Design and Implementation of V - shaped HF Antenna

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***Abstract*—** A novel HF antenna with V-shape dipoles is introduced. Long V-shape dipoles instead of short linear ones are used as elements to rise the directivity. NEC-2 (Numerical Electromagnetic Code Version 2) is included to numerically evaluate the radiation characteristics of this new fishbone antenna with two different arm lengths, 12m and 20m, respectively. Parameters such as open angle of V-shape dipole, loading resistance, spacing between adjacent dipole and total number of dipoles are optimized according to the simulating results. It is found that the directivity of a fishbone antenna with V-type elements is about 2-5dB higher at higher frequency band than that of a traditional fishbone antenna. It is also found that the benefits of a traditional fishbone antenna, such as low side-lobe and wide operating band are well reserved in the new design.

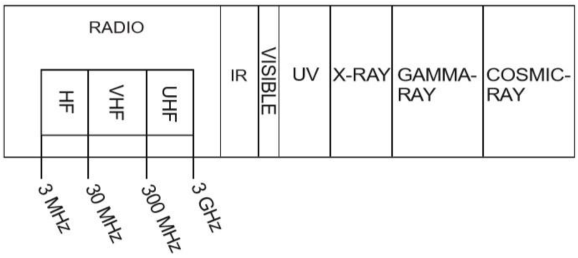
This paper provides the investigation on a horizontally polarized HF antenna_ The antenna is of objective to have a small size, wideband, and high-power gain. V-shape wire-structured bowtie antenna has presentable performance in both aspects of gain and VSWR. Detailed analysis of this V-shape wire-structured bowtie antenna is done with the use of Numerical Electromagnetic Code (NEC-2). The simulated results serve to check the performance of this antenna and to optimize various antenna parameters such as the number of wires, the open angle of two arms and feed gap width. The measured and simulated results show that the VSWR of this antenna is within 2.5:1 over 6~ 30MHz and the average power gain is about 13dBi.

I. INTRODUCTION

Electromagnetic radiation involves radio waves, microwaves, infrared radiation, visible light, ultraviolet waves,

X-rays, and gamma rays. Together they evolve the electromagnetic spectrum. They all displace at the speed of light (186,000 miles/300 million meters per second). The waves with different wavelengths have different amount of energy. The shorter the wavelength, the higher the energy. Figure 1-1 shows the electromagnetic spectrum components according to wavelength and frequency. A portion of the spectrum which is used for HF, VHF, and UHF radio communication has been extended to provide more detail.

Figure 1-1. Electromagnetic Spectrum.



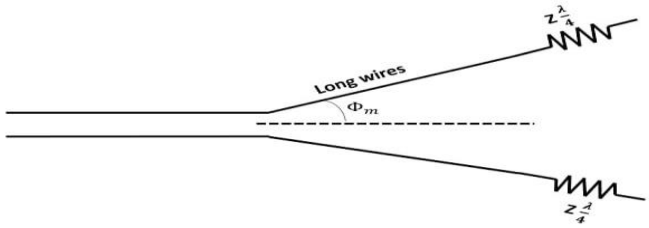
V shaped HF Antenna

An Antenna is a transducer, which translates electrical power into electromagnetic waves and vice versa. Antenna can be used also as a **transmitting antenna** or a **receiving antenna**. (1)

A better version of long-wire antenna is the **V-Antenna**. This antenna is designed by placing the long wire in a V-shaped pattern. The end wires are called as legs. This antenna is a bi-directional resonant antenna. The frequency range of working of V-antenna is about **3 to 30 MHz** This antenna works in high frequency range. There is 180° out of phase in two wire antennas. As the length of these wires increases, the gain and directivity also rise.

Antennas designed for VHF communications are usually huge and protruding due to long wavelengths; e.g., 1λ =10 meters at 30 MHz Most applications located in VHF band experience problems in using such a enormous antenna because of its unpractical size and weight. When those antennas are even designed to situate on terrestrial and airborne platforms, those difficulties become more profound an because they have to be low profile as well. Furthermore, many applications on VHF band favours vertically polarized (VP) radiation towards horizon because VP is more efficaciously transmitted for long range communication. This criterion causes very challenging antenna design issues since the transmitter and receiver must be lifted sufficiently above the ground or ground planes.

