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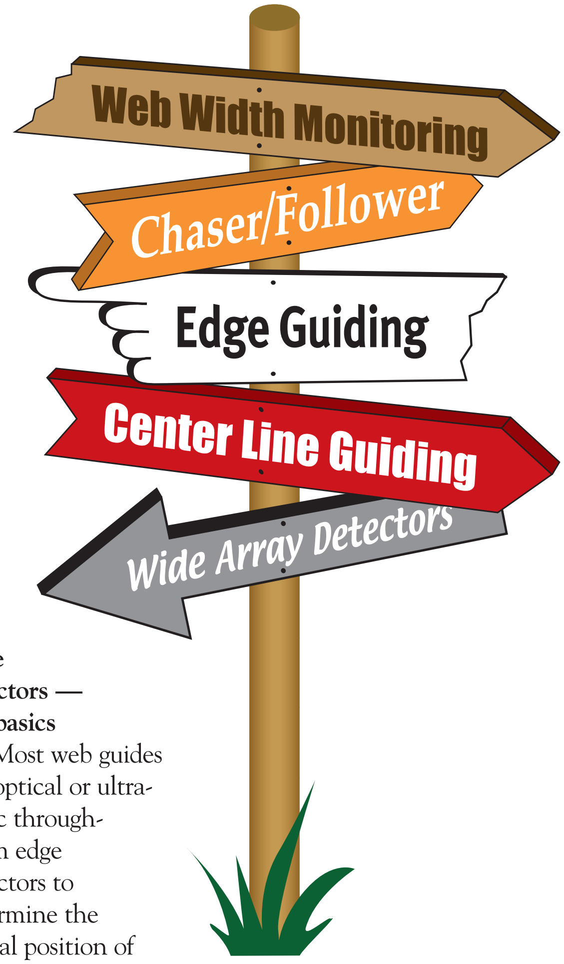
In Search of the Perfect Edge Detector

Compensated ultrasonic and infrared array edge detectors set a new standard for accuracy, reliability and ease-of-use, and are the best solution for edge guiding and web width monitoring applications.



For most companies, precision web guiding is critical to producing a higher quality product at the lowest cost. Market growth has led to increased competition, and anything that gives these companies an edge — anything that helps make their product stand out from all the rest — will be of great value.

For some companies the need for accurate guiding is obvious; maintaining tight control over the exact web path helps ensure superior results at every step of their process, from print registration, slitting and gluing, to producing perfectly wound finished rolls. Other companies may not need this level of accuracy, but can nonetheless greatly benefit from the reduction in scrap and waste that results from reliable control of web position.

In addition, the quest for operating efficiencies has pushed web guide manufacturers to engineer systems that are easier to set up, use, and maintain. Recent innovations in edge detection technology are increasing productivity for many converters by making changeover faster and reducing maintenance downtime.

Web guides have evolved dramatically since their first appearance on converting lines in the 1930s. The earliest units used pneumatic edge detectors and guiding devices powered by hydraulics to keep the web "in the process." Electronic edge detectors and electric motors gradually displaced pneumatics and hydraulics as demand grew for greater accuracy and reliability, and tolerance for leaky hydraulics diminished. The earliest electronic systems were far from perfect — in particular the edge detectors were sensitive to dust and temperature swings — but they were a big improvement over their predecessors.

In 1988 web guide technology took a big leap forward when *AccuWeb Inc* patented a new edge detector technology that solved all of the major problems inherent in first-generation electronic detectors. This development, the compensated ultrasonic edge detector, was the missing element in the quest for a truly accurate and dependable web guide system. To put the significance of this development in perspective it is important to understand how edge detectors work and examine the problems inherent in first-generation detector technology.

