ATME College of Engineering

MODULE 2-SOC-BEC515D

Satellite subsystem and Earth Station

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Satellite Subsystems

- Mechanical structure
- Propulsion subsystem
- Thermal control subsystem
- Power supply subsystem
- Telemetry, tracking and command (TT&C) subsystem
- Attitude and orbit control subsystem
- Payload subsystem
- Antenna subsystem

Power Supply Subsystem

- The power supply subsystem generates, stores, controls and distributes electrical power to other subsystems on board of the satellite platform.
- The electrical power needs of a satellite depend upon the intended mission of the spacecraft and the payloads that it carries along with it in order to carry out the mission objectives.
- The power requirement can vary from a few hundreds of watts to tens of kilowatts.

Types of Power System

- The types of power system used in the satellite platform are

✓Solar Energy Driven Power System

  - Solar Panels

✓Batteries

  - Nickel Cadmium Batteries
  - Nickel Metal Hydride Battery
  - Nickel Hydrogen Batteries
  - Lithium Ion Battery

Solar Energy Driven Power Systems

The major components of a solar power system are the solar panels, rechargeable batteries, battery chargers with inbuilt controllers, regulators and inverters to generate various d.c and a.c voltages required by various subsystems.

Solar Energy Driven Power Systems

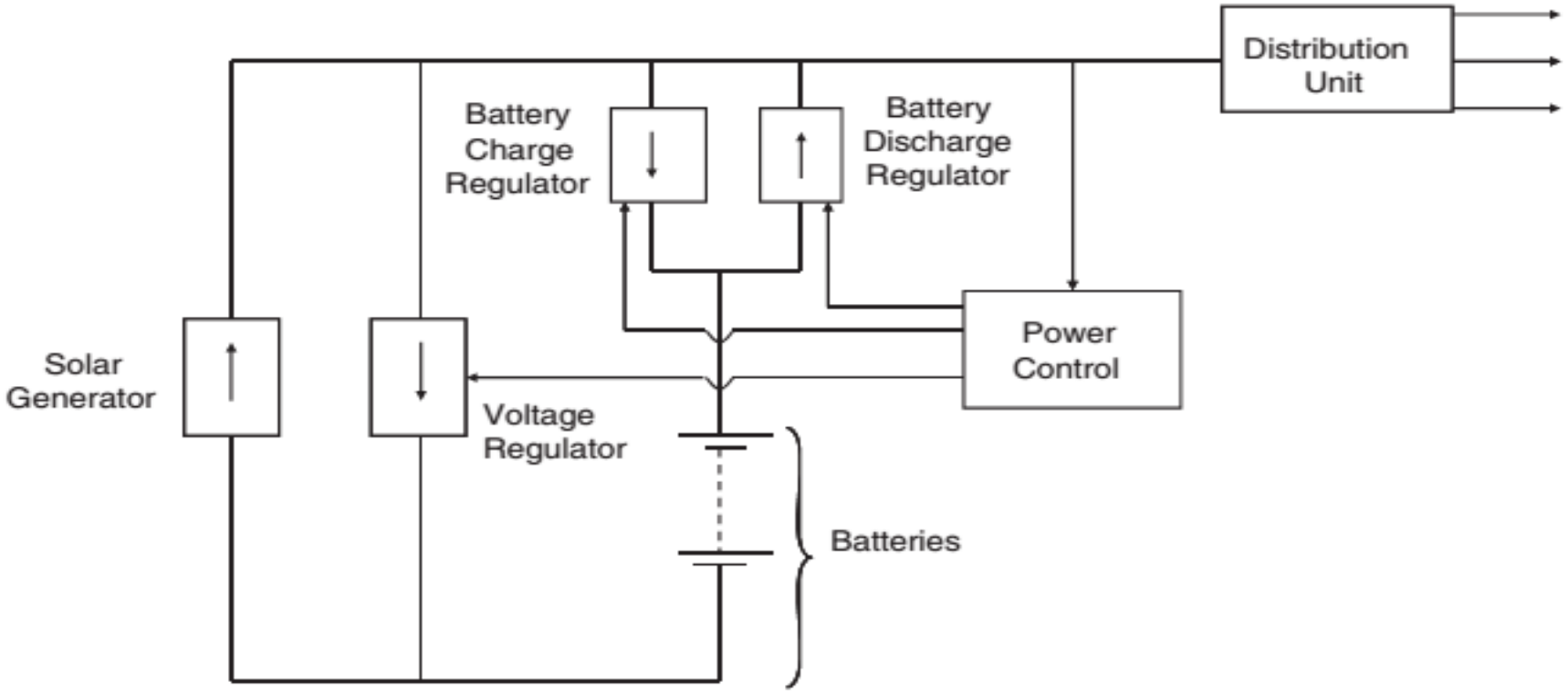
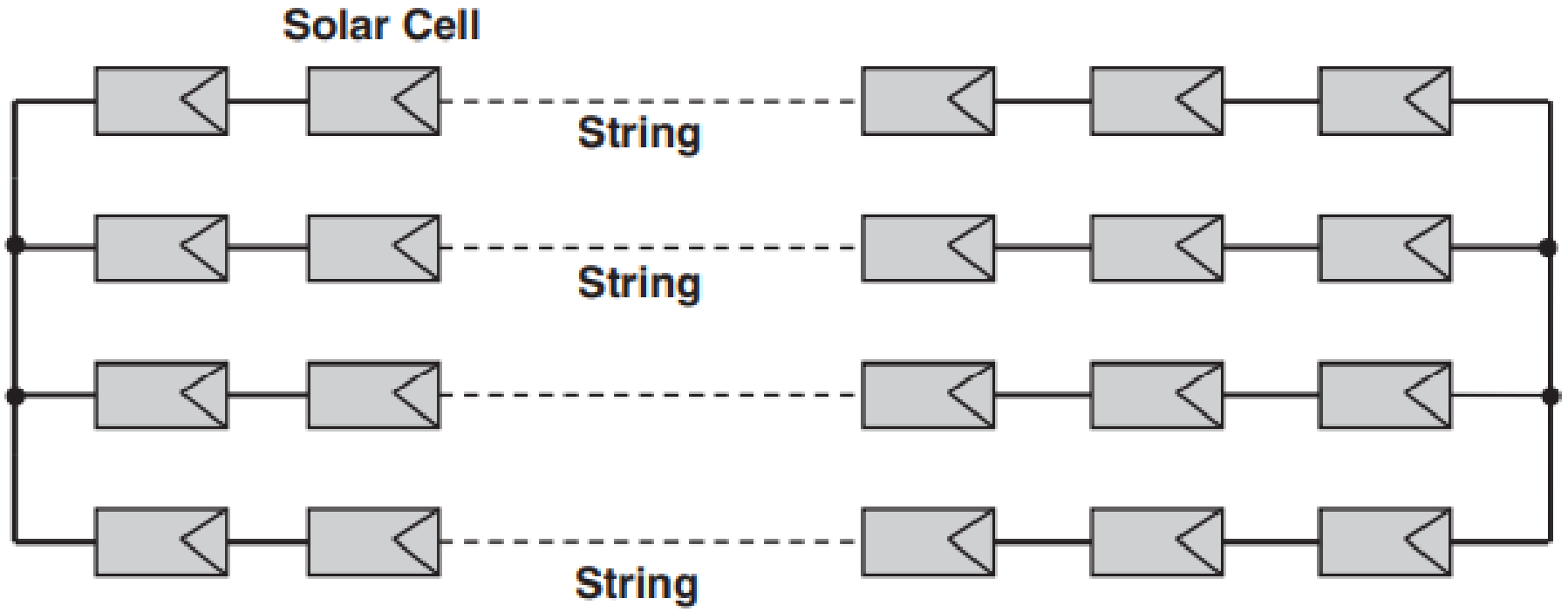


Fig: Basic block schematic arrangement of a regulated bus power supply system

Solar Panels

- Solar panel is nothing but a series and parallel connection of a large number of solar cells.



Batteries

- Nickel Cadmium Batteries
- Nickel Metal Hydride Battery
- Nickel Hydrogen Batteries
- Lithium Ion Battery

Attitude and Orbit Control

- The attitude and orbit control subsystem performs twin functions of controlling the orbital path and to provide attitude control.
- It also ensures that the antennae remain pointed at a fixed point on the Earth's surface.
- The requirements on the attitude and orbit control subsystem differ during the launch phase and the operational phase of the satellite.

Tracking, Telemetry and Command Subsystem

- The tracking, telemetry and command (TT&C) subsystem monitors and controls the satellite right from the lift-off stage to the end of its operational life in space.
- The tracking part of the subsystem determines the position of the spacecraft and follows its travel using angle, range and velocity information.
- The telemetry part gathers information on the health of various subsystems of the satellite. It encodes this information and then transmits the same towards the Earth control centre.

Payload

- Payload is the most important subsystem of any satellite. Payload can be considered as the brain of the satellite that performs its intended function.
- The basic payload in the case of a communication satellite, for instance, is a transponder, which acts as a receiver/amplifier/transmitter.
- A transponder can be considered to be a microwave relay channel that also performs the function of frequency translation from the uplink frequency to the relatively lower downlink frequency.

