DESIGN AND CONSTRUCTION OF A LISTENING AND TRACKING DEVICE

BY

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DEPARTMENT OF ELECTRICAL
AND
COMPUTER ENGINEERING
FEDERAL UNIVERSITY OF
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OCTOBER, 2006.

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Dedication

I dedicate this project to God who facilitated my entry into this university and who has been with me throughout my time here, which has culminated into this final piece of work before your eyes. May the Grace of God, which he showers on me, never cease in my life in Jesus name. (Amen).

DECLARATION

I Ohakanu C. Stephen declare that this work was done by me and has never been presented else where for the award of degree. I hereby also relinquish the copyright to the Federal University of Technology, Minna.

Ohakanu C. Stephen

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10/10/2006

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(Signature and date)

ACKNOLEDGEMENT

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My warm appreciation goes out to my ever caring siblings Obinna and Samuel for their love, encouragement and sincere wish for the success of this project. I also want to say a very big thank you to all my friends and colleques for their support directly and indirectly to the successful completion of this project work. And to my entire friend, I am indebted to you all. Thank you.

ABSTRACT

The Listening and tracking device is a radio frequency device used to intercept covertly intercept conversations or locating the position of an object in space. The device is made up of two units; the transmitter and the receiver which both operates using frequency modulation.

The device has two operational modes listening- mode and the tracking mode. In the listening mode the transmitter unit picks up audio signal in it vicinity, amplifies it and then transmits modulated audio signal. The receiver is tuned to the operational frequency of the transmitter; the transmitted signal is then retrieved, demodulated and amplified; the person on the receiver end can hear what is said on the transmitter end. In the tracking mode the transmitter transmits a unique pulse generated by a pulse generator which is picked up at the receiver end when it is tuned to the transmitter. The person on the receiver end could determine how close he is to the transmitter by the strength of the pulse.

This device has a transmission range of just over 15m and the frequency of operation was set about 70 MHz, so as to prevent user of commercial receiver from tuning to the transmitter and avoid interference from commercial broadcasting stations.

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CHAPTER 1

INTRODUCTION

Sun Tzu the Chinese military theorist stressed the importance of intelligence gathering in his book "ART OF WAR" almost 2500 years ago [9]. Spying could be described as the act of obtaining information clandestinely. The term applies particularly to the covert act of collecting military, industrial and political data about a person or nation for the benefit of another. Again, intelligence refers to evaluated and processed information needed to make decisions [10]. In the last seventy years intelligence activities has been greatly supplement by technological advancement especially in the area of radio frequency technology.

Tracking and listening are both integral part of intelligence gathering activities. Tracking is the location and monitoring of the movement of an object in space. Listening on the other hand is the access of to particular audio massage from a point of interest.

Tracking and listening device are often very small and take advantage of high level electronics, integrated circuit and micro-manufacturing technology. These devices may be disguised to look like a variety of day to day items so as not to attract attention. Information from these devices are received through remote means. Radio technology provides the best wireless link between the user and the device.

1.1 AIM OF THE PROJECT

The aim of the project is to design and construct powered radio frequency device which is used for listening to conversations and monitoring the movement of an object within an effective radius of about 15 meters.

1.2 METHODOLOGY OF THE PROJECT

The project is based on frequency modulation radio application. It consists of two units;

- FM TRANSMITTER which is capable of transmitting both audio and specific or unique pulse pattern signal one at a time. Inputs are provided by a high impedance microphone and pulse generator. The transmitter also includes an audio amplifier and FM modulator.

  It employs a conventional Hartley oscillator design, with the frequency of transmission adjusted by varying the value of the oscillators inductor.

  The transmitter also includes a modulation and amplification stage.

- FM RECIEVER which operates at the frequency of the transmitter (70MHz). The receiver circuit is a super heterodyne receiver which uses a KA2297 integrated circuit. It also has a volume stage and an audio amplifier stage.

1.3 SCOPE OF THE PROJECT

The project is aimed for a 15 meters effective radius of communication. The transmission is under the fm band. The two are unit a powered by 9 volts battery.

CHAPTER 2

LITERATURE REVIEW

2.1 HISTORICAL BACKGROUND

The heart of the project is radio transmission. Originally, radio technology was called 'wireless telegraphy', which was shortened to 'wireless'. The prefix radio- in the sense of wireless transmission was first recorded in the word radio conductor, coined by the French physicist Edouard Branly in 1897 and based on the verb," to radiate". 'Radio' as a noun is said to have been coined by advertising expert Waldo Warren (White 1944) [3]. The word appears in a 1907 article by Lee de Forest, was adopted by the United States Navy in 1912 and became common by the time of the first commercial broadcasts in the United States in the 1920s [13].

The theoretical basis of the propagation of electromagnetic waves was first described in 1873 by James Clerk Maxwell in his paper to the Royal Society A dynamical theory of the electromagnetic field, which followed his work between 1861 and 1865 In 1878 David E. Hughes was the first to transmit and receive radio waves when he noticed that his induction balance caused noise in the receiver of his homemade telephone. He demonstrated his discovery to the Royal Society in 1880 but was told it was merely induction. It was Heinrich Rudolf Hertz who, between 1886 and 1888, first validated Maxwell's theory through experiment, demonstrating that radio radiation had all the properties of waves (now called Hertzian waves), and discovering that the electromagnetic equations could be reformulated into a partial differential equation called the wave equation [9].

In May, 1895, Russian Alexander Popov began transmitting wireless electrical signals through the air over 500 meters; independently of Popov, Italian Guglielmo Marconi accomplishes the same feat three months later. By the end of the year Marconi can send signals over a mile (1.6 kilometers).It was a great success in the history of communication [9].

The invention of a vacuum-tube diode, or thermionic valve, using a cathode and anode by Briton John Ambrose Fleming resulted into great range radio transmission. It improved the act of radio modulation in manner of both amplitude and frequency techniques. Later invention of semiconductor devices greatly reduced size and cost of radio devices .In 1960, Sony introduced their first transistorized radio, small enough to fit in a vest pocket, and able to be powered by a small battery. It was durable, because there were no tubes to burn out. Over the next twenty years, transistors replaced tubes almost completely except for very high power uses[10].

Radio is used for wide range of applications such as Audio Broadcasting, Telephony, Video, Navigation, Radar, and Heating. But two unusual applications are "tracking" and "listening" operations which usually involve espionage. Espionage is usually thought of as part of an institutional effort (i.e., governmental or corporate espionage)[13]. The term espionage is most readily associated with state spying on potential or actual enemies, primarily for military purposes, but this has been extended to spying involving corporations, known specifically as industrial espionage. Many nations routinely spy on both their enemies and allies, although they maintain a policy of not making comment on this [9]. Black's Law Dictionary (1990) defines espionage as: "...gathering, transmitting, or losing...information related to the national defense." The importance of listening and tracking devices was reviewed during the peak of cold war. In which the two super powers demonstrated their extent of their capabilities as related to the subject.

Although, secret listening activities are quite provoking in nature, tacking in the other hand is used for more friendly applications such as seen in the Global Positioning System (GPS)[13].

2.2 RADIO SURVEILLANCE TECHNOLOGY

There were three important trends that contributed to the dramatic increase in surveillance technologies. These were decreased size, decreased cost, and increased availability. Radio technologies specifically related to surveillance were mainly restricted to law enforcement, detective, and espionage applications up until this time. Now they were available to anyone [13].

In the mid-1990s, increased miniaturization was possible, and the price of components dropped dramatically. The birth of the Internet created two significant dynamics in the marketing of radio surveillance devices. Educational articles explained how these devices worked and how to set them up, making people more willing to take a chance on buying them. At the same time, small electronics hobbyist manufacturers who had good technical skills but no marketing skills or distribution rights suddenly had a new way to sell their products on the Internet, without having to set up a physical retail outlet. By cutting out the 'middle man,' this not only greatly increased the number of vendors, it influenced the costs even more, since retail packaging and distribution costs are reduced. The implementation of radio-frequency listening and tracking systems has only just begun, with many more expected over the next decade. The prevalence of radio transmitters for wearable surveillance systems is still in its infancy and is expected to increase. [13]

2.2.1 RADIO LISTENING AND TRACKING TECHNOLOGIES

- **RADIO TAGS**

Radio tags are tiny transmitting or receiving/transmitting units that can be attached to almost anything to provide information about the location, movements, or audio signals associated with their use. Since the tiny size of radio tags usually means their transmission distance is limited, it may be necessary to have many receivers spread over an area. Small receivers can be built and deployed over a wide geographic area, like a receiving array. The data from these receivers can, in essence, create a visual picture, through computer processing, of the movement of tags within the receiving region. Another means of tracking the tags is to bring a hand or vehicle antenna and receiver into the region where the tags are expected to be. A further use of the tags is on vehicles and other objects that regularly move in the vicinity of receiving stations such as bridges, weigh stations, or other check points.

Vendors promoting the use of radio tags for identification refer to them as RF/ID (radio frequency identification) and RF/DCI (radio-frequency data collection) systems. Some of the manufacturers of these systems are familiar names in the electronics industry, including Texas Instruments, Philips Semiconductors, Brady, and Gemplus.RF/ID technology has improved significantly over the last five years[13].

- **LISTENING DEVICES (Covert Transmitters)**

Radio transmitters are widely used in surveillance activities. 'Wearing a wire' is an integral part of many law enforcement investigations and investigative journalism activities.

One interesting area with potential for innovation, now that radio transmitting units and microphones are so compact, is to incorporate them into the design of clothing items, rather than attaching them as separate components.

- **TRACKING DEVICES (Radio Direction Finders)**

Tracking devices are used in search and rescue, covert surveillance, wildlife tracking, and for locating unauthorized radio-frequency transmitters.

Tracking devices is an important technology for navigation as well. Boats and vehicles use radio direction finding to chart a course or determine a position. Radio beacons are usually used in conjunction with direction finders. Several beacons make it possible to more quickly and precisely determine location and relative bearings.

Direction-finding systems have been used in marine navigation systems for decades and are now becoming very important in land-based systems, as well. Combined with Global Positioning System (GPS) consoles and databases of city or terrain maps, a direction finder becomes a very sophisticated positioning or tracking system.

2.3 RADIO FREQUENCY TRACKING DEVICE OPERATION

Basically, the tracking device uses a transmitted signal as a reference for determining the bearing to a target transmitter by evaluating the angle of the radio wave in relation to the antenna site. Theoretically, this is a fairly simple physical/mathematical determination. In real life, however, radio waves don't usually travel unimpeded. There are almost always trees, buildings, particles, and other reflective or absorbent surfaces that scatter and impede the signals so that what reaches the receiving antenna isn't a perfect wave.

Imagine throwing a pebble into the center of a still, smooth pond. Waves radiate out in clean, predictable lines to an 'antenna' near the shore. It is relatively easy to calculate the direction from which the pebble was dropped based on the direction of the waves hitting the antenna. Imagine a pond When you throw in the pebble, some of the waves will be impeded, deflected, or absorbed by the various objects in the water. By the time the 'signal' or wave reaches the antenna near the edge of the pond, there are complex wave patterns that must be processed for the information to be of any value. The directions and relative intensities of the waves must be assessed over time to make a good estimate of which waves are the significant ones.