Edge detectors — the basics

Most web guides use optical or ultrasonic through-beam edge detectors to determine the lateral position of the web. These detectors have a transmitter and receiver located several inches apart and oriented so that the transmitter can direct a beam of optical or ultrasonic energy at the receiver. The detector is mounted so that the beam intercepts the edge of the web. As the web moves laterally it blocks the beam to a greater or lesser extent and this varies the amount of energy arriving at the receiver. The received energy level is roughly proportional to web position, and is used to determine which way to move the guide.

During normal operation the web guide monitors the received energy level and tries to maintain it at a preset target level. It does this by moving the web laterally; moving the web into the beam causes the received energy level to drop and moving it out of the beam causes it to rise. The target level is typically preset to one half of the level measured when the beam is totally unblocked. This target level will cause the guide to move the web until it covers about half of the beam, aligning the edge of the web with the center of the beam.

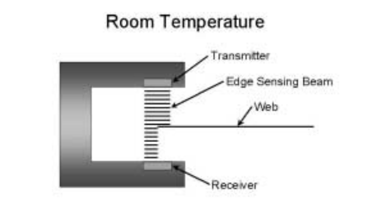


Figure 1

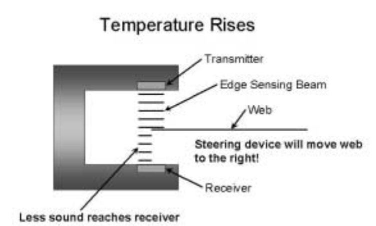


Figure 2

First-generation detectors

First-generation edge detectors can be influenced by a variety of environmental and process factors that degrade accuracy including temperature, humidity, air turbulence, vapors and gases, dust, lint, dirt, ink, coating overspray and vertical web movement caused by flutter, curl and web path changes. Each detection method, optical or ultrasonic, has particular strengths and vulnerabilities. Optical detectors are highly sensitive to build-up of dust and other contaminants on the lenses, but ultrasonic detectors can operate even when completely covered with ink or coating overspray. Conversely, ultrasonic detectors will react strongly to changes in air temperature and vertical web movement that would have little effect on optical detectors.

The optical detector's vulnerability to dust provides a good example of how external factors affect accuracy. Dust accumulating on the detector's lenses will absorb some of the beam's energy and will prevent it from reaching the receiver. Since a decline in received energy is normally the result of a web movement into the beam, the web guide will react by moving the web in the opposite direction. In this example the edge detector is confused by dust build-up, and accuracy suffers as a result.

First-generation ultrasonic edge detectors react in a similar way when the ambient air temperature changes. The propagation of ultrasonic energy through air is highly dependent on temperature — cool air conducts sound better than warm air. If the ambient temperature rises, less ultrasonic energy will arrive at the receiver, and the web guide will react by moving the web out of the beam. Conversely, when the temperature falls, the guide will move the web into the beam. The temperature sensitivity problem is illustrated in ***figure 1*** and ***2***.

First-generation ultrasonic edge detectors are also sensitive to vertical motion of the web. This sensitivity is caused by reflected ultrasonic energy interfering with the direct energy that travels directly across the gap, from transmitter to receiver. The direct energy by itself provides an excellent indication of web position, but when mixed with reflected energy that has bounced off the web and other nearby surfaces, the position readings become erratic. Subtle changes in the flatness, position or orientation of the web can greatly affect the amount of reflected energy arriving at the receiver, giving it a random, unpredictable quality. As with the previous examples, the faulty readings that this produces will cause the guide to move the web away from the correct position. The problems caused by reflected energy are illustrated in ***figure 3*** and ***4***.

The challenge

When AccuWeb's engineers set out to create the ideal edge detector they considered the strengths and weaknesses of the various sensing technologies (optical, ultrasonic, pneumatic, etc.) and came to the conclusion that ultrasonic technology's inherent immunity to dust, ink and other process contaminants far outweighed the strengths of the competing technologies. They knew that if they could solve the air temperature and vertical motion problems, they would have a nearly ideal edge detector. Confronted with this challenge, they developed and patented, in 1988, two key techniques that solved both problems: compensation and pulsing.

