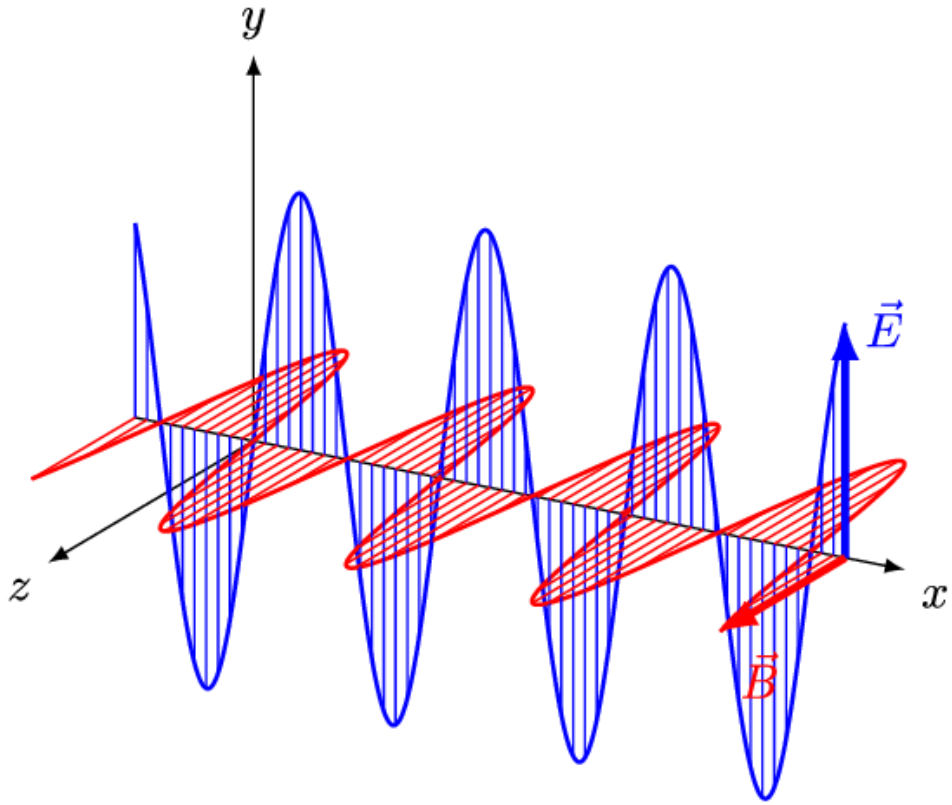
Antennas and Frequency Measurement

Presented by

Ragav VU3VWR

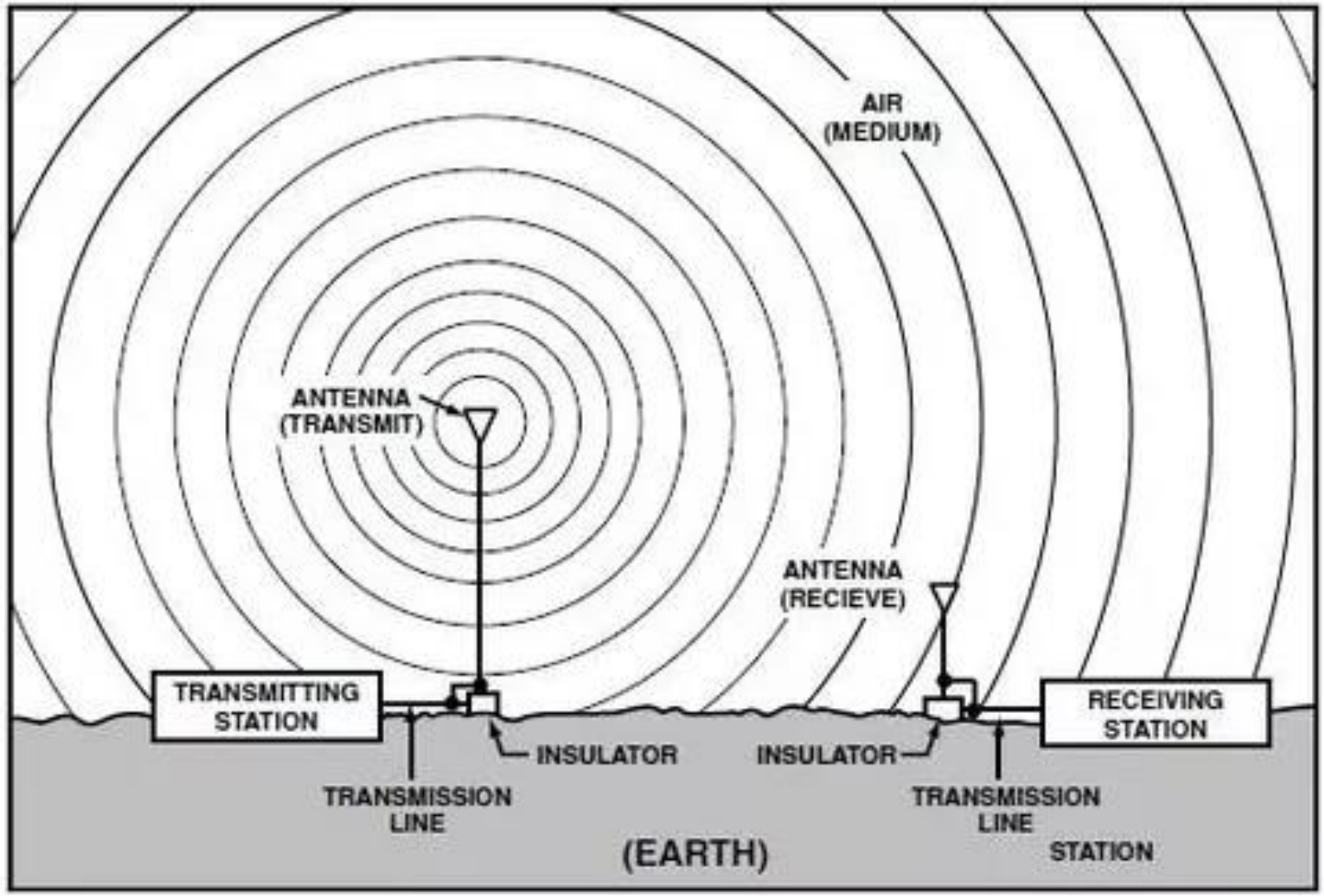
Quick Recap : Radio Waves

- A radio wave is a combination of a magnetic field (B) at a right angle to an electric field (E) ; Both oscillate at a specific frequency, and they travel together in a direction perpendicular to both fields
- These electromagnetic fields move at the speed of light through free space
- Polarization is the orientation of the fields with the earth; vertical polarization means Electric field is vertical to earth's surface , horizontal polarization means Electric field is horizontal to earth's surface



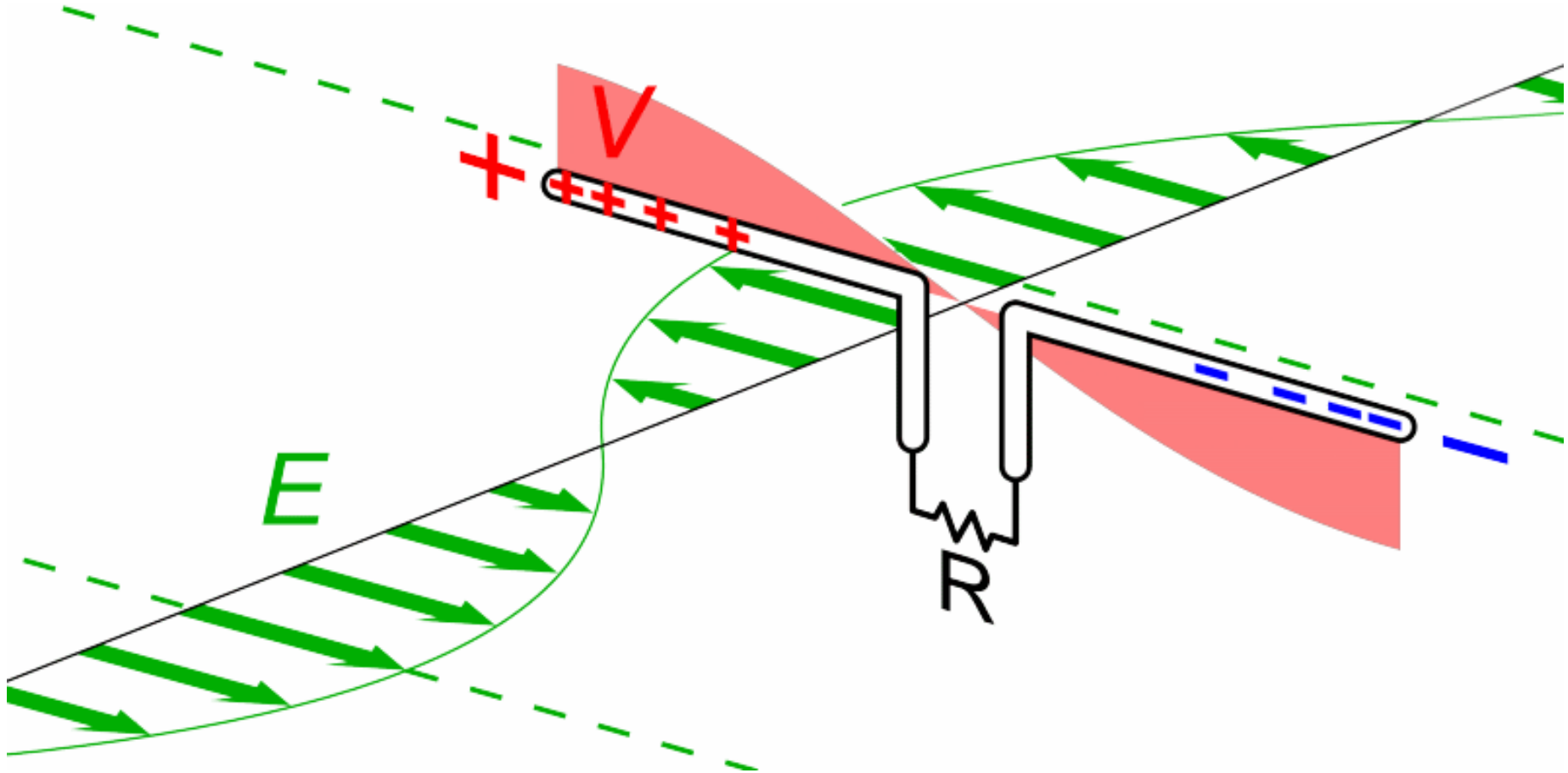
Antennas

- An antenna, or aerial, is an electrical device which converts electric power into radio waves and vice versa; It is usually used with a radio transmitter or radio receiver
- In a transmitter, the radio waves (AC) are applied to an antenna, which radiates these signals; in a receiver, it picks up some of the power from a transmitted signal and sends it to the receiver for further amplification
- Antennas are the most essential part of the radio; without a good antenna, it is impossible to send and receive signals from far away stations – saying in amateur radio goes " You can't work 'em, if you can't hear em!" - if the antenna is poor , it is difficult to hear weak signals and ,hence, impossible to work them!


