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The Gray Hoverman Antenna Construction for Meteor Observation

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ABSTRACT

Meteors typically are small particles, normally no larger than a microscopic of sand, that enter our atmosphere at speeds of up to around 70 kilometers per second. Meteoroids are thought to originate in asteroids or comets, though some may be remnants from the early days of the Solar System. When a meteoroid striking the upper atmosphere, these meteors are produced by the streams of cosmic debris at extremely high speeds on parallel trajectories. Radio meteor scatter by forward scattering is a technique for observing meteors. A forward - scattering technique for radio meteor detection has been well-known for over 50 years ago. The Gray-Hoverman antenna has been designed by Doyt R. Hoverman and was invented in the 1950s covers from 300 to 3000 MHz and shows high performance for most Digital / HD channels broadcasting. The data obtained from the special software named 4nec2. From the results, the high gain obtained by the antenna is around 14.4 dBi at targeted range frequencies of 500MHz to 700MHz. it can be clearly observed that the designed antenna structure provides good amount of gain 14.4 dB, which is highly desirable for various applications. In future, the current Gray Hoverman's antenna can be improved by adding 2 or more antennas which are structured in series or parallel depending on compatibility.

***Keywords*:** Meteor; forward - scattering technique; radio region; gray Hoverman antenna

1. INTRODUCTION

A meteor shower is an astronomical event in which a number of meteors are observed to radiate, or originate, from one point in the night sky [1]. When a meteoroid striking the upper atmosphere, these meteors are produced by the streams of cosmic debris at extremely high speeds on parallel trajectories [2]. Radio meteor scatter by forward scattering is a technique for observing meteors [3]. Meteor trails can reflect radio waves from distant transmitters, then when a meteor appears one can sometimes receive small signals of broadcasts from radio stations up to 2000 km away from the observing site [4].

The amateur astronomer is often used forward scattering technique in detecting meteor shower [5]. This means that even the rarefied atmosphere at heights of around 60 to 110 km above the surface is dense enough to cause the particles to ablate ("burn up") owing to frictional heating by collisions with the air molecules.The data obtained can provide the preliminary information regarding the qualitative meteor characteristics such as velocity, pathway, deceleration and mass of the meteor [5]. Radio meteor observing is technically challenging, but allows continuous meteor observations to be made regardless of the weather or daylight. To perform it, you will need a radio receiver. From regular visual observations, only about one meteor in every 150 is this bright, while a magnitude -8 fireball occurs on average about once in every 2000 meteors. The number of meteors observed over a given time will vary depending on the time of night, the time of year, the sky clarity, the observer's eyesight and, for shower meteors, the elevation of the radiant. Few shower meteors can be expected when the radiant is low in the sky.

The direction of meteor before and after midnight is shown in Figure 1. A forward - scattering technique for radio meteor detection has been well-known for over 50 years ago. The technique involves the use of a distant radio transmitter which is beyond the usual ground wave propagation horizon, to detect, meteor transits through the common scattering volume [5]. In the middle 1980's, this observation method became popular among amateur astronomers and is a different from the radar observation method employed by professional astronomers since the end of World War II. The forward - scattering technique is also sometimes used to communicate with the VHF band over big distances [6].

Most of the amateur astronomer does not focus on the radio meteor astronomy field. This is unfortunate as the field offers an excellent opportunity to contribute observations of scientific value and provides many enjoyable evenings of observing. There are only a few professional astronomers active in meteorological research today, therefore the field relies heavily on the amateur for data [7].

Meteors typically are small particles, normally no larger than a microscopic of sand, that enter our atmosphere at speeds of up to around 70 kilometers per second. The meteor become visible at an altitude of about 100 kilometers due to their impact with the atmosphere. Most particles will evaporate from the effects of heat well before reaching the surface of the Earth [8].

