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Free Space Path Loss Statistics of 35 GHz Wave Prevailing in Desert Region of India

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Abstract: Free space path loss equation derived from Friis transmission relations is verified and validated for lower frequency range. At higher frequencies with wavelengths in millimeters, Friis equation lose its validation as the gap between experimental and theoretical values of loss are huge. About 28.02 dB of difference in every value of loss is been observed. In this paper an attempt is made to present the comparison between the theoretical and observed losses at millimeter wave based on free space loss equation. Behavior of curve for theoretical and observed values of loss is almost similar. The represented data can further be used for advance modelling and approximation of FSPL at millimeter waves.

1. INTRODUCTION

The free space path loss is the loss in signal strength that introduces when an electromagnetic wave travels over a line of sight path in free space. For the lower frequency ranges free space path is defined by a formula which is derived from Friis transmission equations, which says that free space loss is inversely proportional to square of wavelength and directly to square of distance between transmitter and receiver.

$$\text{FSPL} = (4\pi d/\lambda)^2 \text{ dB}$$

where d is distance of separation, f is frequency and c is speed of light. In above equation antenna gains of transmitter and receiver are assumed to be unity.

As applications in communication engineering are enhancing daily it will lead a search for spectrum which can support large bandwidth and high data rate. A communication window at Ka band says that the range from 28 GHz. to 42 GHz have comparatively less atmospheric attenuation as compared with another millimeter wave regime. At higher side of microwave frequencies molecular absorption is the big factor which can attenuate the signal severely. Attenuation offered to millimeter wave is variable in accordance with different environmental conditions. Loss of signal in desert region is assumed to be least due to lack of moisture. Free space losses at 35 GHz are observed by using a trans receiver set-up are very much lesser by calculated theoretical free space loss equation.

2. EXPERIMENTAL SET-UP AND OBSERVATION SIGHT

A transmitter receiver setup used for measurement of attenuation of signal at 35 GHz is consist of major three blocks –(a)Transmitter – It consists of a horn antenna of 22 dBi gain which is fed with signal from a Gunn diode source of 100mW. An isolator is placed between source and antenna to protect source from receives noise signal from air. (b) Receiver-Receiving horn antenna of 22 dBi gain receives the signal and processes it towards mixture. Heart of receiver section is mixture, which down converts 35 GHz to 1 GHz by using locally generated signal of 34 GHz. Intermediate signal of 1 GHz is amplified and then is given to spectrum analyzer (c) Spectrum analyzer- It analyses the signal up-to range of 3.3 GHz and measure the power of received signal.

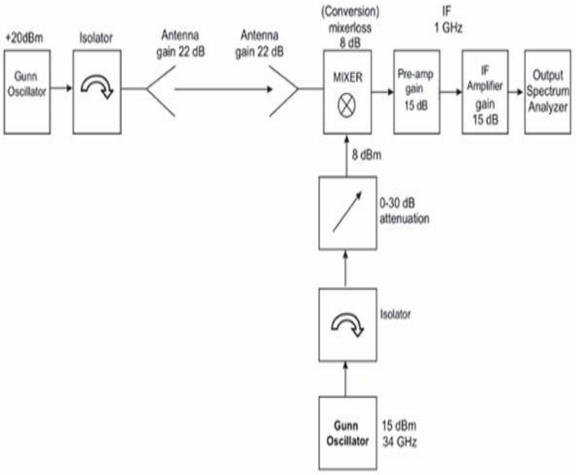

Fig.1 Block diagram of Experimental Set-up

Observations are taken at campus of government engineering college, Bikaner, Rajasthan, India. This college is situated at western part of India and the region is known as Thar desert. Climatic conditions of observational sight can be considered as dry.

3. OBSERVATIONS

For free space loss observations, transmitter is placed rigid while receiver is moved to variable distance with step size of 5 meters. Following are environmental conditions during experimentation

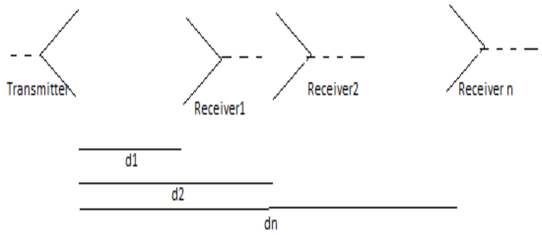

Fig.2 Topology for Attenuation Measurement

Temperature-	320 C
Humidity-	63 %
Wind Speed-	16 Km/Hr
Pressure-	1003 mBar
Bias Voltage-	3 V
Bias Current-	0.58 A
Visibility-	Up-to 16 Km
Antenna Height-	1.84 Meters

TABLE I. EXPERIMENTAL OBSERVATION

DISTANCE D (in meter)	**OBSERVED ATTENUATION (dB)**
5	11.3
10	14.1
15	15.3
20	15.7
25	16.1
30	16.9
35	21.3

4. THEORETICAL VALUES AND COMPARISON

Friis transmission equation is defined as –

$$\text{FSPL} = P_t/P_r = (4\pi d)^2/(GtGr\lambda^2)$$

In above equation d is distance of separation between transmitter and receiver while λ is wavelength. Gt and Gr are antenna gain of transmitter and receiver respectively. For 35 GHz signal, value of λ is 8.8 millimeter. By varying distance starting with 5 meters and then with step size of 5 meters and considering antenna gain as 22 dBi, following are the calculated values of loss:

TABLE II. THEORETICAL AND EXPERIMENTAL LOSSES

DISTANCE d (in meter)	**CALCULATED Loss (in dB)**	**OBSERVED ATTENUATION (dB)**
5	33.3	11.3
10	39.32	14.1
15	42.84	15.3
20	45.34	15.7
25	47	16.1
30	48.86	16.9
35	50.20	21.3

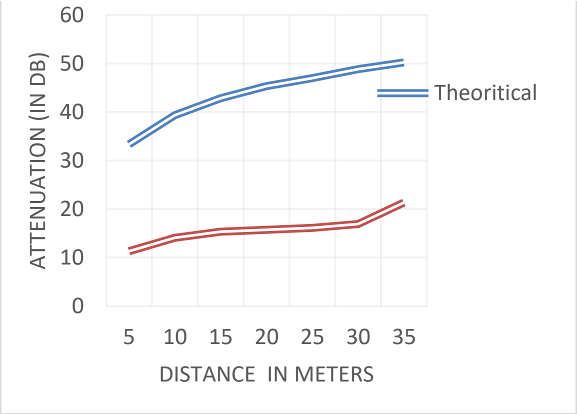

Fig. 3 Theoretical vs. Experimental Losses

5. CONCLUSION

Free space loss equation is well defined and is validated many times for lower radio frequency ranges. Huge difference between experimental and theoretical values of free space loss at 35 GHz suggests that the equation derived by Friis transmission equation does not validate free space loss at millimeter wave range. The curve behavior for observed and calculated values is same. Approximately average difference of 28.02 dB is seen at every step of distance. Presented data can further be used for advance research and modeling.

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