

**Master Thesis**

Measurement of the Directional Characteristics of Antennas in the Testbed

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Master - Thesis

For, Mr Chirag Patel

Measurement of the directional characteristic of antennas in the testbed

Messtechnische Erfassung der Richtcharakteristik von Antennen im Testbed

Focus:

* Setting up testbeds to record radiation patterns from antennas
* Programming of software to control the stepper motors and measurement technology
* Creation of a user interface including data acquisition, display, and backup
* Simulative and practical investigation of the directional characteristics of monopoles, dipoles, and dipole arrays
* Determination of factors influencing the radiation characteristics
* Antenna matching networks

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**Task Statement:**

**Measurement of the directional characteristic of antennas in the testbed**

By Chirag Patel

The aim of this thesis is to investigate the directional characteristics of monopoles, dipoles, array type, and yagi–uda antennas and determine the factors that influence their radiation patterns. The objective is to design and develop a testbed equipped with a software application in any environment to accurately record and update the radiation patterns of various antennas. The project aims to provide a comprehensive examination method of the radiation patterns to support postgraduate education in Information and Electrical engineering at the Hochschule of Wismar.

The following are the specific tasks that will be accomplished in order to meet the project objectives:

1. Setting up testbed: to record the radiation patterns of antennas. This will include the selection of measurement technology and programming language of software to control the stepper motors and Agilent High-end devices.
2. Unique Software development: these will control the testbed and provide data acquisition, display, and backup. The software should be user-friendly, allow the adjustment of time, and step size to achieve high-resolution results.
3. User interface: this will allow for easy data acquisition and display. The user interface should also provide the ability to back up the data for future reference.
4. Simulative and practical investigation: The fourth task is to conduct a simulative and practical investigation of the directional characteristics of monopoles, dipoles, and dipole arrays. This will involve measuring the radiation patterns of the antennas and analysing the results to understand the factors that influence their characteristics.
5. Determination of factors influencing radiation patterns: This will involve an encyclopedic analysis of the results and a discussion of any affecting factors and potential countermeasures.
6. Antenna matching networks: The importance of antenna matching networks and their impact on the radiation patterns.

By completing these tasks, the thesis will provide a comprehensive examination of the directional characteristics of various antennas and the factors that influence their radiation patterns. The testbed and software application will provide a valuable tool for postgraduate education and support future research in the Information and Electrical engineering field.

**Abstract**

**Index:**

**Introduction:**

The measurement of the directional characteristic of antennas is an essential aspect of wireless communication systems. Antennas play a crucial role in the efficient transmission and reception of signals, and their directional characteristics can greatly influence the overall system’s performance. In this Master's thesis, the focus is on setting up a testbed to record radiation patterns from various antennas and investigating the directional characteristics of monopoles, dipoles, and dipole arrays.

The importance

The field of antenna design and characterization is constantly evolving, and new techniques and technologies should be developed all the time. There may be new requirements or specifications for the measurement of the directional characteristic of antennas that arise during the course of the project. The software and programming language being used may need to be updated or improved to accommodate new advancements in technology or changes in industry standards. The user interface needs further refinement to improve the user experience and make the data acquisition and display process more efficient. The findings from the simulative and practical investigation may reveal new areas of research that need to be explored to fully understand the directional characteristics of monopoles, dipoles, and dipole arrays. The determination of factors influencing the radiation characteristics may reveal new challenges that need to be addressed in future developments. The development of antenna-matching networks may require further exploration and refinement to improve their performance and efficiency.

Testbed Environment

The testbed environment will be equipped with state-of-the-art hardware and software systems, which will be utilised for the measurement of the directional characteristic of antennas. The hardware components include the Agilent EXA N9010A signal analyser (9 KHz to 7 GHz), the Agilent MXG N5182A signal generator (100 KHz to 6 GHz), the Arcus Technology stepper motor model DMX-J-SA-17, the Hyper LOG 4060 Broadband antenna, Agilent PNA N5222A network analyzer, and various types of WLAN antennas with diverse frequency range. The programming language used for script writing and code generation will be MatLab, which will be used in conjunction with MatLab App Designer and the FEKO simulation software. The MatLab Control Toolbox utilizes the VISA-IP address through an Ethernet connection as an application programming interface (API)

Software Development

The best practices will take place like software testing methods to carry out the software development process. We will identify the software requirements, and the software tests will be developed and designed in the test environment. We will design the specified software tests as test cases for model-in-the-loop (MiL) and software-in-the-loop (SiL) simulations.

Simulation and Practical Investigation

The directional characteristics of antennas will be studied through simulation and practical investigation respectively using the FEKO simulation software and the developed testbed environment. The results of the comparison between simulation results and the actual practical results will help to validate their accuracy. This investigation will offer valuable insights into the directional characteristics of antennas and can provide meaningful aid to the design process of it and the development of communication systems.

Conclusion

The measurement of directional characteristics of antennas is a critical aspect in the field of communication technology. The testbed environment and software systems used in this thesis will enable the investigation of the directional characteristic of antennas, which will provide valuable insights into the performance of antennas in communication systems. The simulation results will be compared with the actual practical results, which will validate the accuracy of the simulation and contribute to the advancement of the field of communication technology.

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**Programming Language selection:**

Matlab is widely used for control system applications and is the preferred choice for many professionals in this field due to its comprehensive toolboxes and built-in functions. Matlab is a high-level programming language that provides a range of tools and features that simplify the process of designing and implementing control systems. In comparison, Python is relatively new in the control system space and lacks the comprehensive tools and built-in functions that Matlab provides.

In this research work, the Agilent generator, analyser, and arcus stepper motor are vital machines. Matlab provides a range of toolboxes that can be used for controlling and analyzing these hardware components. For example, the Instrument Control Toolbox in Matlab provides functions for controlling and communicating with instruments such as Agilent generators and analysers. Additionally, the class that is developed in MatLab script, supports converting the commands in MatLab to text commands so that the Arcus motor can understand them.

Moreover, the user interface has to develop for controlling the hardware and collecting data. Matlab provides a user-friendly interface for developing graphical user interfaces (GUIs) and includes a range of tools for creating plots and graphs. The developed app in Matlab can be easily integrated with the control system functions, enabling the control of the hardware and collecting data within the same interface.

Finally, the different datasets comparison. Matlab provides a range of functions and tools for comparing data, such as statistical analysis and regression analysis. Additionally, Matlab has a powerful data visualization tool that allows you to plot graphs and visualize the data intuitively.

In conclusion, Matlab is the first choice for control system applications due to its comprehensive toolboxes, built-in functions, and user-friendly interface. These features make Matlab an ideal choice for developing applications for controlling hardware and analyzing data. Additionally, Matlab’s powerful data visualization tools and statistical analysis functions provide the necessary tools for comparing different datasets, making it an excellent choice for this research work

**Matlab code to control Arcus Motor**

This is a very complex communication between the Arcus motor and the MatLab environment over GUI\_CMD.exe and the USB connection. The motor’s firmware is designed to read only the text format using a specific executable file containing the commands. For every single control command, the executable file must run with the predefined ASCII Command Set from Arcus-Technologies Inc.

As the user must have full control of the stepper motor, one must have complete access to the various parameters to operate the motor in certain ways or to control its speed and position according to the use cases and the set of control commands. For the same, a class name MyArcus is developed in the MatLab environment so that it can handle all the inbuilt particular functions for specific purposes.