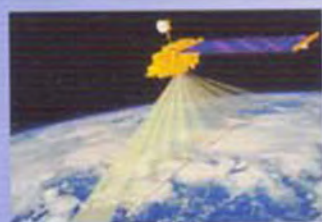




# MICROWAVE REMOTE SENSING

OPN Calla



**Defence Research & Development Organisation**  
Ministry of Defence  
India

# **MICROWAVE REMOTE SENSING**

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## OPN Calla

Director  
International Centre for Radio Science  
Jodhpur



**Defence Research & Development Organisation**

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## **PREFACE**

The radio frequency spectrum is divided into different regions known as High Frequency, Very High Frequency, Ultra High Frequency, SHF and also in microwave, millimeter waves, sub-millimeter waves, etc. The frequency range from 3 GHz to 30 GHz is known as microwaves and millimeter waves range from 30 GHz to 300 GHz. This part of radio spectrum has different applications. These are in (a) communication, (b) remote sensing (c) medical, and (d) industries. The choice of the frequency depends upon the type of application. In this monograph, the remote sensing applications of the microwaves have been dealt with.

The unique capabilities of microwaves like all weather, day and night, sensitivity to soil moisture and ability to penetrate soil and vegetation etc., make the microwave remote sensing capable of having stand-alone application in some areas of oceanography, land and atmospheric applications. For other applications, microwave remote sensing complements as well as supplements other techniques of remote sensing.

The fundamental parameter for microwave remote sensing is the dielectric constant of the material on which other electrical parameters like emissivity and scattering coefficient depend. The information about dielectric constant, emissivity, and scattering coefficient is obtained by measurement of these parameters as well as by estimation using the theoretical models. For microwave remote sensing, the knowledge about these three electrical parameters of the target material is extremely important.

The designing of sensors for microwave remote sensing depends on the emissivity for passive sensors, and scattering coefficient for active sensors. The passive sensors include radiometers, both imaging and non-imaging types. The active sensors are imaging radar, altimeter, and scatterometer. The knowledge of sensors, platform, data products, and applications of microwave remote sensing will provide great inputs for national development. This monograph will serve to those who will be interested in microwave remote sensing.

February 2009

OPN Calla  
Director, International Centre for Radio Science

## **ACKNOWLEDGEMENTS**

At the outset I would like to thank Director, DESIDOC for giving opportunity to ICRS for preparing a monograph on Microwave Remote Sensing. This monograph reflects the contribution of many scientists.

The material was collected, collated, and arranged into chapters and into headings, subheadings with each chapter for logical flow of the material and chapters were written and rewritten till it took a final shape. The author gratefully acknowledges Mr Rajesh Vyas who helped in editing the monograph, Mr Dinesh Bohra, and Mr Sanjeev K Mishra and others who had helped in preparation of the monograph.

The valuable help of Mr Pradeep Mathur, Mr Vikas Parihar, Mr Vinod Panwar, Ms Ultra Purohit and Mr Hari Singh in preparation of this monograph is gratefully acknowledged.

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# Chapter 1

## Introduction to Microwave Remote Sensing

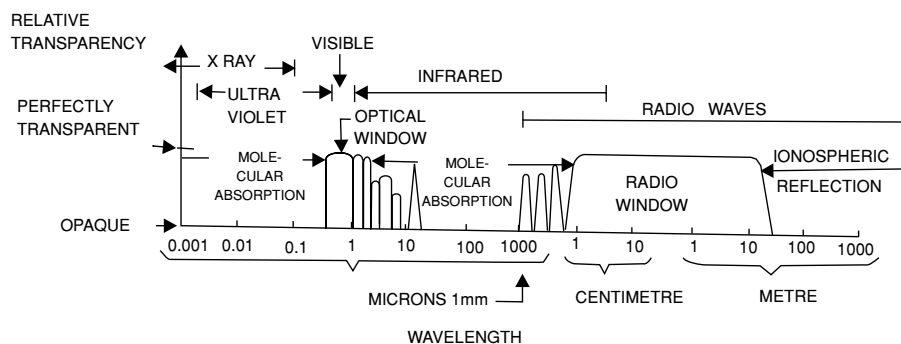
### 1.1 INTRODUCTION

Remote sensing has diverse applications and it has been identified as a technique with good potential to help the nation's economic growth and solve some of its problems. These include better management of natural resources through wasteland mapping, identifying flood-prone areas, water in catchments areas, assessment of situation of reservoirs, estimating forest area, and prediction of crop yield and scarcity of resources etc. The electromagnetic spectrum with different wavelength bands has applications in diverse areas. With increase in demand for natural resources, non-availability causes scarcity and one has to identify the factors behind these. For this, the conventional methods are not adequate, remote sensing can play an important role in solving these problems.

