DESIGN OF FM TRANSMITTER AND RECEIVER OPERATING IN THE RANGE OF 88 MHZ TO 108 MHZ.

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Abstract

This paper addresses the design of FM Transmitter, Tx and Receiver, Rx based on frequency modulation operating in the range of 88MHz to 108 MHz which is the radio frequency range. The individual circuit block was designed and simulated. Further it was tested using breadboard before it was soldered on PCB.The proposed FM Tx and Rx were evaluated in free space by placing at the distance of 10 meter after fabrication. The designed Tx send the signals and received by Rx at 10 meter. The additional features added were LCD display of frequency and power circuit for both FM transmitter and receiver.

Key Words : *Transmitter (Tx), Receiver (Rx),Frequency Modulation(FM), Intermediate Frequency (IF), Demodulator, Local Oscillator(L0), RF amplifier, Receiver Fidelity.*

1. INTRODUCTION

The advancement of wireless communication spread has conquered the larges distance of time and space making our life easier and comfortable. The wireless communication system comprises of electronic devices, antennas and sensors of various shapes and sizes and so transmitters and receivers are one of the deivce having most of the electronic component integrated in it (Kalam, May,2018).

FM Tx and Rx uses radio frequency which lies in very high frequcncy band for broadcasting and reception. The circuit is designed to work with the frequency range of 88 MHz to 108 MHz and so, the operator can transmit and user can tune to the frequency they wish to listen to. The design circuit had part by part simulation and finally combined and fabricated to have complete receiver and transmitter circuit. (Akinyemi, 2014). The fabricated prototype also has LCD display from where frequency can be read and tune accordingly.

2. TOOLS AND MATERIALS USED

The electronic component like reisistors, capaciotors and inducotrs of varying value is used for the design of FM Tx and Rx. Low power high frequency transistors were used for amplification and switching purpose while trimmer capacitor was used for changing resonant frequency to tune to differnt frequency that we would like to listen. IC LM386 is used for audio amplification and speaker for converting electrical signal back to sound signal in FM Rx. Antenna is one of the important component in both FM Tx and Rx for transmitting and receiving but for the proposed project, a copper hook up wires of 60cm to 100cm is used as an antenna for both Tx and Rx.

Different tools like pencil, knife, scales, iron and Caddo Soldering are used in fabrication of FM Tx and Rx.

3. FM TX AND RX DESIGN.

The Tx and Rx circuit are theoritically designed to resonate at 91.1MHz but can be tuned in the range of 88MHz to 108MHz by using trimmer capacitor. Taking the theoretical parameters as initial input, the optimization is performed through simulations using different available software such as orcad pspice and protues. The circuit was divided into blocks because optimization of whole circuit in one software was not possible due to absence of library we needed for the circuit.

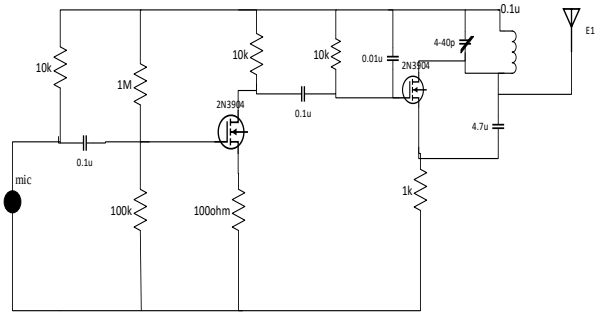

Fig 1 FM Transmitter circuit.

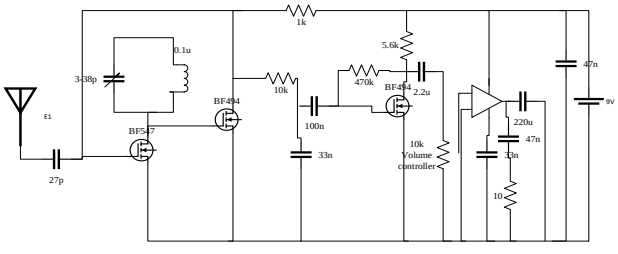

Fig 2 FM Receiver circuit.

The criterias taken into account for optimization are as follows:

- Frequency reponse of individual circuit.
- Frequency range from 88 to 108MHz.
- Resonating frequency at 91.1MHz.
- Reduced complexity by dividing whole circuit into blocks.

