OBJECT DETECTION
&
DISTANCE MEASUREMENT USING TIVA

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"Object Detection and Distance Measurement Using Ultrasonic Sensor"

Working of Project:

As the title of our project reflects that we are aiming to make a system that will detect the presence of an object and the distance of that object from the system. Alongside, we are aiming to make our system scan in all four directions and after one complete revolution display, the number of objects detected and their distances. To carry this out we'll be using an HC-SR04 ultrasonic sensor which will provide us with the distance information. To make our system rotatable we'll use a 28BYJ-48 stepper motor which will be driven by the ULN2003 Stepper Motor Driver Module. All of these peripherals will be controlled by the TM4C1233H6PM microcontroller. Now, let's just view the detailed working of the project:

- After patching the circuit, the first thing we need to do is to trigger the sensor so it can activate and generate 8 pulses. For that, an impulse of 10 µs via a timer delay (in our case Timer0A), using the microcontroller, will be generated on a GPIO pin (in our case PF4) which will be connected to the trigger pin of the HC-Sr04. To generate the pulse first the pin will be turned on digitally and then a delay of 10 µs will be given using the timer and after that, the pin will be turned off. The specification of generating an impulse of 10 µs is given in the HC-SR04 datasheet.

- As aforementioned above, when the HC-SR04 gets triggered, it generates 8 Pulses, and immediately after generating them it sets its echo pin high. Now to measure the distance we will need to measure the pulse duration of the echo pin. For that, we will configure a Timer in input timer capture mode (in our case Timer1A). In working, we will capture the time at which the echo pin first gets high, and to confirm that it is a rising edge we will correspond to the GPIO pin of the timer and see its Data register. If the Data register has the corresponding bit to the pin set it means we have a rising edge. After confirming the rising edge this value will be recorded in a variable. Now the program will wait for the falling edge and store its time in a similar manner.

Note: if the falling edge occurs after 38ms of the rising edge it means that the sensor was not able to sense an object, because HC-SR04 has a measuring range of 2cm to 400cm.

- Now to find the time taken we will subtract the rising edge timer value from the falling edge timer value, in the case of the down counter and vice versa for the up counter. But this will not give us time taken, for that we will need to multiply the subtracted value with the time period of the timer. After that to find the distance, we will use the formula S = V x t, here we have t and we know V = 343 ms^{-1} (the speed of sound) but we will divide it by 2 because when we measured the time t, we actually measured the time taken by the waves from the time of generation till they get reflected back. So, our final formula will be S = (V x t) / 2. This will give us the distance in meters. This distance value will then be stored in an array.

- For object detection, the shortcoming of the sensor is that it can only detect the presence of an object but not the total number of objects. So, it is quite logical to say that if we get a pulse on the echo pin of the sensor which is less than 38ms then it is clear that there is an object. So, for simplicity, we consider there is only one object as the sensor can measure one object at a time.

- In the above steps, we have gathered information regarding the presence of an object and its distance in a particular direction. Now we will move the direction of the sensor using a stepper motor. For that, we will energize the 4 coils of the motor, individually, with a delay of 4ms each. We can rotate the motor at either 90° or 45°, depending on our requirement of data.

- We will follow the above steps again till a complete 360° revolution of the motor, after that all of the acquired data along with the number of objects

detected and their respective distances will be displayed on the UART HyperTerminal (in our case Putty).

Block Diagram:

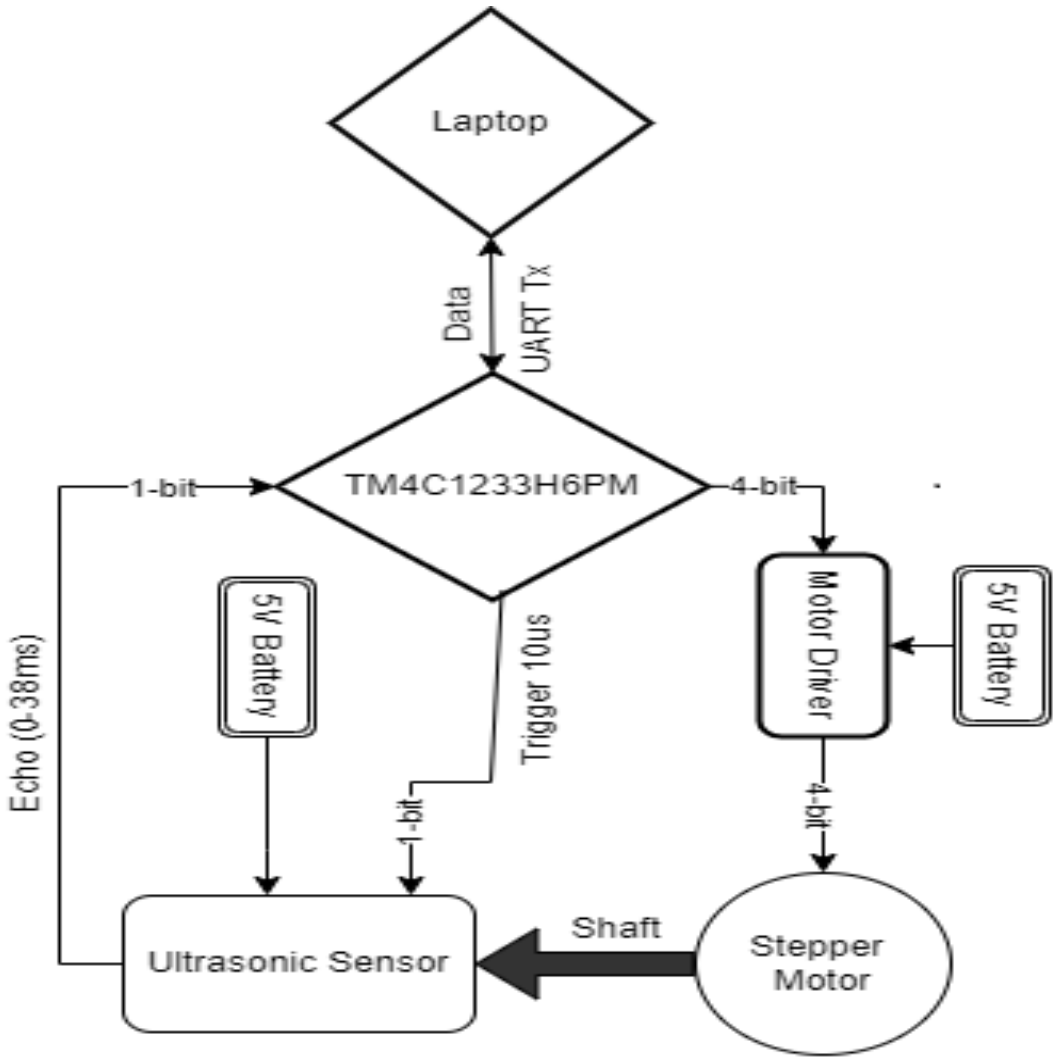

Figure-1: This figure is displaying the block diagram of the project **[1]**.

List of Equipment Used and Details:

- **HC-SR04 Ultrasonic Sensor [1]:**
  Let's discuss with the basic introduction of the HC-SR04 ultrasonic sensor. It is a contactless range or distance measurement sensor. It can measure a distance in range between 2cm to 400cm. It is made of three main circuits which are as an ultrasonic transmitter, an ultrasonic receiver, and a control circuit. HC-Sr04 has a total of 4 pins for external connections. From those four pins, two are power supply pins such as +5V and ground. The remaining two pins are Trigger and echo pins. A trigger pin is used to initiate the sensor

to start ranging. The echo output pulse pin is used to get output from the sensor.

