C.S.E

Menoufia University

Faculty of Electronic Engineering

Embedded Systems(Lab.)

(LM35)

DEPARTMENT:

- **Department of Engineering and Computer Science, 4rd year**

STUDENT NAME:

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  - **سكشن (1)**
  - **مجموعه (8)**

Overview:

The LM35 is a precision integrated-circuit temperature sensor that provides an analog voltage output linearly proportional to the Celsius temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ˚ Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. It's commonly used in various applications like temperature controllers, industrial systems, and consumer electronics for its simplicity and accuracy.

The LM35 series is available packaged in hermetic TO-46 transistor packages, while the LM35C, LM35CA, and LM35D are also available in the plastic TO-92 transistor package. The LM35D is also available in an 8-lead surface mount small outline package and a plastic TO-220 package.

The LM35C is rated for a −40˚ to +110˚C range (−10˚ with improved accuracy).

Temperature Range:

The LM35 can measure temperatures from -55°C to +150°C. This wide range makes it suitable for a variety of applications, from extreme cold to moderately high temperatures.

Output Voltage:

The output voltage of the LM35 increases linearly with temperature at the rate of 10mV per degree Celsius. This linear relationship simplifies interfacing with analog-to-digital converters (ADCs) or microcontrollers for temperature measurement.

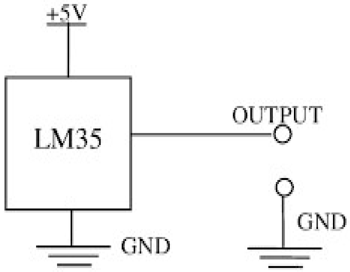
Accuracy:

The LM35 has a typical accuracy of ±0.5°C at room temperature. This accuracy level is sufficient for many applications that require precise temperature monitoring.

Features:

- Calibrated directly in ˚ Celsius (Centigrade)
- Linear + 10.0 mV/˚C scale factor
- 0.5˚C accuracy guaranteeable (at +25˚C)
- Rated for full −55˚ to +150˚C range
- Suitable for remote applications
- Low cost due to wafer-level trimming
- Operates from 4 to 30 volts
- Less than 60 µA current drain
- Low self-heating, 0.08˚C in still air
- Nonlinearity only ±1⁄4˚C typical
- Low impedance output, 0.1 Ω for 1 mA load

The LM35 can be connected as follows:



- Power Supply: Connect the Vcc pin to a power supply voltage between 4V to 30V DC.
- Ground: Connect the GND pin to the ground of the circuit.
- Output: The output pin provides an analog voltage that is linearly proportional to the temperature being sensed. Connect this pin to an analog input of a microcontroller or an ADC to measure the temperature.

Datasheet link: https://www.ti.com/lit/ds/symlink/lm35.pdf

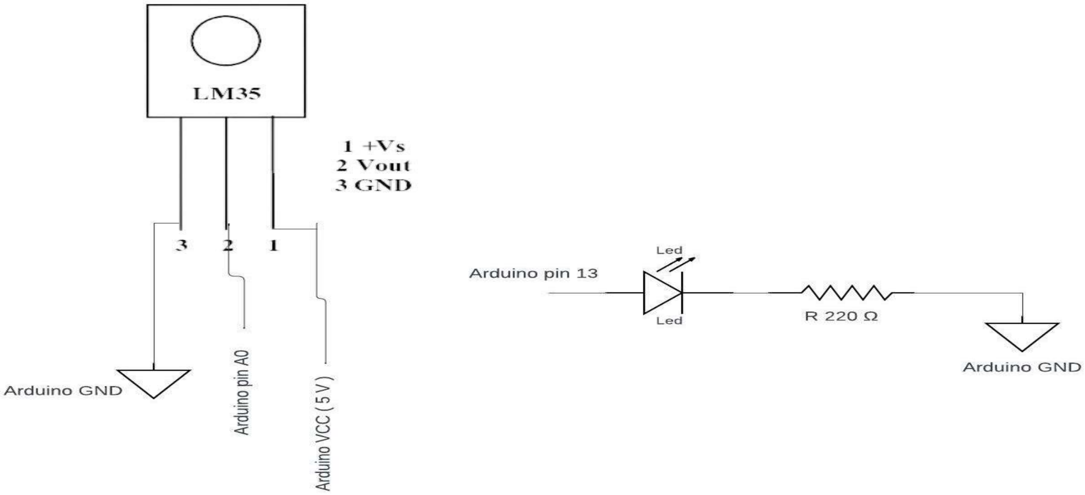
Task #4 (LM35)

In this task, we will measure the temperature using an LM35 module, and a communication serial will be used to display the results. The LED lighting intensity will also be controlled based on the change in temperature.

