Project Progress Report

Implementation of Conventional and Neural Controllers Using Position and Velocity Feedback

Week Ending: February 20, 2000

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Objective

The objective for the week was to finish the system identification of the robot arm system with a small arm, design a P-Controller and test it.

Progress

The result of last week's identification was a 2nd order system with time delay (1).

$$Gp = \frac{10.1 * e^{-0.025s}}{s(s/2+1)} \qquad (1)$$

Next we tried to make a frequency sweep with a sine wave in the open loop system to verify the result. Vin was chosen 1V. The results are shown in the table below.

Freq. Rad/sec	0.2	0.5	1	1.5	2	2.5	3	3.5	4	5	6	7	8	10	20	30	40	50
Vout mV	456	440	432	424	408	384	352	328	312	280	248	224	200	160	70	37	26	20

The resulting plot is calculated by Matlab using axis properties to change to log-log scale.
Matlabcode:

```
y=[456 440 432 424 408 384 352 328 312 280 248 224 200 160 70  37  26  20];
x=[0.2  0.5   1    1.5   2    2.5    3   3.5    4     5     6     7     8    10  20  30  40  50];
plot(x,y)
```

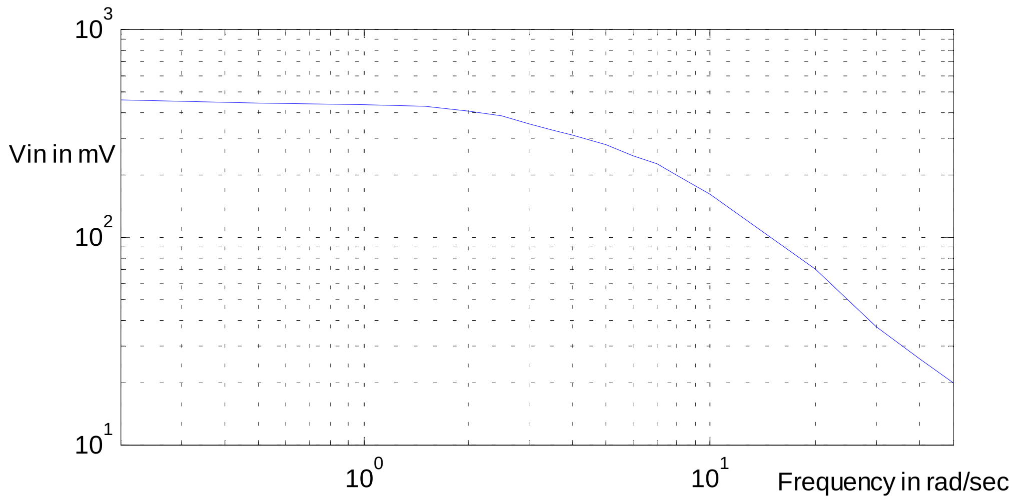

Fig.1 Magnitude Bode plot of system

From this plot it can be clearly seen that there is no integrator, which is not the case. We expected a slope of –1 from DC and a change to –2 at the first pole. So the magnitude Bode plot does give us any hint where to find the second pole. The problem is the high friction of our system. So this approach could not verify our results from last week although we will stay with it in our next steps since it was found in another way experimentally.

Next was to design a proportional controller for our system. From the experimental results we knew already it should be at approximately 0.3 to give us a desired overshoot of 10%.   The gain found to give us 10% overshot was 0.1265, comparing with the experimental results we can see this is not going to work. We found that the DC gain was wrong, the correct plant is:

$$Gp = \frac{5.05 * e^{-0.025s}}{s(s/2+1)} \tag{2}$$

Using this plant the new gain was then found to be 0.256, this is close to the experimental result.

To verify the calculated result of the controller our real time simulation program from Quansar was used. A step function was chosen for the input and then the overshoot was observed by using the graph option. There the %overshoot was measured with a ruler for clockwise and counterclockwise rotation of the robot arm.

Max swing in degree	2	6	10	14	20	24	30	36	40	50	60	90
Clockwise %overshoot	0	0	8	9.6	9.8	12.8	9	9.9	8.1	8.8	7.8	3.7
CClockwise %overshoot	0	0	7.6	9.4	8.2	11.9	7.5	7.5	8.1	7.3	6.6	3

It can be seen that the accuracy is good between 10 and 60 degrees. The problem occurs now that our system has such a low DC-gain that the D/A converter saturates.
The maximum output of the D/A converter is only 4.95 Volts, which gives us a rotation of the arm of just 2 degrees. So we need a step ramp input to let the system catch up with the input signal (Fig 2.)

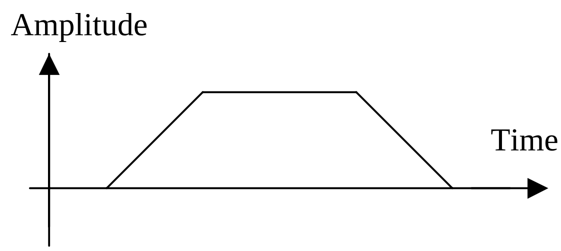

Fig. 2 Input Signal

Next step will be to design a feed forward and minor loop controller and make the system more predictable and more accurate. (Fig. 3)

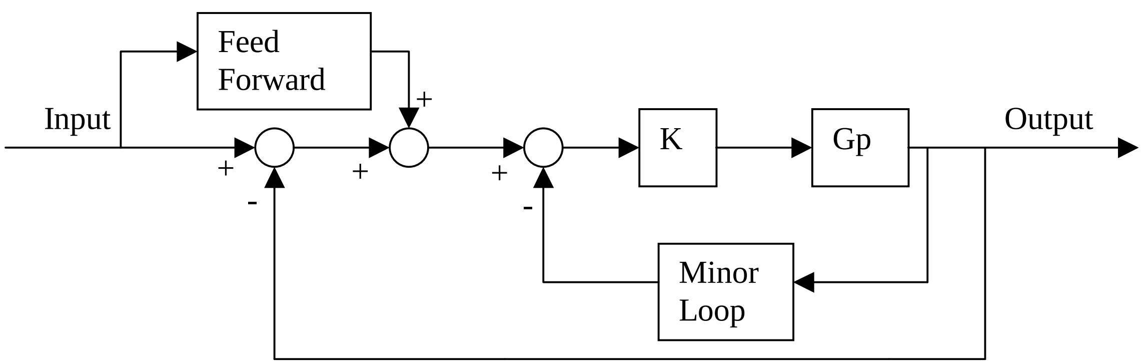

Fig. 3 Minor Loop Feed Forward K-Controller