ANALYSIS OF THE IMAGE SENSOR CONTROL METHOD

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ABSTRACT ... All image data acquisition systems for example the digital camera and digital camcorder, use the image sensor to convert the image data (light) into electronic data. These image sensors are used in satellite camera for high quality and resolution image data. There are two kinds of image sensors, the one is the CCD (charge coupled device) detector sensor and the other is the CMOS (complementary metal-oxide semiconductor) image sensor. The CCD sensor control system has more complex than the CMOS sensor control system. For the high quality image data on CCD sensor, the precise timing control signal and the several voltage sources are needed in the control system. In this paper, the comparison of the CCD with CMOS sensor, the CCD sensor characteristic, and the control system will be described.

KEY WORDS: Image, CCD, CMOS, sensor

1. INTRODUCTION

All digital video data systems use the image sensor to convert the image data (analog data) into digital data. Below the figure shows the electromagnetic spectrum. The visible area is about 400nm ~ 700nm wavelength. The near infrared region is about 700nm ~ 1400nm wavelength and the ultraviolet region is about 180nm ~ 400nm wavelength. The other regions are showed as the figure 1.

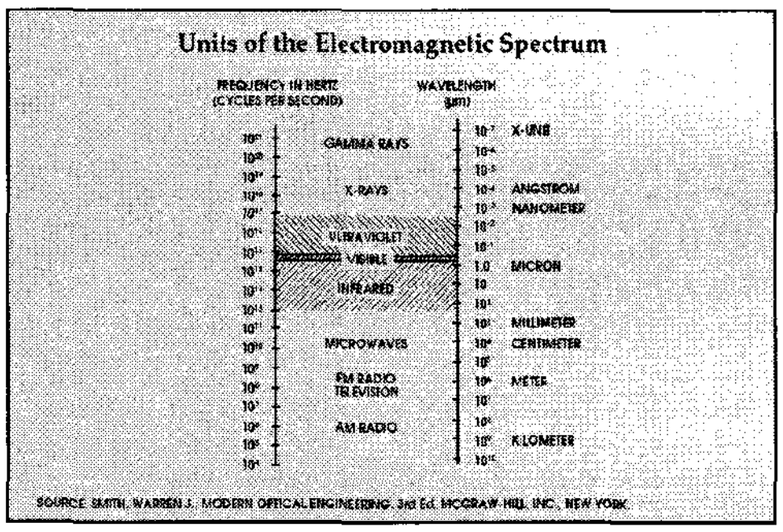

Figure 1. The Electromagnetic spectrum

Below the figure shows the photonic spectrum reference (figure 2).

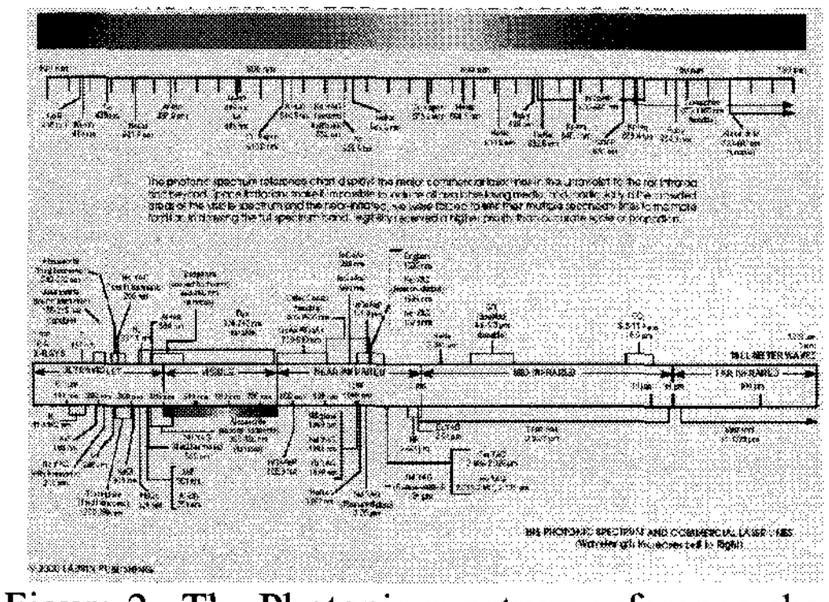

Figure 2. The Photonic spectrum reference chart

2. IMAGE SENSOR

Several image sensors are used to get the image data in wide wavelength area. Below the figures show the relation between the wavelength and the image sensor. Normally, in the long wavelength, the InGaAs image sensor is used, and in the short wavelength, the other image sensors are used. The figure 3 shows the detectable energy level and spectral response range. The figure 4 shows the detectable light level for image sensors.

