DESIGN AND CONSTRUCTION OF FM TRANSMITTER

BY

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Declaration

I sincerely declare that project work was completely carried out by me under the supervision of Mr. Abraham Usman of Electrical/Computer Engineering Department, Federal University of Technology, Minna.

29/[illegible]/07

Komba Umar Abdullahi
(Student's name)

DEDICATION

This project work is dedicated to Maolana Baba Ibrahim Inyass (God's favor) for his blessings over the years manifested through my spiritual fathers Sheikh Yakub and Sheikh Abdulkadir Bida and my holy mother Hajiya fatimat Hammam and father Alhaji mahmud Baba Komba.

CERTIFICATION

This is to certify that this project title **Design and Construction of Frequency Modulation (FM) Transmitter** was carried out by Komba Umaru Abdullahi under the supervision of Mr. Abraham Usman and submitted to Electrical and Computer Engineering Department, Federal University of Technology, Minna, in partial fulfillment of the requirements for the award of Bachelor of Engineering (B.Eng) Degree in Electrical and Computer Engineering.

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ABSTRACT

Due to rapid advancement of science and technology, communication system has attain it fastest growing field in terms of its vast application. One mode of information transmission is through Frequency Modulation (FM) techniques. An FM transmitter was designed and constructed. The transmitting frequency was tested to be 100MHz which conform to the design except that due to mixing effect of the transmitter mixer, image frequencies of transmitting are likely to occur with the factor of $\pm$ 10.

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CHAPTER ONE

1.0 GENERAL INTRODUCTION

Electrical communication started in the 1840s with the discovery of wire telegraphy. The first telegraphy cable was inaugurated in 1950, while the first telephone cable did not appears for another forty years. Radio (i.e wireless) communication did not come into the scene until the beginning of the 20th century when, in 1901, the letter 'S' of the morse code, transmitted at a pre-arranged time from Poldhu in corn wall (united kingdom), was heard across the Atlantic in new foundland (united state). Since this time, Communication systems have gone through many revolutionary stages, brought about mainly by the dynamic development in electronics.[1]

Wireless broadcasting of information, forms a major aspect of communication, which is used in the transfer of information from our point to several areas for public use. There are many modes of wireless broadcasting, among are Amplitude modulation, frequency modulation and phase modulation. Among these modes of broadcasting, frequency modulation (FM) is the most preferred system due to its advantages over the others, some of which are high signal to noise ratio and wider bandwidth which is responsible for its stereo quality. Its also has its short comings, mainly shorter area of broadcasting due to its line of sight characteristics.[3]

The wireless broadcasting type designed in this project is a frequency modulation (FM). Frequency modulation (FM) is a system of broadcasting in which the frequency of the carrier is caused to vary in accordance with some specified information-carrying signals. In other words the frequency modulation is a modulation process in which the instantaneous frequency, W (t), of the modulated wave is equal to the unmodulated carrier frequency, Wc, plus a time-varying component that is directly proportional to the modulating sight, Vm (t). that is, W (t) = Wc + Kf Vm (t). The first practical FM transmitter was put forward in 1936 as an alternative to AM in an effort to make radio transmission more resistant to noise.[13]

A standard Fm system is made up of four main sections namely; the audio pre-amplification unit, oscillatory unit & modulation unit, amplification unit and the transmitting unit. The audio pre-amplification unit, transduces voice or sound (non-electrical) into electrical pulses with the aid of a microphone. The modulating unit receives audio signals from the transducer, processes it then uses it to modulate the carrier to deviate from its resting frequency by a certain amount. The maximum deviation specified by the Federal Communication Commission (FCC) is 75kHz. This amount of deviation ensures that the modulated signal is not transmitted with distortions. The modulated signal is then fed into a class C amplification which amplifies the radio frequency for high transmitting power. The last section which is the transmission unit, consist of an antenna, which converts the modulated signal into electromagnetic waves for wireless transmission for public use.[4]