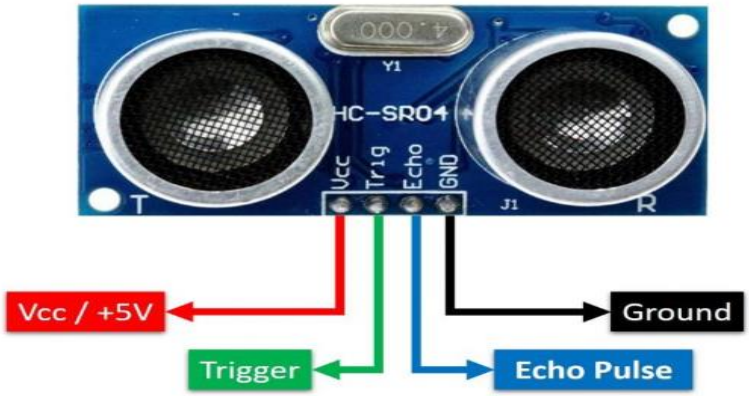

Figure-2: This figure shows the pinout diagram of the HC-SR04 ultrasonic sensor **[1]**.

- **28BYJ-48 Stepper Motor [2]:**

  28BYJ-48 is a unipolar 5-coil stepper motor with an operating voltage of +5V. Which implies 28BYJ-48 has four sequences of coils arrangement and each of these four coils can be powered with +5 volts. Since it is operating at +5V, so we can easily drive this motor from any microcontroller such as TM4C123G Tiva Launchpad. This motor has a stride angle of 5.625 degrees in half step mode. That means 28BYJ-48 will complete one revolution in (360/5.625) 64 steps by taking one step at a time in half step mode and in one step it covers 5.625 degrees angular distance. But this stepper motor can also be used in full-step mode. In full-step mode, the angle of each step is 11.25 degrees. That means the motor completes its one revolution in 32 steps (360/11.25). It has 5 pins out of which one pin is a +5 volts supply pin and four pins are used to provide sequence logic to the coils.

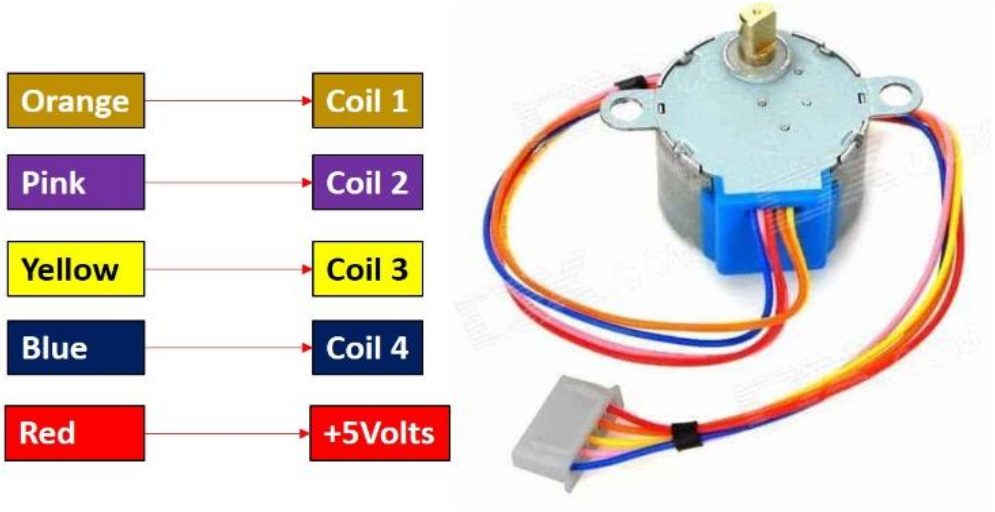

Figure-3: The following figure shows the pinout diagram of 28BYJ-48 stepper motor **[2]**.

- **ULN2003 Stepper Motor Driver Module [2]:**
  Motor drivers are used because the current consumption of 28BYJ-48 is around 240mA. Which implies that the current required to drive coils by applying a sequence of control signals is also almost 200mA. GPIO pins of TM4C123 Tiva Launchpad cannot provide a current of this magnitude. Therefore, we need a ULN2003 driver which translates low current output of TM4C123 GPIO pins into higher current that meets the requirement of stepper motor control signals. It has a total of 6 pins out of which 2 pins are VCC and GND: VCC is a power supply pin and it is used to provide +5 volts power to the stepper motor from an external power source.

