Hall Effect Sensor Guide

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Guide has been tested on

BeagleBone (Target):	Debian 11.8
PC OS (host):	Debian 11.8

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Required Hardware:

- BeagleBone Green/Red
- Hall Effect Sensor (US5881LUA via Adafruit)
- High Strength Magnet (High-strength 'rare earth' magnet via Adafruit)
- 10k resistor (x1)

NOTE
Please take care with your high-strength magnet - it is stronger than it looks, and will be violently attracted to metal. In addition, strong magnets have a reputation for damaging sensitive electronics or storage media. We did not encounter any issues while using this magnet, and safely transported it in the same container as our BeagleBone boards, but would nonetheless recommend taking care and perhaps performing more research into the matter.
NOTE

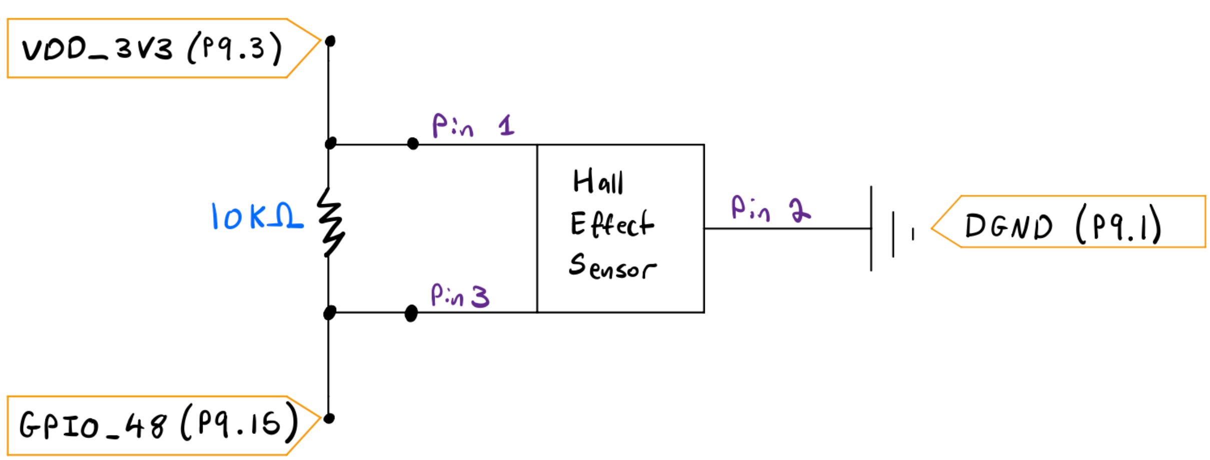
1. Hall Effect Sensor Basics

Hall effect sensors transduce magnetic fields to electrical signals, with a multitude of applications across diverse domains. In our case, the US5881LUA is a unipolar "switch" style Hall effect sensor. This means that it will simply detect the presence or absence of a magnetic flux density exceeding a given threshold - that is, it will detect the presence of the south pole of a magnet of sufficient strength. This can be useful for contactless switches or proximity detection, and in our experience has been quite stable and reliable in practice. Note that this sensor is *highly* directional by nature, which may be a boon or a challenge depending on your desired application.