When a meteor pass by, it will produce a streak of light. This streak of light consists of ionized atoms and molecules along the path behind the meteor [9]. These meteor trails are capable of scattering radio signals from ground stations. Unlike visual observation, radio detection meteor shower can be undertaken in daylight and during bad weather. Similarly, a night sky illuminated by the full Moon has no negative effect on radio detection [10]. Radio detection rates tend to be higher than visual observation rates, because particles down to 10^{-5} kg can be detected visually, while particles down to 10^{-10} kg can be detected by radio. [11].

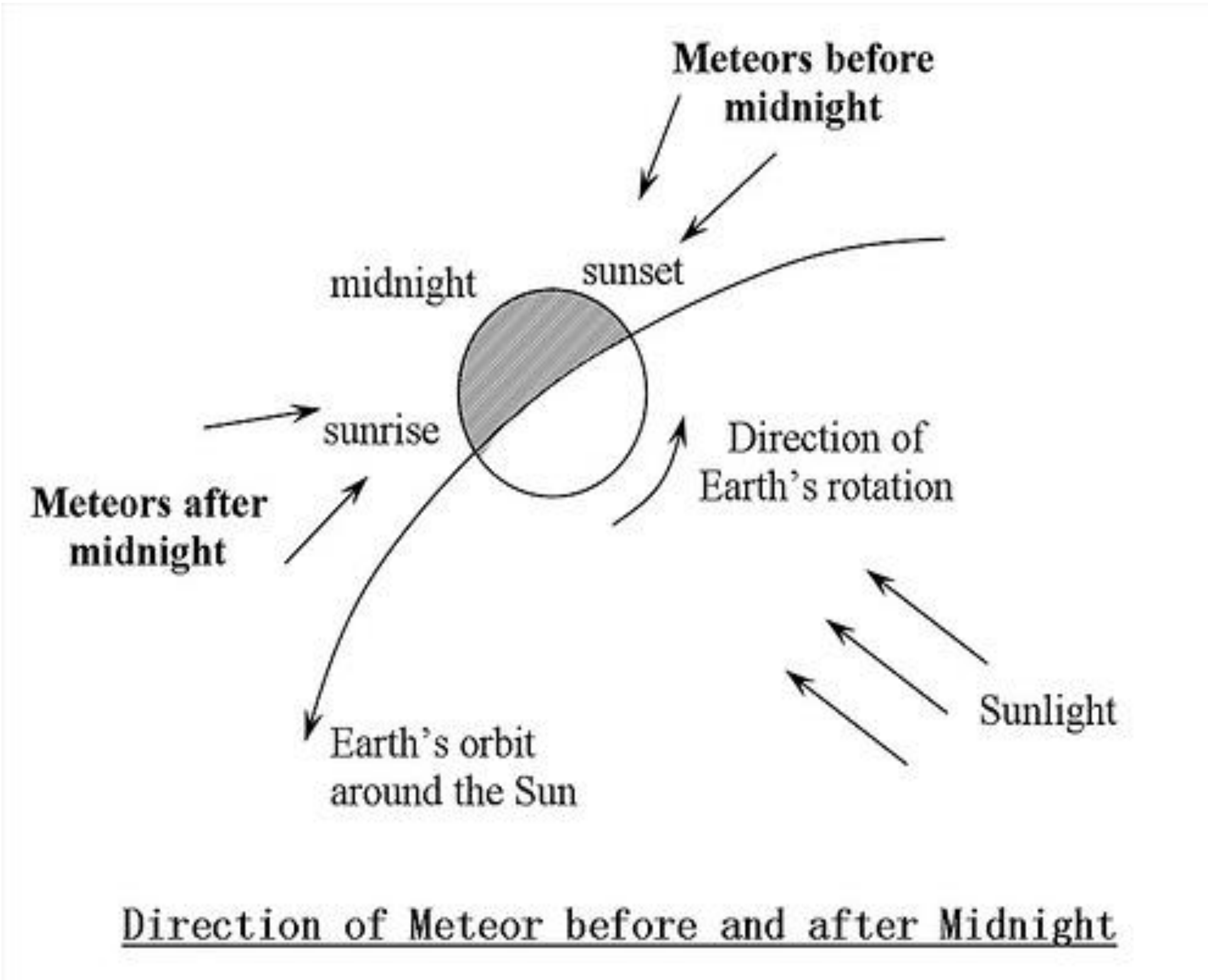

Figure 1. Direction of meteor before and after midnight

Two types of meteor trails exist, underdense and overdense; they are determined by the density of free electrons. Radiated signals from underdense trails which is less than 2×10^{14} electrons per meter rise above the receiver noise almost instantaneously and then decay exponentially. The duration of many meteor bursts is about a second or less. Reflected signals from overdense trails may have higher amplitude and longer duration, but destructive interference due to reflection from different parts of the trail can produce fluctuations in the signal [12].

A lot of information can be extracted from radio waves scattered or reflected by meteor trails. Options include using multiple antennas and clever signal processing to obtain directional information, and high speed data logging to record the interference effects due to time-varying phase shifts along the trail. However, the objective of this experiment is much simpler, namely, to count meteors and look at the changes in the hourly echo rate as a function of time [13].

2. ANTENNA DESIGN

This study is to construct and modifying the Gray's Hoverman antenna to obtain the highest gain thus improved its sensitivity. The Gray-Hoverman antenna has been designed by Doyt R. Hoverman and was invented in the 1950s and it was patented in 1960s. This antenna covered a part of UHF band which covers from 300 to 3000 MHz and shows high performance for most Digital / HD channels broadcasting [14]. However, with some improvements, the antenna can receive well both the UHF as well as VHF-Hi. This post will show two variants of this antenna that can be used to receive 170 to 230 MHz channels (5 - 12) and a part of UHF between 470-720 MHz (21 - 52 channels) with a minimum gain of 5 - 6 dBi [15,16]. These are the simplest to build.

