In-Lab Exam
Optical Tachometer
Procedure

Deliverables: checked notebook, checked circuit, oscilloscope screen shot (attached to email) and fan parameters (typed in body of email) submitted to lab instructors and TA via email

Exam Rules

This is an in-lab final exam designed to test your *individual* laboratory skills. **You have 50 minutes to perform the procedure, make the deliverables, and email them to your TA and lab instructors.** You are to make an entry into your lab notebook as you have been doing through out the semester. Your lab notebook entry *must* follow the lab notebook guidelines posted on the resources page of the course website (https://www3.nd.edu/~prumbach/AME20216/resources/notebook_guidelines.pdf).

When you have the system working or the 50 minutes is up, you must email the deliverables to the TA and lab instructors, then have one of them check your setup and sign your lab notebook. (See Data Analysis and Deliverables section for details).

Optical Tachometer

For this in-lab exam, you will build an optical tachometer to measure the speed of a small computer fan using circuits from the A3 and A8 labs. The tachometer will consist of a green LED light aligned with a CdS photocell. The transient output voltage of the photocell circuit will be measured with the oscilloscope to determine the blade passage rate and ultimately the fan speed in RPM. The entire system will be constructed from scratch on a breadboard.

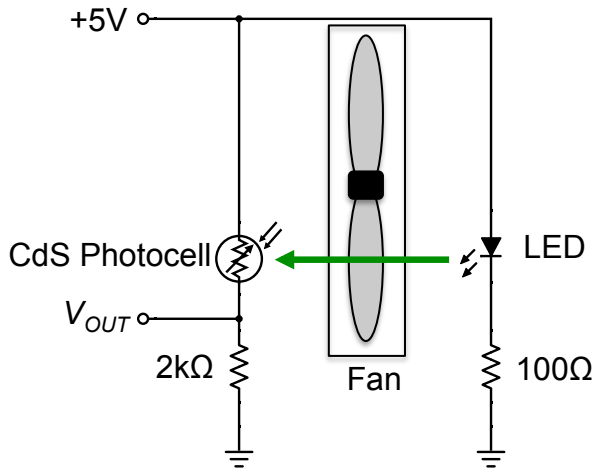

Figure 1 - A schematic drawing of the optical tachometer. (The +12V connections for the fan have been omitted.)

Procedure

1. Turn on the breadboard. Use the handheld DMM to verify that the +5V and variable +15V DC power supplies are working. Let the instructor know immediately if they are not functioning properly.
2. Sketch the schematic shown in Fig. 1 in your lab notebook.
3. Count the number of blades on the fan. How many blades per revolution are there? Write down the number in your lab notebook in units of blades/revolution.
4. Write down the complete part number of the fan, which located directly beneath the green stripe on the center of the fan. The part number should match one of the following:
   a. KDE1205PFVX
   b. MB50101V2-000U-A99
   c. ME50101V1-000U-A99
5. Using the breadboard, construct the CdS photocell voltage divider circuit shown on the left side of Fig. 1. Use a multimeter to test it and make sure it works.

   Pro-tip: Measure each resistor before you place it in your circuit to make sure you have the correct value.
6. Construct the LED circuit shown on the right side of Fig. 1 on the breadboard adjacent to the CdS photocell. Bend the LED and CdS photocell, such that the lens on the top of the LED is facing the CdS photocell. Make sure you leave space for the fan to fit in between. Test it to make sure it works.
7. Set the breadboard's variable +15V DC power supply to +12V. Use it to power the fan. Make sure you can turn the fan on and off by adjusting the appropriate knob on the breadboard.
8. Connect the output of the photocell voltage divider circuit V_{OUT} to CH1 on the oscilloscope.
9. Place the fan in between the photocell and LED, so that the light from the LED passes through the blades to the photocell, as shown in Fig. 1. (Scotch tape is available to hold the fan in place.)
10. Press the yellow CH1 button to bring up the CH1 menu. Set it to "AC coupling".

