

**DESIGN AND CONSTRUCTION OF A
FM BABY MONITORING
TRANSMITTER**

BY

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(2001/13929EE)**

**DEPARTMENT OF ELECTRICAL/COMPUTER
ENGINEERING SCHOOL OF ENGINEERING AND
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FEDERAL UNIVERSITY OF TECHNOLOGY,
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DEDICATION

This project work is dedicated to God Almighty for his love and divine favor over me, members of Jehwo family, Akptohor family, and most especially to my loving wife Mrs. Anna Jehwo, for their love, patience, moral and financial support given to me during my stay in school.

I love you all, God's blessings and protection is what I wish you all.

DECLARATION

I Jehwo A. Benjamin, declare that this work was done by me and has never been presented elsewhere for the award of a degree. I also hereby relinquish the copyright to the Federal University of Technology, Minna.

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ACKNOWLEDGEMENT

All glory and praise to God almighty for life, wisdom, knowledge, divine insight and guidance in the course of my study.

My appreciation goes to my wife, Mrs. Anna Jehwo, who has put in so much to see me through, and to my parents for their guidance and being their for me. I love you all.

Also my sincere thanks goes to my supervisor Mr. Attah for his patience and support, and to the entire staff of the department for their hard work.

Finally to my friends Emmanuel Mulero, Andrew Okeleke, Olatotomiwa, co students, for their cooperation.

ABSTRACT

The project presents the preliminary study, and the final methodology used in the design and construction of a FM BABY MONITOR TRANSMITTER. The aim of this project is to increase the communication link between the mother and her little baby, especially the newly born baby. The report begins with a general introduction, the historical background of radio communication, the components used in the design and the principle of operation of the device. This work is open for great improvement.

TABLE OF CONTENTS

COVER PAGE	i
TITLE PAGE	ii
DECLARATION	iii
ACKNOWLEDGEMENT	iv
ABSTRACT	v
TABLE OF CONTENTS	vi
CHAPTER ONE: INTRODUCTION	
1.0 Communication	1
1.1 Engineering communication	2
1.2 Transmitter	2
1.3 Aim and objective	3
1.4 Methodology	4
1.5 Scope of project	5
CHAPTER TWO	
2.1 Literature review	6
2.2 Technical Background	9
2.3 FM Theory	11
2.4 Derivation of FM equation	11
2.5 Difference between FM and PM	13

CHAPTER THREE

3.0	System Design and Construction	14
3.1	Microphone	14
3.2	Coupling	15
3.3	Module One	16
3.3.1	Design Analysis for Module 1	17
3.3.2	Design Analysis for Common Collector Stage	17
3.3.3	Design Analysis for the Common Base Stage	20
3.4	Module Two	23
3.4.1	Low Pass Filter	24
3.4.2	Band Stop Filters	25
3.4.3	Design Analysis for the Modulating Amplifier Circuit	26
3.4.4	Design Analysis for Tank Circuit	27
3.4.5	Antenna	30

CHAPTER FOUR

4.1	Testing and Design	32
4.2	Discussion of results	33
4.3	Short coming/ limitation	35
4.4	Trouble Shooting of Multistage Amplifier	35
4.5	Flowchart for Troubleshooting the Single Stage Amplifier	36

CHAPTER FIVE

5.1	Conclusion	38
5.2	Recommendation	38
5.3	References	39

CHAPTER ONE

INTRODUCTION

1.0 COMMUNICATION

The sharing of information between two or more people is known as communication, while Engineering communication is the use of electronic gadget to disseminate information. [1]

Communication started when the early men use speech to communicate, but nobody knows when and how speech started. The early men learn to tell stories and folktales to their offspring using speech.

The next stage of development was when early men (cave dwellers) wanted to tell their fellow men the type of animal they hunted, this they did through drawing. This drawing is known as hieroglyphics or picture symbols.

Early men began to multiply and then move apart to found new settlement, they look for means of communicating and they stumble upon the use of smoke and light symbol.

A great stride into communication was the use of electronic gadget in communicating. The first of such gadget was the telegraph, and from then on development in communication became very rapid.

With the advent of telephone, radio, communication satellite, computers and lasers, the world has now been turned into a global village.

1.1 ENGINEERING COMMUNICATION

Disseminating information using electronic gadget is known as engineering communication.

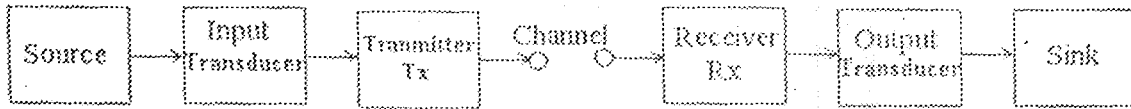


Fig. 1a: Simplified Block Diagram of Engineering Communication

The source is the origin of the information to be communicated. It could be human, machine, analog or digital.

Following closely to the source is the input transducer which converts the output from the source into an electrical form. A good example is the microphone.

The message needs encoding before being transmitted; this is the function of the transmitter. The transmitted message must be passed through a medium to the receiver, this medium is known as a channel, and it could be a wire, optical fiber or space.

The receiver receives the transmitted message, selects and extracts the original information by a process called demodulation, and the output transducer converts the electrical output of the receiver's equipment into a form understandable to the sink.

Communication is incomplete without feedback, so for every information shared there have to be a response which is the feedback.

1.2 TRANSMITTER

A transmitter is an electronic device which with the aid of an antenna propagates an electromagnetic signal such as radio, television or other communication.[2]

A transmitter usually has a power supply, an oscillator, a modulator, and amplifier for audio frequency (AF) and radio frequency (RF). The modulator, is the device which modulate the signal information onto the carrier frequency, which is then broadcast.

Most generally and in communication and information processing, a transmitter is any object (source) which sends information to an observer.

In principle any conductor carrying an alternating current will radiate a radio signal. Thus a basic transmitter is just an oscillator connected directly to a wire antenna.

Transmitters requires excellent frequency stability, hence there are usually several amplifier stages between the oscillator and the antenna.

The intermediate amplifier stage prevents changes in the antenna circuit from affecting the frequency of the oscillator

Often the transmitter frequency is not the frequency produced by the oscillator, but one of its harmonics. This is generated from the oscillator's output by a non-linear device, then filtered with combination of inductors and capacitors and then amplified before reaching the antenna for transmission purpose [2].

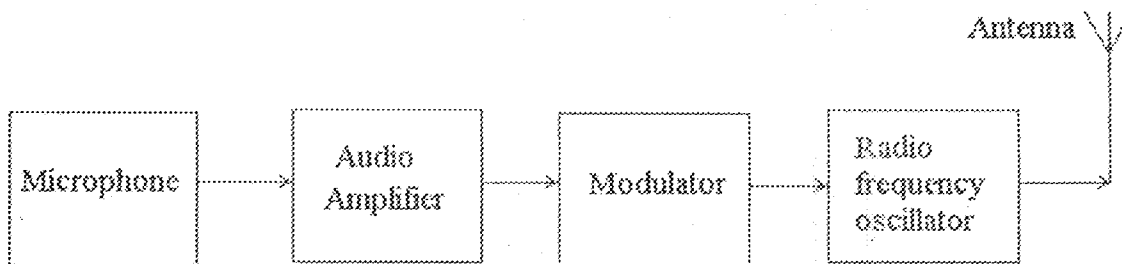


Fig. 1b: Block Diagram of a Transmitter

1.3 AIM AND OBJECTIVE

The aim of the project is to design and construct an FM baby monitor transmitter which will transmit signal (cry) of a baby to a receiver within a flat. The maximum transmitting radius of this transmitter is 20m radius.

