
Kodak DCS Electro-Optic

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The Electro-Optic Camera

The World's First DSLR

The Electro-Optic Camera was designed and constructed by Eastman Kodak Company under a U.S. Government contract in 1987 and 1988. Kodak's Microelectronics Technology Division (MTD) had announced the first megapixel CCD in 1986. In 1987, a government customer asked Kodak's Federal Systems Division (FSD) to build a prototype camera around the new CCD. It was a true skunk works project with a very small team. Ken Cupery was the project manager. I (Jim McGarvey) was the lead engineer. MTD engineer Bill Toohey designed the CCD analog circuitry, and technician Tom McCarthy assembled the whole system.

The camera was intended for unobtrusive use where a film camera would not attract attention. To conceal the unusual nature of this device, we mounted the CCD in a small addition to the back of a standard 35mm camera body and stuffed most of the system in a box that could be carried in a normal camera bag over the shoulder. The ribbon cable connecting the two was thin enough to run inside the bag's strap.

This project led to the Hawkeye II cameras Kodak marketed to government customers and then, in 1991, to the commercial Kodak Professional Digital Camera System and the subsequent series of Kodak DCS cameras. It was not until Nikon introduced the D1 in 1999 that any other company offered a commercial DSLR. See The DCS Story and the links at the bottom of this page for more.

I don't know if this camera still exists. I delivered it in person to the customer's offices and never saw it again. Perhaps it's still hiding in some secret storeroom. The photos here were taken in the FSD studio at Kodak, on film, of course. I have a set of beautiful 8 x 10 prints and these images were scanned from them.

The customer preferred Canon film cameras, so I chose the beautiful and rugged New F-1 body. The removable door was easy to modify to attach the new CCD back. The back housing was milled out of a solid aluminum block. The three small allen screws at the center of the back were used to adjust the focal plane of the CCD. The three LEDs to the left of the viewfinder indicated the status of the digital system.

The original film pressure plate was removed and holes punched in the door for the new parts. The plate surrounding the CCD was a "table" machined from a block of aluminum. It was pressed against the body film rails by springs between it and the door. The table legs passed through the door and supported the back housing.

The back circuit board held the analog circuits that needed to be close to the CCD: Clock drivers, correlated double sample and hold, and output amplifier. Analog video passed through the cable to the A/D converter in the shoulder pack. The CCD was epoxied to a thermoelectric (Peltier) cooler to refrigerate the chip for lower dark current. The cooler was epoxied to a block of copper attached to the back housing to dissipate the heat.

Ideally the cooler goes inside the package directly under the chip, but that would have been too costly for this prototype. But cooling the package means the window could fog or frost up. The white and gold component at the far left is a humidity sensor that allowed the system to maintain the window temperature above the dew point. The result was limited cooling and a negligible improvement in dark current.

The cable coming off the right end of the back goes to the battery compartment of the F-1 body. Body power was supplied by the main system battery and the current was monitored to determine when the shutter was opening and closing. This scheme was the topic of the only patent I bothered to obtain for this very novel product!

That cool looking black box held most of the electronics, a 3.5 inch, 100 Mbyte hard drive to store the images, and a big lead-acid camcorder battery. To get power in to charge the battery and image data back out, I designed the world's first digital camera dock to go with the camera. When the black box was plugged into the dock, the battery was charged (from any worldwide AC outlet, or a 12 volt car lighter socket) and the image data automatically copied to an 8mm video tape (in digital form, of course) using an Exabyte tape drive. The gray connector atop the dock unit carried a SCSI bus and power.

There was no image display anywhere on the system, so you had to take your 8mm tapes to a computer with another Exabyte drive and read off the images, which were stored as raw, uncompressed tar files. The little alphanumeric LCD did offer a crude, 8 bar histogram to help with exposure adjustment, and there was even a 1 pixel spot meter that could be scanned about the image to see where it was light or dark.

Here's the shoulder pack happily docked. This whole stack must have weighed about as much as 4 or 5 modern laptop computers!

The EO Camera was a government project, so the moment I had it working well, I went looking for some military subjects. Rochester isn't a very heavily fortified city, but I did find a fleet of old 2½ ton Army trucks behind the National Guard armory. I felt like a real secret agent shooting these guys from the shadow of a nearby wood.

This is the only sample image I have from the EO Camera. It's scanned from an 8x10 thermal print made in 1988, so it doesn't quite reflect the true image quality of the camera. There are some light scuff marks on the trucks and fence that were not in the image. The sky shows some banding from the printer. Otherwise, it's not a bad sample. The fine diagonal lines at the right edge are digital noise that was part of the image at that point. Click on the image to see it at the original resolution of 1320 x 1035, and you'll have a good idea of the state of the art in 1988!

Here are some interesting documents. The Operating Instructions, unfortunately, are not illustrated. Just typed out in Courier on a dot matrix printer. I still had the original .txt file, so this pdf is from that.

The firmware was written in PL/M, Intel's proprietary language. The CPU was an Intel 80C196 16 bit microcontroller.

The data sheet for the KAF1400 CCD reveals its odd pixel dimensions of 1340 x 1037. Think 4:3 aspect ratio. Think video!

The block diagram shows the main features of the electronics. Analog video from the sensor arrives at the video processor, which includes a logarithmic amplifier to make the most of the 10 bit A/D converter resolution. I made the 10 bit converter from four CA3318 CMOS 8 bit flash converters. 12 bit flash converters that would work at 10 Mhz were available, but too power hungry and expensive.

Images went to DRAM first. The 10 Mbyte bank of DRAM would hold a burst of 6 images, but they could be captured at 5 frames/second with the F-1 motor drive attached. The hard drive would hold 60 images. Image counts for both DRAM and hard drive were displayed on the status LCD.

I drew the block diagram with MacPaint, on a Macintosh Plus, I think.

This is the layout of the main circuit board. The whole thing was hand wire wrapped - all through hole parts! All this stuff would fit on a quarter today.

The first page of the schematic shows the CCD back circuitry. The rest of the schematic was all hand drawn and looks pretty rough for such a historic project. Click the image to download the pdf.

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