APPLICATION NOTE 1193

Sep 09, 2002

Electronic Displays Comparison

Abstract: This note compares advantages and disadvantages of Cathode Ray Tubes, Electro-Luminescent, Flip-Dot, Incandescent Light Bulbs, Liquid Crystal, Light Emitting Diode, Organic LEDs, Polymer LEDs, Glow Discharge, Plasma Display Panels, and Vacuum Fluorescent Display technologies.

This note compares the main electronic displays technologies in the table below. Each display type is described briefly, and the relative advantages and disadvantages are reviewed.

Display Type	Acronym	Emissive or Reflective	Technology	Advantages	Disadvantages
Cathode Ray Tube	CRT	Emissive	The CRT is a vacuum tube using a hot filament to generate thermo-electrons, electrostatic and/or magnetic fields to focus the electrons into a beam attracted to the high voltage anode which is the phosphor coated screen. Electrons colliding with the phosphor emit luminous radiation. Color CRTs typically use 3 electron sources (guns) to target red, green, and blue phosphor patterns on the screen.	• Very bright • Wide viewing angle • No mask, so no pixel size limitation for mono • Minimum pixel size 0.2mm (color) • Low cost standard sizes • Low cost high-res color • Wide operating temperature range • Moderate (20khrs+) life	• High (5kV to 20kV +) drive voltages • Not a flat panel (rare exceptions) • Can be fragile, particularly neck-end • Heavy • Source of X-rays unless screened • Affected by magnetic fields • Difficult to recycle or dispose of
Electro-Luminescent Display	ELD	Emissive	EL displays are solid state displays which use a phosphor to emit light in the presence of an electric field. Phosphors used are usually yellow-orange or green.	• Flat panel • Bright, light emitting mono displays	• 150V+ operating voltages • Color panels difficult to make • Development largely overtaken by PDPs

Flip-Dot Display		Reflective	Each pixel comprises a hinged disk. The disk is matt black on one side (unlit), and fluorescent or reflective on the other (lit). Various techniques are employed to flip the disk. One method balances the disk around an electromagnetic soft iron armature. The winding is energized one way or the other to attract the disk to one side or the other. Remanent magnetism holds the position, so only a short power pulse is required to flip the pixel.	• Only draws power during a transition • Retains display pattern when off • Very wide viewing angle • Low cost for large segments • Can have long life (100khrs+)	• High power required to change pixel state • Difficult to make segments smaller than 8mm diameter • Limited to mono color • Requires some ambient light to be visible
Incandescent Display	Light Bulb	Emissive	A coated tungsten filament is run white hot in vacuum, and it radiates both visible light and infrared (heat).	• Mature technology, very available • Lowest cost for moderate to high light output • Standard sizes easy to obtain	• Short life (1khrs to 10khrs); socket adds cost • Usually inefficient compared with LED • Narrow operating voltage range • High peak current when starting • Usually run hot • Usually fragile
Liquid Crystal Display	LCD	Reflective	An LCD uses the properties of liquid crystals in an electric field to guide light from oppositely polarized front and back display plates. The liquid crystal works as a helical director (when the driver presents the correct electric field) to guide the light through 90° from one plate through the other plate.	• Small, static, mono panels can be very low cost • Both mono and color panels widely available • Static panels offer lowest power/voltage display • Reflective panels in general are low power • Very easy custom segment shapes, sizes • Reverse backlit mono panels are attractive	• Backlight adds cost, and often limits the useful life • Requires AC drive waveform • Fragile unless protection added • Can have narrow temp range (0°C - 50°C) • Temperature compensation usually required • Can have narrow viewing angle • Low yields raise cost for larger (17"+) displays

Light Emitting Diode	LED	Emissive	LEDs are photon emitting semiconductors which emit light due to the injection electroluminescence effect. The wavelength of the emitted light varies primarily due to the choice of semiconductor materials used, and is commonly in visible spectrum or infrared.	• Lowest cost red or green emissive indicator • Available in very small sizes • Very bright versions available (higher cost) • Red and green types work from 3V supply	• LED is point source, so light shaping required to make segment shapes • White and blue LEDs expensive, need >3.6V supply • Can have narrow viewing angle • Color and efficiency vary with temperature and current • Care required to achieve 50 khrs+ life
Organic LEDs Polymer LEDs	OLED PLED	Emissive	These displays use organic electroluminescent materials deposited on a glass or flexible substrate. Devices based on small molecules are usually referred to as OLEDs. Those based on large organic 'polymer' molecules are usually called PLEDs. Light is generated by injection electroluminescence, like LEDs. The choice of organic material sets the emission color OLED pixels are capacitive (tens to hundreds of picofarads) leading to significant switching losses for large displays with high multiplex ratios.	• Moderate cost for small (<4") color panels • Wider viewing angle than LCD • Faster element response than LCD • Emissive, unlike LCD color panels • RGB and mono displays • Can be built on a flexible substrate	• 6V to 16V operating voltages • Differential aging effects limit life • Power consumption high for matrix panels >128 x 64

Glow Discharge (Plasma) Indicators	Nixie	Emissive	A high voltage between two electrodes encapsulated in a tube with an inert gas (typically neon) ionizes the gas allowing current to flow and a glow discharge to appear around the cathode. If the tube is driven from an AC source (e.g., a neon indicator), the glow discharge appears around both electrodes. Complex displays use multiple cathodes shaped either as segments (one or more lit to make a character) or complete numerals (one lit at a time).	• Wide operating temperature range • No phosphor (gas choice sets discharge color) • Long (40khrs+) life • AC or DC operation (indicators) • Unregulated DC operation (digits)	• Obsolete but for specialized applications • Not suitable for small, detailed display • 40V to 150V operating voltages
Plasma Display Panel	PDP	Emissive	Plasma displays use multiple controlled gas discharge paths (one path per color per pixel) but the inert gas is chosen to glow outside the visible spectrum. Each local current discharge path terminates with its own phosphor coated cathode, which in turn emits luminous radiation. The cathodes can be arranged as RGB triads to make a color display.	• Very bright, thin, color display • Available in large (30"+) sizes • Wider viewing angle than TFT color LCD	• Phosphors limit life (5khrs to 20khrs) • 150V+ operating voltages • Moderate power consumption • Entire display must be exercised to avoid phosphor differential aging effects

Vacuum Fluorescent Display	VFD	Emissive	The VFD is a vacuum tube using hot filaments to generate thermo-electrons, A grid (static display type) or multiple grids (multiplexed display type) control and diffuse the thermo-electrons, which are attracted to one or more high voltage phosphor coated anodes, which then emit light. The anodes are at the back of the display, so the emitted light passes through the grid(s) and filaments and the display front to be seen by the user. The filaments are not run hot enough to be usually visible.	• Wide operating temperature range • Long (40khrs+) life • Wide viewing angle • Very bright, attractive, typically green display • Very easy custom segment shapes, sizes • Different colored segments easy • 12V grid/anode voltage versions available	• Filament supply (±8% typ. tolerance) required • 10V to 60V grid/ anode operating voltages • RGB displays available, but expensive • Phosphors other than green limit display life