AIR
(MEDIUM)
ANTENNA
(TRANSMIT)
ANTENNA
(RECIEVE)
TRANSMITTING
STATION
RECEIVING
STATION
INSULATOR
INSULATOR
TRANSMISSION
LINE
TRANSMISSION
LINE
(EARTH)
STATION

Antennas ..

- Antennas are made of metal, but any conductor could be used; typically copper or aluminum is used, but there are even salt-water antennas!
- The antenna is electrically connected to the radio; when the transmitter sends out a radio signal, which is an oscillating current, into the antenna; they create alternating electric and magnetic fields along the antenna
- These fields radiate away from the antenna into space as a moving electromagnetic wave
- During reception, the oscillating electric and magnetic fields induces an oscillating current in the antenna, which is then amplified by the radio


V
E
R

Quick Recap : Resonance

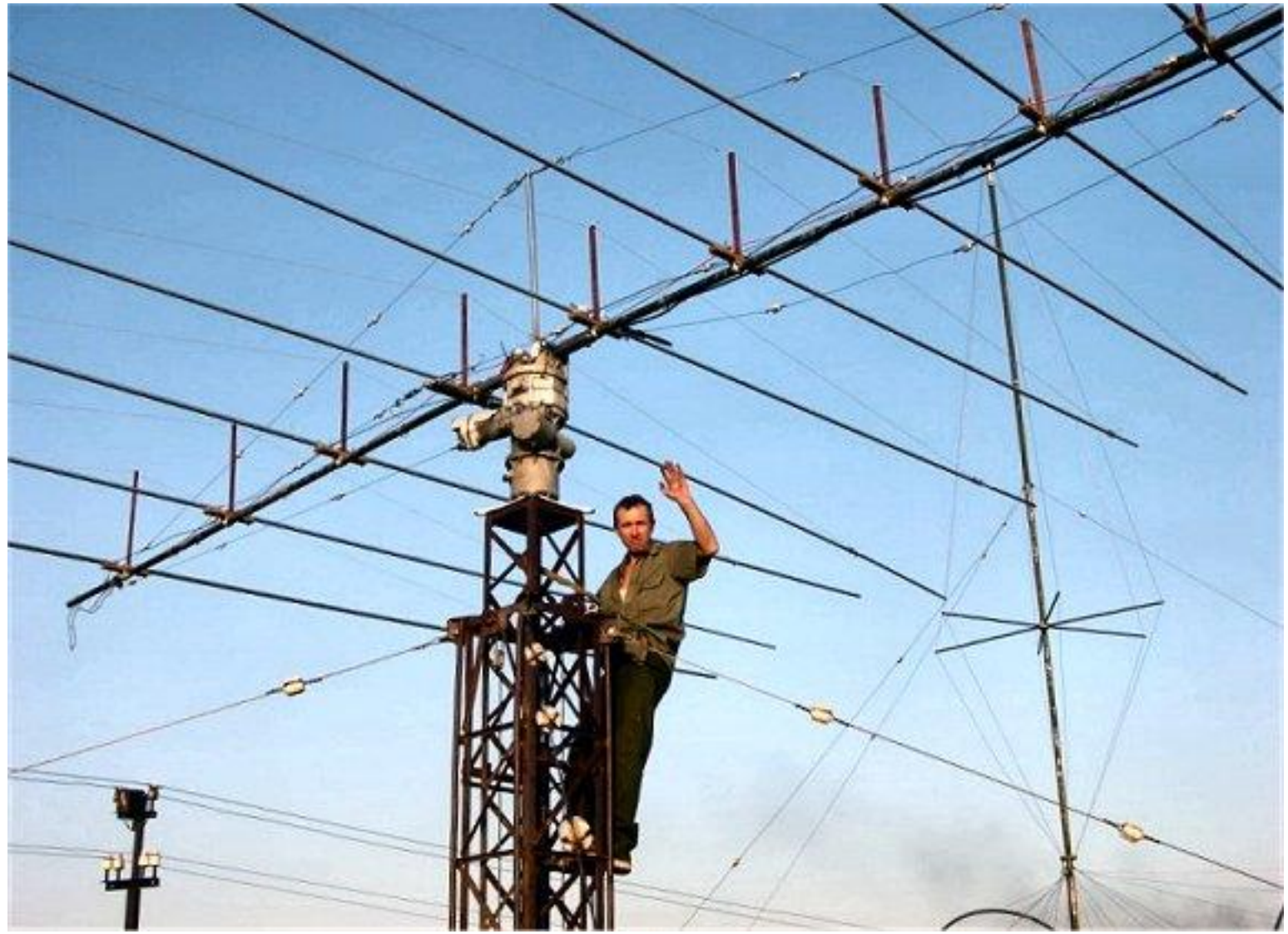
- An object, left free to vibrate, will do so at a specific rate known as its natural or resonance frequency; this frequency depends on the shape, size, and composition of the object
- Such an object will vibrate strongly when subjected to vibrations at a frequency close to or at its resonance frequency; ex : vibrations from a loose object in a vehicle – the object is in resonance with vibrations of the vehicle's engine
- In other words, resonance is the phenomena of increased amplitude the occurs when the frequency of the applied force is equal to or close to the resonant frequency of the object to which the frequency is being applied
- When two objects of the same resonant frequency are placed together and vibration is applied to one, it forces the other object to vibrate with greater amplitude at its resonant frequency
- In a radio, we adjust the natural resonant frequency of the receiver to match the resonant frequency of the transmitter to transfer energy in the form of radio signals