EARTH STATION

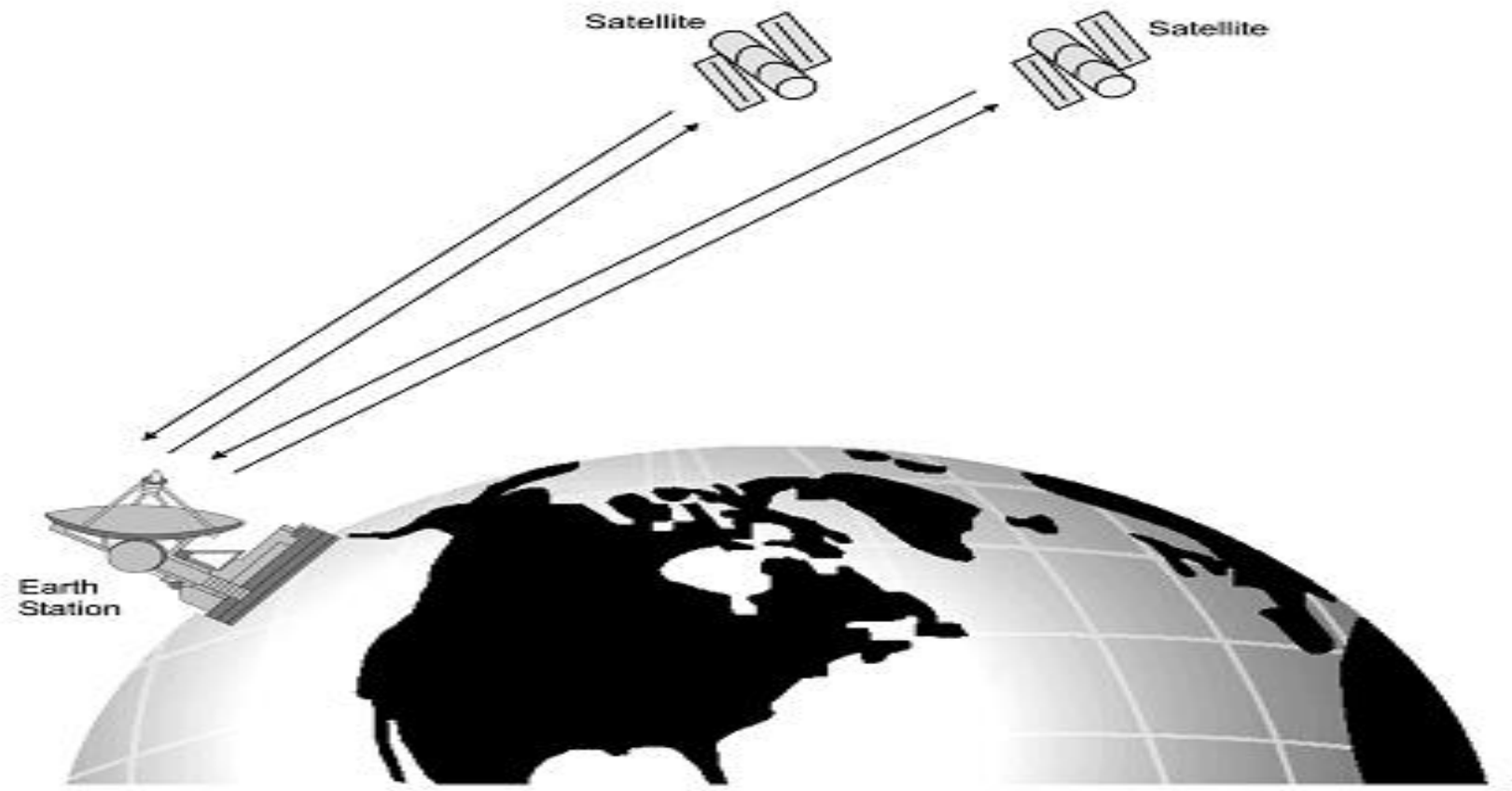


Fig: Earth station communicating with satellites

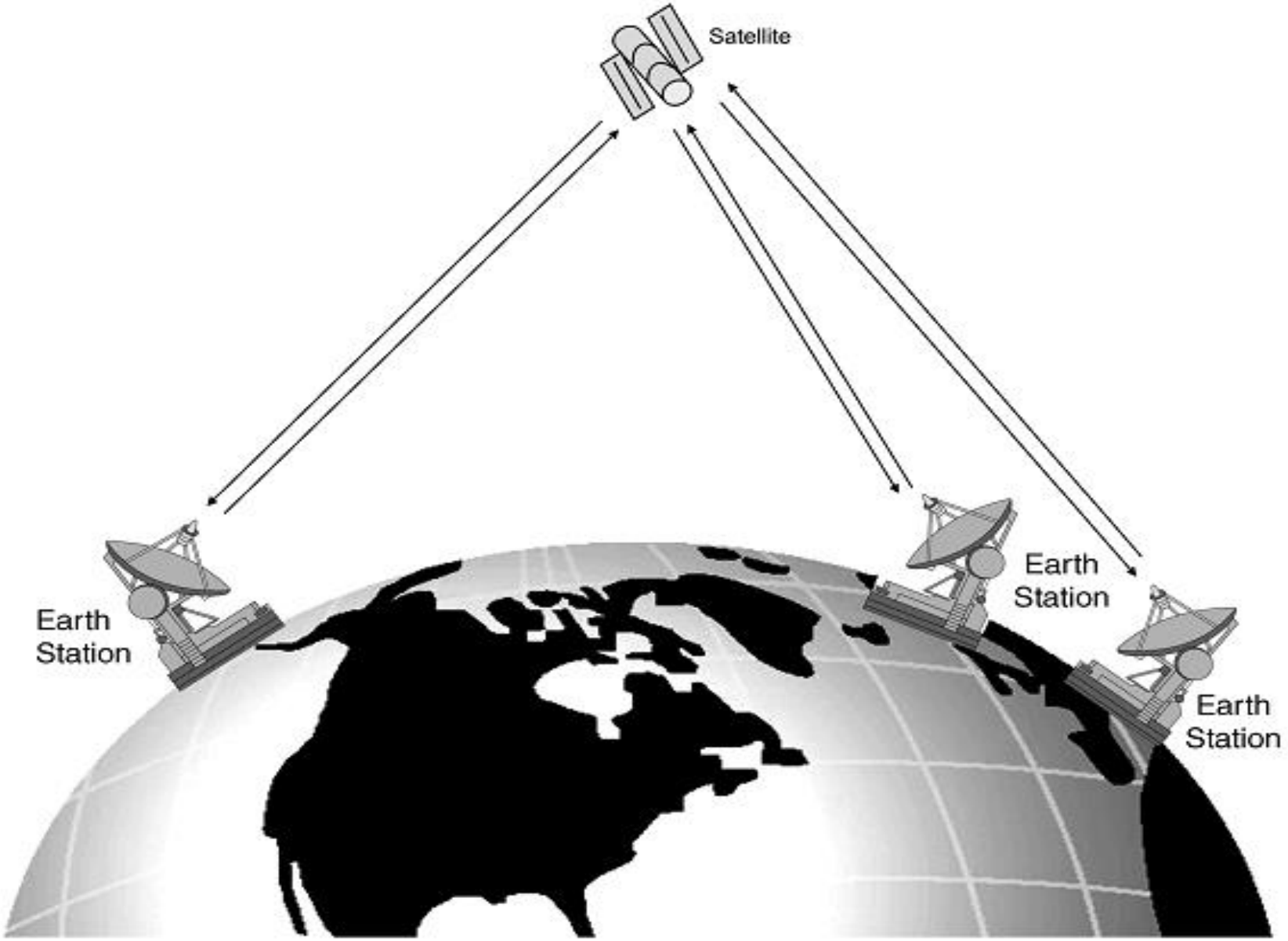


Fig: Earth station communicating with another Earth station

- Earth stations transmit to and receive from satellites.
- In some special applications, the Earth stations only transmit to or receive from satellites.
- Receive-only Earth station terminals are mainly of relevance in the case of broadcast transmissions.
- Transmit-only Earth station terminals are relevant to data gathering applications.

Major subsystems comprising an Earth station

- Transmitter system
- Receiver system
- Antenna system
- Tracking system
- Primary power to run the Earth station
- Test equipment required for routine maintenance of the Earth station and terrestrial interface.

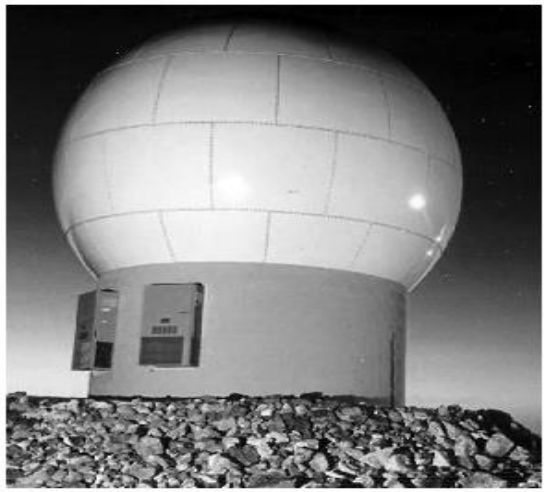
Types of Earth Station

Earth stations are generally categorized on the basis of type of services or functions provided by them.

- Fixed Satellite Service (FSS) Earth Stations
- Broadcast Satellite Service (BSS) Earth Stations
- Mobile Satellite Service (MSS) Earth Stations

Fixed Satellite Service (FSS) Earth Station

We have the large Earth stations ($G/T \sim = 40$ dB/K) ,
medium Earth stations ($G/T \sim = 30$ dB/K),
small Earth stations ($G/T \sim = 25$ dB/K),
very small terminals with transmit/receive functions ($G/T \sim = 20$ dB/K) and
very small terminals with receive only functions ($G/T \sim = 12$ dB/K)



Antenna power gain-to-system noise temperature (G/T)

Broadcast Satellite Service (BSS) Earth Stations

- We have large Earth stations ($G/T \sim =$ 15 dB/K) used for community reception and small Earth stations ($G/T \sim =$ 8 dB/K) used for individual reception.
- It is also known by the name of Direct Broadcast Service or DBS or more commonly as Direct-to-Home or DTH. The term DBS is often used interchangeably with DTH to cover both analog and digital video and audio services received by relatively small dishes.

