Introduction to graphics and LCD technologies

NXP Product Line Microcontrollers
Business Line Standard ICs

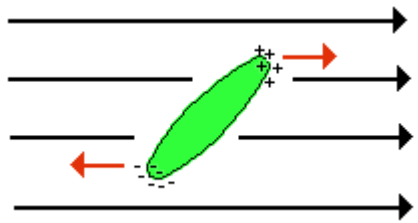
Agenda

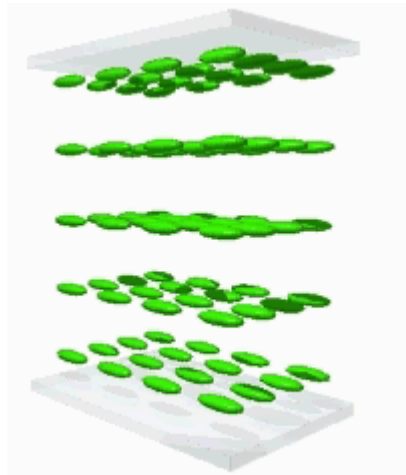
- Passive and active LCD technologies
  - How LCDs work, STN and TFT differences
  - How data is converted to colors on the LCD
- LCD signal interface and timing parameters
  - LCD signals and timing
  - Controlling the backlight
- Introduction to frame buffers with the LPC32x0 MCU
  - How graphics data is stored in memory
  - Color depth and lookup tables
- System considerations for LCD based systems
  - Mapping LCD data signals to the LCD controller signals
  - LCD data bandwidth
- Examples

Passive and active LCD technologies

How an LCD works

- An array of Liquid Crystal segments
  - When not in an electrical field, crystals are organized in a random pattern
  - When an electric field is applied, the crystals align to the field
  - The crystals themselves do not emit light, but ‘gate’ the amount of light that can pass through them
    - Crystals aligned perpendicular to a light source will prevent light from passing through them
- Each LCD segment is aligned with an electric field
- A light source (backlight) is needed to drive light through the aligned crystal field

