DESIGN AND CONSTRUCTION OF AM/FM RADIO RECEIVER

BY

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2000/10658EE

SUBMITTED TO

THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY

FEDERAL UNIVERSITY OF TECHNOLOGY
MINNA, NIGER STATE

IN PARTIAL FUFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B. ENG) DEGREE IN ELECTRICAL AND COMPUTER ENGINEERING

NOVEMBER 2005

DECLARATION

I, Imoru Odunayo do hereby solemnly declare that this project work "Design and Construction of AM/FM Radio Receiver" presented for the award of Bachelor of Engineering (B. Eng.) degree is as a result of my personal effort. It has never been presented elsewhere either wholly or partially for either a degree or diploma. All the information used from published or unpublished works have been duly acknowledged.

IMORU ODUNAYO

07-12-05

Date

CERTIFICATION

This is to certify that this thesis "Design and Construction of AM/FM Radio Receiver" is the original work of Imoru Odunayo carried out under the supervision of Dr Y. A. Adediran for the award of Bachelor of Engineering (B. Eng) degree in Electrical and Computer Engineering of F U T., Minna.

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ACKNOWLEDGEMENT

I acknowledge and remember the wonderful works of Almighty God upon me for His protection and compassion over me before and during this project. To Him be the glory and honour in Jesus name (Amen).

My greatest appreciation however, goes to my family, Mr and Mrs F. O. Imoru and my immediate elder sister Imoru Bukola for standing by me over the years, and for encouraging me to study Electrical and Computer Engineering and realize my dream of returning to the student life. Thanks goes to my family for their love and guidance, for supporting me through University education, and for their continuing support throughout the years.

Many individuals have contributed either directly, or indirectly, to this thesis, and to the education I have received over the years. First and foremost, I am grateful to my supervisor, Dr Y. A Adedidran for overseeing the work, for reading through many progress reports, for helpful guidance in preparation of the project report, and for reviewing and editing the dissertation itself. I am also indebted to late Engr. T. Asula who was my level adviser for two sessions. Their time, encouragement, and advice are greatly appreciated.

In particular, I would like to thank Engr. M D Abdullahi (Head of Department of Electrical/Computer) for his encouragement, patience, and excellent insight into how to get things done, and Dr E N Onwuka for always being available and for the general guidelines given to final-year students for Thesis preparation, even when the duties of the departmental project coordinator demanded some of her time. Also, many of those who have been my lecturers, and I would like to thank them for providing many helpful and engaging lectures and for their devotion to their chosen profession. Indeed, it is the department of a university that makes education possible, and I am deeply indebted to all the lecturers I have had over the years.

Special thanks also goes to my fellowship members who helped me when I needed the spiritual assistance. In addition, I would like to thank Oluuuuuuuu, Lanre, Kolajo Tope, John (Alagbo), Patrick (Pascal), Chidi and other departmental friends for the group discussion we had together helped me in my academic performance. I can not forget Bello Rotimi-Williams who has a sidekick from my puerility and has been of help to me in many ways. Thanks also goes to Fadare Jide, my school son Tokunbo, Olumide, Joseph, Tope and all members of Hall Q 318 for this academic session for being good room mates.

Finally, I would like to give my deep appreciation to Ondo State Government for a Scholarship award received each year, for the last four years has provided a little relief for my parents.

DEDICATION

I dedicate this project to Almighty God, my Parents, Mr and Mrs F O Imoru and my elder sister Imoru Bukola as well as Bello Rotimi-Williams who is my sidekick.

ABSTRACT

The AM/FM Radio Receiver was designed to receive SW and FM signals of frequency ranges (6-22MHz) and (88-108MHz) respectively. The unit selects the wanted signal from all signals picked by the antenna whilst rejecting the other. It also extracts and processes the intelligence contained in modulated signal. The processing includes conversion of selected modulated RF signal into a suitable form for output demodulation and amplification of the weak signal received.

The circuitry for the design is made up of different mixers, oscillators, amplifiers, filters, detectors and conversion of RF to AF signal. This is achieved by using two ICs (KA2297 and LM385 ICs) and few electronic components without transistor.

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CHAPTER ONE

INTRODUCTION

1.1 BRIEF HISTORY ABOUT RADIO RECEIVERS

The technology of the radio receiving-set has also changed dramatically since the origins of broadcasting. According to Hendy [1], the first commercially available radio receivers were crystal sets, which required headphones. They soon gave way to valve receivers with loudspeakers, which enabled people to listen in groups. Growing demand led to larger-scale production of valve receivers, and the price of sets dropped throughout the 1930s.

Even so, the wireless valve remained a relatively expensive item to replace, consumed much primary power, and meant large and cumbersome sets. In 1948, the first manufactured transistor revolutionized reception. It allowed radios to be built that were more reliable, used far less power, and, crucially, were much smaller and cheaper. Transistor radios were mobile in a way that the television sets of the 1950s and 1960s could never be.

The essential components of a modern radio receiver are:

i) an antenna for receiving the electromagnetic waves and converting them into electrical oscillations;

ii) amplifiers for increasing the intensity of these oscillations; detection equipment for demodulating;

iii) a speaker for converting the impulses into sound waves audible to the human ear (and in television a picture tube for converting the signal into visible light waves); and

iv) In most radio receivers, oscillators to generate radio-frequency waves that can be mixed with the incoming waves (audio frequency).

The incoming signal from the antenna, consisting of a radio-frequency carrier oscillation modulated by an audio-frequency or video-frequency signal containing the impulses, is generally very weak. The sensitivity of some modern radio receivers is so great that if the antenna signal can produce an alternating current involving the motion of only a few hundred electrons, this signal can be detected and amplified to produce an intelligible (understandable) sound from the speaker. Most radio receivers can operate quite well with an input from the antenna of a few millionths of a volt. The dominant consideration in receiver design, however, is that very weak desired signals cannot be made useful by amplifying indiscriminately both the desired signal and undesired radio noise. Thus, the main task of the designer is to assure preferential reception of the desired signal.

Most modern radio receivers are of the superheterodyne type in which an oscillator generates a radio-frequency wave that is mixed with the incoming wave, thereby producing a radio-frequency wave of lower frequency; the latter is called intermediate frequency. To tune the receiver to different frequencies, the frequency of the oscillations is changed, but the intermediate frequency always remains the same (at 455 kHz for most AM receivers and at 10.7 MHz for most FM receivers). The oscillator is tuned by altering the capacity of the capacitor in its tank circuit; the antenna circuit is similarly tuned by a capacitor in its circuit.

One or more stages of intermediate-frequency amplification are included in all receivers; in addition, one or more stages of radio-frequency amplification may be included. Auxiliary circuits such as automatic volume control (which operates by rectifying part of the output of one amplification circuit and feeding it back to the control element of the same circuit or of an earlier one) are usually included in the intermediate-frequency stage. The detector, often called the second detector (the mixer being called the first detector), is usually simply a diode acting as a rectifier, and produces an audio-frequency signal. FM waves are demodulated or detected by circuits known as discriminators or radio-detectors that translate the varying frequencies into varying signal amplitudes.

1.2 SCOPE (COVERAGE) OF THE PROJECT

The design is an electronic device consisting of two sets of deferent receivers in a unit. i.e. a frequency modulation (FM) receiver and an amplitude modulation (AM) receiver.

The AM range for medium waves (MW) is between 540-1600 kHz (555-185m wave length), but the design would be based on AM receiver called short wave (SW) of frequency range 6-22MHz and FM of frequency range 88-108MHz.this is because AM of 540-1600kHz is very old frequency location which is attributed to great level of interference. Even most radio transmitting stations are diverting to SW, but only use the MW at night when interference is at its minimum level. Stations such as British

Broadcasting Corporation (BBC), Voice of America (VOA), and other long distance transmission stations transmit in SW frequency. The SW and FM receivers are based on superheterodyne technique whose principle of operation involves mixing two very close frequencies called beat or intermediate frequency (IF).

