HOME TV SYSTEMS

1.Spacecraft Technology- Structure:

A satellite communications system can be broadly divided into two segments— a ground segment and a space segment. The space segment will obviously include the satellites, but it also includes the ground facilities needed to keep thesatellites operational, these being referred to as the *tracking, telemetry, and command* (TT&C) facilities. In many networks it is common practice to employ a ground station solely for the purpose of TT&C.

Figure 2.1 (a) Satellite Structure

The equipment carried aboard the satellite also can be classified according to function. The *payload* refers to the equipment used to pro-vide the service forwhich the satellite has been launched.

In a communications satellite, the equipment which provides the con-necting link between the satellite's transmit and receive antennas is referred to as the *transponder*. The transponder forms one of the main sections of the

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payload, the other being the antenna subsystems.In this chapter the main characteristics of certain bus systems and payloads are described.

2   The Power Supply:

The primary electrical power for operating the electronic equipment is obtained from solar cells. Individual cells can generate only small amounts of power, and therefore, arrays of cells in series-parallel connection are required.

Figure shows the solar cell panels for the HS 376 satellite manufactured byHughes Space and Communications Company.

In geostationary orbit the telescoped panel is fully extended so that both are exposed to sun- light. At the beginning of life, the panels produce 940 W dc power, which may drop to 760 W at the end of 10 years.

During eclipse, power is provided by two nickel-cadmium (Ni-Cd) longlife batteries, which will deliver 830 W. At the end of life, battery recharge time isless than 16 h.
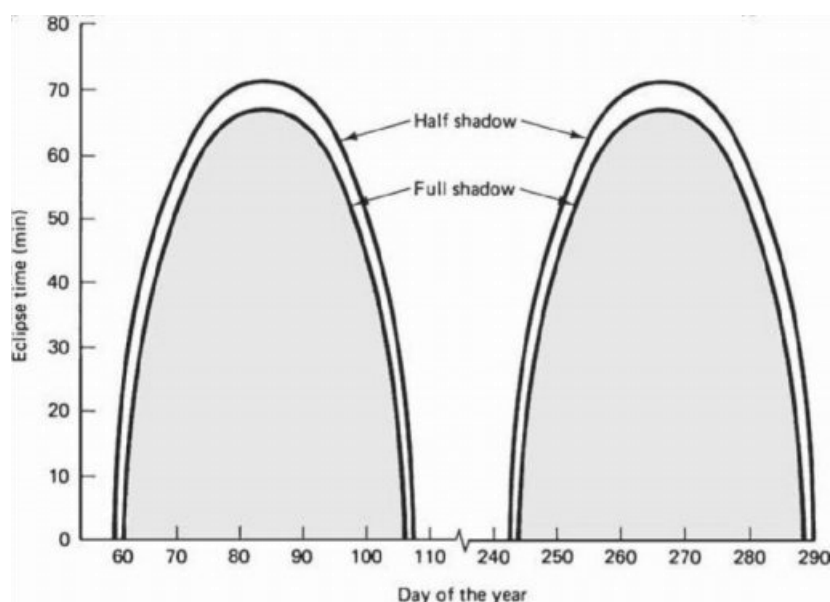

Figure 2.1.(b) Satellite eclipse time as a function of the current

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capacity of cylindrical and solar-sail satellites, the cross-over point is esti- mated to be about 2 kW, where the solar-sail type is more economical than thecylindrical type

3   Attitude Control & Orbit Control:

The *attitude* of a satellite refers to its orientation in space. Much of the equipment carried aboard a satellite is there for the purpose of control-ling itsattitude. Attitude control is necessary, for example, to ensure that directional antennas point in the proper directions.

