UNIT-3 Radiometry & TV Principles

Radiometry: Introduction:-

This is a passive remote sensing system. This develops information about a distant target solely from the lineal pattern of the black body radiation (Noise) that is either directly emitted or reflected from the surrounding bodies.

Radiometer is a very sensitive receiver specially designed to measure this noise power.

* Black body :- An idealized material which absorbs all incident energy & reflects none. Black body under thermal equilibrium radiates energy according to plank's radiation law,

Power radiated = $P = KTB$ K = Boltzmann constant = 1.38×10^{-23} J/°K
T = Temp of body in °K (273 + °C)
B = B.W of the system.

* A non ideal body partially reflects energy. Amount of energy radiated is given in terms of emissivity

$$e = \frac{\text{Power radiated by a body}}{\text{" ideal black body}}$$

$$= \frac{P_r}{P} = \frac{P_r}{KTB}$$ For black body $P_r = P$ $\therefore e = 1$

$$0 \leq e \leq 1$$

* Noise power can also be quantified in terms of T_B (brightness temperature). $T_B = eT$ where T = physical temp of the body

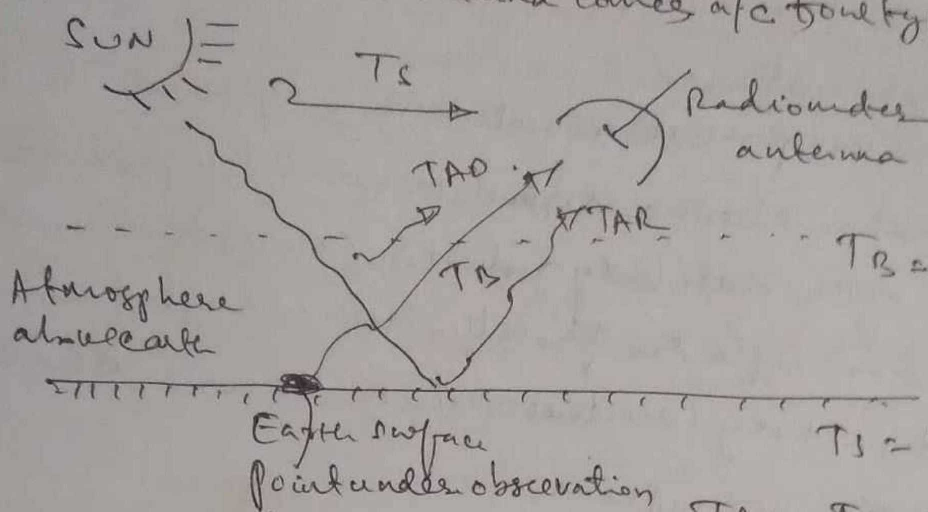
Temp observed $\because e \leq 1$, $T_B \leq T$

e.g. For quiet sun $6000 < T < 1$ lakh °K ; Earth surface temp $= 230 - 320$ °K.
Dry snow $T \leq 273.15$ °K.

... results from fields such as Electrical ...
Oceanography / geophysics / atmospheric & space sciences to ...

22 * Radiometer antenna comes a/c four types of temperatures

MW3-2



T_B = Apparent brightness temp of point under consideration

T_S = Sun temp & temp due to other heavenly bodies.

T_{AD} = Temp. of radiating atmosphere directly radiating towards ant

T_{AR} = Temp of radiating atmosphere reflected from earth towards ant.

Radiometer must be clearly distinguish T_B w.r.t other temps.

* T_B recorded by the radiometer is a function of
  a) ~~shade~~ Brightness / ~~scene~~ colour of scene under observation
  b) observation $\angle$le c) Frequency d) polarization
  e) Attenuation f) Antenna pattern g) Environmental conditions
  h) elevation of ant above earth (i) c/s aperture area of ant
  etc

* objective of radiometry is to infer / predict information about the scene from measured T_B. Analysis ~~[illegible]~~ relates T_B to physical conditions of the scene.

eg:- power reflected from a uniform layer of snow over soil can be treated as a plane wave radiation from a multilayer dielectric, which leads to an algorithm that gives thickness of snow, amount of water content etc
Same method was used to predict water on the surface of moon.

Radiometry is a new technology & is inter disciplinary which involves results from fields such as Electrical engg/ oceanography/ geophysics / atmosphere & space Sciences to name a few.

Applications:-

1) Remote environmental applications:-
* Measurement of soil moisture / fertility
* ore / oil / gas explorations * Seamapping - To locate fish for fishermen
* flood mapping * snow / ice cover mapping
* ocean surface wind speed measurement in weather forecasting
* Atmospheric temp profile / humidity profile / ozone content / "CO" content for global warming.

2) Military
* Target detection * recognition * Surveillance
* Mapping * EWS (Early warning systems)

3) Astronomy
* Deep space tracking of heavenly bodies like stars / planets / comets / Nebulla / Milky ways.
* planetary motion * Solar activity

