

CCD Camera Design for Biometric Imaging

Presented By: S.E Nickols, CTO , DMR LLC

Nick's Background.

- **Experience:** Over 20 years of electro-optical system design, design analysis, design verification experience, and product certification. Have recent experience with medical device development and involvement with design control/regulatory issues (class II and III).
- **Industries:** Scientific, Semiconductor, and Medical.
- **Interests:** Projects requiring a multidisciplinary approach to solve a customer's problem.
- **Approach:** Team player. Quality Oriented. Process oriented. Customer oriented.
- **What I Bring to table:** Aside from technical skill and experience, "hindsight", a can-do attitude, flexible, strong adaptation skills, open minded, here to make you money.

CCD Camera Design for Biometric Imaging



CCD (finger roll)
Camera

- Formally employed with Identix Inc. as the Director of Engineering.
- Designed the CCD camera electronics for the TP3800 Imaging system.
- Characterized camera and Optics for FBI appendix F certification.

Project Issues (Big Picture View).

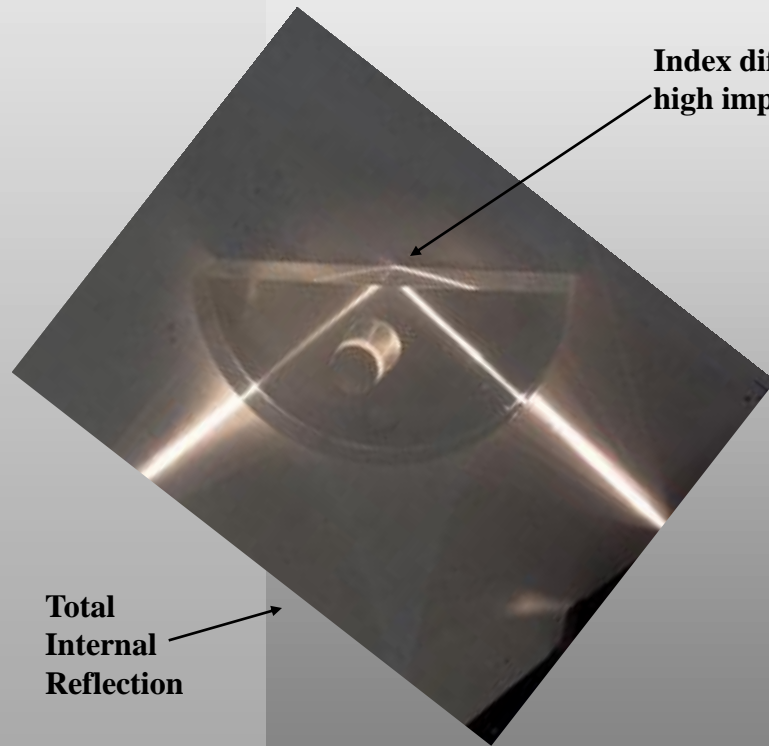
- **TP2000 product release was behind schedule.**
- **Several components, including the CCD, were at end of life.**
- **Optical Scanner partner located in Russia.**
- **A new finger role camera needed to be designed.**
- **Camera had to be compatible with current Optics design.**
- **Camera had to be firmware compatible with current video processing engine.**
- **It was vital that the camera meet certification requirements and be integrated in to the TP2000 by 11/2001.**

Design Process

- **Come up to speed with Identix technology.**
- **Benchmark Old CCD camera design.**
- **“Reverse engineer” Optics and mechanical assemblies.**
- **Come up to speed with Identix certification requirements.**
- **Develop a design specification.**
- **Resolve design requirements with component availability.**
- **Work out CCD delivery issues with Sony. (ICX285 was a new part).**
- **Implement design.**

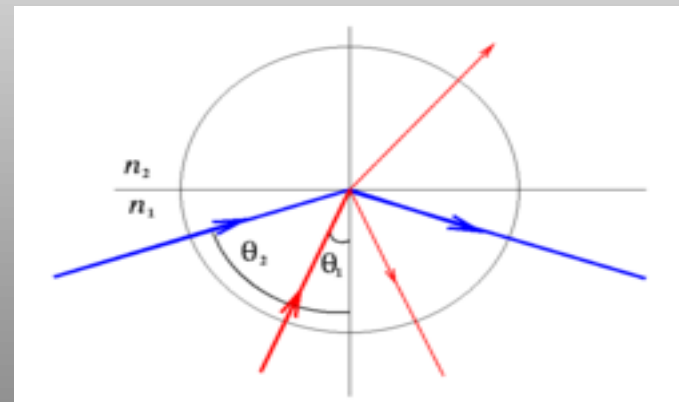
Identix Imaging Technology.

Biometric imaging exploits the principle of “Frustrated Total Internal Reflection”.



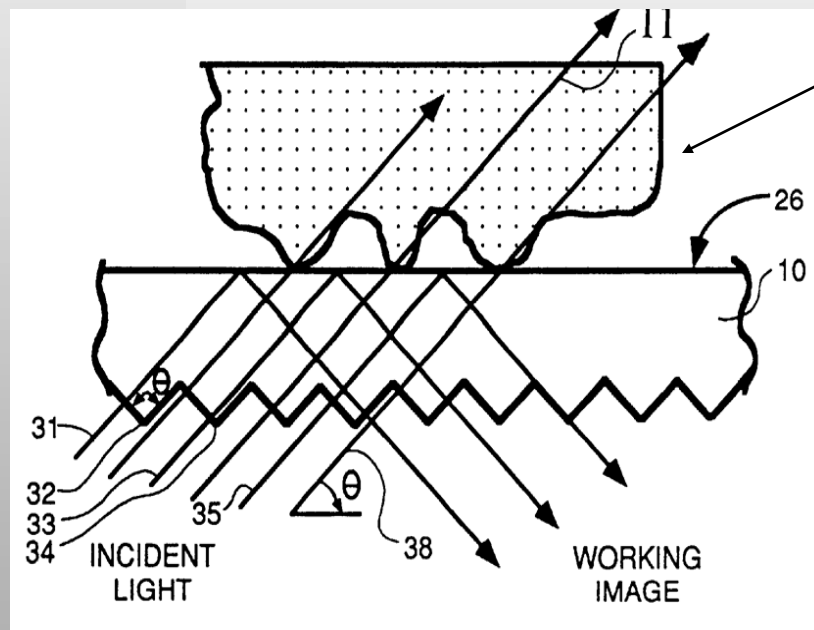
Index difference looks like a high impedance to the light.

