Satellite Subsystems

Learning Outcomes: To Explain the importance and working of the Telemetry, Tracking and control subsystem of the satellite

Thermal Control

- Satellites are subject to large thermal gradients, receiving the sun's radiation on one side while the other side faces into space.
- In addition, thermal radiation from the earth and the earth's albedo, which is the fraction of the radiation falling on earth which is reflected, can be significant for low-altitude earth-orbiting satellites, although it is negligible for geostationary satellites. Equipment in the satellite also generates heat which has to be removed. The most important consideration is that the satellite's equipment should operate as nearly as possible in a stable temperature environment.
- Various steps are taken to achieve this. Thermal blankets and shields may be used to provide insulation. Radiation mirrors are often used to remove heat from the communications payload.
- These mirrored drums surround the communications equipment shelves in each case and provide good radiation paths for the generated heat to escape into the surrounding space. subsystem of the satellite

Thermal Control (contd…)

- One advantage of spinning satellites compared with body-stabilized is that the spinning body provides an averaging of the temperature extremes experienced from solar flux and the cold background of deep space.
- In order to maintain constant temperature conditions, heaters may be switched on (usually on command from ground) to make up for the heat reduction which occurs when transponders are switched off.

TT&C Subsystem

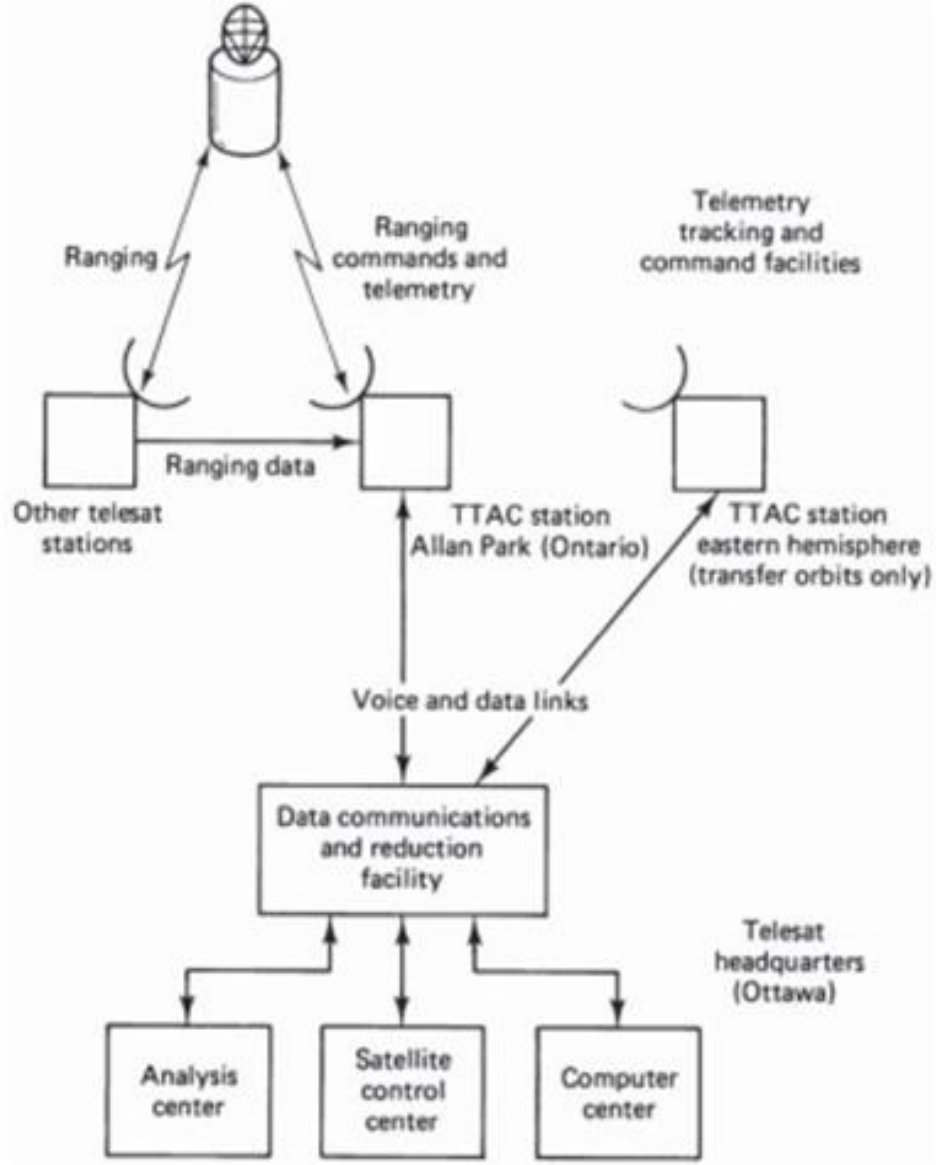
- The TT&C subsystem performs several routine functions aboard the spacecraft. The telemetry, or telemetering, function could be interpreted as measurement at a distance.
- Specifically, it refers to the overall operation of generating an electrical signal proportional to the quantity being measured and encoding and transmitting this to a distant station, which for the satellite is one of the earth stations.
- Data which are transmitted as telemetry signals include attitude information such as that obtained from sun and earth sensors; environmental information such as the magnetic field intensity and direction, the frequency of meteorite impact, and so on; and spacecraft information such as temperatures, power supply voltages, and stored-fuel pressure. Certain frequencies have been designated by international agreement for satellite telemetry transmissions.
- During the transfer and drift orbital phases of the satellite launch, a special channel is used along with an omnidirectional antenna. Once the satellite is on station, one of the normal communications transponders may be used along with its directional antenna, unless some emergency arises which makes it necessary to switch back to the special channel used during the transfer orbit.

