MICRO-EPSILON

# More Precision.

## wireSENSOR applications

## wireSENSOR measurement principle

Draw-wire displacement measurement is classified as a contact measurement method. Every draw-wire sensor consists of the basic wire elements, drum and spring motor (combined as mechanics) and a potentiometer or encoder for the measurement signal generation. Draw-wire sensors are ideal for applications with large measuring ranges, small sensor dimensions and when a low cost solution is required.

Depending on the sensor design, the wire is normally an extremely thin steel wire, which is sheathed with polyamide. The wire is around 0.8mm thick on average, depending on the type of stress forces involved.

## From the movement to the electrical signal

With a draw-wire sensor, a linear movement is transformed into a rotary movement.

The free end of the wire is attached to the movable body. An optional eyelet at the free end of the wire can be screwed onto or attached to the measurement object. The rotary movement produced by drawing out the wire is converted into an electrical signal using a rotary encoder.

A spring motor provides sufficient pre-tension of the wire. The spring motor is a coil spring with torque load, similar to those used in mechanical watch mechanisms. The further the wire is drawn out, the higher the tensioning force of the spring. In horizontal mountings, this has the benefit of minimising wire sag.

## Benefits of draw-wire sensors

- Very compact design compared to the measuring range
- Telescopic measurement principle
- Very robust sensors
- Measuring wire can be deflected using deflection pulleys

## Possible types of output

Analogue connection

There are basically three different types of precision potentiometer used in draw-wire sensors from Micro-Epsilon: wire potentiometers, hybrid potentiometers and conductive plastic potentiometers.

Conductive plastic or hybrid potentiometers are usually used for standard products. For high volume production applications, selection is made based on the required specifications for the application in order to achieve an optimum price/performance ratio for the customer.

Digital connections

Compared to analogue potentiometers, encoders have a significantly longer service life and better linearity. Incremental or absolute encoders are available depending on the application. Both types of encoder are fundamentally different from each other. Incremental encoders are used where the relative position displacement should be measured. In contrast, an absolute encoder assigns a unique position value to each measured value.

# Position measurement on X-ray machines

X-ray machines must provide high quality images in different positions. Previously, an X-ray cassette with film had to be manually aligned with the X-ray tubes. Today, this is performed digitally and is fully automatic.
Modern equipment functions with a camera that digitalises the recordings directly. This saves time and development costs. The camera must be exactly aligned with the X-ray tubes so that high-resolution recordings are produced for digital equipment. The cameras, the X-ray tubes, the table and the wall stands can be moved on several axes, providing as much flexibility as possible.
Draw wire sensors measure five different positions in an X-ray machine.
This parallel running means that the best possible focussing of the X-ray tubes for the camera is achieved.

1. Height position of the camera
2. Height position of the X-ray tubes
3. Horizontal table position
4. Vertical table position
5. Horizontal camera position

**Benefits to the customer:**
- Simple mounting
- Telescopic sensor
- Favourable price performance ratio
- Durability

# Monitoring of Training exercises on rehabilitation and therapy machines

“Ideal design costs and performance” are important requirements when it comes to the conceptual design, physical form and carrying out of rehabilitation measurements. As well as the most modern devices, an intelligent method data recording, control and documentation is also needed for implementing these requirements. Information about the performance of training exercises can be provided to a trainer by using a network or chip card. The medically- ideal performance of exercises can be monitored, therefore avoiding both the under-challenging and overworking of the patient. In this way, optimum efficiency with regard to the medical success of the therapy and the best possible economic utilisation of the equipment can be achieved.
In order to provide this information to the trainer, sensors that measure the execution of movements on the machine are required. As well as force sensors, displacement measurement sensors can also be installed, which measure and output the displacement and chronological progress of movements.
Due to the installation size and favourable price/performance ratio, MK30 and MK46 series draw-wire sensors are ideally suited for these applications. Depending on customer requirements, analogue potentiometer-based outputs or digital encoder-based incremental signals are available.

**Benefits to the customer:**
- Simple mounting
- Telescopic sensor
- Favourable price performance ratio

# Angle measurement in SoloAssist®

SoloAssist gives surgeons a helping hand by reducing the cost per operation and improving quality

The device resembles an arm and can be moved in several degrees of freedom, whilst noting and maintaining its position. Starting from a calibrated zero point, the device automatically performs the required incremental movements in order to traverse a complete specified movement. An endoscopic camera is guided by the robot arm thereby achieving a 360-degree view with up to 80-degrees incline from the perpendicular of the endoscope.