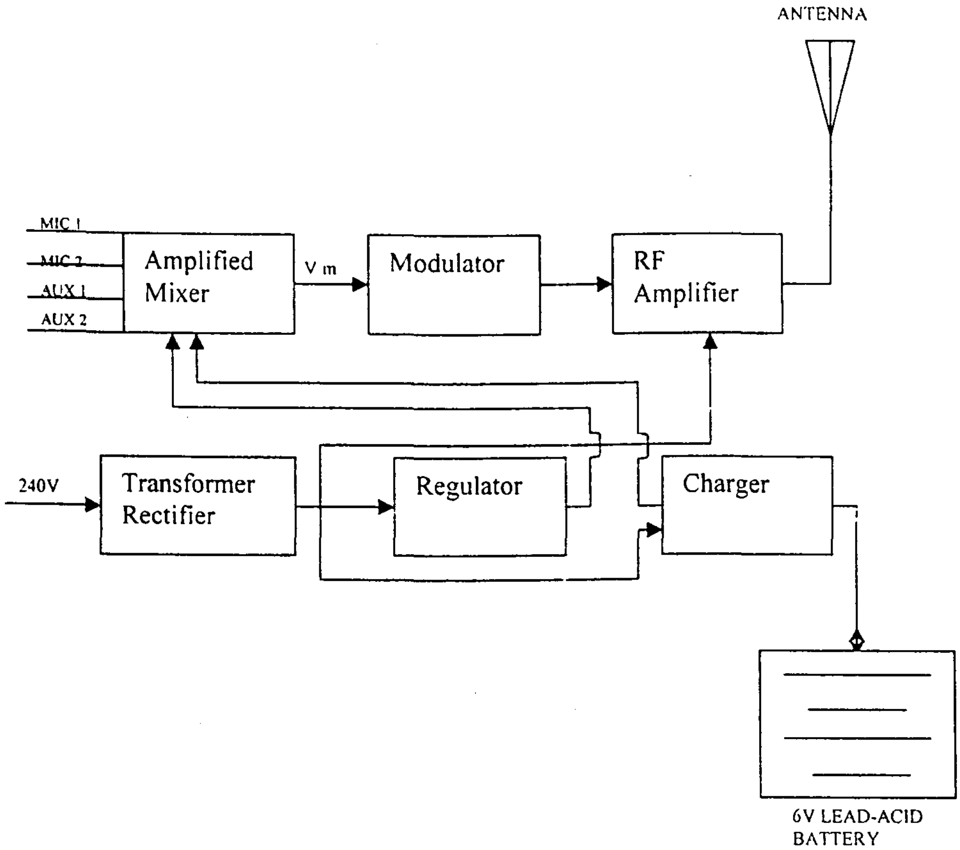


Fig 1: The block diagram of FM transmitter system

1.1 AIMS AND OBJECTIVES

Analog signal broadcast provide a means of a signal processing scheme which utilize difference in the characteristics of the signal and the noise to process the signal more efficient. In particular, in FM systems, an increase in bandwidth provide a proportional increase in output signal-to-noise ratio (SNR), effectively suppressing the noise more and more relative to the signal. This project is however, designed to show how this phenomenon is achieved and also show how FM as an example of a "wideband" modulation scheme, provides a SNR improvement over AM system, which in turn provide an improvement in the ability to transmit information more efficiently.

1.2 PROJECT OUTLINE

In all, there are 5 chapters which contain relevant sections concerning the project.

Chapter 1 is a general introduction and brief historical background of the electronic communication system for a proper understanding of the project.

Chapter 2 has the literature review.

Chapter 3 present designed calculations and analysis of each stage making up the project.

Chapter 4, is the construction, testing and the result of the project construction.

Chapter 5, gives the conclusions and recommendations for further improvement.

References are given thereafter.

CHAPTER TWO

2.0 LITERATURE REVIEW

The performance of any communication system is ultimately limited by the nonzero response time of the system, or equivalently; by the bandwidth, and by the presence of noise in the system.

At the end of the nineteenth century, the electron has been discovered and a great deal of experimental work was being done on electromagnetism. Sparks produce by discharges from a leyden jar through an induction coil of wire fitted with a spark gap were found to be reproduce on touching nearby metal objects. This was the first instance of energy transfer over a distance without wires.

Many theories were put forward for these phenomena, but James Clerk Maxell (1831 - 1879) was the first to consider magnetic and electric fields together to be responsible and formulated his equations from which he predicted electromagnetic radiation on purely theoretical grounds. In 1864 he predicted wave propagation with finite velocity, which he showed to be the velocity of light. [7]

In 1877, a German physicist Heinrich Hertz succeeded in producing electromagnetic wave. He also added a loop of wire and increased the distance over which sparks could be transmitted.

A spark detector was produced by a French physicist called Branley, who noticed that the resistance of a glass tube filled with metal filling, normally high became low when an electric discharge occurred in the vicinity, which could be measured. It was now possible to transmit telegraphy by coding the sparks and using Branley's coherer to receive the sparks over a distance. It is interesting that Branley was the first to use the word "radio" in connection with his experiments.

Guglielmo Marconi was interested in Hertz's experiments and began experimenting in 1895 with a spark induction coil and Branley coherer and succeeded in sending telegraph messages over a short distance. He traveled to Britain in 1896 to exploit his discoveries with W. H. Prece, Engineering Chief of the Government Telegraph Service, and Marconi demonstrated his apparatus to the post office official over distance of 100meters.

Similar work was done in Russia and A. S. Popov gave a demonstration on 12th March, 1896, but was not published until some thirty years later.

Marconi patented his invention in June 1896 and the first radiotelegraph wireless company was formed in 1897 to acquire Marconi's patent and set up manufacturing sparks transmitters and receivers company. Other manufacturers such Siemens Halske were by the late 1890's, also making radio equipment. By this time, aerials had become long wires raised as high as possible [7].

Marconi continued to improve his equipment and succeeded in linking England with France by radio in 1899, and later over longer distances. He also installed equipment on ships for communication ship and shore. To explain why radio communication was possible around the curvature of the earth, Heaviside in England and Kenelly in America proposed an ionized layer in the upper atmosphere which reflected the waves. This was in 1901 and was known as the Heaviside/Kenelly layer.

Spark transmitters were always universal for radiotelegraph, but they were improved when rotary discharger sets were introduced fed from alternators to give more transmitters powers. Atmospherics were a great enemy. Larger and larger were introduced, such as at Polhu in Cornwal, operating in 1911 and at the Clifedn in Ireland. In 1912, the sinking of the Titanic focused attention on radiotelegraphy as, although over 1500 lives were lost, some 7000 were saved by ships summoned by wireless. [7]

In the recent years FM transmitter and receiver station are popular and many in our society compared to other transmission station as result of clear reception it has, and ability to remove all amplitude variation that may be caused by noised, also the guard of channel prevent interference from adjacent channel making FM station more preferable in our country, because everybody likes and appreciate good products.

