NEAR EAST UNIVERSITY

Faculty of Engineering

Department of Electrical and Electronic Engineering

A MW Radio design & Amplifier

Graduation Project
EE 400

Students: Talal Khader (20010829)
Baha Khalaf (20010694)

Supervisor: Assoc. Prof. Dr.
Adnan Khashman

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First of all I would like to thanks Allah {God} for guiding us through my studies. More over we want to pay special regards to my parents who are enduring these all expenses and supporting me in all events. We are nothing without their prayers. They also encmyaged me in crises. We shall never forget their sacrifices for my education so that i can enjoy my successful life as they are expecting. They may get peaceful life in Heaven.

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ABSTRACT

As the human mind is unlimited, as the technology never stopped and the inventing is still goes on without a limit, the radio has played an important role in our life. Radio is portable, reaching people at home, in their automobile, in their office, and many other places, thereby allowing radio advertisers to influence audiences immediately prior to their making decisions, as it works extremely well whether used as a stand alone medium or in combination with complementary media (i.e. Television, Newspaper, Outdoor, & Transit).

One of Radio's greatest strengths of all is that it's Local, offering local news and local community information on a daily basis. Radio creates awareness, moves customers, sells products and/or services and influences listeners, so there are a lot of reasons that makes this divice important in our life.

This project presents a hardware electronic project which is designing and building an MW radio. The design would later on be modified to receive FM signals.

INTRODUCTION

The radio was used within this century widely in the communication purposes in almost the all life parts; as it was installed in some other products as an additional option; to give the opportunity to people to keep up dated and connected to latest news and other life branches. It is almost unimaginable to live without it anymore; radios become a part of our modern life.

The purpose of this project is to design, build and test a MW radio circuit with its basic elements. In four chapters we tried to show the work we have done as clear as the theoretical and method in a simple way for readers to get the maximum usage and gain, as well as to modify our circuit by adding FM radio.

Chapter one will present components which will be used in building the circuit of the radio. Their characteristics, properties and functions will also be discussed. Also safety guidelines, which must be kept in mind when working on electronic projects, will be described.

Chapter two will present frequencies which are used in radio and other purposes are described of course MW transmission is included; differences and applications are also mentioned.

Chapter three will present in detail the operation of the circuit, starting with the input and how it is processed, through each component until it is ready to leave the circuit as a sound.

Chapter four will present the modification that has been done to MW radio, where FM radio has been added to it, explaining the components have been used and how it works as well as what are the differences between MW and FM.

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CHAPTER ONE

ELECTRONIC COMPONENTS

1.1 Overview

This chapter presents an introduction to electronic components that are commonly used in hardware projects. Safety guidelines for electronic projects will also be described.

1.2 Introduction

Electricity is the flow of electrical energy through some conductive material; electronics refers to using changing electrical properties to convey information. Electronic sensors convert some other form of energy (light, heat, sound pressure, etc.) into electrical energy.

The main components used in electronics are of two general types: passive (e.g. resistors and capacitors) and active (e.g. transistors and integrated circuits). The main difference between active and passive components is that active ones require to be powered in some way to make them work. Active components can also be used to amplify signals.

1.3 Resistors

The resistor is an electrical device whose primary function is to introduce resistance to the flow of electric Current. The magnitude of opposition to the flow of current is called the resistance of the resistor. A larger resistance value indicates a greater opposition to current flow. The resistance is measured in ohms. An ohm is the resistance that arises when a current of one ampere is passed through a resistor subjected to one volt across its terminals, the simplest resistors are made from carbon rod with end caps and wire leads, other types are carbon film which is a thin layer of carbon on a ceramic rod, and metal oxide and metal glaze on glass rods. Some resistors are designed to change in value when heated. They are called THERMISTORS and are used in temperature measuring circuits. Some resistors change in value when exposed to light. They are called LIGHT DEPENDANT RESISTORS. The various uses of resistors include setting biases, controlling gain, fixing time constants, matching and loading circuits, voltage division, and heat generation.

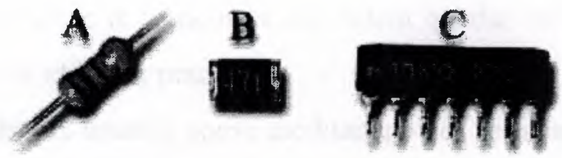


Figure 1.1 Resistors

1.3.1 Color Coding of Resistors

Resistors are generally identified by color coding or direct digital marking. The color code is given in Table 1.1.The color code is commonly used in composition resistors and film resistors. The color code essentially consists of four bands of different colors. The first band is the most significant figure, the second band is the second significant figure, and the third band is the multiplier or the number of zeros that have to be added after the first, two significant figures, and the fourth band is the tolerance on the resistance value where it indicates the percentage accuracy of the resistor value .If the fourth band is not present, the resistor tolerance is the standard 20% above and below the rated value. When the color code is used on fixed wire-wound resistors, the first band is applied in double width.

Table 1.1 Resistor color code.

BAND COLOR	1 BAND	2 BAND	3 BAND	MULTIPLIER x	TOLERANCE ± %
Black	0	0	0	1	
Brown	1	1	1	10	± 1%
Red	2	2	2	100	± 2 %
Orange	3	3	3	1000	
Yellow	4	4	4	10,000	
Green	5	5	5	100,000	± 0.5 %
Blue	6	6	6	1,000,000	± 0.25 %
Violet	7	7	7	10,000,000	
Grey	8	8	8	100,000,000	
White	9	9	9	1,000,000,000	
Gold				0.1	± 5 %
Silver				0.01	± 10 %
None					± 20 %

1.3.2 Types of Resistors

1. **Film resistor:** cheap general purpose resistor, works quite well also on high frequencies, resistance is somewhat dependent on the voltage over resistor (does not generally have effect in practice).
2. **Composite resistor:** usually some medium power resistors are built in this way, has low inductance, large capacitance, poor temperature stability, noisy and not very good long time stability. Composite resistor can handle well short overload surges.
3. **Metal film resistor:** good temperature stability, good long time stability, cannot handle overloads well.
4. **Metal oxide resistor:** mostly similar features as metal film resistor but better surge handling capacity, higher temperature rating them metal film resistor, low voltage dependently, low noise, better for RF than wire wound resistor but usually worse temperature stability.
5. **Thick film resistor:** similar properties as metal film resistor but can handle surges better, and withstand high temperatures.
6. **Thin film resistor:** good long time stability, good temperature stability, good voltage dependently rating, low noise, not good for RF, low surge handling capacity.
7. **Wire wound resistor:** used mainly for high power resistors, can be made curate for measuring circuits, high inductance because consists of wound wire
8. **Variable Resistors:** the variable resistor is a very important component that is found in many electrical for such things as tone and bass controls as well as volume. This is due to the fact that resistors can be joined together with other components to form filters for a desired levels. They can also be found in computer monitors for color or positioning as well as the dimming switch for your lamps. This is done through digital to analog and analog to digital circuits, one great advantage to this is that you are able to turn a knob instead of typing a value in every time you want to change the tint or brightness. The schematic for the variable resistor has stayed the same for quite some time and can be seen at the illustration to the upper right .

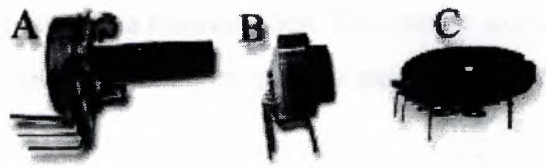


Figure 1.2 Kinds of variable resistors [1]

1.4 Capacitor

Capacitors store electric charge. They are used with resistors in timing circuits because it takes time for a capacitor to fill with charge. They are used to smooth varying DC supplies by acting as a reservoir of charge. They are also used in filter circuits because capacitors easily pass AC (changing) signals but they block DC (constant) signals.

1.4.1 Capacitance

This is a measure of a capacitor's ability to store charge. A large capacitance means that more charge can be stored. Capacitance is measured in farads, symbol F. However 1F is very large, so prefixes are used to show the smaller values.

Three prefixes (multipliers) are used, µ (micro), n (nano) and p (pico):

µ means 10^{-6} (millionth), so 1000000µF = 1F

n means 10^{-9} (thousand-millionth), so 1000nF = 1µF

p means 10^{-12} (million-millionth), so 1000pF = 1nF

Capacitor values can be very difficult to find because there are many types of capacitor with different labeling systems.

1.4.2 Charge and Energy Stored

The amount of charge (symbol Q) stored by a capacitor is given by:

Charge, $Q = C \times V$ where: Q = charge in coulombs (C)
C = capacitance in farads (F)
V = voltage in volts (V)

When they store charge, capacitors are also storing energy:

Energy $E = ½QV = ½CV^2$ where E = energy in joules (J).

The capacitors return their stored energy to the circuit. They do not 'use up' electrical energy by converting it to heat as a resistor does. The energy stored by a capacitor is much smaller than the energy stored by a battery so they cannot be used as a practical source of energy for most purposes.

1.4.3 Capacitors in Series and Parallel

Combined capacitance of capacitors connected in series:

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + ...$$

Combined capacitance of capacitors connected in parallel:

$$C = C_1 + C_2 + C_3 + ...$$

Two or more capacitors are rarely deliberately connected in series in real circuits, but it can be useful to connect capacitors in parallel to obtain a very large capacitance, for example to smooth a power supply.

1.4.4 Charging a capacitor

The capacitor (C) in the circuit diagram is being charged from a supply voltage (Vs) with the current passing through a resistor (R). The voltage across the capacitor (Vc) is initially zero but it increases as the capacitor charges. The capacitor is fully charged when Vc = Vs. The charging current (I) is determined by the voltage across the resistor (Vs - Vc):

Charging current, I = (Vs - Vc) / R (note that Vc is increasing).

At first Vc = 0V so the initial current, Io = Vs / R.

Vc increases as soon as charge (Q) starts to build up (Vc = Q/C), this reduces the voltage across the resistor and therefore reduces the charging current. This means that the rate of charging becomes progressively slower.

A large time constant means the capacitor charges slowly. The time constant is a property of the circuit containing the capacitance and resistance; it is not a property of a capacitor alone.

The time constant is the time taken for the charging (or discharging) current (I) to fall to $^1/e$ of its initial value (Io). 'e' is the base of natural logarithms, an important number in mathematics (like π). e = 2.71828 (to 6 significant figures) so we can roughly say that the time constant is the time taken for the current to fall to $^1/_3$ of its initial value.

After each time constant the current falls by $^{1}/e$ (about $^{1}/_{3}$). After 5 time constants (5RC) the current has fallen to less than 1% of its initial value and we can reasonably say that the capacitor is fully charged, but in fact the capacitor takes for ever to charge fully. Figure 1.4 shows how the voltage (V) increases as the capacitor charges. At first the voltage changes rapidly because the current is large; but as the current decreases, the charge builds up more slowly and the voltage increases more slowly.

After 5 time constants (5RC) the capacitor is almost fully charged with its voltage almost equal to the supply voltage. We can reasonably say that the capacitor is fully charged after 5RC, although really charging continues for ever (or until the circuit is changed).

time constant = R × C where: time constant is in seconds (s)
R = resistance in ohms (Ω)
C = capacitance in farads (F)

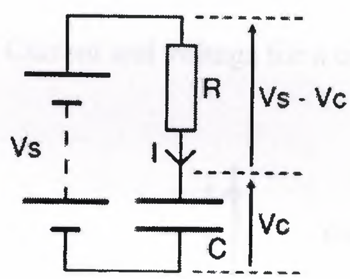


Figure 1.3 A circuit diagram for charging the capacitor

1.4.5 Discharging a capacitor

Figure 1.5 shows how the current (I) decreases as the capacitor discharges. The initial current (Io) is determined by the initial voltage across the capacitor (Vo) and resistance (R): Initial current, Io = Vo / R.

Also it shows how the voltage (V) decreases as the capacitor discharges.

At first the current is large because the voltage is large, so charge is lost quickly and the voltage decreases rapidly. As charge is lost the voltage is reduced making the current smaller so the rate of discharging becomes progressively slower.

After 5 time constants (5RC) the voltage across the capacitor is almost zero and we can reasonably say that the capacitor is fully discharged, although really discharging continues for ever (or until the circuit is changed).

