BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY

Department of Electrical and Electronic Engineering

Course No: EEE 208 **Group No:** 06
Course Title: Electrical Circuits II Laboratory **Section:** B1

PROJECT REPORT

Name of the Report: Frequency Mixer with OP-AMP

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1) Introduction :

In electronics a frequency mixer is a nonlinear electrical circuit that can produce new frequencies from two applied signals. In its most common application, two signals are applied to a mixer and it produces new signals at the sum and difference of the original frequencies. Other frequency components may also be produced in a practical frequency mixer. Moreover, frequency mixers are in use to modulate a carrier signal in radio transmitters as well.

Normally a frequency mixer is a 3 port device used to mix two RF signals, which are applied to the input ports of the mixer (port 1 & 2) and generate new RF signals at the 3rd port at the frequency, which is the sum or difference of the provided RF signals to the mixer.

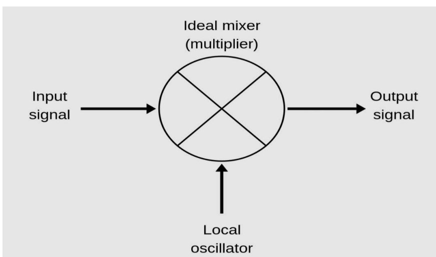


Figure : Frequency mixer

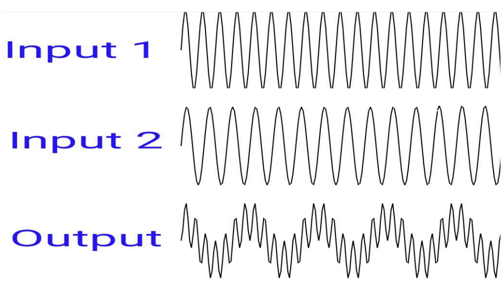


Figure: Sample input and output

Theory:

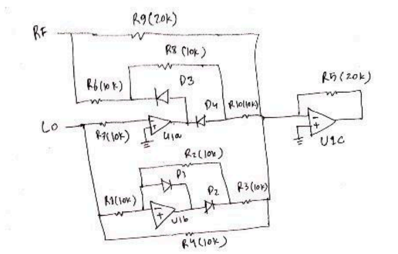
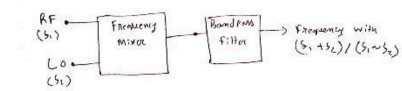


Fig: Main Frequency mixer



Circuit diagram is given. We will examine it part by part .

Analysis: We will now analyze the operation of frequency mixer circuit using 50Hz Frequency as RF and 40 Hz frequency as LO.

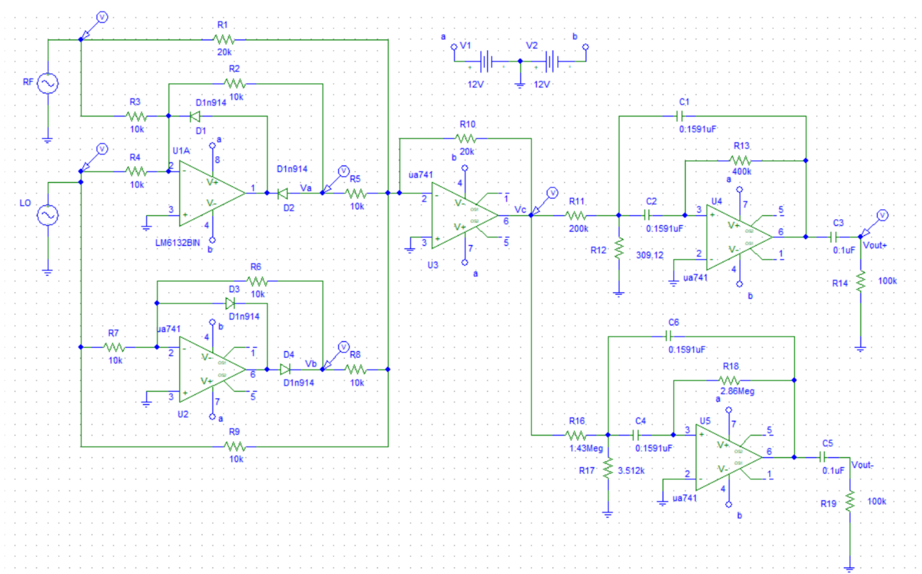
2) **Simulation Software:**

PSpice 9.2

Module /part:

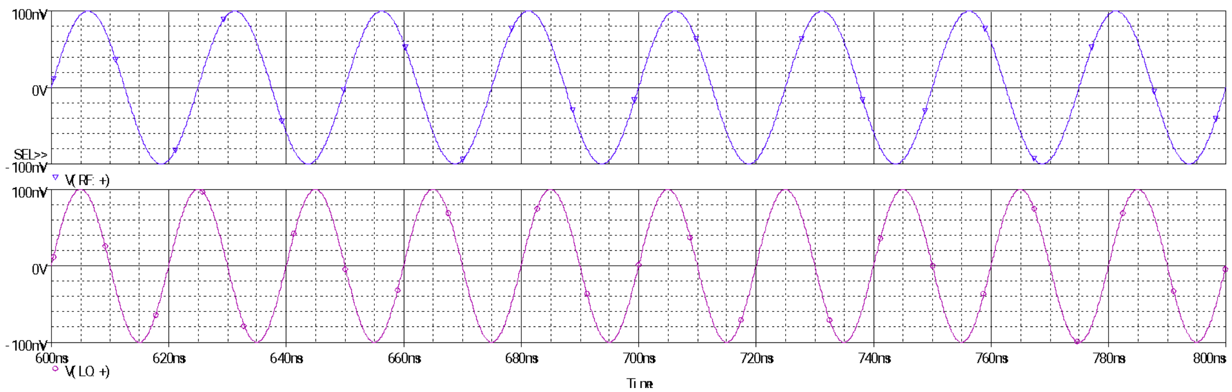
1) Op-amp: UA 741/LM132BIN
2) Diode (D1n914), Capacitor, Resistor
3) Power Supply (VDC), VSIN

