International Journal of Innovative Information Systems & Technology Research 11(3):135-145, July-Sept, 2023

 www.seahipaj.org ISSN: 2467-8562

Construction of FM-Receiver To Serve As Wireless Public Address System (P.A)

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ABSTRACT
The Public address system is an electronic means for increasing the magnitude of sound signal out of microphone and other musical instruments. The use of public address system in tertiary institution makes it possible to render speech intelligence where it was either too weak to be heard above general noise. In certain instances for example in large halls or outdoors the volume range of orchestra at listener location is inadequate for full artistical appeal and the use of public address system is required to increase the power level of the original sound. The basic elements of the system are micro phones, amplifiers, volume controls, tone controls and speakers. The signal from the micro phones, tape recorders or signal generators is connected to the electrical signal that is passed to the amplifier to bring up the level of signal so that it will be able to drive the speaker where the electrical signal is connected to the audio signal. The volume, the bass and tremble control are for attenuating low and high frequency range to sum it up public address system is used to address large gathering of audience clearly and with ease.
Keywords: Frequency Modulation, Receiver, public address system

INTRODUCTION

Communication by electrical means according to Collin (1985) began with the introduction of telegraphy in 1844, followed by telephony in 1878. In these systems, electrical signals are sent over two wire transmission lines that connect the sender and recipient. However, it was not until; 1897 that Marconi first patented a complete wireless telegraphy system based on the use of electromagnetic radiation (radio waves). The actual transmission of voice by means of electromagnetic radiation, according to Oldfield (1960) did not occur before the invention of vacuum tube amplifiers and oscillator in the period from 1904 to 1915. With these inventions, all phases of communication began to develop at a much rapid pace, a pace that seems to show no sign of slowing down. He continued that electronic can be traced back to 1883 when Thomas A. Edison discovered the "Edison Effect" (electronic tubes). It was not until 1897, however, that the electron was actually discovered. These led to the formulation of electronic theory in 1900 by J.J. Thomson and an explanation Edison was finally found.

Also Kennedy and Davis (1999) stated that communications started with wire telegraphy in the eighteen forties, developing with telephony some decades later and radio at the beginning of this century. Radio communication, made possible by the invention of the triode tube, was greatly improved by the work done during World War II. It subsequently became even more widely used and refined through the invention and use of the transistor integrated circuits and other semi-conductor devices.

Radio broadcasting, that is, radio communication, according to Mehta and Mehta (2003) means the radiation of radio waves by a transmitting station, the propagation of these waves through space and their reception by the radio receiver. The first commercial station in the United State, station KDKA in

Pittsburgh, went on the air in 1921 as noted by Huston (1966), but the first network was not established until a number of years after that. The great growth of the industry came then with millions of people from coast to coast enjoying the same programs. Within ten years the radio had become a household necessity. Most cars were equipped with radios and people took portable radios to beaches, picnics and ball games.

Oldfield (1960), observed that in 1935 a new type of radio broadcasting, frequency modulation was introduced by Major Armstrong. These systems are almost completely free from the annoying effects of atmospheric static and interference caused by electrical circuit switching. The frequency band (88 to 108 megacycles) allotted to frequency modulation allows a greater volume range and wider audio frequency range than is possible in standard broadcast bands for an amplitude modulation transmission.

The frequency modulation receiver is the heart of all present day "high fidelity" systems. Most large stations began to broadcast simultaneously both in the fm system and in the older amplitude modulation system. Today, there are number of stations which use only FM. They generally specialize in the broadcast of music. commercial FM broadcast began in 1940, decades after their AM counter parts as opined by Kennedy and Davis (1999). They have a number of advantages due to better planning and other considerations.

The following are the most important ones.

1. Standard frequency allocations (allocated worldwide by the International Radio Consultative Committee (CCIR) of ITU) provide a guard band between commercial FM stations so that there is less adjacent channel interference than in AM.
2. FM broadcast operates in the upper VHF/UHF frequency ranges at which there happens to be less noise than in the MF and HF ranges occupied by AM broadcast.
3. At the FM broadcast frequency the space wave is used for propagation so that the radius of operation is limited to slightly more than line of sight. It is thus possible to operate several independence transmitters on the same frequency with considerable less interference than would be possible with AM. Frequency modulation is a system in which the amplitude of the modulated carrier is kept constant, while its frequency and rate of change are varied by modulating signal. The first practical system was put forward in 1936 as an alternative to AM in an effort to make radio transmissions more resistant to noise.

