Satellite communication subsystems and segments

by
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Abstract:

In satellite communication system, various operations take place. Among which, the main operations are orbit controlling, altitude of satellite, monitoring and controlling of other subsystems.

A satellite communication consists of mainly two **segments**. Those are space segment and earth segment. so, accordingly there will be two types of subsystems namely, space segment subsystems and earth segment subsystems.

Space Segment Subsystems

The subsystems present in space segment are called as space segment subsystems. Following are the **space segment subsystems**.

- AOC Subsystem
- TTCM Subsystem
- Power and Antenna Subsystems
- Transponders

Earth Segment Subsystems

- The subsystems present in the ground segment have the ability to access the satellite repeater in order to provide the communication between the users. **Earth segment** is also called as ground segment.
- Earth segment performs mainly two functions. Those are transmission of a signal to the satellite and reception of signal from the satellite. **Earth stations** are the major subsystems that are present in earth segment.

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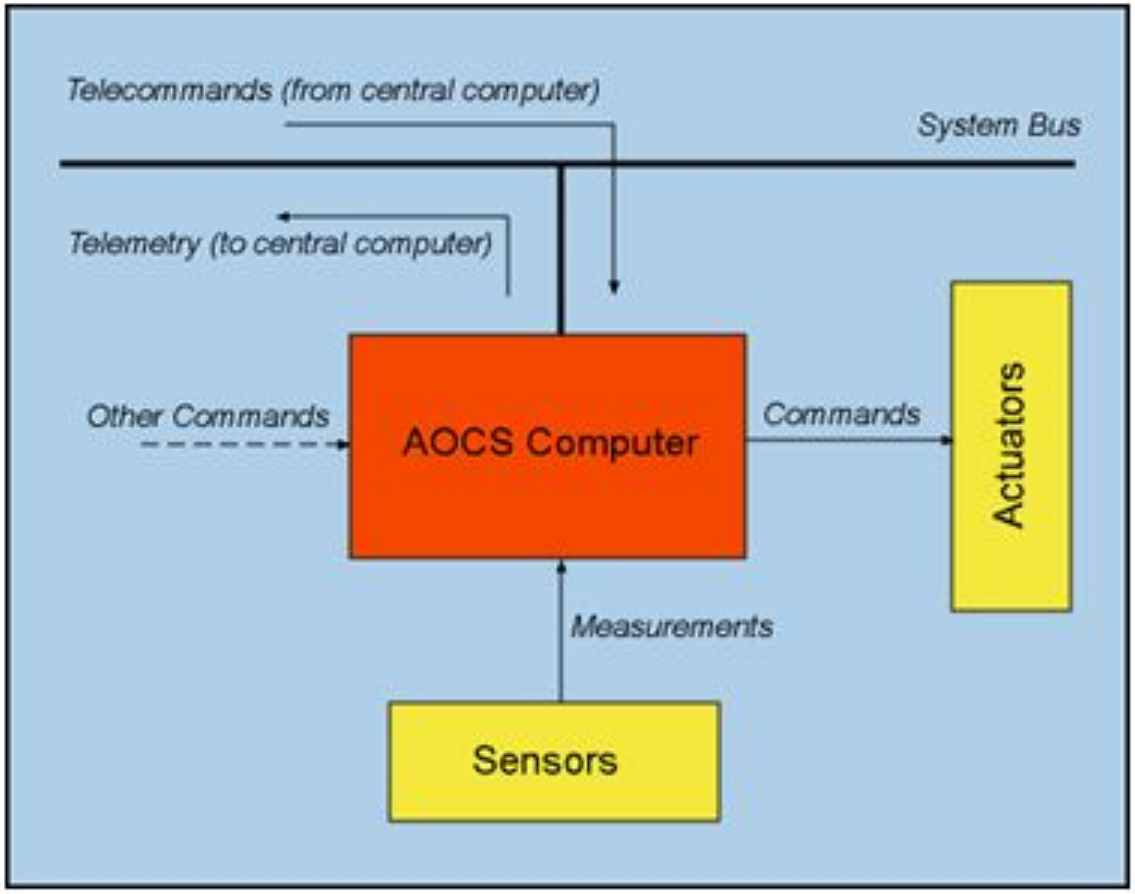
Satellite Communication - AOC Subsystem

We know that satellite may deviates from its orbit due to the gravitational forces from sun, moon and other planets. These forces change cyclically over a 24-hour period, since the satellite moves around the earth.

