8 Labwork

8.1 Image Reading

- Read the image file **"testpat1.png"** 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.

8.2 Modulation

- Turn the message signal matrix to a message signal (m) vector by using *reshape()*.
- **Plot** the magnitude of the frequency spectrum of *m(t)* with respect to frequency axis. The number of DFT points (N) is the length of the message signal. Write title, labels and legends (if necessary) to **get full credit**.
- Define time vector : $t = 0 : (1/F_s) : (numel(y) - 1)/F_s$
- Modulate the message signal with FM for k_{f1} *=100* and k_{f2} *=400*. Carrier frequency f_c *=10 kHz*. Do not use *fmmod(.)* function.
- **Plot** the magnitude of the frequency spectrum of the modulated **signals** (k_{f1} and k_{f2}) with respect to frequency axis on the same figure using *subplot(21x)*.
- Add noise to modulated signals for 0 dB, 25 dB and 50 dB SNR by using *awgn(.)* and **plot** the magnitude of the frequency spectrum of the **0 dB AWGN** modulated signals (k_{f1} and k_{f2}) with respect to frequency axis on the same figure using *subplot(21x)*.

8.3 Demodulation

- Obtain the demodulated signals for each SNR and for both k_{f1} and k_{f2} by using the *fmdemod(.)*. **Plot** the magnitude of the frequency spectrum of the **25 dB AWGN** demodulated signals (k_{f1} and k_{f2}) with respect to frequency axis on the same figure using *subplot(21x)*.
- Design a **LPF** filter with order 5 so that you can obtain over 10 dB PSNR values when you demodulate the signal under **50 dB AWGN** for both k_{f1} and k_{f2}. Filter all of the noisy demodulated signals(**0 dB AWGN**(k_{f1}, k_{f2}), **25 dB AWGN**(k_{f1}, k_{f2}), **50 dB AWGN**(k_{f1}, k_{f2})) with this designed filter. You can use *psnr()* function.
- Reshape the filtered signals to a matrix form that is consistent with the original form of the images. **Show** the images for each SNR and for both k_{f1} and k_{f2} on the same figure using subplot(23x). Use *imshow()* function to show the images. Write title, labels and legends (if necessary) to **get full credit**.

8.4 Mean Square Error (MSE) and PSNR Comparison

- Calculate the PSNR values between the original image and demodulated images with 3 different SNR values by using *psnr()* function and **plot** the calculated PSNR values with respect to SNR=[0, 25, 50] for k_{f1} and k_{f2} results on the same figure by using *hold on*. Write title, labels and legends (if necessary) to **get full credit**.
- Calculate the MSE values between the original image and demodulated images with 3 different SNR values by using *immse()* function and **plot** the calculated MSE values with respect to SNR=[0, 25, 50] for k_{f1} and k_{f2} results on the same figure by using *hold on*. Write title, labels and legends (if necessary) to **get full credit**.

8.5 For Report

Include figures, comments and answers to questions in your reports

- Calculate modulation indices β_1 and β_2 which correspond to frequency deviation constants k_{f1} and k_{f2} given above. While calculating these modulation indices, assume that the message signal consist of single frequency component (f_m). (f_m) can be selected as the frequency value where the magnitude spectrum's **second** maximum valued peak occurs. (Note that the maximum valued peak occurs at DC component. You should find the second highest peak.)
- Write the types of FM signals modulated with k_{f1} and k_{f2} and calculate the threshold k_f value by considering the assumption in previous question.

- Write the FM, PM, SSB and VSB systems from most efficient to least efficient in terms of bandwidth.
- What is the relation between the output SNR and modulation index β for FM?