VE216 Lab 3 Report: Feedback Control

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1 Background

1.1 Closed-Loop Transfer Function

The block diagram is shown in Fig.1

$$G_{cl}(s) = \frac{Y(s)}{X(s)} = \frac{C(s)P(s)}{1 + C(s)P(s)H(s)}$$
$$\frac{E(s)}{X(s)} = \frac{1}{1 + C(s)P(s)H(s)}$$

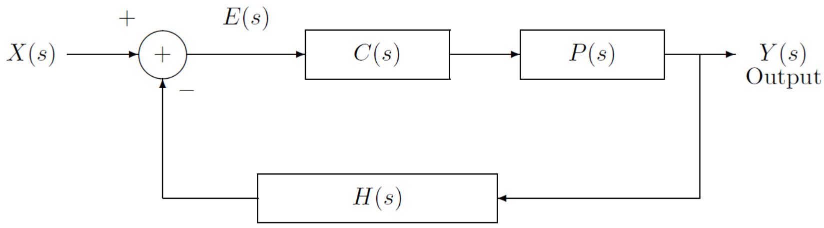

Figure 1: closed-loop feedback control system

1.2 Examples of Feedback Control Systems

1.2.1 DC Motor Model

The angular position, $\theta(t)$ is

$$\frac{d^2\theta(t)}{dt^2} + \frac{d\theta t}{d(t)} = V(t)$$

with the system transfer function

$$P(s) = \frac{1}{s(s+1)}$$

1.2.2 No controller

If the input to the above function is a unit step. Then

$$\theta(s) = V(s)P(s) = \frac{1}{s}\frac{1}{s(s+1)} = -\frac{1}{s} + \frac{1}{s^2} + \frac{1}{s+1}$$

Consequently,

$$\theta(t) = (t - 1 + e^{-t})u(t)$$

which is not going to achieve the desired rotation.

1.2.3 Controller Without Feedback

Shown in Fig.2 is the block diagram of an open-loop controller.

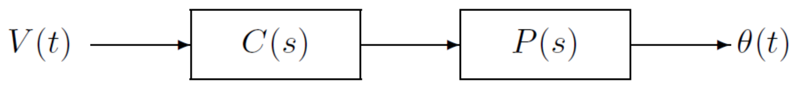

Figure 2: open-loop controller

With unit-step as input,

$$\theta(s) = \frac{1}{s} - \frac{1}{s+1}$$

With ramp as input,

$$\theta(s) = -\frac{1}{s} + \frac{1}{s^2} + \frac{1}{s+1}$$

1.2.4 Feedback Control

Consider the system shown in **??** with $H(s) = 1$, $C(s) = Ks$ and $P(s) = 1/[s(s+1)]$. Then step response becomes

$$\theta(s) = V(s)G_{cl}(s) = \frac{1}{s}\frac{K}{s+(K+1)} = \frac{K/(K+1)}{s} - \frac{K/(K+1)}{s+(K+1)}$$

or equivalently,

$$\theta(t) = \frac{K}{K+1}(1 - e^{-(K+1)t})u(t)$$

1.2.5 Sensitivity of an Open-Loop Controller to Plant Changes

It can be shown that the open-loop controller is sensitive to variations in the plant transfer function.

1.2.6 Using Feedback to Stabilize Unstable Systems

It can be shown that feedback system can stablize unstable systems.

2 Experiment Procedures

2.1 Open Loop Control: Plant

- Construct the plant with $R_0 = 10k\Omega$, $C_1 = 100\mu F$, $C_2 = 0.22\mu F$.
- Impulse response: A = 1V, width = 0.1s, f = 1Hz.
- Step response: A = 1V, f = 1Hz

2.2 Feedback Control

- Add the feedback contorl circuit to the plant with $R_1 = R_3 = 150k\omega$, $R_2 = 3k\omega$, $C_3 = 0.47\mu F$
- Impulse response: A = 1V, width = 0.1s, f = 1Hz.
- Step response: A = 1V, f = 1Hz.

3 Experiment Result

Open Loop Control - Plant The experiment result for input and output of open loop control plant circuit is shown as followed.

Figure 3: Result of open loop control plant circuit of impulse

Figure 4: Result of open loop control plant circuit of step

Open Loop Control - Plant The experiment result for input and output of feedback control circuit is shown in followed

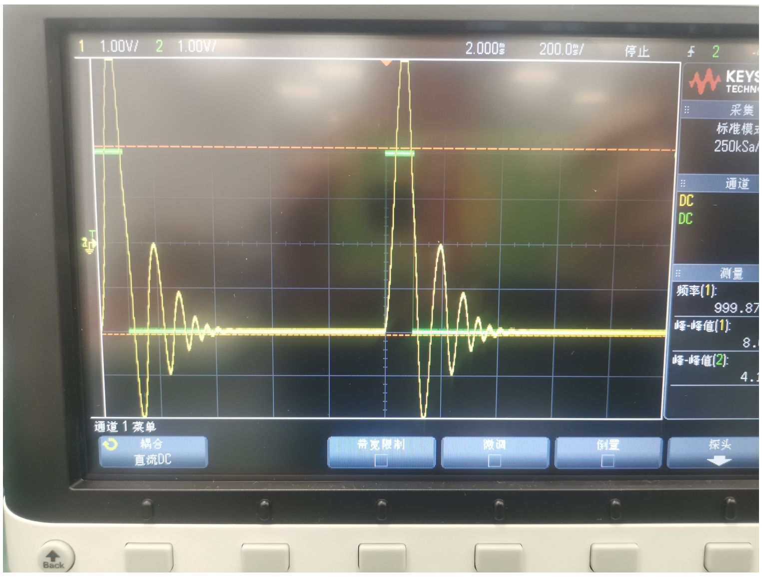

Figure 5: Result of feedback control circuit of impulse

Figure 6: Result of feedback control circuit of step

4 Discussion and Error Analysis

By comparing the output of the feedback circuit and the tested circuit, it can be found that the feedback circuit can better stabilize the unstable system.

The experimental results are in good agreement with the experimental results.

5 Conclusion

In this lab, I knew how to set up a plant and feedback control system, and how feedback systems stabilize unstable systems.