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CRT Monitors

CRT monitors, or cathode ray tube monitors, have existed in various forms since the early 20th century in a series of iterations. Television sets, computer monitors, and oscilloscopes have all used the cathode ray tube and its related electrical magnetic and/or electrostatic componentry to generate imagery from inputted electrical signals onto a viewable screen. The screen, which is the part of the monitor which provides meaningful viewable imagery, translates projected images from the CRT device within. In the case of the modern color CRT this screen contains millions of tiny red, green, and blue phosphor dots that glow when struck by the electron beam emanating from the CRT. [1] The central mechanism in the CRT monitor is the cathode ray tube whose scientific mechanism will be briefly summarized in order to understand the history and development the history of the CRT and how it evolved into the driving force behind monitor display technology for a significant portion of the 20th century.

In order to best understand the CRT monitor we must first investigate the heart of the device; the cathode ray tube. The cathode ray tube is a glass shell with acts as vacuum device which emits electrons towards a display screen using an electron gun. The vacuum effect is achieved by the device being sealed in glass, and the vacuum is necessary so the emitted electrons won't keep crashing into air molecules, thus rendering them useless for the purposes of

[1] https://computer.howstuffworks.com/monitor7.htm

projection. [2] The CRT, which emits electrons as instructed by inputted signals, such as a video signal, is connected to a power supply. The power supply provides heat to a metal plate, called the cathode, at the back of the CRT. The cathode is an electrode, a metal which sends out negatively charged electrons when heated. The same power supply then steals negatively charged electrons via a second positively charged metal plate in front of the cathode, called an anode. Because of the heat and the charges provided by the power supply, the electrons zoom off towards the plate at the front, the anode.[3] The anode plate has a small hole which facilitates a concentrated electron stream shooting out in the form of a small focused beam from the cathode. After passing through the slit in the anode, the electrons shoot towards the inside of the phosphor coated screen at the front of the monitor. In the case of a color CRT, there are three electron guns, one for each primary color, red, green and blue. The combination of these three primary colors can reproduce color images accurately by combining how and when the electron guns shoot off.

In order to organize the stream of electrons coming through the hole in the anode, the electrons shoot towards a phosphor coated screen with three coats of phosphor. The three different phosphors coatings, one for each RGB, are painted onto the glass screen and are arranged in groups of three dots which are clusters called triads.[4] A device call a shadow mask, which is a metal plate with tiny holes intercepts the triple stream of colored electrons and has a single hole for each trio of RGB dots, or triad. [5] Henceforth, the combination of electrons being shot from the three RGB electron guns blends the colors in a stream and shoots into each triad cleanly so there is an accurate depiction of the image as intended from the original video source.

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[2] https://www.youtube.com/watch?v=tUWaLU73LQ8
[3] https://www.youtube.com/watch?v=tUWaLU73LQ8
[4] https://en.wikipedia.org/wiki/Cathode_ray_tube#Color_CRTs
[5] https://www.youtube.com/watch?v=tUWaLU73LQ8

The shadow mask effectively allows the electrons to be cleanly shot into pixels with zero bleeding.

Magnetism plays a role as well in the targeting of electrons to the proper points on the screen. Magnetic deflection yokes bend the stream of electrons to all corners of the screen in a repetitive motion so that the signal reaches all points of the monitor rather than shooting just to one spot in the center of the screen. As the stream of electrons is being bent by the magnetic deflection yokes, the guns are also following a scanning pattern called a raster scan. The beam is moved horizontally back and forth, line by line, in the space of the CRT monitors screen. "As the electron beam moves across each row, the beam intensity is turned on and off to create a pattern of illuminated spots". [6] The scan begins from left to right and at the end of line moves to the left most RGB triad in the next line.[7] When the beams hit the right bottom corner, they move diagonally across the screen back to the top left corner in order to begin the scanning process over again. This process repeats over and over for the duration of the video signal being fed into the CRT monitor.