Total Internal Reflection



Frustrated Total Internal Reflection

Finger Print Imaging



Light wavelength is important (780nm).

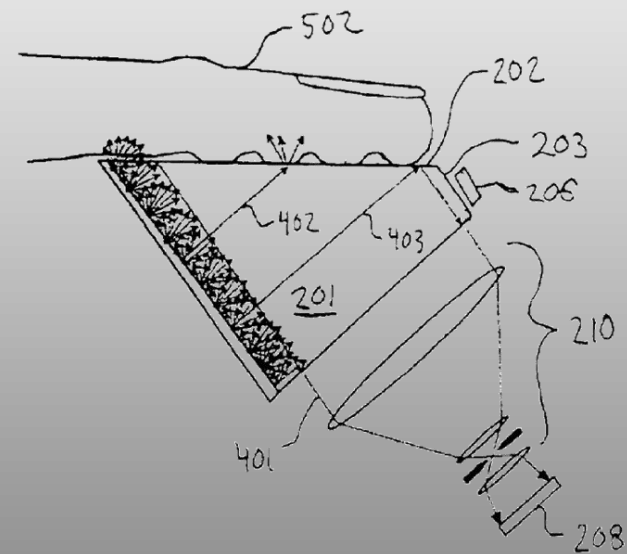
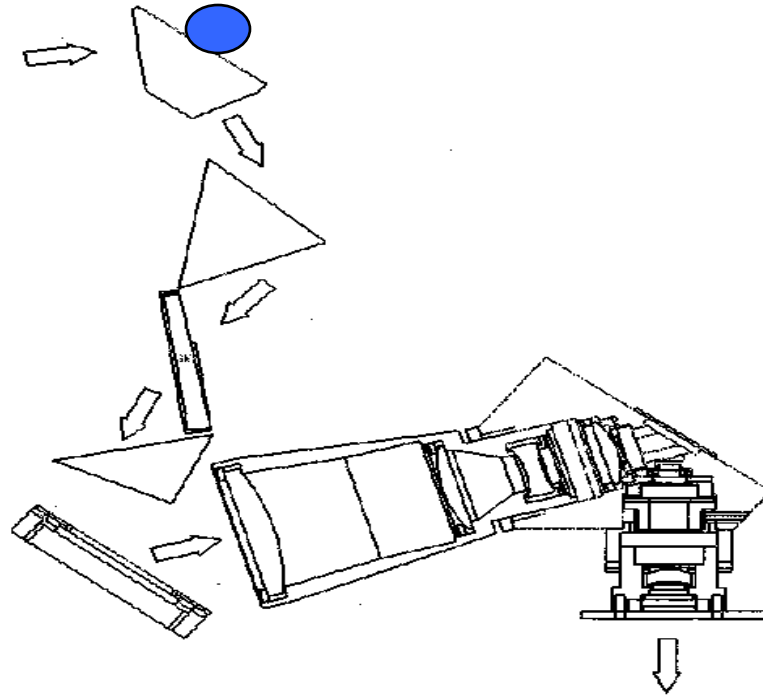
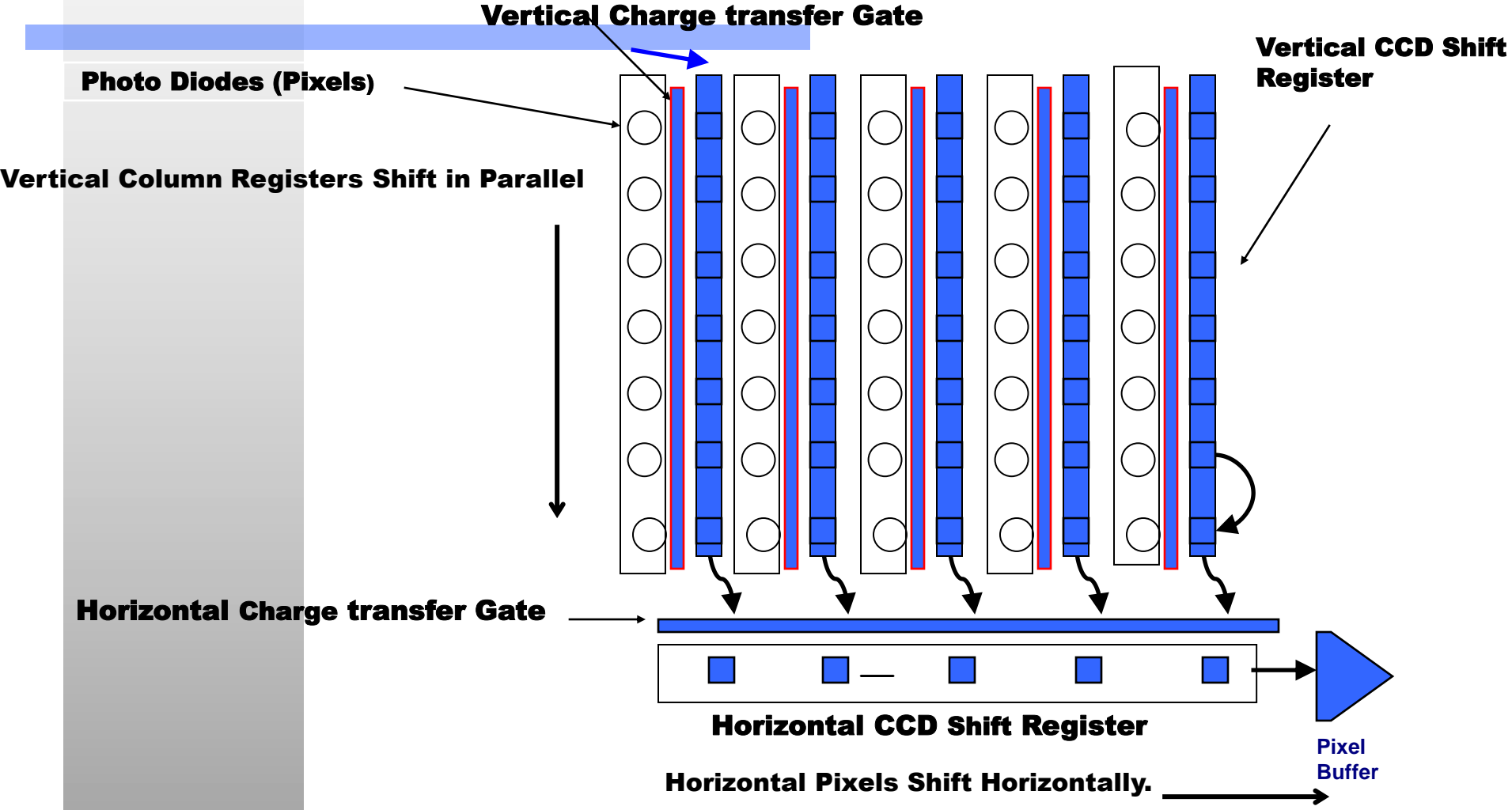


