ICT-3103: Electronic Communications and Microwave Engineering

Full Marks:100
Credit: 3.0
Contact Hours: 39
Exam. Duration: 4Hours

Electronic Communication is any form of communication that's broadcast, transmitted, stored or viewed using electronic media, such as computers, phones, email and video.

Microwave Engineering pertains to the study and design of microwave circuits, components, and systems.

Microwave frequencies range between **10^9 Hz (1 GHz) to 1000 GHz** with respective wavelengths of 30 to 0.03 cm.

Course Objectives: To provide knowledge on television system, satellite communication, radar system and microwave engineering.

Course Learning Outcomes (CLO): After completing this course a student would be able to

CLO1	**Acquire** general idea about the course
CLO2	**Understand** the television system.
CLO3	**Understand** the satellite system
CLO4	**Understand** the Radar system
CLO5	**Analysis** microwave communication networks

Assessment and Evaluation

– Class Attendance & Participation (10%)
– Quiz/Presentation (05%)
– In-course/Tutorial (10%)
– Final Exam (70%)

CIE: (Continuous Internal Evaluation-30Marks)

Bloom's Category Marks:30	**Tutorial/ In-course (10)**	**Assignment (05)**	**Quiz/Presentation (05)**	**Class Attendance 10**
Remember			(05)	
Understand	(05)			
Apply				(10)
Analyze				
Evaluate	(05)			
Create		(05)		

Learning Resources

Text Books

1. *Electronic Communication, Roddy and Coolen, Prentice Hall of India, 4th Ed.*
2. *Radio Engineering, G K Mithal, Khanna Publishers.*
3. *Microwave Devices and Circuits- Samuel Y Laio*

Reference Books and Other Materials

4. *Integrated Electronics, Millman and Halkias, McGraw-Hill*
5. *Microwave Engineering- David M. Pozar*

Google Classroom Code: y6oazih

Chapter-One

Television System

Basic TV System: The basic television system consists of **a television camera and microphone that convert pictures and sound into electrical signals**, and a television set and loudspeaker that convert the signals back into pictures and sound.

Types: From the early experiments with visual transmissions, two types of television systems came into existence: **Mechanical Television(Monochrome/BW) and Electronic Television(Color)**.

Principle Sets of Parts: The television consists of four principle sets of parts, including **the exterior or housing, the audio reception and speaker system, the picture tube, and a complicated mass of electronics including cable and antennae input and output devices.**

