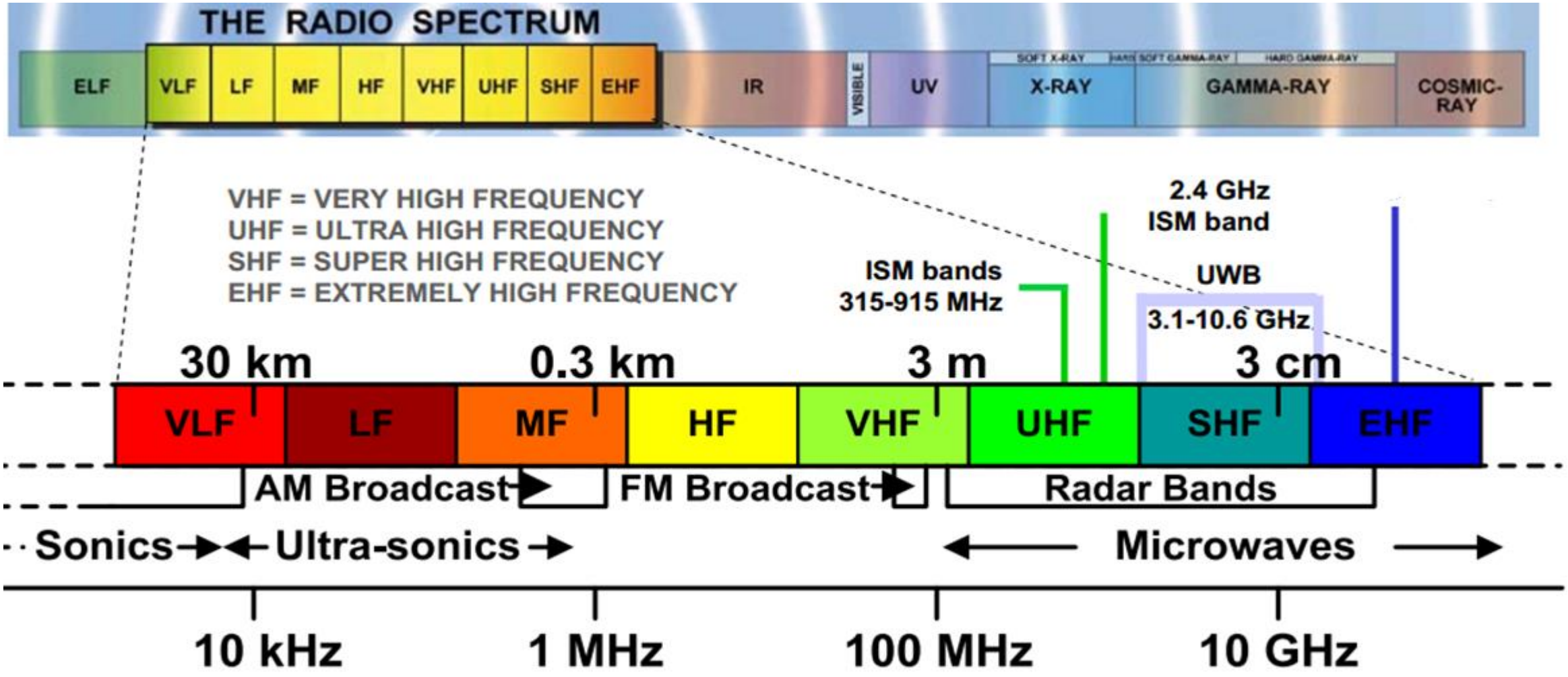
APPLICATIONS - RADIO TRANSMETERS & RECEIVERS

EEEN 462 – ANALOGUE COMMUNICATION SYSTEMS

Monday, 30 June 2025

REVIEW OF RADIO SPECTRUM



INDUSTRY SCIENTIFIC & MEDICINE (ISM) BAND

1. The **Industrial, Scientific and Medical (ISM)** radio frequency bands were originally reserved by the International Communication Union for the use of RF energy for industrial, scientific and medical purposes rather than communications.
2. The original applications in these bands included:
   a) radio-frequency process heating,
   b)microwave ovens,
   c)medical diathermy machines
3. Powerful emissions from these devices can create electromagnetic interference and disrupt radio communication using the same frequency, so these devices were limited to certain bands of frequencies.
4. Overtime, these bands started being used for communications for **Short-Range Devices (SRD)** and the frequency range is sometimes referred to as **ISM/SRD band.**
5. In general, communications equipment operating in these bands must accept any interference generated by ISM equipment.

INDUSTRY SCIENTIFIC & MEDICINE (ISM) BAND

FREQUENCY RANGE		BANDWIDTH	REGION WHERE USED
13.553 MHz	13.567 MHz	14 kHz	Worldwide
26.957 MHz	27.283 MHz	326 kHz	Worldwide
40.660 MHz	40.700 MHz	40 kHz	Worldwide
433.050 MHz	434.790 MHz	1.74 MHz	Region 1 only
902.000 MHz	928.000 MHz	26 MHz	Region 2 only
2.400 GHz	2.500 GHz	100 MHz	Worldwide
5.725 GHz	5.875 GHz	150 MHz	Worldwide

BLUETOOTH

1. **Bluetooth** is a wireless technology standard for exchanging data over short distances in the ISM band from 2.4 to 2.485 GHz.
2. Bluetooth is used in fixed and mobile devices, and building personal area networks (PANs).
3. Was invented by telecom vendor Ericsson in 1994 as a wireless alternative to RS-232 data communication.
4. Named after 10th Century Danish King.

Bluetooth allows you to connect wirelessly several devices to a PC or laptop

FUNCTIONS OF RADIO RECEIVERS

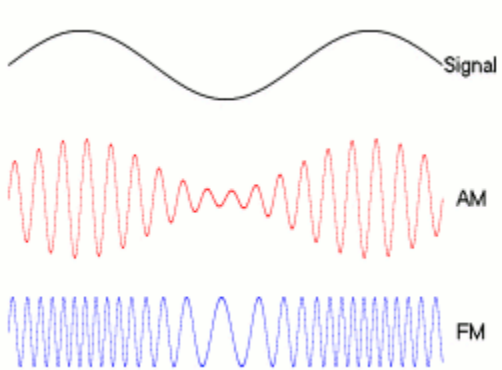
Functions of a Radio Receiver are to:

1. intercept the incoming radio signal by the antenna;
2. Select the desired signal and reject unwanted signals;
3. Amplify the RF signal;
4. Demodulate the Signal;
5. Amplify the demodulated signal.

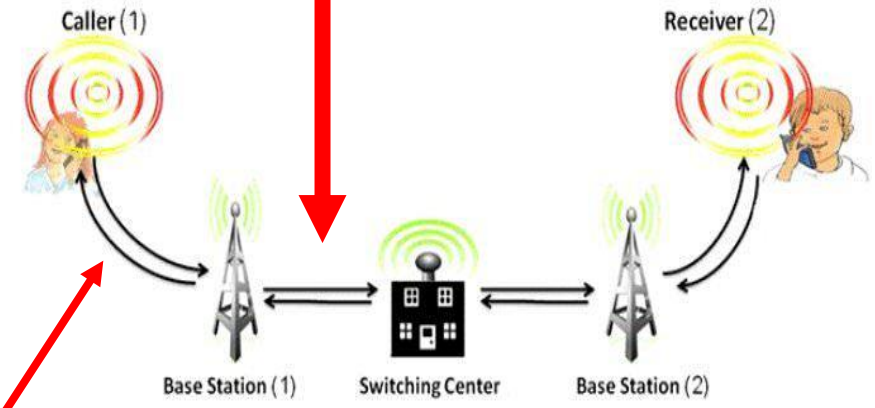
TYPES OF RADIO RECEIVERS

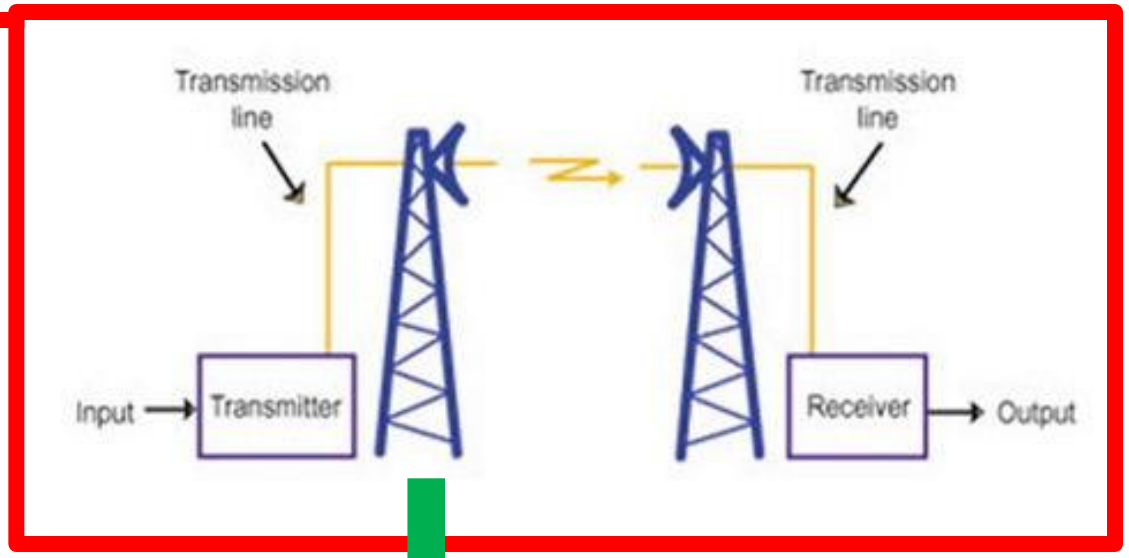
Radio receivers van be classified according:

1. Type of Modulation as:
   a) **AM Receivers** for receiving amplitude modulated signals
   b) **FM receivers** for receiving Frequency Modulated signals
2. Type of application, as:
   a) **Communication receivers** used are receivers in telephone or civil aviation communication systems
   b) **Radar receivers** used to detect Radar (Radio Detection and Ranging) signals
   c) **Television receivers** used to receive TV signals is VHF and UHF bands)
3. Principle of operation, as:
   a) **Tuned Radio Frequency (TRF) receivers**
   b) **Superheterodyne Receivers**



COMMUNICATION TRANSMITERS/RECEIVERS

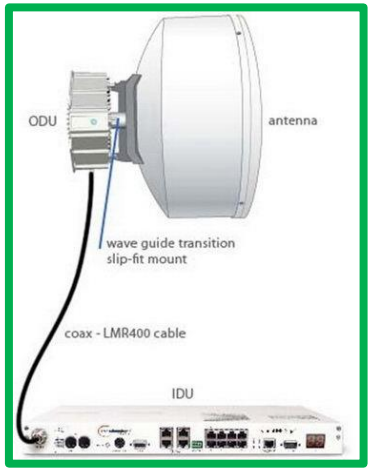




Um Interface

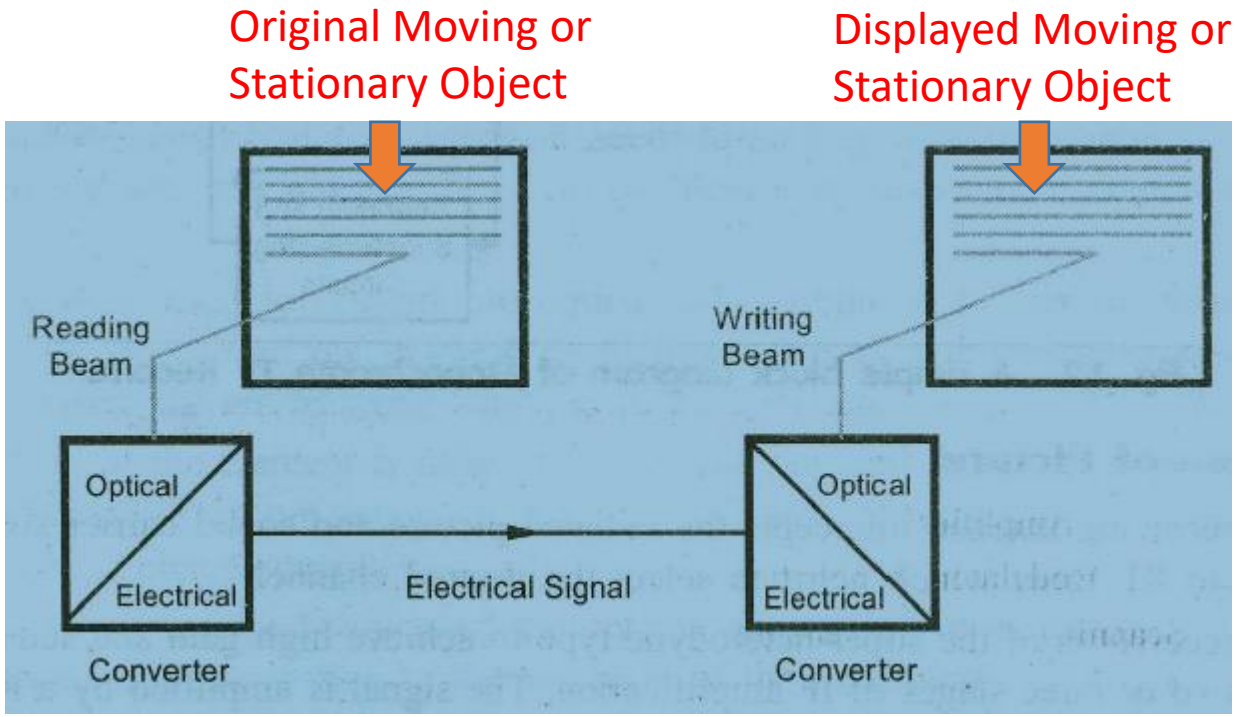
Uplink: 890 – 915 MHz

Downlink: 935 – 960 MHz



TELEVISION

Television may be defined as the transmission images of moving and stationary objects generally with accompanying sound as electromagnetic waves and the reception and reconversion of the received waves into visual images.



BRIEF HISTORY OF TELEVISION

- **1884:** Paul Nipkow patents the first electromechanical Television System
- **1927:** Philo Taylor demonstrates the first Electronic Television.
- **1950:** First Colour Television developed by Columbia Broadcasting Corporation.

TYPES OF TV SYSTEMS

1. 525 Lines with 60 Frames/Sec: USA - Developed by National Television System Committee (NTSC) in 1953
2. 625 Lines with 50 frames/Sec: European – Phase Alternation by Lines (PAL), developed in Germany in 1967
3. 819 Lines: French - Sequential Coloureuses A Memmoirs (SECAM) – Developed in France.

TELEVISION FREQUENCIES

VHF Band:

41 – 68 MHz – Analogue TV

174-230 MHz – Digital Terrestrial Sound and Audio Broadcasting

UHF Band:

470 – 806 MHz – Analogue TV

470-806 MHz – Digital Terrestrial Sound and Audio Broadcasting

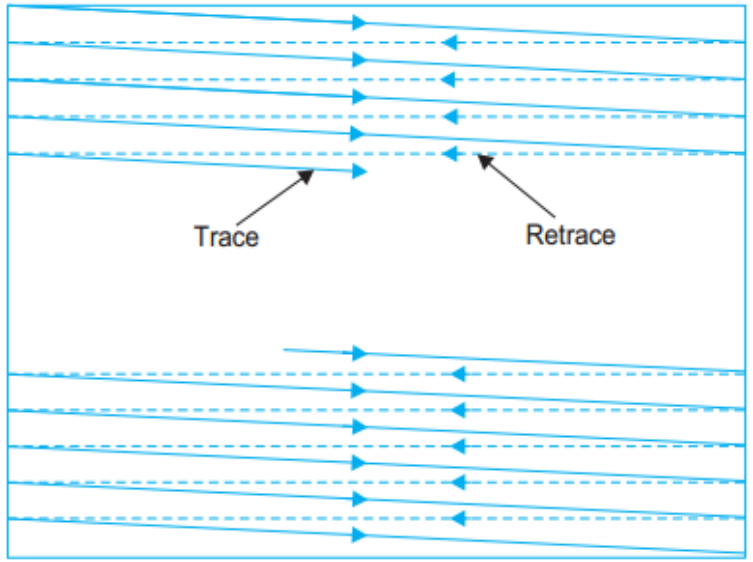
806-960 MHz - fixed and mobile services after digital migration

880-915 MHz and 925-960 MHz – Cellular Mobile Communication

960-1215 MHz - Aeronautical radionavigation service (DME and TACAN)

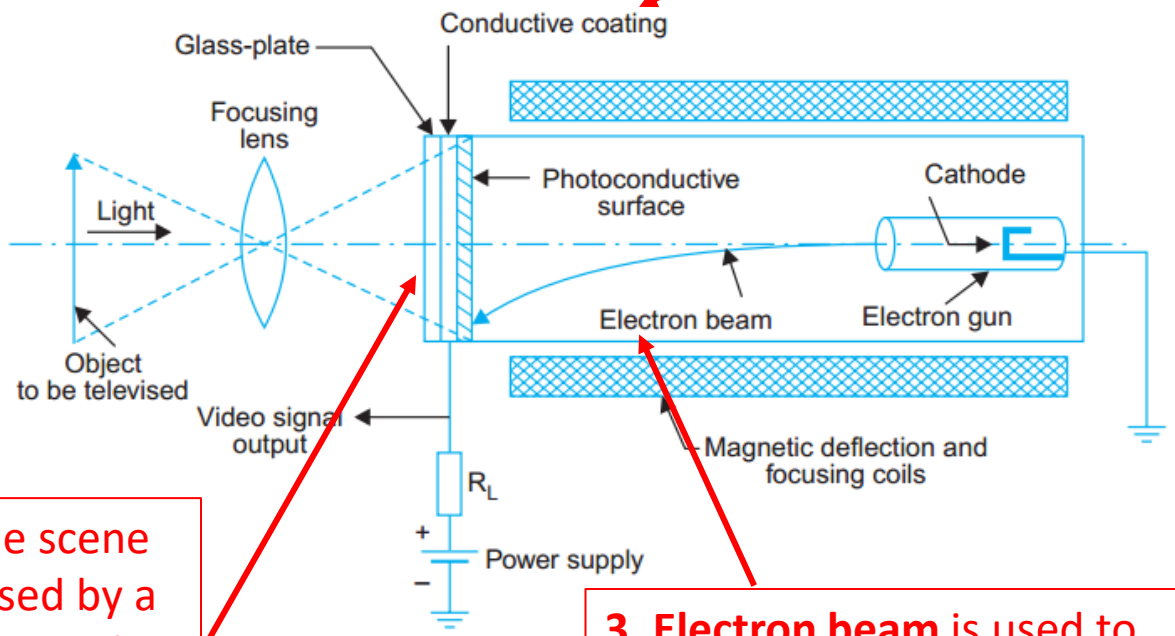
PRINCIPLE OF TELEVISION VIDICOM CAMERA

- **A TV camera** is used to convert optical information into electrical signal, the amplitude of which varies in accordance with variations of brightness.



