Project Title: Physical Distancing Alarm Cap

Group No: 44

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Objective: To make a Physical Distancing Alarm Cap Using an ultrasonic sensor meant for Covid-19 pandemic or similar disease outbreak. Maintaining the proper gap for social or physical distancing is not always feasible. When we are outside, we forget to maintain the distance as soon as we get involved in our daily work. This novel circuit alerts you if you come too close to someone. A cap fitted with an ultrasonic distance sensor alerts you through a buzzer.

Contents

1. Block Diagram

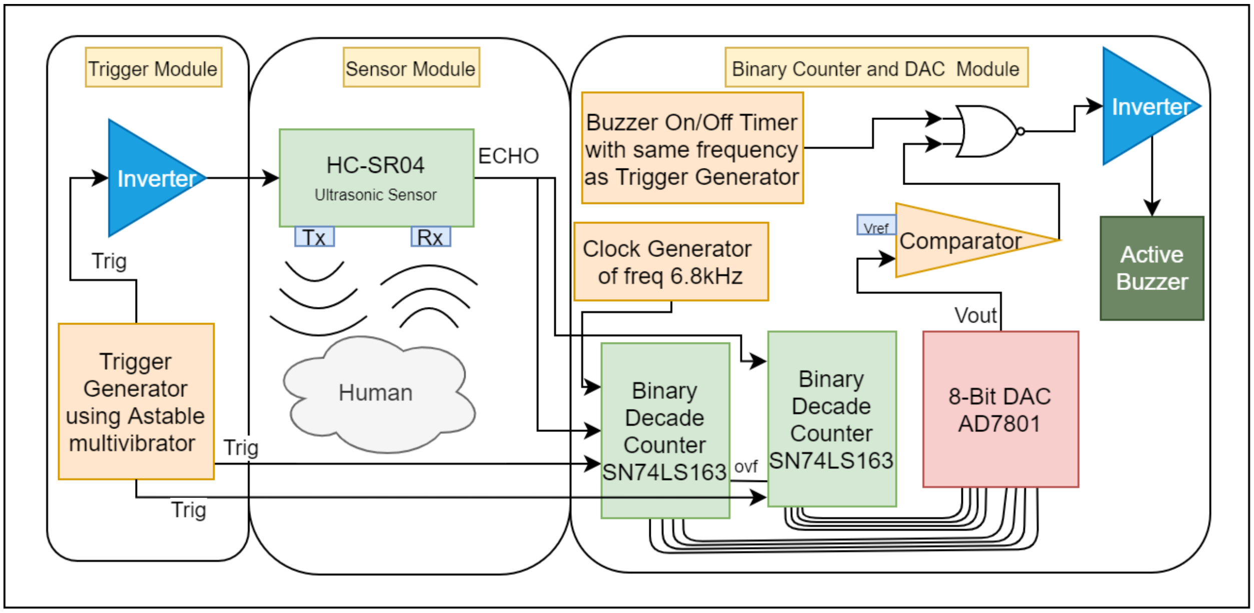


Figure 1 : Block diagram

2. PROJECT DESIGN

2.1 System Design

Our project/system is mainly divided into three subsystems:

1. Trigger generator circuit
2. Transmitter and receiver
3. Binary decade counter and DAC module
4. Comparator circuit and buzzer

2.1.1. Trigger generator circuit

We are using HCSR04 ultrasonic sensor transmitter and receiver pair to measure the distance. To start the measurement, the trigger of SR04 must receive a pulse of high (5 V) for at least 10 us. This will initiate the sensor to transmit eight cycles of ultrasonic burst at 40 kHz and wait for the reflected ultrasonic burst.

This circuit will generate a TL of $693\ \mu s$ as it is greater than $10\ \mu s$ and accordingly TH to be 42 msec.

2.1.2. Transmitter and receiver

The HCSR04 ultrasonic sensor comes with an ultrasonic transmitter and receiver module. When the sensor detects ultrasonic from the receiver, it will set the Echo pin to high (5V) and delay for a period (width) which is proportional to the distance. To obtain the distance, we measure the width (T_{ON}) of the Echo pin.

2.1.3. Binary decade counter and DAC module

The output of the Echo pin of the HCSR04 ultrasonic sensor will be given to a pair of Synchronous 4-Bit Counters. The frequency of the clock given to counters is 6.8 Khz. For an obstacle at a distance of 2 meters, the Echo pin's output will remain high for a duration of 11.6 ms. The counter count for the meter of 2 meters will be

- 11.6 * 6.8 KHz = 79 (rounded up).