The arm is largely designed to be MR- and X-ray neutral, which is why sensors are not used in the area directly above the operating table. For this reason, direct measurement of the turning movements of the arm with angle sensors is not possible.

The angle of rotation is therefore determined indirectly by using draw-wire sensors, which are installed underneath the operating table. A total of three MK30 Series sensors are installed, which measure the rotation movements shown in Picture 1. Due to the compact size of the installation, mounting is easier and reliability improved, Micro-Epsilon's draw-wire sensors are ideal in meeting customer requirements .

The sensors provide a displacement or angle proportional output signal (potentiometer). Alternatively, digital incremental output signals are also possible.

**Benefits to the customer:**
- Measurement outside the actual arm
- Very compact design
- Easy integration of the sensor

# Position measurement in Computer Tomography (CT)

In the latest CT equipment, the most effective diagnoses are determined by how precise and fast the measurement systems are (speed and resolution), as well as their cost effectiveness.

Irrespective of whether spiral, helical or dual source apparatus is used, the requirements are continuing to increase.

In particular, this also concerns the length measurement equipment for the horizontal reclined position. In order to obtain the best possible overall image of the target, the individual X-ray sections, which normally travel through the object, have to be measured with smaller and smaller spacing. To do this, the sections are compiled in a 3D reconstruction to obtain voxels (volumetric and pixel). Based on this complete volume data set, any 3D views or sectional planes can be produced (see 3D image).

In order to correctly assign the sections, the horizontal position of the couch has to be measured precisely. Therefore, a measuring system with very high resolution and long measuring range is required.

In this application, draw-wire sensors from Micro-Epsilon achieve a resolution of up to 0.001% of the measuring range; this is combined with maximum reliability, long service life and a very favourable price/performance ratio.

A number of different sensor designs and signal outputs (analogue, incremental digital or absolute digital) are available which means the sensors can be adapted easily to individual customer requirements.

**Benefits to the customer:**
- High reliability
- Long sensor service life
- Simplified mounting
- Attractive price/performance ratio

# Positioning of operating tables

Utilisation and cost efficiency are playing a more important role in modern medical operating procedures. This is also true for the operating tables. The latest operating tables offer numerous functions for precise handling of the patient and are also efficient and cost-effective.

The tables are modular in design and provide multiple adjustment options for precise positioning of the patient during an operation. As well as the height of the table, the horizontal position and several angle functions, e.g. for the head, torso and legs, can also be adjusted. Complete patient profiles can be pre-programmed for certain positions or can be created by the user and then called up with a single press of a button. Important personnel and cycle times can be saved using this function.

However, in order to facilitate the precise positioning of the adjustable elements of the operating table, suitable measuring technology is required.

Draw-wire sensors from Micro-Epsilon are ideally suited to this task. With regard to the measuring range, these sensors combine a compact design with high precision and long service life.

In addition, the sensors can be easily integrated to the operating table and provide an excellent price/performance ratio. Draw-wire sensors are usually used for vertical and horizontal table positions. However, the sensors can also be used for (indirect) angle measurements in certain cases, since angle sensors often cannot be installed on the rotational axes due to restricted space.

This means that up to five draw-wire sensors can be used on an operating table.

**Benefits to the customer:**
- Long sensor service life
- Very compact design

## Applications in logistics

# Displacement measurement on slag transporter

The use of slag transporters represents an extremely demanding transport task.

Hot (1,300°C) slag weighing 80 tonnes has to be transported to its destination in the shortest possible time without the slag cooling down (otherwise the expensive slag ladle is destroyed) and without endangering human life.

Therefore, the first priority is maximum efficiency coupled with process reliability and work safety. Potential for reducing the transport time is in the time taken for the rear support cylinder to retract and/or in the tipping cylinder for loading and unloading the slag transporter.

Up to now, the measurement of the position of the cylinders has been achieved using limit switches. However, this measurement method was prone to error due to its discrete switching points and the harsh environment. Draw-wire sensors from Micro-Epsilon are now being used at Kamag to reduce the transport time. The sensor is mounted parallel to the tipping cylinder and is protected by an additional steel housing and a steel tube, in which the sensor wire runs. The draw-wire sensor for measuring the position on the support cylinder is securely mounted in the vehicle frame. The sensor is connected to the support cylinder using appropriate wire extensions.

