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EXPERIMENT 5. OPTIMUM FILTERING: FIR WIENER FILTER IMPLEMENTATION FOR NOISE REMOVAL

PART 2

LABORATORY REPORT

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Programming Tasks

a) In addition to the two plots in Fig. 2, add two plots for the frequency characteristics of the Wiener filter and PM filter.

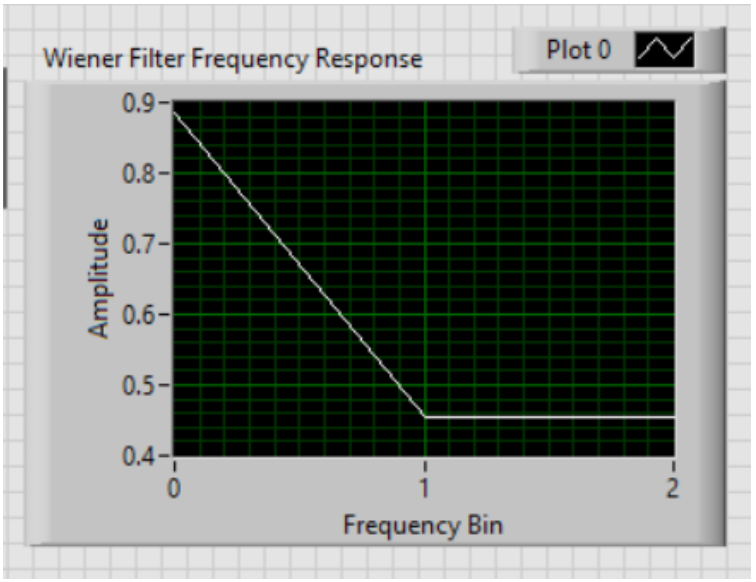


Figure 1: The frequency characteristics of the Wiener filter

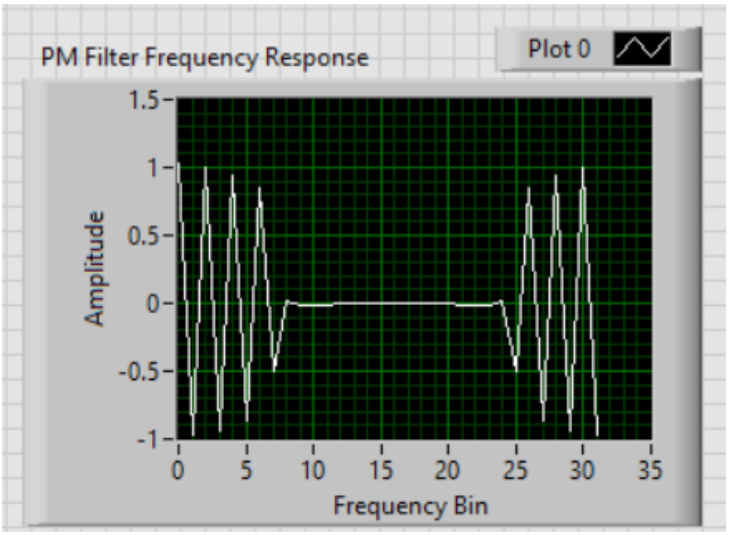
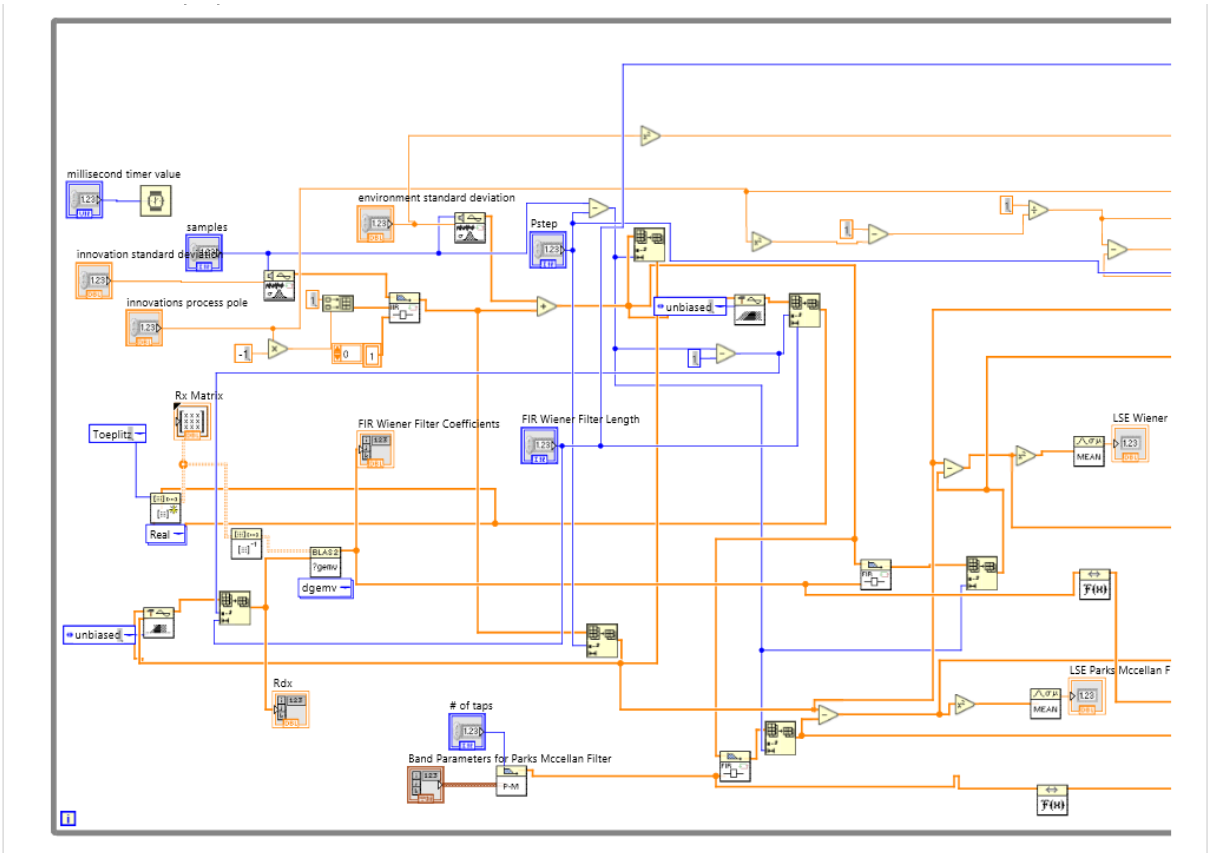