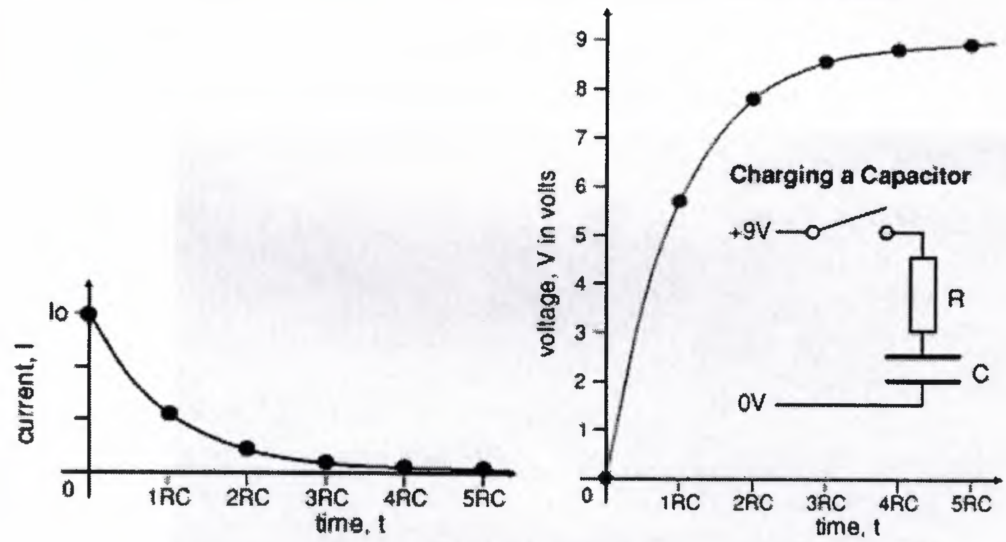


Figure 1.4 Current and voltage for a capacitor charging

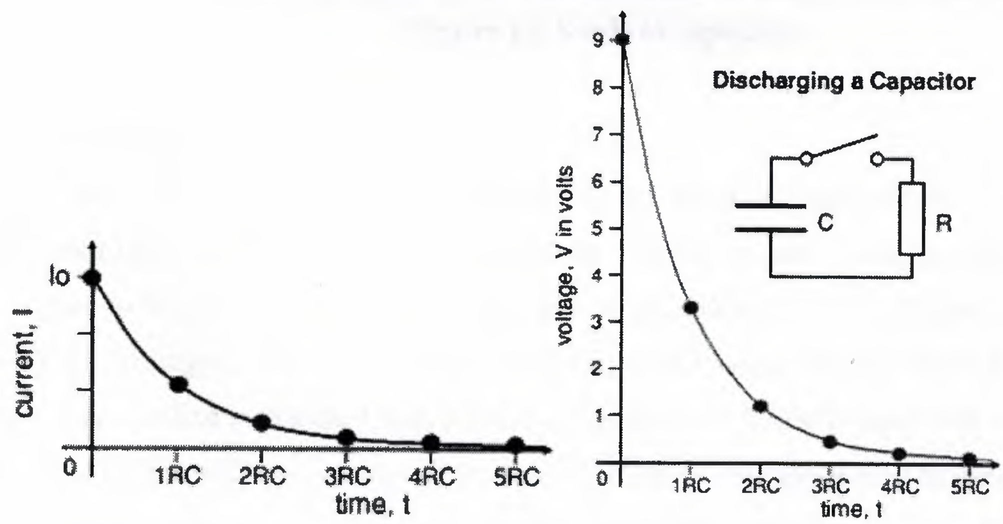


Figure 1.5 Current and voltage for a capacitor discharging [2]

1.4.6 Uses of Capacitors

Capacitors are used for several purposes:

1. Timing - for example with a 555 timer IC controlling the charging and discharging.
2. Smoothing - for example in a power supply.
3. Coupling - for example between stages of an audio system and to connect a loudspeaker.
4. Filtering - for example in the tone control of an audio system.
5. Tuning - for example in a radio system.
6. Storing energy - for example in a camera flash circuit.

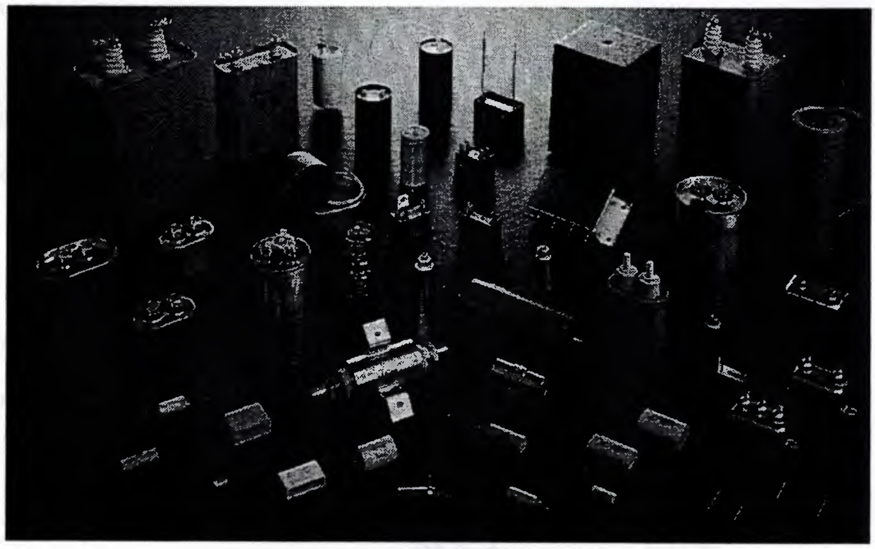


Figure 1.6 Kinds of capacitors

1.5 LM380

The LM380 is a power audio amplifier for consumer application. In order to hold system cost to a minimum, gain is internally fixed at 34 dB. A unique input stage allows inputs to be ground referenced. The output is automatically self centering to one half the supply voltages. The output is short circuit proof with internal thermal limiting. The package outline is standard dual-in-line. A copper lead frame is used with the center three pins on either side comprising a heat sink. This makes the device easy to use in standard p-c layout. Uses include simple phonograph amplifiers, intercoms, line drivers, teaching machine outputs, alarms, ultrasonic drivers, TV sound systems, AM-FM radio, small servo drivers, Power converters, etc. A selected part for more power on higher supply voltages is available as the LM384.

1.5.1 Features

1. Wide supply voltage range.
2. Low quiescent power drain.
3. Voltage gain fixed at 50.
4. High peak current capability.
5. Input referenced to GND.
6. High input impedance.
7. Low distortion.
8. Quiescent output voltage is at one-half of the supply voltage.
9. Standard dual-in-line package.

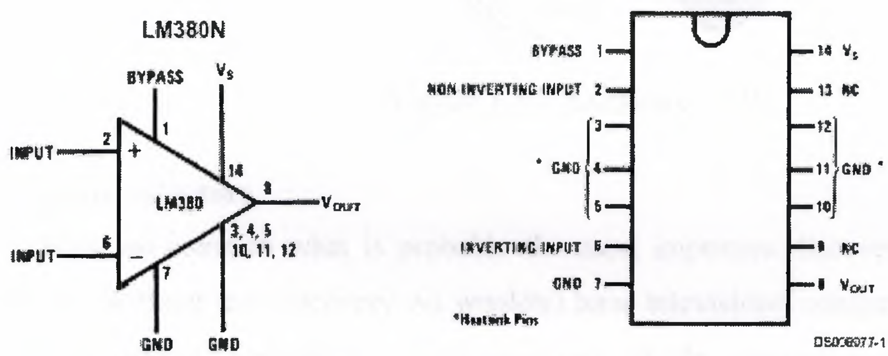


Figure 1.7 Connection diagrams of LM380 [3]

1.6 Loudspeaker

The most common type of loudspeaker is the moving coil speaker, where a coil of wire is suspended in the magnetic field of a circular magnet. When a speech current is passed through the coil a varying magnetic field is generated by the coil. The two magnetic fields interact causing movement of the coil. The movement of the coil causes a cone, which is attached to the coil, to move back and forth. This compresses and decompresses the air thereby generating sound waves.

The loudspeaker is a transducer converting one form of energy to another. Loudspeakers have Impedance, typically 4 or 8 ohms. This must be matched to the output impedance of the amplifier .Loudspeakers are mounted in enclosures (boxes). The design of enclosures is very complicated. Large speakers cannot reproduce high frequencies and small ones cannot reproduce low frequencies. Therefore two speakers are used, a large one (a Woofer) for low frequencies, and a small one (a Tweeter) for high frequencies. Most circuits used to drive loudspeakers produce an audio (AC) signal which is combined with a constant DC signal. The DC will make a large current flow through the speaker due to its low resistance, possibly damaging both the speaker and the driving circuit.

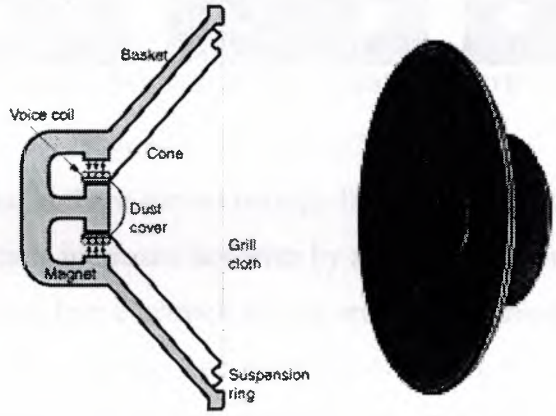


Figure 1.8 Loudspeakers [4]

1.7 Semiconductors

Now we come to what is probably the most important discovery in electronics this century. Without this discovery we wouldn't have televisions, computers, space rockets or transistor radios. Unfortunately it's also one of the hardest areas to understand in electronics. But don't lose heart, read the section through a few times until you've grasped the ideas.

Recall that the reason that metals are such good conductors is that they have lots of electrons which are so loosely held that they're easily able to move when a voltage is applied. Insulators have fixed electrons and so are not able to conduct. Certain materials, called semiconductors, are insulators that have a few loose electrons. They are partly able to conduct a current.

The free electrons in semiconductors leave behind a fixed positive charge when they move about (the protons in the atoms they come from). Charged atoms are called ions. The positive ions in semiconductors are able to capture electrons from nearby atoms. When an electron is captured another atom in the semiconductor becomes a positive ion.

These behaviors can be thought of as a 'hole' moving about the material, moving in just the same way that electrons move. So now there are two ways of conducting a current through a semiconductor, electrons moving in one direction and holes in the other. There are two kinds of current carriers. The holes don't really move of course. It is just fixed positive ions grabbing neighboring electrons, but it appears as if holes are moving.

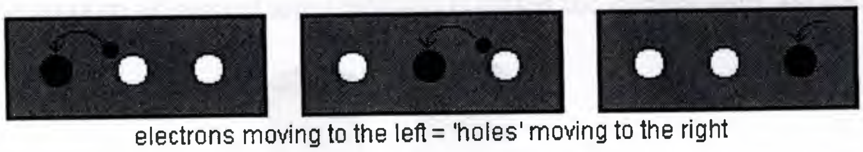


Figure 1.9 Moving of electronic

In a pure semiconductor there are not enough free electrons and holes to be of much use their number can be greatly increased however by adding an impurity, called a donor. If the donor gives up some extra free electrons we get an n-type semiconductor (n for negative). If the donor soaks up some of the free electrons we get a p-type semiconductor (p for positive). In both cases the impurity donates extra current carriers to the semiconductor.
In the n type semiconductors there are more electrons than holes and they are the main current carriers. In p-type semiconductors there are more holes than electrons and they are the main current carriers. The donor atoms become either positive ions (n-type) or negative ions (p-type).

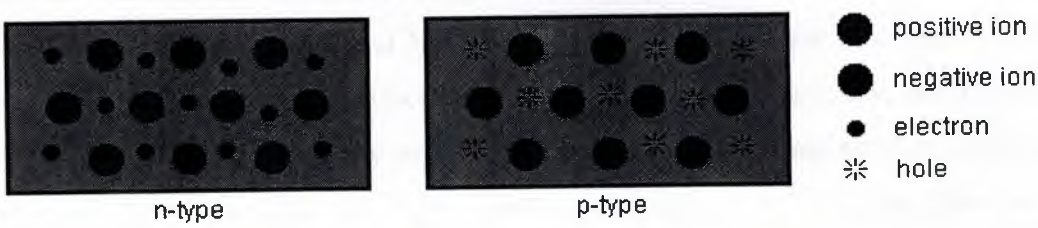


Figure 1.10 Two types of semiconductors [5]

The most common semiconductors are silicon (basically sand) and germanium. Common donors are arsenic and phosphorus.

When we combine n-type and p-type semiconductors together we make useful devices, like transistors and diodes and silicon chips.

1.8 Transistor

Transistors amplify current, for example they can be used to amplify the small output current from a logic chip so that it can operate a lamp, relay or other high current device. In many circuits a resistor is used to convert the changing current to a changing voltage, so the transistor is being used to amplify voltage. A transistor may be used as a switch (either fully on with maximum current, or fully off with no current) and as an amplifier (always partly on). The amount of current amplification is called the current gain, symbol h_{FE}.

