Course No: **EEE 310**

Course Name: **Communication Laboratory**

<u>Project Report</u>

Project Name: Design of an AM Transmitter and Receiver for Voice signal.

Date of Submission: 23.12.2015

Submitted To

Maruf Ahmed
Lecturer
Dept. of EEE, BUET

Ayaz Mahmud Sezan
Lecturer
Dept. of EEE,BUET

Proposed By

Shuvangkar Chandra Das
Std. ID :1106125
Homeira Islam Kafi
ID: 1106124
Shaikat Chowdhudy
ID:1106127
Rifat Kabir Sharna
ID:1106130

Table of Contents

Figures

Amplitude Modulation:

Amplitude modulation (AM) is a modulation technique in which the amplitude of a high frequency sine wave (usually at a radio frequency) is varied in direct proportion to that of a modulating signal. The modulating signal carries the required information and often consists of audio data, as in the case of AM radio broadcasts or two-way radio communications. The high frequency sine wave (the carrier) is modulated by adding the modulating signal to it in a mixer. A simplified AM radio transmitter system is shown below.

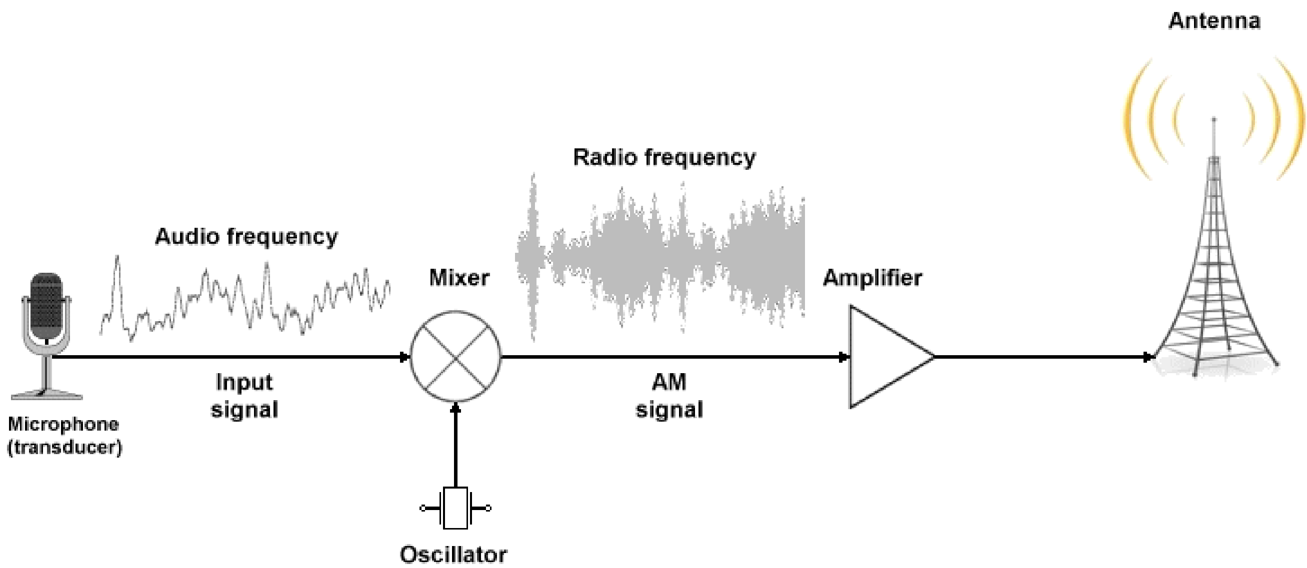


Figure 1: Traditional AM Transmitter

A simple form of amplitude modulation was originally used to modulate audio voice signals onto a low-voltage direct current (dc) carrier on a telephone circuit. A microphone in the telephone handset acts as a transducer, and uses the sound waves produced by the human voice to vary the current passing through the circuit. At the other end of the telephone line, a second transducer (in the form of a small loudspeaker mounted in the remote handset) uses the varying voltage to produce sound waves that are close enough to the original speech patterns to be recognisable as the voice of the caller. Although the human voice is composed of frequencies ranging from 300 to approximately 20,000 hertz, the public switched telephone system limits the frequencies used to between 300 and 3,400 hertz, giving a total bandwidth of 3,100 hertz. This bandwidth is perfectly adequate for purely voice transmission, since the higher frequencies in the human voice (i.e. those above 3,100 hertz) are not really needed for recognizable speech reproduction. The use of a limited bandwidth also makes the telephone system much simpler from an engineering perspective.

Whereas telephone signals can be transmitted at audio frequencies, the same is not really a practical proposition for radio transmissions. The main reason for this is that the optimum length of a radio antenna is a half or a quarter of a wavelength. Since a typical audio frequency of 3,000 hertz has a wavelength of approximately 100 kilometres, the antenna would need to have a length of 25 kilometres to be effective - not a realistic proposition. By comparison, a radio frequency of 100 megahertz would have a wavelength of approximately 3 metres, and could use an antenna 80 centimetres long. It becomes necessary, therefore, to use a radio frequency carrier signal in order to transmit audio signals, which are used to modulate the carrier waveform.