Altitude and Orbit Control **(AOC)** subsystem consists of rocket motors, which are capable of placing the satellite into the right orbit, whenever it is deviated from the respective orbit. AOC subsystem is helpful in order to make the antennas, which are of narrow beam type points towards earth.

We can make this AOC subsystem into the following **two parts**.

- Altitude Control Subsystem
- Orbit Control Subsystem



Altitude and Orbit Control (AOC) subsystem

Altitude Control Subsystem

Altitude control subsystem takes care of the orientation of satellite in its respective orbit. Following are the **two methods** to make the satellite that is present in an orbit as stable.

- Spinning the satellite
- Three axis method

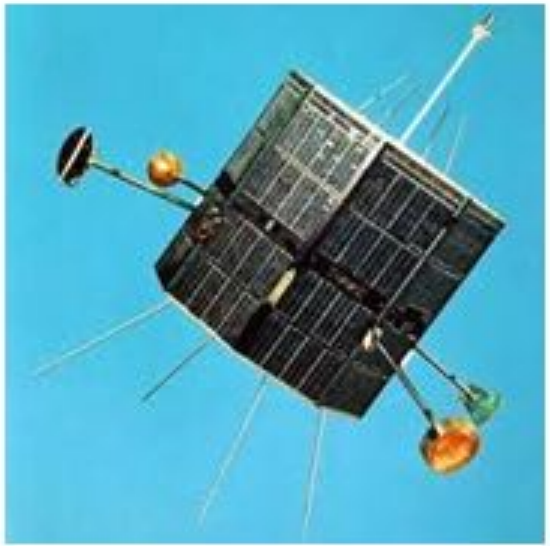
Spinning the satellite

In this method, the body of the satellite rotates around its **spin axis**. In general, it can be rotated at 30 to 100 rpm in order to produce a force, which is of gyroscopic type. Due to this, the spin axis gets stabilized and the satellite will point in the same direction. Satellites are of this type are called as **spinners.**

Spinner contains a drum, which is of cylindrical shape. This drum is covered with solar cells. Power systems and rockets are present in this drum.

Communication subsystem is placed on top of the drum. An electric motor drives this communication system. The direction of this motor will be opposite to the rotation of satellite body, so that the antennas point towards earth. The satellites, which perform this kind of operation are called as **de-spin**.

During launching phase, the satellite **spins** when the small radial gas jets are operated. After this, the **de-spin** system operates in order to make the TTCM subsystem antennas point towards earth station.



