Microwave [CT-1]

Microwave : An electromagnetic wave that has frequencies between ~~\$~~ 300 MHz and 300 GHz and wavelength between 10^{-3} m and 10^{-1} m.

~~*~~ Why are microwave frequencies of interest?

⇒ (microwave frequency এর adv.) · Frequency বাড়লে —

1. System এর capacity বাড়ে।
2. Antenna gain বাড়ে, Antenna size কমে।

~~*~~ ~~Let's assume that~~ we ~~can~~ have to transmit ~~a~~ ~~number of~~ 4kHz voice signal through a wireless link. Let's assume that we have two wireless system to choose from. One operating at 500 MHz and the second at 4 GHz each with a 10% bandwidth around its capacity. [Frequency এর সাথে যে capacity বাড়ে, সেটা প্রমাণের একটা math]

⇒ We know –

$\boxed{\text{সূত্র}}$ → $$\text{Number of channels} = \frac{\text{operating frequency} \times \text{Percent BW}}{\text{BW per channel}}$$

When operating frequency is 500 MHz —

$$\text{Number of channels} = \frac{500 \times 10^6 \times 10\%}{4 \times 10^3}$$

$$= 12500$$

When operating frequency is 4 GHz —

$$\text{Number of channel} = \frac{4 \times 10^9 \times 10\%}{4 \times 10^3}$$

$$= 1,00,000$$

∴ frequency বাড়লে channel এর সংখ্যা বাড়ে অর্থাৎ system এর capacity বাড়ে।

Circuit theory vs EM field theory :

Circuit theory	EM Field Theory
Circuit is a path for transmitting electric current.	EM field is a combination of invisible electric and magnetic field ~~&~~ of force.
Large wavelength	Short wavelength
Small in structure	Large in structure
Not applicable in free space.	Applicable in free space.
Useful at low frequency.	Useful at all frequency.
Deals with voltages and currents.	Deals with electric vector (E) and magnetic vector (H).
Applications: Oscillator, Amplifier, Rectifier, filters etc.	Applications: Satellite, Mobile, Radar etc.

~~Why are microwave frequencies are of interest / Adv. of microwave:~~

Adv. of microwave:

1. High frequency. for this they can carry large amount of information.
2. Short wavelength. for this short antennas can be used.
3. Highly reliable.
4. Increased bandwidth.
5. Lower power requirements.
6. ~~Be~~ Low attenuation.
7. Few ~~near~~ repeaters are needed.

Disadv. of microwave: (difficulties)

1. Difficult to analyse.
2. " " design.
3. Transmission time is high.
4. Difficult to implement.
5. Expensive components.

Applications of microwave :

1. Radar
2. Telecommunication
3. Microwave ovens
4. Medical Science
5. Remote sensing
6. Satellite
7. Mobile

Applications of microwave engineering :

1. Medical Imaging
2. Cancer Treatment
3. Wi-Fi routers
4. Bluetooth devices
5. Development of microwave ovens.
6. Thermal therapy.

How microwave signal generated?/
How microwave engineering generate signal?
=> By vacuum tube devices.

Maxwell Eq :

Application of Maxwell eq.

1. In MRI , CT scan
2. Wireless communication
3. Electromagnetic sensors
4. Antenna design
5. Optical fiber communication
6. Electric motors.
7. " generators.

Advantages of Maxwell eq.

* Maxwell's eq.s are —

Diff. Form
$$
\begin{cases}
\nabla \cdot \vec{D} = \rho & \text{--- (I)} \\
\nabla \cdot \vec{B} = 0 & \text{--- (II)} \\
\nabla \times \vec{E} = -\dfrac{\partial \vec{B}}{\partial t} - \vec{M} & \text{--- (III)} \\
\nabla \times \vec{H} = \dfrac{\partial \vec{D}}{\partial t} + \vec{J} & \text{--- (IV)}
\end{cases}
$$

E = Electric Field
H = Magnetic "
D = Electric Flux Density
B = Magnetic " "
ρ = Electric charge density
M = Magnetic current "
J = Electric "

* State that, charge is conserved (With Maxwell's eq)
or, current is continuous.

⇒ We know,
The divergence of a curl of any vector is zero.

$\therefore \nabla \cdot \nabla \times H = 0$

$\Rightarrow \nabla \cdot \left(\dfrac{\partial \vec{D}}{\partial t} + \vec{J} \right) = 0$

$\Rightarrow \dfrac{\partial}{\partial t} (\nabla \cdot \vec{D}) + \nabla \cdot \vec{J} = 0$

$\Rightarrow \dfrac{\partial \rho}{\partial t} + \nabla \cdot \vec{J} = 0$ — (V)

eq. (V) states charge is conserved or current is continous.

* Maxwell's eq. -

Integral Form

$$\oint_s \vec{D}\cdot d\vec{s} = \int_v \rho \, dv$$
$$\oint_s \vec{B}\cdot d\vec{s} = 0$$
} Gauss

$$\oint_l \vec{E}\cdot d\vec{l} = -\int_s \frac{\partial \vec{B}}{\partial t}\cdot d\vec{s} - \int_s \vec{M}\cdot d\vec{s}$$
} Farad

$$\oint_l \vec{H}\cdot d\vec{l} = \int_s \left(\vec{J} + \frac{\partial \vec{D}}{\partial t}\right) d\vec{s}$$
} Joule

Diff. Form

$$\vec{\nabla}\cdot\vec{D} = \rho$$
$$\vec{\nabla}\cdot\vec{B} = 0$$
$$\vec{\nabla}\times\vec{E} = -\frac{\partial \vec{B}}{\partial t} - \vec{M}$$
$$\vec{\nabla}\times\vec{H} = \frac{\partial \vec{D}}{\partial t} + \vec{J}$$

Time domain frequency: $\frac{\partial}{\partial t} \rightarrow j\omega$

$$\vec{\nabla}\cdot\vec{D} = \rho$$
$$\vec{\nabla}\cdot\vec{B} = 0$$
$$\vec{\nabla}\times\vec{E} = -j\omega\vec{B} - \vec{M}$$
$$\vec{\nabla}\times\vec{H} = j\omega\vec{D} + \vec{J}$$