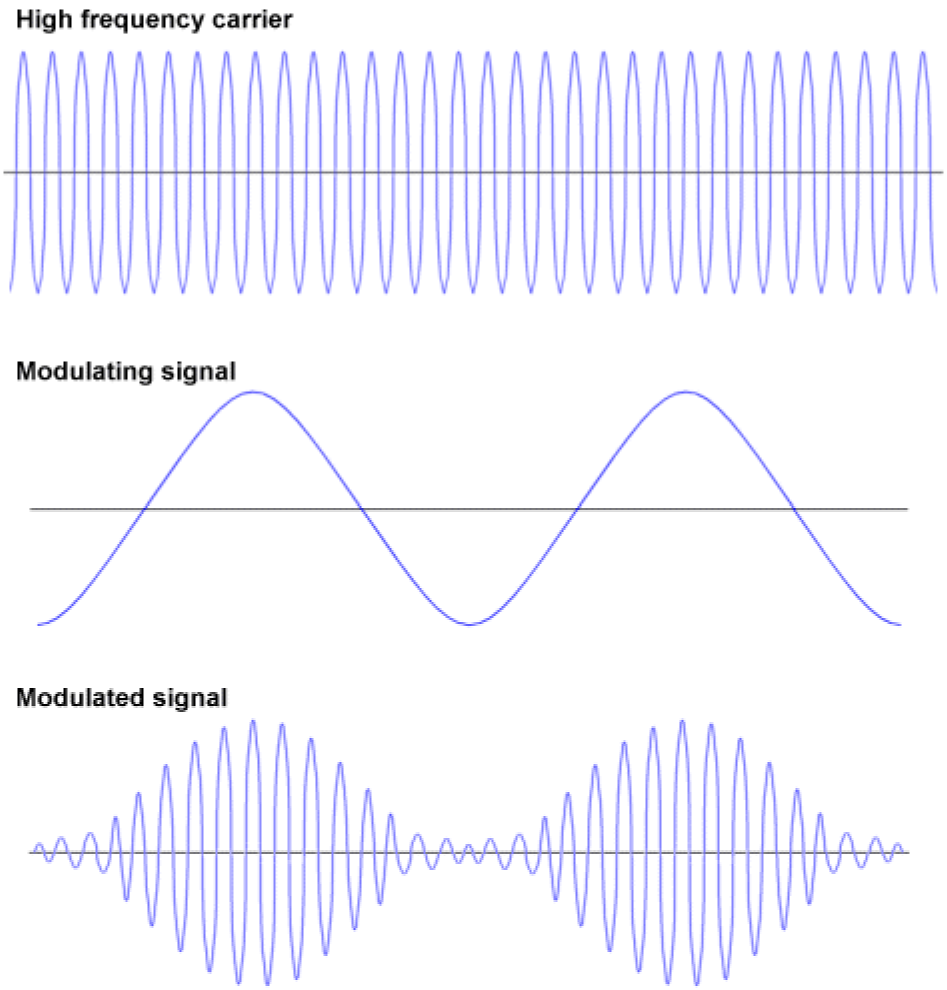


Figure 2:Mixing High Frequency carrier wave with message signal

Most audio signals (speech and music, for example) are far more complex than a single-frequency audio tone, and are composed of many different frequencies. When a carrier is modulated with a more complex audio signal, therefore, all of the frequencies present in the audio signal are represented in the resulting output signal. In this case, the total bandwidth is the difference between the sum and the difference values of the carrier and the highest frequency component of the modulating signal. To simplify things, the modulated signal bandwidth will be twice that of the modulating signal. For a modulating audio signal with frequency components ranging from 0 - 6 kHz, therefore, the bandwidth of the modulated signal for a 100 kHz carrier will be 106 kHz - 94 kHz = 12 kHz. This produces a more complex frequency spectrum, which might look something like that shown below.

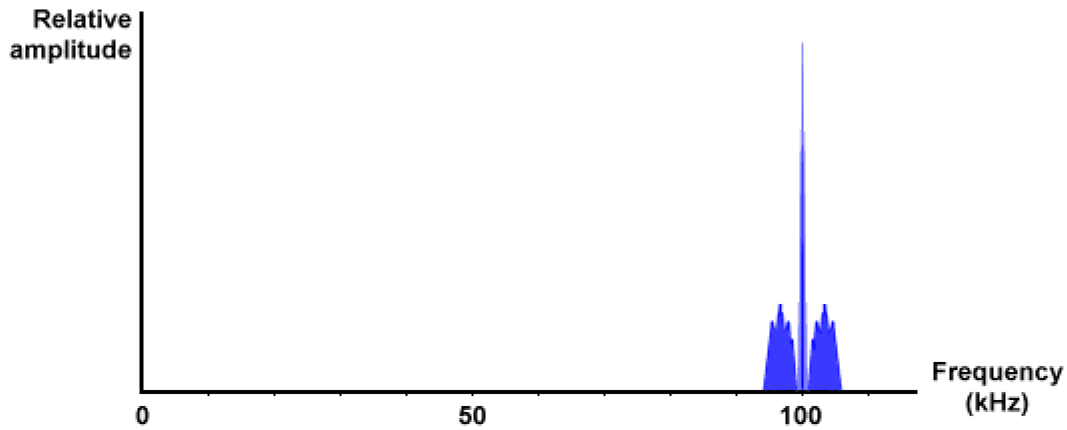


Figure 3: Double side Band Amplitude Spectrum

The bandwidth of each sideband is equal to that of the modulating signal, and the two sidebands are mirror images of each other, each carrying the same information as the original audio signal. This type of basic amplitude modulation, which results in two sidebands and a carrier, is usually referred to as double sideband amplitude modulation (DSB-AM). It is a very inefficient form of modulation in terms of its power usage, because at least two thirds of the transmitted power is concentrated in the carrier signal, with the remaining power being evenly split between the two sidebands. Since the sidebands contain identical information, only one sideband is actually needed to carry the transmitted audio information. The other sideband is redundant, and the carrier signal contains no useful information. DSB-AM is also therefore spectrally inefficient, because fewer stations can make use of a given transmission band. The main benefit of DSB-AM is that, because of its relative simplicity, receiving equipment is cheaper to produce.

Am transmitter Section:

Am transmitter Section consists of 3 sub-circuits.

