Attenuation Due to Foliage Depth at 35 Ghz Prevailing in Desert Region of India

Indu Bhuria, Rajeev Pourush, D. R. Godara

Abstract- Communication window, ka-band (28 to 42 GHz) is to be investigated for the various developing applications. In 5 G communications all the devices are being developed to use millimeter wave as medium of propagation as rest of the spectrum is getting exhausted day by day. 35 GHz frequency can be used to characterize the whole band. For LOS communication foliage is one of the main obstacle which can attenuate the signal. In this paper an attempt is made to specify the rate of attenuation due to cumulative effect of atmospheric gases and foliage in depth on the basis of observational studies. In autumn season, rate of attenuation up-to five trunks is 0.154 dBm per feet and it decreases to .062 dBm per feet if signal prevails through fourteen trunks. Similarly, if signal propagates through canopy area then rate of attenuation is 0.22 dBm per feet for first five tree canopies and it decreases to 0.095 dBm per feet as foliage depth increases to fourteen canopies. For spring season, rate of attenuation for first five canopies is 0.179 dBm per feet and for eleven canopies rate becomes 0.140 dBm per feet. This decrement in rate of attenuation is due to coherent interplays of field component due to collective scatterers. Rate of decrement suggests that there is possibility of 35 GHz to be used for communication applications. Attenuation in autumn is observed to be lesser then in other seasons as leaves density which can offer multiple scattering of field components is less.

Index Terms: Attenuation; Foliage depth; LOS communication; Scattering; Millimeter wave

I. INTRODUCTION

Communication scientist are seeking for a band which can support high rate and can provide high channel capacity. Frequencies above 10 GHz are prone to molecular absorption. Kurtz above band (Ka band) ranges from 28 to 42 GHz can be a good option to fulfill requirement of increasing applications in communication technology. 35 GHz signal can be used to characterize full Ka-band. Attenuation due to foliage depth varies with seasons as molecular absorption varies due to environmental changes. The size of leaves, the distribution of leaves, leaf density, branches and trunks, wind speed, dielectric constant and the height of the tree relative to the antenna heights are the factors that attenuate the signal when propagating through foliage.

Attenuation of millimeter wave depends on atmospheric condition of the propagating region. With uniform planting of trees Schwring's experiments at 9.6 GHz, 28.8 GHz and 57.6 GHz attenuation up to 30 meters was 2 dB/m and then it decays to 0.5 dB/m for further distance.[2]. In studies at 35 GHz by Dr. D.R Godara it was concluded that if coniferous tree of same kind and same height are taken as experimental sight for measurement of attenuation due to foliage depth , the rate of attenuation after 5 feet depth is 1.28 dB/ft and after 25 feet it become 1.052 dB/ft.[10]

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 [7] . The depth of the foliage to impart the attenuation, in 1968 by P.L.McQuate J.M.Harmanthat is the attenuation per meter, is believed to decrease as the distance through foliage increases because some of the energy travels above the tree tops and is thus unaffected by the trees [11]. In above reports there is variation in attenuation in accordance with the place of experiment carried. The only similarity is the rate of attenuation which decreases with depth of modulation. As our studied are carried out in desert area which have lesser moisture in air and lesser natural vegetation and plantation, signal attenuation of millimeter wave is also observed less than previously observed values in other regions of world.

In this paper attenuation, due to foliage depth in autumn season is presented which agrees with previous research work on millimeter wave propagation. According to previous studies rate of attenuation by foliage in depth decreases with distance which is conflicting the conventional scattering theory. Conventional theory of scattering says that scattered particles are independent of each other but if scatteres are in collective form like bunch of tree leaves then there will be correlation between scattered field which is responsible for decrement in attenuation rate.

II. EXPERIMENTAL SET-UP AND OBSERVATIONAL SIGHT

Outdoor observations are taken in western region of Rajasthan, India which is considered as part of Thar desert. Neem Trees (*Methaazadircta)* which are planted on equal distance of 5 feets with each other and are of relatively same age and same canopy distribution with average leaf size of 5 cms in length and 1.5 cms in breadth are taken as attenuation measurement sight. Continuous planted trees are having average height of 5 meters with average trunk height of 2.7 meters. So, for attenuation measurement due to trunk, antenna height is kept 1.86 and for canopy attenuation measurement antenna height is taken 3.75 meters. Neem (*Methaazadircta)* trees are grown in desert areas due to its medicinal properties and its survival with very little water.

Observations are taken by in facing transmitting and receiving antennas keeping a tree in between the line-of-sight of both antennas. Then increasing number of trees by step size of one.

Revised Manuscript Received on December 22, 2018.

