

## Measurement Technology and Uncertainty Analysis – E7021E

### Lab 2

#### Deflection bridges and strain gauges

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##### Introduction

The purpose of this lab is to get acquainted with the principles of deflection bridges and strain gauge type of sensors for measurement of force.

The experimental part of the lab should be done in pairs or in groups of three students. The report, however, should be *written* and handed in individually. Feel free to discuss results and prepare some figures in the group, but make sure you take the time to sit down on your own and formulate the main text of the report. For information on deadline, see the course web page. See guidelines for the report at the end of this document.

# 1 Preparations

Read sections on strain gauges and deflection bridges in the course book (8.1.3 and 9.1).

Do the homework assignments in the next section. Read through the entire lab and make sure you understand what is to be done and how to do it.

## 2 Homework assignments

- Solve problems 8.2 and 8.21 in the course book.
- Given a vector  $\mathbf{y}$  of measured voltages and a vector of loads (in kilograms),  $\mathbf{x}$ , generate the MATLAB code necessary to do a least-squares fit of polynomials of order 1 (straight line), 2 and 3. See `polyfit` in MATLAB.

## 3 Practical lab work

This part of the lab should be done in pairs (or in special cases in groups of three students). Note that all students should write their own reports.

### 3.1 Deflection bridges

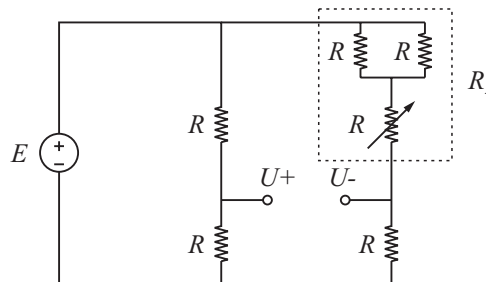


Figure 1: Deflection bridge. All resistances are  $10\text{ k}\Omega$ . The supply voltage should be  $+5\text{ V}$ . The resistance in branch 2 can thus vary from  $5\text{ k}\Omega$  to  $15\text{ k}\Omega$ .

- Build a deflection bridge according to Fig. 1 and connect it to the lab amplifier, according to Fig. 2.
- Measure the voltage,  $U$ , for simple values of  $R_2$  (e.g.  $14\text{ k}\Omega$ ,  $13\text{ k}\Omega$ , ...,  $8\text{ k}\Omega$ , ...). Capture at least 100 measurements for each configuration. Save your data for future use!
- Estimate a polynomial model relating resistance to measured voltage using the results from the homework assignments. Plot the mean of your measured data and the estimated model in the same figure. Use the `errorbar` function to plot a  $2\sigma$  interval of your measured data.
- Compare results with the theoretical value when  $R_2 = 12\text{ k}\Omega$ .
- Discuss differences between practice and theory. Possible reasons for these differences?
- Comment on the linearity of the system.
- What is the sensitivity of the system?

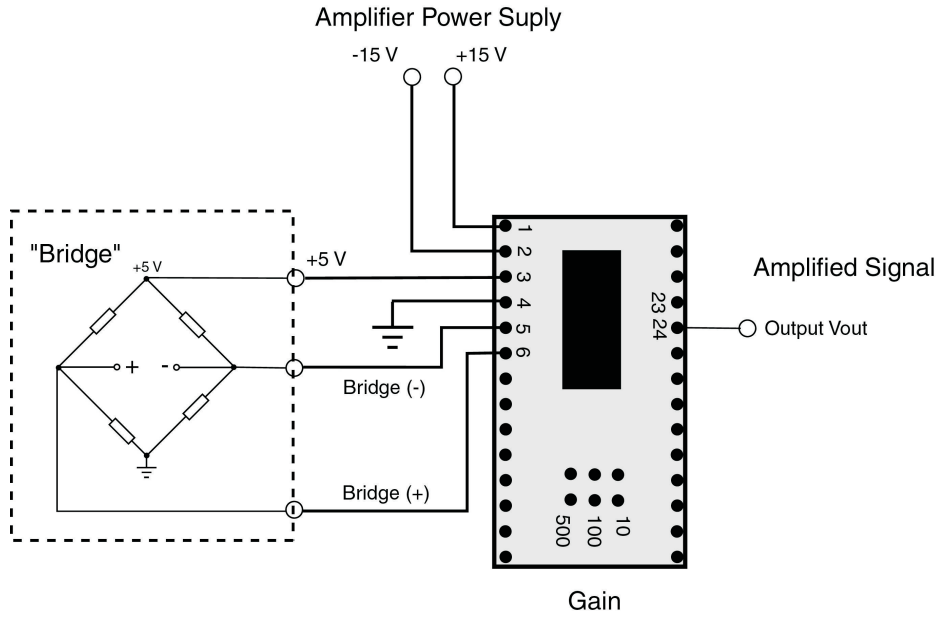


Figure 2: Amplifier circuit for connection to the deflection bridges.

