Microwave

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Introduction

Content:

- What is Microwave?
- EM spectrum
- Microwave frequency bands
- Evolution of Microwave Communication
- Difference between RF and Microwave signals
- Use of Microwaves

Microwave:

Microwave are type of EM radiations having higher frequency.

Micro means ‘small’ and waves means ‘signal’.

Frequency range: 300 MHz to 300 GHz. (include UHF and EHF band)

Wavelength range: 100 cm to 0.1 cm

In RF engineering, Microwave are used between the frequency range of 1 GHz (30 cm) to 100 GHz (0.3 cm)

EM Spectrum:

Name	Wavelength	Frequency (Hz)
Gamma ray	< 0.02 nm	> 15 EHz
X-ray	0.01 nm – 10 nm	30 EHz – 30 PHz
Ultraviolet	10 nm – 400 nm	30 PHz – 750 THz
Visible light	390 nm – 750 nm	770 THz – 400 THz
Infrared	750 nm – 1 mm	400 THz – 300 GHz
Microwave	1 mm – 1 m	300 GHz – 300 MHz
Radio	1 mm – 100 km	300 GHz – 3 kHz

Microwave:

The range of frequencies are defined by IEEE , NATO and ITU designations in bands:

Band	Frequency	Wavelength
L band	1 to 2 GHz	15 cm to 30 cm
S band	2 to 4 GHz	7.5 cm to 15 cm
C band	4 to 8 GHz	3.75 cm to 7.5 cm
X band	8 to 12 GHz	25 mm to 37.5 cm
Ku band	12 to 18 GHz	16.7 mm to 25 mm
K band	18 to 26.5 GHz	11.3 mm to 16.7 mm

Microwave:

Band	Frequency	Wavelength
Ka band	26.5 to 40 GHz	5.0 mm to 11.3 mm
Q band	33 to 50 GHz	6.0 mm to 9.0 mm
U band	40 to 60 GHz	5.0 mm to 7.5 mm
V band	50 to 75 GHz	4.0 mm to 6.0 mm
W band	75 to 110 GHz	2.7 mm to 4.0 mm
F band	90 to 110 GHz	2.1 mm to 3.3 mm
D band	110 to 170 GHz	1.8 mm to 2.7 mm

Evolution of microwave communication:

1. 1930 - Connected U.K. with france using microwave signal
2. 1950 - AT&T use 10 channels of microwave radio relay system in U.S.

   - Television broadcasting on microwave network.
3. 1980 - used in RF system to carry high traffic demand

   - provide long haul communication

Difference:

1. Microwave is just a subset of the RF range
2. RF covers 3 Hz to 300 GHz while Microwaves occupies the higher frequencies at 300MHz to 3GHz
3. RF are commonly used for AM/FM transmission while Microwaves are used in wider applications like heating and high-bandwidth data transmission systems
4. Microwaves also used for transmitting power from one point to another

Microwave Uses:

1. Communication Purposes
2. Navigation
3. In Radar system
4. Radio astronomy
5. Heating Application
6. Spectroscopy

Microwave Signals

Content:

- Microwave measurement Unit
- Modes of Transmission

Measurement Unit:

1. Electronics Technique

Measurement Unit:

2. Mechanical Technique

Measurement Unit:

- **Hertz:** A measurement of signals electromagnetic frequency expressed as number of cycle per second (kHz, MHz, GHz, THz, EHz).
- **Frequency:** The rate of wave oscillation, measured in hertz.
- **Amplitude:** The strength and power level of wave.
- **Phase:** The particular point in the power of waveform, measured in degree.
- **Polarisation:** The orientation of the electric field driving the wave.

Modes of Transmission:

Microwave Transmission:

When microwaves are used to send and receive information then it is known as microwave transmission.

Information may consist of voice, data, television, telephony or radio signals.

Microwaves are also emitted by natural objects and from space.

Modes of Transmission:

Modes of Transmission of microwave signal:

- Guided medium such as a transmission line (cable or waveguide)
- Unguided medium (plane waves in free space and through the atmosphere)

Common options include twisted-pair copper cable, coaxial cable and fiber-optic cable.

MW transmission is a best solution where cost, capacity, flexibility and timing all intersect.

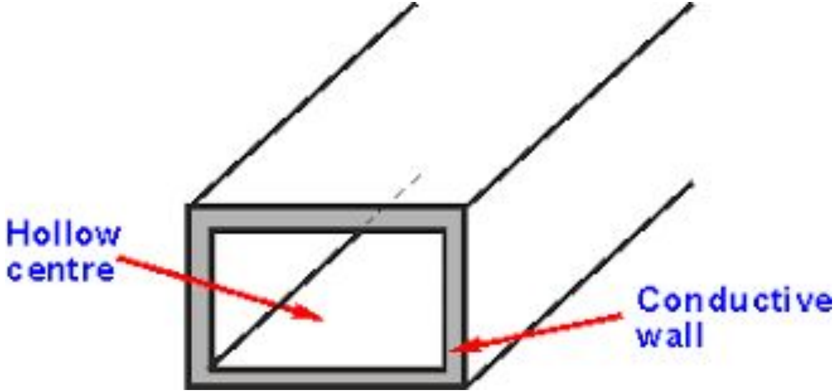
Waveguide

Content:

- Microwave Waveguide
- Features
- Modes of Propagation
- Types of Waveguide
- Advantage and disadvantage of waveguide

Waveguide:

A Hollow metallic tube of uniform cross section for transmitting electromagnetic waves by successive reflections from the inner wall of the tube is called waveguide.



Waveguide:

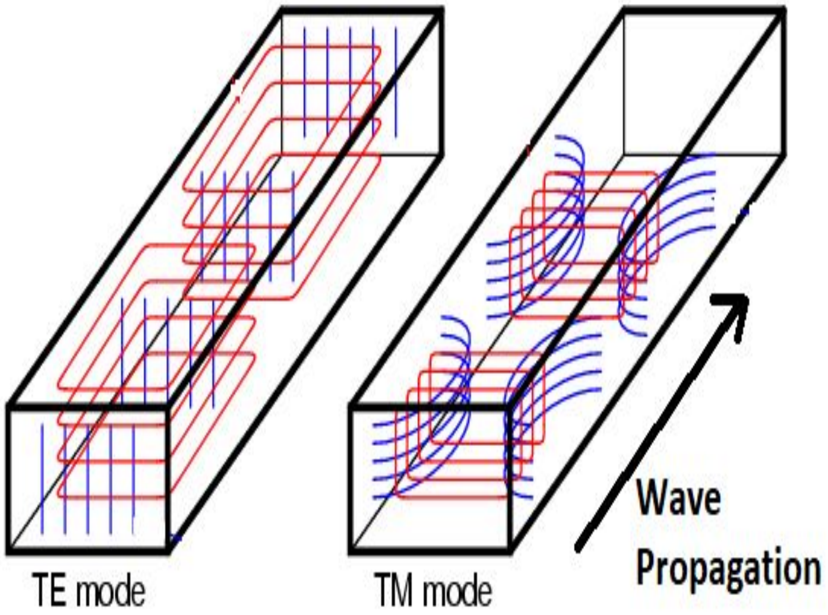
Features of waveguide:

- It consists of rectangular or cylindrical metal tube or pipe.
- The EM field propagates lengthwise.
- It is often used with horn antenna and dish antenna.
- Clean and dry waveguide interior give low loss and high efficiency transmission.
- Waveguide are made of copper and aluminium.

Waveguide:

An EM field can propagate along a waveguide in various modes:

1. Transverse-magnetic (TM) mode
2. Transverse-electric (TE) mode.



Waveguide:

The electric and magnetic fields associated with the signal bounce off the inside walls back and forth as it goes down the waveguide.