3) Schematics

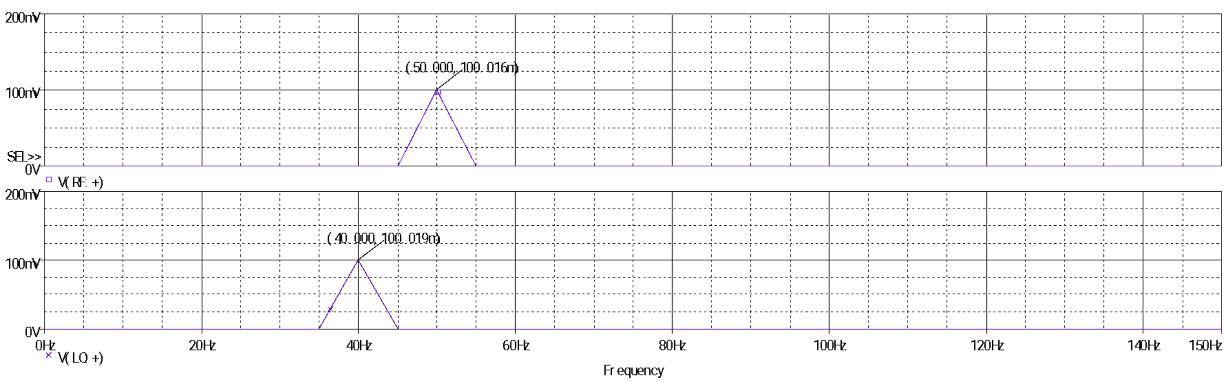


Simulation:

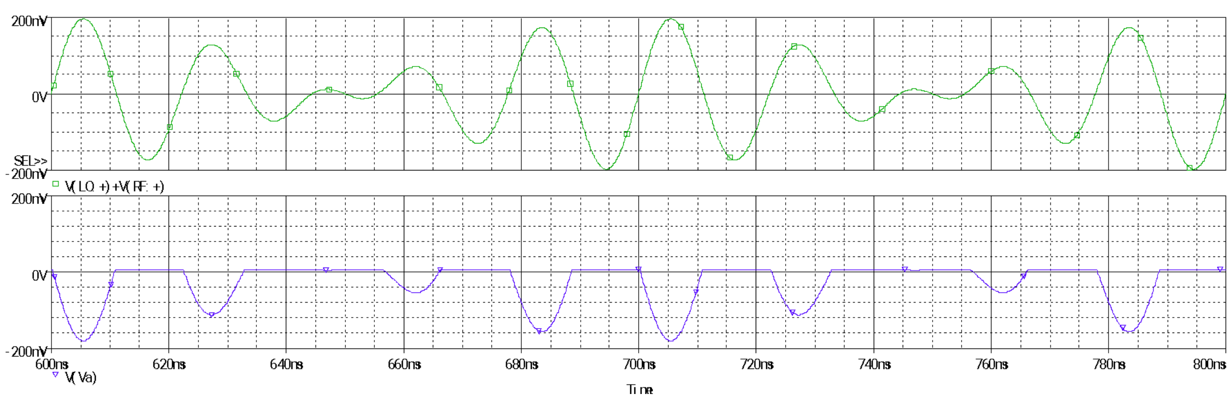
VIN: Time Domain:



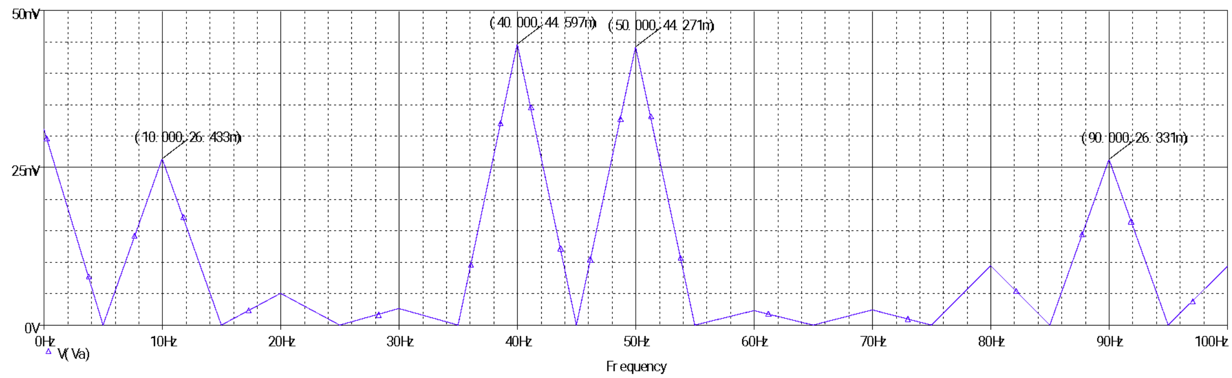
Frequency domain:



Va: Time domain:



Frequency Domain:



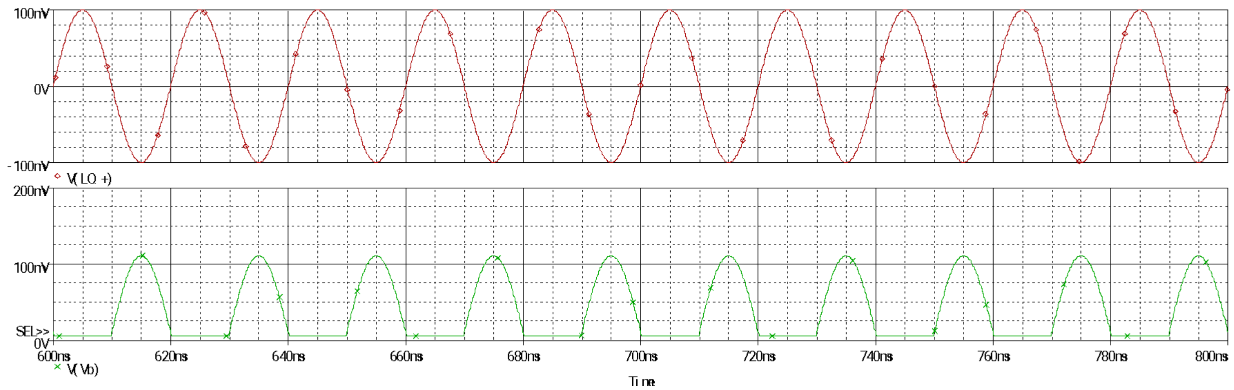
Time domain graph explanation: Here input to U1 is LO and RF. Modified precision wave rectifier is used here. Now, let's assume diode D1 is conducting. So, inverting input terminal to output terminal is complete through D1. So, we get negative feedback consisting D1. Now, applying virtual ground theorem Inverting input of U1 is at ground potential. Since diode D1 is conducting it will have a 0.7V drop. So, output terminal of U1 will be at 0.7V. Applying KCL at Va (Va/R5+Va/R2=0) , and assuming D2 is not conducting in this condition. This KCL results in Va=0. So voltage across D2 is -0.7 , so it is non-conducting as assumed. But since D1 is conducting, in order to satisfy KCL current should flow from inverting input terminal to source. This is only possible when input is negative. So, we get 0 output at negative cycle of RF+LF.

Now, let's assume diode D1 is non-conducting. So, inverting input terminal to Va through D1 is open circuited. To satisfy this current need to flow from source to virtual ground. This is possible if source voltage is positive. Also, current needs to flow from virtual ground to Va of U1 through R2. Hence, Va will be negative and current needs to flow from virtual ground to output of U1 through R2 and D2. So, D2 is conducting and the effective circuit is nothing but an inverting summer.

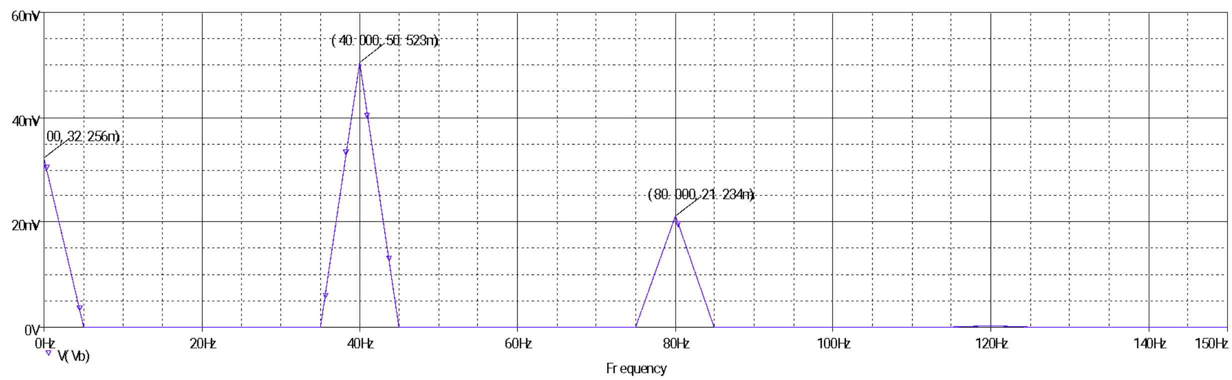
So, this circuit allows only positive half cycle and inverts it to negative half cycle.

Frequency domain graph explanation: Here two signal is getting summed and rectified. So, we get their individual frequency, their cumulative and differential frequency to have major peak. We get minor peak due to their even order harmonics. Odd order harmonics do not appear. Some harmonics seem to have larger amplitude due to superposition of fundamental frequencies.

