A REPORT ON

Achieving Automation
Using
LM741 and IC 555

AN APPLICATION OF OP-AMP AND IC-555

Prepared in partial fulfilment of the

course ANALOG ELECTRONICS (EEE_ECE_INSTR F341)

Birla Institute of Technology and Science, Pilani

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Certificate

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Abstract :

We are living in the world where everything goes to be automatic from your washing machine to your ceiling fan. The world revolves around the word automation and the ones that are automated are said to be of the next generation because they limit the involvement of humans. They are self-sufficient to operate on their own and thereby, saving time and cost by being more efficient than the manual ones. But lighting systems have yet to make its move in these automated crusades. We have just started the crusade in our attempt here.

This Project is one such attempt to automate petty things, in our day to day life situations.

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1. Introduction

We are living in the world where everything goes to be automatic from your washing machine to your ceiling fan. The world revolves around the word automation and the ones that are automated are said to be of the next generation because they limit the involvement of humans. They are self-sufficient to operate on their own and thereby, saving time and cost by being more efficient than the manual ones. We have just started the crusade in our attempt here.

This Project is one such attempt to automate things in our day to day life situations to maximise our utilisation of the resources and reduce their wastage.Here we have used IC 555 and LM 741. The 555 timer chip is extremely robust and stable 8-pin device that can be operated either as a very accurate Monostable, Bistable or Astable Multivibrator to produce a variety of applications such as one-shot or delay timers, pulse generation, LED and lamp flashers, alarms and tone generation, logic clocks, frequency division, power supplies and converters etc.Here we have used LM 741 as a comparator in our circuit.

Together we have used both the devices to form a monostable multivibrator circuit.This provides us the flexibility to use an unstable state and control its pulse width whenever there is a triggering pulse.We have also exploited the fact that the duration of the trigger pulse changes the duration of output pulse to give rise to two different applications.

This setup provides varied practical applications apart from being efficient in terms of resource utilisation. The entire working along with the schematic is explained in the following pages.

2. Function and Applications

In a nutshell,we are saving the resources by automating the things(listed below) using LM741 and IC 555 in monostable multivibrator configuration.
Here we are exploiting the fact that the pulse width of the unstable state depends on the trigger duration.

Case-1: When the duration of the trigger pulse is less than the pulse duration of unstable state

1. **SMART IRRIGATION SYSTEM**

Usually, in the drip irrigation system the irrigation is done on a fixed time intervals without actually considering the fact that how much water is actually required for the plants.So in order to save water(an important natural resource) and improve the growth of the plants, we have to utilise the water in a most efficient way.

To achieve this purpose we use the concept of mono-stable multivibrator and hygrometer (soil moisture sensor). Whenever the soil moisture sensor observes that the water has been dropped below a certain threshold it sends a trigger to the voltage controlled resistance. Since the trigger had been generated, the timer (IC-555)will now go to an unstable state. Unstable state here means irrigation of plants.So depending on the R1,C2 we can control the duration of irrigation. During the process of irrigation if there are any further triggers this won't affect the irrigation process. But if there is any further trigger after once, cycle the irrigation process again. This process will continue until there are no further triggers, which means that there is no further need to water the plants as the water content in the soil is now sufficient for the optimal growth.

Hence, with the application of monostable multivibrators we are not only saving water in large quantities but also ensuring the optimal growth of the plants.

Case-II: When the duration of the trigger pulse if more than the pulse duration of unstable state.
In this case the output pulse duration is the same as that of the triggering pulse.

2. SMART LIGHTING SYSTEM IN ELEVATORS

We usually observe that the lights/Fans in the elevator will be turned on even though there are no people inside the elevator. This is the case in many apartments and offices which inturn increases the electricity consumption. To solve this problem we use a special case of monostable multivibrator to solve this problem.

We make the pulse width very small(in the order of milli secs)by changing the values of R1 in the circuit.Whenever a person comes near the LDR placed in the elevator he would indirectly increase the resistance in the circuit thereby producing the trigger pulse. Hence the duration of the trigger pulse is equal to the time a person/s is in the elevator.Thereby turning on the lights/fans only when there are people inside the elevator.

This simple yet effective solution can save electricity in many places.

3. SMART RESTROOMS

An alternative to motion sensors used in the restrooms we can make use of the LDR’s and monostable multivibrators to implement smart taps and dryers in the restrooms.
Whenever an LDR detects a shadow near a tap or dryer it changes the circuit accordingly to activate the respective devices.
In this way we can maximize the resource utilization and reduce the wastage.

