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Study of Millimeter Wave Scattering from Ground & Vegetation at 35 GHz

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Abstract— ***In the present work, a measurement study is undertaken to quantify the attenuation caused due to tree canopies, at 35 GHz. Now when the frequency is increased the attenuation is increased but there is a less attenuation atmosphere window at 35 GHz. So if the devices having the working frequency near about 35 GHz is taken then communication will be effective.***

It becomes necessary to study the microwave attenuation & Scattering due to Desert foliage & ground. In this investigation, the behavior of wave propagation through coniferous tree, ground & obstacles stands at 35 GHz is characterized Both theoretically and experimentally. An outdoor measurement system will be setup and used for characterizing the channel behavior at 35 GHz.

I. INTRODUCTION

A. *Concept of wave propagation*

Radio propagation is the behavior of radio waves when they are transmitted, or propagated from one point on the Earth to another, or into various parts of the atmosphere. Like light waves, radio waves are affected by the phenomena of reflection, refraction, diffraction, absorption, polarization and scattering.

Radio propagation is affected by the daily changes of atmosphere condition. Understanding the effects of varying conditions on radio propagation has many practical applications, from choosing frequencies for international shortwave broadcasters, to designing reliable mobile telephone systems, to radio navigation, to operation of radar systems.

II. WAVE PROPAGATION ATTENUATION

A. *Vegetation in surrounding*

In a point to point radio communication link, attenuation due to foliage becomes an important factor at frequencies approaching millimeter wavelengths.

This attenuation is due to scattering and absorption of the transmitted wave as it propagates through areas of vegetation. The transmission losses are influenced by parameters such as the dielectric constant, density, physical size, and shape of the foliages.

In the case of attenuation by trees and bushes the incident electromagnetic field is mainly interacting with the leaves and the branches. The trunk does of course also have some influence on the attenuation but since the volume occupied by the trunk is much smaller than the total volume of a tree. In the case of wave propagation between antennas that are located on heights it will in principle only be the upper part of the tree crown (canopy) that affects the attenuation [2]

B. *Scattering*

If the size of an obstacle is on the order of the wavelength of the signal or less, scattering occurs. An incoming signal is scattered into several weaker outgoing signals.

At typical cellular microwave frequencies, there are numerous objects, such as lamp posts and traffic signals that can cause scattering. Thus, scattering effects are difficult to predict.

The production of waves of changed direction,or polarization signal strength when radio waves encounter matter.

Space scattering:-

It takes place only on the border surface between two different but homogeneous media, from one of which E-M energy is incident on the other. Scattering of microwave on the ground surface increases according of complex permittivity, and the direction of scattering depends on the surface roughness.

III. PREDICTION MODELS

A. *Foliage Loss*

As compared to the analytical works (mainly based on Radiative Energy Transfer (RET) theory and Wave theory) for the foliage loss predictions at the microwave and millimeter waves, there are much more empirical studies in the literature, and therefore they will be focused in the following part. Later, the analytical method will be introduced.

Analytical Method

Physics-based models to predict the foliage loss have attained significant prominence recently. As discussed by Bertoni in [4], either Radiative Energy Transfer (RET) theory or wave theory can be used to develop a proper physics-based model.

In the following, the developments of the foliage loss model with both the theories are introduced

1. Radiative Energy Transfer Model

2. Wave Theory Based Model

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IV. SYSTEM HARDWARE

The block diagrams of the transmitter and receiver sections of the millimeter wave system configured for operation at 35GHz. The millimeter wave link system comprises a continuous-wave (CW) 35 GHz transmitter using a 100 mW Gunn source with a transmitting antenna of 18 degree beam width and 22 dB gain. The transmitter has provision for modulating the RF carrier with 1 KHz square wave baseband signals from the carrier multiplex equipment. The modulated signal radiated through rectangular horn antenna connected to transmitter with rectangular waveguide and the modulating signal detected at receiver side. The transmitter transmits a maximum power of 20 dBm. The signal received by the horn antenna identical to the transmitter is down converted to the intermediate frequency (IF) followed by a cavity mixer with a local oscillator operating at 34 GHz.

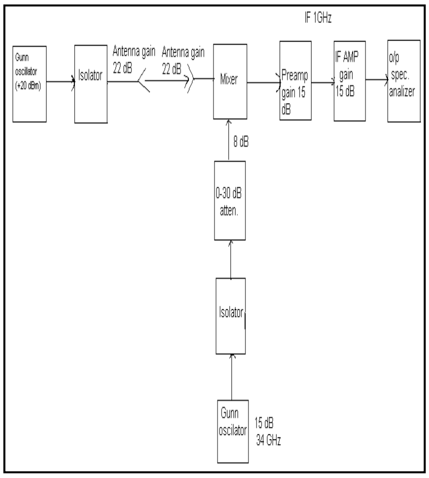

Fig1: Block Diagram of 35 GHz Link System

The IF of 1 GHz output of the mixer is fed to a pre-amplifier followed by a driver amplifier. The amplified IF signal is displayed on a spectrum analyzer (Micronics 3.3 GHz). The spectrum analyzer set in the auto mode shows both received power in dBm and central peak spectrum. The zero-span spectrum analyzer also allows the received power and spectrum to be saved into a laptop computer.

V. RESULTS OF ATTENUATION MEASUREMENT DUE TO FOLIAGE

A. Foliage Result

At 35Ghz, the estimation of foliage caused attenuation is extremely significant for the planning of a radio-link. The size of the leaves, branches and trunks, the distribution of leaves, branches and trunks and the height of the tree relative to the antenna heights are the factors that influence the propagation through vegetation. The presence of foliage in the propagation channel can lead to severe signal attenuation.

B.Attenuation measurement for different foliages of approximately same size canopy

In this case, the above mentioned foliages of approximately same size were chosen for attenuation measurement. Table presents the measured data and shows the maximum attenuation 13.4 db by Neem foliage among the foliages under test. This could be attributed to thick leaves and density distributed branches of Neem. On the other hand, the Ker offers minimum signal loss 2.8 dB, which perhaps due to its thin slender leaves among all the trees.

Link Distance= 80 feet
Temperature= 26·C
Received Power without Storm = -8.0d dBm
Stand Position= Center between Transmitter & Receiver
Canopy Size= Height 1.5m & depth 1.2m
Transmitting Antenna Height = 1.5m
Receiving Antenna Height = 1.5m

Table I: Attenuation for Different Foliage

Name of Tree	Botanical Name	Received Power (-dBm)	Attenua-tion(db)
No Tree		-8.0	0.0
Neem	Metha azadircta	-21.4	13.4
Kiker	Acacia nilotica	-11.6	3.6
Ker	Capparis deciduas	-10.6	2.6
Khejri	Prosopis cineraria	-12.4	4.4
Arandi	Riccnus communis	-12.6	4.6
Aak	Calotropis procera	-12.2	4.2

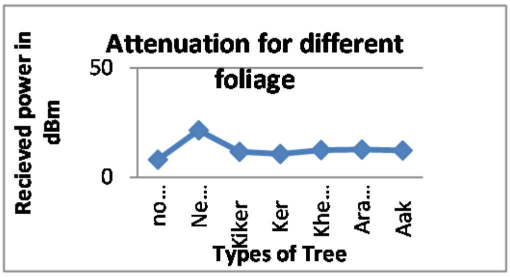

Fig 2: Attenuation for Different Foliage

VI.CONCLUSION

We design an algorithm for power saving on the transmitter saves the power when environment changes. The algorithm can be used for other atmospheric condition like rain, sand dust & humidity.

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