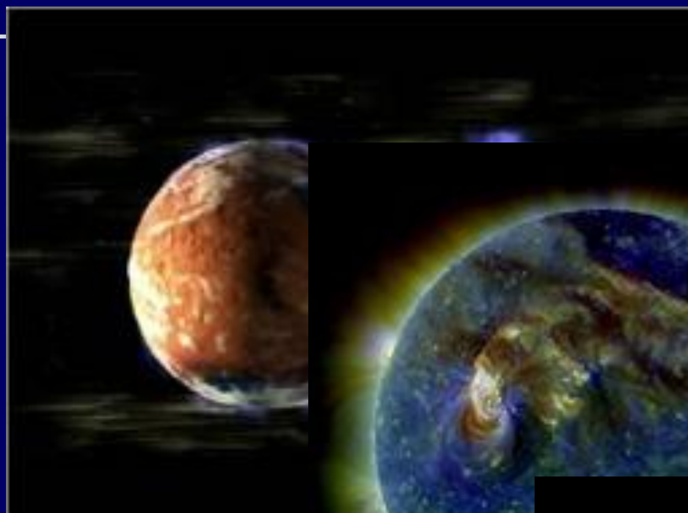
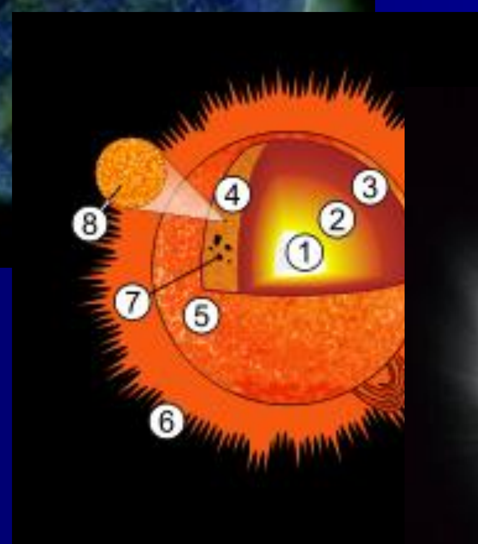
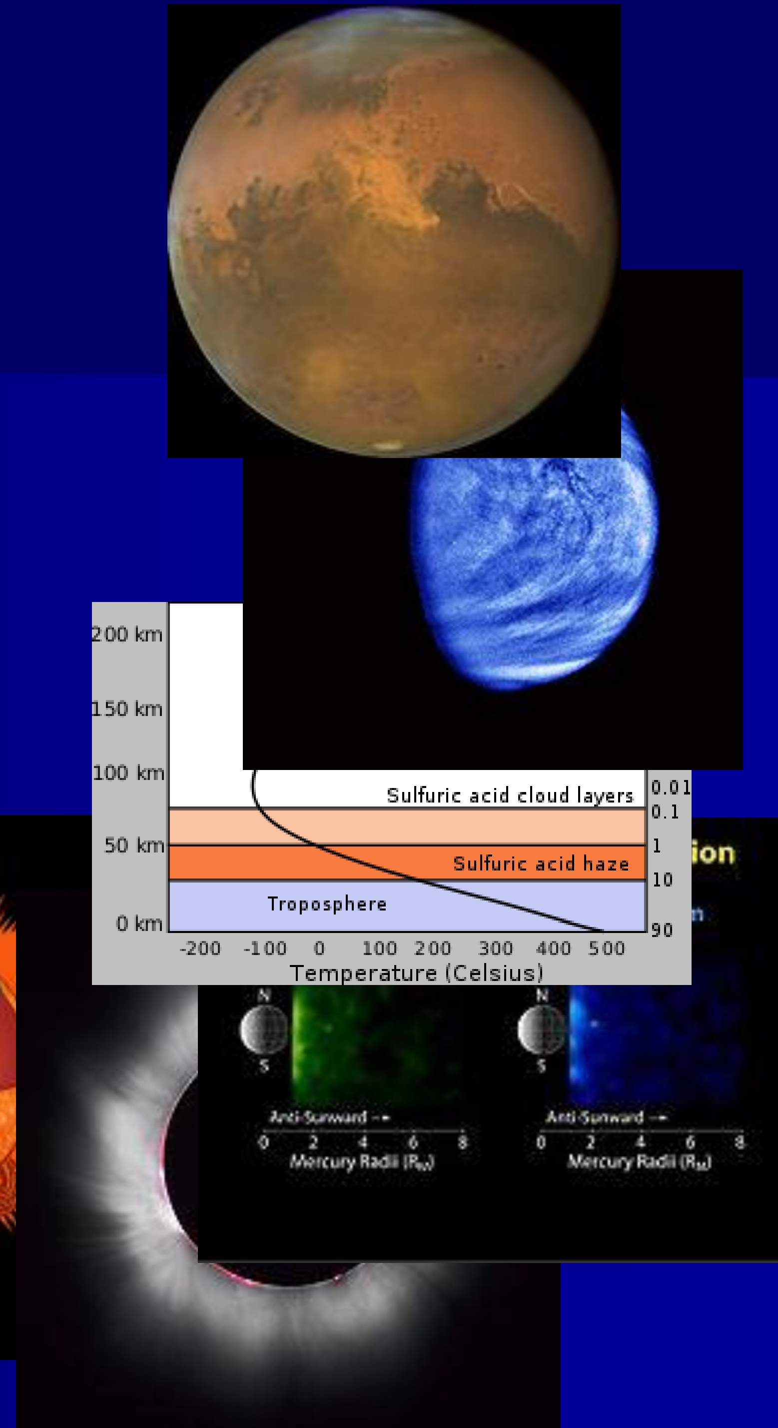
Space Physics