It's not unusual to see wildlife or search and rescue shows in which the searchers are walking around in the wilderness holding up spindly devices that resemble old TV antennas. As the searcher moves this receiving antenna around, a beeping sound is usually emitted by the device to indicate the relative strength of an incoming radio signal. By rotating and waving the antenna, closer approximations to the right direction can be auditorily estimated by the loudness of the beep. The searchers can eventually locate the avalanche victim, whale, or grizzly bear that is wearing a radio beacon to emit the regular pulse that is picked up by the receiving antenna [13].

2.4 THEORICAL BACKGROUND

Radio, system of communication employing electromagnetic waves propagated through space. Because of their varying characteristics, radio waves of different lengths are employed for different purposes and are usually identified by their frequency [9]. The shortest waves have the highest frequency, or number of cycles per second; the longest waves have the lowest frequency, or fewest cycles per second. In honor of the German radio pioneer Heinrich Hertz, his name has been given to the cycle per second (hertz, Hz); 1 kilohertz (kHz) is 1000 cycles per sec, 1 megahertz (MHz) is 1 million cycles per sec, and 1 gigahertz (GHz) is 1 billion cycles per sec. Radio waves range from a few kilohertz to several gigahertz [7]. Waves of visible light are much shorter. In a vacuum, all electromagnetic waves travel at a uniform speed of about 300,000 km (about 186,000 mi) per second for electromagnetic waves, other than radio.

Radio waves are used not only in radio broadcasting but in wireless telegraphy, telephone transmission, television, radar, navigational systems, and space communication. In the atmosphere, the physical characteristics of the air cause slight variations in velocity, which are sources of error in such radio-communications systems as radar. Also, storms or electrical disturbances produce anomalous phenomena in the propagation of radio waves [9].

Because electromagnetic waves in a uniform atmosphere travel in straight lines and because the earth's surface is approximately spherical, long-distance radio communication is made possible by the reflection of radio waves from the ionosphere. Radio waves shorter than about 10 m (about 33 ft) in wavelength—designated as very high, ultrahigh, and super high frequencies (VHF, UHF, and SHF)—are usually not reflected by the ionosphere; thus, in normal practice, such very short waves are received only within line-of-sight distances. Wavelengths shorter than a few centimeters are absorbed by water droplets or clouds; those shorter than 1.5 cm (0.6 in) may be absorbed selectively by the water vapor present in a clear atmosphere.

A typical radio communication system has two main components, a transmitter and a receiver. The transmitter generates electrical oscillations at a radio frequency called the carrier frequency[9]. Either the amplitude or the frequency itself may be modulated to vary the carrier wave. An amplitude-modulated signal consists of the carrier frequency plus two sidebands resulting from the modulation. Frequency modulation produces more than one pair of sidebands for each modulation frequency [4]. These produce the complex variations that emerge as speech or other sound in radio broadcasting, and in the alterations of light and darkness in television broadcasting.

2.4.1 ELECTROMAGNETICS RADIATION

Electromagnetic Radiation is energy waves produced by the oscillation or acceleration of an electric charge[10, 1]. Electromagnetic waves have both electric and magnetic components which are perpendicular to each other and to direction of propagation. As shown in fig 2.4.1

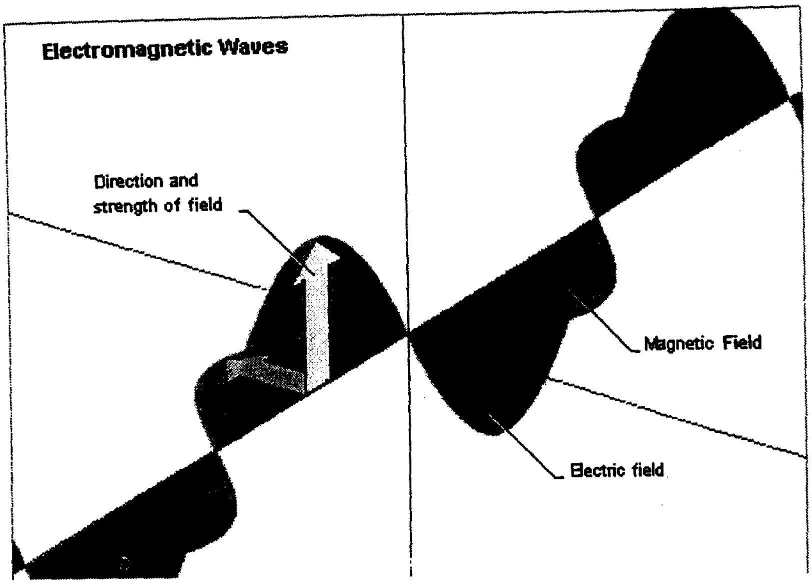


Fig2.42.1 Electromagnetic Wave[9]

Electromagnetic radiation can be arranged in a spectrum that extends from waves of extremely high frequency and short wavelength to extremely low frequency and long wavelength. In order of decreasing frequency, the electromagnetic spectrum consists of gamma rays, hard and soft X-rays, ultraviolet radiation, visible light, infrared radiation, microwaves, and radio waves [11].

2.4.2 FREQUENCY MODULATION

Modulation is the addition of information (or the signal) to an electronic or optical signal carrier. This achieved by varying the characteristic of one wave (carrier wave) in accordance with some of the characteristic of another wave (signal wave). Modulation can be applied to direct current (mainly by turning it on and off), to alternating current, and to optical signals[5].

The basic types of analog modulation are

- Amplitude modulation - voltage applied to the carrier is varied over time.

- Frequency modulation - in which the frequency of the carrier waveform is varied.
- Phase modulation - in which the natural flow of the alternating current waveform is delayed temporarily.

In frequency modulation, [4] the frequency of the carrier signal (f_0) is varied with respect to the amplitude of the information (or modulating) signal while rate of change is determined by the frequency of the information signal (f_m).

When a carrier is modulated; apart from the fundamental frequency $f0$, a number of sidebands are generated at $f0 \pm fm, f0 \pm 2fm, f0 \pm 3fm, fm \pm 4fm$ and so on. [4] The number of side band produced theatrically is infinite, this would imply that modulated signal would occupy the entire FM band, but the strength of the sidebands becomes as the number increase. The size of the modulated signal bandwidth could be approximated by the formula

$$BW = 2\,\mathrm{n}\,fm$$

Or

$$BW = 2\,(\Delta f + fm)$$

Where **BW** is modulated signal's bandwidth, n is the highest order of the significant sideband and Δf is the frequency deviation.

The second expression is based on the assumption that the side bands having amplitude less than 5% of the unmodulated carrier wave are negligible.

Frequency modulation has some advantages which make it attractive for commercial broadcasting and two way radio. One problem with [16] Amplitude modulation is its sensitivity to noise. Lightening, automotive ignition and electric circuit all produce radio Interference which is spread over a wide frequency range. It is not easy to prevent such interference from reaching the detector in an AM receiver. An FM receiver can be made insensitive to noise interference. This noise free interference is highly desirable.

2.4.2.1 MATHEMATICAL EXPRESSION OF FM WAVE

The carrier signal E_c is given by the expression [4]

$$E_c = Ac \sin 2 \prod fo$$

the information (modulating) signal is given by the expression

$$Em = Am \ \sin 2 \prod fm$$

the modulating carrier frequency f swings around the resting frequency fo thus

$$f = fo + \Delta f. \sin 2 fm\ t$$

Hence the equation for the frequency modulated wave is

$$E_{fm} = Ac \sin 2\prod ft = Ac \sin [2\prod(fo + \Delta f. \sin 2 fm\ t)t\ ]$$

$$= A_c \sin(2\prod f_0 t + \tfrac{\Delta f}{fm} + \cos 2\prod f_m t)$$

$$= Ac \sin (2 \prod fo\, t + Mf \cos 2\prod fm\ t\ )$$

2.4.3 HARTLEY OSCILLATOR

Inductive-capacitive (LC) oscillator (also kwon as TANK or FLYWHEEL circuit) circuit are used to generate sinusoidal wave of frequencies that operates at hundred of megahertz (MHz). The frequency of the oscillator is give by the expression [16]

fr is the resonance frequency. It is based on the resonant frequency where the inductive reactance and the capacitive reactance are equal. An energized LC tank circuit will oscillate at resonant frequency.

Practically Tank circuit in addition to inductance and capacitance, have resistance. This resistance will cause the tank circuit oscillator to decay with time. To build a practical LC oscillator, an amplify must be added, so that the gain would overcome the resistive losses and the sine wave of constant amplitude can be generated

A HARTLEY oscillator uses this principle [16]. The tap position of the inductor is important since it determines the feedback of the circuit. In practice, the feedback ratio is selected to a reliable operation. This ensures that the oscillator frequency would be stable every time the power is turn on. Too much feed back would cause clipping and distort the output frequency.

One of the disadvantages of Hartley oscillator is that the output is contain several harmonic and therefore not suitable where a pure sine wave is required [14]

2.4.4 SUPERHETERODYNE RECEIVER

The main functions of a radio receiver are to select the required radio frequency out of the numerous modulated signals reaching the receiver antenna and to convert the selected modulated radio frequency signal into audio frequency[1].

In a super heterodyne receiver the incoming signal is amplified with a signal stage of tuned RF amplification. The amplified signal is mixed with an adjustable local oscillator to produce a signal at a fixed intermediate frequency in this case 10.7MHz. From then on the receiver consist of asset of fixed-tuned IF amplifiers, including selective elements such as crystals or mechanical filters[2].

Changing the local oscillator frequency the receiver since a different input frequency would be mixed to the IF passband frequency.

The input RF amplifier must be gang-tuned with the local oscillator to improve the sensitivity with a stage of low amplification prior to mixing and to reject signals at the "image" frequency, in this case input signal at a frequency of 10.7MHz above the local oscillator.

The mixer generates sum and difference frequencies. In other words the super heterodyne receiver uses a mixer and local oscillator to shift a signal at the input frequency to a fixed intermediate frequency where most of the gain and selectivity are concentrated [2].

Superheterodyne receivers have a high level of selectivity and sensitivity, which are relatively constant over the entire tuning range of the receiver and additional circuit such as automatic gain control could be easily incorporated to the receiver. But the circuitry is complex and more difficult to align and adjust; it also has a annoying "whistling sound" which is caused by the beating together of different harmonics and the oscillator frequency [1].

CHAPTER 3

DESIGN AND IMPLEMENTATION

3.1 PROJECT DESIGN ANALYSIS

The project consist of two units the transmitter and the receiver. Some of the project's design requirement includes

- The transmitter should be able to transmit in the FM band
- The transmitter should be able to operate in two modes. In the tracking mode the transmitter should be able to transmit unique which would not confused with background noise. The second operational mode, the transmitter transmit audio signal in its immediate surrounding.
- The transmitter should not be conspicuous.
- The transmitter should be able to transmit in an effective radius of 15m.
- The receiver should be able to pick up signal transmitted by the transmitter within a 15m radius, in it operational frequency.
- Both units should be powered by 9v batteries.

3.2 CHOICE OF RADIO TRANSMITTER

Since, it is illegal in most countries to operate a transmitter without the proper license. Special care must be given to the transmitter circuit design and operation. For this project transmitter type chosen is the NARROW BAND FM TRANSMITTER TYPE for short distance communication, operating at about 70 MHz. The choice of transmitter type and frequency of operation was selected below the traditional commercial FM band (88 – 168MHz) so as to prevent user of commercial receiver from tuning to the transmitter and to prevent interference from commercial broadcasting stations.

3.3 CHOICE OF RADIO RECEIVER

A superheterodyne receiver was used for this project because its high level of selectivity and sensitivity which are relatively constant over the entire tuning range of the receiver [2].

3.4 CIRCUIT DESIGN ANALYSIS

The project is made 2 communication units (as shown in fig 3.4a and 3.4b) the transmitter and the receiver. Each unit was broken into separate block in order to ease analysis.

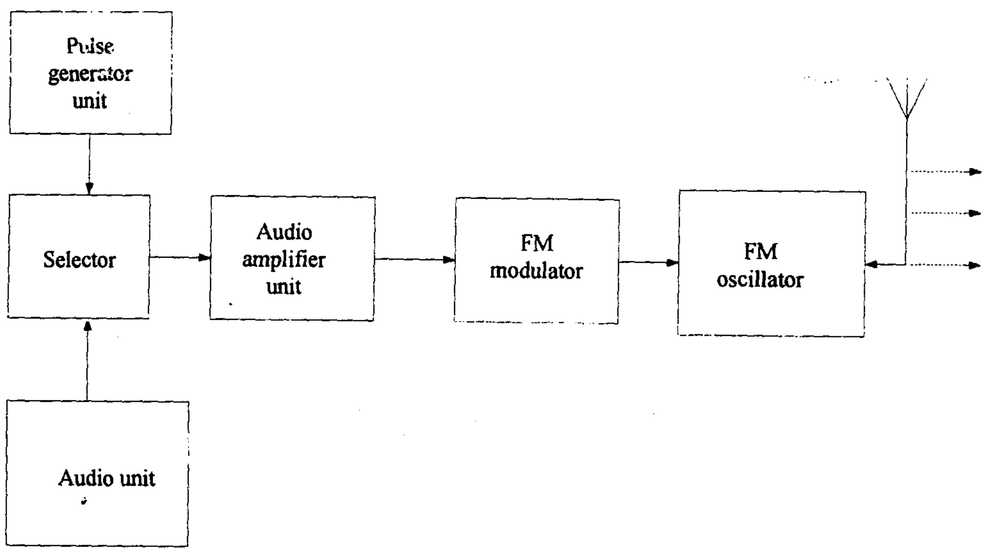


Fig 3.4 (a) Transmitter block diagram

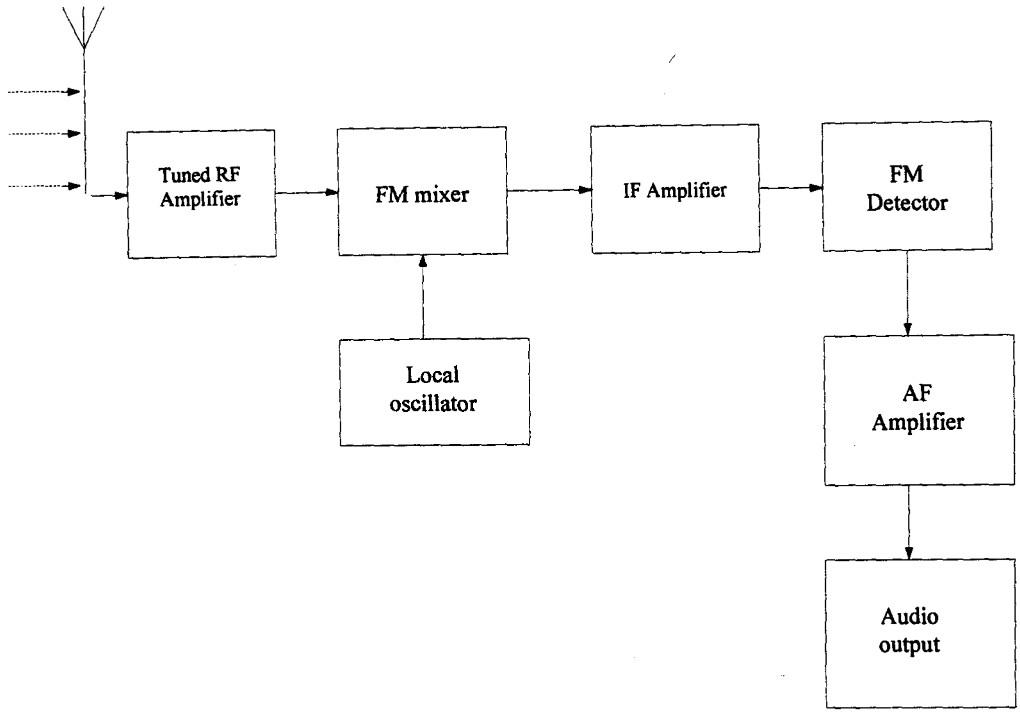


Fig 3.4(b) Reciever block diagram

The design was kept as simple as possible without compromising the basic functionality of the project. The availability of material was also taken in to consideration during the design.

3.4.1 THE TRANSMITTER CIRCUIT

The transmitter's input are got from a high impedance microphone or pulse generator, which is selected one at a time. The input signal is then amplified by an audio amplifier circuit. A Hartley oscillator is used to generate the carrier signal which is modulated by the amplified audio signal from the output of the audio amplifier.

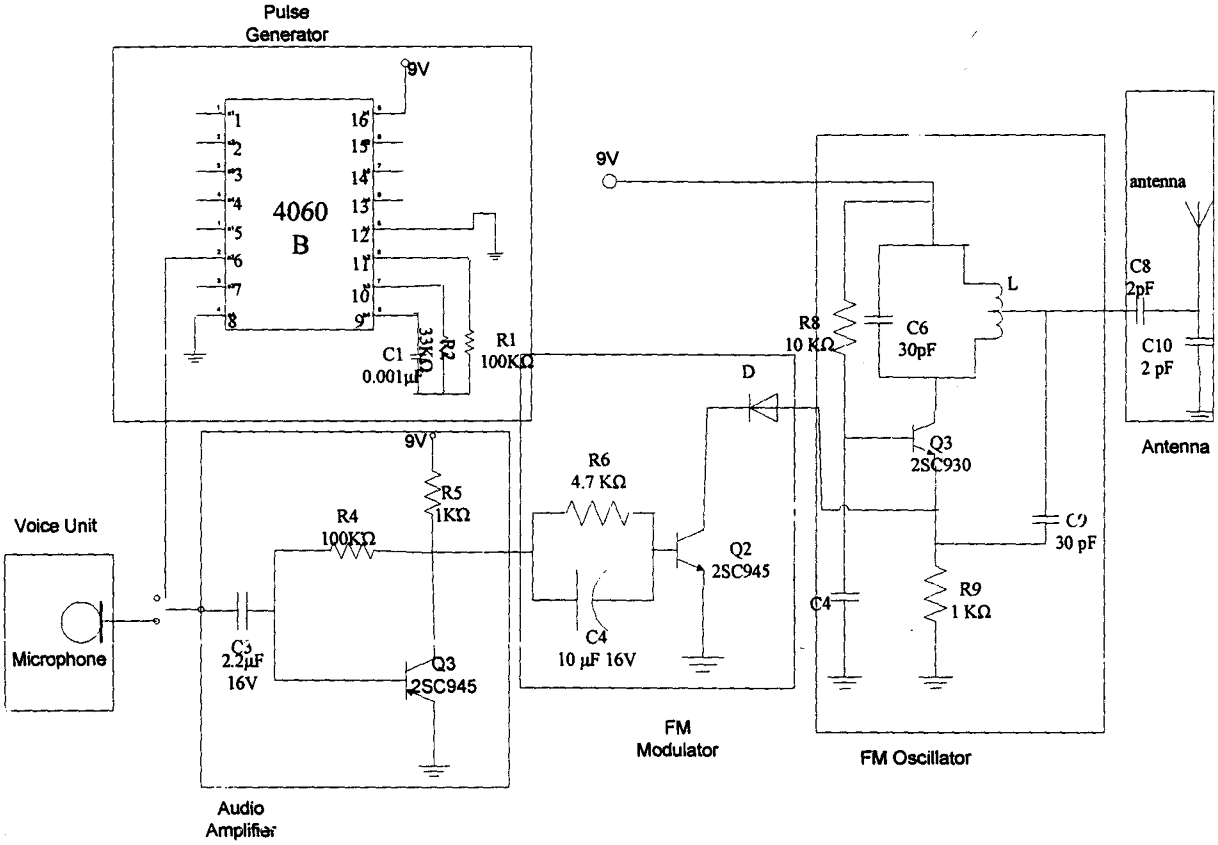


fig 3.4.1.2 The Transmitter Circuit Diagram

3.4.1.1 THE PULSE GENERATOR

The pulse generator is designed with a 4060B integrated circuit. 4060B is a CMOS (complementary metallic oxide semiconductor) 14 stage binary ripple counter with an on–chip oscillator buffer (according to its data sheet). It is useful for this design particular design due to its low power consumption and wide supply voltage range.

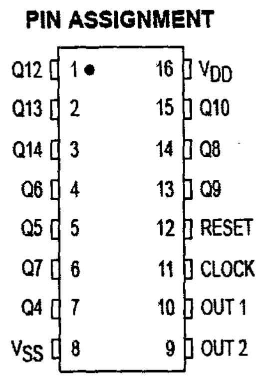


Fig 3.4.1.1.1 Pin configuration for 4060B

The 4060B has the ability of generating ten pulses of different frequencies; this provides a wide choice of operating frequency. The oscillator cloud be configured either using a resistor-capacitor network or by using a crystal. For this project a resistor and capacitor were used to configure the speed of 4060B oscillator.

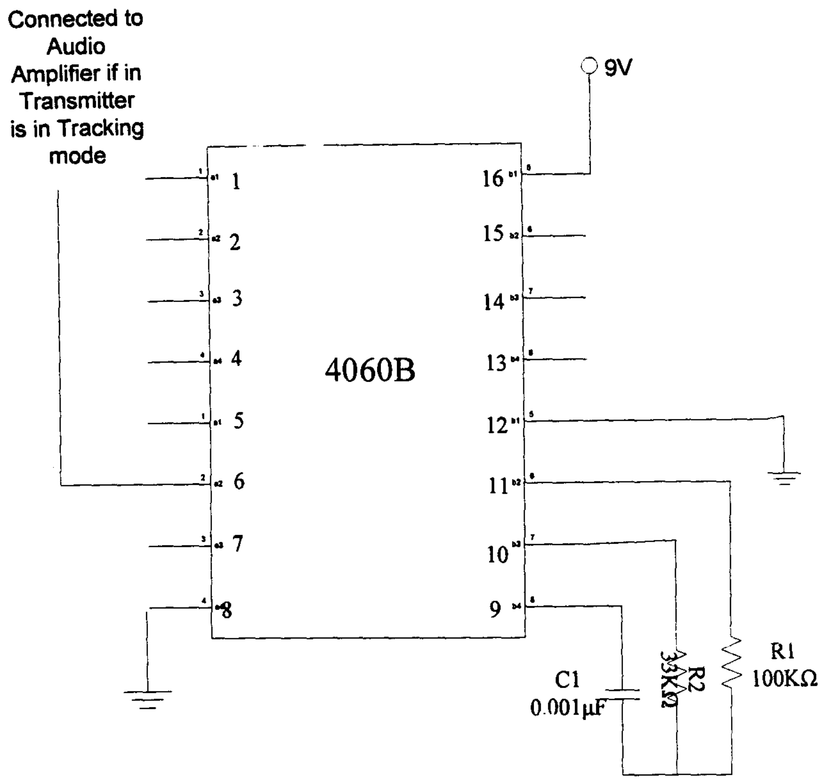


Fig 3.4.1.1.3 The Pulse Generator

The resistor and capacitor are connected to pins 11, 10 and 9 as shown in fig 3.4.1.1.2. The output pulse is tapped from pin 6. The frequency of the output is given by;

$$\text{Frequency of pin 6} = \frac{1/2.3 \times 33 \times 0.001 \times 10^{-6}}{2^7} = 103.125\,\text{Hz}$$

$$\text{Time of pin6} = 1/103.125 \ \text{Sec}$$

$$= 9.69 \times 10^{-3} \ \text{Sec} \approx 9.7\ \text{mS}$$

The signal pulse possesses audio characteristic. The pulse is transmitted by the carrier wave if the transmitter is in the tracking mode. The purpose of the signal is to set an electronic medium that would enhance searching or tracking.

3.4.1.2 THE AUDIO AMPLIFIER

The audio amplifier amplifies the signal from either the microphone or pulse generator. The audio amplifier is coupled to the inputs by 2.2×10^{-6} Farads, 16volts capacitor.

A 2SC945 transistor connected in collector feed back biased (also called self biasing) common emitter bias mode is used to amplify in the incoming signal. 2SC945 is an NPN transistor used low frequency amplification and low speed switching. It has current gain or β_{dc} of about 100 and a maximum operating collector current of 100mA, base current of 20mA and collector-emitter voltage of 50 V at a temperature of 25C (according to its data sheet).

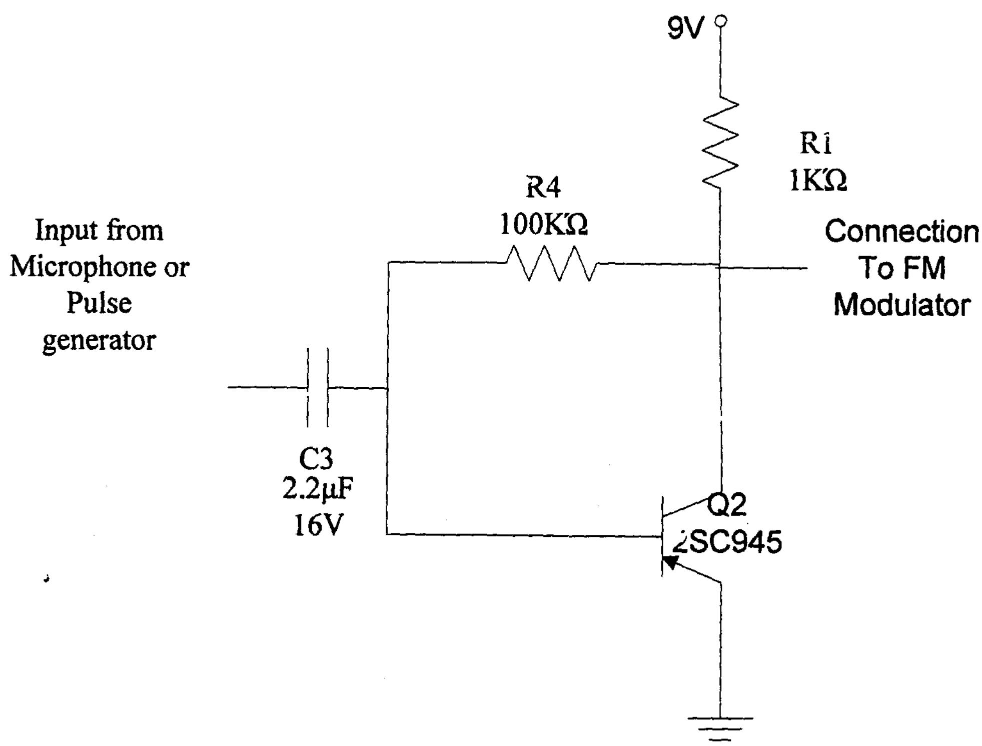


Fig 3.4.1.2.1 The audio amplifier

R1 was fixed as $1k\Omega$, $V_b = 0.7$, $V_{cc} = 9V$. At maximum distortion the output V_{ce} is half the supply voltage V_{cc} i.e.

$$V_{ce} = \frac{Vcc}{2} = \frac{9v}{2} = 4.5v$$

but $$V_{ce} = V_{cc} - I_c R1$$

$$I_c R1 = V_{cc} - V_{ce}$$

$$I_c\, 1k\Omega = 9V - 4.5V$$

$$I_c = \frac{4.5V}{1000\Omega} = 4.5\ mA$$

But $$\beta_{dc} \text{ current gain} = \frac{Ic}{Ib} = 100$$

$$I_b = 4.5mA / 100 = 4.5 \times 10^{-5}\ A$$

But $$V_{ce} = I_b R2 + V_b$$

$$R2 = \frac{Vce - Vb}{Ib}$$

$$= \frac{4.5 - 0.7}{4.5 \times 10^{-5}} = 84444.44\Omega \approx 100k\Omega$$

The feedback resistor R2 was approximated to $100k\Omega$ which is needed to maintain the quiescent collector voltage V_{ce} at $Vcc/2$. This resistor determines the magnitude of amplification provided by the circuits.

3.4.1.3 THE FM MODULATOR

The frequency modulator was designed to impose a particular electric message on the carrier wave that is generated by the oscillator.

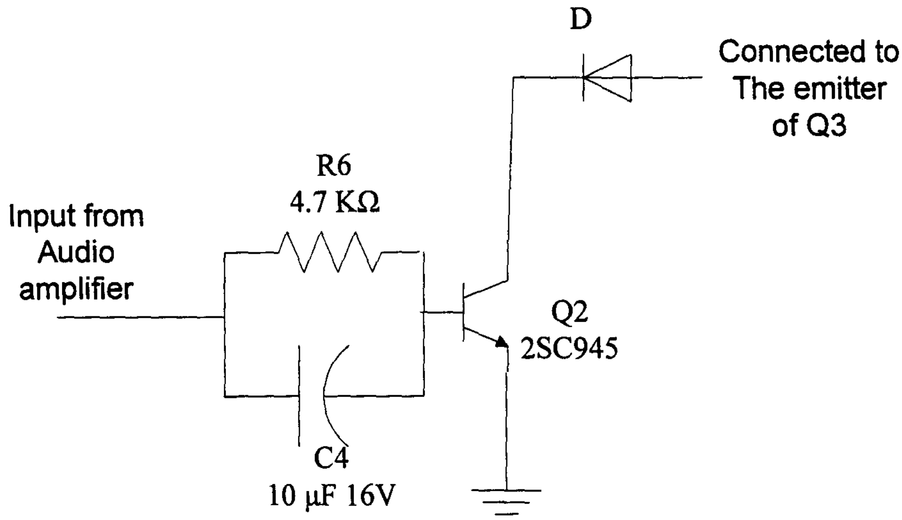


Fig 3.4.1.3.1 The FM Modulator

An NPN transistor (2SC945 same that used in the audio amplifier) is connected in a common emitter mode. The base of the transistor Q1 is coupled to the audio amplifier by an impedance circuit of 4.7kΩ and 16V, 10×10^{-6} Farads connected in parallel, while the collector is connected to emitter of the oscillator's transistor through a diode D.

The modulator transistor Q2 is used to modulate the oscillator's frequency by varying the emitter current of the oscillator transistor with respect to its own base current I_b. the emitter voltage determines the gain Q3 which affects the overall frequency output of the oscillator

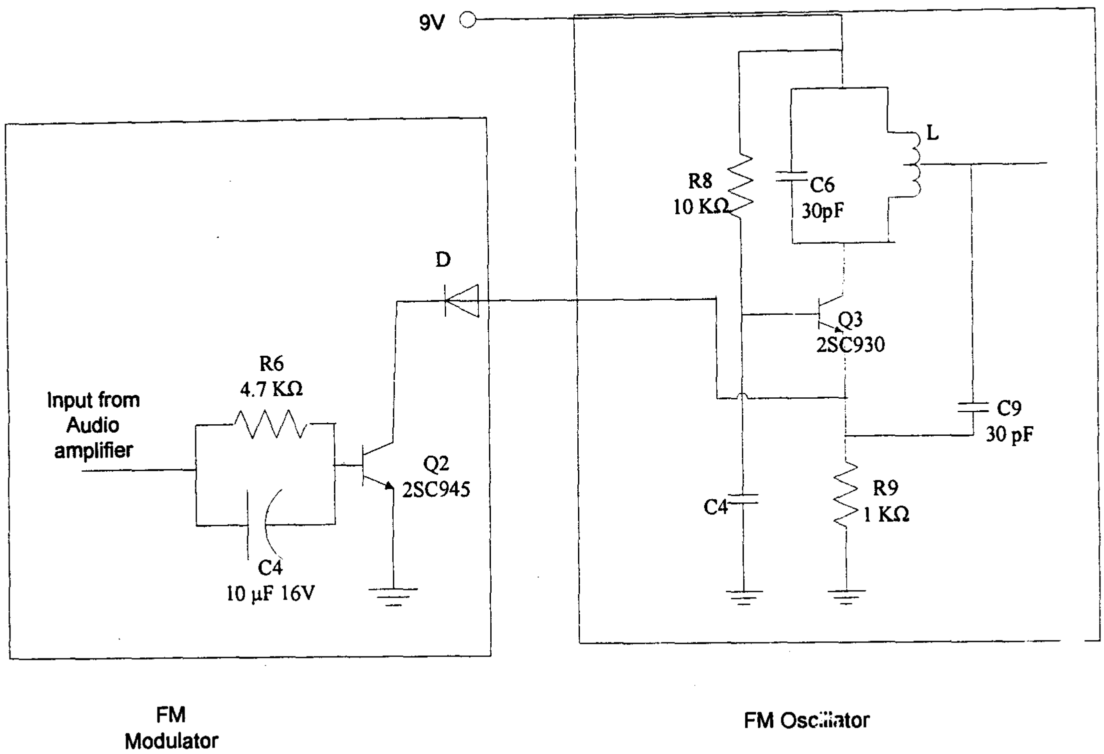


Fig 3.4.1.3.3 FM modulator and FM oscillator

At full saturation of Q2 the base I_b current would be

$$I_b = \frac{9-0.7}{(1+4.7)\times 10^3} = 1.46\text{mA}$$

But β_{dc} current gain of $Q2 = \frac{Ic}{Ib} = 100$

$$I_c = 1.46\text{mA} \times 100 = 146\text{mA}$$

The real current of the collector is much smaller than the calculate value. The series diode connected to the collector of Q2 is incorporated to cause a voltage drop of about roughly 0.5V between the collector of Q2 and the emitter of Q3. The voltage drop is required to moderate the modulation of the carrier wave.

3.4.1.4 THE FM OSCILLATOR

For this project a Hartley oscillator was used to because its reasonable stable. A 2SC930 was used to provide a voltage the gain so as to overcome the resistive losses and so that the sine wave of constant amplitude can be generated.

