Faculty of Health, Science & Technology
School of Engineering, Computing & Mathematics

OXFORD BROOKES UNIVERSITY

Assessment cover

STUDENTS, PLEASE COPY THIS PAGE AND USE AS THE COVER FOR YOUR SUBMISSION

Module No:	ENGR4003	Module title:	Engineering Design and Practice I (Electronics)	

Assessment weighting:	**20%**	Assessment title:	Measuring the speed of a Stirling engine	

Banner assignment identifier	*CWS2WEEK09*	Due date and time:	**23-03-26, 13.00**

Estimated total time to be spent on assignment:	*30 hours per student*

LEARNING OUTCOMES

On successful completion of this assignment, students will be able to achieve the following learning outcomes (LOs): *LO numbers and text to be copied and pasted from the module handbook*
LO 1 Use mathematical skills to solve various problems in engineering, concisely summarise and describe the process and findings from laboratory experiments in the form a report based on first hand practical experience gained during the module
LO 2 Design, understand and critically analyse electrical and electronic circuits and system architecture when provided with a particular problem
LO # and text

FOR ENGINEERING ONLY
Engineering Council AHEP4 LOs assessed (from S1 2024/25 Onwards)
LOs copied and pasted from the AHEP4 matrix (add rows as required)

LO number	LO text
B1	Apply knowledge of mathematics, statistics, natural science and engineering principles to broadly defined problems. Some of the knowledge will be informed by current developments in the subject of study
B2	Analyse broadly defined problems reaching substantiated conclusions using first principles of mathematics, statistics, natural science and engineering principles
B3	Select and apply appropriate computational and analytical techniques to model broadly defined problems, recognising the limitations of the techniques employed
B4	Select and evaluate technical literature and other sources of information to address broadly defined problems
B12	Learning outcome achieved at previous level of study
B17	Learning outcome achieved at previous level of study

Statement of Compliance
By submitting this assessment I declare that the work submitted is my own and that the work I submit is fully in accordance with the University regulations regarding assessments. *(6. Assessment and progression - Oxford Brookes University and 4. Conduct and engagement - Oxford Brookes University)*

Use of AI Tools: You are required to use this form to declare which AI tools you have used and how you have used them. Please complete the form and attach it to your submission as an Appendix, if you have used such tools.

FORMATIVE FEEDBACK OPPORTUNITIES

Formative feedback will be provided during labs and seminar sessions.

SUMMATIVE FEEDBACK DELIVERABLES

Deliverable content and standard description and criteria	**Weighting out of 100%**
Experiment report: This includes the method, results and a brief discussion and conclusion, and references. Evaluate personal learning and development in terms of technology using hardware and group work.	**45%**
Practical circuit limitations and improvements: Discuss the limitations of the photo-sensor circuit of Figure E2.21 and suggest improvements to tackle these limitations. Justify your ideas.	**30%**
Alternative sensors: Propose alternative ideas for measuring the speed of this Stirling engine. State just one type of alternative sensor you could use and explain with a diagram. Discuss its relative advantages and disadvantages to the one you used in the lab.	**25%**

RUBRIC OR EQUIVALENT (BELOW)

The marking grid can be found on the Moodle page.

Part A

The method for measuring the speed of the Stirling engine can be shown through the step by step guide

Step by Step

Step	Instruction
1	First step is to heat the water by using a kettle (1)
2	Connect the power supply to Sensor (2)
3	Connect the Oscilloscope to the sensor (3)
4	Set the sensor onto the clamp so that it can read the rpm from the Stirling engine (4)
5	Finally set the power supply to seven volts
6	Set up oscilloscope and ensure oscilloscope is recording results correctly
7	Then run test and store result

This can be shown through figure 1,2 and 3

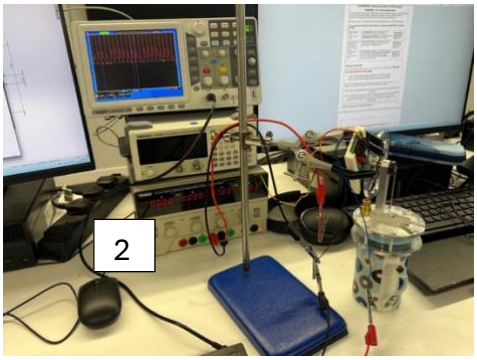


Figure 1 – Shows the power supply to sensor (labelled)

