Unmanned Aerial Systems Techology (RMUAST) Spring 2017
University of Southern Denmark

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Module 4: Fun with Frequency

1 Question 1 - Drone frequency range in DK/Europe

We have found the band plan for Denmark at http://www.dkscan.dk/bplan.htm and have listed the frequencies available for amateur radio:

- $28.0000 - 29.7000$ MHz
- $70.0000 - 70.5000$ MHz
- $144.000 - 146.000$ MHz
- $432.000 - 438.000$ MHz
- $902.000 - 928.000$ MHz
- $1240.000 - 1300.000$ MHz
- $2300.000 - 2450.00$ MHz

When using a higher frequency you get more attenuation on your signal, which requires that you need a lower range or use more power to transmit the signal. On the other hand you are able to transmit more data on the same amount of time, when using a higher frequency. For example it would be hard to transmit a video over the 433 MHz spectrum, but it works nicely when you for example use it to control a drone.

2 Max dist ELOS/BVLOS for 2m antenna & drone at 100m

Using the Pythagorean theorem for an altitude of 100m, we obtain a distance to horizon of 35.7km, corresponding to a radio horizon of 41.2km when corrected for atmospheric reflections under normal weather conditions.[1]

3 Max dist with Tx/Rx unlimited height

For max distance calculation with unlimited height of Drone it is possible to disregard blocking of signal by earth horizon. A model for transmitter/receiver range is called Friis transmission equation. A ratio of power available at the input of the receiving antenna, P_r, to output power to the transmitting antenna, P_t, is given by [2]:

$$\frac{P_r}{P_t} = G_t G_r \left(\frac{\lambda}{4\pi R}\right)^2 ,$$

where G_t and G_r are the antenna gains of the transmitting and receiving antennas respectively, λ is the wavelength, and R is the distance between the antennas.

[1] https://en.wikipedia.org/wiki/Line-of-sight_propagation
[2] https://en.wikipedia.org/wiki/Friis_transmission_equation

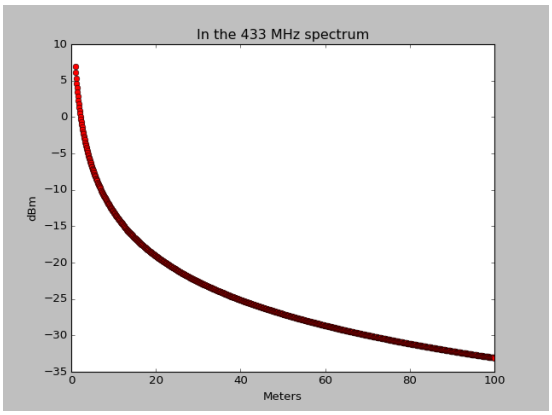
4 Power vs signal strength

Signal strength is referred to as the electric field strength at a given distance from the transmitter. Whereas the signal power is referred to as the strength of the electrical signal squared. This means that you do not get double the signal strength by doubling the power transmitting the signal.

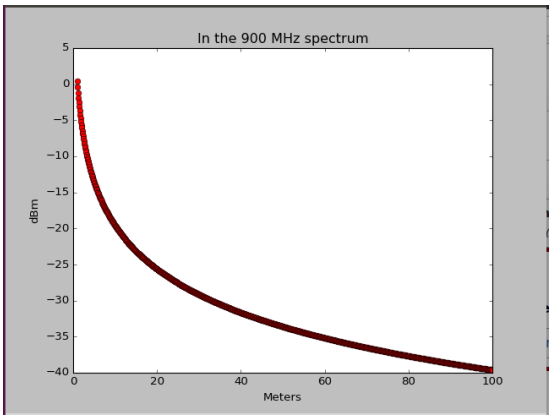
5 433MHz vs 900MHz

Going from 433MHz to 900MHz we introduce a decrease in signal range due to the increased attenuation at higher frequencies. We see from the Friis equation that for a change in frequency to (roughly) a half, we obtain a quarter of the Tx/Rx ratio.

This frequency change also introduces an increase in the maximum data rate in our transmission. At 900MHz, we can send roughly twice as much data when compared to 433MHz. This is significant if we want to send large volumes of data, e.g. video.



(a) 433MHz



(b) 900MHz

Figure 1: This is a plot showing the gain in dBm for the effect of the receiving end as we increase the distance between the transmitter and receiver. For these calculations we have used Friis transmission equation with 6 dBi gain for both antennas, 100 mW of transmitting power and then a frequency of 433 and 900 MHz