TV Standards

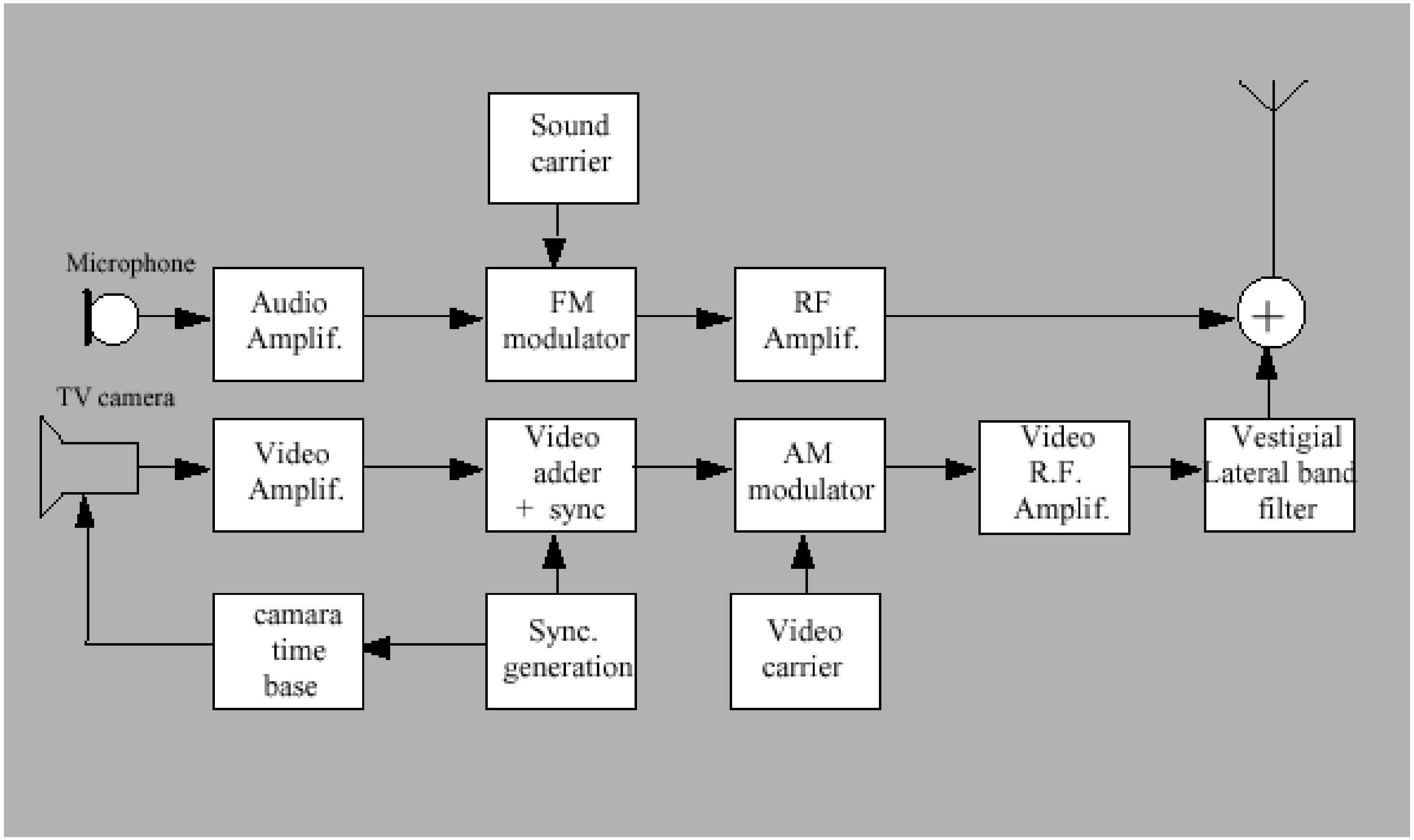
PAL , SECAM and NTSC

- There are three major TV standards used in the world today.

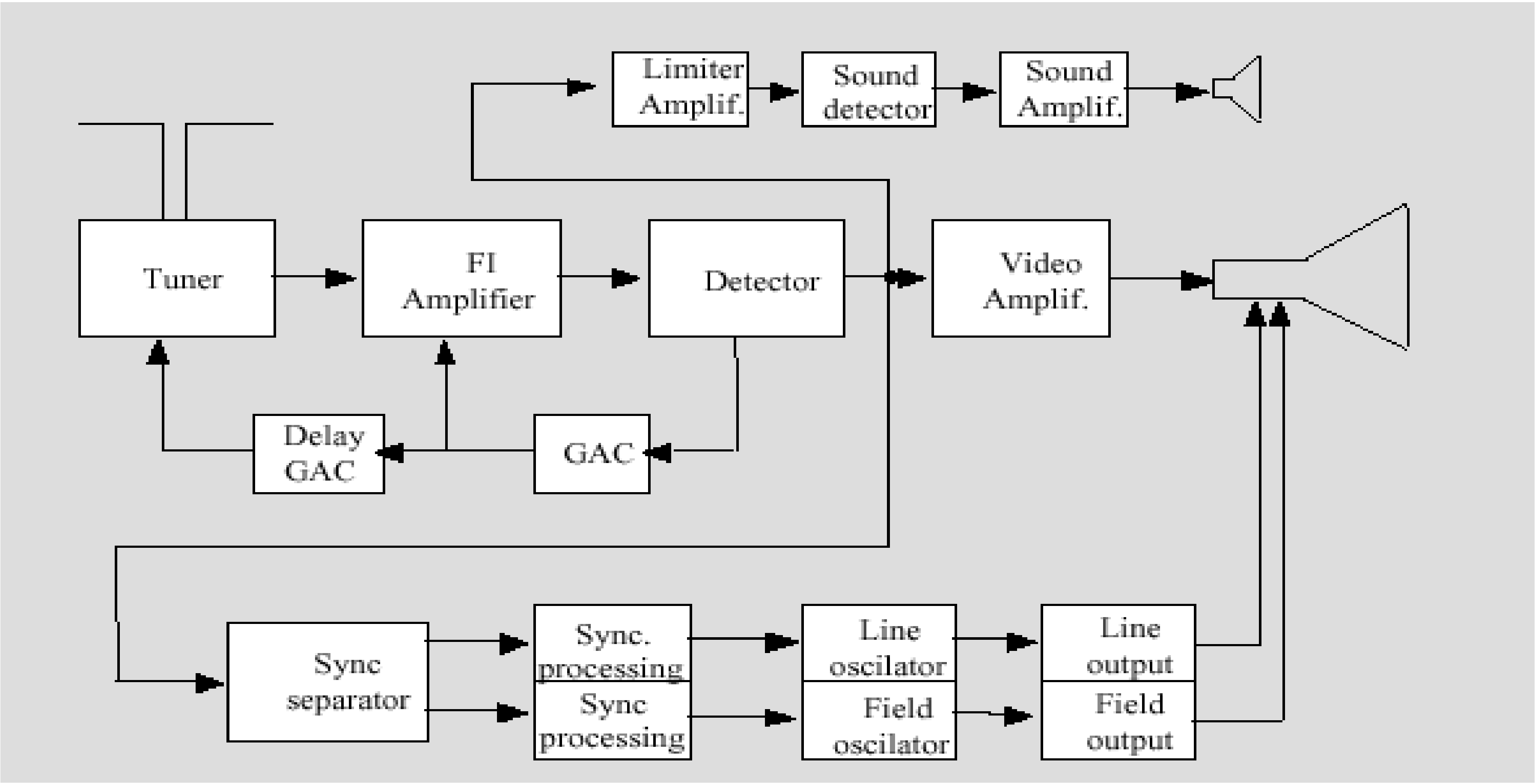
  These are the

1. American NTSC (National Television Systems Committee) color television system,
2. European PAL (Phase Alternation Line rate)
3. French-Former Soviet Union SECAM (Sequential Couleur avec Memoire)

