Digital or HDTV (High definition TV) or IDTV (Improved definition TV)

8

Digital TV principles

[MW3-18]

Important difficiencies of NTSC analog colour Txn are

(1) Luminance resolution is inadequate for large screen

(2) chrominance —||— is good along vertical direction & insufficient along horizontal direction which causes colour smearing

(3) 4:3 aspect ratio is insufficient with commercial motion pictures where aspect ratio is 16:9

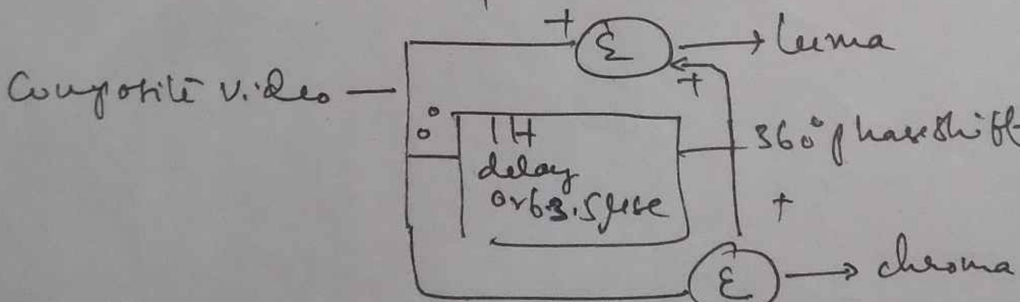
(4) Interleaving of luminance & chrominance signals in 6MHz b.w may conserve b.w but there may be interference or cross luminance (spurious colours in motion pictures)

(5) Interlaced scanning conserves b.w & avoids flickering but not suitable for alphanumeric/medical displays.

Hence analog system must be converted to digital system.

Remedial measures in digital TV are:-

(1) With COMB filtering (Combinational) interference between luminance & chrominance signals at Rx can be reduced.



(2) Greater V resolution is obtained by doing additional scanlines.

(3) Using more elaborate signal processing methods.

100 IRE white level — luminance signal — Chrominance signal

* digitize the signal to reduce noise, distortion, Interference etc.
* use compression techniques JPEG, MPEG, Dolby methods to reduce b/w requirement & better resolution/clarity
* compatibility with computers (storing), mobile units
* sharpen edges of digitized pict. by convolution & correlation to reduce noise/distortion/Interference effects.

(4) picture in picture is another possibility

(5) store video in memory in a compressed format & then use progressive scanning

(6) To get wider aspect ratio use fewer active lines by a technique called letter boxing. used in sport/news/movies etc.

emblem of broadcasting station → unused area

active pict area

commercial/advertisements → unused area

(7) separate luma/chroma TXn improves resolution used in short-distance comm like VCR/DVD use separate wires for audio/video/sound etc.

II Based on quality:-

There are 3 stds in digital TV:-

	Vertical resolution N_H (Pixels)	active V	Aspect ratio	Pixel shape	frame rate/scan
SDTV (Std Defn TV) - 1980	704	480	4:3	square	24p, 30p, 30i, 60p
EDTV (Enhanced DTV) - 1985	1280	720	16:9	-"-	24p, 30p, 60p
HDTV or (High DTV or) IDTV Improved -"- - 1996	1920	1080	16:9	rectangular	24p, 30p, 30i

p - progressive
i - Interlaced

Pict. quality	Bitrate
moderate	225 Mbps
better	922 -"-
best	922 -"- or 1.5 Gbps.

MW3 - 20

18 * Digital TV broadcasts pict & audio signals as digital packets or bursts of data.

* Higher resolution & better quality possible.

* 3 Txn standards globally:

I based on Txn methods.

(1) DVB : Digital video broadcasting (used in India Europe)

* DVB-S (satellite)

This is an

* DVB-T (Terrestrial)

* DVB-C (Cable)

* DVB-H (Handheld)

(2) ATSC : Advanced TV syst Committee : US, Canada, Mexico, South Korea.

(3) ISDB :- Integrated Services Digital broadcasting used in Japan.

India :- DVB-T (8MHz b.w) H.262 / MPEG-2 Video

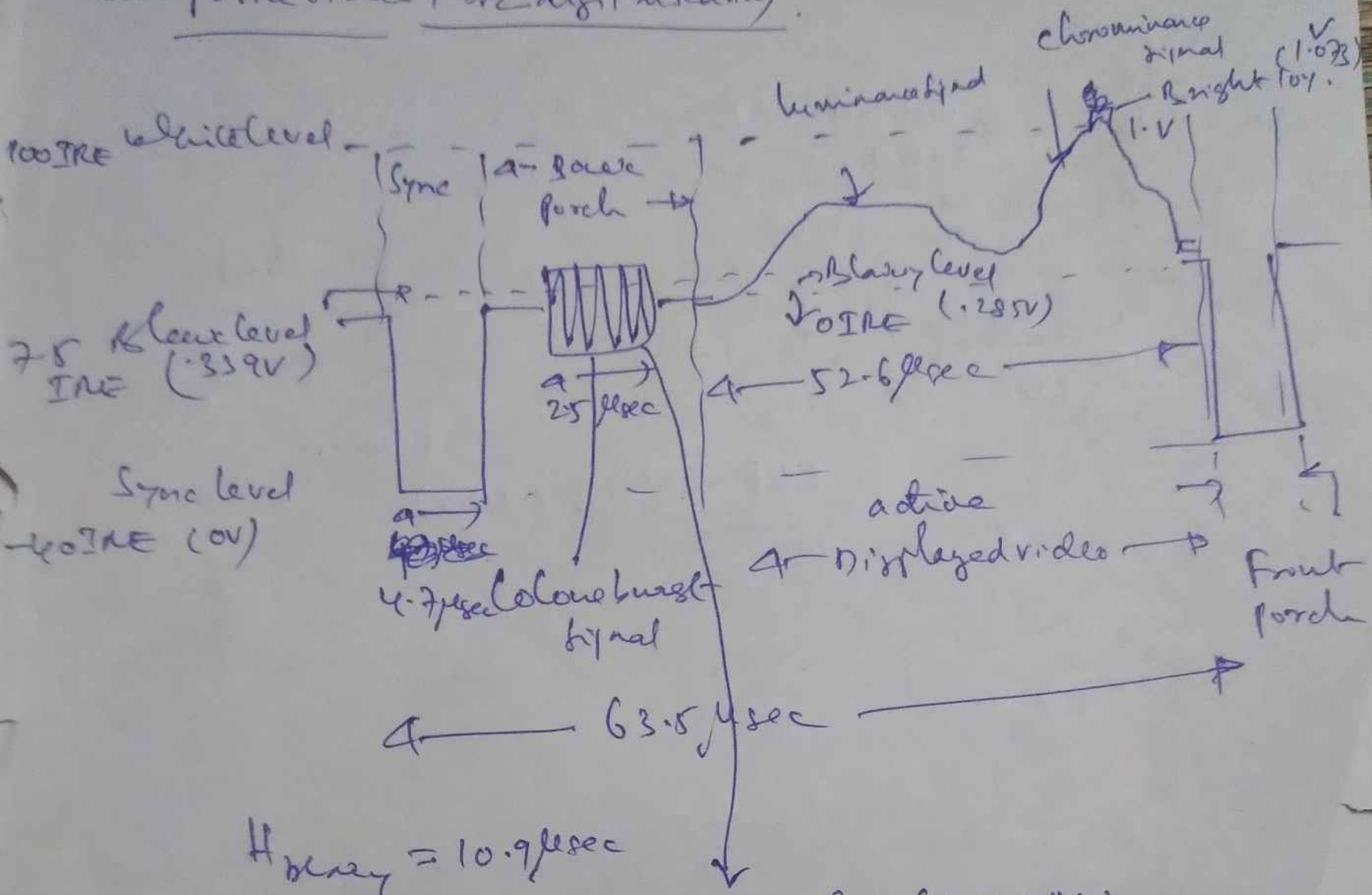
* lossy video - Audio compression

* Theater quality pict & CD quality sound.

* For cable TV (DTH or DVB-C) they use COFDM (coded OFDM) or 256 QAM (data rate 19.39 Mbps) or DCT (Discrete Cosine Transform Algorithm)

* Immune to multipath interference.

