Due Date	Due Date	Due Date

FM TRANSMITTER WITH INTEGRATED BLUETOOTH

Project Report submitted in partial fulfillment of the requirement
for the degree of

Bachelor of Technology.

in

Electronics and Communication Engineering

Under the Supervision of

Mr. Vikas Hastir

By

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to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

Jaypee University of Information and Technology

Waknaghat, Solan – 173234, Himachal Pradesh

Certificate

This is to certify that project report entitled "FM TRANSMITTER WITH INTEGRATED BLUETOOTH", submitted by Kartik Gupta and Abhinav Sood in partial fulfillment for the award of degree of Bachelor of Technology in Electronics and Communication Engineering to Jaypee University of Information Technology, Waknaghat, Solan has been carried out under my supervision.

This work has not been submitted partially or fully to any other University or Institute for the award of this or any other degree or diploma.

Vikas

Date: 18-05-2013

Mr. Vikas Hastir

Lecturer (E.C.E Dept.)

Acknowledgement

The successful completion of our project would be incomplete without mentioning the people who made it possible and under whose constant guidance and encouragement the result is secured.

We wish to express our deep sense of gratitude and thanks to our respected guide ***Mr. Vikas Hasitr****, M.Tech.* ***Lecturer*** *for providing his valuable guidance and constant encouragement right from conception to the end of this report which is also enabled us to complete the project successfully in time.*

It is a great privilege for us to convey our deepest thanks and sincere gratitude to ***Prof. Ravi Prakash, Honorable Vice Chancellor*** *of our college for his direction, acceptance and for providing excellent lab facilities in the college premises.*

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Date: 18-05-2013

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Abstract

The FM transmitter project solves a problem facing many consumers with linking their personal music device to audio systems. For example with no inputs readily available on most car stereos, this project uses FM transmission to solve the problem. The audio signal that is generated by personal music devices is accepted by a device, manipulated into an FM signal, and transmitted to the FM tuner. This device offers flexibility by accepting a range of personal music devices and transmitting to a wide range of stereo systems.

The project adheres to a wide collection of requirements. The transmission frequency will be chosen by the user between 87.5MHz and 108 MHz, in compliance with the FCC regulations. The transmission range is a minimum of 12 feet. The on/off operation is to be dictated by the operator. With the presence of an input signal the device should be turned on and vice versa. The controls of the operator include real time controls and setting/dismissing the system according to the time of need. There are inherent requirements for this device as a result of its intended use. It must to be small and rugged. The environment that this device will work in includes extreme temperatures, constant movement, and small space. The power consumption of the device must be low in order to prevent drain on the power source.

The completed device design can be separated into three different sections; inputs, processing, and outputs. The inputs to the device include the source signal input. This is the only input to the device. The processing category includes a transmission component that would include modulation. The antenna would simply be transmitting the actual signal from the transmission component.

The FM transmitter project creates a marketable solution to a problem facing many portable audio consumers. Using available technology our team has designed a device to link a portable music device to an FM radio. This device design meets or exceeds all project requirements while meeting the desired product price point. The project is currently on time and under budget. The FM transmitter project has been successful to date.

Chapter 1: INTRODUCTION

1.1 Electro Magnetic Spectrum:

The electromagnetic spectrum is the range of all possible frequencies of electromagnetic radiation. The "electromagnetic spectrum" of an object is the characteristic distribution of electromagnetic radiation emitted or absorbed by that particular object.

The electromagnetic spectrum extends from low frequencies used for modern radio communication to gamma radiation at the short-wavelength (high-frequency) end, thereby covering wavelengths from thousands of kilometres down to a fraction of the size of an atom. It is for this reason that the electromagnetic spectrum is highly studied for spectroscopic purposes to characterize matter. The limit for long wavelength is the size of the universe itself, while it is thought that the short wavelength limit is in the vicinity of the Planck length, although in principle the spectrum is infinite and continuous.

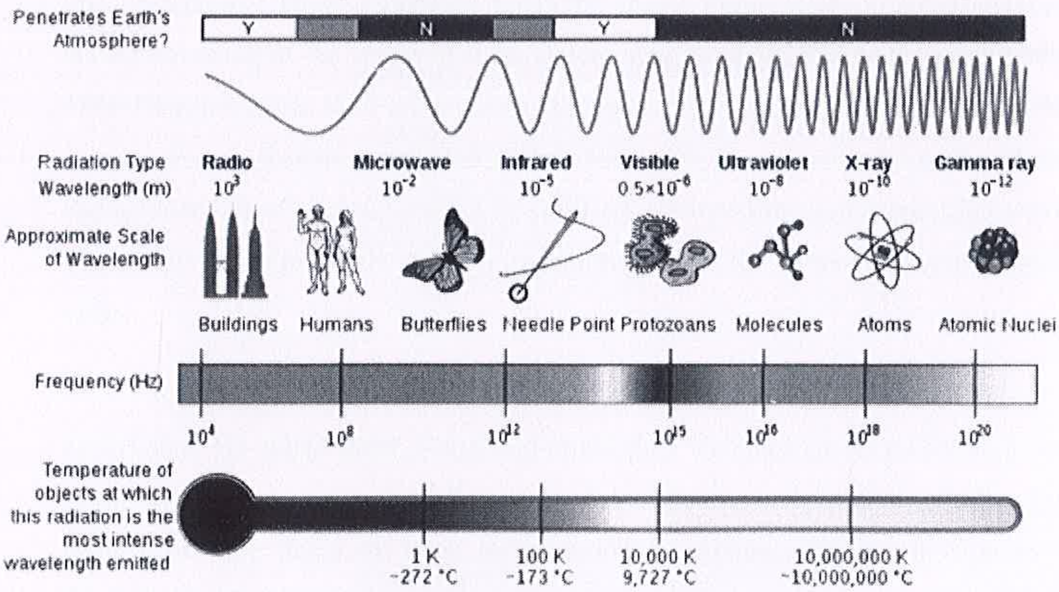

Fig 1.1 EM Spectrum Properties

1.1.1 History: Radio Services

For most of history, light was the only known part of the electromagnetic spectrum. The ancient Greeks recognized that light travelled in straight lines and studied some of the properties of it, including reflection and refraction. Over the years the study of light continued and during the 16th and 17th centuries there were conflicting theories which regarded light as either a wave or a particle. It was first linked to electromagnetism in 1845 when Michael Faraday noticed that light responded to a magnetic field. The first discovery of electromagnetic waves other than light came in 1800, when William Herschel discovered infrared light. He was studying the temperature of different colors by moving a thermometer through light split by a prism. He noticed that the hottest temperature was beyond red. He theorized that there was 'light' that you could not see.

The next year, Johann Ritter worked at the other end of spectrum and noticed that there were 'chemical rays' that behaved similar to, but were beyond, visible violet light rays. They were later renamed ultraviolet radiation. During the 1860s James Maxwell was studying electromagnetic field and realized that they travelled at around the speed of light. He developed four partial differential equations to explain this correlation. These equations predicted many frequencies of electromagnetic waves travelling at the speed of light. Attempting to prove Maxwell's equations, in 1886 Heinrich Hertz built an apparatus to generate and detect radio waves. He was able to observe that they travelled at the speed of light and could be both reflected and refracted. In a later experiment he similarly produced and measured microwaves. These new waves paved the way for inventions such as the wireless telegraph and the radio.

In 1895 Wilhelm Rontgen noticed a new type of radiation emitted during an experiment. He called these x-rays and found they were able to travel through parts of the human body but were reflected by denser matter such as bones. Before long many uses were found for them in the field of medicine. The last portion of the electromagnetic spectrum was filled in with the discovery of gamma rays. In 1900 Paul Villard was studying radioactivity. He first thought they were particles similar to alpha and beta particles. However, in 1910 Ernest Rutherford measured their wave lengths and found that they were electromagnetic waves.

