Microstrip or Patch Antennas.

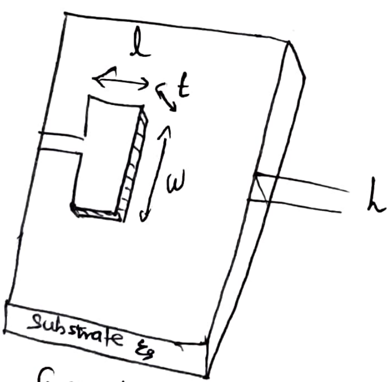
Aim: To study the construction & design of patch antenna

objective: Derive the directivity of patch antenna

* microstrip Antennas consists of a very thin metallic strip (patch) ($t << \lambda$) placed above ground plane

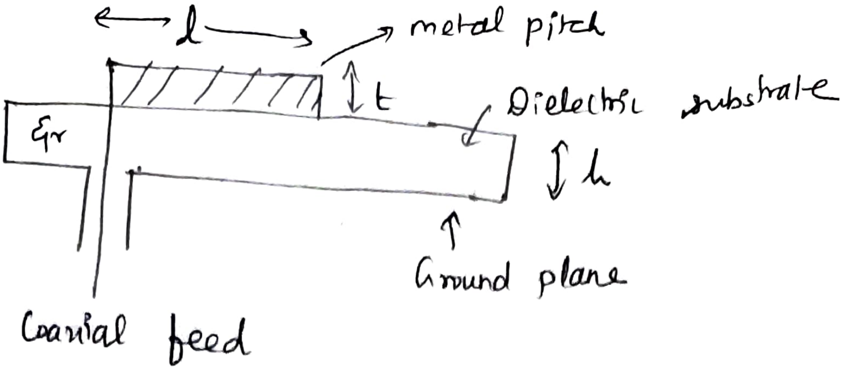
* The strip and ground plane are separated by a dielectric sheet called substrate.

* The radiating element and feed lines are normally protected on the dielectric substrate.



* The radiating patch may be square, circular, elliptical rectangular or any shape.

* The feedline is also a conducting strip normally of smaller width. coaxial line feeds where the inner conductor of the coaxial line is attached to the radiating patch are widely used

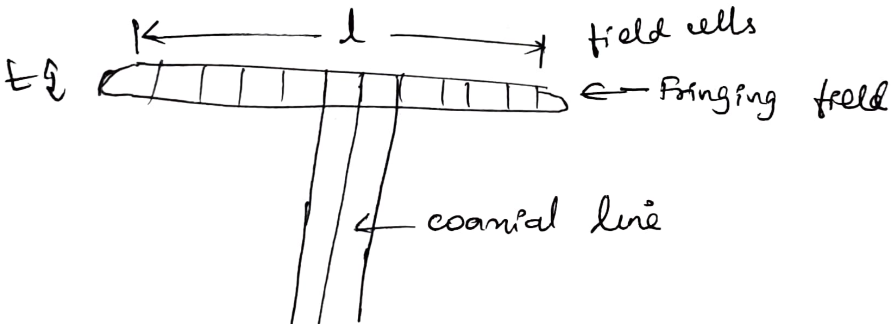


* The Patch Antenna acts as a resonant $\lambda/2$ Parallel plate microstrip transmission line with chara impedance equal to the reciprocal of the No of parallel field cell transmission lines

$$Z_i = \eta_i = \sqrt{\mu/\varepsilon} = \sqrt{\mu_0/\varepsilon_0}\,\sqrt{\mu_r/\varepsilon_r}$$

$$Z_i = 120\pi\sqrt{\mu_r/\varepsilon_r}$$

Patch with gap divided into field cells



* The cross section has 10 parallel field cell transmission line for $\varepsilon_r = 2$

Char. imp of patch Antenna

$$Z_C = \frac{Z_0}{n\sqrt{\varepsilon_r}} = \frac{377}{10\sqrt{2}}$$

$$Z_C = 26.63\ \Omega \qquad n = 1/t$$

$$Z_C = \frac{Z_0 t}{l\sqrt{\varepsilon_r}}$$

Directivity :

* The radiating pattern of patch is broad. The typical value of the beam area Ω_A is half of a half space or about π steredian.

$$D = \frac{4\pi}{\Omega_A}$$

$$= 4\pi/\pi$$

$$D = 4$$

The limitations of the microstrip antenna is its narrow frequency bandwidth which can be increased by

1. Increasing the thickness of the substrate
2. Using high dielectric constant ϵ_r substrate
3. Increasing inductance
4. Adding reactive components to reduce the VSWR

Advantages :

* Linear & circular polarization are possible
* Small size & weight
* Narrow beam of radiation
* Ease of installation & fabrication
* Adding reactive components to reduce VSWR

Disadvantages:

1. Narrow bandwidth
2. Radiate into half plane
3. Poor end fire radiation performance
4. Low power handling capacity
5. No provision for adjusting any design value after fabrication

Applications:

→ Space craft & Aircraft.

Frequency Independent Antenna:

Log Periodic Antenna: HF antenna:

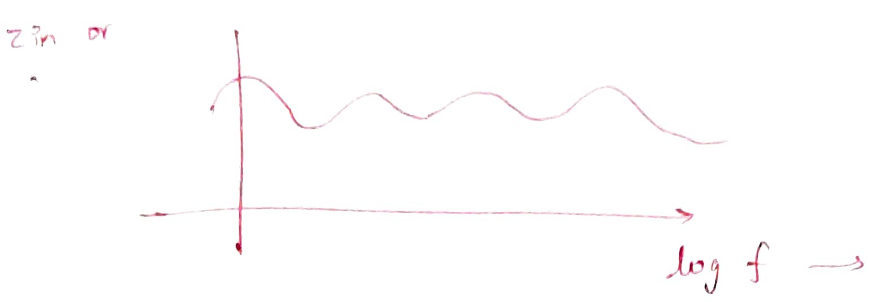
* Circumstances may arise which requires antennas that are frequency independent & which can be used as wide band antennas for which the impedance and radiation pattern & thus the Directivity remains constant or independent (or as a function) of frequency.

* To be frequency independent the antenna should be expand or contract in proportion to λ.

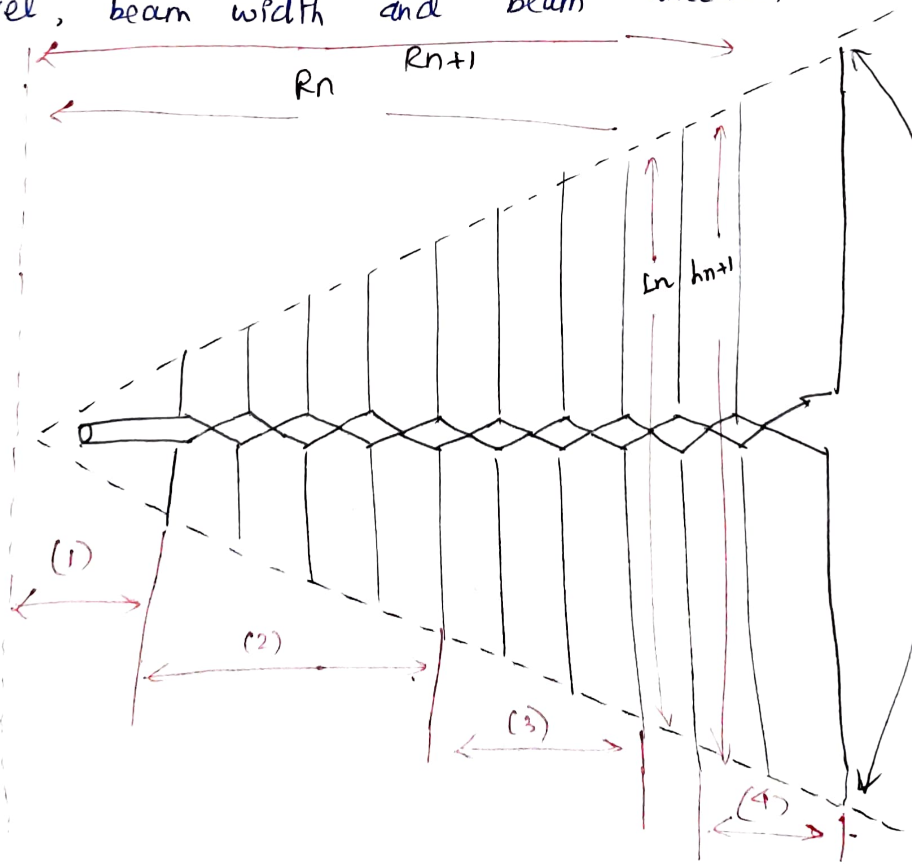
* The development of frequency independent concept leads to log periodic antennas.

