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Advantage of the CMOS Sensor

Latest image sensor technology for HD security

Contents

Introduction

Since the replacement of imaging tube by solid image sensor in the early 80's, 2 types of sensor, CCD (Charge Coupled Device) and CMOS (Complementary Metal Oxide Semiconductor) have been used in the video equipments. The easier processing method and low manufacturing cost popularizes the CMOS image sensor in simple image capturing products like web cams and mobile phones, while the CCD technology remains dominant for professional and consumer video equipments.

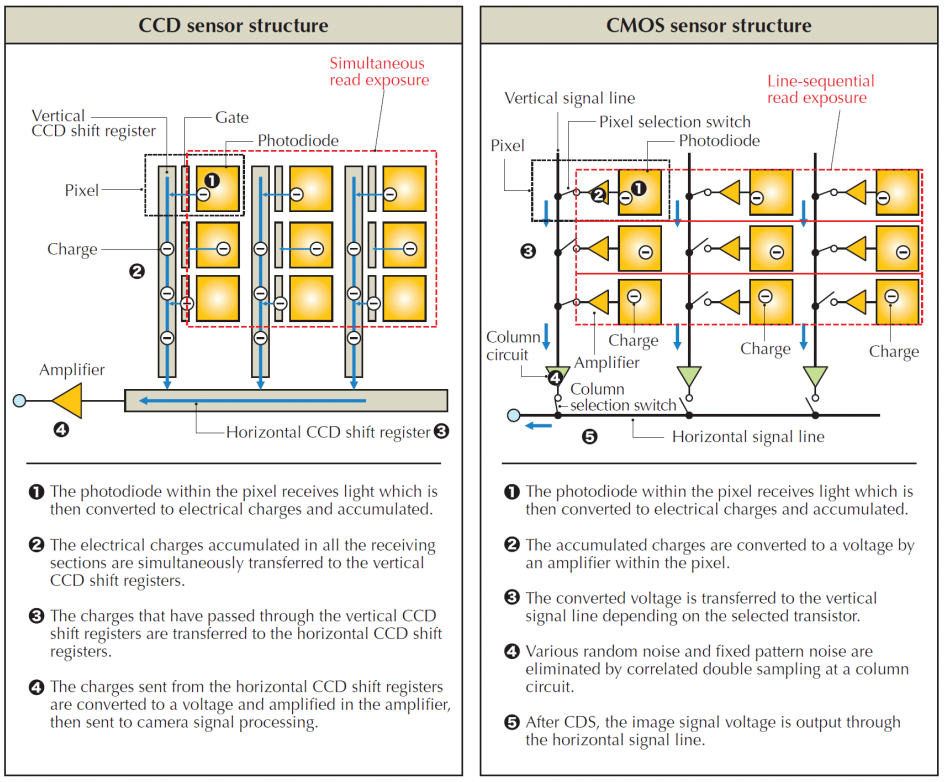
Security industry is one of the largest industry segments which adopted the CCD technology for CCTV camera products. CCD image sensors are used in the majority of analog cameras which are based on TV standard of NTSC or PAL. With the advancement of technology, we see a higher demand for digital security cameras which can transmit digital video signal over IP. The recent pursuit for higher resolution is also increasing the demand for the latest high definition (HD) video standard in the security industry. This rapid shift to HD based system is one of the main driver for the CMOS technology.

Striving to merge the advantages of both the CCD and CMOS sensor, research and development are intensely focused on improving the CMOS sensor to become an imaging device which has an equivalent picture quality as the CCD image sensor. As a result, an improved CMOS sensor – "Exmor" CMOS sensor is developed.

Comparing CCD and CMOS

Although both sensors are image capturing devices for a camera, the latest CCD and CMOS sensors are very different in structure. Figure 1 describes these structures.

Fig.1 Read out signals



The CCDs video applications requires all the vertical and horizontal shift registers to constantly relay received image data as electronic signals. As a result, there is a limitation to achieve high resolution and high speed simultaneously. Power consumption also becomes comparatively high. Alternatively, the CMOS sensors only need to move one readout column of circuitry, so power consumption remains comparatively low even with increased processing speed.

