STUDY OF MONITOR (CRT, LCD, LED)

1. Introduction

Monitors CRT (Cathode Ray Tube)

Technology: It employs focused electron beams to activate phosphorescent dots deposited on the screen's inner surface.

Advantages:

- Superb color authenticity and angles of sight.
- Economical.

Disadvantages:

- Cumbersome and heavyweight.
- High electricity usage.
- Emits more thermal energy.

Application: Mainly in older computers and television sets. Now obsolete due to improvement in display technology.

Monitors LCD (Liquid Crystal Displays)

Technology: A liquid crystal is placed between two glass or plastic panels. These crystals either align allowing or blocking the passage of light to form an image.

Advantages:

- Thin and light in weight.
- Uses less energy.
- Emits less heat.

Disadvantages:

- Narrow viewing angles.
- There is a threat of backlight bleeding.
- Application: Extensively used in computers, TV sets, smart phones and many other devices.

Monitors LED (light Emitting Diode)

Technology: A variation of LCD technology that utilizes LED backlight rather than CCFL- Cold Cathode Fluorescent Lamp backlighting.

Advantages:

- Better colors reproducing.
- Slimmer and energy saving than conventional LCDs.
- Have a longer usage period.

Disadvantages:

- Relatively expensive than basic LCDs.

Application: Mostly found in modern computers, televisions as well as in portable devices.

2. History

Cathode Ray Tube (CRT) Monitors

Early Development: CRT technology was first displayed in the year 1897 and was made available for sale in 1922. These monitors made use of an electron gun to shoot the electrons on the phosphor coated screen to form an image.

Color CRTs Came About: The first commercial color CRT was developed and available in the market in the year 1954. The CR t display technology is applied in both computer monitors and TVs for more than several years.

Decline: In the 2000s, LCDs and other technologies were introduced making the CRT monitors and television sets outmoded cultures as a result of their bulkiness and high energy consumption.

Liquid Crystal Display (LCD) Monitors

Early Research: In 1888 invention of liquid crystals was made, but in 1960 thanks to researches done in RCA, it was in that era that these displays begun to be developed.

First LCDs: The first successful liquid crystal display was developed by James Fergason in the year of 1969. The first LCDs manufactured were used in calculators and in digital wrist watches2.

Advancements: Towards the late 1980s, thin LCD monitors began gaining acceptance as a better option for computer displays thanks to their low power requirements and less weight.

Dominance: By 2000s mid, LCDs were the most preferred computer monitor type thanks to their higher resolution and lower power consumption as compared to CRTs.

Light Emitting Diode (LED) Monitors

Early Development: The LED was invented in the year 1962 by a man called Nick Holonyak when he was working for General Electric. The practical use of an LED display was designed by Hewlett Packard in 1968.

LED Monitors: The introduction of Led backlight LCD monitors was in the disparagement period of the 2000s. These monitors introduced better contrasts, energy efficient designs and agility which were in sharp contrast to the traditional LCDs.

Current Use: At present, the use of LED monitors has extended across all consumers and professionals alike due to their performance and energy efficiency.

3. Available technologies in the field

The following are some novel inventions in the field of monitors:

Cathode Ray Tube (CRT) Monitors

Obsolete: CRT monitors have nearly been phased out mainly because they take up a lot of space, consume much power, and release too much heat.

Liquid Crystal Display (LCD) Monitors

Thin-film Transistor LCD: As the name suggests, this type of LCD employs thin film transistors to enhance image quality as well as response times.

In-Plane Switching: This is because it uses an improved color reproduction technology and offers a wider viewing angle than the conventional TN (Twisted Nematic) panel.

VA (vertical Alignment): Offers better color reproduction and contrast than the TN panel but slower than the IPS panel.

Light Emitting Diode (LED) Monitors

LED-backlit LCD: These screens use light-emitting diodes behind the screen for illumination making them quite power efficient and sleek compared to the CCFL-backlit LCD screens.

Quantum Dot LED: A technology that uses quantum dots to improve the color and brightness.

Please note that Organic Light Emitting Diodes (OLED) Monitors

Self-Emissive: Each pixel generates its own light, which enables true blacks and contrast ratios that are limitless.

Bendable Screens: The use of OLED technology allows the making of bendable and even rollable screens.

Micro-LED Displays

Highly Bright and Efficient: In general LED based arrays which have high-density imaging with the help of microscopic LEDs where each pixel is an individual LED. High bright and energy efficient.

