SIGNAL ATTENUATION MEASUREMENT OF DAILY VARIATION IN FOG AT BIKANER REGION

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ABSTRACT

Millimeter-wave has attracted a great deal of interest from academic, industry, and global standardization bodies due to a number of attractive features of millimeter-wave to provide multi-gigabit transmission rate. The desire to obtain the greatest information rate allowed by the communications technology of the day seems insatiable. Even where there is a clear view of the satellite from the ground station, a range of meteorological phenomena still combine to make propagation impairment a serious problem. So it becomes necessary to study the microwave attenuation due to meteorological parameter such as fog. Line-of-sight (LOS) attenuation at 35GHz was measured at Bikaner (N73º19'E28º1'.) for fog (2013-14). The measurement was made with the intent of highlighting microwave signal attenuation due to Harmattan in daily variation weather conditions. The results are presented in terms of mean signal level and fog attenuation. The observed attenuation values due to Harmattan (fog) and the calculated (using Altshuler's model) are in fairly good agreement. This shows that microwave LOS link in this region and regions with similar climatic characteristics are prone to signal degradation as well as fading in the Harmattan season. The study is being conducted in Bikaner (Rajasthan).

Keywords: Radio Link, Fog, Visibility, Fog Attenuation, Daily Variation, EM Waves.

I. INTRODUCTION

Electromagnetic waves are a form of energy waves that have both an electric and magnetic field. Electromagnetic waves are different from mechanical waves in that they can transmit energy and travel through a vacuum. Electromagnetic waves are classified according to their frequency. Influence of atmospheric refraction on the propagation of electromagnetic waves has been studied from the beginnings of radio wave technology (Kerr, 1987). It has been proved that the path bending of electromagnetic waves due to inhomogeneous spatial distribution of the refractive index of air causes adverse effects such as multipath fading and interference, attenuation due to diffraction on the terrain obstacles or so called radio holes (Lavergnat & Sylvain, 2000). These effects significantly impair radio communication, navigation and radar systems [1].

In [2], it is described that fog forms from the condensation of atmospheric water vapor into water droplets that remain suspended in the air. Fog is suspension of very small microscopic water droplets in the air. Fog forms during early morning hours or night when radiative cooling at the earth's surface cools the air near the ground to a temperature at or below its dew point in the presence of a shallow layer of relatively moist air near the surface. The characterization of fog is based on water content, optical visibility, temperature and drop size distribution [3]. In [4], the types of fog, strong advection fog, light advection fog, strong radiation fog, and light radiation fog is mentioned. Attenuation in the foggy days may cause significant anomalous attenuation for radio relay links in climatic regions such as semi-desert terrain. Radiation fog which is more pertinent to semi-desert climate during night is formed as a result of ground becoming cold at night and cooling the adjacent air mass until super saturation is reached. This necessitates analyzing the impact of the fog on radio relay line of sight communication link [5].

Fog is defined as a water droplet density that restricts the visibility to less than 1km where advection fog is caused by a horizontal movement of a warm air mass over cold water and radiation fog is caused by the cooling of air overnight (often occurs over rivers and swamps). Significant limitations of the radio wave propagation are due to fog, i.e. small water particles in the air, especially when close to the land surface. The presence of these particles causes the scattering of the light and therefore the reduction of the visibility. Fog droplets rarely have diameters larger than 0.1 mm so the Rayleigh approximation is valid throughout essentially the whole millimeter wavelength region [6].

II. METHOD FOR CALCULATING FOG ATTENUATION

There are various methods to determine fog attenuation, however calculation methods are extensively used. In [7], a radiation fog model was discussed in detail considering description of interaction between microphysical structure of fog and atmospheric radioactive transfer. In [3], the various methods for calculation of fog attenuation pertaining to microwave and millimeter wave frequencies were discussed. In [8], model describing attenuation due to clouds and fog expressed in terms of water content was discussed. In [9], under foggy air conditions the propagation properties of millimeter wave and microwave frequencies were discussed. In [9], it is mentioned that attenuation due to fog is a complex function of the density, extent, index of refraction and wavelength. An empirical formula to calculate fog attenuation in the microwave and millimeter wavelength regions can be obtained by [6], [10]. The observed attenuation values due to Harmattan (fog) and the calculated (using Altshuler's model) are in fairly good agreement.

