MIDDLE EAST TECHNICAL UNIVERSITY

ELECTRICAL AND ELECTRONICS ENGINEERING

EE214 ELECTRICAL CIRCUITS LABORATORY

TERM PROJECT

FINAL REPORT

Wireless Fire Detection System

Course Code: 5670214

Course Name: ELECTRICAL CIRCUITS LABORATORY

Semester: 20172

Prepared By

Rafet KAVAK 2166783

Halis YILMAZ 2094761

Assistant: Mesut DOĞAN

Submission Date: 04/06/2018

Table of Contents

1. Introduction

In today’s world fire detection systems are very well developed but to understand the basis of these detection systems this project is essential. First of all, with the development of civilization, electricity and household appliances is become indispensable for our lifestyles. Moreover, although the innovations in technology, still there are some risks arising from these appliances. Correspondingly, engineers have worked a lot for fire detection systems to protect human lives.

A fire detection system consists of devices which are working together to detect a fire and warn people with a loud sound when fire, smoke, etc. are present. Then, in this project we will introduce how these fire systems are working basically.

Figure 1 Smoke and heat detector [1]

Firstly, we are going to construct overall block diagram, which is showing a slight description of our circuit, then we will explain our circuit components and why we use them.

Secondly, we will tell our design, show its important parts and graphical results.

Finally, we will end up our final report with simulation results and the conclusion part.

2. Overall Block Diagram

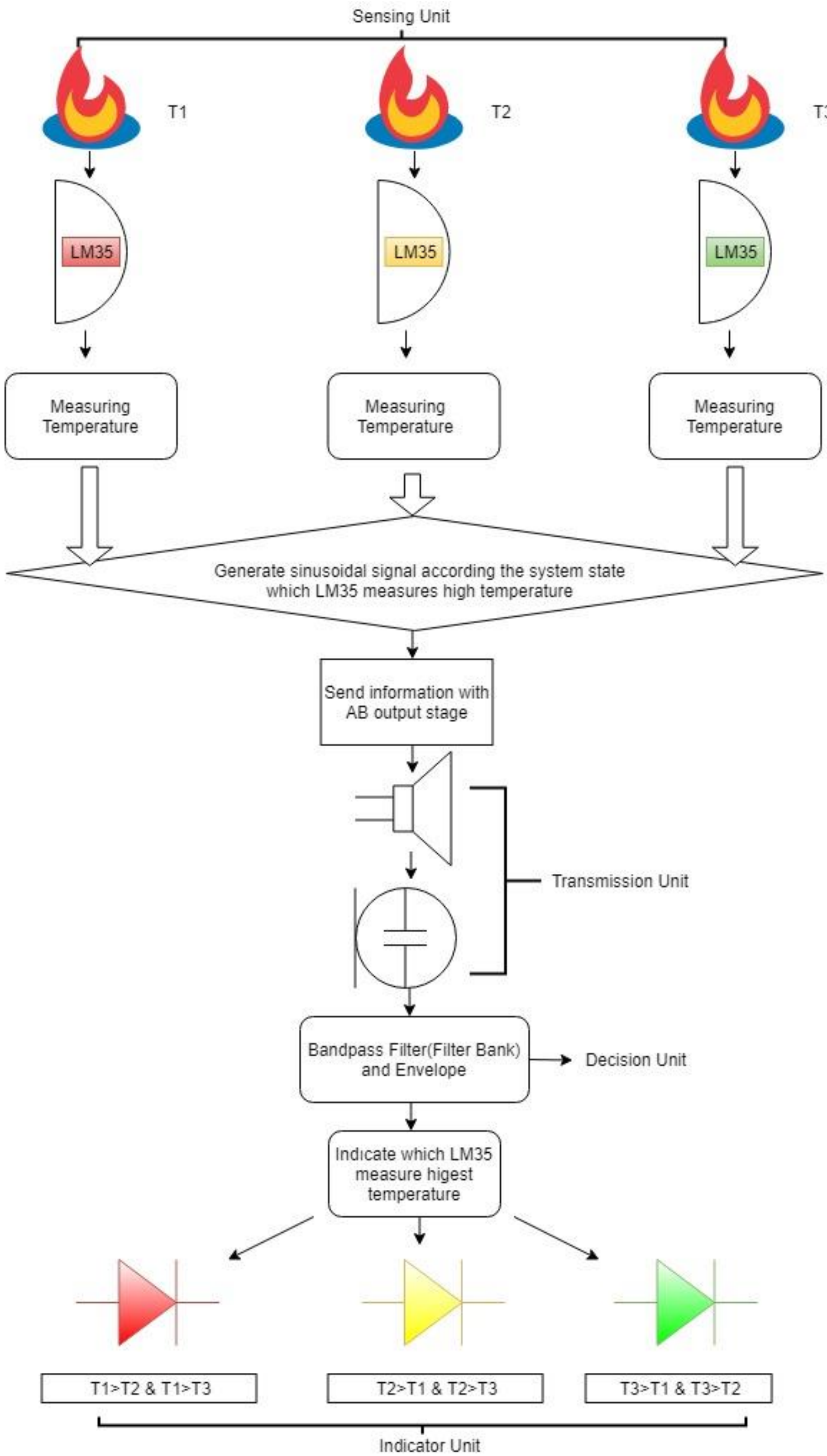


Figure 2 Overall block diagram of our project

3. Selection of Equipment

3.1 Basic Components

3.1.1 Leds

We have used three leds with different colors to indicate which location has highest temperature.

3.1.2 Operational Amplifiers

We used

- Non-inverting op-amp configuration for gain,
- Buffers for transferring our voltage to another part,
- Comparators for compare two different voltage,
- Inverting Operational Amplifiers
- Summing Amplifiers for the case that we need to sum two different voltages from different places

Furthermore, we used op-amps in our bandpass filters to configure these filters.

3.1.3 Resistors

We used resistor to control our circuit. We used several valued resistors because every part of our circuit requires certain valued resistor.

3.1.4 Potentiometers

Potentiometers one of the very commonly used component of our circuit because while adjusting the bandpass filters and sinusoidal signal oscillators we need to use pots.

3.1.5 Diodes

We used diodes for controlling current in some cases. In addition, we used diodes in our output stage. Also, one diode is used as a reverse current protection diode at the positive side of the power supply in case of any misconnection.

3.1.6 Capacitors

We used capacitors also for our bandpass filters and sinusoidal signal generators.

3.1.7 Ground Connections

We connected some of our circuit elements to ground because if we did not connect these components to ground our circuit does not work. Ground connection arranges the voltage differences of our circuit.

3.1.8 Dc Power Supply

Dc power supply is the power source of our circuit and we distribute this source all-around of the circuit.

3.1.9 Transistors

Transistors is mainly used for amplification and in our project, we used NPN transistors (we used just one PNP transistor and we used it in our AB Output Stage) for switching, generating sine wave and in the output stage.

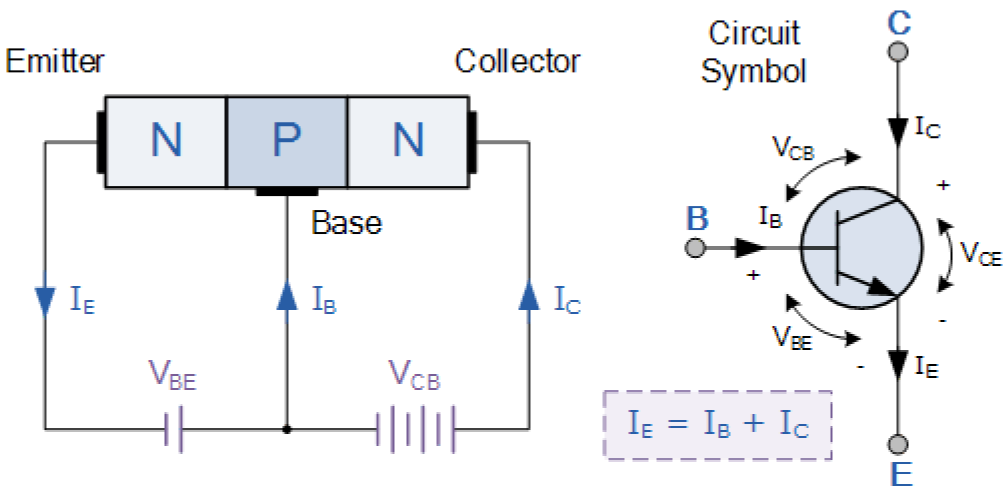


Figure 3 NPN transistor and its circuit symbol [5]

A BJT transistor can be work in four different modes and these are,

Forward Active: When $V_{CB} > 0$ and $V_{BE} > 0$ the collector current is β times base current and β is called proportionality constant.

Saturation: When $V_{CB} < 0$ and $V_{BE} > 0$ our transistor works in saturation mode and in this time collector current is not beta times base current anymore. This mode is useful while we are using our transistors in switch mode.

Reverse Active: When $V_{CB} < 0$ and $V_{BE} < 0$ we can consider our transistor like emitter and collector places are changed.

Cutoff: When $V_{CB} > 0$ and $V_{BE} < 0$ theoretically no current flows through our transistor.

3.2 Lm35 Temperature Sensor

The LM35 is a precision integrated-circuit temperature device with an output voltage linearly proportional to the Centigrade temperature [3] and it can work in different modes. It can measure only positive temperatures or both positive and negative temperatures. In our project we don't need to measure negative temperatures, so we used Basic Centigrade Temperature Sensor (2°C to 150°C) and it is suggested in the datasheet of LM35 like,

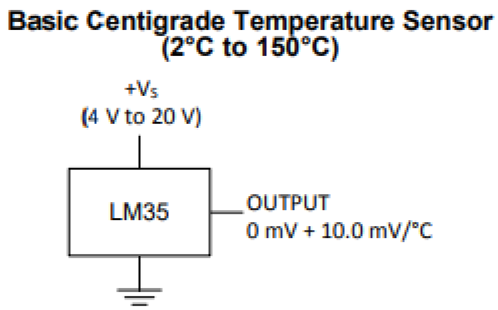


Figure 4 Suggested Basic Centigrade Temperature Sensor Connection in LM35 datasheet [3]

3.3 Electret Microphone

In the design specifications, a microphone that has any integrated circuit is prohibited. Therefore, we used electret microphone.

Figure 5 Image of electret microphone

3.4 Speaker

Again, in the design specifications, a speaker that has any integrated circuit is prohibited and we used 50-ohm speaker.

3.5 Gates

3.5.1 And Gate

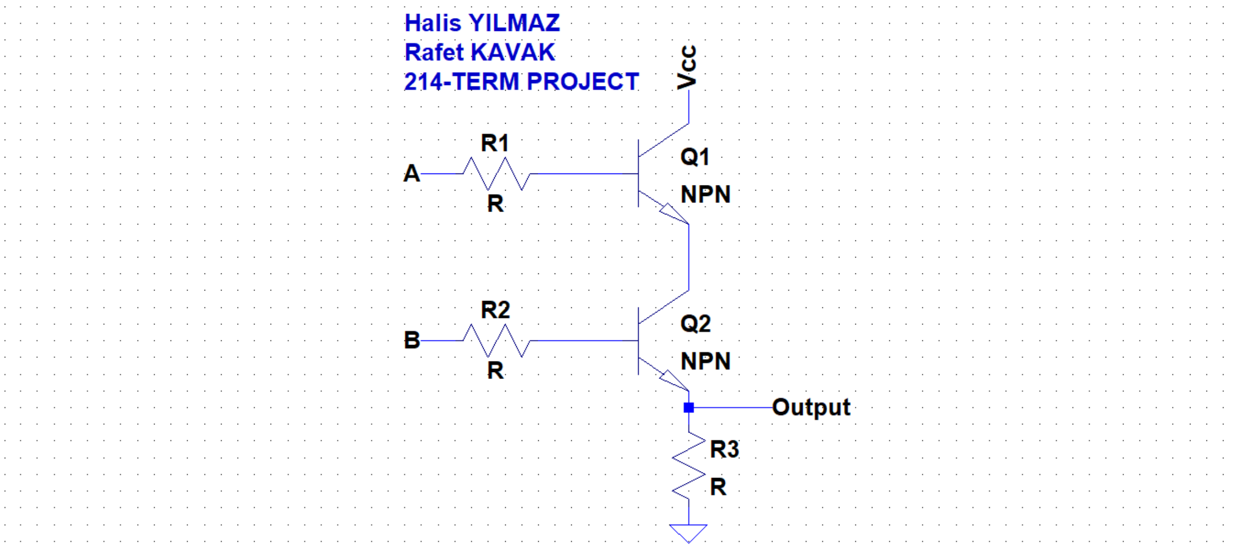


Figure 6 Circuit schematics of and gate

The AND gate is a circuit configuration that gives high output only if all inputs (For example A and B in the figure) are high. (For example, 5V each)

INPUT		OUTPUT
A	B	A AND B
0	0	0
0	1	0
1	0	0
1	1	1

Figure 7 Truth table for an AND gate

3.5.2 Nor Gate

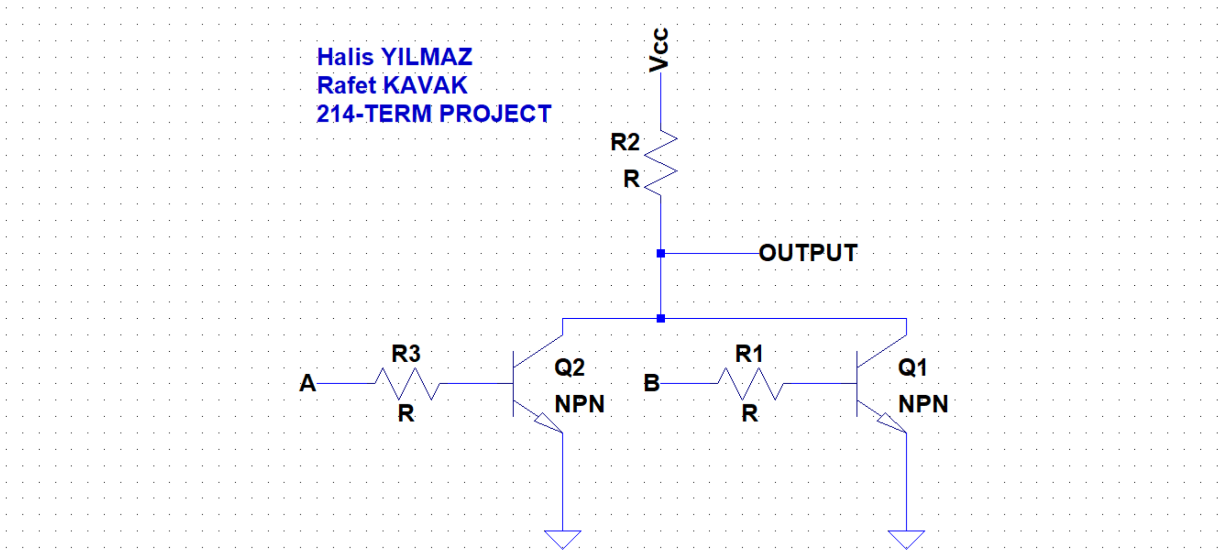


Figure 8 Circuit schematics of nor gate

We can think like NOR gate is formed by NOT and OR gates. Output of a or gate is 1 for firs three cases and 0 only both inputs are low. Therefore, output of NOR gate is 1 only both inputs are low(0-0.2V)

INPUT		OUTPUT
A	B	A NOR B
0	0	1
0	1	0
1	0	0
1	1	0

Figure 9 Truth table for a NOR gate

3.6 Sine Wave Generator

In our project generating sinusoidal wave is one of the main parts. Therefore, we thought that using Basic RC Oscillator Circuit (Phase-shift Oscillator) is more suitable than other sine wave generators. However, we did not use RC oscillator effectively. It is very hard to maintain signal for a while. Therefore, we decided to change our sine wave generator. For this purpose, we preferred Wien Bridge Oscillator which is also constructed by us at previous lab sessions.

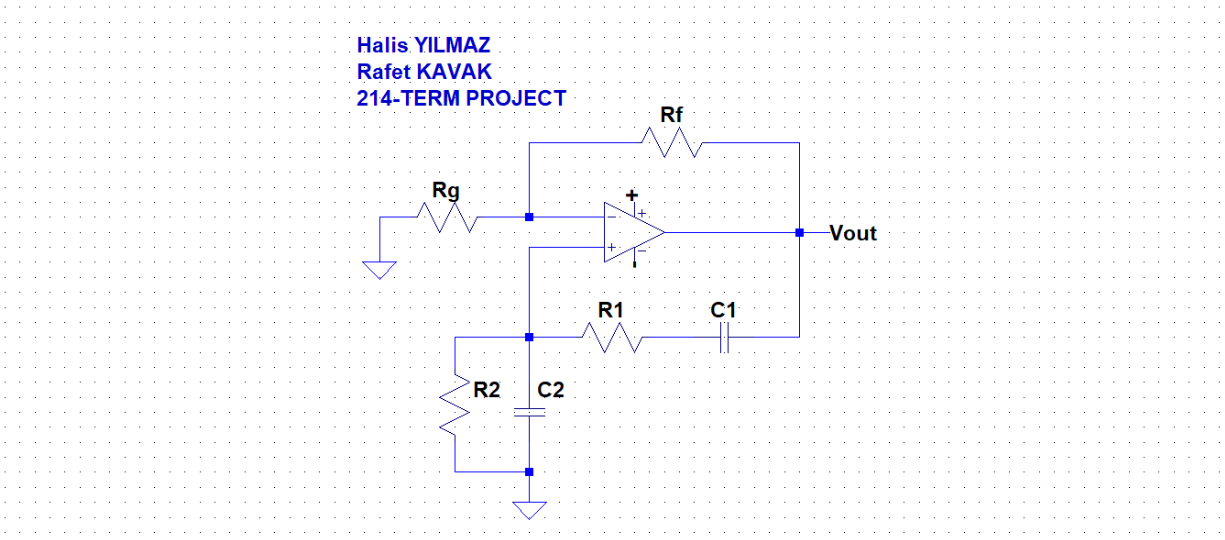


Figure 10 Circuit schematics of Wien-bridge Oscillator

We need to convert DC input to an AC waveform. Therefore, we thought that Wien bridge is the best option. It has a lot of advantages. For example, we constructed our oscillator with very few components, and this is providing very good stability. Also, we adjusted the resistors easily so in other words we can say it is very easy to design.

