EFFECT OF RAIN ON SATELLITE TELEVISION TRANSMISSION

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ABSTRACT

Heavy rainfall has a strong negative impact on the transmission and reception of satellite television signals. This is due to the propagation effect caused by absorption of the wave signal by atmospheric rain. This work investigates the impact of rain on satellite television transmission and reception processes. This investigation was actualized from the analysis of the data obtained for the values of rainfall rate in the eastern part of Nigeria for a period of 3 years. The frequency of operation of interest is the KU band frequency; which could relatively be applied to other satellite frequency band within the specified range (12GHz-18GHz). Simulations were carried out with Matlab software. The graphical results presented the attenuation of signals obtained against rain rate values. The simulation results reveal that; attenuation increases with increase in frequency bands on high rain rate. The significance of this study is relevant for satellite TV providers to understudy the consequence of the result and take adequate measures to avoid signal interference during heavy rainfall.

Keywords: Satellite TV transmission, attenuation, interference, rain rate.

INTRODUCTION

Satellite signal transmission in the Ku and Ka band is highly affected by heavy rainfall; as such signals are susceptible to high level of attenuation. Satellite television transmission is indeed an important area of communication as many individuals seek for clear reception in their received TV signals. There is no doubt that poor TV signal reception is observed during heavy rains (Obiyemi O. and Ibiyemi T). This action bridges the decimation of information by way of scrambling the received signal. Rain has been seen as a major source of interference on signal propagated for satellite communication at frequency above 10GHz (Nweke 2015). In Akobra S. et al, other than rainfall, the effect of Hamartan, sunshine and cloudy weather are investigated on the Ku band for digital satellite television system. It was shown that; of all the adverse weather conditions, rainfall still remains the greatest source of attenuation on signal propagated. Investigation into the impact of rain on the satellite television transmission is a necessity for service providers to ensure adequate signal transmission during poor weather conditions [Imarihiagbe C.G and Ojeh V.N. 2018]. Rainfall can affect the transmission of electromagnetic signals in several ways; as system noise increase, signal attenuations, miss alignment loss, ionospheric losses, fixed atmospheric loss etc (Robert 2000). In Lee and Winkler 2011, investigation on the impact of rainfall on signal quality of a high speed link for video streaming activity was performed on the Ka band. The outcome implies that rain attenuation was not peculiar to the Ku band alone. Satellite transmission involves the passage of radio wave in the space between transmitting and receiving stations (Merriam 2017). The transmission process uses satellite for relaying television programs. Recent advances in satellite transmissions based on digital television system has led to the drastic increase in the utilization of Ku-band frequency in many ways including direct to home broadcast arrangements (Sanjeev, et al., 2013). Communication satellites receives communication signal from a transmitting ground station, amplifies the signal and possibly processes it. The satellite further transmits the signal back to the earth for reception by one or more receiving ground

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stations. In satellite television transmission principle, the satellite microwave systems transmit signals between directional parabolic receiving dishes. They use low gigahertz frequencies and line of sight communication. The satellite transmission involves transmission power and receiver power which covers link power budget. In Liolls K. P. et al., other factors aside rainfall which is a major propagation impairment with respect to mobility include ; multipath effects , shadowing and blockage. A relationship between mobility and rainfall effects were established. In Barthes L and Mallet C 2013, a low cost microwave device was developed to measure average rain rate in a dedicated earth satellite link. The impact of rain as part of losses encountered in transmission system can also be estimated from statistical data. Thus, the thrust of this research is to analyse the impact of rain specifically on the Ku frequency band for satellite TV transmission. The essence of this work is to determine the rain rate against attenuations as well as measure signal strength at different periods or range of time. The deduced data are simulated and indications pointed out that attenuations increase sharply as rain rate increases.

The impact of rain does not only cause attenuation of satellite signals but also affects the cost of signal propagation from the transmission station. This is because; there will be need for increase in transmitting power of the equipment in compensation for loss caused by rain. Research also shows that, Rain attenuation causes a greater power requirement from the transmitting units which results into higher cost per bit of transmission (Eze et al., 2014). Investigation has also shown that at high frequencies, the wave length becomes significantly shorter, these short wavelengths are easily absorbed and scattered as they pass through raindrops (Siva, et al., 2012). This is principally the major reason for which rain signal cause detoriation of the received signal.

During heavy rainfall, signal transmission at frequencies greater than 10GHz leads to a noticeable degradation in the quality of the signal. This is as a result of the direct relationship between frequency and the proportional amount of rainfall commonly known as "rain fade" (Jalal, 2015). It is therefore important to state that, an idea of rain attenuation rate in a given location is necessary to structure out a reliable communication network in such location.

METHODOLOGY

Investigation on the impact of rain on satellite television signal transmission was considered in the Ku frequency band. The information on the rain fall was sourced from the Nigeria Meteorological Agency (NiMet). The data obtained was for a period of three years. This includes the rain rate for different months of the year, rain attenuation and measured signal values. This information was obtained for Owerri North local government area of Imo state in the eastern part of Nigeria. These parameters can be obtained by using reliable equipments which include; digital stop watch, coaxial connecting cable, digital radio frequency power meter for signal strength, parabolic reflector antenna with a known gain, rain gauge and compass. Simulations were performed with the data obtained using MATLAB software. The result showed the relationship between rain rate and signal attenuation on the Ku band frequency as the frequency increases.

