Digital Television Techniques

Exercise 4, COFDM, 25-April-2013

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Deadline is 10 May 2013.

1. A multi-path channel shows a maximum time delay of $\tau_{max} = 0,8\mu s$. How long should the Guard interval (Cyclic Prefix) of an OFDM system with $N = 64$ sub-carriers and a carrier spacing of $\Delta f = 312,5$kHz be dimensioned for the transmission over the channel? Note, select among guard intervals of length 1/4, 1/8, 1/16, 1/32 etc.

2. A OFDM system has the following parameters: Mode 8k (6817 used carriers), Code rate 2/3, Reed-Solomon (204,188), bandwidth 7 MHz, 1/16 Guard interval, 64QAM constellation, 105 pilot carriers. What is the a) symbol length T_s, b) frequency spacing Δf and c) bit rate B of the transport stream? e) What is the maximum extra distance a transmission echo may travel in order not to cause interference?

   Repeat the calculations for a 2k (1705 used carriers) system with the same parameters.

3. A DVB-T2 system is being deployed with the following parameters: FFT size 4k, using pilot pattern PP3 (gives 3228 active carriers), and a guard interval of 1/8. 256-QAM modulation is used, with a LDPC coding rate of 3/5. The system is implemented in a 8 MHz physical channel, however in DVB-T2, the complex sample time of 7/64 us is used, i.e. the effective bandwidth is 64/7 Mhz. Calculate the follwing: symbol duration (T_s), time of useful symbol duration (T_u), payload bitrate (B). According to DVB-T2 implementation guides, the needed SNR for this setup in Rayleigh channel is 20,6 dB. Compare this to the channel limit.

4. The Discrete Fourier and Inverse Discrete Fourier transforms are important parts of an OFDM transmission system. The Inverse Discrete Fourier transform is defined as

$$x\left[kT\right] = \frac{1}{N}\sum_{n=0}^{N-1} X\left[\frac{n}{NT}\right]e^{j2\pi nk/N}$$

   where T is the sampling period, N is the size of the IDFT window x are the time samples and X are frequency samples, $k \in [0, K]$, normally $K = N$. Hence, for calculating an IFT we need N^2 complex multiplications and $N \cdot (N-1)$ complex additions, or a complexity $O(N^2)$ (actually totally $4N^2$ real multiplications and $4N^2 - 2N$ real additions).

   The Fast Fourier Transform (IFFT) reduces the computing complexity to $O(N \log_2 N)$. For the systems given in task 2, calculate the computing power in MFLOPS (Mega Floating Point Operations Per Second) for both standard IDFT an IFFT. *Comparison, a Core i7-780@3.2GHz 40 GFLOPs.A GPU from 25 GFLOPs (mobile/Raspberry PI) to 1500 GFLOPS (Desktop)..*

5. Create a SNR / Error rate graph for a QPSK modulated signal, when no error correcting is used. For this, use either MATLAB or Octave (www.octave.org). Both are installed on 'tuxedo' computer at AAU, but Octave is open-source and can be freely used, e.g. at home. The syntax of MATLAB and Octave is almost identical, even if the functions available might vary. Here, information for Octave is used. The following steps should be done

   (a) Create a constellation diagram, $c = [-1-1i, -1+1i, 1+1i, 1-1i]$;

   (b) Create random integers, $b = randint(1, 1e5, 4)$;

   (c) Modulate using the constellation diagram, $y = genqammod(b, c)$;

   (d) Add noise to the signal, $z = awgn(y, SNR)$, where SNR is a variable

   (e) Demodulate the signal, using $q = genqamdemod(z, c)$

(f) Compare the original signal b to the demodulated signal q, and count the errors (error rate), e.g using functions $size(find(q - b))$

Now, collect SNR, error rate pairs, and draw it in a diagram.