The 2SC930 is high frequency transistor which could be used for radio and intermediate frequency amplification. It has current gain or β_{dc} of about 80 when connected in the common mode and a maximum operating collector current of 30mA and collector-emitter voltage of 20 V at a temperature of 25C (according to its data sheet).

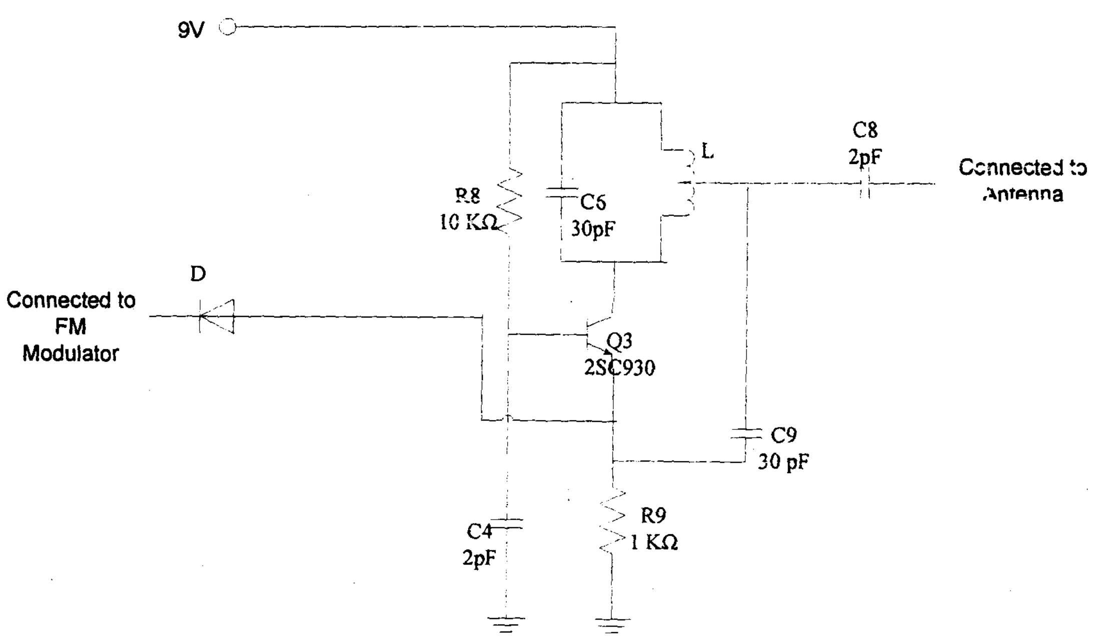


Fig 3.4.1.4.1 The FM Oscillator

The FM oscillator was designed to generate a carrier wave of roughly 70MHz. the frequency was selected below the traditional commercial FM band (88 – 168MHz) so as to prevent user of commercial receiver from tuning to the transmitter and to prevent interference from commercial broadcasting stations.

The capacitors and inductors of the tank circuit are used to set the carrier signal. The Value of the frequency and the capacitor were fixed to 70MHz and 30×10^{-12} Farads. The value of the inductor was estimated

$$f=\frac{1}{2\Pi\sqrt{LC6}}$$

$$L=\frac{1}{4\Pi^2 f^2 C6}$$

$$L=\frac{1}{4\Pi^2\, 30\times10^{-12}\times(70\times10^6)^2}=54.13\ \mu H$$

The feedback capacitor C8 is 30*p*F. A 2*p*F capacitor C9 was used to couple the antenna.

Due to the oscillating nature of the current, calculation based on electric current flow would be very complex. Capacitor C7 and Resistors R8 and R7 where adopted from the circuit of related professional design. C7 =0.02μF, R8 =10KΩ and R7 =1KΩ [14].

3.4.1.5 THE TRANSMITTER ANTENNA

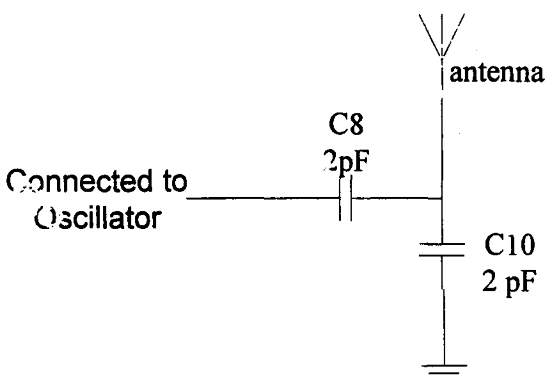


Fig 3.4.1.5.1 Antenna

A copper wire was attached to the oscillator through a coupling 2pF capacitor C9. Another capacitorC10 of value 2pF was used to ground the wire; the capacitor C10 was used as filter capacitor. The length of the antenna was not calculated.

3.4.2 THE RECEIVER CIRCUIT

A super heterodyne receiver was used for this project. A single KA2297 integrated chip was used to implement the tuned FM amplifier FM mixer, FM oscillator, intermediate amplifier and FM detection stages. Other stages include volume control and an audio amplifier.

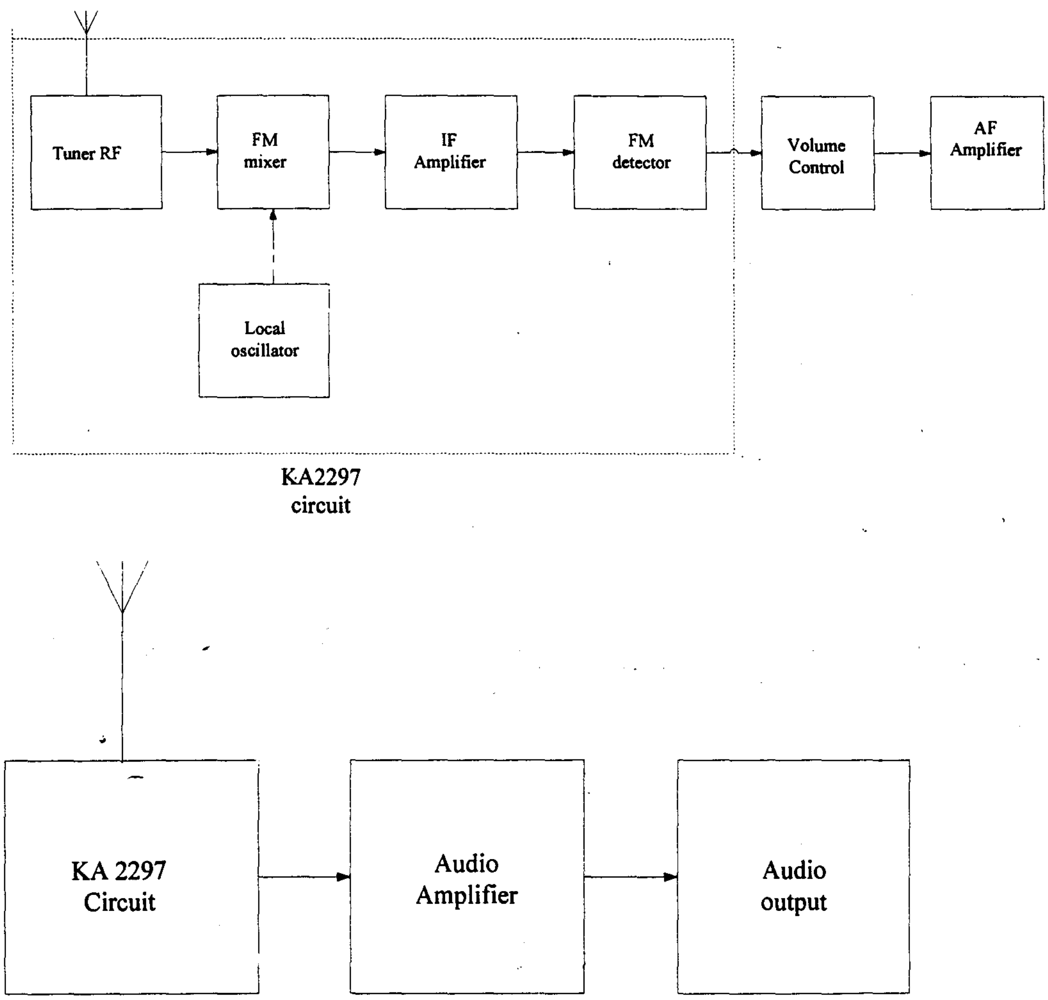


Fig 3.4.2.1 Receiver block diagrams

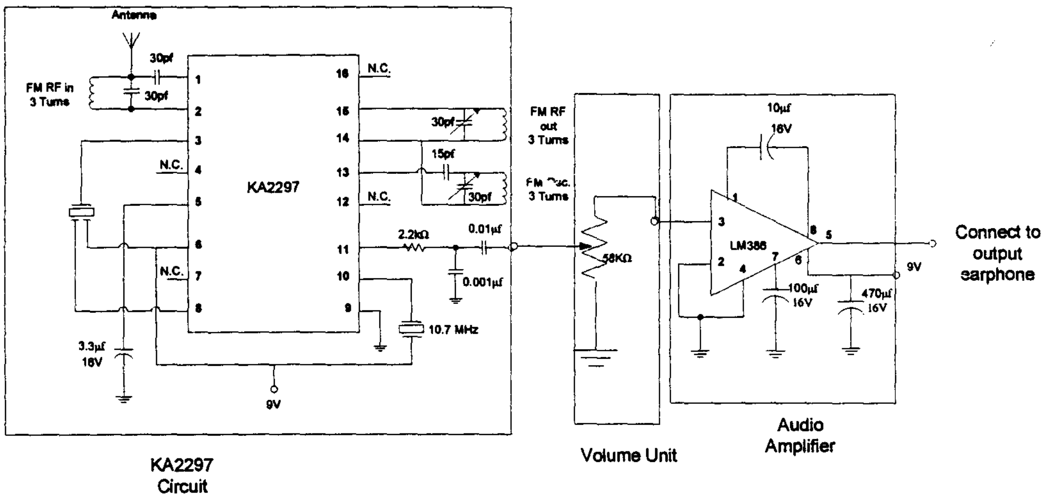


Fig 3.4.2.1 (b) Receiver circuit diagram

3.4.2.1 FM AMPLIFIER, FM MIXER, FM OSCILLATOR IF AMPLIFIER AND FM DETECTOR (KA2297 CIRCUIT)

Tuned FM amplification, FM mixer, FM oscillator, intermediate amplification and FM detection were carried out by a KA2297 IC.

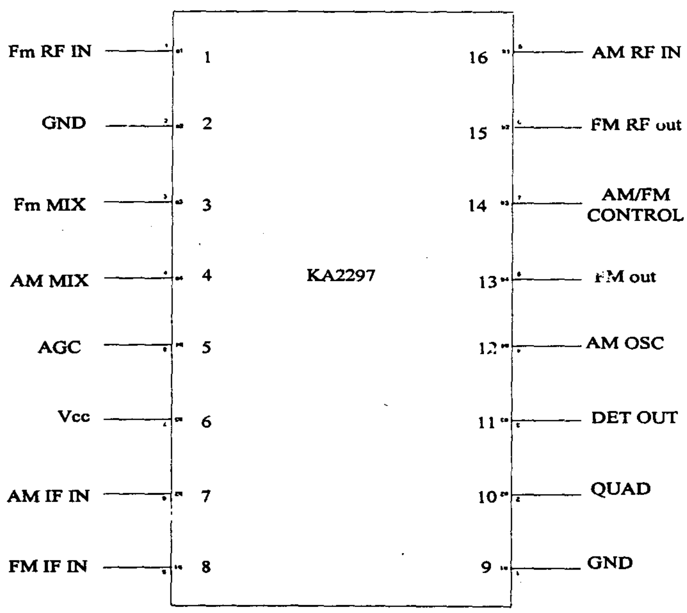


Fig 3.4.2.1.1 Pin configuration of KA2297

KA2297 is monolithic integrated circuit which consist of a FM F/E with AM/FM IF and DET AMP (according to data sheet). It is used in the design of FM and AM receivers.

The design and the values of the components were based on the application diagram on the data sheet.

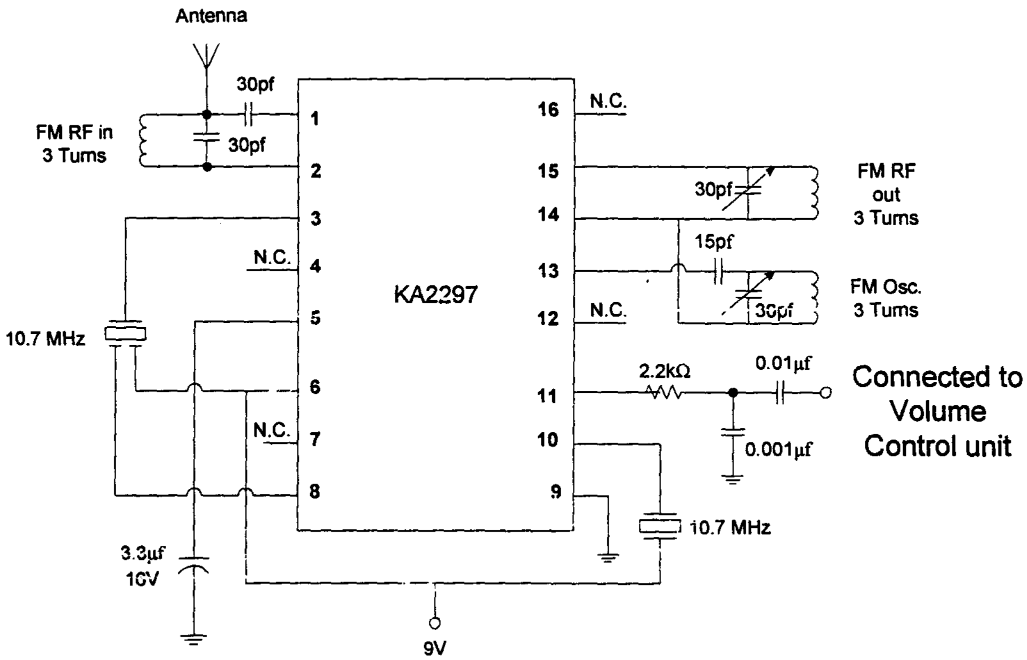


Fig 3.4.1.3.2 KA2297 Circuit

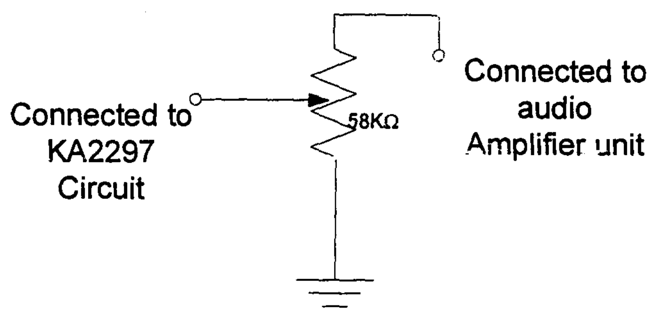
Radio frequency reception and demodulation is effected using the KA2297 RF purposes designed IC. The antenna tuned circuit and the local oscillator are gauged for easier alignment. The beat frequency is passed through a 10. 7MHz band pass surface allow only the true difference frequencies as beating the local oscillator against the incoming RF generates not only the IF but a whole lot of other frequency and sub harmonics.

Thus the 10.7MHz filter separates the desired IF from interference IFs.

The IF is amplified demodulated, and fed into an low power audio amplifier to raise the received avoid voltage to is level sufficient to given a head phone the LM386 has the following specific

3.4.2.2 VOLUME CONTROL

The volume control units consist of a single 50KΩ variable resistor. The output from pin 11 of the KA2297 is connected through a 15*p*F coupling capacitor.



Volume Control Unit

3.4.2.3 AUDIO AMPLIFICATION UNIT

The audio amplification unit mainly consists of a LM386 integrated circuit.

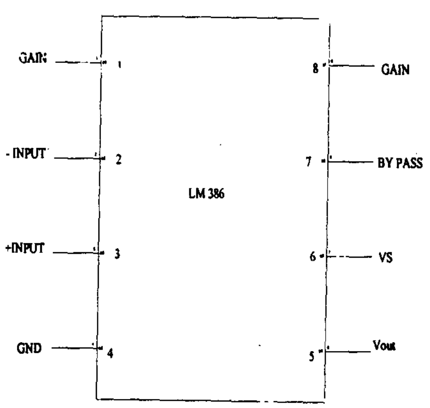


Fig 3.4.2.3.1 Pin configuration of LM386

LM386 is a power audio amplifier designed for low voltage consumption applications. It possess output gain of 20, but if an external resistor and capacitor between pins 1 and 8 , the gain becomes as large as 200.The inputs are ground referenced while the output is automatically biased in one half the supply voltage. The quiescent power drain is only 24 mW (according to the data sheet)

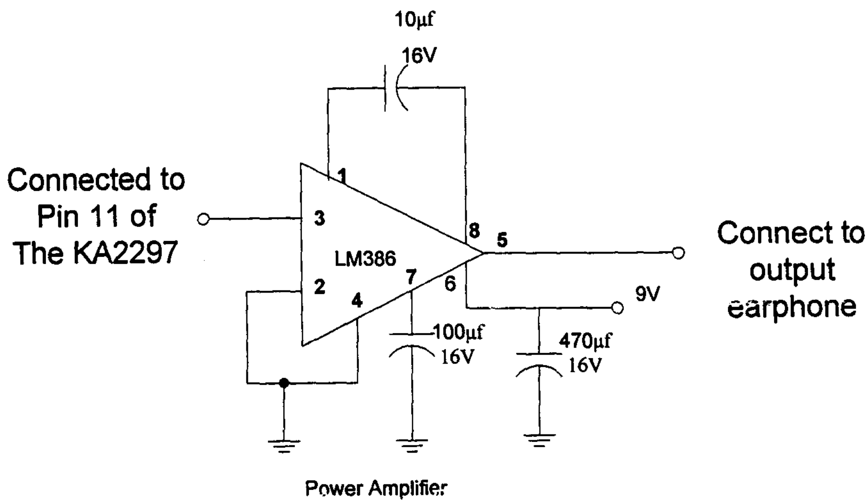


Fig 3.4.2.3.2 Audio amplifier

The design and the values of the components were based on the application diagram on the data sheet.

3.5 ACQUISITION OF MATERIALS AND EQUIPMENT

Most of the materials such as resistors, capacitors, Vero-boards and so on were acquired locally. The only exception was the KA2297 IC, 10.7MHz crystal and 2SC930 transistor; which were not locally available in Minna and had to be purchased from Lagos.

All equipment used were locally available, except a high frequency Oscilloscope which was not available. The equipments are list below:

1. Soldering Iron

2. Digital Multimeter
3. Pen Knife
4. Masking Tape
5. Screw Driver
6. Scissors
7. Pliers

The component list and their prices are contained in the appendix VII.

3.5 CONSTRUCTION

The circuit was not tested on bread board, because has a lot it has a lot of internal conductor which would have affects the inductance of the circuit their by affecting the stability of the tank circuit of the Hartley oscillator.

The circuits were soldering on the Vero-board according to the circuit diagram. The transmitter components such as resistor were soldered erect so as to reduce it size; the circuit was very compact.

Integrated circuits were mounted on sockets so as not to damage during soldering.

After a firm attachment has been obtained the excess wires are then cut off for neatness and uniformity, using a long nose pliers or cutter.

CHAPTER 4

TEST, RESULT AND DISCUSSION

4.1 TEST AND RESULT

4.1.1 CIRCUIT DESIGN TEST

The circuit design was simulated using MultiSIM9 and was found to be working properly, all the expected output was obtained from the simulation.

4.1.2 CONSTRUCTED CIRCIT TESTS

After the circuit was built, tests were carried out on the effective range of transmission, the battery life of the transmitter and the quality of the reception of the receiver. These tests were carried out before the casing of the project.

4.1.2.1 RANGE OF TRANSMISSION

When the transmitter was on listening mode, Audio signal were picked with the receiver at a distance of about 11m from the transmitter on flat open space. When the same test was carried out in a building with wall in-between the receiver and the transmitter the distance was reduced to about 7m.

In the tracking mode, the range test result was about 17m for open space and about 12m in buildings.

4.1.2.2 TRANSMITTER BATTERY LIFE

The transmitter powered by a 9V battery constantly transmitted for 6 hours for a range of 15m in open space.

4.1.2.3 QUALITY OF RECEPTION

The quality of reception of the receiver was good but was affected by noise caused interference from domestic power supply.

When the circuit was on tracking mode the quality of the signal did not fade evenly with increase in distance between the transmitter and the receiver, but rather suddenly vanishes.

4.2 DISCUSSION OF RESULT

- From the result of simulation carried out the design seemed to be in order.
- The target range for both listening and tracking mode was 15m. This was not achieved in both tracking and listening mode.
- The battery life was good. This showed that the design had reasonable power consumption

CHAPTER 5

CONCLUSION

The project is the report of the construction of a listen and tracking device for security surveillance purposes.

Initially set back was quickly overcome and eventually the aim and project requirement were achieved.

The major problem encountered while carrying out this project was un-availability of necessary component, thus, design has to be modified several times to suit available components.

5.1 RECOMMENDATIONS

1. The design was limited to rage of only 15m.The range could be improved by adding additional stages of R.F amplifiers. This would boost the transmission range of the transmitter.
2. A dynamic microphone was used for this project which increased the size of the circuit. A crystal microphone could be used which are smaller in size.
3. The direction of the receiver's antenna could be improved by using a hand held parabolic or Yagi antenna. This would increase the efficiency of the tracking mode.

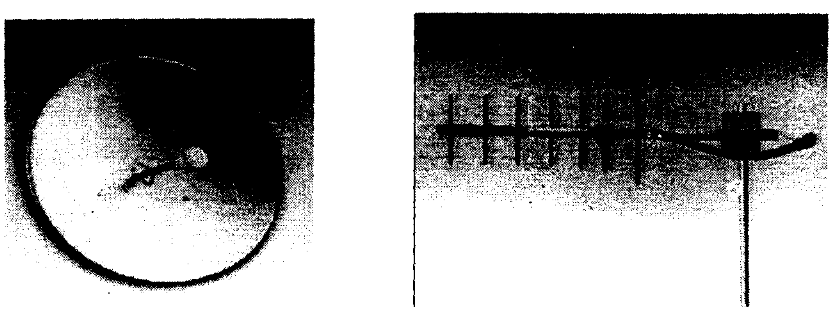


Fig4.1.1 yagi and parabolic antenna

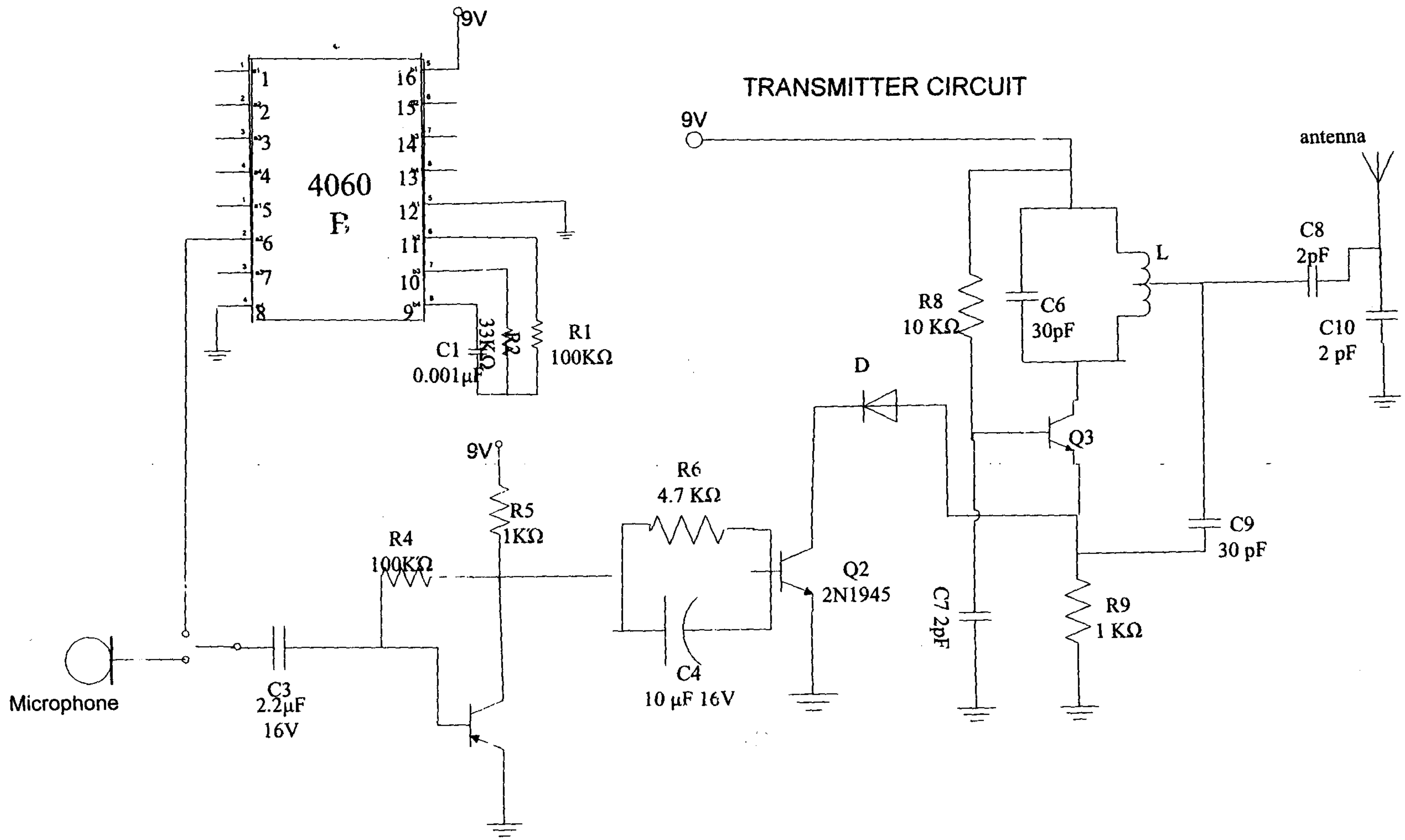
4. Amplitude modulation would be better for the tracking mode. This is because attenuation degrades the quality of the signal evenly with distance unlike frequency modulation whose quality remains the same in the reception range and suddenly vanishes as you move out of range.

5. More specialized designed components (such as components for military use) could be used to reduce the size and increase the efficiency of the transmitter.

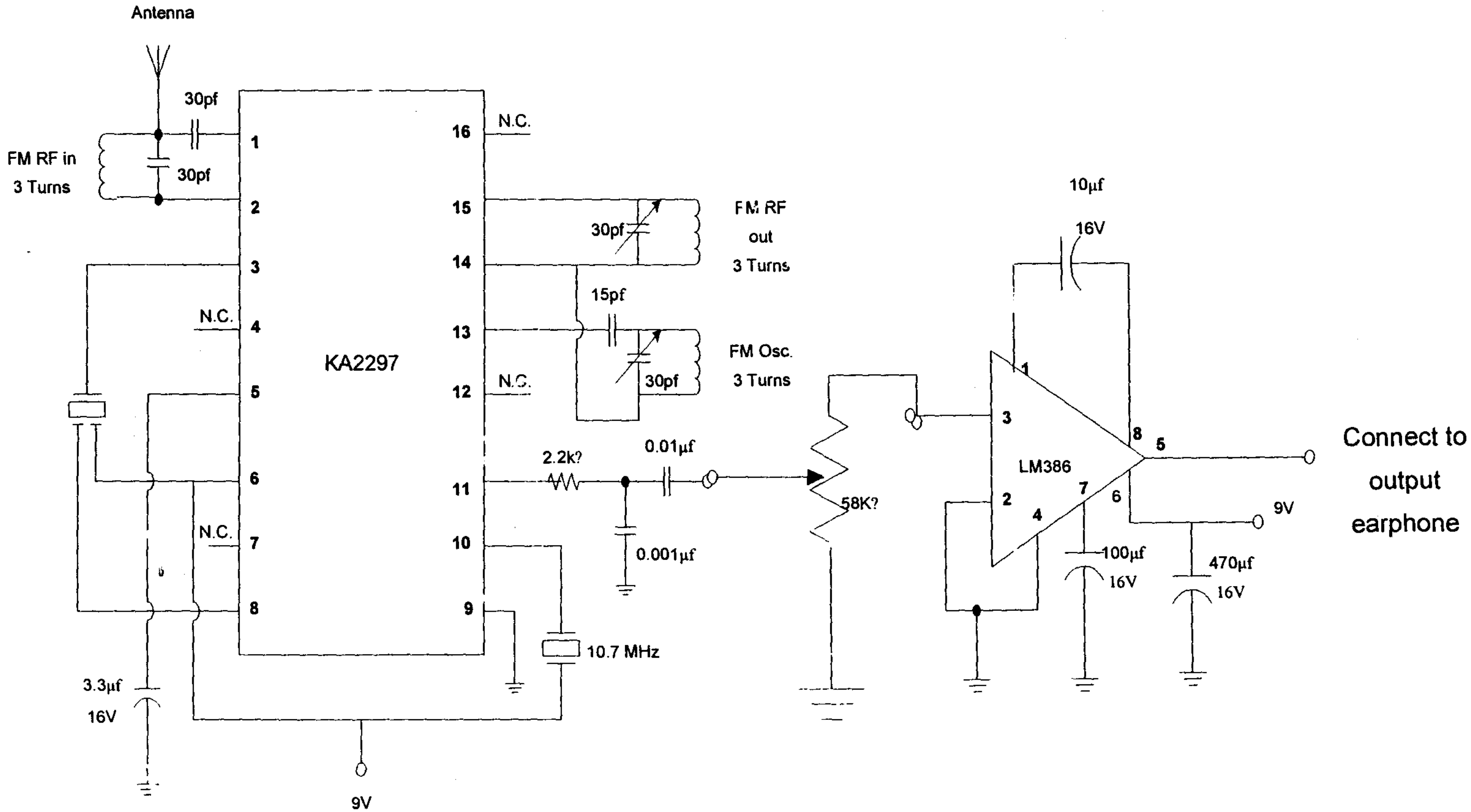
REFERENCE

1. Yinusa A. Adeniran. "Telecommunications principle and systems" 2nd Ed 2005. pp(92-96)
2. Paul Horowitz "Art of Electronics" pp(895-897).
3. http://history.acusd.edu/gen/media/History of Radio.htm
4. B. L. Theraja and A. K. Theraja "A textbook of Electrical Technology" 5th Ed 2003 pp(2213-2217).
5. http:// Whatis.com/modulation.htm
6. http://web.telia.com/~u85920178/right_01.htm
7. http://en.wikkiepdi.com
8. Engr. Musa Abdulahi. Lecture note on "Analog electronics" pp().
9. Microsoft Corporation "Microsoft Encarta" 2006 edition.
10. John D. Kraus and Daniel A. Fleishch. "Electromagnetic with application" 5th Ed pp(2).
11. Jerry C Whitaker Editor. "The Electronic Handbook" 1996 pp(1197-1198)
12. Crutchfield E. B. "National Association of Broadcaster Engineering Handbook" 17th Ed. pp(33-36).
13. Julie K. Petersen. "Understanding Surveillance Technologies Spy device their Origins and application" 2nd Ed 2001. section 3 chapter 5 pp(6-11,34-35) .
14. www.electronics-tutorials.com/hartley_oscilator
15. Campton encyclopedia 2003 edition.

APPENDIX I


TRANSMITTER CIRCUIT
9V
4060
B
1
2
3
4
5
6
7
8
16
15
14
13
12
11
10
9
C1
0.001µF
33KΩ
R2
R1
100KΩ
9V
R5
1KΩ
R4
100KΩ
Microphone
C3
2.2µF
16V
R6
4.7 KΩ
C4
10 µF 16V
Q2
2N1945
D
9V
R8
10 KΩ
C6
30pF
L
Q3
C7 2pF
R9
1 KΩ
C9
30 pF
antenna
C8
2pF
C10
2 pF

APPENDIX II



Antenna
30pf
FM RF in
3 Turns
30pf
KA2297
N.C.
N.C.
N.C.
16
15
14
13
12
11
10
9
1
2
3
4
5
6
7
8
FM RF
out
3 Turns
30pf
15pf
FM Osc.
3 Turns
30pf
N.C.
2.2k?
0.01µf
0.001µf
10.7 MHz
3.3µf
16V
9V
58K?
10µf
16V
LM386
100µf
16V
470µf
16V
9V
Connect to
output
earphone

APPENDIX III

DATA SHEET

NEC

NPN SILICON TRANSISTOR

2SC945

NPN SILICON TRANSISTOR

DESCRIPTION

The 2SC945 is designed for use in driver stage of AF amplifier and low speed switching.

FEATURES

- High voltage
  LV_{CEO} = 50 V MIN.
- Excellent h_{FE} linearity
  h_{FE1} = (0.1 mA)/h_{FE2} (1.0 mA) = 0.92 TYP.

