MOBILE SIGNAL CANCELLATION DEVICE

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ABSTRACT

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(Keywords: Mobile phone, signal cancellation device, block signal)

The number of users of mobile communication devices is rapidly increasing nowadays, proving the communications industry is very important. The use of mobile phones however generates electromagnetic radiation which then scatters to surrounding. The resulting radiation can generate problems and damages to human and surrounding. Sometimes, there is a growing demand for controlling the use of cellular phones in public places such as religious places, examination halls, libraries, and others. Therefore, it is important to block signal to and from mobile phone at certain areas. The overall aim of this project is to design and built a signal cancellation device for mobile phones. The device provides the advantage in preventing mobile phone from receiving and transmitting RF signal to base station.

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LIST OF ABBREVIATIONS

GSM	-	Global System for Mobile
RF	-	Radio Frequency
AMPS	-	Advanced Mobile Phone System
CDMA	-	Code Division Multiple Access
FDMA	-	Frequency Division Multiple Access
TDMA	-	Time Division Multiple Access
PCS	-	Personal Communication Service
DCS	-	Distributed Controlled System
iDEN	-	Integrated Digital Enhanced Network
EMI	-	Electromagnetic interference
BSS	-	Base Station Subsystem
BTS	-	Base Transceiver Station
SNR	-	Signal to Noise Ratio
RACH	-	Random Access Channel
VCO	-	Voltage Controlled Oscillator
IC	-	Integrated Circuit
PCB	-	Printed Circuit Board

CHAPTER 1

PROJECT BACKGROUND

1.1 Introduction

A mobile signal cancellation device is a device that transmit signal on the same frequency at which the GSM system operates, the jamming success when the mobile phones in the area where the device is located are disabled. Sometimes, this device is also known as mobile jammer.

Military initiated the development and utilized communication jamming devices. Where tactical commanders used RF communications to exercise control of their forces, an enemy has interest in those communications. This interest comes from the fundamental area of denying the successful transport of the information from the sender to the receiver. Nowadays the signal cancellation devices are becoming civilian products rather than electronic warfare devices, since with the increasing number of the mobile phone user the need to disable mobile phone in specific places where the ringing of cell phone would be disruptive has increased(Jisrawi). These places included worship places, university lecture rooms, libraries, concert halls, meeting rooms, and other places where silence is appreciated.

Mosques are obvious example for the places that mobile signal cancellation device would be a great solution, although mosques normally asks from prayers to disable their mobile phone during the prayer u, but some people forget and the ringing phone of their mobile phone becomes very annoying.

1.2 Objectives

These are the main objectives of conducting this project:

- To develop a mobile signal cancellation device that can detect and restrict mobile phone signal which is 10 – 20m and up in diameter and 20 meters far from transmitting station.
- To block all kinds of mobile phones ringing sound at certain places such as banks, mosques, libraries, movie theaters, meeting rooms and others.
- To disable effectively mobile phones within the defined regulated zones without causing any interference to other communication.

1.3 Problem statement

Mobile phones are widely used these days and well known for its property as a good medium of communication. However, there are certain areas where the use of mobile phones would be particularly prohibited or where the radio transmissions are dangerous.

Indeed, while the inappropriate ringing, and unreasonably loud conversations can be annoying, the sense of powerless, or lack of control increase the frustration. As a result, there have been some attempts to control cell phone use, to create 'safe zones' of Hertzian space. In some cities, trains and trolleys have designated "quiet cars," for people who prefer no cell usage.

The easiest and most common technique to curbing cell use is requesting courtesy for others. It is somewhat convenient for some businesses and places of worship and also other restricted areas, rather than request polite cell-use, simply disable all cell phones from being used.

This project will investigate and design the device that will be used for canceling the signal to and from mobile phones.

1.4 Project Scopes

Cell phones are full-duplex devices, which mean they use two separate frequencies, one for talking and one for listening simultaneously. Some devices block only one of the frequencies used by cell phones, which has the effect of blocking both. The phone is tricked into thinking there is no service because it can receive only one of the frequencies.