This project, which is a construction of an FM receiver that will serve as wireless public address system is intended to ease the existing problem, associated with addressing large students gathering in schools.

In a broad sense, the term communication refers to sending, receiving and processing of information by electronic means, Kennedy and Davis (1999). Various forms of receivers were proposed at one time or another according to Mehta and Mehta (2003), the tuned radio frequency and superheterodyne. The shortcoming of the tuned radio receiver gave the superhet an overwhelming popularity. It must also be mentioned that when the TRF receiver was first introduced, it was a great improvement on the types used previously-mainly crystal, regenerative and super regeneration receivers. But the TRF receiver suffered from variations in bandwidth over tuning range. It was unable to achieve sufficient selectivity at high frequency.

The problem of instability, insufficient adjacent frequency and bandwidth variation can all be solved by the use of superhet receiver. Although Kennedy and Davis (1999) stated that amplitude modulation is highly effective, it suffers from the following drawbacks. Noisy reception, low efficiency, small operating range and lack audio quality. These distinct disadvantages are overcome by the latest innovation in radio reception which is the frequency modulated receiver.

Smale (1981) also observed that FM receivers give a noiseless and high fidelity reception. FM operating range is quite large and the efficiency of transmission is very high. This study will therefore find the service of FM receiver that could be employed as a wireless public address system most efficient in tackling the existing problems associated with addressing large student gathering in schools for instance. Prize and presentation days, school assemblies, clubs and societies, debate and drama presentation, games/sporting activities.

Large gathering, most especially students gathering, is always very difficult and in most cases strenuous to address. This difficulty may be caused by lack of control, attention, order or noise making that would increase the strength intensity and volume of spoken words during an address. The choice of an FM receiver as a medium for improvement in amplification of voice/sound was made as a result of its compatibility to be incorporated in some other systems, the wireless public address system for instance.

Purpose of the Study

The main purpose of this study is to construct an FM-receiver that could be employed in schools as a wireless public address system.

Specifically the study attempts to construct the FM receiver locally with the following characteristics:

1. Serviceability characteristic
2. High amplification factor
3. Wide-band reception capability

Research questions

This study was guided by the following research questions:

1. What are the Serviceability characteristic?
2. What are the High amplification factor?
3. What are the Wide-band reception capability?

METHODOLOGY

The design of the study will be research and development depicting step-by-step procedure for the constructional processes.

Research and development (R and D) according to Nworgu (1991) is a relatively new type of research, which is different from most educational researches. Research and development programmes aims at developing and testing more efficacious educational products. These products may textbooks, equipments or curricula. These products are developed and trial tested in the field to ensure their effectiveness.

Material and Tools

The materials and tools used include:

1. Stripe Board
2. 12 Volt transformer
3. Heat sink
4. Ohms loud speaker
5. Control knob
6. Antenna
7. Switch
8. Hand drill
9. Soldering bit
10. Plier
11. Screw driver

Material for FM Station

1. 103 paper condenser
2. 25 paper condenser
3. 22 paper condenser
4. 107 paper condenser
5. 18 paper condenser
6. 104 paper condenser
7. 13 paper condenser
8. 18 paper condenser
9. 104 paper condenser
10. 502 paper condenser

11. 33k paper condenser
12. 100k paper condenser
13. 75 paper condenser
14. 203 paper condenser
15. 203 paper condenser
16. 25 paper condenser
17. 30 paper condenser
18. 15 paper condenser
19. 1k paper condenser
20. 3v paper condenser

Material for Sound output oscillator includes

1. 4.7k Resistor
2. 100k Resistor
3. 1k Resistor
4. 1.2k Resistor
5. 6.8k Resistor
6. 4.7k Resistor
7. 100k Resistor
8. 50v 2.2uf capacitor
9. 16v 100uf capacitor
10. 50v 1uf capacitor
11. 50v 4.7uf capacitor
12. 25v 220uf capacitor

Material for Grid Amplifier

1. 68k Resistor
2. 1k Resistor
3. 120k Resistor
4. 5.6k Resistor
5. 10kResistor
6. 4.7k Resistor
7. 220k Resistor
8. 270k Resistor
9. 100k Resistor
10. 2.2k Resistor
11. 10k Resistor

