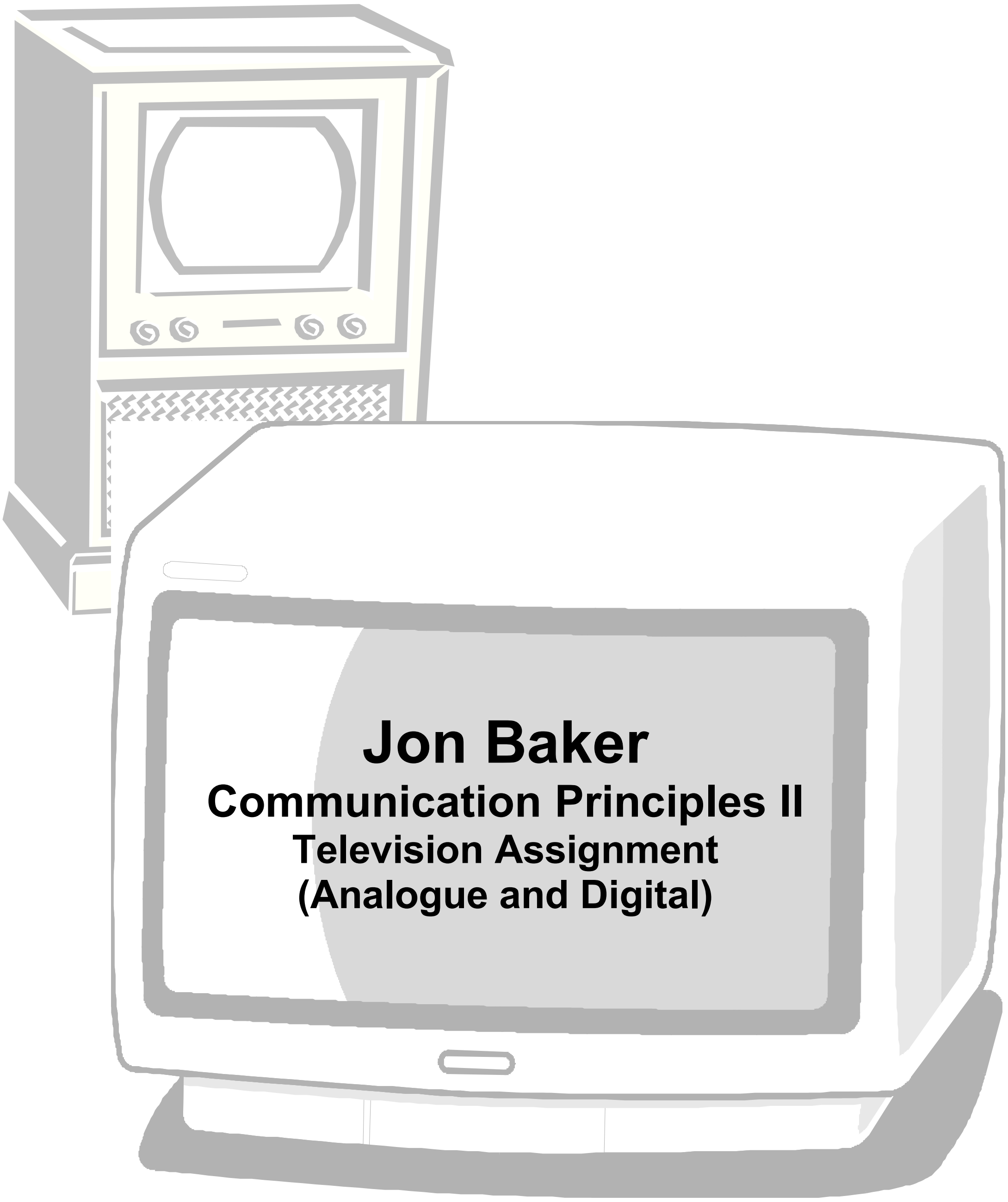


Jon Baker

Communication Principles II

Television Assignment

(Analogue and Digital)

Contents

Introduction

In this assignment I will be looking at commercial television receivers, how they work, the new digital television and why we are being told it is better.

Please note the glossary of terms at the end of the assignment for reference.

I will be starting with analogue television.

Analogue TV

1.1 Investigate the operation of a commercial analogue TV receiver.

In this section of the assignment I will be looking at a standard analogue TV receiver and how it works. To summarise before I go into detail a colour television will have several components:

1. Signal input and selection
2. Audio processing
3. Picture decoding and output
4. Sync signal processing and output

Between all these sections you can create a full television set.

