2000 DPI High Resolution, Large Format, High Speed,Image Scanner

— Technology for Multiple CCD Sensors Alignment —

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KTI has developed a 2000 dot-per-inch, large format, high speed image scanner. The high resolution scanner contains 12 linear CCD sensor elements and it requires very precise alignment for each sensor's positioning. The accuracy required for these CCDs positioning is less than a single pixel width. A special alignment target was designed and used for these sensors to be aligned against. The result showed these sensors can be aligned within 10 micro-meter in positioning and 0.006 degree in azimuth angle.

This article will discuss the technology of these CCD alignment and computerized adjustment.

1 Introduction:

The 2000 dot-per-inch, 25"×32" (635mm×813mm) large format image scanner has utilized 12 linear CCD sensors as the image input device for achieving this high resolution requirement. Since the image is scanned by 12 seperated CCD sensors and later composed together in an array, the positioning accuracy of these sensors becomes very critical. Any misalignment of these CCDs can cause image distortion and poor image quality at the output side of the system.

The scanner basically works as a large format copy machine (see Fig.1) with the moving scan stage which contains 12 linear CCD sensors. These sensors are mounted in an array so the entire width of the document can be scanned in a single pass for higher speed. 12 lens assemblies are used for focusing and image reduction.

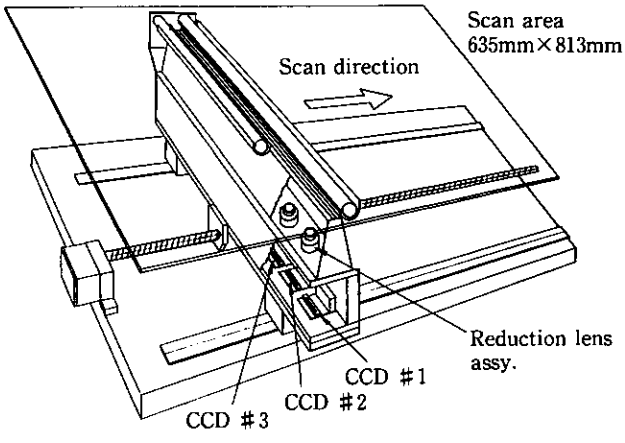

Fig.1 Scanning unit structure

Each CCD sensor will scan a 67.31mm wide area with 5.08mm overlaped section to the adjacent sensors.

Each CCDs sensor is mounted on the special designed sensor fixture which allows 4 axis of the adjustment (x, y,z,and rotation ϕx). All sensors are pre-adjusted separately on the alignment table by using a master alignment target for its positioning, focusing, magnification and parallelism. (see Fig.2)

Since the CCD sensor position is required to be within .0003 inch (7.6μm) to the nominal position. To achieve this, each sensor will be adjusted by using master target within .0002 inch (5.0μm), and then fixed with locking screws and adhesive for maintaining it at position from shock and vibration.

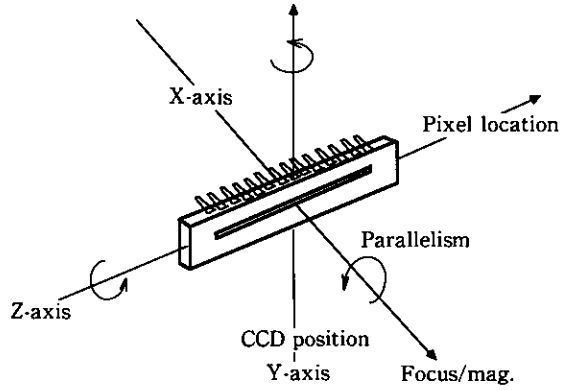

Fig.2 4 axis of CCD adjustment

Table 1. Criteria of CCD alignment

1. Magnification	±2 pixel (.09%)
2. Y-Position	±1/2 pixels (3.0μm)
3. X-Position	±5 pixels (.06mm)
4. ϕX-Position	<.006°

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2 System configuration & adjustment:

The alignment table, (see **Fig.3**) which includes the CCD sensor, lens assembly, master alignment target and electronic hardware for output measurement. Each sensor is adjusted in the fixture to meet the specification.

First, the CCD sensor is adjusted based on the master target for its focusing position. Since the line on target is very thin and hard to locate, a special pattern is designed and implemented on the target which will indicate the necessary direction of adjustment for operator.

Each CCD sensor will then be adjusted for its Z-position to the target. This will ensure the sensor stays in nominal position of the CCD array with specified margin for overlap.

The Y-position adjustment is then taken by using the oscilloscope to measure the CCD output through electronic circuitry. The output level of the CCD under optical setup is correlated to the sensor/target location, it is then an easier adjustment for finding the correct position and parallelism of the CCD. (see **Fig.4**) This shows the alignment scheme by using this master target in the system.

After the CCD sensor positions are adjusted, the magnification of the lens/CCD relation is then checked with the special pixel counter.

Fig.5 shows the basic concept of this counter. By adjusting the eccentric cam on the CCD fixture, the pixel count of specified magnification can be measured directly. Since the master target was design with a fixed line length, the magnification can be precisely measured and adjusted.

