VISVESVARAYA NATIONAL INSTITUTE OF TECHNOLOGY, NAGPUR

ANTENNA SIMULATION WORKSHOP REPORT

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What is a Yagi-Uda Antenna?

A Yagi–Uda antenna is a directional antenna consisting of two or more parallel resonant antenna elements in an end-fire array; these elements are most often metal rods acting as half-wave dipoles. Yagi–Uda antennas consist of a single driven element connected to a radio transmitter and/or receiver through a transmission line, and additional "parasitic elements" with no electrical connection, usually including one so-called reflector and any number of directors. Reflector element is slightly longer than the driven dipole and placed behind the driven element, opposite the direction of intended transmission. Directors, on the other hand, are a little shorter and placed in front of the driven element in the intended direction. These parasitic elements are typically off-tuned short-circuited dipole elements, that is, instead of a break at the feed point a solid rod is used. They receive and reradiate the radio waves from the driven element but in a different phase determined by their exact lengths. Their effect is to modify the driven element's radiation pattern. The waves from the multiple elements superpose and interfere to enhance radiation in a single direction, increasing the antenna's gain in that direction.

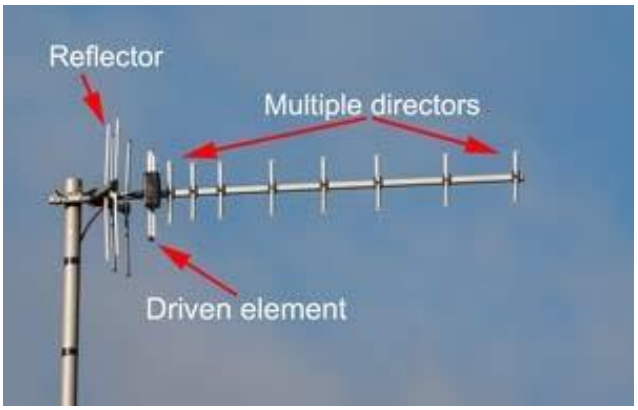

Fig1: A Yagi–Uda Antenna

Applications of Yagi–Uda Antenna

- Used for Television Receivers
- Can be used as a high-gain antenna on the HF, VHF and UHF bands
- RADARs, satellites and RFID applications

Advantages of Yagi–Uda Antenna

- It is an uni-directional antenna
- It is compact in size and light in weight
- It offers wide bandwidth due to use of folded dipole

- It offers substantial increase in directivity and gain compare to simple dipole antenna
- It is lower in cost and simple to build

Disadvantages of Yagi–Uda Antenna

- It does not offer very high gain. It offers moderate gain of about 7 dB. Antenna length increases to achieve higher gain.
- It is sensitive to frequency
- Bandwidth is reduced if more number of director elements are used in array.

What is Monopole Antenna?

A monopole antenna is a class of radio antenna consisting of a straight rod-shaped conductor, often mounted perpendicularly over some type of conductive surface, called a ground plane. The driving signal from the transmitter is applied, or for receiving antennas the output signal to the receiver is taken, between the lower end of the monopole and the ground plane. One side of the antenna feed line is attached to the lower end of the monopole, and the other side is attached to the ground plane, which is often the Earth.

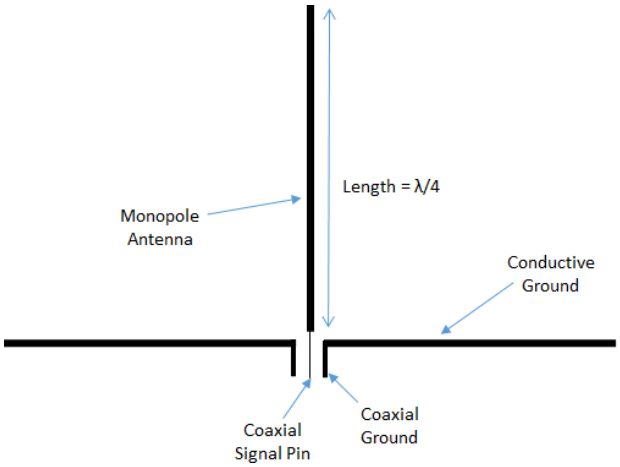

Fig2: This figure depicts the typical construction of Monopole.

