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by

Lo Tsen Yu

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Ground Stations in Satellite Communication

Article by Lo Tsen Yu
Figures by Wang Shu Chang

Under the national leadership and strategic policy of Chairman Hua, and after the successful development of analog satellite communication ground station in 1975, China has independently designed and built her first digital system satellite communication ground station (cover photo and Fig. 1). This achievement is highly significant in the nation's development of satellite communication, in the transmission of telephone, telegram, and television broadcast from Peking to the remote regions. It is also of great importance in the development of overseas communication, space programs and our national defense reinforcement.

Satellite communication has the following advantages: long distance, high volume and reliability, versatile and multi-connection. Communication is carried out between two or more ground stations via the re-transmitted radio signals from earth satellites which act as a relay station, see cover page 3. The working principles are similar to the earth surface microwave relay communication, except the relay station is not on the ground but in the space tens of thousands of miles from earth. Man-made earth satellites serving this function are called communication satellites. Such satellites receive signals from the ground station and send the messages back to earth after amplification and frequency conversion.

In addition to the satellite and the ground stations, satellite communication systems also involve the necessary ground facilities such as tracking,

Fig. 1

remote sensing, command and monitor systems for the launching and control of the satellite. The sensing and control station is usually located at the site of a main ground station and together they constitute the control center of the satellite communication system. The following is a brief description of the ground station.

Simply put, the ground station (including ship, surface, and airborne) refers to the ground facility in the satellite communication circuit which sends radio signals to the satellite and receives signals sent back from it. There are various types of ground stations. According to their function characteristics, there are the central ground station (including the monitor and control application center) and other ground stations. One has the standard station and the non-standard station according to their electrical index criterion. Based on the station site,

they can be divided into permanent station, transportable station and mobile station. As far as the signal transmission mode, they are analog station and digital station.

What are analog and digital station? It is well known that, in order to transmit sound and pictures to a great distance, the sound and graphic message must be processed and converted to electrical signals and then transmitted along some communication channel. Such electrical signals may be continuous waves varying with time and simulate the value of the audio or video messages they are carrying. These signals are known as the analog signals. The analog signals can be quantified and represented by discontinuous signals consisting of two states: "o" and "1", or, the digital signal. In the analog mode, analog signals are transmitted, and similarly digital signals are transmitted in the digital mode of operation. The ground stations are named accordingly, based on their mode of operation. Actually, the two modes of ground station are interchangeable except their terminal facilities are different.

Generally, the ground station (receiving-only stations excluded) consists of the following facilities: antenna, feeding, tracking, transmitting, receiving, communication control, terminals, and electric power source, as shown in Fig. 2. The signals from a ground station cannot be linked directly to telegraph and television stations, as they must go through the process of the intermediate switching facility, which is also housed in the site of the earth station. The major functions of a ground station is listed below:

1. Antenna Feeding System. The feeder antenna is used in both the transmission and the receiving of signals. The criteria for a ground station antenna in satellite communication are high directionality, high gain,

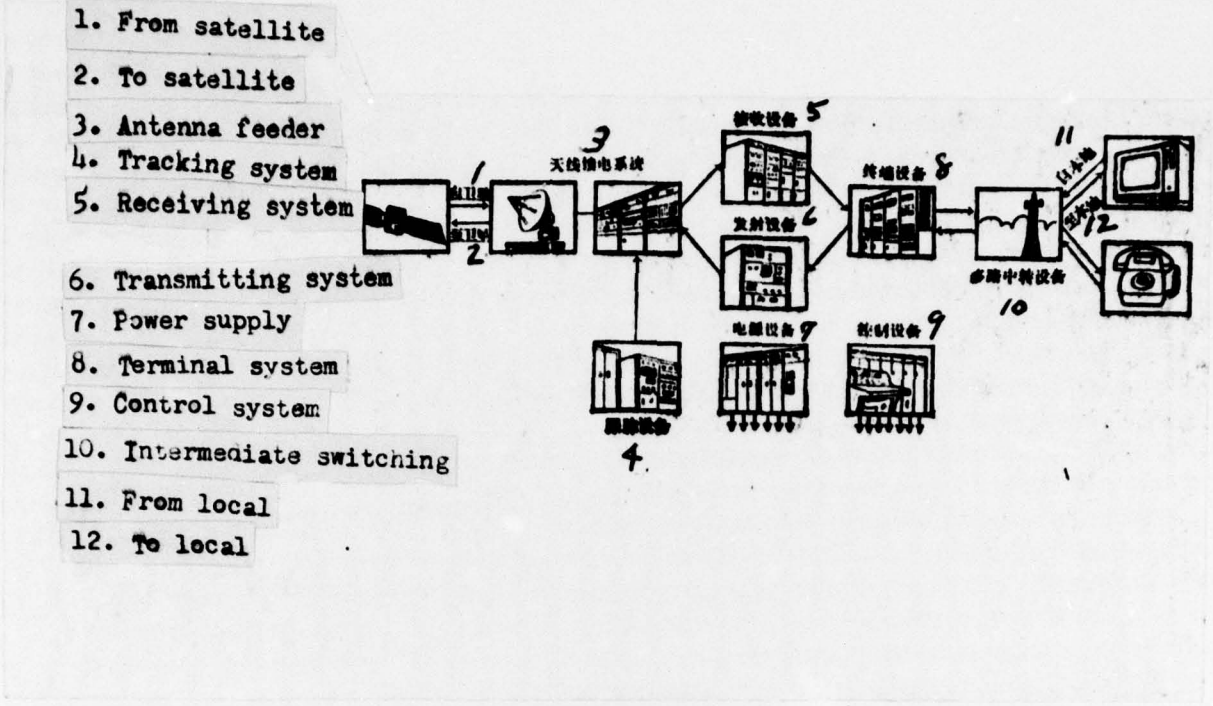
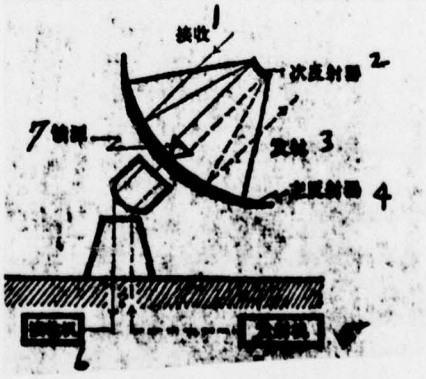