Scanning beam covering the target area

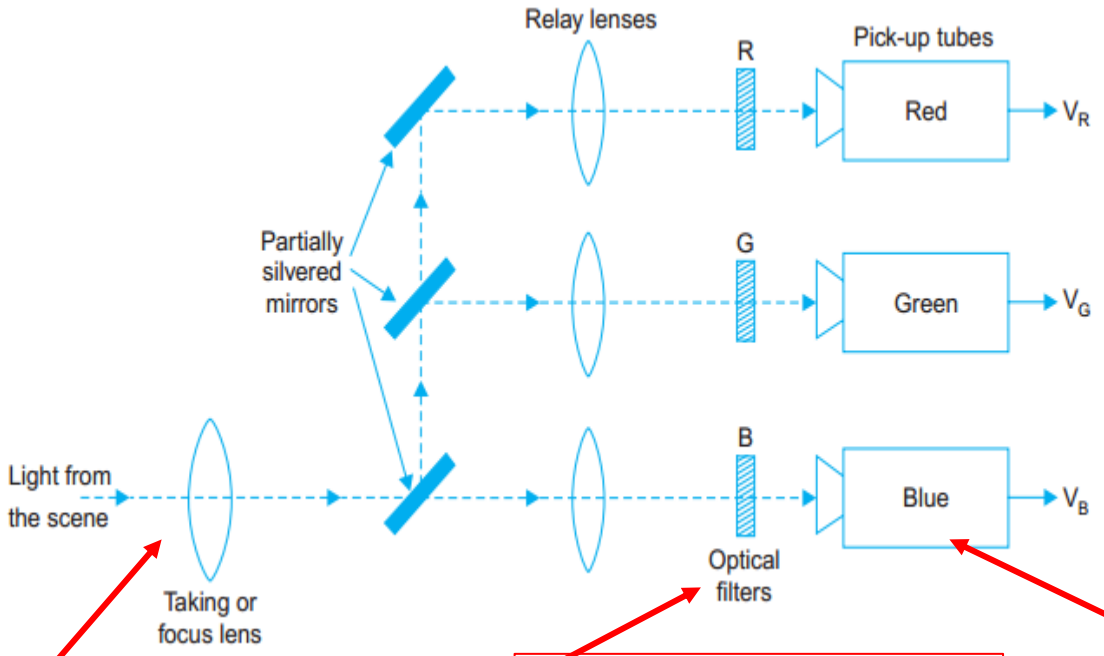
2. The conductive coating has high resistance when no light falls on it which decreases with increasing light intensity



1. 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.

3. Electron beam is used to pick-up picture information on the target plate in terms of varying resistance.

COLOUR TV VIDICOM CAMERA



1. Light from the scene falls on the focus lens

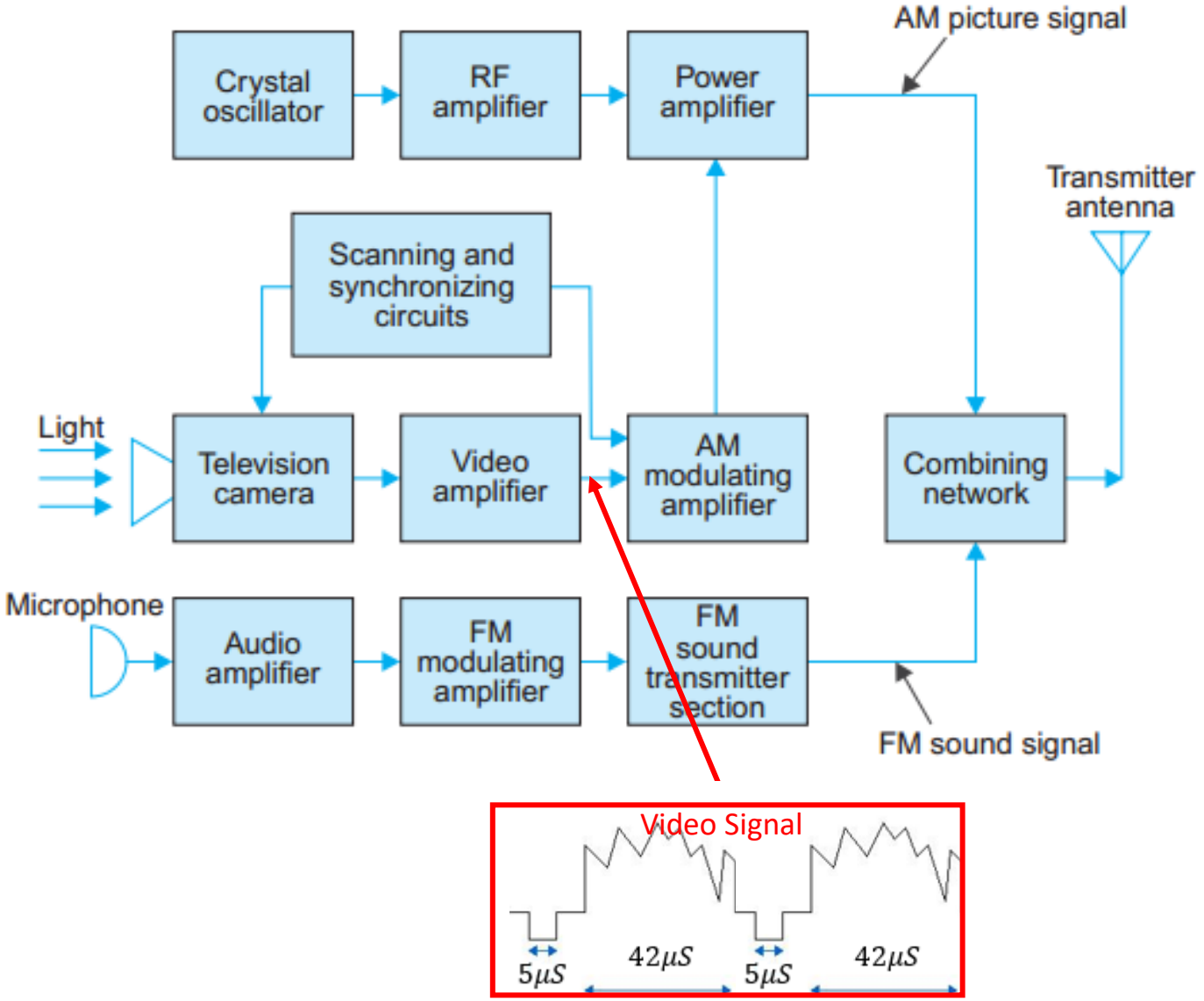
2. Colour filters receive reflected light split it into R, G and B colour lights.

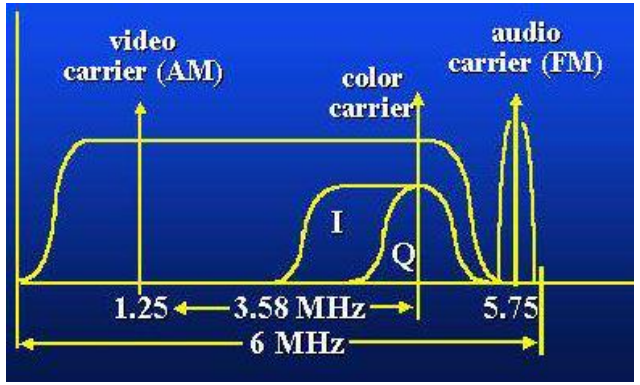
3. Camera tubes (vidicons) receive light of only one primary colour.

MODERN CAMERA

- Today, CCD (charge coupled device) chips are universally used in the cameras and the principle of the deflected electron beam is now only pre-served in TV receivers.
- Most TV receivers are changing to LCD and plasma screens.

BLOCK DIAGRAM OF TELEVISION TRANSMITTER



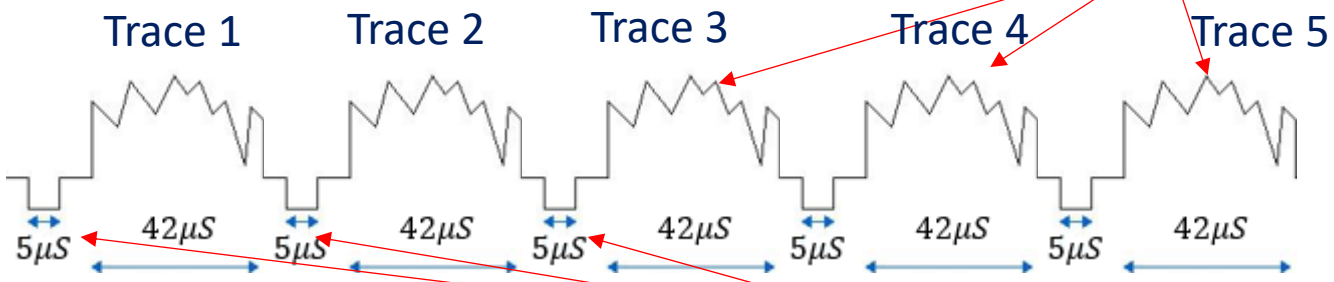


Spectrum of Combined Signal

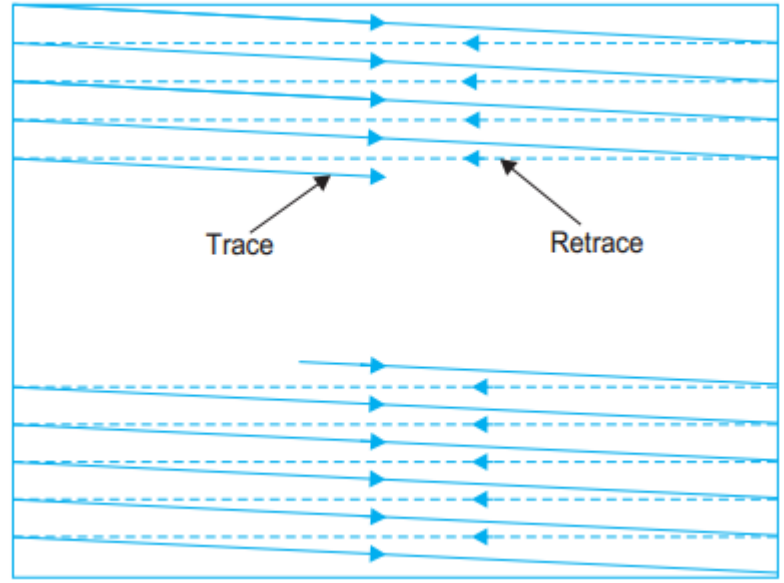
SYNCHRONIZATION

- **Synchronizing pulses** are transmitted during the retrace, i.e., fly-back intervals of horizontal and vertical motions of the camera scanning beam.
- **Sych pulses (see drawing)** 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.

Luminance represents the brightness of each pixel in a horizontal sweep

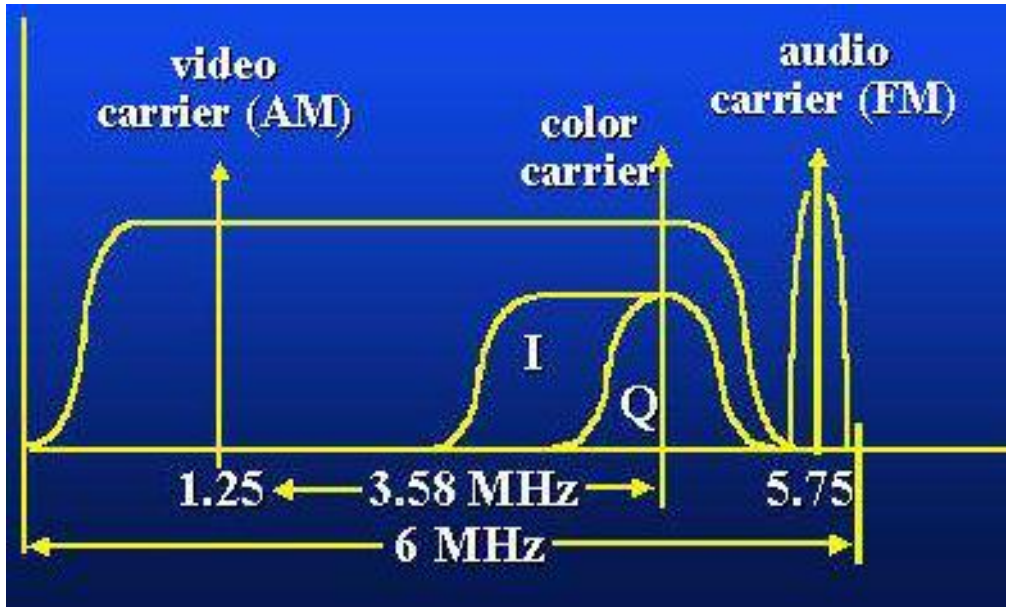


Horizontal sync pulses trigger the horizontal sweep in the TV to reset back to the left to begin another scan line.

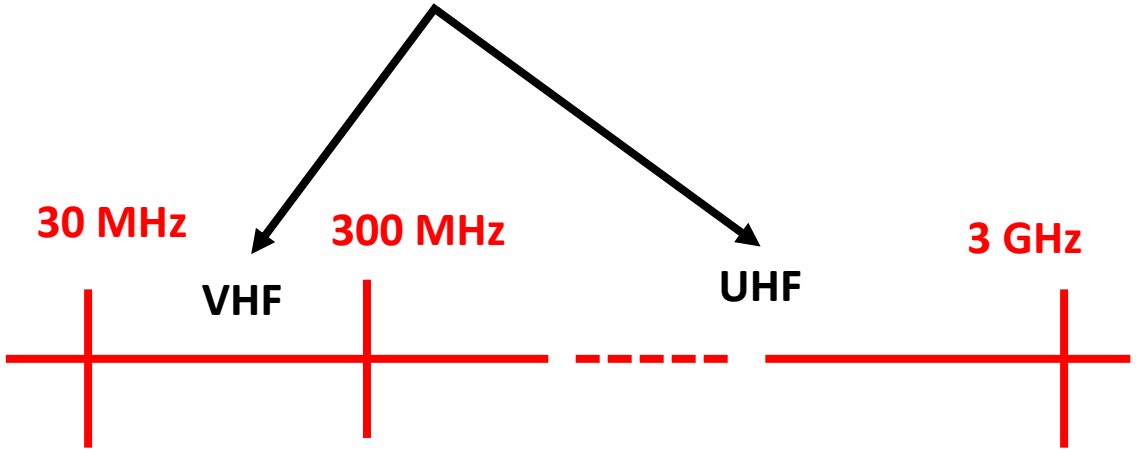


TELEVISION SPECTRUM

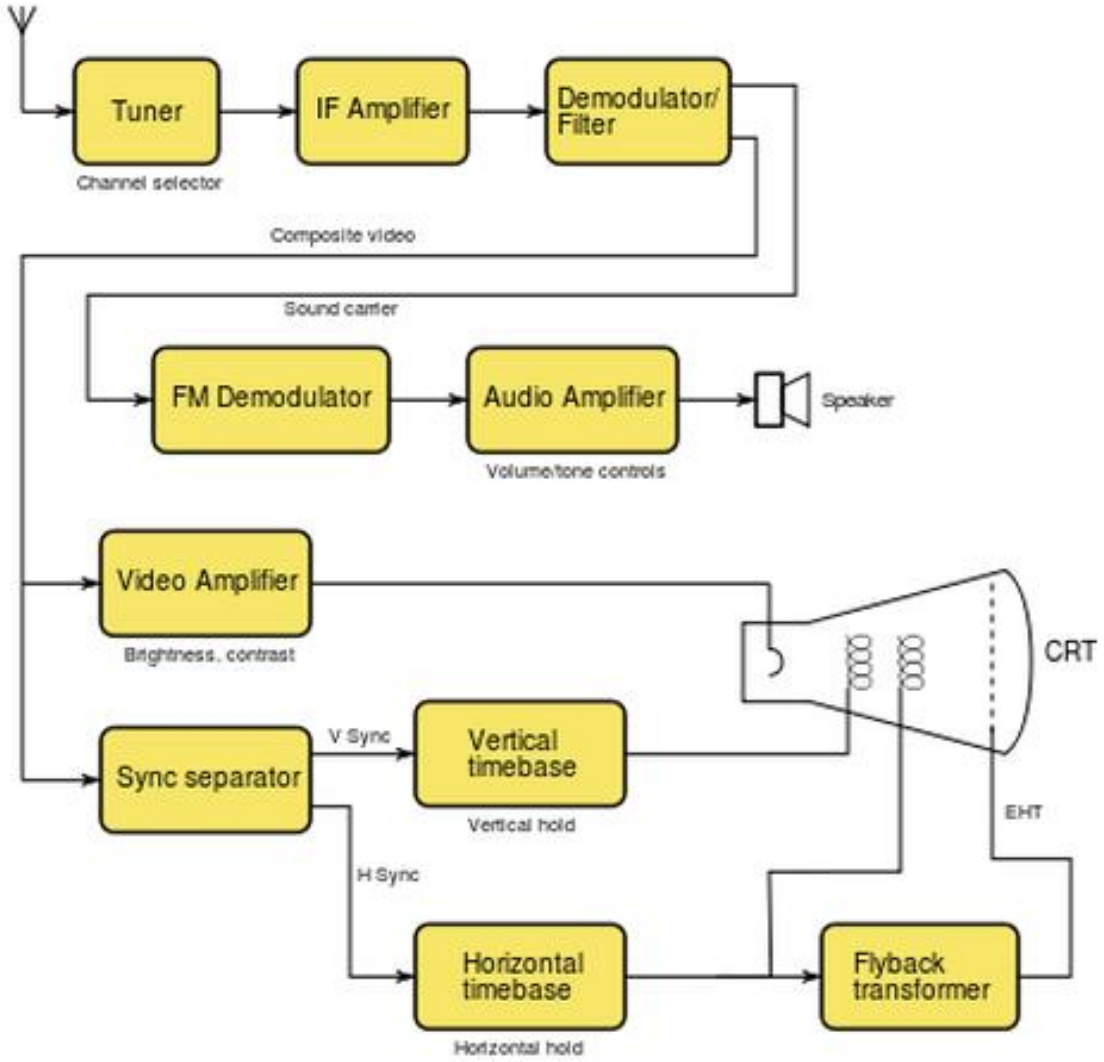
1. The baseband TV signal occupies the frequency range 0 – 6 MHz as shown.

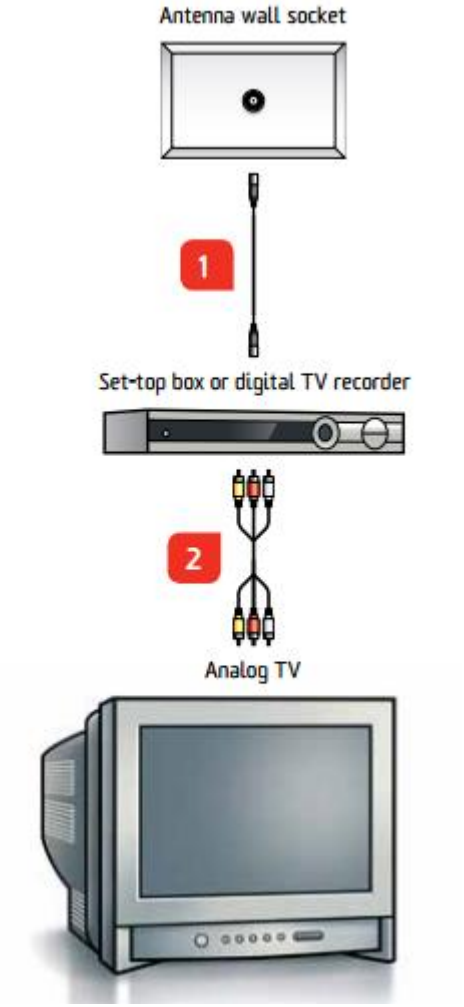


2. The **Video signal** is used to modulate a **carrier** in the frequency in VHF or UHF band.



MONOCHROME ANALOGUE TELEVISION RECEIVER



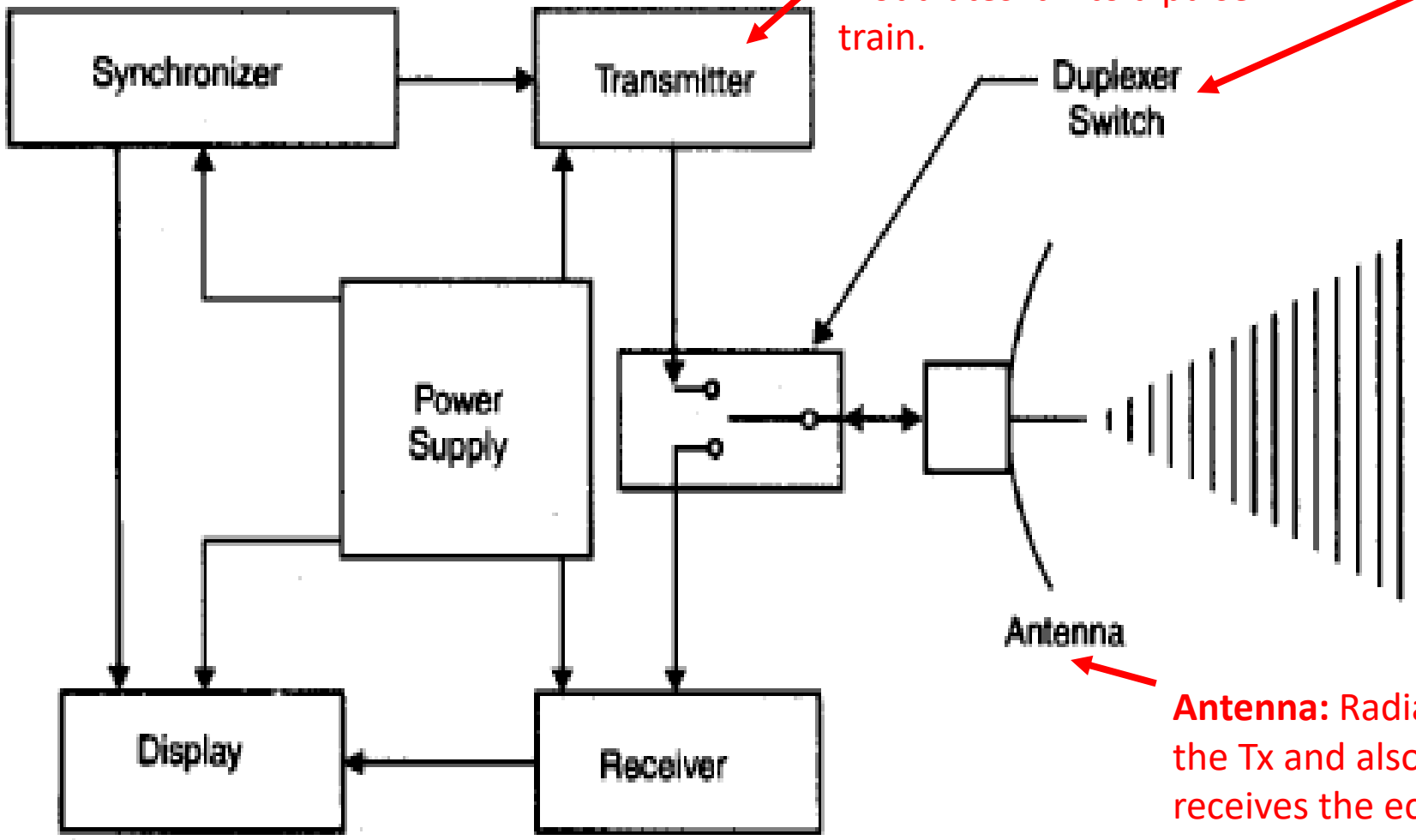


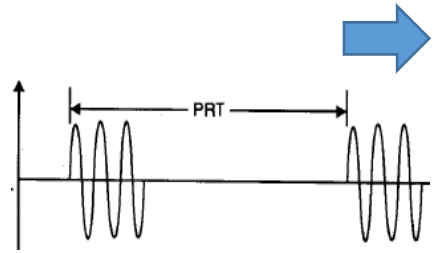
Connecting Analogue TV to Digital

RADAR RECEIVER

Transmitter: Creates the wave to be sent and modulates it into a pulse train.

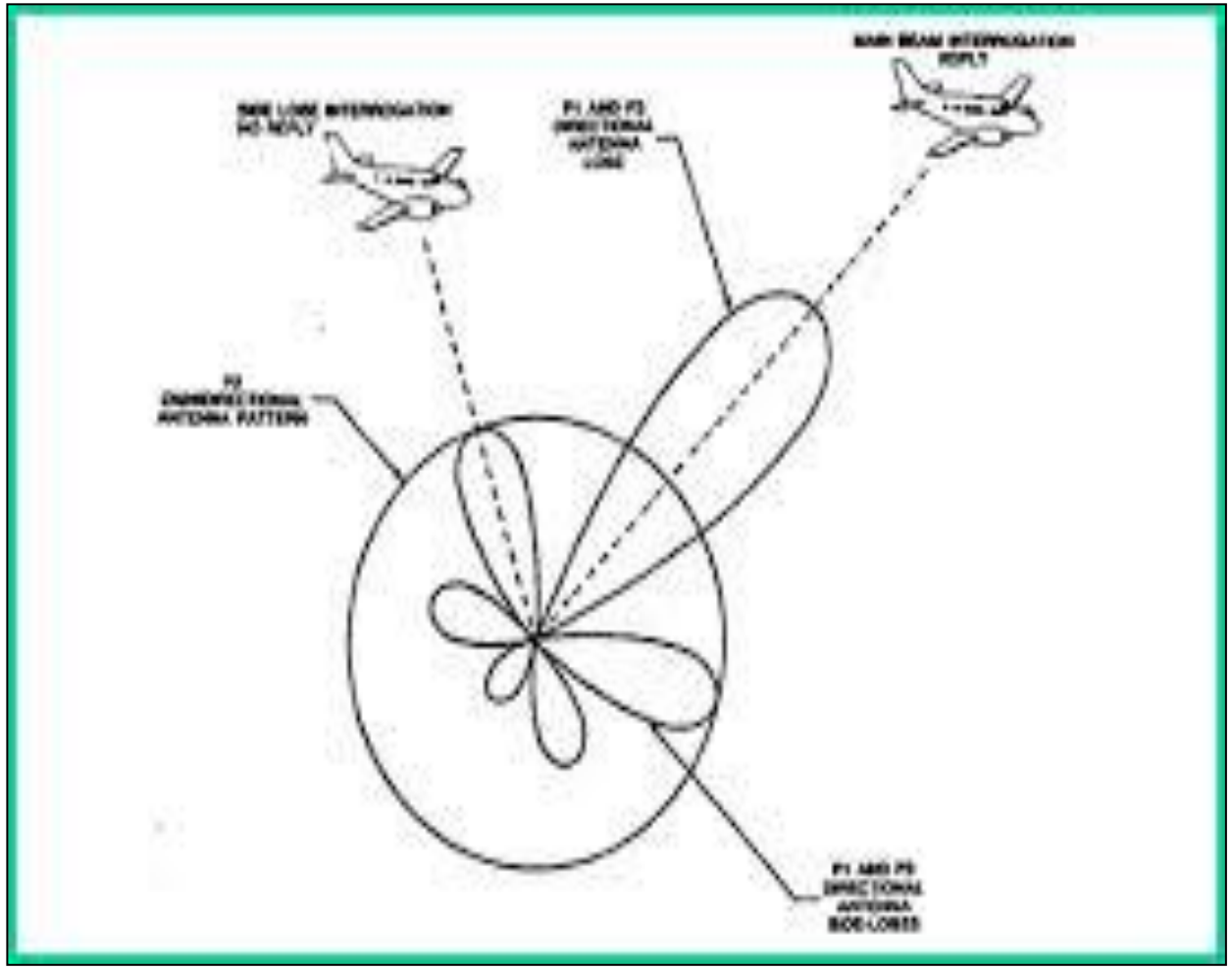
Duplexer: Protects the receiver from the high power transmitted signal

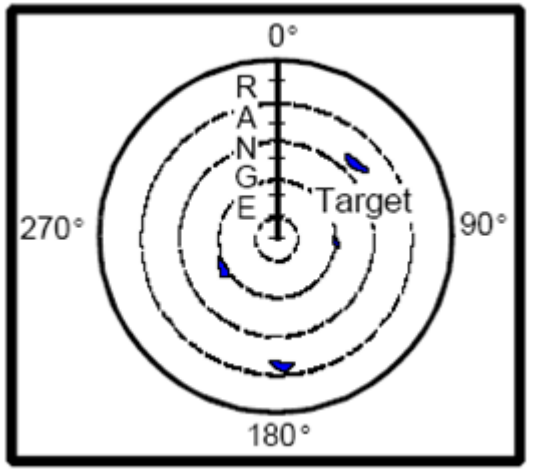




Antenna: Radiates the Tx and also receives the echo signal from target

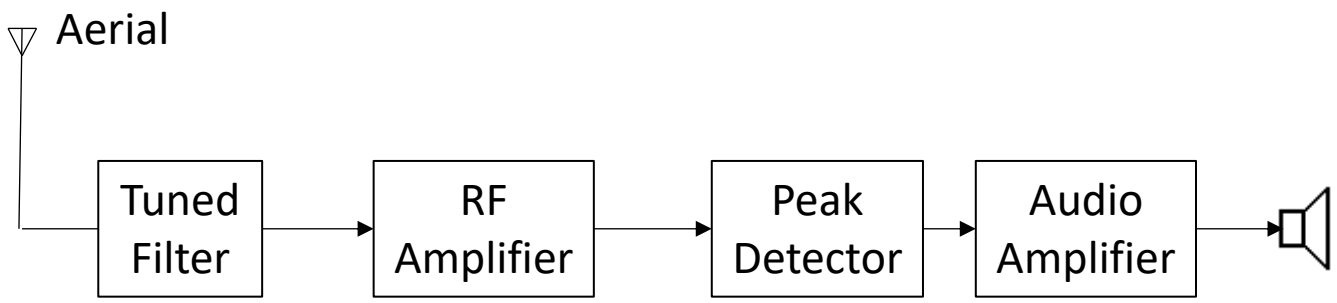
APPLICATION OF RADAR IN AT AIRPORTS





ENVELOPE DETECTOR (from Previous Lecture)

- The envelope detector recovers the transmitted signal riding on the carrier by extracting the envelope of the received signal.
- The AM Envelope receiver circuit consists of 4 major parts:
  1. The tuned tank
  2. The RF amplifier
  3. The peak/envelope detector
  4. The audio amplifier



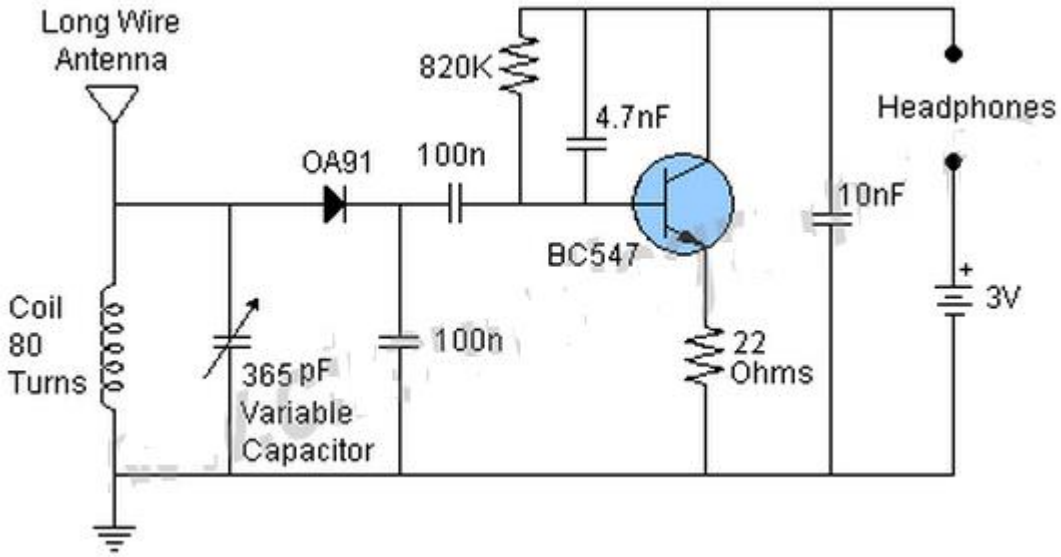
PRACTICAL RADIO RECEIVERS

EEEN 468 – ANALOGUE COMMUNICATION SYSTEMS

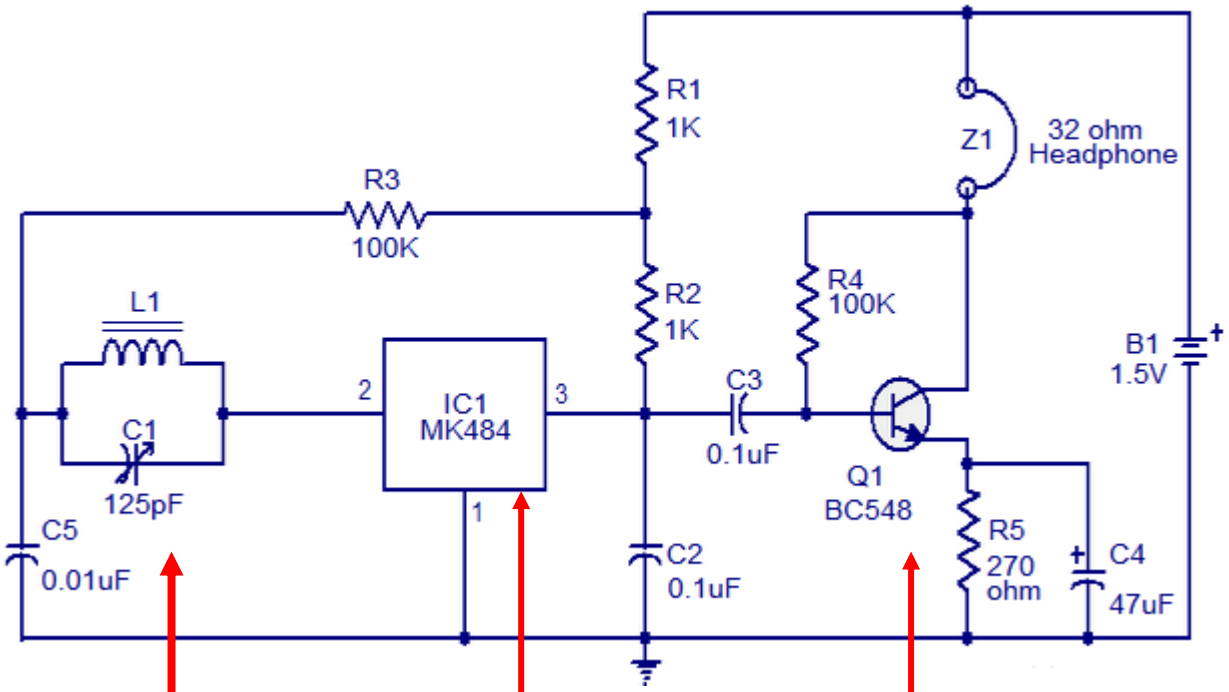
Friday, 04 October 2024

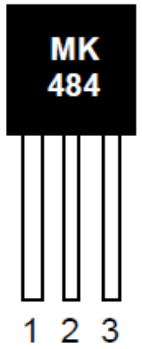
SINGLE TRANSISTOR ENVELOPE RECEIVER (from Previous Lecture)

1. The 80 turns coil and 365pF variable capacitor form a tank circuit
2. The germanium diode and the 100nF capacitor form the envelope detector
3. The general purpose BC547 transistor together with the biasing components form the audio amplifier.
4. The coil is equal to 80 turns of 26 s.w.g. Enameled copper wire wound on an empty card board toilet roll or an off cut piece of plastic waste pipe



PRACTICAL AM RECEIVER CIRCUIT USING MK484 (from Previous Lecture)





Series tuned LC filter

MK484 Envelope detector

Transistor Amplifier

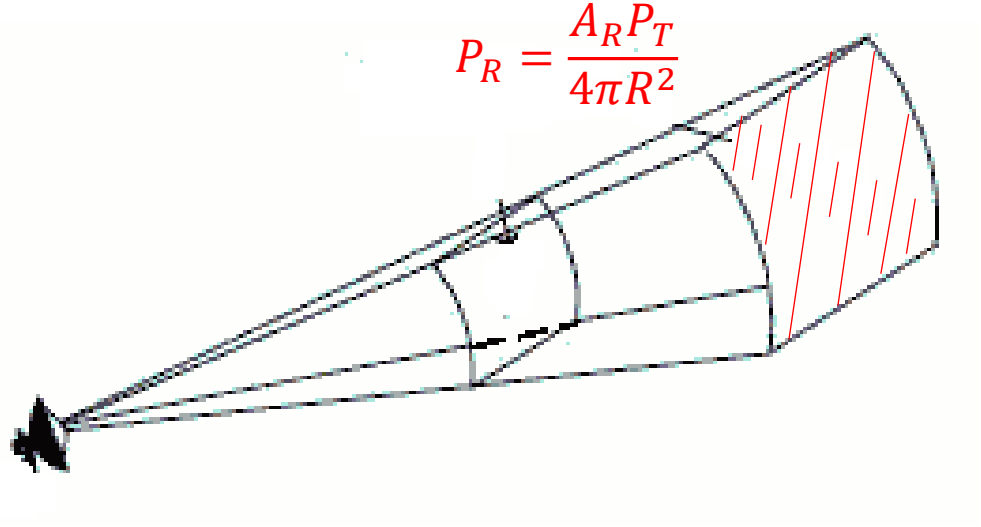
BASIC TRANSMISSION PROBLEM - FADING

1. Consider a transmitter, TX, which is radiating a total power, P_T. All of this power will pass through a sphere of radius, r, centred on the transmitter.
2. The total surface area of such a sphere will be $4\pi R^2$
3. If the TX antenna is isotropic (omnidirectional), an area, A_R , laid on the sphere will intercept a power.
4. Therefore the received power will be:

$$P_R = \frac{A_R P_T}{4\pi R^2}$$

1. This equation is generally referred to as the **Friis Equation.**
2. Friis equation we can see that the received power is directly proportional to the transmitted power P_T but inversely proportional to the square of the distance R.

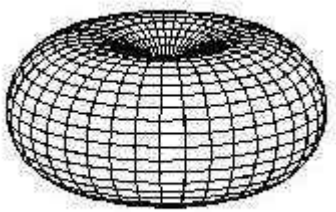
- Even if P_T is in KW, the received signal power several kms will be very small.



OVERCOMING FADING

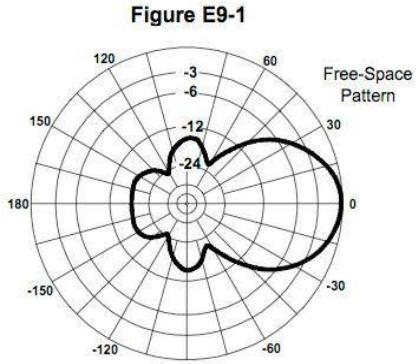
1. Increase the Transmit power
2. Increase the gain of the transmit antenna instead of making them omni-directional
3. Increase the gain of the receive antenna

$$P_R = \frac{G_T G_R A_R P_T}{4\pi R^2}$$



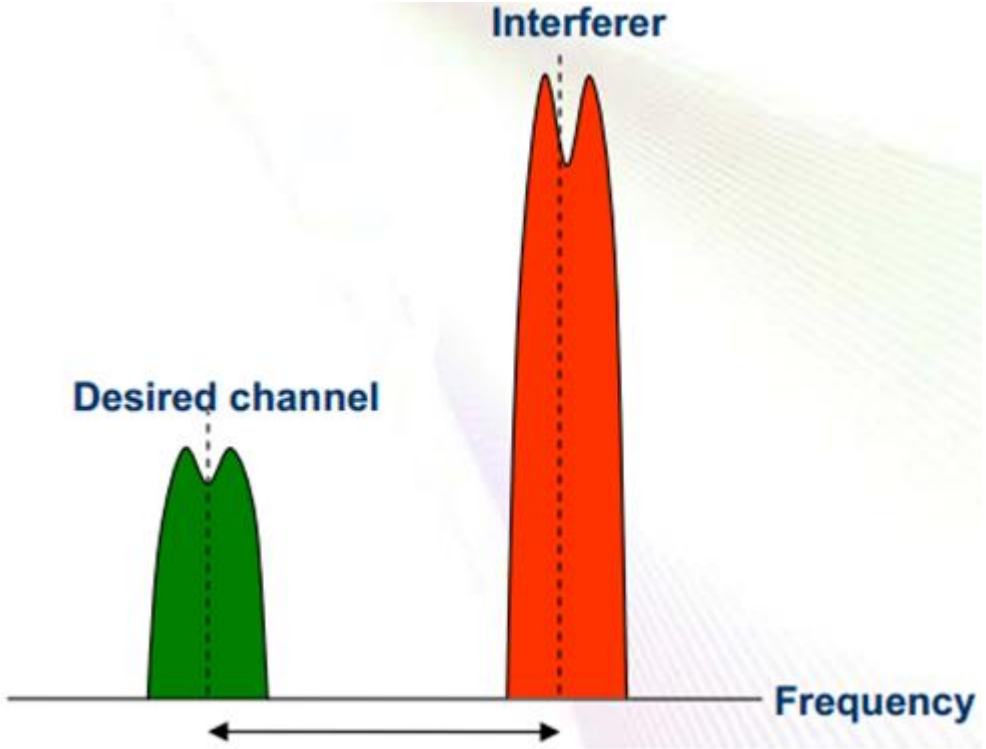
Radiation Pattern of Omni-directional Antenna

Omni-directional Antenna



PROBLEM OF BASIC RECEIVER - SELECTIVITY

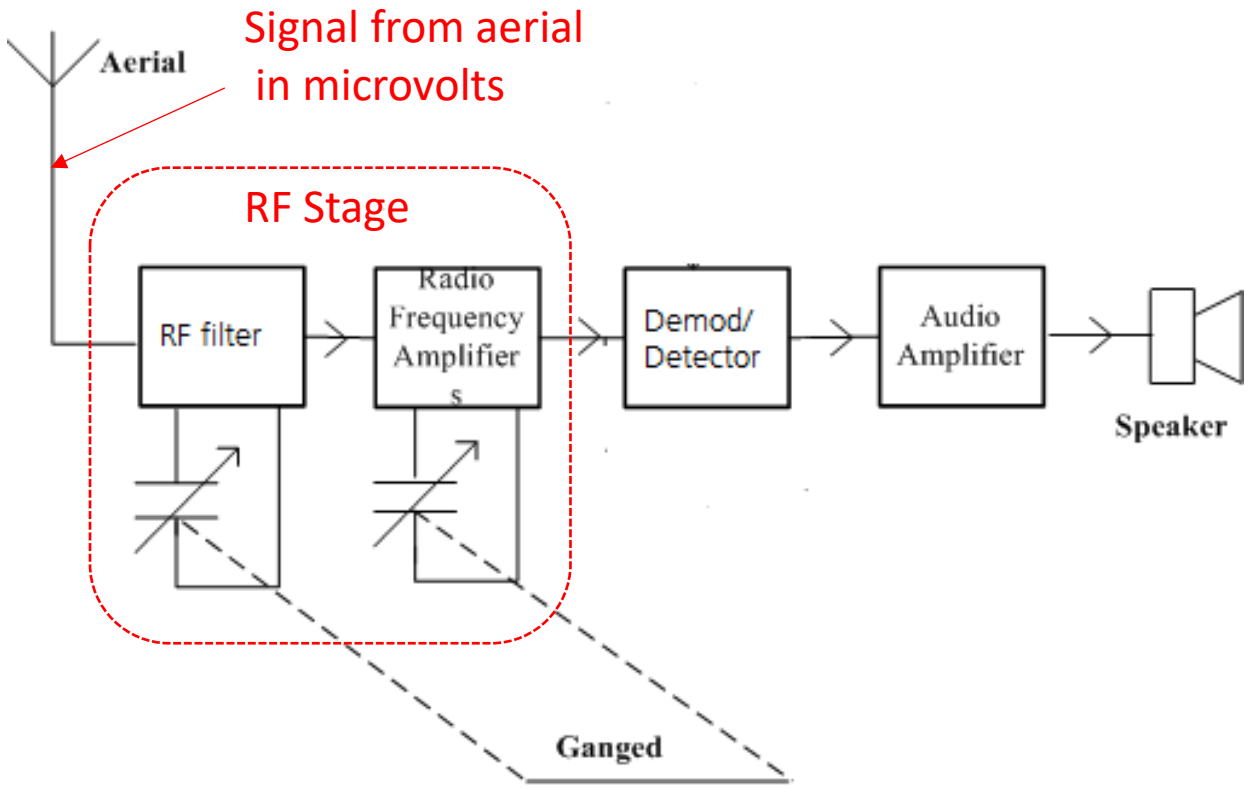
- **Selectivity** measures the ability of the receiver to distinguish between two adjacent channels.



Selectivity

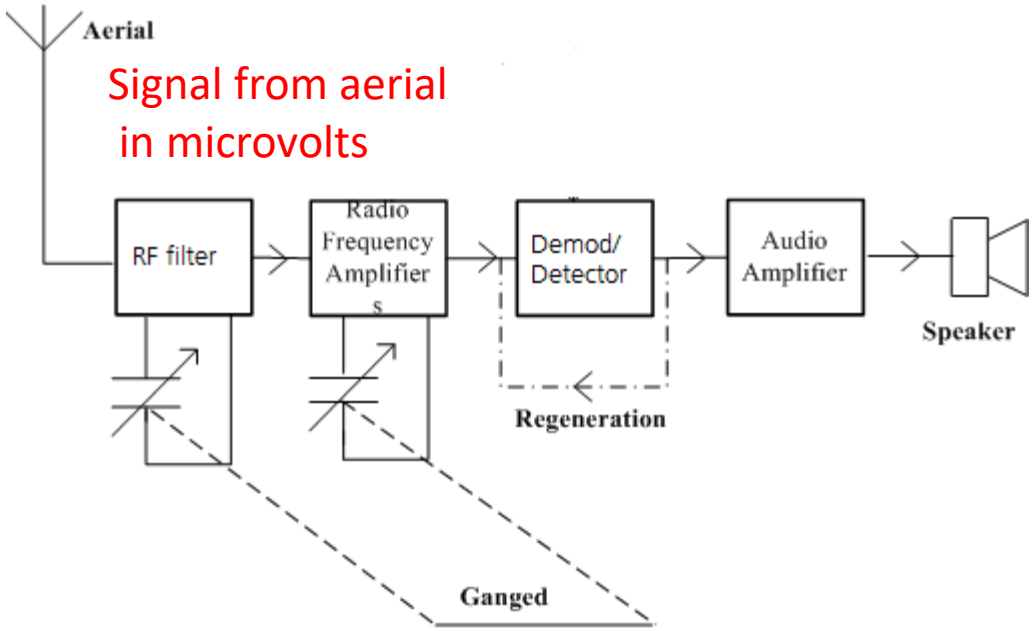
TUNED RADIO FREQUENCY (TRF) RECEIVER

1. A tuned Radio Frequency (TFR) receiver consists of:
   a) **RF Stage** – a tuned Radio Frequency amplifier
   b) **Demodulator or detector** which demodulates the signal
   c) **Audio Amplifier** amplifies the demodulated signal
2. Receiver was widely used in the 1920s but was replaced in the 1930s with the superhetrodyne receiver



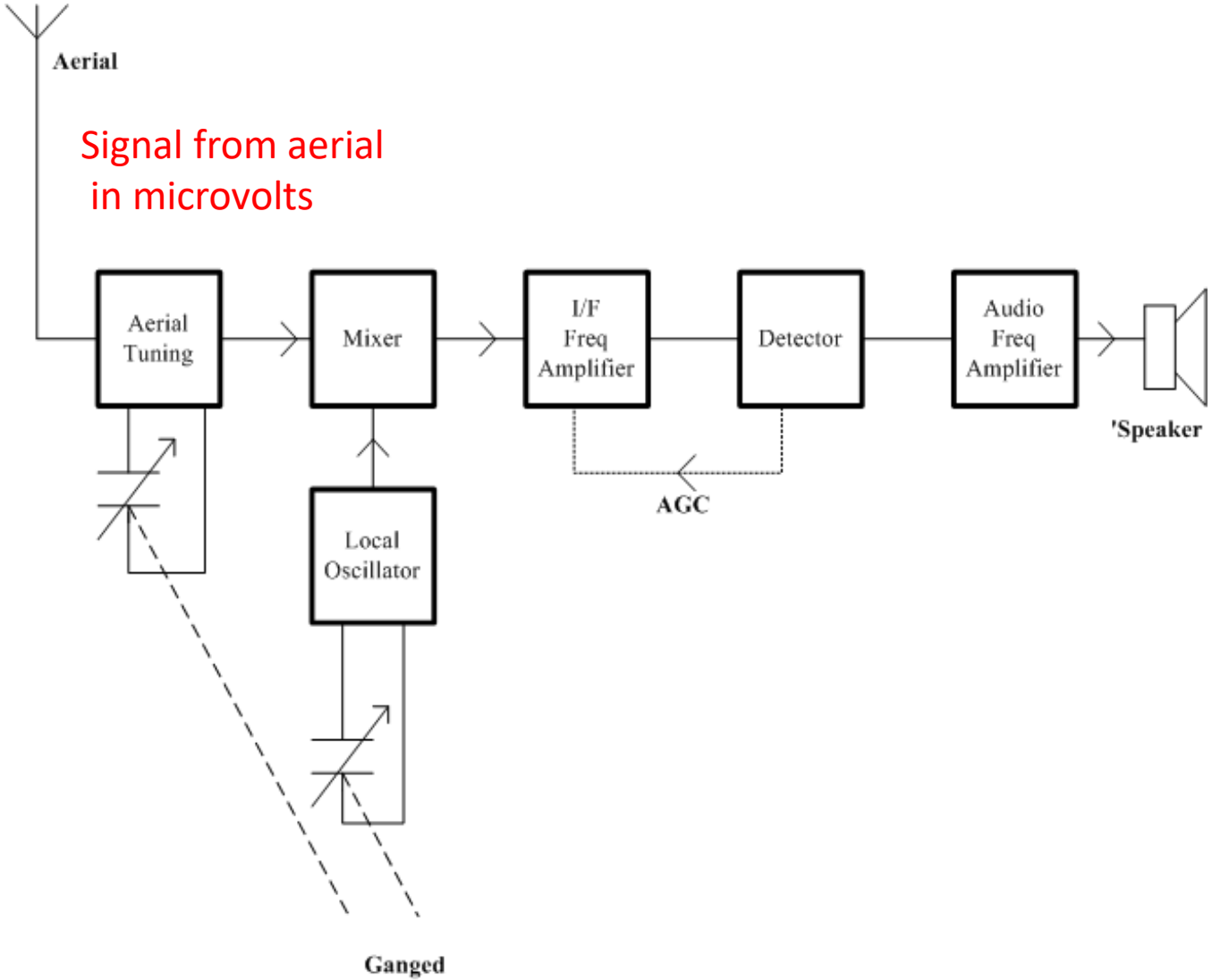
REGENERATIVE TFR RECEIVERS

1. **Regenerative Receiver** is a TRF receiver with positive feedback from its output to increase the gain of that stage.
2. The inclusion of regeneration or "reaction" increases the sensitivity of the receiver.
3. However, if too much regeneration is applied, the set may go into self-oscillation and "howl.
4. It is possible under these circumstances (depending on the design of the receiver) that the set will re-transmit a radio signal from the aerial, possibly causing interference to other users.



SUPERHETERODYNE RECEIVER

1. **Superheterodyne receiver** uses frequency mixing to convert a received signal to a fixed Intermediate Frequency (IF), which can be more conveniently processed than the original radio carrier frequency.
2. **Superheterodyne** is a contraction of "supersonic heterodyne", where:
   a) **supersonic** indicates frequencies above the range of human hearing.
   b) **heterodyne** is derived from the Greek roots hetero- "different", and -dyne "power".



SUPERHETERODYNE RECEIVER

Operating parameters of Superhetrodyne frequency receiver:

1. Two frequency bands:
   a) Medium Wave – 535 kHz – 1650 KHz
   b) Short Wave – 5 – 15 MHz
2. Intermediate Frequency of 455 KHz
3. IF Bandwidth of 10 KHz