III RESULT

The parameters of the equipment used in obtaining the required measurement are specified in table 1.

The attenuation rate values as against the rain rate values were collated as seen in table 2. Matlab was used to perform the simulation to obtain results for various parametric considerations.

Table: 1. Table of values for parameters of measuring tools (Ezeh G. N. et al, 2014).

S/N	PARAMETER	VALUE
1	The satellite in space	Astra 2B (Multi TV Satellite) at 28.2° East
2	Frequency of the downlink signal	12.527 GHz
3	Polarization of the signal	Horizontal
4	Antenna elevation angle	42°
5	Latitude of site	5.28° North
6	Longitude of site	7.03° East
7	Height of antenna	2.9 m
8	Altitude of site	91.44 m
9	Antenna gain	35 Db
10	Antenna diameter	0.6 m

Table 2: Experimental result for rain rate and rain attenuation [Ezeh G.N et al 2014]

S/N	RAIN RATE	RAIN ATTENUATION VALUE (Q-P)	MEASURED SIGNAL
1	154	15.62	36.88
2	150	15.68	36.82
3	142	15.60	36.90
4	136	15.64	36.86
5	128	15.42	37.08
6	120	15.12	37.38
7	112	14.54	37.96
8	104	14.07	38.43
9	92	13.10	39.40
10	86	12.39	40.11
11	72	10.73	41.77
12	64	9.62	42.88

Rate is measured in mm/h. The signal power, Q measured under normal condition (absence of rainfall) was recorded as 52.5 dB.

Rain attenuation values of hourly rain fall rates in the month of August 2010

RANK	RAIN RATE (mm/h)	FREQUENCY (GHz)	RAIN ATTENUATION (dB)
1	154	2	15.6275
2	152	4	15.6525
3	150	1	15.6708
4	149	7	15.6774
5	147	6	15.6856
6	146	7	15.6871
7	145	9	15.6869
8	143	5	15.6812
9	140	2	15.6592

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10	138	9	15.6356
11	137	4	15.6210
12	135	6	15.5862
13	134	8	15.5663
14	133	7	15.5444
15	131	8	15.4949
16	130	10	15.4673
17	129	12	15.4378
18	128	7	15.4065
19	125	13	15.3011
20	124	6	15.2621
21	122	8	15.1785
22	121	2	15.1785
23	118	6	14.9884
24	117	3	14.9360
25	115	5	14.8257
26	114	7	14.7677
27	110	5	14.5166
28	109	4	14.4491
29	108	6	14.3797
30	106	3	14.2353
31	105	1	14.1604
32	104	4	14.0836
33	101	2	13.8421
34	98	3	13.5843
35	96	7	15.4036
36	93	2	13.1193
37	88	4	12.6114
38	84	1	12.1754
39	80	5	117143
40	75	5	11.1044
41	68	4	10.1924
42	65	3	9.7825
43	58	3	8.7884
44	55	2	8.3442
45	51	1	7.7421

Rain attenuation values of hourly rain fall rates in the month of May, 2012

RANK	**RAIN RATE (mm/h)**	**FREQUENCY (GHz)**	**RAIN ATTENUATION (dB)**
1	144	2	15.6849
2	142	2	15.6756
3	138	1	15.6356
4	136	1	15.6046
5	135	4	15.5864
6	134	6	15.5663
7	132	4	15.5206

8	130	4	15.4673
9	129	2	15.4378
10	128	1	15.4065
11	125	8	15.3011
12	124	5	15.2621
13	123	4	15.2213
14	120	3	15.0873
15	117	1	14.9360
16	114	2	14.7677
17	112	1	14.6459
18	109	3	14.4491
19	107	4	14.3084
20	105	1	14.1604
21	103	3	14.0049
22	99	4	13.6721
23	98	6	13.5843
24	96	8	13.4036
25	93	5	13.1193
26	91	6	12.9212
27	90	7	12.8196
28	86	4	12.3966
29	81	2	11,8319
30	80	1	11.7143
31	78	2	11.4747
32	75	3	11.1044
33	73	2	10.8505
34	68	3	10.8505
35	62	3	9.3621
36	60	1	9.0763
37	59	2	8.93319
38	56	3	8.4925
39	52	4	0.1718
40	50	2	7.5896
41	48	1	7.2822

Rain attenuation values of hourly rain fall rates in the month of October 2010

RANK	**RAIN RATE (mm/h)**	**FREQUENCY (GHz)**	**RAIN ATTENUATION (dB)**
1	126	1	15.3381
2	125	2	15.3011
3	122	2	15.1785
4	120	1	15.0873
5	118	3	14.9884
6	117	4	14.9360
7	115	5	14.8257
8	114	7	14.7677
9	112	8	14.7677

10	109	7	14.4491
11	108	3	14.3797
12	107	2	14.3084
13	105	5	14.1604
14	103	2	14.0049
15	102	1	13.9244
16	100	3	13.7580
17	98	4	13.5840
18	95	2	13.3106
19	91	3	12.9212
20	88	9	12.6114
21	85	7	12.2868
22	83	4	12.0225
23	78	1	11.4747
24	76	7	11.2292
25	75	4	11.1044
26	73	8	10.8505
27	66	4	9.9203
28	61	3	9.2197
29	58	2	8.7864
30	55	1	8.3442
31	50	3	7.5896
32	47	1	7.1275
33	44	2	6.6594
34	40	4	6.0277
35	38	1	5.7091

