**ME 104**

**Sensors, Actuators and Computer Interfacing**

# Laboratory 2

# Hall-Effect Sensors

Department of Mechanical Engineering University of California, Santa Barbara

**Fall 2008 Revision**

## Introduction

In this laboratory, you will learn how to use a Hall-Effect sensor to detect the presence of a magnetic field due to a permanent magnet. You will then write a *LabVIEW* program to count the number of times that a magnet is moved past the Hall sensor, in a simulation of an attendance counter at a turnstile. Finally, you will write a program to compute and display the total (cumulative) duration of low pulses. As an extra credit exercise, you will write a program to count and display the number of long low pulses, that is, low pulses that are at least 200 ms in duration.

## Background Reading

Please read the following material prior to this lab:

1. Hall IC's Data Sheet, ***DN6848/SE/S***, pages 1-4, Panasonic. Available online at http://rocky.digikey.com/WebLib/Panasonic/Web%20data/DN6848,SE,S.pdf.
2. ***LabVIEW*** **User Manual**, April 2003 Edition, *Shift Registers*, **pages 8-6 to 8-7**. Available online at www.ni.com.

## Experiment #1: Lab Equipment

### *BREADBOARD and WIRE BASICS:*

Listen to your TA as s/he reviews the anatomy of the breadboard and discusses the various wires you will use for lab instrumentation. This will be important for the rest of the lab.

### *OSCILLOSCOPE:*

Listen first to the TA discuss probe theory. Then build a voltage divider as shown in Figure 1.

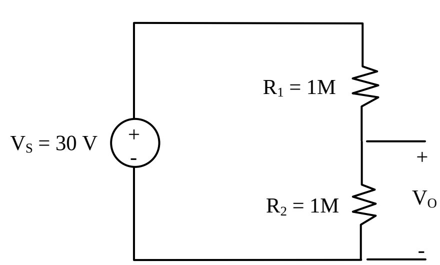


**Figure 1.** Voltage divider.

Compare measurements between using a Scope probe and BNC cable. Record the values and answer the questions at the end of the report. It may help to test a variety of resistors for the questions later.

### *DC POWER Supply:*

Generate the following DC Voltages on the oscilloscope

1. 0 to +15 V
2. 0 to –15 V
3. –15 V to +15 V
4. 5V fixed

**Record** results by drawing how you made connections for each. This will be turned in with the lab report.

### *FUNCTION GENERATOR:*

Generate the following waves (specify your own <u>Amplitude</u> and <u>Frequency</u>) on the oscilloscope:

1. Sine Wave, DC Offset 1 V
2. Square Wave, DC Offset 0 V
3. Triangle Wave, DC Offset –1 V

**Capture the oscilloscope screen with the waveforms** (refer to instruction sheet at each station). What amplitude and frequency did you use? This will be handed in with the lab report.

**Use a BNC Cable and a Scope Probe** to make the same measurements. Are they the same or different?

## Experiment #2: Build an Analog Circuit for a Hall-Effect Sensor

In this experiment, you will build a simple analog circuit for using the Panasonic DN6848 Hall-Effect sensor as a magnetic field detector. You will then test the performance of your sensor circuit using an oscilloscope.