Space Physics

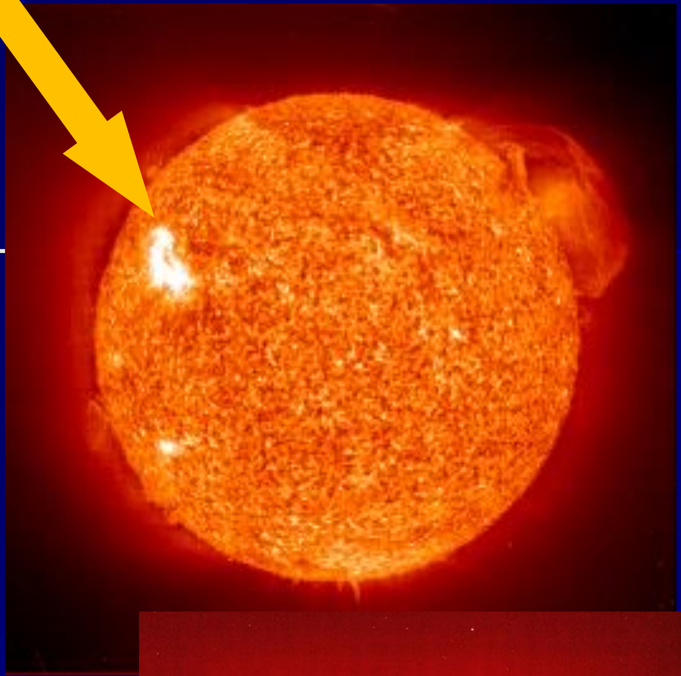




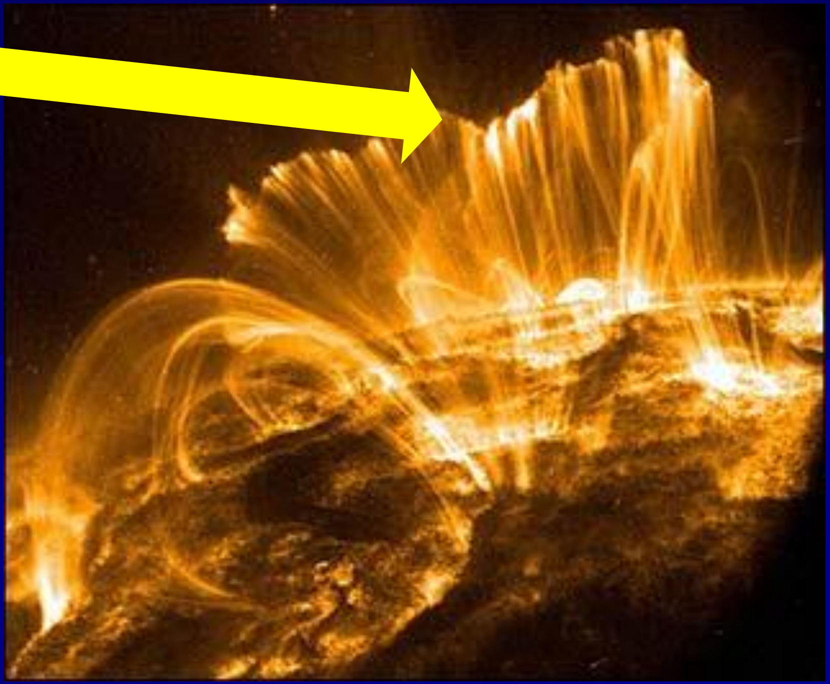


Lecture – 12

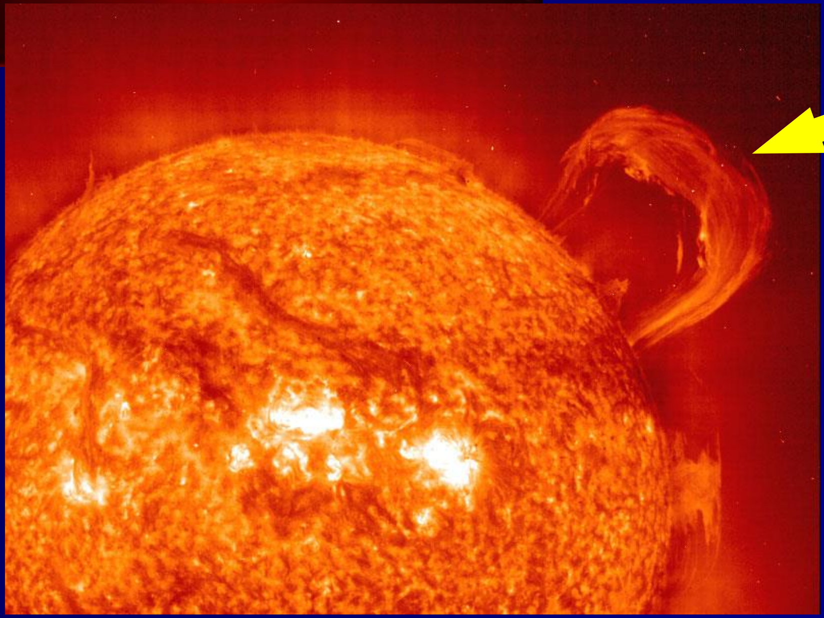
Faculae (දීදුල)



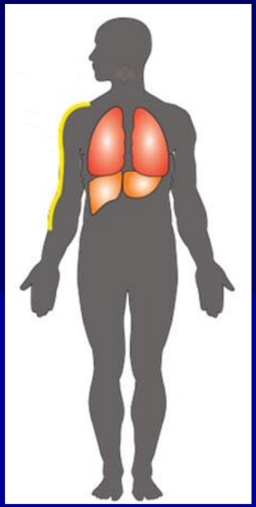
Flares



Prominences (නෙරුම)

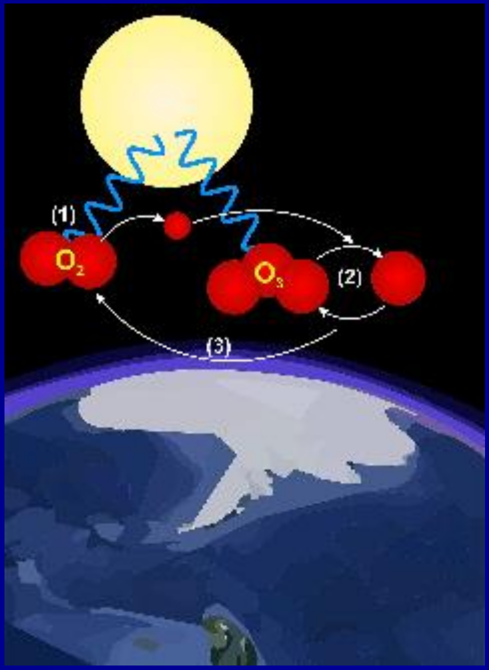


The Solar Cycle, Effects on Earth



- The impact of Solar cycle on living organisms has been investigated (see chronobiology). Some researchers claim to have found connections with human health.

- The amount of UV-B light at 300 nm reaching the Earth varies by as much as 400% over the solar cycle due to variations in the protective Ozone Layer. In the stratosphere, ozone is continuously regenerated by the splitting of O_2 molecules by ultraviolet light. During a solar minimum, the decrease in ultraviolet light received from the Sun leads to a decrease in the concentration of ozone, allowing increased UV-B to penetrate to the Earth's surface.

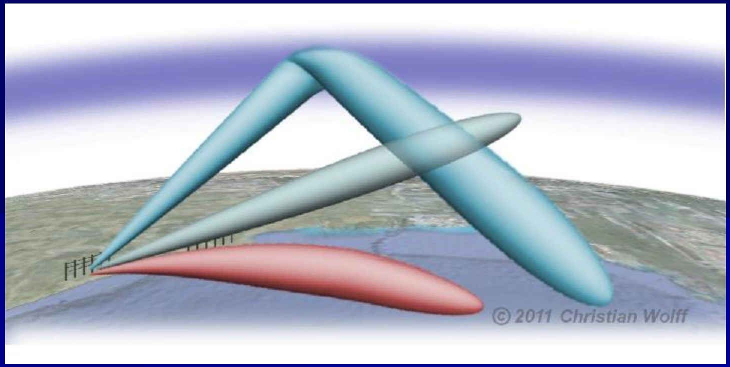


The Solar Cycle, Effects on Earth

- The sunspot cycle has been implicated in having effects on climate, and may play a part in determining global temperature.

The Solar Cycle, Effects on Earth

- Sky-wave modes of radio communication operate by bending (reflecting) radio waves (electro-magnetic radiation) off of the Ionosphere.



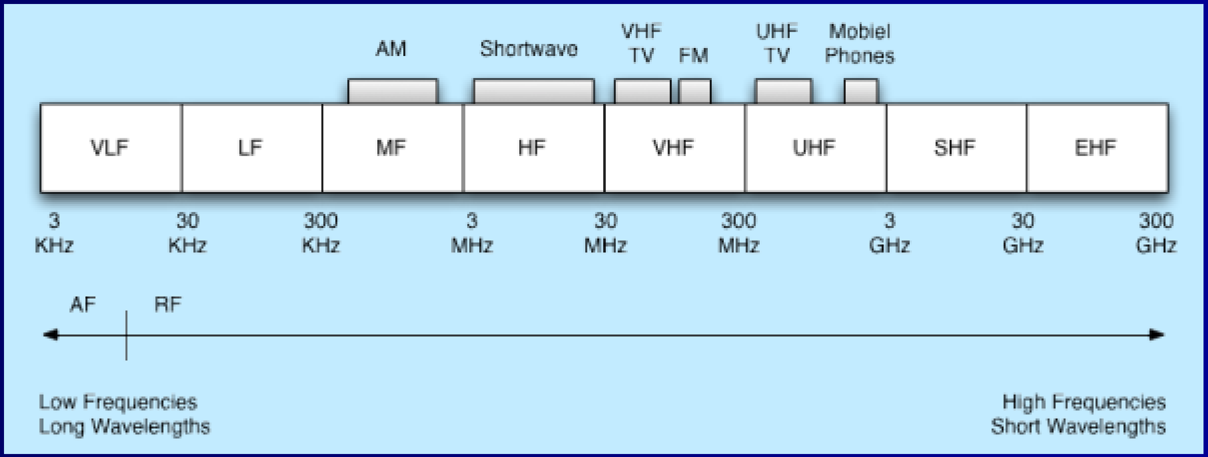
During the "peaks" of the solar cycle, the ionosphere becomes ionized by solar photons and cosmic rays.

This affects the path (propagation) of the radio wave in complex ways which can both facilitate (easy) or hinder (blocked) local and long distance communications.

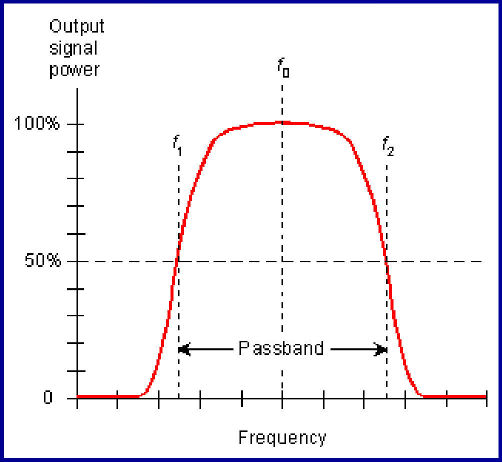
Forecasting of sky-wave modes is of considerable interest to commercial marine and aircraft communication, amateur radio operators, and short wave broad casters.