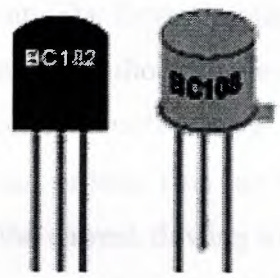


Figure 1.11 Transistors

1.8.1 Types of transistor

There are two types of standard transistors, NPN and PNP, with different circuit symbols. The letters refer to the layers of semiconductor material used to make the transistor. Most transistors used today are NPN because this is the easiest type to make from silicon. The leads are labeled base (B), collector (C) and emitter (E).

The difference between PNP and NPN transistors is that NPN use electrons as carriers of current and PNP use a lack of electrons (known as "holes"). Basically, nothing moves very far at a time. One atom simply robs an electron from an adjacent atom so you get the impression of "flow". It's a bit like "light pipes". In the case of "N" material, there are lots of spare electrons. In the case of "P" there aren't. In fact "P" is gasping for electrons.

A Darlington pair is two transistors connected together to give a very high current gain.

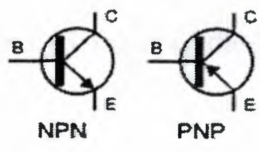


Figure 1.12 Transistor circuit symbols [6]

1.9 Diodes

Diodes allow electricity to flow in only one direction. The arrow of the circuit symbol shows the direction in which the current can flow. Diodes are the electrical version of a valve and early diodes were actually called valves.

Electricity uses up a little energy pushing its way through the diode, rather like a person pushing through a door with a spring. This means that there is a small voltage across a conducting diode, it is called the forward voltage drop and is about 0.7V for all normal diodes which are made from silicon. The forward voltage drop of a diode is almost constant what ever the current passing through the diode so they have a very steep characteristic.

When a reverse voltage is applied a perfect diode does not conduct, but all real diodes leak a very tiny current of a few μA or less. This can be ignored in most circuits because it will be very much smaller than the current flowing in the forward direction. However, all diodes have a maximum reverse voltage (usually 50V or more) and if this is exceeded the diode will fail and pass a large current in the reverse direction, this is called breakdown.

Ordinary diodes can be split into two types: Signal diodes which pass small currents of 100mA or less and Rectifier diodes which can pass large currents. In addition there are LEDs and Zener diodes where it's used to maintain a fixed voltage. They are designed to 'breakdown' in a reliable and non-destructive way so that they can be used in reverse to maintain a fixed voltage across their terminals.

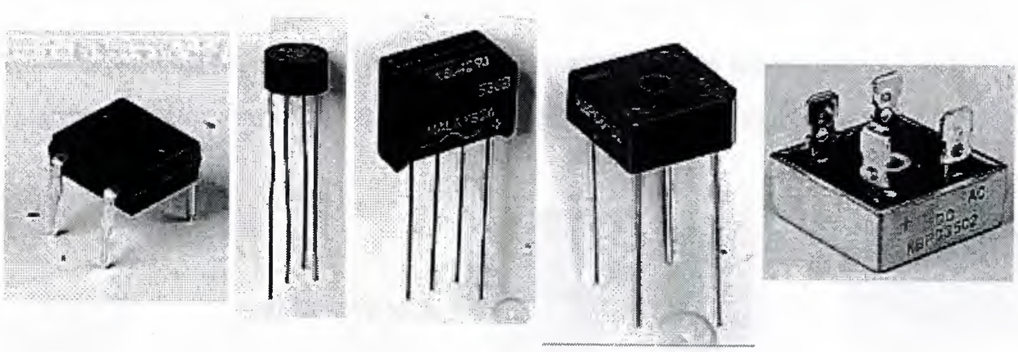


Figure 1.13 Types of diodes [7]

1.10 Switches

A switch is in its simplest form, is just a wire that is connected or disconnected when some mechanical force is applied. The mechanical force can be anything from a person activating it by force (such as pressing a button on a keyboard), or the weight of water pressing on it (pressure switch), magnetic force from a fixed magnet or electromagnet

1.10.1 Selecting a Switch

There are three important features to consider when selecting a switch :

1. Contacts (e.g. single pole, double throw).
2. Ratings (maximum voltage and current).
3. Method of Operation (toggle, slide, key etc).

1.10.2 Switches Contacts

Several terms are used to describe switch contacts:

1. Throw - number of conducting positions, single or double.
2. Way - number of conducting positions, three or more.
3. Momentary - switch returns to its normal position when released.
4. Pole – number of switch contact sets.
5. Open –Off position, contacts not conducting.

Switch contacts are rated with a maximum voltage and current, and there may be different ratings for AC and DC. The AC values are higher because the current falls to zero many times each second and an arc is less likely to form across the switch contacts.

For low voltage electronics projects the voltage rating will not matter, but you may need to check the current rating. The maximum current is less for inductive loads (coils and motors) because they cause more sparking at the contacts when switched off.

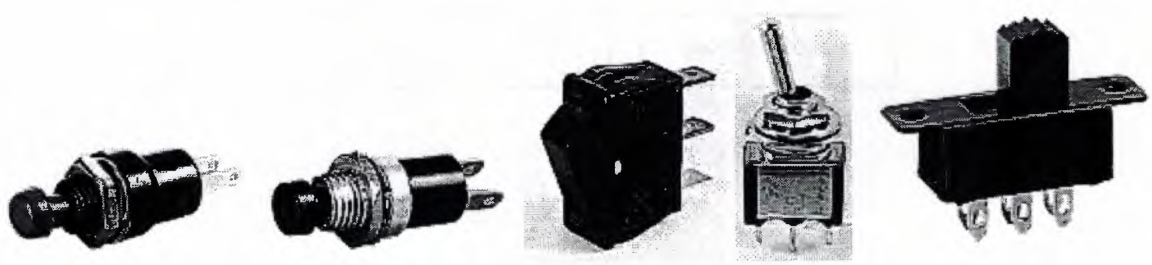


Figure 1.14 Switches [8]

1.11 Ferrite Aerial

The radio receiver in this project uses a medium-wave ferrite aerial, and a suitable type is MW5FR.like all ferrite aerials, this consists of a coil of wire on a piece of ferrite. In the case of the MW5FR the piece of ferrite is a rod measuring about 172mm x 9.5 mm and there are two coils of wire on a paper former which is slipped onto the rod. The two coils are a large (tuned) winding and a smaller (coupling) winding. They are wound using wires of different colors so that it is easy to determine which lead-outs come from which windings. The coils are wound using lids wire (a number of thin enameled copper wire twisted together and given an overall layer of insulation as well),and the ends of the lead-out wires are ready-tinned with solder so that they should fit into the breadboard without too much difficulty.

It is not essential to use MW5FR aerial, and the circuits have been also tested using an MWC2 aerial coil on a 140 mm x 9.5 mm ferrite rod. However, this aerial coil has tag connections rather than lead-out wires, the leads must either be soldered to the tags or connecting using small crocodile clips. The circuits should work properly using any other standard medium-wave ferrite aerial provided the coil has the small coupling windings.

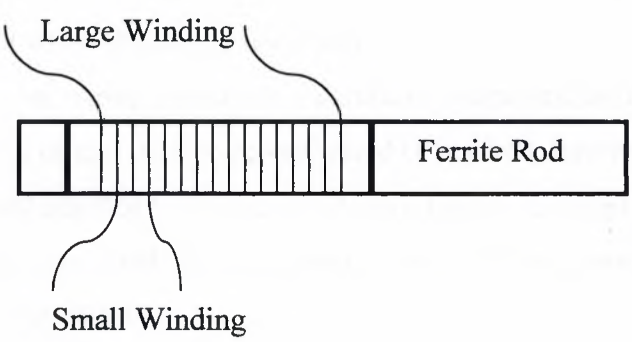


Figure 1.15 Ferrite Aerial

1.12 Battery Clips and Holders

The standard battery clip fits a 9V PP3 battery and many battery holders such as the 6 × AA cell holder shown in Figure 1.15. Battery holders are also available with wires attached, with pins for PCB mounting, or as a complete box with lid, switch, and wires.

Many small electronic projects use a 9V PP3 battery but if you wish to use the project for long periods a better choice is a battery holder with 6 AA cells. This has the same voltage but a much longer battery life and it will work out cheaper in the long run. Larger battery clips fit 9V PP9 batteries but these are rarely used now.

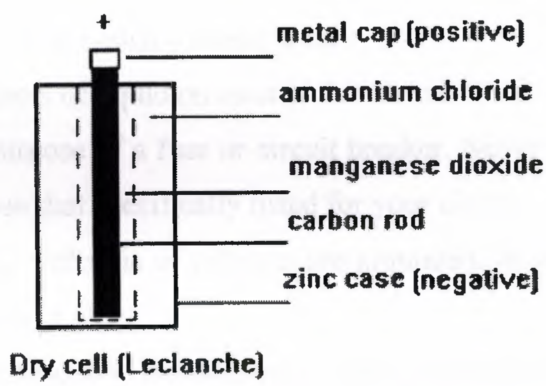


Figure 1.16: Components of the battery

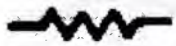
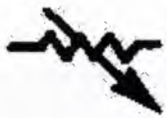
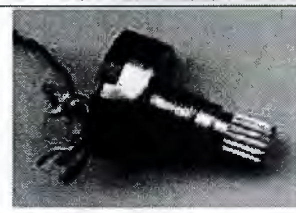
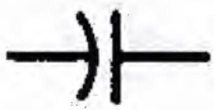
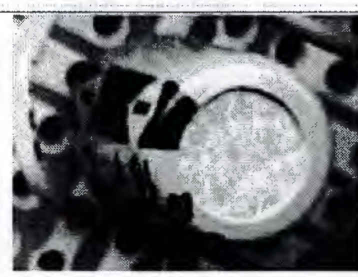
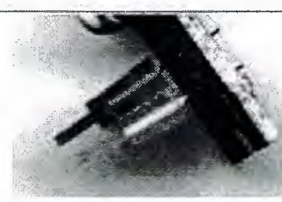
1.13 Safety Guidelines

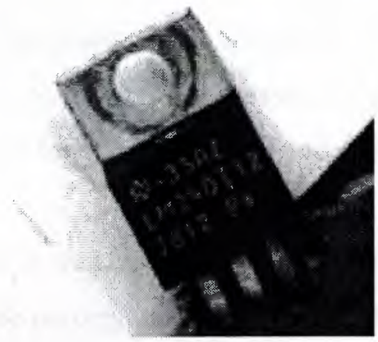
Some electrical and electronic safety guidelines are used pertaining engineers to take care about them.

1. Turn off power and unplug from the wall before working on electric or electronic circuits, except when absolutely necessary.
2. Complete all your wiring and check it carefully before turning on the power supply.
3. When a setup or circuit is to be reconfigured or rewired, turn the power supply off. It is also a good practice to disconnect it from the power supply.
4. When you are done with an experiment, turn off the power supply first before disassembling the circuit.
5. Do not work on electrical equipment in a wet area or when touching an object that may provide a hazardous earth ground path.

6. Turn off power and unplug equipment before checking or replacing fuses. Locate and correct the cause of a blown fuse or tripped circuit breaker before replacing the fuse or resetting the circuit breaker.
7. Immediately report and do not use defective cords and plugs. Inspect cabling for defects such as frayed wiring, loose connections, or cracked insulation.
8. Remove metal jewelry, watches, rings, etc., before working on electrical circuits.
9. Always check the electrical ratings of equipment you use and be sure you use that equipment within its ratings.
10. Never overload circuits.
11. Never leave unprotected systems unattended.
12. Never place containers of liquid on electrical systems.
13. Never defeat the purpose of a fuse or circuit breaker. Never install a fuse of higher amperage rating than that specifically listed for your circuit.
14. Make sure equipment chassis or cabinets are grounded. Never cut off or defeat the ground connection on a plug.
15. Safely discharge capacitors in equipment before working on the circuits. Why? Because, large capacitors found in many laser flash lamps and other systems are capable of storing lethal amounts of electrical energy and pose a serious danger even if the power source has been disconnected.
16. When shifting probes in a live/active circuit, be sure to shift using only one hand: It is best to keep the other hand off other surfaces and behind your back.
17. If you are working on a design project and you plan to work with voltages equal to or above 50 volts, notify your instructor and obtain their approval before proceeding.

Table 1.2 Description of some of the most common components and their schematic symbols [9]

Component	Schematic Symbol	Actual appearance
Resister		
Variable Resister		
Capacitor		
Diode		
Light emitting diode (LED)		
Chassis Ground		This is just a connection to ground.

Earth Ground		This is just a connection to ground.
NPN Bipolar Transistor		
PNP Bipolar Transistor		

1.14 Summary

This chapter covered background information on electronic circuit components. In addition safety guidelines for hardware electronic project were presented.

CHAPTER TWO

RADIO WAVE PROPAGATION AND ITS FRQUENCIES

2.1 Overview

This chapter presents the propagation of radio waves and the affect of atmosphere layers on it, how a radio wave travels and the types of propagation. As this chapter presents classifications of frequencies which are used in radio and other purposes, and describe of course MW and VHW transmission, differences and application is also will be mentioned.

