WRIGHT STATE UNIVERSITY
DEPARTMENT OF MECHANICAL AND MATERIALS ENGINEERING

Vibration Testing and Health Monitoring

Final Exam

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WRITE UP

Three FRF's for H_{11}, H_{12}, and H_{13} were provided. The goal is to perform system identification using the Ho-Kalman method. Markov parameters were constructed from the provided data using two methods. The first method can be seen in Figure 1. Each of the Markov parameters were constructed in this fashion for a total of 803.

```
M[0]
```

```
array([ 0.07125259, -0.08974109, -0.00021652])
```

Figure 1: Markov parameter definition for Option 1

The second method for constructing the Markov parameters can be seen in figure 2. The main idea here is that the Markov matrices are symmetric. Therefore, values of the matrix 12=21 and 13=31.

```
W1=W[:3,:3]
W1
```

```
array([[ 0.07125259, -0.08974109, -0.00021652],
       [-0.08974109,  0.        ,  0.        ],
       [-0.00021652,  0.        ,  0.        ]])
```

Figure 2: Markov parameter definition for Option 2

Using the above definitions $H(0)$, and $H(1)$ were constructed. For a full detail of the math performed please see the IPython notebook files. The next picture shows the significant values from the Sigma matrix. For option 1, there are 6 significant values. For option 2 there are 12. Figure 3 shows a plot for Sigma values in order to show the decreasing trend.

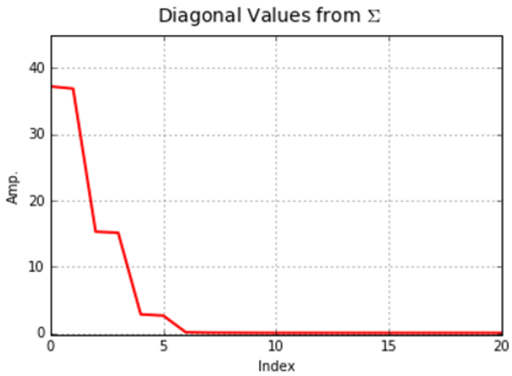

Figure 3: Plots showing Sigma values.

Based on the information gained from the Sigma plots, Option 1 will have a state space comprised of 6 states and option 2 will have 12 states. Based on the state space systems defined for options 1 and 2 here are the reconstructed FRF compared with respect to the original data. Starting first with H_{11} estimate in Figure 4.

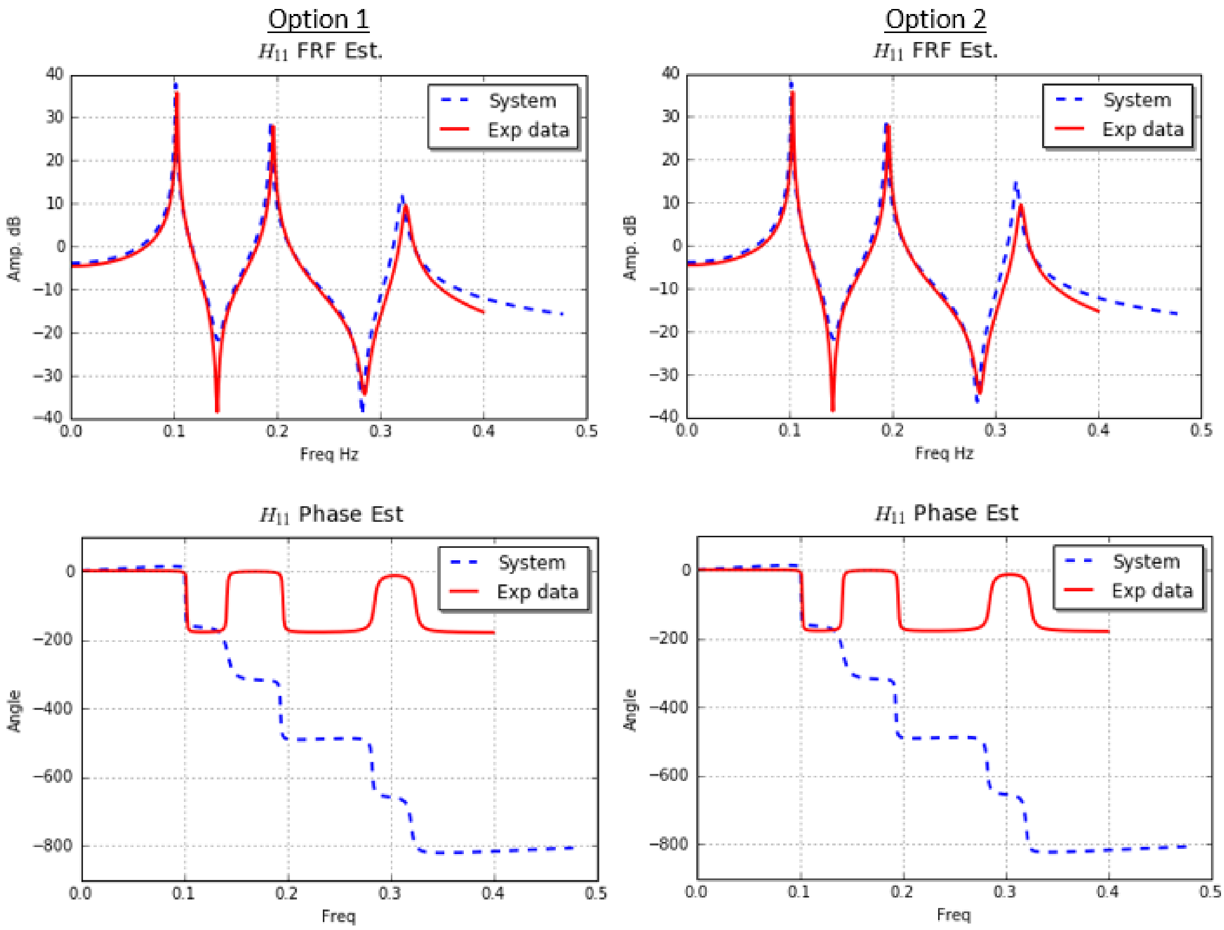

Figure 4: FRF 11 estimate compared with original data.

For the FRF 11 estimate both option 1 and 2 do a good job of obtaining the correct amplitude plots. Despite this fact the phase diagrams are registering a -90 degree phase shift at the zero locations. Not sure yet as to why this is happening.

The next Figure shows the FRF 12 estimate. For this signal, option 2 shows a considerable improvement in both the amplitude plot and phase diagram. For one, option 2 amplitude plot estimates the peaks more accurately. Second, it also pick up the zero, which is missing in the option 1 amplitude plot. As a result, the phase diagram is markedly improved for option 2 vs. option 1 fit.

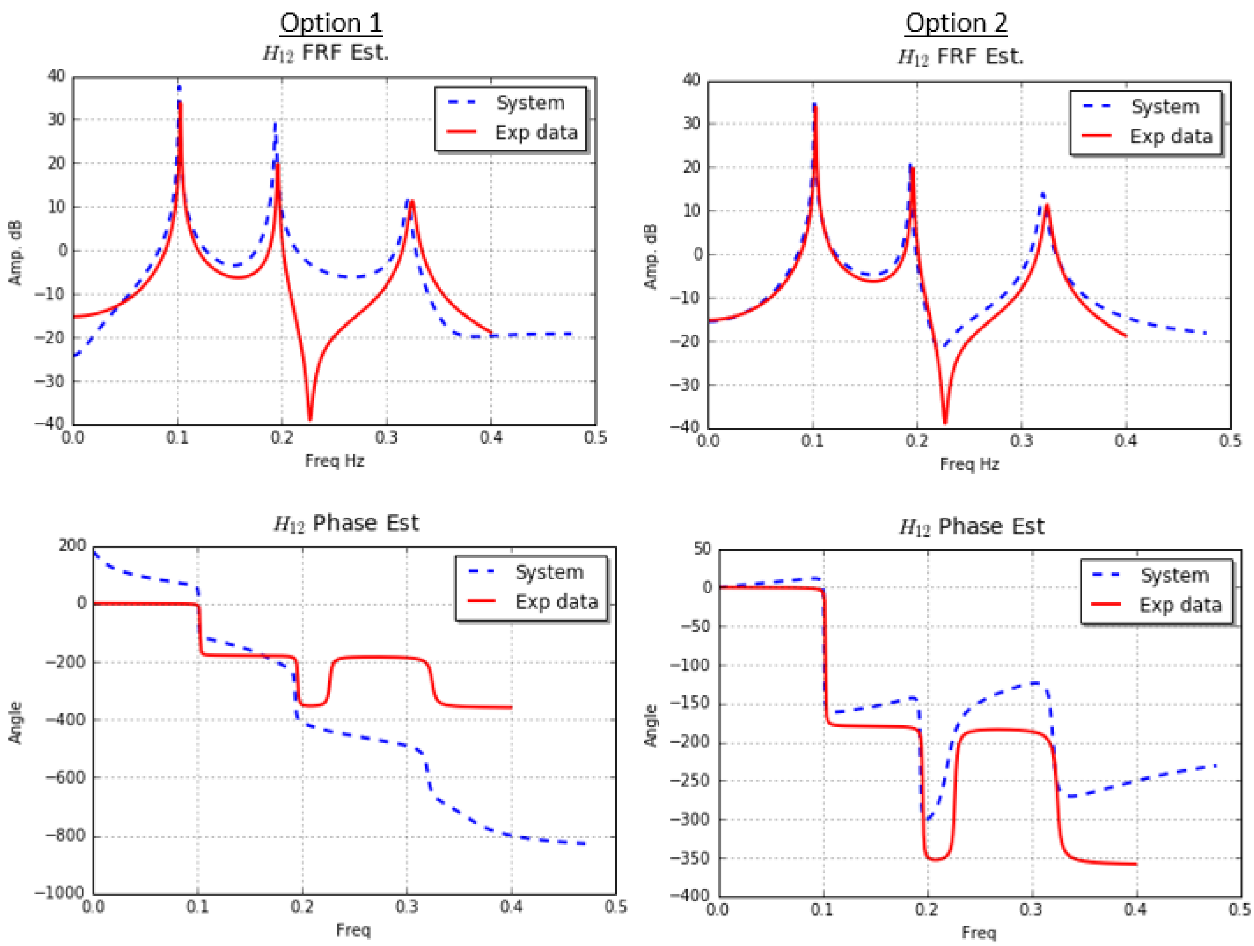

Figure 5: FRF 12 estimate compared with original data.

Finally, Figure 6 shows the FRF 13 estimate. In similar fashion, option 2 estimate is better at overall fit of the amplitude data. It also estimates the peaks better. The better amplitude estimate is also seen in the phase plot estimations as well.

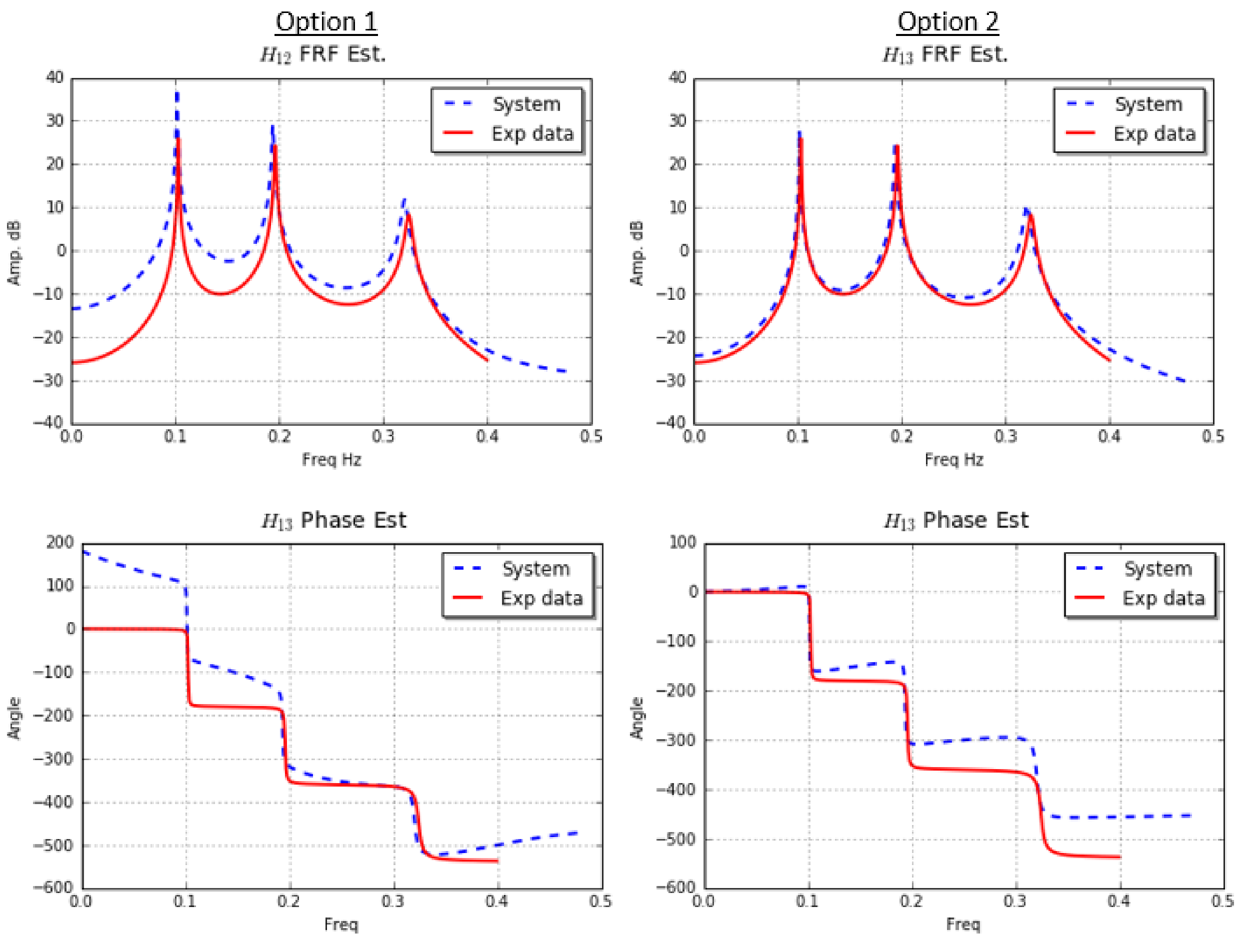

Figure 6: FRF 12 estimate compared with original data.

In closing, it is not sure why option 2 performs a better estimations. Technically the provided system has 6 states but option 2 works by using 12 states instead. As such, there should be a way to obtain a 6 degree of freedom state space matrix A from the 12 degree state space model. This will be investigated further in the future.