Introduction to ADC

When we interface sensors to the microcontroller, the output of the sensor many of the times is analog in nature. But the microcontroller processes digital signals. Hence, we use ADC in between the sensor and microcontroller. It converts an analog signal into a digital and gives it to the microcontroller. There are many applications of ADC like in a biometric application, Environment monitoring, Gas leakage detection etc.

Arduino Uno has 6 0n-board ADC channels i.e. Pins which can be used to read analog signal in the range 0-5V. It has 10-bit ADC means it will give digital value in the **range of 0 – 1023 (2^10).** This is called as a resolution which indicates the number of discrete values it can produce over the range of analog values.

Digital Output Value Calculation:

$$ADC\ Resolution = Vref\ /\ ((2^n) - 1)$$

$$Digital\ Output = Vin\ /\ Resolution$$

Where,

Vref **-** The reference voltage is the maximum value that the ADC can convert.

To keep things simple, let us consider that Vref is 5V,

For 0 Vin, digital o/p value = 0

For 5 Vin, digital o/p value = 1023 (10-bit)

For 2.5 Vin, digital o/p value = 512 (10-bit)

Analog Functions for Arduino ADC

- digitalValue = analogRead (pin)

  This function is used to read analog value from specified analog pin.

  pin **-** number of analog pin which we want to read

  returns **-** digital value 0 – 1023

 e.g. analogRead(A0) //read analog value at A0 channel

- analogReference (type)

  This function is used for configuring the reference voltage used for analog input.

  type: which type of reference to use (see list of options in the URL: https://reference.arduino.cc/reference/tr/language/functions/analog-io/analogreference/).

Let's see How to Read Analog values using Arduino

Let's write a program to read varying analog value generated using **potentiometer** which is connected to A0 analog channel. Display the digital value on Serial monitor which we got from the Arduino ADC.
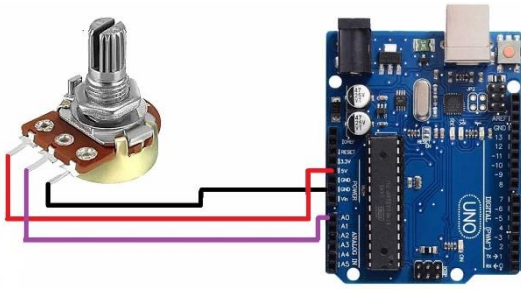
Pin 1 & 3 of Potentiometer: connect them to Vcc and GND of Arduino

Pin 2 of Potentiometer: Connect with A0 pin of Arduino

Fig: Potentiometer connected Arduino ADC Channel

Arduino Code for reading analog value

```
int sensorPin = A0;  // input pin for the potentiometer
int digitalValue = 0;// variable to store the value coming from the sensor

void setup() {
  Serial.begin(9600);
}

void loop() {
  digitalValue = analogRead(sensorPin);// read the value from the analog channel
  Serial.print("digital value = ");
  Serial.println(digitalValue);       //print digital value on serial monitor
  delay(1000);
}
```

Output on Serial Monitor
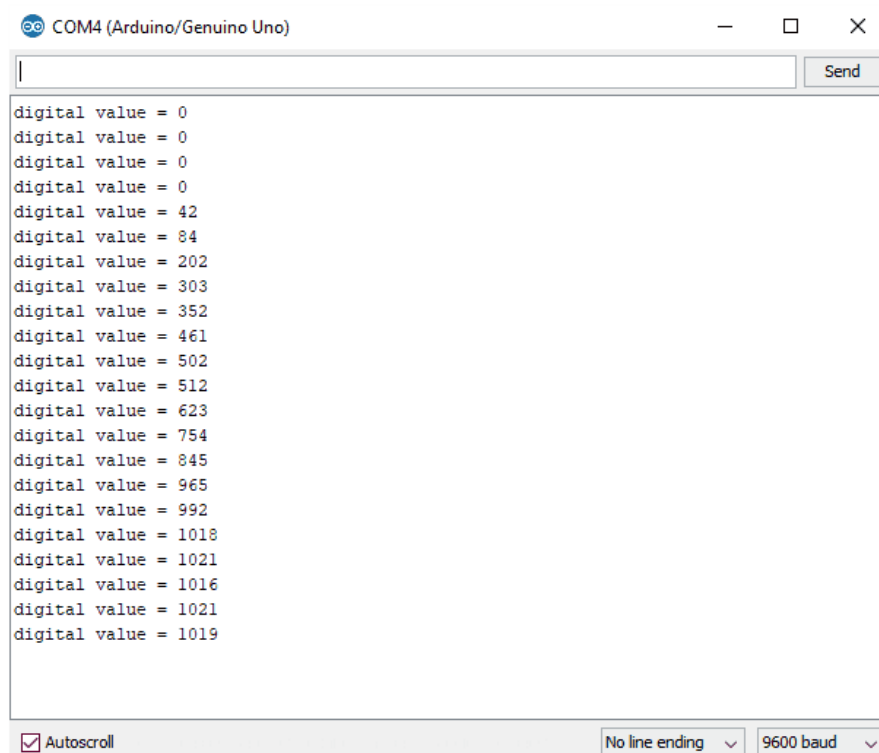
Note: If nothing is connected to analog input channel then the analogRead () function return the noisy fluctuating value.

