Laser Sensor Solutions
Banner Laser Distance Measurement Sensors

Laser measurement sensors from Banner Engineering are ideal for use in a wide variety of discrete, analog, and IO-Link sensing applications. Our portfolio of laser sensors includes powerful problem-solving, high-precision, and long-range sensors. Traditionally laser sensors have been used for their extended range, visible beam, small spot, and precise detection capabilities. These benefits have often been outweighed by their higher costs compared with other technologies. In recent years, pricing on components has been reduced and the technology has advanced so that the benefits of laser sensors outweigh the cost differential. Banner laser measurement sensors have been designed to excel in harsh environments and remove common sensing barriers.

Optimized for the Most Challenging Targets

**Automatic Gain Compensation and Highest Excess Gain in Class**

Other sensors can be oversaturated and experience increased errors from shiny targets. Banner laser sensors automatically decrease gain to maintain accuracy.

**Variety of Beam Spot Sizes for Consistent Detection**

A small spot minimizes measurement variation across color transitions

A small beam spot is ideal for precise profiling of small features

A large spot provides averaging across rough surfaces for more measurement stability

Similarly, dark objects provide a very weak signal, so our laser sensors automatically increase gain to amplify the received signal and reliably measure targets that other sensors cannot see.

**Measure from 25 Millimeters to 24 Meters**

**Triangulation (Short Range/Precise)**

**Time-of-Flight (Long Range)**

Triangulation sensors determine range by the position of the received light on the receiver array.

Time-of-flight sensors derive range from the time it takes light to travel from the sensor to the target and return.

Best-in-Class Combination of Detection and Range

**Minimum Object Separation (MOS)**

The minimum distance a target must be from the background to be reliably detected by a sensor. An MOS of 5 mm means the sensor can detect an object that is at least 5 mm from the background.

The 2-meter triangulation sensor and 5-meter time-of-flight sensor complement each other to solve a wide variety of problems. Triangulation technology is more robust in the near range, while time-of-flight is more consistent across the entire range.

**Clear Object Detection**

Reliably detect transparent objects without the need of a retro reflector

**Error Proofing**

**Contrast**

Detects intensity changes due to variation in surface finish, hue, or tone

Inspections use distance to verify parts presence and position, and intensity to verify correct color

**Dual Mode: Distance with Intensity to Detect Any Change**

Teach a reference target, even past the maximum measuring range, to detect changes in contrast for presence and absence detection

**Excess Gain**

Excess gain is a measure of the minimum light energy needed for reliable sensor operation. Higher excess gain allows the sensor to detect darker objects at steeper angles.

The Q5X Series has very high excess gain. To detect the darkest targets, the 5-meter time-of-flight sensor has higher excess gain as users get further away from the sensor compared to the 2-meter triangulation. Excess gain of 100x means that you can reliably detect an object that only returns 1% of the light reflected off of it. The sensor can easily detect black rubber, foam, or neoprene.

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Choosing a Banner Laser Sensor

If the following are needed:
- Best performance
- Best temperature stability
- Highest excess gain
- Smallest spot size
- Smaller housing
- RS-232 Serial Communication

select Q5X

If the following are needed:
- Longer range
- More excess gain
- Better precision beyond 100 mm

select Q5Z

If the following are needed:
- Longer range
- Better precision beyond 1 m

select LTF

If the following are needed:
- Longer range
- More excess gain
- Better precision beyond 100 mm
- Easy to use problem solver
- Compact size with best in class performance
- Robust housing and reliable detection

select Q4X

Q4X Applications
- Rugged Environments
  - Food and beverage packaging
  - Metal stamping
  - Robotic welding
- Precision Measurements
  - Vibratory feeders
  - Automotive assembly
  - Semiconductor wafer mapping
- Low Contrast Sensing
  - Plastic bottle jam detection
  - Pharmaceutical vial counting
- Material Handling
  - Jam detection
  - Box, tote, and pallet detection
- Packaging
  - Shrink wrap detection
  - Carton full / empty
- Lumber and Construction
  - Timber, plywood, sheetrock manufacturing
  - Steel and asphalt shingle manufacturing
- Automotive
  - Power train and suspension assembly
  - Black plastic/leather/rubber detection
  - Dashboards and interior/exterior panels

