# EE236: Experiment 3
# Hall Effect Sensors

Mohd Safwan, 17D070047

Monday 6$^{\text{th}}$ August, 2018

## 1 Aim of the experiment

We aim to study different characteristics of Hall Effect Sensors through its many applications. The experiment consists of these 3 parts.

- Measuring the head-up distance between the sensor and a permanent magnet.
- Sensing current using solenoid and Hall Effect Sensor.
- Measuring speed of a DC motor using Hall effect sensor as well as an IR pair.

## 2 Methods

We made the circuit on a full size - 830 point breadboard. We used a DC power source for supplying $+12V$, $-12V$, $+1.9V$, etc. We used potentiometers to implement a voltage divider when we ran out of DC sources. All the measurements were made using a multimeter for DC signal and a Digital Storage Oscilloscope otherwise.

### 2.1 Part 1

We made a circuit on the breadboard consisting of power supply to the Hall Effect Sensor and a non-inverting signal amplifier using an op-amp IC741 which amplified the sensor's output. The amplified signal was passed through an offset-removal circuit again made using IC741.

Changes made to the circuit:

- In the non-inverting amplifier, instead of using he $10k\Omega$ resistor, which provided an amplification of 11x, we used a $5.6k\Omega$ resistor because we needed less amplification to prevent saturation of op-amp's output to $V_{dd}$ which was set to $12V$.
- In the offset remover part of the circuit, we changed the $1k\Omega$ resistor with a potentiometer whose resistance was set such that the offset was as close to zero as possible.

A strong neodymium magnet was used and its distance from sensor was measured using a ruler while bringing it towards the magnet 2 times, each side facing towards the sensor one at a time.

## 2.2 Part 2

This part is very similar to part 1. The circuit assembled on the breadboard remains untouched, but instead of a neodymium permanent magnet, we now use a solenoid. We connect the solenoid to a DC supply through a resistor to moderate current and an ammeter to measure it. The current is varied by increasing voltage supplied to the solenoid.

## 2.3 Part 3

We were provided a DC motor on a wooden assembly with Hall Effect Sensor and an IR pair already mounted in correct position. We made a comparator circuit using IC LM311 on the breadboard and passed the output of Hall Effect Sensor through it. We made measurements of maximum voltage obtained from Hall Effect Sensor after mounting the permanent magnet on the motor and set the reference voltage accordingly. We observed the output of the Hall Effect sensor and the IR pair on the Digital Storage Oscilloscope.

# 3 Observations

## 3.1 Part 1

A Neodymium magnet was used for the experiment. The experiment was performed at room temperature. DC voltages of $\pm 12$V was supplied to the op-amps. Hall Effect Sensor was provided 5V. The output of the circuit was saturated at $\sim$10V due to the op-amps' limitations.

| Distance in $cm$ | Voltage in Volts | Voltage in Volts |
|---|---|---|
| $\infty$ | -0.02 | -0.01 |
| 15 | -0.04 | 0.01 |
| 14 | -0.05 | 0.01 |
| 13 | -0.06 | 0.02 |
| 12 | -0.07 | 0.02 |
| 11 | -0.08 | 0.03 |
| 10 | -0.09 | 0.05 |
| 9.5 | -0.1 | 0.06 |
| 9 | -0.11 | 0.07 |
| 8.5 | -0.13 | 0.08 |
| 8 | -0.15 | 0.1 |
| 7.5 | -0.17 | 0.14 |
| 7 | -0.21 | 0.17 |
| 6.5 | -0.26 | 0.22 |
| 6 | -0.32 | 0.28 |
| 5.5 | -0.4 | 0.36 |
| 5 | -0.54 | 0.47 |
| 4.5 | -0.79 | 0.64 |
| 4 | -1.08 | 0.82 |
| 3.5 | -1.26 | 1.19 |
| 3 | -2.1 | 1.76 |
| 2.5 | -3.5 | 2.74 |
| 2 | -5.1 | 4.3 |
| 1.8 | -7.8 | 6.51 |
| 1.6 | -10 | 8.52 |
| 1.4 | -10.04 | 10.4 |
| $< 1.4$ | Saturates at 10.1 | Saturates at 10.4 |

