ISSN 2349-7815

International Journal of Recent Research in Electrical and Electronics Engineering (IJRREEE)
Vol. 5, Issue 3, pp: (1-5), Month: July - September 2018, Available at: www.paperpublications.org

DESIGN AND CONSTRUCTION OF FM TRANSMITER WITH THE RANGE OF 1.5 KM

[1]M. I. Efunbote, [2]T. I. Ibrahim, [3]J. O. Otulana, [4]R. A. Jokojeje

[1]Department of Electrical /Electronics Engineering, Moshood Abiola Polytechnic, Abeokuta, Ogun State, Nigeria
[2]Department of Mechanical Engineering, Moshood Abiola Polytechnic, Abeokuta, Ogun State, Nigeria

Abstract: **This research work highlighted major components of an FM transmitter consisting of audio unit, modulating unit, amplifier unit, RF(Radio Frequency) amplifier unit and transmitting unit. These units worked together to achieve the desired results. The transmitter itself generated alternating current, which was applied to the antenna when excited by this alternating current, basically a VHF colpitt oscillator capable of transmitting sound to any standard FM receiver. The circuit worked on a DC source which was got from rectification. This was made use of by the FM (Frequency Modulation) transmitter and a capacitor microphone which picked up a very weak signal. The electrical signal was then applied to FM (Frequency Module) transmitter where the signal was then frequency modulated with a carrier frequency. The modulated signal was then transmitted to the medium through a transmitting antenna. FM transmitter could be used as cordless microphone, mobile phones and public address purpose. The antenna was attached to the transmitter in a portable device such as cell phone and walkie talkie, the antenna might be located on top of a building or a separate tower and connected to the transmitter by a feed line, that is transmitting line.**

Keywords: **Transmitter, Radio Frequency, Modulation, Receiver and Antenna.**

1. INTRODUCTION

1.1 BACKGROUND INFORMATION:

The world has developed to an era of information when electronics communication systems influence most of human activities. These electronics communication systems consists of three major aspects; the receiver, the channel and the source, which is the transmitter. A transmitter is an electronics device, which, with the aid of an antenna, propagates an electromagnetic signal such as radio, television or other telecommunications. In the previous years, signal energy was generated in transmitting plants using arcs or mechanical alternators. Presently, a transmitter usually has a power supply, an oscillator, a modulator and amplifiers for audio frequency (AF), intermediate frequency (IF) and radio frequency (RF). Transmitters are sometimes classified according to the signal information they process and radiate. Television transmitter's processes sounds and picture signal while radio transmitter processes only sound

The research dealt with the production of an FM transmitter of appreciable range for practical application. This system will incorporate, at the output stage, the very high frequency (VHF) power transistor (NTE343) which has produced excellent results in other circuits.

1.2 FM TRANSMITTER:

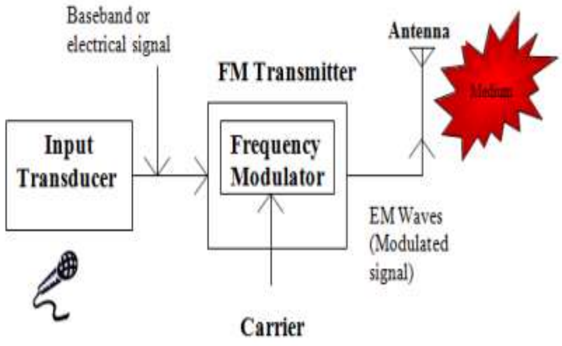

Figure 1: FM Transmission Block

Voice signal was inserted into the system using a microphone. This microphone which acts as a Transducer, converts the voice signal into electrical signal (http://www.unix.ecs.umass.edu). This electrical signal is then applied to FM transmitter where the signal is frequency modulated with a carrier frequency. This modulated signal is then transmitted to the medium through a transmitting antenna (Taub and Scilling, 1986).