Read Analog Voltage using Arduino Uno

As ADC provide digital output which is proportional to analog value. To know what is input analog value, we need to convert this digital value back to analog value through program. To convert this digital value to analog input voltage,

$$\text{Aout} = \text{digital value} * (\text{Vref}/2^n - 1)$$

e.g. digital value = 512 and ADC is 10-bit with 5V Vref. But, we want to know that for what analog voltage it is giving respective digital value. Then,
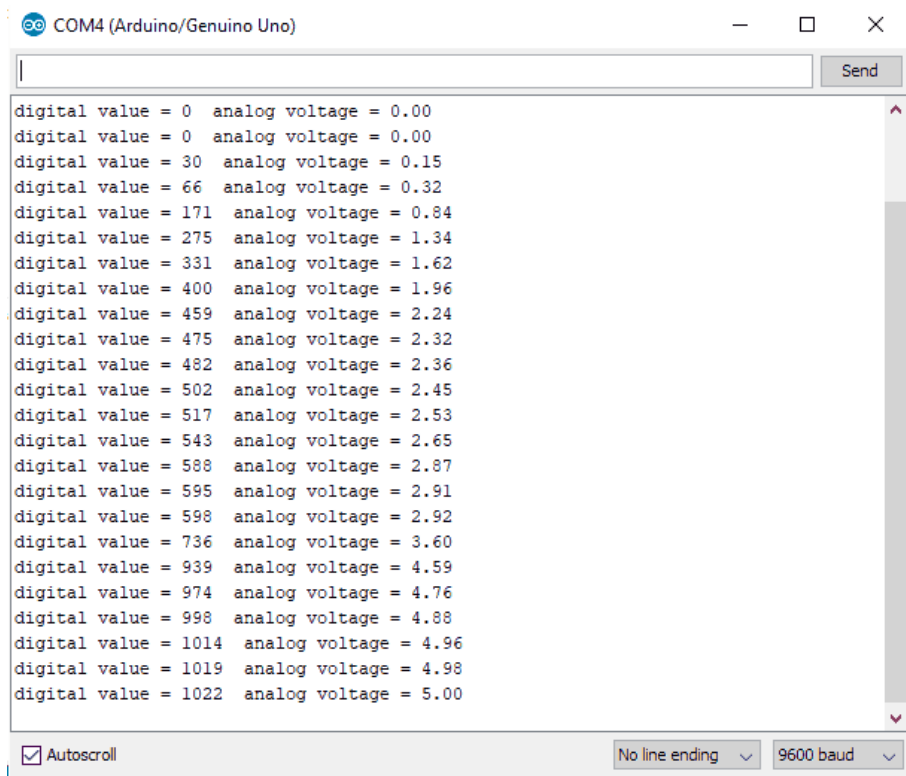
$$\text{Aout} = 512 * (5 \text{ V} / 1023)$$

$$= 2.5 \text{ V}$$

Code for Read Analog Voltage using Arduino

```
int sensorPin = A0;   // select the input pin for the potentiometer
int digitalValue = 0; // variable to store the value coming from the sensor
float analogVoltage = 0.00;

void setup() {
  Serial.begin(9600);
}

void loop() {
  digitalValue = analogRead(sensorPin);// read the value from the analog channel
  Serial.print("digital value = ");
  Serial.print(digitalValue);        //print digital value on serial monitor
  //convert digital value to analog voltage
  analogVoltage = (digitalValue * 5.00)/1023.00;
  Serial.print("  analog voltage = ");
  Serial.println(analogVoltage);
  delay(1000);
}
```

```
COM4 (Arduino/Genuino Uno)                                    —    □    ×

|                                                                    Send

digital value = 0    analog voltage = 0.00
digital value = 0    analog voltage = 0.00
digital value = 30   analog voltage = 0.15
digital value = 66   analog voltage = 0.32
digital value = 171  analog voltage = 0.84
digital value = 275  analog voltage = 1.34
digital value = 331  analog voltage = 1.62
digital value = 400  analog voltage = 1.96
digital value = 459  analog voltage = 2.24
digital value = 475  analog voltage = 2.32
digital value = 482  analog voltage = 2.36
digital value = 502  analog voltage = 2.45
digital value = 517  analog voltage = 2.53
digital value = 543  analog voltage = 2.65
digital value = 588  analog voltage = 2.87
digital value = 595  analog voltage = 2.91
digital value = 598  analog voltage = 2.92
digital value = 736  analog voltage = 3.60
digital value = 939  analog voltage = 4.59
digital value = 974  analog voltage = 4.76
digital value = 998  analog voltage = 4.88
digital value = 1014  analog voltage = 4.96
digital value = 1019  analog voltage = 4.98
digital value = 1022  analog voltage = 5.00

☑ Autoscroll              No line ending  ∨   9600 baud  ∨
```