Basic Elements of Monochrome TV Systems



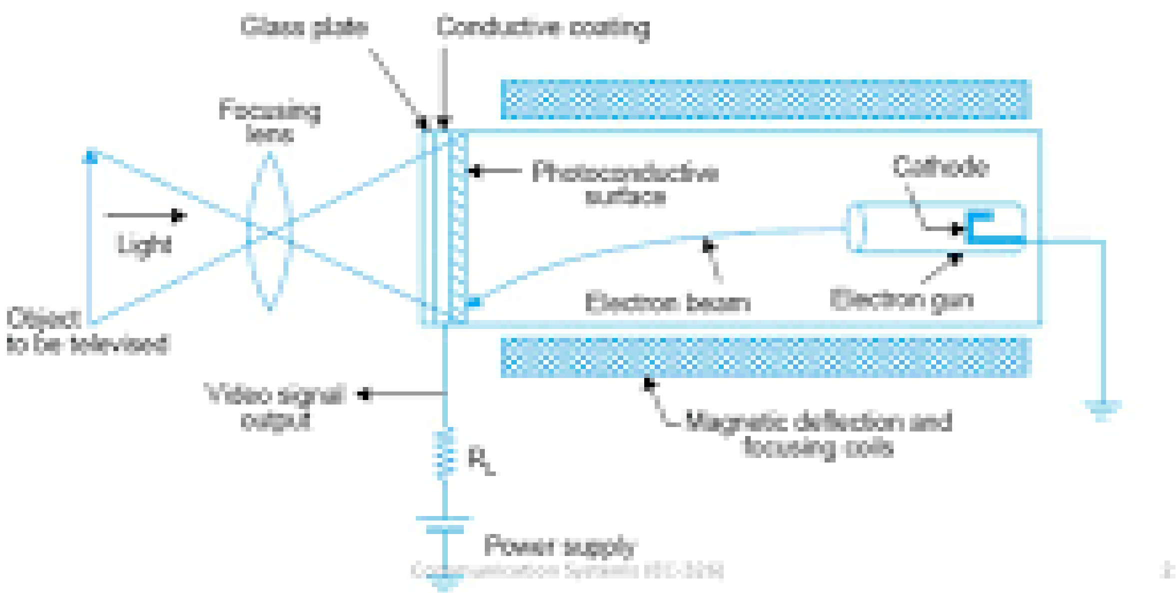
Transmitter


Limiter Amplif.
Sound detector
Sound Amplif.
Tuner
FI Amplifier
Detector
Video Amplif.
Delay GAC
GAC
Sync separator
Sync. processing
Sync processing
Line oscilator
Field oscilator
Line output
Field output

Receiver

PICTURE TRANSMISSION

Simplified cross-sectional view of a Vidicon TV camera tube



The picture information is optical in character and may be thought of as an assemblage of a large number of bright and dark areas representing picture details. These elementary areas into which the picture details may be broken up are known as ‘picture elements’, which when viewed together, represent the visual information of the scene.

A TV camera, the heart of which is a camera tube, is used to convert the optical information into a corresponding electrical signal, the amplitude of which varies in accordance with the variations of brightness. Fig. 1.2 (*a) shows very elementary details of one type of* camera tube (vidicon) to illustrate this principle. An optical image of the scene to be transmitted is focused by a lens assembly on the rectangular glass face-plate of the camera tube.

