

SHOOTING MOVING IMAGES OF EARTH THROUGH MICROWAVE HIGHSPEED TRANSMISSION

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DOI: doi.org/10.34293/seamjr-v1i2-004*

Abstract

Modern communication cannot be done without microwave transmission. It employs the electromagnetic waves of high frequency to transmit the data allowing it to operate over the long distance easily. This paper will discuss principles, frequency ranges and uses of microwave transmission particularly in satellite systems. It talks about different frequency bands such as C, X, Ku, Ka, Q, and W, their benefits and shortcomings at different regions and services. It also examines the design and the purposes of the satellite parts which include antennas, transponders, power systems and thermal regulation units which are used in ensuring that communication is constant. As well, the paper explains the applications of passive and active microwave sensors in weather, water, oceanography and environmental surveillance and how they produce valid data under different weather conditions. Although there are advantages to satellite-based transmission using microwave such as the wide geographical coverage, high bandwidth, and ability to survive a disaster, there are also disadvantages such as high initial expenses, delays of signals, and interference with environments. In the future, technologies such as Low Earth Orbit constellations, enhanced signal processing, and quantum communication could be used to reduce the current shortcomings and enhance the efficiency of the system. On the whole, the process of microwave transmission is still one of the most important components of the global connection that is adapting to new technological and social requirements.

Keywords: *Microwave, Earth Orbit, Satellite.*

Introduction

Microwave Transmission

The use of electromagnetic waves through microwave transmission is very crucial. These waves are radio waves of increased frequencies and increased energy. They are used in numerous applications such as the heating of food in the microwaves, cell phone signal transmission and radar systems. Introduction to Microwave Frequencies: Microwave frequencies fall within a given range of frequencies between 300 MHz to 300 GHz. This implies that the wavelength of these are between 1 meter and down to 1 millimeter. Long-distance signals normally need a sequence of repeaters, referred to as a microwave relay network, since they are best executed with a clear sight of the line. Other systems are able to transmit signals further than the horizon using the troposphere but these are expensive and are used on a special basis. Wireless networks and satellite services are some of the new technologies that have altered the way we get TV and radio. Microwave links of larger size are once again becoming common in the connections of mobile towers, although it is not commonly a part of a large relay network.

Microwave Bands in Satellite Communications: Satellite systems use

different microwave frequency bands, each with unique features:

- C-band (4-8 GHz): This band is mainly applied in areas where the rainfall is high like in some parts of Asia, Africa and Latin America. Such bands need huge antennas (1.82.4 meters) which are effective in rainy weather but are more expensive and occupy more space.
- X-band (8-12 GHz): This is mostly applied to military and weather radar. It has a shorter wavelength which creates clearer images which help in identification of the target. Satellite and radio communication is also using it.
- Ku-band (10.9-17 GHz): This is the most widespread band used with satellite services, such as TV, phones, and internet. It has smaller antennas (0.751.8 meters), which can be used in the daily life of Europe and North America, but the signals may be lost in heavy rain.
- Ka-band (26.5-40 GHz): This frequency is suitable to use in internet and data high-speed transfers. Nevertheless, it is more vulnerable to weather conditions, and thus requires sophisticated signal processing.
- Q-band (33-50 GHz): It is thought to be used in 5G because of its data carrying capacity. It is applied in radar and

communication and may be interfered with by weather and interference.

- W-band (75-110 GHz): A very fast frequency band used in sensing and communication.

Key Parts of Microwave Satellites

Microwave Satellite Major Components:
Microwave satellites are made up of a number of parts that collaborate together to transmit and receive signals:

- **Antennas:** These are used to send and receive signals between the satellite and the earth.
- **Command and Data Systems:** These manage the satellite on earth.
- **Guidance and Stabilization:** These keep the satellite in space.
- **Housings:** These are used to shield the satellite against unfavorable conditions in space.
- **Power Systems:** These supply the power required in the running of the satellite.
- **Thermal Control:** These control the temperature to ensure the satellite is not subjected to adverse conditions.
- **Transponders:** These modify and enhance the signals.
- **Microwave Sensors:** These are applied in both passive and active applications of sensing.

Satellite System Architecture: Modern microwave satellites contain several advanced components that work together:

1. **Antenna Systems:** Designed for optimal signal transmission and reception at specific frequency ranges.
2. **Power Management:** They use solar panels and batteries to ensure continuous operation.
3. **Thermal Regulation:** This is essential to prevent parts from overheating or getting too cold in space.
4. **Stabilization Systems:** These help the satellite maintain its position and keep the antenna directed correctly.
5. **Transponders:** These act like repeaters in space, receiving signals, boosting them, and sending them back.

Passive Microwave Sensors

Their operation: These are sensors that pick up naturally emitted microwave energy of objects that are in sight. This energy depicts the level of temperature and moisture of the emitting sources. **Pros:** Due to their longer wavelengths, they can get through clouds, fog, dust, and most rain, and can therefore be utilized in different weather conditions.

