Design of VHF Yagi Uda antenna for Durdrishti Ground Station

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***Abstract*—This paper presents a design and simulation of VHF Yagi-Uda array antenna to be used for reception of HAM Radio Signals as well as Weather Satellite signals. The antenna is simulated and optimized at 146 MHz. The simulation is done using High Frequency Structuring Software (HFSS). It has impedance bandwidth of 10 MHz (6.84%) which satisfies the requirement of VHF HAM Band and weather prediction satellites.**

Keywords—VHF, Yagi Uda, Return loss, Gain, Bandwidth

I. INTRODUCTION

In the last few years the wireless communication industry has evolved and it will be no surprise if it keeps on evolving more in the coming years. An antenna is a very important device in wireless communication which converts a guided electromagnetic wave on a transmission line to a plane wave propagating in free space [1]. There are wide variety of antennas which have been developed for different applications, such as wire antennas which include dipoles, monopoles, Yagi-Uda arrays and related structures. Aperture antennas consisting of open-ended waveguides, rectangular or circular horn, reflectors and lenses. Printed antennas like printed slots, printed dipoles and microstrip patch antennas. Antenna plays a very vital role in any ground station system. They are the most essential link between free space and transmitter or receiver and determine the characteristics of the complete system. Antenna and its working environment decide the effectiveness of the ground station.

Our objective is to design an antenna for ISS (International Space Station) APT(Automatic Picture Transmission) signal reception via K.J. Somaiya's Durdrishti ground station which will automatically track the NOAA and Meteor weather satellites through the feeded data of their passes over the location of ground station. The antennas are designed by selecting particular Ham band frequency range. Three types of antennas i.e. V-Dipole, Quadrafilar Helix and Yagi Uda are designed to operate on Ham band frequency range of 144MHz to 146MHz for Reception. V-Dipole antenna is the simplest antenna configuration, although the presence of three different parameters, viz. the two arm lengths and the included angle makes it even more difficult. The design procedures available for symmetrical V-Dipole mainly depend on maximizing the directivity with respect to the included angle only. Quadrafilar Helix being directional, consisting of one or more conducting wires, wounded in the form of helix, is an excellent antenna for transmission and reception purpose. Being directional, signal is captured easily along with noise too.

The three element Yagi Uda is used to optimize its directivity and match it to the 50-ohm impedance cable. As frequency is 145 MHz corresponding wavelength for this frequency will be 2.0689 meters. We implemented antennas such that the size will be reduced to such an extent that it can be can be assembled and disassembled at site. The material used is robust in nature in order to survive the extreme weather conditions. In half wave dipole, input resistance and reactance increase along with length of dipole. We preferred dipole antenna over folded dipole, even though we get better results in folded dipole antenna & cross Yagi antenna (50 Ohm). The major reasons for using Yagi Uda over other types of antennas are as follows:

1. The performance of simple Yagi-Uda Antenna is similar to Cross Yagi but with less complex design.

2. We can achieve higher gain and range in cost effective affordable designs which are far less subject to interference.

II. CONSTRUCTION & DESIGN METHODOLOGY

Yagi-Uda antenna consists of mainly three elements i.e. directors, reflectors and dipole where directors and reflectors are parasitic element. Yagi-Uda antenna dimensions are as follows
Dipole=0.48λ
Director=0.45λ
Reflector=0.55λ

The basic design is as shown in Fig. 1.

III.

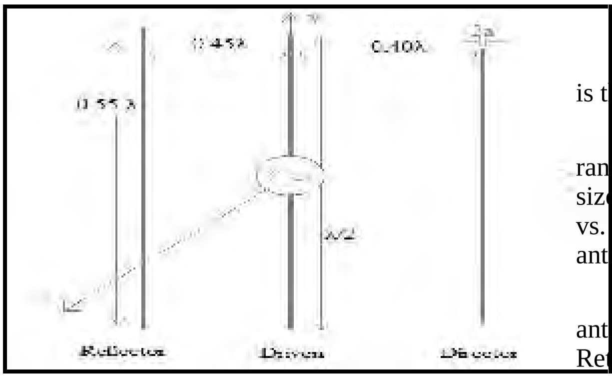


Fig. 1 Yagi-Uda basic design

This antenna is designed to operate at 144 MHz-146 MHz which is HAM RADIO Wireless Communication Band. For this frequency, wavelength is 2.0689 meters. For this VHF band frequency which is, Yagi-Uda is the best fitted antenna to be used [2].