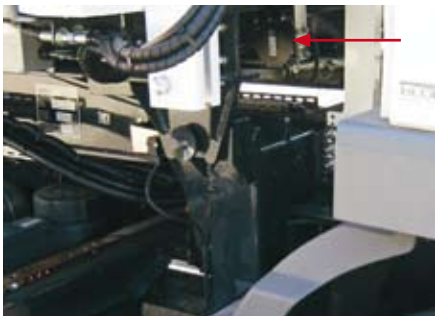
Sensors in the wireSENSOR P60/P96/P115 series are used on the slag transporter. A high signal stability is ensured due to the metal housing and the extremely robust design.

**Ambient conditions:**
- Temperature: -40°C to 80°C
- Interference fields: EMC

## Positioning of catering trucks at Airbus A380

Catering trucks are an important supply medium for modern airliners. They are used for loading and unloading aircraft with food. Based on an hydraulic scissors mechanism, the van body of the truck is raised until the best position to access the supply door is reached.
The company Doll from Oppenau produces these catering vehicles. As one of a few suppliers, they are able to also safely supply an Airbus A380 whose supply door can be located at a level of more than 8 m.
The catering truck can not drive directly to the supply door, because this door is above the wing and not next to it. Therefore the complete van body is longitudinal
moveable.
A further challenge on the design is the ambient temperature range from -25°C to +65°C. The corresponding change in the oil viscosity causes also changes in the speed of the positioning hydraulics. Anyway, to dock safe and reliable to the airliner, the movement of the van body has to be detected with a measurement system.

Draw-wire sensors in the Series WDS-xx-P115 from Micro-Epsilon are used here. Mounted between the the van body and the scissors system, the movement is measured precise and reliable. The extreme ruggedness and long service life convinced Doll about integrating these sensors. They provide precise measurement results, high reliability against failure even in bad weather and optimize the setting up and removal time of the catering vehicles.



**Reasons for the system selection:**
- Price/performance ratio
- High protection class

## Lift-height measurement in fork-lift trucks

Logistics are important today and will be more so in the future. Increasing streams of goods must be shipped and transferred in ever shorter time periods. As a result, logistic service providers are trying to shorten the transfer times in the warehouse and to optimize warehouse movements. Here, a high level of potential optimization can be exploited through the application of displacement sensors in fork-lift trucks. When raising and lowering the load, normally large safety margins have to be observed, so that when rounding a corner or braking and accelerating, the truck is not put into a dangerous tilted position. If the lift height of the load can be acquired, the optimum driving speed can be determined from it. In addition, the system is protected against erroneous operation, i.e. the operator cannot knowingly or unintentionally cause critical driving condi-tions. This then both optimizes the speed and also improves safety for the operator. In addition, the sensor is also used to automatically bring the load to the right lift height to speed up the movement to the correct shelf height.

The manufacturer of these innovative fork-lift trucks, Still-Wagner in Reutlingen, employs a draw-wire displacement sensor from MICRO-EPSILON for this application. They are specially adapted to the requirements on the fork-lift truck. An especially flat construction was chosen so that the sensor could be used in the tight installation space. The sensor is designed redundantly for safety reasons. Two electrically independent signals ensure that a high level of safety is achieved. The high quality and measurement accuracy of the draw-wire sensors from MICRO-EPSILON enable the customer to achieve a competitive lead for the markets in the future.

**Benefits to the customer:**
- Compact, customized sensor
- Two separate output signals (potentiometer, encoder)
- High accuracy
- Favorable price/performance ratio

## Lift height measurement for two-column lifts

Modern two-post lifting systems are normally designed without a base frame. This means that in contrast to conventional lifts that have a chain between the two lifting columns, modern systems require no mechanical connection.
Therefore, the previously normal threshold between the lift columns is not required. This makes the user's daily work much easier. No "obstacle" has to be overcome during entry and exit and it is much easier to position the vehicle. However, "automatic" lift height synchronisation, which was previously provided by the mechanical connection of the two columns, is now missing.
The lift therefore requires a synchronisation controller or lift height monitoring system in order to ensure that the vehicle is raised evenly on both sides. Draw-wire sensors are the preferred choice for height measurement.