Uses:

- **Meteorology:** This is utilized in sending signals and examining the planet at a high altitude, making it possible to trace the speed and direction of ocean winds

(as with the Sea Winds device of the QuikSCAT satellite) or even hurricanes.

- Hydrology: It is a remote sensing technique that is used to monitor the activities of the earth in terms of tectonic activities, location of minerals, erosion and rivers.
- Oceanography: Assists in the study of the interaction of the microwaves with the ocean, which enables monitoring of the coastal water temperature and salt concentration and quantifying the water content in the atmosphere.

Active Microwave Sensors

How They Work: These sensors produce their own microwave to scan things. The most used one is radar (Radio Detection and Ranging). **In RADAR Operation:** Radar, a microwave signal is transmitted to an object and the reflection is listened to. The distance to an object is known by the reflection time and the strength of the returned signal aids in identifying the object.

Advantages:

- Motion and Speed Detection: It has the capability of using the Doppler Effect (the change in frequency of waves) in establishing speed and direction of moving things.

- Works in All Conditions: It is used in the light and dark condition, and it passes through glass and even walls.
- Longer Range: It is able to see objects at a farther distance as compared to the ultrasound systems.
- Safe: It does not cause harm to human beings or animals.

Types of Radar Sensors

- Doppler Radars: These are detectors that apply the Doppler Effect in order to know the speed of an object at different distances.
- FMCW Radar Sensors: These change their frequency in the form of a triangle wave with time with the aim of determining distance.
- The Doppler Effect: This is when the frequency of the wave is altered by the movement of the source of the wave or the observer. It is named after the Austrian physicist Christian Doppler and implies that as the source approaches the frequency rises and vice versa.

Advantages of Satellite Microwave Transmission

- Wide Coverage: Ability to cover wide areas particularly in sparsely populated areas.
- Fast speed: Supports fast data transmission.

- **Wireless and Mobile Communication:** It is used to provide communication arrangements that are not based at a location.
- **Multipurpose Applications:** It can be used in numerous applications such as the mobile world, personal business networks, long distance telecommunication, weather prediction, television broadcasting, military intelligence, navigation, connecting the remote locations, and division of television signals.
- **Security:** This is normally safeguarded with the help of the coding and decoding devices.
- **Consistent Service:** One provider is capable of providing consistent service.
- **Long Distance Economical:** Saves on expenses where it is used over a long distance.
- **Simple to install and to maintain:** It is easy to set up, as well as maintain and is not very costly.
- **Fast Relocation:** Earth stations can be moved rather fast in the case of an emergency.
- **Easy Ground Station:** Ground stations are easy to set up and maintain.
- **Propagation Delay:** This is the delay associated with the transmission of signals to the satellite (270320 milliseconds) that may result in echoes when people talk on the phone.
- **Difficult to Service:** It is difficult to troubleshoot a satellite in orbit.
- **-Environmental Interference:** Signals may be interfered with by adverse weather or sunspots.
- **Frequent Maintenance:** Satellites should be checked regularly to ensure that they are in the right place.

Disadvantages of Satellite Microwave Transmission

- **Large Startup Costs:** Construction, deployment and insuring of satellite can be very expensive.

Microwave Sensing Technologies

Passive Microwave Sensors: These are sensors that receive naturally occurring microwave emission on the surface and the atmosphere of the earth. They can see through clouds and this can be advantageous to them in:

- **Weather Forecasting:** Surface winds of the ocean (as with the QuikSCAT satellite).
- **Environmental Surveillance:** Soil moisture, ice cover and atmospheric water vapour.
- **Disaster Response:** Availing dependable data at any time of the day and night, irrespective of weather conditions.

Active Microwave Sensors (Radar): Here microwave pulses are emitted by a sensor in

order to get detailed images and measurements:

- Doppler Radar: Tracks storm systems and checks the wind speed.
- Synthetic Aperture Radar (SAR): Produces high-resolution maps of the land - Special Skills Can work both during the day and night, is able to see through vegetation and detect small changes in the surface. Doppler Principle in Modern Uses Christian Doppler discovered in 1842 regarding the change in frequency in accordance with motion that is now crucial to:

Weather Radar: This is helpful in the process of tracking the rain and speed of the wind - Speed Enforcement: This is used to check the speed of cars by the police.

Astronomical Observation: Provides an insight into how stars and planets move Benefits and Disadvantages of Satellite Microwave Systems Advantages that make people use these systems.

Wide Coverage: It is able to cover geographical areas that are hard to cover with land based systems.

- Rapid Implementation: Ground stations can be established within a short time in case of crisis.
- High Bandwidth: Handling of massive data and video- Disaster Readiness:

Enables communication when everything goes wrong.

Ongoing Challenges:

- Delay Problems: Delays of 270-320 ms are a worry with applications that were supposed to be attended to urgently.
- Position Keeping: The satellites have to be constantly corrected to maintain their position.
- Space Debris: An augmentation of space junk connotes.

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IEEE 2012 IEEE 9th International Conference on Mobile Ad-Hoc and Sen