Once the magnification adjustment is completed, the focusing of the CCD setup will be checked and re-adjusted again for consistancy. The CCD fixture will be then fastened with locking screws and adhesive to assure the positioning accuracy is maintained. This procedure of the adjustment (see **Fig.6**) will be repeated

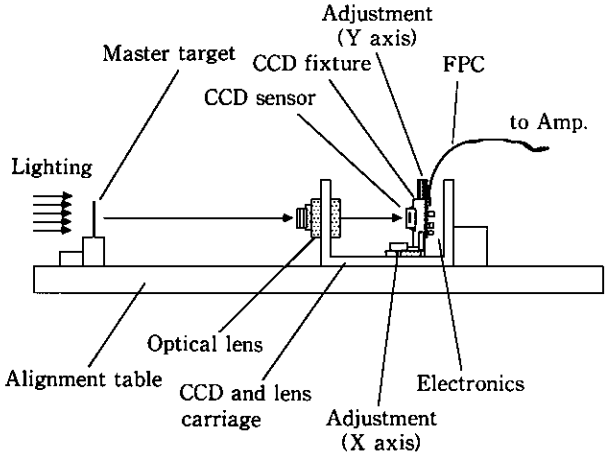

Fig.3 Sensor alignment table setup

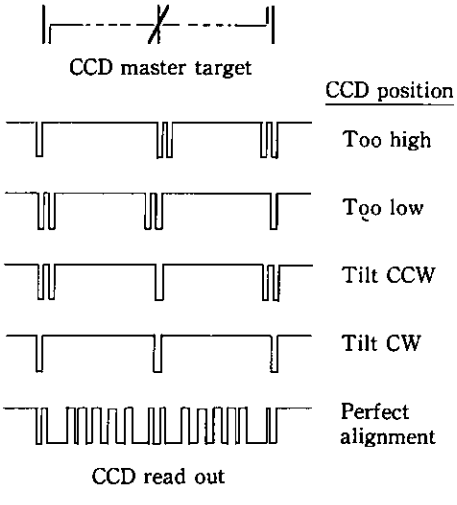

Fig.4 CCD sensor alignment scheme

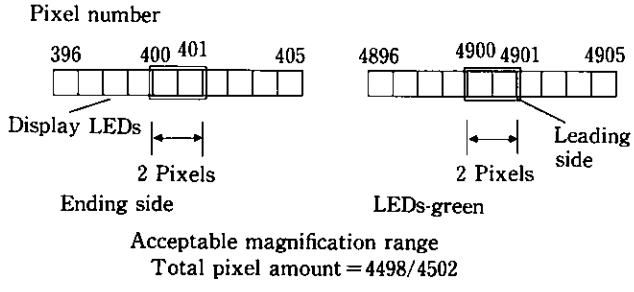

Fig.5 CCD pixel counter

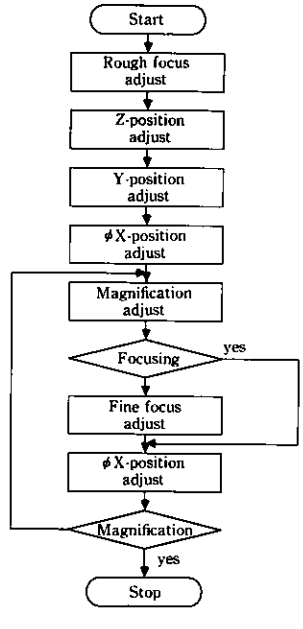

Fig.6 CCD adjustment flow

for the rest of 11 CCDs in the same manner to the very same master target until all sensors are aligned.

The result of the sensor alignment are measured with CCD output, Figure 7 shows the signal output from the misaligned and perfect aligned CCD sensor to the master target.

After all CCD sensors are aligned, the sensor carriage will be installed in the system scan table for final alignment.

A long reference alignment scale will be used at this stage for system adjustment. All CCD sensors will be exercised to scan the alignment scale and be recorded with pixel output, the system computer will then count each CCD sensor for starting pixel number, Xn and Yn as the stopping pixel number (Where n=1 to 12), there are 4500 active pixels for each sensor. These number will be calculated for setting the entire array of CCDs from number 1 to number 12 with no gap nor overlap between sensors, and this assures the continuity of the image. The scanning table will be also aligned perpendicular to the scanning window to 0.5mm of positioning to assure the correct squareness of the image.

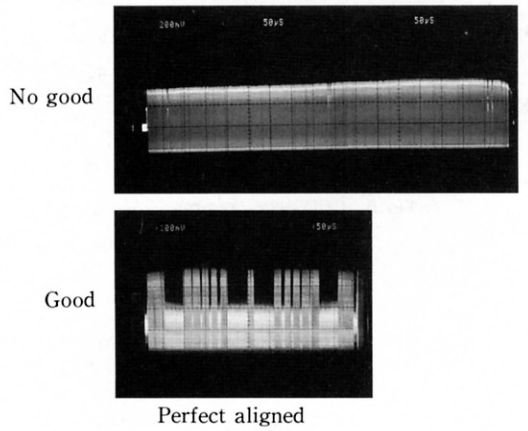

Fig. 7 Sensor output (to target)

3 Result and Conclusoin:

Since this scanner utilize 12 CCD sensors mounted in an array to achieve the high resolution, large area and high speed scanning, the alignment of these CCDs becomes very critical and challanging. The CCD master scale method has been proved to be useful and effective to achieve the tight requirement of positioning accuracy.To apply this type of the concept, design and process to other image scanning devices is highly desired and remains as the future task for the design team.

We appreciate the input and supports from Imaging Systems Division and Research & Development Center members. We look forward to work together as one team continuously for all the future product and technology development.