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Analog & Digital Television System

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Abstract--
The twentieth century has given birth too many inventions. Television is one of them which has created a revolution in the field of long distance communication.TV became possible when variation in light intensity could be converted into electrical signal and the electrical signal reconverted into brightness. From the simple TV today one can have smart TV with varying features satisfying all section of society. These introductory papers put the Analog TV system and explain how it is converted into Digital TV and also highlighting their features.

Keywords— Image Continuity, Interlace Scanning, MPEG, Compression, DSB

I. INTRODUCTION

Television is a popular and powerful medium which plays a central role in the multimedia environment in the present day world. Television includes both sound and picture which makes a magic medium allows us to watch the World from home.

Live nature of television allows it to transmit visuals and information almost instantly. This capacity of transmission makes it ideal for transmitting live visuals of news, sports and entertainment event.

All these capabilities are the result of research and advances in technology in many fields. In a relatively short period, TV is regarded as one of marvelous inventions. Combined with the computer, internet and web technologies, today TV is becoming an excellent example of convergence of communication. Technically the information content of video signals is very high and its transmission and reception by conventional means would require a very high bandwidth which would be practically impossible. The advances in coding, compression and signal processing techniques have made the low bandwidth video possible. This was further possible in making large number of TV channels and programs available in limited spectrum.

This paper provides difference between Analog TV and Digital TV has its roots in the way TV signal is transmitted from the source to the TV, as per consumer needs. II Analog TV

The fundamental aim of a television system is to extend the sense of sight beyond its natural limits, along with sound associated with scene being televised.TV system is an

extension of the science of radio communication with the additional complexity that besides sound and picture details are also to be transmitted.

The frame adopted in all television system is rectangular with width/height ratio known as aspect ratio [1]. Television implies viewing motion far from the observer that is to see at a distance, so televising picture element of the frame by means of the scanning process, it is necessary to present the picture to the eye in such a way that an illusion of continuity is created and any motion in the scene appear on the picture tube screen as a smooth and continuous change. To achieve this, advantage is taken of persistence of vision or storage characteristics[3] of the human eye .This arises from the fact that the sensation produced when nerves of the eye's retina by incident light does not ceased immediately after the light is removed but persist for about $1/16^{th}$ of a second. Thus if the scanning rate per second is made greater than sixteen, the eye is able to integrate the changing levels of brightness in the scene. So when the picture elements are scanned rapidly enough, they appear as a complete picture.

In television pictures an effective rate of 50 vertical scans per second is utilized to reduce flicker. This is accomplished by increasing the downward rate of travel of the electron beam, so that every alternate line gets scanned instead of successive line. When the beam reaches the bottom of the picture frame, it quickly returns to the top to scan to those lines that were missed in the previous scanning. This method of scanning is known as interlace scanning [2]. This method of scanning reduces flicker to an acceptable level since area of the screen covered at twice rate.

In most television system, the picture signal is amplitude modulated and sound signal is frequency modulated before transmission. The channel bandwidth is determined by highest video frequency required for proper picture reception and the maximum sound carrier frequency deviation permitted in a TV system. The total bandwidth per channel is 7MHz. which include picture signal, sound signal and color information of the picture. The frequency bands that have been assigned for the use of TV station is given in Table I

Band I	41-68MHz	Lower VHF range
Band III	174-230MHz	Upper VHF range
Band IV	470-582MHz	Ultra High frequency range
Band V	606-790MHz	UHF range

Frequency Spectrum Band

Composite video signal [3] consist of a camera signal corresponding to the desired picture information, blanking pulses to make the retrace invisible and synchronizing pulses to synchronize the transmitter and receiver scanning, horizontal synchronizing pulse is needed at the end of each active line period whereas a vertical sync pulse is required after each field is scanned. The amplitude of both horizontal and vertical sync pulses is kept the same to obtain higher efficiency of picture signal transmission but their duration is chosen to be different for separating them at the receiver. Since sync pulses are needed consecutively and not simultaneously with the picture signal, they

are sent on time division basis and thus form a part of the composite video signal.

TV Transmitter and Receiver : At the TV studio ,the TV camera i.e. vidicon camera, pumbicon camera or solid state camera based on CCD focuses an optical image of the scene on its photosensitive plate and the picture element of various light intensity are converted into correspondingly varying electrical signals by a process of electronics scanning. The electrical signal so formed by scanning the picture image by an electric beam are called video signal. At this stage certain synchronizing signals are added to the video information. The composite video signal so formed is amplified by video amplifier and made sufficiently strong to amplitude modulate a picture carrier .The sound signal picked up by microphone is converted into electrical current called audio signal and is amplified by audio amplifier

.Audio signal is frequency modulated by a separate carrier. Two separate RF carriers are used for video and audio transmission. The power output of the picture and sound transmitters are combined in a diplexer and feed to common transmitting antenna. The transmitting antenna is turnstile antenna array used to radiate equally in all direction. At the receiving end both the picture and sound carriers are intercepted by the same receiving antenna and passed to a wideband circuit called tuner. The tuners consist of RF amplifier, mixer and local oscillator. In the tuner two separate intermediate frequencies for picture and sound signal are formed by heterodyning with local oscillator frequencies. The video and sound IF's frequencies are amplified and detected by video detector and FM detector respectively.