Modern mothers want privacy; they want their babies to be in their own room in a separate room from theirs.

In cases like this, the need for a baby monitor arises

A typical baby monitor is sometimes known as a baby alarm [1], is a simple unidirectional radio transmitter and receiver system used to remotely listen for noises made by infants. The transmitter equipped with microphone, is placed near the child and the receiver, equipped with speaker is carried by or near to person caring for the baby at that time. Some baby monitors are duplex i.e. using transceivers that allows the caregiver to communicate back to the baby.

The primary uses of a baby monitor are when the infant is asleep in a separate room, allowing caregivers to keep track of any problems while away from the baby.

1.4 METHODOLOGY

Each stage was separately i.e. modular approach, discrete components were used to realize the project.

Modular one consist of three amplifier stages, the reason was to maintain excellent frequency stability.

Modular two consist of a single transistor stage which makes up the radio frequency stage (oscillator).

1.5 SCOPE OF PROJECT

This project is limited to the historical background and working principle of various models . Material for this project work(i.e. component), used for the

construction were sourced and put together locally, so this make it possible to mass produce this project.

The baby monitor FM transmitter can also be used in offices and conference hall for the purpose of speech recording

CHAPTER TWO

2.1 LITERATURE REVIEW

Radio is a system communication using electromagnetic waves propagated through space. The radio waves have several areas of application such as telephone transmission, wireless telegraphy, radar, television, and navigation system and space communication.

Radio has no specific inventor but a series of attempts by several people. In 1873, James Clerk Maxwell (1831-1879) published the theory of electromagnetic waves hence predicting that electromagnetic waves exist. 1884, Heinrich Rudolf Hertz (1857-1894) a German physicist clarified and expanded the electromagnetic theory which James Maxwell predicted. Hertz then proved that electromagnetic waves can be used to transmit electricity which travels at the speed of light. He then managed to create an oscillating electric discharge whose energy was radiated in the form of EM waves. But the problem of waves not traveling to great distances remained.

In 1896, Guglielmo Marconi (1874-1937) an Italian electrical engineer was able to transmit signals for a distance of more than 1 mile (1.6km). Within a year of first demonstration, signals were transmitted from shore to a ship at sea which was 18 miles away. By 1899, commercial communication between England and France was established. In 1901, simple message was sent across the Atlantic. This success was attributed in the development of a receiver and an oscillator which was connected to an antenna to transmit the radio waves over good distance. In 1904, John Ambrose Fleming an English Electrical Engineer used the thermionic two electrode valve (also called diode).

Reginald Fessenden in 1906 designed a system that transmitted both speech and music over a hundred miles out to sea from Massachusetts coast, earlier than that time only signals were transmitted but not sound. [2]

The creation of vacuum tube oscillator provided the transition from signal transmission to sound transmission because it gave a continuous signal that was effective for speech transmission.

In 1906, De Forest Lee an American inserted a third electrode into the valve hence making a triode (called the audion by De Forest). This device was then able to amplify weak signals. The audion was used then in nearly all radio, television and computer systems until the early 1950 when transistors became available hence replacing vacuum tubes. By 1910, De Forest presented the first live opera radio broadcast and six years later announced the result of the presidential election in first radio news broadcast.

With all these developments, the first significant users of radio were the Coastal, Marine, Army and Intelligence services of the British and German forces during World War I. The war led to large scale production of the thermionic valve and introduced a lot of people into the use of radios.

By 1920 the first time radio station (KDKA) began broadcasting in Pittsburg, Pennsylvania in the United States. By 1922 the radio stations were now in their hundreds. Radios then operate at different frequencies (ranging from Hertz to Giga Hertz) hence used for different purposes.

The essential components of a radio (also called radio transmitter) include an oscillator generator (for converting electric power into oscillations of a predetermined radio frequency), amplifiers (for increasing the intensity of the oscillation while retaining

the desired frequency), a transducer (for converting the information to be transmitted into varying electrical voltage), Modulator (which uses the proportionate voltages to control the variations in the oscillation intensity) and the antenna (which radiates a modulated wave).

Frequency modulation (FM), which is a system of radio transmission in which the carrier wave is modulated so that its frequency varies with audio signal being transmitted was 1st developed by Armstrong Edwin Howard in 1930.

In Armstrong's method of generating FM, the phase of a crystal oscillator's output is varied. Varying the phase of the signal also causes its frequency to be changed. The modulating signal is pre-emphasized and applied to a frequency correcting network (low RC circuit) which makes the audio output amplitude inversely proportional to its frequency. The Armstrong method of generating FM is that it has very little frequency deviation hence cannot be used for commercial broadcasting.

In the varactor diode method of generating FM, a varactor diode is constructed to exhibit characteristics such as the capacitance varying by the amount of reverse bias of the diode. A potentiometer is used to provide the variable capacitance which is needed for tuning. When the signal is applied to the varactor diode, its reverse bias is varied which then causes the diodes junction capacitance to vary in step with the signal. The frequency of the oscillator is then varied as required for FM. The disadvantage of this method is that the stability of the required frequency is not attained which is a very important factor in FM transmission (i.e. their frequency cannot be made to deviate reasonably to provide a workable wideband FM system).

In Voltage Controlled Oscillator (VCO), the output frequency is directly proportional or varied by a voltage applied to its control terminal. The VCO consist of linear frequency/voltage characteristics, free running (which is adjusted to a wanted figure) and good frequency stability. The VCO is considered as a functional block and not a complete transmitter. To make the VCO into a transmitter an audio amplifier will have to be inserted to interface with microphone for modulation and an amplifier (usually class C) which is then terminated with impedance matched network before coupling into an antenna. The disadvantage of this method is that changing frequency would involve varying the resistor and changing the output frequency of the class C resonant tank.

In the Phase Locked Loop (PLL) method of generating FM, a closed feedback system in which the generated signal establishes synchronization with input signal used. The PLL consist of a Phase Detector, Low Pass Filter, Amplifier and VCO. The feedback divides the output frequency by a factor which makes it equal to the reference frequency, such as a crystal oscillator and also minimizes interference from the crystal oscillator. The low pass filter prevents the feedback of the modulated frequencies and eliminates the possibility of the loop locking to a side band. The disadvantage of this method is its poor stability with respect to frequency drifts and the circuitry is always very large and complicated.