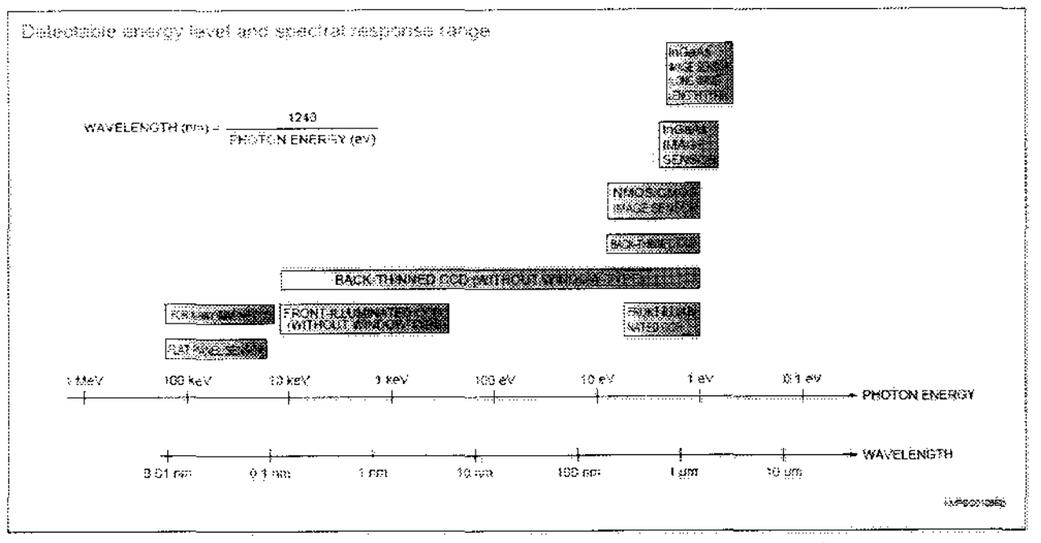

Figure 3. Detectable energy level and spectral response range

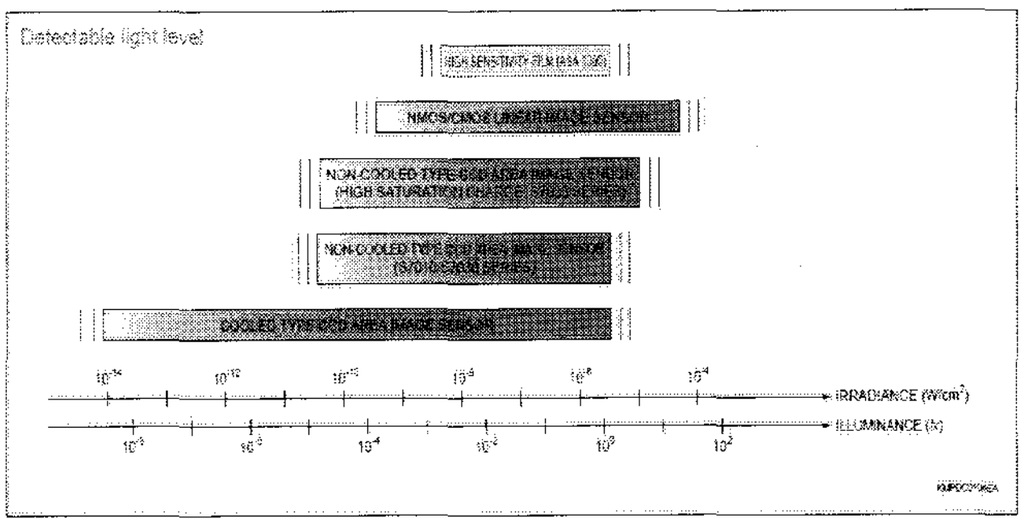

Figure 4. Detectable light level

Below the table shows the characteristic and spectral response of the each sensor (table 1).