Frequency Modulation additionally has the advantage over both AM and PM, of providing greater protection from noise for the *lowest* modulating frequencies. The resulting noise signal distribution is here seen as triangle where as its rectangular in both AM and PM. A consequence of this is that FM is used for analog transmission, where as PM is not. [4]

FM is also not affected by the amplitude variation as the amplitude modulation (AM), thus allowing more efficient transmitters to be build. We can summarize by saying that the resultant of the two side band vectors in the FM case will always be perpendicular to (or in phase quadrature with) the unmodulated carrier, while the same resultant in the AM case is collinear with the carrier term. The FM case thus gives variations with very little amplitude change ($B < < \pi/2$), while the Am case gives amplitude variation with no phase deviation. However, phase modulation (PM)and FM differ only by a possible integration of the input modulation signal. The noise and interference reduction advantages of FM over AM, mentioned previously, become significant, however, only for large modulation index ($B > \pi/2$). The bandwidth required to pass this signal become correspondingly large. Most FM systems in use are of this wideband type.[4]

Wideband FM is for broadcast transmissions, with or without stereo multiplex, and for the sound accompanying TV transmissions. Two basic methods of generating FM are in general use. The reactance modulator is a direct method of generating FM, in which the tank circuit reactance, and the frequency of an oscillator, is varied electronically by the modulating signal. To ensure adequate frequency stability, the output frequency is then compare with that of a crystal oscillator and corrected automatically as required. This method is one employed for this project. The alternative means of generating FM, the Armstrong system, is one in which PM is initially generated, but the modulating frequencies are correctly bass booted. FM results in the output. Because only small frequency derivations are possible in the basic Armstrong system, extensive frequency multiplication and mixing are used to increase derivation to the wanted value. All the power amplifiers can be operated in a Class C i.e Very efficiently since FM has an advantage here as an output amplitude modulation system.[34]

CHAPTER THREE

3.0 INTRODUCTION

By the definition of FM, $\omega(t) = \omega_c + k_f V_m{}^{(t)}$ (1)

where

K_f = frequency sensitivity of the modulator circuit and measure in radian per volt second, V_m (t) is a voltages signal, and $\omega(t)$ and ω_c are the instantaneous frequency and the unmodulated carrier frequency respectively.

By integrating the equation (1) with respect to time, we get the instantaneous phase angle, thus,

$$\theta(t) = \int \omega(t)dt = \omega_c t + k_f \int v_m(t)dt \qquad (2)$$

Therefore, the frequency modulated (FM) wave is given by the expression

$$v_{FM}(t) = v_c \cos\theta = v_c \cos\left(\omega_c t + k_f \int v_m(t)dt\right) \qquad (3)$$

Consider a single time frequency modulated signal with modulating signal expressed as

$$v_m(t) = v_m \cos\omega_m t \qquad (4)$$

Putting equation 4 into 1 to get the instantaneous frequency of the FM signal.

i.e $\omega(t) = \omega_c + k_f v_m(t)$

$$= \omega_c + k_f (v_m \cos \omega_m t)$$

$$= \omega_c + \Delta\omega . \cos \omega_m t \qquad (5)$$

Where $\Delta\omega = k_f v_m$

i.e the instantaneous frequcny is

$$2\pi F(t) = 2\pi (F_c + \Delta F . \cos \omega_m t)$$

$$F(t) = F_c + \Delta F \cos \omega_m t \qquad (6)$$

Where $\Delta F = \frac{\Delta\omega}{2\pi} = \frac{k_f v_m}{2\pi}$ (7)

ΔF is known as the frequency deviation which is defined as the maximum departure of the instantaneous frequency of the FM wave from the carrier frequency F_c. The ΔF as could be observed from equation (7) is proportional to the peak amplitude of modulating wave, but is independent of the modulating frequency.

If the frequency deviation of the carrier is known and the frequency of modulating voltage (F_m) is known, we now establish the modulating index (β); (deviation ratio).

$$\beta = \frac{\Delta F}{F_m} \qquad (8)$$

Some notable important characteristic of the modulating index (β) are

- The greater the amplitude of the modulating signal the greater the β

- Modulation index (β) is independent of the amplitude and frequency of the carrier signal.
- The greater the frequency deviation (ΔF), the greater the β e.t.c.

The above expressing are so relevant to note because of the bandwidth limitation placed in wide-band FM transmitting station by the regulating agencies through out the world. [1,2,5]

For this project, the carrier frequency is made adjustable under the receiving band range of 88 – 108MHz. However, its preset to be 95.0MHz

3.1 TRANSDUCER

Transducers are element or device that convert one form of energy into the other. The input transducer employed in communication systems convert the message (e.g sound, picture) into electrical current or voltage to the message signal. The one used in this system, converts sound into electrical pulses, by changing movement caused by air pressure into electrical pulses. This process is achieved with the use of carbon microphone.[1,4]

A single 4 kilo-ohms MC 480 carbon microphone is used to achieved this purpose. The circuit diagram is shown below in Fig. 2

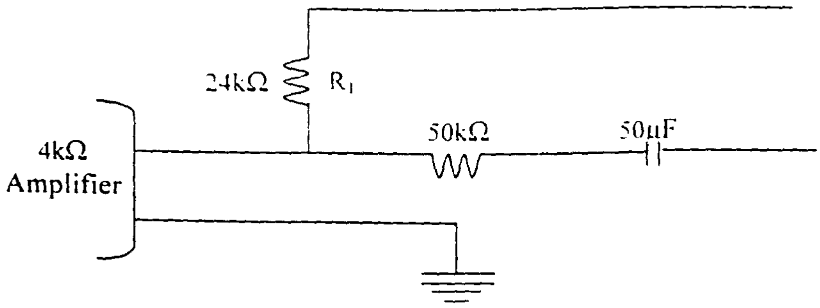


Fig. 2, Carbon Microphone Circuit

R_1 biases the carbon microphone to produce the required current needed for its operation.