Required components for this lab:

- Breadboard
- Wires (male - male)
- 1 Led
- 1 resistor in range of 220Ω to 1KΩ.
- LM35

Circuit diagram



Code

```
#define sensor  A0 // LM35 sensor connected to analog pin A0
#define led  13     // LED connected to digital pin 13 (PWM capable)

void setup() {
  Serial.begin(9600); // Initialize serial communication
  pinMode(led, OUTPUT); // Set LED pin as output
  pinMode(sensor, INPUT); // Set sensor pin as input

}

void loop() {
  int sensorValue = analogRead(sensor); // Read analog value from LM35
  float voltage = sensorValue * (5.0 / 1023.0); // Convert analog value to
voltage (0-5V)
  float temperature = voltage * 100.0; // Convert voltage to temperature in °C

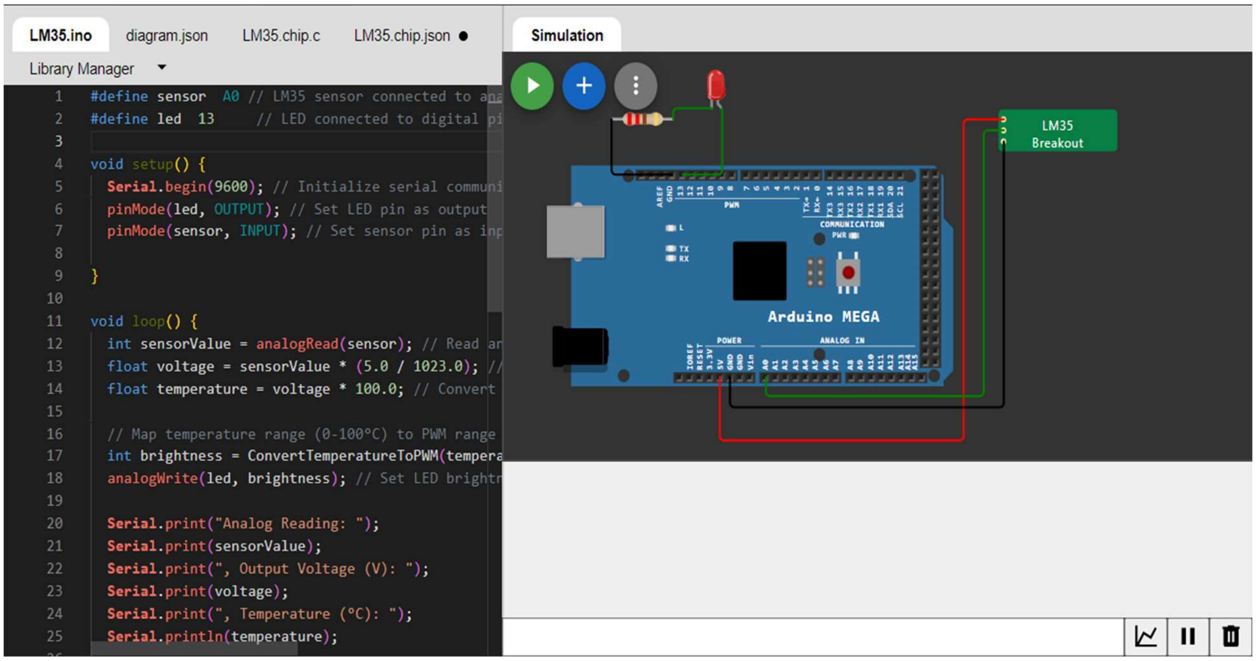
  // Map temperature range (0-100°C) to PWM range (0-255)
  int brightness = ConvertTemperatureToPWM(temperature);
  analogWrite(led, brightness); // Set LED brightness using PWM

  Serial.print("Analog Reading: ");
  Serial.print(sensorValue);
  Serial.print(", Output Voltage (V): ");
  Serial.print(voltage);
  Serial.print(", Temperature (°C): ");
  Serial.println(temperature);

  delay(1000); // Delay for readability
}

int ConvertTemperatureToPWM(float temperature) {
  if (temperature <= 0) {
    return 0; // If temperature is below 0°C, set PWM to 0 (LED off)
  } else if (temperature >= 100) {
    return 255; // If temperature is above 100°C, set PWM to 255 (full
brightness)
  } else {
    return int(temperature * 2.55); // Scale temperature linearly to PWM range
(0-255)
  }
}
```