If we examine how this oscillator works, firstly we need to look at positive feedback side. The path from positive feedback side to the output creates oscillations because of non-stability. Moreover, negative feedback side provides a gain. If we say V+ to the positive feedback output (+ input side of op-amp) and define impedances of series and parallel combinations at below part of oscillator,

$$Z_s = R_1 + \frac{1}{j\omega C_1} = R_1 - \frac{j}{\omega C_1} \quad (1)$$

$$Z_p = R_2 || \frac{1}{j\omega C_2} = \frac{R_2}{1 + j\omega R_2 C_2} \quad (2)$$

And the feedback-output ratio is,

$$\frac{V_+}{V_0} = \frac{Z_p}{Z_s + Z_p} \quad (3)$$

If we substitute equation 1 and 2 into 3,

$$\frac{V_+}{V_0} = \frac{R_2}{R_2 + \left(R_1 - \frac{j}{\omega C_1}\right)(1 + j\omega R_2 C_2)} \tag{4}$$

$$\frac{V_+}{V_0} = \frac{\omega R_2 C_1}{\omega(R_2 C_1 + R_1 C_1 + R_2 C_2) + j(\omega^2 R_1 C_1 R_2 C_2 - 1)} \tag{5}$$

And right this moment, if we want to oscillations, we learned that we have to satisfy second Barkhausen criterion and this is total phase shift must be 0 or integral multiples of 2π. In other words, V+ must be in phase with output voltage therefore our equation must be purely real. If we want to imaginary part is equal to zero, we need to,

$$\omega^2 R_1 C_1 R_2 C_2 - 1 = 0 \tag{6}$$

Or,

$$\omega_0 = \frac{1}{\sqrt{R_1 C_1 R_2 C_2}} \tag{7}$$

For simplicity and create simple circuit, we can select same resistors and capacitors. Therefore, if R1=R2=R and C1=C2=C, we can say,

$$\omega_0 = \frac{1}{\sqrt{RC}} = 2\pi f_0 \tag{8}$$

Or,

$$f_0 = \frac{1}{2\pi RC} \tag{9}$$

If we substitute R1=R2=R and C1=C2=C to the equation 5,

$$\frac{V_+}{V_0} = \frac{1}{3} \tag{10}$$

Also, for oscillation, we have to satisfy first Barkhausen criterion too. It is possible to compensate out op-amp by providing a gain 3 or greater than 3. Therefore,

$$\frac{V_+}{V_0} = 1 + \frac{R_f}{R_g} = 3 \tag{11}$$

Or,

$$R_f = 2R_g \tag{12}$$

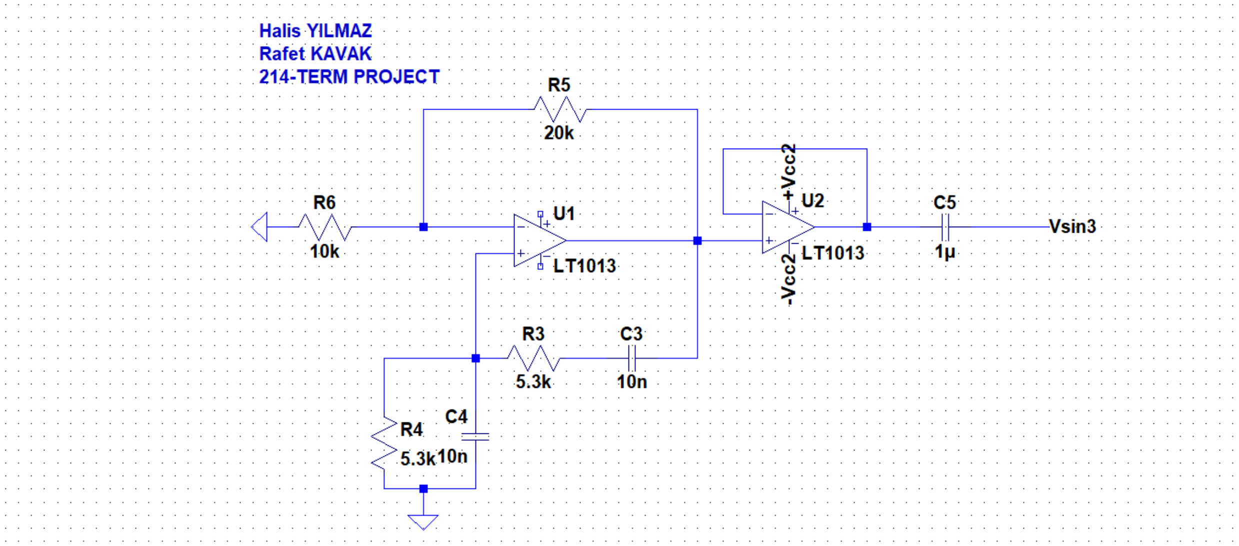


Figure 91 Example of our Wien-bridge oscillator

We adjusted our frequency according to equation 9 and other requirement according to Equation 12.

3.7 AB Output Stage

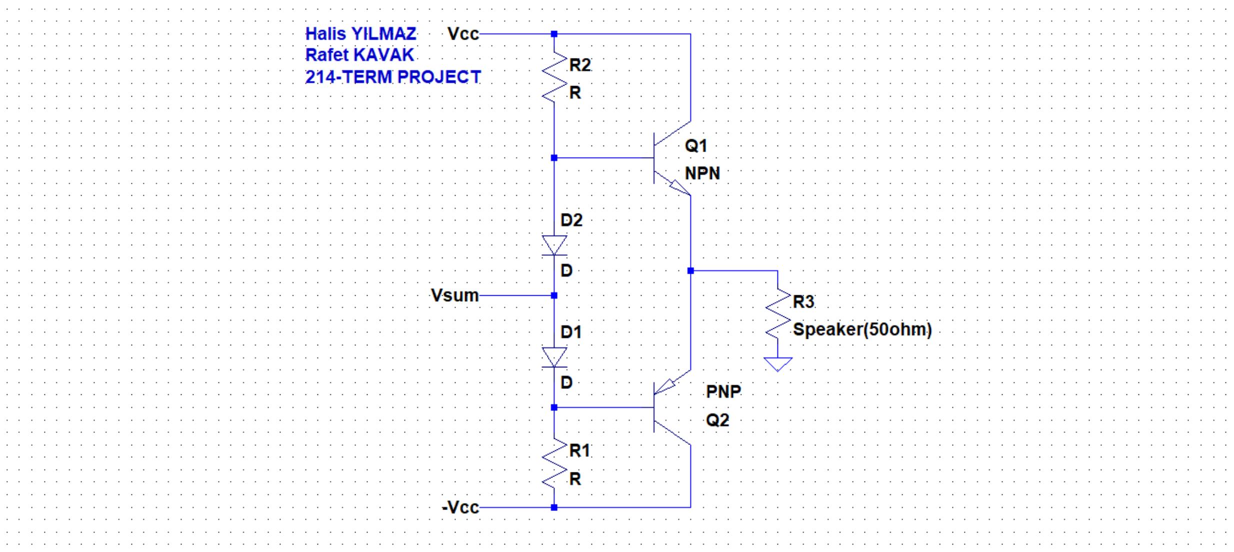


Figure 10 Circuit schematics of Class AB Output Stage

As suggested to us, we used class AB output stage because it is between class A and class B output stage. It has less distortion than class B and has more efficiency than class A. In other words, it combines their advantages.

3.8 Active Bandpass Filter

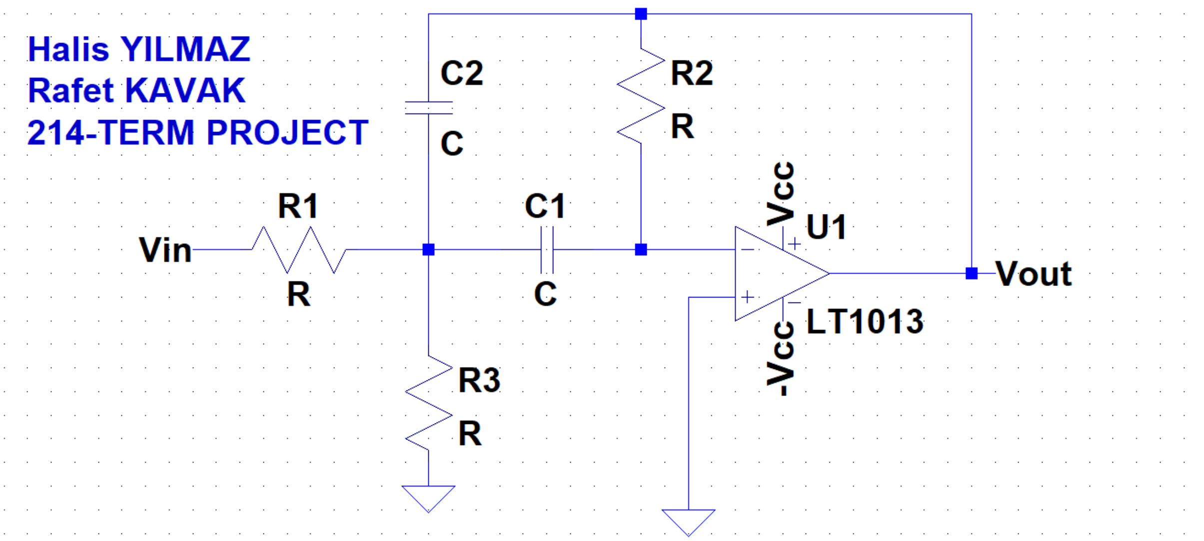


Figure 13 Our bandpass circuit schematics

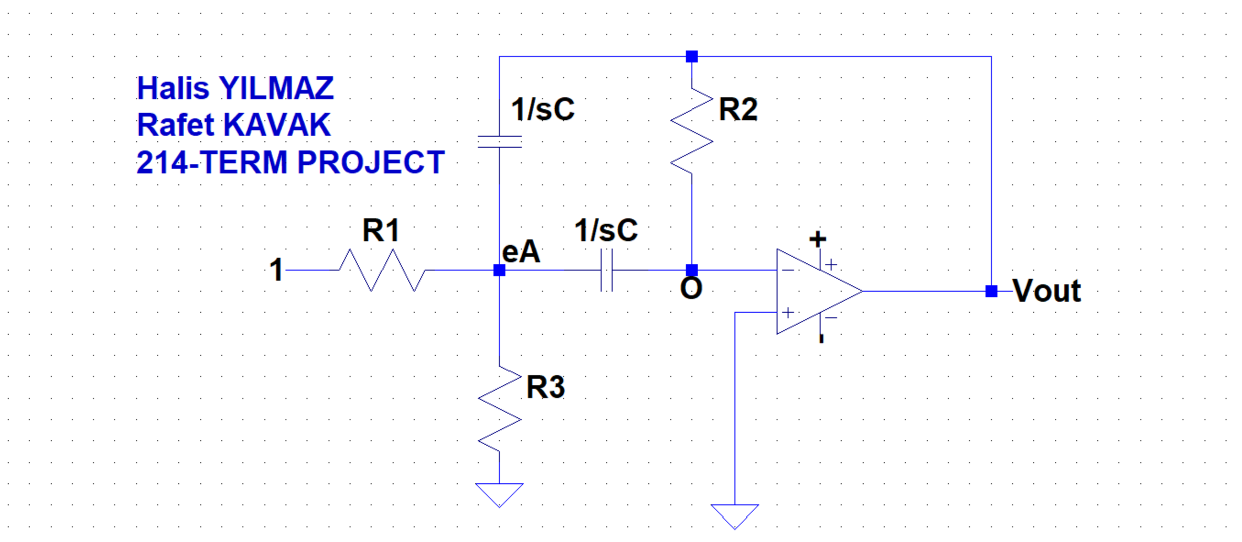


Figure 11 Out bandpass circuit in s-domain

If we apply KCL in node A;

$$\frac{e_A - 1}{R_1} + \frac{e_A}{R_3} + (e_A - e_B)sC + e_A sC = 0 \tag{13}$$

Then KCL at V-;

$$-e_A sC - \frac{e_B}{R_2} = 0 \tag{14}$$

Then replace e_B with s$R_2 C$ and our transfer function becomes,

$$H(s) = \frac{-s\frac{R_2}{R_1}C}{\left(\frac{1}{R_1} + \frac{1}{R_3}\right) + 2sC + R_2 C^2 s^2} \tag{15}$$

After normalizing our transfer function,

$$H(s) = \frac{-\frac{sC}{R_1}}{\left(\frac{1}{R_1} + \frac{1}{R_3}\right) * \frac{1}{R_2 C^2} \quad + \frac{2}{R_2 C}s + s^2} \tag{16}$$

Then if we replace all s with jw,

$$H(jw) = -\frac{R_2}{2R_1}\frac{\frac{2}{R_2 C}jw}{\left(\frac{1}{R_1} + \frac{1}{R_3}\right) * \frac{1}{R_2 C^2} \quad + \frac{2}{R_2 C}jw - w^2} \tag{17}$$

Then we can consider $-\frac{R_2}{2R_1}$ is our gain.

Maximum value of $|H(jw)|$ is possible when real part of the denominator is zero.

Therefore,

$$w_0 = \sqrt{\frac{R_1 + R_3}{R_1 R_2 R_3} * \frac{1}{C^2}} \tag{18}$$

If we want to find half power frequencies, we must seek certain w value which makes real part of denominator equal to complex part in magnitude. This is possible when,

$$w_0^2 - w^2 = \pm\frac{2w}{R_2 C} \tag{19}$$

Therefore, we have,

$$w^2 + \frac{2w}{R_2 C} - w_0^2 = 0 \quad w_1 = \frac{-\frac{2}{R_2 C} + \sqrt{\Delta}}{2} \tag{20}$$

$$w^2 - \frac{2w}{R_2 C} - w_0^2 = 0 \quad w_2 = \frac{\frac{2}{R_2 C} + \sqrt{\Delta}}{2} \tag{21}$$

$$w_2 - w_1 = \frac{2}{R_2 C} = \boldsymbol{Bandwith} \tag{22}$$

$$-\frac{R_2}{2R_1} = \boldsymbol{Gain} \tag{23}$$

$$\frac{w_0}{Bandwidth} = \boldsymbol{Quality\ factor} \tag{24}$$

We used band-pass filter in order to get rid of noise and strengthen the certain signal. If we adjust quality factor of our circuit to high values, our signal quality will increase according to the filter. Furthermore, we can consider our multiple feedback active band-pass filter with 3 different values and we derived them above.

3.9 Envelope Detector

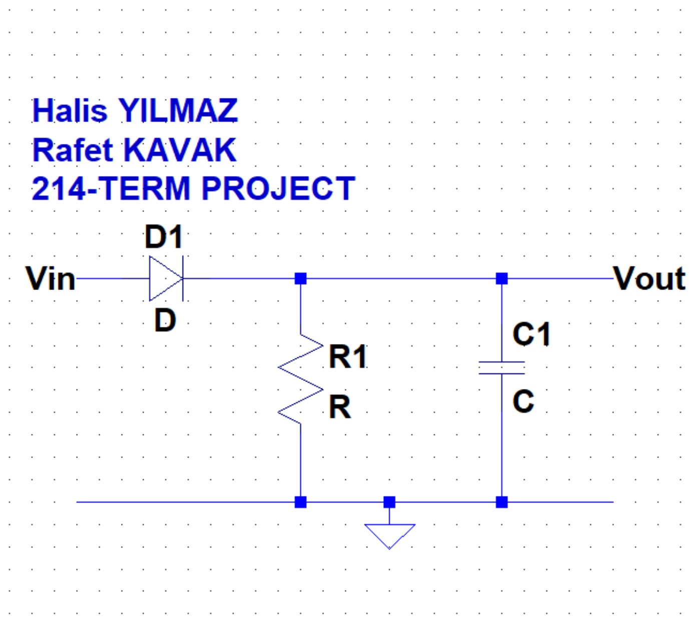
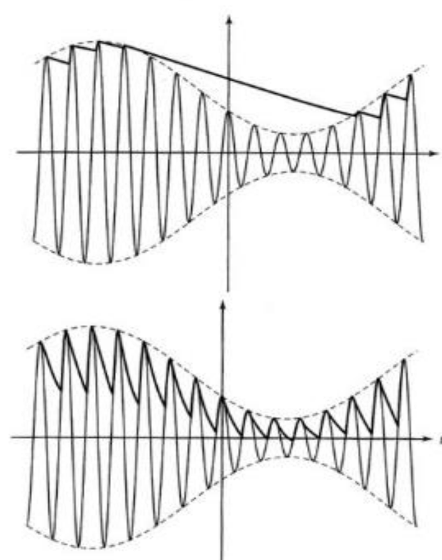


Figure 12 Circuit schematics of Envelope Detector

In this configuration, diode is using for half wave rectifying and we used this configuration for checking existence of signal because we need our signal's amplitude information. We can think envelope detector like a circuit that takes high frequency signal as input and gives an envelope as output.

In addition, this detector I a combination of half-wave rectifier and low-pass filter. In terms of low-pass filter, while signal is rising, capacitor is charging and while signal is falling capacitor is discharging through the resistor. In other words, the capacitor in the circuit stores up charge on the rising edge, and releases it slowly through the resistor when the signal falls. [4] Therefore low-pass filter filters high frequencies.

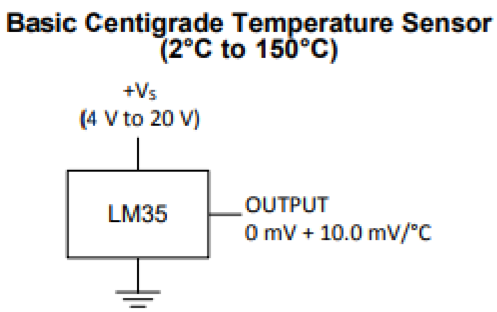
Time constant RC must be selected suitable for aim. If RC is too large, discharging time of capacitor becomes larger and output cannot follow the envelope. If RC is too small, output of the filter falls very rapidly and again it cannot follow the envelope.



Effect of (a) large and (b) small RC values on the performance of the envelope detector.

4. Description of Circuit

4.1 Sensing Unit



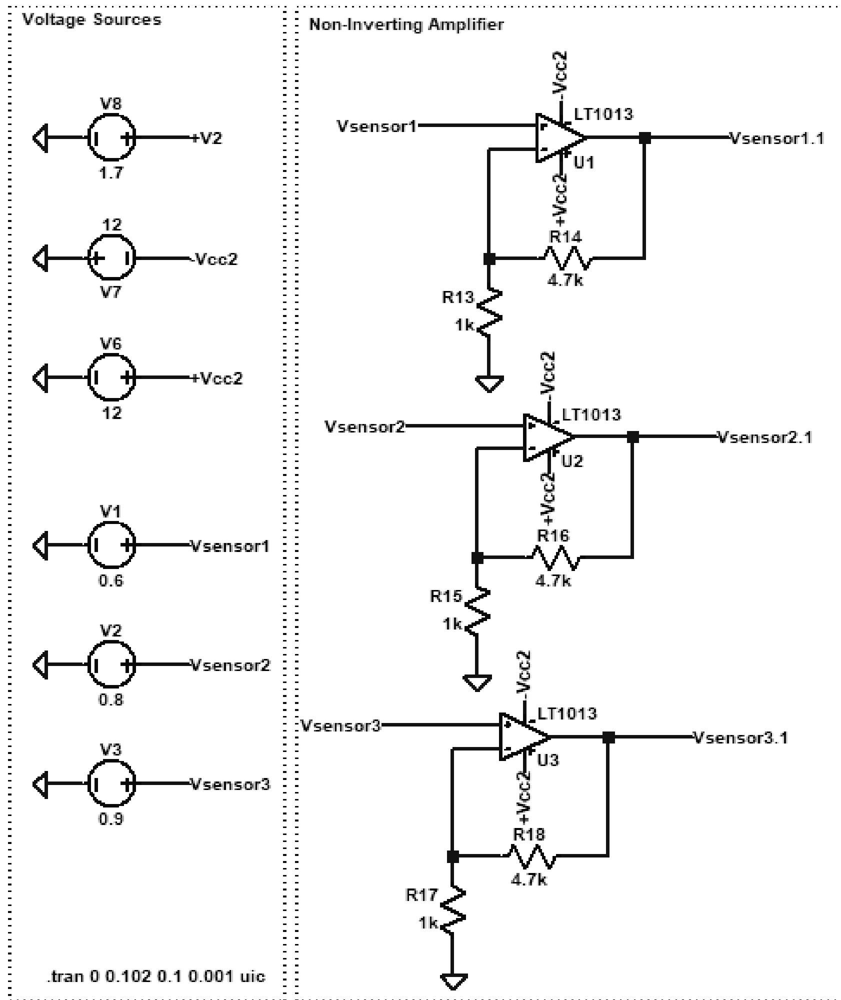


Figure 11 Circuit schematics of Sensing Unit

In the sensing part we used the LM35 sensor described in section 3.2. Output voltage of the sensor is between [0,1.5] V. After obtaining the temperature information as different voltages. We benefited from non-inverting amplifiers to amplify the sensor output voltage. The purpose of amplification is making easy to compare the temperature data at the comparator part. The amplification factor is 5.7. As an example, at 50° the output voltage of sensor 2 is Vsensor2=0.5V and after the amplification Vsensor2.1=2.85V

The simulation results can be found at the simulation results section of this document.

