DESIGN AND DEVELOPMENT OF GSM JAMMER OPERATING IN GSM 900/1800 BANDS

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Project Report Submitted to Faculty Of Electrical Engineering, Military College of Signals, National University of Sciences and Technology, Rawalpindi in Partial Fulfillment For The Award Of B.E Degree In Telecommunication Engineering

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Program authorized to offer degree	**Bachelor of telecommunication engineering**

بسم الله الرحمن الرحيم

"In the Name of Allah,

The Most Beneficent,

The Most Merciful"

ABSTRACT

DEVELOPMENT OF GSM JAMMER

The improvised explosive device (IED) is one of the greatest threats to armed forces personnel taking part in the ongoing war against terrorism and due to its success the new modernized weapon systems are focused to minimize it. In order to nullify the risk of IED attacks, jammers are used.

The project aims at jamming the downlink frequency bands of the GSM 900 and DCS 1800 bands as the entire communication via the mobile phone is taking place within this frequency range.

DECLARATION

No portion of the work presented in this dissertation has been submitted in support of another award or qualification either at this institution or elsewhere.

DEDICATION

Dedicated to our parents and mentors who have been a constant source of encouragement for us and to our teachers who have given us inspiration throughout our degree

ACKNOWLEDGEMENT

All praises for ALLAH who gave us the strength and determination and enlightened us with the requisite knowledge on portion of this subject to complete this project. We gratefully acknowledge the continuous guidance and motivation provided to us by our project advisor Col. (R) Raja Iqbal without his personal supervision advice and help timely help completion would not have been possible

We deeply treasure the unparalleled support and forbearance that we received from our friends for their critical reviews and useful suggestions that helped us in completion of our degree project. We are deeply indebted to our family for their never ending patience and support for us and to our parents for the strength they gave us through their prayers

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LIST OF ABBREVIATIONS

FSL: Free space loss

GSM: Global system for mobile communication

DCS: Digital Communication System

IED: Improvised explosive device

IF: Intermediate frequency

RF: Radio Frequency

VCO: Voltage controlled oscillator.

BSC: Base station controller

BTS: Base transceiver station

MS: Mobile station

CHAPTER1

INTRODUCTION

1.1 Background:

Since the last few years there is an ever increasing threat of bomb blasts which has mostly been in the shape if mobile triggered IED blasts at public places or large gatherings such as mosques, business centers, rallies etc. To save the public from harm and to help stabilize the current situation, it is extremely important for such activities to be stopped. The element of fear and terrorist activities has had a great impact on destabilizing this developing country and in causing a lot of suffering to the people. A possible and effective solution to overcome this problem is by deploying GSM jammers at crowded places in order to avoid such mishaps and the loss of precious lives.

Low-power emitters are greatly contributing to the complexity of the electronic warfare dilemma They are used to detonate IEDs remotely without any warning Quickly locating the source of the detonation signal, especially in an urban environment where various obstacles and other signals cause interference, is difficult. Thus an effective solution is to jam the signals instead of looking for the source and neutralizing it.

One prominent form of the Improvised explosive devices is the RCIED i.e Radio Controlled IED, which is triggered remotely via radio signals. Commercially available radio controlled devices such as garage door openers, cellular phones and cordless telephones are utilized by insurgent forces to remotely detonate these deadly roadside bombs. To prevent RCIED attacks electronic jammers are used to disrupt the communication between the trigger and the bomb itself.

1.1.1 Introduction

A GSM Jammer is a device that transmits signals on the same frequency at which the GSM system operates. The jamming is regarded as successful when the mobile phones in the area are disabled.

Communication jamming devices were first developed and used by military. As communication between ground forces is very important mostly for used for coordination and to exercise control, an enemy has interest in those communications which is to the successful transport of the information from the sender to the receiver.

Nowadays the cellular jammer is becoming more of a civilian product rather than EW (electronic warfare) device. This is due to the fact that as the number of the mobile phone users is increasing, the need to disable mobile phones at places where it may cause disturbance, has increased.

These places include mosques, class rooms, halls, conference rooms, libraries etc.

Figure 1.1: A Mobile Triggered IED

1.2 Specific Objectives:

To save general public from the side effects of IEDs' blasts at public places like mosques, business centers, schools and Colleges, Universities we need a mass production of jammers at an affordable cost. Hence, industry must support the project as it would benefit the general public.

1.2.1 Methodology:

The device is to be introduced on trial basis. For prototype development the different parts after being constructed on a printed circuit board will be assembled together. The aim will be to generate enough power from the device in order to disrupt or block out GSM signals from the area in which the device is functional. The development will be such that while minimizing the cost, optimal performance will be acheived.

1.2.2 Project Description with Technical details:

The nature of this project is an applied one, catering for the need of the public. The project aims at the provision of jamming devices at an affordable price so that they can easily be available to the public sector and overcome the disastrous effects of mobile triggered explosive devices. The provision of such devices can be made possible to smaller organizations and general public as a low cost module

1.2.3 Action, Plans and Milestones:

The purpose of using a 'GSM' jammer is that this is the band the insurgents are more likely to use as it has been determined from the various incidents of the same nature. The speed of GSM hopping is 200 hops/s which does not provide real protection against jamming attacks.

The basic plan is to mitigate the risk of a mobile triggered IED attack, so a jamming device is being used to interrupt the communications between the IED trigger and the remote device.

CHAPTER 2

GLOBAL SYSTEM FOR MOBILE COMMUNICATION

2.1 History Of GSM:

During the early 1980s , cellular phones experienced a rapid growth in the European countries particularly in the United Kingdom Germany and France. Every country had developed its own system which was incompatible with everyone else's in equipment and operation. Thus its operation was limited to national boundaries, which was much undesirable.

GSM primarily stood *Groupe Speciale Mobile,* a committee whose task was to define a new standard for mobile communication in the 900 MHz range based on digital technology. The goal of GSM was to replace the purely national and over-loaded technologies of the member countries with an international standard. They proposed system had to support international roaming ,provide low terminal and service cost and good subjective speech quality

In 1991 the meaning of GSM changed that same year to **Global System for Mobile Communications.** The first derivative of GSM which translated it into the 1800MHz frequency range was introduced the same year

By 2005, GSM networks revolutionized the cellular network market having accounted for more than 75% of the cellular subscribers worldwide. Today according to an estimate the GSM standard technology serve 80% of the global mobile market

2.1.1 Technical Details:

GSM is a cellular network, meaning whereby all cell phones connect to it by searching for cells in their immediate vicinity. In a GSM network five different cell sizes are available.. The coverage area of each cell varies according to the implementation environment. Macro cells can be regarded as cells where thebase station antenna is installed on a mast or a building above average roof top level. Micro cells are cells that are typically used in urban areas. Pico cells have a coverage diameter of a few dozen meters; they are mainly for indoor uses. Femto cells are for use in residential or small business environments. Umbrella cells provide coverage to shadowed regions and help to fill in the gaps in coverage area between cells.

The modulation used in GSM is Gaussian Minimum-Shift Keying (GMSK), which is a continuous-phase FSK. By using GMSK, the interference to neighboring channels is significantly reduced (adjacent-channel interference).

2.1.2 GSM carrier frequencies:

A GSM channel is divided into 8 timeslots for individual phones to use. This means that eight full-rate or 16 half-rate speech channels per radio frequency area available . The data rate for all the channels is 270.833 Kbit/s. A GSM frame has a duration of 4.615 ms.

GSM networks operate on a number of different carrier frequencies, with most networks operating in the 900 MHz or 1800 MHz bands. Other derivatives include EGSM-900 which are mostly use in Africa, Europe, Asia and Australia. GSM-850 and GSM-1900 are used A less common version GSM-450 is also used. It uses the same band as the old analog NMT systems they can co-exist.

2.2 GSM Architecture: A Network of Cells

Mobile Stations within the cellular network are located in the cells, which are provided by the BSSs. Cells are represented by a hexagonal-shaped , as it is the most effective approximation, that fit together to form a honeycomb pattern , but in reality they are irregular in shape.

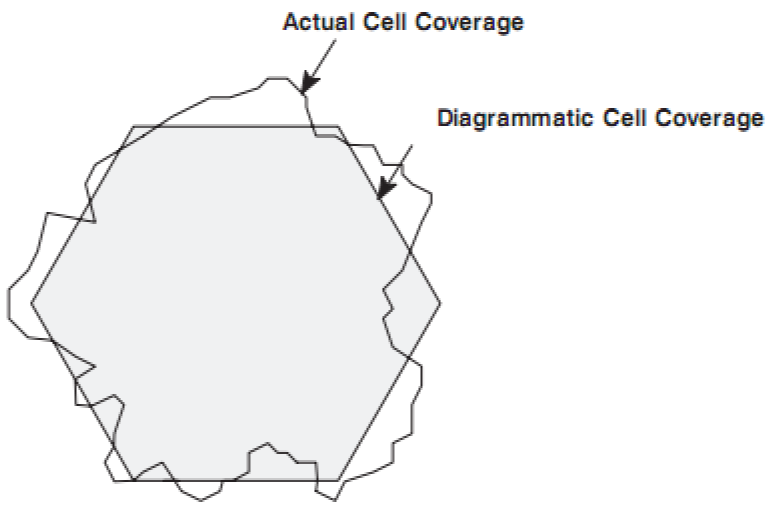


Figure 2.1 : Cell Shape (Hexagon)

2.3 The GSM System:

A GSM network partitions the available frequency range thus assigning only parts of the frequency spectrum to the BTS to increase frequency reuse or to limit the range of the base station. A GSM system consists of various integral components by the help of which the functioning of the system is kept in order.

The GSM system comprises of mobile stations, multiple base transceiver stations (BTS) which are in turn connected to BSC's. Then there are other components of the system that help in determining the factors such as call routing, billing and to maintain the data regarding the user. This data is continuously updated at the system end. These components include the home location register (HLR), visitor location register (VLR), transcoding rate and adaptation unit (TRAU) and the subscriber identity module (SIM). All these components form the basic architecture of a GSM system.

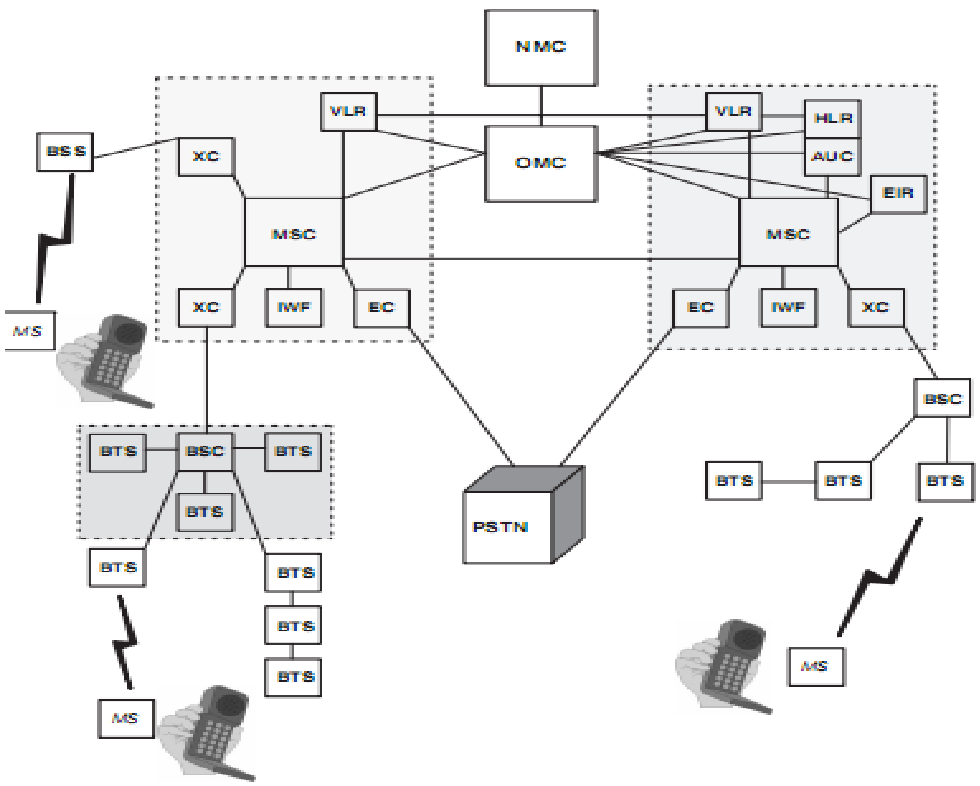


Figure 2.2: GSM Architecture

CHAPTER 3

INTRODUCTION TO JAMMING

3.1 Jamming Basics:

Radio based jamming is the deliberate transmission of radio signals in order to disrupt communications by decreasing the SNR. Jamming does not necessarily mean to block out all communications signals but is to hinder or disrupt communication by the use of radio noise or signal.

