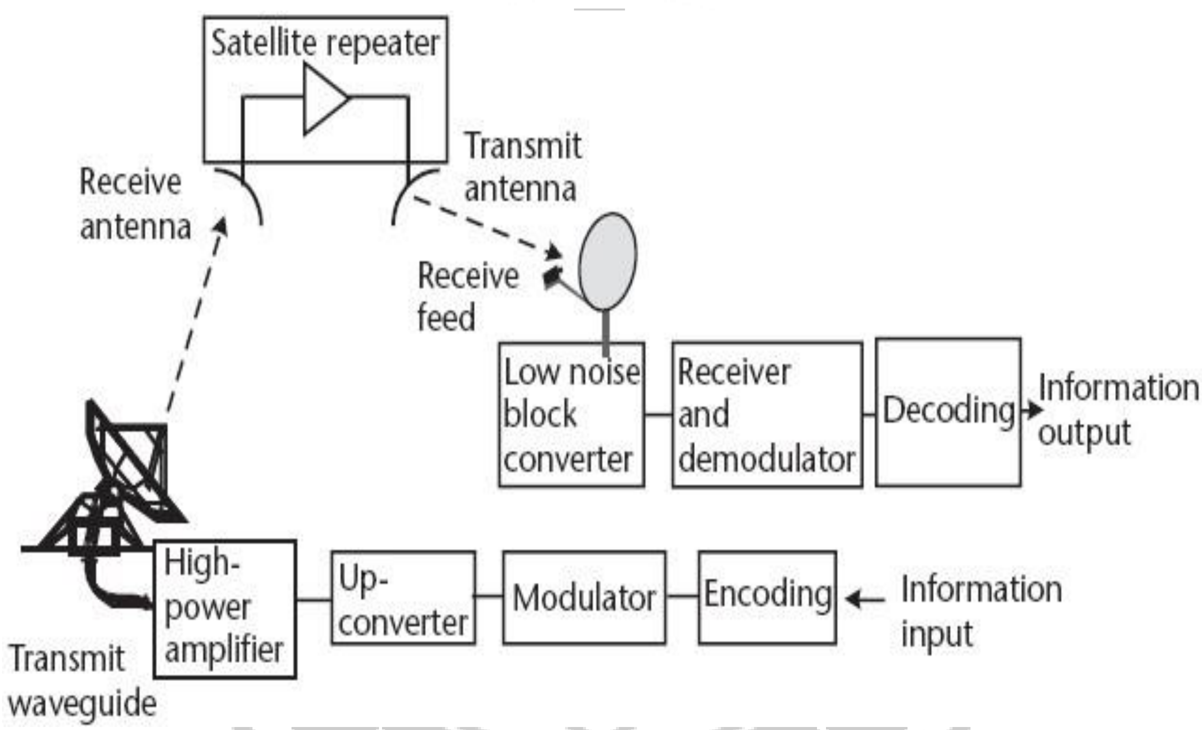
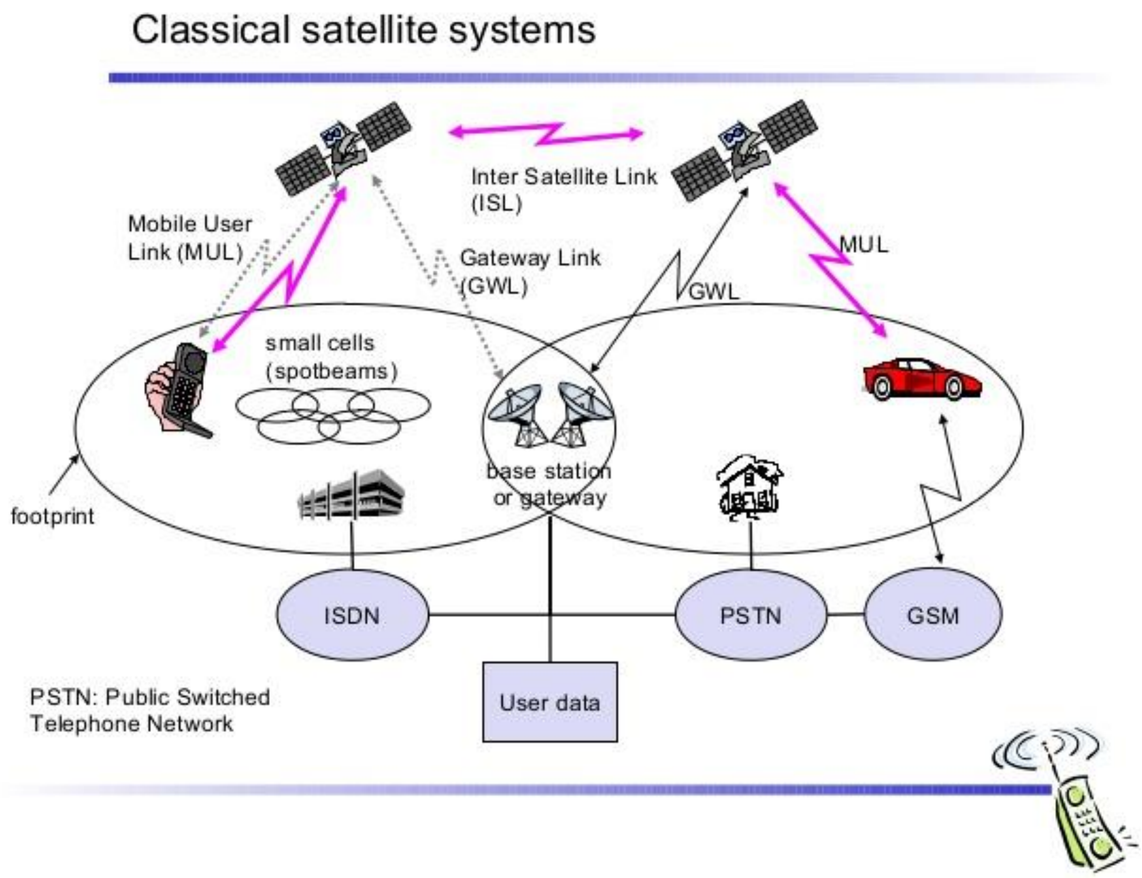
3.5 Link Design with and without frequency reuse