4.2 Temperature Comparator Unit

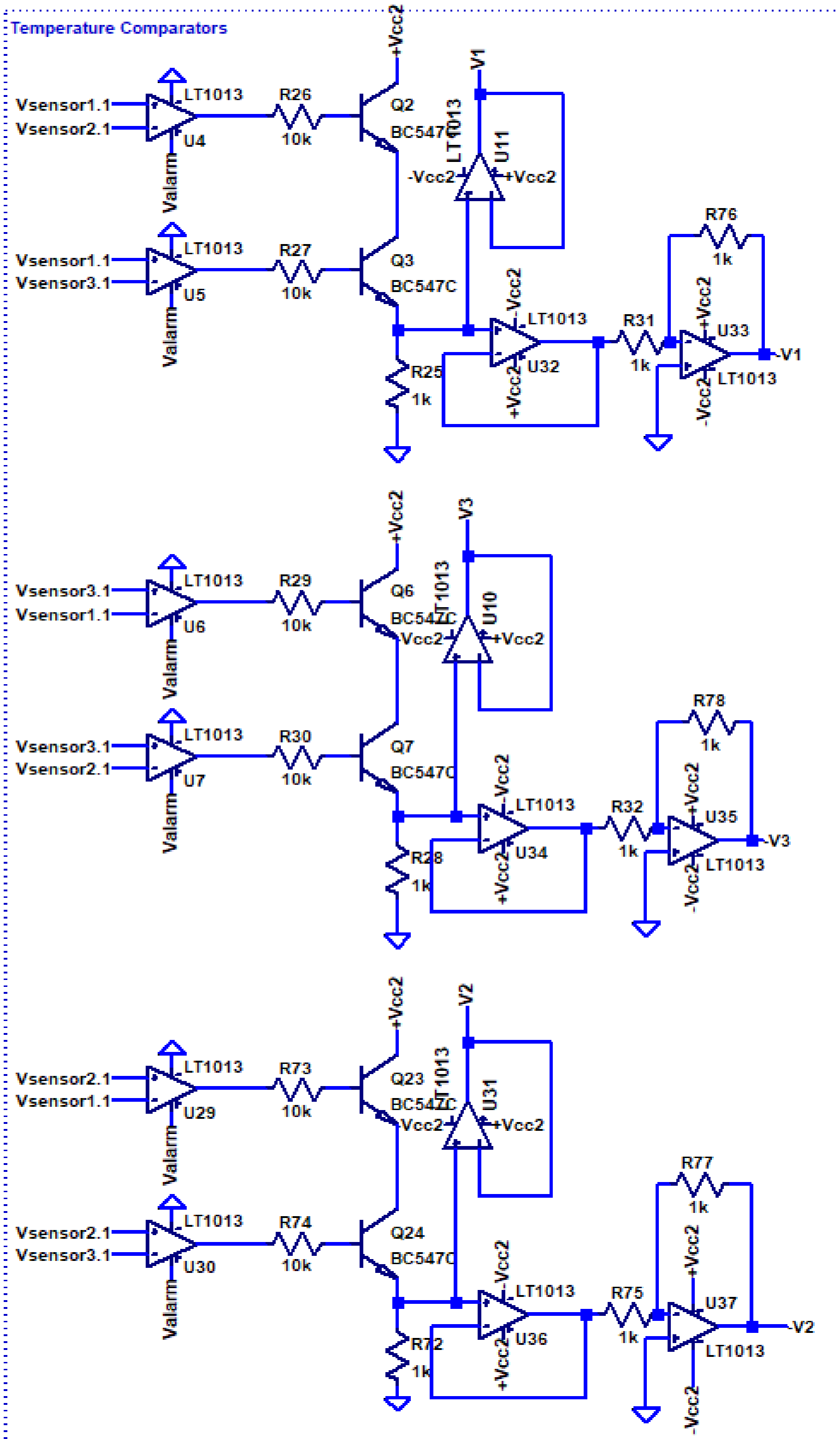


Figure 13 Circuit Diagram for Comparator Unit

We use the output of the amplifiers form the previous sensing unit as an input to our basic comparators. We compare all 3 room temperatures with each other, and we obtain 3 voltages as outputs. Which will be called as V1, V2, V3 and –V1, V2, V3 after this section. These voltages give us which rooms temperature is the biggest in binary.

As stated in the circuit diagram at figure 13, -V1,-V2,-V3 are obtained by inverting amplifiers with 1 amplification factor. This – voltages are needed to activate and de-activate the op-amps at sine wave generators properly.

If room 1 temperature is the biggest the V2 voltage will be to 8.7V, –V1 = -8.7V and V2, V3 < 0.5V (logic 0)

If room 2 temperature is the biggest the V2 voltage will be to 8.7V, –V2 = -8.7V and V1, V3 < 0.5V (logic 0)

If room 3 temperature is the biggest the V3 voltage will be to 8.7V, -V3 = -8.7V and V1, V2 < 0.5V (logic 0)

Added a buffer at the end of the circuits to make sure they is not affected by what we connect after it.

BONUS: The Valarm voltages checks if the temperatures are higher than 40°(idle state temperature) and if at least one of them is higher Valarm is 10.2V and it activates the comparators. If the rooms are cooler than the idle state temperature Valarm=0.1mV and it stops the comparator unit make V1, V2, V3=0. As a result, the sine waves never created, and the idle (00) state is sent to the microphone.

4.3 Sine Wave Generator and Summing Unit

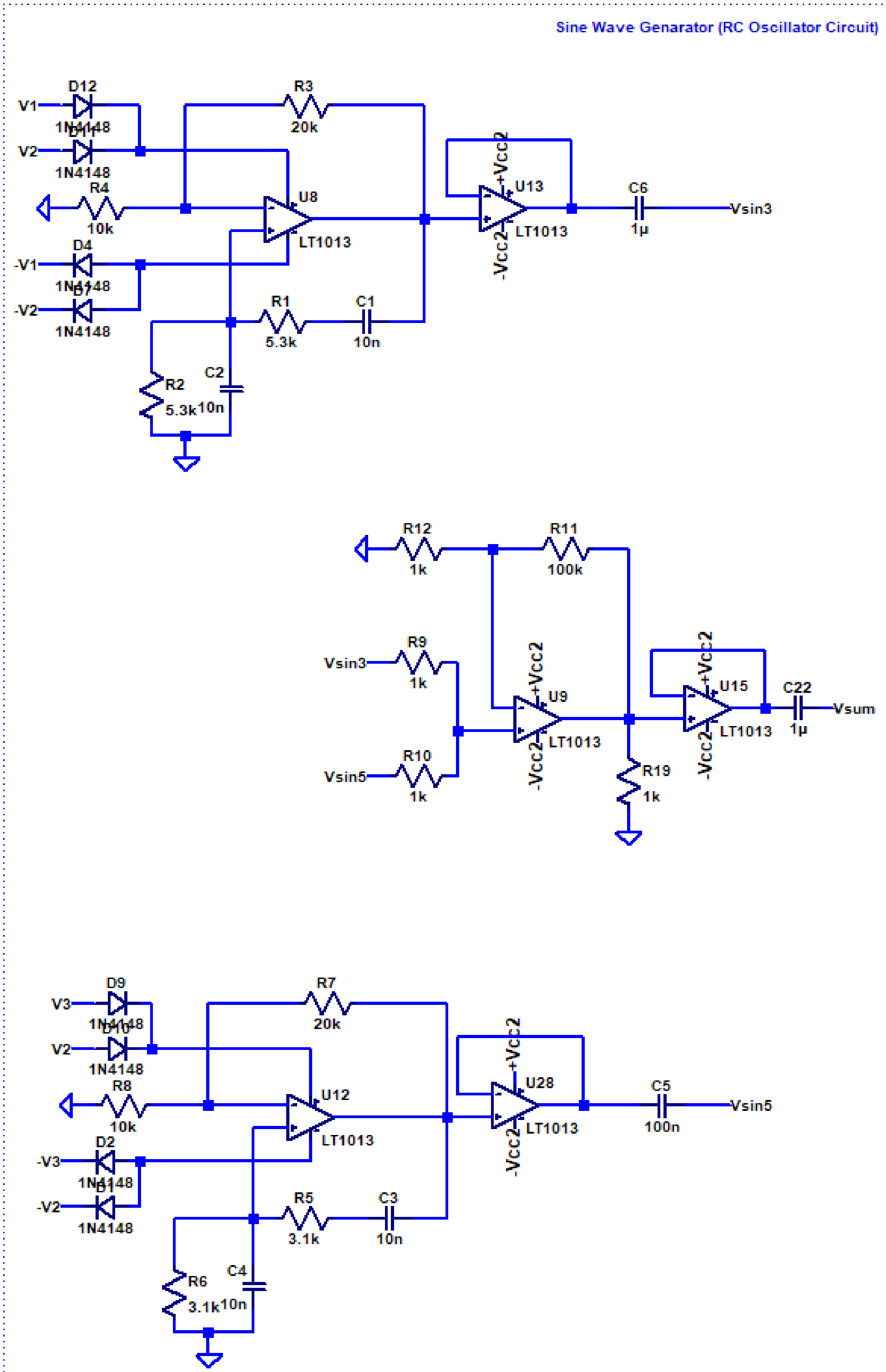


Figure 14 Circuit Diagram for Sine Wave Generator and Summing Unit

For simplicity in this section the explanations are made with V1,V2,V3 because the –V1,-V2,-V3 voltages are activate exactly in same way with the –voltages.

In our design we preferred to use an RC oscillator works with a op-amp because it is easier to operate this design ON/OFF with our V1, V2, V3.

We calculated the C, R values for the desired frequencies as 3kHz, 5kHz by using the formula obtained at the previous Sinewave Generator section in fundamental components.

After we obtained the desired sine waves. This process is controlled by the V1,V2,V3's. The relation between V1, V2, V3 and output of the sine waves is in this manner: If V1 or V2 are 8.7V the oscillator is active the sine wave generator with 3kHz frequency starts working. On the other hand, if V2 or V3 voltages are 8.7V the sine wave generator with 5Khz is activated.

The outputs of the sine wave generators is connected to a basic summing amplifier and it adds the signals. This summing adds two 1-bit signal and makes the output 2bit so that we can send all V1, V2, V3, V0 (idle) state to the receiver part. The summing amplifier also adds some amplification to the sum so that the signals can be send to the AB stage with enough magnitude to be heard from 25cm.

Added a buffer at the end of the circuits to make sure they are not affected by what we connect after it.

4.4 Transmitter Unit

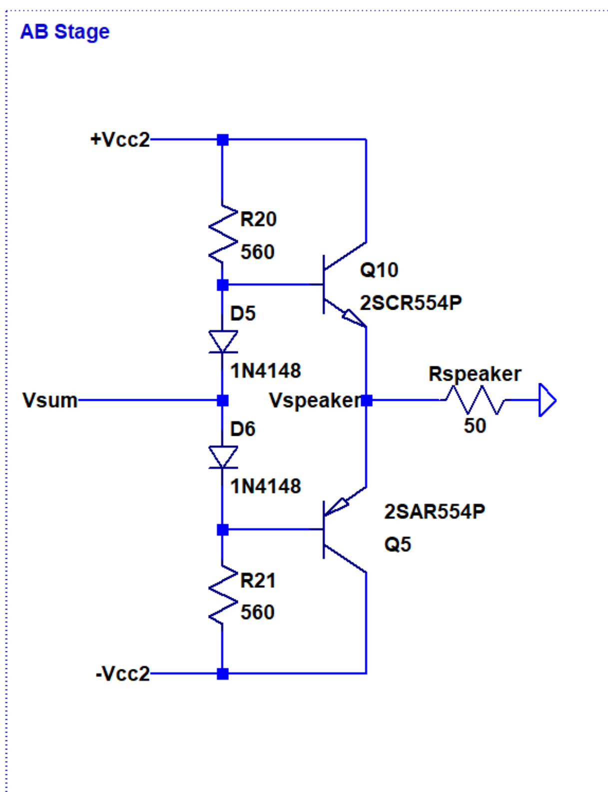


Figure 15 Circuit Diagram AB Stage

In this unit we just send the summed signal to the 50-ohm speaker, but we added a AB stage between the output of the summing amplifier and load(speaker). The AB stage is required to drive the speaker as talked before under the fundamental units section at the AB stage heading. The reason behind we are using an AB stage not an A or B is it is the best option for efficiency and distortion management. The simulation results that shows that the AB stage works very well under the simulation results.

4.5 Microphone Volume Adjustment Unit

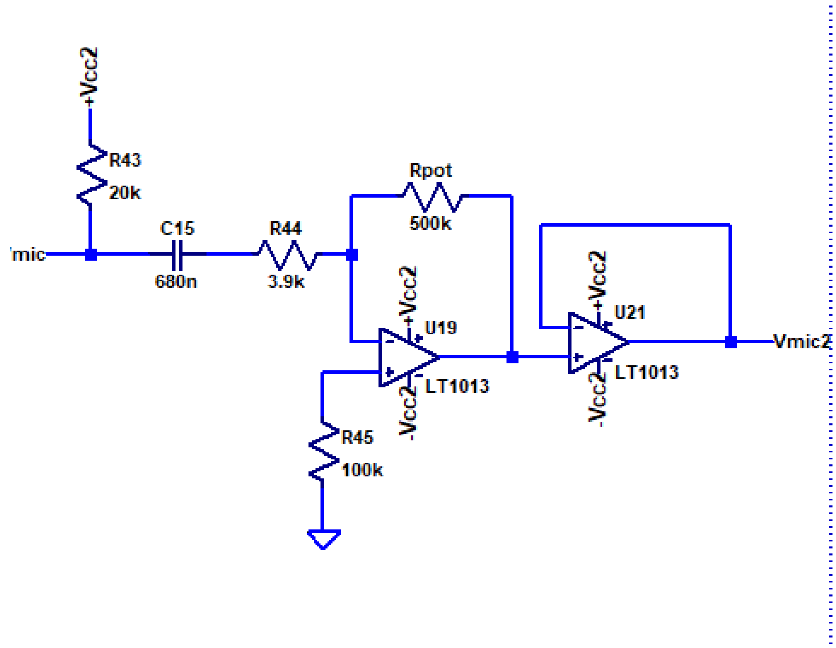


Figure 16 Circuit Diagram for Microphone Volume Adjustment Unit

In this part we used a basic inverting amplifier and a buffer after the microphone output. The aim of this part is giving us the ability to adjust the amplitude of the signal we will send through our band pass filters in the next part. The amplification needed because of the low output voltages from the microphone output. The Rpot value is 500k. This pot's value has been chosen to make sure the input signal to the band-pass filters is >1V so that the filtering can be done properly.

The use of an inverting amplifier did not be a problem because we are interested in the amplitude of the signal and the phase is not important for our band pass filter.

4.6 Band-Pass Filter

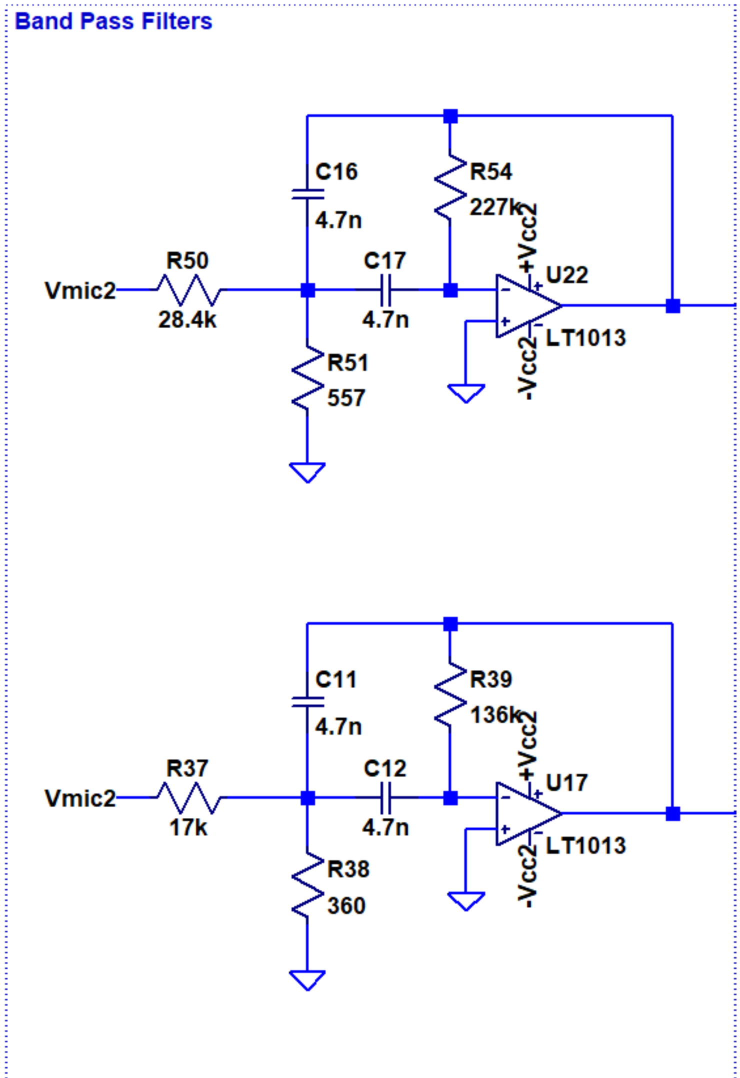


Figure 17 Circuit Diagram for Band Pass Filters

We have two band pass filters which work parallel. One for 3kHz signal and one for 5kHz signal. We control the gain of our band pass filters by changing R50, R37 mainly. The gain of 3kHz and 5 kHz band pass filter is 4. This gain is enough for use at envelope detectors because we have already pre amplified the signals before going into the band pass filters. The quality factor of the band pass filters are 10 and sufficient for the purpose and in the range of 5% error which is given in the project design specifications. The capacitors have chosen arbitrarily and same to make calculations easier and we obtained the desired frequencies by using the R values at the (-) feedback, R38 and R51. The frequency response of the band-pass filters is at the Results section 6.4.

4.7 Envelope Detector

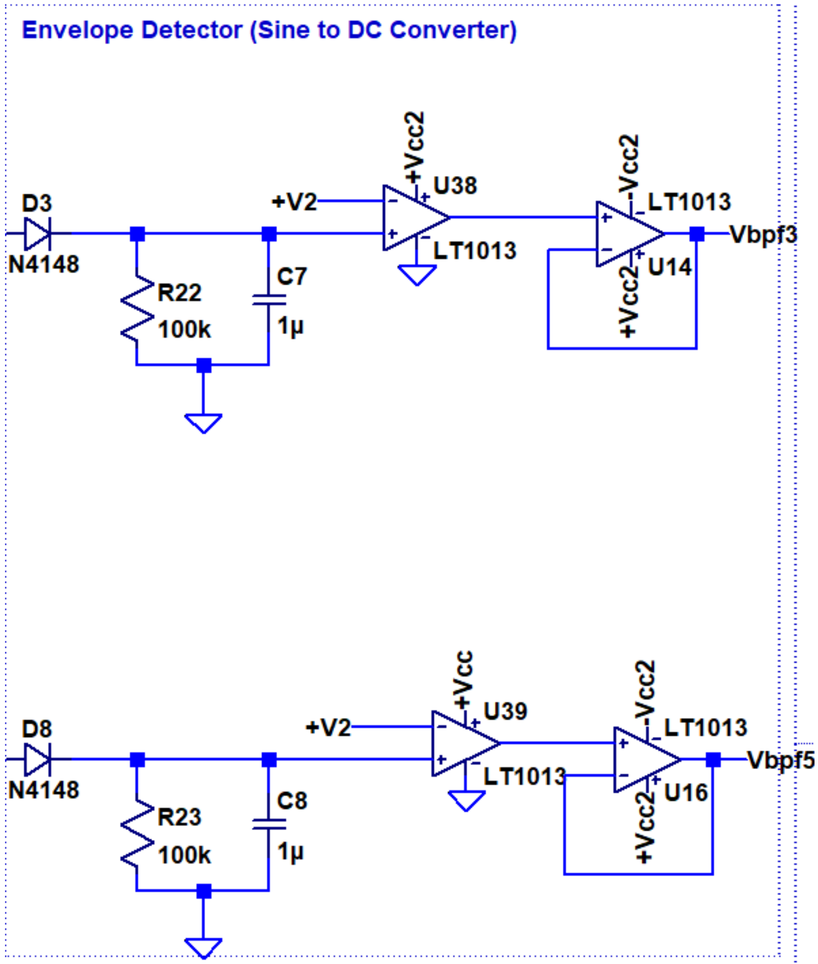


Figure 18 Circuit Diagram for Envelope Detectors

These envelope detectors just make the output of the band-filters to DC(almost) signals. So basically, this part gives us a positive value of the signal proportional to its amplitude. The only thing we had to be careful while designing these is to make sure RC time constant is much bigger than the T(period) of the input signals. And we found the 100k and 1uF are appropriate for our purpose. When we used the output of the envelope detectors as input of logic gates, we were obtaining different voltages for 3 and 5 kHz cases so we added a basic comparators and compared with +V2 the +V2 is chosen to simplify the design because it was already obtained by voltage division and it was good enough to compare. After the cooperation we obtained very stable logic inputs for our led circuit. Adding comparator stopped any leakage current cold came from low outputs of filters. Also added a buffer at the end of the circuit to make sure it is not affected by what we connect after it.

