Lecture 13

6.111 Flat Panel Display Devices

Outline

- Overview Flat Panel Display Devices
  - How do Displays Work?
  - Emissive Displays
  - Light Valve Displays
- Display Drivers
  - Addressing Schemes
  - Display Timing Generator
  - Gray Scale / Color Schemes

Tayo Akinwande

Some modifications of these slides by D. E. Troxel

For more info take graduate course, 6.987 on flat panel displays

Applications of Flat-Panel Displays

SMALL FORMAT

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Medical Defibrillator

MP3 Player

Personal Digital Assistant

Car Navigation & Entertainment

LARGE FORMAT

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Desktop Monitor (color)

Large Screen Television (color)

Some Display Terminologies

Term	Definition
Pixel	Picture element—The smallest unit that can be addressed to give color and intensity
Pixel Matrix	Number of Rows by the Number of Columns of pixels that make up the deisplay
Aspect Ratio	Ratio of display width to display height; for example 4:3, 16:9
Resolution (ppi)	Number of pixels per unit length (ppi=pixels per inch)
Frame Rate (Hz)	Number of Frames displayed per second
Viewing Angle (°)	Angular range over which images from the display could be viewed without distortion
Diagonal Size	Length of display diagonal
Contrast Ratio	Ratio of the highest luminance (brightest) to the lowest luminance (darkest)

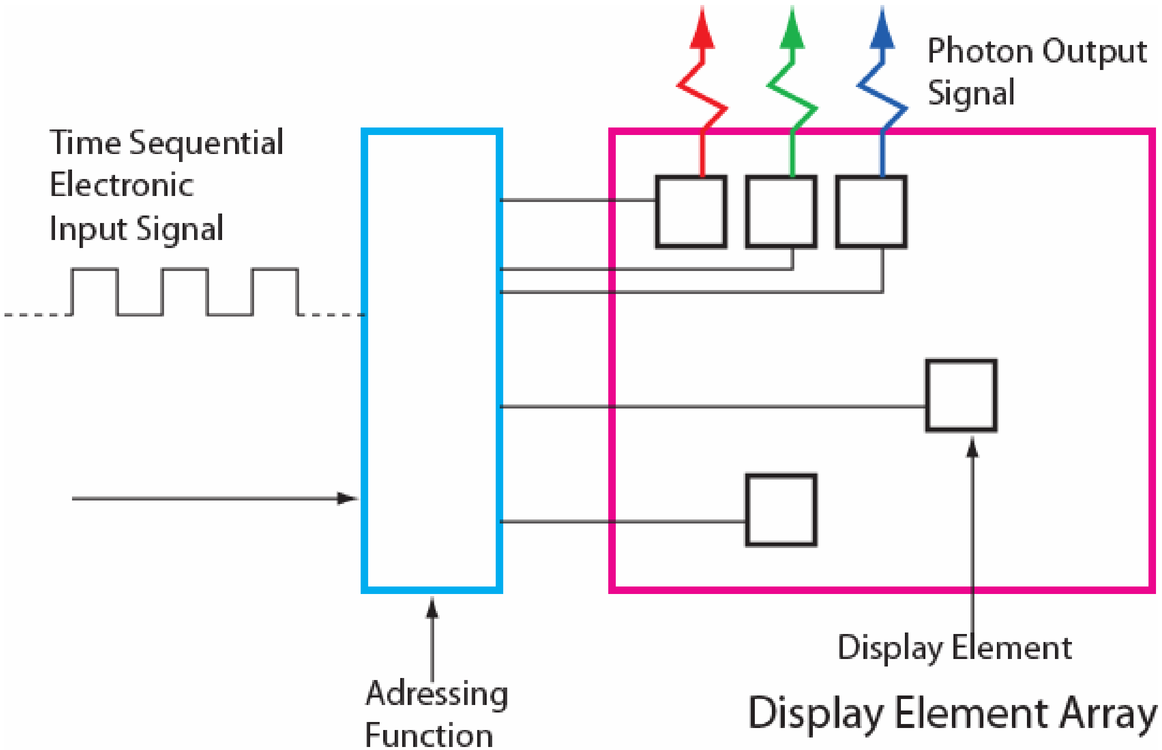
Information Capacity of Displays

(Pixel Count)

Resolution	**Pixel**	**Ratio**
Video Graphic Array (**VGA**)	640 x 480 x RGB	4:3
Super Vedio Graphic Array (**SVGA**)	800 x 600 x RGB	4:3
eXtended Graphic Array (**XGA**)	1,024 x 768 x RGB	4:3
Super eXtended Graphic Array (**SXGA**)	1,280 x 1,024 RGB	5:4
Super eXtended Graphic Array plus (**SXGA+**)	1,400 x 1,080 x RGB	4:3
Ultra eXtended Graphic Array (**UXGA**)	1,600 x 1,200 x RGB	4:3
Quad eXtended Graphics Array (**QXGA**)	2048 x 1536 x RGB	4:3
Quad Super eXtended Graphics Array (**QSXGA**)	2560 x 2048 x RGB	4:3

Display Devices, No. 21, Spring 2000, p. 41

How Do Displays Work?