Rain attenuation values of hourly rain fall rates in the month of November, 2011

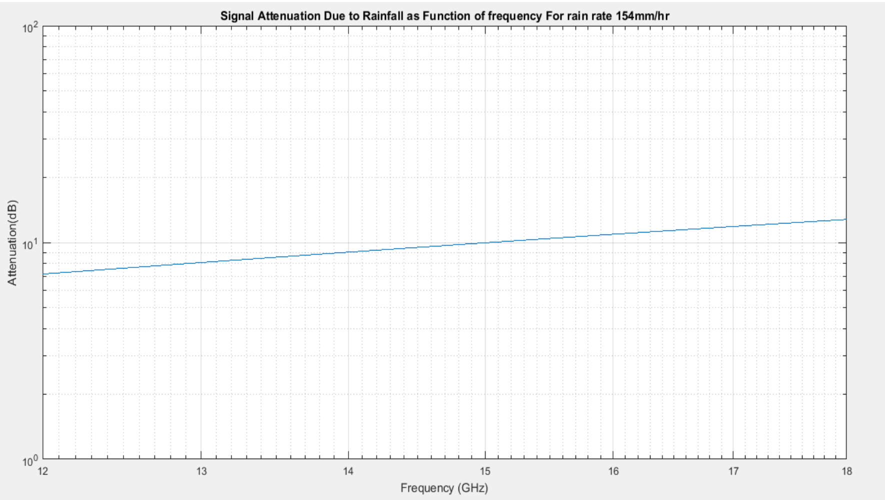
RANK	RAIN RATE (mm/h)	FREQUE1NCY (GHz)	RAIN ATTENUATION (dB)
1	132	1	15.5206
2	127	1	15.3733
3	122	1	15.1785
4	117	1	14.9360
5	114	1	14.7677
6	109	1	14.4491
7	105	2	14.1604
8	104	1	14.0836
9	102	2	13.9244
10	101	1	13.8421
11	97	1	13.4948
12	91	1	12.9212
13	83	1	12.0625
14	81	3	11.8319
15	79	1	11.5952
16	77	1	11.3527
17	74	1	10.9781

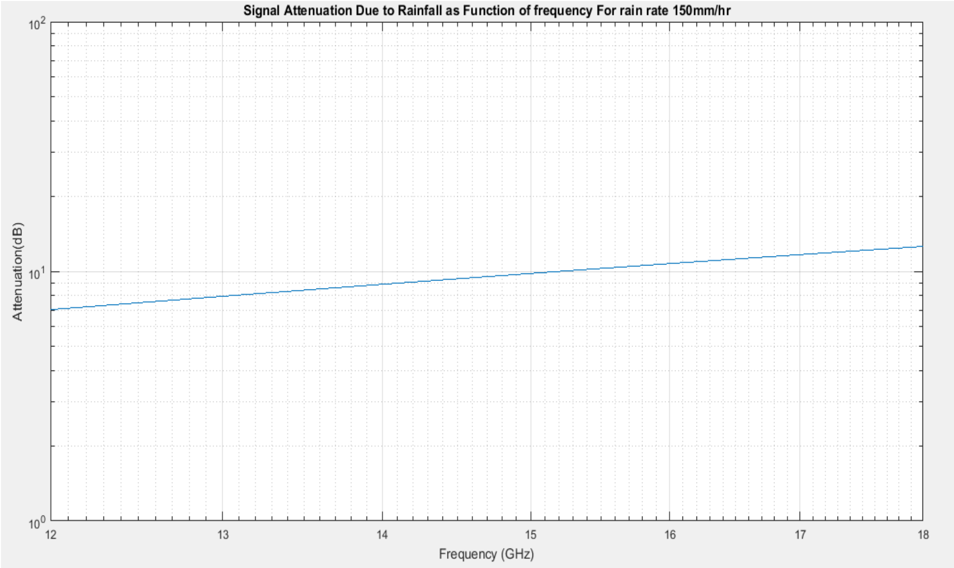
18	60	1	9.0763
19	53	1	8.0449
20	46	1	6.9721
21	45	1	6.8161
22	41	3	6.1863

