# HSST- ELECTRONICS

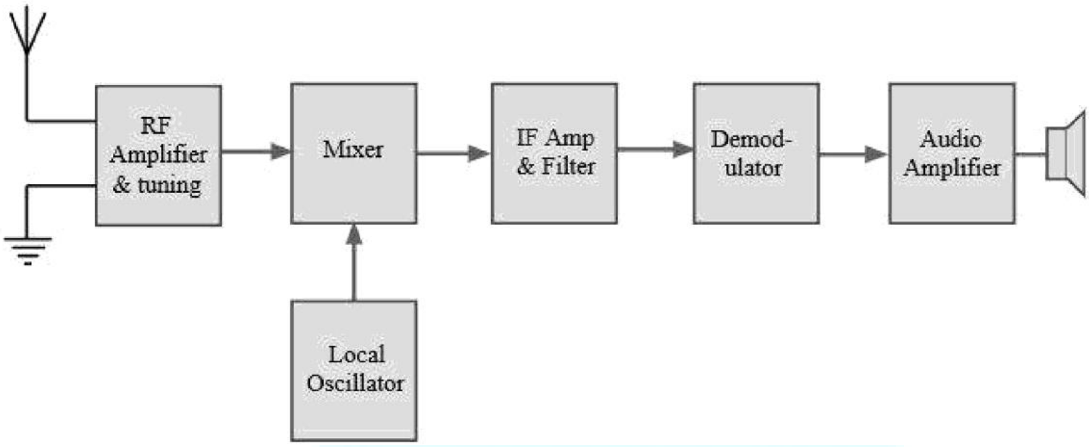
## Communication

### Communication Receivers

A communications receiver is a type of radio receiver used as a component of a radio communication link. This is in contrast to a broadcast receiver which is used to receive radio broadcasts. A communication receiver receives parts of the radio spectrum not used for broadcasting, that includes amateur, military, aircraft, marine, and other bands. They are often used with a radio transmitter as part of a two-way radio link for shortwave radio or amateur radio communication, although they are also used for shortwave listening.

**Super heterodyne AM receiver**

A radio transmitter radiates a modulated carrier signal. It is intercepted by the antenna of a radio receiver. The signal is amplified and demodulated in the receiver section to produce original information signal. Super heterodyning involves mixing of frequency




Block diagram of **Super heterodyne AM receiver**

**RF Stage:** The RF stage of the receiver provides initial tuning to remove the undesired image signal. This RF amplifier block also raises the signal level so that the high noise immunity is achieved.

**Local oscillator**: Local oscillator frequency is generally higher than the incoming signal frequency by a value equal to intermediate frequency

**Mixer:** Both the local oscillator and incoming signals enter this block within the super heterodyne receiver to form the intermediate frequency.

**IF amplifier & filter:** This super heterodyne receiver stage provides the majority of gain and selectivity. Crystal filters, LC or ceramic filters may be used within domestic radios.

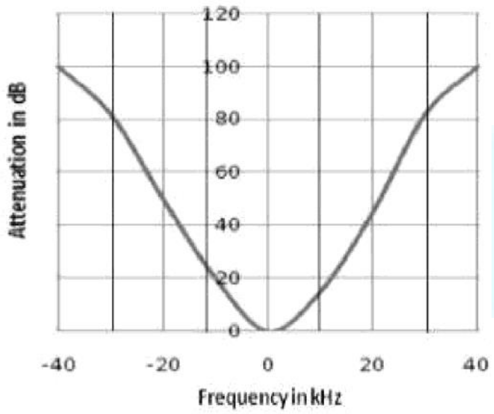
**Demodulator:** The super heterodyne receiver block diagram only shows one demodulator, but in reality, radios may have one or more demodulators dependent upon the type of signals being received.

**Audio amplifier:** Once demodulated, the recovered audio is amplified through audio amplifier stage to the required level for loudspeakers.

**Performance Characteristics of radio receiver**

*Selectivity*

The selectivity of a receiver is defined as its ability to accept or select the desired band of frequency and reject all other unwanted frequencies which can interfere with the original signals. Hence, the adjacent channel rejection of the receiver can be obtained from its selectivity parameter. Selectivity depends upon the response of IF section, mixer and RF section. The signal bandwidth must be narrow for better selectivity.



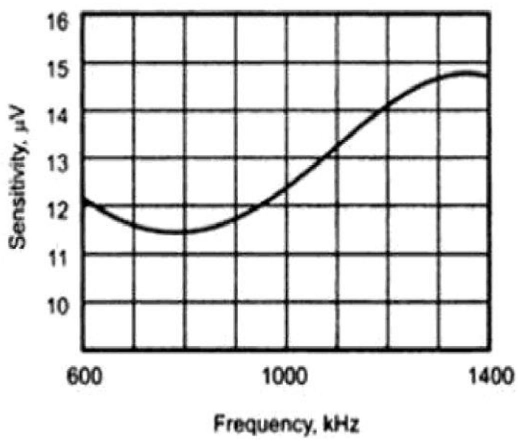

Selectivity Curve

*Fidelity*

Fidelity of a receiver may be defined as its ability to reproduce the exact replica of the transmitted signals at the receiver output. The amplifier must pass high bandwidth signals to amplify the frequencies of the outermost sidebands for achieving better fidelity, while for better selectivity the signal should have narrow bandwidth. Thus, a tradeoff between selectivity and fidelity is necessary.

*Sensitivity*

Sensitivity of the radio receiver is defined as its ability to amplify weak signals. It is defined in terms of voltage/power that must be applied to the input terminals of the receiver to produce a standard output power which is measured at the output terminals. The high value of receiver gain ensures smaller input signal necessary to produce the desired output power. Thus, a receiver with good sensitivity will detect minimum RF signal at the input and produce useful demodulated signal.




Sensitivity is expressed in microvolts or decibels. It depends on the gain of IF amplifier. It can be enhanced by reducing the noise level and bandwidth of the receiver. Sensitivity can be represented as a curve shown in Fig 2 above, which shows the variation of sensitivity over the tuning band.

*SNR*

It is defined as the ratio of signal power to noise power at the same point in the circuit. It is used to measure radio receiver sensitivity. The lower the noise generated in the receiver, the better will be the SNR.