$$\mathbf{Fa= L_D [0.0372\ \lambda_t + 180/\ \lambda_t - 0.022\ T - 1.347]\ Db\ Km^{-1}} \qquad (1)$$

Where F_A is attenuation in (dB/km), L_D is liquid water content in (g/m^3), λ_t is wavelength in mm, and T is temperature in degree Celsius (° C). The relation in Equation (1) is valid only if 3 mm<λ_t<3 cm and -8 ° C < T < 25 ° C. The liquid water content L_D is given in terms of visibility in Km, when fog density data are not available but visibility data are available[6],[11].

$$\mathbf{L_D = (0.024/V)^{1.54}\ g^{-3}} \qquad (2)$$

Where V is the visibility in km and L_D is the liquid water content in g/m3. The definition of visibility is given in [3], which define visibility as the greatest distance at which it is just possible for an observer to see a prominent dark object against the sky at the horizon. The visibility is also defined as that distance from an observer at which a minimum contrast ratio C between a black target and a bright background is equal to C=0.02 [12].

III. EXPERIMENT SETUP

The block diagram of the transmitter and receiver sections of the 35GHz system are shown in figure1. The millimeter wave link system comprises a continuous wave 35 GHz transmitter using a 100 mW (20dBm) Gunn source with a transmitting antenna of 18 degree beam width and 22 dB gain. The receiver section has the requisite down conversion and de-spreading circuitry. The signal received by the horn antenna is down converted to the intermediate frequency (IF) followed by a cavity mixer with a local oscillator operating at 34

GHz. The IF of 1.0 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. The spectrum analyzer shows both received power in dBm and central peak's frequency. The spectrum analyzer also allows the received power and spectrum to be saved into a laptop or computer. Receiver is capable of providing a useable base band output with received millimeter wave signal levels as low as -80 dBm.

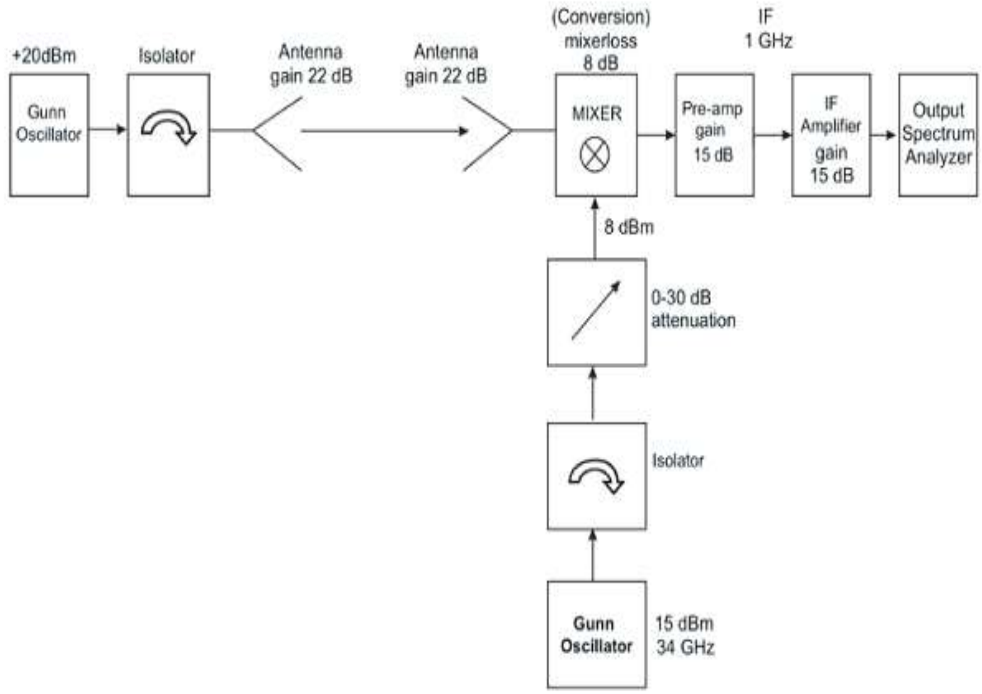

Fig1. Block Diagram of 35 GHz Link System

IV. CLIMATIC CONDITIONS OF BIKANER

The climate in Bikaner is characterized by significant variations in temperature. In the summer season it is very hot when the temperatures lie in the range of 28–48.5°C (82.4–119.3 °F). In the winter it is fairly cold with temperatures lying in the range of 5–23.2 °C (41.0–73.8 °F). Extreme summer heat of up to 50 °C and winter cold as low as 1°C. May and June are hottest; December and January are coldest. During winters, temperatures in some areas can drop below freezing due to waves of cold air from Central Asia. There is a large diurnal range of about 14°C (25.2 °F) during summer; this widens by several degrees during winter.