Mobile Satellite Service (MSS) Earth Stations

- We have the large Earth stations ($G/T \sim = -4$ dB/K), medium Earth stations ($G/T \sim = -12$ dB/K) and small Earth stations ($G/T \sim = -24$ dB/K).
- Both large and medium Earth stations require tracking, small MSS Earth stations are without tracking equipment.
- Satellite phone is the most commonly used mobile satellite service. It is a type of mobile that connects to satellites instead of terrestrial cellular sites.

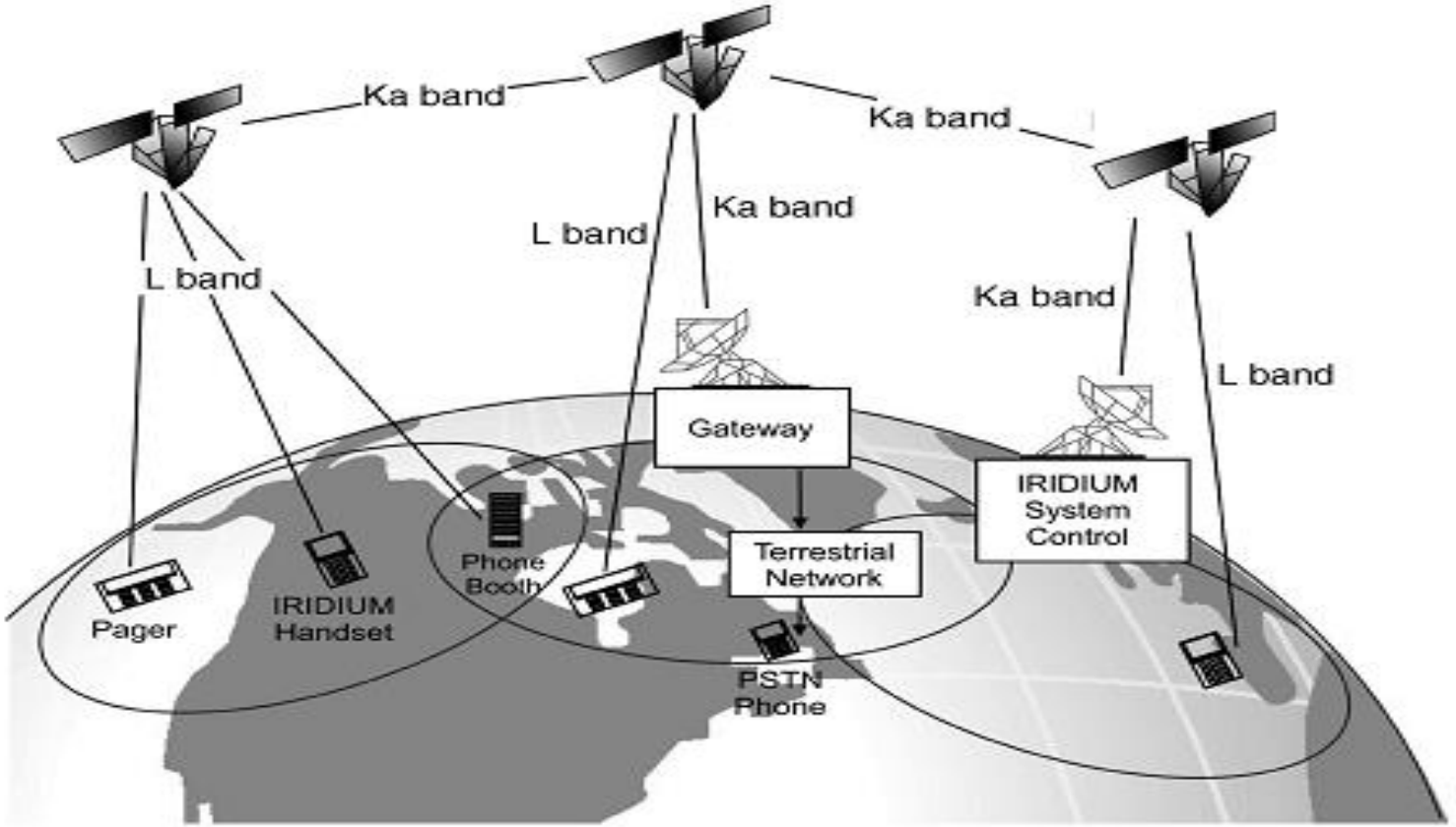


Fig: Iridium system

- Iridium and Globalstar are the two major LEO satellite systems offering mobile satellite services.
- Globalstar uses 44 satellites with the orbital inclination of the satellites being 52◦.
- Iridium operates 66 satellites orbiting in polar orbits.
- Radio links are used between the satellites in order to relay data to the nearest satellite connected to the Earth station.

Earth stations are also sometimes conveniently categorized into three major functional groups depending upon their usage. These categories are the following.

1. Single function stations
2. Gateway stations
3. Teleports

Single Function Stations

- Single function stations are characterized by a single type of link to a satellite or a satellite constellation. These stations may be transmit-only, receive-only or both.
- Some common examples of single function stations include television receive-only (TVRO) terminals used for TV reception by an individual ,satellite radio terminals, receive-only terminals used at a television broadcast station to pick up contribution feeds.

Gateway Stations

- Gateway stations serve as an interface between the satellites and the terrestrial networks and also serve as transit points between satellites.
- In the case of gateway stations, signal processing is the major activity.
- A lot of signal manipulation activities therefore need to be carried out on these signals before they are routed to the intended satellite. There are both independent as well as satellite system owner's gateway stations.

Teleports

- Teleport is a type of gateway station operated by firms that are usually not a part of a specific satellite system.
- Teleports are useful for those companies whose not-too-high requirement of satellite connectivity.
- The services offered by teleport stations typically include format conversion, encryption, production and post production, turn-around services and even leasing transportable uplinks for temporary events.

Earth Station Architecture

- The major components of an Earth station include the *RF section*, the *baseband equipment* and the *terrestrial interface*.
- The complexity of Earth station architecture depends upon the application.
- Every Earth station has support facilities such as tracking, control and monitoring equipment, power supply with back-up and environmental conditioning unit.