4. SMART SANITIZER DISPENSERS

Building on the same circuit of a smart restroom, we could implement a smart sanitizer dispenser as well with a pulse width of say - 3 seconds.

3. Design

The circuit consists of three main units. These parts are discussed and elucidated as follows:

1. **Detection circuit** - built by using an **LDR(Light Dependent Resistor)**
   - The light dependent resistor is a resistor whose value varies based on intensity of light falling on it. When light falls on it, the resistance reduces and increases when exposed to darkness.
   - As LT spice does not support LDR for simulation we took the basic operating principle of a typical LDR and replaced it with a SW switch to simulate this model.
   - A typical LDR works by changing the cell resistance in it as the surroundings get darker or brighter. When the LDR detects the surroundings are bright (1000 Lux) it offers a resistance of 400 Ohms and if the LDR detects the surroundings are darker (10 Lux) then it offers a resistance of 9K Ohms (data sheet)
   - The SW switch has 4 parameters (R_{on},R_{off},V_{th},V_{hs}). Here V_{hs} is zero as there are only two states either on/off. V_{th} is 0.5, and if the voltage V across the switch is greater than 0.5V then the switch offers resistance of a value R_{on}, and when V_{th} is less than 0.5V then the switch offers a value of R_{off}.
   - R_{on} is taken as 9k Ohms, R_{off} is taken as 400 Ohms (typical LDR values)

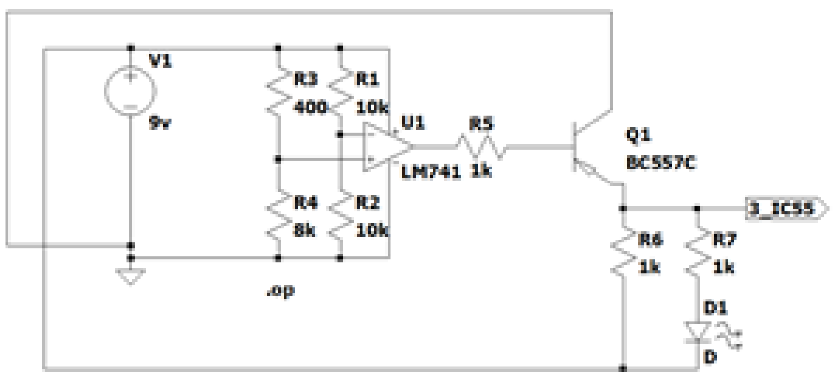


Fig 1: Detection and decision circuit

2. **Decision circuit** - *a comparator circuit* built using an opamp **LM741**
   - The input of the negative terminal is the output of a voltage divider circuit.

     $V_{-} = V_{dc} * (R_5/(R_5+R_4)) \quad = 9 *(10k/10k+10k) = 4.5$ V

   - The input to the positive terminal is the voltage divider circuit comprising the switch

     $V_{dc} = 9$ V, $R_{ON} = 9k\ \Omega$, $R_{OFF} = 400\ \Omega$

V_+ When the switch is ON,

$V_+ = V_{dc} * (R_7/(R_{ON}+R_7))$ = 9 *(8k/9k+8k) = 4.2353 V

V_+ When the switch is OFF,

$V_+ = V_{dc} * (R_7/(R_{OFF}+R_7))$ = 9 *(8k/400+8k) = 8.5714 V

- The output of the comparator will be at $+V_{SATURATION}$ ($V_+ > V_-$), when the switch is OFF
- This output will fall to $-V_{SATURATION}$ when the LDR is triggered by a shadow(i.e when the switch is ON), *this falling from +Vsat to -Vsat will trigger the monostable multivibrator in the next stage by turning on the pnp transistor.*

3. **Execution circuit** - *a monostable multivibrator circuit* built by using a **timer IC - NE555** triggered by a pnp transistor
    - Once triggered, the output of this circuit will be in high state depending on the time period of the circuit which can be tweaked as required using the result **T = Pulse width = 1.1RC** (Where **R** & **C** can be modified depending on the application).
    - **Two cases** arise from the multivibratior circuit which can be used depending on our application.
        - Trigger time < Pulse width : The LED will be high for time T
        - Trigger time > Pulse width : The LED will be high as long as the LDR is triggered