Now we know the number of the cycles counted in counter for 2m, we calculated the corresponding output voltage of DAC (AD7801), i.e., after applying the Vout formula given in the datasheet of DAC, we got Vout
for N = 79

VO = (2 * 2.5 * 79) / 256 = 1.543V

2.1.4. Comparator circuit and buzzer

We approximate the output of DAC as 1.54V and use a potentiometer to get the required voltage and design the comparator accordingly. Then we are multiplying it to the buzzer on-off timer output to get the output of the comparator after a certain time so there is enough time for the counters to count till 79 if the echo pulse is that long. So now we have no problem with having a buzzer on at the start of the count as we know at the start the count is 0 so the comparator will give output thinking that the distance is less than 2 m but actually it hasn't checked for Vout corresponding to the whole count for the whole echo pulse.

3. Sub Systems

3.1 Clock Generator of frequency 6.67 kHz

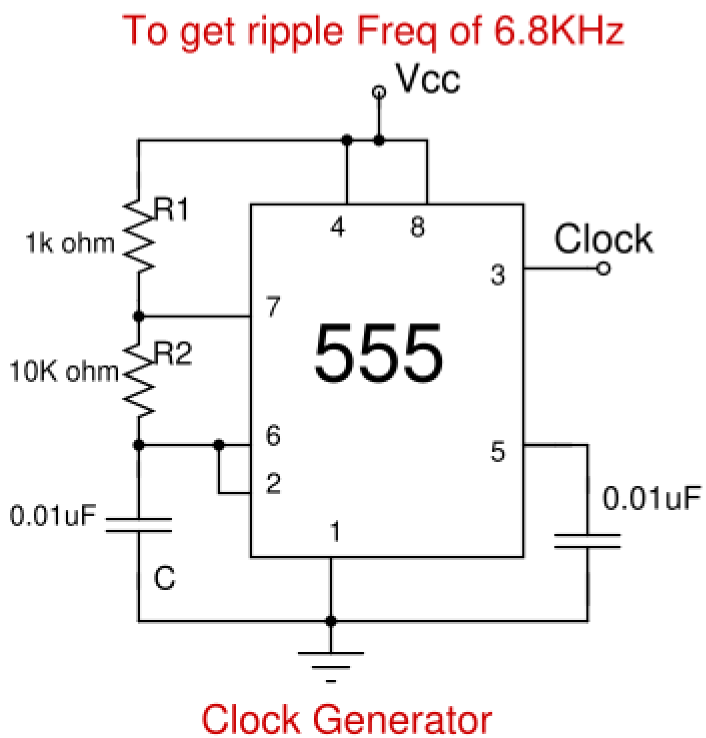


Figure 2 : Circuit diagram of clock generator circuit

The IC used is the LM555 Timer IC.

Calculations :

For the 6.67 kHz frequency requirement, the theoretically calculated values are as follows :
R1 = 1.5 K , R2 = 10.5 K , C = 0.01F .

But due to practical reasons, we will use resistors of the following values:
R1 = 1 K, R2 = 10 K, C = 10nF .
So the frequency of the Clock Generator will be 6.8 kHz.

3.2 Trigger generator circuit

Requirement: Trigger generating circuit with T_low at least $10\ \mu s$ and T_high around 60 msec

