ELEX 7860 : Wireless System Design
2019 Winter Term

Assignment 2

Due Monday, March 18, 2019. Submit your assignment using the appropriate Assignment folder on the course web site. Assignments submitted after the solutions are made available will be given a mark of zero. **Show how you obtained your answers.**

Question 1

(a) You are designing an OFDM system that must tolerate propagation path delay differences of up to 1800 m. What would be an appropriate minimum duration for the cyclic extension?

(b) What OFDM symbol duration would result in this cyclic extension duration being less than 10% of the OFDM symbol duration (not including the cyclic extension)?

(c) Assuming complex sampling and a channel bandwidth of 800 kHz, what is the smallest number of subcarriers that could be used that is also a power of 2?

(d) What is the resulting symbol duration in samples and microseconds?

(e) How many samples will be used for the cyclic extension (round up)?

Question 2

(a) What is the PAPR of the envelope of a QPSK signal? Note that for an (unfiltered) QPSK signal this is a complex value with values $\pm 1 \pm j$, not a sine wave. Explain your reasoning, don't just quote a result.

(b) What is the maximum possible (peak) magnitude squared (normalized power) of a complex OFDM baseband signal composed of the sum of N sinusoids each with amplitude 1 and uniformly-distributed random phase? What is average (expected value)? You may assume that N is large. As above, explain your reasoning.

(c) Write a Matlab (or Octave) simulation to verify your previous result. Explain why your results do or do not match your predictions.

(d) Assuming large N, what is the p.d.f. of the *power* of the signal? What fraction of the time is the power of the OFDM signal more than 9 dB above the average? *Hint: Matlab, Octave and Wolfram Alpha have functions to compute this value.*

Question 3

To avoid interference between OFDM subcarriers they must be at frequencies that are multiples of the symbol duration. If a receiver does not estimate the carrier frequency accurately, the down-converted subcarriers will be shifted in frequency. This will result in the subcarriers being non-orthogonal and in interference between them.

Assume two subcarriers at frequencies $f_0 = \frac{n}{T} + \delta$ and $f_1 = \frac{n+1}{T} + \delta$ where T is the symbol duration and δ is a frequency offset.

(a) Find the integral of the product of these two subcarriers over the interval 0 to T.

(b) Plot the absolute value of this integral as a function of δ over a range of 0 to $\frac{1}{T}$.

Question 4

Given the following parameters for a wireless communication system, what transmit antenna gain, x, is required?

quantity	value	units
transmit power	3	W
transmission line loss	3.5	dB
transmit antenna gain	x	dB
frequency	30	GHz
free-space distance	2	km
atmospheric attenuation	1.5	dB
standard deviation of log-normal fading	6	dB
required service probability	95	%
receive antenna gain	10	dB
receiver noise figure	4	dB
noise bandwidth	100	MHz
required receiver SNR	6	dB