Spin stabilized satellite

Three axis stabilized satellite

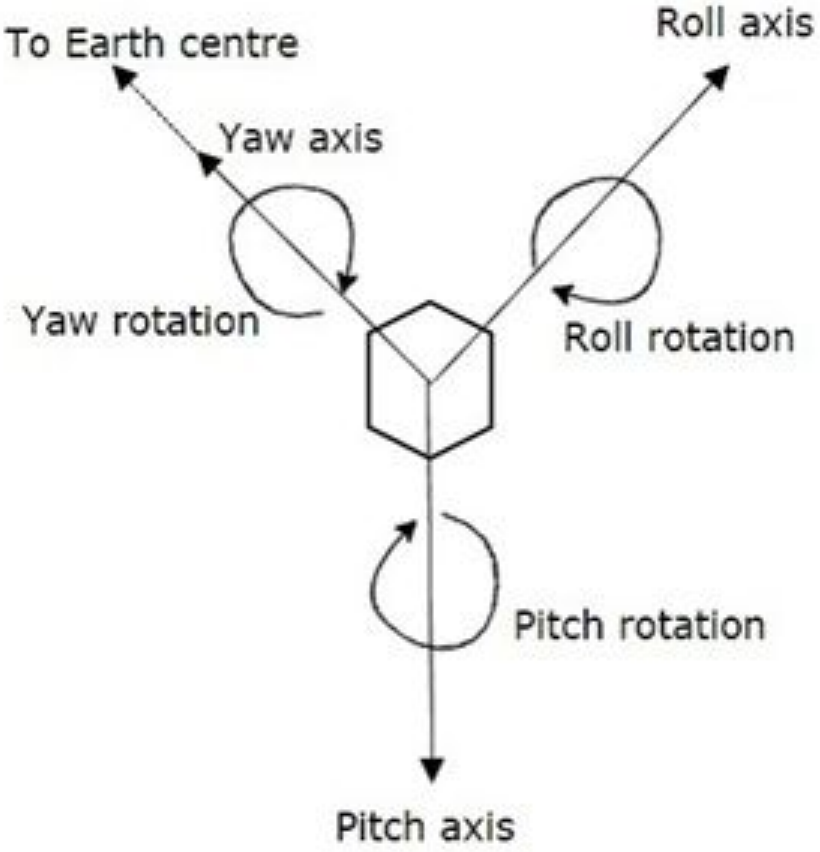
Three Axis Method

In this method, we can stabilize the satellite by using one or more momentum wheels. This method is called as **three-axis method**. The advantage of this method is that the orientation of the satellite in three axes will be controlled and no need of rotating satellite's main body.

In this method, the following **three axes** are considered.

- **Roll axis** is considered in the direction in which the satellite moves in orbital plane.
- **Yaw axis** is considered in the direction towards earth.
- **Pitch axis** is considered in the direction, which is perpendicular to orbital plane.

These three axes are shown in below **figure**.


To Earth centre
Roll axis
Yaw axis
Yaw rotation
Roll rotation
Pitch rotation
Pitch axis

Let X_R, Y_R and Z_R are the roll axis, yaw axis and pitch axis respectively. These three axis are defined by considering the satellite's position as **reference**. These three axes define the altitude of satellite.

Let X, Y and Z are another set of Cartesian axes. This set of three axis provides the information about orientation of the satellite with respect to reference axes. If there is a change in altitude of the satellite, then the angles between the respective axes will be changed.

In this method, each axis contains two gas jets. They will provide the rotation in both directions of the three axes.

- The **first gas jet** will be operated for some period of time, when there is a requirement of satellite's motion in a particular axis direction.
- The **second gas jet** will be operated for same period of time, when the satellite reaches to the desired position. So, the second gas jet will stop the motion of satellite in that axis direction.

Orbit Control Subsystem

Orbit control subsystem is useful in order to bring the satellite into its correct orbit, whenever the satellite gets deviated from its orbit.

The TTCM subsystem present at earth station monitors the position of satellite. If there is any change in satellite orbit, then it sends a signal regarding the correction to Orbit control subsystem. Then, it will resolve that issue by bringing the satellite into the correct orbit.

In this way, the **AOC subsystem** takes care of the satellite position in the right orbit and at right altitude during entire life span of the satellite in space.

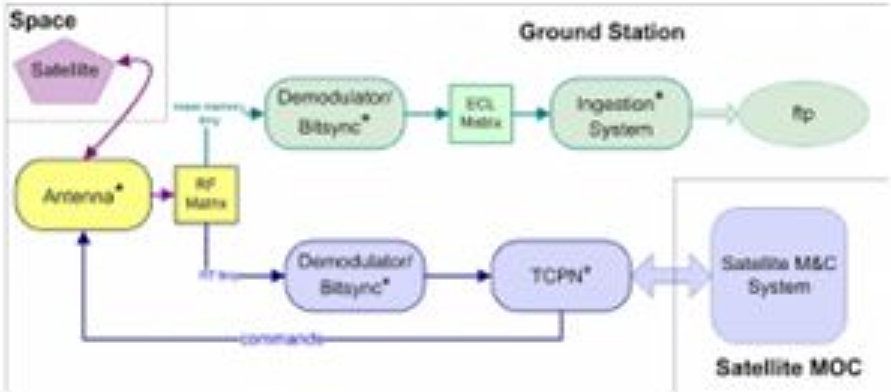
Satellite Communication - TTCM Subsystem

