**4 Magnetism**

**4.1 Design and Sensor Choosing**

The aim is to identify both the polarity and strength of the static magnetic field inside the alien. As a first step, we decided to use the Hall effect that when a magnetic field perpendicular to the current is applied to an electrical conductor, a Hall voltage results. According to this, both unipolar and bipolar sensors were considered. The former, also known as unipolar switches, only display a digital output in a specific magnetic field direction (e.g. North Pole). As it is not possible to indicate the magnetic field strength, a bipolar sensor with an analog output was chosen.

Analog sensors use a continuous voltage output that increases within a strong magnetic field and decreases in a weaker field. With linear output, as the strength of the external magnetic field increases as the device comes into contact with the magnet, the output signal increases in parallel until it reaches the limits imposed by the power supply. Based on this, we determined to use the DRV5053 Analog-Bipolar Hall Effect Sensor (Fig 4.1.1) which has superior temperature stability and high sensitivity over a wide voltage range as shows in Fig 4.1.2 from the datasheet of DRV5053.

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Fig 4.1.1. DRV5053 Fig 4.1.2. Sensitivity vs VCC

**4.2 Circuit Construction**

At the very beginning, we built a simple resistor circuit shows in Figure 4.2.1 to ensure the current limits of the components are not reached, allowing for safe operation without damaging the components. Also, we tested for the quiescent output voltage to be 1.02V, the same with that in the datasheet to make sure our sensor is under the normal condition when there is no field.

After conducting numerous experiments, we have discovered that the sensor and the magnet exhibit a response only when they are in extreme proximity to each other. Other than using a single bypass capacitor, we designed a new sketch with a RC filter shows in Fig 4.2.2 to reduce the bandwidth. On top of this, we could further higher the sensitivity and lower the noise on the analog output OUT.

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Fig 4.2.1. Protection Circuit Fig 4.2.2. RC Filter

However, we discovered that reinserting the magnet into the alien didn't yield any response. We decided to solder the three pins of the sensor with some wires and then shaped them in a way that forced the sensor to be perpendicular to the top of the alien. This was necessary because the magnet is placed inside the alien, about 10mm below its highest point. With this setup, we were finally able to get the response we were looking for. (Fig 4.2.3)

桌子上放满了不同类型的电子产品

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Fig 4.2.3 Final Implementation

**4.3 Data Analysis**

We used Arduino IDE to do operations on results obtained.

In order to analyze the output effectively, it is important to establish a baseline data range when there is no magnetic field present. This will enable us to accurately assess any changes in the data when a field is introduced. To do this, we connected the OUT to A1 first and set the *PINMODE* to *INPUT* in the *setup()*. We then used *analogRead* to get the values and continuously displayed them through *serial.println()* in Arduino with the help of Serial Monitor. Our tests revealed that the results were located approximately between 313 and 317. Additionally, to ensure that there was no field detected, we used a multimeter to measure the voltage at the OUT pin and confirmed that it consisted of 1.02V before conducting any further tests.

To achieve more precise identification of the data ranges for the North and South Poles, it is crucial to closely monitor any variations in data that may occur as the magnet is moved towards the sensor. In our experiment, we chose to use the South Pole magnet and observed a clear decrease in data as we gradually moved it closer to the sensor. Therefore, we set the region less than 313 to be the South region. Our methodology involves consistently collecting and analyzing data readings, which will ultimately allow us to obtain the exact data ranges for both the North and South Poles. By prolonging the experiment, we gathered more data and further improve the accuracy of our results.

We employed a similar approach to observe the magnetic field data changes when the North Pole was in proximity to the sensor. The data collected indicated a noticeable increase as we moved the magnet closer to the sensor. Accordingly, we made values larger than 317 to be the North region and output “North Detected”. To better validate our data, more experiments were conducted and the results are shown in Fig 4.3.1, Fig 4.3.2 and Fig 4.3.3.

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Fig 4.3.1. When South Pole. Fig 4.3.2. When North Pole. Fig 4.3.3. When no field

Having successfully confirmed the range of magnetic field polarities, we also need to establish how the magnetic field strength is represented. Since there is a linear relationship between the strength and the distance between the magnet and the sensor, as the magnet gets closer to the sensor, the difference between the value demonstrated by the Serial Monitor and the value in the absence of the magnetic field becomes larger and larger. Consequently, we defined the magnetic field strength to be the value minus the margin for the North pole and oppositely for the South pole.

After extensive testing, we have found that the final design is highly effective in detecting both the polarity and the strength of the magnetic field from a considerable distance. Although the thickness of the alien may affect the amplitude of the measurements, our design was still able to differentiate between each case with great accuracy. The final code is showed in Fig 4.3.4 and would be inserted into our server.

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Fig 4.3.4. The final code to detect and represent features of the magnetic field

\*Reference:

Fig 4.1.2 and Fig 4.2.2: the datasheet of DRV5053,

<https://www.ti.com/lit/ds/symlink/drv5053.pdf?HQS=dis-dk-null-digikeymode-dsf-pf-null-wwe&ts=1654186442426>