Table 1. Image Sensor Characteristic

	Characteristic	Spectral Response
InGaAs Linear Sensor	Near Infrared Image Sensor. The built-in CMOS-IC allows easy handling and operation.	Near infrared
CCD Image Sensor	Low-light-level detection. High S/N and wide dynamic range. High Quantum efficiency (back-thinned type).	UV/visible /X-ray
NMOS Linear Image Sensor	Large active area per pixel. High UV sensitivity. Low noise and high output linearity.	UV/visible
CMOS Linear Image Sensor	Integrated with signal processing circuits. Low power consumption. Downsizing of detector unit.	UV/visible

The InGaAs linear sensor is used in near infrared area and the other sensors are used in UV/visible area. The CCD image sensor requires less of an electrical charge than CMOS linear image sensors. The CCD image sensor has the higher charge-to-voltage conversion efficiency. The CMOS linear image sensor allows a much simpler external driver circuit design than NMOS linear image sensor. Using NMOS linear image sensor in application where higher output accuracy is needed.

Below the table 2 shows the difference between CCD and CMOS image sensor.

Table 2. Comparison of the CCD with CMOS

	CCD (Charge coupled device)	CMOS (Complementary metal oxide semiconductor)
Characteristic	- Converting light to charge - Charge transportation	- Converting light to charge - CMOS switch used
Advantage	- high image quality - High sensitivity - High transportation speed in pixel data	- One-chip - Low power consumption - Simple manufacturing process
Disadvantage	- Complex manufacturing process - Lower Yield - Complex control circuit - High power consumption	- High noise - Lower Sensitivity - Narrow dynamic range - Low speed charge transportation - lower uniformity
Application	- High quality digital system	- Low quality digital system
Antiblooming	- CCDs require specific engineering to achieve this capability.	- CMOS generally has natural blooming mmunity.
Biasing and clocking	- CCDs typically require a few higher-voltage biases.	- Generally operated with single bias voltage and clock level
Reliability		- CMOS imagers have an advantage because all circuit function can be placed on a single integrated circuit chip.
Multiple read out during integration	- No	- Yes

Below the figure shows the difference between CCD and CMOS image sensor operation concept. The CCD sensor moves a photo-generated charge from pixel to pixel and converts it to voltage at an output node, but the CMOS sensor convert a charge to voltage inside each pixel.

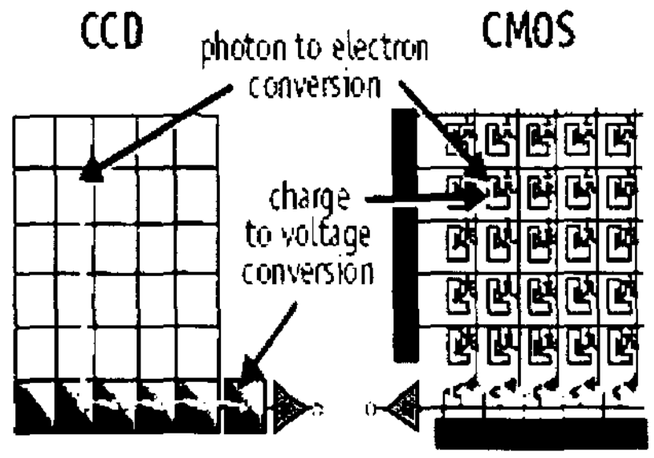

Figure 5. CCD & CMOS sensor operation concept

Specially, the CCD and CMOS concepts are used on chip (figure 6). The CMOS sensor can be fabricated with more "camera" functionality on-chip. This offers advantages in size and convenience, although it is difficult to optimize both imaging and processing functions on the same device.