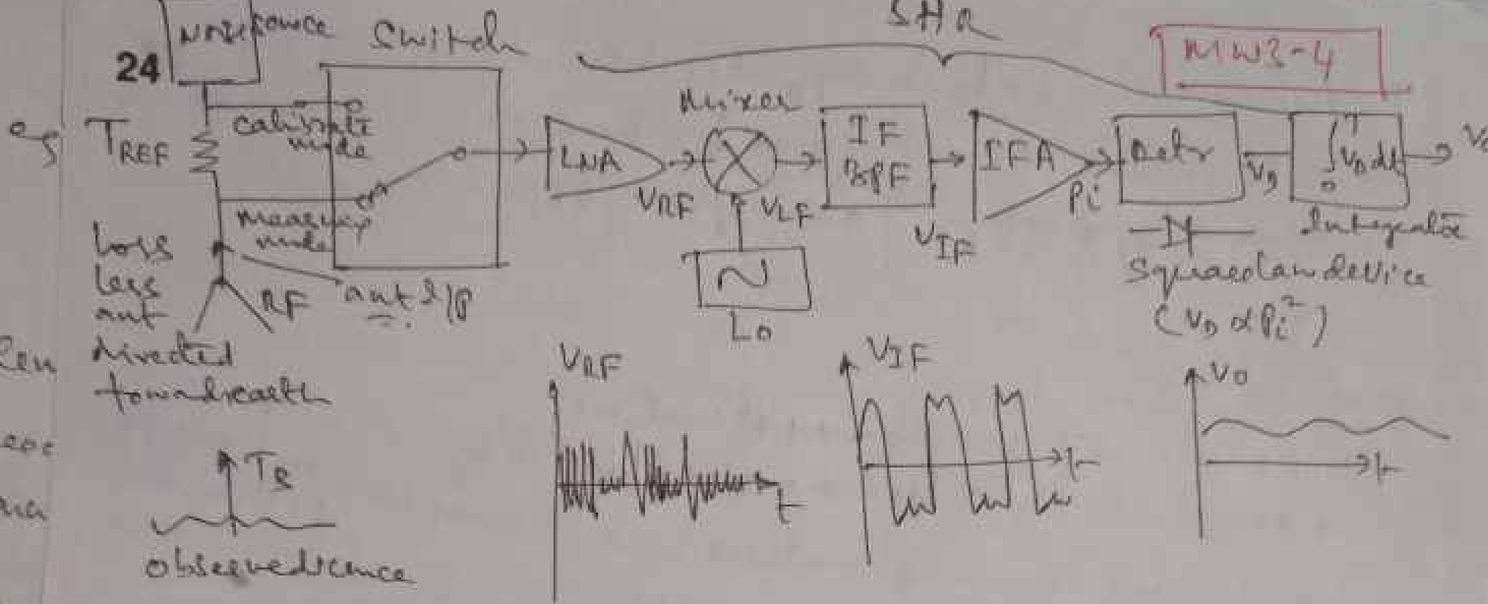
Total power radiometer:-

Very difficult to design because Rx has to distinguish between desired brightness noise temp & inherent / background noise temp. This is because power in the former case is very small compared to the latter.

Errordecta random Variation... time ΔT_N is almost negligible
is because ...

17

24



There are two modes of operation namely measurement mode & calibration mode.

Available power at the i/p of antenna terminal is $P_A = KT_BB$

If T_R is the noise temp of the RX ($\because$ RX also contributes noise, this is measured in terms of T_R) then power contributed by RX is $P_R = KT_RB$.

If G is the gain of the RX, then $V_0 = G(T_B + T_R)KB$

System is calibrated by replacing ant i/p with calibrated noise source from which GKB & GT_RBK can be determined.

Hence T_B can be measured with in the system.

i.e. $V_{01} = GT_BKB$ with direct connection to ant calibrated noise source hence $V_0 = V_{01} + V_{02}$

$V_{02} = GT_RKB$ — " —

$\therefore V_{01}/V_{02} = T_B/T_R \quad \therefore T_B = T_R(V_{01}/V_{02})$

* Two types of errors :-

(i) ΔT_N = Error in measured T_B due to noise fluctuation. This is based on measurement time τ

$$\Delta T_N = \frac{T_B + T_R}{\sqrt{B\tau}}$$, As $\tau \uparrow$, $\Delta T_N \downarrow$.

MW3-5

For longer measurement time ΔT_N is almost negligible.

(ii) ΔT_G: Error due to random variations in system gain. This is because gain of RF ampl. (LNA), mixer & IF ampl. varies w.r.t. time

$$\Delta T_G = (T_B + T_R)\frac{\Delta G}{G}$$, ΔG = rms change in system gain

eg:- at f = 10 GHz, B = 100 MHz, T_R = 500°K, τ = .01 sec
$\Delta G/G$ = .01. If T_B = 300°K, ΔT_N = .8°K & ΔT_G = 8°K
More serious.

problem of gain variation can be overcome by repeated calibration where a feedback is provided. This is the principle of Dicke null balancing radiometer.

$V_{o1} = G T_R k B$ —(1) $V_o = V_{o1} + V_{o2}$

$V_{o2} = G T_B k B$ —(2) $V_o = G k B (T_B + T_R)$ —(3)

$\frac{eq(3)}{eq(1)}$ $\frac{V_o}{V_{o1}} = 1 + \frac{T_B}{T_R}$ $\therefore$ $\boxed{T_B = T_R\left(\frac{V_o}{V_{o1}} - 1\right)}$

or

$\frac{eq(2)}{eq(1)}$ $\frac{V_{o2}}{V_{o1}} = \frac{T_B}{T_R}$ $\therefore$ $\boxed{T_B = T_R\left(\frac{V_{o2}}{V_{o1}}\right)}$

MW3-7

TV standards:- Tele - means distance, Vision - seeing } Invented by Joseph Baird.