Simulation



```
#define sensor  A0 // LM35 sensor connected to ana
#define led  13      // LED connected to digital pi

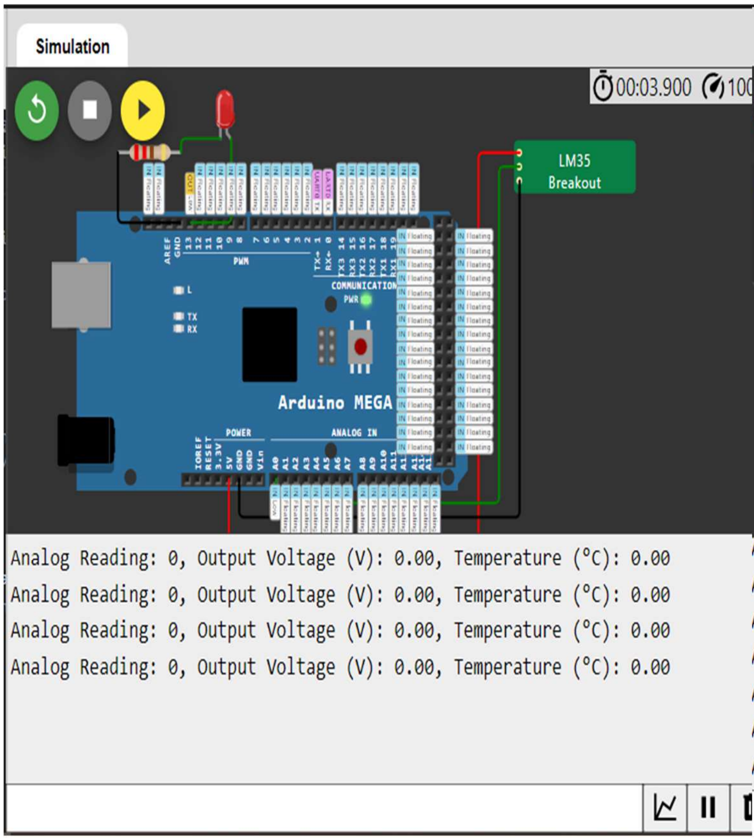
void setup() {
  Serial.begin(9600); // Initialize serial communi
  pinMode(led, OUTPUT); // Set LED pin as output
  pinMode(sensor, INPUT); // Set sensor pin as inp

}

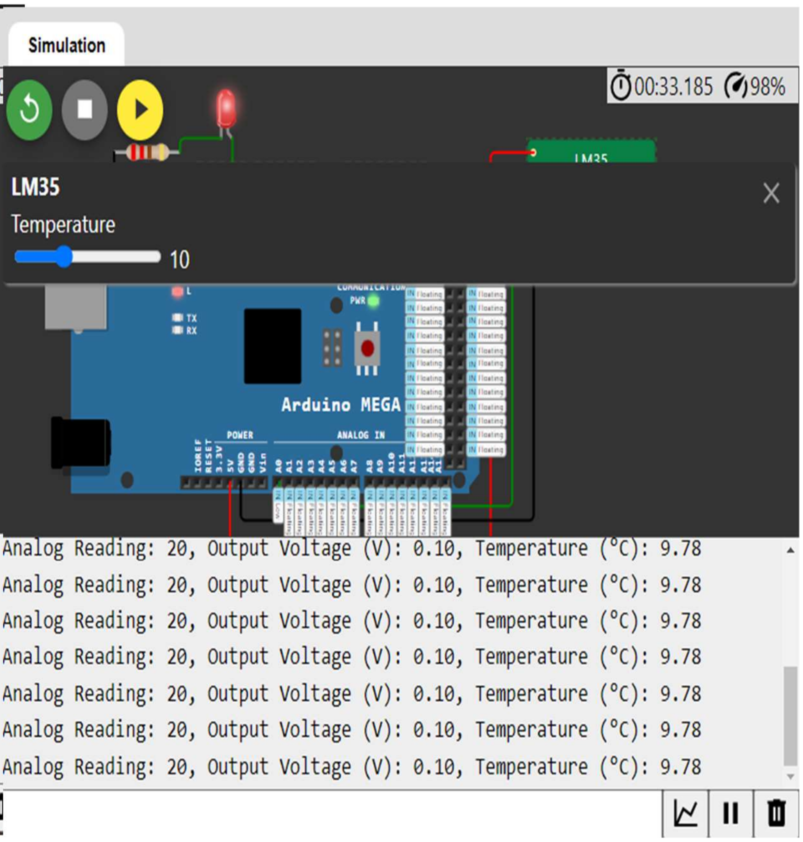
void loop() {
  int sensorValue = analogRead(sensor); // Read an
  float voltage = sensorValue * (5.0 / 1023.0); //
  float temperature = voltage * 100.0; // Convert

  // Map temperature range (0-100°C) to PWM range
  int brightness = ConvertTemperatureToPWM(tempera
  analogWrite(led, brightness); // Set LED brightn

  Serial.print("Analog Reading: ");
  Serial.print(sensorValue);
  Serial.print(", Output Voltage (V): ");
  Serial.print(voltage);
  Serial.print(", Temperature (°C): ");
  Serial.println(temperature);
```



```
Analog Reading: 0, Output Voltage (V): 0.00, Temperature (°C): 0.00
Analog Reading: 0, Output Voltage (V): 0.00, Temperature (°C): 0.00
Analog Reading: 0, Output Voltage (V): 0.00, Temperature (°C): 0.00
Analog Reading: 0, Output Voltage (V): 0.00, Temperature (°C): 0.00
```