Quick Recap : Resonance

Antennas …

- All wireless devices require an antenna to perform send and receive signals; the size and shape of the antenna depends on the wavelength it is intended to operate on
- Lower frequency radio waves have longer wavelengths, so longer antennas are needed; higher frequencies have shorter wavelengths so the antenna can be short
- The part of the antenna that is responsible for transmitting or receiving radio waves is known as the antenna “element”

66*13MM



Classification of Antennas : Frequency

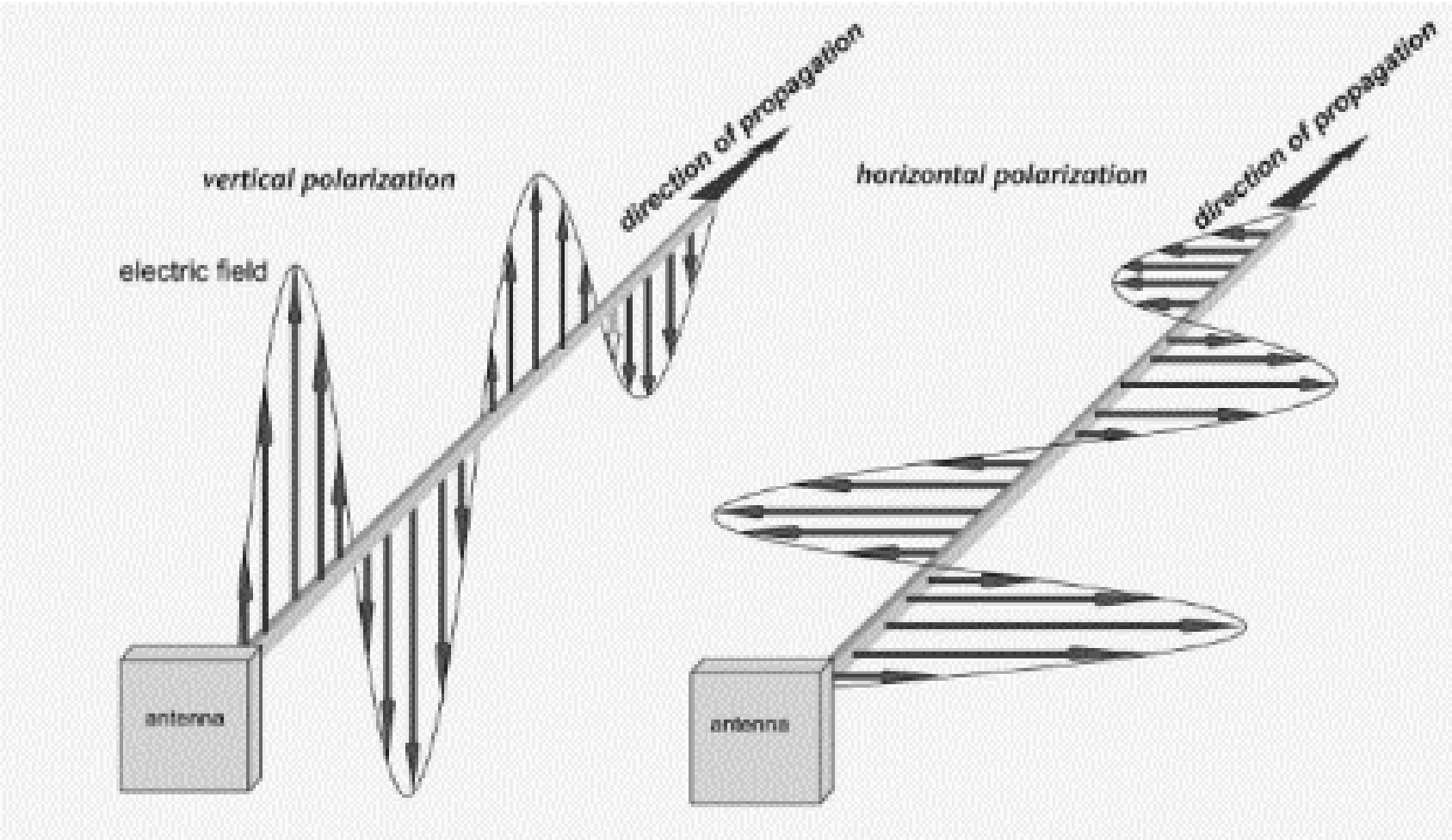
- Antennas can be classified based on their naturally resonant frequency as VLF, LF, MF, HF, VHF, UHF, SHF and EHF antennas
- When the radio signal from the transmitter matches the resonant frequency of the antenna, there is no reactance in the circuit and the maximum AC signal flows through the antenna, allowing for efficient transmission
- For a receiver antenna, antenna's output impedance should match with the input impedance of the receiver amplifier circuit
- For a transmitter antenna, antenna's input impedance should match with transmitter amplifier's output impedance, along with the transmission line impedance