2.2 TECHNICAL BACKGROUND

Communication systems depends on frequency of the carrier. The various frequency ranges and their designation are shown in the table 2.0

FREQUENCY	DESIGNATION	ABBREVIATION	WAVELENGTH
3-30kHz	Very low frequency	VLF	100,000-10,000m
30-300s kHz	Low frequency	LF	10,000-1,000m
300-3,000 kHz	Medium frequency	MF	1,000-100m
3-30MHz	High frequency	HF	100-10m
30-300 MHz	Very high frequency	VHF	10-1m
300-3,000 MHz	Ultra high frequency	UHF	1m-10cm
3-30GHz	Super high frequency	SHF	10cm-1cm
30-300 GHz	Extremely high frequency	EHF	1cm-1mm

Table 2.0 Radio Frequency Spectrum

The frequency that is of interest for FM is 88- 108 MHz having a wavelength ranging from 3.4-2.7m

$$\text{i.e. } v = f\lambda$$

Where v = velocity (m/s)

f = frequency (Hz)

λ = wavelength (m)

$$v = 3 \times 10^8 \text{ m/s}$$

2.3 FM THEORY

For sine wave, three parameters associated with it can be altered to carry a low frequency intelligence signal. These parameters are Amplitude, Phase and Frequency.

The phase and frequency are related in that altering one will also alter the position of others, hence they are categorized under Angle Modulation.

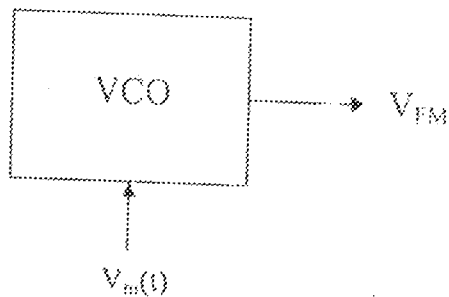
Angle modulation occurs when the angle of sine wave is varied from its reference point.

Angle modulation can be divided into two categories:

- (1) **PHASE MODULATION (PM):** This is where the phase angle of the carrier is varied with respect to the modulating signal amplitude.
- (2) **FREQUENCY MODULATION:** This takes place when the instantaneous frequency of the carrier is varied with respect to the modulating signal amplitude. [4]

2.4 DERIVATION OF FM EQUATION

Using a voltage controlled oscillator with a running frequency f_c , a voltage source of $V_m(t)$ which makes the VCO to deviate from f_c by f_o which is then multiplied by its sensitivity (K_o). The output is an FM voltage.



$$V_{FM} = A \times \cos\theta(t) \dots \dots \dots \text{Equation 1}$$

$$F = F_c + \Delta F \dots \dots \dots \text{Equation 2}$$

Where $\Delta F = K_o \cdot V_m(t)$

$$F = F_c + K_o V_m(t) \dots \dots \dots \text{Equation 3}$$

These set of equations govern the VCO's output

$$\omega = d\theta(t)/dt = 2\pi f \dots \dots \dots \text{Equation 4}$$

Differentiating the angle $\theta(t)$ gives the angular velocity of the output and equating it to $2\pi f$

$$\frac{d\theta}{dt} = 2\pi f_c + 2\pi \Delta f \dots \dots \dots \text{Equation 5}$$

From $F = F_c + \Delta F$

Cross multiplying

$$d\theta(t) = (2\pi f_c + 2\pi \Delta f) dt \dots \dots \dots \text{Equation 6}$$

$$\theta(t) = 2\pi f_c \int dt + 2\pi \int K_o V_m(t) \dots \dots \dots \text{Equation 7}$$

$$V_m = V_{pk} \cos(2\pi f_m t) \dots \dots \dots \text{Equation 8}$$

Substituting into $\theta(t)$ the equation becomes.

$$\theta(t) = 2\pi f_c \int dt + 2\pi \int K_o V_m(t) \cos(2\pi f_m t) \dots \dots \dots \text{Equation 9}$$

$$\theta(t) = 2\pi f_c t + \frac{2\pi K_o V_{pk}}{2\pi f_m} \sin(2\pi f_m t) \dots \dots \dots \text{Equation 10}$$

$$\text{hence } \theta(t) = 2\pi f_c t + \frac{K_o V_{pk}}{f_m}$$

$$\text{Where } M_f = \frac{K_o V_{pk}}{f_m}$$

$$\text{i.e } M_f = \frac{\Delta f}{f_m}$$

Substituting into FM equation

$$V_{FM} = A \cos \theta(t) = A \cos(2\pi f_c t + M_f \sin(2\pi f_m t)) \dots \dots \dots \text{Equation 12}$$

Hence the standard FM Equation becomes

$$V_{FM} = A \cos \theta(t) = A \cos(2\pi f_c t + M_p \sin(2\pi f_m t)) \dots \dots \dots \text{Equation 13}$$

FM and PM equations are similar, but the difference is in their modulation index and varying angle in the brackets.

2.5 DIFFERENCES BETWEEN FM and PM

$$\text{Modulation index } M_p = \frac{\Delta f}{f_m}$$

In phase modulation, M_p is constant, but in frequency modulation M_p varies.

- (1) In PM the amount of phase change is proportion to the intelligence amplitudes while in FM, it is the frequency change that is proportional to intelligence amplitude.
- (2) FM can produce high index frequency modulation while PM requires multipliers to do so.

CHAPTER THREE

3.0 SYSTEM DESIGN AND CONSTRUCTION

This chapter gives the final detailed circuit diagram of the FM baby monitor transmitter and the construction process that made the project to be realized.

The different stages are hence analyzed.

3.1 MICROPHONE:

A microphone is an acoustic to electric transducer that converts sound into an electrical signal.

All microphones capture sound waves with thin, flexible diaphragm. The vibration of this element is then converted by various methods into an electrical signal that is an analog of the original sound.

Most microphones in use today use electromagnetic generation (dynamic microphone), capacitance change (condenser microphones) or piezoelectric generation to produce the signal from mechanical vibration.

For the purpose of the project the condenser or capacitor microphone was used.

In this type of microphone, the diaphragm acts as one plate of a capacitor, and the vibrations produced causes changes in the distance between the plates. Since the plates are biased with a fixed charge (Q), the voltage maintained across the capacitor plate changes with vibration in the air, according to the capacitance equation

$$Q = CV \dots \dots \dots \text{Equation 3.1}$$

Where Q = charge in Coulombs

C = capacitance in farads

V= potential difference in volts.

The capacitance of the plate is inversely proportional to the distance between them for a parallel-plate capacitor

$$C \propto \frac{A}{d} \dots \dots \dots \text{Equation 3.2}$$

3.2 COUPLING

The desirable or undesirable transfer of energy from one medium such as a metallic wire or an optical fiber to another like medium, including fortuitous transfer.

For this project RC coupling was used, the purpose is to block any DC at the input and allow AC to flow.

Allowing DC into the circuit causes the circuit to oscillate i.e. DC has zero frequency but capacitance reactance $X_C = 1/2\pi fC$.

Since f for a DC current is 0

$$X_C = \frac{1}{2\pi \times 0 \times C} = \frac{1}{0} = \infty$$

This causes the circuit to oscillate.

Secondly allowing DC into the circuit causes a shift in the operating point.

To achieve excellent audio fidelity, only calculated values of capacitors should be used. The values of capacitors are chosen so that all frequencies of interest are passed by the High Pass Filter (HPF).

The coupling capacitor value is gotten from the formula

$$C \geq \frac{1}{2\pi f(R_1 // R_2)} \dots \dots \dots \text{Equation 3}$$

C = the required capacitance.

At audio frequency, the frequency that will pass through a high pass filter at 3dB is 200Hz.

