Department of

Electrical & Electronics Engineering

Abdullah Gül University

Radio Project Report

EE110 Electronic System Design Capsule

Submitted on: 26.05.2019

Submitted by: Electrickers

Group Member: İzzet Korkmaz (110110167)

Ahmet Yasir Cilvez (110110168)

Hamza Karakuş (110110165)

Group Advisor: Abdullah Oran

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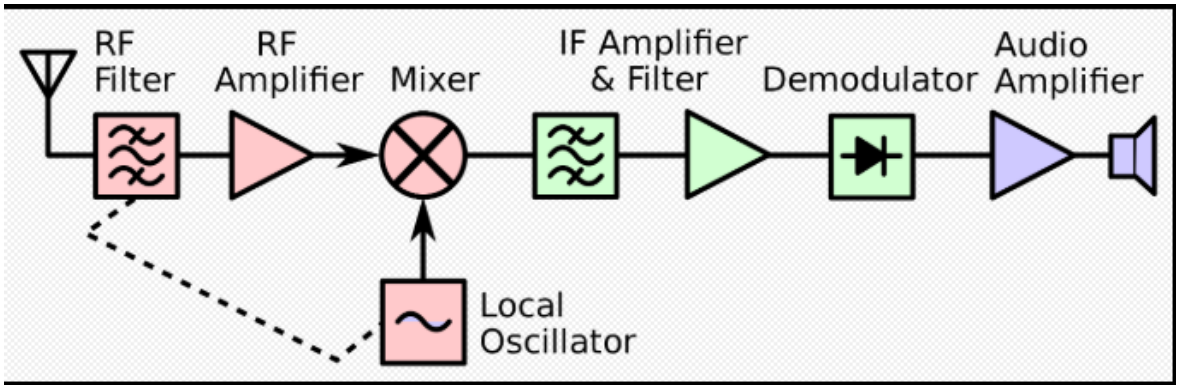


The radio will be done in this order.

OBJECTIVE OF PROJECT

Our objective in this project build and implement an air band FM radio receiver to listen Erkilet airport communication between tower and pilot.

1-ANTENNA

2- RF AMPLIFIER AND FILTER

3- MIXER

4- OSCILLATOR

5- IF AMPLIFIER AND FILTER

6- FREQUENCY DEMODULATOR

7- AF AMPLIFIER AND FILTER

8- AUDIO SPEAKER

1- ANTENNA

OBJECTIVE

Generally, antennas are being used in almost every electrical communication device. Antennas is used for catching or broadcasting electromagnetic waves having signals including valuable information. In our radio project we use an antenna to catch electromagnetic FM radio waves have 122.1 Mhz frequency.

BACKGROUND

The end of our research about antennas, we understand that these components have a lot of kind of different types and they have some mathematical calculations. The common antennas are quarter dipole antennas. In this type, the antennas length equal to quarter of wavelength.

$$ANTENNA'S\ LENGTH = \frac{C}{\lambda}$$

DESIGN AND TEST PROCEDURES

First of all, we calculate the length of antenna by $ANTENNA'S\ LENGTH\ \lambda = \frac{c}{f}$ formula.

However, the previous antenna which was in our buying radio used in this project. The big reason is that, the previous one is more practical and useful.

Working Mechanism

Antenna is occurred by just metal sticks and have just one terminal. Electromagnetic waves in the air, effects conductor materials such as iron, copper. Antennas are a special version of them and it is effected by electromagnetic waves. Waves oscillate electrons on antennas, in this way waves turns to electromagnetic signal on antennas. Basically, antennas catch the electromagnetic waves.

RESULTS AND DISCUSSION

In antenna part, there are a lot of kind of antennas could be used for the radio. We could built our own antenna but using of available antenna is more logical for us.