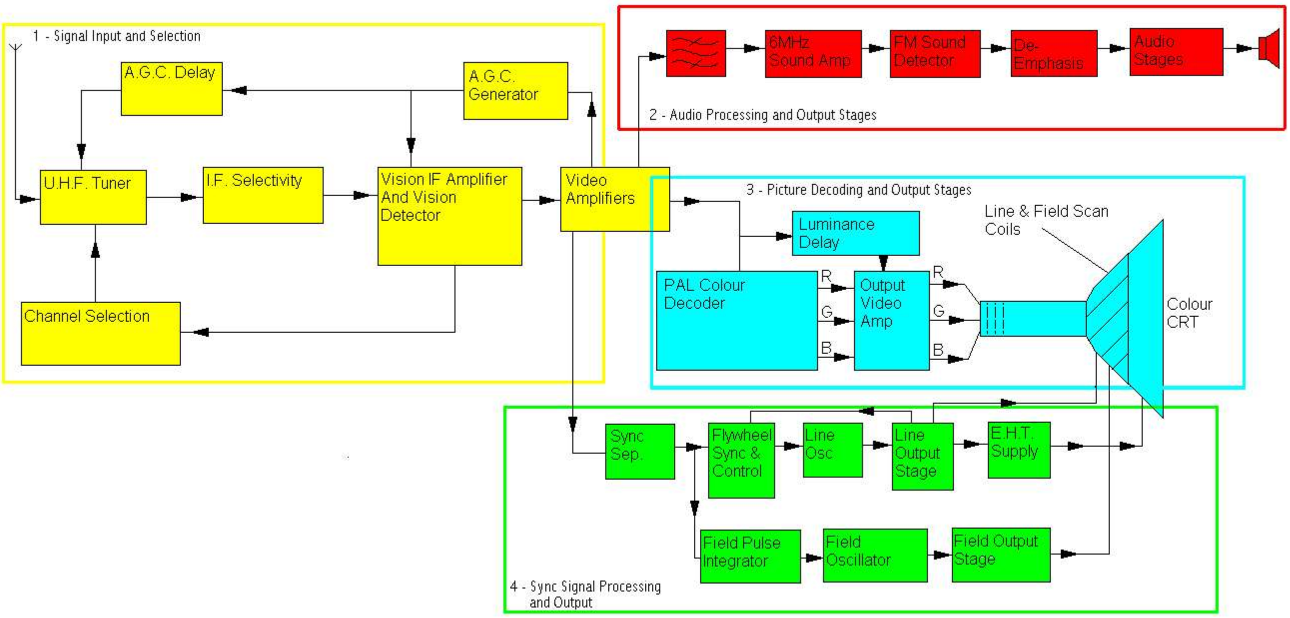
The signal path is as follows:

1. The channel selector locks onto one station
2. The signal is taken in through the aerial and goes to the amplifiers
3. The signal is amplified
4. Filters separate the audio and video signals
5. The FM audio signal is amplified, de-modulated and sent to a speaker
6. The video signal is separated: picture information and sync signals
7. The picture information is sent to the CRT for output
8. The sync signals are sent to the CRT to keep in time with the picture

This is a very simplistic guide to the operation of a television but explains how they work to an extent. Over the rest of this section I will go into detail on the operation, the procedure for displaying a picture on the screen and briefly the construction of the CRT.

There are two things that can differ in a television those are the refresh method (either *interlaced* or *progressive*) and the picture standard (mostly either *PAL* or *NTSC*). I will explain about the refresh method in section 1.4. The difference between PAL and NTSC is quite simply that PAL refreshes at 50Hz with 625 lines while NTSC refreshes at 60Hz and has 525 lines. These video format standards are called Videonorms, PAL is used almost all over Europe and Australia while NTSC is used in the USA, Canada and Asia. PAL is however better than NTSC as NTSC can suffer from one serious effect, if any of the carriers are attenuated then colour can be lost and if its phase is disturbed the colour can in fact change totally. PAL has a way of preventing this effect by alternating the phase every line and thus stopping this for having such a disastrous effect, and so its name Phase Alternation Line. This has little effect on the circuitry but does make the decoding of a PAL signal a much more complex process to understand.

1.2 Draw a comprehensive block diagram of a typical analogue TV receiver.



1.3 **Describe the operation of the receiver with reference to the block diagram**

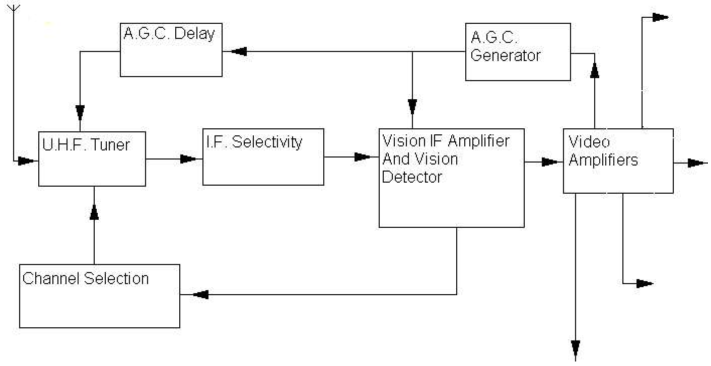
You can easily split the above diagram into four sections:

1. Signal input and selection
2. Audio processing and output stages
3. Picture decoding and output stages
4. Sync signal processing and output

As I have already said.

I will start moving deeper into the block diagram, and start with the first point.

Signal Input and Selection



UHF Tuner
This block takes the input from the aerial and also the frequency selection from the *Channel Selection* block and the gain control voltage from the *AGC Delay*. Once the frequency range is tuned it outputs this range to the *IF Selectivity* block.