$SNR = P_{signal} / P_{noise}$

*Image frequency ratio*

Image frequency is termed as any frequency other than the selected radio frequency carrier that will produce a cross-product frequency that is equal to the intermediate frequency if allowed to enter a receiver and mix with the local oscillator. The image frequency rejection ratio is defined as the ratio of the intermediate frequency (IF) signal level produced by the desired input frequency to that produced by the image frequency. The image frequency rejection ratio is expressed in dB. Mathematically it is expressed as,

$IFRR = \sqrt{(1 + Q^2\rho^2)}$

where $\rho = (f_{im}/f_{RF}) - (f_{RF}/f_{im})$

Q = quality factor of a pre-selector

If an image frequency has down-converted to IF, it cannot be removed. In order to reject the image frequency, it has to be blocked prior to the mixer stage. So, the bandwidth of the pre-selector circuit must be sufficiently narrow to restrain image frequency from entering the receiver.

**Selection of Intermediate Frequency**

The value of IF depends upon following criteria:

• The choice of IF is affected by the selectivity of the RF end of the receiver. If the receiver has a number of RF stages, it is better able to reject an image signal close to the signal frequency and hence a lower IF channel can be tolerated.

• The chosen IF frequency should be free from radio interference. 455 KHz is a common IF for AM broadcast.

• High IF results in poor selectivity and therefore poor rejection of adjacent channels. High IF results in problems in tracking of signals in the receivers. Image frequency rejection becomes poor at low and very high IF.

**Simple & Delayed AGC**

Automatic gain control (AGC) is a process where the overall gain of the radio receiver is automatically varied according to the changing strength of the received input signal. This is carried out to maintain the output at a constant level. The AGC dc bias voltage is derived from the part of the detected signal to apply to the RF, IF and mixer stages to control their gains. The Trans conductance and hence the gain of the devices used in these stages of the receiver depend on the applied bias voltage or current. When the signal level increases, the value of the applied AGC bias increases, decreasing the gain of the connected stages. When there is no/low signal, the AGC bias becomes minimum which results in maximum amplifier gain.

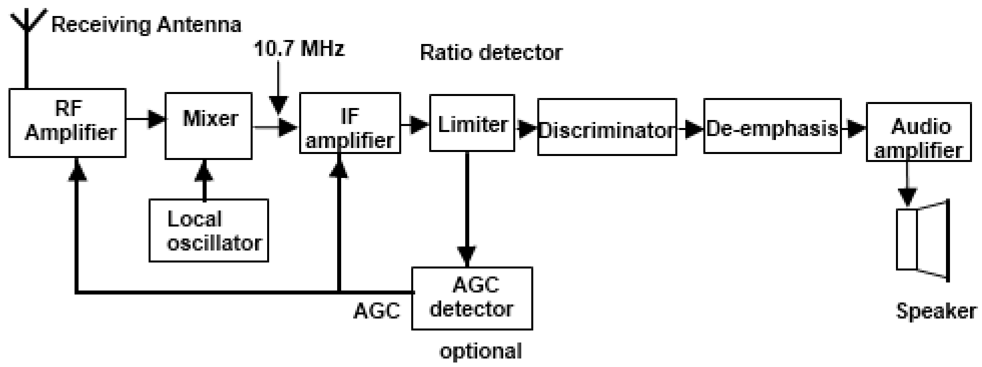
There are two types of AGC circuits:

**Simple AGC:** The gain control mechanism is active for high as well as low value of carrier voltage.

**Delayed AGC:** AGC bias is not applied to the amplifiers until signal strength crosses a predetermined threshold level, after which AGC bias is applied

**FM RECEIVER**

An FM receiver is a super heterodyne receiver with the following block diagram:




**RF section:** It consists of a pre-selector and an amplifier. Pre-selector circuit is a widely tuned band pass filter with an adjustable centre frequency used to reject undesired radio frequency and to decrease the noise bandwidth. RF amplifier determines the sensitivity of the receiver.

**Mixer and local oscillator:** It consist of a radio-frequency oscillator and a mixer. The choice of oscillator depends on the stability and accuracy desired. Mixer is a nonlinear device used to translate radio frequency to intermediate frequencies (i.e. heterodyning process).

**IF section:** It consists of a series of IF amplifiers and band pass filters to achieve most of the receiver gain and selectivity. The IF value is always lower than the RF because it is easier and less expensive to construct high-gain, stable amplifiers for low frequency signals.

**Limiter:** It limits the IF signal to a particular level and keep the amplitude constant after removing amplitude variations.

**Discriminator:** It converts the IF signals back to the original source information (demodulation).It can be as simple as a single diode or as complex as a PLL or balanced demodulator.

**De-emphasis network:** It is used to bring the high frequency signals back to the proper amplitude relationship with the lower frequencies.

**Audio amplifier:** Comprises several cascaded audio amplifiers

**AGC (Automatic Gain Control):** It operates to adjust the IF amplifier gain according to signal level. AGC is a process by which the overall gain of radio receiver is varied automatically with the variations in the received signals strength, to maintain the output constant. AGC circuit is also used to adjust and stabilize the frequency of local oscillator

**<u>Communication receiver</u>**

The receiving antenna intercepts the electromagnetic radiations and converts them into RF voltage. The RF signal is then applied to the RF amplifier through the antenna coupling network, which matches the impedances of the antenna and the RF amplifier. The RF stage amplifies this signal, which lies in the frequency range of 2 - 30 MHz. The amplified signal is fed to the first mixer, in order to be mixed with the locally generated signal. The frequency of the local oscillator is 650 kHz above the frequency the receiver signal. The first local oscillator and the RF amplifier are ganged together to generate the correct oscillator frequency.

The mixer stage generates an IF signal at frequency of 650 kHz. The IF signal is amplified by the first IF amplifier. After this, the IF signal is fed to the second mixer, which mixes this signal with another locally generated signal. The second local oscillator frequency is fixed at 500 kHz. Therefore, a crystal oscillator is used here to have good frequency stability