- Intra –orbital links :connect consecutive satellites on the same orbits
- Inter –orbital links :connect two satellites on the different orbits



Design of the Satellite System



LNB (LOW NOISE BLOCK DOWN CONVERTER)

- A device mounted in the dish, designed to amplify the satellite signals and convert them from a high frequency to a lower frequency. LNB can be controlled to receive signals with different polarization. The television signa can then be carried by a double-shielded aerial cable to the satellite receive while retaining their high quality. A universal LNB is the present standard version, which can handle the entire frequency range from 10.7 to 12.75 Gl and receive signals with both vertical and horizontal polarization.

Demodulator

A satellite receiver circuit which extracts or "demodulates" the "wanted "signals from the received carrier.

Decoder

- A box which, normally together with a viewing card, makes it possible to view encrypted transmissions. If the transmissions are digital, the decoder usually integrated in the receiver.
- recorded video information to be played back using a television receiver tuned to VHF channel 3 or 4.

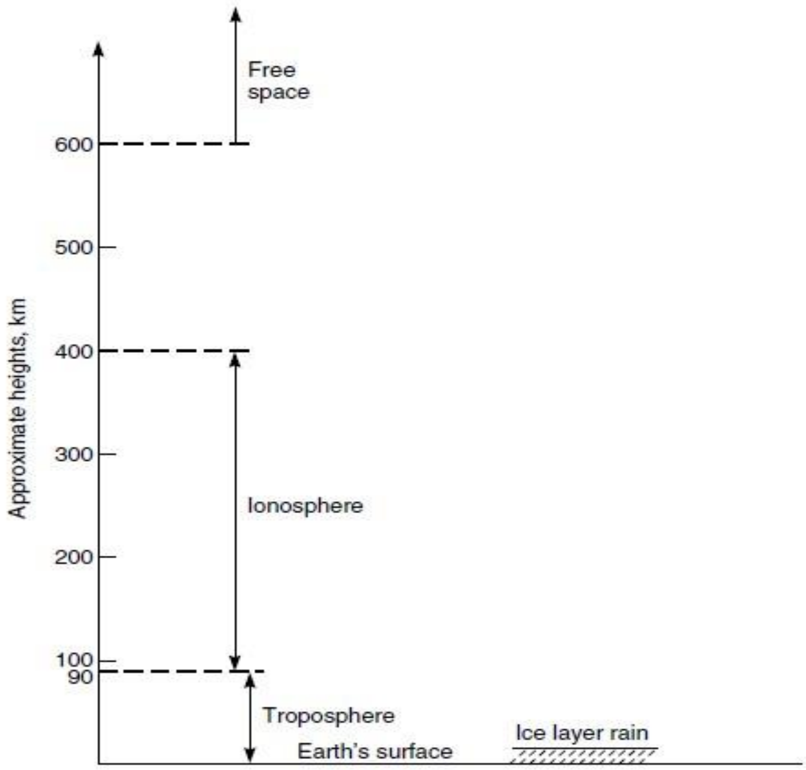
- **Modulation**
  The process of manipulating the frequency or amplitude of a carrier in relation to an incoming video, voice or data signal.
- **Modulator**
  A device which modulates a carrier. Modulators are found as components in broadcasting transmitters and in satellite transponders. Modulators are also used by CATV companies to place a baseband video television signal onto a desired VHF or UHF