2.2 Introduction

Radio waves have the longest wavelengths in the electromagnetic spectrum. These waves can be longer than a football field or as short as a football. Radio waves do more than just bring music to your radio. They also carry signals for your television and cellular phones.

Electromagnetic waves are formed when an electric field couples with a magnetic field. Magnetic and electric fields of an electromagnetic wave are perpendicular to each other and to the direction of the wave.

2.3 Waves and the electromagnetic spectrum

We do not know exactly what really electromagnetic waves are, excepting that they look sometimes like waves, sometimes like particles (quanta). The simplest representation of a wave is a three dimensional structure made of an electric and a magnetic field crossed-polarized in both vertical and horizontal planes. Its energy is moving back and forth from one field to the other; this phenomenon is known as oscillation. If the signal is omni directional, this complex field evolves evenly into space like waves that we observe on the water surface or still better, like a sphere that gradually become more a larger. If the signal is directional the sphere becomes a cardiod more or less extended in the propagation direction.

Radio waves are a form of electromagnetic radiation sensible to charged particles like free electrons. In free space they travel in straight line (in fact following geodesics) at the velocity of light (300000 km/s) and reduce a bit in denser medium. Their intensity is defined in volts per meter (practically in µV/m); in effective or peak values like AC current or by reference to the signal strength expressed in dB an other dBW unit.

The wavelength is defined as the distance between two points of equal phase or period taken as unit of time measurement. It is also defined as the ratio between the velocities of the wave to the current field frequency (f). For a free space wave the wave length is λ

$$\lambda(m) = \frac{300}{f(MHZ)}$$

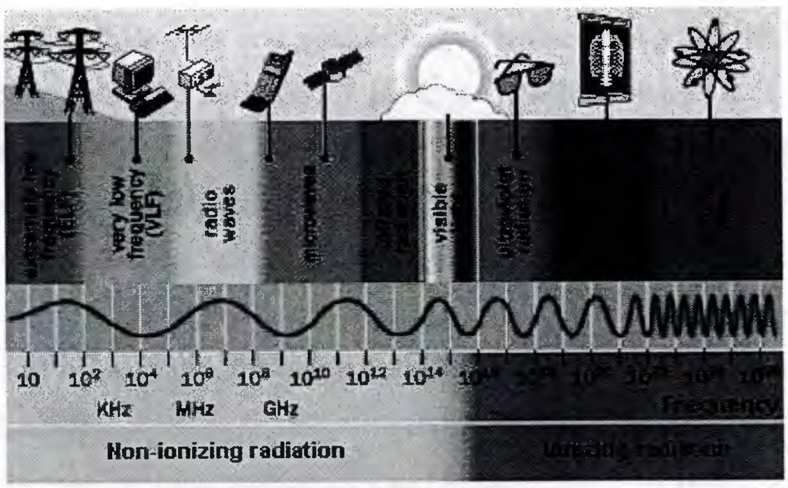


Figure 2.1 The electromagnetic spectrum [10]

2.4 How a radio wave travels

All radio signals will have their own coverage area. The coverage area of a radio transmitter will depend on several things like how much power is being transmitted from the antenna, and the terrain around the transmitter - hilly or mountainous ground will restrict signals coverage. Within the coverage area, the signal will be strong and easy to receive. Moving further away from the transmitter will result in the signal getting weaker and reception is degraded. On a stereo FM station for instance the signal will become noisy. On a television picture there will be a snowy appearance and perhaps a loss of color.

The weather can play a big part in reception. Yet even an object as far away as the sun, over 93 million miles away from the earth, can affect the way radio signals behave. Signals can travel further over sea paths and this is why people at coastal locations may be able to receive radio or TV stations from nearby countries. Even the trails of meteors in the night sky are able to bounce radio signals way beyond their normal coverage area.

2.5 Radio Frequencies

Radio frequencies are ranging from a few hertz, wavelengths of several thousands of km from peak-to-peak for brain waves, subsonic and oscillating at less than one cycle per second, to several thousands of gigahertz, wavelengths of a few mm from peak-to-peak for microwaves. Above we enter in the world of light (IR, visible, UV, X-ray and gamma).

This spectrum is divided in octaves, the natural way to represent frequencies. An octave represents eight diatonic degrees or a gradual frequency increasing of a 10-factor. Humans can hear sounds (vibrations) between 20 Hz and 20 kHz, a range of 3 octaves. Their wavelengths are ranging between 1500 and 15 km. The electromagnetic spectrum is also arbitrary divided into "bands". Each band extends over 3 octaves or so, the energy level increasing of about 10 times between the beginning and the end of the band. Natural radiation becomes a health hazard only from the UV light and above frequencies, even though, because all depends on the duration of exposure to the radiation, the distance to the source, and its intensity.

ELF are only used by some submarines and to carry AC over power lines. Otherwise, its main use is of course to carry the sound of low and mid frequencies as well infrasonic vibrations (animals).

VLF are also the carrier of sound up to about 20 kHz. This band is also used for long distance communications (few thousands km) and experimentation by scientists and the Navy.

LF is mainly used for regional broadcasting purposes while MF are used for worldwide broadcasting. HF are of our concern, these are formerly frequencies ranging from 1.8 to 30 MHz (160-10 m bands). Know as "short waves", these bands are very appreciated by all radio services and operators as they allow long distance communications, broadcasting and trans horizon radar operations.

VHF and **UHF** begin at 30 MHz (10 m) to end well above 1 GHz and are mainly used for radio and TV broadcasting as well as mobile communications over short distances (a few hundreds km) and more recently by cell phones.

Above these frequencies we find cent metric and mill metric waves, the famous microwaves. We know them essentially through home devices like microwave ovens (Short or S-band), wireless LAN (compromise or C-band), and some satellite and radar transmissions (Kurtz or K-bands). Then close your ears and open your eyes, you enter in the near infrared and visible parts of the spectrum! Over it, wear your anti UV-glasses to protect you against ultraviolet radiations. At last take your lead protection, we enter the world of X and γ rays.

Most services work in the lower bands of the electromagnetic spectrum, the only one frequency able to transport information on long distances with a very simple technology and low energy.

Each band requests special receivers and aerials according to the frequency used and the type of waves (ground, space, ionosphere, etc). However these waves are affected by the medium in which they propagate its electronic density and its dielectric constant.

In this project MWand VHW transmissions will be discussed in detail.

2.5.1 MF Medium Frequencies

This segment of spectrum is between 300-3000 KHz. Within this segment there is Medium Wave radio broadcasting band which is between 520-1610 KHz.

Channel spacing is 9 kHz for Continental Europe and the Middle East and 10 kHz for north and South America. MW is quite different than LW as to reflection effect of ionosphere; half of MW frequencies below 1000 kHz are almost similar to LW frequencies; however frequencies above 1000 kHz are almost similar to short wave frequencies in the high frequency segment of the frequency spectrum. Especially at night, MW frequencies maybe reflected from the ionosphere and may reach to far distances. For instance many Middle Eastern MW transmitters can be received in Turkey while Turkish MW transmitters can be received at far distances such as Cairo. This characteristic requires that MW frequencies are not purely domestic frequencies and they have to be regionally planned. Such plans must be realized with close relationship of neighboring countries. In the history of MW broadcasting there had been many instances of tense relationships between the countries with hostile positions.

Due to the ionospheric reflection possibilities of MW frequencies, MW is a band not only for domestic radio broadcast but also for international radio broadcast. This may easily be seen in the relays that carry a program of a far distanced transmitter. VOA (Voice of America has MW relays in Rhodes while BBC has in Southern Cyprus (1323 KHz. Radio Monte Carlo (relays also Trans World Radio program) has a MW relay in Southern Cyprus (1233 KHz). Lower and upper ends of MW band are allocated for navigation finding and wireless communication. 2182 KHz.

2.5.2 VHF Very High Frequencies

They range between 30-300 MHz. Within this segment of the spectrum there exist FM radio broadcast band between 88 and 108 MHz. FM radio band is usually for local radio broadcasters since the electromagnetic waves on this band can only travel on the surface up to 100 Km. if there are no physical obstacles such as mountains. Relay (repeaters) stations must be used if a larger geographic area is to be covered in FM band. FM band is very suitable for music broadcasting because it has a wider audio bandwidth nearly enough for Hi-Fi music reproduction. Additionally in FM band stereo broadcasting is also possible and this is vital for good quality music reproduction in the receiver. TV Band I, S- Band (for cable-TV) and TV Band III are also in VHF segment of the spectrum. Other portions of the segment are used for several telecommunication services [10].

Figure 2.2 Radio

Table 2.1 Radio bands [10]

Band	Abbreviation	Frequency	Wavelength	Energy
X-rays	X-rays	30.3 PHz - 3 EHz	10 - 0.1 nm	125 - 12.5 keV
Extreme ultraviolet	EUV	4.5 - 30.3 PHz	70 - 10 nm	18 - 125 eV
Visible (red - violet)	....	398 - 750 THz	800 - 400 nm	1.6 - 3.1 eV
Super High Frequency,	SHF	3 - 30 GHz	10 - 1 cm	13 - 132 μeV
Ultra High Frequency	UHF	300 MHz - 3 GHz	100 - 10 cm	1.1 - 13 μeV
Very High Frequency	VHF	30 - 300 MHz	10 - 1 m	132 neV - 1.1 μeV
High Frequency	HF	3 - 30 MHz	100 - 10 m	13 - 132 neV
Medium Frequency	MF	300 kHz - 3 MHz	1000 - 100 m	1.3 - 13 neV
Low Frequency	LF	30 - 300 kHz	10 - 1 km	120 peV - 1.3 neV
Very Low Frequency	VLF	3 - 30 kHz	100 - 10 km	13 - 120 peV
Extreme Low Frequency	ELF	30 Hz - 3 kHz	10000 - 100 km	125 - 13 peV

2.6 Propagation of waves

Propagation is defined as the travel of waves through or along a medium. In practice this medium is the earth's atmosphere which is divided up into layers those of main importance being the Troposphere and the ionosphere.

The success or the failure of a radio transmission depends on the way that radio signals travel around the earth. Basically there are five types of propagation:

1. **Ground waves**: also called evanescent or surface waves, these waves propagate along the earth surface, close to the ground, and never reach the ionosphere. Typically signals carried by ground waves can be heard up to a distance of 160 km or more during the daytime. They are however subject to a high attenuation throughout HF bands to reach distances less than 15 km at 30 MHz.. Therefore these surface waves are mainly used at low frequencies below 1.8 MHz (MW, LW and VLF) by geophysicists and the U.S Navy (submarines).
2. **Tropospheric waves:** below 10 km or so of the atmosphere, where weather patterns and temperature inversions form, VHF can be refracted permitting short distances contact (a few thousands km).
3. **Space waves:** these waves travel directly from an antenna to another without reflection on the ground. This phenomenon occurs when both antennas are within line of sight of each another. This distance is longer that the line of sight because most space waves bend near the ground and follows practically a curved path. In the field we must also add the effects of the atmospheric refraction and diffraction near the earth surface that extend this distance of about 20% in the lowest bands. On V/UHF on the contrary diffraction is very small and signals tend to drop off quite rapidly at a shorter distance. In this way of propagation antennas must display a very low angle of emission in order that all the power is radiated in direction of the horizon instead of escaping in the sky. A high gain and horizontally polarized antenna is thus highly recommended.
4. **Sky waves:** They essentially concern frequencies below 30 MHz (longer than 10 meters) and V/UHF in a less extent that are able to escape into free space (that begins over 800 km aloft). Called sky waves these waves are however stopped in their travel by the ionospheric layers and, under low incidence angles, they are reflected to the ground. These waves are then called ionospheric waves. They are very influenced by the presence of electrons gas and plasma in the upper atmosphere of the Earth. Under certain conditions these layers reflect or refract short waves, permitting amateurs to reach stations located on the other side of the

Earth in a succession of jumps between the ground and the ionosphere, called multihops.

5. **Free space waves:** they are the most common but the less used! We encounter them working in VHF or UHF where, due to their very high frequency, at incidence angles higher that the critical angle, short waves escape into space instead of be reflected by ionospheric layers.

If waves travel in straight line and at the velocity of light in free space, on Earth, the ground, the air and the ionosphere affect wave propagation; radio waves do no more travel from one point to another in straight line and their signals are often altered. The fading is probably the alteration, Radio waves are mainly subject to four effects and they are Attenuation, Reflection, Refraction and Diffraction.

