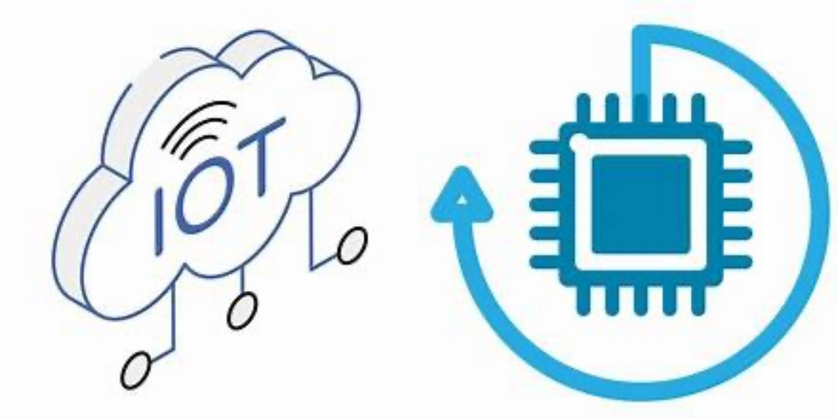
Internet of Things (IoT) Systems

Week 7

Raspberry Pi Programming



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Spring – 2025

Announcement

- Midterm Exam:

  When: Tuesday, April 22, 2025
  Location: Same Classroom 301

  Duration: 01:10 pm- 02: 40 pm

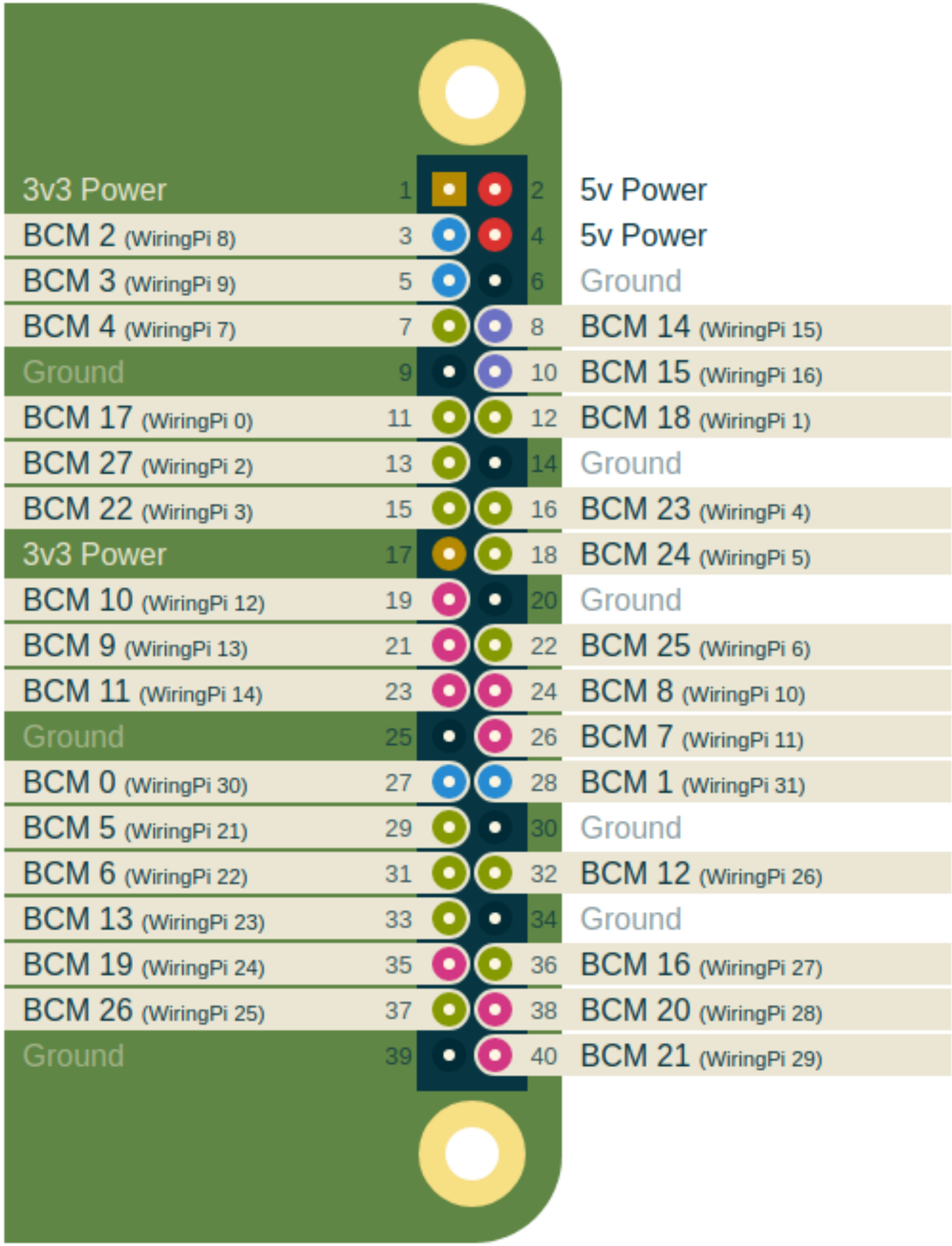
- Exam Style:

  During the exam, you will be assigned tasks to complete.

  The tasks will involve working with a Raspberry Pi, connecting various sensors, and writing C code to accomplish specific objectives.

GPIO Pin Numbering Schemes

- Physical
  - The actual pin numbers on 40-pin connector
- BCM
  - Broadcom pin numbers often called GPIO numbers
  - This is the most common method of naming the GPIO pins
- WiringPi
  - Pin numbers used in WiringPi library



3v3 Power	1	2	5v Power
BCM 2 (WiringPi 8)	3	4	5v Power
BCM 3 (WiringPi 9)	5	6	Ground
BCM 4 (WiringPi 7)	7	8	BCM 14 (WiringPi 15)
Ground	9	10	BCM 15 (WiringPi 16)
BCM 17 (WiringPi 0)	11	12	BCM 18 (WiringPi 1)
BCM 27 (WiringPi 2)	13	14	Ground
BCM 22 (WiringPi 3)	15	16	BCM 23 (WiringPi 4)
3v3 Power	17	18	BCM 24 (WiringPi 5)
BCM 10 (WiringPi 12)	19	20	Ground
BCM 9 (WiringPi 13)	21	22	BCM 25 (WiringPi 6)
BCM 11 (WiringPi 14)	23	24	BCM 8 (WiringPi 10)
Ground	25	26	BCM 7 (WiringPi 11)
BCM 0 (WiringPi 30)	27	28	BCM 1 (WiringPi 31)
BCM 5 (WiringPi 21)	29	30	Ground
BCM 6 (WiringPi 22)	31	32	BCM 12 (WiringPi 26)
BCM 13 (WiringPi 23)	33	34	Ground
BCM 19 (WiringPi 24)	35	36	BCM 16 (WiringPi 27)
BCM 26 (WiringPi 25)	37	38	BCM 20 (WiringPi 28)
Ground	39	40	BCM 21 (WiringPi 29)

Access and Control of IoT Devices

- Light Sensors are photoelectric devices that convert light energy whether visible or infra-red light into an electrical signal

  - Auto screen brightness adjustments

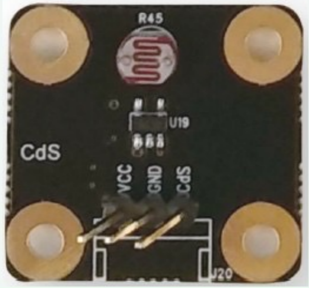
  - Automatically turn on light systems if getting dark

