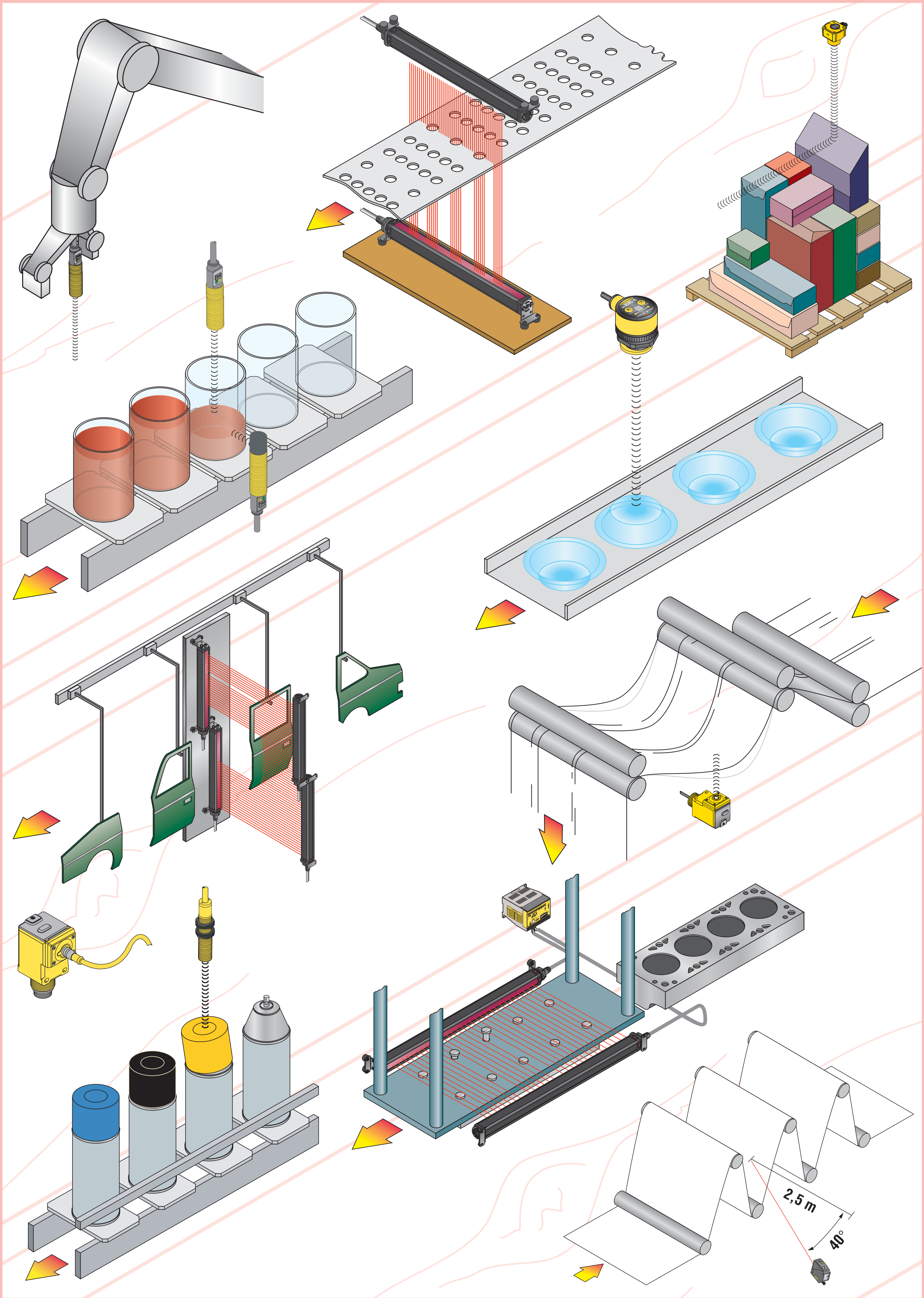

2,5 m
40°

⚠ Important Safety Warning!