2- RF FILTER

OBJECTIVE

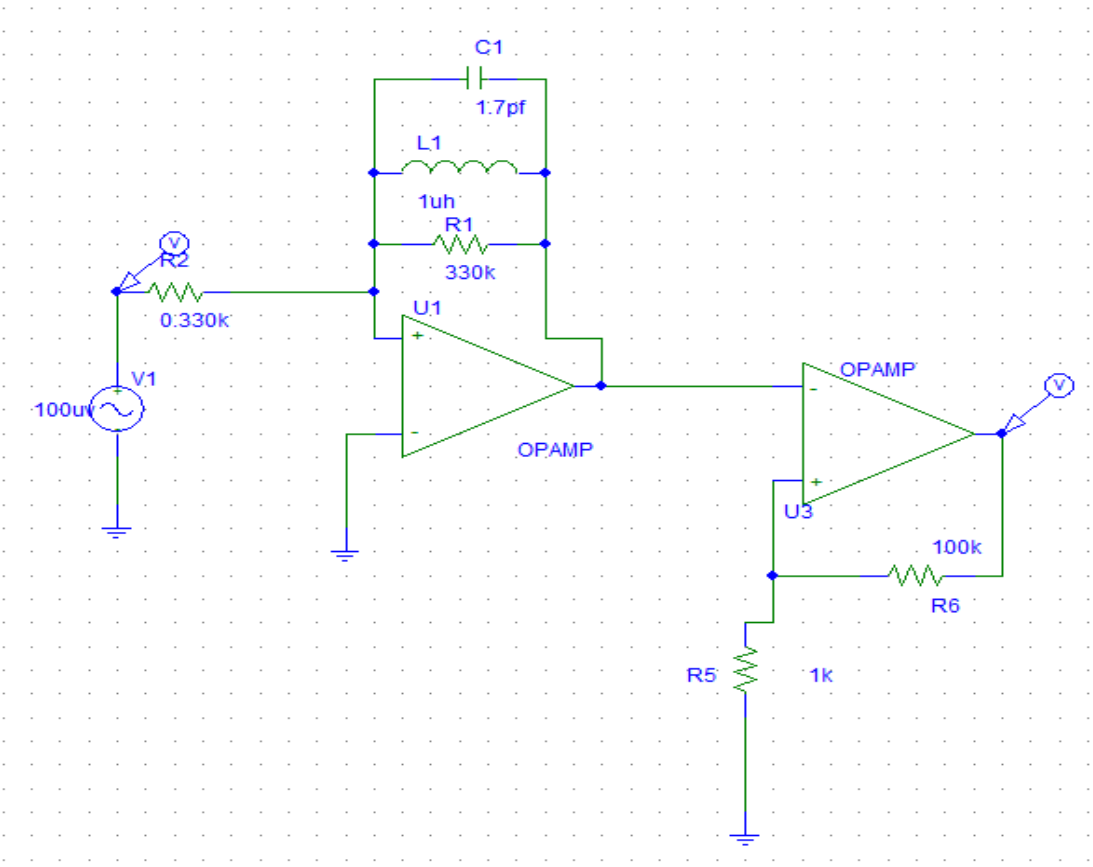
At the Radio Frequency Amplifier (RF Amplifier) part, radio signals capturing by antenna are filtered and increased amplitude of them. The aim of it that selecting and filtering the true frequency because an electromagnetic signal spectrum in air from 1 Hz to GHz.

BACKGROUND

RF filter can be RC and RLC. We use RLC type because of its advantages.

DESIGN AND TEST PROCEDURES

Mainly, RF part includes two parts in it. First filtering. RLC filter is used in our RF filter. RLC filter is a kind of band-pass filter. It has a very sharp interval because of this the true frequency band can be passed. The circuit and equations are:



This is first order RLC filter and amplifier diagram. We use LM7171 Op-amp 0.330k, 0.330k 100k, 330k, 1k resistors, 1.7pF capacitor, 1uH inductor. The cut-off frequency of the filter is gives allowing frequency. Also we can add a changeable capacitor instead of 1.7pF for change the passing band. Equation of it:

$$fc = \frac{1}{2\pi\sqrt{LC}} \rightarrow fc = 122.1\ MHz \rightarrow 1.7pF\ , 1uH$$

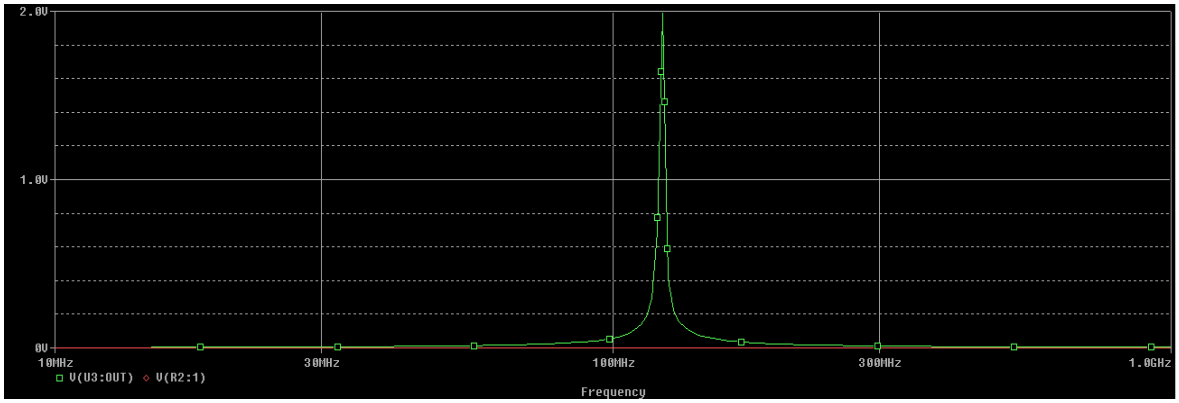
At the first Op-amp we used 0.330k and 330k. The amplitude rate is:

$$\frac{R2}{R1} + 1 \rightarrow \frac{330k}{0.330k} + 1 = 1001$$

At the second Op-amp, we used 100k and 1k resistors. The amplitude rate is:

$$\frac{100k}{1k} + 1 = 101$$

The graph of RLC filter's input and output voltages respect to frequency.



RESULTS AND DISCUSSION

RLC filter is the best choice for us because it has very sharp passing band.

3- MIXER

OBJECTIVE

The essential objection of mixer is multiply both signals which are coming from antenna and local oscillator.