3.2 Working :

Cell phones are full-duplex devices. Two separate frequencies are used for talking and listening simultaneously. Blocking out one of these frequencies has the effect of blocking both. As the cell can receive only one of the frequencies it is tricked into thinking that the service is not available.

A jammer transmits in the same frequency range as the mobile station, discontinuing the communication between the mobile station and the BTS

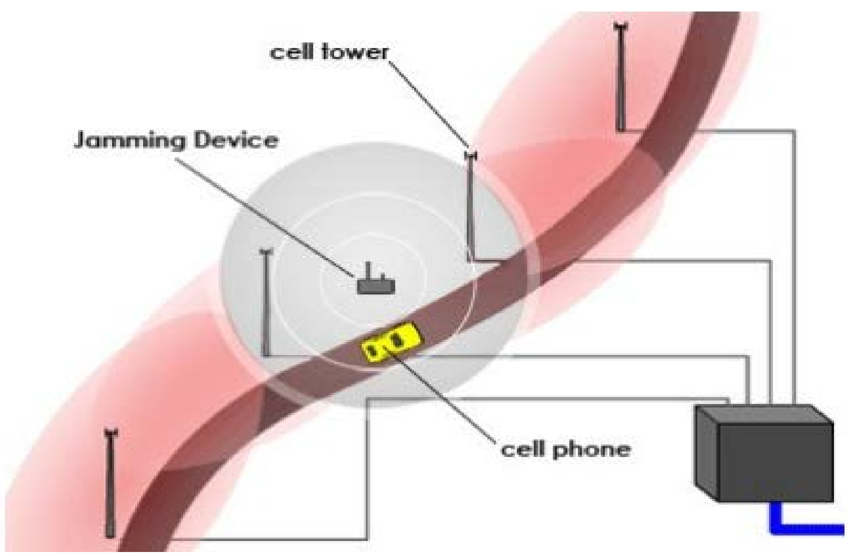


Figure 3.1: Working of a Jammer

3.3 Jamming Principles And Definitions

3.3.1 Antenna:

The two main types of antenna used in electronic warfare are of the type that cover a 360-degree azimuth or that cover a smaller angular area. A vehicle mounted or man-pack antenna which is typically an omnidirectional antenna. This type of antenna is assumed as used in this study of radio frequency jammers. The omnidirectional antenna is one type of isotropic antenna which radiate equally in all directions. These antennas are used in the tactical ground environment

3.3.2 Distance:

Propagation of a signal greatly depends on the distance. In the free-space propagation model, the direct loss is a ratio of the distance as the wave radiates out in a circular motion by the length of the transmitted radio wave. This only focuses on the LOS models along the earth's surface

$$L = \frac{(4\pi)^2 d^2}{\lambda^2} \qquad \text{……………………………………………Equation No.3.1}$$

Where L is direct loss ratio , d is distance in meters and λ is length of transmission wavelength in metres

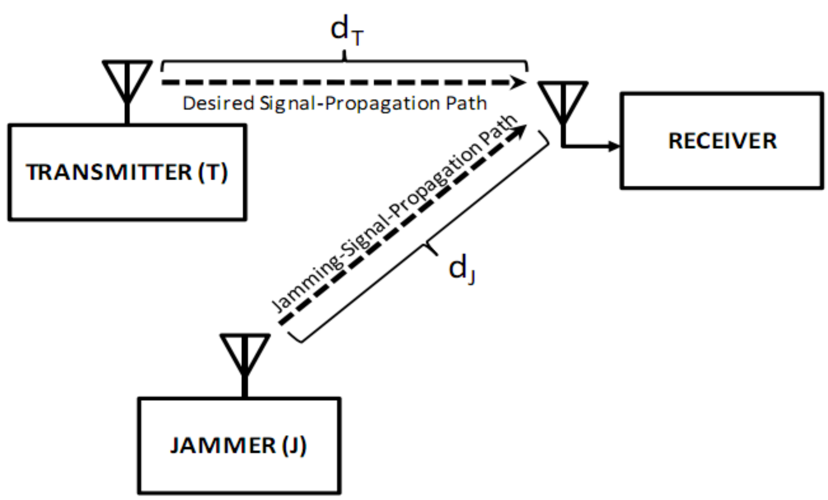


Figure 3.2 : Distance to be Jammed

3.3.3 Range

Range of the jammer is the distance in which it effectively keeps the GSM signal barred. This too depends on many factors including noise. The actual range of the jammer depends on the power and the local environment, which may include any obstacle that blocks the jamming signal. The efficiency of a jammer is depicted by its range.

3.3.4 Duty Cycle and Time Sharing:

Radio frequencies are emitted in the form of pulses having a rest time between them. The ratio of the pulse time to the pulse repetition time is known as the duty cycle .

$$DC = \frac{PW}{PRT}$$ ………………………………………….. Equation No.3.2

Sample jamming scenario of a single transmission over two duty cycles

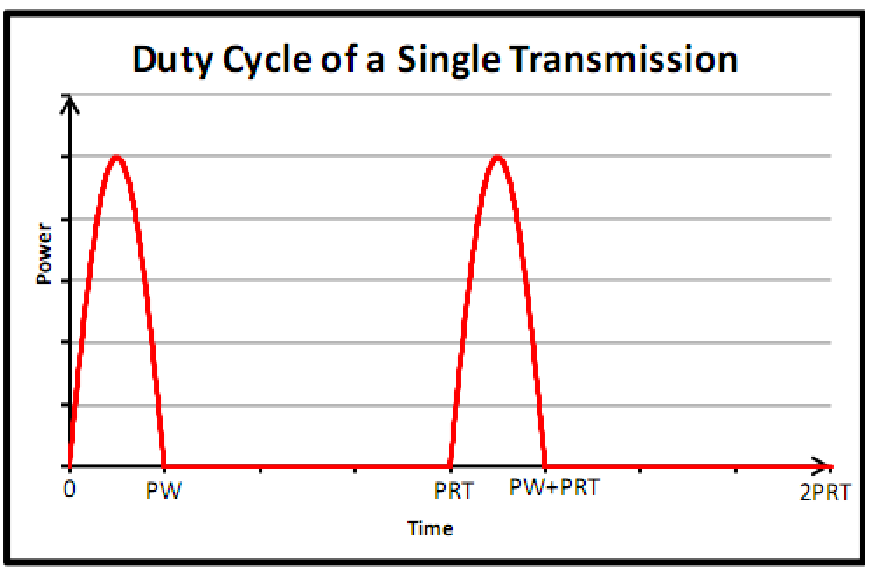


Figure 3.3: Duty Cycle of Single Transmission

CHAPTER 4

DESIGN PARAMETERS

4.1 Design Parameters

In order to develop an efficient jamming device based on DOS technique, some design parameters were considered to fulfill the requirements

4.1.1 The Distance to be Jammed :

This parameter is very important as the amount of the output power of the jammer depends on the area to be jammed. This design would be established upon D=10 meters for GSM 1800 band and D=20 meters for GSM 900 band.

4.1.2 The Frequency Bands:

Band	**Up-Link**	**Down-Link**
GSM 900	890-915 MHz	935-960 MHz
GSM 1800	1710-1785 MHz	1805-1880 MHz

Table 4.1 GSM Frequency Bands

The jamming frequency must be the same as the downlink, because it needs lower power to do jamming than the uplink range and there is no need to jam the base station itself. So, the frequency design is be focused on both the downlink bands

4.1.3 Jamming to Signal Ratio

For jamming to be successful, the output power of the jamming signal should be twice or thrice than that of the communication device.

$$\frac{J}{S} = \frac{P_j G_{jr} G_{rj} R_{tr}^2 L_r B_r}{P_t G_{tr} G_{rt} R_{jr}^2 L_j B_j}$$ ………………………………………………Equation No.4.1

Pj=jammer power, **Gjr=** gain from jammer to receiver, **Grj=** gain from receiver to jammer, **Rtr=**range between communication transmitter and receiver, **Br=**communication receiver bandwidth, **Lr =**communication signal loss, **Pt=**transmitter power, **Gtr=** gain from transmitter antenna to receiver, **Grt=** gain from receiver antenna to transmitter, **Rjr=** distance between jamming device and receiver, **Bj=**jamming device bandwidth, and **Lj=**jamming signal loss.

For GSM, the **SNR** in the worst case is 9 dB which will be received at the mobile if it is the near vicinity of the BTS. Power received at mobile if taken for a limit (best case) is -15 dBm.

4.1.4 Intermediate Path loss {F}:

The path loss can be determined by using Friis transmission equation

Path loss (dB) = 32.44 + 20 log d (km) + 20 log f (MHz) ……………….………Equation No 4.2

Using 960 MHz we get an FSL value of

F (dB) = 32.44+20 log 0.02 + 20 log 960 = 58 dB

4.1.5 Power Calculations:

Here, we need to find the power that is needed to be transmitted to jam any cell phone within a distance of around 20 meters for GSM 960. Keeping in view the earlier parameters, the required output power from the device can be found.

Using **SNR=9 dB**, the maximum power of signal at the mobile receiver is - 15 dBm, which gives J= -24 dBm. From these values the output power from the device can be found by adding the FSL to the amount of power at the mobile receiver amounts to **34 dBm**

CHAPTER 5

THE POWER SUPPLY

5.1 Design And Development

Design and development of the power supply is a very key stage in this case as it performs the function of providing the different voltages throughout the circuit that are essential for the efficient working of the different parts of the jammer. The key components of the power supply as discussed in detail.

5.1.1Transformer:

Transformer is used to transform the 220VAC to desired levels of voltages. It works on the principle of electromagnetic induction. In this case a step down transformer is used. Instead of using a transformer direct 12 V DC voltage can also be applied by means of a standard DC adapter available in the market having the same output current and voltage levels.

5.1.2 Rectifier:

A rectifier converts the AC voltage, which changes its direction periodically, to a DC one. This process is called rectification. The rectified output voltage occurs during both the positive and negative cycles of the input signal. A rectifier is an integral component of a power supply and direct current transmission systems. Rectifiers are of two types namely half wave and full wave rectifiers

5.1.3 Filter:

The Filter is used to eliminate the fluctuations in the output of the full wave rectifier so that a constant DC voltage is produced. A constant voltage is required by the key components of the circuitry for their smooth functioning and giving their optimal performance .This filter is actually a large capacitor which minimizes the ripple in the output. The purpose of

5.1.4 Regulator:

A voltage regulator automatically maintains a constant voltage level as per the requirement. Here it is used to provide the desired voltages by regulating the input DC voltage to the required levels. They too are an integral component of the power supplies. The voltage regulation is specified by the measurements of load regulation and the input regulation. These help in keeping the different voltage levels constant.