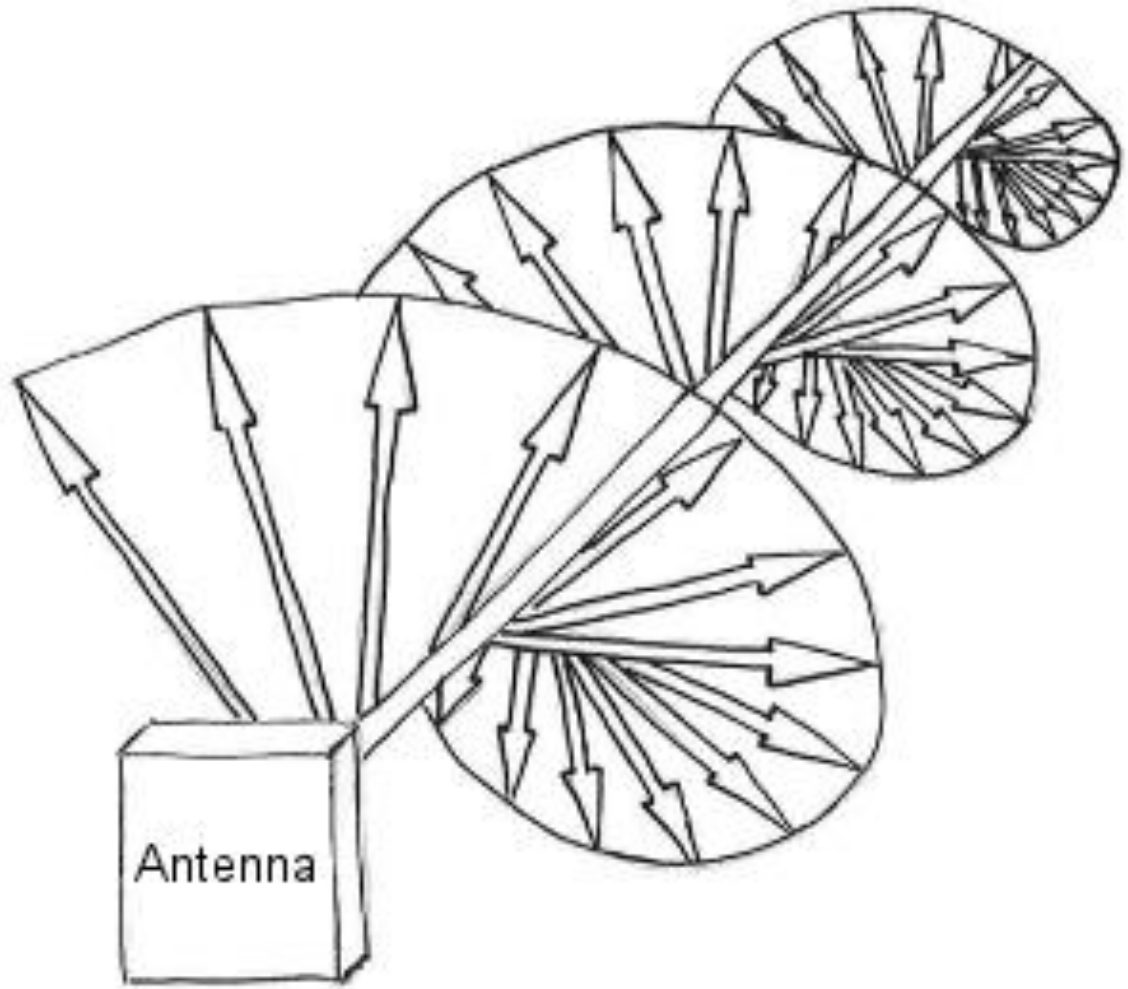
Classification of Antennas : Aperture

- In radio communications, antenna aperture is a measure of how effective an antenna is at receiving the power of the signal; the larger the aperture the more power it can collect from a given signal
- Larger aperture antennas are needed for very weak signals, such as celestial radio emissions or for UHF/SHF/EHF applications such as long distance wifi or mobile transmissions and satellite tv transmissions
- Smaller aperture antennas are used when signals are not too weak to be received; mostly wire antennas

Classification of Antennas : Polarization

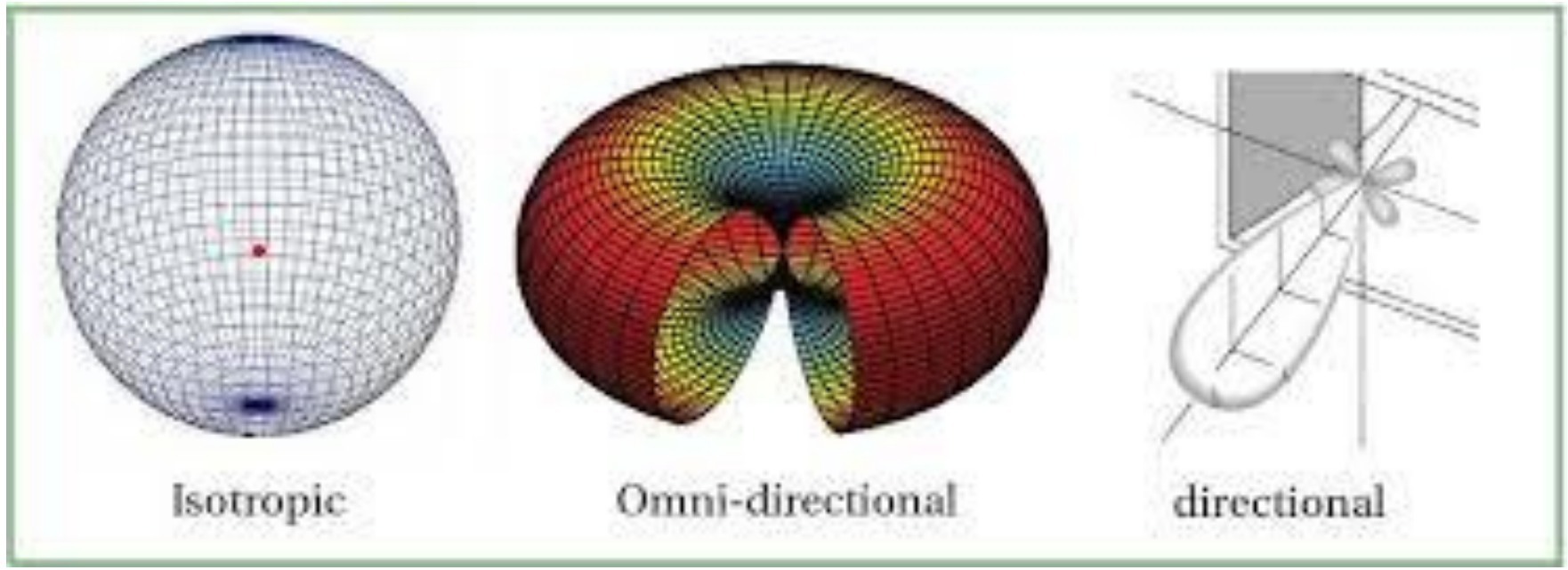
- Polarization indicates the orientation of the Electric field of an EM wave with respect to the earth
- In a vertically polarized antenna, the Electric field is vertical with respect to the earth; in Horizontally polarized antenna, it is horizontal – Linear Polarized – ex: AM mast transmitter –V.P , HF wire antennas – H.P
- There are also circularly polarized antennas , in which the Electric field rotates perpendicular to the direction in which the wave travels; rotation could be clockwise or anticlockwise – Circularly polarized – ex: Satellite antennas , GPS antennas


