Fabrication and calibration of a load cell

Equipment needed: Instrumentation amplifier, strain gages, bridge completion box, channel section load cell, load cell gripping accessories, power supply, digital voltmeter, solder iron and soldering accessories, strain gage cement and accessories, sand paper, dead weights. **（請帶備可以工作的 instrumentation amplifier，或向其他同學或助教借用。）**

預習：(1) 應變計黏貼與焊接程序與注意事項; (2) Wheatstone bridge 理論及應用 (3) load cell 基本構造與原理。 （以上皆可從上課講義中找到）

預習報告:

1. Load cells normally employ a spring element to convert the applied force into strain. What are the fundamental designs of these spring elements commonly used? Explain their working principles briefly.
2. In this experiment, we use the spring element as shown in figure 1. The strain gages are laid out as shown (numbers indicate their position in the bridge circuit in figure 2):
   a. Explain how such lay-out can give an output proportional to the applied load P.
   b. If the applied loading P departs from the centerline of the hole, will the bridge output be affected?
   c. Do you still need a bridge balance resistor R_b and shunt resistor R_S? Why or why not?
3. Can you suggest at least one other layout for strain gage that can allow the applied load P to be measured. Compare the advantages and disadvantages between your layouts and the layout shown in figure 1.

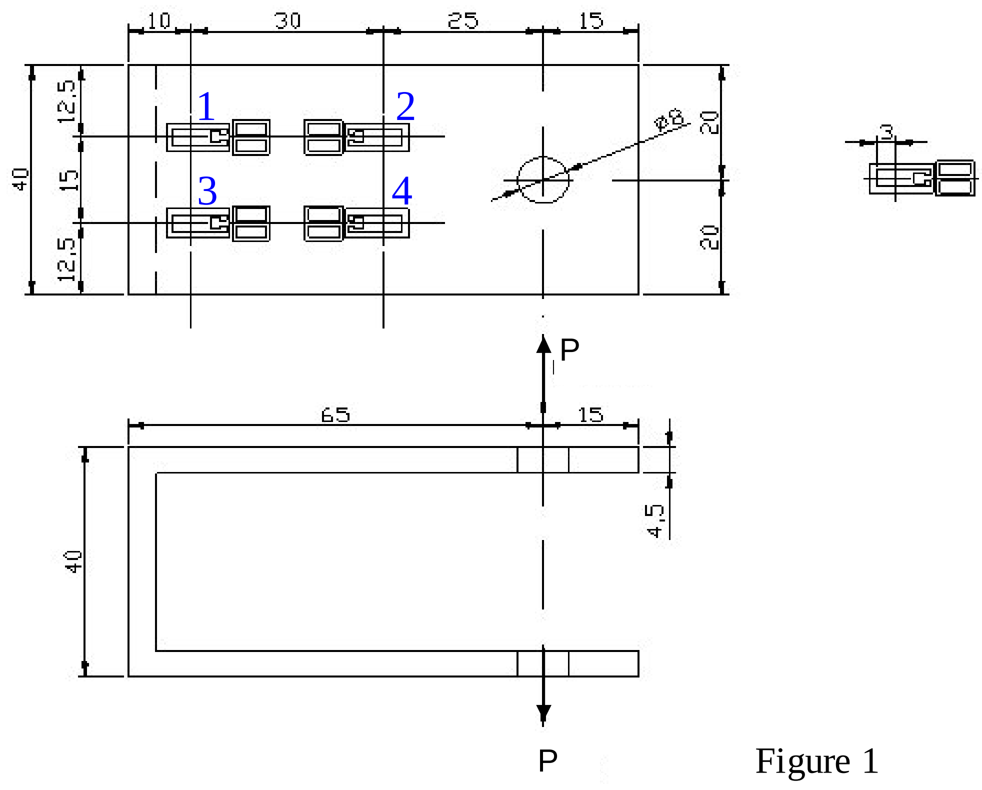

Figure 1

Installing the strain gage:

4. Use sand paper for cleaning and abrading positions for strain gage installation (see fig.1).
5. Clean the abrading debris thoroughly with cotton and acetone.
6. Mark off the gage alignment lines using light scribing or burnishing with a 4H pencil.
7. Degrease and clean again with acetone, then with iso-propyl alcohol (IPA). Do not touch the surface with finger any more from now on.
8. Use tweezers to take out the strain gages and terminals and position them against the alignment lines. Fix the relative position of gages and 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. (see figures in the lecture notes)
9. Apply a small drop of CN glue to the backing sheet of the strain gage and terminal. Too much glue will not bond.
10. 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.
11. Remove the cellophane tape carefully.
12. Solder lead wires from the strain gages to one side of the terminals. Also solder connecting cables to the other side of the terminal. (Remember the unacceptable soldering results mentioned in the lecture notes).
13. Check gage resistance (350Ω) and inspect for unacceptable bonding conditions. Correct all errors before connecting to the bridge and instrumentation amplifier circuit

Completing the Wheatstone bridge:

1. Build up the Wheatstone **full** bridge as shown in figure 2. Use the bridge connection box if necessary. Use systematic color code for the wires!