5.1.5 Block Diagram

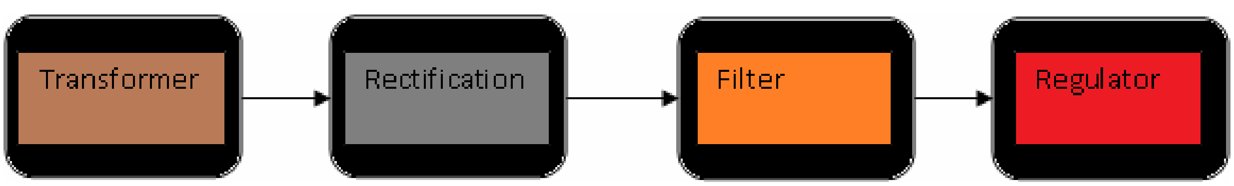


Figure 5.1: Power Supply

CHAPTER 6

SWEEP AND NOISE GENERATOR

6.1 Noise Generator

Noise generator circuit simply generates a random noise of 0.5 mv peak to peak for this purpose a zener diode is used from which the signal is amplified by use of NPN transistor. The noise is generated is then modulated over the sweep signal. The noise is generated by operating the zener in reverse mode which due to avalanche effect causes wide band noise

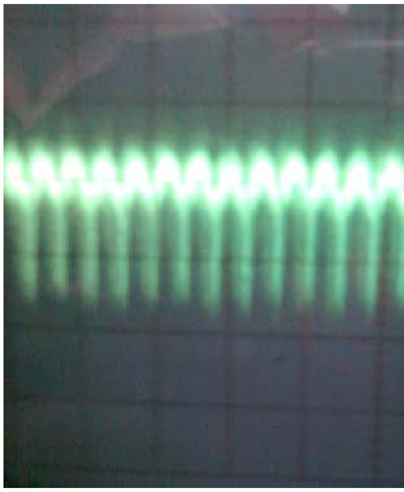


Figure 6.1: Noise Signal

6.2 Sweep Generator

For generating the sweep signal a HEF 4069UB Hex inverter is used. The input to the hex inverter is a noise signal which is generated by means of a zener diode. The hex inverter through an external circuitry provides a unified output of both the square and the triangular waves . This wave is already modulated with a noise signal. The ouput of the section is noise modulated signal having a frequency of 26kHz and a sweep time of 0.3 micro seconds

The input volatge is 9 V DC which by means of the HEX inverter provides us with a saw tooth wave. That along with other intermediate signals are below. The frequency of the output signal is 26 kHz. The peak to peak and the rms voltages are 3 V and 1.02 V respectively

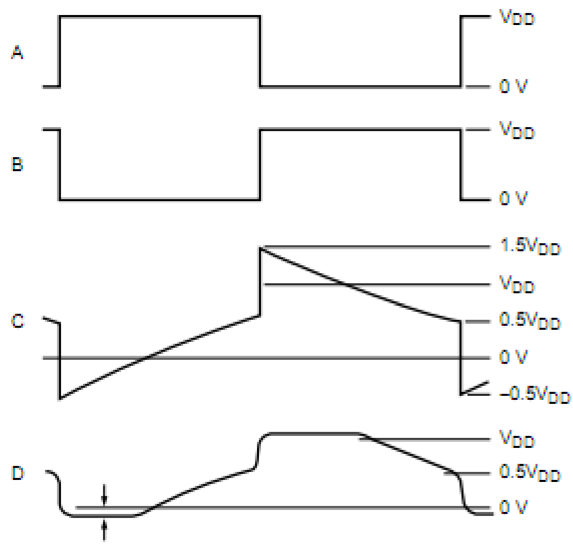


Figure 6.2 : General Input / Output Patterns

The frequency stablility of this circuit is not affected significantly by variations in the power supply voltage, V_{DD}.

6.2.1 Working

The noise signal from the zener diode is fed at the input of the hex inverter where it through its logic NOT gates and the external circuitry converts it into a semi triangular wave. Then output of the hex inverter is passed through several amplification stages in order to amplify the noise modulated signal to the desired power level. Linear amplification is also a key feature of this hex inverter.

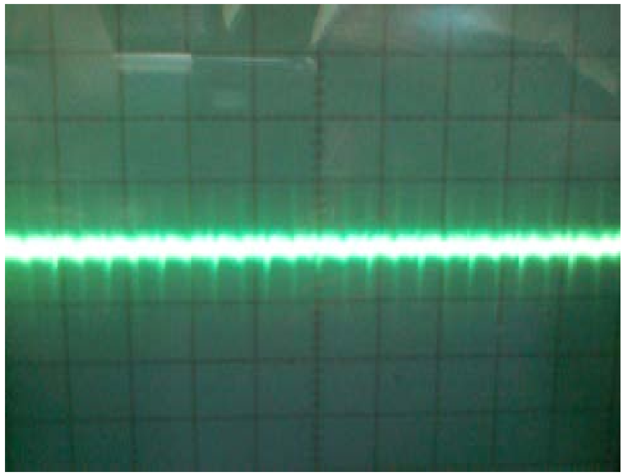


Figure 6.3: Input To Hex Inverter

6.2.2 Frequency Adjustment

To control frequency, regulators were used to which the output of the hex inverter was fed. This was used to adjust the central operating frequency of the jammer.

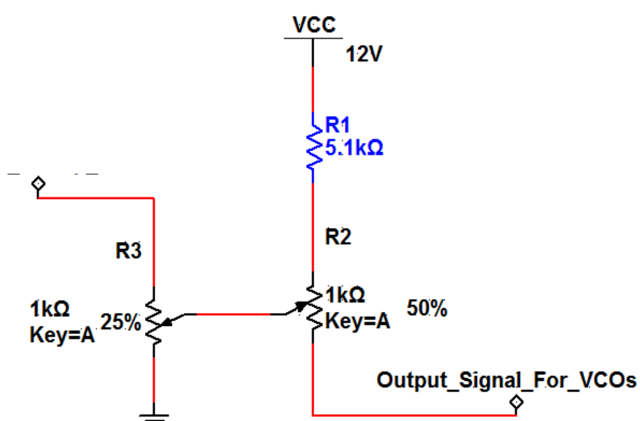


Figure 6.4: Frequency Band Adjustment Circuit

The schematic layout of the sweep generator is of a simulation carried out in the proteus simulating software

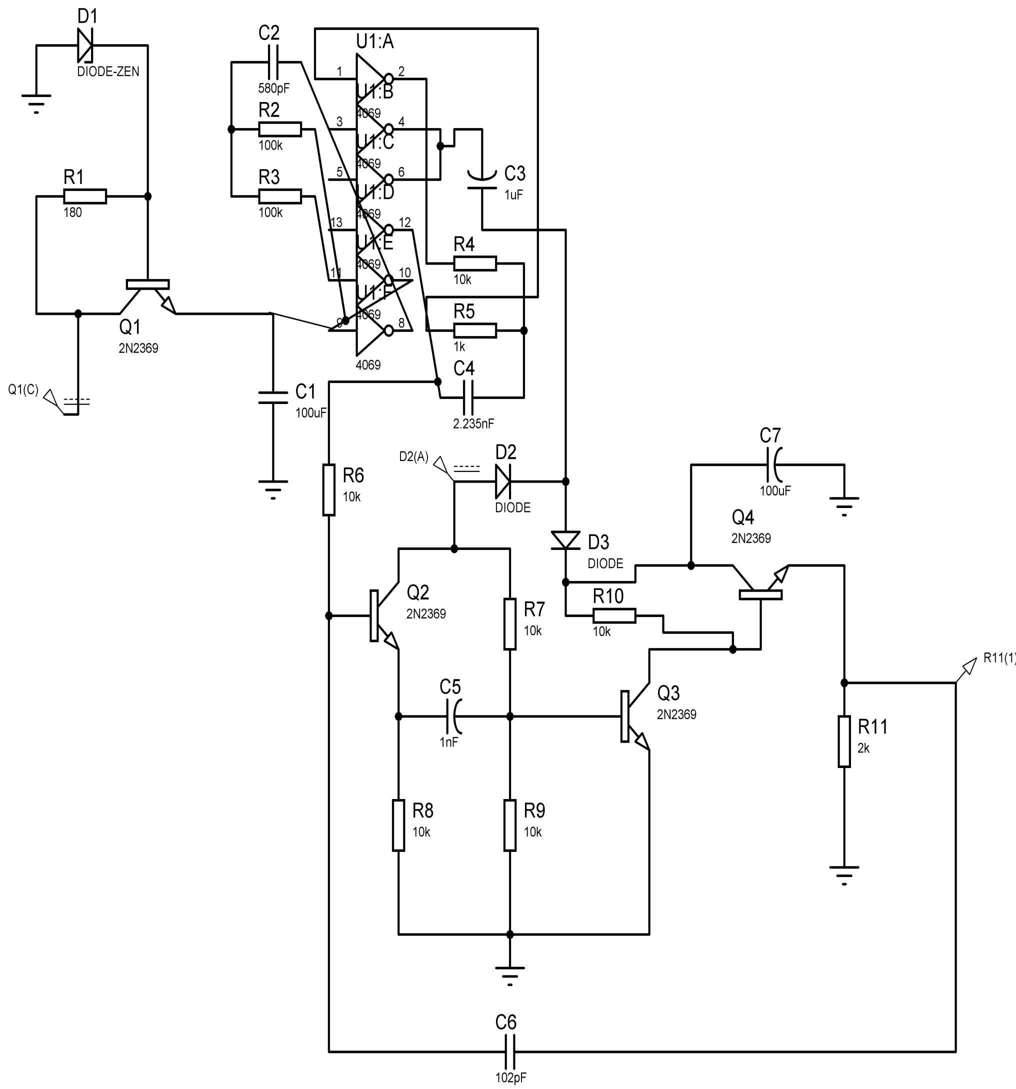


Figure 6.5: Schematic Layout- Sweep Generator

6.2.3 Different Wave Patterns

The sweep signal prior to going to the VCO has a frequency of 26 kHz which translates into a sweep time of 0.3 micro seconds

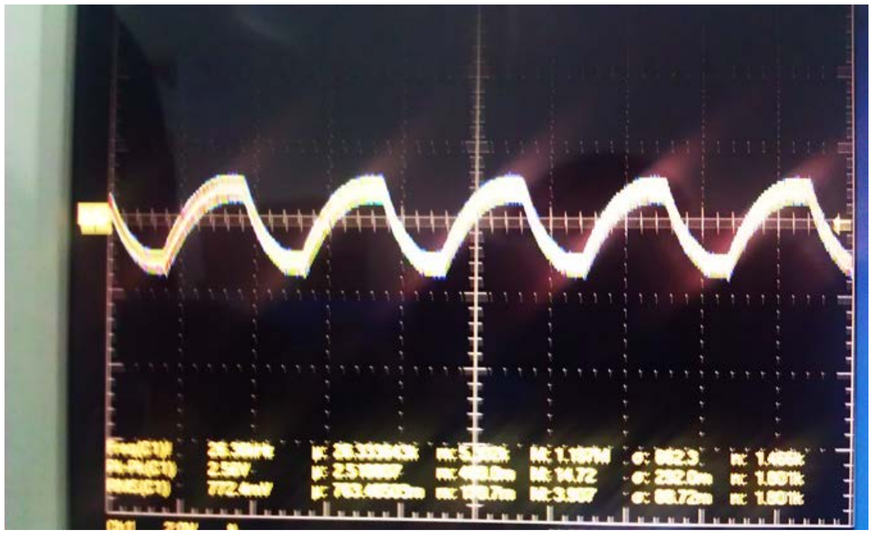


Figure 6.6: Sweep Signal

The intermediate semi rectangular wave received from pin 12 of the HEX inverter lays the foundation for the sweep signal. It has a peak to peak voltage of 11.38 V having a rms value of 3.08V

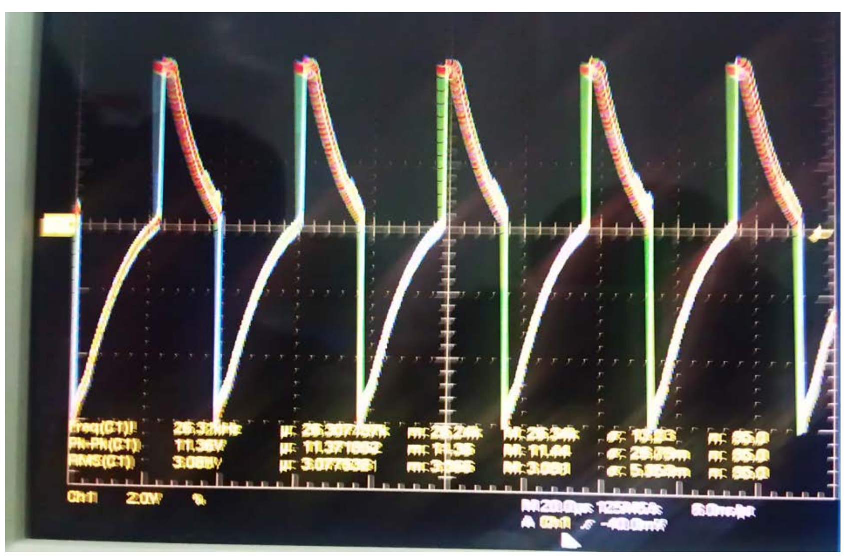


Figure 6.7 : Output Signal

CHAPTER 7

HEF 4069UB HEX INVERTER

7.1 Working:

The HEF 4069UB consists of six inverter circuits and is manufactured using CMOS to achieve lower power consumption, wide power supply operating range, greater noise immunity and controlled rise and fall times. It is used for all general purpose applications pertaining to inversion.