CMOS Sensor "Exmor"

In recent years, the growing interest in small High Definition camcorders sparked the significant development of CMOS sensors which are low power consumption devices with high-speed image readout capabilities. The high definition trend is also starting to grow in the video security industry. Coupled with the prevalence of IP networks, the IP video camera no longer depends on the conventional TV format.

To address the demands of higher resolution from the video security industry, Sony started the research and development of an improved CMOS sensor using its image quality knowledge accumulated in CCDs. The result is a CMOS sensor with an entirely new structure, the "Exmor" CMOS sensor.

Both CCD and CMOS sensors have the same component that converts light into electricity (a key element of image quality). With the "Exmor", however, Sony uses high image quality pixel technology accumulated in CCD development to enlarge as much as possible the light-receiving section of the photodiode. Tables 1 and 2 show specifications and Image Sensor Characteristics for the "Exmor" CMOS, CMOS and CCD sensors.

Table1 Specifications

Item	IMX035	IMX012	ICX445
Sensor type	"Exmor" CMOS	CMOS	CCD
Image size	Diagonal 6.08 mm (1/3 type)	Diagonal 4.7 mm (1/3.8 type)	Diagonal 6.0 mm (1/3 type)
Transfer method	All-pixel	All-pixel	Interline
Total number of pixels	approx. 1.49M pixels 1384 (H) x 1076 (V)	approx. 1.33M pixels 1304 (H) x 1017 (V)	approx. 1.32M pixels 1348 (H) x 976 (V)
Number of effective pixels	approx. 1.39M pixels 1329 (H) x 1049 (V)	approx. 1.28M pixels 1296 (H) x 985 (V)	approx. 1.25M pixels 1296 (H) x 966 (V)
Chip size	7.64 mm (H) x 7.64 mm (V)	6.452 mm (H) x 6.402 mm (V)	6.26 mm (H) x 5.01 mm (V)
Unit cell size	3.63 µm (H) x 3.63 µm (V)	2.925 µm (H) x 2.925 µm (V)	3.75 µm (H) x 3.75 µm (V)

Table 2 Characteristics

Item		IMX035	IMX012	ICX445	Remarks
Sensitivity (F5.6)	Typical value	460 mV	290 mV	460 mV	3200K, 706 cd/m^2 (Exposure time: 1/30 s)
Saturation signal	Minimum value	830 mV	550 mV	350 mV	Tj = 60 °C

Another major element that affects image quality is noise reduction. In the "Exmor" CMOS sensor, noise on the analog circuit is eliminated by the built-in Correlated Double Sampling (CDS) circuit. Other new structural elements incorporated into the sensor also drastically decrease the noise-contamination level. Figure 2 and Figure 3 describe these structures.

- The A/D conversion conventionally done just before signal readout is now performed immediately after the light-to-electricity conversion for each column. This helps to reduce noise because the analog circuit is made shorter, and the frequency lower.

- Noise-elimination circuits (CDS circuit) are equipped in the digital domain.