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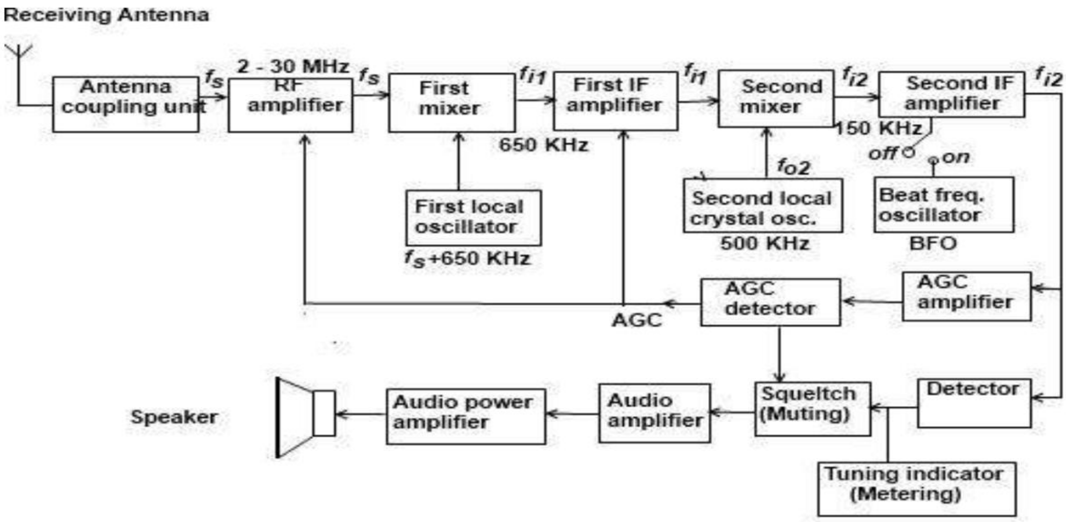



The second mixer generates the second IF signal. Value of the second IF is 150 kHz (difference between first IF (650 kHz) and second local oscillator frequency (500 kHz)). The second IF frequency is put below the normal IF frequency (455 KHz) of the AM receiver. The first IF signal frequency is above 455 kHz, up to a value of 650 kHz. Due to this arrangement, the communication receiver has the benefits of both low and high IF frequency. This mechanism of using two frequencies is known as double conversion. The second IF signal is amplified using the IF amplifier stages again to the required value.

After this, the detector circuit demodulates the received signal to produce an audio signal. This audio signal is then amplified by the audio driver amplifier and the audio output power amplifier. The audio signal is given to the speaker to produce the sound output. AGC is employed to control the gains of the amplifiers of the system. The AGC voltage helps to keep the volume of the receiver constant to the level set by the user. The salient features of the communication receiver are:

**Beat Frequency Oscillator (BFO):** Communication receivers can also receive telegraphic signals that use Morse code, which is a pulse modulated RF carrier signal. Morse code is transmitted as dots, dashes, and spaces. A switch is used in the receiver to select either the audio signal or the telegraph signal at a time.

**Squelch or Muting:** When the communication transmitter does not transmit any signal, the receiver receives only the noise present at its input. It is necessary to control the noise level in the absence of a carrier signal. This problem is overcome by providing a Squelch circuit in the system.

**Metering:** A tuning indicator is provided in the receiver so that the operator knows if the receiver is tuned to the correct signal frequency. It is called metering of the strength of the received signal.

**Double Conversion:** In the double conversion method, two intermediate frequencies are generated instead of a single intermediate frequency used in commercial AM receivers. This technique uses two local oscillators and two mixers.

**<u>Transmitters</u>**

A radio transmitter or just transmitter is an electronic device which produces radio waves with an antenna. The transmitter itself generates a radio frequency alternating current, which is applied to the antenna. When excited by this alternating current, the antenna radiates radio waves.

Transmitters are necessary component parts of all electronic devices that communicate by radio, such as radio and television broadcasting stations, cell phones, walkie-talkies, wireless computer networks, Bluetooth enabled devices, garage door openers, two-way radios in aircraft, ships, spacecraft, radar sets and navigational beacons. The term transmitter is usually limited to equipment that generates radio waves for communication purposes; or radiolocation, such as radar and navigational transmitters.

**Classification of Radio Transmitters**

Classification on the basis of type of modulation used

1. **Amplitude Modulation Transmitters:** Here the modulating signal modulates the carrier with respect to its amplitude. AM transmitters are used for radio broadcast, radio telephony, radio telegraphy and TV picture broadcast.

2. **Frequency Modulation Transmitters:** In FM transmitters, the frequency of the carrier is varied in accordance with the modulating signal. These are used for radio broadcast, TV sound broadcast and radio telephone communication.

3. **Pulse Modulation Transmitters:** The signal changes any of the characteristics like pulse width, position, amplitude of the pulse carrier.

Classification on the basis of the service involved

1. **Radio Broadcast transmitters:** These transmitters are particularly designed for broadcasting speech signals, music, information etc. These systems may be amplitude or frequency modulated.

2. **Radio Telephone Transmitters:** These transmitters are mainly used for transmitting telephone signals over long distance by radio waves. The transmitter uses volume compressors, peak limiters etc.

3. **Radio Telegraph Transmitters**: It transmits telegraph signals from one radio station to another radio station. The transmitter uses either amplitude modulation or frequency modulation.

4. **Television Transmitters:** TV broadcast requires transmitters for transmission of picture and sound separately. Both operate VHF and UHF frequency range.

5. **RADAR Transmitters:** RADAR stands for Radio Detection And Ranging. These transmitters are of two types: Pulse Radar and Continuous Wave Radar.

6. **Navigation Transmitters: S**pecial types of radio transmitters and receivers are used these days for sea and air navigation, blind landing of aircrafts etc.

Classification on the basis of Frequency range used

1. **Long Wave Transmitters:** These transmitters operate on frequencies below

300 kHz. Such long wave radio transmitters are used for broadcasting, where atmospheric disturbances on long waves are not severe.

**2. Medium Wave Transmitters:** The frequency range of MW transmitters is from 550 to 1650 kHz. The carrier power varies from 5 kW to 1000kW.

**3. Short Wave Transmitters:** The SW transmitters work on frequencies in the short wave range i.e. from 3 to 30MHz. For example, ionospheric propagation.

*Classification on the basis of power*

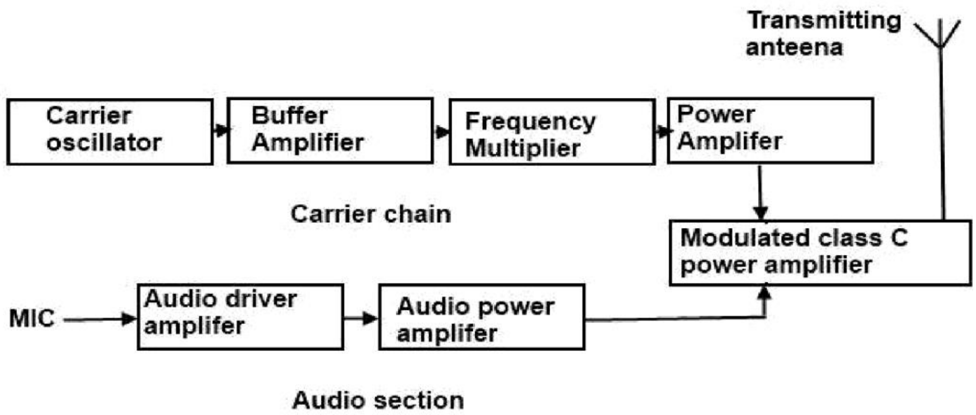
1. **High level modulation Transmitter*:*** In high level AM modulator, the modulation is carried out at high power level of the carrier and baseband signal. Its advantage is that linear amplifiers are not required for the RF amplification stages after AM modulation. The efficiency of high-level modulation is very high due to the use of class C power amplifiers.
2. **Low level modulation Transmitter:** In low level AM modulator, the modulation is done at low power level of the input signals, typically in the RF generation stages. It

has the advantage of lesser distortion in output. The disadvantage of this method is that linear amplification is needed for the RF stages.