In the case of earth environmental satellites, the earth-sensing instruments must cover the required regions of the earth, which also requires attitude control. A number of forces, referred to as *disturbance torques*, can alter the attitude, someexamples being the gravitational fields of the earth and the moon, solar radiation, and meteorite impacts. Attitude control must not be con- fused with station keeping, which is the termused for maintaining a satellite in its correct orbital position, although the two are closely related.
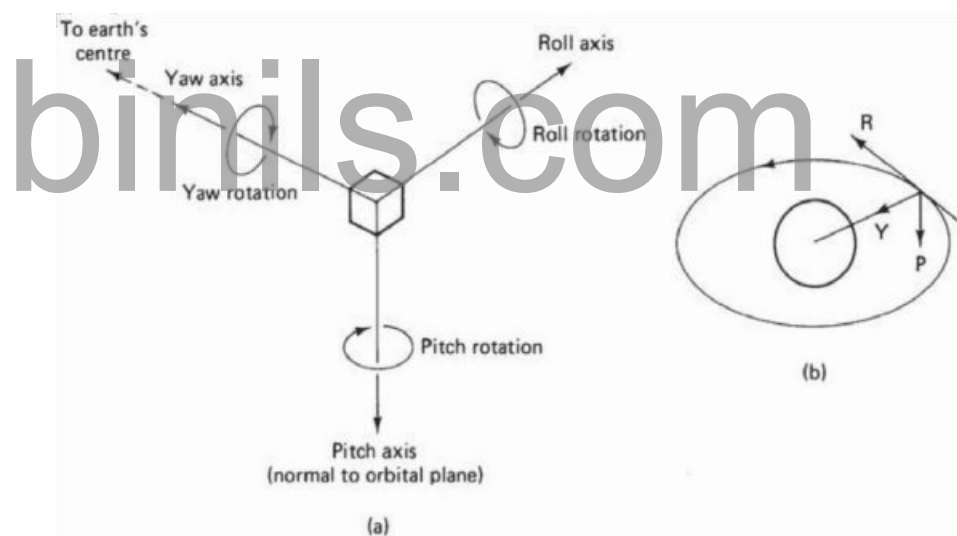
To exercise attitude control, there must be available some measure of a satellite's orientation in space and of any tendency for this to shift. method, infrared sensors, referred to as *horizon detectors*, are used to detect therim of the earth against the background of space.

With the use of four such sensors, one for each quadrant, the center of the earthcan be readily established as a reference point.

Usually, the attitude-control process takes place aboard the satellite, but it is also possible for control signals to be transmitted from earth, based on attitudedata obtained from the satellite.

Also, where a shift in attitude is desired, an *attitude maneuver* is executed. Thecontrol signals needed to achieve this maneuver may be transmitted from an earth station.

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Controlling torques may be generated in a number of ways. *Passive attitude control* refers to the use of mechanisms which stabilize the satellite without putting a drain on the satellite's energy supplies; at most, infrequent use is madeof these supplies, for example, when thruster jets are impulsed to provide corrective torque. Examples of passive attitude control are *spin stabilization* and*gravity gradient stabilization.*The other form of attitude control is *active control.* With active attitude control,there is no overall stabilizing torque present to resist the disturbance torques.Instead, corrective torques are applied as required in response to disturbance torques. Methods used to generate active control torques include momentum wheels, electromagnetic coils, and mass expulsion devices, such as gas jets andion thrusters.

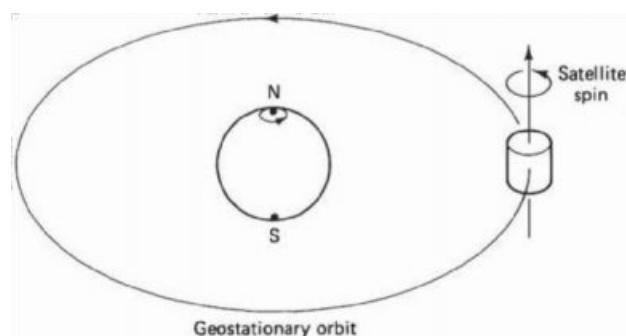center, the pitch axis is normal to the orbital plane, and the roll axis is perpendicular to the other two. (*b*) RPYaxes for the geostationary orbit. Here, the roll axis is tangential to the orbit and lies along the satellite velocity vector.The three axes which define a satellite's attitude are its *roll, pitch*, and *yaw* (RPY) axes. These are shown relative to the earth in Fig. 7.4. All three axes passthrough the center of gravity of the satellite. For an equatorial orbit, movement of the satellite about the roll axis moves the antenna footprint north and south;

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movement about the pitch axis moves the footprint east and west; andmovement about the yaw axis rotates the antenna footprint.