Fig. V Shape HF Antenna



While designing this antenna we take "Idarganj forest site" which is in Radhanagari reserved forest into account. This site contains a watch tower which is having our communication unit within. Besides this tower there is huge valley. at the end of this valley there is konkan forest post. our goal is to join this Idarganj station with this Konkan post. So, the scenario is one station is up & anther station is down. To fulfil this need we use the reflector element location 45degree tilt. due to this we can communicate with down side. this function is similar to disc and cone antenna. we can see this in our simulation results.

The antenna design comprises of a V-shaped patch with unequal arms coupled electromagnetically to a single feed isosceles triangular PIFA through two unequal slots [70]. The six multiband operations were achieved by the different lengths and widths of the V-shaped patch as well as the two coupling slots. By folding the shorting wall of the triangular PIFA, UWB operation with 53% bandwidth was formed.

Ansoft HFSS- The CAD tool

Ansoft HFSS is one of the finest commercial Finite Element Method (FEM) solver for electromagnetic structures. The optimization tool available with HFSS is very efficient for antenna engineers to optimize the antenna parameters very precisely. There are several types of boundary schemes available in HFSS. Radiation and PEC boundaries are commonly used in this work. The vector as well as scalar representation of E, H and J values of the device under simulation gives a good view into the issue under simulation. Time domain antenna analysis: UWB systems often employ short pulses to provide information, in other words, huge bandwidth is occupied. Thus, the influence of the antenna on the transmitted signal emanates as a crucial issue. The antenna cannot be considered as a “spot filter” any more but a “band-pass filter”. Subsequently, antenna parameters will have to be evaluated as functions of frequency and some elemental antenna parameters need to be re-considered within the UWB definition scope and because of UWB’s unique features, it is important to study UWB antennas from a time domain perspective. Moreover, the received UWB signal should maintain exactly the same shape as the source pulse. Practically, the signal waveforms reaching the receiver usually do not resemble the input pulse at the transmitter. The received signals normally are contorted in shape and sometimes present a long tail termed the “ringing effect”.

II. LITERATURE SURVEY

Many widely used HF transmitting communication antennas such as curtain antenna, rhombic antenna and double LPDA have amazing high gain and mainly fit for long range communication. However, their need of large installation space has reduced their usage. On the other hand, a whip antenna or a loaded dipole occupies quite small space but the typical gain of it is low, and usually become worse in lower HF band.

Thus, it is significant to design a wideband antenna with small size and comparatively high gain. Bowtie plate antenna is a mainly used antenna in VHF/UHF band. It derives broadband characteristic from biconical antenna. In addition, it uses a relatively small volume. The shortcoming is that its gain is relatively low. In order to increase the gain, one can fold its two arms into a V-shape. In this paper, two measures, pentagonal (or tapered bowtie) arms and parasitic guys, are assimilated to further upgrade the VSWR as well as power gain. The pentagonal antenna has been well-studied before, but most of them belong to planar antennas. For HF application, planar structure is not practical, so wire structure is utilised instead. The prototypes of different antenna were made using photolithographic process and the antenna characterization was done using Vector Network Analyse in the anechoic chamber. Parametric analysis of different antenna parameters was conducted with the use of Ansoft HFSS. A more detailed account of the measurement methods, for frequency and Time domain studies, are provided in this chapter. A review of literature about monopole antennas is also carried out.

- **Antenna Fabrication**

The precision of the antenna dimension is very crucial at microwave frequencies. Therefore, photolithographic technique is used to invent the antenna. Photolithography is the process of transferring geometrical shapes from a photomask to a surface. The CAD design of the antenna is printed on a high-quality butter paper with a high-resolution laser printer. The copper clad of suitable dimension is cleaned with an appropriate chemical like acetone to remove any impurities. A thin layer of photo resist material is then coated over the copper clad using a high-speed spinner. The antenna mask is carefully aligned over the photo resist coated clad and exposed to UV. Extra care must be taken to assure that no dust or impurities are present in between the mask and copper clad. The layer of photo resist material in the exposed portions hardens, meanwhile the unexposed region remains unaffected and it can be extracted by carefully rinsing with a proper developer solution. The unwanted copper over the copper clad can be removed by processing the copper clad in a ferric chloride ($FeCl_3$) solution.

The laminate is then cleaned to eradicate the hardened photo resist with the use of acetone solution.