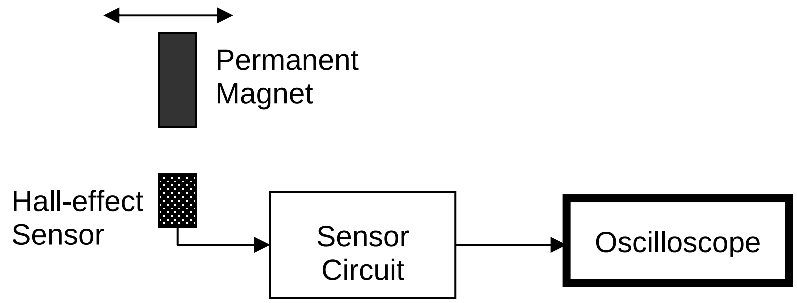

**Figure 2.** Hall-effect sensor system.

1. Build the analog circuit shown in Figure 3 on an electronic breadboard. Remember to use red wire for positive power connections and black wire for ground connections. Provide power ($V_{CC}$ = 5 volts) and ground (GND) to your circuit board using the "5 V FIXED 3 A" output from your Tektronix PS280 DC Power Supply. (Use the provided banana connectors.)
2. Turn on your oscilloscope and set its vertical scale to 5 volts/division and its horizontal scale to 1 second/division. Connect the voltage output (Hall sensor pin 3) and ground (GND) from your circuit to the oscilloscope. (Use wires with stripped ends).
3. Verify that, in the absence of a magnetic field, the voltage output from the Hall sensor circuit is of the same magnitude as the supply voltage ($V_{CC}$) to your circuit. Move a magnet near the Hall sensor and observe the resulting low-voltage pulses on your oscilloscope. As indicated on page 3 of the Hall sensor data sheet, the magnetic flux should be applied from the unmarked side of the Hall sensor.

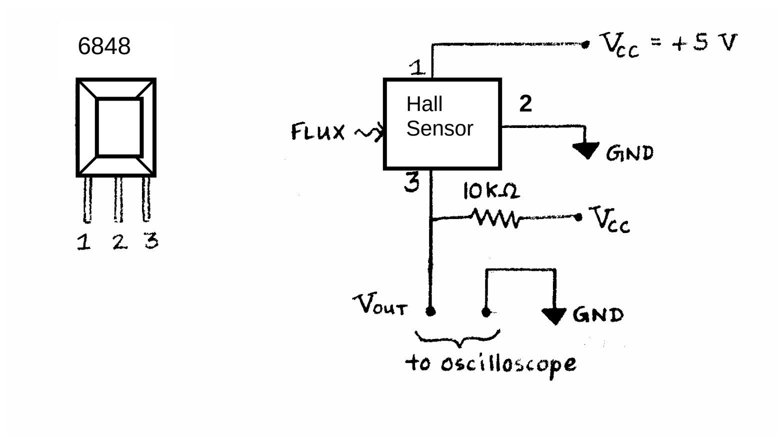


**Figure 3.** Hall-Effect sensor circuit diagram.

## Experiment #3: View Hall-Effect Sensor Output on Computer Screen

In this experiment, you will use your *LabVIEW* VI to sample and display the output from the Hall sensor circuit you built in Experiment #1.

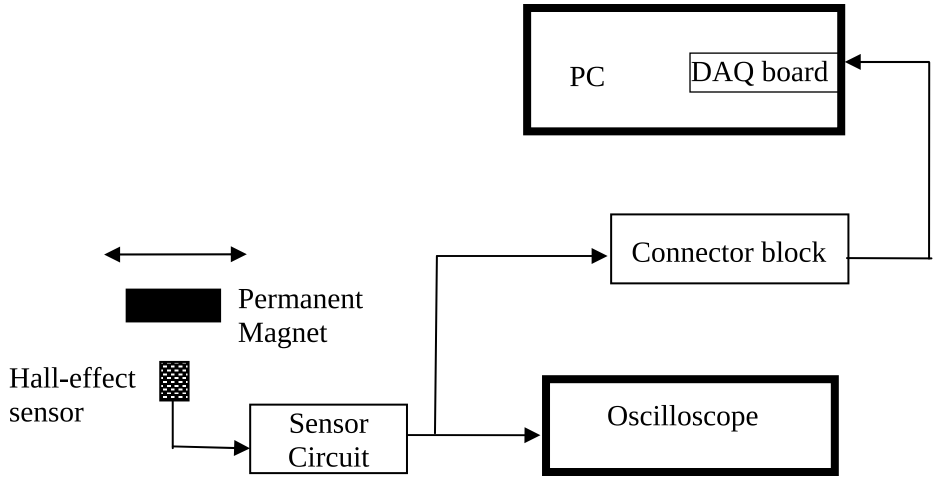


**Figure 4.** Hall-effect sensor computer interface.

1. Open **`yourname_lab2_AcquireAI.vi`**.
2. Set the sampling rate to 10 Hz (time delay of 0.1 seconds).
3. To view the analog voltage signal from the Hall sensor, connect the voltage output (Hall sensor pin 3) from your sensor circuit to the CB-68LP connector block as shown in Table 1. (Use wires with stripped ends.) Do not remove the connections to the oscilloscope.

