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STUDY OF PROPAGATION EFFECTS ON WIRELESS COMMUNICATION SIGNALS AT RADIO FREQUENCY

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ABSTRACT

A satellite communication system so as to operates in radio frequency range specifically above 10 GHz with low angle of elevation below 10º tropospheric scintillation attenuation is more effected on the received signals than attenuation because of rain. Scintillation is most significant fade with large scale variations inside meteorological parameters, solar energy radiation, path length, turbulence layer height from sea and surface levels, day as well as night times and short and long time scales. Hyderabad has its own special tropical climatic conditions are changing by means of metrological parameters like temperature, humidity and wind pressure for long term basis. To overcome the scintillation effects on signal degradation as well as enhancement in received signal from satellite communication systems. We need an innovative and develop tropospheric scintillation prediction models fit to Hyderabad tropical climatic conditions. For that this paper proposed tropospheric scintillation prediction models for long term basis give statistically estimation and graphically representation at 40 GHz and 50 GHz beacon frequency using mat lab software which give the study, analysis and diurnal characteristics of scintillation for Hyderabad tropical region.

Keywords *: Scintillations, V band, Satellite signals, Tropical climate*

INTRODUCTION

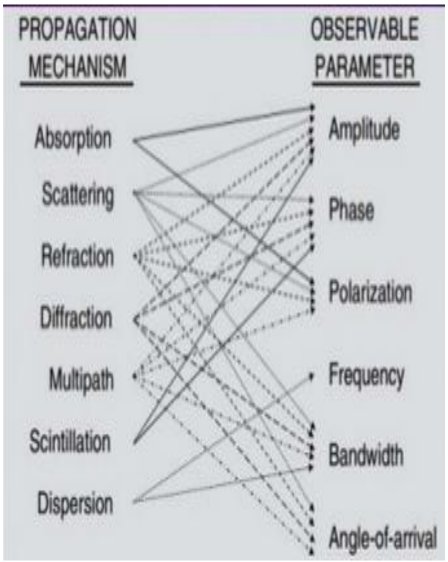
Propagation Effects & their Impact

Many phenomena causes lead signal loss from end to end on the earth's atmosphere:

1. Atmospheric Absorption (gaseous outcomes)
2. Cloud Attenuation (aerosolic and ice particles)
3. Tropospheric Scintillation (refractive outcomes)
4. Faraday Rotation (an ionospheric impact)
5. Ionospheric Scintillation (second ionospheric impact)
6. Rain attenuation
7. Rain and Ice Crystal Depolarization

The rain attenuation is the most important for frequencies above 10 GHz. Rain model are used to estimate the amount of degradation (or fading) of the signal when passing all the way through rain. Rain attenuation model: Crane 1982 & 1985; CCIR 1983;ITU-Rp,618-5(7&8).

Table:1 .Propagation Mechanism and their observable parameters



ATTENUATION

The primary, and most well known, effect of rain is that it attenuates the signal. The attenuation is due to the scattering and absorption of electromagnetic waves by drops of liquid water. The scattering diffuses the signal, even as absorption includes the resonance of the waves with human being molecules of water. Absorption increases the molecular energy, corresponding to a mild growth in temperature, and results in an equivalent lack of signal strength. Attenuation is negligible for snow or ice crystals, in which the molecules are tightly sure and do no longer engage with the waves. The typical method of representing rain attenuation is through an equation of the form

$$L_r = \alpha R^{\beta} L = \gamma L \quad \text{----(1)}$$

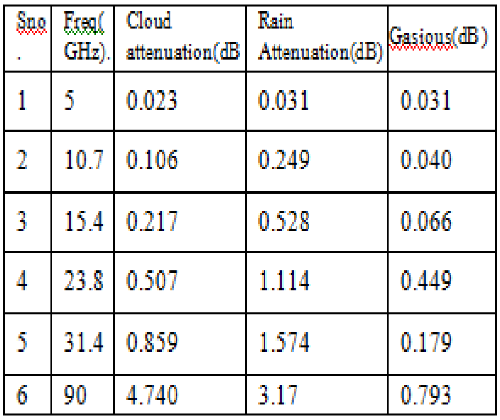
In which

Lr is the rain attenuation in decibels (dB)

R is the rain rate in millimeters per hour

L is an equivalent path length (km) α and β are empirical coefficients that rely upon frequency and to a degree on the polarization. The factor γ is known as the specific rain attenuation, that is expressed in dB/km. The equivalent path length depends on the angle of elevation to the satellite, the height of the rain layer, and the latitude of the earth station.

Table:2 Attenuation in dB by atmospheric Gases, Clouds and Rain.



Sno.	Freq(GHz).	Cloud attenuation(dB	Rain Attenuation(dB)	Gasious(dB)
1	5	0.023	0.031	0.031
2	10.7	0.106	0.249	0.040
3	15.4	0.217	0.528	0.066
4	23.8	0.507	1.114	0.449
5	31.4	0.859	1.574	0.179
6	90	4.740	3.17	0.793

DEPOLARIZATION

Rain additionally adjustments the polarization of the signal really. due to the resistance of the air, a falling raindrop assumes the shape of an oblate spheroid. Wind and other dynamic forces reason the raindrop to be rotated at a statistical distribution of angles. therefore, the transmission path length through the raindrop is one-of-a-kind for one of a kind signal polarizations and the polarization of the acquired signal is altered. For a satellite communication system with dual linear polarizations, the trade in polarization has two consequences. First, there's a loss inside the signal energy because of misalignment of the antenna relative to the clear sky orientation given via

$$L = 20 \log(\cos \tau) \quad \text{---- (2)}$$

Where in,

τ is the tilt perspective relative to the polarization path induced through the rain. second, there may be additional interference noise due to the admission of a part of the signal in the contrary polarization. The common canting attitude with recognize to the local horizon may be taken to be 25. it is an exciting belongings of earth-satellite geometry that a LP signal is not oriented with the nearby horizontal and vertical guidelines, despite the fact that a horizontally polarized signal is parallel to the equatorial plane and a vertically polarized signal is perpendicular to the equatorial plane when transmitted from the satellite. For that reason the optics of the earth station antenna should be efficaciously rotated to be able to reap the perfect polarization alignment with the satellite.

ATMOSPHERIC ABSORPTION

The propagation are mostly due to the results of the earth's ecosystem and their impact on device availability and margin. Distortions because of multipath propagation do not affect the millimeter wave. But, a few atmospheric effects at the millimeter wavelengths are gaseous absorption, cloud attenuation rain attenuation and tropospheric scintillation. Gaseous absorptions are particularly due to atmospheric gaseous additives predominantly oxygen and water vapor) and usually have a small contribution to the whole course attenuation in the W/V band.

Cloud attenuation at the W/V bands can contribute to significant loss (> 10 dB). Rain attenuation has the most dominant contribution to the total propagation loss when handling better frequencies. Troposphere scintillation is the rapid fluctuations in the refractive index of owing to turbulence and produces random fades and enhancements of the acquired signal amplitude. This phenomenon can significantly affect satellite-earth 3 links at frequencies above 10 GHz and at very low elevation angles (<= 5 degrees).

Rain & Ice effects

Rain affects the transmission of an electromagnetic signal in three ways:

(1) It attenuates the signal

(2) It increases the system noise temperature

(3) It changes the polarization.

All three of those mechanisms motive degradation in the acquired signal fine and turn out to be increasingly more widespread as the carrier frequency will increase. because the wavelength decreases and approaches the dimensions of a standard rain drop (approximately 1.5mm), more scattering and absorption takes place and the attenuation increases. additionally, as the rain fee will increase at some stage in a heavy downpour, the dimensions of the rain drops, and subsequently the attenuation, will increase.

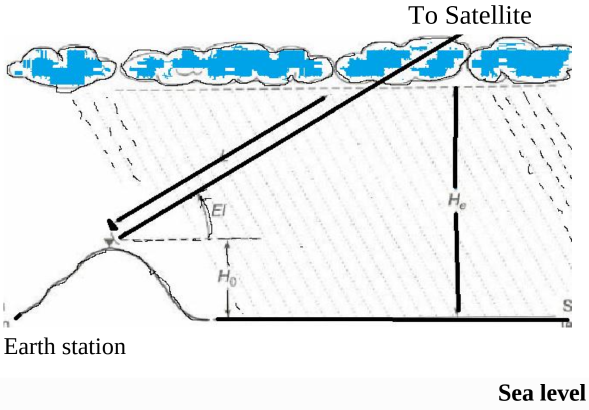


Fig: 1 Geometry of Satellite Signal Path Through Rain

Cloud Effects

Cloud attenuation turns into increasingly more important to bear in mind for reliable satellite communications at frequencies above 10 GHz . For clouds or fog include small droplets, much less than 0.01 cm, the Rayleigh approximation is valid for frequencies beneath 200 GHz and it's miles viable to express the attenuation in terms of the total water content material in line with unit extent . the subsequent equation may be used to acquire the attenuation because of clouds for a given chance:

$$A = L.KI.\sin\theta \text{ , for } 90^\circ \geq \theta \geq 5^\circ \quad \text{---(3)}$$

wherein L is the total columnar content of liquid water (kg/m^2), Kl is the specific attenuation with the aid of water droplet and θ is the elevation angle.

SCINTILLATION EFFECTS

Rapid signal fluctuations occurred in amplitude and angle of the received signal due to small scale variations inside refractive index when satellite signal passing all the through turbulent atmosphere call scintillation effects shown in below figures 1.a & b.

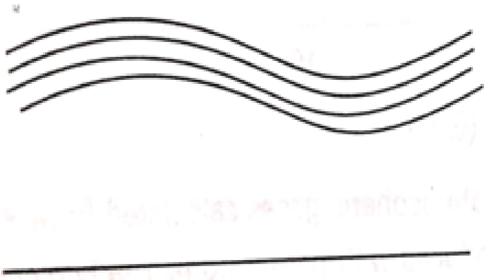


Fig.2.a Calm condition of atmosphere

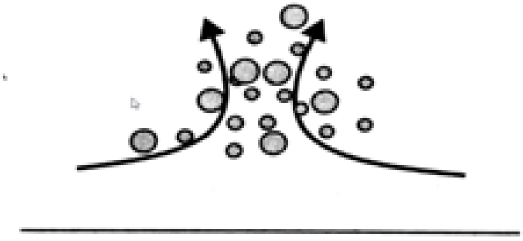


Fig.2.b.Convectivie condition of atmosphere

Tropospheric Scintillation Effects Bulk of fluctuations caused within 4kms height of the atmosphere from earth's surface called Tropospheric Scintillation Effects

Table:3.Comparison with existing model

Model	Scintillation Intensity at 0.01%
ITU-R	0.9dB
Van de Kamp	2dB
Otung	14dB
DPSP	32dB
Ortgies	11.8dB
Marzano	12dB

TROPOSPHERIC SCINTILLATION EFFECTS

For σ_{st} ,standard deviation of scintillation, at receiving antenna received signal with short term signal variability written as the fades and enhancements for given time percentage as follows.

The time percentage enhancement factor for p≤50% is:

$$a_{ste}(p)=-0.0597(\log(p))^3-0.0835(\log(p))^2-1.25(\log(p))+2.6720 \quad -(4)$$

The time percentage fade factor $q=100-p, q>50\%$ is:

$$a_{stf}(q)=-1.71\log(q)+0.072(\log(q))^2-0.061(\log(q))^3+3.0 \quad -(5)$$

Tropospheric attenuation depth due to Scintillation for p not exceeded factor is:

$$A_{st}(p)= -\sigma_{st}\, a_{ste}(p) \qquad \text{for } p\leq 50\% \quad \text{dB}$$

$$= \sigma_{st}\, a_{stf}(100-p=q) \qquad \text{otherwise} \quad \text{dB—(6)}$$

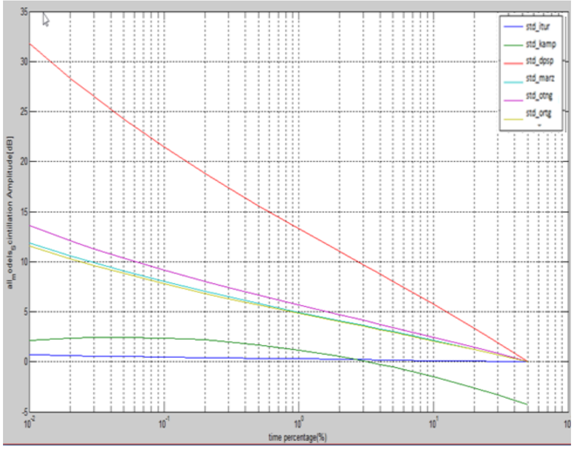


Fig.3.Different existing models comparison

Well known prediction models are ITUR, Kamp, Karasawa, Otung, Ortgies, Marzano, DPSP prediction models. The scintillation measured at the time percent of 0.01% faded signal stretched to 0.30dB and an enhanced signal stretched to 0.27dB.The RMS error is highest fade by ITUR model. Ortgies prediction model best for faded signal and ITUR is best for signal enhancement but both are not suitable to apply for the prediction of scintillations in Indian climatic conditions because both will give highest rms errors. The scintillation intensity will raise with frequency and low elevation angles. These are proven with simulation results.

FUTURE SCOPE

Investigations on propagation effects on different locations of interest would be proposed. To predict the various parameters need in satellite links at upper frequency bands for tropical climate.

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