A Literature Review on Yagi Uda Antenna: Old but Still used in Communities

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DOI: https://doi.org/10.51244/IJRSI.2025.120700051

Received: 12 June 2025; Revised: 25 June 2025; Accepted: 03 July 2025; Published: 31 July 2025

ABSTRACT

Antennas are the basic components of any communication system. They are connecting links between the transmitter and free space or free space and the receiver. There are different types of antennas. Yagi-Uda antenna is a kind of antenna that is widely used where specified gain and directivity are required. It is very easy to increase directivity in Yagi-Uda antenna. Recently Microstrip antennas can be configured in a Yagi-Uda configuration for low- angle satellite reception for mobile communications [3]. The electromagnetic energy is coupled from the driven patch to the parasitic patches not only through space but also by surface waves in the substrate in the microstrip Yagi array. The microstrip patches to function similarly to the Yagi dipoles, the adjacent patches need to be placed very closed to each other so that a significant coupling can be obtained through surface waves in the substrate. Although the configuration and coupling mechanism of the microstrip Yagi array and dipole Yagi antenna are different, the rules of these two types of Yagi-Uda are very similar. By increasing the thickness of the dielectric substrate between the radiator and the ground plane, bandwidth can be increased. Basic principle, characteristics and different works on Yagi-Uda antennas are discussed here with its potentiality.

Keywords: DBi, polarization, resonance, impedance matching, Yagi-Uda antenna, active element

INTRODUCTION

The Yagi-Uda antenna was invented in 1926 by Shintaro Uda with Hịdetsugu Yagi at Tohoku University, Sendai, Japan [4]. The main objective of designing this antenna is for cellular mobile communication. Wireless communication systems consist of antennas that convert the electronic signals into Electromagnetic waves. The selection, position and design of the antenna suite have a great impact on characteristics of the parent communication system. Frequency, aperture, polarization and radiation pattern are major criteria for classifying antennas. The Yagi-Uda antenna has directional characteristics. The Yagi-Uda antenna is widely popular for its exceptional performance in radio communications and TV reception since its inception continues to be a subject of enhancement by researchers aiming to refine its design for modern communication needs. This review penetrate wide innovations to fill up the ever changing demands of burgeoning 5G network. By miniaturizing the antenna's design and integrating driven elements, feeding networks and comprehensive impedance matching techniques, a single antenna can now adapt to numerous 5G bands.

John Huang proposed a new antenna structure. This structure is formed by combining the Yagi-Uda array concept and the microstrip radiator technique. This type of antenna is a low profile, low cost and mechanically steered medium-gain land-vehicle antenna. The microstrip Yagi-Uda array antenna has a single driven element patch, a single parasitic reflector patch and two or three director patches.

Evolution

One of the Key contributors to the growth of broadcasting technology was the development of Yagi-Uda antennas. The popularity of Yagi-Uda antenna design was increased in 1930s and 1990s (in the fields of radio and television broadcasting). Due to its simplicity and effectiveness along with the great gain it provided and its perfect directionality, this antenna become heart of the point-to point communication systems. Designers and

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VII July 2025

engineers have taken various efforts to enhance its working capacity, bandwidth and adaptability. For these changes done in Yagi-Uda antenna (by designers and engineers), these antennas can be utilized in various sectors of wireless communication systems like cellular networks, satellite communications and radar applications [7].

To increase the operational BW, wide band Yagi-Uda antennas have been developed by using tapered elements, additional director elements and multi-resonant driven elements. Tapered means diminish or reduce in thickness toward one direction. Adding amplifiers, phase shifters in conjunction with a Yagi-Uda antenna, we got 5G base stations and user equipment antenna systems that are compact [7]. By changing and modifying the usual Yagi-Uda antenna design it has become possible to use Yagi-Uda antenna in 5th generation and wireless market and the next generation communication networks.

With simplified manufacturing [1], a quasi-Yagi- Uda antenna with bi-band radiator, patterned ground and 3 radiator sets achieved 8.5 dB gain 24.25-28.5 GHZ and 8.2 dB in 47.2-48.2 GHZ, providing a practical 5G solution. Versatile Yagi-Uda antennas for 5G include a dual band microstrip quasi-Yagi with loop resonator and dipole. A quasi-Yagi antenna with dielectric lens achieved 15.5 dBi gain and 2 GHz bandwidth, increasing performance of 5G technology in a cost effective design [12]. Different a simulation software currently used.

Antenna Terminology

The performance of an antenna is characterized by different parameters. Depending on these parameters one can say which antenna is good for which application and not suitable for other application. Important antenna parameters are Grain, Radiation Pattern, Directivity, DBi and Polarization [4].