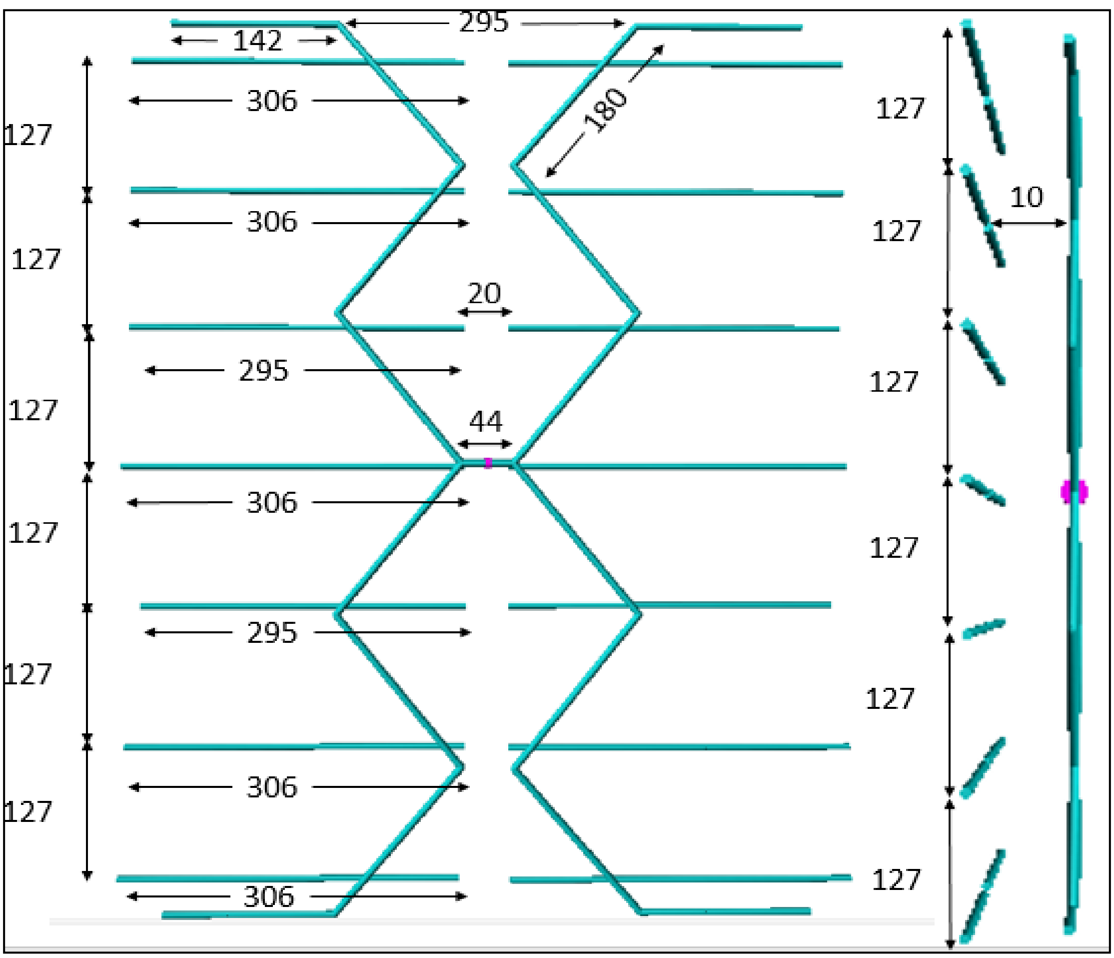

Figure 2. Design Planning

Conducting a field observation certainly has many parameters that must take into account [17-19]. The crucial factor that can completely influence my data obtained is the weather [20-22]. To get relevant data, the weather must be clear and there is no cloud covering the field of observation [23,24]. The impedance of an antenna is that presented to the feeder cable connecting it to the transmitter or receiver. It is the result of the vectorial addition of the inductive, capacitive and resistive elements of the antenna [20,25]. Each resonant antenna possesses an impedance characteristic of the type, and when an antenna operates at its resonant frequency the reactive elements cancel out and the impedance becomes resistive [26].

Figure 2 above shows the design of the antenna with the measurement. All the measurement is in millimeter (mm). The antenna design is using NEC software. The design of the antenna has a little modification from the original design in order to increase the performance. According to the enthusiast in an online forum, the original design of the gray Hoverman antenna had a poor SWR performance after much research and attempt being conducted. With the addition of aluminium reflector and the aid of NEC software, the performance shows an impressive improvement.