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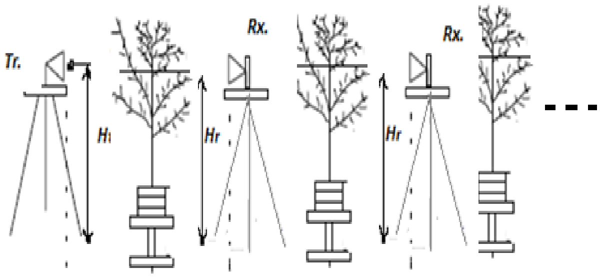

Figure 1 Topology of Observational set-up

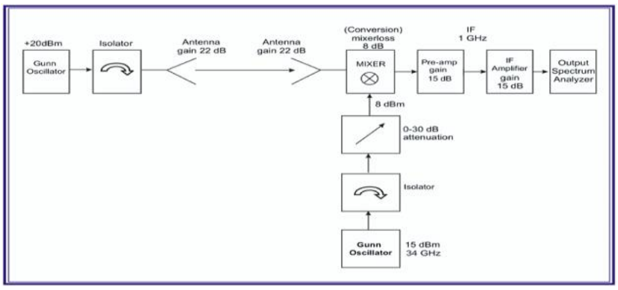

Figure 2 Block Diagram of Experimental Set-up

An outdoor experimental set-up consists of a transmitting horn antenna and a Gunn oscillator of 100mW, an isolator between oscillator and antenna to protect antenna from unwanted received signals. At receiving end, a mixer is fed with locally generated 34 GHz signal and signal of 35 GHz received by horn antenna. Finally signal of 1 GHz at output of mixer amplified by pre- amplifier then by IF amplifier of 15 dB gain of each amplifier. Amplified signal fed to analyzer for spectrum analysis. Down conversion of 35 GHz frequency to 1 GHz is done to make analysis simpler by commercial spectrum analyzer. Antenna height is calculated by taking care of Fraunhofer's and Fresnels zone.

III. OBSERVATIONS AND RESULTS

Autumn Season
(a) Across trunk-
Temperature: 24-degree C.
Wind speed: 5 Kmph.
Humidity: 25%
Antenna height: 1.86 mtr.
Distance between Tx & Rx: Adjustable
Power Received without any obstacle: -35 dBM
Bias voltage: 2.54 volt.
Bias current: 0.54 A

Table 1 Attenuation with No. of Trunks

Trunk No.	Distance b/w transmitter and receiver (in meters)	Received Power (In dBm) Across trunk	Attenuation (Atmospheric + due to foliage in depth
1	4.8	-55.2	20.2
2	9.6	-61.5	26.5
3	15.7	-64.4	29.4
4	21.8	-64.7	29.7
5	26.6	-68.7	33.7
6	32.7	-69.5	34.5
7	38.8	-69.5	34.5
8	45.5	-69.9	34.9
9	53.1	-69.9	34.9
10	57.9	-69.9	34.9
11	62.8	-69.9	34.9
12	67.7	-70.3	35.3
13	73.1	-71.2	36.2
14	78.5	-71.3	36.3

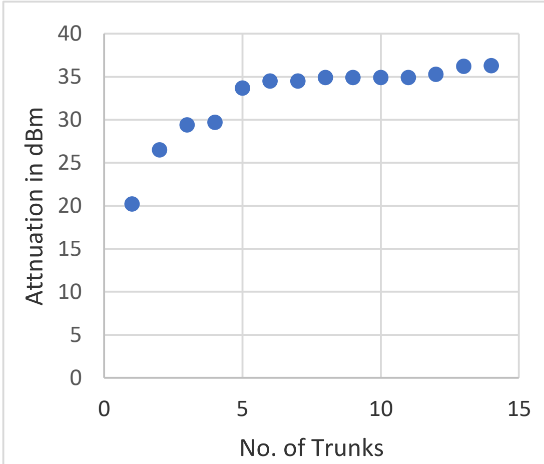

Figure 3 Attenuation Vs. No. of Tree Trunks

(b) Across Canopies-

Environmental conditions for attenuation measurement are same as for trunk but there is difference in antenna height.
Antenna height: 3.75 mtrs.
Distance between Tx & Rx: Adjustable
Power Received without any obstacle: -35 dBm
Bias voltage: 2.54 volt.

Table 2 Attenuation with No. of Tree canopies(Autumn Season)

Canopy No.	Distance b/w transmitter and receiver (in meters)	Received Power (In dBm)	Attenuation in dBm(Atmospheric + due to foliage in depth)
1	4.8	-50.1	15.1
2	9.6	-56.3	21.3
3	15.7	-61.4	26.4
4	21.8	-63.5	28.5
5	26.6	-69.3	34.3
6	32.7	-69.3	34.3
7	38.8	-69.4	34.4
8	45.5	-70.5	35.5
9	53.1	-71.1	36.1
10	57.9	-70.5	35.5
11	62.8	-70.9	35.9
12	67.7	-74.7	39.7
13	73.1	-74.7	39.7
14	78.5	-74.8	39.8