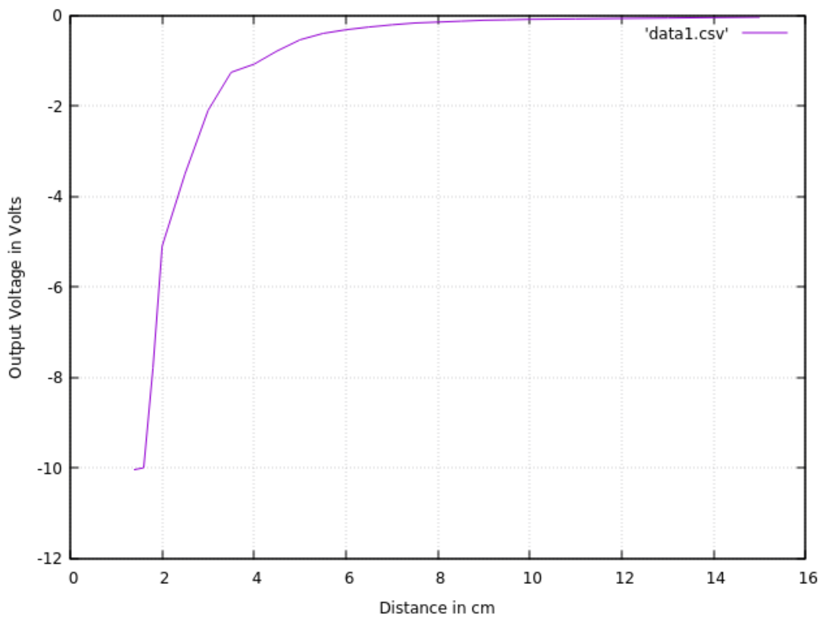



Figure 1: Polarity 1

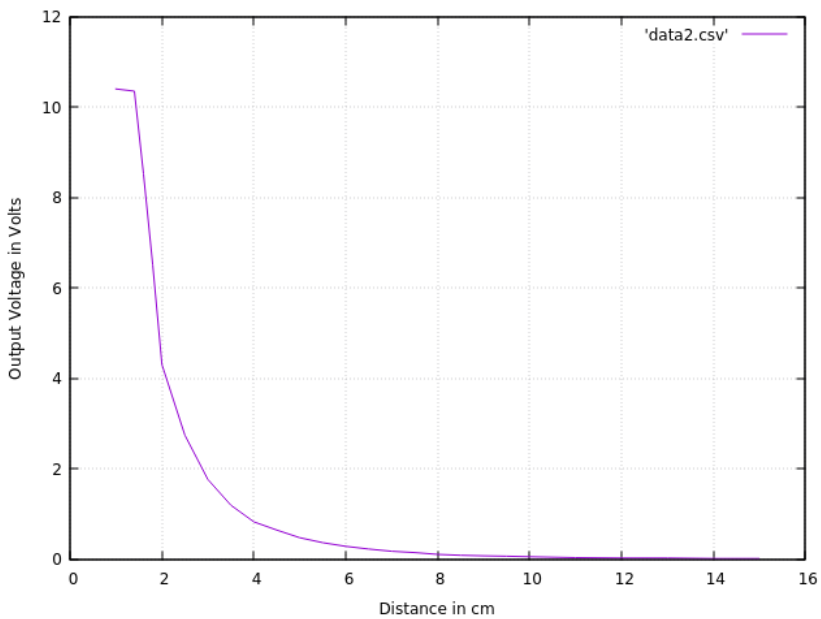



Figure 2: Polarity2 - Opposite of polarity 1

## 3.2 Part 2

We performed the experiment at room temperature. The solenoid was powered using DC supply through a 5W 2.2Ω resistor. DC voltages of ±12V was supplied to the op-amps. Hall Effect Sensor was provided 5V.

| Current | Voltage | Voltage(opp) |
|---|---|---|
| 0 | 0.036 | -0.032 |
| 0.07 | 0.043 | -0.04 |
| 0.12 | 0.046 | -0.043 |
| 0.19 | 0.052 | -0.051 |
| 0.26 | 0.058 | -0.056 |
| 0.31 | 0.066 | -0.064 |
| 0.39 | 0.076 | -0.074 |
| 0.45 | 0.085 | 0.0845 |
| 0.52 | 0.087 | -0.088 |
| 0.59 | 0.095 | -0.096 |
| 0.66 | 0.1 | -0.1 |