For this project, a four stage amplifier was used the reason that, transmitters require excellent frequency stability.

The functioning units used for this project will be grouped under two modules.

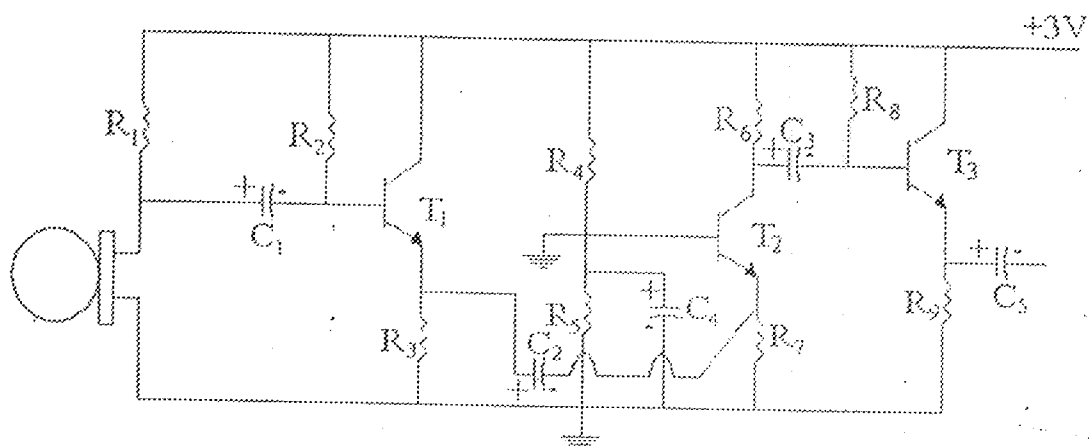
(1) MODULE I

This is the circuit consisting of a condenser microphone and three transistor.

(2) MODULE II

This consist of filter circuit and amplifying oscillator circuit.

3.3 MODULE I



T1 = T2 = T3 = Transistor BC109

Fig 3a: module I circuit

3.3.1 DESIGN ANALYSIS FOR MODULE 1

The impedance of the condenser microphone is 600Ω , resistor value of $1.5k\Omega$ is used in biasing it so that a proper current flow through it. The value of the coupling capacitor is given by:

$$C \geq 1/(2\pi f R_1/R_2)$$

Where R_1 = resistor value $1.5k\Omega$

R_2 = impedance of condenser microphone = 600Ω

f = 200Hz at 3dB

$$R_1/R_2 = (600 \times 1500)/(600+1500) = 428.571\Omega$$

$$C \geq 1/(2\pi \times 200 \times 428.571)$$

$$C \geq 1.8 \times 10^{-6}\text{F}$$

For the purpose of this project, the capacitor value is $10.0 \times 10^{-6}\text{F}$ ($10\mu\text{F}$)

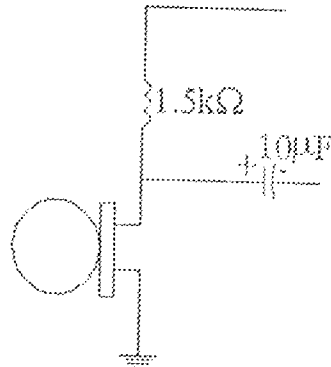


Fig 3b: microphone with a biasing resistor and a coupling capacitor.

3.3.2 DESIGN ANALYSIS FOR THE COMMON COLLECTOR STAGE

The common collector has the following characteristics

- (1) High current gain
- (2) Good DC stability
- (3) Has good compensation

- (4) High driving voltage
- (5) Matching high impedance to low impedance load

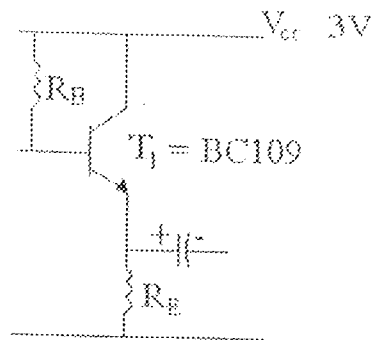


Fig 3c. The common collector stage

Normal DC voltage transistor indication are

$$V_{ce} = V_{cc}/2, \quad V_E = V_{cc}/4, \quad V_B = 3V_{cc}/4.$$

If instead of a load resistor R_L , there is a low resistance coil in the circuit,

Then ,

$$V_{CE} = V_{cc}/2, \quad V_E = V_{cc}/2, \quad V_C = V_{cc} \quad [1]$$

From transistor data sheet, the gain for BC109 transistor ranges from 200-800

$$h_{FE} = 800$$

$$I_C = 2 \times 10^{-3}$$

V_{BE} for silicon transistor = 0.7V

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

$$I_C = \beta I_B$$

$$I_B = \frac{I_C}{\beta} = \frac{2 \times 10^{-3}}{800}$$

$$I_B = 2.5 \times 10^{-6} \text{A}$$

$$I_E = I_B + I_C = 2.0025 \times 10^{-3} \text{A}$$

It must be noted that when designing low power transistor stages the following steps must be followed.

- 1) Take emitter resistor $R_E = 500-1000 \Omega$
- 2) i. The output impedance of a transistor is very high at 1mA. This increases the voltage gain
 ii. There is little danger of overheating as 1mA is quite a small collector current.
- 3) The value of resistor R_1 and R_2 are so selected that current I_B flowing through R_1 and R_2 is at least 10 times I_B i.e $I_B \geq 10I_B$. when this condition is satisfied a good stabilization is achieved. [6]

$$\frac{1}{2}V_{CC} = V_E \dots \dots \dots \text{Equation 3.4}$$

$$V_E = \frac{1}{2} \times 3 = 1.5V$$

$$V_E = I_E R_E$$

$$R_E = \frac{V_E}{I_E} = \frac{1.5}{2.0025 \times 10^{-3}} = 749.06 \Omega$$

$$I_B = \frac{V_{CC} - V_{BE}}{R_B + R_E(1 + \beta)}$$

$$R_B = \frac{V_{CC} - V_{BE} - I_B R_E(1 + \beta)}{I_B}$$

$$= \frac{3 - 0.7 - [(2.5 \times 10^{-6})(749.06)(801)]}{2.5 \times 10^{-6}}$$

$$R_B = 320k\Omega$$

The final circuit for the common collector stage is shown below.