FIG. 5

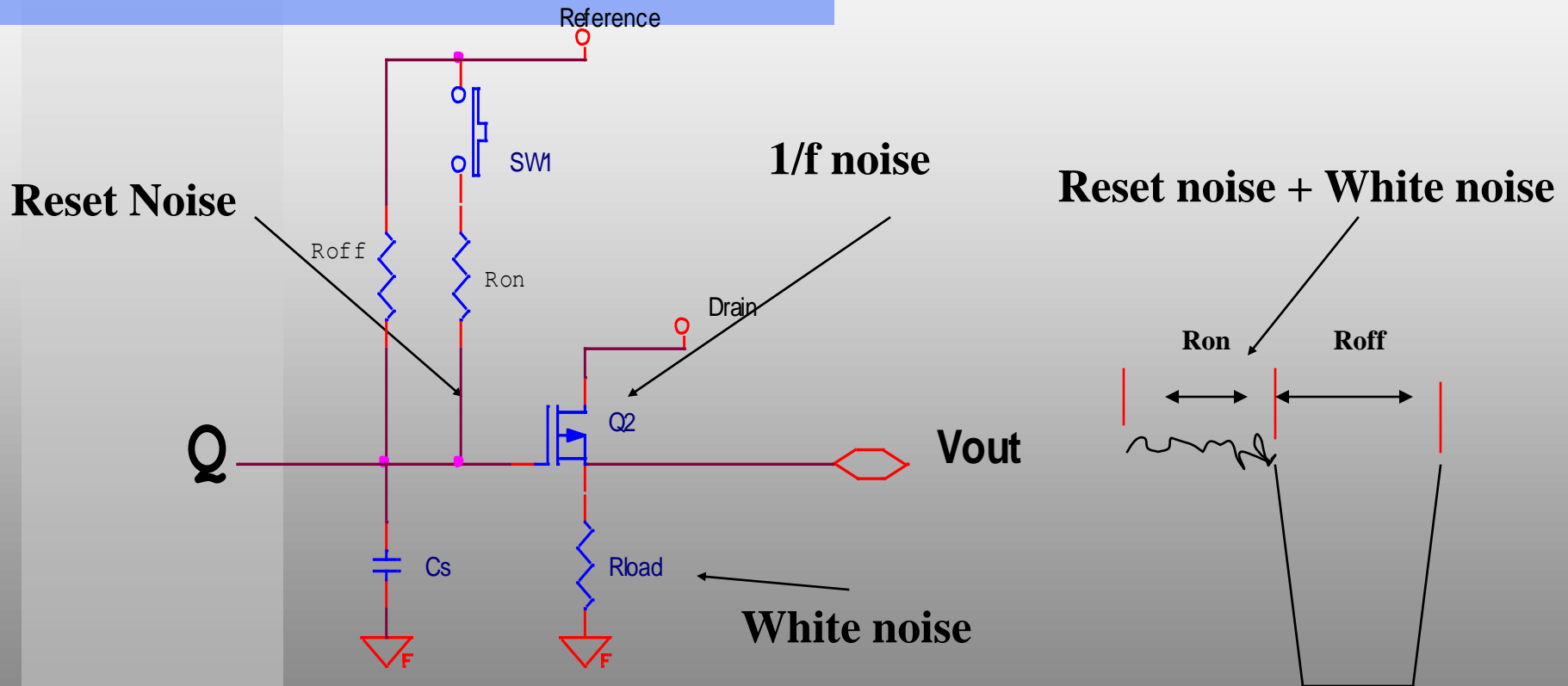
Finger Roll Optics



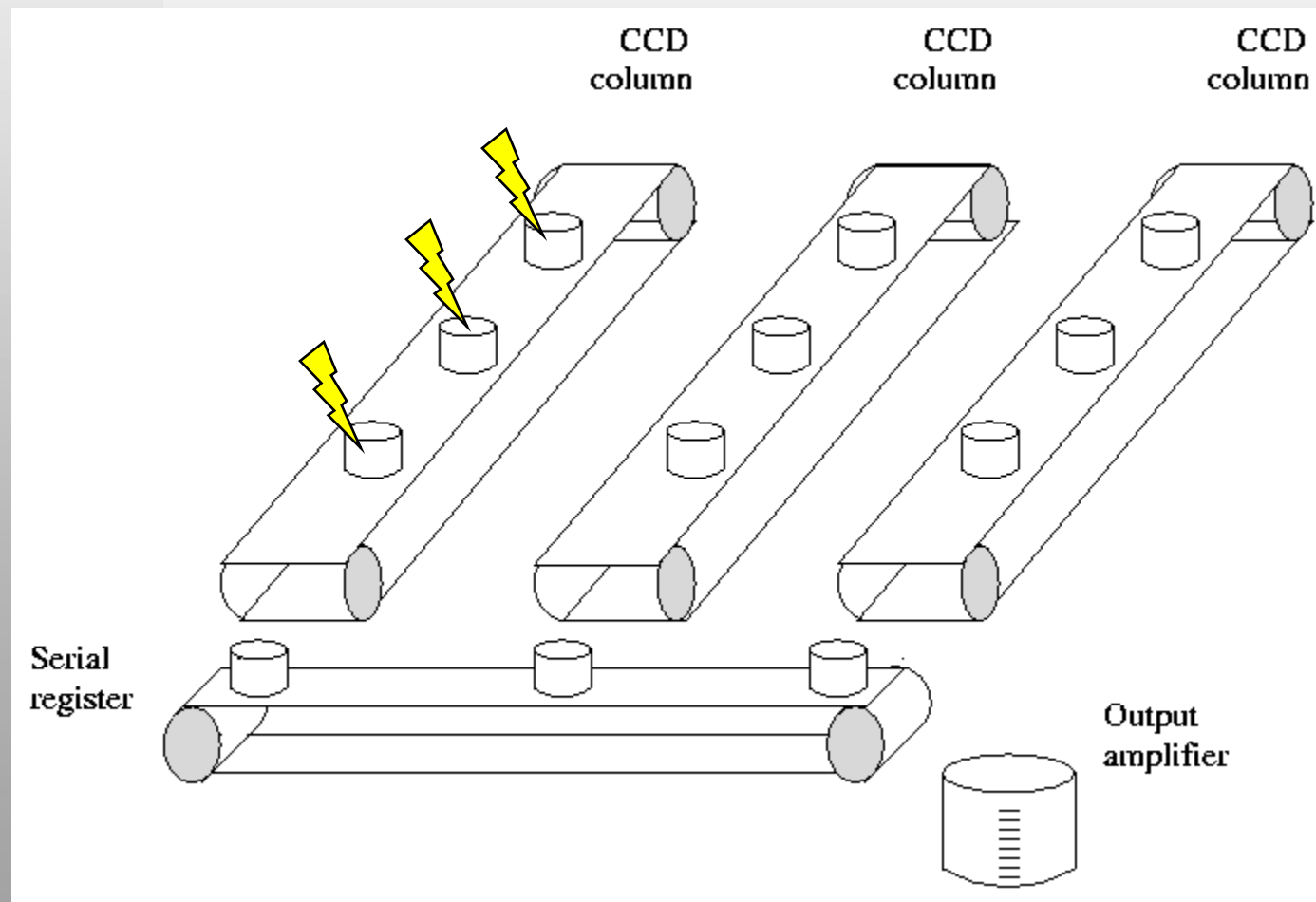