4.8 LED’s

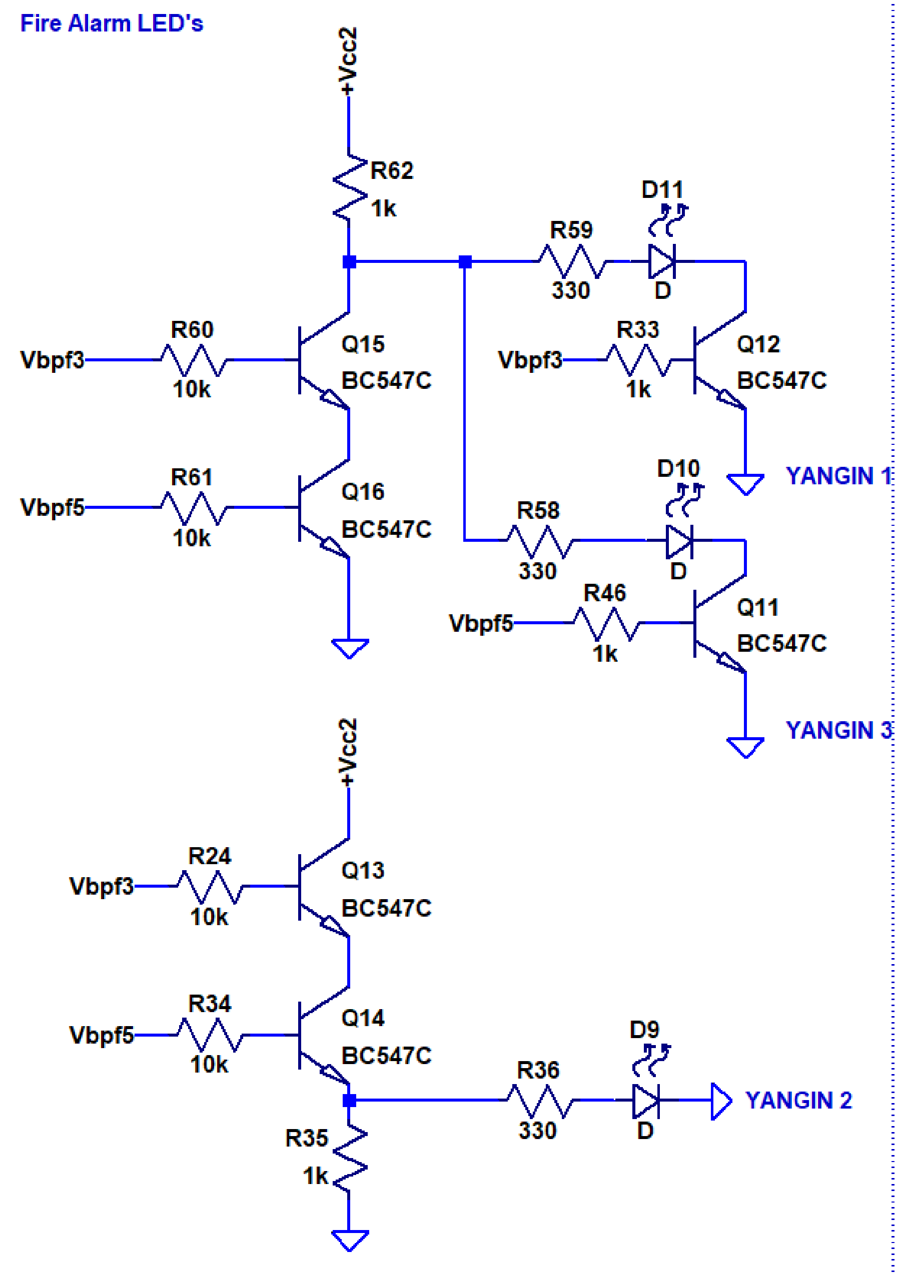


Figure 19 Circuit Diagram for the LED’s

In this unit we are getting the DC outputs of comparators connected just after the envelope detectors (Vbpf3, Vbpf5) and use them as logic inputs to our AND, NOR, NAND gates and basic switches.

First, we check if the Vbpf3 and Vbpf5 are high with a NAND gate so that if one of them is high the gate sends high to its output than two basic NPN switches are connected to the output of OR gate and checks which one is high and lights the LED corresponding to that voltage with another word the room which is on fire. Secondly if Vbpf3 and Vbpf5 are both high if this is true it lights the led that says fire is at room 2.

4.9.1 IDLE Bonus

Bonus part adds 2 extra parts to our circuit and changes the comparator parts op-amps' Vcc. We also chose the 40° as the idle state critical temperature because our research showed that most of the modern fire alarms use a value near to this and also if a room is hotter than 40° it shows that even there is no fire yet there will be soon.

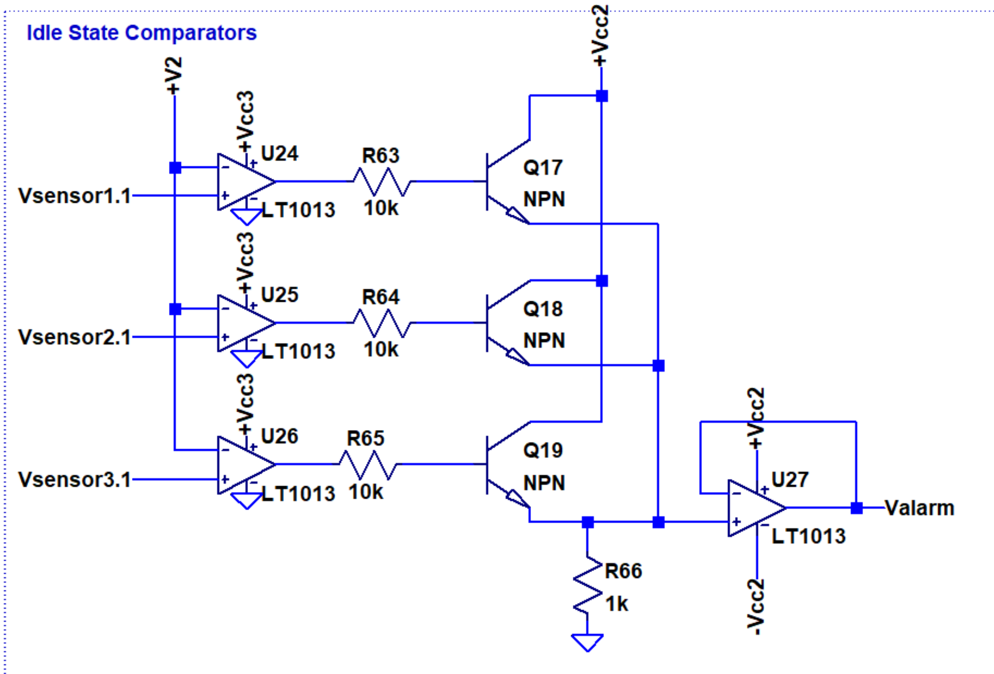


Figure 20 Circuit Diagram for Idle State Comparator

Firstly, we check if any of the temperatures are higher than 40° (idle temperature) with basic comparators (op-amps) than we take the output of the OR gate as Valarm. Now we have a Valarm value which is 1 for fire and 0 for idle. We also adjusted the +Vcc3 values so that Valarm(active)=10.2V that the voltage needed to operate the comparators at temperature comparator unit.

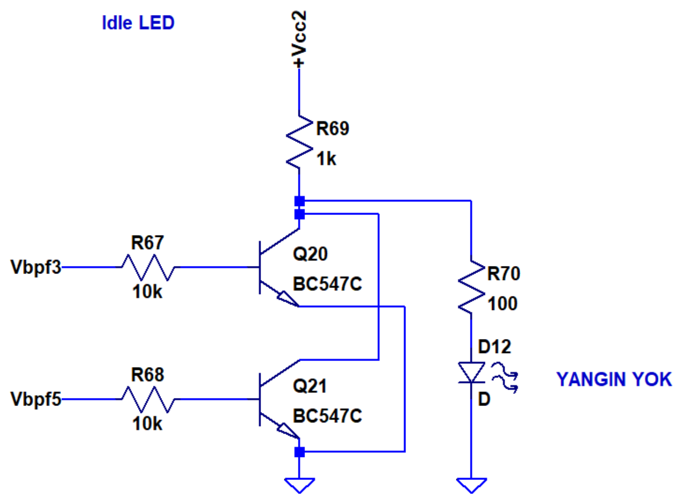


Figure 21 Circuit Diagram for the idle state LED

Lastly, we check the Vbpf3 and Vbpf5 if they are 0 with a NOR gate and If they are 0 it shows that the sine waves are not created (00 state) and we are at idle state. The light connected to the NOR gates output shines at idle state.

4.9.2 Distance Bonus

For the distance we did not add any new parts to our circuit design just increasing the amplification at the summing amplifier at the sine generation part and increasing the Rpot value at the amplification after the microphone part was enough. We also positioned the microphone and speaker to look each other for less lost.

We have also thought to add a cone to the speaker to make it lauder, but it was not needed the amplification was enough for the desired distance.

5. Simulation Results

Simulation results for 4 states are shown below. The states are Fire at room 2, Fire at room 1, Fire at room 3 and idle state respectively