4. RESULTS AND EVALUATONS

In this section the simulated results of the individual block circuit are presented. The important parameters in the optimization is the gain and the frequency response of the designed circuit where the output are compared with the theoretically calculated results.

4.1 RF amplifier

The RF Amplifier is used for converting radio frequency signal of low power into a the high power radio frequency signal and it usually drives the transmitter's antenna. (RF Power amplifier., n.d.). The gain from the transient response of the simulated RF amplifier circuit in terms of gain is calculated from the output result i.e. from the graph and compared with the theoretically calculated result.

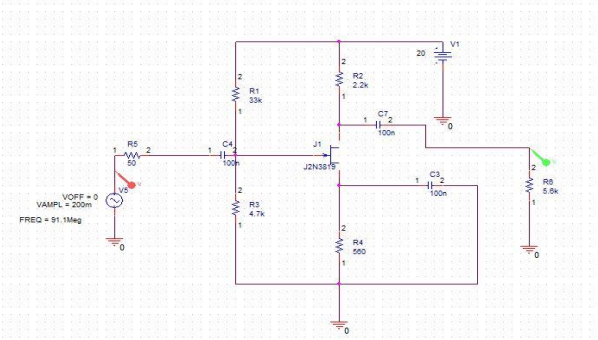

Fig 3 Simulation circuit of RF amplifer

The Figure 3 shows the RF amplifier circuit used for simulation.The Vsin of amplitude 200m is used as input source with frequecncy 91.1MHz. The gain was theoretically calculated as follows (Andrei, n.d).

Gain=Rd/Rs

= 2.2k/560

=3.93

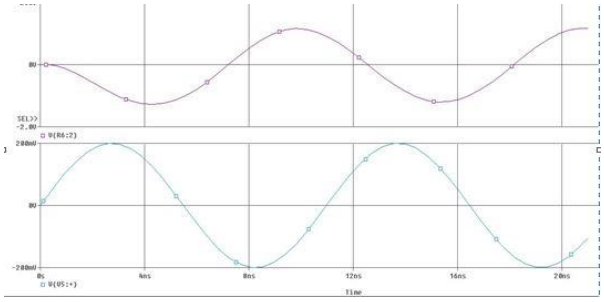

Fig 4 Simulated RF amplifier

The figure 4 is the transient response of the amplifer where blue colored sine wave is an input with 200m having the amplified output with 0.8V represented by purple color giving the gain of 4. The simulated gain was approximately near to the theoretically calculated gain.

4.2 Tank circuit

It consist of LC in parallel and is designed to generate resonant frequency. The simulation was done using fixed capacitor value and so the resonant frequency that we would get is 91.1 MHz.

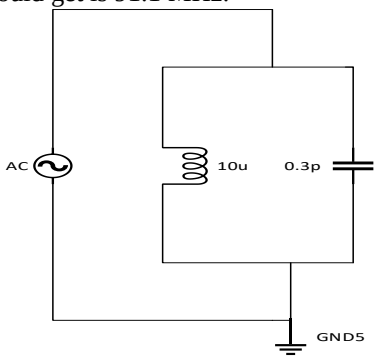

Fig 5 tank circuit design

For having variable frequency as an resonant, trimmer is used in place of fixed capacitor which provides an alterantives to change frequency of our interest. This tunable capacitor is used to change resonanting frequency in the range of 88MHz to 108 MHz and so the designed circuit is very important for determining the Tx and Rx operating range.

4.3 Audio amplifier

To improve the sound performance of the receiver, audio amplifier is designed and simulated in pspice orcad. LM386 is a low voltage audio amplifier and it is powered with battery of 9V. It is used in music devices like radios, guitars, toys etc. The gain of this amplifier range from 20 to 200 which can be adjusted with the help of capacitor. If no external component are used, gain is internally set to 20 but can be increased to 200 by using resistor and capacitor between PIN 1 and 8. When gain is 200, it means that the output is 200

times greater than the input voltage (D. Saswata, May, 2018).