Interline CCD Technology Simplified



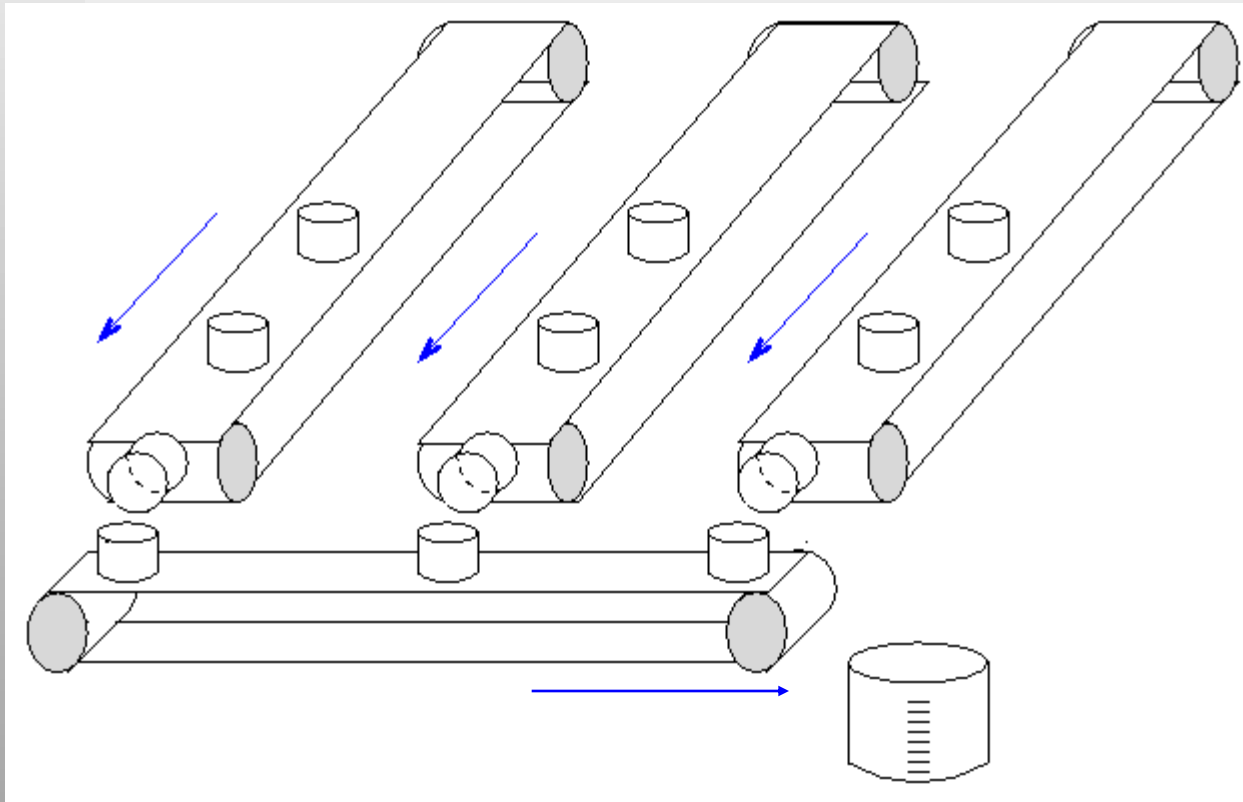
On chip output stage.