Wavepath of waves in waveguide various at various frequencies such as:

- At high frequency
- At medium frequency
- At low frequency
- At cut-off frequency

Waveguide:

Types of waveguides:

1. Rectangular waveguide
2. Circular waveguide

Waveguide:

Advantages of Waveguides:

- Propagation with lower loss.
- Good amount of immunity against any RF interference.
- Higher power handling capacity.
- Lower attenuation at cutoff wavelength.
- Easy to install in a microwave transmission systems

Waveguide:

Disadvantages of Waveguide:

- Not operate at lower frequencies due to increased dimensions.
- Very bulky
- Not flexible in nature.
- Supports narrow band of operation.
- TEM mode of propagation is not possible.

Elliptical Waveguide

Content:

- Elliptical Waveguide
- Construction
- Connector
- Flanges
- Transition Point
- Pressure Window
- Gaskets

Elliptical Waveguide:

Elliptical Waveguide is most suitable for microwave systems transmission line operating between 1.7 GHz and 23.6 GHz.

Features of Elliptical waveguide

1. Elliptical cross section - minimizing VSWR and eliminate signal distortion.
2. Lowest loss optimization in significant user bands.
3. Elliptical waveguide attenuation is less than rectangular waveguide
4. Have high signal transfer and excellent system performance.

Elliptical Waveguide:

Elliptical Waveguide:

Construction: Formed of

- Corrugated high-conductivity copper
- Outer jacket - Rugged black polyethylene material (waterproofing and UV stabilization)
- Operating waveguide temperature low as -54˚C (-65˚F),
- Has an elliptical cross section (high strength and flexibility)
- light weight.
- Waveguide Pressurization (prevent moisture from getting inside and attenuating the signal)

Waveguide:

Flexible waveguide:

Used to eliminate vibration and also reduce installation difficulties.

Flex twists are made of helically-wound waveguide core supported by protective neoprene jacketing.

Rectangular Waveguide:

Rigid waveguide used at final assembly point in the equipment rooms, connecting to the radios.

Connector:

Connectors:

It is made of brass and passed through multiple steps of transition to get in shape decided acc to industrial standards waveguide flanges.

Each connector has a pressure inlet to allow the connection of pressurization equipment.

They have long service life and compatibility with the metals used in the waveguide .

Waveguide:

- Connector

Flanges:

Flanges are used at a point where waveguide is connected to antenna.

Types of Flanges:

1. PBR flanges
2. PDR
3. CPR G
4. UG choke cover

Transition Point:

Waveguide to coaxial cable transitions point is a point where rectangular waveguide interface is connected to a coaxial cable flange interface.

Termination Load:

These are used when polarization ports of a polarized antenna are not currently in use.

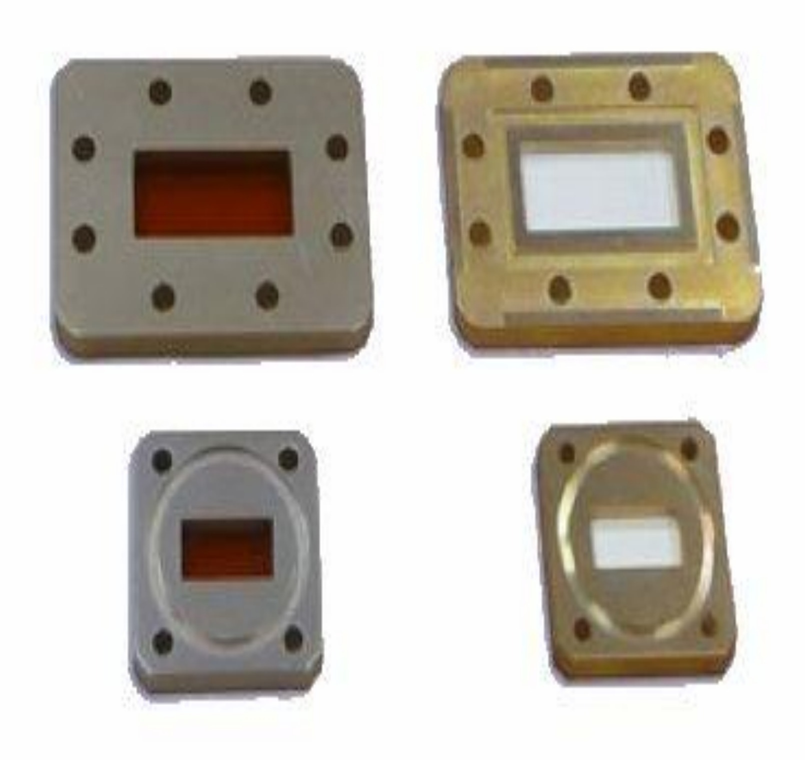
For Long-Haul microwave antenna it is made of ferrites.

For short-haul microwave antenna it is made of rubber absorber material

Pressure Window:

It is used for separation between the components that require pressurization and which do not require.

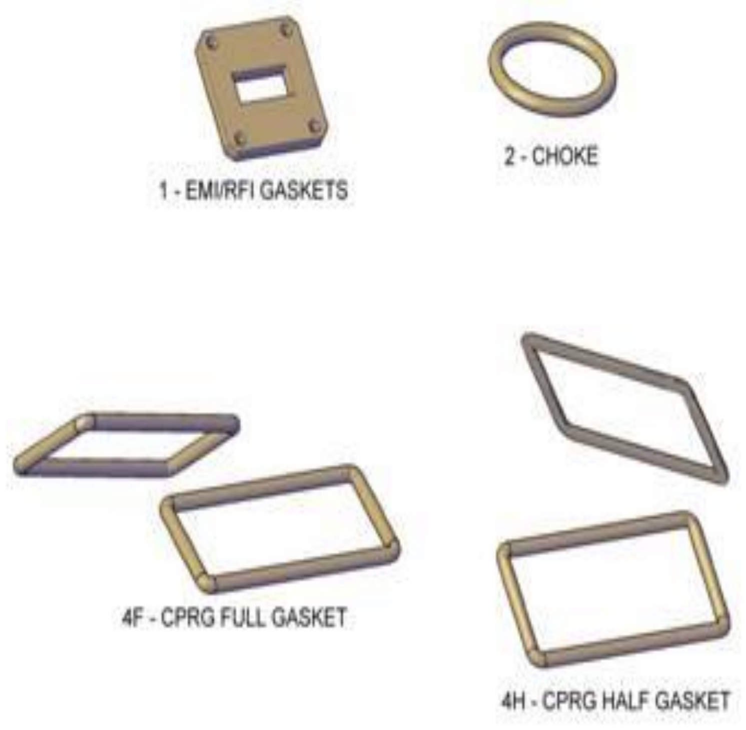
Installed at the equipment room and to end of the feeder line.



Gaskets:

Gaskets are present throughout the systems wherever pressurization is required.

Full or half gaskets are used in flange mating combinations,



Waveguide Pressurization

Content:

- What is Waveguide Pressurization
- Methods of Pressurization
- Nitrogen Tanks
- Heat Regeneration Dehydrator
- Membrane Dehydrator

Waveguide Pressurization:

Pressurization is the method of applying positive pressure in the form of dry air or nitrogen to elliptical waveguide

It is used to prevent the introduction of humidity or moisture that affect the signal transmission.

Amount of pressure applied to waveguide is calculated by using its length and cross sectional area.

Waveguide Pressurization:

Inside waveguide this positive pressure is kept below the maximum pressure rating.

Most components are rated up to 70 kPa

Pressurization of only 3.5 to 35 kPa (0.5 to 5 PSI) is generally used .

Waveguide is pressurized to keep it dry lowers the maintenance costs and reduces service interruptions.

Waveguide Pressurization Methods:

1. Static Pressurisation Method:
    - In a non pressurized system, breathing static desiccator is used.
    - The desiccator have short lifespan and it require periodically replacement.
    - Air is forced out through desiccator, when breathing increase the pressure.
    - New air enters through the desiccator,when breathing decreases the pressure,
    - In this way moisture is absorb before it enters the waveguide.

