Parametric Study of Wideband Planar Printed Quasi-Yagi Antenna

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Abstract – The revolution in the field of wireless communication systems have necessitated the development of compact wideband antennas with good electrical characteristics. The advantages such as low profile, wide bandwidth, high directivity and stable radiation patterns, Quasi Yagi antennas are considered as one of the promising solutions for the urgent need. In this paper, a parametric study of wideband planar printed Quasi-Yagi antenna is performed. A 3D full wave electromagnetic simulation is applied to study the parameters which affect the performance of the Quasi-Yagi antenna. Optimum design considerations are obtained to get wide bandwidth with moderate gain.

Index Terms – Quasi-Yagi antenna, parametric analysis, Wide band width, planar antenna.

1. INTRODUCTION

With the fast development of wireless communication systems, the requirement for wideband and low profile antennas with good electrical characteristics is steadily increasing [1], [2]. More and more multiple high speed wireless applications are integrated to small terminals day by day, which also increase the demand for compact wide band antennas provide stable radiation pattern throughout the wide bandwidth [3]. In some cases, for example, high-speed point-to-point data communication systems and wireless local networks, antennas with low profile, stable unidirectional radiation patterns, small size and high gain are urgently needed.

The Yagi antennas are widely used to achieve unidirectional radiation pattern and high gain in a very simple structure, Since Yagi described for the first time in English language the antenna with his name [4]. Planar printed Quasi-Yagi antenna is a new antenna structure, which is formed by combining the microstrip radiator technique and the Yagi-Uda array concept [5]. Since the microstrip-fed quasi-Yagi antenna was first introduced by Huang in 1991, the 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, high directivity, high radiation efficiency, ease of fabrication and installation, etc.

The conventional planar printed Quasi-Yagi antenna has narrow bandwidth. To overcome this narrow bandwidth problem, various methods are proposed in literature and now, wide bandwidth is attained. A planar Quasi-Yagi antenna with microstrip-to-slotline transition structure was presented in [6]. By using this method, bandwidth of approximately 46% was achieved. But the large ground plane increases the overall antenna size. A broadband microstrip-to-coplanar stripline transition structures (CPS) is used to enhance the bandwidth of the Planar Quasi-Yagi antenna in [7]. Approximately 48% bandwidth is achieved. A recently developed planar printed quasi-Yagi antenna with microstrip line to slot line transition structure achieves an approximate fractional bandwidth of 100% [8].

Antenna characteristics of quasi-Yagi antennas are sensitive to many parameters. It is very important to understand such parameters and their effects in performance of an antenna, for proper design. There are some parametric studies of quasi-Yagi antennas in literature [9].This paper investigates the effects of five main design parameters of the planar printed Quasi-Yagi antenna on its impedance bandwidth, operational frequency and gain. They parameters considered in this paper are

1. The arm length of the driver dipole
2. The arm length of the directors
3. The distance between the striplines of the CPS
4. The length of the stub extended from its ground plane
5. The distance between the driver and director.

The study identifies the effects of each parameter on the performance of quasi-Yagi antenna. The presented findings should be of interest to the quasi-Yagi antenna designers for applications such as a phased array, spatial power combining and other wireless communications applications.

The remainder of this paper is organized as follows. In section 2, the selected configuration of antenna for the parametric study is described. Section 3 discuss the effects of each parameter on the performance of wide band quasi-Yagi antenna with the help of simulation study and finally, section 4 presents our conclusions.

2. ANTENNA CONFIGURATION

The configuration of the antenna used for the simulation study is almost same as that of the Quasi-Yagi antenna in [8]. Small changes in the dimensions and step like structure in the feed are made for better impedance matching. The structure of the Quasi-Yagi antenna for parametric study is shown in figure 1 and the dimensions are shown in table 1.