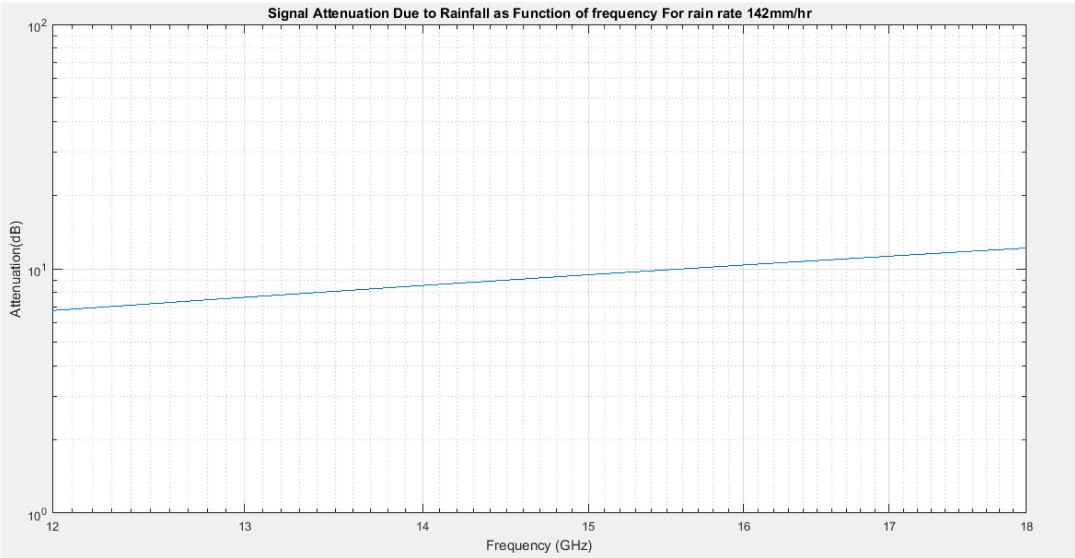
Using the rain rate values in table 2, a matlab code will be used to simulate the attenuation of satellite signals in the KU band (12GHz to 18GHz) for a 1km distance. For each rain rate the attenuation will be plotted against the frequencies.

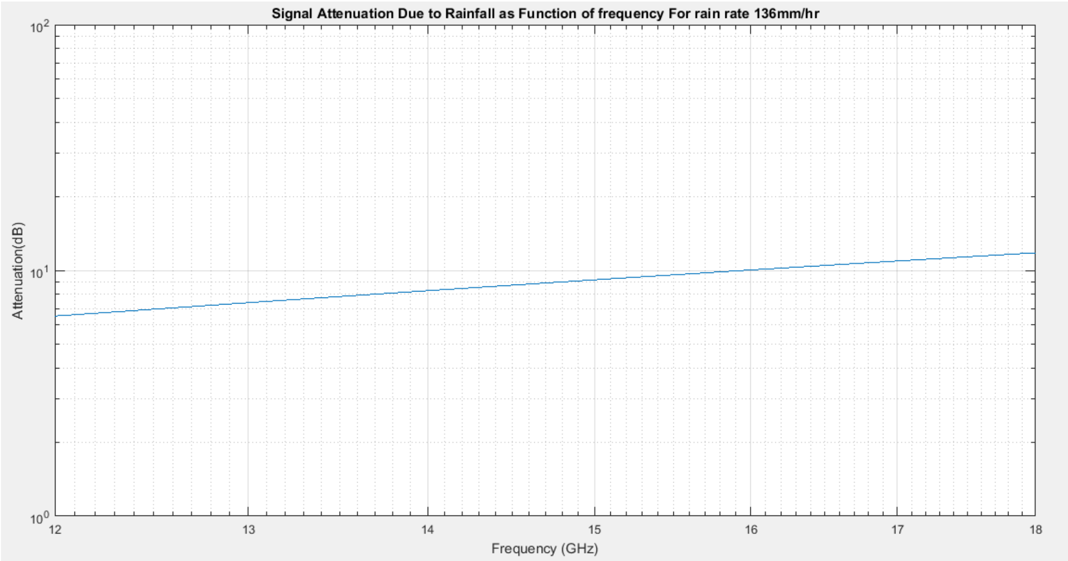
MATLAB CODE

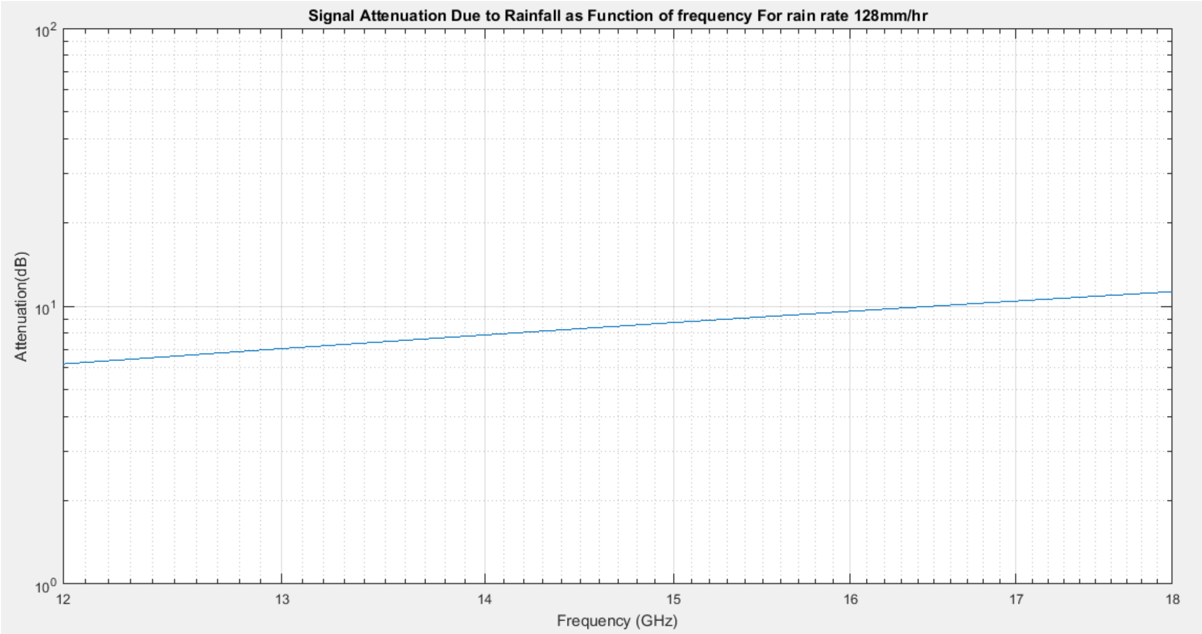
```
F= [12:0.5:18]*1e9; %KU band from 12GHz to 18GHz;
R = 154; %Rain rate mm/hr( will we use 154,150,142,136,128,120,112,104,92,86,72,64)
L= rainpl(10000,F,R); %Attenuation for 10km
loglog(F./1e9,L);
grid
xlabel('Frequency (GHz)');
ylabel('Attenuation(dB)');
title('Signal Attenuation Due to Rainfall as Function of frequency');
```