1. Carrier frequency generator
2. Voice signal Amplifier
3. Amplitude modulator

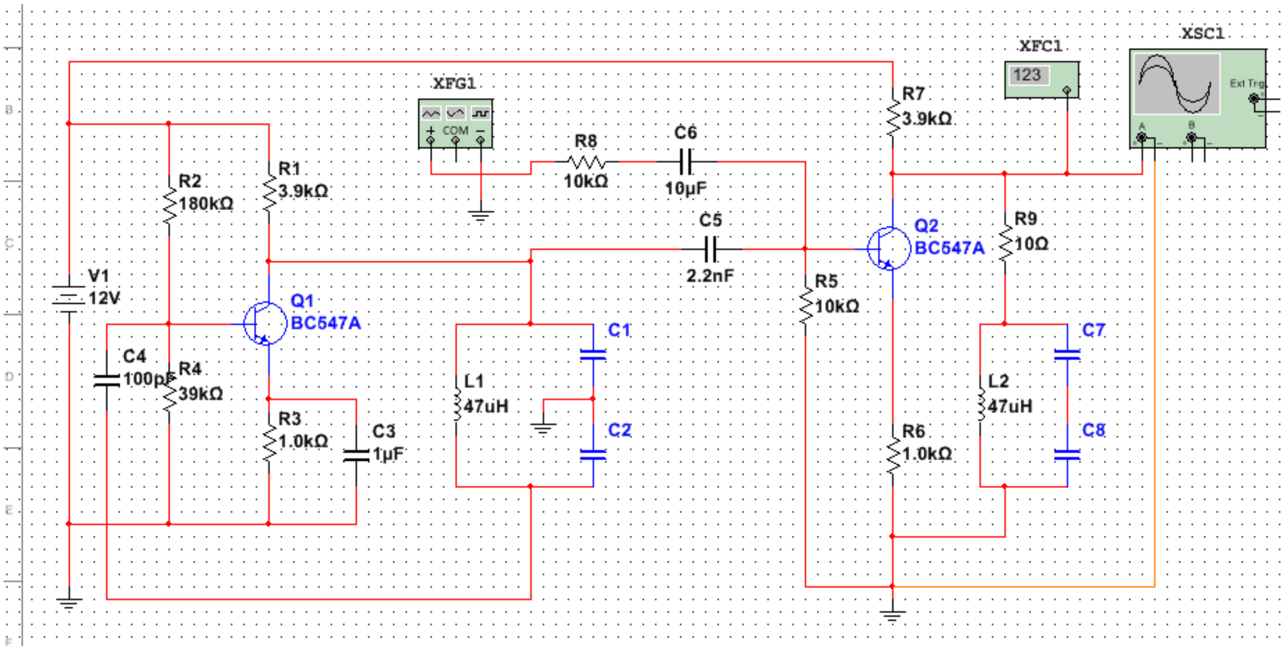


Figure 4: Our designed Transmitter circuit in Multisim 14.0

Carrier Frequency generator:

Normally allotted AM Radio Range is 500kHz-1.6MHz and sinusoidal signal is normally used as carrier frequency. There are many ways to generate carrier frequency within the allotted range. Few types of sinusoidal oscillators are

- Phase Shift Oscillator
- Colpitts Oscillator
- Hartley Oscillator
- Wien Bridge Oscillator

For oscillation to be sustained, certain conditions known as Bark-Hausen criteria, must be fulfilled. These conditions are

I. Loop gain of the circuit must be equal or greater than 1
II. Phase shift around the circuit must be 0 or 360 degree

In our project we use Colpitts oscillator for generating carrier frequency Fc. A brief description of Colpitts Oscillator is given below.

A LC circuit generates Sinusoidal signal at it’s resonant frequency. But it decays after few oscillatons. So There requires an amplifier which keeps amplifier gain greater than 1 and maintains second condition of Bark–Hausen Criterian.

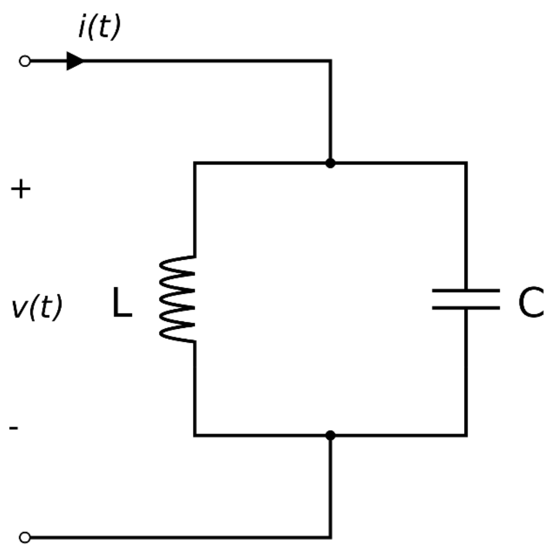


Figure 5: LC tank Circuit

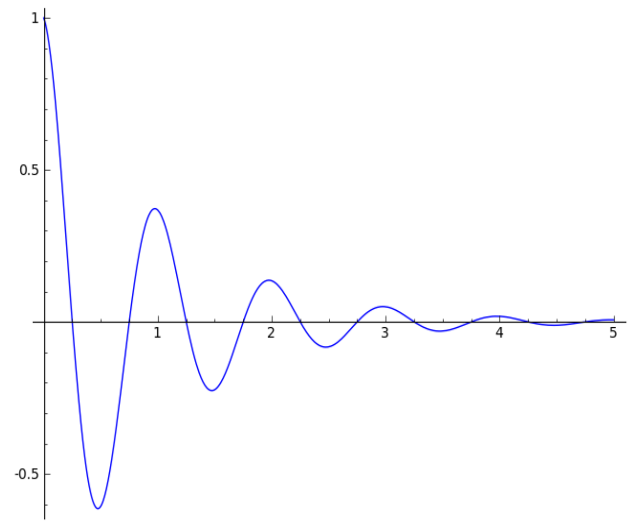


Figure 6: Damping Sinusoidal Signal

We designed an amplifier using Transistor BC547.