BACKGROUND

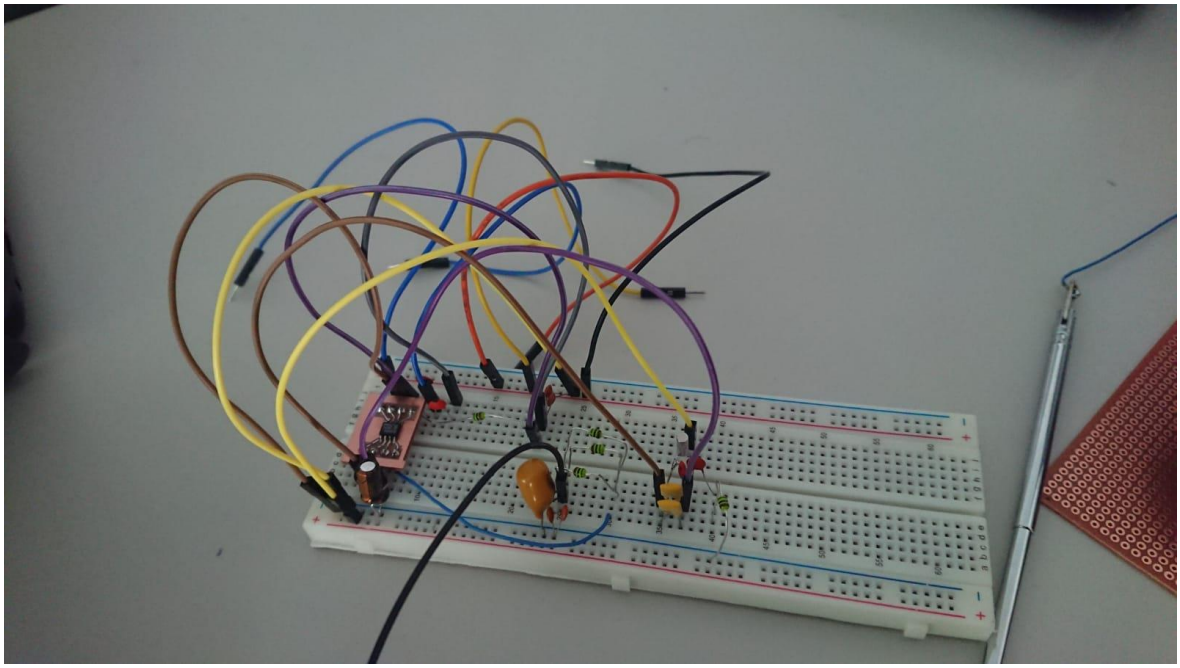
The process of experiment the signal source was used instead of local oscillator in order to get clearer signal. And mixer model is SA602A . it's data sheet was attached.

DESIGN AND TEST PROCEDURES

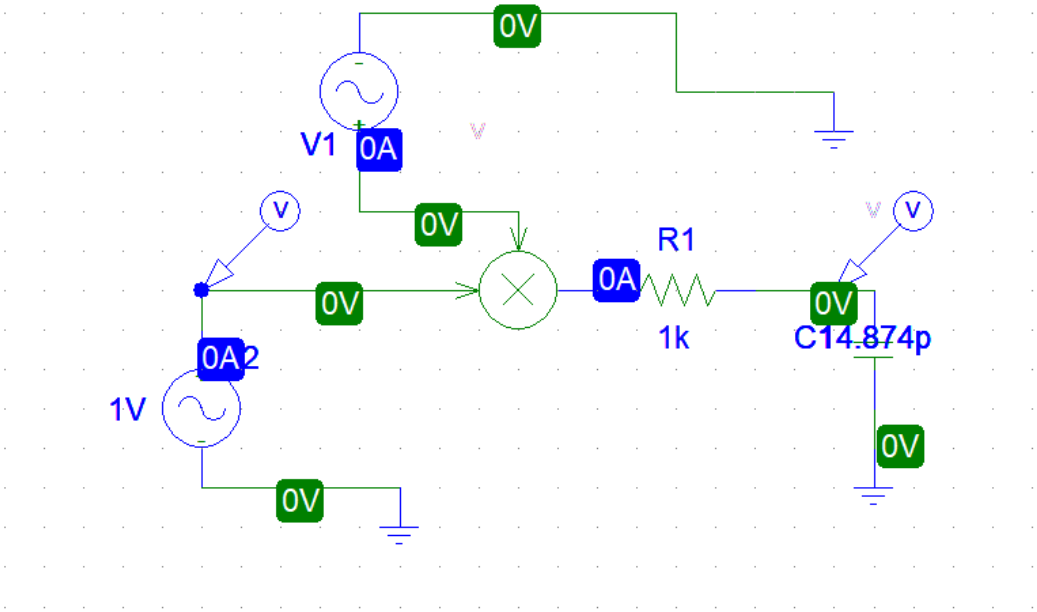
After RF part, mixer part is coming with local oscillator. The essential purpose of mixer is that obtains a low frequency value instead of high frequency. Because work on low frequency is easier than to work with high frequency band. Mixer multiplies both signals which are coming from antenna

and local oscillator. As we know the convolution system again a multiplication equation time domain. If we change the domain from time domain to frequency domain , we obtain directly multiply system.

Circuit of Mixer



Circuit diagram



Equation of mixer:

sum of cos and sin waves (comes from antenna)*our produced cos wave(local oscillator signal)=1/2(cos(a-b)+cos(a+b)) there are two signal which is similar, in here and we filter one of them with low pass filter. And if our local oscillator value is bigger, signal approaches requested frequency ban.