vertical polarization
direction of propagation
electric field
antenna
horizontal polarization
direction of propagation
antenna


Antenna

Classification of Antennas : Radiation pattern

- Radiation is the term used to represent the emission or reception of wave front at the antenna, specifying its strength; In any illustration, the sketch drawn to represent the radiation of an antenna is its radiation pattern - One can simply understand the function and directivity of an antenna by having a look at its radiation pattern
- The radiation pattern of an antenna, determines the reach and range of a signal
- Based on the radiation pattern antennas can be classified as isotropic, omni directional, directional, etc.


Isotropic
Omni-directional
directional

Types of antennas : Omni directional

- Omni directional antennas can send and receive radio signals in all directions, parallel to the horizon
- They provide a wide reach as they can pick up and send out signals on all directions
- They can be disadvantageous if signals from only one direction is required; for example, satellite TV signals must be picked up from the sky, using an omnidirectional antenna it would be difficult to catch the weak signal from the satellite, and we use a directional dish antenna

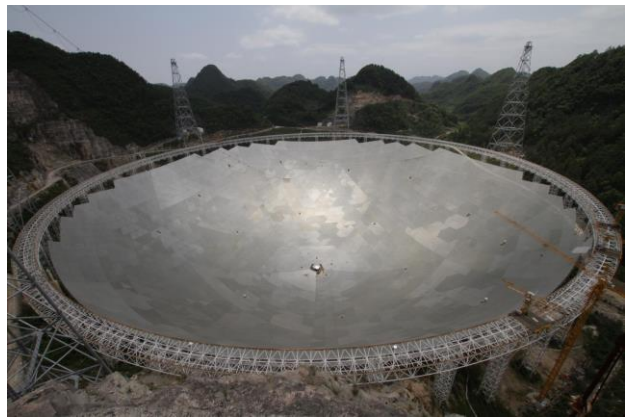

FM/AM RADIO RECEIVER
FM
AM
INDIN
BC-R22


BAOFENG


MOTOROLA

Types of antennas : Directional

- Directional antennas can send and receive radio signals in only a particular direction
- They are best used in situations where signals need to be sent or picked up from only one direction
- Using a directional antenna, it is possible to work longer distances compared to an omni directional antenna, as the radio waves are much more focused; however, this can prove to be a disadvantage if the signal source is in the opposite direction as the antenna tends to “ignore” signals from the other direction