IF Selectivity
This block takes the input frequency range from the *UHF Tuner* and down-converts it to an IF frequency for this circuit to work most efficiently. It outputs this frequency range to the *Vision IF Amplifier and Vision Detector*.

Vision IF Amplifier and Vision Detector
This process amplifies the IF frequencies and demodulates the video data stream to acquire the signal strength. It also outputs this information to the *Channel Selector* to keep the tuner locked to this frequency. The *AGC generator* voltage is as a gain for the amplifier to keep the signal strength at a reference level. The final data stream is sent to the *Video Amplifiers* block.

Video Amplifiers
This block simply amplifiers the whole frequency range. It outputs its signal to the other three areas, audio processing, video processing and sync signal processing.

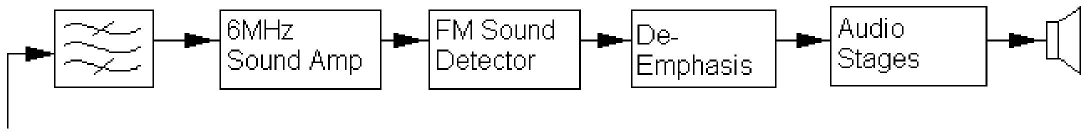
AGC Generator
This block checks the amplitude of the signal coming in and compares it to a reference. The block is also used to generate the voltage required to stabilise the incoming signal strength to maximise the frequency range useful to the *UHF Tuner*, it outputs the voltage signal to both the *AGC Delay* and *Vision IF Amp and Detector* to adjust the signal to the required strength.

AGC Delay
The AGC delay is a CR timing circuit used to delay the change the AGC makes on the signal so it doesn't immediately implement the change, the lower the CR constant the quicker the system replies to signal strength change.

To summarise this section, the signal is tuned and locked to the right frequency for the selected channel, this signal is amplified with reference to the AGC gain, the video data is demodulated and the whole lot is amplified before being sent to the rest of the system.

The next section deals with the processing and output of the audio signal.

Audio Processing and Output Stages



Band Pass Filter
This filter takes the entire received signal and leaves only the sound stream required. A 6MHz band pass filter.

6MHz Sound Amplifier
This amplifies the 6MHz sound data band.

FM Sound Detector
This block de-modulates the signal by standard frequency modulation into a normal audio stream.

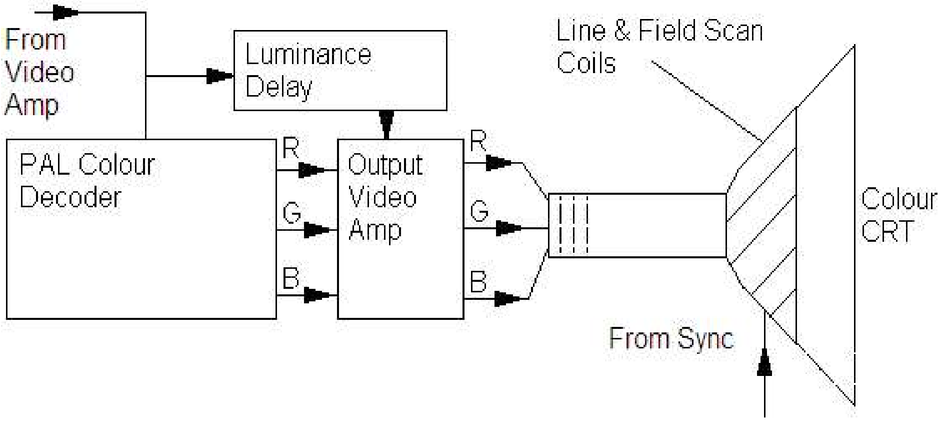
De-Emphasis
This circuit is here to remove the pre-emphasis from the transmitter as FM systems require this so the sound will not sound distorted. Pre-emphasis is done on this to start with because when you frequency modulate a signal the highest modulating frequencies cause a lot of noise so it can be advantageous to emphasise these first, therefore the de-emphasis is required to restore the original response.

Audio Stages
This stage is simply final amplification and often a driver stage (so there is no loading) before output to the speaker.

To summarise these stages take the audio stream out of the whole signal, decode it and output it.

The next set of stages deals with the picture being put onto the screen.