1.3 SIGNIFICANCE (IMPORTANCE) OF THE PROJECT

Radio receivers are obviously very important part of radio and wireless technology. Some of the functions are:

1. to extract the intelligence contained in modulated signal;
2. to produce an audio-frequency output of sufficient power to operate the loudspeaker;
3. to select the wanted signal from all signals picked by the antenna, whilst rejecting all others;
4. to convert the selected modulated RF signal into AF signal; and
5. to make it compact and economical by using simple and cheap components.

1.4 JUSTIFICATION FOR THE PROJECT (THE NECESSITY)

It is generally accepted that information and news transmitted from a radio station may be important and useful if they are well received at the appropriate frequency on a radio receiver. A simple radio receiver, portable, affordable and easy to maintain, that adequately caters for the news and information needed will be most welcomed development.

The fact that information is required eliminates the unnecessary travelling made at times. All this, beyond reasonable doubt, has provided justifications to the reason(s) for which the project has been carried out.

1.5 PROJECT METHODOLOGY

As it is being done in any design layout, the various components used for this dissertation would be properly analysed under "choice of components" in chapter three to give the deep insight into the whole process.

Most of the components used in this thesis are in accordance with the conventional value ratings (in standard manufacturer specification from data sheet) which do not need much of calculation.

Some certain parameter conditions (selectivity, output power, sensitivity etc) of a good-quality radio receiver were satisfied.

1.6 CONSTRAINTS (LIMITATIONS) TO THE PROJECT

At the present time, various manufacturers offer a wide range of IC building blocks for receiver design, including RF amplifiers, mixers, synthesizers, and IF amplifier/demodulators. However, completely integrated, high performance receivers ICs are essentially non-existent. One of the main challenges faced was lack of suitable on-chip RF and IF filtering. Thus, there is limitation to a KA2297 (AM/FM receiver IC) in realizing high performance integrated band pass filter.

Another constraint faced was exact the values of some components to be used were not easily found in the market, so close values to such components were used in the course of design.

1.7 OBJECTIVE OF THE PROJECT

The thesis is aimed at designing and constructing an easy, but efficient, electronic device capable of receiving an amplitude modulation (AM), with short wave (SW) of frequency range (6 – 20 MHz) and frequency modulation (FM) of frequency range (90 – 103 MHz). The reception of the device is ensured to meet an acceptable standard. The features in the radio receiver make it useful for offices and homes. News, adverts and other information about specific and timely events can be received using this device by tuning-in to a frequency of any radio station within its frequency range.

CHAPTER TWO

LITERATURE REVIEW

2.1 HISTORICAL BACKGROUND OF RADIO RECEIVER

The radio receiver has undergone considerable development since the first signals were received. Today there is a great interest in vintage (obsolete) radio receivers, valve technology and the way in which radio has developed since the earliest days of wireless.

In 1895 Marconi demonstrated the first viable radio system. Now, over 100 years later the radios that are in use bear no resemblance to the early equipment that was used. The equipment that was used in the 19th century was crude and very insensitive. Nowadays receivers are very sensitive and they offer many facilities. They are also used in a wide variety of applications from broadcast reception, through cellular telecommunications to satellite links and much more. To be able to operate in all these diverse areas, receiver technology has change beyond all recognition. These developments represent the work of many people from the earliest days of wireless, right to the modern day.

The story behind the development of the radio receiver begins with the discovery of radio waves themselves. A brilliant Scottish physicist named Maxwell James Clerk (1831-1876) was the first person to prove the existence of electromagnetic waves at London University in 1864. However, he only showed this mathematically and he was never able to demonstrate them in practical form. It was a Heinrich Hertz Rudolph (1857-1894), a German physicist who demonstrated these new waves which Maxwell had proved existed. In 1887, he used some spark gap equipment to transmit and receive radio or Hertzian waves as they were first called.

2.2 CATEGORIES OF RADIO RECEIVERS

The following are the categories of receivers are considered.

- Crystal radio receivers,
- AM broadcast receivers,
- FM broadcast receivers,

2.2.1 CRYSTAL RADIO

According to Purdie [3], the crystal radio receiver (also known as a crystal set) was first built around 1900 by Greenleaf Whittier Pickard, who used crystalline minerals to detect radio signals. A crystal set is the simplest radio receiver, consisting of a long-wire antenna, a tuner to select the desired radio signal by frequency, and a detector consisting of a diode demodulator usually consisting of a sharp wire or pin pressing against a sensitive point on a galena mineral crystal in a holder.

The detector extracts the amplitude modulation from the radio signal and provides an audio output in proportion to the strength of the signal coming from the antenna. The entire set is passive, requiring no external power. Because no electrical amplification is used, sensitive earphones are required. These sets have no way to control the audio volume. Fig 2.1 shows a basic crystal radio set.

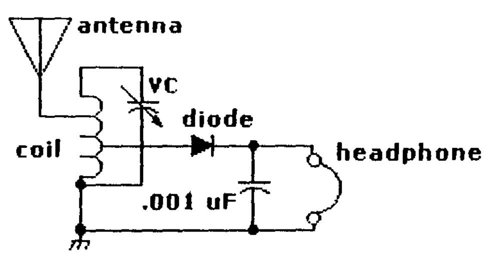

Figure 2.1 - Schematic of a basic crystal radio [2]

2.2.2 AM BROADCAST RECEIVERS

AM broadcast receivers are designed to receive amplitude-modulated signals between 540 and 1,600kHz (555 to 185m wavelength), with channel assignments spaced 10 kHz. To enhance ground-wave propagation the radiated signals are transmitted with the electromagnetic field vertically polarized according to [4]. The receiver circuitry is made up of different types of filters and amplifiers performing certain functions as well as detector circuits that do the conversion from RF to AF signal. A good-quality one should satisfy specific parameter conditions of which essential ones are selectivity, sensitivity, wavelength range, output power, output voltage and quality of production.

Two types of AM broadcast receivers configurations (the TRF and the modern superheterodyne receiver) are discussed below according to Adediran [5].

2.2.2.1 TUNED RADIO FREQUENCY (TRF) RECEIVERS

The tuned radio frequency (TRF) receiver is the smallest type of practical receivers for AM radio. Its block diagram is shown in Fig 2.2

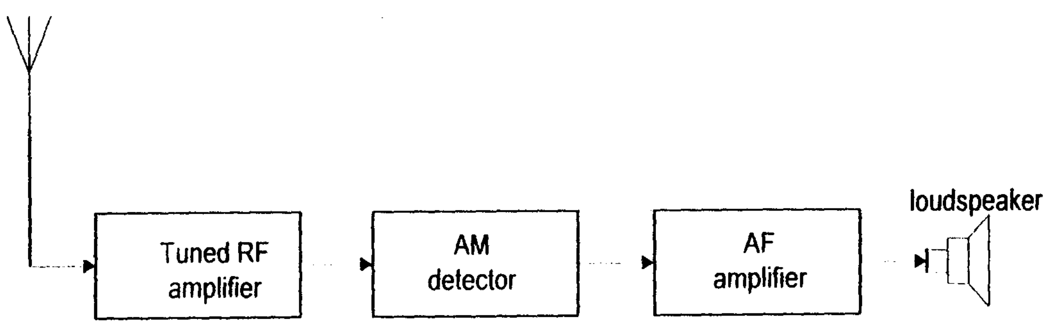

Fig 2.2-Block diagram of a TRF receiver [5]

The incoming amplitude-modulated RF signals are picked up by the antenna and fed to several stages of amplification with tuned LC tank circuits at the input stage. The tuned amplifiers provide some preliminary selectivity by separating the wanted radio station from the numerous others. The RF amplifier must, therefore be tuned to the wanted frequency band. The AM detector converts the RF signal to an AF signal by removing the carrier content of the input signal to it. The AF amplifier finally boosts the power of the low-frequency signal to a level high enough to drive the loud speaker or earphone connected to its output.

Although the TRF receiver is uncomplicated, it nonetheless, performs well on a single low-frequency or medium band. It is not only suitable at high frequencies because its amplification and selectivity fall rapidly at high frequencies, but also unused as a multi-band receiver.