A portion of composite video signal is given to synchronizing separator where synchronizing signals are separated from video signal and applied to deflection circuit to keep electronics scanning beam in the picture tube in synchronizing with electronic beam at the transmitter. Generally picture tubes used are delta gun, precision in line tube or trintron tube. This picture tube convert electrical signal again into colour picture having various brightness levels.

Horizontal deflection section plays an important role to generate low and high voltages required for various part of TV receiver. Generally 18V to 20kV is produced but the current requirement is extremely low ranging about 300µA.

Colour TV is based on additive color mixing where all colours including white can be created by mixing red, green and blue lights. The colour camera provides video signal for the red, green and blue information. These are combined and transmitted along with the brightness signal.

At the receiver, the three colour signals are separated and feed to the three electron guns of colour picture tube. Each gun produces an electron beam to illuminate the three colour phosphors separately on the fluorescent screen. The eye then integrates the red, green and blue colours information and their brightness to perceive the actual and brightness of the picture being televised as per Grassman's Law.

Analog TV transmissions were subject to interference, such as ghosting and snow, depending on the distance and geographical location of the TV receiving the signal.

Television has following specification Given in Table II

Parameters	Standard values
Number of lines per frame	625
Aspect Ratio	4:3
Line Frequency	15625Hz
Field Frequency	50Hz
Picture Frequency	25Hz
Interlace ratio	2:1
Scanning Sequence	Line: Left to Right Field: Top to Bottom
Video bandwidth	5MHz
Channel Bandwidth	7MHz
Sound Carrier relative to Picture carrier	5.5MHz
Sound carrier relative to the nearest edge of the channel	-0.25MHz
Vestigial sideband lower	0.75MHz
Type and polarity of video modulation	A5C AM negative
Sync level as percentage of peak carrier	100%
Blanking level as percentage of peak carrier	72.5to 77.5%
Peak white level	10 to 12.5%
Type of Sound modulation	F3FM
Pre-Emphasis	50µSec
Resolution	400max.
Colour subcarrier frequency	4.43MHz

Specification of Analog TV System

III Digital TV

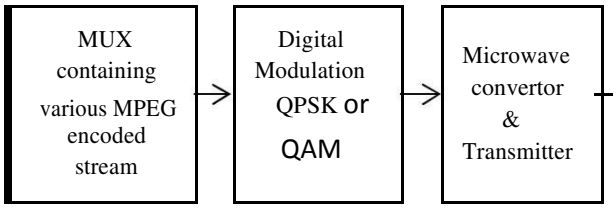
Digital technology has an edge over analog technology in combating noise to increase the clarity of signal hence there has been a shift towards digital techniques. Digitization leads to many advantages like easy detection at the receiver, reduction in power required for the transmission, cost of digital transmission is less, biggest advantage being improvement in SNR even without use of error control coding techniques compared to analog transmission , but at the same time demands higher bandwidth for operation. With the development in compression techniques and bandwidth efficient modulation techniques digital transmission has become a reality. Digital TV has removed the line of distinction between the computer and TV and merged TV and computing because of the digital representation of image and video. Fig.1 gives the basic block diagram of DBS-TV transmission and reception. Digital TV also called as Direct Broadcast Satellite (DBS) TV and Direct to Home (DTH) TV [6]. It is broadcasted using satellite system, where before transmission the signals which originate from various sources are converted to digital, compressed, time division multiplexed and QPSK[7] modulated before transmitting on uplink to the satellite transponder. The receiver unit at home of the user has an important device called Digital Set top box which provides the user the access to various digital content. The basic work of these set top boxes is translation of signals in the format that can be displayed on the screen. The set top box should have capability to support cable, terrestrial, satellite, IP broadcasting, as well

have hybrid capability. They should stream data from anywhere in the world whether it is occurring live or stored in some device and should provide high quality user experience.