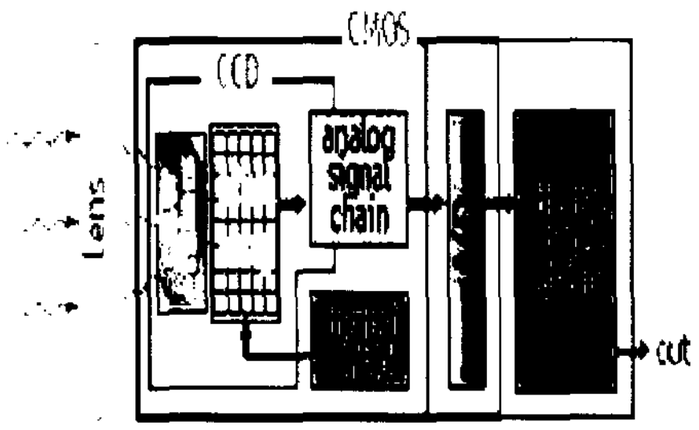

Figure 6. CCD & CMOS on chip system

Below figure 7 shows the CCD and CMOS sensor layout.

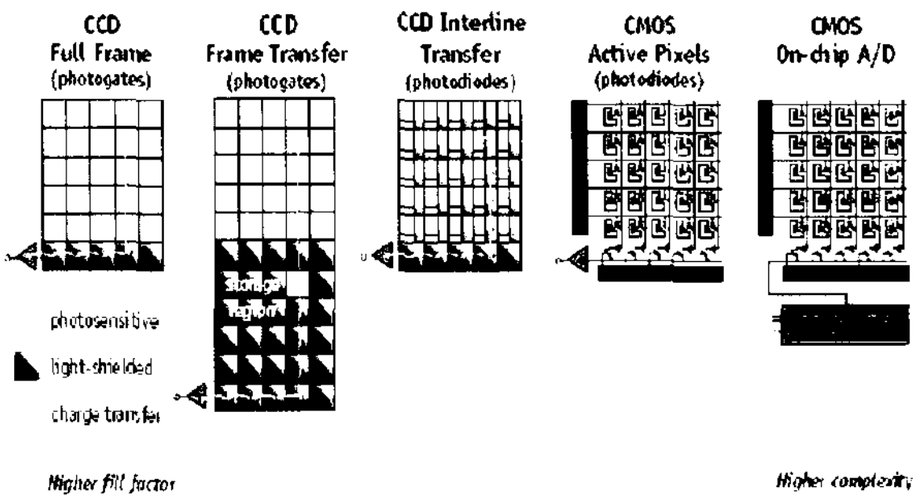

Figure 7. CCD & CMOS sensor layout

Some micro satellites and small size satellites use the CMOS image sensor for science research and other purposes. But, almost satellites use the CCD image sensor for high resolution and image quality. Next, the CCD image sensor's specification, organization, and operation methods are described.

3. CCD IMAGE SENSOR

Most of the satellite cameras use the CCD image sensor for high quality image data. Almost linear CCD sensors have the TDI (Time Delay Integration) configuration. Below the figure 8 shows the linear CCD sensor block diagram.

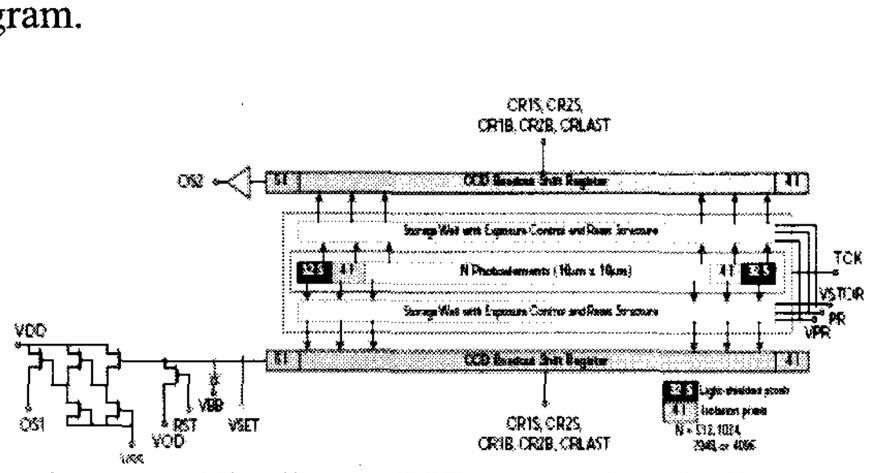

Figure 8. The linear CCD sensor block diagram

The CCD sensor moves the charge from pixel to pixel and converts it to voltage at an output node. Below the figure 9 shows the image data pixel diagram. The transfer clock needs very fast clock.