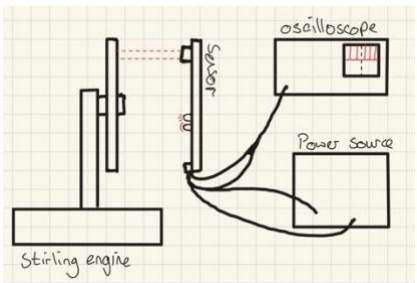


Figure 3– Drawing to further illustrate the design

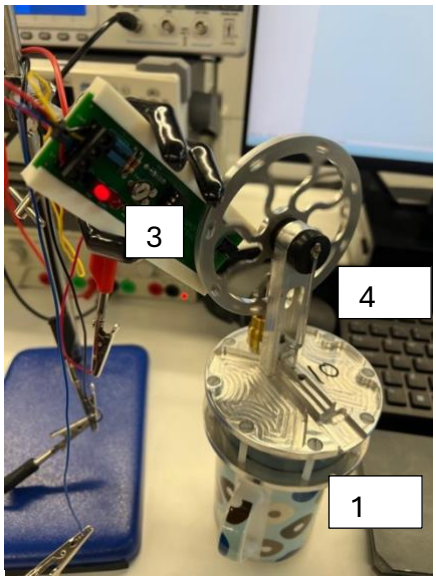


Figure 2 – Setup showing the optical sensor aligned with the Stirling engine

Results

Max Frequency Measured (Hz)	Max Frequency (Hz)	Revolutions per minutes (RPM)
31	3.875	232.5
35	4.375	262.5
36	4.5	270
37	4.625	277.5
32	4	240

These results are found by using the calculation

$$\text{RPM} = \frac{\text{Frequency}}{\text{number of pulses per revolution}} * 60$$

Number of pulses per revolution = 8

The frequency was found from the oscilloscope.

The average RPM is 256.5. This is done by:

$$\text{Average RPM} = \frac{\text{Average Frequency}}{\text{number of pulses per revolution}} * 60$$

This shows the results were consistent indicating the sensor is reliable. Although there are some small variations. This could be due to alignment issues.

Evaluate personal learning and development in terms of technology using hardware and group work.

The personal learning as the group went well as we were able to set up the equipment efficiently and as a team. In this test it allowed for the learning of how to measure the speed of the Stirling engine. This was done by using a red-light sensor and oscilloscope to measure the spokes of the Stirling engine model. The gap between the spokes allowed us to work out the frequency and then the rpm. This displayed how using technology it allowed us as a group to figure out what the RPM is and how this could be used in other applications.

Part B

One limitation of the photo-sensor circuit in Figure E2.21 is the use of 5% tolerance resistors. This means that there is a potential for inaccuracy. The way to fix this would be to use a 1% resistor as it will increase the accuracy (Jain, J, 2026). However, a 1% resistor does cost more than a 5% (Jain, J, 2026). However due to the need of accuracy of this test to find the RPM it means that a 1% has to be chosen due to accuracy being more important in this scenario.

Another limitation is the use of a linear regulator, which is inefficient because excess voltage is dissipated as heat, especially at higher input voltages. This can reduce reliability due to increased thermal stress. A better alternative is a switching (buck) regulator, which is more efficient as it converts excess voltage instead of wasting it (Castaldo, A. 2012). However, switching regulators introduce electrical noise (Ziel, S, 2024), so additional filtering may be required.