3. RESULTS AND ANALYSIS

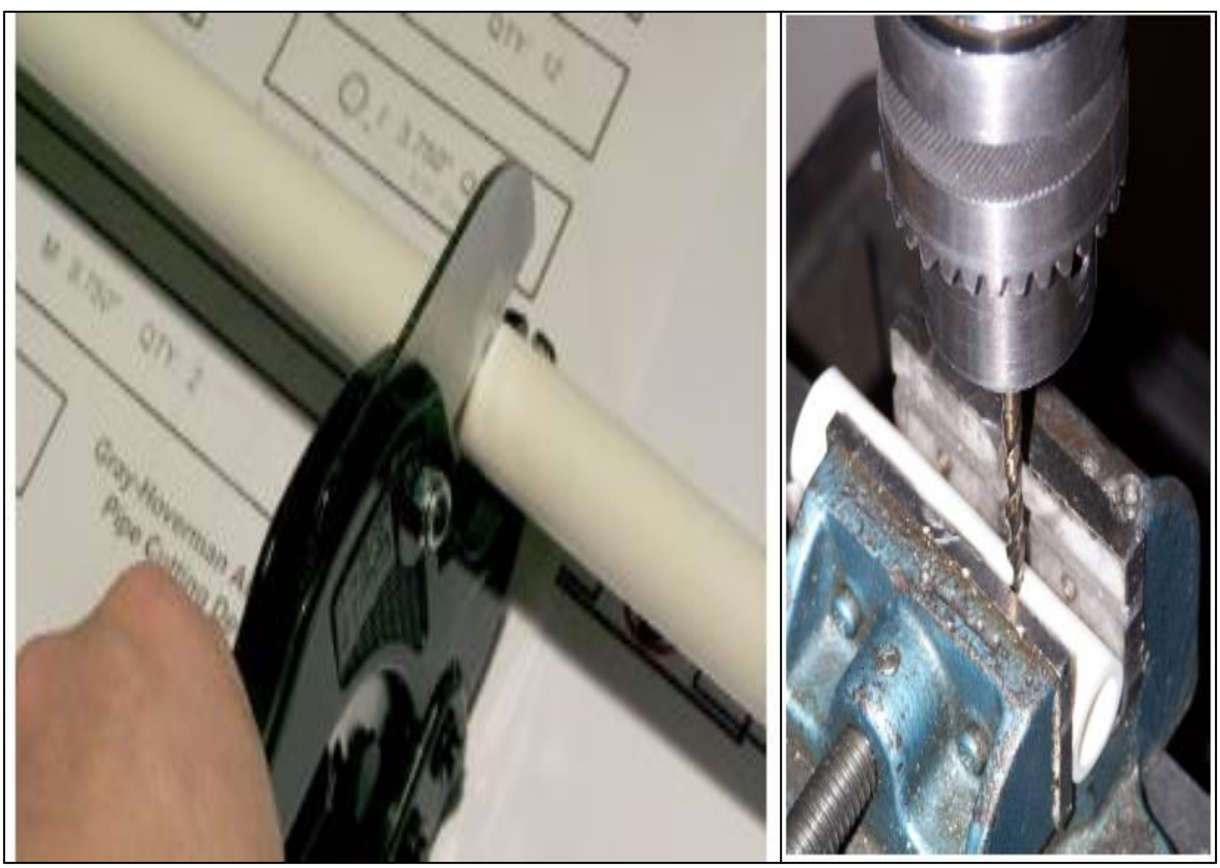

Figure 3. Process of construction of the antenna

Basically, in this process, all the material is cut into specific measurement according to the designer. After that, the PVC pipe was drilled for aluminium reflector connection. The last part was to assemble all the material into one framework. To have an antenna impedance of 50 Ohms, it is important that the visible surface of the internal insulator of the connector (the white area around the central pin) is at the same level as the surface of the plate. For this reason, cut 0.5 cm of copper pipe with an external diameter of 2 cm, and place it between the connector and the plate.

This is to help our project become easier. The past few weeks, we have conducted this project to collect the data that wanted. The data obtained from the special software named 4nec2. This software is very useful in this experiment. It can simulate the designated antenna virtually and produce very accurate data. The antenna impedance relates to the voltage and current input of the antenna. The plotted graph in Figure 5 shows the function of impedance to the unit frequency. The impedance measurement at targeted range frequency is around 100ohm. From the electronic system perspective, when the antenna is connected, the antenna is being a circuit element with a complex impedance that need to be matched to the rest of the network in delivering efficient power transfer.