2.1.2.2 SUPERHETERODYNE RECEIVERS

The principle of operation of the superheterodyne (or superhet) receiver is based on the conversion of all incoming signals to a single INTERMEDIATE FREQUENCY (IF), which is kept fixed. As such, the amplifier circuit operates with maximum stability, selectivity and sensitivity. The block diagram of a superhet AM radio receiver for broadcasting is shown in fig 2.3

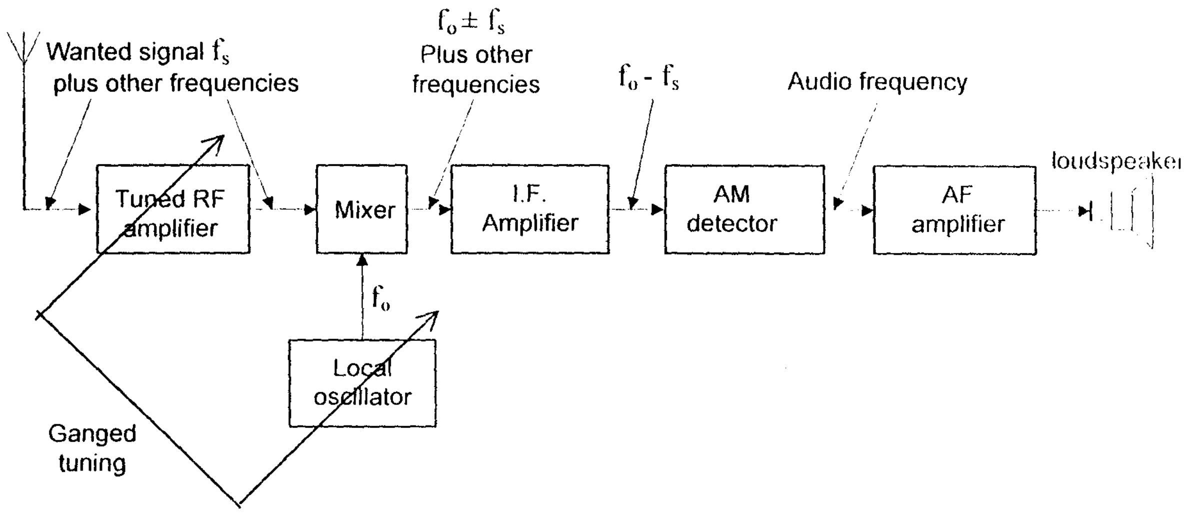

Fig- 2.3-Block diagram of a superhet AM receiver [5]

The tuned RF amplifier selects and amplifies the required frequency band signals from the various signals intercepted by the antenna. The amplified RF signal is coupled to the input of a mixer stage which beats together two frequency signals. The first input to the mixer is the amplified RF signal of frequency f_s, while the other input is from a local oscillator signal of frequency f_o. The output of the mixer is the sum and difference signals of frequencies $f_o \pm f_s$. The function of the IF amplifier is to amplify the IF signal further, thus to select the difference-frequency signal. That is

$$f_i = f_o - f_s \tag{2.1}$$

where,

f_i is known as the intermediate frequency (IF),

f_o is the local oscillator frequency and

f_s is the wanted signal frequency.

The IF is kept constant by gang-tuning the local oscillator and the RF amplifier. The local oscillator frequency is preferably chosen to be higher than the radio frequency for narrower relative turning. The AM detector, usually an envelop detector in broadcasting receivers, carries out the conversion of the IF signal to AF signal, which is power-boosted by the AF amplifier.

ADVANTAGES OF SUPERHETERODYNE RECEIVERS

1. The superhet receiver offers the following advantages over the TFR receivers,
2. It has higher selectivity due to the greater number of tuned circuits.
3. It provides higher sensitivity due to the greater number of amplifier stages.
4. Selectivity and sensitivity values are more constant over the entire tuning range of the receiver.

DISADVANTAGES OF SUPERHETERODYNE RECEIVERS

1. The circuit is more complex and more difficult to align and adjust.
2. Superheterodyne whistles are generated and they are caused by the beating together of different harmonics and fundamental frequencies in the receiver (e. g 2 f_s and f_o).
3. The receiver noise is higher and is a form of internal noise caused by the chaotic thermal movement of electrons in the receiver wiring and resistances.
4. Image signal is produced by a superhet receiver. It was stated in equation (2.1) that $f_s = f_o - f_i$. However, the signal of frequency $f_o + f_i = f_s + 2f_i$

also produces the same IF value, hence can also be processed by the superhet receiver. This frequency signal is known as the IMAGE SIGNAL. As an example, a superhet receiver of IF= 455 kHz and tuned to f_s =540 kHz, it must have an oscillator signal frequency of 540+455 = 995 kHz. The image signal frequency is, therefore, equal to 540+2(455) =1450 kHz.

The superhet receiver is also referred to as 'double-detection' receiver with the mixer as the first detector and the envelope detector as the sound. f_i is normally 455kHz and 10.7MHz for AM and FM sound broadcast receivers respectively.

2.2.3 FM BROADCAST RECEIVERS

Broadcast FM receivers are designed to receive signals between 88 and 108 MHz (3.5 to 2.8 m wave length). The broadcast carrier is frequency-modulated with audio signal up to 15 kHz, and the channel assignments are spaced 200 kHz. FM band is primarily intended to provide a relatively noise-free radio service with wide-range audio capability for the transmission of high-quality music and speech. The service range in the FM band is generally less than that obtainable in the AM band, especially when sky-wave signals are relied on for extending the AM coverage area [4].

FM receivers always employ the superheterodyne circuit which could provide enough gain to boost the weak signal levels. The block diagram of an FM receiver is shown in fig 2.4

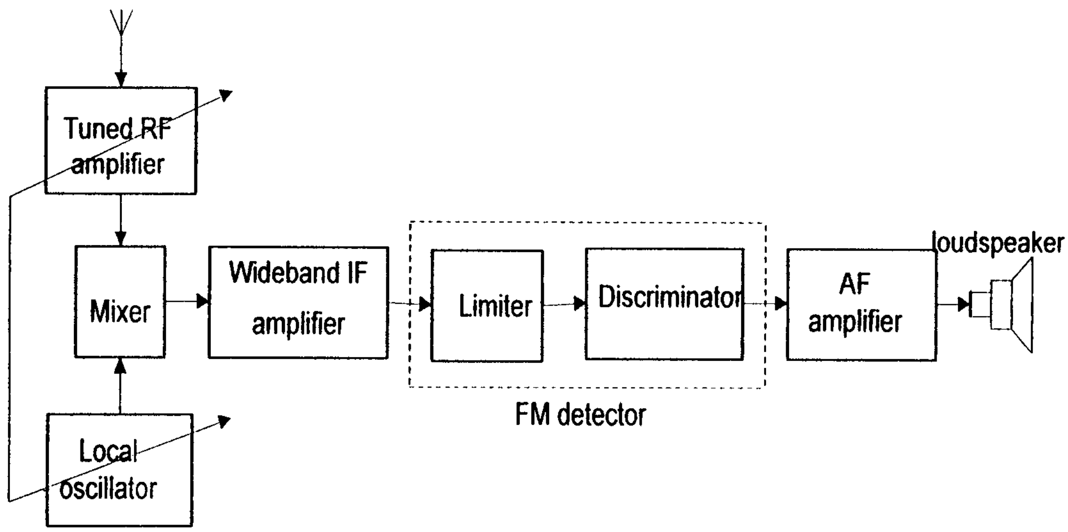

Fig 2.4-Block diagram of an FM receiver [5]

The major difference between the AM receiver and FM receiver is the usage of FM detector in fig 2.7 instead of an AM detector. The FM detector converts the FM-IF signal to AF signal while keeping the carrier amplitude constant. In addition, the bandwidth of the IF stage should be at least 150 or 200 kHz (instead of 9 or 10 kHz for AM) while the intermediate frequency is usually 10.7MHz.

2.3 DESIGN METHODOLOGY

Two receivers (AM and FM sound receivers) are combined in a unit using integrated circuits which are increasingly employed in radio receivers.

Fig 2.5 shows the block diagram of the design adopted. It comprises AM and FM sections of the receivers which are completely separate up to the outputs of the two detector stages.