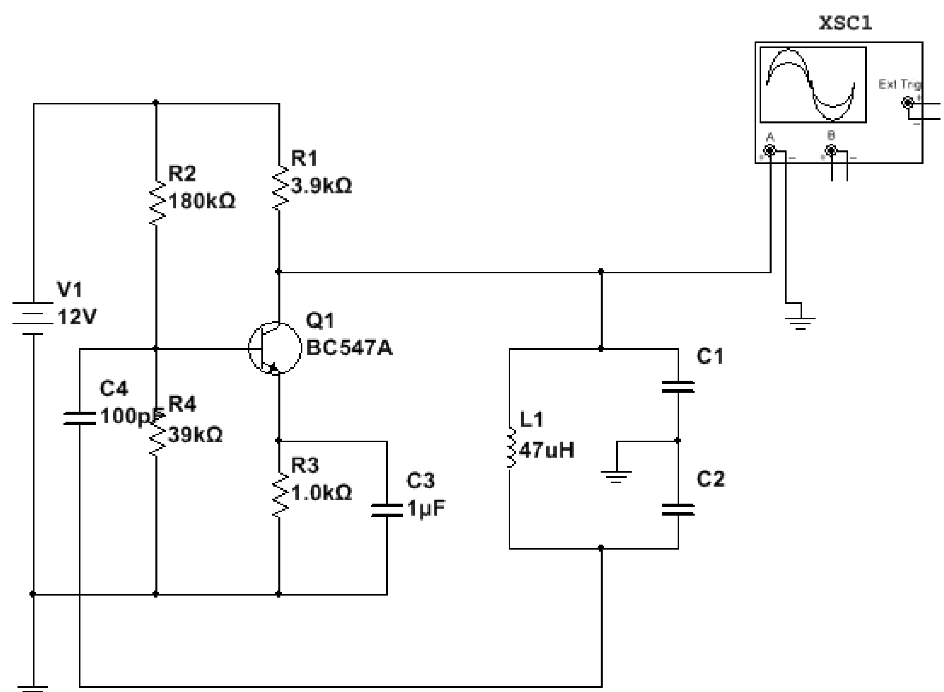


Figure 7: Colpitts Oscillator Schematic section

Here LC tank circuit oscillates in it’s resonant frequency.

Resonant frequency is $f = \frac{1}{2\pi\sqrt{LC}}$. In our circuits we use L= L1=47uH and C1=C2=C=2200pF. After calculation we get resonant frequency $= 494.94KHz \approx 500Khz$.

For simulation we used National Instrument Multisim 14.0. Oscillator output graph from simulation result is given below.

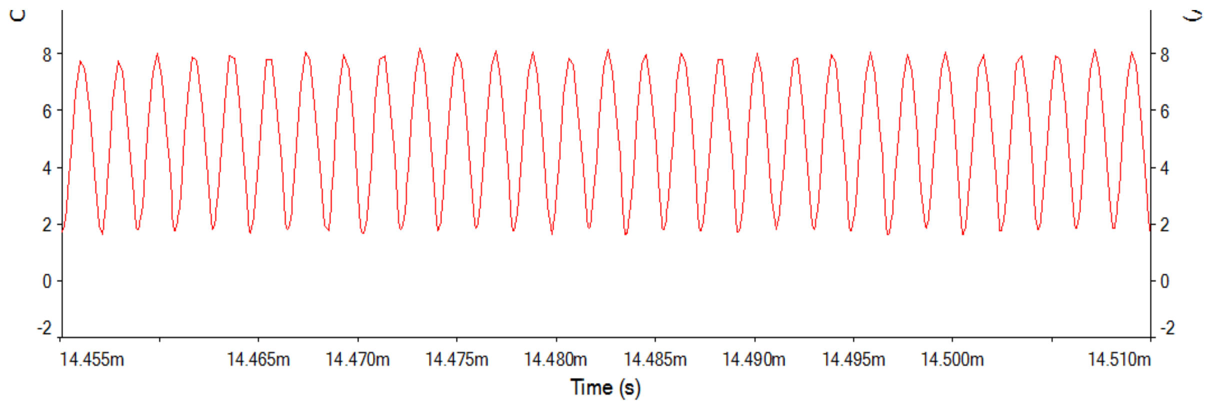


Figure 8:Simulated Carrier wave in Multisim 14.0

Oscillator Frequency found from simulation is 528.653KHz.

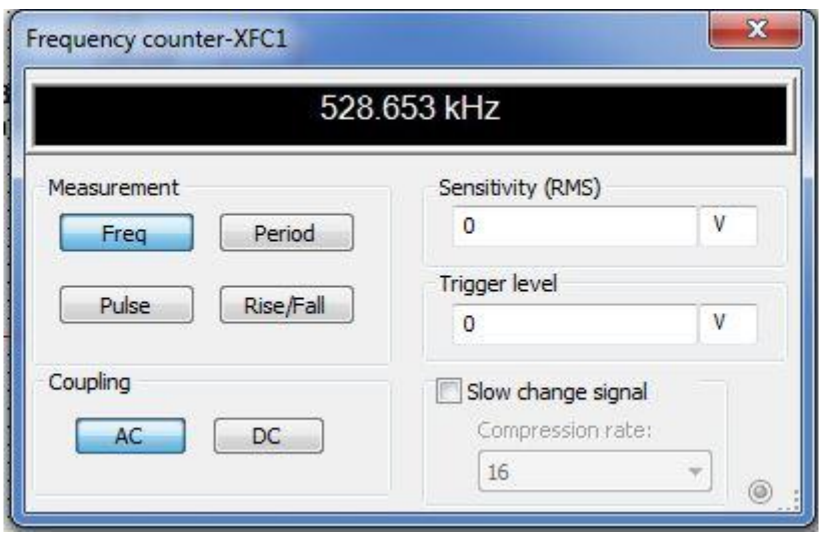


Figure 9: Carrier Wave Frequency in Multisim 14.0 Frequency counter

But in real circuit the frequency differs from the calculated value. From Oscilloscope output we get the sinusoidal output is slightly distorted and the carrier frequency is 833KHz.

