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Reduce and Control the Impact of Rain Attenuation for Ku Band in Sudan

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Abstract

Rain can make a distorting effect on Ku band signal fidelity resulting in excessive digital transmission errors. Rain attenuation prediction is one of the vital steps to be considered when analyzing a satellite communication links. The goal of this paper is to reduce and control the rain attenuation impact on the performance of Ku band signal in Sudan for five chosen cities, namely Khartoum, Wadi-Halfa, Nyala, Kosti, and ED-Dmazeen.

Keywords: *Digital Transmission, Prediction, Attenuation.*

1. Introduction

Attenuation due to rainfall is one of the most important constraints in the performance of line of sight (LOS) microwave links above a certain threshold frequency. This frequency threshold, in temperate climates, is about 10 GHz. In tropical and equatorial climate, due to higher rainfall and larger raindrops than in temperate climates, the incidence of rainfall on radio links becomes important for frequencies as low as about 7 GHz [1]. The typical satellite communication system comprises of a ground segment, space segment and control segment. The function of the ground segment is to receive or transmit the information to the satellite in the most reliable manner while retaining the desired signal quality. The general organization of a satellite ground station consists of antenna subsystem with associated tracking system, transmitting and receiving equipment, monitoring system and power supply as presented in Figure 1. The separation of the transmission and reception is achieved by means of duplexer [2]. Control systems attempt to minimize the effect of attenuation by adjusting the transmission parameters and signal characteristics. However, exciting system rely on total attenuation in actuating the transmission control. Consequently, the control of transmission parameters have been less than the optimal as the detail knowledge of occurrence probabilities for different impairments would have been missing. Knowing expected impairments separately for different attenuation factors, more specifically the weather factors, would help us utilize the most appropriate methods for mitigating impairments with mechanisms like up-link power control, adaptive coding, antenna beam shaping, an site diversity[3][4]. That is means, improve in quality of service (QoS). For Ku-band satellite services, a threshold of 7dB is generally considered as the economical limit [5].

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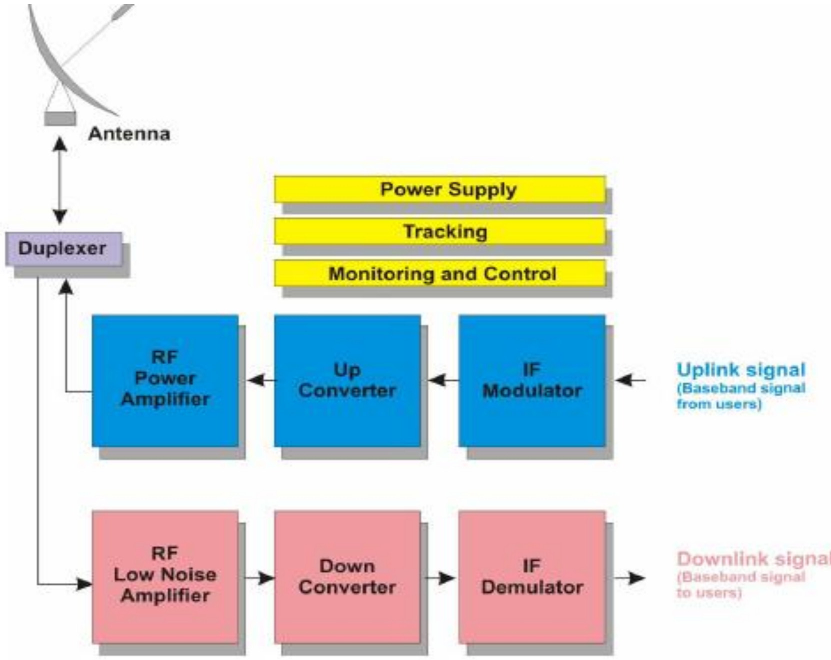

Figure 1: Satellite System Components

2. Impact of Rain Attenuation

Rain attenuation is the dominant factor in path loss variation above 10GHz, and can have an effect below that frequency at low elevations. Rain affects the transmission signal by [6]:

1. Change polarization
2. Increases the system noise temperature
3. Attenuates the signal

All the above mechanisms cause degradation in the received signal quality and become increasingly significant as carrier frequency increases. Rain fade is an interruption of wireless communication signals as a result of rain or snow droplets whose separation approximates the signal wavelengths. The phenomenon can affect satellite Internet connections as well as satellite television and other systems. Most satellite communication takes place in the microwave portion of the electromagnetic radiation spectrum. Signals at these wavelengths, typically on the order of a few inches, are affected by heavy concentrations of water droplets or ice crystals in the atmosphere. When the mean distance between water droplets or crystals is comparable to the wavelength of the electromagnetic signals, severe attenuation can occur. The observed effect is degradation or loss of communications during heavy downpours, snow squalls, and blizzards. Rain fade usually does not last long. Once a heavy shower or squall has passed, normal communications returns. However, during tropical storms or severe winter storms at northern latitudes, fadeouts can persist for hours at a time. The phenomenon occurs with all types of satellite systems, including geostationary (GEO), low-earth-orbit (LEO), and medium-earth orbit (MEO). It can also affect the Global Positioning System (GPS). [7] Rain attenuation depends on: number of raindrops along the path, the size of drops and the rain path length. Due to the higher operating frequency for a Ku, the signal’s wavelength is generally shorter as compared to the C band. Therefore, it is more susceptible to signal degradation as the wavelength approaches the size of a typical raindrop. The two major causes of rain attenuation are:

Absorption: water molecules in a rain droplet absorb portions or all of the signal energy of the passing radio wave. With shorter wavelength, there will be more interaction between the radio wave and water molecules, leading to increased energy losses.

Scattering: this is a physical process, caused by either refraction or diffraction, in which the direction of the radio wave deviates from its original path as it passes through a medium containing raindrops. This disperses the energy of the signal from its initial travel direction. The accumulation of these different reactions ultimately leads to a decrease in the level of received signal, thus resulting in rain attenuation.

3. Simulation Scenario

To evaluate the performance of Ku band signal under the rain attenuation impact, we have designed and implemented rain attenuation control and reduce simulation modules in MATLAB simulator.As illustrated by Figure 2, the flowchart simulation. It is consist of: Rain gauge: to read the values of rain rate R_p in mm/h. Attenuation measurement: to read attenuation value in dB. Random wait time: to avoid and control transmission repeating After read the values of rain rate $R_{p,}$ compare that values with threshold rain rate value R_{th}=0.25 mm/h if the R_p is greater than R_{th} automatically polarization changes to get good chance in performance else transmission signal directly. After changing polarization, we need to read the value of rain attenuation A and compare this value with threshold rain attenuation value A_{th} =7dB. If the A value is greater than A_{th} automatically the band change, else transmission signal directly.