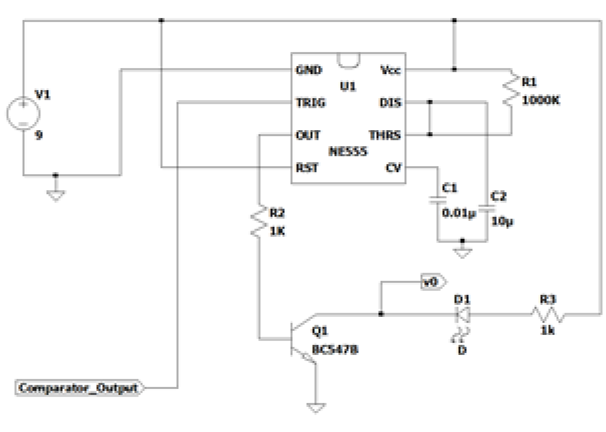


Fig 2 : Execution circuit

NOTE

- The LDR can be housed in a dark tube to increase sensitivity.
- The sensitivity is very important here. If the required sensitivity properly can not be adjusted properly, one LOW resistance (~1K) in series with R7(in the circuit schematic) can be used for fine adjustment

4. Simulation setup

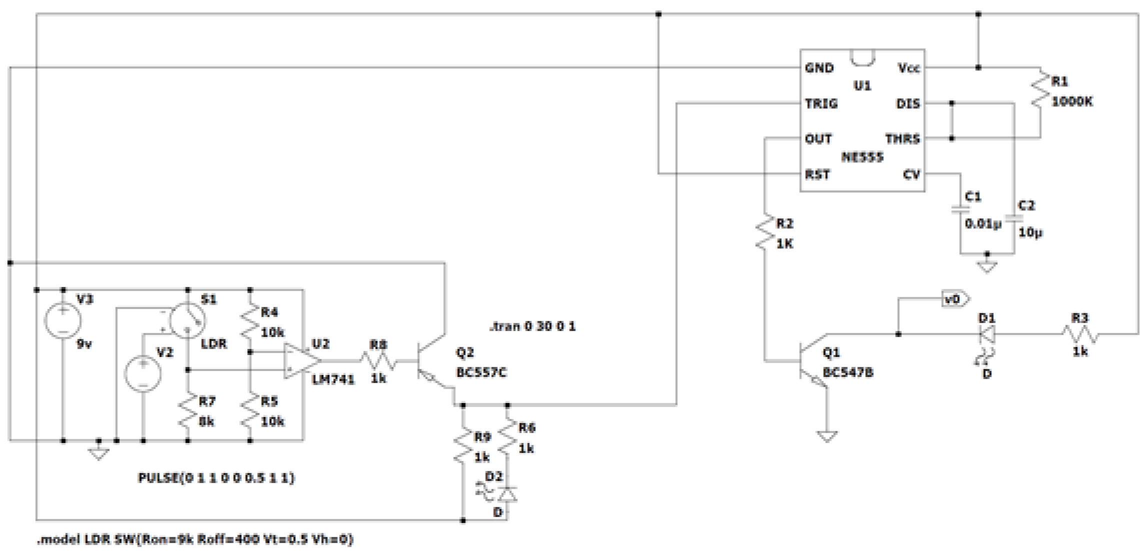


Fig 3 : Main circuit

1. Input pulse width(trigger time) = 0.5 seconds

2. The parameters of SW are set up as follows :

   a. R_{on} = 400 Ohm
   b. R_{off} = 9k Ohm
   c. V_{th} = 0.5V
   d. V_h = 0V

3. Vref for comparator circuit = 4.5V

4. Output pulse width is set up for approx 1.1RC

R=R1=1000K or 1M ohms

C=C2=10µF

Hence 1.1RC = 1.1*1000K*10micro = 11seconds

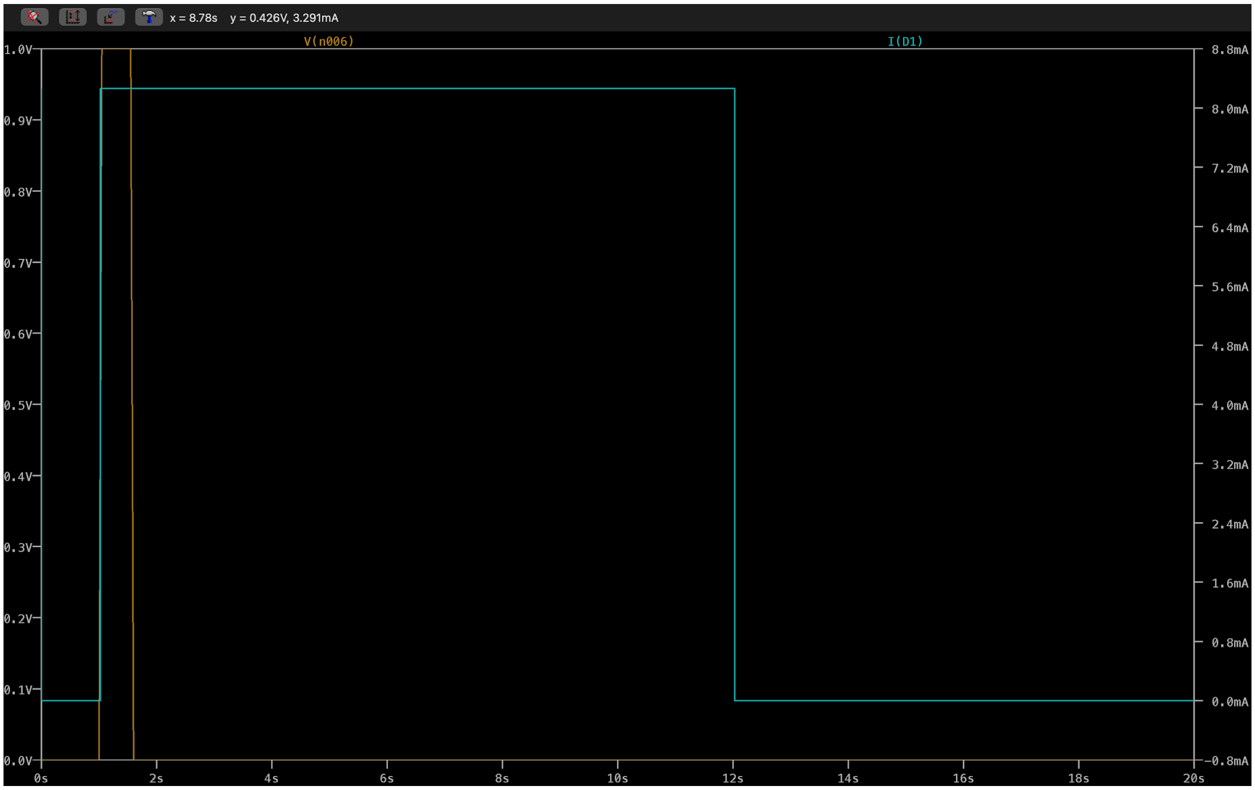
5. Working

- The circuit generally is in “OFF” condition (i.e the LDR offers the 400 Ω resistance),So the voltage and non-inverting terminal is 8.5714 V.
- The voltage at inverting terminal is fixed by the two 10 kΩ resistors placed across the voltage source.(which is reference voltage set as 4.5V in our circuit)
- The LM741 Op Amp IC is used here as the comparator goes high or low based on the voltage at the inverting and non-inverting terminal. In “OFF” condition as the voltage at the inverting terminal is higher than the non-inverting terminal, the output of Op Amp is high and equal to $+V_{SATURATION}$ =9V ideally(here it goes nearly 8.6V). When ever the LDR is triggered then the resistance of LDR goes high (here 9 kΩ), this makes the voltage at non-inverting terminal as 4.2353 V which is less than the the voltage at inverting terminal, So the output voltage of Op Amp goes $-V_{SATURATION}$ =0V ideally(here it goes to 1.06V).