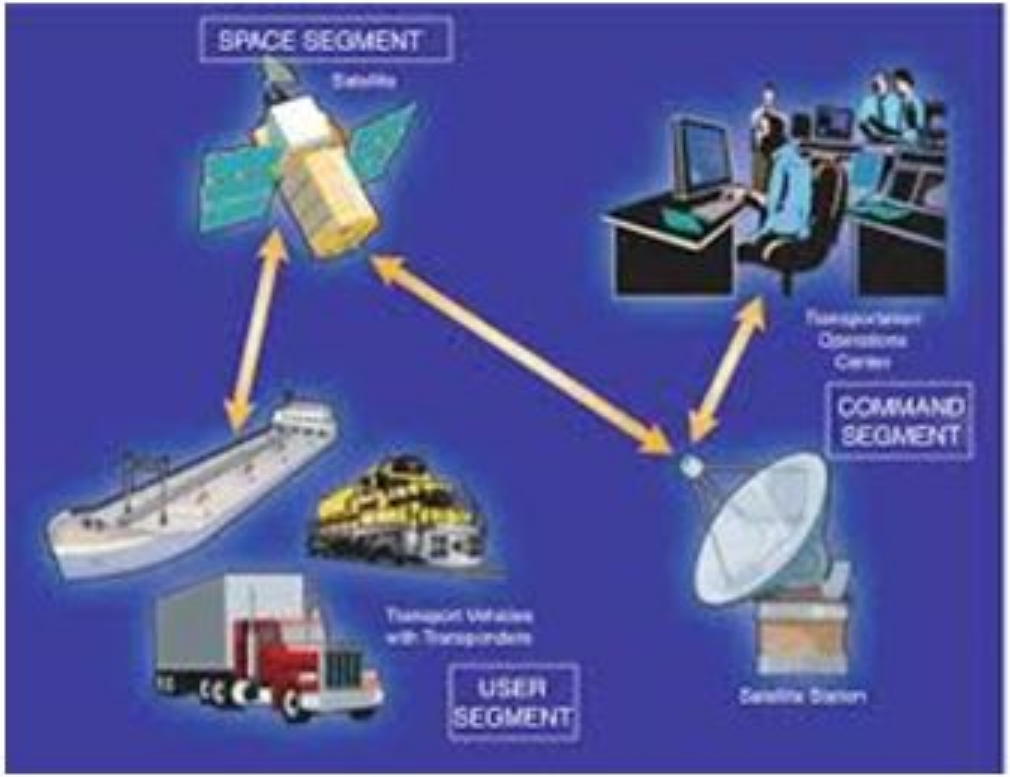
Telemetry, Tracking, Commanding and Monitoring **(TTCM)** subsystem is present in both satellite and earth station. In general, satellite gets data through sensors. So, Telemetry subsystem present in the satellite sends this data to earth station(s). Therefore, TTCM subsystem is very much necessary for any communication satellite in order to operate it successfully.

It is the responsibility of satellite operator in order to control the satellite in its life time, after placing it in the proper orbit. This can be done with the help of **TTCM subsystem**.

We can make this TTCM subsystem into the following **three parts**.

- Telemetry and Monitoring Subsystem
- Tracking Subsystem
- Commanding Subsystem




SPACE SEGMENT
Satellite
COMMAND SEGMENT
Satellite Station
USER SEGMENT

Telemetry and Monitoring Subsystem

The word '**Telemetry**' means measurement at a distance. Mainly, the following operations take place in 'Telemetry'.

- Generation of an electrical signal, which is proportional to the quantity to be measured.
- Encoding the electrical signal.
- Transmitting this code to a far distance.

Telemetry subsystem present in the satellite performs mainly two functions –

- receiving data from sensors, and
- transmitting that data to an earth station.

Satellites have quite a few sensors to monitor different parameters such as pressure, temperature, status and etc., of various subsystems. In general, the telemetry data is transmitted as FSK or PSK.

Telemetry subsystem is a remote controlled system. It sends monitoring data from satellite to earth station. Generally, the **telemetry signals** carry the information related altitude, environment and satellite.

Tracking Subsystem

Tracking subsystem is useful to know the position of the satellite and its current orbit. Satellite Control Center **(SCC)** monitors the working and status of space segment subsystems with the help of telemetry downlink. And, it controls those subsystems using command uplink.

We know that the **tracking subsystem** is also present in an earth station. It mainly focusses on range and look angles of satellite. Number of techniques that are using in order to track the satellite. For **example**, change in the orbital position of satellite can be identified by using the data obtained from velocity and acceleration sensors that are present on satellite.

The **tracking subsystem** that is present in an earth station keeps tracking of satellite, when it is released from last stage of Launch vehicle. It performs the functions like, locating of satellite in initial orbit and transfer orbit.

