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Gray-Hoverman Antenna: Designing an Antenna Array for Channel Optimization

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ABSTRACT —

This study investigates the design and performance of a Gray-Hoverman Antenna, a low-cost alternative to commercial antennas optimized for UHF digital TV signal reception. The antenna, constructed of copper wire, aluminum rods, and a hardwood frame, achieved great gain and directivity, collecting 38 channels, including 24 digital TV channels. Testing revealed a robust signal reception across a wide range with low interference. The results illustrate the Gray-Hoverman design's efficacy and show that DIY antennas can give greater performance and sustainability, making them a feasible choice for improving HDTV viewing experiences.

Keywords — Antenna, Antenna Design, DIY Antenna, Gray- Hoverman, HDTV reception

I. INTRODUCTION

An antenna is a crucial instrument used to transmit and receive data information, playing an integral role in modern communication systems. Antennas convert electrical signals into radio waves and vice versa, enabling wireless communication across various devices [1].

The Gray-Hoverman antenna is one kind of television antenna; it is a Yagi-Uda Antenna variant made specifically for optimal digital TV signal reception, especially in the UHF band [2]. In order to optimize signal reception, the Gray- Hoverman antenna usually consists of a number of horizontal and vertical elements organized in a certain design. To increase gain and directivity, reflector elements were incorporated into the original design behind the active elements [3]. In order to build and innovate antenna design, it is important to understand the importance of antenna design for HDTV (High-Definition Television) reception such as several critical areas in: Basics of HDTV and Broadcast Signals, Types of Antennas, Signal Path and Interference, Antenna Design Principles, and Environmental Factors.

Building a DIY antenna for HDTV reception offers a personalized and cheap strategy that boosts signal quality and overall performance, effectively resolving the inadequacies of commercial antennas [4]. By tailoring the design to match unique local broadcasting conditions, DIY antennas can achieve greater gain and directivity, which enhances their ability to capture weak or distant signals while minimizing interference. The choice of materials and combinations that best meet specific demands can be made possible by this customized approach, frequently for a much lower cost than with commercial alternatives. Furthermore, DIY antennas offer an affordable and environmentally friendly alternative to costly cable or satellite service subscriptions for watching high-definition television.

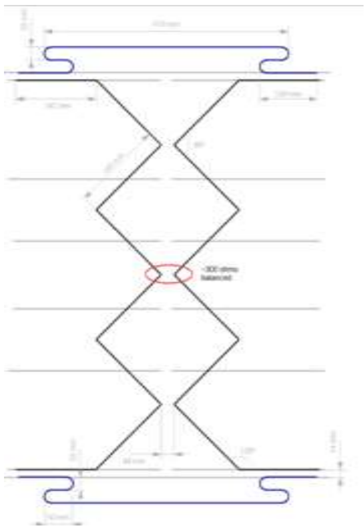

Figure 1. Gray-Hoverman Antenna Diagram [2]

The number of channels an antenna receives can be used to determine its efficacy and efficiency. An antenna's performance is rated according to how many channels it can successfully capture. This is due to the fact that an efficient antenna has a high gain and good directivity since it can take up a greater variety of broadcast signals from different angles and frequencies [5]. An increased number of received channels indicates that the antenna is well-designed to maximize signal reception, minimize interference, and function effectively even in difficult settings. As a result, one useful indicator of an antenna's quality and capacity to provide an excellent HDTV viewing experience is the quantity of channels it can receive.

Recognizing the growing demand for effective and affordable HDTV reception solutions, the study investigates the Gray- Hoverman antenna as a DIY solution for HDTV reception.

The researchers will design and build an antenna using copper wire, aluminum rods, and wood, optimized for UHF digital signals. Further, the researchers will then evaluate the antenna's performance in terms of channel reception and picture quality. Finally, the study will explore the technical aspects of the Gray-Hoverman design, involving how reflectors, impedance matching, and adjustments can affect reception across frequencies.

II. METHODOLOGY

A. Antenna Specification:

The constructed antenna is based on the Gray-Hoverman design, renowned for its efficiency in UHF television reception. These specifications provide a robust framework for constructing a Gray-Hoverman antenna. Detailed specifications for the antenna are as follows:

Frame: The material used as frame is wood.

Size: The height of the frame of the antenna is at 22 inches long, while the width is at 4 inches wide.

Reflector Material: The material used as frame is aluminum rod.

Reflector Length: The length of the reflectors is 12 inches. Reflector Distance: The distance between the aluminum rods that is used as a reflector is at 4 inches.

Coaxial Cable: RG-59

Length of Coaxial Cable: The length is 5 meters long.

B. Materials:

In creating a DIY antenna, the materials used are crucial to the outcome and performance of the antenna. The choice of materials directly impacts the antenna's ability to receive and transmit signals effectively.

The materials used in this project are: copper wire, coaxial cable, screws, aluminum rod, balun, and wood.

C. Construction of Antenna:

The frame of the antenna is constructed using wood. Wood is chosen for its availability, ease of handling, and non- conductive properties, which prevent interference with the antenna's ability to receive signals. The overall dimensions of the frame is 22 inches by 12 inches.

Place 8 screws at specific points on the wooden frame where the driven elements and reflector elements will be mounted. These screws act as anchors for the copper wire.

Secure the screws tightly using washers to ensure that the wire remains in place and maintains the required tension.

Copper wire is used for the driven element due to its excellent conductivity and durability. The wire should be thick enough to maintain its shape but still flexible for bending into the required pattern. The copper wire is bent into a zigzag pattern. This shape is essential for the Gray-Hoverman antenna as it enhances the reception of UHF signals. Attach the zigzag- shaped copper wire to the screws on the wooden frame, ensuring it is centered and properly spaced from the reflector grid. Secure the wire tightly around the screws and washers to maintain the shape and position of the driven element.

Aluminum rods are chosen for the reflector due to their excellent conductivity and lightweight properties. These rods will act as passive elements, reflecting the incoming signal towards the driven element, thereby increasing the antenna's gain. Cut 5 aluminum rods, each to a length of 12 inches, and screw it at the back of the frame. The entire reflector assembly should be placed approximately 4 inches with each other. This spacing is crucial for optimal performance, as it ensures that the reflected signals are properly directed towards the driven element.

Attach the balun at two points of the antenna. Attach the coaxial cable to the balun, ensuring a secure connection. This cable will transmit the received signal from the antenna to your TV.

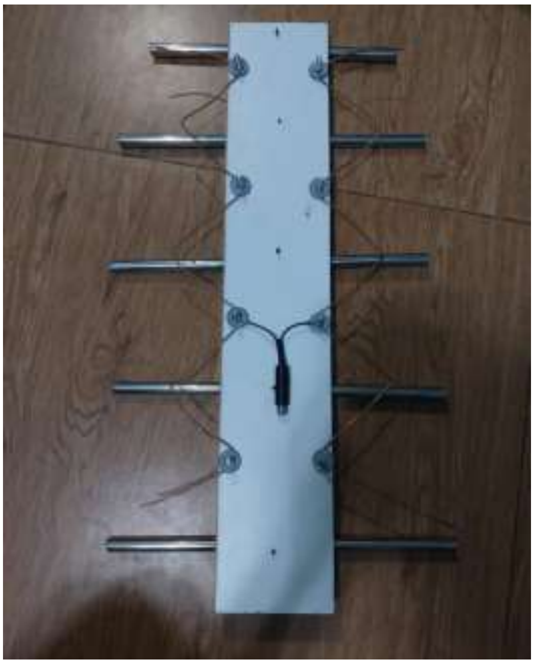

Figure 2. Designed Gray-Hoverman Antenna.

D. Testing the Antenna

Connect one end of the coaxial cable to the antenna's connector in order to properly test the specified antenna. Secure the connection to prevent signal loss. Attach the coaxial cable's other end to the coaxial input on the television. Navigate to the menu and turn on the TV. Go to the setup or settings section. Choose the channel scanning option. Launch the scanning procedure. All of the available channels will be found and stored by the TV. Navigate the channels once the scan is finished. Take note of each channel's quality and clarity. Based on the quantity and quality of the received channels, assess the performance. Good antenna performance is indicated by clear, reliable channels.

Figure 3. Testing the Antenna

III. RESULTS & DISCUSSION

After constructing the Gray-Hoverman Antenna, the researchers tested the antenna design thoroughly. The researchers found that the antenna cost about P 180.00 to build, much cheaper than most HDTV antennas. Figure 4 shows that the antenna picked up 38 channels, both UHF and VHF. The HDTV picture quality was clear and stable with hardly any pixelation or interruptions. The antenna also consistently received strong signals during the channel tuning. Consequently, the DIY Gray-Hoverman antenna proved effective and affordable for getting reliable TV reception across many channels.