V. DATA BASE

The recorded signal strength data were statistically computed into hourly averages for 2 days. The radio signal data used for this analysis are for the days 2 January 2013 and 24 January 2014. The field strength variations were recorded for daily behavior at the receiving end, Lagos daily on 24 hours basis. The period was classified as follows:

• Period of measurement : 1 am to 12 pm

Information on some meteorological parameters like air temperature, relative humidity and water vapour pressure during the fog season i.e. harmattan (Nov-Feb) were obtained from the daily visibility records.

Gunn Voltage = 3.87 Volt

Current = 0.53 Ampere

IF frequency = 1.08GHz

Reference Level = -12dBm

Height of Transmitting and Receiving Antenna = 1.5m

Fog occurs only in clear sky natural condition signal level = -52 db & attenuation is increased by variation factor additive to clear sky level condition.

VI. OBSERVATIONS

Table 1-Daily Variation of 2 January 2013

Sr. No.	Time	Visi (Km)	M g/m^3	Temp (°C)	Fog Att.(Db/Km) Calculated	FogAtt.(Db/Km) Measured
1	1:00 am	.5	.009	10	.177	.3
2	2:00 am	. 5	.009	12	.177	.3
3	3:00 am	.5	.009	12	.177	.3
4	4:00 am	.2	.038	10	.750	.8
5	5:00 am	.2	.038	12	.748	.9
6	6:00 am	.2	.038	10	.750	.9
7	7:00 am	.2	.038	12	.748	.9
8	8:00 am	.2	.038	13	.748	.9
9	9:00 am	.5	.009	13	.177	.3
10	10:00 am	.2	.038	10	.750	.82
11	11:00 am	.5	.009	13	.177	.36
12	12:00 am	.5	.009	15	.176	.4
13	1:00 pm	.5	.009	15	.176	.4
14	2:00 pm	.5	.009	16	.176	.4
15	3:00 pm	.5	.009	15	.176	.34
16	4:00 pm	1	.003	16	.058	.2
17	5:00 pm	1	.003	16	.058	.34
18	6:00 pm	1	.003	15	.058	.34
19	7:00 pm	1	.003	16	.058	.34
20	8:00 pm	1	.003	16	.058	.34
21	9:00 pm	1	.003	13	.059	.34
22	10:00 pm	1	.003	12	.059	.4
23	11:00 pm	1	.003	12	.059	.4
24	12:00 pm	1	.003	12	.059	. 4

