# CHALMERS – Space, Earth and Environment

## RRY100 – Satellite Communications – 2023 – LAB-2

**Satellite communications exercise**

## 1 Introduction

The purpose of this lab exercise is to introduce you to practical measurements related to satellite communication, signal analysis, signal polarization and signal attenuation. The lab uses a ground station for reception of direct broadcast TV-signals that are transmitted by geo-stationary satellites at frequencies between 10.70–12.75 GHz. Figure 1 shows a sketch of the lab setup. There are two sets of receiving systems available that you can use in parallel.

**Expected learning outcome:**

- Empirical measurement of carrier-to-noise ratio (C/N) and bandwidth for several satellite transponders.
- Estimation of the number of multiplexed TV channels.
- Investigate C/N, BER and cross-polarization levels.
- Study different modulation constellations.
- Investigate the effect of rain on satellite communication.
- Report your results and main lessons learned in the combined ”lab report”.

## 2 The laborative exercise

1. Calculate a preliminary link-budget for a TV-satellite of the Astra satellite fleet at 19$^{o}$ longitude at the input of the spectrum analyzer. Use the parameters given in Table 1. What is the theoretical Carrier-to-Noise ratio C/N?
2. Do measurements of Carrier-to-Noise ratio observing the satellite. Use the low band (no # 22 kHz), vertical polarization (13 V) setup for the spectrum analyzer. Observe the spectra and determine the actual Carrier-to-Noise ratio C/N. Do the measurements with both spectrum analyzers.

   a) How do the theoretical and the observed C/N relate to each other?

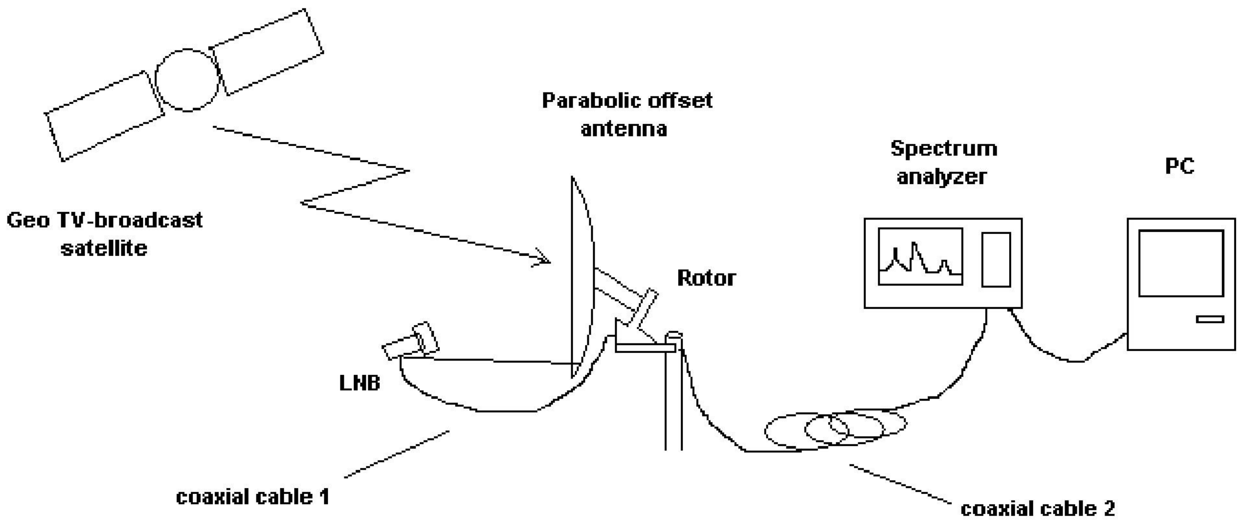


Figure 1: Sketch of a receiving system for direct broadcast TV-signals.