Applications of Monopole Antenna:

- Used as a resonant Antenna
- As the size of the monopole is less, used in wearables
- Can be extended to be used as helical and bent antennas

Advantages of Monopole Antenna:

- Compact in size
- Easier to build, can achieve efficiencies up to 80%
- Can be used with multiple bands to get good bandwidth

Disadvantages of Monopole Antenna:

- Poor radiation in some directions
- The conducting ground may cause deflections
- Basic monopole cannot be used for high radiation

Construction in CAD-FEKO (Yagi–Uda Antenna V/S Monopole Antenna)

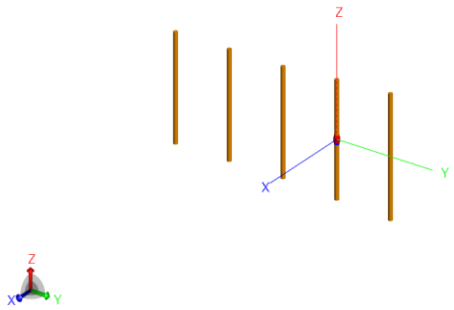

Fig3: Yagi–Uda Antenna

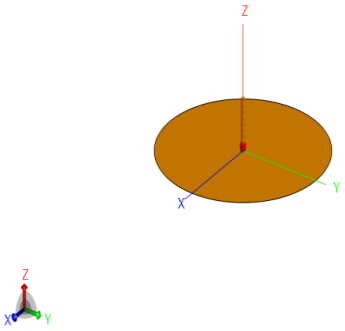

Fig4: Monopole Antenna

The frequency of operation is 1400 MHz for both the antennas. To get the exact calibration for output, certain measurements for antennas are taken. For Yagi–Uda Antenna, the length of driver is taken as 0.465 λ/2, length of reflector as 0.49 λ/2 and the lengths of the three directors as 0.433 λ/2, each separated by a distance of λ/4. For Monopole Antenna, we have considered a circular ground base at z = 0 plane of radius $3\lambda/2\pi$ and the length of the monopole is taken as 0.228 λ. The value of λ is C_0/Frequency where C_0 is the velocity of light in vacuum.

Gain Comparison

The total gain obtained for Yagi–Uda antenna is found to be 12.5 at 1400 MHz whereas the total gain obtained for Monopole antenna is found to be 1.8 at the same frequency. Yagi–Uda antenna has a larger gain but more narrow transmission area.

Radiation Pattern

The radiation pattern of Yagi–Uda antenna is uni-directional while radiation pattern of monopole antenna is omni-directional. This can be observed from the figures below.