All inputs are protected from damage due to static dis-charge by diode clamps to VDD and VSS.

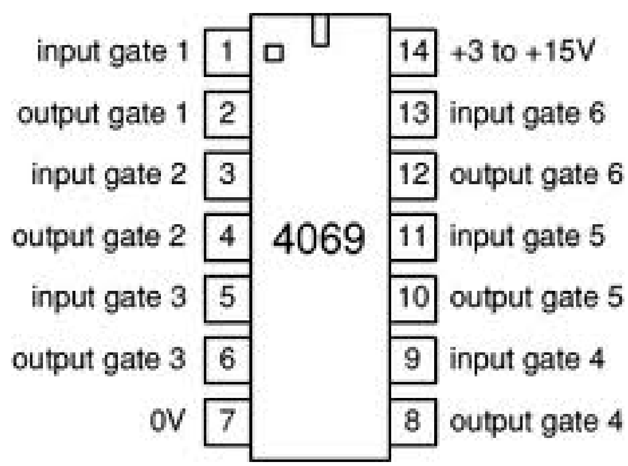


Figure 7.1: HEF 4069 Hex Inverter Pin Configuration

7.1.1 Features:

The key features include a wide supply voltage range (3.0 V to 15 V), high noise immunity of 0.45 VDD and a low power TTL compatibility

7.2 Applications Of Hex Inverter:

Applications of the hex inverter include logic inversion, pulse shaping, to produce oscillation and to act as high input impedance amplifiers. All these applications are achieved by using different combination of the NOT logic that is a part of this IC.

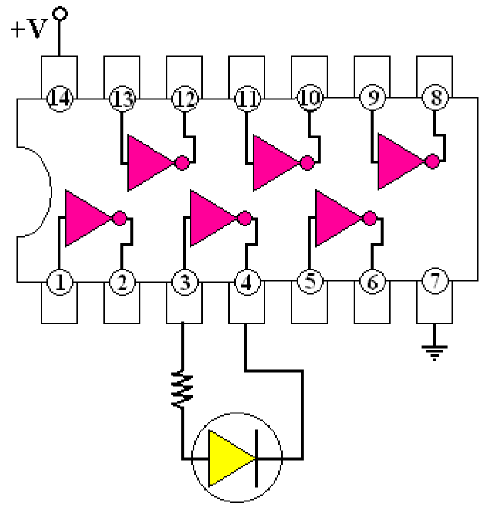


Figure 7.2: Astable configuration of Hex Inverter

7.3 HEF 4069 UBT as an Oscillator:

In the functional diagram the diodes are connected in order to prevent the backflow of current. The oscillations depend on the value of R1 and R2. R2 minimizes the influence of the forward voltage across the protection didoes on the frequency

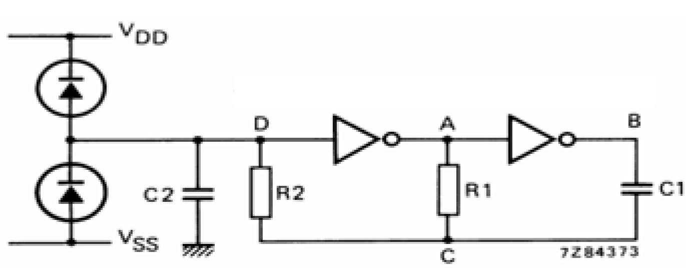


Figure 7.3 : HEF 4069 UBT Oscillator Circuit

CHAPTER 8

RF AMPLIFIER SECTION

This is the most important part of the product, as its output will be interfacing with the mobile. The sweep signal coming from the IF-section is being fed to two separate VCOs (one for each of the two GSM bands). These VCOs swept the signal over their entire respective frequency bands thus providing a sweeping signal effectively covering both the frequency bands. The output of the VCO's is further amplified by the use of separate power amplifiers that are commonly used in mobile phone circuits. The respective outputs are then fed to separate antennas for transmission meaning thereby two separate jamming signals were generated for each of the two GSM 900 and GSM 1800 bands.

8.1 DESIGN:

The RF-section has three parts namely the voltage controlled oscillator (VCO), the power amplifier and the antenna.

The voltage controlled oscillator (VCO) is the heart of the RF-section. It generates the RF signal which will interfere with the cell phone. The output frequency of the VCO is directly proportional to the input voltage level, so the output frequency can be changed by controlling the input voltage. As the input provided to it is a triangular wave the output spans over the desired frequency range.

In our design, separate oscillators for both the GSM 900 and GSM 1800 bands are used instead of only one. They were selected keeping in view the factors of cost, power consumption and most importantly the frequency bands covered. Moreover, size was another key point addressed here.

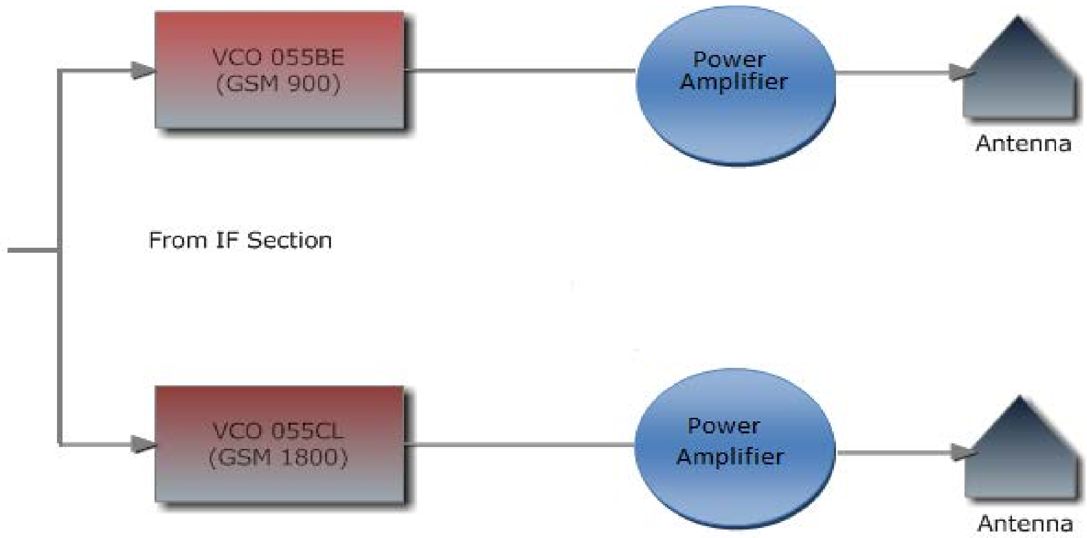


Figure 8.1 :Block Diagram RF Section

8.1.1 Voltage Controlled Oscillators:

The IC's used as VCO's are the CVCO55BE and CVCO55CL which are for the GSM 1800 and GSM 900 respectively. The output frequency of CVCO55BE is 1785-1900 MHz and the output power is up to 5 dBm whereas for CVCO55CL it is 925-970 MHz and the output power is up to 8 dBm.

8.1.2 Reasons for IC Selections:

The reason to choose these ICs is that they are surface mount, which reduces the size of product. They have a large output power that reduces the number of amplification stages required. They have the same value of power supply which is typically equal to 5 volt and have the same noise properties

8.1.3 The Power Amplifier:

Since the output power from the VCO were considerably low and did not achieve the desired output power of a GSM jammer, an amplifier, with a suitable gain had to be added to increase the VCO output to 34dBm. The amplifier IC used is a type **PF08109B**, commonly used in old mobile phones, which is a convenient source. The PF08109B has high gain of 35dB. This IC is designed to work in dual band GSM & DCS.

The sweep signals from both the VCOs were amplified separately because when they were fed to a common amplifier the output was not favorable as only one of the signals was being amplified. Thus a separate assembly for both the sweep signals was employed

Figure 8.2 : Power Amplifier

8.2 Design Basics :

Analog signals may be used to generate any voltage and current by using various techniques. Microwave signals are more disrupted by noise as compared to other signals in the same frequencies. Impedance should be precisely matched in order to keep the Return Loss / VSWR minimum.

8.2.1 Block Diagram RF Section

The RF section comprises of the two VCO and the power amplifiers connected in a separate assembly to channel out the sweep signal for both the GSM 900 and the GSM 1800 bands. The connection is done by means of a micro strip transmission line which is an efficient conductor.

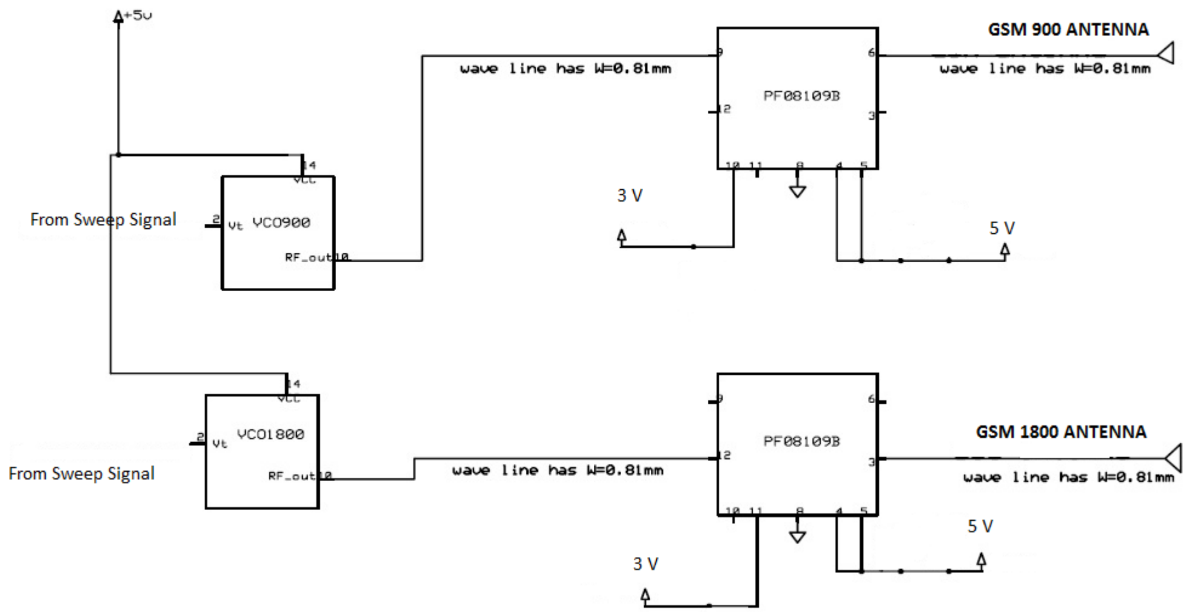


Figure 8.3 : RF Section

8.2.2 Effective Dielectric constant: Microstip:

In order to construct a transmissiopn line trace with the desired characteristic impedance, the width is required to be calculated. For this purpose the dielectric constant is required because part of the field generated by the conductor exixts in the air as well as in the dilelectic.