The mobile signal cancellation device will be designed to:

- restrict the mobile phone signal which 10m~20m & up in diameter and 20 meters far from the transmitting station.
- shield only mobile phone signals, but has no influence on other electronic equipments, audio equipments and human bodies.
- be easily installed and the connector plug is the only one that is needed to install.

To jam a cell phone, a device that broadcasts on the correct frequencies is needed. Although different cellular systems process signals differently, all cell-phone networks use radio signals that can be interrupted. The device's effect can vary widely based on factors such as proximity to towers, indoor and outdoor setting, presence of buildings and landscape, even temperature and humidity play a role.

1.5 Technical Parameters

Technical parameters related to the device are:

1) Working frequency : 935 MHz – 960 MHz
2) Working frequency band : GSM 900
3) Power Input : 240 V
4) Dimensions : 210 (L) * 135 (W) * 45 (H)mm
5) Antenna : Helical antenna (Omni directional radiation pattern)

Jammers can broadcast on any frequency and are effective against AMPS, CDMA, TDMA, GSM, PCS, DCS, iDEN and Nextel systems.

The GSM transmission frequencies band is presented in the following table.

Table 1.1 GSM 900 Frequency Bands

	UP-LINK	DOWN-LINK
GSM 900	890-915 MHz	935-960 MHz

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter explains the literature review involved regarding the project title. Basic definition and operation of mobile signal cancellation device are described.

2.2 Mobile Signal Cancellation Device

Also known as mobile jammer, a mobile signal cancellation device is a transmitter used to broadcast electromagnetic signals capable of blocking frequencies used by cellular/PCS systems. When active in a certain area, the mobile jammer will prevent any cellular/PCS system from communicating with the base station, and by this prohibiting all incoming and outgoing calls (Azza, Hijazi, & Mahmoudy).

Jamming devices overpower the cell phone by transmitting a signal on the same frequency as the cell phone and at a high enough power that the two signals collide and cancel each other out. Cell phones are designed to add power if they experience low-level interference, so the jammer must recognize and match the power increase from the phone. Cell phones are full-duplex devices, which mean they use two separate frequencies, one for talking and one for listening simultaneously. Some jammers block only one of the frequencies used by cell phones, which has the effect of blocking both (Wollenhaupt, 2005). The phone is tricked into thinking there is no service because it can receive only one of the frequencies.

Less complex devices block only one group of frequencies, while sophisticated jammers can block several types of networks at once to head off dual-mode or tri-mode phones that automatically switch among different network types to find an open signal. Some of the high-end devices block all frequencies at once and others can be tuned to specific frequencies (Wollenhaupt, 2005).

2.2.1 Mobile Signal Cancellation Device Operation

To jam a mobile phone, what is needed is a device that broadcasts on the correct frequencies. Although different cellular systems process signals differently, all cell-phone networks use radio signals that can be interrupted. GSM, used in digital cellular and PCS-based systems, operates in the 900-MHz and 1800-MHz bands in Europe and Asia and in the 1900-MHz (sometimes referred to as 1.9-GHz) band in the United States. Jammers can broadcast on any frequency and are effective against AMPS, CDMA, TDMA, GSM, PCS, DCS, iDEN and Nextel systems (Wollenhaupt, 2005). Old-fashioned analog cell phones and today's digital devices are equally susceptible to jamming. Disrupting a cell phone is the same as jamming any other type of radio communication. A cell phone works by communicating with its service network through a cell tower or base station. Cell towers divide a city into small areas, or cells. As a cell phone user drives down the street, the signal is handed from tower to tower.

A jamming device transmits on the same radio frequencies as the cell phone, which is 900MHz disrupting the communication between the phone and the cell-phone base station in the town. The power of the jammer's effect can vary widely based on factors such as proximity to towers, indoor and outdoor settings, presence of buildings and landscape, even temperature and humidity play a role. There are concerns that crudely designed jammers may disrupt the functioning of medical devices such as pacemakers. However, like cell phones, most of the devices in common use operate at low enough power output (<1W) to avoid causing any problems (Wollenhaupt, 2005).