**Block diagram of AM transmitters**

The transmitters which transmit AM signals are known as AM transmitters. These transmitters are used in medium wave and short-wave frequency bands for AM broadcast. The MW band has frequencies between 550 KHz and 1650 KHz, and the SW band has frequencies ranging from 3 MHz to 30 MHz.

In high-level transmission, the powers of the carrier and modulating signals are amplified before applying them to the modulator stage as shown in below given figure.




**Carrier oscillator:** The oscillator generates the carrier signal of RF range. It is very difficult to generate high frequencies with good frequency stability. The oscillator generates only a sub multiple of the required carrier frequency. The frequency multiplier multiplies this sub multiple frequency to get the desired carrier frequency.

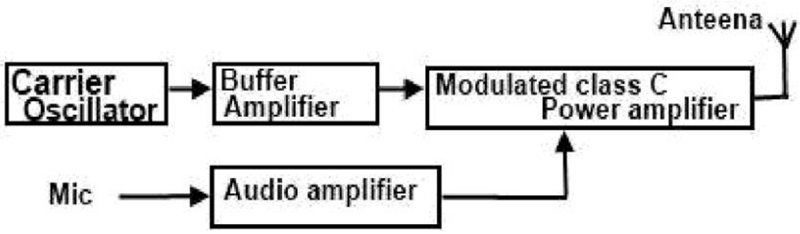
**Buffer Amplifier:** The purpose of the buffer amplifier is to match the output impedance of the carrier oscillator with the input impedance of the frequency multiplier. So, it isolates the carrier oscillator and frequency multiplier.

**Frequency Multiplier:** The sub-multiple frequency carrier signal, generated by the carrier oscillator, is applied to the frequency multiplier. The frequency multiplier (also called harmonic generator) generates higher harmonics of carrier oscillator frequency. **Power Amplifier**: The power of the carrier signal is then amplified using the power amplifier stage. A class C power amplifier is used to give high power current pulses of the carrier signal at its output.

**Audio Section:** The audio signal obtained from the microphone is amplified using the audio driver amplifier. This amplification is necessary to drive the audio power amplifier. Then, a class A or B power amplifier amplifies the power of this audio signal.

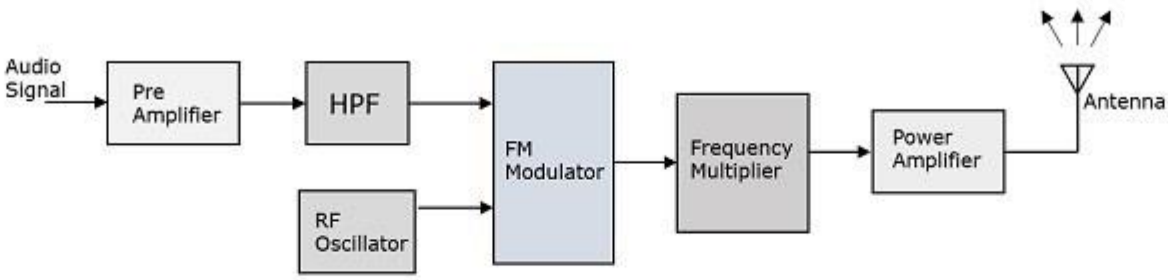
**Modulated Class C Amplifier:** The amplified modulating audio signal and the carrier signal are applied to this modulating stage to carry out AM modulation. This signal is finally passed to the antenna, which radiates the signal into space.

In low-level modulation, the modulation is carried out at low power level of the two input signals. First modulation is done and after that the power of this modulated signal is raised to the desired value using linear power amplifiers. The low-level AM transmitter shown below is similar to a high-level transmitter, except that the powers of the carrier and audio signals are not amplified. These two signals are directly applied to the modulated class C power amplifier.




## FM Transmitter

FM transmitter is the whole unit, which takes the audio signal as an input and delivers FM wave to the antenna as an output to be transmitted. The block diagram of FM transmitter is shown in the following figure.

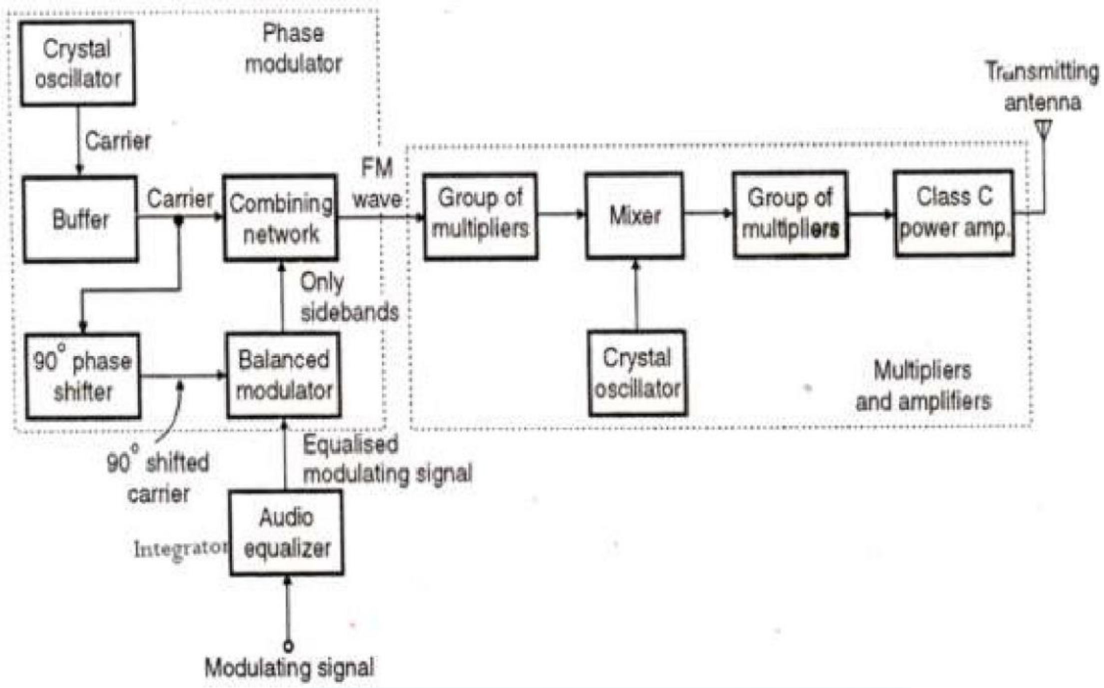



The working of FM transmitter can be explained as follows.