The Solar Cycle, Effects on Earth

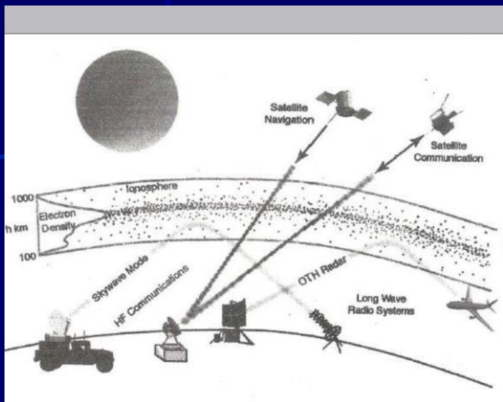
- These users utilize frequencies within the high-frequency or 'HF' radio spectrum which are most **affected by these solar and ionospheric variances**.



- Changes in solar output affect the maximum usable frequency, a limit on the highest frequency usable for communications.



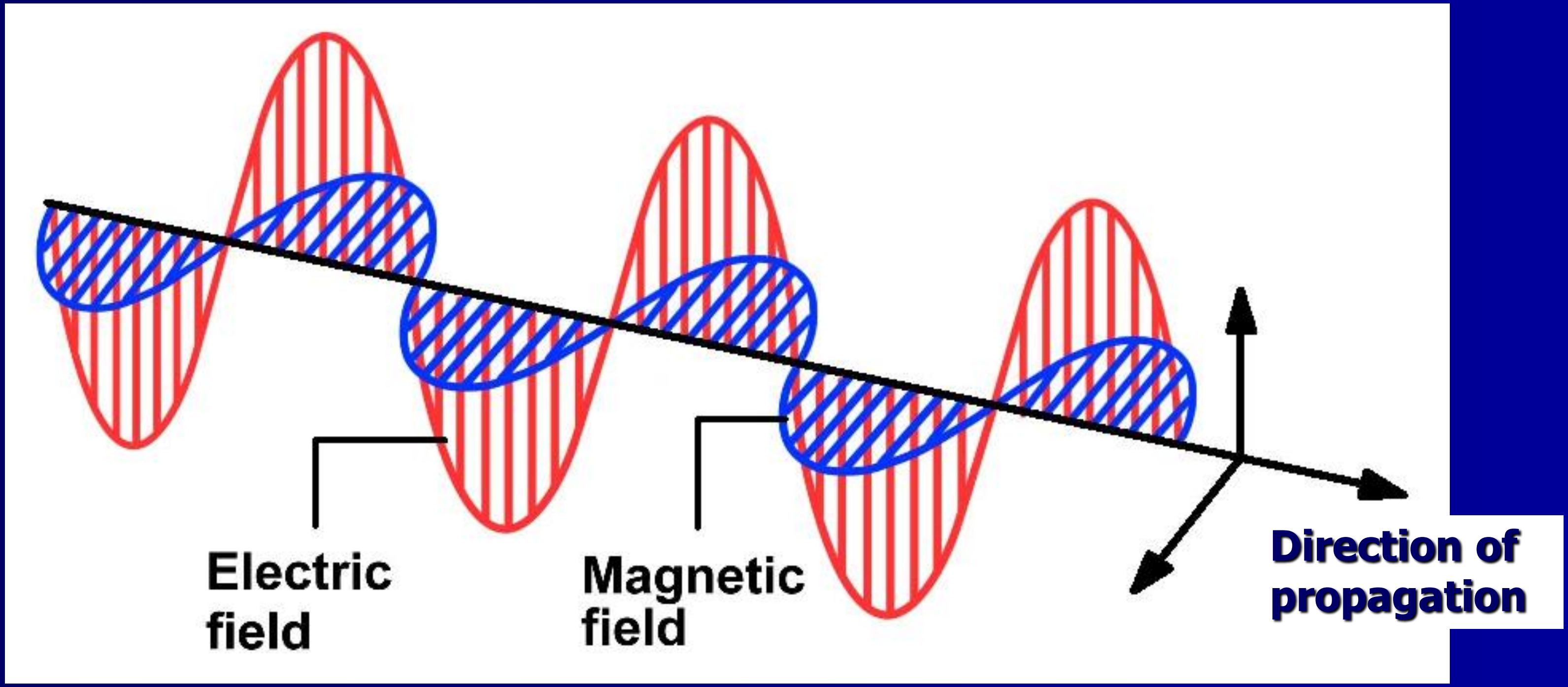
Radio Wave Communication



Reflection of Radio Waves
Absorption of Radio Waves
Complex Refractive Index
Reflection Heights
Deviating Region Absorption, Non- Deviating Region Absorption
Ionosphere – Sounding Techniques
Pulse Reflection Methods

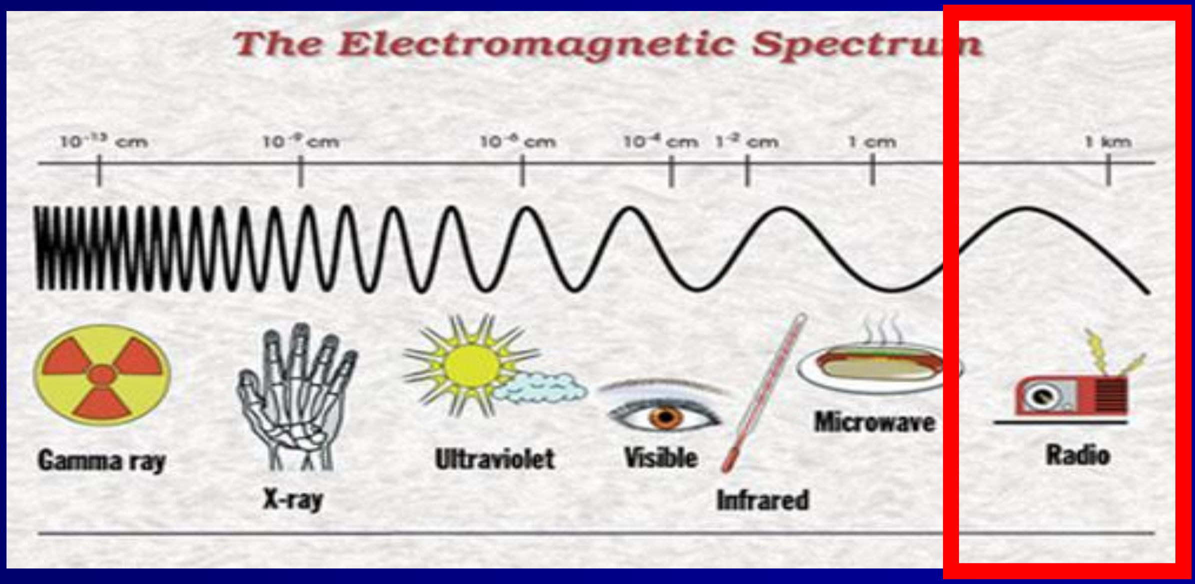
Radio waves

Radio waves are a type of **electromagnetic radiation** with wavelengths in the electromagnetic spectrum longer than infrared light. Like all other electromagnetic waves, they travel at the speed of light. Naturally-occurring radio waves are made by lightning, or by astronomical objects.

