuring standard from negative factors associated with transportation, mounting, and the surrounding environment. This approach ensures that the accuracy measured at HEIDENHAIN is fully transferred from the measuring machine to the application. The calibration table is included.





Straightness deviation relative to measuring length

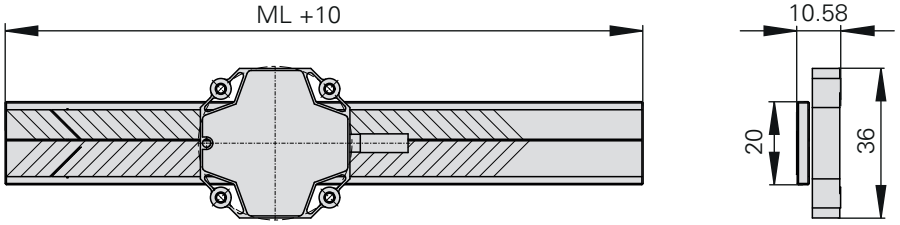
LIP 6031 D*plus*

Incremental exposed linear encoder

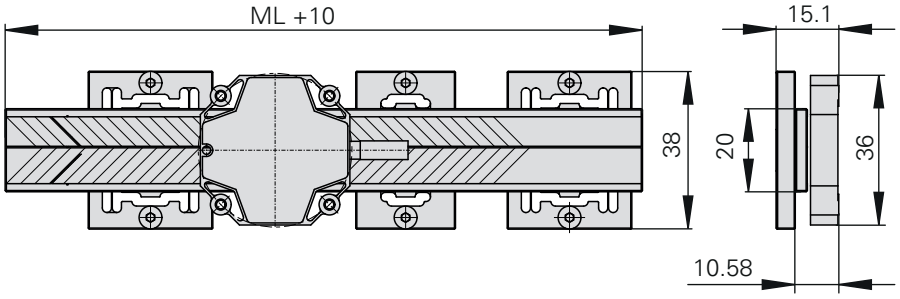
- Two diagonal graduations ±45° for measuring the primary and secondary directions
- Scale made of glass ceramic

Main dimensions (without tolerances)

Mating dimensions
for bonding with adhesive film



Mating dimensions
for fastening with flex elements



For technical drawings, visit www.heidenhain.com/documentation.

Mating dimensions (bonded)
ID 1359299

Mating dimensions (flex elements)
ID 1471886

Scale	LIP 6001 D*plus*
Measuring standard Coefficient of linear expansion	OPTODUR phase grating on Zerodur glass ceramic; graduation period: 8 µm $\alpha_{therm} \approx (0 \pm 0.1) \cdot 10^{-6}\ K^{-1}$
Accuracy grade	X direction: ±3 µm; Y direction: ±20 µm
Baseline error	X direction: ±0.175 µm/5 mm; Y direction: ±0.350 µm/5 mm
Measuring length (ML) in X direction in mm*	70 120 170 220 270 320 370 420 470 520 570 620 670 720 770 820 870 920 970 1020 1140 1240 1340 1440 1540 1640 1840 2040 2240 2440 2640 2840 3040
Measuring length in Y direction	±2 mm
Reference mark	One at 68 mm from beginning of measuring length (for ML up to 120: at midpoint of ML)
Mass	0.15 g/mm

Scanning head		AK LIP 603 D*plus*
Data interface		EnDat 3
Ordering designation		E30-R4
Measuring step		172 pm
Availability of position value		X direction: < 11 µs at 12.5 Mbit/s; < 8.2 µs at 25 Mbit/s[1)] Y direction: < 18.7 µs at 12.5 Mbit/s; < 12.1 µs at 25 Mbit/s[2)]
Traversing speed		≤ 240 m/min[3)]
Interpolation error		±5 nm
RMS position noise		0.5 nm (1 MHz)
Electrical connection		Cable (0.5 m / 1 m / 3 m) with interface electronics in the connector (15-pin D-sub (male))
Cable length		12.5 Mbit/s: ≤ 100 m; 25 Mbit/s: ≤ 40 m During signal adjustment with the PWM 21: ≤ 3 m
Supply voltage		DC 3.6 V to 14 V (recommended: 12 V)
Power consumption[4)] (max.)		3.6 V: ≤ 1.5 W; 14 V: ≤ 1.8 W
Current consumption		At 12 V: 110 mA (without load, typical)
Vibration 55 Hz to 2 kHz **Shock** 11 ms		≤ 500 m/s² (EN 60068-2-6) ≤ 1000 m/s² (EN 60068-2-27)
Operating temperature		–10 °C to 70 °C
Mass	Scanning head APE connector Cable	30 g 77 g 36 g/m

* Please select when ordering
1) This value is stored as the parameter XEL.timeHPFout in the encoder and indicates the time interval between the position-value request (latch) and the availability of the position value in the master (without cable influences)
2) With transmission in the first LPF
3) Maximum traversing speed when crossing the reference mark: 120 m/min
4) See "General electrical information" in the *Interfaces of HEIDENHAIN Encoders* brochure

LIP 6081 D*plus*

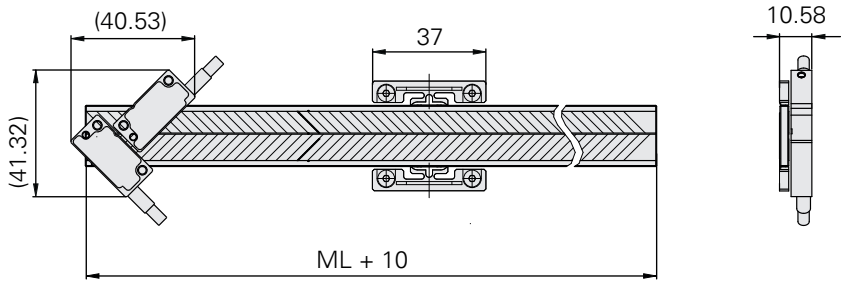
LIP 6000 D*plus* series

Incremental exposed linear encoder

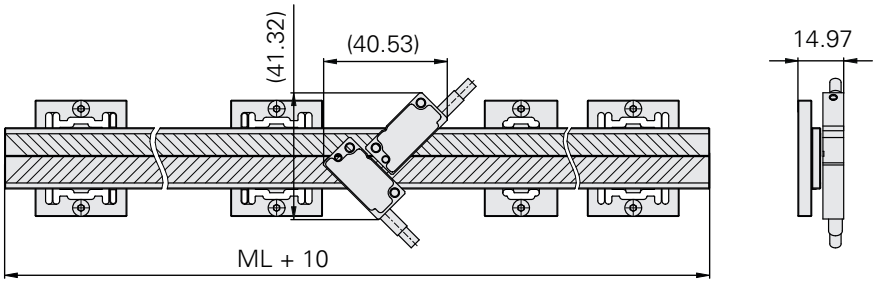
- Two diagonal graduations ±45° for measuring the primary and secondary directions
- Scale made of glass ceramic

Main dimensions (without tolerances)

Mating dimensions
for bonding with adhesive film



Mating dimensions
for fastening with flex elements



For technical drawings, visit www.heidenhain.com/documentation.

