LISTEN.
THINK.
SOLVE.®

Error-Proofing

Using sensors to prevent product defects and drive customer satisfaction

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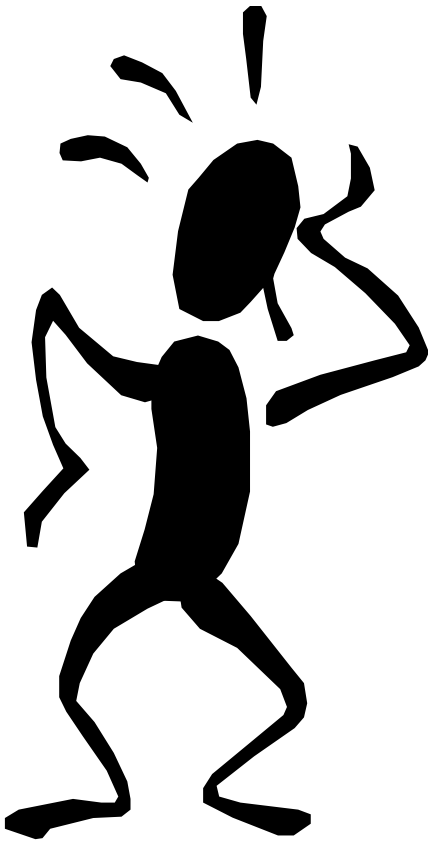
Why Error-Proofing?

Things done right 99.9% of the time means…

- One hour of unsafe drinking water per month
- Two unsafe landings at O'Hare Airport each day
- 16,000 lost pieces of mail per hour
- 20,000 incorrect drug prescriptions per year
- 500 incorrect surgical operations per week
- 50 newborn babies dropped each day by doctors
- 22,000 checks per hour deducted from wrong accounts
- 32,000 missed heartbeats per person each year



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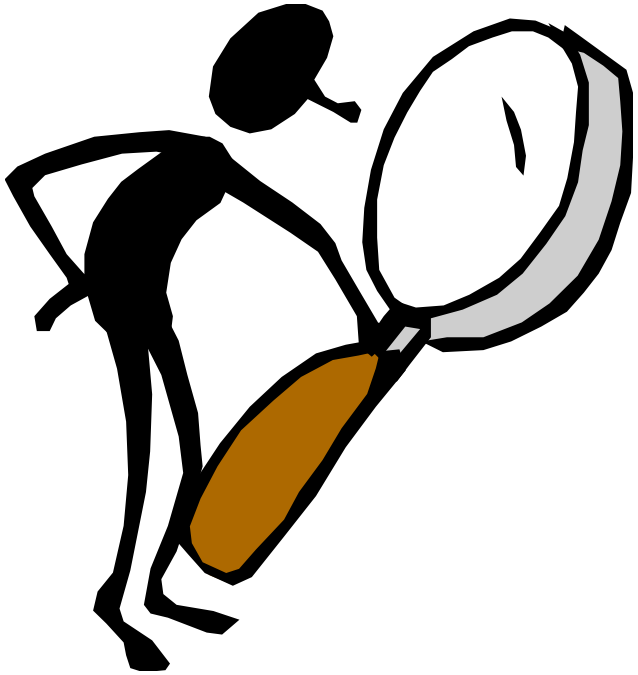
Why Error-Proofing?



- If errors are so easy to make, how will we ever send our customers 100% good product?????
- By designing our products and processes so that they minimize the opportunity for the mistakes to happen in the fist place
- This is where the concept of ERROR PROOFING comes in…….

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Reasons Companies Implement Error-Proofing Systems

- To reduce scrap
- To reduce labor costs
- To reduce inspection costs
- To reduce rework costs
- To reduce warranty claims
- To reduce customer complaints
- To increase quality
- To increase productivity
- To protect equipment

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Aspects of Error-Proofing

- Error-Proofing consists of two main aspects:

1. Preventing errors
   - Designing parts and processes to prevent errors from occurring in the first place
   - Examples include painting similar parts two different colors, keying components so that they only fit together in the correct manner, and pick-to-light systems
2. Detecting errors as soon as possible
   - 100% inspection at the source rather than down the line, after additional value has been added (wasted)
   - Each step in the process is inspected and confirmed before the part moves down the line; if the inspection fails, the part is rejected or reworked
   - An error only becomes a defect if it makes it to your customer!

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Error-Proofing Systems – Steps

Steps in an error-proofing system

1. Prevent errors
2. Detect errors as soon as possible
3. Remove (or rework) non-conforming product
4. Indicate that the error occurred
5. Collecting data on the error and saving it to a database for traceability.

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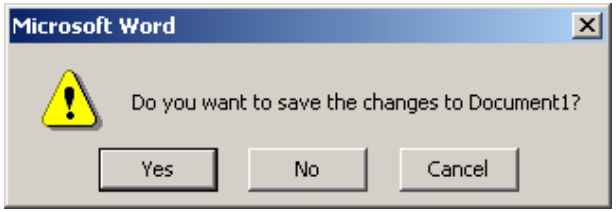
Every-Day Examples of Error-Proofing

- When you close a computer file, the operating system may ask you if you want to save your work first to prevent losing it inadvertently.



- Childproof caps on medicine bottles keep children from taking medication that could be harmful.

- A patient about to undergo surgery for a problem on his right arm, concerned about reports of surgery accidents, wrote "Wrong Arm" with a magic marker on his left arm.

- Speed-dial on your phone that improves accuracy as well as speed - if you hit the right speed dial button!

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Error Proofing Examples

Detection: *the compact disc is only able to work in one orientation when inserted into the computer.*

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Error Proofing Examples

Prevention: *the fuel receptacle of this car has three mistake-proofing (prevention) devices*

1. Insert in fill pipe keeps incorrect fuel from being used.
2. Gas cap tether does not allow the motorist to drive off without the cap
3. Cap is fitted with ratchet to signal proper tightness and prevent over-tightening.

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Error Proofing Examples

Prevention: *to ensure cars will fit into low-clearance garages, many are fitted with a go/no-go gauge at the entrance. Contact with the sign will not damage the vehicle but will alert the driver.*

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Industry Examples of Error-Proofing

- Color-coding of components that otherwise look similar.
- A sensor connected to the electric nut-runner in an automobile assembly plant triggers a horn if a suspension assembly is moved to the next operation before a bolt is properly tightened.
- Different color bins for different components

- Bins of parts that are electronically connected to the bill of materials through a bar code scanner, so that only the proper bin door opens for a given product.
- Bar-code scanning at the check-out lane to eliminate errors and increase speed

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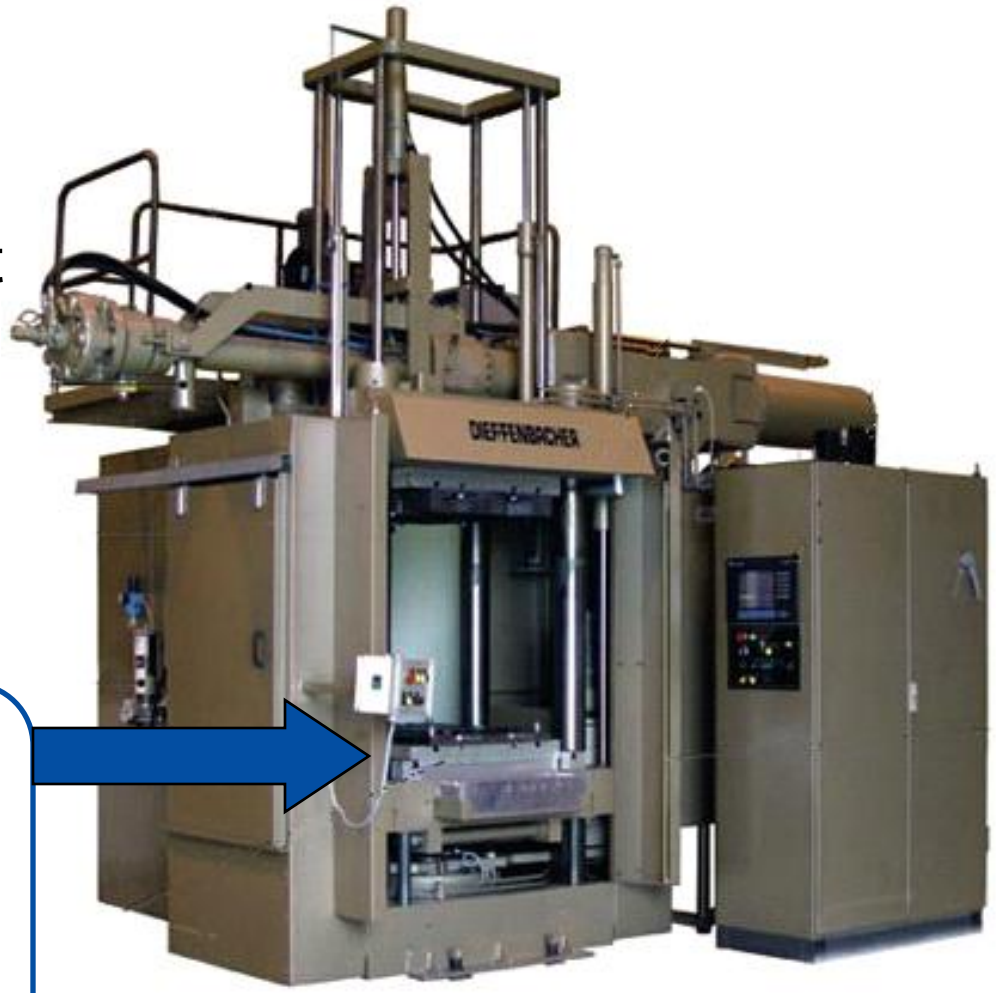
Industry Example

- Mechanical press
- If pressed part isn't removed before next cycle begins press could be damaged (and product will be destroyed)
- Use 45MLD laser sensor to confirm part has been removed before beginning next cycle



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Error Notification

The most effective types of error notification

- Getting the Operator's Attention
  - Visual signal (flashing light is best)
  - Audio Signal (loud and persistent, e.g. burglar alarm)
  - Protective Barrier (to prevent defect or operator injury)

- Shutting Down the Operation
  - Upon detecting a "non-conformance" the operation is simply shut down, i.e. the next part will not be processed

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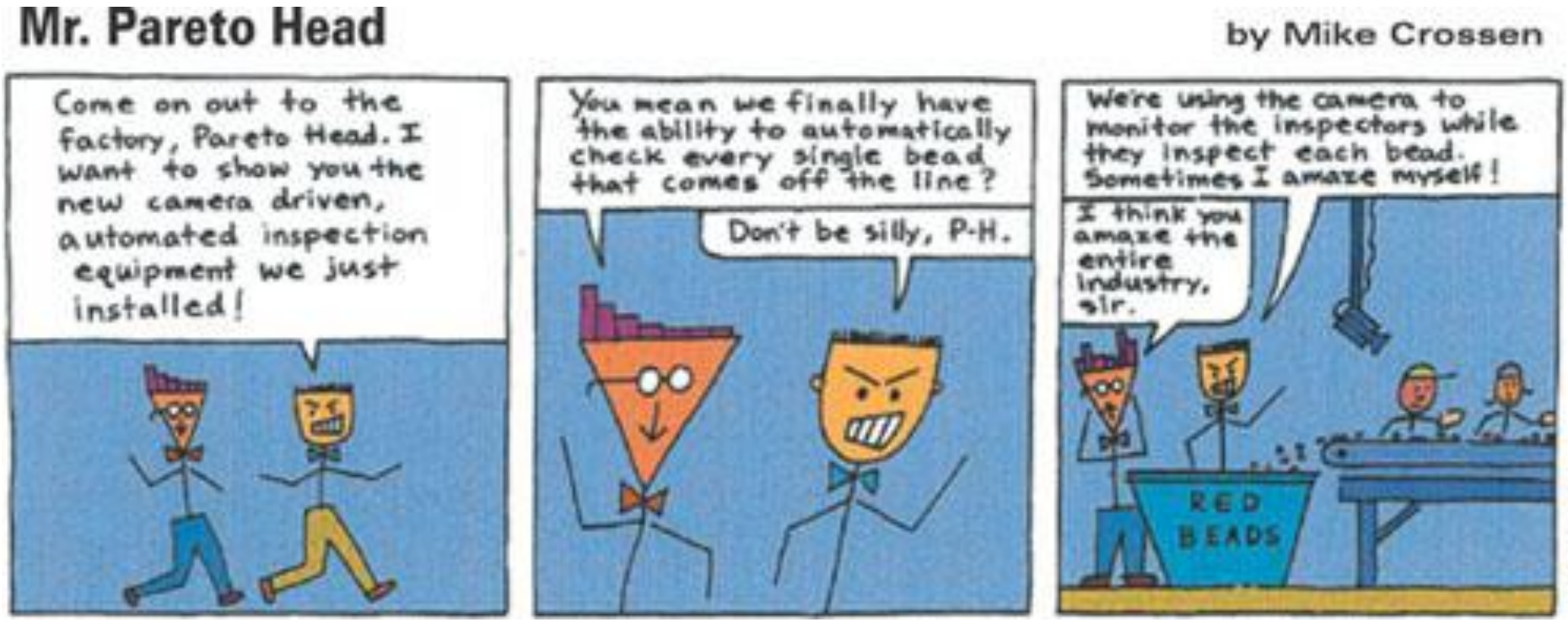
Definition of 100% Inspection



Inspection requires sensors -

Humans make mistakes!

