SRWC- Unit2 part1 - ....

Short Range Wireless Communication (SRM Institute of Science and Technology)

UNIT-2

Antennas & Baseband Coding Basics.

Types of Antennas - Dipole, ground plane, loop. Helical Patch antennas - Antenna characteristics, Impedance, directivity and gain, Effective area polarization, Bandwidth, Antenna factor, Baseband Data format & Protocol - Radio Communication Link diagram code Hopping, Baseband coding - Digital systems wireless microphone system RF frequency & Bandwidth - factors, propagation characteristics modulation types - modulation for digital event Communication Continuous Digital Communication, Advanced Digital modulation Spread spectrum, DHSS spread spectrum, FHSS RFID transceiver, Design issues for RFID.

UNIT-II

Antennas and Baseband coding Basics.

Introduction :-

* Antenna - Interface between transmitter / receiver and the propagation medium

* deciding factor in the performance of radio Communication System.

* Principle Properties of antenna - directivity, gain & radiation resistance.

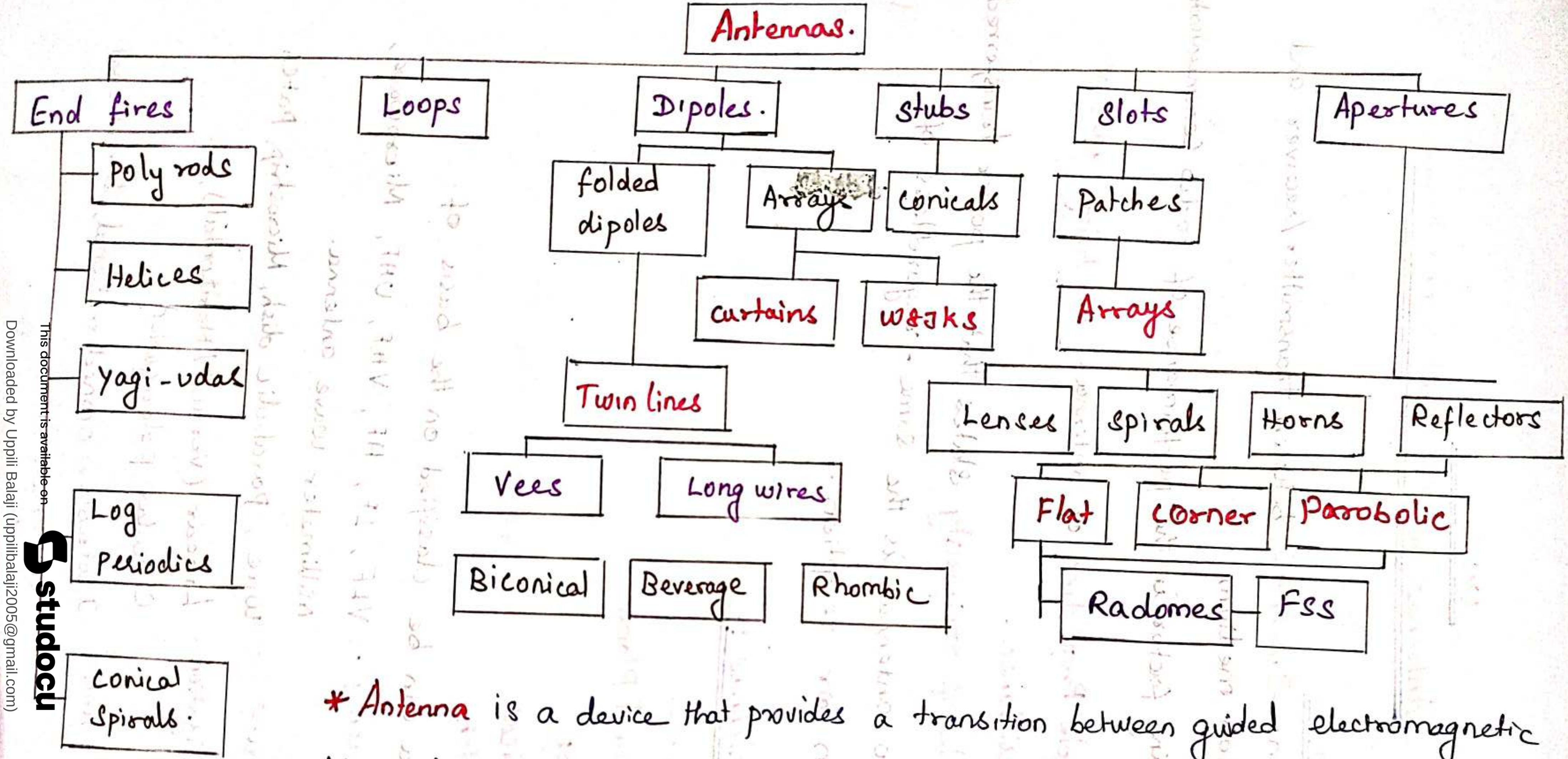
* Principle of reciprocity states that the power transferred between two antennas is the same - regardless of transmission or reception.

