Technische Universität Braunschweig

Institut für Nachrichtentechnik

Fundamentals of Mobile Radio Communications

Exercise 7: Link Budget

M.Sc. Maik Weber

June 2, 2025

1 Thermal noise

1.1 Calculate the noise spectral density in Ws for a temperature of 17 °C.

1.2 Calculate the thermal noise power for a radio channel with bandwidth $B = 200\,\text{kHz}$.

2 Link budget in mobile radio systems

The non-ideal receiver of a mobile station uses an amplifier with a noise factor of $z = 3$ (or $F = 3$) and a gain $G_{\mathrm{dB}} = 10\,\mathrm{dB}$. A bandpass filter with a bandwidth of 200 kHz must also be considered between the receiving antenna (omnidirectional radiator) and the amplifier. The block diagram of the receiver can be found in fig. 1.

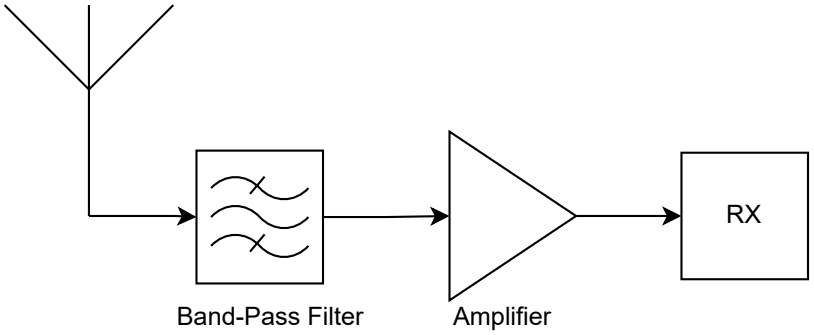

Figure 1: Receiver Block Diagram

2.1 How is the noise factor defined and what is the corresponding noise figure in dB?

The noise factor is defined as the ratio of the SNRs at the input and output of a system.

Noise factor F (in german often z):

$$F = \frac{SNR_i}{SNR_o}$$

Noise figure NF (in german often Z):

$$NF = 10 \cdot \log_{10} F = 10 \cdot \log_{10} \frac{SNR_i}{SNR_o} = SNR_{i,\mathrm{dB}} - SNR_{o,\mathrm{dB}}$$

In this example:

$$NF = 4.77\,\mathrm{dB}$$

2.2 Consider a receive power level at the mobile station of $P_{\mathrm{dBm}} = -110\,\mathrm{dBm}$ and calculate the signal-to-noise ratio (SNR) at the output of the bandpass filter.

2.3 Calculate the signal power level and SNR at the output of the amplifier.

2.4 The amplifier contributes to the total noise power at the receiving end. Calculate the additional noise power generated by the amplifier.

2.5 What is the total noise power at the output of the amplifier?

2.6 If an SNR of 8 dB is required at the receiver input to guarantee QoS for voice services, what is the minimum receive level at the mobile station?

2.7 The transmitter under consideration is a 3-sector site with an antenna gain of 18 dBi (antenna diagram: see exercise 4). The transmit power amplifier delivers a maximum power of 43 dBm. The cable loss from the amplifier to the antenna is 3 dB. What is the EIRP?

2.8 At the receiver end, add 3 dB antenna/human losses. Allow an additional margin of 6 dB. The carrier frequency is 1.8 GHz. What is the link budget in the DL case for the main radiation direction? Use the receive and transmit levels from tasks 2.6 and 2.7 in your calculation.

2.9 What is the link budget when the MS is at a horizontal (azimuth) angle of 20° or 90° to the main beam? (see fig. 2)

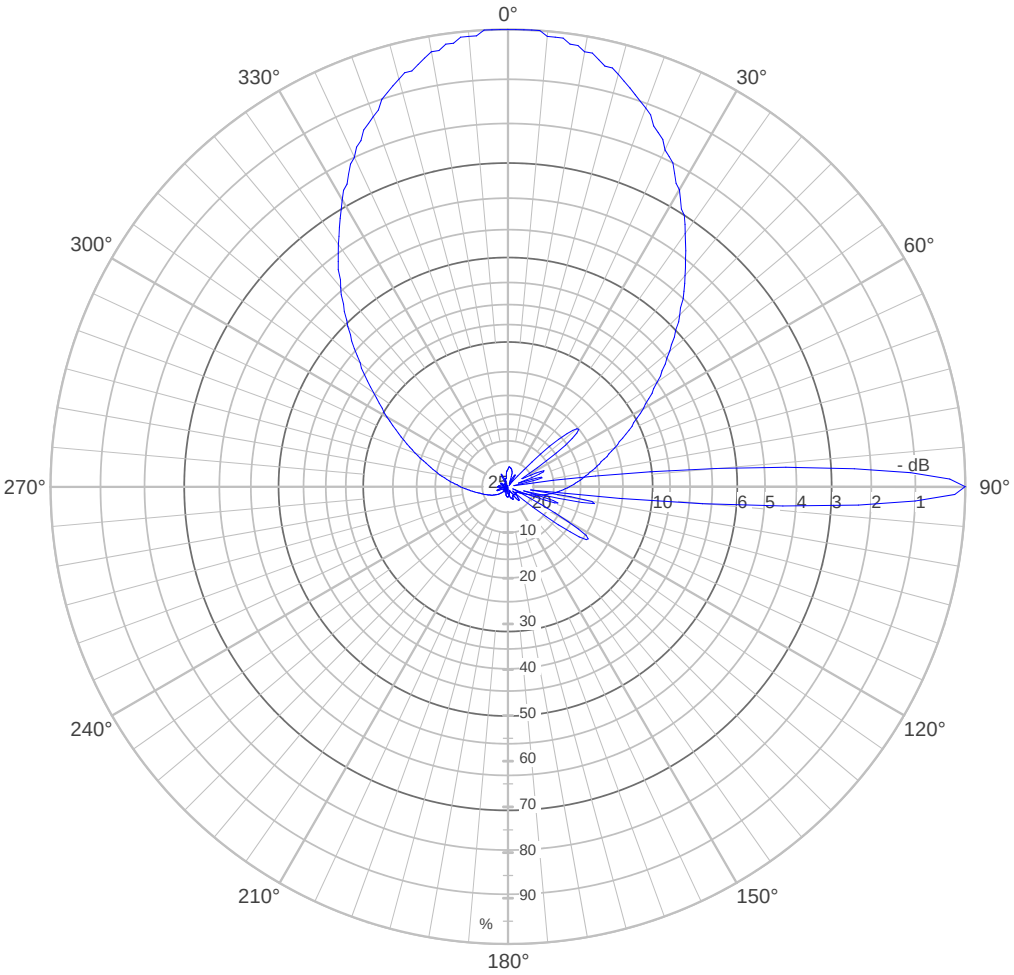

Figure 2: Radiation pattern of Kathrein 742 212 Multi-band antenna