Circuit diagram

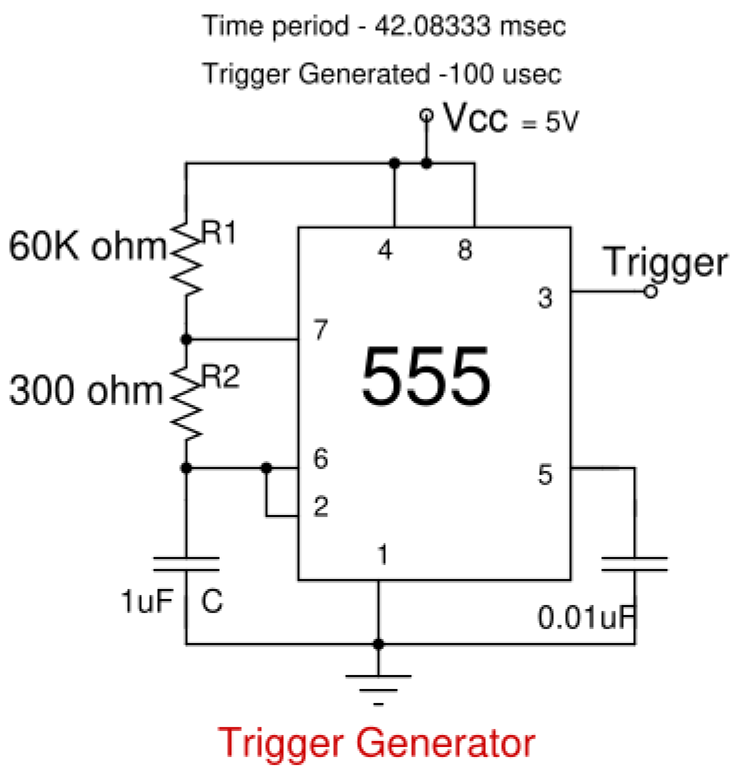


Figure 3 : Circuit diagram of trigger generator circuit

We are going to use IC lm555 operating in astable mode. The RC timing circuit incorporates R1, R2, and C.

Charging period, TH = ln 2 . (R1+ R2) C

Discharging period, TL = ln 2 . R2 .C

Calculations :

We cannot have $10\ \mu s$ as TL, which can be very low, so we choose an optimistic value of $693\ \mu s$ as it is greater than $10\ \mu s$ and accordingly TH to be 42 msec considering the output of the echo pin of the ultrasonic sensor. So, now after calculating values of R1 and R2 for undated requirements, we get

R1 = 60 K, R2 = 300, C = 1uF .

So the frequency of the Trigger pulse of the period around 42 msec and the trigger pulse is around 100 microsecond.

3.3 Transmitter and receiver (HCSR04 ultrasonic sensor.)

We will apply a trigger pulse having T_low as 693 us and T_high as 42 msec. Now the trigger is generated, we will transmit a signal of 8 pulses with 40KHz frequency, and after a delay, we will echo the signal in the receiver module. When the sensor detects ultrasonic from the receiver, it will set the Echo pin to high (5V) and delay for a period (width) which is proportional to the distance. We will give the pulse generated at the Echo pin to a pair of counters.

Figure 4 : HCSR04 ultrasonic sensor module

Pin connections of HCSR04 ultrasonic sensor:

Vcc: 5 Volt DC supply

Trig : connected to the not Gate output of trigger generator circuit

Echo: connected to the input of a pair of Synchronous 4-Bit Counters.

GND: connected to ground

3.3 Binary decade counter and DAC module

3.3.1 Binary decade counter

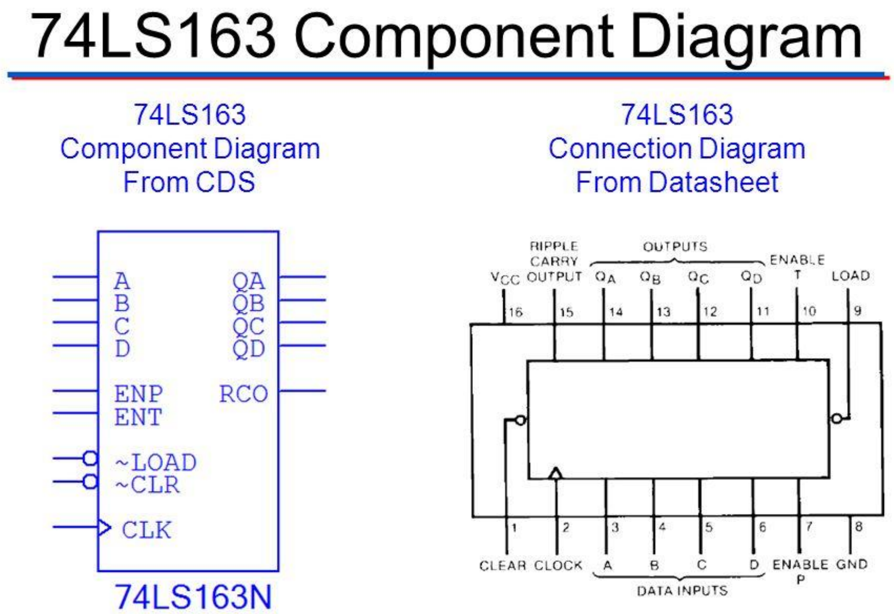


Figure 5 : IC SN74LS163 pin diagram(Source : RAINHA SEGUROS)

Now we are using 2 such IC's So we will get around 0-256 count after connecting the carry to the 2nd decade counter. Now the below pin connection for both decade counters are same except the clock input for 1st IC is from clock generator and for 2nd IC is from 1st IC Ripple carry out pin and these 8 bit are given to Digital to analog converter AD7801 below