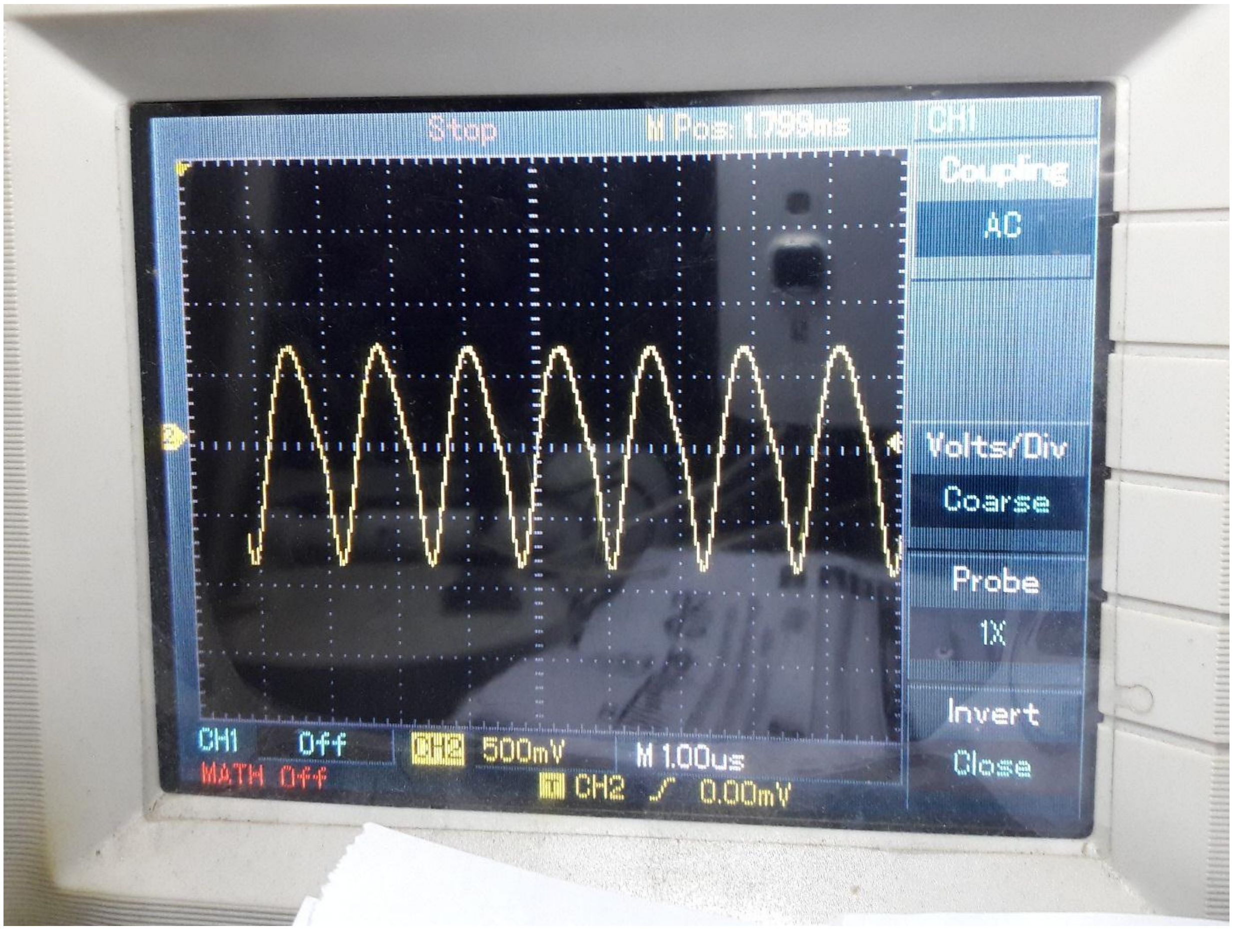


Figure 10: Experimental carrier wave in Oscilloscope

Voice Signal Amplifier

For converting human voice signal into electrical signal we require a transducer. Transducer are device which converts energy from one form to other. A microphone is a transducer which converts sound energy to electrical energy. Here we use a electret microphone condenser for converting human voice signal into electrical signal.

The electrical signal from the electrical microphone is a current signal which is very week so we need a necessary amplifiers to convert the voice current signal to amplified voice voltage signal. Here we use a Transimpedance Amplifier. The schematic is given below.

Figure 11: Transduce to convert voice signal into electrical signal

This topology was selected for a few reasons.

1) it allows for single-supply operation to be easily accommodated by biasing the non-inverting input of the op amp to the mid-supply point.
2) The gain of the pre-amp is determined by R5 but the noise gain of the op amp is determined by the ratio of R5 to R1. Therefore it is possible to achieve lower noise with this topology than with a non-inverting amplifier. Finally, because capacitor C3 is chosen to have a very low impedance

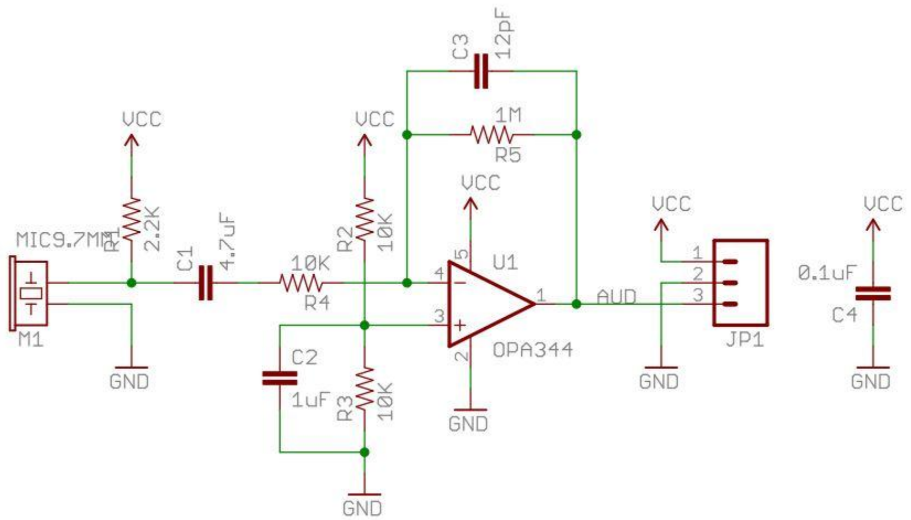


Figure 12: Transimpedance Audio Amplifier

at audio frequencies.