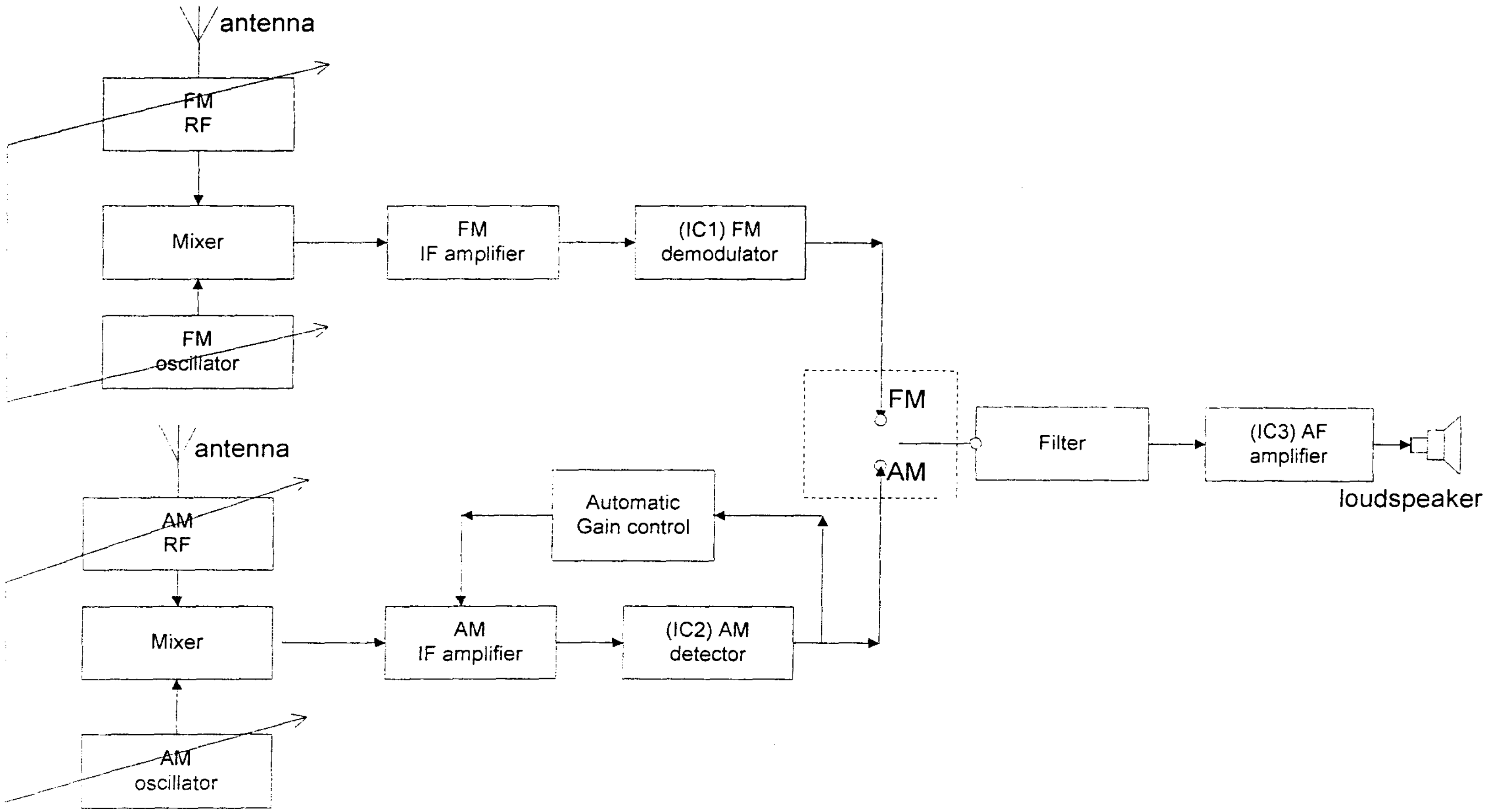

Fig 2.5- FM/AM superheterodyne radio receiver using integrated circuits

CHAPTER THREE

BASIC CIRCUIT DESCRIPTIONS

3.1 CHOICE OF COMPONENTS FOR DESIGN

The various components used for the project design have been properly analysed in section 3.2 to give clear understanding of the thesis. The analyses were done according to conventional rating value from (standard manufacturer specification from data sheet); therefore little calculations involved were carried out where necessary.

In the course of designing, some of the appropriate basic components chosen are:

- Integrated circuits (IC)-LM 386,KA 2297
- Antenna
- Transformer
- Resistors
- Capacitors
- Loudspeaker
- Diodes- rectifier (4 IN4001), LED
- Switches

3.2 THE ANALYSIS OF EACH COMPONENT

3.2.1 INTEGRATED CIRCIUTS

The two main ICs used are LM386 and KA 2297

3.2.1.1 THE LM386

The LM386 is not only AM/FM amplifiers, but also intercoms, TV sound system, line drivers amplifiers designed for use in low voltage consumer applications. The pin assignment diagram is shown in fig 3.1

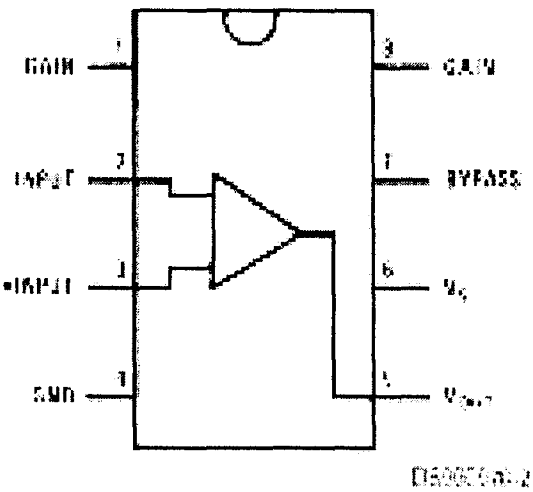

Fig 3.1- Pin assignment of LM386 IC [6]

The LM386 is made more versatile amplifier when two pins (1and 8) are provided for gain control. If a capacitor is connected between pin 1 to 8, the gain will be about 200 (46 dB). If a resistor is placed in series with the capacitor, the gain can be set to any value from 20 to 200. In the design circuit diagram in fig 3.5, the inputs of the LM386 are biased to ground with a 50kΩ variable resistor which acts as the volume of the receiver and the output is connected to a 1W, 8Ω loudspeaker via a 470μF capacitor. This is a typical application from the data sheet. [6]

3.2.1.2 THE KA 2297

This is a Samsung monolithic IC for a FM/AM receiver that has a built-in FM front end with a minimum number of external parts required. The operating voltage is between 1.8-7V. Another good AM/FM receiver IC is Toshiba TA2003P/F which has the same pin assignment as Samsung KA2297 (see Appendix 1.2 & 1.3). Apart from scarcity of this old Toshiba IC, it requires more external components than the new Samsung IC when their data sheets were thoroughly gone through [7],[8]. Fig 3.2 shows the block diagram of the Samsung IC.

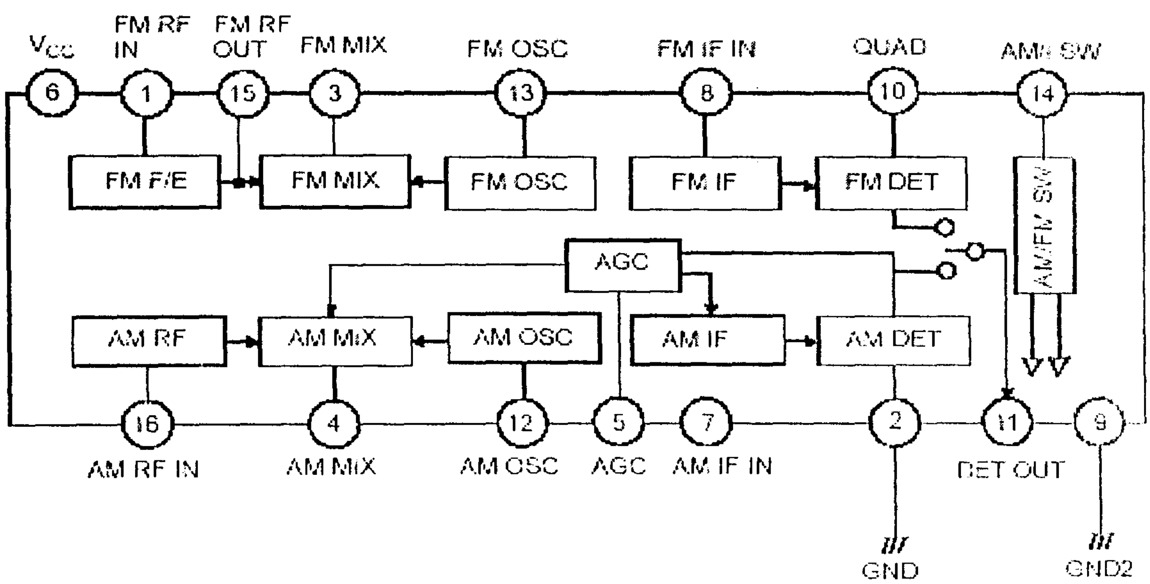

Fig 3.2-Block diagram of KA 2297 IC [8]

