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Reflection studies of Millimeter wave (35 GHz) by foliage in desert region of Thar, India

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Abstract:
Fifth generation communication systems are designed on base signal of millimeter wave. Millimeter wave range offers broad spectrum for various application. The only limitation for uses of millimeter wave is molecular absorption which totally depends on environmental conditions of local area. In Thar desert, foliage and vegetation are in least amount and environment is with less humidity which supports application of millimeter wave for military and civilian purposes. In this paper an attempt is made to represent the data which can be useful in designing RADAR or any other signal reflection-based system. A transceiver outdoor setup is used for measurement of reflected signal by different foliage types grows in desert. Five different foliage types are chosen for experimentation, and it is observed that Neem tree which have leaf size in order of wavelength of 35 GHz signal, reflects least signal as it attenuates it in most. About 19.1 dBm and 17 dBm signal is get back by receiver when placement of receiver is on 15^0 right and 15^0 left from transmitter. Maximum signal is reflected by Peepal tree which have larger leaf size. About 21.3 dBm and 21.2dBm of signal strength is received back at right and left sides of transmitter. Cumulative modelling of reflected signal is very complex as it depends on various environmental factors and specific foliage type. Above presented data will be useful for designing system based on millimeter wave.

Keywords: Millimeter wave, Foliage, Reflection

I. INTRODUCTION

Reflection is the phenomenon which characterize any signal to be used for various application like RADAR, traffic control, communication etc. Technology growth leads lower frequency spectrum to be fully exhausted in coming few years and this inspires scientistfor inspection of upper spectrum range. Millimeter wave range is prone to molecular absorption which restrict its use for long distance communication butstrong possibility of its uses in short distance LOS communication.Foliage and vegetation are one of the main obstacles which may interrupt signal. According to Majeed and Tjuata. foliage not only introduces attenuation and broadening of the beam but also depolarization of the electromagnetic wave[3]. Gary Comparetto in 1993 concluded that foliage is shown to be extremely imparting with signal attenuation of the order of 3 to 4 dB per meter of foliage [4].Kajiwara (2000) investigated attenuation characteristics of foliage and the effect of swaying foliage on an obstructed channel where the result at 5 and 29.5 GHz were compared in order to perform a relative evaluation of the attenuation characteristics. He reported the obstruction of line of sight path by foliage causes significant propagation attenuation at 29.5 GHz, while the attenuation at 5 GHz is relatively small as compared with 29.5 GHz because of less diffraction loss through leaves. It has also been found that attenuation is likely to depend on the leaf size, the total area of leaves and humidity of climate. Further in obstructed channel by foliage, swaying foliage in wind causes a significant channel fading at 29.5 GHz. The fading depends on the velocity of wind, tree species, foliage density, humidity of climate and leaf structure

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and vary approximately 15 dB which is much larger than that for 5 GHz. This is because the motion of leaves is comparable to a wavelength of 29.5 GHz, thereby resulting in a significant effect on obstructed channel.[12]. Vegetation attenuation and ground reflectivity was examined by various scientist with various angles of incidence. T. S Rappaport, S. Deng observed 0.4dB/m of attenuation by foliage and reflection by ground on millimeter wave of 73GHz [1]. Nashashibi *et al*. (2004) and Wang (2005) reported that the main goal of foliage concealed target detection is to develop means to interrogate electromagnetically, a composite scene of target under vegetation in such a manner as to either penetrate the canopy without corrupting the phase and amplitude of the return from the target of interest or use the return from the canopy itself to establish the distortion matrix for the effects of the clutter and subsequently account for these effects in order to electromagnetically defoliate the scene.[10]. Experimentation by Godara in Thar desert concluded thatNeem attenuate signal maximum if compared with other type of foliage[2].Purohit*et al.* (2012) described the use of radar system to measure the attenuation through trees and the bistatic scattering pattern of tree foliage. The data were found to be in good agreement with a first-order multiple scattering models. Measurements were also made to study the angular variations of the bistatic scattering coefficient of a smooth sand surface, a rough sand surface, and a gravel surface. Reflection by foliage may also limits the use of millimeter wave for RADAR operation. In this paper an attempt is made to analyze part of signal reflected by different foliage types in Thar desert. Reflection by different kind of foliage depends on various factors like leaf size, water contents of leaves, branch distribution of foliage, leave density etc so observed values by experimentation represents a complex function of above said parameters. In this paper conclusion is related with leaf size as it plays major role in case of short wavelength.

II. EXPERIMENTAL SETUP AND FOLIAGE SPECIFICATION

An outdoor tans-receiver setup is established in Engineering college Bikaner which is situated in Thar desert of India. Trees of almost similar height, similar canopy size are chosen for reflection measurement. Sight of experimentis a desert region where vegetation is very low and most of the foliage have thorns. Bikaner is situated on international border of India and Pakistan where RADAR applications have their own importance regarding defense purposes.As applications which uses millimeter wave have to be designed on local environmental basis, presented data can be useful.Following is the specifications of leaf size of foliage taken for experimentation-

Table 1 Specification of foliage types

Name of Foliage	Botanical Name	Average Leaf length Size (in cms)
Aadu	*Prunus persica*	7
Khejari	*Prosopis cineraria*	2.5
Ber	*aZizyphusmauritian*	3
Neem	*Methaazadircta*	5
Peepal	*Ficus religious*	13

Above chosen foliage types have natural plantation in desert. Foliage types with relatively different leaf size is chosen so that effect of size can be quantified.

