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SATELLITE COMMUNICATION

By Gaurish Kumar Tripathi ....

1.0 INTRODUCTION:

The use of satellite in communication system is very much a fact of everyday in life. This is evidence by the many homes, which are equipped with antennas and dishes. These antennas were used for reception of satellite signal for television. What may not be well known that satellites also form an essential part of communication system worldwide carrying large amount of data, telephone traffic in addition to television signals.

Satellites offers a number of important features, which are not readily available with others means of communication. Some of them are enumerated below.

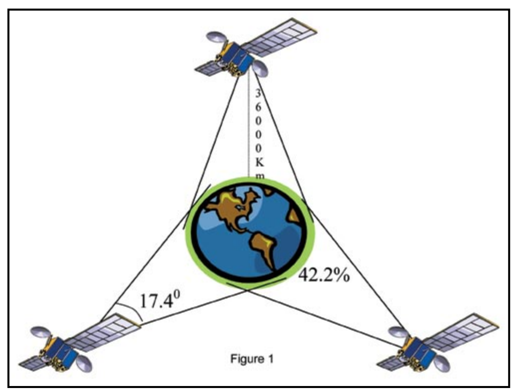


Figure 1

1. Very large area of earth is visible from satellite (about 42%) i.e. communication is possible beyond earth curvature (beyond line of sight)

2. Satellite offers communication with remote communities in sparsely populated area, which are difficult to access by other means of communication.

3. Satellite communication ignores political boundaries as well as geographical boundaries.

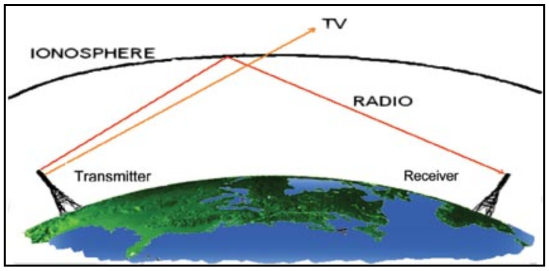
4. Satellite provides communication with moving aircraft from ground control station across the country.

5. Satellite provides remote sensing i.e. detection of water pollution, oil field, monitoring and reporting of weather conditions etc.

6. The combination of three satellites, with the ability to relay messages from one to the other could interconnect virtually all of the earth except the Polar Regions as shown in figure 1

2.0 REQUIREMENT FOR SATELLITE COMMUNICATION:

The communication between one point to other depends upon frequency of the transmitted signal as well as mode of communication. The frequency up to appropriately 10 MHz was used for small distance communication through Ground Wave Propagation. As frequency increases, the attenuation of ground wave increases (Earth starts behaving like absorber for high frequency signals) because of which, it is not possible to establish a reliable communication link through ground waves for frequencies more than 10 MHz. Since Earth is elliptical in shape, thus direct wave which are reaching at receiving antenna are restricted by curvature of Earth (The direct wave communication is not possible beyond Line of Sight).



The above limitation for long distance communication requires a reflector above the earth surface, which reflects the signal towards receiving antenna. The Sky Wave Propagation is possible due to Ionosphere present in the atmosphere. The ionosphere has property that it reflect transmitted signals up to a certain frequency and after that the layer is behaving as transparent medium and signal passes the layer. This natural reflector present in the atmosphere provides radio broadcasting link to larger area of Earth beyond Line of Sight (Figure 2).

The signals having frequency more than 30 MHz are pass through ionosphere and these are required to reflected back to earth by some artificial medium for establishing reliable communication between transmitter and receiver. For fulfilling the requirement of high frequency and long distance communication across the globe, the artificial reflector (Satellite) above the ionosphere are required for transmitted signal.

The satellites were used for reflecting the signals having frequencies more than 30MHz. The transponders in the satellite receive the signal and after signal conditioning (suppressing noise, amplification) re-transmit back to ground for reception. The frequency at which signal is transmitted from ground to satellite is known as uplink frequency and signal frequency transmitted from satellite to ground is known as downlink frequency. It has been decided by international community that uplink frequency is always higher than downlink frequency.

It is to be noted that as frequency of communication increases, the size of transmitting and receiving antenna as well as the size of the electronics components required are decreases drastically (Inversely proportional).

3.0 FREQUENCY ALLOCATION FOR SATELLITE COMMUNICATION:

The allocation of frequency for satellite communication is a complicated process. This requires international co-ordination and planning and this is carried out under the auspices of the International Telecommunication Union (ITU). The allocation of frequency shall be carried out depending upon the type of service provided by the satellite, for example, Broad casting satellite service is providing land and aeronautical communication. Navigational satellite services include Global Positioning System (GPS). The ITU has decided the frequency bands for various type of communication. The band designation, their nominal frequency range and principle use is given in table 1.