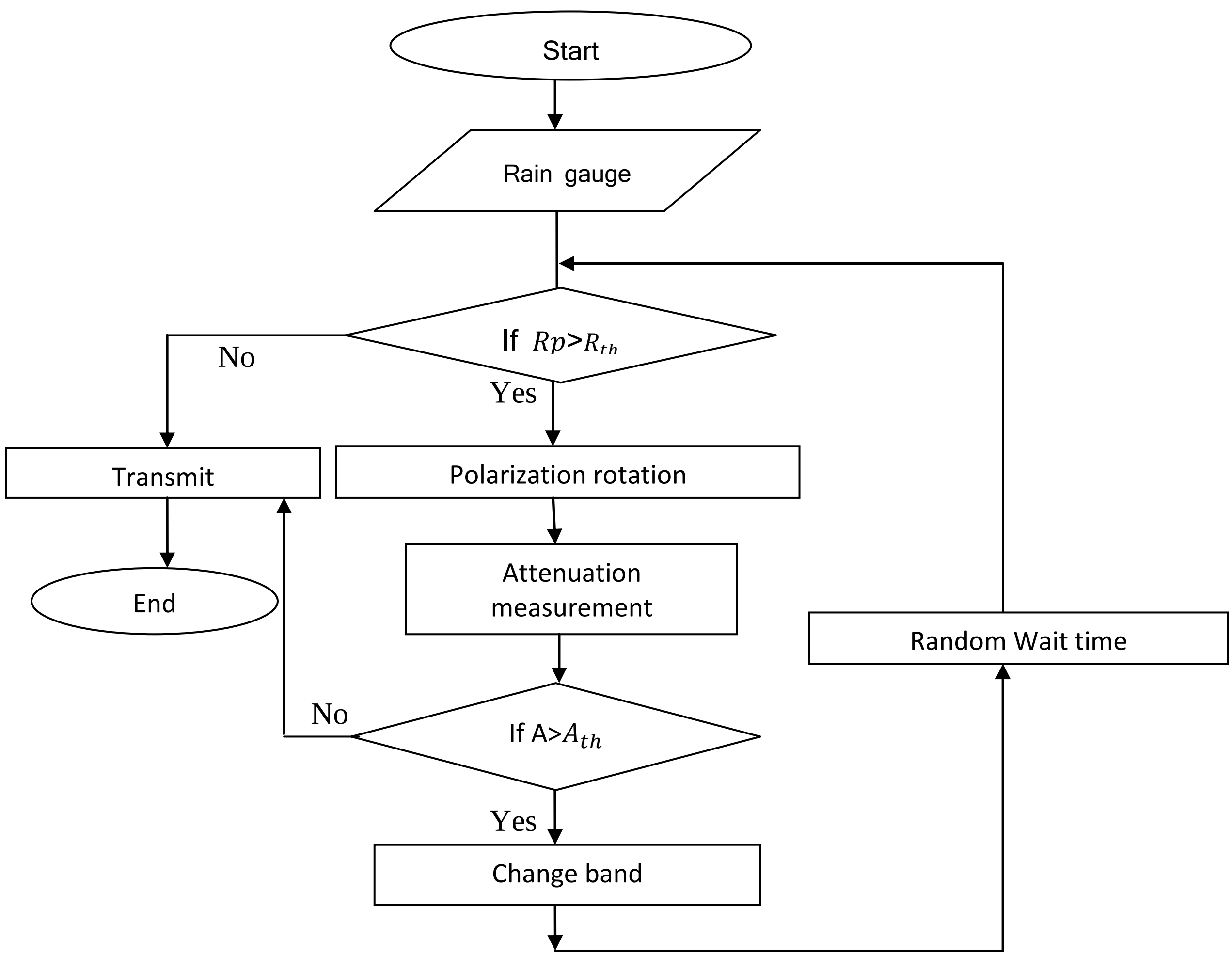

Figure 2: Flowchart of the Simulation

4. Rain Rate Modeling

The rain rate generated in the simulation using the data gathered from the metrological authority, ministry of environment, forestry and physical development. In this paper the annual rain rate and monthly variation of rate are summarized in table (1) for five cities of Sudan, namely Khartoum, Halfa, Nyala, Kosti, and ED-Dmazeen in year 2013 and 2014.

Table 1: Rp for five Sudanese different cities in august 2013 and 2014[8]:

City	Rp (mm/h) 2013	Rp (mm/h) 2014
Khartoum	0.0927	0.0703
ED-Dmazeen	0.373	0.4614
Wadi-Halfa	0.0067	0
Nyala	0.187	0.157
Kosti	0.316	0.233

