

Semester Project – Digital Logic Design

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Title: **Tap Water Conservator**

**Table of Contents**

1. Introduction 3
2. Project Description 3
3. Project Requirements 4
4. Block Diagram 4
5. Hardware Components Specification
6. Ultrasonic Sensor 5
7. Servomotor 5
8. 555 Timer 7
9. Counter 8
10. 7 Segment Display 9
11. Limitations 10
12. References 10
13. **Introduction**

We all know that water is a precious resource that we have all taken for granted and waste in huge amounts everyday even without realizing. Our design allows us to mitigate this wastage in an effective yet cost-efficient way. The goal of our project is to conserve the water that is wasted from taps. With the mixture of concepts, we learnt from Digital Logic Design and our own ideas, we designed the ‘tap water conservator’. It works by controlling the tap-water only using the basic components without any programming.

1. **Project Description**

Water should only be utilized when hands are in front of the tap, otherwise water is being wasted. We wanted to stop the tap when hands are not close to the tap, and vice-versa. For this purpose, an ultrasonic sensor is required. It is an obstacle detection sensor which will detect the hands only. It will be placed in such a way that it will not detect the incoming water, or other small obstacles.

Now that the ultrasonic sensor is set up, this will be linked to the two major components of the device. One is the servomotor, and other is the liter-counter. We designed a special circuit through which the servomotor can rotate in both directions without using any mechanical switching. We must not use mechanical switches because if the user must press the switches, then he/she can turn on the tap instead. For the ease of user, the whole working is without the intervention of the user, i.e., automatic. The servomotor is tightly attached with the valve of the tap-handle and can rotate it by 75% of the total at a relatively normal speed which turns on the tap almost instantaneously when the sensor detects user’s hands. On the other hand, the motor will rotate the handle backwards and will completely close the valve.

The liter-counter will count the total number of liters the water is used. It can count from 0 to 99, after which it will reset back to 0. We experimentally performed the manual calculations, and it turns out that it takes around 10 seconds for 1 liter of water to leave the tap when the valve is opened at 75%. Hence the display will increment by 1 every 10 seconds in which the motor is one. When the motor is on the other direction, i.e., tap is not being used, then the counter will be paused.

1. **Project Requirements**

* Ultrasonic Sensor
* 12 Volts Battery
* 2 AND Gates
* 1 NOT Gate
* Servomotor
* Astable 555 Timer
* Resistor A (24k) and B (2.4k)
* Capacitor (500 uF)
* 4026 ICs (two)
* Two 7-segment displays

1. **Block Diagram**

Diagram

Description automatically generated

1. **Hardware Components Specifications**
   1. **Ultrasonic sensor**

An ultrasonic sensor is an instrument that measures the distance to an object using ultrasonic sound waves. An ultrasonic sensor uses a transducer to send and receive ultrasonic pulses that relay back information about an object’s proximity. High-frequency sound waves, i.e., hence named ultrasonic waves, which are not audible to humans, reflect from boundaries to produce distinct echo patterns. The range of ultrasonic sensor can be modified as per our purposes. The working principle of this module is simple. It sends an ultrasonic pulse out through the air and if there is an obstacle or object, it will bounce back to the sensor. In our case, the object is human hand and arms. The objects can be detected accurately regardless of the color, surface, or material unless the object is sound absorbing material.

Application

Description automatically generated with low confidence

**5.2 Servomotor**

The purpose of servomotor in this project is open or close the tap valve as per the signals received by the sensor. A servomotor is a rotary actuator that allows for precise control angular position. It consists of a motor coupled to a sensor for position feedback.

There are some special types of applications of an electric motor where the rotation of the motor is required for just a certain angle. For these applications, we require some special types of motor with some special arrangement which makes the motor rotate a certain angle for a given electrical input (signal). For this purpose, servo motor comes into the picture.

The servo motor is usually a simple DC motor controlled for specific angular rotation with the help of additional servomechanism (a typical closed-loop feedback control system). Nowadays, servo systems are used widely in industrial applications.

The main reason behind using a servo is that it provides angular precision, i.e., it will only rotate as much we want and then stop and wait for the next signal to take further action. The servo motor is unlike a standard electric motor which starts turning as when we apply power to it, and the rotation continues until we switch off the power. We cannot control the rotational progress of electrical motor, but we can only control the speed of rotation and can turn it ON and OFF.