Input current, $I_{in} = \frac{V_s}{R_{in}} = \frac{6}{24k} = 0.00025A, \quad I_{in} \approx 0.25mA$

Capacitor C_1 allows only alternating signal to pass while blocking dc signal from upsetting the next bias stage. The 50μF capacitor used work by providing a high reactance for direct current, while providing a low reactance for signal current.

3.2 MODULATION UNIT

The term modulation is generally defined as the process by which a parameter [e.g amplitude, frequency, or phase] of a high frequency signal {known as the carrier} is modified in accordance with the instantaneous value of the message signal {or modulating signal}. Modulation unit is therefore, a unit where the audio signal is combined with a carrier frequency to produce the frequency modulation. At this stage, the audio signal is used to very or shift the frequency of a carrier. The frequency of the carrier is determined by the values of the capacitance and inductance.[1,4]

This purpose is achieved with oscillator circuit which encompasses the modulating circuit and the carrier circuit that work together to generate the required modulated signal for transmission. The carrier frequency for this design is meant to be 95.0MHz. The values of the capacitance and inductance were carefully evaluated to achieve a 95.0MHz carrier frequency. Detail is show in the circuit diagram, figure 7 .

At the pre-amplification stages audio signal is mixed/ filtered and amplified within the required voice bandwidth of about 5kHz.The output is then fed into the input of the Cg014 transistor through resistor R1 for amplification which is used to modulate the carrier frequency of the oscillator. The action of the audio signal is to modulate the carrier frequency of the oscillator by amount determined by the amplitude of the modulator signal i.e the higher the amplitude of the modulator, the higher the shift or deviation of the oscillator frequency. The RFC is a radio frequency chokes that prevent or blocks oscillatory.

At the FM modulator and amplification stage, resistor R1 set the base emitter bias, R2 set the collector-emitter bias. C1 and L1 combined to form an oscillator to provide the carrier frequency needed for modulation. The resulting signal is then passed through a series of frequency multipliers that produce the required operating frequency. The final RF power amplifier boost the power to a level high enough for radiation in the antenna.

The carrier frequency is evaluated as thus;

$$F = \frac{1}{2\pi\sqrt{Lc}}$$

Where c = 23pf = 23 x 10^{-12}f

L = 0.1521μH = 0.1521 x 10^{-6}

$$F = \frac{1}{2\pi\sqrt{23\times10^{-12}\times0.1521\times10^{-6}}} = 95.0MHz$$

$$hfe = \frac{I_o}{I_i}$$

Where hfe of the transistor cg 014 = 100and

Input current I_i =0.25mA

Output current I_o = ?

$I_o = I_i$ * hfe

= 0.25 x 10^{-3} x 100 = 25mA

Deviation ratio (modulating index) (β) $= \frac{\Delta F}{F_m}$

Where ΔF = carrier frequency deviation = 75kHz

F_m = modulating frequency = 15kHz

$\beta = \frac{75}{15} = 5$ i.e the maximum allowed index in commercially broadcast FM

The carrier power P_c is given as follows

$$P_c = \frac{V_c^2[r.m.s]}{R}$$

Where V_c = carrier voltage = 6v

R = carrier resistance = 4ohm

$$P_c = \frac{\left[\frac{6}{\sqrt{2}}\right]^2}{R} = \frac{6^2}{2 \times 4} = \frac{36}{8} = 4.5W$$

Signal power P_s=VI

Where V = signal current = 25mA

P_s = 6 x 25mA = 0.15W

Modulation power (P_m) is the summation of the carrier power and signal power which is given as:

$P_m = P_c + P_s$ where P_c = 4.5W

P_s = 0.15W

P_m = 4.5 + 0.15

= 4.65W

3.3 TRANSMISSION UNIT

A transmitter is an electronics device which with the aid of an antenna propagates an electromagnetic signal such as radio, television or other telecommunications. Thus, transmission unit consist of basically an antenna which converts the modulated signals into electromagnetic waves for wireless broadcasting.[1]

Since transmitters require excellent frequency stability, there are usually several amplifier stages between oscillator and antenna. The intermediate amplifier stages prevent changes in the antenna circuit from affecting the frequency of the oscillator Often the transmitter frequency is not the frequency produces by the oscillator, but one of its harmonics. This is generated from the oscillator out put by a non- linear device (e.g a diode or are over driven amplifier) then filtered with combination of inductor and capaitor and then amplified on the antenna type and height and the transmitting power of the modulated signal. The predicted transmitting range is about 500 meters. However a convenience substitute of an antenna height that is, more amplifier stages that gives maximum power transfer is used to achieve the predicted range.[4] The single tower of the 7oh m yagi-nda autenna is shown in figure 4.

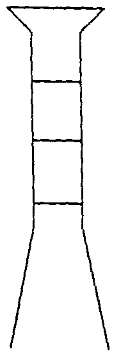


FIG 3 YAGI-UDA ANTENNA.