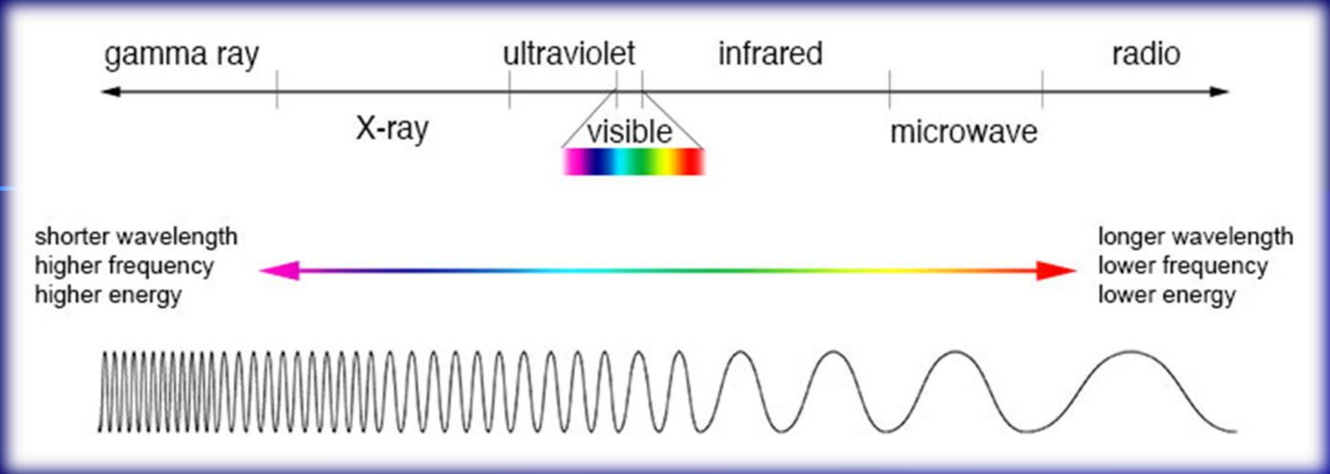


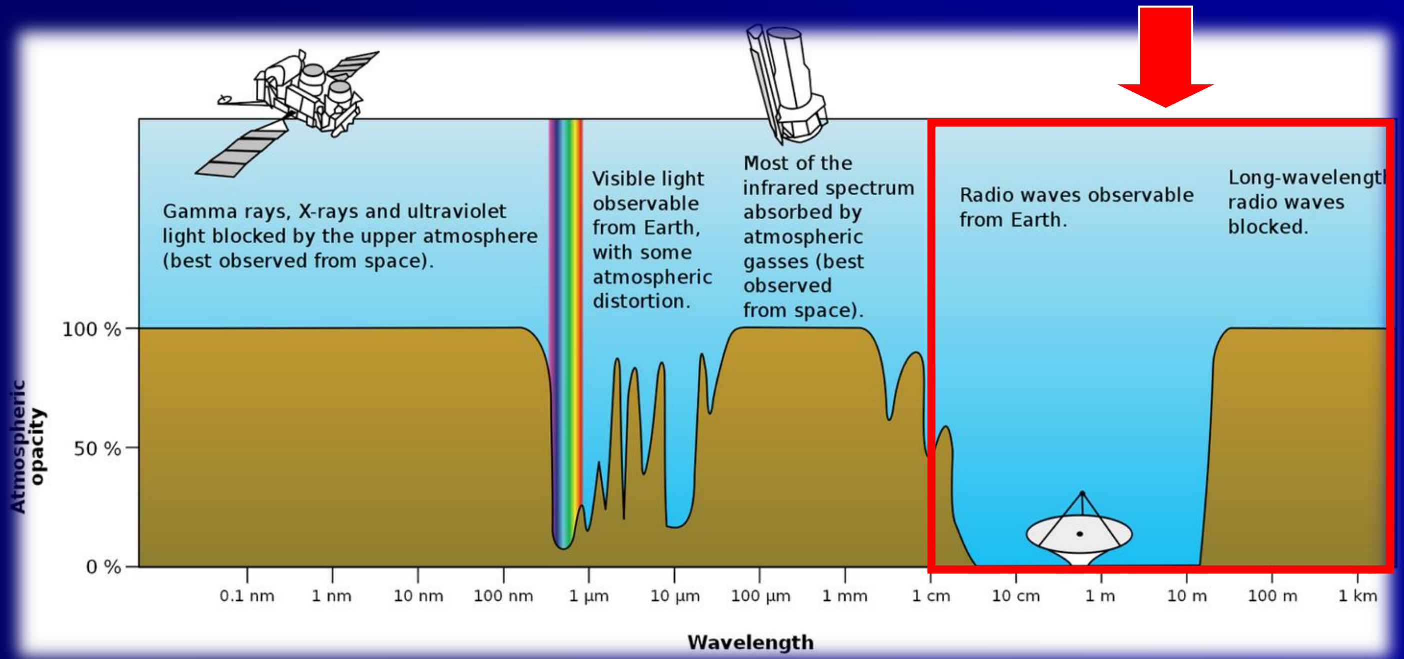
Radio waves

Artificially-generated radio waves are used for fixed and mobile radio communication, broadcasting, radar and other navigation systems, satellite communication, computer networks and innumerable other applications. Different frequencies of radio waves have different propagation characteristics in the Earth's atmosphere;
long waves may cover a part of the Earth very consistently,
shorter waves can reflect off the ionosphere and travel around the world, and
much shorter wavelengths bend or reflect very little and travel on a line of sight.



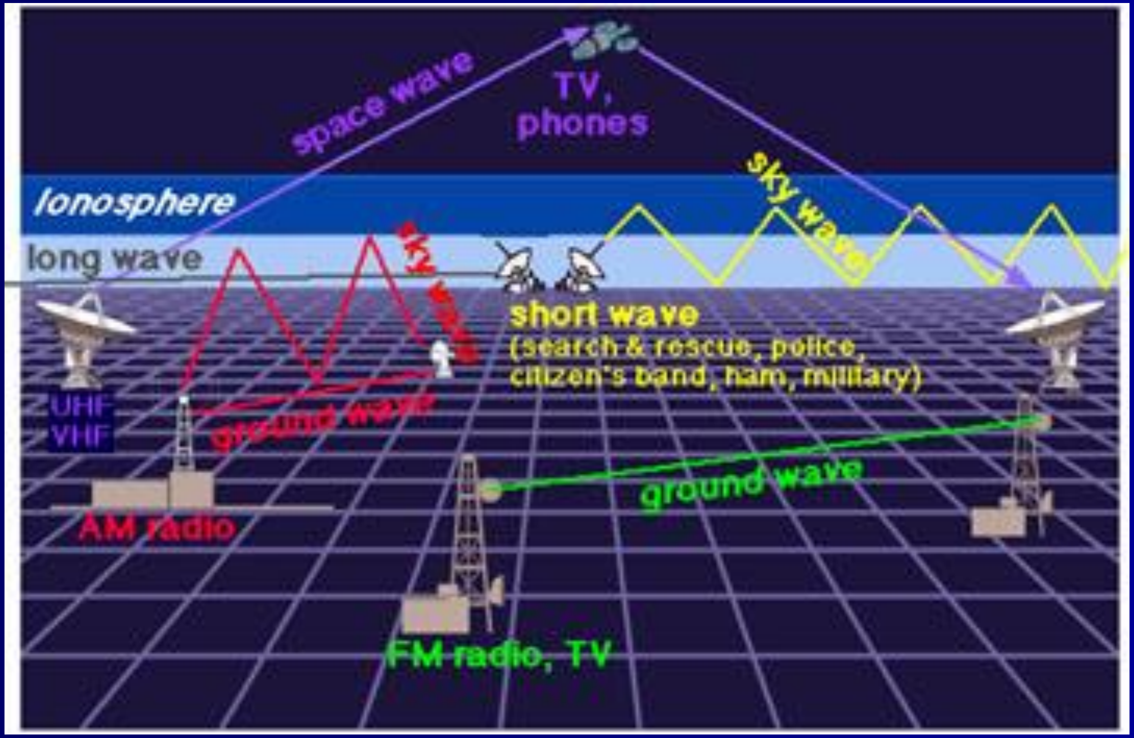
Radio waves


gamma ray
ultraviolet
infrared
radio
X-ray
visible
microwave
shorter wavelength
higher frequency
higher energy
longer wavelength
lower frequency
lower energy


Gamma rays, X-rays and ultraviolet light blocked by the upper atmosphere (best observed from space).
Visible light observable from Earth, with some atmospheric distortion.
Most of the infrared spectrum absorbed by atmospheric gasses (best observed from space).
Radio waves observable from Earth.
Long-wavelength radio waves blocked.
100 %
50 %
0 %
Atmospheric opacity
0.1 nm
1 nm
10 nm
100 nm
1 µm
10 µm
100 µm
1 mm
1 cm
10 cm
1 m
10 m
100 m
1 km
Wavelength

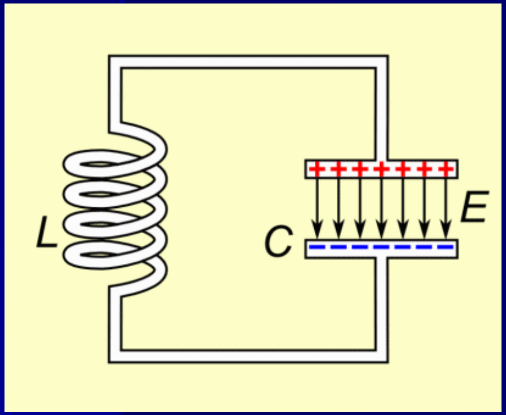
Propagation…

The study of electro magnetic phenomena such as reflection, refraction, polarization, diffraction and absorption is of critical importance in the study of how radio waves move in free space and over the surface of the Earth. Different frequencies experience different combination of these phenomena in the Earth's atmosphere, making certain radio bands more useful for specific purpose than others.