For FM, pin 1 is connected to the FM RF of fig 3.5. The FM mixer is designed to mix the incoming frequency from the RF (radio frequency) and the FM oscillator (Pin 13). The oscillator frequency is 10.7MHz which is the FM IF (intermediate frequency). The output of mixer from pin 3 is passed through a 10.7MHz crystal which is filtered into pin 8 where the amplification is done before FM detector.

Similarly, for AM, pin 16 is connected to the AM RF (ferrite rod) of fig 3.5. The AM mixer beats the incoming frequency from the FR and that of the AM oscillator (pin 12). The oscillator frequency is 455 kHz which is the intermediate frequency for AM. The output of the mixer from pin 4 is connected to AM detector via a 455 kHz crystal.

The automatic gain control (AGC) in the IC maintains the carrier level at the AM input to the AM detector at a more or less constant value even though the level at the antenna may vary considerably. The AGC also ensures that a large receiver gain can be made available for the reception of weak signals without causing overloading of the amplifier stages, with consequent distortion, by strong signals.

3.2.2 ANTENNA

Antenna, in electronics, is a device used to propagate radio or electromagnetic waves or to capture radio wave. Antennas are necessary to transmit and receive radio. When an antenna is used for reception, these waves induce a weak electric current in the antenna wire or rod. This current is amplified by the radio receiver. An antenna can generally be used for reception and transmission on the same wavelength if transmission power is not too great. The dimensions of an antenna usually depend on the wavelength, or frequency, of the radio wave for which the antenna is designed. A resonant antenna is an efficient propagator and receptor of electromagnetic energy at its design wavelength. Small loop antennas used in radios are resonant at the long, 300-m wavelengths of the broadcast (AM) band because they contain a core of magnetic material called ferrite.

3.2.3 TRANSFORMER

Transformer is an electrical device consisting of one coil of wire placed in close proximity to one or more other coils and is used to couple two or more alternating-current (AC) circuits together by employing the induction between the coils. The coil connected to the power source is called the primary coil, and the other coils are known as secondary. A transformer in which the secondary voltage is higher than the primary is called a step-up transformer; if the secondary voltage is less than the primary, the device is known as a step-down transformer.

The smaller type of power transformers (rectifier transformer) are used in electronics system (like Radio and TV receivers to step down the mains voltage of 240V to the lower voltage that can operate the electronic system [9]. A 240/9V step-down transformer is used for this project work as show in the circuit diagram in fig 3.5

The voltage transformation ratio is given by

$$(N_P/N_S)= (V_P/V_S) =K \qquad (3.1)$$

where,

K= Voltage ratio transformation,

V_P= primary voltage,

V_S= secondary voltage,

N_S= Number of turns in the secondary, and

N_P= Number of turns in the primary

Hence the voltage ratio of the transformer used in the design is

$$K = 240/9$$

$$= 80/3 = 26.7 \approx 27$$

For an ideal transformer, primary power= secondary power i. e.

$$I_P V_P = I_S V_S \qquad (3.2)$$

where,

I_P =primary current, and

I_S =secondary current

And from equation 3.1 and 3.2

$$(I_P / I_S) = (N_S/N_P) = (V_S/V_P) \qquad (3.3)$$

The product of current and voltage (i. e Power) is constant in each set of coils for an ideal transformer, so that in a step-down transformer, the voltage decreases in the secondary with a corresponding increase in the current. [9]

3.2.4 RESISTOR

According to Hodgson [9], resistor is component used to control current flow in an electronic or electric circuit. The size of the current that flows depends on several factors, including a property of the component called its resistance. The greater the resistance, the smaller the current that flow in the circuit. Resistance is very small in the wires joining components, but is significant in the components themselves.

A fixed-value resistor has a series of coloured bands around its body, which signifies the resistor's value and tolerance.

A 50Ω is a current limiting resistor of the power supply to KA2297 IC in fig 3.5 and is justified with the calculation below.

Maximum supply voltage for the IC ,Vcc =7.5V at 25°C

Power dissipation at 25°C, P_D=250mW

Supply voltage from the rectifier V= 9V

Therefore,

Current through the IC, I= P_D /Vcc

$=(250 \times 10^{-3})/7.5$

$= 33.33mA$

The limiting resistor resistor R= (V- Vcc)/I

$= (9-7.5)/(33.33 \times 10^{-3})$

$=1.5/0.03333$

$= 45\Omega$

Therefore a standard value of 50 Ω which is available is used to limit current of the IC KA2297.

Variable resistors are ones whose resistance can be varied between an upper and lower limit. They may be adjusted by rotary or linear controls, and are often used in sound level and tone controls on radio sets and sound systems. A 50kΩ variable resistor is used as volume control of the LM386 output (loudspeaker) in fig 3.5 is a standard value from the Data sheet. [6]

3.2.5 CAPACITOR

According to Adediran [9], capacitor is a device for storing an electrical charge, and sometimes called a condenser. In its simplest form, a capacitor consists of two metal plates separated by a non-conducting layer called the dielectric. The dielectric may be air, plastic, waxed paper, or another substance such as the mineral mica. When one plate of a capacitor is charged using a battery or other source of direct current, the other plate becomes charged with the opposite sign; that is, positive if the original charge is negative, and negative if the original charge is positive.

The electrical size of a capacitor is its capacitance that is the amount of electric charge it can hold per unit potential difference across its plates and is given by

$$C = Q/V \tag{3.4}$$

The capacitance of a parallel plate capacitor can also be calculated from the relationship

$$C = \frac{\varepsilon_r \varepsilon_0 A}{d} \tag{3.5}$$

where,

A is the area of the plates,

d is the distance between them,

ε_0 is the permittivity of free space, and

ε_r is the relative permittivity of the dielectric between the two plates.

In fig 3.5, 1000μF for filtering the rectifier output, 470μF for audio speaker and other fixed-capacitors with few variable-capacitors used with coils in RF circuits were conventional values seen in MikroElectronika [11].

3.2.6 LOUDSPEAKER

In an article review of Barry [12], he writes that loudspeaker is an electromechanical device that produces audible sound from amplified audio voltage. They are extensively used in radio receivers, motion-picture sound systems, public address systems, and television sets as well as music systems. They come in all shapes and sizes, from the size of a small building to tiny earphones.

Several types of speaker exist, but almost all loudspeakers in use are dynamic speakers. These have a very light coil of wire, called the voice coil, mounted within the magnetic field of a permanent magnet or electromagnet. A varying electrical current from the amplifier passes through the voice coil and alters the magnetic force between the voice coil and the speaker's magnetic field. As a result, the coil vibrates with the change in current. A large paper or plastic cone, or diaphragm, attached to the voice coil duly generates sound waves in the air as the coil moves. A 1W, 8Ω speaker is chosen for this design as specified from the data sheet of LM386 IC [6]. Fig 3.3 shows a moving-coil loudspeaker

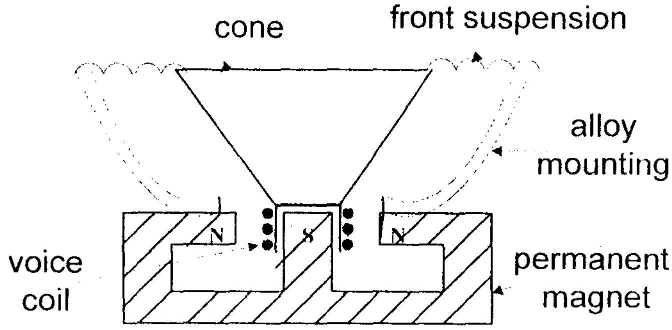

Fig 3.3- A moving-coil loudspeaker [5]

3.2.7 DIODE

Diode is an electronic device that allows the passage of current in only one direction. Four (IN4001) rectifying diodes are used as bridge rectifier at the secondary side of the transformer with 1000μF capacitor to supply a 9V DC power supply in fig 3.5. A switch is connected in series with the DC supply to power the circuit ON or OFF.