Pankove

- Electronic display converts "**Time Sequential Electrical Signals**" into spatially and temporally configured light signal (**images**).
  - Electrical signals are appropriately routed to the various display elements (**similar to memory addressing**)
  - Display element (pixel) converts the routed electrical signal at its input into light of certain wavelength and intensity (**inverse of image capture**)

Human Eye— Spectral Response

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Emissive Displays

- Displays that **generate photons** when an electrical signal is applied between the terminals
- Energy causes excitation followed by excitation relaxation
  - Hole + Electron recombination
  - Exciton formation and annihilation
  - Relaxation of excited radicals in a plasma
- The different types of **Luminescence** differ mostly in the way the holes and electrons are generated
  - holes and electrons are generated by UV in a phosphor which then recombine and generate **red**, **green** or **blue** light —**Photoluminescence or Phosphorescence**
  - holes and electrons injected by pn junction or generated by impact ionization or excitation which then recombine and generate **red**, **green** or **blue** light — **Electroluminescence**
  - holes and electrons generated by electron beam which then recombine and generate **red**, **green** or **blue** light — **Cathodoluminescence**
- Examples of Emissive Flat Panel Displays
  - Electroluminescence (**L**ight **E**mitting **D**iode, **O**rganic-**L**ight **E**mitting **D**evices & In-organic **EL**ectroluminescent Displays)
  - Cathodoluminescence (**C**athode **R**ay **T**ube, **V**acuum **F**lorescent **D**isplay, **F**ield **E**mission **D**isplay)
  - Photoluminescence (**PL**asma **D**isplays)

Light Valve Displays

- Displays that "**spatially and temporally**" modulate ambient lighting or broad source of light and redirect to the eye.
- Display element spatially changes the intensity of plane wave of light using
  - Refraction
  - Reflection
  - Polarization change
- These displays are part of a broader class of devices called **Spatial Light Modulators** which in general operate though local
  - Amplitude change
  - Polarization change
  - Phase change
  - Intensity change
- Examples of Light Valve Displays
  - **L**iquid **C**rystal **D**isplays (active & passive matrix)
  - **D**eformable **M**irror **D**isplays
  - **M**embrane **M**irror **D**isplays
  - **E**lectrophoretic **D**isplays (E-Ink)

Cathode Ray Tube

CRT Display

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Courtesy of PixTech

Electrons beam "boiled off a metal" by heat (**thermionic emission**) is sequentially scanned across a phosphor screen by magnetic deflection. The electrons are accelerated to the screen acquiring energy and generate light on reaching the screen (**cathodoluminescence**)

Plasma Displays

Image from Weber, SID 00 Digest, p. 402. Image removed due to copyright restrictions.

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- Electrons are accelerated by voltage and collide with gasses resulting in ionization and energy transfer
- Excited ions or radicals relax to give UV photons
- UV photons cause hole-electron generation in phosphor and visible light emission*c*

Organic Light Emitting Diode

Figure 1. Figure removed due to copyright restrictions.

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Figure 1 from Rajeswaran et al., SID 00 Digest, p. 974

17-inch Active Matrix OLED

H.-K. Chung et al., SID 05 Digest, p. 956

Digital Mirror Device

Courtesy of Texas Instruments

Image removed due to copyright restrictions.

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Applied voltage deflects
Mirror and hence direct light

Liquid Crystal Displays

Liquid Crystals rotate the plane of polarization of light when a voltage is applied across the cell

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Courtesy of Silicon Graphics

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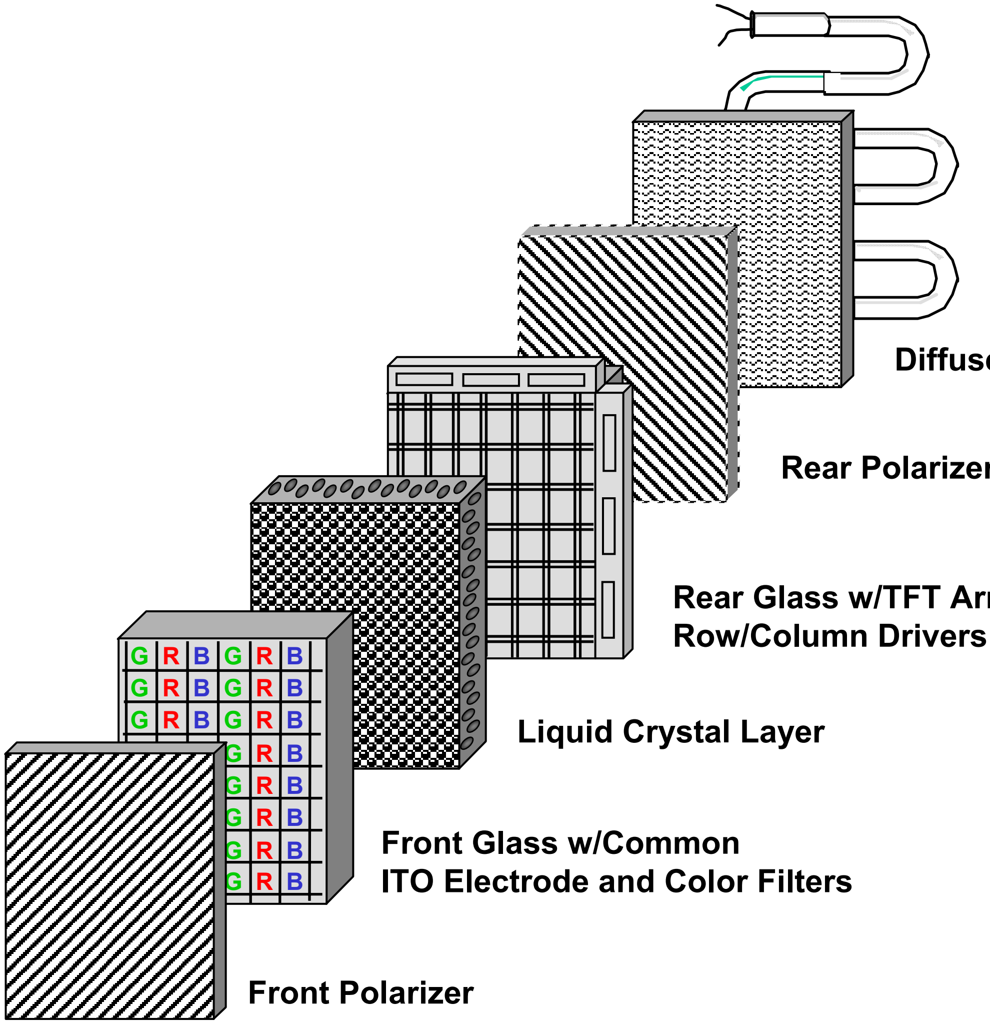
TFT AMLCD