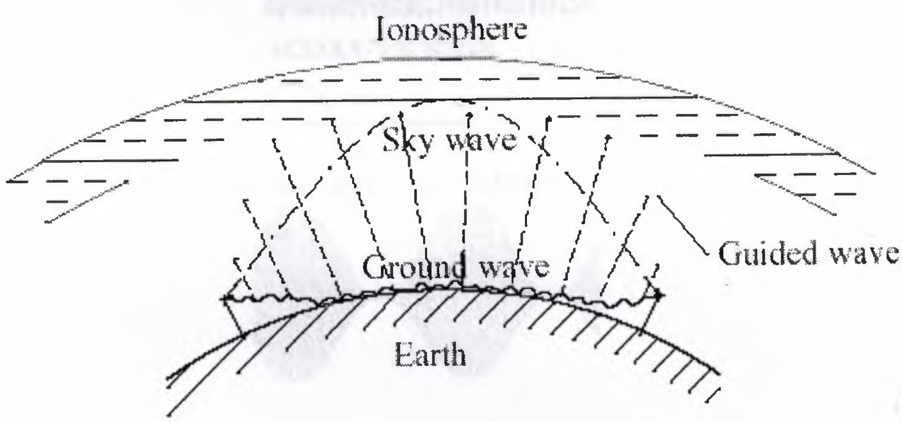


Figure2.3 Wave propagation [11]

2.7 Modulation

The important thing in any communications system is to be able to send information from one place to another. This means we have to find a way to impress that information on the radio wave in such a way that it can be recovered at the other end. This process is known as modulation. In order to modulate a radio wave, we have to change either or both of the two basic characteristics of the wave: the amplitude or the frequency.

2.7.1 (AM) Amplitude Modulation

If we change the amplitude, or strength, of the signal in a way corresponding to the information we are trying to send, we are using amplitude modulation, or AM. The earliest means of radio communications was by Morse code, and the code key would turn the transmitter on and off. The amplitude went from nothing to full power whenever the key was pressed, a basic form of AM. Modern AM transmitters vary the signal level smoothly in direct proportion to the sound they are transmitting. Positive peaks of the sound produce maximum radio energy, and negative peaks of the sound produce minimum energy. The main disadvantage of AM is that most natural and man made radio noise is AM in nature, and AM receivers have no means of rejecting that noise. Also, weak signals are (because of their lower amplitude) quieter than strong ones, which requires the receiver to have circuits to compensate for the signal level differences.

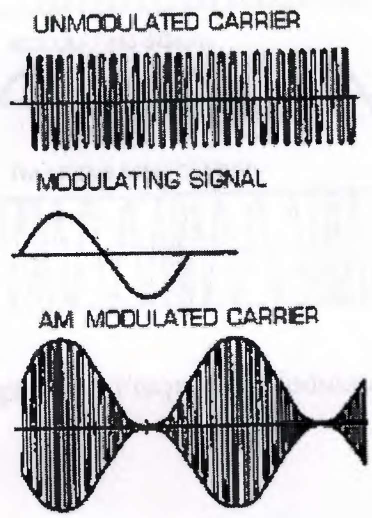


Figure 2.4 Amplitude Modulation

2.7.2 (FM) Frequency Modulation

In an attempt to overcome these problems, a man named Edwin H. Armstrong invented a system that would overcome the difficulties of amplitude noise. Instead of modulating the strength (or amplitude) of the transmitted signal, or carrier, he modulated the frequency. Though many engineers at that time said that FM was not practical, Armstrong proved them all wrong, and FM today is the mainstay of the broadcast radio services. In a frequency modulated system, the frequency of the carrier is varied according to the modulating signal. For example, positive peaks would produce a higher frequency, while negative peaks would produce a lower frequency. At the receiving end, a limiting circuit removes all amplitude variations from the signal, and a discriminator circuit converts the frequency variations back to the original signal. In this way, the effects of amplitude noise are minimized. Since the recovered audio is dependent only on the frequency, and not the strength, no compensation for different signal levels is required, as is the case with AM receivers.

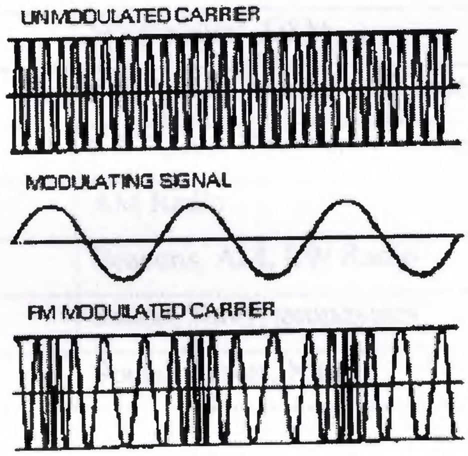


Figure 2.5 Frequency Modulation [12]

2.8 Application

Each band of frequency has its own applications which are used in our life, these application are shown in table 2.2.

Table 2.2: bands and its Applications [10]

Band	Applications
X-rays	X-ray machines, sun flare
Extreme ultraviolet	UV, ionosphere ionization
Visible (red - violet)	Visible spectrum, light
Super High Frequency,	Microwaves, satellite
Ultra High Frequency	Microwaves, GSM
Very High Frequency	FM Radio, Television channels
High Frequency	SW Radio, Emergency services radio
Medium Frequency	AM Radio
Low Frequency	Beacons, AM, LW Radio
Very Low Frequency	Sound, Navy, geophysics
Extreme Low Frequency	Sound, power, Navy

2.9 Summary

This chapter presented the propagation of radio waves, how a radio wave travels, the types of propagation and kinds of modulations. As we presented classifications of frequencies which are used in radio and other purposes.

CHAPTER THREE

HARDWARE APPROACH OF THE MW RADIO

3.1 Overview

This chapter presents the components used in the circuit and the circuit diagram. The operation of each part of the circuit will be described.

3.2 Radio Circuit

The circuit as shown in fig. 3.1 is a bit complicated and it is difficult to understand the function of each component, so it is better to separate the circuit into two sides, each side has specific job to do, oscillating side and amplifying one.

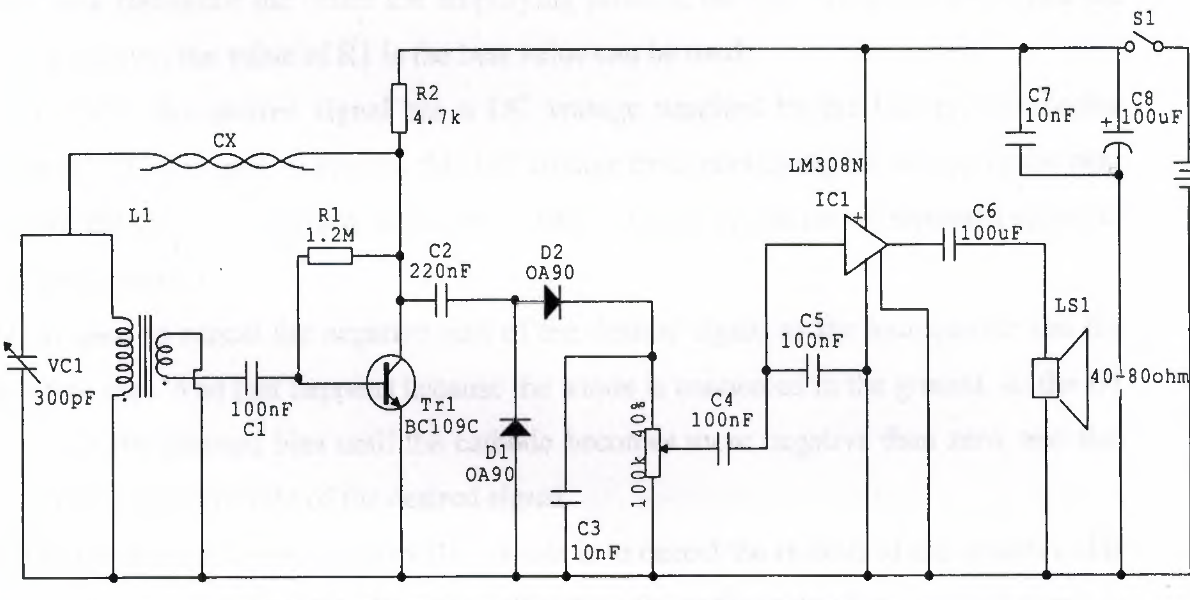


Figure 3.1 Circuit diagram of MW radio [13].

3.2.1 Oscillating Part

The oscillating part as shown in fig 3.2 is quit smoother than it was shown above. Here the connection between variable capacitor (VC 1) and the ferrite aerial (L1) is the receiving part of the radio, the ferrite aerial is the component which converts the radio waves into electrical signals, but it is convert all waves in the MW transmission frequencies, so the connection between it and VC1 is introduced to pass the desired frequency. But how that happens?

$$f_0 = \frac{1}{CLW} \tag{3.1}$$

The above equation gives the output of a capacitor and inductor connected in parallel, this frequency is called resonance frequency. And when the resonance frequency equal to transmission frequency, the transmitter radio signal enter to the circuit as electrical signal and passed into the circuit through the LC connection.

After the desired signal enters through the parallel connection between VC 1 and L1, the signal reaches C1, which is used to filter any DC voltage carried with desired signal, which is an AC type.

After the signal has been filtered out from any undesired DC voltage it is ready to enter the phase of pre-amplifying process. This process is performed by the NPN transistor and R1 which is used as feedback path, it is know in general that the larger the feedback resistance the better the amplifying process, but this rule has a limit, and for this transistor, the value of R1 is the best value can be used.

Again after the desired signal has a DC voltage supplied by the battery, so another capacitor (C2) is used to prevent this DC voltage from continuing its way up to the next part of the circuit (it is know that a DC voltage will act as a noise or unwanted signal in the loudspeaker).

D1 is used to cancel the negative part of the desired signal as the loudspeaker use the positive part. And that happens because the anode is connected to the ground, so the D1 is not in the forward bias until the cathode becomes more negative than zero, and that means the negative side of the desired signal.

D2 has a minor role compared to D1; its role is to cancel the residue of the negative side of the desired signal, as D1 allow a small value of negative side of the desired signal to reach D2. That happens due to the triggering voltage which is needed to change the statues of D1 from isolator to conductor, and this voltage depends on the type of the diode, so if the diode is made of silicon, this needed voltage equal to -0.7V, and Wit is made of germanium -0.3V is the needed voltage to trigger D1.

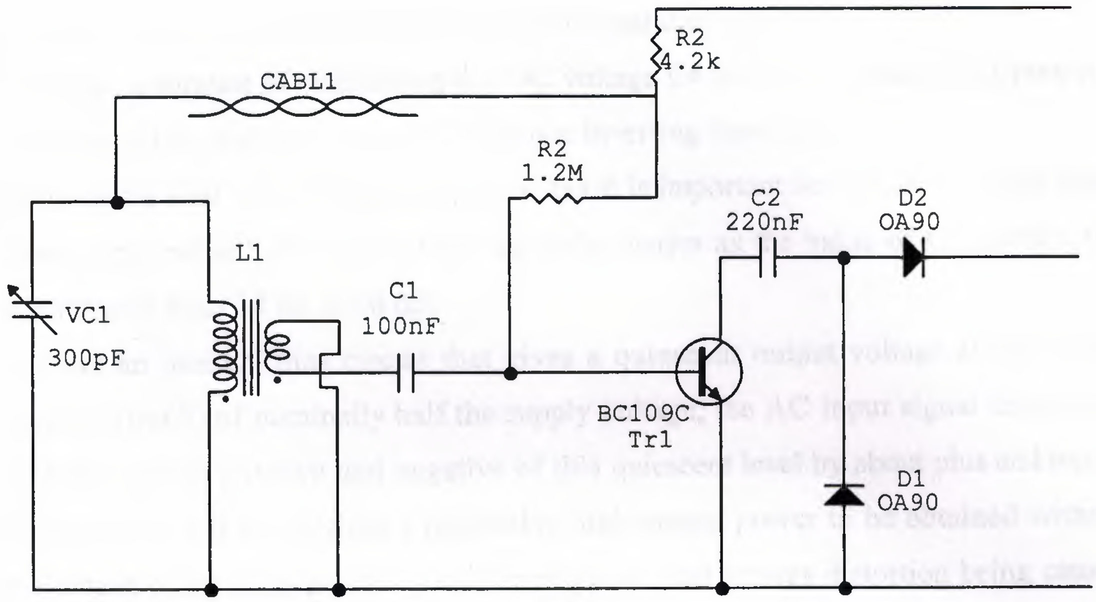


Figure 3.2 Oscillating part diagram of MW radio.

3.2.2 Amplifying part

After the desired signal is cleanly out of the huge number transmission frequencies, and prepared to be amplified by filtering any DC voltage from it, it is almost ready to enter to the amplifying phase, see fig.3.3.

This extremely simple circuit provides an output of power of about 200 mW RMS (about equal in volume to a small or medium-size transistor radio) and has an input sensitivity of about 50 mV RMS into 100 kΩ for maximum output. This enables the unit to be fed from a variety of signal sources, such as a crystal or ceramic pickup, radio tuner, etc.

The circuit is primarily intended as a simple one to demonstrate the properties of the LM380N audio-power amplifier device, and it makes a very useful and inexpensive workshop amplifier if the circuit is built as a proper, cased project.

When a capacitor is connected between the earth and the path of any signal, it allows a certain band of frequency to pass through (it acts like a band pass filter), so to make sure that no any other radio waves entered to the circuit, C3 is used to let only the desired signal to pass, the values of the capacitance and the impedance of C3 control the range of allowed frequencies to pass, in MW it allows frequencies up to 3000 kHz.

VRl is the volume control resistance; by tuning it we can control the input signal going to IC (LM308N) and coming in from the radio circuit and which has been filtered by the C3 capacitor which is connected parallel with VR1.

As a final assurance of eliminating any DC voltage C4 is used, so that almost pure AC will enter to the amplifier from pin-2 (the non inverting input pin).

C5 has not a vital role in filtering process, but it is important for LM380N's gain value determining, actually the gain of this amplifier varies as the value of C5 change, the gain range is from 34 dB to 40 dB.

IC1 has an internal bias circuit that gives a quiescent output voltage at the output terminal (pin 8) of nominally half the supply voltage, the AC input signal causes the output to swing positive and negative of this quiescent level by about plus and minus 3 volts or so, and this enables a reasonably high output power to be obtained without the output going fully positive or fully negative, and serious distortion being caused by clipping of the output waveform.

If a DC component on the input signal was allowed to reach the input of IC 1 this would alter the quiescent output voltage of IC 1, and could result in the output going almost fully positive or negative. Only a very small output power would then be possible without the signal becoming badly distorted.

C6 provides DC blocking at the output so that loudspeaker only receives the varying output voltage from IC 1, and not the quiescent (DC) output voltage, which would Give a high standing current through the loudspeaker produce a very high level of current consumption.

The LM380N has a class AB output stage, and this means that the average current consumption of the device (which is around 10 mA) remains virtually constant at low and medium output powers, but increases somewhat at high output powers. This gives reasonable battery economy, and a PP6 or larger 9-volt battery makes a suitable power source.

There is some variation in the supply voltage due to variations in the loading on the battery by IC 1 as the output power inevitably fluctuates quite rapidly and over a fairly wide range with any practical input signal This can result in a loss of performance or instability, and decoupling capacitors C7 and C8 are included to prevent either of these occurring.

As finally the C7 and C8 are connected in parallel with battery to cancel any AC signal coming from it. An additional decoupling capacitor can be added from pin 1 of IC 1 to the negative supply, and this decouples the supply to the preamplifier stages of the device. This is not normally necessary when the LM380N is employed with a battery supply, and is a facility give a high standing current through the loudspeaker produce a very high level of current consumption.

An additional decoupling capacitor can be added from pin 1 of 10 to the negative supply, and this decouples the supply to the preamplifier stages of the device. This is not normally necessary when the LM380N is employed with a battery supply, and is a facility that is normally only required when the device is used with a mains power supply that has high ripple content.

You might be confused by the fact that one lead to IC1 in Fig. 3.3 is marked 3, 4, 5, 7, 10, 11, and 12. This lead is marked with six pin numbers merely because these six pins are internally interconnected, and a connection to one of them is a connection to the other five.

The case should ideally be an all metal type so that it screens the Circuitry from stray pickup of mains hum and similar electrical signals, and the case should be earthed to the negative supply.

With most types of audio socket, this chassis connection will be automatically provided through the earth lead to the socket. The test leads should use screened cable (the outer braiding connecting to the chassis of the amplifier).

An interesting feature of the LM380N device is that it has two inputs, pin 2 is the non-inverting input and pm 6 is the Inverting input.

An input signal to pin 6 produces a change in output voltage that is of the opposite polarity, whereas an input to pin 2 gives a change in output voltage that is of the same polarity as the input signal.

There is no audible difference between the two, and the fact that the signal is inverted through IC 1 if the input at pin 6 is used is not really of any practical importance. The circuit works equally well whichever of the two inputs is used and this fact can easily be demonstrated in practice

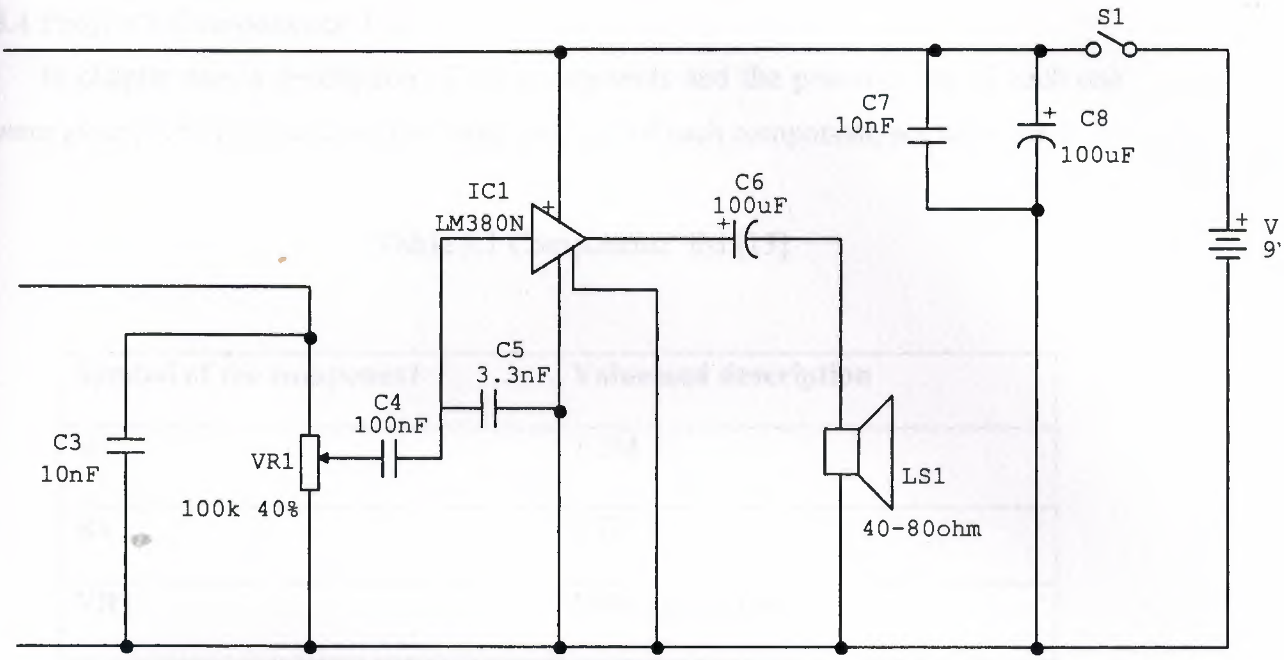


Figure 3.3 Amplifying part diagram of MW radio

3.3 Modification recommendation

There are many ways that we can modify the MW radio such as adding FM radio so that there will be switch between them (on-off -on),also a small lamp or a fan can be added to the circuit if we were listening to the music the lamp can be on or off by using (on-off) switch .

In this project FM radio is added to modify our circuit as well using other amplifier in the MW radio so that to give a clear noise which is LM386.

3.4 Project's Components' List

In chapter one, a description of the components and the practical use of each one were given, but in this section, the value and type of each component, see table 3.1.

Table 3.1 Components' list [13]

Symbol of the component	**Value and description**
R1	1.2M
R2	4.7k
VR1	100k log. carbon
C1	100nF, polyester
C2	220nF, polyester
C3	10nF, polyester
C4	100nF, polyester
C5	3.3nF, ceramic
C6	100µF, 10V electrolytic
C7	10nF, polyester
C8	100µF,10 electrolytic
VC1	300pF solid dielectric
TR1	BC101C
IC1	LM380N
D1	OA90 but as the diodes where not found the alternative is AA114
D2	OA90 ⟶ AA114
S1	SPST miniature toggle type
LS1	Miniature type having an impedance in the range 40-80 ohms
L1	Ferrite aerial
B1	PP6 size 9V and connector to suit

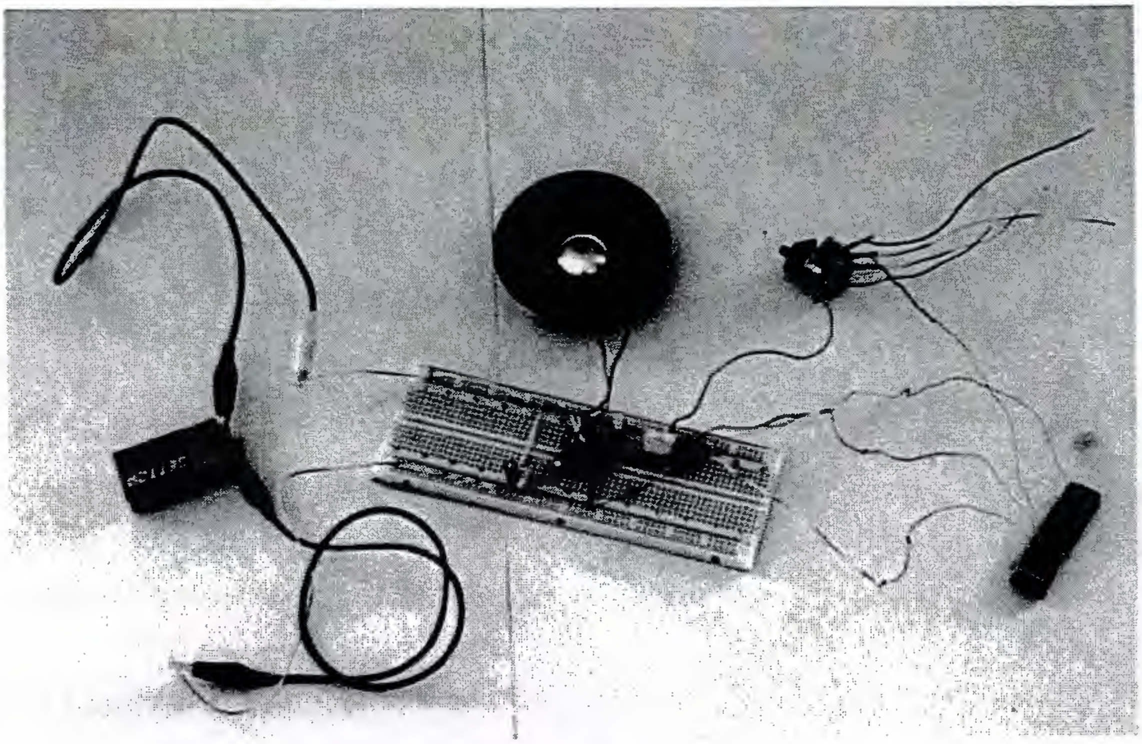


Figure 3.4 MW Radio after connection

3.5 Summary

This chapter has presented the components of the radio and amplifier circuit and the function of each component, and how does it contribute in the process of filtering and amplifying, it is possible to connect the circuit and have MW radio circuit as shown in fig 3.4.

But it is not guaranteed 100 % to work properly using exactly the theoretical way of connection as described, because practical work has very different circumstances than theoretical one, and so many problems may occur.

CHAPTER FOUR

MODIFICATION OF THE MW RADIO

4.1 Overview

This chapter present the FM radio where it's added to the AM radio and it explains the design of the FM circuit, the components that has been used .This chapter also contains explanation about the differences between the FM and AM radio.

4.2 Electrical components

In chapter one information about electronics components where discussed but in this chapter there are new components that has been used on the hardware of the FM radio.

4.2.1 CXA1619BS

CXA1619BS is a one-chip FM/AM radio IC designed for radio-cassette tape recorders and headphone tape recorders.

4.2.2 Features

- Small number of peripheral components.
- Low current consumption (VCC=3 V).
- For FM: ID=5.8 mA.
- Built-in FM/AM select switch.
- Large output of AF amplifier.

4.2.3 Function

- RF amplifier, Mixer and OSC ((incorporating AFC variable capacitor).
- IF amplifier.
- Quadrature detection.
- Tuning LED driver.

