

Contact Image Sensors as a viable alternative to conventional Line Scan Cameras

Abstract

This article describes a new imaging principle which can be employed in industrial web applications for the inspection of paper, textiles, glass or plastics. It represents an attractive alternative to conventional Line Scan Cameras by offering high light sensitivity and data rates of up to 100KHz in a compact housing without the requirement for expensive optics.

A customer recently enquired about an optical sensor which he had difficulty in sourcing elsewhere. He wanted to retrofit his existing web inspection system with an optical detector which had the following requirements:

- fast line rate (10 kHz) with high resolution at high transport speed
- high resolution (>1000 pixels) across transport width
- 2.5 m inspection width
- high light sensitivity
- compact construction (less than 100 x 100 mm cross-section) to fit the existing system.

Although the first three requirements can be achieved using one or more traditional line scan cameras, the other requirements were more demanding.

A possible solution for the customer is adapting the well-known **Contact Image Sensor (CIS)** construction principle for high line rates. CIS sensors have been in use for quite some time in devices with low line rates such as telecopiers or scanners.

Conventional “**Reduction Type**” systems work with a largely reduced image of the object under inspection. This is why the distance between the object and sensor needs to be comparable - as a rule of thumb - to the width of the object. CIS sensors, on the other hand, have the same size as the object under inspection, but can be built using much shorter optics (typically from 20 to 70 mm).

Industrial Contact Image Sensors are made up of the following components

The **light source** is a long linear source, typically a fluorescent tube driven from a high frequency inverter, preferably with daylight characteristics, or a long LED line. Light Emitting Diodes (LEDs) are known for their long lifetime and the option of pulsed operation to reduce stray light effects.

The **optics** employed is a lens array made up of several graded index lenses. In a graded index lens the light diffraction is not affected by the curved shape of a homogenous lens, but by the continuous (hence graded) change of refractive index inside a cylinder shaped lens. The desired grading is achieved by proper doping of the lens. This technique - first developed for graded index fibers - lends itself much better to mass production than conventional lens construction.

Every single lens in the array forms an image over a limited region. The imaging regions of neighbouring overlap to give a sharp overall image along a narrow line.

The **sensor** itself is made up of silicon photodiodes implemented either in CCD or CMOS technology. Several diodes are combined with support circuitry on a chip, several chips are stacked together to form a long (up to 1m) detector without violating the pixel spacing. Appropriate signal processing facilitates much higher data rates than conventional CIS devices. Data sorting and standardized interfacing (Camera Link or parallel LVDS) makes the CIS devices attractive as a Line Scan Camera replacement. For noisy environments a fiberoptic interface is available.

The advantages of the **Industrial Contact Image Sensor** over conventional Line Scan Cameras are

- compact overall dimensions (typ. 50 x 50 mm) due to short imaging distances
- less critical mechanics because the image is not reduced, aspect ratio is 1:1
- high line rates (up to 75 kHz) independent of inspection width
- high light sensitivity independent of width
- high resolution (up to 600 dpi) independent of width

The advantages of the **Industrial Contact Image Sensor** over conventional CIS sensors are

- object distances of up to 20 mm for industrial environments
- rugged construction for industrial environments
- high line rates (up to 75 kHz) independent of sensor width
- transmissive or reflective sensors
- sufficient lighting for the high line rates
- standardized interfacing (Camera Link, parallel LVDS or fiberoptic)