The University of New Mexico

School of Engineering

Electrical and Computer Engineering Department

ECE 535 Satellite Communications

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Module # 7: 7.1, 7.2, 7.6, 7.7, 7.8, 7.12, 7.13

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7.1 Describe the TT&C facilities of a satellite communications system. Are these facilities part of the space segment or part of the ground segment of the system?

Tracking, telemetry, and command (TT&C) facilities are designated to keep satellites operational. The facilities are part of the ground segment. They can also provide radio interfaces to satellites, as well as payload data transmission and reception.

7.2 Explain why some satellites employ cylindrical solar arrays, whereas others employ solar-sail arrays for the production of primary power. State the typical power output to be expected from each type. Why is it necessary for satellites to carry batteries in addition to solar-cell arrays?

Satellites that employ cylindrical solar arrays for many reasons. As a reference, the HS 376 satellites produced 940W of power. Cylindrical solar arrays can be more compact and lighter weight than solar-sail arrays. They do not require a deployment mechanism the same way as solar-sail arrays.

Solar-sail arrays can generate higher power. The HS 601 can be designed to provide dc power from 2-6kW. The panels can be extended outward and oriented towards the sun to maximize power.

Batteries are included in addition to solar-cell arrays due to the earth's eclipse of geostationary satellites twice a year. These occur 23 days before the spring and autumnal equinoxes and end 23 days after. Ni-Cd batteries are commonly used.

7.6 Briefly describe the three-axis method of satellite stabilization.

The three-axis method uses pitch, yaw, and roll with momentum and reaction wheels. Each wheel is used to stabilize the satellite. This is achieved by using the torque and angular momentum of the wheels. Using the wheels will also use the satellite’s fuel supply.

7.7 Describe the east-west and north-south station-keeping maneuvers required in satellite station keeping. What are the angular tolerances in station keeping that must be achieved?

Orbital corrections are carried out by the TT&C earth station. The geostationary satellite will drift slowly along its orbit, between 75°E and 105°W. Oppositely directed velocity components are used, typically jets, pulsed once every 2 or 3 weeks. These are east-west station-keep maneuvers.

Geostationary satellites will also drift in latitude due to perturbing forces of celestial bodies. The inclination can change around 0.85° per year, causing the inclination to steadily increase from 0° to 14.67° in 26.6 years, cyclically. Counteracting jet maneuvers are used with this north-south corrections as well but take much more fuel than east-west corrections.

7.8 Referring to Fig. 7.10 and the accompanying text in Sec. 7.4, determine the minimum -3-dB beamwidth that will accommodate the tolerances in satellite position without the need for tracking.

Section 7.4 has the following variables:

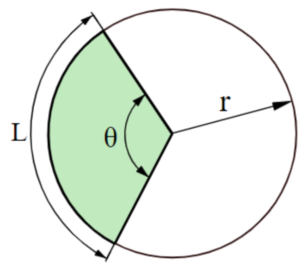
$f = 6GHz; Slant\ Range(r) = 38{,}000km; Antenna\ Diameter(D): 5 - 30\ meters$

$Box\ Bound\ by: 147km$

Half Power Beamwidth:

$$\theta_{-3dB} \cong 70\frac{\lambda}{D}$$

We can also calculate the arc length of the beamwidth:

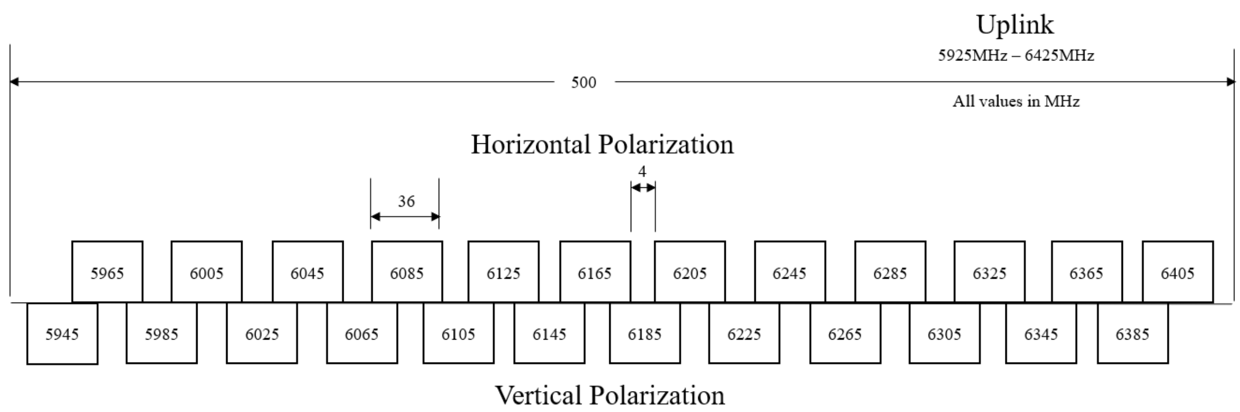


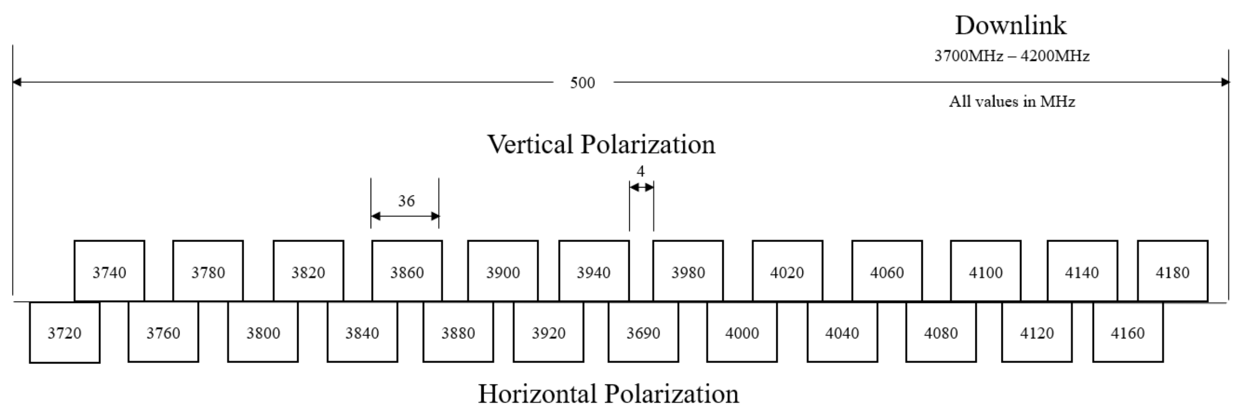
$L = \theta(radians) * r$

38000km Slant Range		
Diameter (r*2)	HPBW(deg)(r)	BW Diameter (km)(L)
30	0.12	77.32
29	0.12	79.99
28	0.12	82.85
27	0.13	85.91
26	0.13	89.22
25	0.14	92.79
24	0.15	96.65
23	0.15	100.86
22	0.16	105.44
21	0.17	110.46
20	0.17	115.98
19	0.18	122.09
18	0.19	128.87
17	0.21	136.45
16	0.22	144.98
15	0.23	154.65
14	0.25	165.69
13	0.27	178.44
12	0.29	193.31
11	0.32	210.88
10	0.35	231.97
9	0.39	257.74
8	0.44	289.96
7	0.50	331.38
6	0.58	386.61
5	0.70	463.94

The beamwidth of a 16 meter antenna would have the minimum -3dB beamwidth required at 0.22 degrees with a slant range of 38000km.

7.12 Draw to scale the uplink and downlink channeling schemes for a 500-MHz-bandwidth C-band satellite, accommodating the full complement of 36-MHz-bandwidth transponders. Assume the use of 4-MHz guardbands.





7.13 Explain what is meant by frequency reuse, and describe briefly two methods by which this can be achieved.

Frequency reuse is utilizing frequency due to polarizing isolation and overlapping frequencies. Polarization isolation refers to the fact that carriers, which may be on the same frequency but with opposite senses of polarization, can be isolated from one another by receiving antennas matched to the incoming polarization. With linear polarization, vertically and horizontally polarized carriers can be separated. Circular polarization utilizes the left- and right-handed polarization of the carrier.

Besides the polarization of the antenna elements, frequency reuse can also be achieved with spot-beam antennas. This method employs earth stations geographically separated but transmitting on the same frequency. Another term for this is space-division multiple access (SDMA).