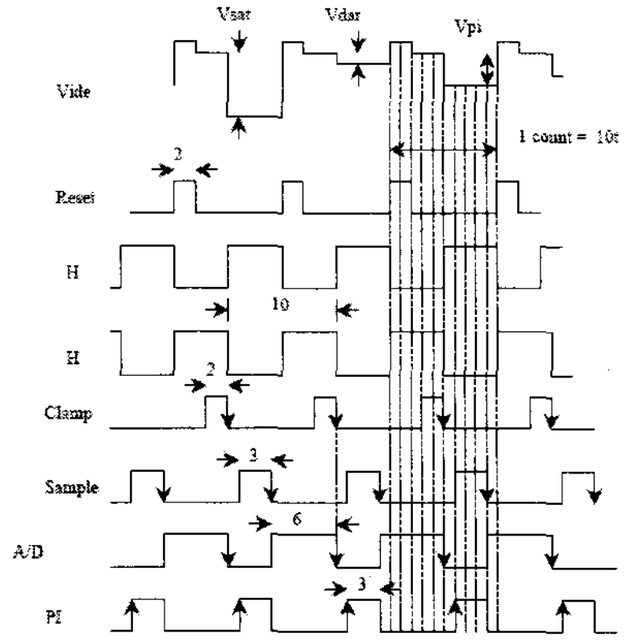

Figure 9. The image data pixel diagram

The converting system of the charge transportation needs the bias voltage (high power voltage) for analog image data converting.

4. IMAGE CONTROL SYSTEM

Below the figure shows the CCD sensor timing diagram (figure 10). There are several control clock for the CCD control. The main control clocks are vertical clock and the horizontal clock. The vertical clocks consists of 3 or 4 phase clocking, should do charge transport in the parallel shift register. The horizontal clock should do serial transport into converting system. The others clocks and signal for example delay, reset, bias are needed for CCD sensor control. The sensor control system needs the high reliability and low power consumption same as other satellite system, supplies exact clock signal to the CCD detector for the accurate control. In this paper, the vertical clock and the horizontal clock are described. The figure 11 is the vertical clock driver circuit and the figure 13 is the horizontal clock driver circuit. The figure 12 shows the simulation result of the vertical clock driver (figure 11), and the figure 14 shows the simulation result of the horizontal clock driver (figure 13).