The sensors described in this section of this catalogue do not include the self-checking redundant circuitry necessary to allow their use in personnel safety applications. A sensor failure or malfunction can result in either an energised or de-energised output condition. Never use these products as sensing devices for personnel safety.

Glossary of Terms

Accuracy

Accuracy is defined as the difference between the indicated value and the actual value at room temperature. In most cases, the accuracy comprises of two main sources of error: the resolution and the linearity.

Analogue Output

The analogue output of a sensor is the continuous output of a measured variable. The format of this output may be 4 to 20 mA, 0 to 10 V or others.

Beam Angle

Ultrasonic sensors emit a cone sonic energy that diverges with distance. The angle of this beam is usually defined as the total (included) angle. Ultrasonic beams are not perfect cones. Most of the ultrasonic energy is in the centre of the beam. The energy level decreases with distance away from the centreline. The beam angle is defined as the region where the energy is 50% of the energy measured on the centreline. See Figure 1.

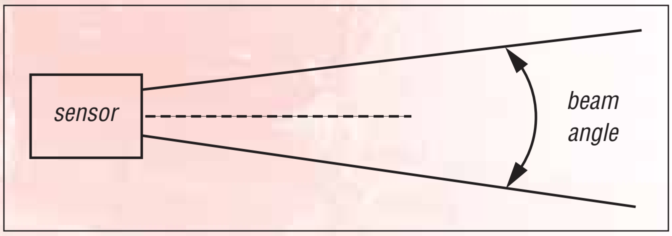


Figure 1: *Beam Angle*

Colour effects

The colour of the object being measured can affect the resolution and accuracy of the readings. White, red, yellow and orange targets reflect more light than green, blue or black targets. The resolution specifications listed in this catalogue are for white targets. The resolution for dark targets may be up to four times less than for white targets. Figure 2 shows the relative amount of received light that is reflected from various target colours. The resolution

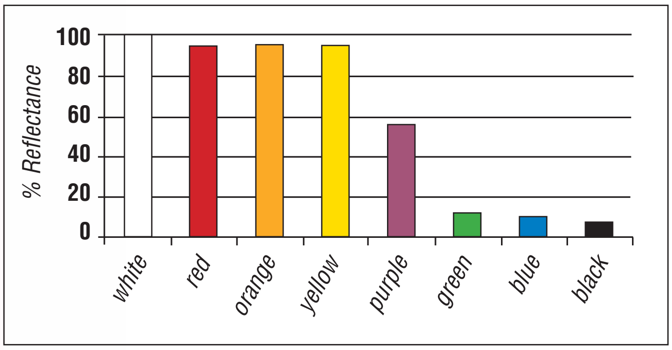


Figure 2: *Relative reflected light from a red LED light source*

is roughly affected according to the square of the received light. For example, reducing the amount of light by a factor of nine degrades the resolution by a factor of three. Note that ultrasonic sensors are unaffected by colour or transparency of the target.

Colour Sensitivity

For optical sensors, colour sensitivity refers to the change in output when the colour of a target changes. For example, the LG5 typically changes less than 75 µm as the target changes from a bright white to a near black target (approximately 90% reflectance to 10% reflectance. Note: for very precise measurements, Banner uses precision ground ceramic targets, as opposed to Kodak standard cardboard targets).

Deadband

Deadband refers to the region where the sensor cannot make measurements. For example, the deadband of the Q45U ultrasonic sensor is 100 mm, i.e. the output is unusable when a target is in this deadband area. Mounting hardware should be positioned so that the intended target is always within the measuring range.

Digital Output

Digital outputs are on-off outputs that signal when a continuous measurement has reached a specific value. Digital outputs are typically signaled with PNP or NPN transistors or an electromechanical relay.

Load Resistor

A load resistor, also called a dropping resistor, is a precision resistor used to convert a 4 to 20 mA signal to a voltage signal. The most common dropping resistor is 250 Ω ± 0,025 Ω, which converts the current to a 1 V to 4 V signal. For good stability over temperature, the dropping resistor should have a temperature coefficient of 0,01% per °C or better.