The power indicator is a light-emitting diode (LED) that is connected in series with a 1kΩ limiting resistor. The LED used is designed for maximum voltage of 2.3V and any excess voltage to the LED can damage it.

Consider the power indicator circuit in fig 3.4

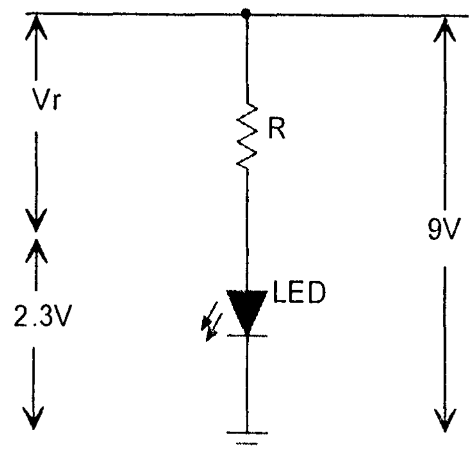

Fig 3.4- Circuit for power indicator

If the LED maximum Voltage=2.3V,

supply voltage=9V

Then,

the voltage across the resistor,

Vr=9-2.3

=6.7V

From ohm's law, R=V/I (3.6)

where, R=resistance of the resistor,

V=voltage across it is 6.7V, and

I= current flow in the circuit (assuming conventional rating of 7mA)

Therefore, using equation 3.6, R=6.7/0.007=957Ω

From the calculation above, a 1kΩ resistor was chosen as an appropriate limiting resistor for the power indicator (LED) in the circuit design.

3.2.8 SWITCH

In another article of Hodgson [13], switch is the part of an electronic or electric circuit that controls the flow of electric current. In its simplest form, a switch consists of two metal contacts that are held together so that current flows through them from. The mechanical contacts may be held together in different ways, depending on the purpose of the switch and the way in which it has been designed. The contacts are held together after the switch is flicked to the ON-position and they are released when the switch is pushed to the other (OFF)-position.

Two switches (power and AM/FM) are used in the circuit design in fig 3.5. The power switch is a one-way switch for powering the Radio receiver while the AM/FM switch is a two-ways switch used to switch between AM reception and FM reception.

3.3 THE (AM/FM RECEIVER) DESIGN CIRCIUT DIAGRAM

The circuit diagram of this project design that choice of components described above is shown in fig 3.5. It shows the circuit of the block diagram in fig 2.5

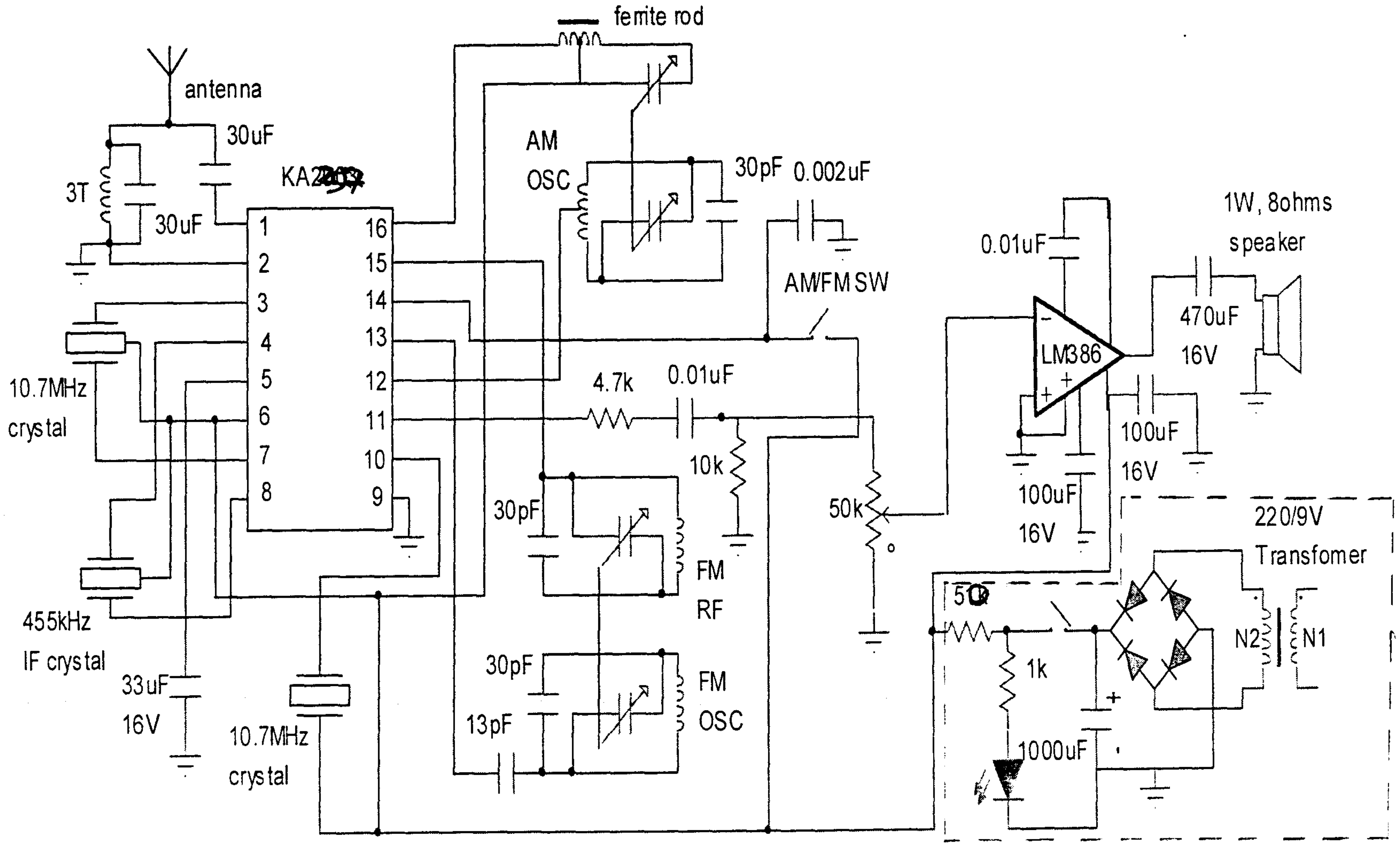

Fig 3.5- Circuit Diagram of AM/FM Receiver using integrated circuits

3.4 POWER SUPPLY UNIT

Power supply unit is an electrical circuit that supplies a device with electrical energy. The radio receiver and many other electronic circuits require a direct current (D C) voltage source. Batteries (chemical to electrical) may be used to power the receiver since it is portable, but a rectified alternating current (A C) voltage source was used in this project.

The dotted area of fig 3.5 is the power supply unit of circuit and the unit consist of (220-240V)/9V transformer, a bridge rectifier circuit, a 1000μF shunt capacitor filter, power switch and the LED to indicate when the circuit is switched ON.

The bridge rectifier is preceded by a transformer, which steps down the alternating current supplied to suit the requirement of the equipment. Transformer also performs an important function of isolation between A C supply and the rest of the circuit. The shunt capacitor filter is required to remove the fluctuation (called ripples) present in the output voltage supplied by the rectifier. The block diagram of fig 3.6 illustrates the stages of the supply.