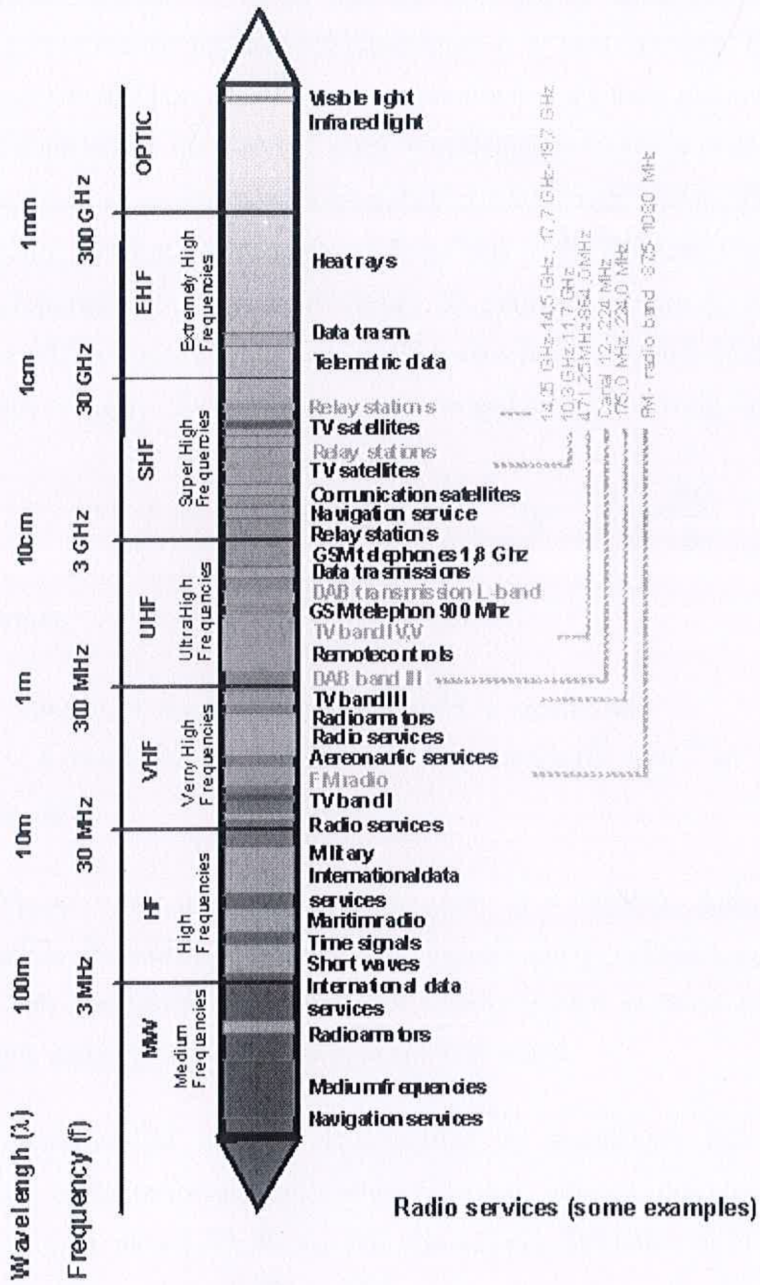

Fig 1.2 Radio Services

1.1.2 Range of the spectrum

Electromagnetic waves are typically described by any of the following three physical properties: the frequency f, wavelength λ, or photon energy E. Frequencies range from 2.4×10^{23} Hz (1 GeV gamma rays) down to the local plasma frequency of the ionized interstellar medium (~1 kHz). Wavelength is inversely proportional to the wave frequency, so gamma rays have very short wavelengths that are fractions of the size of atoms, whereas wavelengths can be as long as the universe. Photon energy is directly proportional to the wave frequency, so gamma rays have the highest energy (around a billion electron volts) and radio waves have very low energy (around a femto electron volts). These relations are illustrated by the following equations:

$$f = \frac{c}{\lambda}, \quad \text{or} \quad f = \frac{E}{h}, \quad \text{or} \quad E = \frac{hc}{\lambda},$$

Where:

- $c = 299{,}792{,}458$ m/s is the speed of light in vacuum and
- $h = 6.62606896(33) \times10^{-34}$ J s $= 4.13566733(10) \times10^{-15}$ eV s is Planck's constant.

Whenever electromagnetic waves exist in a medium with matter, their wavelength is decreased. Wavelengths of electromagnetic radiation, no matter what medium they are travelling through, are usually quoted in terms of the *vacuum wavelength*, although this is not always explicitly stated.

Generally, EM radiation is classified by wavelength into radio wave, microwave, terahertz (or sub-millimeter) radiation, infrared, the visible region we perceive as light, ultraviolet, X-rays and gamma rays. The behavior of EM radiation depends on its wavelength. When EM radiation interacts with single atoms and molecules, its behavior also depends on the amount of energy per quantum (photon) it carries.

1.1.3 Rationale

Electromagnetic radiation interacts with matter in different ways in different parts of the spectrum. The types of interaction can be so different that it seems to be justified to refer to different types of radiation. At the same time, there is a continuum containing all these "different kinds" of electromagnetic radiation. Thus we refer to a spectrum, but divide it up based on the different interactions with matter.

Region of the spectrum	Main interactions with matter
Radio	Collective oscillation of charge carriers in bulk material (plasma oscillation) an example would be the oscillation of the electrons in an antenna.
Infrared	Molecular vibration, plasma oscillation (in metals only)
Visible	Molecular electron excitation (including pigment molecules found in the human retina), plasma oscillations (in metals)
Ultraviolet	Excitation of molecular and atomic valence electrons, including ejection of the electrons (photoelectric effect)
X-rays	Excitation and ejection of core atomic electrons, Compton scattering (for low atomic numbers)
Gamma rays	Energetic ejection of core electrons in heavy elements, Compton scattering (for all atomic numbers), excitation of atomic nuclei, including dissociation of nuclei

Table 1.1: Region of the spectrum & Main interactions with matter

1.2 Introduction: FM Modulation

Frequency modulation (FM) is a method of impressing data onto an alternating-current (AC) wave by varying the instantaneous frequency of the wave. This scheme can be used with analog or digital data.

In analog FM, the frequency of the AC signal wave, also called the *carrier*, varies in a continuous manner. Thus, there are infinitely many possible carrier frequencies. In *narrowband FM*, commonly used in two-way wireless communications, the instantaneous carrier frequency varies by up to 5 kilohertz (kHz, where 1 kHz = 1000 hertz or alternating cycles per second) above and below the frequency of the carrier with no modulation. In *wideband FM*, used in wireless broadcasting, the instantaneous frequency varies by up to several megahertz (MHz, where 1 MHz = 1,000,000 Hz). When the instantaneous input wave has positive polarity the carrier frequency shifts in one direction; when the instantaneous input wave has negative polarity, the carrier frequency shifts in the opposite direction. At every instant in time, the extent of carrier-frequency shift (the *deviation*) is directly proportional to the extent to which the signal amplitude is positive or negative.In digital FM, the carrier frequency shifts abruptly, rather than varying continuously. The number of possible carrier frequency states is usually a power of 2. If there are only two possible frequency states, the mode is called frequency-shift keying (FSK). In more complex modes, there can be four, eight, or more different frequency states. Each specific carrier frequency represents a specific digital input data state.

Frequency modulation is similar in practice to phase modulation (PM). When the instantaneous frequency of a carrier is varied, the instantaneous phase changes as well. The converse also holds: When the instantaneous phase is varied, the instantaneous frequency changes. But FM and PM are not exactly equivalent, especially in analog applications. When an FM receiver is used to demodulate a PM signal, or when an FM signal is intercepted by a receiver designed for PM, the audio is distorted. This is because the relationship between frequency and phase variations is not linear; that is, frequency and phase do not vary in direct proportion.

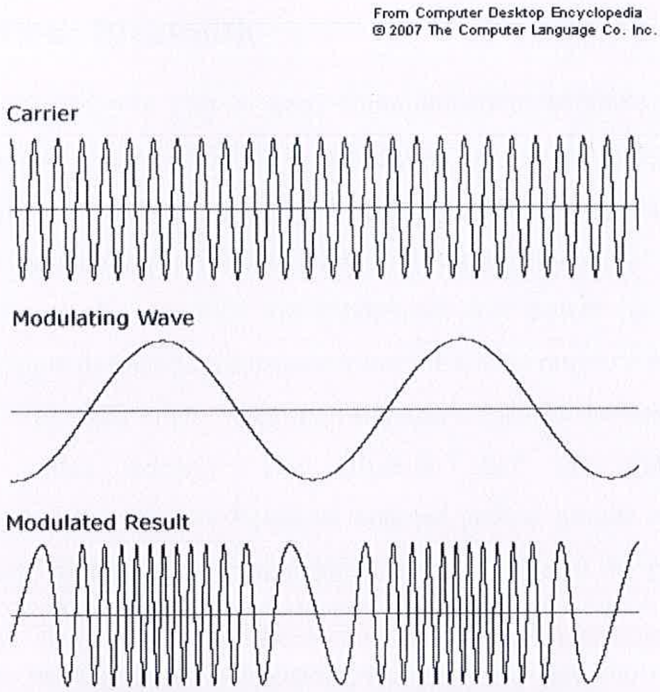

Fig 1.3: Frequency Modulation

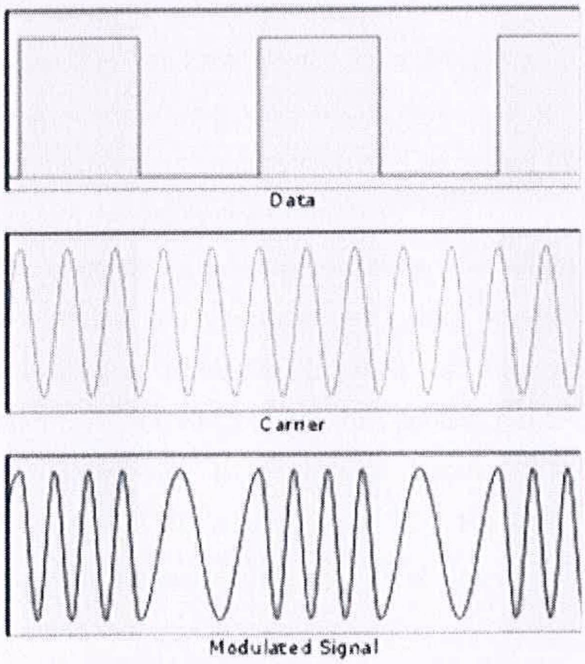

Fig 1.4: Frequency Modulation (FSK)

1.3 Introduction: Bluetooth

Bluetooth technology is a short-range communications technology that is simple, secure, and everywhere. You can find it in billions of devices ranging from mobile phones and computers to medical devices and home entertainment products. It is intended to replace the cables connecting devices, while maintaining high levels of security. The key features of *Bluetooth* technology are robustness, low power, and low cost. The *Bluetooth* Specification defines a uniform structure for a wide range of devices to connect and communicate with each other. When two *Bluetooth* enabled devices connect to each other, this is called pairing. The structure and the global acceptance of *Bluetooth* technology means any *Bluetooth* enabled device, almost everywhere in the world, can connect to other *Bluetooth* enabled devices located in proximity to one another.

Connections between *Bluetooth* enabled electronic devices allow these devices to communicate wirelessly through short-range, ad hoc networks known as piconets. Piconets are established dynamically and automatically as *Bluetooth* enabled devices enter and leave radio proximity meaning that you can easily connect whenever and wherever it's convenient for you.Each device in a piconet can also simultaneously communicate with up to seven other devices within that single piconet and each device can also belong to several piconets simultaneously. This means the ways in which you can connect your *Bluetooth* devices is almost limitless.