Composite video for digital scanning:



$H_{blank} = 10.9\,\mu sec$

8-10 cycles (3.58 MHz)

(40 IRE p-p)

IRE - International Radio Engineers. (Defines the level measurement unit)

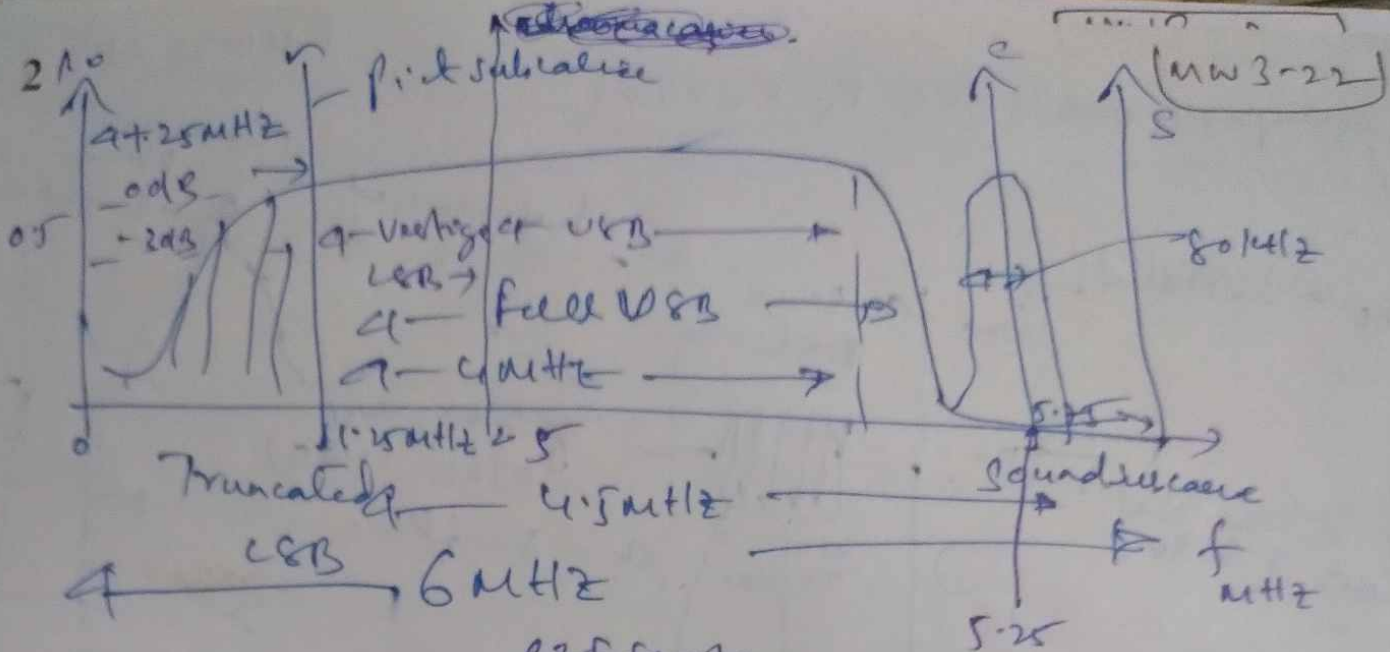
<u>B.W requirement</u>

$B.W = 0.8\,R_H\,F_R\,N_L$

f_R = frame repetition rate

N_L = No of scanning lines

R_H = aspect ratio



CSF system (ITU).

Advanced Radars:-

DVB: Digital Video Broadcasting

UNIT3-23

- open standard for digital TV
- ETSI - European Telecomm Std. Institute maintains the std
- DVB-S,T,C,H are the std, defined for the Physical & data link layers of OSI model
- Device ~~are connected to~~ interact with physical layer the SPI (Synchronous Parallel Interface) or ASI (Asynchronous Serial Interface).
- All data are TX in MPEG streams.
- DVB-S uses 8-QPSK, 16QAM
- DVB-C -"- 16, 32, 64, 128, 256 QAM
- DVB-T -"- 16 or 64 QAM (QPSK), COFDM

	DVB-S2	DVB-T2	DVB-C2
I/P Interface	← multiple transport stream & generic stream encapsulation →		
Modes	Variable & adaptive coding/modln	Variable coding & modln →	
FEC	LDPC + BCH	—"—	—"—
modln/scheme	Single carrier QPSK	OFDM/QAM	OFDM
Fourier transform digt	NA	DFT	Inverse FFT
Interleaving	Bit interleaving	Bit-time-freq Interleaving	→ "—

HDTV Principles:-

$\boxed{\text{UNIT3-24}}$

- Eye is more tolerant to q. noise (8 to 10 bits/sample are used)
- In digital audio with 14 to 18 bits/sample - poorer tolerance of ear.
- No. of bits/sample $m = \dfrac{f_b}{N_{PT}\ R_f}$

where f_b = bitrate, N_{PT} = No. of pixels/frame including luma & chroma signals, R_f = frame repetition rate

& N_{PL} = No. of luminance pixels/frame

$= \underbrace{N_V \times N_H}$

No. of vertical & horizontal resolution pixels

Generally $N_{PT} = 1.5\ N_{PL}$

---

eg: Consider a digital video resolution of 640×480 pixels with $R_f = 30\,Hz$ using p-scan. Assume luminance signal is sampled using 8 bits/sample. Find approximate bit rate of video neglecting synchn., correlation, compression etc.

Soln:-

$m = 8$

$R_f = 30$

$N_{PL} = N_H N_V = 307.2 \times 10^3$ pixels

$N_{PT} = 1.5 N_{PL} = 460.8 \times 10^3$ pixels

$f_b = N_{PT}\ m\ R_f = 110.6\ Mbps.$

Video Compression methods

- Lossy
- Lossless

10 (UNIT 3-25)

- JPEG: Joint picture Expert Group - used for
(lossless) Compressing still pictures
- MPEG: Motion " ---------------
(lossy) live motion pictures
(Audio compression is also done).
→ MPEG 1, 2, 3, 4 stds

MPEG1: Deals with low data rate video like CD-ROMs, Internet etc → (1D, 2D, 3D are common)
MPEG2: uses DCT for reducing data rate to 19.39 Mbps for Terrestrial broadcasting in 6MHz band. Signal is converted from 't' to 'f' domain, digital filtering is used to reduce data rate

other video compression methods:-

I lossless - [Huffman coding, Runlength coding] H.W.

II lossy - [Spatial coding (lossy), Temporal " — (lossy)]

- Spatial: Redundancies within a frame is used. used for still images. This is the basis of JPEG
- Temporal: This includes std video codes such as H.261, H.263, H.264, MPEG 1 to 4
  - This is based on 4 fundamental redundancy reduction principles.

✓ to reduce redundancy among pixels within a picture (Similarity of pixels in a frame is looked into) ~~Using~~ data compression methods like transform coding / predictive coding are used

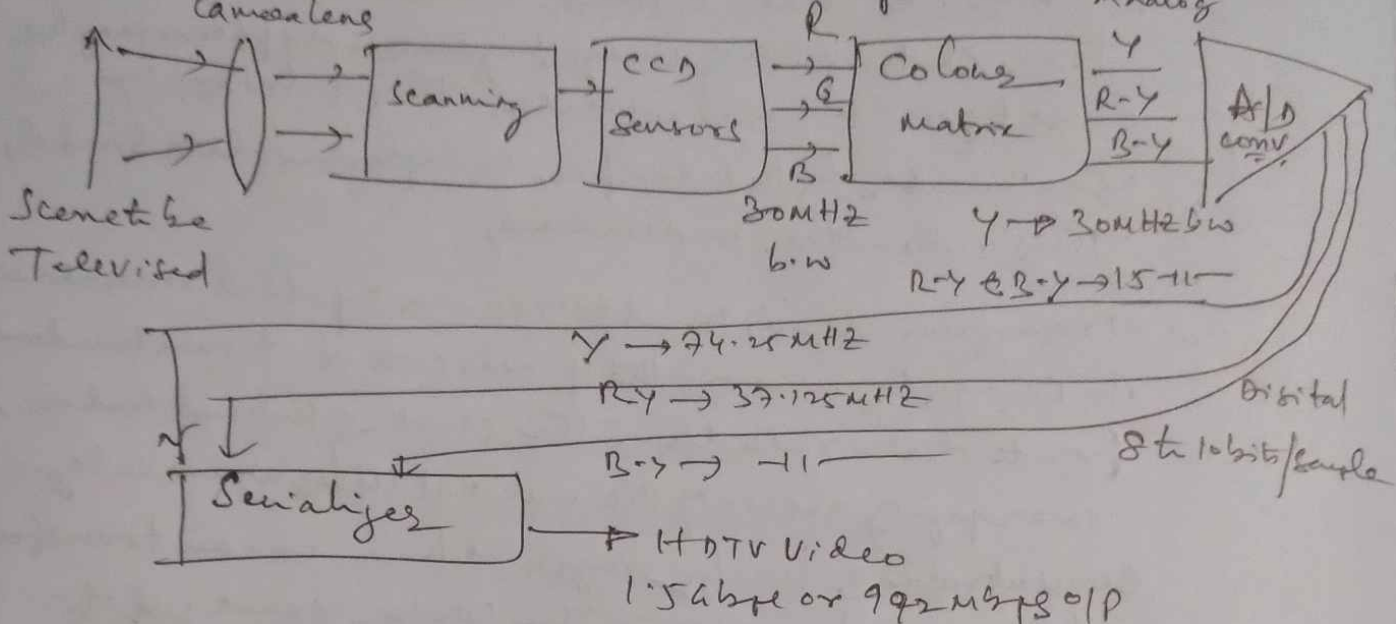
- To remove similarities between successive pictures, we code difference between them. For static part of image sequence, difference may be close to zero & hence not coded. This ↑ bit saving.
- Use variable length coding for compressed data symbols. This reduces the redundancy.
- Transform coding is used to remove spatial redundancies in images by mapping the pixels into a transform domain prior to data reduction. The strength of this method is, energy of most of the natural scenes is mainly concentrated in low freq region & hence we can transform them into few coeffts. They can be quantized to remove insignificant coeffts.