TT&C Subsystem

- Telemetry and command may be thought of as complementary functions. The telemetry subsystem transmits information about the satellite to the earth station, while the command subsystem receives command signals from the earth station, often in response to telemetered information.
- The command subsystem demodulates and, if necessary, decodes the command signals and routes these to the appropriate equipment needed to execute the necessary action.
- Thus attitude changes may be made, communication transponders switched in and out of circuits, antennas redirected, and station-keeping maneuvers carried out on command.
- It is clearly important to prevent unauthorized commands from being received and decoded, and for this reason, the command signals are often encrypted.

TT&C Subsystem

- Tracking of the satellite is accomplished by having the satellite transmit beacon signals which are received at the TT&C earth stations.
- Tracking is obviously important during the transfer and drift orbital phases of the satellite launch. Once it is on station, the position of a geostationary satellite will tend to be shifted as a result of the various disturbing forces, as described previously.
- Therefore, it is necessary to be able to track the satellite's movement and send correction signals as required. Tracking beacons may be transmitted in the telemetry channel, or by pilot carriers at frequencies in one of the main communications channels, or by special tracking antennas.
- Satellite range from the ground station is also required from time to time. This can be determined by measurement of the propagation delay of signals especially transmitted for ranging purposes.


Ranging
Ranging commands and telemetry
Telemetry tracking and command facilities
Ranging data
Other telesat stations
TTAC station Allan Park (Ontario)
TTAC station eastern hemisphere (transfer orbits only)
Voice and data links
Data communications and reduction facility
Telesat headquarters (Ottawa)
Analysis center
Satellite control center
Computer center

