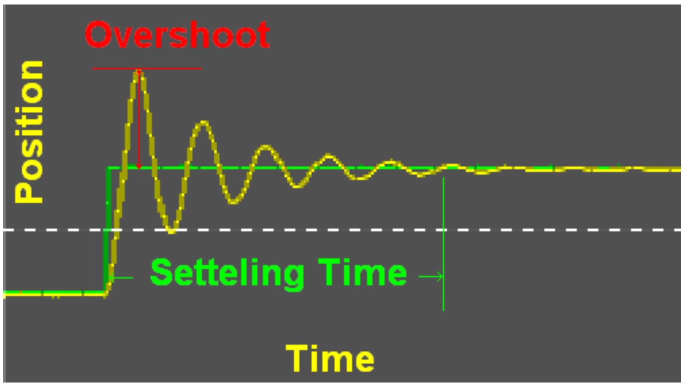
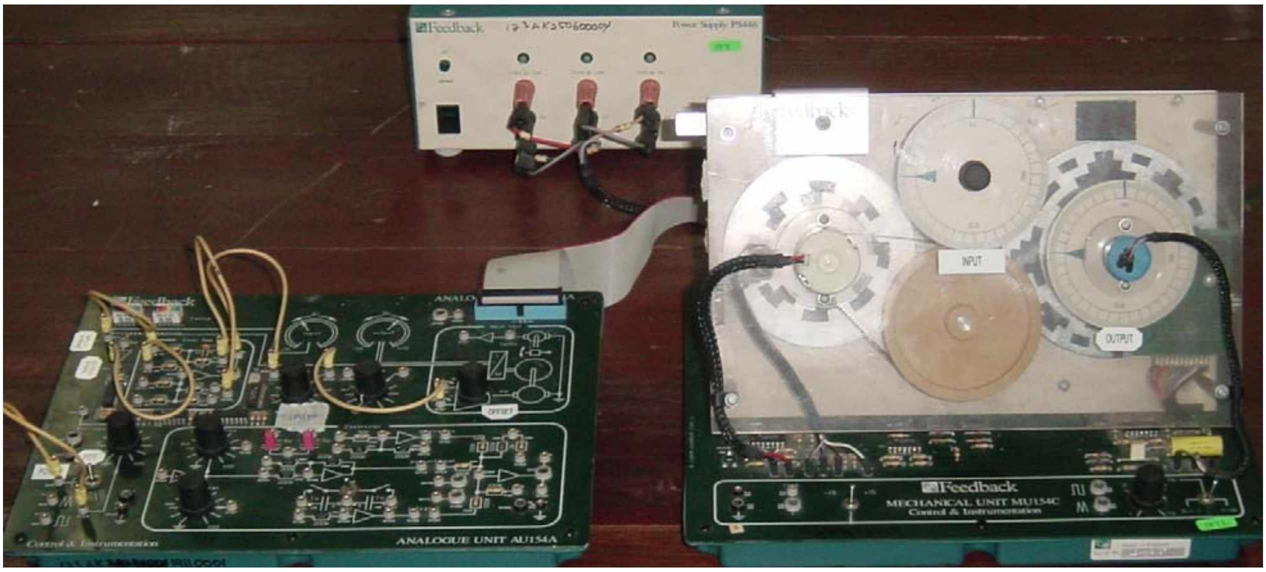
USM Mechanical Engineering Dr. HORIZON GITANO
EML 342/2 Proportional Position Control

INTRODUCTION



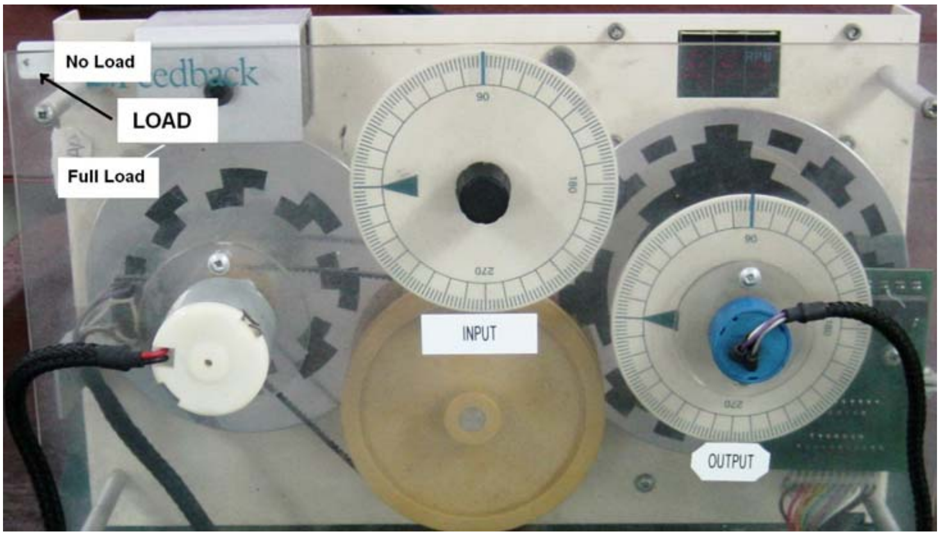
Control systems are an integral part of many processes and equipment. In this lab we will investigate the effects of gain and load on various performance parameters (Error, Overshoot and Time Constant) of a position servo system. *Error* is the difference between the desired set point, and the actual operation point. *Overshoot* is the deviation beyond the desired set point encountered during a "step input change". The *time constant* can be defined in different ways, but it basically expresses how long it takes for the output to come to its final steady-state value after a step input. For heavily damped systems without overshoot, it can be the time to achieve the final value. For under damped systems (as in the figure) it may include a significant amount of "settling time" as oscillations in the system are gradually reduced.

