Liquid Crystal Display Technology

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Introduction

- Liquid Crystal Display (LCD) technology is a critical facet of the electronics industry

- Readily available, relatively inexpensive way to provide detailed feedback

Topics of Discussion

- Reasons for use
- Technology overview
- Active v. Passive Matrix displays
- Addressing Methods
- Performance Enhancement Techniques

Reasons for Use

- Inexpensive (compared to other display technologies)
- Compact
- Versatile
- Low Power Consumption
- Proven Technology

Technology Overview

- Liquid crystal sandwiched between electrodes, alignment layers, glass, and polarizers

- Most common liquid crystal structure used is 'twisted nemantic' (TN)
  - Light enters first polarizer into helical liquid crystal
  - Rotated light exits the second, offset polarizer

- Apply bias across electrodes - result: dark area
  - Crystal molecules no longer have helical structure
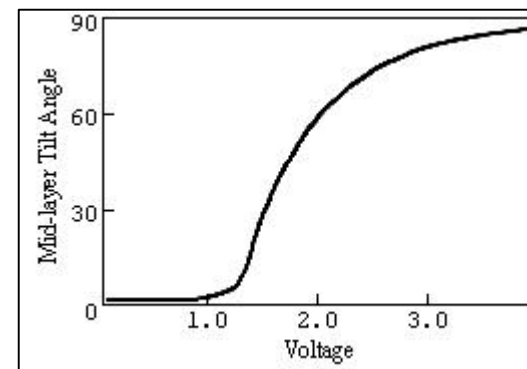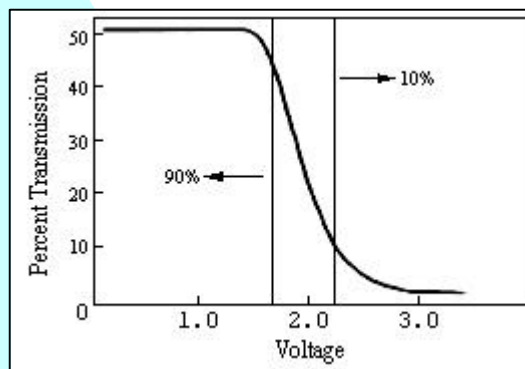 - Light not rotated - blocked by second polarizer

