Calibration of strain gages

Equipment: Instrumentation amplifier, strain gage, bridge completion box. spring steel strip, PMMA curvature block, power supply, digital voltmeter, solder iron and soldering accessories, strain gage cement and accessories, sand paper, vernier caliper. calculator.

準備事項：(1) 帶游標卡尺; (2) 複習黏貼應變計方法與注意事項; (3) 研習 Wheatstone bridge 相關原理，並回答下面 Theory 一節的問題； (5)複習梁之彎曲理論，請預先計算一厚度為 *t* mm, 曲率半徑為 *R* mm 之梁，其表面應變為若干。

Theory:

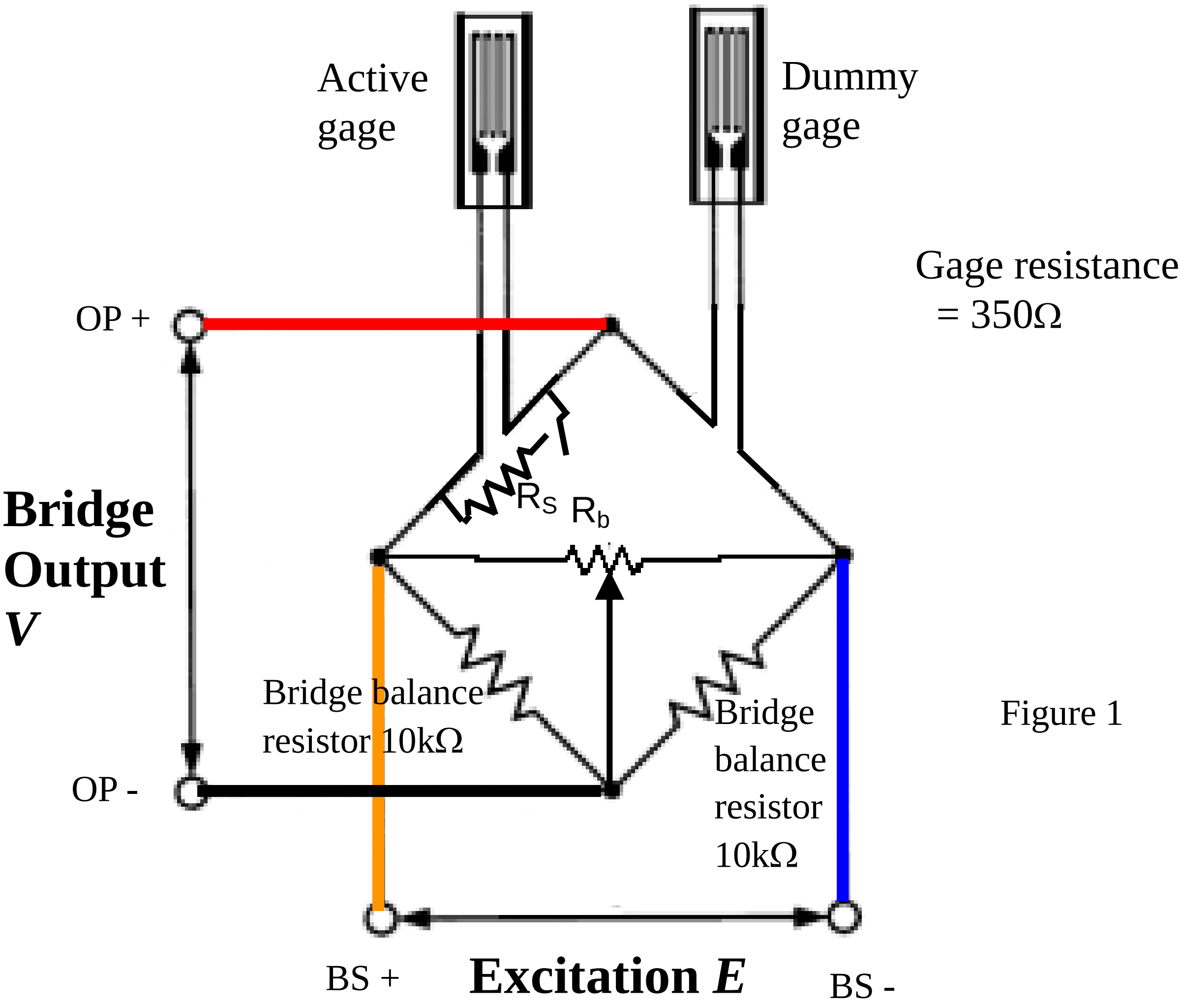

Figure 1

預習報告：

1. Suppose R_b and R_s are non-existent, what is the relationship between the Bridge output voltage *V*, Excitation *E* and the change in resistance ΔR_g in the active gage.
2. What is the gage factor? In the absence of R_b and R_s, what is the relationship between the Bridge output voltage *V*, Excitation *E* and the strain ε sensed by the active gage?
3. The bridge balance resistors provided are 10 kΩ, *Can they have different values?*
4. What is the use of R_b in the bridge circuit in Figure 1? Please briefly explain the underlying principle.
5. What is the use of R_s in the bridge circuit in Figure 1? Please briefly explain the underlying principle.
6. Suppose R_s =100kΩ and the bridge is initially balanced. What will the bridge output voltage become if R_s is shunted across the active gage.
7. What happen if +ve and –ve bridge excitation voltage are interchanged?
8. What happen if the bridge output and bridge excitations are interchanged (ie. OP+ is interchanged with BS+ and OP- is interchanged with BS-)?
9. What is the relation between the surface strain, radius of curvature, Young's modulus and the thickness of a beam under bending?

Experimental procedures

Installing the strain gage

1. Use sand paper for cleaning and abrading of the spring steel strip.
2. Clean the abrading debris thoroughly with cotton and acetone.
3. Measure the thickness of the section where you are going to stick the strain gage with a vernier caliper.
4. Mark off the gage alignment lines using light scribing or burnishing with a 4H pencil.
5. Degrease and clean again with acetone, then with iso-propyl alcohol (IPA). Do not touch the surface with finger any more from now on.