Waveguide Pressurization Methods:

2. Dynamic Pressurization Methods:
    - A dynamic system remains connected to a pressurization pump so it provide additional dry gas.
    - This method is used to maintain a specified pressure level.
    - The nitrogen gas is stored in a tank with a regulator or dehydrators.

Waveguide Pressurization Methods:

Nitrogen tanks:

- Are small, tight systems with no ac power and no moving parts
- Provide a low dew point to kept out moisture.
- Disadvantage: Relatively high cost and the frequency

Heat regeneration dehydrators:

- Used in small to medium-sized systems require low pressure and low power
- Continuously monitor system pressure using an integrated controller and adjust the air pumps appropriately.

Waveguide Pressurization Methods:

Membrane Dehydrators:

- Designed for low to high system volumes and for distant remote site locations.
- Use a membrane filtration system to remove moisture from the air.
- Operate continuously to monitor system pressure

These system include basic alarm functions which will alert the operators about low pressure, excess runtime, humidity and power failure problems.

LOS

Content:

- Line of sight Transmission
- Operating Frequencies
- Modulation Techniques

Line of sight Transmission:

Microwaves are transmitted using Point-to-point radio links.

It is also known as Line of Sight communication.

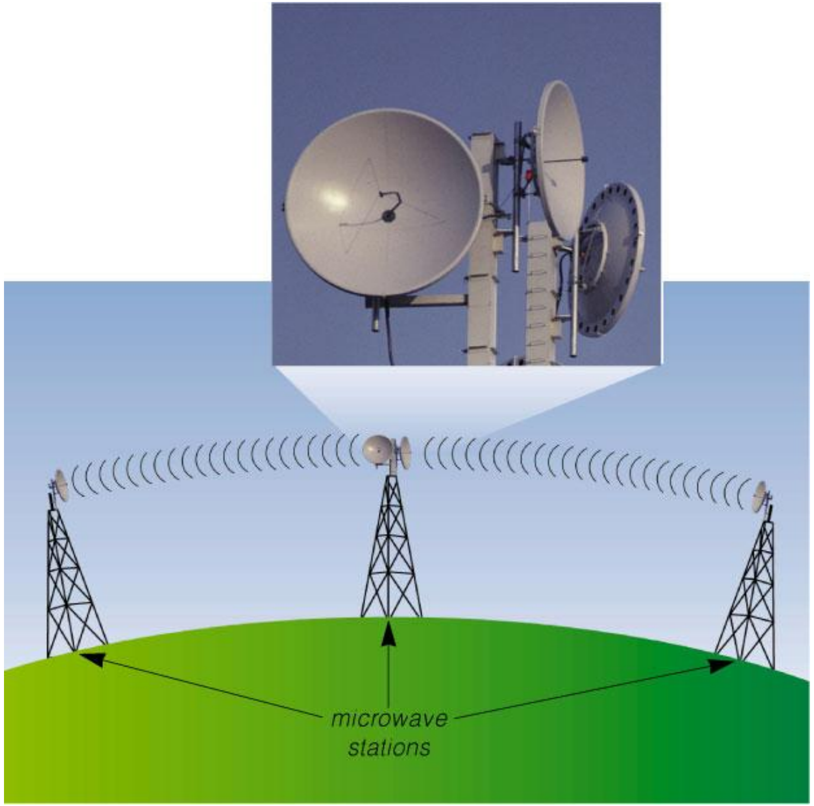
Features:

- Low cost.
- Use highly focused line of sight beam
- Ease of installation.
- Not need to deploy expensive cables.
- Highly directional antennas such as parabolic dishes are used.

Line of Sight Transmission

A parabolic dishes have a reflective surface.

It is used to collect or project energy such as light, sound, or radio waves.



Line of sight Transmission:

Operating Frequencies:

1. Lower frequencies (≤11 GHz) :

   It can propagate over a long distances with larger long-haul antennas.

2. Higher frequencies (>11 GHz):

   It can propagate over lesser distances via smaller short-haul antennas.

Line of sight Transmission:

Microwave signal use two type of modulation technique:

1. Frequency-division duplex (FDD): Each hop is allocated a frequency channel pair known as a uplink/downlink pair. This provide simultaneous transmission in both directions across the link.
2. Time-division duplex (TDD): Use one channel to achieve two-way communication by synchronized selection of the direction of transmission.

Microwave Antennas

Content:

- What is Antenna?
- Antenna Parameters
- Types of Antennas

Antennas:

An antenna is a transducer that converts radio frequency (RF) fields into alternating current or vice versa.

Antennas are used for both sending or receiving radio transmissions.

Above 3 GHz dish antennas are used whereas below 3 GHz other type of antennas are used.

Uses: wireless local area networks, mobile telephony and satellite communication.

Antennas:

Parameters associated with antennas are:

- **Operating Frequency** : Frequency bands and channels are defined by ITU.
- **Radiation Patterns** : In frequency congestion period, it describe the capability of antenna to differentiate the unwanted signal.
- **Gain** : measures antenna directivity and electrical efficiency
- **Half Power beamwidth** : refers to the peak effective radiated power of the main lobe.

Antennas:

Parameters associated with antennas are:

- **Polarization**: about orientation of electric field that drive the signal (Horizontal or vertical).
- **Inter Port isolation**: isolation of multi port antenna from each other.
- **Front to back ratio**: Ratio of signal strength transmitted in a forward direction to that transmitted in a backward direction.

Antennas:

Parameters associated with antennas are:

- **Cross Polar Discrimination**: Ability to maintain radiated or received polarization purity between horizontally and vertically polarized signals.
- **VSWR**: indicates the value of mismatch between an antenna and feed-line connected to it.

Antennas:

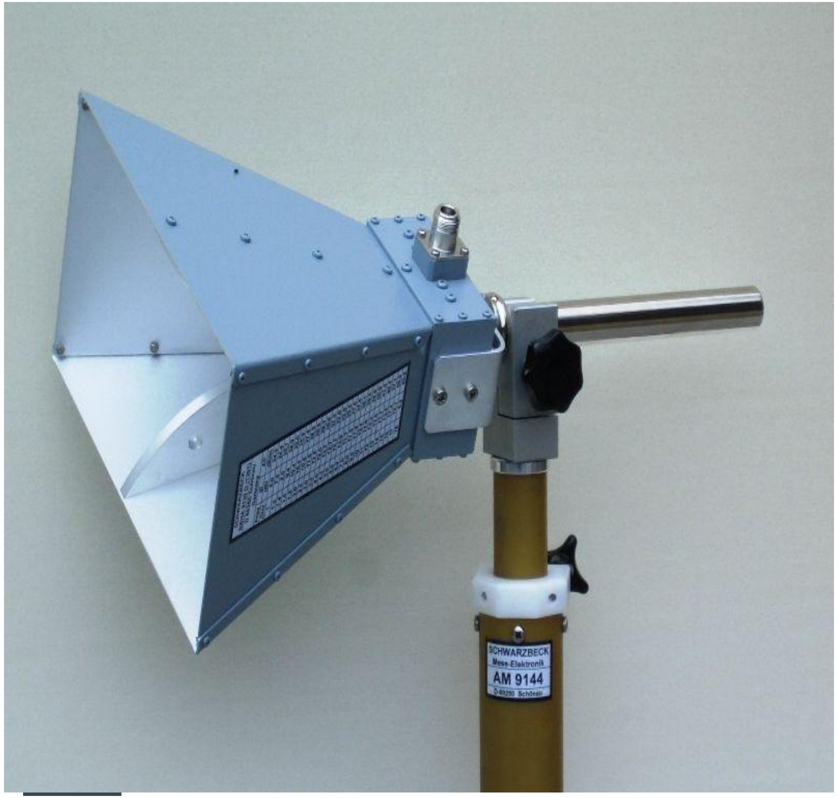
Types of Antennas:

1. Horn Antenna
2. Parabolic Antenna
3. Slot Antenna
4. Dipole Antenna
5. Dielectric Resonator Antenna
6. Array Antenna

Antennas:

Horn Antenna:

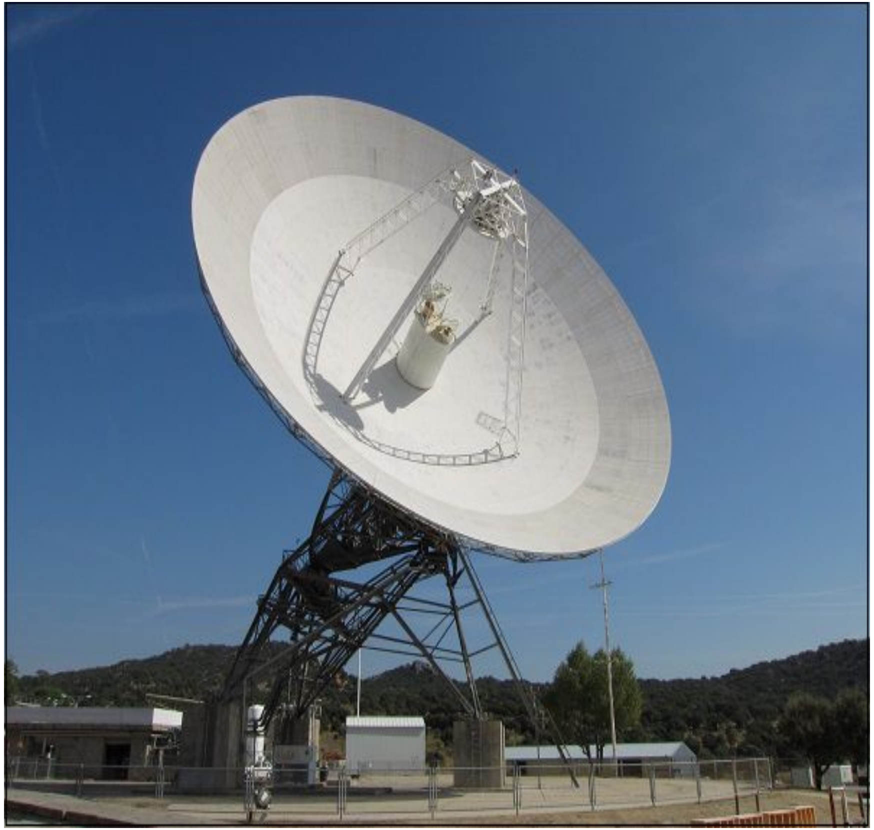
- Consist of flaring metal waveguide shaped like a horn.
- It direct radio waves in the form of beam.
- Commonly used at UHF.



Antennas:

Parabolic Antenna:

- Consist of curved surface with the cross-sectional wave of parabola.
- Well known as reflector antenna.
- Have high directivity.



Antennas:

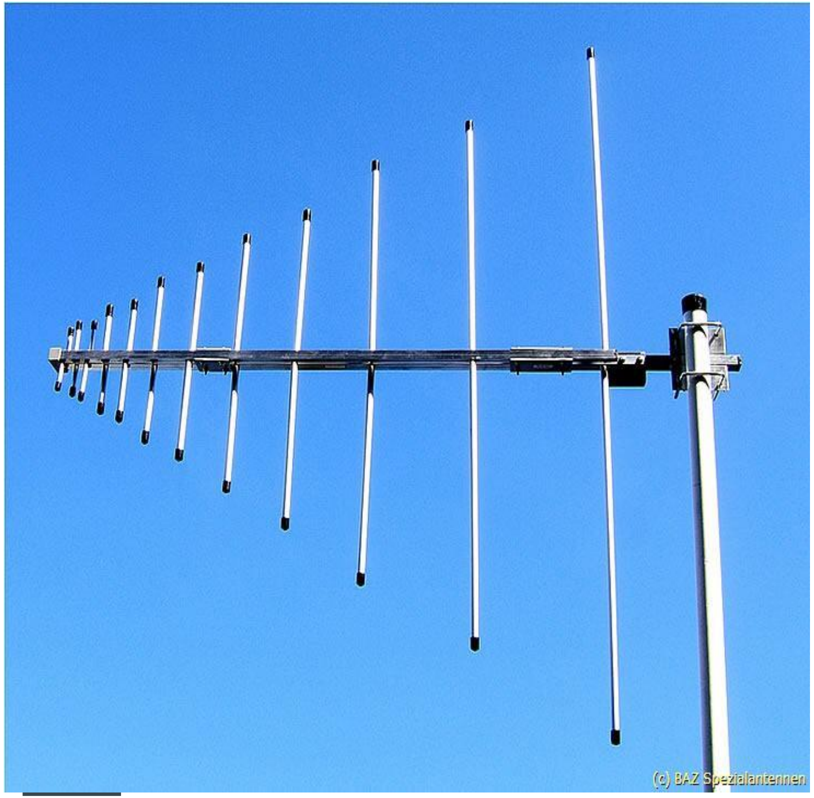
Slot Antenna:

- Consist of metal surface, usually a flat plate with one or more holes or slots cut out.
- Used at microwave and UHF

Antennas:

Dipole Antenna:

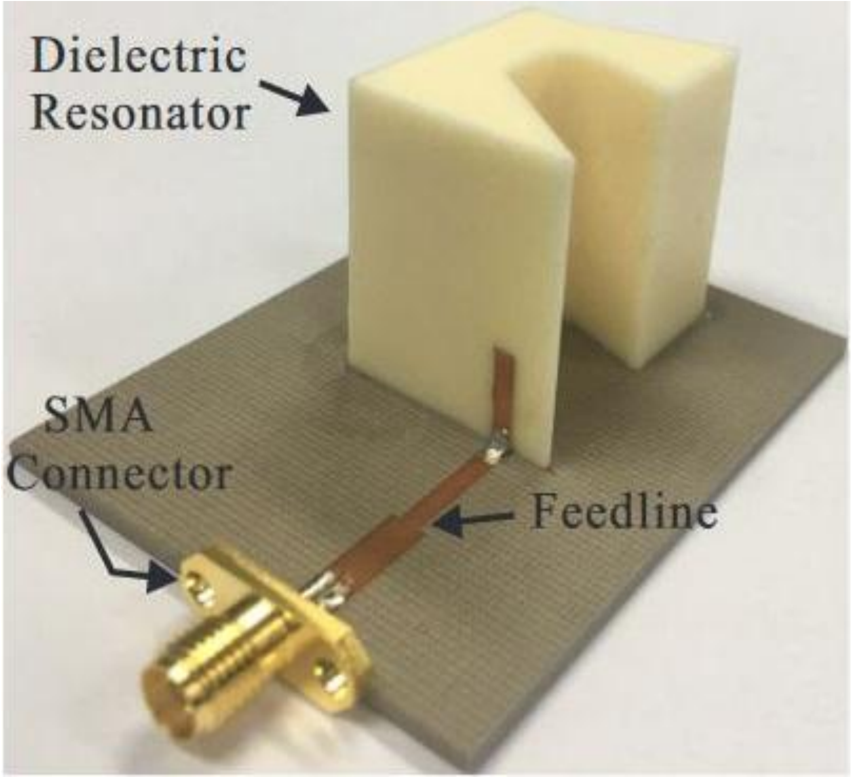
- Consist of two identical conductive elements such as metal wire and rods.
- Widely used antenna.