LM35

Temperature 10

```
Analog Reading: 20, Output Voltage (V): 0.10, Temperature (°C): 9.78
Analog Reading: 20, Output Voltage (V): 0.10, Temperature (°C): 9.78
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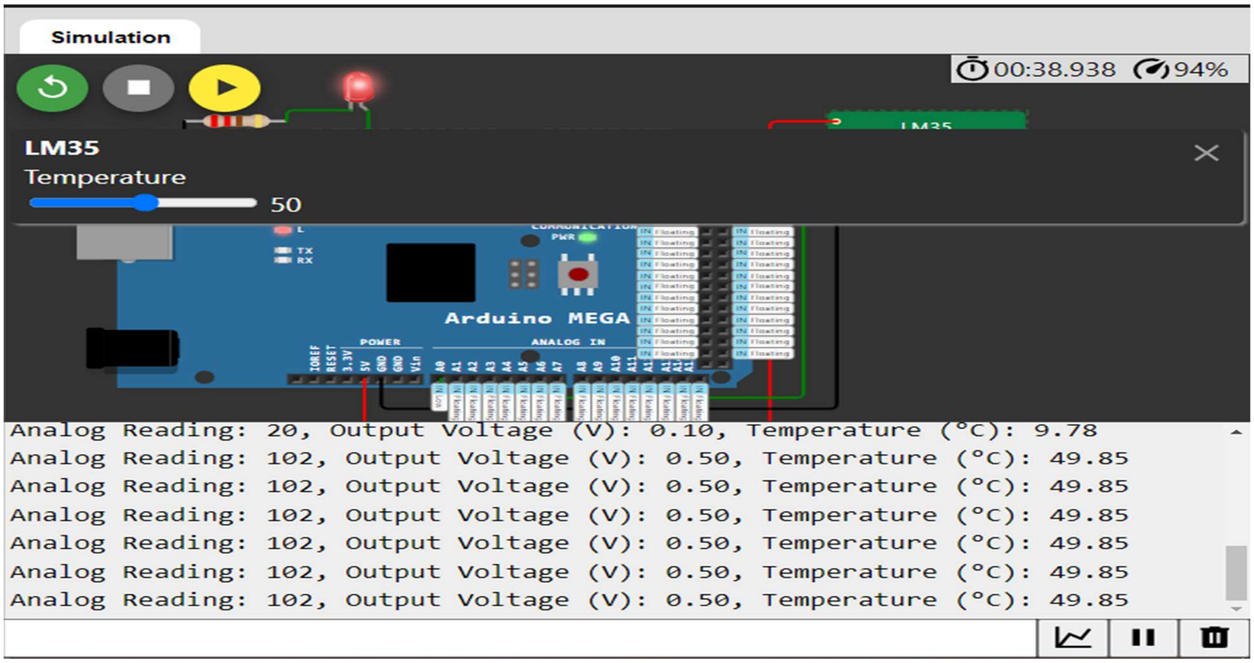

