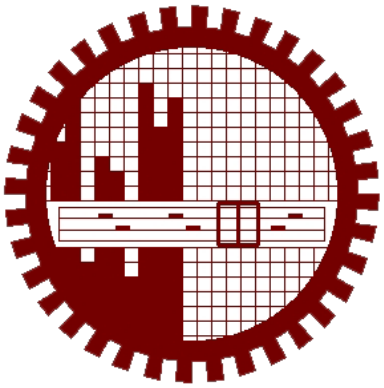
Bangladesh University of Engineering and Technology



Department of Electrical and Electronic Engineering

Project Report

FM Radio Receiver

Course No. : EEE 310
Course title : Communication Laboratory
Group No. : 01

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Introduction:

Frequency modulation:

Frequency modulation is a type of modulation in which the frequency of a carrier wave is varied in proportion to the instantaneous amplitude of a modulating signal. This modulating signal is typically an audio signal in communication applications, but it can also be any type of signal such as a video signal or data signal.

Let us consider the message signal is m(t)

And the carrier wave = $Acos(2\pi f_c t)$

In the frequency modulation, the frequency is modulated as follows:

$f_i(t) = f_c + k_f m(t)$;

Then the overall phase of the modulated wave is :

$$\theta_i(t) = 2\pi \int_0^t f_i(\tau)d\tau = 2\pi f_c t + 2\pi k_f \int_0^t m(\tau)d\tau$$

Thus, the frequency modulated signal:

$$s(t) = Acos(2\pi \int_0^t f_i(\tau)d\tau = 2\pi f_c t + 2\pi k_f \int_0^t m(\tau)d\tau)$$

