EE236: Electronic Devices Lab
Lab No.-12
Hall Effect Sensor,

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1 Aim of the Experiment

- To study the Hall Effect and observe the output voltage of a Hall Effect sensor with varying distance for different magnetic strengths.
- To determine the strength of the given bar magnet.
- To calculate the doping concentration of the Hall element within the sensor.

2 Components Used

- 3-terminal Hall sensor
- 3 bar magnets
- 2 Multimeters
- 15cm scale
- 2 breadboards
- Connecting wires

3 Theory

The Hall Effect suggests that the voltage generated in a conductor is directly proportional to the applied magnetic field and the current passing through the conductor. A Hall Effect sensor uses this phenomenon to generate an output voltage in response to an applied magnetic flux.

4 Experimental Setup

1. A DC voltage input of 8V was provided between V_{CC} and GND terminals of the Hall sensor.
2. A multimeter was connected across the output and GND terminals to measure the output voltage.
3. Two breadboards were placed with a 15cm scale between them. The Hall sensor was mounted on one breadboard, and the magnets were placed on the other.
4. The curved surface of the Hall sensor was positioned to face the magnet.

5 Procedure

1. One bar magnet was placed 15cm away from the Hall sensor.
2. The distance between the magnet and the sensor was reduced in steps of 2mm until the distance was approximately 0. The output voltage was recorded at each step.
3. After reaching minimum distance, the pole of the magnet facing the sensor was reversed, and the magnet was moved back to the 15cm position.
4. Step 2 was repeated for the reversed polarity.
5. The entire process was repeated for 2 bar magnets and 3 bar magnets.
6. The current flowing between the V_{CC} and GND terminals (I_{in}) was measured when no magnetic field was applied.

6 Observations

6.1 Single Magnet

Table 1: Observed Data for Single Magnet

Reverse Polarity		Normal Polarity	
Distance (cm)	Vout (V)	Distance (cm)	Vout (V)
15.0	1.008	15.0	0.99
14.8	1.008	14.5	0.98
14.6	1.009	14.0	0.98
14.4	1.009	13.5	0.98
14.2	1.009	13.0	0.98
14.0	1.009	12.5	0.98
13.8	1.010	12.0	0.98
13.6	1.010	11.5	0.97
13.4	1.010	11.0	0.97
13.2	1.010	10.5	0.97
13.0	1.010	10.0	0.96
12.8	1.011	9.5	0.96
12.6	1.011	9.0	0.96
12.4	1.011	8.5	0.96
12.2	1.012	8.0	0.95
12.0	1.012	7.5	0.95
11.8	1.012	7.0	0.95
11.6	1.012	6.5	0.94
11.4	1.013	6.0	0.92
11.2	1.013	5.5	0.91
11.0	1.013	5.0	0.89
10.8	1.013	4.8	0.89
10.6	1.013	4.6	0.88
10.4	1.014	4.4	0.87
10.2	1.014	4.2	0.84
10.0	1.015	4.0	0.83
9.8	1.016	3.8	0.82
9.6	1.016	3.6	0.80
9.4	1.017	3.4	0.77
9.2	1.017	3.2	0.75
9.0	1.018	3.0	0.72
8.8	1.018	2.8	0.69
8.6	1.019	2.6	0.66
8.4	1.020	2.4	0.60
8.2	1.021	2.2	0.54
8.0	1.022	2.0	0.47
7.8	1.023	1.8	0.40
7.6	1.024	1.6	0.30
7.4	1.025	1.4	0.18
7.2	1.0266	1.2	0.05
7.0	1.028	1.0	0.04
6.8	1.030	0.8	0.03
6.6	1.032	0.6	0.03
6.4	1.035	0.4	0.03
6.2	1.036	0.2	0.03
6.0	1.040	0.0	0.02