A fundamental strength of *Bluetooth* wireless technology is the ability to simultaneously handle data and voice transmissions. which provides users with a variety of innovative solutions such as hands-free headsets for voice calls, printing and fax capabilities, and synchronization for PCs and mobile phones, just to name a few.

The range of *Bluetooth* technology is application specific. The Core Specification mandates a minimum range of 10 meters or 30 feet, but there is no set limit and manufacturers can tune their implementations to provide the range needed to support the use cases for their solutions.

The Piconet

Bluetooth devices can interact with one or more other Bluetooth devices in several different ways. The simplest scheme is when only two devices are involved. This is referred to as point-to-point. One of the devices acts as the master and the other as a slave. This ad-hoc network is referred to as a ***piconet***. As a matter of fact, a piconet is any such Bluetooth network with one master and one or more slaves. A diagram of a piconet is provided in Figure 1. In the case of multiple slaves, the communication topology is referred to as point-to-multipoint. In this case, the channel (and bandwidth) is shared among all the devices in the piconet. There can be up to seven active slaves in a piconet. Each of the active slaves has an assigned 3-bit Active Member address (AM_ADDR). There can be additional slaves which remain synchronized to the master, but do not have a Active Member address. These slaves are not active and are referred to as parked. For the case of both active and parked units, all channel access is regulated by the master. A parked device has an 8-bit Parked Member Address (PM_ADDR), thus limiting the number of parked members to 256. A parked device remains synchronized to the master clock and can very quickly become active and begin communicating in the piconet.

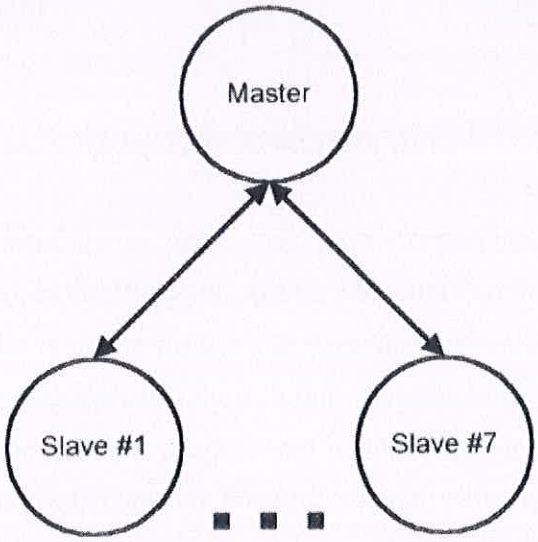

Fig 1.5: A Piconet

The Scatternet

We may be wondering what would happen if two piconets were within the same coverage area. For example, you might have a piconet consisting of your cell phone and your PC, while the person in the neighboring cubicle has a piconet consisting of a cell phone, headset, and business card scanner. A diagram is presented in Figure 2 below.

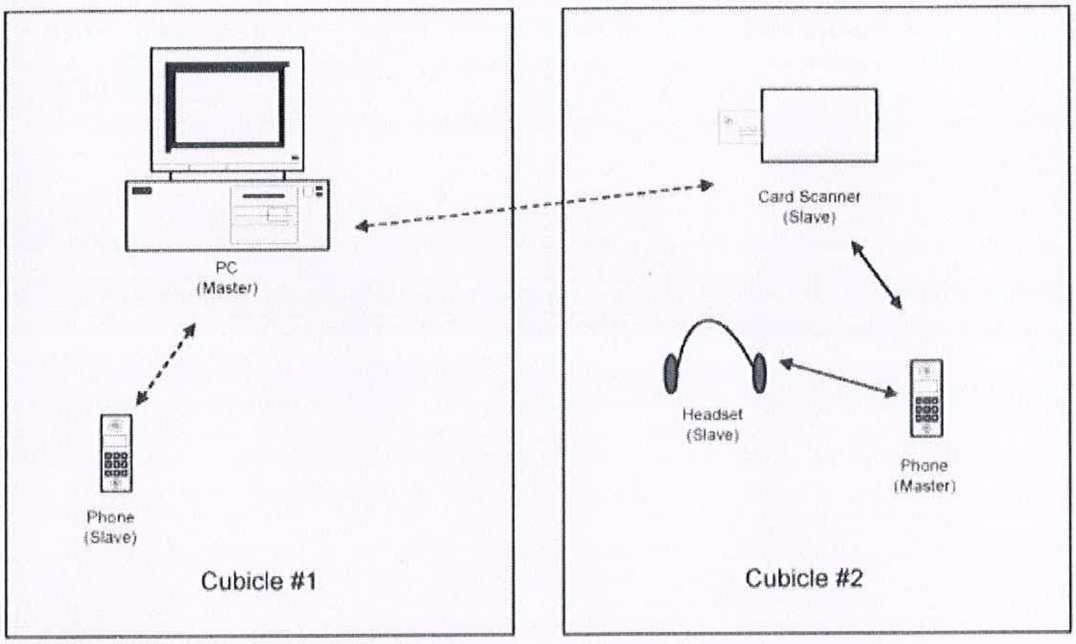

Fig 1.6: A scatternet

Because the two piconets are so close, they have overlapping coverage areas. This scenario is provided for in the Bluetooth specification and is referred to as a scatternet. As a matter of fact, slaves in one piconet can participate in another piconet as either a master or slave. This is accomplished through time division multiplexing. In a scatternet, the two (or more) piconets are not synchronized in either time or frequency. Each of the piconets operates in its own frequency hopping channel while any devices in multiple piconets participate at the appropriate time via time division multiplexing. Returning to the example, you may want to set up your neighbour's business card scanner to also transmit the information that is scanned to your PC so that you will have access to his business contacts information. Of course, this would have to be a mutually agreed upon usage. This brings us to the next topic, Bluetooth security.

Bluetooth Core Specification

Unlike other wireless standards, the *Bluetooth* Core Specification provides product developers both link layer and application layer definitions, which support data and voice applications.

Spectrum

Bluetooth technology operates in the unlicensed industrial, scientific and medical (ISM) band at 2.4 to 2.485 GHz, using a spread spectrum, frequency hopping, full-duplex signal at a nominal rate of 1600 hops/sec. The 2.4 GHz ISM band is available and unlicensed in most countries.

Interference

Bluetooth technology's adaptive frequency hopping (AFH) capability was designed to reduce interference between wireless technologies sharing the 2.4 GHz spectrum. AFH works within the spectrum to take advantage of the available frequency. This is done by the technology detecting other devices in the spectrum and avoiding the frequencies they are using. This adaptive hopping among 79 frequencies at 1 MHz intervals gives a high degree of interference immunity and also allows for more efficient transmission within the spectrum. For users of *Bluetooth* technology this hopping provides greater performance even when other technologies are being used along with *Bluetooth* technology.

Range

Range is application specific and although a minimum range is mandated by the Core Specification, there is not a limit and manufacturers can tune their implementation to support the use case they are enabling.

Range may vary depending on class of radio used in an implementation:

- Class 3 radios – have a range of up to 1 meter or 3 feet
- Class 2 radios – most commonly found in mobile devices – have a range of 10 meters or 33 feet
- Class 1 radios – used primarily in industrial use cases – have a range of 100 meters or 300 feet

Power

The most commonly used radio is Class 2 and uses 2.5 mW of power. *Bluetooth* technology is designed to have very low power consumption. This is reinforced in the specification by allowing radios to be powered down when inactive.

The Generic Alternate MAC/PHY in Version 3.0 HS enables the discovery of remote AMPs for high speed devices and turns on the radio only when needed for data transfer giving a power optimization benefit as well as aiding in the security of the radios.

Bluetooth low energy technology, optimized for devices requiring maximum battery life instead of a high data transfer rate, consumes between 1/2 and 1/100 the power of classic *Bluetooth* technology.

Chapter 2: RADIO FREQUENCY

2.1 Radio frequency:

Radio waves generally are utilized by antennas of appropriate size (according to the principle of resonance), with wavelengths ranging from hundreds of meters to about one millimetre. They are used for transmission of data, via modulation. Television, mobile phones, wireless networking, and amateur radio all use radio waves. The use of the radio spectrum is regulated by many governments through frequency allocation.

Radio waves can be made to carry information by varying a combination of the amplitude, frequency, and phase of the wave within a frequency band. When EM radiation impinges upon a conductor, it couples to the conductor, travels along it, and induces an electric current on the surface of that conductor by exciting the electrons of the conducting material. This effect (the skin effect) is used in antennas.

2.2 Radio spectrum:

Radio spectrum refers to the part of the electromagnetic spectrum corresponding to radio frequencies – that is, frequencies lower than around 300 GHz (or, equivalently, wavelengths longer than about 1 mm).

Different parts of the radio spectrum are used for different radio transmission technologies and applications. Radio spectrum is typically government regulated in developed countries and, in some cases, is sold or licensed to operators of private radio transmission systems (for example, cellular telephone operators or broadcast television stations). Ranges of allocated frequencies are often referred to by their provisioned use (for example, cellular spectrum or television spectrum).

2.2.1 Frequency Bands:

A **band** is a small section of the spectrum of radio communication frequencies, in which channels are usually used or set aside for the same purpose.

Above 300 GHz, the absorption of electromagnetic radiation by Earth's atmosphere is so great that the atmosphere is effectively opaque, until it becomes transparent again in the near-infrared and optical window frequency ranges. To prevent interference and allow for efficient use of the radio spectrum, similar services are allocated in bands. For example, broadcasting, mobile radio, or navigation devices, will be allocated in non-overlapping ranges of frequencies.