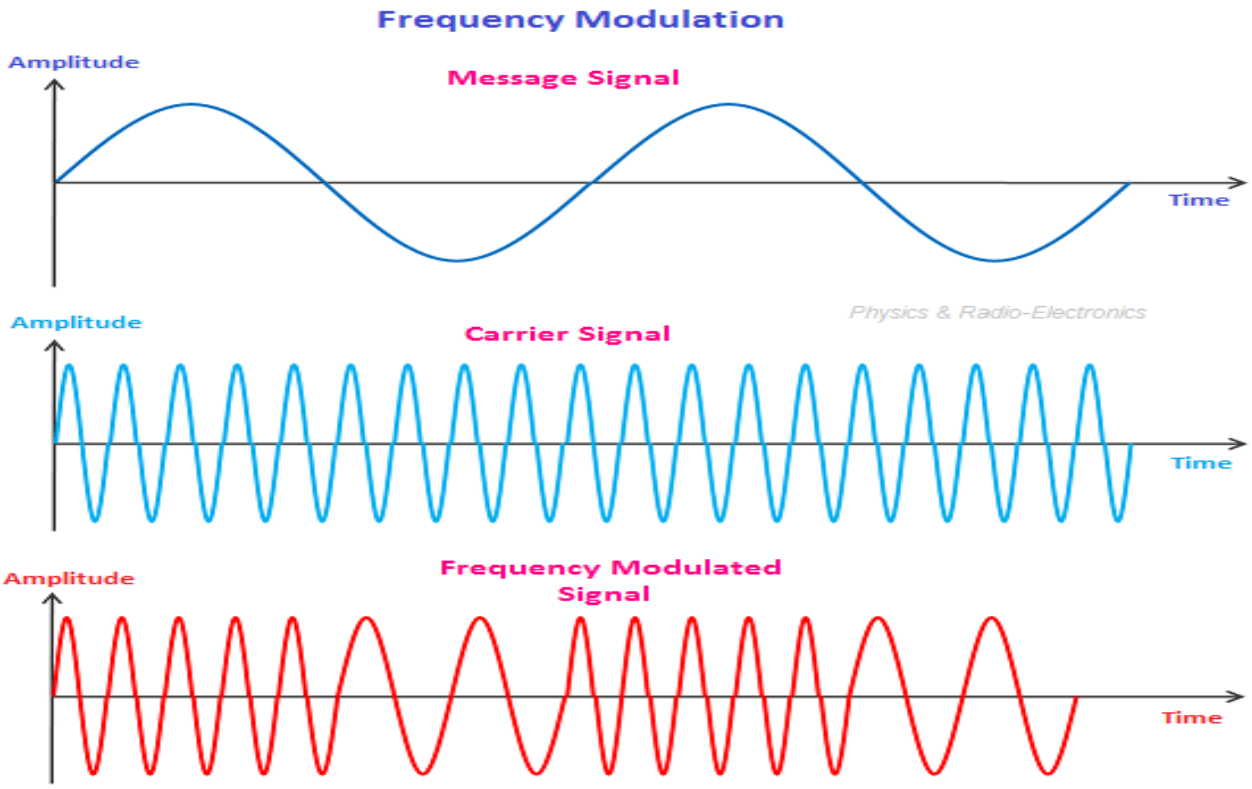


Figure: Frequency Modulation

Frequency Demodulation:

Frequency demodulation is the process of extracting the modulating signal from an FM carrier wave. In other words, it is the process of converting the frequency variations in the FM signal back into the original modulating signal.

The most common method of frequency demodulation is the phase-locked loop (PLL) demodulator, which is a feedback control system that locks the frequency and phase of a local oscillator to the incoming FM signal. The output of the phase-locked loop is then passed through a low-pass filter, which removes the high-frequency noise and recovers the modulating signal.

The basic concept behind frequency demodulation is that the frequency of the FM signal varies with the amplitude of the modulating signal, as shown in the following equation:

$$c(t) = A\cos[2\pi fct + \varphi(t)]$$

Here, c(t) is the modulated carrier wave, A is the amplitude of the carrier wave, fc is the carrier frequency, φ(t) is the phase deviation caused by the modulating signal, and f(t) is the modulating signal.

When the FM signal is passed through a PLL demodulator, the phase-locked loop adjusts the frequency of the local oscillator to track the frequency variations in the FM signal. The resulting output of the phase-locked loop is a voltage that is proportional to the frequency deviation of the FM signal. This voltage can be passed through a low-pass filter to extract the modulating signal, which is then amplified and output as an audio signal.

Frequency demodulation is used in FM radio receivers to extract the audio signal from the FM carrier wave. It is also used in various other applications such as telemetry, radar, and wireless communication systems.

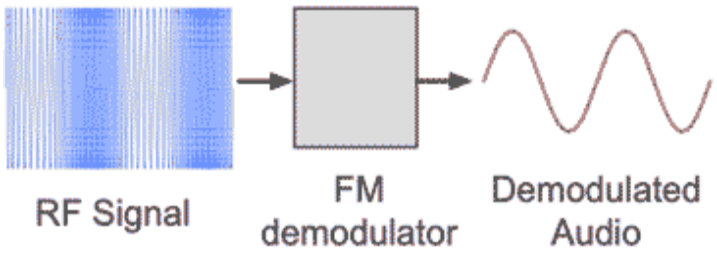


Figure: Frequency Demodulation

A radio receiver is a piece of electronic equipment that is built to capture and process radio waves. Its primary function is to take the information that is being transmitted through these waves and convert it into a format that can be easily understood and used by humans. In order to capture the radio waves, the receiver uses an antenna. The antenna is designed to pick up a specific range of frequencies, depending on the type of radio waves that the receiver is intended to capture. Once

the waves have been intercepted by the antenna, they are sent to the rest of the receiver for further processing.

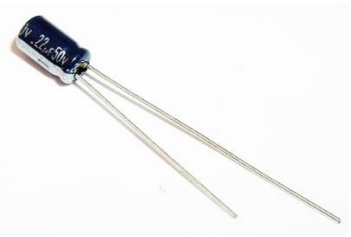
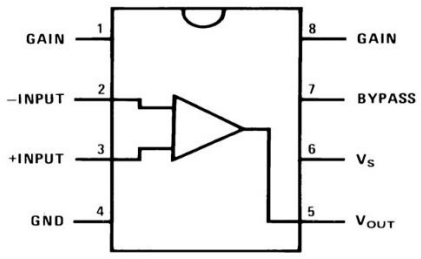
The first step in this processing involves using electronic filters to separate the desired radio frequency signal from all of the other signals that have been picked up by the antenna. This is an important step, as it helps to ensure that the information being received is accurate and reliable. After the desired radio frequency signal has been isolated, an electronic amplifier is used to increase the power of the signal. This is necessary because the signal is often quite weak by the time it reaches the receiver, and needs to be strengthened in order to be processed effectively.