82” TFT AMLCD

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K. Sarma

SID 05

Figure 1

Standard Display Addressing Modes

- Sequential Addressing (pixel at a time)
  - CRT, Laser Projection Display
- Matrix Addressing (line at a time)
  - Row scanning, PM LCD, AMLCD, FED, PDPs, OLEDs
- Direct Addressing
  - 7-segment LCD
- Random Addressing
  - Stroke-mode CRT

Sequential Addressing (Raster Scan)

- Time is multiplexed
  - Signal exists in a time cell
- A pixel is displayed at a time
  - Single data line
- Rigid time sequence and relative spatial location of signal
  - Raster scan
- Data rate scales with number of pixels
- Duty cycle scales with number of pixels
- Horizontal sync coordinates lines
- Vertical sync coordinates frames
- Blanking signals (vertical & horizontal) so that retraces are invisible

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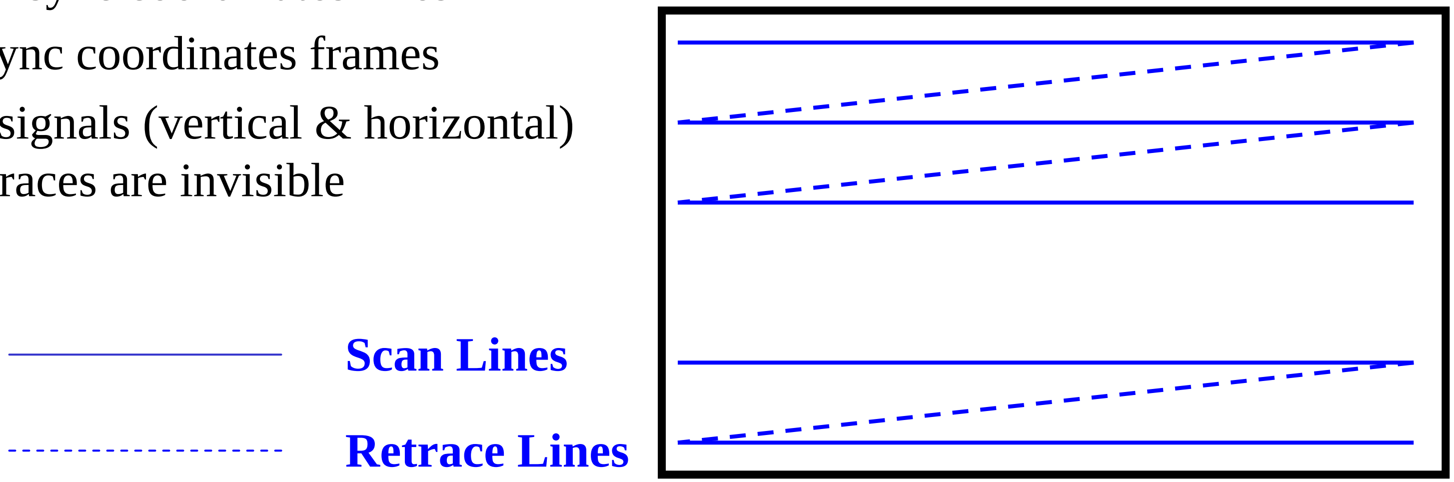
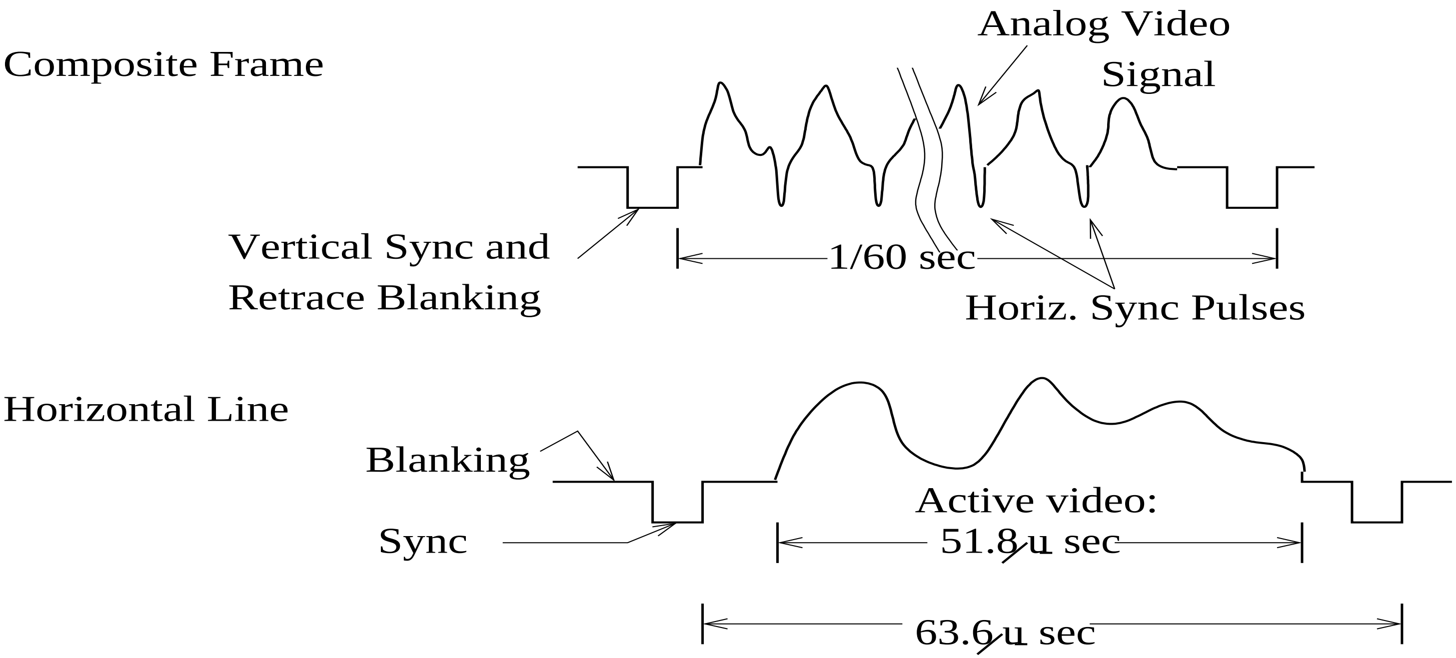


