COMMUNICATION ENGINEERING LAB

Course Code: EC255

PROJECT REPORT

In Electronics and Communication Engineering

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To

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Contribution

- ***21ECE1023***: Compiling snapshots, generating circuit model on Tinkercad Autodesk and designing block diagram on paint.
- ***21ECE1024***: Implementation of detector Circuit in Hardware.
- ***21ECE1025***: Designing the Detector circuit on LTspice Simulator.
- ***21ECE1026***: PCB designing of the implemented Circuit on Altium Designer.
- ***21ECE1027***: Designing of low pass filter for the demodulated wave.
- ***21ECE1028***: Documentation of the project report.

RF DEMODULATOR / DETECTOR

ABSTRACT:

The project is called the RADIO FREQUENCY DETECTOR. In this project, we have designed a demodulator circuit for Amplitude modulated waves in general. We have made some modifications to the first-order envelope detector and designed a second-order envelope detector whose efficiency is better than the preceding method.

It applies the second-order envelope detector approach, which produces the original signal's demodulated envelope as an output from a high-frequency amplitude-modulated input. After that, a second-order low-pass filter was used to reduce ripple. We obtained the demodulated wave we sought due to the filtering operation.

The hardware for the circuit was created using resistors, capacitors, and diodes on a breadboard after the circuit was first realized using LT SPICE, and the output waveform was obtained. The range of the output waveform has been examined. it operates within a range

of 500 Hz to 20K Hz. Finally, we improved the hardware's current carrying capacity by designing it on a PCB.

INTRODUCTION:

Radio Frequency (RF) refers to a range of frequencies in the electromagnetic spectrum between 3 kHz to 300 GHz. RF signals are used for wireless communication and are used for a wide range of applications including radio and television broadcasting, mobile phones, satellite communications, Wi-Fi networks, Bluetooth, and GPS.

The properties of RF signals, such as their frequency, wavelength, amplitude, and phase, make them suitable for long-distance communication as they can travel through the air and penetrate obstacles such as buildings and trees. However, RF signals can also be affected by factors such as interference, noise, attenuation, and multipath propagation, which can degrade the quality of the communication.

RF signals are generated by electronic devices such as transmitters, which convert electrical signals into RF signals and emit them through antennas. RF signals are received by receivers, which convert them back into electrical signals for processing.

RF technology has revolutionized how we communicate and enabled wireless communication to become an integral part of our daily lives.

Frequency Detector:

A frequency detector is an electronic device used to measure the frequency of a periodic waveform, such as a signal or a sound wave. Frequency detectors are used in a variety of applications, including audio and music processing, telecommunications, signal analysis, and scientific research.

Frequency detectors typically work by measuring the period of the input waveform and using it to calculate the frequency. They may also use other methods, such as counting the number of cycles over a specific period or analyzing the waveform's spectral content.

There are different types of frequency detectors available, including analog and digital versions. Analog frequency detectors usually use a filter or a resonant circuit to select the frequency of interest, while digital frequency detectors use techniques such as Fourier analysis or phase detection.

Frequency detectors are used in many applications, such as in musical instruments to detect and measure the pitch of a note, in radio receivers to tune to a specific frequency, and in signal processing to analyze and filter signals based on their frequency content. In telecommunications, frequency detectors are used to measure the frequency of radio waves and to detect and analyze the modulation of signals.

Radio Frequency Detector:

A radio frequency (RF) detector is an electronic device used to detect and measure the presence and strength of RF signals in the environment. RF signals are emitted by various electronic devices, such as mobile phones, wireless routers, Wi-Fi networks, and other electronic devices that emit electromagnetic radiation.

An RF detector typically consists of an antenna, a signal amplifier, and a detector circuit. The antenna is used to pick up RF signals in the environment, and the signal amplifier amplifies the weak signals to a detectable level. The detector circuit is used to detect the presence and strength of the RF signals.

Detecting radio frequency (RF) requires specialized equipment designed for that purpose. Here are some common methods for detecting radio frequency:

1. Spectrum analyzer: This is a device that is used to measure the frequency spectrum of RF signals. It displays the signal strength versus frequency on a graphical display, allowing you to identify the specific frequency or frequencies of the RF signal.

2. Antenna: An antenna can be used to detect RF signals. Different types of antennas are designed to detect different frequencies. By connecting an antenna to a receiver, you can detect RF signals and measure their strength.