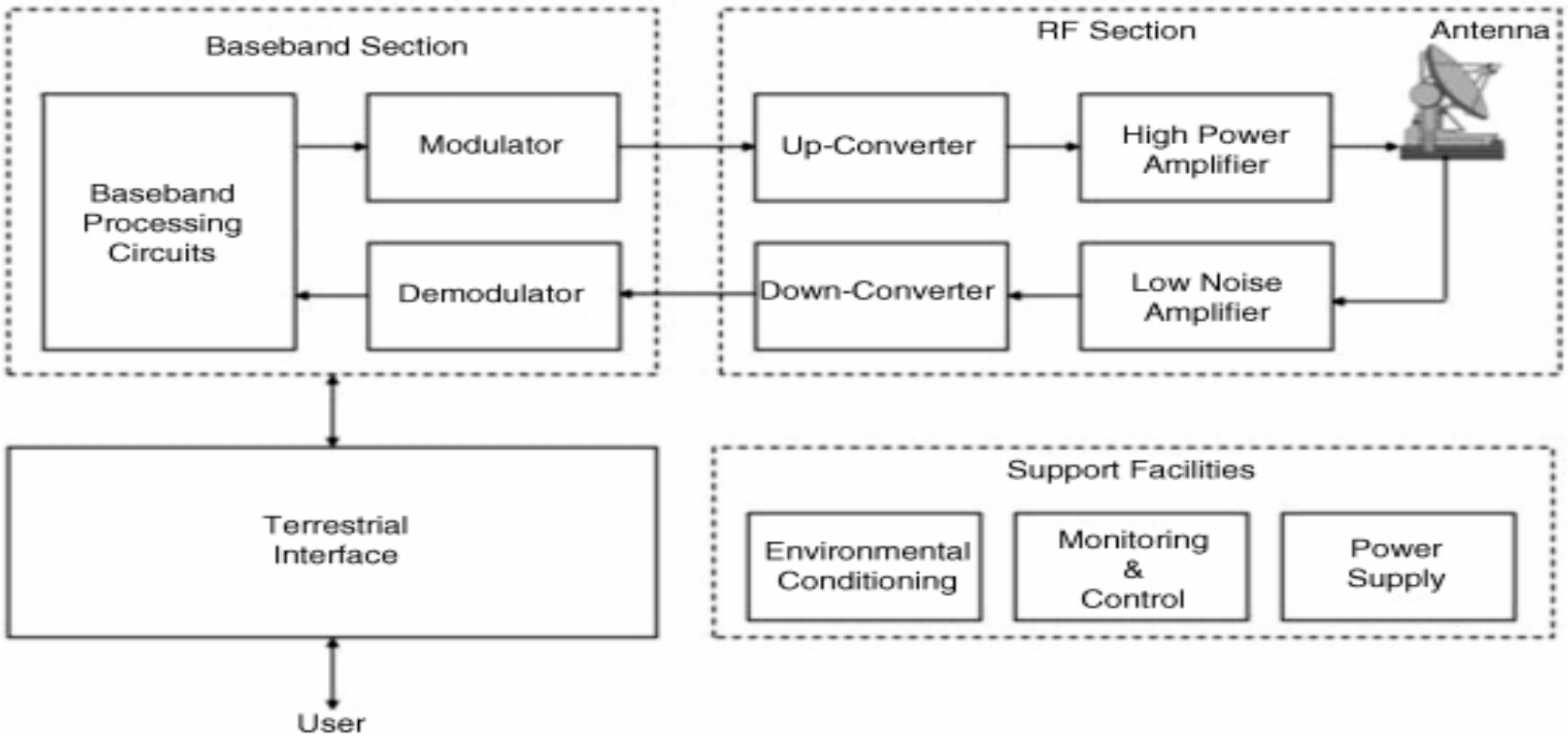


Fig: Block schematic arrangement of a generalized Earth station

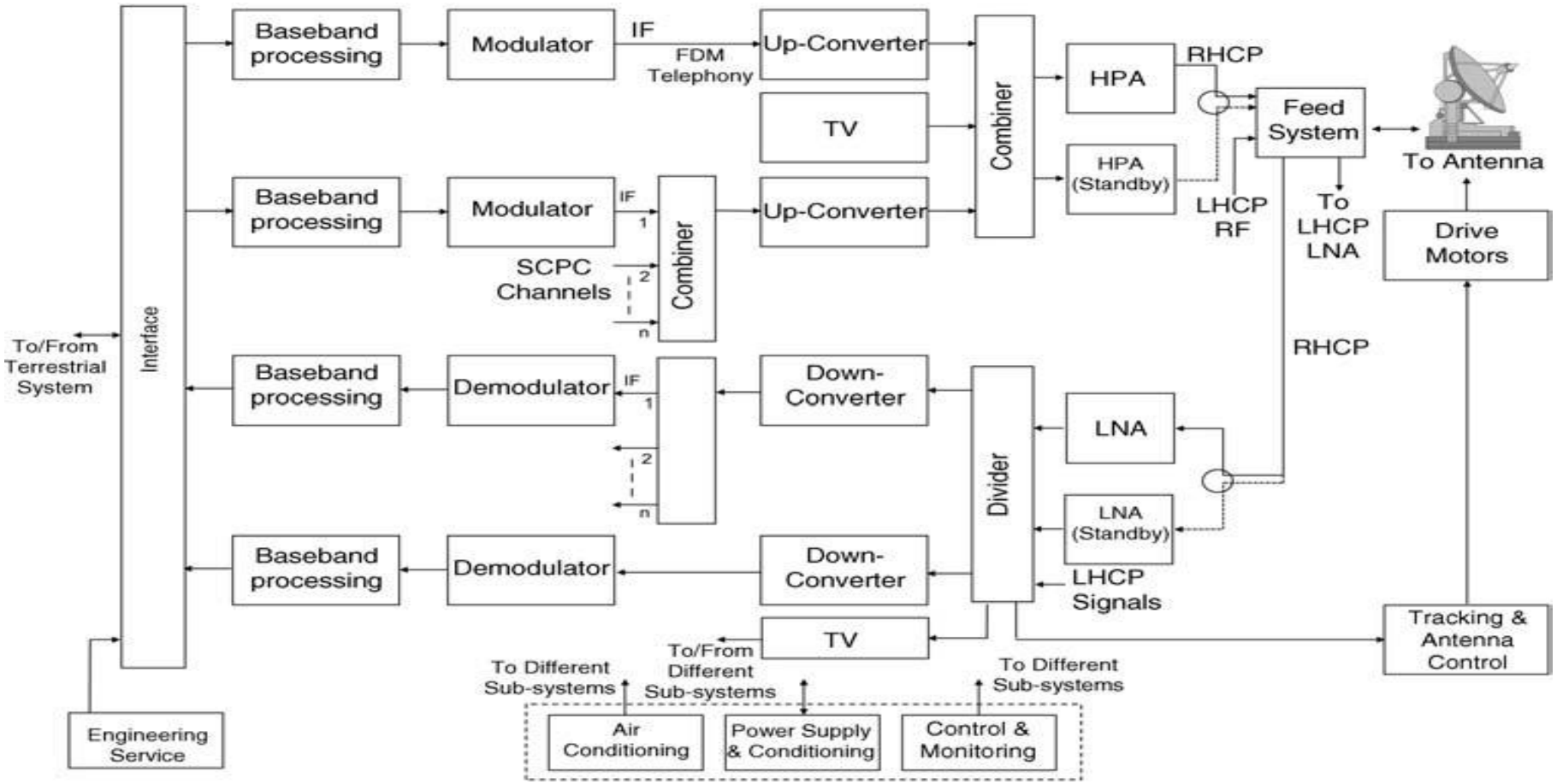


Fig: Block schematic of a typical large FSS Earth station

Earth Station Design Considerations

Design of an Earth station is generally a two-step process.

1. The first step involves identification of Earth station requirement specifications and
2. The second step is about identifying the most cost effective architecture that achieves the desired specifications.

Earth Station Design Considerations

Requirement specifications affecting the design of an Earth station include type of service offered (Fixed satellite service, Broadcast satellite service or Mobile satellite service), communication requirements (telephony, data, television etc.), required base band quality at the destination, system capacity and reliability.

Earth Station Testing

- Having chosen the Earth station equipment, it is important to ensure that the equipment would not only meet the specified requirements of the intended Earth station.
- It is also necessary to ensure that the Earth station would not cause any problems either to other users of the satellite or to any adjacent satellites

- **Testing is started at component or unit level followed up by subsystem level testing.**

Mandatory Tests

Mandatory tests include measurements of

(a) Transmit cross-polarization isolation

(b) Receiver figure-of-merit

(c) *EIRP stability and*

(d) Spectral shape.

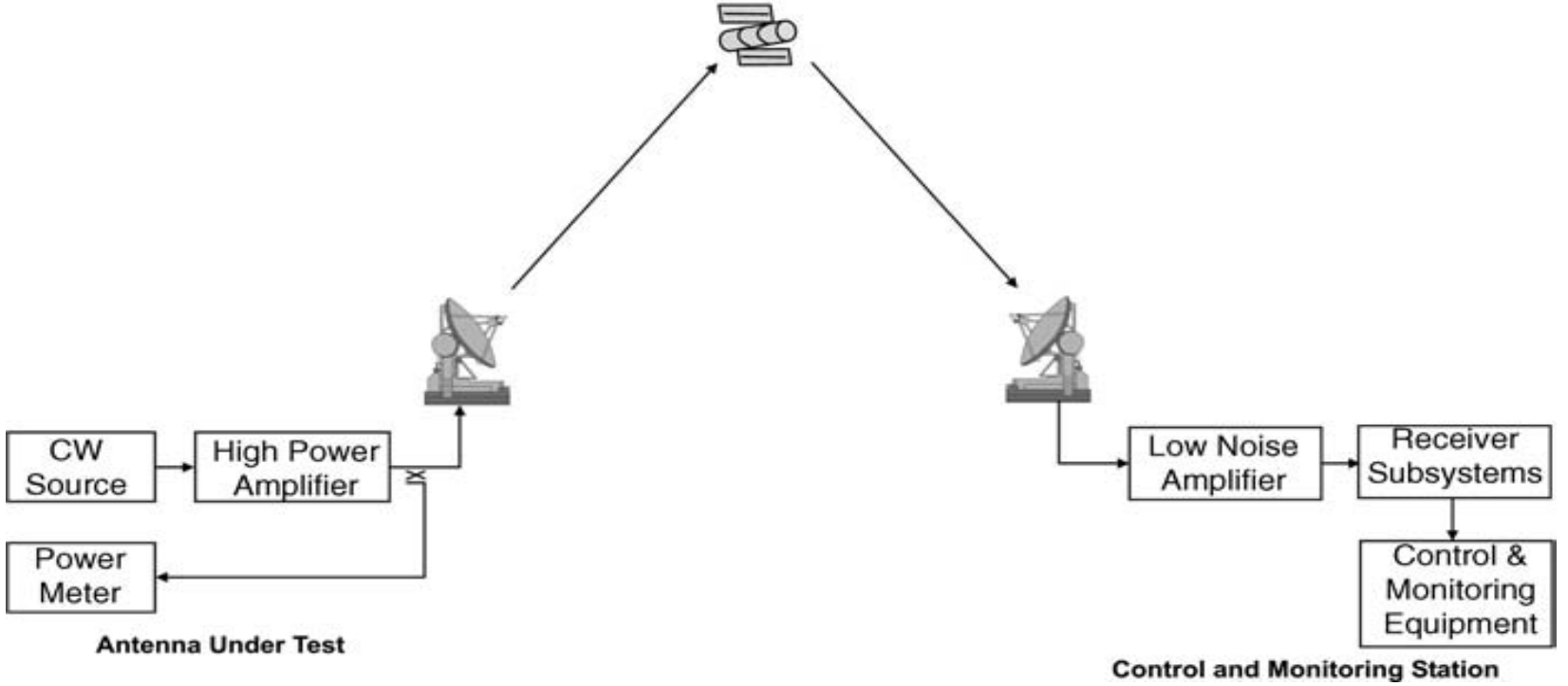


Figure Schematic arrangement of transmit cross-polarization isolation measurement