RESULTS AND DISCUSSION

As a result the signal which is requested (10.7 MHz), is obtained and it passes to if filter which has 10.7 cut off frequency, and if the value of local oscillator is changed, as known if filter is constant so we just change the signal

4- LOCAL OSCILLATOR

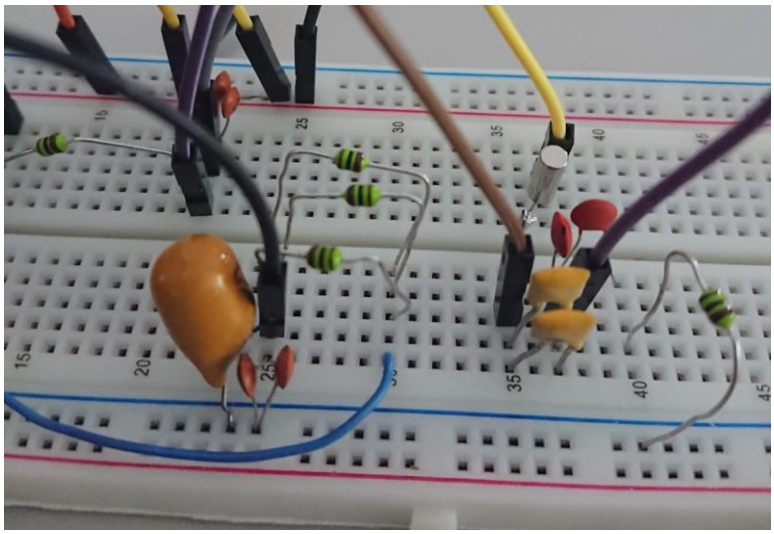
OBJECTIVE

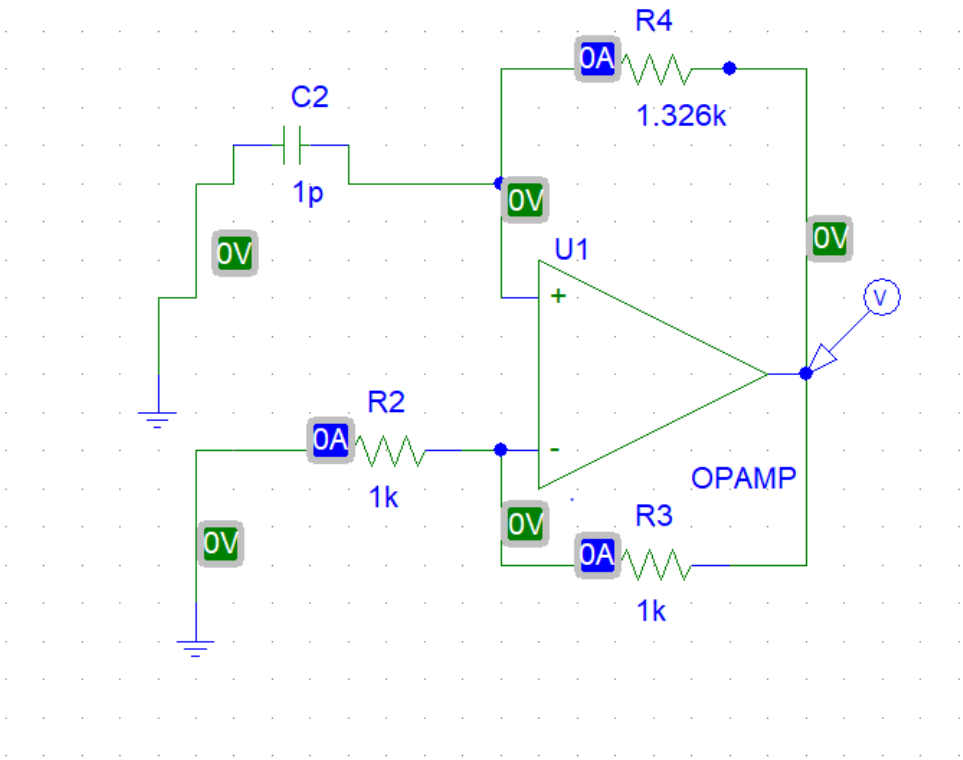
The essential objection of local oscillator is to help the obtaining a signal which is requested (cos or sin wave), to send it mixer and in order to start multiplication process.

BACKGROUND

In order to calculate the system, the filter calculation process was applied. Op amp usage is necessary for this process.

DESIGN AND TEST PROCEDURES





As it shown in the picture, it produces sin waves to provide signal which is multiplying with another signal coming from RF output. Fundamental principles of local oscillator working are behind the filter logic. If the setting of capacitor changes, the requested value is again changing and its formula is the same like cut off frequency formula = 1/2piRC. If the values which are shown above will be chosen, directly 120MHz is obtained. At the same time if the capacitor value is changed, the signals coming from antenna are chosen the again local oscillator value cause if the equation is investigate ½(cos(a+b)+cos(a-b)) . The IF filter is constant to 10.7 MHz so it means if we change the local oscillator value, we have to obtain the same output value 10.7 MHz which is passing through filter, so if we increase the local oscillator we should increase our signal too.

RESULTS AND DISCUSSION

As a result of local oscillator part, local oscillator helps to generate a signal which is necessary and it regulates to find a requested signal.

