In our system, for the equilibrium point, the desired voltage is V\_{desire}=0.9 V, bias voltage V\_{bias}= 1.85 V. After experiment, we found that V\_{command} varies from 0.85V to 0.96V. In our Simulink program, the non-linear model can range from V\_{command}= 0.16V to 1.49V, while the linear model should be range from 0V to 1.52V.

According to what’s above, controllable range of linear control system is larger than our experimental results, while the range is around the balanced position. As for nonlinear control system, the range is even larger and also ranged around the equilibrium point. Both models agreed on that the iron ball is controllable.

We think it is not likely to accurately predict the actual range in the experiment since some assumptions in modelling the system cannot apply in real life situations. For example:

1. For our driver circuits we assume the Op-Amp is ideal. Voltage at inverting and non-inverting terminals is equal and their current is zero. The input impedance is infinite and output impedance is zero.

2. For our feedback sensor system, we assume that when the path between the emitter and detector is completely blocked, no current flows through the detector. When no object is placed between the emitter and detector, a maximum amount of current flows through the detector. The current flowing through the transistor is converted to a voltage potential across a (sense) resistor. The light from the emitter are parallel to each other and they are not influenced by irrelevant objects in the neighborhood.

3.For our electromagnet system, we assume flux density is uniform for all cross section, and the material is linear in this system, etc.

4.Others assumptions like there is no air flow resistances, the heated electromagnet will not cause any side effects in our system, etc.

When we measured the system response, the input signal varies from 0.01Hz to 70Hz. The reason why we stop at 70Hz is that the labview program went into error when trying to collect data in 100Hz. The amplitude of the sinusoidal signal is about 0.048V and the experimental data(magnitude and phase) is attached below along with the ideal Bode plot:

(插图)

From the picture above, we noticed that no significant difference can be found on the Bode amplitude curves. The amplitude of the experimental Bode plot is almost as predictable at lower frequency such as those below 5Hz. The measurement runs into unstable situations when the phase curve approaches its phase margin. Fortunately, the tendency of amplitude is acceptable.

On the other hand, the phase curve is larger than we expected, in the lower frequencies, deference between ideal value and the experimental value is about 10°to 20°, and phases keep shifting on higher frequencies, such as 7Hz and more. These errors may result from the non-linear fragments of the Meg-Lev system since we use the linearized model as the theoretical reference. Moreover, the magnitudes of noises are somehow proportional to the frequency of the sinusoidal signals. As the frequency grows, noises from the electrical circuit gains larger thus cause the phase measurement even more inaccurate.