Radio Communication

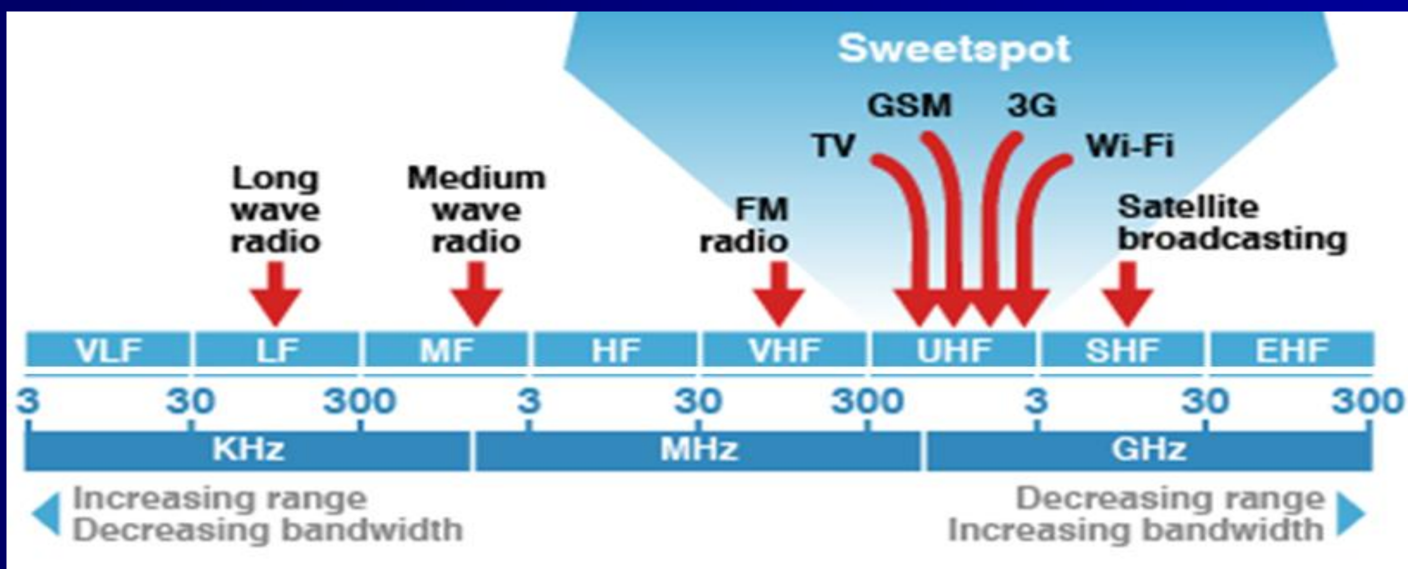
In order to receive radio signals, for instance from AM / FM radio stations, a radio antenna must be used. However, since the antenna will pickup thousands of radio signals at a time, a **radio tuner** is necessary to tune in to a particular frequency (or frequency range).

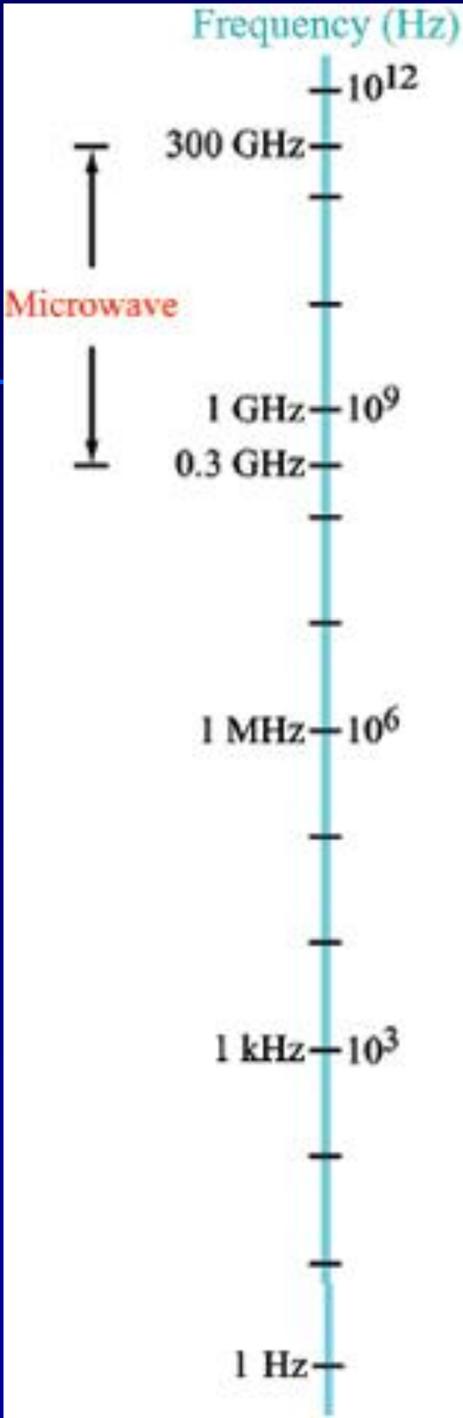


This is typically done via a **resonator** (in **the simplest form, a circuit with a capacitor and an inductor**). The resonator is configured to resonate at a particular frequency (or frequency band), thus amplifying since waves at that radio frequency, while ignoring other **sine waves**. Usually, either the inductor or the capacitor of the resonator is adjustable, allowing the user to change the frequency at which it resonates.

Radio Spectrum

Band	Frequency range	Wavelength range
Extremely low frequency (ELF)	< 3 kHz	>100 km
Very low frequency (VLF)	3 - 30 Hz	10 - 100 krn
Low frequency(LF)	30 - 300 kHz	1 - 10 km
Medium frequency (MF)	300 kHz - 3 MHz	100m - 1km
High frequency (HF)	3 - 30 MHz	10 - 100m
Very high frequency (VHF)	30 - 300 MHz	1 - 10m
Ultra high frequency (UHF)	300 MHz - 3 GHz	10cm - 1m
Super high frequency (SHF)	3 - 30 GHz	1 - 10cm
Extremely high frequency (EHF)	30 - 300 GHz	1mm - 1cm





Band	Applications
Extremely High Frequency (30–300 GHz)	Radar, advanced communication systems, remote sensing, radio astronomy
Super High Frequency (3–30 GHz)	Radar, satellite communication systems, aircraft navigation, radio astronomy, remote sensing
Ultra High Frequency (300 MHz – 3 GHz)	TV broadcasting, radar, radio astronomy, microwave ovens, cellular telephone
Very High Frequency (30–300 MHz)	TV and FM broadcasting, mobile radio communication, air traffic control
High Frequency (3–30 MHz)	Shortwave broadcasting
Medium Frequency (300 kHz – 3 MHz)	AM broadcasting
Low Frequency (30–300 kHz)	Radio beacons, weather broadcast stations for air navigation
Very Low Frequency (3–30 kHz)	Navigation and position location
Ultra Low Frequency (300 Hz – 3 kHz)	Audio signals on telephone
Super Low Frequency (30–300 Hz)	Ionospheric sensing, electric power distribution, submarine communication
Extremely Low Frequency (3–30 Hz)	Detection of buried metal objects
	Magnetotelluric sensing of the Earth's structure

How Radio Communication Works ?

Sound and **Radio Waves** are different phenomena.

Sound consists of pressure variations in matter, such as air or water. Sound will not through a vacuum.

Radio Waves, like infrared, ultra-violet, visible light, X-rays and Gamma rays are **electro-magnetic waves** that do travel through a vacuum. When you turn-on a radio you have sounds because the transmitter at the radio station has converted the sound waves in to electro-magnetic waves, which are then encoded into an electro-magnetic wave in the radio frequency range
(generally in the range of

500 kHz - 1600 kHz for AM stations

or

86 MHz - 108 MHz for FM stations

).

How Radio Communication Works ?

Radio **FM waves** are used because they can travel **very large distance** through the atmosphere **without** greatly **attenuated** due to scattering or **absorption**.

Your Radio Receives the radio waves decodes this information , and uses a speaker to change it back into a sound wave. An picture illustration of this process is given below.

