S-72.245 Transmission methods in Telecommunication Systems
Tutorial 6

Objectives
- Getting familiar with analysis of some analog CW - systems
- Learn how to use Matlab to analyze CW-systems

Quizzes

Q6.1 Sketch a block diagram by denoting respective input and output signals and briefly explain the following abbreviations:
a) VCO b) FDM c) OFDM d) PLL

Q6.2 A single conversion receiver is to be designed for the range $f_c = 1.6 - 2.6 MHz$ with transmission bandwidth $B_T = 6$ kHz. Unwanted strong signals in the vicinity of the received signal reside at 1.4-1.5 MHz and at 3.0-5.6 MHz.

a) Set $f_c = f_{LO} - f_{IF}$ and find the value for f_{IF} that can avoid image frequency interference.
b) Repeat (a) with $f_c = f_{LO} + f_{IF}$.

Q6.3 Find the output signals of the quadrature-carrier system in Figure 1 if the receiver local oscillator after the channel has the phase error ϕ'.

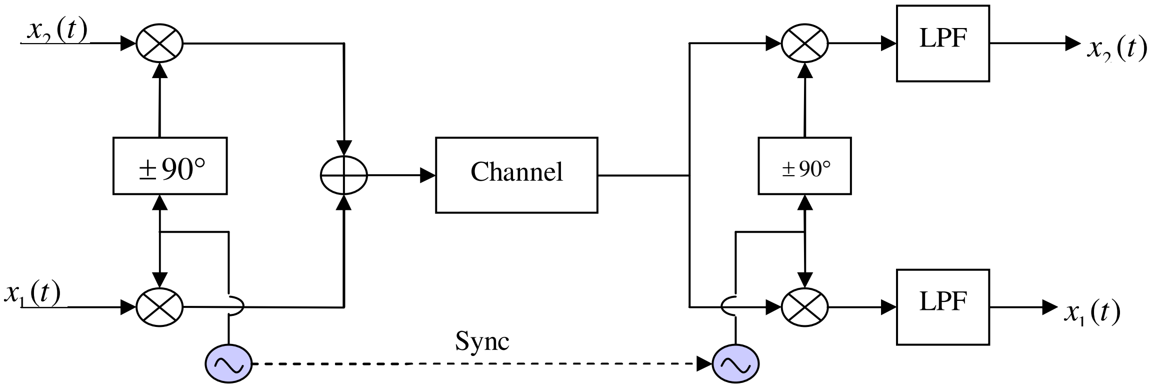

Figure 1

Q6.4 An FDM system comprises of ten SSB multiplexed signals of bandwidth *W* using guard bands of B_g between the subchannels. The band pass filters at the receiver have the transfer functions $\left|H(f)\right| = \exp\left\{-\left[1.2(f - f_0)/W\right]^2\right\}$, where f_0 equals the center frequency of each subcarrier. Find B_g so that the filters fulfill the condition $\left|H\left(f_i\right)\right| \leq 0.1$, where f_i is the frequency in the middle of any two subchannels. Then calculate the resulting transmission bandwidth of the FDM signal.

<u>Matlab assignments</u>

<u>M6.1</u> Consider a sinusoidal ($f_0 = 4\,\mathrm{Hz}$), unity amplitude signal that is transmitted in a baseband channel in a bandwidth yielding overall noise power of $\sigma^2 = 0.01\,\mathrm{W}$ over the transmission band. (a) What is the received SNR of the signal at the channel bandwidth? (b) Generate by Matlab 10 000 samples of respective signal and noise and <u>determine based on these samples</u> the respective estimated SNR and compare to (a). (c) Generate three statistically independent set of noise samples and the respective signal samples, each with the size of 10 000 samples, add these together to yield 10 000 averaged noise and signal samples. Now, determine based on these samples the improved SNR and compare to the theoretical SNR improvement factor as derived in the lecture.

<u>M6.2</u> QAM (Quadrature Amplitude Modulation) applies the quadrature-carrier transmitter of Figure 1 with $x_1(t)$ and $x_2(t)$ selected as

$$x_1(t) = 0.5 \cdot sin(2\pi \cdot 10t) + sin(2\pi \cdot 20t)$$
$$x_2(t) = 0.7 \cdot sin(2\pi \cdot 15t) + 0.3 \cdot sin(2\pi \cdot 25t)$$

Plot the resulting QAM-signal at the output of the quadrature-carrier transmitter by using Matlab in time and frequency domain (magnitude spectra). Estimate QAM-signal total power from frequency and time domain plots and compare to theoretical result. Assume carrier frequency of 250 Hz.

<u>M6.3</u> a) Demodulate the QAM-signal of <u>M6.2</u> by using quadrature-carrier demodulator and plot the resulting $x_1(t)$ and $x_2(t)$. Change the phase of the receiver local oscillator and monitor the changed $x_1(t)$ and $x_2(t)$. Summarize your conclusions.

<u>M6.4</u> Create a Matlab program to verity the operation of the XOR-based phase

comparator discussed in lecture.