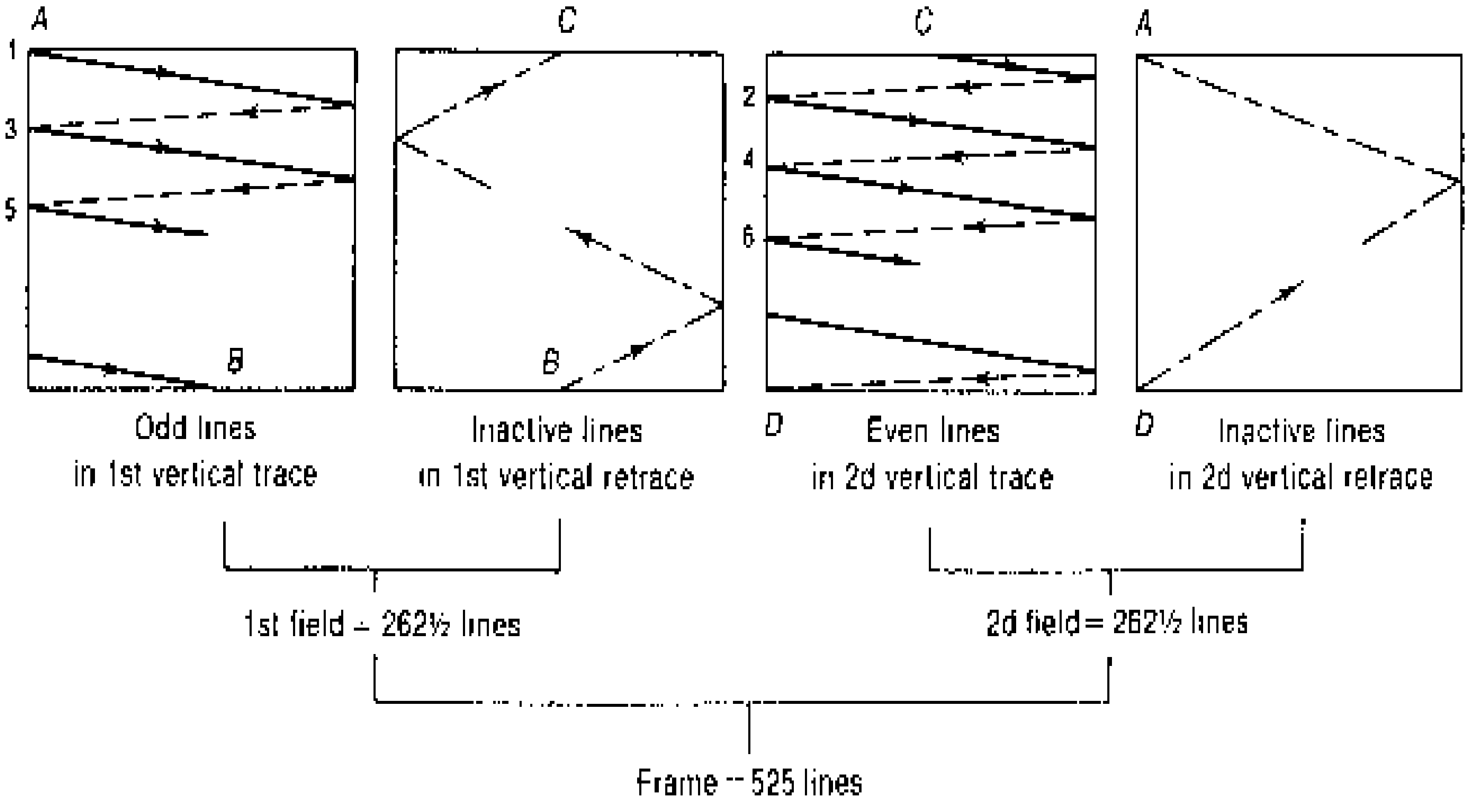
The inner side of the glass face-plate has a transparent conductive coating on which is laid a very thin layer of photoconductive material. The photolayer has a very high resistance when no light falls on it, but decreases depending on the intensity of light falling on it. Thus depending on the light intensity variations in the focused optical image, the conductivity of each element of the photolayer changes accordingly. An electron beam is used to pick-up the picture information now available on the target plate in terms of varying resistance at each point. The beam is formed by an electron gun in the TV camera tube. On its way to the inner side of the glass faceplate

it is deflected by a pair of deflecting coils mounted on the glass envelope and kept mutually perpendicular to each other to achieve scanning of the entire target area. Scanning is done in the same way as one reads a written page to cover all the words in one line and all the lines on the page (see Fig. 1.2 (*b*)). *To achieve this the deflecting coils are fed separately from two* sweep oscillators which continuously generate saw-tooth waveforms, each operating at a different desired frequency. The magnetic deflection caused by the current in one coil gives horizontal motion to the beam from left to right at a uniform rate and then brings it quickly to

Basic black and white television

- In a basic black and white TV, a single electron beam is used to scan a phosphor screen. The scan is interlaced, that is -- it scans twice per photographed frame.
- The information is always displayed from left to right. After each line is written, when the beam returns back to the left, the signal is blanked. When the signal reached the bottom it is blanked until it returns to the top to write the next line
-