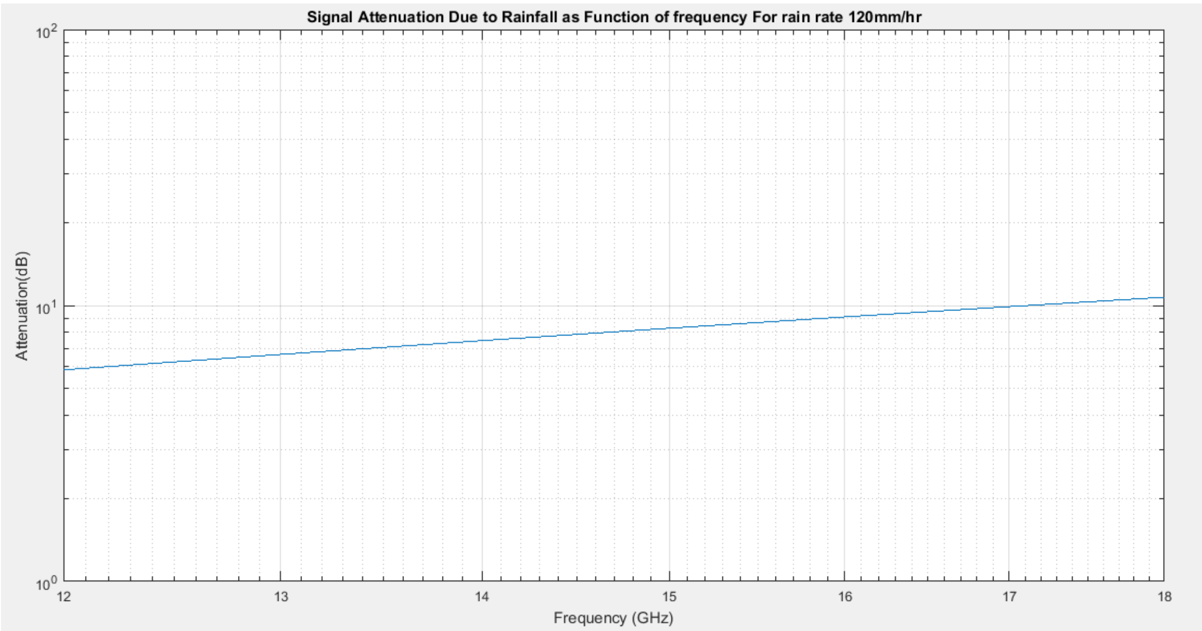


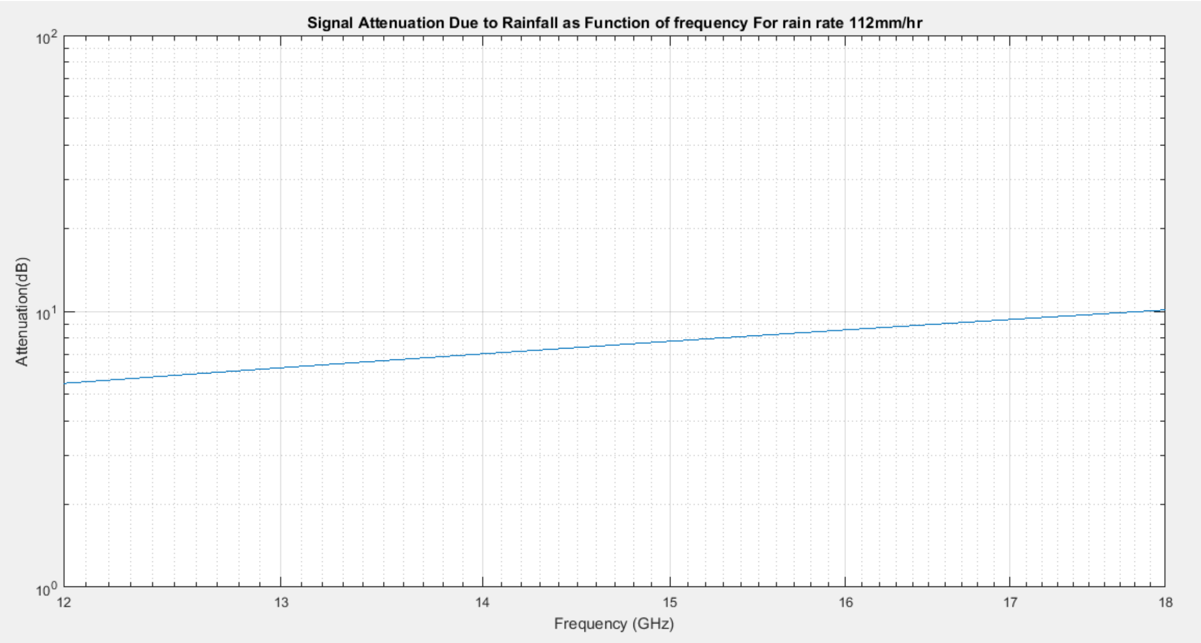

Signal Attenuation Due to Rainfall as Function of frequency For rain rate 150mm/hr
Attenuation(dB)