2. Wiring Guide

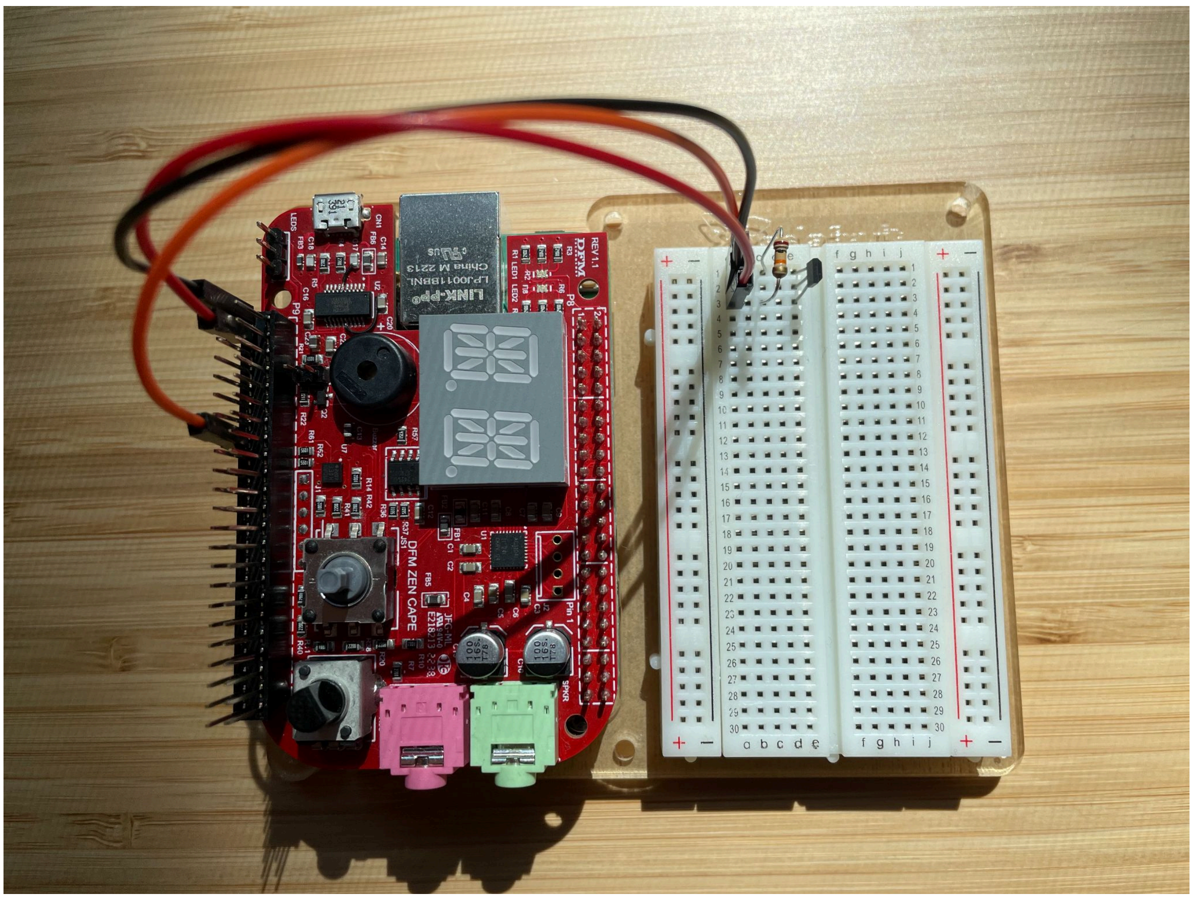
2.1 Basic Wiring

First, note that the 'front' of the Hall effect sensor is the smaller face of the trapezoidal prism - this is the side that will detect our magnet. Although the datasheet specifies an operating voltage range of 3.5V to 24V, in our testing we found that this sensor functions adequately when used with a 3.3V GPIO pin. This thankfully means that a basic setup is quite simple, requiring only one free GPIO pin (in this case, we are making use of GPIO 48).



Connect the circuit as follows:

- Connect the leftmost leg (pin 1) of the Hall effect sensor to:
  P9.3: VDD_3V3
- Connect the middle leg (pin 2) to:
  P9.1: DGND
- Connect the rightmost leg (pin 3) to:
  P9.15: GPIO_48
- Add a pull-up 10k resistor between the rightmost leg (pin 3) and our power pin (VDD_3v3)



2.2 Testing

To test this circuit on the command line, first ensure that your desired GPIO pin is exported and configured to `gpio` as per the GPIO guide.

```
$ (bbg)  cd /sys/class/gpio
$ (bbg)  echo 48 > export     *iff not already exported*
$ (bbg)  config-pin p9.15 gpio
```

Now, you may read values from the command line as follows:

```
$ (bbg)  cd /sys/class/gpio/gpio48
$ (bbg)  cat value
```

The value should change from 1 to 0 whenever the south pole of the magnet is held within roughly a half inch from the front of the Hall effect sensor. Note that this behavior may be inverted by changing the value of the `active_low` file in this directory, which we found to be desirable when testing and implementing a HAL for this sensor.

2.3 Notes On Mounting and Prototyping

Due the low range of detection for this sensor, reliable mounting can be quite a challenge. Note that tape will not interfere with the strength of the magnetic field produced by the magnet, and was our solution for mounting while prototyping.

When prototyping, we found it very useful to visualize the current value read by the Hall effect sensor with an LED. This made it much easier to get a feel for the range and efficacy of the sensor.

2.4 Troubleshooting

- Ensure that the south pole of the magnet is facing towards the ‘front’ of the Hall effect sensor, and within a half inch distance. Also, ensure that the magnet is with a ~45° angle of the the front of the sensor.
- Double check that you have not connected 3.3V to pin 3 and a GPIO pin to pin 1. Due to the most efficient wiring position of the sensor, it can be easy to flip the orientation by mistake.

3. C Code

After configuring p9.15 for `gpio` with a direction of `in`, the following C code will test the functionality of the Hall effect sensor. Please note that this example is assuming 0 as the active low for GPIO 48, which may not be the default.

```
while(1) {
   // open file
   FILE* pFile = fopen("/sys/class/gpio/gpio48/value", "r");
   if (pFile == NULL) {
       printf("ERROR: Unable to open file (%s) for read\n",
"/sys/class/gpio/gpio48/value");
   }

   // read string (line)
   const int MAX_LENGTH = 1024;
   char buff[MAX_LENGTH];
   fgets(buff, MAX_LENGTH, pFile);

   // close file
   fclose(pFile);

   int sensorValue = atoi(buff);
   if (sensorValue == 0) {
       printf("Nothing detected...\n");
   } else {
       printf("Magnet detected!\n");
   }

   // sleep for 20ms
   struct timespec reqDelay = {0, 20000000};
   nanosleep(&reqDelay, (struct timespec*) NULL);
}
```

4. Building a Speedometer

A Hall effect sensor may be used to build a simple speedometer. By mounting a magnet to a fixed point on a wheel and our sensor elsewhere on the frame, we may calculate the revolutions per minute of this wheel by observing the frequency with which we detect the presence of our magnet. From this, our wheel diameter may be used to calculate ground speed in miles per hour via the formula:

```
Speed = RPM * Wheel Diameter * π * (60 / 63360)
```

Where we multiply by 60 to convert from minutes to hours, and divide by 63,360 to convert from inches to miles. In practice, this may be approximated by multiplying by a constant of 0.000947 if better efficiency is required. When implementing a speedometer in this way, ensure that sensor values are debounced and that your code waits until a new low value is detected (after this debouncing interval) before registering a new high value.

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