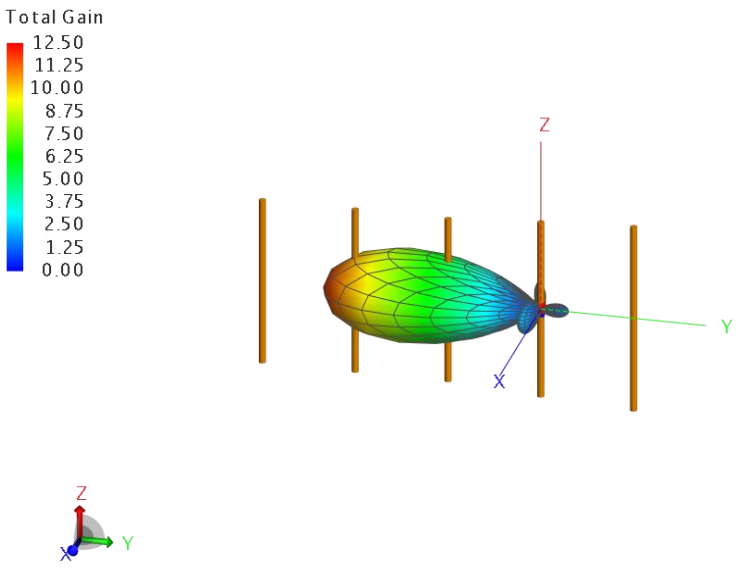

Fig5: Yagi–Uda antenna radiation pattern

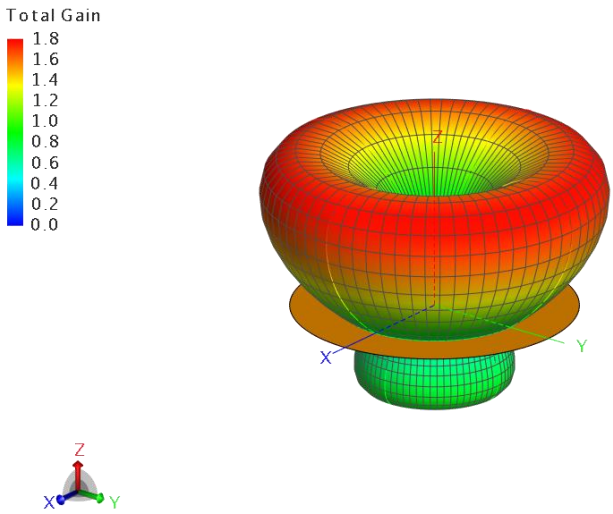

Fig6: Monopole antenna radiation pattern

Current Distribution

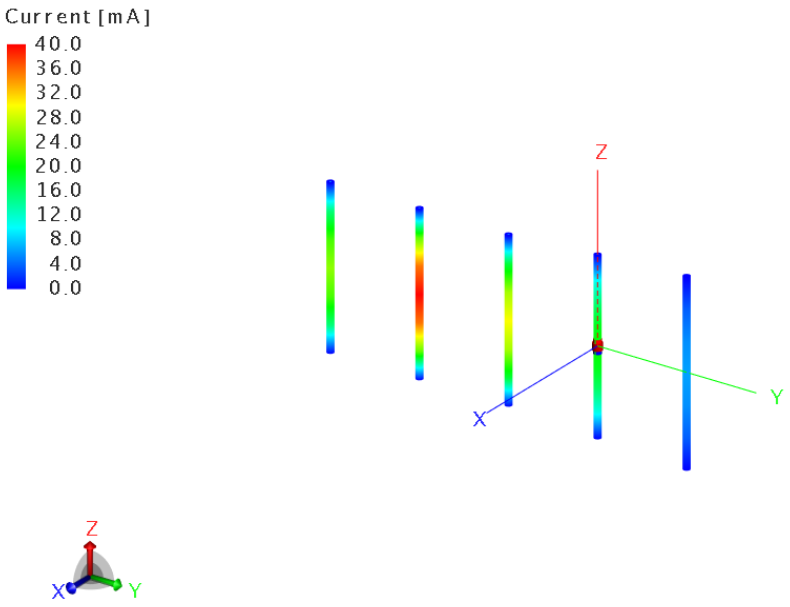

Fig7: The current distribution in Yagi–Uda antenna (max current = 40 mA)