Trace and Retrace

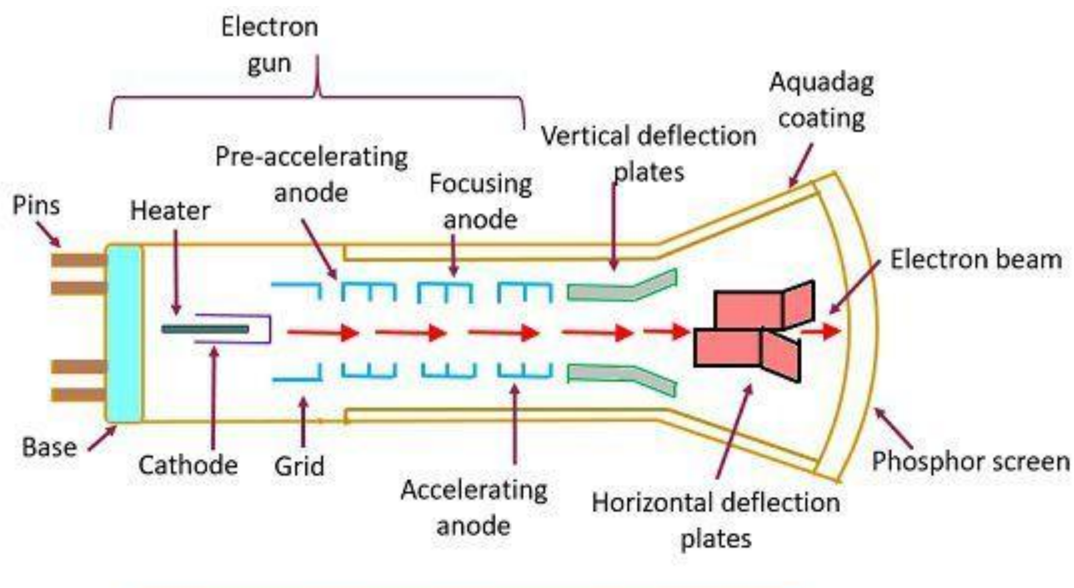


SOUND TRANSMISSION

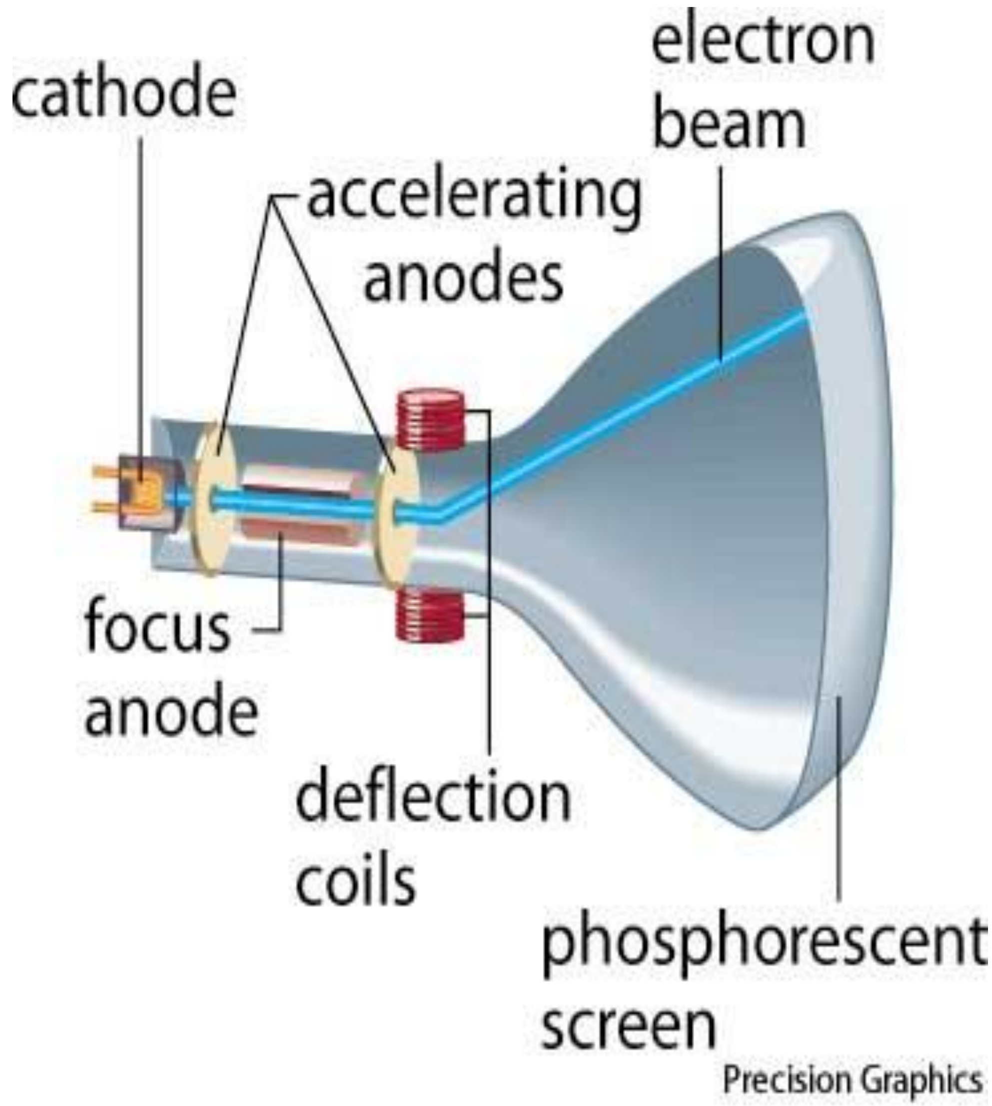
The microphone converts the sound associated with the picture being televised into proportionate electrical signal, which is normally a voltage. This electrical output, regardless of the complexity of its waveform, is a single valued function of time and so needs a single channel for its transmission. The audio signal from the microphone after amplification is frequency modulated, employing the assigned carrier frequency. In FM, the amplitude of the carrier signal is held constant, whereas its frequency is varied in accordance with amplitude variations of the modulating signal. As shown in Fig. 1.1 (*a*), *output of the sound FM transmitter* is finally combined with the AM picture transmitter output, through a combining network, and fed to a common antenna for radiation of energy in the form of electromagnetic waves.