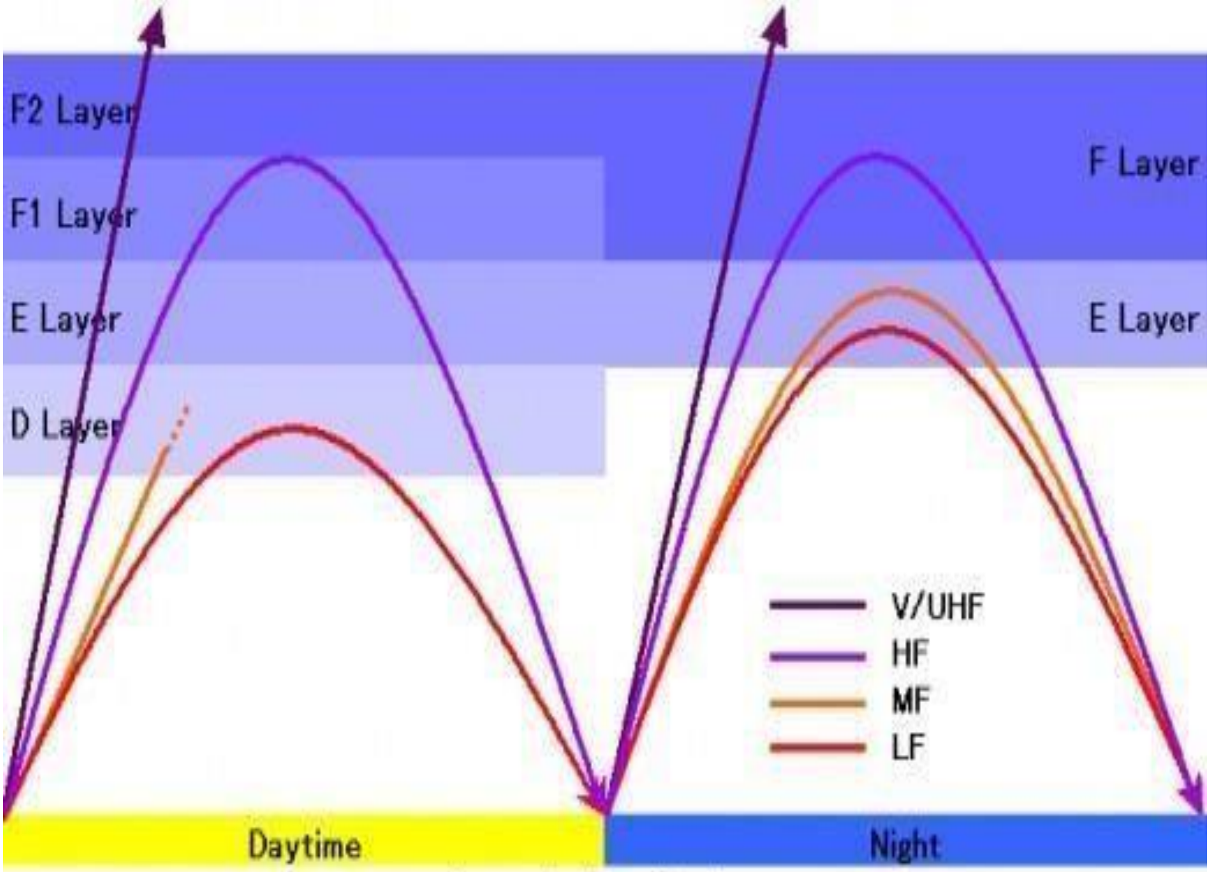
Atmospheric Layers

A signal traveling between an earth station and a satellite must pass through the earth's atmosphere, including the ionosphere, as shown

Atmospheric Losses

- Losses occur in the earth's atmosphere as a result of energy absorption by the atmospheric gases.
- The weather-related losses are referred to as *atmospheric attenuation* and the absorption losses by gases are known as *absorption.* **Atmospheric scintillation:**
- This is a fading phenomenon, the fading period being several tens of seconds.
- It is caused by differences in the atmospheric refractive index, which in turn results in focusing and defocusing of the radio waves, which follow different ray paths through the atmosphere.
- Fade margin in the link power-budget calculations are used for Atmospheric Scintillation.