Q5X Applications

LE Applications
- Automotive
  - Robot positioning
  - Assembly inspection
- Packaging
  - Fill level
  - Box profiling
- Web Applications
  - Loop control
  - Roll diameter
  - Web thickness gauging

LTF Applications
- Positioning
  - Automated guided vehicle
  - Automated warehouse
  - Mobile equipment collision avoidance
- Measurement
  - Hopper fill level
  - Port crane height
  - Pallet height
- Process Control
  - Roll diameter
  - Loop/tension control
  - People counting

LM Applications
- Automotive
  - Precise part inspection
  - Assembly accuracy checks
  - Dimensional control
- Electronics and Semiconductor
  - Product position control
  - PCB warp inspection
- Consumer Packaged Goods
  - Correct product placement
  - Thickness/height measurement

Start with the Q4X

If the following are needed:
- Better temperature stability
- Higher precision
- Larger display

select LM

If the following are needed:
- Simplified user interface
- Plug and play integration

select LE
### Laser Measurement Sensors Comparison

#### Key Specifications for Analog Applications

**Accuracy** is a measure of how closely a sensor’s analog output represents the actual distance. It is typically expressed as an absolute number instead of ±.

**MOS** is the minimum object separation. Minimum object separation is the most important and valuable specification for discrete applications. This is because MOS captures dynamic repeatability by measuring different points on the same object at the same distance. This gives you a better idea of how the sensor will perform in real-world discrete applications with normal target variability.

**Resolution** is the smallest change in distance a sensor can detect in a single measurement. It is especially useful when comparing measurements from multiple sensors.

**Linearity** is the maximum deviation between the interpolated measurement and the actual distance. If a sensor’s range is ± 0.5 mm, means that the greatest variance in measurement across the sensor’s range is ± 0.5 mm. In other words, linearity is the maximum deviation between the interpolated measurement and the actual distance. If a sensor’s 4 mA point is set to 100 mm and its 20 mA point is set to 200 mm, we would expect a 12 mA measured value to represent exactly 150 mm, halfway between 100 and 200 mm. In real life, that 12 mA value would usually represent 150 mm ± the sensor’s linearity spec. Linearity is the most relevant error spec for many applications with normal target variability.

**MOS** refers to the minimum distance a target must be from the background to be reliably detected by a sensor. A minimum object separation of 0.5 mm means the sensor can detect an object that is at least 0.5 mm away from the background.

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### Key Specifications for Analog Applications

#### Repeatability

Repeatability (or reproducibility) refers to how reliably a sensor can repeat the same measurement in the same conditions. Repeatability of 0.5 mm means that multiple measurements of the same target will be within ± 0.5 mm. This specification is commonly used among sensor manufacturers and can be a useful point of comparison; however, it is a static measurement that may not represent the sensor’s performance in real-world applications.

Repeatability specs are based on detecting a single-color target that does not move. The specification does not factor in variability of the target, including speckle or color/reflectivity transitions that can have a significant impact on sensor performance.

### Key Specifications for Discrete Applications

#### Resolution

Resolution tells you the smallest change in distance a sensor can detect. A resolution of <0.5 mm means that the sensor can detect changes in distances of 0.5 mm. This spec is the same as best-case static repeatability, but it is expressed as an absolute number instead of ±.

The challenge with resolution specs is that they represent a sensor’s resolution in “best-case” conditions, so they don’t provide a complete picture of sensor performance in the real world and sometimes overstate sensor performance. In typical applications, resolution is affected by target conditions, distance to the target, sensor response speed, and other external factors. For example, glossy objects, speckle distance to the target, sensor response speed, and other external factors. For example, glossy objects, speckle

#### Repeatability

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Repeatability specs are based on detecting a single-color target that does not move. The specification does not factor in variability of the target, including speckle or color/reflectivity transitions that can have a significant impact on sensor performance.