Typical Sound waveform when we play a music in front of Electret microphone is included here,

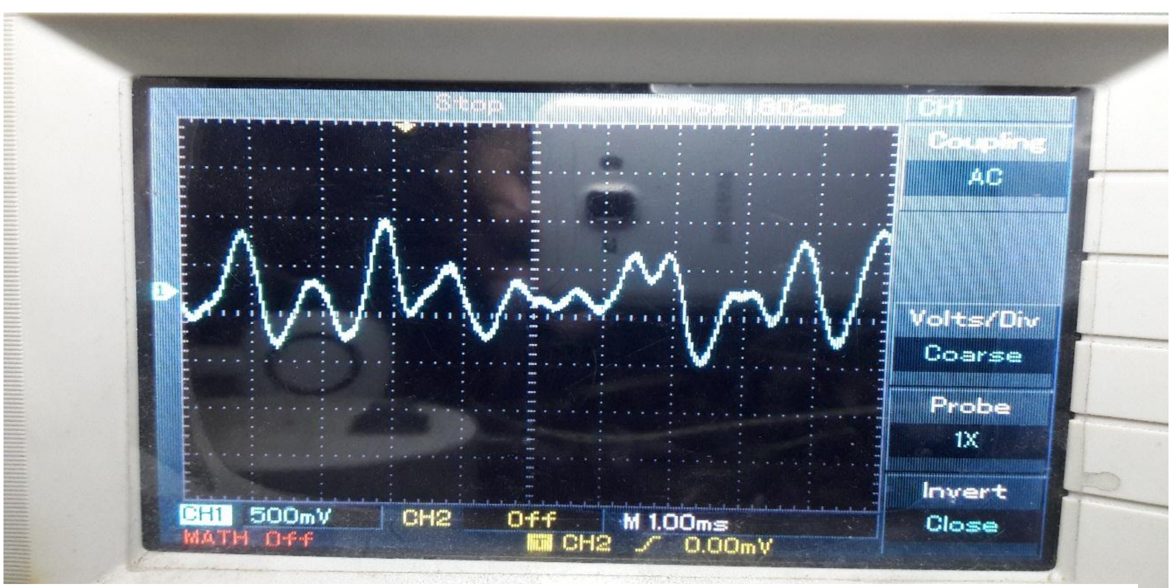


Figure 13: Observed voice signal from Amplifier output

Amplitude Modulator

The amplitude modulator consists of a simple BJT and Bias circuitry with it. Here C6 is used to block DC portion of Audio waveform. It is selected such a way so that it's impedance is keep minimum so audio wave of low frequency can pass through it.

$$C_6 = \frac{1}{2\pi f_{low(audio)} R_8} = 10uF$$

C5 is is used to block the Dc portion of Colpitts Oscillator output. As it allows to pass high frequency, So it's impedance can be lower enough for low value of c5.

$$C_5 = \frac{1}{2\pi f_{low(colpitts)} R_5} = 2.2nF$$

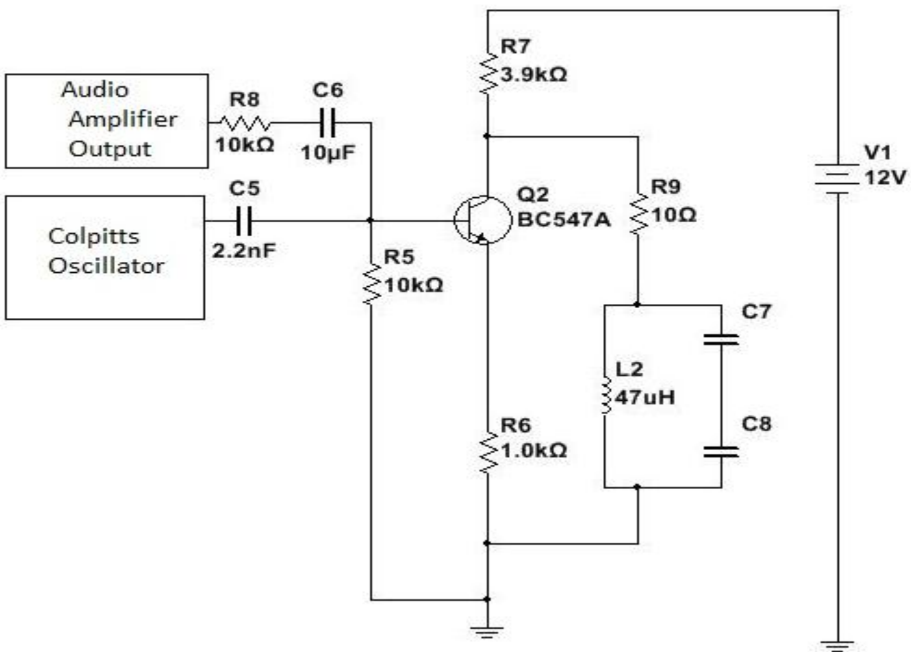


Figure 14:Amplitude Modulator Circuit

Simulation results found from NI Multisim 14.0 are shown below

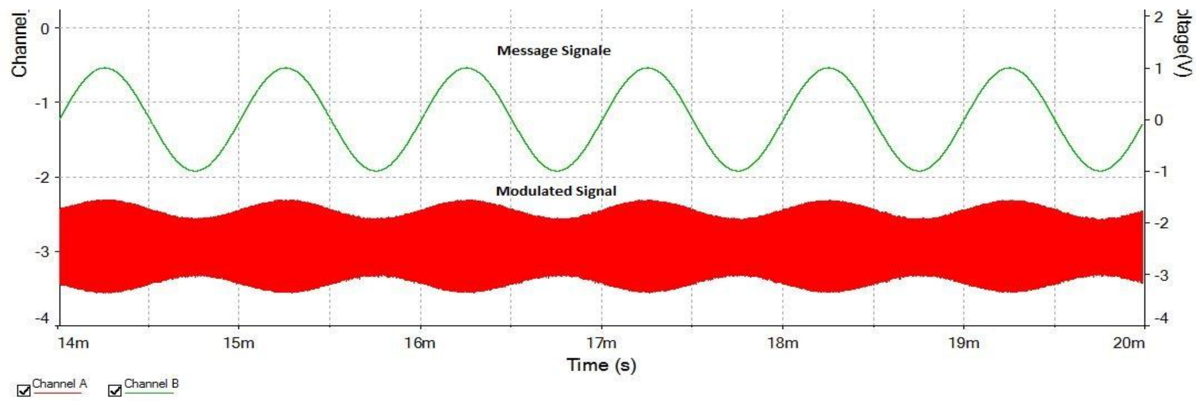


Figure 15: Message signal(200mVp-p) and modulated signal

So from the simulation we see that message signal is modulated in Double sideband (DSB) modulation.