6.2 Double Magnet

Table 2: Observed Data for Double Magnet

Reverse Polarity		**Normal Polarity**	
Distance (cm)	Vout (V)	Distance (cm)	Vout (V)
15.0	1.010	15.0	0.99
14.5	1.011	14.5	0.99
14.5	1.011	14.5	0.99
14.0	1.012	14.0	0.98
14.0	1.012	14.0	0.98
13.5	1.013	13.5	0.98
13.5	1.013	13.5	0.98
13.0	1.013	13.0	0.98
13.0	1.013	13.0	0.98
12.5	1.014	12.5	0.98
12.5	1.014	12.5	0.98
12.0	1.014	12.0	0.98
12.0	1.014	12.0	0.98
11.5	1.016	11.5	0.98
11.5	1.016	11.5	0.98
11.0	1.017	11.0	0.98
11.0	1.017	11.0	0.98
10.5	1.018	10.5	0.98
10.5	1.018	10.5	0.98
10.0	1.020	10.0	0.97
10.0	1.020	10.0	0.97
9.5	1.022	9.5	0.97
9.5	1.022	9.5	0.97
9.0	1.024	9.0	0.97
9.0	1.024	9.0	0.97
8.8	1.025	8.8	0.97
8.5	1.026	8.5	0.97
8.6	1.026	8.6	0.97
8.0	1.027	8.0	0.96
8.4	1.027	8.4	0.96
7.5	1.028	7.5	0.96
8.2	1.029	7.5	0.96
7.0	1.030	7.0	0.96
8.0	1.030	7.0	0.96
6.5	1.032	6.5	0.95
7.8	1.032	6.5	0.95
6.0	1.034	6.0	0.94
7.6	1.034	6.0	0.94
5.5	1.033	5.5	0.93
7.4	1.036	5.5	0.93
5.0	1.038	5.0	0.92
7.2	1.038	5.0	0.92
4.8	1.040	4.8	0.91
7.0	1.040	4.8	0.91
4.6	1.042	4.6	0.90
6.8	1.042	4.6	0.90
4.4	1.047	4.4	0.89
6.6	1.047	4.4	0.89
4.2	1.049	4.2	0.87

6.3 Triple Magnet

Table 3: Observed Data for Triple Magnet

Reverse Polarity		**Normal Polarity**	
Distance (cm)	Vout (V)	Distance (cm)	Vout (V)
15.0	1.013	15.0	0.99
14.5	1.014	14.5	0.99
14.5	1.014	14.5	0.99
14.0	1.015	14.0	0.99
14.0	1.015	14.0	0.99
13.5	1.015	13.5	0.98
13.5	1.015	13.5	0.98
13.0	1.016	13.0	0.98
13.0	1.016	13.0	0.98
12.5	1.017	12.5	0.98
12.5	1.017	12.5	0.98
12.0	1.018	12.0	0.98
12.0	1.018	12.0	0.98
11.5	1.020	11.5	0.98
11.5	1.020	11.5	0.98
11.0	1.022	11.0	0.98
11.0	1.022	11.0	0.98
10.5	1.023	10.5	0.98
10.5	1.023	10.5	0.98
10.0	1.025	10.0	0.98
10.0	1.025	10.0	0.98
9.5	1.028	9.5	0.98
9.5	1.028	9.5	0.98
9.0	1.031	9.0	0.98
9.0	1.031	9.0	0.98
8.8	1.033	8.8	0.97
8.5	1.034	8.5	0.97
8.6	1.034	8.6	0.97
8.0	1.035	8.0	0.97
8.4	1.035	8.4	0.97
7.5	1.037	7.5	0.97
8.2	1.037	7.5	0.97
7.0	1.039	7.0	0.97
8.0	1.039	7.0	0.97
6.5	1.041	6.5	0.96
7.8	1.041	6.5	0.96
6.0	1.044	6.0	0.96
7.6	1.044	6.0	0.96
5.5	1.046	5.5	0.95
7.4	1.046	5.5	0.95
5.0	1.049	5.0	0.94
7.2	1.049	5.0	0.94
4.8	1.052	4.8	0.94
7.0	1.052	4.8	0.94
4.6	1.055	4.6	0.94
6.8	1.055	4.6	0.94
4.4	1.058	4.4	0.93
6.6	1.058	4.4	0.93
4.2	1.062	4.2	0.92

