

Understanding the LCD, I2C, Ultrasonic Sensor, Breadboard, and Arduino Mega 2560

Beginner's Guide

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1 Introduction

In this guide, we'll explore some fundamental components used in electronics and programming: the LCD (Liquid Crystal Display), I2C (Inter-Integrated Circuit), Ultrasonic Sensor, Breadboard, and Arduino Mega 2560. Understanding these components will help you build and control simple electronic projects.

2 LCD (Liquid Crystal Display)

An LCD, or Liquid Crystal Display, is a flat-panel display that uses liquid crystals to produce images. In electronics projects, a common type of LCD is the 16x2 character display, which can show 16 characters per line over 2 lines. This display is useful for showing data like sensor readings or status messages from your projects.

2.1 How Does an LCD Work?

An LCD works by using a backlight and liquid crystals to display characters. When a voltage is applied to the liquid crystals, they align in such a way that they either allow light to pass through or block it. By controlling this alignment, an LCD can display characters or images.

In our setup, the LCD is connected to an Arduino Mega 2560 through an I2C interface, which allows for simpler wiring and easier control.

3 I2C (Inter-Integrated Circuit)

I2C, or Inter-Integrated Circuit, is a communication protocol used to connect low-speed devices like sensors and displays to microcontrollers. It allows multiple devices to be connected on the same two-wire bus, significantly reducing the number of connections needed.

3.1 How Does I2C Work?

I2C uses two lines: SDA (Serial Data) and SCL (Serial Clock). The SDA line carries the data, while the SCL line provides the clock signal that synchronizes data transfer between devices. Each device on an I2C bus has a unique address, which allows the master device (in this case, the Arduino Mega 2560) to communicate with specific devices (like the LCD).

4 Ultrasonic Sensor

An ultrasonic sensor is a device that measures distance by emitting sound waves and measuring the time it takes for the echo to return. The most common type is the HC-SR04, which can measure distances from 2 cm to 400 cm.

4.1 How Does an Ultrasonic Sensor Work?

The ultrasonic sensor has two main components: a transmitter that sends out sound waves and a receiver that listens for the echo. When the sensor emits a sound wave, it bounces off an object and returns to the sensor. The sensor calculates the distance based on the time it takes for the echo to return, using the formula:

$$\text{Distance} = \frac{\text{Speed of Sound} \times \text{Time}}{2}$$

The factor of 2 accounts for the round-trip of the sound wave.

5 Breadboard

A breadboard is a tool used for prototyping electronics. It allows you to build circuits without soldering, making it easy to experiment and make changes. The breadboard has rows of connected holes where you can insert electronic components and wires to create circuits.

5.1 How Does a Breadboard Work?

Breadboards have rows of holes that are electrically connected underneath. You can connect components by inserting their leads into the holes in the same row. Power rails run along the sides of the breadboard to provide power and ground connections to your circuit.

In our project, the breadboard is used to connect the ultrasonic sensor to the Arduino Mega 2560, allowing us to measure distances and display the results on the LCD.

6 Arduino Mega 2560

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560 chip. It has 54 digital input/output pins, 16 analog inputs, and 4 UARTs (hardware serial ports). It is used to control various sensors and actuators, making it a versatile choice for electronics projects.

6.1 How Does the Arduino Mega 2560 Work?

The Arduino Mega 2560 runs a program written in the Arduino programming language (a simplified version of C++). This program, or sketch, is uploaded from a computer to the board via a USB cable. Once uploaded, the Arduino continuously executes the instructions in the sketch, such as reading sensor data, controlling outputs like LEDs or motors, or displaying information on an LCD.

In our project, the Arduino Mega 2560 reads the distance from the ultrasonic sensor, processes this data, and sends the information to the LCD using the I2C protocol.

7 Detailed Code Explanation

In this section, we'll delve deeper into the Arduino code to provide a comprehensive understanding of its operation and structure.

7.1 Including Libraries

```
#include <LiquidCrystal_I2C.h> // Include the LiquidCrystal_I2C library
#include <Ultrasonic.h>        // Include the Ultrasonic library
```

- `#include <LiquidCrystal_I2C.h>;` This line imports the `LiquidCrystal_I2C` library, which provides functions for controlling an I2C-based LCD display.
- `#include <Ultrasonic.h>;` This line imports the `Ultrasonic` library, which offers functions for using an ultrasonic sensor to measure distances.

