University of British Columbia
Electrical and Computer Engineering
ELEC 291/292

Magnetic Field Controlled Robot

Introduction

For the second project of ELEC291/ELEC292, you will design, build, program, and test a remote controlled autonomous robot using a varying magnetic field. The robot must be battery operated and controlled using a microcontroller system. The robot will have two modes of operation. In one of the modes, the track mode, the robot will be able to keep a fixed distance from the magnetic transmitter. If the transmitter changes position, the robot must adjust its position to keep a constant distance from it. In the other mode, the command mode, the robot will receive commands from the controller via the magnetic field and actuate as required by such commands.

Project Requirements

The project **must** include the following components and/or functionality:

1. **Two Different Microcontroller Systems:** This project can be completed with two microcontroller systems: one for the transmitter and one for the robot. These microcontroller systems MUST be from different families. An example of a valid combination: the transmitter using the EFM8LB12 (8051 family) and the robot using the PIC32MX130 microcontroller (MIPS family). An example of an **invalid** combination: the transmitter using the LPC824 (ARM Cortex M0 family) and the robot using the STM32L051 (ARM Cortex M0 family) since both microcontrollers belong to the same family.
2. **Battery operated:** Both the robot and controller must be battery operated. Batteries are neither provided in any of the kits nor will be provided to you. You need to buy your own batteries. An AA battery holder and a couple 9V battery clips are included in the project kit. In the project demonstration, both the transmitter and receiver MUST use batteries.
3. **Robot construction:** The project #2 kit includes the parts listed below. These parts can be used to assemble the mechanical component of the robot. Instructions on how to assemble the robot are posted on Canvas.

Part #	**Description**
2 x Solarbotics GM4	Gear Motor 4 - Clear Servo
2 x Wheels	6.7cm wheels (pair)
Tamiya 70144	Ball Caster
4 x AA	Battery holder
Switch	DPDT. Can be used to switch two different power sources.
1 x 9V cable	9V battery clip
Folded chassis	Aluminum box with holes!

You can buy the project kit for 80$ using the EECE e-payment site and pick it up in MCLD 1032.

4. **C programming:** The code for this module must be completed using the C programming language.
5. **MOSFET drivers:** To drive and control the motors of your robot you must use MOSFETs (Metal Oxide Semiconductor Field Effect Transistors). You should have both NMOS and PMOS transistors from your ELEC201/CPEN211 parts kit. For increased reliability, you may want to consider isolating the MOSFETs from the microcontroller system using opto-isolators. The LTV847/LTV846 opto-isolator is included in the microcontroller kit you acquire at the beginning of the term. Your motor drivers should allow the robot to move forward and backward as well as turn left or right.
6. **Transmitter:** While one microcontroller system is used to control the robot, another microcontroller system is used to transmit an electromagnetic signal or beacon at a **constant frequency**. The robot controller reads this signal using a couple of inductive sensors and determines its distance and direction from the beacon adjusting its position accordingly when in tracking mode. Additionally, the transmitter must be able to send commands to the robot when in command mode. Your design must support at least these four commands: move left, move right, move forward, and move backward.
7. **Distance**: The robot must be able to track the transmitter when they are both separated by at least 50 cm. The farther your robot can track the transmitter the better. In order for tracking distance to be considered an extra feature, it must be at least twice the required distance: 100 cm. To design your transmitter/receiver you can use Microchip's application note 232: "Low-Frequency Magnetic Transmitter Design" available at

   http://ww1.microchip.com/downloads/en/AppNotes/00232B.pdf

Project Evaluation

The evaluation of this project consists of a functional demonstration and interview (worth 30% of the final mark), a written project report (worth 5% of the final mark), and a presentation video (worth 5% of the final mark). In the project demonstration, your design is evaluated using the following criteria:

Mark	The project:
9.0-10	Is exceptional, did everything it was supposed to do well plus lots of additional functionality.
7.5-9.0	Did everything required, circuitry / project well designed / some additional functionality.
7.5	Did everything required. The project lacks originality, innovation, or extra functionality.
7.0-7.5	Mostly worked, not entirely, not the greatest design.
6.0-7.0	Didn't really work, ok design but didn't really come together.
5.0-6.0	Didn't work, not very good design.
0.5-5.0	Didn’t work, poor design. (Pile of parts!)
0	No project demonstrated.