Frequency Response

Frequency response refers to the maximum frequencies that an analogue sensor can track. All analogue sensors have an inherent response time that limits their ability to measure periodic motions at high frequencies. For example, consider a laser displacement sensor with a 1,6 ms response time that is measuring runout on a rotating cylinder. Since the laser sensor is averaging data over a 1,6 ms period, it will under report the amplitude of the peak runout. This error increases as the rotational speed increases. Typically, this error is specified as the rotational speed that produces a -3 dB error (-3 dB equals a 30% error). For a 1,0 ms averaging time, the -3 dB frequency response is 450 Hz. At 450 Hz, a 1,0 mm displacement reports as 0,7 mm by the laser sensor. For reference, note that the crankshaft of a car engine running at 3.000 rpm is only 50 Hz.

Full Scale

The full scale range of a sensor represents the maximum measuring range possible. For example, a laser displacement sensor that measures from 75 to 125 mm has a full scale range of 50 mm. Even if the user has configured the sensor to read from 100 to 120 mm, the full scale remains at 50 mm. This is important to keep in mind if a manufacturer lists a performance specification in terms of “% of full scale”. The errors don’t shrink with the calibrated measuring span, as they would if the manufacturer listed the spec in terms of “% of span”.

Hysteresis

Hysteresis is commonly used to represent the difference in switching points for digital outputs. For example, an output might turn on when a target reaches 25 mm, but does not turn off until the target is 24 mm away. Therefore there is 1 mm of hysteresis. Hysteresis is also used in regard to analogue sensors to represent the difference in an output from moving upscale and moving downscale. For example, a contact probe is calibrated to output 4 to 20 mA from 0 to 10 mm. When travelling from 0 to 10 mm, the 5 mm point corresponds to an output of 11,98 mA. When travelling from 10 to 0 mm, the 5 mm point corresponds to 12,02 mA. Therefore, the hysteresis is 0,04 mA or 0,25% of span. The analogue hysteresis in electro-mechanical measuring systems is often measurable; in non-mechanical sensors, such as photoelectrics, it is most often insignificant.

Linearity

Linearity actually refers to the maximum amount of nonlinearity in the output of the sensor. It is usually defined as the maximum deviation above or below the ideal output of the sensor. It should be noted that linearity errors are repeatable errors and do not affect the sensor’s ability to repeatably activate digital outputs. Furthermore, since linearity errors are repeatable, they are potentially correctable within the host system. A linearisation scheme in a host system could consist of a table of actual and ideal values that serves as table for interpolation. See Figure 3.

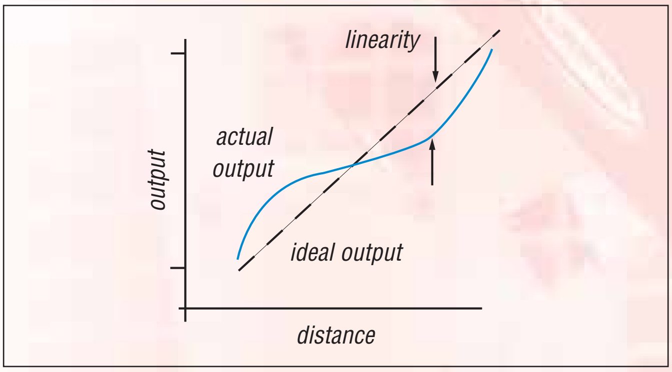


Figure 3: *Linearity*

M & I

Measuring Range

The measuring range represents the maximum range of values that a sensor can measure.

Measuring Span

The measuring span usually refers to the actual configured values that the sensor is set up for. For example, a sensor with a measuring range of 0,2 to 1 m, is set up with a measuring span 0,5 to 0,8 m.

Reference Conditions

The performance specifications for measuring sensors are typically given for reference conditions. Reference conditions are usually 20 °C and 1 atmosphere of pressure (approximately 1 Bar). In addition, a reference target must also be described in the specifications. For laser measuring devices, a white ceramic target is often used. For ultrasonics, a square metal target is typically called out.