Picture Decoding and Output Stages



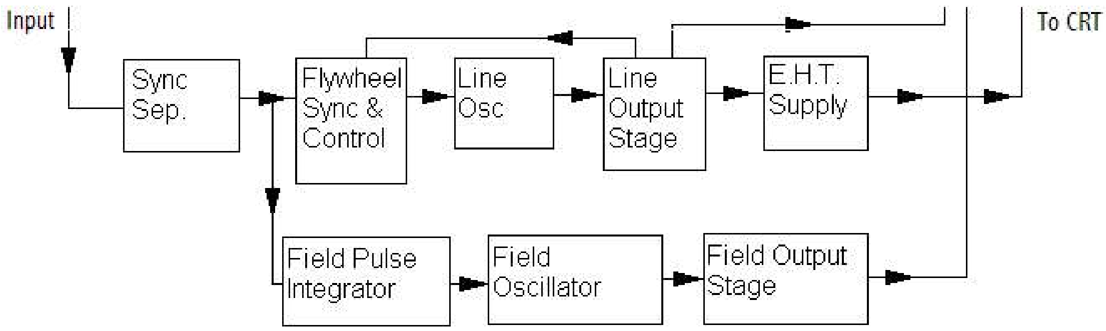
Although this is the smallest set of stages it is the most complex. The PAL Colour Decoder is a complex IC or ICs. As I said to the introduction to this analogue section PAL is a difficult system to understand. At a simple level, the video signal is sent to the decoder which turns the signal into the colour data which can be sent to the CRT. The *Output Video Amp* then amplifies this signal relative to the amount of luminance required before finally sending it to the CRT. Quite simply the luminance delay provides the gain for the amplifier. All the time this is happening, the outputs of the sync stages are being sent to the CRT too, this keeps the lines and fields in sync with each other.

Luminance Delay
This block is used to keep all the sections in step with each other, as signals have different bandwidths they all take different amounts of time to arrive, this delay is used to make sure the luminance information is arriving at the same time as the RGB signal that it matches too.

PAL Decoder
The main job of the PAL decoder is to take the incoming data from the input signal and turn this pixel by pixel into the intensity of the other 3 colours, this is done primarily by a DAC.

The final section to go through is the video sync section.

Sync Signal Processing and Output



Here you can see the separate sections that allow the picture to be displayed correctly.

Sync Separator
This block takes the whole input signal and filters out the two bits of required information for these stages, the line and field sync pulses. It then outputs the line and sync pulses to the *Flywheel Sync & Control* block and the *Field Pulse Integrator* block respectively.

Flywheel Sync & Control
There are two ways of controlling line syncs, they are direct and flywheel. Direct is easier but simply works on using the pulses in the signal, however if one of these is missing or too noisy the signal is lost and the picture becomes out of sync and line tearing occurs. Flywheel however does not use this system. The flywheel uses a phase locked loop system in which whenever the horizontal sync pulse is registered it locks onto this timebase and keeps it in case the pulse doesn't appear after the next line (due to noise etc… as said above) so that it stays in sync even if that error does occur. The timebase that was registered is sent back from the *Line Output Stage* to complete the phase locked loop.

Line Oscillator
This is part of the above mentioned phase locked loop. This stage generates the oscillating frequency which gives a reference to the phase locked loop.

Line Output Stage
This stage sends back the flyback pulses to the *Flywheel Sync & Control* and processes the sawtooth waveform so that whenever it passes through 0v on a negative edge the output waveform causes a current pulse through the deflection coils.

EHT (Extra High Tension) Supply
This stage takes the output from the *Line Output Stage* and using several transformers takes this signal and increases its voltage to or above +10kV for monochrome and up to or above +24kV in a colour receiver. This is then supplied to the CRTs final anode. To make this signal suitable for the final anode it has to be rectified and smoothed with a capacitor for supplying it.

Field Pulse Integrator
To sync the fields, you require a 50Hz pulse. This integrator is the first stage which turns the vertical sync pulses into a sawtooth waveform.

Field Oscillator
The integrated signal here creates the oscillating pulse in the similar sawtooth form.
This is often where the positive feedback from the output stage is fed in. This is done to improve the quality of the sawtooth waveform so when it is used it will defiantly more accurate for the timing than the original would have been. There is a driver stage in here too which makes sure the oscillator doesn't become loaded. This will usually be an emitter-follower as this provides a

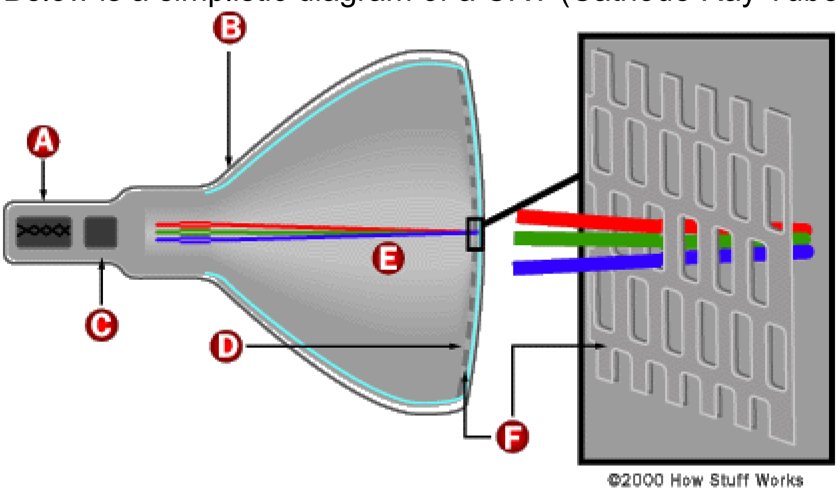
good match between the high output impedance of the *Field Oscillator* and the low input impedance of the *Field Output Stage*.