- **Antenna measurement facilities**

A brief description of equipment and facilities utilised for the measurements of antenna characteristics is conferred in this section. The HP 8510C series microwave vector network analysers provide a complete solution for characterizing the linear behaviour of either active or passive networks over the 45 MHz to 50 GHz frequency range. The network analyser measures the magnitude, phase, and group delay of two-port networks to characterize their linear behaviour. The analyser is also able of portraying network's time domain response to an impulse or a step waveform by computing the inverse Fourier transform of the frequency domain response. The HP 8510C network analyser contains a microwave generator, Parameter test set, signal processor and the display unit as depicted. The synthesized sweeper generator, HP 83651B, operates an open loop YIG tuned element to provide the RF stimulus. The frequencies can be synthesized in step mode or ramp mode, depending upon the desired measurement accuracy. The antenna under test is connected to the two-port s-parameter Test unit, HP8514B. This module cut off the incident, reflected and transmitted signals at the two ports. The signals are then down converted to an intermediate frequency and fed to the IF detector. These signals are suitably processed to display the magnitude and phase information of S-parameters in log magnitude, linear-magnitude, or Smith chart formats.

All these constituent modules of the network analyser are joined using the HP1B system bus. A completely automated data acquisition is made possible using the HPBASIC based MERLSOFT, developed indigenously at the Centre for Research in Electromagnetics and Antennas (CREMA), Department of Electronics, Cochin University of Science and Technology. The Anechoic chamber is a room operated to measure the antenna characteristics accurately. The room consists of microwave absorbers fixed on the walls, roof and floor to avoid EM reflections. High quality low foam impregnated with dielectrically magnetically lossy medium is used to fabricate the microwave absorber. The tapered shapes of the absorber provide good impedance match for the microwave power impinging upon it. Aluminium sheets are used to protect the chamber from electromagnetic interference from surroundings. A turntable assembly contains of a microcontroller-based antenna positioner, interfaced with the PC for the radiation pattern measurement. The antenna under test (AUT) is mounted over the turntable assembly and a linearly polarized; wideband standard horn antenna is used as the transmitter for the radiation pattern measurement. The main lobe tracking for gain measurement as well as the polarization pattern measurement are processed through this setup. The MATLAB based graphical user interface (GUI) manages the antenna characterization by synchronizing each component in the system.

- **Antenna Characterization**

The major antenna characterization procedures are represented in the following: In order to measure the return loss characteristics of the antenna under test, the test antenna is connected to any one of the networks analyser ports and operating the VNA in S11 or S22 mode. The specific port of the analyser should be adjusted for the frequency range of interest using the standard open, short and matched load, prior to the measurement. The S11 values of the antenna in the whole frequency band are then saved in a computer in Comma Separated Variable, "CSV", format with the help of "CREMA SOFT"-the indigenously innovated measurement automation software. The frequency at which the return loss value minimum is taken as the resonant frequency of the antenna. The range of frequencies for which the return loss value is within the -10dB points is usually considered as the band width of the antenna.

- **Efficiency Measurement**

The IEEE definition of the antenna proficiency the ratio of total radiated power to the net accepted power by the antenna at its terminals during the radiation process. A more reasonable definition would involve the reflected power because of a mismatch as an explicit loss and radiation efficiency is defined as the ratio of the total power radiated by the antenna to the net power applied at its terminals. A way for assessing the competency over the UWB, that explicitly contain mismatch reflected power as a loss term, is presented in. This method is an amendment of the Wheeler Cap method conventionally used to measure radiation efficiency of narrow band antennas. Instead of inhibiting radiation efficiency from the antenna to a

radiation sphere with radius r =λ/2π as in the narrow band approach, UWB Wheeler Cap method permits the antenna to radiate freely and then receive its own transmitted-reflected signal. Radiation Pattern Measurement: The radiation pattern measurement is done in the anechoic chamber with the help of HP 8510C VNA. The antenna under test is mounted on a turntable assembly in the anechoic chamber and connected to one port of the network analyser configured in the receiver mode. The other port of the network analyser is connected to a wideband horn which act as the transmitter.

The network analyser and the turntable controller are interfaced to a computer which runs the measurement automation software “CREMA SOFT”. The measurement automation software includes the measurement band, start angle, stop angle angular step size and file name as input. The system automatically performs THRU calibration prior to the measurement and undergoes the transmission measurement for each step angle and records the angular transmission characteristics in a data file.