Repeatability

The repeatability of a sensor is the difference in the sensor's output when the same input is given multiple times. Banner typically uses repeatability to quantify the performance of a digital sensor. For a digital sensor, repeatability represents the variation in switching distances for a standard target at reference conditions. For example, a laser displacement sensor is programmed to switch its output at a distance of 100 mm. The actual switching distance is measured with a micrometer twenty times. The data show a standard deviation of 0,01 mm; the two-sigma repeatability is 0,02 mm.

Resolution

Resolution is one of the most important specifications in measuring devices. It is a measure of smallest change in the position of a target that can be sensed by the measuring device. It is also a measure of the expected fluctuations in the output of a device when the target is at a fixed distance away from the sensor. For example, consider a device with a resolution of "0,2% of measuring distance" that is 100 mm away from the target.

The resolution is 0,2% times 100 mm or 0,2 mm. This means that any change greater than 0,2 mm in the position of the target causes a measurable change in the output of the sensor. It also implies that if the target does not change position, one could expect the noise of the output signal to be less than 0,2 mm. Sometimes a manufacturer specifies output resolution and list a specification in bits such as "12 bit". This means that the output portion of the circuit has a resolution of one in 2^{12} (4096). If the sensor has a measuring window of, say, 100 mm, this would equate to 100/4096 = 0,024 mm. When specifications are written this way, make sure that the rest of the circuit has a resolution smaller than the output portion of the circuit (the digital-to-analogue converter). In other words, if a sensor has an output resolution of 0,02 mm, and the rest of a sensor's measuring system produces a resolution of 0,5 mm, the overall resolution is limited to 0,5 mm. Influences on resolution include response speed, target conditions, distance to target and external factors such as noise from unterminated outputs and shields or lighting, motors, etc.

Response Time

Response time is a measure of how quickly a sensor can react to a change in the input variable. This is generally reported as the time it takes for the sensor to output a signal representing 63% of the change in the input. For example, a temperature sensor at 0 °C is quickly placed in 100 °C water. The sensor reads 63 °C after 4 seconds. Therefore, the response time of the sensor is 4 seconds.

Span

The span of a sensor is the range over which the linear output is configured. For example, an ultrasonic sensor is calibrated so that 4 mA equals 500 mm; 20 mA equals 1200 mm. The span of the sensor is 700 mm.

Span Adjustment Range

This represents the amount of adjustability in the linear output of the sensor. For example, a laser displacement sensor might have a span adjustment range of 5 to 15 mm, meaning the 4 to 20 mA signal can be correlated to spans as small as 5 mm or as large as 15 mm. This range is sometimes referred to as turndown ratio. In the example above, the turndown ratio is 15:5 or 3:1.

Standoff Distance

The distance from the face of the sensor to the midpoint of the measuring range.

Target Angle

For ultrasonic sensors, a flat target that is perpendicular to the beam axis reflects the most sound energy back to the sensor. As the target angle increases, the amount of energy received by the sensor decreases. At some point, the sensor will not be able to "see" the target. For most ultrasonic sensors, the target angle should be 10º or less. See Figure 4.

Target Surface

Sometimes, the choice of a sensor can be determined by the target surface. Optical sensors usually don't work well on mirror-like surfaces and measurement errors result from semi-transparent targets (such as clear plastic) or from porous materials (such as foam). Ultrasonic sensors don't work well on sound-absorbing materials but are the best choice for transparent, different colour or highly reflective surfaces.

Temperature Warm Up Drift

The error that occurs as the sensor warms from a cold power up. Allow proper warm up before programming or operating.

