PRINCIPLES OF TELEVISION ENGINEERING /01

Persistence of Vision, Flicker, Line Merging, Picture Quality, Kell Factor

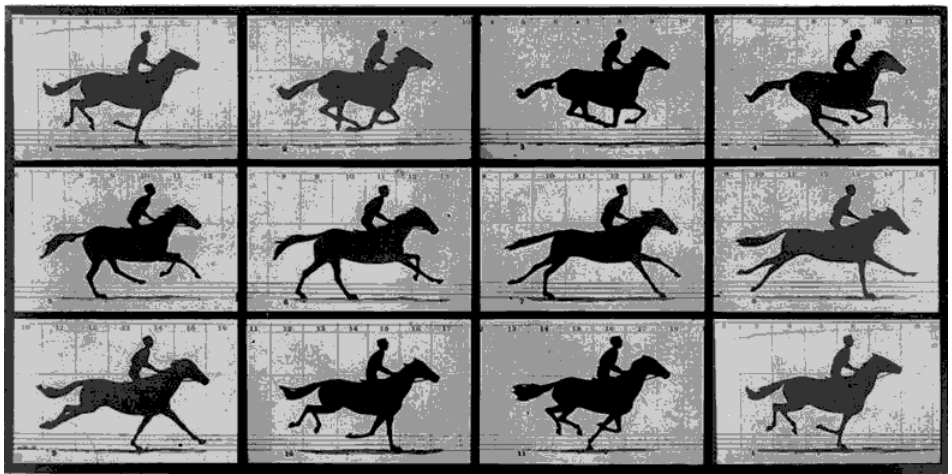
ECE 523E – ANTENNA & RADIOWAVE PROPAGATION

Tuesday, 29 September 2026

BASIC PRINCIPLE OF TV

1.0 Persistence of vision

- The eye (or the brain rather) can retain the sensation of an image for a short time even after the actual image is removed.
- This allows the display of a video as successive frames as long as the frame interval is shorter than the persistence period, The eye will see a continuously varying image in time.



BASIC PRINCIPLE OF TV

1.1 Frame Flicker

1. When the frame interval is too long, the eye observes frame **flicker**. The minimal frame rate (frames/ second or fps or Hz) required to prevent frame flicker depends on display brightness, viewing distance.

2. To remove flicker, higher frame rate is required with closer viewing and brighter display.

3. Typical frame rates:
   a) Movie viewing: 24 frames/s
   b) TV viewing: 50- 60 frames/s
   c) Computer monitor: > 70 frames/s

BASIC PRINCIPLE OF TV

Line merging

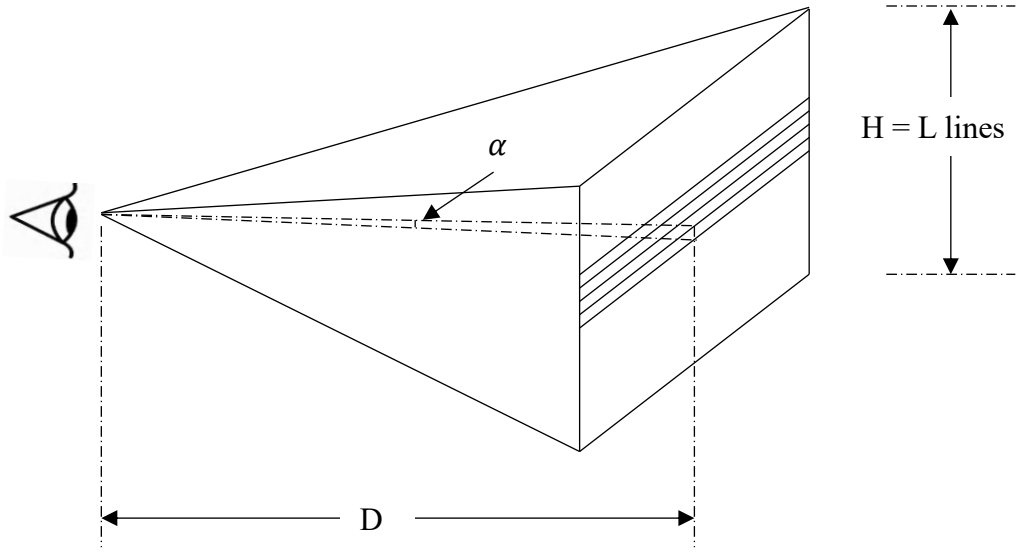


1. As with frame merging, the eye can fuse separate lines into one complete frame, as long as the spacing between lines is sufficiently small.
2. The maximum vertical spacing between lines depends on
   a) viewing distance,
   b) the screen size,
   c) display brightness.
3. For common viewing distance and small TV screen size, 500- 600 lines per frame is acceptable

TV PICTURE QUALITY

The quality of the reproduced picture is determined by

1. Resolution - The higher the number of lines the better the resolution.
2. Distance of the viewer from the screen
3. Resolving capability (acuity) of the human eye.