Mating dimensions (bonded)
ID 1407768

Mating dimensions (flex elements)
ID 1418362

Scale	**LIP 6001 D*plus***
Measuring standard Coefficient of linear expansion	OPTODUR phase grating on Zerodur glass ceramic; grating period: 8 µm $\alpha_{therm} = (0 \pm 0.1) \cdot 10^{-6}\ K^{-1}$
Accuracy grade	X direction: ±3 µm; Y direction: ±20 µm
Baseline error	X direction: ±0.175 µm/5 mm; Y direction: ±0.350 µm/5 mm
Measuring length (ML) in X direction in mm	70 120 170 220 270 320 370 420 470 520 570 620 670 720 770 820 870 920 970 1020 1140 1240 1340 1440 1540 1640 1840 2040 2240 2440 2640 2840 3040
Measuring length in Y direction	±2 mm
Reference mark	One at 68 mm from beginning of measuring length (for ML up to 120: at midpoint of ML)
Mass	0.15 g/mm

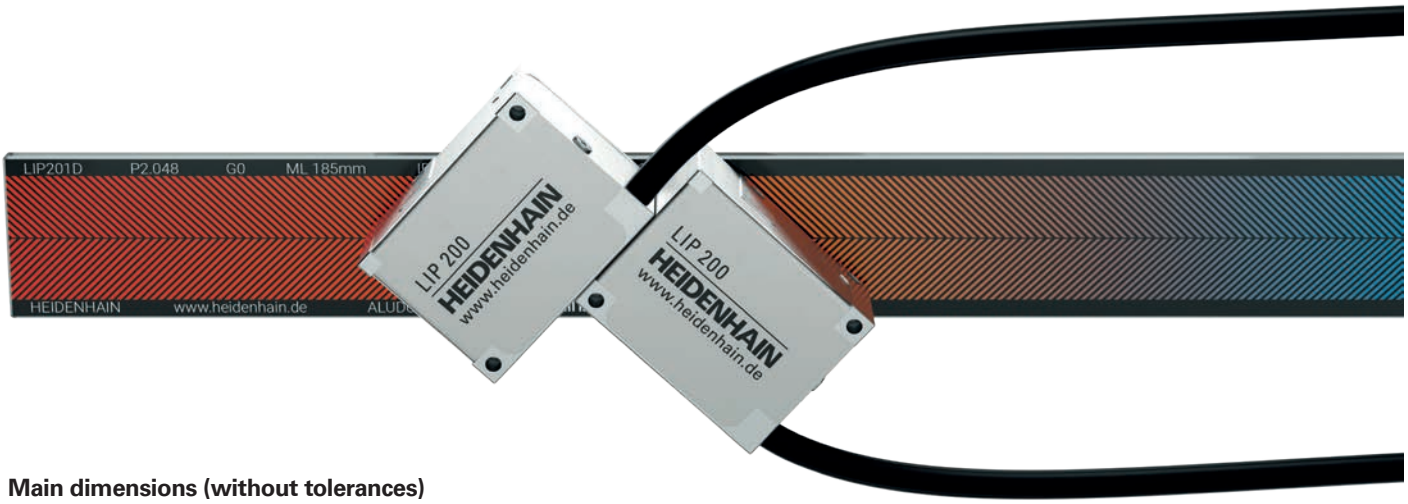
Scanning head	**LIP 608 D*plus***
Data interface	1 V_{PP}
Signal period	4 µm
Cutoff frequency –3 dB	≥ 1 MHz
Traversing speed	≤ 240 m/min[1)]
Interpolation error	±5 nm
RMS position noise	0.5 nm (1 MHz)
Electrical connection	Cable (0.5 m / 1 m / 3 m) with interface electronics in the connector (15-pin D-sub (male))
Cable length	With HEIDENHAIN cable ≤ 20 m During signal adjustment with the PWM 21: ≤ 3 m
Supply voltage	DC 5 V ±0.5 V
Current consumption	≤ 150 mA
Vibration 55 Hz to 2 kHz **Shock** 11 ms	≤ 500 m/s² (IEC 60068-2-6) ≤ 1000 m/s² (IEC 60068-2-27)
Operating temperature	–10 °C to 70 °C
Mass Scanning head APE connector Cable	≈ 5 g (without connecting cable) ≈ 71 g ≈ 24 g/m

[1)] Maximum traversing speed when crossing the reference mark: 120 m/min

LIP 211 D*plus*/LIP 281 D*plus*/LIP 291 D*plus*

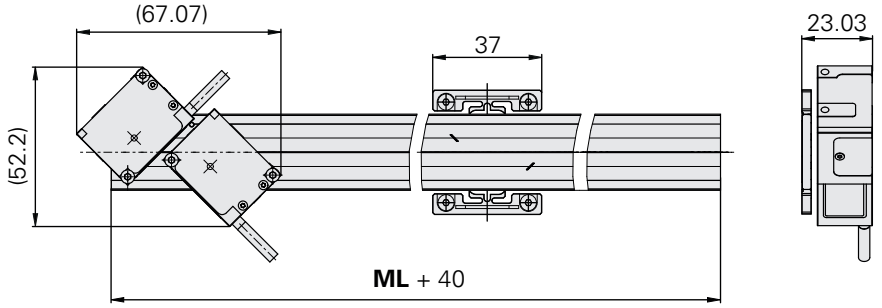
Incremental exposed linear encoder

- Two diagonal graduations ±45° for measuring the primary and secondary directions
- Scale made of glass ceramic

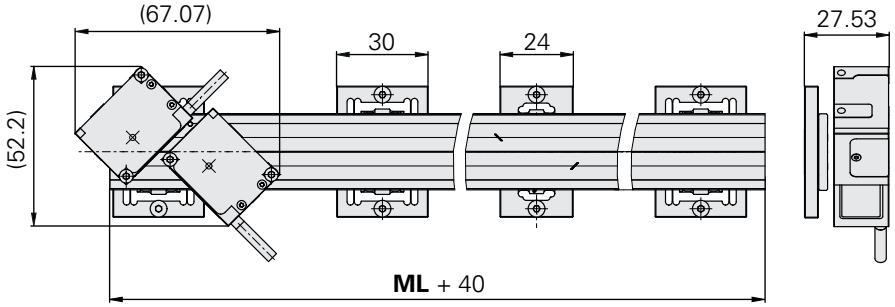


Main dimensions (without tolerances)

Mating dimensions
for bonding with adhesive film



Mating dimensions
for fastening with flex elements



For technical drawings, visit www.heidenhain.com/documentation.