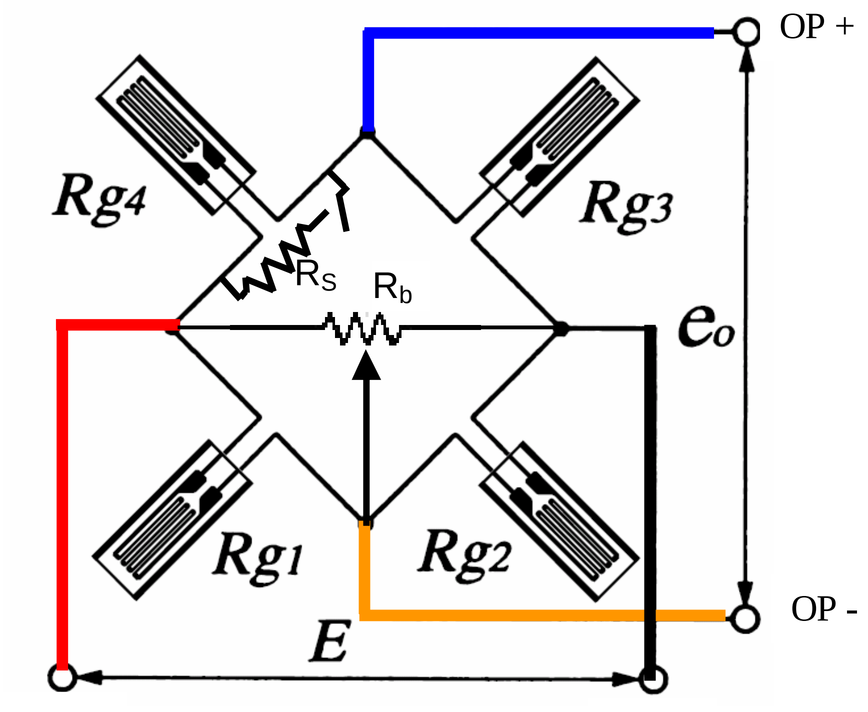

Figure. 2

2. We used a full bridge here but we still need the 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 *Why should we need R_b and R_s ?*
3. Before connecting to the instrumentation amplifier, check resistance across any two of the four connecting wires to make sure you have wired up the bridge correctly.
4. Connect +12V, 0V and -12V power supply to the instrumentation amplifier. Do this by switching on the main power button, adjust for the correct voltage on both supplies, then press the output button on the power supply to apply the voltage.
5. Use a digital voltmeter (DVM) to measure the output from the amplifier.
6. ***What happen if BS+ and BS- are interchanged*****, try doing this and record your observation?**
7. ***What happen if the OPs and BSs are interchanged*** **(*ie. OP+ is interchanged with BS+ and OP- is interchanged with BS-*), try doing this and record your observation?**

Calibration Procedures:

1. ***Does the DVM read zero when the load cell is freely lying on the table? If not, why not?***
2. Hang your load cell up to the support provided. Zero your amplifier output first before applying any load. ***Why we should not zero the output before hanging up the load cell?***
3. Apply the dead weights provided incrementally. Record the applied weight and the strain amplifier output. ***What is the relation between this DVM reading and weight?***
4. After loading up using all the dead weights, do an unloading calibration. You may repeat the loading and unloading calibration as many times as time allows. Plot the DVM output versus applied loading. Discuss the reproducibility during different cycles of loading and unloading. How do you check the linearity of your load cell?
5. *If we do not have the calibration equipment the next time we use the load cell with the current circuit, is there any way to confirm that the current calibration is still applicable? Try using the shunt resistor to help!*

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 suitable conclusions for your report.

