Touchless Gesture Recognition
Ideation and Simulation Report

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August 18, 2018

1 Goal

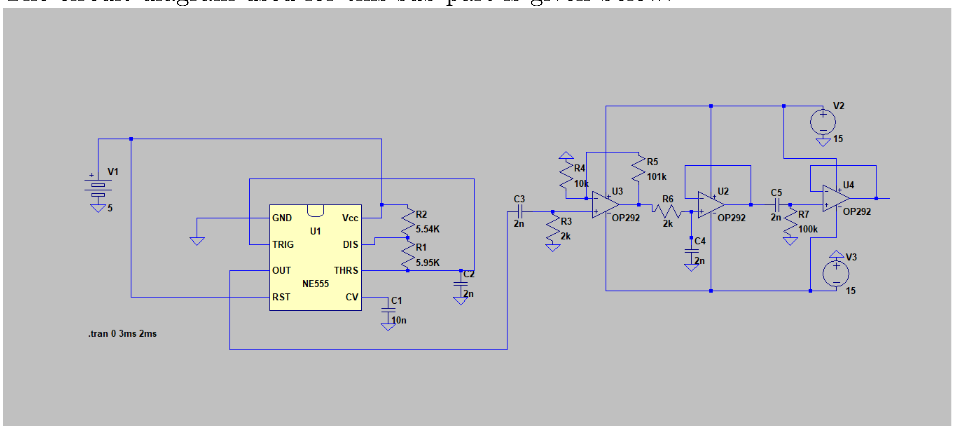
The aim of this project is to make a circuit which will respond to different types of gestures and identify the type of gesture which has been performed. This will be performed by using a sensor pair consisting of a transmitter and receiver which will give the distance of the object from that specific pair. Two pairs of these sensors should theoretically give us the xy coordinates of the desired object and tracking its location through an Finite State Machine (using a KRYPTON board) we should be able to identify some simple gestures. The steps leading up to this would be :

1. To decipher the output of the sensor and analyze its relationship with its relative position to the sensor pair. This will tell us on how to convert it to digital values
2. To partition the area of interest into squares which will be our smallest unit of position.
3. This partition will then be mapped to an LED matrix which will light up according to the current position of the object.

2 Simulation Setup

2.1 Transmitter

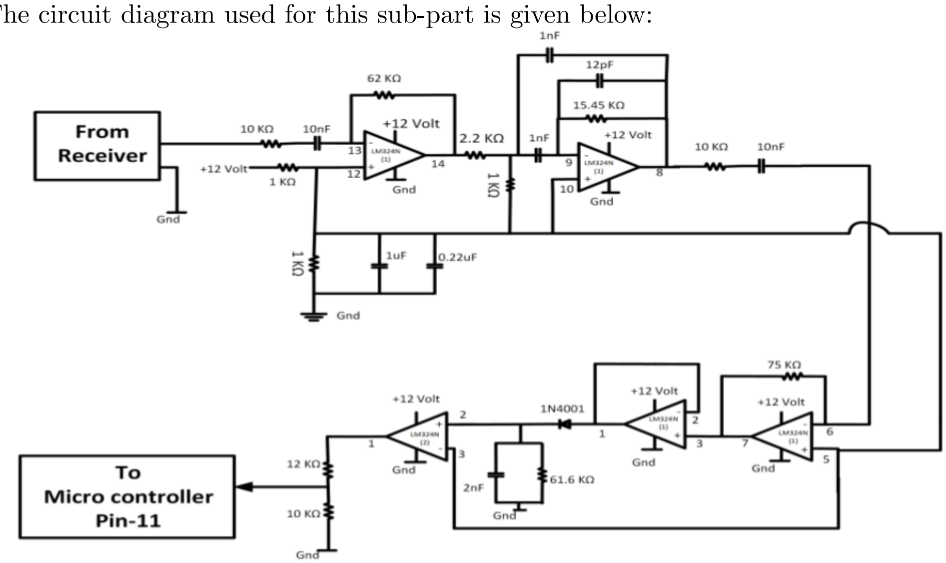
The circuit diagram used for this sub-part is given below:



This part of the simulation was performed by using the LTSpice software.The NE 55 IC takes 5V supply as its input. We plan to create this input by using a resistor divider network followed by a buffer. This is because this software has an inbuilt model for the NE 55 multivibrator and hence is much easier to use than ngSpice. The op-amps used are dual supply op-amps with +- 15V operating voltage.