Capacitors include;

1. 50v 1uf
2. 16v 10uf
3. 16v 22uf
4. 25v 3.3uf

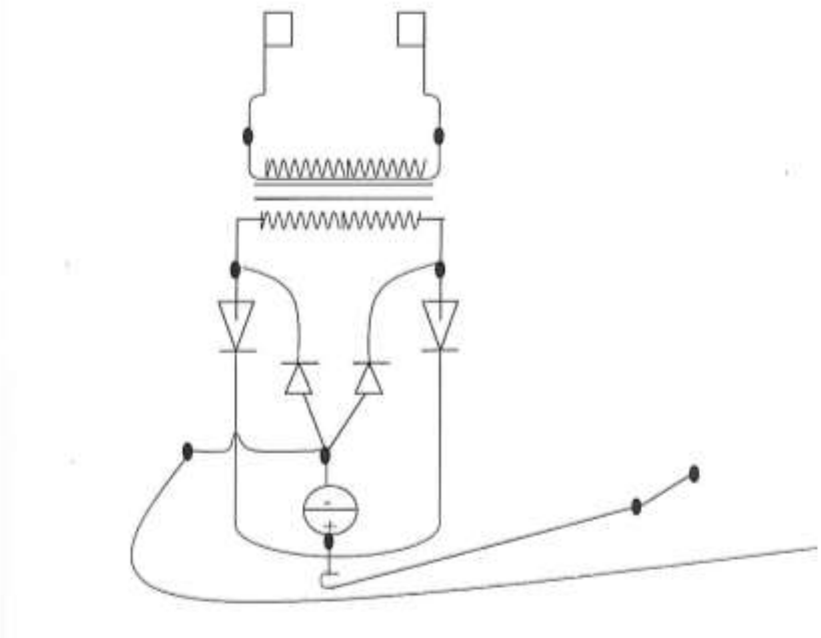


Fig 9: Mains lead wire that lead in 220v A.C

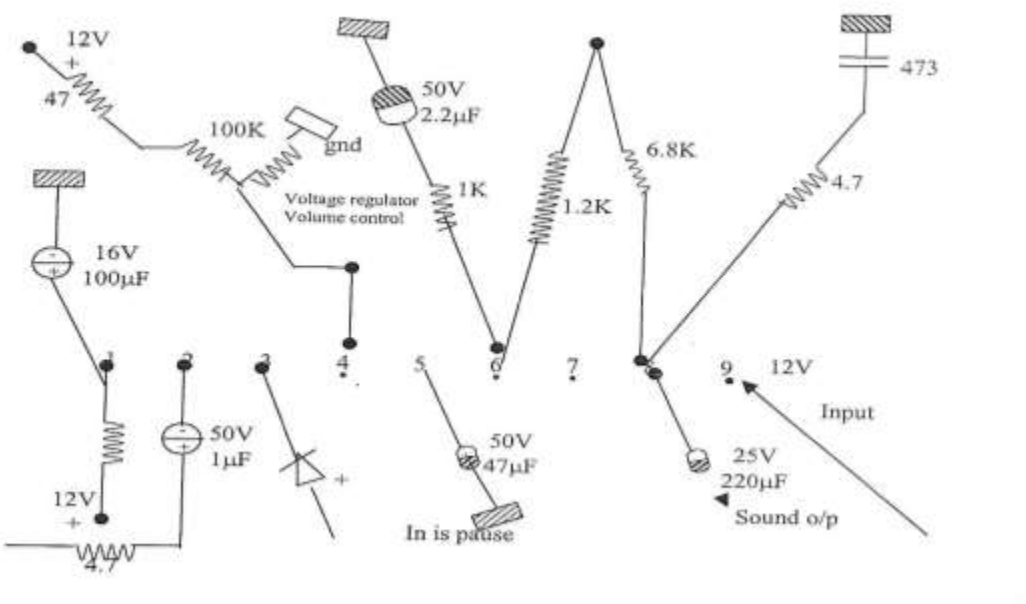


Fig 10: A 5265 sound output oscillator I.C

Design Procedure

The laboratory construction of the FM receiver focuses primarily on the use of available electrical material in our local electronic shops, researcher's level of experience and technical know how. Based on these considerations the components will be mounted based on the circuit diagram in fig. 9-11 using the following procedure.