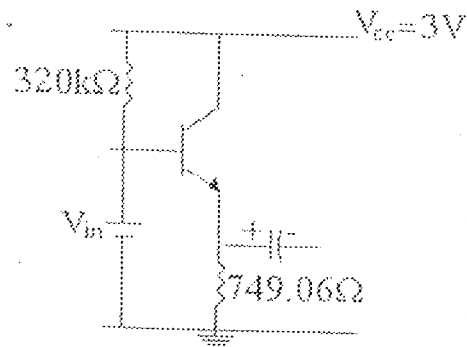


Fig 3d: The final circuit for common collector stage

3.3.3 DESIGN ANALYSIS FOR THE COMMON BASE STAGE

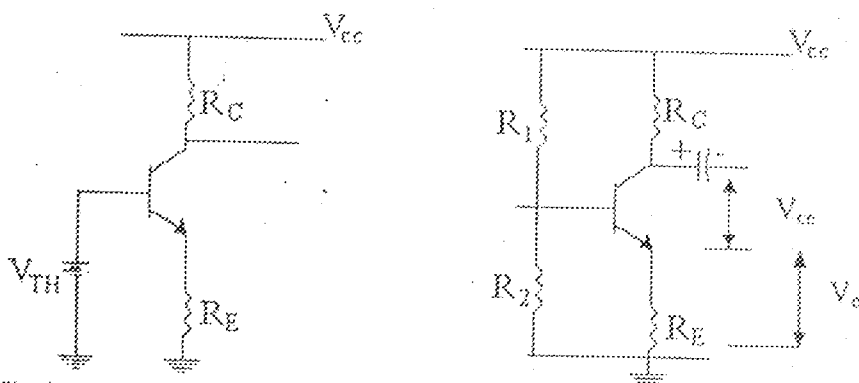


Fig 3.e: Open circuit of a common base configuration

Resistors R_1 and R_2 are for biasing while R_c is for stabilization.

The Thevenin voltage that drives the base is given as

$$V_{TH} = (V_{cc} \times R_2) / (R_1 + R_2) \dots \dots \dots \text{Eqn 3.3}$$

Using the voltage divider bias,

$$V_2 = (V_{cc} \times R_2) / (R_2 + R_1)$$

$$V_E = V_2 - V_{BE}$$

$$I_E = V_E / R_E = (V_2 - V_{BE}) / R_E$$

$$V_c = V_{CC} - I_c R_C$$

$$V_{CE} = V_C - V_E$$

$$V_{CE} = V_{CC} - I_c (R_C + R_E)$$

$$I_C = I_E \dots \dots \dots \text{Equation 3.4}$$

We should bear in mind that β_{DC} which affects all other biasing networks does not appear here. The base voltage is set purely by V_{CC} , R_1 and R_2 . The D.C bias circuit is independent of transistor β .

To design using voltage divider bias, the following should be remembered,

1. select an appropriate operating point I_C , I_B , and V_{CE} from the manufacturers data sheet.
2. Assume $V_E = I_E R_E = I_C R_E$.
3. Select V_{CC} and R_C
 - i. If V_{CE} is specified, $R_C = (V_{CC} - V_{CE} - V_E) / I_C$
 - ii. If R_C is specified, $V_{CE} = V_{CC} - I_C R_C - V_E$
4. Arbitrarily select $R_B = \beta R_E / 10$
 - i. Take $R_C = 2-5 R_E$
 - ii. $R_B = 0.1 \beta R_E$

The following can be deduced from the design procedure above

$$V_E = 0.1 V_{CC} \dots \dots \dots \text{Equation 3.5}$$

$$R_E = V_E / I_E$$

$$R_C = 5 R_E \text{ (approximately)} \dots \dots \dots \text{Equation 3.6}$$

$$R_1 = R_2 V_1 / V_2 = (V_{CC} - V_B) / 10 I_B$$

$$R_2 = V_B / 10 I_B$$

$$V_E = V_B - V_{BE} \dots \dots \dots \text{Equation 3.7}$$

$$V_C = V_{CC} - I_C R_C \dots \dots \dots \text{Equation 3.8}$$

$$V_{CE} = V_C - V_E \dots \dots \dots \text{Equation 3.9}$$

$$I_C = 2 \times 10^{-3}$$

$$I_B = 2.005 \times 10^{-6}$$

$$V_{CC} = V_C - V_E$$

Using $R_E = 500\Omega$ and $R_C = 5R_E$

$$R_C = 5 \times 500 = 2500$$

$$V_B = V_E + V_{BE}$$

$$R_B = 0.3 + 0.7 = 1V$$

$$R_1 = (V_{CC} - V_B) / (10I_B)$$

$$R_1 = (3 - 1) / (10 \times 2.5 \times 10^{-6})$$

$$R_1 = 2 / (10 \times 2.5 \times 10^{-6}) = 80K$$

$$R_2 = V_B / (10I_B) = 1 / (10 \times 2.5 \times 10^{-6}) = 40,000\Omega$$

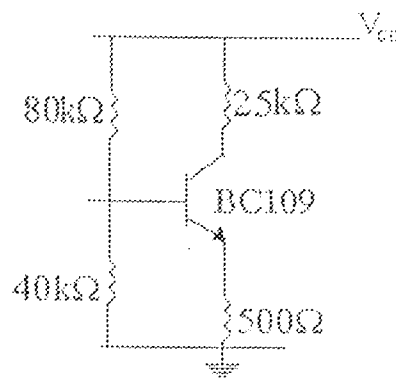


Fig 3f Final common base circuit.

COUPLING CAPACITOR

$$R_{eq} = R_1 R_2 / (R_1 + R_2)$$

$$R_{eq} = (80K\Omega \times 40K\Omega) / (80 + 40)K\Omega$$

$$R_{eq} = 26.67 \times 10^3$$

$$C \geq (2 \times 200 \times 26.67 \times 10^3 \times 11)^2$$

$$C \geq 2.9837 \times 10^{-8} \text{F}$$

The value of the coupling capacitor used for the project is 10 μ F.

The last stage is a common collector stage and is the replica of the first stage. The last stage has already been analyzed.

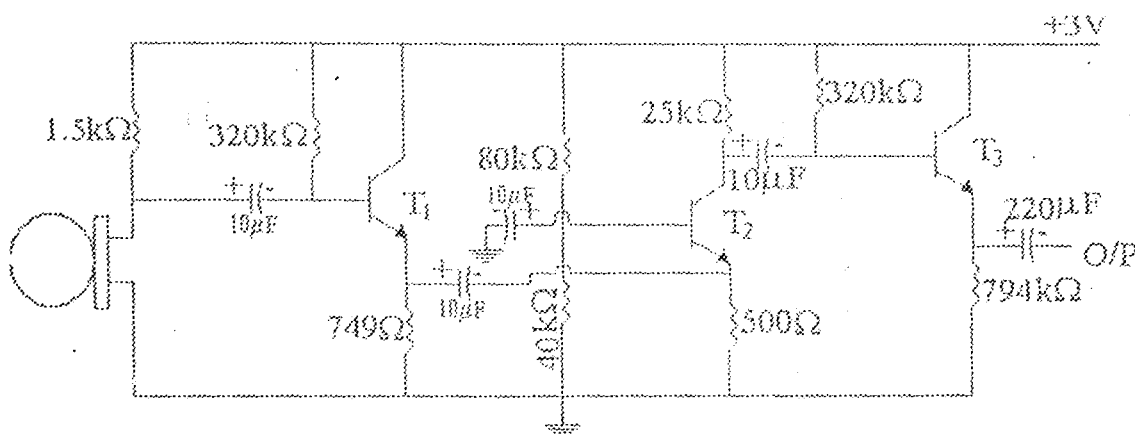


Fig 3g: The final circuit of module 1

3.4 MODULE 2

MODULE 2 consists of an AC filter network known as active network. It is known as AC active filter network because it consists of a transistor in combination with an RC element to obtain the desired filtering effect and a modulating amplifier. This active filter network contains a low pass filter, the function of which is to eliminate undesirable hum in DC power supplies.