Finally, the information that is being carried by the radio waves is recovered through a process called demodulation. This involves extracting the original data that was modulated onto the radio waves and converting it back into a usable form. One common type of radio broadcast that employs frequency modulation is the 88-108MHz VHF band. This particular range of frequencies is labeled as FM on the band scales of radio receivers. Receivers that are capable of receiving these FM signals are known as FM receivers, and they are commonly used for listening to music and other forms of audio broadcasting.

Frequency Modulation Advantages:

- Frequency modulation is a robust modulation technique that is able to tolerate changes in the signal level without affecting the quality of the output signal, provided that the receiver is capable of handling the variations in the signal level. This feature makes FM ideal for use in two-way radio communication systems or mobile communication applications, where the signal strength may vary due to factors such as distance, obstacles, or interference. In such situations, FM allows for clear and reliable communication, as the variations in signal level are not reflected in the quality of the received signal. This resilience to signal level variations makes FM a popular choice for a wide range of communication applications where reliable transmission and reception are critical.
- Frequency modulation is also resilient to noise and interference.
- It is also easier to apply modulation at a low-level power stage of a transmitter.
- With the help of frequency modulated signals, we can use RF amplifiers.

Components:

Name	Photo
➢ Transistor BF494 (2pieces)	
➢ Variable Capacitor C1(22 pF)	
➢ Capacitor C2 (0.22 µF)	
➢ Capacitor C3 (0.1 µF)	
➢ Capacitor C4(220 uF)	
➢ Trimmer Capacitor 5 (120 pF)	
➢ LM 386 IC	
➢ Audio Jack	

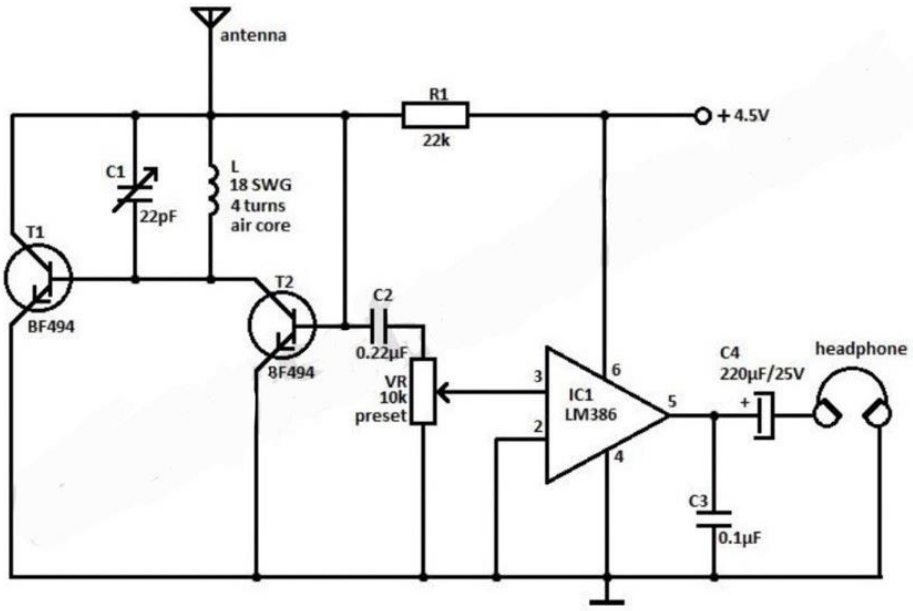
- Inductor (around 5uH)

- Resistor (22k ohm)

- Potentiometer(10k)

- Speaker

Circuit Diagram:



Work Flowchart:

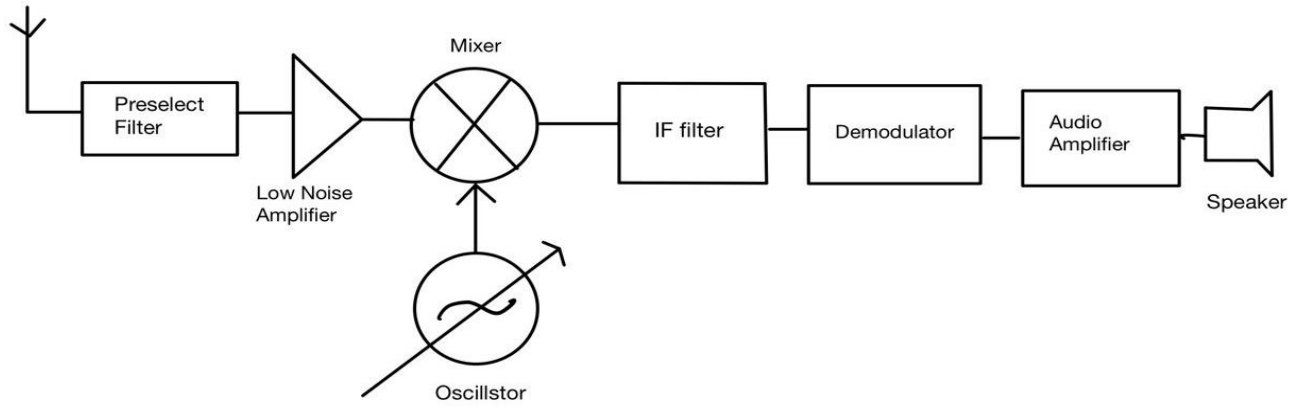


Figure: FM Block Diagram

Explanation:

The Signal from the transmitter that is antenna and then signal is pass through preselect filter which isolates the FM signal out of the electromagnetic region, that is amplified by the low noise amplifier and the output signal is sent to mixer that takes two different inputs one from Amplifier and the other is from oscillator. We can tune our oscillator to change the output of our mixer so that we can select different stations. The output of mixer is then sent to Intermediate Frequency (IF) Filter that can filter the specific frequency that we require, that signal is sent to a demodulator which takes the important information and turns it back to audio. We can then amplify that audio using Audio Amplifier and get the output in the form of some Sound from Speaker/headphones/buzzer etc.

Basic Components of a FM receiver:

- Antenna
- Pre-select filter
- Low noise amplifiers

- Mixer
- Oscillator
- IF filter
- Demodulator
- Audio amplifier
- Speaker

Antenna:

The antenna, also known as an aerial, is a crucial component of a radio receiver that is used to transmit and receive signals from the air. A radio transmitter supplies a current to the antenna's terminals, causing it to radiate that energy as electromagnetic waves. Another antenna located at a distance receives these signals and uses them for a radio receiver.

Pre-select filter:

It is a filter that is used to eliminate the spurious noise received by the antenna.

Low Noise Amplifier:

A low noise amplifier is an electronic device that amplifies weak signals without significantly decreasing the signal's quality in comparison to the noise level. Amplifiers tend to increase both the signal and noise power at their input, but low noise amplifiers are built to reduce the extra noise introduced during the amplification process, allowing the signal to stand out.

Oscillator and Mixer:

An oscillator is an electrical circuit that generates a repeating waveform on its output using only the DC supply voltage as input, and sometimes a synchronization signal. A mixer, on the other hand, is another type of circuit that produces new frequencies by combining two input signals, one of which comes from the oscillator. The resulting output from the mixer contains either the sum or difference of the original input frequencies.

IF filter:

These are electronic filters designed to work with signals in the medium to extremely high frequency ranges, typically in the megahertz to gigahertz range. These frequencies are commonly used for radio broadcasting. These filters, also known as duplexer and diplexers, are used to combine or separate multiple frequency bands.

Demodulator:

As a signal is modulated, we need to demodulate it with the help of demodulator. Demodulation is the extraction of original information bearing signal from bearing moderator carrier mail. The signal output from a demodulator may represent sound an (analog audio signal) or binary data.