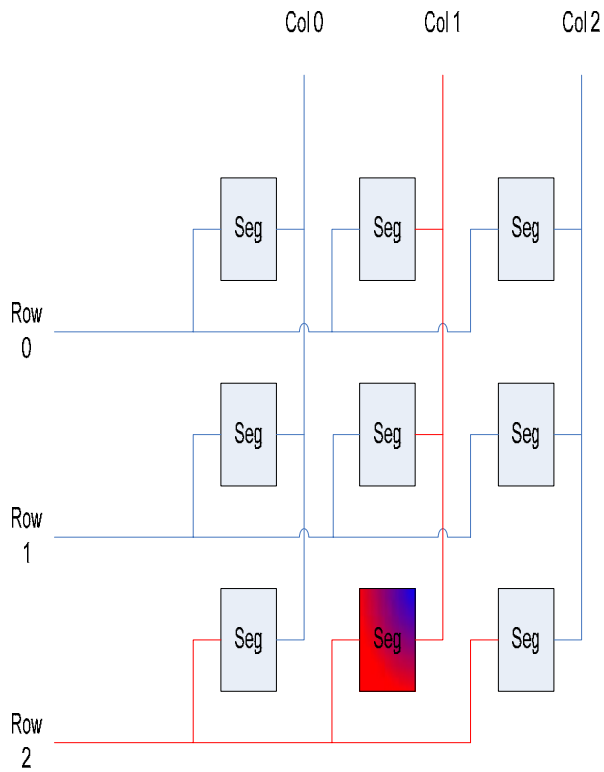




Courtesy of Sharp

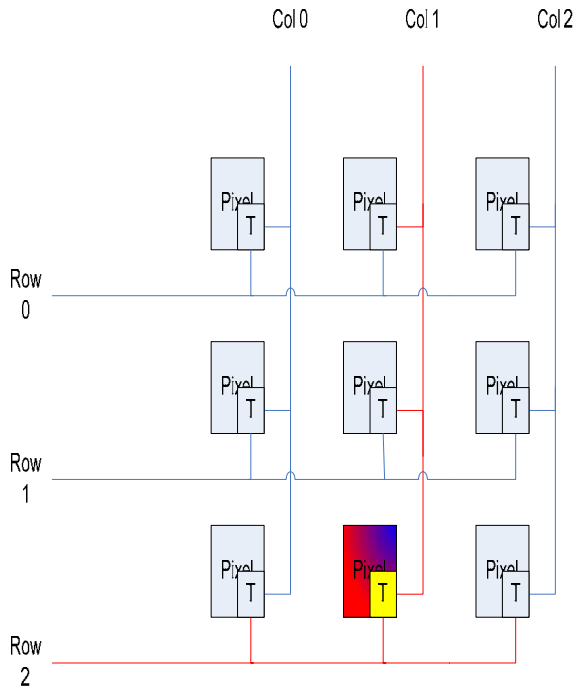
Passive displays

- Passive LCD panels
  - Consists of a grid of row and columns electrical signals
  - Columns and rows connect perpendicularly to every segment in the LCD
    - Columns and rows are multiplexed to many different segments
  - An IC controls which column and row are selected to enable or disable the segment at the row/column intersection
  - A small bias is applied to the row and column to generate a field at the intersection
    - No charge is stored at the segment
    - It may take multiple passes to correctly align the field to the desired value
- STN LCDs are passive displays



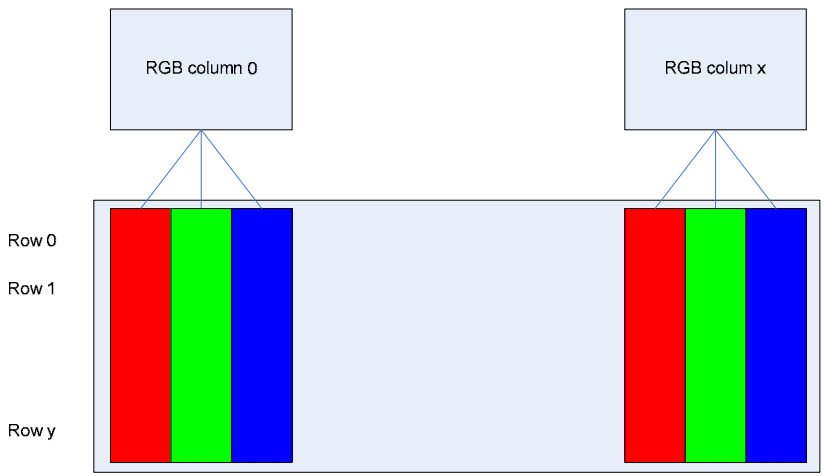
Active displays

- Active LCD panels
  - Consists of a grid of row and columns electrical signals
  - Columns and rows connect perpendicularly to a active device (transistor) for every segment in the LCD
    - Columns and rows are multiplexed to many different segments
  - An IC controls which column and row are selected to enable or disable the segment at the row/column intersection
  - The selected row and column enable the transistor
    - Charge is stored at the transistor
    - One pass will set the aligned state of the transistor (although it may still take a little time for all the crystals to align)
  - A stronger backlight is needed than a passive display
- TFT displays are active displays