Compensating for a changing environment

The new ultrasonic edge detector uses an innovative design to compensate for environmental changes. Two ultrasonic beams are used at all times — a sensing beam that senses the edge of the web and a reference beam that monitors ambient conditions. The two beams are located side by side, less than 1 inch [25.4 mm] apart, but oriented so that the web passes only through the sensing beam (***figure 5***). Locating the reference beam near the sensing beam ensures that each is affected as much as the other by environmental conditions.

Because the web never blocks the reference beam it provides a direct, real-time indication of how environmental and other changes are affecting the performance of the detector. This information is

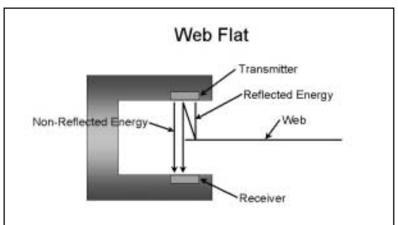


Figure 3

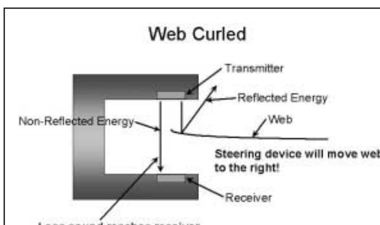


Figure 4

combined with the sensing beam measurement to produce the truest possible indication of the web's position.

In addition to compensating for air temperature, this design also compensates for all of the other environmental factors and process contaminants described previously, plus many not considered here.

Handling flutter, curl and other web motion

The new ultrasonic detector incorporates a second innovation to eliminate sensitivity to vertical motion of the web. It takes advantage of the fact that reflected energy always travels a longer path than direct energy on its journey from transmitter to receiver. By transmitting a very short pulse of ultrasonic energy every few milliseconds the edge detector can easily filter out the unwanted reflected energy. Each pulse will typically make several trips across the gap, bouncing off the web and edge detector on each pass, before completely dissipating.

After each pulse is transmitted the receiver will typically see a train of pulses arrive — these are actually the same pulse as it makes several trips back and forth across the gap, hitting the receiver each time. The first pulse to arrive is the one that travelled directly across the gap, from transmitter to receiver (direct energy), followed by several smaller pulses that took a longer path (reflected energy). To filter out the reflected energy the edge detector just looks for the first (and largest) pulse and discards the rest. The result is a detector that is completely insensitive to curl, flutter and other vertical motion of the web.

The compensation and pulsing technologies solved all of the major problems confronting first-generation ultrasonic edge detectors. The result was an edge detector so reliable and easy to use that most customers install and operate it right out of the box. After an initial calibration it never needs re-calibration or maintenance again.

Ultrasonic array dramatically increases sensing area

In 1998 *AccuWeb* patented a new type of edge detector — the ultrasonic array — that uses the proven compensation and pulsing technologies to solve a whole new class of application problems. These new edge detectors have an ultra-wide sensing area, created by arranging dozens of sensing beams in two overlapping rows that form one large sensing area. Any number of beams can be combined in one detector to provide a sensing area of any required size. *AccuWeb's* 18.4 inch [467.36 mm] array, for example, has 96 ultrasonic beams.

The ultrasonic array uses a technique called dynamic scanning to track the edge of the web. At any given moment only two beams are active — one to sense the edge of the web, and another nearby that monitors ambient conditions. As the web moves within the detection area, pairs of beams are sequentially activated to chase the edge of the web. This is illustrated in ***figure* 6, 7** and **8** using a simplified four-beam sensor as an example. In this sequence of figures, the web is moving from left to right, and new pairs of beams are activated as it moves.

The ultrasonic array is ideal for applications that handle a variety of web widths or require large adjustments of web position. Most single-beam edge detectors have a small sensing area and need to be physically moved in order to adjust web position or accommodate changing web widths. This typically requires an electro-mechanical positioner — an expensive, bulky, and maintenance-prone item. *AccuWeb* array technology can replace these electromechanical positioners with an all-electronic solution that has no moving parts, requires no maintenance, instantly adapts to changing web width, and allows the operator to make large or small changes in web position with the touch of a button.