These sensors are easy to integrate, very compact and provide a very attractive price / performance ratio relative to the measuring range, as well as high accuracy. Depending on the measuring range and required protection class, the P60, P96 or MK77 series are ideally suited to this application. There are many different output signals available, which means the sensors can be easily adapted to the respective controller used. As well as analogue signals (voltage, current, resistance), incremental (HTL, TTL) or absolute (CANopen, Profibus, SSI) digital outputs are also possible.

**Benefits to the customer:**
- Compact sensor design
- Simple mounting
- Very attractive price/performance ratio
- High reliability

## Variable support for mobile cranes and cherry picker platforms

Cherry pickers and mobile cranes are used for a multitude of different tasks. In this respect the load moment available plays an important role, because this determines the amount of load that can be lifted for a given (lateral) range. If the permissible load moment is exceeded, serious accidents can arise due to the crane tipping. For this reason since 1964 this type of vehicle must be equipped with a load moment limiter. The possible maximum load moment for the current use essentially depends on the width of the support. The maximum load moment is also only possible when the supports are fully extended.
Often cranes and cherry pickers must be used in confined spaces. In such cases the full support width and therefore the full load moment is not available.

The fully variable support then offers the possibility of determining and permitting the maximum load moment for any support width. To achieve this, the support width is measured automatically, acquired by the on-board computer and the possible load moment is calculated from it. This takes place fully automatically without involving the operating personnel. In this way optimum use is ensured under difficult spatial conditions while maintaining a high level of safety.
The measurement of the support width is provided by draw-wire sensors of the series P60 and P96 with measurement ranges between 1500 and 4000 mm. In order to achieve the highest level of safety, normally two sensors per support are used for a redundant measurement. In this respect the interface for the sensors and the vehicle electronics can be realised by analogue means via voltage, current or potentiometer as well as digitally via buses (CANopen, Profibus, etc.). In particular, the telescopic feature and easy mounting (also possible as retrofit) make draw-wire sensors ideal for this application.

**Reasons for the system selection:**
- Price/performance ratio
- Low space requirement (telescopic)
- Easy fitting (also possible as retrofit)
- Various measurement ranges and types of output

## Height of lifting platforms on automobile production lines

It is in the automotive sector more than almost any other that sustainable process optimization leads to significant competitive advantages. In the assembly process on the new types of vehicle production lines lifting platforms are used on which the vehicle bodies are placed. The platforms enable the respectively optimum working height in each operational step on the vehicle. In each of these lifting systems draw-wire displacement sensors are integrated which continually acquire the exact platform position. In this way, each lifting platform is automatically brought to the respective required height, facilitating the optimization of the individual production steps in terms of time and ergonomics.
The link between the sensors and the central controller occurs mostly via radio. Depending on the controller design, sensors are used with analog as well as digital interfaces (e.g. CAN bus, Profibus).

**Reasons for the system selection:**
- Very good price/performance ratio
- Extremely low space requirement
- Various measurement ranges and types of output
- High accuracy
- Simple mounting

## Lift height measurement on wheel gripper and lifting systems

Apart from the classical approach of permanently installed lifting platforms, in the field of lifting systems for commercial and rail vehicles, mobile systems which can be flexibly assembled from individual lifting trestles are becoming more and more popular.
In this respect almost any number of lifting trestles can in principle be assembled to form a system. The lifting trestles for commercial vehicles are often realised as so-called wheel grippers. In contrast, rail vehicles (or even complete trains) are normally lifted on the frame. Since the individual lifting trestles are mobile, complex lifting systems for large loads can be simply and flexibly set up and dismantled, and can also be equipped with more or fewer lifting trestles.
Therefore, each lifting trestle must be equipped with its own drive.

In order to facilitate a uniform lifting process, the height of each single trestle is measured with a draw-wire sensor, to guarantee a synchronised movement. In this way it is possible to achieve precise control of synchronised lifting even with unequal load distribution and a build up of the load is prevented.
Also, additional (convenience) functions, such as a lift height restriction or the running up to predefined heights can be very easily realised.
Draw-wire sensors from Micro-Epsilon are particularly suitable for this measurement task due to their size and their excellent price/performance ratio. Depending on the requirements for the protection class, measurement range and output signal, there are many different models available for optimum matching to each application.

