APPLICATION NOTE

Architecture and Features of the KLI-4104 Image Sensor

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The Kodak KLI-4104 image sensor provides 600 dpi color scans of A4 paper at over 150 pages per minute.

This application note covers the following topics:

- General description of KLI-4014 imager
- High resolution luminance / low resolution chrominance
- Image Processing
- Effective center alignment of pixels
- High speed scanning

For further information please also see the Kodak KLI-4104 Device Performance Specification.

General description:

The KLI-4104 is a high-resolution, quadri-linear array designed for high-speed color document scanning applications. Each device includes 4 rows in total. The chroma section contains 3 rows of 4080 active photoelements each, consisting of high performance pinned diodes for improved sensitivity, low noise and the elimination of lag. Each row is selectively covered with a red, green or blue integral filter stripe for spectral separation. The pixel height and pitch is 10 microns and the center-to-center spacing between color channels is 90 microns, giving an effective nine line delay between adjacent channels during scanning.

The luma section contains 1 row of 8160 active photoelements also consisting of high performance pinned diodes. This channel has a monochrome response. The pixel height and pitch is 5 micron and the center-to-center spacing between this luminance channel and the blue color channel is 122.5 microns, giving an effective 12 ¼ line delay.

The architecture of the Kodak KLI-4104 provides the ability to achieve high-resolution color scans (600dpi) by utilizing information from all 4 channels. The edge data from the luminance channel (which provides the image "detail") can be combined with the chroma data and the result is a full resolution color image. In this design there are 4 outputs on the luminance channel to match the read out rate of the chroma channels. Both resolution and throughput are thereby maximized.

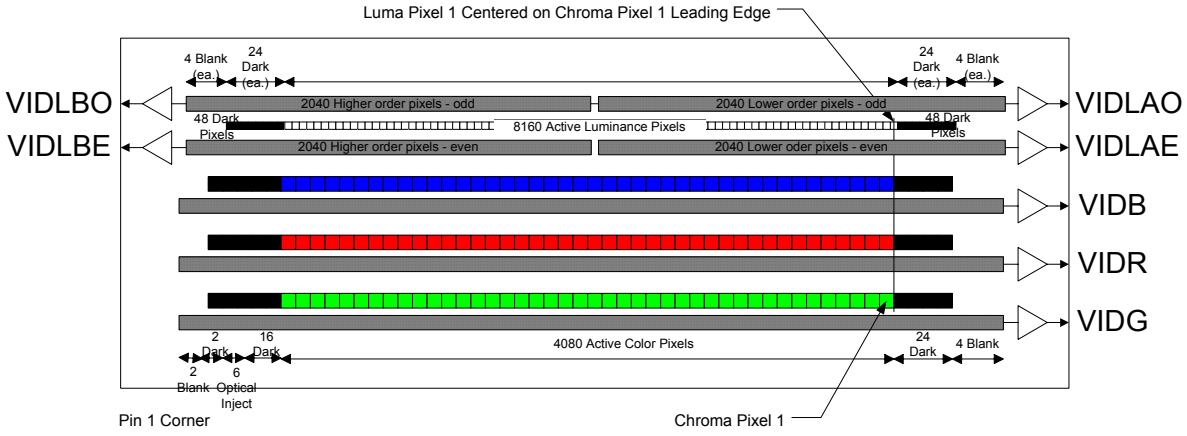

Figure 1. Block Diagram

Why high-resolution luma / low-resolution chrominance?

The human visual system uses more luminance information than chrominance information. Based on this, we know that high spatial frequency luminance data represents the “details” in an image. To achieve a full resolution (8160 pixels) color scan, the chrominance data can be of lower resolution (4080 pixels) as long as the “edge/detail” information is sampled at the higher frequency.

Notice that each chroma pixel covers 4 times the area of a single luma pixel. An advantage to having larger pixel sizes is increased responsivity. This is especially useful in the chroma channels where some light is absorbed by the color filter material. Please refer to Figure 5 in the Kodak KLI-4104 Device Performance Specification for the responsivity data.

Image Processing:

By utilizing the data from all 4 channels, a high-resolution color scan can be achieved. The luminance channel can be used to provide the edge detail in the image.