The director is made to be smaller than the driven element. The director is placed in front of the driven element that is in the direction of maximum sensitivity. Typically director will add around 1 dB of gain in the forward direction. A director acts as a capacitive element. The director can be made capacitive by tuning it above the resonant frequency. The second alternative is more commonly used. Feed box is connected with driven element to feed the signal from cable RG-58 (50 Ohm). This cable is connected using SMA female connector. Feed box is isolated from environmental resistance.

This is behind the main driven element that is the side away from the direction of maximum sensitivity. Reflector reflects the EM waves. This helps in achieving unidirectional propagation.

IV. RESULTS AND DISCUSSION

Simulation is the connecting medium between design idea and hardware manufacturing. After receiving signals from antennas which were made from general designs available, we found that some of the parameters need to be improved in order to receive the weather signals more accurately. Hence we have simulated this linear polarization Yagi-Uda antenna using HFSS software.

In order to provide an efficient result, the parametric analysis of various components is considered. Different parameters were toggled with to find the optimum value. The parameters which were used for the same and the results of the same are as mentioned below.

A. Return Loss and Bandwidth

Return loss signifies the degree to which the antenna is matched with the transmission line. It indicates how much of the incident power is reflected back because of a mismatch in impedance. Generally, the impedance of the transmission line is considered to be 50Ω, although the values can sometimes differ. Return loss is calculated as follows:

$$R_L(dB)=10 \log_{10}(p_i/p_r) \quad (1)$$

In the above equation, p_i is the incident power and p_r is the reflected power.

The simulated results are carried over a frequency range of 100 MHz to 200 MHz with a frequency step size of 20MHz. The fig. 2 shows the graph of frequency vs. Return loss parameter of the simulated Yagi-Uda antenna.

As shown in the fig. 2, this simulated Yagi-Uda antenna resonates around 146 MHz and exhibits a -20dB Return Loss bandwidth of around 30 MHz from 130 MHz to 160MHz.

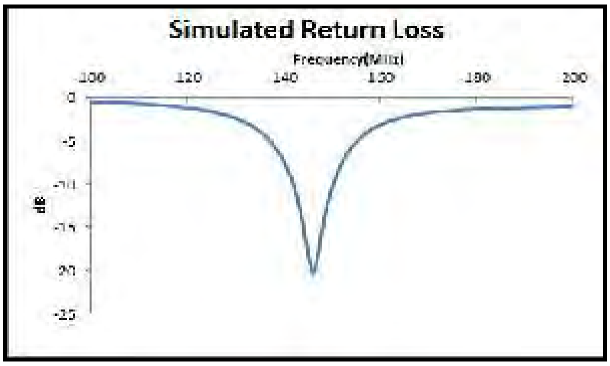


Fig. 2 Simulated Return Loss of the proposed antenna

B. Gain

Gain indicates the radiation in selected direction in comparison to an isotropic antenna. Gain provides us with a value to how efficiently an antenna converts input power into electromagnetic waves. Fig. 3 shows the gain plot of the simulated antenna.

Further studies are required to improve the gain. Techniques such as introduction of parasitic elements and further parametric analysis are considered for the same.

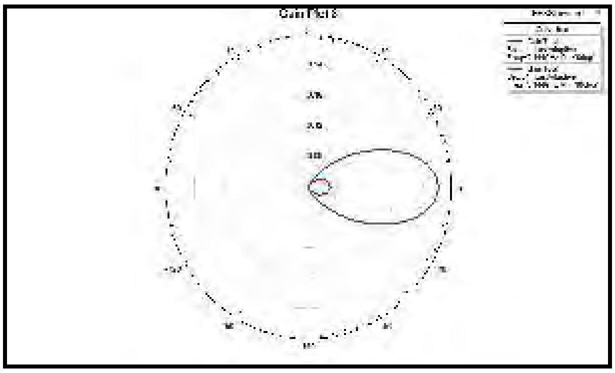


Fig. 3 Gain Plot of Simulated Antenna

C. Radiation Pattern

Radiation pattern is graphical representation of the intensity of the antenna plotted against the angle from perpendicular axis.