**Reasons for the system selection:**
- Simple mounting
- Excellent price/performance ratio
- Compact design

## Release of satellites into space

In order to be able to launch a satellite from the Areane rocket unobstructed into space, the nose cone section, together with the side shield, have to be separated from the main rocket immediately before the release of the satellite.
Simultaneous and controlled activation of a series of preloaded springs, provide the propulsion force for the separation of the nose cone and side shield.
It is of vital importance that the section separates itself in an absloute linear motion from the main rocket, with-out any non-linear tumbling movement that could cause damage to the satellite.
The separation movement is controlled by three draw-wire sensors mounted on the booster rocket. The ends of the draw wires are attached to the nose cone section via a preset and rated breaking point connector. These connectors automatically disconnect the wire from the nose cone at the end of the measuring-range of the sensor.
Immediately following the separation of the draw-wire from the nose cone section, the draw wire is automatically retracted in its housing, in order to avoid damage to the satellite during its subsequent separation from the carrier.

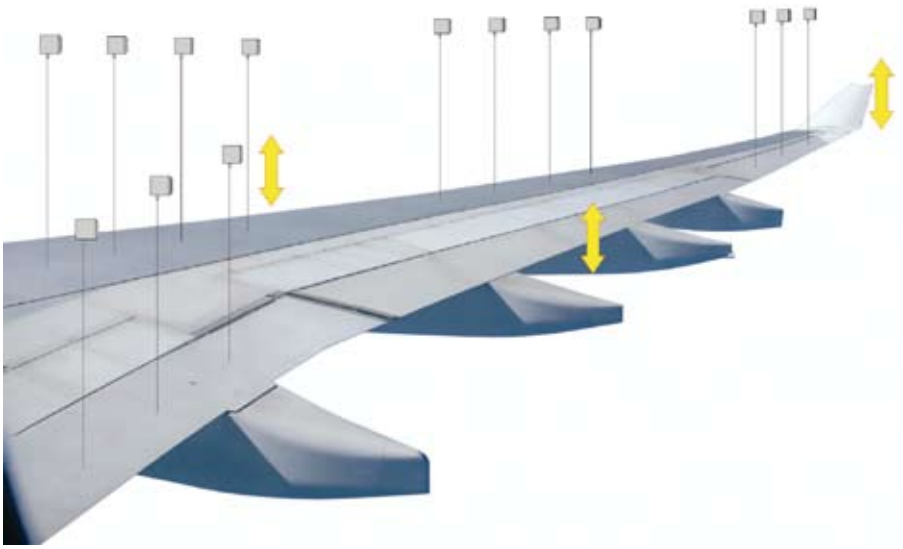
**Reasons for the system selection:**
- High Linearity
- Compact, light and reliable construction in combination with large measuring range
- Tested and proven high reliability

## Stress tests on aircraft wings

Wings are one of the essential components on the aircraft and must be designed to be very durable. The vibration and bending behavior under various stress conditions is of outstanding significance for the continuous optimization of the wing shape and construction. Based on these results, some of the parameters optimized are the service life, safety and fuel consumption.

To this end, draw-wire displacement sensors in the Series P60 are employed for the vertical measurement of the wings in structural tests. They are fixed to the wing at 120 measuring points and acquire displacements of up to 1200 mm.

To obtain convincing measurement results for optimization, the 120 sensors are synchronized to one another and supply a detailed picture of the vibration and deflection behavior of the wing.