Commanding Subsystem

Commanding subsystem is necessary in order to launch the satellite in an orbit and its working in that orbit. This subsystem adjusts the altitude and orbit of satellite, whenever there is a deviation in those values. It also controls the communication subsystem. This **commanding subsystem** is responsible for turning ON / OFF of other subsystems present in the satellite based on the data getting from telemetry and tracking subsystems.

In general, control codes are converted into command words. These command words are used to send in the form of **TDM frames**. Initially, the validity of command words is checked in the satellite. After this, these command words can be sent back to earth station. Here, these command words are checked once again.

If the earth station also receives the same (correct) command word, then it sends an execute instruction to satellite. So, it executes that command.

Functionality wise, the Telemetry subsystem and commanding subsystem are opposite to each other. Since, the first one transmits the satellite's information to earth station and second one receives command signals from earth station.

Antenna Subsystems

Antennas are present in both satellite and earth station. Now, let us discuss about the satellite antennas.

Satellite antennas perform **two types** of functions. Those are receiving of signals, which are coming from earth station and transmitting signals to one

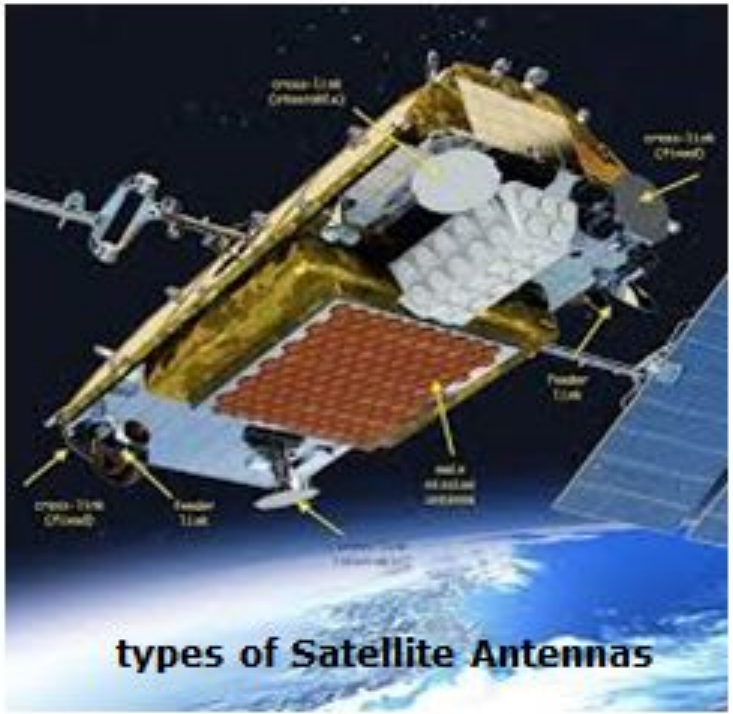
or more earth stations based on the requirement. In other words, the satellite antennas receive uplink signals and transmit downlink signals.

We know that the length of satellite antennas is inversely proportional to the operating frequency. The operating frequency has to be increased in order to reduce the length of satellite antennas. Therefore, satellite antennas operate in the order of **GHz** frequencies.

Satellite Antennas

The antennas, which are used in satellite are known as satellite antennas. There are mainly four **types of Antennas**. They are:

- Wire Antennas
- Horn Antennas
- Array Antennas
- Reflector Antennas



types of Satellite Antennas

Satellite Communication – Transponders

The subsystem, which provides the connecting link between transmitting and receiving antennas of a satellite is known as **Transponder**. It is one of the most important subsystem of space segment subsystems.

Transponder performs the functions of both transmitter and receiver (Responder) in a satellite. Hence, the word 'Transponder' is obtained by the combining few letters of two words, Transmitter **(Trans)** and Responder **(ponder)**.

Power Systems

We know that the satellite present in an orbit should be operated continuously during its life span. So, the satellite requires internal power in order to operate various electronic systems and communications payload that are present in it.

Power system is a vital subsystem, which provides the power required for working of a satellite. Mainly, the solar cells (or panels) and rechargeable batteries are used in these systems.

Solar Cells

Basically, the **solar cells** produce electrical power (current) from incident sunlight. Therefore, solar cells are used primarily in order to provide power to other subsystems of satellite.