Some of the important standards are

(1)

	American	European	Remark
No of lines/frame	525	625	Differences
-||- frames/sec	30	25	Differences
Field freq	60Hz	50Hz	Differences
Line freq	15,750	15,625	Differences
channel b.w	6MHz	7MHz	Differences
Video b.w	4.2 -||-	5 -||-	Differences
Colour subcarrier freq	3.58 -||-	4.43 -||-	Differences
Sound Txn by	FM	FM	Differences
Sound freq deviation	25KHz	50KHz	Differences
Intercarrier freq separation	4.5MHz	5.5MHz	Differences
Txn	VSB	VSB	Similarities
polarity	-ve modln	-ve modln	Similarities
	(Black level has higher modln index compared to white)		Similarities
Interlace ratio	2:1	2:1	Similarities
Aspect ratio	4:3	4:3	Similarities
	(horizontal to vertical dimension of TV display)		Similarities

(2) Analog & digital Txns.

(i) Analog:- Pict & Sound are Tx as analog signal with Pict AM, Sound FM

(ii) Digital: ——"—— digital packets used QAM

There are three important standards in analog.

...images formed ... like cadmium sulphide & ...

22 (a) NTSC (National TV system committee) :- [MW3-8]

Invented in USA - 1967. This is also called M-format
used in Korea, Japan, US, Canada & Most of South America.
Monochrome | B/W standard in 1941 & colour in 1953.

* 29.97 interlaced frames of video/sec · cycle for 60HZ · 110VAC

analog * 486 active lines (525-486 = 39 lines as overheads - synch, retrace, captioning etc.) · Video b.w 4 MHZ

* Interlaced scanning * flicker free image. gives · Noise is high

(b) SECAM - French word "sequential colour avec memorie" i.e sequential colour with memory" Invented in France 1970

analog France, Belgium, Iran, Iraq, Africa

* 625 lines, 25 frames system * extra hundred lines (625-525) gives better clarity of video · 6 MHZ b.w · very high noise

* 50 fields/sec may cause flicker · 50HZ · 220VAC

(c) PAL :- phase Alternating line

* colour encoding system (used in India), Britain, Western Europe, Australia * developed first in Germany (1967)

analog Here colour information on the video signal is reversed with each line, which automatically corrects phase errors in Txn by cancelling them out.

* with a refresh rate of 100 HZ flicker is eliminated.

· Video b.w 5MHZ, 50HZ, 230VAC · 625 lines

Noise is high.

TV broadcast standards vary from country to country. Standards can be cable, terrestrial, digital, HDTV, analog, digital etc. They come under FCC or ITU or CCIR. Earlier there were 14 stds but now only 3 stds.

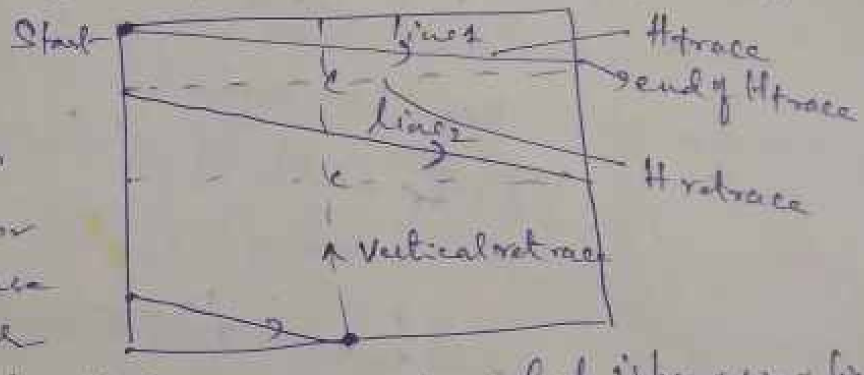
Principle of scanning :-

This is 111^lel to reading a page in a book starting from top LH corner we end at bottom.

Is a process of converting visual information on picture frame to electrical information. Pict plate is coated with photosensitive material like cadmium sulphide such that an image is formed.

Electron beam moves behind the pict plate in such a way such that relative brightness spots (pixels) are converted to electrical signals. This process is scanning.

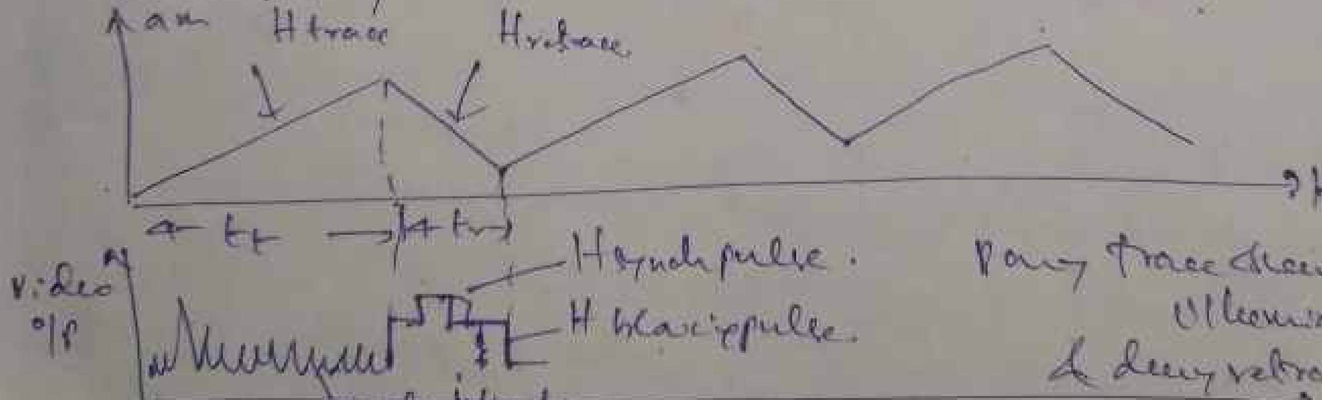
Once pict frame is scanned 50 times/sec in a 111^lel manner to reading a page of a book. Magnetic defl coils are used (H & V) which move the signal on pict frame.