The power dissipated by this antenna is calculated using

$P_A=I^2*R$ (i)

Where I= the modulating current =?

R= Antenna resistance = 7Ω

Modulating current I is evaluated using $I^2=P\backslash R$ (ii)

Where P is the modulating power =4.65w

R is the choosen antenna resistance =6 Ω

N.B 6 Ω is used here to establish impedance matching to prevent over driving the modulating system or the antenna. Thus from equating (ii)

$$I^2 = \frac{P}{R} = \frac{4{,}64}{6} = 0775A$$

There for, power dissipated by the antenna P_A from equation (i) gives

$P_A = 7 \times 0775 = 5.425W$

From the result obtained, P_M=4.65W and that of P_A is 5.425W. The discrepancies between them indicate an ideal level of impedance matching which enhance the system normal operation.

3.3 THE POWER SUPPLY

Transmitter are sometime fed from a higher voltage level of the power supply grid than necessary in order to improve security of supply. As such the main voltage of 220v is used and step down by a 220v/9v 0.5A transformer. It's then rectified by a full wave bridge rectifier. Zener diode is used to further step down the supply voltage to 6v to be able to charge 6v battery. The supply is also regulated to prevent any fluctuation in the voltage level. Detail is shown in the circulate diagram Fig 7

The wave form has no negative component after rectified with full wave bridge rectifier, but a lot of ripple occur. Something capacitor are needed to reduce the ripple to an acceptable level. The result ripple voltage can be calculated by considering the wave given below in fig. 4

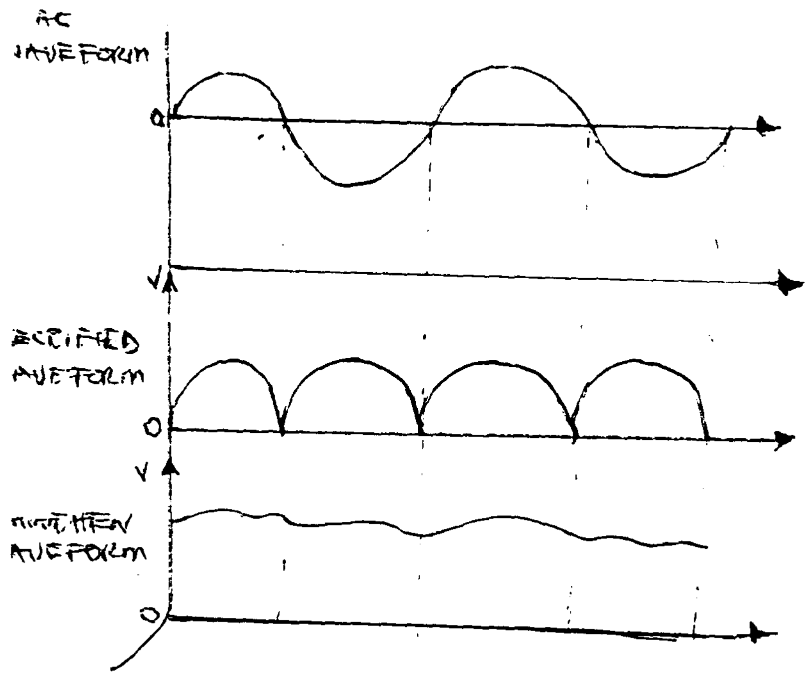


Figure 4: Power Supply wave forms

Capacitor discharged between half cycles as shown above due to the load effect. If the load current I_L remains constant, as it will for small ripple, then from;

$$I_L = C\frac{dv}{dt} \qquad \text{(i)}$$

Where dv is the change in the voltage level

dt is the cyclic period of the wave form. dt can be approximated as;

$$dt = T = \frac{1}{2F} \qquad \text{(ii)}$$

F is the frequency = 50Hz

$$T = \frac{1}{2x50} = 0.01s$$

Which is on the safe side, as the capacitor begins charging up in less than half cycle. The maximum current that can be drain by the circuit is determined by the voltage regulator, the 3177 following the filtering capacitor. It can supply a maximum of 1A if it is heat sink properly. T5his current will be drawn from the supply.

Thus,

Load current I_L = 1A, taking the value of the capacitance C to be 3300μF

$$dv = \frac{I_L \times dt}{C}$$

$$\frac{1 \times 0.01}{3300 \times 10^{-6}} = 3.03V$$

This means that the wave goes from a peak value of 2 x 9v = 18v to 18 - 3.03 = 14.97v.

This is acceptable since the input to the 3177 requires that the voltage level does not fall below 2v above its output, i.e below 7v the ripple is further neglected by the 3177 to a negligible value. The average DC voltage going to the 3177 is calculated by

$$V_p - 0.5V_{pp} = 18 - 0.5 \times 3.03$$
$$= 16.485v$$

The output from the 3177 is at maximum current output of 1A. A heat sink is necessary and is screwed on to its back. The output remains constant in spite of the input voltage variations. To prevent arcing from power supply, a 0.1 μF capacitor is connected across the output of the main source.

