

TECH2004 – Video and Imaging Techniques

**Electronic Display Systems:
A comparative study**

ABSTRACT

A study of common visual display technologies, identifying working principles, key features and viewer-related factors with a comparison of products based on viewing characteristics, performance, compatibility and cost.

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1 - Introduction

Since the invention of the Nipkow disk and the subsequent development of the analogue television screen by John Logie Baird in the late 20s, display technology has evolved and improved in a multitude of ways. The advancement of moving and still image media technology has brought an increasing need for electronic devices to display information in a number of environments and applications, from mobile devices such as portable game machines and cell-phones, to home-use appliances and commercial/industrial large-screen displays.

In this comparative study, I will be examining the current display solutions available today and the technology behind their use. I will identify viewer-related factors such as environment, ergonomics, compatibility and function, and compare the technologies and various models on the consumer market.

2 - Current display systems

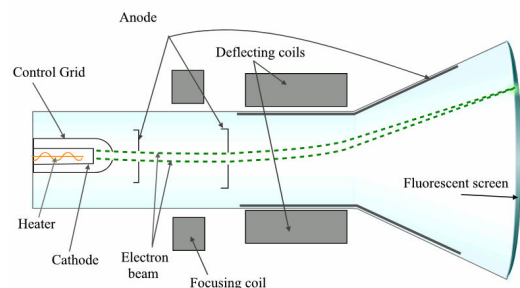
The development of display devices has lead to the development of several fundamental technologies, each one different in concept, cost and application, and each with distinct advantages and disadvantages over the others. The most currently used technologies in modern display devices are CRT, LCD, Plasma, and Projection (using DLP, LCoS, and CRT projectors, rear and forward projecting).

2.1 - Cathode Ray Tube (CRT)

Still the most commonly used technology (although beginning to be replaced by other methods) is the CRT, invented by Karl Ferdinand Braun. This technology is primarily used in low-to-mid range televisions and computer monitors, providing a relatively cheap, but excellent quality direct-view image at up to 115cm¹.

2.1.1 - Workings

The basis of the CRT display is a vacuum tube, heated filament cathode² and phosphorous screen. The cathode emits high speed electrons which form beams (known as cathode rays) when a voltage



tv-cathode.gif - <http://electronics.howstuffworks.com/tv4.htm>
(accessed 01/04/06)

¹ Diagonal measurement of a screen running in a 16:9 ratio. The current largest 4:3 screen is 100cm.

² Three cathodes are used in colour displays, one for red, green and blue colour values.

difference is applied across two electrodes. The direction of these beams is then altered (deflected) by an electric or magnetic field created by steering coils, tracing them over the inside surface of the phosphorescent screen (usually covered with rare earths or transition metals). Light is emitted by the materials in the screen and filtered through an aperture mask or grill (known as a shadow mask on most televisions). A 'raster scan' is used to 'paint' the entire screen of the tube one line at a time, faster than the human eye can discern, giving the impression of a single image.

2.1.2 - Viewer-related factors

CRT displays feature excellent quality and colour fidelity and are comparatively cheap to produce, so they are well suited for use in the home and the printing and broadcasting industries. They also have excellent response time (more accurately, refresh-rate for raster-based devices) so are well suited for fast-moving images such as videogames. Due to their non-native resolution capabilities, CRT screen are also very flexible and compatible with many video outputs, being able to run at many different resolution and refresh settings. The main problem of CRT-based displays is that they require a relatively large amount of power for operation, as well as being rather bulky³, so they are beginning to be phased out in favour of newer technologies.

Recommended products are the 17" ViewSonic E 70f at around £100, or the 19" Samsung SyncMaster 957MB selling for around £200.

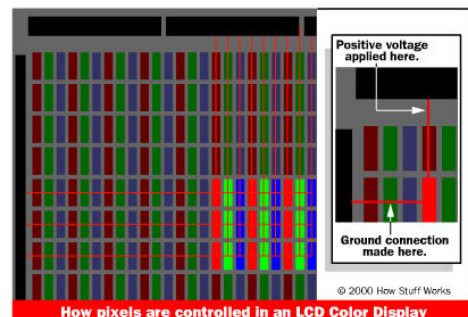
2.2 - Liquid Crystal Display (LCD)

Advances in passive and active matrix technology have lead to the widespread use of LCD screens in a variety of applications. LCD displays require small amounts of electrical power to operate, and can be produced to be very thin and light, so are suitable for a great number of portable devices

2.2.1 - Workings

In Passive Matrix LCD systems, each pixel in is comprised of liquid crystal molecules that are suspended between two transparent electrodes and two polarising

³ CRT devices tend to be very deep due to the long vacuum tube.



LCD: Passive Matrix - <http://electronics.howstuffworks.com/lcd7.htm> (accessed 04/04/06)

filters with perpendicular axes of polarity. The liquid crystal molecules are electrically charged, and 'twist' when small electrical charges are emitted from the electrodes. This twisting lets through varying amounts of light from a mounted backlight.