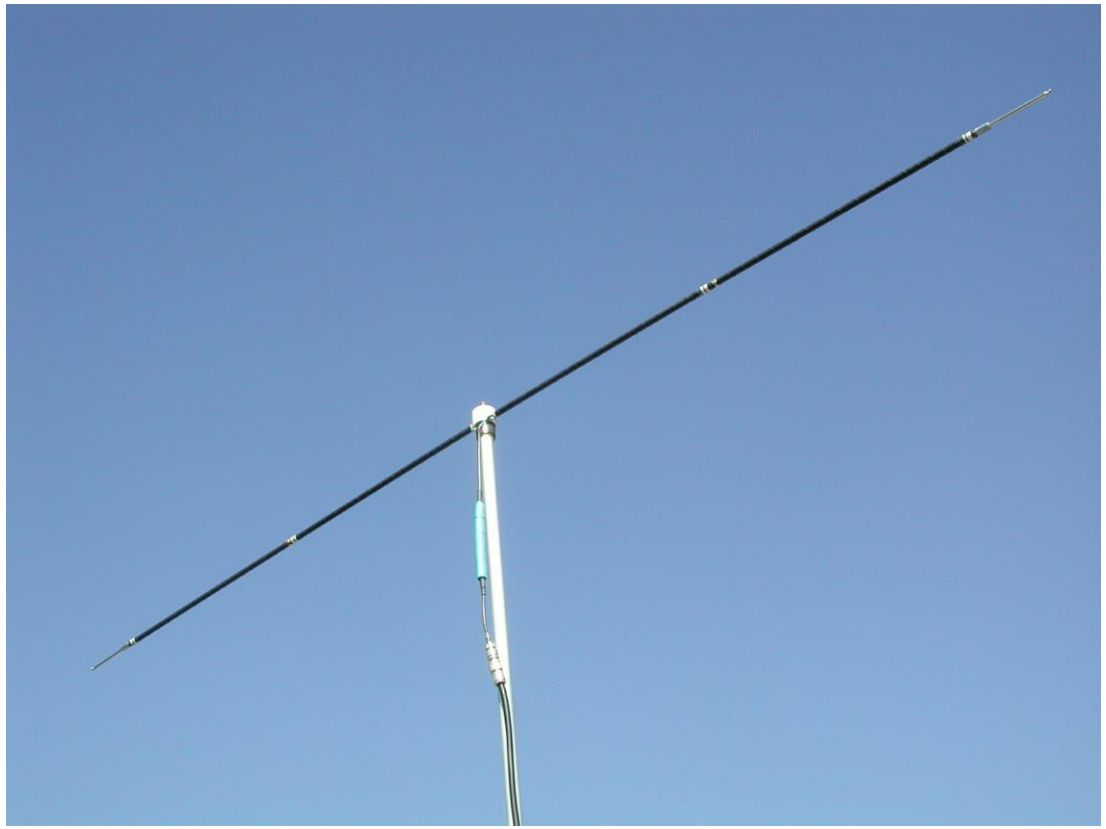


Basic antennas : The isotropic radiator

- This is a purely theoretical antenna that radiates equally in all directions ; unlike an omni, this will radiate perpendicular to the horizon!
- Although this theoretical model cannot be physically built, it is useful to compare this perfect antenna with antennas that are practical to build
- An antenna's gain is measured with reference to an isotropic radiator; it is given in dBi (Decibels with respect to an isotropic radiator)

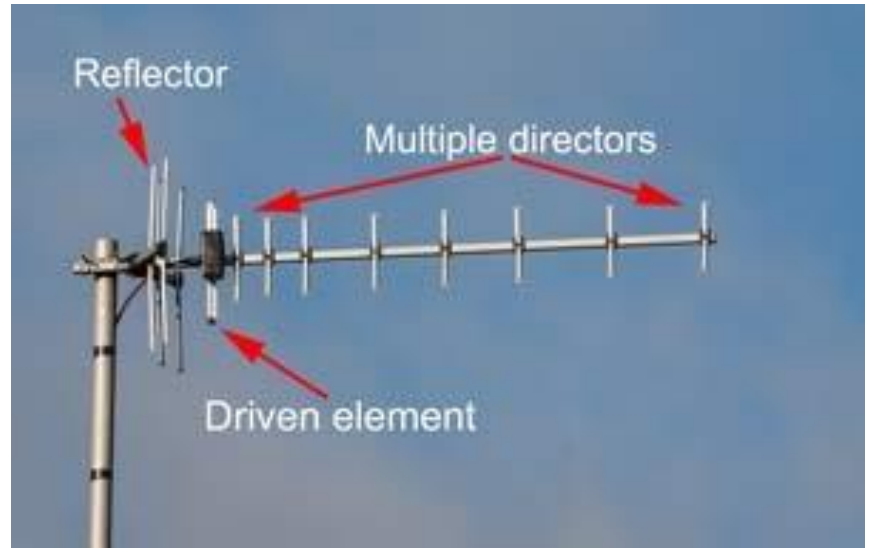
Basic antennas : Dipole

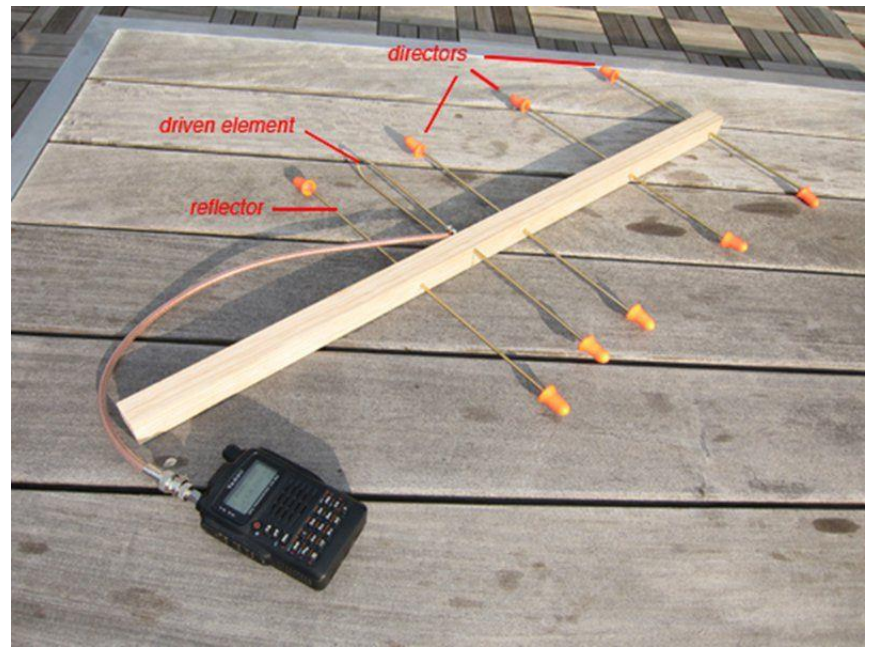
- The dipole is probably the easiest antenna to build; It consists of two wires, running in the opposite directions, connected to a radio
- The dipole is an omnidirectional antenna, but it has a sharp “nulls” – blind spots – in the direction of its axis
- There are many slight variations of the dipole – folded dipole, inverted V dipole, inverted L dipole, etc