PICTURE RECEPTION

The receiving antenna intercepts the radiated picture and sound carrier signals and feeds them to the RF tuner (see Fig. 1.1 (*b*)). *The receiver is of the heterodyne type and employs two* or three stages of intermediate frequency (IF) amplification. The output from the last IF stage



Internal structure of CRT


cathode
accelerating
anodes
electron
beam
focus
anode
deflection
coils
phosphorescent
screen
Precision Graphics

is demodulated to recover the video signal. This signal that carries the picture information is amplified and coupled to the picture tube which converts the electrical signal back into picture elements of the same degree of black and white. The picture tube shown in Fig. 1.3 is very similar to the cathode-ray tube used in an oscilloscope. The glass envelope contains an electron gun structure that produces a beam of electrons aimed at the fluorescent screen. When the electron beam strikes the screen, light is emitted. The beam is deflected by a pair of deflecting coils mounted on the neck of the picture tube in the same way and rate as the beam scans the target in the camera tube. The amplitudes of the currents in the horizontal and vertical deflecting coils are so adjusted that the entire screen, called raster, gets illuminated because of the fast rate of scanning.

The video signal is fed to the grid or cathode of the picture tube. When the varying signal voltage makes the control grid less negative, the beam current is increased, making the spot of light on the screen brighter. More negative grid voltage reduces the brightness. if the grid voltages is negative enough to cut-off the electron beam current at the picture tube there will be no light. This state corresponds to black. Thus the video signal illuminates the fluorescent screen from white to black through various shades of grey depending on its amplitude at any instant. This corresponds to the brightness changes encountered by the electron beam of the camera tube while scanning the picture details element by element. ***The rate at which the spot of light moves is so fast that the eye is unable to follow it and so a complete picture*** is seen because of the storage capability of the human eye.

SOUND RECEPTION

The path of the sound signal is common with the picture signal from antenna to the video detector section of the receiver. Here the two signals are separated and fed to their respective channels. The frequency modulated audio signal is demodulated after at least one stage of amplification. The audio output from the FM detector is given due amplification before feeding it to the loudspeaker.

SYNCHRONIZATION

It is essential that the same coordinates be scanned at any instant both at the camera tube target plate and at the raster of the picture tube, otherwise, the picture details would split and get distorted. To ensure perfect synchronization between the scene being televised and the picture produced on the raster, synchronizing pulses are transmitted during the retrace, *i.e.*, fly-back intervals of horizontal and vertical motions of the camera scanning beam. Thus, in addition to carrying picture detail, the radiated signal at the transmitter also contains synchronizing pulses. These pulses which are distinct for horizontal and vertical motion control, are processed at the receiver and fed to the picture tube sweep circuitry thus ensuring that the receiver picture tube beam is in step with the transmitter camera tube beam.

COLOUR TELEVISION

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

Each colour TV system* is compatible with the corresponding monochrome system.

Compatibility means that colour broadcasts can be received as black and white on monochrome receivers. Conversely colour receivers are able to receive black and white TV broadcasts. This is illustrated in Fig. 1.5 where the transmission paths from the colour and monochrome cameras are shown to both colour and monochrome receivers.

At the receiver, the three colour signals are separated and fed to the three electron guns of colour picture tube. The screen of the picture tube has red, green, and blue phosphors arranged in alternate dots. 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 colour information and their luminance to perceive the actual colour and brightness of the picture being televised.

* The three compatible colour television systems are NTSC, PAL and SECAM.