R5=10k is just to give the base a fixed non-floating voltage.

100% modulation is found for 1500mVp-p value of message signal.(From simulation value)

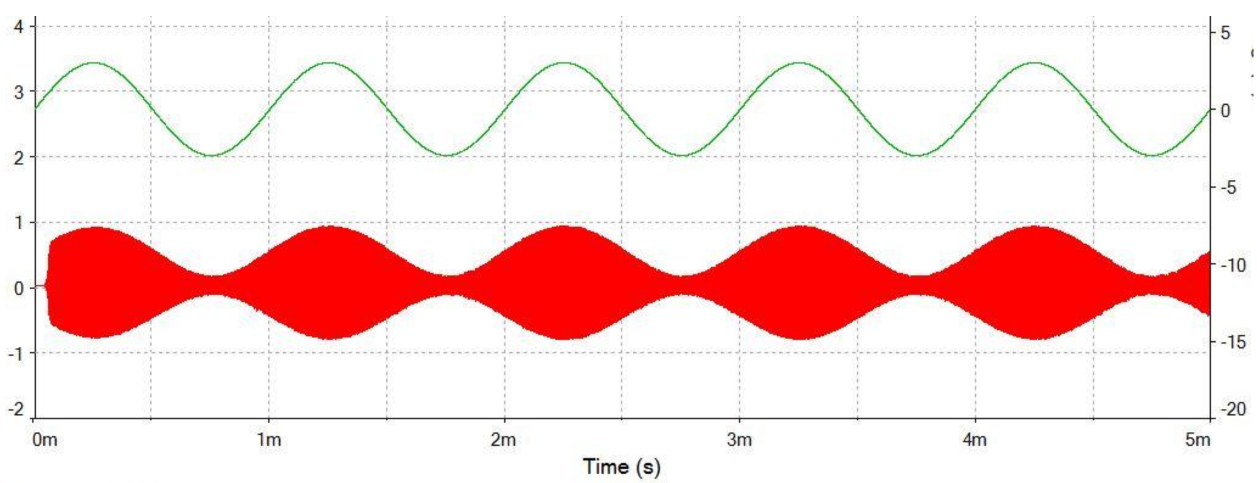


Figure 16: Message signal(1500mVp-p) and modulated signal(100% modulation)

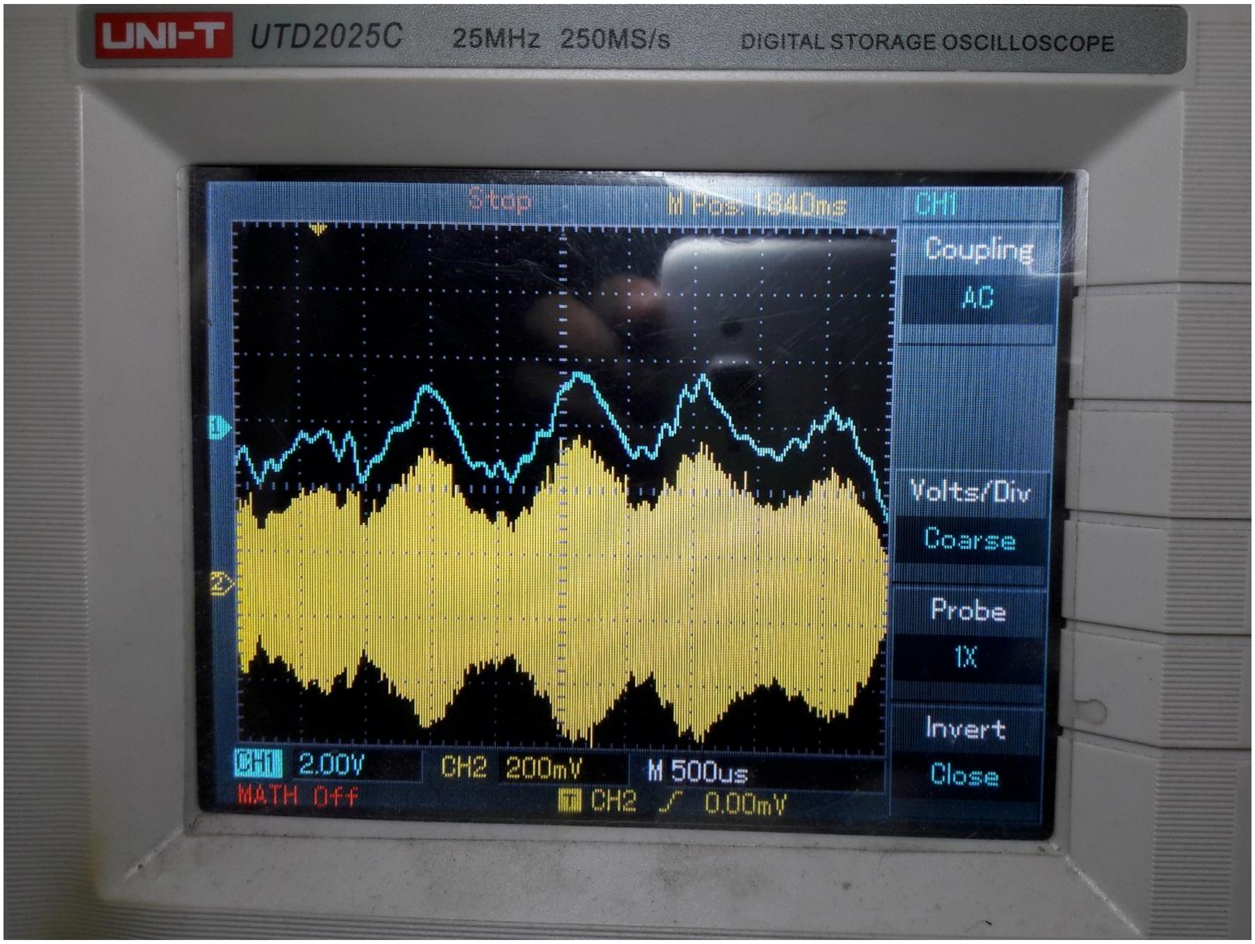


Figure 17: Observed Voice signal Modulation

To ensure the situation so that the signal does not distort we have design a voltage divider to ensure the input voltage of the Amplitude modulator is less than 1.5V