III. SYSTEM DEVELOPMENT

A. Block diagram

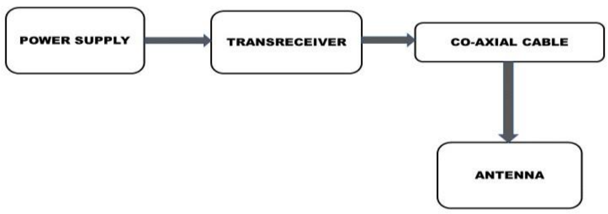


Fig. Block Diagram of V Shaped HF Antenna.

 Power Supply-

- Power supply is the first unit of this circuit. It is utilized to supply the antenna and the received signal
- Supplied to the time switch which are fed in on this line at the same time.
- In the event of power failure, the clock continues to run with quartz precision.
- The clock is radio synchronized again when the main voltage is fixed.

 Transceiver: -

- This is the second unit of the circuit.
- It is used for transmission and reception of the radiated microwaves travelling through the free space.
- Same antenna is used for transmittion and receiving function.

 Co-axial Cable: -

- The basic function of co-axial cable is to transmit and receive the propagating signal.
- It is a wired-based configuration within the circuit.
- It connects the main element to the transceiver unit.

 Antenna: -

- Antenna is the device used to generate radiation in various patterns.
- It is used to transmit and receive the microwaves.

B. **Methodology**

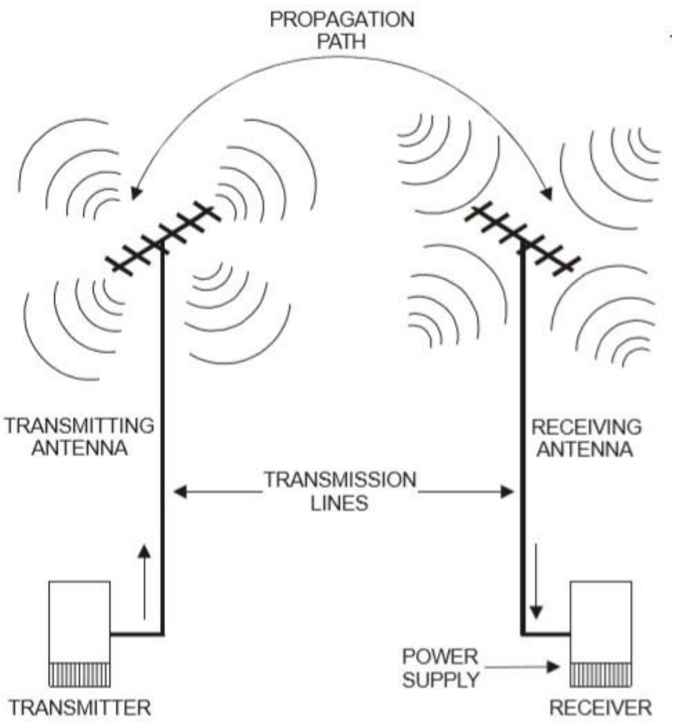


Fig. Typical Radio Link.

- **SOFTWARES: -ANSYS HFSS**

ANSYS HFSS is a 3D radiation pattern of electromagnetic simulation software for simulating and designing high frequency electronic products such as antennas, RF or microwave components, arrays of antenna, high-speed connectors, filters, interconnects, IC packages and PCBs. Engineers all over the world use ANSYS HFSS to design high frequency, high-speed electronics found in communications systems, radar systems, advanced driver assistance systems (ADAS), satellites, internet-of-things (IoT) products and other high-speed RF and digital devices.

HFSS (High Frequency Structure Simulator) employs versatile solvers and an intuitive GUI to give you unparalleled performance plus deep overview into all your 3D EM issues. By use of ANSYS fluid, structural and thermal dynamics tools, HFSS is a powerful and overall Multiphysics analysis of electronic products, making sure their thermal and structural reliability. HFSS is equal with gold standard reliability and validity for tackling 3D Electromagnetic challenges by using its auto adaptive meshing technique and sophisticated solvers, which can be escalated through high performance computing (HPC) technology.