Fig.2 Sensor structure

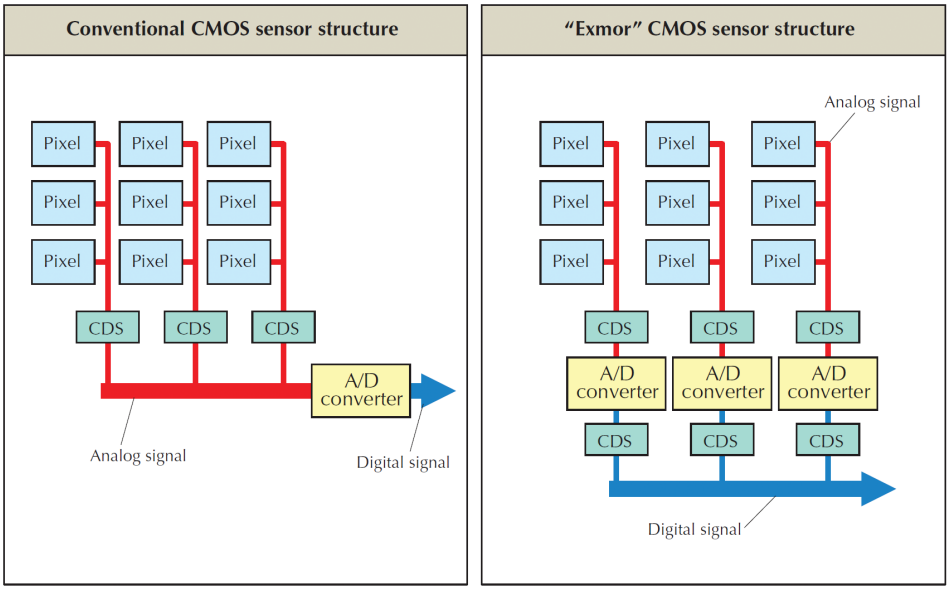
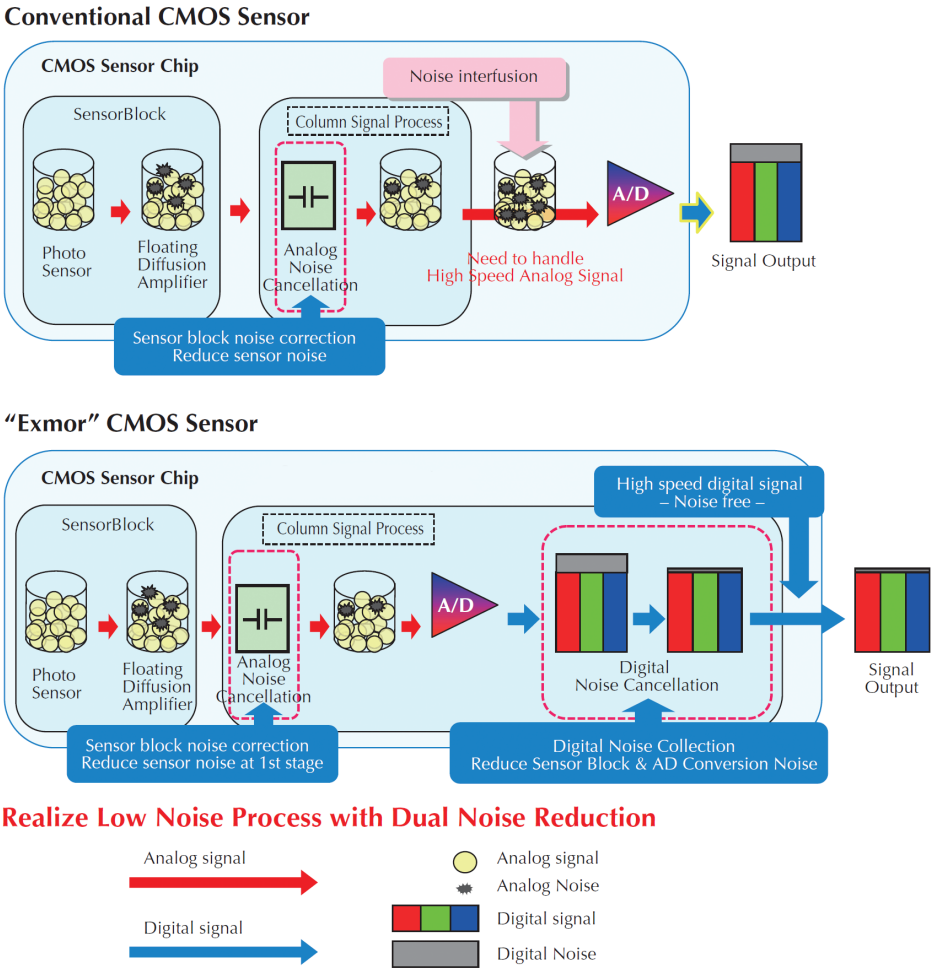