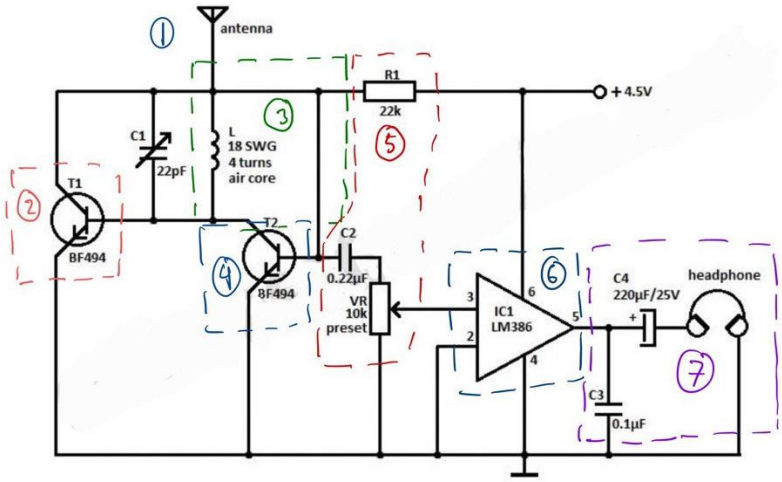
Audio amplifier:

An audio power amplifier (or power amp) is an electronic amplifier that amplifies low-power electronic audio signals such as the signal from radio receiver. It is the final electronic stage in a typical audio playback chain before the signal is sent to the loudspeakers.

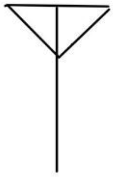
Speaker:

A loudspeaker is an electroacoustic transducer; a device which converts an electrical audio signal into a corresponding sound.

Individual Parts:

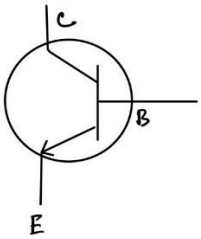


1.



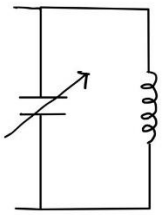
This is antenna which receives input FM modulated signal from 88 MHz to 108 MHz frequency for FM receiver.

2.



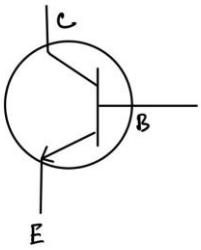
When we receive input signal which is very weak and then this BJT BF494 acts as an amplifier and then it sends the signal into variable capacitor.

3.



This segment acts as an oscillator. It is basically a tuning circuit. It tunes the signal received from the 1st BJT and send then into the second BJT.

4.



Here, we get signal from tuner circuit and this BJT(BF494) works in purpose of mixer and oscillator combination.

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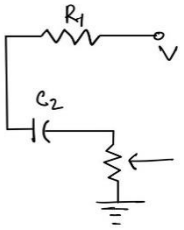
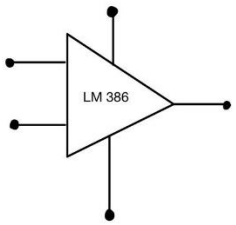


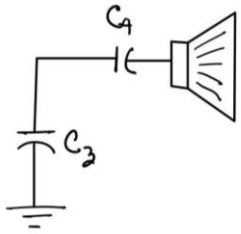
Next, we have C2 and R1 resistor capacitor combination which act as filter. After the filtering process, the signal is sent to the variable resistor. This variable resistor acts as the volume controller.

6.



After getting the amplitude limited signal controlled by the potentiometer, this op map (model LM 386) receives the signal and works as an audio amplifier. The output of the audio amplifier is then sent to speaker or headphone for listening.

7.



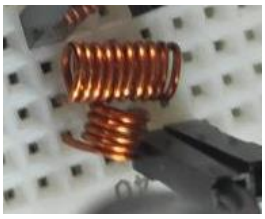
After getting signal from the op amp, we use two capacitors to reduce the noise from the audio signal. Then the total demodulation process is complete. From the speaker, now the audio sound can be heard.