Movement will be in an inclined fashion.

For L to R movement or R to L —11— we use H-mag defl coil; for bottom to top movement we use V defl coil. H osc works at a fs which is fn of no. of lines/frame i.e 50 lines, FAR = 50 FPS.

* Scanning signal will be a sawtooth wave

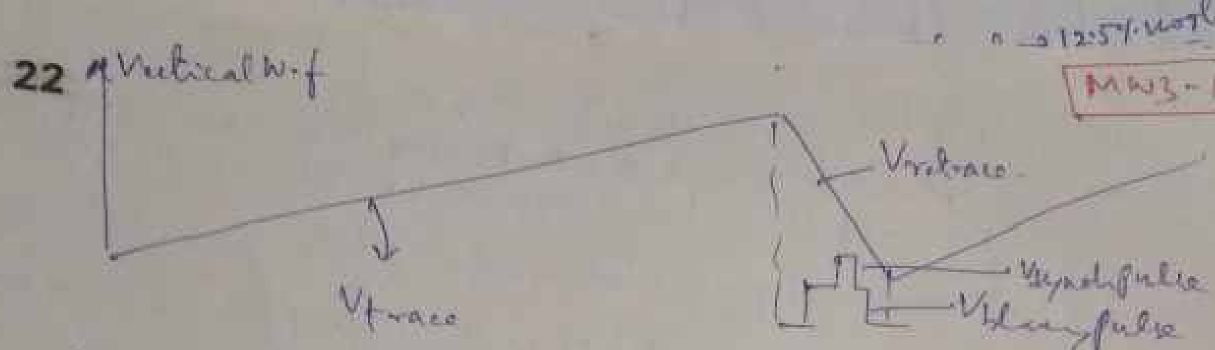


During trace screen is illuminated & during retrace the screen will be dark.

During trace period of line screen is ... scanning can be vertical and retrace screen is blanked out.

12.5% width

MW3-10

22 

During inclined motion wave also travel downwards.

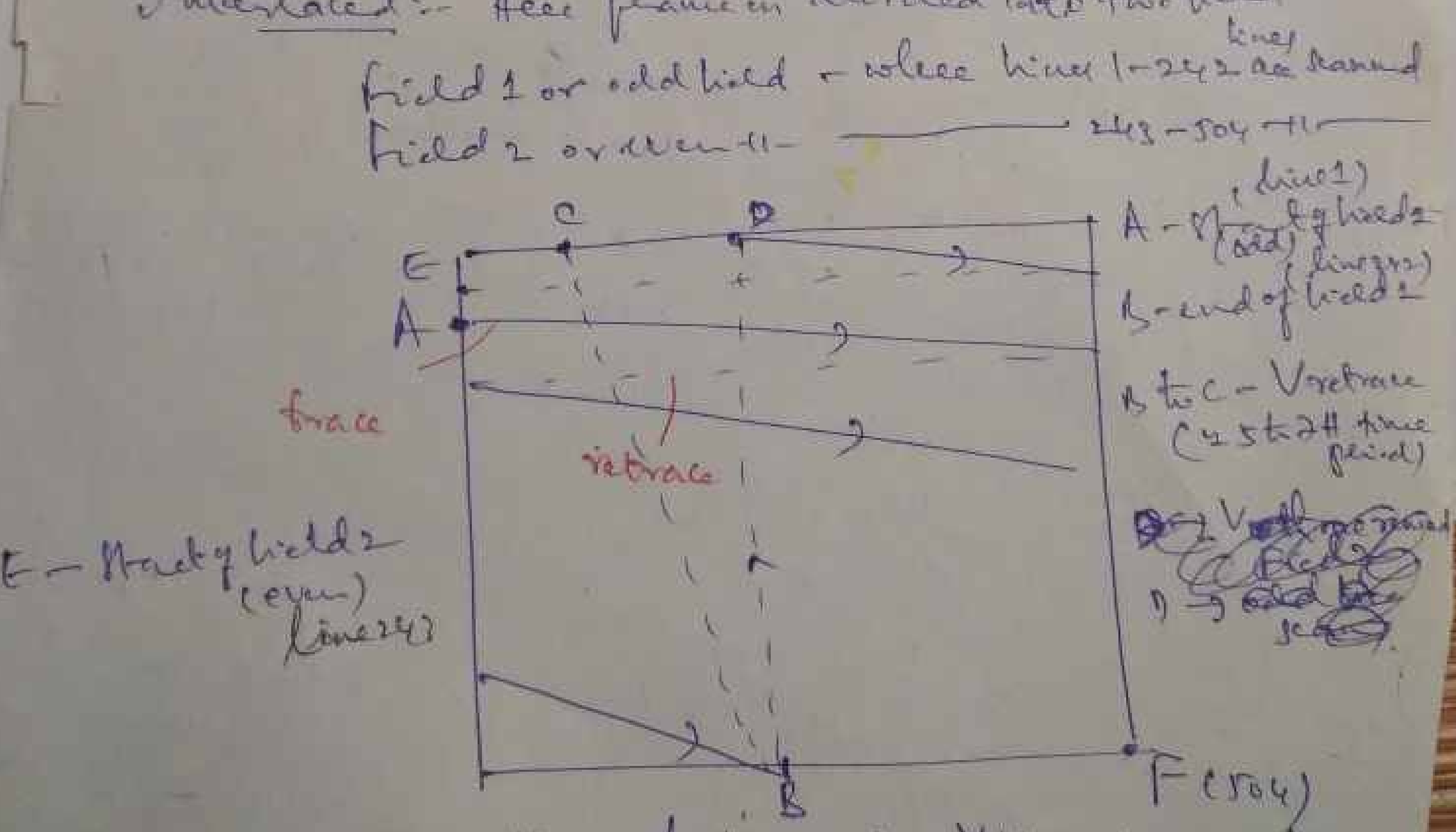
Two types of scanning Interlaced & progressive scanning:-

What we discussed earlier is called progressive. w.r.t a frame consisting 525 active lines such that all these lines are scanned one by one. But this is slow process & we observe flicker at RX during reconstruction. Hence we use interlaced scanning.