1.3 Frequency Modulator:

Frequency Modulation (FM) is that type of modulation in which the frequency is varied in linearly with a message or baseband signal about a modulated carrier frequency . This means that the instantaneous value of the angular frequency will be equal to the carrier frequency plus a time-varying component proportional to the baseband signal. Edwin Howard Armstrong (1890–1954) was an American electrical engineer and inventor who invented frequency modulation (FM) radio (Lucky et al). Suppose the baseband data signal (the message) to be transmitted is and is restricted in amplitude to be and the sinusoidal carrier is Where *fc* is the carrier's base frequency and *Ac* is the carrier's amplitude. The modulator combines the carrier with the baseband data signal to get the transmitted signal (Acharya et al, 2015),

$$y(t) = A_c \cos\left(2\pi \int_0^t f(T)dT\right) \quad (1.0)$$

$$= A_c \cos\left(2\pi \int_0^t \{f_c + f_\Delta xm(T)\}dT\right) \quad (1.1)$$

$$= A_c \cos\left(2\pi f_c t + 2\pi f_\Delta \int_0^t xm(T))dT\right) \quad (1.2)$$

In this equation, $f(T)$ is the Instantaneous frequency of the oscillator and f_Δ is the Frequency Deviation, which represents the maximum shift away from *fc* in one direction, assuming $xm(T)$ is limited to the range ±1(Scwartz et al, 1995).

FM signals may be put into two different categories as under (Lathi et al, 1990).

i. The Direct method or parameter variation method

ii. The Indirect method or the Armstrong method.

1.4 FM RECEIVER:

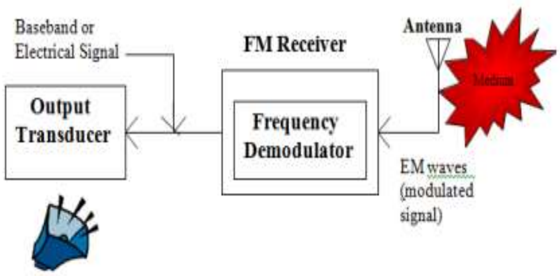

Figure 2: FM Reception block

International Journal of Recent Research in Electrical and Electronics Engineering (IJRREEE)
Vol. 5, Issue 3, pp: (1-5), Month: July - September 2018, Available at: www.paperpublications.org

Here the modulated signal is received through the receiving antenna from the medium and then applied to the FM receiver where the signal frequency is demodulated. Then the original electrical signal is inverse transduced by the output transducer like amplifier box, speakers etc. which converts the electrical signal into sound or it can be further processed (Moumita and Rumpa, 2015).

1.5 FM Demodulator:

The FM demodulator performs the extraction of modulating signal in two steps as follows:

i. It converts the FM signal into a corresponding amplitude modulated signal with the help of frequency dependent circuits like L-C circuits. These circuits are generally known as **Frequency Discriminators** (Sharma, 2009).

ii. The original baseband signal is recovered from this AM signal with the help of the linear diode detector or envelope detector. FM demodulators are of following types:

I. Slope Detector:

- Single-tuned detector circuit or simple slope detector
- Stagger-tuned detector circuit or balanced slope detector.

II. Phase Difference Detectors:

- Foster-Seeley detector
- Ratio detector
- PLL-FM demodulator

2. METHODOLOGY

2.1 CIRCUIT ANALYSIS:

This system is made up of three stages: 9V FM transmitter (Tx) with a range of up to 1 kilometer in the open sky. It uses an RF transistor in its output stage and two BC547's for the first two stages. Distance of transmission is mainly dependent on the operating Conditions (in a building or out on the open) and type of aerial used (single wire or dipole).The best operating voltage is 12V which makes the circuit to attain its peak maximum performance. The system is constructed on a single-sided printed circuit board (PCB) which has a silk screen overlay on top to aid construction. On the bottom there is a solder mask to help in soldering. Protel Autocrat and Schematic were used to design the board.