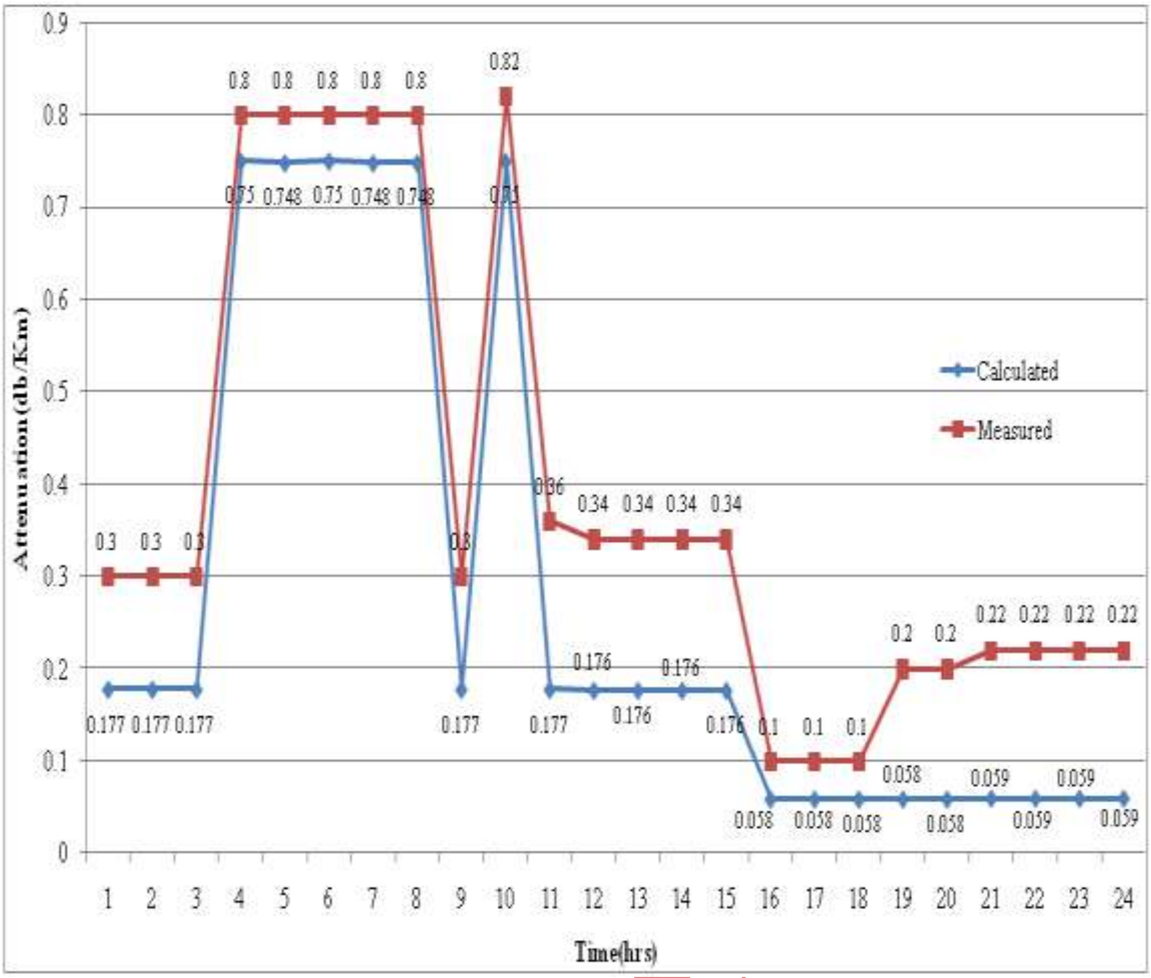

Fig 2. Daily Variation Graph of 2 January 2013

Table 2-Daily Variation of 24 January 2014

Sr. No.	Time	Visi (km)	M	Temp	Fog Att.(db/Km) Calculated	Fog Att.(db/km) Measured
1	1:00 am	.2	.038	10	.750	0.9
2	2:00 am	.2	.038	11	.742	0.9
3	3:00 am	.2	.038	10	.750	0.92
4	4:00 am	.05	.322	11	6.28	6.52
5	5:00 am	.05	.322	11	6.28	6.52
6	6:00 am	.05	.322	12	6.34	6.6
7	7:00 am	.05	.322	13	6.33	6.6
8	8:00 am	.05	.322	12	6.34	6.6
9	9:00 am	.05	.322	11	6.28	6.4
10	10:00 am	.5	.009	12	.177	0.3
11	11:00 am	.5	.009	12	.177	0.3
12	12:00 am	.5	.009	13	.177	0.3

13	1:00 pm	1	.003	15	.058	0.2
14	2:00 pm	1	.003	15	.058	0.2
15	3:00 pm	1	.003	16	.058	0.2
16	4:00 pm	2	.001	18	.0196	0.04
17	5:00 pm	2	.001	18	.0196	0.04
18	6:00 pm	2	.001	13	.0196	0.04
19	7:00 pm	2	.001	14	.0196	0.03
20	8:00 pm	2	.001	14	.0196	0.04
21	9:00 pm	2	.001	13	.0196	0.04
22	10:00 pm	2	.001	12	.0196	0.04
23	11:00 pm	2	.001	12	.0196	0.04
24	12:00 pm	2	.001	12	.0196	0.04