Interlaced:- Here frame is divided into two field

field 1 or odd field - where lines 1-242 are scanned

Field 2 or even -- 243-504 --



B-D - 24 lines are lost

D - V blanking is removed.

During trace period of line screen is illuminated & during retrace screen is blanked out. Blanking can be vertical and horizontal.

Blanking & Synch pulses:-

Video volt is limited to certain amplitude. white level → 12.5% modh & black level 67.5% modh & gray correspond to intermediate of these two

During H & V retraces blanking pulses are applied, when pict is blanked out. Blanking is nothing but raising the signal (pict level) to the blanking level of max 75% modh.

To synch Tx & Rx synch pulses are Tx. This is necessary because pict must be reconstructed at Rx in the same fashion as at Tx (i.e. pixel elements must have same (x,y) coordinates on pict plate (at Tx) & at screen (at Rx)). They are Tx between H & V blanking pulses. These are generated by respective oscs which are triggered during the leading edge of the pulse.

Composite video:-

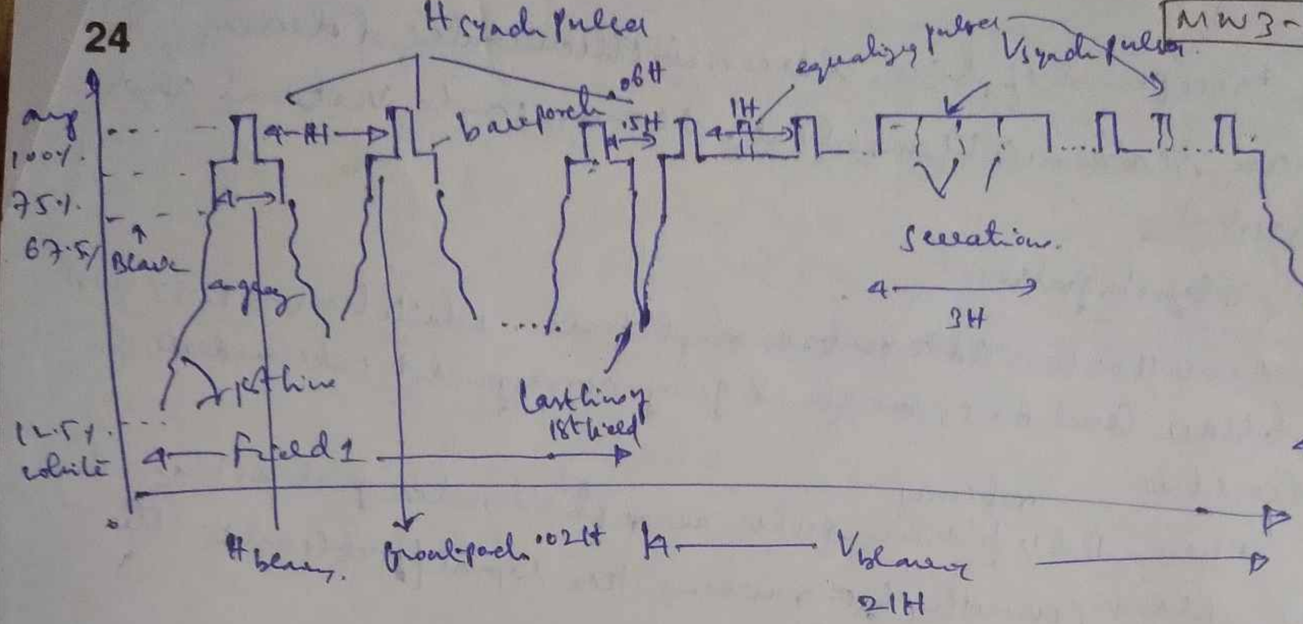
- Video signals
  - brightness (luminance)
  - colour content (chrominance)
- H & V blanking signals.
- H & V synch -"-
- Equalizing pulses

at the end of odd field | at the end of even field

* Diff between the two videos is spacing is 0.5 H in odd field & 1 H in even field.
* To maintain smooth working of H oscs during V blanking these pseudo pulses (in the form of equalizing pulses) are added to the video.
  Also serrations or interruptions are provided in the V synch pulse to maintain synch.

VSB Transmission:- I.T.U has ...

