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Planar Printed Quasi-Yagi Antenna- A Study

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ABSTRACT: In wireless communication, antenna plays an important role in deciding the quality and overall performance of the device over different communication standards. The need for low-profile and wideband unidirectional antennas with superior electrical characteristics is ever demanding. One of such antenna is quasi-Yagi antenna. In this paper, the various researches and studies in quasi-Yagi antenna is reviewed. Many methods to improve the bandwidth and gain are also discussed. The highlights and limitations of these methods are noted to guide the antenna designers.

KEYWORDS: Quasi-Yagi antenna, Low profile, Bandwidth enhancement, Gain enhancement.

I. INTRODUCTION

Antenna is one of the most critical elements in all wireless communication system. Generally, an antenna behaves as a transducer between the free space and guided wave. Antennas in the modern wireless communication require careful design and thorough knowledge of the concepts involved. The choice of an antenna normally depends on many factors such as gain, bandwidth, directivity, etc. Most of the current wireless networks assume the use of omnidirectional antennas in each of their nodes. Nevertheless, a particular topology case can suggest the use of a directional antenna. For example, end access node or a far access node in a point-to-point or point-to-multi-point radio-link in a wireless sensor network. In such cases, the electrical characteristics of the directional antenna should match those of its omnidirectional counterpart [1], while enhancing the radiating properties. Also directional antennas have been used to suppress unwanted radio frequency emissions as well as interference in other directions.

The Yagi antennas are widely used to achieve high gain in a very simple structure. Since 1928, when Yagi described for the first time in English language the antenna with his name [2]. With the advantages of simple fabrication, easy feeding, good directivity and high gain performance Yagi antenna has found many applications in military and civilian use. However, typical Yagi antenna has the disadvantages of relative large size, narrow band (<5%) character and tuning difficulty. Therefore, the applications of this antenna were limited [3]. Researchers are made great effort to overcome these disadvantages and apply the Yagi-Uda antenna concepts in microwave area. As a result, a new antenna structure is formed by combining the microstrip radiator technique and the Yagi-Uda array concept [4]. Since the microstrip-fed quasi-Yagi antenna was first introduced by Huang in 1991, the planar printed quasi-Yagi antenna has attracted much attention for using in microwave and millimeter wave application because of the advantages such as low profile, light weight, ease of fabrication and installation, high directivity, high radiation efficiency etc.

An ideal planar antenna should have some characteristics like

- Good radiation characteristics such as well defined pattern, good front to back ratio and low cross polarization;
- Wide frequency bandwidth;
- Small as possible to easy integration with microwave integrated circuits;
- Simple and low cost fabrication.

The planar printed quasi-Yagi antenna has almost all these characteristics. However the bandwidth of conventional quasi-Yagi antenna is narrow. To overcome this limitation, various methods are proposed in literature and now very good bandwidth is achieved. Another limitation of Quasi-Yagi antenna is it can’t provide a high gain owned by Yagi-Uda antenna. Various methods to enhance the gain of the Quasi-Yagi antenna are also highlighted in literature.

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The remainder of this paper is organized as follows. In section II, the related works are grouped. Section III discusses the basic structure of Quasi-Yagi antenna and comparison with classic Yagi-Uda antenna. The techniques to enhance the bandwidth are presented in Section IV, which is followed in Section V by a discussion of various methods of gain enhancement. Finally, section VI presents our conclusions.

II. RELATED WORK

Yagi-Uda antennas and its variations are interesting topics for researchers since 1928, when the concept of Yagi-Uda antenna was described in English language [2]. Recent works in Yagi related antennas are concentrated mainly on the planar printed quasi-Yagi antenna. By combining the concept of microstrip antenna and Yagi-Uda antenna, J. Huang et al proposed a new antenna structure for mobile satellite vehicle applications in 1991 [4]. After this, many studies and researches are carried out by various researchers on Quasi-Yagi antennas. The present research works are mainly focused in the following areas:

- Study of various characteristics of quasi-Yagi antennas [5],
- Study of performance of quasi-Yagi antennas for different applications
- Size and complexity reduction [16],
- Bandwidth enhancement [8]-[20],
- Gain enhancement [21]-[25]
- Performance of quasi-Yagi antenna as an array element [26], [27].