- The audio signal from the output of the microphone is sent to the pre-amplifier, which boosts the level of the modulating signal.
- This signal is then passed to high pass filter, which acts as a pre-emphasis network to filter out the noise and improve the signal to noise ratio.
- This signal is further passed to the FM modulator circuit.
- The oscillator circuit generates a high frequency carrier, which is sent to the modulator along with the modulating signal.
- Several stages of frequency multiplier are used to increase the operating frequency. Even then, the power of the signal is not enough to transmit. Hence, a RF power amplifier is used at the end to increase the power of the modulated signal. This FM modulated output is finally passed to the antenna to be transmitted.

## Armstrong FM Transmitter

The direct methods of FM generation cannot be used for the broadcast applications. Therefore, the indirect method called as the Armstrong method of FM generation is used. In this method, the FM is generated through phase modulation. A crystal oscillator is used to make the frequency stability very high




A crystal oscillator is used to provide the appropriate carrier frequency. A pre-emphasized, integrated and amplified modulating signal is fed to the balanced modulator stage. A part of the carrier voltage is also applied to the balanced modulator. The resulting sideband components are shifted in phase by $90^0$ and are then combined with the amplified carrier voltage in a combining network. Its output is the desired frequency modulated voltage.

The relative amplitudes of the modulating voltage and the carrier voltage are adjusted to make the maximum phase deviation small. But the frequency deviation $f_d$ is also small. The modulated signal is fed to six frequency doubler to get very high carrier frequency, but frequency deviation is still small.

**VHF- Very High Frequency**

Very high frequency is commonly used for FM radio broadcast, two-way land mobile radio systems, long-range data communication, and marine communications, just to name a few. VHF includes radio waves from 30 MHz to 300 MHz.

VHF waves must not exceed the local radio horizon of 100 miles. VHF frequencies are less likely to be interrupted by atmospheric noise, issues with electrical equipment, and other interferences.

There are different bands within VHF frequency, including low-band and high-band. Low-band VHF range of 49 MHz includes transmission of wireless microphones, cordless phones, radio-controlled toys and more. Slightly higher VHF range of 54-72 MHz operates television channels 2-4, as well as wireless systems defined as “assistive listening.” VHF frequencies 76-88 MHz operate channels 5 and 6. The highest low band VHF is 88-108 MHz and operates the commercial FM radiobroadcast band.

With so many different users the low-band VHF is not recommended for use of serious applications due to the levels of radio "noise" present at these frequencies. Despite the potential background noise this a popular option because of the low-cost equipment. Transmission power is limited to under 50 mW, unless you are operating an assistive listening system in the 72-76 MHz range. Also, a large antenna booster is necessary, measuring as much as 3 feet in length, thus limiting portability.

High-band VHF range is popular for professional applications. The lowest high-band (169- 172 MHz) includes 8 different frequencies designated by the FCC, and is often used by the general public and wireless microphone devices. These frequencies are known as "traveling frequencies" because they can be used all around the US without fear of interference from broadcast television. Power is limited to 50 mW, although antenna size is smaller (around 20 inches per ¼ wavelength type). Businesses, government operations and the Coast Guard operate on this "traveling" band. For best results you typically only want to operate two to three units on this frequency.

The high-band VHF between 174 and 216 MHz is used for VHF television channels 7-13. High quality audio is possible as well as smaller antenna size, down to 14 inches or less. The same 50 mW power restrictions apply.

Low-band VHF frequencies are far more likely to incur interferences than high-band VHF frequencies

## UHF- Ultra High Frequency

UHF radio waves are much shorter in length than VHF, measuring around 12 to 24 inches. As a result, antenna length is reduced as well as radio range. Anything from a building to a human body can interfere with UHF transmissions. Dropouts and interferences are far more likely, but greater bandwidth occupation is permitted. As a result, you may find a wider frequency range as well as wider range of audio signal. Up to 250 mW is allowed, exceeding the 50 mW power restrictions applied to VHF.

Low-band UHF overlaps with high-band UHF, low is 450-536 MHz and high is 470-806 MHz. Typically, business services and UHF television channels 14 through 69 operate using these frequencies. High-band UHF (anything above 900 MHz) offers the least number of disturbances and requires antennas measuring between 3 and 4 inches. These channels operate studio-to-transmitter links as well as other primary users and additional channels.

UHF radio waves generally only go as far as line of sight. Anything in the way of your sight will also interfere with frequency range, such as buildings, tall trees or any other obstruction. The transmission is high enough to penetrate through building walls, making indoor reception a possibility. It is the limited line-of-sight broadcast range that makes UHF unsuitable in some instances. VHF offers a much larger broadcast range, which is preferred in some industries.

UHF radio signals are used in many facets of life including satellite communication, GPS, Wi-Fi, Bluetooth, walkie-talkies, cordless phones, cell phones, and television broadcasting.

A large advantage of UHF transmission is the short wavelengths produced by the high frequency. The size of the radio wave relates directly to the length of transmission as well as the reception antennas. In general, UHF antennas are short and wide.

The cost of operating UHF equipment outweighs the operation of VHF equipment. This is because it is more work to create UHF compatible devices based on the ways high frequency and short wavelength radio signals interact together. The difference in cost largely relates to the need for antennas, cables and other additional equipment.

## Microwave Radio Systems

Microwave transmission is the transmission of information by electromagnetic waves with wavelengths in the microwave range (1 m - 1 mm) of the electromagnetic spectrum. Microwave signals are normally limited to the line-of-sight, so long-distance transmission using these signals requires a series of repeaters forming a microwave relay network. It is possible to use microwave signals in over-the-horizon communications using tropospheric scatter, but such systems are expensive and generally used only in specialist roles.

A Microwave Radio System is a system of equipment used in broadcasting and telecommunications transmissions. The microwave system includes radios located high atop microwave towers, which are used for the transmission of microwave communications using line of sight microwave radio technology.