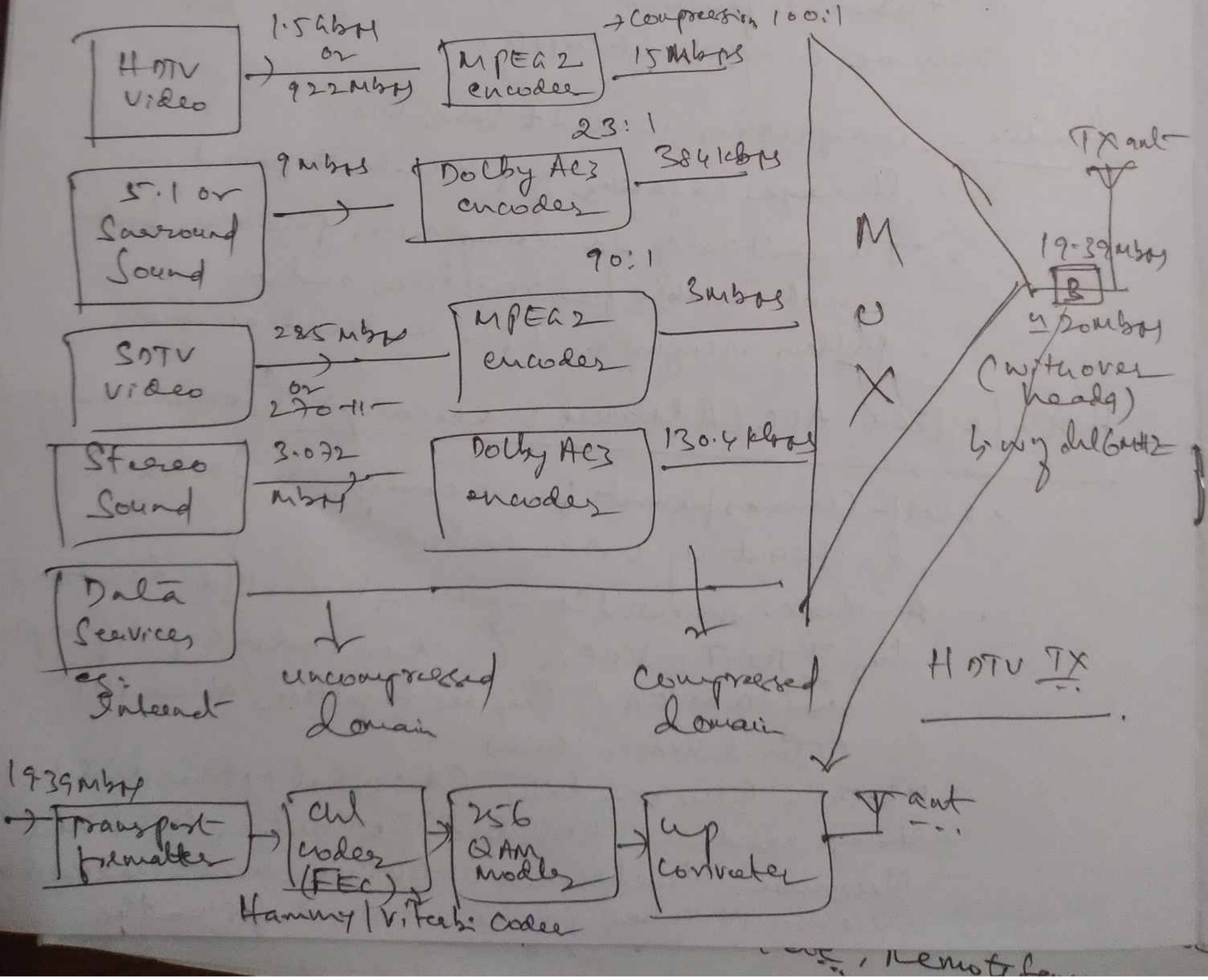
Audio:- . Compression is used to save b/w.
 · Storage capacity of files can be improved.
 · Theoritically 87% compression possible but not suitable for real time audio
 · Pattern recognition, LPC methods are used.

H.264 (MPEG-4 AVC (Advanced Video Coding) (lossy method)

- Most common format for recording, compression & distributing video content.
- A block oriented compression video std. developed by ITU-T-VCEG (Video coding expert group) with MPEG. They are together called JVT (Joint Video Team)
- Used in Blue ray disc (digital optical disc)
- Storage used for HD video. Resolution 1080 pixels. Blue means blue laser or violet laser used to read the disc.
- Vimeo, Y-Tube, itune, HDTV-T, C, S use this

HDTV Signal generation:-





(UNIT3-28)

13

Analog TV	Digital TV
1) AM, FM signal modln	Digital packets
2) Y, I, Q signals	Y, B-Y, R-Y signals
3) AM-VSB	8VSB-TCM, MPEG-2, AVC-Advanced Video coding
4) 6MHZ + Audio chl	6MHZ chl + Multicasting / Multiprogram Viewing
5) EIRP - 45 to 75 kW	5 to 7.5 kW
6) Noise & multipath Interference more	Nil
7) Phosphor, LED screens	LCD, plasma screens
8) Aspect ratio 4:3	16:9
9) poor quality	Best quality

UNIT4:- RADAR principles:-

("RAdio Detection And Ranging)

Introduction:- "Gathering Information about distant objects or targets by sending EM waves and analyzing echoes"

These words were coined by US Navy in 1942 during worldwar.

* Radar can improve human Vision during darkness|fog|haze|rain|snow etc to detect targets (airplanes|ships etc)
* Frequency bands are Similar to trading µwave band.

VHF (30-300MHZ), UHF (300-1GHZ), L, S, C, X, ku, k, ka are used. power will be from 0.25MW to fewtens of MW.

Applications:- Used on ground, space, sea.

a) Groundbased: Sunami early warning, weather, tracking of targets

b) Air/Spacebased: Detect aircraft, ships, land vehicles movement, Storm avoidance, navigation, Remote sensing, guidance of spacecraft etc.

c) Seabased: Navigation of ships, locating shore, Rescue operations etc

d) Military applications.

Major areas:-

1) ATC - Air traffic control: GCA - Ground Control approach, ILS - Instrument landing system, Radar beacons

2) Satellite tracking, Missile guidance, Space Station docking, outer space mission etc, Remote sensing apply

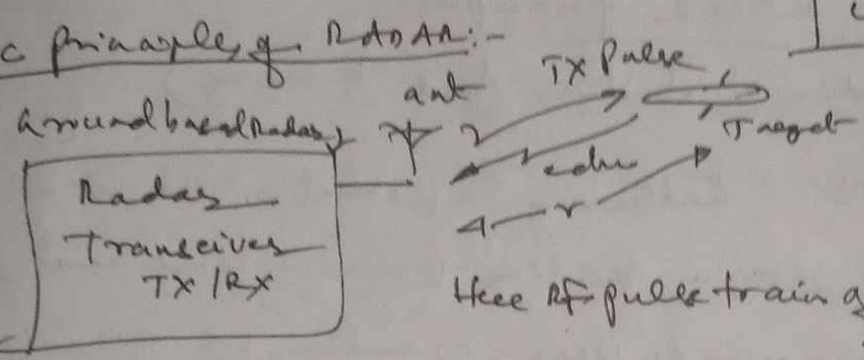
3. Torch ...

Types of Radars

1) Pulse Radar ← Search ...

UNIT 4-2

Basic principle of RADAR:-



Here RF pulse train of specific PRF, pulse width, power, duration are transmitted towards the target. Echo from the target is analyzed for parameter like

- Range • direction • Velocity • Direction of motion etc.

- If T_R is the round trip delay for RF pulse, r the range then $r \simeq \frac{cT_R}{2}$ $c \to$ vel of EM wave 3×10^8 m/sec
  2 → (Two way motion)

- r can be in km or miles or Nautical miles (NM)
  1 NM = 1.854 km or 1854 meters.

- T_R is function of f_p (pulse repetition rate)
  $T_R = 1/f_p$ $\therefore r = \frac{c}{2f_p}$ as $f_p \downarrow$ or $T_R \uparrow$ $r \uparrow$.

- MUR:- (Max Unambiguous Range)

For correct estimation of range of a target, correct detection of echo from target is necessary. Hence sufficient time must be given to Rx for detecting the echoes from desired target. Hence MUR is important.

MUR(miles) $\simeq \frac{PRT}{12.2}$ PRT → pulse repetition time in µsec

But PRT = $\frac{\text{Pulse width}}{\text{Duty cycle}}$

UNIT-4-25

Classification of Radars

UNIT-4-3

1) Pulse Radars — Search Radars / Tracking — " — / Search while Tracking radars

2) Continuous wave Radars

3) Doppler Radars

4) Radar beacons

5) MTI - Moving Target Indicator

6) ILS - Instrument Landing System

7) Advanced Radars.

Radar Range equation: (Unambiguous range)

- Correct equation for range can be developed by incorporating parameters like transmitted power (P_t), gain of antenna (A_p), antenna aperture (A_o), wavelength of transmission (λ), c/s area of target etc.