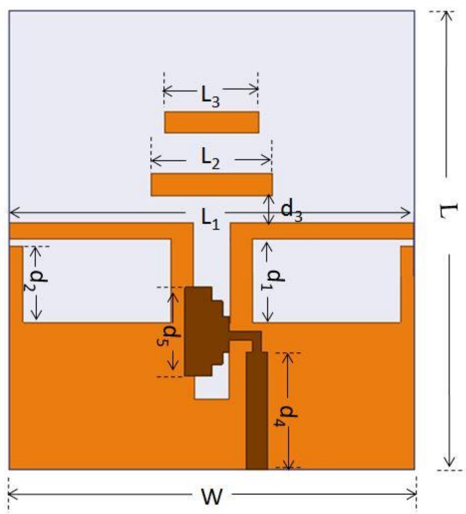

Figure 1: Structure of the Quasi-Yagi antenna under study

Parameter	Dimensions(mm)	parameter	Dimensions(mm)
L	34	d_1	6.2
W	30	d_2	5.6
L_1	30	d_3	2
L_2	9	d_4	8.7
L_3	7	d_5	6.6

Table 1: Dimensions of the antenna

We selected this Quasi-Yagi structure for the parametric study is because of it achieves a wide bandwidth of 3.6GHz to 11.6GHz [8]. The antenna uses a microstrip line to slot line transition structure. By modification in the ground plane, the antenna achieves size reduction of around 16%.

3. PARAMETRIC STUDY

The procedures adopted for this study is varying only one parameter at a time while keeping all other parameters are same as that of reference antenna. The frequency range selected for the study is 2GHz to 13GHz which will cover UWB band completely and some other important bands also. All the simulations are done using Finite element method.

3.1 The arm length of driver dipole

The first parameter to study is the length of the driver dipole. Initially the total length of driver which is marked as L_1 is taken as 30 mm. For parametric analysis, the L_1 is varied from 24mm to 30mm with an increment of 2mm. The results show in terms of VSWR, S_{11} and Gain is shown in the figure 2 below.

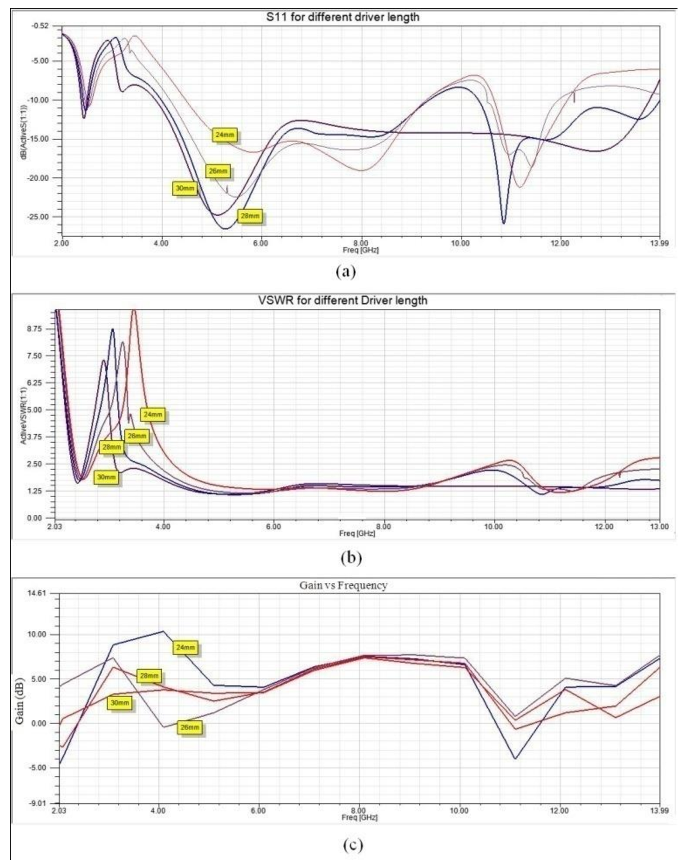

Figure 2: Variation of antenna characteristics for different length of driver dipole in terms of (a) S_{11} , (b) VSWR and (c) Gain

From the figure 2 (a) and (b), as the L_1 increases, the resonating frequency is decreases .The driver length 30mm gives maximum impedance matching because we designed, optimized the Quasi Yagi antenna with L_1 30mm .From the figure 2 (c), it is clear that the driver length slightly changes the gain of the antenna, especially in the lower frequencies and higher frequencies of the operational band.