2.2 UV Receiver

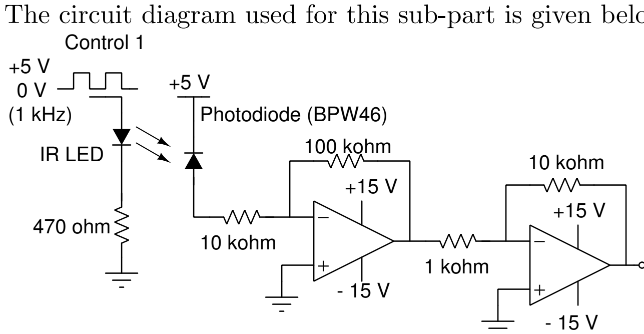
The circuit diagram used for this sub-part is given below:



This part of the simulation was performed by using the ngSpice software.The LM324 IC takes 12V supply as its input. Due to attenuation, the signal received by the sensor is very weak. Thus, we use an amplifier and along with it and a filtering block. After that, we implement a peak detector which gives the peak value of its input. Comparator gives a voltage high when the output of the peak detector crosses a threshold level. Thus, when the peak detector detects a sine wave at its input, the voltage of the comparator goes high so as to indicate the reception of acoustic wave at the receiver.

2.3 IR Receiver

The circuit diagram used for this sub-part is given below:

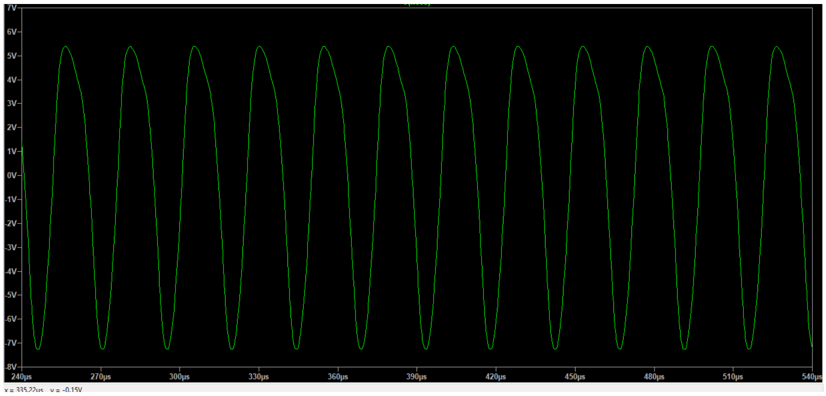


We use the circuit of the 'How dark is dark' experiment. We model the photodiode as a current source, dc as well as ac.

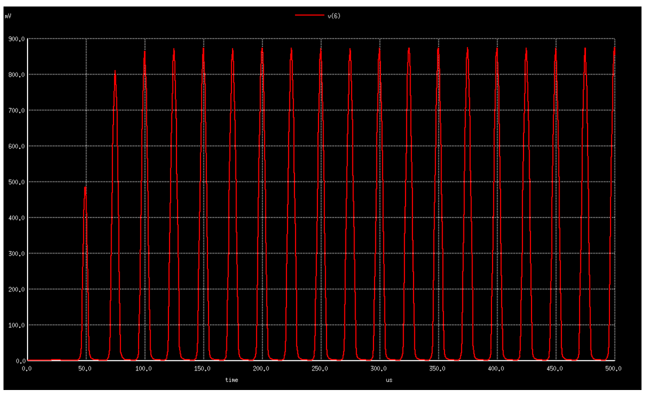
3 Simulation Results

3.1 Transmitter

The 555 timer is used to produce a square wave with $5V_{p-p}$ amplitude with 2.5 V as its mean value. The transducer requires a sine wave of around 40 kHz to operate. Thus a square wave is produced from 555 timer and is passed through a low pass and and a high pass filter thus leaving only the 40 kHz component of the square wave. This gives us a DC shifted sine wave whose DC value is then removes by using another non-inverting low pass filter. The sine wave of 40kHz is attached below :

