MADE EASY

Electronics Engineering

Toppers Handwritten Notes

MICROWAVE ENGINEERING

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⁂ Microwave ⁂

1. Introduction
2. MW components
   - ↳ E-plane Tee
   - ↳ H-plane Tee
   - ↳ Magic Tee [E-H plane Tee / Hybrid Tee] [8 Marks]
   - ↳ S-Matrix
   - ↳ Rat race Junction
   - ↳ Directional coupler [15 Marks]
   - ↳ Ferrite device
     - ⇒ Isolator
     - ⇒ Gyrator
     - ⇒ Circulator [6 Marks]
3. MW signal generation & application
   - ↳ MW Tubes
   - ↳ Limitation of conventional tubes [8 Marks]
   - ↳ Two cavity klystron
   - ↳ Multi cavity klystron } [15 Marks] → Amplifier
   - ↳ Reflex klystron → oscillator
   - ↳ TWT [15 Marks] → Amplifier
   - ↳ BWO → oscillator
   - ↳ Magnetron [15 Marks] → Oscillator
4. Solid state device
   - ↳ Gunn Diode [15 marks]
   - ↳ Tunnel diode [10 marks]
   - ↳ Avalanche transit time device
     - ⇒ IMPATT [Read Diode] [20 Marks]
     - ⇒ TRAPATT
     - ⇒ BARITT

↳ Parametric Amplifier [15 Marks]

↳ MASER & LASER

↳ Cavity Resonator

⑤ MW measurement [10 Marks]

⑥ MW communication

↳ Terristerial comm.

↳ Sattelite comm. [15 Marks]

⑦ Microwave Antenna

⑧ microstrip [8 Marks]

↳ Introduction

→ MW Frequency range

300 MHz to 300 GHz

MW devices can be used upto 10^6 GHz. i.e. 10^{15} Hz

$$c = \lambda f$$

$$\boxed{\lambda = \frac{c}{f}} \quad c = 3\times10^8 \text{ m/sec}$$

↳ case-1

$f = 300$ MHz

$$\lambda_1 = \frac{3\times10^8}{300\times10^6} = 1\text{m}$$

↳ case-2

$f = 300$ GHz

$$\lambda_2 = \frac{3\times10^8}{300\times10^9} = 1\text{ mm}$$

↳ case-3

$f = 10^6$ GHz

$$\lambda_3 = \frac{3\times10^6}{10^6\times10^9} = 0.3\mu m$$

In case-3 $\lambda_3 = 0.3\mu m$ (in the range of μm) hence the name microwave.

⇒ MW are so called because they are defined in terms of their wavelength.

⇒ Advantage of MW

It ↑es B.W. availability.

B.W. is some % of center frequency
Let B.W. is 1% of center frequency

B.W. of T.V. channel in India = 7MHz.

Audio signal - FM
Video signal - VSB (AM)

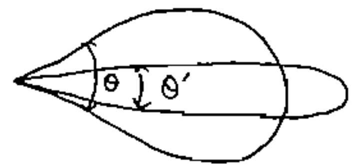
carrier freq.	BW	No. of TV channel
70 MHz	0.7 MHz	0
700 MHz	7 MHz	1
7 GHz	70 MHz	10
70 GHz	700 MHz	100

↳ Improved directive property

θ → Beam width

Directivity $\propto \frac{1}{\theta}$

$\theta \propto \lambda$

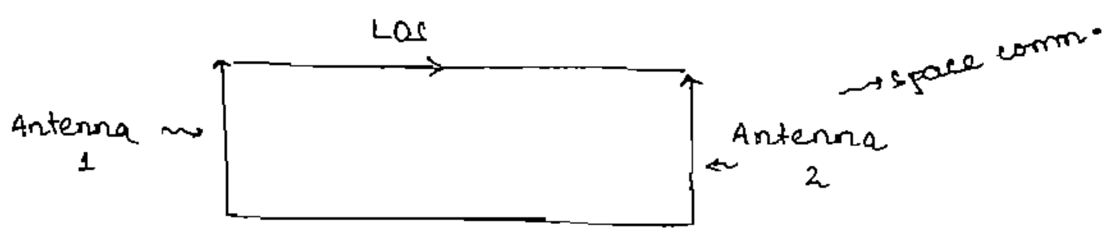


$\theta' < \theta$

$f \uparrow \quad \lambda \downarrow \quad \theta \downarrow \quad D \uparrow$.

