Comparative Analysis of Quagi and Yagi-Uda Antenna using 4NEC2 Tool

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Abstract- A Yagi-Uda antenna is one of the most widely used antenna in communication. Quagi antenna is a variation on vulnerable Yagi-Uda. Both the antennas are designed using 4NEC2 tool. Comparative analysis is being done on both 8-element Yagi-Uda antenna and 8-element Quagi antenna at 432 MHz frequency. A Quagi antenna is merely one of the most interesting amateur antenna designs to come down the pike in recent years. The need for low cost, high gain antenna for Moon bounce Communication, where moon is used as Passive communication satellite, inspired the development of Quagi antenna. Since Quagi is easy and non critical construction, cheap as well as simple, matching of feed line to the driven element, makes Quagi an attractive alternate to both Quad and Yagi-Uda antennas. At 432 MHz both Quagi and Yagi-Uda give almost same efficiency and gain, but Quad loop make an excellent driven element and reflectors, rods seem to be superior directors. So doing comparative analysis on both these antennas at 432 MHz would make sense and this made me to take up this topic.

Keywords*- Quagi, Yagi-Uda, 4NEC2, Gain, Quad, Reflector, Driving element, Director*

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I. INTRODUCTION

Yagi-Uda antenna was developed in 1926. Sir Uda from Japan invented it and Sir Yagi introduced it to the world in English, since it was introduced in English by Sir Yagi, it was popularly called as Yagi antenna. The Quagi was originally designed on the K6YNB/N6NB backyard antenna range in 1972, with the assistance of Will Anderson. The need for low cost, high gain antenna for Moon bounce Communication inspired the development of Quagi antenna. Some of the commercial antennas then available had varying gain figures, especially at 432MHz. After a series of attempts to improve the performance of one particular commercial 11-element Yagi, attention was focused on the driven element which had inefficient gamma match. A Quagi antenna uses the same strategy as in Yagi-Uda, using a reflector, a driven element, and then a number of director elements. However, a Quagi constructs the reflector and the driven elements as "quads" rather than as linear elements. In a Quagi the first two elements of the antenna are quads, the directors are all simple straight wire elements, as in the traditional Yagi-Uda design. The name Quagi is a simple contraction of Quad-Yagi. There is a "Quad" class of antennas. They come in single elements, and as arrays. A Quad antenna is typically a single wire formed into a square. The dimensions of the square are adjusted so that the antennas resonate at the intended frequency of operation. Both the Quad and the Yagi-Uda antennas are resonant antennas. If one tries to use them outside of their design frequency limits, results will be poor at best. During transmission the reflected power from the antenna may cause radio damage. The benefits of Quagi antenna are:

- Cheap materials
- Easy to build, doesn't need advanced tools
- Easy to tune
- It has the same Gain as Yagi-Uda's
- Quad loop makes excellent driving element and reflectors
- Best suited for Moon bounce communication

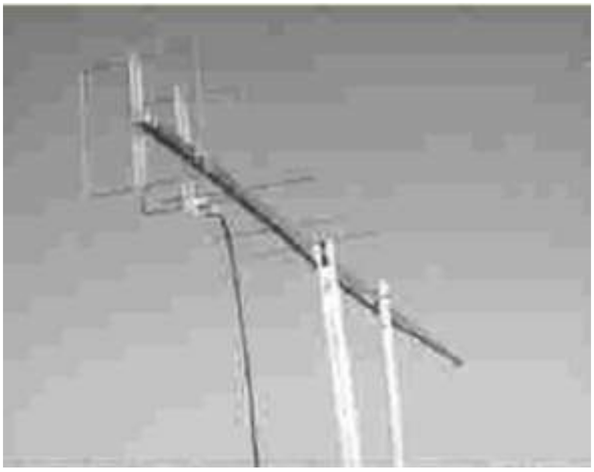

Figure-1: Quagi antenna mounted on a pole

Figure-2: 8 element Quagi antenna

II. DESIGN OF ANTENNAS

Main requirements for designing of antennas are:

- Operating frequency of 432 MHz
- Gain
- Impedance

Design considerations:

- The dimensions are frequency dependent
- Driving element length(DE)=292.03*10^6/f(MHz)
- Reflector element length(RE)=307.15*10^6/f(MHz)

III. SOFTWARE SELECTION FOR SIMULATION

The software used to model and simulate the Quagi and Yagi-Uda antenna is 4NEC2. It can be used to calculate and plot Gain, Front to back ratio, Return Loss (RL), Voltage Standing Wave Ratio (VSWR), Radiation pattern (Azimuth and Elevation), Smith chart and various other parameters.