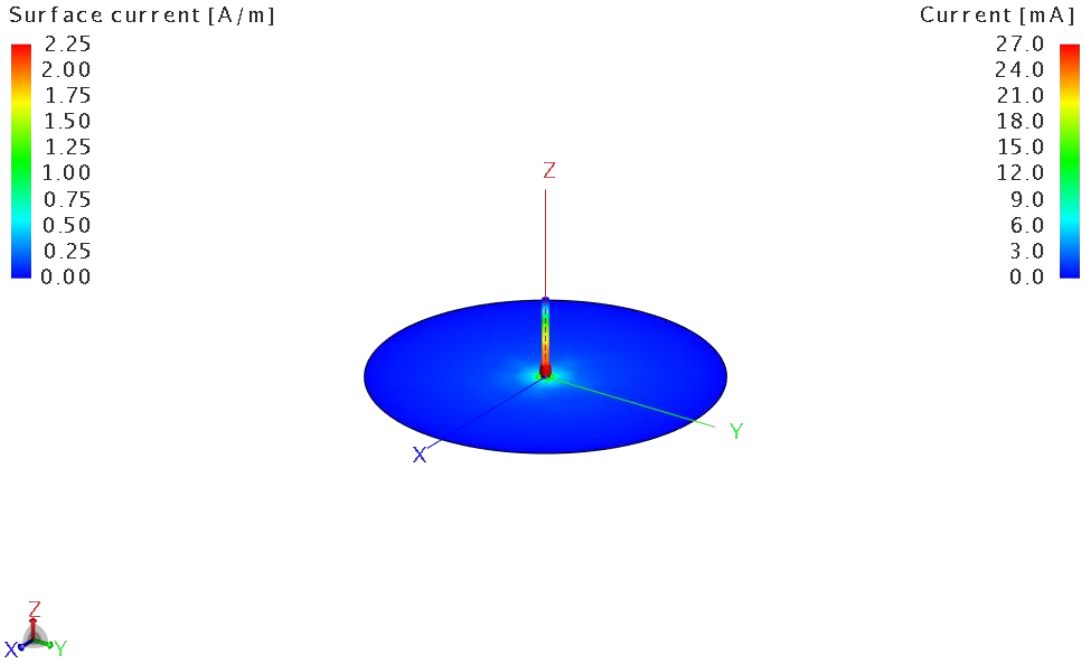

Fig8: The current distribution in monopole antenna (max current = 27mA) at 1400 MHz