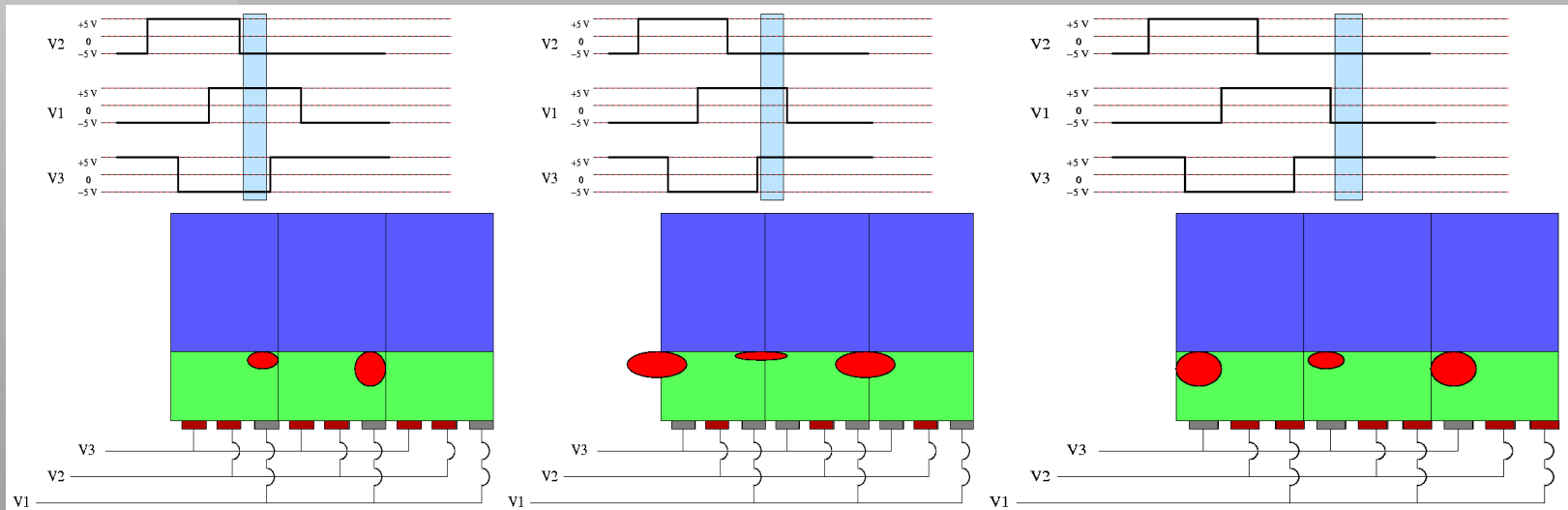
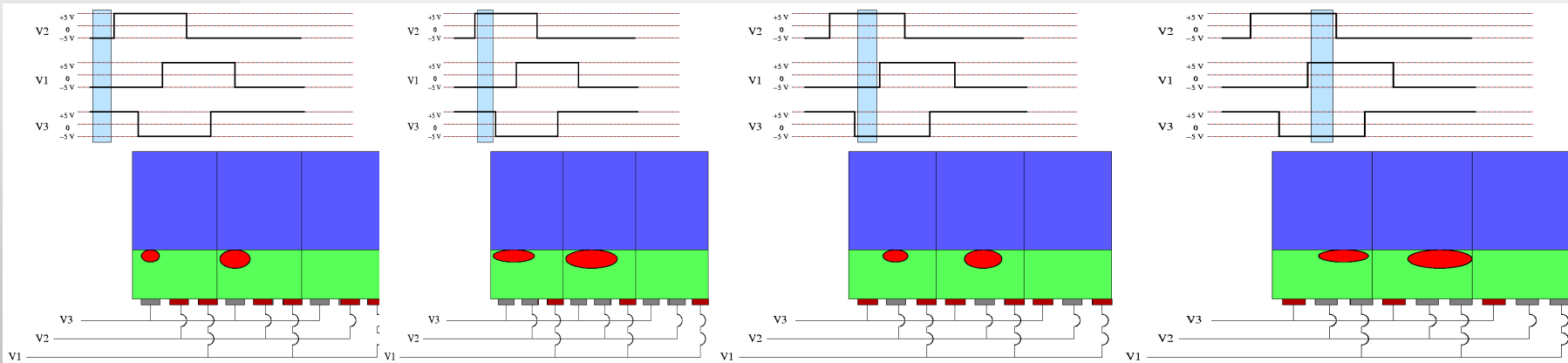
Charge Integration Analogy