5-IF AMPLIFIER

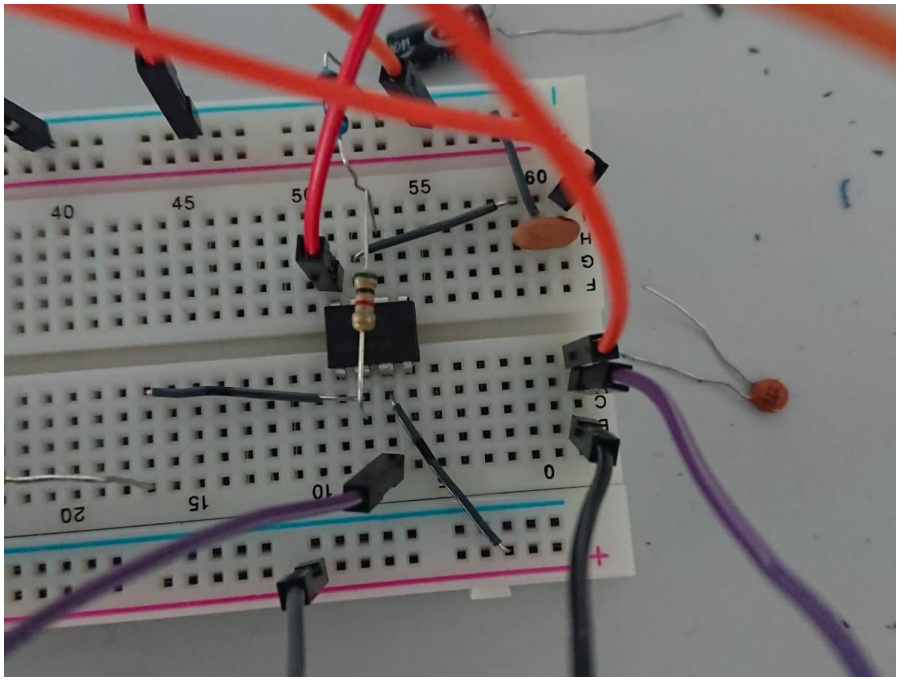
OBJECTIVE

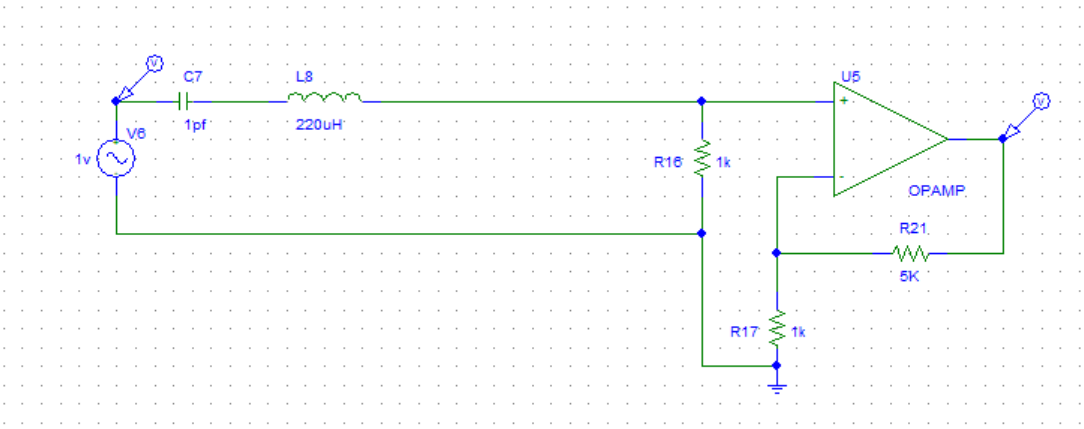
The aim of this part is filtered to output signal of mixer which is subtraction and summation of carrier signal and information signal. Actually our information signal coming at 122.1 MHz and we convert and decrease this signal up to 10.7 MHz If filter allowed 10.5-10.7 band it is so sharp because filter is rlc which is known as sharp filter. And amplifier part we use LM7171 [1] op-amp to increase amplitude of signal.

BACKGROUND

We choose rlc filter because we don't want to take the wide output. We calculated cut-off frequency as 10.7 MHz We use $fc = \frac{1}{2\pi\sqrt{l.C}}$ equation to detect inductor and resistor values.

DESIGN AND TEST PROCEDURES



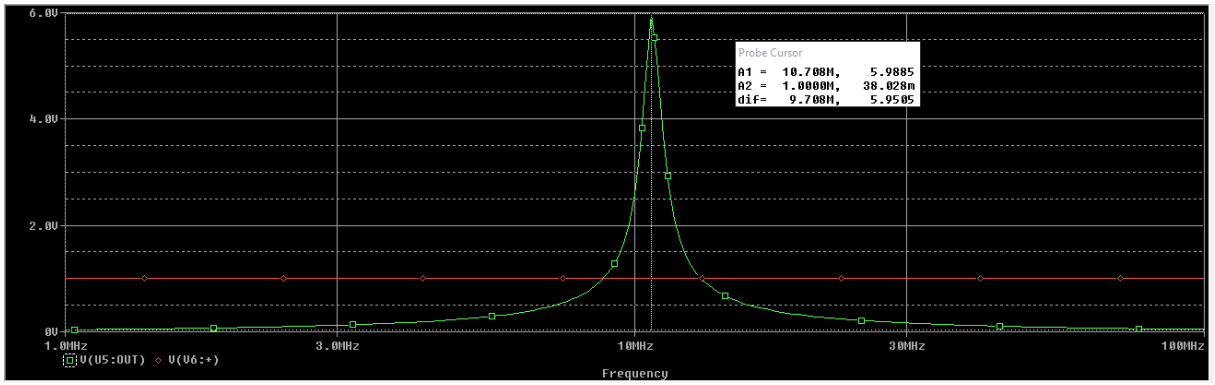


Circuit 1

First of all we detected the inductor, capacitor, and resistor values with cut-off equation mentioned it above. Inductor: 220 uH capacitor: 1 pf and 2 pieces 1k and 5k for amplification and LM7171. After determination we design our circuit with these components.

$$f_c = \frac{1}{2\pi\sqrt{LC}} \Rightarrow f_c = 10.7MHz \Rightarrow LC = \frac{1}{2\pi f_c} \Rightarrow (\frac{1}{2*\pi*10.7*10^6})^2 \Rightarrow 220*10^{-18}$$

Output of Filter and Amplifier :



Graph 1

RESULTS AND DISCUSSION

As an output of if filter and amplifier part which is figured above is work clearly in experiment but our filter doesn't seem to like *circuit 1* because we use available components filter did same job with *circuit 1.* As a result output is very clear filter only allow the 10.5-10.7Mhz band which is great situation for our design because we didn't send a lot of information to demodulator.