3.2 Length of the director

The next parameter to investigate is the length of the director1 which is marked as the L_2 in the figure 1. Initially the length of the director1 is set to be 9mm. For study the effects of director length on the performance of the quasi-Yagi antenna, L_2 is varied from 7mm to 9mm with an increment of 1mm. The results in terms of S_{11}, VSWR and gain versus frequency are shown in figure 3 below.

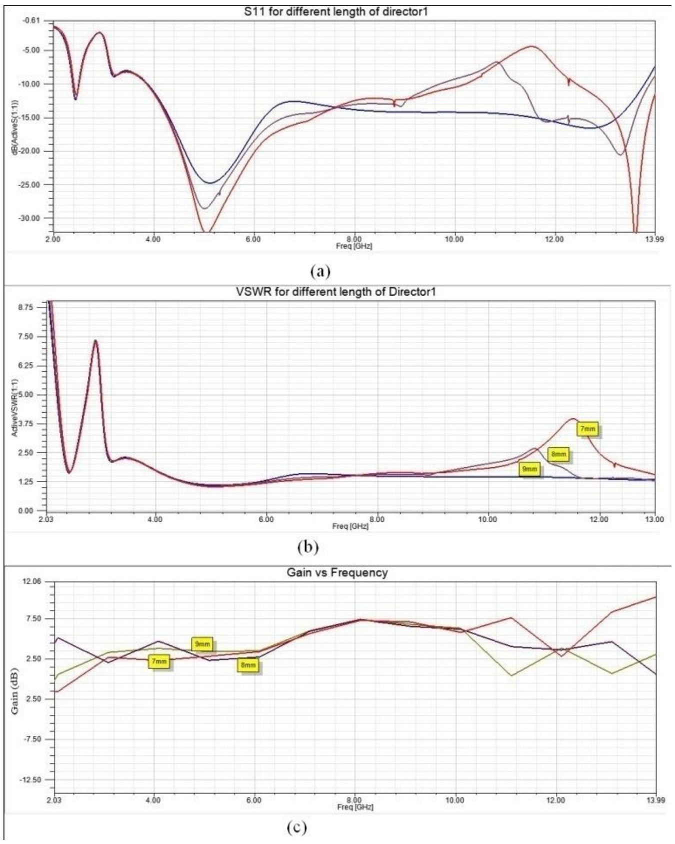

Figure 3: Variations of antenna characteristics for different length of director 1 in terms of (a) S_{11}, (b) VSWR and (c) Gain.

The figure 3 (a) shows the variation in the reflection coefficient of the antenna for different lengths of director1. From the results, it is clear that, the resonating frequency is not affected by the length of the director1. But in the case of wideband antenna, length of director is play an important role in impedance matching and hence in bandwidth of the antenna. From figure 3 (b), the best performance in terms of gain is provided by the L_2=8mm.

3.3 The distance between the striplines of the CPS

The third parameter to investigate is the distance between the strip lines of the coplanar stripline. The distance d_6 is varied from 1.8mm to 3.8mm with an increment of 1mm. The variations in S11, VSWR and gain of the antenna for different values of d_6 are shown in the figure 4 below.