Reflection Coefficient / Return Loss

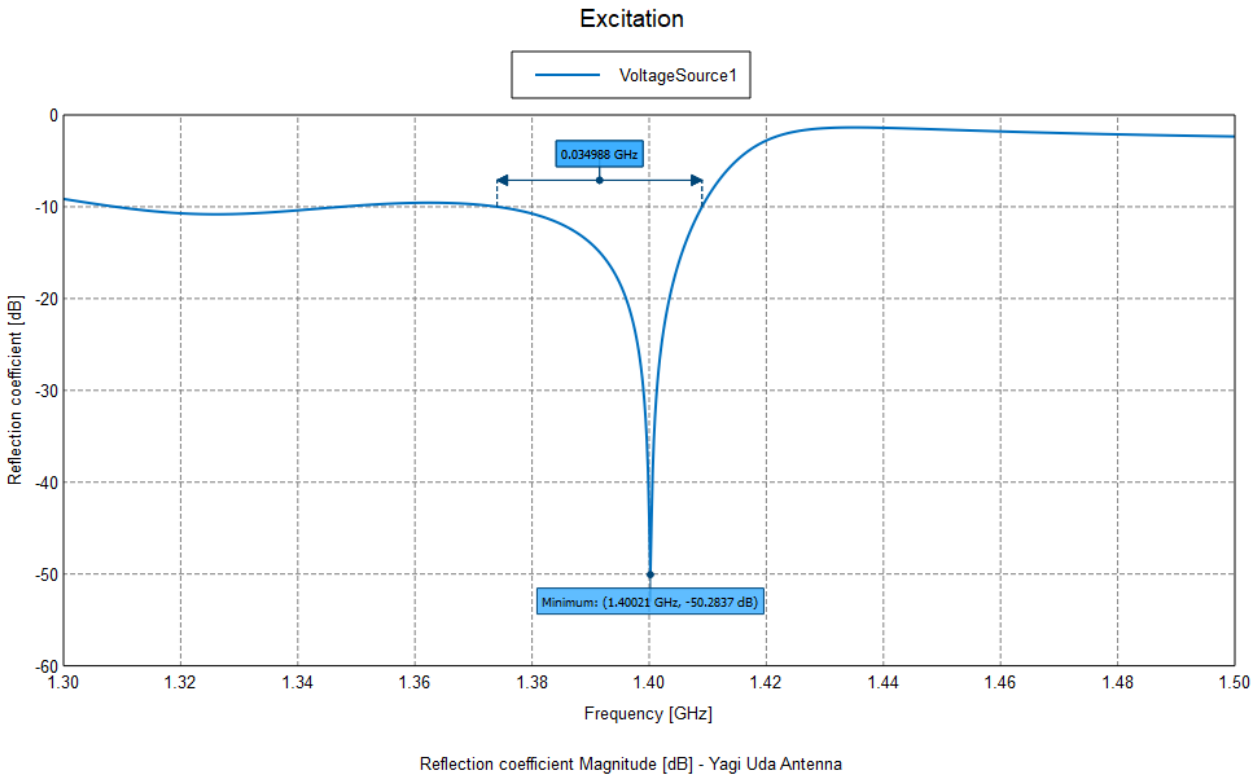

Fig 9: Frequency (GHz) vs Reflection coefficient (dB) graph for Yagi-Uda Antenna

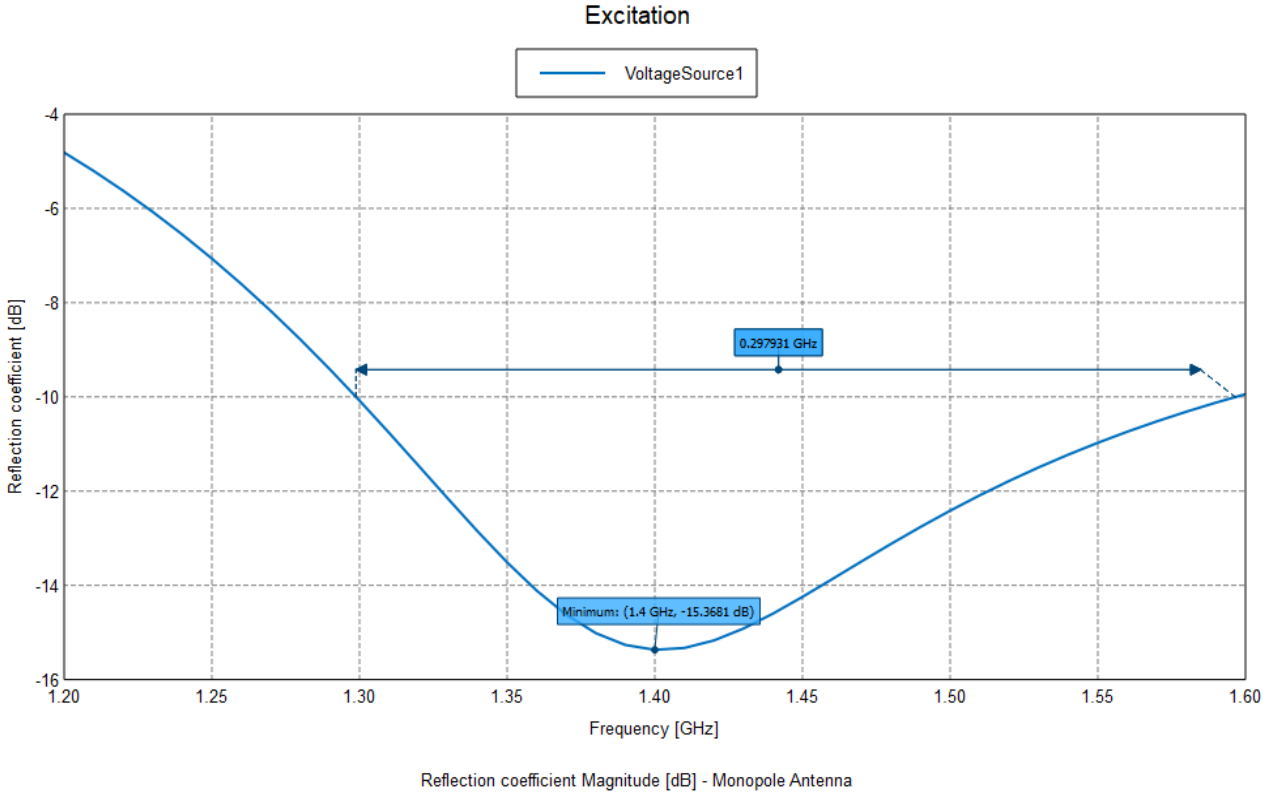

Fig10: Frequency (GHz) vs Reflection coefficient (dB) graph for Monopole Antenna

From figure 9 and figure 10, we can observe that the return loss for Yagi-Uda antenna is -50.2837 dB and the return loss for monopole antenna is - 15.3681 dB.