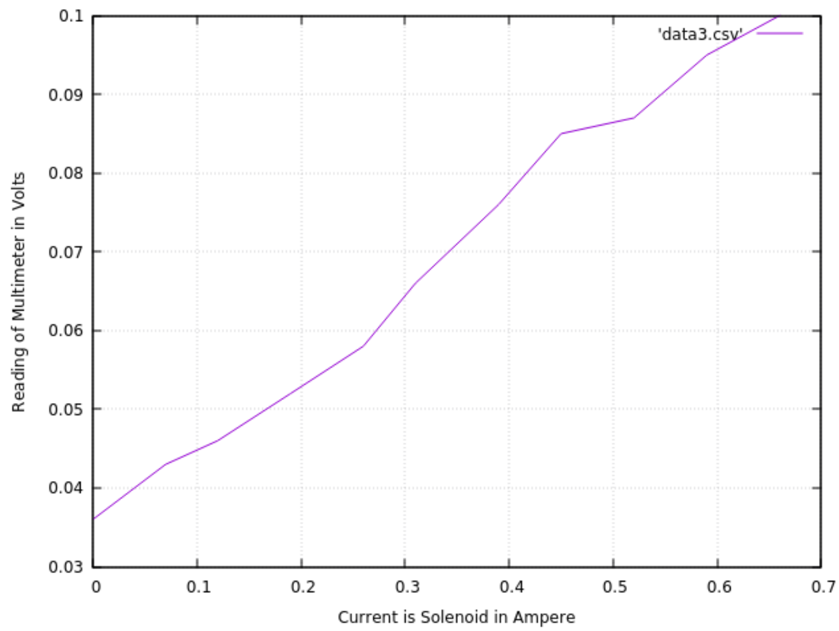



Figure 3: Polarity 1

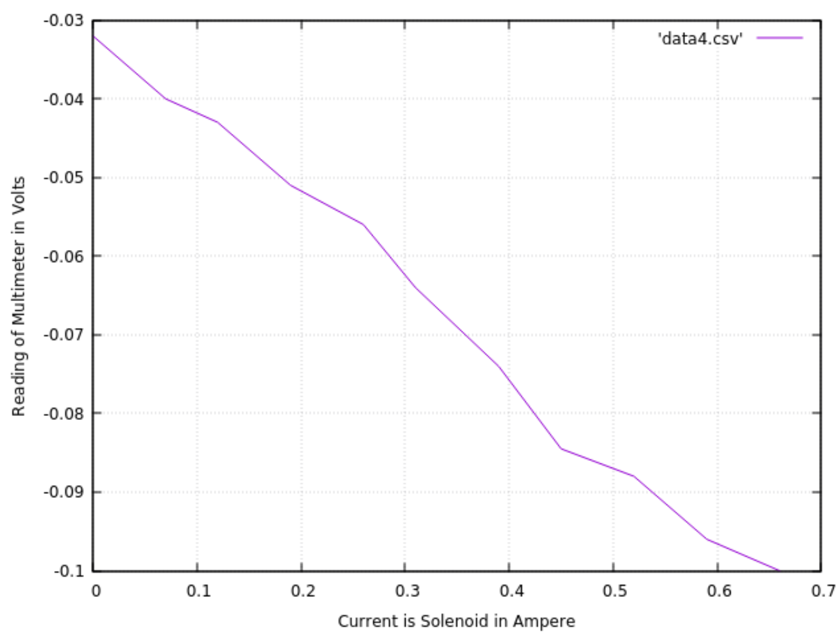
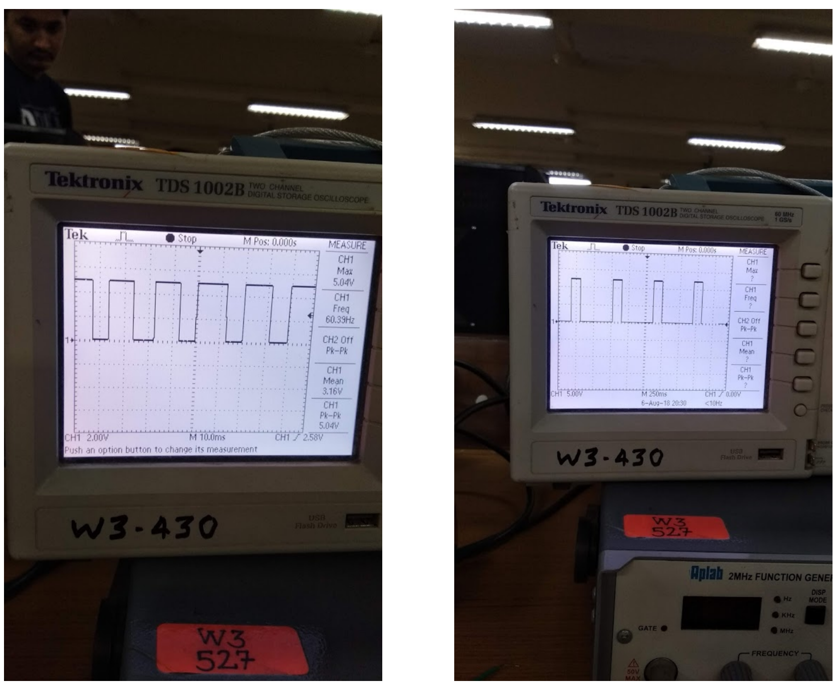