Basic antennas : Yagi-Uda

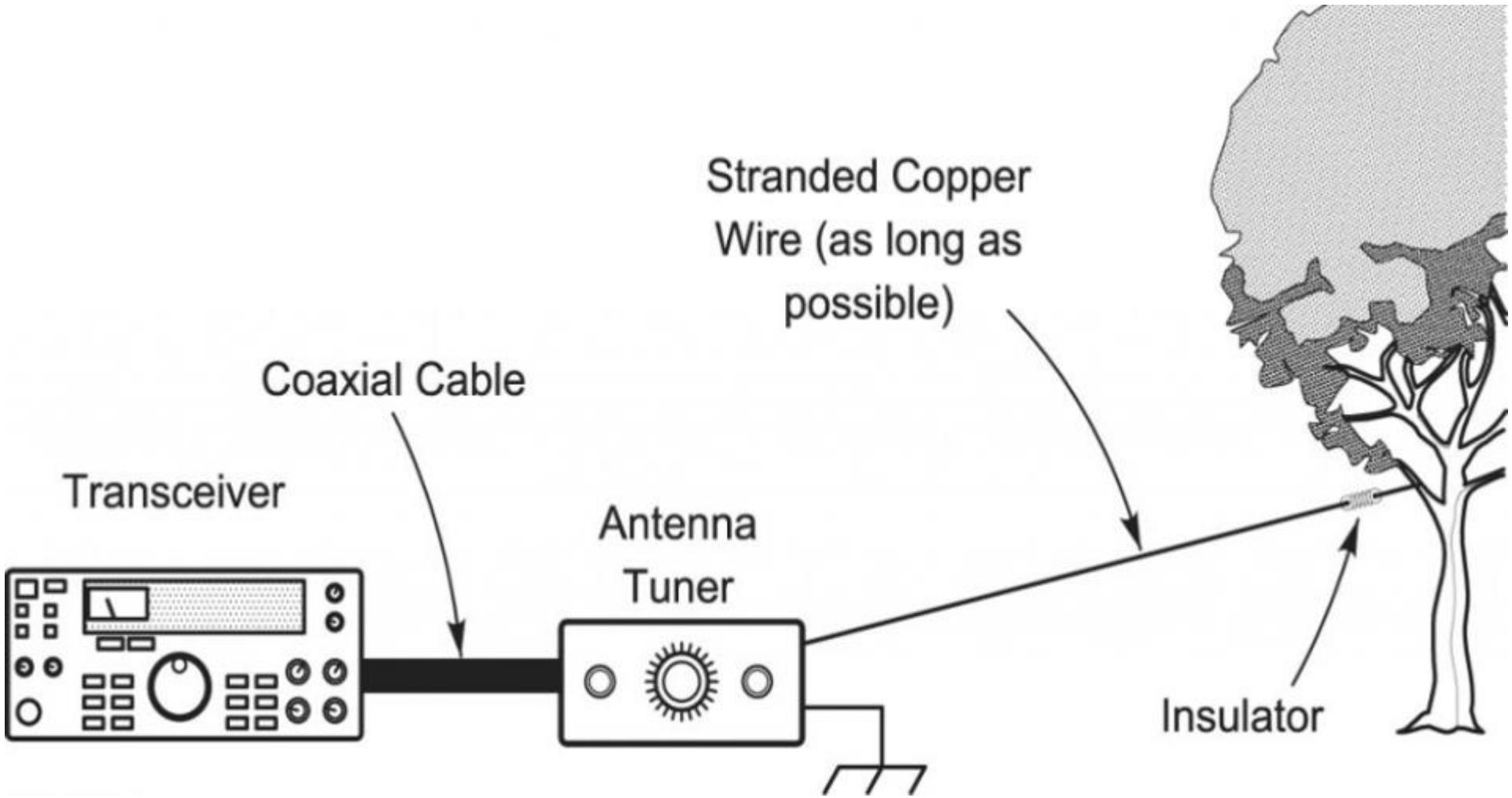
- The Yagi-Uda antenna is a directional variation of the dipole antenna design, was invented in 1926 by two Japanses professors, Hidetsugu Yagi and Shintaro Uda
- Even though Yagi played a small part, it is after him that we refer to this design as the Yagi
- The Yagi design consists of a single dipole, which is connected to the radio, which is surrounded by “parasitic” elements are not connected to the radio electrically
- These parasitic elements can either reflect or direct the radio signals to and from a particular point, based on their placement from the dipole, which is known as the “driven element”
- Parasitic elements placed opposite to the direction the signal is to be sent, are known as “reflectors” – they reflect the signal from the dipole in the opposite direction
- Parasitic elements placed in the direction of the signal are known as “directors” – they direct the signal from the dipole in a particular direction


Reflector
Multiple directors
Driven element


directors
driven element
reflector

Basic antennas : Random, Long wire

- As the name suggests, these are long, random length wire antennas with one end attached to the radio and the other end unattached to anything and tied up the highest point
- Random wire antennas are typically non resonant antennas, which need their impedances matched with the radio for any sort of signals to be sent or received; this is done using an impedance matching circuit known as the antenna tuner; the circuit tries to match the impedance of the random wire antenna by adding either inductance or capacitance to the antenna to raise or lower the impedance
- These antennas are only meant for use in emergencies and situations where resonant antennas such as dipoles cannot be installed, as these are not the most efficient antennas and performance can be unpredictable


Stranded Copper
Wire (as long as
possible)
Coaxial Cable
Transceiver
Antenna
Tuner
Insulator

Devices for RF measurement

A few devices that we use to do RF measurements :

- Frequency counter : a circuit that measures the frequency of a radio signal and displays it in Hertz
- Power meter : It is used to measure the output power of RF circuits and display it in Watts
- SWR bridge/meter : it is used to measure the “Standing Wave Ratio” which is the measure of impedance matching between a radio and the antenna; when SWR is 1:1 the impedance matching is ideal and maximum power flows from and to the antenna
- Frequency standard : it is used to generate a signal of a fixed, known frequency against which other frequencies can be measured

Thank you!

Question and doubts in the chat box!

https://tinyurl.com/ASOC01

For visual learning resources