High Gain Yagi-Uda Antenna for High Data Rate Communication System

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Abstract — **This paper presents a high gain yagi-uda antenna for high data rate communication system. The design has been simulated at frequency of 5.2 GHz by using HFSS simulation software. FR-4 substrate material with dielectric constant of 4.4 and height of 1.6 mm is being used to design the antenna. It achieves high gain with wide bandwidth.**

Keywords— Yagi-Uda antenna, Reflector, Director, Driven dipole, FR-4, HFSS

I. INTRODUCTION

In 1927 and 1928 ShintaroUda and Hidetsugu Yagi were discovered an antenna which is known as Yagi Uda antenna [1]. It consists of driven dipole (Driven Element) and a set of parasitic elements (reflector and one and more directors) are arranged on the same substrate [2]. Yagi Uda antenna is widely used owing to various advantages like ease of fabrication, low cost, high gain, simple structure etc. The growth in communication system requires a directional beam antenna for many such applications radar, medical, industrial and wireless communication and yagi-uda antenna is used for above application because it is a uni-directional antenna which means that it radiates greater power in one direction consequently reducing the interference from all other sources. In order to enhance the antenna characteristics the driven element, reflector and parasitic element of yagi-uda antenna are arranged on the same substrate.

Grajek et al. designed a Yagi-Uda antenna which achieved a directivity of 9.3 dB at 24 GHz [3]. Zheng et al. presented a Yagi-Uda antenna with one director, a truncated ground plane acting as a reflector and with a simplified feeding structure [4]. Kaneda et al. presented a microstrip-fed Quasi-Yagi antenna with a moderate gain of 3–5 dB at X-band [5]. H. K. Kan et al. presented a coplanar waveguide-fed Quasi-Yagi antenna at X-band [6].

In this project, Yagi-Uda antenna is designed at 5.2 GHz to achieves high gain and low backside radiations, which is used in recent WLAN and is being considered for next generation mobile network (NGMN) applications. The structure consists of driven dipole, director and a truncated ground plane act as a reflector, thus eliminating the need of reflector, which are placed on the FR4 substrate with dielectric constant (ε_r) of 4.4 and substrate height (h) of 1.6 mm and connector with characteristics impedance of 50 Ω is used for providing the excitation to driven dipole of antenna.

II. DESIGN EQUATIONS

The general rules of design for a Yagi Uda antenna operating at 5.2 GHz is given by

$$\text{Reflector Length} = .475\, \lambda / \sqrt{\epsilon_r} \quad (1)$$

$$\text{Active Element Length} = 0.46\, \lambda / \sqrt{\epsilon_r} \quad (2)$$

$$\text{Director Length} = 0.44\, \lambda / \sqrt{\epsilon_r} \quad (3)$$

$$\text{Spacing between elements, } d = 0.31\, \lambda / \sqrt{\epsilon_r} \quad (4)$$

And $\lambda = c/f$

Where λ is the wavelength in meters, c is the velocity of light in free space (3x108m/s), f is the operating frequency in GHz.

III. ANTENNA GEOMETRY

The design of the proposed antenna is shows in Fig. 1. As can be seen from the figure, the Yagi-Uda antenna was built on a FR4 substrate (ε_r = 4.4) with the thickness of 1.6 mm. The design consists of one director element, a driven element and a ground plane acting as a reflector. Truncated ground plane is used to maximize the antenna gain, if truncated ground plane is not used then a power given to the driver dipole element will not radiate and return to the ground plane itself. The metallization is done on the bottom plane that will act as a truncated micro-strip ground plane, which serves as the reflector element for the antenna and the parasitic director elements is placed on the top plane simultaneously which directs the antenna propagation toward the end-fire direction, and acts as an impedance matching element. The driven dipole is built on both sides of the substrate and connector with characteristics impedance of 50 Ω is used for providing the excitation to driven dipole of antenna.

It was noticed that the use of second director does not give the appreciable increment of gain, but leads to increase the size of antenna only.

To enhance the gain of antenna coupling structures are placed between the reflector and the driven element. The Yagi-Uda antenna is one of the most popular endfire antennas but the microstrip structure usually radiates in all the direction that's why a metal plate is placed at a distance of 15 mm to reflect the power back to the dipole. So that maximum radiation takes place in endfire direction.