Antennas:

Dielectric Resonator Antenna:

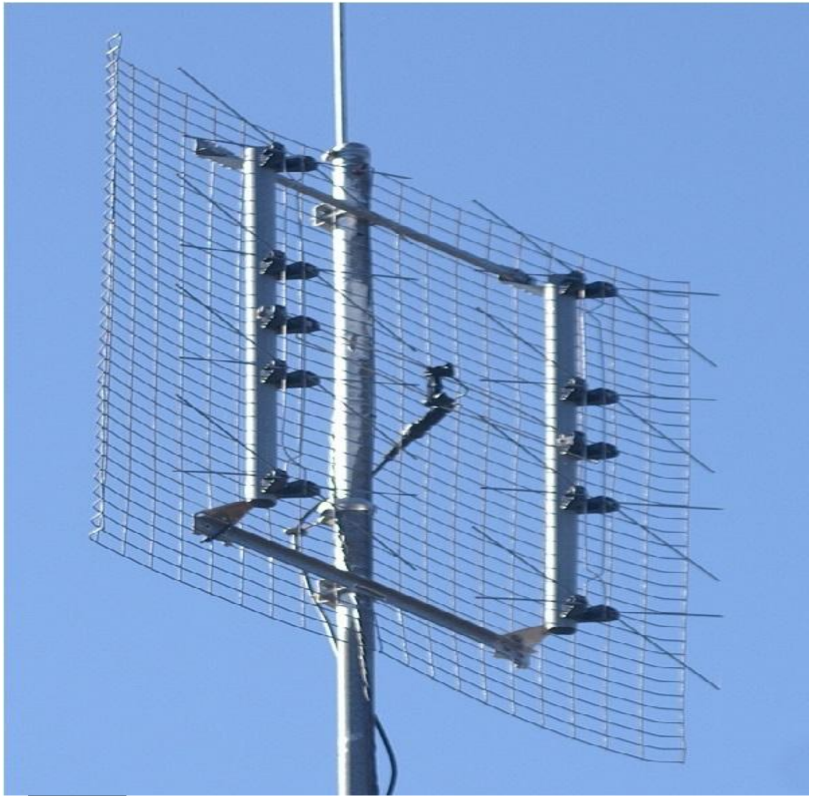
- Consist of block of ceramic material of various shape.
- The dielectric resonator is mounted on a metal surface, on ground plane.
- Widely used at microwave and higher frequency.



Antennas:

Array Antenna:

- Multiple antennas are connected that worked as single antenna.
- It transmit and receive radio waves.
- Feedline is connected to provide power to each element.

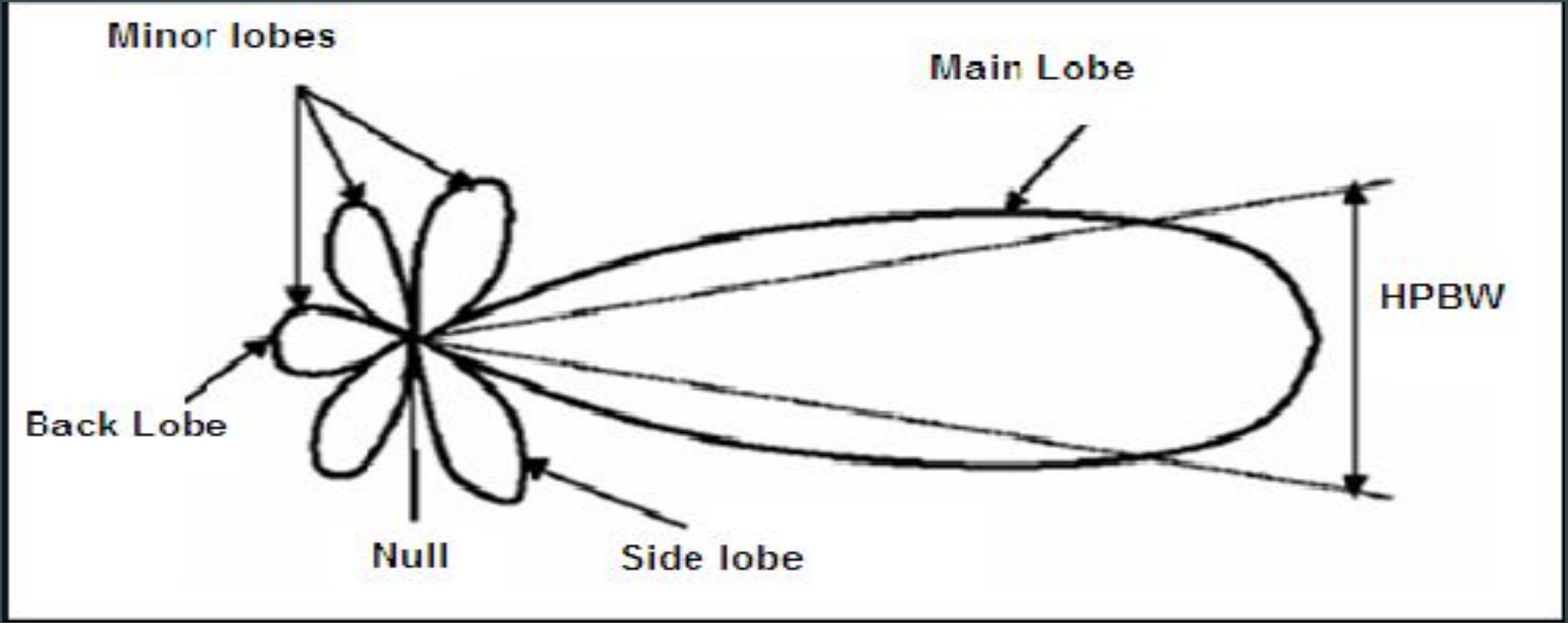


Microwave Propagation

Content:

- Antenna Radiation Pattern
- Microwave Propagation
- Microwave antenna infrastructure

Antenna Radiation Pattern:



Antenna Radiation Pattern:

Types of Antenna Radiation Pattern:

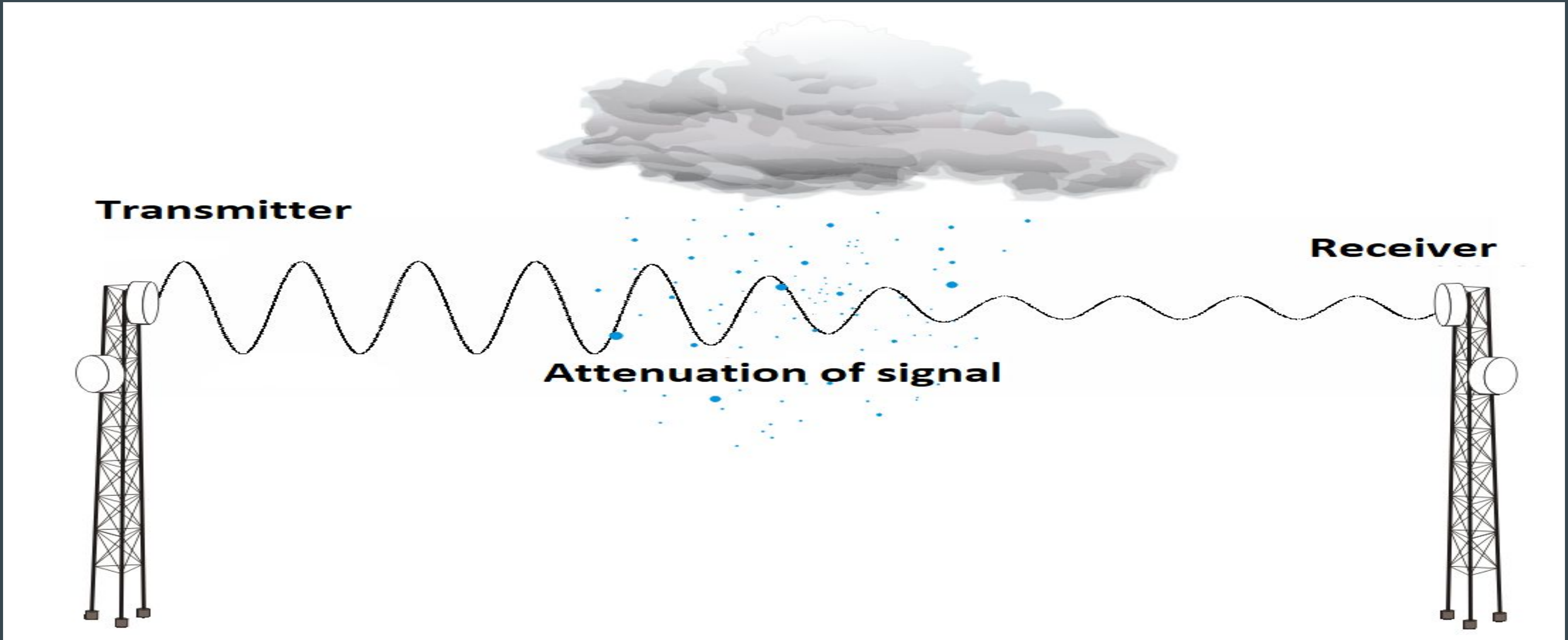
1. Isotropic Radiation
2. Omnidirectional Radiation
3. Directional Radiation