Infrared array excels with nonwovens

The fully compensated ultrasonic array edge detector is an ideal solution for most applications, but for those running extremely lightweight nonwovens or mesh materials, ultrasonics are not the best fit. These materials are so porous that they do not have enough solid area to block the ultrasonic energy beam. For these applications *AccuWeb* recently developed a (patent pending) compensated infrared (IR) array edge detector that perfectly complements the ultrasonic array. IR array detectors use the same compensation and dynamic scanning technologies found in the ultrasonic array to eliminate sensitivity to dust and lint build-up on the lenses. They also share the same range of sensing areas, physical dimensions and mounting configurations as the ultrasonic arrays to provide effortless interchangeability.

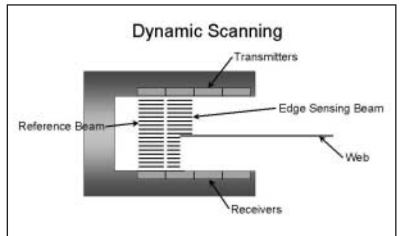


Figure 6

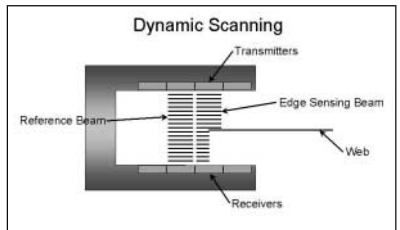


Figure 7

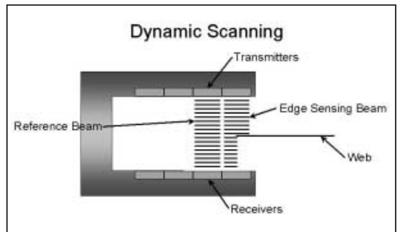


Figure 8

Conclusion

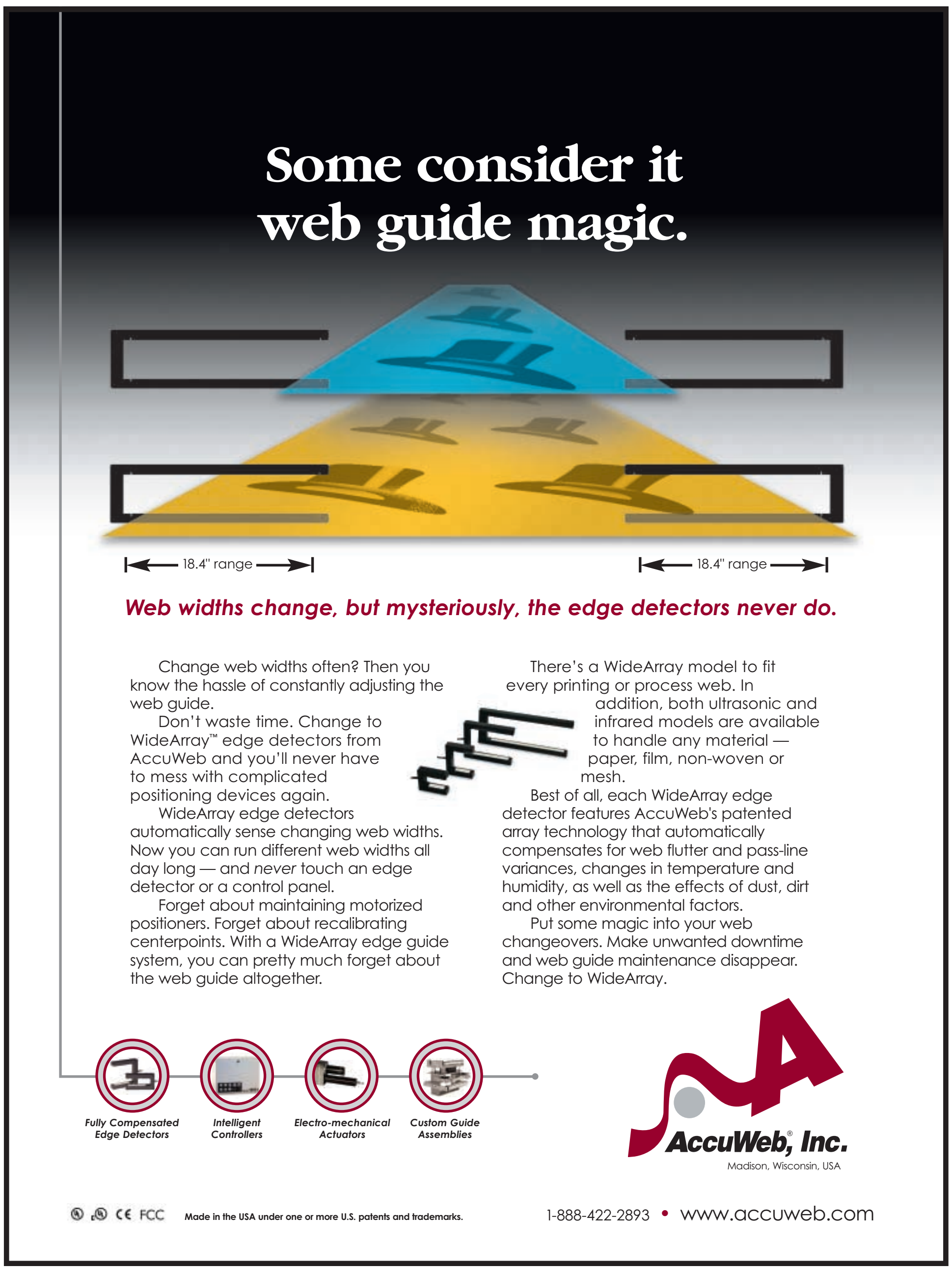
A web guide system that includes compensated ultrasonic or infrared edge detectors brings several advantages to the typical converting operation:

- Automatically adapts to changing environmental conditions (Benefit: no periodic adjustment or calibration required).
- Not sensitive to web curl, flutter or other vertical motion of the web (Benefit: increases accuracy).
- Available with sensing areas up to 18.4 inches [467.36 mm] wide (Benefit: no electromechanical positioner is needed to accommodate width changes or to adjust position, reducing cost and eliminating maintenance).