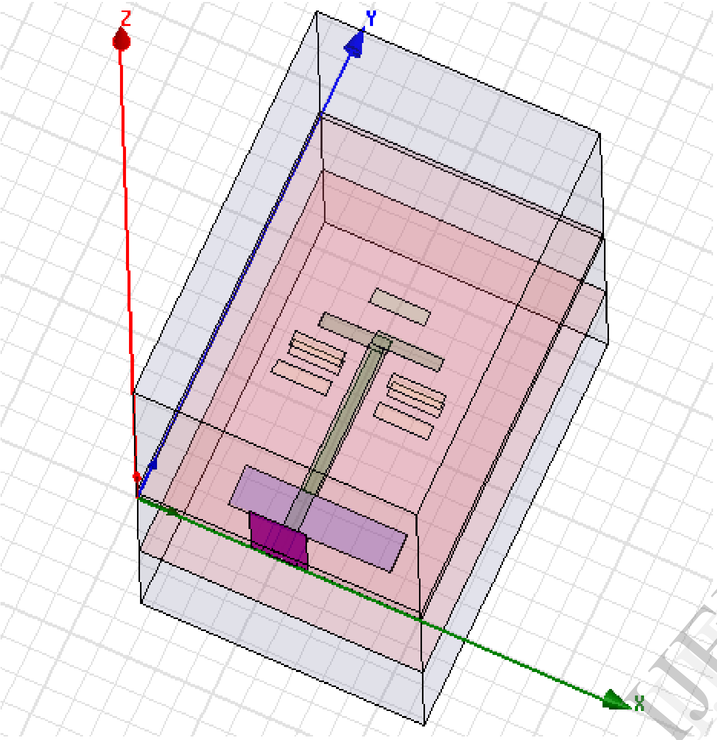

Fig. 1: Geometry of proposed Yagi-Uda antenna

IV. SIMULATIONS AND RESULTS

The proposed antenna is simulated using HFSS simulation software and various parameters such as Bandwidth, Return loss, VSWR, Gain, Directivity and Radiation efficiency are observed.

Fig. 2 shows gain of 7.05 dB (9.19 dBi) of the Yagi Uda antenna at 5.2 GHz. Antenna gain is the ability of an antenna to direct radiations in a particular direction.

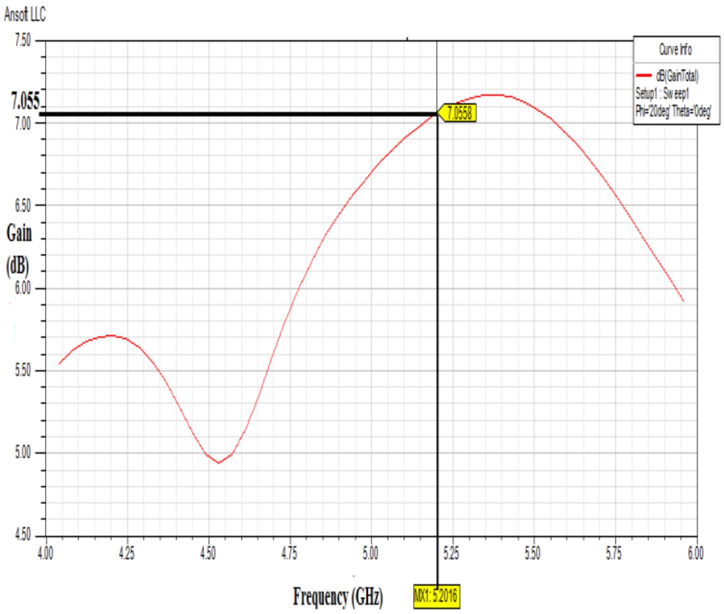

Fig. 2: Measured and Simulated gain of proposed Yagi-Uda antenna.

Fig. 3 shows the return loss and bandwidth of the Yagi Uda antenna that operates at a frequency of 5.2 GHZ. The simulated yagi uda antenna has wide bandwidth of 1.8 GHz with return loss of <-10 dB.

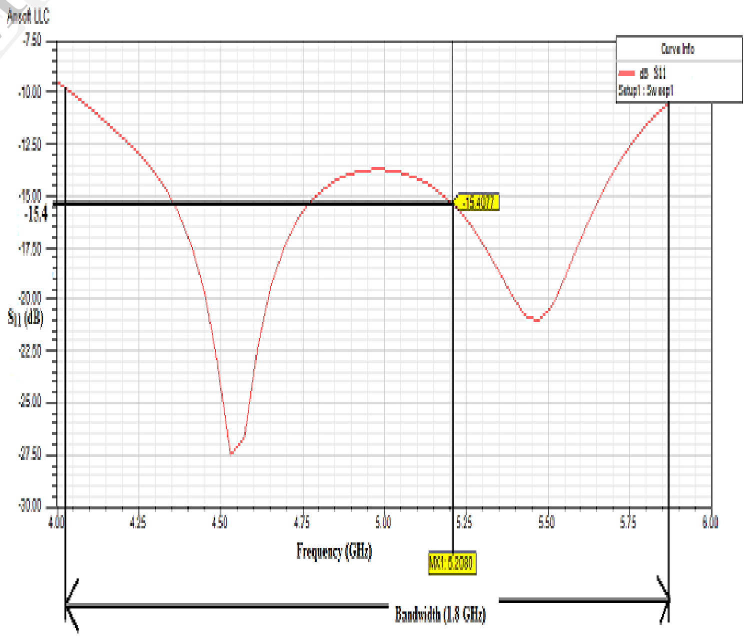

Fig. 3: Measured and Simulated return loss and bandwidth of proposed Yagi-Uda antenna

Table 1.1 enlists all the measured parameters of proposed design.

Table1.1: Analyzed Parameters

Parameters	Simulated value
Frequency	5.2 (GHz)
Return loss	-15.4 (dB)
Gain	9.19 (dBi)
Bandwidth	1800 MHz

V. CONCLUSION

A Yagi-Uda antenna has been successfully designed with one director, driven dipole and a reflector by using HFSS simulation software at 5.2 GHz. After simulating the design gain of 9.19 dBi, return loss of 15.4 dB with wide bandwidth (1.8 GHz) has been obtained. Thus, high gain and broad band antenna is suitable for WLAN, NGMN and high data-rate communication system applications.

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