"Numerical Electromagnetic Code": is a simulation method for wire antenna, developed by Livermore Laboratory in 1981.Here the antenna is divided into short segments with linear variations of current and voltage. Since the results obtained from this tool were very convenient, it was used as a standard for simulation techniques (NEC2). But as time passed, simulation errors like wire crossing in a very short distance or when using buried wires, couldn't be solved. So to overcome all these errors, 4NEC2 was developed. 4NEC2 offers a huge amount of possibilities and options and was programmed by Arie Voors. Its main advantages are the optimizing tools and the parameter sweep. It can be found and downloaded free of charge from the Internet.

IV. PROPOSED ALGORITHM

The 8-element Yagi-Uda and Quagi antennas are designed at 432MHz operating frequency with wire radius of 2.54*10^-5 m

- Length of elements:

Element	Length at 432 MHz (in meters)
Reflector (RE)	0.711
Driving element(DE)	0.676
Director-1 (D1)	0.2984
Director-2 (D2)	0.2968
Director-3 (D3)	0.2952
Director-4 (D4)	0.2936
Director-5 (D5)	0.2921
Director-6 (D6)	0.2905

- Spacing between the elements:

Elements	Spacing b/w them
RE-DE	0.1778 m
DE-D1	0.1333 m
D1-D2	0.2794 m
D2-D3	0.1485 m
D3-D4	0.2217 m
D4-D5	0.2217 m
D5-D6	0.2217 m

V. SIMULATION RESULTS

Using calculated design parameters and proposed algorithm, antennas are simulated using 4NEC2. Comparison is being made depending upon the results obtained.