Assuming the thickness of the trace, T, is small as compared to the height H of the dielectic where W is the width of the microstrip trace.

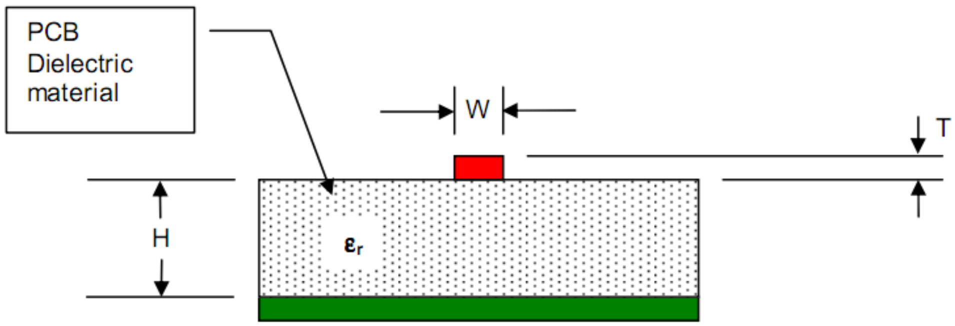


Figure 8.4 : Labeled Diagram of Microstip line parameters

8.2.2.1 Effective Dielectric constant Equation:

The effictive dielectric constant for the micro strip transmission line is determined by means of the parameters such as heigh, width and relative permitivity. The constant differs for different rations of the width and height.

$$\left(\frac{W}{H}\right) < 1: \qquad \varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[\left(1 + 12\left(\frac{H}{W}\right)\right)^{-\frac{1}{2}} + 0.04\left(1 - \left(\frac{W}{H}\right)\right)^2\right]$$ ……..…………………….Equation 8.1

$$\left(\frac{W}{H}\right) > 1: \qquad \varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + 12\left(\frac{H}{W}\right)\right)^{-\frac{1}{2}}$$ ……………...……………..……… Equation 8.2

$$\left(\frac{W}{H}\right) < 1: \qquad Z_O = \frac{60}{\sqrt{\varepsilon_{eff}}} * \ln\left(8\frac{H}{W} + 0.25\frac{W}{H}\right)$$ …………..………..……………… Equation 8.3

$$\left(\frac{W}{H}\right) > 1: \qquad Z_O = \frac{\frac{120\pi}{\sqrt{\varepsilon_{eff}}}}{\frac{W}{H} + 1.393 + 0.667\ln\left(\frac{W}{H} + 1.444\right)}$$ ………….…………………………… Equation 8.4

8.3 Surface-Mount Device (SMD):

Surface-mount device (SMD) is one in which components that are mounted directly onto the surface of the PCB. While dealing with RF energy this technology is far better than through hole technology because of the reduced inductances and higher component density. Physical dimensions of circuit are reduced.

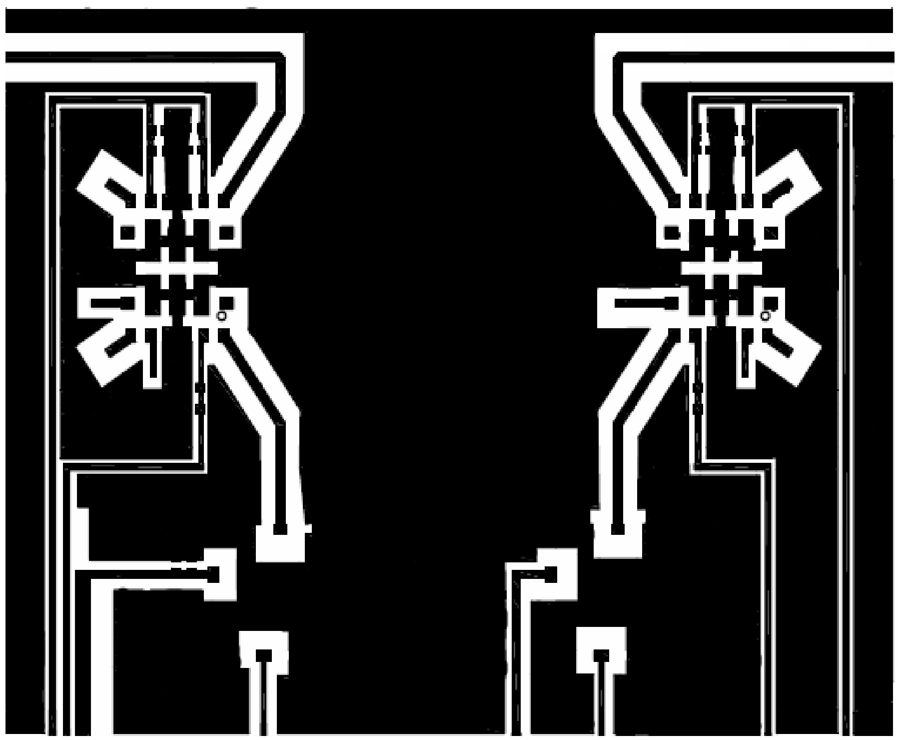


Figure 8.5: RF Section PCB design

CHAPTER 9

VOLTAGE CONTROLLED OSCILLATOR (VCO)

A voltage controlled oscillator (VCO) is an oscillator that varies its output frequencies between a minimum and a maximum value, designated for a particular VCO, when the input is a continuously varying waveform. The VCO is tuned across its band because for each level of input voltage, the VCO produces a different frequency.

VCOs are used in virtually all types of systems that may include RF, wireless or spread spectrum systems. Every type of synthesizer and PLL has at-least one VCO in it, thus designers should know about them.

In this jammer the VCO works as a circuit element that converts the amplitudes to frequency, e.g., for a particular voltage level, it produces a particular frequency. The VCO, namely CVCO55BE and CVCO55CL are described in detail.

9.1 Choice Of VCO For The Design:

GSM-900 uses 890-915 MHz for the uplink and 935-960 MHz for the downlink transmission. GSM uses a total of 124 ARFCNs having a spacing of 200 KHz. Duplex spacing used is of 45 MHz. Whereas GSM-1800 uses 1710-1785 MHz for uplink and 1805-1880 MHz for downlink transmissions respectively.

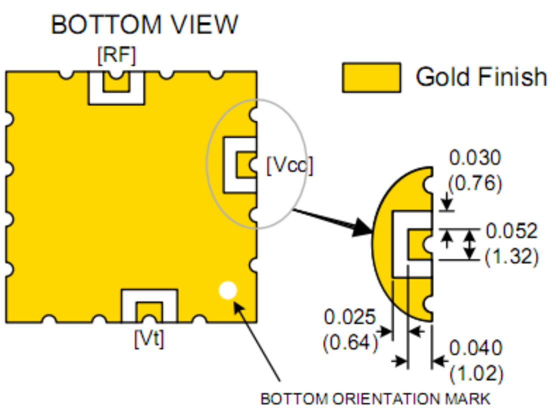
Figure 9.1: VCOs Selected

Since we are jamming the downlink bands of GSM-900 and GSM-1800, so we will have to look for VCOs covering these ranges. Most appropriate VCOs found were CVCO55BE and CVCO55CL spanning over the ranges 1785-1900 MHz for GSM-1800 and 925-970 MHz for GSM-900 respectively.

CVCO55BE ⟶ 1785-1900 MHz

CVCO55CL ⟶ 925-970 MHz

9.2 CVCO55BE/CVCO55CL:



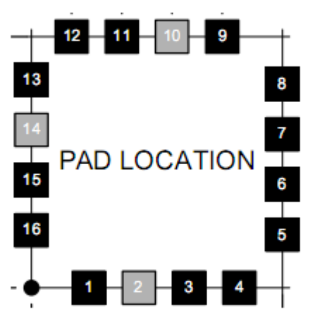


Figure-a

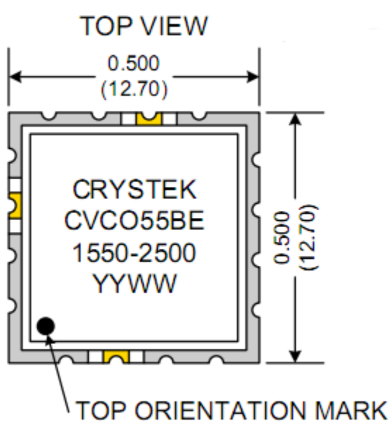


Figure-b

Figure-c

Figure 9.2 : Voltage Control Oscillator Pad Design

9.3 Frequency Modulation:

Frequency modulation (FM) is a form of modulation in which information is conveyed over a carrier wave with variations in the instantaneous frequency while the amplitude is kept constant. Digital data can be represented by shifting the carrier frequency. This method is called frequency shift keying (FSK). FSK is also called FM which is commonly used in the VHF for the broadcast of music, speech data and some video transmission systems.

9.4 Tuning Safeguard:

In reality VCO doesn't respond to the fast changes in input. So sudden change in voltage level for square wave may very well be neglected by the VCO and the functionality remains no more effective at all. This is why we used a saw tooth in place where a change of voltage from one level to another is gradual and is more responsive for VCO.

9.5 Impedance Matching:

It helps to maximize the transfer of power from source to load as well as in minimizing the transmission line losses. It maximizes the SNR at input stages of the receivers. Impedance matching reduces the signal distortion. It also performs the functions of voltage and current amplification and attenuation

CHAPTER 10

ANTENNA SYSTEMS

10.1 The Basics:

The antenna gain depicts the ability of how well the antenna will transmit or receive radio signals. The gain is measured in decibels (dB). The decibel-isotropic is a unit that measure how better an antenna is by comparing it to an isotropic radiator. An antenna which transmits signals symmetrically in all the directions is known as an isotropic radiator. The higher the decibel value, higher the gain. Generally the radio antenna tends to specify their gain by using dBi values.

The radiation pattern of an antenna has a near and a far field. Electric and magnetic force fields form the near field. This holds true about 4 wavelengths of the radiator and the predominant radiation is the electromagnetic field.

An antenna is an essential part of a jamming device which is required to transmit the jamming signal. To have optimal power transfer, the antenna system was matched to the transmission system. We used two quarter wavelength monopole antennas, with 50 ohm input impedance in order to match them to the system. We used two monopole antennas for either frequency bands since the radiation pattern is omni-directional.

10.2 Antennas Selected:

10.2.1 Specifications for DCS 1800 Antenna:

The antenna has an operating frequency in the range of 1700-1900MHz with an input impedance of 50 ohms. The antenna is designed in such a manner to keep the VSWR less than 2 so as to achieve optimal performance

10.2.2Specifications for GSM 900 Antenna:

It is a type of rubber ducky antenna with an operating frequency range varying from 850MHz to 1GHz. The input impedance is matched at 50 ohms to avoid transmission losses. The VSWR for this antenna is also kept below 2. The antenna is designed keeping in view the VSWR and wavelength requirements

10.3 Voltage Standing Wave Ratio (VSWR):

The **VSWR** stands for **Voltage Standing Wave Ratio.** It is a measure that numerically describes how well impedance of the antenna and the transmission line, to which it is connected, are matched. It is a function of the reflection coefficient.