```
Analog Reading: 20, Output Voltage (V): 0.10, Temperature (°C): 9.78
Analog Reading: 102, Output Voltage (V): 0.50, Temperature (°C): 49.85
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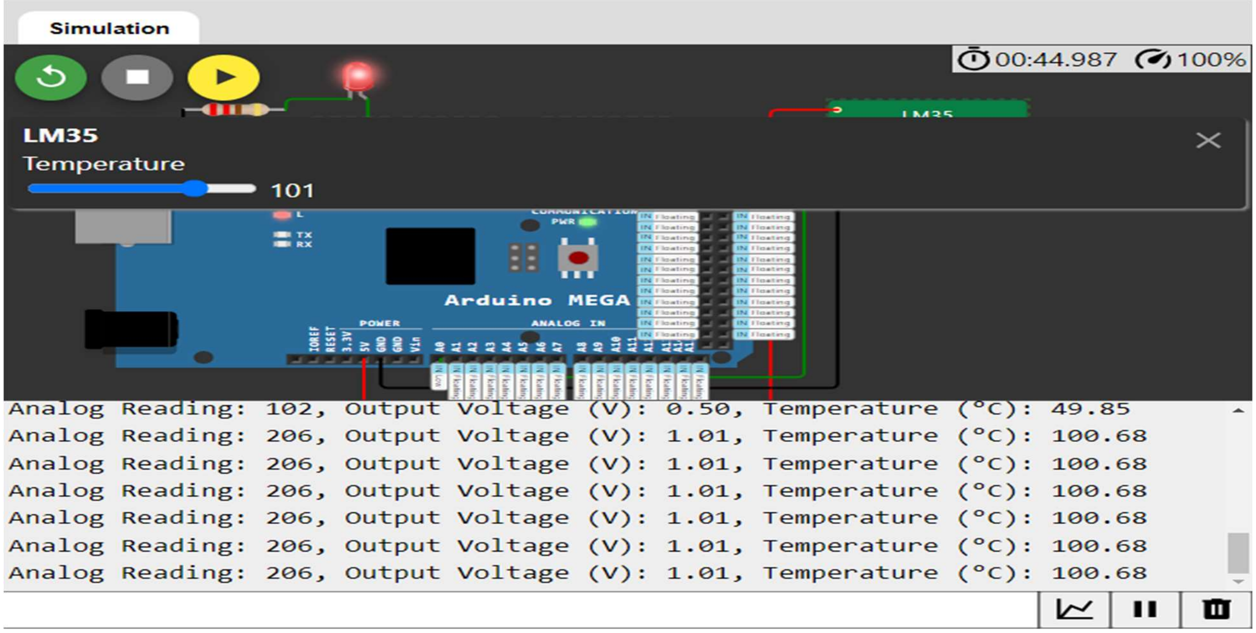
Analog Reading: 102, Output Voltage (V): 0.50, Temperature (°C): 49.85
```



```
Analog Reading: 102, Output Voltage (V): 0.50, Temperature (°C): 49.85
Analog Reading: 206, Output Voltage (V): 1.01, Temperature (°C): 100.68
Analog Reading: 206, Output Voltage (V): 1.01, Temperature (°C): 100.68
Analog Reading: 206, Output Voltage (V): 1.01, Temperature (°C): 100.68
Analog Reading: 206, Output Voltage (V): 1.01, Temperature (°C): 100.68
Analog Reading: 206, Output Voltage (V): 1.01, Temperature (°C): 100.68
Analog Reading: 206, Output Voltage (V): 1.01, Temperature (°C): 100.68
```

My Simulation to run code:

https://wokwi.com/projects/395155660245730305

Or Scan QR Code: