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הפקולטה למדעי ההנדסה  
המחלקה להנדסת חשמל ומחשבים

Four Year Engineering Project

Preliminary Design Report

**Computerized drive for permanent magnets in a spectroscopic setup**

Project number: p-2022-048

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Submitting Date: 17/09/2021

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**1. Abstract**

Computerized drive for permanent magnets in a spectroscopic setup  
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* 1. **English Abstract**

In the near future, we may not be able to solve any problem with Silicon, therefore the need to research alternative materials grows. Certain material characterization methods require conditions of a magnetic field in a Faraday cage. The purpose of this project is to enable computerized control of such measurement conditions.  
The innovation of this measurement tool is the first measurement tool that measures in conditions of a magnetic field in a Faraday cage that is remotely controlled.  
The suggested method consists of an FPGA microprocessor, Step motor, LEDs, power supply, printed circuit boards, Interface, Infrared sensors, belt conveyor, Rare Earth Magnet, and a Shock Absorber which together should make up the required measurement tool.  
The expected result is a working system that can take measurements under the desirable conditions.  
Keywords: Magnet, Rare Earth Magnet, FPGA Microprocessor, Step motor, Hall effect, LabView, Position Sensors.

**1.2 Hebrew Abstract**

בעתיד לא בטוח שיהיה ניתן לפתור כל בעיה עם סיליקון ולכן הרצון לחקור חומרים ודגמים שונים תמיד יהיה קיים. לשם כך נדרשות מערכות מדידה שיכולות למדוד את הרכיבים בתנאים של שדה מגנטי ובתוך כלוב פאראדיי הנשלטים מרחוק בדיוק רב.   
בעקבות כך המטרה של מכשיר המדידה תהיה לדעת למדוד את התכונות הרצויות תוך מתן תנאים רצויים.   
החדשנות היא בכך שלא קיים כיום כלי מדידה המבצע את המדידות לצד שדה מגנטי בתוך כלוב פאראדיי המבודד ספקטרום של כל גלי האור הלא רצויים (מלבד אורך הגל הרצוי) שניתן לשלוט עליו מרחוק.  
המתודה המוצעת היא שילוב של הרכיבים הבאים: מיקרו בקר, מנוע צעד, כרטיס המיועד להתממשק עם המנוע ולהפעיל אותו, לדים להמחשת מיקום המודל, ספק מתח מתאים, חיישני אינפרא אדום, מעגל מודפס המחבר בין הבקר לחיישנים, למתחי הספק ולנגדים חיצוניים , בולם זעזועים, מסוע ודגם שנמצא במרכז המסוע. התוצאה שאנו מצפים לה היא מערכת עובדת שניתן לבצע באמצעותה מדידות בתנאים הרצויים הנשלטת על ידי תוכנת מדידה חיצונית.  
מילות מפתח: מגנט עופרת נדירה, מגנט, מיקרו-בקר, מנוע צעד, אפקט הול, חיישני מיקום, lab-view.

**2. Project’s purpose**  
The semiconductors industry is in continuous progress and researchers try to find materials that can solve problems Silicon cannot, for this reason, they need a variety of different and unique measurement tools. Some tools measure magnetic fields, like Hall effect sensors, Magnetometers, etc. But a tool that takes measurements under conditions of changing magnetic fields for specific wavelengths is yet to exist. Our project’s purpose is to answer that need and build a remotely controlled measurement device inside a Faraday cage that takes measures under conditions of changing magnetic fields for specific wavelengths.

**3. Specification sheet**  
**Computerized drive for permanent magnets in a spectroscopic setup**

The purpose of this project is to create a remotely controlled measurement tool that can take measures with or without a magnetic field inside a Faraday cage.  
The reason for using Rare Earth Magnet and not the commonly used Electromagnet like Hall Effect measurement tools is that the Rare Earth Magnet is smaller and cheaper, so it is both space- and cost-effective for our circumstances. The disadvantage of Rare Earth Magnet is that we cannot control its magnetic field with electricity, and the solution is to build a belt conveyor system and control the distance from the sample because the magnetic field weakens as the distance grows ( ). So we control the magnetic field with distance and not with electricity.

**2.1 Technology and methodology**

The included technologies in our project are electrical devices that can drive the magnet on the belt conveyor (or devices that can support them) which also can be remotely controlled.  
The work methodology is to separate the project into several smaller tasks, generally decide and understand how the solution for every task should be, and finally assemble all the tasks properly.

**2.2 Work Phases**

1) Buy all the necessary parts and devices

2) Achieve an understanding of the devices to integrate them properly.