Free
space
600
500
400
300
200
100
90
Approximate heights, km
Ionosphere
Troposphere
Earth's surface
Ice layer rain

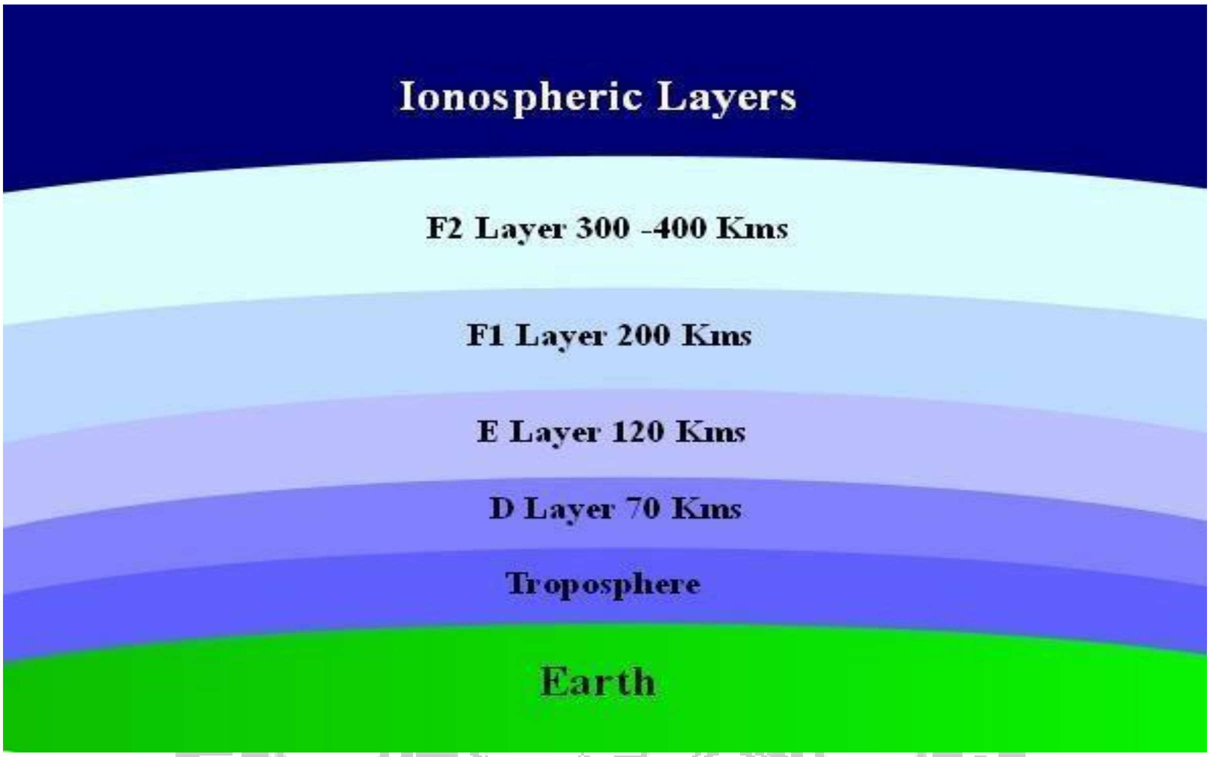


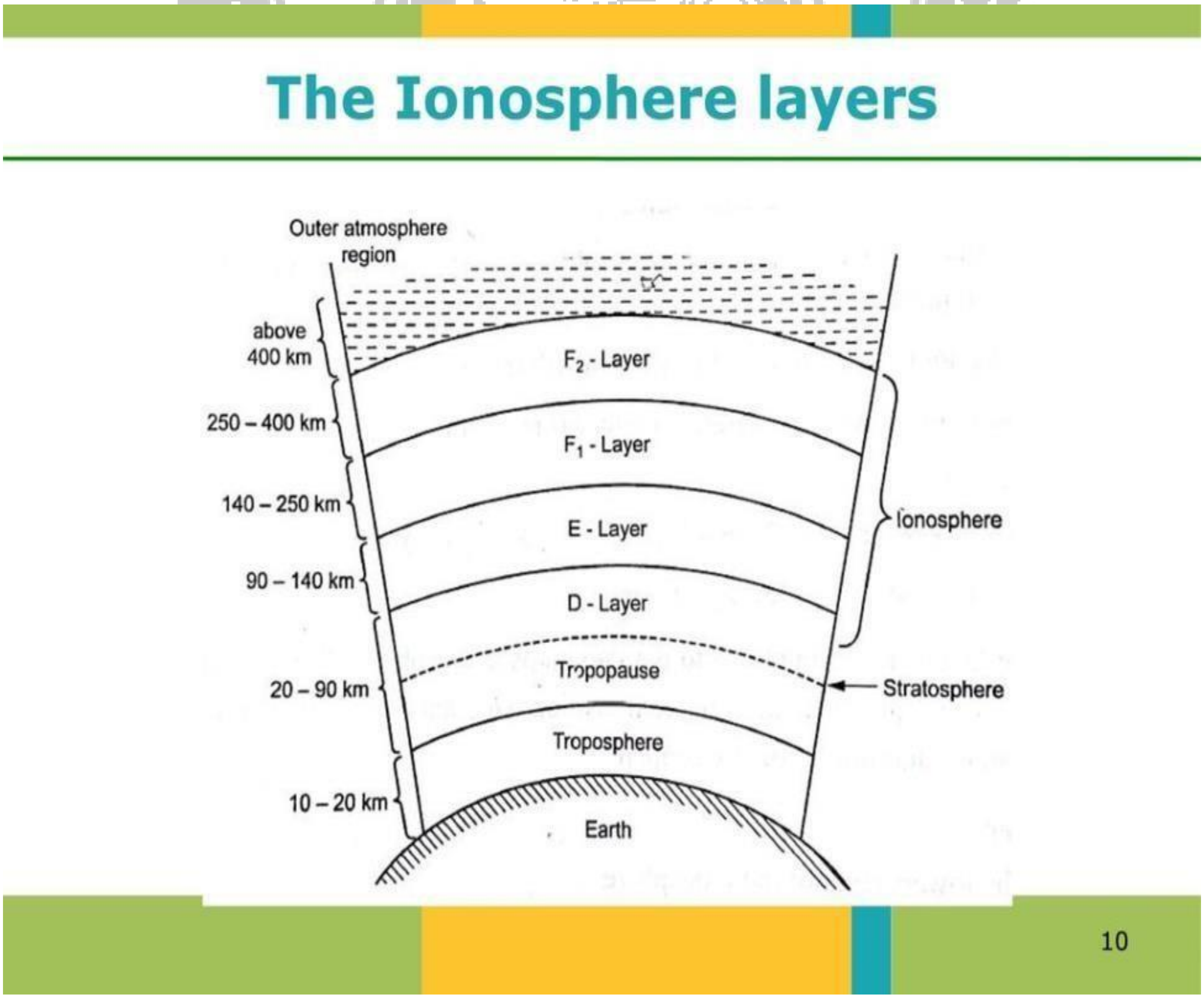
Ionospheric reflection
(under normal condition)