Table 1: Parameters for the link budget calculation.

| | |
|---|---|
| Longitude and latitude of Astra | $\lambda = 19.2^o$, $\beta = 0^o$ |
| Longitude and latitude of Onsala | $\lambda = 11^o$ 55', $\beta = 57^o$ 23' |
| Average orbital radius of a geostationary satellite | 42164 km |
| EIRP of the satellite | 51 dBW |
| TWTA output power of the satellite | 98 W |
| Loss of coaxial cable at 11.034 GHz | 4.3133 dB |
| Loss of coaxial cable at 11.977 GHz | 4.5002 dB |
| LNB noise figure | 0.3 dB |
| LNB gain | 55 dB |
| Transponder bandwidth | 33 MHz |
| Boltzmann's constant | $-228.6$ dBW/K/Hz |
| Loss of waveguide | 0.4576 dB |
| Loss in atmosphere | 0.2 dB |
| Antenna dimensions | radius $r = 0.78$ m |
| Antenna efficiency | 0.6 |
| Antenna noise pickup | 40 K |

Table 2: Carrier-to-Noise results.

| | | | | |
|---|---|---|---|---|
| Theoretical | C/N | = | | (dB) |
| Observed | C/N | = | | (dB) |

b) Check the modulation constellation and the BER of a digital channel. Do this by pressing the button number 2 on the spectrum analyzers.

c) Before April 2012 there were still analogue channels on European TV satellites. Can you imagine how they looked in the spectrum?

3. Determine the transponder bandwidth and number of multiplexed channels in a transponder.

   Also calculate the number of multiplexed TV-channels for the transponders given in Table 3. This can be done by dividing the Useful Bit Rate (UBR) of a transponder by the Needed Bit Rate (NBR) for one TV-channel (4 Mb/s). The Useful Bit Rate (USB) can be calculated from the Symbol Rate (SR), the Reed-Solomon coding (RS) and the Forward Error Coding (FEC):

$$\mathrm{UBR} = \mathrm{SR} \cdot 2 \cdot \mathrm{RS} \cdot \mathrm{FEC} \tag{1}$$

Table 3: Results of the transponder bandwidth measurements and the number of multiplexed TV-channels.

| Frequency (GHz) | Channel type | Measured bandwidth (MHz) | SR –Symbol rate (kSymb/s) | RS –Reed-Solomon coding | FEC Viterbi-coding | Number of TV channels |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

4. Do measurements of Carrier-to-Noise ratio (C/N), Bit-Error-Rate (BER) and Cross-polarization (X-pol) for a number of different transponders. Use the option ”digital” on the spectrum analyzer to do the measurements. Also observe whether the modulation constellation is resolved or not. Use transponders that are vertical polarized (13 V) in the low frequency band (no # 22 kHz) on the spectrum analyzer.

Table 4: Measurement results.

| Frequency (GHz) | C/N (dB) | BER | X-pol (dB) | modulation constellation |
|---|---|---|---|---|
| | | | | |
| | | | | |
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| | | | | |

5. Optional: Since rain is an important factor that impacts the quality of satellite communication, you shall study this effect by simulating rain events. For this purpose you shall place a sponge in front of the LNB of one of the two TV satellite dishes and study the communication link under different conditions of the sponge. Chose a digital transponder of your choice, ideally one with high signal intensity, and observe it with both spectrum analyzers. Do measurements of C/N, BER, X-pol and observe the modulation constellation for different experiment setups, see Table 5. Note also the polarization of the signal that you observe.

Table 5: Measurement results for different rain simulations.

| Experiment Setup | reference antenna C/N (dB) | BER | X-pol (dB) | modulation constellation | test antenna C/N (dB) | BER | X-pol (dB) | modulation constellation |
|---|---|---|---|---|---|---|---|---|
| No sponge | | | | | | | | |
| Dry sponge | | | | | | | | |
| Wet sponge | | | | | | | | |

| |
|---|
| Observed frequency (GHz) = |
| Signal polarization = |

a) What conclusions can you draw from your measurements?

b) Would the results change for differently polarized signals?

# 3 Feed back

Comments and suggestions for improving this lab exercise are much appreciated and can be sent to: Rüdiger Haas (`rudiger.haas at chalmers.se`)