This paper goes on brief discussions of major findings in some of the above mentioned areas.

III. PRINTED PLANAR QUASI YAGI ANTENNA

The classic Yagi-Uda antenna is a popular and widely used antenna since its origin. It is because of its simplicity, low coast, directional radiation pattern and relatively high gain. The antenna consists of linear array of parallel dipoles forming a parasitically coupled array as shown in figure 1.

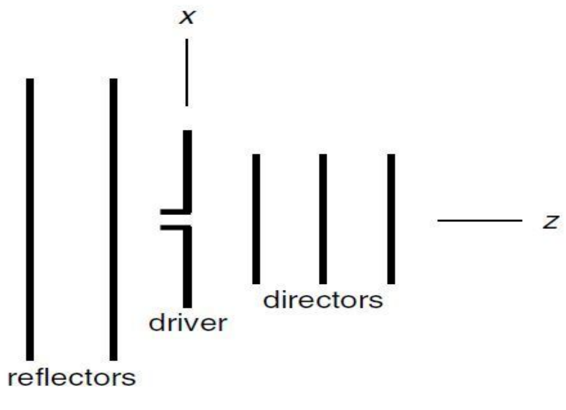

Fig. 1 Layout of classic Yagi-Uda antenna.

The classic Yagi-Uda antenna array consists of three main components, namely a driven element, reflector element and one or more parasitic director elements. The driven element is used to execute the array structure. The field radiated by driven element is reflected by the long reflector element positioned at the reverse endfire direction. The parasitic director elements serve to improve further the radiation in the endfire direction. The basics design parameters are the length of driven element (0.45λ – 0.49λ), the length of directors (0.4λ - 0.45λ) and the separation between directors (0.3λ – 0.4λ).The length of the directors and the separation between the directors need not be uniform. The length of the reflector should be greater than that of driver.

In 1991, John Huang proposed a microstrip fed quasi-Yagi antenna for low angle satellite reception for mobile vehicle applications [4].The planar printed quasi-Yagi antennas have some similarities in operation and configuration with

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classic Yagi-Uda antenna. However certain difference between the Yagi-Uda and quasi-Yagi also exist. Hence the name ‘quasi-Yagi’ comes [6].

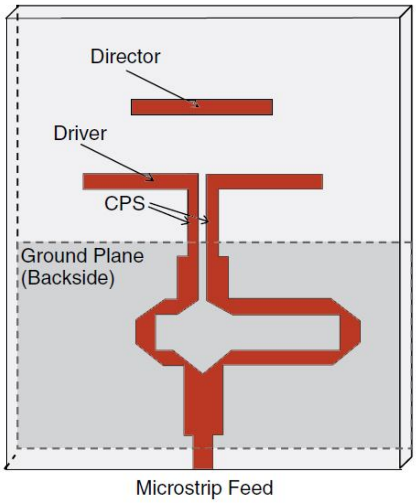

Fig. 2. Schematic of quasi-Yagi antenna [7].

The figure 2 shows the structure of a microstrip-fed quasi-Yagi antenna [7].We can see the similarities and differences of the quasi-Yagi (figure 2) with the classic Yagi-Uda antenna (figure 1).In quasi-Yagi, the driver dipole and director dipole can be easily identified and the ground plane acts as a reflector element.