3.4.1 LOW PASS FILTERS

Low Pass Filters allows frequency ranges from 20Hz to 200Hz only.

The maximum frequency which it allows to pass through is called cut off frequency (f_c).

The range of frequency up to f_c is called the pass band of the filter

$$f_c = \frac{1}{2\pi RC}$$

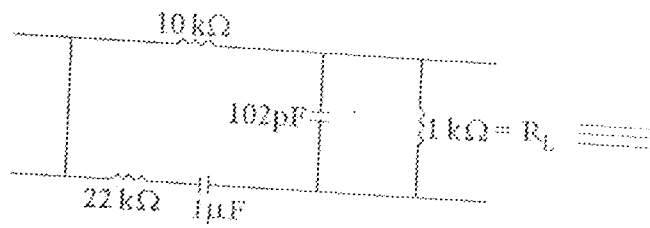
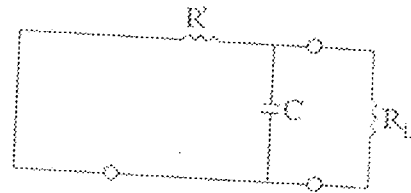


Fig 3h: Low pass filter



$$R' = 10K\Omega // 22 K\Omega$$

$$= \frac{10 \times 10^3 \times 22 \times 10^3}{10 \times 10^3 + 22 \times 10^3}$$

$$R' = 6875\Omega$$

$$R_{equivalent} = R' // R_L$$

$$R_{eq} = \frac{6875 \times 1 \times 10^3}{6875 + 1 \times 10^3} = 873.0\Omega$$

$$C_{eq} = C_1 // C_2 = 102\text{pF} + 1\mu\text{F}$$

$$= 102 \times 10^{-12} + 1 \times 10^{-6}$$

$$C_{eq} = 1.00 \times 10^{-6}$$

Cut off frequency f_c

$$f_c = \frac{1}{2\pi RC}$$

$$f_c = \frac{1}{2\pi \times 1.00 \times 10^{-6} \times 873} = \frac{1}{5.49 \times 10^{-3}}$$

$$f_c = 182.291\text{Hz}$$

So the low pass filter allows frequencies of up to 201Hz to 182Hz but cut off frequencies of above 181Hz. From the calculation above the frequency of 182.291Hz which is the frequency of the battery hum is cut off.

3.4.2 BAND STOP FILTERS

Band filter is a series of low pass and high pass RC filters. This filter alternates a single band of frequencies and allows those on either side to pass through.

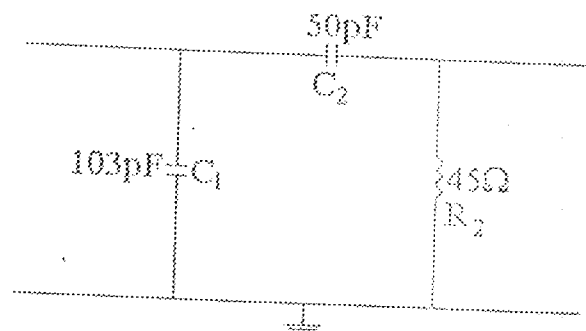


Fig 3i: Band stop filter

The formula for the cut off frequency is given by:

$$f_{c1} = \frac{1}{2\pi C_1 R_1} \text{ and } f_{c2} = \frac{1}{2\pi C_2 R_2}$$

$$f_{c2} = \frac{1}{2\pi \times 50 \times 10^{-12} \times 45}$$

$$f_{c2} = \frac{1}{1.4137 \times 10^{-8}}$$

$$f_{c2} = 70.736\text{MHz}$$

This circuit cut off 70.736MHz where response is below -60 dB

3.4.3 DESIGN ANALYSIS FOR THE MODULATING AMPLIFIER CIRCUIT

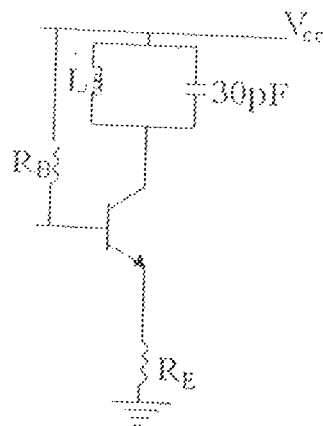


Fig 3j: The oscillating Amplifier Circuit

Modulation is the process of combining an audio frequency signal with a radio frequency signal or carrier wave.

The resultant wave is called modulated carrier wave.

A carrier wave is a high frequency undamped radio wave produced by radio oscillators. The transistor used for this stage is the C930 transistor with the following data from the data sheet.

$$H_{fe} = 70$$

$$I_c = 50\text{mA}$$

$$V_{BE} = 0.7\text{V}$$

For normal circuit operation

$$V_B = \frac{1}{4}V_{CC} \text{ or } V_E = \frac{1}{4}V_{CC} \text{ and } V_{CE} = \frac{1}{2}V_{CC}$$

$$\beta = \frac{I_c}{I_b} = 70$$

$$I_b = \frac{I_c}{\beta} = \frac{50 \times 10^{-3}}{70} = 7.14 \times 10^{-4} \text{ A}$$

$$I_E = 50.7 \times 10^{-3} \text{ A}$$

$$V_E = \frac{1}{4} V_{CC}$$

$$V_E = \frac{1}{4} \times 3 = 2.25$$

$$V_E = I_E R_E$$

$$R_E = \frac{V_E}{I_E} = \frac{2.25}{50.7 \times 10^{-3}}$$

$$R_E = 45 \Omega$$

$$I_E = \frac{V_{CC}}{R_F + \frac{R_B}{\beta}}$$

$$V_{CC} = I_E R_E + I_E \frac{R_B}{\beta}$$

$$R_B = \frac{(V_{CC} - V_{CE}) \beta}{I_E}$$

$$R_B = \frac{(3 - 2.25) 70}{50.7 \times 10^{-3}}$$

$$R_B = \frac{52.5}{50.7 \times 10^{-3}}$$

$$R_B = 1035 \Omega$$

3.4.4 DESIGN ANALYSIS FOR TANK CIRCUIT

The tank circuit is a combination of a capacitor and an inductor connected in parallel or series, but for this project they are connected in parallel. When this circuit is energized electrical resonance occurs. The response of this circuit is maximum when the frequency of the applied voltage equals the natural frequency of the circuit.

$$\text{i.e. } X_L = X_C$$

$$2\pi fL = \frac{1}{2} \pi fC$$

Where L = Inductor value in Henry

C = Capacitor value in Farads

The resonance frequency/resonance frequency is given by

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

For the purpose of this project, a fix capacitor of 30pF was used and the aim was to transmit at a frequency of 103.4MHz on the FM band

$$f_r = 103.4 \times 10^6 \text{ Hz}$$

$$C = 30 \times 10^{-12} \text{ F}$$

$$L = ?$$

$$L = \frac{\left(\frac{1}{2\pi f}\right)^2}{C}$$

$$= \frac{\left(\frac{1}{2\pi \times 103.4 \times 10^6}\right)^2}{30 \times 10^{-12}} = \frac{2.369 \times 10^{-18}}{30 \times 10^{-12}}$$

$$L = 7.897 \times 10^{-8}$$

$$L = 789.7 \times 10^{-6} \text{ H}$$

$$L = 789.7 \text{ uH}$$

from Lenz law the value of inductor used can also be gotten from the formula

$$L = N\phi/I$$

L = value of inductor in Henry

N = number of turns of coil

ϕ = flux in Weber

From the project result

$$L = 789.72 \mu\text{H}$$

$$N = 5 \text{ turns}$$

$$I = 4.8 \text{ mA}$$

$$\Phi = LI/N$$

$$= \frac{789.72 \times 10^{-6} \times 4.8 \times 10^{-3}}{5}$$

$$= 7.58 \times 10^{-7}$$

the value of the flux can also be determined using a flux meter.

