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An Investigation of Magnetic Field Detection using the Technique of Hall Effect Sensor and Raspi Pico with Micropython Programming

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Abstract: In the present paper an attempt has been made to detect magnetic field and its direction using Hall effect sensor with Raspi Pico. Raspberry Pi (Raspi) is a series of single-board computers (SRCs) which is a programmable computer. The Hall effect sensor works in combination of magnetic fields and flux. This magnetic field is generated using a magnet. A Hall effect sensor with Raspberry Pi Pico requires interfacing the sensor with the Pico's general-purpose input/output (GPIO) pins. For our research, we assembled the entire circuit on a PCB prototype. In addition, PYTHON programming (Micropython) is employed to investigate the detection of magnetic field, ultimately turning ON the on-board LED, else if not in contact with magnetic field the LED will be OFF.

Keywords: Raspi Pico; Hall effect sensor; LED; Micropython; Magnetic Field; GPIO Pins

1. INTRODUCTION

1.1 Raspi Pico

Raspberry Pi (Raspi) is a series of small single-board computers (SRCs) developed in the United Kingdom [1]. From the family of Raspberry Pi SRCs, Raspberry Pi Pico is the first high performance, low-cost microcontroller board built with RP2040 chip. It has a Dual-core cortex M0+ processor with on-chip phase-controlled loop for adjusting the core frequency. With 133MHz clock speed, Pico has a 264byte SRAM and 16byte on-chip cache. Sixteen Pulse Width Modulation (PWM) channels, Real Time Counter, 12-bit Analog to Digital Converter, thirty multi-function IOs and an on-board USB [2].

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General- Purpose Input/Output (GPIO) pins are considered to be the coolest features of the Raspi Pico. These GPIO pins allow the Raspi Pico to control and monitor the outside world by being connected to electronic circuits. The Pico can control LEDs, turning them on or off, run motors and many other things [3]. Pico doesn't run any operating system; instead, it runs a simple code written in Micro Python, an implementation of Python 3 programming. When working with Micro Python, we edit the code using a development environment compatible with this interpreter (for example, Thonny Python) and then load the source code into the microcontroller. Since the code is now stored in the microcontroller's Flash memory, we can view and edit the source code at any time [4].

Figure 1 Image of Raspi Pico

1.2 Hall Effect Sensor

The effect of generating a measurable voltage by using a magnetic field is called the Hall Effect. It was discovered by Edwin Hall back in the 1870's with the basic physical principle underlying the Hall effect being Lorentz force. To generate a potential difference across the device the magnetic flux lines must be perpendicular (90°) to the
flow of current and be of the correct polarity, generally a south pole. The hall effect sensor is a type of magnetic sensor that can be used for detecting the strength and direction of a magnetic field produced from a permanent magnet or an electromagnet with its output varying in proportion to the strength of the magnetic field being detected [5]. The Hall effect is an ideal sensing technology. Hall sensors convert magnetic or magnetically encoded information into electrical signals for processing by electronic circuits. The Hall element is constructed from a thin sheet of conductive materials. The output connections for these sensors are made perpendicular to the direction of current flow and under the influence of a magnetic field, it responds with an output voltage proportional to the magnetic field strength. The voltage output is usually very small in the range of microvolts and requires additional electronics to achieve useful output levels.

When the Hall element is combined with the associated electronics, it forms a Hall Effect Sensor. The heart of every Hall Effect device is the integrated circuit chip that contains the Hall element and the signal conditioning circuitry. In this generalised sensing device, the Hall Sensor senses the field produced by the magnetic system.
The magnetic system responds to the physical quantity to be sensed through the input interface. The output interface converts the electrical signal from the hall sensor to a signal that meets the requirements of the applications.[6]. A Hall sensor is an analog device that varies its output voltage proportional to the magnetic field it is sensing [5]. Hall effect sensors are cheap, robust, and reliable, tiny, and easy to use, so we'll find them in lots of different machines and everyday devices, from car ignitions to computer keyboards and factory robots to exercise bikes [7]. In section 2 and 3 we have discussed materials and method used and in section 3 we have explained results and the mechanism of Hall effect sensor and microcontroller device like Raspi Pico

for the detection of magnetic field. Finally, in section 4 we have summarized the work and discussed the further scope of our research work.