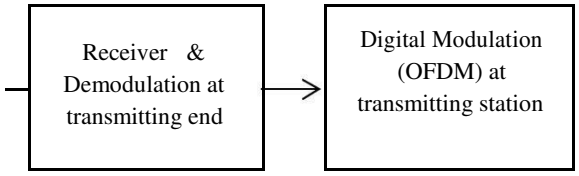
The set top box contains various parts, some of the important components are

- Microcontroller
- Digital information processor
- Video interface unit
- Audio Interface unit
- User interface unit
- Power converter
- Connectivity

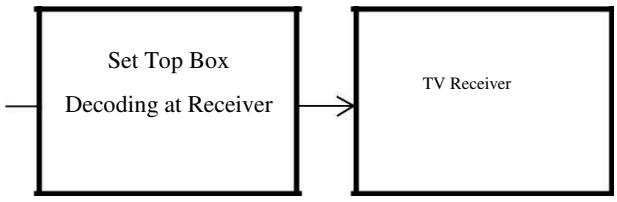
Fig.1 gives a broad overview of digital television broadcasting system at production, transmission and receiving ends. As the bandwidth required for digital transmission is very high compared to that required for analog transmission so there is a strong need for compression of coded video bits before transmission. The predictive coding does the compression of each pixel by quantizing the difference between the actual and the predicted value based on the coding techniques employed, whereas the transform coding employs Discrete Cosine Transform (DCT).



TV Production Station



Digital TV Transmitter Station



Receiver End

Fig. 1 Digital TV Broadcasting Station

Advantage of DCT is that using it the samples are de correlated so that they can be compressed independent of each other. For standardization of video coding for digital TV efforts were done by ISO's MPEG (Moving Pictures Expert Group). Before MPEG, CCITT recommendation H.261 defined a video codec [5]. MPEG has now collaborated with various world representatives to evolve a unified standard. In developing these standards an important factor which is taken into account is human visual system. With the improvement in motion picture compensation techniques coding efficiency has improved widely. The H.264/AVC[7] standard offers advantages in terms of improvement of coding efficiency, error robustness enhancement and flexibility that can be used over a variety of applications. Video coding layer (VCL) design of H.264[4] is based on block based motion compensated hybrid video coding concepts but when compared to previous standards some notable differences include

- Improvement in motion prediction
- Small block size is used
- Improvement in de-blocking filter
- Coding method is enhanced

Another important aspect of digital transmission is bandwidth efficient modulation techniques employed for

transmission. With the entertainment becoming on the go we as a user want to control what to watch, when to watch and want more and more services, the modulation techniques employed play a vital role in providing all the services. Table II gives a comparison of basic compression and modulation techniques used for audio and video information. Table II

Summary of Audio & Video Coding& Compression Techniques for Digital TV

Data Type	Data Format	Coding Compression Techniques	Compressed Data Rata	Uncompressed Data Rate
Voice	4Khz Speech Signal	ADPCM	32 kbps	64 kbps
Voice	4KHz Speech Signal	RELP	16 kbps	64 kbps
Voice	4KHz Speech Signal	CELP	8 kbps	64 kbps
Music	16-24KHz audio	MP3	32-384 kbps	512-748 Kbps
Image	8×10 inch photo scanned at 400 pixels per inch	JPEG	1.2-8 Mbps	38.4 Mbps
Video	176 ×144 frames at10 frames per second	H.261	64 kbps-1.544 Mbps	2-36.5 Mbps
Video	1920 × 1080 frames per Second	MPEG -2	19-38 Mbps	1.6 Gbps

Comparison of Analog & Digital TV Standard given in Table III

TV Standard	Total Lines	Resolution	Compression Fotmat	Aspect Ratio
PAL	625	720× 575	Analog	4:3
SECAM	625	720× 575	Analog	4:3
NTSC	625	720× 486	Analog	4:3
DVB	1250	1920 × 1152	MPEG-2	16:9
HDTV	1125	1920 × 1080	MPEG-2	16:9

Signal Distribution to Subscribers: There are three ways by which digital television TV signals can be made available to subscribers. These are

1) Cable Television
2) Domestics Broadcast System
3) Direct To Home (DTH) Satellite Television

IV Conclusion

This paper presents an overview of progress of television from Analog TV to Digital TV giving important technical features at various stages of development. From the above study it is found that Analog TVs can only accept

analog signals while Digital TVs can accept both digital and analog signals. Analog TVs are prone to noise and distortion while Digital TVs are not.

Analog TV sets use cathode ray tubes as their display while digital TV sets use flat panel display like LCD, plasma or LED. The amount of bandwidth assigned to an analog TV channel restricted the resolution and overall quality of the image. Digital TVs are beginning to gain widespread acceptance all over the world while analog TVs are slowly disappearing. Many challenges have been faced and hurdles overcome in developing and advancing the television. Finally we say that technology converts a dream and scientific idea into reality.

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