Enhanced Color Performance: Improved color performance and quicker response rates are offered in comparison to OLED.

4. Working and Basic concepts

Each type of monitor—CRT, LCD, and LED operates on different principles to display images:

CRT (Cathode Ray Tube) monitors

Fundamental Ideas:

Electron Gun: propels a stream of charged particles toward the phosphorescent surface.

Phosphorescent Surface: made of a coating material which glows when bombarded with electrons.

Magnetic Deflection: where magnetic fields are used to position the electron beam on different targets on the screen.

Working:

- At first an electron gun produces an electron flow.
- Then these electrons are shaped into a coherent beam.
- Magnets of the magnetic deflection yoke steer the horizontal and vertical movements of the beam to the screen perimeter.
- When the beam strikes the surface the phosphor layer glows and form the picture.
- Color CRT picture tubes contain three electron guns (red, green, and blue) to reproduce a color image.

Multimedia LCD monitors

Basic concepts:

Liquid Crystals: A class of substances composed of large molecules which are capable of reorienting themselves in a controlled manner when an electric signal is applied.

Backlight: (as applied to a display) Light source placed behind translucent image forming elements such as liquid crystals.

Polarizers: Element used to garb the light that comes out of liquid crystals.

Working:

- The backlight is made at the back of the liquid crystals.
- Light currents make liquid crystals twist and turn like shutters.
- This affects the light coming from behind the filters and the light cutting through the layers, mixing them up.
- The light along with the colors creates an image on the display.

LCD (Light Emitting Diode) Monitors

Basic Concepts:

Use of Light Emitting Diode Technology: backlighting is done using an array of LED's instead of using the standard CCFL used in most LCDs.

Edge-Lit and Direct-Lit: These are the two categories of LED backlighting. In edge-lit, LEDs are placed at the edges of the screen while direct-lit, they are placed behind the screen.

Working:

- Backlighting is also provided by LEDs, which results in improved brightness and color reproduction.
- The technology of forming images works the same ways as it does in LCD's where liquid crystals and polarizing screens are employed.
- In some high-end LED monitor versions, local dimming technology is used in which certain sections of the backlight can be turned off to enhance contrast and black levels.

5. Study various parameters like cost, speed and performance

CRT (Cathode Ray Tube) Monitors

Cost: Generally cheaper than modern LCD and LED monitors due to widespread phasing out of CRTs.

Speed: High refresh rates (60-85 fps), but limited by the phosphor decay time (about 5 milliseconds).

Performance: Capable of good color reproduction and contrast, however they tend to be chunky and use a lot of energy.

LCD (Liquid Crystal Display) Monitors

Cost: Average rated cost, in which individual TFT LCDs is relatively cheaper than all IPS and VA or MP panels.

Speed: Different models tend to feature different response times, generally falling between one to eight milliseconds while older designs are even less effective.

Performance: Everything about them is digital, lightweight, compact with effective power usage and good color performance.

LED (Light Emitting Diode) Monitors

Cost: More than just plain LCDs because of the complex design involving internal anti-glare and light emitting diodes.

Speed: Timeliness has reached better levels with the response times going as low as 1microsecond and even better refresh rates.

Performance: Interestingly, truer color contrast and truer color reproduction, simpler cooler working.

6. Market study

CRT Monitors

Market Size: The global CRT monitors market was valued at approximately USD 517.2 billion in 2023 and is expected to reach USD 762.1 billion by 2032, growing at a CAGR of 4.4%.

Key Players: Samsung Electronics, LG Electronics, Dell Technologies, HP Inc., Acer Inc., Lenovo Group Limited, ASUS, Philips, and ViewSonic are some of the important companies in the CRT monitor market.

LCD Monitors

Market size: USD 147.61 billion was the valuation of the global display market inclusive of LCD monitors in 2023 and projected to rise to USD 295.04 billion in 2032 growing with a CAGR of 8.3%.

Key Players: Samsung, LG Electronics, Dell Technologies, HP Inc., Acer Inc., ASUS, BenQ, ViewSonic, and Lenovo4 have been the major players within the LCD monitor market.

LED Monitors

Market Size: The global LED monitor market, was estimated at USD 1.23 billion in 2024 and expected to reach a value of USD 1.77 billion in 2030 growing at a CAGR of around 6.3%.

Key Players: Prominent companies in the LED monitor market include Samsung, LG Electronics, Dell Technologies, HP Inc., Acer Inc., ASUS, BenQ, ViewSonic, and Lenovo.