- Adapts instantly to web width changes (Benefit: faster changeover).
- Permits instant adjustment of web position (Benefit: faster changeover).

In addition, each compensated sensing technology has particular strengths:

- Compensated ultrasonic detectors can sense a wide variety of materials, from clear film to opaque paper, without readjustment (Benefit: faster changeover).
- Compensated ultrasonic detectors are very tolerant of build-up of dust, ink and other process contaminants (Benefit: increases reliability and cuts maintenance time).
- Compensated infrared detectors can sense a wide variety of non-woven and mesh materials, and are tolerant of dust and lint build-up (Benefit: increases reliability and cuts maintenance time).

Compensated ultrasonic and infrared array edge detectors provide accurate, stable and reliable operation in a wide variety of demanding converting applications, including printing, coating, slitting and rewinding — often in the harshest environments. Ultrasonic and infrared edge detection technologies have teamed up to handle a wide variety of web materials. Through *AccuWeb's* technological innovations, web guides are becoming almost "invisible" — requiring little initial set-up, no routine maintenance or adjustment, and often no operator intervention during changeover.



About the author …

Andrew Kalnajs, Director of R&D, AccuWeb, Inc., Madison, WI, USA. and co-developer of AccuWeb's compensated array technology. AccuWeb holds two patents on the Compensated Ultrasonic Edge Detection technology described in this article. For more information, call 608-223-0625.