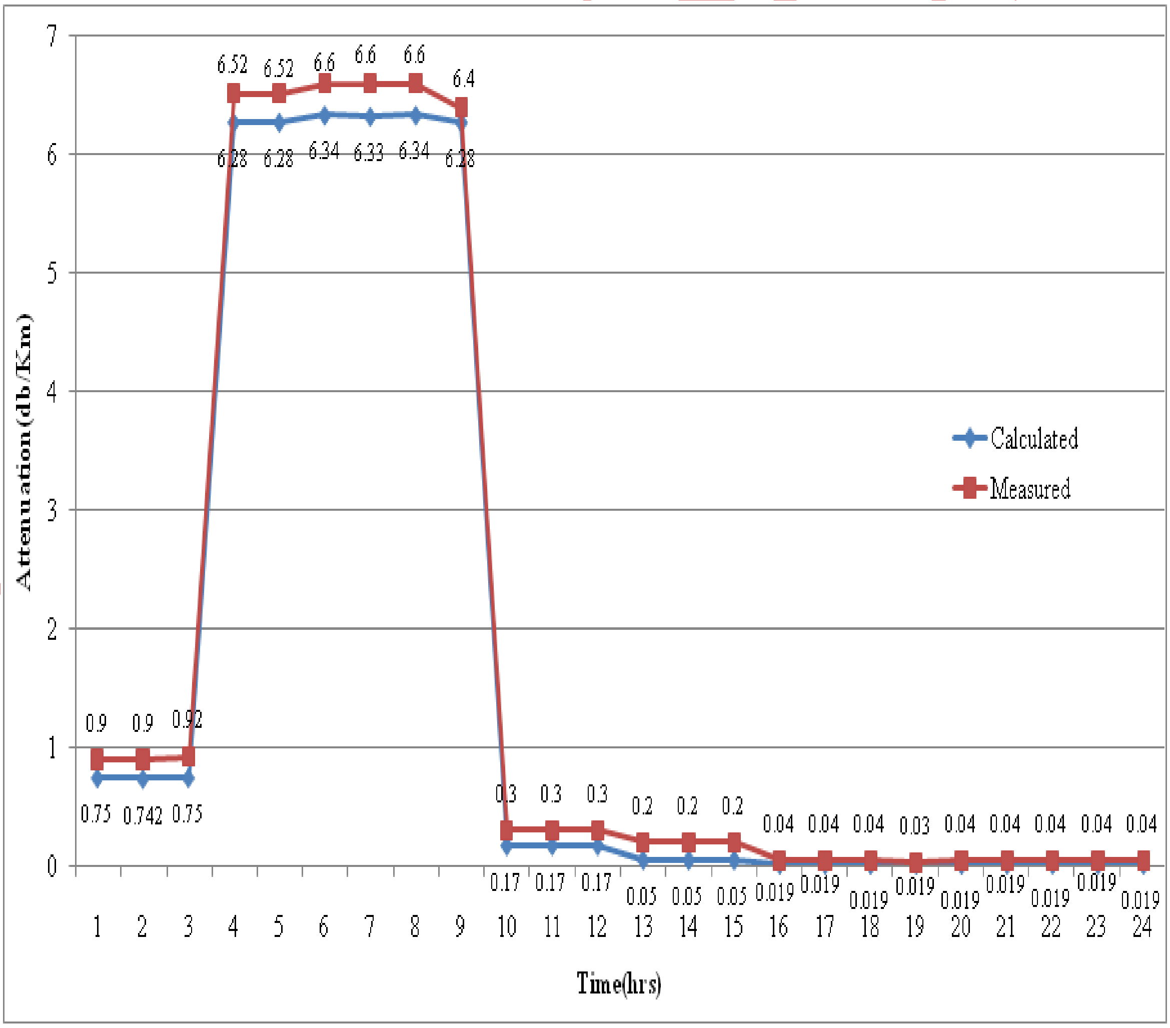

Fig 3. Daily Variation Graph of 24 January 2014

VII. CONCLUSION

Figure 2 and 3 shows that during the daily variation of the Harmattan (FOG), the amplitude variation of the signal is much higher at night and early hours of the day compared to late hours of day. In the days of Harmattan, the average signal in 2013 is 0.3 to 0.2 dB while in 2014 the variation however, appears low i.e. 0.9 to 0.04 dB. The calculated fog attenuation in 2013 lie between 0.177 to 0.059 dB while in 2014 is 0.750 to 0.0196 dB. From this we conclude that measured and calculated results seem approximately equal. The measured results are also following the altshuner equation. Due to fine sand particles very less and unpredictable changes are observed in atmosphere. Sometimes when temperature is higher and visibility is less the attenuation observed is constant. It was concluded, that the temperature and M are the most significant factors for effecting attenuation. The link reliability can be improved by increasing the transmission power or using high gain directional antennas in the cases when the foggy conditions occur and the visibility is less than 600 meters.

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