### Key Specifications for IO-Link Applications

#### Repeatability

Repeatability, or how reliably the sensor can repeat the same measurement, is a common specification for IO-Link sensors. However, as with discrete applications, repeatability is not the only factor for IO-Link applications.

Accuracy is the difference between the actual and measured values. It would be used in an application when you are looking at the measurement of an unknown distance, without a reference target. It is especially useful when comparing measurements from multiple sensors.

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#### Linearity

Linearity would be used instead of accuracy if looking at relative changes in measurements from a known reference target. This is similar to teaching the 4 mA and 20 mA points for an analog sensor, where all distance measurements are relative to the taught conditions.

Tip: Use the IOL Filter parameter (available with Banner IO-Link sensors) to average together more measurements for a more repeatable measurement.
Q4X Series
Versatile, Rugged Laser Measurement Sensor

- Best price with performance short-range sensing solution
- Most compact, rugged IP69, Ecolab-certified, stainless-steel housing
- Dual mode for contrast and clear object detection without a reflector
- Flush mount or barrel mount housing options for versatility in mounting

### Threaded-Barrel Q4XT

<table>
<thead>
<tr>
<th>Family</th>
<th>Housing Style</th>
<th>Output</th>
<th>Mode</th>
<th>Range</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Q4X</td>
<td>T</td>
<td>B</td>
<td>LAF</td>
<td>600 – 25–600 mm</td>
<td>Q8 – Integral QD</td>
</tr>
<tr>
<td></td>
<td>Threaded Barrel</td>
<td></td>
<td></td>
<td>500 – 25–500 mm*</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>300 – 25–300 mm</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100 – 25–100 mm</td>
<td></td>
</tr>
</tbody>
</table>

*Not available in Dual Discrete with IO-Link models

### Flush-Mount Q4XF

<table>
<thead>
<tr>
<th>Family</th>
<th>Housing Style</th>
<th>Output</th>
<th>Mode</th>
<th>Range</th>
<th>Connector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q4X</td>
<td>F</td>
<td>N</td>
<td>LAF</td>
<td>610 – 35–610 mm</td>
<td>Q8 – Integral QD</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>310 – 35–310 mm</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>110 – 35–110 mm</td>
<td></td>
</tr>
</tbody>
</table>

Clear Object Detection

Distance: Precision Measurement and Detection Regardless of Target

Minimum object detection size for challenging targets (6% reflectivity) at close range:

- Q4X...100 / 110 0.5 mm
- Q4X...300 / 310 1 mm
- Q4X...500 1 mm
- Q4X...600 / 610 1 mm

Error Proofing

Challenge

In a car speaker assembly, the presence and placement of all components must be verified to ensure that defective or incomplete products are not shipped to the customer. The small sizes, slim profiles, and similar colors of many components can make identifying errors difficult.

Solution

By measuring the distance from the sensor to the mounting bracket, a Q4X verifies that a single spacer is present and properly seated. Using dual-mode detection, the Q4X can also measure the amount of light received to determine if the spacer has been placed with the adhesive side up or down. The compact size of the Q4X allows for an unobtrusive installation into congested assembly stations.

Distance to Target (mm)

Discrete Repeatability (mm)

0.1 mm

5.0 mm

0.5 mm

0.2 mm

100 200 300 400 500 600

Minimum object detection size for challenging targets (6% reflectivity) at close range:
### Automotive Seat Inspection

**Challenge**
In automotive quality inspections, verifying the presence of dark parts against an equally dark background is extremely common. For example, many car seats consist of black fabric or leather material with black plastic components, such as levers and buttons to adjust seat height and tilt.