Microwaves are widely used for point-to-point communications because their small wavelength allows conveniently-sized antennas to direct them in narrow beams, which can be pointed directly at the receiving antenna.

This allows nearby microwave equipment to use the same frequencies without interfering with each other, as lower frequency radio waves do. Line of sight between point-to-point communications is very important to prevent any interference due to tall buildings and blockages, thus specialist experts are usually needed to engage for preliminary site surveys.

The FM signal is fed to a frequency mixer which shifts the carrier frequency down to a low value, so as to increase the frequency deviation. The frequency multipliers increase the carrier frequency and frequency deviation to a standard value. The output is applied to the transmitting antenna, after sufficient power amplification.

## SATELLITE COMMUNICATION

If the communication takes place between any two earth stations through a satellite, then it is called as satellite communication. In this communication, electromagnetic waves are used as carrier signals. These signals carry the information such as voice, audio, video or any other data between ground and space and vice-versa.

Soviet Union had launched the world's first artificial satellite named, Sputnik 1 in 1957. Nearly after 18 years, India also launched the artificial satellite named, Aryabhata in 1975.

Need of Satellite Communication

The following two kinds of propagation are used earlier for communication up to some distance.

- **Ground wave propagation** – Ground wave propagation is suitable for frequencies up to 30MHz. This method of communication makes use of the troposphere conditions of the earth.
- **Sky wave propagation** – The suitable bandwidth for this type of communication is broadly between 30–40 MHz and it makes use of the ionosphere properties of the earth.

The maximum hop or the station distance is limited to 1500KM only in both ground wave propagation and sky wave propagation. Satellite communication overcomes this limitation. In this method, satellites provide **communication for long distances**, which is well beyond the line of sight.

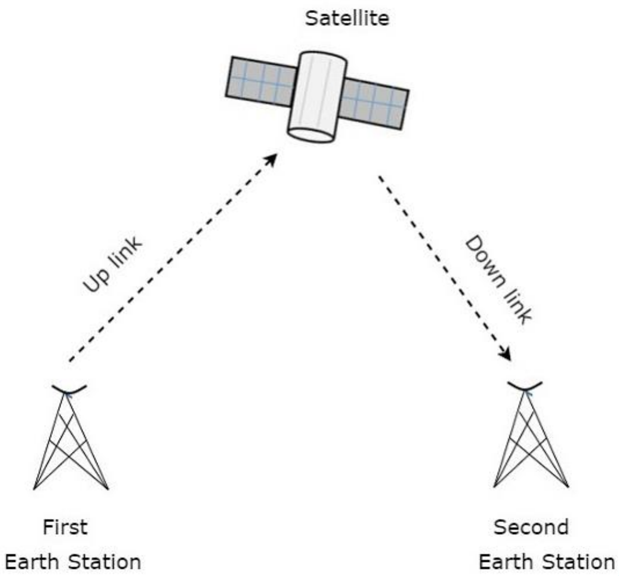
Since the satellites locate at certain height above earth, the communication takes place between any two earth stations easily via satellite. So, it overcomes the limitation of communication between two earth stations due to earth's curvature.

### How a Satellite Works

A **satellite** is a body that moves around another body in a particular path. A communication satellite is nothing but a microwave repeater station in space. It is helpful in telecommunications, radio and television along with internet applications.

A **repeater** is a circuit, which increases the strength of the received signal and then transmits it. But, this repeater works as a **transponder**. That means, it changes the frequency band of the transmitted signal from the received one.

The frequency with which, the signal is sent into the space is called as **Uplink frequency**. Similarly, the frequency with which, the signal is sent by the transponder is called as **Downlink frequency**. The following figure illustrates this concept clearly.




The transmission of signal from first earth station to satellite through a channel is called as **uplink**. Similarly, the transmission of signal from satellite to second earth station through a channel is called as **downlink**.

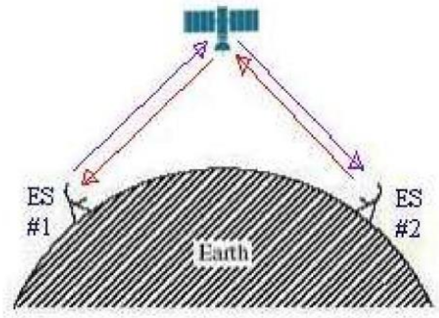
**Uplink frequency** is the frequency at which, the first earth station is communicating with satellite. The satellite transponder converts this signal into another frequency and sends it down to the second earth station. This frequency is called as **Downlink frequency**. In similar way, second earth station can also communicate with the first one.

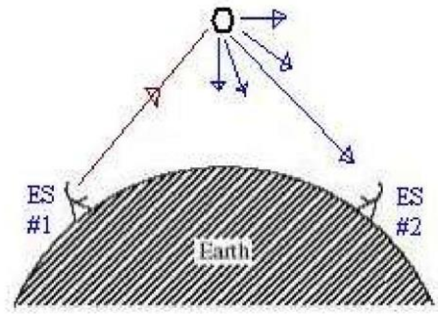
The process of satellite communication begins at an earth station. Here, an installation is designed to transmit and receive signals from a satellite in an orbit around the earth. Earth stations send the information to satellites in the form of high powered, high frequency (GHz range) signals.

The satellites receive and retransmit the signals back to earth where they are received by other earth stations in the coverage area of the satellite. Satellite's **footprint** is the area which receives a signal of useful strength from the satellite.

**Active Satellite:** The active satellite has its own transmitting and receiving antennas. It amplifies the signal received from earth station or ground station and retransmits the amplified signal back to earth. It also performs frequency translation of the received signal before retransmission. Active satellite can generate power for its own operation. It is also known as active repeater.

***Passive Satellite:*** It is basically a reflector which receives the signal from the transmitting earth station and scatters the signal in all the directions. It reflects the electromagnetic radiations without any modification or amplification. Passive satellite cannot generate power if its own and simply reflects the incident power.



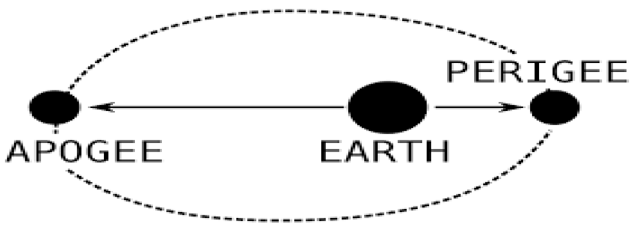




**ACTIVE SATELLITE** **PASSIVE SATELLITE**

*Orbit:* A curved path (usually elliptical) followed by the satellite while revolving around the earth is known as orbit. For example, in geostationary satellite, the position of the satellite is constant with respect to earth because its time period of revolution is equal to time period of rotation of earth on its own axis.