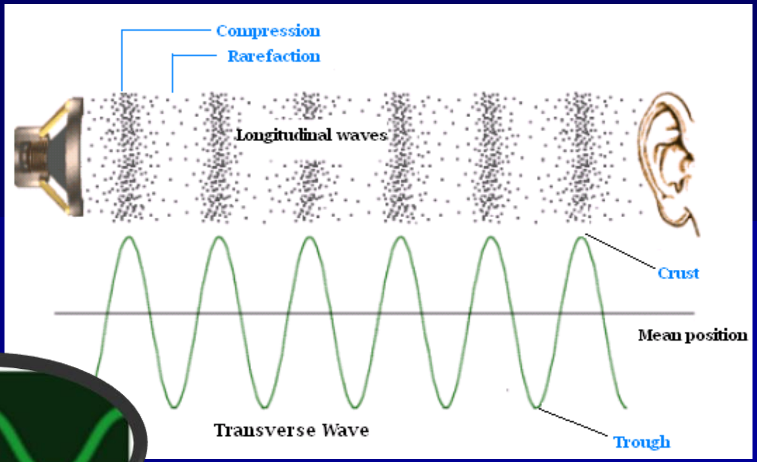
Step – 01

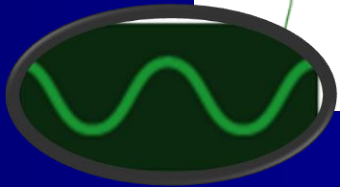
A sound wave produced with a frequency of 5 Hz – ~20 kHz

How Radio Communication Works ?

Step – 02

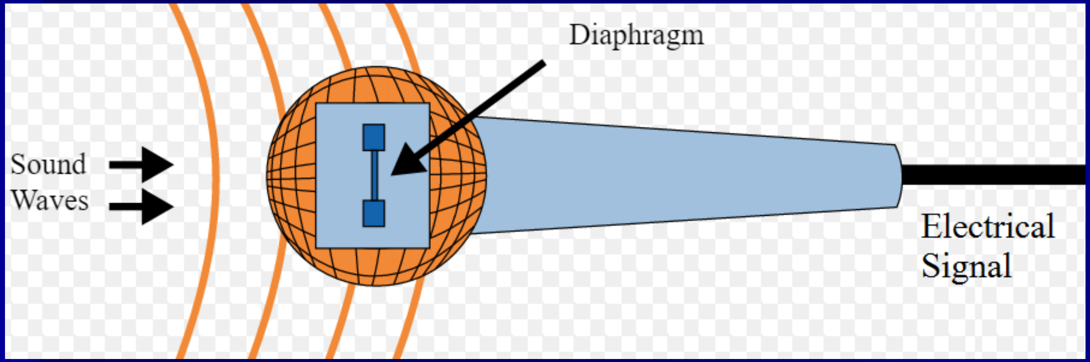
The sound wave is equivalent to pressure wave travelling through the air.

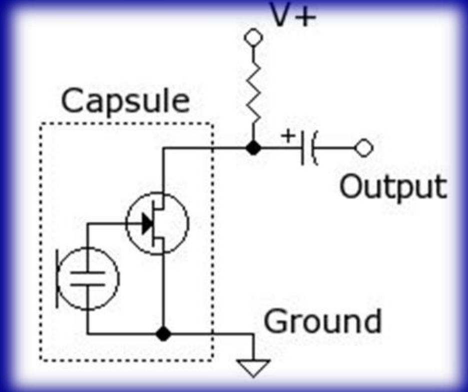




Step – 03

A microphone converts the sound wave into an electrical signal

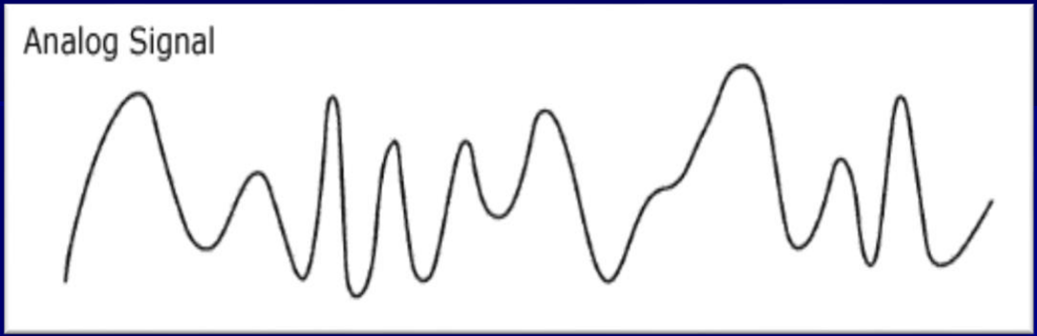




How Radio Communication Works ?

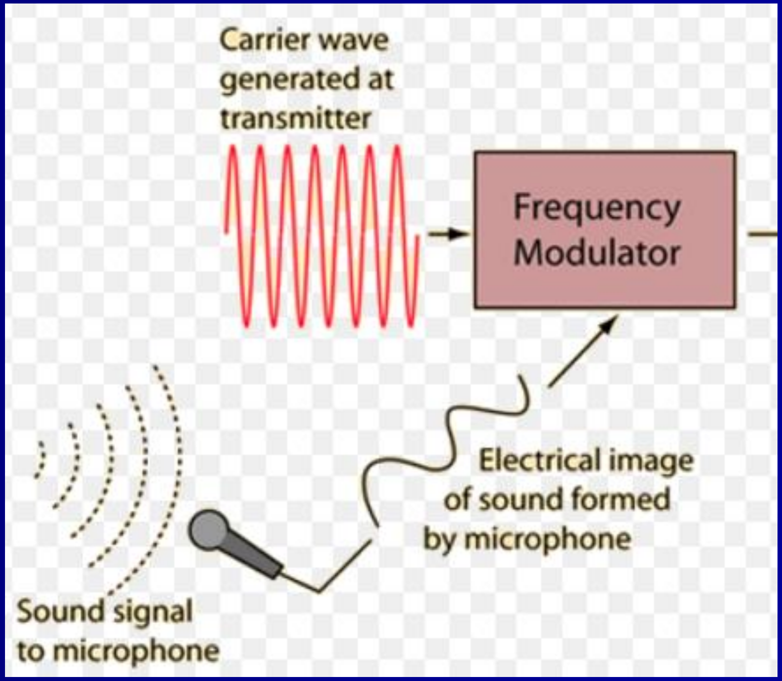
Step – 04

The electrical wave travelling through the microphone wire is analogous to the original sound wave.



Step – 05

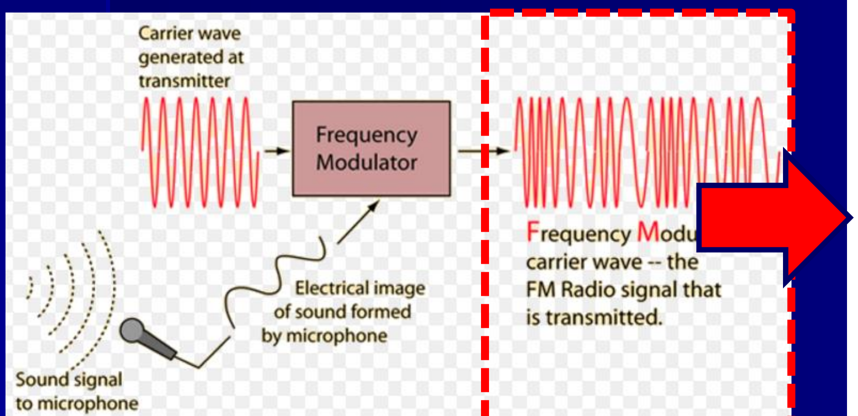
The electrical wave is used to encode or modulate a high-frequency “carrier” radio wave. The carrier wave itself does not include any of the sound information until it has been modulated.