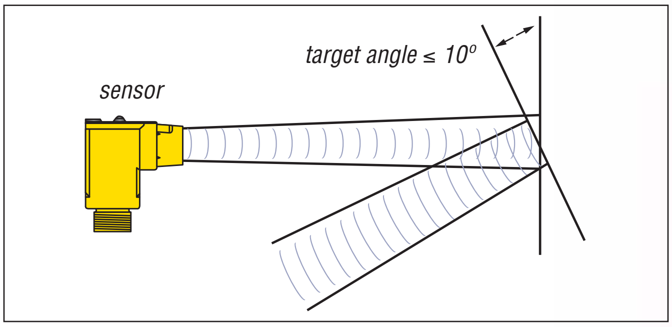


Figure 4: *Target angle*

Temperature Effect

The temperature effect is defined as the maximum change in output per change in ambient temperature. An example of a temperature effect spec is "1% of distance per 10 °C", meaning that the sensor's output changes less than 1% for every 10 °C change in temperature. For ultrasonics, the speed of sound is dependent upon the chemical composition of the gas in which it is travelling, the pressure of the gas and the temperature of the gas. For most applications, the composition and pressure of the gas are relatively fixed, while the temperature is not. In air, the speed of sound varies with temperature, according to the following approximation:

$$C_{m/s} = 20\sqrt{273 + T}$$

where $C_{m/s}$ = speed of sound in m/s
T = temperature in ºC

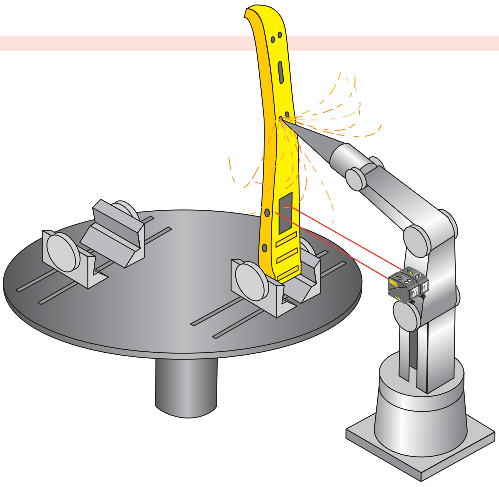
The speed of sound changes roughly 1% per 6 °C. Some of Banner's ultrasonic sensors are available with temperature compensation. Temperature compensation reduces the error due to temperature by about 2/3. Also, keep in mind that if the sensor is measuring across a temperature gradient, the compensation technique is less effective.

Total Error

The sum of all errors associated with Accuracy (Linearity, Resolution/Repeatability), Temperature Effect and Temperature Warm Up Drift. To estimate the expected error of a measuring device, use the root sum of the squares (RSS) method to combine the individual sources of error. For example, a sensor with 3 mm resolution and 4 mm of linearity would have an expected error of $\sqrt{3^2 + 4^2} = 5$ mm.

Update Rate

The update rate of a sensor is the rate at which a new value is outputted from the sensor. This should not be confused with response time, which is often quite slower than the update rate. For example, a sensor may compute a moving average of 10 ms worth of data that is outputted every 1 ms. In this case, the update rate is 1/1 ms or 1 kHz, while the response time would be 6 ms.



Error-Proofing a Laser Cutting Operation

Application: To verify that holes cut into a chassis are properly positioned.

Sensor: LT3 diffuse-mode sensor.

Operation: A robotic laser-cutting process is used to cut openings in automotive chassis sections. As soon as a section is cut out, the LT3 inspects the region to verify that the hole is in its proper place. Because the sensor cannot be located within the robot's range of motion, the LT3's long operating range is vital for this process.

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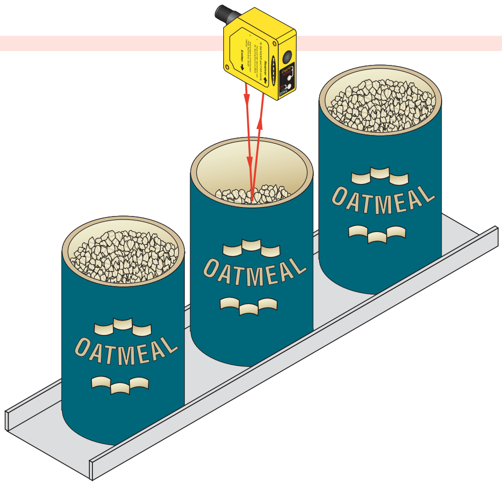

Fill Level Control

Application: To monitor and control fill level of dry cereal in a packaging operation.