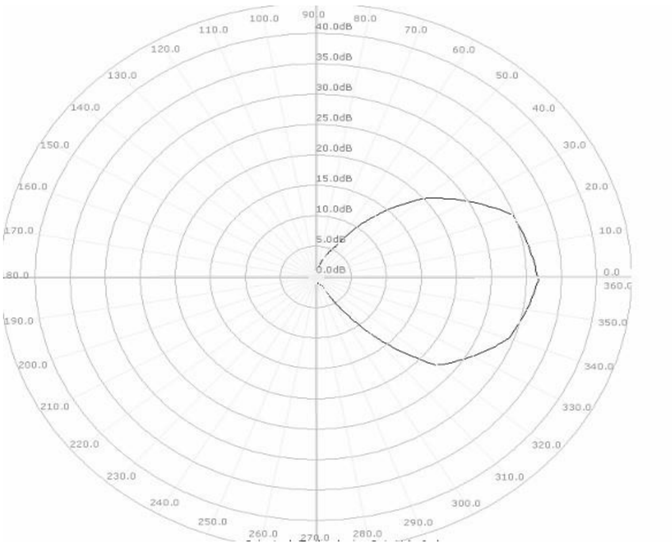
The ANSYS HFSS simulation suite comprises of a comprehensive set of solvers to address various electromagnetic problems ranging in detail and scale from passive IC components to extremely large-scale EM analysis known as automotive radar scenes for ADAS systems. Its reliable automatic adaptive mesh refinement lets you concentrate on the design instead of spending time determining and creating the best mesh. This guaranteed accuracy and automation differentiate HFSS from all other electromagnetic simulators, which need manual user control and many solutions to assure that the generated mesh is useful and accurate. The physics defines the mesh rather than the mesh defining the physics in ANSYS HFSS.

ANSYS HFSS is the premier EM tool for virtual design prototyping & research and development. It lessens design cycle time and boosts your product's reliability and performance to win the competition and capture your market with ANSYS HFSS.

HFSS is a commercial FEM solver for electromagnetic structures from ANSYS. The acronym stands for high-frequency structure simulator. HFSS is a unique commercial tool put to use for antenna design, and the design of complex RF electronic circuit elements including filters, packaging and transmission lines. It was originated by Professor Zoltan Cendes and his students at Carnegie Mellon University. Prof. Cendes and his brother Nicholas Cendes started Ansoft and sold HFSS stand-alone under a 1989 marketing relationship with HP, and merged into Ansoft products. [1] In 1997 Hewlett-Packard obtained

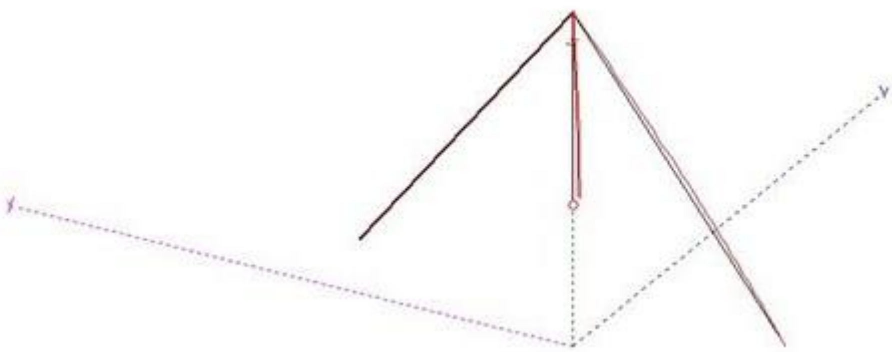
Optimization Systems Associates Inc. (OSA), a company John

Bandler founded in 1983. HP's acquisition was driven by the HP's necessity for an optimization capability for HFSS. [2] After several business encounters over the period 1996–2006, HP and Ansoft went their separate pathways: [3] Agilent with the crucially acclaimed [4] FEM Element and Ansoft with their HFSS products, respectively. Ansoft was later claimed by Ansys.