Mating dimensions (bonded)
ID 1476903

Mating dimensions (flex elements)
ID 1412088

Scale	LIP 201 D*plus*
Measuring standard Coefficient of linear expansion	OPTODUR phase grating on Zerodur glass ceramic; graduation period: 2.048 µm $\alpha_{therm} \approx (0 \pm 0.1) \cdot 10^{-6}\ K^{-1}$
Accuracy grade	X direction: ±3 µm; Y direction: ±20 µm
Baseline error	X direction: ±0.125 µm/5 mm; Y direction: ±0.225 µm/5 mm
Measuring length (ML) in X direction in mm*	70 120 170 220 270 320 370 420 470 520 570 620 670 720
Measuring length in Y direction	±1 mm[1)]
Reference mark	One at midpoint of measuring length
Mass	7.2 g + 0.18 g/mm

Scanning head	AK LIP 21	AK LIP 29F	AK LIP 29M	AK LIP 28
Data interface	EnDat 2.2[2)]	Fanuc Serial Interface[2)]	Mitsubishi high speed[2)]	∿ 1 V_{PP}
Ordering designation	EnDat22	Fanuc02	Mit02-4	–
Integrated interpolation	16384-fold (14 bits)			–
Clock frequency	≤ 16 MHz	–		–
Calculation time t_{cal}	≤ 5 µs	–		–
Measuring step	0.03125 nm (31.25 pm)			–
Signal period	–			0.512 µm
Cutoff frequency –3 dB	–			≥ 3 MHz
Traversing speed	≤ 120 m/min			≤ 90 m/min
Interpolation error	±0.4 nm[3)]			
RMS position noise	0.12 nm			0.12 nm (3 MHz[4)])
Electrical connection	Cable 0.5 m or 1 m (2 m and 3 m for 1 V_{PP}) with interface electronics in the connector (15-pin D-sub (male))			
Cable length	See interface description; however ≤ 15 m (≤ 30 m with 1 V_{PP}) with HEIDENHAIN cable During signal adjustment with the PWM 21: ≤ 3 m			
Supply voltage	DC 3.6 V to 14 V			DC 5 V ±0.25 V
Power consumption[5)] (max.)	At 14 V: 2500 mW; at 3.6 V: 2600 mW			–
Current consumption	At 5 V: 300 mA (without load, typical)			≤ 390 mA
Laser	Mounted scanning head and scale: Class 1; non-mounted scanning head: Class 3B			
Vibration 55 Hz to 2000 Hz **Shock** 11 ms	≤ 200 m/s² (IEC 60068-2-6) ≤ 400 m/s² (IEC 60068-2-27)			
Operating temperature	0 °C to 50 °C			
Mass	Scanning head: 59 g; connector: 140 g; cable: 22 g/m			

* Please select when ordering; [1)] Measuring length in Y direction when crossing the reference mark: ±0.6 mm; [2)] Absolute position value after crossing the reference mark in "position value 2"; [3)] With HEIDENHAIN signal converter; [4)] –3 dB cutoff frequency of the downstream electronics; [5)] See "General electrical information" in the *Interfaces of HEIDENHAIN Encoders* brochure

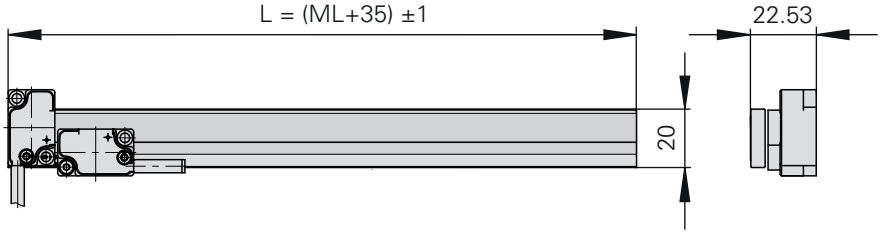
LIF 481 D*plus*

Incremental exposed linear encoder

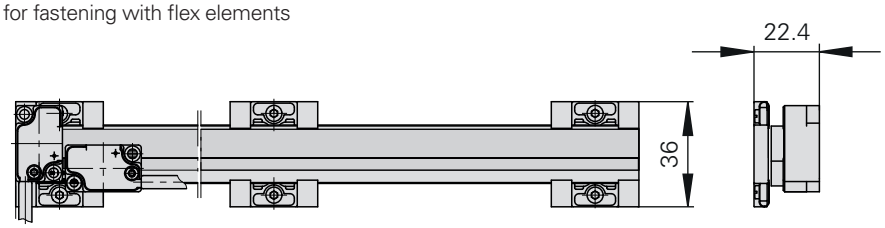
- Additional Y track for measurement of deviations perpendicular to the direction of measurement
- Glass ceramic, fastened with PRECIMET or fixing clamps

Main dimensions (without tolerances)

Mating dimensions
for bonding with adhesive film



Mating dimensions
for fastening with flex elements



For technical drawings, visit www.heidenhain.com/documentation.

Mating dimensions (bonded)
ID 1034159

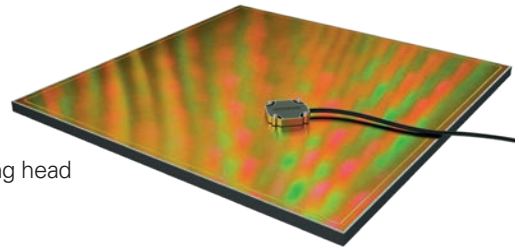
Mating dimensions (clamped)
ID 632154

Scale	LIF 401 D*plus*
Measuring standard Coefficient of linear expansion Grating period	SUPRADUR phase grating on Zerodur glass ceramic $\alpha_{therm} \approx (0 \pm 0.1) \cdot 10^{-6}\ K^{-1}$ 8 µm
Accuracy grade*	X direction: ±3 µm; Y direction: ±20 µm
Measuring length ML* in mm	70 120 170 220 270 320 370 420 470 520 570 620 670 720 770 820 870 920 970 1020 1140 1240 1340 1440 1540 1640 1840 2040 2240 2440 2640 2840 3040
Measuring range of Y track	±1 mm
Reference marks	One reference mark at beginning of measuring length
Mass	247 g/m