Tannas, SID 00 Applications Seminar

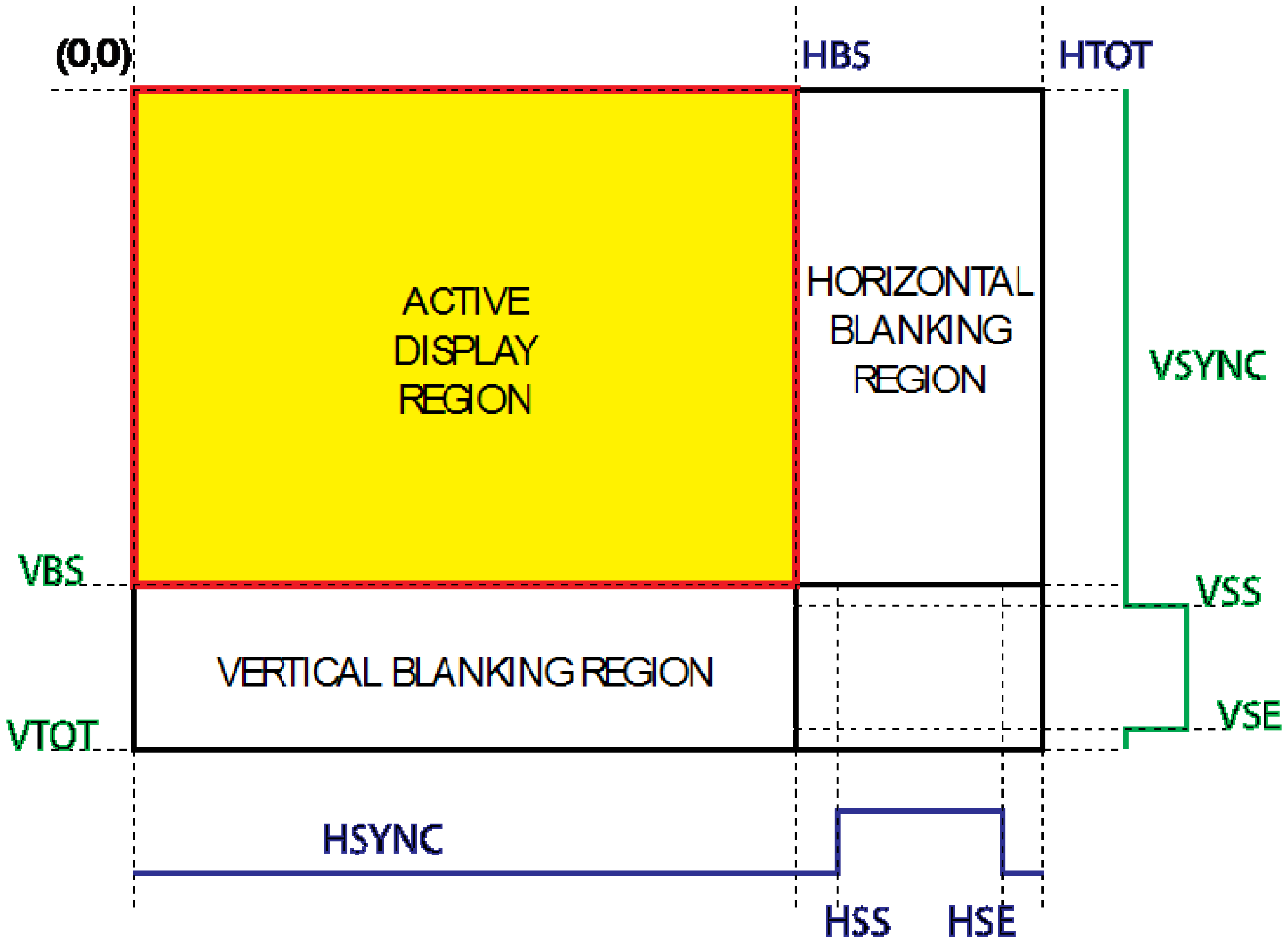
Composite Frames

- The ‘frame’ is a single picture (snapshot).
  - It is made up of many lines.
  - Each frame has a synchronizing pulse (vertical sync).
  - Each line has a synchronizing pulse (horizontal sync).
  - Brightness is represented by a positive voltage.
  - Horizontal and Vertical intervals both have blanking so that retraces are not seen (invisible).



Slide by Professor Don Troxel

Display Timing Generator Parameters



HTOT = Horizontal Total
HBS = Horizontal Blanking Start
HSS = Horizontal Sync Start
HSE = Horizontal Sync End

VTOT = Vertical Total
VBS = Vertical Blanking Start
VSS = Vertical Sync Start
VSE = Vertical Sync End

Direct vs. Matrix Addressing

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Kim, SID 2001

Matrix Addressing

- Time multiplexed
- Row at a time scanning
  - A column displayed during the time assigned to a row
- For a N rows by M columns display
  - M + N electrodes are required
- Row scanning rate scales with number of rows
- Data rate scales with number of pixels
- Duty cycle scales with number of rows

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Tannas, SID 00 Applications Seminar

Active Matrix Addressing

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•Introduce non linear device that improves the selection.