Fig.3 Noise reduction



Through these methods, drastic improvements have been made in CMOS sensor image quality, achieving the same image capture performance level as CCD sensors. In the new Sony IP video security cameras, the minimum object luminance specifications for cameras equipped with either a CCD or an "Exmor" CMOS sensor are as follows:

Sony IP video security camera with CCD – SNC-CM120: 1.3M, Minimum illumination: 0.8 lx
Sony HD IP video security camera with CMOS – SNC-CH140: 720P HD, Minimum illumination: 0.2 lx

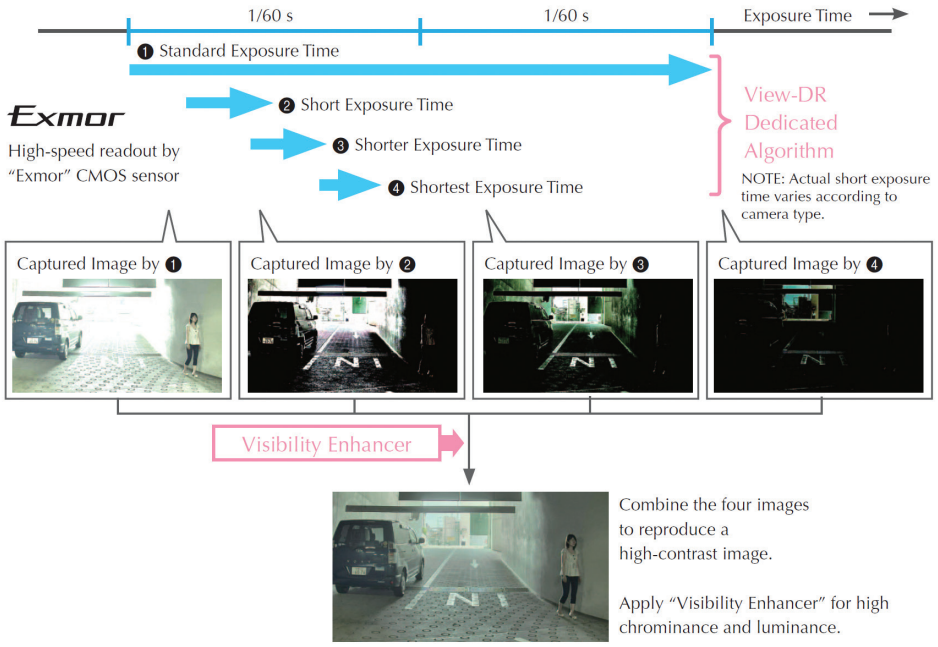
View-DR : New Wide-D Technology

Vier-DR uses the High-speed Readout of the CMOS Sensor. When comparing the newly developed "Exmor" CMOS sensor with the CCD sensor, not only has the sensitivity improved, but data (image) readout is dramatically faster. Using these high-speed readout capabilities, Sony's HD IP cameras now comes with a newly-developed Wide-D technology, called the View-DR function.

With a CCD sensor, the user is restricted to taking successive 1/60-second images or two 1/30-second images and combining them. In View-DR, the user can take one 1/30-second image at long exposure, and take other images over the same period at short exposure, and then image process them in real-time to achieve an industry-best wide dynamic range.

Figure 4 shows the structure of this industry-best Wide-D (View-DR function) as used by the "Exmor" CMOS sensor:

Fig.4 View-DR structure



View-DR

Future Developments

The demand for image with greater details and less noise will continue to grow. The requirement of higher resolution in video security applications will continue, and this will drive the development of HD technology in the video security market. As a result, CMOS sensors, which have a higher speed of readout data than CCD sensors, will become predominant in the security industry and both the professional and consumer market.

Looking into the future, Sony is researching on a more sensitive CMOS sensor called the "back-illuminated high-sensitivity CMOS image sensor". This CMOS sensor is now available in video camcorders and digital still cameras. The CMOS sensor delivers both improvements in sensitivity and reduction of image noise, both crucial in the capture of high image quality.

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