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Finding the right sensor

Making the correct choice in web-guide sensors is a combination of knowing what you need and what a sensor can do.

By John Plumb, Senior Systems Engineer, Fife Corp.

The sensor is the eye of the automatic web guide. As you stand and watch a moving web, sensing the position of the material doesn't seem like a difficult task, but think about the different challenges that a web sensor may face.

Could you provide proportional feedback to motion of a couple of thousandths of an inch? Could you watch the web in a harsh environment? Could you watch both edges at once? Could you watch the web in that small, hard-to-get-to place? If you were the right web guide sensor, you could.

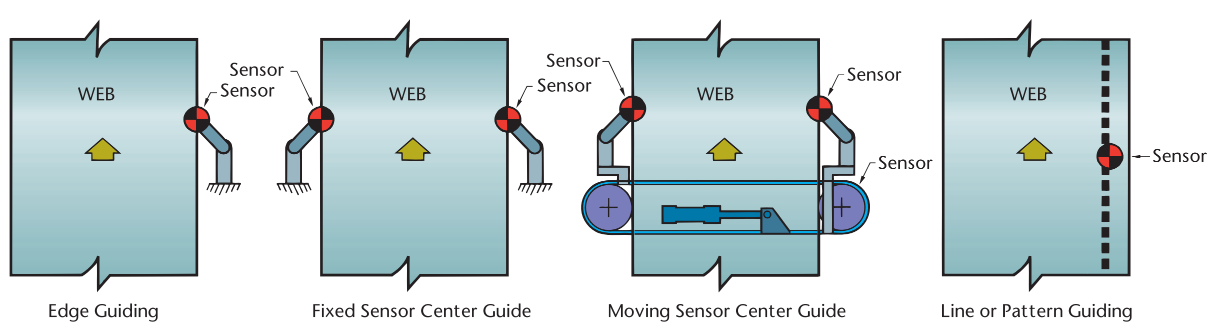
Finding the right sensor is a combination of knowing what you need and what a web guide sensor can do.

What do you need to detect?

Web Material Properties: What is your web? Converting processes involve many different materials, including paper, foils, wovens, nonwovens, and an unlimited variety of laminated or coated materials. To the sensor, it's not the material, but the material properties that are important. Does your web reflect or block light? Does your web block ultrasonic energy in the air? Does the density of your web restrict airflow through it?

Edge, Center or Line Guiding: Do you want to detect your web's edge, center, or a feature on your web's surface? Most web guides work off the transition at the web's edge. This is sufficient for many applications, especially if

Figure 1. Sensor Configurations for Web Guiding Systems



your web width is consistent and your operators are conscientious enough to move the sensor for product width changes. If you have larger width changes and want to guide relative to the center of the web or measure the web width, the web guide needs to detect both edges using either a pair of edge sensors or a full-width "curtain" system (See Figure 1).

Edge or Line Quality: What is the quality of your edges or the surface feature you want to detect? For edges, are they sharp or ragged? For surface features, are they visually distinct? Continuous or intermittent? Do you have step changes in the edge position at splices, especially if you have width changes?

Irregular web edges may cause the sensor signal to be too noisy, causing sudden actuation movements and poor performance. Sensors that are able to see a larger sample of the edge can average out the web edge variations. Center guiding, which detects and averages both edges, may also smooth the signal from measuring ragged edges. Advanced sensing or signal processing can also compensate for ragged edges or line quality, such as changing the dead band or averaging the signal over time.

At high line speeds, line or edge variations may pass so fast that the guide system will not respond to them. Some camera-based systems can be programmed to ignore certain features.

Physical Constraints: What physical constraints do you have? Does the sensor have to fit into a tight location? Does the web edge flutter? How much does the web plane change, especially considering an offset pivot or steering-guide exit span twisting?

What would happen if the web touched the sensor? Is your web sticky, abrasive, or wet? Does your web scratch or tear easily?

Environment: What is the environment at the detection point? Is the web in a challenging environment such as extreme hot oven, a hazardous atmosphere (solvents), a vacuum process (no convective cooling for electronic components), or a dusty location?

Range and Resolution: What is range of lateral position you need to detect? What is your edge position variation from lateral motion and width variation? Do you want your web guide to automatically adjust for width changes or have your operators manually reposition the sensor?

How fine of resolution do you need? In general, a wider sensing range will decrease sensing resolution. For example, a camera- or light-based sensor with a linear array of 1,000 pixels or elements sensor can differentiate 0.001" if the range is 1", but the resolution will drop by three times if the sensing range is increased to 3" without an increase in pixels or sensing elements.

Did you count the number of question marks in this discussion? Yes, quite a few. Taking the time to answer as many of these questions as possible will help in selecting which of the many standard of customized web sensor designs will be best for you application.

Options: How do sensors differ?

This section should help you to understand the variety of standard and customized sensors available to meet your needs.

Mode of Sensing: The most common sensing modes are pneumatic, ultrasonic, and optical.

Pneumatic sensors are the grandfather of web guide sensors, often paired with hydraulic actuation and a pneumohydraulic logic controller. With their remote or purged electrical components, pneumohydraulic systems have long been the favorite for intrinsically safe or hot processes.

Infrared sensors are best for opaque webs (opaque in the wavelength of the sensor). Infrared sensors can detect visibly clear webs if they have enough absorption at key infrared wavelengths. Analog infrared sensors are affected by dust or other contamination (which can be reduced with an air nozzles cleaning option).

Ultrasonic sensors are best for clear or transparent webs, but may have trouble sensing light non-woven or mesh webs.