IV. RESULTS AND DISCUSSION.

A. **Simulation Results, Snapshots for h/w project**



B. **Radiation Pattern of V Shaped HF Antenna**

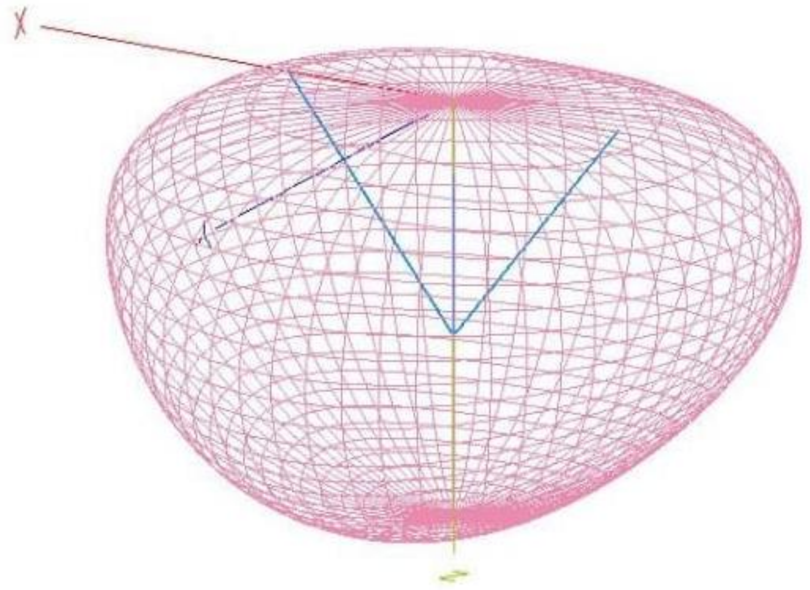


Fig. Radiation Pattern of V Shaped HF Antenna. A general 3D radiation pattern is also shown in figure above.

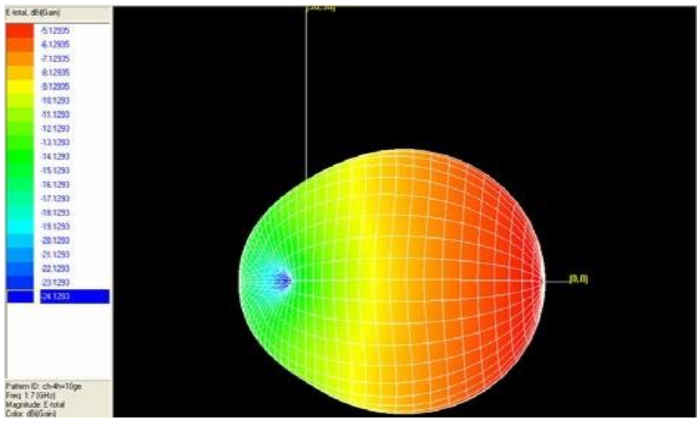


Fig. 3D Radiation Pattern for a rectangular patch

V. CONCLUSIONS

A horizontally-polarized, compact, wideband and high-power gain V-shape wire-structured pentagonal antenna has been successfully originated. The high gain benefits from the V-shape structure. The whole HF band coverage is made possible with a compact size by including parasitic guys as well as a convex pentagonal shape of the arm. Due to stable, single narrow main beam, this antenna is particularly suitable for point to point communication circuit or narrow sector coverage application in medium or long distance.

A small size, wideband, and high-power gain horizontally-polarized V-shape wire-structured bowtie antenna has been successfully developed after number of simulations with the help of NEC-2 software package. It works in frequency band ranging from 6MHz to 30MHz.

The measured and simulated results show that the VSWR of this antenna is within 2.5:1 over the operating band and has an average power gain of 13dBi. Due to stable, single narrow main beam, this antenna is appropriate for point to point communication circuit or narrow sector coverage application. Fishbone antenna with V-shape elements gains benefits such as low VSWR and high directivity from the traditional fishbone antenna and a higher directivity can be obtained by rightfully selecting parameters such as arm length, open angle, number of dipoles and the separation of dipoles. Fishbone antenna with V-shape elements inherits significant advantages in either directivity or space occupation aspects.

ACKNOWLEDGMENT

Ability and ambition are not sufficient for success. Many persons fail to achieve anything worthwhile because they have not been properly guided and directed. Success of any project depends solely on support, guidance and motivation received from the guide, our parents and well-wishers that involves all our staff members and friends. We have been fortunate enough to have more than one pillar of strength in our humble effort to make this project successful.

Gratitude is the hardest emotion to express and often one does not find enough words to convey what entirely one feels. We are pleased to express our deep sense of gratitude to our project guide **Prof. Meeta Bakuli** who has opened floodgates of knowledge for us and her extending continuous cooperation, encouragement and her great insistence on research work to undertake.

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