The only effort required is the reading and following of values along the circles. Fig. 4 shows the impedance matching of the simulated antenna.

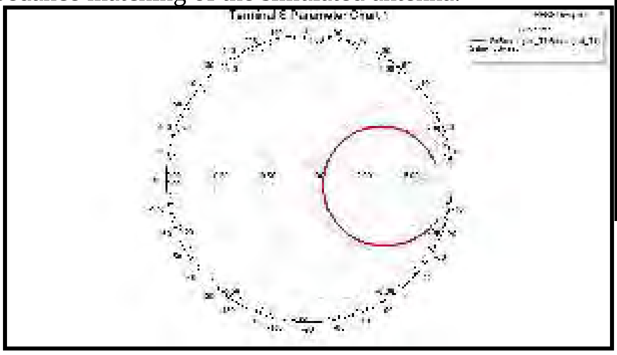


Fig. 4 Impedance Matching of Simulated antenna

Fig. 5 shows the top view of radiation pattern and Fig. 6 shows the front view of radiation pattern.

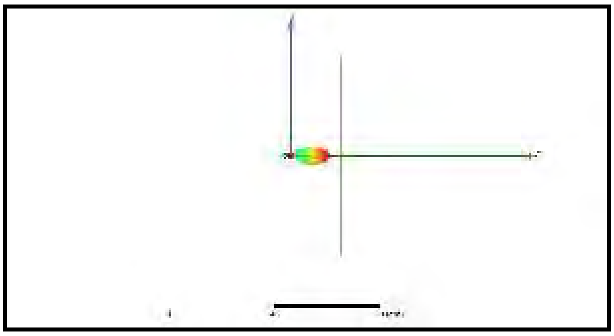


Fig. 5 Top View of Radiation Pattern in HFSS

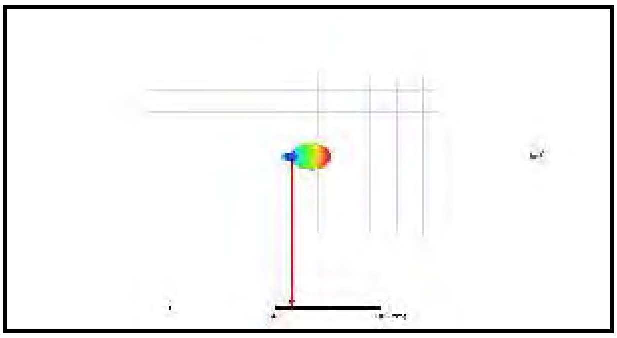


Fig. 6 Front View of Radiation Pattern in HFSS

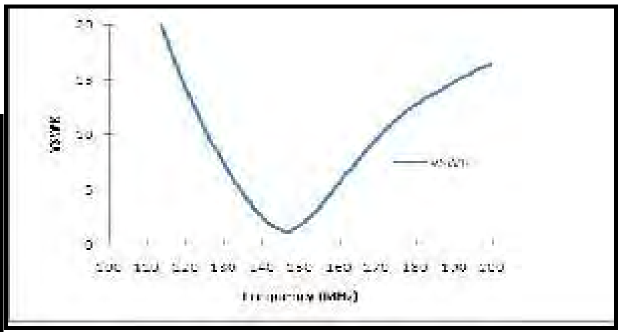
D. Voltage Standing Wave Ratio (VSWR)

Standing Wave Ratio (SWR) is a measurement of how efficiently the antenna will radiate the power available from the radio. In simple terms, the radio would like to radiate all of its power, but can only do so if the other components co-operate. Bad co-axial cables and mounts , or insufficient antenna and ground plane can cause system bottlenecks.

$$VSWR = V_{MAX} / V_{MIN}$$

Fig.7 Simulated VSWR of the proposed antenna

The simulated graph of VSWR vs. Frequency is shown in fig.7.



IV. CONCLUSION

In this paper, 3 element Yagi-Uda antenna for VHF weather satellite reception is designed and simulated using HFSS. Yagi-Uda antenna is simulated and optimized at 146MHz. The antenna operates around the 146 MHz VHF band with its resonating frequency at 146 MHz and impedance bandwidth of 10MHz. The antenna is suitable for reception of weather satellite signals. Further studies are required to improve the gain of the antenna to improve its working efficiency.

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