3) Integrate the devices and parts.

4) Program the FPGA micro-processor.

5) Design and print the interface board to connect between the devices.

6) Finalize the project by organizing the parts inside the Faraday cage.

**2.3 Applications of the product**

The application of this product is to be a part of a system that can measure research samples under conditions of magnetic fields and isolation of light.

**2.4 Performances specification**

The system will take as input signals a power supply and a signal which specifies if the magnet is close to the measured sample or far away from it. The system’s output is the magnet’s location shown on LED screens that are visible from the outside in addition to the magnet movements inside the Faraday cage. It should operate in a way that wouldn’t make much noise and physical disturbances to the system (which is sensitive and need to be reliable) and preferably with a fast response time.

**2.5 Schematic of system**

Diagram

Description automatically generated

**4. Literature review**The first approach we thought about was using an electromagnet[1] because it is the common solution for problems that require changing magnetic fields strengths. An electromagnet is a magnet that can be controlled by an electric current. However, we concluded that since the electromagnet heats up due to the power it consumes, it needs a cooling system that can satisfy those demands, and that in addition to its size, make it expensive.  
Since we concluded that we won’t use a stationary magnet to change the magnetic field, we will use a moving mechanism in the system because the farther away the sample will be from the magnet, the weaker the magnetic field will be.   
Therefore, the approach was to use a permanent magnet[2] in our system, supported by a system that drives it farther or closer to our measured sample, it solved the problems from the first approach since we don’t need a cooling system and we are using a Rare Earth Magnet material so that the size of the magnet is smaller than the electromagnet, this approach required more elements to the system like a step motor, sensors, etc. but we managed to solve those problems, therefore, this approach was the way we decided to solve the problem.

**5. Proposed plan**

Diagram, schematic

Description automatically generatedThe following is a proposal of the final system:

Detailed explanation on every part of the system:

Sensors:

The sensor is an integrated circuit that is described by the following schematic:

Diagram, schematic

Description automatically generated

The connections to the sensor are supply voltages, input connection to a resistor to bias the LED, and an output connection. The pull-up resistors between pins 3,4 of the sensor are not needed to be placed on the board since the PSoC microprocessor has a resistive pull-up input option.

The sensor method of operation is that the LED emits light, and the belt conveyor can either block the light or not, depending on its location, therefore changing the output voltage.

PSoC microprocessor:

The microprocessor integrates the needed signals, and the processing is described by C language code that is written to it using the PSoC creator FPGA program.

We use the general-purpose I/O pins of the microprocessor with different options, for example, the sensors input signals are resistive pull-up and the magnet’s location user input is a high impedance input, those options aid to match the signal to the microprocessor correctly.

PC-837:

As seen by the schematic, the PC837 component is a buffer that does not load the connector. Its method of operation is like the sensor and consists of a diode that emits light whenever enough current is driven through it or, equivalently, is under enough voltage, the light reaches a transistor and causes an output voltage.

STK6722H:

The step motor driver receives supply voltages of 36V and drives the step motor according to the input signals of the step motor controller component TD62803P

TD62803P:

The step motor controller receives signals for the driver to move the step motor according to the input signals which are described by the following function table:

A picture containing text, crossword puzzle, receipt

Description automatically generated

We can move the step motor in the clockwise or counterclockwise direction by having one of the ck1\ck2 pins receive pulses and the other one to have constant voltage, the CW/CCW pin is connected to the ground in the interface.

LEDs:

The LEDs component is an integrated circuit that receives the supply voltage of 5V and input signals from the microprocessor about the magnet’s location (which can be known using the sensors and user input) and is displaying the magnet’s location using LEDs.

**6. Constraints**

The constraints of the project are:

1. The system needs to be remotely controlled.
2. The system contains a moving magnet. Therefore, we will need to make sure there are not physical disruptions.

**7. Assumptions**

The assumptions of the project are:

1. We assume that the FPGA will be able to support the logic needed for the rest of the system, i.e., it should be able to produce and process the signals needed to operate the electrical devices that drive the step motor.
2. We assume that the maximal distance of the magnet from our sample, which will be determined by the belt conveyor we will choose to use, which will correspond to the minimal magnetic field strength, will be weak enough to be negligible for our measurements.

In case those assumptions will turn out as incorrect, we will need to decide on different devices for the system, for example, a different FPGA microprocessor.

**8. Risks**

The magnetic field combined with the step motor momentum can make the belt conveyor shake which is not sustainable as a closed system and may not be able to make accurate measurements of the sample.