7 Results and Analysis

7.1 Graph

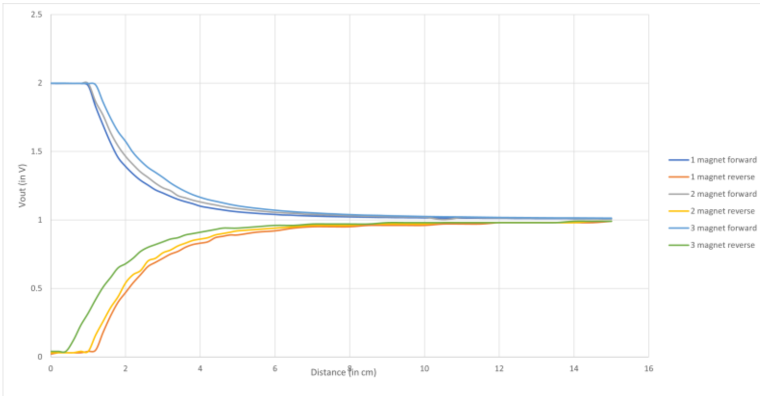

Figure 1: Output Voltage vs. Distance for Different Magnet Configurations

7.2 Calculations

Given parameters:

- Hall element side length, $a = 0.53$ mm
- Input voltage, $V_{in} = 8$ V
- Mobility, $\mu = 0.8\,\mathrm{m^2\,V^{-1}\,s^{-1}}$
- Hall element thickness, $t = 0.053$ mm
- Elementary charge, $e = 1.6 \times 10^{-19}$ C

Measured values:

- $V_{out,0} = 1.005$ V
- $V_{out,max} = 2$ V
- $I_{in} = 2.62$ mA

7.2.1 Calculating the Strength of the Bar Magnet

Longitudinal electric field:

$$E_{long} = \frac{V_{in}}{a} = \frac{8}{0.53 \times 10^{-3}} = 15\,094.34\ \mathrm{V\,m^{-1}} \tag{1}$$

Lateral electric field due to Hall effect:

$$E_{lat} = \frac{|V_{out,0} - V_{out,max}|}{a} = \frac{|1.005 - 2|}{0.53 \times 10^{-3}} = 1877.36\ \mathrm{V\,m^{-1}} \tag{2}$$

Magnetic field strength of one bar magnet:

$$B = \frac{E_{\text{lat}}}{3\mu E_{\text{long}}} = \frac{1877.36}{3 \times 0.8 \times 15094.34} = 0.0518\,\text{T} \tag{3}$$

7.2.2 Determining Doping Concentration

Hall coefficient:

$$R_H = \frac{V_{\text{out,max}} \cdot t}{I_{\text{in}} \cdot B} = \frac{2 \times 0.053 \times 10^{-3}}{2.62 \times 10^{-3} \times 0.0518} = 0.7807\,\text{m}^3\,\text{C}^{-1} \tag{4}$$

Doping concentration:

$$N = \frac{1}{R_H \cdot e} = \frac{1}{0.7807 \times 1.6 \times 10^{-19}} = 8.0057 \times 10^{18}\,\text{cm}^{-3} \tag{5}$$

8 Conclusion

Based on the experimental results and analysis, we can conclude:

- The output voltage of the Hall Effect sensor varies inversely with the distance between the sensor and the magnet.
- The strength of the magnetic field influences the rate of change of the output voltage with distance.
- Reversing the polarity of the magnet results in an inverted response curve.
- The calculated strength of a single bar magnet is approximately 0.0518 T.
- The estimated doping concentration of the Hall element in the sensor is 8.0057×10^{18} cm^{-3}.

This experiment demonstrates the practical application of the Hall Effect in sensing magnetic fields and highlights the relationship between magnetic field strength, sensor output, and material properties of the Hall element.