Types of Antennas :-

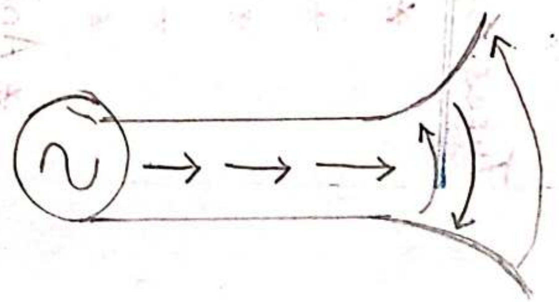
* Dipole
* Ground Plane
* Loop
* Helical
* Patch.

* Antenna can be classified on the basis of.

1. frequency - VLF, LF, HF, VHF, UHF, Microwave, Millimeter wave antenna.
2. Apeture - wire, parabolic dish, Microstrip, Patch
3. Polarization - Linear (Vertical / Horizontal), Circular polarization
4. Radiation - Isotropic, omnidirectional, Directional Hemispherical



* **Antenna** is a device that provides a transition between guided electromagnetic waves in wires and electromagnetic waves in free space.



Types of Antennas.

* Size of Antenna is related to the wavelength — found when frequency is known

$$\text{Wavelength} = \frac{\text{Velocity of Propagation.}}{\text{frequency.}}$$

$$\lambda = \frac{v}{f}$$

* The maximum velocity of propagation occurs in Vaccum approx 300 000 000 meters/second.
* In Solid materials wavelength will be shorter for antennas Printed on circuit board materials or protected with plastic Coating.

Types of Antennas :-

* Dipole
* Ground plane
* Loop
* Helical
* patch.

Dipole Antenna :-

* Wire antenna fed at its centre.
* Term usually refers to an antenna whose overall length is one half wavelength.
* In free space its radiation resistance is 73 ohms, but the value varies when the ground or other large conducting Objects are within a wavelength distance from it.
* Dipole is usually mounted horizontally - but if mounted vertically its transmission line feeder cable should

from it at right angle for a distance of least a quarter wavelength.

* Directivity of 1.64 (or) 2.15 dB

* Radiation is 8 dB down from maximum along the direction of the wire.

* Indoor, there are multi reflections from walls, floor & ceiling, the horizontal dipole gives good results in all directions.

* Half wave dipole antenna is convenient to use because it is easy to match a transmitter or receiver to its radiation resistance.

* It has high efficiency. Since wire ohmic losses are only a small fraction of radiation resistance.

* A dipole Antenna cas of two pieces of wire, rod or tubing that are one quarter wavelength long at the operating resonant frequency.

* The radiation of energy when passed through such a bent wire, the end of such transmission line is termed as dipole (or) dipole antenna.

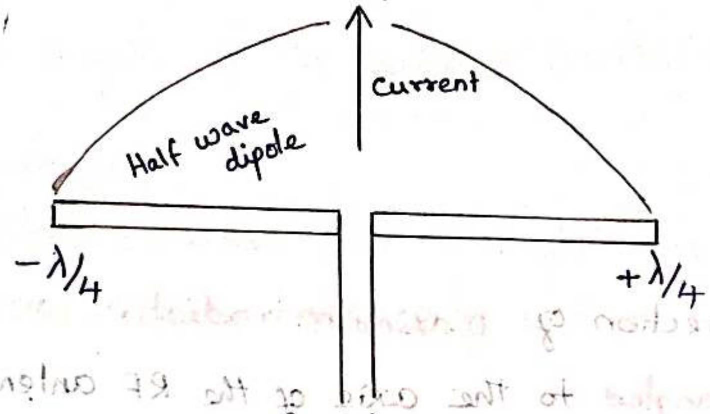
* The reactance of the input Impedance is a function of radius and length of the dipole.

