Analog Video Wiki

- HOW DO Cathode Ray Televisions and Oscilloscopes work
- Video Signals and terminators

HOW DO Cathode Ray Televisions and Oscilloscopes work

cathode ray tubes

- Cathode Ray: a stream of electrons in a vacuum tube
- neon tubes work along a similar basis, but with different gases inside the tube
- in order to display dynamic images on a cathode ray tube, some kind of phosphoresent substance must be applied. phosphors are substances that glow when struck by electrons. diff from florescence which is glowing when struck by photons (??)

oscilloscopes

- in order to adjust where the electons strike front of a tube, magnets/electromagnets are used
- in an oscilloscope, tthere are two standard ways of displaying a signal: the standard way involves the beam scanning from right to left at a selectable rate with the input signal displacing the beam up or down depending on the amplitude of its voltage. the secondary way involves sending two signals in and the beam pointing straight ahead in the center with one signal assigned to an x displacement and the other to a y displacment. Industrial usage of this was for deterimining phase & ratio relationships between signals. you can also use transducers (vibrations to voltage) to analyze relationships between mechanical components in engines
- oscilloscopes can work at many different rates, fastest analog ones being 1 gigahertz

how does a CRT work

- in a Television, the beam scans constantly from the top left hand side of the screen down to the bottom right hand side in a fixed number of lines in what is called raster scan.
- history of electronic image transmission
  - this predates television but not by a lot. with the infrastructure in place for telegraph and newspapers it was inevitable. early fax machines were able to transmit the

motion of a pen writing electically

RASTER VS VECTOR

- anyone who has worked with computer graphics knows raster vs vector. raster is often referred to instead as a bitmap. the origins of these image types comes from these two methods of displaying images on cathode rate tubes. an oscilloscope in x-y mode can draw a vector image, a crt draws a raster image.
- a vector in the scope is more 'analog' in one way of thinking, b/c it doesn't involve any sort of encoding/decoding of information. voltage comes in and is used to control electromagnetic deflection. a raster on a crt, even if black and white, requires both encoding and decoding in order to scan correctly for horizontal and vertical placement of each pixel.
- vectors are actually parameterized 1 dimensional shapes in 2 dimensional space. they are represented as continuous one dimensional lines drawn in two dimensional space. vectors are very compact ways of storing and displaying information, but with many serious limitations
- rasters are fully 2 dimensional images
- in a vector, if a certain 'pixel' is not used for the image, then no information is stored. in raster, information still needs to be stored even if 'nothing' is being displayed
- vectors in a scope aren't really capable of doing full color (going back to encoding/decoding). crts have more complex electronic architecture before the signal is displayed that can decode the chrominance information and create a full color image

SO HOW TO TURN A CRT into an OSCILLOSCOPe

- THIS IS DANGEROUS AND YOU CAN DIE AND KILL OTHERS AROUND YOU
- this is also much much easier to do with older ass crts. start with like a tiny black and white unit from the 70s if possible. there are probably more steps involved for color units from the 90s and 2000s.
- to use a crt as a horizontal scanning scope (voltage over time) you have to desolder the vertical deflection coil (refer to service manual or just trial and error, theres only two). where you detached the vertical coil, solder a wire that you can pull out through the case and if you prefer, add some kind of input jack here.
- to use crt as in an x-y mode you just do the same for the horizontal deflection and now use both inputs to create lissajous patterns
- issues: your horizontal and vertical rates are limited by the hardware. horizontal scan rate is about 15khz, so actually below the highest audio frequencies. i forget vertical scan, but in ntsc you have 525 lines so is fixed at a rate of how m

SO WHAT IS XYZ MODE?

- some oscillscopes have a z input on the back. this input is typically 'fixed' in that you don't have any ability to control rate or amplitude of how it gets displayed. its functionality is just amplification of the brightness (not displacement) of one or both of the input signals. its usage was to send in trigger signals to highlight certain time steps so you can syncronize things running at very fast speeds.
- z mode was used in scanimate systems (more on that later) to create illusions of depth. brightness is interpreted as something being closer so a z input could be used to to create the illusion of certain lines being 'in front of' other lines. keep in mind that much of the depth illusion involved in oscillographics is done by using multiple oscillators as inputs to X and Y to begin with, so when doing complex 3-d shapes you have to have at least two 'z oscillators', one involved in amplitude modulation of your x and y oscillators, and another involved in the direct brightness modulation

general terms definitions

- encoding and decoding:

Video Signals and terminators

.signals

- CVBS (Composite Video Broadcast Signal) including NTSC, PAL, SECAM) - when you see CVBS on a device, most likely it will automatically detect and switch between NTSC and PAL signals
  - different ways of transmitting & terminators used
  - broadcast at radio frequencies VHF (very high frequency) and UHF (ultra high frequency)
  - from antenna to F-type connector
  - rate was 59.94 for each Field
    - fields vs frames. 1 frame contains 2 interlaced fields (every other scanline). technically speaking, the Frame rate of CVBS was 29.97 while field rate was 59.94
  - amplitude of .75 volts, with an offset of like .1 volts at the bottom for black level. (IRE ?) i think main difference between japanese and standard NTSC was in here somewhere
    - modern analog modular video synthesis works at 1 volts unipolar vs +-5 volts bipolar eurorack standard
  - for NTSC a resolution of 720 x 525 pixels, which was nearly always cropped in both x and y. actual amounts cropped were not terribly standardized,(tho y direction was pretty close to 480) usually only a broadcast monitor had the means to display an entirely uncropped signal **fact check on this
    - the signal itself was analog on each horizontal line, why does it make sense to talk about discrete Pixels here?
      - while an analog signal is theoretically continuous at all points (quantum mechanics aside), practically speaking there are fundamental limits to how much information can be encoded in any actual signal based on rate (how fast) and depth (how tall). this is called nyquist limit. fill in the horizontal rate by the voltage amplitude and you get 720 pixels
        - A visually appealing metaphor is with vinyl records. The different speeds of vinyl playback (33/3, 45, 78) and different depths of vinyl records themselves (usually referred to by the weight by grams) allowed for highly varying qualities of sound.

        - a flexidisc at 33rpm vs 180gram at 45 rpm would represent a vast change in tonal quality.
      - in digital realms the sample rate (for a cd 44.1k) and bit depth (24 bits) are relevant measurements
    - non square pixels: pixel aspect ratio
    - pixel aspect ratio along with interlacing
  - signal itself contains H & V sync, color burst, Luminance, and chrominance. chrominance is subdivided into Pb and Pr
  - The signal is in the YIQ color space. often times in non professional engineering settings referred to as YUV. YIQ and YUV are color spaces which have linear transformations from one to another and (in practice but not necessarily) linear but not isomorphic transformations into/from RGB (information is lost from RGB into YIQ which is measured by the term Color Subsampling)
  - YIQ is a form of compression compared to RGB. More information is devoted to representing Luminance information (Y) than chrominance information. There is some philosophical justification given in that humans tend to prioritize brightness in image perception and use saturation and hue as secondary. However there is *not* more brightness information present in a YIQ/YUV signal, it is the same amount as in the transformed RGB signal so this is somewhat silly. The actual reason fousing YIQ encoding is that 1. it already existed and 2. it was necessary to maintain backwards compatibility for black and white televisions.
  - To visualize the color space we need to first imagine an RGB cube. Imagine that the XYZ axes are each Red Green and Blue with 0 on each axis being black and 1 on each axis being full saturated RGB respectively. You'd notice immediately, that the corner of the cube opposite Black (0,0,0) is White (1,1,1) If we were able to slice down the middle of the cube along that diagonal we would find that there is a line of completely unsaturated gradient from black to white there. We then want to tilt that cube up so that the line from black to white sits perfectly on the Y axis (hence Y= luminance). To properly preserve the scale of how chroma is subsampled we would also want to squeeze the sides of the cube in to reflect that less information is devoted to hue and saturation in this representation.
  - "pb is the blue - Luminance. pr is the red - Luminance" This looks better when you can draw the YIQ cube
  - there is some fairly sexy and somewhat basic trigonometry that is used to encode/decode pb pr into chrominance into luminance
  - P means phase shift/phase burst is used to decode hue information
  - S-video seperates luminance and chrominance. Y pin carries H and V sync and Luminance, C pin contains color burst and chrominance. chrominance must still be seperated into Pb and Pr
- VGA is RGB HsyncVsync. can be many resolutions, most all of which where 4:3. Could also support many different refresh rates, higher than NTSC 59.97hz. XGA was an extension of VGA into more HD worlds with max of 1600x1200 (double check??) is all the way up to WHUXGA now (wide hex ultra extended graphics array) but who the heck uses it??