Each of these bands has a basic band plan which dictates how it is to be used and shared, to avoid interference and to set protocol for the compatibility of transmitters and receivers. As a matter of convention, bands are divided at wavelengths of 10^n metres, or frequencies of 3×10^n hertz. For example, 30 MHz or 10 m divides shortwave (lower and longer) from VHF (shorter and higher). These are the parts of the radio spectrum, and not its frequency allocation.

2.2.1.1 ITU/IEEE:

The ITU radio bands are designations defined in the ITU Radio Regulations. Article 2, provision No. 2.1 states that "the radio spectrum shall be subdivided into nine frequency bands, which shall be designated by progressive whole numbers in accordance with the following table"

The table originated with a recommendation of the IVth CCIR meeting, held in Bucharest in 1937, and was approved by the International Radio Conference held at Atlantic City in 1947. The idea to give each band a number, in which the number is the logarithm of the approximate geometric mean of the upper and lower band limits in Hz, originated with B.C. Fleming-Williams, who suggested it in a letter to the editor of *Wireless Engineer* in 1942. (For example, the approximate geometric mean of Band 7 is 10 MHz, or 10^7 Hz.)

Band Number	Symbols	Frequency Range	Wavelength Range†
4	VLF	3 to 30 kHz	10 to 100 km
5	LF	30 to 300 kHz	1 to 10 km
6	MF	300 to 3000 kHz	100 to 1000 m
7	HF	3 to 30 MHz	10 to 100 m
8	VHF	30 to 300 MHz	1 to 10 m
9	UHF	300 to 3000 MHz	10 to 100 cm
10	SHF	3 to 30 GHz	1 to 10 cm
11	EHF	30 to 300 GHz	1 to 10 mm
12		300 to 3000 GHz	0.1 to 1 mm

Table 2.1: ITU Radio Bands

Band	Frequency range	Origin of name [citation needed]
HF band	3 to 30 MHz	High Frequency
VHF band	30 to 300 MHz	Very High Frequency
UHF band	300 to 1000 MHz	Ultra High Frequency
L band	1 to 2 GHz	Long wave
S band	2 to 4 GHz	Short wave
C band	4 to 8 GHz	Compromise between S and X
X band	8 to 12 GHz	Used in WW II for fire control, X for cross (as in crosshair)
K_u band	12 to 18 GHz	Kurz-under
K band	18 to 27 GHz	German Kurz (short)
K_a band	27 to 40 GHz	Kurz-above
V band	40 to 75 GHz	
W band	75 to 110 GHz	W follows V in the alphabet
mm band	110 to 300 GHz	

Table 2.2: IEEE Radio Bands

Chapter 3: RADIO SPECTRUM ALLOCATION

3.1 FCC Policy:

The radio spectrum is the radio frequency (RF) portion of the electromagnetic spectrum. In the United States, regulatory responsibility for the radio spectrum is divided between the Federal Communications Commission (FCC) and the National Telecommunications and Information Administration (NTIA). The FCC, which is an independent regulatory agency, administers spectrum for non-Federal use (*i.e.*, state, local government, commercial, private internal business, and personal use) and the NTIA, which is an operating unit of the Department of Commerce, administers spectrum for Federal use (*e.g.*, use by the Army, the FAA, and the FBI). Within the FCC, the Office of Engineering and Technology (OET) provides advice on technical and policy issues pertaining to spectrum allocation and use.

The International Table (columns 1-3 of § 2.106) reflects Article 5, Section IV of the ITU Radio Regulations, Edition of 2008, except for the corrections and updates listed below:

Band (MHz); Table	Action
698-806; Region 2	The primary services are listed in alphabetical order according to the French language followed by the secondary service.
790-862; Region 1	The services are listed in alphabetical order according to the French language.
960-1164, 1300-1350, 9300-9500 & 9500-9800; All Regions	
1452-1492; All Regions	Footnote 5.345 is placed below the allocated services.
2120-2170; Regions 1 & 3	The bands 2120-2160 and 2160-2170 MHz have been merged.
International Footnote	Action (The notation "(FCC)" has been added to the end of these footnote)
5.138A, 5.139, 5.141C, 5.143E	Footnotes relating to the recently concluded 7 MHz Realignment are not shown.
5.208B	Note * is not shown.
5.335	"Earth" is capitalized.
5.345, 5.353A, 5.357A, 5.388, 5.388A, 5.396, 5.462A, 5.516B	The cross references to ITU Resolutions 33, 124, 143, 212, 221, 222, 223, and 528 have been updated to reflect the version listed in the *Radio Regulations*.
5.482	"service" is corrected to read "services" in the last sentence.

Table 3.1: Frequency band and its action

Currently, only frequency bands between 9 kHz and 275 GHz have been allocated (*i.e.*, designated for use by one or more terrestrial or space radio communication services or the radio astronomy service under specified conditions). OET maintains the FCC's Table of Frequency Allocations, which is a compilation of allocations. The FCC's Table of Frequency Allocations consists of the International Table of Frequency Allocations ("International Table") and the United States Table of Frequency Allocations ("United States Table"). The FCC's Table of Frequency Allocations is codified at Section 2.106 of the Commission's Rules.

3.2 FCC Frequency Allocations:

A summary of the FCC Table of Frequency Allocations, based on the Oct '93 Code of Federal Regulations - 47 CFR 2.106

30 - 50 MHz: FM @ 20 kHz steps

30.000 - 30.560	US Government
30.560 - 31.980	Business / Industry / Forestry
31.990 - 32.000	Public Safety
32.000 - 33.000	US Government
33.000 - 33.100	Public Safety
33.120 - 33.400	Business / Petroleum
33.420 - 34.000	Fire
34.000 - 35.000	US Government
35.020 - 36.000	Business / Paging
36.000 - 37.000	US Government
37.020 - 37.420	Police / Local Govt
37.460 - 37.860	Power, Water, Pipeline
37.900 - 38.000	Highway Maint / Special Emergency
38.000 - 39.000	US Government
39.020 - 40.000	Police / Local Govt
40.000 - 42.000	US Government
42.020 - 42.940	State Police
42.960 - 43.680	Business / Paging
43.700 - 44.600	Transportation - bus, truck
44.620 - 45.060	State Police / Forestry Conservation
45.080 - 45.860	Police / Local Govt / Highway Maint
45.900 - 46.040	Police / Emergency
46.060 - 46.500	Fire
46.520 - 46.580	Local Govt
46.610 - 46.970	Cordless Phones - base (20/40 kHz steps)

47.020 - 47.400 Highway Maint
47.440 - 47.680 Industry / Emergency
47.700 - 49.580 Industry
49.670 - 49.990 Cordless Phones - handset (irregular steps)

50 - 150 MHz

50.000 - 54.000 Amateur (6-meter)
54.000 - 72.000 Broadcast TV chs 2-4 (6 MHz steps - FMw)
72.000 - 76.000 (various)
76.000 - 88.000 Broadcast TV chs 5-6 (6 MHz steps - FMw)
88.000 - 108.000 FM Broadcast (200 kHz steps - FMw)
108.000 - 118.000 Aero - navigation
118.000 - 136.000 Aero - communications (25 kHz steps - AM)
136.000 - 138.000 Satellite
138.000 - 144.000 US Government
144.000 - 148.000 Amateur (2-meter)
148.000 - 150.800 US Government

150 - 162 MHz: FM @ 15 kHz steps

150.815 - 150.965 Auto Emergency
150.995 - 151.595 Highway / Forestry / Industry
151.625 - 151.955 Business (30 kHz steps)
152.030 - 152.240 Mobile phone (Base) / Page (30 kHz steps)
152.270 - 152.450 Taxi (Base)
152.510 - 152.840 Mobile phone (Base) / Page (30 kHz steps)
152.870 - 153.725 Industry
153.740 - 154.445 Fire / Govt (mobile)
154.452 - 154.482 Industry (telemetry) (7.5 kHz steps)
154.490 - 154.625 Industry
154.650 - 156.240 Police / Govt / Emrgncy / Hwy
156.025 - 157.425 Maritime (ship) (25 kHz steps)
157.470 - 157.515 Auto Emergency
157.530 - 157.710 Taxi (mobile) / Business
157.770 - 158.100 Mobile phone (mobile) / Page (30 kHz steps)
158.130 - 158.460 Industry
158.490 - 158.700 Mobile phone (mobile) / Page (30 kHz steps)
158.730 - 159.210 Police / Govt / Highway
159.225 - 159.465 Forestry Conservation
159.495 - 160.200 Transportation - bus, truck
160.215 - 161.610 Railroad
160.625 - 160.950 Maritime - Coast (25 kHz steps)
161.640 - 161.760 {Broadcast Pickups
161.500 - 162.025 {Maritime - Coast (25 kHz steps)

162 - 450 MHz

162.025 - 174.000 (various, mainly US Government)
174.000 - 216.000 Broadcast TV chs 7-13 (6 MHz steps-FMw)

216.000 - 218.000	Maritime - AMTS, coast	(25 kHz steps)
218.000 - 219.000	IVDS - Interactive Video & Data	
219.000 - 220.000	Maritime - AMTS, ship	(25 kHz steps)
220.000 - 221.000	(Private land Mobile) - base	(5 kHz steps)
221.000 - 222.000	(Private land Mobile) - mobile	(" " ")
222.000 - 225.000	Amateur (1.25-meter)	
225.000 - 400.000	US Government - Aero	(AM)
400.000 - 406.000	US Govt - Meteorological / Space	
406.000 - 420.000	US Government	
420.000 - 450.000	Amateur (70cm) / military radar/radiolocation	

450 - 460 MHz: FM @ 25 kHz steps (450-455 base, 455-460 mobile)