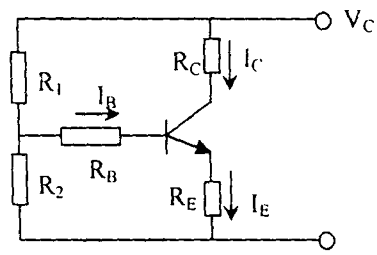
For power indication, a diode is connected from the positive supply Line immediately after the capacitor to ground through a resistor. The resistor value is determined by the current carrying capacitor of the diode. Thus, resistor of 1kΩ produces a current of 16.485/1k = 16.485mA which fully lights up the diode. The diode and resistance also serves as a path to ground through which the smoothing capacitor can discharge after the supply has been turned off. This prevents high voltages that might damage other parts of the circuit from remaining in the system. Also to prevent battery from overcharging, a 6v zener diode in series with a resistor (1kΩ) is connected to the base of two coupled capacitors Cg014. When the battery attain maximum value, the supply main cut off automatically.

3.6 DC ANALYSIS OF BIOPOLAR JUNCTION TRANSISTOR (BJT)

Most of the transistors used in this designed are in common emitter configuration. Hence, emphasis shall be given to its DC analysis.

The BJT has three modes (or regions) of operation; cutoff, active (or normal) and saturation modes. In the cutoff region both junctions are reversed biased. The transistor is off because the base current is not large enough to turn it on. In the active mode the transistor acts as an amplifier and a linear relationship exist between collector and base currents. The CBJ is reversed biased while the BEJ is forward biased. In the saturation modes, both CBJ and BEJ are forward biased. The based current is relatively high and collector emitter voltage drop (VCE) is low.[2,5,6]

Below is a circuit for NPN common emitter transistor connected for the purpose of analysis



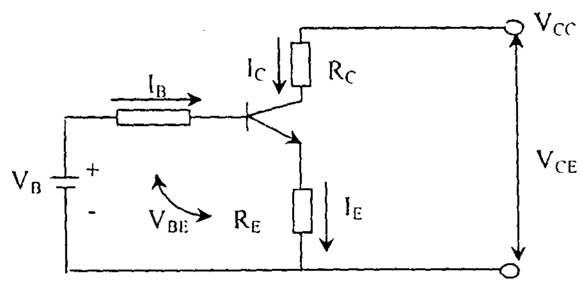


Figure 5: common-emitter BJT configuration,

From common-emitter configuration, we have

$$R_B = \frac{R_1 R_2}{R_1 + R_2} \qquad \text{(i)}$$

By voltage divider theorem

$$V_B = \frac{R_2}{R_1 + R_2} \times V_{CC} \qquad \text{(ii)}$$

From fig (b), applying KVL

$$V_B = I_B R_B + V_{BE} \qquad \text{(iii)}$$

But $I_E = I_B + I_C$ (iv)

Also $I_C = \beta I_B$ (v)

$$I_E = I_B(1+\beta) \qquad \text{(vi)}$$

From (iii)

$$I_B = \frac{V_B - V_{BE}}{R_B} \qquad \text{(vii)}$$

Similarly,

$$V_{CC} = I_C R_C + V_{CE} + I_E R_E \qquad \text{(viii)}$$

From which

$$V_{CE} = V_{CC} - I_C R_C = V_{CC} - \beta I_B R_C \qquad \text{(ix)}$$

Also

$$V_{CE} = V_{CB} + V_{BE} \qquad \text{(x)}$$

V_{CC} = common collector voltage

I_C = collector current

R_C = collector resistor

R_1 and R_2 = load resistors

R_E = emitter resistor

I_E = emitter current

V_B = base voltage

R_B = base resistor

V_{BE} = base emitter voltage

V_{CE} = collector emitter voltage

DATA

$V_{CC} = 6V$

$R_2 = 100k\Omega$

$R_1 = 1k\Omega$

$$R_B = \frac{R_1 R_2}{R_1 + R_2} = \frac{100 \times 1}{100 + 1} = 0.99k\Omega$$

$$V_B = \frac{R_2}{R_1 + R_2} \times V_{CC} = \frac{100}{101} \times 6 = 5.94V$$

$$I_B = \frac{V_B - V_{BE}}{R_B} = \frac{5.94 - 0.6}{0.99 \times 10^3} = 5.4mA$$

$$\frac{I_C}{I_B} = 100$$

$$I_C = 100 \times I_B = 100 \times 5.4 \times 10^{-3} = 0.54A$$

$$I_E = 0.0054(1 + 100) = 0.5454A$$

3.7 THE AUDIO FREQUENCY AMPLIFIER SPECIFICATION

The audio frequency amplifier chip LM358 was used to amplified the output signal from the mic/auxiliary-input circuit. The LM358 is a audio frequency amplifier chip designed for use in a low voltage application. The gain is internally set to 20, but the addition of an external capacitor between pin 1 and 8 will increase the gain to any value from 20 to 200. The input ground referenced while the output automatically biased to have the supply voltage. It features wide supply range 4V - 12 or 5V - 18, low quiescent current drain 4mA and low distortion [?]