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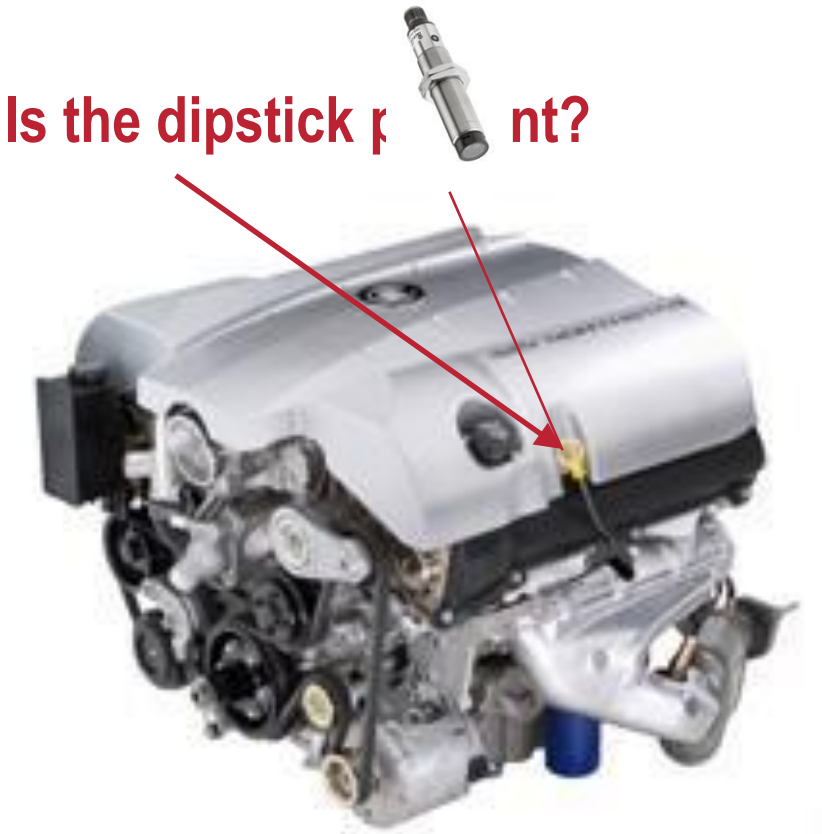
Application Example



- Eddie is responsible for checking if the dipstick is installed
- Eddie is also responsible for checking the belt, a few other parts, the general workmanship, and the name on the engine (which changes every third unit)
- Eddie sometimes misses the dipstick
- Check with a photo sensor
  - Use background suppression for targets close to background

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Application Example

Printing machine

- Where to cut?

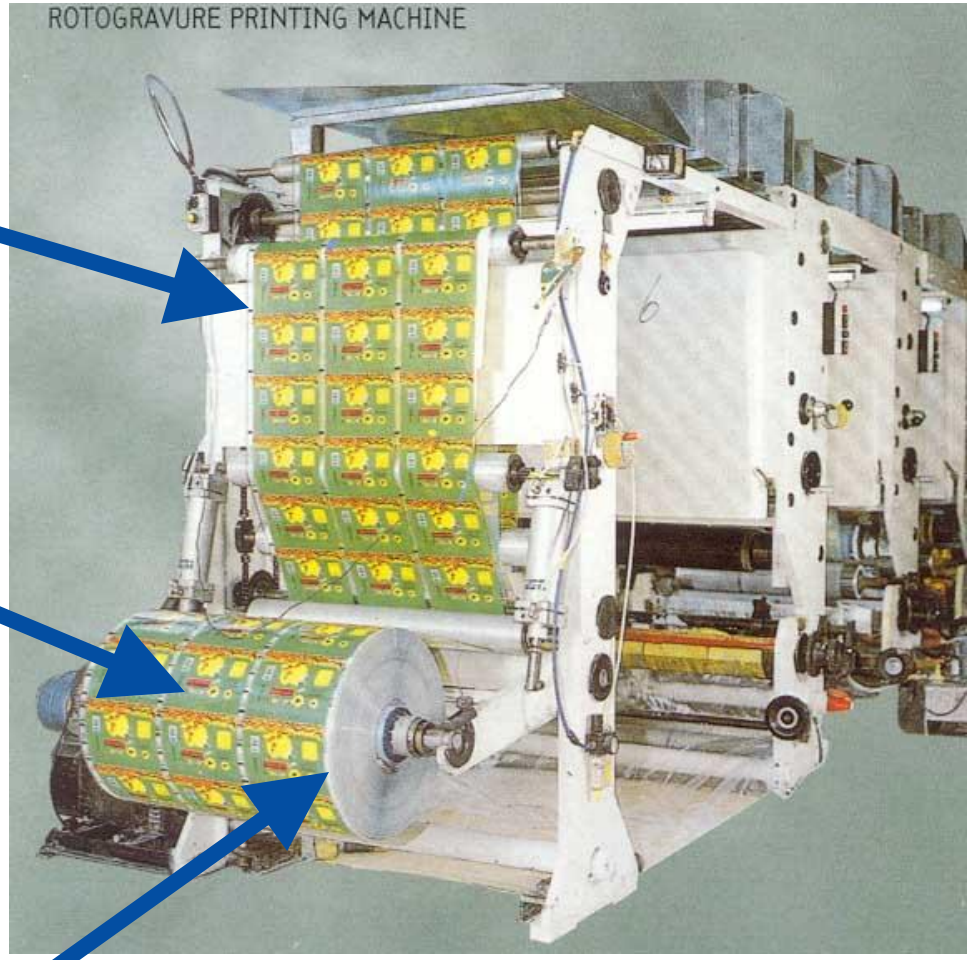
  Use Fixed Focus RightSight to detect registration mark

- Is print roll full?

  Use 45BPD laser sensor for roll diameter detection (analog or discrete output)

- Edge Detection

  Use 45MLD laser sensor



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Application Example - Feed Control

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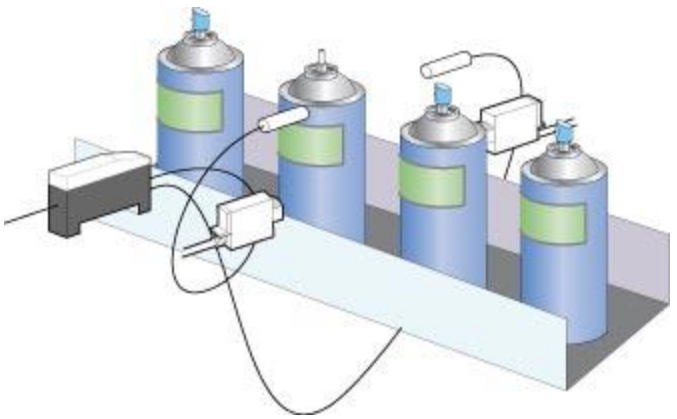
Gating Application

- Check bottle for nozzle
- Nozzle detection is two part question:
  - Is the bottle present?
  - If the bottle is present, is the nozzle present?
- How do we solve this application?



Is the nozzle present?
(Gating App.)

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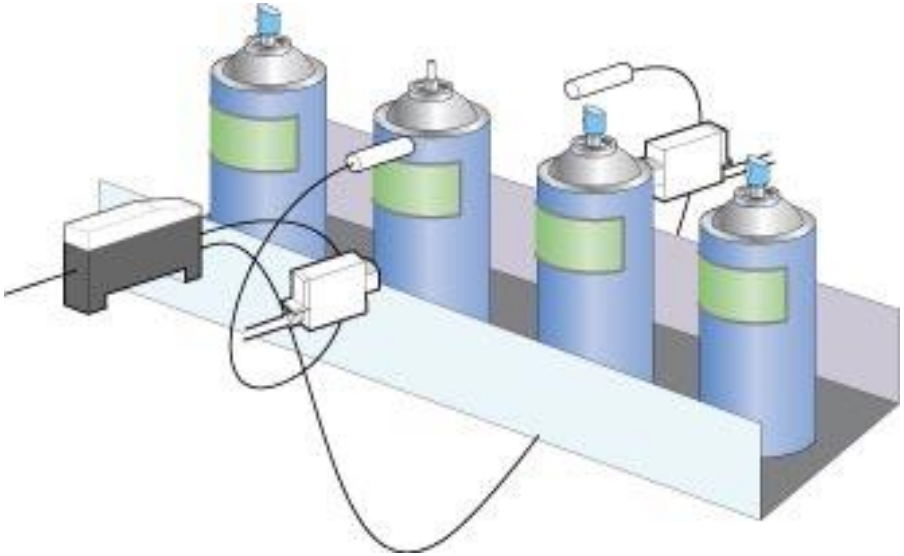
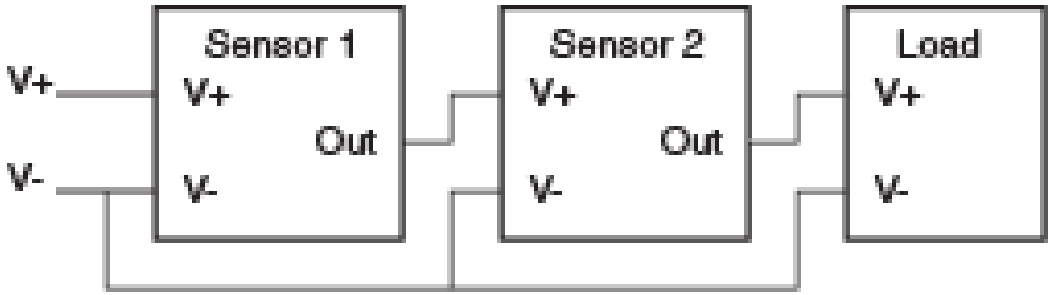
Gating Application - Solution

- Two part question requires two sensors
  - One sensor checks for bottle presence
  - Second sensor checks for nozzle
- Sensors connected in series – called "Gating"
- Output of first sensor provides power to second sensor



Wiring Diagram - Series PNP



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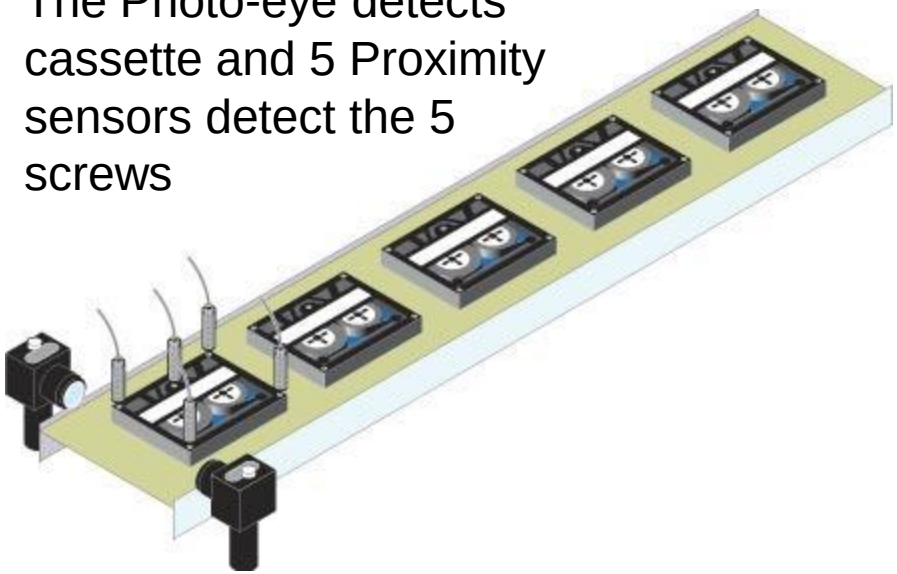
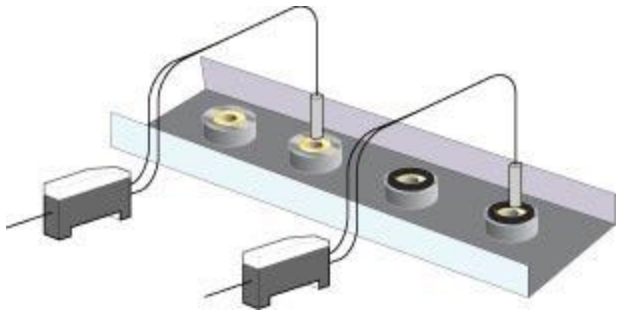
Error Proofing Examples

The Photo-eye detects cassette and 5 Proximity sensors detect the 5 screws



One sensor detects the white washer and the other sensor detects the black washer



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Error-Proofing with Laser Measurement Sensors

- Precise position or distance measurement
- Detect small objects due to a smaller beam spot than standard photoeyes and ultrasonic sensors
- Visible red sensing beam - easy sensor alignment
- Precise analog signal
- 6m (19.7ft) or 300mm (1 ft) range
- 4-20 mA output plus discrete (on/off) output
- Improve quality, throughput and overall process by performing in-line inspections, measurement and positioning

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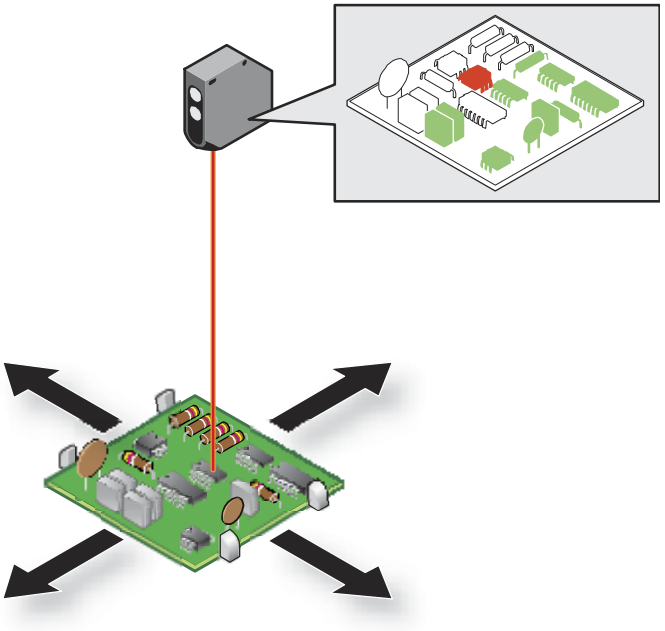
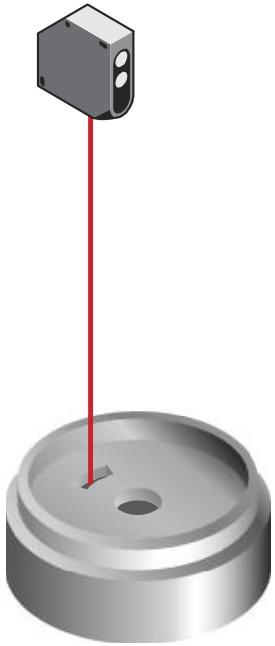
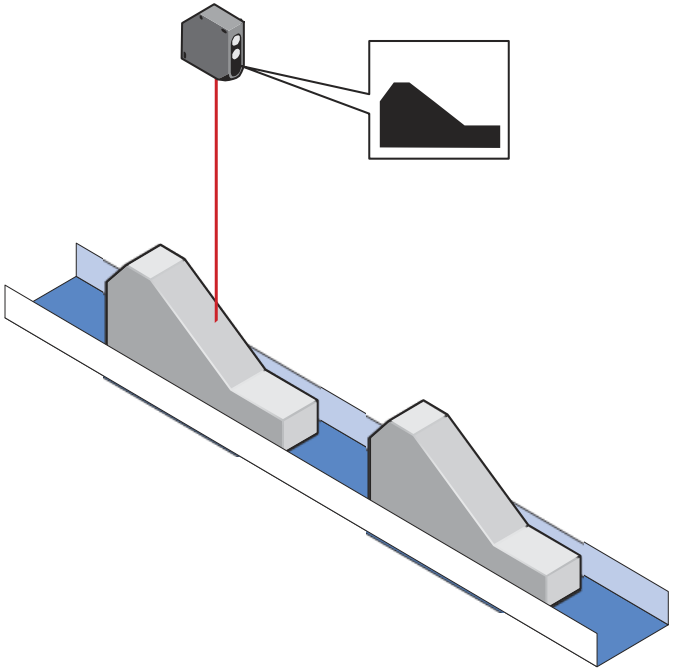
Assembly and Part Verification