EQUIPMENT



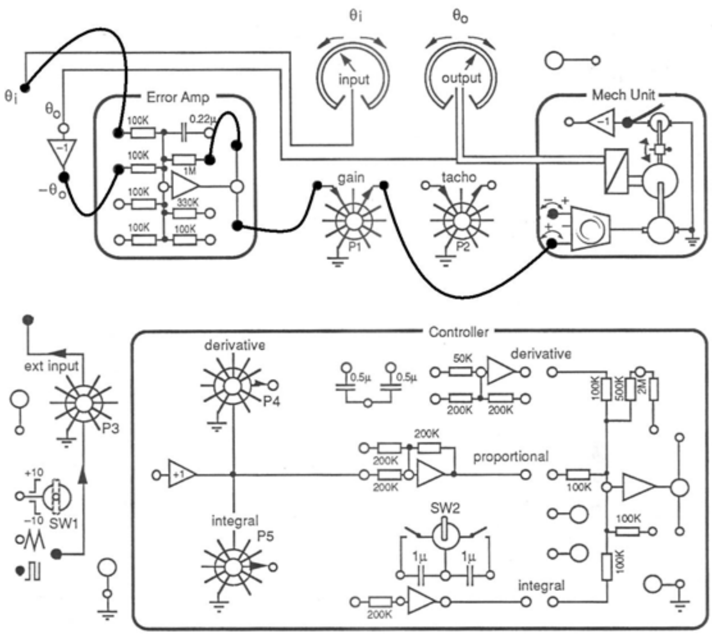
This lab uses the Feedback Instruments Power supply PS446, Mechanical Unit MU154A and Analog Unit AU154A interconnected as described in the "*Servo Fundamentals Trainer*" manual SFT154. In addition you will need a stopwatch.

THE POSITION SERVO



In the Mechanical Unit an electrical motor is connected via a 2-stage pulley system to a dial indicating the output position (white disk on right side of Mech. Unit). The position of this dial is read by a potentiometer, and sent to the Analog Unit where it is labeled Output Position. It is the job of the motor and control system to maintain the output position as close as possible to a requested set position input. We will take the input either from the Input Position dial (on the mechanical unit) or from a switch (SW1) on the Analog Unit. The actual position is inverted, and added to the desired set position in an op-amp (labeled Error Amp on the Analog Unit). The output of the amplifier (which is proportional to the difference between the output position and the desired position) is then sent into a power amplifier in the Mechanical Unit, and rotates the motor to reduce the difference between the actual position (output) and the requested position.

