

Microwaves are the electromagnetic or radio waves having higher frequencies of order GHz. Microwaves Technology have many Applications in our daily life. Microwaves have many advantages over general radio waves. General Radio waves have low frequencies while Microwaves are Waves having frequencies laying in SHF i.e. Super High Frequency Band. Due to higher frequencies, Microwaves have advantages like larger bandwidth and higher data rates

Electro Magnetic Spectrum

CLASS	FREQUENCY	WAVELENGTH	ENERGY
Y	300 EHz	1 pm	1.24 MeV
HX	30 EHz	10 pm	124 keV
SX	3 EHz	100 pm	12.4 keV
SX	300 PHz	1 nm	1.24 keV
EUV	30 PHz	10 nm	124 eV
NUV	3 PHz	100 nm	12.4 eV
NIR	300 THz	1 μm	1.24 eV
MIR	30 THz	10 μm	124 meV
FIR	3 THz	100 μm	12.4 meV
EHF	300 GHz	1 mm	1.24 meV
SHF	30 GHz	1 cm	124 μeV
UHF	3 GHz	1 dm	12.4 μeV
VHF	300 MHz	1 m	1.24 μeV
HF	30 MHz	10 dam	124 neV
MF	3 MHz	100 hm	12.4 neV
LF	300 kHz	1 km	1.24 neV
VLF	30 kHz	10 km	124 peV
VF/ULF	3 kHz	100 km	12.4 peV
SLF	300 Hz	1 km	1.24 peV
ELF	30 Hz	10 Mm	124 feV
ELF	3 Hz	100 Mm	12.4 feV

γ = Gamma rays

HX = Hard X-rays

SX = Soft X-Rays

EUV = Extreme ultraviolet

NUV = Near ultraviolet

Visible light

NIR = Near infrared

MIR = Mid infrared

FIR = Far infrared

EHF = Extremely high frequency
(Microwaves)

SHF = Super high frequency (Microwaves)

UHF = Ultra high frequency

VHF = Very high frequency

HF = High frequency

MF = Medium frequency

LF = Low frequency

VLF = Very low frequency

VF/ULF = Voice frequency

SLF = Super low frequency

ELF = Extremely low frequency

Microwave spectrum given by IEEE Standard

Frequency range	Wavelength	IEEE band
300KHz-3 MHz	1 km to 100 meters	MF
3-30 MHz	100 meters to 10 meters	HF
30-300 MHz	10 meters to 1 meter	VHF
300 MHz -3 GHz*	1 meter to 10 cm	UHF
1-2 GHz	30 cm to 15 cm	L band
2-4 GHz	15 cm to 5 cm	S band
4-8 GHz	5 cm to 3.75 cm	C band
8-12 GHz	3.75 cm to 2.5 cm	X band
12-18 GHz	2.5 cm to 1.6 cm	K _u band
18-26 GHz	1.6 cm to 1.2 cm	K band
26-40 GHz	1.6 cm to 750 mm	K _a band
40-75 GHz	750 mm to 40 mm	V band
75 to 111 GHz	40 mm to 28mm	W band
Above 111 GHz	"millimeter wave"	

Some of the Advantages of Microwaves are described below

Advantages of Microwaves

Large Bandwidth: The Bandwidth of Microwaves is larger than the common low frequency radio waves. Thus more information can be transmitted using Microwaves. It is very good advantage, because of this, Microwaves are used for Point to Point Communications

Better Directivity: At Microwave Frequencies, there are better directive properties. This is due to the relation that As Frequency Increases, Wavelength decreases and as Wavelength decreases Directivity Increases and Beam width decreases. So it is easier to design and fabricate high gain antenna in Microwaves.

Small Size Antenna: Microwaves allows to decrease the size of antenna. The antenna size can be smaller as the size of antenna is inversely proportional to the transmitted frequency. Thus in Microwaves, we have waves of much higher frequencies and hence the higher the frequency, the smaller the size of antenna.

Low Power Consumption: The power required to transmit a high frequency signal is lesser than the power required in transmission of low frequency signals. As Microwaves have high frequency thus requires very less power.