Sensor: Q50BU sensor.

Operation: Many food processing lines now fill by level, instead of by weight. Infrared analogue Q50 sensors are the best choice for fill level monitoring of irregular surfaces, such as dry cereals.

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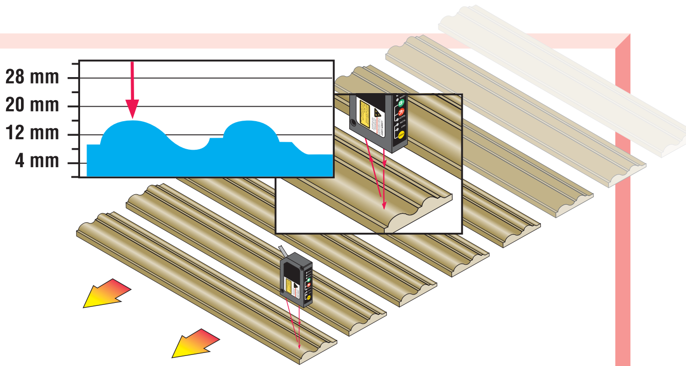

Wood Profiling

Application: Profile wood mouldings; inspect milled dimensions.

Sensor: LG10A65NU sensor.

Operation: The LG10, with a 100 mm stand-off distance and a 50 mm measuring window, can accurately profile a wide variety of wooden mouldings in milling applications. Not only is the LG10 fast and accurate, it is also very tolerant of changing wood colours. For example, changing from dark walnut to light ash requires no change in sensor configuration.

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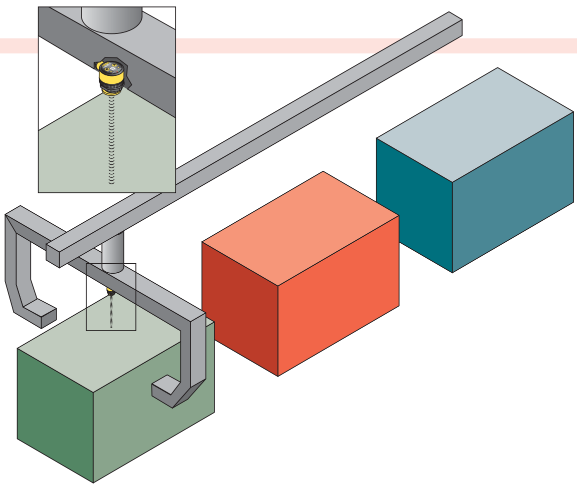

Crane Anti-collision

Application: To insure that the crane apparatus does not contact the top of the container.

Sensor: T30UDNBQ sensor.

Operation: The T30U senses the distance to the top of the container and outputs a signal if the distance is less than a critical pre-set value.

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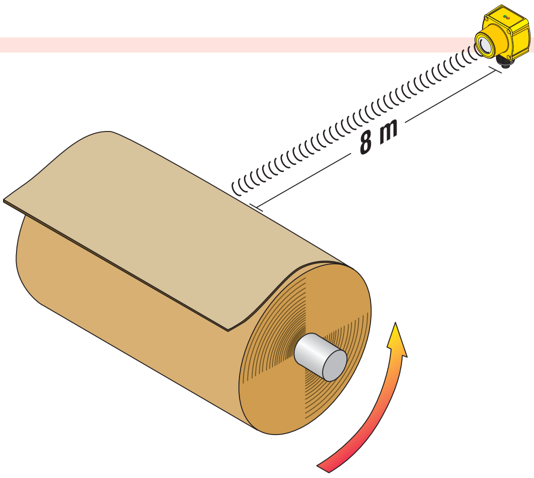

Roll Size Monitoring

Application: To monitor the size of a large roll of goods from a distance of up to 8 m.

Sensor: QT50U sensor.

