BROADBAND TACTICAL ANTENNA

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ABSTRACT

BROADBAND TACTICAL ANTENNA

Broadband tactical antenna along with its connecting module has been designed to operate with maximum gain and excellent impedance matching. A single broadband tactical antenna has been developed to cover the complete range of VHF and UHF frequencies of M3TR transceiver. New techniques for maximum gain and impedance matching were implemented. Several techniques were to increase the bandwidth of the antenna by varying length, radius, material and antenna types. Antenna covers the desired frequency range and can be used with the M3TR transceiver. The antenna design is composed of the antenna and connecting unit. A new compact antenna design is able to be used with manpack, vehicular and fixed station of the M3TR transceiver.

DECLARATION

The user state that this thesis entitled “Broadband Tactical Antenna” is the result of our own work except for as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Project Supervisor Signature

DEDICATIONS

To our Parents, Whose prayers and hard work has made us to withstand the challenges of life and we were able to contribute in development tactical antenna and serve the Pakistan Army. It is dedicated to all Soldiers of Pakistan Army, who has laid down their lives for our Honor, Independence and Integrity of Nation.

ACKNOWLEDGMENT

We are very grateful to Allah Almighty for giving us the confidence and strength for carrying out this project and for making us able to come up with a product that will not only be useful in the current era, but will be used as product in Pakistan Army. We also thank our instructors and friends for their moral and technical suggestions without which we might not have made it this far. NRTC has contributed in completion of the project. Above all, we are deeply thankful to our beloved parents for their patience, support and prayers that helped us gain our goal. We simply cannot thank them in words for they sacrificed their own comfort in order to give us a life that we need and by sponsoring us throughout our life.

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ABBREVIATIONS

CNR - Combat Net Radio

PRP - Packet Radio Services

REN – Relay, Range Extension Node

Rebro – Rebroadcast

NCW-Network Centric Warfare

Chapter 1

INTRODUCTION

1.1 Introduction

A broadband tactical antenna is the combination of various antennas of M3TR radio transceiver operating at different frequencies. Antenna has been designed and constructed from 30 MHz to 512 MHz to cover the complete range of frequencies of M3TR transceiver. Now days, wireless communication systems are becoming increasingly popular. However, the technologies for wireless communication still need to be improved further to satisfy the higher resolution and data rate requirements. In the communication system the more things is look to is the cost and low power device and it is the monopole which previous thing is used and still be improve for the communication system. Wireless Radio communication for the military used is totally based on the security and ruggedness.

Pakistan Army has purchased the Harris and M3TR radio sets for military purposes to fulfill the security and ruggedness demands of the battle field. Rhode & Schwarz tactical radio M3TR has been in use in Pakistan Army for quite some time now, is particularly used for its tactical, ground to air and long range communication. The type of antenna incorporated by R&S is monopole. These radio sets are very expensive and have maintenance problem. It was planned to redesign the same monopole antenna for a wide band i.e VHF and UHF range, covering ground to ground and ground to air communication. The figure 1.1 represents the tactical use of M3TR in the battlefield with the concept of network centric warfare.

Figure 1.1: Network Centric Warfare

1.2 **Proposed Solution**

The present antennas are very expensive and user has to switch off the radio set to shift from one frequency to another frequency for changing of the antenna. So the current antenna design covers the complete band of frequencies of M3TR radio set. The M3TR software defined radio family is a new generation of high-performance digital radios. It represents a revolutionary change, both technically and economically, in the tactical communications sector. The heart of the new integrated communications system is the light-weight ¸MR300xH/U manpack transceiver (1.5 MHz to 108 MHz or 25 MHz to 512 MHz), which offers solutions for all aspects of tactical communications as well as uniform and reduced inter service logistics.

Table 1.1 shows the different types of antennas used with M3TR. Monopole is a type of the radio antenna formed by replacing one half of a dipole antenna with a ground plane at right angles to the remaining half. If the ground plane is large enough, the monopole behaves exactly like a dipole, as if its reflection in the ground plane formed the missing half of the dipole.

Table 1.1: Antennas Used with M3TR

Type of Antenna	**Frequency Range**	**Power Rating**	**VSWR**	**Impedance**	**Length**
50 W UHF Vehicular Broadband Antenna	225-512 MHz	50 W	<3.5	50 Ohm	1 m
Long-wire directional half-rhombic Antenna	30-88 MHz	32 W	<=4	50 Ohm	10 cm
50 W VHF Vehicular Broadband Antenna	30-108 MHz	50 W	<3.5	50 Ohm	3.1 m
50 W VHF Low-Profile Antenna	30-108 MHz	50 W	<3.5	50 Ohm	1.88 m
VHF Manpack Antenna	25-108 MHz	25 W	<3.5	50 Ohm	1.65 m
Hang-Up Antenna	30-88 MHz	12.6 W	Max 4	50 Ohm	2 m

Monopole antennas are commonly employed in airborne and ground based communication systems at a wide range of frequencies. The electrical properties of such antennas are dependent upon the geometry of both the monopole element and the ground plane.

Typically, the monopole element may be electrically short (length is much less than a quarter wavelength) or near resonant (length approximately a quarter wavelength), and it may be thin (length to radius ratio is much greater than 104) or relatively thick (length to radius ratio of 101 to 104). Figure 1.2 shows the antennas used with M3TR. The broadband monopole antenna is vertically polarized, has a low angle radiation pattern and is used for short range circuits by ground wave and medium to long range circuits by sky wave.

Figure 1.2: Different Types of Antennas of M3TR

1.3 Aim of the Project

The aim of the project Broadband Tactical Antenna is to design an antenna, which covers the complete range of M3TR radio transceiver for its efficient use in Pakistan Army. Which must be capable of providing reliable communication by using all the frequencies and modes of operation. A single unit antenna will reduce the carrying load of operators and changing trouble in the battlefield.

1.4 **M3TR**

Multiband, Multimode, Multirole Tactical Radio. The M3TR is multiband-capable, covering the HF, tactical VHF, ATC VHF, maritime VHF and UHF aeronautical frequency bands between 1.5 MHz and 512 MHz. The M3TR enables users to choose from multiple waveforms, including NATO HF House, SECOM-H, SECOM-V, SECOM-P and SECOS. It can also be software-upgraded to adapt to changing requirements. The M3TR can be used as a manpack or installed in ground vehicles and ships. Irrespective of its role, it incorporates easily into tactical networks via standard IP interfaces. The figure 1.3 front panel show the antenna ports and programming keys. M3TR have manpack, vehicle station and base station configurations.

Figure 1.3: M3TR front Panel

1.5 **Key Capabilities for Ground Forces**

M3TR is very efficient radio transceiver in the battle field. The Data capability, In today's missions, armed forces need continuous access to the latest level-specific operational pictures if they are to respond swiftly to situational changes and accomplish their mission successfully. The figure 1.4 shows the inter portability of the radio transceiver according to power requirement. The Interoperability make it ready to meet tomorrow's interoperability requirements Rohde & Schwarz is a leading global provider of interoperable radio communications solutions for Joint operations, Combined operations and Interagency communications. The Networking is very important for military commanders are tasked with doing whatever it takes to effectively accomplish missions while ensuring the safety of their troops. To achieve this aim, access to the right information at the right place and time and the ability to leverage that information into sustained information superiority is a crucial factor.

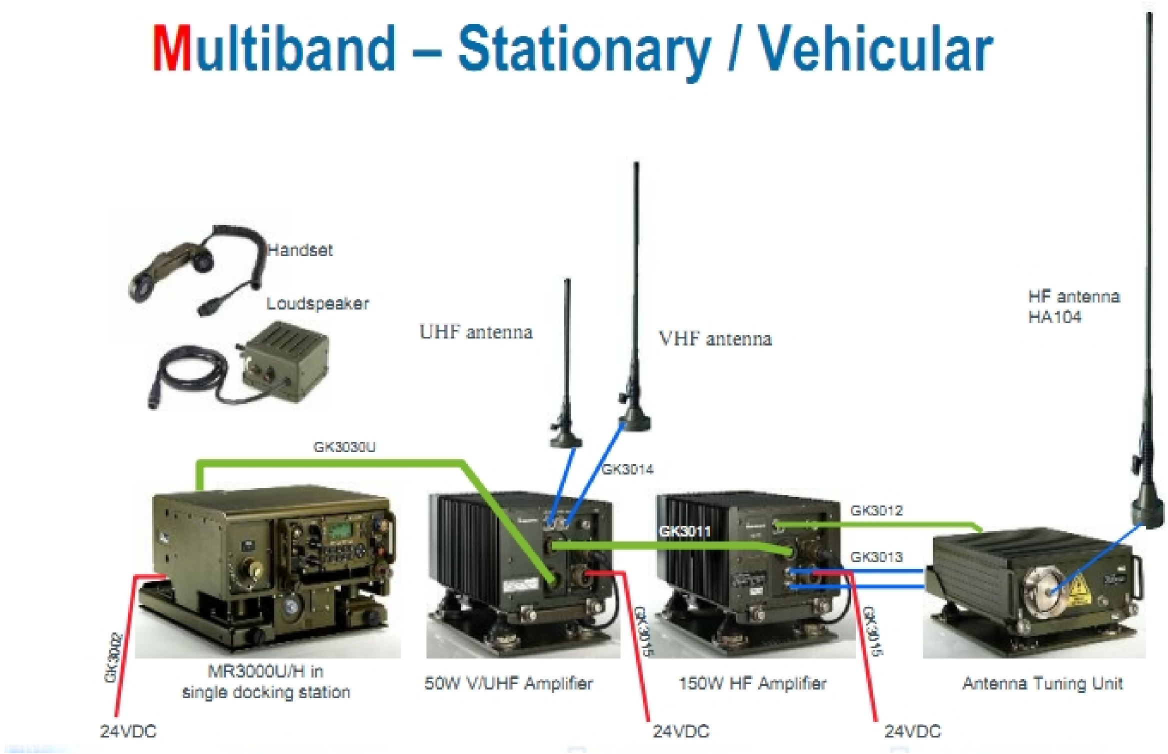


Figure 1.4: Accessories of M3TR

1.6 **Organization of Project Report**

The project report has been drafted carefully deciding the sequence to be followed. After the introduction section, the report incorporates the Literature Review chapter summarizing the text studied and research aspects of project before and during the project's execution. Subsequently, the Software Analysis chapter comes which includes various designs on HFSS. Next is the fabrication of antenna, then comes testing and future work.

2.1 Introduction

Few areas needed to be studied in order to get a better understanding of some basic knowledge required for developing antenna. Topics which were studied are:

Bandwidth enhancement techniques, Antenna Design Parameters, Modern development and techniques in antenna designing, Research work carried out by different people around the globe published in IEEE papers. Much software was used for simulation purposes like HFSS, ADS and PSpice.

2.2 Methods of Increasing Bandwidth

Monopoles and dipoles are resonant antennas and hence are narrowband antennas, There are different methodologies were extensively searched from the sources mentioned above to increase the bandwidth of the antenna, which will be incorporated in our simulations.

Different techniques which were learned to enhance the bandwidth of the narrowband monopole antenna are decreasing impedance variations, decreasing the l/d ratio, less variation between reactance and impedance, increasing the dimensions from classical narrowband to conical intermediate band or hemispherical wide band antenna. But these designs are impractical and can be approximated by intersecting wires, Instead of straight wire a helix can be used which is far efficient design. Helical antennas will also be considered because of their broadband characteristics, including its two configurations i.e. axial and normal, Dielectric coating on antenna enhances bandwidth, Discone and conical skirt monopole are simple in design and are easy to install and have broadband characteristics, Frequency independent antennas like fractal and log periodic antennas were also studied as part of enhancing knowledge and then applying the knowledge of enhancing bandwidth of antenna in simulations.

2.3 Antenna Basics

Antennas are a very important component of communication systems. By definition, an antenna is a device used to transform an RF signal, traveling on a conductor, into an electromagnetic wave in free space. Antennas demonstrate a property known as reciprocity, which means that an antenna will maintain the same characteristics regardless if it is transmitting or receiving. Most antennas are resonant devices, which operate efficiently over a relatively narrow frequency band.

An antenna must be tuned to the same frequency band of the radio system to which it is connected, otherwise the reception and the transmission will be impaired. When a signal is fed into an antenna, the antenna will emit radiation distributed in space in a certain way. A graphical representation of the relative distribution of the radiated power in space is called a radiation pattern.

2.4 **Monopole Antenna**

Nowadays wireless communication sys are becoming increasingly popular. However the technologies for wireless still needs to be improved further to satisfy higher resolution and data rate requirements. Figure 2.1 shows the designed Monopole sleeve antenna. In the communication sys the most imp things are the cost and the low power device and it is the monopole antenna that satisfies the above mentioned Objectives and still provides the space for improvement.

Figure 2.1: Monopole Sleeve Antenna

2.5 **Feed Mechanism**

A typical feed for the monopole antenna is a coaxial line with its inner conductor connected through a hole in the ground plane to the vertical monopole element and its outer conductor connected by means of a flange to the ground plane. Typically, the inner conductor's diameter is equal to the monopole element's diameter and the outer conductor's diameter is equal to the ground plane hole diameter. Unless stated otherwise, such a feed will be assumed in this study. The figure 2.2 shows the conceptual diagram of monopole antenna. The ratio of the coaxial line's outer to inner conductor diameters affects the antenna's input impedance, but only significantly for a relatively thick monopole element on a very small ground plane.

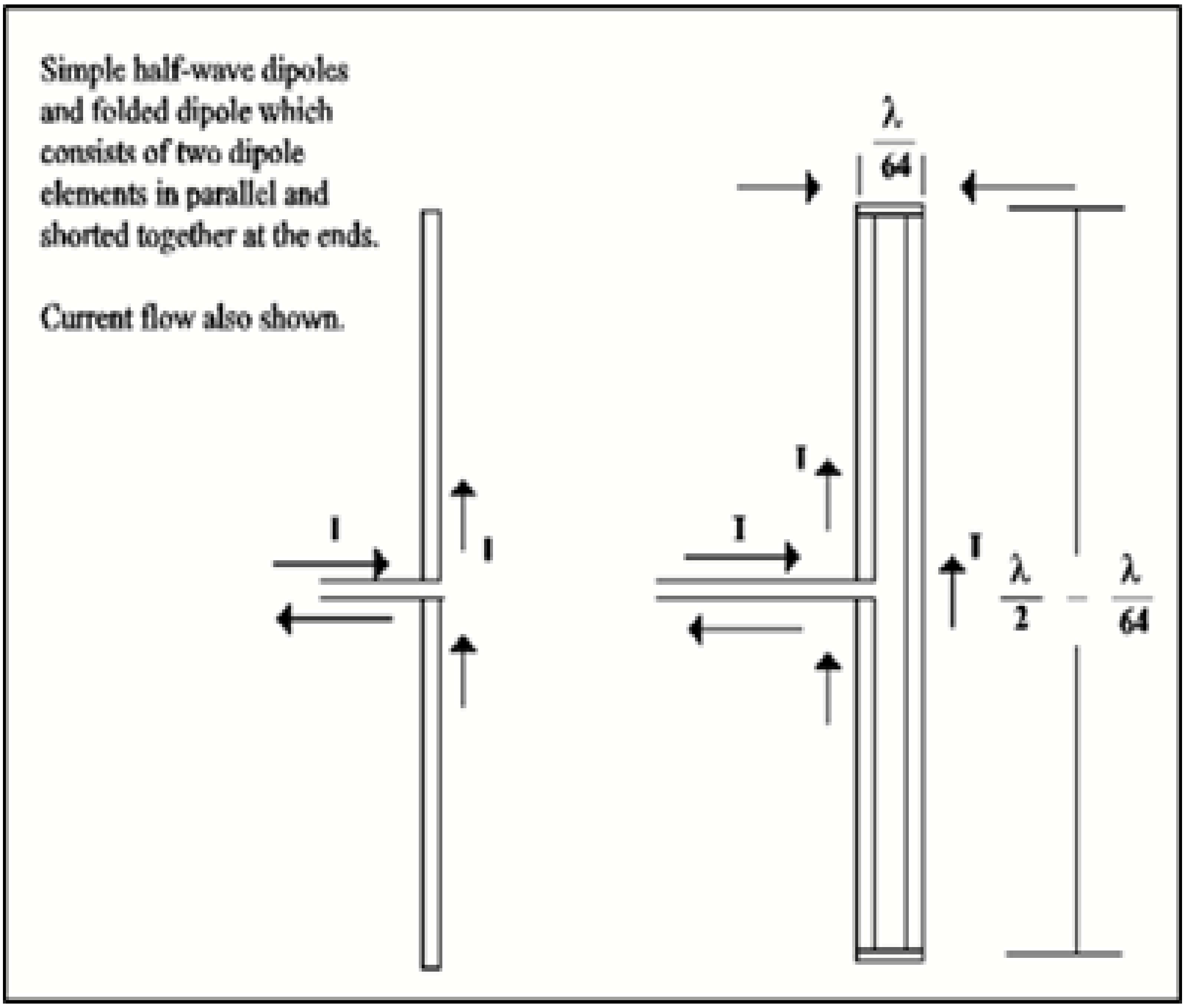


Figure 2.2: Monopole Antenna

For the idealized case of a ground plane of infinite extent and infinite conductivity, the monopole antenna may be modeled by the method of images as a dipole with one half the input impedance and double the peak directivity of the dipole. The infinite ground plane prevents monopole radiation into the hemisphere below the ground plane, but allows a radiation pattern identical to that of the dipole in the upper hemisphere. However, for a monopole element mounted on a ground plane of finite extent, the outer edge of the ground plane diffracts incident radiation in all directions, and consequently modifies the currents on the ground plane and the vertical element from those of an infinite ground plane. At the outer edge of the ground plane, the currents on its top and bottom faces are equal in magnitude but opposite in direction because the net current must be zero at the edge. Outer edge diffraction becomes increasingly significant with decreasing size of the ground plane because of the increasing magnitude of the currents on the ground plane faces at the outer edge. Edge diffraction can alter the input impedance by more than 3 dB and directivity in the plane of the ground plane by more than 6 dB from the values for a ground plane of infinite extent.

2.6 **Theoretical Models**

Theoretical models exist for predicting the effects of diffraction by the outer edge of the ground plane. The existing models may be classified into two categories, distinguished by whether the current distribution on the monopole element is initially.

When the monopole element is very thin and not too long, its current distribution is approximately sinusoidal and independent of the radius of the ground plane. Consequently, the element's current distribution can be initially specified and wended only determine the ground plane's current distribution. For this category of monopoles, the theoretical models reported in the literature essentially consist of Bardeen's integral equation method for a ground plane radius that is small compared to a wavelength, Richmond's method of moments(ground plane only) for a ground plane radius that is not too large compared to a wavelength , Leitner and Spence's method of oblate spherical wave functions for a ground plane radius that is comparable to a wave length , Tang's scalar theory of diffraction and the geometric theory of diffraction (GTD) for a ground plane radius that is large compared to a wavelength, and Storer's variation method for a ground plane radius that is very large compared to a wavelength.

When the monopole element is relatively thick, its current distribution is no longer sinusoidal, and the current distribution on both the monopole element and the ground plane consequently need to be determined as a function of the ground plane radius. For this category of monopoles, the theoretical models reported in the literature essentially consist of Richmond's method of moments for ground plane radius that is not too large compared to a wavelength and Awadalla Maclean's method of moments (monopole element only) combined with the geometric theory of diffraction for ground plane radius that is large or comparable to a wavelength. Thiele and Newhouse have also reported a model that combines the method of moments with the geometric theory of diffraction, but their computer program is unavailable.

2.7 Applications of Monopole Antenna

Monopole antennas are commonly employed in airborne and ground based communication systems at a wide range of frequencies. The electrical properties of such antennas are dependent upon the geometry of both the monopole element and the ground plane. Typically, the monopole element may be electrically short (length is much less than a quarter wavelength) or near resonant (length approximately a quarter wavelength), and it may be thin (length to radius ratio is much greater than 104) or relatively thick (length to radius ratio of 101 to 104). In addition, the ground dimensions may vary from a fraction of a wavelength to many wavelengths. Therefore, it is desirable to know how the input impedance and radiation pattern of the antenna change as the dimensions of the monopole element and the ground plane vary. The directivity on or near the radio horizon (the ground plane is assumed to be horizontal) is of particular interest because the maximum operational range of a communication system often depends on the directivity on the radio horizon.

2.8 Polarization of Monopole Antenna

The broadband monopole antenna is vertically polarized, has a low angle radiation pattern and is used for short range circuits by ground wave and medium to long range circuits by sky wave. The antenna is broadband, Omni directional and conical. The broadband frequency capability does not require tuning. The radiation pattern in the azimuth plane is essentially unidirectional, while the elevation pattern varies with frequency. The support structure is a guyed mast supported on a base insulator. The radiator comprises a bi conical cage of wire. Monopole antennas require a radial ground screen for specified performance. The ground screen consists of wire conductors laid out radials from the tower base and terminated at the outer end.

The monopole Antenna is commonly used in radio broadcasting, the radio frequency power from the broadcasting transmitter is fed across the base insulator between the tower and a ground system.

2.9 Electric and Magnetic Field in Near and Far Field Regions

For the current constraints the total magnetic and electric field intensities H(total), E(total) at an arbitrary field point P(X,Y,Z) external to the element excitation source points are simply the vector sum of the fields resulting from the element current and the current induced on the ground plane by the fields incident by the element.

2.10 **Concept of Ground Plane**

Monopole antenna in actual is dipole antenna. Antenna element server as radiating part and ground plane serves as the other part of antenna. Consider a monopole antenna excited by a coaxial line with an outer conductor of radius that is terminated by free space, rather than by a ground plane. The ground plane for such an antenna is denoted as being of zero extent. The coaxial line excitation may be replaced by an equivalent magnetic current sitting on top of a thick ground plane of radius. For sufficiently lossy ferrite toroids along the outside of the coaxial line, the current on the exterior of the coaxial line's outer conductor may be neglected. The magnetic frill may be removed from the circuit without appreciably affecting the results because for the assumed sinusoidal current distribution on the monopole element. The input impedance is derived by way of the induced EMF method.

Chapter 3
SOFTWARE ANALYSIS

3.1 **Use of Software**

After successfully completion the literature review phase, several IEEE papers and selected topics from various other sources were the guiding stars for designing and testing the antenna in the software design part. Large number of parameters and variables are involved. A lot many antennas were designed and optimized and tested for almost all of the fundamental parameters. Many designs were simulated but only four designs were finalized for fabrication. Antennas presented below were all tried, tested and optimized in Ansoft HFSS. Whereas, a few other software's were also used but HFSS stands the most accurate.

Different variants of monopole antenna were designed in HFSS, like rod monopole, conical skirt monopole, blade monopole, patch monopole, L-shaped monopole, sleeve monopole, hollow monopole, helical monopole etc. the antenna designs given below offers great insight into various types of antennas behaving very differently for the same frequency band. Every antenna presented here has a unique capability which can be further explored. However hollow sleeve monopole and L-shaped monopole are the recommended solutions.

3.2 Helical Antenna

The helical antenna was designed as per IEEE paper. Figure 3.1 shows the helical antenna. Antenna covers the complete range of frequencies having excellent radiation pattern, S11 below -10 db for wide range of frequencies. Figure 3.2 shows the S11 graph of the antenna. The antenna size was the only problem in fabrication and implementation of the antenna. The size of helical antenna was about 4 feet in diameter. This was not fabricated due to its impractical design.

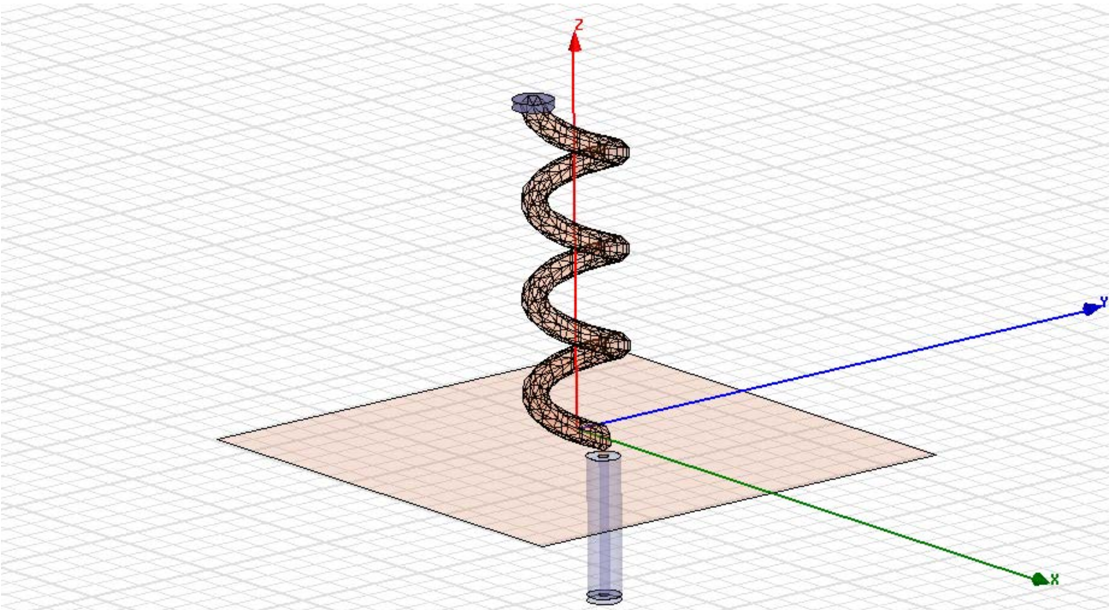


Figure 3.1: Helical Antenna

The radiation pattern of the antenna was fully ominidirectional. The antenna can be used as only ground station.

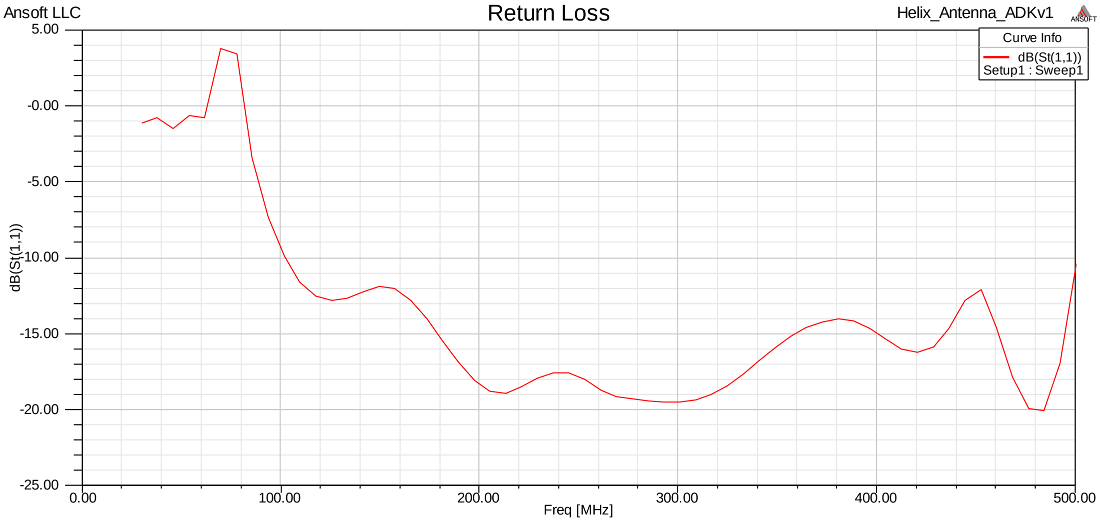


Figure 3.2: S11 Graph of Helical Antenna

3.3 **L-Shaped Monopole**

The L shaped antenna has been fabricated for the complete range of frequencies. Antenna is small in size and light in weight. Brass was used in antenna fabrication for better results. The antenna covers the complete range with perfect S11 graph representation. Figure 3.3 shows the design of the antenna.

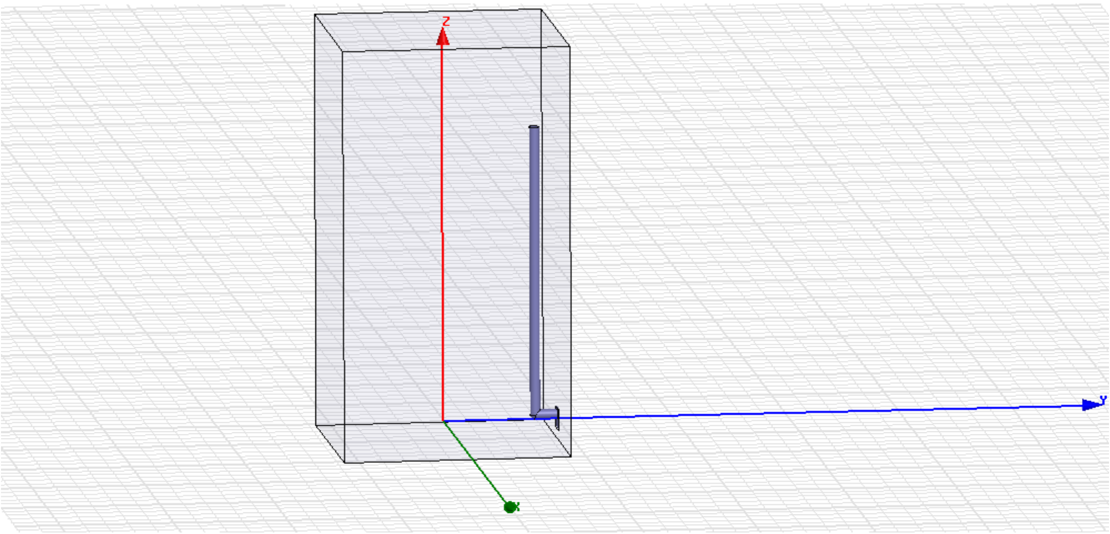


Figure 3.3: Design of L Shaped Antenna

Figure 3.4 shows the energy flow in the antenna. It shows that all the energy is delivered to the antenna with minimum losses.

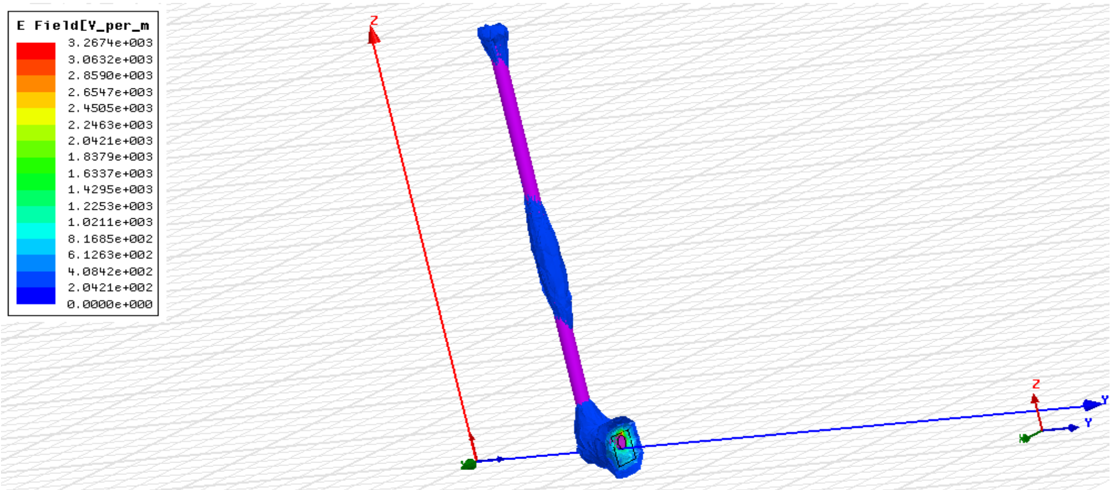


Figure 3.4: Energy Flow of L Shaped Antenna

Figure 3.5 shows the S11 graph of the L Shaped antenna. Most of the graph representation is below -15 db. Its shows that it is below -10 db for the complete frequency range.

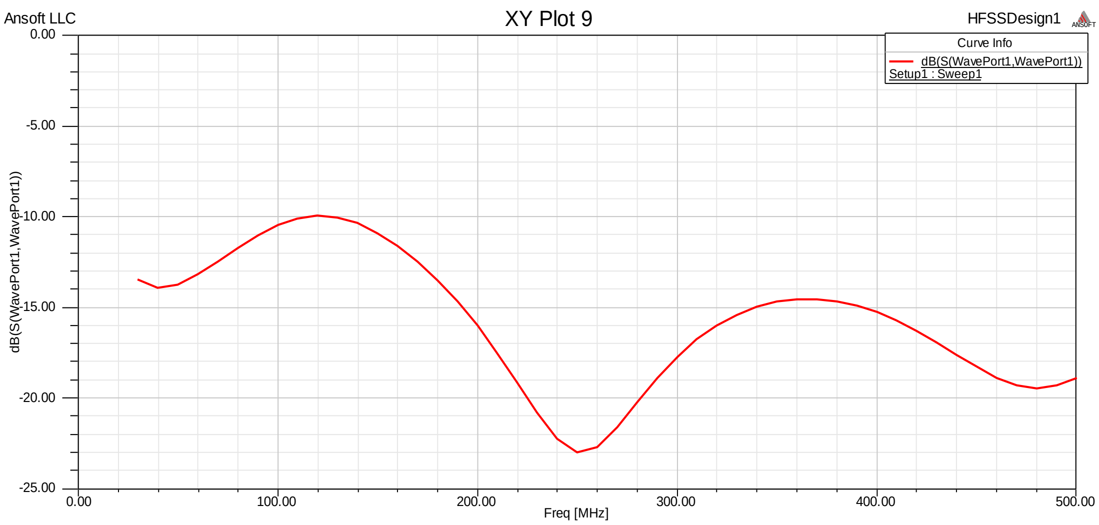


Figure 3.5: S11 Graph of L Shaped Antenna

VSWR is the most important antenna parameter. R&S has provided the antenna with the specification less than 3.5, but the antenna has VSWR below 1.9. The figure 3.6 shows the VSWR of the antenna.

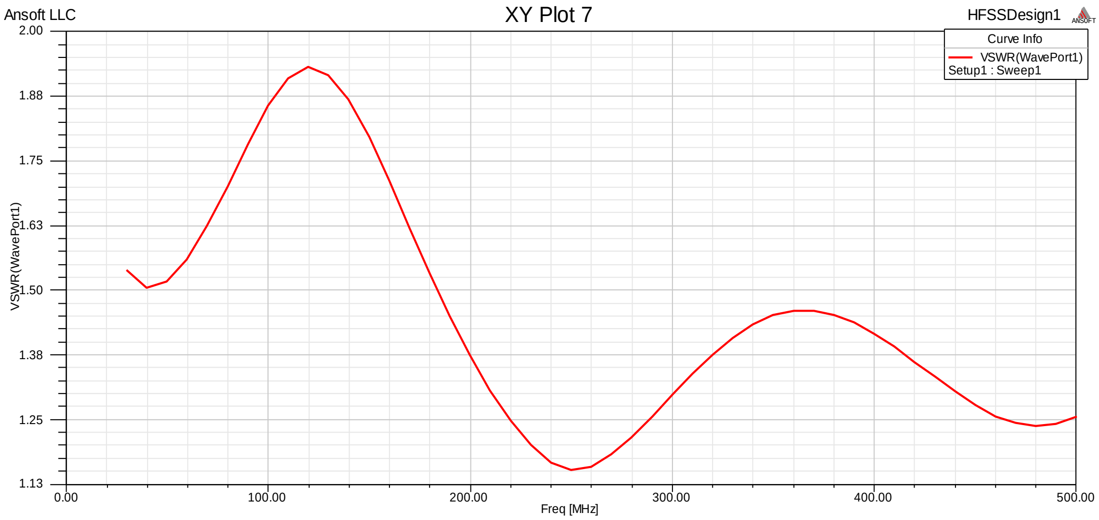


Figure 3.6: VSWR of L Shaped Antenna

3.4 **Hollow Sleeve Monopole**

The Hollow sleeve monopole antenna has been fabricated and tested under field environment. The antenna covers the frequency range from 200-480 MHz. Figure 3.7 shows the design of hollow sleeve monopole antenna.

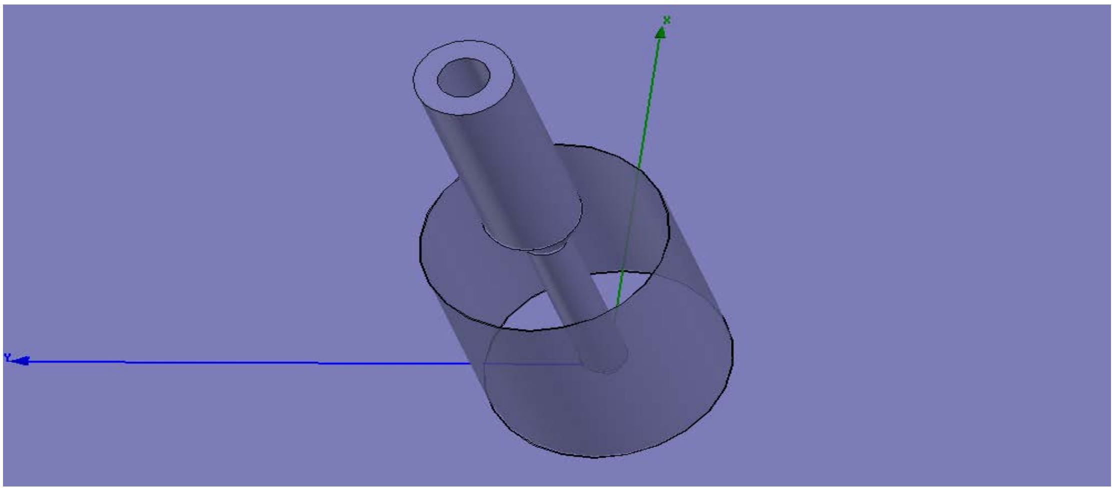


Figure 3.7: Design of Hollow Sleeve Monopole Antenna

The S11 graph shows the range below -10 db for the frequency range 200-480 MHz. Figure 3.8 shows the S11 graph of the antenna.

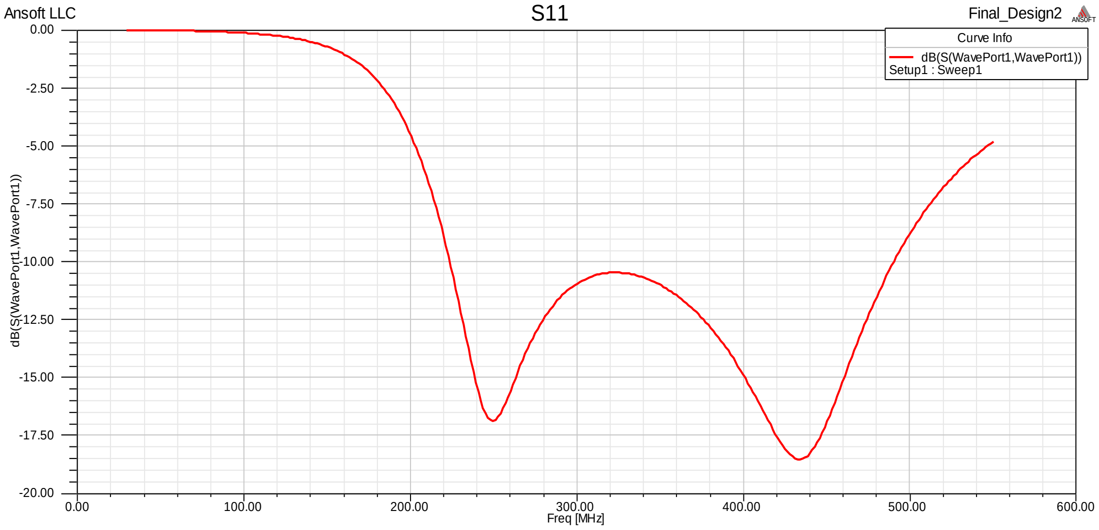
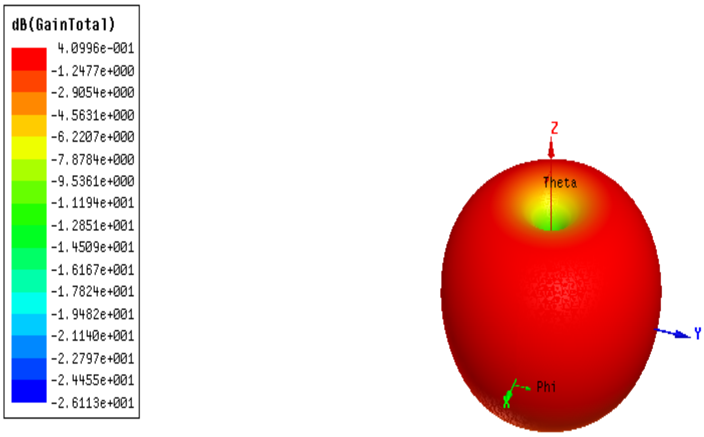


Figure 3.8: S11 of Hollow Sleeve Monopole Antenna

The antenna have omini directional radiation pattern as desired for the military applications. Figure 3.9 shows the 3D and 2D radiation pattern.



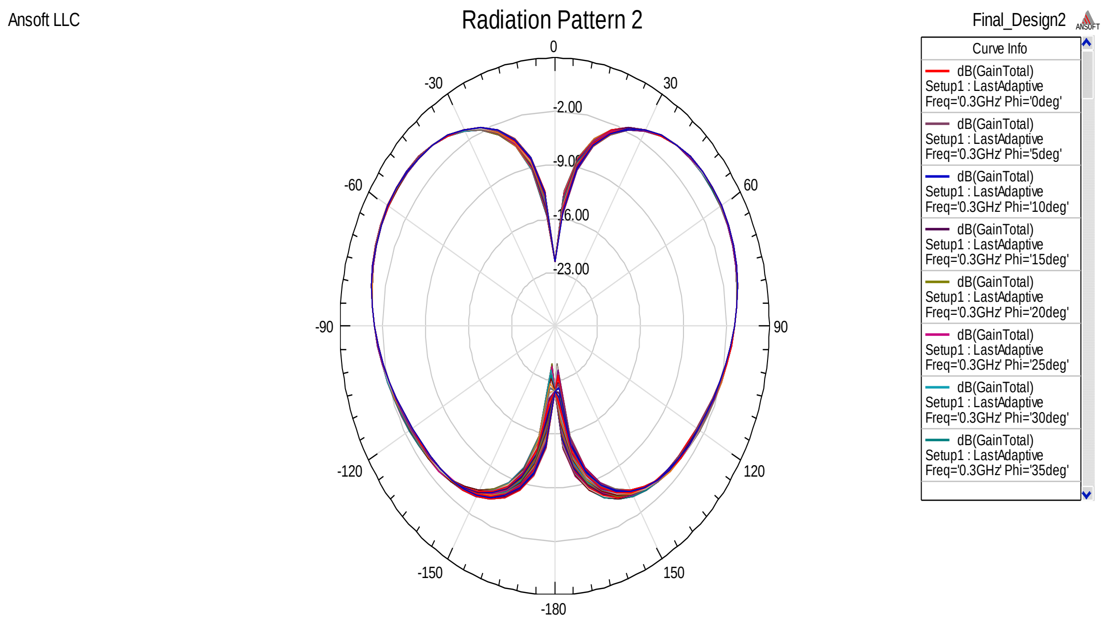


Figure 3.9: Radiation Pattern of Hollow Sleeve Monopole Antenna

Chapter 4

FABRICATION

4.1 Selection of Material for Fabrication

Material plays very important in antenna performance. The selection of material is based on its weight, strength and radiating performance. There are several types of material used in antenna fabrication like aluminum, brass, copper and many more. Every material differs from one another in its performance and quality. The working efficiency also depends on the antenna resistance against weather.

4.1.1 Aluminum

Although aluminium is, after oxygen and silicon, the third most abundant element in the Earth's crust, it is by far the youngest of the major industrial metals, first produced on a commercially significant scale only just over a hundred years ago. Like lead, tin, iron aluminium exists naturally only in the form of compounds.

4.1.1.1 Light Weight

Aluminium is a very light metal with a specific weight of 2.7 g/cm^3, about a third that of steel. For example, the use of aluminium in vehicles reduces dead-weight and energy consumption while increasing load capacity. Its strength can be adapted to the application required by modifying the composition of its alloys.

4.1.1.2 **Corrosion Resistance**

Aluminium naturally generates a protective oxide coating and is highly corrosion resistant. Different types of surface treatment such as anodising, painting or lacquering can further improve this property. It is particularly useful for applications where protection and conservation are required.

4.1.1.3 **Electrical and Thermal Conductivity**

Aluminium is an excellent heat and electricity conductor and in relation to its weight is almost twice as good a conductor as copper. This has made aluminum the most commonly used material in major power transmission lines. Ductile Copper is a ductile metal. This means that it can easily be shaped into pipes and drawn into wires. Copper pipes are lightweight because they can have thin walls.

4.1.1.4 **Reflectivity**

Aluminium is a good reflector of visible light as well as heat, and that together with its low weight, makes it an ideal material for reflectors in, for example, light fittings or rescue blankets. They don't corrode and they can be bent to fit around corners. The pipes can be joined by soldering and they are safe in fires because they don't burn or support combustion.

4.1.2 **Copper**

Copper and gold are the oldest metals known to man and were found in ancient times in their native form. Their bright colour made them easily visible. They do not shatter when they are dropped or become brittle when cooled below 0 °C. Non magnetic Copper is non magnetic and non sparking. Because of this, it is used in special tools and military applications.

4.1.2.1 **Corrosion Resistant**

Copper is low in the reactivity series. This means that it doesn't tend to corrode. Again, this is important for its use for pipes, electrical cables, saucepans and radiators. However, it also means that it is well suited to decorative use. Jewellery, statues and parts of buildings can be made from copper, brass or bronze and remain attractive for thousands of years.

4.1.2.2 **Antibacterial**

Copper is a naturally hygienic metal that slows down the growth of germs such as E-coli (the “burger bug”), MRSA (the hospital “superbug”) and legionella. Tough Copper and copper alloys are tough. This means that they were well suited to being used for tools and weapons. Imagine the joy of ancient man when he discovered that his carefully formed arrowheads no longer shattered on impact.

4.1.2.3 **Easily Joined**

Copper can be joined easily by soldering or brazing. This is useful for pipework and for making sealed copper vessels.The property of toughness is vital for copper and copper alloys in the modern world. They do not shatter when they are dropped or become brittle when cooled below 0 °C. Non magnetic Copper is non magnetic and non sparking. Because of this, it is used in special tools and military applications.

4.1.2.4 **Attractive Colour**

Copper and its alloys, such as brass, are used for jewellery and ornaments. They have an attractive golden colour which varies with the copper content. They have a good resistance to tarnishing making them last a long a time. However, it also means that it is well suited to decorative use. Jewellery, statues and parts of buildings can be made from copper, brass or bronze and remain attractive for thousands of years.

4.1.2.5 **Alloys Easily**

Copper can be combined with other metals to make alloys. The most well known are brass and bronze. Although copper has excellent electrical and thermal properties, it needs to be hardened and strengthened for many industrial applications. It is therefore mixed with other metals and melted. The liquid metals form a solution which, when they solidify, are called alloys.

4.1.2.6 **Catalytic Compounds**

Copper can act as a catalyst. For example, it speeds up the reaction between zinc and dilute sulphuric acid. It is found in some enzymes, one of which is involved in respiration. So it really is a vital element. Copper and gold are the oldest metals known to man and were found in ancient times in their native form. Their bright colour made them easily visible. They do not shatter when they are dropped or become brittle when cooled below 0 °C. Non magnetic Copper is non magnetic and non sparking.

4.1.3 **Bronze and Brass**

The two most commonly used metal alloys in the modern world are bronze and brass. These metal alloys are utilized in industries as diverse as architecture, machinery and the manufacture of industrial items. Other variations of bronze are common in other industries: alpha bronze, which is commonly used in the manufacture of coins, fine blades and turbines; and bismuth bronze, used in light reflectors and mirrors. Brass, on the other hand, is an alloy consisting of copper.

4.1.3.1 **Components**

Bronze is a metal alloy consisting primarily of copper and other metals with tin as the main additive. Other variations of bronze are common in other industries: alpha bronze, which is commonly used in the manufacture of coins, fine blades and turbines; and bismuth bronze, used in light reflectors and mirrors.Brass, on the other hand, is an alloy consisting of copper and zinc.

4.1.3.2 **Malleable and Durable Alloy**.

It is an extremely malleable and durable alloy, and can last for years. Bronze is less brittle than other metals, like iron and steel. . It is often used in modern architecture, especially for railings and grills, which gives many public buildings an air of grandeur and charm. Bronze is also the alloy of choice in the casting of public, outdoor statues. Its malleability makes it ideal for pouring into elaborate moulds and has a distinguished aesthetic finish. Other variations of bronze are common in other industries: alpha bronze, which is commonly used in the manufacture of coins, fine blades and turbines; and bismuth bronze, used in light reflectors and mirrors.Brass, on the other hand, is an alloy consisting of copper.

4.1.3.3 **Weather Resistant**.

Bronze is also tremendously weather-resistant and does not rust when exposed to moisture. It is often used in modern architecture, especially for railings and grills, which gives many public buildings an air of grandeur and charm. Bronze is also the alloy of choice in the casting of public, outdoor statues. Its malleability makes it ideal for pouring into elaborate moulds and has a distinguished aesthetic finish. Other variations of bronze are common in other industries: alpha bronze, which is commonly used in the manufacture of coins, fine blades and turbines; and bismuth bronze, used in light reflectors and mirrors.Brass, on the other hand, is an alloy consisting of copper and zinc. It is known for its luminous, gold-like sheen. It is commonly used in making locks, gears, doorknobs and electrical parts.

4.1.3.4 **Recyclable**.

Most important, the different bronze and brass alloys are usually recyclable. This helps keep landfills from filling up and assist with the conservation of resources. It is an extremely malleable and durable alloy, and can last for years. Bronze is less brittle than other metals, like iron and steel. . It is often used in modern architecture, especially for railings and grills, which gives many public buildings an air of grandeur and charm. Bronze is also the alloy of choice in the casting of public, outdoor statues.

Chapter 5

TESTs and TRIALs

5.1 **Features of M3TR**.

It is Multirole, Multiband and multiband radio transceiver. These are very important features which were considered in design and fabrication of antenna. Table 5.1 shows the important features of M3TR.

Table 5.1: Features of M3TR

Frequency Range	1.5 MHz – 512 MHz
Frequency Bands	HF, VHF, UHF
VSWR	< 3.5
Impedance	50 Ohm
Power Rating	15-50 W
Radiation Pattern	Omni directional
Connector	BNC with 50 Ohm
Wind Rating	55 mps

5.2 **Applications of Broadband Tactical Antenna.**

Monopole antennas are commonly employed in airborne and ground based communication. Systems have wide range of frequencies. The electrical properties of such antennas are dependent upon the geometry of both the monopole element and the ground plane. Typically, the monopole element may be electrically short (length is much less than a quarter wavelength) or near resonant (length approximately a quarter wavelength), and it may be thin (length to radius ratio is much greater than 104) or relatively thick (length to radius ratio of 101 to 104). In addition, the ground plane dimensions may vary from design to design.

5.3 **Monopole Antenna**.

The efficiency of the antenna varies from fraction of a wavelength to many wavelengths. Therefore, it is desirable to know how the input impedance and radiation pattern of the antenna change as the dimensions of the monopole element and the ground plane vary. The directivity on or near the radio horizon (the ground plane is assumed to be horizontal) is of particular interest because the maximum operational range of a communication system often depends on the directivity on the radio horizon.

The broadband monopole antenna is vertically polarized, has a low angle radiation pattern and is used for short range circuits by ground wave and medium to long range circuits by sky wave. The antenna is broadband, Omni directional and conical. The broadband frequency capability does not require tuning. The radiation pattern in the azimuth plane is essentially unidirectional, while the elevation pattern varies with frequency. Monopole antennas require a radial ground screen for specified performance. Monopole Antenna is commonly used in radio broadcasting, the radio frequency power from the broadcasting transmitter is fed across the base insulator between the tower and a ground system.

5.4 **Field Strength Measurement**.

Anyone wishing to measure electric and magnetic field strengths, which is becoming an increasingly important activity in view of the ever-rising number of radio services and the fast-growing significance of EMI suppression, will have to deal in detail with measuring instruments. Figure 5.1 shows the variation in radiation pattern at different frequencies. There is also an occasional tendency to overlook the fact that field strength measurement cannot be reliably performed without thorough knowledge of the test antenna.

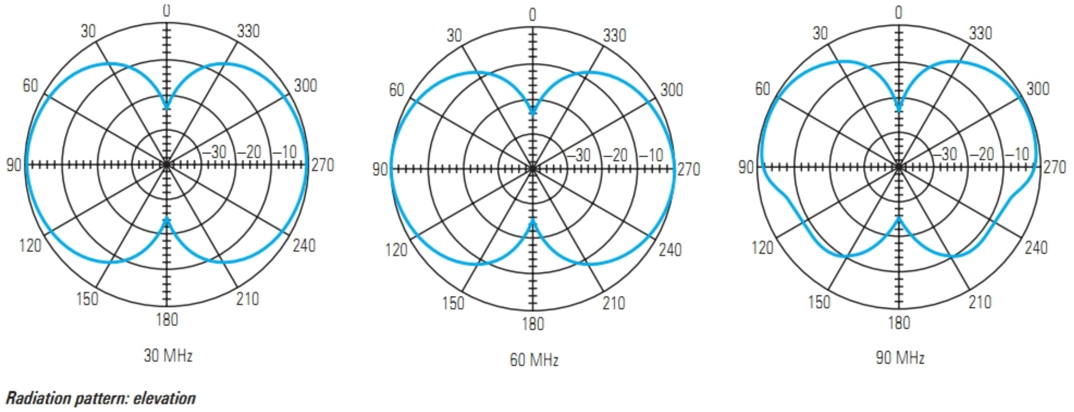


Figure 5.1: Radiation Pattern at different frequencies

5.4.1 **Useful Field Strength**.

The expression useful field-strength is generally used in connection with radio emissions and stands in contrast to the term unwanted radiation, which refers to the interference generated by items such as household appliances and motor vehicle ignition systems. The juxtaposition of all kinds of communications services using electromagnetic waves to transmit information requires rules to ensure that the various services do not cause mutual interference. However, radio waves do not stop at national boundaries, which mean that their use also results in international problems.

5.4.2 **Radio Monitoring**

Radio monitoring was therefore put on an international footing in the International Telecommunications Convention (Atlantic City 1947) since when there has been constant worldwide improvement.

5.4.3 **Coverage Measurements**

Coverage measurements such as those performed on mobile radio or broadcasting networks also fall within the scope of useful field-strength measurement. Network operators are regularly required to generate a signal with adequate field strength in a specified area, and to verify these using measurements.

5.4.4 **EMI Measurements**,

However, has as its objective the detection and quantitative assessment of unintentionally emitted radiation. Basically every electrical or electronic device (vacuum cleaners and computers alike) is capable of emitting electromagnetic waves. The legislator therefore requires that electromagnetic fields generated in this way shall not exceed certain maximum values, and in most cases manufacturers or importers must produce evidence that this requirement is satisfied.

5.4.5 **Immunity to External Fields**.

In view of the strong increase in wanted and unwanted emissions, it is all the more important to check devices and systems (including even entire aircraft) for their immunity to external fields. Field strength measurements are necessary in order to obtain quantitatively usable and comparable evidence.

5.5 I**nstruments Needed to Measure Field Strengths**.

The instruments needed to measure field strengths can be divided into four or, more accurately, five groups:

5.5.1 **Antennas**

Which transform the electromagnetic wave into a conducted wave (or vice versa) and whose electrical characteristics must be accurately known. A single antenna or an antenna array will be used, depending on the application.

5.5.2 **Signal Distribution**

Which can be implemented by a simple RF cable. When there are several switchable antennas, signal distribution is sometimes very complex. It may include switchable relay matrixes, diode switches and electronic signal multipliers.

5.5.3 **Receivers**

Which cover the frequency range of interest. They are equipped with different demodulators depending on the intended purpose, and must comply with applicable requirements regarding selectivity and bandwidth. These requirements are often defined in relevant standards. The receiver must have a calibrated test instrument for the voltage at its antenna input and should have a computer interface so that both measurement and analysis of the measured data can be performed automatically.

5.5.4 **Control Units(s)**

Which automate measurement and result processing, and by so doing can significantly reduce personnel costs. Industry-compatible, advanced-technology computers or PCs are Antenna Basics, ideal for this purpose. Some test receivers are already equipped with the control software and interfaces necessary for handling data or can be upgraded with the appropriate options. Combining the modules mentioned with a well-thought-out installation of system modules that provide protection from lightning, electromagnetic interference (EMI) and the like will make little or no difference to the convenience, speed and reliability of measurement.

5.6 **Calibration Methods**

The following parameters are very important like effective aperture, gain, effective length / effective height and antenna factor. Figure 5.2 shows the antenna calibration configuration. A purely computer-based definition of the parameters for the antenna type being used (or such information taken from a catalog, data sheet or manual) is normally not enough to ensure the accuracy demanded for many measurement tasks.

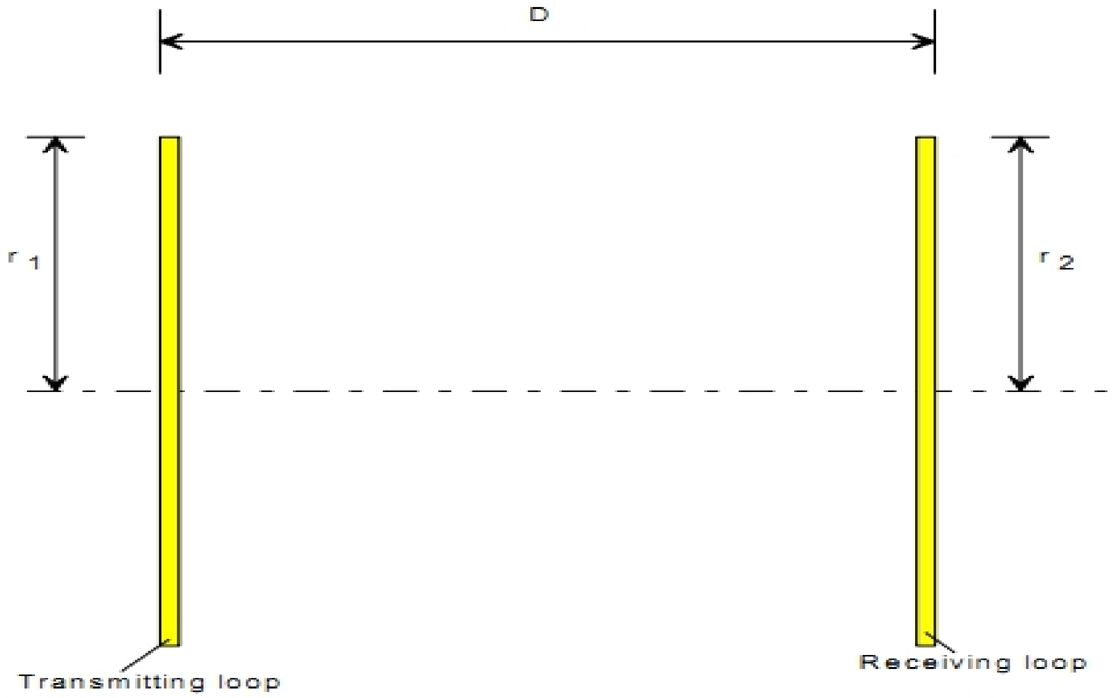


Figure 5.2: Antenna calibration configuration

National and international standards institutions and telecommunications authorities have defined a series of methods for calibrating test antennas. The purpose of these is to work toward standardization of the terms and expressions used and to ensure reproducibility of the results obtained during calibration and measurement, to take into account the physical characteristics of the frequency ranges and forms of antenna under investigation, and where possible to compensate any systematic errors may occur.

5.7 **Methods of Calibrations**.

If the electric field strength is precisely known at the point where the antenna being calibrated is located, the antenna factor for this antenna can be obtained by evaluating the defining equation for the antenna factor (standard field method). For a clearer understanding it should be remembered that the majority of terms defined in the context of radiation and wave propagation assume fully idealized environmental conditions (free space, matching and quite often far field). Therefore, a distinction first needs to be made between two classes of test methods:

5.7.1 **Free Space Methods**

It requires a test path that very closely simulates free space propagation conditions.

5.7.2 **Reflection Methods**

The increase in field strength caused by reflection from a highly conducting surface is utilized for calibration.

5.8 **Free Space Method**.

At first it would seem obvious to use free space calibration methods because the antenna parameters that need to be determined are themselves free space parameters. This would require a completely homogeneous total space in which transmitting and receiving antennas would be a virtually infinite distance apart.

In practice the situation is limited to a propagation path having an unobstructed Fresnel ellipsoid. The extent to which such a configuration matches ideal free space conditions depends first and foremost on the frequency and the antenna radiation pattern. The method include On the one hand, the dimensions of the ellipsoid to be kept unobstructed increase in proportion to the frequency, On the other, the antennas used in practice at higher frequencies also have larger dimensions, On the one hand, environmental influences that could affect the free space conditions become negligible as antenna directivity increases, On the other, high directivity complicates accurate antenna alignment and is more sensitive to the actual antenna being calibrated.

5.9 **Reflection Method**.

If there is no way of reliably guaranteeing that free-space propagation conditions will be maintained, these conditions are deliberately breached by introducing a highly conducting surface. Since the field strength that can theoretically be received at the reception site when using this type of configuration is fairly easy to calculate, conclusions about the antenna data are possible on the basis of the measured transmission loss.

When calibrating in line with the reflection method it is very important to ensure that The field strength maximum is actually used by making an appropriate height adjustment to the antenna being calibrated, The reflecting surface is either very highly conducting, The reflecting surface is smooth enough; this can generally be assumed to be so if the Rayleigh criterion is fulfilled, The reflecting surface is large enough and reflections of currents induced in the surface at its boundary are reliably avoided or suppressed by suitable measures and the test path and its surroundings are free from other reflectors and obstacles.

5.10 **Evaluation Methods**

Whatever the chosen test setup, the next question is the method to be used to analyze and evaluate the measurement data. There are basically two different methods available for this purpose. The method about to be described, the comparison method, is gradually losing ground in the area of precision measurement.

5.11 **Comparison Method**

Antenna comparison methods can be used for measuring both the practical gain and the quantitative radiation pattern (in free space measurement), provided a calibrated reference antenna is available. Both antennas are introduced one after the other into a constant electromagnetic field. When doing so it is particularly important to ensure that the field strength at the reception site does not alter when the antennas are changed and both antennas are placed at precisely the same spot and with the same alignment.

5.12 **Reciprocity Methods**

Unlike the comparison method, the following test methods do not need a reference antenna. Antenna factors or gain are instead obtained from a comparison between measured and calculated field parameters.

5.13 **VSWR Measurement using VNA**

A Lab measurement equipment is used for Lab test of the antenna. VSWR have to be less the -10 db but more it will be less then more efficient will be the antenna. As antenna is designed for M3TR Radio transceiver to cover the complete range of frequencies.

5.14 **Antenna Impedance Test**.

Impedance matching is the key to efficiency of the antenna. Connectors, coaxial cable has to be of equivalent impedance of radio transceiver. These are few applications of the antenna like Use as portable antenna with M3TR radio transceiver set, Its large band of frequencies can made it compatible to be used for different radio sets used in Pakistan army with slight modifications and presently antenna is designed for vehicular version, but it can be used as control station and man pack antenna.

5.15 **Radiation Pattern Test**.

Monopole antennas are Omni directional and these antennas has to radiate equally in all directions for efficient results. When doing so it is particularly important to ensure that the field strength at the reception site does not alter when the antennas are changed and both antennas are placed at precisely the same spot and with the same alignment.

5.16 **Weather Test**

The efficiency of the antenna changed with atmospheric conditions. So it must be tested under rain, snow or wind storm conditions. These are few applications of the antenna like Use as portable antenna with M3TR radio transceiver set, Its large band of frequencies can made it compatible to be used for different radio sets used in Pakistan army with slight modifications and presently antenna is designed for vehicular version, but it can be used as control station and man pack antenna.

5.17 **Breakage Test**.

As antenna has to be used as vehicular version, so it must go through under jerk test. These are few applications of the antenna like Use as portable antenna with M3TR radio transceiver set, Its large band of frequencies can made it compatible to be used for different radio sets used in Pakistan army with slight modifications and presently antenna is designed for vehicular version, but it can be used as control station and man pack antenna.

5.18 **Material Test**.

As antenna has to be used under all weather conditions so it must be tested for material for corrosion or other metal damages. Most important, the different bronze and brass alloys are usually recyclable. This helps keep landfills from filling up and assist with the conservation of resources. It is an extremely malleable and durable alloy, and can last for years. Bronze is less brittle than other metals, like iron and steel. . It is often used in modern architecture, especially for railings and grills, which gives many public buildings an air of grandeur and charm. Bronze is also the alloy of choice in the casting of public, outdoor statues

5.19 **Fitting Compatibility Test**.

There are several types of vehicles used in Pakistan Army, so antenna mounting must be designed so that it can be easily fitted to all types of vehicles.

Chapter 6

CONCLUSION

6.1 Applications.

As antenna is designed for M3TR Radio transceiver to cover the complete range of frequencies. These are few applications of the antenna like Use as portable antenna with M3TR radio transceiver set, Its large band of frequencies can made it compatible to be used for different radio sets used in Pakistan army with slight modifications and presently antenna is designed for vehicular version, but it can be used as control station and man pack antenna.

6.2 Scope of Future Work

Presently antenna has not been tested with the radio set, because few compatibility and calibration tests were not carried out. Antenna testing facilities are not available in NRTC, AWC, R&S or SEECS. Its size weight can be further reduced to use it with man pack version of the set and it can be made compatible to be used with other types of radio sets of Pakistan army.

6.3 Advantages

During extensive battle field it is very difficult to change the antenna for every changing frequency. But now there is no need of changing the antenna time and again with the frequency. M3TR radio transceiver costs equals to the cost of (Mashaq) PAF trainer plane, it also include different types of costly antenna. But Broadband Tactical antenna has reduced or almost eliminated the cost of antenna, A first step toward self reliance.R&S have also provided the antenna with the set covering the complete band of frequencies. But it is greater than in size of a normal human being. Broadband Tactical antenna is very small in size and can be used anywhere. Due to larger size it is very difficult to conceal the equipment from enemy in battle field but Broadband Tactical antenna is smaller in size and can be easily camouflage from the enemy air and ground forces. R&S broadband antenna is very heavy and a common person can pick it for installation. It can also injure the soldier and also damage the vehicles, on which these are mounted. But Broadband Tactical Antenna is very light in weight.

6.4 Conclusion

Antennas provide the primary interface between the radio and the propagation environment. The antenna requires special considerations in terms of performance requirements, design constraints, design and realization. Specification of the antenna gain and relating those requirements to the system performance in terms of range and system link gain is a foundation for the design goals of the antenna. During the antenna topology/structure selection process, consider packaging constraints in terms of the size, location and possible obstructions. Be prepared to compromise performance versus package conformance.

Ideally, one should use a simulation tool to assess the performance of the antenna prior to realization, not only to gauge the fundamental performance of the antenna, but also to check the effects of antenna compaction, obstructions and other compromised parameters. The final physical realization and consequent measurement of input terminal reflection/impedance and antenna gain complete the design process. Often, the measurement results require that the antenna structure be modified to empirically optimize its performance.

The overall working of antennas was understood. The major parameters (such as Return Loss curves, Radiation Patterns, Directivity and Beamwidth) that affect design and applications were studied and their implications understood. The constructed antennas operated at the desired frequency and power levels. Several antennas were simulated (using HFSS) and the desired level of optimization was obtained. It was concluded that the hardware and software results we obtained matched the theoretically predicted results.

APPENDIX A

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