  The remaining 4 pins are 1N1 to IN4: These are input pins used to provide control signals to stepper motor such as control sequences. We will connect these pins with GPIO pins of the TM4C123 Tiva Launchpad. Furthermore, the TM4C123 microcontroller does not have an onboard 5 volts signal. Therefore, we will need to provide power from an external power source. Additionally, the 28BYJ-48 stepper motor requires 240mA current to operate and it also consumes power at an idle condition. Therefore, it is recommended not to power the 28BYJ-48 stepper motor directly from any microcontroller instead use an external 5 volts power supply.

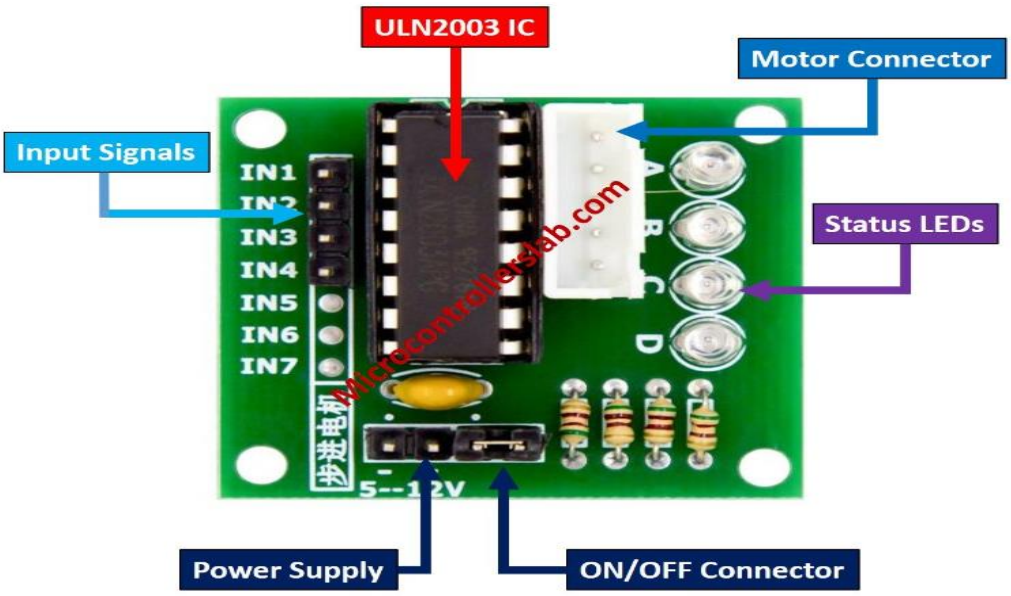

Figure-4: The following figure shows the pinout diagram of ULN2003 stepper motor driver **[2]**.

Budget of the Project:

All of this equipment was sourced from Hall Road, Lahore. These were the prices of the equipment:

- 28BYJ-48 Stepper Motor + ULN2003 Motor Diver for Rs 300.
- HC-SR04 Ultrasonic Sensor for Rs 150.
- Stand for HC-Sr04 Ultrasonic Sensor for Rs 60.
- Male to male and Male to female jumper wire for Rs 200.
- LM7805 Voltage Regulator for Rs 40.
- 9V battery Rs 80.

After adding the total amount comes out to be Rs 830 exclusive of TM4C123's cost which was Rs 6500.

Circuit Diagram:

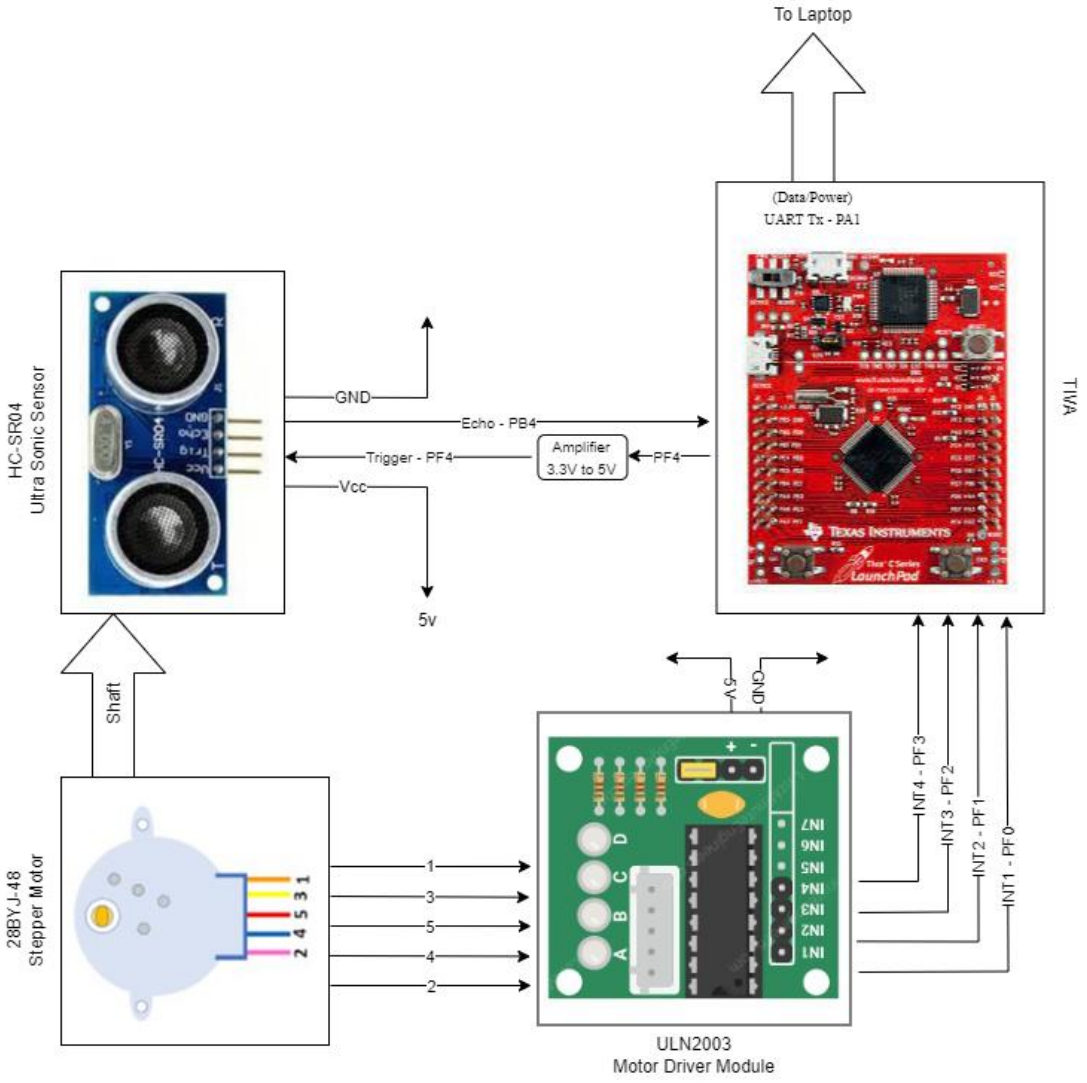

Figure-5: This figure shows the circuit diagram for the project **[1]**.

References:

[1] microcontrollerslab.com, 'HC-SR04 Ultrasonic Sensor Interfacing with TM4C123 – Distance Measurement Example', 2021. [Online]. Available: https://microcontrollerslab.com/hc-sr04-ultrasonic-sensor-interfacing-with-tm4c123-tiva-c-launchpad/. [Accessed: 27- Nov- 2022]

[2] microcontrollerslab.com, 'Stepper Motor Interfacing with TM4C123 Tiva Launchpad', 2021. [Online]. Available: https://microcontrollerslab.com/stepper-motor-interfacing-with-tm4c123-tiva-launchpad-keil/#:~:text=Stepper%20Motor%20Control%20Code%20TM4C123G. [Accessed: 27- Nov- 2022]