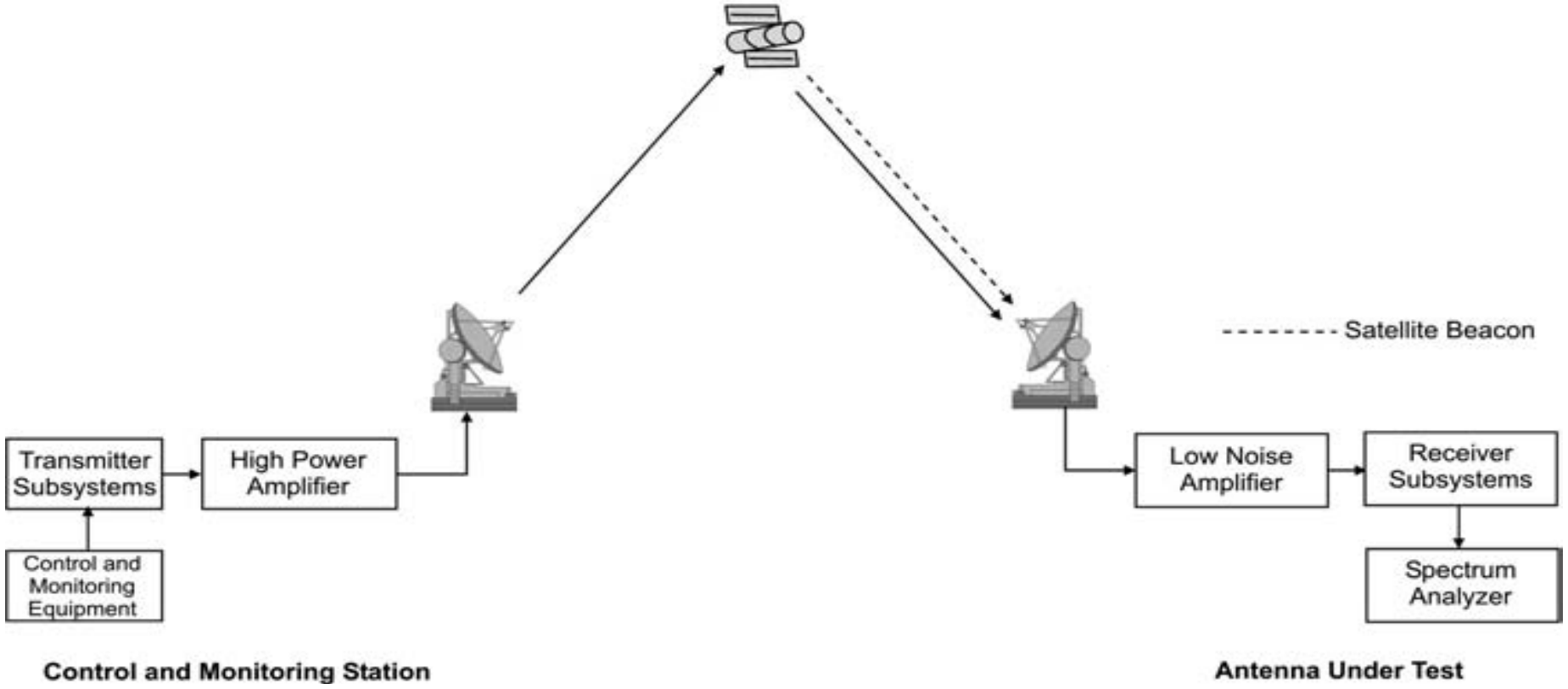


Figure Schematic arrangement of test set-up for measurement of receiver *G/T*

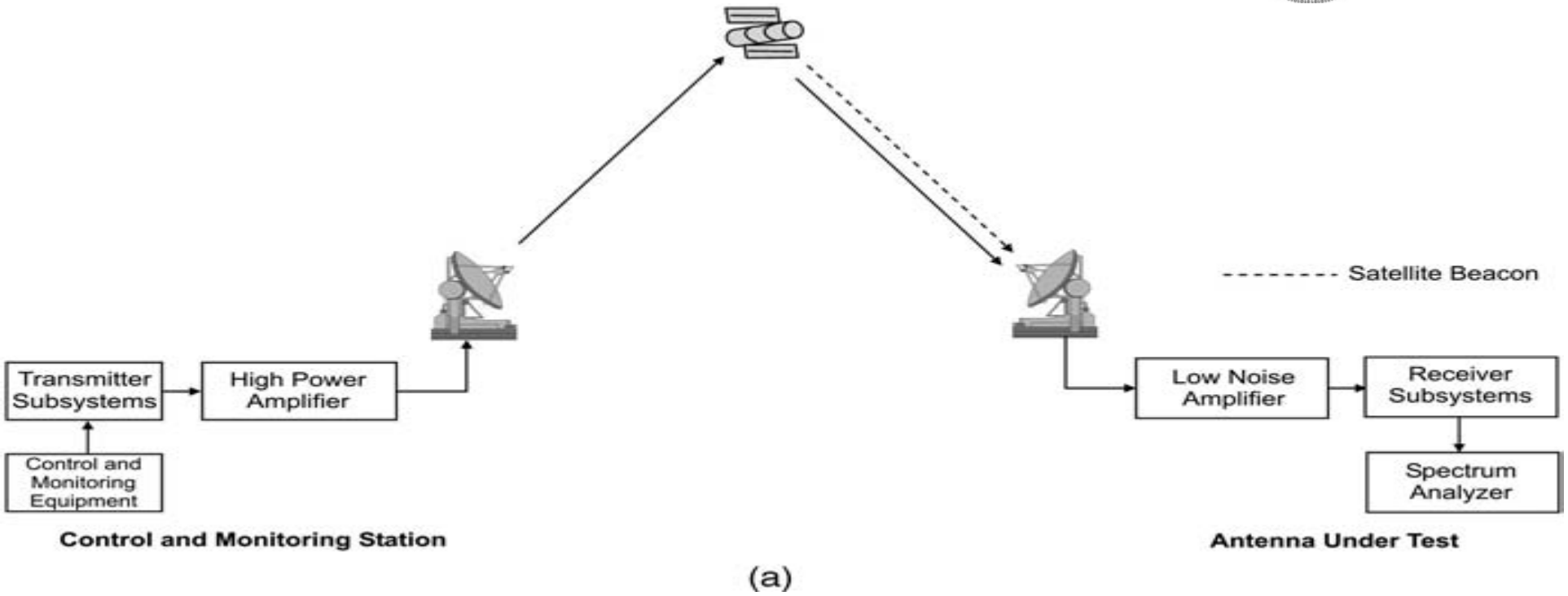


Figure Receiver gain and system temperature method (a) Measurement of receiver gain

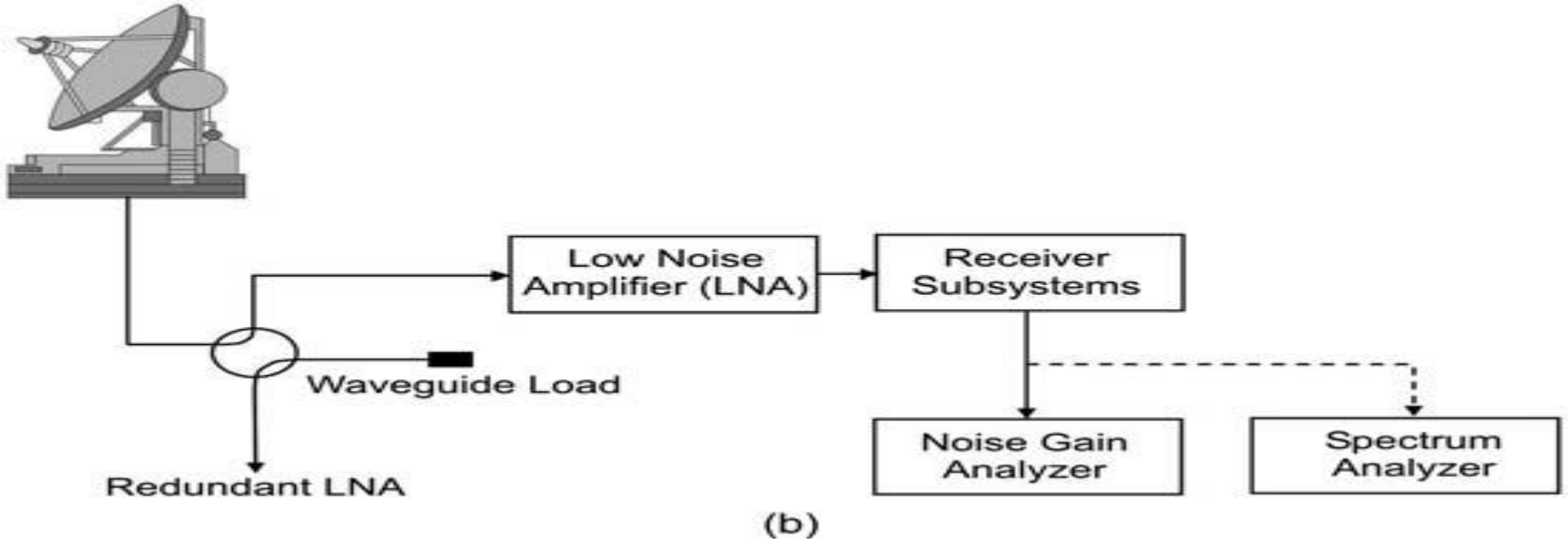


Figure Receiver gain and system temperature method (b) Measurement of system temperature