Sample Calculation:

The center frequency of the oscillator is,

$$f = \frac{1}{2\pi\sqrt{LC}}$$

Here, we made inductor with copper SWG-25 wire. We added 2 such inductors in parallel.



Inductor-1:

Number of turns, N = 13;

Diameter, d =0.01 inch

Length = 1 inch

The formula for calculating inductance: $L = \frac{N^2.d^2}{18d+40L}\ \mu H$

Therefore, the inductance of inductor 1, $L1 = \frac{13^2*0.01^2}{18*0.01+40*1}\ \mu H = 4.22\ \mu H$

Inductor-2:

Number of turns, N = 5;

Diameter, d =0.01 inch

Length = 0.4 inch

The formula for calculating inductance: $L = \frac{N^2.d^2}{18d+40L}\ \mu H$

Therefore, the inductance of inductor 1, $L2 = \frac{5^2*0.01^2}{18*0.01+40*0.4}\ \mu H = 1.56\ \mu H$

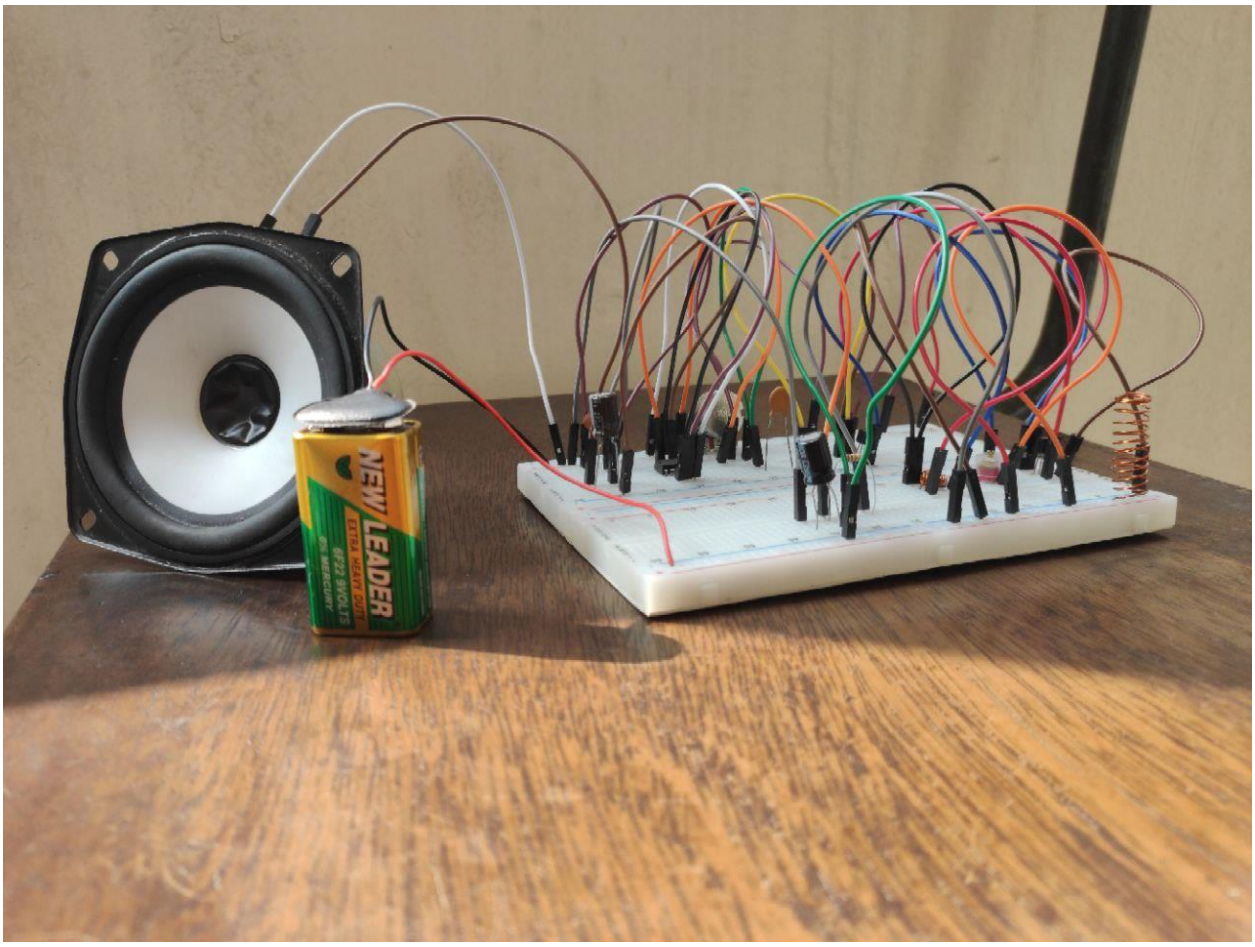
Equivalent inductance, L = $\frac{L1\ L2}{L1+L2} = \frac{4.22*1.56}{4.22+1.56}\mu H = 1.14\mu H$