Scanning head	AK LIF 48	AK LIF 47				
Data interface	∿ 1 V_{PP}	⊓⊔ TTL				
Integrated interpolation* Signal period Measuring step[1]	– 4 µm –	5-fold 0.8 µm 0.2 µm	10-fold 0.4 µm 0.1 µm	20-fold 0.2 µm 0.05 µm	50-fold 0.08 µm 0.02 µm	100-fold 0.04 µm 0.01 µm
Cutoff frequency –3 dB	≥ 1 MHz	–				
Scanning frequency*	–	≤ 500 kHz ≤ 250 kHz ≤ 125 kHz	≤ 250 kHz ≤ 125 kHz ≤ 62.5 kHz	≤ 250 kHz ≤ 125 kHz ≤ 62.5 kHz	≤ 100 kHz ≤ 50 kHz ≤ 25 kHz	≤ 50 kHz ≤ 25 kHz ≤ 12.5 kHz
Edge separation *a*	–	≥ 0.080 µs ≥ 0.175 µs ≥ 0.370 µs	≥ 0.080 µs ≥ 0.175 µs ≥ 0.370 µs	≥ 0.040 µs ≥ 0.080 µs ≥ 0.175 µs	≥ 0.040 µs ≥ 0.080 µs ≥ 0.175 µs	≥ 0.040 µs ≥ 0.080 µs ≥ 0.175 µs
Traversing speed[2]	≤ 240 m/min	≤ 120 m/min ≤ 60 m/min ≤ 30 m/min	≤ 60 m/min ≤ 30 m/min ≤ 15 m/min	≤ 60 m/min ≤ 30 m/min ≤ 15 m/min	≤ 24 m/min ≤ 12 m/min ≤ 6 m/min	≤ 12 m/min ≤ 6 m/min ≤ 3 m/min
Interpolation error **RMS position noise**	±12 nm 0.6 nm (1 MHz[3])	–				
Electrical connection*	Cable (0.5 m / 1 m / 3 m) with 15-pin D-sub connector (male); interface electronics in the connector					
Cable length	See interface description; however, incremental: ≤ 30 m; if homing/limit switch: ≤ 10 m (with HEIDENHAIN cable)					
Supply voltage	DC 5 V ±0.25 V					
Current consumption	< 150 mA	< 165 mA (without load)				
Vibration 55 Hz to 2000 Hz **Shock** 11 ms	≤ 400 m/s² (EN 60068-2-6) ≤ 500 m/s² (EN 60068-2-27)					
Operating temperature	0 °C to 50 °C					
Mass Scanning head* Connector Cable	For scale made of Zerodur glass ceramic: 25 g 75 g 38 g/m					

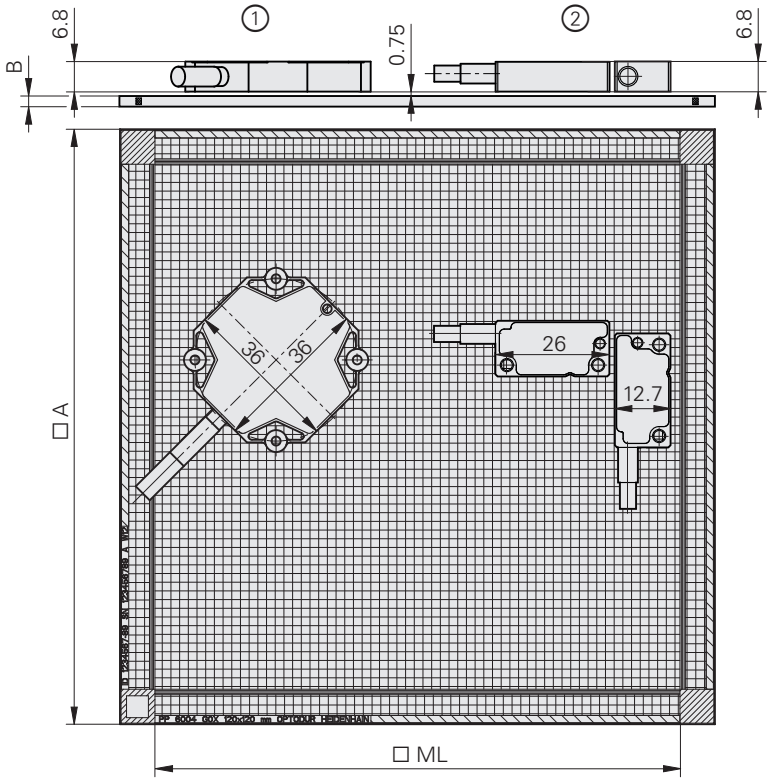
* Please select when ordering
[1] After 4-fold evaluation
[2] With TTL: Maximum traversing speed during referencing: 9.6 m/min (40 kHz)
[3] –3 dB cutoff frequency of the downstream electronics

PP 6000

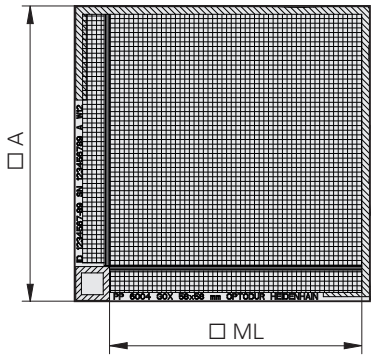


Two-coordinate incremental encoder

- Two main directions of measurement
- Simultaneous measurement of two degrees of freedom with one AK PP 603 scanning head
- Grid plate made of glass ceramic
- Adhesively bonded grid plate (centered thermal fixed point)



Reference mark along all edges



Reference mark along two edges

Grid plate	ML*	A	B	Reference mark
PP 6002	480 x 480	498 x 498	10	Along all edges
	237 x 237	248 x 248		Along two edges
PP 6004	120 x 120	136 x 136	2.9	Along all edges
	58 x 58	68 x 68		Along two edges

1 = AK PP 603 scanning head
2 = Multiple AK PP 608 scanning heads
* The achievable measuring length when using multiple scanning heads depends on how they are arranged.

For technical drawings, visit www.heidenhain.com/documentation.