Linearity and Proportional Feedback: Web sensors are not on/off devices. For accurate web control, the sensor must provide a linear proportional feedback of web position. A proportional signal, from low to high output as the web moves through the sensing range of the sensor, is the first component of a tunable, accurate, and stable guiding control loop.

Center vs. Width Sensing: There are two options to upgrade from edge sensing and an assumed web center to a system that automatically detects the center:

1. Wide sensing range fixed sensors – In this system two fixed sensors are used to detect the position of each edge. A typical sensor will have a 6"-plus sensing range to detect and center a web with width changes of up to 12".

2. Web-seeking edge sensors – The mechanical alternative to wide range fixed sensors uses two sensor actuators to "find" the web. Two sensors are mounted on synchronized actuators. Initially outboard of the web, when the guide goes into run mode, the two sensors move inward, finding one edge, then the other.

Analog vs. Digital: Most sensors are analog, providing a signal proportional to how much of the emitted media (whether pneumatic, optical, or ultrasonic) reaches the receiver. If the web is partially transparent to the media, some of the media will pass through the web and add to the off-web signal. If web transparency varies product to product (again, whether pneumatic, optical or ultrasonic transparency), the system must be recalibrated to guide to the same sensor target line.

Some sensors are digital, such as camera systems or optical array sensors. Digital sensors detect the web with a row of small individual receiver elements or pixels in discrete lanes spread over the sensing range. Advanced image processing algorithms identify all the lateral transitions in the web, so with a strong contrast, the system can guide off the web's edge, the transition from coated to uncoated web, or a printed line or pattern on the web.

Sensor Performance: Good sensor performance results from several features. A good web sensor is:

* Insensitive to any ambient signals near the sensor, such as general airflow and other sources of light or ultrasonics.

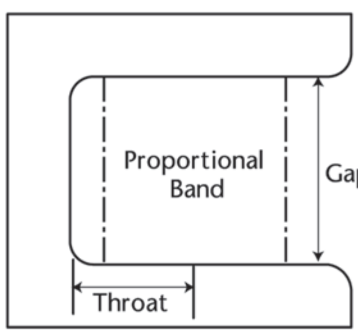
* Insensitive or auto-compensating over time or temperature changes. Maximum operating temperatures are limited by the electronic components in the sensor.

* Resistant to contamination appropriate to the application. Ultrasonic sensors that are properly sealed will be partially resistant to loose contamination. Digital sensors should include internal logic to ignore small amounts of contamination.

* Able to minimize the effects of web plane changes. (Some optical sensors, such as surface pattern sensors, rely on reflected light and are more sensitive to sensor-to-web variations).

Sensor Geometry: Most sensors detect the web by comparing a transmission through the web vs. open atmosphere.

Figure 2. Sensor Geometry



A U-shaped sensor is the most common form factor for web guide sensors. The two-sided design is used to different advantages depending on the mode of sensing. The U-shaped design allows each jaw to house laterally registered emitter and receiver elements. The U-shape design could also allow measurement from both sides or include a mirror on one side to double measured signal strength with two passes through the web.

The two-sided U-shaped sensor also has some limitations (See Figure 2). The gap is the opening distance between the two sides and limits the web plane deviations without contact. The throat is the distance from the sensing centerline to the base of the "U" and determines the maximum lateral shift without contact. The proportional band is the linear portion of the sensing range (See Figure 2).

The sensor gap needs to be larger than the maximum web thickness plus the maximum plane change. Web plane change may be cause by web edge flutter or bagginess, but is also normal at the exit of offset pivot and steering guides. If the web drags on the sensor, the web or sensor may be damaged. To reduce web plane changes in the sensor gap a fixed web support bar or roller can be mounted next to the sensor, making it possible to use a smaller gap sensor.

The sensor throat should be deep enough to prevent the web edge from striking the back of the sensor.

With analog sensors, narrow sensing ranges are generally more accurate. Wide sensing range sensors are recommended if the guide structure is loose or flexible.

Specialty Sensors: Beyond standard optical, ultrasonic, and pneumatic sensors, there are several sensing modes or sensor designs used for specific applications. These sensors are an example of how a good sensor supplier will innovate to solve any web sensing challenge.

- *Line Array Camera* – The most advanced and versatile optical sensors use line array receivers to increase resolution and apply digital processing to compensate for changing surface patterns or contamination.
- *Laser Curtain Sensor* – Used for both width measurement and center guiding, a laser curtain sensing system can have extremely large gaps and sensing range.
- *Ragged Edge Sensor* – As mentioned above, either sensor design or signal processing can reduce the noisy signal of a ragged edge or line.
- *Fiber Optics Sensor* – Optical sensors can be placed in hazardous, vacuum, or constricted locations by using fiber optics to remotely locate the emitting and receiving electronics.
- *Raised Feature Sensor* – For example, an optical sensor can detect the raised tufts in a carpet as it goes over a roller, guiding off the raised tuft edge rather than the actual carpet edge.
- *Capacitance or Inductance Sensor* – Metallic webs or strips can be sensed by capacitance or inductance.
- *Mechanical Paddle or Finger Sensor* – A flag or paddle that rests against the web edge. Obviously a contacting sensor is not good for thin or delicate webs, but they work well for thick belts (e.g. conveyor belts) and may be the only way to sense "open" webs (such as netting).

Choosing a web guide sensor is more than just "pneumatic, optical, or ultrasonic" or "edge vs. center." For any new product or process challenge, an experienced web guide supplier will help you answer these questions and show which sensor provides the best solution. No matter the application, there is a sensor waiting to be your eyes in the web-guiding process. ■