![Diagram, engineering drawing

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generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEASABIAAD/4UaaRXhpZgAATU0AKgAAAAgABgALAAIAAAAmAAAIYgESAAMAAAABAAEAAAExAAIAAAAmAAAIiAEyAAIAAAAUAAAIrodpAAQAAAABAAAIwuocAAcAAAgMAAAAVgAAEUYc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAFdpbmRvd3MgUGhvdG8gRWRpdG9yIDEwLjAuMTAwMTEuMTYzODQAV2luZG93cyBQaG90byBFZGl0b3IgMTAuMC4xMDAxMS4xNjM4NAAyMDIyOjAxOjA5IDIxOjM0OjM2AAAGkAMAAgAAABQAABEckAQAAgAAABQAABEwkpEAAgAAAAMwMAAAkpIAAgAAAAMwMAAAoAEAAwAAAAEAAQAA6hwABwAACAwAAAkQAAAAABzqAAAACAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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**5.3 Astable 555 Timer**

The 555 timer IC is an integrated circuit (chip) used in a variety of timer, delay, pulse generation, and oscillator applications. There are 3 different modes of 555 timer – monostable, bi-stable and a-stable. Each mode has different characteristic that determine how the 555 timer produces output. In this project we will be using a-stable mode.

* Pin 1 – Ground: Connected to 0 V
* Pin 2 – Trigger: Turns on the output when the voltage supplied to it drops below 1/3 of Vcc.
* Pin 3 – Output
* Pin 4 – Reset: Resets the timing operation of the output when grounded.
* Pin 5 – Not required for a-stable mode.
* Pin 6 – Threshold: Turns off the output when the voltage supplied to it reaches above 2/3 Vcc.
* Pin 7 – Discharge: When output voltage is low, it discharges the capacitor in the RC circuit to ground.
* **Diagram

  Description automatically generated**Pin 8 – Vcc (supply voltage): Can range from 4.5 V to 15 V.

**­**In this configuration of 555 timer, an output of the following waveform is created (through the continuous charging and discharging of the capacitor):

**A screenshot of a computer

Description automatically generated with low confidence**

The timer consists of 2 external resistors, Ra and Rb, and a capacitor C. When connected to a 5 volts Vcc the capacitors charges in time t1 given by:

While the discharging time is given by:

Hence total time is:

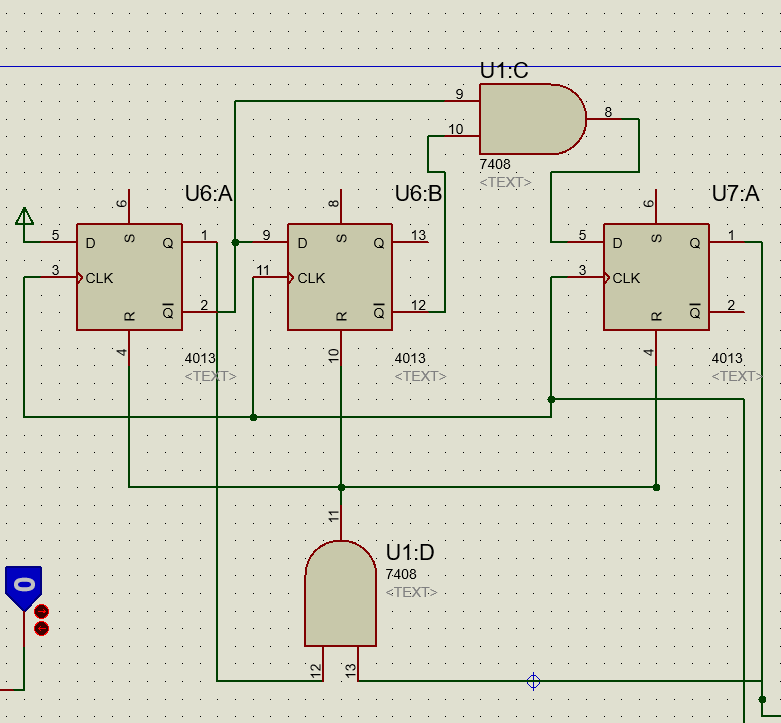
The Time Period of the abovementioned square waveform will be as above. We wanted period to be around 2.5 seconds, hence we setup the values as:

This suits our purpose.

{\displaystyle t\_{\text{high}}=\ln(2)\cdot (R\_{1}+R\_{2})\cdot C}

**5.4 3-Bit Synchronous (Truncated) Up Counter**

As we are producing 2.5 seconds delay through the 555 timers but the required delay is 10 seconds so we will achieve this using a 3-bit counter. In a **Synchronous counter,** if all the flip-flops receive the same clock signal. Hence, the outputs of all flip-flops change the same time. So, there is not much delay in the circuit as compared to the a-synchronous counter.



The 3-bit Synchronous binary up counter contains three D flip-flops & two 2-input AND gates. All these flip-flops are positive edge triggered and the outputs of flip-flops change affect synchronously. The D inputs of first, second and third flip-flops are **D0 D1 D2** respectively. The output of first D flip-flop toggles for every positive edge of clock signal. The output of second D flip-flop toggles for every positive edge of clock signal if **Q0** is 1. The output of third D flip-flop toggles for every positive edge of clock signal if both **Q1** and **Q2** are 1.

In this project, we will be using the counter as a frequency divider. The output of the first flip flop divides the incoming clock signal by 2, then the second one again by 2 and then the third one. The time-period will be multiplied by the same factor. This way, the incoming clock signal from the 555 timer of 2.5 sec will be multiplied by 4 to become 10 seconds. These 10 second interval clock pulses from Q3 will then be used as an input to the 4026 IC for increment 7-segment.