Some LCD monitors, notably those used in high-resolution applications, use TFT (Thin Film Transistor) technology, which relies on an Active Matrix. One to four field effect transistors with transparent electrodes are used to control the light allowed to pass through each pixel.

2.2.2 - Viewer-related factors

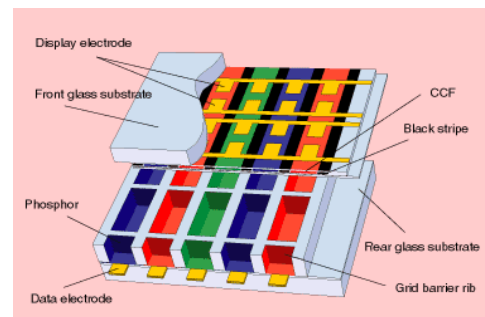
LCD screens can be constructed very thinly and weigh very little, meaning that their practical use is flexible and they can be incorporated into sleek, compact cases. Although LCD screens can reproduce colours very effectively, they often suffer from a poor contrast ratio; they are not as bright as CRT displays, and cannot produce deep blacks. A native resolution is used for each model, but lower resolutions can be achieved with image down-sampling and resizing. Older LCD models may also have low response times, causing noticeable blurring on fast moving images, although the problem is reduced on newer models. There is also the issue of viewing-angles; some older or cheaper models requiring an angle closer to 90 degrees to avoid colour distortion.

Models range from around £100 (15" Sharp LL T15G3-H) to £700 for the Princeton SENergy 981 LCD monitor.

2.3 - Plasma Display

2.3.1 - Workings

The plasma display consists of a network of cells filled with bubbles of plasma injected with neon-xenon gas. When this gas is charged, it strikes red, green and blue phosphors; each group of three forming a single pixel. This works similarly to fluorescent light bulbs. All photo-excited pixels react together, so the 'flicker' effect



http://www.audioholics.com/techtips/specsformats/images/plasma_lg.gif (accessed 01/04/06)

found with other devices is not an issue.

2.3.2 - Viewer-related factors

Plasma screen technology enables higher contrast ratios than many direct view TVs, a wide viewing angle, and rich colour reproduction, providing excellent image quality. Like LCD screens, they suffer from problems with deep black levels. They can also be made similarly thin, although they are somewhat heavier than LCD screens, and use a considerably large amount of power to operate. A large drawback of plasma screen technology is that the gas used has a relatively short life and needs to be replaced, which can be costly. Software such as videogames and operating menus that use static interfaces during play should not be used on Plasma screen displays, as forcing pixels to remain one colour for too long can develop 'burn-in', causing permanent ghosted images on the screen.

2.4 - Video Projection (including Rear Projection)

The concept of video projection is the shining (projecting) of bright light through a filter and lens onto a screen surface, allowing for image sizes that are only limited by the strength of the light bulb. The same technique can be used for rear projection televisions, offering a cheaper alternative to large-screen LCD and Plasma screens, by using a mirror to reflect the image onto the inside the screen. The technology is used for applications where a large screen is required, such as cinemas, home theatre systems and presentations.

2.4.1 – Workings

The basis of a projection system is a very strong light bulb, capable of 1000 to 3000 ANSI lumens, depending on the size of the room and screen required. There are currently three widely used methods of filtering the light that a projector uses: CRT, LCD⁴ and DLP (Digital Light Processing). CRT and LCD projectors work in a similar way to their television and monitor equivalent, but have a separate tube for each of the three colour channels. Developed by Texas Instruments, DLP technology uses a microscopic mirror for each pixel, laid out in a matrix on a DMD (Digital Micromirror Device) semiconductor chip. Extremely fast repositioning of these mirrors reflects varying amounts of light as required by the image; shades of grey produced by quickly

⁴ and its variants LCoS (Liquid Crystal on Silicon), JVC's D-ILA (Digital Imaging Light Amplification) and Sony's SXRD (Silicon Crystal Reflective Display).

alternating the mirrors. Some models of DLP utilise a single-chip setup with a rotating colour filter to sequentially display each channel faster than the eye can discern.

2.4.2 – Viewer-related factors

Projection systems not only produce very large, clear images, but are extremely portable too⁵. Light bulb life is an issue, requiring replacement, which can be costly depending usually on the brightness of the bulb. The bulb brightness required is dependant on the size of the room and screen required, as well as ambient light levels. For a projector to display a clear image, low levels of ambient light must be present. Projection systems are also rather expensive, but provide good value for money in terms of screen size. In this way, rear projection offers a cheaper alternative to large LCD/Plasma screens.

CRT and LCD provide similar benefits and disadvantages as their television and monitor counterparts; the larger CRT with its vivid colours and deep blacks, and the compact LCD with occasionally questionable response time and inability to display the darkest blacks.