Vb: Time domain**:**



Frequency domain:



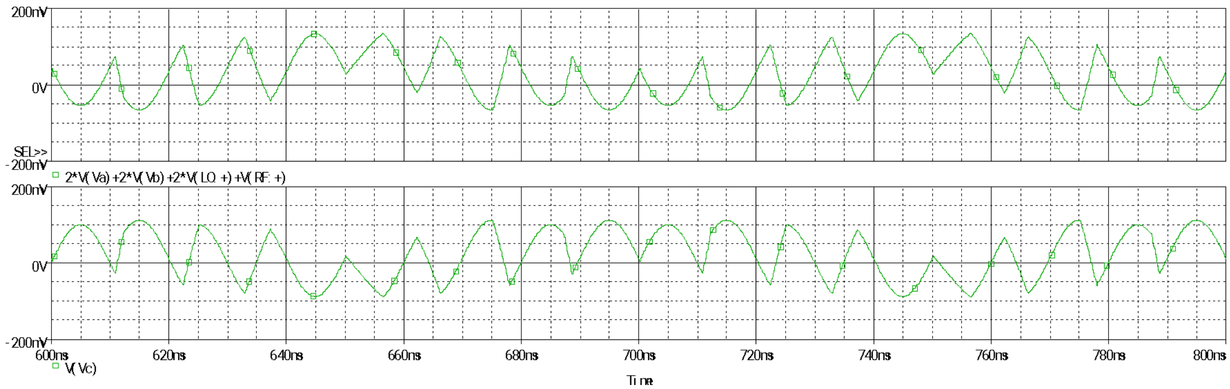
Time Domain Explanation: Here input to U2 is LO. Modified precision wave rectifier is used here. Now, let's assume diode D3 is conducting. So, inverting input terminal to output terminal of U2 is complete through D3. So, we get negative feedback consisting D3. Now, applying virtual ground theorem Inverting input of U2 is at ground potential. Since diode D3 is conducting it will have a 0.7V drop. So, output terminal of U2 will be at -0.7V. Applying KCL at Vb (Vb/R8+Vb/R6=0) , and assuming D4 is not conducting in this condition. This KCL results in Vb=0. So voltage across D4 is -0.7 , so it is non-conducting as assumed. But since D3 is conducting, in order to satisfy KCL current should flow from source to inverting input terminal. This is only possible when input is positive. So, we get 0 output at positive cycle.

Now, let's assume diode D3 is non-conducting. So, inverting input terminal to Vb through D3 is open circuited. To satisfy this current need to flow from virtual ground to source. This is possible if source voltage is negative. Also, current needs to flow from Vb to virtual ground of U2 through R6. Hence, Vb will be positive and current needs to flow from output terminal of U2 To Vb through D4. So, D4 is conducting and the effective circuit is nothing but an inverting amplifier.

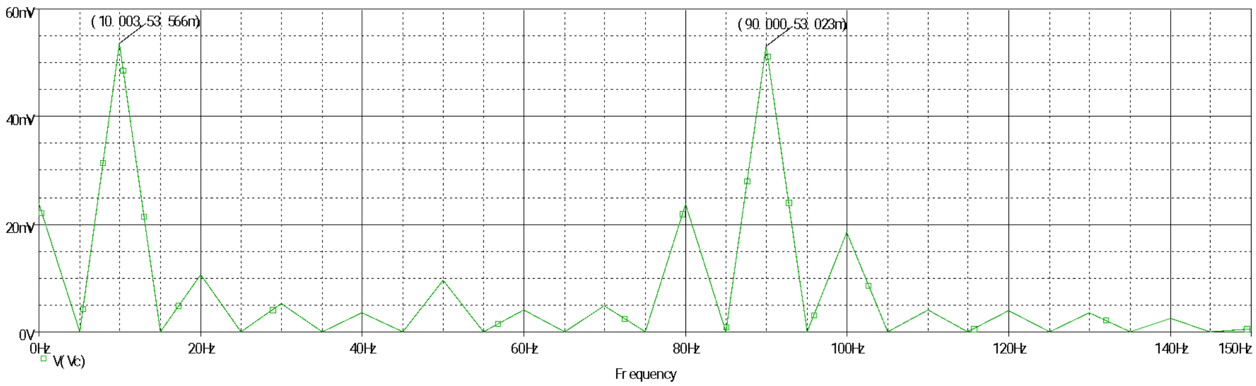
So, this circuit allows only negative half cycle and inverts it to positive cycle.

Frequency Domain Explanation: Here LO is getting rectified. So, we get LO's frequency and its even order harmonics.

Vc: Time Domain:



Frequency Domain:



Time Domain Explanation: RF, LO, Va, Vb is passed thorugh a inverting summer.