**5.5 7-Segment Display and 4026 IC**

Two types of 7-segment displays are the LED and the LCD. Each of the seven segments in an LED display uses a light-emitting diode to produce a colored light when there is current through it and can be seen in the dark. An LCD or liquid-crystal display operates by polarizing light so that when a segment is not activated by a voltage, it reflects incident light and appears invisible against its background; however, when a segment is activated, it does not reflect light and appears black. LCD displays cannot be seen in the dark.

The seven pins in both LED and LCD displays are labeled *a*, *b*, *c*, *d*, *e*, *f*, and *g* as indicated in part. The 4026 IC also has the corresponding pins and thus they can be connected. The cascading pin of one 4026 IC (unit digit) t) will act as a clock signal for the second one (tens digit).

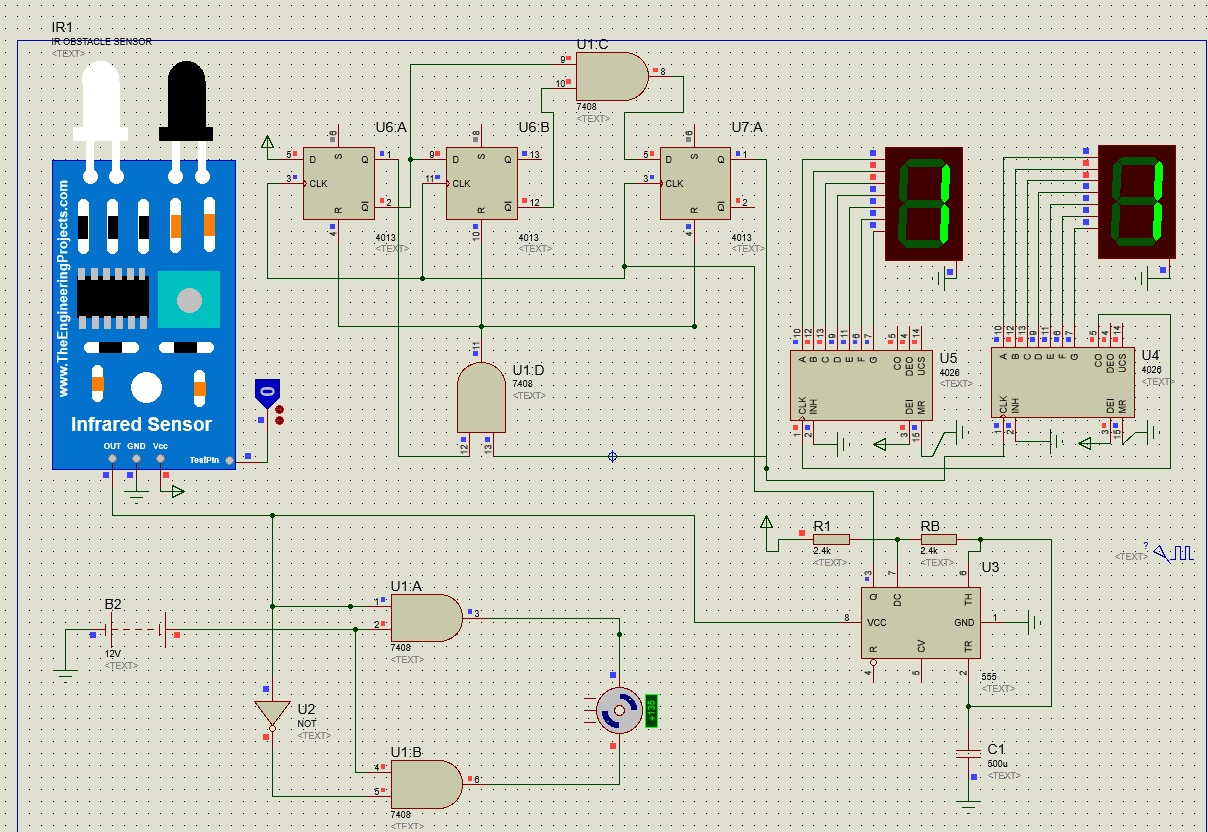
A picture containing diagram

Description automatically generatedA picture containing text, clock

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The pin configuration can be found using the official site as mentioned in the references.

1. **Proteus Schematics**

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**7. Limitations**

* The current design works for only specific types of taps, e.g., the ones in our hostels in GIKI.
* The sensor may detect other obstacles my mistakes and will turn on the tap. For example, the water leaving from the tap acts a big obstacle in the way of sensor. However, we tried our level best to optimize the sensor with the available resources.
* The liter counter can approximate the amount of liters of water leaving the tap. This approximation is subject to our experimental calculation, which may change during different water conditions.

**8. Improvements in design**

* Two servo motors can be used on both sides of tap, and based on temperature of the environment, the left or right motor will automatically turn on, thus giving hot or cold water as desired without user’s intervention.

**9. References**