**Solution**
Banner’s Q5X problem-solving triangulation-based laser sensor has no difficulty detecting dark targets on dark backgrounds when there is a height difference. The exceptionally high excess gain enables the Q5X sensor to reliably detect even the darkest objects (<6% reflective black targets) even against a dark background at all distances from 95 mm to 2 m.

### Package Detection and Singulation

**Challenge**
Facilities that rely on a singulation process to arrange packages into an even, single-file procession utilize many sensors to determine the presence and location of those packages. Before singulation, items on belts are clumped together and disorganized, with irregular placement and spacing. To command the mechanical systems to reposition them, sensors are needed to take accurate measurements of where they are, the amount of space they occupy, and the speed at which they are moving.

Installing multiple sensors would make it possible to collect all the data points necessary; however, programming them one by one is time-consuming, negatively affecting setup and commissioning.

**Solution**
The Banner Q5Z Laser Measurement Sensor with IO-Link uses a laser detection method with high excess gain, which makes it an ideal device to accurately identify the position of items as they travel through a conveyor system. When multiple Q5Zs are used together in an array, they can measure the position, size, and speed of objects in motion—even dark black targets on black backgrounds or shiny metal surfaces. This enables the collection of real-time data that can be used to calculate the appropriate timing to sort the packages.

The Q5Z is also designed for plug-and-play integration in typical industrial applications. Banner has preconfigured its settings so that users can simply mount the sensors, activate the Q5Z teach mode with a single on-board button or remotely using IO-Link, and then start up the conveyors. No individual sensor programming is required.

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### Q5X

**High Power, Multi-Purpose Laser Measurement Sensor**

- Best price with performance mid-range sensing solution
- Highest excess gain for detecting the darkest targets at extreme angles
- Dual-mode for contrast and clear object detection without a reflector
- Jam detection model alerts operators to production line jams reducing or preventing downtime
- 100 G shock spec for rugged applications

**Q5Z**

**High Power, Multi-Purpose Laser Measurement Sensor**

- Preconfigured at the factory for simple plug-and-play integration
- Teach with simplified single button interface with feedback from bright indicators
- Durable and reliable design easily integrates into machines
- High excess gain to detect black rubber, shiny metal and other hard to detect objects
- Visible red Class 2 laser with small spot for easy alignment

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### tables

<table>
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<th>Series</th>
<th>Output</th>
<th>Emitter</th>
<th>Mode</th>
<th>Range (mm)</th>
<th>Connector</th>
<th>Options</th>
</tr>
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<tr>
<td>Q5X</td>
<td>K</td>
<td>L</td>
<td>AF</td>
<td>2000**</td>
<td>M12</td>
<td>Jam model†</td>
</tr>
<tr>
<td>KU</td>
<td>0–10 V with Push/Pull discrete output or IO-Link</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KI</td>
<td>4–20 mA with Push/Pull discrete output or IO-Link</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

* K models available in 2000 or 5000 mm range
** KU and KI models available in 3000 mm range only
† Jam model only available with 2000 mm range

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**Note:** The Q5Z Global Laser Measurement Sensor is a Class 2 laser sensor with IO-Link and a multifunction output. The single teach button and no display mean the sensor must be configured at the factory. This is so that it is ready for installation out of the box. To customize the configuration for an application, contact Banner Engineering.
LTF Series
Long-Range Laser Measurement Sensor

- Highest precision for long-range sensing—beyond 1 meter
- Highest ambient light immunity
- Time-of-flight vs. triangulation
- 100G shock spec for rugged applications
- Intuitive display

Tension and Speed Measurement on a Calendering Machine

**Challenge**
To prevent damage to long sheets of material that are processed through calendering machines, and adjust tension and operating speed, the amount of slack must be measured. The dark color and sheen of the rubber makes consistent and accurate detection at a long range difficult for most sensors.

**Solution**
The LTF takes advantage of high excess gain, superior signal processing, and automatic adaptive laser power control to enable the sensor to reliably detect challenging dark and reflective targets from a distance and at an angle.

