Mechatronics I Laboratory Exercise 10
MOTOR CHARACTERISTICS
FORCE/TORQUE SENSORS AND DYNAMOMETER PART 1

Force Sensors

Force and torque are not measured directly. Typically, the deformation (strain) of some material is what is measured and the force or torque is inferred from that measurement. The deformation can be measured in many ways. If the displacement is large as with a spring, the displacement can be read directly on a scale. If the displacement is smaller, an LVDT or other sensitive displacement measuring transducer can be used. If the deformation is very small, strain gages can be used. In this laboratory experiment you will use strain gages to measure the deformation of a cantilever beam. You will construct and calibrate a cantilever beam type force sensor. Strain gages will be applied to one end of the beam. The beam will be clamped on one end, and deflected by suspending known weights from the free end. The force exerted by the weights is proportional to the strain along the beam. This strain will be measured using two or four strain gauges. You will calibrate (equation and plot) the output of the strain gages as a function of the applied force.

Strain Gages

A strain gage creates an electrical resistance that is proportional to the strain in the beam on which it its mounted. It is important that the gage adheres well to the beam to obtain accurate results. One or two gages will be mounted below, and one or two above the beam. They will be wired together to form a bridge circuit which provides maximum sensitivity to the very slight changes in resistance. The bridge will be explained in lab. Think about how to mount these gauges on the beam to obtain the most sensitive response. Where on beam is the highest strain?

Laboratory Exercise

This is the first of a two part lab. You will use your force measurement setup you build in this lab to later construct a dynamometer. If you be careful and take your time with this part of the lab then your next lab will go much more smoothly. Do not tear down your circuit when you are done! Instead, demonstrate to your T.A. that it works and then let them store for you until the next lab.

The gages in the laboratory are of the etched foil variety. There is one gage on each plastic backing. The gages must be applied carefully for them to work properly. Ask the T.A. for a data booklet on the strain gauges if you have any questions about mounting them or how to wire them. The surface of the beam is first cleaned with emery paper and a solvent such as alcohol or acetone. Next use scotch tape to position the gauge over the beam by allowing one end of the tape to stick, make sure the gauge will be glued with the right side up. Apply a small amount of catalyst to the underside of the strain gauge (the side to be glued). Apply a small amount of glue to the beam where the tape touches and pull the tape over and down while pressing the glue along underneath the strain gauge. Hold or clamp tightly for 2 minutes. Pull back the tape and gage should stay put, be careful at this stage not to peel off the gauge or you will need to start over.

Solder wires on each of the gage wires and firmly tape or tie the wires to the beam so that they will not pull on the gages. Connect the wires in a bridge configuration. The strain gauges will provide a very weak signal. You will want to boost this signal to obtain usable results. Connect the bridge to an instrumentation amplifier similar to the one you built in your LVDT lab (see figure 1). Additionally, you may need to apply one or two amplifier stages after the stage shown below in order to boost the signal. Don't be afraid to apply capacitors to your amplifier stages to filter the signal. The computer or voltmeter can be used to record the output voltage of the bridge for different masses hung from the end of the beam. Record several different readings for different applied masses. Obtain a calibration constant for your setup by determining the output voltage to the applied weight ratio.

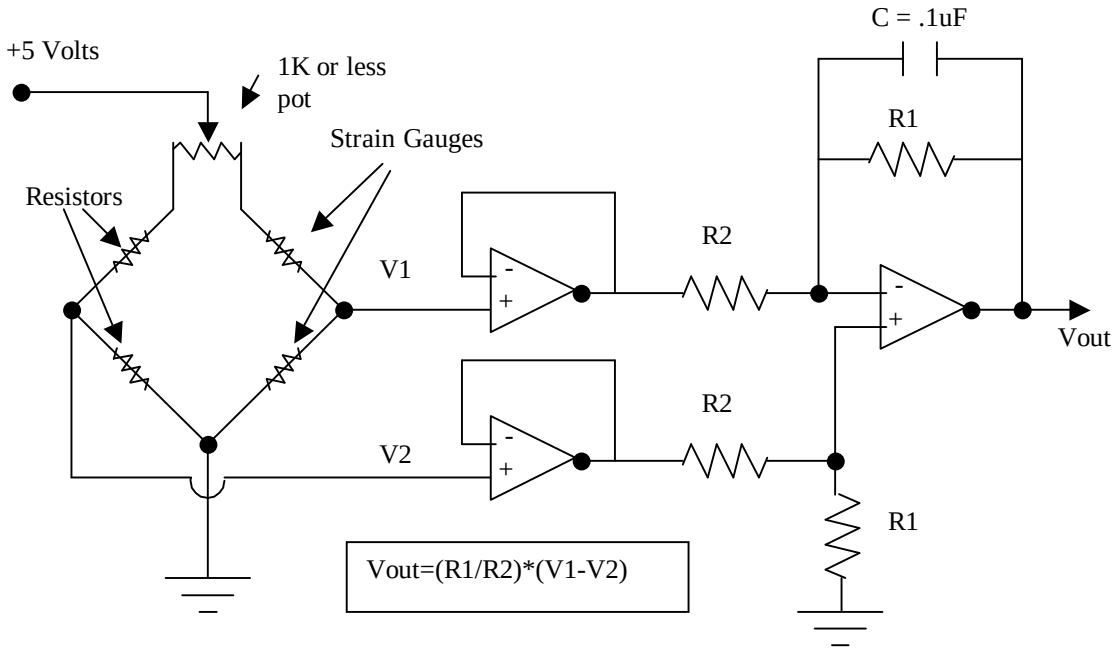

Figure 1. Strain-Gauge and Amplifier Circuit.

REPORT

Reports should include:

1) The transfer function of your force sensor (relationship between the input force, and the output voltage).

2) Plot of the output voltage versus load.

3) An explanation of any anomalies - differences from theory or what you thought should happen.

4) The expected transfer function of your sensor based on the beam strain analysis and theoretical bridge output.