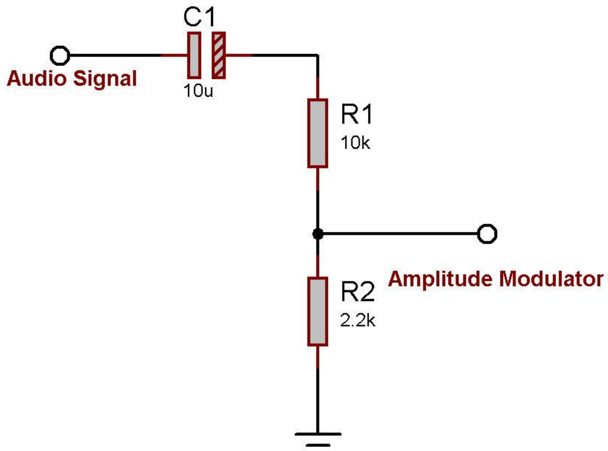


Figure 18: Voltage divider to prevent Distortion of voice signal

AM Receiver

The process of demodulation for DSB-AM is relatively straightforward. The radio frequency carrier can be removed from the signal using a simple diode detector consisting of a diode, a resistor, and a capacitor. The incoming signal is rectified by the diode, which allows only half of the alternating waveform to pass through it. The capacitor removes the remaining radio frequency signal components to provide a smooth output, and the resistor allows the capacitor to discharge. An AM receiver can thus be produced relatively cheaply, since there is no requirement for specialized components. The basic circuit diode detector circuit is shown below.

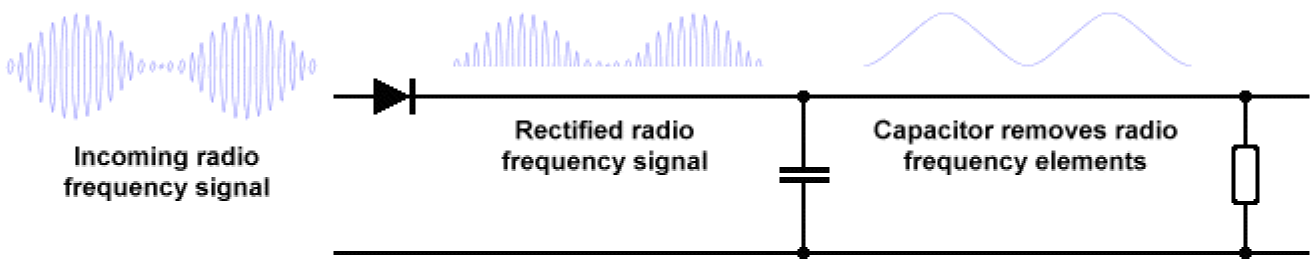


Figure 19: Envelope Detector circuit

Time constant $\tau = RC$ selected such a way so that it maintains the following conditions

$$\frac{1}{f_c} \ll \tau \ll \frac{1}{B}$$

Where $f_c = 833kHz$ is the carrier frequency and B=6800Hz is the Bandwidth of the signal.

So$1.2us \ll \tau \ll 147us$. For this condition to fulfill we select the value of $R = 10\Omega \ and \ C = 4.7uF$.

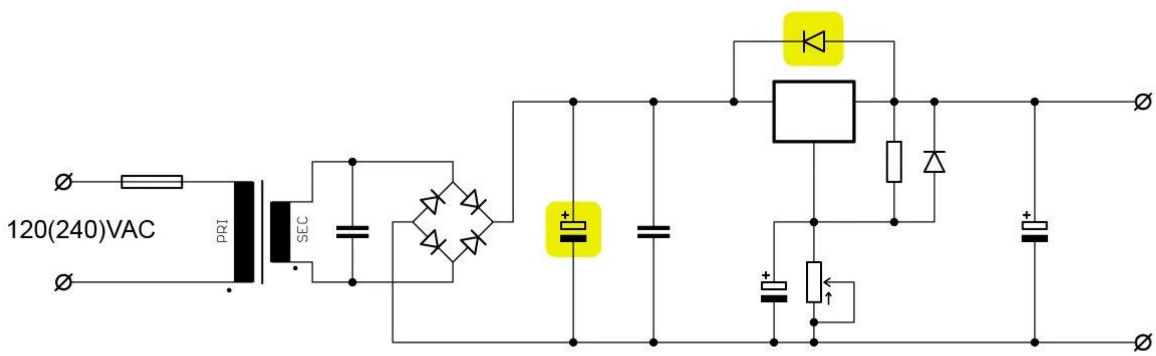
Diode Selection: In diode detection circuit we use a germanium diode to detect the message signal.

Figure 20: Voice signal(Blue) & Recovered voice signal(Yellow)

Here blue color is the original voice signal and yellow color is the diode detected signal.

Power Supply:

We designed a 12V voltage power supply from 220V AC system using LM317 Linear regulator.



Discussions:

1. The designed circuit cannot generate DSD-SC Modulation
2. We were unable to design power amplifier stage after modulator circuit. As a result we could not make this modulation process wireless
3. Our Electret Audio Amplifier Circuit works in the range of 2.7V-5.2V. Unfortunately while using it for the first time we biased it with the voltage of 12V. As a result it was burnt. So as a precaution we designed a 5V power supply using 7805 Linear voltage Regulator.

4. As audio amplifier output is in the range of 0-5V and our modulator circuit takes maximum of 1.5V for 100% modulation. So to prevent distortion a voltage divider circuit was designed.