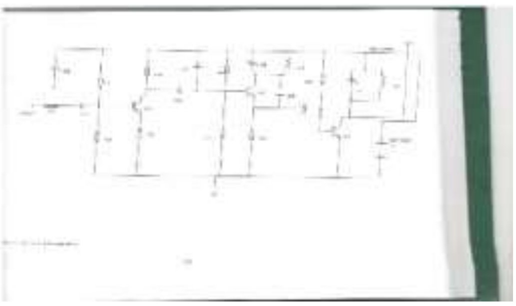

Figure 3: Circuit Diagram of the FM Transmitter

2.2 CIRCUIT STAGES:

The circuit is basically a radio frequency (RF) oscillator that operates around 100 MHz Audio picked up and amplified by the semiconductor microphone which feeds signal into the audio amplifier stage built around the first transistor. Output from the collector is fed into the base of the second transistor where it modulates the resonant frequency of the tank circuit (L1 coil and the red trim cap) by varying the junction capacitance of the transistor. Junction capacitance is a function of the potential difference applied to the base of the transistor T2. The tank circuit is connected in a Hartley oscillator circuit. The final stage built around T3 amplifies the output RF signal. Let us look at the individual blocks of the circuit more closely: The electrets microphone: Electrets is a permanently charged dielectric. It is made by heating a ceramic material,

ISSN 2349-7815

International Journal of Recent Research in Electrical and Electronics Engineering (IJRREEE)
Vol. 5, Issue 3, pp: (1-5), Month: July - September 2018, Available at: www.paperpublications.org

placing it in a magnetic field and then allowing it to cool while still in the magnetic field. It is the electrostatic equivalent of a permanent magnet. In the electret microphone a slice of this material is used as part of the dielectric of a capacitor in which the diaphragm of the microphone forms one plate. Sound pressure moves one of its plates. The movement of the plate changes the capacitance. The electrets capacitor is connected to an FET amplifier. These microphones are small, have excellent sensitivity, a wide frequency response and a very low cost. First amplification stage: this is a standard self-biasing common emitter amplifier. The 22n capacitor isolates the microphone from the base voltage of the transistor and only allows alternating current signals to pass. Oscillator stage: every transmitter needs an oscillator to generate the RF carrier waves. The tank circuit, the transistor and the feedback capacitor are the oscillator circuit here. An input signal is not needed to sustain the oscillation. The feedback signal makes the base-emitter current of the transistor vary at the resonant frequency. This causes the emitter-collector current to vary at the same frequency. This signal fed to the aerial and radiated as radio waves. The name 'tank' circuit comes from the ability of the LC circuit to store energy for oscillations. In a pure LC circuit (one with no resistance) energy cannot be lost. (In an AC network only the resistive elements will dissipate electrical energy. The purely reactive elements, the C and the L, just store energy to be returned to the system later.) Note that the tank circuit does not oscillate just by having a DC potential put across it. Positive feedback must be provided. Trim Cap. The slots inside the trim cap are shaped like the head of an arrow. The maximum capacitance value is when the arrow is in pointed to the 1 2 o'clock position. A 1800 turn brings the trimcap value to its minimum rated value. With experimentation you will be able to build up a table of total capacitance value (remember to add in the 10pF) to FM frequency. You can also change the frequency by altering the space between the coils of L1. Spread out the L1 coil wide apart. The 10pF ceramic capacitor in parallel with the red trim cap will enable you to tune the Tx in the 98 MHz to 105 MHz range of the commercial FM band. If you use a higher value (for example, 27pF) you will move the frequency down towards the other end of the FM band. This end generally has more commercial stations in it. Final Amplification Stage: this RF stage adds amplification to the RF signal. It needs an RF transistor to do this efficiently. L2 (an RFC - radio frequency choke) and the 10p capacitor in parallel with it are designed to reduce harmonics from the circuit. Output power from this stage will be maximum when it is tuned to oscillate at the same frequency as the previous stage. This can be done with the peaking circuit provided and described separately below. A small (10pF) coupling capacitor on the aerial is optional to minimize the effect of the aerial capacitance on the final stage LC circuit. (We have not used one in this circuit.)