Figure 2: The frequency characteristics of the PM filter

b) Attach below a screenshot of your block diagram and front panel.



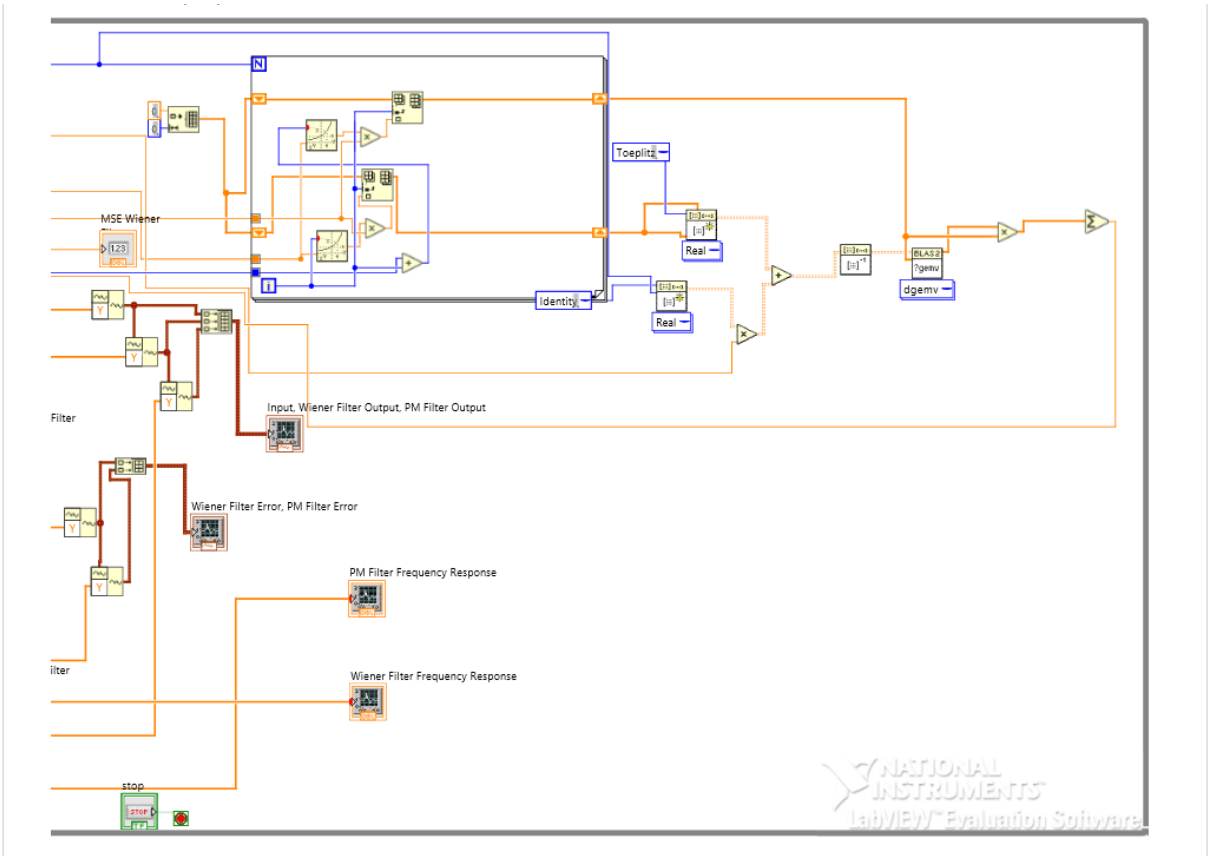


Figure 3: Screenshot of the block diagram

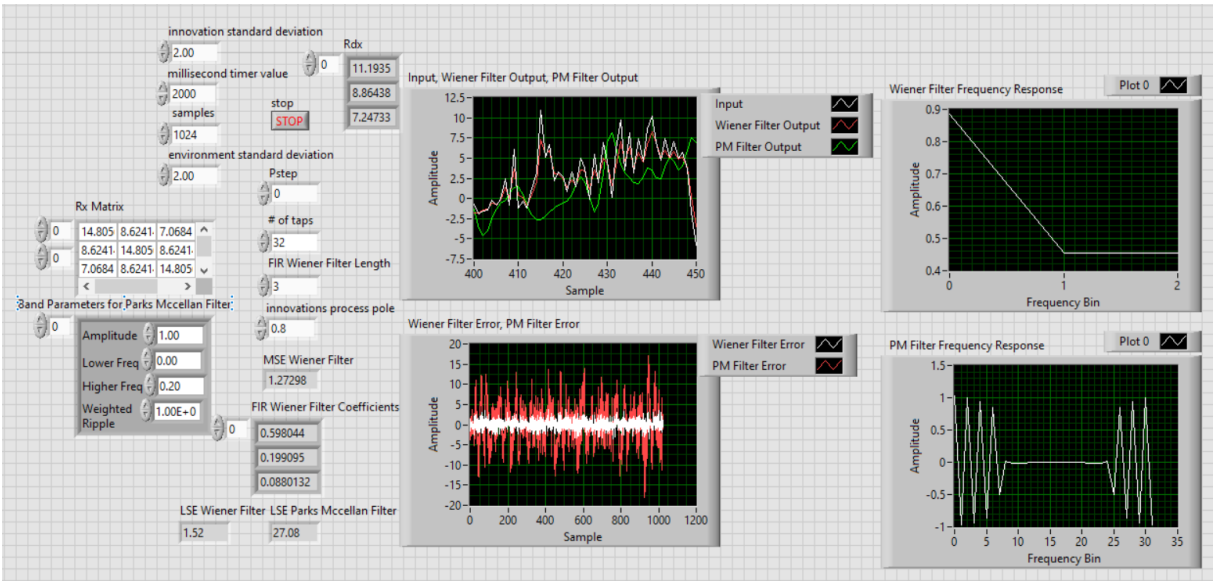


Figure 4: Screenshot of the front panel

c) Let the innovations process pole, **a=0.8**, **Wiener filter length=3**, **Pstep=0 and noise standard deviation 1**. Obtain and note the **filter coefficients**, **Rx**, **rdx**, **MSE and LSE values** in your **report**. Also **include** the **all waveform plots in your report**. Can you design a PM filter which gives a better LSE than the Wiener filter? **Explain** your reasoning. You may zoom in your graphs by right clicking your graph, then choosing properties and scales, respectively. In scales window you may disable autoscale and enter minimum/maximum axis values.

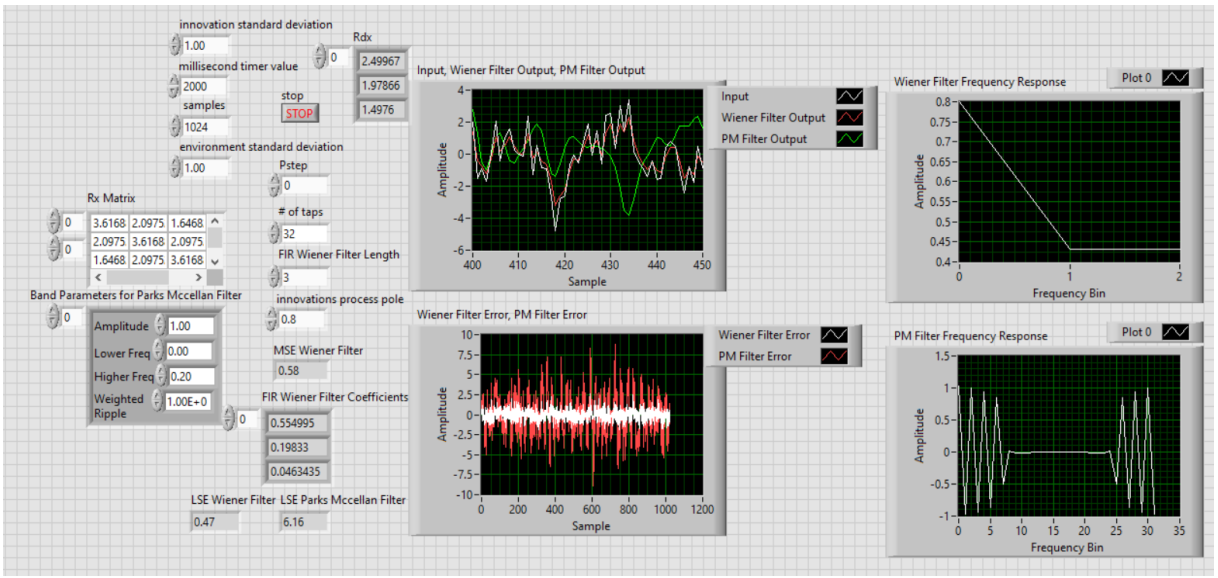


Figure 5: Front panel for the experiment given in part c

LSE is calculated as 0.47 with a Wiener filter with an order of 3. LSE is calculated as 6.16 with a Parks-McClellan filter with an order of 32. In optimum filtering, as in the Wiener filter, statistical characteristics of the input signal are used to extract the useful information. Whereas, Parks-McClellan filter does not use prior knowledge about the signal, which is, thus, a deterministic filter. As seen from LSE results, having prior knowledge decreases the error between filter output and the desired signal. Not only that, but also the order of the filter has significantly decreased. A Wiener filter of order 3 gave more accurate results than a Parks-McClellan filter of order of 32. We cannot design a PM filter that can give less LSE than the Wiener filter, because, Wiener filter is an optimal filter in the MSE sense such that the error for that stochastic process is minimized. So, the best PM filter that is designed should be the same as the Wiener filter, however, this goal cannot always be achieved without knowing the process characteristics.

d) Let the innovations process pole, **a=0.8**, **Wiener filter length=3**, **Pstep=0 and noise standard deviation (both for innovation process and environment noise) 2**. Obtain and note the **filter coefficients**, **Rx**, **rdx**, **MSE and LSE values** in your **report**. Also **include** the **waveform plots in your report**. **Compare your results with c and comment.**