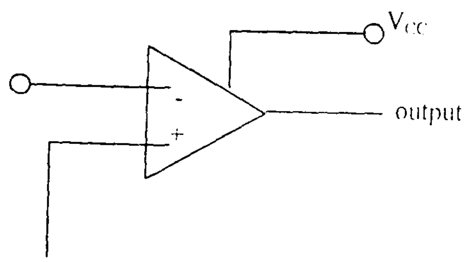
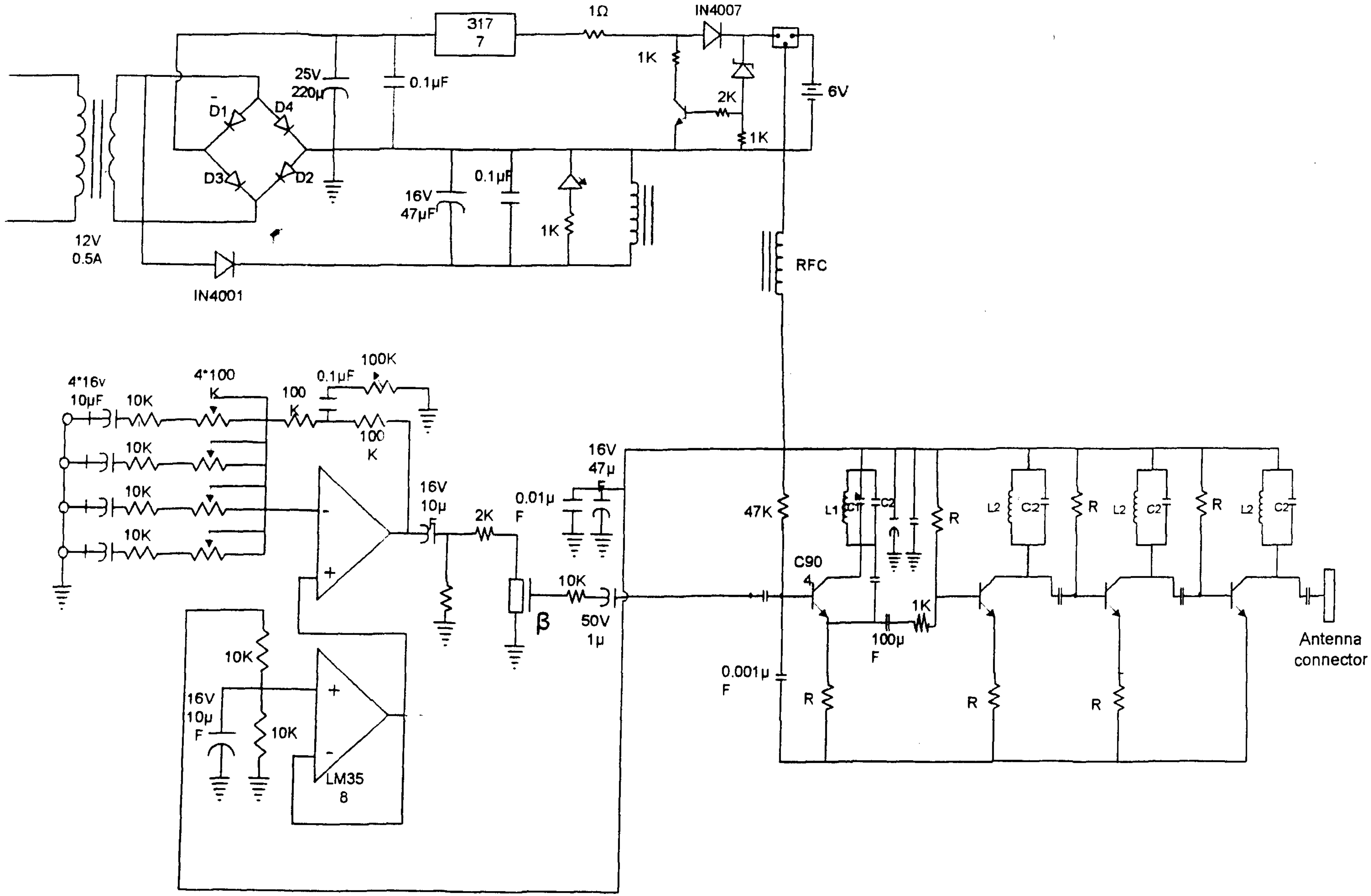


Figure6: Operational Amplifier

$$V_0 = \frac{V_{CC}}{2} = 3V$$



Fg.7 CRCUIT DIAGRAM OF FM TRANSMITTER

CHAPTER FOUR

4.0 CONSTRUCTION, TESTING AND RESULT

The design of the various circuits comprising the FM transmitter system was tested using the specified components, and built on Breadboard, to ensure it fully functioning state of the design. When the system's working condition was certified, the components were then permanently fixed by soldering on a veroboard.

Breadboards are prototype boards, which are modules containing well arranged pin-sockets for fitting-in components. The breadboard is ideal for testing full working of systems and components, as it serves as a temporary construction board. For this project, all the components used in the work were laid out on the breadboard according to specification of the project design. The complete FM transmitter circuit design consists of five main stages, the pre-amplifier stage, the modulation stage, the oscillation stage, the class C amplifier stage and the transmission stage. These stages perform their various functions to achieve the desired goal of this project.

4.1 CONSTRUCTION

The design was carried out in stages, one unit after the other using a breadboard. The first stage, which is the pre-amplification stage, consists of carbon microphone for transducing voice or sound into electrical signals. Capacitors were also used to filter and block any DC signal at the output of this stage from upsetting the next bias. At this stage, resistors were also used to established the required bias voltage and current levels for the other components in action.

The second stage which is the modulation unit, consists of a transistor, capacitor, resistor and an inductor. The transistor here, amplifies the audio signals to an ideal level for modulation. The capacitors block all the DC component from affecting the AC signals. The inductor establishes the bias for the collector and prevents the AC signals from driving into the power supply. The resistors established bias at various terminals for the transistor operation. The third stage which is the oscillation stage, consists of an inductor, capacitors, resistors and a transistor.