* It's is propotional to wavelength.

* Impedance is around 72 Ω

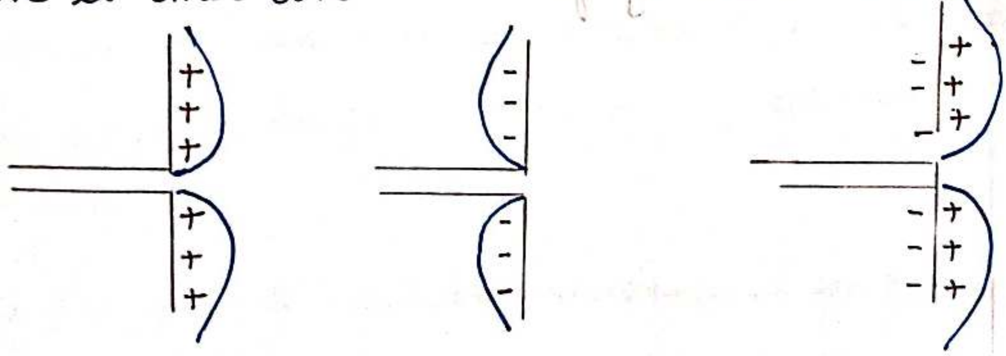
* The different types of dipole antenna are

* Half wave dipole
* Folded dipole
* full wave dipole



Half wave dipole :-

* Most widely used antenna
* also called as doublet. & formally known as Hertz antenna.
* It is a normal dipole antenna, where the frequency of its operation is half of its wavelength
* Edge of the dipole has maximum Voltage.
* The voltage is Alternating (AC) in nature.
* At positive peak of the voltage, the electron trend to move in one direction and at negative peak, the electron move in other direction.



* When the charges induced are in positive half cycle, the electrons tend to move towards the charge.

* Negative charges induced on the dipole ; tends the electrons to move away from the dipole

Radiation Pattern :-

* The direction of maximum radiation (or) sensitivity is at right angles to the axis of the RF antenna.

* In three dimensional plot, the radiation pattern envelope for points of equal radiation intensity for a doughnut type shape, with the axis of the antenna passing through the hole in the centre of the doughnut.

Folded Dipole Antenna :-

* Folded dipole is the main element in yagi uda antenna

* The main element used here is the folded dipole, to which the antenna feed is given.

* Used extensively for television reception.

Advantages of dipole antenna

* Input Impedance is not sensitive
* Matches well with transmission line Impedance
* Has re sonable length.
* Length of the antenna matches with size & directivity

Disadvantages

* Not effective due to single element
* can work better only with a Combination.

Ground plane:-

* The dipole element mounted Perpendicular to a large metal plate does not require a bottom element - Virtual element will be electrically reflected from the plate.

* When metal plate is approximately one half wavelength Square (or) larger, the radiation resistance of the antenna is 36 ohms. & a good match to the receiver or transmitter.

* The quarter wave groundplane antenna is ideal if receiver or transmitter is encased in a metal enclosure that requires horizontal area for an efficient vertical antenna.

* In this case, the radiation resistance is much lower than 36 ohms & there is considerable capacitance reactance.

* An Inductor is needed to cancel the reactance as well as a matching circuit to assure maximum power transfer

* The ohmic losses in the inductor & other matching components; with low radiation resistance, results in low antenna efficiency.

* The antenna length should be increased to a point, where the antenna is resonant, that is has no reactance

* The electrical length can be increased & capacitive reactance reduced, by winding the bottom part of the antenna element into a coil having several turns.

* The loss resistance may be reduced & efficiency increased.

Loop Antenna :-

* The Loop antenna is popular for hand held transmitter because it can be printed on a small circuit board and is less affected by conducting objects than other small resonant antennas.

* Loop Antenna consists of a single turn (or) many turns of wire forming a loop.

* It is excited by generator dialy

* The field produced by loop antenna is similiar to a Smaller dipole

* An RF current carrying coil given as a single turn into loop can be used as an antenna called as loop antenna.

* The current through loop antenna will be inphase

* The magnetic field will be perpendicular to the whole loop carrying the current.

* The frequency range of operation is around 300 MHz to 3GHz and the antenna works in UHF range.

* The loop antenna dimensions are small compared to a wavelength less than 0.1λ has constant current throughout.