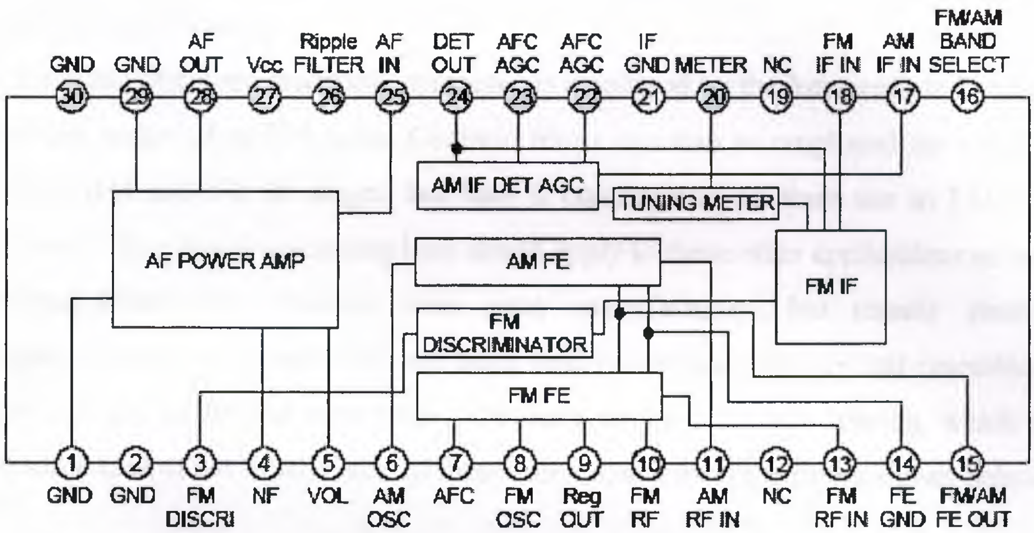


Figure 4.1: Block diagram of CXA1619BS [14]

4.2.3 Variable Resistors (Potentiometer)

Variable resistors consist of a resistance track with connections at both ends and a wiper which moves along the track as you turn the spindle. The track may be made from carbon, cermets (ceramic and metal mixture) or a coil of wire (for low resistances).

The track is usually rotary but straight track versions, usually called sliders, are also available. Variable resistors used as potentiometers have all three terminals connected. This arrangement is normally used to vary voltage, for example to set the switching point of a circuit with a sensor, or control the volume (loudness) in an amplifier circuit.

If the terminals at the ends of the track are connected across the power supply then the wiper terminal will provide a voltage which can be varied from zero up to the maximum of the supply.

Figure 4.2: Potentiometer [15]

4.2.4 Ceramic Filters

Ceramic filters are electronic components employed by the Intermediate Frequency (IF) amplifier stages of an FM radio. Ceramic filters can also be employed for other purposes such as AM and TV IF stages, but here it concentrates on their use in FM tuners and receivers. The general discussion here would apply to these other applications as well. Ceramic filters are available from many manufacturers, but usually share several characteristics in common. They are three lead rectangular devices that resemble ceramic capacitors except for the three leads. The leads are on 1/10 inch spacing, which will give you some idea of the relative size of these components from the figure shown below.

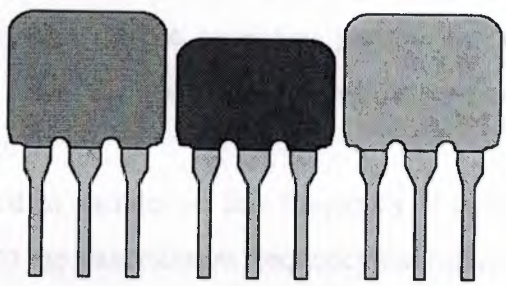


Figure 4.3: Ceramic Filters [16]

The three pins from left to right are input, ground, and output. The devices are polarized make sure that you get the input pin connect. The electrical function that ceramic filters perform is that of a band pass filter centered on 10.7 MHz. band pass filter passes its center frequency, while rejecting frequencies to each side of the center. The quality or "Q" factor of a band pass filter is a measure of how sharply it rejects the frequencies to each side of the center frequency. The Q of FM ceramic filters is not specified directly; instead it is stated as the bandwidth at which the filter has rolled off by 3 dB above and below the center frequency. For a 150 kHz ceramic filter, then, the signal would be rolled off 3 dB at 10.625 MHz and 10.775 MHz.

4.3 Radio circuit

This circuit as shown in fig 4.4 is a bit complicated where it contains one integrated circuit, capacitors, resistors, variable capacitors, resistors and one filter.

Some components has been discussed in the first chapter .In this chapter it will represent an introduction of the new electrical components that are used in the FM radio .Beside the MW radio the FM radio will be connected by ON-OFF-ON switch where it's a special version of the standard SPDT switch. It has a third switching position in the centre which is off. Momentary (ON)-OFF-(ON) where the switch returns to the central off position when released.

When the switch is ON in the FM side it will start to work, the radio has oscillating part and amplifying part as shown in figure 4.4 .In oscillating part the connection between variable capacitor and the aerial is the receiving part in the radio, this aerial is the component which converts the radio waves in to electrical signal in the HF transmission frequencies as it is FM radio.

C7 and L1 are connected in parallel so this frequency is called resonance frequency .When the resonance equal to the transmission frequency the radio signal enter to the circuit as electrical signal and passes in to the ceramic filter where its an electrical component employed by the intermediate frequency (IF) and it's a amplifier stage it has a band pas filter centered as 10.7 MHz so the radio signal is going to be filtered and pass to the circuit through the IC connection .the desired signal which has DC voltage supplied by battery . D1 is used to cancel the negative part of the desired signal in one of the legs of the Potentiometer which controls the volume of the loudspeaker using the positive part. And that happens because the anode is connected to the ground, so the D1 is not in the forward bias until the cathode becomes more negative than zero, and that means the negative side of the desired signal.

In the amplifying part after the desired signal is cleanly out of the huge number transmission frequencies and prepared to be amplified by filtering any DC voltage from it.

This IC works also as an audio power amplifier device ,VR(variable resistor) is the volume control resistance by tuning it signal going to the IC can be controlled .from these process the channels will be received by the tuning the VC(variable capacitor) we an get different channels .

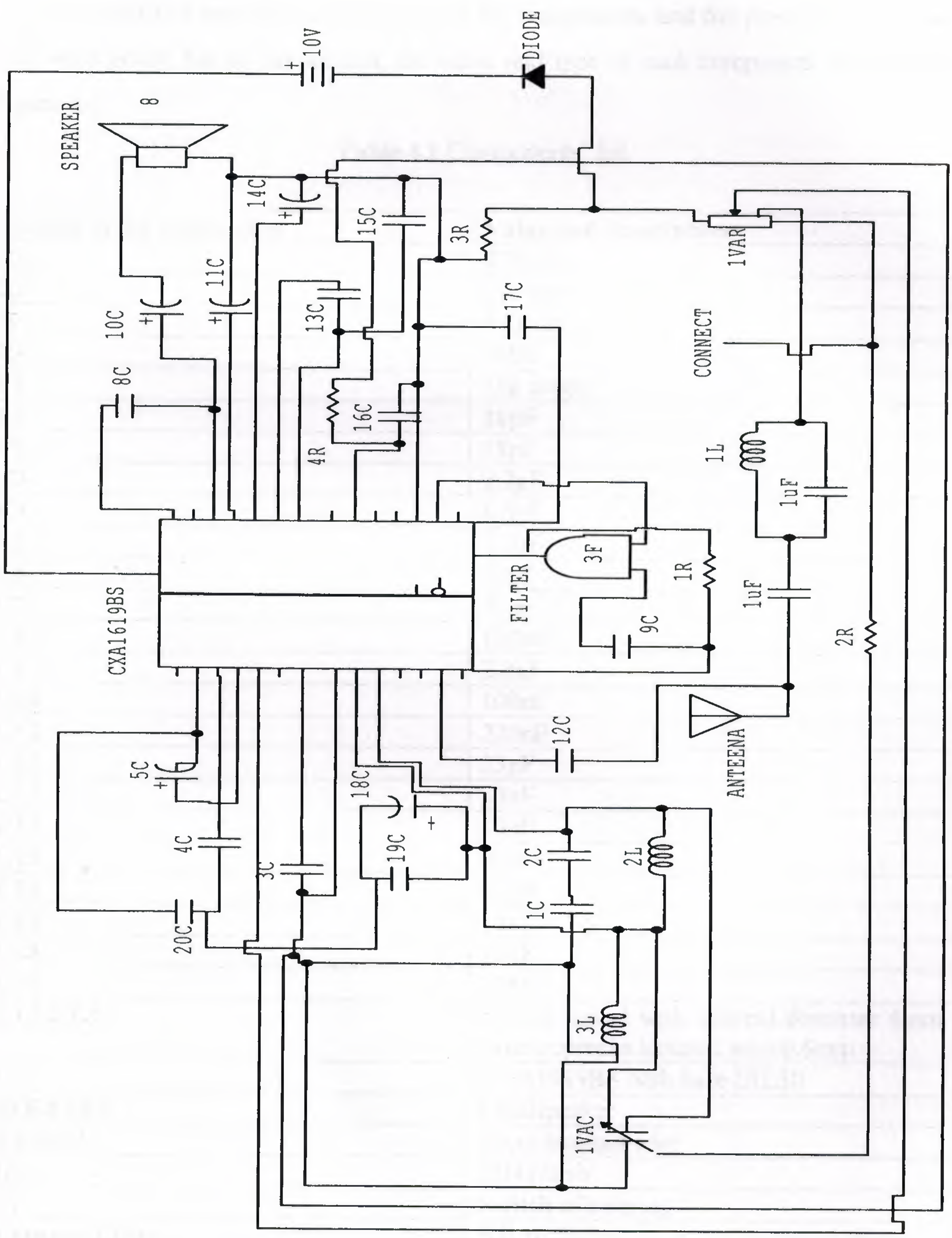


Figure 4.4: Circuit of FM radio [17]

4.3.1 Project components list

In chapter one and four a description of the components and the practical use of each one were given, but in this section, the value and type of each component are shown in figure 4.1.

Table 4.1 Components' list

Symbol of the component	Value and description
R1	470ohm
R2	470ohm
R3	470ohm
R4	100k
P1	10k ceppot
C1	18pF
C2	18pF
C3	2.2pF
C4	6.8pF
C5	2.2uF
C6	33pF
C7	33pF
C8	100nF
C9	2.2nF
C10	100uF
C11	220nF
C12	33pF
C13	33nF
C14	10uF
C15	22nF
C16	2.2uF
C17	10nF
C18	10uF
C19	10nF
L1,L2,L3	5 coils linked with internal diameter 4mm from cupreous isolated wire 0.6mm
IC1	CXA1019BS with base DIL30
SPEAKER	Loudspeaker
AERIAL	50cm isolated wire
D1	1N4148vb
S1	Switch of catering
Ceramic Filter	S.F 10.7Mhz
Battery	9V

4.4 In general how radio works?

Radio station launches a radio wave by moving electric charges rhythmically up and down their antenna. As this electric charge accelerates back and forth, it produces a changing electric field a structure in space that pushes on electric charges and a changing magnetic field a structure in space that pushes on magnetic poles. Because the electric field changes with time, it creates the magnetic field and because the magnetic field changes with time, it creates the electric field. The two travel off across space as a pair, endlessly recreating one another in an electromagnetic wave that will continue to the ends of the universe. However, when this wave encounters the antenna of your radio, its electric field begins to push electric charges up and down on that antenna. Your radio senses this motion of electric charges and thus detects the passing radio wave.

To convey audio information (sound) to you radio, the radio station makes one of several changes to the radio wave it transmits. In the AM or Amplitude Modulation technique, it adjusts the amount of charge it moves up and down its antenna, and hence the strength of its radio wave, in order to signal which way to move the speaker of your radio.

These movements of the speaker are what cause your radio to emit sound. In the FM or Frequency Modulation technique, the radio station adjusts the precise frequency at which it moves charge up and down its antenna. Your radio senses these slight changes in frequency and moves its speaker accordingly [18].

4.5 What are the differences between FM and AM radio?

These days, radios just look like electronic circuit boards inside AM and FM are both techniques whereby the radio station tells your radio which way to move the diaphragm of its speaker and by how much, in order to make sound. In the AM or Amplitude Modulation technique, the station raises or lowers the power of its radio wave to tell your radio to move its speaker diaphragm toward you or away from you, respectively.

The higher the power of the radio wave, the more your radio pushes its diaphragm toward you. In the FM or Frequency Modulation technique, the station raises or lowers the frequency of its radio wave slightly to tell your radio to move its speaker diaphragm toward you or away from you, respectively.

The more it raises the frequency of its radio wave, the more your radio pushes its diaphragm toward you.

4.5.1 AM radio

The AM band covers 535KHZ to 1.7MHZ .There are signals from thousands of radio transmitters on many different frequencies inducing signal voltages in the aerial. The RF filter selects the desired station from the many.

It is adjustable so that the selection frequency can be altered. This is called TUNING. The selected frequency is applied to the mixer; the output of an oscillator is also applied to the mixer.

The mixer and oscillator form a FREQUENCY CHANGER circuit. The output from the mixer is the intermediate frequency (i.f.) .The i.f. is a fixed frequency of about 455 kHz. No matter what the frequency of the selected radio station is, the i.f. is always 455 kHz. The i.f. signal is fed into the i.f. amplifier. The advantage of the i.f. amplifier is that its frequency and bandwidth are fixed, no matter what the frequency of the incoming signal is. This makes the design and operation of the amplifier much simpler. The amplified i.f. signal is fed to the demodulator. This circuit recovers the audio signal and discards the R.F. carrier.