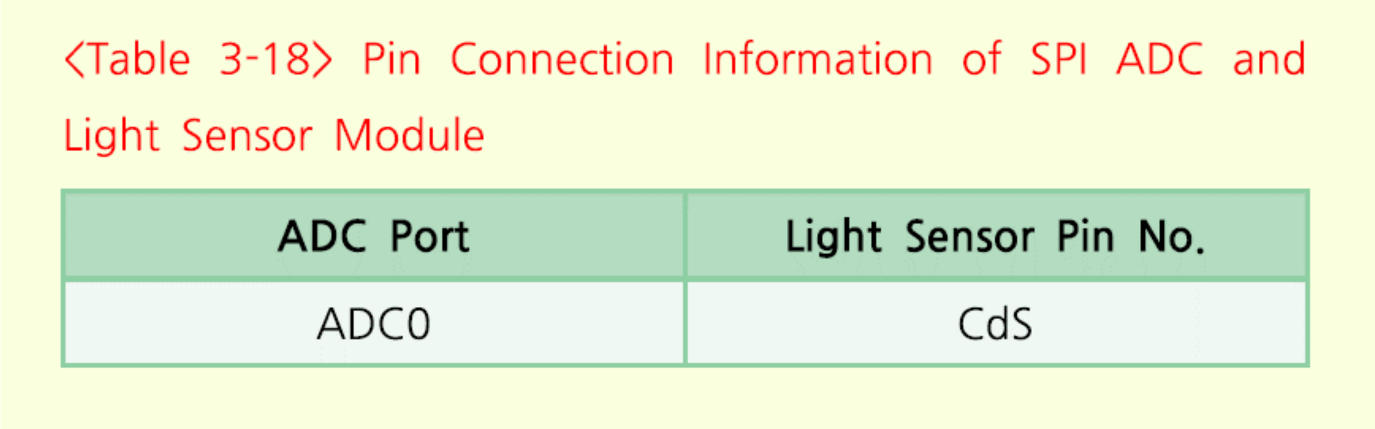
Access and Control of IoT Devices

A CDS photocell or Light Dependant Resistor is a resistor where the resistance changes based on the amount of light. As the amount of light increases the resistance of the sensor decreases and vice versa.

CDS = **Cadmium Sulfide**

<Table 3-17> Specifications of Light Sensor Module

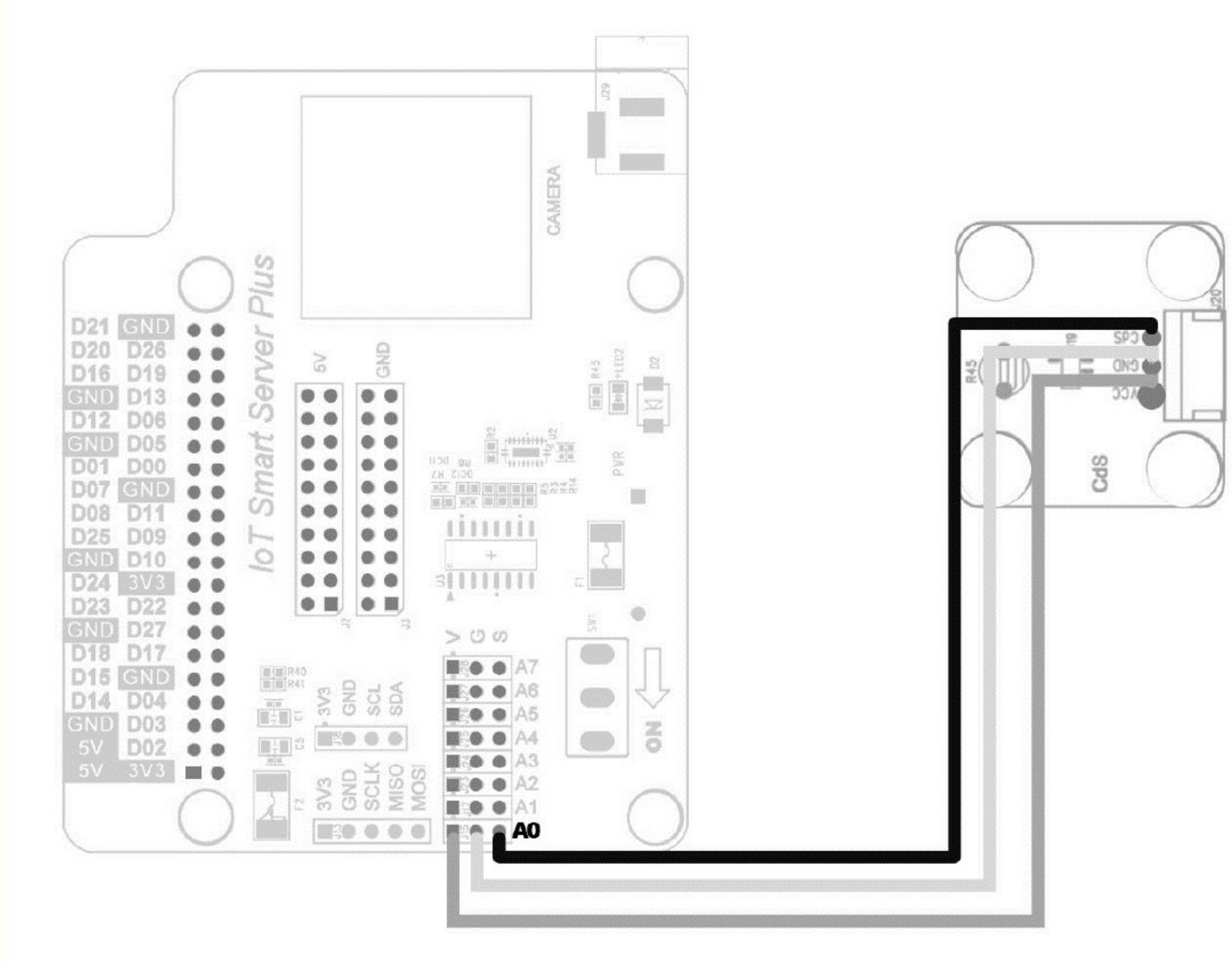
Shape	Category	Description
	Sensor	Light(CDS)
	Interface	1pin Analog OUTPUT
	Operating Voltage	5V



