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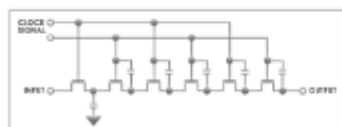


A comparison of some of the key technologies and characteristics in CCD and CMOS sensors

— Andrew Kirby, Technical Specialist, ATIK Cameras

### Historical background

The first Charged Coupled Devices (CCDs) were conceived by Boyle and Smith in the late 1960s whilst working at Bell Laboratories. Their initial interest was to develop a method of transferring a charge along a row of Metal Oxide Semiconductor (MOS) capacitive devices. Their pioneering work subsequently led to the creation of a device that they termed 'Bucket Memory', in essence it is a form of the analogue 'Bucket Brigade Delay Line' (BBD). Imagine that a charge is introduced at one end of a row of capacitors. It can be stimulated by a clock pulse to gradually move along the row, a veridical appearing at the other end. Simply put, the charge goes in at one end, and out at the other, at a speed that can easily be regulated – it is a form of controllable electronic delay.



Left: A simple schematic of an electronic Bucket Brigade Delay Line formed from a capacitor network and transistors in analogue circuit design. Right: A red bucket brigade in action. A line of firemen passing water down a line bucket to bucket.

A close derivative of this idea, known as a 'Shift Register', would later be implemented in CCD image sensors. This highly significant step, created a mechanism of conveniently moving around the accumulated charges to different parts of the image sensor.



### The Architecture of the CCD Sensor

This article will primarily focus on discussing the behaviour of 'satellite' CCD sensors, however please be aware that other related technologies exist, these are most notably 'full frame' and 'frame transfer'.

In a CCD sensor, each pixel (or its photosensitive area) accumulates and converts incoming light into electrons – i.e. electronic charges. Referring to the diagram below, immediately adjacent to each pixel is a transfer gate which allows controlled access to the vertical shift register. This is a vertical column that behaves like the Bucket Brigade Line discussed above. In operation the following sequence of events typically occurs:

- The exposure is started, and light arrives at each image pixel in the form of photons
- These photons are converted into electrons via the photoelectric effect

## A Comparison of Some of the Key Technologies and Characteristics in CCD and CMOS Sensors

To assist in choosing the right technology for an application, this paper covers: • Historical background • Architecture • Improvements • Binning • Fill factor • Full well depth and capacity • Dynamic range • Frontside and backside illumination • Shutter types • Noise • Quantum efficiency • Image artifacts

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