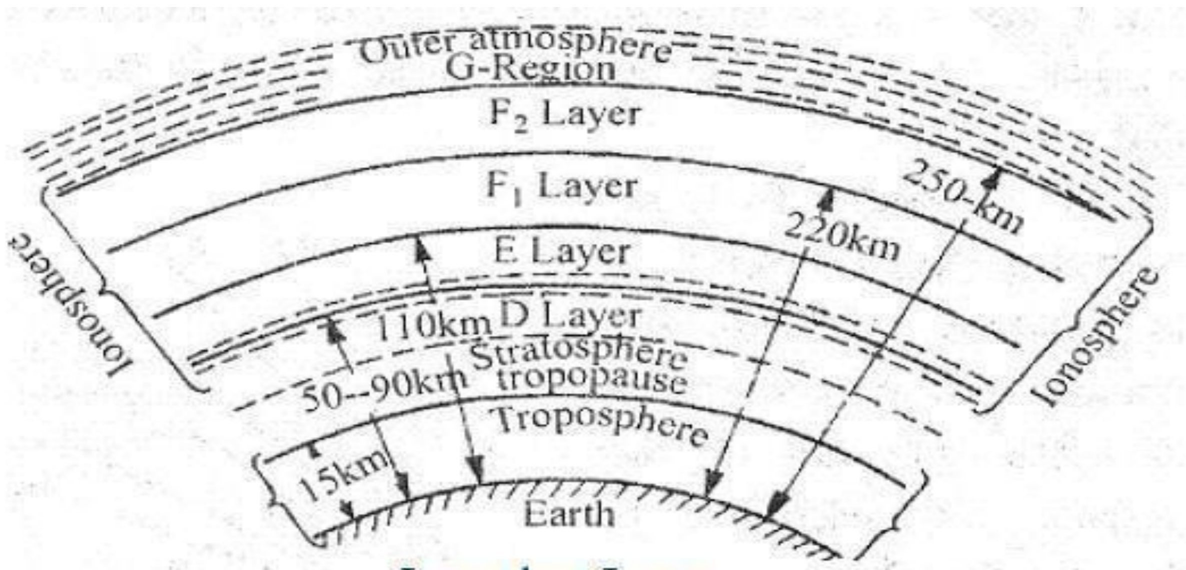
3.6 Ionospheric Effects

- Radio waves traveling between satellites and earth stations must pass through the ionosphere.
- The ionosphere is the upper region of the earth's atmosphere, which has been ionized, mainly by solar radiation.
- The free electrons in the ionosphere are not uniformly distributed but form in layers, which effect the signal.

Ionospheric Layers



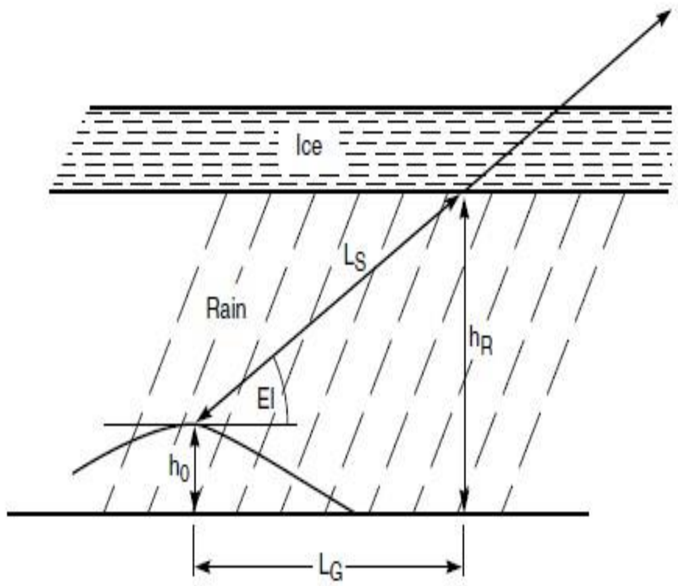




Ionosphere Layers

3.7 Rain Induced Attenuation

- Rain attenuation is a function of *rain rate.* The rain rate is measured in millimeters per hour. The total attenuation is given as $A = \alpha L$ dB
- *α-Specfic attenuation*
- *L- Effective path length* of the signal through the rain
- The geometric, or slant, path length is shown as L_S. This depends on the antenna angle of elevation and the *rain height* h_R, which is the height at which freezing occurs.



$$L_S = \frac{h_R - h_O}{\sin El}$$

- The effective path length is given in terms of the slant length by $L = L_S r_p$
- where r_p is a *reduction factor* which is a function of the percentage time *p* and L_G, the horizontal projection of L_S. $L_G = L_S \cos El$
- With all these factors together into one equation, the rain attenuation in decibels is given by,

$$A_p = aR_p{}^b L_S r_p \text{ dB}$$

Link budget calculations

Equivalent Isotropic Radiated Power:

- A key parameter in link budget calculations is the equivalent isotropic radiated power (EIRP).
- An isotropic radiator with an input power equal to GP_S would produce the same flux density. Hence this product is referred to as the equivalent isotropic radiated power.

- EIRP = GP_S,

  G= Gain and P_S = Power Supplied.

Free Space Loss

- In the loss calculations, the power loss resulting from the spreading of the signal in space must be determined.
- The power flux density at the receiving antenna is given as

$$\Psi_M = \frac{\text{EIRP}}{4\pi r^2}$$

The power delivered to a matched receiver is this power flux de ty multiplied by the effective aperture of the receiving antenna, g by Eq. The received power is therefore

$$P_R = \Psi_M A_{\text{eff}}$$

$$= \frac{\text{EIRP}}{4\pi r^2} \; \frac{\lambda^2 G_R}{}$$

$$= (\text{EIRP})\,(G_R)\left(\frac{\lambda}{4\pi r}\right)^2$$

$$[P_R] = [\text{EIRP}] + [G_R] - 10\log\left(\frac{4\pi r}{\lambda}\right)^2$$

$$[\text{FSL}] = 10\log\left(\frac{4\pi r}{\lambda}\right)^2$$

$$[P_R] = [\text{EIRP}] + [G_R] - [\text{FSL}]$$

3.8 Interferance

- With many telecommunications services using radio transmissions, interference between services can arise in a number of ways.