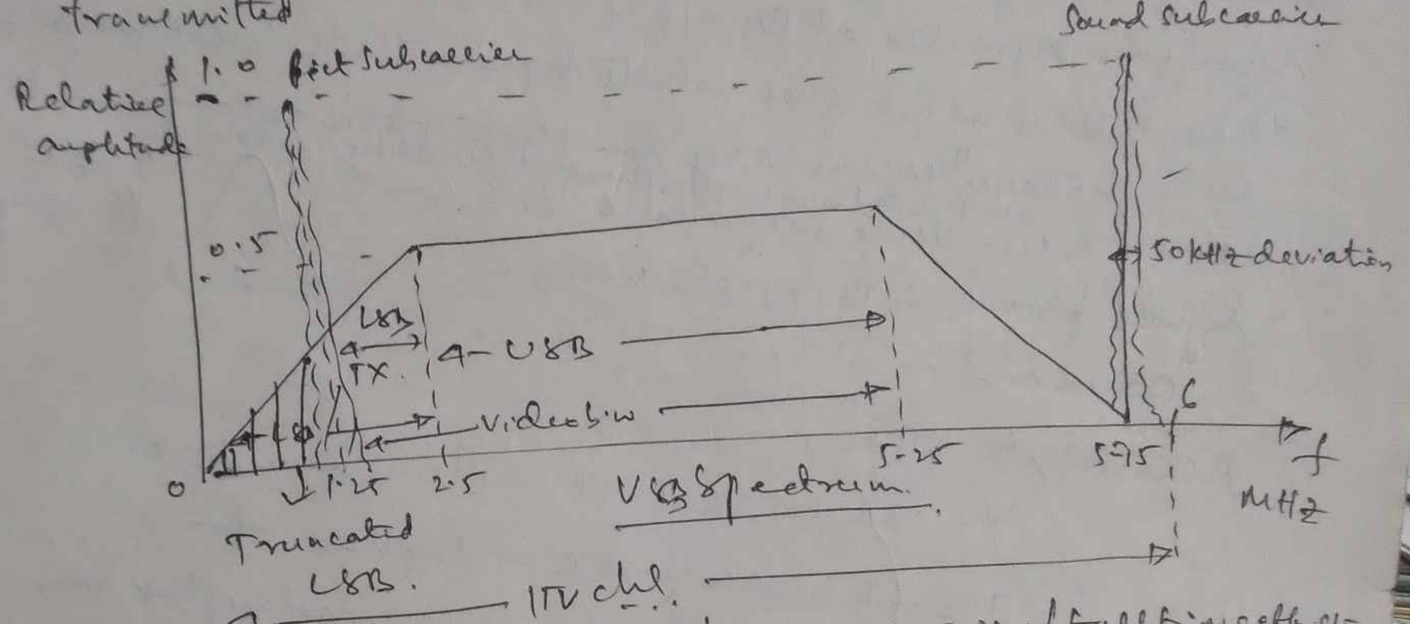
MW3-12



composite video at the end of odd field

[MW3-13]

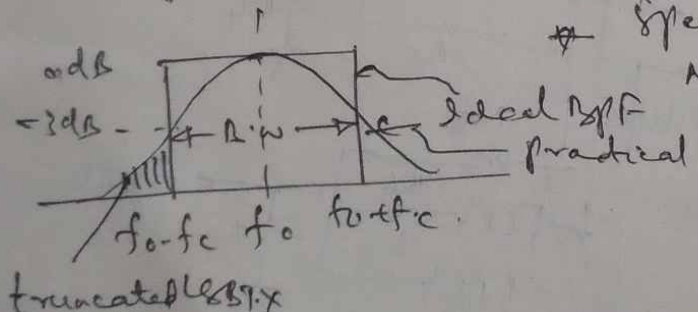
VSB Transmission:- I.T.U has recognized this as C3F (earlier A5C, AM DSBFC or A3 modln etc). Here a trace of truncated LSB (or vestige of LSB), USB & full carrier is transmitted. This is ||| to DSBFC system. Main aim is to conserve bw for video TXn. To simplify video demodln at the RX, carrier is TX undiminished. Phase response of BPF at the edges would have harmful effect on received video. To prevent this unwanted portion of truncated LSB is also transmitted



VSB spectrum.

VSB filter at RX is non-ideal because of rise/fall time effects. Hence by using VSB TXn

* lower spectrum of USB is undisturbed by 3MHz
* Spectrum saving is possible i.e Normal 9MHz ch.l is reduced to 6MHz



X

~~42, 46, 47, 50, 40, 44, 46~~, 50,

~~56, 61, 64, 68, 69~~,

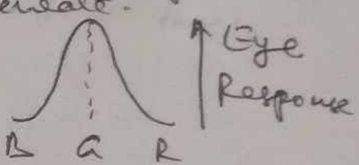
orange is obtained (yellow) (MW3-14)

Principle of colour transmission:-

6 This is nothing but luminance & chrominance signal fxn. Requirements

* compatibility
* Same b.w of 6MHZ must be used
* colour shades must be proper

Generally three primary colours R (Red), G (Green) & B (Blue) signals are separated at the o/p of lens. If we add 33.3% of these colours we get pure white signal. This is not so simple in TV because (i) eye is very sensitive to green as compared to Red & Blue. (ii) R, G, B have complex phases, difficult to generate. Hence we generate Y, I, Q signals from R, G, B signals using a colour matrix at TX.