Frequency (GHz)

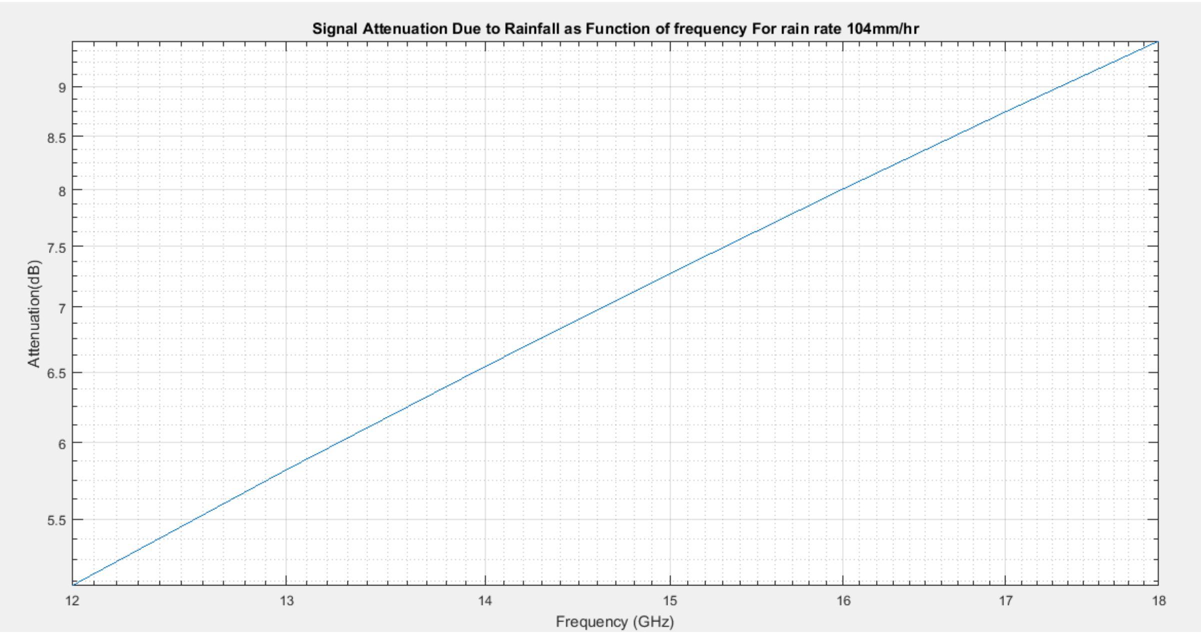

Signal Attenuation Due to Rainfall as Function of frequency For rain rate 142mm/hr
Attenuation(dB)
Frequency (GHz)