The reflection coefficient is denoted by Γ, thus the **VSWR** can be defined as:

$$VSWR = \frac{V_{max}}{V_{min}} = \frac{1+|\Gamma|}{1-|\Gamma|} = \frac{1+|S11|}{1-|S11|}$$ ………………………………..Equation No.10.1

10.3.1 Physical Meaning of VSWR

The voltage measured along a transmission line leading to the antenna determines the value of VSWR. It is the ratio of the peak amplitude of a standing wave to the minimum amplitude of a standing wave,

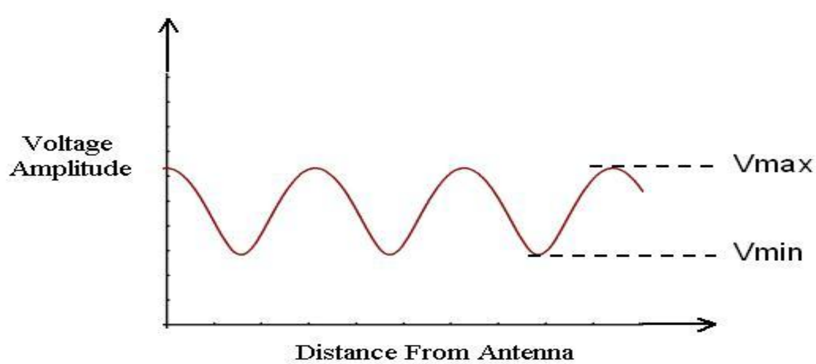


Figure 10.1 : Voltage Measured Along a Transmission Line

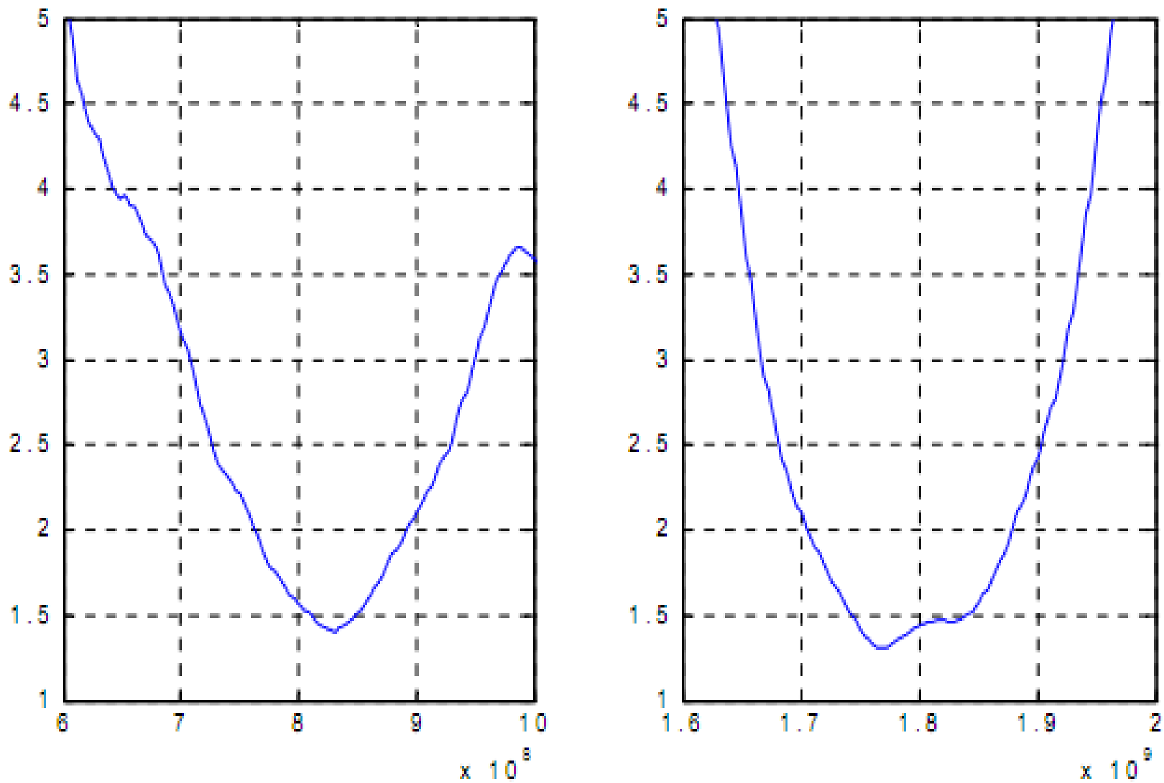


Figure 10.2 : VSWR (From Network Analyzer)

A VSWR value of 1 means that there is no reflection and the system is perfectly matched. Corresponding to this, a high VSWR means that the signal is reflected back to the source which may damage the equipment by heating up .Moreover in case the antenna is poorly matched there will be trouble in transmitting the information bits.

The VSWR is always a real and positive number for antennas. Smaller VSWR means better matching between the antenna and the transmission line and more power is delivered to the antenna.

10.4 Helical Antenna:

A **helical antenna** consists of a conducting wire wound in the form of a helix. Mostly, helical antennas are mounted over a ground plane. Between the bottom of the helix and the ground plane, we have a connected feed line. Helical antennas operate in two principal modes: normal mode or axial mode.

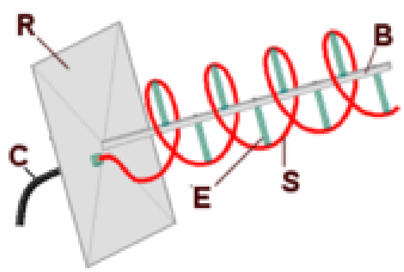


Figure 10.3 : Helical Antenna

10.4.1 Modes of operation:

10.4.1.1 Normal Mode:

In this mode the diameter and the pitch of the helix are small as compared to the wavelength. The antenna in this mode acts as a linearly polarized, electrically short monopole antenna with similar omnidirectional radiation pattern having maximum radiations at right angle to the helix axis.This is the mode that we have used for our project.

10.5 Rubber Ducky Antenna:

10.5.1 Description:

The **Rubber Ducky antenna** is quarter-wave monopole antenna which functions like a base-loaded whip antenna. The antenna is made of a thin, flexible helix of a wire like spring making it less prone to damage. The antenna is further enclosed in a plastic or rubber jacket to prevent damage. The length of these antennas is typically 4-15 % times the wavelength.

Figure 10.4 : Rubber Ducky Antenna.

CHAPTER 11

CONCLUSION

11.1 Conclusion:

If the daily incidents of IED explosions are not stopped, they impose a serious threat to the safety of the people and make it difficult to maintain law and order. The employment of jammers in field provides a protective measure against such explosions in order to avoid the increasing rate of casualties. This proposal acts as a preventive measure against the mobile triggered IED's thus ensuring the safety of the civilian and military people.

Such economical jamming devices are bound to be used for the purpose of safety. Their function is not only that of preventing IED explosions but can also be employed is conference halls, class rooms etc. where disturbance may be caused by the mobile phones

11.2 Technical And Economic Merits Of The Project:

Details of end user/beneficiary of the product/result:

An important aspect of this project is the acquisition of GSM technology. It will facilitate the carrying out of research activity in order to overcome the gap/existing weaknesses and further enhancement as per customized requirements. The project will broaden the horizon and will help to train students with state of the art trends related to wireless communication systems which is essential for them as a telecom engineer.

The end product provides us with an indigenously developed jammer prototype to industry for indigenous production of IED jammer which is cost effective and easily available to the public. It will further facilitate in revitalizing the telecommunication and information technology industry in and making them capable to offer system based on latest wireless technologies.

GLOSSARY:

555 timer IC: A chip used for generating wave at a regular interval

FSL: Free space loss is the loss in power of the signal due to attenuation

GSM: Global system for mobile communication

IED: Improvised explosive device

IF: Intermediate frequency

RF: Radio Frequency

VCO: Voltage controlled oscillator. It provides oscillations to the incoming signal. It changes (increases) the frequency of the signal according to its specified value.

APPENDIX 1

WORKS CITED:

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3. Siwiak, K., RadiowavePropagationandAntennas forPersonalCommunications, Artech House, 2nd.ed, p138.

4. Floyd, ElectronicDevices, PrenticeHall, 5th. Ed, pp.60-85

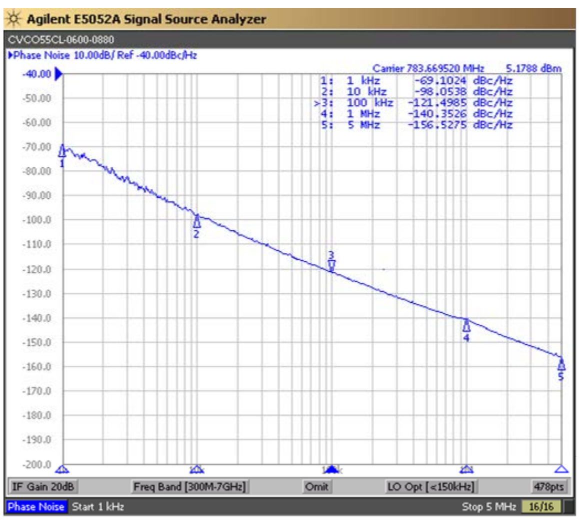
APPENDIX 2

Voltage Controlled Oscillator-VCO
CVCO55CL-0600-0880

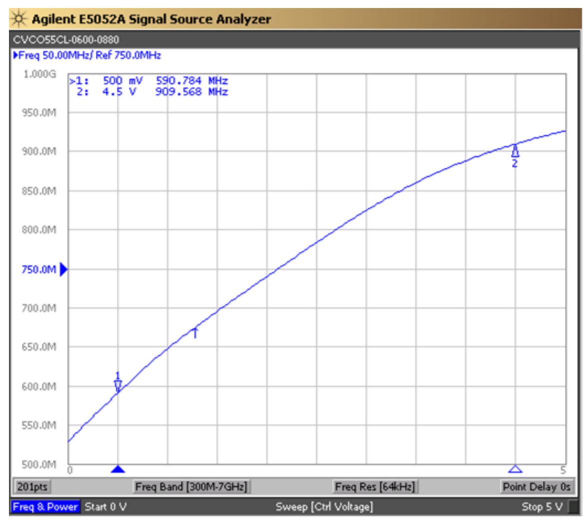
PERFORMANCE SPECIFICATION	MIN	TYP	MAX	UNITS
Lower Frequency:			600	MHz
Upper Frequency:	880			MHz
Tuning Voltage:	0.5		4.5	VDC
Supply Voltage:	4.75	5.0	5.25	VDC
Output Power:	-3.0	0	+3.0	dBm
Supply Current:		10	20	mA
Harmonic Suppression (2nd Harmonic):		-10		dBc
Pushing:		2.0	4.0	MHz/V
Pulling, all Phases:		4.0	8.0	MHz pk-pk
Tuning Sensitivity:		60		MHz/V
Phase Noise @ 10kHz offset:		-98	-95	dBc/Hz
Phase Noise @ 100kHz offset:		-121	-118	dBc/Hz
Load Impedance:		50		Ω
Input Capacitance:			100	pF
Operating Temperature Range:	-40		+85	°C
Storage Temperature Range:	-45		+90	°C

RoHS Compliant

Phase Noise (1 Hz BW, Typical)



Tuning Curve (Typical)



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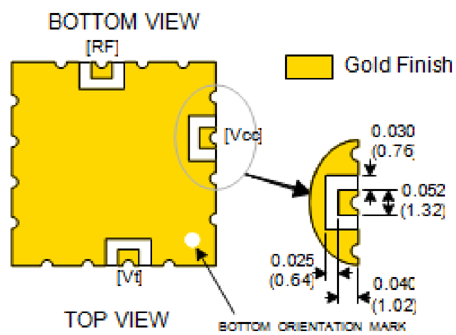
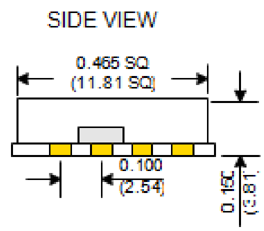
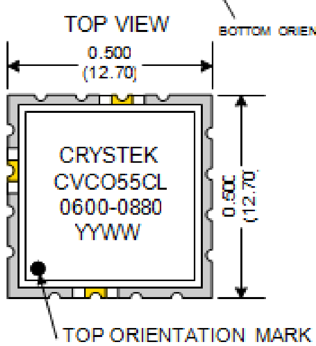
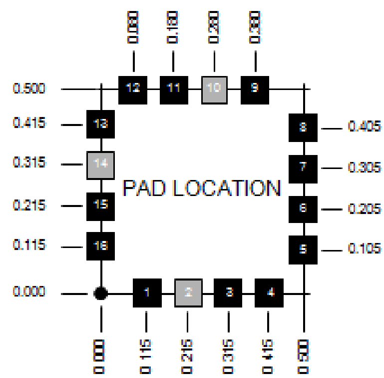
Voltage Controlled Oscillator-VCO
CVCO55CL-0600-0880





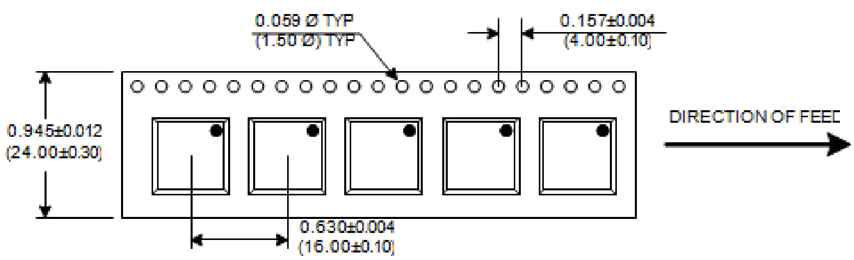




Pad	Connection
2	Vt
10	RF-OUTPUT
14	Vcc
Others	GROUND

- Unless otherwise specified, Dimensions are in: IN / (mm)
- Pad Location Dimensions are in: Inches

TAPE AND REEL



Drawing not to scale

Product Control:

Crystek Part Number:	CVCO55CL-0600-0880	Release Date:	04-Feb-09
Revision Level:	I	Responsible:	C. Vales

Specification is subject to change without notice

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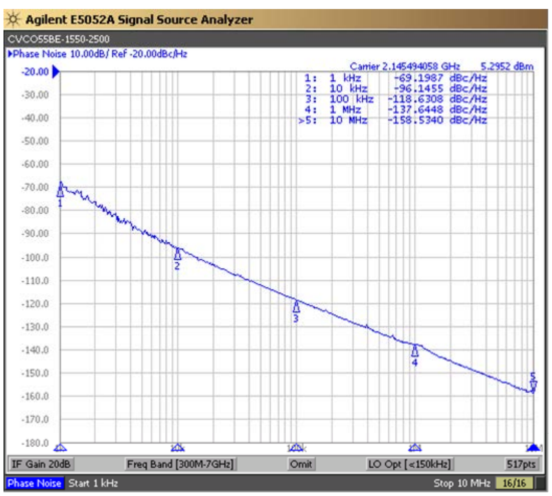
CRYSTEK MICROWAVE
A Division of Crystek Corporation

Voltage Controlled Oscillator-VCO
CVCO55BE-1550-2500

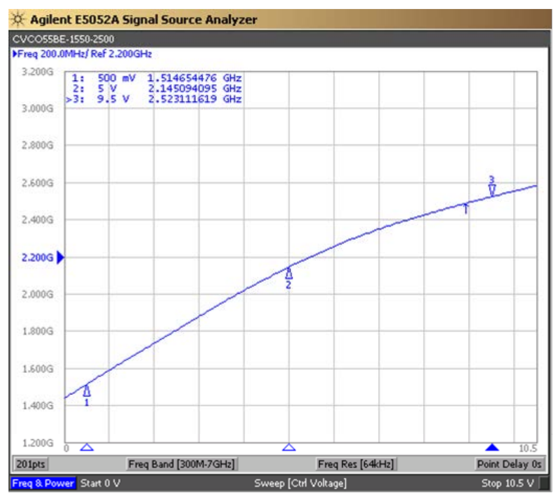
PERFORMANCE SPECIFICATION	MIN	TYP	MAX	UNITS
Lower Frequency:			1550	MHz
Upper Frequency:	2500			MHz
Tuning Voltage:	0.5		9.5	VDC
Supply Voltage:	9.75	10.0	10.25	VDC
Output Power:	+3.0	+6.0	+9.0	dBm
Supply Current:		13		mA
Harmonic Suppression (2nd Harmonic):		-7		dBc
Pushing:			5.0	MHz/V
Pulling, all Phases:			23.0	MHz pk-pk
Tuning Sensitivity:		115		MHz/V
Phase Noise @ 10kHz offset:		-95		dBc/Hz
Phase Noise @ 100kHz offset:		-119		dBc/Hz
Load Impedance:		50		Ω
Input Capacitance:			50	pF
Operating Temperature Range:	-40		+85	°C
Storage Temperature Range:	-45		+90	°C

RoHS Compliant

Phase Noise (1 Hz BW, Typical)



Tuning Curve (Typical)



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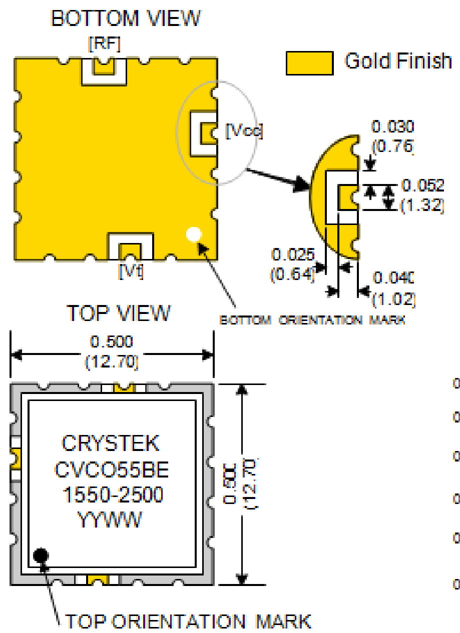
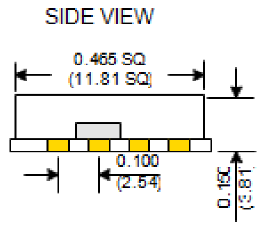
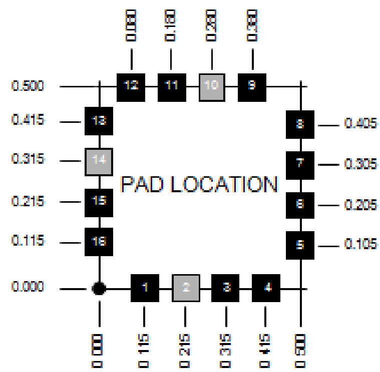
Voltage Controlled Oscillator-VCO
CVCO55BE-1550-2500

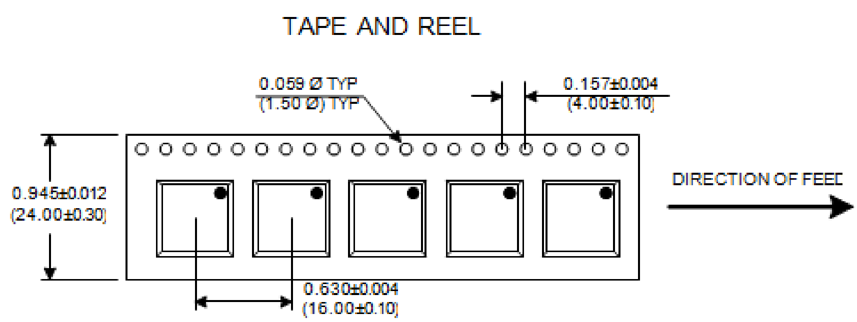






Pad	Connection
2	Vt
10	RF-OUTPUT
14	Vcc
Others	GROUND

- Unless otherwise specified, Dimensions are in: IN / (mm)
- Pad Location Dimensions are in: Inches



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Product Control:			
Crystek Part Number:	CVCO55BE-1550-2500	Release Date:	06-Jan-09
Revision Level:	D	Responsible:	C. Vales

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HEF4069UB

Hex inverter

Rev. 8 — 16 November 2011 **Product data sheet**

1. General description

The HEF4069UB is a general purpose hex inverter. Each inverter has a single stage.

It operates over a recommended V_{DD} power supply range of 3 V to 15 V referenced to V_{SS} (usually ground). Unused inputs must be connected to V_{DD}, V_{SS}, or another input.

2. Features and benefits

- Fully static operation
- 5 V, 10 V, and 15 V parametric ratings
- Standardized symmetrical output characteristics
- Specified from −40 °C to +85 °C and −40 °C to +125 °C
- Complies with JEDEC standard JESD 13-B

3. Applications

- Oscillator

4. Ordering information

Table 1. Ordering information

All types operate from −40 °C to +125 °C.

Type number	Package		
	Name	Description	Version
HEF4069UBP	DIP14	plastic dual in-line package; 14 leads (300 mil)	SOT27-1
HEF4069UBT	SO14	plastic small outline package; 14 leads; body width 3.9 mm	SOT108-1
HEF4069UBTT	TSSOP14	plastic thin shrink small outline package; 14 leads; body width 4.4 mm	SOT402-1

5. Functional diagram

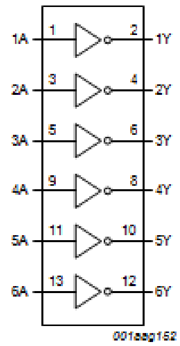


Fig 1. Functional diagram

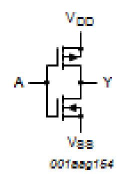


Fig 2. Schematic diagram (one inverter)

6. Pinning information

6.1 Pinning

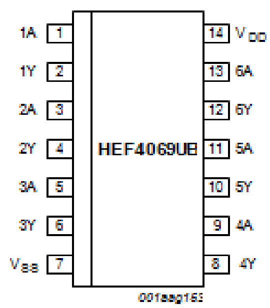


Fig 3. Pin configuration

6.2 Pin description

Table 2. Pin description

Symbol	Pin	Description
1A to 6A	1, 3, 5, 9, 11, 13	input
1Y to 6Y	2, 4, 6, 8, 10, 12	output
V_{SS}	7	ground (0 V)
V_{DD}	14	supply voltage

7. Limiting values

Table 3. Limiting values
In accordance with the Absolute Maximum Rating System (IEC 60134).

Symbol	Parameter	Conditions		Min	Max	Unit
V_{DD}	supply voltage			−0.5	+18	V
I_{IK}	input clamping current	$V_I < -0.5$ V or $V_I > V_{DD} + 0.5$ V		-	±10	mA
V_I	input voltage			−0.5	$V_{DD} + 0.5$	V
I_{OK}	output clamping current	$V_O < -0.5$ V or $V_O > V_{DD} + 0.5$ V		-	±10	mA
$I_{I/O}$	input/output current			-	±10	mA
I_{DD}	supply current			-	50	mA
T_{stg}	storage temperature			−65	+150	°C
T_{amb}	ambient temperature			−40	+125	°C
P_{tot}	total power dissipation	T_{amb} = −40 °C to +125 °C				
		DIP14	[1]	-	750	mW
		SO14	[2]	-	500	mW
		TSSOP14	[3]	-	500	mW
P	power dissipation	per output		-	100	mW

[1] For DIP14 packages: above T_{amb} = 70 °C, P_{tot} derates linearly with 12 mW/K.

[2] For SO14 packages: above T_{amb} = 70 °C, P_{tot} derates linearly with 8 mW/K.

[3] For TSSOP14 packages: above T_{amb} = 60 °C, P_{tot} derates linearly with 5.5 mW/K.

8. Recommended operating conditions

Table 4. Recommended operating conditions

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{DD}	supply voltage		3	-	15	V
V_I	input voltage		0	-	V_{DD}	V
T_{amb}	ambient temperature	in free air	−40	-	+125	°C

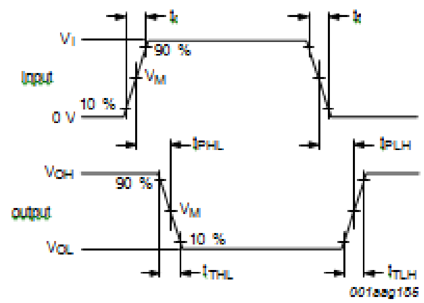
9. Static characteristics

Table 5. Static characteristics

V_{SS} = 0 V; V_I = V_{SS} or V_{DD}; unless otherwise specified.

Symbol	Parameter	Conditions	V_{DD}	T_{amb} = −40 °C		T_{amb} = +25 °C		T_{amb} = +85 °C		T_{amb} = +125 °C		Unit
				Min	Max	Min	Max	Min	Max	Min	Max	
V_{IH}	HIGH-level input voltage	$\|I_O\|$ < 1 µA	5 V	4	-	4	-	4	-	4	-	V
			10 V	8	-	8	-	8	-	8	-	V
			15 V	12.5	-	12.5	-	12.5	-	12.5	-	V
V_{IL}	LOW-level input voltage	$\|I_O\|$ < 1 µA	5 V	-	1	-	1	-	1	-	1	V
			10 V	-	2	-	2	-	2	-	2	V
			15 V	-	2.5	-	2.5	-	2.5	-	2.5	V
V_{OH}	HIGH-level output voltage	$\|I_O\|$ < 1 µA	5 V	4.95	-	4.95	-	4.95	-	4.95	-	V
			10 V	9.95	-	9.95	-	9.95	-	9.95	-	V
			15 V	14.95	-	14.95	-	14.95	-	14.95	-	V
V_{OL}	LOW-level output voltage	$\|I_O\|$ < 1 µA	5 V	-	0.05	-	0.05	-	0.05	-	0.05	V
			10 V	-	0.05	-	0.05	-	0.05	-	0.05	V
			15 V	-	0.05	-	0.05	-	0.05	-	0.05	V
I_{OH}	HIGH-level output current	V_O = 2.5 V	5 V	-	−1.7	-	−1.4	-	−1.1	-	−1.1	mA
		V_O = 4.6 V	5 V	-	−0.64	-	−0.5	-	−0.36	-	−0.36	mA
		V_O = 9.5 V	10 V	-	−1.6	-	−1.3	-	−0.9	-	−0.9	mA
		V_O = 13.5 V	15 V	-	−4.2	-	−3.4	-	−2.4	-	−2.4	mA
I_{OL}	LOW-level output current	V_O = 0.4 V	5 V	0.64	-	0.5	-	0.36	-	0.36	-	mA
		V_O = 0.5 V	10 V	1.6	-	1.3	-	0.9	-	0.9	-	mA
		V_O = 1.5 V	15 V	4.2	-	3.4	-	2.4	-	2.4	-	mA
I_I	input leakage current		15 V	-	±0.1	-	±0.1	-	±1.0	-	±1.0	µA
I_{DD}	supply current	all valid input combinations; I_O = 0 A	5 V	-	0.25	-	0.25	-	7.5	-	7.5	µA
			10 V	-	0.5	-	0.5	-	15.0	-	15.0	µA
			15 V	-	1.0	-	1.0	-	30.0	-	30.0	µA
C_I	input capacitance	digital inputs		-	-	-	7.5	-	-	-	-	pF

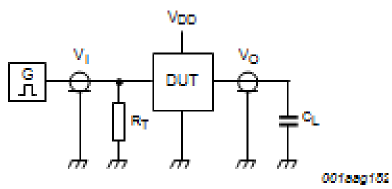
11. Waveforms



Measurement points: $V_M = 0.5V_{DD}$.

Logic levels: V_{OL} and V_{OH} are typical output voltage levels that occur with the output load.

Fig 4. Propagation delay and transition times



Definitions for test circuit:

C_L = load capacitance including jig and probe capacitance;

R_T = termination resistance should be equal to the output impedance Z_o of the pulse generator;

For test data refer to Table 8.

Fig 5. Test circuit for measuring switching times

Table 8. Test data

Supply voltage	Input		Load
V_{DD}	V_I	t_r, t_f	C_L
5 V to 15 V	V_{SS} or V_{DD}	≤ 20 ns	50 pF

PF08109B

MOS FET Power Amplifier Module
for E-GSM and DCS1800 Dual Band Handy Phone

ADE-208-821C (Z)

Rev.3
Feb. 2001

Application

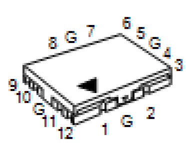
- Dual band Amplifier for E-GSM (880 MHz to 915 MHz) and DCS1800 (1710 MHz to 1785 MHz)
- For 3.5 V nominal battery use

Features

- 2 in / 2 out dual band amplifire
- Simple external circuit including output matching circuit
- High gain 3stage amplifier : 0 dBm input Typ
- Lead less thin & Small package : 11 × 13.75 × 1.8 mm Typ
- High efficiency : 50% Typ at nominal output power for E-GSM
  43% Typ at 32.7 dBm for DCS1800

Pin Arrangement

• RF-O-12



1: N/C
2: N/C
3: Pout DCS
4: Vdd DCS
5: Vdd GSM
6: Pout GSM
7: N/C
8: Vtxlo
9: Pin GSM
10: Vapc GSM
11: Vapc DCS
12: Pin DCS
G: GND

Absolute Maximum Ratings

(Tc = 25°C)

Item	Symbol	Rating	Unit
Supply voltage	Vdd	8	V
Supply current	Idd_{GSM}	3	A
	Idd_{DCS}	2	A
Vtxlo voltage	Vtxlo	4	V
Vapc voltage	Vapc	4	V
Input power	Pin	10	dBm
Operating case temperature	Tc (op)	□30 to +100	°C
Storage temperature	Tstg	□30 to +100	°C
Output power	Pout GSM	5	W
	Pout DCS	3	W

Note: The maximum ratings shall be valid over both the E-GSM-band (880 MHz to 915 MHz), and the DCS1800-band (1710 MHz to 1785 MHz).

Electrical Characteristics for DC

(Tc = 25°C)

Item	Symbol	Min	Typ	Max	Unit	Test Condition
Drain cutoff current	Ids	—	—	100	∝A	Vdd = 8 V, Vapc = 0 V
Vapc control current	Iapc	—	—	3	mA	Vapc=2.2 V
Vtxlo control current	Itxlo	—	—	100	∝A	Vtxlo = 2.4 V

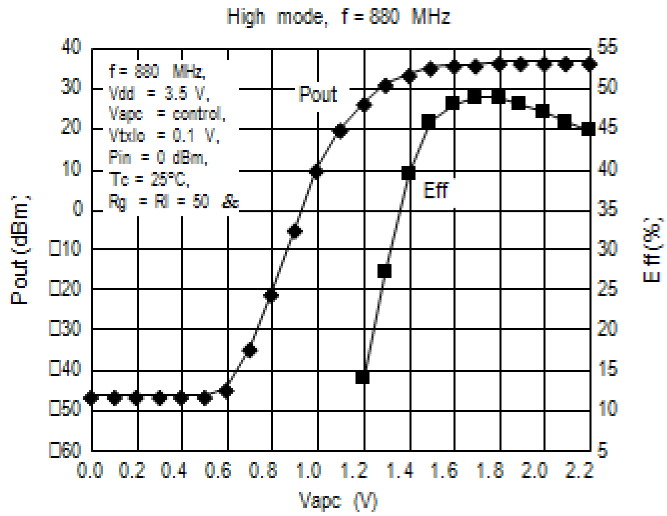
Electrical Characteristics for E-GSM mode

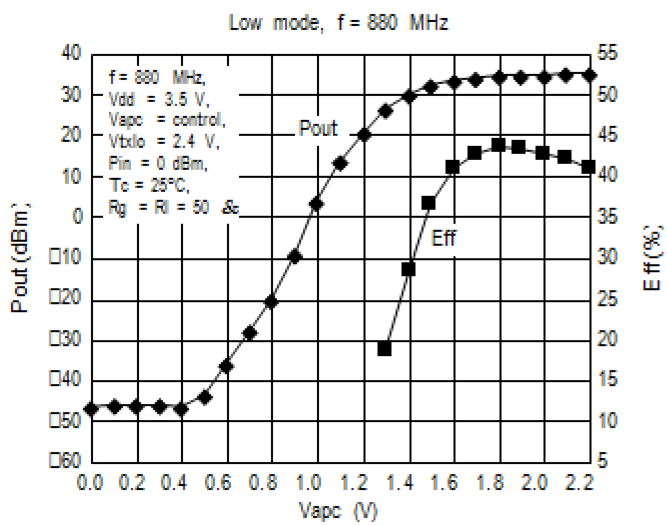
(Tc = 25°C)

Test conditions unless otherwise noted:
f = 880 to 915 MHz, Vdd $_{GSM}$ = 3.5 V, Pin $_{GSM}$ = 0 dBm, Rg = Rl = 50 &, Tc = 25°C, Vapc$_{DCS}$ = 0.1 V
Pulse operation with pulse width 577 ∝s and duty cycle 1:8 shall be used.

Item	Symbol	Min	Typ	Max	Unit	Test Condition
Frequency range	f	880	—	915	MHz	
Total efficiency (Hi)	$\eta_{T(Hi)}$	41	50	—	%	Pout $_{GSM}$ = 35.5dBm, Vtxlo = 0.1V, Vapc $_{GSM}$ = controlled
2nd harmonic distortion	2nd H.D.	—	□ 45	□38	dBc	
3rd harmonic distortion	3rd H.D.	—	□ 45	□40	dBc	
Input VSWR	VSWR (in)	—	1.5	3	—	
Total efficiency (Lo)	$\eta_{T(Lo)}$	27	35	—	%	Pout $_{GSM}$ = 30.8dBm, Vtxlo = 2.4V, Vapc $_{GSM}$ = controlled
Output power (1)(Hi)	Pout (1)(Hi)	35.5	36.0	—	dBm	Vapc $_{GSM}$ = 2.2V, Vtxlo = 0.1V
Output power (1)(Lo)	Pout (1)(Lo)	30.8	31.3	—	dBm	Vapc $_{GSM}$ = 2.2V, Vtxlo = 2.4V
Output power (2)(Hi)	Pout (2)(Hi)	33.5	34.0	—	dBm	Vdd $_{GSM}$ = 3.0V, Vapc $_{GSM}$ = 2.2V, Tc = +85°C, Vtxlo = 0.1V
Output power (2)(Lo)	Pout (2)(Lo)	28.8	29.3	—	dBm	Vdd $_{GSM}$ = 3.0V, Vapc $_{GSM}$ = 2.2V, Tc = +85°C, Vtxlo = 2.4V
Isolation	—	—	□ 42	□36	dBm	Vapc $_{GSM}$ = 0.2V, Vtxlo = 0.1V
Isolation at DCS RF-output when GSM is active	—	—	□ 23	□17	dBm	Pout $_{GSM}$ = 35.5dBm, Vtxlo = 0.1V Measured at f = 1760 to 1830MHz
Switching time	t_r, t_f	—	1	2	∝s	Pout $_{GSM}$ = 0 to 35.5dBm Vtxlo = 0.1V
Stability	—	No parasitic oscillation			—	Vdd $_{GSM}$ = 3.0 to 5.1V, Pout $_{GSM}$ ≤ 35.5dBm, Vtxlo = 0.1, 2.4V, Vapc $_{GSM}$ ≤ 2.2V, GSM pulse. Rg = 50&, Output VSWR = 6 : 1 All phases
Load VSWR tolerance	—	No degradation			—	Vdd $_{GSM}$ = 3.0 to 5.1V, t = 20sec., Pout $_{GSM}$ ≤ 35.5dBm, Vtxlo = 0.1, 2.4V Vapc $_{GSM}$ ≤ 2.2V, GSM pulse. Rg = 50&, Output VSWR = 10 : 1 All phases

Characteristic Curves





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