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USING SENSORS TO MAKE GRIPPERS MORE PRODUCTIVE

White Paper

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Sensor-equipped grippers enhance quality and productivity of automated assembly processes and can enable fully automatic, recipe-driven flexible production.

Making Grippers Smarter is Smart Business

Growing your business while remaining profitable in the global manufacturing economy is crucial to long term survival. In the drive to become more competitive, it is crucial to realize a maximum return on investment from your capital equipment. That means reaching maximum uptime, minimum maintenance, maximum throughput, and delivering perfect quality.

Achieving peak output requires that every process and component be selected, tuned, and optimized like the parts and systems of a high-performance race car. It's the sum of the parts that makes a winning machine, where the collective outcome of innumerable small advantages adds up to make the difference between winning and losing.

In the field of automated assembly, pneumatic grippers are a key component that is often overlooked as a candidate for upgrade and improvement. Like the tires on a race car that make contact with the racetrack, grippers make contact with the product and process. However, unlike the tires of a race car, grippers don't have the advantage of an expert human being constantly monitoring and controlling their performance.

Too often, grippers operate blindly without any feedback regarding their status or condition. These "dumb" grippers don't give the host controller any information about whether or not they opened or closed, how far they opened or closed, or whether or not they successfully grabbed a part or product. The result is processes that can fail when the actual gripper status differs from the expected condition. Innovative manufacturing companies and automated machinery builders have identified this problem and are actively seeking ways to address it.

Sensors Make Grippers More Productive

Fortunately, various sensor technologies are now available that can give dumb grippers the feedback necessary to become smart. The optimum sensor technology to choose depends on what parameter of gripper performance needs to be monitored.

There are three most commonly monitored gripper parameters:

- Gripper jaw open/jaw closed/jaw closed on part
- Gripper jaw actual position
- Part present/absent in gripper jaw

The Most Popular Sensor Applications for Grippers

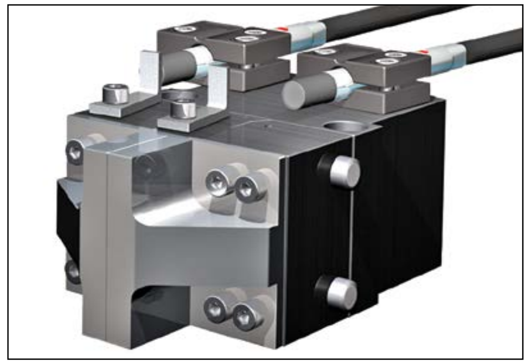
Gripper Jaw Position Open/Closed/Closed on Part (End-of-Stroke)
This is the most basic form of gripper status monitoring. Discrete on/off signals from sensors confirm that the gripper is mechanically executing control commands as expected. Failure to confirm gripper status could result in line stoppage and damage to work-in-process and production equipment. Reliable gripper status signals can detect gripper faults when they occur, allowing automatic, orderly stopping of the process so that problems can be corrected before scrap is produced or machinery is damaged.

For grippers operated by linear-acting prime movers such as built-in pneumatic cylinders, there are two primary approaches to determining gripper jaw position open/closed:

- Direct: Monitor the jaws themselves
- Indirect: Monitor the mechanism that moves the jaws

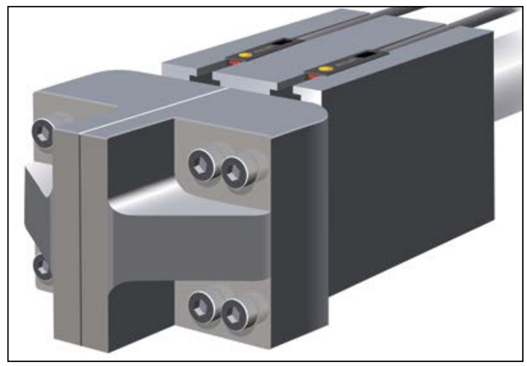
Direct (Inductive Proximity Sensor)
The open/closed status of gripper jaws can also be monitored directly using miniature inductive sensors that detect the metal of the jaws themselves, or metal targets attached to the jaws, such as screw heads or brackets. This technique is useful when the indirect method cannot be employed (for example when the piston has no magnet installed or when the cylinder walls are made from ferromagnetic steel instead of aluminum or non-magnetic stainless steel).