Figure 4. The Complete Antenna

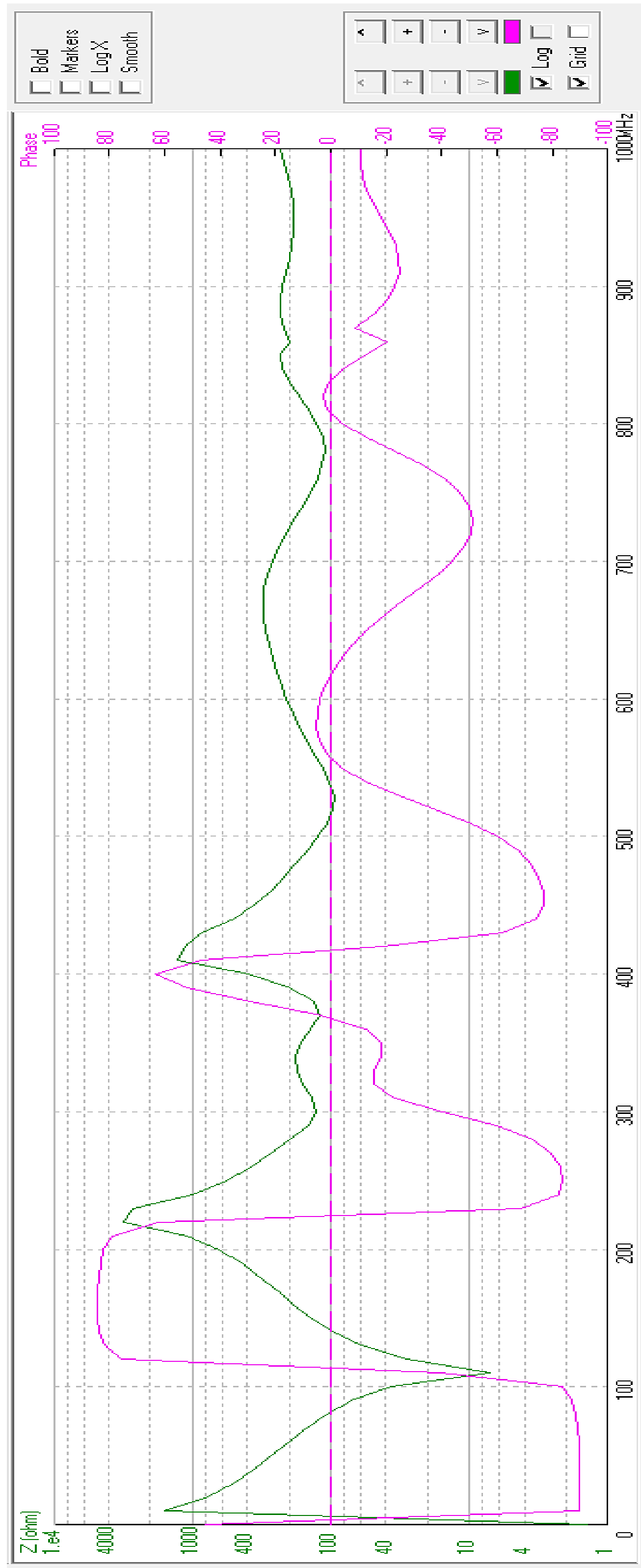

Figure 5. Graph of Impedance vs Frequency

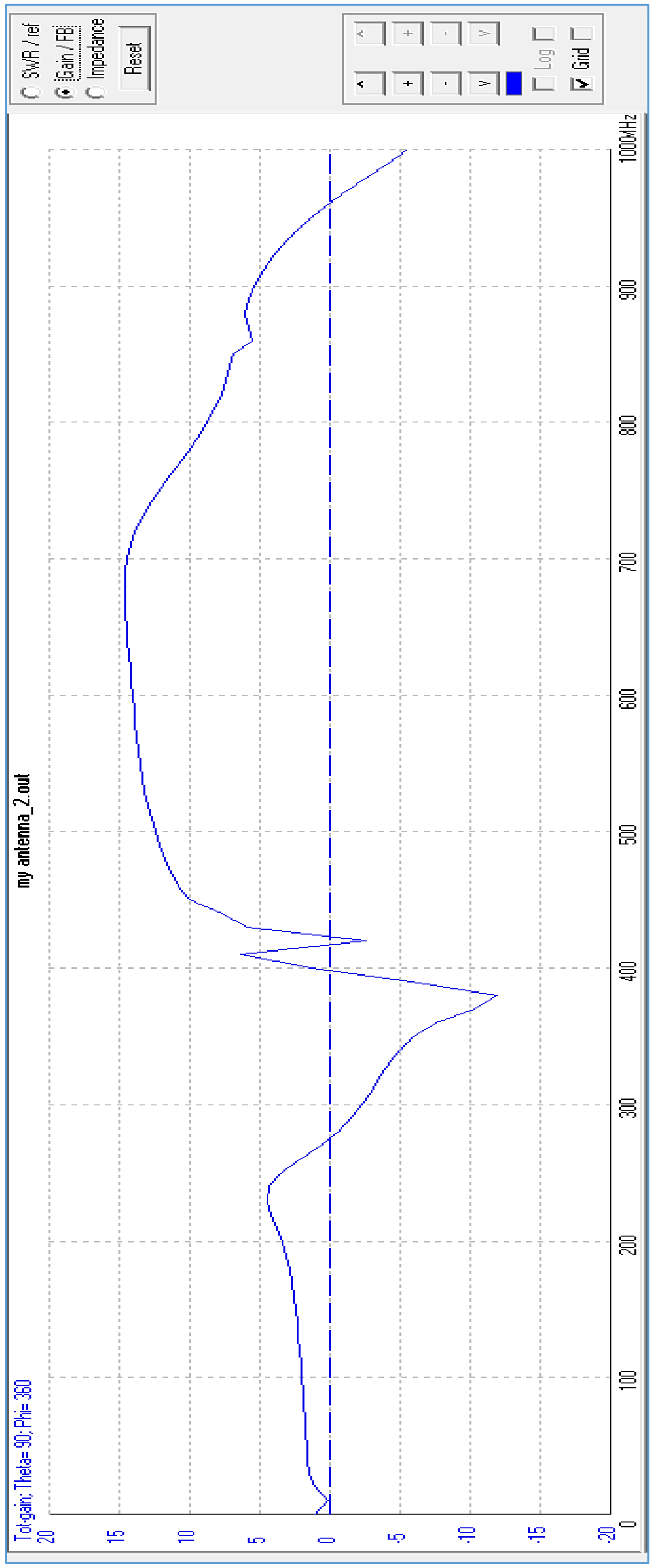

Figure 6. Graph of Gain v's Frequency

Most of the antennas experiencing a complicated frequency-dependence of the input impedance, which limits the bandwidth of operation when connected to a generator with a different internal impedance. Some propagating wave antennas and matching structures that are physically large compared with a wavelength can have a wide range of operating frequencies. In general, smaller antennas support a standing wave of current and consequently display multiple resonance characteristics. Most often the antenna is used in a limited range of frequencies around a well defined center frequency. In this case, the antenna impedance can often be adequately modeled by a simple series or parallel RLC circuit. The choice of model is dictated by the nature of the resonance.

The antenna impedance relates to the voltage and current input of the antenna. The plotted graph in Fig. 5 shows the function of impedance to the unit frequency. The impedance measurement at targeted range frequency is around 100 ohm. From the electronic system perspective, when the antenna is connected, the antenna is being a circuit element with a complex impedance that need to be matched to the rest of the network in delivering efficient power transfer. Most of the antennas experiencing a complicated frequency-dependence of the input impedance, which limits the bandwidth of operation when connected to a generator with a different internal impedance. Some propagating wave antennas and matching structures that are physically large compared with a wavelength can have a wide range of operating frequencies. In general, smaller antennas support a standing wave of current and consequently display multiple resonance characteristics. Most often the antenna is used in a limited range of frequencies around a well defined center frequency. In this case, the antenna impedance can often be adequately modeled by a simple series or parallel RLC circuit. The choice of model is dictated by the nature of the resonance.

Figure 6 shows the graph plot of gain versus frequency. The high gain obtained by the antenna is around 14.4 dBi at targeted range frequencies of 500 MHz to 700 MHz. This region of frequency is said to be the best performance of the antenna due to high gain. The lower gain is around -11 dBi. Analyzing the curve shown in Fig 6 it can be clearly observed that the designed antenna structure provides good amount of gain 14.4 dB which is highly desirable for various applications.

4. CONCLUDING REMARKS

In future, a different type of antenna could be used in searching of high performance antenna and of course the implementation of the antenna is convenient for radio meteor detection activity. Also, the current Gray Hoverman's antenna can be improved by adding 2 or more antennas which are structured in series or parallel depending on compatibility.

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(SWPC) for the sunspot, radio flux and solar flare data for comparison purpose. The research has made use of the National Space Centre Facility and a part of an initiative of the International Space Weather Initiative (ISWI) program.

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