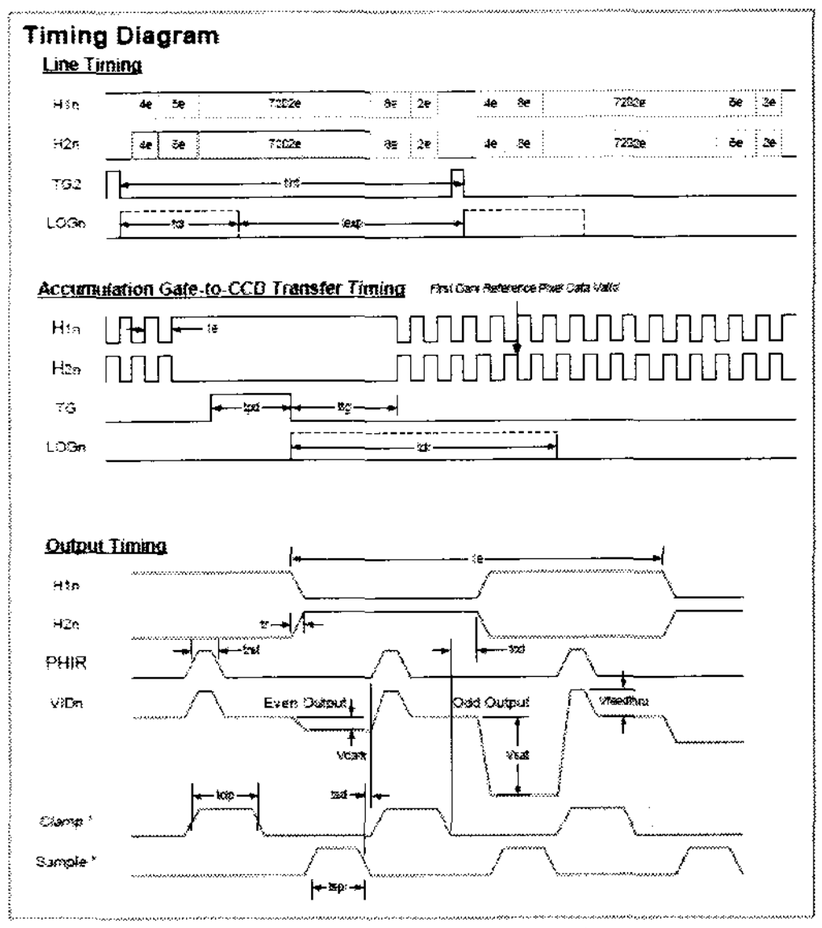

Figure 10. The CCD sensor timing diagram.

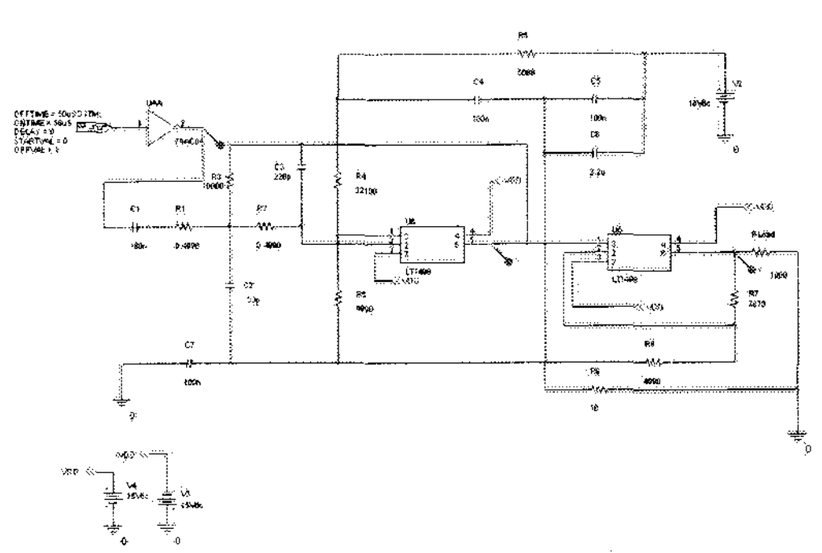

Figure 11. The V-clock circuit diagram.

The v-clock needs the high power control signal for high quality image data. Most of the v-clock driver uses the FET components for the high voltage.