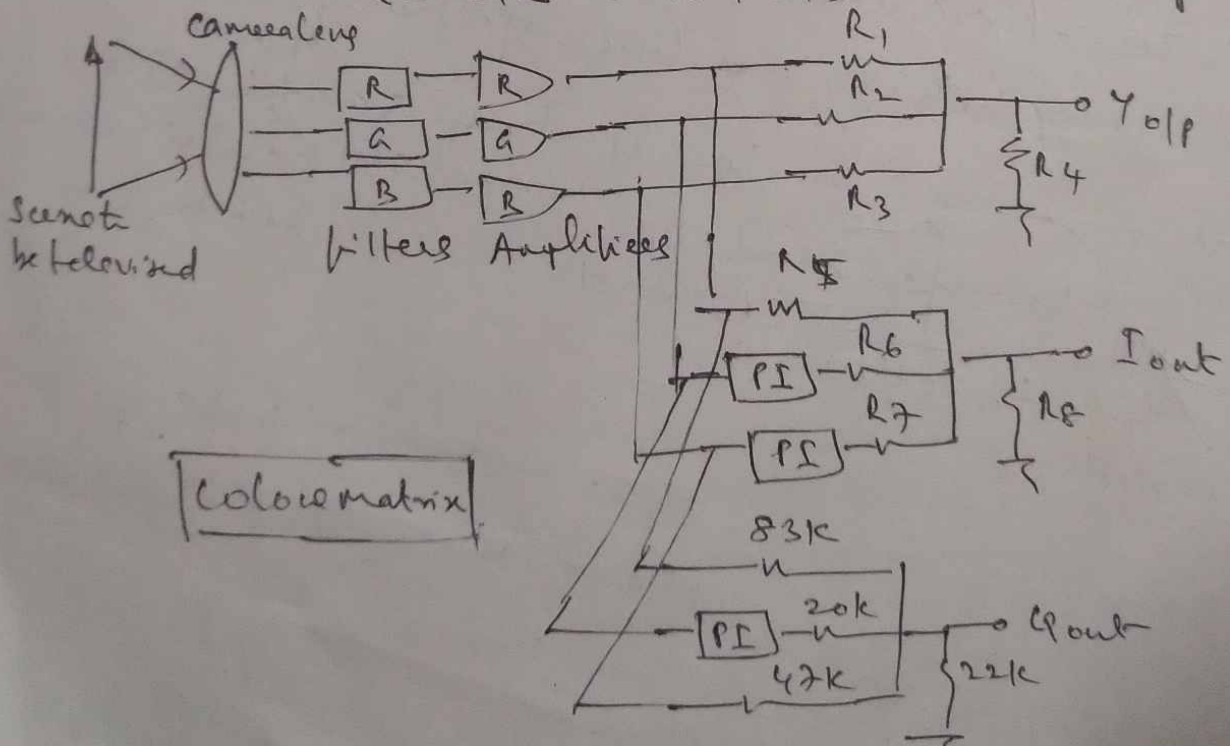


According to NTSC,

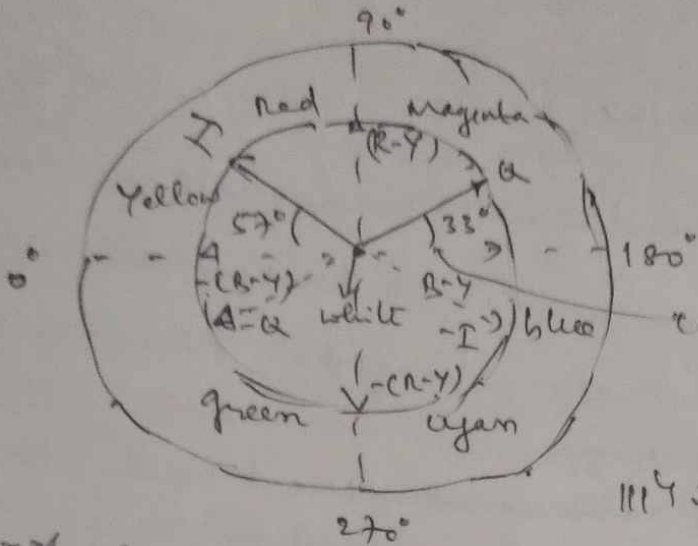
$$Y = .3R + .59G + .11B \rightarrow \text{luminance signal}$$

$$I = .6R - .28G - .32B \rightarrow \text{Inphase } \text{''}$$

$$Q = .21R - .52G + .31B \rightarrow \text{Quadrature phase } \text{''}$$



At Rx we use colour disc to get the R, G, B signals. (MW3-15)



* If we receive a signal with Q = 0 & I is max saturated reddish orange is obtained (red + yellow)

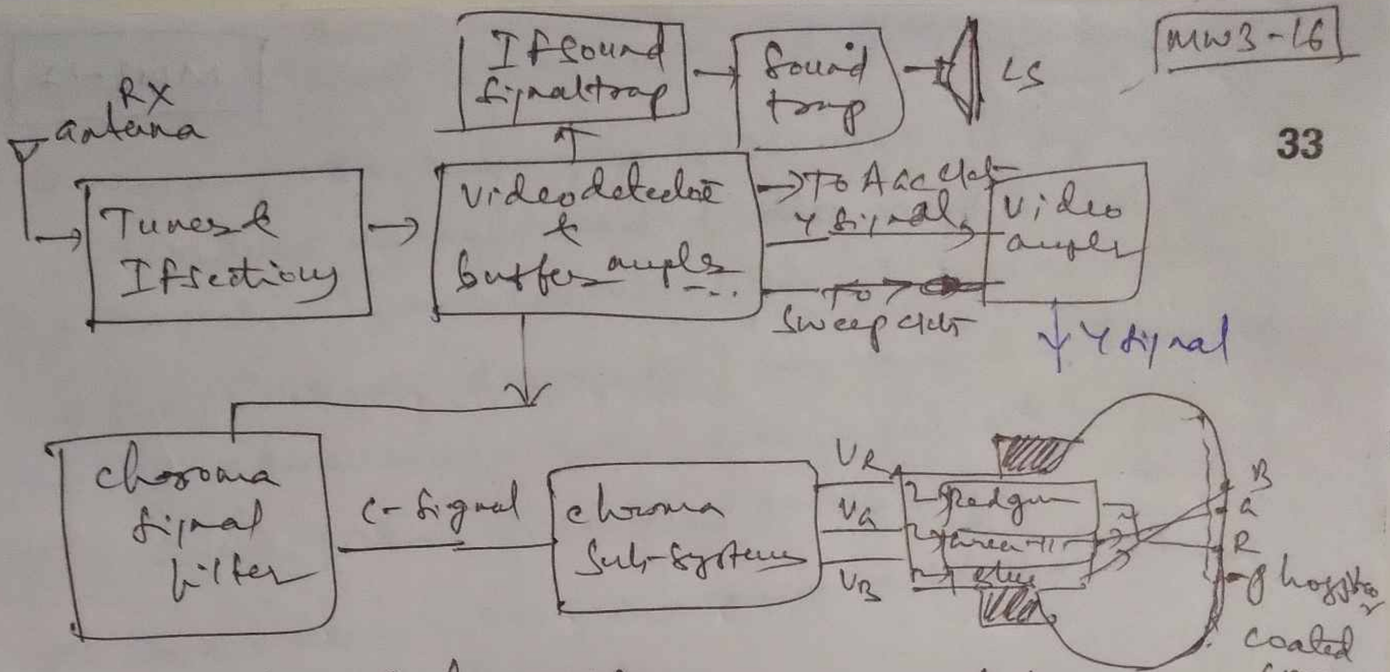
If I < Imax a paler reddish orange colour is produced.