    Pro-tip: Turn off the light on the lab bench, so it does not interfere with the optical measurement.
11. Adjust the vertical and horizontal scale on the scope until you can see a waveform on CH1. The signal should have an amplitude of at least 10mV pk-pk with a timescale ~1 ms.
12. Adjust the trigger level knob to stabilize the signal.
13. Use the "Measure" feature to measure the frequency of CH1. This will be the "blade passage rate" in units of blades/sec. (Alternatively, you may use the cursors to measure the period if you prefer.) Write the frequency or period down in your lab notebook. Be sure to include units.

14. Take a screenshot of the waveform on the oscilloscope.
    a. Insert the thumb drive into the oscilloscope.
    b. Press the "menu" button below the screen, and press "Save screen image" then "OK" to save a screenshot to the thumb drive.
    c. Make sure the screenshot shows the frequency or period of the signal.
    d. Transfer the screenshot to your laptop or computer. (The oscilloscope screenshot has a timestamp on it, so no funny business!)
    e. Let the instructor know if the time and date are incorrect on the oscilloscope.
15. **Delete the screen shot from the thumb drive** after you have transferred it to your computer.
16. Turn off the breadboard and examine the fan. In your lab notebook, calculate the fan speed in RPMs. Make sure the units all work out correctly.
17. Email your results to your lab TA, Prof. Rumbach, and Prof. Ott for grading. See the "**Data Analysis and Deliverables**" section for details.
18. **IMPORTANT:** Ask the lab instructor to grade your circuit and lab notebook. **Do NOT take apart your set-up until it has been graded.**
19. Return the lab bench to its initial state:
    a. Press the "Default Setup" button on the oscilloscope.
    b. Disassemble the experiment.
    c. Return all resistors to the appropriate bins.
    d. Return the thumb drive to the lab instructor.

Data Analysis and Deliverables

Please email the following deliverables to your lab section TA, Prof. Ott, and Prof. Rumbach—**all 3 of us**—with the subject line "LAB FINAL – AME20216". A list of the TA email addresses can be found in Appendix B.

1. A **screenshot** of the signal on the oscilloscope with the frequency measurement and the correct time and date stamp in the bottom right corner. (Attach it to the email.)
2. In the body of the email, type the **lab bench station number** where you were performed the experiment (i.e., "Station 6").
3. In the body of the email, type the **measured fan speed in RPM**.
4. In the body of the email, type the **part number of the fan**, which located directly beneath the green stripe on the center of the fan. The part number should match one of the following:
    a. KDE1205PFVX
    b. MB50101V2-000U-A99
    c. ME50101V1-000U-A99

Appendix A

Equipment Required

- Tek DPO3012 oscilloscope
- BNC to minigrabber cable
- Digital multimeter with minigrabber leads
- Breadboard with jumper wires
- Resistor kit (normally on lab bench)
- CDS Cell 520nm 4 ~ 11 kOhms @ 10 lux (Digikey # PDV-P8101-ND)
- Green LED (Digikey # TLPG5600-ND or TLCPG5100-ND)
- Computer fan, 50X10MM, 12VDC WIRE (Digikey # 259-1548-ND)
- Computer fan, 50X10MM, 12VDC WIRE – (Digikey # 259-1543-ND)
- Computer fan, 50X10MM, 12VDC WIRE – (Digikey # 259-1356-ND)

Appendix B

TA Contact Info

Lab TAs

Tues. 11:00 – 1:00 – Alin Stoica, astoica@nd.edu

Tues. 3:30 – 5:30 – Haley Marco, hmarco@nd.edu

Weds. 11:30 – 1:30 – Aubrey Denico, adenico@nd.edu

Weds. 3:00 – 5:00 – Nicholas Adrian, nadrian@nd.edu

Thurs. 11:00 – 1:00 – Will Jordan, wjordan2@nd.edu

Lab Instructors

John Ott – jott@nd.edu.

Paul Rumbach – prumbach@nd.edu