2.3 DESIGN PROCEDURE:

The design procedure for the system was based on an existing frequency modulated (FM) transmitter circuit. This transmitter circuit, which the researchers constructed and tested, exhibited some desirable characteristics that qualified it as a base for further design. Operating efficiently on a low-power 12vdc which process minimal safety problem, the transmitter produced sound output with optimum signal-noise ratio (SNR) and high fidelity comparable to practice broadcast transmitter. However, the transmitter incorporates a low power (250mw) output stage using transistor 2N2369 which produces a range too short for practical application. The design procedure then involved the calculations experiments and exercises required to successfully replace the low output of the existing transmitter with medium output stage of useful broadcast value.

2.4 OPERATIONAL ANALYSIS:

Let us see how radio broadcasting stations broadcast speech or music from the broadcasting studios, the speech or music which consist of a series of compressions and rare fractions is translated into a ting varying electric current with the help of a crystal microphone. The frequency of variation of this current lies in the audio-range, hence it is known as audio frequency signal. The audio-frequency signal cannot be radiated out from the antenna directly because transmission at audio-frequency is not practical. For this purpose, oscillations of very high frequency of radio-frequency are produced with the help of any one of the oscillators discussed. The electromagnetic waves so produced are of constant amplitude but of extremely high frequency. These waves, which are neither seen nor heard, travel through space with the velocity of light i.e. 3×10^8m/s (approximately). The audio frequency signal which is been broadcast, is then super imposed on the RF waves, which are known as carrier waves (because the carry AF signal through space to distant places). In a way, the carrier wave can be linked to a horse and the audio frequency signal to a rider. The process by which AF signal or information is impressed on the carrier wave is known as modulation. The horse and rider travel through space at the receiving end, they strike the receiving aerial and enter the receiver which separates the horse from the rider. The horse i.e. carrier wave is returned and the rider i.e. audio-frequency signal is converted back into sound. The process by which the R.F waves and A.F waves are separated is known as detection or demodulation (because it is the reverse of modulation)

3. RESULTS

Block-by-block design and construction of the FM transmitter and receiver was the right approach. We become familiar with the benefits and limitations of each stage and could optimize them individually in the first few weeks. When integration occurred, the firsthand knowledge of the separate blocks became an invaluable part of debugging. The main achievement of this project is the successful construction of two systems. Our transmitter is able to output at 5dbm, while our receiver is able to detect signals as weak as -110db and as far away as 1.5km. Our two circuits are by no means ideal. Given more time, we would fix some issues we have noticed during construction. The IF amplifiers currently contribute too much noise in the region around 300khz. We can try a different op-amp and different values of bias resistors, as well as sharpen the cutoff of the passive band-pass filter by using a higher-order Butterworth topology. Neither mixer is providing any conversion gain, so we would try using a different mixer chip. There is certainly an impedance mismatch between the VCO output and mixer input, which we would solve by impedance matching one to the other or both to 50ω. Also, with more time, we would explore the transmission route through the culprit's oscillator, to increase the transmission power without sacrificing stability.

4. CONCLUSION

So far, the test result of this project which is the outcome of construction procedures has revealed the successful achievement of the primary objective; the design and construction of an FM transmitter of appreciable range of 1.5km, operating on 12v power supply. Because of the impressive good result, obtained from the usability test, the FM transmitter is now ready for either instructional or entrepreneur purposes. The successful completion of this study has indicated that practical FM transmitter requiring low power input between a distance ranges of 1.5km can be designed and constructed.

REFERENCES

[1] Farex, L. Transmitter-encyclopedia articles about transmitters. (2005)

[2] Moumita Acharya and Rumpa Biswas, "Design and Implementation of Frequency Modulated Transmission and Reception of Speech Signal and FPGA Based Enhancement", Volume-1 Issue-1 November-2015.

[3] Sharma Sanjay, Communication Systems‖, 4th edition, S.K. Kataria & Sons, 2009. Leon W. Couch, Digital and Analog communication System , 6th edition.

[4] Taub and Scilling, Principles of Communication Systems , TMH Publishing Company limited, 1986.

[5] Lathi Bhagwandas P. Modern digital and analog communication systems. Oxford University Press, Inc., 1990.

[6] Scwartz. M, Bennet W.R, and Stenin.S , ―Communication Systems and Techniques―, McGraw Hill, New York, 1995.

[7] Walter, L and Anaemena Communication Source book. London: MCGraw Hill.