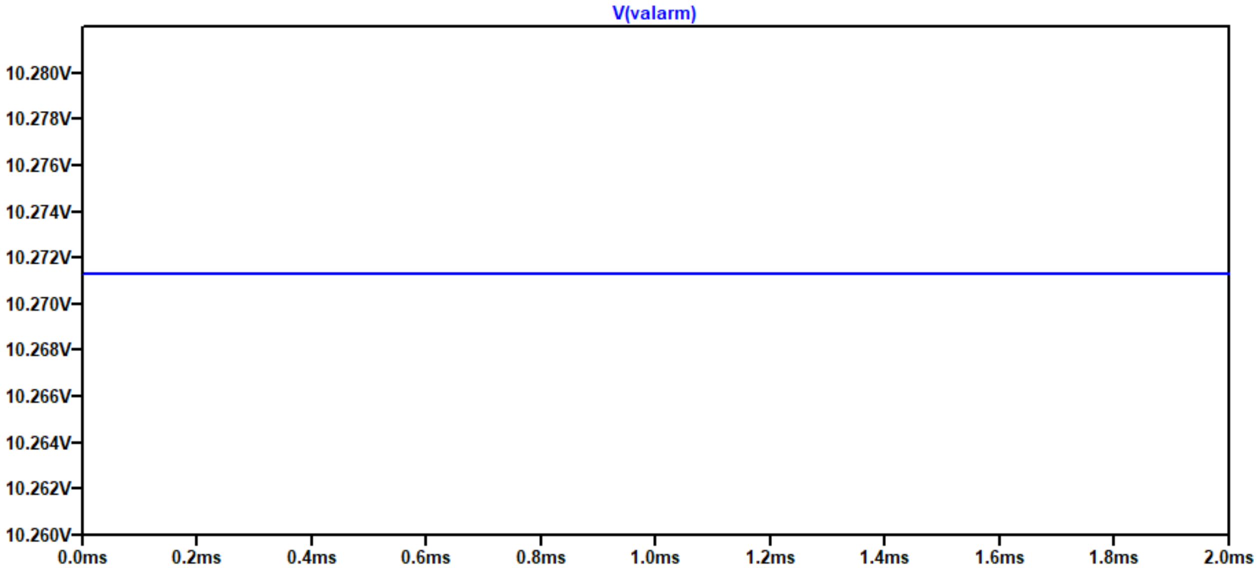


Figure 21 Simulation Results for the Valarm>0

5.1 Fire at Room 2 (T2>T1>T3 & T2>40)

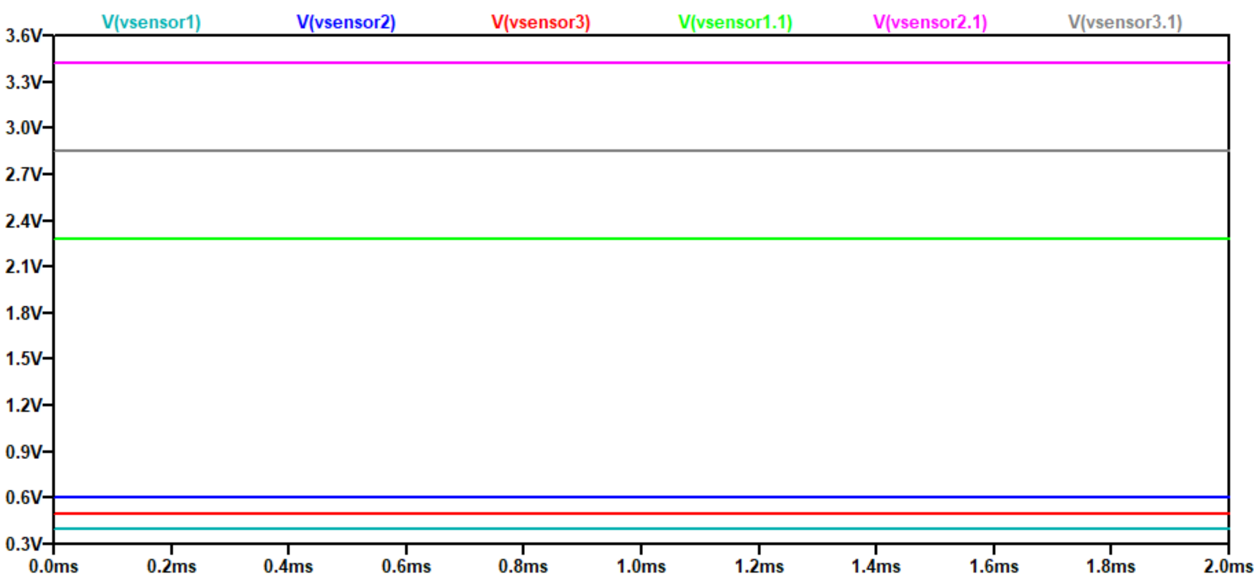


Figure 22 Simulation Results for sensor outputs and amplifier output voltages

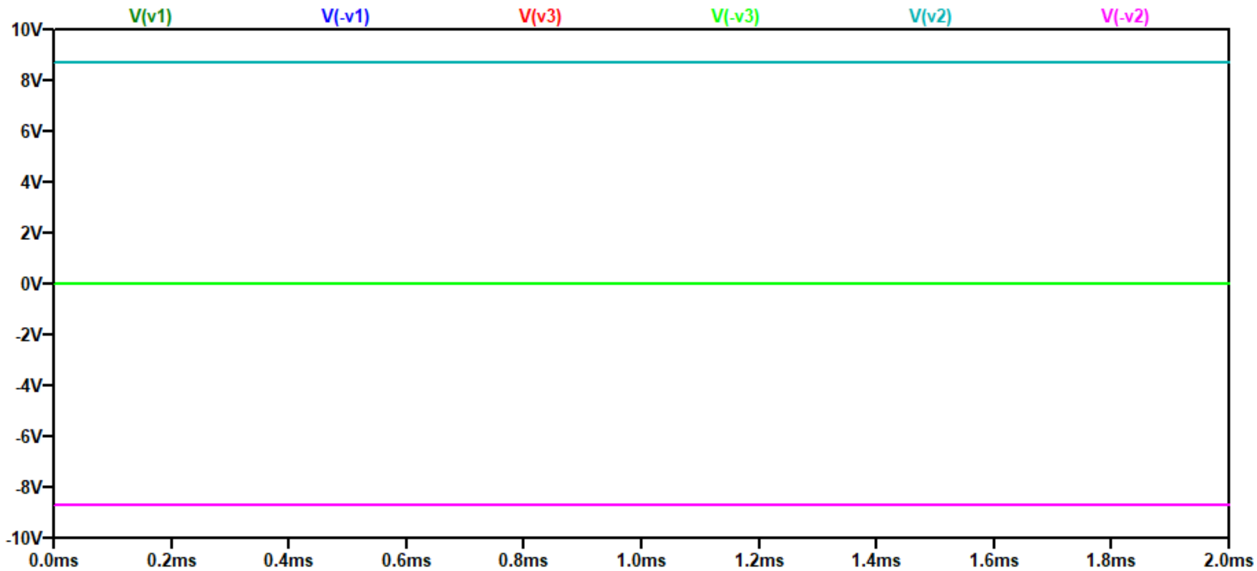


Figure 23 Simulation Results for Comparator Output Voltages

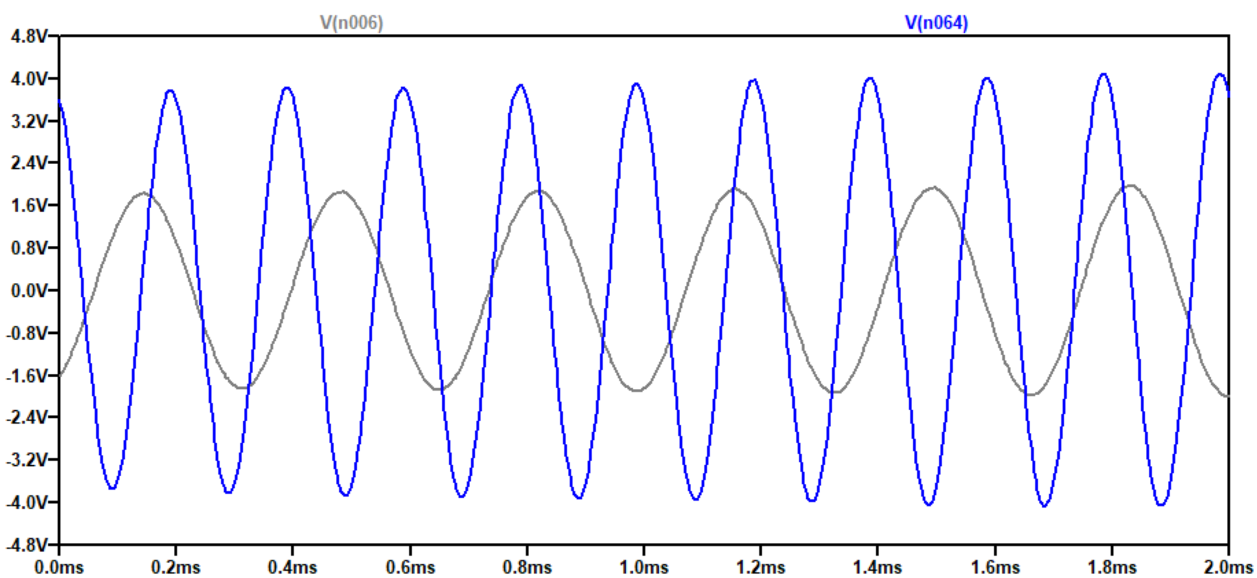


Figure 24 Simulation Results for Sine Wave Generator Outputs

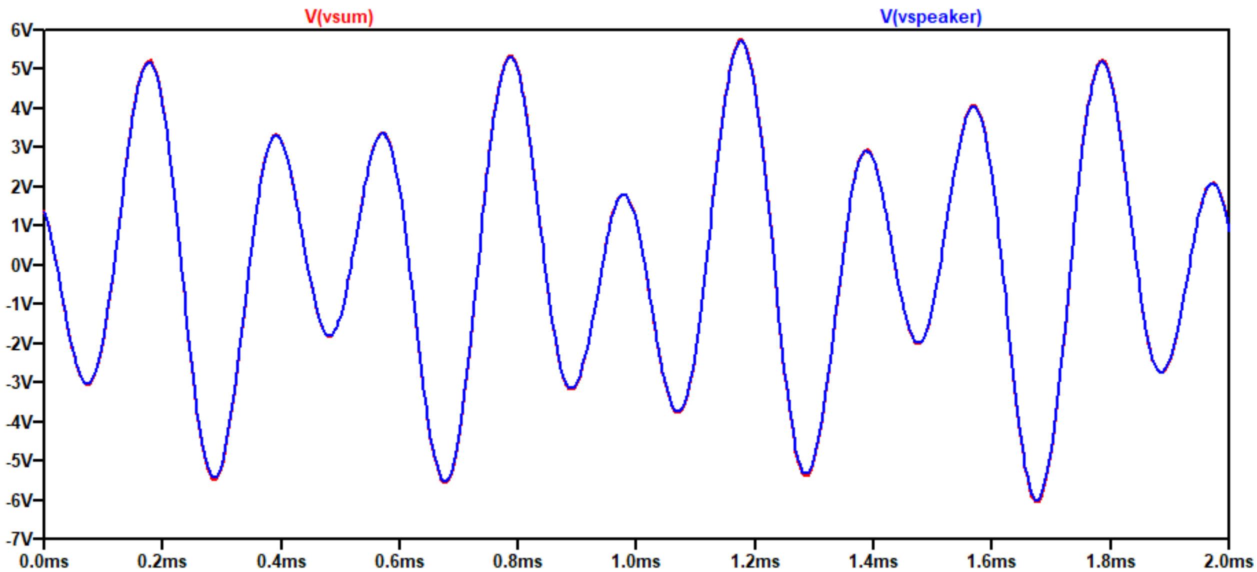


Figure 25 Simulation Results Summed Signal and Speaker Voltage

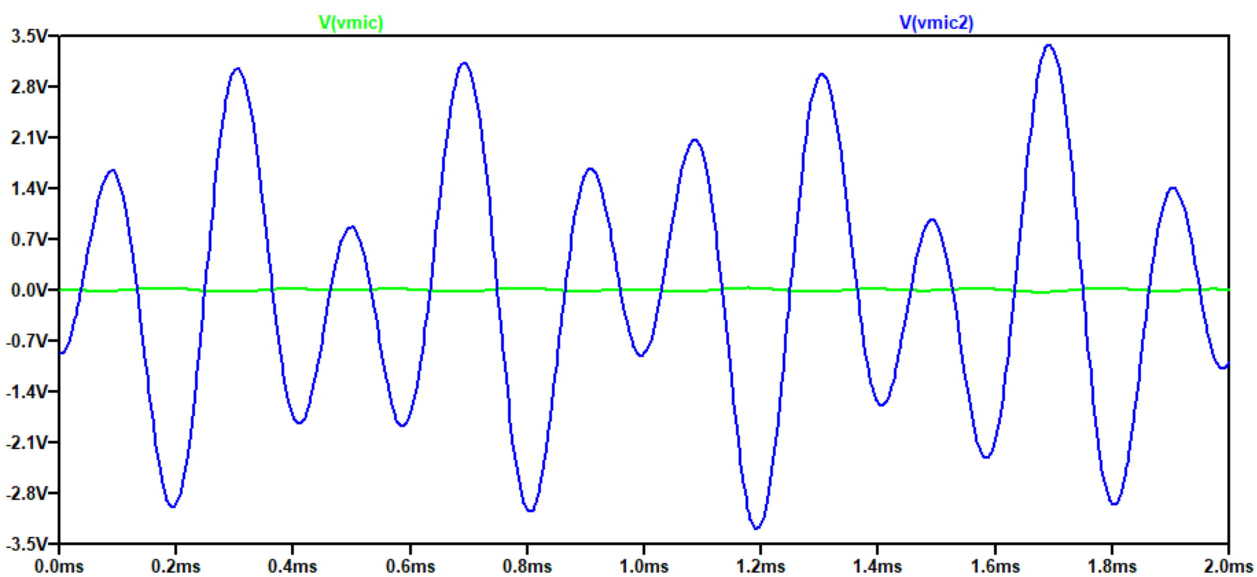


Figure 26 Simulation Results for Microphone Input and Volume Adjustment Output Voltages

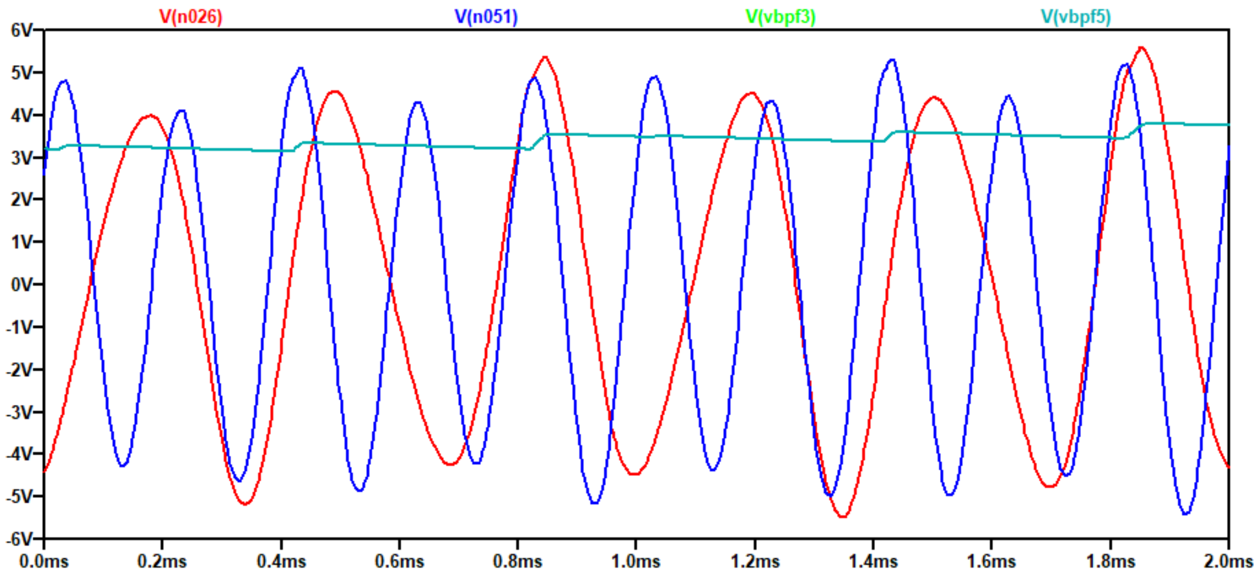


Figure 27 Simulation Results for Band-Pass Filter Input and Envelope Detectors Output Voltages

Figure 28 Simulation Results for LED's Output Currents

5.2 Fire at Room 1 (T1>T3>T2 & T1>40)

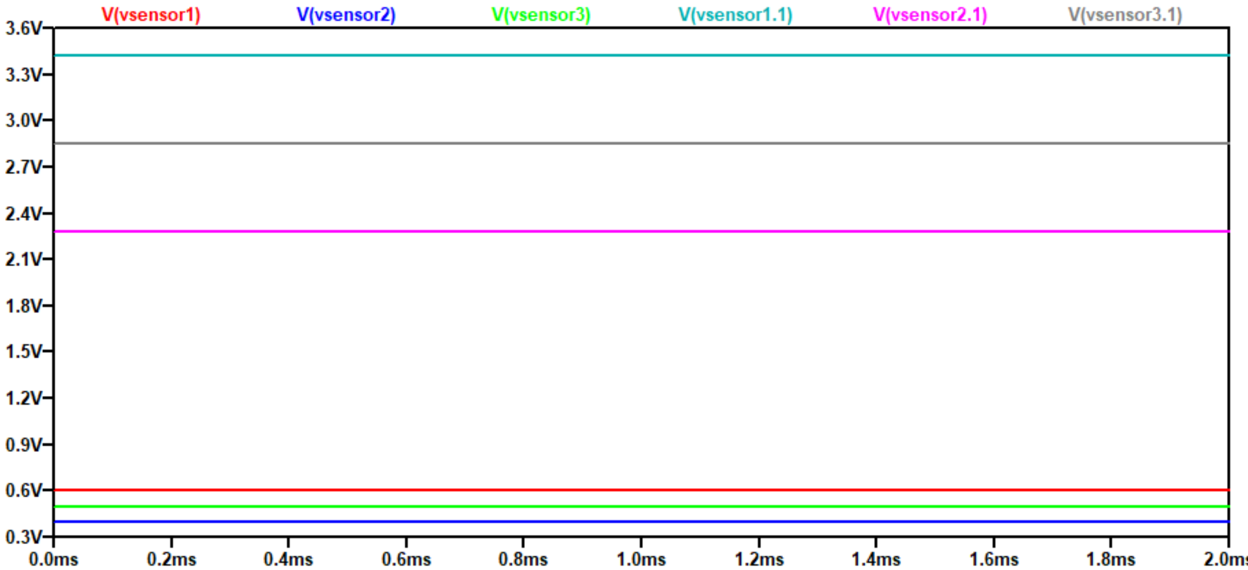


Figure 29 Simulation Results for sensor outputs and amplifier output voltages

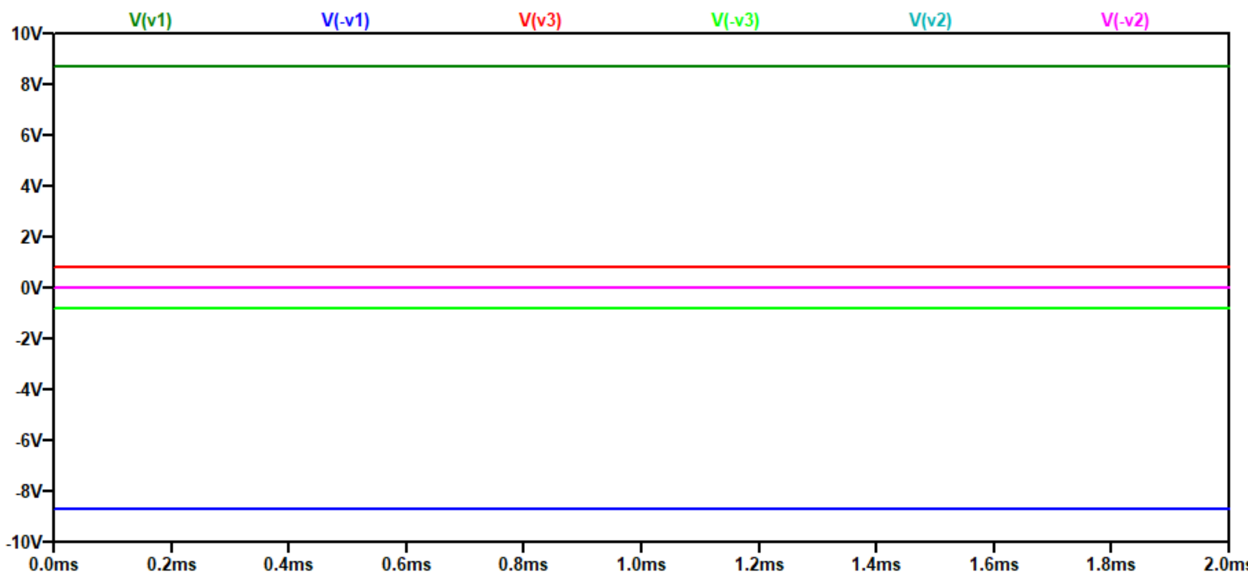


Figure 30 Simulation Results for Comparator Output Voltages

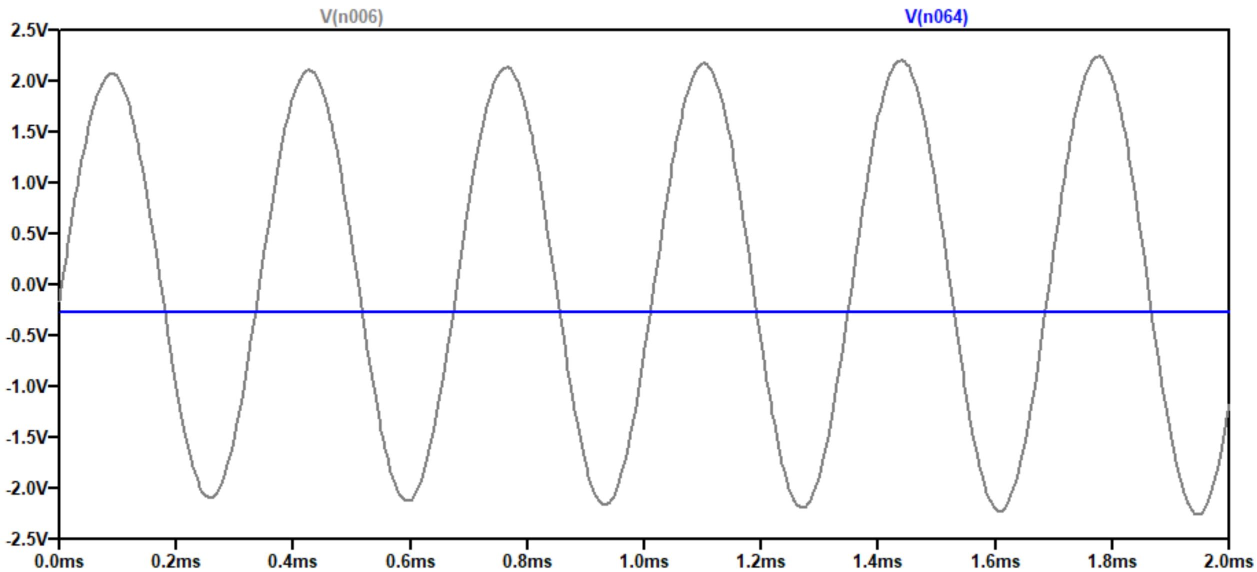


Figure 31 Simulation Results for Sine Wave Generator Outputs

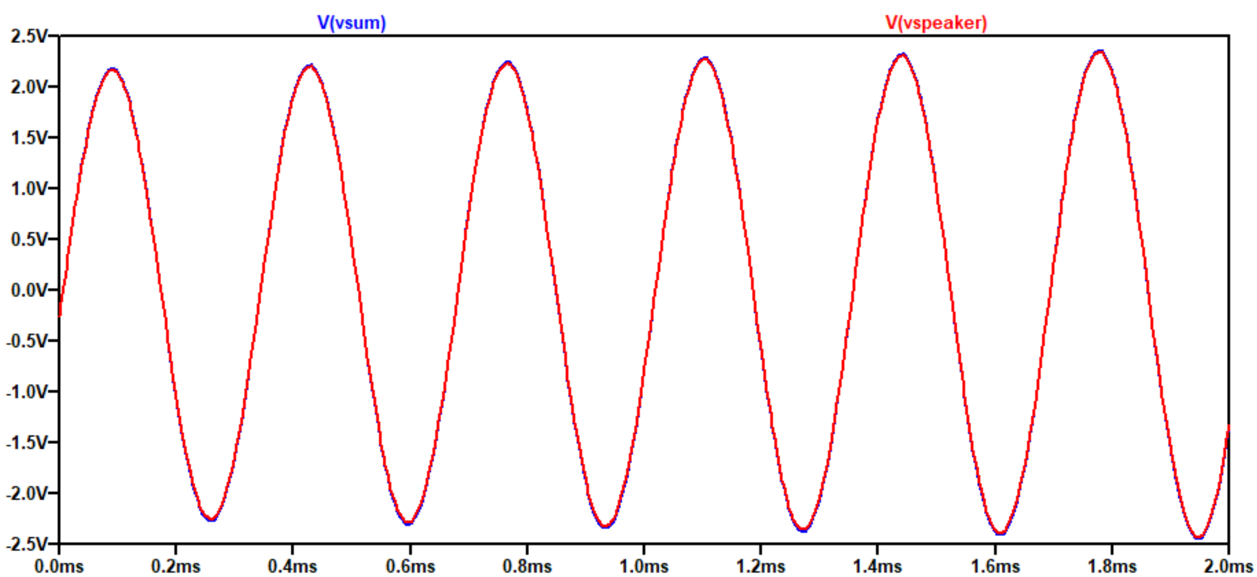


Figure 32 Simulation Results Summed Signal and Speaker Voltage

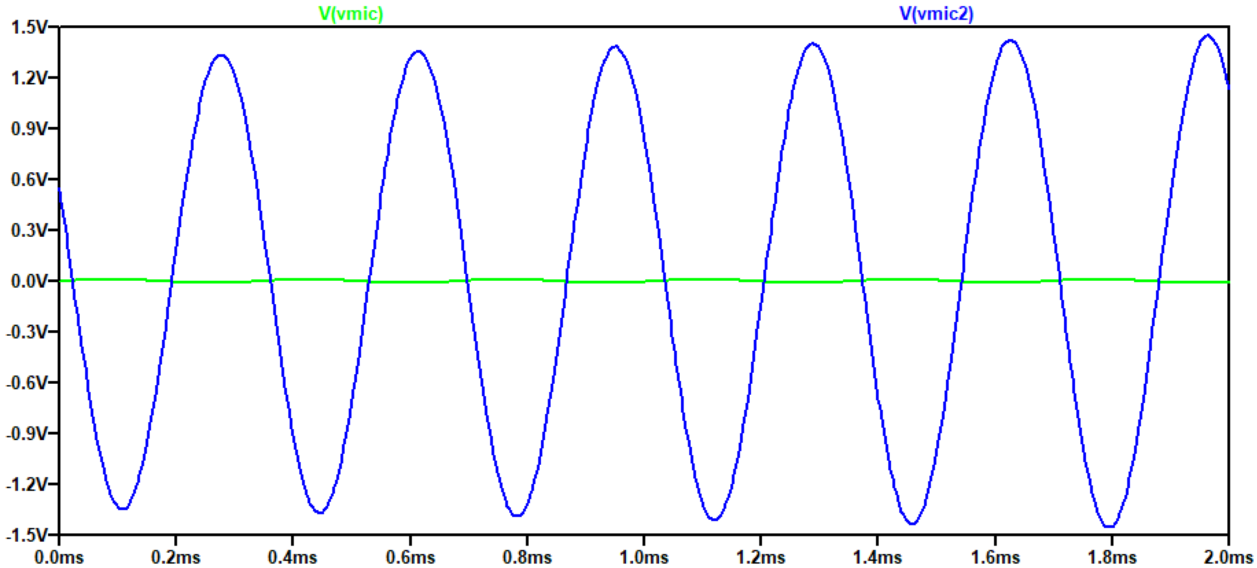


Figure 33 Simulation Results for Microphone Input and Volume Adjustment Output Voltages