*Apogee:* The point in the orbit of the satellite which is at the farthest distance from the center of the earth is called as Apogee. It is denoted by $r_a$.

*Perigee:* It is the nearest point from the earth existing on the satellite orbit and is denoted by $r_p$.




## Geostationary Satellite and Its Need

A geostationary satellite is an earth-orbiting satellite, placed at an altitude of approximately 36000 kilometers directly over the equator. It revolves in the same direction the earth rotates (west to east) and takes 24 hours (the same time period as the earth requires to rotate once on its axis).

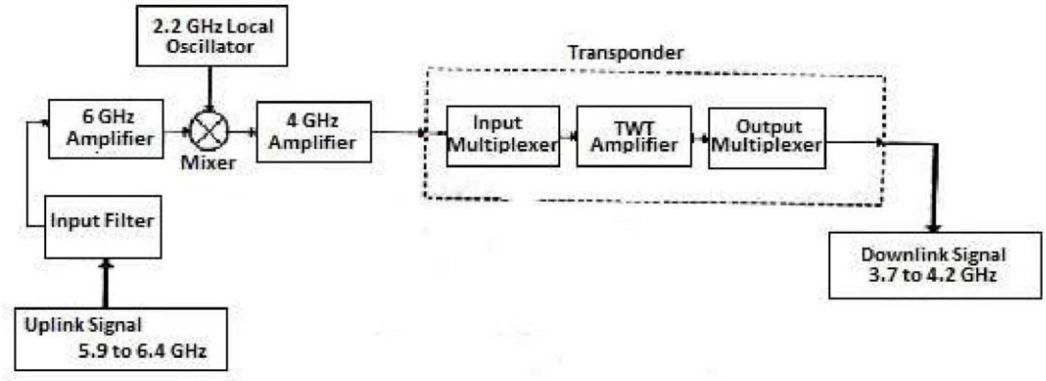
A geostationary satellite appears nearly stationary in the sky when seen by an observer on earth. A single geostationary satellite can cover about 40% of the earth's surface. Hence three such satellites, each separated by 120 degrees of longitude, can provide coverage of the entire planet. It has the main advantage of permanently remaining in the same area of sky, so ground based antennas do not need to track them. The geostationary satellites are needed for weather forecasting, global communication, satellite TV and radio etc.

## Satellite Communication link

Communications Satellites consist of the following subsystems:

- Communication Payload, normally composed of transponders, antennas, and switching systems
- Engines used to bring the satellite to its desired orbit
- A station keeping, tracking and stabilization subsystem used to keep the satellite in the right orbit, with its antennas pointed in the right direction, and its power system pointed towards the sun
- Power subsystem, used to power the Satellite systems, normally composed of solar cells, and batteries that maintain power during solar eclipse
- Command and Control subsystem, which maintains communications with ground control stations. The ground control Earth stations track the satellite performance and monitor its functionality during various phases of its life-cycle.

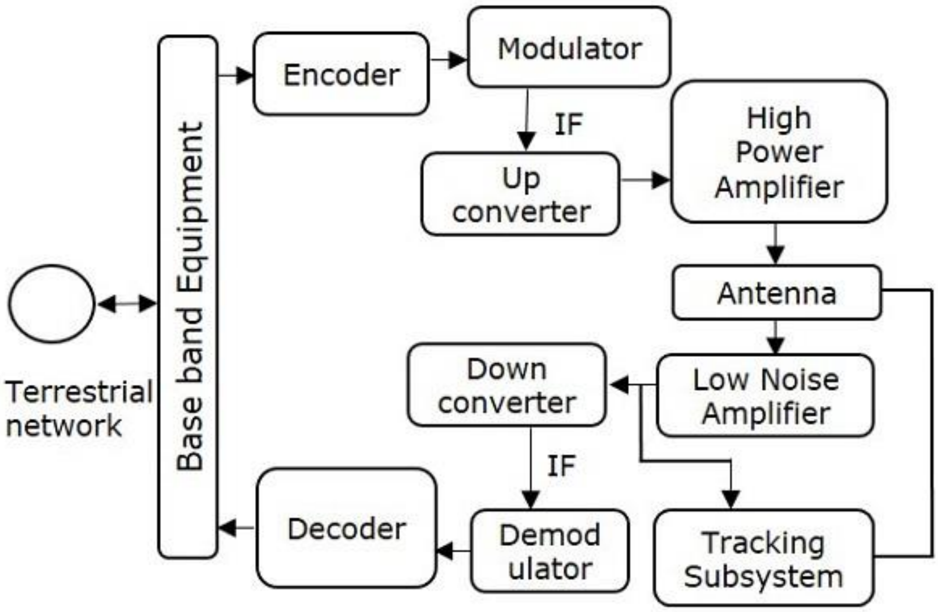
The available bandwidth depends upon the number of transponders provided by the satellite. Each service requires a different amount of bandwidth for transmission.




Satellite Communication System Block Diagram

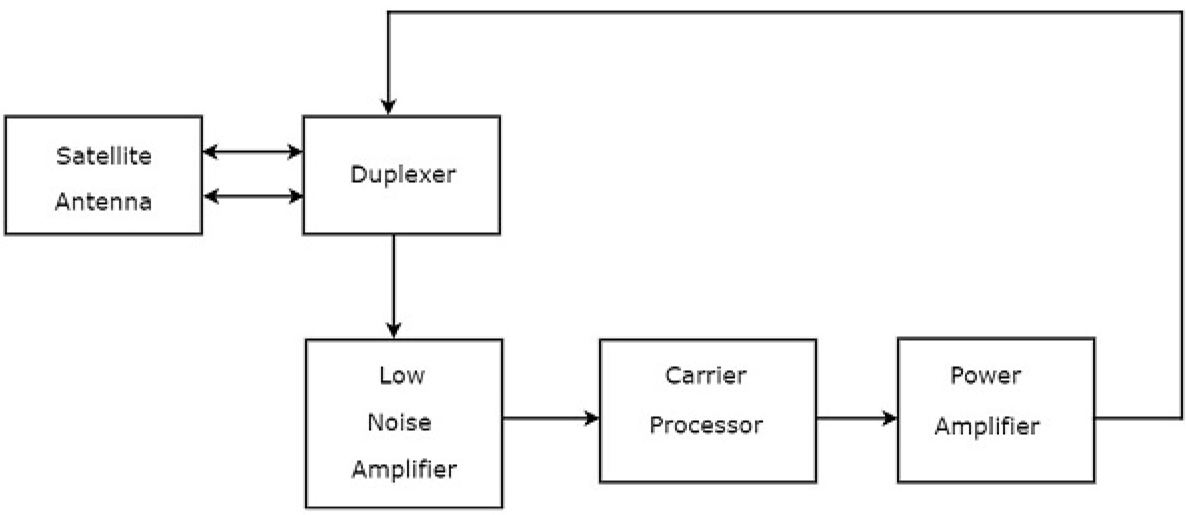
Uplink, downlink filters, amplifiers, local oscillator and transponder are the basic blocks of the satellite communication system. The uplink and downlink frequency ranges are respectively 5.9 - 6.4 GHz and 3.7 - 4.2 GHz. The mixer and local oscillator convert the uplink frequency to lower frequency. The satellite receives the signals transmitted from the ground stations, amplifies it and retransmits it at downlink frequencies to avoid interference. A satellite can have many transponders. The transponder consists of input and output multiplexer and one TWT amplifier.