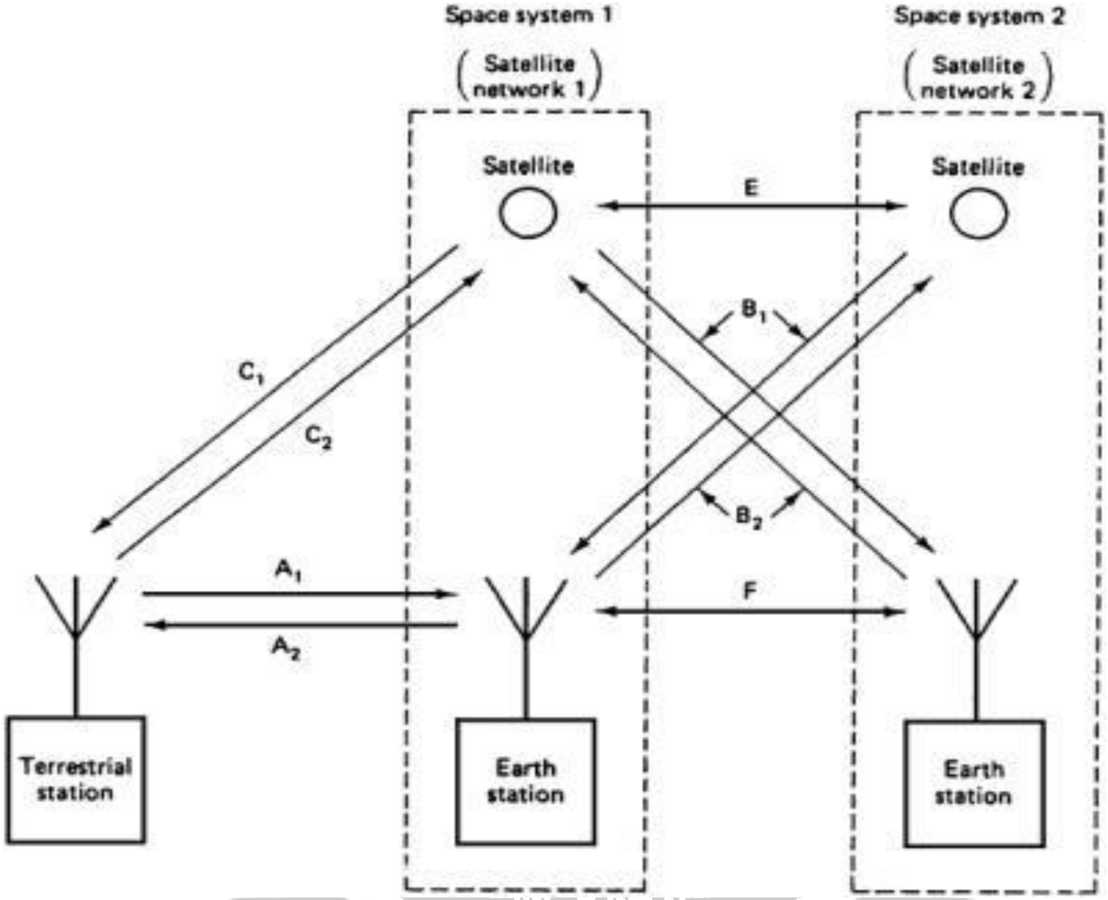


Fig (a)

Possible interference modes between satellite circuits and a terrestrial station

Fig. (a) are classified by the International Telecommunications Union (ITU, 1985) as follows: A1: terrestrial station transmissions, possibly causing interference to reception by an earth station A2: earth station transmissions, possibly causing interference to reception by a terrestrial station B1: space station transmission of one space system, possibly causing interference to reception by an earth station of another space system B2: earth station transmissions of one space system, possibly causing interference to reception by a space station of another space system C1: space station transmission, possibly causing interference to reception by a terrestrial station C2: terrestrial station transmission, possibly causing interference to reception by a space station E: space station transmission of one space system, possibly causing interference to reception by a space station of another space system F: earth station transmission of one space system, possibly causing interference to reception by an earth station of another space system