6. Use tweezers to take out the strain gage and terminals and position them against the alignment lines. Fix the relative position of gage and bondable terminals to the strip using low tack cellophane tape. The metal foil grid should face up. One end of the cellophane tape should be fixed to the strip. The other end rolled up to expose the backing sheet. (refer to the lecture notes)
7. Apply a small drop of CN glue to the backing sheet of the strain gage and terminals. Too much glue will give a weak bond.
8. Stick the cellophane tape back in place. Place a plastic sheet over the strain gage position and

press hard on it for one minute to squeeze out any excess glue.

9. Remove the cellophane tape carefully. Stick a section of cellophane tape (pink) between the gage and the terminals to act as insulator (see figure 2). Solder the lead wires between the gage and the terminals. Stick another section of tape (orange) on top to fix and protect the lead wires. During soldering, the soldering iron tip must be clean and shiny to enable a good joint. The resulting solder joint should wet the wire thoroughly and is also shiny.
10. Cut away suitable length of plastic sleeves to expose the metallic connecting wires. Take two to three strands of the copper wire. Solder the connecting wires to the other ends of the terminals. Use cellophane tape to fix the connecting wire to the steel strip.

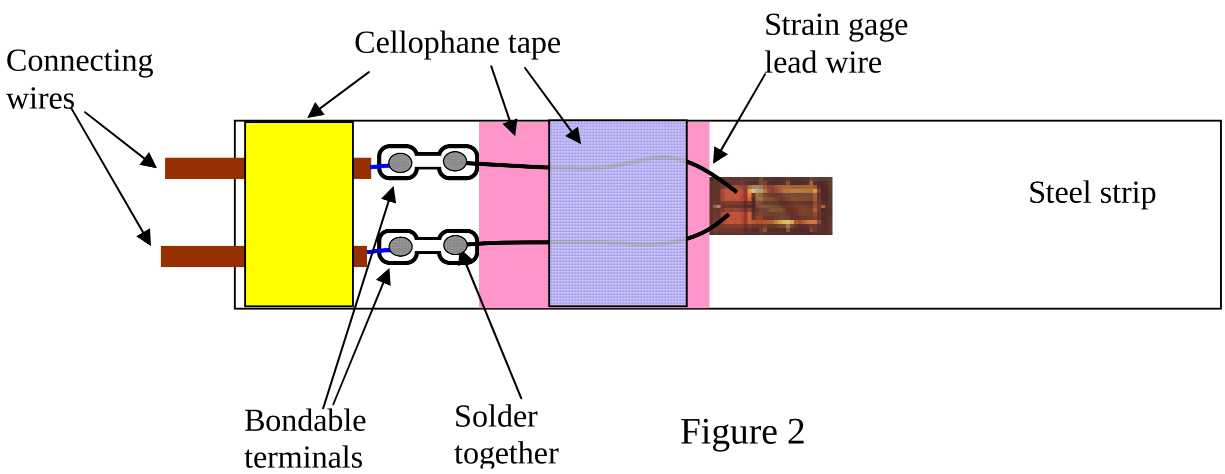

Figure 2

Completing the Wheatstone bridge

1. The gage you just stuck is the active gage. A dummy gage, two bridge balance resistors, R_b and R_s are provided in a bridge completion box. Layout of the box is shown in figure 3. Use these to build up the Wheatstone bridge as shown in figure 1 and connect the bridge outputs to your instrumentation amplifier (IA) inputs as in fig.4 . Use Channel 3 of the power supply for bridge excitation. Remember to connect the ground of Channel 3 to the ground of the IA
2. Connect power supply to your instrumentation amplifier. Do this by switching on the main power button, adjust for the correct voltage (± 12V) on both supplies, then press the output button on the power supply to apply the voltage.
3. Use a digital voltmeter (DVM) to measure the output from your instrumentation amplifier.