- If P_t is the peak transmitted pulse power, according to inverse square law power density (forward direction) at a distance 'r' from an isotropic antenna is

$$P_1 = P_t / \underbrace{4\pi r^2}_{\text{surface area of a sphere}} \quad \text{--- (1)}$$

- we use directional antennas for Txn & reception. Then power density is $P_2 = A_p P_1$ where A_p is the power gain of TX. ant

$$= \frac{A_p P_t}{4\pi r^2} \quad \text{--- (2)}$$

- power intercepted by a target with c/s area of 'S' is

$$P_3 = P_2 S = \frac{A_p P_t S}{4\pi r^2} \quad \text{--- (3)}$$

k - Boltzmann constant $= 1.38 \times 10^{-23}$ J/°K

UNIT 4-5

- A portion of the signal will be reflected back in the form of an echo, hence power density at the radar receiving ant is

UNIT 4-4

$$P_4 = \frac{P_3}{4\pi r^2} \rightarrow \text{Inverse square law in reverse direction}$$

$$= \frac{A_p P_t S}{(4\pi r^2)^2} \quad -(4)$$

- If A_o is the capture or aperture area of receiving antenna at the RX, then power intercepted is

$$P_5 = P_4 A_o = \frac{A_o A_p P_t S}{(4\pi r^2)^2} \quad -(5)$$

- For better efficiency same antenna is used for both TXn & RXn. A_p & A_o are related by $A_p = \frac{4\pi A_o}{\lambda^2}$ $-(6)$

where $\lambda \rightarrow$ wavelength of TX RF pulse

eq (6) in (5) gives $P_5 = \frac{P_t A_o^2 S}{4\pi r^4 \lambda^2}$ or $\frac{P_t A_p^2 \lambda^2 S}{(4\pi)^3 r^4}$ $-(7)$

- except 'r' & 'P_5' all other parameters are constants.

For 'r' to be maximum, 'P_5' must be minimum (i.e radar receives weakest echo from farthest target)

i.e as $P_5 \rightarrow P_{min}$ then $r \rightarrow r_{max}$

$\therefore$ from eq (7) $r_{max} = \left(\frac{P_t A_o^2 S}{4\pi \lambda^2 P_{min}}\right)^{1/4}$ or $\left(\frac{P_t A_p^2 \lambda^2 S}{(4\pi)^3 P_{min}}\right)^{1/4}$ $-(8)$

$\hookrightarrow$ Ideal radar range equation

Note:- No effect of noise, interference is considered.

- Mostly the RX work under threshold, where threshold limit is thermal noise limit.

$$\therefore P_{min} = kT_o \delta f (F-1) \quad -(9)$$

k = Boltzmann constant = 1.38×10^{-23} J/°K

UNIT 4-5

$T_0 = 273 + t°C$ → Temp in degree kelvin.

δf = b.w of the Rx, F → noise figure ratio = $\frac{(SNR)_{i/p}}{(SNR)_{o/p}}$ of Rx

eq (9) in (8) gives

$$r_{max} = \left(\frac{P_t A_0^2 S}{4\pi \lambda^2 k T_0 \delta f (F-1)} \right)^{1/4} \quad \text{--- (10)}$$

- Mostly the time we use dish antenna, whose aperture area is given by $A_0 = \eta \frac{\pi D^2}{4}$ where η is the aperture efficiency $\simeq 0.65$ (typically)

(D = mouth dia of ant.

→ $\left[A_0 = \eta A \right.$ → physical area of the mouth c/s i.e πR^2 or $\left.\frac{\pi D^2}{4}\right]$

Assuming $T_0 = 300°K$ (room temp), substituting these & simplifying

$$\underset{\downarrow \text{ km}}{r_{max}} = 48 \left[\frac{\overset{\to \text{watts}}{P_t}\ \overset{\to m}{D^4}\ \overset{\to m^2}{S}}{\underset{\downarrow Hz}{\delta f}\ \underset{\downarrow m}{\lambda^2}\ \underset{\downarrow \text{ratio}}{(F-1)}} \right]^{1/4} \quad \text{--- (10A)}$$

→ Range equation considering noise effects.

Factors affecting the range :- From eq (10A)

1. $r_{max} \propto \sqrt[4]{P_t}$ → To double the range P_t must be ↑ by 16 fold, uneconomical not suggested.

2. $r_{max} \propto \frac{1}{\sqrt[4]{P_{min}}}$ → By ↓ P_{min}, optimizing of r_{max} possible

But ↓ P_{min} may result in less sensitivity of Rx & Rx may prone to jamming & interference.

3. ↑ for ↓ λ

aerial target that are ...

3.(a) $r_{max} \propto D$ (b) $r_{max} \propto \frac{1}{\sqrt{\lambda}}$ [UNIT-6]

- As D ↑, r_{max} also ↑ → This is better & economical
  Also as λ ↓ or f ↑ then also r_{max} ↑
- Here there is a consequence, as Half power beam width of an antenna (B.W.) is = $\frac{70\lambda}{D}$, then
  ✓ as D ↑, B.W ↓ — advantage in tracking radars
  but disadv in search " —
  (Radar takes more time for searching)
  ✓ as λ ↓ then also B.W ↓
- Hence compromise is necessary between D & λ for optimizing r_{max} for a specific appln.

4. $r_{max} \propto \sqrt[4]{S}$ → c/s area of target as viewed from the ant is assumed to be constant, No control here

5. Ground interference (magnetic effect of ground) affects sidelobes of the antenna, if ant is not properly elevated. Hence ✓ target detection becomes difficult — which may be used as an advantage in military appln.. Aircrafts can fly at very low altitude without being detected by enemy radar — F16, Mirage, Stealth bomber etc.
✓ range will be affected.

Radar Beacons:-

UNIT4-7

- This is active target detection.
- Beacon is a ~~[illegible]~~ target that contains a small radar set and an omnidirectional antenna.
- Signal processing is possible in beacon radar, hence range optimization possible.

Applications: * Satellite transponders — work under UL & DL

* In aircraft — Beacons — for commn with ATC
  - Altimeters — continuous monitoring of height of aircraft during flying safety. This is necessary to maintain constant pressure/humidity/temp/oxygen etc inside the craft at high altitudes.

* Military: IFF appln
(Identification of Friend or Foe)
In border areas there will be airzone intrusion from the enemy aircraft. ATC sends a coded message to the target during the interrogation link. If it is a friend aircraft it replies, otherwise enemy aircraft doesn't reply. ATC takes suitable action.

Beacon range equation: on similar lines as we have derived radar range eqn, here also we can derive.

- Interrogation link range: (Ground based RR is Txr & beacon radar is Rxr.)

Power intercepted by beacon antenna is

$$P_B = \frac{A_{PT} P_{tT} A_{0B}}{4\pi r^2} \quad -(1)$$

Subscript T → ground based RR, B → Beacon radar

A tor v

Radar Beacons:-

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Beacon range equation: on similar lines as we have derived radar range eqn, here also we can derive.

- Interrogation link range: (Ground based RR is Txg & beacon radar is Rxg)

Power intercepted by beacon antenna is

$$P_B = \frac{A_{PT} P_{tT} A_{oB}}{4\pi r^2} \quad -(1)$$

Subscript T → ground based RR, B → Beacon radar

3. ↑ for r

$\therefore \delta f = 5\ \text{kHz}$

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as $P_B \to P_{min,B}$ then $r \to r_{max,I}$ $\boxed{\text{UNIT-8}}$

↳ Interrogation

$$r_{max,I} = \sqrt{\frac{A_{PT}\, P_{tT}\, A_{OB}}{4\pi\, P_{min,B}}} \quad —(2)$$

· w.k.T $A_{PT} = \frac{4\pi A_{OT}}{\lambda^2}$ and $P_{min,B} = kT_0\, \delta f\,(F_B - 1)$

ground based Radar — min detectable power of beacon

· $$r_{max,I} = \sqrt{\frac{A_{OT}\, P_{tT}\, A_{OB}}{kT_0\, \delta f\, \lambda^2 (F_B - 1)}} \quad —(3)$$

· ||| ly for reply link (beacon RR Tx & ground based RR)

$$r_{max,R} = \sqrt{\frac{A_{OB}\, P_{tB}\, A_{OT}}{kT_0\, \delta f\, \lambda^2 (F_T - 1)}} \quad —(4)$$

· Here we assume $\lambda, T_0, \delta f$ are same for both ground based RR & beacon RR

· In satellite applications eq (3) may correspond to UL

where $T_0 \to$ temp of sat Rx, $\delta f \to$ b.w of sat Rx

$\lambda \to \lambda_U$

eq (4) corresponds to down link

$T_0 \to$ temp of earth station Rx, $\delta f \to$ b.w of ES Rx

$\lambda \to \lambda_D$

∴ As $P_{tT} >> P_{tB}$, $r_{max,I} >> r_{max,R}$

Hence smaller of the two is considered as the beacon range.

Problem: In Moon mission following data are available

UNIT-4-9

$f = 2.5 GHz$, $T_0 = 290°K$, $\delta f = 5 kHz$

	Ground radar	Beacon radar
P_t	0.5 MW (P_{tT})	50 W (P_{tB})
Ant dia	64 m	1 m
Noise Fig (F)	1.1 (ratio) (F_T)	13 dB (ratio ≃ 20) (F_B)

Assume $\eta = .65$ for dish antenna

- Is tracking possible? • How range can be optimized
- What will the range of beacon?

Soln.

$$A_{oT} = \frac{(0.65)(\pi)(64)^2}{4} \ m^2 \qquad A_{oB} = \frac{(.65)(\pi)(1)^2}{4} \ m^2$$

Substituting & simplifying

$\therefore$

$r_{max,I} =$ km $\qquad r_{max,R} =$ km

Inferences:-
- $r_{max,I}$ extends beyond our solar system ($\simeq$ 1.5 times that the dia of our solar system) Hence tracking a beacon on moon, which is at a shorter distance is easily possible
- Beacon range is $r_{max,R} =$ km

Range optimization!

1. Increase ant dia — This is easily possible in ground based radar, but difficult in beacon. Hence use folded umbrella type ant on beacon. Ant will be in folded form during launching & after it it is in orbit, ant can be defolded.
2. Increase sensitivity of Rx
3. $\uparrow f$ or $\downarrow \lambda$

period.

$0.1 < \tau < 1\,\mu sec$, $T >> \tau$ T – Time per

$\boxed{\text{UNIT-4-10}}$

Pulse Radar:- Emits short & powerful pulses & receives echo signals during silent period.

$0.1 < \tau < 1 \mu sec$, $T >> \tau$.

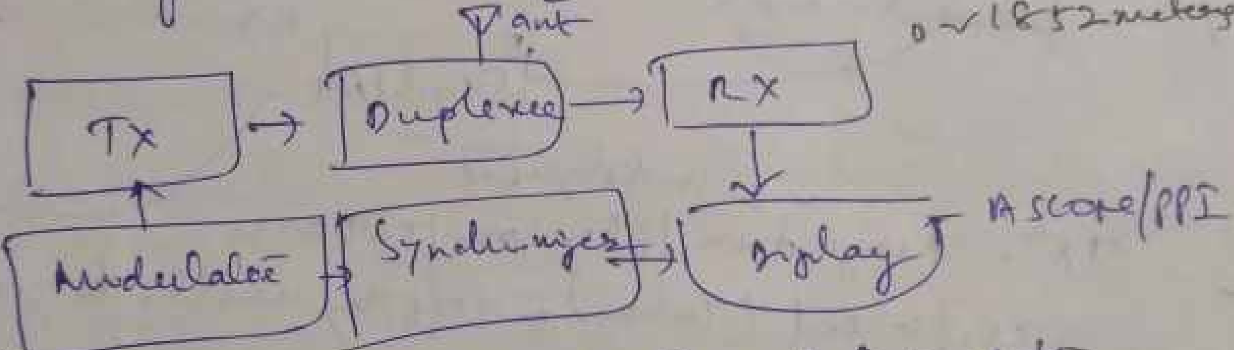
T – Time period of pulses
τ → pulse width

$T \approx 1 msec$

* PRF, T & τ have influence on the range i.e minimal measuring range & MUR.

* Range resolution $\Delta R = 0.5 \tau c$
* B.W of radar $B = \frac{1}{\tau}$

1NM = 1.852 km or 1852 meters



* pulse RR – Monostatic – Tx & Rx at same site
  Bistatic —"— different "

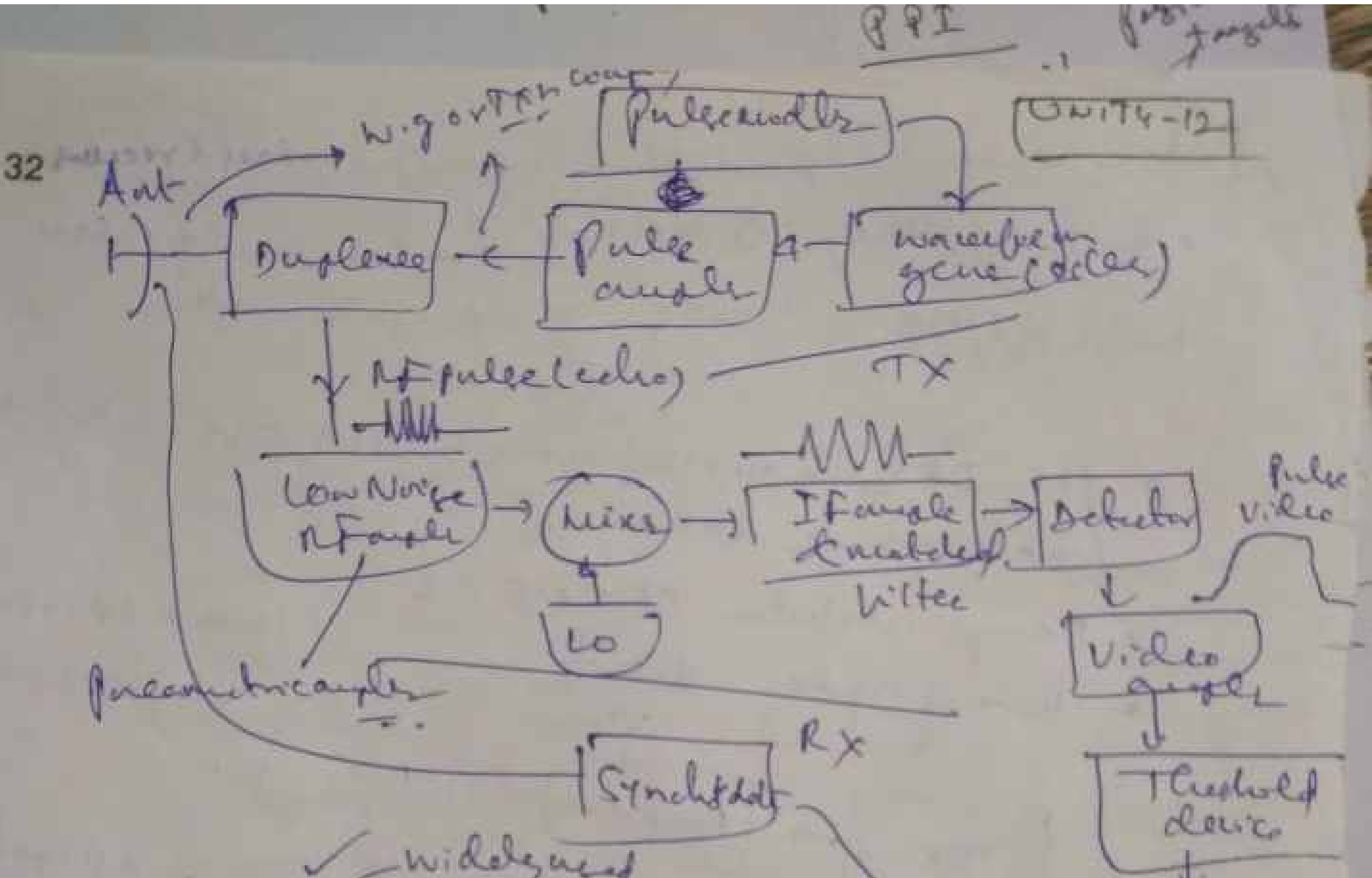
* Appl:- Search RR, Tracking
✓ long distance comm
✓ ATC
✓ weather monitoring
✓ Remote sensing

* Duplexer has TR/ATR switch. So that during Tx of a pulse TR switch connect Tx to ant & isolate Rx from strong signal & during Rx mode, ATR switch is inactive & connects echo to Rx isolating the Tx.

* If T_R is the round trip delay then
$$R(km) \approx 0.15 T_R(\mu sec)$$
$$\text{or } R(nmi) \approx 0.081 T_R / \mu sec$$

PPI

UNIT4-12



✓ wideband

TX:- Magnetron / Klystron / TWT oscillator is pulsed (Turned on/off) by modulator to generate a train of pulses. For R ≈ 100 to 200 NMi in ATC requires 1 MW peak power. For air surveillance IF ope freq will be 30 to 60 MHz & b.w ≈ 1 MHz.

Ant will be a reflector / phased array ant.