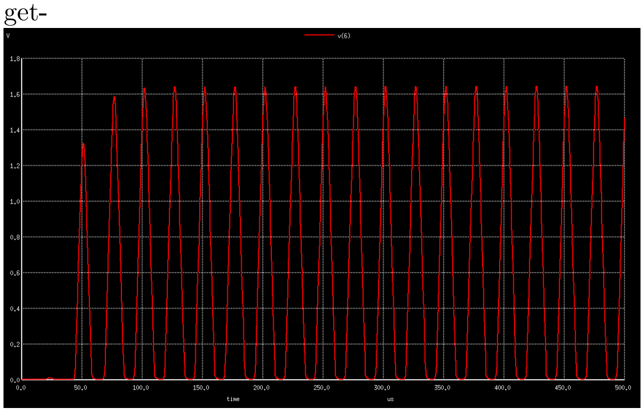


3.2 Ultrasound Receiver



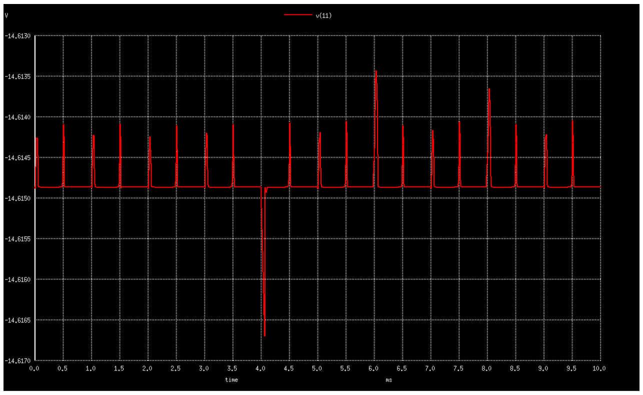
We assume that the receiver is getting a 5 mV, sinusoidal input, 40 KHz (from the transmitter), and simulate the circuit for receiver. This signal is actually received by an ultrasonic transducer which converts the sound wave to an electrical wave.

When we increase the input signal amplitude from 5 to 6 mV, this is what we get-

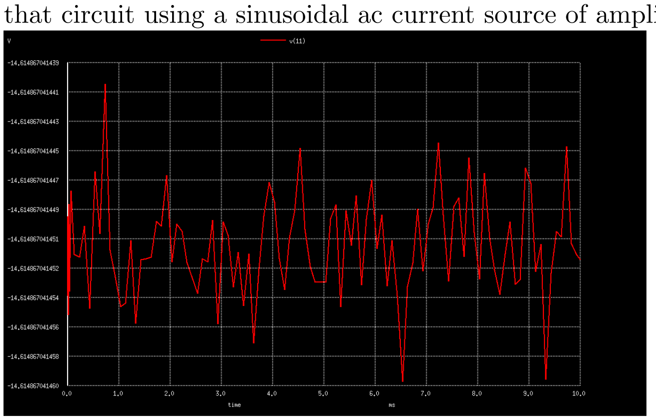


That is, peak amplitude varies as signal varies.

3.3 IR Receiver



From the experiment, 'How Dark is Dark' that we did in lab 9, we simulate that circuit using a sinusoidal ac current source of amplitude 100 uA.



We simulate that circuit using a dc current source of amplitude 100 uA.

4 Observations and inferences

4.1 Transmitter

It can be seen that the 555 timer provides a square wave pulse whose time period is equal to sum of charge and discharge times of the capacitor.Thus :
$t1 = 0.693 * (R_1 + R_2) * C_2$
$t2 = 0.693 * (R_1 * C_2)$
Thus, we get : $t = 0.693 * C_2 * 2R_1 + R_2$ $f = \frac{1.414}{C_2 * 2R_1 + R_2}$