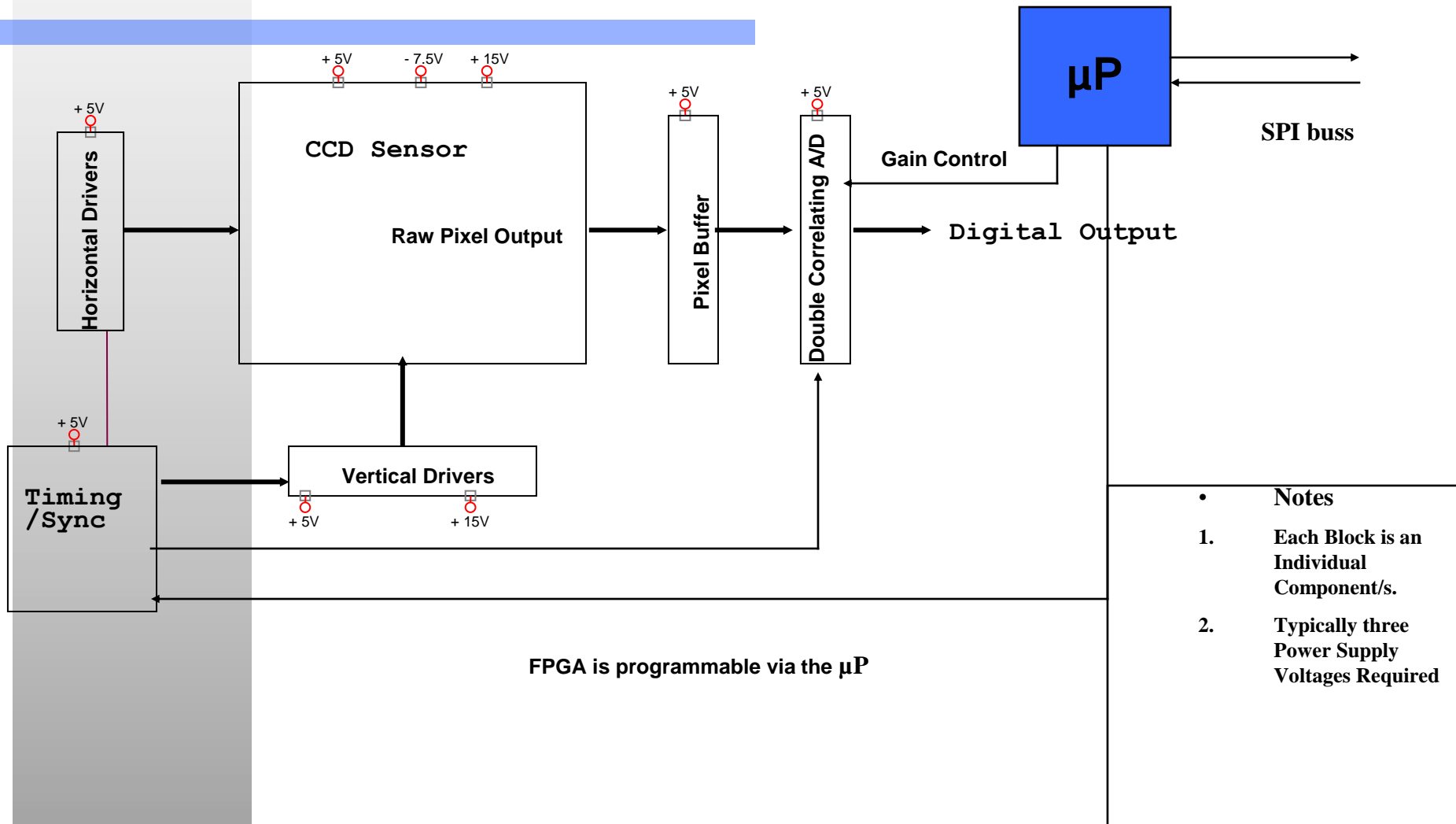
Charge Transfer Analogy



Three Phase Vertical Transfer Timing Model



Typical CCD Camera Front-end



Design considerations.

- **Power supplies must be low noise.**
- **Clocks are derived from frame rate (10 fps) (13 mega pixels/sec).**
- **Horizontal drive (pixel clock = 13mhz). Need to drive 40 pfd.**
- **Vertical clock needs to transfer 1434 shifts/frame 14.34 khz clock rate. Need to drive 22000 pfd.**
- **Components are selected for appropriate bandwidth.**

Accounting for noise sources in a CCD

$$\frac{S}{N} = \frac{S_{led}}{\sqrt{S_{led} + (N_{amb} + N_{dark} + N_{readout}^2)}}$$

dark noise: 30 electrons / pixel

readout noise: 12 electrons / pixel

bias noise / offset level: 1300 electrons / pixel

CCD max out put voltage of .3 volts = 1,187,500e-

Reset noise = 126e-

Reset noise voltage = .203 mVrms

White noise = 5.75 uVrms

$$v_n = \sqrt{k_B T / C}$$

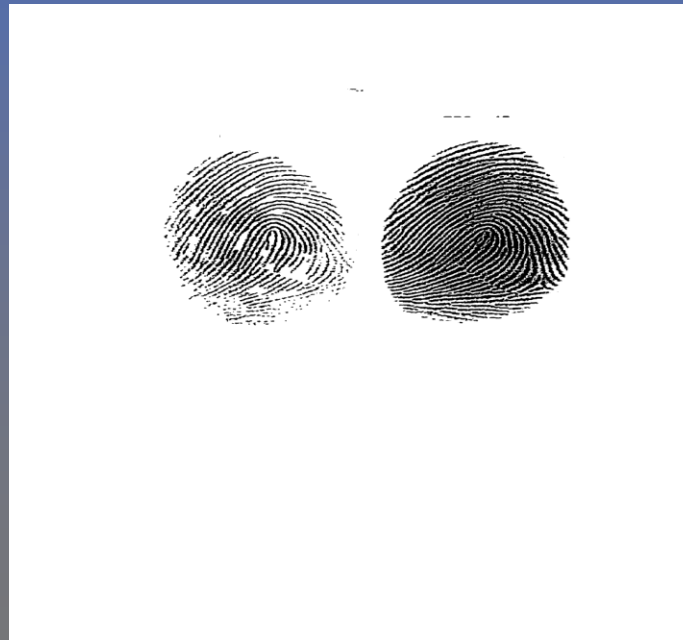
$$V_n = \sqrt{4k_B T \Delta f R}$$

Important: Using gain of 3, a 10 bit A/D, and a 1 volt reference. 1volt/1024 = 1mV per bit.

Note: Temperature was worst case at 25C

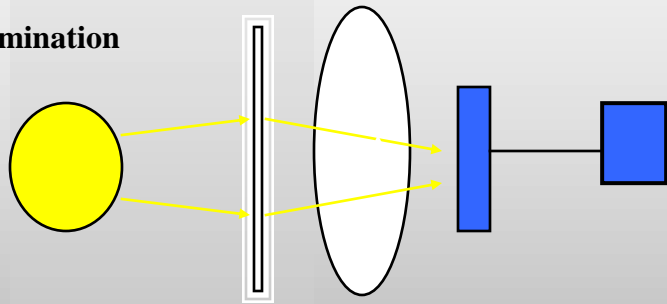
FBI Appendix F Specs For Image Quality Summarized

- 500 Dots Per inch
- Must resolve 20 line pairs per mm. at 10 % MTF. (50 microns)
- At least 80.0% of the captured individual fingerprint images shall have a gray-scale dynamic range of at least 200 gray-levels, and at least 99.0% shall have a dynamic range of at least 128 gray-levels.
- SNR = The white signal-to-noise ratio and black signal-to-noise ratio shall each be greater than or equal to 125.0, in 97% of the test cases. (Use to set up a low reflectance target and a high reflectance target. They split the scale.)