**The block diagram of an earth station**




**Earth station:** The input baseband signal from the terrestrial network enters the earth station at the transmitter. The signal is encoded, modulated and up-converted. Then it is amplified and passed through antenna terminal. The signal received from the satellite is amplified in a low noise amplifier, and down-converted. It is then demodulated and decoded to get the original baseband signal.

**The block diagram of Transponder**




**Transponder:** Duplexer is a two-way microwave gate. Duplexer receives uplink signal from the satellite antenna and transmits downlink signal to the satellite antenna. The Low Noise amplifier increases the strength of the weak received signal. Carrier Processor carries out the frequency down conversion of received signal (uplink). The power of frequency down converted signal (down link) is amplified to the required level using a suitable power amplifier.

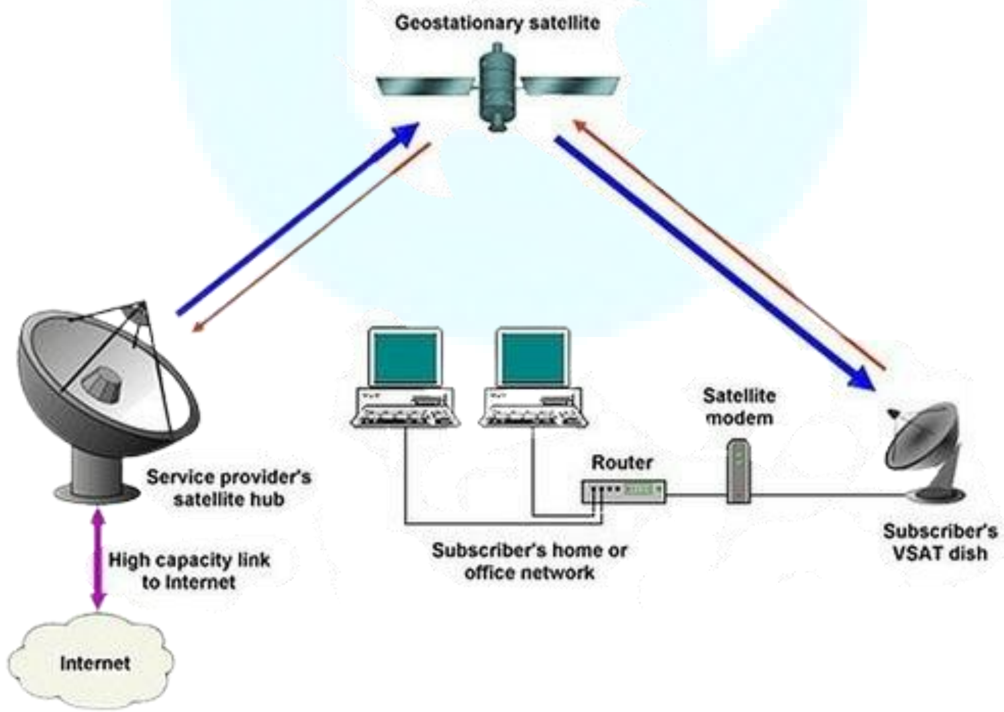
VSAT and its features:

A very small aperture terminal is a satellite ground station with a dish antenna with a diameter of size smaller than 3.8 meters. The VSAT antennas range from 75 cm to 1.2 m. Data speed range from 4 kbit/s up to 16 Mbit/s. VSATs access satellites in geosynchronous orbit to relay data from small remote Earth stations to other terminals or master Earth station.

**VSAT Network:**

- The ground segment of a VSAT network consists of a high-performance hub Earth station and a large number of low performance terminals referred to as VSATs.
- The space segment consists GEO satellites acting as communication links between the hub station and the VSATs.

A typical VSAT network is shown below.




- VSATs use a high performance central station so that the various remote stations can be simpler and smaller in design.

- The hub station is usually a large, high performance Earth Station comprising an outdoor antenna for transmission, RF terminals for providing a wideband uplink of one digital carrier per network, base band equipment comprising modems, and various kinds of interfacing equipment to support a wide variety of terrestrial links.
- The terrestrial links connect the hub station to the head office.
- VSATs are smaller and simpler in design as compared to the hub center and comprise an outdoor antenna, an RF terminal comprising an LNB for reception and baseband equipment.
- VSAT networks use either C band or Ku band.
- VSATs generally carry digital signals. BPSK or QPSK modulation schemes with forward error correction are often used.
- Applications of VSAT include File transfers, Computer communications, Database enquiries, Video conferencing, Reservation systems, Credit checks and credit card verification, Billing systems, Stock control and management, electronic mail and Point of sale transactions.

**Pros and Cons of Satellite Communication**

The **advantages** of using satellite communication:

- Area of coverage is more than that of terrestrial systems
- Each and every corner of the earth can be covered
- Transmission cost is independent of coverage area
- More bandwidth and broadcasting possibilities

The **disadvantages** of using satellite communication –

- Launching of satellites into orbits is a costly process.
- Propagation delay of satellite systems is more than that of conventional terrestrial systems.
- Difficult to provide repairing activities if any problem occurs in a satellite system.
- Free space loss is more
- There can be congestion of frequencies.

**Applications of Satellite Communication**

Satellite communication plays a vital role in our daily life. Following are the applications of satellite communication –

- Radio broadcasting and voice communications
- TV broadcasting such as Direct To Home (DTH)
- Internet applications such as providing Internet connection for data transfer, GPS applications, Internet surfing, etc.
- Military applications and navigations
- Remote sensing applications
- Weather condition monitoring & Forecasting