Gain

The gain of the antenna can be measured by measuring the concentration of the radiated power in a particular direction [11].

Radiation Pattern

The radiation pattern is graphical plot of the power or field strength radiated by the antenna in different angular direction [3]. The radiation pattern of the antenna is a very important property for an antenna because different antennas have different radiation pattern which means it radiates in different directions. For example in omnidirectional pattern the antenna radiates in all directions meanwhile the pencil beam pattern radiates in one direction [3]

Directivity

The directivity of the antenna is the ratio of the maximum radiation intensity to the average radiation intensity [9].

DBi

Decibels relative to isotropic (DBi) is a unit of measurement that describes how much power an antenna transmits in a single direction when compared to an isotropic radiator which transmits in all directions at once [10].

Other antenna terms that one should know in the research of antennas. These terms are discussed below.

Nul

The nul is the area within the antenna where the radiation pattern of transmitted signal or received signal is at zero strength [11].

Polarization:

Polarization of the wireless antenna is the orientation of the wireless signal with regard to its coverage both horizontally and vertically. Polarization can be vertical, horizontal, circular or combinations of these. The E-

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VII July 2025

plane and H- plane are reference planes for linearly polarized antenna. If the electric field of a wave is vertical , then it is called vertically polarized and if the electric field is horizontal then it is called horizontally polarized .The polarization of the transmitting antenna and receiving antenna should be the same.

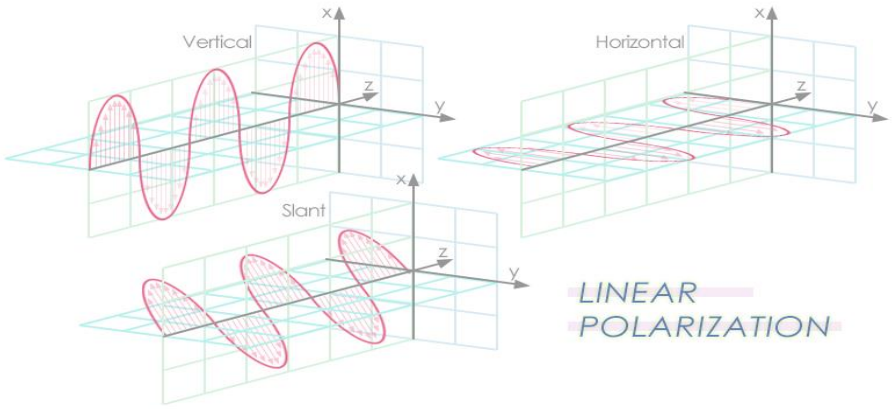


Figure 3.1- Linear polarization,

Resonance

The resonance is a certain frequency that makes oscillation occurring at higher amplitude than normal in the system

Antenna Array:

A group of radiating elements arranged to produce a particular radiation characterstic is called an antenna array [3]. By tuning the elements current of the array in the appropriate phases to improve the directional characterstics, the antenna array produces higher antenna gain so that the antenna radiates the signal in one direction or in the direction of interest [11].

STRUCTURE AND WORKING PRINCIPLE

Structure:

It consists of three parts: a driven element, a reflector element and one or more director elements. The reflector element & director elements are called passive elements. The driven element is a part where power supply is provided The driven element can be dipole or folded dipole. The driven element is called active element.

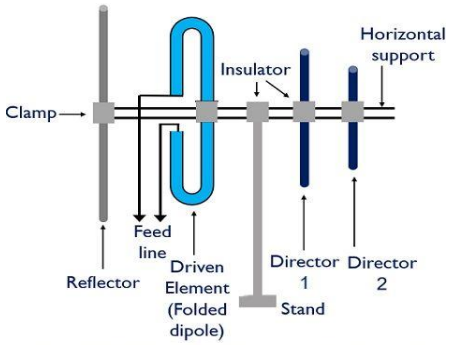


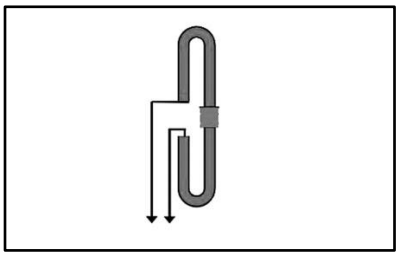
Figure-4.1 Basic Structure of Yagi-Uda Antenna

Radiation

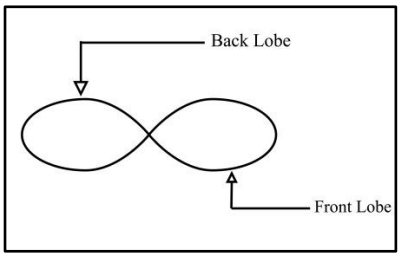
The antenna is functioning based on two principles: one is based on reflection and another is based on direction. Since reflection is based on impedance mismatched. Here with reflector element impedance mismatch is

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VII July 2025

provided so that the incoming signals get reflected toward the front direction. Director elements are kept impedance matched. So this antenna can radiate higher power in front direction. Impedance matching is a process in which the impedance of the load is matched with the impedance of the source so that maximum power is transferred to the load. In simple folded dipole antenna the radiation pattern will be given as fig - 3·2.