ABSOLUTE MAXIMUM RATINGS

Maximum Temperature

Storage Temperature		−55 to +150°C
Junction Temperature		+150°C Maximum

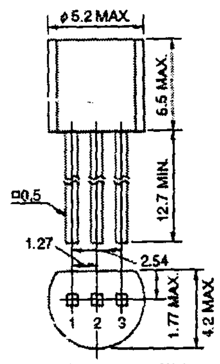
Maximum Power Dissipation (T_A = 25°C)

Total Power Dissipation		250 mW

Maximum Voltages and Currents (T_A = 25°C)

V_{CBO}	Collector to Base Voltage	60 V
V_{CEO}	Collector to Emitter Voltage	50 V
V_{EBO}	Emitter to Base Voltage	5.0 V
I_C	Collector Current	100 mA
I_B	Base Current	20 mA

★ PACKAGE DRAWING (Unit: mm)



1. Emitter EIAJ: SC43B
2. Collector JEDEC: TO92
3. Base IEC: PA33

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

CHARACTERISTIC	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT
DC Current Gain	h_{FE1}	V_{CE} = 6.0 V, I_C = 0.1 mA	50	185		
DC Current Gain	h_{FE2}	V_{CE} = 6.0 V, I_C = 1.0 mA	90	200	600	
Gain Bandwidth Product	f_T	V_{CE} = 6.0 V, I_E = −10 mA		250		MHz
Collector to Base Capacitance	C_{ob}	V_{CB} = 6.0 V, I_E = 0, f = 1.0 MHz		3.0		pF
Collector Cutoff Current	I_{CBO}	V_{CB} = 60 V, I_E = 0 A			100	nA
Emitter Cutoff Current	I_{EBO}	V_{EB} = 5.0 V, I_C = 0 A			100	nA
Base to Emitter Voltage	V_{BE}	V_{CE} = 6.0 V, I_C = 1.0 mA	0.55	0.62	0.65	V
Collector Saturation Voltage	$V_{CE(sat)}$	I_C = 100 mA, I_B = 10 mA		0.15	0.3	V
Base Saturation Voltage	$V_{BE(sat)}$	I_C = 100 mA, I_B = 10 mA		0.86	1.0	V

CLASSIFICATION OF h_{FE2}

Rank	R	Q	P	K
Range	90 to 180	135 to 270	200 to 400	300 to 600

Remark h_{FE2} Test Conditions: V_{CE} = 6.0 V, I_C = 1.0 mA

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Not all products and/or types are available in every country. Please check with an NEC Electronics sales representative for availability and additional information.

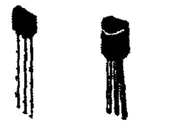
Document No. D17117EJ2V0DS00 (2nd edition)
(Previous No. TC-3005C)
Date Published March 2004 N CP(K)
Printed in Japan

The mark ★ shows major revised points.

APPENDIX IV

T-31-15
T-31-17

2SC930



2033 2003A

NPN Epitaxial Planar
Silicon Transistor

AM Converter, FM RF・IF Amp Applications

©345E

The 2SC930 has two types of packge: SPA and NP.

Use

- FM RF amp, mixer, OSC, converter, and IF amplifier.

Absolute Maximum Ratings at Ta=25°C

		2SC930SPA	2SC930NP	unit
Collector to Base Voltage	V_{CBO}	30	30	V
Collector to Emitter Voltage	V_{CEO}	20	20	V
Emitter to Base Voltage	V_{EBO}	5	5	V
Collector Current	I_C	30	30	mA
Collector Dissipation	P_C	120	250	mW
Junction Temperature	T_j	125	125	°C
Storage Temperature	T_{stg}	-40 to +125	-55 to +125	°C

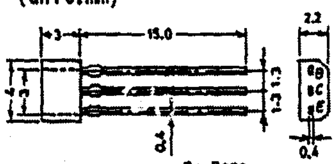
Electrical Characteristics at Ta=25°C

			min	typ	max	unit
Collector Cutoff Current	I_{CBO}	V_{CB}=10V, I_E=0			1	uA
Emitter Cutoff Current	I_{EBO}	V_{EB}=4V, I_C=0			1	uA
DC Current Gain	h_{FE}	V_{CE}=6V, I_C=1mA	40*	80	320*	
Gain Bandwidth Product	f_T	V_{CE}=6V, I_C=1mA	170	300		MHz
Reverse Transfer capacitance	C_{re}	V_{CB}=6V, I_C=1MHz (2SC930SPA)	0.8		1.6	pF
		V_{CB}=6V, f=1MHz (2SC930NP)	1.0	1.3	1.8	pF
Base to Collector Time Constant	$r_{bb'}C_c$	V_{CE}=6V, I_C=1mA f=31.9MHz		20	36	pS
Noise Figure	NF	V_{CE}=6V, I_C=1mA f=100MHz		4.0		dB
Turn-on Time	t_{on}	V_{IN}=+12V, V_{BB}=-3V, appointed circuit		30		ns
Turn-off Time	t_{off}	V_{IN}=-12V, V_{BB}=+3V, appointed circuit		30		ns

*The 2SC930 is graded as follows by 1mA h_{FE}:

40 C 80	60 D 120	100 E 200	160 F 320

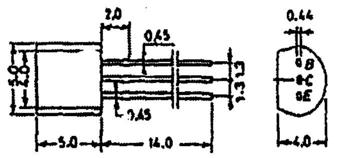
Case Outline 2033
(unit:mm)



B: Base
C: Collector
E: Emitter

SANYO: SPA

Case Outline 2003A
(unit:mm)



JEDEC: TO-92
EIAJ : SC-43
SANYO: NP

B. Base
C. Collector
E. Emitter

The 2SC930 is scheduled to be discontinued soon. Use the 2SC2839, instead of the 2SC930, in new applications where you are planning to use the 2SC930.

APPENDIX V

National Semiconductor

January 2000

LM386
Low Voltage Audio Power Amplifier

General Description

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

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

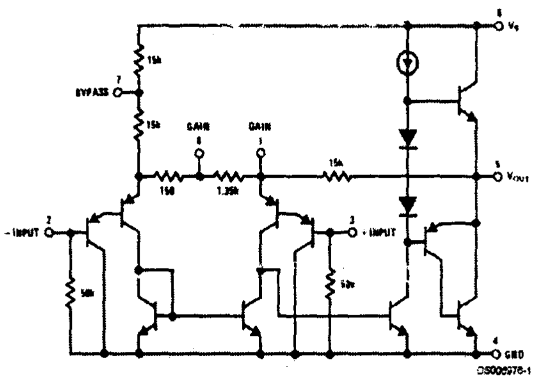
Features

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

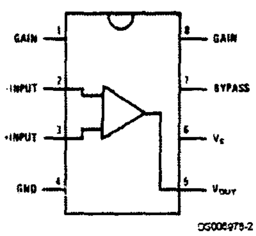
Applications

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

Equivalent Schematic and Connection Diagrams



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



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

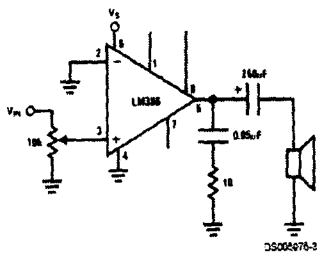
 DS006976

www.national.com

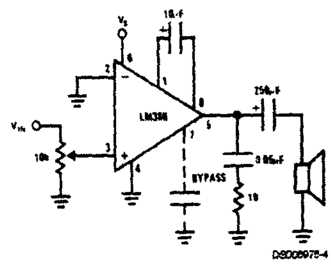
APPENDIX VI

Typical Applications

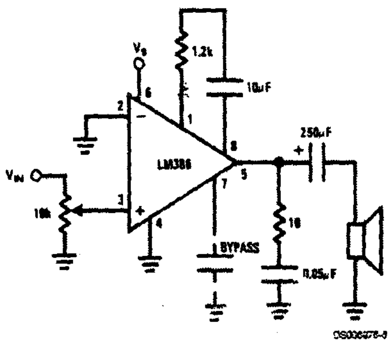
Amplifier with Gain = 20
Minimum Parts



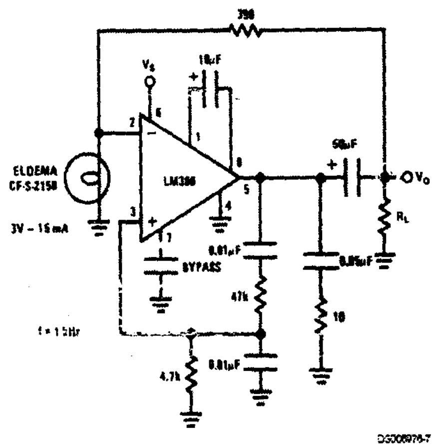
Amplifier with Gain = 200



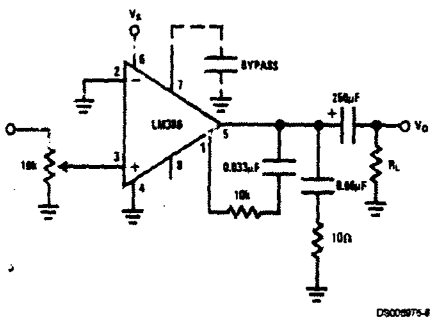
Amplifier with Gain = 50



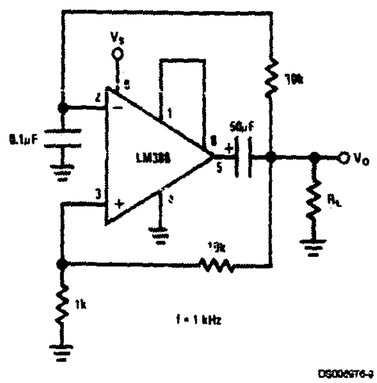
Low Distortion Power Wienbridge Oscillator



Amplifier with Bass Boost



Square Wave Oscillator

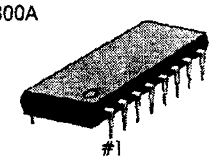


APPENDIX VII

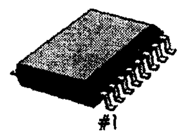
INTRODUCTION

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

16-DIP-300A



16-SOP-375



FEATURES

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

ORDERING INFORMATION

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

BLOCK DIAGRAM

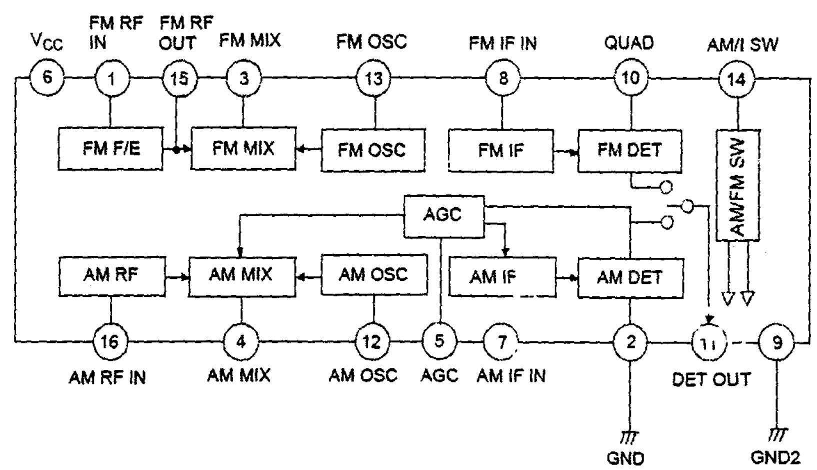


Figure 1.