•Storage of data values on capacitor so that pixel duty cycle is 100%

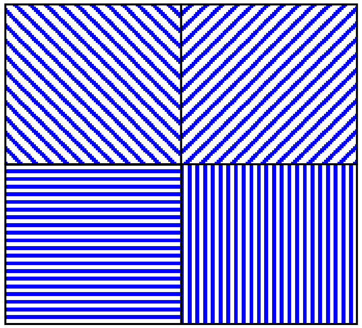
•Improve brightness of display by a factor of N (# of rows) over passive matrix drive

•Display element could be LC, EL, OLED, FED etc

Yeh & Gu

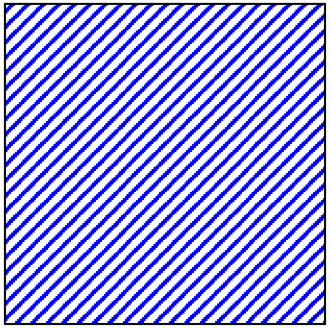
Grey Shades Generation Techniques

Spatial Modulation



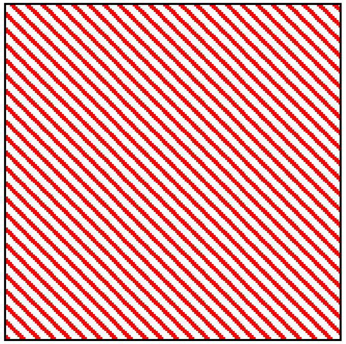
Individually
selectable
Areas per pixel area
per dwell time

Frame Modulation



Reduced intensity
by skipping frames
per pixel area

Amplitude Modulation

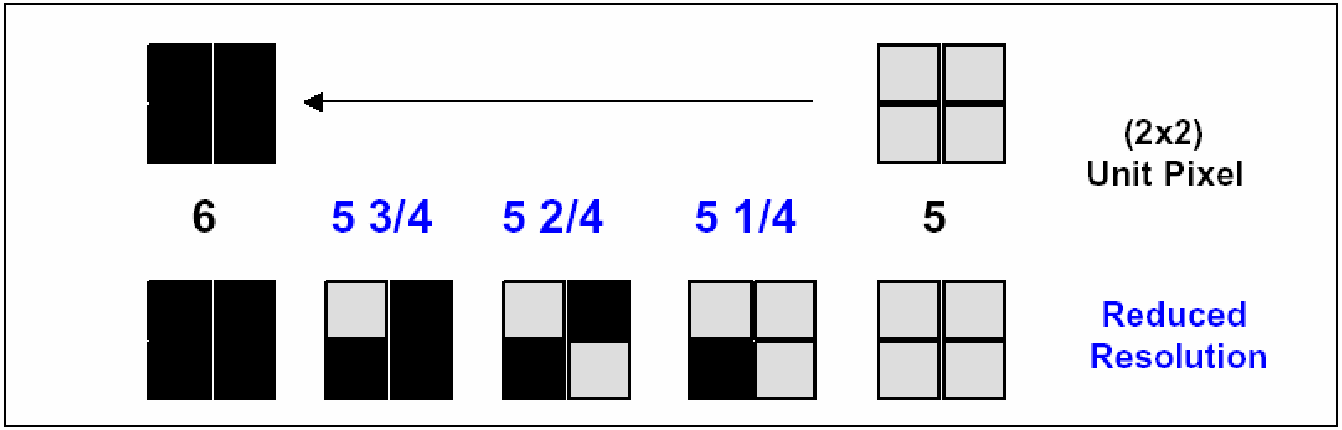


Analog intensity at
full dwell time per
pixel

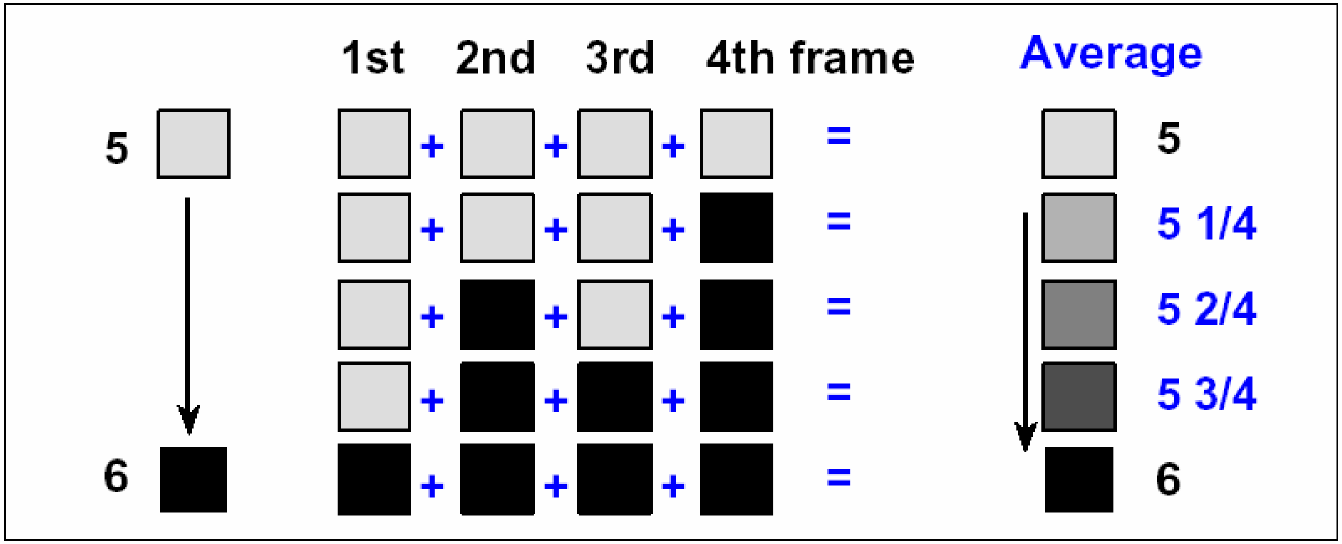
Grey Scale Generation

(Spatial Modulation / Frame Rate Control)

Dithering



Frame Rate Control (FRC)