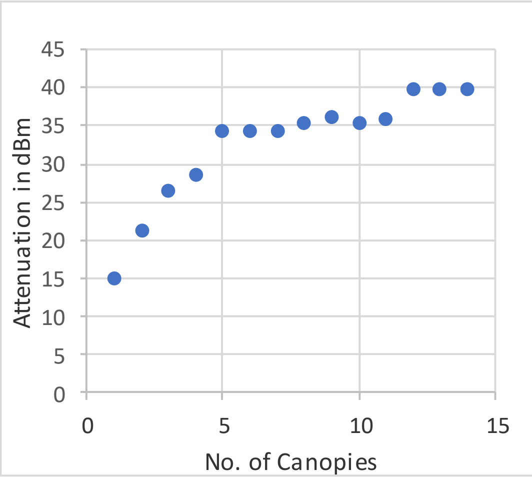

Figure 4 Attenuation Vs. No. of Tree Canopies

(c) Spring season-
Across Canopies

Temperature: 32-degree C.
Wind speed: 17 Kmph.
Humidity: 35%
Antenna height: 3.75 mtr.
Distance between Tx & Rx: Adjustable
Power Received without any obstacle: -35 dBM
Bias voltage: 2.54 volt.
Bias current: 0.54 A

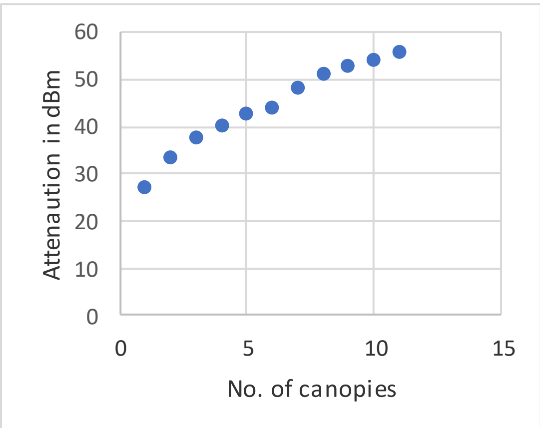

Figure 5 Attenuation Vs. No. of Tree Canopies

After eleventh canopy, received signal strength become weak to observe or in other words signal was not received due to attenuation by dense leaves.

As season at the time of observation is autumn the leave density is very less, main component of scattering of signal will be by branches of trees.

In rainy season attenuation is assumed to maximum due to absorption of signal by water droplets similarly in spring attenuation offered by foliage is observed to be more as compared with autumn because of the full leave density. Attenuation after few hours of rain decreases as dust particles get removed by rain but water droplets on tree leaves can absorb most of the signal and causes severe attenuation.

Table 3 Attenuation with No. of Tree canopies (Spring Season)

Canopy No.	**Distance b/w transmitter and receiver (in meters)**	**Received Power (In dBm)**	**Attenuation in dBm(Atmospheric + due to foliage in depth)**
1	4.8	-62.1	27.1
2	9.6	-68.4	33.4
3	15.7	-72.7	37.7
4	21.8	-75.3	40.3
5	26.6	-77.8	42.8
6	32.7	-79.2	44.2
7	38.8	-83.3	48.3
8	45.5	-86.4	51.4
9	53.1	-88.1	53.1
10	57.9	-89.3	54.3
11	62.8	-91.0	56
12	67.7	-	-

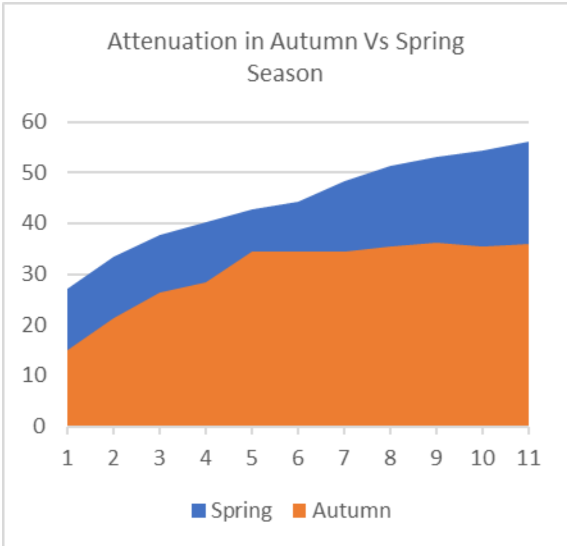

Figure 6 Attenuation in Autumn Vs Spring season

IV. CONCLUSION

In autumn season, rate of attenuation up to 5 trees is 0.154dBm per feet but as foliage depth increases rate of attenuation decreases to average .062 dBm per feet when signal propagated through trunks.

For canopy, attenuation rate is 0.22 dBm and 0.179 per feet up-to five trees for autumn and spring seasons respectively, but as foliage depth increases rate of attenuation decreases to average 0.095 dBm per feet for fourteen canopies in autumn and 0.140 dBm per feet for eleven canopies in spring. Average attenuation by canopy region of tree is relatively higher then trunk due to multiple scattering due to canopies.

Above results shows that rate of attenuation decreases as foliage depth increases, this is due to the coherent interplays of field due to scattering as scatterers are collective in nature.

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