NORGES TEKNISK-
NATURVITENSKAPELIGE UNIVERSITET
Institutt for elektronikk og telekommunikasjon

Contact during the exam:
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EXAM IN COURSE
TTT4234 SPACE TECHNOLOGY I

Thursday December 17, 2009
Time: 0900 - 1300

English version

Permitted material: Calculator, of a make according to a list
approved by NTNU. Printed material: formula sheet attached to the exam.

All sub-problems have approximately equal weight (to some extent depending on the amount of work).
Answers should be short and concise

The results will be announced at the latest January 17th, 2010

Exercise 1: TV signals over a GEO satellite

We are going to send TV signals over a GEO-stationary satellite. The transfer rate of the TV signal is 30Msymb/s, and the modulation scheme is QPSK.
We have also been given the following figures for the uplink:

EIRP = 40dBW

Transmit frequency f = 14.4GHz

Atmospheric loss = 0.9dB

Rain fading = 2.0dB

Earth station transmitter to satellite distance d = 39000km

Satellite receiver antenna G_r/T = 20dB/K

Boltzmann constant = -228.6dBW/Hz/K

a) Calculate the signal to noise ratio S/N for the uplink in dB, departing from the linear expression:
$S/N = EIRP/L_o \cdot G_r/T \cdot 1/kB \cdot 1/L_a$

b) Explain what L_0 is, and what G_r/T represents.

c) The general formula for the antenna gain is $G=\eta \cdot 4\pi \cdot A/\lambda^2$
By taking components of the S/N expression into consideration, explain why the uplink frequency is always chosen higher than the downlink frequency. In this case the downlink frequency is at 11.2GHz.

d) Imagine that a part of the TV-channel is used for an interactive video play. The forward link (from the earth station to the player) is continuous transmission (streaming). We assume the player to be at the same distance from the satellite as the earth station delivering the uplink is from the satellite. What would be the worst case and the best case total delays experienced by the player (before the video play responds to his action), if we have the following time delays in the system in addition to the radio propagation delay:
   - The latency in the satellite transponder is 10 ms to filter, frequency transpose and amplify the signal (bent pipe)
   - The processing time at the earth station is 70 ms from reception of the command from the player to transmission of the video signal
   - The user has a satellite terminal in a TDMA (Time Division Multiple Access) return link system. He has been given a constant rate allocation with a slot every 400 ms.
   - His own terminal has a processing delay at the receiver of 15 ms, and 2 ms at the transmitter.

   So, calculate best case and worst case delays.

Do you have any comments to the results, or any suggestions on how to improve performance?

Exercise 2: Launch of a two stage space vehicle

You have got the task to design a launch of a two stage space vehicle. It should deliver a total ΔV, i.e. ΔV_{design}, of 10 000 m/s. The mass of the second stage structure and propellant is 12 000 kg. Of this the propellant mass is 9 000 kg. The weight of the payload is 1 800 kg.

I_{sp} (the specific impulse) of the first stage is 370s and of the second one 400 s. The structural mass of the first stage is 7 800 kg.

a) How big is the total mass of the vehicle at the launch?
b) How much propellant (kg) must be loaded in the first stage in order to reach ΔV_{design}?
c) What percentage of the total mass at launch is represented by the payload?

Exercise 3: IRIDIUM

The Iridium satellites are moving in orbits 780km above the earth surface. The system operator is obliged to remove dead satellites by lowering them into the atmosphere in order for them to burn up and evaporate.

This is done by reducing the speed of the satellite and transfer it into an elliptic orbit. If perigee is reduced to 10km height above the earth surface, the satellite will burn up rapidly.

Calculate the speed reduction necessary in order to reduce the satellite orbit to an orbit with a perigee height of 10km.

Exercise 4: Description

Choose one of the topics below.

a) Earth Observation

Give a description of different methods for earth observation. You may start with a general description of the challenges for earth observation. Then you may focus on the following factors:

- A description of the method
- The advantages and the limitations of the method
- If the system is active or passive
- Applications, examples are welcome

b) Space environment

Give a description of different factors characterizing the space environment, and the possible influence on space crafts and satellites, both for unmanned and manned space missions. Give some ideas about how negative effects can be reduced, where such possibilities exist.