3.1 Spinning satellite stabilization:

Spin stabilization may be achieved with cylindrical satellites. The satellite is constructed so that it is mechanically balanced about one partic- ular axis and isthen set spinning around this axis. For geostationary satellites, the spin axis is adjusted to be parallel to the N-S axis of the earth, as illustrated in Fig. 7.5. Spinrate is typically in the range of 50 to 100 rev/min. Spin is initiated during the launch phase by means of small gas jets.

In the absence of disturbance torques, the spinning satellite would maintain itscorrect attitude relative to the earth. Disturbance torques are generated in a number of ways, both external and internal to the satellite. Solar radiation, gravitational gradients, and meteorite impacts are all examplesof external forces which can give rise to disturbance torques. Motorbearing friction and the movement of satellite elements such as the antennas also can give rise to disturbance torques. The

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overall effect is that the spin rate will decrease, and the direction of the angular spin axis will change. Impulse-type thrusters, or jets, can be used to increase thespin rate again and to shift the axis back to its cor- rect N-S orientation.

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Nutation, which is a form of wobbling, can occur as a result of the disturbance torques and/or from misalignment or unbalance of the control jets. This nutationmust be damped out by means of energy absorbers known as *nutation dampers*.The antenna feeds can therefore be connected directly to the transponders without the need for radiofrequency (rf) rotary joints, while the complete platform is despun. Of course, control signals and power must be transferred to the despun section, and a mechanical bearing must be provided.

The complete assembly for this is known as the *bearing and power transferassembly* .

Certain dual-spin spacecraft obtain spin stabilization from a spinning flywheelrather than by spinning the satellite itself. These flywheels are termed *momentum wheels*, and their average momentum is referred to as *momentum*

3.2 Momentum wheel stabilization

In the previous section the gyroscopic effect of a spinning satellite was shown toprovide stability for the satellite attitude.

Stability also can be achieved by utilizing the gyroscopic effect of a spinningflywheel, and this approach is used in satellites with cube-like bodies

(such as shown in Fig. and the INTELSAT V type satellites shown in Fig.These are known as *body-stabilized* satellites.

The complete unit, termed a momentum wheel, consists of a flywheel,the bearing assembly, the casing, and an electric drive motor with associatedelectronic con- trol circuitry.

The flywheel is attached to the rotor, which consists of a permanent magnetproviding the magnetic field for motor action. The stator of the motor is attached to the body of the satellite.