- The base terminal of pnp transistor is connected to the output of Op Amp through 1kΩ,this 1kΩ protects the transistor by preventing excess current flow. Here this transistor is working as a switch, when the base voltage is high the transistor is in “OFF” and when the transistor is “ON” condition.
- So whenever the LDR is triggered it makes the output voltage at Op Amp low and the transistor completes the circuit and the emitter voltage of the transistor goes low.
- This emitter voltage is used as the trigger pulse for the IC555 (which is here working as the monostable muti-vibretor).
- IC 555 - monostable multi-vibretor.
    - Ground pin - It is connected to the ground
    - Reset - Is connected to the to 9V , this resets after generating the output voltage for a specified time period (based on external R ,C values).
    - Trigger - This is connected to the emitter of the pnp transistor, this triggers the IC555.
    - Output - This pin gives the output voltage for time period (based on external R ,C values) from the instance the trigger pin receives the trigger from the decision circuit.
    - C_v - In this event this pin is not used ,so it is recommended to bypass this to ground through the capacitor (0.06 microF) for immune to noise.
    - External R & C - These are used to decide the time period of unstable state of the output and this is given as RCl(ln3). Here since the R is 1 MΩ and the C is 10 micro F the time period is 11sec. (*T=1.1RC)*
- Changing the R or C values enable us to change the time period of unstable state.
- If the trigger pin goes low the output pin goes high for a given time period from the triggered instant.
- The npn transistor here acts as a switch. The output of IC555 is connected to base of the transistor through 1 kΩ resistor (which protects the transistor).
- The high voltage makes the transistor “ON” and the complete circuit makes the flow of current through the LED.