Miniaturization of inductive proximity sensors allows them to be successfully applied to today's increasingly small grippers. Designers can select from the latest inductive proximity sensors with diameters as small as three millimeters and overall lengths as short as six millimeters. These devices are now fully integrated and do not require bulky external amplifiers.


Proximity sensors sense tabs on moving gripper jaw mechanism to indicate fully open or closed position.

Indirect (Magnetic Field Sensor)
A sensor monitors the position of the actuator that moves the gripper jaws, giving an indirect indication of whether the gripper jaw position is open or closed. Two magnetic field sensors installed on the exterior of the built-in pneumatic cylinder of the gripper give jaw position. The air piston inside the aluminum-walled cylinder of the gripper is manufactured with a factory-installed magnetic ring around its circumference. The sensors detect the presence of the magnetic ring as it moves past them, causing them to change their outputs from low to high. The magnetic sensors are typically mounted in extruded slots on the outside of the cylinder, so that they can be precisely positioned along the axis of motion to set the exact switch point required. Normally, two, or even three sensors can be installed to indicate:

- Jaw fully open
- Jaw fully closed
- Jaw closed on a part


Magnetic field sensors sense magnets internally mounted on gripper mechanism to indicate open or closed position.

Very small magnetic field sensors are now available that allow installation in tight spaces and/or where the actual piston stroke is extremely short, for example, half an inch or less.

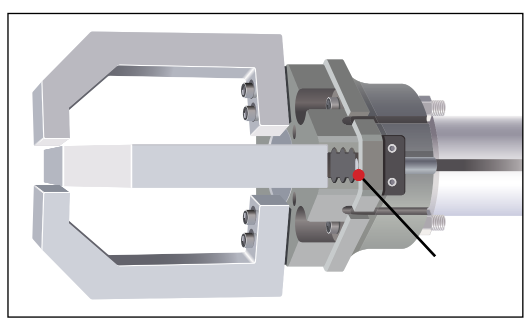
Gripper Jaw Actual Position – Absolute Analog Position Measurement

Absolute analog position measurement of grippers can deliver precise jaw-position feedback signals for higher process speed, improved quality control, and act as an indicator for preventive maintenance. Analog signals can be used to create multiple software set points in the controller for recipe-driven flexible production systems. These signals can also be used to differentiate between fully gripped objects of different physical sizes. And for soft or deformable items, the amount of applied gripper pressure can be dynamically adjusted to produce just the right degree of squeeze on the product to ensure a secure grip without marking or otherwise damaging the item.

Analog signals can also be used to monitor the operating efficiency of the gripper mechanism – for example, if there is a supply line air leak or a failing jaw mechanism, the gripper will operate more slowly. This abnormally slow motion can be detected by analyzing the rise and fall time of the real-time analog signal in the control software. Preventive maintenance messages can be generated to alert personnel to service the gripper at the earliest convenient opportunity, to stop a pending failure before it stops the line.

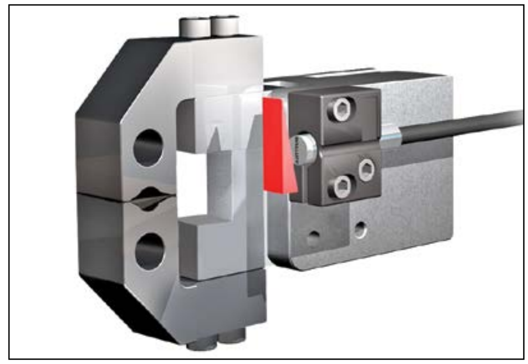
For grippers driven by linear-acting prime movers, there are again two primary approaches to determining gripper jaw actual (analog) position: direct and indirect.

Direct (Analog Inductive Proximity Sensor)
An analog inductive proximity sensor can be configured to directly sense the linear motion of the gripper jaws. The sensor outputs an absolute analog position signal that is directly proportional to the motion of the gripper jaws.


Analog inductive proximity sensor continually tracks position of gripper jaws.

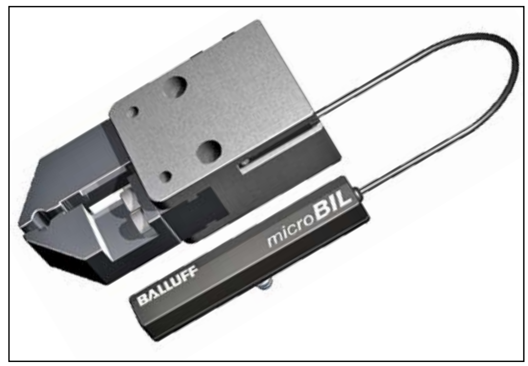
Direct (Analog Inductive Proximity Sensor)
The gripper jaw is fitted with an angled or sloping metal target that moves with the jaw. An analog inductive proximity sensor provides a high-resolution voltage or current output that is directly proportional to the target distance from the sensor, and thus its signal is directly proportional to absolute jaw position.

The sloping metal target is used to translate the one or two inch jaw motion into a smaller target displacement that is within the relatively short sensing range (typically one or two millimeters) of the analog inductive sensor. Because the sensor is an absolute rather than incremental device, after a power interruption the analog inductive sensor turns on and supplies the correct actual jaw position signal without any need for re-homing the gripper jaws (which might be inconvenient if there is a part already held in the jaws).



Analog inductive proximity sensor continually tracks position of gripper jaws by reading distance of wedge face from the face of the sensor.

Indirect (Analog Magnetoinductive Linear Position Sensor)
Instead of discrete magnetic field sensors, an analog magnetoinductive linear position sensor is fitted to the gripper cylinder housing in order to continuously sense the internal magnet mounted on the pneumatic actuator piston. Rather than on/off position signals, the magnetoinductive linear position sensor outputs an absolute analog position signal (such as 4-20mA or 0-10V) that is fed back to the control system.



Magnetoinductive sensor tracks position of internally installed magnet to provide constant position information.

Part Present/Part Absent in Jaw

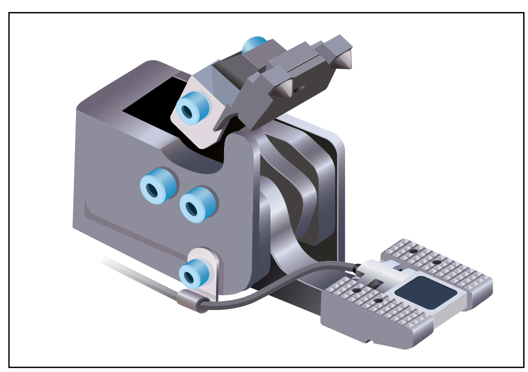
Detecting the presence or absence of a part in a gripper jaw can provide key information about the status of an assembly or production process. If a gripper expects to pick up a part and no part is detected, it could mean that the gripper is starved for parts by a stoppage farther up the line. It also might mean that the end of the production lot has been reached and the process is ready to be shut down.

In some cases, multiple grippers must simultaneously grab a large or heavy part. If one or more grippers fail to properly grip the part, the “lift and move” operation could fail, dropping or dragging the part, causing damage to the part and the surrounding equipment. Moreover, the time spent clearing the subsequent line jam could incidentally harm work-in-process farther up the line, for example, parts remaining too long in a baking oven or chemical bath.

There are two convenient and reliable sensor technologies used for detecting parts in grippers:

- Inductive proximity sensors
- Self-contained photoelectric through-beam sensors

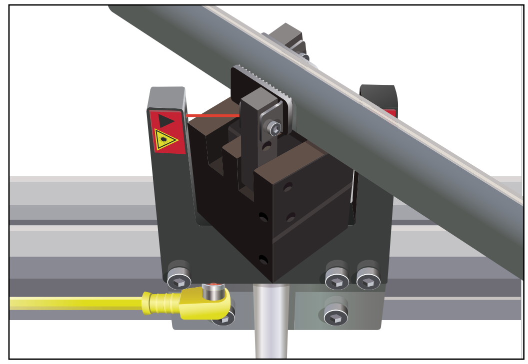
Part-in-Jaw Detection Using Inductive Proximity Sensors
If the part being handled is metallic such as sheet metal, machined parts, or castings, inductive proximity sensors can be integrated into the gripper jaws to directly sense the metal part. Sensors used in this manner are typically low-profile block style housings commonly called “flat packs”. The flat pack housings can be either plastic or metal, but in any case, the sensor must be high-quality and designed rated to withstand repeated shock and vibration. The sensor cable should also be flex-rated for continuous flexing in the application without internal conductor fatigue and breakage.



Flat pack inductive proximity sensor provides positive part-in-jaw verification.

Part-in-Jaw Detection Using Self-Contained Through-Beam Photoelectric Sensors
Self-contained through-beam photoelectric sensors can detect part presence regardless of material. Certain versions can even detect clear glass or plastic. Various light sources can be employed (for example infrared, visible red, or visible red laser) depending on the characteristics of the part, the operating environment (clean or dirty), and the required precision of the part positioning in the gripper.

Self-contained through-beam sensors are available in U-slot or L-style configurations. U-slot types require the part to be introduced from one direction, while L-style sensors can accept part introduction and removal from multiple directions. Available in a variety of physical sizes, self-contained through-beam sensors can be fitted to virtually any size or style of gripper.

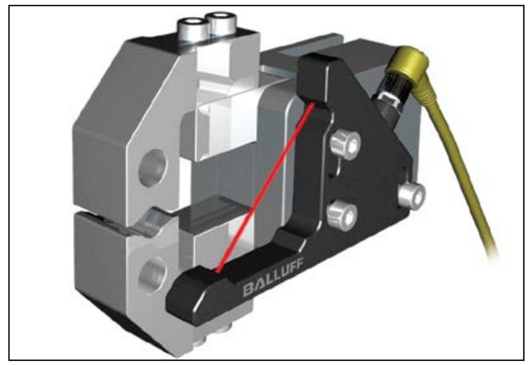


U-shaped photoelectric sensor provides positive part-in-jaw verification.

Key Considerations for Selecting Gripper Sensors

When selecting sensors for gripper applications, some key points to consider include:

Wear-Prone vs. Wear-Free
Electro-mechanical limit switches are prone to mechanical failure and contamination of their electrical contacts. Magnetically-actuated reed switches are prone to contact sticking and welding. When applying sensors to grippers, it's important not to introduce additional failure modes into the process. Unreliable sensors can be as bad as no sensors at all, and can derail your smart gripper initiative. *Always look for wear-free, solid-state sensor technologies such as magnetoresistive, inductive, magnetoinductive, capacitive, and photoelectric.*



L-shaped photoelectric sensor provides positive part-in-jaw verification.

Temperature Stability
Look for sensors that maintain stable sensing characteristics despite changes in temperature within their rated operational range. Sensors whose switch-points or signals drift with temperature can create all kinds of setup and adjustment headaches.

Environmental Ratings
Select sensors with enclosure protection and temperature ratings that meet or exceed the demands of the production environment. For example, don't install standard-temperature sensors into extremely hot applications or wash-down environments. Be sure to seek sensors specifically designed and specified for such extreme conditions.

Quick-Disconnect vs. Pre-Wired
Sometimes it's a matter of preference, but in general, use sensors with quick-disconnects. This allows faster sensor replacement if necessary and enables easy change-out of entire grippers with sensors already pre-installed and adjusted. Just disconnect the sensors and remove the entire gripper assembly, sensors included.

Infrared vs. Visible Red vs. Visible Red Laser

- Infrared is the light source of choice for dirty, dusty conditions. Infrared light has enough power to burn through accumulated dirt and grime and keep on working.
- Visible red is useful where it's important for human operators to be able to see the beam spot with the naked eye.
- Visible red laser light is selected where the part features being detected are very small or precise, for example if a part contains numerous perforated holes, it is necessary to align the narrow laser light beam so that it is broken by a solid area and doesn't pass through any of the holes to the receiver.

Today's advanced sensors can add an entirely new level of flexibility and performance to your robotic grippers. Once installed, they will lower your unplanned downtime, and raise the productivity and profitability of your entire operation.

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