450.050 - 450.925	Auxiliary Broadcasting
451.025 - 452.025	Industry
452.050 - 452.500	Taxi / Industry / Transport
452.525 - 452.600	Automobile Emergency
452.625 - 452.950	Transportation - Trucks / Railroad
452.975 - 453.000	Relay Press
453.025 - 453.975	Local Govt / Public Safety
454.025 - 454.650	Mobile Telephone
454.675 - 454.975	Mobile Telephone Air (ground)
455.050 - 455.925	Auxiliary Broadcasting
456.025 - 457.025	Industry
457.050 - 457.500	Taxi / Industry / Transport
457.525 - 457.600	{Maritime-shipboard repeater (mobiles@ 467.xxx) {Business - low power}
457.625 - 457.950	Transportation - Trucks / Railroad
457.975 - 458.000	Relay Press
458.025 - 458.975	Public Safety / Local Govt
459.025 - 459.650	Mobile Telephone
459.675 - 459.975	Mobile Telephone Air (airborne)

460 - 470 MHz: FM @ 25 kHz steps (460-465 base, 465-470 mobile)

460.025 - 460.550	Police / Public Safety	
460.575 - 460.625	Fire	
460.650 - 460.875	Business - Airport use	
460.900 - 461.000	Business - Central Alarms	
461.025 - 462.175	Business	
462.200 - 462.525	Manufacturers / Industry	
462.550 - 462.725	GMRS	(12.5 kHz steps)
462.750 - 462.925	Business (paging)	
462.950 - 463.175	MED (Ambulance/Hospital)	
463.200 - 465.000	Business	
465.025 - 465.550	Police / Public Safety	
465.575 - 465.625	Fire	
465.650 - 465.875	Business - Airport use	
465.900 - 466.000	Business - Central Alarms	

466.025 - 467.175 Business
467.200 - 467.525 Manufacturers / Industry
467.550 - 467.725 GMRS (25 kHz steps)
467.750 - 467.925 {Business (2w, telemetry)
467.750 - 467.825 {Maritime - shipboard (rptr at 457.xxx)
467.950 - 468.175 MED (Ambulance/Hospital)
468.200 - 469.975 Business

470 - 806 MHz: 6 MHz per channel, wide FM audio
470.000 - 512.000 {Broadcast TV, chs 14-20
{Large Metro Public Safety (25 kHz steps - FM)
512.000 - 806.000 Broadcast TV, Chs 21-69

806 - 896 MHz: FM @ 25 kHz steps (mobile 806-851, base 851-896)
806.0125- 809.7375 General - conventional
809.7625- 810.9875 General - single channels
811.0125- 815.9875 General - trunked
816.0125- 820.9875 SMR - trunked
821.0125- 823.9875 Public Safety - trunked (12.5 kHz steps)
824.040 - 834.360 Cellular Telephone (30 kHz steps)
834.390 - 835.620 Cellular Telephone (data) (30 kHz steps)
835.650 - 848.970 Cellular Telephone (30 kHz steps)
849.000 - 851.000 Aircraft Telephone (6 kHz steps-AM)
851.0125- 854.7375 General - conventional
854.7625- 855.9875 General - single channels
856.0125- 860.9875 General - trunked
861.0125- 865.9875 SMR - trunked
866.0125- 868.9875 Public Safety - trunked (12.5 kHz steps)
869.040 - 879.360 Cellular Telephone (30 kHz steps)
879.390 - 880.620 Cellular Telephone (data) (30 kHz steps)
880.650 - 893.970 Cellular Telephone (30 kHz steps)
894.000 - 896.000 Aircraft Telephone (6 kHz steps-AM)

896 - 1300 MHz:
896.000 - 901.000 SMR/Business/Industry - mobile(12.5 kHz steps)
901.000 - 902.000 Personal Communications Services
902.000 - 928.000 Amateur (33cm) / various secondary
928.000 - 929.000 ()
929.000 - 930.000 paging
930.000 - 931.000 Personal Communications Services - base
931.000 - 935.000 ()
935.000 - 940.000 SMR/Business/Industry - base (12.5 kHz steps)
940.000 - 941.000 Personal Communications Services - base
941.000 - 960.000 ()
960.000 -1215.000 Aeronautical navigation
1215.000 -1240.000 US Govt - Radiolocation / Space
1240.000 -1300.000 Amateur (23cm)

Chapter 4: DESIGN APPROACH

4.1 Introduction:

This FM transmitter project allows transmission of signal from base station (Portable Music Device) to receiver station. It can transmit audio signal. In this project the FM transmitter consists of modulator and power supply which generates an efficient signal for transmission. The signal is fed in to free space with an antenna. Here we use an aerial antenna for short range purpose.

The result can be verified on any general FM radio receiver by tuning to the corresponding frequency of transmitted signal limited to the range 87.5 MHz to 108.5 MHz. Low range applications like College radio, Transmission of music inside a car from its audio system, scheduling the work in an industry, etc. There is a huge scope in future in the field of 'Near Field Communication. This project uses regulated 9V power supply.

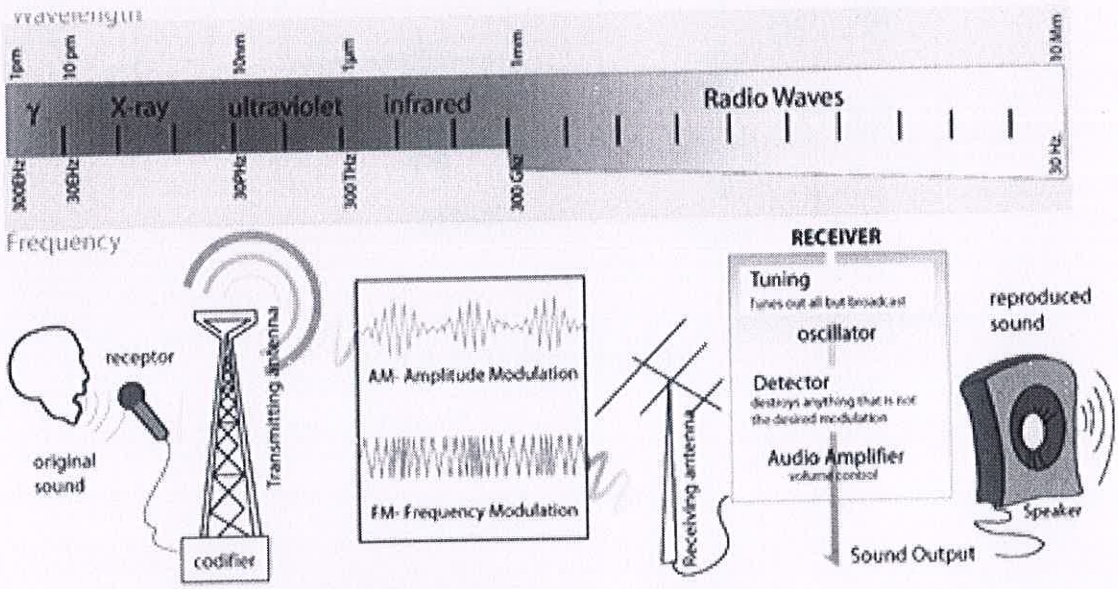

Fig 4.1: Outlay of transmission

4.2 Power Supply:

The circuit takes 220V AC and then steps it down to 12V AC using a transformer. Then the stepped down voltage is further converted to DC using a bridge rectifier. To have a fixed DC power supply we have used a regulator (7809) which limits the output voltage to 9V DC. Smoothening capacitors with high capacitances are also used to smoothen out the rectified signal.

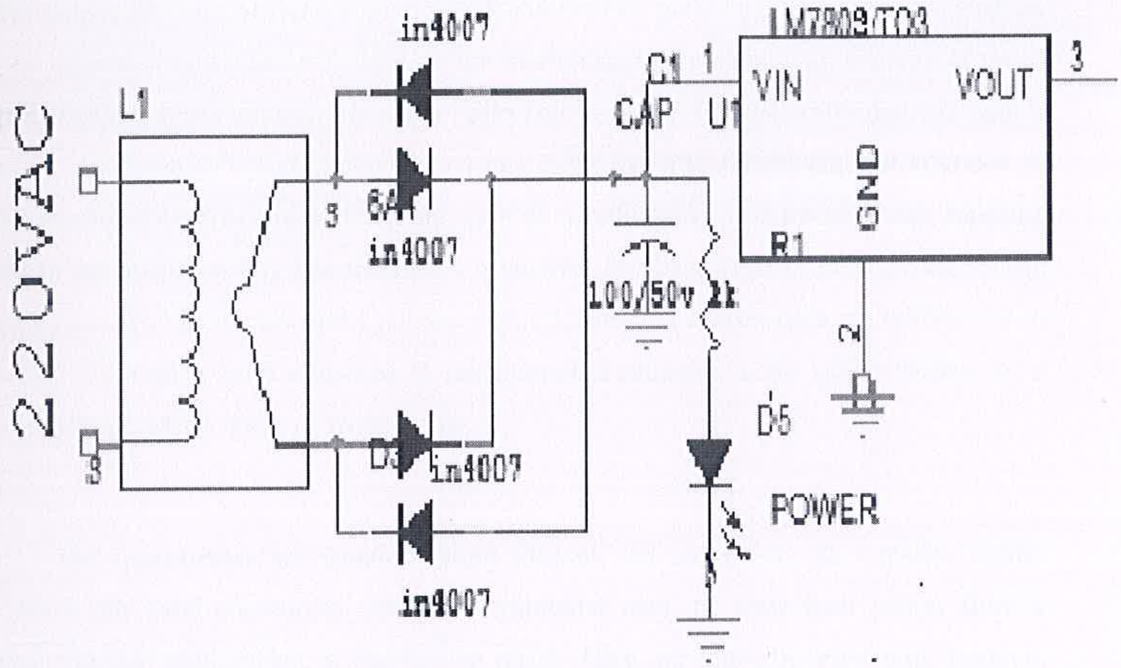

Fig 4.2: Power Supply

4.3 FM Transmitter:

An FM transmitter is a portable device that plugs into the headphone jack or proprietary output port (Bluetooth in our case) of a portable audio or video device, such as a portable media player, CD player, or a Mobile phone. The sound is then broadcast through the transmitter, and plays through an FM broadcast band frequency. Purposes for an FM transmitter include playing music from a device through a car stereo, or any radio.