Effective center alignment of pixels:

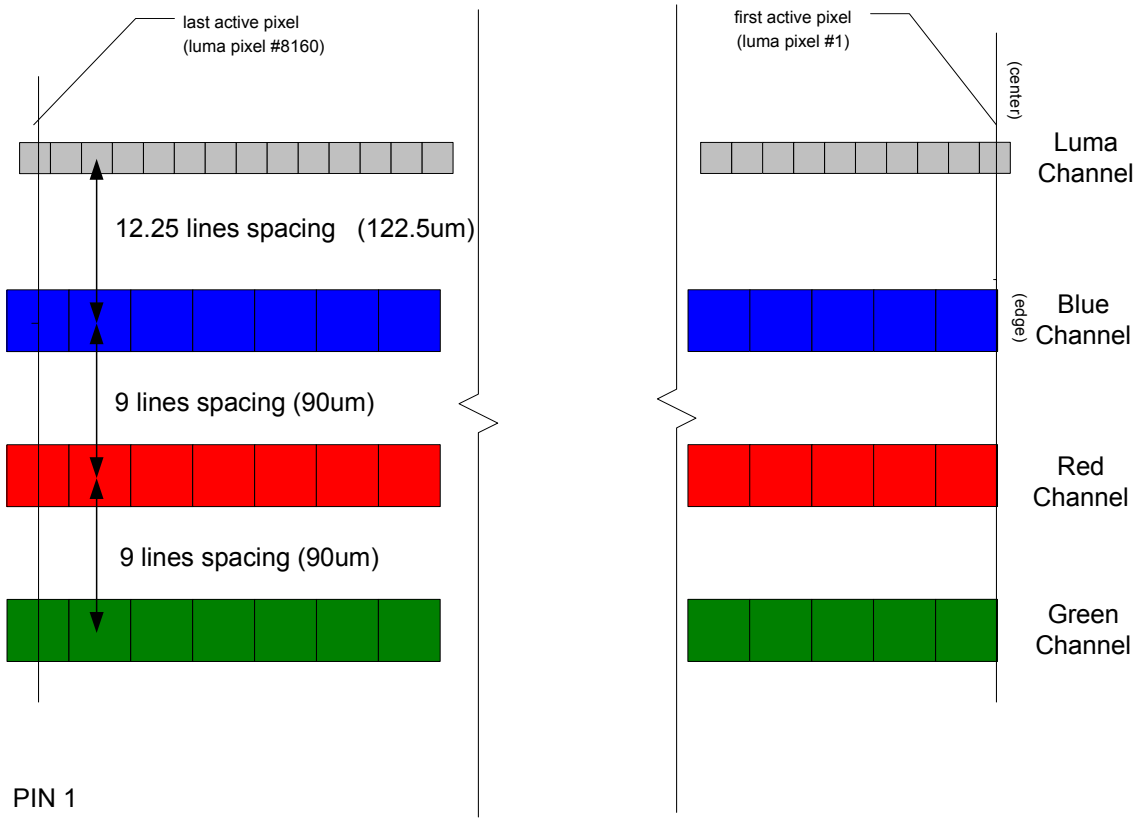

Figure 2. Channel Alignment Diagram

Zero re-phasing errors in the final color image is accomplished by having **effectively center-aligned sampling apertures** in the luminance and chroma channels.

Even though the luminance and chroma channels are physically edge-aligned vertically, when scan motion is introduced it has a "center-weighted" sampling effect at the full resolution scan speed.

The following pixel alignment diagram explains in more detail the reason for being edge-aligned in the vertical direction and how the 12.25 line spacing (122.5um) works out to achieve zero re-phasing errors at full resolution.

