# Hall Effect Sensor

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# Acknowledgement

**We would like to thank Texas Instruments for providing the Hall Effect sensors for this experiment!**

# Aim

In this experiment, our main objective is to study the characteristics of Hall effect sensors, and use them for following applications:

1. Head-up distance measurement.
2. Current sensing using Solenoid and Hall effect sensor
3. Speed measurement of DC Motor using Hall effect sensor and IR pair.

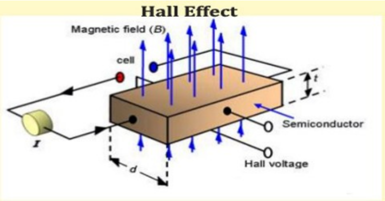
# Pre Lab Work

**Read this entire document carefully and prepare yourselves for the lab experiment.**

1. Read up about Hall effect in detail.
2. Go through following videos from TI site to get a good idea about such sensors: `https://training.ti.com/hall-effect-and-magnetic-concepts?cu=1135508`
3. Download and read the datasheet `www.ti.com/lit/ds/symlink/drv5053.pdf` to get acquainted with the Hall effect sensor.
4. Download and read the datasheet of IC311 from `www.ti.com/lit/ds/symlink/lm311.pdf`
5. Carry out NGspice simulation. A small exercise has been uploaded separately.

# Theory: Part 1

Hall voltage generated in a conductor is proportional to the applied magnetic field and the current passing through the conductor.




* In the first part of the experiment (distance measurement), permanent magnets are used to generate the magnetic field. Magnetic flux at any point depends on the distance from the magnet (revise your JEE level electromagnetism). This property can be used to measure distance of magnet from the sensor. As distance of magnet from the sensor changes, effective magnetic flux at the sensor location changes and the output voltage varies accordingly.

# Theory: Part 2

- Here, in this part of the experiment, we use a solenoid (electromagnet) to generate the magnetic field.
- When a current is passed through a conductor (solenoid), it generates a magnetic field proportional to the current.
- The direction of magnetic field is given by right hand thumb rule, which you must have studied for JEE.
- **You will have to design a setup where you appropriately orient the Hall effect sensor to the magnetic field lines**.
- Then change the magnetic flux by varying the current through conductor, thereby causing the sensor output voltage to change accordingly. This acts a good current sensing mechanism as well as verification of the Ampere circuital law.

# Theory: Part 3

- In this part of the experiment, speed of a DC motor is measured using Hall effect sensor.
- **You will design a setup wherein the field lines generated by a magnet attached to the motor shaft intercept the Hall effect sensor exactly once per rotation of motor.**
- Whenever the magnetic flux intercepts the sensor, it generates a peak in the voltage output.
- We use a comparator IC that has a built-in BJT in the output stage.
- The comparator compares the sensor output with the reference voltage (voltage corresponding to maximum magnetic field intercepting the sensor) and whenever sensor output is greater than reference voltage, it provides clean pulse at the output.

# Experiment Part 1: Head-up distance measurement

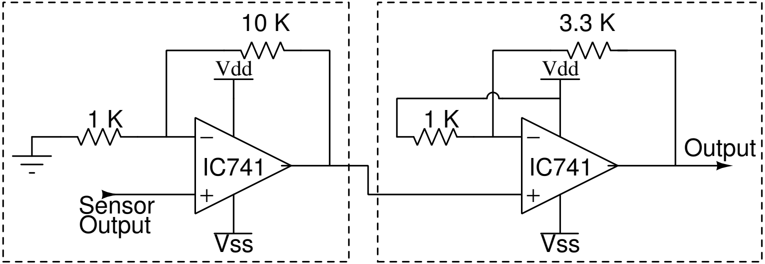
In this part, we will measure the distance of magnet from the sensor using the apparatus provided to you. If you need any additional material, justify your request, and if deemed reasonable, you will be provided the material you request. **The Neodymium magnets you are using have very large field, so please do not bring them in vicinity of your electronics, or magnets on other tables!**

1. Construct a setup where you can accurately measure the distance of the Hall effect sensor from the permanent magnet provided to you. Ensure that the output voltage of sensor is $1V$ when no magnet is placed in its vicinity (this corresponds to $B = 0$ condition). Use $Vcc = 5V$ and connect capacitor of $0.1\mu F$ between $Vcc$ and $Gnd$. What is the purpose of this capacitor?