- DV digital video - pretty much the most barebones digital representation of analog video. oftentimes visibly much worse quality than the analog. usually recorded directly to magnetic tape, ala DAT and old school computer biz. HDV could do 720 and 1080. the tapes were usually useless after 2-4 uses.
- sGRB was a broadcast signal used in some situations aka sync on green
- YPbPr aka component aka betamax. could also support HD 16:9 resolutions and progressive scan signals at 29.97 and 59.94 including 720i/p and 1080i/p. could it do true 30 and 60? got to ask rob schafer lol.
- YCbCr is digital used in SDI, DVI, and HDMI
  - SDI (the new and current broadcast standard) very similar to the CVBS signal but oversampled, ie instead of having a digital queue of (Cb Y Cr) (Cb Y Cr) where adjecent pixels are enclosed in parenthesis, for sd resolutions sdi will have (Cb Y Cr) Y' (Cb Y Cr) where Y' is an oversample in between sequential Y samples.

cables

  - people in non pro settings tend to call cables by their terminators. however, the cables (for analog) are all coaxial with 75 ohms resistance. VGA, DVI, HDMI, SCART cables are actually many little cables all in the same shielding. many of the digital cables are same construction and resistance up until you get into 4k and past territories

terminators (images are necessary here, possibly a table)

- skinnier threaded nut with a little needle inside : f type. used for a video signal at VHF/UHF frequencies, ie directly from an antennae
- yellow rca - CVBS
- bnc -CVBS or SDI or used with a d-sub 15 breakout ANY signal!
- 4 pin mini Din: s video- y/c
- component- a Green, Blue and Red cable YPbPr
- d-sub 15 - VGA & XGA but also any and every of the above when paired up with
  - d-sub 15 to bnc breakout. for video you usually see a maximum of 5 bnc breakouts (for a RGB H and V sync outputs). often see these in use on Test Pattern Generators, older computer monitors, and twilight era analog video mixers capable of switching between numerous analog video signals i/o

- SCART in europe - could do signal i/o, audio, various controls and various video signals
- firewire 400, 800, and up into thunderbolts: DV. probably only 800 and up hdv
- DVI (digital video interface): the world of DVI was meant to be a bridge from analog into digital video. Different letters suffixes (dvi-a, dvi-d) reflected slightly different arrangments of pin outs on the terminators that could transmit analog or digital video at various resolutions, rates, and color spaces. The many tiny pins and subtley different terminators resulted in an obnoxious amount of pins getting bent out of place when attempting to put them where they didn't belong. disliked heavily by nearly anyone who had to use them regularly.
- HDMI- carried the same VIDEO signals as DVI but with ability to handle audio, handshaking (a back and forth signal to find the best compromise for desired video color encoding, resolution, and rate) and EDID (copy protection in a futile attempt to dissuade piraters). the lack of any kind of lock system, low lifespan, and infinite handshake loops when connections got loose of most terminators made many people nostalgic for dvi, which is saying something.
- mini BNC used in hd SDI.

.misc terms

- broadcast : usually in reference to broadcast standards. the main television stations transmitted over VHF radio frequencies for public consumption (abc, cbs, nbc, and pbs with fox and others coming later). typically broadcast standards are contrasted with public access (transmitted over UHF with less range), cable (transmitted over physical cables), and consumer standards. Means both higher quality and also the occult accumulation of quirks and intricacies that invariably accompany any massive set of standards that require infinite backwards compatibility
  - also contrasted with video standards for areas in which there was no need for broadcasting, ie medical, military, engineering & science, etc. most of the gear in these worlds from 80s-early 00s would be as likely to be VGA based as CVBS.
- video: shortened from video tape. used in contrast with Television (typically broadcasted live) and Film (entirely different method, quality, philosophy of recording sequential images) in 70s and 80s until becoming somewhat inchoate in late 90s onwards as Broadcast stations increasingly shot & transferred archives to/on video tape and the home video market exploded. in the 00s (SOV) Shot On Video as a qualifier for a move shifted from "peice of shit" to "experimental art " (lynch, von trier, et al) read radical software to explore the emotional & social connations of video and television in a more immediate context.
  - in modern usage, video seems to reflect the more rough and ready DIY aspects of recording