j0349987[1]EE418: Satellite Communications

**Practice Problem: Satellite Sub-Systems**

**Dr. Ali Hussein Muqaibel**

**1.** The telemetry system of a geostationary communications satellite samples 100 sensors on the spacecraft in sequence. Each sample is transmitted to earth as an eight-bit word in a TDM frame. An additional 200 bits are added to the frame for synchronization and status information. The data are then transmitted at a rate of 1 kilobit per second using BPSK modulation of a low-power carrier.

**a.** How long does it take to send a complete set of samples to earth from the satellite?

**b.** Including the propagation delay, what is the longest time the earth station operator must wait between a change in a parameter occurring at the spacecraft and the new value of that parameter being received via the telemetry link? (Assume a path length of 40,000 km.)

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**2.** A spinner satellite has solar cells wrapped round a cylindrical drum 3.00 m in diameter, with a height of 5.0 m on station. The drum is rotated at 60 rpm to spin-stabilize the satellite. At the end of life, the solar cells are required to deliver 4.0 kW of electrical power.

**a.** Calculate the efficiency of the solar cells at end of life. Assume an incident solar power of 1.39 kW/m2, and that the effective solar radiation absorbing area of the solar cells is equal to the cross sectional area of the drum.

**b.** If the solar cells degrade by 15 percent over the lifetime of the satellite, so that the end-of- life output power is 85% of the beginning-of- life output power, what is the output of the solar cells immediately after launch?

**c.** If the drum covered in solar cells of the spinner design had been replaced by solar sails that rotated to face the sun at all times, what area of solar sails would have been needed? Assume that cells on solar sails generate only 90% percent of the power of cells on a spinner due to their higher operating temperature.

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**3.** Batteries make up a significant part of the in-orbit weight of a communications satellite but are needed to keep the communications system operating during eclipses. A direct broadcast

TV satellite requires 500 W of electrical power to operate the housekeeping functions of the satellite and 5 kW to operate its 16 high power transponders. The longest duration of an eclipse is 70 minutes, during which time the batteries must provide power to keep the satellite operating, but the batteries must not discharge below 70% of their capacity. The satellite bus operates at 48 volts.

**a.** What is the current that must be supplied by the power conditioning unit to keep the satellite operating normally?

**b.** Battery capacity is rated in ampere hours, the product of the current (in amps) that the battery can supply multiplied by the length of time that this current can be supplied before the battery is fully discharged. The satellite batteries must not discharge beyond 70% of their rated capacity during eclipse. Find the battery capacity required for this DBS-TV satellite.

**c.** If batteries weigh 1.25 kg per ampere-hour of capacity, how much weight on this satellite is devoted to batteries?

**d.** If half of the transponders are shut down during eclipse, what saving in battery weight is achieved?

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**4**. A geostationary satellite provides service to a region which can be covered by the beam of an antenna on the satellite with a beamwidth of 1.8o. The satellite carries transponders for Ku band and Ka band, with separate antennas for transmit and receive. For center frequencies of 14.0/11.5 GHz and 30.0/20.0 GHz, determine the diameters of the four antennas on the satellite.

**a.** Find the diameters of the two transmitting antennas. Specify the diameter and calculate the gain at each frequency.

**b.** Find the diameters of the two receiving antennas. Specify the diameter and calculate the gain at each frequency.

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