1. The rating of various components such as resistors, capacitors, diodes, transistor and i.c will be tested using multimeter before they will be mounted on the stripe board.

2. The home-wound coils L_1 and L_2 will be constructed. L1 will consists of 5 turns of 20 swg enameled copper wire wound on a temporary former 6 to 6.5 mm in diameter. A twist drill of about this size or potentiometer spindle can be used as a former; the coil will be 15mm long.
3. The leads, which connect vct to board, should be between 10mm to 30mm long.
4. Vci should be connected thr right way round or hand capacity effect will make turning practically impossible.
5. Power will be obtain either from man's source pass to the receiver through 12volt transformer connected to a rectifier circuit which will block AC and pass d.c. into the circuit.
6. 8 ohms impedance loudspeaker diameter will be ideal for best volume.
7. The unit can be fitted into a metal, plastic or wooden case, but wooden case is the best, as to will not have a detuning effect on the two tune circuit.
8. The aerial should be fairly long type having a swivel base.
9. The coil of L_2 should be adjusted before the set will be ready for use.
10. The winding and core to the former should be glued so that these coils will be as rigid as possible.
11. Sensitivity of the set is peak by bunching the turns on L1 together or spreading them apart.

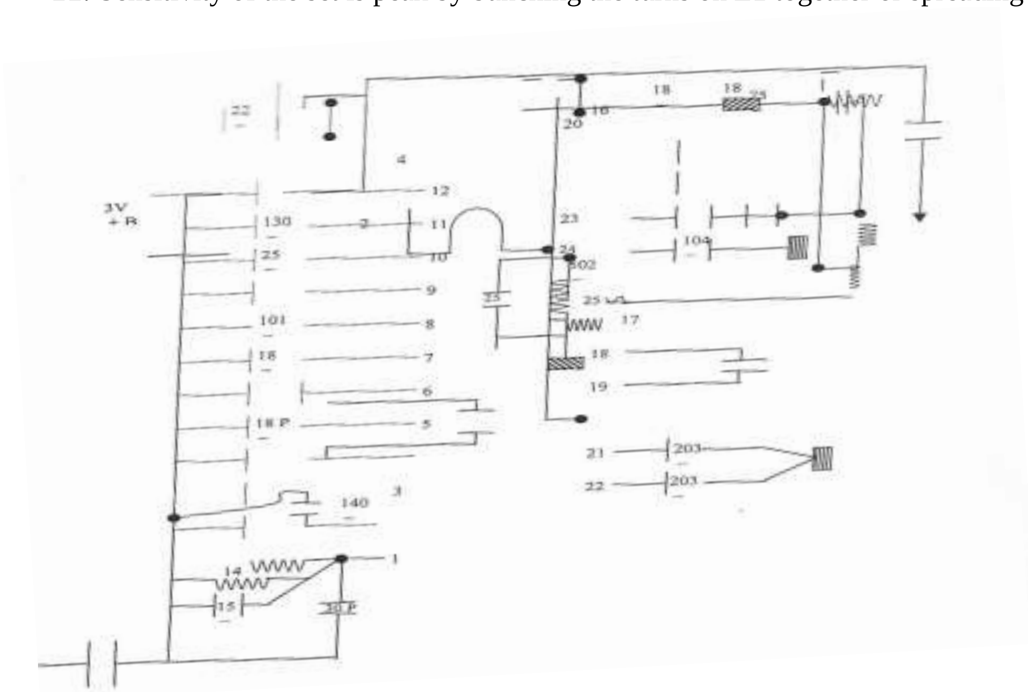


Fig. 11: A circuit for FM section

Incorporation of Components in Printed Circuit Board

The important considerations to be made while building the circuit in Fig. 9-11 are two. First, the permissible level of soldering temperature, the second point concerns with minimum length which the soldering of the component pin will be impermissible. The soldering temperature will be maintained easily when soldering bits is incorporated with automatic temperature control. The length of resistors, diodes, capacitors pins will be cut at a distance of appropriately 2mm to 3mm from its based.

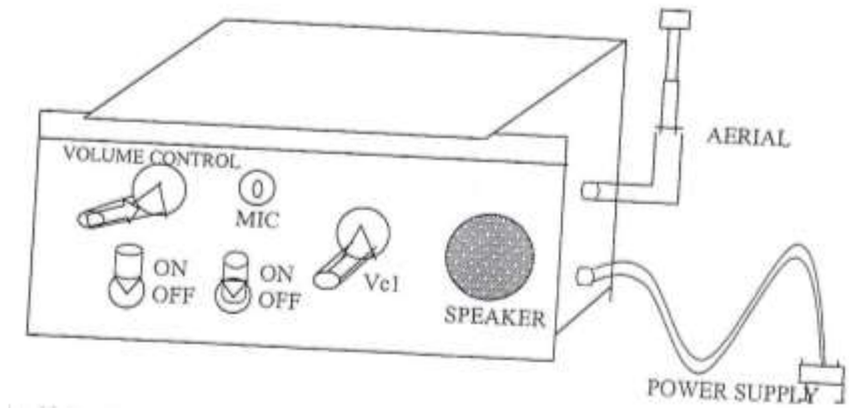
The soldering will be done a distance of approximately 5mm from the pin leg, during the soldering it will ensured that the copper lead was perfectly set on the joint being soldered. Then the surplus pins of the components will be cut off.

Cabinet Construction

There are many types of engineering materials that can be used for cabinet construction of an FM receiver. But for this construction a rectangular a rectangular cabinet of the following dimension will be used.

Holes will be drilled for the following purpose.

1. To produce an opening for speaker
2. On/off switches
3. Volume control
4. Power source (AC)
5. Swivel base aerial
6. For mounting of printed circuit board and transformer
7. Screws for coupling the various parts of the cabinet.



FM Receiver Cabinet

Reference Designation

The various electronic components will be mounted on the stripe board in such a way that bridging and short-circuiting of terminal lead are avoided. Each component will enter reference designation design on the surface of printed circuit board.

Mounting of such components as resistors, diodes, transistors and capacitors into their designated reference positions will be shown in fig.

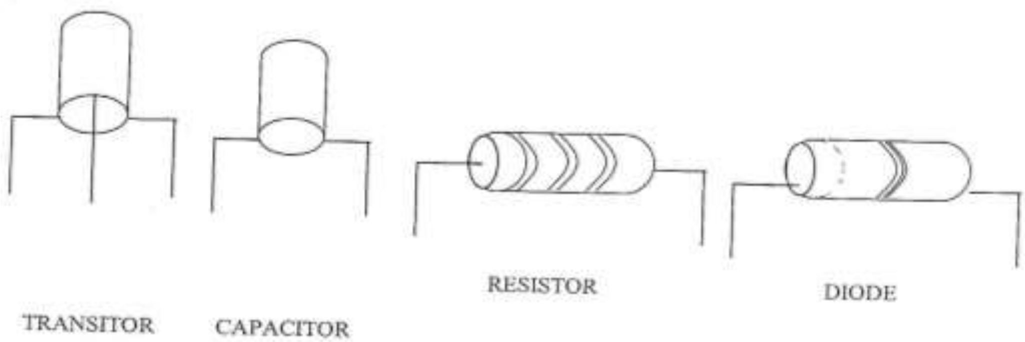


Fig 13: Reference designations

All components will be mounted approximately 5mm above the panel or stripe board (Kovocs, 1989) and excess leads will be done after soldering has been completed. 220/12 volt step down transformers will be mounted inside the cabinet using screws.

Soldering Technique

According to Kelly (1981), soldering is the fundamental process in construction of circuits. It is an alloy of tin and lead with a low melting point usually about 190^0C. The purpose of soldering is to obtain good electrical conduction between components in a joint.

The solder normally melts by touching the component lean or pin of the iron, care should be taken to ensure that the component leads are hot enough for the solder to flow over them.

TEST AND RESULTS

In this chapter, the component parts of the FM receiver are displaced and explained. The assembled FM and its operational principles are also discussed. The design and the realized circuit of various sections that constitute, the operation of FM receiver at very high frequencies of 88-108MHz were tested to verify their performance. The results obtained are given below.

Supply Voltage

The regulator gives an output of 12V with little ripples. This power supply was used to test all the receiver circuits at different stages. However, for the purpose of this project a 9V d.c. dry cell battery was used at the final stage/phase. This consequently not only reduced the signal level of each stage but also helped to eliminate noise caused by the power supply.

R.F. Amplifier

The very high frequency radio waves are amplified using a double stage amplification process. The output from a single stage amplifier is usually insufficient to drive an output device. In other words, the gain in a single amplifier is inadequate for practical purposes. Consequently, additional amplification over two or three stages are necessary. To achieve this, the output of each amplifier stage is coupled in some way to the input of the next stage. The resulting system is referred to as multi-stage amplifier. Each stage consists of one transistor and associated circuitry and coupled to the next stage through a coupling device.

Locator Oscillator and Mixer

Capacitor C_1 and C_2 in the R.F. amplifier and C_3 in the local oscillator were gauged together in such a way that when properly turned a constant output frequency is maintained at the output of the mixer. The output of the mixer is usually designed to correspond to the FM intermediate frequency, which is designed to be higher than the received carrier signed by the I.F. value. For instance, if the receiver is to be tunable over the frequency modulation band (88 – 108MHz) the local oscillator must be tunable from (88 + 10.7 + 108 + 107) that is from 98.7 to 118.7 MHz which is a frequency ratio of 118.7/98.7 or 1.203:1 such as a frequency ration would require the use of variable capacitor having a ratio of maximum capacitance to minimum capacitance ration of (1.263); 1 or 1.45. This type of capacitance is easily obtainable.

Intermediate Frequency Amplifier

The frequency output (10.7 MHz) of the mixer wad fed into the I.F. amplifier. As shown in fig 4.1 T1, T2 and T3 are all turned to allow only a frequency of 10.7 MHz to enjoy all the 2-stage of amplification. Two stages of amplification were required to produce signal whose voltage level is sufficient enough to be detected by the demodulator.

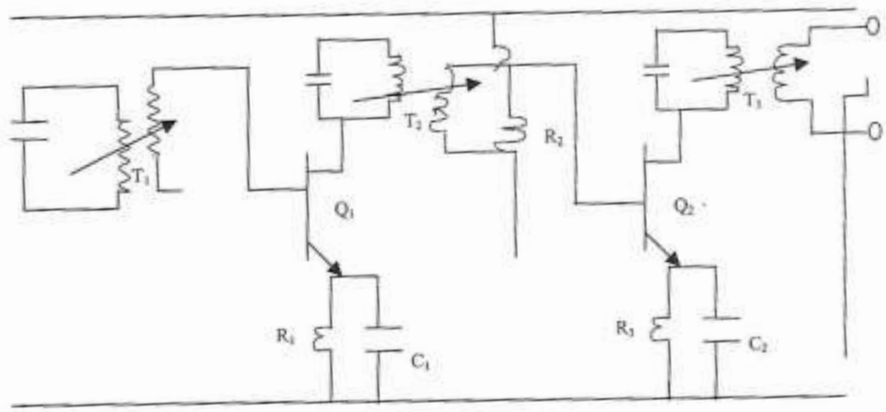


Fig. I.F. Amplifier:

Audio Amplifier

With 12V as a supply to the circuit, the audio output power was quite enough to drive an 8 ohm, load speaker. With 9 V d.c., the output of the amplifier was built to improve the performance output. The output was found to be closed to 2 watts, which is high enough for any conventional receiver like the one employed in this project. And the amplifier has a constant gain for frequency from 0 -12kHz.

Automatic Switch over Supply

The area of amplification of the FM radio receiver designed in this project will require uninterrupted supply of power. This will ensure that there is no break in communication between the sender and recipient (transmission and reception) ends due to power failure from the main.

It is this reasoning that informed the decision for the provision of the battery power. The device automatically switches on in the event of the failure of power from the mains. When power from the mains is on, the resistor is biased hence the relay is energized to open the battery circuit. On the other hand, when the main fails the relay loses its magnetism and hence the battery to the radio receiver. When power from the main is restored, the relay is re-energized to open the battery circuit; the receiver system is then powered from the mains.

References Designation

Various electronic components were mounted on the stripe board in such ways that caution has been taking that bridging and short-circuiting of terminal leads are avoided. Each component entered reference designated design on the surface of printed circuit board. All components were mounted at approximately 5mm above the panel or stripe board. 220/12volt step down transformer was mounted inside the cabinet using screwdriver.

Component Layout

Component placement; wiring density, functional performance of some electronic components and other electrical devices were essential. Any electrical device that was picked and placed on the heat sink material was fastened securely. Likewise, component placed in a hole was immediately soldered so that it did not fall out. Electrical device and printed circuit board were mounted with enough opening to provide ventilation for cooling.

Rectifier

This is a semiconductor device such as diode which has the ability to convert sinusoidal input waveform into a unidirectional wave form with a non-zero average component. Thus, a full-wave rectifier element for converting current into direct current was provided in the current.

Power Supply

220 volts energy supply enters the step down transformer, which is then passed to the rectifier element. This element converts the alternating current (a.c.) into direct current (d.c.) which is suitable for the operation of the receiver and other components.

Cabinet

The cabinet was fabricated to accommodate the entire circuit assembling. The following factors were considered during the fabrication process. Heat dissipation, vibration, air circulation, shock risk, bridging of circuit, dust etc. the cabinet was fabricated to the following dimensions 405 x 320 x 220mm.

After realizing all the individual section of the receiver, a final assemblage was completed, and the whole circuit network was brought together. The result was an FM receiver with a range of (88 -108MHz) that will serve as a wireless public address system. However, a serious limitation was observed or encountered in testing the performance characteristic of FM receiver designed in this project.

This limitation was in the area of unavailability's of the equipment needed in measuring receiver performance. These performance characters tics included, sensitivity, frequency response, and impedance. This notwithstanding, tests were carried out at the intermediate frequency, audio frequency stages and the I.F. (Intermediate Frequency) stage.

The quality measured at the I.F. stage is the voltage input into the detector stage where the receiver systems (wireless microphones) were at a minimum distance of separation at which the receiver can still pick up signal reasonably from the transmitter. The practical distance of separation in this case is taken to be the minimum signal detectable by the receiver system and he value is about 64.8mV. This output signal is an audio frequency signal.

The A.F. (Audio Frequency) Stage

At this stage, test was carried out in two phases:

(a) Test with standard audio input in this phase, an unmodulated 1kHz signal (sinusoid) of 10mV level was fed from a signal generator in the input of the audio frequency amplifier. The output value was observed to be about 199.78mV. From this value (input and output voltage). The gain of the audio frequency power amplifier can therefore be calculated thus:

$$\text{Gain} = \frac{199.78}{10} = 20$$

The power delivered to the speaker (load)

$$\frac{VO^2}{R} = \frac{(0.19978)}{8}$$

$$P_0 = 5mV$$

(b) Test with commercial FM broadcast signal in this phrase, the input voltage level at the radio frequency power amplifier was 0.186V and the output voltage level was 3.72V. From this practical values it follows that amplifier is thus;

Gain $v_o/v_1 = 3.72/8 = 20$

Hence, the output power with the speaker is driven.

$$Po = v_0^2/v_1 = (3.72)^2/8 = 1.73$$

This is the input power fed from the detector stage into the audio power amplifier through a pre amplifier stage in-built in the detector (I.C.).

$P_1 = P0^2/G = 1.73/20 = 86.5mV$

CONCLUSION

It is concluded from the finding of this study that frequency modulation receiver (FM) deals with frequency at V.H.F. range. This posed a lot of problem, as the available oscilloscope could not handle such frequencies. The maximum frequency that the available oscilloscope could handle is around 50 MHz, therefore signal at frequencies higher than 50MHz cannot be monitored. Thus, a need for an oscilloscope that could monitor a high frequency.

Other limiting factors to this project include distortion due to noise temperature, signal to noise ratio, frequency responses are factors affecting analogue technology signal processing. This has prompted manufacturers to turn to digital technology especially the pulse cord modulation (P.C.M.) that has made possible to achieve the highest possible audio fidelity. This led to entire new level of quality sound.

RECOMMENDATIONS

The following recommendations were made, based on the findings of the study and their implications.

1. An antenna of high gain and good receiving properties be constructed or used in order to improve the signal reception.
2. Also, high gain frequency amplifier be adopted. This will improve the level of audio output.
3. Adequate knowledge of circuiting, practical application and awareness of various implementation methods are very essential for the attainment of the project.

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