Rain attenuation and depolarizations prediction techniques engineering essay

Engineering

BTP reportRain attenuation and depolarization prediction techniques in satellite communicationBhavin pandya-200901002 krishna chaitanya-200901027Rain attenuation and depolarization prediction techniques in satellite communicationAbstract- 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. Introduction- The atmosphere surrounding our earth causes several problems on satellite communication. It becomes a serious issue when we operate in the bands above 10GHz. The three major factors which effects the communication are1) Frequency – As frequency increases the attenuation increases mainly due to rain. 2) Elevation – If angle of elevation 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 10GHz which can cause performance degradation. There are three forms of precipitation1) ice2) water3) 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 modles in detail. Rain attenuation- as mentioned above rain is the most serious atmospheric problem. Rain is not homogeneous both in time and space. The rainfall can be measured both by empirical and non-empirical 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`s 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 means the rate at which rain water gets accumulated at earth station. In calculations we measure rain rate in millimeters per hour. The specific attenuation is determined by using regression coefficients and the rain rate of interest. The ITU and crane model differ in the values for rain fall rate and in the equations but the regression coefficients for both are the same. These are dependent on polarization and frequency. We use the following expressions for calculating the coefficients. $k = [kH+kv+(kH-kV)\cos 2 (\theta) \cos (2\tau)]/2$ $\alpha = [kH\alpha H-kV\alpha V+(kH\alpha H-kV\alpha V)\cos 2 (\theta) \cos(2\tau)]/2k$ θ- Elevaion path angle τ- Polarization tilt angleAs mentioned above many models have been proposed to predict the effect of rain on communication link. Mostly we use two models those are crane global rain model and ITU-R model as these are based on empirical data. Crane global rain model- This model was developed by crane. In this we make use of geo physical data to determine the rain rate given the percentage of the year the attenuation value is exceeded. It also helps to know about the station to station and year to year variations of attenuation prediction for a given percent of the year. It basically thrives that specific rain rate for the desired availability must be used. The rain rates versus probability are used as per table for each of the Crane rain regions. For ground-to-space links, the height of the rain cell must be taken into account, just as it is with the ITU model. This model uses data pertaining to rain cell height that are a function of latitude and probability. The attenuation model is quite different than ITU. It provides rain data for a variety of rain probabilities, but does not use an availability adjustment factor like the ITU model. Even then, experience shows that the models generally produce results that are in reasonably close to each other. h001 : rain height for p = 0. 001%h1 : rain height for p = 1%Then, it uses a procedure for doing a logarithmic interpolation over availability: HR(p) = h1 + ln(p)The approximate path length in rain is thend = 2(HR - HS)/(√tan(ζ) + tan2(ζ) + 2(HR- HS)/Re)where, HR is the effective rain cell heightHS is the effective station heightζ is the elevation angleRe is the 4/3 earth radius, 8500kmandδ(RR)(function of rain rate) = 3. 8-0. 6ln(RR) kmd = link distance in kmy = 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)AttenuationwhereL = √[(Hs-Re)2sin2(ζ)+2Re(HR-HS)+HR2-HS2]-(HS+Re)sin(ζ)As mentioned above maximum value of d can be 22. 5, it shows that this model can be used only for distance up to 22. 5 km. ITU-R model-The following procedure provides estimates of the long-term statistics of the slant-path rain attenuation at a given location for frequencies up to 55 GHz. The following parameters are required: R0. 01 : point rainfall rate for the location for 0. 01% of an average year (mm/h)hs : height above mean sea level of the earth station (km)🗘 : elevation angle (degrees)✈ : latitude of the earth station (degrees)f : frequency (GHz)Re : effective radius of the Earth (8 500 km). If local data for an earth station is not found then an estimation can be obtained from the topographic altitude maps. Step 1: Determine the rain height, hR, as given in Recommendation ITU-R P. 839. Step 2: For 🗘 💿 5🎹 com pute the slantpath length, Ls, below the rain height from:(1)For 🗘 ■ 5🎹, the following formula is used:(2)If hR – hs is less than or equal to zero, the predicted rain attenuation for any time percentage is zero and the following steps are not required. Step 3: Calculate the horizontal projection, LG, of the slantpath length from: LG ● Ls cos 🗘 km(3)Step 4: Obtain the rainfall rate, R0. 01, exceeded for 0. 01% of an average year (with an integration time of 1 min). If this long-term statistic cannot be obtained from local data sources, an estimate can be obtained from the maps of rainfall rate given in Recommendation ITUR P. 837. If R0. 01 is equal to zero, the predicted rain attenuation is zero for any time percentage and the following steps are not required. Step 5: Obtain the specific attenuation, █R, using the frequency-dependent coefficients given in Recommendation ITUR P. 838 and the rainfall rate, R0. 01, determined from Step 4, by using:█R ● k (R0. 01)✓ dB/km(4)Step 6: Calculate the horizontal reduction factor, r0. 01, for 0. 01% of the time:(5)Step 7: Calculate the vertical adjustment factor, v0. 01, for 0. 01% of the time: For 🚭