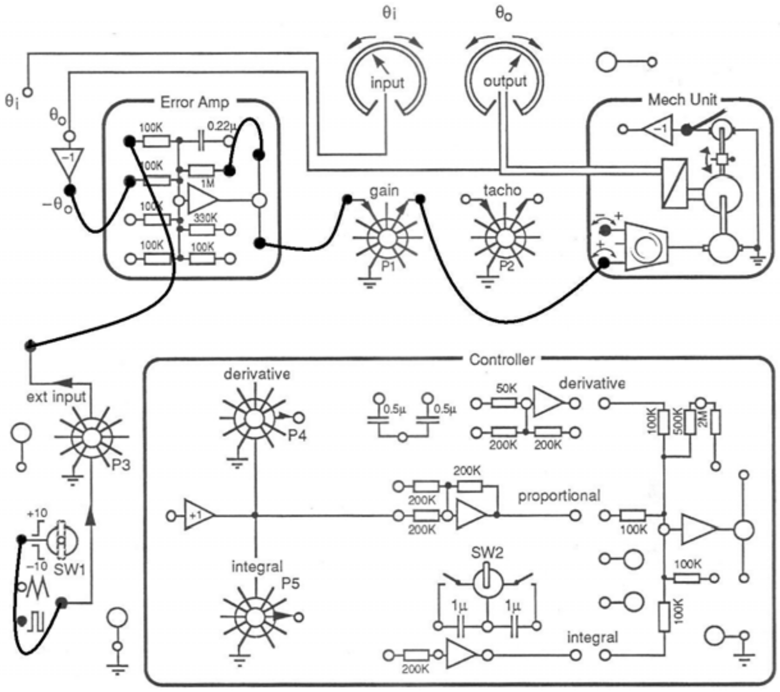
EXPERIMENTAL SETUP



Wire the Analog Unit to use the **Input Dial** for the requested position, as shown.

Connect the input position signal to one of the 100K ohm inputs to the error amp. Similarly connect the inverted Output Position signal to one of the 100k inputs. Feed back the output of the op-amp via the 1M ohm resistor. Connect the output of the error amp to the left input of the Gain knob. Connect the Gain knob's output into the power amplifier's "+/-" Offset control knob. The output dial should now rotate until its position is close to the input dials position. Set the gain knob to about 50% and adjust the offset knob back and forth until the output dial position equals the input dial position.

For “**Step Function**” testing, remove the wire from the Input Signal, and instead connect it to the output (SK4) of the Potentiometer (Pot) as shown below. Connect the Pot’s input (SK13) to the switch (SK5). Now the position should follow the switch position. Set the switch to the +10V position (up), and adjust the Pot until the output dial reads 270°. In the down position the dial should go to approximately 90°. You may need to re-adjust the “Offset” knob to read close to 0 deg. When the switch is in the middle position.



Using the Input Dial to control the position, (go back and switch the wire back to use the dial as the input control), try several different gains, and see how quickly the output responds to changes in the input position. You should see that at higher gains the output changes faster, and may even overshoot the desired position, while at low gains the output dial “lags” the input dial, and may even have a significant error. Also notice how this is affected by the Load (lever at upper left of Mechanical Unit). With no load (lever fully up) the disk moves faster. When the load is increased (Lever moved down) it resists rotation of the aluminum disk (due to eddy currents induced by the magnet when the disk is rotating).

PROCEDURE: ERROR MEASUREMENT

- Set the load to Zero (Lever fully up)
- Set the gain to 20%
- Set the input position to 0°
- Adjust the Offset knob until the output is also at 0°
- Slowly move the input position and observe the output position dial.
- Rotate the input position the opposite direction slowly.

How much can you move the input dial before the output dial moves?
You may also move the input dial rapidly from 90 to 270 or from 270 to 90°.

- Record the maximum observed difference between the input and output positions (stationary) as the error

Repeat this at gains of 40, 60 and 80%

- Now set it to full load.

Again measure the maximum error as a function of gain for 20, 40, 60 and 80%.

PROCEDURE: OVERSHOOT AND TIME CONSTANT MEASUREMENT

Rewire the Analog Unit for Step Function testing, readjusting the “offset” knob for minimum error.

- Set the load to Zero.
- Set the gain to 20%
- Place the power switch to the “up” position. The output dial should read 270°.
- Switch the power switch to the lower position, and measure how long it takes for the output dial to come to rest at it’s new position (near 90°)
- Also observe the “overshoot”. How far did the dial move past 90° before settling down? . *HINT: It may be easiest to place your finger beside the output dial’s vertical mark, on the side where overshoot occurs. During overshoot the dial temporarily stops with the number (either 90 or 270) offset from the vertical mark. You can mark the position of maximum overshoot with your finger, then calculate how many degrees it is once the dial has stopped.*

- Record both the settling time and overshoot.
- Repeat this for gains of 40, 60 and 80%.
- Now set it to full load.
- Again measure the settling time and overshoot as a function of gain for 20, 40, 60 and 80% gains.

WRITE UP

On a single graph plot the maximum error, settling time and overshoot as a function of gain. Use bold lines for the full load case, and fine lines for the Zero Load case. Describe the graph (as you would in a scientific paper), and how you got the data. Submit the lab write up. Follow the laboratory writing guide (SPC or a generic version at: http://www.skyshorz.com/university/resources/SPC.pdf). Be sure to include answers to the following questions.

QUESTIONS

1) Increasing gain causes the output dial to move faster. If we want to have the output react as fast as possible, can we keep increasing the gain in a proportional controller?
If not, why not?

2) What are the possible causes of steady-state (ie. stationary) error in this experiment?

3) Is the steady-state error larger with high or low gain? Why?

4) If we want to have a faster step function response, but minimize the overshoot and error, what techniques could we apply to our control system?

5) Why does overshoot occur?