Component Insertion



Hole Depth Inspection



Part Profile Inspection

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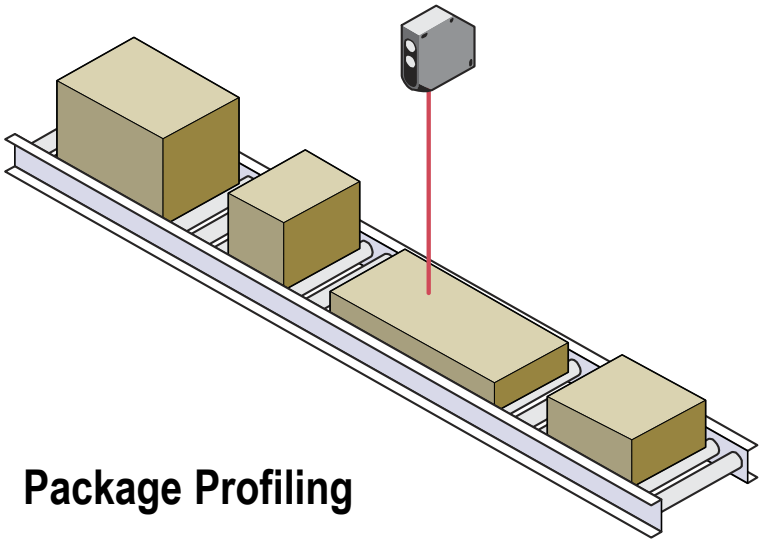
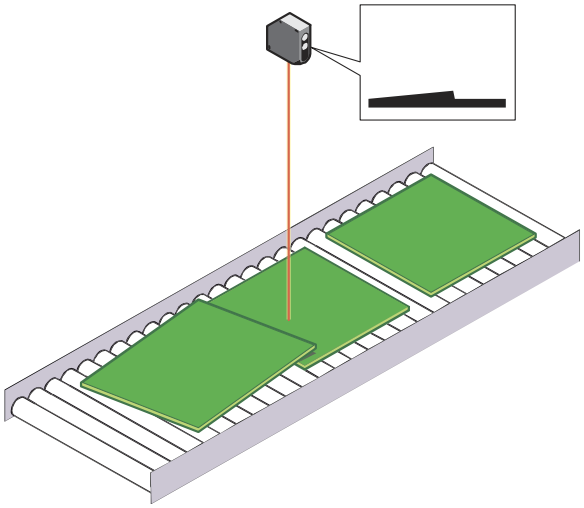
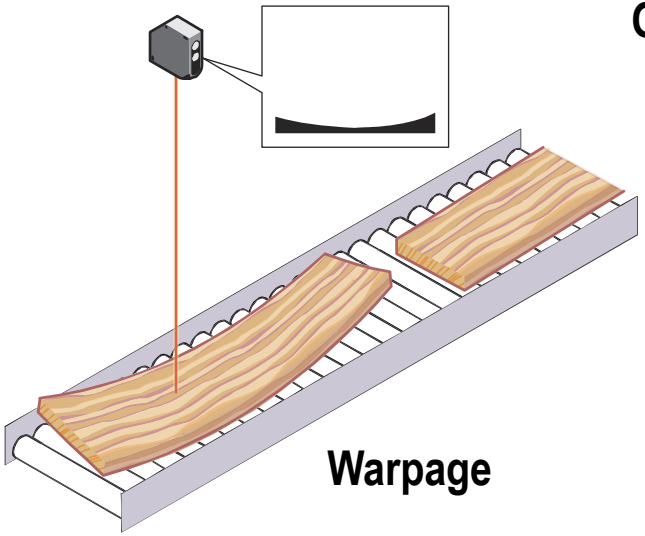
Profiling and Material Inspections



Package Profiling



Overlapping Boards



Warpage

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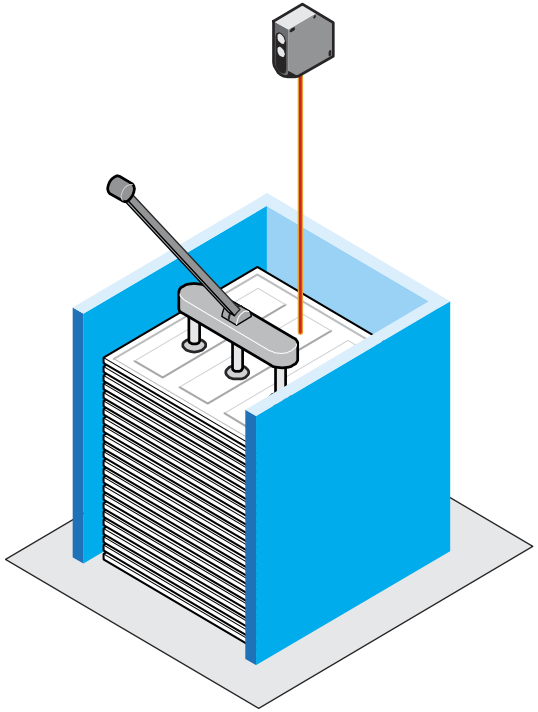
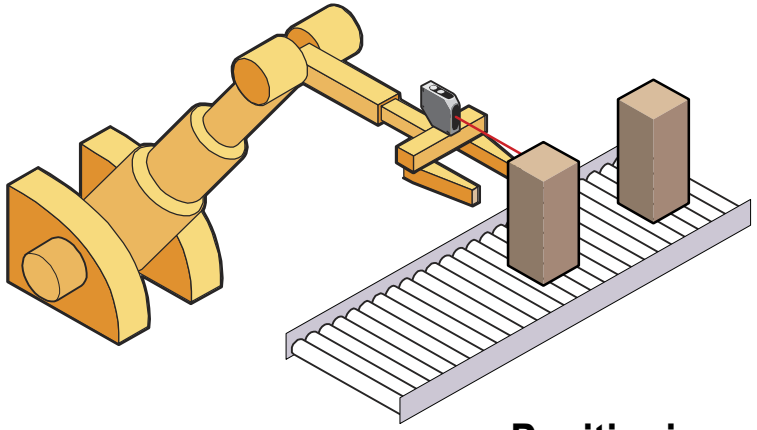
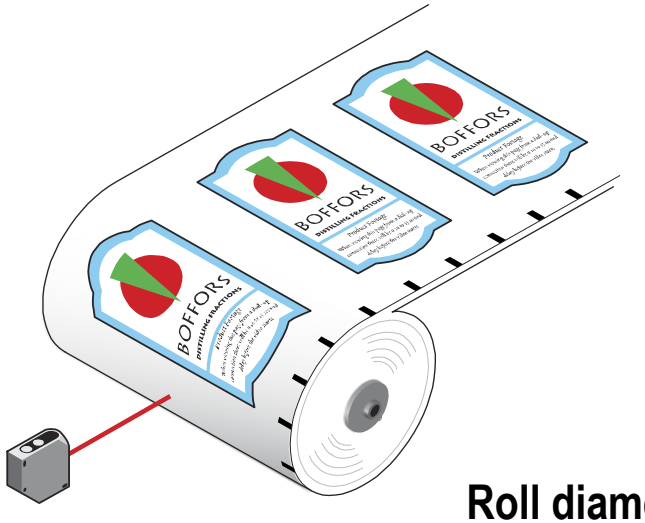
Level, Diameter and Position Measurements



Stack Height



Positioning



Roll diameter

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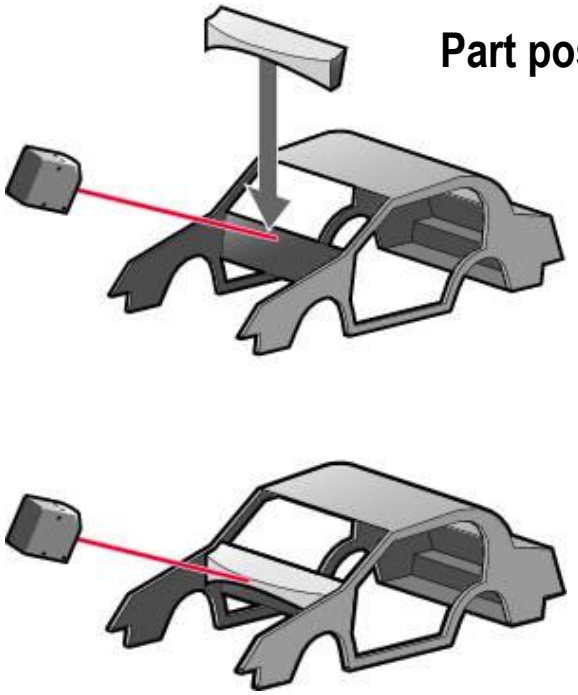
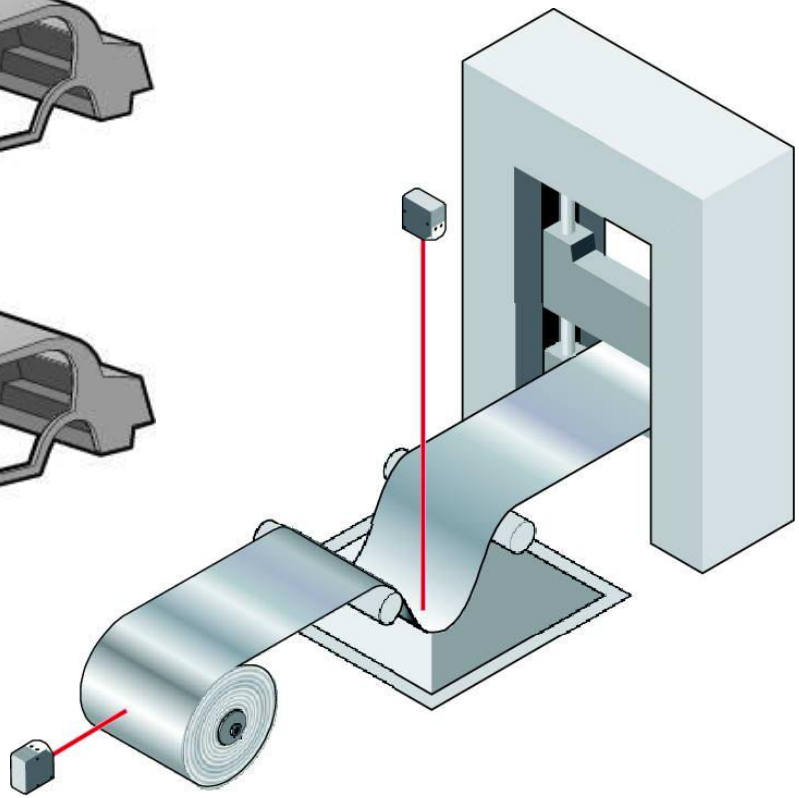
Long Range Error-Proofing and Inspection

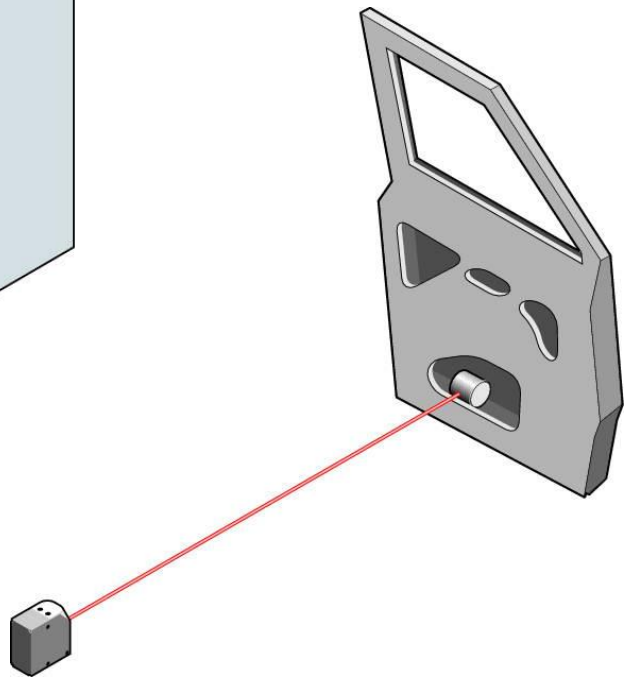
Part position



Diameter and web control



Confirm component placement (discrete output)



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45CLR ColorSight™ Color Sensor

- Sensing range:12-32 mm
- Wide sensing range tolerance
  - detects target even with varying distance to target
- 3 output channels (concurrent 3 color detection)
- 50 x 50 x 12 mm rectangular package
- 500 Hz switching frequency (1mS response time)
- Local and Remote Teach
- Teachable color tolerance

- **Color Scan**
  - Teach multiple colors per output channel
- **Models with RS-485 communications also available:**
  - Internally match up to 5 colors
  - True RGB values communicated for remote processing of additional colors
  - One discrete output available