Figure 4: Polarity2 - Opposite of polarity 1

## 3.3 Part 3

We performed the experiment at room temperature. DC voltages of $\pm 12$V was supplied to the op-amps. Hall Effect Sensor was provided 5V. DC motor was supplied 3V through a voltage divider circuit. Reference voltage was 1.9V because max output of Hall Effect Sensor was recorded as 2V. Time periods measured for IR pair is roughly around 30x the time period of Hall Effect Sensor for same speed of DC motor. This is in agreement with the fact that the wheel had 30 spokes and the communication between IR pair is cut everytime a spoke passes, hence it triggers 30 times per rotation.

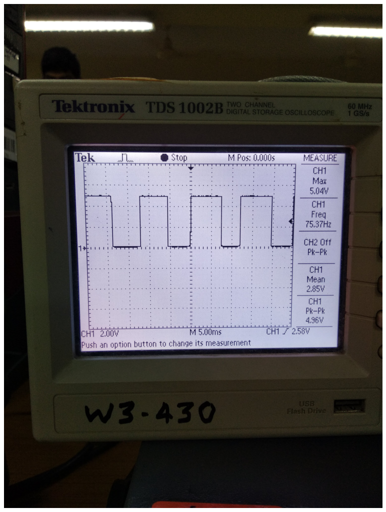
| Voltage | H.E.S output time period | IR pair output time period | Frequency(H.E.S) |
|---|---|---|---|
| 3V | 550 ms | 18 ms | 1.82 Hz |
| 4V | 375 ms | 12.5 ms | 2.67 Hz |
| 4.9V | 310 ms | 10 ms | 3.23 Hz |



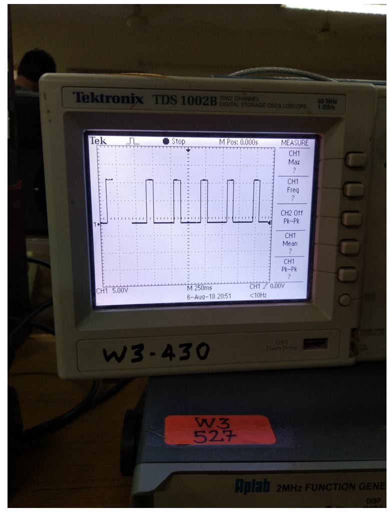

(a) IR Pair Output

(b) Hall Effect Sensor Output

Figure 5: 3V supplied to motor

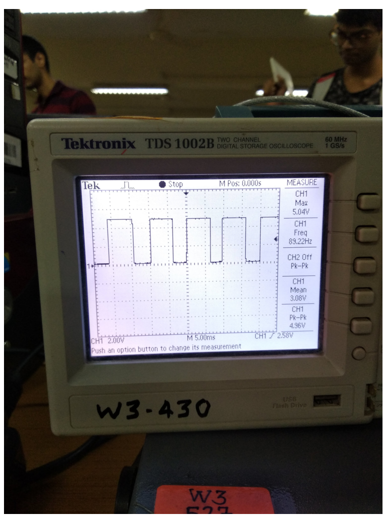



(a) IR Pair Output

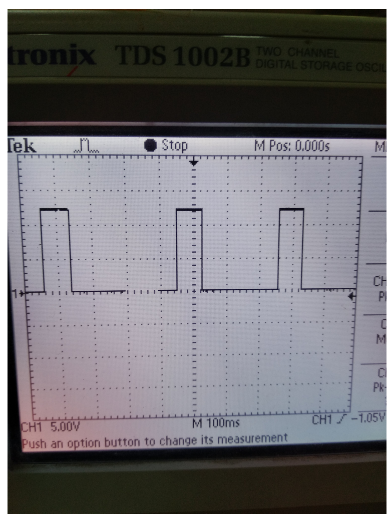



(b) Hall Effect Sensor Output

Figure 6: 4V supplied to motor




(a) IR Pair Output




(b) Hall Effect Sensor Output

Figure 7: 4.9V supplied to motor

# 4 Simulation results

```
Comparator using IC LM311
.include lm311.txt
x1 1 2 3 4 5 6 LM311
v1 1 0 sin(5 5 1k 0 0)
v2 2 0 2
vdd 3 0 12
vr 7 0 12
vss 4 0 0
v3 6 0 0
r1 7 5 18k
.tran 0.0001m 6m
.control
run
plot v(5) v(1)
.endc
.end
```