7.2 Defining Constants and Objects

```
// Define LCD I2C address
#define I2C_ADDR 0x27
// Define LCD dimensions
#define LCD_COLS 16
#define LCD_ROWS 2

// Define pins for ultrasonic sensor
#define TRIG_PIN 12
#define ECHO_PIN 11
```

```
// Create an LCD object
LiquidCrystal_I2C lcd(I2C_ADDR, LCD_COLS, LCD_ROWS);
// Create an Ultrasonic object
Ultrasonic ultrasonic(TRIG_PIN, ECHO_PIN);
```

- `#define I2C_ADDR 0x27`:: This line defines the I2C address of the LCD display. This address is specific to the LCD module used and might need to be adjusted based on your setup.
- `#define LCD_COLS 16` and `#define LCD_ROWS 2`:: These lines define the number of columns and rows on the LCD display. This is typically 16 columns and 2 rows for most standard LCDs.
- `#define TRIG_PIN 12` and `#define ECHO_PIN 11`:: These lines define the Arduino pins connected to the trigger and echo pins of the ultrasonic sensor. You might need to adjust these values depending on your wiring.
- `LiquidCrystal_I2C lcd(I2C_ADDR, LCD_COLS, LCD_ROWS)`:: This line creates an object called `lcd` of the `LiquidCrystal_I2C` type, initializing it with the defined I2C address, columns, and rows. This object will be used to control the LCD display.
- `Ultrasonic ultrasonic(TRIG_PIN, ECHO_PIN)`:: This line creates an object called `ultrasonic` of the `Ultrasonic` type, initializing it with the defined trigger and echo pins. This object will be used to control the ultrasonic sensor.

7.3 Setup Function

```
void setup() {
  // Initialize the LCD display
  lcd.begin();
  // Turn on the LCD backlight
  lcd.backlight();
}
```

- `void setup() {}`: This function is called once at the start of the program. It's used for initializing components and setting up the system.
- `lcd.begin()`:: This line initializes the LCD display, preparing it for use.
- `lcd.backlight()`:: This line turns on the backlight of the LCD, making the display visible.

7.4 Loop Function

```
void loop() {  
  // Get the distance measurement from the ultrasonic sensor  
  long duration = ultrasonic.ping();  
  // Calculate the distance in centimeters  
  float distanceCm = duration * 0.034 / 2;  
  // Calculate the distance in inches  
  float distanceInch = duration * 0.0133 / 2;  
  // Cap the maximum distance to 200cm  
  if(distanceCm > 200) {  
    distanceCm = 200;  
    distanceInch = distanceCm * 0.3937;  
  }  
  // Clear the LCD display  
  lcd.clear();  
  // Move the cursor to the first line of the LCD  
  lcd.setCursor(0, 0);  
  // Print the distance in centimeters  
  lcd.print("Distance: ");  
  lcd.print(distanceCm);  
  lcd.print(" cm");  
  // Move the cursor to the second line of the LCD  
  lcd.setCursor(0, 1);  
  // Print the distance in inches  
  lcd.print("Distance: ");  
  lcd.print(distanceInch);  
  lcd.print(" inch");  
  // Delay for 500 milliseconds  
  delay(500);  
}
```

- `void loop() {}`: This function is called repeatedly after the setup function finishes. It contains the main logic of the program, continuously executing the code within its curly braces.
- `long duration = ultrasonic.ping();`: This line calls the `ping()` function of the `ultrasonic` object, which triggers the ultrasonic sensor to send a pulse and measure the time it takes for the pulse to return. The duration of the echo is stored in the `duration` variable.
- `float distanceCm = duration * 0.034 / 2;`: This line calculates the distance in centimeters using the formula `distance = duration * speed of sound / 2`. The speed of sound in air is approximately 0.034 cm/ μ s, and dividing by 2 accounts for the round trip of the sound wave.
- `float distanceInch = duration * 0.0133 / 2;`: This line calculates the distance in inches using a similar formula. The speed of sound in air

is approximately 0.0133 inches/ μ s.

- `if(distanceCm > 200) { ... }`: This conditional statement checks if the measured distance is greater than 200 centimeters. If it is, the distance is capped to 200 centimeters, and the corresponding distance in inches is recalculated.
- `lcd.clear();`: This line clears the LCD display, preparing it for new data.
- `lcd.setCursor(0, 0);`: This line moves the cursor to the top-left corner of the first line of the LCD display.
- `lcd.print("Distance: "); lcd.print(distanceCm); lcd.print(" cm");`: These lines print the text "Distance: ", the measured distance in centimeters, and " cm" on the first line of the LCD.
- `lcd.setCursor(0, 1);`: This line moves the cursor to the top-left corner of the second line of the LCD display.
- `lcd.print("Distance: "); lcd.print(distanceInch); lcd.print(" inch");`: These lines print the text "Distance: ", the measured distance in inches, and " inch" on the second line of the LCD.
- `delay(500);`: This line pauses the program for 500 milliseconds before taking another distance measurement.

7.5 Summary

The code utilizes two libraries to control an LCD display and an ultrasonic sensor. It measures the distance using the ultrasonic sensor, calculates distances in centimeters and inches, and displays the results on the LCD. The loop function continuously repeats this process, providing real-time distance measurements.

8 Conclusion

By understanding these components — the LCD, I2C, Ultrasonic Sensor, Breadboard, and Arduino Mega 2560 — you're now equipped with the basic knowledge needed to start building and experimenting with simple electronics projects. Each component plays a vital role in creating interactive and functional devices. Keep experimenting and learning!