* The name log periodic is derived as the geometry of the antenna structure is so chosen that the electrical properties repeat periodically with the logarithm of the frequency

Plot of i/p Impedance Vs log f



* The i/p impedance is a logarithmically periodic function of frequency. Not only this, all the electrical properties undergo similar periodic variation particularly radiation pattern, directive gain, side lobe level, beam width and beam direction.



1. Induced transmission region
2. Loaded transmission region } Inactive region ($L < \lambda/2$)
3. Active region ($L \simeq \lambda/2$)
4. Reflective region ($L > \lambda/2$)

Analysis of log periodic Antenna:

1) Inactive region ($L < \lambda/2$)

→ Antenna elements are short with resonant length ($L \leq \lambda/2$)

→ current is small & leads base voltage by 90°

→ Small radiation in backward direction

2) Active region ($L \approx \lambda/2$)

→ Dipole length $\approx \lambda/2$

→ resistive impedance

→ Element currents are large & inphase with base voltage

→ strong radiation

3) Inactive reflective region

→ Dipole lengths are longer than the resonant length.

→ Inductive impedance

→ Active region is reflected back towards the backward direction

Relationship b/w L & R

The relationship b/w the length (L) & distance from the origin (R) is given by

$$\frac{R_1}{R_2} = \frac{R_2}{R_3} = \cdots = \frac{R_n}{R_{n+1}} = \tau = \frac{L_1}{L_2} = \frac{L_2}{L_3} = \cdots = \frac{L_n}{L_{n+1}}$$

∴ τ the design ratio or scale factor or periodicity factor is given by

$$\tau = \frac{R_n}{R_{n+1}} = \frac{L_n}{L_{n+1}} \quad (\tau < 1)$$

(or)

$$\frac{S_{n+1}}{S_n} = \frac{L_{n+1}}{L_n} = \frac{1}{\tau} = k, \quad k > 1$$

S → spacing b/w the two adjacent elements

$\alpha = 30°$ & $\tau = 0.7$

Applications:

→ High frequency communication

→ TV reception (even upto UHF Band)

→ Best suited for all round monitoring

Relation b/w apex angle, scale factor & spacing factor

$$\text{spacing factor} = \frac{1 - \left(\frac{1}{\text{scale factor}}\right)}{4 \tan(\text{apex angle})}$$

$$\tan\alpha = \frac{1-(1/\tau)}{4 S_\lambda}$$

$$S_\lambda \text{ or } \sigma = \frac{1-1/\tau}{4\tan\alpha}$$

$$\alpha = \tan^{-1}\left[\frac{1-(1/\tau)}{4\sigma}\right]$$

S_λ → spacing factor

τ → scale factor

α → Apex angle.

Outcome:

Able to learn the design of patch Antenna & log periodic antenna.