III^ly if I = 0, Q is -ve max saturated yellowish green is obtained.

* pure blue = 0.8Q - 0.6I etc.

* colour burst signals are transmitted once during horizontal scan w.r.t. which phases of other signals are located.

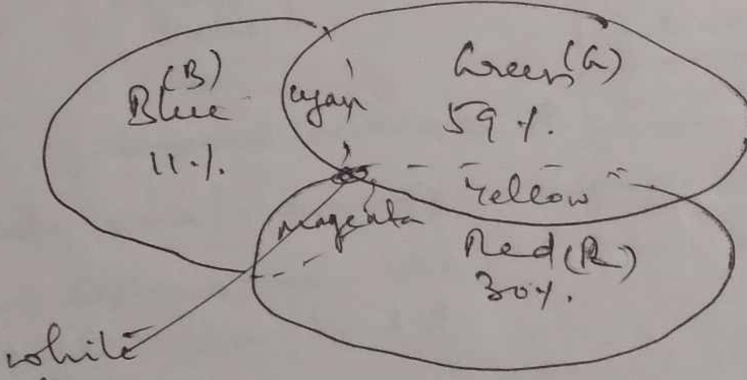
* colour mask (disc with no. of apertures (2 lacks)) is used to produce correct colour on the phosphor screen.



Colour TV RX.

Colour pict tube

Three basic colours in TV:- R-G-B.



Colour characteristics:-

- Hue — adjusted colour sometimes called tint control (from green to red)
- Brightness — illumination of the picture that includes sharpness of edge including the contrast control.
- Saturation: when sunlight passes through glass prism will separate into multitude of colour components
This dispersion called ...
- Optical signal — 430×10^{12} Hz (Tera Hz) to 750×10^{12} Hz
red
- 400nm → deep blue
- brown, purple not corresponding any one λ

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

Digital TV principles

MW3-18

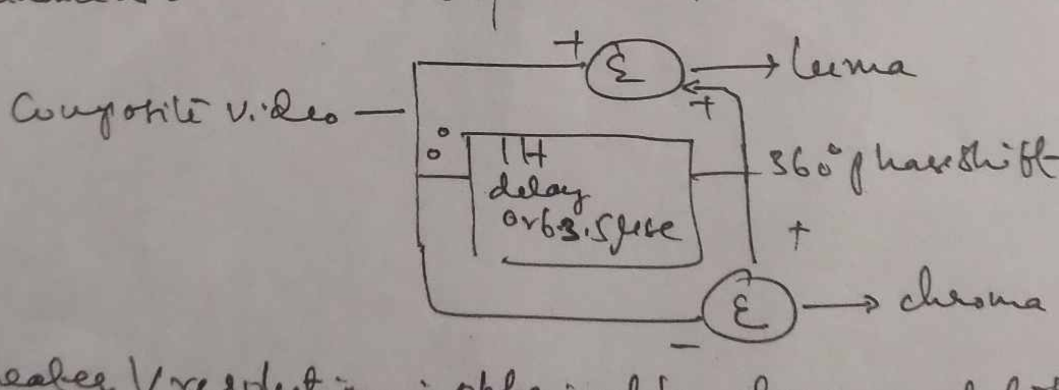
Important difficiencies of NTSC analog colour Txn are

(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 deriving additional scanlines.

(3) using more elaborate signal processing methods.

MW3-21 1

* digitize the signal to reduce noise, distortion, interference etc.

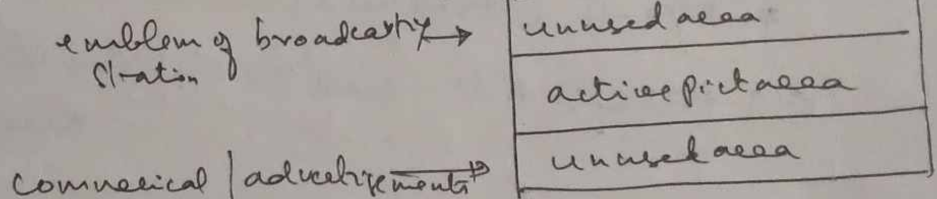
MW3-19 17

* 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 using 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 letterboxing. used in sport / news / movies etc.



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

II Based on quality:-

There are 3 stds in digital TV:-

		Horizontal resolution NH	Vertical resolution active V (pixels)	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	927 -"-
best	922 -"- or 1.5 Gbps.