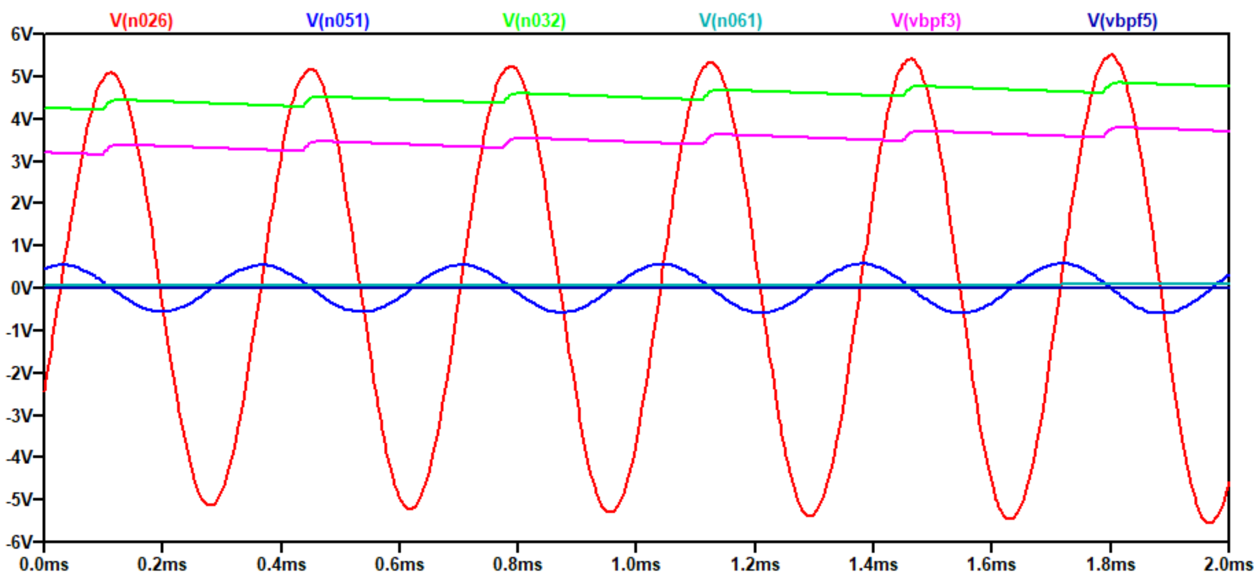


Figure 34 Simulation Results for Band-Pass Filter Input and Envelope Detectors Output Voltages

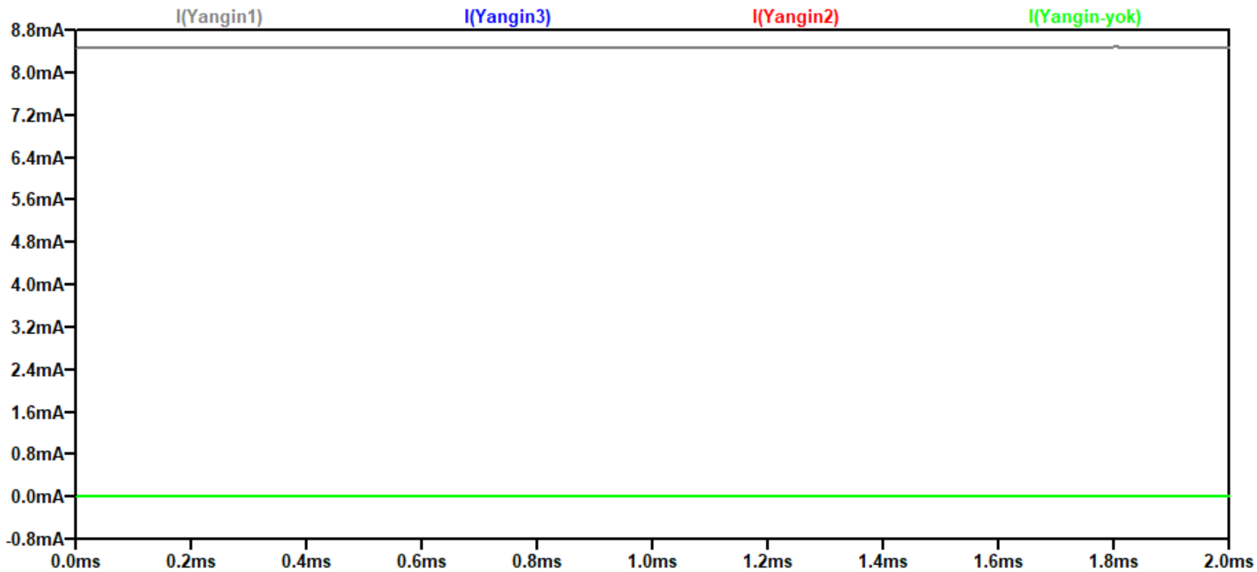


Figure 35 Simulation Results for LED's Output Currents

5.3 Fire at Room 3 (T3>T1=T2 & T3>40)

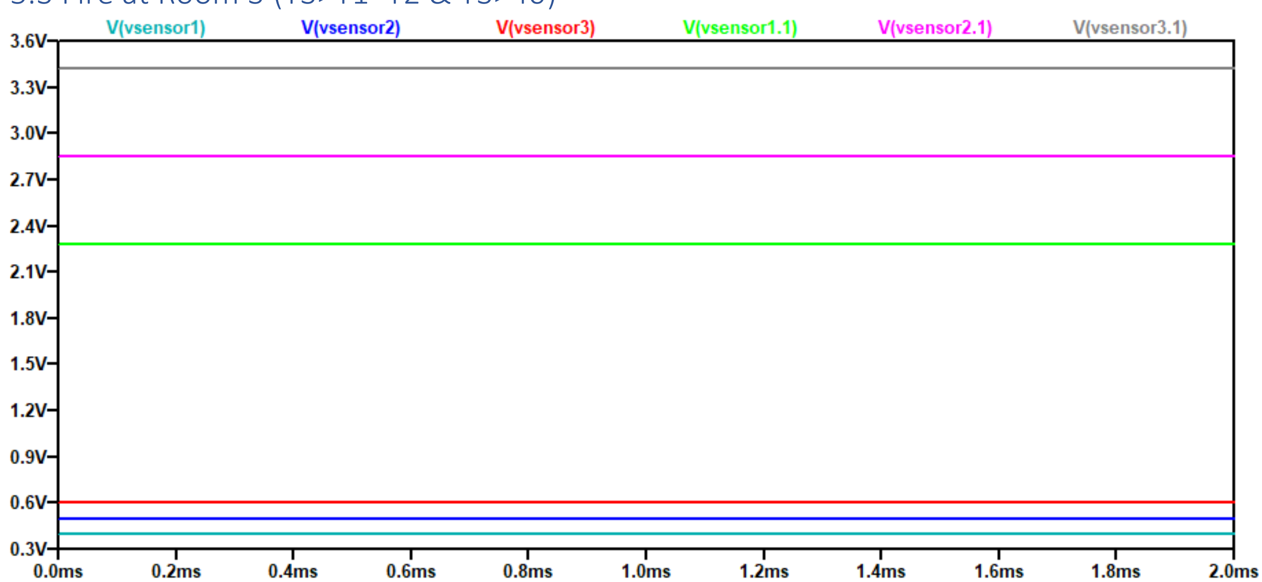


Figure 26 Simulation Results for sensor outputs and amplifier output voltages

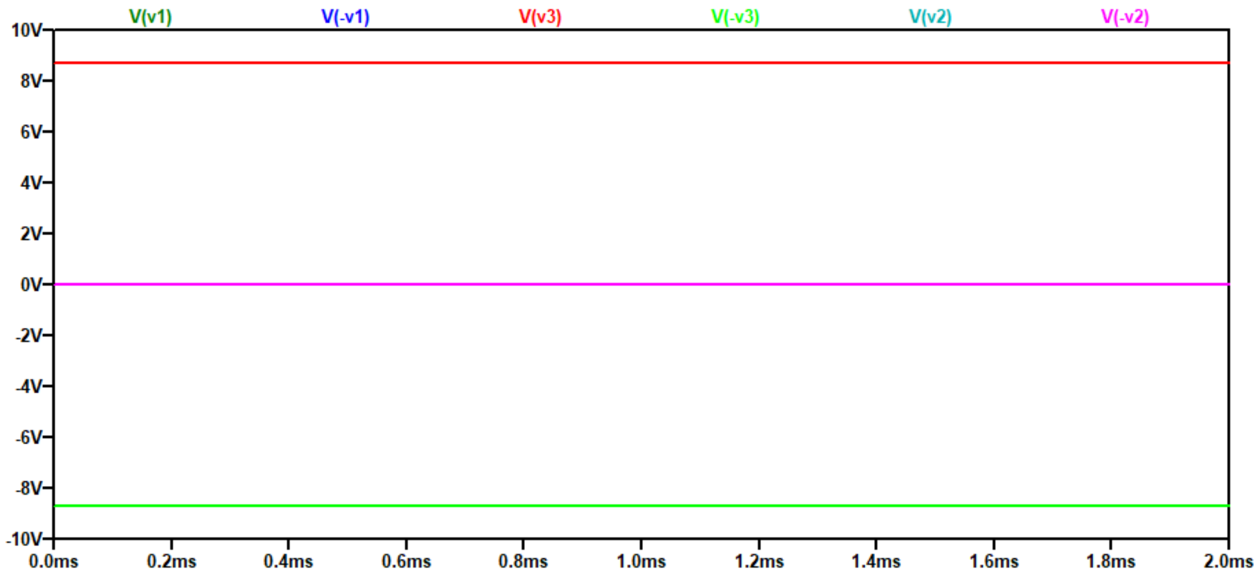


Figure 37 Simulation Results for Comparator Output Voltages

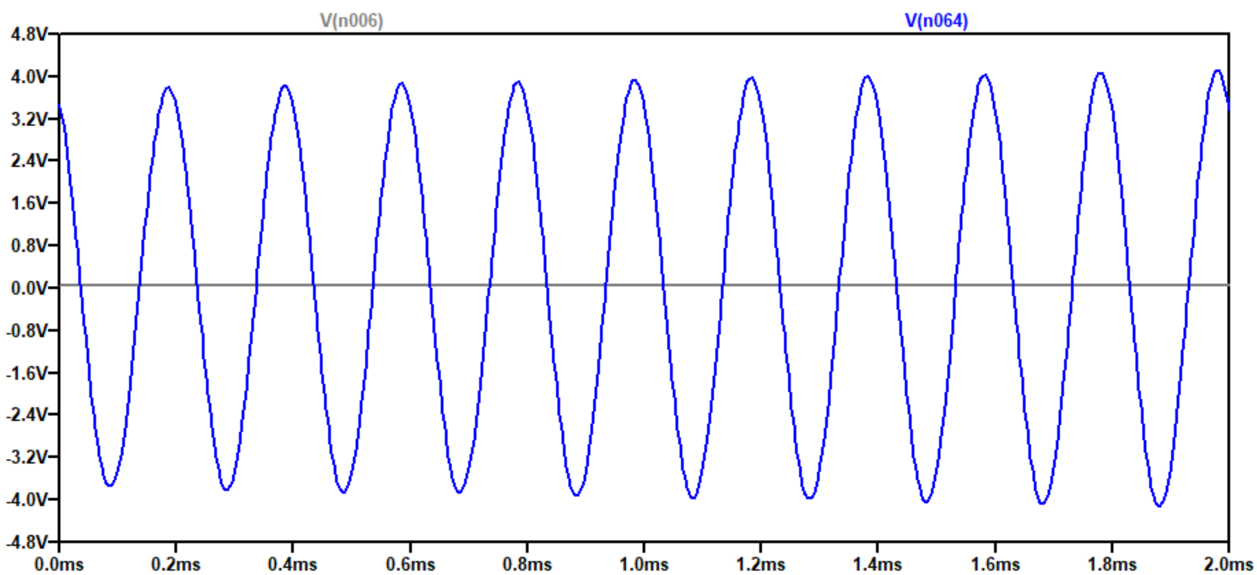


Figure 38 Simulation Results for Sine Wave Generator Outputs

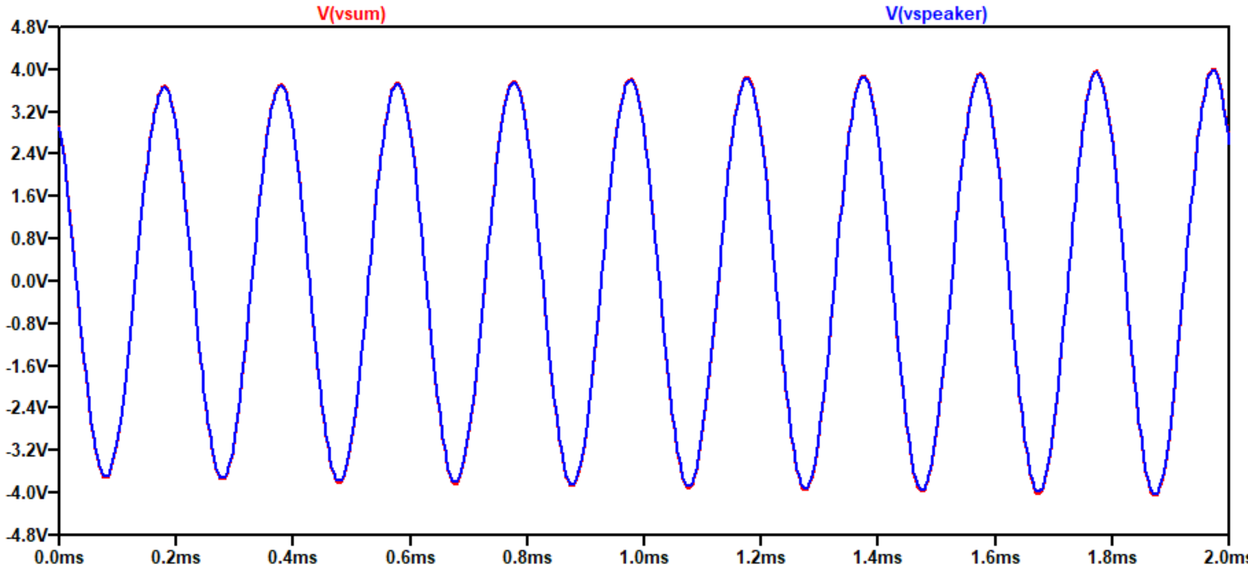


Figure 39 Simulation Results Summed Signal and Speaker Voltage

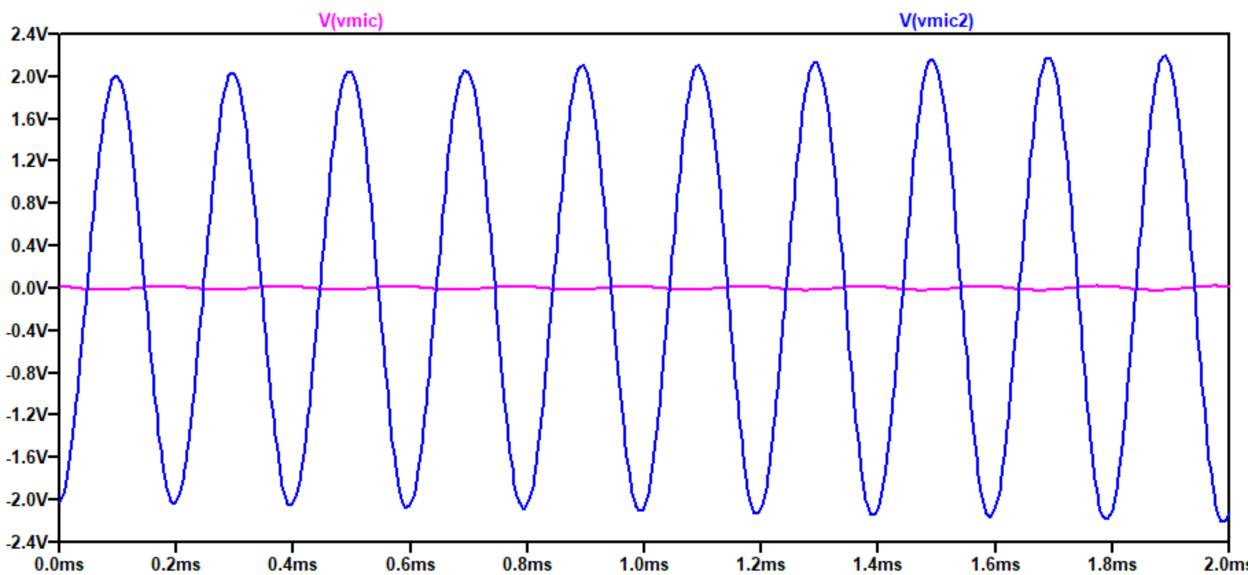


Figure 40 Simulation Results for Microphone Input and Volume Adjustment Output Voltages

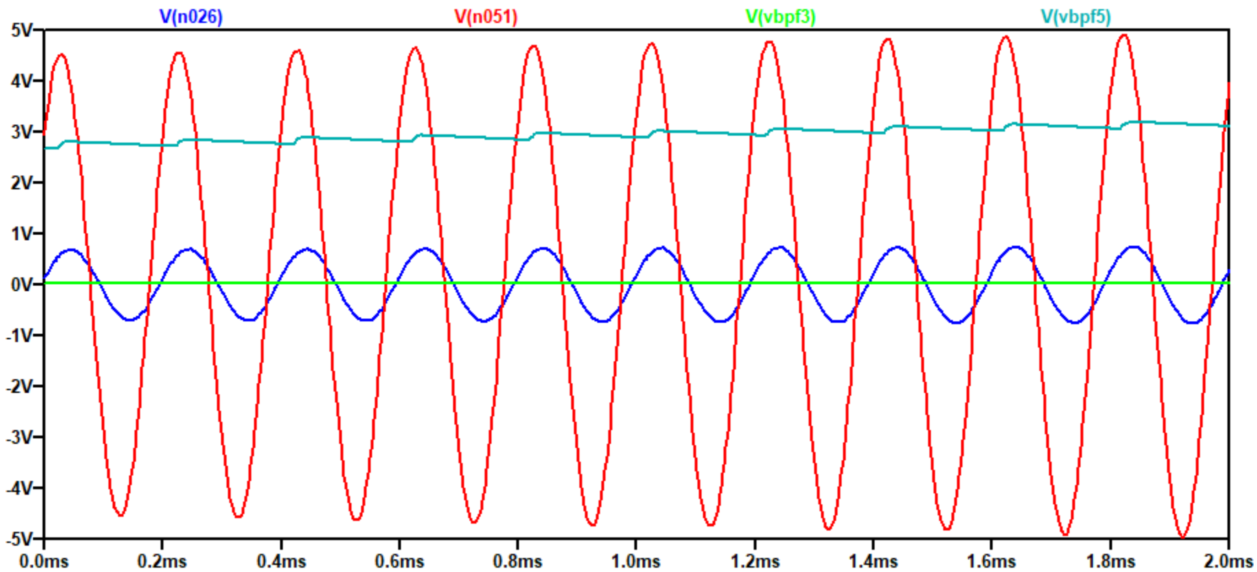


Figure 41 Simulation Results for Band-Pass Filter Input and Envelope Detectors Output Voltages