NOTE: The 1 kΩ resistor is placed in series of LED to protect LED from excess current flow.

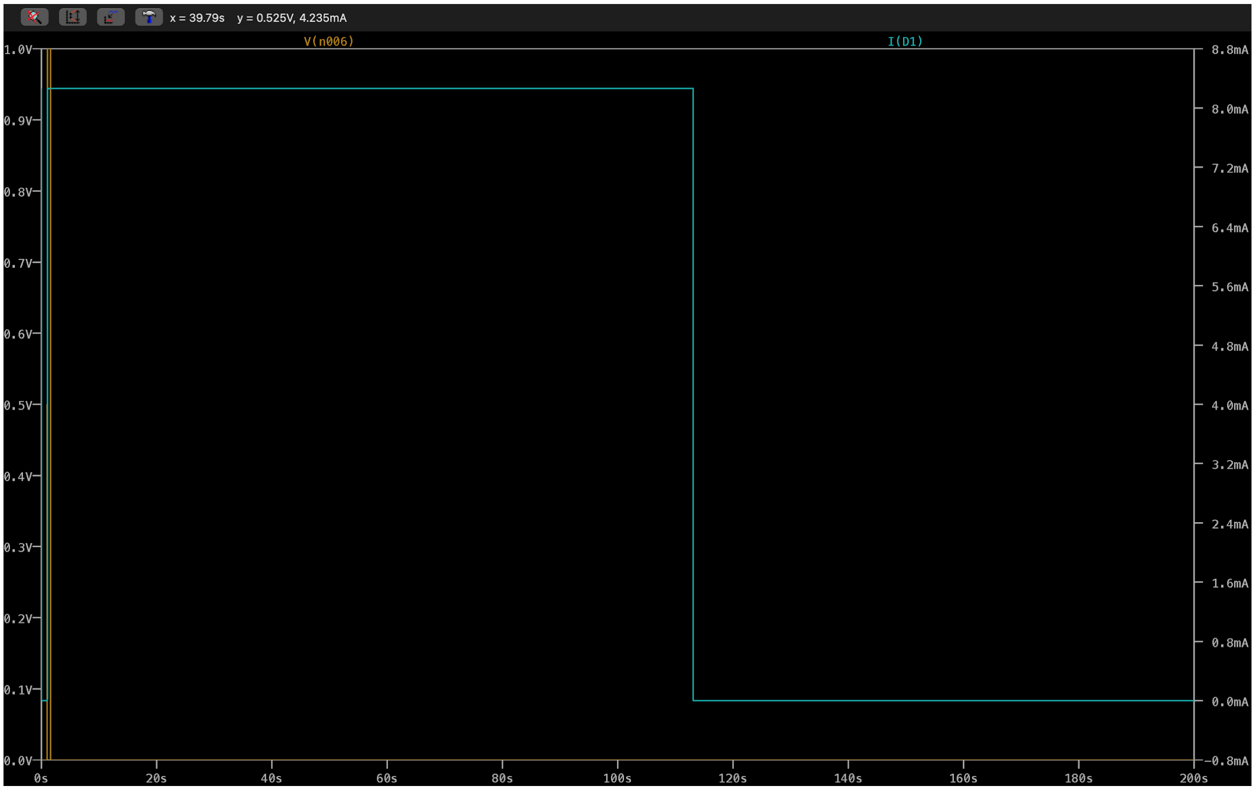
6. Simulation results

CASE 1a : Output pulse width = 11seconds (R1 = 1MOhm, C2 = 10microFarad) and trigger time = 0.5 seconds