Parabolic reflector:- A_p = 34 dB, HPBW = 11 to 19°

τ = 60 sec, R_{min} = 2 NMi to 200 NMi

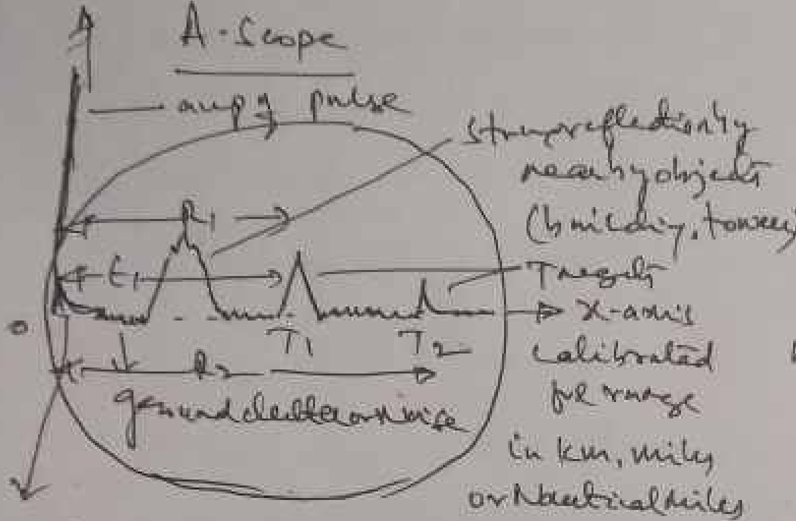
PRF = 300 Hz N.F = 4.2

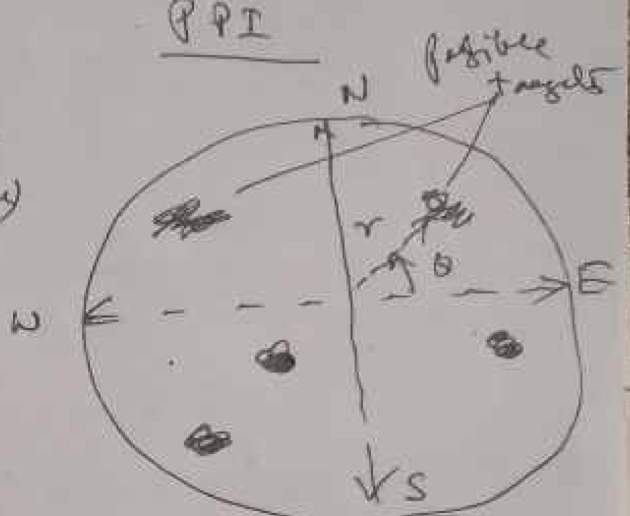
Advanced Radars:-

UNIT-4-13

Display in Radars:- A-Scope

PPI – plan position Indicator





Ref blip (pulse) that on TX

$t_1 \rightarrow$ round trip delay of Target

Map of illuminated area near ATC

Comparison

A-Scope	PPI
1. Deflection Modulated CRT (Electrostatic defln)	1. Intensity Modulation CRT (magnetic defln)
2. Range only	2. Range & direction
3. Spiral scanning	3. Conical scanning
4. short / long persistance phosphor coated screen	4. long persistance...
5. Used in tracking radars	5. Used in search Radars
6. x axis calibrated for range; y → displays amplitude of echoes / pulses	6. x & y axis for direction
7. Rectangular coordinates (distance only)	7. polar coordinates r/θ; r → distance; θ → direction

UNIT4-14

CW Radar (Continuous wave Radar)

UNIT-5

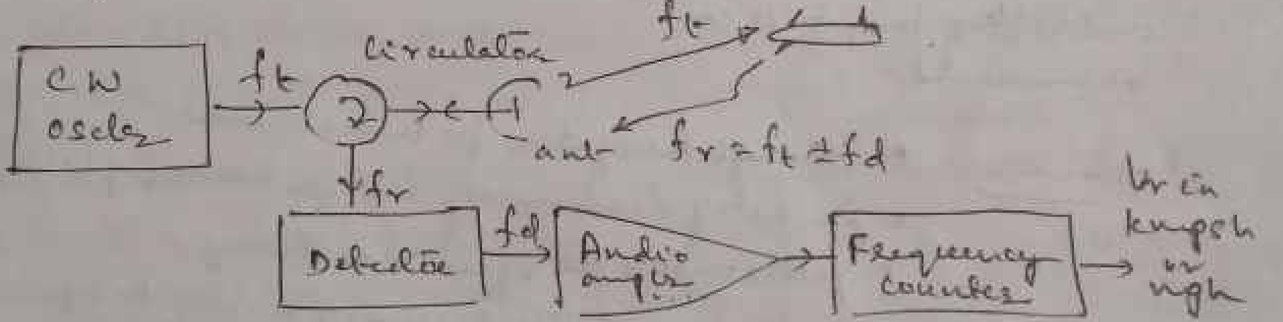
Detects objects and able to measure radial vel of target using Doppler shift principle. (Austrian mathematician)

* Doppler principle: Doppler shift in freq due to relative motion of the target is $f_d = \frac{2V_r\cos\theta}{\lambda} = \frac{2V_r\cos\theta f_t}{c}$

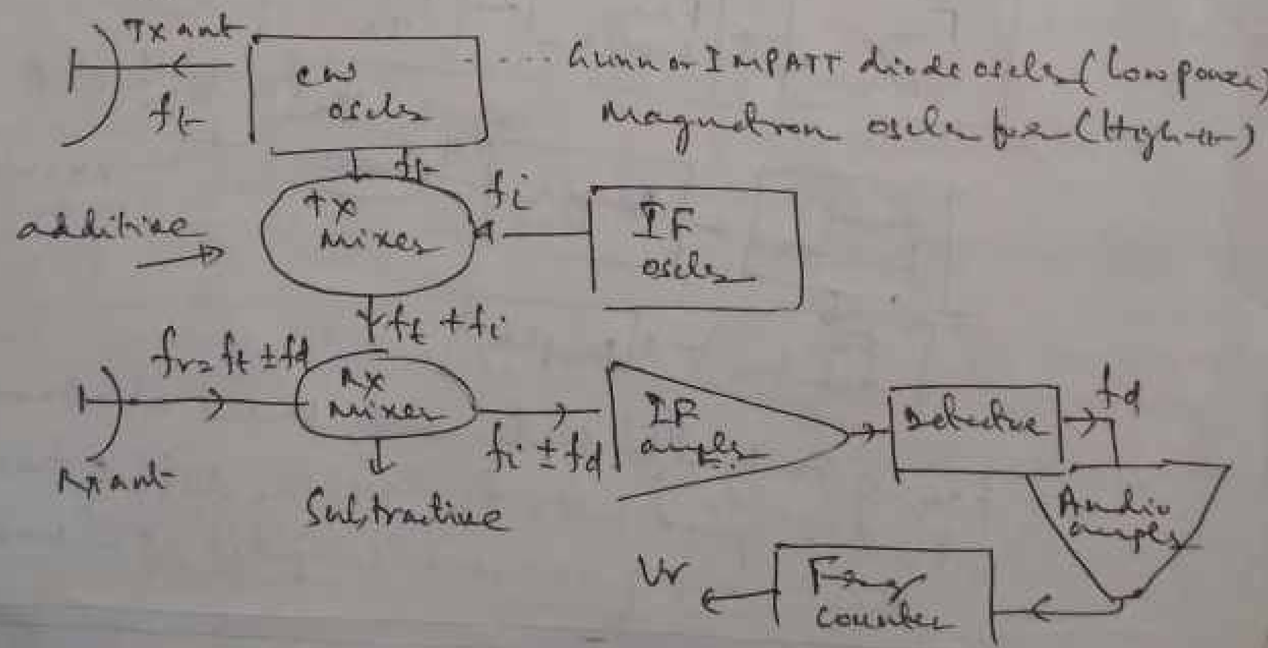
  V_r — Radial vel, $c = 3\times10^8$ m/sec, f_t = Tx frequency

* For approaching targets $f_r = f_t + f_d$ & hence $f_r > f_t$ i.e Rx receives a higher freq
* For receding —"— $f_r = f_t - f_d$ —"— $f_r < f_t$
* If $\theta=0$ → Inline reception $f_{d\,max} = \frac{2V_r}{\lambda}$

  If $\theta=90$ → orthogonal —"— $f_d=0$ No doppler shift is observed



Due to LF FM noise of detector Rx is less sensitive. Hence we use 2 antennas one for Tx and another for Rxn, Also SHR Rx.



(↳ Moving Target Indicator)

UNIT-6 | 2

Instead of detector we can use 3rd mixer

f_t will be around 30 MHz. Since Tx n is continuous a circulator is used.

Advantages

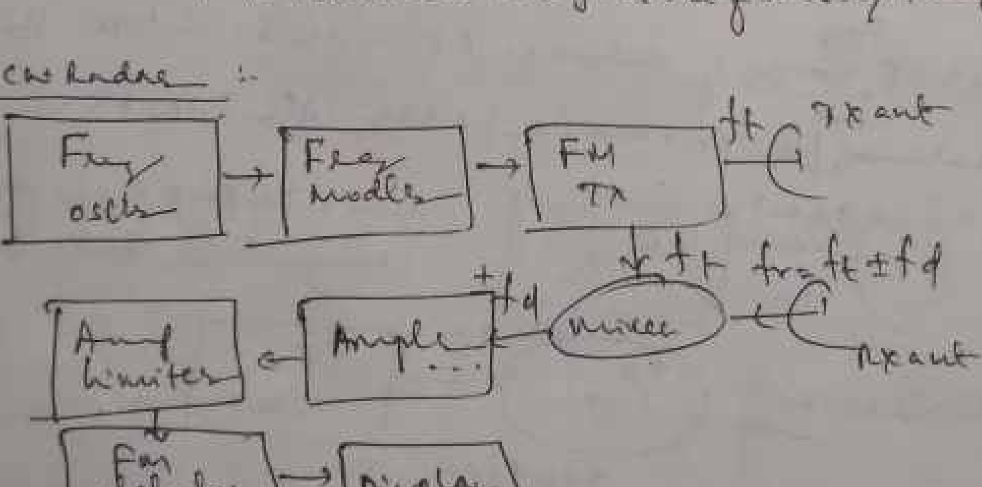
* Accurate measurement of V_r possible
* Low Tx power
* Improved sensitivity
* It can work up to zero range
* If we preserve polarity of f_d we can determine direction of motion.
* Elevation angle of target 'θ' can be measured.