Field Output Stage
This stage takes in the sawtooth waveform from the driver stage, the signal being a voltage changing sawtooth waveform. Through a series of transistors this change in voltage controls the current output through the deflection coils being the same sawtooth waveform at a fixed voltage. This current controls the field flyback.
Often from this stage positive feedback is sent to the oscillator to linearise the waveform sent to the driver stage.

To summarise these stages, the signal is stripped of everything but the sync pulses which are then altered in such a way that they can be sent to the CRT at the appropriate time. This is the point at which point they are sent to the CRT and these signals keep the timing of the display correct so the picture is correct and the EHT Supply stage supplies the power to drive the electron beam.

1.4 **Describe how the picture is formed on the screen**

Below is a simplistic diagram of a CRT (Cathode Ray Tube).



A	Cathode	**D**	Phosphor-coated Screen
B	Conductive Coating	**E**	Electron Beams
C	Anode	**F**	Shadow Mask

The input signal from the reception circuitry is connected to the cathode. As the anode is positive and the electrons are being sent to the cathode they are attracted towards the anode. This anode is a focusing anode there are one or more pairs of these, and there are also accelerating anodes. In fact these electrons can end up moving at $8*10^{7}$ metres per second! At the end of the vacuum is a phosphor coated screen. Phosphor emits visible light when exposed to radiation. The procedure runs as follows:

The signal is sent to the cathode and is attracted to the anode, the electrons pass through the focusing anode then the accelerating anode. As the electrons pass out of the anodes they are travelling in a tight high-speed beam. This beam flies through the vacuum and hits the phosphor screen at the end which then glows.

This shows how to get the signal on the screen with the exception of one important point, how to steer the beam. Currently if you connect an input signal the beam will simply shine in the centre of the screen. However if you look at the diagram it shows a conductive coating around the outside of the vacuum tube. This conductive coating allows us to *steer* the beam. There are circuits inside the TV to control deflection coils (inductors) that move the electron beam left to right and top to bottom.

One *run* of the screen is from the top left over to the top right, then there is a *flyback* which returns the beam to the left and then moves down slightly. Then the beam moves over to the right again, and so on until it hits the bottom right, this *run* is called a *raster scan*. At the bottom right of the screen a *flyback* is also performed to reset to the top left.

Raster Scan – A full trace of the screen
Line Flyback – The movement back from the right of the screen to the left
Field Flyback – The movement from bottom right to top left of the screen
Line Scan – The left to right motion of the electron beam
Field Scan – The vertical motion of the electron beam

To synchronise the timing of the scan signals to the recorded images being transmitted certain timing signals must be included in the transmission to execute these *flybacks*, they are named:

Line Flyback Sync – This, as the name suggests, is transmitted at the end of each line to inform the CRT to perform a line flyback
Field Flyback Sync – Transmitted at the end of a field to perform a full screen reset

At this point it is probably a good idea to explain how the image on a CRTs screen is made up. The image is separated into lines, as I've said, 625 for PAL. Each line is made up of dots or *pixels*.

For the actual picture information the brightness or intensity of the dot is sent, all this together is enough to display a black and white picture on the screen, for producing colour there is a little more to it. To start with there are three electron guns, each producing a different coloured beam, red, blue, and green. Also the phosphor coating on the screen is not a single layer of one colour, but three strips, red, blue and green to match the guns. Just behind this layer is a thin metal coating with small perforations. To create different coloured dots, you can fire the guns in different ways. Each one can be fired by itself which can produce three different colours, all three can be fired together to produce a white dot and lastly you can not fire any of them creating a black dot. Any other colour is a combination of the three colours and is embedded in the signal (the *chrominance* signal) right after the line flyback sync pulse as a sine wave with a phase shift, the phase and amplitude of the signal determines the colour and brightness respectively.

As I mentioned in the overview at the beginning there are two ways to scan the screen: progressive and interlaced. The one described here is progressive, this is however rarely used in televisions. Interlaced is the same basic principle except this method is designed to double the refresh rate, it works by only refreshing half of the screen per raster, the odd lines first scan the even ones on the second scan theoretically double the refresh rate.

1.5 Give a brief description of the construction of the TV tube.

A TV tube, or CRT, is both complex and simple, simple in the sense there isn't much in the quite large device, but complex in what little is there is very delicate and complicated equipment. At the back of the CRT is a set of anodes and a cathode. Please see section *1.4* for a diagram of a CRT. The signal is connected to the cathode, the anodes inside are more complex than a simple connection, it contains focusing and accelerating elements in the form of electrostatic lenses. The actual tube is a vacuum through which electrons can flow, and it is covered in a conductive coating to allow the electrons to be controlled in direction. The controls are actually opposingly charged deflection coils (inductors) that are weak enough as to not attract the electrons and hold them, but strong enough to influence their path. At the front of the screen is a phosphor covered surface, this is what you actually see, it glows showing a picture. That is all there is really to the tube, the cathode, anodes, vacuum tube, deflection coils and phosphor surface. In a colour tube there are three colours of phosphor (red, blue, and green) and also a thin metal sheet behind this surface with small perforations in, allowing which colour the electrons hit, to be controlled giving a control over colours.