Measuring Procedures:

1. Strip bending calibration

1. ***Does the DVM read zero when your steel strip is freely lying on the table? If not, why not?***
2. Zero your strain gage output by adjusting the potentiometer R_b. Before adjustment, press your spring steel strip flat on the top surface of the PMMA block.
3. Now press your spring steel strips against one of the edge of the triangular PMMA block. Record the reading on the DVM. Calculate the strain on the strip using the elementary beam bending theory. ***What is the relation between this DVM reading and the strain?***
4. Repeat the above step three times. Are the measured results the same? Why?
5. With the information from point 3, what readings will you predict if the strip is pressed against the other two edges of the PMMA block. Go ahead to check it. Discuss your results.

2. Shunt calibration

1. Zero your bridge output as before with your spring steel strip lying freely on the top flat surface of the PMMA block.
2. Momentarily press the shunt resistor switch to connect a 100kΩ precision resistor in parallel with your strain gage. Note the DVM reading.
3. With your results in the last section, how much apparent strain has been created by shunting your gage with the 100kΩ precision resistor?
4. Try to compute the gage factor of your strain gage.

3. Strain gage amplifier characteristics

1. Zero your strain gage output by adjusting the potentiometer R_b. Before adjustment, press your spring steel strip flat on the top surface of the PMMA block.
2. Now press your spring steel strips against one of the edge of the triangular PMMA block. Record the reading on the DVM (V_a). Repeat your measurement thrice.
3. Interchange the bridge excitations (ie. BS+ is interchanged with BS-). Repeat Step 2 and let the reading be V_b.
4. Leave the bridge excitation connections as above, interchange the bridge output (ie. OP + is interchanged with OP -). Repeat Step 2 and let the reading be V_c.
5. Leave all connections as above. Press your spring steel strip flat on the top surface of the PMMA block. Now perturb the "Zero" by adjusting the potentiometer R_b to a random position so that the output voltage is <0.5V. Record your output reading (V_{01}). Now repeat Step 2 and get the reading V_d. Can you find some relation between V_c, V_d and V_{01}?

6. Repeat Step 5 but increase the “Zero” reading to >0.5V but <1V. Get V_{02} and V_e.
7. Repeat the above step, each time increase your “Zero” reading by above 0.5V. (V_{03} and V_f, V_{04} and V_g,…). In each case, discuss the relation between measured output, new “Zero” reading and the original V_c in step 4?
8. Draw up a conclusion about the connection polarities and about the effect of zeroing.

Report:

Write up a report detailing the aim, theory, procedures, results and discussion of your work. Pay particular attention to the questions in ***italic*** above. Draw up a suitable conclusion for your report.

1. Strip bending calibration

	Edge 1	Edge 2		Edge 3	
Reading 1 (V)					
Reading 2 (V)					
Reading 3 (V)					
Average (V)					

2. Shunt calibration

	DVM output	Gage factor
Reading 1 (V)		
Reading 2 (V)		
Reading 3 (V)		
Average (V)		

3. Strain gage amplifier characteristics

	V_a	V_b	V_c	V_{01}	V_d	V_{02}	V_e	V_{03}	V_f	V_{04}	V_g
Reading 1 (V)											
Reading 2 (V)											
Reading 3 (V)											
Average (V)											

Expand the table to hold your readings.