So, high gain & directive anteena can be decigned & fabricated more easily at MW frequency.

→ <u>Fadding effect and Reliability</u>



Line of sight propag. (Used in FM)

Due to line of sight propagation & high freq. there is less fadding effect & MW comm. is more reliable.

→ Power requirements

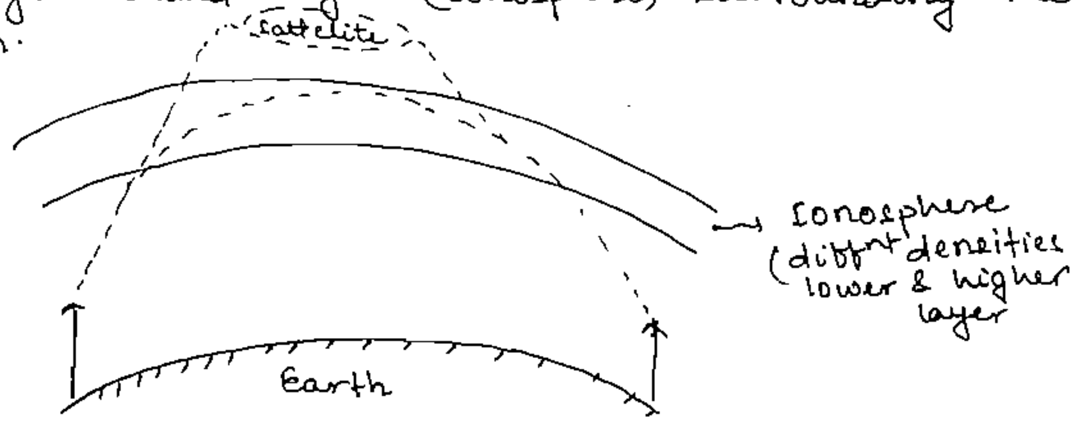
Tx & Rx power requirements is very low at MW frequency.

$P_r \propto \frac{1}{f}$

↳ Receiving power requirements

→ Transparency property of MW

MW frequency bands are capable of free propagation through ionised layer (Ionosphere) surrounding the earth.



μ-wave can penetrate ionospheric layer.

Ionospheric comm. (sky wave propagation).

→ Size of component is directly proportional to wavelength, therefore smaller system is possible.

⇒ Application

↳ Telecommunication

↳ Intercontinental Telophone & TV, space comm., telemetry comm. link for railways.

↳ Radar

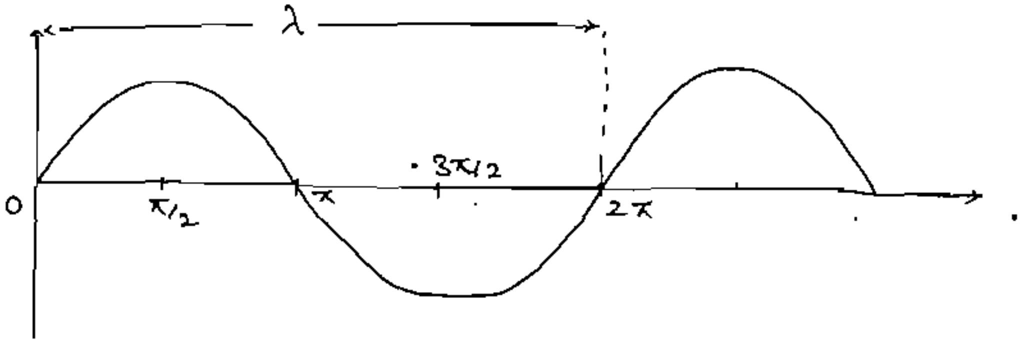
↳ commercial & Industrial application uses heating property of μ-wave

eg. – μ-wave oven
– Drying machine
– Machine / Public works
– food processing Industry