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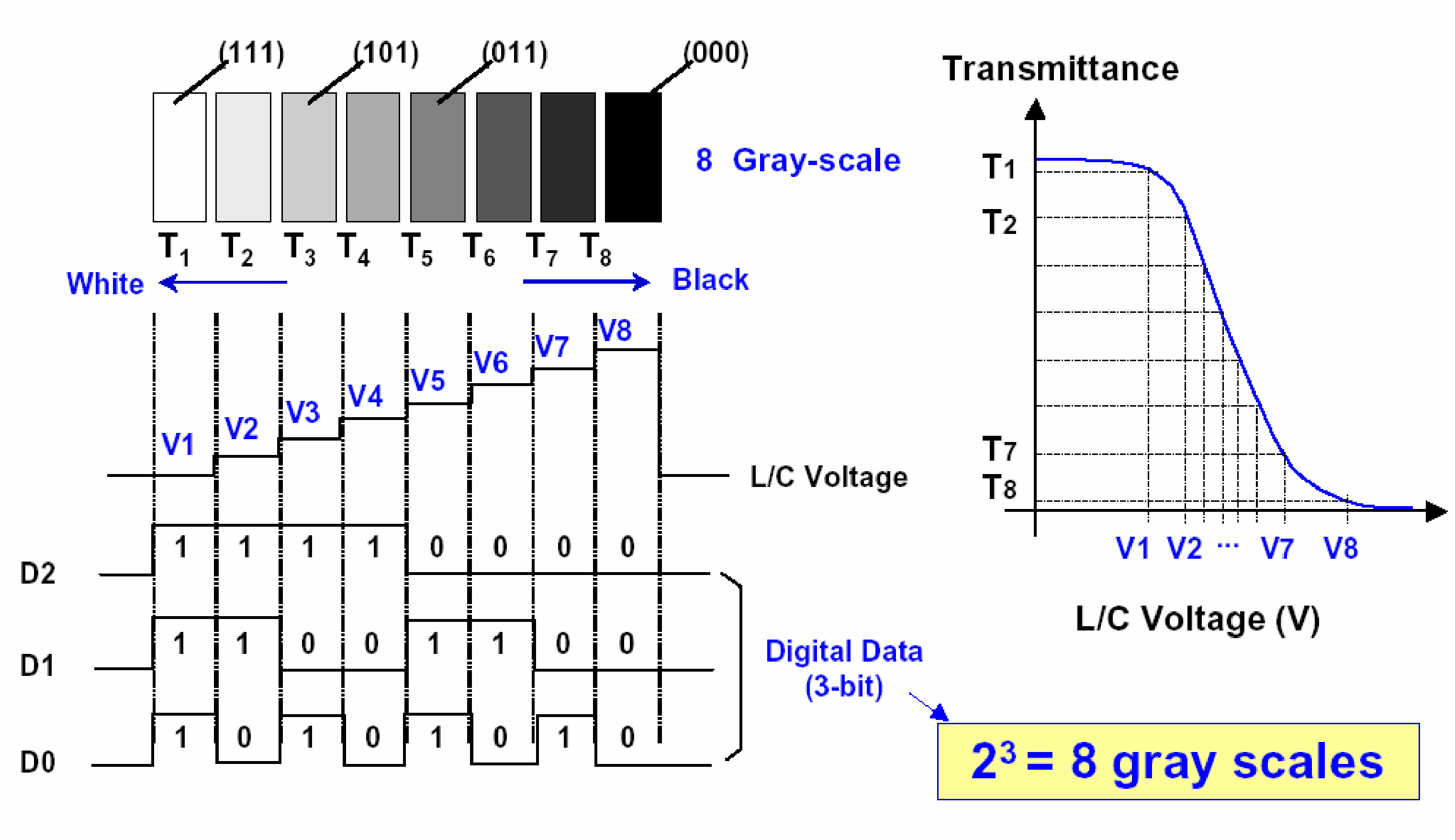
Grey Scale Generation
(Amplitude Modulation)



$2^3 = 8$ gray scales

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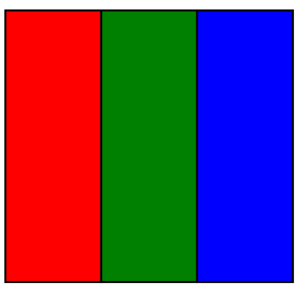
Color Generation Techniques

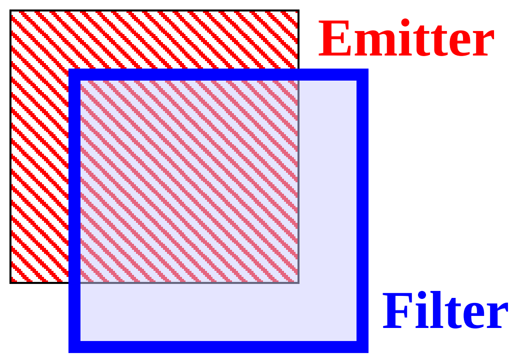
Spatial Color



Three selectable color areas per pixel area per dwell time at three times intensity

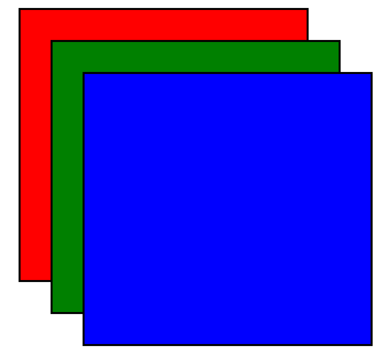
Sequential Color

One broadband emitter per pixel area addressed three times per dwell time at three times the intensity.



Electronic filter changed three times per dwell time.