Tech Overview - Diagrams
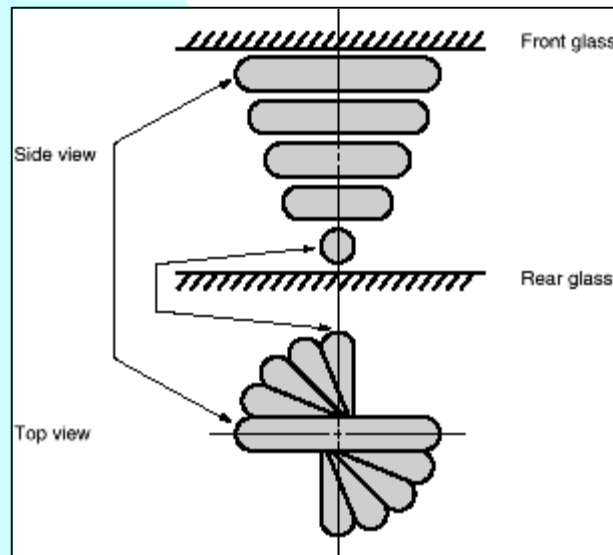
Source: Simar International Services, Ltd.
http://www.simar.ie/wlcd.htm
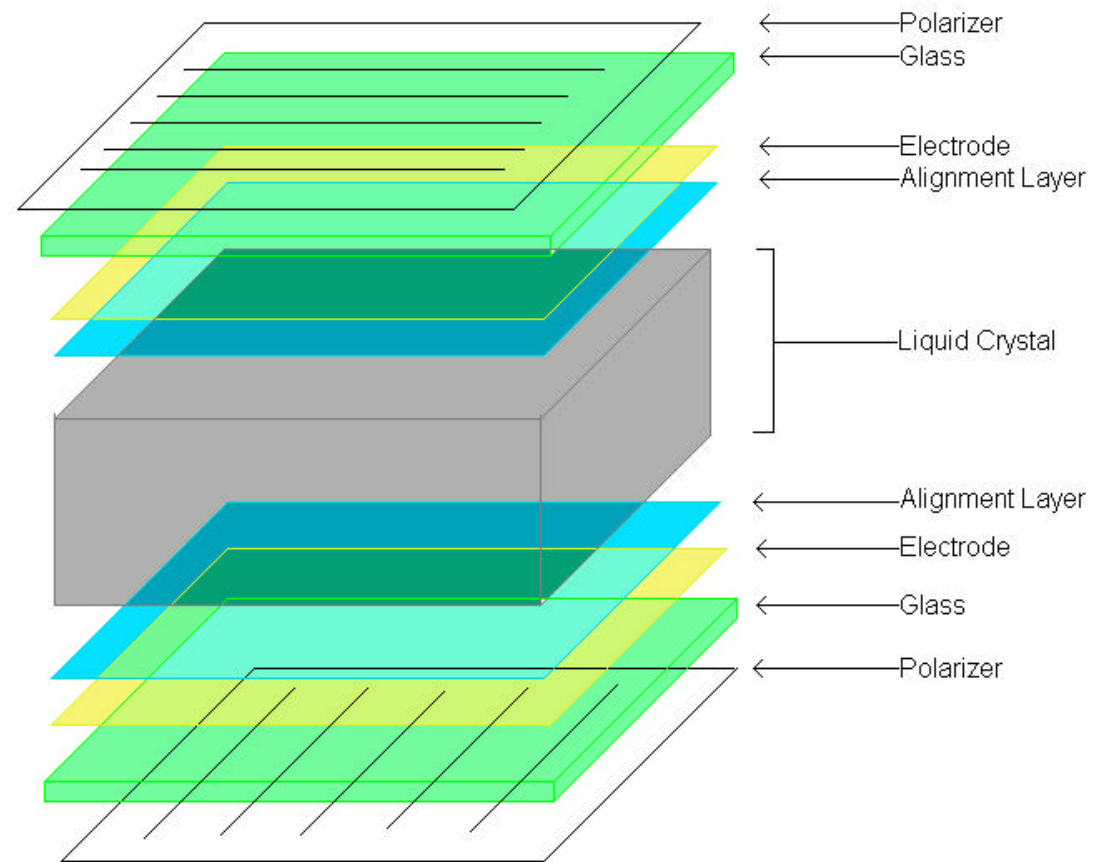
Tech Overview - Color & Contrast

- Types of LCD contrast - reflective and transmissive
- Grayscale achieved by varying bias across cell

- Color typically achieved through color filters
  - Must be capable of passing white light for full color
  - Other methods are currently being explored
- Color via filters decreases already inefficient light transmission

Passive vs Active Matrix Displays

- Two different methods for producing multi-bit images

- Both rely on 'slow' electrical response of crystal to retain a bit for duration of scan time

- Directly related to addressing schemes

Passive Matrix

- Row & Column approach
- Apply small bias to perpendicular lines of electrodes
- Bias strong enough to darken bit at line intersection
- Multiplexed addressing scheme
- Advantage: Simple to implement
- Disadvantage: Can cause distortion ('ghosting' or 'crosstalk')

Active Matrix

- Each cell has its own thin-film transistor (TFT)
- Addressed independently from behind LCD
- Direct addressing scheme
- Advantages: Sharp display, better viewing angle, 40:1 contrast
- Disadvantages: Need better backlight, complex hardware
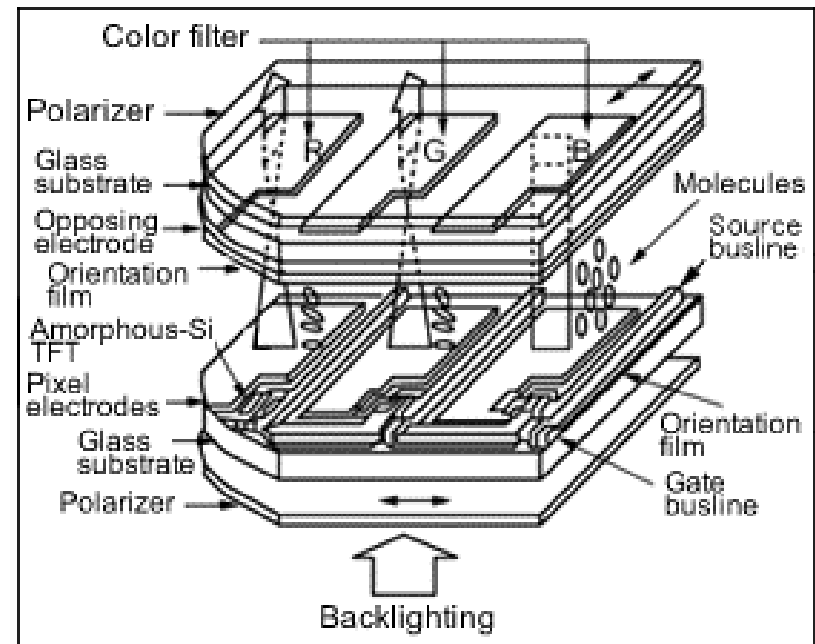
Addressing Methods