Bandwidth Comparison

The 10 dB bandwidth of Yagi-Uda antenna is found to be 0.034988 GHz and the 10 dB bandwidth of the monopole antenna is found to be 0.297931 GHz. The bandwidth of the monopole antenna is higher when compared to the bandwidth of the Yagi-Uda antenna. (From Fig.9 and Fig.10)

Polar plot Comparison

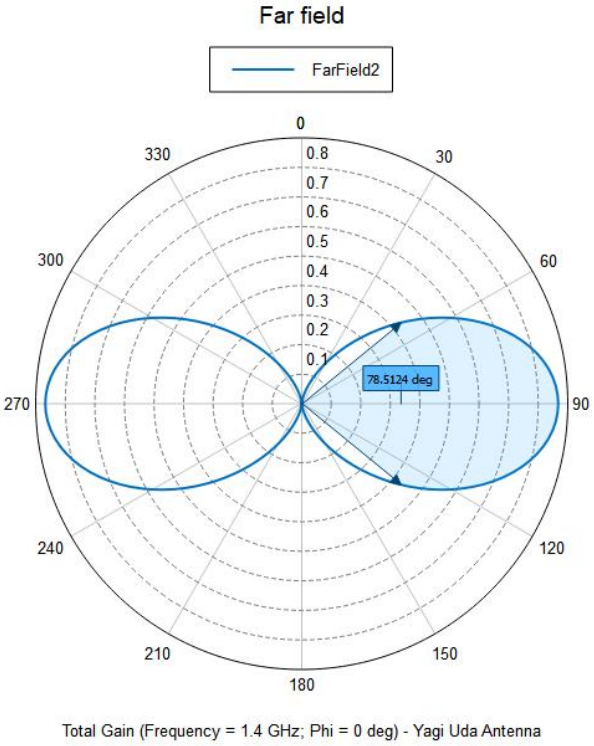

Fig11: Polar plot of Yagi-Uda antenna (Beamwidth = 78.5124°)

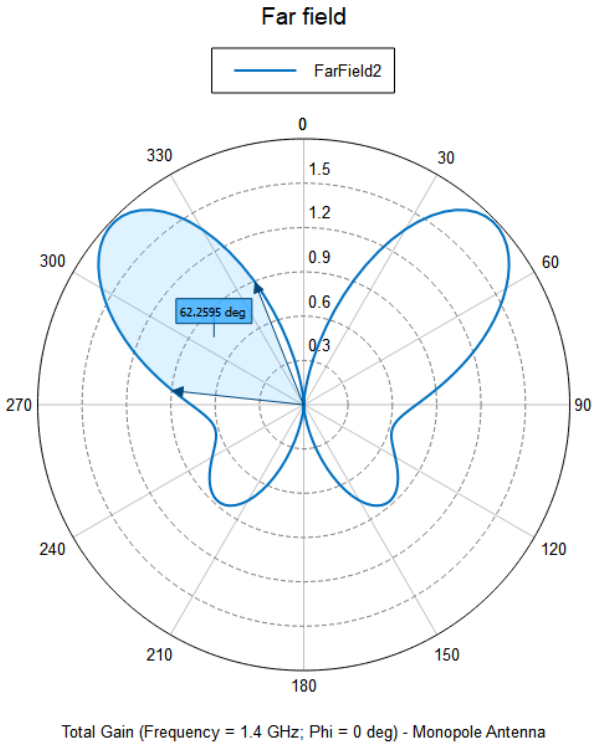

Fig12: Polar plot of Monopole antenna (Beamwidth = 62.2595°)