<Table 3-18> Pin Connection Information of SPI ADC and Light Sensor Module

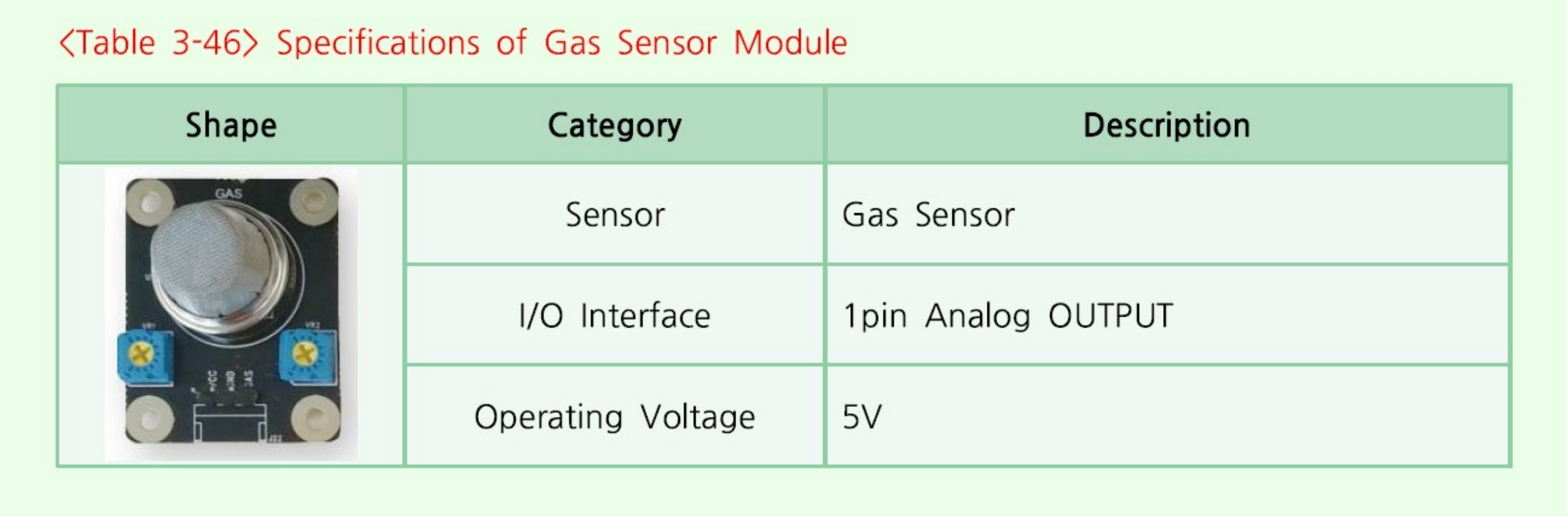
ADC Port	Light Sensor Pin No.
ADC0	CdS

Connect module without applying power to RPi



Access and Control of IoT Devices

- Gas Sensor detect and identify different types of gasses
  - Gas sensors are employed in factories and manufacturing facilities to identify gas leaks, and to detect smoke and carbon monoxide in homes
  - MQ-6 gas sensor can detect kinds of flammable gases, especially has high sensitivity to LPG

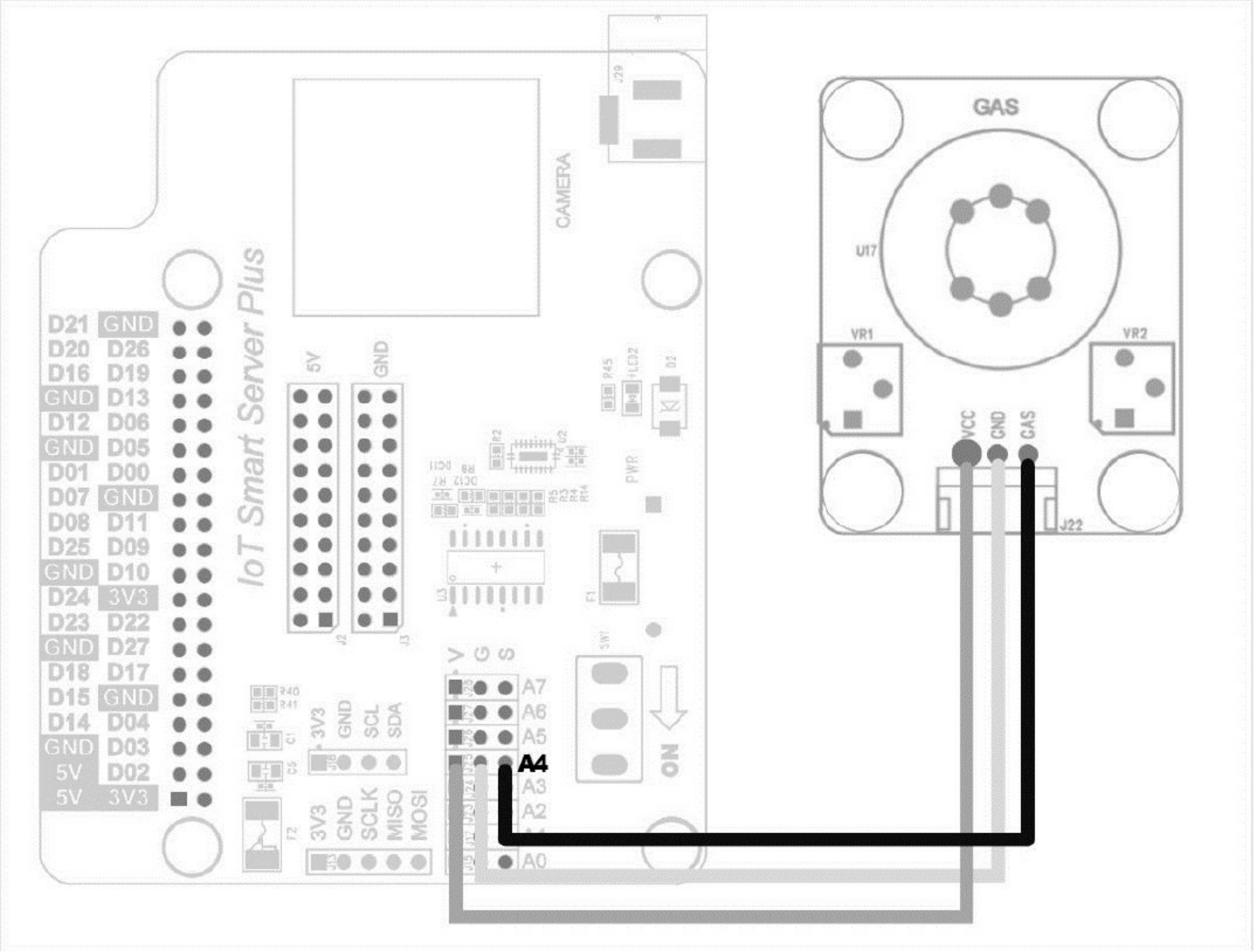


〈Table 3-46〉 Specifications of Gas Sensor Module

Shape	Category	Description
	Sensor	Gas Sensor
	I/O Interface	1pin Analog OUTPUT
	Operating Voltage	5V

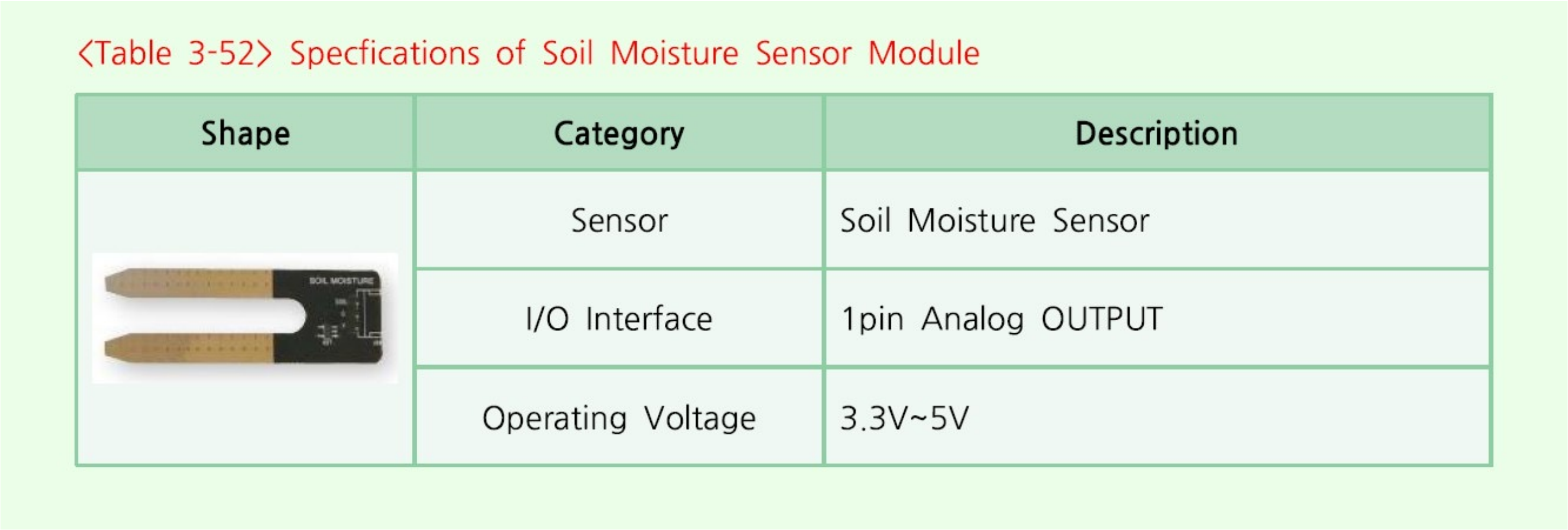
https://components101.com/sensors/mq-6-gas-sensor-pinout-equivalent-datasheet