**Reasons for the system selection:**
- Very good price/performance ratio
- Easy and rapid fitting
- High accuracy

# Monitoring thermal expansion of pipelines in power stations

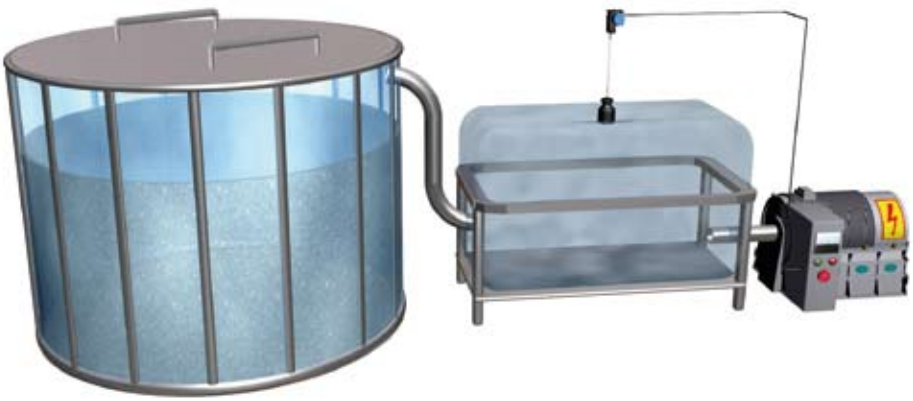
Pipelines in power stations have to withstand pressures of 300bar and temperatures of up to 620°C. These extreme conditions cause the pipes to vibrate and result in thermal line movements of up to 1 metre in some places. Constant supports are required in order to compensate for these thermal movements. Previously, this was only possible by spending a lot of time and effort manually inspecting the mechanically and thermally stressed pipelines on the surface of a power station. Experienced personnel therefore had to assess whether pipeline vibrations or movements were still within specified tolerance limits. Miscalculations or recognising that tolerances had been exceeded too late could result in damaging, costly consequences.
Using a well devised concept, the Technip company under the management of Dr. rer. nat, Ulrich Reiners succeeded in eliminating this risk. The solution was found in the central monitoring of the respective vibrations and the thermal movements of the pipelines at the sensitive locations within the power station. Mr. Reiners relies on draw-wire sensors from Micro-Epsilon to reliably and safely transmit movement information to a central control room. The combination of mature monitoring software and long service life of Micro-Epsilon's WDS-P60 draw-wire sensor have enabled the previous time-consuming manual checks of pipe movement to become more flexible and accurate.

**Requirements for the measuring system:**
- Measuring range: 500mm to 1,000mm
- Service life up to 5,000,000 cycles

# Filling quantity measurement in biogas tanks

Biogas is a modern renewable energy source and potentially a lucrative source of income for many farmers. Its special feature is the generation of electricity, heat and fertiliser from biomass. Combustible gases are produced by anaerobic fermentation and putref-action processes.
Depending on the source material, biogas basically contains methane, carbon dioxide and water vapour. A fermenter consists of an airtight round silo, which is connected to a gas tank made of a film.
The objective is to create a constant fermentation process so that the combustion can take place constantly with maximum efficiency.
Depending on the gas quantity, the gas tank film inflates due to increasing pressure. The fill quantity to be fermented can be determined from the bulge of the film. To date, inductive limit switches which measure the bottom, middle and top position of the film have been used to measure this.
This discrete measurement of the fill quantity did not take account of the inertia of the fermentation process and made the control of the biogas generation inefficient.
The fill quantity in the fermenter can be measured continuously by using draw-wire sensors. A weight is attached to the film for a constant pressing force, which keeps the sensor wire tensioned. The sensor is located in the generator building and is connected to the weight on the film using wire extensions. The measured distance also changes as the expansion of the film changes.
The distance between film and displacement sensor increases as the filling quantity in the gas tank decreases.

The control unit reduces the speed of the generator due to the increase of the displacement signal in order to restore the target fill quantity in the gas tank.
Therefore, the efficiency of the biogas generation and combustion is increased many times as the fill quantity is measured at each point in time of the fermentation process and new fermentation material can be added if necessary.



**Reasons for the system selection:**
- Price/performance ratio
- Robust design

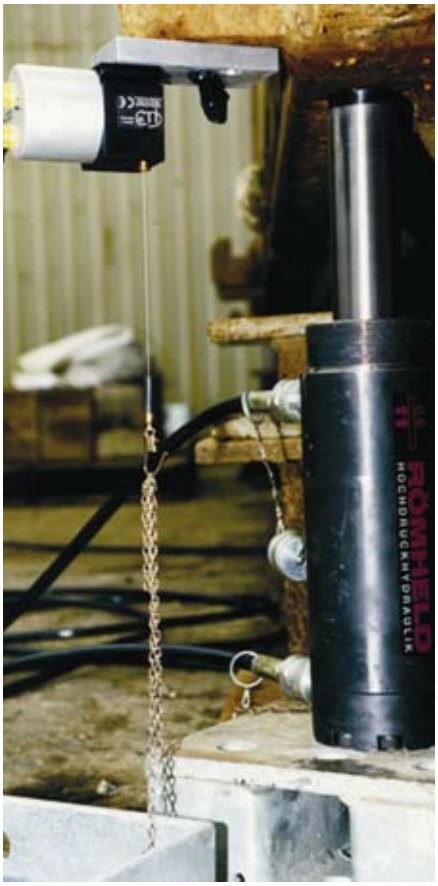
## Precision synchronized lifting system

Synchronized lifting systems enable the raising and lowering of heavy loads controlled for distance and force or the controlled forward feed of large components. To achieve this, eight or more cylinders are connected to a central high pressure hydraulic system (700 bar). The travel displacement of each individual cylinder must be measured as the actual value for the synchronized movement and supplied to the closed/open loop controller.