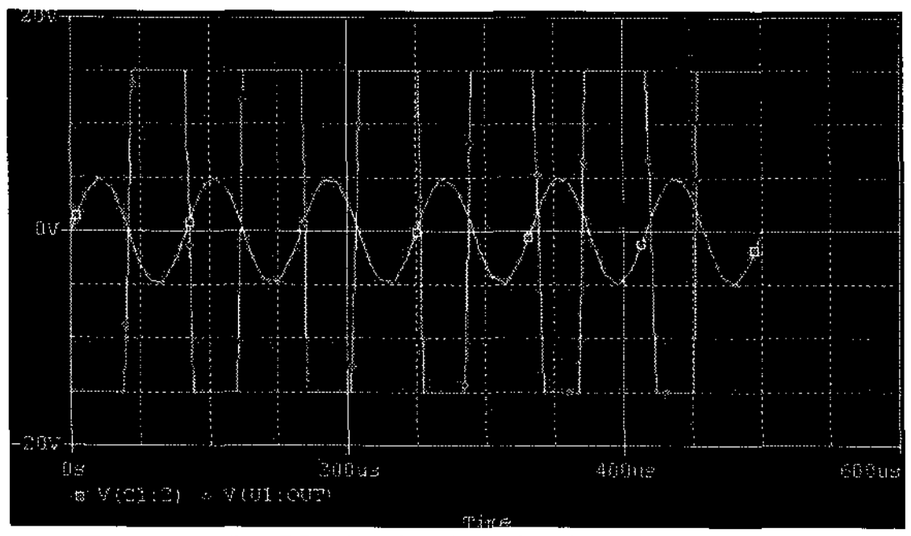

Figure 12. V-clock circuit simulation result

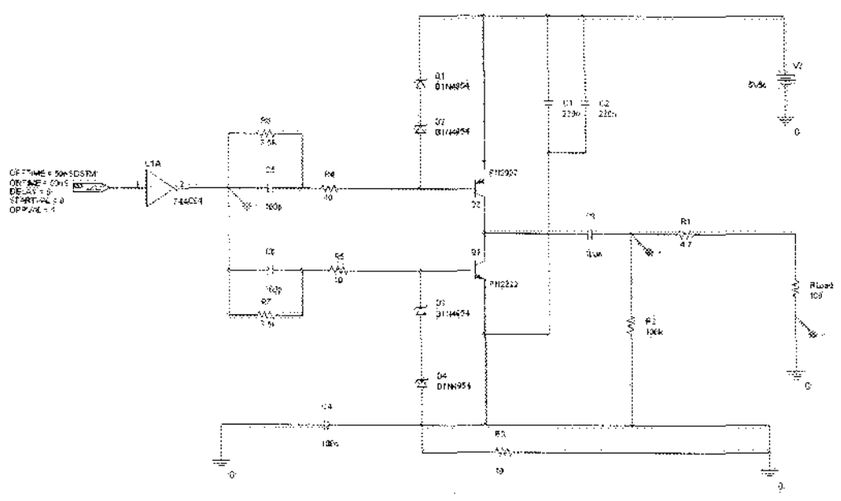

Figure 13. The H-clock circuit diagram.

The h-clock needs the high speed control signal for the fast image data transmission. The totem-pole output is used for the v-clock drivers.

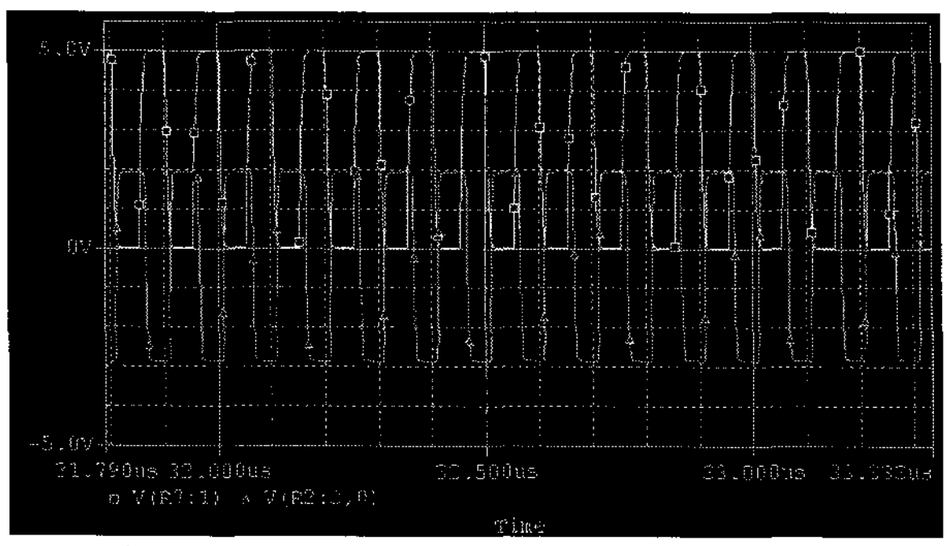

Figure 14. H-clock circuit simulation result

5. CONCLUSION

All image data converting systems need the image sensor. In this paper, the several image sensors are described in the characteristic, advantage, and disadvantage. The CCD image sensor has the advantages, image sensitivity, dynamic range, and space product heritage. But, the CCD sensor control system is complex and needs the exact and sharp control clock for high quality image data. In the future, the CMOS image sensor has the advantages, low power consumption, no-needed anti-blooming design, and system reliability, is described in the complement to its disadvantages.

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