Connect module without applying power to RPi



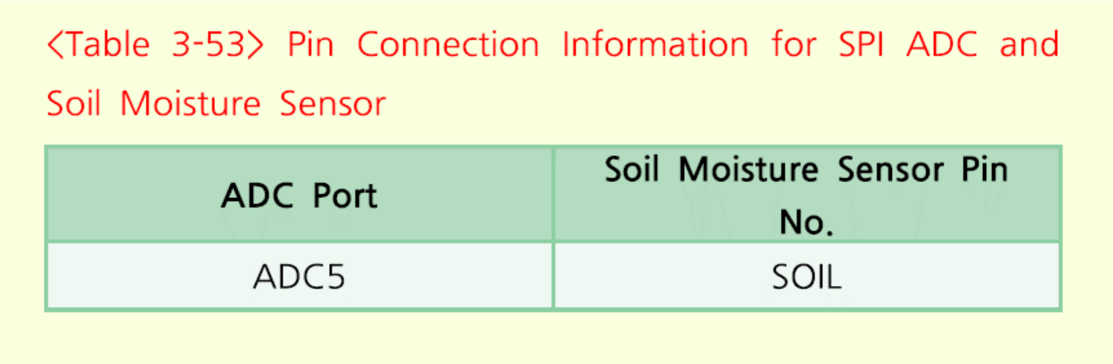
Access and Control of IoT Devices

- Soil Moisture Sensor is used for measuring the moisture in soil and similar materials
  - Smart farming systems



<Table 3-52> Specfications of Soil Moisture Sensor Module

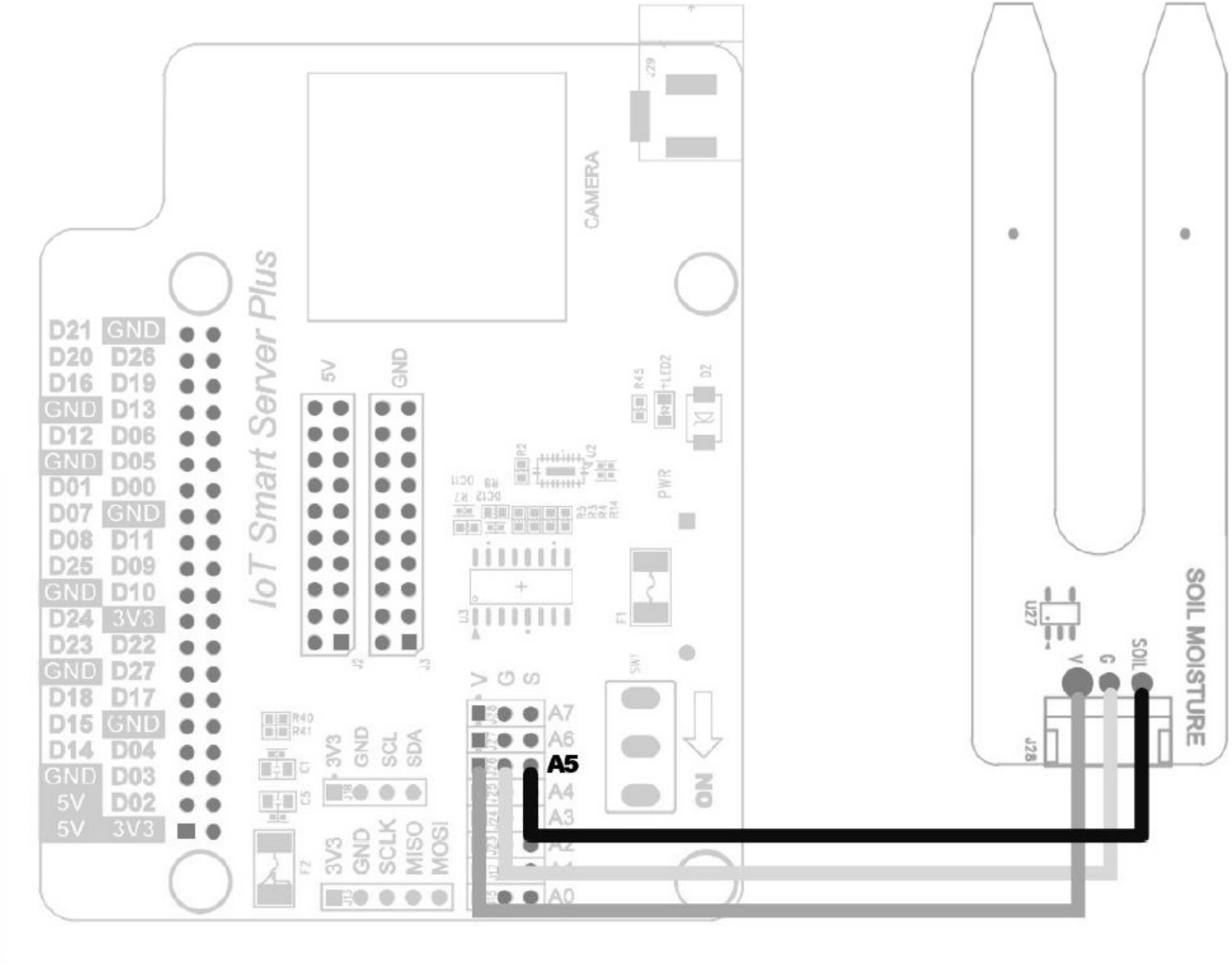
Shape	Category	Description
	Sensor	Soil Moisture Sensor
	I/O Interface	1pin Analog OUTPUT
	Operating Voltage	3.3V~5V