Frequency Domain Explanation: Here,-V3=RF+2Va+2Vb+2LO

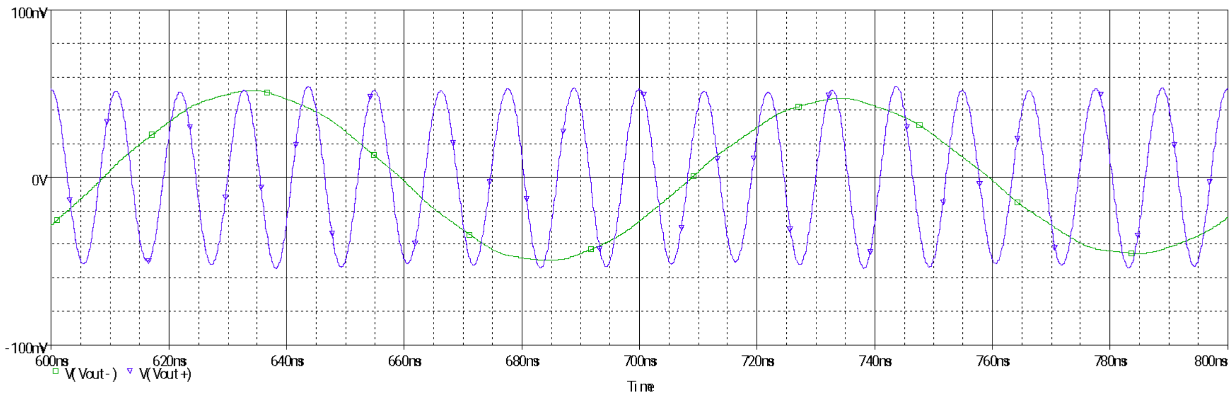
For 40 Hz

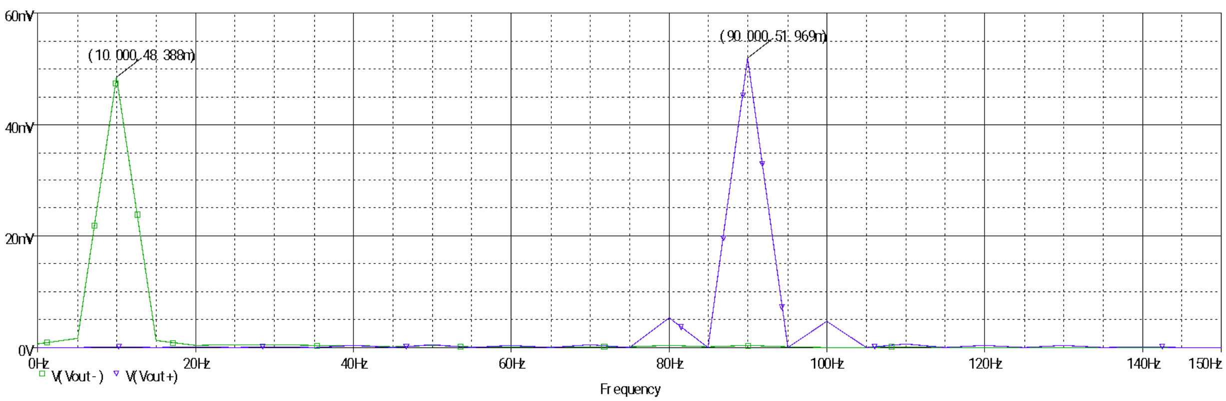
-V3=(2*100)+(-2*45)+(-2*51)+0=8mV

Bandpass Filter Explanation:

Vout:

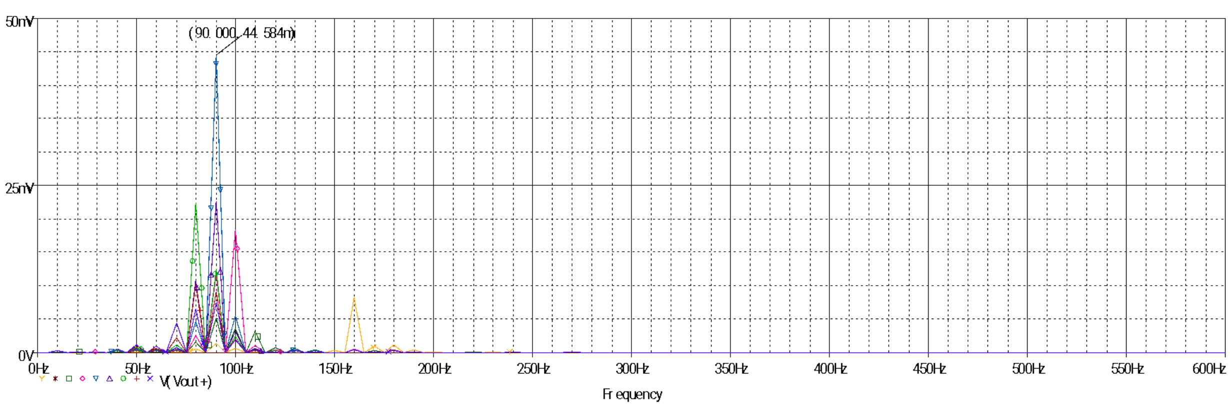
Approach 1: Here we get output by using two filter.





Approach 2:

First, we have to design appropriate bandpass filter. We can get the output by placing a potentiometer in R12.



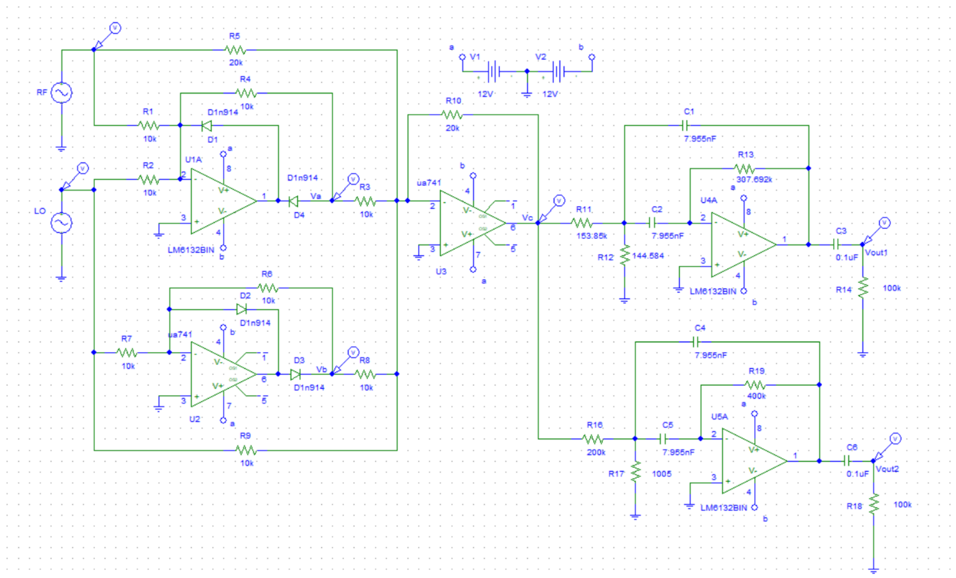
We get maximum output at 90 Hz. That’s how we can minimize the hastle of using two bandpass filter. But it is not efficient in low frequency. But it is convenient above 100 Hz.