3. Radio receiver: A radio receiver is a device that can receive and demodulate RF signals. By tuning the receiver to the frequency of the RF signal, you can detect the signal and listen to the audio or data carried by the signal.

The method we have used to detect Radio Frequency is Second Order Envelope Detector / Demodulator

HARDWARE

List of Components:

Sr.No	Components	Value	Qty
1	Diode	1N34	2
2	Capacitor	10n	3
3	Resistor	1k, 22k	2
4	Terminal Block	-	2

Table 1: Component and Quantity used

Components Description

Resistors:

A resistor is a passive electronic component that opposes the flow of electrical current in a circuit. It is designed to have a specific resistance value, measured in ohms (Ω), and is used to control the amount of current flowing through a circuit or to divide voltage in a circuit or it is a two-terminal electronic component that produces a voltage across its terminals that is proportional to the electric current through it in accordance with Ohm's law:

$$V = IR$$

22K ohm

1K ohm

Fig 1: Resistors

Capacitors:

A capacitor is a passive electronic component that stores electrical energy in an electric field between two conductive plates. It is designed to have a specific capacitance value, measured in farads (F), and is used in electronic circuits for a variety of purposes, including energy storage, signal filtering, and timing.

10n F

Fig 2: Capacitor

Diodes:

A diode is an electronic component that allows current to flow in only one direction. It has two terminals, the anode and the cathode, which are polarized in such a way that current can only flow from the anode to the cathode. When a voltage is applied across the diode in the forward direction, the diode conducts and allows current to flow. In contrast, in the reverse direction, the diode blocks the current flow

1N34

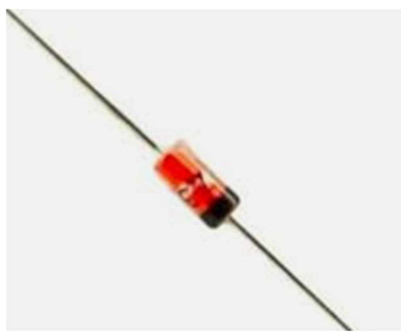

Fig 3: Diode

CIRCUIT DIAGRAM:

The circuit we have designed demodulates message signal whose frequency lies in the range of 500Hz to 20K Hz. We can use this circuit whenever we want to obtain the demodulated waveform. We can use this circuit to quickly get the demodulated waveform of an Amplitude modulated wave. Also, the device we have designed is small in size, so we can easily carry it from one place to another. Also since the circuit we have designed is passive in nature, we don't have to connect a separate power supply to it.

Block Diagram:

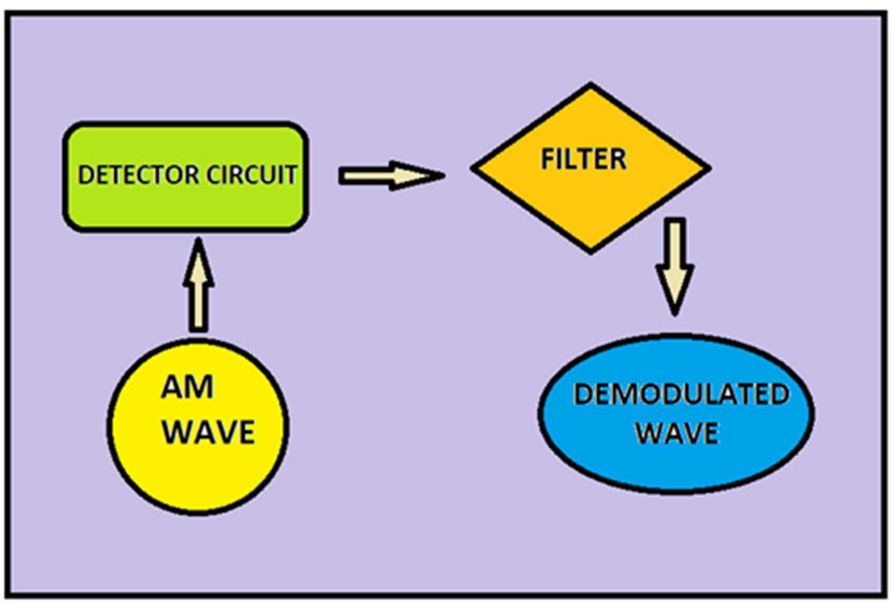

Fig 4: Block Diagram of RF Detector

Component Layout on Breadboard:

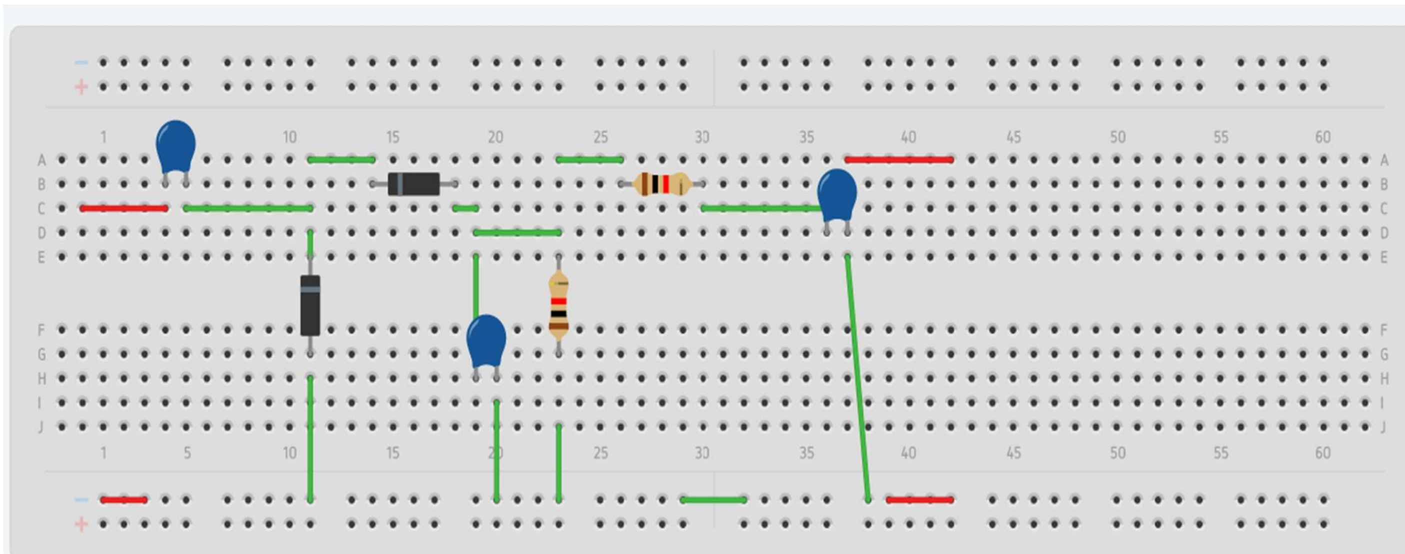

Fig 5: Component layout on Breadboard

Component Layout of the PCB:

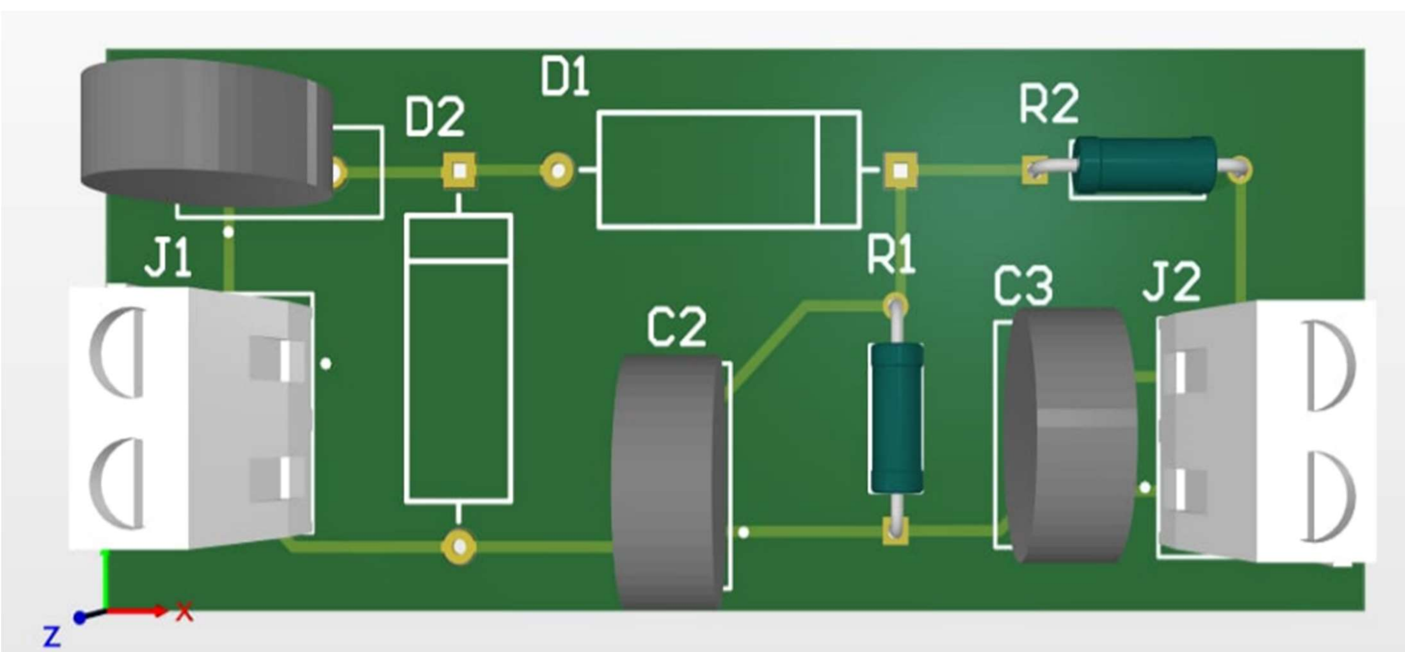

Fig 6: Component Layout on PCB - 1

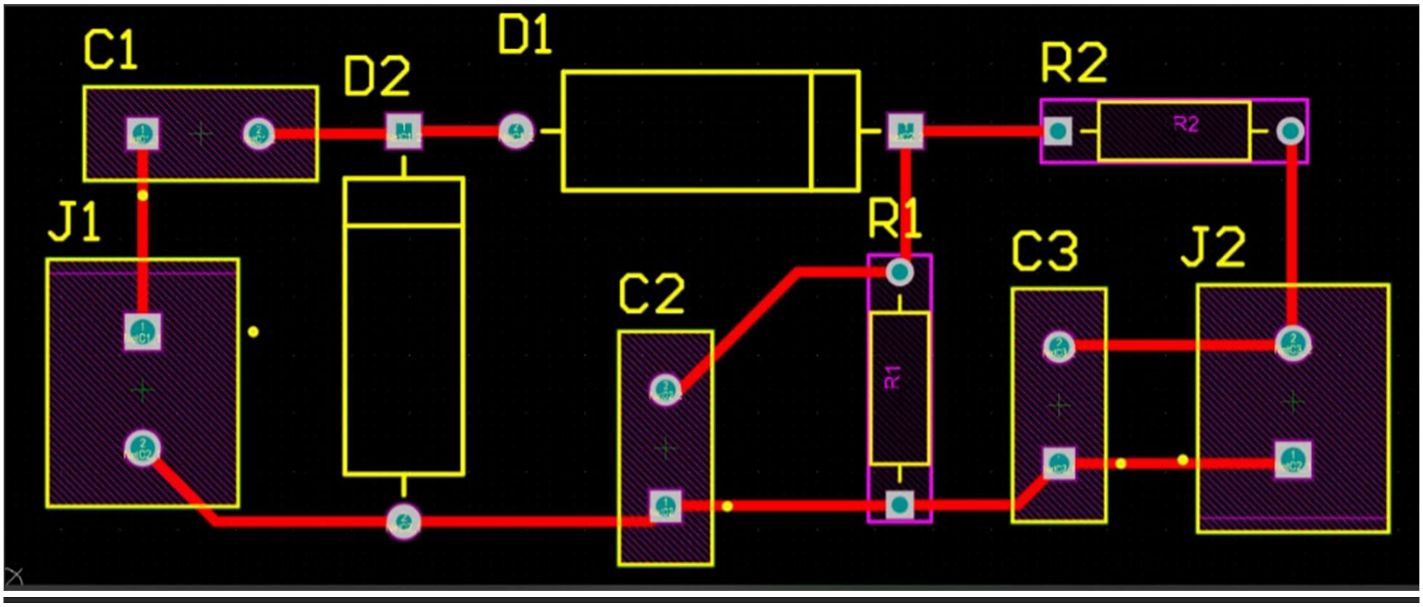

Fig 7: Component Layout on PCB - 2

LTspice Circuit:

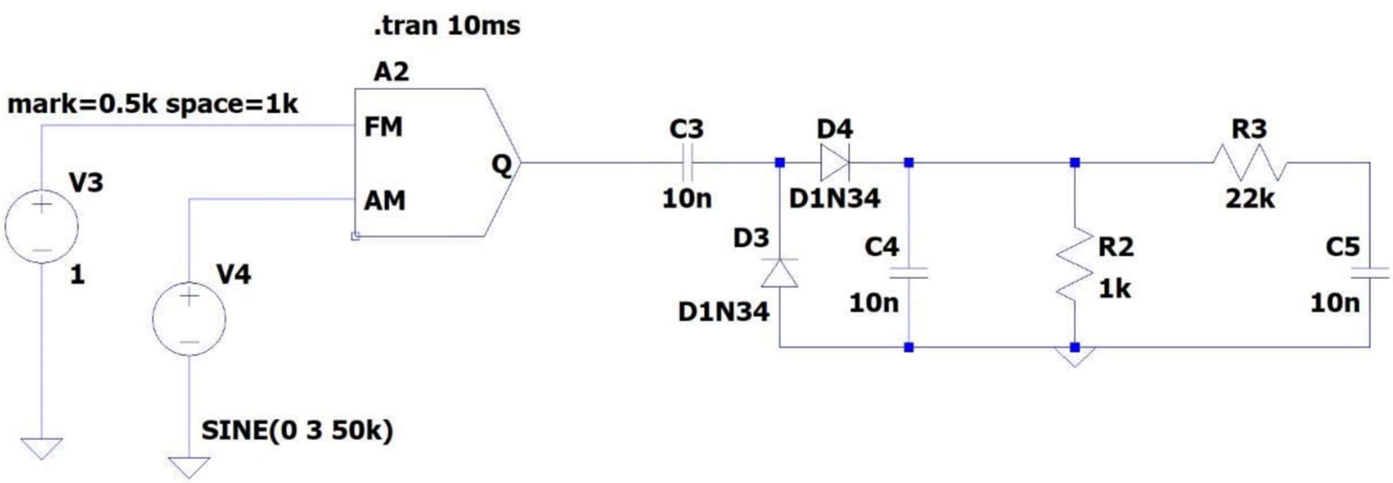

Fig 8: Circuit on LTspice Simulator

Final Circuit:

Fig 9: Circuit prototype-1

Fig 10: Circuit prototype-2

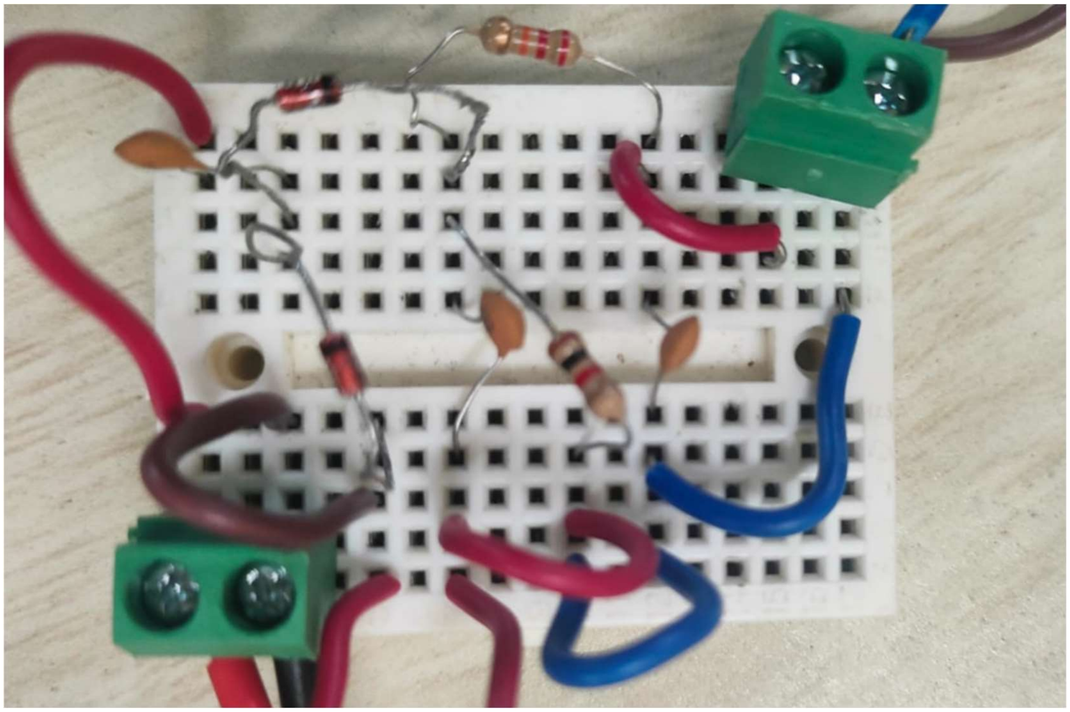

Fig 11: Circuit prototype-3

WORKING PRINCIPLE:

The working principle of an RF detector is based on the rectification of the RF signal using a diode and the filtering of the rectified signal to extract the information signal.

When an RF signal is applied to a diode, it rectifies the signal, producing a DC voltage proportional to the amplitude of the RF signal. This rectification process creates an envelope signal that has the same shape as the original RF signal but is at a much lower frequency.

02It works similarly to an RF peak-to-peak detector, As the RF voltage in the input falls, it eventually turns on the diode(D2) which builds up the voltage across the capacitor(C1) which turns the other diode(D100) ON and then transfers the charge to capacitor(C2). This process continues until the capacitor charges up until it reaches a value close to the peak-to-peak RF Amplitude. Resistor(R1) is used to pull the charge off the capacitor. It is also to be noted that the charging time constant has to be greater than that of the discharging time constant.

The rectified RF signal is then filtered to remove the high-frequency RF component and retain only the lower-frequency envelope signal. This filtering can be achieved using a low-pass filter, which allows only the low-frequency components to pass through while attenuating the high-frequency components.

The resulting output is the envelope signal, which contains the original information carried by the RF signal. The envelope signal can be further processed to recover the original information using demodulation techniques appropriate for the type of modulation used in the RF signal.

Snaps of the output:

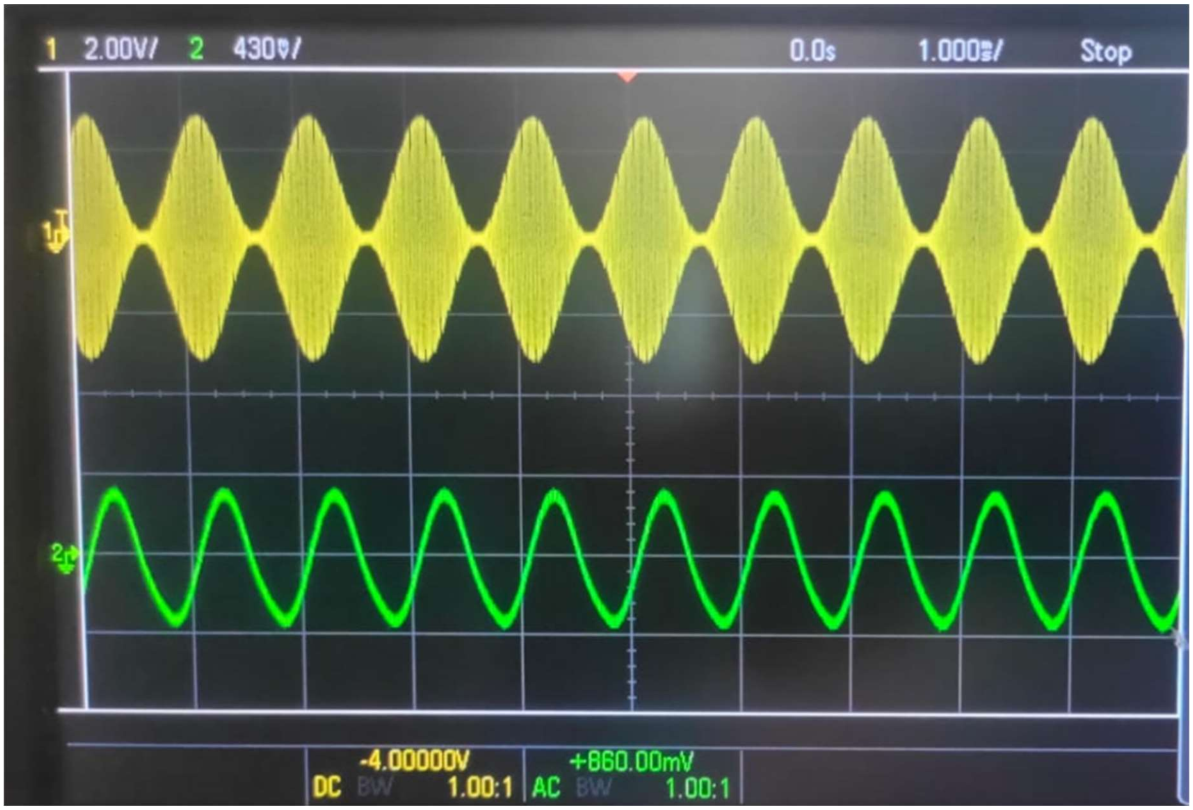

Fig 12: Output waveform as observed on DSO

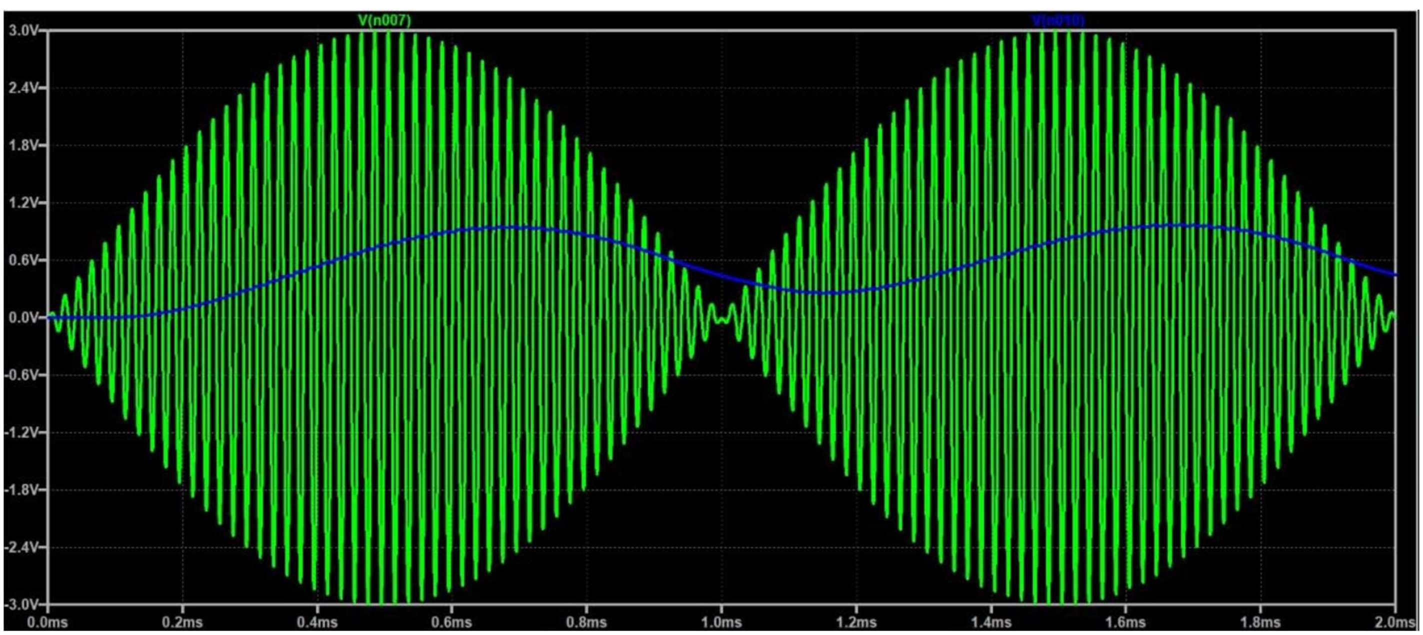

Fig 13: Output waveform observed on LTspice simulator

RESULT and OBSERVATION:

It is observed that the detector functions efficiently in the range of 500Hz to 20K Hz(maximum upper limit of function generator). As we move further away from the range, we observe ripples getting introduced within the output waveform as we move beyond this range. As we move to higher frequencies we also observe that the output waveform gets further and further deamplified. When we try to demodulate Amplitude modulated wave with message frequency less than 500 Hz we observe non horizontal clipping. We can further improve the detector by connecting variable resistor and variable capacitor so we can vary it in response to the message signal.

