Problem 1 (5%)

You designed and measured a Patch antenna in the course which operated at 2,45 GHz in a 50 Ohm system. What should you do to tune your antenna if:

1.a (3%) The operation frequency of your antenna is too high, say at 2,6 GHz?

Solution: The antenna Patch is too small. The length is controlling the resonance frequency, so it need to be extended. The approx. length increase is actually as simple as $L_{new} = L_{old}\frac{2.6\ GHz}{2.45\ GHz}$

1.b (2%) The impedance was too high, say 70 Ohm?

Solution: The impedance is mainly controlled by the point where the feeding is connected to the Patch. For the present design we make cut to have the microstrip to feed at the intended point. The impedance is high at the edge and 0 at the center. There is a Cosine function of the impedance. So a too high impedance tell that the cuts do not extend enough towards the center of the Patch. So make the cuts a bit larger.

Problem 2 (20%)

Small satellites in an orbit close to the earth is under investigation for future 5G mobile systems as a new type of basestations. Which transmit power is required for such a system to work with similar phones as the ones we have today?

The phone in present systems can receive correctly with a signal which is minimum -110 dBm on the input of its receiver. The phone antenna has a realized gain of some -10dBi due to losses in both the antenna itself and the user at the frequency of interest, 2.3 GHz. The distance from the earth to the satellite in so called Low Earth orbit is 500 KM.

2.a (5%) If the area for the antenna on the satellite is 0,5 m^2 how large a theoretical gain can be obtained at the frequency of 2,3 GHz?

Solution: $A = G\frac{\lambda^2}{4\pi}$ and $\lambda = \frac{c}{f}$ having the frequency and area in m^2 the theoretical gain can be found to 369 or 25,7 dBi

2.b (10%) Find the minimum transmit power needed from the satellite if the gain of the antenna on the satellite is 20 dBi?

Solution: Use Friis transmissions equation. For the minimum power (best case link) the polarization, impedance matching and losses will be perfect. This reduces the Friis equation to $P_{RX} = P_{TX}\left(\frac{\lambda}{4\pi R}\right)^2 G_{TX}G_{RX}$, recalculate to SI units and natural numbers (not log / DB). $G_{TX} = 20dBi = 100$ $G_{RX} = -10dBi =$

$0,1$ and $P_{RX} = -110\ dBm = -140\ dBw = 10^{-14} Watt$ Indsert values gives 2,32 Watt

2.c (5%) What more to consider when it is two way communication to a satellite instead of a ground base station? Hint; two way communication and polarization.

Solution: To have two link communication both links need to be fulfilled according to Friis equation. This is to say that link balance must be considred. The gain of the antennas is the same for transmit as for receive if the same frequency is used. The transmit powers might be different from a small battery powered phone and a satellite. The receiver sensitivity might be better at the satellite as there is more space and power available than in a small phone. Further the polarization must match. In communication with a satellite circular polarization is often used and if an antenna is receiving Left Hand Polarization if will transmit Right Hand Polarization – so must be considered here.