EXPERIMENT NO.:

➢ **Title:**
Interfacing sensors and actuators with Raspberry Pi 3.

**Sensors**
- IR sensor
- PIR sensor
- Ultrasonic sensor
- Temperature and humidity (DHT11) sensor

**Actuators**
- DC motor

➢ **Objectives:**
1. To know about various sensors available in the market.
2. To know about various actuators available in the market.
3. To Know how to work with Raspberry Pi 3.

➢ **Outcomes:**
1. Students will learn to interface various sensors with Raspberry Pi 3
2. Students will learn to interface various actuators with Raspberry Pi 3
3. Students will learn to Install Operating System Raspberry Pi 3.
4. Students will learn to program Raspberry Pi 3

➢ **Hardware Requirement :**
Raspberry Pi 3, USB to VGA Converter, Monitor, Keyboard, Mouse, 9v adaptor, USB cable, IR sensor, PIR sensor, Ultrasonic sensor, Temperature and humidity (DHT11) sensor, Temperature (LM35) (analog) sensor, DC motor, Stepper Motor, Breadboard.

➢ **Software Requirement :**
Raspbian OS, Python 3 IDE.
Theory:
IR (Infrared) Sensor
IR (Infrared) Sensor works by emitting infrared signal/radiation and receiving of the signal when the signal bounces back from any obstacle. In other words, the IR Sensor works by continuously sending signal (in a direction) and continuously receive signal, if comes back by bouncing on any obstacle in the way.

Components:
- IR Sensor Emitter: This component continuously emits the infrared signal
- Receiver: It waits for the signal which is bounced back by obstacle
- Indicator: On board LED to signal if obstacle is deducted by the sensor
- Output: Could be used as Input for further processing of the signal
- Ground: Ground/Negative point of the circuit
- Voltage: Input 3.3V

In this tutorial we will learn how we can Interface an IR sensor with Raspberry Pi. These sensors are most commonly use in small robots like line follower robot, Edge avoiding robot etc. Simply putting, it can detect the presence of objects before it and also differentiate between white and black colour.

So lets learn how to interface this sensor with Raspberry Pi. In this project, when there is no object in front of IR sensor then the Red LED remains turned on and soon as we put something in front of IR sensor then red LED turns off and Green LED turn on. This circuit can also serve as Security Alarm Circuit. IR Sensor Module:
IR sensors (Infrared sensor) are modules which detect the presence of objects before them. If the object is present it give 3.3V as output and if it is not present it gives 0 volt. This is made possible by using a pair of IR pair (transmitter and receiver), the transmitter (IR LED) will emit an IR ray which will get reflected if there is a object present before it. This IR ray will be received back by the receiver (Photodiode) and the output will be made high after amplified using an op-amp link LM358

The IR Sensor used in this assignment is like all IR sensor it has three pins which are 5V, Gnd and Out respectively. The module is powered by the 5V pin from Raspberry Pi and the out pin is connected to GPIO14 of Raspberry Pi. The potentiometer on top of the module can be used to adjust the range of the IR sensor.

Circuit Diagram and Explanation
The circuit diagram for connecting Raspberry Pi with IR sensor is shown below. As you can see the circuit diagram is very simple. We have directly powered the IR module from the 5V and Ground Pin of Raspberry Pi. The output pin of the IR module is connected to the GPIO14. We have also used two LED (Green and Red) to indicate the status of the object. These two LEDs are connected to GPIO3 and GPIO2 respectively. Since the GPIO pins of Raspberry Pi are 3.3V, a current limiting resistor is not mandatory. However if desired a resistor of value 470 ohms can be added between the ground pin of LEDs and Raspberry Pi. The whole circuit is powered by a 5V mobile charger through the micro USB port of the Raspberry Pi.

Note: When connecting any sensor, make sure the ground of the sensor is connected to ground of the MCU or MPU (here Raspberry Pi). Only then they will be able to communicate.

Code: Here we are using Python Programming language for programming RPi. There are many ways to program your Raspberry Pi. The complete Python program is given at
the end of this tutorial. Working: Once you have created your python code, execute it using the run command and see the result. You should also see the red colour LED going high when there is no object in front of the sensor. Now, bring something close to the IR led and you should notice the red LED turning off and the Green turning on.

Applications: As mentioned in the earlier sections, Proximity Sensor or Obstacle Detection is the main application of interfacing IR Sensor with Raspberry Pi.

b) Interfacing PIR sensor with Raspberry pi

All living beings radiate energy to the surroundings in the form of infrared radiations which are invisible to human eyes. A PIR (Passive infrared) sensor can be used to detect these passive radiations. When an object (human or animal) emitting infrared radiations passes through the field of view of the sensor, it detects the change in temperature and therefore can be used to detect motion.

HC-SR501 uses differential detection with two pyroelectric infrared sensors. By taking a difference of the values, the average temperature from the field of view of a sensor is removed and thereby reducing false positives.

Interfacing HC-SR501 with Raspberry Pi is easy because the output of a sensor is Pi friendly ie. 3.3V and it can be powered from the 5V rail of Pi.

The PIR sensor consists of 3 pins:
1. Vcc – 4.5V to 20V, Input power
2. OUTPUT – TTL output of sensor 0V, 3.3V
3. GND – Ground

The module has a rectangular window with two sub-probes 1 and 2 located at two ends of the rectangle. When a body emitting infrared radiation moves from side to side, the time for each probe for detection varies. Larger the time difference, more sensitive the
device. It also uses a Fresnel lens to improve sensing aperture and filter in infrared waves.

Adjustment:
For adjusting the detection delay (0.3 seconds to 600 seconds): Turn the potentiometer clockwise to increase and anticlockwise to decrease.
For adjusting the sensing distance (3 meters to 7 meters): Turn the potentiometer clockwise to increase and anticlockwise to decrease.