The FM transmitter plugs into the audio output of audio devices and converts the audio output into an FM radio signal, which can then be picked up by appliances such as car or portable radios. Most devices on the market typically have a short range of up to 100 feet (30 metres) with any average radio (up to about 300 feet (100 metres) with a very good radio under perfect conditions) this range can also be enhanced if operated in fixed locations of good high elevation, such as a multi-story apartment or tall building and can broadcast on any FM frequency from 87.5 to 108.0 MHz in most of the world, (or 88.1 to 107.9 in the US and Canada). Some lower-cost transmitters are hard-wired to the 87.7–91.9 MHz band allocated to educational broadcasts in the United States, or a certain other smaller range of frequencies.

FM transmitters are usually battery driven, but some use the cigarette lighter socket in cars (and sometimes outside of vehicular use), or draw their power from a mains powered wall socket or the device itself. They are typically used with portable audio devices such as MP3 players, as well as hi-fi systems, message systems, etc. They are also used to broadcast other outputs (such as that from a computer sound card) throughout a home or other building.

Fig 4.3: Car FM Transmitter

4.4 FM Transmitter Circuit:

This is a simple and cheap F.M transmitter. This runs at low voltage, by a 9V power supply discussed above, current consumption is also low. The total size of this F.M transmitter (excluding antenna) can be less than that of a matchbox. The circuit is a two stage circuit. In the first state the first Transistor Q1 is used as a pre-amplifier that amplifies the signal received from the Bluetooth receiver and then passes it on to the second Transistor Q2 which is used as a central RF oscillator. A coil takes care of the output frequency. The input from the audio output of Bluetooth module is given to the biased base of the transistor. The transistor gives a RF humming accordingly to the audio input, and the FM wave is spread by the external antenna (Ariel). By using a standard T.V antenna, the range of this transmitter can go up to 1KM radius, using small(15-20cm) Ariel, it can work up to around 50M range. This circuit is most suitable for miniature FM transmitter for use in computer, mobile etc to send music to home theater system without wires, and in homemade wireless walky-talkies.

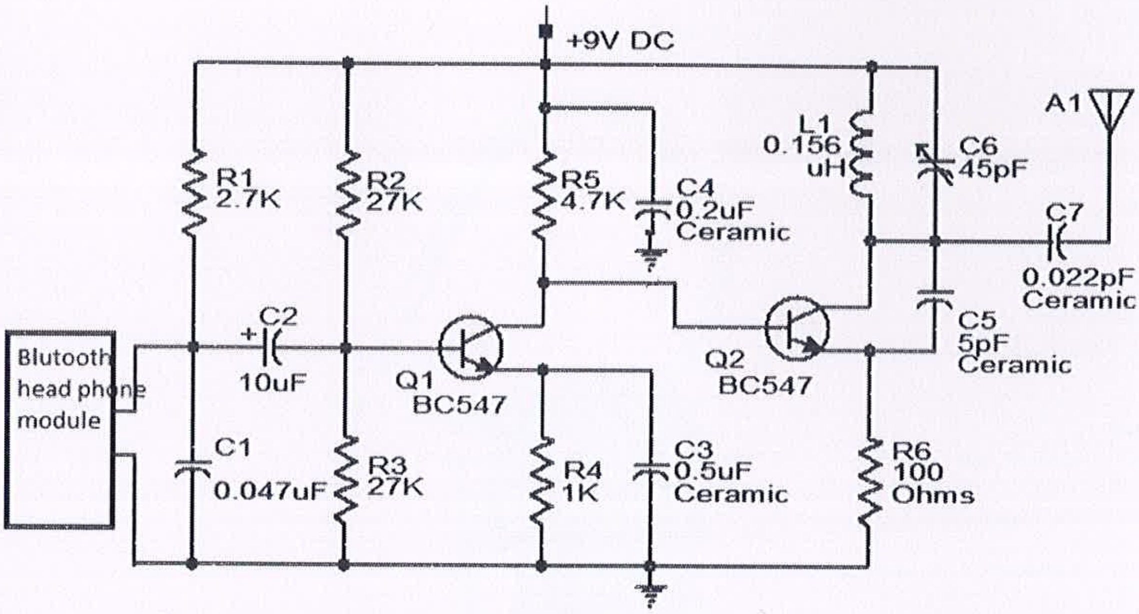

Fig 4.4: FM Transmitter Circuit

4.5 Audio Input:

The audio signal is fed into the FM Transmitter by using a Bluetooth module (BH-219). The Bluetooth module is actually a Bluetooth headset which has been purposefully reverse engineered to make it suit for our needs. The Bluetooth module receives input via A2DP (Advanced Audio Distribution Profile), which is a protocol already defined in Bluetooth for Streaming audio/music wirelessly. So, any device which is used for transmitting wireless music in form of FM modulated signal needs to be connected to this Bluetooth module and then the output of this headset is connected to the input of the FM transmitter which then modulates the Signal into FM signal.

Fig 4.5: Bluetooth Headset

4.6 Modulator:

In electronics and telecommunications, **modulation** is the process of varying one or more properties of a high-frequency periodic waveform, called the carrier signal, with a modulating signal which typically contains information to be transmitted. This is done in a similar fashion to a musician modulating a tone (a periodic waveform) from a musical instrument by varying its volume, timing and pitch. The three key parameters of a periodic waveform are its amplitude ("volume"), its phase ("timing") and its frequency ("pitch"). Any of these properties can be modified in accordance with a low frequency signal to obtain the modulated signal. Typically a high-frequency sinusoid waveform is used as carrier signal, but a square wave pulse train may also be used.

In telecommunications, modulation is the process of conveying a message signal, for example a digital bit stream or an analog audio signal, inside another signal that can be physically transmitted. Modulation of a sine waveform is used to transform a baseband message signal into a pass band signal, for example low-frequency audio signal into a radio-frequency signal (RF signal). In radio communications, cable TV systems or the public switched telephone network for instance, electrical signals can only be transferred over a limited pass band frequency spectrum, with specific (non-zero) lower and upper cut-off frequencies. Modulating a sine-wave carrier makes it possible to keep the frequency content of the transferred signal as close as possible to the centre frequency (typically the carrier frequency) of the pass band.

A device that performs modulation is known as a modulator and a device that performs the inverse operation of modulation is known as a demodulator (sometimes *detector* or demod). A device that can do both operations is a modem (from "**mo**dulator–**dem**odulator").

4.7 Oscillator:

An **electronic oscillator** is an electronic circuit that produces a repetitive electronic signal, often a sine wave or a square wave. They are widely used in many electronic devices. Common examples of signals generated by oscillators include signals broadcast by radio and television transmitters, clock signals that regulate computers and quartz clocks, and the sounds produced by electronic beepers and video games.

Oscillators are often characterized by the frequency of their output signal: an audio oscillator produces frequencies in the audio range, about 16 Hz to 20 kHz. An RF oscillator produces signals in the radio frequency (RF) range of about 100 kHz to 100 GHz. A low-frequency oscillator (LFO) is an electronic oscillator that generates a frequency below ≈20 Hz. This term is typically used in the field of audio synthesizers, to distinguish it from an audio frequency oscillator. Oscillators designed to produce a high-power AC output from a DC supply are usually called inverters.

There are two main types of electronic oscillator: the harmonic oscillator and the relaxation oscillator.

4.7.1 Oscillator Circuits:

Energy needs to move back and forth from one form to another for an oscillator to work. You can make a very simple oscillator by connecting a capacitor and an inductor together. If you've read How Capacitors Work and How Inductors Work, you know that both capacitors and inductors **store energy**. A capacitor stores energy in the form of an electrostatic field, while an inductor uses a magnetic field.

Imagine the following circuit:

If you charge up the capacitor with a battery and then insert the inductor into the circuit, here's what will happen:

- The capacitor will start to discharge through the inductor. As it does, the inductor will create a magnetic field.

- Once the capacitor discharges, the inductor will try to keep the current in the circuit moving, so it will charge up the other plate of the capacitor.
- Once the inductor's field collapses, the capacitor has been recharged (but with the opposite polarity), so it discharges again through the inductor.

This oscillation will continue until the circuit runs out of energy due to **resistance** in the wire. It will oscillate at a frequency that depends on the size of the inductor and the capacitor.

4.7.1.1 Colpitts Oscillator:

A **Colpitts oscillator**, invented in 1920 by American engineer Edwin H. Colpitts, is one of a number of designs for oscillator circuits using the combination of an inductance (L) with a capacitor (C) for frequency determination, thus also called LC oscillator. The distinguishing feature of the Colpitts circuit is that the feedback signal is taken from a voltage divider made by two capacitors in series. One of the advantages of this circuit is its simplicity; it needs only a single inductor. Colpitts obtained US Patent 1624537 for this circuit.

The frequency is generally determined by the inductor and the two capacitors at the bottom of the drawing.

A Colpitts oscillator is the electrical dual of a Hartley oscillator. Fig. 4.3 shows the basic Colpitts circuit, where two capacitors and one inductor determine the frequency of oscillation. The feedback needed for oscillation is taken from voltage made of two capacitors, whereas in the Hartley oscillator the feedback is taken from a voltage divider made of two inductors (or a single, tapped inductor).

As with any oscillator, the amplification of the active component should be marginally larger than the attenuation of the capacitive voltage divider, to obtain stable operation. Thus, a Colpitts oscillator used as a variable frequency oscillator (VFO) performs best when a variable inductance is used for tuning, as opposed to tuning one of the two capacitors. If tuning by variable capacitor is needed, it should be done via a third capacitor connected in parallel to the inductor (or in series as in the Clapp oscillator).

Fig. 4.4 shows an often preferred variant, where the inductor is also grounded (which makes circuit layout easier for higher frequencies). Note that feedback energy is fed into the connection between the two capacitors. This amplifier provides current, not voltage, amplification.

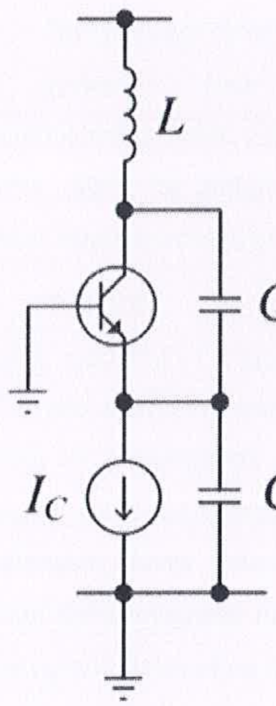

Fig: 4.6: Simple common Colpitts oscillator

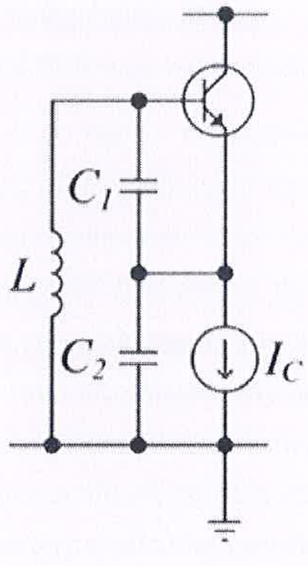

Fig: 4.7: Colpitts Oscillator with current amplification

4.8 Antenna:

An antenna is an electrical device which converts electric currents into radio waves, and vice versa. It is usually used with a radio transmitter or radio receiver. In transmission, a radio transmitter applies an oscillating radio frequency electric current to the antenna's terminals, and the antenna radiates the energy from the current as electromagnetic waves (radio waves). In reception, an antenna intercepts some of the power of an electromagnetic wave in order to produce a tiny voltage at its terminals that is applied to a receiver to be amplified. An antenna can be used for both transmitting and receiving.

Antennas are essential components of all equipment that uses radio. They are used in systems such as radio broadcasting, broadcast television, radio, communications, radar, cell phones, and satellite communications, as well as other devices such as garage door openers, wireless microphones, Bluetooth enabled devices, wireless computer networks, baby monitors, and RFID tags on merchandise.

Typically an antenna consists of an arrangement of metallic conductors ("elements"), electrically connected (often through a transmission line) to the receiver or transmitter. An oscillating current of electrons forced through the antenna by a transmitter will create an oscillating magnetic field around the antenna elements, while the charge of the electrons also creates an oscillating electric field along the elements. These time-varying fields radiate away from the antenna into space as a moving electromagnetic field wave. Conversely, during reception, the oscillating electric and magnetic fields of an incoming radio wave exert force on the electrons in the antenna elements, causing them to move back and forth, creating oscillating currents in the antenna.

Antennas may also contain reflective or directive elements or surfaces not connected to the transmitter or receiver, such as parasitic elements, parabolic reflectors or horns, which serve to direct the radio waves into a beam or other desired radiation pattern. Antennas can be designed to transmit or receive radio waves in all directions equally (unidirectional antennas), or transmit them in a beam in a particular direction, and receive from that one direction only (directional or high gain antennas).

4.8.1 Terminology:

The words *antenna* and *aerial* are used interchangeably. Occasionally a rigid metallic structure is called an "antenna" while the wire form is called an "aerial". However, note the important international technical journal, the *IEEE Transactions on Antennas and Propagation*.[2] In the United Kingdom and other areas where British English is used, the term aerial is sometimes used although 'antenna' has been universal in professional use for many years.

The origin of the word *antenna* relative to wireless apparatus is attributed to Italian radio pioneer Guglielmo Marconi. In 1895, while testing early radio apparatus in the Swiss Alps at Salvan, Switzerland in the Mont Blanc region, Marconi experimented with long wire "aerials". He used a 2.5 meter vertical pole, with a wire attached to the top running down to the transmitter, as a radiating and receiving aerial element. In Italian a tent pole is known as *l'antenna centrale,* and the pole with the wire was simply called *l'antenna.* Until then wireless radiating transmitting and receiving elements were known simply as aerials or terminals. Because of his prominence, Marconi's use of the word *antenna* (Italian for *pole*) spread among wireless researchers, and later to the general public.

In common usage, the word *antenna* may refer broadly to an entire assembly including support structure, enclosure (if any), etc. in addition to the actual functional components. Especially at microwave frequencies, a receiving antenna may include not only the actual electrical antenna but an integrated preamplifier or mixer.

4.8.2 Overview:

Antennas are required by any radio receiver or transmitter to couple its electrical connection to the electromagnetic field. Radio waves are electromagnetic which carry signals through the air (or through space) at the speed of light with almost no transmission loss. Radio transmitters and receivers are used to convey signals (information) in systems including broadcast (audio) radio, television, mobile telephones, Wi-Fi (WLAN) data networks, trunk lines and point-to-point communications links (telephone, data networks), satellite links, many remote controlled devices such as garage door openers, and wireless remote sensors, among many others. Radio waves are also used directly for measurements in technologies including RADAR, GPS, and radio astronomy. In each and every case, the transmitters and receivers involved require antennas, although these are sometimes hidden (such as the antenna inside an AM radio or inside a laptop computer equipped with Wi-Fi).

According to their applications and technology available, antennas generally fall in one of two categories:

1. Omnidirectional or only weakly directional antennas which receive or radiate more or less in all directions. These are employed when the relative position of the other station is unknown or arbitrary. They are also used at lower frequencies where a directional antenna would be too large, or simply to cut costs in applications where a directional antenna isn't required.
2. Directional or *beam* antennas which are intended to preferentially radiate or receive in a particular direction or directional pattern.

In common usage "omnidirectional" usually refers to all horizontal directions, typically with reduced performance in the direction of the sky or the ground (a truly isotropic radiator is not even possible). A "directional" antenna usually is intended to maximize its coupling to the electromagnetic field in the direction of the other station, or sometimes to cover a particular sector such as a 120° horizontal fan pattern in the case of a panel antenna at a cell site.

One example of omnidirectional antennas is the very common *vertical antenna* or whip antenna consisting of a metal rod (often, but not always, a quarter of a wavelength long). A dipole antenna is similar but consists of two such conductors extending in opposite directions, with a total length that is often, but not always, a half of a wavelength long. Dipoles are typically oriented horizontally in which case they are weakly directional: signals are reasonably well radiated toward or received from all directions with the exception of the direction along the conductor itself; this region is called the antenna blind cone or null.

Both the vertical and dipole antennas are simple in construction and relatively inexpensive. The dipole antenna, which is the basis for most antenna designs, is balanced component, with equal but opposite voltages and currents applied at its two terminals through a balanced transmission line. The vertical antenna, on the other hand, is a *monopole* antenna. It is typically connected to the inner conductor of a coaxial transmission line (or a matching network); the shield of the transmission line is connected to ground. In this way, the ground (or any large conductive surface) plays the role of the second conductor of a dipole, thereby forming a complete circuit. Since monopole antennas rely on a conductive ground, a so-called grounding structure may be employed to provide a better ground contact to the earth or which itself acts as a ground plane to perform that function regardless of (or in absence of) an actual contact with the earth.

Antennas more complex than the dipole or vertical designs are usually intended to increase the directivity and consequently the gain of the antenna. This can be accomplished in many different ways leading to a plethora of antenna designs. The vast majority of designs are fed with a balanced line (unlike a monopole antenna) and are based on the dipole antenna with additional components (or *elements*) which increase its directionality. Antenna "gain" in this instance describes the concentration of radiated power into a particular solid angle of space, as opposed to the spherically uniform radiation of the ideal radiator. The increased power in the desired direction is at the expense of that in the undesired directions. Power is conserved, and there is no net power increase over that delivered from the power source (the transmitter.)

For instance, a phased array consists of two or more simple antennas which are connected together through an electrical network. This often involves a number of parallel dipole antennas with certain spacing. Depending on the relative phase introduced by the network, the same combination of dipole antennas can operate as a "broadside array" (directional normal to a line connecting the elements) or as an "end-fire array" (directional along the line connecting the elements). Antenna arrays may employ any basic (omnidirectional or weakly directional) antenna type, such as dipole, loop or slot antennas. These elements are often identical.

However a log-periodic dipole array consists of a number of dipole elements of *different* lengths in order to obtain a somewhat directional antenna having an extremely wide bandwidth: these are frequently used for television reception in fringe areas. The dipole antennas composing it are all considered "active elements" since they are all electrically connected together (and to the transmission line). On the other hand, a superficially similar dipole array, the Yagi-Uda Antenna (or simply "Yagi"), has only one dipole element with an electrical connection; the other so-called parasitic elements interact with the electromagnetic field in order to realize a fairly directional antenna but one which is limited to a rather narrow bandwidth. The Yagi antenna has similar looking parasitic dipole elements but which act differently due to their somewhat different lengths. There may be a number of so-called "directors" in front of the active element in the direction of propagation, and usually a single (but possibly more) "reflector" on the opposite side of the active element.

Greater directionality can be obtained using beam-forming techniques such as a parabolic reflector or a horn. Since the size of a directional antenna depends on it being large compared to the wavelength, very directional antennas of this sort are mainly feasible at UHF and microwave frequencies. On the other hand, at low frequencies (such as AM broadcast) where a practical antenna must be much smaller than a wavelength, significant directionality isn't even possible. A vertical antenna or loop antenna small compared to the wavelength is typically used, with the main design challenge being that of impedance matching. With a vertical antenna a *loading coil* at the base of the antenna may be employed to cancel the reactive component of impedance; small loop antennas are tuned with parallel capacitors for this purpose.

An antenna lead-in is the transmission line (or *feed line*) which connects the antenna to a transmitter or receiver. The *antenna feed* may refer to all components connecting the antenna to the transmitter or receiver, such as an impedance matching network in addition to the transmission line. In a so-called aperture antenna, such as a horn or parabolic dish, the "feed" may also refer to a basic antenna inside the entire system (normally at the focus of the parabolic dish or at the throat of a horn) which could be considered the one active element in that antenna system. A microwave antenna may also be fed directly from a waveguide in lieu of a (conductive) transmission line.

An antenna counterpoise or ground plane is a structure of conductive material which improves or substitutes for the ground. It may be connected to or insulated from the natural ground. In a monopole antenna, this aids in the function of the natural ground, particularly where variations (or limitations) of the characteristics of the natural ground interfere with its proper function. Such a structure is normally connected to the return connection of an unbalanced transmission line such as the shield of a coaxial cable.

An electromagnetic wave *refractor* in some aperture antennas is a component which due to its shape and position functions to selectively delay or advance portions of the electromagnetic wavefront passing through it. The refractor alters the spatial characteristics of the wave on one side relative to the other side. It can, for instance, bring the wave to a focus or alter the wave front in other ways, generally in order to maximize the directivity of the antenna system. This is the radio equivalent of an optical lens.

An antenna coupling network is a passive network (generally a combination of inductive and capacitive circuit elements) used for impedance matching in between the antenna and the transmitter or receiver. This may be used to improve the standing wave ratio in order to minimize losses in the transmission line and to present the transmitter or receiver with a standard resistive impedance that it expects to see for optimum operation.

4.8.3 Basic Antenna Models:

There are many variations of antennas. Below are a few basic models. More can be found in Category: Radio frequency antenna types.

- The isotropic radiator is a purely theoretical antenna that radiates equally in all directions. It is considered to be a point in space with no dimensions and no mass. This antenna cannot physically exist, but is useful as a theoretical model for comparison with all other antennas. Most antennas' gains are measured with reference to an isotropic radiator, and are rated in dBi (decibels with respect to an isotropic radiator).
- The dipole antenna is simply two wires pointed in opposite directions arranged either horizontally or vertically, with one end of each wire

connected to the radio and the other end hanging free in space. Since this is the simplest practical antenna, it is also used as a reference model for other antennas; gain with respect to a dipole is labeled as dBd. Generally, the dipole is considered to be omnidirectional in the plane perpendicular to the axis of the antenna, but it has deep nulls in the directions of the axis. Variations of the dipole include the folded dipole, the half wave antenna, the ground plane antenna, the whip, and the J-pole.

- The Yagi-Uda antenna is a directional variation of the dipole with parasitic elements added which are functionality similar to adding a reflector and lenses (directors) to focus a filament light bulb.
- The random wire antenna is simply a very long (at least one quarter wavelength wire with one end connected to the radio and the other in free space, arranged in any way most convenient for the space available. Folding will reduce effectiveness and make theoretical analysis extremely difficult. (The added length helps more than the folding typically hurts.) Typically, a random wire antenna will also require an antenna tuner, as it might have random impedance that varies non-linearly with frequency.
- The horn antenna is used where high gain is needed, the wavelength is short (microwave) and space is not an issue. Horns can be narrow band or wide band, depending on their shape. A horn can be built for any frequency, but horns for lower frequencies are typically impractical. Horns are also frequently used as reference antennas.
- The parabolic antenna consists of an active element at the focus of a parabolic reflector to reflect the waves into a plane wave. Like the horn it is used for high gain, microwave applications, such as satellite dishes.
- The patch antenna consists mainly of a square conductor mounted over a groundplane. Another example of a planar antenna is the tapered slot antenna (TSA), as the Vivaldi-antenna.

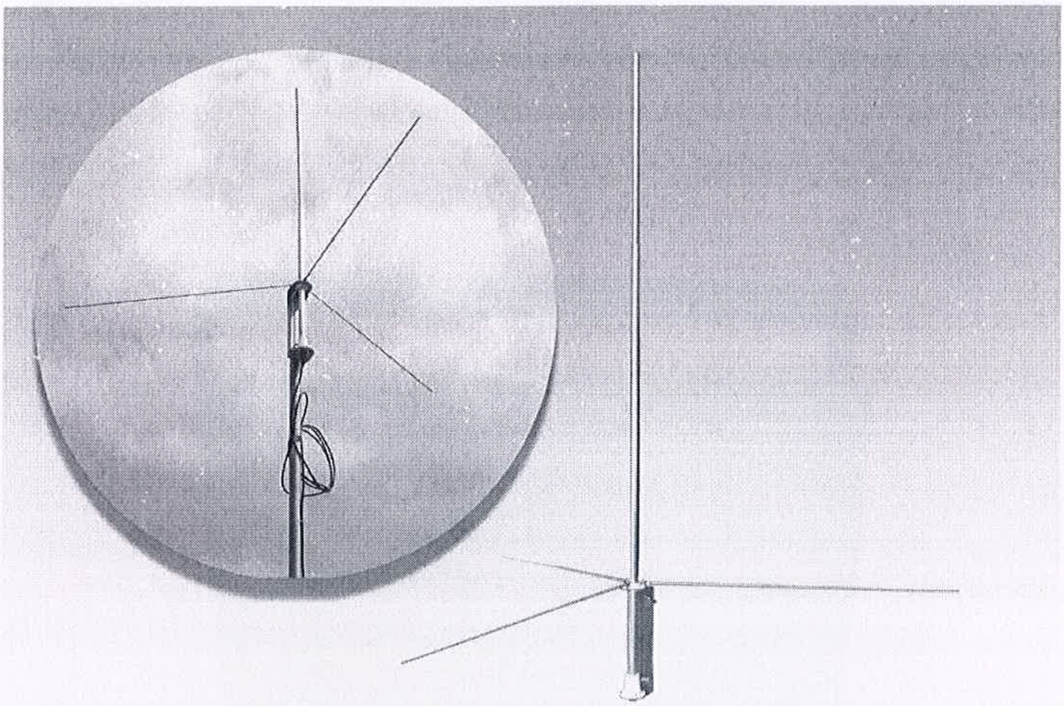

Fig 4.8: FM Antennas

4.9 FM Receiver:

The FM Receiver is the end part of the communication. We can find this section in every general FM receiver available in the market

Fig 4.9 FM Receiver

In these mixers, frequency changers, am modulation and amplifiers. The F.M. 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.

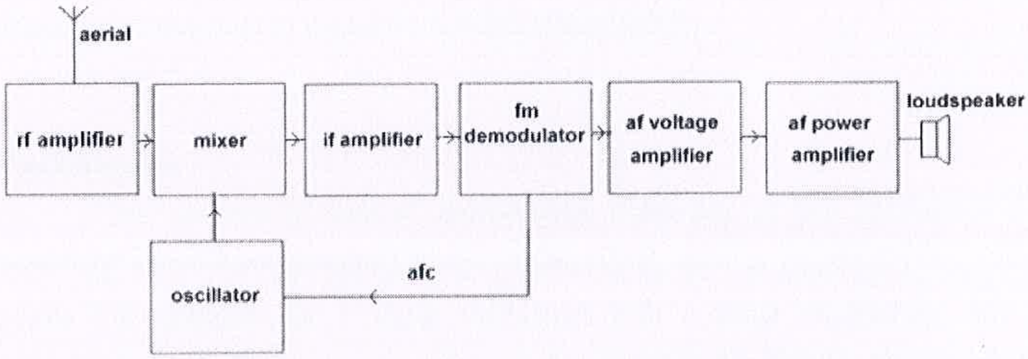

Fig 4.10 FM Receiver Internal Block Diagram

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.

4.10 FM Demodulator:

Demodulation is the act of extracting the original information-bearing signal from a modulated carrier wave. A demodulator is an electronic circuit (or computer in a software-defined radio) that is used to recover the information content from the modulated carrier wave.

These terms are traditionally used in connection with radio receivers, but many other systems use many kinds of demodulators. Another common one is in a modem, which is a contraction of the terms modulator/demodulator.

Techniques:

There are several ways of demodulation depending on how parameters of the base-band signal are transmitted in the carrier signal, such as amplitude, frequency or phase. For example, for a signal modulated with a linear modulation, like AM (Amplitude Modulation), we can use a synchronous detector. On the other hand, for a signal modulated with an angular modulation, we must use an FM (Frequency Modulation) demodulator or a PM (Phase Modulation) demodulator. Different kinds of circuits perform these functions.

Many techniques—such as carrier recovery, clock recovery, bit slip, frame synchronization, rake receiver, pulse compression, Received Signal Strength Indication, error detection and correction, etc. -- are only performed by demodulators, although any specific demodulator may perform only some or none of these techniques.

CONCLUSION:

In summary, the designed FM transmitter will be able to take in an audio input from a Bluetooth input and transmit it to an FM receiver. The transmitter will be able to transmit from 87.5MHz to 108MHz. The device is powered from a 9V dc, which is stepped down through a circuit connected to a 50Hz 220VAC standard outlet.

The design implements all requirements and takes into consideration limitations imposed by internal and external forces. Some of these forces include, client needs, government regulations, and size constraints. After researching possible technologies, the design has been implemented in a simple, yet thorough manner using proven components. The designed solution meets or exceeds all specifications.

The end-product is expected to not only perform the required functions, but prove to be a competitive model in the commercial market of FM transmitters. This design is capable of meeting the goal of having a product that will stand out in the marketplace. All current indications are that this project is successful and there is a huge scope in future to develop this design in the field of "Near field communication".

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