MTF Test Procedure

illumination



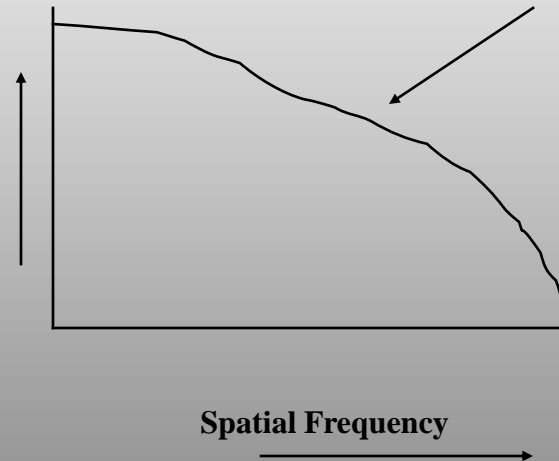
Target

Linear System

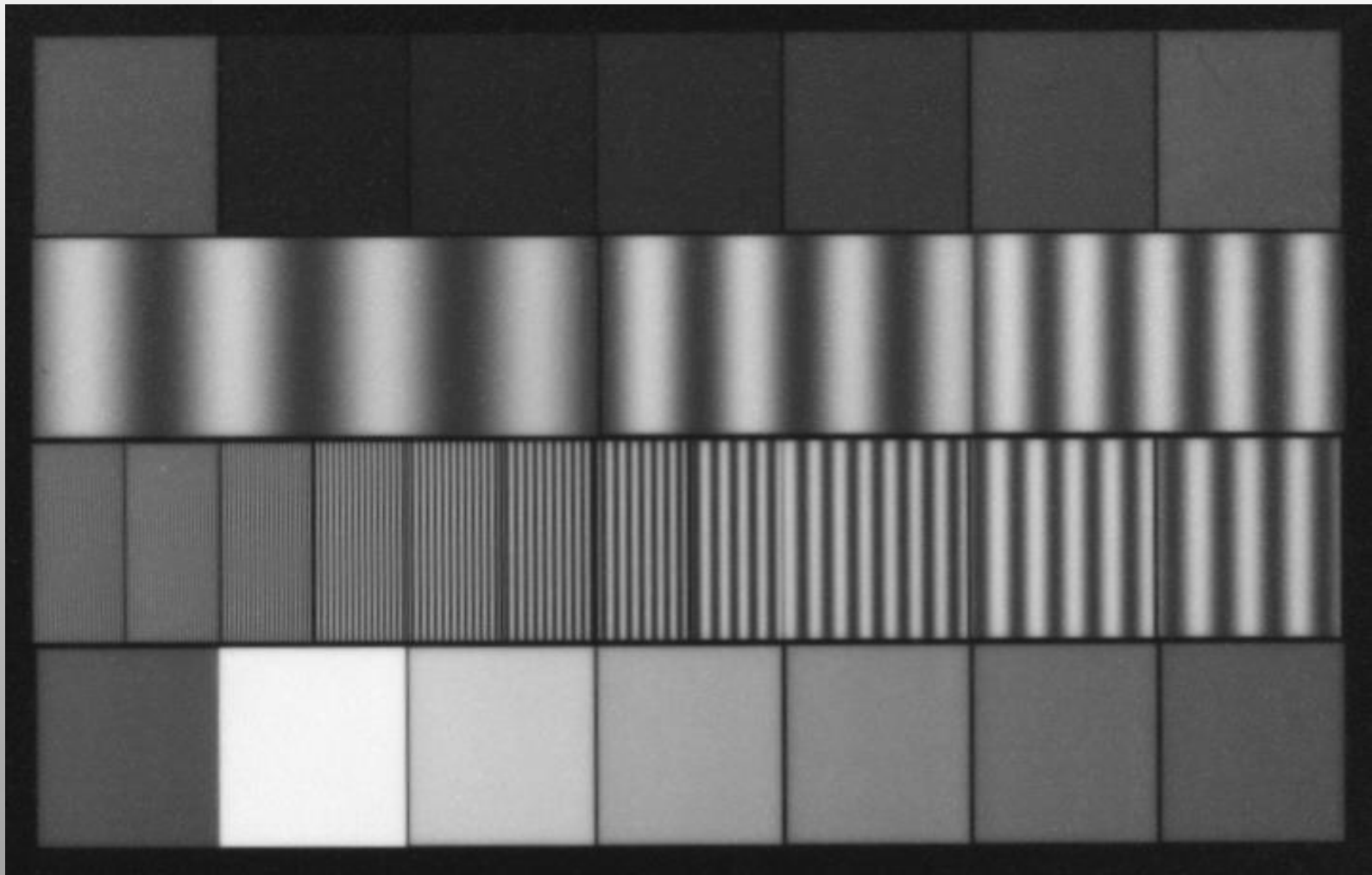
Response

Spatial Frequency

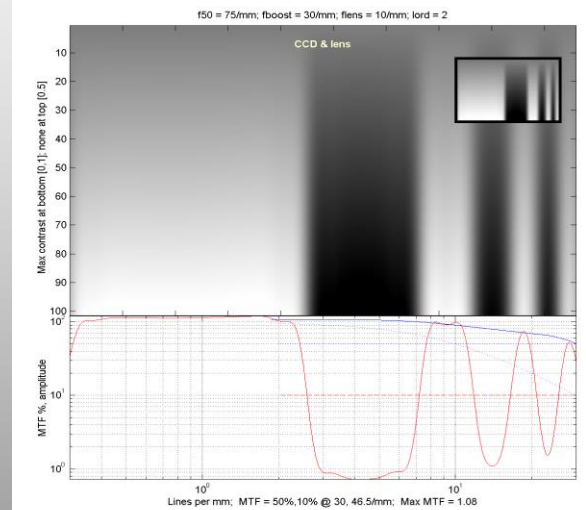
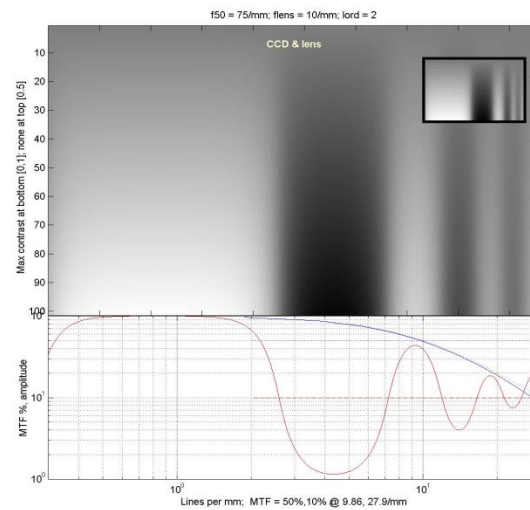
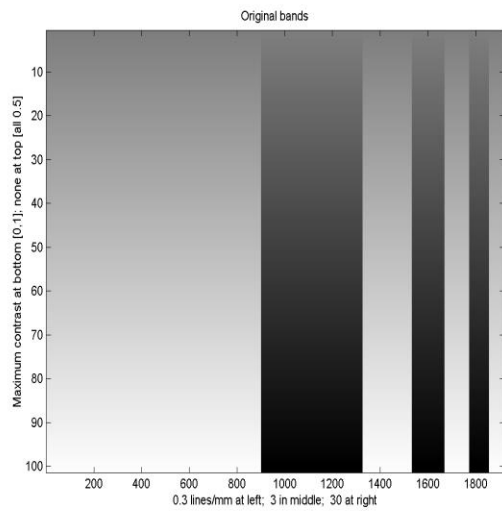
MTF CURVE