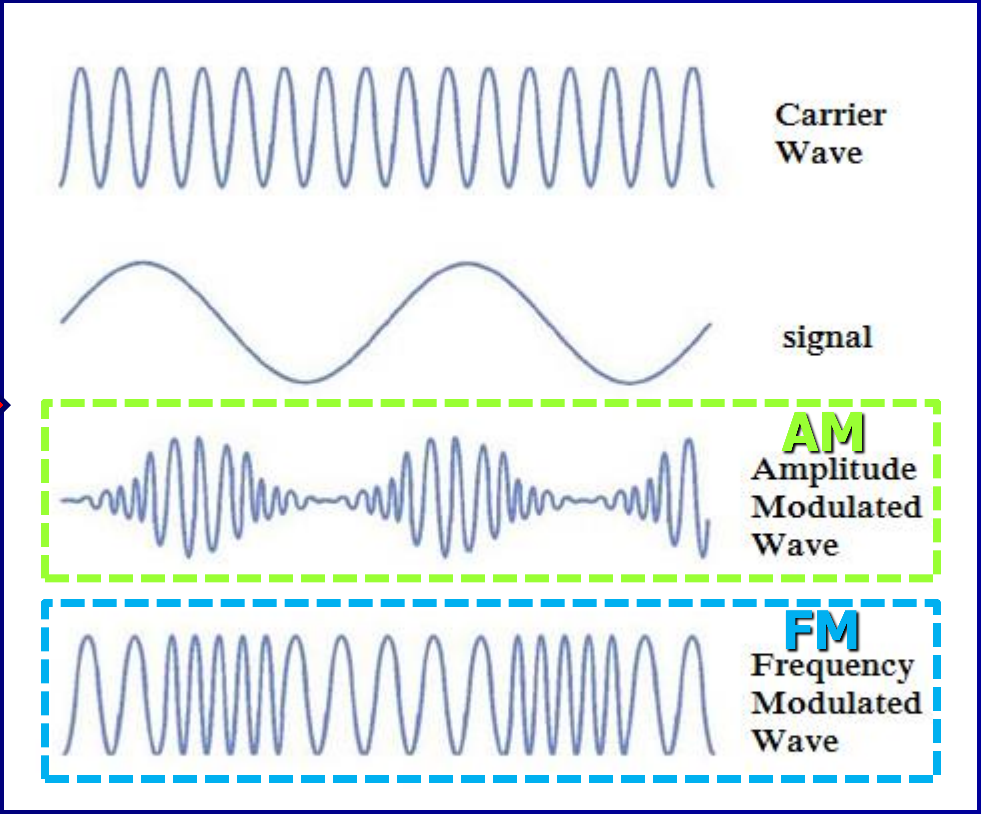


How Radio Communication Works ?

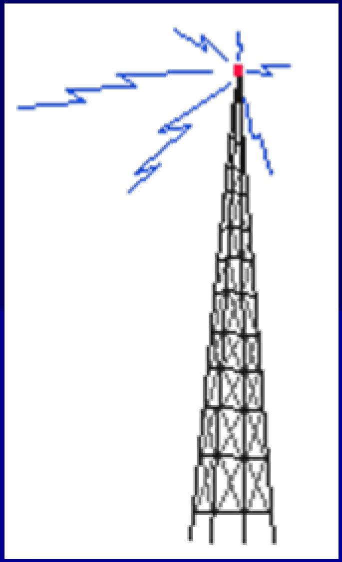
Step – 06

The carrier wave can either be amplitude modulated (AM, top) by the electrical signal, or frequency modulated (FM, bottom).





How Radio Communication Works ?



Step – 07

The signal is transmitted by a radio broadcast tower.

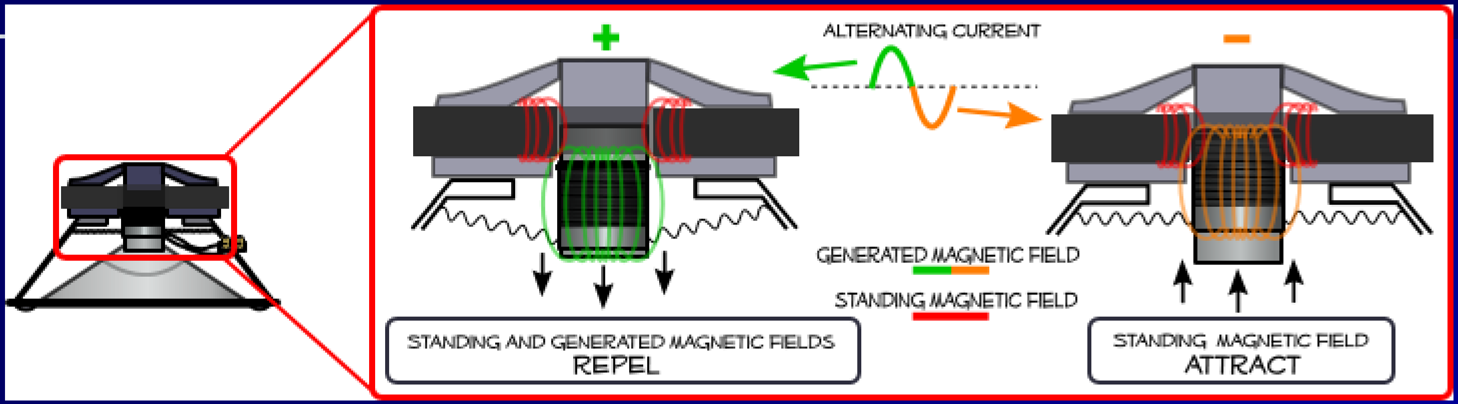
Step – 08

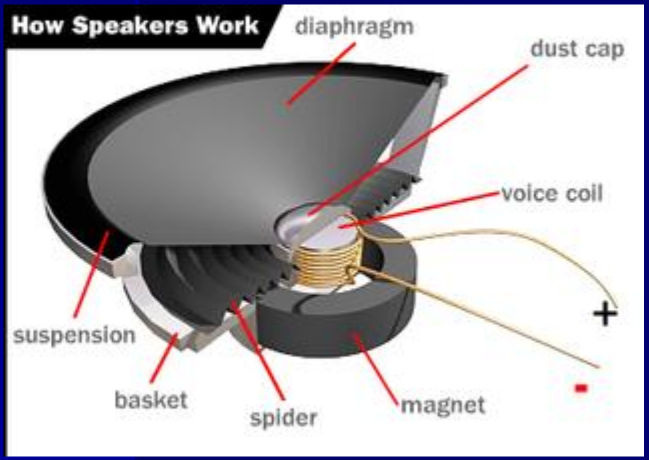
Your radio contains an antenna to detect the transmitted signal,
a tuner to pick out the desired frequency,
a demodulator to extract the original sound wave from the transmitted signal, and
an amplifier which sends the signal to the speakers.

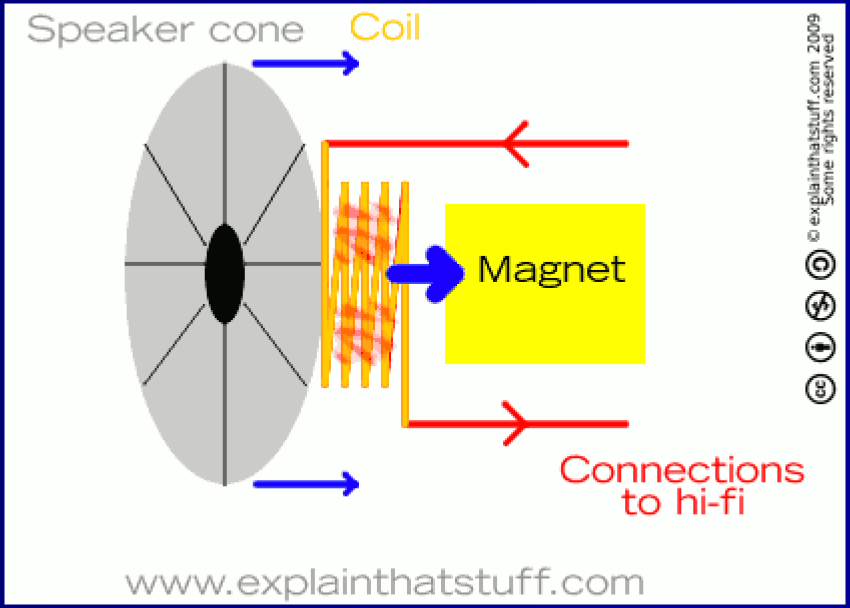
The speakers convert the electrical signal into physical vibrations (sound).

How Radio Communication Works ?

Step – 08 : How to a speaker works ?

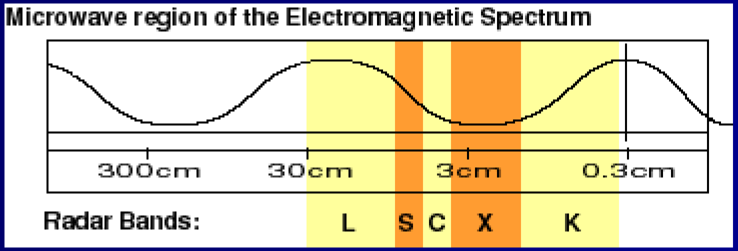






Microwave Transmission

Microwave Transmission refers to the technology of transmitting information by the use of the **radio waves** whose wavelengths are conveniently measured in small numbers of centimeters, by using various electronic technologies. These are called **microwaves**.