Disadv:-

* As Tx power is limited, range is also limited
* Radar is confused if there are large no. of targets in the vicinity
* Range determination not possible

Applications:-
* Aircraft navigation for V_r measurement
* In rate of climb meter of vertical takeoff planes/helicopters
* police radars for speed monitoring.
* to indicate the presence of moving targets.

FM-CW Radar :-



FM modulation
* Sinusoidal
* Saw tooth
* Bias
* Noise mod
* Dual …

Tx freq of FM signal (f_t) is continuously varied at a known rate & reflected f_r is compared with f_t. Using the diff of two frequencies slant range of target is computed at an instant when an echo is received

Advanced Radars:-

· · · · / Transceiver

MTI Radar principle:-

(↳ Moving Target Indicator)

- Moving targets can be distinguished from stationary targets using this principle.
- Both A scope & PPI displays can be used.

(i) A-Scope display:-

- By observing video o/p (amp vs range) for successive sweep intervals.
- echoes from fixed targets appear at fixed time distance whereas moving target echoes amplitude & position vary in the window based on the f_d
- If we superimpose the o/p together, due to butterfly effect moving targets can be detected.

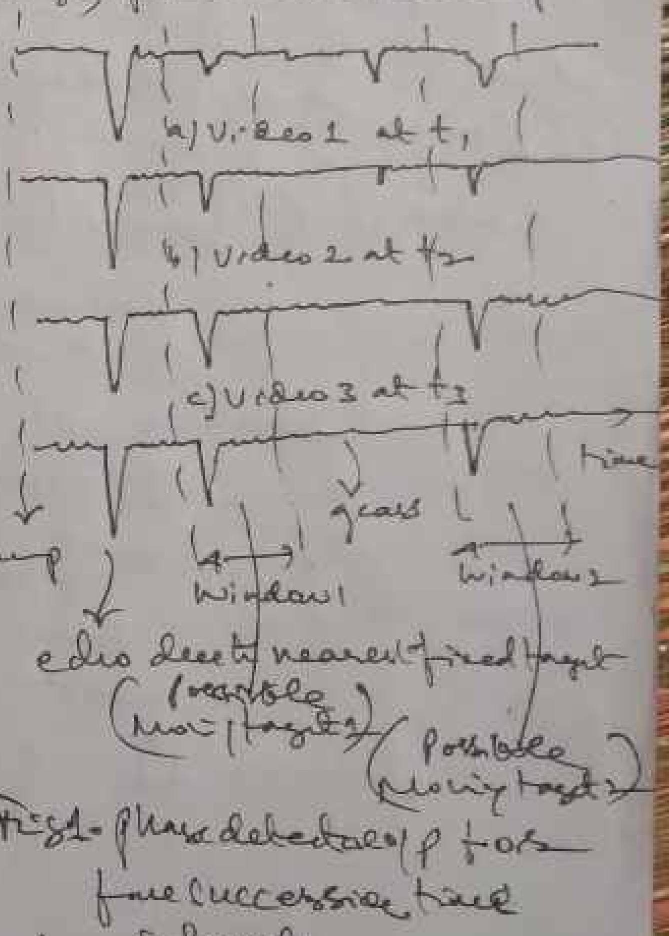


Fig1- phase detector o/p for four successive time intervals.

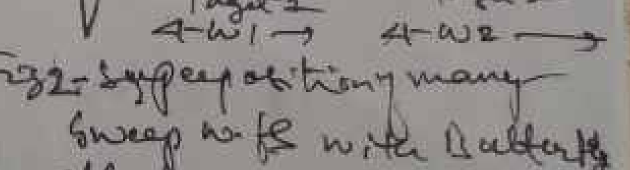
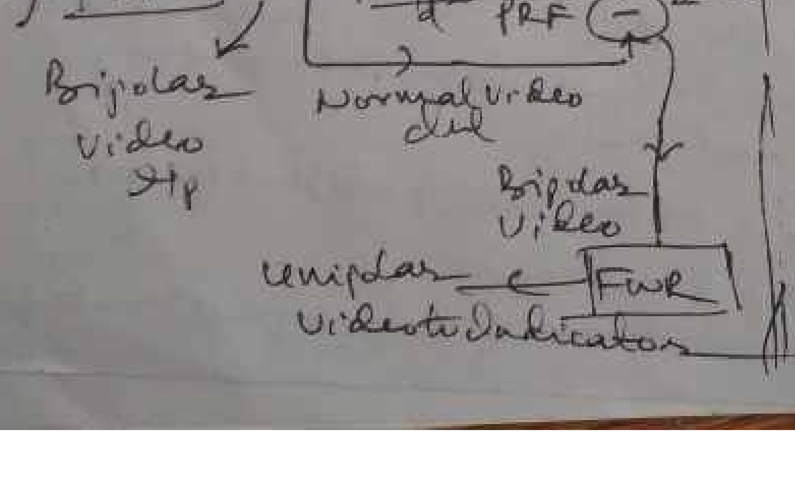


Fig2- superpositioning many sweep w.fs with butterfly effect.

(ii) PPI display:-

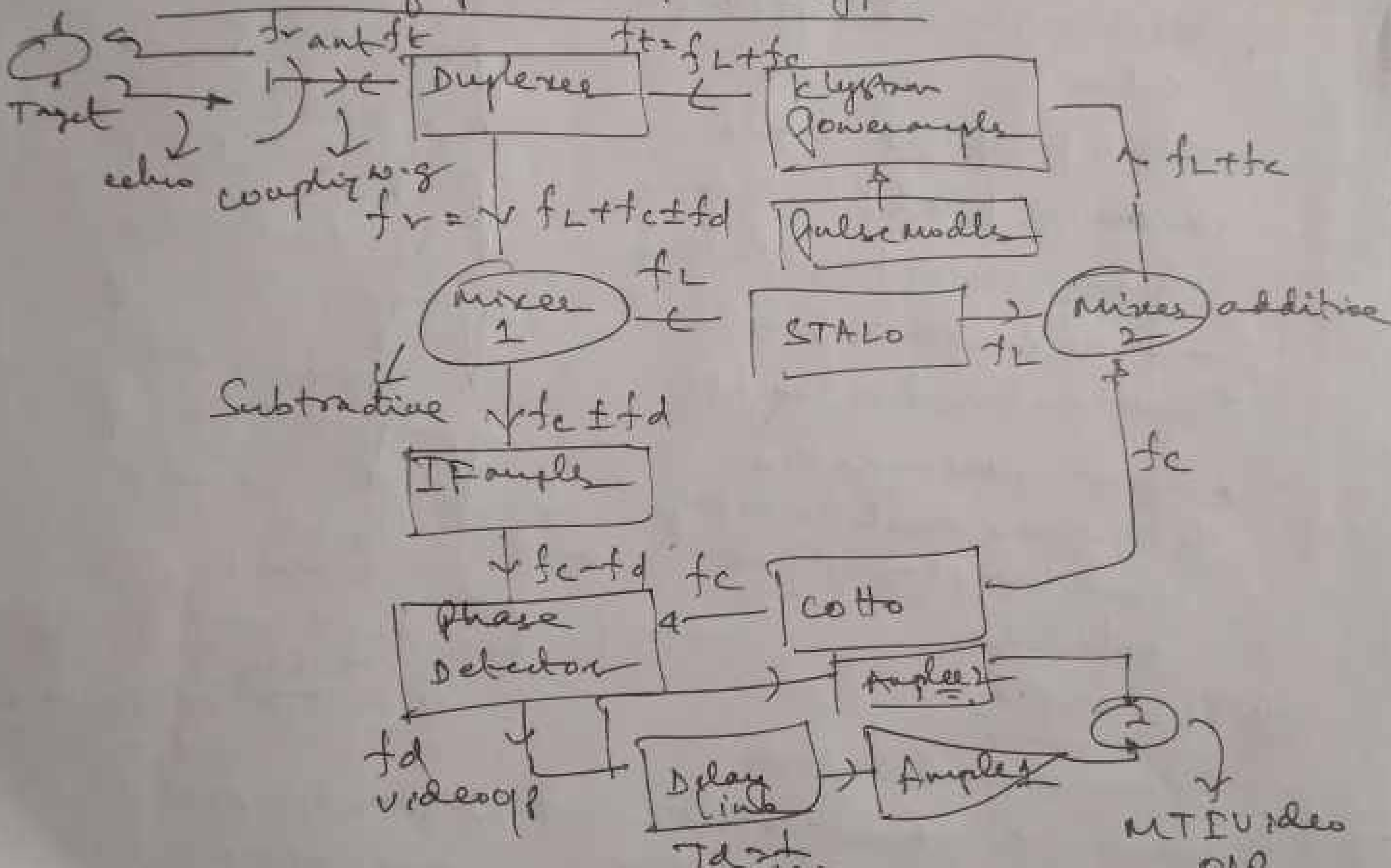
- Here we use delay line cancellers to extract doppler information.