Microwave Propagation:

Cause of interference:

- Weather condition such as Rain, hail, snow, fog etc.
- Extremely high temperature.
- Strong dangerous high winds.
- Exposure to lightning strikes.
- Adjacent-link interference in low LOS clearance.

Microwave Propagation:



Microwave Propagation:

Microwave Transmission at Low frequency:

- Low frequency transmission transmit upto distance 50 km (30 miles).
- These waves can reflect off of the ionosphere and the surface, multiple times.
- A system known as Adaptive Transmit Power Control (ATPC).
- ATPC is used to adjusts power levels to compensate for link hindrances.

Microwave Propagation:

Microwave Transmission at Higher frequency:

At higher frequencies (> 11 GHz):

Rain and other weather conditions create big problem such as scattering of signals.

1. One method: Change in the link’s length can be done using ATPC.
2. Another method: Signal polarization that is the orientation of the signal’s wave relative to the ground either Vertically or Horizontally.

Microwave Propagation:

Microwave Transmission at Higher frequency:

- **Horizontal Polarisation**: adversely affected by rainfall due to the shape of the falling raindrops
- **Vertical Polarization**: is likely affected by rainfall so it is a better choice for link planning.
- **Cross Polar Interference Cancellers (XPIC)**: used with sample signals in both polarizations to cancel any interference in signals.

Microwave Propagation:

Microwave Transmission at Higher frequency:

- **Adaptive Modulation:** also reduce atmospheric attenuation by allowing the signal to increase and decrease the modulation to adapt to changing environmental conditions.
- **Multi-Hop Topology:** is the arrangements of links in the network. Mesh and ring topologies provide alternative paths that help to maintain the optimal connectivity.

Microwave Propagation:

Microwave Transmission at much higher frequency:

At frequency of 60 GHz (mmW), Fog become a threat factor in signal propagation.

Effect to microwave link: Drop in air temperature in case if any water vapor is present in transmission lines it will condensed to form liquid droplet in waveguide giving same effects as rain in a link.

Solution: waveguides are filled with pressurized dry air or nitrogen to keep the moisture out.

Microwave Antenna Infrastructure:

Effect of weather condition on hardware part of microwave antenna:

Building up of snow and ice over the antenna structure account in the increase weight on the tower

Solutions:

- Antennas are fitted with protective covers or radomes,
- Ice shields are also used to prevent antenna damage from ice.

Microwave Antenna Infrastructure:

To cope with increasing demand of wireless technology, there is a constant pressure on microwave backhaul for:

- Increasing capacity
- enhancing reliability
- low capital cost
- Less Operating costs

Return on Investment (ROI) is a term that define the balance between cost and performance of antenna structure.

Installation Factor
of
Antenna

Content:

- Selection Procedure
- Total antenna deployment cost

Antenna Selection steps:

How to make selection of microwave antenna?

- Determine radio congestion in the area
- Link’s capacity
- Physical access to the site for installation purpose
- Easy commissioning and maintenance of site
- Low installation budget and TCO targets
- Weather conditions in the area
- Space available on tower for antenna installation

Antenna Selection steps:

Detailed RF analysis and planning include:

- Antenna type, and size
- Range: km to 4 m
- Operation frequency bands: 3 GHz to 90 GHz.

Total Antenna deployment Cost:

1. Shipping Cost of microwave antenna is high and it is more prone to damage while transportation.

   Solution: use small antennas, split-reflector antennas

2. Large microwave antennas are difficult to Install and sourcing of materials from multiple manufacturers create installation errors.

   Solution: buy products from a quality vendor who provide full assistance in installation and maintenance purpose

Total Antenna deployment Cost:

3. Downtime in link lead to loss of traffic that account in overall profit. Passing this traffic to other Frequent site further add to operational costs.

   Solution: A high-performance and durable antenna with long lifetime and simple installation.

4. Investment in buying spectrum to meet future need.

   Solution: usage of dual-polarized antenna over single polarized antenna. It have double capacity handling power.

Microwave Radiation Pattern

Content:

- Regulation Agreements
- Capacity Formula
- Methods to improve C/I ratio
- Advantages of Low side lobes
- Radiation Pattern Envelope

Microwave Radiation Pattern:

Regulation Agreement:

Better network performance, better TCO and better implementation of regulation is accomplished by

- Higher-quality antennas
- RPE characteristics

Microwave Radiation Pattern:

Parameters:

- **Carrier Power:** The amount of energy received in point to point communication is called the received signal level (RSL) or carrier power (C).
- **Interference (I):** loss in transmitted energy.

Shannon's Law tells the relationship between capacity and signal noise.

$$Capacity = B \times Log2\,(1 + C/(N + I)\,)$$

C/I ratios is critical to link planning and design

Microwave Radiation Pattern:

How to improve C/I ratio?

- Method 1: Increase value of C
- Method 2: Decrease value of I

Method 1 : Accomplished by enhancing transmission power and Increasing gain with a bigger antenna.

Method 2: Use different frequency and different link path. Deploying antenna with smaller side lobes.

Microwave Radiation Pattern:

Advantages of maintaining Low side lobes:

- Higher modulation schemes efficient usage
- Increase the link capacity
- Smaller antenna sizes reduce project cost
- Simplified end point coordination and planning
- Less maintenance is required
- Greater spectrum reuse

Microwave Radiation Pattern:

Radiation Pattern Envelope:

It is the way of antenna to radiates signal energy in different directions and the area around the radiation pattern is called radiation pattern envelope (RPE).

Indicate the distance and direction for efficient propagation of signals.

The specification of antennas are used by operators before deploying in network

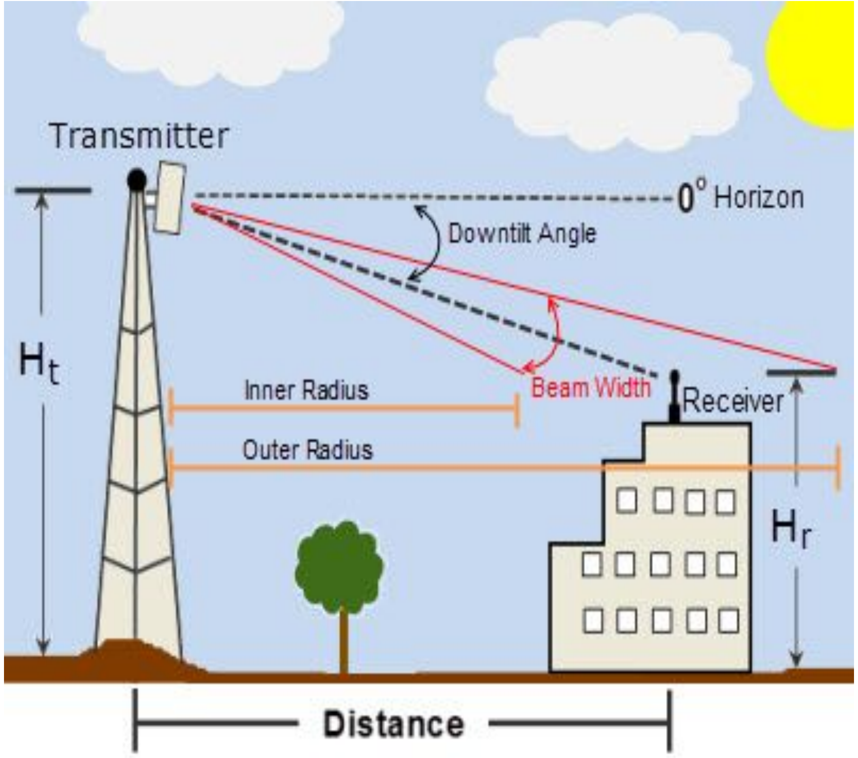
Antenna Tilting Method

Content:

- What is antenna tilt?
- Type of antenna Tilting
- Antenna radiation without tilting
- Methods of tilting
- Mechanical tilting
- Electrical tilting
- RET

Antenna Tilting:

The tilt represents the inclination or angle of the antenna to its axis.