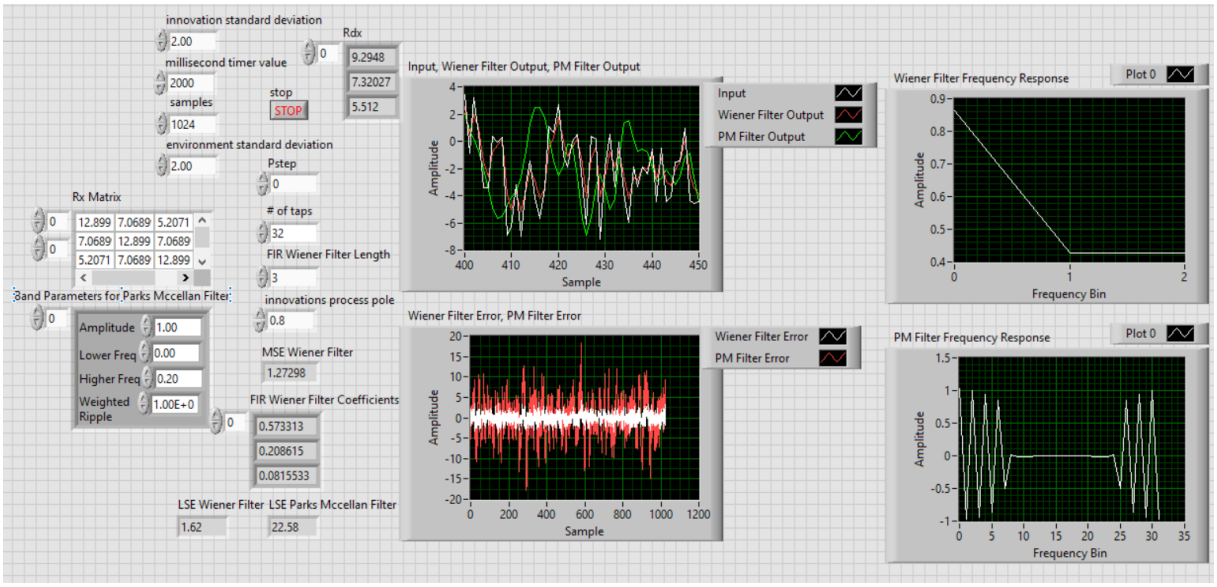


Figure 6: Front panel for the experiment given in part d

We expect that the error increases, since the power of the noise increases. As seen From Figure 6, when compared to the results of part c, both MSE and LSE values are increased.

e) Let **Pstep=2** and **repeat d**. **Explain** the **differences** between the results obtained in **d and e.**

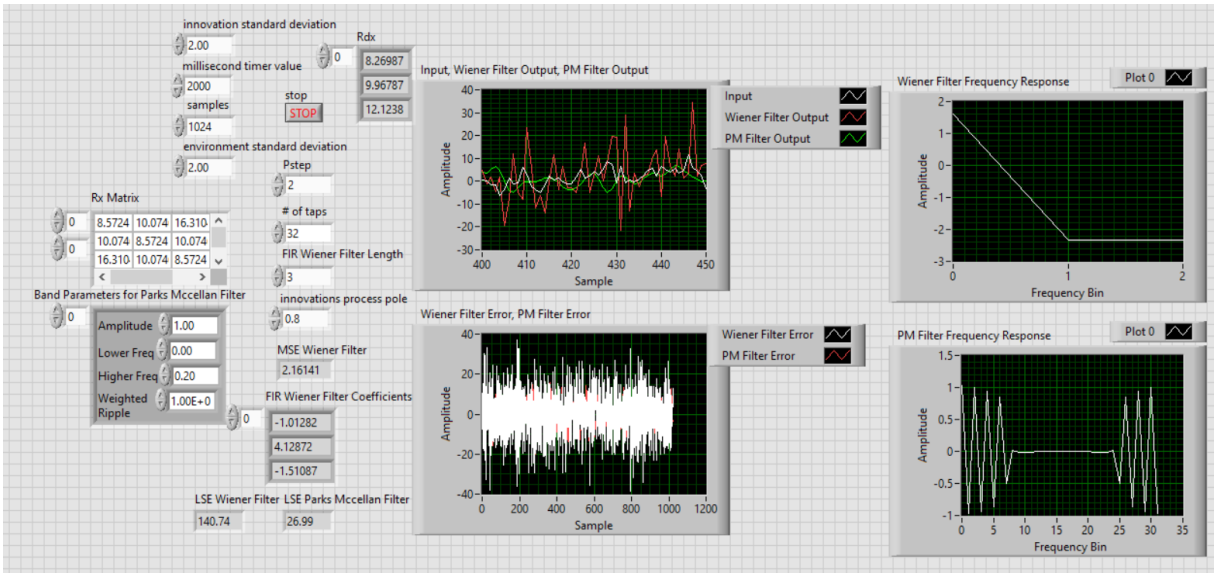


Figure 7: Front panel for the experiment given in part e

MSE is calculated as 2.16, whereas MSE value was 1.27 for P_{step}=0, as P_{step} increases error values are increasing both theoretically. However, only for P_{step}=2, we have obtained bad results for our experiment. As can be seen from P_{step}=100 for part f, experiment gives better results, which was unexpected. The problem about P_{step}=2 cannot be identified.