- Multiplexed - used for passive matrix et al

- Direct - highest contrast, wide temperature range

- VGA/SGA/XGA interfaces available

- Serial interfaces available (similar to assembly addressing of an I/O port)

Performance Enhancement Techniques

- Goals: Better response, greater contrast, greater pixel density, and lower power consumption

- Several tricks employed / being developed to increase functionality
  - Sub-pixel addressing
  - Material experimentation
  - Multi-layer designs

- 3-D LCD displays

PET: Sub-Pixel Addressing

- Old algorithm applied to new technology

- Uses optical illusion to increase perceived resolution

- Complimentary color pixels eliminate need for full pixel to be used

Normal print

Sub-pixeled print

Implementation
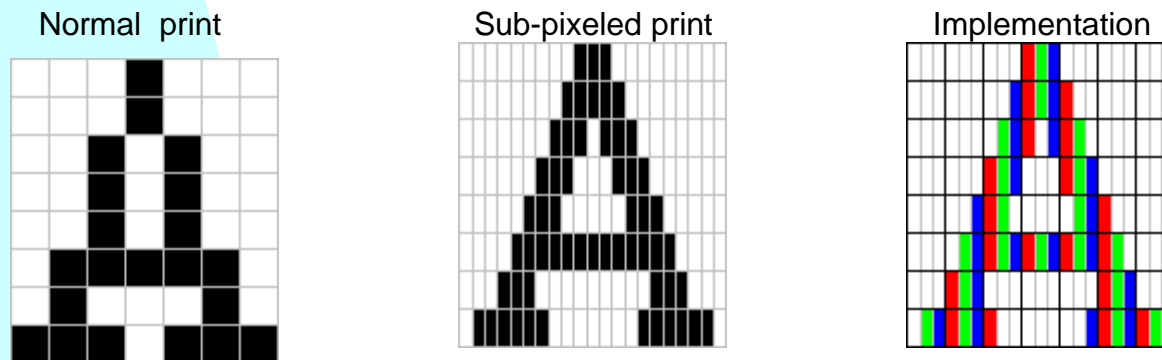
Source: Gibson Research Corporation - http://grc,com/ctwhat.htm

PET: Material Experimentation

- Goals:
  - Improve response
  - Expand operational environment
- Heaters employed for low-temp conditions
- "Barrier coatings" protect from contamination by conductive particles
- Liquid crystal material must be carefully chosen for correct viscosity at desired operating temp.

PET: Multi-layer Designs

- Greater brightness per unit of power or extended battery life

- Needs no filters to generate colors

- Sharp, Toshiba are important contenders in this field

- Currently, contrast needs improvement (~7:1 reflectivity)

SHARP TAKES A TWO-LAYER TACK IN DISPLAYS
Reflective LCD divides each pixel into six dots, driven by TFT arrays

Organic black matrix

Negative photoresist
W: 10 µm
H: 8 µm

Transmissive thin-film transistor (TFT) substrate

Indium-tin oxide (ITO) and alignment layer

6 µm polyethylene telephthalate polymer

Internal scattering aluminum reflector

TFT substrate

300 µm

SOURCE: SHARP

Source: EDTN
http://www.eet.com

PET: 3-D LCD Displays

- Current work by Phillips laboratories

- Goal: To create a 3-dimensional display without the need for special glasses

- Combination of active-matrix LCD with lenticular lens to achieve stereoscopic effect

- Applications: medical imaging, entertainment

Summary

- LCD technology is an immensely powerful tool for system feedback

- Different addressing schemes and display implementations have various trade-offs

- Several techniques are being employed to increase LCD functionality - plenty of room for discovery!