Firstly we learn how can I design rlc filter also cut-off equation of this kind of filter. We didn't choose exact value detected in *circuit 1*. Because our devices (multimeter) cannot measure Piko values. We can improve our design with pcb because when we build circuit on breadboard we use a lot of cables it can be better. Output is very sharp, it is unexpected situation.

6-FREQUENCY DEMODULATOR

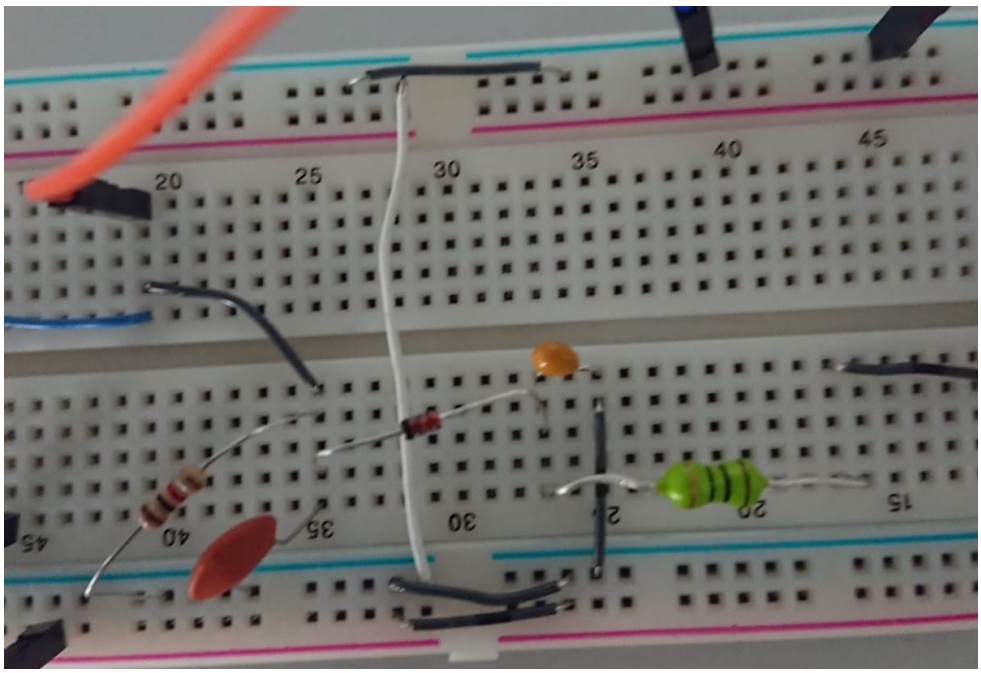
OBJECTIVE

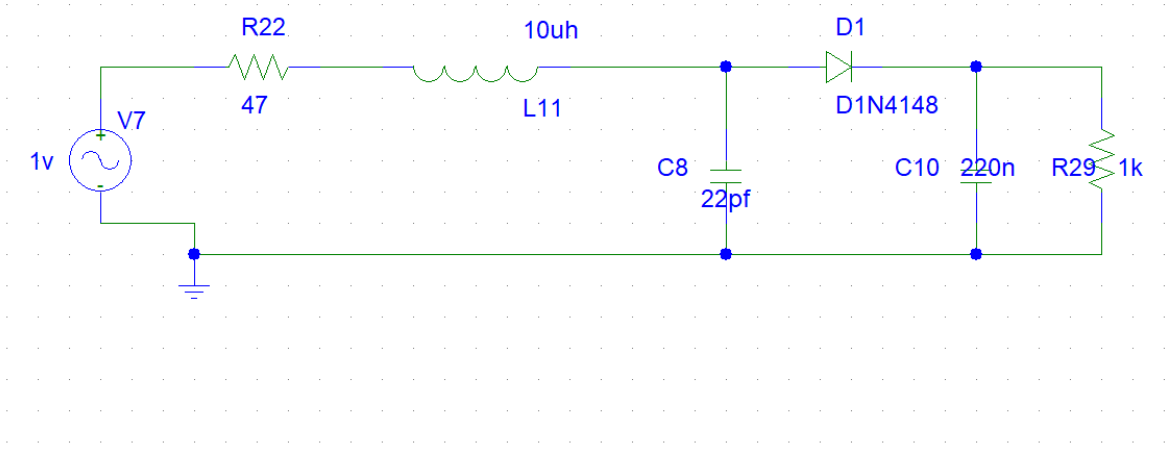
The essential part of demodulator is the demodulate the signal which is modulated to high frequency and turn back is to old situation.