Smith chart Comparison

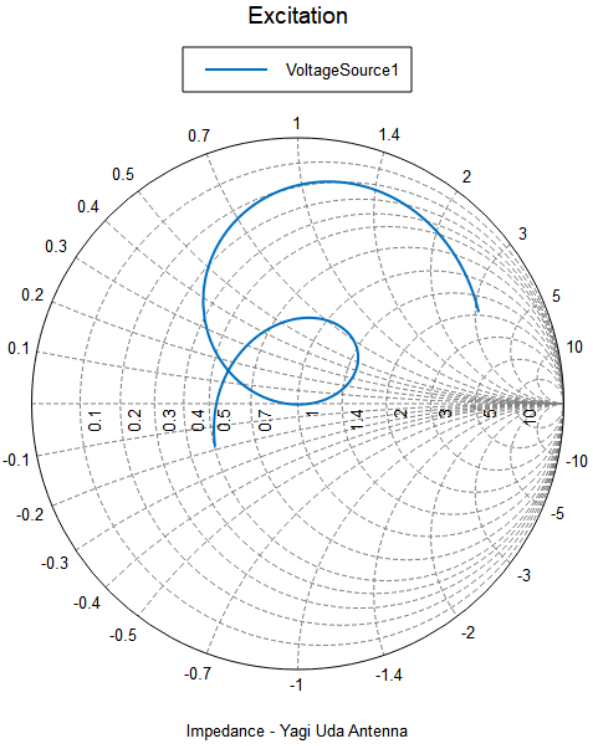

Fig13: The smith chart representation of Yagi-Uda antenna impedance

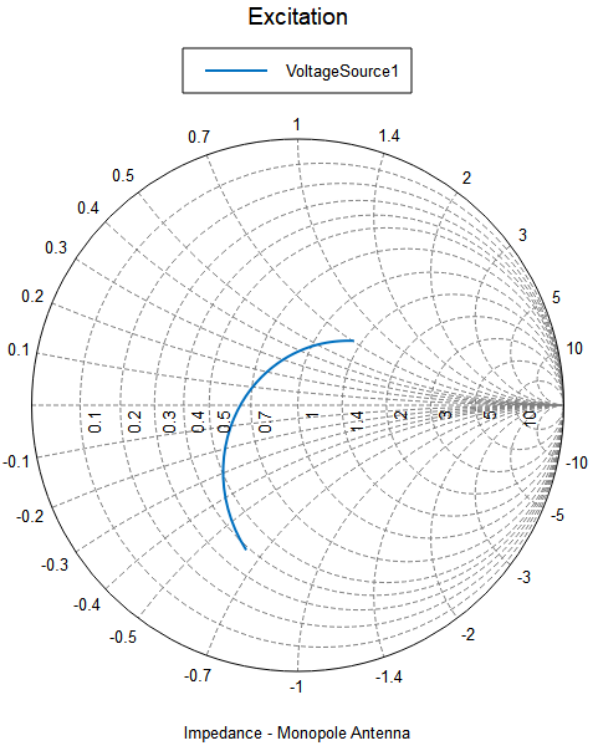

Fig14: The smith chart representation of Monopole antenna impedance

VSWR COMPARISON

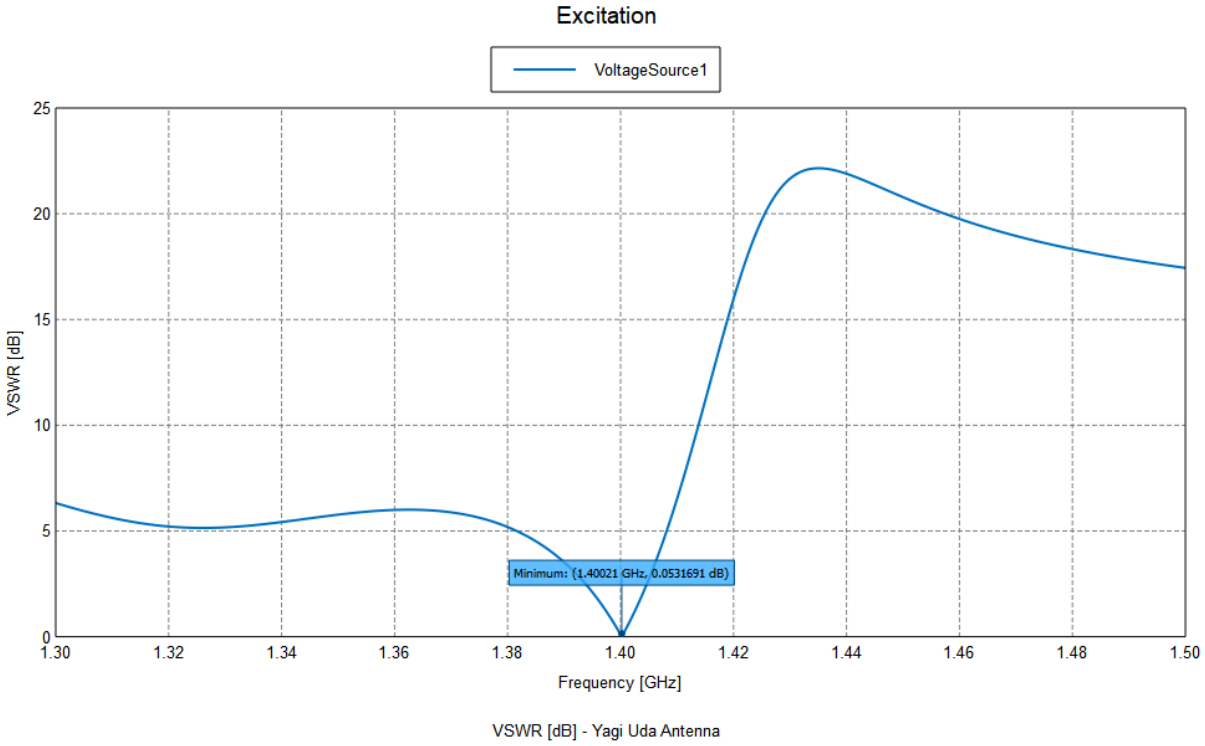

Fig15: Frequency (GHz) vs VSWR (dB) comparison of Yagi-Uda antenna