Mating dimensions
ID 1411216

Adhesive interface
ID 1459013

Grid plate	PP 6004 grid plate		PP 6002 grid plate	
Measuring standard[1] Coefficient of linear expansion	OPTODUR phase grating on glass ceramic; graduation period: 8 µm α_{therm} = (0±0.5) · 10^{-6} K^{-1} (ML 120 x 120) α_{therm} = (0±0.1) · 10^{-6} K^{-1} (ML 480 x 480)			
Accuracy grade	±2 µm (measuring range: 58 x 58 and 120 x 120)		±3 µm (measuring range: 237 x 237 and 480 x 480)	
Baseline error	±0.175 µm/5 mm (not adhesively bonded) ±0.300 µm/5 mm (adhesively bonded by customer)			
Measuring range in mm*	58 x 58	120 x 120	237 x 237	480 x 480
Outer dimensions in mm	68 x 68	136 x 136	248 x 248	498 x 498
Thickness in mm	2.9		10	
Reference mark	One for each direction of measurement	Two for each direction of measurement	One for each direction of measurement	Two for each direction of measurement
Mass	130 g	540 g	1555 g	6250 g
Scanning head	**AK PP 603**		**AK PP 608**	
Data interface	EnDat 3		1 V_{PP}	
Ordering designation	E30-R4		–	
Measuring step	244 pm		–	
Availability of position value	X direction: < 11 µs at 12.5 Mbit/s; < 8.2 µs at 25 Mbit/s[2] Y direction: < 18.7 µs at 12.5 Mbit/s; < 12.1 µs at 25 Mbit/s[3]		–	
Traversing speed	≤ 240 m/min[4]			
Interpolation error	±5 nm			
RMS position noise	0.8 nm (250 kHz); 1.5 nm (1 MHz)			
Electrical connection	Cable (0.5 m / 1 m / 3 m) with interface electronics in the connector (15-pin D-sub (male))		Cable (0.5 m / 1 m / 3 m) with 15-pin D-sub connector (male) Cable (0.5 m / 1 m / 1.5 m / 3 m) with 12-pin SHR-12V-S connector (female)	
Cable outlet	Straight		Left, right, straight, angled	
Cable length	12.5 Mbit/s: ≤ 100 m; 25 Mbit/s: ≤ 40 m During signal adjustment with the PWM 21: ≤ 3 m		With HEIDENHAIN cable ≤ 20 m During signal adjustment with the PWM 21: ≤ 3 m	
Supply voltage	DC 3.6 V to 14 V (recommended: 12 V)		DC 5 V ±0.5 V	
Power consumption[5] (max.)	3.6 V: ≤ 1.5 W; 14 V: ≤ 1.8 W		–	
Current consumption	At 12 V: 110 mA (without load, typical)		≤ 150 mA	
Vibration 55 Hz to 2 kHz **Shock** 11 ms	≤ 500 m/s^2 (IEC 60068-2-6) ≤ 1000 m/s^2 (IEC 60068-2-27)			
Operating temperature	–10 °C to 70 °C			
Mass Scanning head APE connector Cable	≈ 30 g ≈ 77 g ≈ 36 g/m		≈ 5 g ≈ 71 g ≈ 24 g/m	

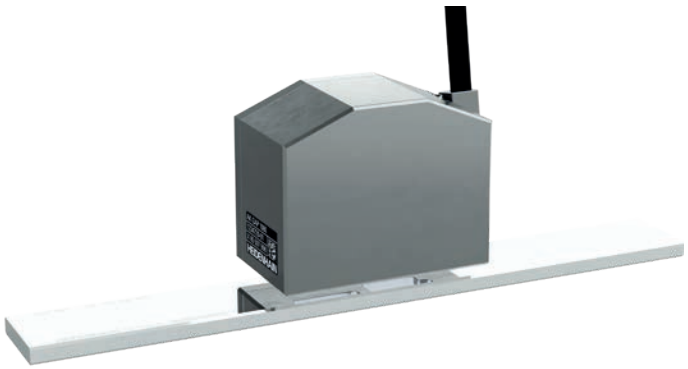
* Please select when ordering
[1] Other materials upon request
[2] This value is stored in the encoder as the parameter XEL.timeHPFout and indicates the time interval between the position-value request (latch) and the availability of the position value in the master (without cable factors)
[3] With transmission in the first LPF
[4] Maximum traversing speed when crossing the reference mark: 120 m/min
[5] See "General electrical information" in the *Interfaces of HEIDENHAIN Encoders* brochure

GAP 1081

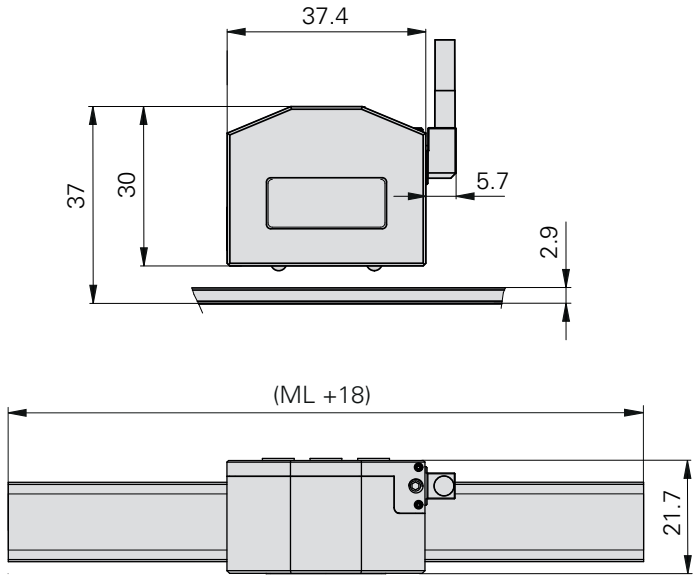
GAP 1081

Incremental exposed linear encoder

- For vertical gap measurement
- Mirror on glass; mounting with PRECIMET



Main dimensions (without tolerances)



For technical drawings, visit www.heidenhain.com/documentation.

Mating dimensions
ID 1345874

Mirror	**GAP 1001**
Mirror Coefficient of linear expansion	Glass or glass ceramic with OPTODUR surface layer $\alpha_{therm} \approx (0 \pm 0.1) \cdot 10^{-6}\ K^{-1}$ (Zerodur glass ceramic)
Measuring length (ML) in mm*	20 30 50 70 120 170 220 270 320 370 420 470 520 570 620 670 720 780 820 870 920 970 1020 1140 1240 1340 1440 1540 1640 1840 2040 2240 2440 2640 2840 3040
Mass	1.1 g + 0.11 g/mm of mirror length

Scanning head	**AK GAP 108**
Scanning gap (nominal)	4.139 mm
Measuring range	±2 mm
Reference mark	Possible upon request
Data interface	1 V_{PP}
Cutoff frequency –3 dB	≥ 27 kHz
Signal period Coefficient of linear expansion	2.22 µm ±0.002 µm $\alpha_{therm} \approx 0.5 \cdot 10^{-6}\ K^{-1}$
Traversing speed	3.6 m/min
Accuracy grade	±0.2 µm (stationary measurement in the direction of measurement) ±20 µm (motion perpendicular to the direction of measurement)
Baseline error	≤ ±30 nm/4 mm (stationary measurement in the direction of measurement) ≤ ±0.5 µm/5 mm (motion perpendicular to the direction of measurement)
Thermal position drift	≤ ±36 nm/K
Interpolation error	±2 nm
Non-reproducible position error	±5 nm
Electrical connection	Cable (0.5 m / 1 m / 3 m) with 15-pin D-sub connector; interface electronics in the connector
Cable length	With HEIDENHAIN cable: ≤ 30 m During signal adjustment with the PWM 21: ≤ 3 m
Supply voltage	DC 5 V ±0.25 V
Current consumption	≤ 200 mA (without load)
Laser	Class 3B
Vibration 55 Hz to 2 kHz **Shock** 11 ms	≤ 200 m/s^2 (IEC 60068-2-6) ≤ 400 m/s^2 (IEC 60068-2-27)
Operating temperature	10 °C to 40 °C
Mass Scanning head Connector Cable	50 g 80 g 27 g/m