↳ Biomedical application

↳ Electronic warfare

⇒ Relation between path travelled and phase change



Path travelled	Phase change
λ	2π
$\lambda/2$	π
$\lambda/4$	$\pi/2$
l	$\frac{2\pi}{\lambda} \cdot l$

Rate of change of phase → $\omega = \frac{d\theta}{dt} = 2\pi f = \frac{2\pi}{T}$

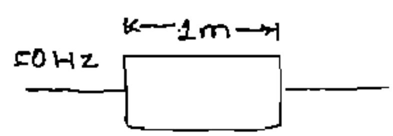
$f = \frac{1}{T}$

If $f = 50\,Hz$; $T = \frac{1}{f} = 20\,msec$.

$\lambda = \frac{c}{f} = \frac{3\times10^8}{50} = 6\times10^6\,m = 6000\,km$

& if $f = 10^6\,GHz$; $\lambda = 0.34\,m$

$\phi = \frac{2\pi}{\lambda} \cdot l = \frac{2\pi}{6\times10^6} \times 1 \cong 0$

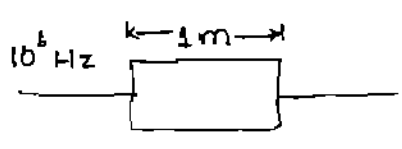


$\phi = \frac{2\pi}{6\times10^6} \times 1 \cong 0$

[lumped parameter]

R, L, C

because rate of change of phase is very low



$\phi = \frac{2\pi}{0.3\times10^{-6}} \times 1$

[distributed parameter]

Ω/m, Farad/m, H/m

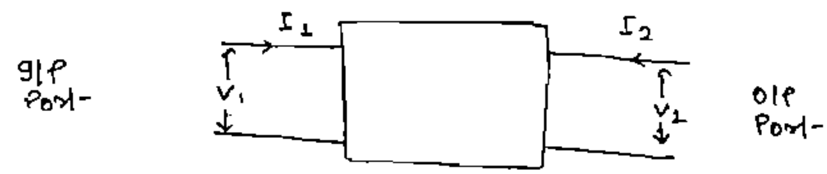
when λ is large there is negligible phase variation across the components so lumped parameter or simple ckt. theory is applicable for small λ there is high phase variation across the components therefore el-wave components are represented as distributed parameter.

↳ **Band designation**

IEEE : Institute of electrical & electronics eng.

Band	Freq. range
L	1 - 2 GHz
S	2 - 4 GHz
C	4 - 8 GHz
X	8 - 12 GHz
KU	12 - 18 GHz
K	18 - 27 GHz
Ka	27 - 40 GHz

⇒ μ-wave components

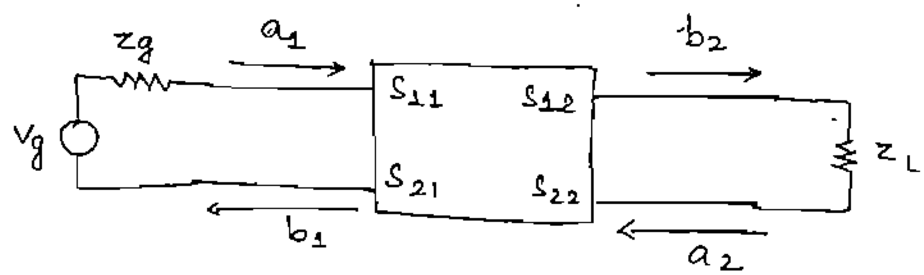


$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

If the frequencies are in μ-wave range then h, Y, Z-parameters can't be used for following reasons:-

- ↳ Equipment is not readibly available to measure total voltage & total current at the port of network.
- ↳ SC & OC are difficult to achieve over broad band of frequency.
- ↳ Active device such as power transistors, tunnel diode etc frequently will not have stability for SC or OC.

⇒ S-parameter [Scattering]



$$\begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \end{bmatrix}$$