Figure 4. Results of Channel Scanning

Table 1 findings show that the DIY Gray-Hoverman antenna is quite good at receiving digital television (DTV) signals, with 24 channels identified. This reinforces the design's adaptability for modern HDTV reception, as digital channels are becoming the norm for over-the-air-broadcasts. The smaller number of analog TV channels (9) corresponds to the limited availability of analog transmissions.

The antenna design is optimized for television frequencies rather than AM/FM radio bands; hence the absence of radio channels is to be expected. The reception of 5 cable television channels could be owing to local signal leakage or unencrypted cable broadcasts, although this is not the antenna's primary role.

1: Results of Channel Scanning Conducted with the Antenna

Category	Number of Channels Found
TV	9
DTV	24
Radio	0
CATV	5

The antenna received signals over a wide range of UHF frequencies (589.25 MHz to 799.25 MHz), with signal intensities varying from 83% to 100%. Two VHF frequencies (91.25 MHz and 103.25 MHz were also recorded albeit with slightly lower signal intensities of 87% and 88%.

Table 2 results show that the Gray-Hoverman antenna is highly effective at receiving UHF digital TV transmission, with continuous high signal strength across a wide range of frequencies. The concept also demonstrates some capabilities in receiving VHF broadcasts. This performance validates the antenna's optimum shape for current digital television signals.

Table 2. CATV Channel Tuning Frequency

Percent (%)	Frequency
83 %	589.25 MHz
84 %	591.25 MHz
85 %	619.25 MHz
86 %	631.25 MHz
87 %	91.25 MHz
88 %	103.25 MHz
89 %	649.25 MHz

90 %	661.25 MHz
91 %	679.25 MHz
92 %	691.25 MHz
93 %	709.25 MHz
94 %	721.25 MHz
95 %	739.25 MHz
96 %	751.25 MHz
97 %	769.25 MHz
98 %	775.25 MHz
99 %	793.25 MHz
100 %	799.25 MHz

The Gray Hoverman Antenna is designed with folded dipole driven components arranged in a "W" shape, suitable for UHF signal wavelengths, which interact with electromagnetic waves and pick up signals more effectively. Impedance matching, which matches the output source and input load, was significant in antenna design because it allowed maximum power transfer without loss or reflection. The role of the balun is to match the antenna's impedance to the input of the HDTV tuner so that it minimizes the reflections. Moreover, reflectors positioned behind the main elements functioned by bouncing radio waves back to the antenna's active element, enhancing signal reception quality. Securely attaching copper wires to the wooden board requires a careful approach involving drilling and fastening to prevent weak connections. To enhance the performance of the antenna, grounding was suggested to minimize signal loss and maintain signal integrity. Also, aligning the antenna's elements with the signal's polarization significantly enhances the clarity and strength of reception. Finally, placing the antenna away from reflective surfaces and obstacles helps to deal with multipath interference and further improve reception clarity.

IV. CONCLUSION

The Gray-Hoverman HDTV Antenna has great promise for improving television signal reception while remaining affordable and ecologically friendly. Antennas are critical components of modern communication systems because they convert electrical impulses into radio waves and vice versa. Because of its combination of horizontal and vertical elements and reflector components, the Gray-Hoverman design, a version of the Yagi-Uda antenna, is very good for UHF digital TV signal reception.

Building a DIY antenna adapted to local broadcasting conditions can solve many problems with commercial antennas. The Gray-Hoverman antenna, made from widely available materials such as copper wire, aluminum rods, and wood, produces high gain and directivity, resulting in improved signal reception, including the capacity to catch weak or distant signals while minimizing interference.

The tested DIY Gray-Hoverman antenna successfully received 38 stations, including 24 digital TV channels, confirming its effectiveness in a digital broadcast setting. Its architecture also enabled it to record signals of varying frequencies with high signal intensities. The use of appropriate materials such as copper wire for the driving element and aluminum rods for the reflectors, as well as careful construction and alignment, all contributed to its outstanding performance.

Overall, the experiment demonstrates that DIY antennas, particularly the Gray-Hoverman design, are viable alternatives to commercial antennas, offering superior performance at a lower cost and with less environmental effect. This strategy allows viewers to have better HDTV watching experiences while also supporting sustainable practices.

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