### 3.2 Strain gauges and force measurements

Two strain gauges are mounted on each side of an iron bar. The gauges are connected to a Wheatstone deflection bridge as in the Fig. 3. There is a jumper on the bridge circuit. Connecting it pins 1–2, only the  $G1$  sensor is connected. Connecting pins 2–3, enables both  $G1$  and  $G2$  strain gauges.

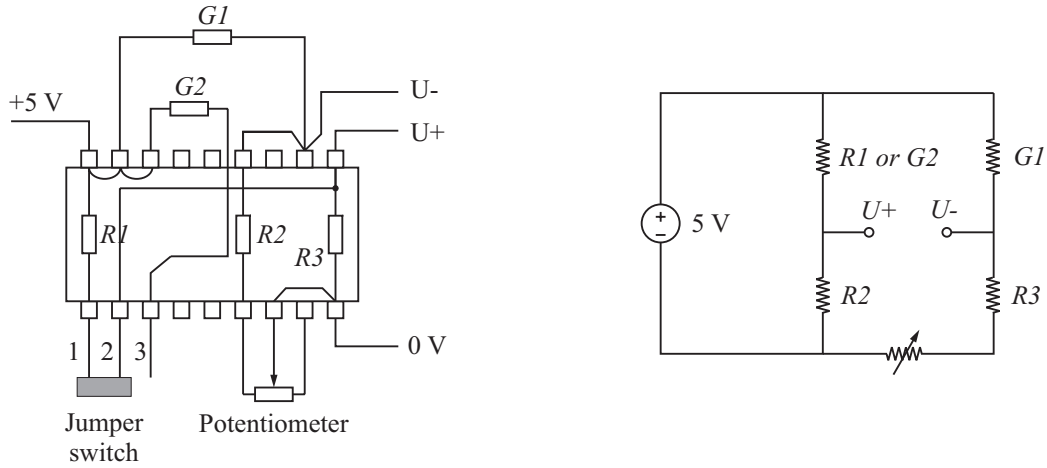


Figure 3: Deflection bridge with two strain gauges,  $G1$  and  $G2$ . With the jumper in position 1–2, only  $G1$  is connected. With the jumper in position 2–3, both  $G1$  and  $G2$  are connected.

- Connect the deflection bridge and the strain gauge sensor to the amplifier in Fig. 2.
- Balance the bridge using the potentiometer.
- Load the strain gauge sensor with 50 g, 100g, ..., increasing the load. Measure (at least 100 points) for each load.

- Decrease the load and measure again. Do you see any hysteresis effects? If so, try to quantify this.
- Implement models in MATLAB that given a the measured voltages give you the load (in kg).
- What is the sensitivity of this force measurement system?
- Discuss the linearity of the system, Can you model the force using a straight line? If not, what polynomial model order do you suggest? How will any hysteresis affect the performance of the different models?

## 4 Useful MATLAB functions

You can use the `help` command in MATLAB to get information on how to use the function. Below is a list of functions that may be useful for this lab:

- `polyfit` and `polyval`
- `errorbar`
- `mean` and `std`
- `plot`, `grid`, `xlabel`, and `ylabel`

## 5 Writing the report

- Write the report so that a person who has not seen the lab instruction can follow the work flow and understand the purpose and all results.
- All figures axes should be labeled and all figures should have a descriptive caption.
- Comment on the figures. What do they tell you? Does it support the assumptions you have made? If not, discuss why.
- Discuss uncertainties, sources of error, etc. This does not mean you have to do the detail uncertainty analysis, but you should do some serious thinking about what is causing errors and uncertainties.
- The report should be written using a modern word processor. No hand-written math or figures will be accepted.