Antenna Tilting:

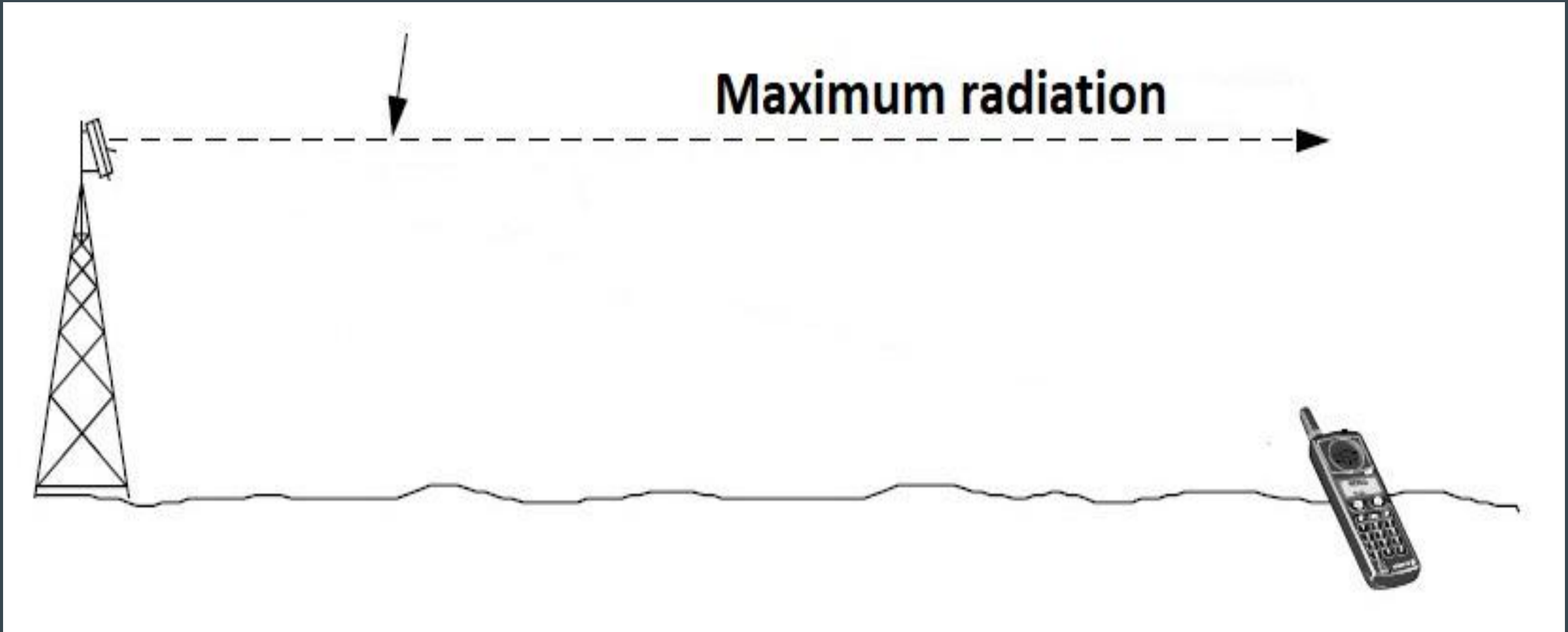
Two type of antenna tilting:

- **Downtilt:** is when the antenna is tilted down and is most commonly used.
- **Uptilt:** is If the inclination is up and rarely used.

Uses of antenna tilting:

- To Reduce interference
- Increase coverage in some specific areas

Antenna Tilting:



Antenna Tilting:

Antenna tilting method:

- Electrical Tilt: This modification is obtained by changing the characteristics of signal phase of each element of the antenna.
- Mechanical Tilt: Tilting the antenna, through specific accessories on its bracket, without changing the phase of the input signal.

Both of the methods are applied together

Antenna Tilting:

- Mechanical Tilting
- With the mechanical tilt, the coverage area is reduced in central direction, but the coverage area in side directions are increased.

Antenna Tilting:

- Electrical Tilting
- With the electrical tilt, the coverage area suffers a uniform reduction in the direction of the antenna azimuth, that is, the gain is reduced uniformly.

Antenna Tilting:

Electrical Tilting:

- The electrical tilt can have a fixed or variable value.
- It is adjusted through an accessory such as a rod or bolt with markings. This adjustment can be either manual or remote (Remote Electrical Tilt)
- RET is a small engine connected to the screw stem/regulator that does the job of adjusting the tilt.

Antenna Tilting:

Remote Electrical tilting:

It is a remote control machine of tower mounted telecommunication equipment.

It optimize the network in real time, save time and cost of visiting also

No specialized manpower or equipment needed.

Microwave Link Components

Content:

- Microwave link
- Microwave Radio unit
- Microwave Transmission Line
- Microwave Antenna
- Microwave Losses

Microwave link:

The length of microwave link depends on:

- The size of the antennas
- Antenna heights
- Allocated frequency to antennas
- Presence of obstacles such as buildings, trees, mountains or tall objects.

Practically, Range of microwave lies between 1 km (about 0.6 miles) and 100 km (about 60 miles) in length.

Microwave link:

Microwave communication system basic building blocks:

- Radio Transmitter
- Microwave Antenna
- Transmission Line

The microwave radio transmitter is connected to a directional antenna via a transmission line.

The Transmitting antenna is aligned with a distant receiving antenna, which is connected to a radio receiver.

Microwave Radio Unit:

Radio Unit:

- It have both transmission (TX) and receiving (RX) capabilities.
- Power usage: about 1 watt of power or less at 30 dBm.
- Throughput range: 100 and 300 Mbps
- Bandwidth :50 MHz (modulation technique)
- Modulation schemes: QPSK (loworder) to 2048 QAM (higher-order).
- Adaptive modulation mostly used to equalized the reliability as well as throughput.

Microwave Transmission Line:

Transmission lines:

Physical media connecting the radio unit and directional antenna

- Coaxial Cable : suitable at frequencies > 2 GHz.
- Waveguide : suitable at higher frequencies.

Microwave Antenna:

The antenna:

- Microwave system use directional antenna having shape of parabolic.
- Focus greater power in single beam
- According to the feed connection the antennas are vertically or horizontally polarized

Microwave Losses:

Path Loss: Cause due to various factors:

- Free space path loss (FSPL).
- Atmospheric absorption
- Diffraction.

Microwave Losses:

Path Reliability: also known as path availability

The path loss caused by the poor weather conditions and reflections or refraction, multipath fading make transmission and reception of signal unsuccessful.