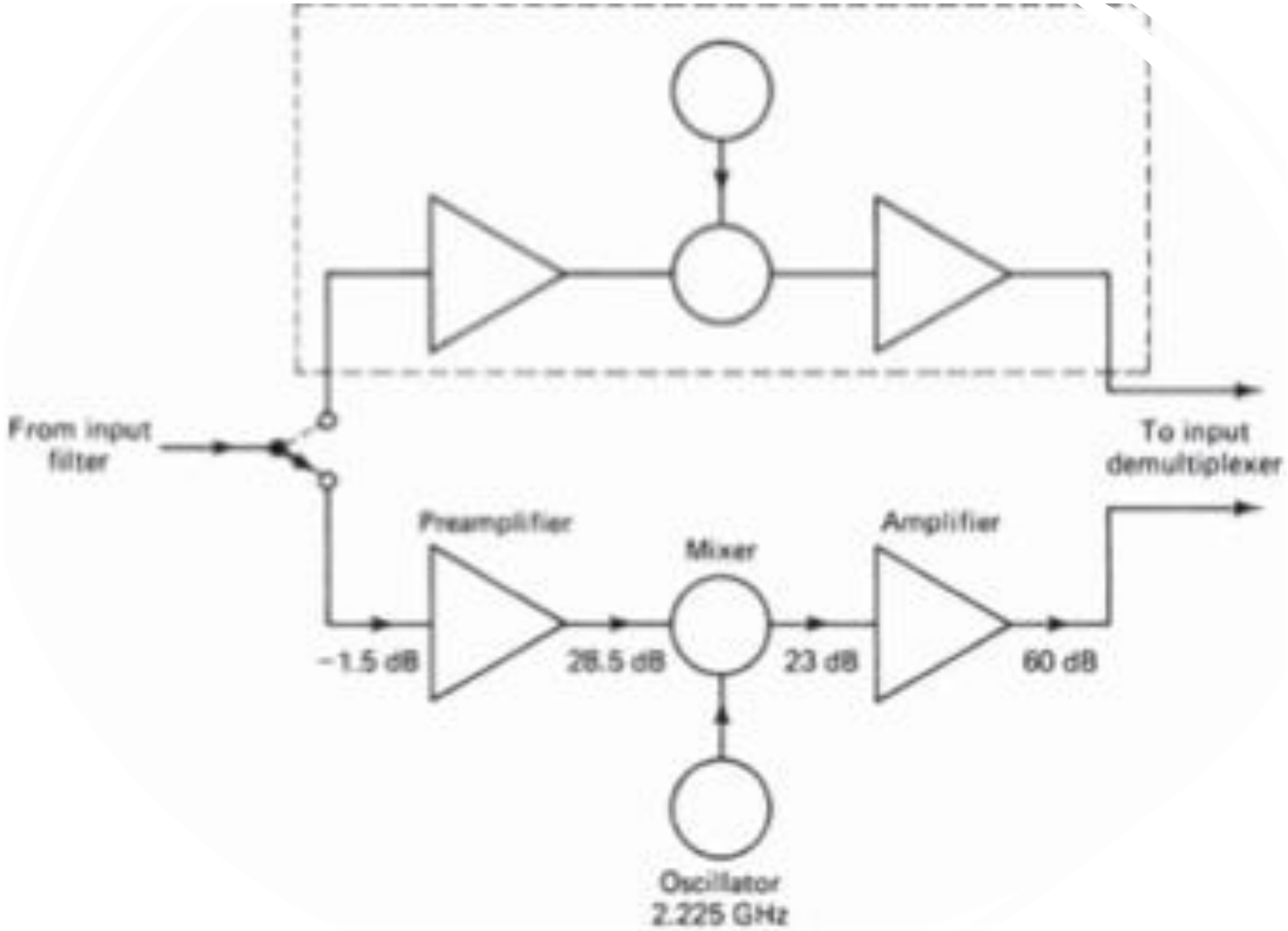
Communications Subsystem

Transponders

A transponder is the series of interconnected units which forms a single communications channel between the receive and transmit antennas in a communications satellite.

The wideband receiver

A duplicate receiver is provided so that if one fails, the other is automatically switched in. The combination is referred to as a redundant receiver, meaning that although two are provided, only one is in use at a given time.


From input filter
To input demultiplexer
Preamplifier
Mixer
Amplifier
-1.5 dB
28.5 dB
23 dB
60 dB
Oscillator
2.225 GHz

Wide band Receiver

- The first stage in the receiver is a low-noise amplifier (LNA). This amplifier adds little noise to the carrier being amplified, and at the same time it provides sufficient amplification for the carrier to override the higher noise level present in the following mixer stage.
- The LNA feeds into a mixer stage, which also requires a local oscillator (LO) signal for the frequency-conversion process. The oscillator frequency must be highly stable and have low-phase noise.
- A second amplifier follows the mixer stage to provide an overall receiver gain of about 60 dB.

The input demultiplexer

- The input demultiplexer separates the broadband input, covering the frequency range 3.7 to 4.2 GHz, into the transponder frequency channels.
- The output from the receiver is fed to a power splitter, which in turn feeds the two separate chains of circulators. The full broadband signal is transmitted along each chain, and the channelizing is achieved by means of channel filters connected to each circulator.

Thank You