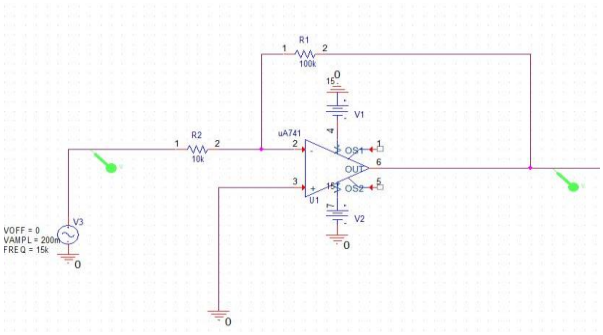

Fig 6 Audio amplifier simulation circuit

The circuit of audio amplifier is designed using UA741 with the gain of 10. The UA741 was used for audio amplification as it is designed to be used for low power amplification in high frequencies.

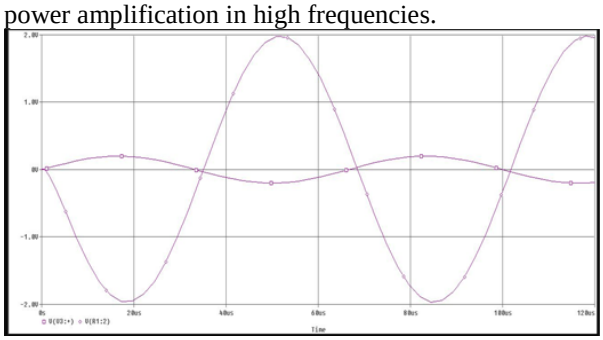

Fig 7 Simulated output of audio amplifier.

As an input, 200m was given with 15k (which are usually audio signal) and is fed to UA741 IC for amplification. The gain from the above result is as follows

Gain = 2V/ 0.2V

= 10

5. CIRCUIT TESTING ON BREADBOARD.

This section have the detailed of FM transmitter and Receiver circuit which are tested on breadboard. The circuit analysis are also done in this section and the steps taken to improve the design are also explained in this section.

5.1 FM Transmitter on breadboard.

This is the breadboard implementation of the designed circuit before fabricating. The components were tested and then implemented on the bread board. The use of wire in the design was made less as far as possible to have less losses. Inductor coil was made to have the value of 0.1u and was measured using LC meter for the confirmation. To power the circuit, 9V battery is used.

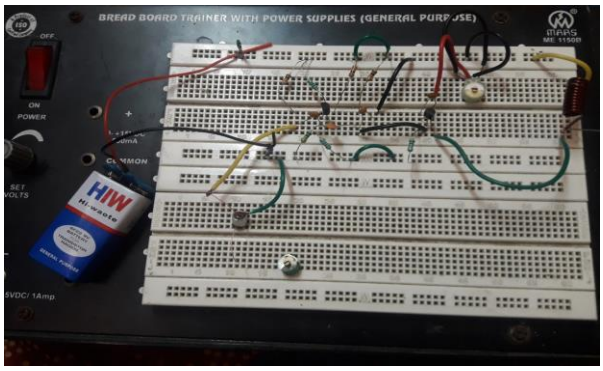

Fig 8 Breadboard implementation of FM Transmitter circuit.

The design was able to transmit the signal but the frequency at which it was transmitting was challenging to note because the trimmer capacitor was of high range and so, the small change in trimmer shifted resonant frequency to the greater value. The transmitting range of the designed transmitter was very less and it was able to cover up to only one to two meter (Q. Risa, 2016, april 28).

5.2 FM Receiver on breadboard.

This is the breadboard implementation of the FM receiver circuit after testing the individual component such as audio amplifier and the speaker. While designing on the breadboard, the polarity was to be taken care because the slight change in the polarity of one block could stop the functioning of whole circuit. So the polarity of all the component was studied before designing. Similarly in FM transmitter, 9V battery were used to power the circuit. (D. Saswata, May, 2018)

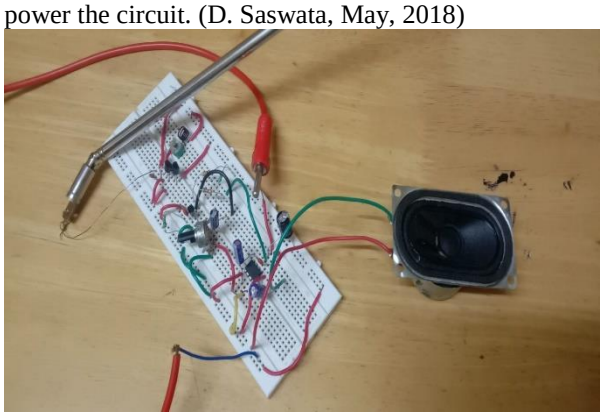

Fig 9 Breadboard implementation of FM Receiver circuit.