Operation: During the printing process, the roll of paper, which may be mounted at an inconvenient location near the ceiling, must be monitored to prevent running out of paper during the print run. A QT50U sensor is mounted perpendicular to the roll, at a distance up to 8 m from an empty roll. Because the sensor can be taught remotely, it may also be located near the ceiling.

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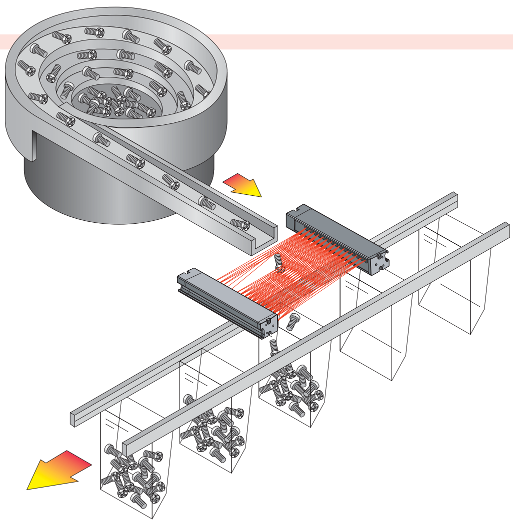

Parts Counting

Application: To count hardware as it leaves a vibratory feeder.

Sensor: LX6ESR emitter and LX6RSR receiver.

Operation: The output of the LX6RSR receiver includes a 5 ms pulse stretcher (OFF-delay) to improve count accuracy. Successive parts must be separated by at least 7 ms. Minimum object detection size is 5,6 mm.

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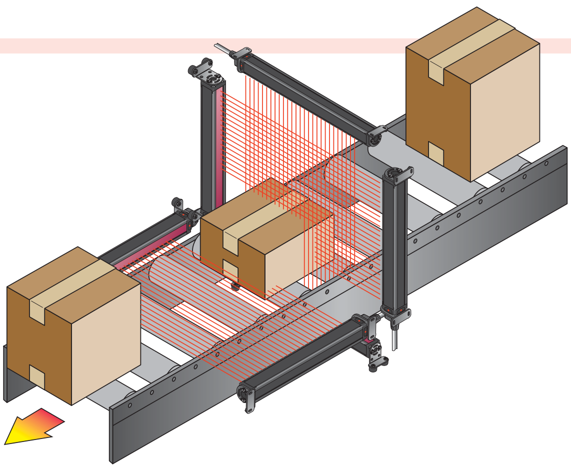
M & I



Parcel Profiling

Application: To accurately measure boxes to be shipped.

Sensor: 3 High-resolution MINI-ARRAY MAHE64A emitters and MAHR64A receivers.

Controller: 3 MAHCN-1 control modules.

Operation: The 3 arrays are positioned at right angles to each other. Array controllers transmit box length, width and height data to the host process controller. The host compiles size information for all of the parcels and determines a packing program which optimises use of cargo container space.

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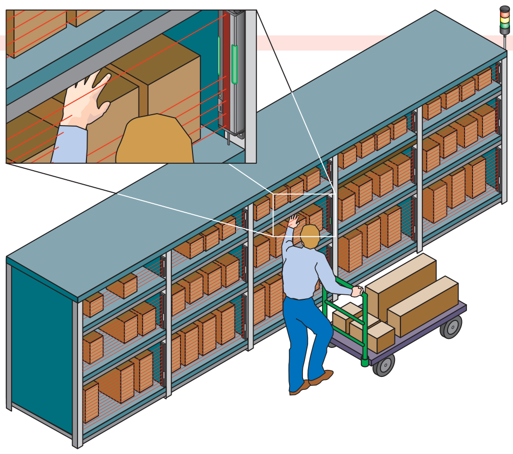

Warehouse Order Picking

Application: To indicate which bin to pick from and verify that an item was removed.

Sensor: PVA Series emitter/receiver pairs.

Operation: The system controller (typically a computer) issues an instruction to pick an item from a particular location. The controller turns ON the PVA's "job lights" at the specified location. The job lights go OFF when an item from that location is removed. If multiple items are required from one location, the job light stays ON until the correct number of items are removed.

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