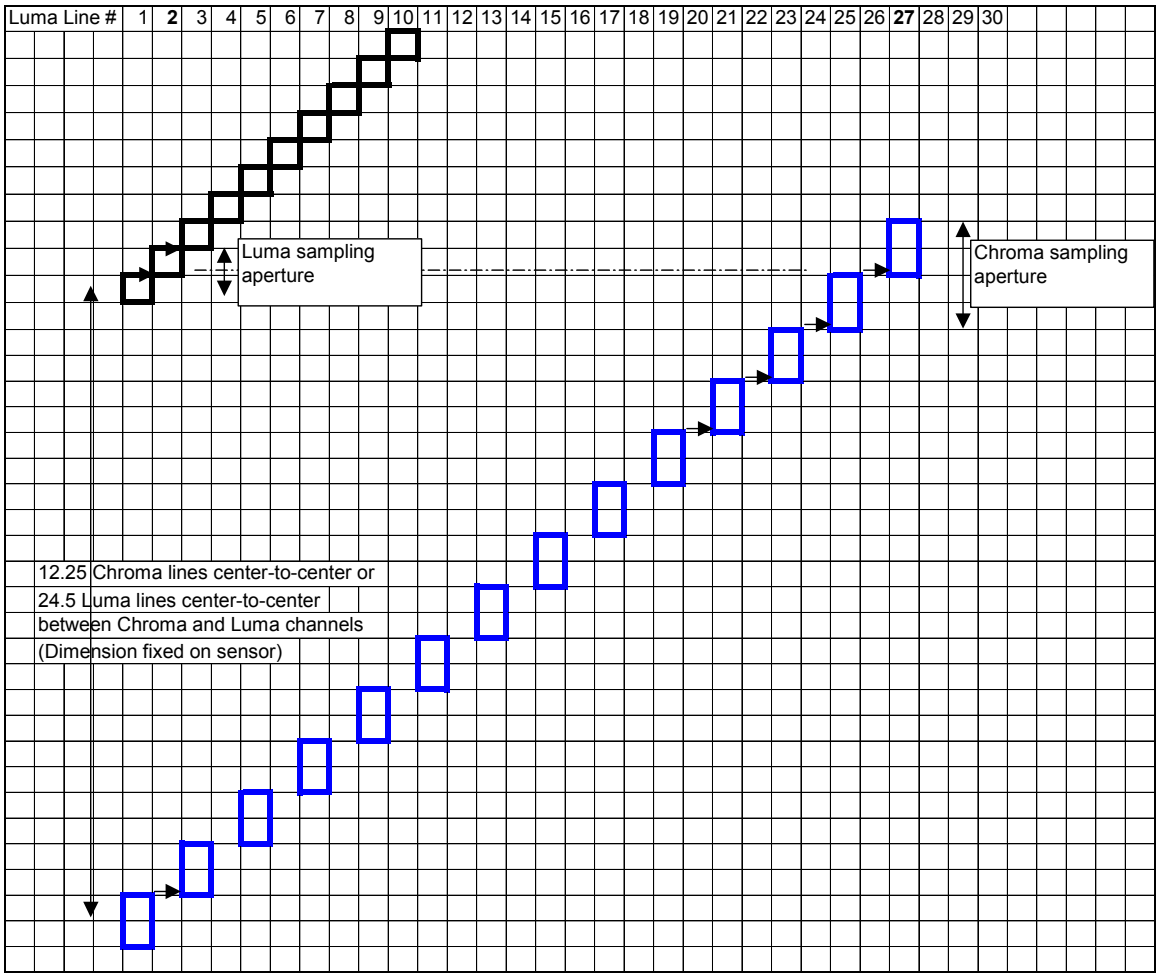

Figure 3. Pixel Alignment Diagram

The y-axis of the diagram is the direction of scanning motion (luminance-leading scan in this case). Note on the x-axis, that the luminance sampling rate (represented by the arrows) is 2X that of the chroma channel. Also note the horizontal dotted line, showing that the arrows are synchronized, depicting the effective center-aligned sampling of luminance and chroma channels after 25 luminance lines have been acquired.

This equates to zero re-phasing error between luminance and chroma signals at full resolution.

If scan speed is changed to lower the vertical resolution, a small rephasing error may be introduced.

High speed scanning:

The KLI-4104 sensor is ideal for applications such as high-speed document scanning.

High data throughput is achieved by having a total of 7 outputs, 4 outputs on the luminance channel (4*30MHz=120MHz total data rate), and 1 output per chroma channel (30Mhz each).

Readout of the pixel data for the luminance channel is accomplished through the use of two CCD shift registers in an odd/even pixel readout configuration (4 outputs total).

A system can be designed with the Kodak KLI-4104 to achieve high-resolution color scans (600dpi), when scanning the longer length side of A4 paper size at over 150 pages per minute.

An evaluation board is available for the KLI-4104 image sensor. Please contact imagers@kodak.com for more information.