- **Results of Yagi-Uda Antenna:**

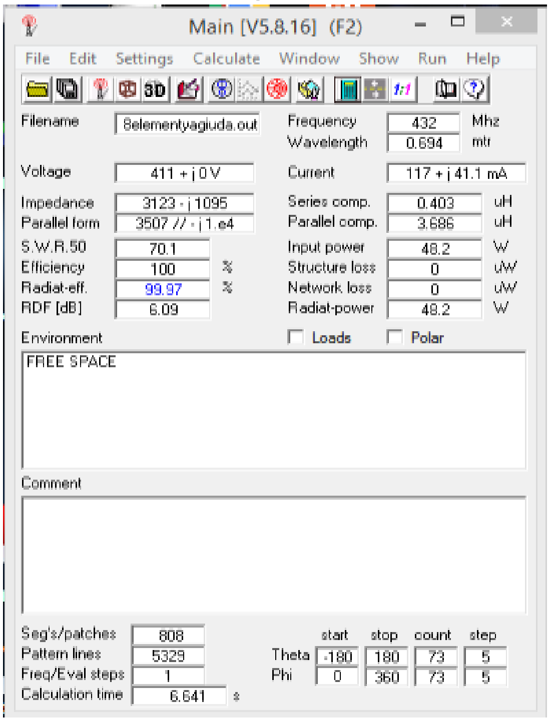

Figure-3: Input power, SWR and radiating efficiency of Yagi-Uda antenna

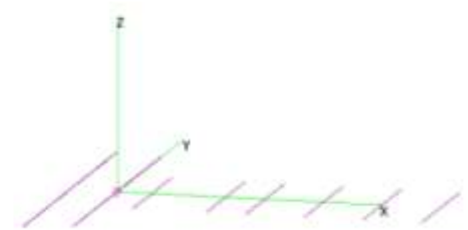

Figure-4: The geometry

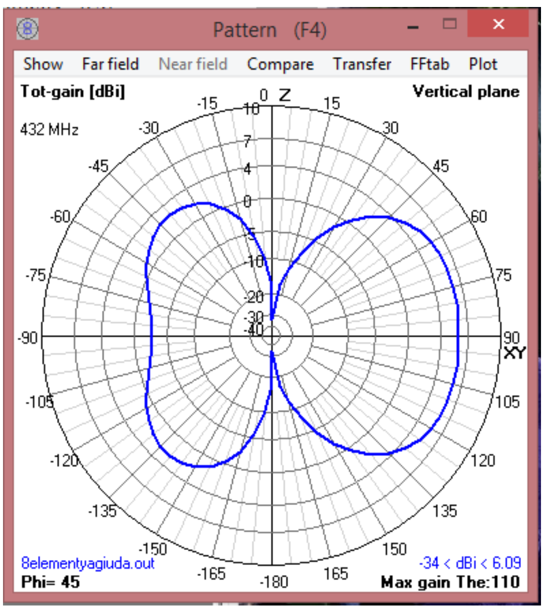

Figure-5: The pattern

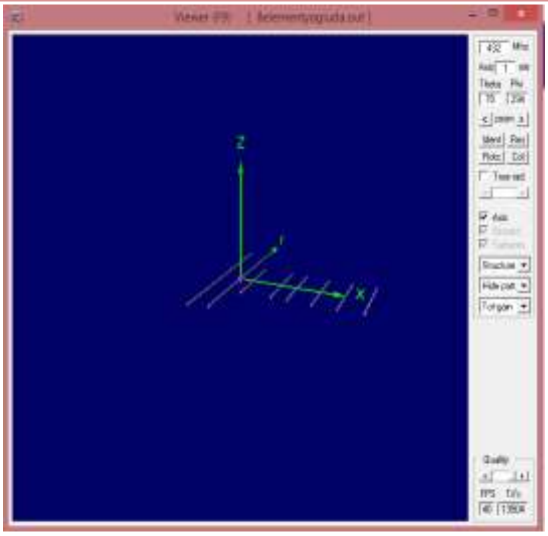

Figure-6: 3D geometry

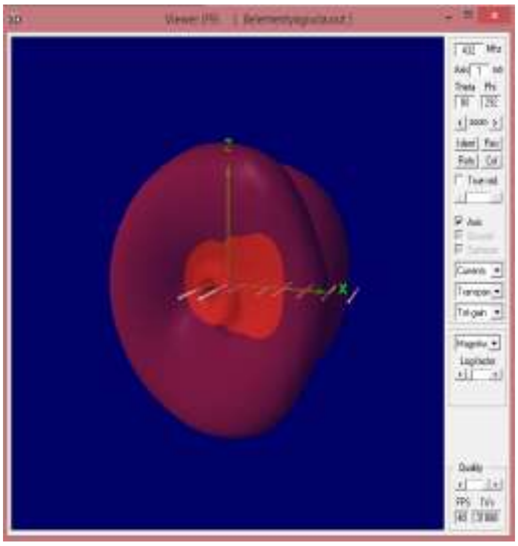

Figure-7: Radiations in 3D pattern

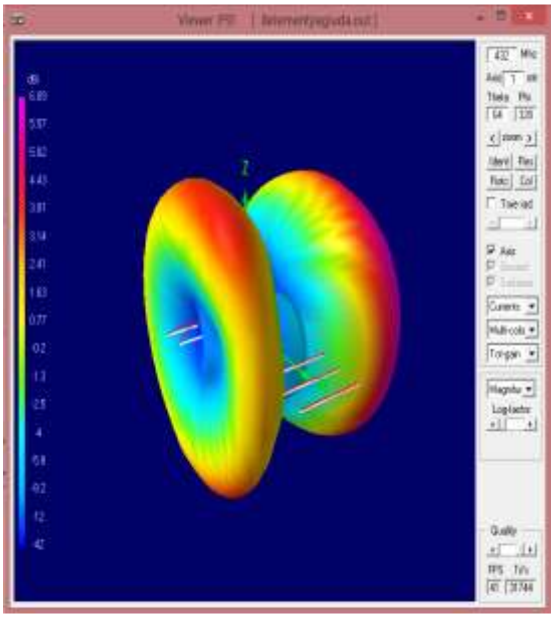

Figure-8: The multi-colour 3D radiation pattern

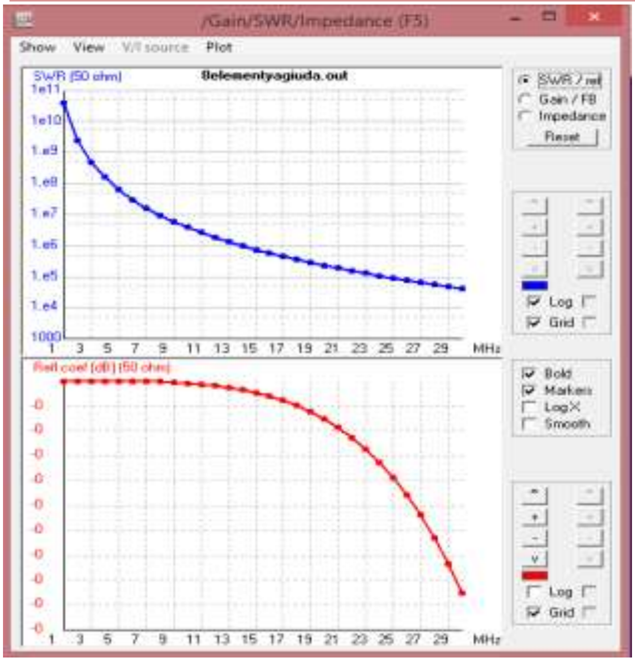

Figure-9: The graph of VSWR v/s Frequency

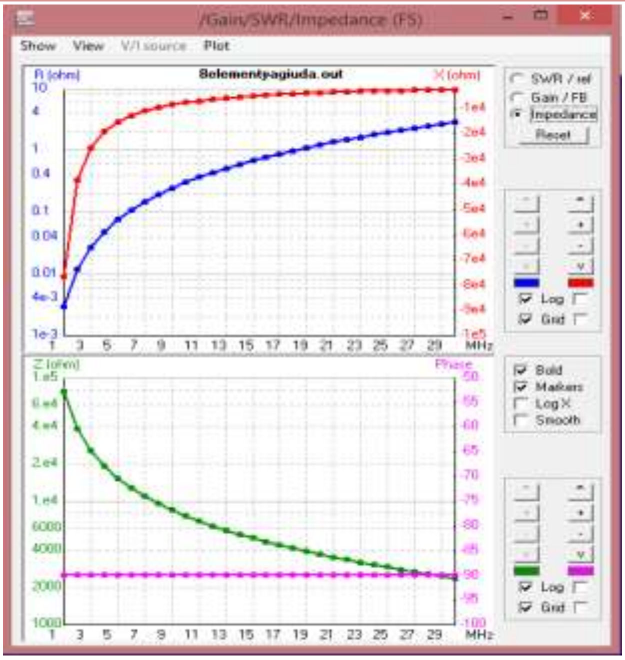

Figure-11: The graph of Impedance v/s Frequency

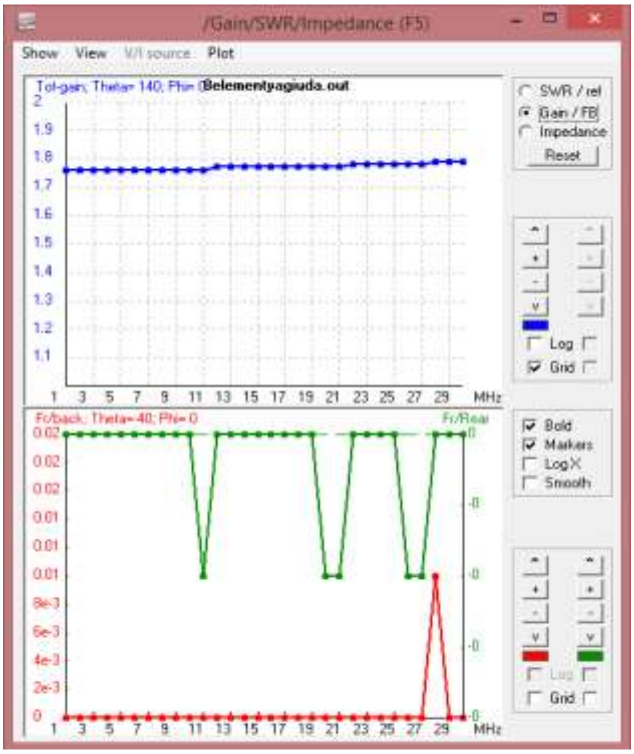

Figure-10: The graph of Gain v/s Frequency

- **Results of Quagi Antenna:**

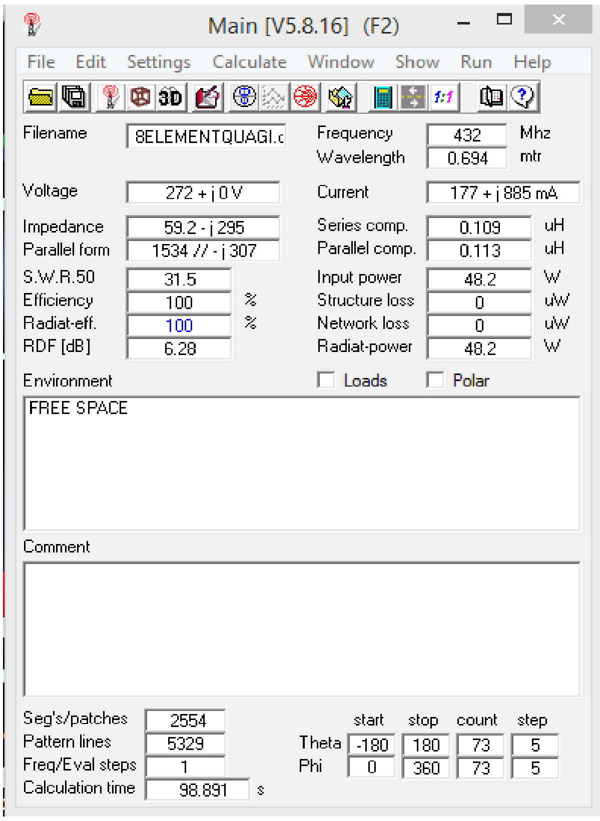

Figure-12: The input power, SWR and radiating efficiency of Quagi antenna