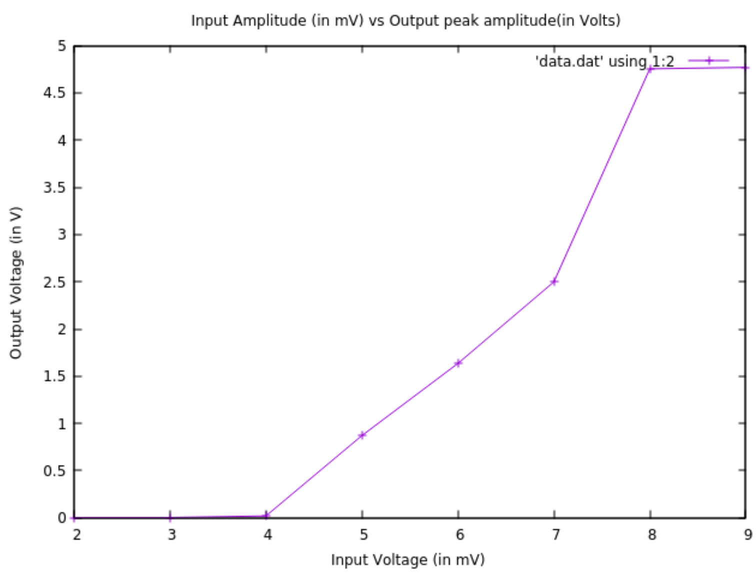
Thus , for our setup , on substituting these values we get a frequency almost equal to 40 kHz. Thus , the simulation results are according to our expectations. The low pass and high pass filters eliminate the other frequency waves present in fourier series of the square wave and the last high pass filter is used to remove the DC part of the sine wave. Thus, a 40kHz sine wave is obtained.

4.2 Ultrasound Receiver

Input Amplitude (in mV)	Output peak amplitude(in Volts)
2	0.00212
3	0.00257
4	0.0188
5	0.870
6	1.635
7	2.498
8	4.754
9	4.77

Basically, saturates at nearly 8mV which is okay because we don't expect that good a signal either.

The following graph gives the characteristics of this ultrasound receiver-



We can see that it functions pretty well as a receiver.

4.3 IR Receiver

On simulating it, we can see sharp peaks on detecting a photocurrent. These sharp peaks don't give a very large variation as much as the ultrasound detector on varying the input. On simulating it with a dc current source, we get a constant voltage at the output.

5 Appendix

5.1 Code for Transmitter

```
* C:\Users\Harsh Deshpande\Documents\LTspiceXVII\Draft2.asc
XU1 0 N006 N013 N002 N014 N006 N011 N002 NE555
R1 N011 N006 5.95K
C1 N014 0 10n
C2 N006 0 2n
R2 N002 N011 5.54K
V1 N002 0 5
C3 N009 N013 2n
R3 N009 0 2k
R4 0 N003 10k
R5 N003 N007 101k
R6 N010 N007 2k
C4 N010 0 2n
V2 N001 0 15
V3 0 N012 15
XU2 N010 N004 N001 N012 N004 OP292
XU3 N009 N003 N001 N012 N007 OP292
C5 N008 N004 2n
R7 N008 0 100k
XU4 N008 N005 N001 N012 N005 OP292
.tran 0 3ms 2ms
.lib ADI1.lib
.lib NE555.sub
.backanno
.end
```

5.2 Code for Ultrasound Receiver

```
 receiver
.include Diode_1N914.txt
.include lm324.txt
X1 11 12 1 0 13 LM324
X2 11 22 1 0 23 LM324
X3 11 32 1 0 33 LM324
```

```
X4 33 42 1 0 42 LM324
X5 51 11 1 0 53 LM324
vss 1 0 dc 12
r1 2 3 10k
c1 3 12 10n
r2 1 11 1k
r3 11 0 1k
c2 11 0 1u
c3 11 0 0.22u
r4 12 13 62k
r5 13 4 2.2k
r6 4 11 1k
c4 4 22 1n
c5 4 23 1n
r7 22 23 15.45k
c6 22 23 12p
r8 23 5 10k
c7 5 32 10n
r9 32 33 75k
d1 42 51 1N914
r10 51 0 61.6k
c8 51 0 2n
r11 53 6 12k
r12 6 0 10k
vin 2 0 sin(0 5m 40k)
.tran 0.0001 0.5ms
.control
run
plot v(6)
.endc
.end
```

5.3 Code for IR Receiver

```
receiver ir
.include ua741.txt
Is 1 2 sin(0 100u 1k)
vdc 1 0 dc 5
r1 2 3 10k
X1 0 3 5 6 7 ua741
vdd 5 0 dc 15
vss 6 0 dc -15
r2 5 7 100k
r3 7 8 1k
X2 0 8 5 6 11 ua741
r4 8 11 10k
```

```
.tran 0.0001 10ms
.control
run
plot v(11)
.endc
.end
```