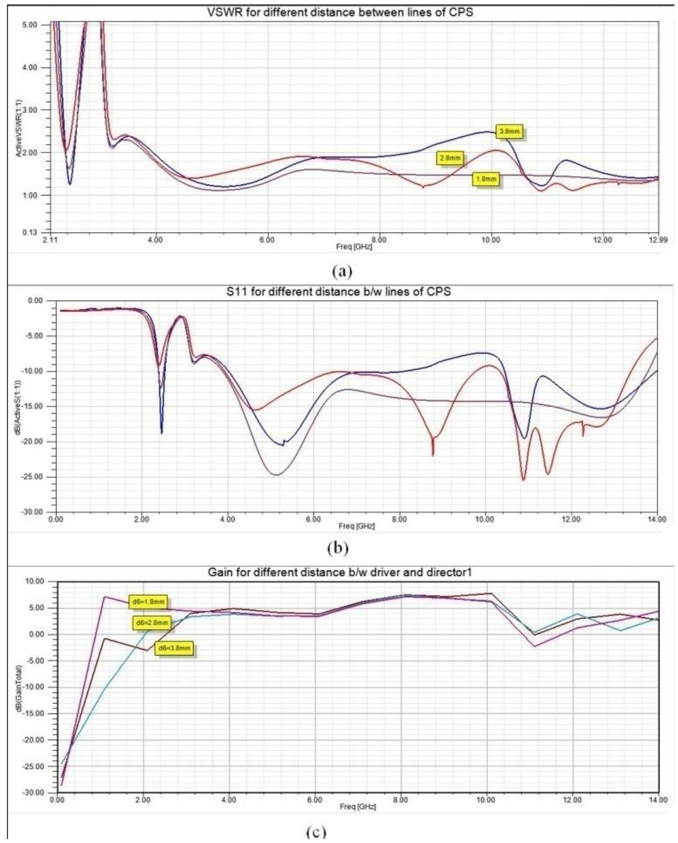

Figure 4: Variations of antenna characteristics for different values of d_6 in terms of (a) VSWR, (b) S_{11} and (c) Gain of the antenna

The simulation results shows that the distance between strip-lines of coplanar strip-line is only negligible effects in resonant frequency of the antenna and little effects in the gain of the antenna. But, by adjusting or tuning this distance, we can improve the impedance matching and hence increases the bandwidth of the quasi-Yagi antenna.

3.4 The length of the stub extended from the ground plane

The next parameter to investigate is the length of the stub extended from the ground plane which is marked as d_2 in the figure 3. The distance d_2 is varied from 4.5mm to 5.5mm with an increment of 0.5mm. The simulation results in terms of S_{11}, VSWR and gain of the antenna is shown in the figure 5.

The figure 5 (a) shows the variation in reflection coefficient of the antenna for various values of $d_{2.}$ The value 5.5mm gives good impedance matching and wide bandwidth. The effect of d_2 in resonant frequency of the antenna is not significant.

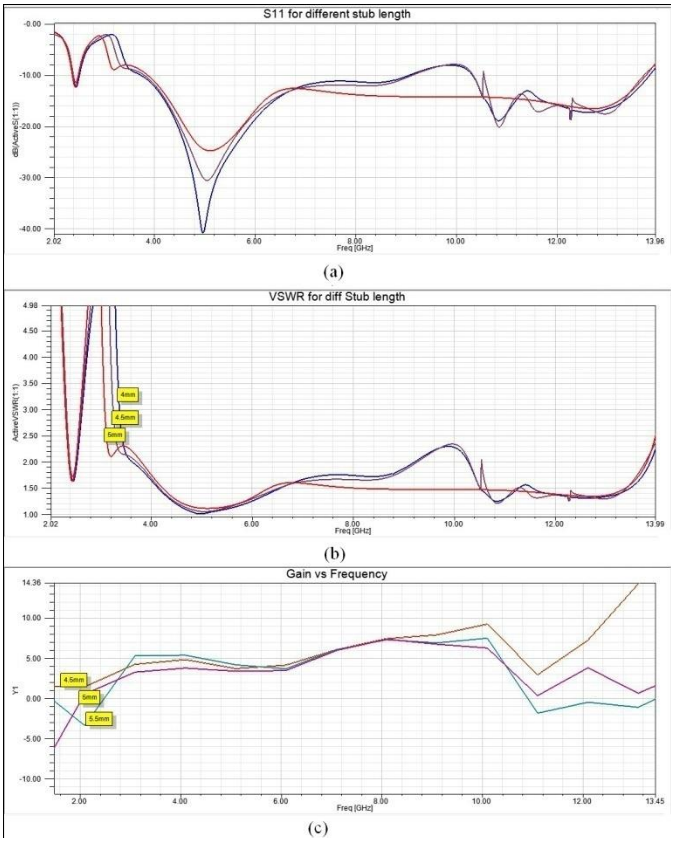

Figure 5: Variations of antenna characteristics for different values of d_2 in terms of (a) S_{11}, (b) VSWR and (c) Gain of the antenna