Our expectation was as follows:

The case in Figure 7 can be explained by Rx having singular values that are very low, which creates an increase in output power. As P_{step} increases error values should be increasing both theoretically and practically. This is because correlations between predicted elements and the elements that we are predicting from decreases. If we write the theoretical correlations between d[n] and x[n], we see that correlations decrease. Therefore, we will expect more erroneous results.

f) Increase **Pstep** to 100. **Explain** your observations.

As P_{step} increases error values are increasing both theoretically and practically. This is because correlations between predicted elements and the elements that we are predicting from decreases. When it is equal to 100, MSE has a value of 2.78 and we see that the prediction is not good because of this high error. Also, error for PM filter has also increased.

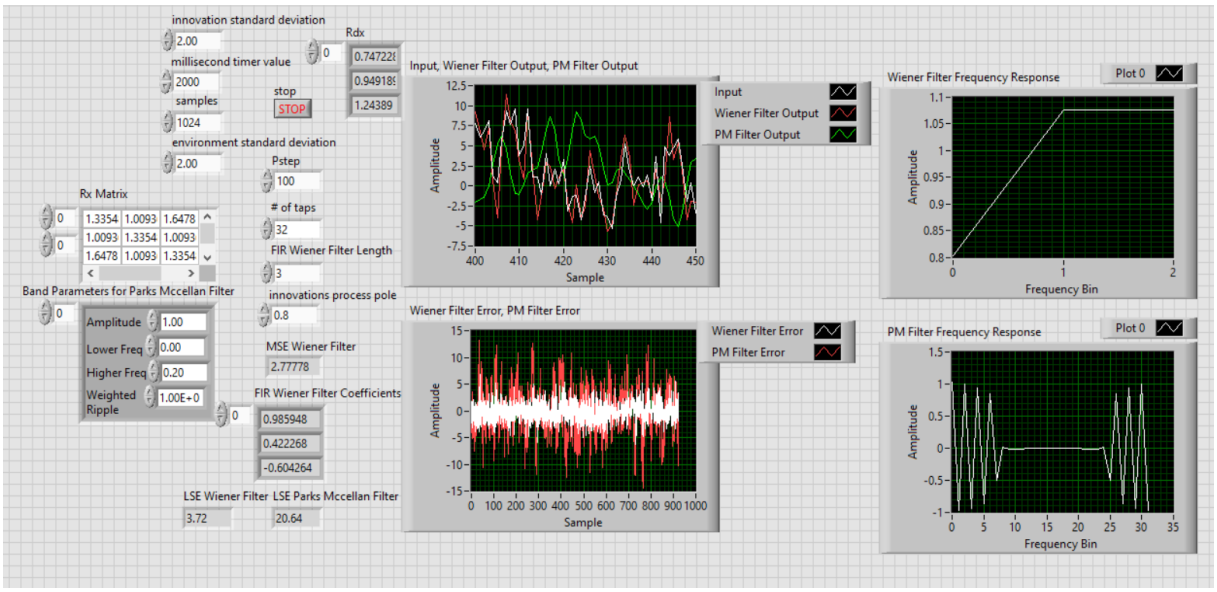


Figure 8: Front panel for the experiment given in part f

g) Set your parameters as part d. Now increase the length of the Wiener filter one by one by noting the MSE. Please use a table to note the MSE values. **Explain** the MSE result as the filter length increases.

Table 1: MSE values for different values of length of the filter

Filter Length	**3**	**5**	**7**	**10**	**20**
MSE	**2.1614**	**2.1482**	**2.1470**	**2.1469**	**2.1469**

As the length of the filter increases, the MSE decreases, as seen from Table 1. This was expected, since increasing the length of the filter means a higher order filter and a better realization of the system. In effect, MSE decreases and converges to a value as we increase the filter length.