Monitoring Levels Inside a High-Volume Hopper

**Challenge**
Dust and other debris generated during the processing of peanuts can accumulate on the face of a sensor. Gradually this can negatively affect a sensor’s performance and may result in unscheduled downtime for maintenance.

**Solution**
An LTF Series sensor with IO-Link communicates configuration and application trending data via an IO-Link master device to a controller on an industrial network. Monitoring data such as excess gain can help identify debris build-up and assist in preventative maintenance and maximizing machine uptime. If the sensor is ever damaged and requires replacement, configuration data saved on the IO-Link master will automatically update the new sensor.

Best-in-Class Combination of Accuracy, Repeatability, and Range

The LTF detects dark targets at 7 meters and white targets at 12 meters with repeatability of <5 millimeters and accuracy from ±10 millimeters.
LE Series
Precision Mid-Range Laser Measurement Sensor

- Highest-precision sensor for mid-range applications from 100 mm to 1 m
- Low-temperature effect for measurement stability in any environment
- Intuitive display
- Class 1 and Class 2 laser options
- Small and large spot options

Automated Inspection
Challenge
To work properly, the weight sensor connector on the underside of the seat cushion must be fully inserted. If it is not, airbags will not deploy appropriately in an accident. These systems cannot be used by the vehicle manufacturer and will be returned. The difference between a fully inserted connector and one that is not is a distance of 4 mm. Implementing an automated inspection system would verify that weight sensor connectors were properly installed prior to being shipped.

Solution
Deployed alongside the assembly line, the LE550 targets the back of the weight sensor connector. The visible beam makes it easy to align, and the LCD display greatly simplifies setup. To ensure unimpeded travel on the conveyor, the LE550 is located 500 mm from the target. From this range, it is capable of recognizing changes in distance as slight as 0.5 mm.

As the seat passes by, the LE550 measures the distance between it and the back of the connector. If the connector is measured at a distance less than 500 mm, an alarm notifies the operator and the line is briefly stopped. The operator can then correct the problem while it is easy to access the connector.

Roll Diameter
Challenge
Accurately determining the diameter of a roll of shrink wrap is essential to prevent material from running out during the shrink-wrapping process and ensure proper tensioning. As pallets enter the shrink-wrapping station, a reliable solution must provide accurate data to ensure the shrink wrap tension is what it should be and to alert operators if the roll of plastic wrap is empty.

Solution
Banner’s LE550 is factory configured with a range of 100 to 1000 mm and can start measuring immediately. The laser sensor’s range can be adjusted easily, either manually or automatically, with an intuitive user interface featuring a two-line, eight-character display. The LE550 provides repeatability and accuracy across challenging targets, from metal to black rubber, which allows for reliable measurement of the shrink wrap.

The analog output can be used to control wind or unwind speeds on the shrink wrap roll. The two-point teach option can be used to set the outside edge of the roll as the 20 mA point and the core diameter as the 4 mA point. This allows easy adjustment without having to unwind the entire roll. The discrete output can also be utilized for a roll diameter application. It can alert operators that the roll is almost empty.

The setup is simple using a single switch point. The user would adjust the feature to set a limit near the diameter of an empty core. No unwinding is needed to complete the discrete output setup.
LM Series
Compact Precision Laser Measurement Sensor

- Short-range, high precision, even on shiny metals
- Smallest spot size for more measurements and fewer color-transition errors
- High excess gain for detecting the darkest targets
- Least affected by temperature changes, for measurement stability in any environment
- Small stainless-steel housing for longevity and durability
- Dual mode for contrast and clear-object detection without a reflector

<table>
<thead>
<tr>
<th>LM Series</th>
<th>Range (mm)</th>
<th>Output</th>
<th>Connector</th>
</tr>
</thead>
<tbody>
<tr>
<td>LM 150</td>
<td>50–150</td>
<td>KI</td>
<td>QP-PVC M12 Euro Pigtail QD</td>
</tr>
<tr>
<td></td>
<td>40–80</td>
<td></td>
<td>X232-RS-232 Serial Communication*</td>
</tr>
</tbody>
</table>

150 = Discrete with IO-Link and 4–20 mA analog
80 = Discrete with IO-Link and 0–10 V analog
IRSD = 4–20 mA analog and Communications

Crankshaft Runout Measurement
Crankshaft runout is measured to make sure it is within the manufacturer’s tolerance. If the crankshaft is out of tolerance, it can lead to mechanical failures and damage to the engine.