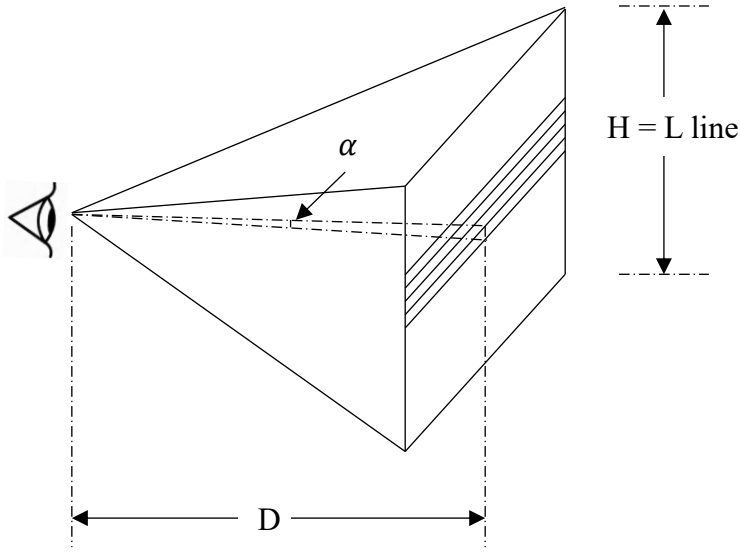
NUMBER OF SCANNING LINES

The maximum number of lines which can be resolved by a human eye is given by

$$N_{vr} = \frac{1}{\alpha}\rho$$

where

- N_v is the number of lines resolved in the vertical direction
- α is the minimum resolvable angle, it's approximate value is 1 minute (or $\frac{1}{60}$ deg).
- $\rho = \frac{D}{H}$



EXAMPLE

A TV optimum viewing distance is stated as four times the picture height. Find the maximum number of lines which can be resolved by the human eye.

SOLUTION

Minimum resolvable angle α is approximately one minute

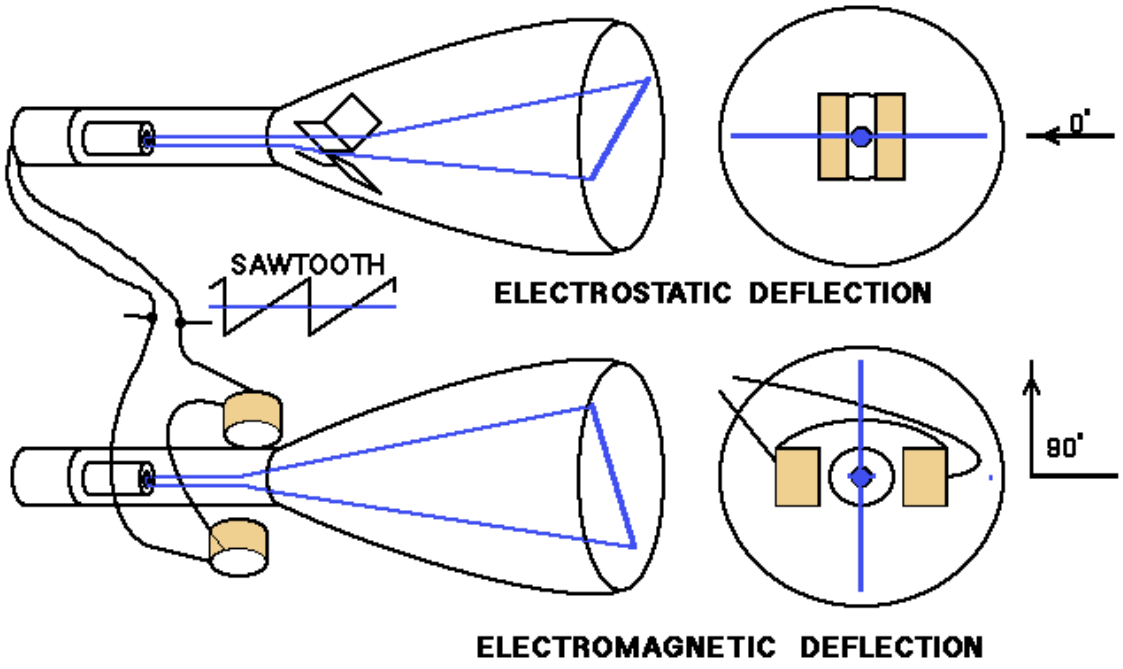
i.e $\alpha = \frac{\pi}{60 \times 180} = 0.000291$