5. Results

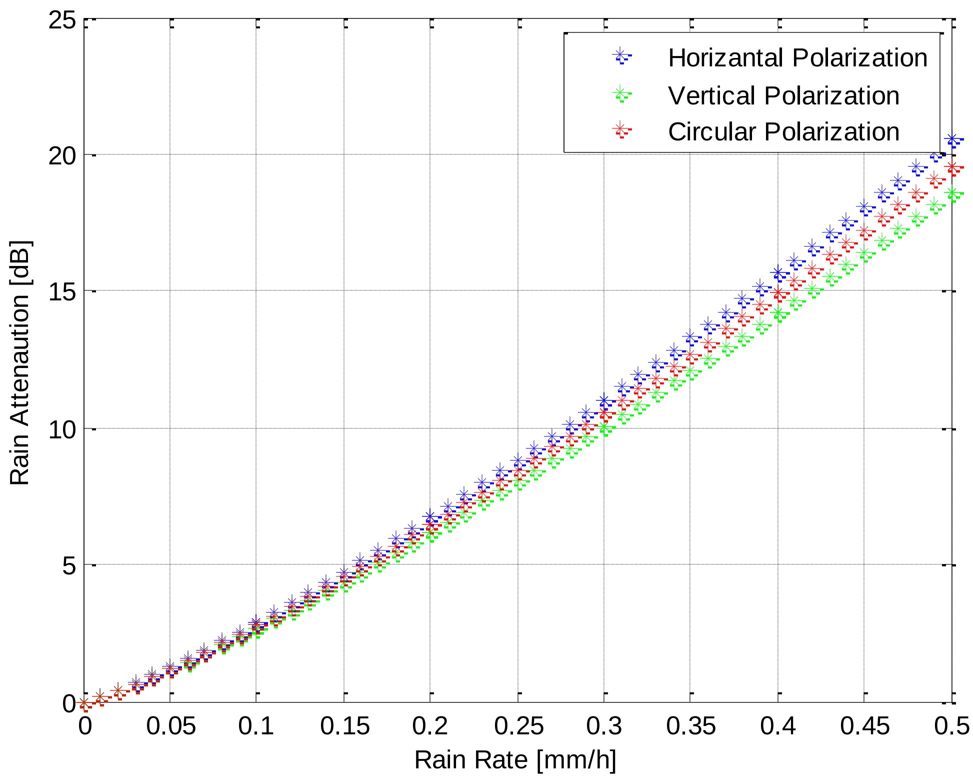

Figure 3: Rain Attenuation and its Rate

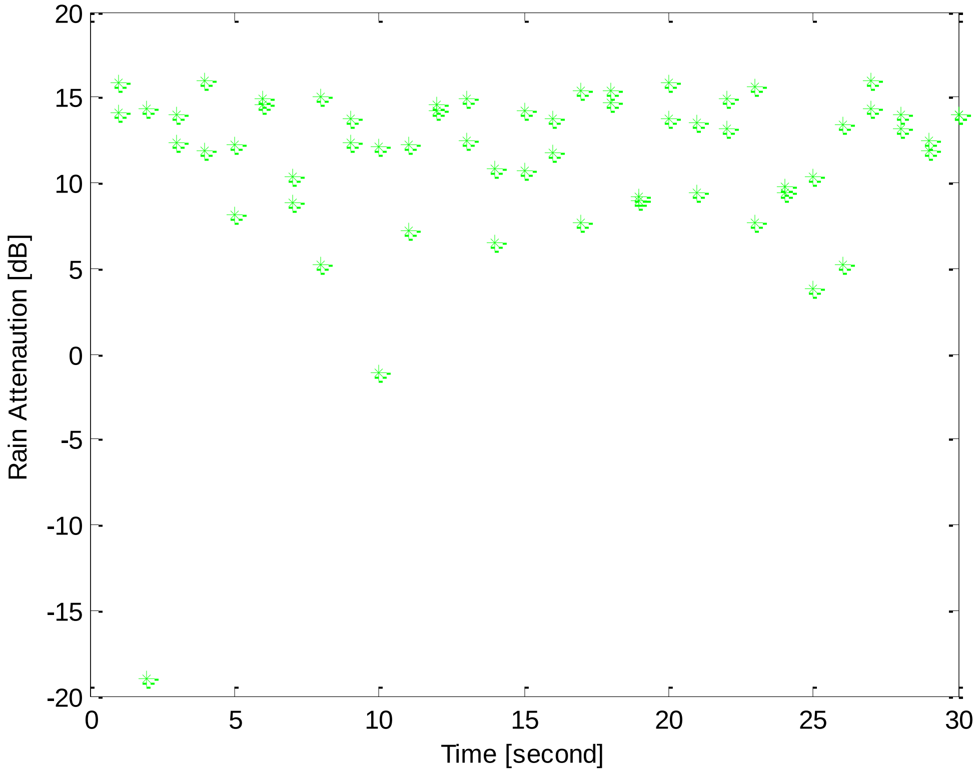

Figure 4: Rain Attenuation and Time in Vertical Polarization

6. Conclusion

This paper presented the rain attenuation for ku band VSAT link for the selected cities in Sudan. The specific attenuation of the mentioned cities has the maximum value of 20 dB and the minimum value of 0dB, followed by significant difference for various height of antenna. It is also found that the horizontally polarized signal is more attenuated by the rain than the circularly and vertically polarized signal. The threshold value of rain attenuation in Ku band is 7 dB at rain rate equal 0.25 mm/h. At this value we must change for C band because it has less affect from attenuation than Ku band.

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