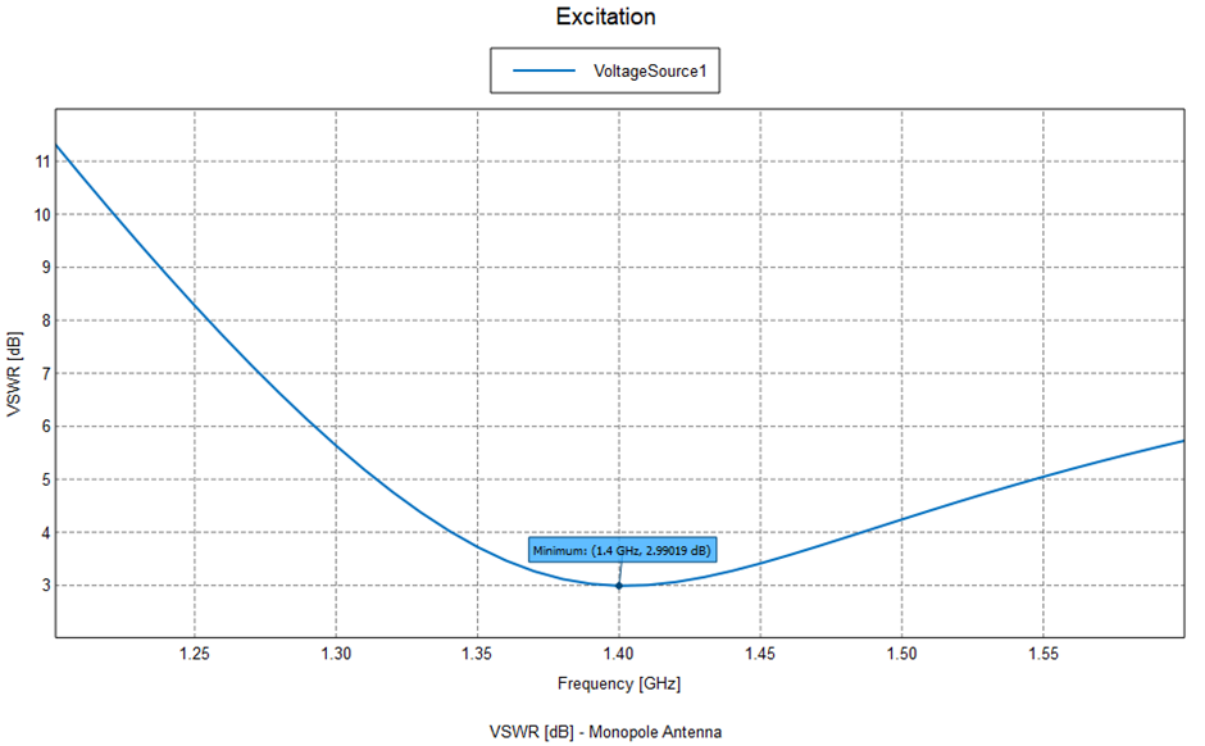

Fig16: Frequency (GHz) vs VSWR (dB) comparison of Monopole antenna

The VSWR of Yagi-Uda antenna came out to be 0.0531691 dB at 1.4 GHz which is in the range of below 5 dB of being a good antenna.

For monopole antenna, VSWR came out to be 2.99019 dB at 1.4 GHZ, thus both values are considered good for fabrication of the antennas.