FIG 3.6 Block diagram of power supply unit

CHAPTER FOUR

LAYOUT AND CONSTRUCTION

4.1 CIRCUIT CONSTRUCTION

The components described in chapter three were gotten from the market and were carefully checked to eliminate damaged ones. The circuit construction started with metric layout of components on paper, which were thoroughly ascertained before transferring it to the breadboard. From the breadboard, the components were transferred into Vero board and all necessary interconnection of lines were joined using soldering Iron and connection leads. The ICs connections were soldered carefully to the right pins as indicated in the pin connection diagram from the data sheet and care was also taken to avoid bridging within the circuit. During the soldering process, extra care was taken not to over heat the components, because it could lead to loss of rating or total damage to some of the components.

Each of the stages from power and RF inputs to AF output were carefully tested and checked to reduce noise interferences. The possible faults and error were immediately rectified after troubleshooting them thoroughly.

The secondary voltage of the transformer used was connected to bridge rectifier diodes (4-100NF) which had been soldered on the Vero board.

The RF coil was constructed by winding a very tiny wire round a ferrite rod and ganged tuning was mounted on the board by making small holes that hold the legs firm so that the nub could be turned without shaking. An antenna was fixed to complete the circuit through the hole made on the casing by drilling it.

The circuit was carefully planned to simplify the wiring, minimizing errors and to make the troubleshooting very easy. The final circuit connections were carried out according to the circuit diagram in fig 3.5.

4.2 CONSTRUCTION TOOLS AND EQUIPMENT

Some of the major electronic equipment used is discussed below.

a) BREAD BOARD: This was used to test the circuit by firstly constructing the tested circuit on it before it is transferred to Vero board.

b) VERO BOARD-This is a board in which the circuit was built on. All the electronic components were soldered on it using soldering iron to melt the connection leads on them and blade to make and break continuity.

c) CONNECTION LEAD- These is wire used to solder (join) the components in the circuit when melted with.

d) SOLDERING IRON- This is a tool with a point that is heated for melting, usually by electricity for melting and putting on solder [13].

e) LEAD SUCKER- This is a tool used to remove badly soldered from the Vero board.

f) DIGITAL MULTIMETER- Multimeter is a universal instrument combining Ohmmeter, Volt Meter, and Ammeter e t c. A digital type of multimeter was used at different stage in the construction to perform the following functions.

- Voltage was measured at each stage of the construction to maintain the standard range specified from the data sheet.

- Checking the secondary voltage of the transformer before connecting it to the circuit.
- Test for continuity of the wire connections and soldered points.

4.3 TESTING

The different tests carried out at each stage of the design to obtain desirable results were highlighted below;

- The frequency of operation was known by tuning in the radio receiver to a frequency of known radio station. A radio station such as ASO Radio (Abuja), Crystal Radio (Minna), Voice of America (VOA) and British Broadcasting Corporation (BCC) of known frequency was for the adjustment of the frequency range.
- The Receiver reception was compared with the one manufactured by factory to maintain the acceptable standard.
- The noise and distortion of the audio output was carefully observed and necessary corrections were made.

4.4 RESULTS

The results obtained after testing the constructed radio receiver were as follows;

- The selectivity was high because it selected the signal of the required radio station and rejected the signals of unwanted adjacent stations.
- The distortion was low due to high quality of reproduction.
- The sensitivity was high because it could pick up and reproduce some weak signals.

- The power supply is 9 Volts
- The reception was satisfactory as compared with the ones manufactured from factory.
- The frequency range of AM is (6-22MHz) and that of FM is (88-108MHz).

4.5 PRECAUTIONS

The following were some of the precautions taken during the construction to ensure accuracy of results;

- The power supply unit was switched off from the circuit when working (fixing, connecting and removing) components during the test construction on breadboard and the final construction on Vero board.
- Overheating of components was avoided during soldering to ensure the components were not burnt.
- Test construction was checked thoroughly to be functioning well before the final construction on Vero board.
- The pin assignments instruction of ICs from the data sheet was properly followed during the test construction and final construction.
- The wiring and soldering was reduced to ensure low interference due to the high frequency involved in the circuits.

4.6 COVERING CASE

The radio receiver was housed in a wooden case based on the size of the fabricated components used. This is because it is readily available, cheaper and convenient to construct. The case is of rectangular cross-section and it contained the speaker, power supply unit, area of constructed circuit and the antenna. Fig 4.1 shows the schematic diagram for the casing and its dimensions.

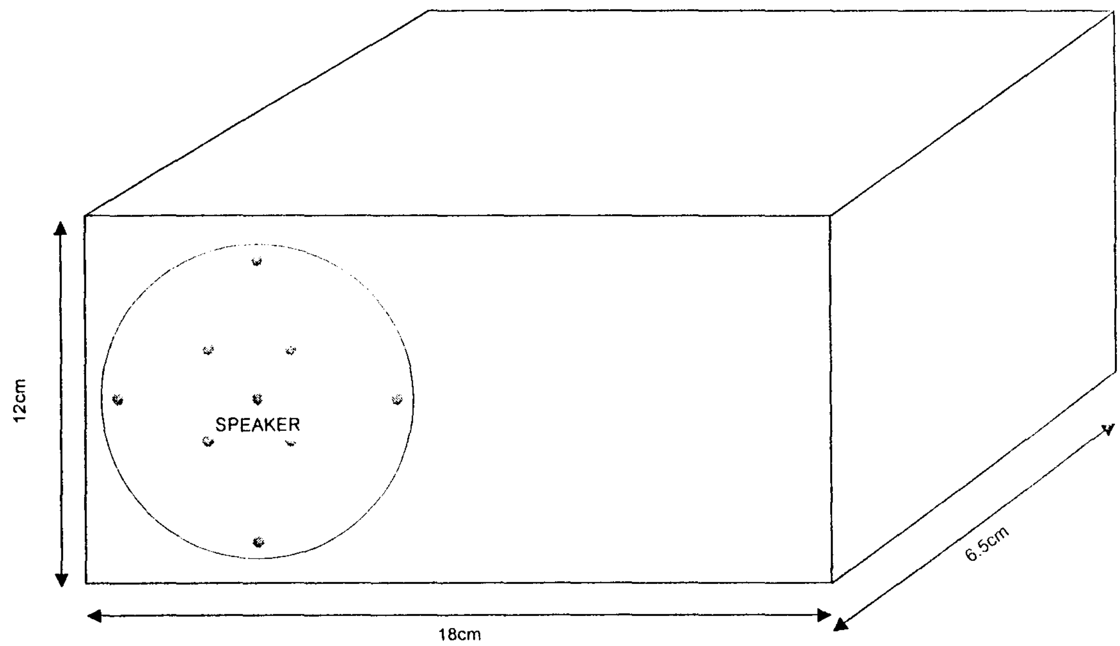

Fig 4.1 schematic diagram for casing

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The AM and FM superheterodyne radio receiver was designed and constructed successfully and the aim of the thesis was achieved from the satisfactory results obtained form testing. The reception from radio stations was clear and quite acceptable.

The project has not only exposed me to proper comprehensive of electronic circuits, but also increased my knowledge to understand and recognize identical components made from different companies and how they are connected especially the integrated circuit.

Informants, journalists, students and will find this device very good in seeking information about specific and timely events or news of any kind.

5.2 RECOMMENDATION

Lord Chesterfield (1694 - 1773), a British statesman and writer said and I quote "Advice is seldom welcome; and those who want it the most always like it the least."

I would suggest that the students should make good use of both school and departmental libraries because there are enough books on electronic design and construction. Improvement on this is the practical experience which could be achieved by organising practical class for them. This will expose them to handing and using electronic tools and equipment effectively and as such give them more understanding of the theory about design.

I would also advice students to acquaint themselves with softwares (like EWB, Multisims, TinaPro e t c) for simulating and testing of electronic circuit design diagrams. Then this project (AM/FM radio receiver design and construction) can be make better by those who had study it and have an improvement on the circuit design.

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APPENDIX A

A1 GENERAL DESCRIBTION OF LM 386 IC [6]

National Semiconductor

January 2000

LM386 Low Voltage Audio Power Amplifier

LM386
Low Voltage Audio Power Amplifier

General Description

The LM386 is a power amplifier designed for use in low voltage consumer applications. The gain is internally set to 20 to keep external part count low, but the addition of an external resistor and capacitor between pins 1 and 8 will increase the gain to any value up to 200.

