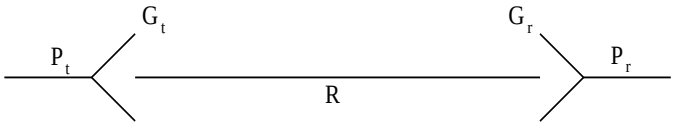
Karadeniz Technical University
Faculty of Engineering
Department of Electrical and Electronics Engineering
Antennas and Propagation Laboratory

A SIMPLE MICROWAVE RADIOLINK SYSTEM

In this experiment, a simple radiolink system with horn antennas will be set up, and its fundamental operating principle will be examined.

Preliminary Information :

A radiolink, in its simplest form, can be defined as the establishment of a connection between two points in space using electromagnetic waves. This connection is described by the Friis transmission equation.



Let's derive the Friis transmission equation for the simple radio link shown in the figure below. In this setup, P_t is the power at the input of the transmitting antenna, and P_r is the power at the terminals of the receiving antenna.
Given that G_t and G_r are the maximum gains of the transmitting and receiving antennas, respectively, the power density at a distance R from the transmitting antenna is calculated by the relation:

$$W_r = \frac{P_t G_t}{4\pi R^2} \quad (\mathrm{W/m^2}) \qquad (1)$$

The power at the receiving antenna terminals, where the effective aperture of the receiving antenna is Ae is:

$$P_r = W_r A_e \quad (\mathrm{W}) \qquad (2)$$

The effective aperture of the receiving antenna is calculated as:

$$A_e = \frac{\lambda^2}{4\pi} G_r \quad (\mathrm{m^2}) \qquad (3)$$

By substituting (1) and (3) into (2), the power at the receiver input is:

$$P_r = P_t G_t G_r \left(\frac{\lambda}{4\pi R}\right)^2 = \frac{P_t G_t G_r}{L_{FS}} \quad (\mathrm{W}) \qquad (4)$$

This equation is the Friis transmission equation. The denominator term on the right side of this equation, L_{FS}, is the free-space path loss, given by:

$$L_{FS} = \left(\frac{4\pi R}{\lambda}\right)^2 \qquad (5)$$

Equation (4) can also be expressed in terms of decibel (dB) values as:

$$P_r(dBm) = P_t(dBm) + G_t(dB) + G_r(dB) - L_{FS}(dB) \quad (6)$$

In this equation, L_{FS}, with R in meters (m) and f in gigahertz (GHz), is calculated as:

$$L_{FS}(dB) = 32{,}4 + 20 \log R + 20 \log f \quad (7)$$

Experimental Procedure:

1. General Procedures

1.1 Set up the experimental apparatus as shown in the figure. The microwave signal generator provides a 10.7 GHz signal that can be square-wave modulated.

1.2 Position the antennas directly facing each other at the same height.

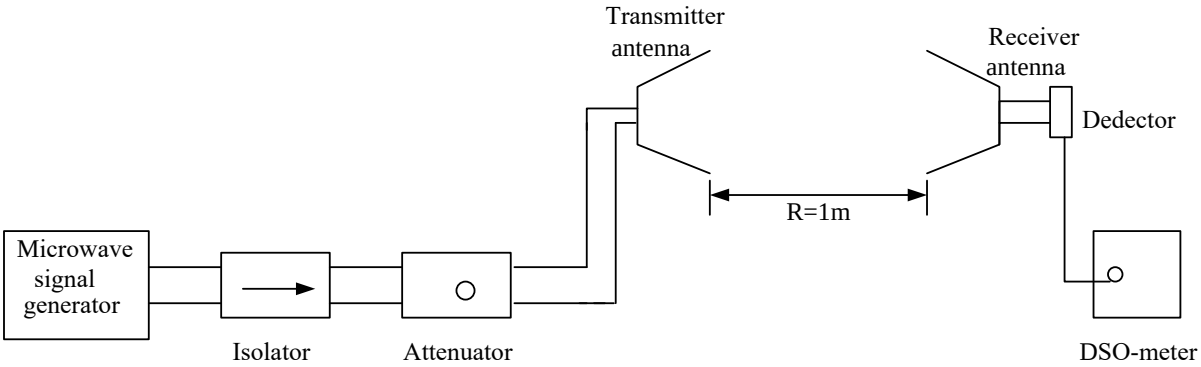


Figure: A simple radiolink system setup with horn antennas.

2. A Simple Radiolink System

2.1 In the setup shown, connect the output of the detector on the receiving antenna side to the oscilloscope.

2.2 Observe the modulation signal on the oscilloscope. Sketch the waveform and measure its frequency.

2.3 Move a metal plate vertically between the transmitting and receiving antennas and observe the effect on the signal on the oscilloscope.

2.4 Set the modulation switch on the microwave signal generator to the continuous wave (CW) position.

2.5 Adjust the distance between the antennas to 30 cm.

2.6 On the Spectrum Analyzer, which is connected to one of the ports of the 4-port magic-T on the receiving antenna side, set the Start frequency to 10.6 GHz and the Stop frequency to 10.8 GHz.

2.7 Read and record the power value displayed on the spectrum analyzer in dBm.

2.8 Double the distance between the antennas to 60 cm and record the new power value shown on the spectrum analyzer.

2.9 Compare and interpret the results using equation (7).

2.10 Move a metal plate vertically between the transmitting and receiving antennas, observe, and record the change in the power value displayed on the spectrum analyzer.

Questions/Tasks:

1. The gain of the standard horn antennas used in the experiment is approximately 16 dB at 10 GHz. If there are differences between your experimental results and your calculated values, what do you think could be the reasons? Explain.
2. Interpret the results you observed in step 2.10 and explain the underlying reasons.