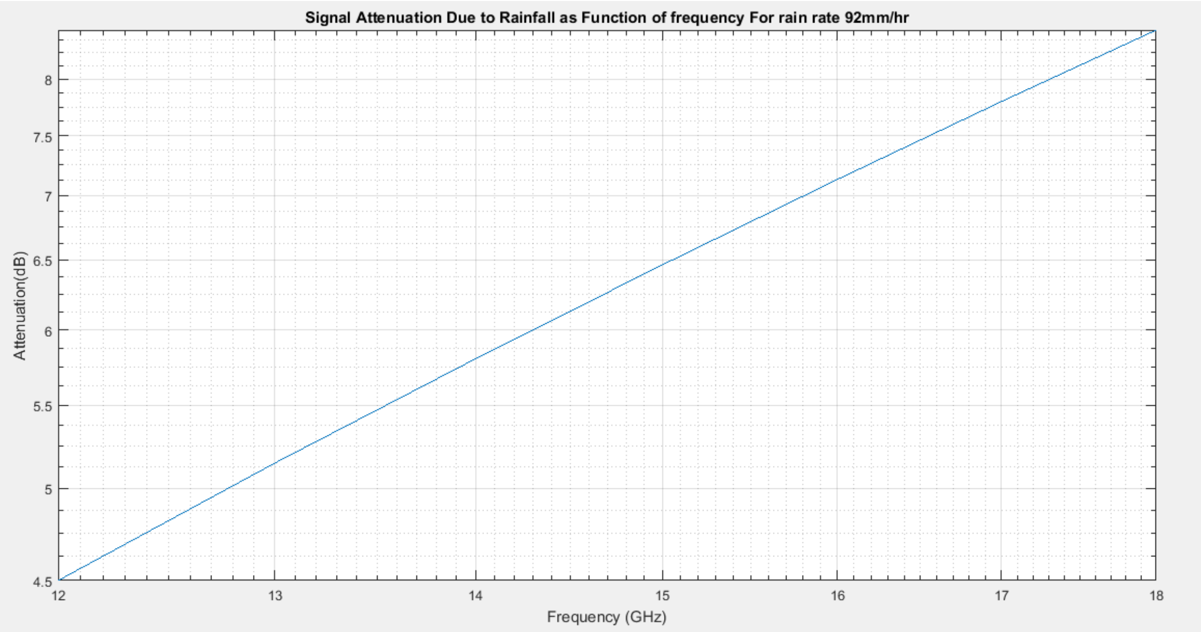

Signal Attenuation Due to Rainfall as Function of frequency For rain rate 136mm/hr
Attenuation(dB)
Frequency (GHz)

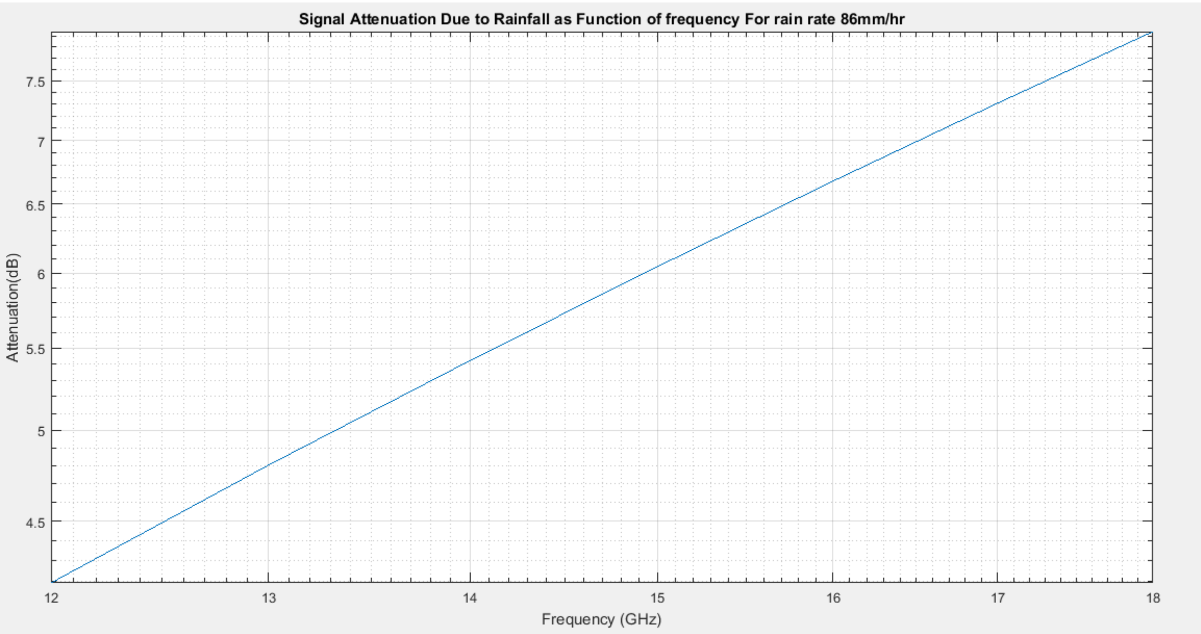

Signal Attenuation Due to Rainfall as Function of frequency For rain rate 128mm/hr
Attenuation(dB)
Frequency (GHz)
10^2
10^1
10^0
12
13
14
15
16
17
18