* Please select when ordering

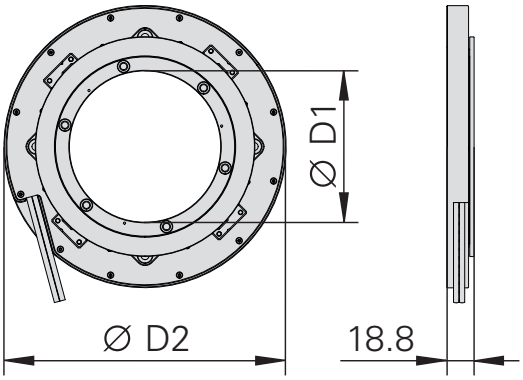
ERP 1080 D*plus*

ERP 1080 D*plus*

High-accuracy angle encoder without integral bearing

- Very high system accuracy
- Robust angular measurement
- Low mass and low mass moment of inertia
- Consisting of a scanning ring and a circular scale

Main dimensions (without tolerances)



For technical drawings, visit www.heidenhain.com/documentation.

Mating dimensions (bonded)
ID 1410142

Encoder	ERP 1080 D*plus*
Measuring standard	OPTODUR circular scale on steel hub
Signal periods*	63000
System accuracy	±0.4″
Position error per signal period[1]	±0.02″
RMS position noise (500 kHz)	0.001″
Reference marks	One
Outside diameter of scanning ring	194 mm
Inside diameter of hub	104 mm
Outside diameter of circular scale	151 mm
Mech. permiss. shaft speed	≤ 950 rpm
Elec. permiss. shaft speed	≤ 475 rpm
Moment of inertia of the scale hub	$1.1 \cdot 10^{-3}$ kgm^2
Protection EN 60529	Complete encoder when mounted: IP00
Data interface[2]	4 × ∿ 1 V_{PP}
Reference mark signal	Square-wave pulse
Cutoff frequency –3 dB	≥ 500 kHz
Electrical connection[2]	Four 1.5 m cables with 15-pin D-sub connector (male)
Cable length[2]	With HEIDENHAIN cable: ≤ 20 m during signal adjustment with the PWM 21: ≤ 3 m
Voltage supply[2]	DC 5 V ±0.5 V
Current consumption[2]	≤ 150 mA (without load)
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 200 m/s^2 (EN 60068-2-6) ≤ 200 m/s^2 (EN 60068-2-27)
Operating temperature	0 °C to 50 °C
Storage temperature	–20 °C to 60 °C
Mass Scanning ring Connector Cable Disk/hub assembly	≈ 1.1 kg (without cable) ≈ 75 g ≈ 22 g/m ≈ 289 g

[1] The encoder-specific error is determined based on the position error within one signal period and on the accuracy of the graduation; for information about additional errors due to the mounting and bearing of the measured shaft, see "Measurement accuracy" in the *Modular Angle Encoders with Circular Scale* brochure

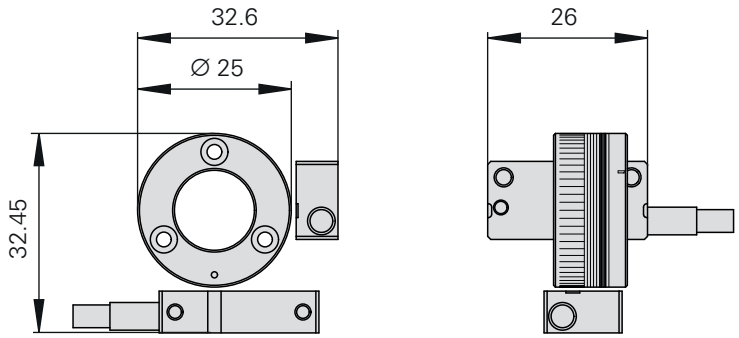
[2] Separate electrical connection for each scanning head

ERO 2900 D*plus*

Modular angle encoder with linear measurement capability

- High resolution and accuracy
- Low mass and low mass moment of inertia
- Consisting of a scale drum (TTR) and two scanning heads (AK)
- Linear track in addition to angular measurement

Main dimensions (without tolerances)



For technical drawings, visit www.heidenhain.com/documentation.

Mating dimensions
ID 1398594

Cable outlets/connecting elements
ID 1223068

Scale drum	TTR ERO 2900 D*plus*		
Measuring standard	Steel: $\alpha_{therm} = 16 \cdot 10^{-6} K^{-1}$		
Measuring range	360°		
Drum inside diameter	13 mm		
Drum outside diameter	25 mm		
Drum height	12 mm		
Vibration 55 Hz to 2000 Hz	≤ 500 m/s² (EN 60068-2-6)		
Shock 11 ms	≤ 500 m/s² (EN 60068-2-27)		
Mech. permiss. shaft speed	≤ 15 000 rpm		
Angular track		**Linear track**	
Signal periods	4400	Measuring range	±1 mm over 360°
Reference marks	One	Reference marks	One (circumferential)
Accuracy of graduation[1]	±15″	Accuracy grade	±1 µm after linear length-error compensation in the downstream electronics
Baseline error[2]	Upon request		
Position error per signal period[2]	Upon request	Position error per signal period[3]	Upon request
Position noise RMS (400 kHz)	Upon request	Position noise RMS (400 kHz)	Upon request

[1] When centered with two scanning heads
[2] For mechanical centering as per the mounting instructions
[3] Along the reference mark: ±40 nm

Scanning head	AK ERO 2980/AK ERO 2980 L
Data interface	∿ 1 V_{PP}
Reference mark signal	Square-wave pulse
Cutoff frequency –3 dB	≥ 400 kHz[1]
Electrical connection*	15-pin D-sub connector (male) with 0.5 m / 1 m / 1.5 m / 3 m cable 12-pin SHR-12V-S connector (female) with 0.5 m / 1 m / 1.5 m / 3 m cable Cable outlet on the left or right and straight or angled
Cable length	With HEIDENHAIN cable: ≤ 20 m during signal adjustment with the PWM 21: ≤ 3 m
Supply voltage	DC 5 V ±0.5 V
Current consumption	≤ 150 mA (without load)
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 500 m/s² (EN 60068-2-6) ≤ 1000 m/s² (EN 60068-2-27)
Operating temperature	–10 °C to 70 °C
Protection	IP50
Mass	Scanning head ≈ 5 g (without cable); connector ≤ 75 g; cable ≈ 22 g/m