Experimental setup is consisting of transmitter and receiver system.At the transmitting end 100 mW millimeter wave signal is generated by Gunn diode which is fed to horn antenna(18^{o}degree beam width and 22 dB gain.) followed by an isolator to protect Gunn diode from environmental signals. The transmitter has provision for modulating the RF carrier with 1 KHz square wave baseband signals from the carrier multiplex equipment. Transmitting capacity of whole transmitter setup is up-to 20dBm.

At the receiver's side signal received by horn antenna is processed by mixer. A34 GHz signal is locally generated to mix with received signal so that resulting 1 GHz signal is amplified and analyzed by spectrum analyzer.

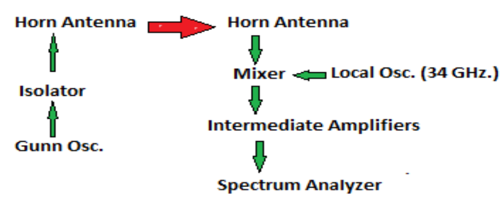

Figure 1 Flow graph representation of experimental setup

Figure 2 Transmitter and Receiver

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Approximately same size of trees are marked and reflection measurement will be done using following topology-

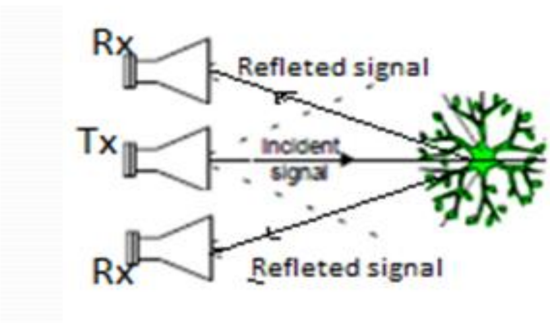

Figure 3 Topology for measurement

III. OBSERVATIONS

Observations taken by placing transmitter on distance two meter more from radius of canopy and receiver will be placed 15^0apart in left and right directions from transmitter.

Following is the environmental conditions at time of observation-

Temperature-36^0 C

Humidity- 9 %

Antenna Height- 4.2 meters

Bias Voltage -2.49 Volts

Atmospheric Pressure- 1013 mBar

Table 2 Received and Reflected signal for different foliage

Foliage Type ⇨ / Parameters (in dBm) ⇩	Khejri	Neem	Aadu	Ber	Peepal
Free Space signal at 0^0	106.3	106.3	106.3	106.3	106.3
Signal Received at 0^0	81.5	83.4	79.4	81.2	78.9
Reflected at 0^0	24.8	22.9	26.9	25.1	27.4
Free Space signal at 15^0 Left	104.6	104.6	104.6	104.6	104.6
Signal Received at 15^0 Left	4.2	85.6	84.2	83.5	83.4
Reflected Signal at 15^0 Left	20.4	19.0	20.4	21.1	21.2
Free Space signal at 15^0 Right	103.9	103.9	103.9	103.9	103.9
Signal Received at 15^0 Right	85.3	86.2	84.8	84.3	82.6
Reflected Signal at 15^0 Right	18.6	17.7	19.1	19.6	21.3

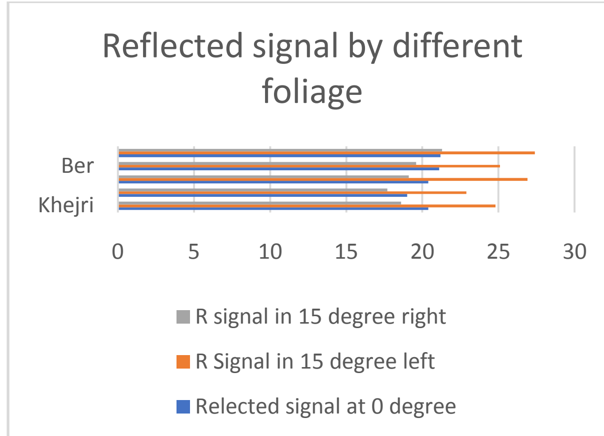

Figure 4 Reflection signal of different foliage

IV. CONCLUSIONS

From previous studies on 35 GHz , it was concluded that attenuation by Neem tree is maximum in desert region of Thar and the reason behind it is the size of neem tree leaves are of order of 8mm(wavelength of 35 GHz.) From above observations it can be concluded that minimum reflection of 35 GHz signal is by Neem tree as signal get attenuated by Neem tree leaves. Maximum reflection of 35 GHz signal is by Peepal tree. Above data presented will be helpful in designing application of 35 GHz signal for RADAR or traffic control system or in any other field in which reflected signal carries information.

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