Additional Tests

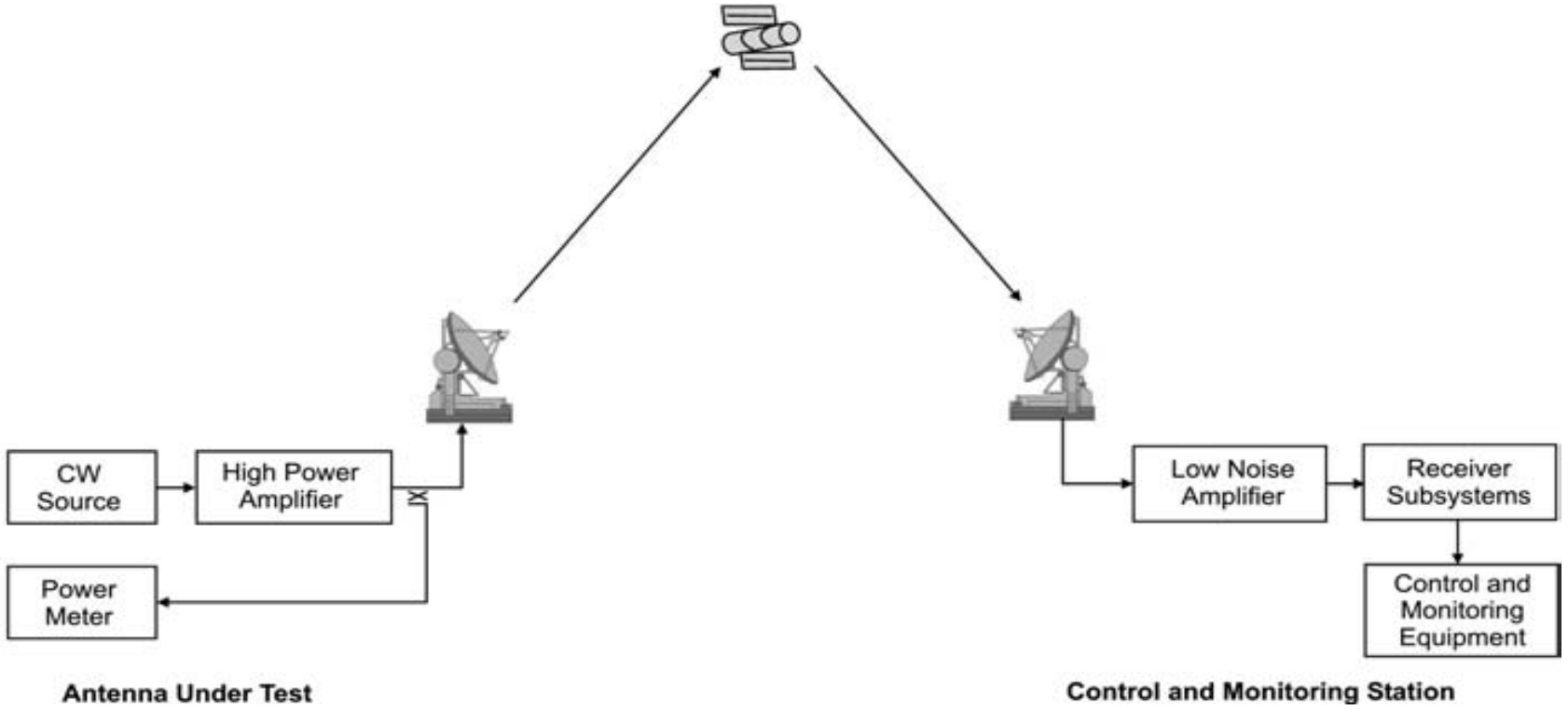


Figure Test set-up for measurement of transmit side lobe pattern

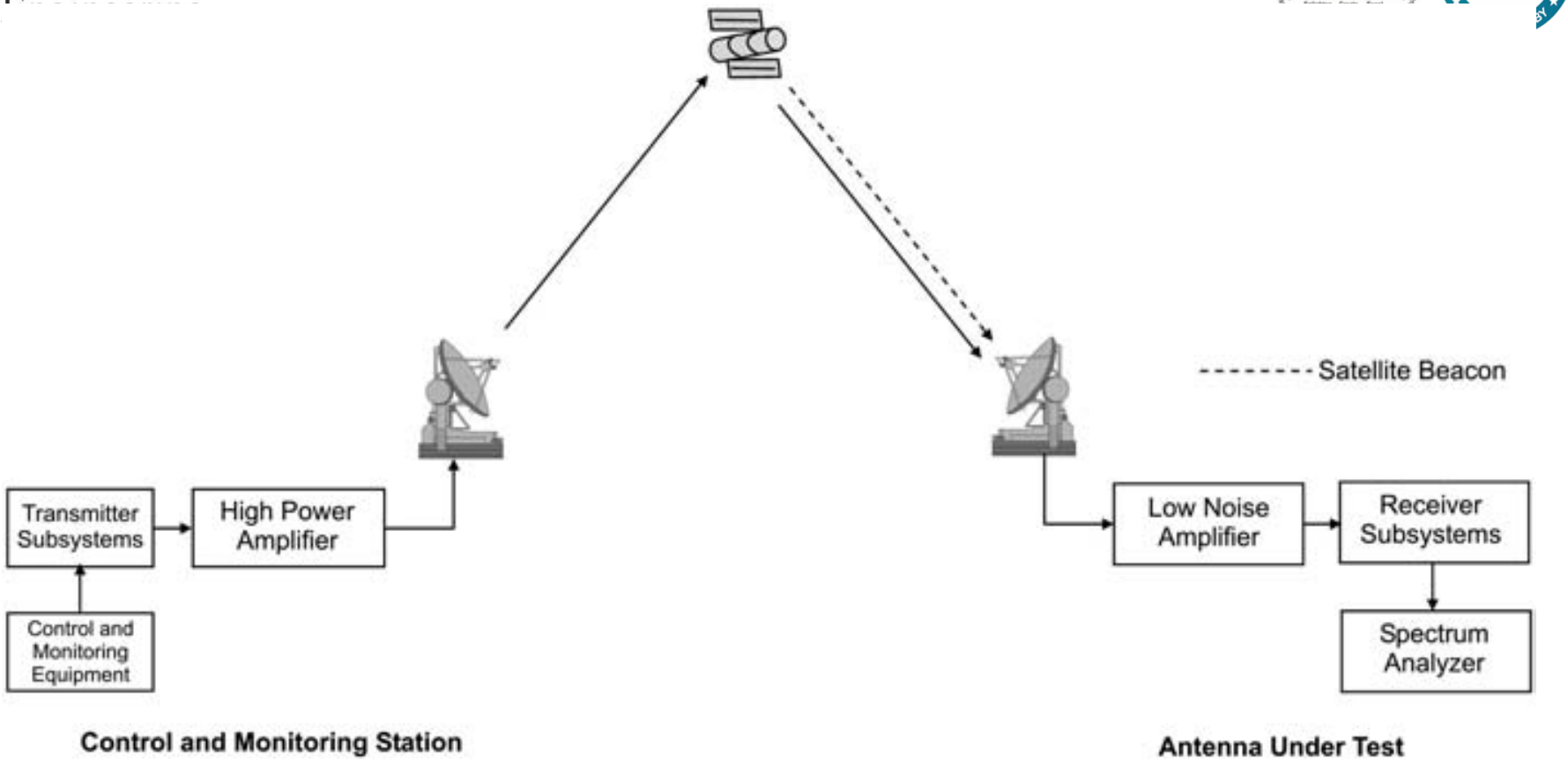


Figure Test set-up for receive side lobe pattern measurement

High Power Amplifier

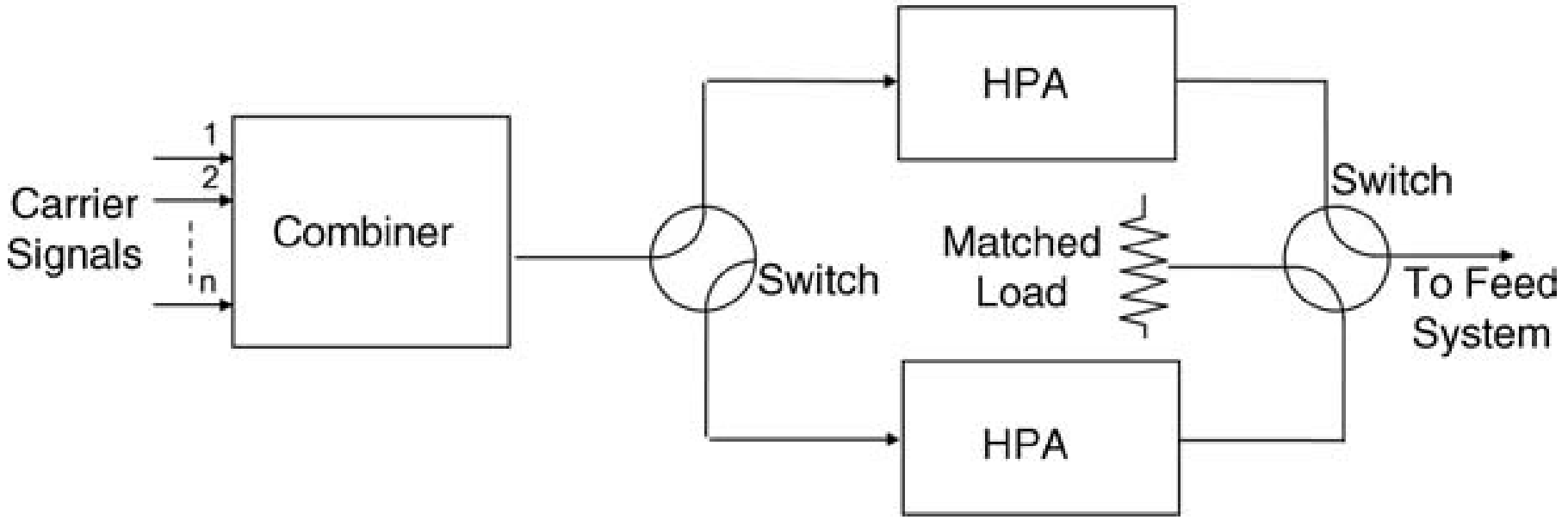


Figure Single amplifier HPA configuration

Up-converters/Down-converters

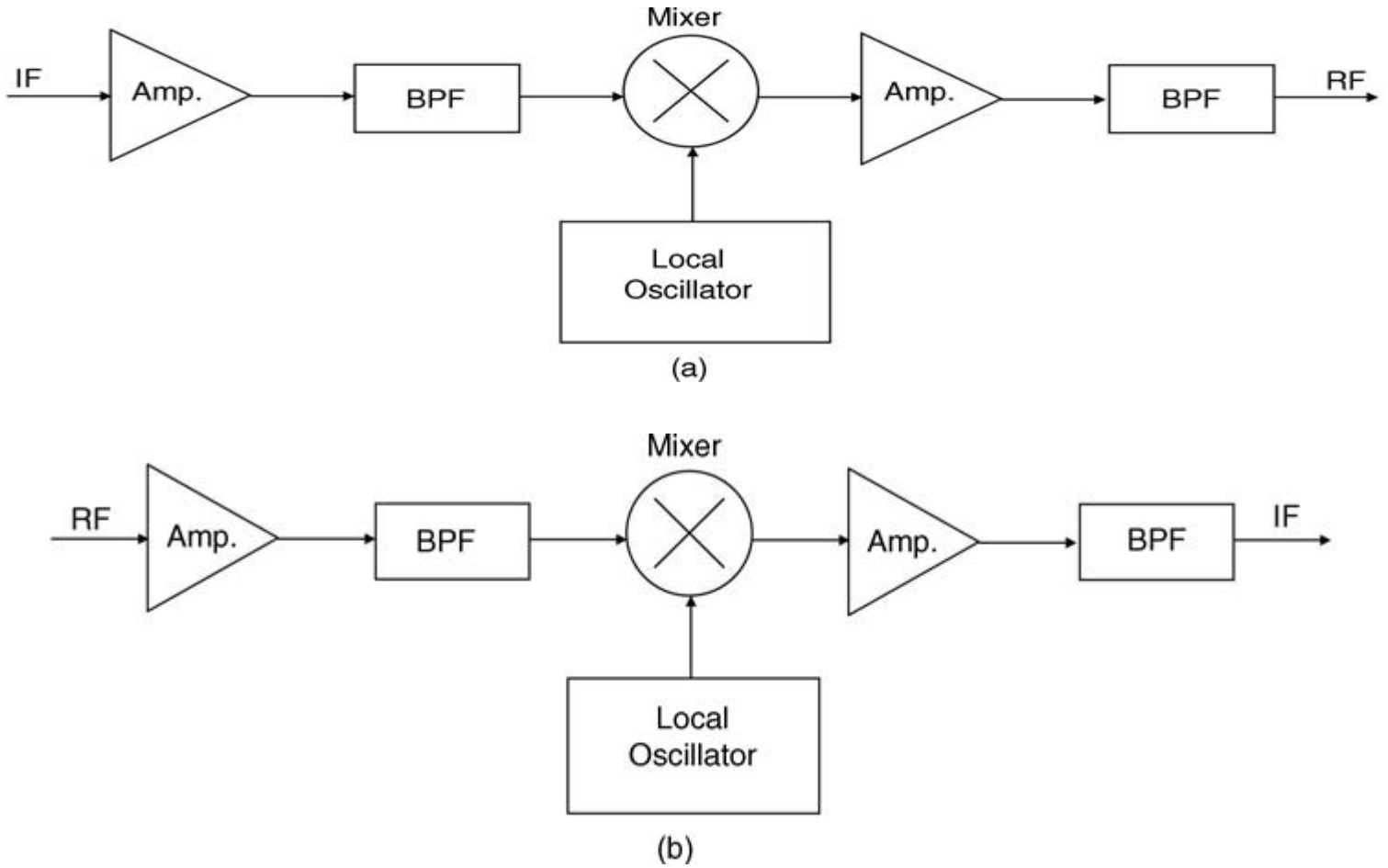


Figure Simplified block diagram of single frequency conversion frequency converters

(a) up converter (b) down-converter

Low Noise Amplifier (LNA)

- While the high power amplifier (HPA) is an important element of the up-link path that together with the transmit antenna gain decides the *EIRP of the Earth station; the low noise amplifier*
