Strain Gage Measurements

OBJECTIVES

(1) Assemble a Wheatstone bridge and use it to measure strain with a strain gage.

(2) Use a Vishay Strain Indicator, computer based VXI system, and a custom made instrumentation amplifier to acquire strain data.

(3) Estimate the uncertainties associated with strain measurements.

BACKGROUND

Measurement of strain is a fundamental tool used by engineers in both research and design. Strain measurements are often used in systems where force or pressure measurements are required. In addition, in some application the strain (and associated stress) of a part can only be determined by measurement, as calculation is either too complicated or not accurate enough. In this experiment, you will learn to use a resistance type strain gage to measure strain in a loaded cantilever beam. In this case, it is possible to compare the strain measurements with calculated values.

Associated with the strain gage is a measurement system. With a resistance type strain gage, strain is measured by detecting the change of resistance in the gage as it undergoes deformation, which is assumed to be the same as the deformation in the specimen. The change of resistance is very small – so a Wheatstone bridge is typically used to convert a resistance change to a voltage signal as described in class.

In this laboratory, you will assemble a Wheatstone bridge circuit and measure strain for a series of loads on one cantilever beam. Then you will use a data acquisition system (workstation/VXI system which includes a Wheatstone bridge circuit internally) to measure the strains for the same series of loads.

PREPARATORY EXERCISES

(1) Use your strength of materials experience to obtain the equation for strain on the top surface of a cantilevered beam of rectangular cross section, given a load at the end.
   (a) List the geometrical measurements needed to calculate this strain.
   (b) List the material properties needed to calculate strain.
   (c) Show how to estimate the uncertainty on the calculated strain based upon the uncertainties of the measured quantities.

(2) Use the null method equation to calculate the change in voltage for a strain of 18 microstrain and of 255 microstrain. Use $GF = 2.14$, $E_i = 4.7$ volts. This is good to do before going to the lab so you know what range of voltage to expect.

LABORATORY EQUIPMENT

(1) Strain gages mounted a cantilevered bar.
(2) One 120 Ohm and two 350 Ohm resistors.
(3) Breadboard and instrumentation amplifier from last lab.
(4) Vishay strain indicator
(5) Constant voltage power supply.
(6) PC with IEEE488 card.
(7) VXI data acquisition system.
(8) HP 1411B 5 1/2 Digit Multimeter.
(9) HP E1351-66201 16 Channel FET MUX.
(10) HP E1355A Strain Gage Muliplexer

LABORATORY INSTRUCTIONS

(1) **Calculate** the strain at a strain gage for three different weights for the beam at your table. **Record** all the measurements that you used to calculate the strain. Estimate and record the uncertainty of each of these measurements.
(2) Measure the strain for the same loads and at the same gage that you made the calculations for in step one using the yellow **Vishay** “lunch box” strain indicator. Record and compare to the calculated values.
(3) Measure the strain for the same loads and at the same gage that you made the calculations for in step one using the **VXI** and a LabView program provided. Record and compare.
(4) Build a Wheatstone bridge on your breadboard from last week. Use two 350Ω presicion resistors for one side of the bridge and the two strain gages for the other side of the bridge. Your T.A. will sketch a circuit diagram on the marker board.
(5) Obtain the resistance and gage factor of the strain gages from your instructor.
(6) Connect the output voltage of the Wheatstone bridge to the input of your instrumentation amplifier.
(7) Take strained and unstrained readings from the instrumentation amplifier as a succession of weights are added to the end of the beam (say from 1000g to 2000g, increment 200g).
(8) Convert the voltage readings to strain readings.
(9) Observe how temperature changes of the **completion resistors** influences the output of the bridge. Ask your T.A. how to perform this test.
(10) Make voltage measurements to obtain the common mode voltage of your Wheatstone bridge circuit. Your T.A. can advise you on these measurements.

CALCULATIONS

Graph the strains calculated from the three different strain measurement and the strain calculated from bending theory as a function of applied load. Use data points for each measured strain and a solid line for the calculated strain. Estimate the precision error of your **calculated** strain values by applying the RSS method. Mark (by hand) a few error bars on the solid line that is on the graph.

DISCUSSION QUESTIONS

(1) Discuss the VXI method for strain measurements. Where are the bridge completion resistors located? Does the VXI use the null method or the deflection method? Print out the main VI and/or sub VI's that show the strain calculations – comment on these calculations.

(2) What are some of the limitations of the resistance change type strain gage, i.e., what are some factors which will cause the gage to give readings which are inaccurate?

(3) Describe an engineering application where you would use a strain gage. How would you make the strain readings? With the VXI, the Vishay box, or with an instrumentation amplifier?

Laboratory Grading Form

Specific Item	*Possible*	*Ntbk*
Table of Contents	2	
Experiment Titled	3	
Preparatory Exercises	10	
Your Objectives	5	
Date, Time, Place, Amb. Conditions	5	
Apparatus/Equipment Sketches. Make the sketch such that you could set up this experiment from you notebook.	10	
Equipment Description. Write a sentence for each piece of equipment – to describe what it was used for.	10	
Lab Procedure that you did. Record the steps that you made, data that you took, and any comments that would help you conduct this type of work in the future. Do not just paste in the given procedure.	10	
Calculations	20	
Discussion of Results	10	
Discussion Questions	10	
Organization and Readability	5	
Total		