Thus the motor provides the coupling between the flywheel and the satellitestructure. Speed and torque control of the motor is exercised through the currents fed to the stator.
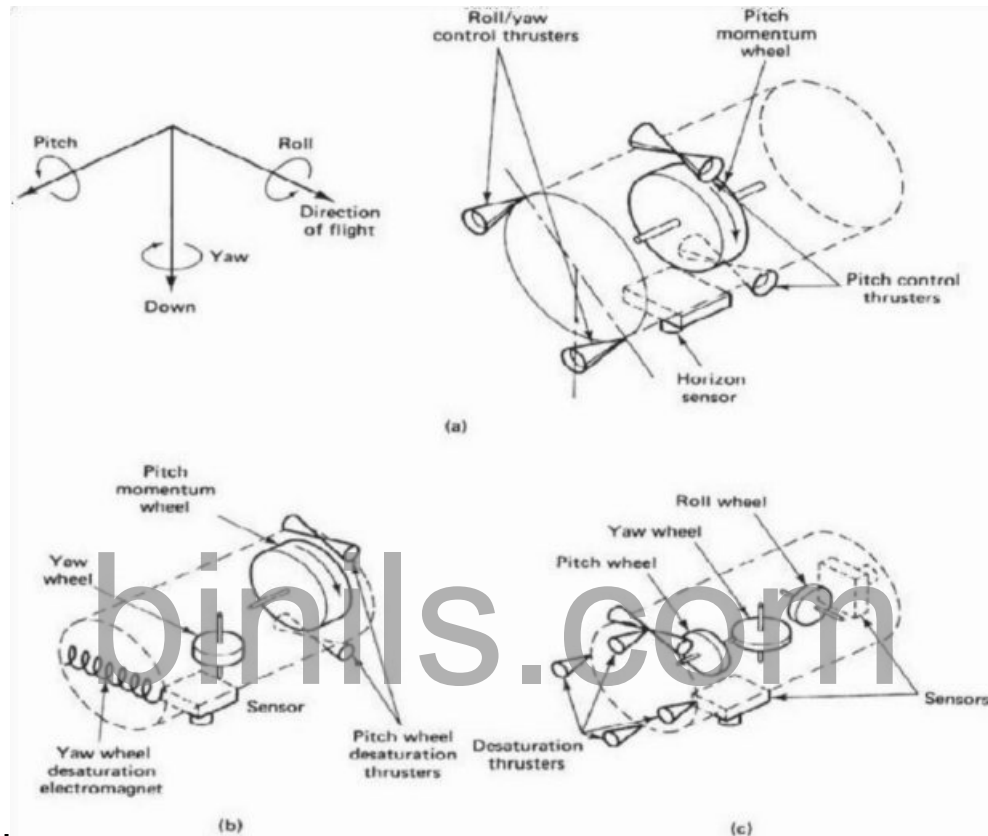
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Figure 2.5 Alternative momentum wheel stabilization systems: (*a*) one-wheel, (*b*) two- wheel, (*c*) three-wheel.

When a momentum wheel is operated with zero momentum bias, it is generally referred to as a *reaction wheel*. Reaction wheels are used in threeaxis stabilized systems. Here, as the name suggests, each axis is stabilized by a reaction wheel,as shown in Fig. 7.8*c*. Reaction wheels can also be combined with a momentumwheel to provide the control needed.Random and cyclic disturbance torques tends to produce zero momentum on average. However, there will always be some disturbance torques that causes a cumulative increase in wheel

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momentum, and eventually at some point the wheel *saturates*. In effect, it reaches its maximum allowable angular velocity and can no longer take in any more momentum. Mass expulsion devices are then used to unload the wheel, that is, remove momentum from it (in the same way a brake removes energy from a moving vehicle). Of course, operation of the mass expulsion devices

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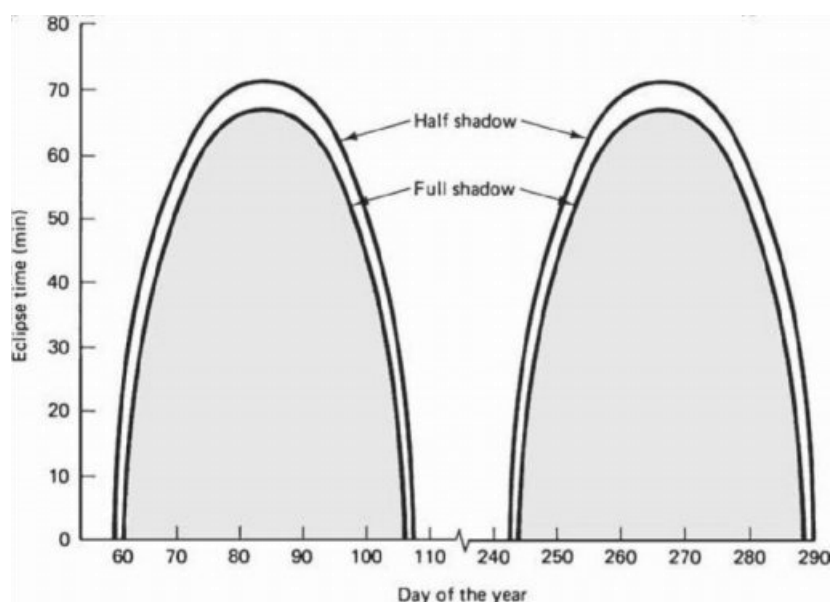

