COMMUNICATION THEORY, Exercise 9, Fall 2023

1. Find the minimum value of the subcarriers frequency separation Δf in an OFDM communication system which guarantees the orthogonality of the subchannels.

2. An OFDM system is required to support a bitrate R_{bit} = 6 Mbps, and to work properly in a multipath channel scenario with delay spread τ_{max} = 100 μs. The bandwidth available for this system is B = 2 MHz, and it is decided that the OFDM symbol duration should not exceed 400 μs, to avoid a possible time-variant behaviour of the transmission channel.

   Assuming all subcarriers will use the same modulation scheme, determine all the other OFDM system parameters necessary to fulfill the given requirements, including the number of subcarriers, the subcarrier separation, and the minimum symbol constellation size.

3. An OFDM communication system operating at fc = 500 MHz has 4 active subcarriers plus 2 additional non-active subcarriers, and all the available subchannels use 4QAM modulation. The OFDM symbol duration is T_{sym} = 100 μs.

   a) Assume that basic rectangular pulses and only positive subcarrier indexes are used, and draw a rough picture of the OFDM power spectral density using minimum carrier spacing, estimate the required transmission bandwidth, and calculate the total bitrate of the OFDM system.

   b) Draw a sketch of a possible transmitter and receiver for the system.

   c) The resulting OFDM signal is transmitted through a multipath channel with the following power-delay profile:

Path	#1	#2	#3	#4
Power (dB)	0	-6	-12	-14
Delay (μs)	0	1	5	10

   Use Matlab to determine the frequency response of this multipath channel in the system bandwidth, and draw a picture of the signal constellations for each OFDM subchannel, as they become distorted by the multipath.

   d) Assume that the frequency response within each OFDM subchannel is sufficiently “flat” in amplitude and with linear phase, and add to the previous sketch an equalization stage with appropriate coefficients to compensate for the distortion introduced by the multipath channel.

   e) Calculate the length of the cyclic prefix T_{cp} necessary to eliminate possible interference between consecutive OFDM symbols, and recalculate the total bitrate of the system.

   f) Recalculate the total bitrate of the system once again, when it is decided that all the subchannels attenuated at least 2.5 dB more than the strongest active subcarrier should have their modulation size reduced to the next possible smaller value.