**Table 1.** CB-68LP connector block pin assignment for measuring a voltage signal using Analog Input Channel 0.

| External Signal | Connect to: |
|---|---|
| Hall sensor voltage (pin 3) | Pin 68 (ACH0) |
| Analog ground | Pin 67 (AIGND) |

4. Click the **Run** button to see the output from the Hall sensor circuit. Verify that the low voltage pulses viewed on your computer screen are similar to the low voltage pulses (simultaneously) viewed on your oscilloscope.

## Experiment #4: Count Low Pulses

In this experiment, you will use your *LabVIEW* VI to count and display the number of low pulses that have been produced by your Hall sensor circuit.

1. Open `yourname_lab2_AcquireAI_CountLP.vi`
2. Click the **Run** button and verify that the Low Pulse Counter works. Your counter should initialize to `0` and then increment by 1 every time a new low pulse occurs.
3. **For your lab report**, capture the tiled front panel and block diagram with data that makes it obvious that your VI is working. If each the block diagram or front panel doesn't fit in the tiled screen save separately.

## Experiment #5: Time the Total Duration of Low Pulses

In this exercise, use your *LabVIEW* VI to not only count and display the number of low pulses, but also compute and display the total time during which the output from the Hall sensor circuit is low (less than 1V). A straightforward way to do this is--at each iteration of the While loop--to check whether the voltage output $V_i$ of the top shift register is less than 1V. Every time this is true, a "low pulse timer"[*] should be incremented by 100 milliseconds.

1. Open `yourname_lab2_AcquireAI_CountLP_TimeLP.vi`.
2. Test the performance of your VI.
3. **For your lab report**, capture the tiled front panel and block diagram with data that makes it obvious that your VI is working. If each the block diagram or front panel doesn't fit in the tiled screen save separately.

## Saving Files

Before you leave, remember to save all of your files to **your ECI account**, a **floppy disk, or email it to yourself** (for later use and backup purposes). For this laboratory, you should save the following files from the Desktop:

## Laboratory Report

1. Impedance Questions

---

[*] This name was chosen for descriptive purposes.

1.1. What is the input impedance of the oscilloscope?

1.2. What is the output impedance of the function generator?

1.3. Why can a BNC cable be used to connect the function generator directly to the oscilloscope?

1.4. If the 1M Ohm resistors were replaced with 100 Ohm resistors in voltage divider above, would the BNC and scope probes read different voltages? Why?

2. Attach sketches of the DC Power Supply connections.
3. Attach printouts of the Function Generator data
4. For the VI's you wrote in this laboratory (listed in the preceding section), provide a printout that shows the front panel and block diagram. Be sure to capture the front panel COLLECTING data and not just a black front panel.
5. Explain how you implemented your working timer in Experiment #5.
6. Imagine you are given a Hall-Effect sensor that outputs 0V in the absence of a (sufficiently strong) magnetic field and 5V in the presence of a magnetic field. In such a scenario, how would you modify your VI from Experiment #4 to work as a "high" pulse counter?

Your lab report should clearly state your name, lab report number, lab date, and your laboratory partner's name (if any). Your lab report should be thorough, but concise. You will be graded on quality, not quantity. **Lab Report #2 is due at the beginning of Laboratory #3.**

## Additional Reading and Practice

1. Feel free to experiment with *LabVIEW* programming in the CAD Lab. Doing so is an excellent way to reinforce and expand on the material you learned in today's laboratory.

## Extra Credit Exercise: Count Long Low Pulses (5-10 points)

In this extra credit exercise, your task is to count and display the number of "long low pulses" that are being produced by your Hall sensor circuit. For the purposes of this exercise, a "long low pulse" is defined as any low pulse that has a measured duration of 200 ms or longer. Note that, since the VI's you have been using in this lab sample at the rate of once every 100 milliseconds, the shortest measured duration of a single low pulse is 100 milliseconds.

1. Open **`Yourname_Lab2_AcquireAI_CountLP_TimeLP.vi`**.

2. Modify (add to) this VI so that you can not only count and display the number of low pulses, but also count and display the number of long low pulses. (Hint: See *Shift Registers*, page 3-14. The **And** function from the **Functions>Booleans** sub-palette may also be useful.)
3. Test the performance of your VI.
4. Save your new VI as `yourname_lab2_extra.vi`.

**Lab Report**

5. For your new VI, provide a printout that shows the front panel and block diagram. In your own words, explain how you implemented your long low pulse counter.