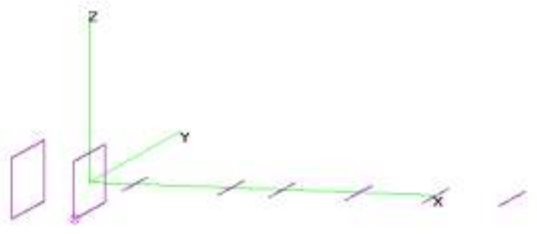

Figure-13: The geometry

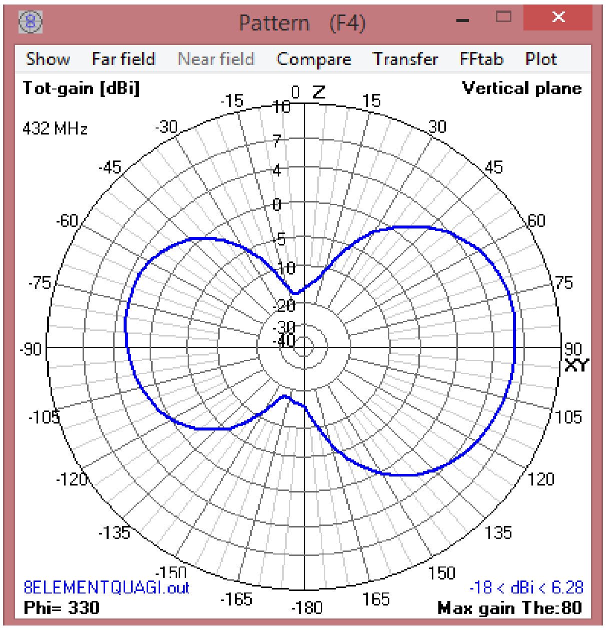

Figure-14: The pattern

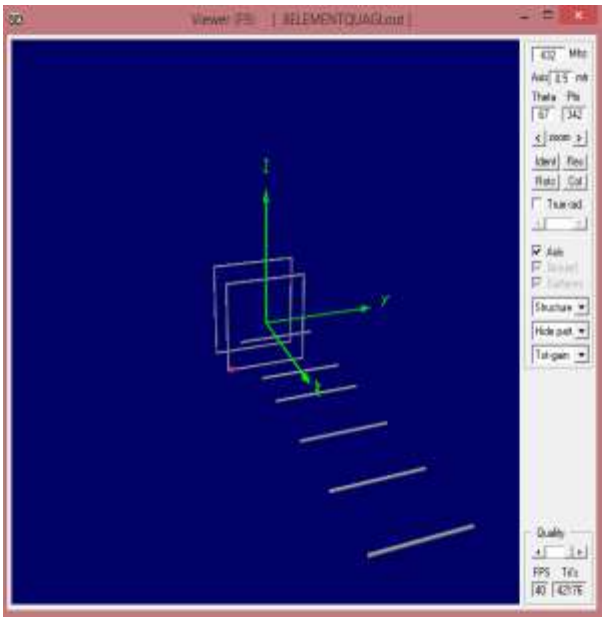

Figure-15: The 3D geometry

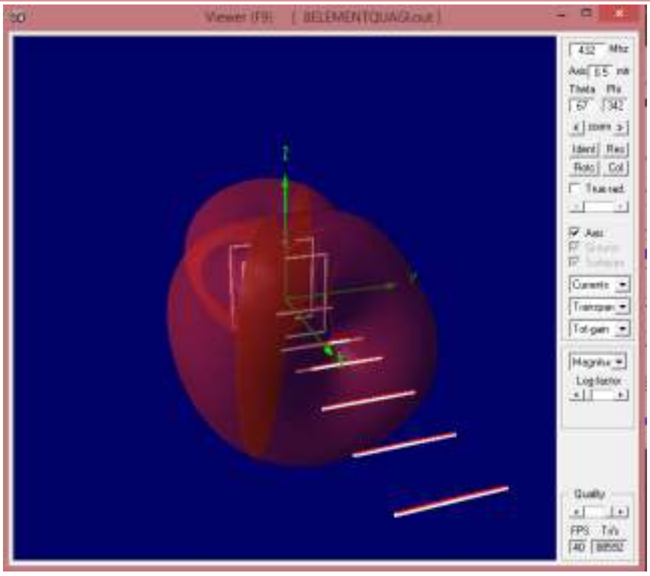

Figure-16: The radiations in 3D pattern

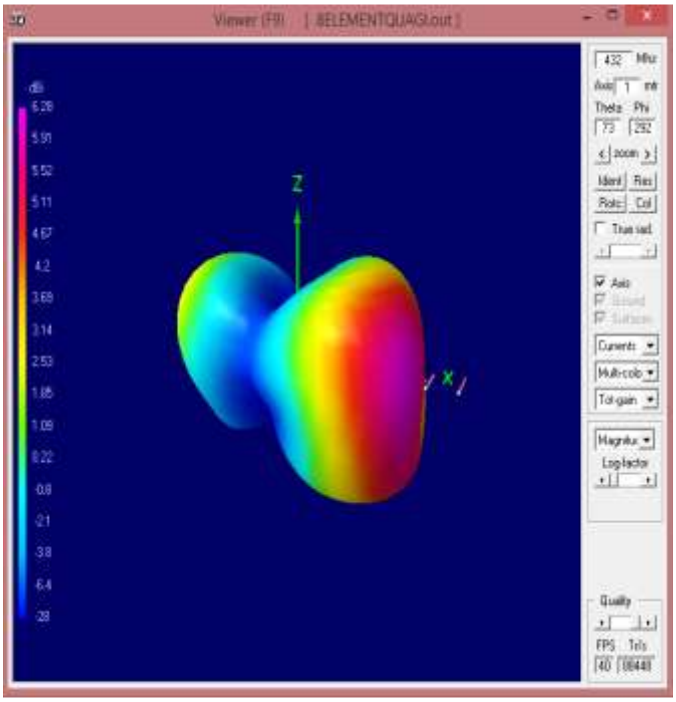

Figure-17: The multi-colour 3D radiation pattern

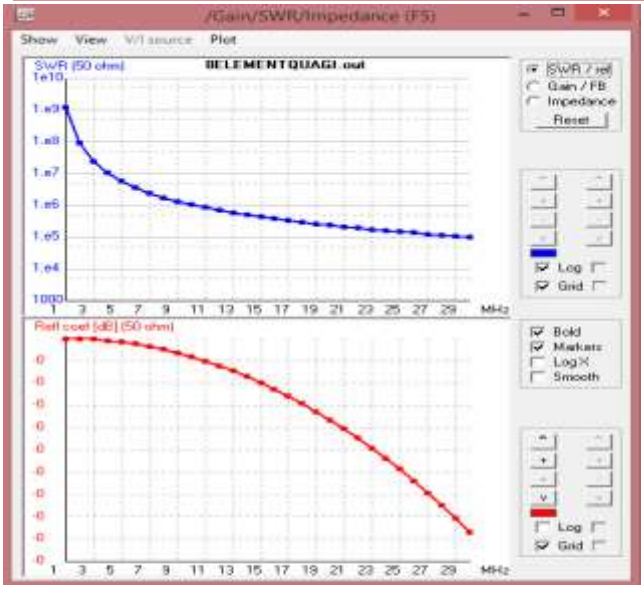