Digital TV

2.1 Investigate the operation of a commercial Digital TV receiver.

The Digital TV receiver is much more complex electronically than an analogue TV receiver is, however some basics still apply, there is a tuner unit, a CRT and synchronising signals. The change comes in the way the signal is transmitted and decoded.

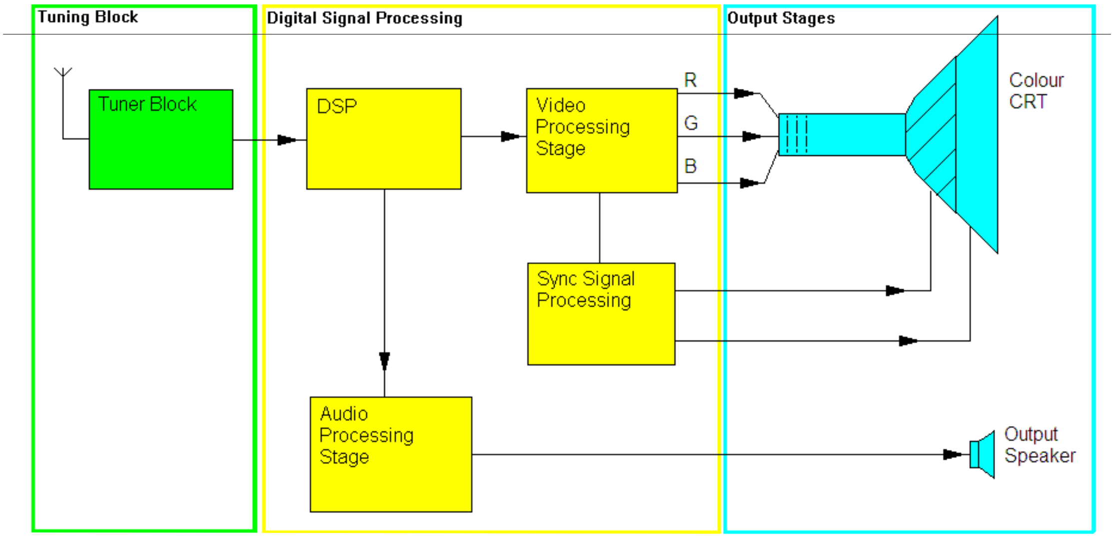
To fit more data into the signal, the video and audio information is *encoded* using what is known as MPEG encoding. This is the same way that PC video files and even similar to the way DVDs are encoded. Without going into too much detail MPEG isn't actually the way the data stream is encoded it's the name of the group that developed it, *Moving (or Motion) Picture Experts Group*. The compression method is DCT (*Discrete Cosine Transform*) and it works by using the fact that adjacent pixels in a picture being either physically close in the same frame or in successive images (spatial and temporal respectively) may be the same (or very similar) colour value and as such blocks of 8 by 8 pixels are transformed mathematically into the same colour, this doesn't directly reduce the bitrate but it does mean that some of the higher and lower frequencies contain information that can be discarded as it is the same as information contained elsewhere, therefore reducing the bandwidth of the transmission. Using these compression schemes MPEG-2 can reduce the amount of bits by about 55 to1!

This more computerised approach makes the receiver more complex and expensive but does allow for a better use of the frequency spectrum and a better viewing experience for the watcher as more information can be transmitted.

Here are the main block stages involved in a Digital TV:
1. Tuner and Channel Selection
2. Digital Signal Decoder
3. Audio, Video and Sync signal splitter
4. Audio Processing
5. Video Processing
6. Sync Signal Processing
7. AV And Sync Signal Output

Here is a simplified data flow of the information through a digital TV:
1. The selected channels frequency is locked into the tuner
2. The signal input is sent to the DSP (*Digital Signal Processor*) which decodes the MPEG stream
3. The audio and video streams are separated (de-multiplexed)
4. The audio is sent to an audio decoding stage and then outputted
5. The video and sync signals are separated
6. The video stream is PAL decoded
7. The sync signals are processed
8. The video is outputted to the CRT to the time of the sync signals

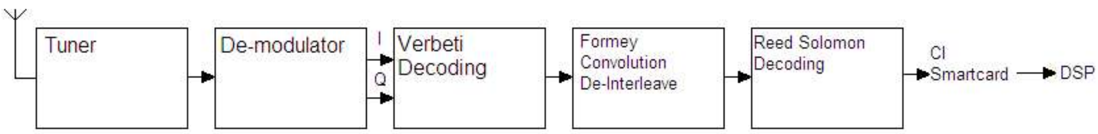
2.2 Draw a block diagram of a typical digital TV receiver



2.3 Describe the operation of a digital TV receiver

The above block diagram is a very simplified version of a much more complex system, and I will therefore in this section be going into more detail on each stage. Before I start I would like to note that the video and sync processing stages are the same as in the analogue system I detailed earlier (See sections 1.2, 1.3) and I will therefore focus more on the DSP block and the tuning stages. The operation of the CRT has also being covered previously (See sections 1.4, 1.5).