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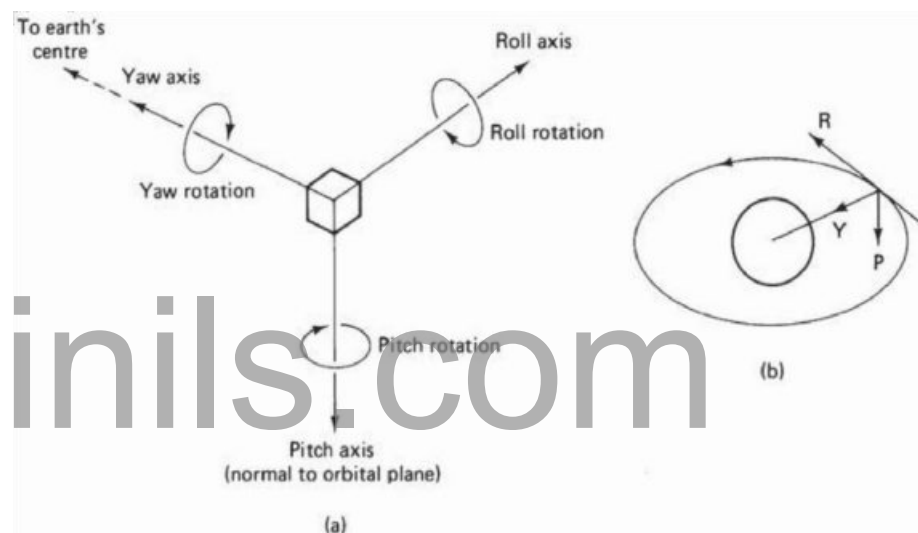
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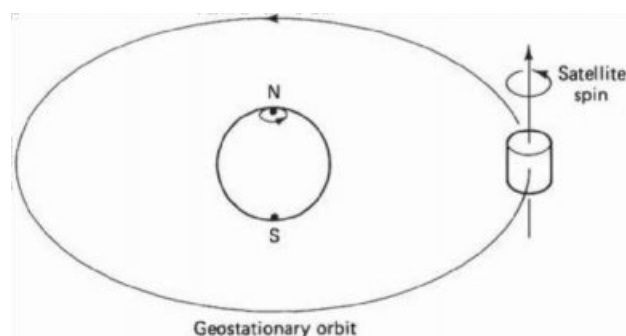

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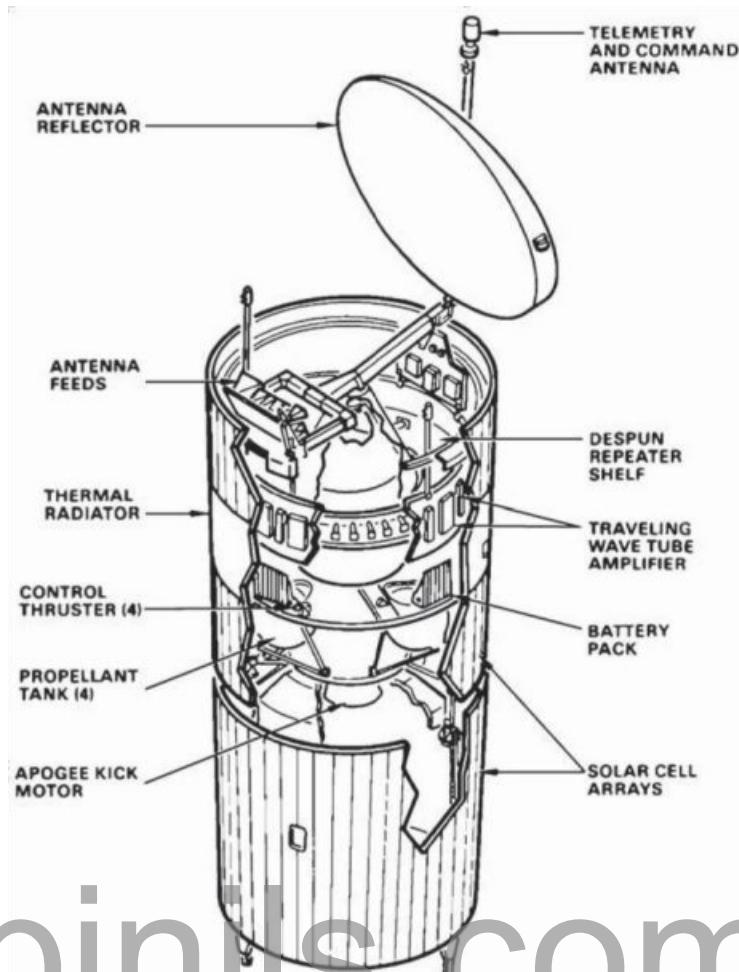
Figure 2.4 HS 376 spacecraft. (*Courtesy of Hughes Aircraft*