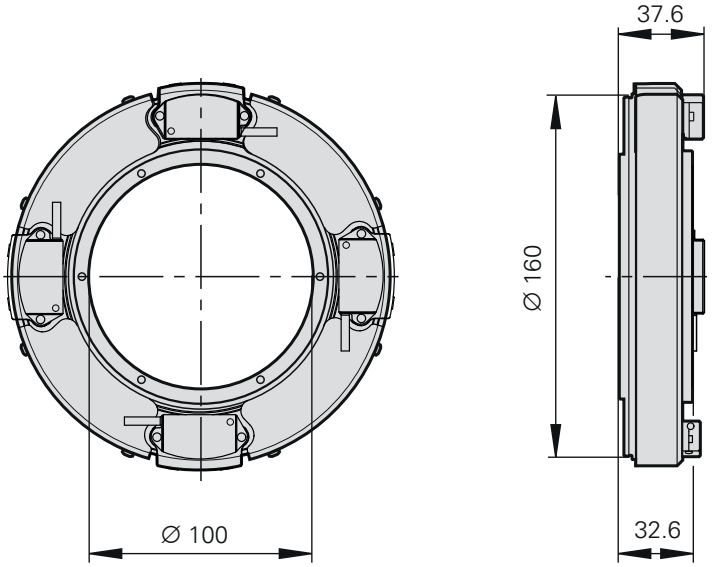
* Please select when ordering
[1] Up to 1 MHz can be implemented

MRP 8081 D*plus*

Angle encoder module with four scanning heads and compensation data

- Very high system accuracy
- Robust angle measurement
- Hollow shaft: Ø 100 mm
- Axial load of up to 300 N

Main dimensions (without tolerances)



For technical drawings, visit www.heidenhain.com/documentation.

Mating dimensions
ID 1453106

Encoder	MRP 8081 D*plus*
Measuring standard	OPTODUR circular scale
Signal periods	63000
System accuracy	±0.40″
Position error per signal period	±0.06″
Repeatability	From both directions: 0.1″
RMS position noise	Typically 0.0015″
Data interface[1)]	4 x ∿ 1 V_{PP}
Reference marks	150 (distance-coded)
Cutoff frequency –3 dB	≥ 500 kHz
Electrical connection[1)]	4 x 1.5 m cable with 15-pin D-sub connector; interface electronics inside the connector
Cable length[1)]	≤ 30 m (with HEIDENHAIN cable)
Supply voltage[1)]	DC 5 V ±0.25 V
Power consumption[1)] (max.)	5.25 V: ≤ 950 mW
Current consumption (typical)[1)]	175 mA (without load)

[1)] Separate electrical connection for each scanning head

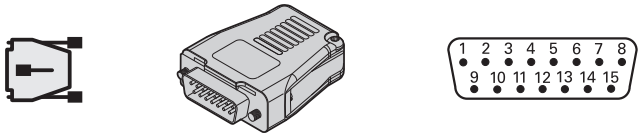
Bearing	MRP 8081 D*plus*
Shaft	Hollow through shaft D = 100 mm
Max. permiss. axial load[1)]	300 N (centered load)
Max. permiss. radial load[1)]	100 N
Max. permiss. tilting torque[1)]	6 Nm
Contact stiffness	Axial: 684 N/µm Radial: 367 N/µm (calculated values)
Resistance to tilt	1250 Nm/mrad (calculated value)
Mech. permiss. shaft speed	300 rpm
Moment of friction	≤ 0.2 Nm
Starting torque	≤ 0.2 Nm
Max. transferable shaft torque[1)]	10 Nm
Moment of inertia of rotor	$2.8 \cdot 10^{-3}$ kgm^2
Radial guideway accuracy	≤ 0.15 µm (measured at distance h = xx mm from the mating surface of the rotor[2)])
Non-reproducible radial guideway accuracy	≤ 0.20 µm (measured at distance h = xx mm from the mating surface of the rotor[2)])
Axial guideway accuracy	≤ ±0.15 µm
Axial runout of the shaft	≤ 4 µm
Wobble of the axis	0.5″
Vibration 55 Hz to 2000 Hz **Shock** 6 ms	≤ 200 m/s^2 (EN 60068-2-6) ≤ 1000 m/s^2 (EN 60068-2-27) (without load)
Protection EN 60529[3)]	IP20
Operating temperature **Storage temperature**	0 °C to 50 °C 0 °C to 50 °C
Relative air humidity	≤ 75% without condensation
Mass	2.15 kg (without cable or connector)

1) Purely static load, without additional vibrations or shock load
2) See the "Measuring and bearing accuracy" section in the *Angle Encoder Modules* brochure
3) When mounted

Pin layout

LIP 603 D*plus* and PP 603

15-pin D-sub connector



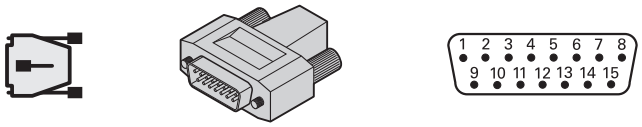
	Power supply				Other signals									Serial data transmission	
	4	**12**	**2**	**10**	**1**	**9**	**3**	**11**	**14**	**7**	**13**	**5**	**6**	**8**	**15**
	U_P	**Sensor** U_P	**0 V**	**Sensor** 0 V	**Vacant**	**Vacant**	**Vacant**	**Vacant**	**Vacant**	**Vacant**	**Vacant**	**Vacant**	**Vacant**	**SD+**	**SD–**
1)	Brown/ Green	/	White/ Green	/	/	/	/	/	/	/	/	/	/	Violet	Yellow

1) Color assignment of the connecting cable

Shield on housing; **U_P** = Power supply voltage
Sensor: The sense line is connected in the encoder with the corresponding power supply line.
Vacant pins or wires must not be used.

Pin layout for LIP 211 D*plus* (EnDat) and LIP 291 D*plus* (Fanuc)

15-pin D-sub connector

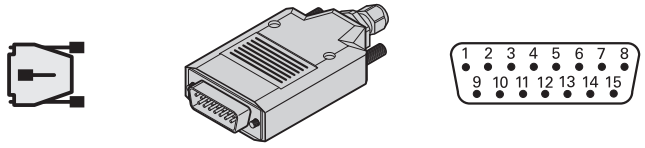


	Power supply				Serial data transmission			
	4	**12**	**2**	**10**	**5**	**13**	**8**	**15**
EnDat	**U_P**	**Sensor** U_P	**0 V**	**Sensor** 0 V	**DATA**	**$\overline{\text{DATA}}$**	**CLOCK**	**$\overline{\text{CLOCK}}$**
Fanuc					**Serial Data**	**$\overline{\text{Serial Data}}$**	**Request**	**$\overline{\text{Request}}$**
	Brown/Green	Blue	White/Green	White	Gray	Pink	Violet	Yellow

Shield on housing; **U_P** = Power supply voltage
Sensor: The sense line is connected in the encoder with the corresponding power supply line.
Vacant pins or wires must not be used.