<Table 3-53> Pin Connection Information for SPI ADC and Soil Moisture Sensor

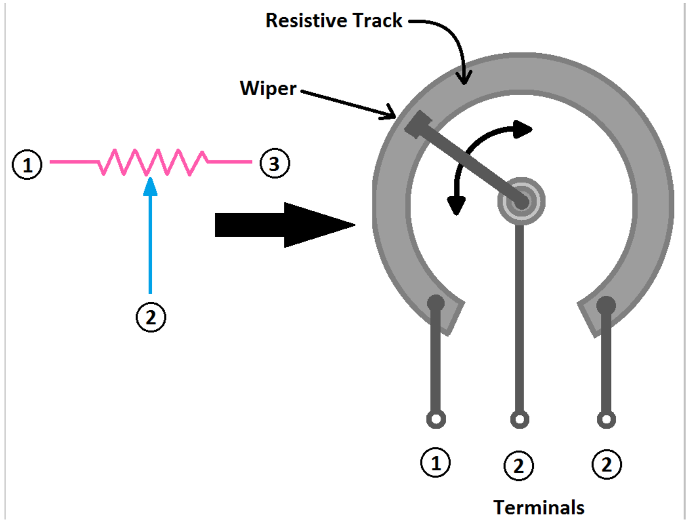
ADC Port	Soil Moisture Sensor Pin No.
ADC5	SOIL

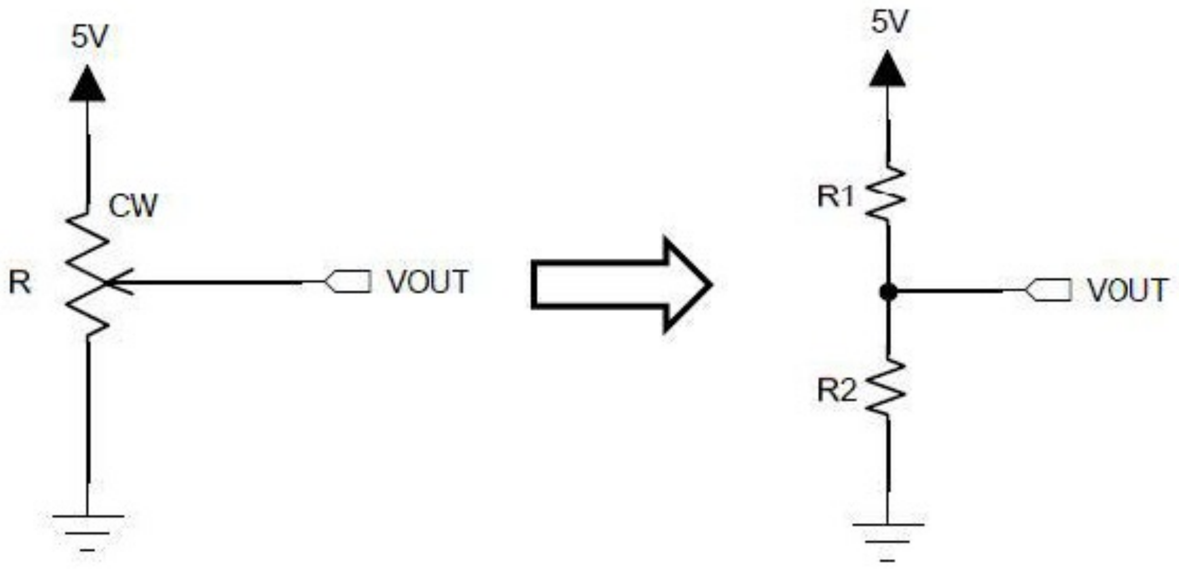
Connect module without applying power to RPi



Variable Resistor

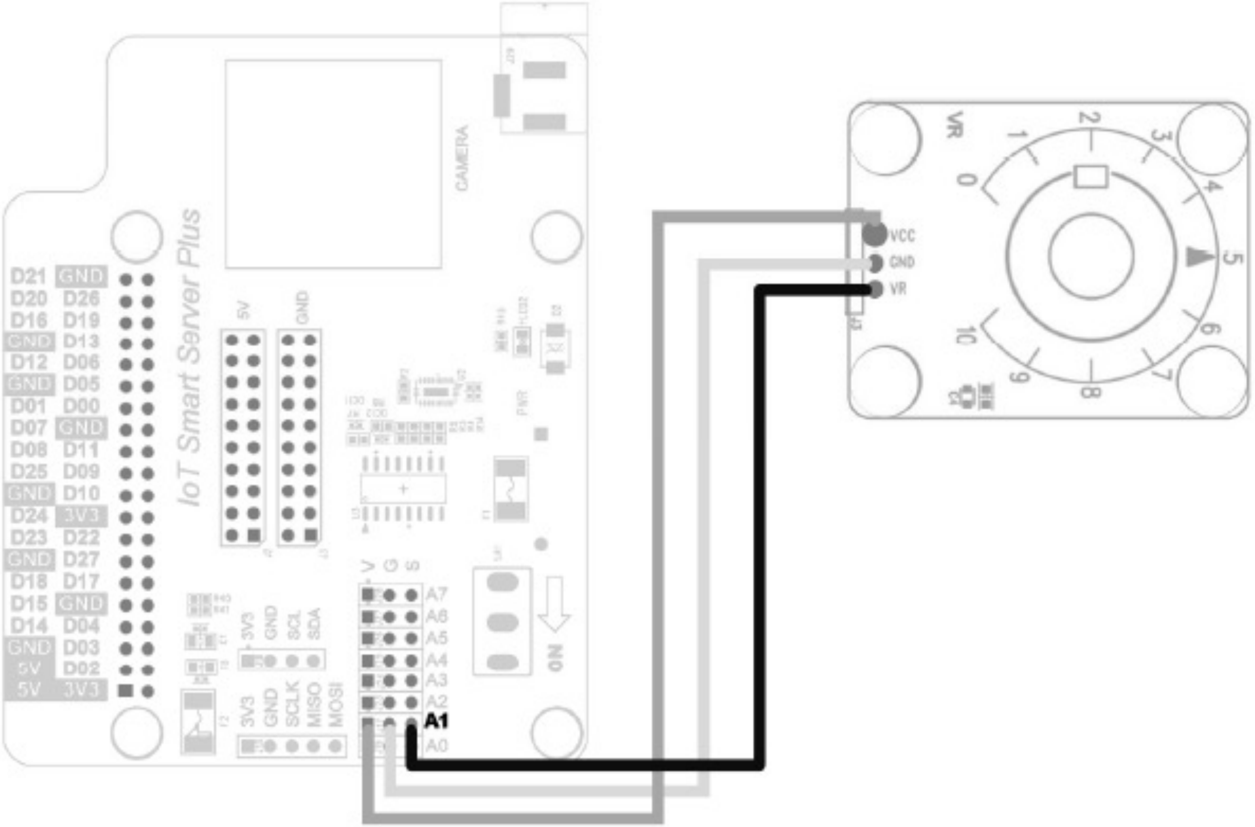
- Change the resistance value in an electronics circuit