Remote sensing can be applied in areas like prediction of climatic conditions, rainfall, cloud cover, etc., and to help identify the areas covered by clouds, and other physical parameters. In cloud covered areas, i.e., during *kharif* season when crops get affected and yield prediction of wheat is difficult, and on crops like groundnuts, coffee, tea etc., which require high rainfall remote sensing can play a vital role. During rainy season, another area of concern is flood. Flood wreck havoc for many years. Movement of clouds could not be predicted as the clouds restrict the observation by conventional methods. Observation is not possible during night so one needs sensors which can work in night as well as in cloud covered areas.

### 1.2 ELECTROMAGNETIC SPECTRUM

The applications of remote sensing depend on the choice of frequency. The Radio Regulations of International Telecommunication Union limit the term radiowaves to electromagnetic waves of frequencies arbitrarily lower than 3000 GHz. For both active and passive microwave remote sensing, different parts of radio spectrum is used. Figure 1.1 gives the electromagnetic spectrum.



**Figure 1.1. Electromagnetic spectrum showing relative transparency of the earth's atmosphere and ionosphere<sup>1</sup>.**

The Table 1.1 gives the radio spectrum starting from Extremely Low Frequency (ELF) to Extremely High Frequency (EHF) and from myriametric waves to sub-millimeter waves. This spectrum extends from 30 GHz to 3000 GHz. Different portions of radio spectrum have different applications.

The microwave spectrum is from 0.3 GHz to 30 GHz and millimeter wave spectrum ranges from 30 GHz to 300 GHz, the sub-millimeter wave spectrum is from 300 GHz to 3000 GHz. For utilisation of these spectra for various applications, it is split into different bands.

The nomenclature of the bands with frequencies is given in Table 1.2 and the nomenclature for bands adopted by US Military in 1970 is given in Table 1.3.

**Table 1.1. Part of the electromagnetic spectrum**

Frequency bands	Wavelength	Descriptive designation
30–300 Hz	1000–10000 km	ELF
3–30 kHz	10–100 km	Myriametric waves–VLF
30–300 kHz	1–10 km	Kilometric waves–LF
300–3000 kHz	100–1000 m	Hectometric waves–MF
3–30 MHz	10–100 m	Decametric waves–HF
30–300 MHz	1–10 m	Metric waves–VHF
300–3000 MHz	10–100 cm	Decimetric waves–UHF
3–30 GHz	1–10 cm	Centimetric waves–SHF
30–300 GHz	1–10 mm	Millimetric waves–EHF
300–3000 GHz	0.1–1 mm	Sub-millimetric waves

## *DRDO Monographs/Special Publications Series*

### *About the Author*

Prof OPN Calla, presently working as Director, International Centre for Radio Science, completed his BE and ME from Rajasthan University. He started his career in 1962 from Atomic Energy Establishment and INCOSPAR where he was involved in R&D activity. In 1970, he was appointed as Head, Electronic Division of Microwave Antenna System Engineering Group (MASEG) and Secretary, MASEG. He joined Indian Space Research Organisation (ISRO) in 1972 where he served in various capacities such as Head, Microwave Division, Chairman, Communications Area of Space Application Centre, and Principal Investigator for 13/18 GHz Millimeter Wave Propagation Studies using ATS-6 satellite.

As Principal Scientist, he was responsible for development of Satellite Microwave Radiometer, one of the primary payloads of Bhaskara-I & II Satellites. He was Project Director of various prestigious projects like Satellite Telecommunications Experiment Project using Symphonic satellite, UNDP/ITU Projects of ISRO. This project included propagation study at frequencies above 10 GHz, and facility augmentation of Space Applications Centre.

During his tenure, he organised and presided over many conferences of international and national repute. He has published more than 200 papers in national/international journals on satellite communications, microwave remote sensing, delivered invited papers/lectures, and also wrote six books.

### *About the Book*

Microwave Remote Sensing deals with the applications of Microwave Remote Sensing. The monograph describes the unique properties of microwaves which enable stand-alone applications in Oceanography, Topography, and Atomistic fields. For achieving optimum results, the theoretical principles and parameters like emissivity and scattering coefficient and dielectric constant are described.

The designing of sensors, their types, and platforms used for remote sensing are described. A detailed information about radiometers is given under passive sensors and radar altimeter, and scatterometer is given under active sensors with their operational as well as technical details. On the whole, the monograph would prove useful for students of microwave remote sensing.

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