Coincident Color



Three selectable transparent color areas per pixel area per dwell time at one times intensity

- Dwell time is allotted for each pixel operation
- Pixel area is total area allotted for spatial infomation

Driver Circuits

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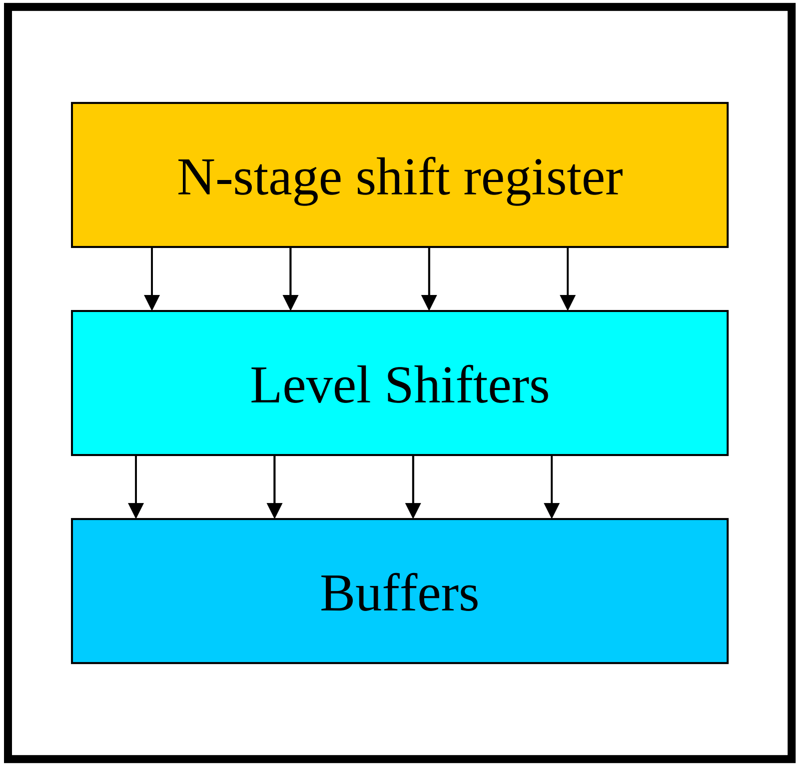
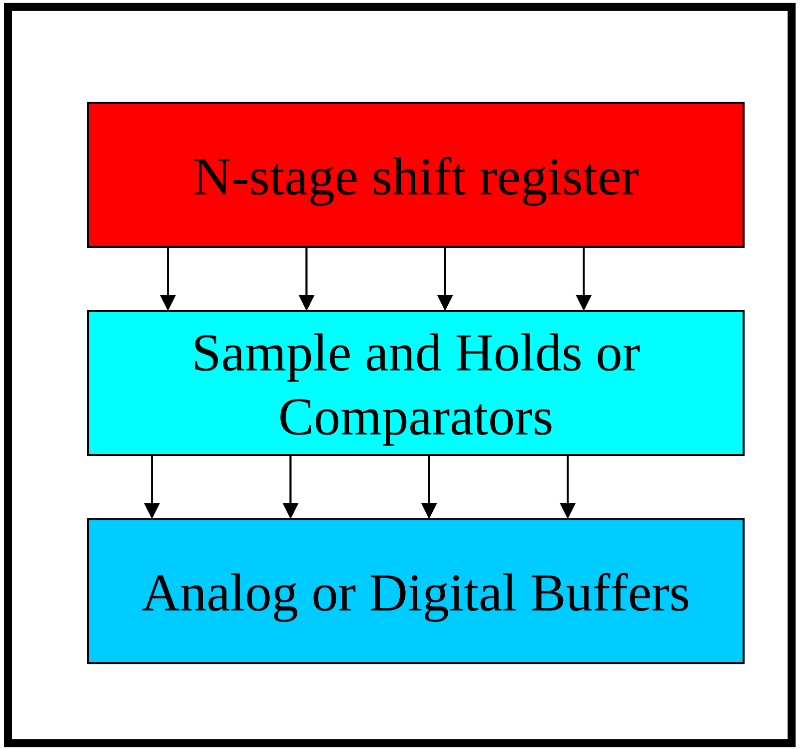
Row Driver Circuits

- Shift Registers
  - N stage shift registers
  - Static vs Dynamic
- Level shifters
  - Match outside signal to signal on display
- Output buffers
  - Typically bi-level



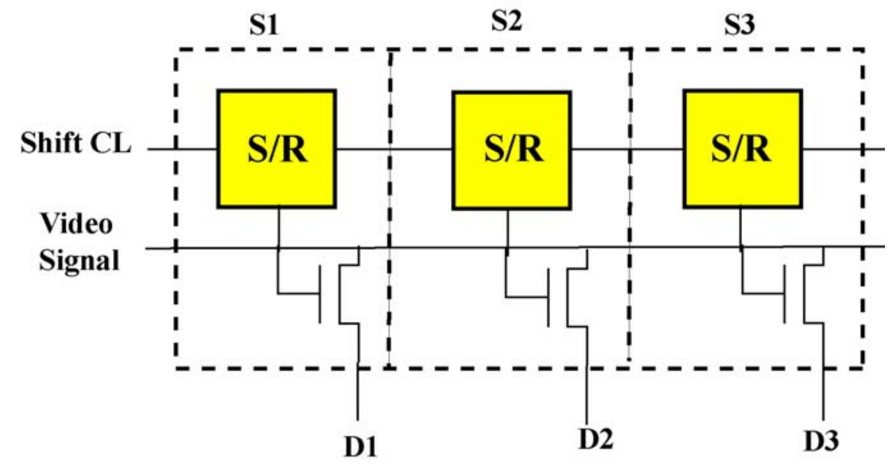
Column Driver Circuits

- Shift Registers
  - N stage shift registers
  - Static vs Dynamic
- Level shifters
  - Match outside signal to signal on display
- Output buffers
  - Typically bi-level