2.3 Mobile Signal Cancellation Device Techniques

Five types of devices are known to have been developed (or being considered for development) for preventing mobile phones' communications in certain specified locations (RABC):

2.3.1 Type "A" Device: JAMMERS

In this device we overpower cell phone's signal with a stronger signal, This type of device comes equipped with several independent oscillators transmitting 'jamming signals' capable of blocking frequencies used by paging devices as well as those used by cellular/PCS systems' control channels for call establishment. When active in a designated area, such devices will (by means of RF interference) prevent all pagers and mobile phones located in that area from receiving and transmitting calls. This type of device transmits only a jamming signal and has very poor frequency selectivity, which leads to interference with a larger amount of communication spectrum than it was originally intended to target. Technologist Jim Mahan said, "There are two types. One is called brute force jamming, which just blocks everything. The problem is, it's like power-washing the airwaves and it bleeds over into the public broadcast area. The other puts out a small amount of interference, and you could potentially confine it within a single cell block. You could use lots of little pockets of small jamming to keep a facility under control."

2.3.2 Type "B" Device: INTELLIGENT CELLULAR DISABLERS

Unlike jammers, Type "B" devices do not transmit an interfering signal on the control channels. The device, when located in a designated 'quiet' area, functions as a 'detector'. It has a unique identification number for communicating with the cellular base station. When a Type "B" device detects the presence of a mobile phone in the quiet room; the 'filtering' (i.e. the prevention of authorization of call establishment) is done by the software at the base station.

When the base station sends the signaling transmission to a target user, the device after detecting simultaneously the presence of that signal and the presence of the target user, signals the base station that the target user is in a 'quiet' room; therefore, do not establish the communication. Messages can be routed to the user's voice- mail box, if the user subscribes to a voice-mail service. This process of detection and interruption of call establishment is done during the interval normally reserved for signaling and handshaking. For 'emergency users', the intelligent detector device makes provisions for designated users who have emergency status. These users must pre-register their phone numbers with the service providers. When an incoming call arrives, the detector recognizes that number and the call are established for a specified maximum duration, say two minutes. The emergency users are also allowed to make out going calls. Similarly, the system is capable of recognizing and allowing all emergency calls routed to "911".

It should be noted that the Type "B" detector device being an integral part of the cellular/PCS systems, would need to be provisioned by the cellular/PCS service providers or provisioned by a third-party working cooperatively with full support of the cellular/PCS service providers.

2.3.3 Type "C" Device: INTELLIGENT BEACON DISABLERS

Unlike jammers, Type "C" devices do not transmit an interfering signal on the control channels. The device, when located in a designated 'quiet' area, functions as a 'beacon' and any compatible terminal is instructed to disable its ringer or disable its operation, while within the coverage area of the beacon. Only terminals which have a compatible receiver would respond and this would typically be built on a separate technology from cellular/PCS, e.g., cordless wireless, paging, ISM, Bluetooth. On leaving the coverage area of the beacon, the handset must re-enable its normal function.

This technology does not cause interference and does not require any changes to existing PCS/cellular operators. The technology does require intelligent handsets with a separate receiver for the beacon system from the cellular/PCS receiver. It will not prevent normal operation for incompatible legacy terminals within a "quiet" coverage area, thus effective deployment will be problematic for many years.

While general uninformed users would lose functionality, pre-designated "emergency" users could be informed of a "bypass terminal key sequence" to inhibit response to the beacon. Assuming the beacon system uses a technology with its own license (or in the license exempt band), no change to the regulations are needed to deploy such a system. With this system, it would be extremely difficult to police misuse of the "bypass key sequence" by users.

2.3.4 Type "D" Device: DIRECT RECEIVE & TRANSMIT JAMMERS

This jammer behaves like a small, independent and portable base station, which can directly interact intelligently or unintelligently with the operation of the local mobile phone. The jammer is predominantly in receiving mode and will intelligently choose to interact and block the cell phone directly if it is within close proximity of the jammer.

This selective jamming technique uses a discriminating receiver to target the jamming transmitter. The benefit of such targeting selectivity is much less electromagnetic pollution in terms of raw power transmitted and frequency spectrum from the jammer, and therefore much less disruptive to passing traffic. The jam signal would only stay on as long as the mobile continues to make a link with the base station, otherwise there would be no jamming transmission – the technique forces the link to break or unhook and then it retreats to a passive receive mode again.

This technique could be implemented without cooperation from PCS/cellular providers, but could negatively impact PCS/cellular system operation. This technique has an added advantage over Type B in that no added overhead time or effort is spent negotiating with the cellular network. As well as Type B, this device could discriminate 911 calls and allow for breakthroughs" during emergencies.

2.3.5 Type "E" Device: EMI SHIELD - PASSIVE JAMMING

This technique is using EMI suppression techniques to make a room into what is called a Faraday cage. Although labor intensive to construct, the Faraday cage essentially blocks, or greatly attenuates, virtually all electromagnetic radiation from entering or leaving the cage or in this case a target room.

With current advances in EMI shielding techniques and commercially available products one could conceivably implement this into the architecture of newly designed buildings for so-called "quiet-conference" rooms. Emergency calls would be blocked unless there was a way to receive and decode the 911 transmissions, pass by coax outside the room and re-transmitted.

This passive configuration is currently legal in Canada for any commercial or residential location insofar as DOC Industry Canada is concerned, however municipal or provincial building code by- laws may or may not allow this type of construction.

2.4 GSM – MOBILE JAMMING REQUIREMENTS

Jamming objective is to inject an interference signal into the communications frequency so that the actual signal is completely submerged by the interference. It is important to notice that transmission can never be totally jammed - jamming hinders the reception at the other end. The problem here for the jammer is that only transmitters can be found using direction finding and the location of the target must be a specific location, usually where the jammer is located and this is because the jamming power is never infinite. Jamming is successful when the jamming signal denies the usability of the communications transmission. In digital communications, the usability is denied when the error rate of the transmission cannot be compensated by error correction. Usually a successful jamming attack requires that the jammer power is roughly equal to signal power at the receiver. The effects of jamming depend on the jamming-to-signal ratio (J/S), modulation scheme, channel coding and interleaving of the target system. Generally Jamming-to-Signal ratio can be measured according to the following Equation.

$$\frac{J}{S} = \frac{P_j\, G_{jr}\, Gr_j\, R^2{}_{tr}\, L_r\, B_r}{P_t\, G_{tr}\, G_{rt}\, R^2{}_{jr}\, L_j\, Bj}$$

$$\frac{J}{S}$$

P_j= jammer power P_t= transmitter power

G_{jr}= antenna gain from jammer to receiver

G_{rj}= antenna gain from receiver to Jammer

G_{tr}= antenna gain from transmitter to receiver

G_{rt}= antenna gain from receiver to transmitter

B_r= communications receiver bandwidth

B_j= jamming transmitter bandwidth

R_{tr}= range between communications transmitter and receiver

R_{jt}= range between jammer and communications receiver

L_j= jammer signal loss (including polarization mismatch)

L_r= communication signal loss

The above equation indicates that the jammer Effective Radiated Power, which is the product of antenna gain and output power, should be high if jamming efficiency is required. On the other hand, in order to pr event jamming, the antenna gain toward the communication partner should be as high as possible while the gain towards the jammer should be as small as possible. As the equation shows, the antenna pattern, the relation between the azimuth and the gain, is a very important aspect in jamming.

Also as we know from Microwave and shown in the equation distance has a strong influence on the signal loss. If the distance between jammer and receiver is doubled, the jammer has to quadruple its output in order for the jamming to have the same effect. It must also be noted here the jammer path loss is often different from the communications path loss; hence gives jammer an advantage over communication transmitters. In the GSM network, the Base Station Subsystem (BSS) takes care of the radio resources. In addition to Base Transceiver Station (BTS), the actual RF transceiver, BSS consists of three parts. These are the Base Station Controller (BSC), which is in charge of mobility management and signaling on the Air-interface between Mobile Station (MS), the BTS, and the Air-interface between BSS and Mobile Services Switching Center (MSC).

The GSM Air-interface uses two different multiplexing schemes: TDMA (Time Division Multiple Access) and FDMA (Frequency Division Multiple Access). The spectrum is divided into 200 kHz channels (FDMA) and each channel is divided into 8 timeslots (TDMA). Each 8 timeslot TDMA frame has duration of 4.6 ms (577 s/timeslot) [3]. The GSM transmission frequencies are presented in Table 1.

Table 2.1 GSM 900 Frequency Bands

	Uplink	Downlink
GSM 900	890-915 MHz	935-960 MHz

Frequency Hopping in GSM is intended for the reduction of fast fading caused by movement of subscribers. The hopping sequence may use up to 64 different frequencies, which is a small number compared to military FH systems designed for avoiding jamming. Also, the speed of GSM hopping is approximately 200 hops /s; So GSM Frequency Hopping does not provide real protection against jamming attacks.

Although FH does not help in protection against jamming, interleaving and forward error correction scheme GSM Systems can protect GSM against pulsed jamming. For GSM it was shown that as the specified system SNR is 9 dB, a jammer min requires a 5 dB S/J in order to successfully jam a GSM channel. The optimum GSM SNR is 12 dB, after this point the system starts to degrade.

GSM system is capable to withstand abrupt cuts in Traffic Channel (TCH) connections. These cuts are normally caused by propagation losses due to obstacles such as bridges. Usually another cell could be used to hold communication when the original BTS has disconnected. The GSM architecture provides two solutions for this: first handover when the connection is still available, second call reestablishment when the original connection is totally lost. Handover decisions are made based on transmission quality and reception level measurements carried out by the MS and the BTS. In jamming situations call re-establishment is probably the procedure the network will take in order to re-connect the jammed TCH.

It is obvious that downlink jamming (i.e. Jamming the mobile station 'handset'(receiver) is easier than uplink, as the base station antenna is usually located far away from the MS on a tower or a high building. This makes it efficient for the jammer to overpower the signal from BS. But the Random Access Channel (RACH) control channels of all BTSs in the area need to be jammed in order to cut off transmission. To cut an existing connections, the jamming has to last at least until the call re-establishment timer at the MSC expires and the connection is released, which means that an existing call can be cut after a few seconds of effective jamming.

The GSM RACH random access scheme is very simple: when a request is not answered, the mobile station will repeat it after a random interval. The maximum number of repetitions and the time between them is broadcast regularly. After a MS has tried to request service on RACH and has been rejected, it may try to request service from another cell. Therefore, the cells in the area should be jammed. In most cases, the efficiency of a cellular jamming is very difficult to determine, since it depends on many factors, which leaves the jammer confused.

2.5 DESIGN AND IMPLEMENTATION OF GSM MOBILE JAMMER

The Implementation of type "A" JAMMER is fairly simple, the block diagram for this type is shown in Figure 2.1, it shows the main parts which are: RF-section, IF-section, and the power supply.

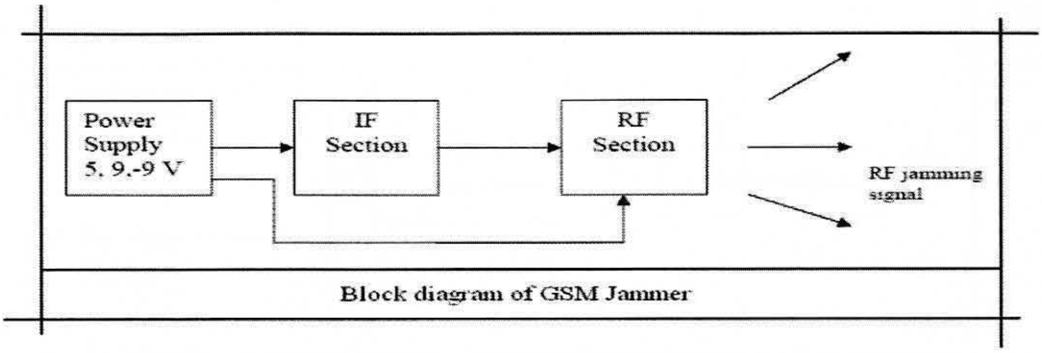


Figure 2.1: Block diagram of GSM Jammer

2.5.1 IF-Section

The function of the IF-section of the Mobile jammer is to generate the tuning signal for the VCO in the RF-Section, which will sweep the VCO through the desired range of frequencies. This tuning signal is generated by a triangular wave generator (110 KHz) along with noise generator, and then offset by proper amount so as to sweep the VCO output from the minimum desired frequency to a maximum.

The components of the IF Section are as follows:

i. 555 Timer IC (Triangular Wave Generator)

ii. Zener Diode (Noise Generator)

iii. Op-Amp in Summer Configuration (Signal Mixer)

iv. Diode–Clamper (Offset Circuit)

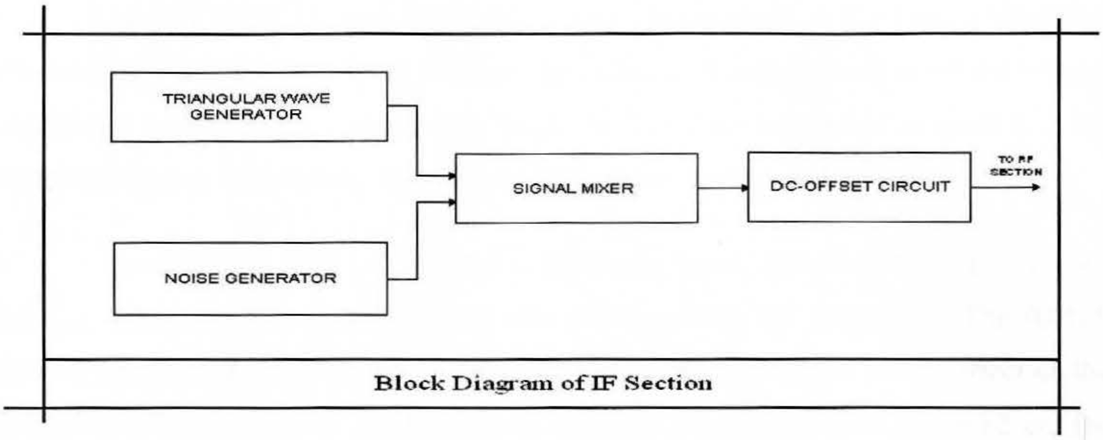


Figure 2.2: Block diagram of IF Section

2.5.1.1 Triangular Wave Generator

Our requirement is to have a 110 KHz wave for which we have used a 555 timer IC. The 555 timer is used in the astable multivibrator mode. It basically consists of two comparators, a flip-flop, a discharge transistors and a resistive voltage divider to set the voltages at different comparator levels. The Figure (2.3) shows the 555 timer connected to operate in the astable multivibrator mode as a non-sinusoidal oscillator.

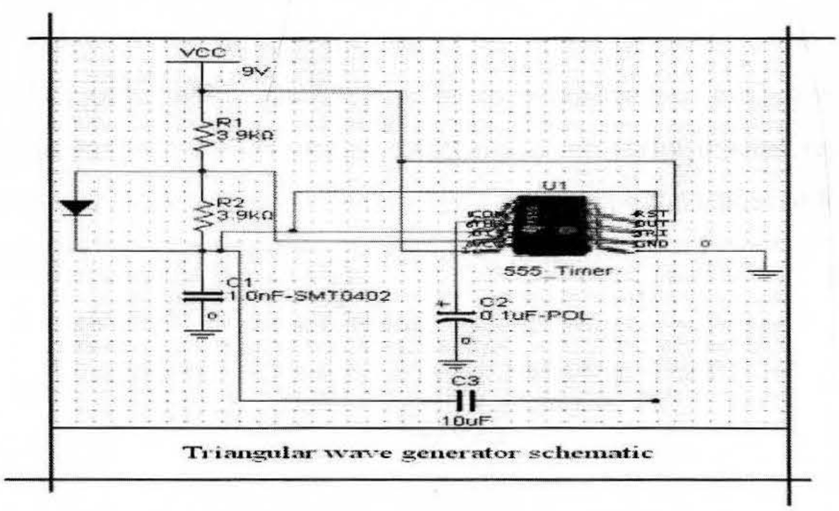


Figure 2.3: Timer connected as Oscillator

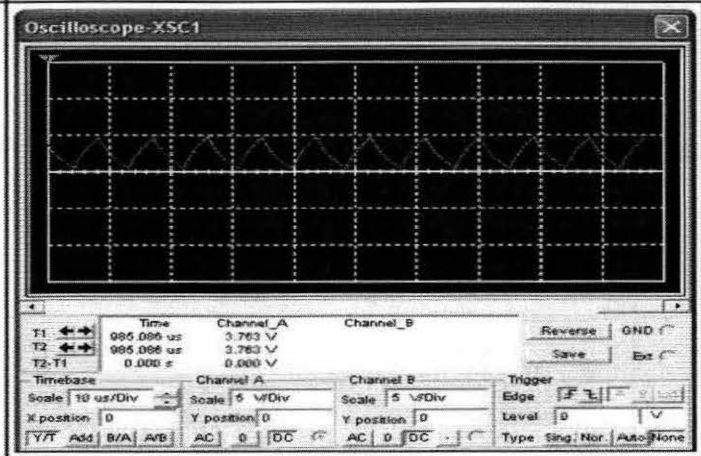
The 555 timer consists basically of two comparators, a flip-flop, a discharge transistor, and a resistive voltage divider. The resistive divider is used to set the voltage comparator levels all three comparator levels. A 555 timer connected to operate in the astable mode as a free-running nonsinusoidal oscillator (astable multivibrator).

The threshold input is connected to the trigger input. The external components R_1, R_2&C_{ex} Form the timing circuit that sets the frequency of oscillation. The 0.01uF capacitor connected to the control input is strictly for decoupling and has no effect on the operation; in some cases it can be left off. Initially, when the power is turned on, the capacitor C_{ex} is uncharged and thus the trigger voltage (pin 2) is at 0 V. This causes the output of the lower comparator to be high and the output of the upper comparator to be low, forcing the output of the flip-flop, and thus the base of Q, low and keeping the transistor off. Now, C_{ext} begins charging through R_1& R_2 (to obtain 50% duty cycle, one can connect a diode parallel with R_2 and choose $R_1= R_2$).

When the capacitor voltage reaches 1/3Vcc , the lower comparator switches to its low output state, and when the capacitor voltage reaches 2/3Vcc the upper comparator switches to its high output state. This resets the flip flop causes the base of Q_d to go high, and turns on the transistor. This sequence creates a charge path for the capacitor through R2 and the transistor, as indicated. The cap now begins to discharge, causing the upper comparator to go low. At the point whet capacitor discharges down to 1/3Vcc , the lower comparator switches high, setting the flip flop, which makes the base of Q_d low and turns off the transistor. Another charging cycles begins, and the entire process repeats. The result is a rectangular wave output whose duty cycle depends on the values of R1 and R2. The frequency of oscillation is given by the following formula

$$f=\frac{1.44}{(R1+R2)\,C_{ext}}$$

Using the above equation for frequency equal 110 KHz, one can found the values of R_1(3.9K) , R_2(3.9K) , and C_{ext}(1nF). Then the output was taken from the voltage on the external capacitor which has triangular wave form. A simulation was done to verify the operation of circuit and the output is shown in Figure (2.3).



Simulation of triangular wave by 555 timer

Figure 2.4: The output voltage on C_{ext}

To avoid loading the timing circuit and changing the operating frequency, the triangular wave on the terminal of the external capacitor was buffered using OP-Amp.

2.5.1.2 Noise Generator

To achieve jamming a noise signal is mixed with the triangle wave signal to produce the tuning voltage for the VCO. The noise will help in masking the jamming transmission, making it look like random "noise" to an outside observer. Without the noise generator, the jamming signal is just a sweeping, unmodulated Continuous Wave RF carrier.

The noise generator used in this design is based on the avalanche noise generated by a Zener breakdown phenomenon. It is created when a PN junction is operated in the