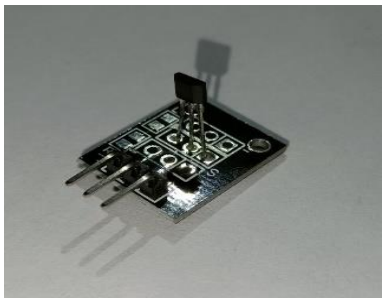

Figure 2 Image of Hall Effect Sensor

2. EXPERIMENTAL SETUP

2.1. Materials and Methods

The following physical components used in our research work are described here: Raspi Pico (RP2040) (a microcontroller with USB support used to control and receive input from variety of electronic circuit) as depicted in figure 1. Hall sensor module (SS49E) used to detect magnetic field) as shown in figure 2. Digital solderless breadboard (a way of connecting electronic components to each other without having to solder them together); LED (a semiconductor light source that emits light when current

flows through it); Magnets (any substance or thing that generates a magnetic field); Jumper wires (male-to-male) (used on breadboards to 'jump from one connection to another); Thonny Python IDE (a new development environment for Python programming); Micropython language (a programming language) and a Resistor (220Ω) are used. The whole circuit was assembled on the solderless breadboard. The GPIO (general-purpose input output) pins of Raspi Pico, main components of the circuit which runs a code written in Python 3 programming, were inserted on the center part of the breadboard. It was made sure to insert the side of the Raspi

Pico, where USB cable will be connected with laptop, on the corner side of center part then there will be enough space for the other components of the circuits on the other side of Raspi Pico. The breadboard has two power rails with '+' and '-' sign, one at the top and other at the bottom. The two power rails

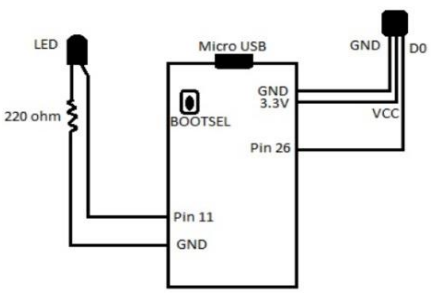

Figure 3 Block diagram of the circuit used.

should be connected to provide power on both the sides of the breadboard. '+' of top power rail and '+' of bottom power rail was connected and '-' of top power rail and GND (ground) pin (hole b 18) of the Raspi Pico was connected. The LED was plugged in top power rail, anode (long leg) in '+' and cathode (short leg) in '-'. One terminal of a resistor is connected to the Raspi Pico (hole b-20) and other to the '+' of bottom power rail.

A Magnetic Hall Sensor was inserted on the breadboard to detect the magnetic field. The three leads of the sensor were pushed into the hole a-28, a-29 and a-30. With the help of jumper wires, the Power pin (VCC) of Hall Sensor and 3.3V pin (hole j-4) of Raspi Pico; GND pin of Sensor and GND pin (hole j-3) of Raspi Pico and Output pin of Sensor and any of the GPIO pin (hole j-10) of the Raspi Pico were connected. To run the *Micropython* programming for the investigation of detection of magnetic field, Raspi Pico along with the Hall Sensor was connected to the laptop.

3. RESULTS AND DISCUSSION

To understand the proper functioning of the Hall effect sensor with Raspi Pico, we have used the Micro Python programming code. The following command was used in Micro python coding to read the Hall sensor data.

```
from machine import Pin
import time,utime
he=Pin(26,Pin.IN)
led=Pin (11, Pin.OUT)
while True:
  try:
if he.value() == 0:
led.value(0)
elif he.value()==1:
led.value(1)
except KeyboardInterrupt:
break [8]
```

When magnet comes closer in contact with the sensor, the LED starts glowing and, in that case, the Hall sensor value also becomes '1'. This shows the presence of the magnetic field in the surrounding as depicted in figure 4. However, when the magnet was placed away from the sensor, it was observed that LED did not glow. Also, it was found that the value of the Hall sensor was '0'. This suggested us that there is absence of the magnetic field in the surrounding therefore LED was not glowing as shown in figure 5.