Armed with the information above, an inductor value $789.72 \mu\text{H}$ is constructed.

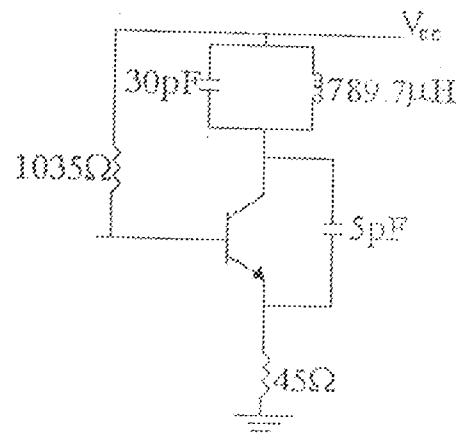


Fig 3k: The complete circuit of an Amplifying oscillator

The 5pF capacitor placed across the transistor is a SWAMPING capacitor. Due to exchange of energy between the inductor and the capacitor (i.e conversion of electrical energy of the capacitor into magnetic energy of the coil and vice versa), the oscillations of the capacitor discharge are damped because energy is dissipated away gradually so that amplitude becomes zero after sometime. The reasons for the damped oscillations are

1. energy is lost in the form of heat produced in the resistance of the coil connecting wires.

- energy is lost in the form of electromagnetic waves that are radiated out from the circuit [5] through which an oscillating current is passing. To curb damp oscillation the capacitor 5pF is inserted across the transistor.

3.4.5 ANTENNA

This is used to transmit electrical signals through the air waves. The size of an antenna determines the length of broadcast. In this project, the length of wire used is 30cm, gauge 22.

Longer length could be used, but to avoid interference with other FM transmitting stations, it was not used. Secondly, the longer wire has some inherent capacitance and impedance that will be compensated for by changes on other parts of the oscillator circuit.

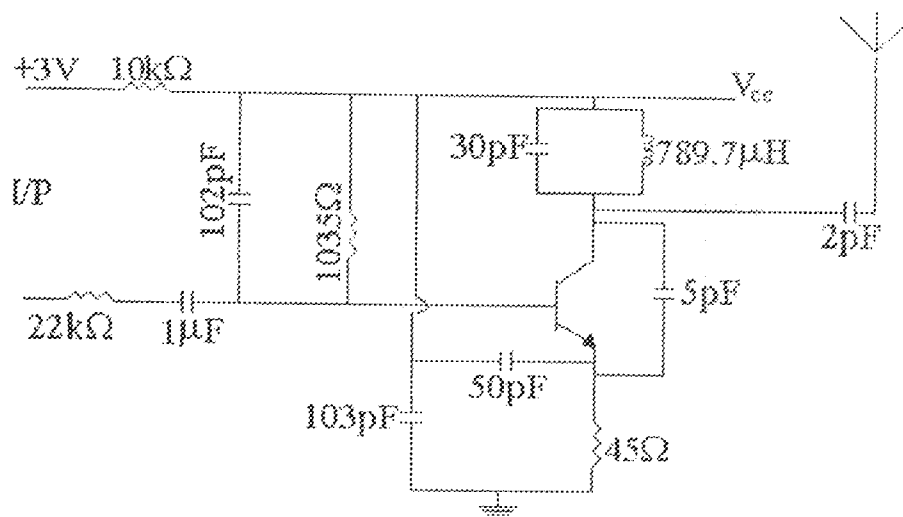


Fig 31. The final circuit of Module 2

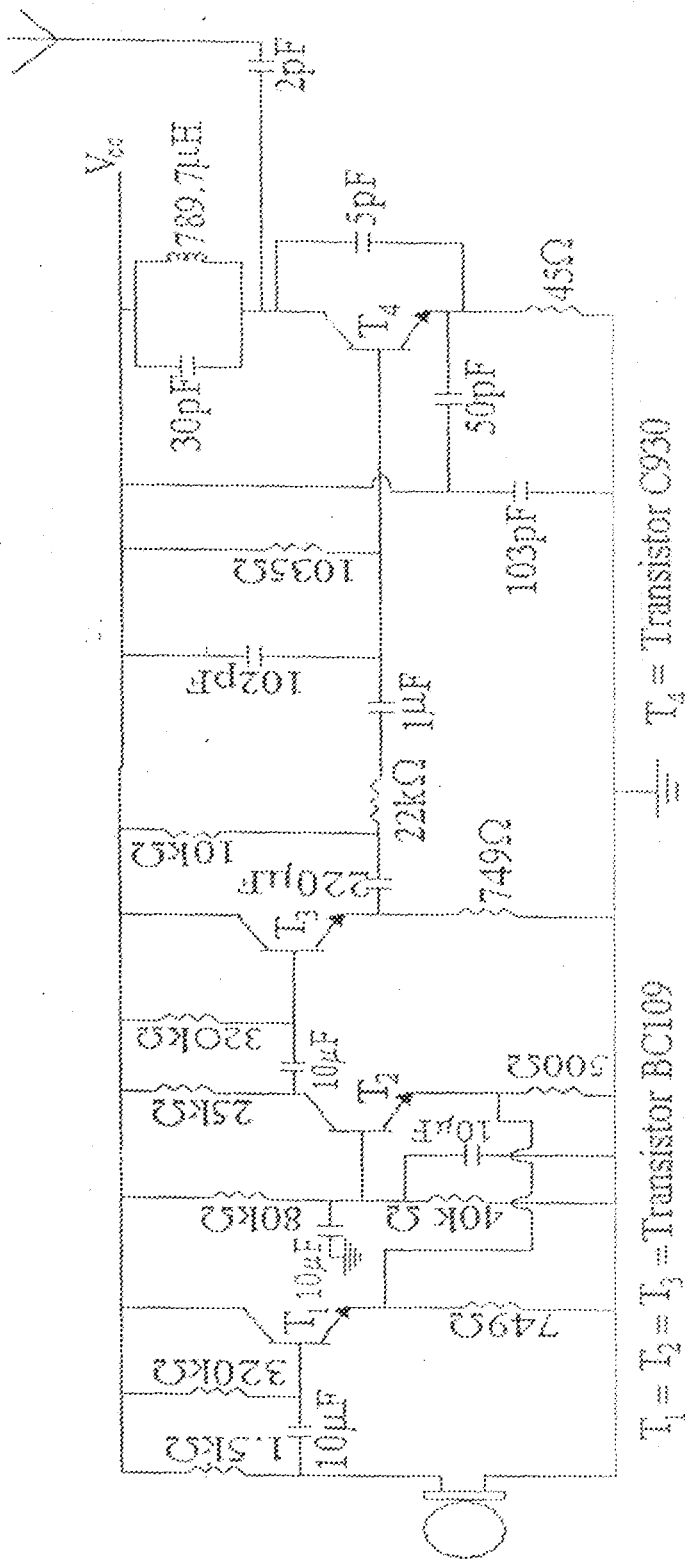


Fig. 3m: The final FM transmitter circuit

CHAPTER FOUR

4.1 TESTING AND DESIGN

In carrying out the test for the basic components of this project the main are digital Multimeter and an oscilloscope.