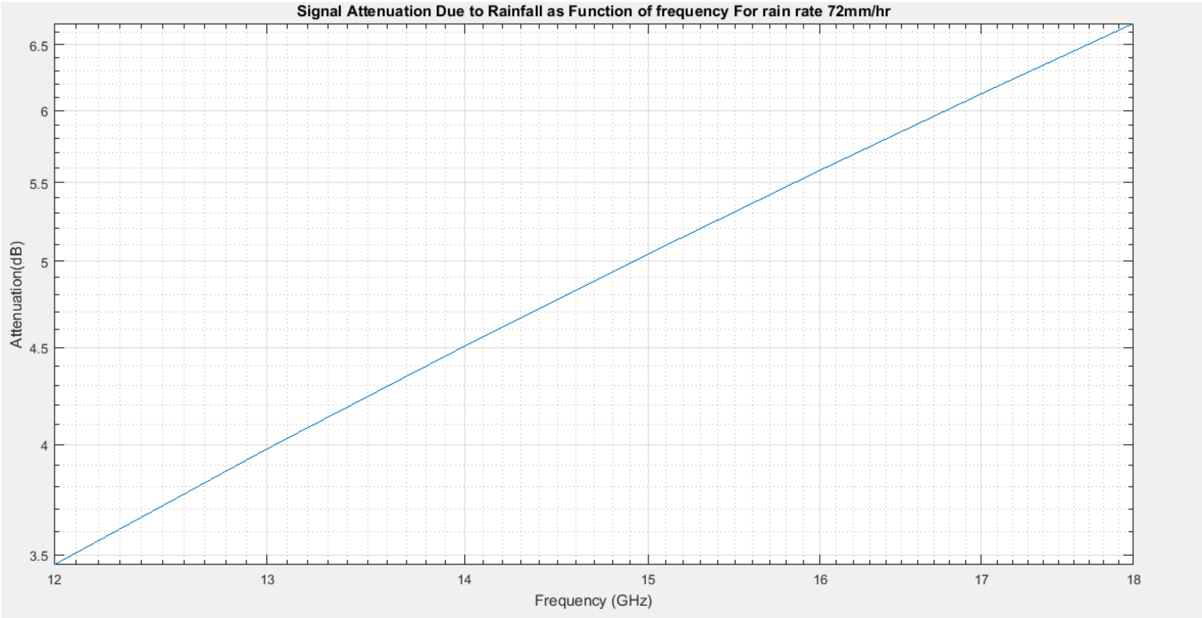

Signal Attenuation Due to Rainfall as Function of frequency For rain rate 120mm/hr
Attenuation(dB)
Frequency (GHz)
10^2
10^1
10^0
12
13
14
15
16
17
18

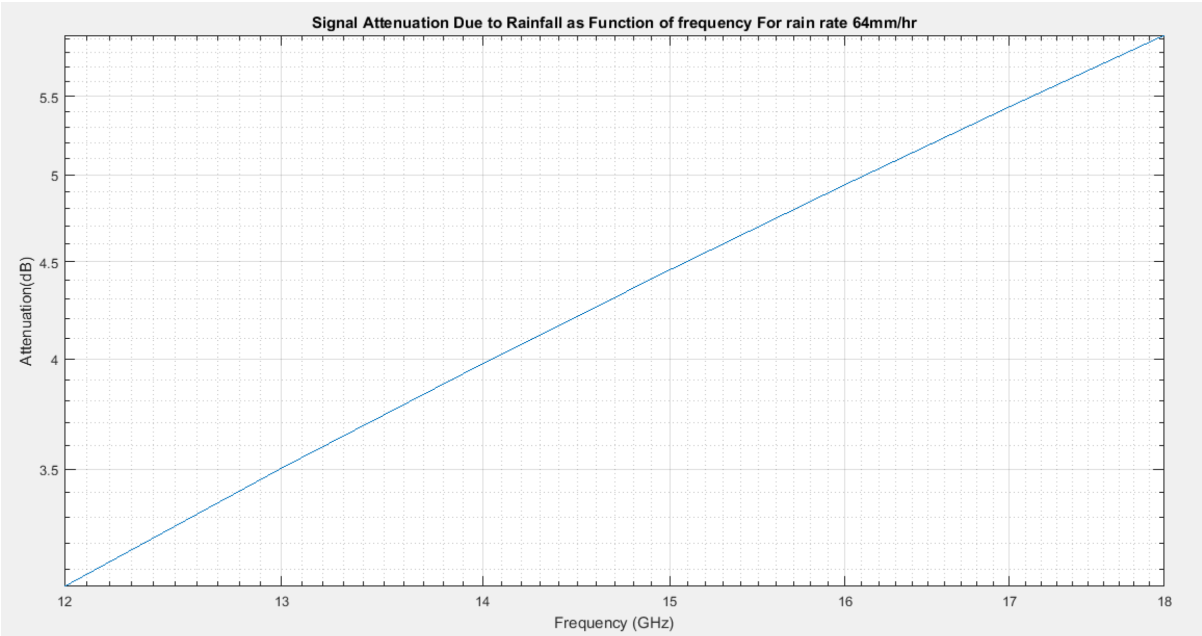

Signal Attenuation Due to Rainfall as Function of frequency For rain rate 112mm/hr
Attenuation(dB)
Frequency (GHz)


Signal Attenuation Due to Rainfall as Function of frequency For rain rate 104mm/hr
Attenuation(dB)
Frequency (GHz)


Signal Attenuation Due to Rainfall as Function of frequency For rain rate 92mm/hr
Attenuation(dB)
Frequency (GHz)
4.5
5
5.5
6
6.5
7
7.5
8
12
13
14
15
16
17
18


Signal Attenuation Due to Rainfall as Function of frequency For rain rate 86mm/hr
Attenuation(dB)
Frequency (GHz)
4.5
5
5.5
6
6.5
7
7.5
12
13
14
15
16
17
18





OBSERVATION

It can be seen that for high rain rate the attenuation is higher and with increase in the frequency bands, the attenuation increases sharply.

CONCLUSION

The impact of rain on satellite TV transmission was investigated. The outcome of the result reveals that rainfall is a major challenge in signal propagation at frequencies greater than 10GHz and at very high rain rate. The data obtained from NiMet when simulated showed outcome which is in agreement with results obtained from previous works. MATLAB was used for simulation and clear indications pointed out; strengths of signals at different intervals, as against measured power. It further shows the effect of rain attenuation following the rain rate.

The information showed signal variations during rainy season thereby portraying absorption of part of this signal radiation power by raindrop. This action will bring about scattering effect due to the contribution of diffraction and refraction effects from rain. Rain attenuation likely shows up in most cases at frequency of 10GHz and above. The increase in frequency brings about reduction in wavelength. By this, the rain drop size will increase thereby approaching the wavelength of the signal.

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