It usually incorporates a diode in the circuit. Some of the audio is fed back to the i.f. amplifier as an AUTOMATIC GAIN CONTROL voltage.

This ensures that when tuning from a weak station to a strong one, the loudness from the loudspeaker stays the same. The audio signal voltage is increased in amplitude by a voltage amplifier. The power level is increased sufficiently to drive the loudspeaker by the power amplifier.

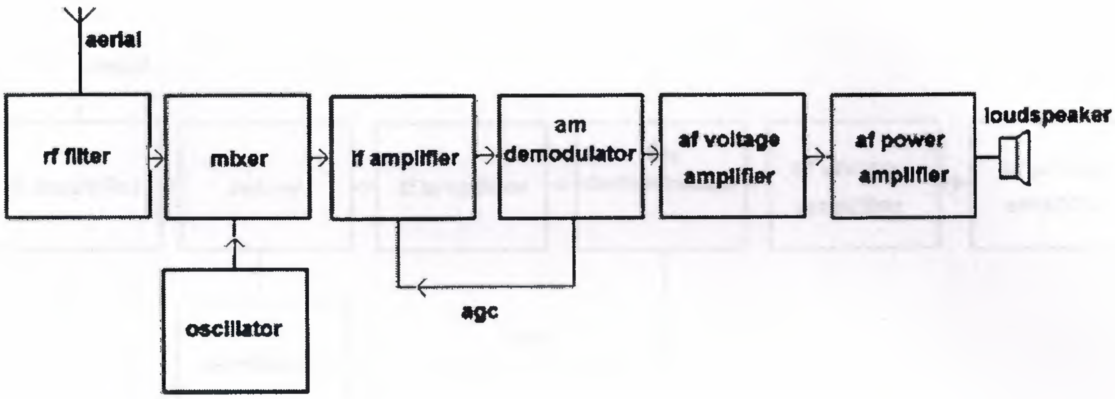


Figure 4.5: AM receiver block diagram [19]

4.5.2 FM radio

The FM band covers 88-108 MHz. There are signals from many radio transmitters in this band inducing signal voltages in the aerial. The RF amplifier selects and amplifies the desired station from the many; it is adjustable so that the selection frequency can be altered. This is called TUNING.

In cheaper receivers the tuning is fixed and the tuning filter is wide enough to pass all signals in the F.M band. The selected frequency is applied to the mixer. The output of an oscillator is also applied to the mixer. The mixer and oscillator form a FREQUENCY CHANGER circuit. The output from the mixer is the intermediate frequency (i.f.). The i.f. is a fixed frequency of 10.7 MHz. No matter what the frequency of the selected radio station is, the i.f. is always 10.7 MHz.

The i.f. signal is fed into the i.f. amplifier. The advantage of the i.f. amplifier is that its frequency and bandwidth are fixed, no matter what the frequency of the incoming signal is. This makes the design and operation of the amplifier much simpler. The amplified i.f. signal is fed to the demodulator.

This circuit recovers the audio signal and discards the r.f. carrier. Some of the audio is fed back to the oscillator as an AUTOMATIC FREQUENCY CONTROL voltage. This ensures that the oscillator frequency is stable in spite of temperature changes. The audio signal voltage is increased in amplitude by a voltage amplifier. The power level is increased sufficiently to drive the loudspeaker by the power amplifier.

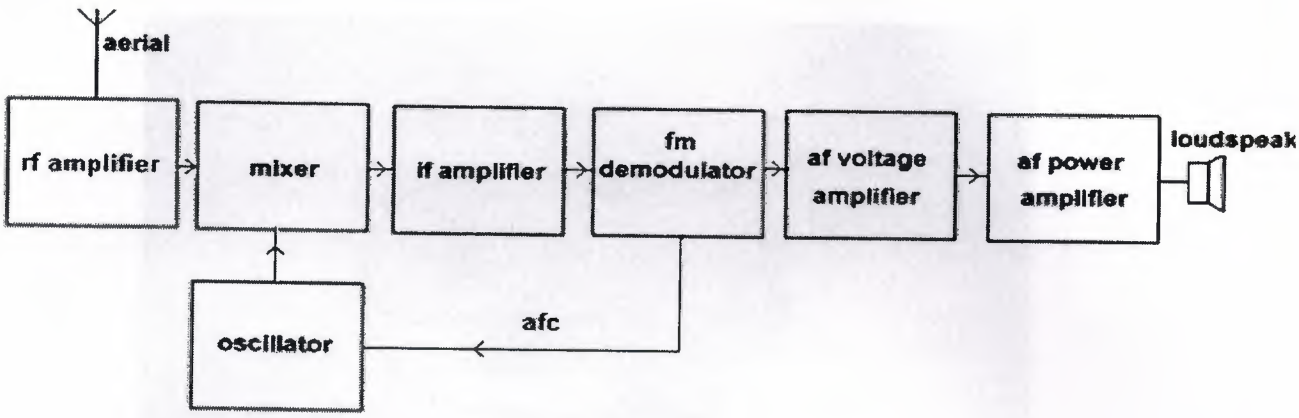


Figure 4.6: FM receiver block diagram [20]

4.6 Modification recommendation

In Figure 4.4 there is a word (connect) from that side u can connect this device (**Connector DB25**) where it can check the frequency by using the PC where there will be a programming language Pascal, C++, Delphi …etc where the program will send in the parallel door (378 I) of PC a number from 0 until 255 checking thus the tendency of expense of simple D/A of converter (that it is in blue frame) and consequently and frequency of radio via passage VARICAP.

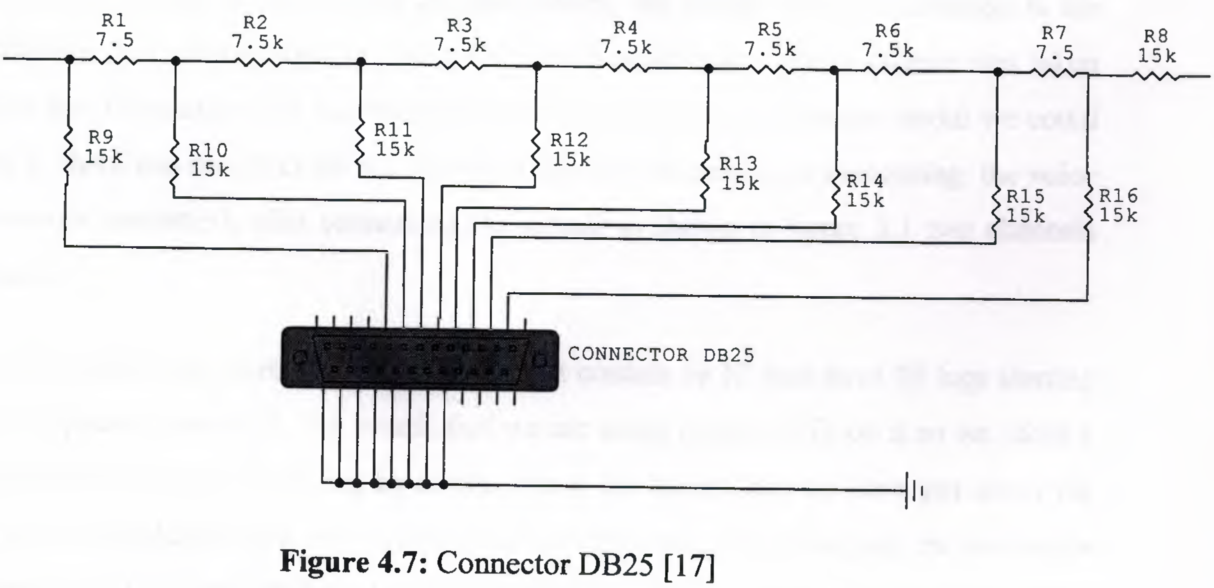


Figure 4.7: Connector DB25 [17]

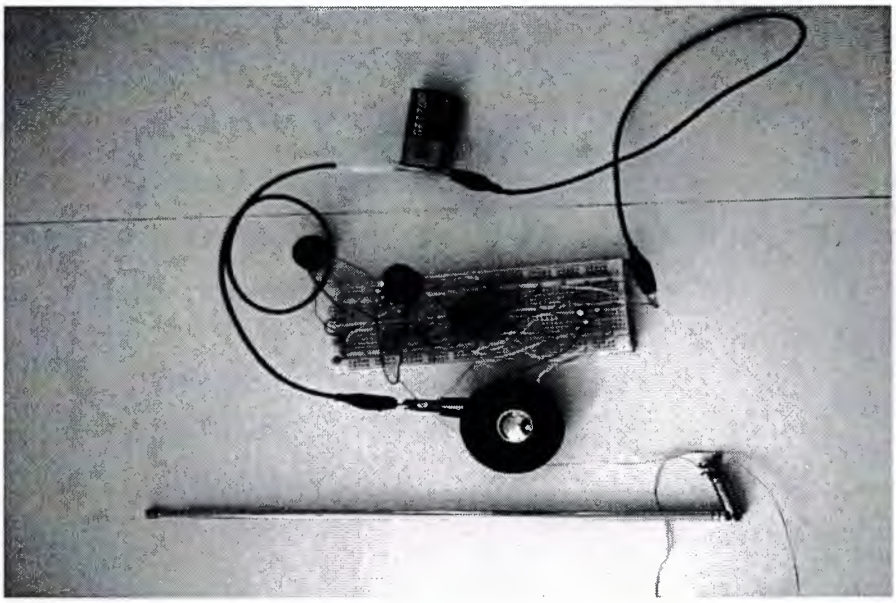


Figure 4.8: FM radio after connection

4.7 Results and Analysis

From chapter three and chapter four the AM and FM radio were connected. In AM radio the most important parts were the diodes which were not available in the market but from using the books we could find the alternatives, the Ferrite Aerial connection is the most difficult part in the radio by using the digital multimeter the resistance was taken and from the information that has been presented in chapter one about this aerial we could connect it ,there was no effect for the variable resistor in increasing or decreasing the voice so it was not connected, after connecting the circuit as shown in figure 3.1 two channels were heard .

The FM radio was more complicated where it contain an IC that have 30 legs starting from the capacitor number 8, the boards that we are using could not fit on it so we faced a lot of problems, we weld each leg by a wire .From the design that we have got about the FM circuit we couldn't know the polarity shape of the capacitors (changing the both sides were done) and from that we have known the polarities. This circuit had a lot of problems in the resonance side where the oscillating was too much, resistor (R2) was changed in order to get more clear voice and squeezing the inductors, many channels were heard but there was a lot of noise the aerial here is an isolated wire.

4.8 Summary

This chapter has presented the FM radio and the component which has been used, the function of it, the results that we have got after connecting the MW and FM radio, how it works and the differences between the FM and MW radio.

CONCLUSION

After a great deal of working while preparing this project theoretically and practically; we found out how much knowledge we gained and how much techniques we learnt in receiving, filtering and amplifying the input signal in MW radio, and how to manage to have alternatives for not available components, how to enhance filtering process, to understand amplifying one.

This project consists of four chapters; each chapter presented a specific aspect of MW radio subject as a working principle, components which the radio circuit consists of and more.

Chapter one presented sought components in details, how they function and how they must be connected. Also safety guidelines for electronics projects mentioned to prevent possible mistakes that may damage the circuit.

Chapter two presented the techniques of transmission and propagations, the frequencies which are used as channels to transmit information as radio waves in specific and electromagnetic waves in general, kinds of propagation and modulation.

Chapter three was the most important chapter of this project, it presented the operation of the circuit and how it does affect the behavior of the input signal by filtering and amplifying processes with used techniques, also describe the contribution of each components in mentioned processes.

Chapter four was the modification of the MW radio where FM radio is connected to it by ON-OFF-ON switch, explain the main ICs that has been used and how does it works as well as the differences between the FM and MW.

The main guidelines of this project were:

1. To design, build and test a working MW radio
2. To gain experience as much as we could with practical electronics projects.

3. To sort out problems within the circuits and make modifications, to overcome the problems.
4. To get information about the kinds of frequencies, modulation, propagation and the main application of each kind of the frequency bands.
5. Modifying the MW where FM radio is added.

Firstly while the project was in progress, we realized the components which were supposed to be used in the project, then we started connecting the circuit as planned.

When the circuit got ready, we started testing the circuit and detecting the problems were preventing circuit from working properly.

While connecting the radio circuit; and during some of unpleasant conclusions we realized that we were doing mistakes in some positions. By trial we got more careful and aware while we were working, and also gave us the motivation and determination to make the circuit work.

The main problem was when a component was not available and since the market in North Cyprus is limited we were forced to find alternative components by using the internet or some references, getting some components from Istanbul if we couldn't find the alternatives of it and also by asking some advices from experienced people.

In summary, a great experience and knowledge of hands-on work with electronic projects have been gained. Problem solving skills where also developed through out working on this project.

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