Draw-wire displacement sensors of the wireSENSOR Series P60 are employed for this task. Due to their compact shape, they are easy to fit even under tight spatial conditions. Complicated alignment is not necessary. The measuring wire is simply attached to the load or component with a hook.

The output signal from the displacement sensors which is proportional to the displacement (resistance value, voltage, current or increment) is fed into a PLC which controls the synchronism of the cylinders.

On the synchronized lifting system, the measurements are displayed via a PC and the parameters for the lifting/lowering and the permissible tolerances and limits for the travel displacement adjusted. The displacements (positions) can also be output via digital panel-mounted displays (accessories).




**Reasons for the system selection:**
- Compact design
- Easy mounting
- Telescopable system

## Lift height measurement for maintenance work on bridges

As well as asphalt work, the supports on bridges must also be replaced from time to time. The supports withstand the highest loads as they bear the weight of the bridge superstructure and also absorb the vibrations and elongations of the bridge. The properties of the rubber bearings can change over many years which is why they must be replaced from time to time.

The bridge piers are relieved of any load for such types of maintenance work whereby heavy-duty jacks are used.

The bridge is lifted by 10mm to 15mm for this. After the maintenance work has been completed, the superstructure is lowered onto the new supports.

An absolutely synchronised lifting process is important when lifting bridges so that no torsion forces can damage the bridge. A heavy-duty jack is used at each corner of the bridge and these are connected via a control system. Draw-wire sensors are also used for each jack; these sensors notify the current lift to the controller.

A major manufacturer of heavy-duty jacks uses P60 wireSENSORs from Micro-Epsilon for this due to their robust design and outstanding price/performance ratio.

**Reasons for the system selection:**
- Very simple mounting
- Favourable price/performance ratio
- Robust design
- Synchron lift possible

# Available sensor series

## wireSENSOR MK30/MK77/MK120

The MK series is available in the measuring ranges between 50mm and 7500mm. The sensors are characterised by a robust plastic housing and a very compact design. Potentiometer and incremental encoder outputs are available. MK sensors have a particularly long service life, a high protection class and high precision.

## wireSENSOR MPM/MPW

The MPM / MPW series with measuring ranges from 50mm to 1000mm are used for particularly challenging ambient conditions. This means that the wire acceleration can be very fast; the service life is not affected by accelerations of up to 100g. Despite the robust metal housing, the sensor has a surprisingly compact design. The mounting flange contributes to the sensor's high flexibility. This is tightly fastened and the sensor remains freely rotatable on it.

## wireSENSOR P60/P96

A very high number of applications can be solved using the P60 series, which has measuring ranges between 100mm and 1500mm, with the P96 offering even higher measuring ranges of 2000mm and 2500mm. These sensors are extremely robust due to their metal housing and can be easily installed using the mounting rails.

## wireSENSOR P115

The P115 series is available for larger measuring ranges. Also with mounting grooves, metal housing and high spring force, the P115 series is comparable to sensors in the P96 and P60 series. Measuring ranges between 3m and 15m are used. All common field bus and analogue outputs are provided for the connection of the sensor.

## wireSENSOR P200

The P200 sensors are used for extremely large measuring sections such as those in lifts or elevators for example. Their measuring range reaches up to 50m and therefore represents the upper limit of measuring ranges that can be achieved using draw-wire sensors. Nevertheless, the compact design and flexibility of use due to mounting grooves opens up a wide range of potential applications.

## wireSENSOR Mechanics

Many different draw-wire mechanisms with up to 15m measuring range are provided for customer-specific encoders or potentiometers. These mechanisms consist of the complete sensor, but without the electronics component. Using a special adapter, the customer can install almost every encoder on the mechanism.

## Specific Sensors

Despite the range of wireSENSOR models available, application-specific modifications to the sensor are often required to suit a specific application. For high volume production, Micro-Epsilon can modify the sensor according to customer requirements. Modifications are often made to the length and design of the measuring wire, the tensioning force of the spring package or different output types.

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