IV. BANDWIDTH ENHANCEMENT OF QUASI-YAGI ANTENNA

As we know that the bandwidth is a very important factor and modern communication systems require higher bandwidth. So researchers take the bandwidth enhancement as a hot topic and many works are reported in literature. The simplest technique of bandwidth enhancement is to increase the distance between the ground plane and radiator [8]. But it will increase substrate thickness. From the literature it is clear that the main limiting factor of bandwidth of quasi-Yagi antenna is its feed. So many attempts are reported [9]-[15] in which the feed structure and feeding method is modified. A printed quasi-Yagi antenna with microstrip-to-slotline transition structure [9] was presented. By using this, a fractional bandwidth of approximately 46% was achieved. But the antenna has a large ground plane, which increases the overall antenna size. A broadband microstrip-to-coplanar stripline transition structures (CPS) is used to enhance the impedance bandwidth of the quasi-Yagi antenna in [10] and [11]. Approximately 38.3% and 48% bandwidth were achieved respectively. However the delay line used in the balun structures still restrict the antennas bandwidth. Ultra wideband balun or coplanar waveguide feeding were presented to enhance the bandwidth in some papers [12], [13]. A wide bandwidth of 44% was obtained in [13]. However, the unidirectional radiation patterns are affected by the asymmetric nature of the quasi-Yagi antenna. Some other feeding techniques are also used to enhance bandwidth, like CPS feeding [14] and slot feeding structure [15]. The maximum fractional bandwidth achieved by these techniques is about 55%. A recently developed quasi-Yagi antenna with microstripline to slot line transition structure and modifications in ground plane achieves an approximate fractional bandwidth of 100% and a size reduction of around 16% [16].

Almost all the techniques discussed above utilize the property of different feeding structures and methods to enhance the bandwidth. Some methods in which the bandwidth is enhanced by the modifications in the driven element are also in literature. The use of folded dipole driven element is significantly increase the impedance matching [17], [18]. Another method is to modify the driven element to a bowtie driver or tapered driver, which will also improve the bandwidth [19]-[20]. But in these cases the antenna size is still larger and sometimes the structure was complex.

V. GAIN ENHANCEMENT OF THE QUASI YAGI ANTENNA

We know that the conventional Yagi-Uda antennas provide high gain in a very simple structure. The gain of the planar printed quasi-Yagi antenna is moderate or low when compared to gain owing by the Yagi-Uda and in many cases the high gain antennas are required. So the gain enhancement of the printed quasi-Yagi antenna is an interesting topic among researchers. The gain of the antenna can be increased by adding more director element, but it will reduce the bandwidth. Many gain enhancement techniques are described in literature. The gain of the antenna is significantly improved by rotating the driver and parasitic strips in [21]. But due to the grating lob occur at high frequencies, only moderate gain is achieved in high frequencies. In [22], different strip widths and spacing between the elements are used to enhance the gain and bandwidth. A vertically stacked structure is used in [23], in which the patches slit with slots act as the parasitic and driving elements instead of dipoles. This method also improves gain but the antenna volume is also increased. It is clear that the method, in which each director is divided into two and arrange symmetrically on both sides of the dielectric substrate is also increases the gain [24]. Another method is by using zero index metamaterials [25]. The paper shows the antenna gain increases for a frequency range over the metamaterial shows the zero index metamaterial property. By using this method only the gain of a particular frequency band will enhanced.

There are many methods in literature to enhance the gain of quasi-Yagi antenna. In some methods, the increase in gain will be small whereas in some other methods it will be high. Some methods increase the antenna size while some other methods enhance the gain without increase the antenna size.

VI.CONCLUSION

In this paper, we have attempted to do an intensive survey of the works done by various researchers on quasi-Yagi antenna. In this review, structures of classic Yagi-Uda antenna and quasi-Yagi antenna have been discussed. The planar printed quasi-Yagi antenna has attracted much attention for using in microwave and millimeter wave application because of the advantages such as low profile, light weight, ease of fabrication and installation, high directivity, high radiation efficiency etc. many methods to enhance the bandwidth and gain of the quasi-Yagi antenna also discussed. More research works are needed to explore full potential of the quasi-Yagi antenna and we expect it to have a good future in almost all wireless communication systems, especially in phased arrays and power combining systems.

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