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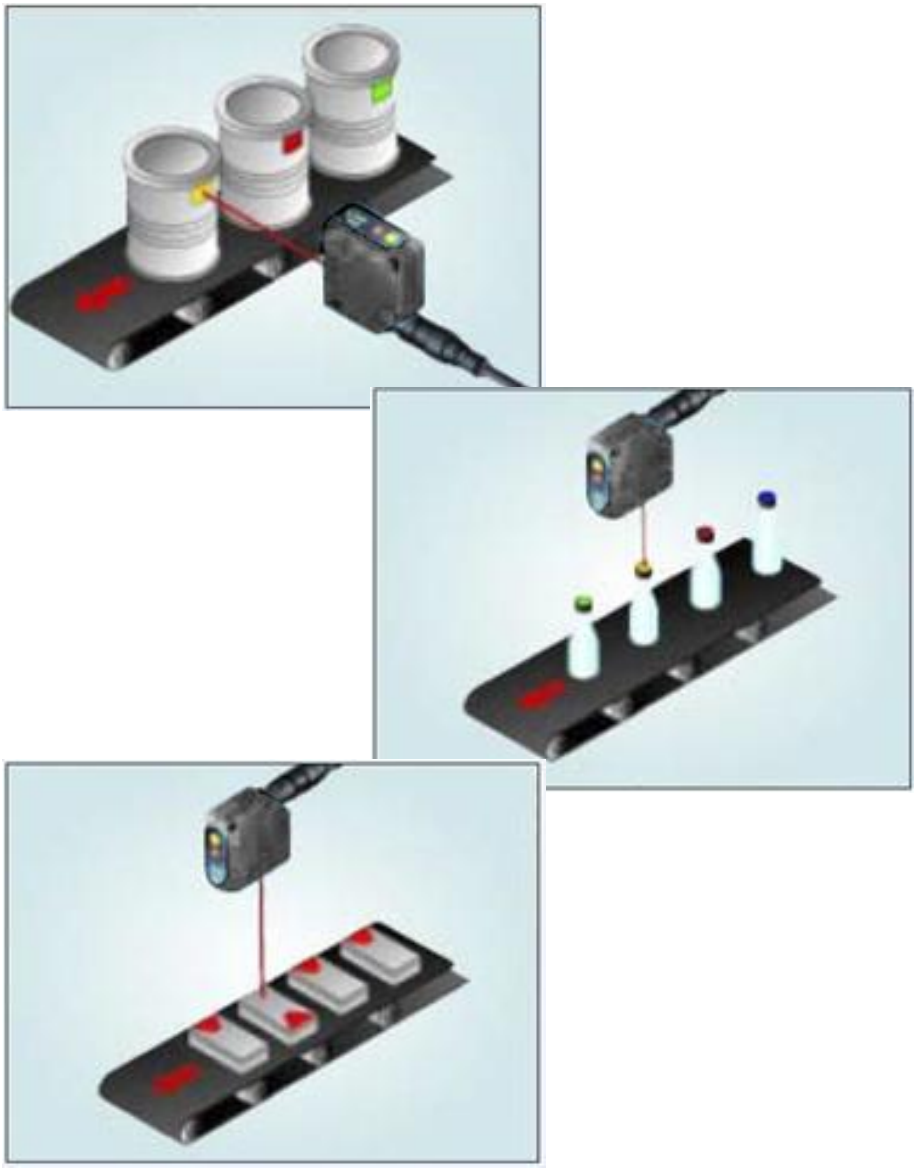
Typical Color Sensor Applications

- Detection of different color labels
- Detection of different color caps
- Object orientation detection
- Additional Applications
  - Paint color matching in Automotive
  - Paint mark detection on tires and brake drums (used for balancing)
  - Paint mark on lumber (to differentiate board quality)
  - Packaging color matching applications



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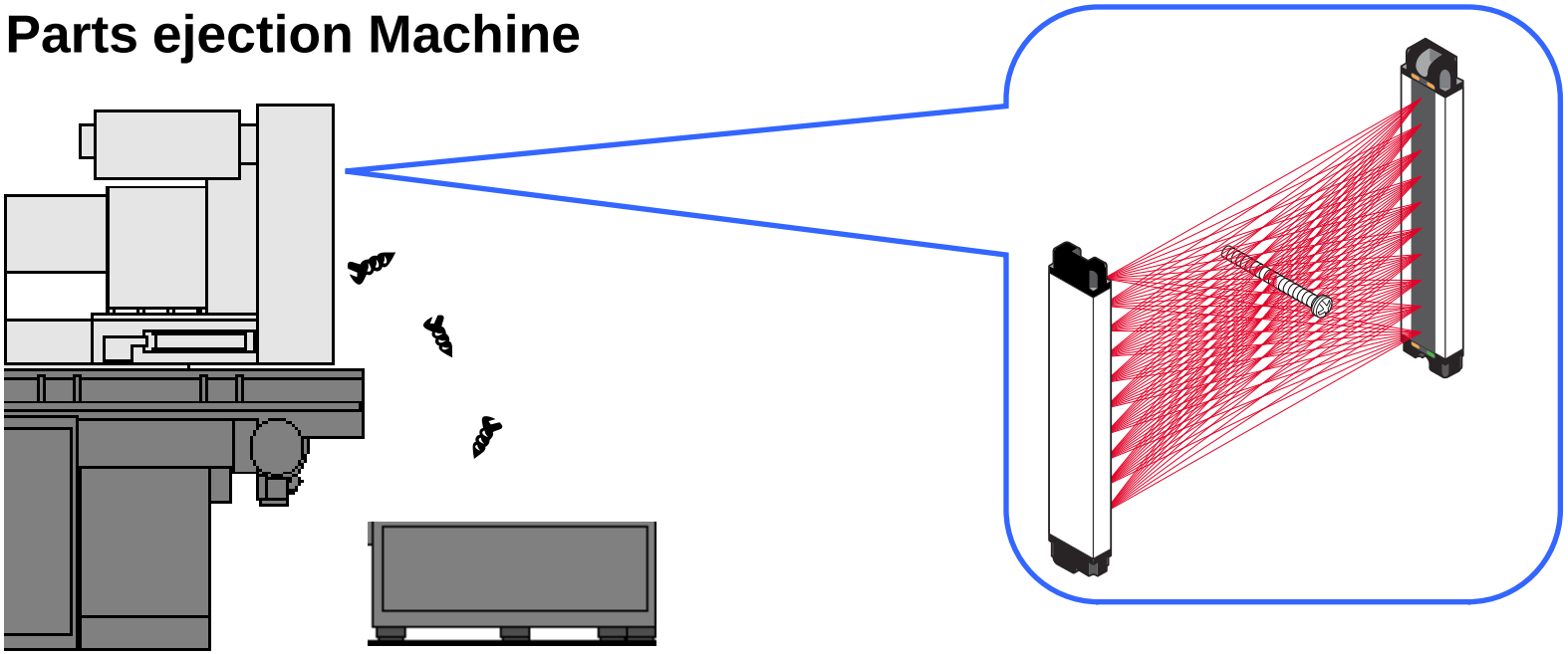
45AST Scanner Solution

Parts ejection Machine



Application Examples:

- Parts Ejection
- Gravity Feed

Features include:

- 2 Dimension Scanning Technology
- 50, 100, 150mm Sensing Heights
- Rugged Housing (IP67)
- 4 ms / 8 ms response time (depending on model)

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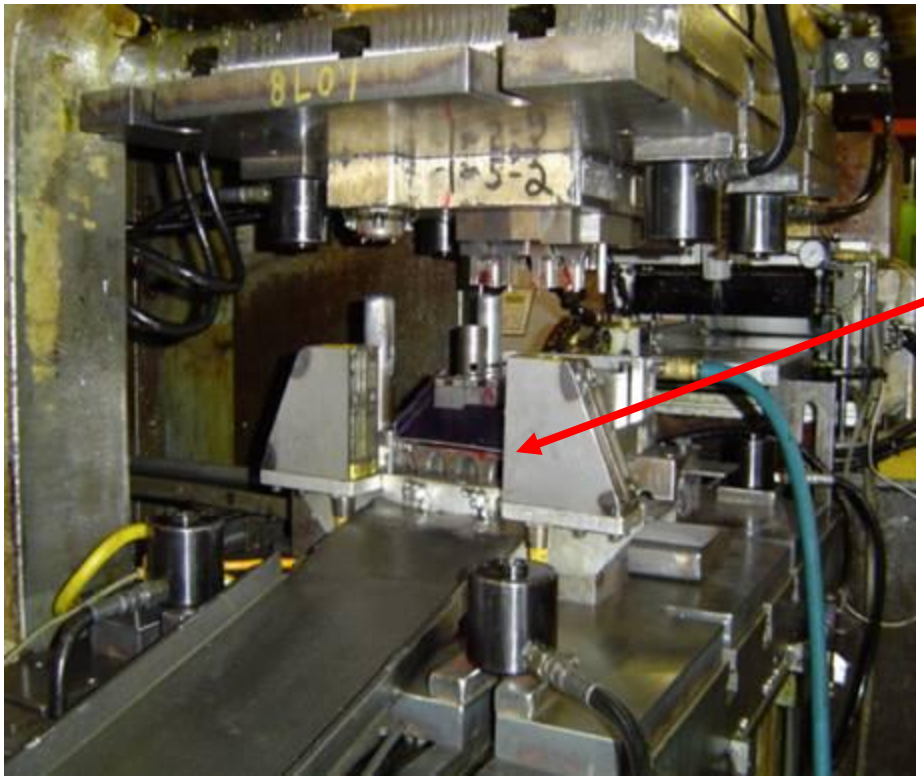
45AST Array Application

Part Ejection Detection



Sensing part ejection with light array. Sheet metal protects sensors from incidental contact.

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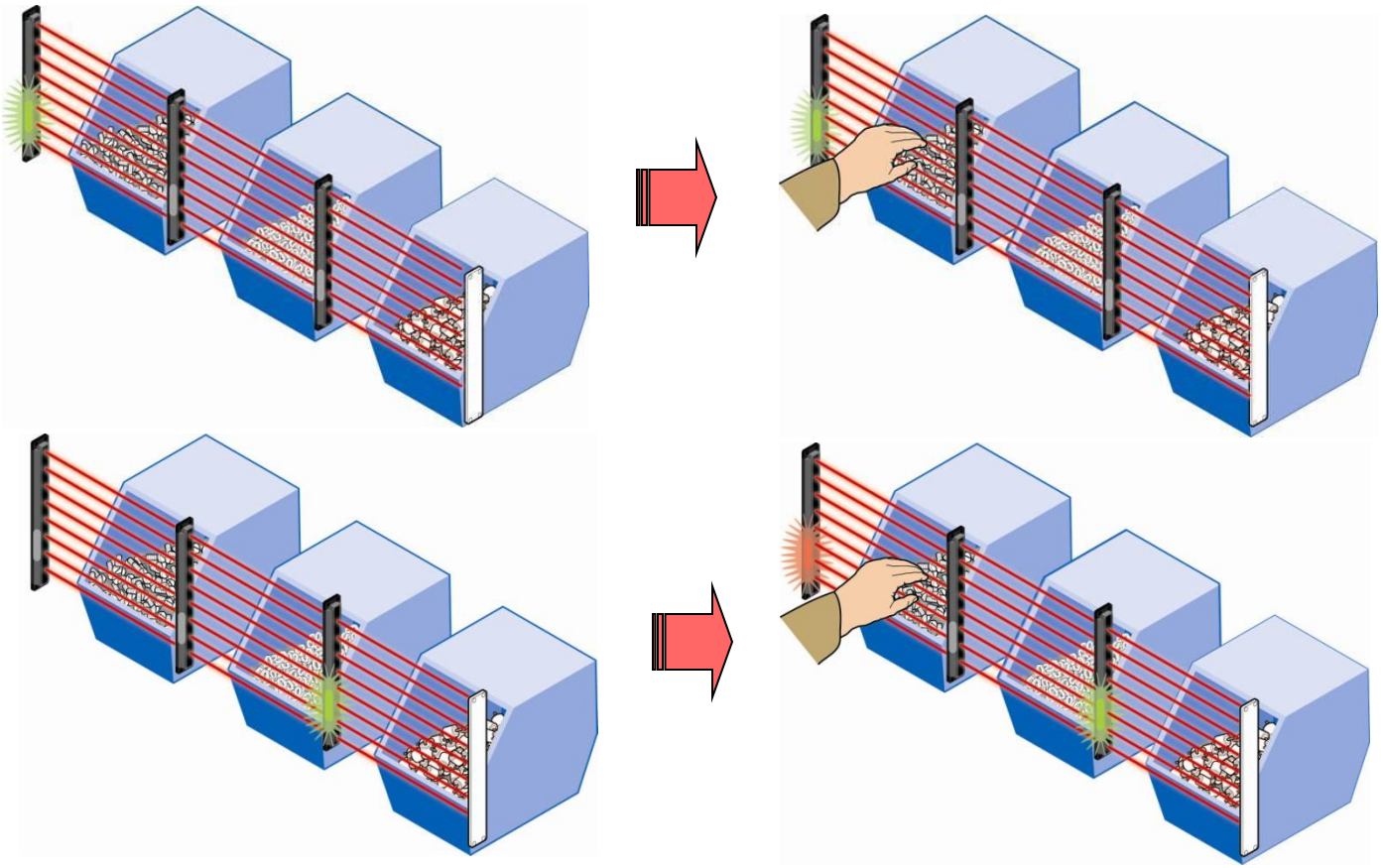
Parts Verification Array for Bin Picking Applications



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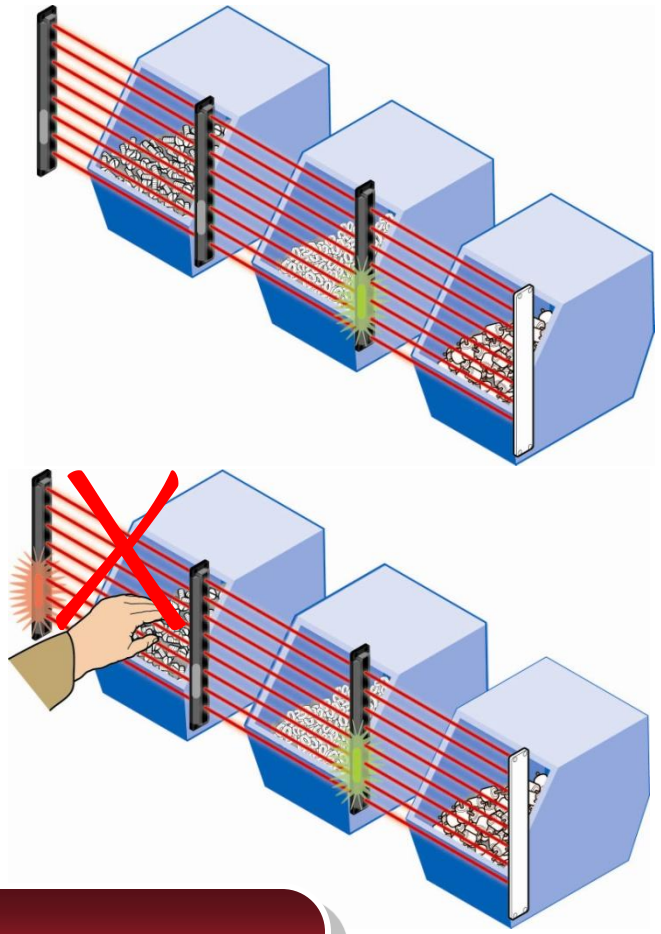
Parts Verification Array

45PVA for Bin Selection Applications

1. Provides visual indication of correct – AND incorrect – bin selection
2. Allows tracking of bin selection
3. Significantly reduces potential for operator error in assembly areas
4. Provides Error-Proofing solution – Prevent mistakes before they happen!



45PVA – Preventative Error-Proofing with a sensor!

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45PVA Parts Verification Array

Low Voltage
12-24VDC

Four Height Styles
100mm, 225mm, 300mm, 375mm

Green Job Light
“pick from this bin”

Red Warning Light
“wrong bin picked”

Optical Sensing
2m range

Transmitted Beam or Retro / Diffuse models available

Switch Selectable Operating Modes
NPN/PNP, frequency, flash rate

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Error Proofing : PVA to I/O Interface

Bin Picked = Output ON

Job light ON

You Picked The Wrong Bin!

Job light ON

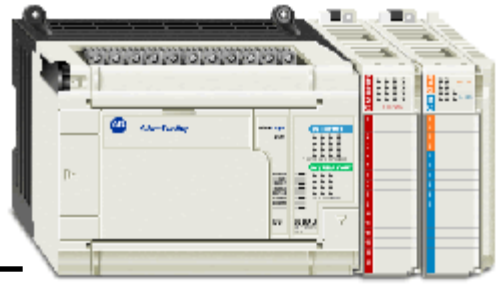
Bin Picked = Output ON

PROCESS

- Initiate Logic
- Pick Bin
- Wrong Bin ?

PLC or I/O

Driven with Ladder Logic



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MultiSight™ Vision Sensor

- Pass/Fail Output
- Robust sensor-like enclosure / IP67
- Integrated LED lighting
- Configure via PC - Ethernet connection
- Multiple virtual detectors
- Evaluation methods - Pattern Match, Contrast, Brightness
- Self contained imager, processing, I/O, lighting

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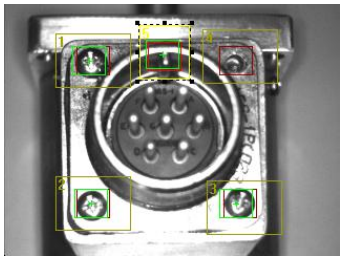
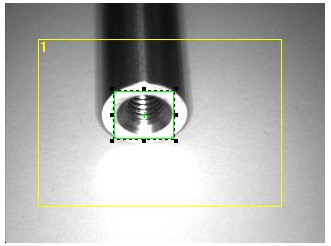
MultiSight™ Target Applications

- **Multiple - Inspections, Positions, Products**
  - **Multiple photo sensors required to inspect part**
    - Multiple sensors, complex set-up, bracket design, spacing, cost
  - **Difficult photoelectric sensor applications**
    - Presence, shape, pattern, position, completeness, count, orientation, flaws
  - **Part position uncertainty**
    - Expensive part fixture required to present target
    - Standard photoelectric sensors require precise part positioning
  - **Product mix**
    - Customers requiring flexible changeovers on their machine
    - Requires complex and time consuming sensor adjustments for each setup





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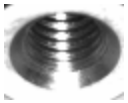
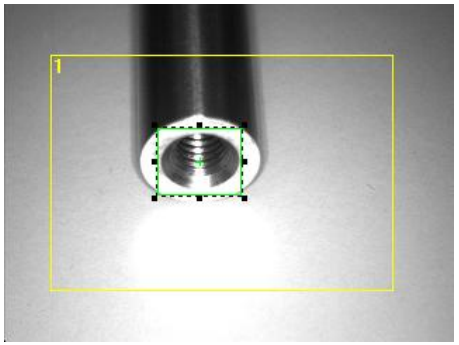
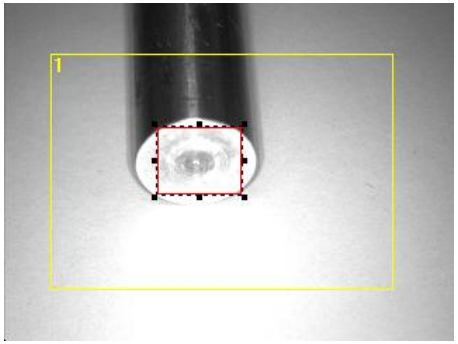
Good and Bad Parts

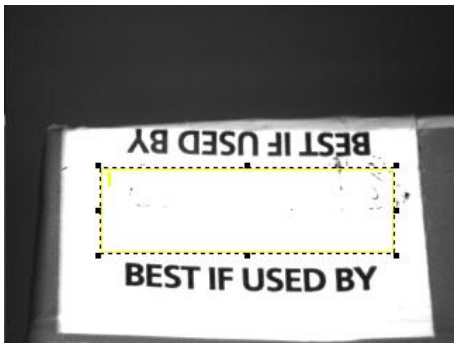




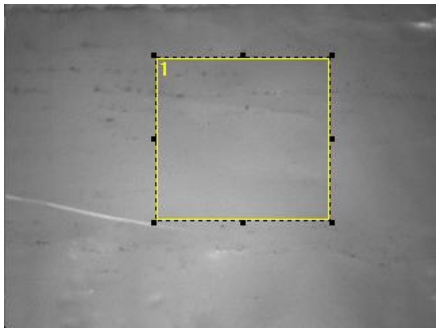


Good

Vs.



Bad



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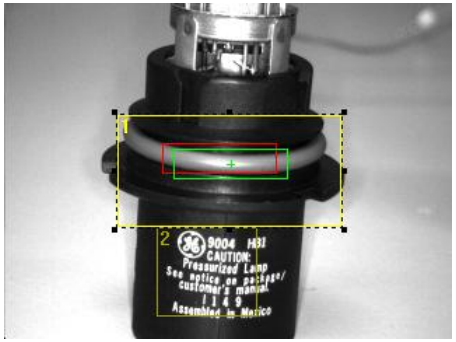
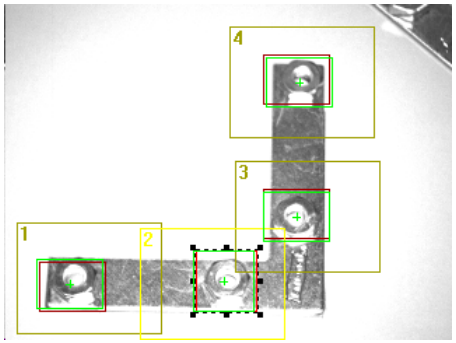
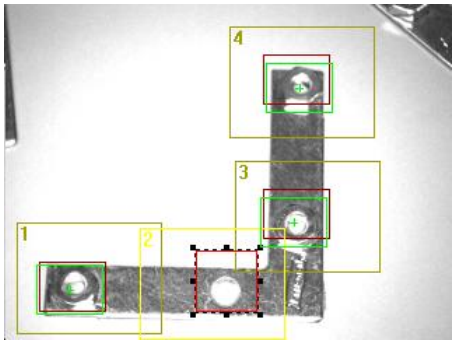
Good and Bad Parts

Good

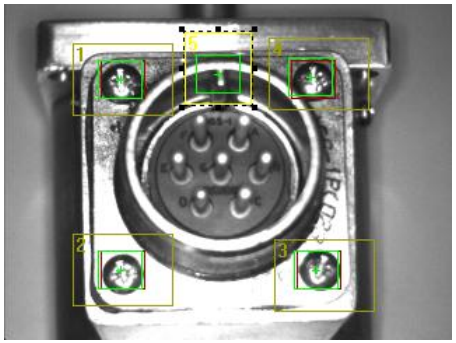


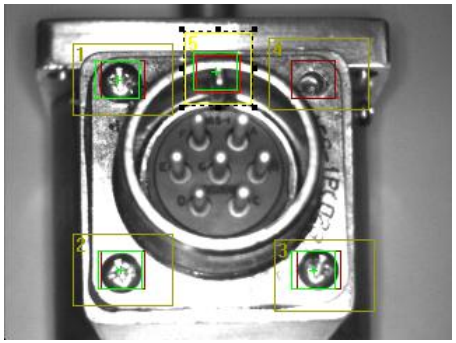


Vs.



Bad





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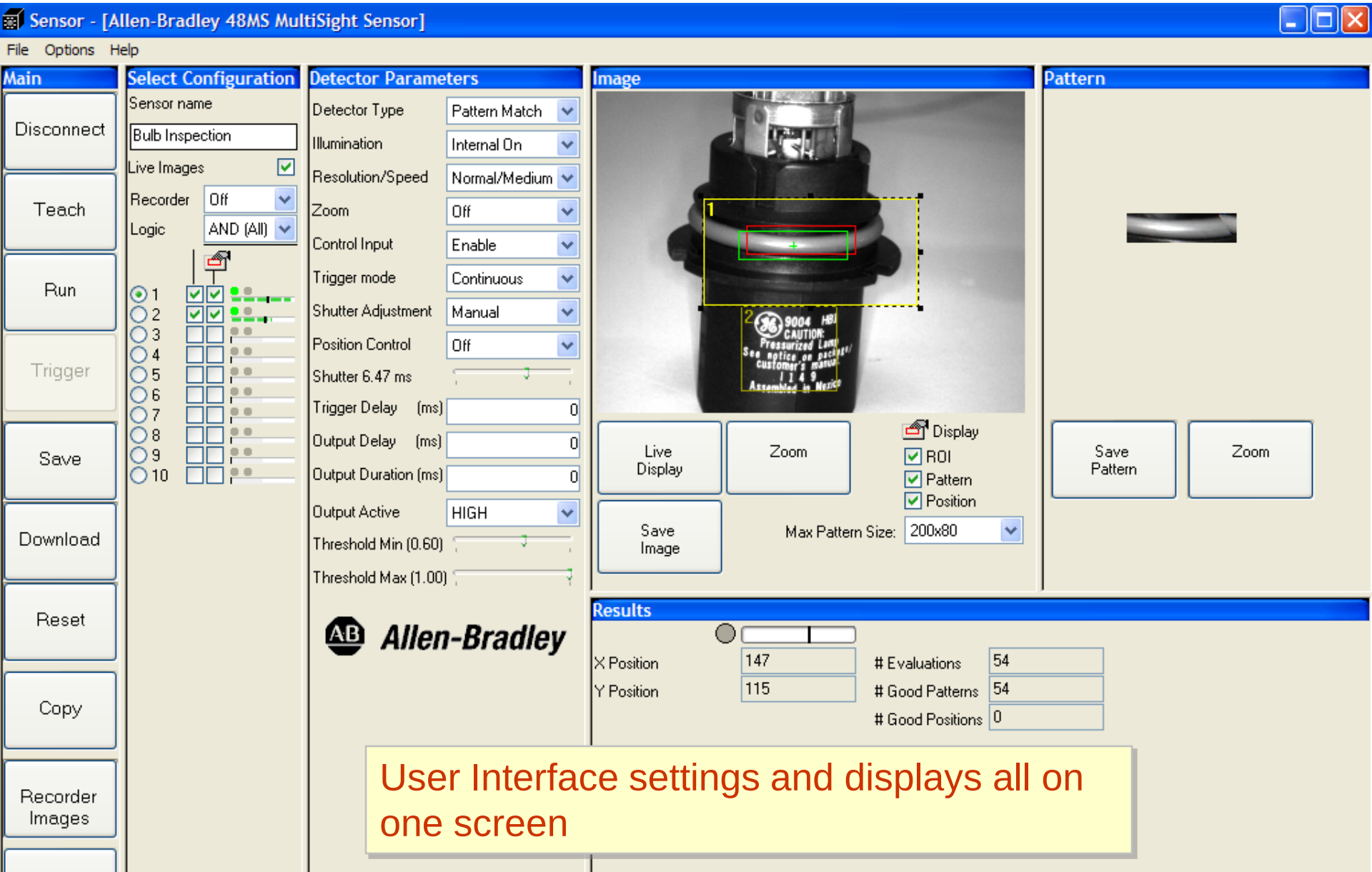
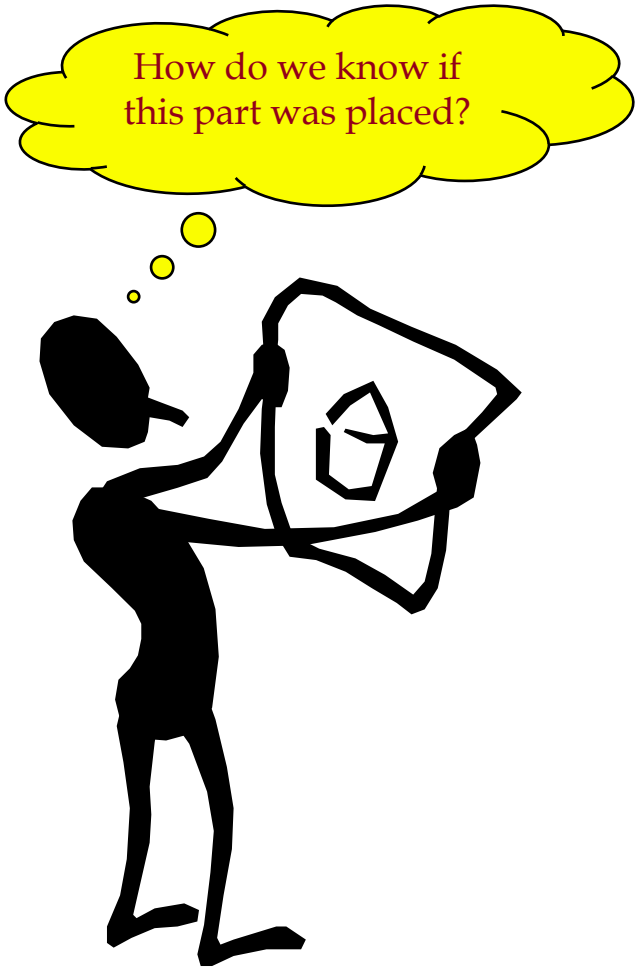
MultiSight™ Configuration Software



User Interface settings and displays all on one screen

Keys to Successful Error Proofing

- Consider Error Proofing early in the design phase
  - Error Proofing solutions are much easier to implement on new machines than existing ones
- Ask lots of questions
  - How will we distinguish between these two parts?
  - What happens if this part isn't installed?
- Remember importance of early detection
  - A mistake only becomes a defect if it is passed along to the next process
  - Any value add after a mistake is wasted



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873P Ultrasonic Sensors

- Standard models
  - **Discrete output**
  - **Analog output**
- Programmable models
  - **2 Discrete and 1 Analog output in one sensor**
- Several sensing ranges
- M18 and M30 Plastic Barrel
  - **IP67 enclosure rating**
  - **Micro QD connection style**

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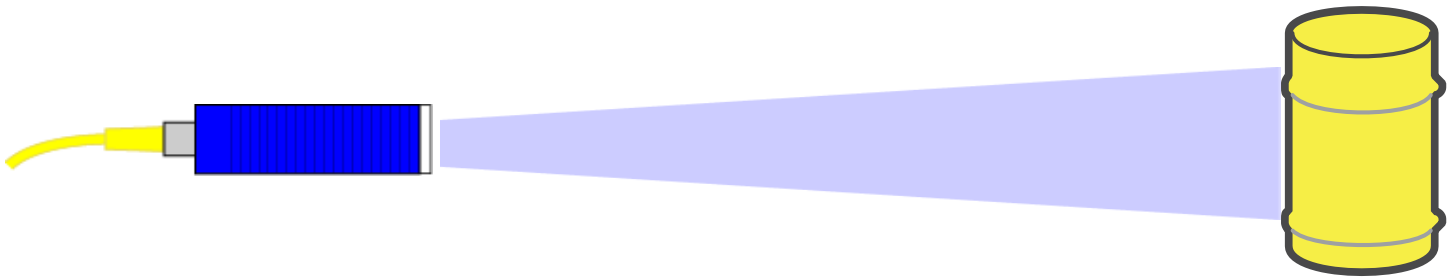
Ultrasonic Sensor Operation