Band Designation	Nominal Frequency Range	Principal uses
HF	3 -30 M Hz	Short-wave Broadcast
VHF	30 -300 M Hz	FM, TV
UHF	300 -3000 MHz	TV, LAN, cellular, GPS
L	1 -2 GHz	Radar, GSO satellites
S	2 - 4 GHz	- do -
C	4 -8 GHz	Satellite data links
X	8 -12 GHz	- do -
Ku	12 -18 GHz	Radar, satellite data links
K	28 -27 GHz	- do -
Ka	27 - 40 GHz	Radar ,Automotive data
mm (millimeter) wave	40 -300 GHz	

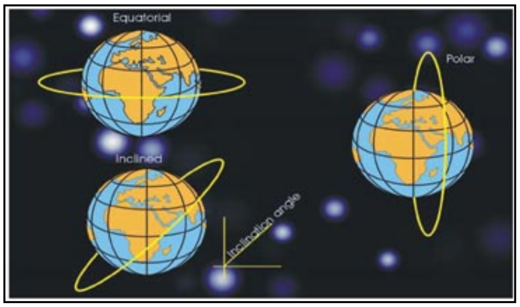
Table 1

4.0 ORBITS OF SATELITTE:

There are two most favorable orbits of satellite for providing the communication links:

4.1 Polar Orbits:

The polar orbiting satellites orbit the earth in such a way as to cover the north and south Polar Regions. The altitude of polar orbiting satellite is constant over the polar region and it is approximately 1000 Km. The period of orbiting is about 1.5 Hrs and at 90°inclination to ensure that satellite passes every region of earth. Example :IRIDIUM, GLOBAL STAR etc.



4.2 Equatorial Orbit:

The equatorial orbit has 0° inclination from Equator. The most popular orbit is Geostationary orbits which is present at 35786 Km from the Earth surface. The satellite in Geostationary orbit appears to be stationary with respect to earth and period of satellite is 23 Hrs, 56 minutes, 4 second means solar time (ordinary clock time). The one disadvantage (for some purposes) of the geosynchronous orbit is that the time to transmit a signal from earth to the satellite and back is approximately % of a second - the time required to travel 35786 Km up and 35786 Km back down at the speed of light. For telephone conversations, this delay can sometimes be annoying but for data transmission and other uses it is not much significant.

Today, there are approximately 150 communications satellites in orbit, with over 100 in geosynchronous orbit. These satellites around the globe are making provision to relay from one satellite to another, they made it possible to transmit 1000s of phone calls between almost any two points on the earth. It was also possible for the first time, due to the large capacity of the satellites, to transmit live television pictures between virtually any two points on earth.

Note:
It to be noted that there are infinite number of Polar Orbits across the globe where as there is only one Geostationary Orbit. Various communication satellites are present in Geostationary orbit. Example: INSAT/ GSAT. Communication authorities throughout the world regards Geostationary orbit as a natural resource and its use is carefully regulated through national and international agreement.

5.0 NATIONAL & INTERNATIONAL COMMUNICATION SATELLITES:

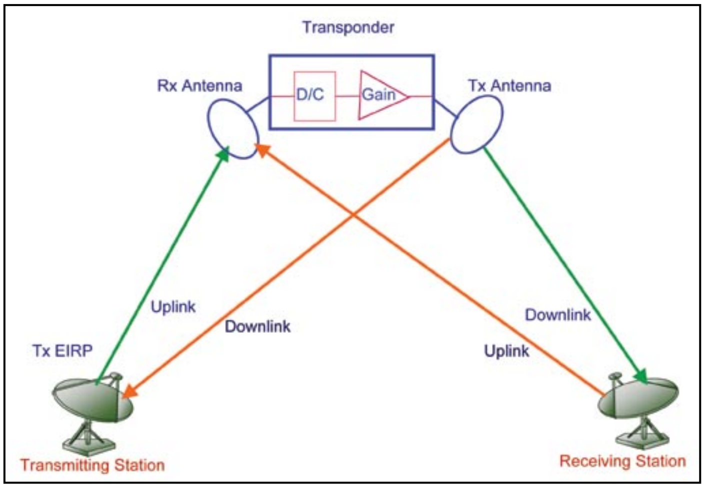
Some Indian & International communication satellites along with their location, year of launch and availability of transponder is given in table 2 & table 3.

Satellite	Location	Launch Month / Year	Transponders
IN SAT 2A	74° E	July 1992	12 C, 6 Ext C
INSAT 2B	93.5°E	July 1993	12 C, 6 Ext C
INSAT 2C	93.5°E	December 1995	12 C, 6 Ext C, 1 Pair MSS & 3Ku (MSSS non -operational)
INSAT 2D	74° E	June 1997	12 C, 6 Ext C, 1 Pair MSS & 3Ku (abandoned)
INSAT 2E	83°E	1995	12 C, 5 Ext C
INSAT 3B	83°E	March 2000	12 Ext C, 1 Pair S-MSS & 3 Ku (MSS non-operational)