From the figure 5, it is clear that the stub length has significant effects on the gain of the antenna. From the graph, length 4.5mm gives best gain value, but 5.5mm gives best bandwidth

3.5 The distance between the driver and director

The last parameter to investigate is the distance between the driver and director and it is marked as d_3 in the figure 1. To study the effects of d_3 on the performance of the Quasi-Yagi antenna, the values of d_3 varied from 1mm to 3mm with an increment of 1mm. The results in terms of s11, VSWR and gain of the antenna are shown in figure 6.

The figure 6 (a) shows the variations in the S_{11} for different values of d_3. There is no significant effects are there in the resonating frequency of the antenna. But the bandwidth is improved by improving the impedance matching when the director and driver is an optimum distance. From the figure 6(b), the values 2mm and 3mm give wide bandwidth. Here, the gain of the antenna is almost equal for all the three values of d_3 which is shown in th figure 6(c).

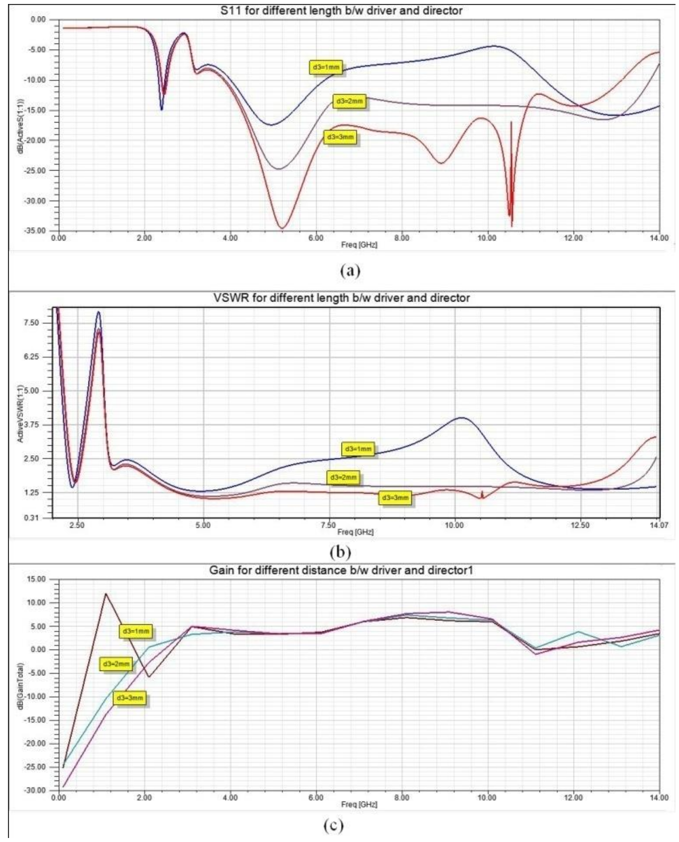

Figure 6: Variations of antenna characteristics for different values of d_3 in terms of (a) S_{11}, (b) VSWR and (c) Gain of the antenna

4. CONCLUSION

A parametric study of wideband Quasi-Yagi antenna with reduced size has been performed. It has been found that the resonating/design frequency is insensitive to the changes in the length of director and the distance between the driver and directors. The distance or gap between the coupled microstrip lines affects the bandwidth moderately. The length of the driver dipole is most sensitive parameter when considering the operating/designed frequency.

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