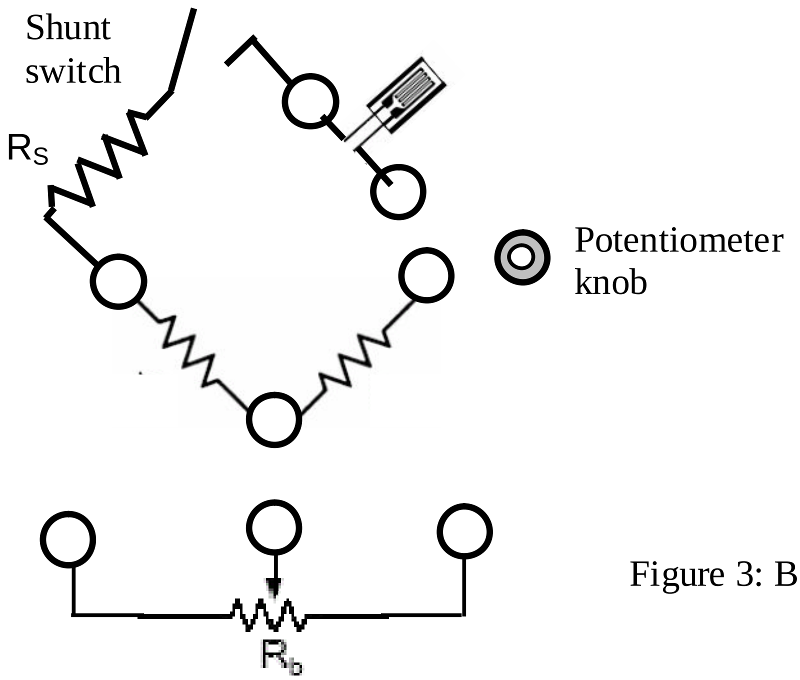

Figure 3: Bridge completion box layout.

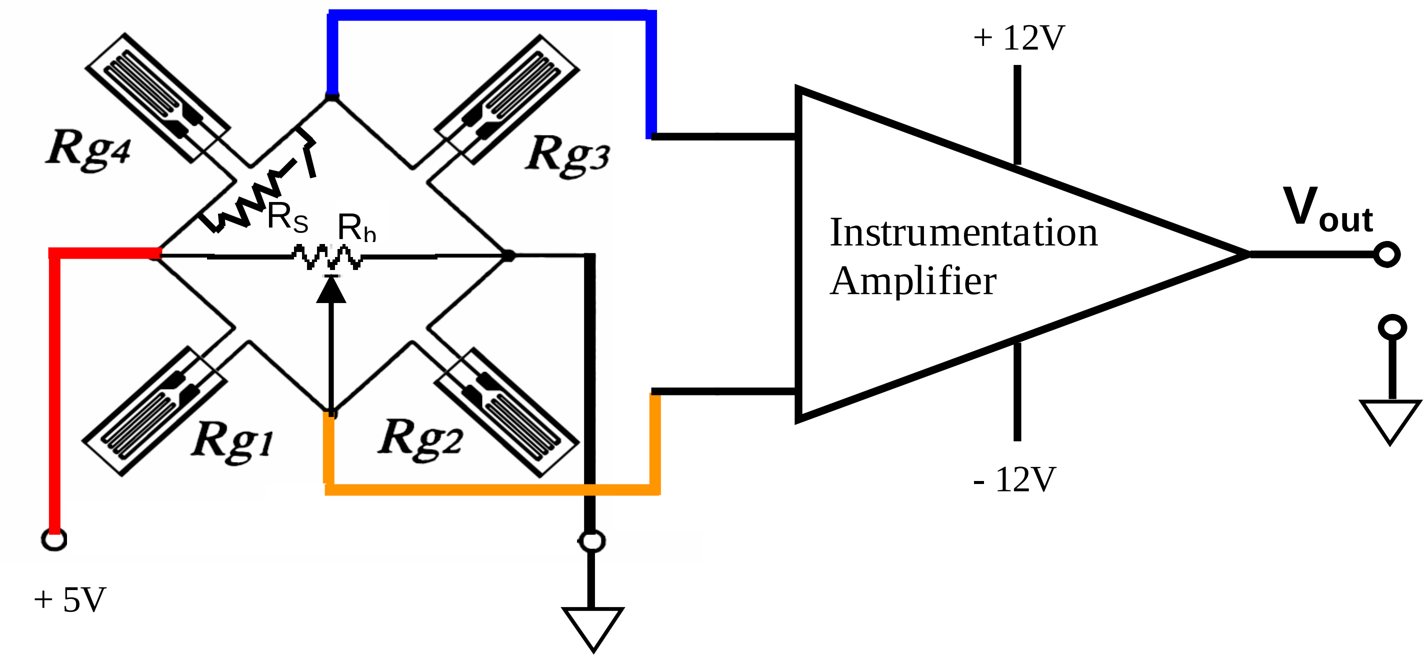

Figure 4: Circuit for load cell signal read out.