The designed circuit were able to receive the signal but we couldn't find the frequency because of the value of trimmer capacitor. There were need for a LCD display where we can read the frequency at which the receiver is tuning into. The received signal was not clear so there were need for improving the audio quality.

5.3 Circuit Analysis.

The transmitter was not able to cover the desired distance and at the same time we were not able to say at what frequency we are transmitting. The FM receiver also needed to determine at which frequency were we tuning to and needed to have good audio quality. So considering all this, to improve the design, following changes were made to the circuit.

The transmitting power of the transmitter was increaded.The transmitting power of the transmitter can be increased by adding RF amplifier before feeding to antenna. The transmitting power of the system will be amplified which will help cover longer distance (Abhishek, 28 Oct, 2017).

Audio quality of the received signal is greatly affected by the sensitivity of the design where sensitivity is defined as how well a radio tuner can receive radio signal of different strength. So the value of trimmer will also affect the audio quality because if we are not able to perfectly tune to the frequency what we want to listen, there will be noise in the tuned signal due to varying frequency.

6. FABRICATION

After doing all the modification and improvement in the circuit, fabrication was done on the PCB board. Circuit analysis proved to be very useful in order to get better result. The fig 10 shows the fabricated FM transmitter and for the better look, the outer case was designed.

Fig 10 Outer case of FM Transmitter.

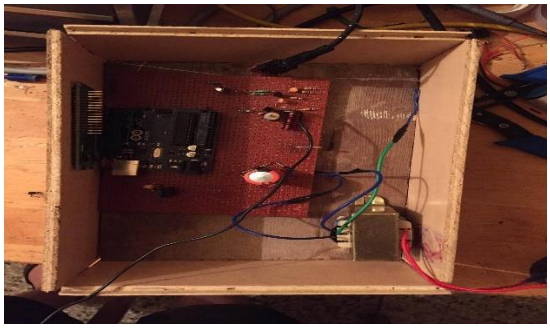

Fig 11 Fabricated FM Transmitter.

The Tx is able to transmit signal up to few meters and the frequency is set to 91.1 MHz which is our campus radio frequency. It is able to transmit up to the range of 8 to 10 meters.

Similarly, FM receiver is also fabricated after doing circuit analysis. For displaying frequency, LCD is used and as we tune the frequency using trimmer, the frequency change is displayed on the LCD screen. The designed receiver is able to receive the transmitted signal at the frequency 91.1 MHz

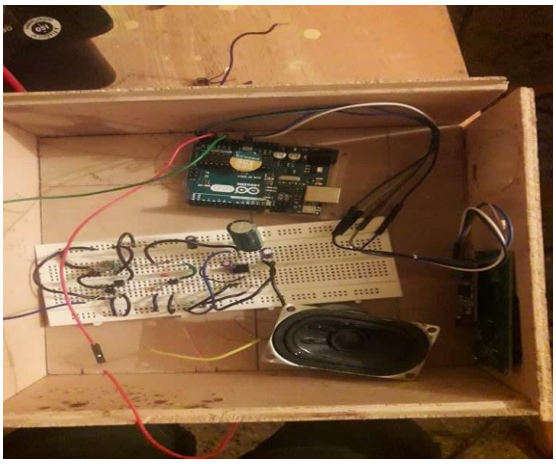

Fig 12 Fabricated FM Receiver.

7. CONCLUSION AND FUTURE SCOPE

The initial designs started from a very simple basic structure with the theoretical design of FM Tx and Rx circuit. Then the individual block circuit is introduced to increase the fedility of the design while simulating. Every sub-circuit created in this project was sized to correctly operate in specification and in collaboration with the other sub-circuits to obtain the final result i.e. FM transmitter and receiver.

All the objectives established at the beginning of this project was accomplished and the results attained are considered satisfactory. From the design of individual block to the fabrication of the final circuit with new features was delivered by the end of the project.

Following the common workflow in the design of FM transmitter and receiver, the next stage involves the improvement in the distance coverage of transmitter and sound quality of the receiver to have good performance and better system.

The next suggestions intent to give a further insight into what the next stages of this projects involves.

- Design good filter for noise removable.
- Increase the transmitting range
- Design better audio amplifier

Finally, it is expected that the performance of this work will be reliable and in accordance with the results presented in this document.

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