🗚 🗘, Else, If | 🛪 | ■ 36🖮,□ ● 36 – | 🛪 | degreesElse,□ ● 0 degreesStep 8: The effective path length is: LE ● LR ⬤0. 01 km(6)Step 9: The predicted attenuation exceeded for 0. 01% of an average year is obtained from: A0. 01 ● █R LE dB(7)Step 10: The estimated attenuation to be exceeded for other percentages of an average year, 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🖮: 🚲 ● –0. 005(| 🛪 | – 36)Otherwise: 🚲 ● –0. 005(| 🛪 | – 36) + 1. 8 – 4. 25 sin 🗘(8)Depolarization- The direction of the line that is traced by the tip of the electric field vector determines the polarization of the wave. In the far field zone of the transmitting antenna the wave has the characteristics of the TEM wave which means the electric field vector E and magnetic field vector H are transverse to the direction of propagation where the propagation vector is K. In general E and H are functions of time and H varies exactly in phase with E and their respective amplitudes are also proportional to each other. The magnitudes of E and H are related as E= HZ0There are 2 major types of polarization1) liner polarization- in this the tip of the electric field vector will trace out a straight line. a.) vertical polarization- In this electric field will be perpendicular to the earth`s surface. b.) horizontal polarization- In this E will be parallel to the earth`s surface. 2) Circular polarization- The tip of the resultant electric field vector traces out a circle. Again there are two types of circular polarization1) RHC polarization- IEEE defines RHC as a rotation in the clockwise direction when the wave is viewed along the direction of propagation. 2) LHC polarization- in LHC rotation occurs in anticlockwise direction when viewed along the direction of propagation. Antenna polarization- An antenna`s is defined by the polarization of the wave it transmits. For maximum power transfer the polarization of the receiving antenna has to be aligned to that of the wave. Cross polarization-The path that the wave travels from the earth station to the satellite passes via ionosphere, ice crystals and rain which can alter the polarization of the wave travelling through them. In this process an orthogonal component may be generated which results in depolarization. This results in interference where orthogonal polarization is used to provide isolation between signals, as in the case of frequency reuse. Measuring Depolarization - There are two ways to measure the effects of polarization interference one being cross polarization discrimination (XPD) and other being polarization isolation (I). But mostly we use cross polarization discrimination (XPD). When we transmit two signals having same magnitude and when the receiver introduces some polarization then I and XPD gives same results. Intense rain governs the reductions in XPD observed for small percentages of time. For paths on which more detailed predictions or measurements are not available, a rough estimate of the unconditional distribution of XPD can be obtained from a cumulative distribution of the co-polar attenuation (CPA) for rain using the equi-probability relation: The coefficients U and Vare in general dependent on a number of variables and empirical parameters, including frequency, f . For line-of-sight paths with small elevation angles and horizontal or vertical polarization, these coefficients may be approximated by: U ● U0. 30 log fAn average value of U0 of about 15 dB, with a lower bound of 9 dB for all measurements, has been obtained for attenuations greater than 15 dB. The variability in the values of U and V(f) is such that the difference between the CPA values for vertical and horizontal polarizations is not significant when evaluating XPD. Carrier to noise ratio (C/N ratio)C/N ratio is a good measure to check the quality of signal. After calculating the C/N, we then compare it to the requirements for the type of signal that we are trying to send, based on details of coding, modulation and multiplexing used with the signal. For different uses, C/N is different, e. g for digital signals C/N correlates to bitrate and bit-error rate, for video signals it correlates to on-screen video quality, for audio it correlates to audio quality. C/N(Link Budget) = EIRP + G/T +228. 6 -space loss –atmospheric loss –misc loss –bandwidth usedEIRP(Effective isotropic radiated power): effective strength of the transmitter. It is the sum of transmitting amplifier power and gain of the transmitting dish(changes as per size of the dish). G/T: gain of the receiving dish(G) minus the system noise temperature(T) of the receiving electronics(determined by LNA electronics and noise environment). 228. 6: decibel equivalent of physical constant(Boltzmann’s constant) that comes in due to conversion of noise temperature(in Kelvin) to noise figure(in dB). Space loss: amount of power lost because the signal travelling the distance. Atmospheric loss: power lost due to absorption.(generally around 5 dB for Ku-band). Misc loss: due to slight mis-alignment of dish, or in polarization orientation, losses in connection between antenna and amplifier(usually form 0 to few dB). Bandwidth used: wider bandwidth used, more the interfering noise it receives from the environment. Out of the above mentioned parameters, only G/T and EIRP can be changed effectively. Losses are generally frequency dependent. Now to compensate the effects of rain on our signal we make use of rain fade margin. It is the amount by which we need to turn up the power of the transmitter (EIRP) or increase the sensitivity of the receiver (G/T). It helps the service provider to continue his services. Analysis –MATLAB SimulationC: UsersKrishDesktopim1. jpgC: UsersKrishDesktopim2. jpg