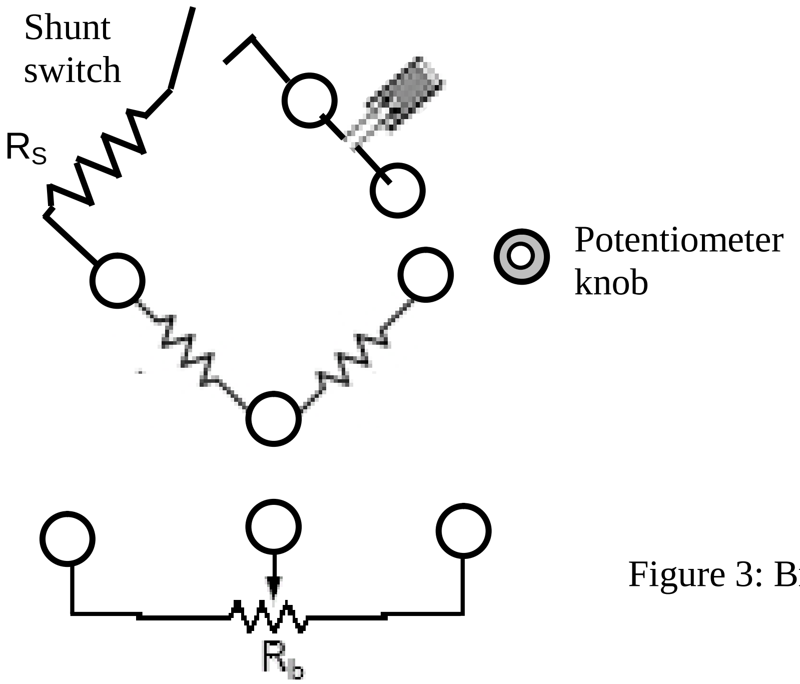

Figure 3: Bridge completion box layout.

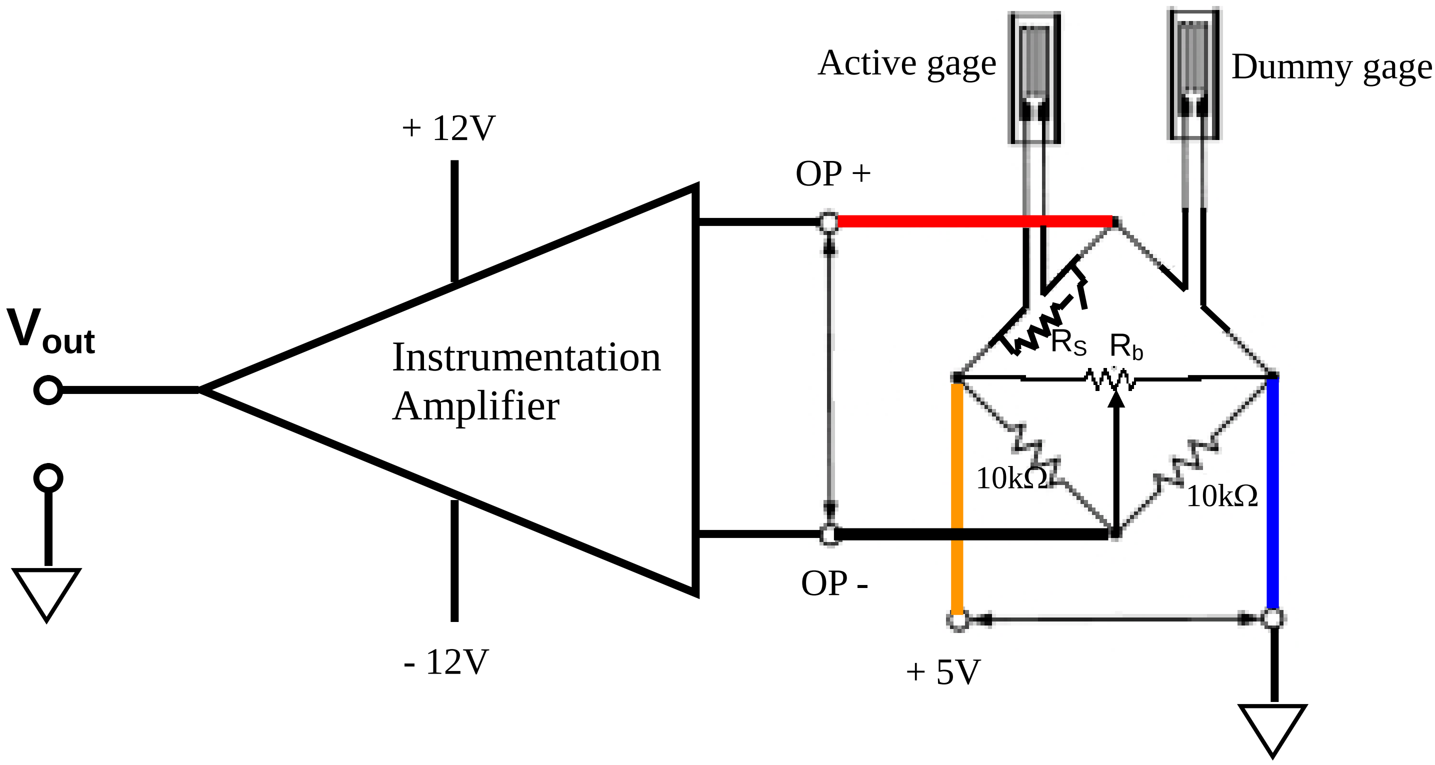

Figure 4: Circuit for strain read out.