The testing was carried out primarily on transistor to determine their input and output voltage.

Table 4.1: Input and output voltages value for transistor amplifier stages.

Component (Transistor)	Input Voltage (V)	Output Voltage (V)
BC 109		
Stage 1	2.06	2.69
Stage 2	0.12	1.36
Stage 3	2.67	2.08

$$\text{Voltage Gain of first stage } (G_1) = \frac{\text{output voltage}}{\text{input voltage}} = \frac{2.06}{2.69}$$

$$G_1 = 0.765$$

$$\text{Voltage Gain of second stage } (G_2) = \frac{\text{output voltage}}{\text{input voltage}} = \frac{1.36}{0.12}$$

$$G_2 = 11.333$$

$$\text{Voltage Gain of third stage } (G_3) = \frac{\text{output voltage}}{\text{input voltage}} = \frac{2.08}{2.67}$$

$$G_3 = 0.779$$

$$\text{Total Voltage Gain } G = G_1 G_2 G_3$$

$$= 0.765 \times 11.333 \times 0.779$$

$$= 6.753$$

Decibel gain in dB

$$\text{First stage dB gain } GV_1 = 20 \log_{10} \frac{2.06}{2.09}$$

$$GV_1 = 20[\log_{10} 2.06 - \log_{10} 2.09]$$

$$GV_1 = 20 \times (-0.1158) = -2.3 \text{ dB}$$

$$\text{Second stage dB gain } GV_2 = 20[\log_{10} 1.36 - \log_{10} 0.12]$$

$$GV_2 = 20 \times 1.054 = 21.08 \text{ dB}$$

$$\text{Third stage dB gain } GV_3 = 20[\log_{10} 2.08 - \log_{10} 2.67]$$

$$GV_3 = 20 \times (-0.1084) = -2.1689 \text{ dB}$$

$$\text{Total decibel gain} = GV_1 + GV_2 + GV_3$$

$$GV = (-2.3 + 21.08 - 2.169) \text{ dB}$$

$$GV = 16.61 \text{ dB}$$

4.2 DISCUSSION OF RESULTS

The transmitting range of this baby monitor F.M. transmitter is twenty meters radius (20m) which is the distance within a flat. This agrees with the aim of the project.

From reliability studies, topmost events depends on the reliability of each of the transistor stages connected in series.

The high transmitting efficiency of the transmitter was due to the combine high voltage gain of the transistor stages.

The results above shows that, the voltage gain for the common base configuration was high, this confirm with the characteristics of common base configuration "high voltage gain".

4.3 SHORT COMING/LIMITATION

In engineering design, it is widely believed that no design can be said to be a complete and perfect design.

This project work is not an exception to this fact, however, there could be remedies to the defect of any design.

The shortcoming likely to be encountered in this project are in the area of availability.

Limitation to this design is that of obscurity by large buildings and only single source of power of power supply (d.c power supply).

This shortcoming/limitation can however be controlled to a minimal level but may not be totally eliminated, since no engineering design or system can be proven to have an efficiency of 100%.

4.4 TROUBLESHOOTING OF MULTISTAGE AMPLIFIER

Any multistage amplifier consist of a number of single stage amplifier. For proper functioning of the single stage amplifier, it is necessary to establish and maintain proper d.c conditions.

The first step employed in troubleshooting this multistage amplifier is to locate the malfunctioning single stage. This was done using the signal injection method. The instruments used was the oscilloscope, which is the most versatile and widely used signal tracer in electronics.

STEPS

1. The amplifier and frequency control of the signal generator was set to produce a signal within the specification of the input of the amplifier. This signal is then connected across the input terminals of the amplifier
2. The input signal was then checked with the oscilloscope to verify that it is proper. The output of stage one and input of stage two was checked and found to be equal. Do the same for all other stages.

By this procedure, the point where a defect in the signal is introduced is easily localized. It must be noted that during this process all negative feedback paths should be disconnected/disabled.

4.5 FLOWCHART FOR TROUBLESHOOTING THE SINGLE STAGE AMPLIFIER

INSTRUMENT: OSCILLOSCOPE

ADDITIONAL AIDS: SERVICE NOTES, DATA SHEETS PERTAINING TO THE AMPLIFIER IN QUESTION.

PROCEDURE: DYNAMIC OPERATION CHECK

First verify that the amplifier is not functioning normally.

Use signal generator to inject signal of the frequency and amplitude that the stage is supposed to handle.

Use oscilloscope to measure and verify characteristics of the input and output signal, if proper proceed to next check.

CHECKS FOR ESSENTIAL DC CONDITIONS

Measure V_C and bias voltages V_B and V_E . if V_C , V_B or V_E are improper, proceed to check possible causes.

Table 4.2: Checks for Essential DC Conditions

A. Improper V_C	B. Improper bias	C. Defective Transistor
<p>Improper V_C can result from wrong I_C or wrong value load. For wrong value load measure R_L; if R_L is correct, it suggests that I_C must be wrong.</p> <p>$V_C = V_{CC} - I_C R_L$</p> <p>If I_C is wrong, this may be due wrong bias I_B or defective transistor, then proceed to checks B and C.</p>	<p>Improper bias voltages (V_E, V_B and V_{EB}) and current can result from leaky capacitors (CE or C) wrong value resistors (R_1, R_2, R_E and R_B) or defective transistor</p> <p>To check for leaky capacitors, disconnect one end of suspected capacitor and recheck to see if V_C and other voltage have returned to normal; measure resistors, disconnecting the other end.</p> <p>If necessary, to avoid the influence of parallel circuits. If difficulty is not found (i.e. no problem found) proceed to check C</p>	<p>Check diode action of collector-base junction and emitter-base junction for low forward resistance and high reverse resistance with ohmmeter or check transistor in transistor checker or check by substituting a known good transistor and rechecking V_C and bias voltages.</p>

CHAPTER FIVE

RECOMMENDATION AND CONCLUSION

5.1 CONCLUSION

The design and construction of a baby monitor FM transmitter was necessitated by the need to develop a fast means of communication between mother and her child or the care giver and the little baby.

The design however encountered some problems such as availability of component.

In the event of a need to mass produce this product design, it would also be in the interest of the manufacturers of such design to increase the coverage range and then to incorporate a dual power supply.

With all these in place, the communication link between the care giver and the child will be strengthened.

5.2 RECOMMENDATION

The project design is recommended for use not only between the care giver and the baby, it can be used in the home/offices and in conference halls for the transmission and recording of speech.

I also wish to recommend on how this project can be improved

1. Impedance matching between the transmitters antenna should be properly calculated for maximum power transfer.

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