- (LNA) is one of the key components deciding the system noise temperature and hence the figure-of-merit *G/T of the Earth station. The design of LNA and the active devices around* which the design of a LNA is configured have undergone many changes since the advent of satellite communication.

IF and Baseband Equipment

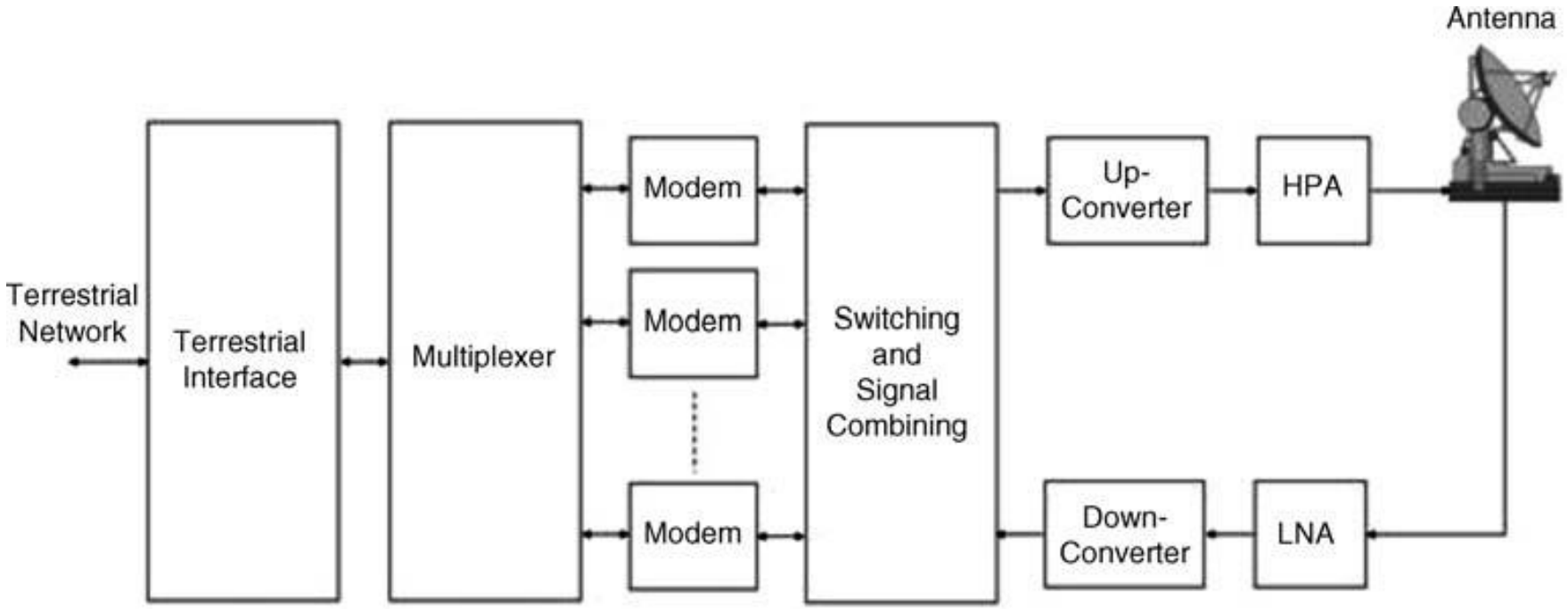


Figure Block schematic of a full duplex FDMA digital communication Earth station

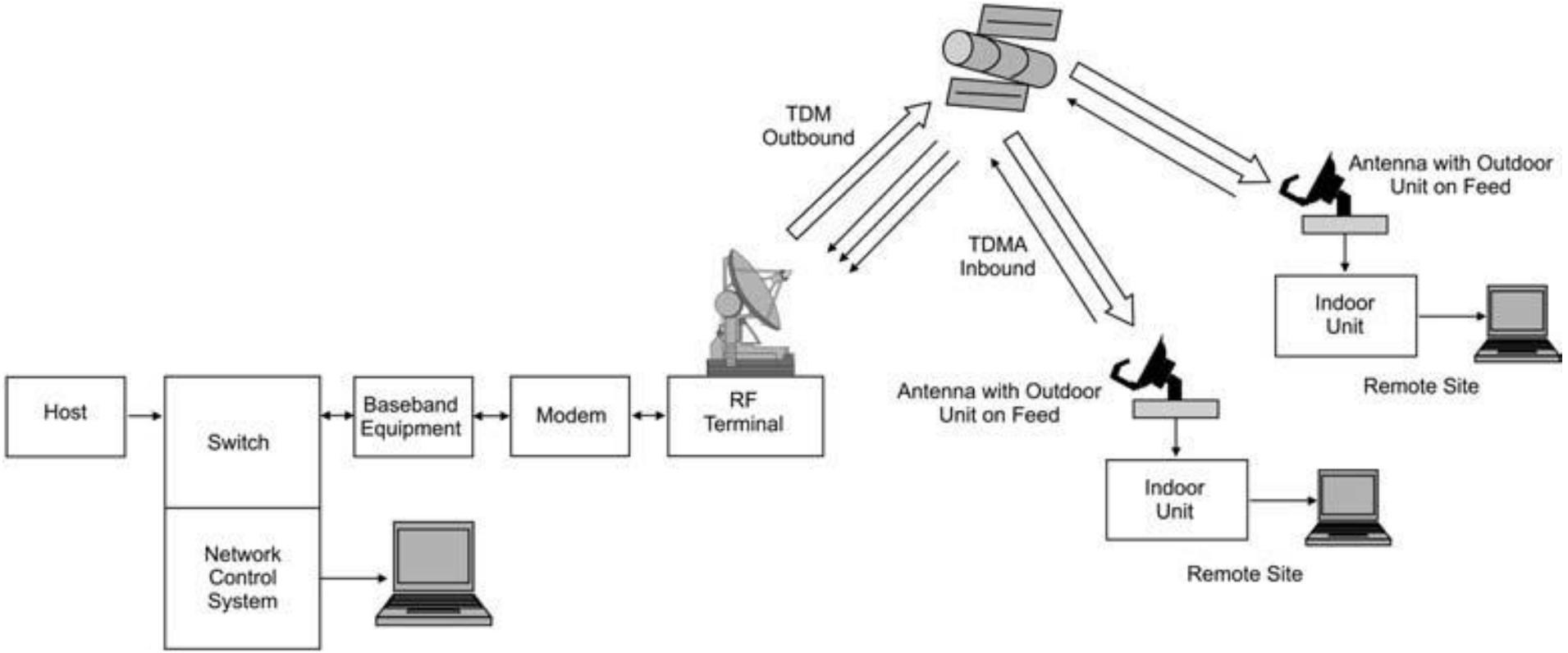


Figure Block schematic arrangement of a typical TDM/ TDMA interactive VSAT terminal

