7 Labwork

7.1 Image Reading

- Read the image file **"cameraman.tif"** that is given in the MATLAB library by using *imread()* and change the class of data by using *im2double()* and name it y.
- Define the sampling rate F_s the size of the image y.

7.2 Modulation

- Turn your message signal matrix to a message signal (m) vector by using *reshape()*.
  Hint: Use time vector t = 0:(1/Fs):(numel(y) - 1)/Fs.
- Construct the carrier signal where $c(t) = cos(2\pi f_c t)$, with $f_c = 20kHz$.
- Modulate the message signal with conventional AM with $k_a = 0.9$
- Add noise to your modulated signal for 0 dB, 10 dB and 30 dB SNR, you are not allowed to use *awgn(.)*.
  - Compute (by MATLAB) the average transmit power of the transmit signal m which is named as P. You should take the sum of the square of all elements' absolute value and divide it by the length of the transmitted signal array.
  - m is transmitted over additive white Gaussian noise (AWGN) channel by the following equation.
    $$r = m + n \tag{1}$$
    where n is AWGN with zero mean and σ^2 variance.
  - In this part, it is not allowed to use MATLAB built in function *awgn(.)*. You should create a random noise vector $\mathrm{n}_i = \mathrm{sqrt}(\mathrm{var}_i)\mathrm{randn}(1, \mathrm{length}(\mathrm{m}))$, $i \in \{1, 2, 3\}$, 1 for 0dB 2 for 10dB and 3 for 30dB. To get the received signal array r_i, $i \in \{1, 2, 3\}$ you can add the corresponding noise array n_i and the transmitted signal array m.
  - When computing (by MATLAB) the variance of the corresponding noise, firstly you should calculate the linear value of the corresponding SNR by,
    $$\mathrm{SNRlin}_i = 10^{(0.1 \times \mathrm{SNRdB}_i)}, \quad i \in \{1, 2, 3\} \tag{2}$$
    Then the corresponding variance of the noise var_i is computed (by MATLAB) by,
    $$\mathrm{var}_i = \frac{\mathrm{P}}{\mathrm{SNRlin}_i}, \quad i \in \{1, 2, 3\} \tag{3}$$

7.3 Demodulation

- Demodulate the signals for each SNR value with a square law detector.
- Reshape your signals to a matrix form that is consistent with the first form of the images. Plot the original image and the demodulated images on the same figure using *subplot(22x)*, note that it must be a 2×2 figure. Use *imshow()* command to see your figures.

7.4 Mean Square Error (MSE) and comparison

- Calculate the MSE values between the message image and demodulated images with 3 different SNR values by using:
  $$\mathrm{MSE} = \frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} [OriginalImageMatrix(i, j) - DemodulatedImageMatrix(i, j)]^2 \tag{4}$$
  where m and n are the numbers of the rows and columns of the image, respectively.
- Plot the calculated MSE values with respect to SNR=[0,10,30].

7.5 Questions for Report

Include figures, comments and answers to questions in your reports

- What is the definition of the SNR?
- What happens to the demodulated image as the SNR increases, and why?
- Is there another way to add noise to the signal without using *awgn(.)*?
- We know that noise has the mean value and the variance value, which one represents the power of the noise?