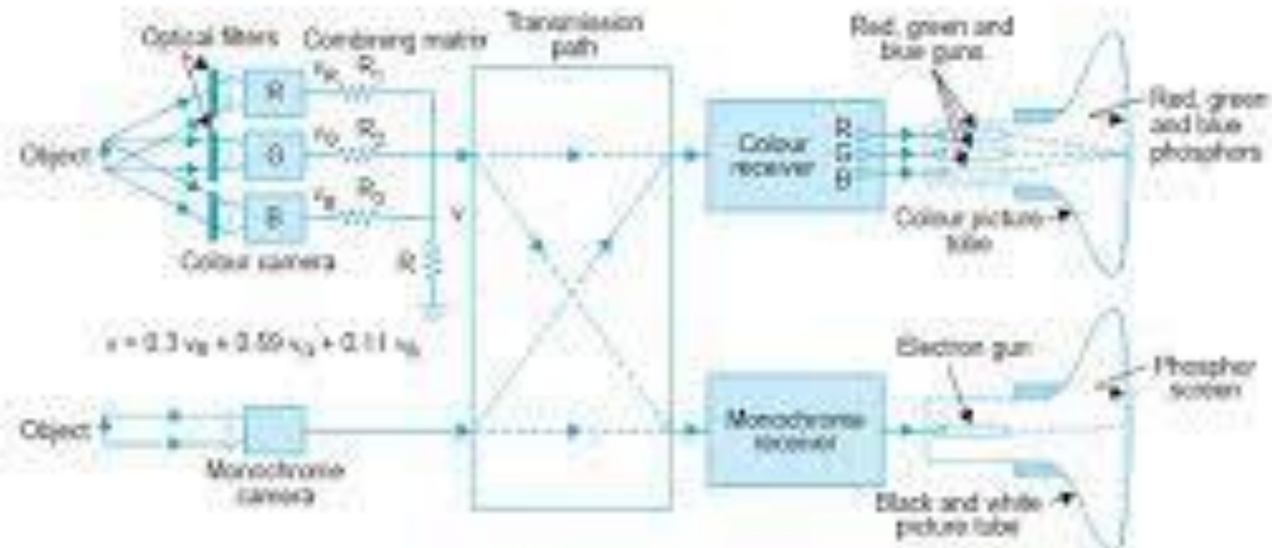
Colour Receiver Controls

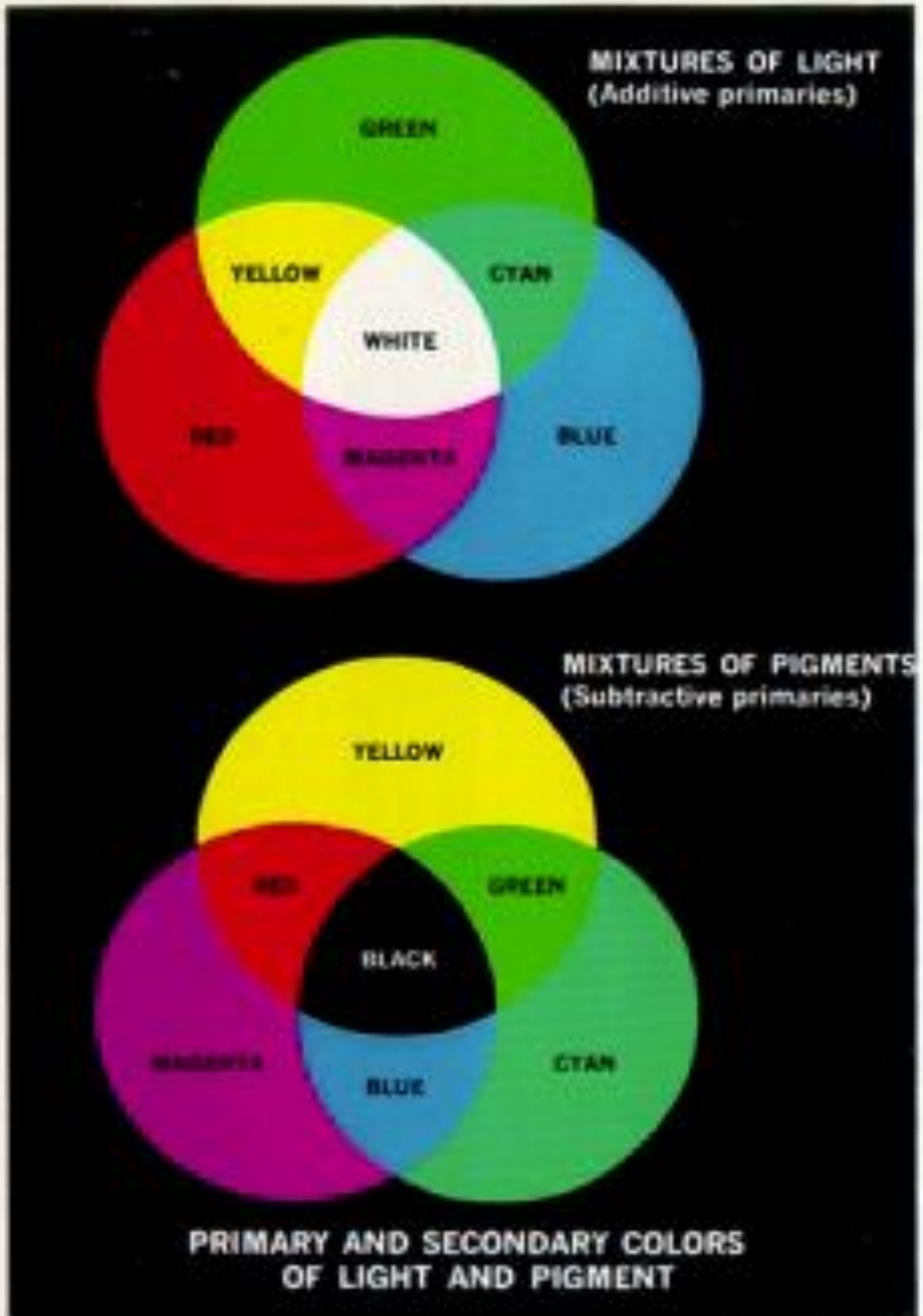
NTSC colour television receivers have two additional controls, known as Colour and Hue controls. These are provided at the front panel along with other controls. The colour or saturation control varies the intensity or amount of colour in the reproduced picture. For example, this control determines whether the leaves of a tree in the picture are dark green or light green, and whether the sky in the picture is dark blue or light blue. The tint or hue control selects the correct colour to be displayed. This is primarily used to set the correct skin colour, since when flesh tones are correct, all other colours are correctly reproduced.