Fig. 2

and low noise. In general, the antenna is parabolic and consists of the primary reflector, the secondary reflector and the feeder source (also known as the radiator), as shown in Fig. 3.



1. Receiving; 2. Secondary reflector; 3. Transmitting; 4. Primary reflector; 5. Transmitter; 6. Receiver; 7. Feeder source.

Fig. 3

In the transmission process, local signals are converted and sent to the transmitter feeder via feeding lines. The feeder then radiates the signals to the secondary reflector which in turn transmits the signals to the primary reflector. After reflected from the primary reflector, the electrical signals become a well defined and concentrated plane wave aimed at the satellite. The reverse process is true in receiving.

2. Tracking System. Its function is to keep the ground antenna aimed at the satellite, that is, to ensure the tracking of the satellite by the antenna. Nowadays, synchronous satellites are often used in communication. Synchronous satellites revolve around the earth in orbits approximately 36,000 kilometers from the earth's surface with a revolving speed equal to that of the earth's self-rotation or one revolution per 24 hours. Since such satellites are stationary relative to any point on the earth surface, they are called synchronous or stationary satellites. Since the synchronous satellites are floating at a great altitude, their exact positions wander in a certain range. If the antenna is not aimed accurately at the satellite, the communication will be interrupted for both directions. The tracking system is therefore an indispensable part in a reliable communication system.

3. Transmitter facility. The transmitter consists of the modulator, frequency converter and the power amplifier. Telephone and television carrier signals from the terminals first go through the modulator for modulation at a specified frequency. The modulated wave form then goes through the converter where the frequency is converted from the modulation frequency to the microwave frequency suitable for transmission. The power amplifier then raises the level of the microwave power and feeds the signal to the antenna for radiation to the satellite.

4. Receiver System. Consisting of the differential amplifier, frequency converter, and the demodulator, the receiver does the opposite function of a transmitter and its working principles are similar to those of a radio receiver. Signals received by the antenna are first amplified by a low noise amplifier and then converted to lower frequencies before they reach the demodulator. The demodulator recovers the carrier signals from the wave and sends them to the terminals of the earth station. Since the signals received from the satellite are usually very weak, they must be amplified before frequency conversion. Receivers in the earth station usually use the low noise differential amplifier to gain the necessary amplification without introducing its own noise.

5. Terminal Facility. This could include telephone carrier terminal, television video frequency terminal, television sound track terminal, digital signal channel terminal and voice terminal. Its function is to convert the signals obtained from the receiver system to telephone and television signals directly transferable to local telegram office or TV stations. In the meantime, it also changes the local incoming telephone and television signals to carrier signals transmittable by the facilities of the ground communication station.

6. Electric Power Source. This refers to the power supplies which keep all the various equipment operating. In particular, the spare power source (generator) keeps the supply of power uninterrupted even without the benefit of city electricity.

7. Control Facilities. This is the nerve center of the entire circuit. It monitors the communication signals and collectively controls the operation of all the systems in the ground station, such as the control

of the inclination and azimuth of the antenna, the monitoring of the working condition of high power transmitter, and the operation of the low noise amplifier. It also controls the switching between main generator and spare generator.

Satellite communication is a modern means of communication developed in the 1960's, and has had a rapid growth in the past decade. Today it has assumed a leading role in practical communication. Many nations in the world are accelerating their development of national or regional satellite communication. Applications in special communications (such as military, aeronautical and navigational) have also been widened. Furthermore, satellites are increasingly used in the transmission of television programs and direct broadcast of television by satellite has been put in use. In other words, television viewers may equip their regular TV sets with a specially made antenna (often a parabolic antenna with a diameter of less than one meter) and a switching device and receive television programs directly from broadcasting satellites.

To date, more than twenty satellite communication systems are in existance and an estimated twenty more systems will be established by 1985. The largest system presently in use is the International Satellite Communication System (INTELSAT), a system involving 72 countries and regions and 121 ground stations. At the end of 1975, INTELSAT commands 12,000 international telephone lines and is capable of communicating with more than 100 countries and regions in providing telephone, telegraph, facsimile transmission, television and data services. The standard ground station antenna of this system has a diameter of 30 meters and is going toward 10 meter and 4.5 meter small scale earth stations.

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