Pin No.	**Name**	**description**	**Connected to**
1	$\overline{CLR}$	8-bit Parallel Data Inputs	The output of a pair of counters
2	CLK	Clock generator output for counting	Clock
ENP, ENT	$\overline{CS}$	Count and Carry enabled on when ECHO is high	ECHO
9	$\overline{LD}$	So only when trig pulse comes the preset occurs and A, B, C, D loaded	Trig
15	RCO	It is Given as Input for 2nd IC	Clock for 2nd Counter
3,4,5,6	A,B,C,D	Kept Low so preset is 0000	GND
8	GND	ground	GND
16	VCC	Power supply	5 V

3.3.2 DAC module

The outputs of the pair of synchronous counters will be given to the DAC as 8-bit input. The IC used as DAC is AD7801. The number of cycles counted on the counter for a distance of 2 m is 79. We calculated the corresponding output voltage of DAC (AD7801), i.e., after applying the Vout formula given in the datasheet of DAC, we got Vout for N = 79

$$Vout = (2 * 2.5 * 79) / 256 = 1.543 \text{ V}$$

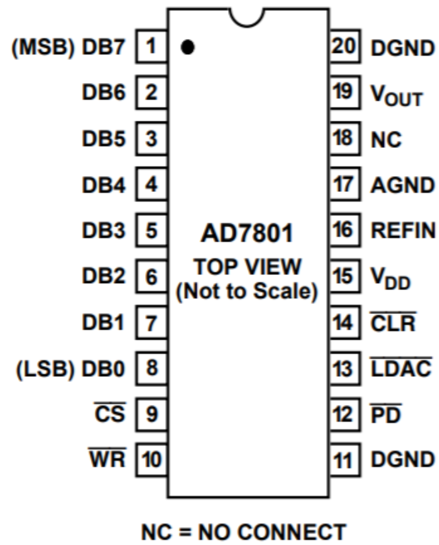


Figure 6 : IC AD7801 pin diagram (source: IC datasheet)

Pin connections of IC AD7801:

Pin No.	**Name**	**description**	**Connected to**
1-8	D7–D0	8-bit Parallel Data Inputs	The output of a pair of counters
9,10	$\overline{CS}$, $\overline{WR}$	Chip Select, Write Input Active low logic input	GND
11	DGND	Digital Ground	GND
12	$\overline{PD}$	Active low input used to put the part into low power mode	5 V
13	$\overline{LDAC}$	Input is loaded at the rising edge of	GND

		Clock when this pin is tied to low	
14	$\overline{CLR}$	Asynchronous Clear Input (Active Low).	5 V
15	VDD	Power Supply Input(+2.7 V to +5.5 V)	5 V
16	REFIN	External Reference Input	5 V
17	AGND	Analog Ground reference point	GND
18	NC	No Connect Pin	-
19	VOUT	Analog Output Voltage from the DAC	comparator circuit input 1
20	DGND	Digital Ground reference point	GND

3.4 Comparator circuit and buzzer

PIn diagram of IC LM358 :

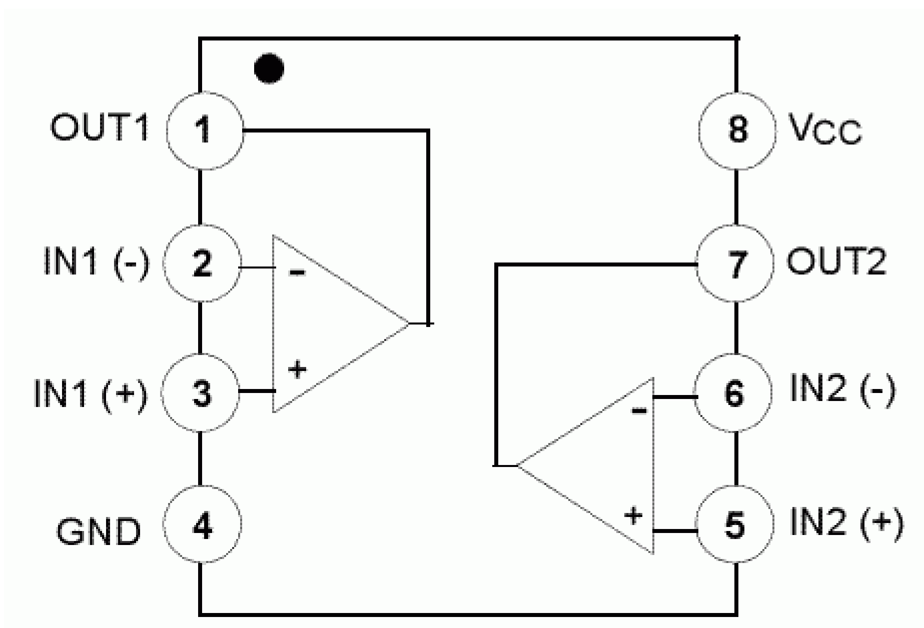


Figure 7 : LM358 pin diagram (source: PIJA education))

Pin connections of IC AD7801:

Pin connections

Name	number	description	Connected to
IN+	1	Non-Inverting Input	Output of DAC
GND	2	GND	GND
IN1-	3	Inverting Input	Reference voltage 1.54 V
OUTPUT	4	OUTPUT	Buzzer
VS	5	Supply	5 V

The IC used is LM397 Single General-Purpose Voltage Comparator.

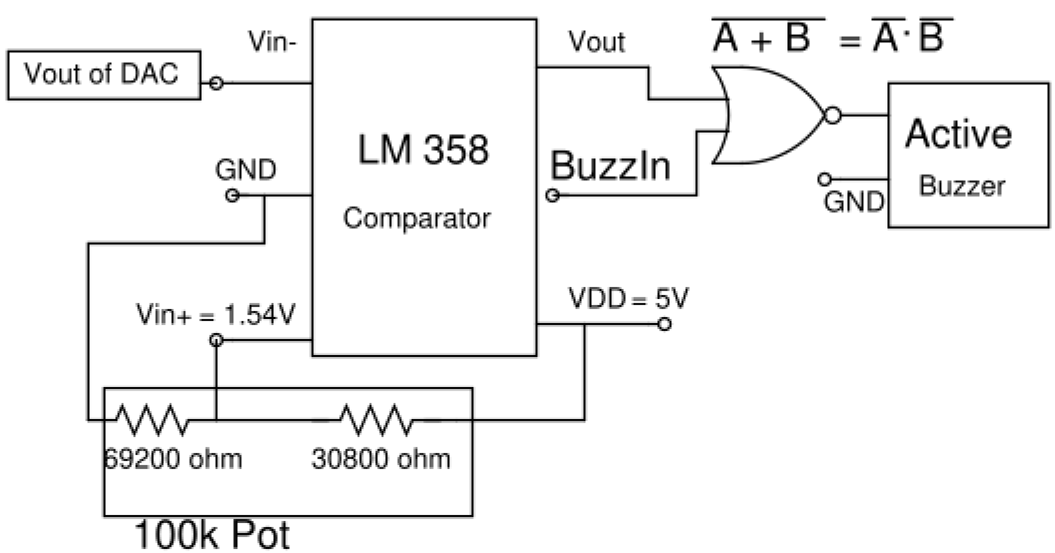


Figure 8 : LM397 comparator circuit

The Vout of the Comparator is Considered as Cout in the next Timing Diagram.