Challenge
A crankshaft can be a challenging target for any optical sensor, because the shiny metal generates specular reflections while oil residue can present a much darker target. In production environments, crankshafts are often rotated quickly to minimize the time spent on inspection and increase throughput.

Solution
The LM has dynamic power adjustment for precision measurement across shiny and dark targets, providing less measurement variation and enabling more reliable inspections. The LM is capable of a 4 kHz measurement rate, a best in class measuring speed, for more precise tracking of geometry changes and more robust inspections.

The accuracy of the LM sensor can assure parts meet tight tolerances with fewer missed defects and false failures.

Precision Measurement Regardless of Target or Environment

Linearity
Linearity is the maximum deviation between an ideal straight-line measurement and the actual measurement. The more linear a sensor is, the more consistent and precise the sensing results. NOTE: Results shown in the following charts are based on LM150. Better performance will be achieved with the LM80.

Material Thickness
Many times, product quality is verified at the end of the line. Material that is too thin or too thick must be scrapped. When running long rolls of cardboard sheathing, it is preferable to continuously monitor the thickness, preventing large quantities of product from being out of specification and reducing scrapped material.

Challenge
Cardboard material is run in wide sheets, and the thickness can vary from side to side as well as along the entire length. The temperature in a factory can fluctuate several degrees throughout the day, introducing measurement errors with most sensors.

Solution
Three LM150s placed across the span of material monitor real-time changes in material thickness. The 0.004 mm resolution can detect very small changes in thickness and signal a PLC to speed up or slow down the process, reducing waste. The LM150’s stainless-steel design makes it more stable across temperature changes in this environment.

Temperature Effect
A sensor with minimal temperature effect is critical for precise sensing applications, since the induced error from just a few degrees of temperature shift can significantly affect the sensors’ results.

Banner LM150
Competitor #1
Competitor #2

Example temperature effect at max range

Ambient Operating Temperature (ºC)

Example linearly on 92% white card

Example linearity on 90% white card

Banner LM150
Competitor #1
Competitor #2

Example temperature effect at max range
RSD
Remote Sensor Display

The RSD remote display is designed to provide easy sensor configuration and monitoring. Equipment manufacturers can use it for initial setup and to copy settings across many sensors.

- Allows for configuration of remote sensor heads
- Easy to set up and use with a two-line, eight-character display
- Displays live distance measurement for remote monitoring
- Able to save up to six unique configurations
- Not required for continuous operation of configured sensor(s)
- Compatible with the LM, QM600, QX9, and LTF sensors

- Output A LED indicator
- Power LED indicator
- Output B LED indicator
- Push buttons
- Quick disconnect pigtail connector
- Din rail mountable

Simple device replacement with saved configurations

Ability to save up to six unique configurations for faster product changeover
More Sensors, More Solutions.

Banner Engineering designs and manufactures industrial automation products including sensors, smart IIoT and industrial wireless technologies, LED lights and indicators, measurement devices, machine safety equipment, as well as barcode scanners and machine vision. These solutions help make many of the things we use every day, from food and medicine to cars and electronics. A high-quality, reliable Banner product is installed somewhere around the world every two seconds. Headquartered in Minneapolis since 1966, Banner is an industry leader with more than 10,000 products, operations on five continents, and a world-wide team of more than 5,500 employees and partners. Our dedication to innovation and personable service makes Banner a trusted source of smart automation technologies to customers around the globe.