LIP 281

15-pin D-sub connector



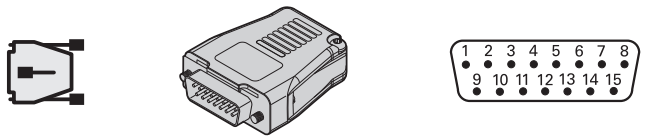
	Power supply				Incremental signals						Other signals			
	4	**12**	**2**	**10**	**1**	**9**	**3**	**11**	**14**	**7**	**13**	**5**	**6/8**	**15**
~ 1 V_{PP}	**U_P**	**Sensor** 5 V	**0 V**	**Sensor** 0 V	**A+**	**A–**	**B+**	**B–**	**R+**	**R–**	**As-signed**[1] **Vacant**[3]	**As-signed**[1] **Vacant**[3]	**/**	**As-signed**[1] **Vacant**[3]
[2]	Brown/ Green	Blue	White/ Green	White	Brown	Green	Gray	Pink	Red	Black	Violet	Red/ Black	/	Yellow

[1] For adjustment purposes only; do not assign in normal operation
[2] Color assignment of the connecting cable
[3] PP 281 R

Shield on housing; **U_P** = Power supply voltage
Sensor: The sense line is connected in the encoder with the corresponding power supply line.
Vacant pins or wires must not be used.

LIF 481 D*plus*, LIP 6081 D*plus*, and PP 6081

15-pin D-sub connector



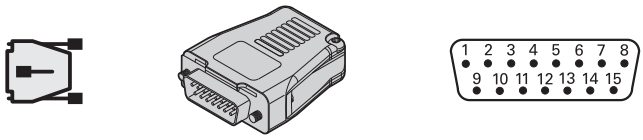
	Power supply				Incremental signals						Other signals				
	4	**12**	**2**	**10**	**1**	**9**	**3**	**11**	**14**	**7**	**13**	**8**	**6**	**15**	**5**
~ 1 V_{PP}	**U_P**	**Sensor** 5 V	**0 V**	**Sensor** 0 V	**A+**	**A–**	**B+**	**B–**	**R+**	**R–**	**As-signed**	**Vacant**	**Vacant**	**As-signed**	**Vacant**
[2]	Brown/ Green	Blue	White/ Green	White	Brown	Green	Gray	Pink	Red	Black	Violet	Green/ Black	Yellow/ Black	Yellow	/

[1] TTL/11 μA_{PP} conversion for the PWT
[2] Color assignment of the connecting cable

Shield on housing; **U_P** = Power supply voltage
Sensor: The sense line is connected in the encoder with the corresponding power supply line.
Vacant pins or wires must not be used.

GAP 1081

15-pin D-sub connector



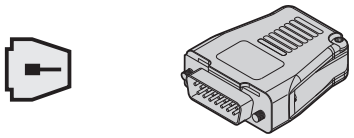
	Power supply				Incremental signals						Serial data transmission				
	4	**12**	**2**	**10**	**1**	**9**	**3**	**11**	**14**	**7**	**13**	**15**	**8**	**6**	**5**
~ 1 V_{PP}	**U_P**	**Sensor** 5 V	**0 V**	**Sensor** 0 V	**A+**	**A–**	**B+**	**B–**	**R+**	**R–**	**SD+**	**SD–**	**Vacant**	**Vacant**	**Vacant**
[1]	Brown/ Green	Blue	White/ Green	White	Brown	Green	Gray	Pink	Red	Black	Violet	Yellow	/	/	/

[1] Color assignment of the connecting cable

Shield on housing; **U_P** = Power supply voltage
Sensor: The sense line is connected in the encoder with the corresponding power supply line.
Vacant pins or wires must not be used.

ERP 1080 D*plus*

15-pin D-sub connector (male)



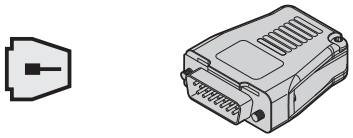
	Power supply				Incremental signals						Other signals				
	4	**12**	**2**	**10**	**1**	**9**	**3**	**11**	**14**	**7**	**13**	**15**	**5**	**6**	**8**
~ 1 V_{PP}	**U_P**	**Sensor** U_P	**0 V**	**Sensor** 0 V	**A+**	**A–**	**B+**	**B–**	**R+**	**R–**	**Vacant**[1]	**Vacant**[1]	**Vacant**	**Vacant**	**Vacant**
	Brown/ Green	/	White/ Green	/	Brown	Green	Gray	Pink	Red	Black	Violet	Yellow	/	/	/

[1] Required for signal adjustment with the PWM 21

Shield lies on housing; **U_P** = Power supply voltage
Sensor: The sense line is connected in the connector with the corresponding power line.
Vacant pins or wires must not be used.

ERO 2900 D*plus*

15-pin D-sub connector (male)



12-pin SHR-12V-S connector (female)

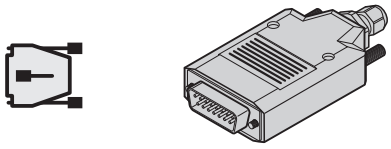
	Power supply				Incremental signals						Other signals			
	4	**12**	**2**	**10**	**1**	**9**	**3**	**11**	**14**	**7**	**13**	**8**	**6**	**15**
	1	**–**	**2**	**–**	**3**	**4**	**6**	**5**	**8**	**7**	**9**	**12**	**10**	**11**
1 V_{PP}	**U_P**	**Sensor** U_P	**0 V**	**Sensor** 0 V	**A+**	**A–**	**B+**	**B–**	**R+**	**R–**	**Vacant**[1)]	**/**	**/**	**Vacant**[1)]
	Brown/ Green	/	White/ Green	/	Brown	Green	Gray	Pink	Red	Black	Violet	Green/ Black	Yellow/ Black	Yellow

[1)] Required for signal adjustment with the PWM 21

Shield lies on housing; **U_P** = Power supply voltage
Sensor: The sense line is connected in the connector with the corresponding power line.
Vacant pins or wires must not be used.

MRP 8081 D*plus*

15-pin D-sub connector



	Power supply				Incremental signals						Other signals		
	4	**12**	**2**	**10**	**1**	**9**	**3**	**11**	**14**	**7**	**5/6/8/15**	**13**	**/**
1 V_{PP}	**U_P**	**Sensor** U_P	**0 V**	**Sensor** 0 V	**A+**	**A–**	**B+**	**B–**	**R+**	**R–**	**Vacant**[1)]	**Vacant**[1)]	**Vacant**
	Brown/ Green	Blue	White/ Green	White	Brown	Green	Gray	Pink	Red	Black	/	Violet	Yellow

Cable shield connected to housing; **U_P** = Power supply voltage
Sensor: The sense line is connected in the encoder with the corresponding power supply line.
Vacant pins or wires must not be used.

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1349070-23 · 03/2026 · CD · Printed in Germany