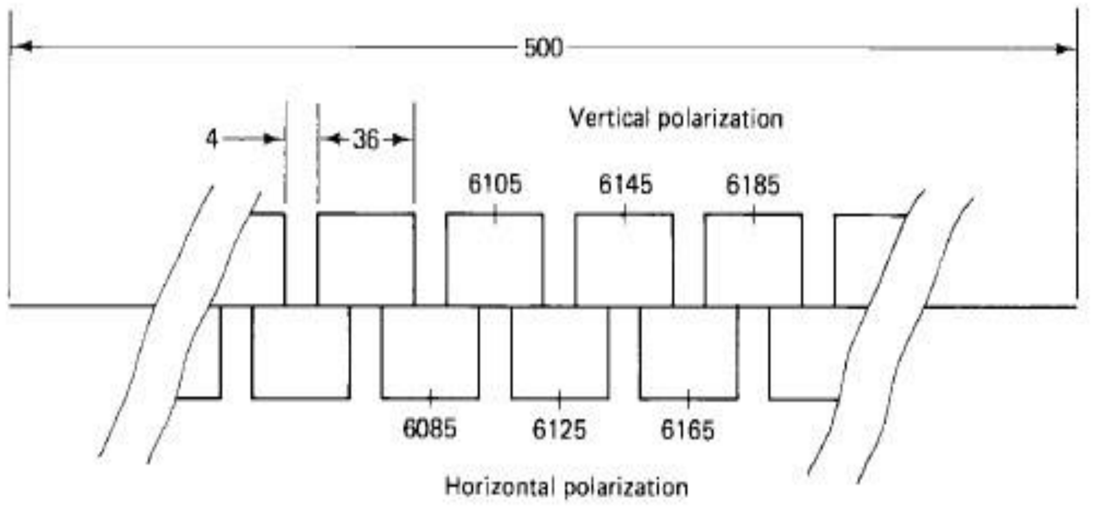
Interference between satellite circuits

- A satellite circuit may suffer from B1 and B2 mode of interference with the number of neighbouring satellite circuits. This resultant effect termed as **aggregate interference**.
- But the study of aggregate interference is limited, instead **single entry interference** studies considered into account.
- **single entry interference** refers to the interference produced by single interfering circuit on a neighbouring circuit.
- The system performance is determined by the ratio of wanted carrier to the interfering carrier power.
- The radiation pattern of the antenna controls the interference. To relate C/I ratio to the antenna radiation pattern , consider some parameters. They are geocentric point, topocentric point, orbital spacing and orbital spacing angle.

Combined [C/I] due to interference on both uplink and downlink

Interference may be considered as a form of noise, and assuming that the interference sources are statistically independent, the interference powers may be added directly to give the total interference at receiver B. The uplink and the downlink ratios are combined in exactly the same manner described for noise, resulting in Here, power ratios must be used, not decibels, and the subscript "ant" denotes the combined ratio at the output of station B receiving antenna

3.9 Link Design With and without Frequency Reuse



- Frequency reuse is employed to reduce the crosspolarization caused by ionosphere, ice crystals in the upper atmosphere and

- rain, when the wave being transmitted from satellite to earth station.

- Frequency reuse achieved with spot-beam antennas, and these may be combined with polarization reuse to provide an effective bandwidth.

- The bandwidth allocated for C band service is 500 MHz, and this is divided into sub bands, one for each transponder. A typical transponder bandwidth is 36 MHz, and allowing for a 4-MHz guard band between transponders, 12 such transponders can be

- accommodated in the 500-MHz bandwidth. this number can be doubled. Polarization isolation refers to the fact that carriers, which may be on the same frequency but with opposite senses of polarization, can be isolated from one another by receiving

- With antennas linear match polarized carriers can be separated in this way, and with circular polarization, left-hand circular and right-hand circular polarizations can be separated. Because the carriers with opposite senses of polarization may overlap in frequency, this technique is referred to as *frequency reuse*

				RHCP	
	1	3	5		31
Uplink MHz	17324.00	17353.16	17382.32	. . .	17761.40
Downlink MHz	12224.00	12253.16	12282.32		12661.40

				LHCP	
	2	4	6		32
Uplink MHz	17338.58	17367.74	17411.46	. . .	17775.98
Downlink MHz	12238.58	12267.74	12296.50		12675.98