We know that individual solar cells generate very less power. So, in order to generate more power, group of cells that are present in an array form can be used.

Solar Arrays

There are two **types of solar arrays** that are used in satellites. Those are cylindrical solar arrays and rectangular solar arrays or solar sail.

- **Cylindrical solar arrays** are used in spinning satellites. Only part of the cylindrical array will be covered under sunshine at any given time. Due to this, electric power gets generated from the partial solar array. This is the drawback of this type.

- The drawback of cylindrical solar arrays is overcome with **Solar sail**. This one produce more power because all solar cells of solar sail are exposed to sun light.

Rechargeable Batteries

During eclipses time, it is difficult to get the power from sun light. So, in that situation the other subsystems get the power from **rechargeable batteries**. These batteries produce power to other subsystems during launching of satellite also.

In general, these batteries charge due to excess current, which is generated by solar cells in the presence of sun light.

Earth Segment Subsystems

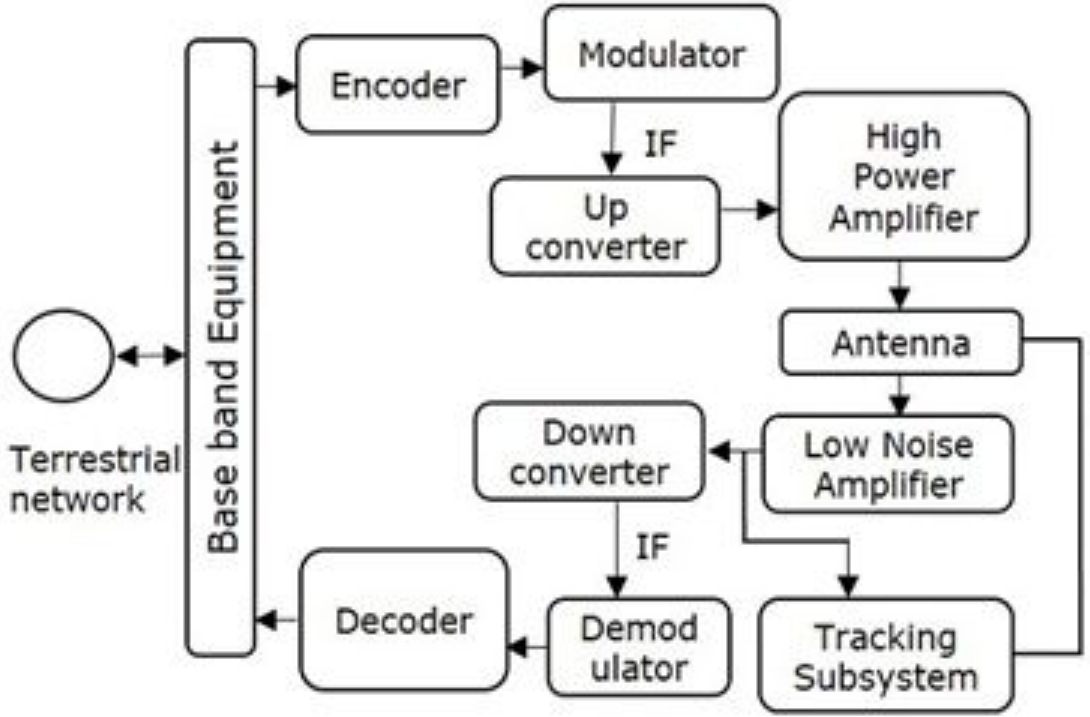
The **earth segment** of satellite communication system mainly consists of two earth stations. Those are transmitting earth station and receiving earth station.

The transmitting **earth station** transmits the information signals to satellite. Whereas, the receiving earth station receives the information signals from satellite. Sometimes, the same earth station can be used for both transmitting and receiving purposes.

In general, earth stations receive the baseband signals in one of the following forms. Voice signals and video signals either in analog form or digital form.

Initially, the analog modulation technique, named **FM modulation** is used for transmitting both voice and video signals, which are in analog form. Later, digital modulation techniques, namely Frequency Shift Keying **(FSK)** and Phase Shift Keying **(PSK)** are used for transmitting those signals. Because, both voice and video signals are used to represent in digital by converting them from analog.

Earth segment of satellite communication system
(Earth Station)



Block diagram of Earth Station system

Thank you