Company Space and

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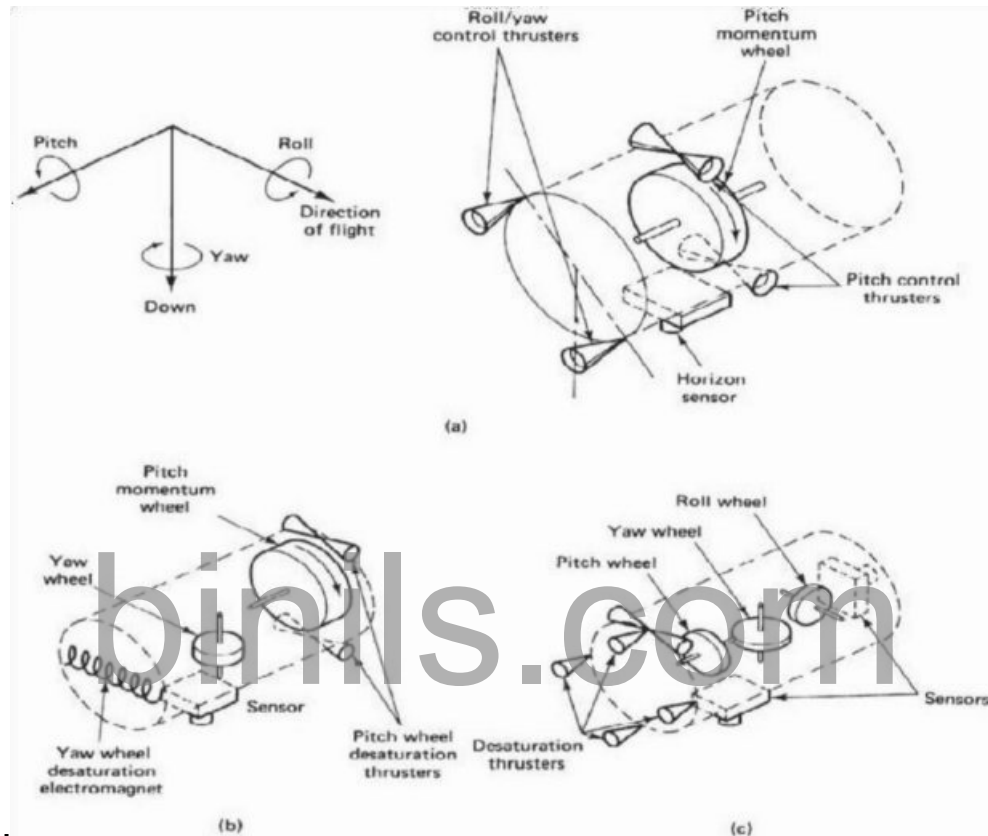
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