Ultrasonic Ranging Module HC-SR04

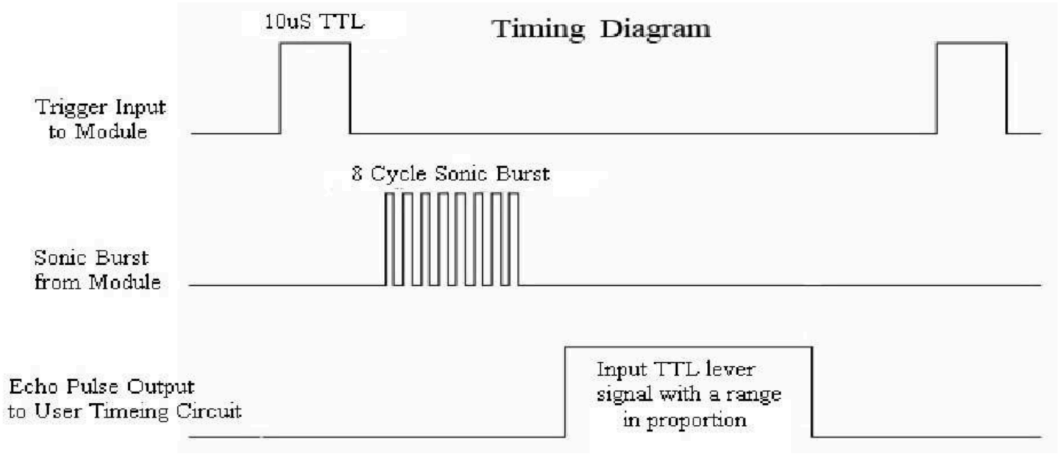
The **HC-SR04 Ultrasonic Sensor** is a device used to measure the distance between the sensor and an object. It uses ultrasonic sound waves, which are inaudible to human ears, to determine the distance. This module is commonly used in robotics, obstacle detection, and other applications requiring distance measurement.

How HC-SR04 Works

1. **Trigger Signal**:
    - A **short 10-microsecond pulse** is sent to the sensor's **trigger pin** to initiate the measurement process.
2. **Ultrasound Emission**:
    - The module generates an **8-cycle burst** of ultrasonic sound at **40 kHz**. This sound travels through the air.
3. **Echo Detection**:
    - When the ultrasonic sound hits an object, it reflects back to the sensor.
    - The **echo pin** remains HIGH (active) for the duration of the time it takes for the sound wave to travel to the object and return to the sensor.
4. **Distance Calculation**:
    - The time interval (pulse width of the echo signal) is proportional to the distance of the object.
    - The distance is calculated using the formula:
        - **uS / 58 = centimeters**
        - **uS / 148 = inches**
        - Or, using the speed of sound:
          Distance = (High-level time × 340 m/s) / 2
5. The division by 2 accounts for the round trip of the ultrasonic wave (to the object and back).

Timing Diagram Explanation

1. **Trigger Pulse**:
    - A pulse of **10 microseconds** is sent to the trigger pin to start the measurement.
2. **Ultrasonic Burst**:
    - The sensor emits an **8-cycle burst** of sound waves at 40 kHz.
3. **Echo Pin**:
    - The echo pin outputs a HIGH signal for the duration it takes the sound wave to travel to the object and return.
4. **Measurement Cycle**:
    - It is recommended to wait at least **60 milliseconds** between trigger signals to prevent overlapping of trigger and echo signals.



Key Formulas for Calculating Distance

1. **Using Microseconds**:
    - **Distance in cm** = `Pulse Duration (uS) / 58`
    - **Distance in inches** = `Pulse Duration (uS) / 148`
2. **Using Speed of Sound**:
    - **Distance (meters)** = `(High-level time × 340 m/s) / 2`
        - The division by 2 accounts for the round trip of the sound wave.

Summary

The HC-SR04 is a reliable and inexpensive way to measure distances. It works by emitting ultrasonic waves and measuring the time it takes for them to bounce back. Understanding the timing diagram is crucial for implementing it in projects, ensuring accurate measurements, and avoiding signal interference.

[How Ultrasonic Sensors Work]

[Transducer]

[The Basics of Ultrasonic Sensors]

[Intro to Arduino - Ultrasonic Sensors (Fall 2024)]

[Unbelievable Noise Cancellation Experiment]

[Active Noise Cancellation]