Radio Wave Propagation

Lecture # 6

By

Kamran Ahmed

Radio Wave Propagation

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  - **Atmospheric losses**
  - **Rain Attenuation**
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- **This section discusses the basic effects of the propagation anomalies as they influence the communication satellite system performance**
- **The greatest difference between the bands above 10 GHz and those between 1 and 10 Ghz**
- **The 1-10 GHZ range is already extensively used by both terrestrial microwave and satellite services.although the noise level and attenuation are lower than the higher frequencies, the potential for interference from terrestrial point-to-point services has limited earth station locations.**

- **Above 10GHz the rain attenuation increases, but the chances of interference with other services are minimum.**
- **At certain wavelengths signals encounter absorption bands due to atmospheric components (like water vapor and oxygen) within the range of 1-10 GHz**
- **Frequencies above 30GHz have been underutilized, there is spectrum available, especially for services that do not pass through the atmosphere like ISL(Inter Satellite Link)**

- **The fundamental equation for the free-space position of the slant range losses(L_{range}) is;**

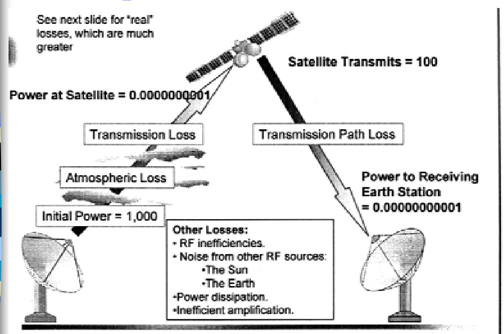
  $$L_{range} = (4\Pi S/\lambda)^2$$

  where;
  S= Slant Range in m
  λ =Wavelength in m
- **At 6GHz the slant range attenuation is about 200db**

Atmospheric Losses

- In satellite communications, *atmospheric losses* results from the absorption of the Earth-satellite or satellite-Earth signals as they pass through the Earth's atmosphere. The value of the atmospheric loss is strongly dependent on frequency.

Atmospheric Losses



Atmospheric Losses

- Beam-spreading Loss
- Polarization Loss
- Rayleigh fading
- Scintillation Loss
- Free-space loss
- Weather Loss
- Doppler Effect

Beam-spreading loss

- In satellite communications, *beam-spreading loss* results from the spreading of the earth-satellite signals as they pass through the Earth's atmosphere

Scintillation loss

- In satellite communications, scintillation loss results from rapid variations in the signal's amplitude and phase due to changes in the refractive index of the Earth's atmosphere.

Polarization loss

- In satellite communications, polarization loss results from a rotation of the polarization of the signal as it passes through the Earth's atmosphere

Rayleigh Fading

- Rayleigh fading is fading in a satellite communications channel due to the interference caused to the main signal by the same signal arriving over many different paths, resulting in out-of-phase components incident at the receiver.
- Rayleigh fading occurs commonly in wireless communications channels, including satellite communications channels.

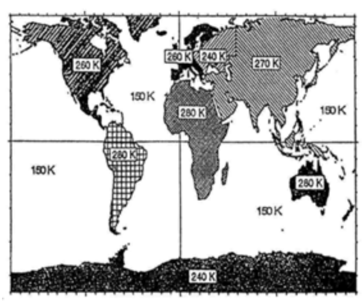
Free Space Losses

- **In satellite communications, free-space loss is the major loss suffered by signals in traveling over the Earth-satellite path. The loss is inversely proportional to the square of the distance traveled and inversely proportional to the square of the frequency used. That is, as the distance is doubled the received power is reduced by a factor of four. Similarly, as the frequency is doubled the received power is reduced by a factor of four.**
- **Free-space loss for geo-stationary satellite communications satellites varies between 190-210 dB depending on the frequency used**

Weather Losses

- In satellite communications, weather loss results from attenuation of the Earth-satellite signals by hydrometers as they pass through the Earth's atmosphere

Brightness Temperature of the Earth

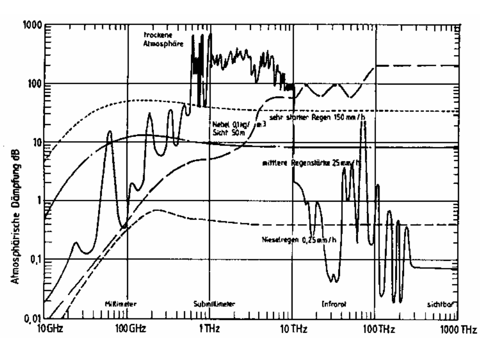


14 GHz (ESA/EUTELSAT-Modell)

Doppler Effect

- **The Doppler effect in satellite communications is the change in frequency of an electromagnetic signal that results from the relative speed of the satellite and the Earth terminal. When the orbital parameters of a satellite are known, Doppler shift can be used to determine the position of the Earth terminal. When an Earth terminal's position is known, Doppler shift can be used to estimate the orbital parameters of a satellite. When the satellite (or the Earth station) is moving quickly, the Doppler effect is an important consideration in satellite communications**

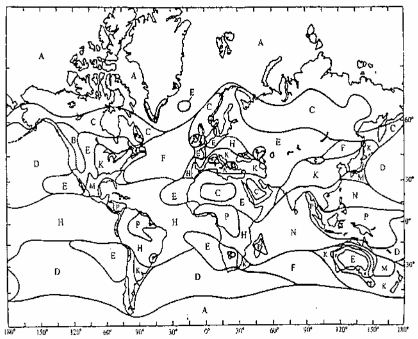
Atmospheric and Rain Attenuation



Rain Attenuation

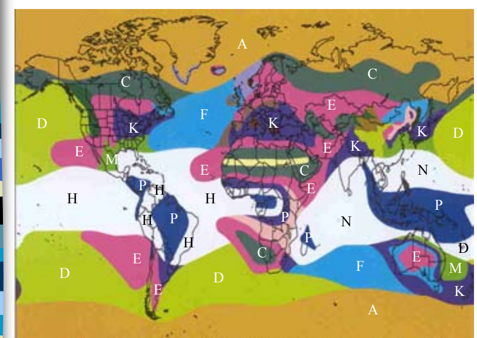
- Rain is predominant loss element below 60GHz.
- Fog is shown has attenuation 0.1 g /m3
- The total link attenuation is the sum of the losses due to slant range , the atmosphere, precipitation and any additional losses(such as scintillation etc.)

Climatic Zones



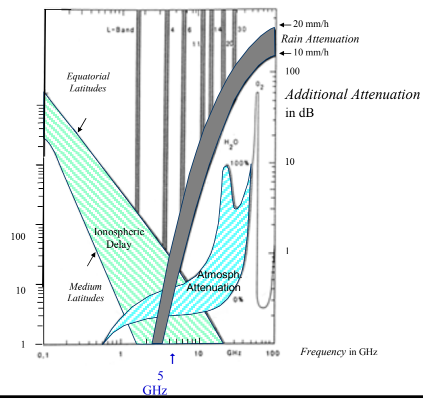
A: is extremely dry climate, . . . P: extremely humid climate

Climatic Zones



Ochre is extremely dry climate, dark blue extremely humid climate

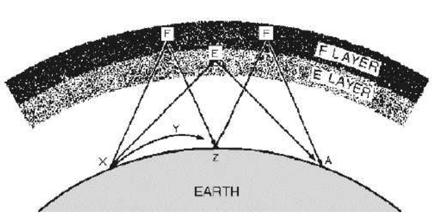
Atmospheric and rain attenuation



Ionospheric Losses

- Al lower frequencies (e.g 1.5 and 2.5 GHz) ionospheric effect may be encountered, particularly scintillation.
- The magnitude of these losses vary considerably with the time of day and the sunspot activity level (the affect the ionosphere).

Ionospheric Losses



Ionospheric Losses

- **All radio waves propagated over ionospheric paths undergo energy losses before arriving at the receiving site. As we discussed earlier, absorption in the ionosphere and lower atmospheric levels account for a large part of these energy losses.**
- **There are two other types of losses that also significantly affect the ionospheric propagation of radio waves. These losses are known as ground reflection loss and free space loss.**
- **The combined effects of absorption, ground reflection loss, and free space loss account for most of the energy losses of radio transmissions propagated by the ionosphere**