* Radiation field is expressed as

$$E(\theta) = \frac{120\pi^2 I \cdot N \cdot A}{r \cdot \lambda^2} \cos\theta$$

where

- I - current
- A - loop area
- r - distance
- θ - angle from the plane to the loop
- N - number of turns.

* Radiation resistance is

$$R_r = 320\pi^4 \frac{(A \cdot N)^2}{\lambda^4}$$

* Loop antennas are frequently used in small hand held remote control transmitters on the low UHF frequencies.

* The radiation resistance is generally below a tenth of an ohm & the efficiency under 10%.

* The different types of loop antennas
  - Large loop antenna
  - Small loop antenna

Large loop Antenna

* also called as resonant antenna
* They have high radiation efficiency.
* These antennas have length nearly equal to wavelength

$$L = \lambda$$

L - length of antenna
λ - wavelength.

Small loop Antenna

* also called as magnetic loop antenna.
* These are less resonant & mostly used as receivers.
* Antennas are of size of one tenth of wavelength

$$L = \lambda/10$$

Helical Antenna :-

* The Helical Antenna is made by winding stiff wire in the form of a spring, whose diameter & pitch are very much smaller than a wavelength, or by winding wire on a cylindrical form.

* The helical winding creates an apparent axial velocity along the Spring - much less than the velocity of propagation along a straight wire approximately the Speed of light in space.

* A quarter wave on the helical spring will be much shorter than on a straight wire.

* The antenna is resonant for the length, but the radiation resistance will be lower & consequently the efficiency is less than standard quarter wave antenna.

* The Helical antenna resonates when the wire length is in the neighborhood of a half wave length.

* Impedance matching to transmitter or receiver is relatively easy.

* The radiating surface of helical antenna has both vertical & horizontal components, so its polarization is elliptic

* The helical antenna should have a good ground plane for best & predictable performance.

* In hand held devices, the users arm and body serve as a Counterpoise & antenna should be designed for this Configuration.

* Helical antenna is an example of wire antenna and forms the shape of a helix.

* The frequency range of operation of helical antenna is around 30 MHz to 3 GHz & works in VHF & UHF range

* The conducting wire is wound in helical shape & connected to the ground plate with a feeder line.

* It is the simplest antenna which provides circularly polarized waves.

* It is used in extra terrestrial communication in which satellite relay etc. are involved.

* The helical antenna used for satellite communication requires wider outdoor space.

* It consists of a helix of thick copper wire or tubing wound in the shape of a screw thread used as an antenna in conjunction with a flat metal plate called a ground plate.

* One end of the helix is connected to the center conductor of the cable & the outer conductor is connecte to the ground plate.

Modes of operation :-

* The predominant modes of operation of helical antenna a

    * Normal (or) perpendicular mode of radiation
    * Axial (or) end fire (or) beam mode of radiation

Normal mode :-

* The radiation field is normal to the helix axis & the radiated waves are circularly polarized waves.

* This mode of radiation is obtained if the dimensions of a helix are small compared to the wavelength
* The radiation pattern of this helical antenna is a combination of short dipole & loop antenna.

Axial mode :-

* The radiation is in the endfire direction along the helical axis & the waves are circular or nearly circular polarized waves.
* This mode of operation is obtained by raising the circumference to the order of one wavelength (C/λ) & a spacing of approximately $(\lambda/4)$
* The radiation pattern is broad and directional along the axial beam producing minor lobes at oblique angles.

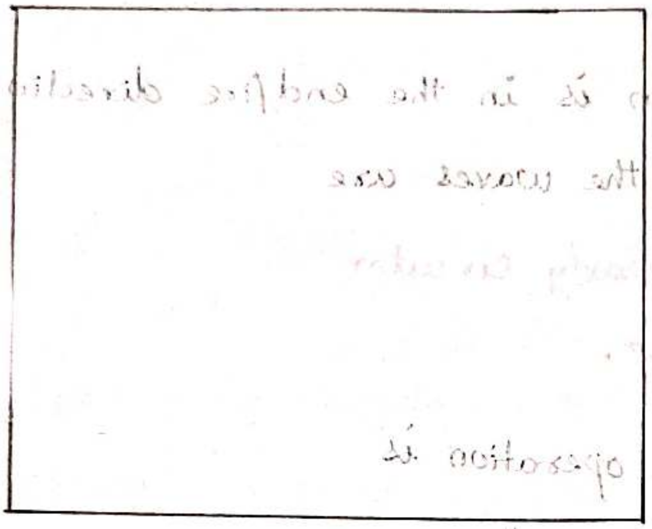
Patch Antenna :-

* The patch antenna is convenient for microwave frequencies specifically on the 2.4 GHz band & higher.
* It consists of a plated geometric form (the patch) on one side of a printed circuit board, backed up on the opposite board side by a groundplate plating which extends beyond the dimensions of the radiating patch.