CRT monitors also use vector scanning methods rather than raster scan methods when used to convey imagery in the test instrument known as an oscilloscope. Vector scanning uses electrostatic deflection rather than magnetic deflection to create images. In this version of the CRT, an electric field is created by pairing two sets of electrodes mounted at right angles which allows an electron stream to flow between the electrodes and to be sent out towards the screen. These electrodes are known as deflection plates. [8] In this sort of scan, known as a vector scan,

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[6] https://www.tutorialspoint.com/computer_graphics/computer_graphics_basics.htm
[7] https://www.youtube.com/watch?v=NCAwPBuAb1A
[8] https://en.wikipedia.org/wiki/Electrostatic_deflection

the electron beam is sent directly to the point on the screen where imagery correlates to whatever test pattern is being inputted into the CRT monitor. Rather than scanning line by line, a beam in the form of a geometric shape is sent directly to the correct spot on the CRT screen. Below is a good explanation of how the vector scan used in an oscilloscope works as opposed to a raster scan.

"Fundamentally an analog oscilloscope works by applying the measured signal voltage directly to an electron beam moving across the oscilloscope screen. The signal voltage deflects the beam up and down proportionally, tracing the waveform on the screen. The more frequently the beam hits a particular screen location, the more brightly it glows. This gives an immediate picture of the waveform." [9]

In the last ten years CRT monitors have been broadly replaced by flat panel plasma, LCD, and OLED displays. In 2008, LCD flat panel screens outsold CRT's for the first time and Sony shut down its last CRT manufacturing plants the same year.[10] While CRT monitors have been phased out for most modern computing and television applications, let us look back briefly at the history and development of the CRT and its historical and cultural significance.

In 1897 German physicist Karl Ferdinand Braun invented the first CRT tube and CRT oscilloscope, known as the Braun Tube. Cathode ray tubes were previously unable to focus electron beams. However, by using alternating voltage, Braun was able to focus the electron stream and trace patterns with his primitive oscilloscope onto a fluorescent screen.[11] By 1931

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[9] http://ecee.colorado.edu/~mcclurel/txyzscopes.pdf , p.2
[10] https://www.theverge.com/2018/2/6/16973914/tvs-crt-restoration-led-gaming-vintage
[11] https://www.britannica.com/biography/Ferdinand-Braun

American inventor Allen B. Dumont began manufacturing commercial television receivers based on his improved cathode ray tube.[12] Dumont's tubes for the first time used magnetic deflection rather than electrostatic deflection.[13] Dumont's tube technology paved the way for the modern CRT monitor and by 1960 nearly 90 percent of American households had a CRT television in their homes.[14]

Computing's history is also closely tied to the CRT monitor. The first computer monitors used CRTs and these early computers commonly had CRT monitors physically attached to the computer along with keyboards in a single chassis. [15] These screens were monochrome often using a green phosphor.[16] As home computing became more common by the early 80s, color CRT monitors became more prevalent. For color graphics, in 1981 IBM designed the CGA adaptor which hooked to a composite-video monitor. Using a special RGB connection color monitors were now available for home computing applications for the first time. [17]

CRT monitors remain of crucial importance in regard to digital video preservation for a few reasons. Perhaps most importantly, it is important to see what your original source material looks like on the technology it was broadly designed to be viewed upon. Before digitizing, tapes should ideally be monitored on a properly calibrated CRT monitor. Once this test has been completed the digital file version of the tape can be cross referenced during quality control in order to feel confident that your digitization has the proper look and feel of the original analog source material. Test instruments such as the vectorscope and waveform monitor are also crucial

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12 https://www.britannica.com/biography/Allen-B-DuMont
13 https://www.crtsite.com/page3.html
14 https://www.theverge.com/2018/2/6/16973914/tvs-crt-restoration-led-gaming-vintage
15 https://en.wikipedia.org/wiki/Computer_monitor#Cathode_ray_tube
16 https://en.wikipedia.org/wiki/Monochrome_monitor
17 https://www.pcworld.com/article/209224/displays/historic-monitors-slideshow.html#slide13

analog tools for testing video signals before digitization. These test instruments use CRT technology as well. We are currently in an era in which digitization is the only solution to safeguard the contents of rapidly decaying magnetic media. CRT monitors remain a crucial and indispensable tool for modern video preservation.