Hardware Requirement
1. Raspberry Pi setup (screen, mouse, keypad, raspberry pi, AC to 5V DC converter).
2. 3 female to female connector wires
3. A PIR sensor.

c) Interfacing of Ultrasonic sensor with Raspberry Pi 3
Ultrasonic Sensors, particularly HC-SR04 Ultrasonic Sensor, are very popular among electronic hobbyists and are frequently used in a variety of projects like Obstacle Avoiding Robot, Distance Measurement, Proximity Detection and so forth. In this project, we will learn about HC-SR04 Ultrasonic and see how to interface one with Raspberry Pi.

The range of this Ultrasonic Sensor seems very less but it is sufficient for the applications it is implemented in i.e. Proximity Detection and Obstacle Avoiding, for example. The Raspberry Pi Ultrasonic Sensor Interface is different from interfacing LED,
Button, LCD, Motors, etc. with Raspberry Pi. This is because the output of the HC-SR04 Ultrasonic Sensor is at a 5V logic level whereas the Raspberry Pi works on a 3.3V logic level.

It basically consists of three parts: an ultrasonic transmitter, a control circuit and an ultrasonic receiver. Coming to the pins of the HC-SR04 Sensor, it has only four pins namely VCC, TRIG (Trigger), ECHO (Echo) and GND.

The following image shows the connections between the Raspberry Pi and the HC-SR04 Ultrasonic Sensor. This circuit diagram is made with Fritzing Software.

**Components Required**

- Raspberry Pi 3 Model B
- HC-SR04 Ultrasonic Sensor
- 680 Ω Resistor (1/4 Watt)
- 1.5 KΩ Resistor (1/4 Watt)
- Connecting Wires
- Mini Breadboard
- Power Supply
- Computer

**Circuit Diagram:**

![Circuit Diagram Image]
d) Interfacing of DHT11 with Raspberry Pi 3:

**Hardware used:**
- Raspberry-Pi Board
- DHT11 Temperature and Humidity Sensor
- Connecting Wires
- Software used:
  - Python Interpreter

**Theory:**
In this project, we will learn about DHT11 Humidity and Temperature Sensor and how the Raspberry Pi DHT11 Humidity Sensor interface works. Overview DHT11 is a Digital Sensor consisting of two different sensors in a single package. The sensor contains an NTC (Negative Temperature Coefficient) Temperature Sensor, a Resistive-type Humidity Sensor and an 8-bit Microcontroller to convert the analog signals from these sensors and produce a Digital Output. Circuit Diagram The following is the circuit diagram of the DHT11 and Raspberry Pi Interface.
If you observe the circuit diagram, there is not a lot of stuff going on with respect to the connections. All you need to do is to connect the VCC and GND pins of the DHT11 Sensor to +5V and GND of Raspberry Pi and then connect the Data OUT of the Sensor to the GPIO4 i.e. Physical Pin 7 of the Raspberry Pi.

**Installing DTH11 Library**

Since we are using a library called Adafruit_DHT provided by Adafruit for this project, we need to first install this library into Raspberry Pi.

- First step is to download the library from GitHub
- Now, enter the following command to download the files related to the Adafruit_DHT library.
  ```
  git clone http://github.com/adafruit/Adafruit_Python_DHT.git
  ```
- All the contents will be downloaded to a folder called ‘Adafruit_Python_DHT’. Open this directory using cd Adafruit_Python_DHT. To see the contents of this folder, use ‘ls’ command.
- In that folder, there is file called ‘setup.py’. We need to install this file using the following command.

  ```
  sudo python setup.py install
  ```

**e) Interfacing of DC motors with Raspberry Pi 3**

**Principle of Operation**

The main principle in controlling a DC Motor with Raspberry Pi lies with the Motor Driver. A Motor Driver is a special circuit or IC that provides the necessary power (or rather the current) to the motor for smooth and safe operation. Even a small 5V DC Motor draws a high initial current of around 300–400 mA. This current will then fall down 150–200 mA as the motor gains speed to around. This is a huge current for devices like Microcontrollers, Arduino, Raspberry Pi etc. Hence, we should never connect a motor directly to Raspberry Pi (or any other microcontroller).

Motor Driver play an important role in this situation. They take the control signals from Raspberry Pi and provide the necessary drive current to the motor from the power supply.

In this project, the motor driver (L293D) is given with two control signals from Raspberry Pi through GPIO Pins. As per the Python Program, the motor will rotate in either forward or reverse direction.

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Components Required

- Raspberry Pi 3 Model B
- L293D Motor Driver IC or Module
- Small DC Motor (5V)
- Connecting wires (Jumper Wires)
- 5V – 2A Power Supply for Raspberry Pi
- 5V Supply for Motor
- Miscellaneous (Computer, Ethernet Cable, etc.)

Circuit Diagram

- The design of the circuit for controlling a DC Motor with Raspberry Pi is very simple. First, connect the pins 8 and 16 (VCC2 and VCC1) of L293D to external 5V supply (assuming you are using a 5V Motor).
- There are four ground pins on L293D. Connect pin 4 to the GND of supply. Also, connect the ground pin of L293D to GND pin of the Raspberry Pi.
- Finally, we have the enable and control input pins. Connect the pin 1 of L293D (1,2EN) to GPIO25 (Physical Pin 22) of Raspberry Pi. Then connect control input pins 2 and 7 (1A and 2A) to GPIO24 (Physical Pin 18) and GPIO23 (Physical Pin 16) respectively.
Conclusion:

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Questions:

1. Explain RFID communication in details.
2. Classify and Summarize types of actuators.