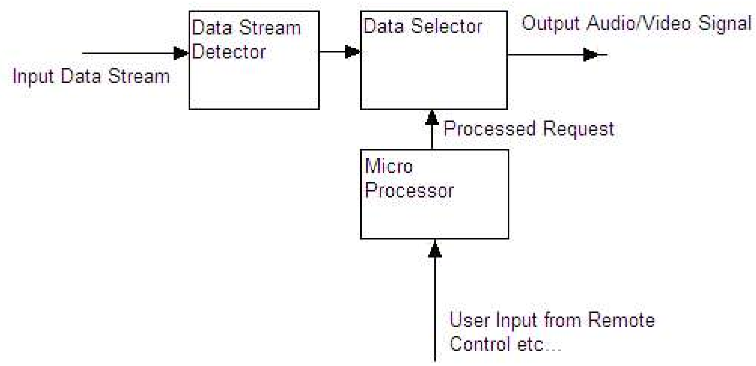
To start with, the *Tuner Stage* is used, quite simply this stage amplifies the incoming signal locks onto a channel and down-converts this signal to an IF. For further information see Section 1.3 on the Tuning Stages as this is a very similar process. The only section here that differs is the *Vision IF Detector and Amplifier* stage as in the case of digital signals the data stream is very different. Firstly the signal is demodulated producing two signals called I and Q in the case of nQAM systems which is normally the case. Following this is a Viterbi decoding stage, this is the form of error correction used in digital systems to make sure that none of the incoming bits have been registered incorrectly. There are several other stages here that occur and they are shown in the diagram below:



As you can see, the tuner section follows through to the demodulator which then produces our two outputs which are processed for errors. The next stage following is there to re-order the bits into the correct order. The next stage is *Reed Solomon Decoding* which is based on an area of mathematics called finite fields, this process as the two before it are all performed to encode the data at the transmitter so the inverse must be performed at the receiver to decode the information. The processes are performed simply to make sure the data is error corrected and the picture is how it should be. Although digital data is much easier to detect as it's only a 1 or 0 this process can ensure the data is correct. This is one thing that makes digital TV better, although it's as prone to errors as analogue they can actually be corrected in digital. Following these stages the CI (*Common Interface*) is accessed, this is the part that contains the smartcard.

Next there is the Digital Signal Processing. This is the different stage, in here is the DSP block which is the IC that processes the MPEG stream. The stream has to be *de-multiplexed*. This means the audio and video signals have to be stripped away from each other and can be sent to separate processing for all the sync signals, video signals and audio signals.

One process here I haven't mentioned is the user interface. As digital offers much more information in the DSP stage it is possible for the user to choose a video/audio stream from the channel or other information. All this is processed as follows:



The Data Stream Detector processes the incoming signal to determine what it contains, how many audio/video streams and any other data, a table of where all this data is to be found in the stream is kept. A micro processor takes the users selection and processes what they selected to the Data Selector can match this with the table and output only the data wanted. This can then be separated and sent to the separate audio and video processing stages which work as explained in Section 1.3.

Once all this is completed all this information is sent to the Output Stages and the signals can be seen and heard. This output is also explained in Section 1.3 and is the same process.

Comparison

3.1 Compare the two methods given above

I will breakdown this comparison into several sections to make it more comprehensive. In each section I will describe both the analogue and digital side for the next section when I will compare them to each other. The topics in discussion are:

1. Bandwidth
2. Quality of Output
3. Complexity of System
4. Features Available
5. Noise Effects

Bandwidth
A normal analogue channel which can contain picture information, mono and stereo sound as well as teletext data is contained in the bandwidth of a channel.
A digital channel can contain between one and four audio/video data streams dependant on quality with mono, stereo and surround sound channels embedded in it. Other data such as programme information, subtitles, a more informative teletext service and web access plus games can be incorporated too.

Quality of Output
The audio streams are as follows:

Analogue	Mono, Stereo
Digital	Mono, Stereo, Surround, Digital, SPDIF

The picture quality of an analogue system in the UK on PAL is 585 active lines.
The picture quality of a digital TV is at the same definition as a analogue TV if connected as a set-top box since you are using the same CRT, however, there will be no interference, it is possible to connect the system to better quality television sets, in the US you can buy TVs that are as higher resolution as computer monitors. Standard televisions have a horizontal resolution of 390 pixels and a vertical resolution of 585 lines. In the US a standard ATSC screen can have up to 1920 pixels over 1080 lines! The system can also support a DVI connection.

Complexity of System
An analogue TV can be said to be complex but in practice compared with a digital TV it is much simpler since the Digital Signal Processor is not required. Apart from that the system is very similar but the DSP requires a clock and a decoding system and the system also has several other inputs and outputs such as digital and analogue AV outputs and a smartcard reader.

Features Available
Analogue systems are capable of the following:

1. A single video stream for each channel
2. A mono and stereo audio stream

3. Teletext signals

A digital system is capable of multiple video streams per channel, audio from mono to surround sound and much more such as interactive games, subtitles, programme information, and the teletext system. In the future digital TV will be capable of much more.

Noise Effects

In an analogue based system the incoming signal has the picture information directly coded into the amplitude of the signal, therefore noise directly alters the picture quality. The audio component isn't affected as much since the audio is FM not AM therefore noise affecting amplitude won't affect the audio as that is encoded in the frequency of the signal.