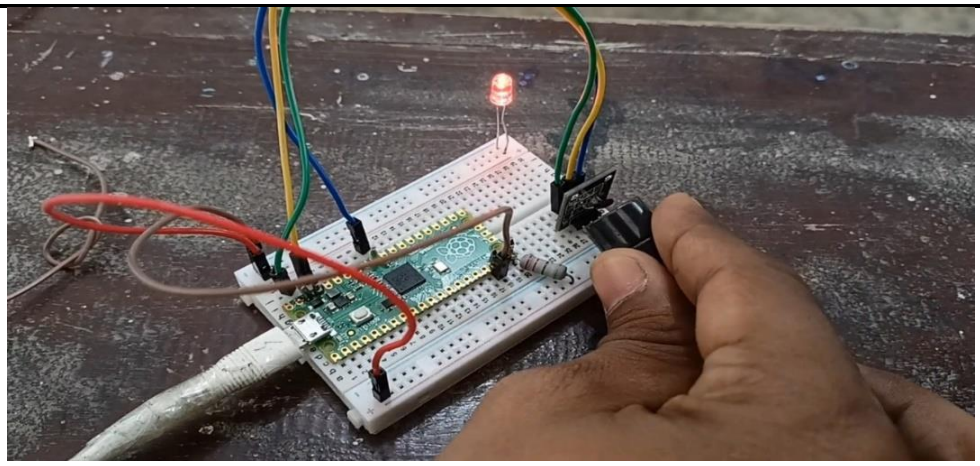

Figure 4 Picture reveals the presence of magnetic field.

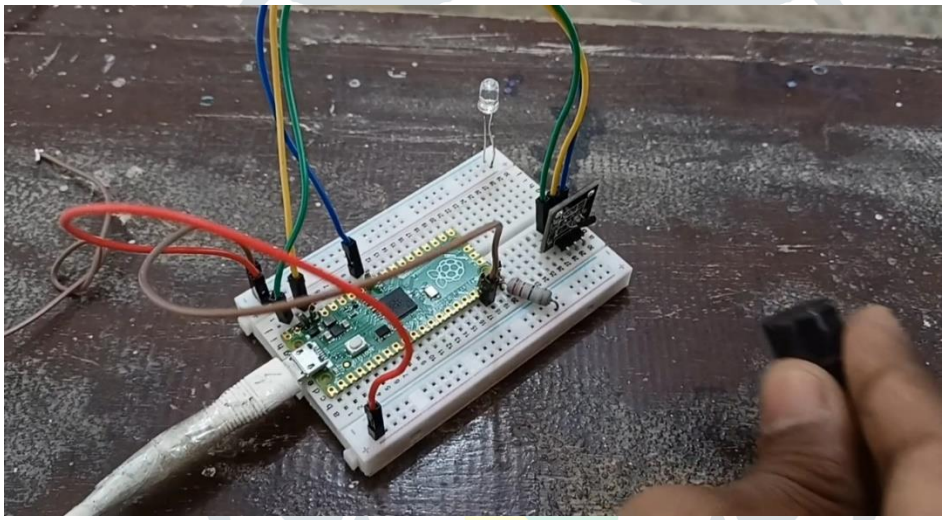

Figure 5 Picture shows the absence of magnetic field.

4. SUMMARY AND CONCLUSIONS

The use of Python programming for magnetic field detection using a Hall effect sensor and a Raspi Pico has demonstrated the powerful combination of hardware and software in scientific experimentation. The Raspi Pico provides a reliable platform for data acquisition and control, while the Hall effect sensor allows for accurate measurement of magnetic fields. Application of Python programming, researchers and students can easily interface with the Raspi Pico and the Hall effect sensor, allowing for real-time data visualization and analysis. This approach is especially useful in physics experiments where magnetic field measurement is critical, such as plasma diagnostics, electron mobility measurements, and magnetic levitation experiments. Finally, this project has demonstrated the versatility of the Raspi Pico and its potential to be used in a wide range of scientific applications. The low cost and ease of programming make the Raspi Pico an attractive platform for both academic and industrial researchers. Furthermore, our future aspect in our present research is to further design and modify a necessary circuit/equipment by incorporating serial monitor for measuring the magnitude of magnetic field.

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