UNIT-IV(E)

- Delay lines acts as filters to block dc components o/p from fixed targets & passes accompanied of moving targets.
- In the o/p of subtractor, echoes from fixed targets are cancelled, but gives moving targets residue.
- FWR converts bipolar to unipolar, which can intensity modulate the PPI screen.

MTI Radar of power Amplifier type:-



* Signal transmitted is

$V_t = A_1 \sin 2\pi f_t t$ — (1) Sinewave carrier pulse modulated.

↳ Includes losses in coupling n/w

* Strength of echo signal is

$$V_{echo} = A_2 \sin \left[2\pi (f_t \pm f_d) t - \frac{4\pi f_t R_0}{c} \right]$$

$R_0 \rightarrow$ Range of the target

$A_2 \rightarrow$ amplitude of echo signal from target

Advanced Radars:-

After heterodyning in mixer 1,

$$V_{diff} = A_3 \sin\left(2\pi f_d t - \frac{4\pi f_t R_0}{c}\right)$$

* For stationary targets $f_d = 0$, $\Rightarrow$ V_{diff} does not vary w.r.t time, A_3 assumes the values from $+A_3$ to $-A_3$ including zero

* For moving targets $f_d \neq 0$, V_{diff} varies w.r.t time which can be detected & displayed.

operation:-

1. klystron power amplr :- It will be a CFA / triode / tetrode / TWT device amplr. It is a stable amplr with sufficient gain. It is also called MOPA - Master oscln power amplr

STALO - stable local oscln :- cascaded stages of varactor diodes which generates the RF freq.

COHO - coherent oscillator. operates at IF, provides coherence between TX & RX signals for noise cancellation

Mixers 1 & 2 are identical, hence phase between i/p & o/p are preserved. This helps in f_d detection easier at IF than RF.

phase detector :- This is phase to amp converter, where phase difference between $f_1 = f_c$ & $f_2 = f_c - f_d$ are compared.

For stationary targets : $f_d = 0$, $f_1 = f_2$, hence detector o/p is zero. If $f_1 > f_2$ or $f_1 < f_2$ then bipolar o/p is produced

UNIT 4-20

Blindspeeds:- If V_r is such that it produces a phase change of 2π radians between successive pulses (i.e. No phase change). These target appears as stationary & echoes from the target are blindly cancelled by MTI action. The radial vel corresponding to this situation is called blindspeeds & must be avoided.

n^{th} order blind speed is given by

$$V_{r_n} = PRF \frac{n\lambda}{2} \quad \text{where } n = 1, 2, 3 \ldots$$

Remedy:- As λ is constant, for a given order PRF is varied for successive pulses such that phase change produced by $V_r \neq 0$

- operate at longer λ • High PRF must be used • constantly change λ

Characteristics:- • It is a form of pulsed Radar

- Low PRF is used & hence No range ambiguity
- $R_{unambiguous} \simeq \frac{c}{PRF}$
- V_r can be determined from f_d.
- Eliminates clutter, echoes from stationary targets
- Identifies moving targets

Advanced Radars:-

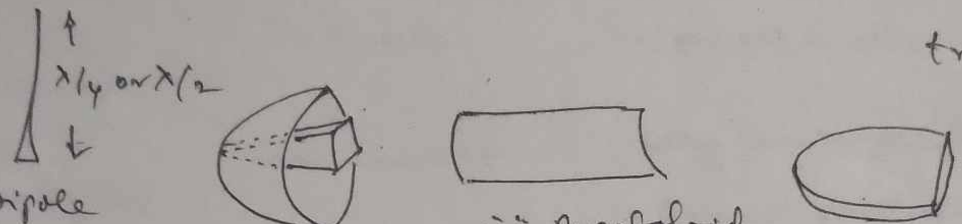
UNIT-25

UNIT-21

Scanning principles:-

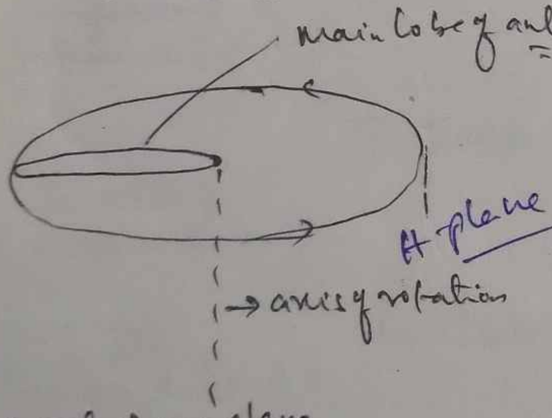
Scanning is nothing but searching a portion of a sky for the presence or absence of a target. Scanning depends on type of application like search radar and tracking radar. Search RR. first locates the target & tracking radar establishes the forward link. Different antennas are used for scanning.

Search while tracking is other option.



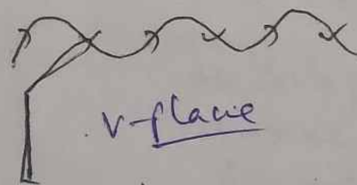
Adv:-
* Reduced ant size & weight
* Steerable ant
* reduced losses
* reduced wind loading
* Smaller drive motors etc.

(a) Horizontal scan:-



* only in one plane
* used in ship to ship.

(b) Nodding scan



* tracking of stars/heavenly bodies
* airplane navigation

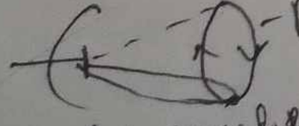
(c) Spiral scan

* Defence system Missile ...

V, H

(a) to (d) are used in search RRs.

(e) conical scanning

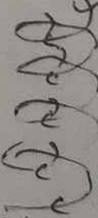


used in ~~search and~~ tracking radar.

(d) Helical scan

* search over complete hemisphere
* Elevation of ant is slowly raised while it rotates more rapidly in azimuth
* 6 rpm, rise rate 20°/min

(ALS system) ALS



100km
above earth

10km-50km

0km-10km

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~~Propagation modes~~ :-

Radar Freq bands and applications

Band	Freq	Appln
HF (High fre)	3-30MHZ	• Coastal Radar • OTH - over the horizon
P (Previous)	30-300MHZ	• Conventional Radar
UHF (Ultra High fre)	300-1000MHZ	• Very long range (Ballistic Missile) early warning • Ground penetration (Remote Sensing)
L (Long)	1-2GHZ	• Long range air traffic control • Surveillance
S (Short)	2-4GHZ	• ATC terminal • Long range weather • Marine appln
C (Compromise between X & S)	4-8GHZ	• Satellite transponders (beacons) • weather
X (Secret) (During world war 2)	8-12GHZ	• Missile guidance • Marine, weather, mapping • Ground Surveillance • Airport Radar
Ku (under K band)	12-18GHZ	• High resolution mapping • Satellite telemetry
K	18-27GHZ	• Meteorology - monitoring clouds for storm prediction • Police - Speed monitoring • Automotive
Ka (above K band)	27-40GHZ	• Mapping - flood, rain etc • Surveillance • photoradar by RTO to detect license plates

... Radar (Mesosphere Stratosphere & Troposphere Radar

50km to 100km — 10km-50km — 0km-10km

38

UNIT4-24

Q	40-60 GHZ	Military communication
V	60-75 GHZ.	Atmospheric monitoring CO, ozone, temperature profiles.
W	75-110 GHZ	High resolution meteorological observation, imaging, automotive appln..

Advanced Radars:-

UNIT-25

1) MST-Radar (Mesosphere Stratosphere & Troposphere Radar)

Mesosphere → 50km to 100km above earth

Stratosphere → 10km-50km

Troposphere → 0km-10km

* Designed to measure wind speeds & other atmospheric parameters like snow, rain, hail, clouds etc.
* mainly used for weather forecasting
* High power TX are used to penetrate different layers of atmosphere (P_t 2.5MW). Large aperture dish antennas used (100m < D < 300m). phased array & 3 element Yagi-Uda antennae also used

D → diameter

* PRF is 62.5 Hz to 8KHz

2) SAR (Synthetic Aperture Radar):

* Dynamically moves beams of antenna a/c an area to synthesize the target. provides excellent L (lat, elevation), range, c/s area & high resolution - Two dimensional images
* can work with both stationary & moving targets
* Inverse SAR (ISAR) is used to find the aircraft parameters from ground or ship.
* can work under multiple reflection echos.
* used in weapon targeting, geological & mineral explorations.

targeting → missile guidance

* It can work in adverse weather conditions

3) LIDAR: Light Detection And Ranging):

* used for measuring precise distance of targets in defence apps. (can carry out surgical attacks)
* uses large gain & low antennas
* gives 3 dimensional image of targets

* provides fd on a extended scale so that we can recognize slow moving targets
* Antenna are highly directional & devoid of side lobes

4) ILS (Instrument Landing System):-

* used in airodromes for safe takeoff or landing of aircrafts in adverse weather conditions.
* It consisting three parts namely (i) localizer (ii) glide slope (iii) marker beacons

(i) localizer: provides azimuth angle information to pilot & properly guides aircraft to runway

(ii) glide slope:- usually placed on the side of runway. It provides signal to the aircraft regarding vertical altitude during landing or takeoff. This is necessary to control vel of air craft

(iii) marker beacons:- provides information at the ultra movement either for defolding of wheels during landing or folding of wheels during takeoff.