**9. Project contents**

This project is a system of a moving magnet with a sample holder.  
In addition to that, the system can be supported in a Faraday cage that will isolate light and electromagnetic disruptions, additionally it will hold the system in a way that prevents physical disruptions.  
The limitations of the system are the size of the sample we can fit in, the range of the strength of the magnetic field since we use a permanent magnet that is limited by its distance from the sample, and therefore the magnetic field strength will be limited.

**10. Final tests proposals**

The product we provide is a system of a moving magnet with a sample holder, which is placed inside a Faraday cage. To verify that the system functions properly we will first need to use it outside of the cage to see that the result for each input is correct, for example, if we send the signal for the magnet to move to the sample’s location, we will verify it by seeing that it moves there. We will also verify that the LEDs are responding correctly to the magnet’s movement. Afterwards, we will verify that the system works inside the cage by using the LEDs.

**11. Estimated budget**

|  |  |  |
| --- | --- | --- |
| **Product** | **Price** | **Source** |
| FPGA Cypress CY8CKIT-059 PSoC 5LP Prototyping Kit. sample: CY8C5888LTI-LP097 | 10$ | https://www.cypress.com/documentation/development-kitsboards/cy8ckit-059-psoc-5lp-prototyping-kit-onboard-programmer-and |
| Step Motor SST55D3C020 SHINANO KENSHI CO.LTS.JAPAN | 15$ | https://www.ebay.com/itm/265166457228 |
| Nikon 2s700-601 PCB Pulse Motor Drive | 440$ | https://www.ebay.com/p/1637081306 |
| Power Supplies 220V/36V TDK-Lambda SCB | 167$ | https://il.farnell.com/tdk-lambda/gws-250-36/psu-switch-mode-36v-250w/dp/1996025 |
| Power Supplies 220V/5V TDK-Lambda SCB | 45$ | https://il.farnell.com/tdk-lambda/ls150-5/psu-enclosed-5v-26a-150w/dp/1657459 |
| Infra-red Sensors Nikon J1 | 8$ |  |
| Rare Earth Magnet | 8$ | https://www.aliexpress.com/item/32824638879.html |
| Belt conveyor | 25$ |  |
| LEDS PCB | 12$ |  |
| Breadboard | 6$ | https://www.amazon.com/4Pcs-MCIGICM-Point-Solderless-Breadboard/dp/B08115P2T4 |

**To sum up, the estimated budget including overhead is 730$ (while the overhead is 25%)**

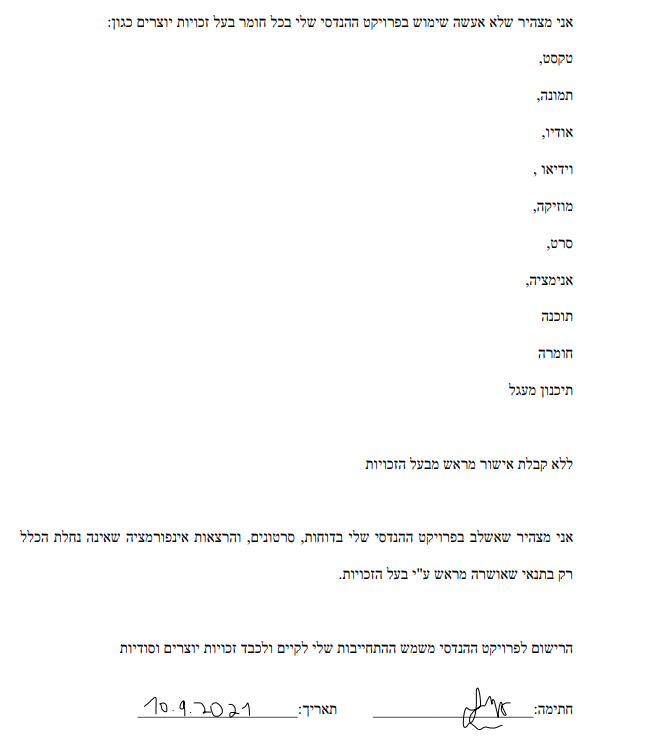
**12. References**

*[1] “The National High Magnetic Field Laboratory”* [*https://nationalmaglab.org/education/magnet-academy/learn-the-basics/stories/magnets-from-mini-to-mighty*](https://nationalmaglab.org/education/magnet-academy/learn-the-basics/stories/magnets-from-mini-to-mighty)

[2] Cullity, B. D., Graham, C. D. (2008). Introduction to Magnetic Materials. Wiley-IEEE. p. 489. ISBN 0-471-47741-9

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**13. Appendix  
13.1 Copyright and secrecy form**



**13.2** **Perliminary design report recommendation**