The project demonstration evaluation and interview will be carried out by either the course instructor or the laboratory TAs. This demonstration should not take more than 5 to 10 minutes if everything is working reasonably well.

Team Self Evaluation

Similar to what has been done in previous years and other courses, the team members will determine the final mark distribution. There will be 100 total percentage points available per student. For example, if a group has six students, the total number of percentage points will be 600. The team will assign a portion of these points to each member, and the final individual mark will be computed by multiplying the group mark by this individual percentage. For example:

Project 1 Grade (out of 30%) = 20% (function) + 4% (report) = 24%

Student	Points	Grade	
Liu Kang	120	28.8%	
Johnny Cage	110	26.4%	
Goro	60	14.4%	Failed!
Raiden	90	21.6%	
Sonya	110	26.4 %	
Scorpion	110	26.4 %	
TOTAL	**600**	**24% (mean)**	

If the team is in disagreement about the individual percentage assignments, the individual percentage assignment will be determined by the course instructor and/or TAs by means of interviews and laboratory book reviews.

Project Report Format

The project report should be written for a reasonably expert reader such as a project manager (an engineer) in a company for whom you might have designed this prototype product. The project report should have sufficient detail that someone skilled in the art could reproduce or improve upon your results. The number of pages for the report should be ≤ 20 (not including the title page and appendices, double spaced, 'Arial' or 'Times New Roman' font size 12 for text, and 'Courier New' font size 8 or 10 for the source code, approximately one inch margin for the top, bottom, left, and right margins) and include the following sections:

1. **Title Page** – It should include the course name and number, instructor name, section, project name, group number, names and student number of the students in the group, the percentage contribution of every member in the group (with each student signature), and the date of submission. If the front page is missing any of this information, 2% will be deducted from the project report mark.

2. **Table of Contents**

3. **Introduction** – Design objective and specifications. Overview of the overall design approach including **system block diagrams for both the hardware and software designs**.

4. **Investigation** – This section must include the following subsections:

    A. **Idea Generation** – Describe how your group generated ideas and working hypotheses.
    B. **Investigation Design** – Describe how you group perform the design investigations involving information and data gathering, analysis, and/or experimentation.
    C. **Data Collection** – Describe how your group used appropriate procedures, tools, and techniques to collect and analyze data.
    D. **Data Synthesis** – Describe how your group synthesized data and information to reach appropriate conclusions.
    E. **Analysis of Results** – Describe how your group appraised the validity of conclusions relative to the degrees of error and limitations of theory and measurement.

5. **Design** – This section must include the following subsections:

    A. **Use of Process** – Describe how your group adapted and applied general design processes, accesses to design systems and components, or processes to solve open-ended complex problems as relevant for this project.

    B. **Need and Constraint Identification** – Describe how your group identified customer, user, and enterprise needs, and applicable constraints.

C. **Problem Specification –** Describe how your group specified additional design requirements based on needs and constraints presented in the point above.

D. **Solution Generation** – Briefly describe potential design solutions suited to meet functional specifications. If possible, include even those that didn't work!

E. **Solution Evaluation** - Perform systematic evaluations of the degree to which several design concept options meet project criteria. Clearly explain why you choose the final design.

F. **Detailed Design** – Explain how you applied appropriate engineering knowledge, judgment, and tools, in creating and analyzing design solutions. This has to be one of biggest parts of the report. In this section you must include the description and evaluation of each block (e.g. "A-stable Circuit", or "Counter Initialization"): Describe the approach taken to design each block. For circuits, include a detailed circuit diagram and describe how it works. For programs, include the source code in the appendices, and refer to it while you describe it.

G. **Solution Assessment** – Describe how you assessed the design performance based on requirements, needs, and constraints. This section must include an **evaluation of the complete system** by mean of tests you carried out including plots of performance, reproducibility numbers, tables, etc. as judged appropriate for this project. Describe how each relevant part of your design was tested and the testing results. Also in this section, the strengths and weaknesses of the design must be pointed out.