MTF Test Pattern

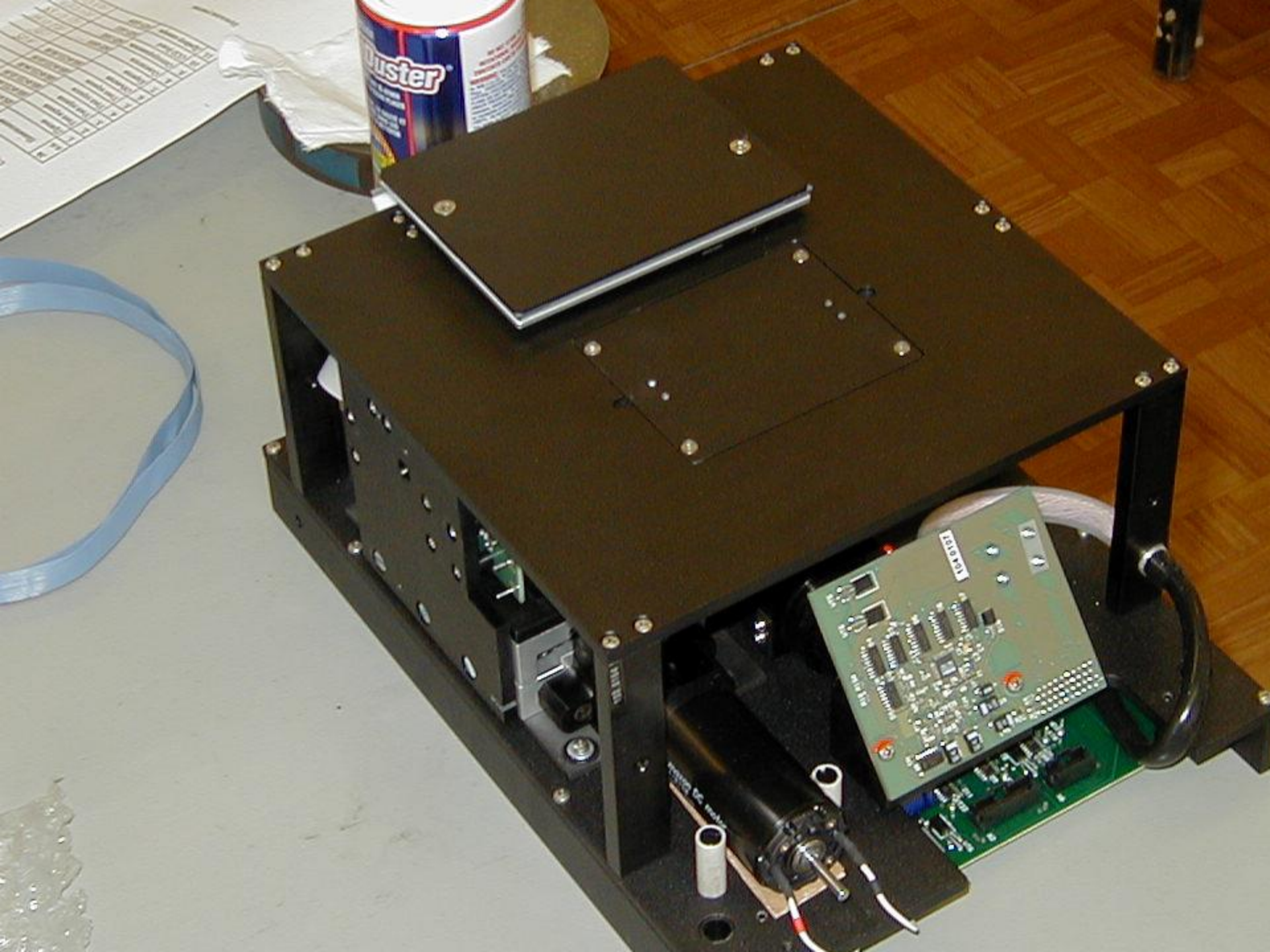


MTF Test Data



Design Control

- **Design Control did not formally exist at Identix.**
- **Past: R&D co-existed with manufacturing. Company was traditionally, “engineering” driven.**
- **Present: R&D was now geographically separated from Manufacturing.**
- **Took the approach that manufacturing group was my customer.**
- **Opened a dialogue with manufacturing organization.**
- **Resolved what they needed to succeed.**
- **Worked with Intek (Russia) to develop the analysis/process control tools and optical system test techniques.**



Team play + process = quality
(and happy customers)



Results and Project Conclusions.

- **Camera/imaging system received FBI, UL, and FCC certification.**
- **Camera was integrated into TP 2000 later renamed to TP 3800.**
- **Scanner yields greatly improved.**
- **First systems shipped in January 2002.**
- **Identix shipped 20 systems per month in 2001-2002.**
- **Identix merged with Visionics in 2/2002.**