* Rectangular & Circular forms are the most common while trapezoid shapes are sometimes used.

* Maximum Radiation is generally perpendicular to the board.

* A Square half wave patch antenna has a directivity of 7 to 8 dB.



* The dimension "L" is approximately a half wavelength, calculated as half the free space wavelength "λ" divided by the square root of the effective dielectric constant "ε" of the board material.

* The Impedance at the feed point depends on the width 'W' of the patch.

* A microstrip transforms it to the required load for transmitter (or) source for receiver impedance.

* A microstrip antenna consists of radiating patch, dielectric substrate, feed and ground plane.

* Patch & ground plane made of material such as Copper (or) gold.

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* There are different shapes of Patch for different type of application.

* Microstrip patch is like rectangular, circular, circular ring, Dipole, Elliptical (or) Triangular.

Feeding Methods :-

* In microstrip patch antenna there are various types of feed methods categorized into two main types.

→ Contacting

→ Non Contacting.

Contacting :-

* RF Power is directly applied to the patch through BNC Connector

* The contacting feed methods are

→ Microstrip feed line

→ Coaxial probe.

NonContacting :-

* power is given through Coupling.
* It depends on the
  → Aperture Coupled Feed
  → proximity Coupled feed.

Comparison of various feeding technique.

	Microstrip Line feed	Coaxial feed	Aperture Coupled feed	Proximity Coupled feed
Spurious	more	more	less	minimum
Reliability	better	Poor due to Soldering	good	good
Ease of fabrication	easy	soldering & drilling needed	alignment required	Alignment required
Impedance matching	easy	easy	easy	easy.
Bandwidth	2-5%	2-5%	2-5%	12%

Advantages of patch Antenna :-

* Relatively inexpensive to manufacture & design
* Usually employed at UHF & higher frequencies
* Maximum gain of around 6-9 dB.
* easy to print an array of patches on a single Substrate
* Provides much higher gain

Antenna Characteristics :-

* Antenna Impedance
* Directivity & Gain
* Effective Area
* polarization
* Bandwidth
* Antenna factor.

Antenna Impedance :-

* Antenna is an Interface between Circuits & space.
* facilitates the transfer of power between space & the transmitter / Receiver.
* Antenna Impedance is load for the transmitter (or) input Impedance to the receiver.
* Composed of two parts
  - radiation resistance
  - ohmic resistance.

Radiation Resistance :-

* Radiation Resistance is a Virtual resistance
* when multiplied by the Square of RMS current is the antenna at its feed point equals the power radiated by the antenna.
* Radiation Resistance to Current maximum for ungrounde
  Current at base for grounde
* Transmitter power delivered to an antenna will always be greater than the power radiated.

* The difference between the transmitter power & the radiated power is power dissipated in ohmic resistance of the antenna conductor & in other losses.

* The efficiency of antenna is the ratio of radiated power to the total power absorbed by antenna

* expressed in terms of radiation resistance (R_r) & loss Resistance (R_l)

$$\text{Antenna Efficiency } (\%) = 100 * \left(\frac{R_r}{R_r + R_l}\right)$$

* Total power loss in an antenna is sum of two losses

Total power loss = ohmic loss + Radiation loss.

* The resistanke of transmitter & receiver at the antenna terminals are equal to the radiation resistance Plus the loss resistance, if the terminals are located at the point of maximum current flow.

* The Impedance have a reactive component and when there is no reactive component the antenna is said to be resonant.

* Maximum power transfer between antenna transmitter or receiver only when Impedance from antenna terminal is Complex Conjugate of the antenna Impedance.

* Maximum power transfer is attained if the transmitter is matched to the antenna.

* Radiation Resistance depends on
  → Proximity of antenna to conducting & Insulating objects.
  → depends on the height of antenna from ground.

Directivity and Gain :-

* The directivity of an antenna relates to its radiation Pattern.