Figure-18: The graph of VSWR v/s Frequency

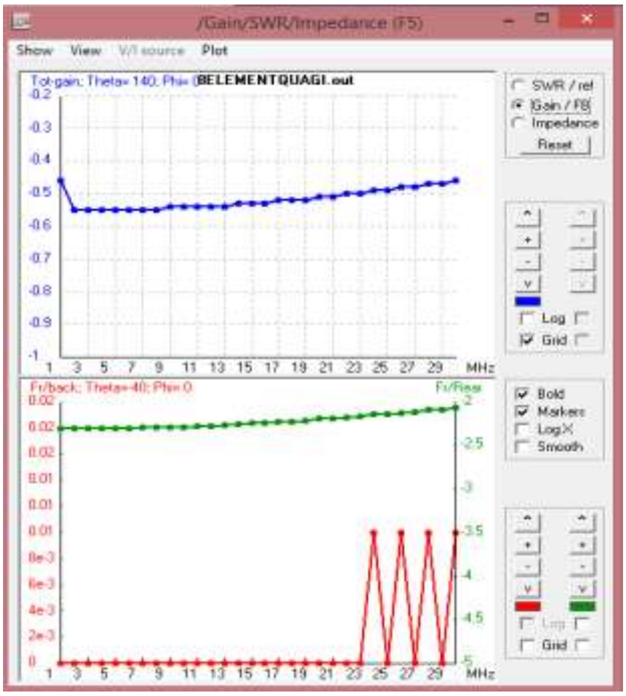

Figure-19: The graph of Gain v/s Frequency

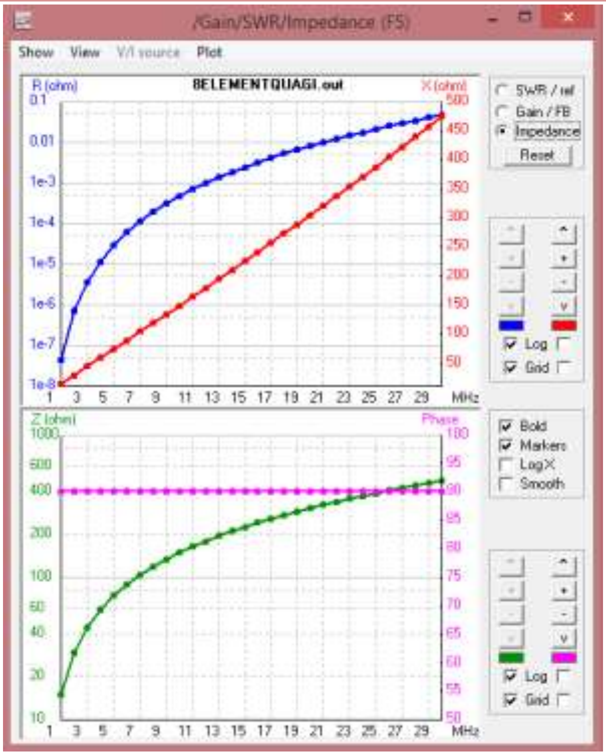

Figure-20: The graph of Impedance v/s Frequency

VI. CONCLUSION

The tool provides the precise values of gain, radiating efficiency, SWR and many other parameters of both 8-element Yagi-Uda antenna and 8-element Quagi antenna. The results show that both Yagi-Uda and Quagi antennas have almost equal Gain. But the use of a quad-style driven element and reflector offers several advantages, including good gain, good immunity to noise resulting from static build ups like multi-storey buildings, trees etc, and extreme ease of construction and impedance matching. Hence 8-element Quagi antenna is more preferred than 8-element Yagi-Uda at 432MHz operating frequency.

VII. REFFERENCES

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