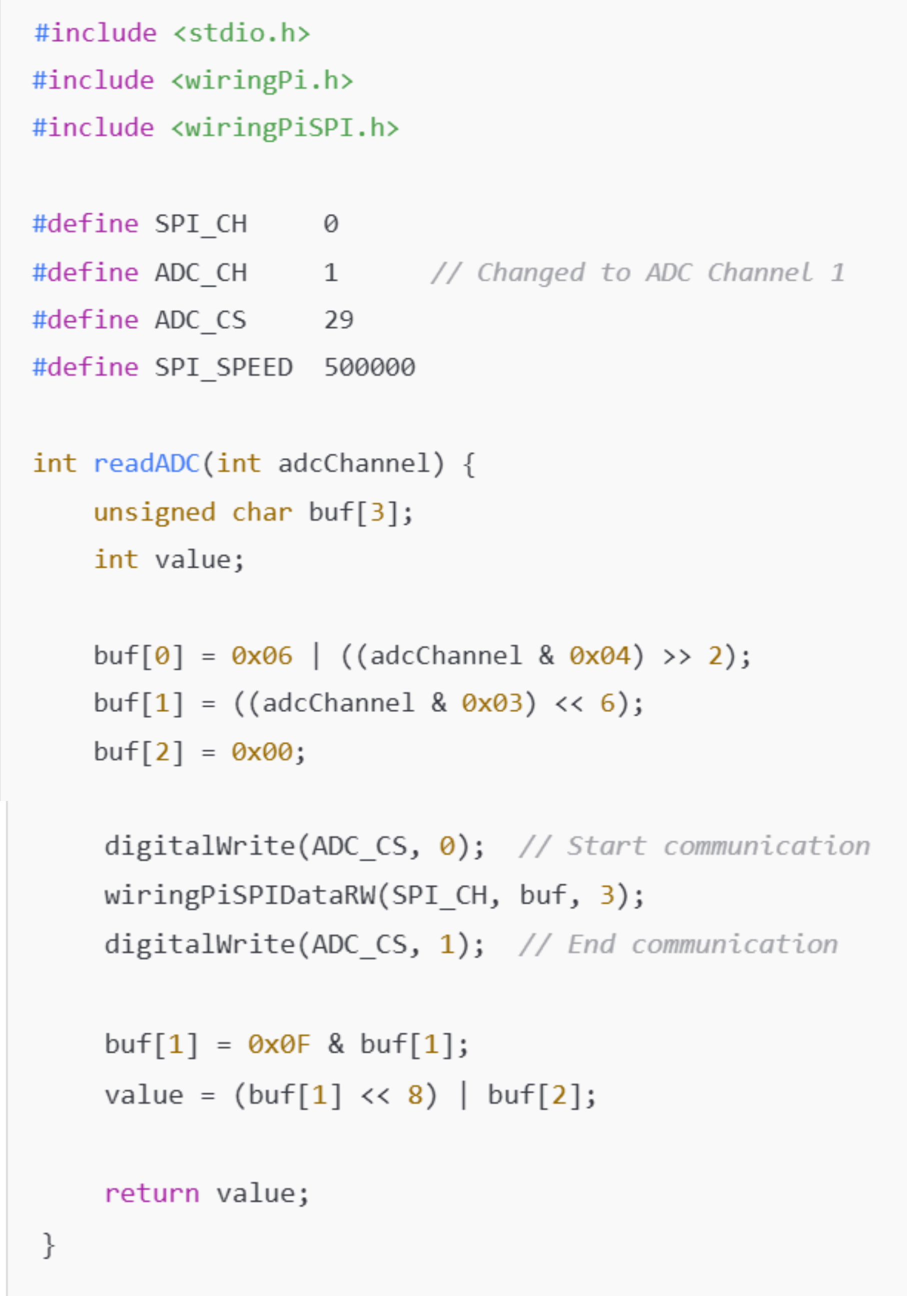




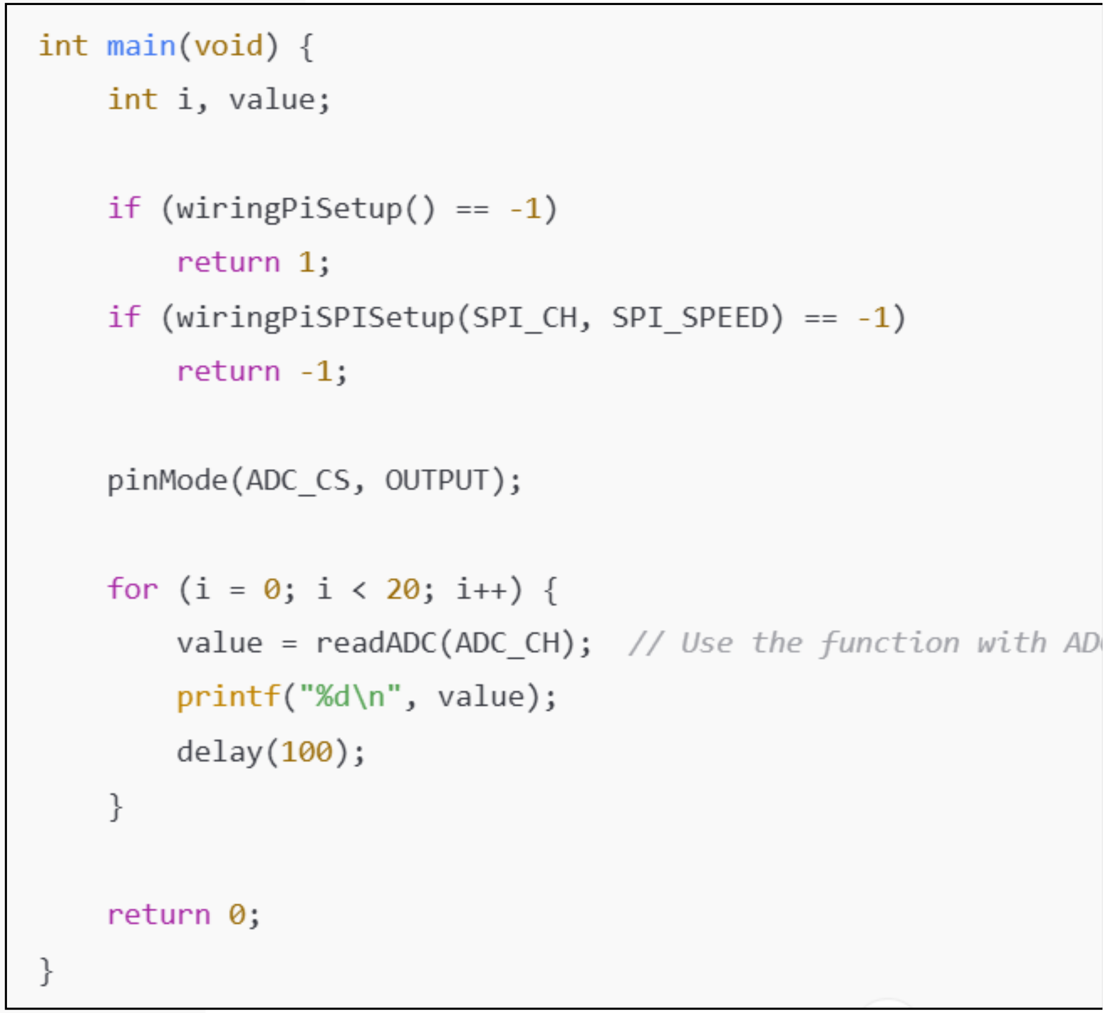
Shape	Category	Description
	Module	Variable Resistor
	Operating Voltage	5V
	I/O Interface	1 Analog OUTPUT

ADC Port	Variable Resistor Pin No.
ADC1	VR





```
#include <stdio.h>
#include <wiringPi.h>
#include <wiringPiSPI.h>

#define SPI_CH     0
#define ADC_CH     1      // Changed to ADC Channel 1
#define ADC_CS     29
#define SPI_SPEED  500000

int readADC(int adcChannel) {
    unsigned char buf[3];
    int value;

    buf[0] = 0x06 | ((adcChannel & 0x04) >> 2);
    buf[1] = ((adcChannel & 0x03) << 6);
    buf[2] = 0x00;

    digitalWrite(ADC_CS, 0);  // Start communication
    wiringPiSPIDataRW(SPI_CH, buf, 3);
    digitalWrite(ADC_CS, 1);  // End communication

    buf[1] = 0x0F & buf[1];
    value = (buf[1] << 8) | buf[2];

    return value;
}
```