The inputs are ground referenced while the output is automatically biased to one half the supply voltage. The quiescent power drain is only 24 milliwatts when operating from a 6 volt supply, making the LM386 ideal for battery operation.

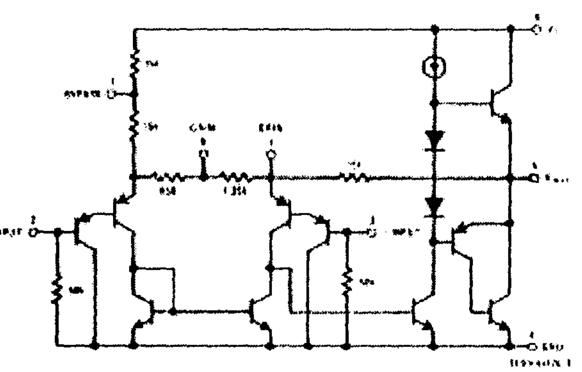
Features

- Battery operation
- Minimum external parts
- Wide supply voltage range: 4V–12V or 5V–18V
- Low quiescent current drain: 4 mA
- Voltage gains from 20 to 200
- Ground referenced input
- Self-centering output quiescent voltage
- Low distortion
- Available in 8 pin MSOP package

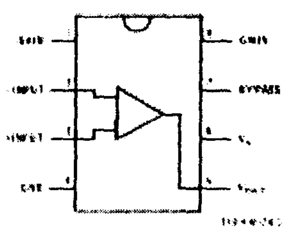
Applications

- AM-FM radio amplifiers
- Portable tape player amplifiers
- Intercoms
- TV sound systems
- Line drivers
- Ultrasonic drivers
- Small servo drivers
- Power converters

Equivalent Schematic and Connection Diagrams



Small Outline,
Molded Mini Small Outline,
and Dual-In-Line Packages



Top View
Order Number LM386M-1,
LM386MM-1, LM386N-1,
LM386N-3 or LM386N-4
See NS Package Number
M08A, MUA08A or N08E

www.national.com

APPENDIX B

B1 FEATURES AND BLOCK DIAGRAM OF TA2003 IC [7]

TOSHIBA BIPOLAR LINEAR INTEGRATED CIRCUIT SILICON MONOLITHIC

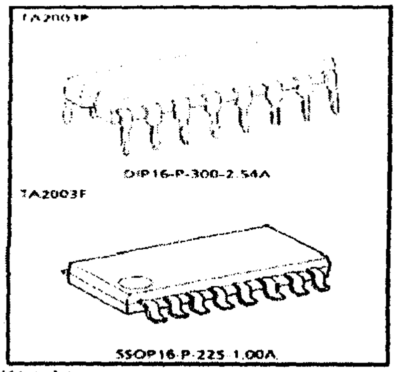
TA2003P, TA2003F

AM / FM RADIO IC

The TA2003P, TA2003F are AM / FM Radio IC (FM F / E + AM / FM IF) which are designed for AM / FM Radios Combining with the TA7368P (Mono PW IC), a suitable AM / FM Radio System is able to be constituted.

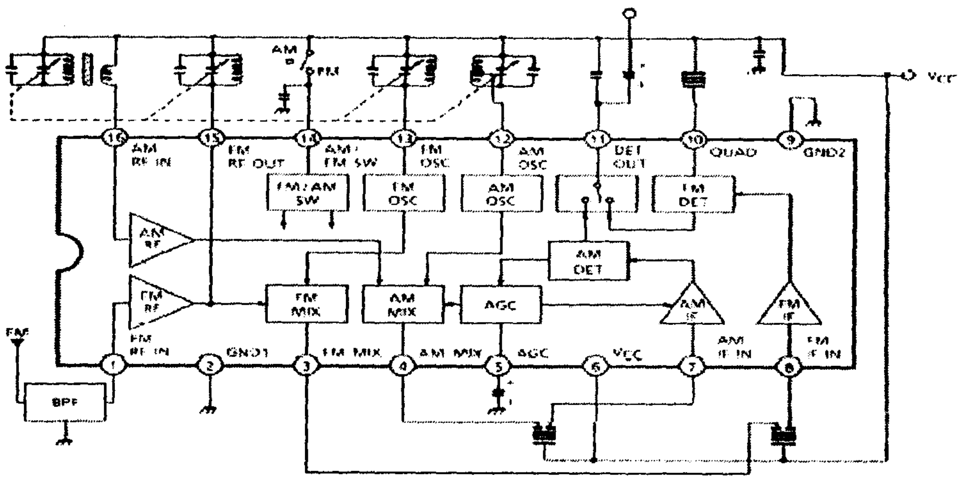
FEATURES

- FM IFT, AM IFT and FM Detector Coil are not needed.
- Pin compatible of TA8164P.
- Operating Supply Voltage Range
  : $V_{CC\,(opr)} = 1.8 \sim 7V$ ($Ta = 25°C$)



Weight
DIP16-P-300-2.54A : 1.00g (Typ.)
SSOP16-P-225-1.00A : 0.14g (Typ.)

BLOCK DIAGRAM



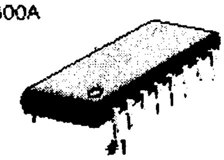
APPENDIX C

C1 FEATURES AND BLOCK DIAGRAM OF KA2297 IC [8]

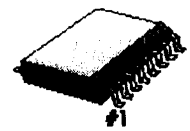
INTRODUCTION

The KA2297/D is a monolithic integrated circuit which consists of an FM F/E + AM/FM IF and DET AMP.
The KA2297/D is a no-adjustment AM/FM IF. DET coil.

16 DIP 300A



16 SOP 375



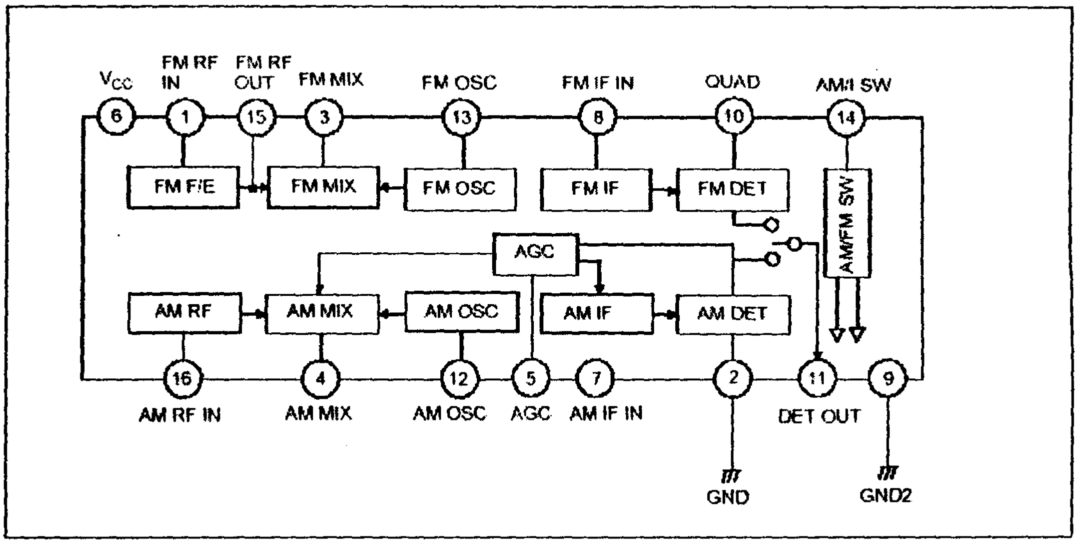
FEATURES

- Does not need AM/FM IF. FM DET COIL
- Built-in FM Front End
- Minimum number of external parts required
- Operating voltage . V_{CC} = 1.8V ~ 7V

ORDERING INFORMATION

Device	Package	Operating Temperature
KA2297	16 DIP 300A	-20°C ~ + 75°C
KA2297D	16 SOP 375	

BLOCK DIAGRAM



SAMSUNG ELECTRONICS