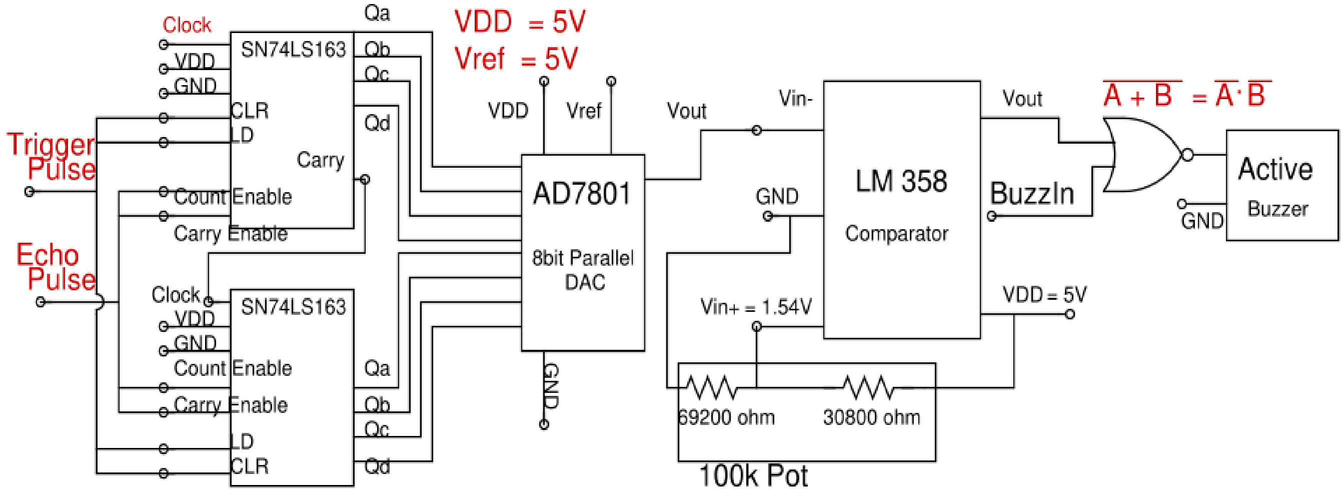


Figure 9 : Circuit with Binary-Counter part and Buzzer logic part

3.5 Power Supply

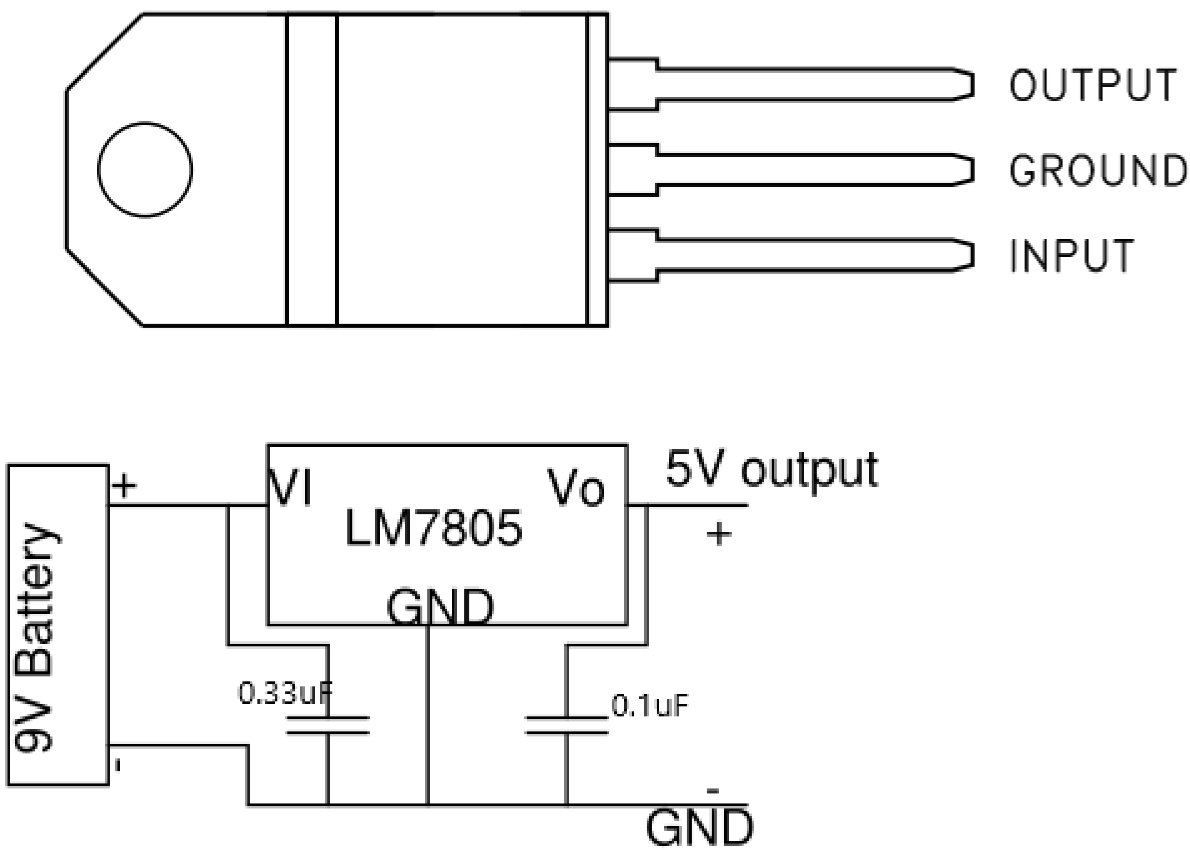


Figure 10 : Power supply part

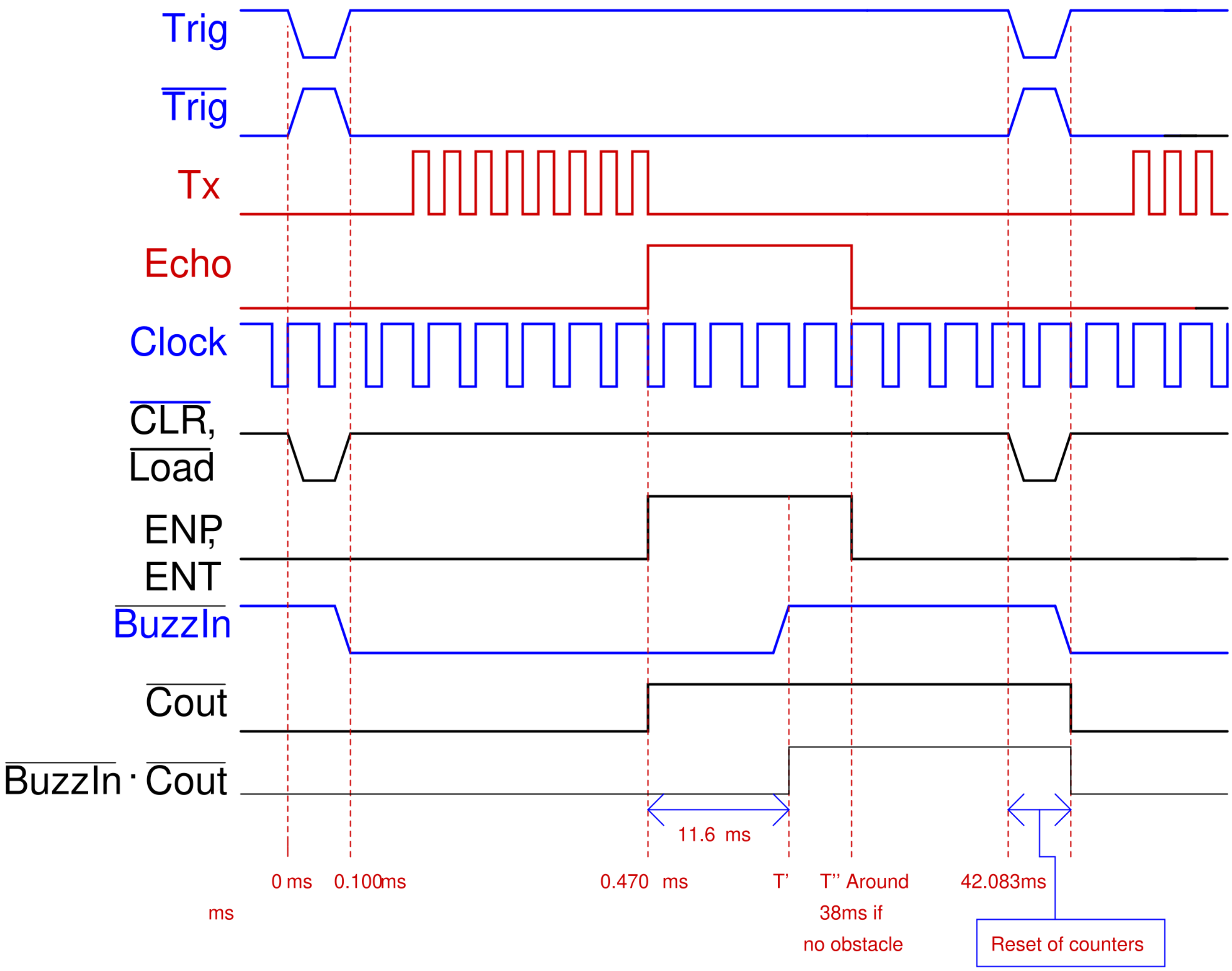


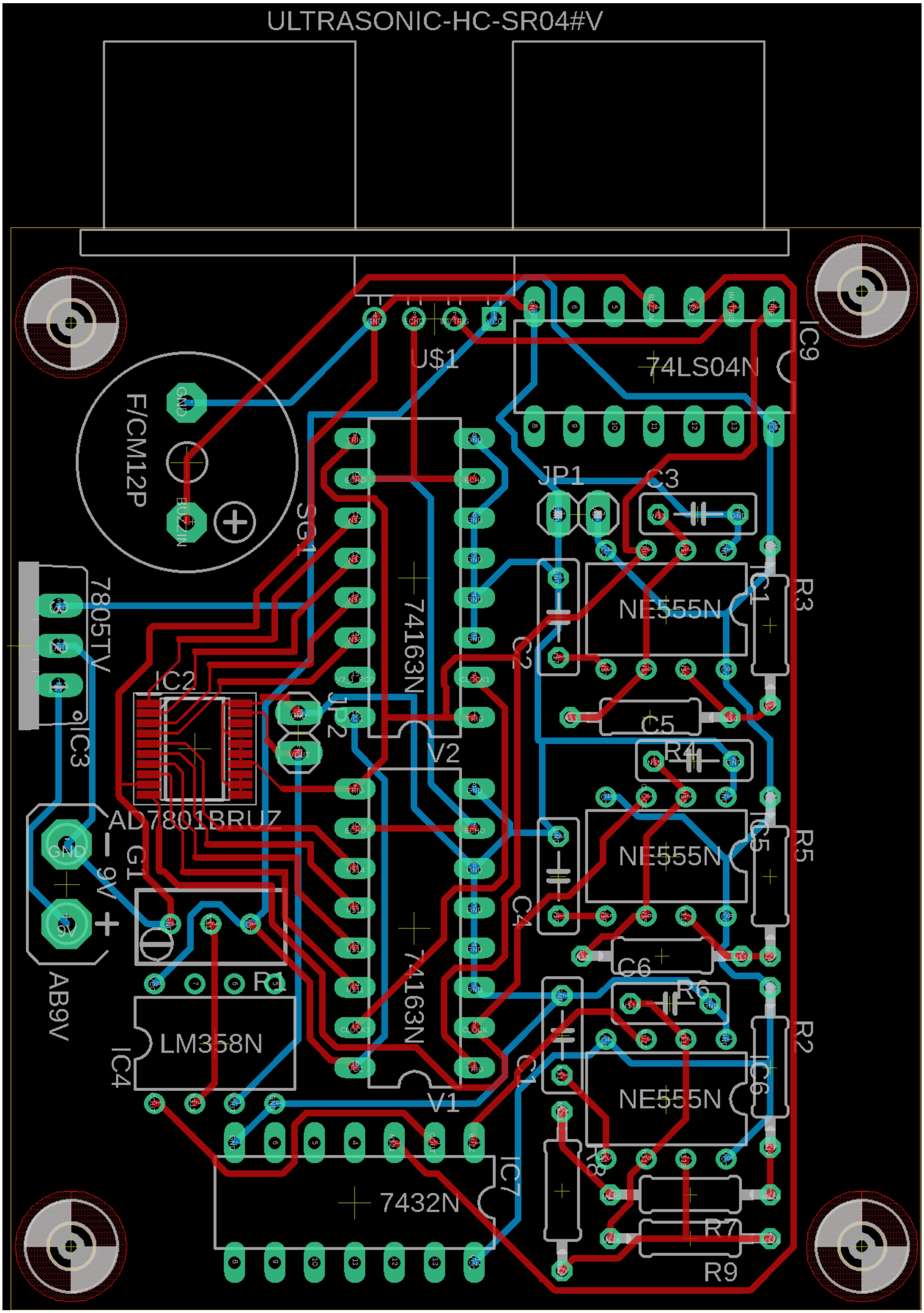
Figure 11 : Timing Diagram of the whole Circuit

4. PCB design layout

The PCB layout is given at the end of the PDF

5. Bill of materials

Item	Item name	Description	quantity	Cost each (in Rs.)	Extended cost (in Rs.)
1.	NE555N	Timer IC	3	10	30
2.	HC-SR04	Ultrasonic sensor	1	75	75
3.	SN74LS163	Counter IC	2	37	75
4.	AD7801	DAC IC	1	180	180
5.	LM397	Voltage Comparator IC	1	15	15
6	74LS04	Inverter IC	1	17	17
7.	SN7432	OR gate IC	1	19	19
8.	LM358	Dual op-amp IC	1	10	10
9.	Buzzer	5V active buzzer	1	33	33
10.	9V Battery	Power supply	1	20	20
11.	LM7805	Voltage regulator	1	20	20
				Total :	494


ULTRASONIC-HC-SR04#V
U$1
74LS04N
IC9
F/CM12P
SG1
JP1
C3
NE555N
IC1
R3
7805TV
IC3
74163N
C2
C5
R4
IC2
JP2
V2
AD7801BRUZ
G1
GND
9V
AB9V
NE555N
IC5
R5
C4
C6
R6
R1
LM358N
IC4
74163N
V1
C1
NE555N
IC6
R2
R8
7432N
IC7
R7
R9