4) More Sample Input and Output:

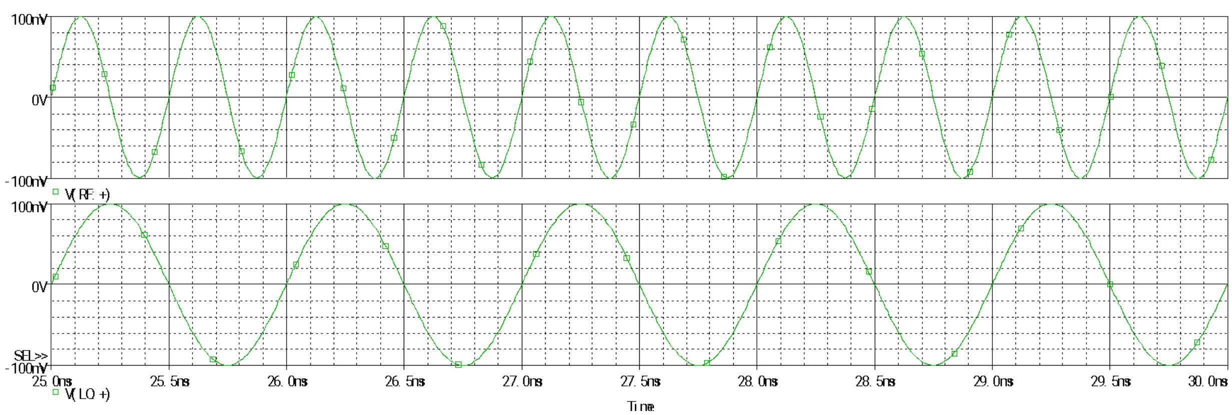
Sample 2:

RF=2kHz, LO=1kHz

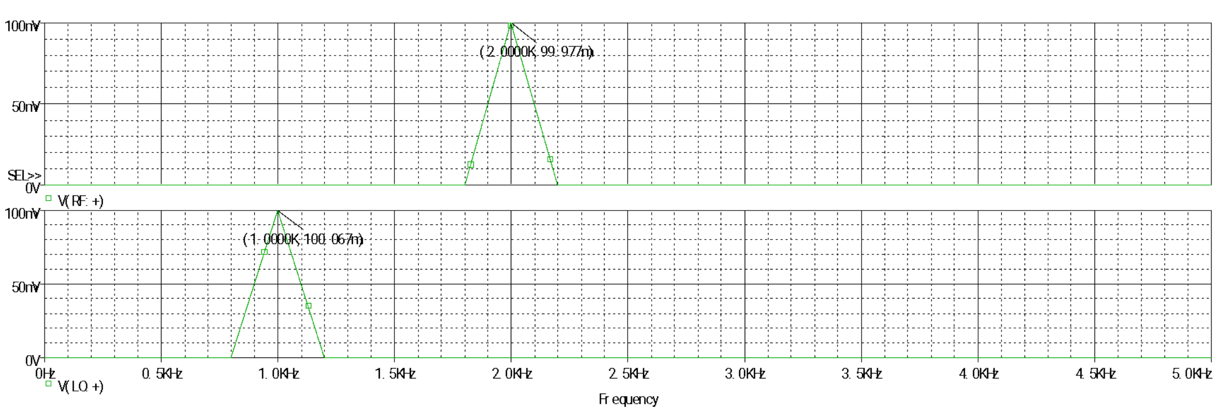
Schematic:



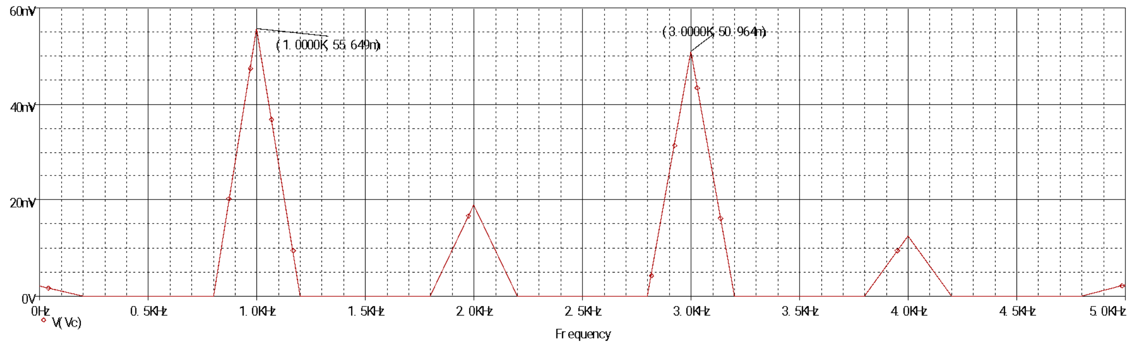
Input: Time Domain:



Frequency Domain:

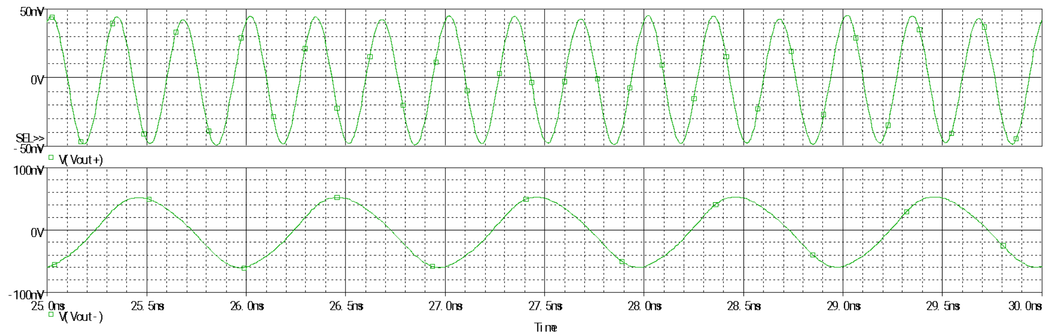


Vc: Frequency Domain:

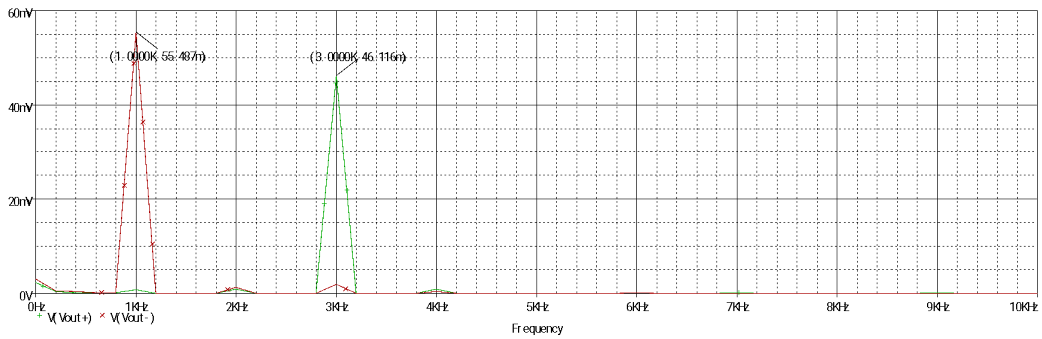


Vout:

time domain:



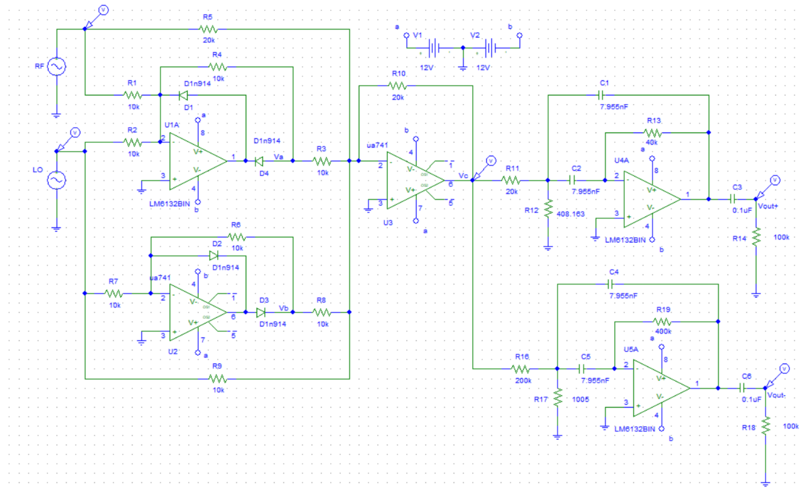
Frequency Domain:



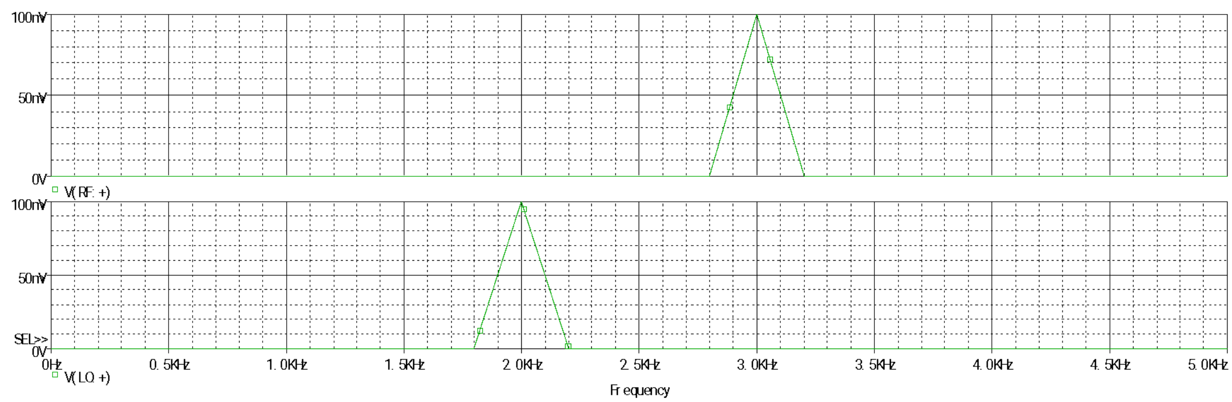
We get output at (2k+1k)=3k and (2k-1k)=1k as expected.

