ITRAINONLINE MMTK

Exercises with answers: Basic Radio Physics

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Exercise 1: Electromagnetic fields and waves

Question: What is the wavelength of a 900 MHz electromagnetic wave?
Answer: 33 cm, because wavelength = speed of light / frequency

Question: What is the wavelength of visible light, roughly?
Answer: Light is the visible portion of the electromagnetic spectrum, between the frequencies of 7.5×1014 Hz and 3.8×1014 Hz, corresponding to wavelengths from circa 400 nm (violet/blue) to 800 nm (red)

Question: What is the polarization of the electromagnetic field emitted by a dipole?
Answer: Linear and parallel to dipole direction – e.g. for a vertical standard dipole antenna, it is vertical.

Question: VSAT satellites often used for Internet connectivity are geostationary satellites at a eight of 35,785 km above the equator. What minimum delay (latency) does this imply for data travelling over VSAT?
Answer: It takes the radio signal circa 0.12 seconds for one trip from earth to satellites For a normal TCP/IP communication from point A to B, we have 4 times that travel – the packet goes from A to Satellite, from Satellite to B, and then B sends an ACK (acknowledgement). All in all: about 0.5 seconds, as minimum latency.

Question: A specific radio device has a timeout window of 10 microseconds – this means, it expects an answer from the other end within 10 microseconds. From how any kilometres of distance would this begin to affect the radio link?
Answer: 10 microseconds corresponds to 3 km, but since the answer to the packet has to be back in time, it is 2 x 1.5km. Practically, most radio cards do not keep their time windows that strictly, so you will still get packets through at longer distances. But, keep an eye on it – if you have lots of TCP/IP packet loss although your radio signal looks good, this might be the cause.

Exercise 2: Electromagnetic spectrum

Question: What are the relevant frequency ranges for wireless networking?
Answer: If we are interested in unlicensed or license exempt parts of the spectrum – then it is
around 915 MHz, 2.4 GHz (802.11b/g) and 5.8 GHz (802.11a). Keep in mind that regulations vary from country to country.

Question: Which of the following devices could potentially interfere with a wireless network?

a) Wireless microphone in a conference room
b) Microwave oven in a kitchen
c) Mobile phone
d) Rontgen (X-Ray) Lab in a hospital
e) Car or diesel engine

Answer:

a) Wireless microphone in a conference room: possible in principle, but most of this equipment uses frequencies much lower – from some 10 MHz up to circa 900 MHz - so it is not very likely to interfere, at least not with 802.11a/b/g.
b) Microwave oven in a kitchen – yes – if it is leaking radiation: a lot!
c) Mobile phone: unlikely – look up the frequencies of mobile phones in the spectrum overview in your handout!
d) Rontgen (X-Ray) lab in a hospital: Unlikely – again, check the frequencies.
e) Car or diesel engine: While this would not be very likely to interfere through radiation, an engine is a massive metal block – and that might have an impact.
(This was a good example of an answer from the participants which the trainer had not expected, but which was of course absolutely right! :)

Exercise 3: Radio wave propagation

Question: If you have to reach clients within a village with trees and various types of buildings, which frequency would be the best choice? Discuss!

a) 915 MHz
b) 2.4 GHz
c) 5.8 GHz

Answer: The lowest frequency would probably be best, because lower frequencies are better at reaching through obstructions and 'around corners'.

Question: How wide does the radio 'line' of sight become for a 100 km link – roughly? Some centimetres, some meters, some kilometres?
Answer: See the Fresnel zone values – it is about 60 meters.

Question: What materials and substances should you most look out for when planning a wireless link? In other words, what will cause most problems?
Answer: Metal and water (in all forms).

Exercise 4: Working with dBs

Question: Express these values in dBm / mW

Best strategy is to remember that
to double (x 2) means + 3 dB
one order of magnitude (x 10)+10 dB

let us use that:

1 mW = 0 dB

x 10 gives:
10 mW = 10 dB

x 2 gives:
20 mW = 13 dB

x 2 gives:
40 mW = 16 dB

starting again from
10 mW = 10 dB

x 10	gives:	
100 mW	=	20 dB

x 2	gives:	
200 mW	=	23 dB