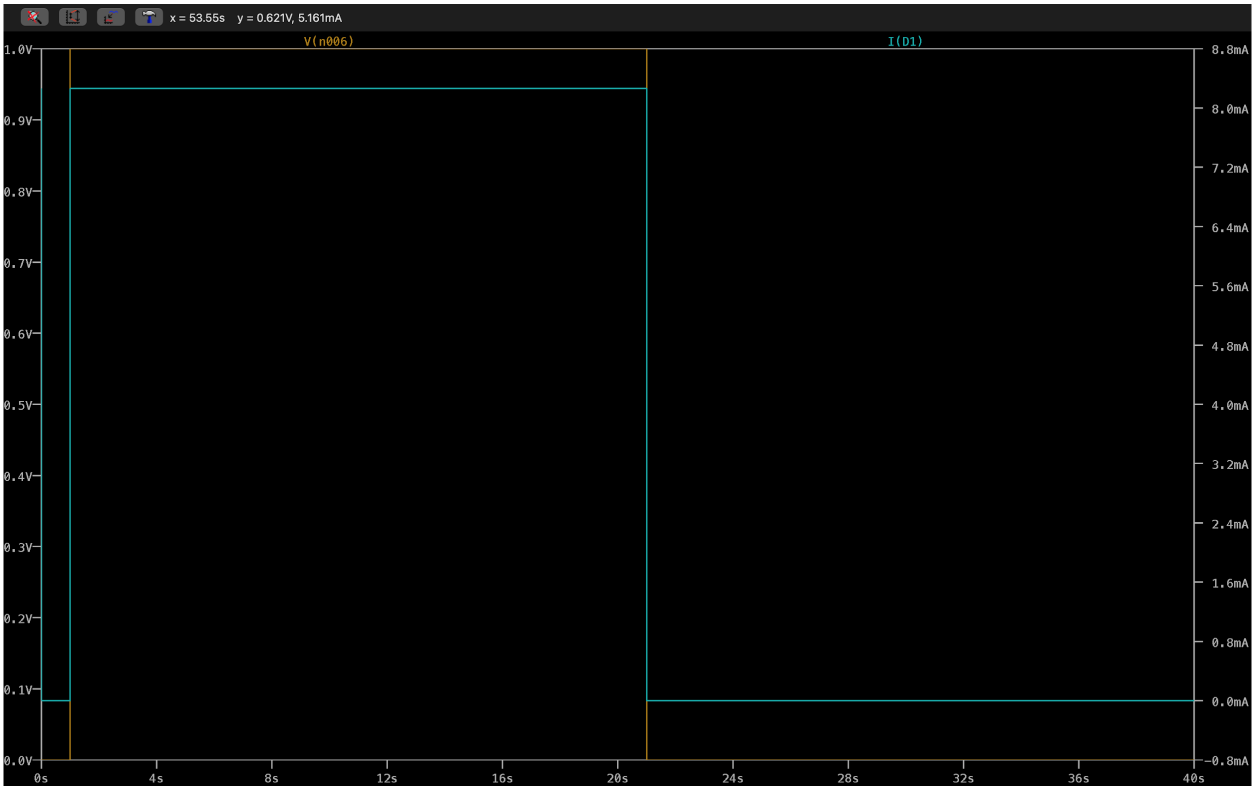
The output will be triggered for approximately 11 seconds for an input trigger of 0.5 seconds

CASE 1b: Output pulse width = 110seconds (R1 = 10MOhm, C2 = 10microFarad) and trigger time = 0.5 seconds i.e output pulse width is increased ten-fold with ten-fold increase in time constant



The output will be triggered for approximately 110 seconds for an input trigger of 0.5 seconds. This is achieved by increasing the time constant ten fold by increasing the value of R1 to 10MOhm.

CASE 2 : Output pulse width = 20seconds (R1 = 1MOhm, C2 = 10microFarad) and trigger time = 20 seconds



In this case since the trigger time is greater than the predefined pulse width, the circuit will be on as long as the input is triggered.

7. Conclusion

In our audacious attempt to build autonomous circuits using the basic building blocks of any circuit - LM741 and IC555, we have built another circuit one level above that can be a building block for various-multitude of other circuits for varied applications. Say, the LDR could be replaced by an Infrared sensor, to detect motion in a room to make a smarter lighting system, or as simple as a burglar alarm by replacing the light with an sound output or a smart door bell in this times of COVID, without physically touching the switch triggering the doorbell or even a sanitiser dispenser building upon the same circuit that we have built. We hope in our attempt to build automated circuits, we paved the way for more complex circuits in making the world a better place.