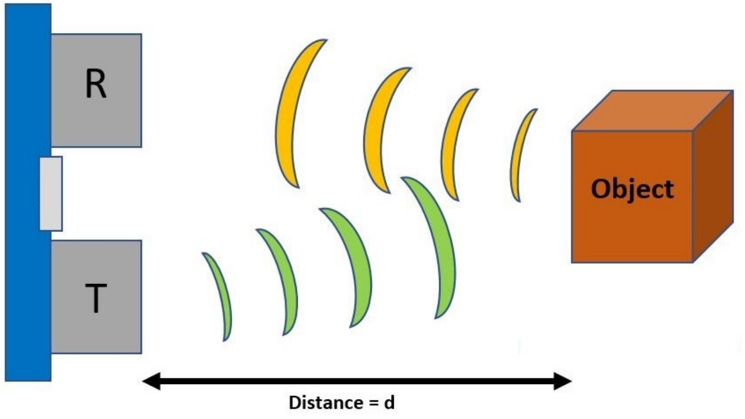
```
int main(void) {
    int i, value;

    if (wiringPiSetup() == -1)
        return 1;
    if (wiringPiSPISetup(SPI_CH, SPI_SPEED) == -1)
        return -1;

    pinMode(ADC_CS, OUTPUT);

    for (i = 0; i < 20; i++) {
        value = readADC(ADC_CH);  // Use the function with AD
        printf("%d\n", value);
        delay(100);
    }

    return 0;
}
```

Access and Control of IoT Devices

- Ultrasonic Sensor
  - An ultrasonic sensor is an electronic device that measures the distance to a target object by emitting ultrasonic sound waves, and converts the reflected sound into an electrical signal.
  - It has two main components
    - Transmitter which emits the sound using piezoelectric crystals
    - Receiver which encounters the sound after it has travelled to and from the target

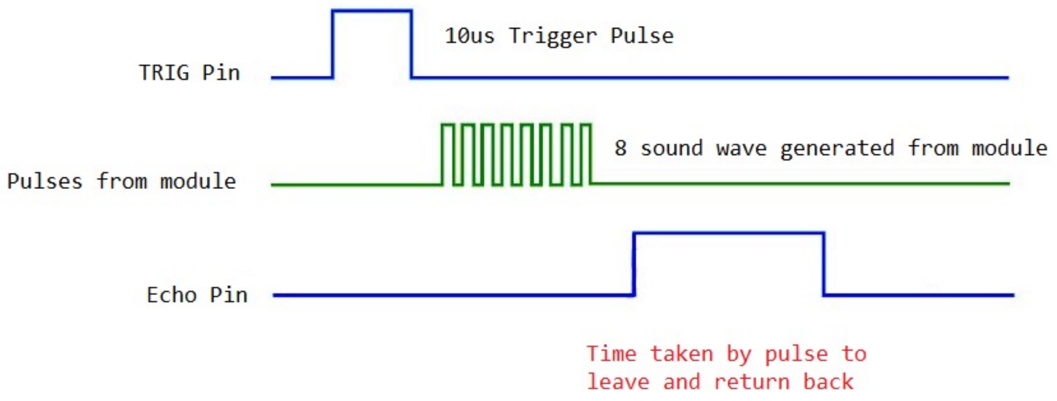
$$\text{Sound } speed = 340\ m/s = 0.034\ cm/\mu s$$

$$distance = \frac{speed * time}{2}$$



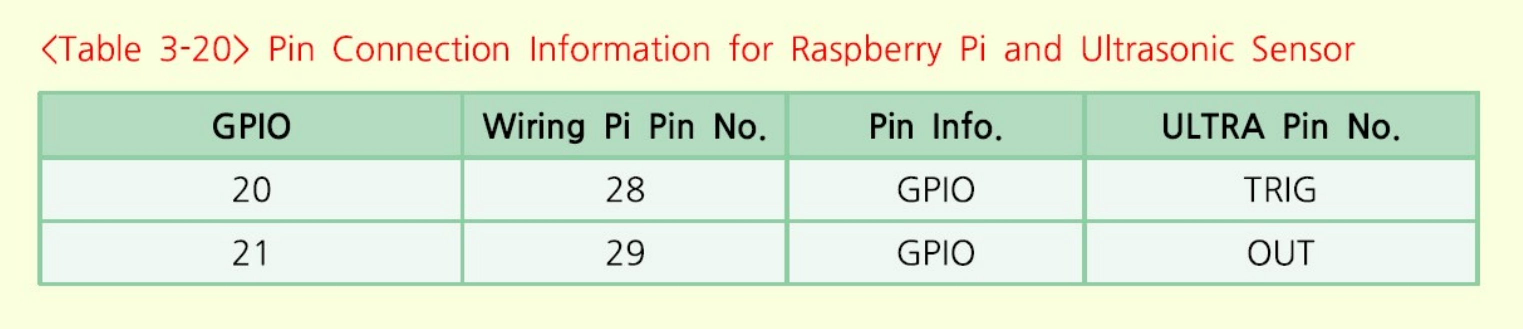
Access and Control of IoT Devices

- Working Principle
  - To start measurement, TRIG pin has to be made high for 10uS and then turned off
  - The sensor module automatically sends sound wave
  - Wait for rising edge output at Echo pin
  - When rising edge capture occurs at Echo pin, start Timer and wait for falling edge on Echo pin
  - As soon as the falling edge is captured at the Echo pin, read the count of the Timer


TRIG Pin
10us Trigger Pulse
Pulses from module
8 sound wave generated from module
Echo Pin
Time taken by pulse to leave and return back

〈Table 3-19〉 The Specifications of Ultrasonic Sensor Module

Shape	Category	Description
	Detecting Range	2 ~ 500cm
	Interface	1pin Digital Input , 1pin Digital OUTPUT
	Operating Voltage	5V