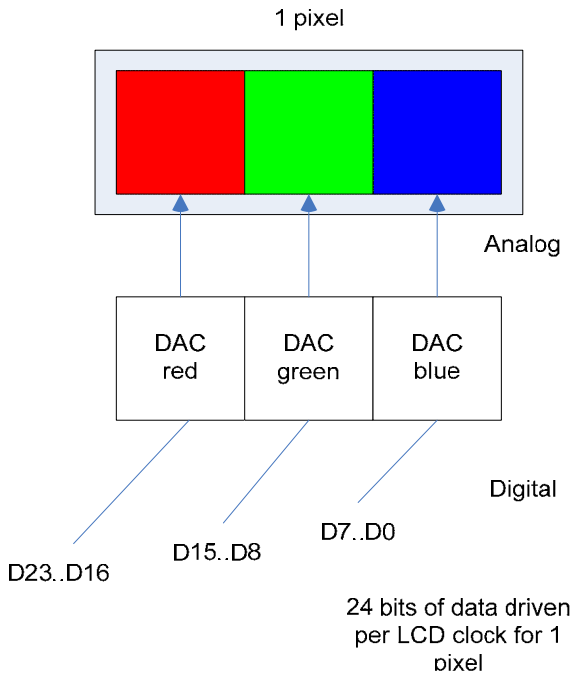
LCD panel Technologies – making colors

- Each LCD segment only gates reflected or generated light
  - Color filters allow generation of specific colors (RGB) at a segment
  - To generate a real world color, 3 segments are needed – these 3 segments individually pass light through a red, green, and blue filter to make a group of segments, or a RGB pixel
  - For a 320x240 RGB LCD display, there are actually 320*3=960 segments (columns) and 240 rows



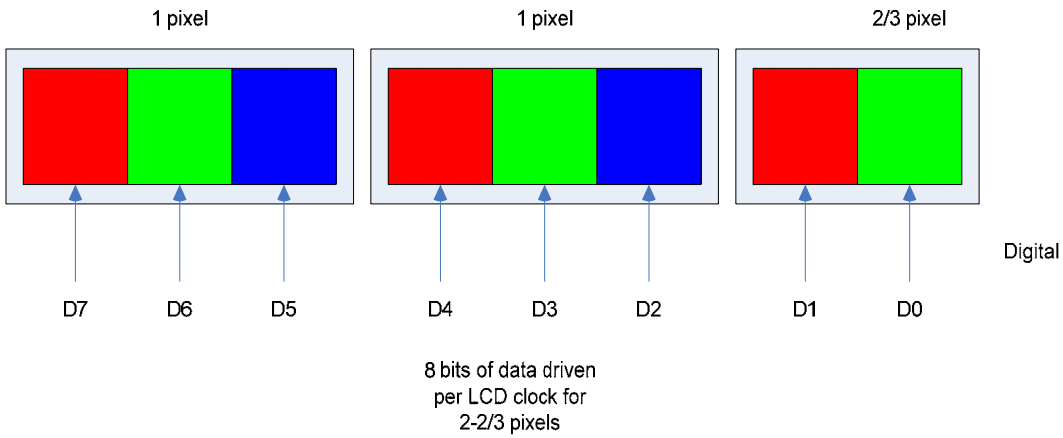
Generating color on an TFT display

- TFT displays can drive 3 segments (1 pixel) per clock with variable electric field strength
  - Supports many colors
  - Always 1 pixel per clock (3 segments of Red, green, and blue)
  - Color levels depend on the number of data lines on the LCD panel and number of LCD controller data output signals
    - May be 24 lines - 24bits per pixel (bpp)
    - 18bpp, 16bpp, 15bpp, 8bpp
  - Parallel data interface
    - 320 clocks require to place 320 pixels



Generating color on an STN display

- STN displays drive 1 or more segments per clock (full field strength on or off)
  - Can drive fractional pixels per clock
  - Serial interface
    - 120 clocks required to drive 320 pixels @ 2-2/3 pixels per clock (8 bit data bus)
    - 240 clocks required to drive 320 pixels @ 1-1/2 pixel per clock (4 bit data bus)
- Segments are alternated between on and off states to generate color depth
  - May take multiple refresh cycles to get the LCD color to a desired value (slow to respond due to a maximum of 1 digital state change per refresh cycle)
  - For example, a 50% duty cycle on a segment will give about 50% brightness



LCD signal interface and timing parameters