2. Connect output of sensor to input of the noninverting amplifier as shown in Figure shown in slide no. 9.

3. Place the magnet at a distance of $\approx 15cm$ and measure the output voltage of the circuit you connected. Measure the output while bringing magnet closer to sensor in small steps (choose step size wisely).

# Experiment Part 1: Head-up distance measurement - continued



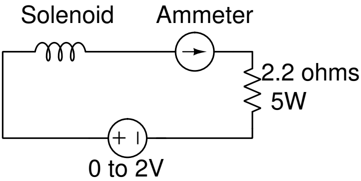

Non-Inverting Amplifier

Circuit for Offset Removal

4 Repeat the steps in [3] by placing magnet in reverse polarity to reverse the direction of magnetic field.

5 Plot a graph of distance vs voltage. What is the trend you observe? Justify your observation intuitively.

# Experiment Part 2: Current sensing using solenoid




1. Assemble a setup where the Hall effect sensor is correctly aligned to sense the magnetic field generated by the solenoid electromagnet. Use resistor of rating $2.2\Omega, 5W$ series with solenoid to limit the current, as shown above.

2. Connect the circuit for the noninverting amplifier and the circuit for offset removal using IC741 shown in slide no.9. You will use this for sensor readout, as in the earlier measurement.

# Experiment Part 2: Current sensing using solenoid

3. Vary the voltage in the solenoid circuit from $0V$ to $+2V$ to vary current and note down the output voltage. Tabulate your results (current vs voltage).

4. Now reverse the direction of current and follow the instructions in [3]. Tabulate these readings as well. Note down the experimental conditions.

5. Plot a graph of current vs voltage. What is the trend you observe? Explain this trend intuitively.

# Experiment Part 3: Measuring speed of a DC motor

In this part, we will measure the speed of a DC motor using the setup shown below. Firstly we will use Hall effect sensor to determine the speed and later will use IR pair as an alternative to such measurement.

1 Assemble the setup as shown in the figure. Connect the circuit for sensor interface and also connect the circuit for conditioning the output pulses. We will be using IC LM311 (a comparator IC) for conditioning of output pulses.

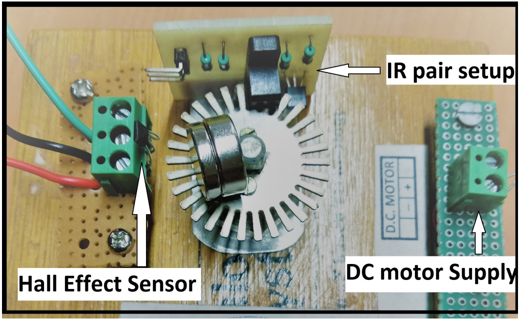



Figure: Setup for speed measurement

# Experiment Part 3: Measuring speed of DC motor

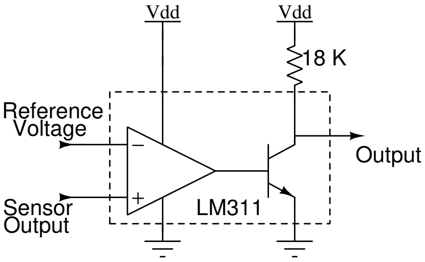



Figure: Circuit for Comparator using LM311.

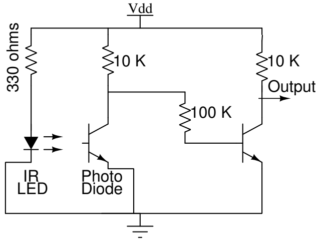



Figure: Circuit for IR pair sensor.

# Experiment Part 3: Measuring speed of DC motor

2 After assembling the setup, align the magnet attached to the motor shaft such that its flux intercepts the sensor. At this position, note down the output voltage of sensor. Set your reference voltage about 0.1 V lesser than this observed voltage.

3 Provide a supply voltage of $+3V$ to the DC motor and observe the frequency of comparator output.

4 Speed measurement can also be made using a slotted wheel driven by the motor which interrupts an infra red light beam from an LED to a photo detector as the motor rotates. The circuit for this has been given in slide no. 13.

5 Connect another probe of DSO to IR pair output and observe the frequency of its output.

4 Repeat step 2 with different values of speed of motor by varying supply voltage.

5 What is the relation between frequency of output of Hall effect sensor and that of IR pair? Does it match your expectations?

6 How can this setup be used to measure speed of motor? What is the fastest speed that one can measure with such a setup?