Rain attenuation and depolarization prediction techniques english language essay

Linguistics, English

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Abstract—Satellite communication plays a major role in today's communication across the earth. It is more advantageous compared to terrestrial mode of communication. In wireless communication one needs to use higher frequencies in order to increase the bandwidth and get much wider bands. But the increase of frequency will lead to many disadvantages which will degrade the performance. We should be able to predict the losses before we design the communication channel. Rain attenuation, gas attenuation and depolarization are the major losses along earth station and satellite communication.

Index Terms—Rain fall Rate, Rain Attenuation, Depolarization, Carrier-to-Noise ratio, Ku-band.

IntroductionThe atmosphere surrounding our earth causes several problems on satellite communication. It becomes a serious issue when we operate in the bands above 10 GHz. The three major factors which effects the communication are: 1) Frequency: as it increases the attenuation increases. 2) Elevation angle: If it is high then the length through which the signal passes in the atmosphere becomes low and it results in less attenuation compared to lower angle of elevation. 3) Climate of the location of earth station: If the sky at the earth station is clear then we won' t be facing much attenuation. Sometimes even if the sky is clear we face attenuation due to the absorption of signals by the atmospheric gasses like oxygen, water vapor. In satellite-earth communication, precipitation can cause much attenuation particularly in systems operating above 10 GHz which can cause performance degradation. There are three forms of precipitation : a.) ice b.) water c.) gaseous. However the attenuation that is caused by ice and fog is very much less compared to rain when we operate in Ku band. There are various models developed to calculate losses that occur due to rain attenuation, gaseous attenuation and depolarization. Now we go through the problems and the prediction models in detail. RAIN ATTENUATIONAs mentioned above rain is the most serious atmospheric problem. Rain is not homogeneous both in time and space. The amount link margin allocated to rain fades, the communication link distance, and the local climate all factor into determination of the rain availability. Rain availability is essentially the percentage of time that the available rain fade margin is not exceeded. It is important that the rain fade margin not be used for other margins unless the other factor is exclusive of rain. The rainfall can be measured both by empirical and non-empirical models by collecting data over a period of time. Empirical methods won‘ t give us good results as rain is totally dependent on nature and is mostly random in nature. Main problem of rain is that it absorbs the signal and reduces the strength of the carrier. It is mainly dependent on the frequency being used. It normally shows up when we operate above 10GHz. Raining on the dish antenna directly will lead to absorption of signals at higher frequencies. It can even cause depolarization. Rain attenuation is a function of rain rate which is the rate at which rain water gets accumulated at earth station. In calculations we measure rain rate in milli-meters per hour. MODELSIn order to understand the application of rain fade analysis is the concept of link availability and its relation to the link budget. In general, a communications link designer must decide (or be told) what percentage of time the link must be operational. This availability is then allocated between the various sources that can cause link outages, including rain fades, interference, and hardware failures. Once a rain availability allocation is determined, the rain fade models can be applied to determine what level of fade will not be exceeded with probability equal to the rain availability allocation. That rain fade value is then incorporated into the link budget, and the resulting link budget can be used to determine either the maximum link distance or some other key parameter such as the required transmit power. The specific attenuation is determined by using regression coefficients and the rain rate of interest. The models differ in the values for rainfall rate and in the modeling equations used, but they share the same regression coefficients for the specific attenuation. To determine the specific attenuation for a given rain rate, the frequency of operation is used to select the appropriate linear regression coefficients and interpolate them if necessary. The interpolation of the coefficients is performed using a log scale for frequency and the ‘ k’ values and a linear scale for the ‘ a’ values. through 40 GHz in 1-GHz steps. These coefficients are frequency and polarization-dependent. The final coefficients are determined using the following expressions, which account for the path elevation angle and the polarization. Note that for circular polarization, a tilt angle , of 45 degrees is used. Where, is the elevation path angle, is the polarization tilt angle(0, 45, and 90 degrees for horizontal, circular, and vertical, respectively). T1:

Regression Coefficients for Estimating Specific

AttenuationFrequency(GHz)kHkV

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✓ v20. 000650. 0005911. 1211. 07560. 001750. 001551. 3081. 26580. 004540. 003951. 3271. 31100. 01010. 008871. 2761. 264120. 01880. 01681. 2171. 2200. 07510. 06911. 0991. 065300. 1870. 1671. 0211400. 350. 310. 9390. 929Source: Table 1 , courtesy of the ITU. The coefficients suggest that the effect of rain on horizontally polarized signals is greater than that for vertically polarized signals. This is in fact true and is generally attributed to the vertically elongated shape of most raindrops. The effect on circularly (right-hand or left-hand) polarized signals is in between the two as might be expected. Though rain attenuation prediction models have been developed by a good number of researchers and mathematicians. But most useful of them with better prediction statistics close to experimentally determined results are the following two models: ITU-R modelCrane modelITU-R MODELThe ITU model determines the rain statistics using data filesindexed by latitude and longitude to provide a more precise estimate of rain statistics than the rain region concept. The model assigns rain rate to each region(denoted by A to P excluding I and O) along with the probability of that rain rate being exceeded. Most areas of India fall in region K of it. The ITU model used here employs only the 0. 01% rain statistics and then applies an adjustment factor to the predicted rain fade depth for other probabilities. The slant path attenuation is no longer a function of link distance because the atmosphere above the earth is not entirely homogenous. The first step of calculating hR below is for geosynchronous orbit (GEO) i. e for geo-stationary satellites The good point using them is they have the advantage of minimal Doppler shift, the corresponding higher orbital altitude produces a much longer time delay and greater free-space loss than the lower orbits. The first step is the method of computing the expected rain cell height as a function of latitude and the rainfall rate. The method is as follows: S1: Determine the rain height, hR(in km) as in ref[1]hR = hs + 0. 36where hs(in km) is the height of the earth-station above mean sea level. Next we do is calculation of elevation angle using earthstation and satellite geometry: Here: re is the earth's radius (6378km). h is the satellite height above the center of the earth and 🗘 is the elevation angle at which the satellite appears. Using Sin law: = = Which gives rs = central angle is: Ψ = (sin(π/2 + θ) - θ)to find θ: Cos(Ψ)= cos(Le)cos(Ls)cos(ls-le) + sin(Le)sin(Ls), where Le is the earth station latitude, le is the earth station longitude, Ls is the subsatellite latitude, ls is the subsatellite longitude. With the central angle known, the slant-path distance and elevation angle are readily found using: rs = h√(1+ (– 2()cos(Ψ))and , cos(θ) = S2: For 🗘 💿 5🎹 compute the slantpath length, Ls, below the rain height from: else, if 🗘 ■ 5🎹, the following formula is used: S3: Calculate the horizontal projection, LG(in km), of the slantpath length from: LG ● Lscos🗘S4: Obtain the rainfall rate, R0. 01,(in mm/hr) exceeded for 0. 01% of an average year (with an integration time of 1 min) using ITU maps as in ref[2] and below in T2. T2: ITU Rain Rate Data for 0. 01% Rain FadesS5: Obtain the specific attenuation, █R(in dB/km), using the frequency-dependent coefficients as given in T1 on page 2 and the rainfall rate, R0. 01, determined from S4, by using:█R ● k (R0. 01)✔S6: Calculate the horizontal reduction factor, r0. 01, for 0. 01% of the time: S7: Calculate the vertical adjustment factor, v0. 01, for 0. 01% of the time: For 🚭 🗚 🗘, Else, If | 🛩 | ■ 36🎘, ☐ ● 36 – | 🛩 | degreesElse,☐ ● 0 degreesS8: The effective path length(in km) is: LE ● LR ⬤0. 01S9: The predicted attenuation exceeded for 0. 01% of an average year is obtained from: A0. 01 ● █R LE dBS10: The final step is to deduce estimated attenuation(in dB) to be exceeded for other percentages of an average year(Ap), in the range 0. 001% to 5%, is determined from the attenuation to be exceeded for 0. 01% for an average year: If p 🖸 1% or | 🛩 | 🖸 36🎘: 🚲 ● 0If p < 1% and | 🛩 | < 36🎘 and 🗘 🖸 25🎘: Then 🚲 ● –0. 005(| 🛩 | – 36)Otherwise: 🚲 ● –0. 005(| 🛩 | – 36) + 1. 8 – 4. 25 sin 🗘We see that the overall expected attenuation on an earth–space path ends up being a function of the rain rate (availability), frequency, and elevation angle only. When testing this model in MATLAB for Ahmedabad at a frequency of 13 Ghz, where hs is about 0. 05 km and lat/long of 23oN/72oE θ obtained as 65o , with rain rate of 45, the attenuation came out to be around 19. 2 dB. CRANE MODELCrane provides rain data for a variety of rain probabilities, but does not use an availability adjustment factor like the ITU model. Also the regions denoted are different than ITU(alphabets are from A to but different letters for different regions compared to ITU). The difference is that the specific rain rate for the desired availability must be used. Crane uses rain cell height data that are a function of latitude and probability. Most regions of India fall in D region of it. It first takes rain heights for 0. 001% rain fade and 1% rain fade(as in T4) for a given latitude and then follows a procedure for doing a logarithmic interpolation over availability as follows: h001 : rain height for p = 0. 001%, h1 : rain height for p = 1%HR(p) = h1 + ln(p)T3: Crane Rain Rates for Different Probabilities andRain RegionsT4: Crane Model Rain Cell Heights for Different LatitudesThe approximate path length in rain is then: d = 2(HR - HS)/(√tan(ζ) + tan2(ζ) + 2(HR- HS)/Re)where, HR is the effective rain cell height, HS is the effective station height, ζ is the elevation angle, Re is the 4/3 earth radius(8500km)(correction factor due to ionosphere effects). The expression for terrestrial path rain attenuation is employed to determine the horizontal path attenuation as: and, δ(RR)(function of rain rate)(in km) = 3. 8-0. 6ln(RR)d(km)= link-distancey= α[(0. 83-0. 17ln(RR))/δ(RR)+0. 26-0. 33ln(RR)]z = α.(0. 026-0. 03ln(RR))Total slant path attenuation due to rain is given byAs=(L/d)Attenuationwhere, L=√[(Hs-Re)2sin2(ζ)+2Re(HR-HS)+HR2-HS2]-(HS+Re)sin(ζ)It is important to note that the Crane global model is only validated up to 22. 5-km link distance, whereas the ITU model is valid to 60km. Unpredictable results will be obtained if Crane model is used for distances greater than 22. 5 km. Testing it in conditions similar to ITU model, the attenuation obtained was almost equal to that obtained by ITU model. The entire document should be in Times New Roman or Times font. Type 3 fonts must not be used. Other font types may be used if needed for special purposes. Recommended font sizes are shown in Table 1. 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