TLT-5706 Multicarrier Techniques

You may use either English or Finnish language.
Use of literature is not allowed.
Use of the Faculty calculator is allowed.
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1. Please answer all the following questions:
   a) Describe the basics of Filter Bank based Multicarrier (FBMC) systems. What are the advantages and limitations in FBMC systems? Give also an example on prospective use of FBMC. How the channel equalization might be carried out in these systems? (3p)
   b) What is meant by multicarrier CDMA systems? Present at least two different methods to implement multicarrier CDMA. Use block diagrams. (3p)

2. Why nonlinear distortion is more likely to occur in OFDM systems? What are the effects of nonlinear distortion on the OFDM system? What is the peak-to-average power ratio (PAPR)? How can PAPR be reduced in OFDM systems?

3. Please answer all the following questions:
   a) What are the advantages and drawbacks of OFDM? (2p)
   b) Why Guard interval (GI) is used in OFDM systems? What condition the GI should satisfy with respect to the maximum delay spread of channel? (1p)
   c) What are the basic operations that the OFDM receiver should be able perform? Present the block diagram of a typical OFDM receiver. Explain the operation of each block briefly (3p)

4. Consider a time-invariant frequency-selective block fading channel that has three subchannels of bandwidth $B=2MHz$. The frequency responses associated with each subchannel are $H_1=1$, $H_2=1/2$, and $H_3=4$, respectively. The transmit power limitation is $P = 200mW$ and the noise PSD is $N_0 = 10^{-8}W/Hz$.

   a) Find the Shannon capacity of this channel and the optimal power allocation that achieves this capacity
   b) What is the capacity in the case of evenly allocated power?

   How does the situation change, if the transmit power is lowered to 20mW? Find the corresponding capacities [as in a) and b)] in this case.

5. Design a multicarrier system for 15.0 MHz bandwidth. The required transmission rate is 40 Mbits/s and maximum delay spread of the channel is 15 µs. Guard band of 2· 0.5 MHz is reserved for spectral shaping purposes and at least 5% of the carriers should be reserved to be used for synchronization (continual pilots) etc purposes. Channel is supposed to change insignificantly in time. It can be also assumed that noise is not a limiting factor.

   a) What are suitable symbol and guard interval durations in this case? (2p)
   b) In FFT implementation, the number of carriers should be a power of 2. Give the length of FFT in your design. (1p)
   c) What kind of submodulation might be useful? (1p)
   d) What is the number of continual pilots in the design? (1p)
   e) Describe possible and practical pilot configuration used for the channel estimation in the system. (1p)