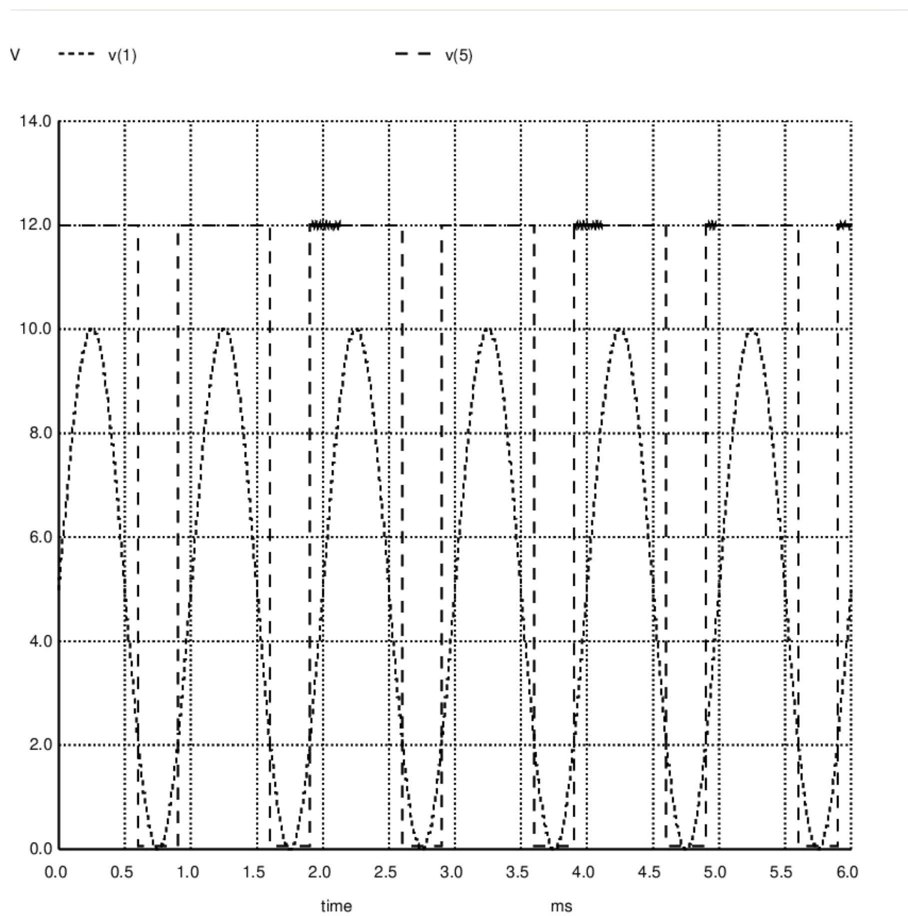



Figure 8: Plot from Simulation

# 5 Inference

## 5.1 Part 1

We see that the magnetic flux intercepted by sensor which is directly proportional to magnetic field of magnet decreases drastically as magnet moves away(or vice versa), we can infer that the field strength is inversely proportional to some positive power of distance.

### 5.2 Part 2

The output voltage(linearly proportional to field strength) increases linearly(by eyeballing) with current in solenoid. It is in agreement with solenoid's behaviour as studied in previous years.

### 5.3 Part 3

Time periods measured for IR pair is roughly around 30x the time period of Hall Effect Sensor for same speed of DC motor. This is in agreement with the fact that the wheel had 30 spokes and the communication between IR pair is cut everytime a spoke passes, hence it triggers 30 times per rotation, as should be the case.

## 6 Learning objectives

I think debugging a circuit, figuring out correct orientation of magnet, understanding working and applications of Hall effect sensors were main objectives. Yes they were fulfilled.

## 7 Quick feedback

### 7.1 What about this experiment did you find helpful?

My circuit debugging skills improved. I learnt time management.

### 7.2 What about this experiment is still unclear?

Working of IR pair.