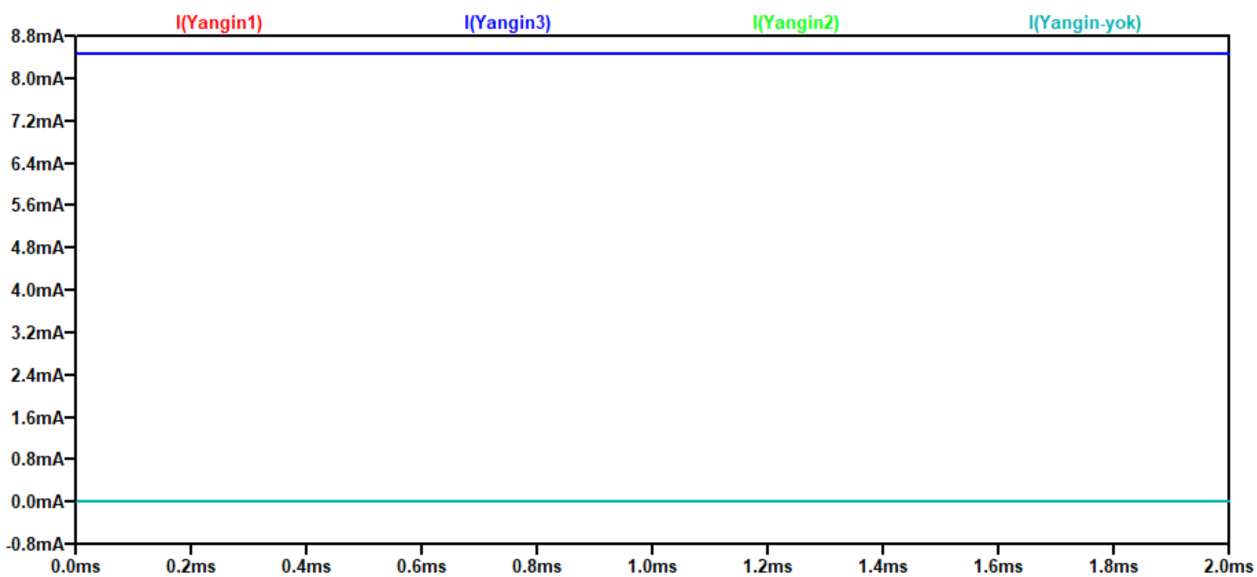


Figure 42 Simulation Results for LED's Output Currents

5.4 BONUS: No Fire at Home (40>T1>T2>T3)

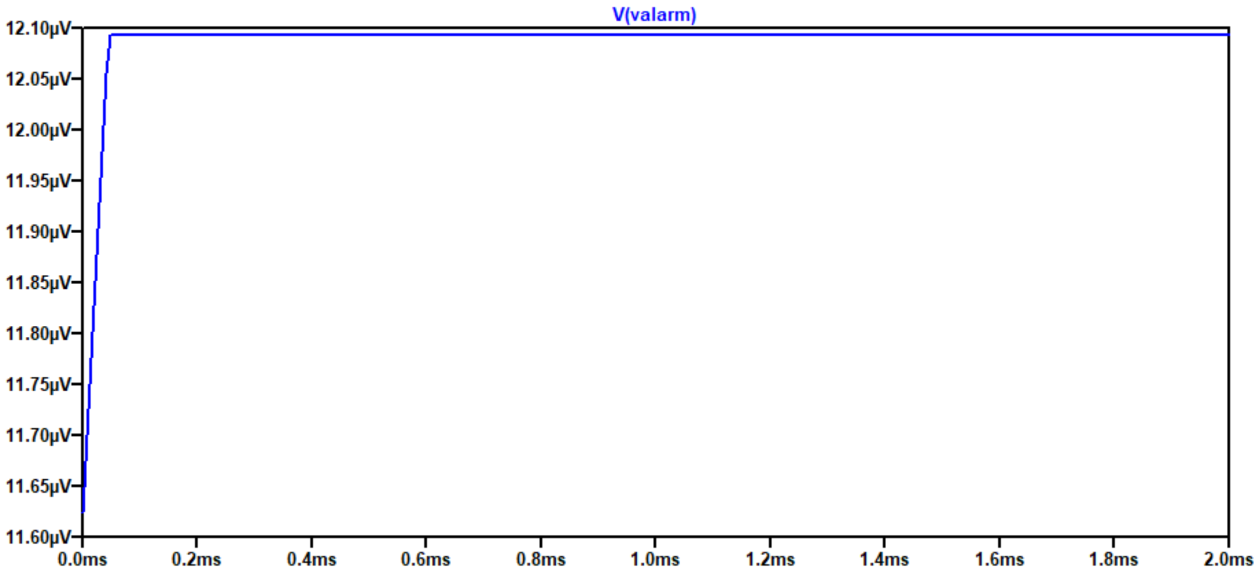


Figure 43 Simulation Results for the Valarm=0

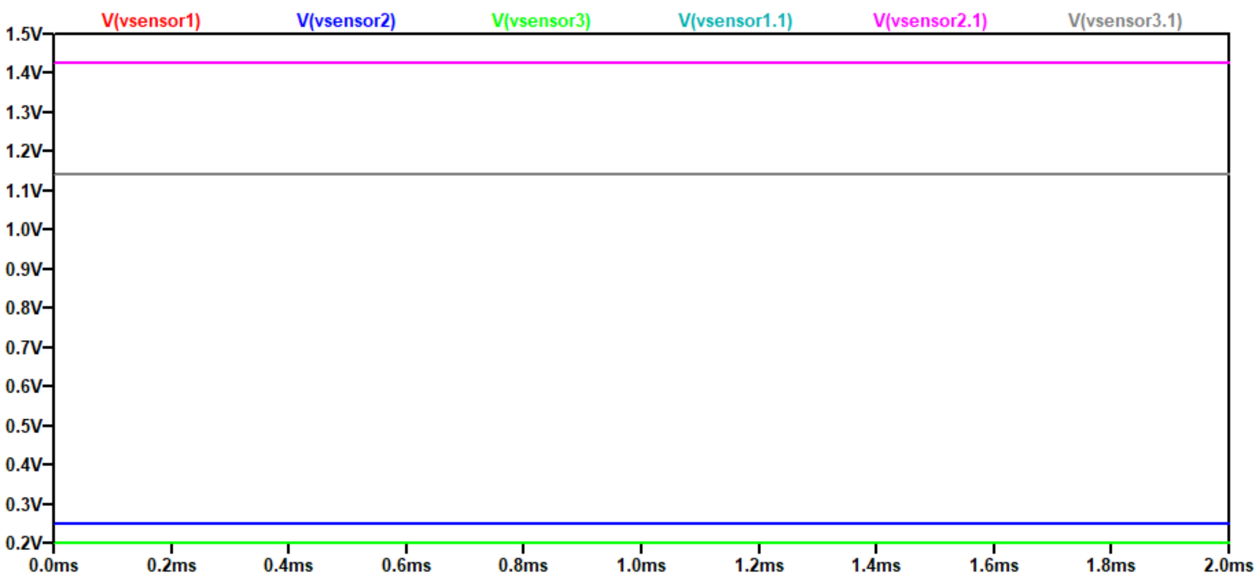


Figure 44 Simulation Results for sensor outputs and amplifier output voltages

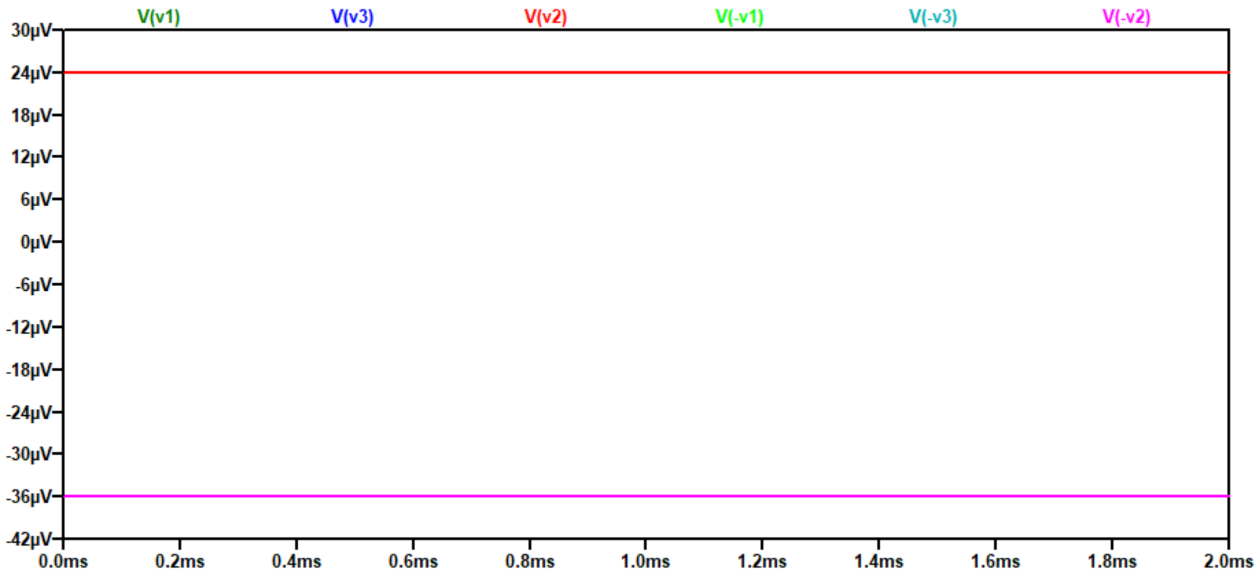


Figure 45 Simulation Results for Comparator Output Voltages

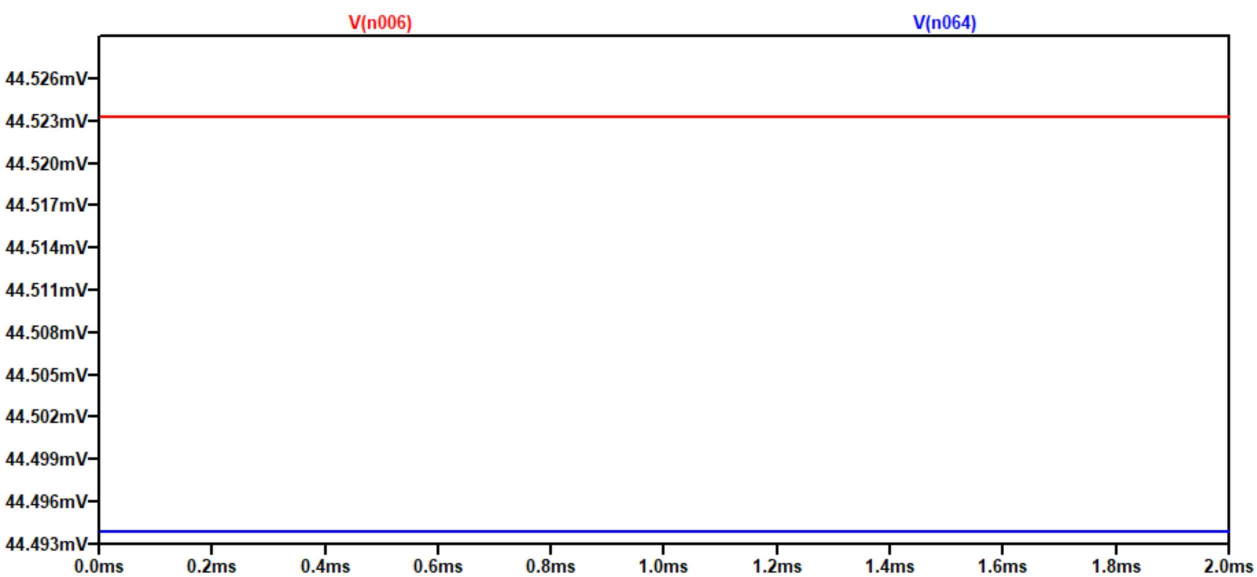


Figure 46 Simulation Results for Sine Wave Generator Outputs

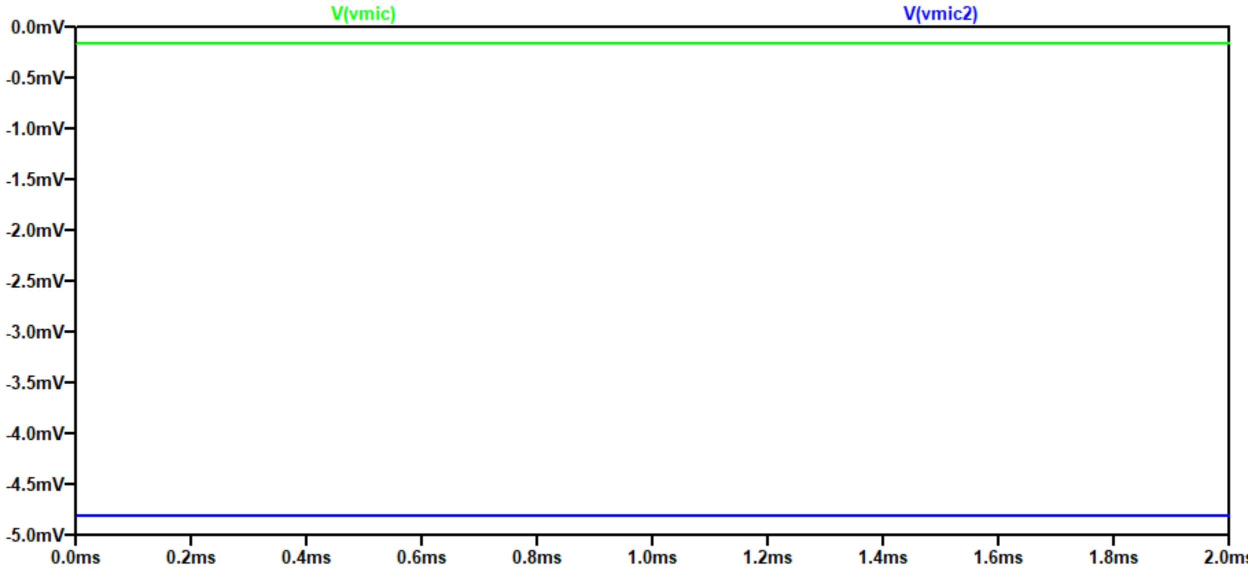


Figure 47 Simulation Results for Microphone Input and Volume Adjustment Output Voltages

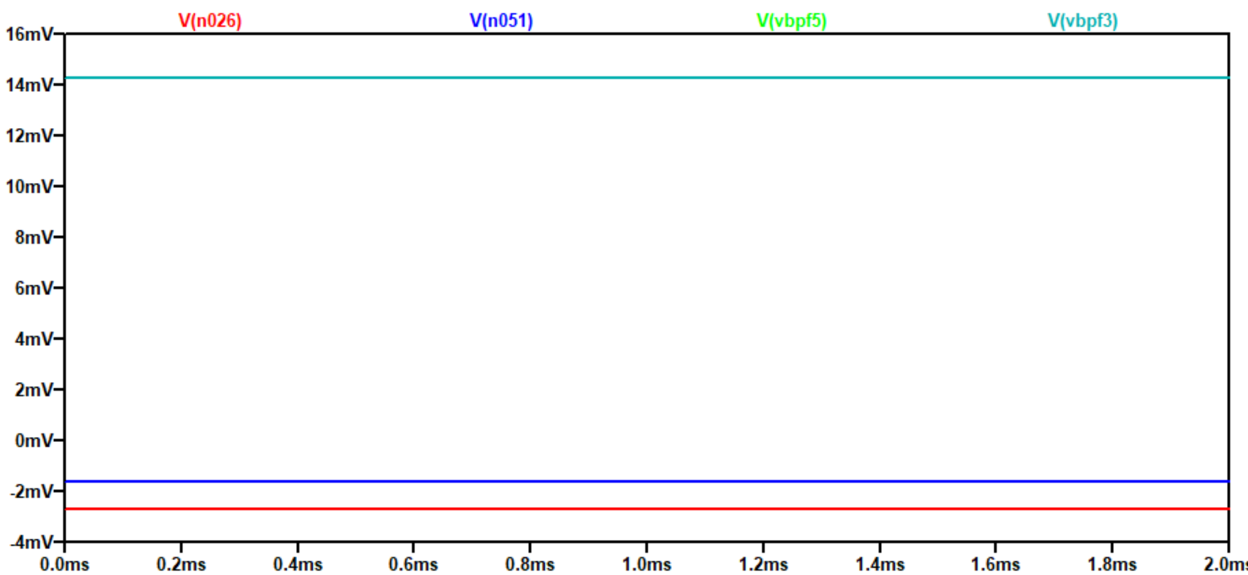


Figure 48 Simulation Results for Band-Pass Filter Input and Envelope Detectors Output Voltages

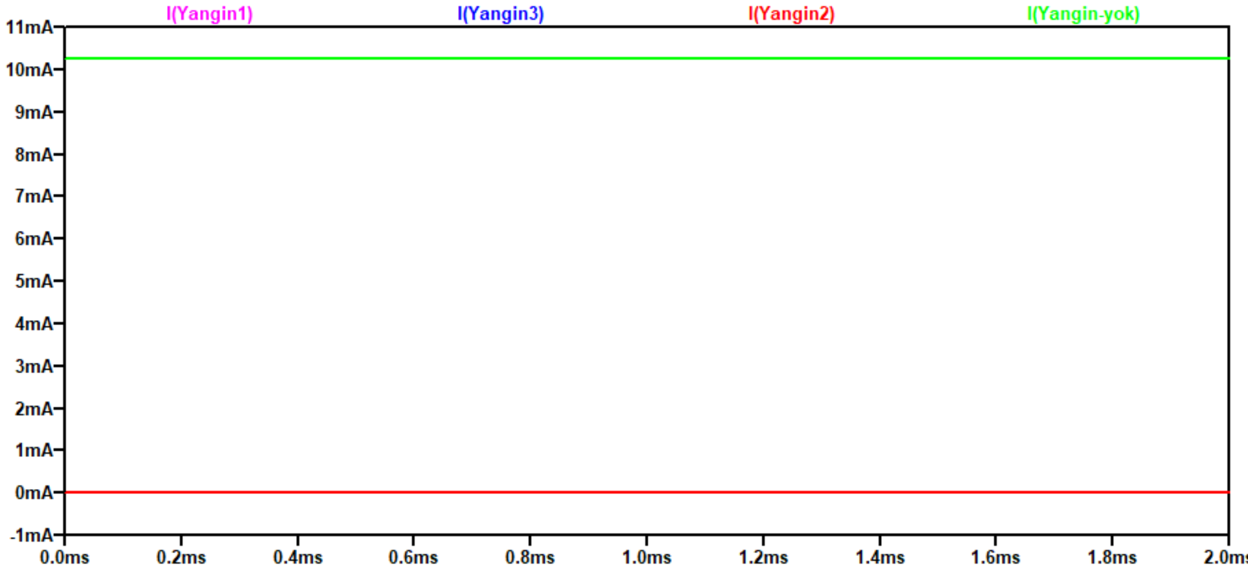
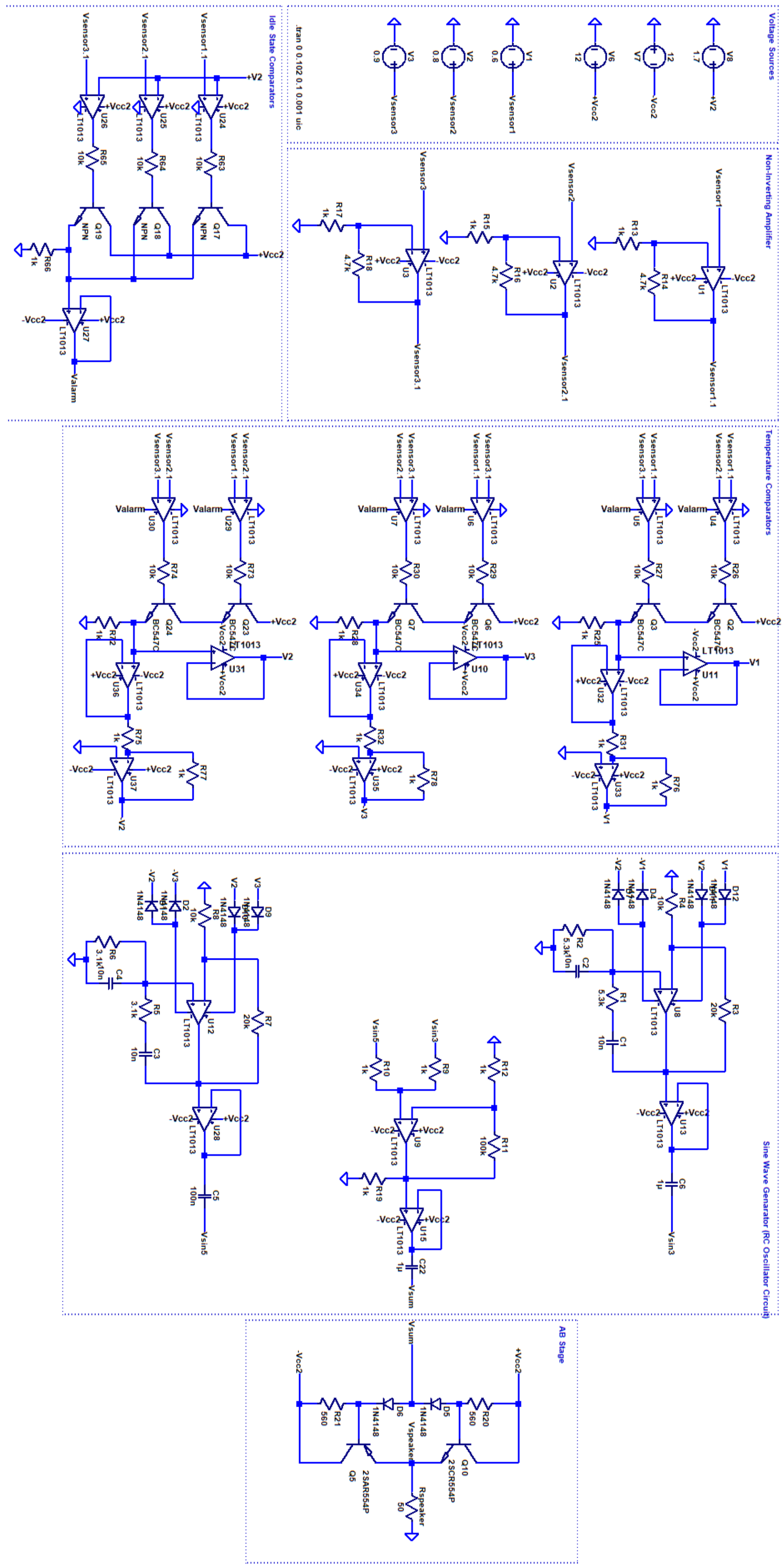
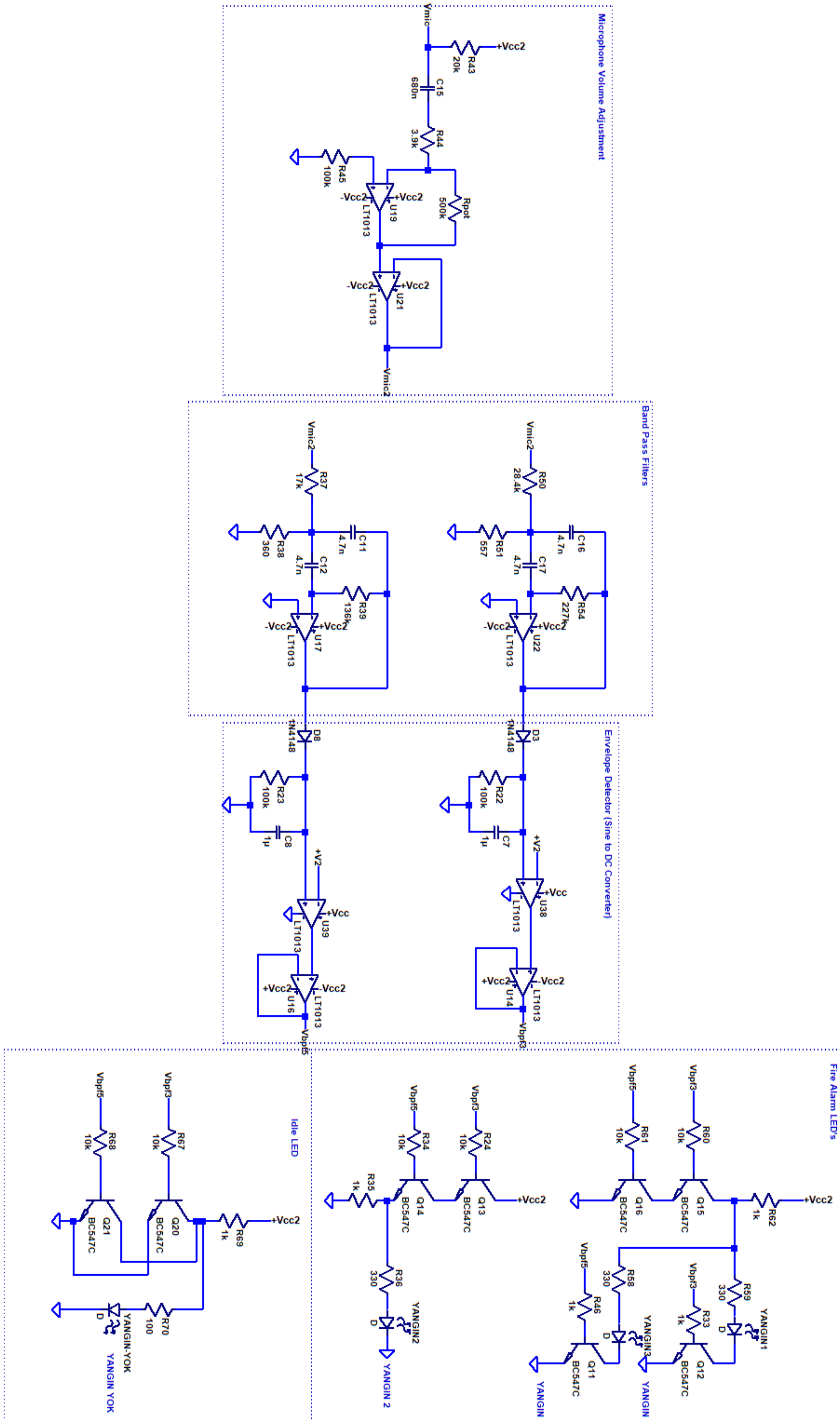