The capacitor and inductor combine in parallel form to produce an oscillator which produces the carrier frequency to be modulated.

The transistor amplifies the carrier frequency and also act as a feedback for the oscillator in order to stabilize the frequency of oscillation. The resistors here, also establish the required bias for the transistor terminal.

The fourth stage which is the amplifying stage, consists of a class C amplifier, resistors and capacitors. The class C amplifier which is ideal for

RF amplification is used to amplify the RF signal, to an ideal level for broadcasting. The resistors here also establish the necessary bias for the terminals of the class C transistors. The capacitors also filters the signal output and blocks all the DC component of the signal from affecting the next bias.

The fifth stage, which is the transmitting stage depend, (mostly for transmitting at greater distance), on the output power and the antenna type. For this project, antenna is not necessarily required to achieve the aim of transmitting at a shorter distance of about 100meter. For a commercialized transmitter, the choice of antenna is inevitable. The best antenna needed in this case, is the Yagi-Uda antenna which is capable of dissipating the output RF signal of the class C amplifier.

After these stages were assembled in different breadboards and tested accordingly, they were later connected together sequentially, for final testing before assembling and soldering on veroboard. The result of the test was satisfactorily after minor adjustment in the circuit design. The device on the breadboard was later transferred stages by stages for final soldering on a veroboard.

The device on the veroboard was later transferred to a housing of a well treated casing having the following dimensions: 20.3cm x 13.8cm x 5.2cm. The pictorial view is shown in figure 8

4.2 TESTING

To ensure high reliability of any system or device, design of the system prototype and testing to reveal system behaviours and wickness is highly inevitable. It' s the result obtained that would be work upon to reduce the system failure rate and increase its performance by re-addressing the necessary steps or processes that produced the distortion, then the reliability of such system would be assured.

Project test was carried out to determined it behaviours after which the steps were traced backed to gives a targeted objectives of the project. Microphone was considered first in the testing of this device because it's the first component in the Fm system. Two important characteristics of the microphone are their impedance and pick-up patterns for this test A 10k impedance microPhone of about 2.5mV output voltage was chosen to match the input impedance of the pre-amplified circuit. Initially when the system was tested with an FM receiver, there was a serious distortion in the signal output, which was due to over modulation. It was corrected by limiting the modulating signal to an ideal level. The final testing was carried out by checking the frequency range of the transmitting frequency. This necessary due for the fact that commercial broadcasting frequency modulation channel occupies 200kHz of which 150kHz is used, and the remaining 20kHz guard band goes a long way towards reducing adjacent channel interference even further. This test is necessary to ensure that too much frequency range is not occupied. The use of a digital FM receiver goes a long way to produce the exact and accurate transmitting frequency. The frequency of transmitting was tested to be 100MHz. However, due to mixing effect of the transmitter mixer, image frequencies of transmitting are likely to occur with the factor of $\pm$ 10.

4.2 RESULT

After the testing was done, the following point were noticed and deduced:

It was noticed that as the inductor of the oscillation was varied, the carrier frequency also changed. This particular property is very useful, in the sense that the transmitting frequency can be changed in case the transmitting frequency interferes with another broadcasting stations transmitting frequency.

The transmitting range of this system occupies about 100meter radius desired. The distance of transmission depends on the transmitting power and the type and height of the antenna. High quality antenna like the Yagi-Uda antenna is mostly preferred when transmitting at a greater radius. But it was deduced that transmitting at about 100meter depend mostly on the transmitting power and not the antenna. If the required antenna is gotten, then there is possibility of having a greater radius of transmitting not below 2kilometers, which fall beyond the scope of this project.

4.3 TROUBLE SHOOTING CHECKS

The following trouble checks will help to locate major faults occurring in the FM transmitter

1. When the system is on and the light emitting diodes not glowing, the supply unit may be faulty.
2. When the system is on but there is no output, the system may be put under fault investigation. The fault may be a disconnection of a component in its complete deterioration
3. When a loud humming sound is heard from the receiver unit, the system may be two close to the receiver.

4. When there is transmission signal but no sound the microphone may be faulty.

5. When the output signal is not loud as expected at the receiver, transmitter base volume may be adjusted.

4.4 DISCUSSION OF RESULT

This project has been designed to produce a predicted transmitting range of about 100meters. Since there is no formula to estimate the maximum transmitting range, the height of the antenna and the transmitting power are used to estimate transmission range particularly for a longer area. This could sometime not be achieved due to the following reasons.

- Power losses along the connecting cables.
- Error introduced by measuring equipment.
- The non-exactness of components value.
- Power consumed by power components (transistor and resistors).

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

Having examined the entire project work with carefulness, the implied objectives of this project and possible lessons were derived. Mean while, the FM transmitter in this project worked within the limit of human errors. As true with every human endeavor, major constraints encounter in the course of this project include the finance, availability of materials, and the problem of obtaining the right device elements and components.

However, with the successful application of the principles and arriving at desirable results, the problems are then regarded solved.

5.2 RECOMMENDATION

The FM transmitter designed is recommended for used since it has successfully passed through all the tests carried out. However, if this project is to be carried out other than the techniques used which were purely mannual, when an advance manufacturing technology is applied such as using computer aided design (CAD) and manufacture, the work will be much easier, neater, more durable, highly reliable and more of it kind could be produce in short time possible.

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