INSAT 3C	74° E	January 2002	24 C, 6 Ext C, 1 pair MSS
INSAT 3A	93.5°E	February 2003	12 C, 6 Ext C
INSAT 3D	93.5°E	2003/2004	Met Payloads
INSAT 3E	55°E	April 2003	24 C, 12 Ext C
GSAT 1	48°E	April 2001	3 C (non-operational)
GSAT 2	48°E	May 2003	4 C, 2 Ku & 1 pair MSS
GSAT 3	74° E	2nd Half of 2004	7 Ku (5 Regional + 2 National)
GSAT 4	48°E	Early 2006	8 Channel Ka Band regenerative & Bend pipe
Table 2			

Satellite	Coverage Area	Launch Year	Frequency Band/Service
INTELSAT (I-IX Generations)	Atlantic/Indian/ Pacific Ocean Regions	I-Generation 1964 IX-Generation 2002	C&Ku-Band; Global Voice & Data Communication, Newsgathering DTH-TV
Asia Sat (1 to 3)	Asian region	Asia Sat 1-1984 Asia Sat 3-1999	C&Ku-Band; Domestic TV for China, Myanmar, Mongolia & Pakistan
AP Star 1 & 2 (Asia Pacific Telecom Sat)	China, East & South East Asia	AP Star 1-1995 AP Star 2-1997	C&Ku-Band; General & Business Communication & TV
MARISAT I,II, III	Atlantic/Pacific/ Indian Ocean Regions	1976	UHF, L&C-Band; MSS (Voice & Data for Navy & Commercial Ships)
INMARSAT (A,B,C,D,M, Mini M & Aero)	Atlantic /Pacific/ Indian Ocean Regions	1976-1998	L&C-Band; MSS (Maritime, Land & Aero:Voice & Data Communication)
IRIDIUM	Global (with 66 LEO Satellites in six plane)	1997-1999	L&K-Band Worldwide Comm. Through Handheld Terminals
Gapfiller/ Gapsat (Defence Satellite)		1973-1976	UHF; British Navy
FLT/AF SATCOM	Global	1979-1989	UHF, X-Band & EHF: US Navy & Air Force
Table 3			

6.0 BASIC COMPONENTS OF COMMUNICATION SATELLITE



Every communications satellite in its simplest form (whether low earth or Geosynchronous) involves the transmission of information from an originating ground station to the satellite (the uplink), followed by a retransmission of the information from the satellite back to the ground (the downlink). The downlink may either be to a select number of ground stations or it may be broadcast to everyone in a large area. Hence the satellite must have a receiver and a receive antenna, a transmitter and a transmit antenna, some method for connecting the uplink to the downlink for retransmission, and prime electrical power to run all of the electronics. The exact nature of these components will differ, depending on the orbit and the system architecture, but every communications satellite must have basic components shown in figure 5.

6.1 Transmitting and Receiving antenna:

Functional requirements of transmitting and receiving antenna have markedly different but directional characteristics apply equally to both antenna. A single antenna may be, and frequently be used for transmitting and receiving the signal simultaneously.

One of the biggest differences between a low earth satellite and a geosynchronous satellite is in their antennas. Transmitting antenna for low earth satellite requires less power (approximately 9,000 times less) in compression to geosynchronous satellite transmitting antenna. Transmitting antenna transmits the energy in one direction for reducing the loss and this characteristic will decide the gain of antenna. Gain simply tells us how much more power will fall on 1 square meter (or square centimeter) with this antenna than would fall on that same square meter (or square centimeter) if the transmitter power were spread uniformly (isotropically) over all directions.

6.2 Transmitter (Power Amplifier)

The amount of power which a satellite transmitter needs to send out depends a great deal on whether it is in low earth orbit or in geosynchronous orbit. This is a result of the fact that the geosynchronous satellite is at an altitude of 36000 Km, while the low earth satellite is only a few hundred Km. The geosynchronous satellite is nearly 100 times as far away as the low earth satellite, thus fairly large amount of microwave power is required for transmitter in case of higher satellite than low-orbiting one, if everything else were the same.

6.3 Control System and Electronics:

One other big difference between the geosynchronous antenna and the low earth antenna is the difficulty of meeting the requirement that the satellite antennas always be "pointed" at the earth. For the geosynchronous satellite, of course, it is relatively easy (geosynchronous satellite relatively stationary with respect to earth). As seen from the earth station, the satellite never appears to move any significant distance. As seen from the satellite, the earth station never appears to move. The low earth orbiting satellite, on the other hand, as seen from the ground is continuously moving.

Likewise, the earth station, as seen from the satellite is a moving target. As a result, both the earth station and the satellite need some sort of tracking capability, which will allow its antennas to follow the target during the time that it is visible thus a precise and accurate control electronics is required to track the motion of satellite. The other alternative is to make that antenna beam so wide that the intended receiver (or transmitter) is always within it. Of course, making the beam spot larger decreases the antenna gain as the available power is spread over a larger area, which in turn increases the amount of power which the transmitter must provide. n

Mr. Gaurish Kumar Tripathi has had a distinguished academic career. He is a life member of the Aeronautical Society of India & has published several papers on a variety of topics ranging from Hydro Mechanical Control Systems and Wide Band Communication systems as well as in Avionics.

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