Applications:

- Tuning or adjusting IF stages during alignment
- Filter response
- Peaking RF circuits
- Examining amplitude modulation characteristics.
- Wireless communication systems: In these systems, RF detectors are used to monitor the strength of the RF signal being transmitted and received by the system. This information is then used to adjust the power of the transmitter and optimize the performance of the system.
- Radio astronomy: Radio telescopes use RF detectors to measure the strength and frequency of the RF signals emitted by celestial bodies. This information is used to study the properties of stars, galaxies, and other celestial objects.
- Radar systems: where they are used to detect and measure the strength of the RF signals reflected by objects in the radar's field of view. This information is used to determine the location and velocity of objects and is used in applications such as air traffic control, weather monitoring, and military surveillance.
- Radio broadcasting: RF demodulators are used to extract the audio signal from a modulated radio frequency carrier wave in radio broadcasting systems.
- Telecommunications: RF demodulators are used in various telecommunications applications to recover the original signal from a modulated carrier wave, such as in satellite communications, mobile phone networks, and digital TV.

Advantages:

- Safety: RF detectors can help identify sources of potentially harmful RF radiation, which can be useful in ensuring safety in various environments.
- Security: RF detectors can be used to detect the presence of hidden surveillance devices, such as hidden cameras or microphones, which can be useful in maintaining privacy and security.
- Convenience: RF detectors are often small and portable, which makes them convenient to use and carry around.
- Cost-effective: RF detectors are relatively inexpensive and can be a cost-effective solution for detecting RF signals.
- Easy to use: RF detectors are usually easy to use, requiring little to no technical expertise or training to operate.

The advantages of an RF demodulator include:

- Compatibility: RF demodulators can be used to demodulate a wide range of RF signals, including those used for radio broadcasts, TV broadcasts, and cable TV.
- Simplicity: RF demodulators are relatively simple devices, requiring only a few components to perform the demodulation process. This makes them easy to design and manufacture.
- Low cost: Because of their simplicity, RF demodulators are relatively inexpensive to produce. This makes them a cost-effective solution for demodulating RF signals.
- Reliability: RF demodulators are typically very reliable, with few components that can fail or require maintenance.
- Signal quality: RF demodulators can produce high-quality audio and video signals, with good signal-to-noise ratios and low distortion.
- Versatility: RF demodulators can be used with a variety of output devices, including speakers, televisions, and computer monitors.

Limitations:

- Limited frequency range: RF demodulators can only demodulate signals within a certain frequency range.
- Interference: RF demodulators can be susceptible to interference from other RF signals or electromagnetic interference, which can degrade the quality of the demodulated signal.
- Compatibility: While RF demodulators are generally compatible with a wide range of signals, some signals may require additional processing or specialized demodulation techniques.
- Signal loss: RF demodulators can experience a signal loss due to cable attenuation, which can reduce the strength of the demodulated signal.
- Complexity: While RF demodulators are relatively simple devices, more advanced demodulation techniques can be complex and require specialized knowledge and equipment.
- Noise: One of the main limitations of RF demodulators is noise. RF signals are often very weak and can be easily degraded by noise. This can result in a poor signal-to-noise ratio (SNR), which can make it difficult to accurately demodulate the signal.
- Nonlinear distortion: RF demodulators can also be affected by nonlinear distortion. This occurs when the demodulator is not able to accurately reproduce the original signal due to the nonlinear characteristics of the demodulator.
- Frequency response: The frequency response of an RF demodulator is another limitation. RF signals can have a wide range of frequencies, and a demodulator must be able to accurately extract the original signal across this entire frequency range.
- Multipath distortion: In some cases, RF signals can be reflected or refracted by objects in the environment, resulting in multipath distortion. This can cause the demodulator to receive multiple versions of the same signal, which can make it difficult to accurately extract the original signal.

Conclusion:

We have successfully designed an RF detector circuit which demodulates signals in the range of 500Hz to 20K Hz. The special feature of our detector is that it doesn't require the use of the battery to power it on, It operates on the voltage of the modulated signal which we feed to it in order to obtain the demodulated waveform. Also, we have designed a compact circuit, hence we can carry it along with us as well, so whenever we need to demodulate a signal we can just connect it to the circuit

References:

www.google.com

www.wikipedia.org

www.ti.com