6. Live-Long Learning – Identify a specific learning need or knowledge gap. For example, did your learn something new by yourself? You didn't take a course that would have helped with the project? You found that one of the courses you took was particularly useful for the project?

7. Conclusions – Summarize the design and functionality of your project. Summarize also the problems you encounter, and how many hours of work the project took.

8. References – A specific book, paper, datasheet, or website is referred to in the **body** of the report at the point at which you say something about it, by a numerically-ordered, square-bracketed number, the first one being [1]. Then, at the end of the Report in a section called **REFERENCES** located just before the **Appendices** section**,** the same square-bracketed number is followed by the Author List, Article Title, Journal or Book Title, Volume, Number, Pages, ISBN Number, Publisher, Date of Publication. Although the Reference list can be listed alphabetically by author, instead we do not recommend this for an Engineering Report. With an alphabetical listing, the location in the body where any particular reference is discussed is then hard to find, since the references are no longer in order of appearance. Examples of references are [1] and [2] (note that the numbers in the square brackets here refer to the appropriate numbers in the Reference list). The Reference list itself might look like:

REFERENCES

[1] Smith, J, and F. Jones, “Designing an universal logic circuit”, Journal of Impossibly Wonderful Electronic Circuits, v.3, n.1, pp. 21-35, March, 1910.
[2] Jones, F and J. Smith, “Why universal logic circuits are impractical” , …

9. Bibliography – Items in a section at the end of a report called **BIBLIOGRAPHY** are NOT referred to in the body of the report. It is a list of appropriate background or additional reading and is located after the **References** section and before the **Appendices** section. The items in the Bibliography are usually ordered by last name of the first author. It is sometimes appropriate to have BOTH a Reference list and a Bibliography list. An example Bibliography looks like:

BIBLIOGRAPHY

• Sedra, A., and K.C. Smith, Microelectronic Circuits, 4th Edition, Oxford University Press, 1998.

1. **Appendices –** Supporting documents such as extensive theoretical analyses, mechanical drawings, and source code. Your source code should be properly documented and indented. Do not append datasheets, compiler manuals, or other already published material to the report.

Project Report Marking Rubric.

Report Content	**Worth**	
Title page (all information present including student names/numbers/section?)	0.2	
Table of contents	0.25	
Introduction	0.3	
Investigation		
Idea Generation	0.2	
Investigation Design	0.2	
Data Collection	0.2	
Data Synthesis	0.2	
Analysis of Results	0.25	
Design		
Use of Process	0.25	
Need and Constraint Identification	0.25	
Problem Specification	0.25	
Solution Generation	0.35	
Solution Evaluation	0.2	
Safety/Professionalism	0.2	
Detailed Design		
Hardware block diagram?	0.5	
Circuit explained?	1.0	
Software block diagram?	0.5	
Software explained?	1.0	
Solution Assessment		
Tests include data/plots?	0.5	
Life Long Learning	0.2	
Conclusions	0.5	
References (present and used correctly?)	0.25	
Bibliography (present and used correctly?)	0.25	
Appendices (if present, used correctly?)	0.25	
Report Format		
Double space?	0.25	
Correct Fonts?	0.25	
Margins?	0.25	
Number of pages? (<20 not including appendices)	0.25	
Clear & clean figures? (Bad scans of poorly hand drawn figures are not acceptable)	0.25	
Page numbers.	0.25	
Clean presentation.	0.25	
Weeks late (-2 points per week)		
GRADE (out of 10)		

Sample report front page

University of British Columbia
Electrical and Computer Engineering
ELEC291/ELEC292 Winter 2022
Instructor: Dr. Jesus Calvino-Fraga
Section 201

Project 2 – Magnetic Field Controlled Robot

Group #: B4

Student #	Student Name	%Points	Signature
91234567	Liu Kang	120	
97878474	Johnny Cage	110	
96456637	Goro	60	X
94214331	Raiden	90	
96562002	Sonya	110	
99873737	Scorpion	110	

Date of Submission: April 8, 2022