* Isotropic Antenna → radiates uniformly in all directions in three dimensional space — doesn't exist

* All real Antennas radiate stronger in some directions

* Directivity of an antenna is defined as the power density of the antenna in its direction of maximum radiation in three dimensional space divided by its average power density.

* The directivity of hypothetical isotrophic radiator - 1 (or) 0 dB
  half wave dipole antenna - 1.64 (or) 2.15 dB

* A vertical wire antenna is omnidirectional - it has a circular horizontal radiation pattern & directivity in the vertical plane.

* The Gain of an antenna is the directivity times the antenna efficiency. [antenna losses - low → both terms are almost same]

* . Gain is used to find the maximum radiated power when the power of the antenna is known.

Effective Area :-

* Wave propagation is described as if all of the radiated power is spread over the surface of the sphere whose area expands according to the square of distance.

* The power captured by the receiving antenna is then the capture area (or) effective area of the antenna times the power density at that location.

* Power density is the radiated power divided by surface area of the sphere.

* The effective area of the antenna related to gain & wavelength is

$$A_e = \frac{\lambda^2 G}{4\pi}$$

* The capture ability of an antenna of gain G grows proportionally as the square of the wavelength.

* When the electric field strength E is known, power density

$$P_d = \frac{E^2}{120\pi}$$

* The Received power can be found when field strength is known.

$$P_R = \frac{E^2 \lambda^2 G}{480\pi^2}$$

* Effective antenna area is connected with the Physical size of the antenna.

* for a given radiated power & field strength, the lower frequency systems will give stronger receiver signals than high frequency equipment.

* Short range devices are often portable or otherwise limited in size & roughly same dimensions, regardless of frequency.

* The lower frequency antennas whose sizes are small fractions of a wavelength have poor efficiency & low gain & have effective areas similiar to their high freq counter parts.

Polarization

* Electromagnetic radiation is composed of a magnetic field and an electric field.
* The fields are at right angles to each other, & both are in a plane normal to the direction of propogation.
* Direction of polarization refers to the direction of electric field in relation to the earth.
* Linear polarization is created by a straight wire antenna.
* A wire antenna Parallel to earth - horizontally polarized
  normal to earth - Vertically polarized.

* Elliptical polarization – electric & magnetic fields may rotate in their plane around the direction of propagation. Two types of polarization < Right hand, Left hand

* Created by perpendicular antenna elements being fed by coherent RF signals that are not in same time phase with each other.

* Circular polarization – elements are fed by equal power RF signals which differ in phase by 90° which causes the electric field to make a complete 360° rotation every period of the wave.

* Helical Antenna produces elliptic (or) circular polarization inherently without having two feed points.

* Horizontally polarized receiving antenna cannot receive vertically polarized radiation from a vertical transmitting antenna & vice versa. While right hand and left hand circular antenna systems are also not compatible.

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* The degree of reflection of radio signals from the ground is affected by Polarization.

* The phase and amount of reflection of vertically Polarized waves from ground are much more dependent on the angle of incidence than horizontally polarized waves.

* Cross polarization defines the degree to which a transmission from an antenna of one polarization can receive an antenna of opposite polarization.

Bandwidth :-

* Antenna Bandwidth is the range of frequencies the antenna can operate
* Bandwidth is related to antenna Impedance expressed as Standing wave ratio.
* Bandwidth demands for a Single frequency device.
* Narrow Bandwidth (or) high Q antenna discriminates harmonics & radiation and reducing the requirements for a filter necessary for radio approval.
* Drifting of antenna physical dimensions (or) matching components cause the power output to fall with time.

Antenna Factor:-

* Antenna factor is commonly used with calibrated test antennas to make field strength measurements on a test receiver (or) spectrum analyzer.

* It relates the field strength to the voltage across the antenna terminals when antenna is terminated in its specified Impedance.- usually 50 (or) 75 ohms.

$$AF = \frac{E}{V}$$

where AF – antenna factor in $meters^{-1}$

E – field strength in V/m

V – load voltage in V

* The antenna factor is stated in dB.

$$AF_{dB}(m^{-1}) = 20 \log \left(\frac{E}{V}\right)$$

* The relationship between numerical Gain(G) and antenna factor AF is

$$AF = \frac{4\pi}{\lambda}\sqrt{\frac{30}{R_L \cdot G}}$$

where R_L – load resistance – usually 50 ohms.