Digital systems, as I've already said, have the audio and video streams encoded as digital information therefore noise effecting amplitude will almost never have an effect as there would have to be serious noise induced on the signal to stop the system recognising the zeros and ones of the stream. However since this will happen at times in practice there are sophisticated stages in the tuner to correct this and restore the information, please see Section 2.3 for further information.

3.2 Motivate why the digital method is better than the analogue method

The two methods given above (analogue and digital) despite having similar components and stages in places are very different at signal level, this being the major change. Now, a digital image isn't automatically better than an analogue image, it could be better or worse, the reason is more complex than that.

The reasons can be broken down into three distinct advantages:

1. How much data it can transmit
2. The consistency of the data over distance
3. Type of data the signal can carry

Since the data is encoded using MPEG on digital transmission the bandwidth required is less, therefore more data can be sent in the same channel space. MPEG is a *lossy* system however, the compression ratio does give a poorer picture. There is a loss between the camera and the screen, it is however as good as or better than an analogue signal but not up to the quality of a DVD for example. Still it is better in every way than analogue, therefore digital scores its first point on utilising the frequency spectrum in a much more efficient manner.

One thing anyone who has ever watched an analogue TV will notice is the problem of *noise*, a *snowy* picture for example. Digital does not suffer from this, as long as it receives a signal, the signal is clear. This is because the signal being received is analogue but the embedded MPEG stream is digital, either a 0 or a 1, there is never any doubt as to what the amplitude of the signal is to acquire picture information because it doesn't matter. So the picture is clearer, score two for digital.

Lastly digital TV is not only capable of carrying a video stream and a basic Teletext system as analogue is. Since there is more bandwidth left over after the video stream other types can be embedded in the remaining bandwidth, extra video streams, other audio (surround sound for example), more information on content (like teletext only more advanced and with extra information). Digital TV really can make television truly interactive. Finally in this area there is the subject of *multi-casting*. This is where a digital channel sends a standard-definition picture instead of a high-definition picture. This may sound stupid as we've worked hard to increase the quality of TVs but the reasoning is sound as it's possible to include four video streams at standard quality instead of one at high quality, this is called *multi-casting*. Again digital wins out over analogue television.

So in conclusion analogue has no bonus over digital except (currently) cost since the system is more complex. Electronically and in every other aspect the digital method has advantages over the analogue method.

Glossary

AGC
Automatic Gain Control. This is a system used to control the gain of a circuit. It is usually used to alter the amplitude of a signal in such a way as to keep the output signal amplitude at a constant level. For further information see Section 1.3.

CR
A *Capacitor* and *Resistor* that in the case mentioned here are arranged in such a way as to produce a delay before the circuit continues.

CRT
This stands for *Cathode Ray Tube*, this is the device which produces and contains the viewable screen. The operation of the device is contained in Section 1.4, the construction of it in Section 1.5.

IC / ICs
Integrated Circuit. Simply a chip with thousands of transistors and capacitors in.

DAC
Digital to Analogue Converter. A circuit which turns a digital signal into an analogue waveform.

DCT
Discrete Cosine Transform. The compression method employed in MPEG files and digital TV. Working on the principle outlined in Section 2.1.

DSP
The *Digital Signal Processor* is the heart of the new digital TV sets. This chip de-compresses the MPEG stream and returns it to a state which can be processed and outputted by a CRT, see Section 2.2 and 2.3 for further details.

DVD
Digital Versatile Disc. The disc now commonly used to store data for computers and video streams for films.

DVI
Digital Video Interface. A connection used to output a digital video signal.

EHT
Extra-High Tension. The supply for the CRT is created in this stage shown in the diagram in Section 1.3.

IF
Intermediate Frequency. This is a frequency used inside a device. Often an input signal is down-converted to an IF so that it is at the optimum frequency for the system to use. If you don’t use an IF, systems have to have a very

large bandwidth and have to operate efficiently over it. As this can be expensive it's often much simpler to alter the frequency of the signal.

MPEG
This stands for *Motion/Moving Picture Experts Group*. The organisation that developed the MPEG file format and compression used in it. For further information see DCT and Section 2.1.

nQAM
Quadrature Amplitude Modulation. This is the modulation process used in most digital transmitters.

NTSC
The *National Television Standards Committee*. This is the US standard for television (Videonorm). The standard requires a 60Hz refresh rate (interlaced), and the screen output to have 525 lines. For further information please see Section 1.1.

PAL
This stands for *Phase Alternating Line*. This is the standard for television (or Videonorm) in the UK. The standard requires the refresh rate of the signal to be 50Hz (interlaced), the screen output to have 625 lines. For further information please see Section 1.1.

RGB
A *Red Green Blue* colour signal used to transmit the different colours through to the electron guns.

Smartcard
A device used in a digital TV to store data such as codes to access pay per view stations and owner/subscription information.

SPDIF
Sony/Philips Digital Interface. A connection used for outputting a digital audio stream.

UHF
Ultra-High Frequency. A signal between 300MHz and 3000MHz.

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