The variable capacitor was approximately at 2.5 pF when we tuned a station.

Therefore, the resonant frequency, f = = $\frac{1}{2\pi\sqrt{1.14\times10^{-6}\times2.5\times10^{-12}}}Hz = 94.27MHz$

The resonant frequency is absolutely inside in the spectrum fixed for FM radio.

Circuit Picture:



FM Applications:

- Frequency modulation (FM) is a method of broadcasting FM radio signals, which enhances the signal to noise ratio by transmitting the audio signal as variations in the frequency of the carrier wave. This results in a higher quality of sound transmission and reception, with less interference from external factors such as static or other radio signals

- The technique of frequency modulation is not limited to just FM radio broadcasting, but is also utilized in various other applications such as telemetry, radar, seismic prospecting, and EEG monitoring of newborns. In telemetry, frequency modulation is used to transmit data over long distances wirelessly, while in radar it is used to detect and locate objects by analyzing the frequency of the reflected waves. Similarly, in seismic prospecting, frequency modulation is used to generate and analyze seismic waves for the exploration of natural resources. EEG monitoring of newborns involves measuring the electrical activity in the brain by using frequency modulation to transmit the signals to a monitoring device. Overall, the versatility and effectiveness of frequency modulation make it a widely used technique in a variety of fields.
- Frequency modulation is also used in other diverse applications such as music synthesis, some video transmission systems, and magnetic tape recording systems. In music synthesis, frequency modulation is used to create new sounds by combining and modulating different waveforms. Some video transmission systems also use frequency modulation to transmit audio signals alongside the video signal, allowing for synchronized sound and picture. In magnetic tape recording systems, frequency modulation is used to encode audio signals onto the tape, which can be later decoded and played back as sound. The flexibility and versatility of frequency modulation make it an essential tool in various fields and applications.

Limitations:

- One of the limitations of this circuit is that it has a limited frequency range. This circuit is designed to receive signals in the FM frequency range, typically between 88 MHz to 108 MHz. Signals outside of this frequency range will not be received.
- Another limitation of this circuit is that it may not provide high-quality audio output. The low-pass filter used in the demodulator stage may introduce distortion and noise to the audio signal. Additionally, the circuit may be susceptible to interference from other radio signals, which can also affect the quality of the audio output.
- This FM receivers requires moderate signal strength to demodulate and send it to the speaker. At ground level it is really hard to find FM signal of moderate or good

strength. Sometimes, we needed to go to higher ground to catch signal. We went to the 11^{th} floor of ECE building to make the receiver functioning.

Conclusion:

In conclusion, our FM receiver project has demonstrated the principles of frequency modulation and frequency demodulation in a practical application. Through our project, we have learned about the various components and circuitry involved in FM radio reception, including the antenna, mixer, local oscillator, IF amplifier, and demodulator. We have also gained experience in circuit design, prototyping, and testing, as well as in troubleshooting and problem-solving as we made our own inductor and we used variable capacitor. Overall, this project has given us a deeper understanding of the technical aspects of FM radio communication and has provided us with valuable skills for future projects and endeavors.