Factor affecting the Path Reliability are:

- Longer Microwave link length
- Area such as flat or terrain surface
- Extremely Hot climates
- More frequent rainfalls

Microwave Losses:

Improvement of Path Performance is done by

- Enhancing transmission power
- Reduction in transmission lines losses
- Enlarging antenna size

Microwave Losses:

Path Reliability Requirement:

- Five nines (99.999 %) is the standard for most wireless operators with 5 minute of downtime per year,
- some applications demand even greater availability such as six nines (99.9999 percent) with 30 seconds of downtime per year.
- Some applications such as email or web page downloads require 99.995 percent availability, with 53 minutes of downtime per year.

Designing Microwave Link

Content:

- Microwave Link design steps

Designing Microwave Link:

Designing the microwave link involves four basic steps:

1. Nominal Design
2. Path Survey
3. Final Design
4. Frequency Planning and Licensing

Designing Microwave Link:

1. **Nominal Design** : This step involves:
   - Set design guidelines
   - Get reading of maximum antenna heights for each site
   - Layout of network routing
   - Analysing the capacity requirements for the link.

   Once an initial routing is determined,

   - Select appropriate frequency band acc. to path length and the design guidelines.
   - use a link design tool to confirm clear LOS along the path.

Designing Microwave Link:

2. **Path survey**:
   - Visit the decided site
   - Calculate the link's Endpoint coordinates and Ground elevation.
   - Analyse site parameters such as electrical power availability and accessibility
   - Take photograph of the site to specify required antenna space
   - Find the presence of obstacles and their dimensions
   - Calculate the antenna height with clear LOS

Designing Microwave Link:

3. **Final design**:
   - Use data from both previous steps and design a link site
   - Decide the particular use of radio equipment
   - Define antenna size, mounting height and type of transmission lines
   - Finalized the site
   - Further check link site for reliability, clearance and capacity.

Designing Microwave Link:

3. **Final design**: Parameters include:
   - End point Coordinate and Ground elevations
   - Radio transmit power
   - Transmission losses and Receive losses
   - Antenna Model
   - Cell Pattern information
   - Filtering information
   - Frequency allocation
   - Polarization

Designing Microwave Link:

4. **Frequency planning and licencing:** involves the selection of
   - Specific frequencies within the band
   - Decide Antenna polarizations
   - Complete licensing as per regulation
   - Detailed interference analysis
   - Frequency reuse

Designing Microwave Link:

Total cost of ownership (TCO): describe the calculation of total costs in an antenna deployment,

This include

- Purchase price of antenna
- Power energy requirement
- Installation and Maintenance costs
- Time expenditure
- Labour cost

Environmental factor affecting Microwave Signals

Content:

- Wind
- Temperature
- Snowfall
- Corrosion
- UV Radiation

Mean Velocity Wind:

Wind load:

The amount of force encounter by an exposed microwave structure due to high speed winds at some height and terrain locations.

Wind load can be calculated using three methods:

1. Numerical simulation of the wind flow
2. Wind tunnel testing
3. Calculation according to standards

Wind Load will increase dramatically at greater height.

Gusty Wind:

Gust Prone area is the area between the two tall buildings, mountain passes and cliff tops.

This create a funnel forming a high speed wind in particular area

These gusts increase winds up to 50 percent above their mean speeds.

Site location investigation include weather report from international and national meteorologist bodies, local weather report agency and report of residents acc to their experience.

Light Winds:

Wind Vibrations:

It is caused when the frequency of antenna structure match approximate frequency(8 Hz) of light wind flowing around.

It affect the structural material of tower as well reduce the operating life of antenna.

Solution: Strut is a stiffening arm installed with a large antenna to improve its stability, accuracy and wind survivability.

Temperature:

Extremely High Temperature: Affect the propagation of radiation and increased signal loss.

Low Temperature: Convert the water vapours into liquid droplet, change signal polarisation in waveguide.

Waveguide must installed and operate in dry condition.

Snowfall:

Snowfall will cause the building up of ice over the antenna

Due to high humid area the antennas are more prone to this effect.

Antennas and their mounts are designed to bear the weight of ice.

But sometimes this ice obstructs the antenna's LOS path.

Solution:

- Flexible fabric radomes provide self shedding
- Rigid planar radomes for smaller antennas.

Corrosion:

The condition that account in the corrosion of antenna structural materials are:

- Airborne salt cause corrosion in sea side antenna installed.
- Pollution from vehicle exhaust in densely populated area corrosion effect.
- In industrial areas, presence of high concentrations of corrosive chemicals in air release by factories, refineries or other sources.

Reduced by using special coating material on antenna as well as over add-on equipment.

UV Radiation:

Expose of microwave antenna to sunlight make it prone to this hazard.

Component made of non-UV-resistant plastic will degrade with UV rays.

Microwave antenna manufacturers specify UV-resistant materials in their products.

They als verify the performance of antenna through rigorous testing.

Microwave System Installation

Content:

- Steps to install microwave system

Microwave Installation:

Steps taken prior the installation of microwave system:

1. Available space for installing tower
2. Fine tuning measurement
3. Rough idea for the orientation of antenna
4. Presence of Clear LOS
5. Find perfect location for strut deployment
6. Find strut vendor-specific tolerance.
7. No turns or bends more than flexibility of the co-cable or waveguide
8. Allowance for potential movement during the alignment process.

Microwave Installation:

1. Assembly and lifting of Antennas:
   - First challenge is Tower mounting.
   - Unpacking and assembling a microwave antenna
   - Read manufacturer instructions carefully to assemble and lift it.
   - Non-specified lifting point will damage the antenna.
   - side struts should be installed with great care.

Microwave Installation:

2. Connecting transmission lines:
    - Install transmission lines without kinking or damage it.
    - Specifications regarding allowable twist degrees per foot or meter of length to waveguide and feeder cable.
    - After making connection, test the VSWR/return loss.
    - Install all electrical grounding connections.

Microwave Installation:

3. Alignment:

   Alignment of two antennas properly is done by analysing:

   - Size and frequency parameters of the antenna
   - Distance between two antennas
   - Clear LOS path between end points
   - Proper calculation of signal strength to confirm alignment.
   - Troubleshoot the system and provide fine tuning.

   The technician uses a map, compass and GPS data to align the antenna.

Microwave Installation:

4. Final step:
   - After antenna alignment completed, properly calibrate the torque wrench to fully tighten all adjusting hardware to the torque values specified on the manufacturer's instructions.
   - Pressurize elliptical waveguide and antenna feed systems as soon as possible
   - Finally, complete the commissioning documentation and keep site secure and tidy by removing all rubbish and packaging materials.

Millimeter Waves

Content:

- What is mm Waves?
- Mm Waves Bands
- Limitation
- Advantages and Requirements

Millimeter microwave (mm Wave):

Microwaves with short wavelengths of 1 to 10 millimeters.

High frequencies up to 300 GHz

Advantage: Offer an efficient and high capacity for microwave links.

In telecommunications, millimeter wave is used for a variety of services on mobile and wireless networks.

It can provide higher data rates up to 10 Gbps.

Millimeter microwave (mm Wave):

There are two bands used in LOS link applications:

- E-band : 10 GHz Spectrum
  Range: 71 GHz to 76 GHz and 81 GHz to 86 GHz
  Used for Microwave Backhaul.
- V-band : 8 GHz Spectrum
  Range: 57 GHz to 64 GHz
  Used for point to point microwave link

Millimeter microwave (mm Wave):

Limitation:

V-band frequencies are readily absorbed by oxygen in the atmosphere, so link lengths are restricted to about one kilometer or less

E-band does not absorb by oxygen it can be used for a link of several kilometers long.

Millimeter microwave (mm Wave):

- Narrow beams minimize the risk of interference at congested link area
- Accessible in location where fiber cannot be installed.
- mmWave antennas support increasing capacity options like dual polarization with the efficient integrated radio configurations.
- This high capacity, high-reuse scheme gives mmWave systems high TCO value.
- Antennas built at high quality standards for high performance and capacity.
- Easy and inexpensive to license.