Effect Of Fading: The effect of fading is minimized by using Line Of Sight propagation technique at Microwave Frequencies. While at low frequency signals, the layers around the earth causes fading of the signal.

Applications of Microwaves

There are many Industrial, Scientific, Medical and Domestic Applications of Microwaves. The great example of Application of Microwaves is 'Microwave Oven' which we uses in our daily life. Following are the other main application areas of Microwaves:

Communication: Microwave is used in broadcasting and telecommunication transmissions. As described above, they have shorter wavelengths and allows to use smaller antennas. The cellular networks like GSM, also uses Microwave frequencies of range 1.8 to 1.9 GHz for communication. Microwaves are also used for transmitting and receiving a signal from earth to satellite and from satellite to earth. Military or Army also makes use of Microwaves in their communication system. They uses X or Ku band for their communication.

Remote Sensing: Most of you may be familiar with this Application. The most common application of Microwave is its use in RADAR and SONAR. RADAR is used to illuminate an object by using a transmitter and receiver to detect its position and velocity. Radiometry is also one of the Remote Sensing Applications.

Heating: You all are familiar with this application. We uses Microwave Oven to bake and cook food. It is very convenient electronic machine which performs the heating task very cleanly and in a very less time. If you Want to know How Does a Microwave Works? then you may wonder that is based on the vibration of electrons present in the Food Particles. That is why Microwave Oven heats the food uniformly without heating the container.

Medical Science: Microwave's heating properties are also used in Medical Science. Microwaves also have Medical Applications such as it is used in diagnosis and various therapies. There are also some other applications of heating property of microwave such as Drying, Precooking and Moisture Levelling.

WAVE EQUATIONS

If we assume all the field vectors vary with respect to time 't' in a sinusoidal manner.

$$\mathbf{E} = E_o e^{j\omega t} \dots\dots\dots (1)$$

E_o is the Maximum value of the electric field intensity, $\omega = 2\pi f$ differentiating eq 1 wrt to t we get

$$\frac{\partial \mathbf{E}}{\partial t} = E_o e^{j\omega t} j\omega \dots\dots\dots (2)$$

$$j\omega \mathbf{E}$$

we can define an operator $\frac{\partial}{\partial t} = j\omega$

differentiating eq 2 wrt to t again we get

$$\frac{\partial^2 \mathbf{E}}{\partial t^2} = j\omega E_o e^{j\omega t} j\omega$$

$$\frac{\partial^2 \mathbf{E}}{\partial t^2} = -\omega^2 E_o e^{j\omega t} = -\omega^2 \mathbf{E}$$

we can define another operator $\frac{\partial^2}{\partial t^2} = -\omega^2$

consider a medium which does not contain any free charges and is also non conducting, i.e air or free space. Then we have $\rho = 0, \sigma = 0$

from Maxwells 1st equation $\nabla \times \mathbf{H} = \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t} = \sigma \mathbf{E} + \frac{\partial}{\partial t}(\epsilon \mathbf{E})$

$$\nabla \times \mathbf{H} = 0 + \epsilon \frac{\partial \mathbf{E}}{\partial t} = \epsilon j\omega \mathbf{E} = j\omega \epsilon \mathbf{E}$$

$$\nabla \times \mathbf{H} = j\omega \epsilon \mathbf{E}$$

From Maxwells 2nd equation

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t} = -\frac{\partial}{\partial t}(\mu \mathbf{H}) = -j\omega \mu \mathbf{H}$$

$$\nabla \times \mathbf{E} = -j\omega \mu \mathbf{H}$$

taking curl of $\nabla \times E$ we get

$$\nabla \times \nabla \times E = \nabla \times (-j\omega\mu H) = -j\omega\mu(\nabla \times H)$$

$$j\omega\mu(\nabla \times H) = -j\omega\mu(j\omega\epsilon E)$$

$$\nabla \times \nabla \times E = \omega^2 \mu\epsilon E$$

from vector analysis $\nabla \times \nabla \times E = \nabla(\nabla \cdot E) - \nabla^2 E$