7. Future advancements that are in progress

I. Quantum Dot Enhancement Displays (QDEs)

Advancement: Quantum dots increase brightness and color accuracy through more efficient color light conversion.

Impact: Enhances the color vividness and reproduction quality for a better viewing experience.

II. 8K Resolution Monitors

Advancement: 8K resolution (7680 x 4320 pixels) monitors give ultra-high definition images and video.

Impact: Suited for the most cutting – edge tasks such as professional picture and video editing; besides high imaginative game plays.

III. Flexible and Curved Displays

Advancement: Flexible display can be used in like bending or rolling while a curved display has a benefit aiming at the user by a curve.

Impact: Increases the ease of use as well the engagement of the users especially with smart phones, tablets and gaming monitors.

IV. High Refresh Rate Monitors

Advancement: LCDs, displays or screens with a higher refresh rate 120Hz, 144Hz, to even more motion is smoother and eliminates motion blur.

Impact: Ideal for gaming and fast movies for smoother visual play.

V. Integrated AI Features

Advancement: Monitors with built in AI for brightness adjustment, contents recognition as well as configurations management.

Impact: Complete ease of usage by adjusting default settings to mode based on the user’s usage patterns and preferences.

VI. Micro-LED Technology

Advancement: Employs microscopic LEDs that are placed in each pixel making it very bright and power friendly.

Impact: OLED technology is inefficient as it offers less color precision and takes longer to respond.

VII. Modular and Stackable Designs

Advancement: Monitors which can be stacked or connected in various orientations to suit the user's liking.

Impact: Enable creation of constructive and adaptable work spaces especially within an office setting.

8. Conclusions

CRT Monitors (Cathode Ray Tube)

Overview: In the past, cathode ray tube monitors were the most widely used display devices. They had phosphorescent screens onto which electron beams were shot. CRT monitors offered good color reproduction levels and refresh rates. However, these devices were quite thick, heavy and power hungry as well.

Current Assessment: Presently, these displays are practically rendered obsolete with the invention and incorporation of better display systems.

LCD Monitors (Liquid Crystal Display)

Overview: The displays include control of liquid crystals in front of a light source for image generation. CRT has been replaced in most devices and cut down on the bulk and weight of monitors.

Benefits: Easy to carry; very limited power is required to operate; has a range of available prices for the consumers.

Disadvantages: Not as high imaging angles and contrast ratios are offered in this class of devices when compared to the latest technology which is the OLED.

LED Monitors (Light Emitting Diode)

Overview: A sub-division of LCD technology, LED monitors have incorporated LED for the backlight instead of CCFL thereby enhancing the brightness and color saturation and energy efficiency.

Benefits: Elegant form factor, sophisticated color accuracy, greater energy efficiency, and long operational life.

Future Trends: Technologies like micro-LED and quantum dot advancement create advanced LED monitors that still enhance display superiority.

9. Indian contribution to the field

While India hasn't played an active role in the manufacturing of display panels (CRT, LCD, LED) to a great extent, it has successfully carved a niche for itself in the research, development and application of display technologies. Some of the aspects of Indian contribution are discussed below:

Research and Development:

Academic Institutions: Many Indian institutes of technology (IITs) and research organizations have investigated display technologies, more specifically OLED, quantum dot and flexible displays, and so on.

Industry Collaborations: Indian companies have partnered with different international display firms to assist in designing revolutionary technologies as well as enhancing the existing ones.

Application and Integration:

Mobile and Consumer Electronics: Design and production of mobile handsets, tablets and other consumer electronic products with more sophisticated display technology has been actively carried out by Indian firms.

Automotive Industry: Advanced displays such as features that include the digital clusters, navigation system among others is being incorporated by Indian auto manufacturers in their vehicles.

Healthcare: Certain medical equipment such as diagnostic machines or surgical instruments incorporate high-quality displays and India has helped in the development and production of such instruments.

Government Initiatives:

Production-Linked Incentive (PLI) scheme: The PLI schemes have been implemented by the Indian government in order to encourage local production of electronic parts including screens. This is expected to lessen the amount of importation from foreign nations and increase employment levels.

Research and Development Funding: The state has made provisions of some R & D funding for some technological areas where display technologies are also included.

10. References

Book reference :-

1. "Modern All About Monitors" by Manahar Lotia.

2. "All About Modern Monitors" by Elektor.

Website reference :-

1. Javapoint – Moniter, https://www.javatpoint.com/monitor.