Sample 3:

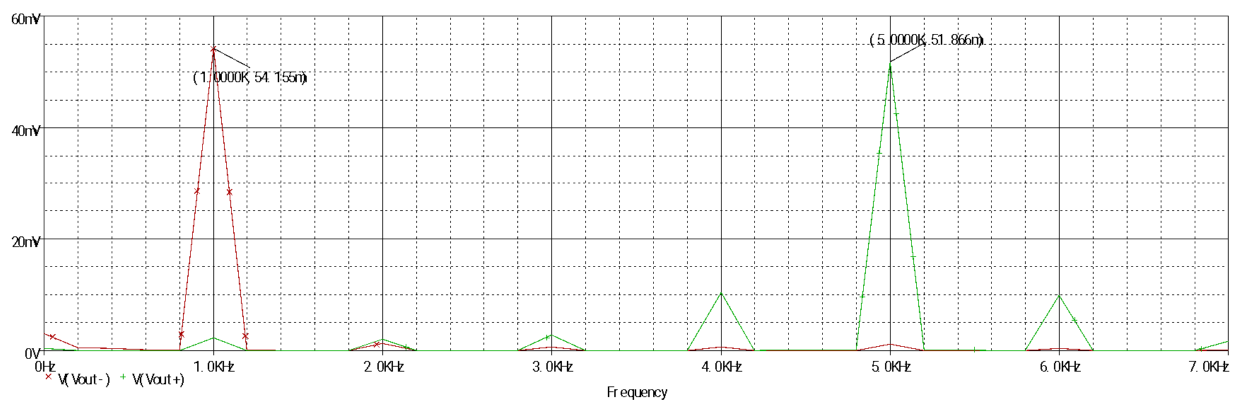
Input:



Input:



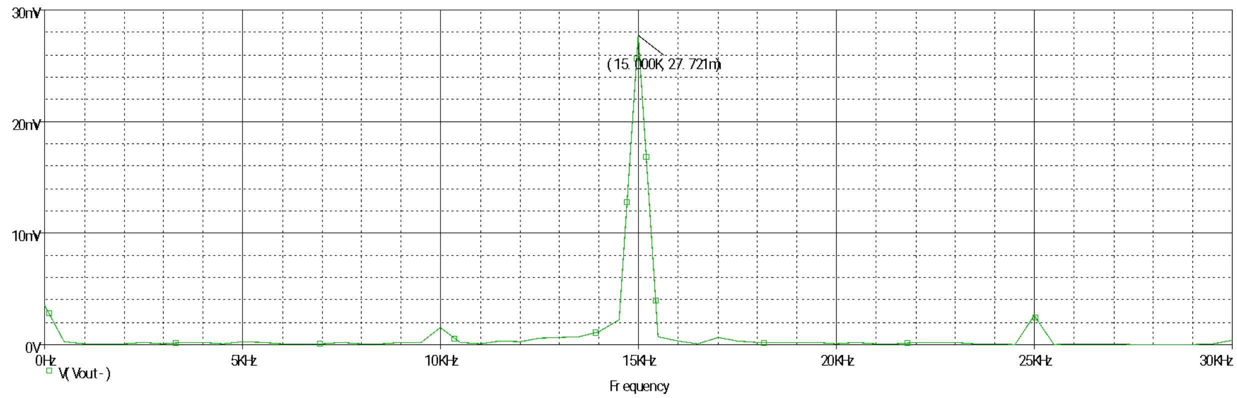
Output:



5) Limitation and scope of improvement:

i) Bandpass filter used cannot filter out garbage frequency in high frequency.

For example, in sample 2 output of bandpass filter is



We can improve it by using op-amp with high quality frequency response.

ii) Use of potentiometer is not useful in low frequency. We can reduce this by using different range potentiometer.

6)Future Work:

Improvement: We can use Proteus to simulate the circuit. User do not need to specify print step, Final time. Also, user can modify the circuit in the middle of simulation.

Applications of Frequency Mixer**:**

- Frequency Mixers are widely used in RF circuits to shift signals from one frequency to another, this process is known as heterodyning, for the further processing of the received signal or the transmission of the processed signal.
- Furthermore, frequency mixer circuits can not only use to shift the frequency of an applied signal, for example, in a receiver but also as a product modulator, detector, frequency multiplier, and phase detector as well
- RF and microwave mixers are primarily used to modulate the original signal with the carrier signal in radio communication transmitters.
- Frequency mixer circuits provide improved functionality in terms of signal transmissions.
- It is used in phase-locked loop as it helps to detect the phase difference between two signals.
- It is used for frequency translation. One major application is in Superheterodyne receiver.

Conclusion:

In this project we implemented the knowledge of electronics and signals and systems. We faced several difficulties for example choosing appropriate op-amp model. We solved this problem by analyzing data sheet of op-amp. We worked as a team to analyze a circuit. We took help from text book. We made error and learned from it. Along with solidifying our knowledge this project showed application of our study, improved our skill to work as a team. Our project has some limitation as mentioned earlier. We hope we can overcome the limitation and make our circuit more efficient.