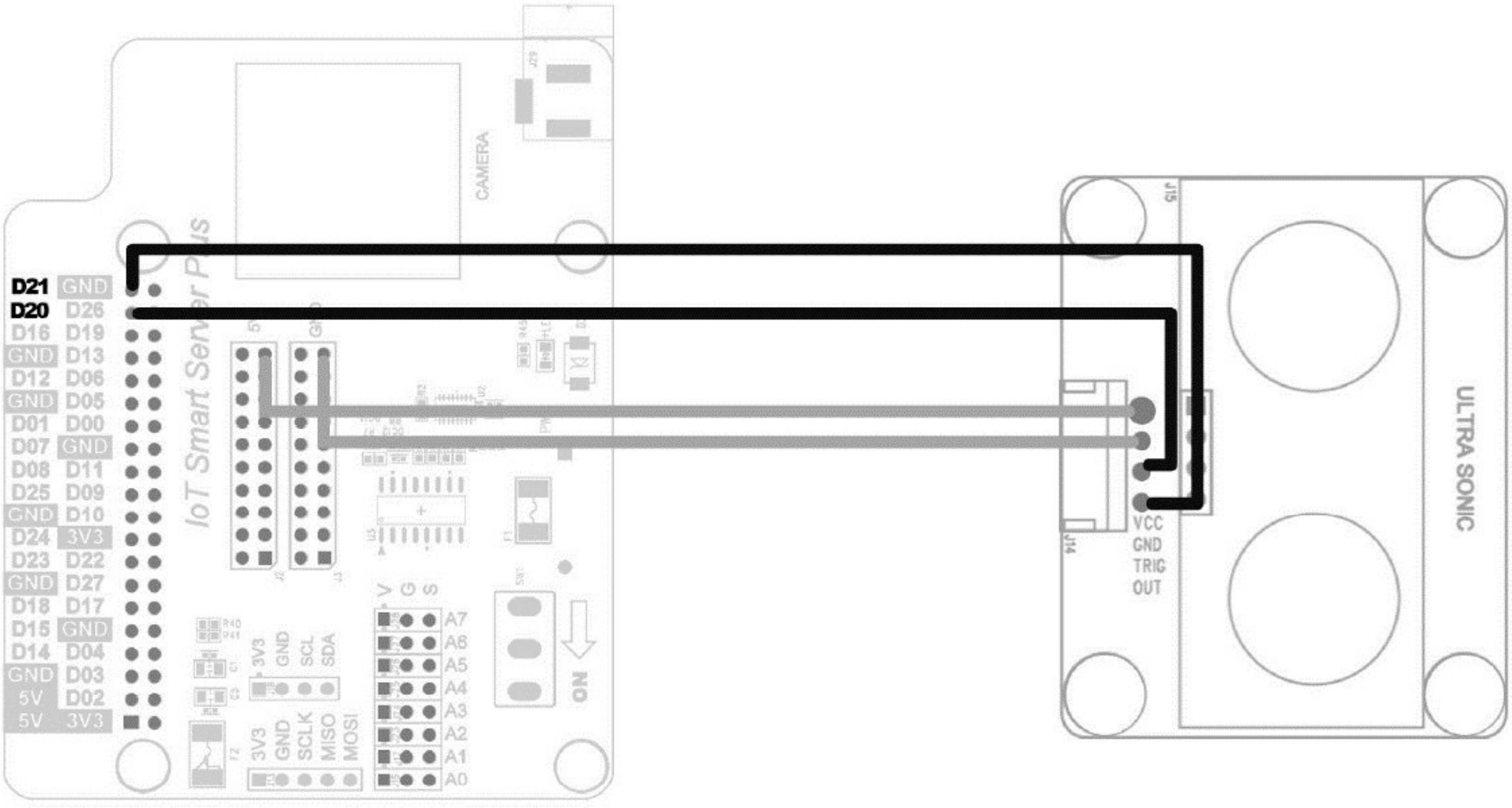


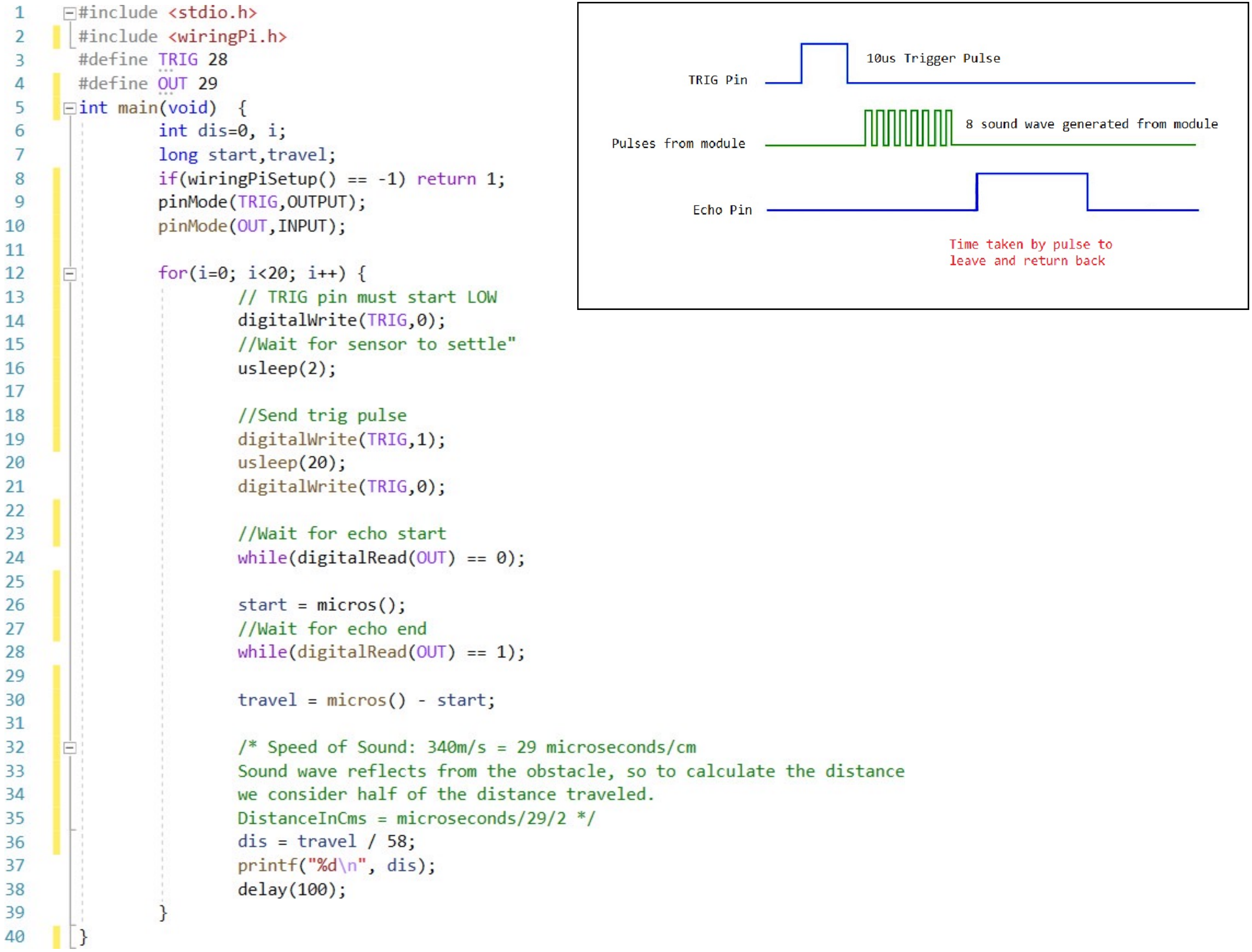
〈Table 3-20〉 Pin Connection Information for Raspberry Pi and Ultrasonic Sensor

GPIO	Wiring Pi Pin No.	Pin Info.	ULTRA Pin No.
20	28	GPIO	TRIG
21	29	GPIO	OUT

TRIG = Trigger input of sensor

Connect module without applying power to RPi





```c
#include <stdio.h>
#include <wiringPi.h>
#define TRIG 28
#define OUT 29
int main(void)  {
    int dis=0, i;
    long start,travel;
    if(wiringPiSetup() == -1) return 1;
    pinMode(TRIG,OUTPUT);
    pinMode(OUT,INPUT);

    for(i=0; i<20; i++) {
        // TRIG pin must start LOW
        digitalWrite(TRIG,0);
        //Wait for sensor to settle"
        usleep(2);

        //Send trig pulse
        digitalWrite(TRIG,1);
        usleep(20);
        digitalWrite(TRIG,0);

        //Wait for echo start
        while(digitalRead(OUT) == 0);

        start = micros();
        //Wait for echo end
        while(digitalRead(OUT) == 1);

        travel = micros() - start;

        /* Speed of Sound: 340m/s = 29 microseconds/cm
        Sound wave reflects from the obstacle, so to calculate the distance
        we consider half of the distance traveled.
        DistanceInCms = microseconds/29/2 */
        dis = travel / 58;
        printf("%d\n", dis);
        delay(100);
    }
}
```

Any Questions!