Figure 49 Simulation Results for LED's Output Currents

6. Overall Circuit Diagram




Microphone Volume Adjustment
Vmic
R43 20k
+Vcc2
C15 680n
R44 3.9k
R45 100k
Rpot 500k
U19 LT1013
U21 LT1013
-Vcc2
+Vcc2
Vmic2
Band Pass Filters
R37 17k
R38 360
C11 4.7n
C12 4.7n
R39 136k
U17 LT1013
R50 28.4k
R51 557
C16 4.7n
C17 4.7n
R54 227k
U22 LT1013
Envelope Detector (Sine to DC Converter)
D8 1N4148
R23 100k
C8 1µ
+V2
U39 LT1013
+Vcc
U16 LT1013
Vbpf5
D3 1N4148
R22 100k
C7 1µ
U38 LT1013
U14 LT1013
Vbpf3
Fire Alarm LED's
R60 10k
R61 10k
Q15 BC547C
Q16 BC547C
R62 1k
R59 330
R58 330
R33 1k
R46 1k
Q12 BC547C
Q11 BC547C
YANGIN1
YANGIN3
YANGIN 1
YANGIN 3
R24 10k
R34 10k
Q13 BC547C
Q14 BC547C
R35 1k
R36 330
YANGIN2
YANGIN 2
Idle LED
R67 10k
R68 10k
Q20 BC547C
Q21 BC547C
R69 1k
R70 100
YANGIN-YOK
YANGIN YOK

7. Results

7.1 Cost Analysis

Table 4, Price of each component used in the wireless fire detection system

Component	Unit Price	Total Amont of Comp.	Total Cost
LM35 Temperature Sensor	3.84 TL	3	11.52 TL
BC547 NPN Transistor	0.11 TL	17	1.87 TL
1N 4007 Diode	0.06 TL	12	0.72 TL
LM 741 Op-amp	0.57 TL	30	17.1 TL
LM 358 Op-amp	0.48 TL	3	1.44 TL
Mini Breadboard 170Point	2.00 TL	3	6.00 TL
BD136 PNP Transistor	0.45 TL	1	0.45 TL
BD135 NPN Transistor	0.53 TL	1	0.53 TL
Heat Sink	2.69 TL	2	5.38 TL
Trimpot	0.62 TL	10	6.2 TL
Elecret Microphone	0.96 TL	1	0.96 TL
50Ω Speaker	3.6 TL	1	3.6 TL
50V Ceramic Capacitor	0.14 TL	4	0.56 TL
63V Polyester Capacitor	0.22 TL	6	1.32 TL
1/4 W Resistors	0.05 TL	55	2.75 TL
22 kΩ Potentiometer	0.69 TL	4	2.76 TL
5mm Led	0.1 TL	4	0.4 TL
Breadboard	6.42 TL	7	44.94 TL
Jumper Cable	0.08 TL	31	2.48 TL
Cable	-	-	Approximately 5 TL

According to the Table 4, total cost is **115.98 TL**.

7.2 Power Analysis

The voltages connected to system are 12 V -12 V and the voltage for indicate idle case. These voltage differences provide the system with current flow.

$$Power = V \times I$$

In equation ,the power delivered to circuit is calculated. The current information, indicated by "I", is gotten from DC power supply.

For four cases; in other words, which room temperature is highest or idle case, the power is delivered to circuit is calculated.

First room temperature is the highest;

Table 5, Voltage sources, currents flow on them and the power.

Voltage	Current	Power
12 V	0.105 A	1.26 W
-12 V	0.034 A	0.408 W

According to the Table 5, delivered total power is 1.668 W based on the Power Equation when First room temperature is the highest.

Second room temperature is the highest;

Table 6, Voltage sources, currents flow on them and the power.

Voltage	Current	Power
12 V	0.106 A	1.272 W
-12 V	0.042 A	0.504 W

According to the Table 6, delivered total power is 1.776 W based on the Power Equation when Second room temperature is the highest.

Third room temperature is the highest;

Table 7, Voltage sources, currents flow on them and the power.

Voltage	Current	Power
12 V	0.088 A	1.056 W
-12 V	0.044 A	0.528 W

According to the Table 7, delivered total power is 1.584 W based on the Power Equation when Third room temperature is the highest.

For Idle Case;

Table 8, Voltage sources, currents flow on them and the power.

Voltage	Current	Power
12 V	0.03 A	0.36 W
-12 V	0.02 A	0.24 W

According to the Table 8, delivered total power is 0.6 W based on the Power Equation for Idle Case.

7.3 Band-Pass Filters Frequency Response

The responses are obtained by the Keysight BenchVue program and drawn at the MATLAB.

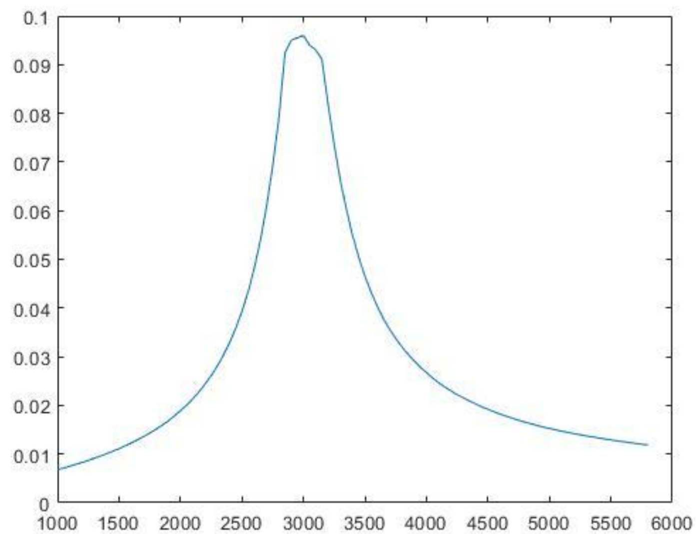


Figure 50 Frequency response for 3kHz band-pass filter

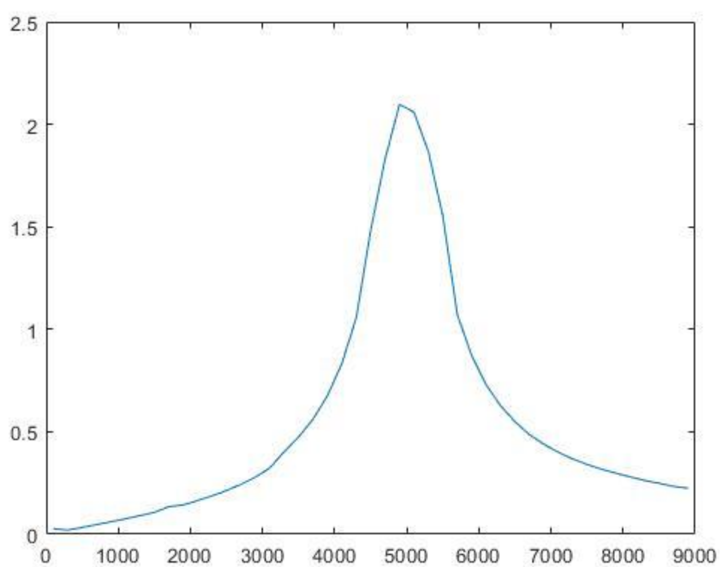
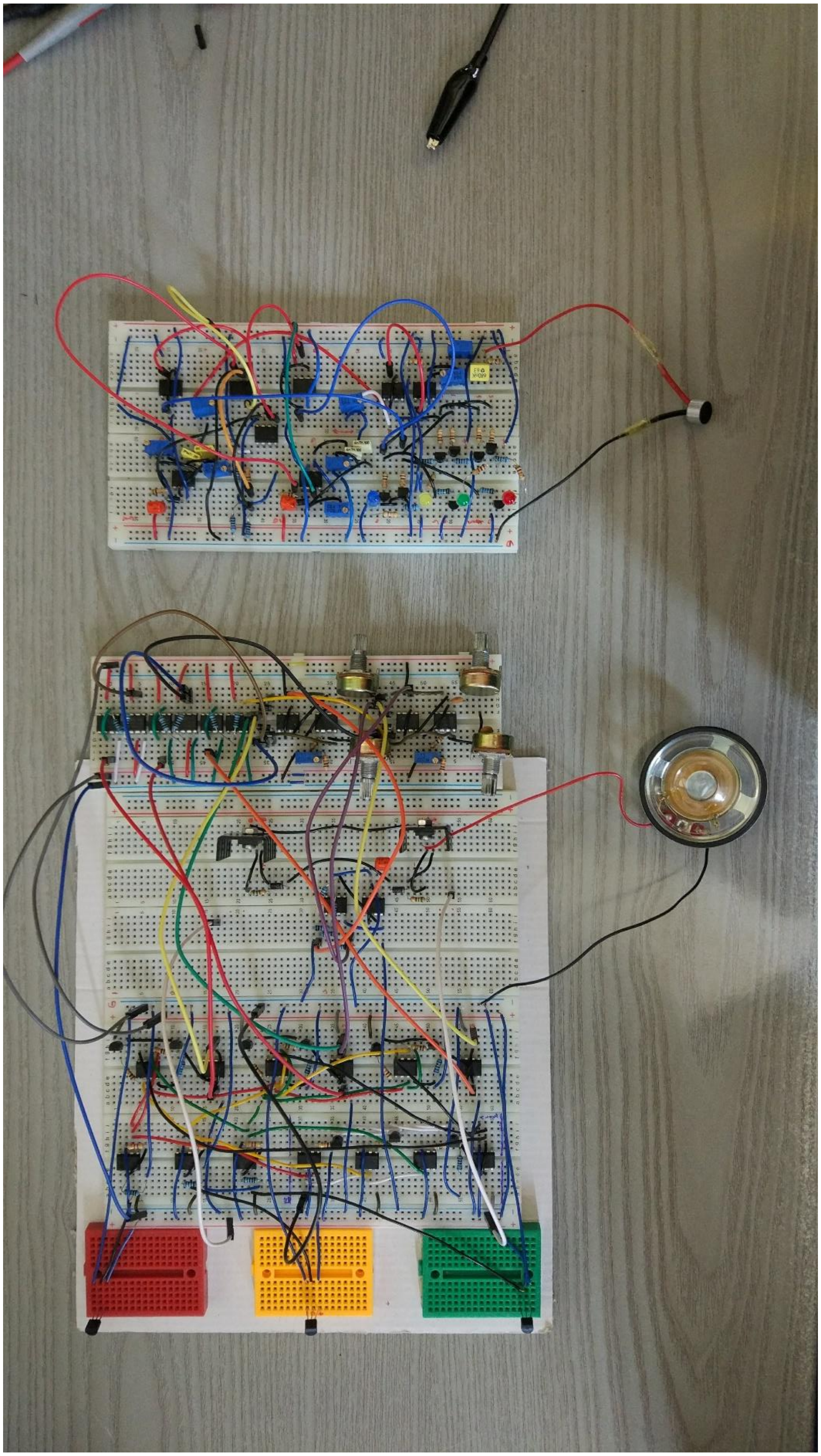


Figure 13 Frequency response for 5kHz band-pass filter

7.4 Illustration



8. Conclusion

In this project we have designed a fire detector from the sketch, and we learned the things below:

1. How to design a band pass filter, adding two band pass filters to increase gain.
2. LM35 can be used in two-way basic mode or the full range mode but we preferred the basic mode because it is a fire alarm and we do not need the (-) degrees.
3. Buffers are very important and useful and very basic units to virtually separate the parts of the circuit from each other so that they won't affect each other.
4. An RC oscillator with transistor could be used as a sine wave generator but we preferred an oscillator with an op-amp because of the difficulty with tuning the transistor to the right operation region.
5. To eliminate the DC part of a signal we can add a capacitor to the output so the capacitor acts as a low pass filter, but the capacitor value should be chosen carefully so that we do not disturb the important signals.
6. Envelope detectors are used to obtain the amplitude of an AC signal.
7. Amplifying a voltage before comparing it is a good idea.
8. AB stages are a requirement for driving speakers and if we do not use them there will not be enough current on the load(speaker). Also, AB stages are the ideal for medium distortion and efficiency. 2 op-amps can also be used to drive a speaker by connecting two of them in parallel so that the gain is increased.
9. Just 2 sine waves are enough to send 2bit (4 state) information wirelessly.
10. Logic gates are very important for decision making mechanisms in the circuits.
11. When we use a led, we should also use a resistor to reduce the current on the led or we can burn it.
12. Some applications of BJT transistors can require cooling because high currents can cause heating on BJT's
13. When sending 2bit data the 00 state is the hardest one to send because it is very open to noise.
14. When we are using semiconductor devices like BJT's and diodes we should be careful about the leakage currents and take the precautions for a good design.
15. To stabilize the BJT circuits we can add a resistor and capacitor between the emitter leg and ground.
16. All different color leds have different characteristics so to light them at the same light level the resistance values may differ from one to another.

17. The breadboards are very fragile instruments, and they may cause connectivity problems especially with trim pots in the next projects the PCBs with holes can be used with solder so that we can focus more to design rather than the connectivity problems.
18. To equalize the output of the envelope detectors using a basic comparator helped a lot for both logic purpose and the accuracy purpose.
19. Being organized while constructing the circuit and not using jumpers all over the place makes debugging proses very easy.
20. We have invented home-made power supply and oscillator. For testing purposes when we do not have an oscillator, we connect a speaker as a probe and measure the signals via a telephone microphone. And if we do not have 2 output power supply, we can connect a battery reverse direction as -12 V and by connecting a multi-meter in series we can also save the circuit from too much current by controlling the value on multi-meter.

9. Changelog

This section of the report shows the main changes made after the pre-report:

1. Added a reverse protection diode to input of power supply connection for safety
2. Sine wave generation changed with a op-amp version.
3. Resistance of Leds increased to lower the power consumption.
4. One of 2 band pass filters in series has been extracted from design because 1 was enough.
5. Inverters added to the V1, V2, V3's to obtain –V1, -V2, -V3 voltages.
6. The resistors at envelope detectors changed with 100k.
7. The summing amplifier now has amplification.
8. Rpot after microphone is set to 500k
9. Added a comparator after envelope detectors.

10. References

[1] BS-657, Retrieved from https://www.olympia-electronics.gr/9FDCD80A.en.aspx

[2] Free flowchart maker and diagrams online, Retrieved from https://www.draw.io/

[3] Texas Instruments. (2017). LM35 Precision Centigrade Temperature Sensor Datasheet. Retrieved from http://www.ti.com/lit/ds/symlink/lm35.pdf

[4] Envelope detector. (2018, April 10). Retrieved from https://en.wikipedia.org/wiki/Envelope_detector

[5] NPN Transistor Tutorial - The Bipolar NPN Transistor. (2018, February 24). Retrieved from https://www.electronics-tutorials.ws/transistor/tran_2.html

[6] Wien Bridge Circuit - The Wien Bridge Oscillator Tutorial. (2018, February 21). Retrieved from https://www.electronics-tutorials.ws/oscillator/wien_bridge.html

[7] RC Phase Shift Oscillator. (n.d.). Retrieved from https://www.electrical4u.com/rc-phase-shift-oscillator

[8] Sarkar, S. (2015, September 10). What is the Barkhausen criterion? Retrieved from https://www.quora.com/What-is-the-Barkhausen-criterion