It may be noted that PAL colour receivers do not need any tint control while in SECAM colour receivers, both tint and saturation controls are not necessary. The reasons for such differences are explained in chapters exclusively devoted to colour television.

Signal transmission paths illustrating compatibility between colour and monochrome TV systems.

R, G and B represent three camera tubes which develop video signals corresponding to the red, green and blue contents of the scene being televised





PRIMARY AND SECONDARY COLORS
OF LIGHT AND PIGMENT

Color information transmission in TV

- In the most basic form, color television could simply be implemented by having cameras with three filters (red, green and blue) and then transmitting the three color signals over wires to a receiver with three electron guns and three drive circuits.

- Unfortunately, this idealized view is **not compatible** with the previously allocated ***6 MHz bandwidth*** of a TV channel. It is also not compatible with previously existing **monochrome receivers.**

- Therefore, modern color TV is carefully structured to preserve all the original monochrome information -- and just add on the color information on top.

- To do this, one signal, called **luminance (Y)** has been chosen to occupy the major portion (0-4 MHz) of the channel. Y contains the brightness information and the detail. Y is the monochrome TV signal.

- Consider the model of a scene being filmed with three cameras. One camera has a red filter, one camera a green filter and one camera a blue filter.

- Assume that the cameras all adjusted so that when pointed at "white" they each give equal voltages. To create the Y signal, the red, green and blue inputs to the Y signal must be balanced to compensate for the color perception misbalance of the eye. The governing equation is:

$$Y = 0.3 \times R + 0.59 \times G + 0.11 \times B$$

- ***For example****, in order to produce "White" light to the human observer there needs to be 11 % blue, 30 % red and 59% green (=100%).*

- This is the "monochrome" part of the TV signal. It officially takes up the first 4 MHz of the 6 MHz bandwidth of the TV signal. However, in practice, the signal is usually band-limited to 3.2 MHz.

- Two signals are then created to carry the **chrominance (C)** information. One of these signals is called **"Q"** and the other is called **"I".** They are related to the R, G and B signals by:

$$Q = 0.21 \times R - 0.52 \times G + 0.31 \times B$$

$$I = 0.6 \times R - 0.28 \times G - 0.32 \times B$$

$$R-Y = R - (0.30R + 0.59G + 0.11B) = 0.7R - 0.59G - 0.11B$$

$$B-Y = B - (0.30R + 0.59G + 0.11B) = -0.3R - 0.59G + 0.89B$$

$$I = 0.877\,(R - Y)\cos 33 - 0.493\,(B - Y)\sin 33$$

$$Q = 0.877\,(R - Y)\sin 33 + 0.493\,(B - Y)\cos 33$$

Conversion between RGB and YIQ

$$Y = 0.299\,R + 0.587\,G + 0.114\,B$$

$$I = 0.596\,R - 0.275\,G - 0.321\,B$$

$$Q = 0.212\,R - 0.523\,G + 0.311\,B$$

$$R = 1.0\,Y + 0.956\,I + 0.620\,Q$$

$$G = 1.0\,Y - 0.272\,I - 0.647\,Q$$

$$B = 1.0\,Y - 1.108\,I + 1.700\,Q$$

Bandwidth of Chrominance Signals

- With real video signals, the chrominance component typically changes much slower than luminance Furthermore, the human eye is less sensitive to changes in chrominance than to changes in luminance

- The eye is more sensitive to the orange- cyan range (I) (the color of face!) than to green- purple range (Q)
- The above factors lead to

  I: bandlimitted to 1.5 MHz and

  Q: bandlimitted to 0.5 MHz

Basic Factors of TV Systems

The basic factors with which the television system must deal for successful transmission
and reception of pictures are:

(*a*) ***Gross Structure:*** *Geometric form and aspect ratio of the picture*.

(*b*) ***Image Continuity:*** *Scanning and its sequence*.

(*c*) ***Number of Scanning Lines:*** *Resolution of picture details.*

(*d*) ***Flicker:*** *Interlaced scanning*.

(*e*) ***Fine Structure:*** *Vertical and horizontal resolution.*

(*f*) ***Tonal Gradation:*** *Picture brightness transfer characteristics of the system*.