5.4 Model File- Diode_1N914.txt

```
* Diode 1N914 SPICE Model Data

.MODEL 1N914 D (IS=6.2229E-9
+ N=1.9224
+ RS=.33636
+ IKF=42.843E-3
+ CJO=764.38E-15
+ M=.1001
+ VJ=9.9900
+ BV=100.14
+ IBV=.25951
+ TT=2.8854E-9)

*Developed by Wadhwani Electronics Lab
*Dept. of Electrical Engg.
*IIT Bombay
*January 09, 2015.
```

5.5 Model File- lm324.txt

```
* LM324 OPERATIONAL AMPLIFIER "MACROMODEL" SUBCIRCUIT
* CREATED USING PARTS RELEASE 4.01 ON 09/08/89 AT 10:54
* (REV N/A)      SUPPLY VOLTAGE: 5V
* CONNECTIONS:   NON-INVERTING INPUT
*                | INVERTING INPUT
*                | | POSITIVE POWER SUPPLY
*                | | | NEGATIVE POWER SUPPLY
*                | | | | OUTPUT
*                | | | | |
.SUBCKT LM324    1 2 3 4 5
*
  C1   11 12 5.544E-12
  C2    6  7 20.00E-12
  DC    5 53 DX
  DE   54  5 DX
  DLP  90 91 DX
  DLN  92 90 DX
```

```
  DP    4  3 DX
  EGND 99  0 POLY(2) (3,0) (4,0) 0 .5 .5
  FB    7 99 POLY(5) VB VC VE VLP VLN 0 15.91E6 -20E6 20E6 20E6 -20E6
  GA    6  0 11 12 125.7E-6
  GCM   0  6 10 99 7.067E-9
  IEE   3 10 DC 10.04E-6
  HLIM 90  0 VLIM 1K
  Q1   11  2 13 QX
  Q2   12  1 14 QX
  R2    6  9 100.0E3
  RC1   4 11 7.957E3
  RC2   4 12 7.957E3
  RE1  13 10 2.773E3
  RE2  14 10 2.773E3
  REE  10 99 19.92E6
  RO1   8  5 50
  RO2   7 99 50
  RP    3  4 30.31E3
  VB    9  0 DC 0
  VC 3 53 DC 2.100
  VE   54  4 DC .6
  VLIM  7  8 DC 0
  VLP  91  0 DC 40
  VLN   0 92 DC 40
.MODEL DX D(IS=800.0E-18)
.MODEL QX PNP(IS=800.0E-18 BF=250)
.ENDS
```

5.6 Model File- ua741.txt

```
*----------------------------------------------------------------------------
*
* To use a subcircuit, the name must begin with 'X'.  For example:
* X1 1 2 3 4 5 ua741
*
* connections:   non-inverting input
*                |  inverting input
*                |  |  positive power supply
*                |  |  |  negative power supply
*                |  |  |  |  output
*                |  |  |  |  |
.subckt ua741    1  2  3  4  5
*
  c1   11 12 8.661E-12
  c2    6  7 30.00E-12
  dc    5 53 dx
```

```
  de   54  5 dx
  dlp  90 91 dx
  dln  92 90 dx
  dp    4  3 dx
  egnd 99  0 poly(2) (3,0) (4,0) 0 .5 .5
  fb    7 99 poly(5) vb vc ve vlp vln 0 10.61E6 -10E6 10E6 10E6 -10E6
  ga    6  0 11 12 188.5E-6
  gcm   0  6 10 99 5.961E-9
  iee  10  4 dc 15.16E-6
  hlim 90  0 vlim 1K
  q1   11  2 13 qx
  q2   12  1 14 qx
  r2    6  9 100.0E3
  rc1   3 11 5.305E3
  rc2   3 12 5.305E3
  re1  13 10 1.836E3
  re2  14 10 1.836E3
  ree  10 99 13.19E6
  ro1   8  5 50
  ro2   7 99 100
  rp    3  4 18.16E3
  vb    9  0 dc 0
  vc    3 53 dc 1
  ve   54  4 dc 1
  vlim  7  8 dc 0
  vlp  91  0 dc 40
  vln   0 92 dc 40
.model dx D(Is=800.0E-18 Rs=1)
.model qx NPN(Is=800.0E-18 Bf=93.75)
.ends
```