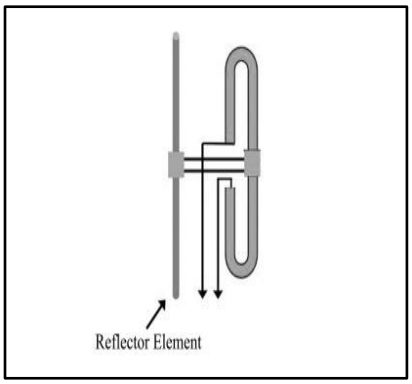
Dipole Antenna



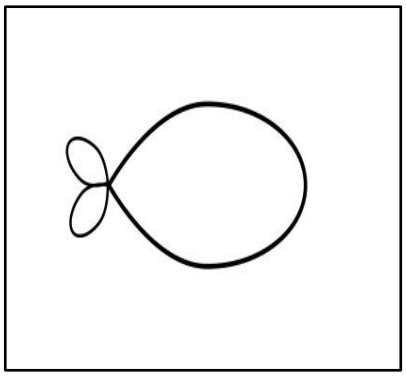
Radiation Pattern

Figure-4.2: Dipole antenna and its radiation pattern

If we connect a reflector element towards the back side, then the reflector element will reflect power in front direction. Because of reflector element, whatever power going backside is got reflected towards front direction. So radiation towards front side will be increased as shown in fig-3.3. Towards backside, we have minor lobes. Now it is found that in front direction higher power is going. Back lobe is reduced due to the reflector element.



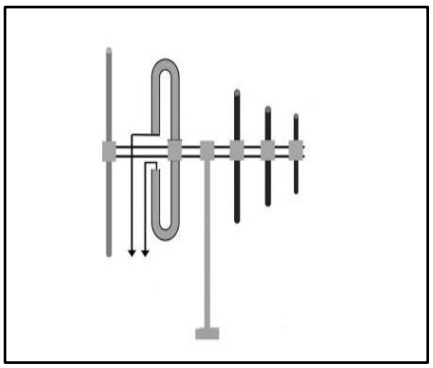
Dipole with reflector element



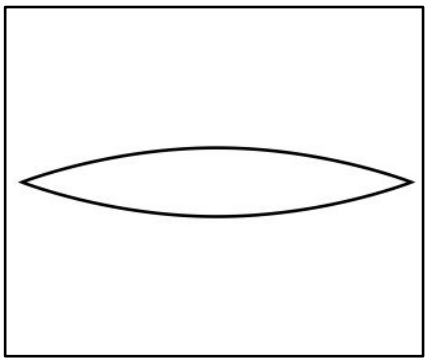
Radiation Pattern

Fig-4.3: Dipole antenna with reflector element and its radiation pattern

The director elements increased directivity of the front lobe. So increasing the number of director elements, we can increase directionality.



Dipole with a reflector and 3 director element



Sharp front lobe due more director element

Fig-4.4: Dipole antenna with reflector and directors and its radiation pattern

In majority cases, the spacing between the reflector element and driven element is kept 0.25 lamda.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue VII July 2025

Potentiality Of Yagi-Uda Antenna

The specialty of Yagi-Uda antenna is that the directivity can be controlled by changing director elements (parasitic elements). Using reflector element in backside, back lobe radiation can be stopped. In addition, it offers very high gain and it shows suitability towards high frequency operations. It is low cost, light weight and feeding mechanism is simple. Furthermore, it is power efficient and offers ease of construction and handling. The Yagi antenna can be used as both transmitter as well as receiver.

CONCLUSION

For flexibility in design and nice directionality controlling power of Yagi-Uda antenna, it has become a potential candidate for 5G technology. Due to huge advantages and applications of Yagi-Uda antenna, many researches and studies have been conducted on it. This paper put forward a review on potentiality of Yagi-Uda antenna. Study on the evolution of it's design has become remarkable, maintaining pace with the ever-advancing field of wireless communication. More researches on Yagi-Uda antenna can be done by changing the dielectric materials in between parasitic elements and by changing the materials of the parasitic elements.

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