BACKGROUND

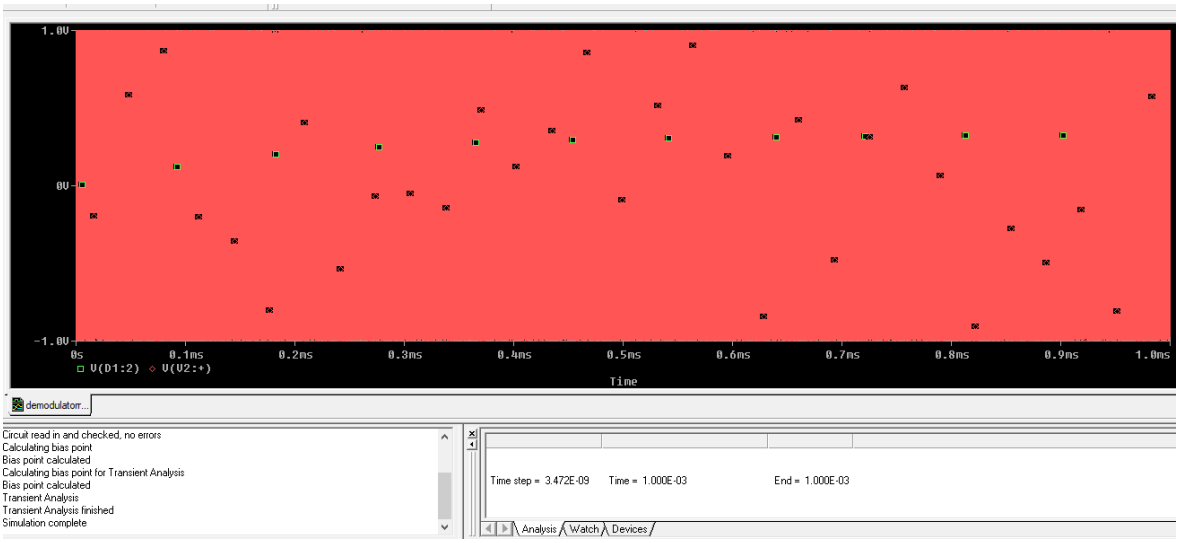
The diode and filter was used during the process. As the shown below modulated signals comes and diode cut its under the zero. And rest of the signal is filtering.

DESIGN AND TEST PROCEDURES





First part of circuit (until diode) is RLC filter and the other one is slope detector as I explained it is again a filtering process. We were dealing with filter it with this circuit. Input of this circuit signal coming from IF amplifier and it is 10.7 MHz and output of this system was obtained 1 kHz and 3 kHz voice to move it speaker. And slope detector passes through signals with noise and it named deviation. Deviation determines passing amount of noise if it is more the voice has a lot noisy if it is less it



RESULTS AND DISCUSSION

As a result of this process to hear a speech which is modulated with demodulation process.

7- AF AMPLIFIER AND FILTER

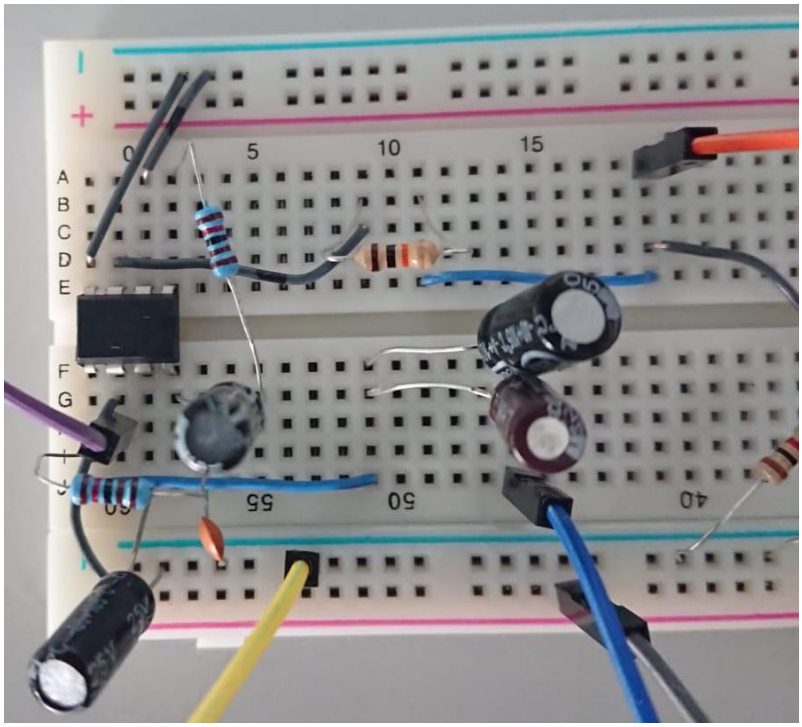
OBJECTIVE

We filtered output of demodulator for hearable sound by people because human hears between 0-20kHz. And also we can set volume level in amplifier. Therefore AF parts can boost signal or cut signal.

BACKGROUND

We build filter at 1916 Hz for maximum amplitude. And we use $f_c = \frac{1}{2\pi\sqrt{LC}}$ this equation to calculate inductor and capacitor.