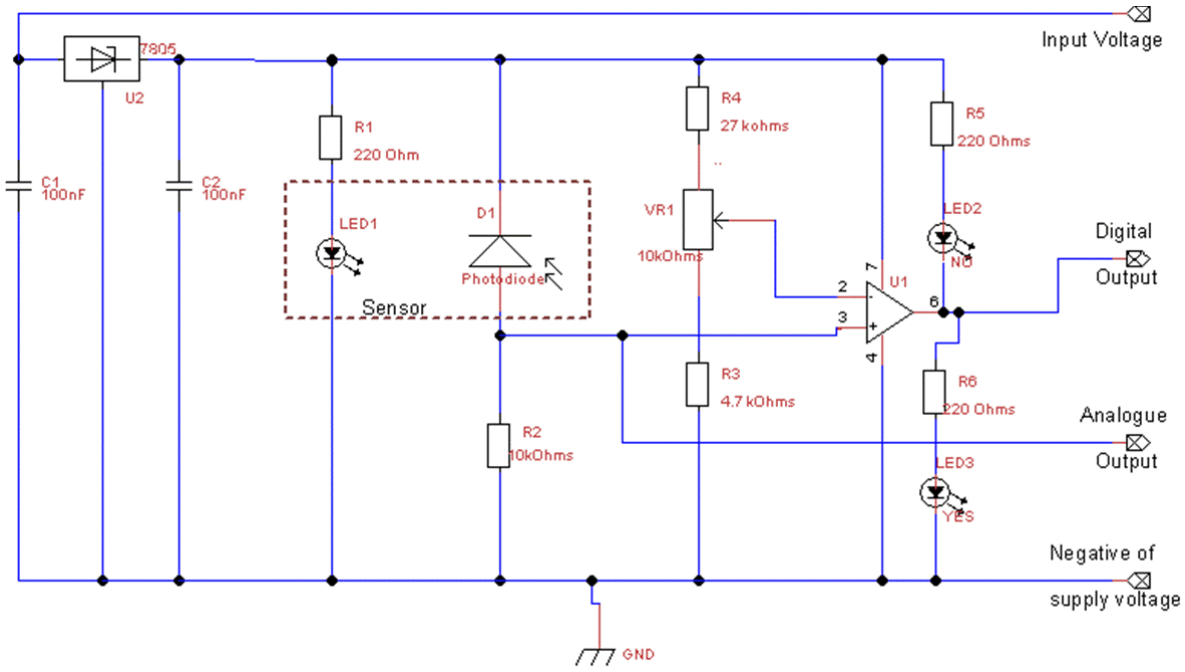


Figure E2.21 Complete circuit diagram of the photo-sensor

Part C

One alternative is the hall effect sensor which needs to have attached 8 semiconductor materials around the Stirling wheel as shown in figure 5. So, when the material passes through the sensor the magnet will force electrons to one side and then protons to the other side. This is because there is a potential difference across the plate which the sensor will detect as shown in figure 5 and 6. This allows the reading to take place.

(ElProCus, 2019)

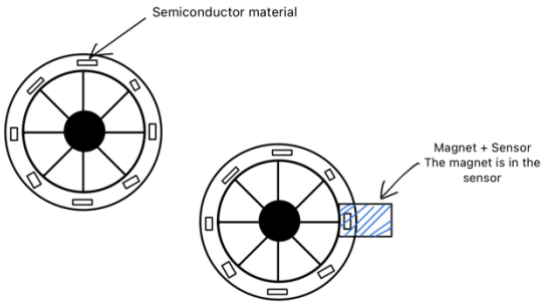


Figure 4- Proposed Design

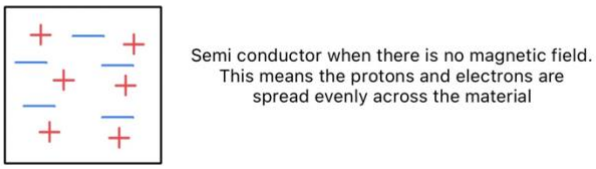


Figure 5 – Diagram to explain the theory side behind it

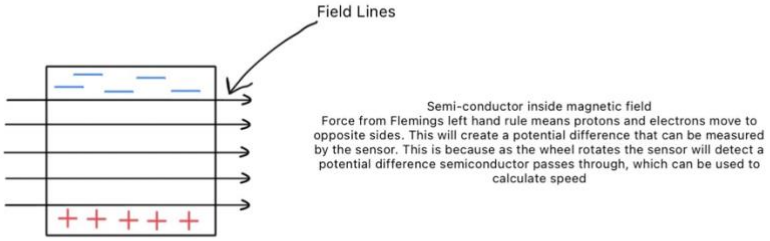


Figure 6 – Diagram to further illustrate the theory behind it

Advantages and Disadvantages to using a hall sensor instead of an optical sensor	
Advantages	Disadvantages
It is more robust as there isn't the issue of dust, dirt, water or ambient light effecting the measurement of speed	Can be magnetic interference from external surrounds (Bong, N, 2025) which could effect the measurement of speed while the optical sensor wouldn't be effected by this
Isn't as tricky to align which can save time in the set up (Bong, N, 2025) . When compared to optical sensor	Doesn't have as fast a response time as an optical sensor
Lower cost when compared to an optical sensor (Bong, N, 2025) . This means money can be saved during testing.	Hall sensors can be affected by temperature (Bong, N, 2025) . This means readings could be off if the temperature is too high

References

Bong, N. (2025) *Comparing Technologies: Optical Encoders VS Hall Effect Sensors*, *Progressive Automations*. Available at: https://www.progressiveautomations.com/en-gb/blogs/news/comparing-technologies-optical-encoders-vs-hall-effect-sensors (Accessed: 22 March 2026).

Castaldo, A. (2012) *Switching regulator fundamentals Application Report Switching regulator fundamentals*. Available at: https://www.ti.com/lit/an/snva559c/snva559c.pdf?ts=1774182581054&ref_url=https%253A%252F%252Fwww.google.com%252F (Accessed: 22 March 2026).

Definition, Working Principle, Application & Examples of Hall Effect Sensor (2019) *ElProCus - Electronic Projects for Engineering Students*. Available at: https://www.elprocus.com/hall-effect-sensor-working-principle-and-applications/.

Jain, J. (2026) *Star Rating Guide for Resistors: 1% vs 5% Tolerance Explained - Zbotic*, *Zbotic*. Available at: https://zbotic.in/star-rating-guide-for-resistors-1-vs-5-tolerance-explained/?srsltid=AfmBOoqEyP8auGWV0bHel-5pwokbTUjP3aQg-SJfvLyk_rwu7j9YGurk (Accessed: 22 March 2026).

Ziel, S. (2024) *Tips, Tricks and Advanced Applications of Linear Regulators*. Available at: https://www.ti.com/lit/ml/slup415/slup415.pdf (Accessed: 22 March 2026).