Uses Reflected Sound
Target shape, material and alignment are key to success

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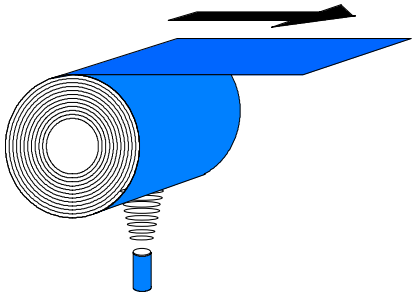
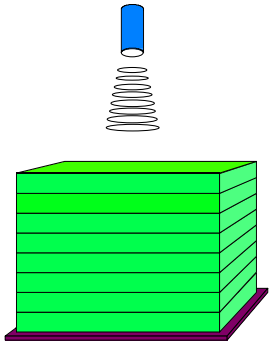
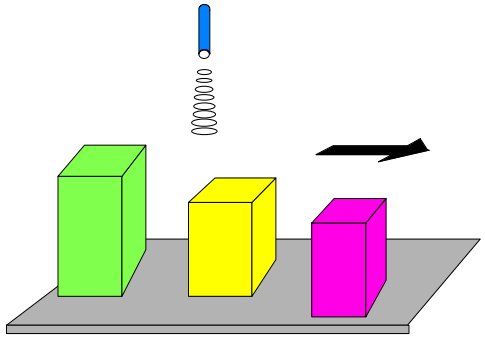
Ultrasonic Applications



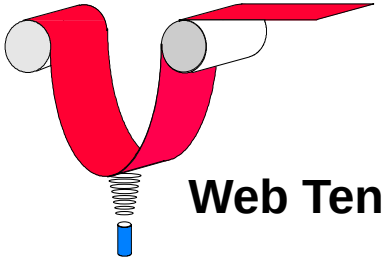
Roll Diameter



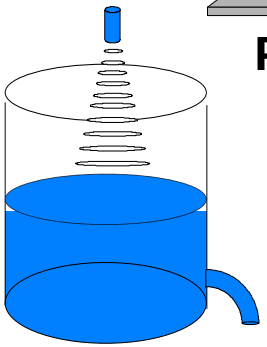
Height Measurement



Parts Counting



Web Tension



Level Detection

- Difficult targets
  - Color independent – Clear, shiny, or black objects
  - Material independent – Liquids, solids, granular, plastics, metals
- Difficult environments
  - Dust, humidity, light

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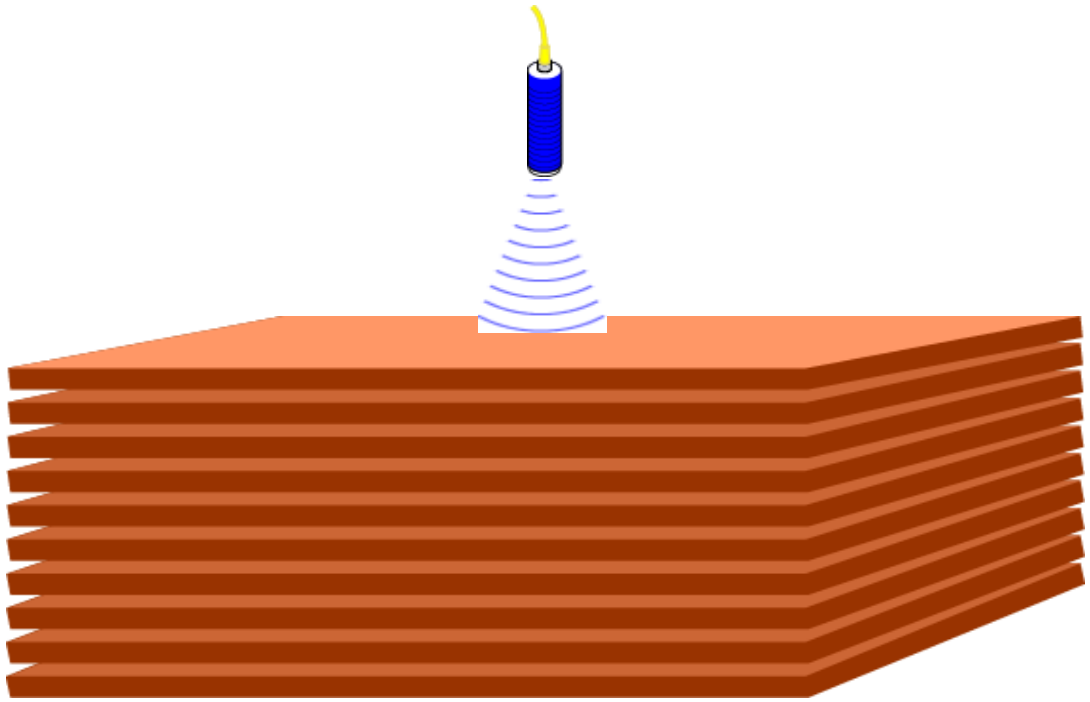
Stacking / Height Detection



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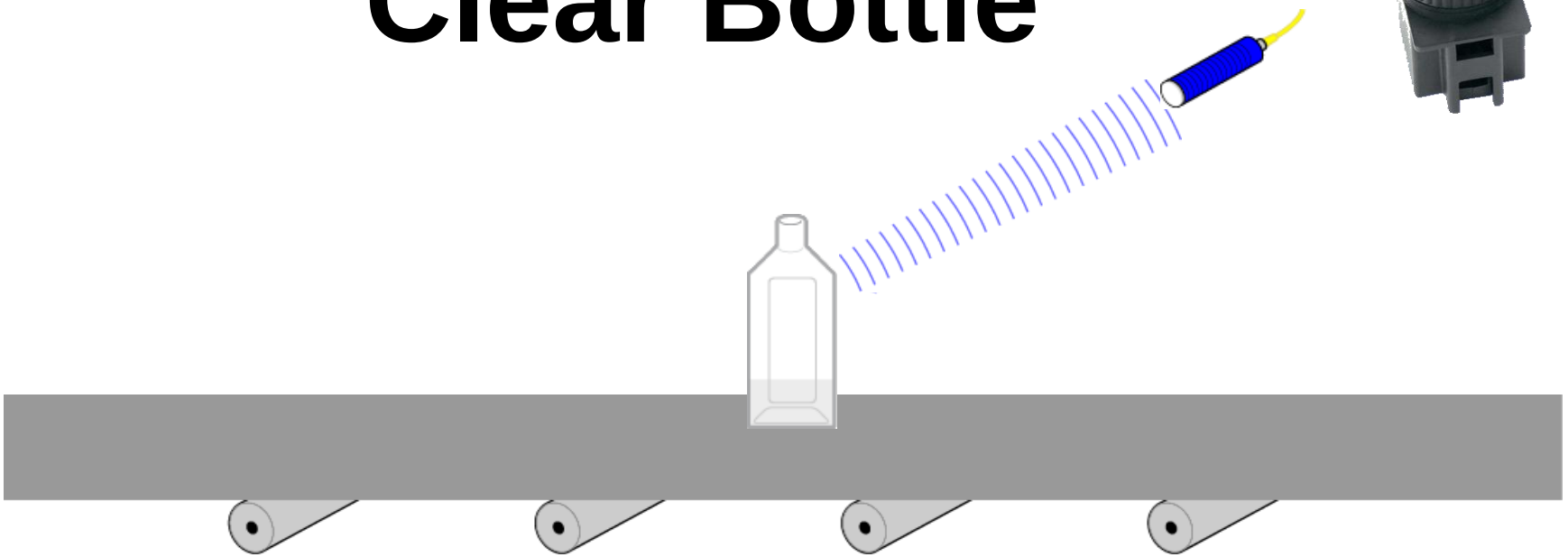
Ultrasonic Applications

Clear Bottle



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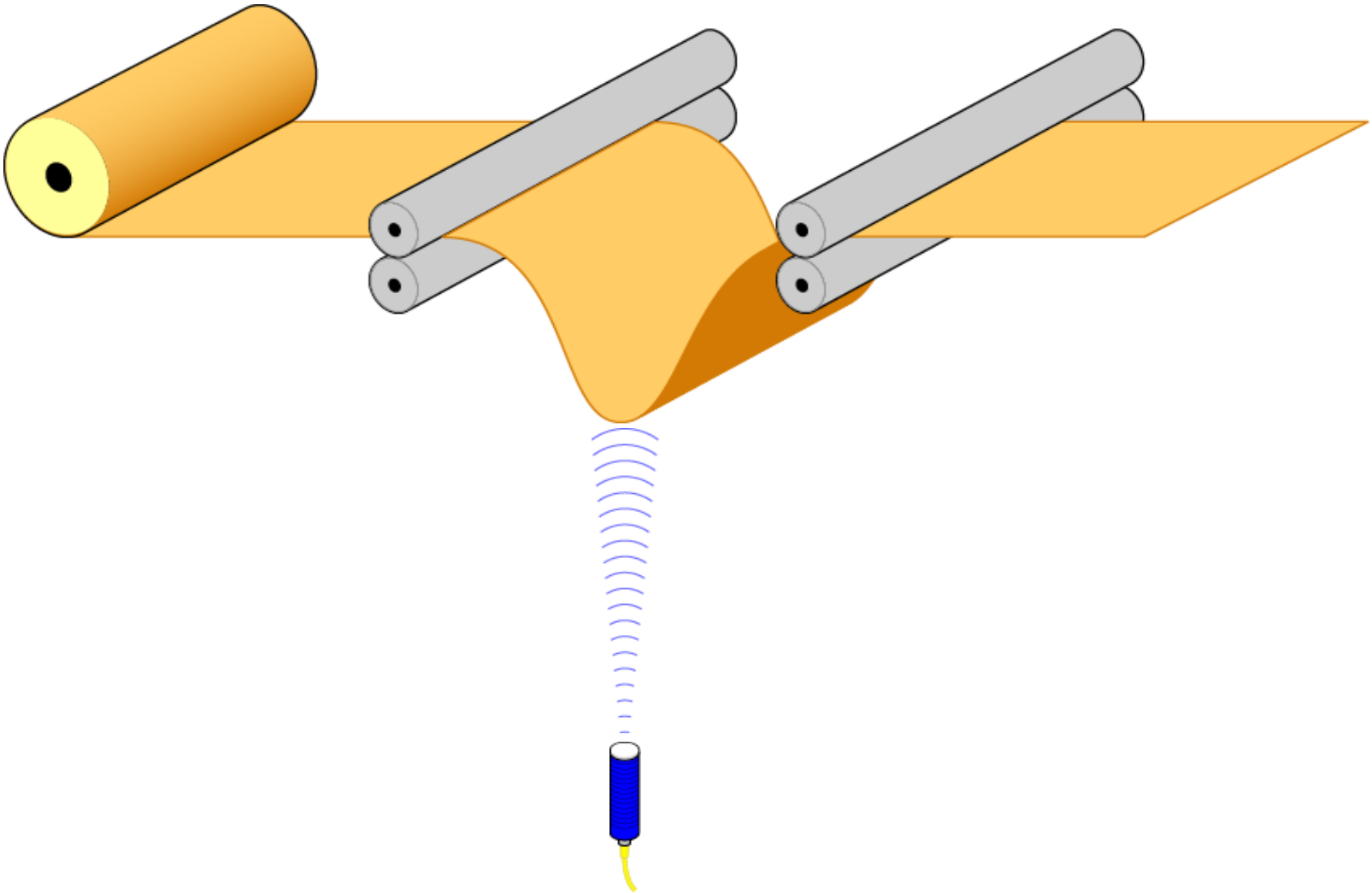
Ultrasonic Applications

Web Loop Control



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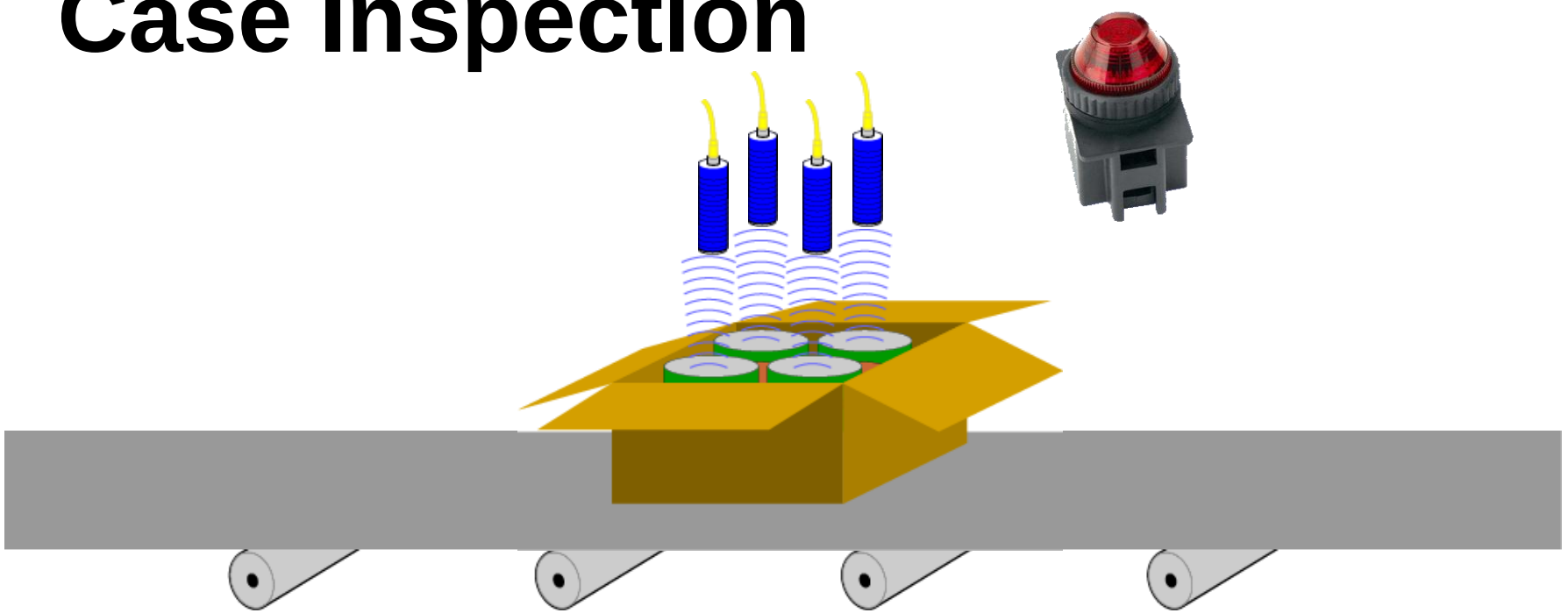
Case Inspection