This part of the radio spectrum ranges across frequencies of roughly **1 GHz – 30 GHz**. Also by using the formula $c = f\lambda$, these correspond to wavelengths from **30 cm** down to **1 cm**.

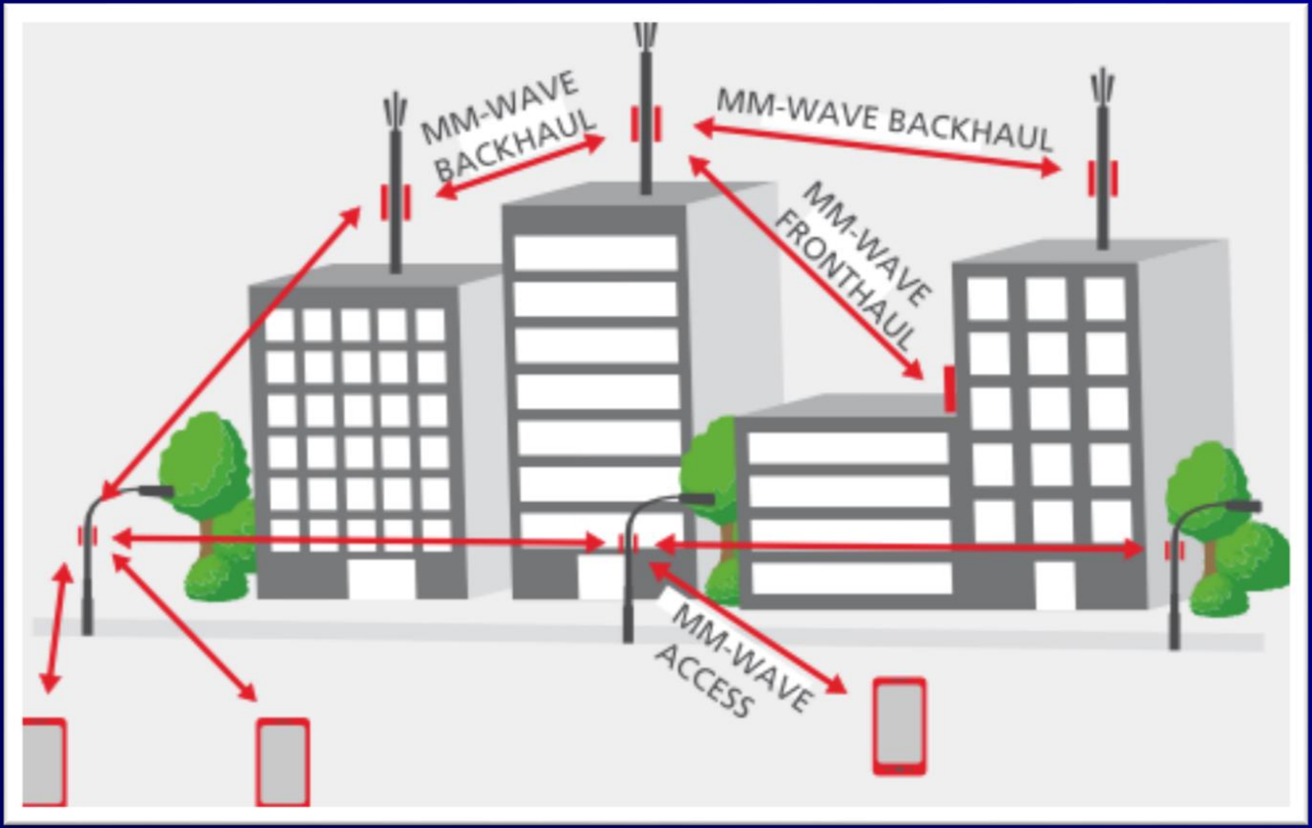
In the microwave frequency band, **antennas** are usually of convenient sizes and shapes and also the use of **metal waveguides** for carrying the radio power works well.

Microwave Transmission

Microwave radio transmission is commonly used by communication systems on the surface of the Earth, in satellite communications, and in deep space radio communication. Other parts of the microwave radio band are used for **radars**, **radio navigation systems**, **sensor systems** and **radio astronomy**.

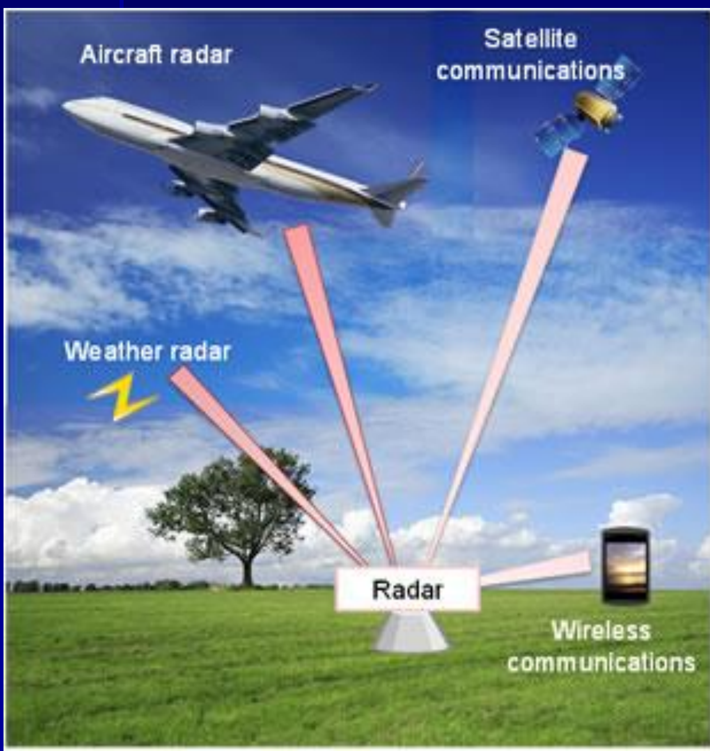
Radio Transmission – (MM Waves)

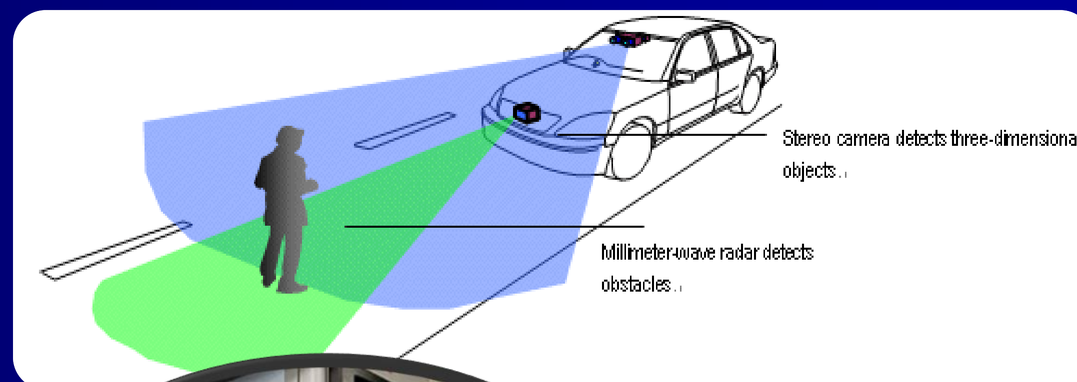
The next higher part of the radio electro magnetic spectrum, where the frequencies are **above 30 GHz** and **below 100 GHz** are called "**Milimeter Waves**" because their wavelengths are conveniently measured in milimeters, and their wavelengths range from **10 mm** down to **3 mm**.

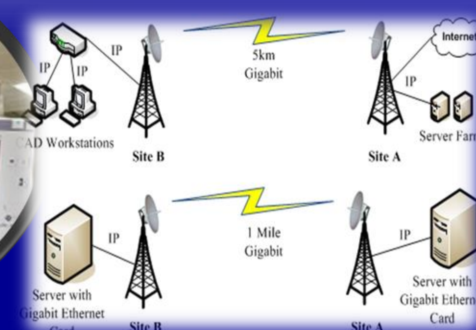


Radio Transmission – (MM Waves)

Radio waves in this band are usually strongly attenuated by the Earth atmosphere and particles contained in it, especially during wet weather. Also in wide band of frequencies around **60 GHz**, the radio wave are strongly attenuated by molecular oxygen in the atmosphere. The electronic technologies needed in the millimeter wave band are also much more difficult to utilize than those of the microwave band.







Thank You !