$$\rho = \frac{H}{D} = \frac{1}{4}$$

$$N_{vr} = \frac{1}{\alpha}\rho = \frac{0.25}{0.000291} = 860 \text{ lines}$$

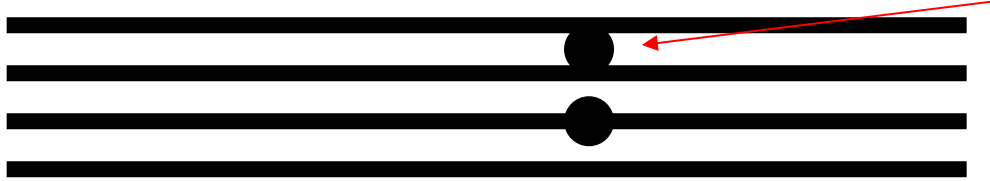
TELEVISION PRINCIPLES

- The eye can fuse separate **pixels** in a line into one continuously varying line, as long as the spacing between pixels is sufficiently small.



KELL FACTOR EXPLAINED

- It was observed that approximately 70% of the lines get scanned in the vertical direction while 30% are merged with others due to the beam spot falling between two consecutive lines due to random distribution.



The beam spot covers partially 2 pixels. The resultant luminance will be grey (black + white)

- The distinction between the two pixels is therefore not reproduced.
- About 25% - 35% of the pixels are lost due to this. This is referred to as the **Kell factor**.
- As a result of this loss, the effective lines are worked out by multiplying the active lines by a factor of between 65% to 75%.

KELL FACTOR DEFINITION

- Kell factor is a subjective number of lines of resolution that can be visually perceived in a video display system, expressed as a percentage of the total number of lines of resolution.
- The effective number of lines is determined by multiplying the active lines by the Kell factor. This can be expressed in mathematical form as

$$k = \frac{N_e}{N_a}$$

Where

k is the Kell factor,

N_a is the number of active lines,

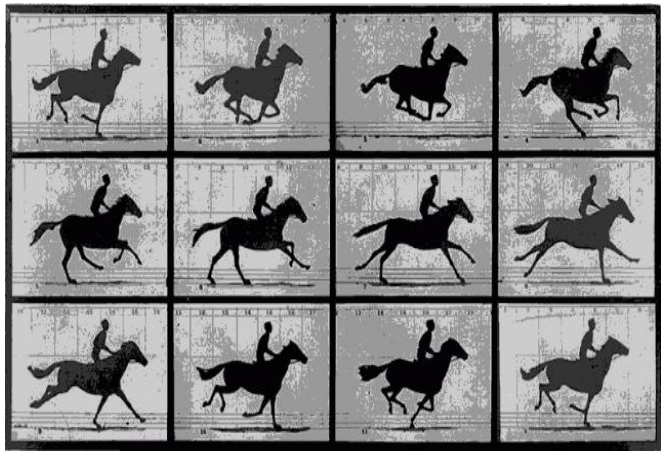
N_e is the number of effective lines.

PERSISTENCE OF VISION

- **Persistence of vision** refers to optical illusion that occurs when visual perception of an object does not cease for some time after the rays of light coming from it have ceased to enter the eye.

- When the eye sees light, the brain continues to have the illusion of the presence of light for about 60ms after the light is removed.

- It is possible to see movies because of this feature of the eyes.
- In TV systems, the frame rate must be faster than the persistence of vision.



FLICKER EQUATION

- Time for persistence of vision is more for dark light than for bright light resulting in a phenomena called flicker.
- Dark intervals between bright pictures become visible for a very short time and appear as flicker.
- The relationship between flicker and brightness is given by the Ferry Poster law as

$$F_c = F + 12.6 log_{10} B$$

where

F_c is the critical frequency at which flicker will not be seen.

F is a constant related to viewing conditions.

B is the luminance of the picture