Terrestrial Tail Options

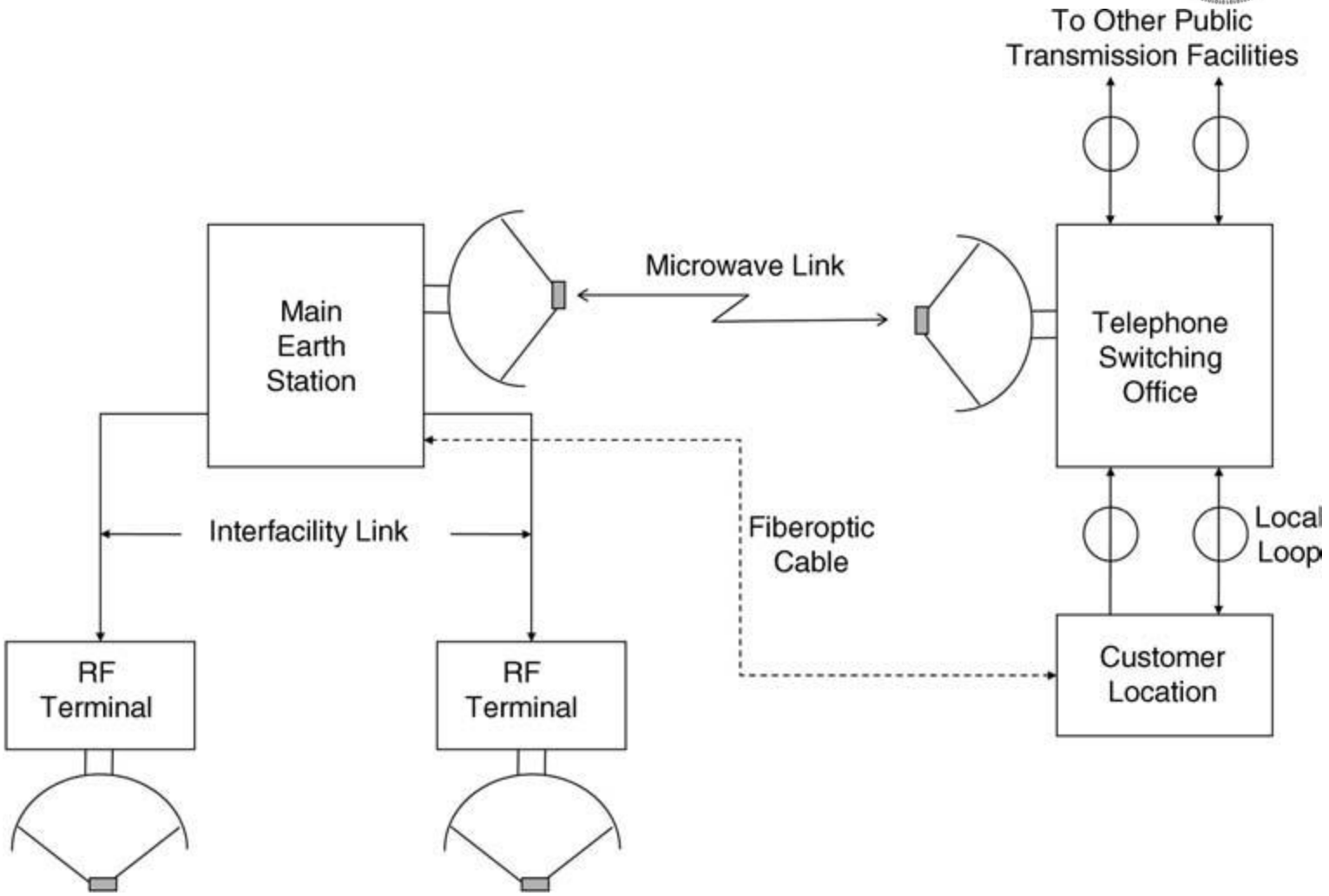


Figure Typical Earth station set-up with terrestrial tail links

Interface

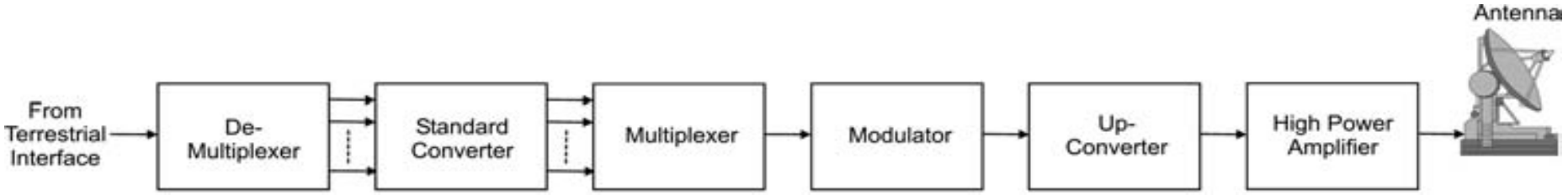


Figure Terrestrial interface – up-link

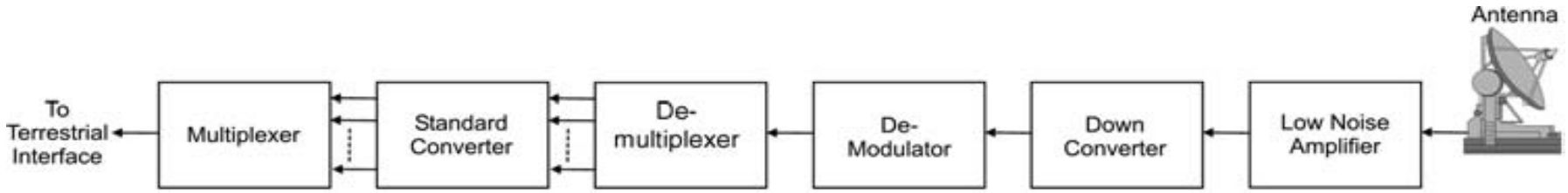


Figure Terrestrial interface – down-link

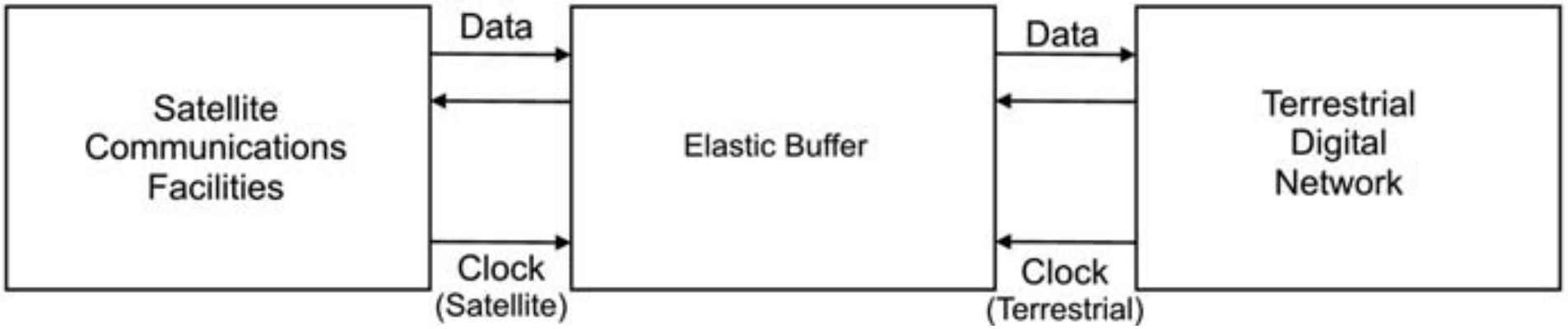


Figure Use of elastic buffer to absorb data rate variations

Satellite Tracking

- The Earth station antenna needs to track the satellite when the beam width of the antenna is only marginally wider than the satellite drift seen by it.
- The tasks performed by the Earth station's satellite tracking system include some or all of the following.

  1. Satellite acquisition
  2. Manual tracking
  3. Automatic tracking
  4. Programme tracking

Tracking Techniques

Tracking techniques are classified on the basis of the methodology used to generate angular errors. Commonly used tracking techniques include the following.

1. Lobe switching
2. Sequential lobing
3. Conical scan
4. Monopulse track
5. Step track
6. Intelligent tracking

THANK YOU