

You may use either English or Finnish language.
Use of literature is not allowed.
Use of the Faculty calculator is allowed.
Compiler of the exam: Jukka Rinne.

1. 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?
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. Answer to the following questions:
 - a) Explain the basics of OFDM? (2p)
 - b) What are the advantages and drawbacks of OFDM? (1p)
 - c) 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)
 - d) What are the basic operations that the OFDM receiver should be able perform? (2p)
4. Study the Guard Interval Correlation (GIC) method. Write the mathematical derivations for the output of GIC in case of multipath channel with one delayed component. The sampled channel response is $h(n) = \delta(n) + A\delta(n-D)$, where $n \in]-\infty, \infty[$, $\delta(\cdot)$ is (Kronecker) delta function, A and D are arbitrary constants. Define and justify other needed assumptions. Give also illustration of the output of GIC.
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 μ s. Guard band of $2 \cdot 0.5$ 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)