DLP projection systems require at least 12-14" depth to contain the lamp technology, and are susceptible to a 'rainbow effect' on single-chip variants. The excellent colour and contrast reproduction of CRT is available through DLP, but is much lighter and features a longer lamp life. DLP is fully compliant with DVI (Digital Video Input) so is very flexible, although it does not offer variable resolutions.

Prices range from around £1000 to £20,000, depending on technology, native resolution and brightness.

3 - Comparison of technologies

The multitude of display technologies available on the market means that there is a lot of choice for the consumer, but such choice can be baffling and it is important to select the correct device according to how it will be used.

Although the quality of CRT displays is outstanding, they are beginning to be phased out⁶, mainly due to smaller and lighter technologies giving similar results. LCDs such as those used in monitors, laptops and handheld devices offer light, portable and low-power display capabilities at a cost of contrast

⁵ CRT projectors are slightly less portable and are usually found in fixed setups.

⁶ Many companies ceasing production in the coming years

ratio and colour reproduction. Plasma screens have proved to provide similar results, but with slightly better response times and darker blacks. Plasma screen displays are also around 30-40% cheaper than a comparative LCD display on screens over 30".

	D-ILA	DLP	LCD	Plasma	LCOS	RP LCD	RP CRT	CRT
Contrast Ratio****	1500:1	5000:1*	1300:1*	3000:1**	2000:1	800:1*****	5000:1*****	4000+:1††
Max Brightness	7000+ lumens	750+ cd/m2	450 cd/m2	1000 cd/m2†††	750+ cd/m2	450 cd/m2	NA	1000 cd/m2
Longevity (hours)	1000†	8-10k (lamp)	50-75k**	25-30k	80k+	8-10k (lamp)	80k+	80k+
Burn-in	No	No	No	Yes	No	No	Yes	No†
Viewing Angle	180°	170°	160°	180°	180°	170°	180°	180°
Fully Digital Display	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Refresh Rate	NA	NA	10-12ms ^e	8ms	10-12ms ^e	10-12ms ^e	NA	NA
Max Resolution	2048 × 1536	1280 × 720	1280 × 1024	1366 × 768	1920 × 1080	1280 × 1024	720p 1080i+	720p 1080i+
Weight (lbs)	15-200	15-300	20-100	50-150+	100-120	100-120	100-200+	60-300
Set Depth	NA	7" - 20"	2"	4-6"	24" - 30"	13" - 20"	24" - 30"	16" - 30"
Screen Size	NA	43" - 65"	1" - 57" ^{ns}	30" - 80"	42" - 80"	42" - 70"	42" - 65"	20" - 40"
Power consumption	High	Medium	Low	Medium	Medium	Low	High	High

*Fairly new HD2+ development noticed at CES 2004 (note [Sony VPL-HS20](#) for LCD) **Real world tests drop this number considerably (400:1)
 **** Expected LCD backlight lifespan ***** Higher-end known value given
 † Fixed images can result in burn-in over long-term (unusual) †† Calculated. CRTs not generally shown with contrast ratios.
 ††† Plasma "real-world" measure about 100 cd/m2 † Front projection lamp life is typically <2000 hours

Display Technologies Guide: Comparisons - http://www.audioholics.com/techtips/specsformats/displays_LCD_DLP_plasma8.html (accessed 03/04/06)

Front projection units provide huge screen sizes an excellent portability, and although the brightness of many projection systems is very high, they must compete with environmental lighting, so they are not as suitable for a typical home environment. Rear projection screens however provide large-screen display capabilities for as low as £1000, ideal for a home theatre setup.

4 - Future developments – SED Displays

Canon's SED (Surface-conduction Electron-emitter Display) flatscreen display is currently in research and development stages⁷; a possible replacement for current Plasma and LCD technology. It was created using a combination of Canon's electron emission and microfabrication and the CRT and LCD technologies offered by Toshiba.

Similarly to CRT technology, SED uses electron emitters to excite a phosphor screen. Instead of a single emitter however, SED uses one for every single pixel on the screen, achieving CRT's quality and contrast ratio without using raster scanning.

One drawback of the technology is a very poor image quality outside of the native resolution, limiting the chance of commercial success somewhat when there are devices without such degradation.

⁷ Starting mass production in mid-2007

Further future price drops for LCD displays will also make it hard for Canon to enter the market, so the future of SED as a viable solution to existing technologies is questionable.

5 - Conclusion

As we have seen, there are a great number of display technologies available, each suitable for different applications and environments. The advantages and disadvantages aren't always clear, so it is important for the consumer to be aware of the differences in order to make a suitable purchase decision. Of course, expensive technologies inevitably become less so, as production techniques are streamlined and technologies mature. Old technologies are phased out as newer systems are introduced, providing higher image quality, better ergonomics, increasing flexibility, and more cost-effective production.

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