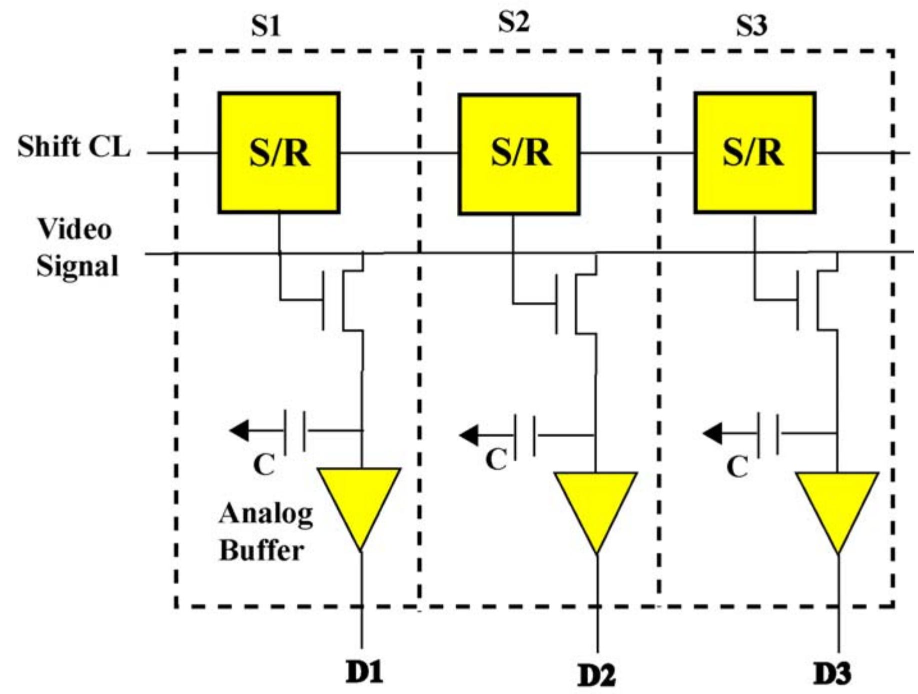
Analog Data Driver

Point at a time



Shift Registers

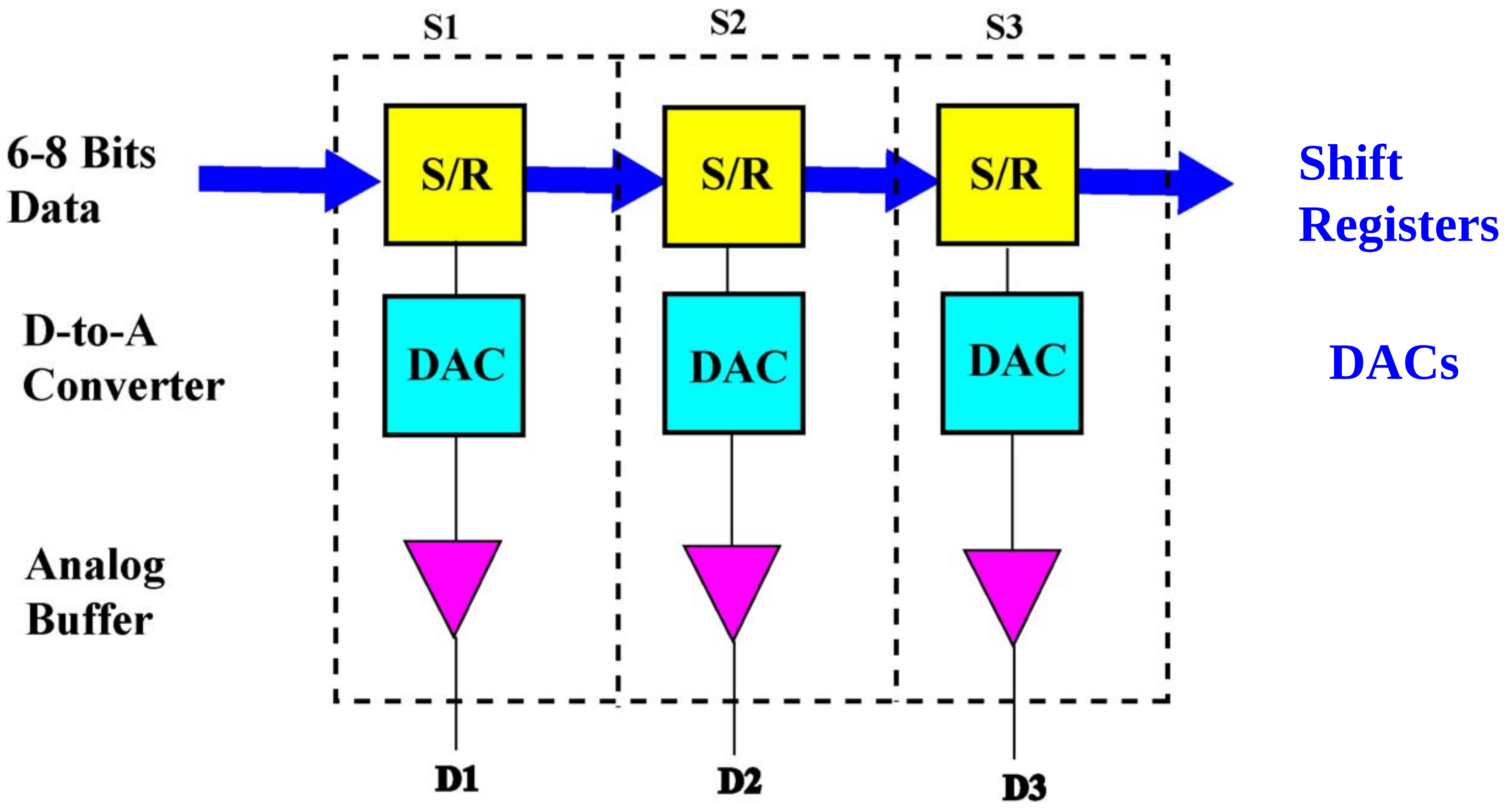
Line at a time



Shift Registers

Morozumi, SID 00 Seminar Notes

Digital Data Drivers



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