DESIGN AND TEST PROCEDURES



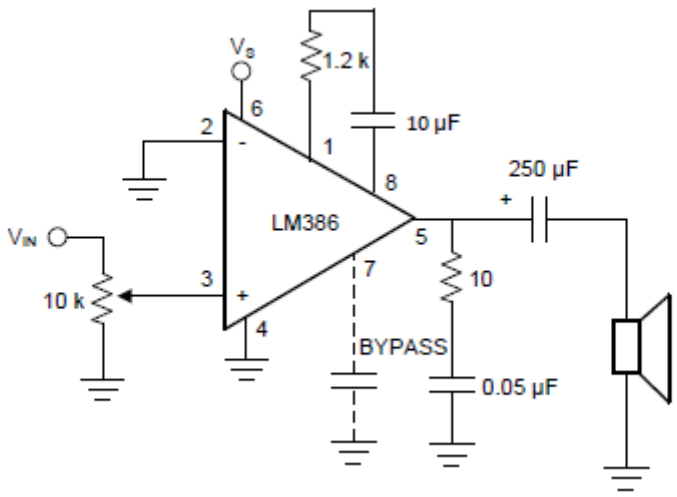
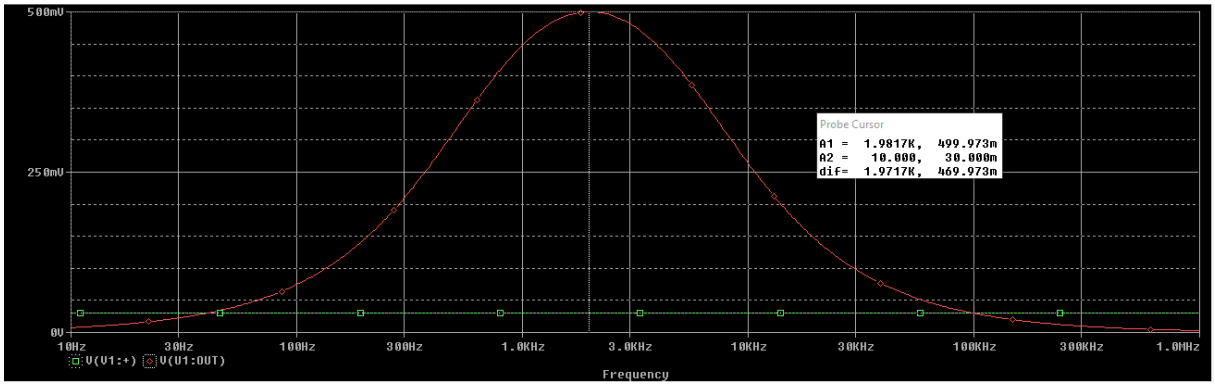


Figure 1

(I take picture of circuit from LM386's datasheet because there isn't LM386 op-amp in pspice so that i must take picture.)

$$f_c = \frac{1}{2\pi\sqrt{LC}} \Rightarrow f_c = 1920Hz \Rightarrow LC = \frac{1}{2\pi f_c} \Rightarrow (\frac{1}{2*\pi*1920})^2 \Rightarrow 6.9*10^{-9}$$

We use this equation and values for simulation because we couldn't build *figure 1*. So that after here results are not belong to *figure 1* but results are very similar with this *figure 1*. We use LM386 [2] known as audio amplifier because gain is greater then LM741 and its working band wide. *Figure 1* has approximately 50 gain so about 48 dB. Radio components 10 k is for change volume level, 1 to 8 pin are using for gain 7th terminal for bypass to isolate noise and output (5th) terminal we connect filter and speaker. Also we use 0.5 watt speaker which is taken from digital radio.



Graph 2

This graph is from rc filter circuit therefore passing signal band is wide. And approximately it is filtered 1.918 hz.

RESULTS AND DISCUSSION

As a result we try this module. This module worked correctly and also we can change volume level with potentiometer. Firstly, we learn new type op-amp as a group first demo it came very different because its terminals are different other op-amps which is used other parts of radio. For example we only use positive supply to work it. Yes results were as expected. Sound can hear clearly.

8- SPEAKER

OBJECTIVE

At the end of the radio, electrical signals are converted to audio signal by audio speaker. Because electrical signals cannot be heard directly, speaker generates vibration with uses signals.

BACKGROUND

Audio speakers are being used almost every electronic devices giving sound. This component's using is very easy and it is very cheap.

DESIGN AND TEST PROCEDURES

An audio speaker's generating is very hard to us. It requires some materials and we are far from them. For this reason, we used audio speaker coming from our available radio. Despite the fact that there are audio speakers in lab, we didn't choose it because our previous radio's audio speaker requires less voltages to working.

Working Mechanism

Audio speaker has to pole which are positive and negative sides. The signal which must be converted to sound waves goes directly to speaker's positive side and it is converted to sound waves. In this process, audio speaker's constant magnet and temporary electrical magnet effect each other and we can hear the sound.

RESULTS AND DISCUSSION

Audio speaker is working very well and this part is very easy.

CONCLUSIONS OF THE PROJECT

The radio is occurred by 8 steps. From antenna until audio speaker, the radio catch electromagnetic radio waves and converts to audible sounds and information is understood. Also while radio is being done, a couple of problem were meet. The components requiring are not in AGÜ labs and Turkey, alternative components were searched and ordered such as LM7171, LM386, capacitors, inductors etc. Power supplies which is in lab was decided to use for provide electricity instead of battery. To be activating of Op-amps, 9V DC current is preferred.

REFERENCES

[1] http://www.ti.com/lit/gpn/LM7171

[2] **http://www.ti.com/lit/ds/symlink/lm386.pdf**

[3] PSpice

[4] Capsule Slides

[5] https://www.nxp.com/docs/en/data-sheet/SA602A.pdf