–Synchronize and Hold functions can be used to reduce crosstalk between sensors in close proximity to one another

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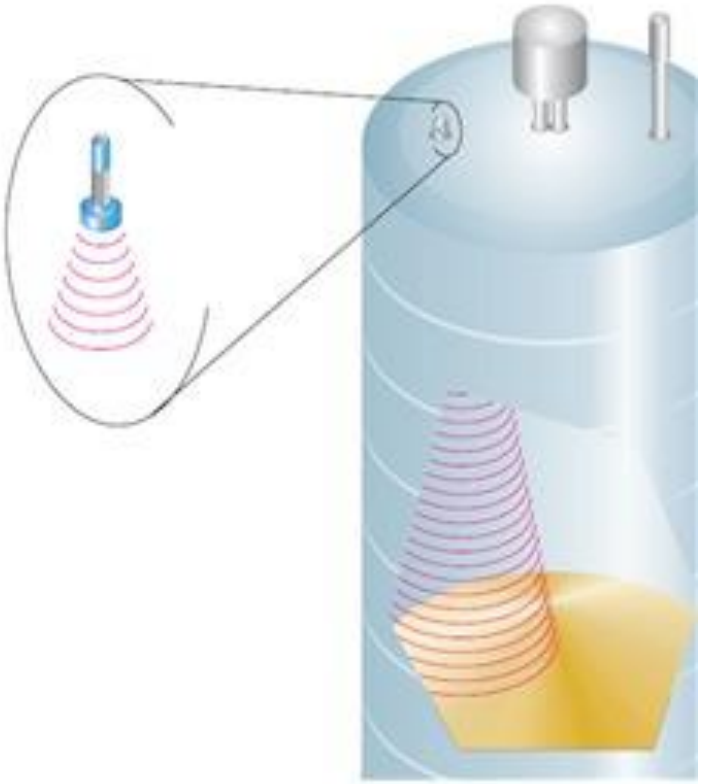
Ultrasonic Applications

Level detection in a tank using Ultrasonic sensors



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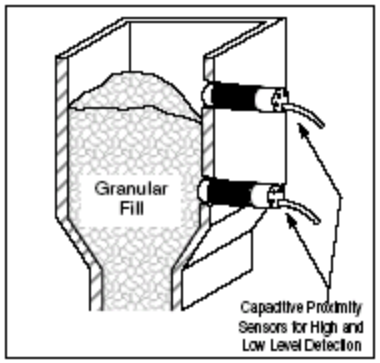
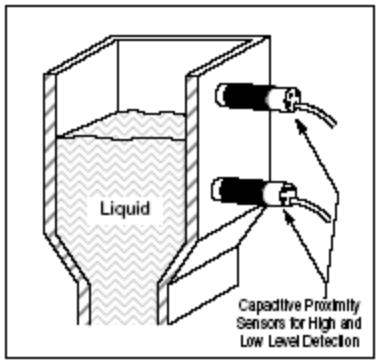
Capacitive Applications

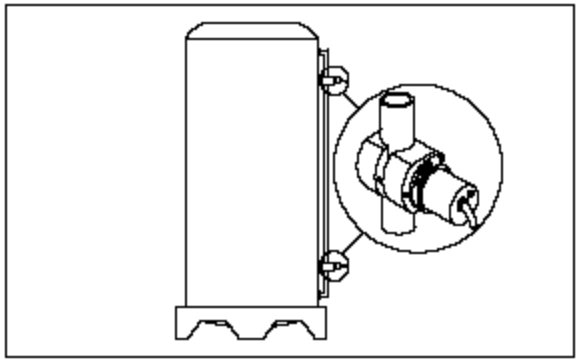
Level Detection



Liquid Level Detection



Sight-Tube Level Detection



- Non-metal solid or liquid sensing
- Pallet detection
- Liquid level monitoring
- ‘Container full’ verification
- ...and more!

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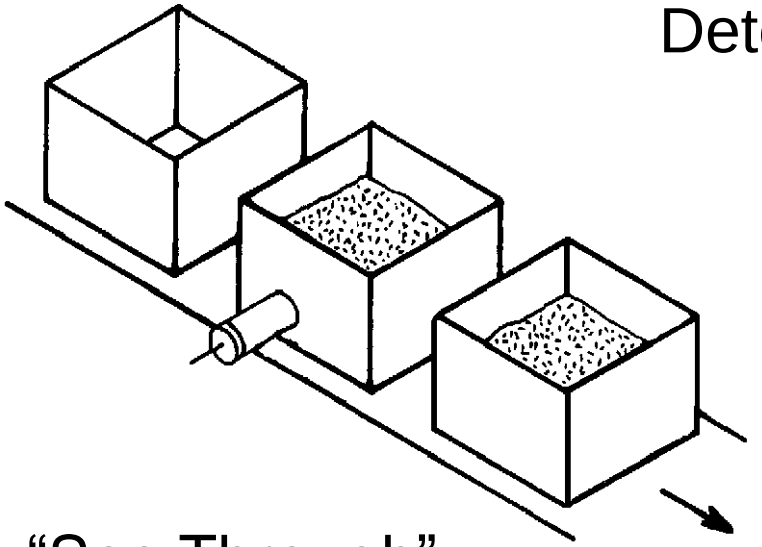
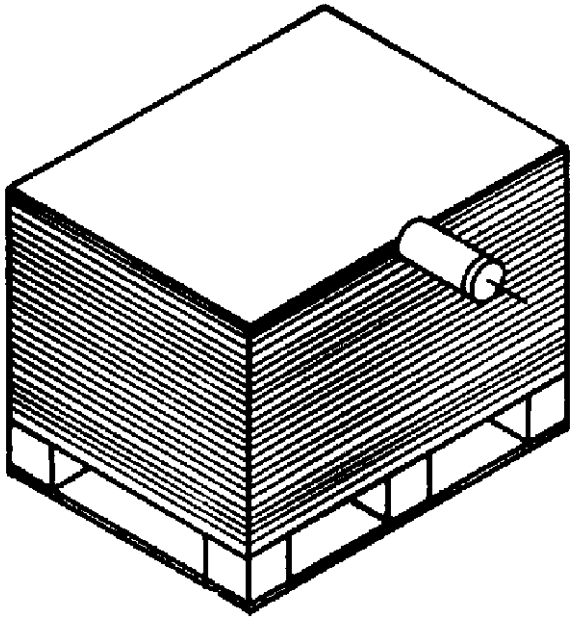
Capacitive Applications

"See Through" Detection



"See Through" Detection



Pallet Detection

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Detecting the spring in a pen

Problem: You need to detect if the spring is on the ink cartridge before final assembly.

Solution: How would you solve this application?

What questions would you ask?

- How fast?
- What material?
- What is the background?
- What is the orientation?
- How can the sensor be mounted?

What are the advantages of your solution?

What are the drawbacks?

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Detecting the spring in a pen

Solution: Small Prox

Pros

- Lowest cost
- Easy set up

Cons

- Metal ink tip may cause false reading
- Mounting proximity

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Detecting the spring in a pen

Solution: MultiSight Vision Sensor

Pros

- Part can move without affecting inspection
- Product changeover is easy

Cons

- Expensive
- More difficult to set up

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Detecting the spring in a pen

Solution: Wide Angle Diffuse

Pros

- Good for detecting springs, wires, etc
- Low cost

Cons

- Depth of field – detects cartridge in addition to spring
- Mounting concerns

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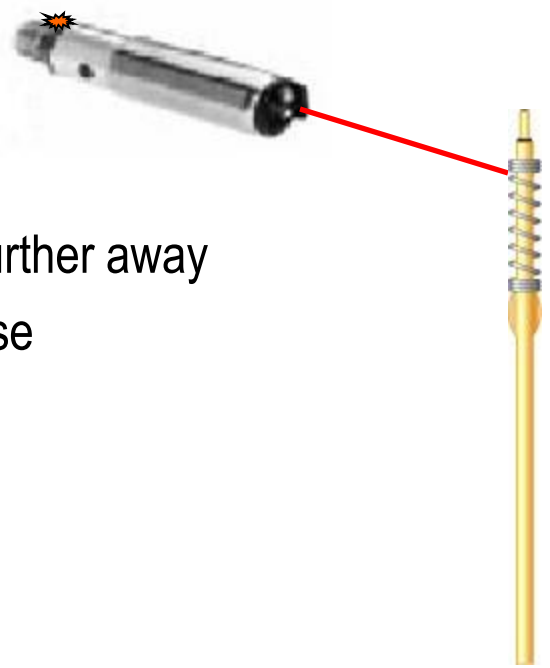
Detecting the spring in a pen

Solution: Laser



Pros

- Mounted further away
- Very Precise

Cons

- Expensive
- Larger – mounting requires more space
- Spring must be in exact same position and orientation

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Detecting the spring in a pen

Solution: Fixed Focus Diffuse

Pros

- Cost

Cons

- Mounting concerns
  - Enough space?
  - Requires precise position

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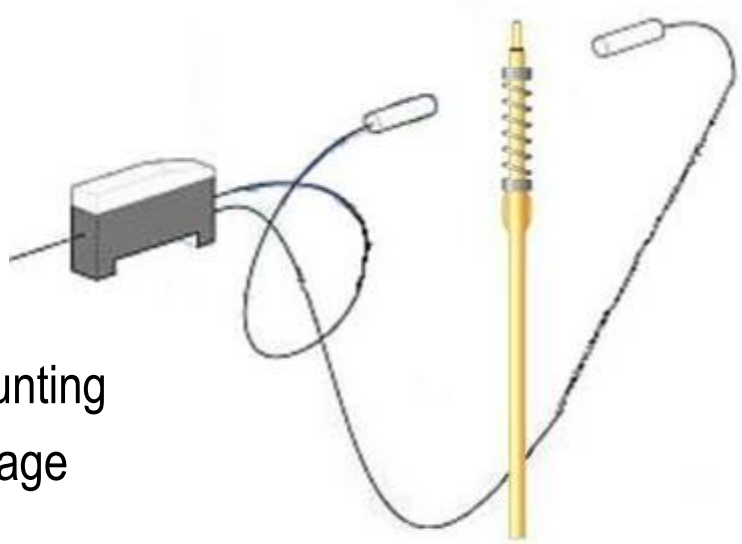
Detecting the spring in a pen

Solution: Fiber Optics



Pros

- Ease of Mounting
- Size advantage

Cons

- Expensive

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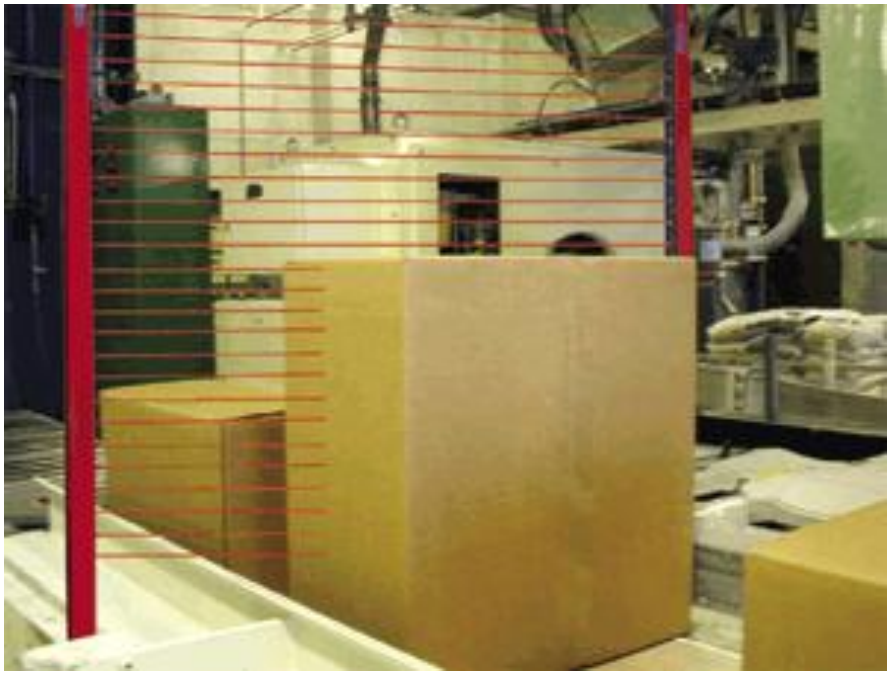
New Measuring Light Array – 45MLA / 45DLA

- Compact housing – Array profile of 15x20mm (0.6in x 0.8in)
- Length 50-1200mm (2 in to 3.94 ft)
- Cost effective
- Teach Button for local setup
- Serial communication option for additional measurement information (RS-485 or CAN)
- Long operating range from 0 m up to 4 m
- Fast reaction time and measurement speed
- IP54 (Light Array)



- Narrow angled optics to avoid reflections
- Small object recognition due to slim aperture
- Integrated LED status indicators on array (Power, Object Detected, and Measurement Error)

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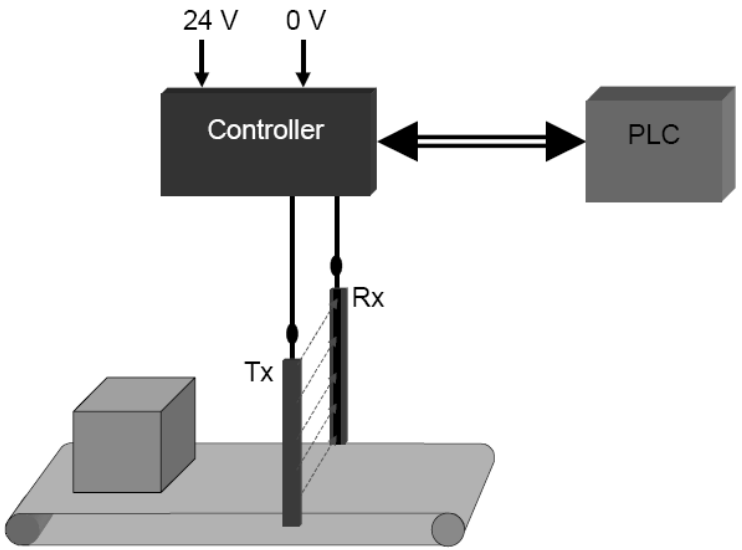
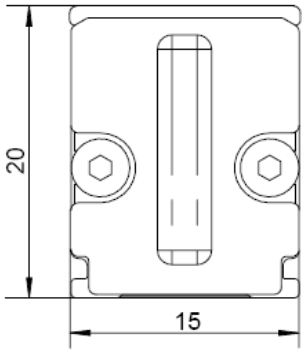
Product details

- Measuring Light Array system consists of a local controller and a transmitted beam pair of light arrays (emitter and receiver)
- Light Array Controller communicates with PLC via 6 discrete outputs or serial messages (RS-485 or CAN)



Profile (mm)



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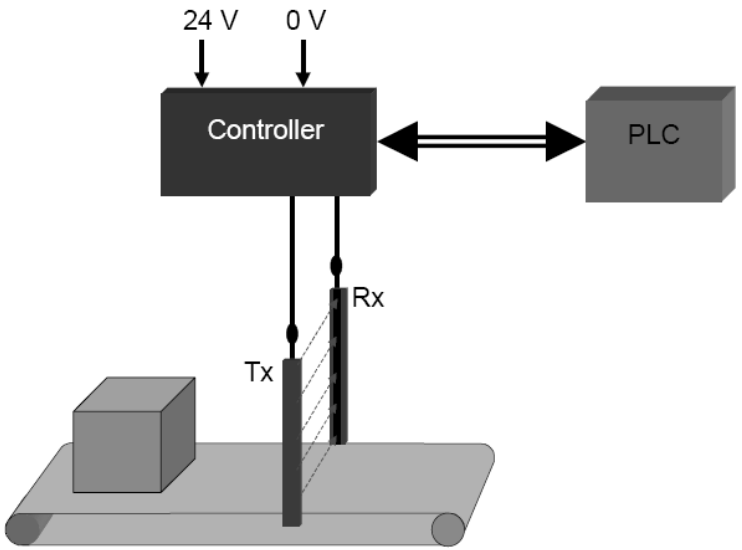
Product details - controller

- Light Array Controller communicates with PLC via 6 discrete outputs or serial messages (RS-485 or CAN) depending on the controller type
- I/O controller model
  - 6 outputs
  - 2 inputs
  - Teach button
  - 2 potentiometers (output timer adjustment and overhang timing adjustment)
- RS-485 controller model
  - 2 outputs
  - 2 inputs
  - 2 potentiometers
  - RS-485 interface



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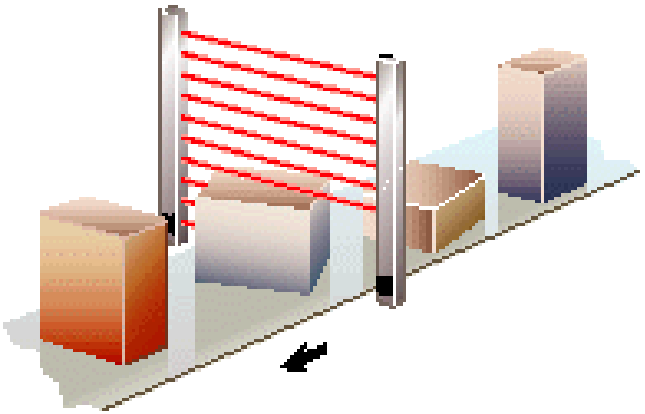
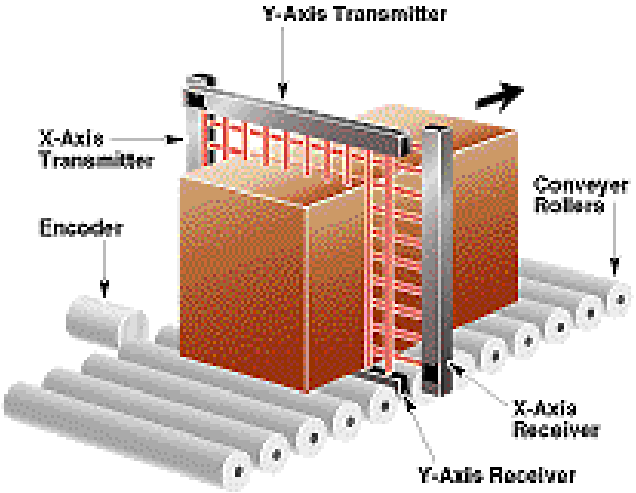
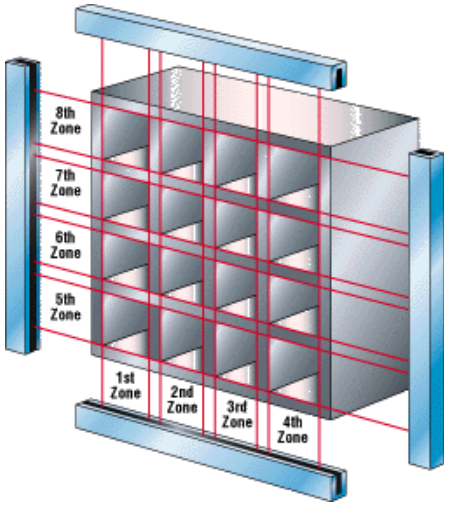
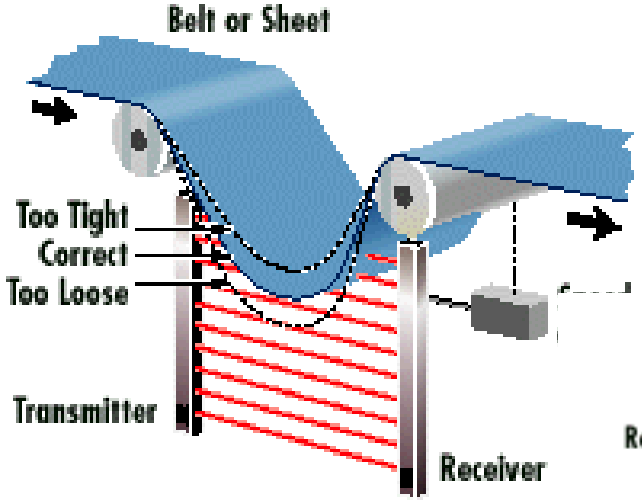
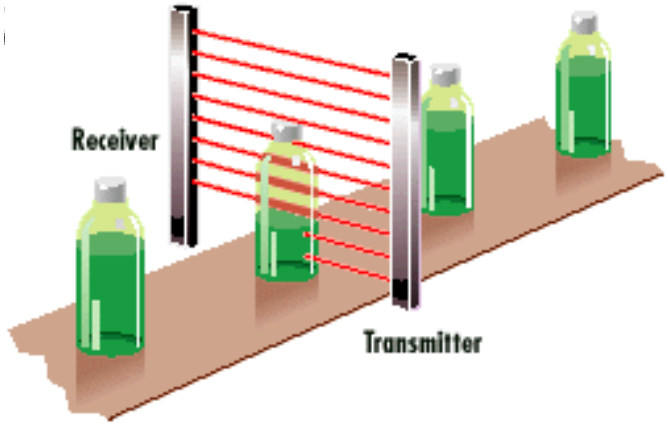
Applications

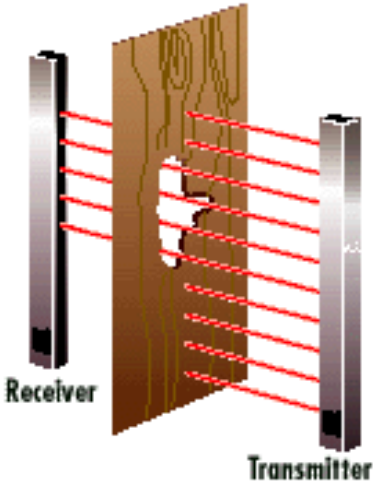












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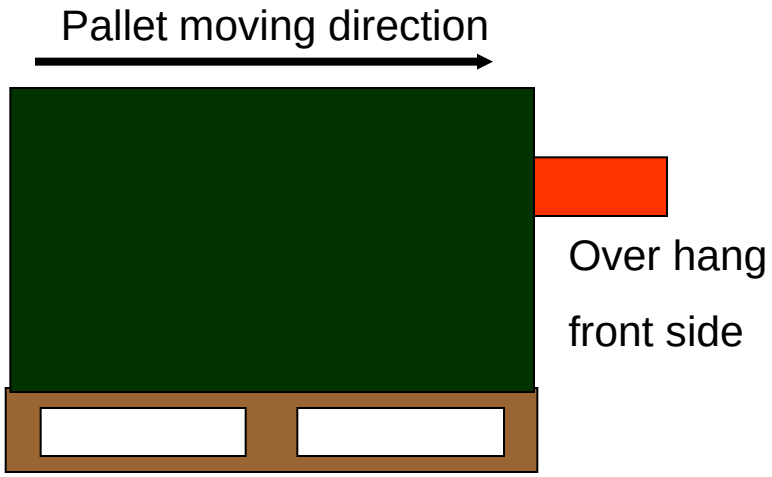
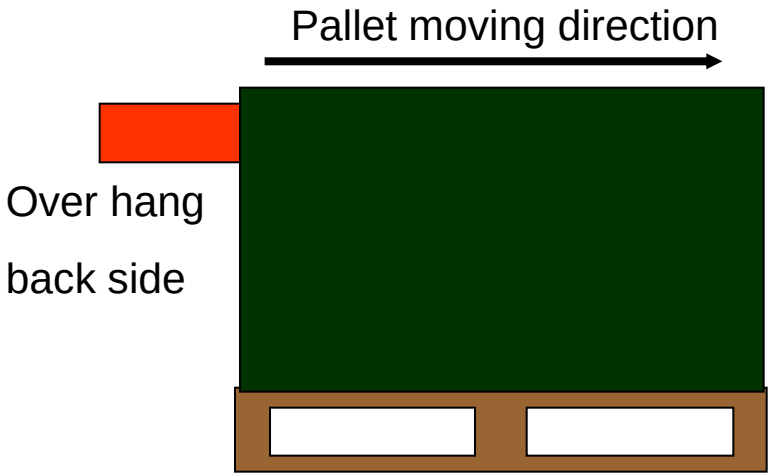
Applications

Pallet Overhang





Overhang detection

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45DLA Discrete Light Array - Specifications

- **Resolution** — 30mm (1.2 inches)
- **Sensing area** — 100, 200, 400, 600 & 800mm (4, 8, 16, 24, and 32 inches)
- **Enclosure dimension** — 15 x 20mm (0.6 x 0.8 in)
- **Integrated LEDs for output status**
- **Operating range** — 0.1 to 1.5 m or 0.8 to 8m (0.3 to 5 ft or 2.6 to 26 ft)
- **Response times** — 45ms for 400mm sensing area
- **Connection type** — Pigtail with M12 4-pin QD
- **IP54**

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45DLA Discrete Light Array - Features

Features

- Cost Effective
- Integrated light array controller
- IP54
- Simple, flexible mounting
- Optically Synchronized
  - No electrical connection between emitter and receiver required
- Push/Pull outputs
  - Connect to Sinking or Sourcing I/O
- Wiring selectable Range and Logic
  - Open wiring defaults to “typical” state

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45DLA Discrete Light Array Applications

- Simple Part Presence – On/Off Operation
- Product Protection

Cost Effective Object Detection

Overhang Detection

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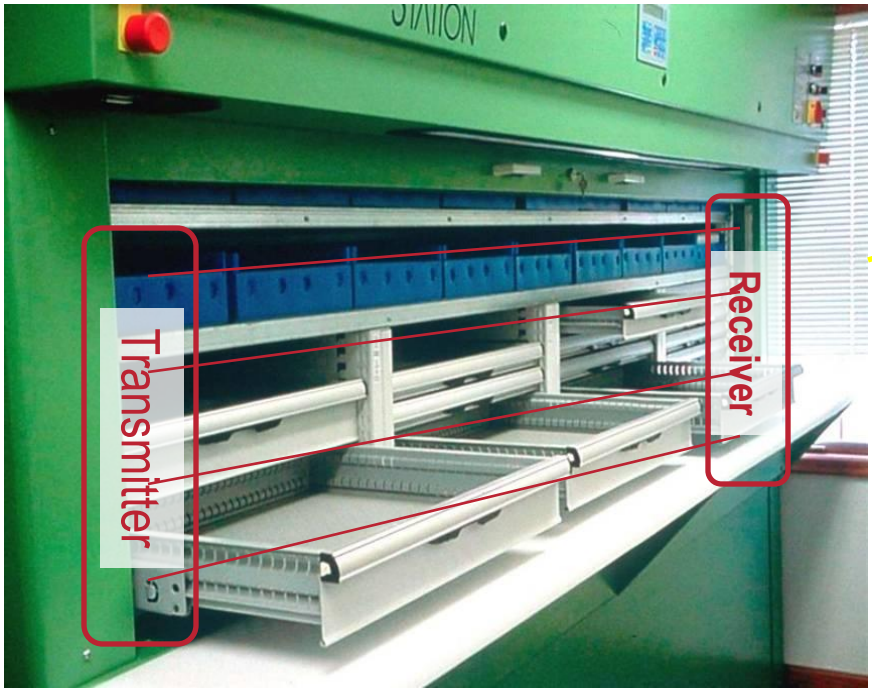
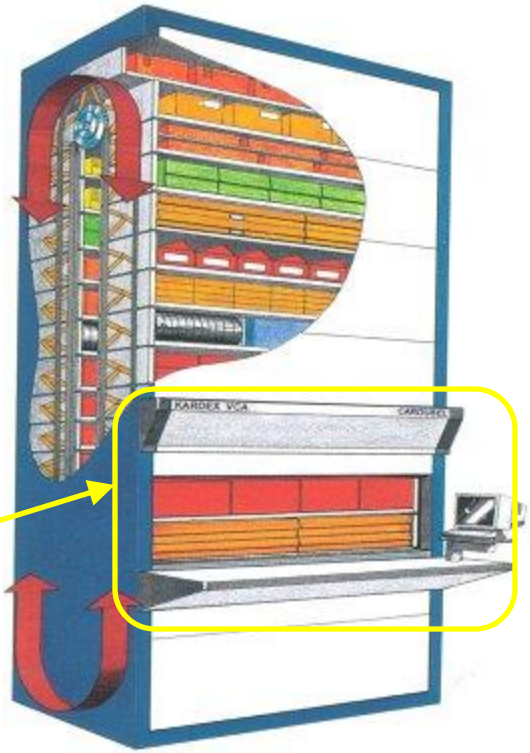
45DLA Discrete Light Array Applications

- Product Protection - Vertical Carousel
  - Discrete Light Arrays confirm that draws are completely in place before the machine starts moving the trays





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Please complete the session survey.

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