

Broadband Quasi-Yagi Antenna for WiFi and WiMax Applications

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Received January 17th, 2013; revised February 21st, 2013; accepted March 7th, 2013

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ABSTRACT

In this paper, we present a broadband quasi-Yagi antenna. Good impedance matching is obtained by using parasitic elements. The antenna has been designed and successfully measured. Experimental results show that the 10 dB return loss bandwidth of this antenna is 50% operating from 2.3 GHz to 3.8 GHz. We obtain very flat gain (around 5 dB) over the entire bandwidth. For the design and optimization of antennas, we use HFSS CAD software from ANSOFT.

Keywords: Printed Dipole Antenna; Quasi-Yagi Dipole Antenna; Broadband; Director; Reflector

1. Introduction

Nowadays, quasi-Yagi antenna is widely used in wireless communication for its high directivity, high radiation efficiency, low cost, low profile, as well as easy to fabrication [1,2]. However, the main disadvantage of these antennas is narrow bandwidth and the bandwidth commonly achieves just 10%. To solve this problem, researchers have made great efforts to improve the bandwidth of Yagi antenna using many ways.

Several different techniques have been proposed in literature, concerning the enhancement of impedance bandwidth in microstrip antennas, mostly by increasing the substrate thickness, by decreasing the substrate dielectric constant [3], and by alternative feeding methods (aperture coupled or proximity instead of direct contacting feed). Moreover, by increasing the width of the printed dipole antennas, the bandwidth of antenna increases [4]. By using triangular instead of rectangular dipole arms (bow-tie-configuration), the bandwidth can be further expanded to 37% as presented by Bailey [5]. Coplanar parasitic elements have been proposed by Deal *et al.* [6] in a quasi-Yagi configuration, yielding an impedance bandwidth of 48%. A similar Yagi-like double sided antenna [7], achieved a bandwidth of 37%. Stacked parasitic elements (aperture attacked patches) are widely used for enhanced bandwidth, but their fabrication is relatively complicated and expensive. Additionally, a broad-band quasi-Yagi antenna achieving a measured 48% band-

width is presented for radar systems and millimeter-wave imaging arrays in [8]. We have presented few year ago in [9] a multi-band frequency printed dipole antenna with operation at 2.45, 5.8 and 10 GHz.

The paper is organized as follows: first, we present the design concept of the proposed printed dipole antenna with reflector (with minimal complexity design). In Section 3, a parasitic element is embedded to increase the bandwidth of antenna. Finally, the printed dipole antenna with a three parasitic elements is studied to enable the operation of wideband. The antennas have been designed and successfully measured.

2. Basic Antenna

The quasi-Yagi printed dipole antenna is composed of the dipole and reflector as shown in **Figure 1**. The two arms of the dipole are printed on each side of a CuClad substrate of thickness 0.8 mm and permittivity of 2.17 (to overcome the complicated feeding technique). We use a microstrip line combined with a bifilar printed line. The length of these arms and the distance between them and reflector are around quarter-wavelength ($\lambda_0/4$). λ_0 is the wave-length in free space corresponding to resonant frequency around 2.45 GHz.

The reflector has to be longer than the length of the two arms of the dipole in order to reflect the radiated power in the front direction ($\theta = 0^\circ$). In the case of a shorter reflector, the radiation is concentrated in back

direction, it performs as a director ($\theta = 180^\circ$).

The advantage of this structure is to increase the gain of the printed dipole and to decrease the backside radiation. The **Figure 2** shows the realized printed dipole antenna with reflector.

The simulated reflection coefficient evaluation is shown in **Figure 3**. The printed dipole antenna is matched to -29 dB in simulation around the operating frequency. The measurements were achieved in the laboratory anechoic chamber and have been compared to simulation. The return loss of the tested antenna is presented in **Figure 4**. The level of measured S_{11} is lower than -10 dB over the frequency bandwidth [2.3 GHz - 2.7 GHz].

We present the radiation pattern in 3D at 2.45 GHz obtained in simulation and measurement (**Figures 5 and 6**). We note a good comparison between simulation and measurement. The measured gain in 0° and 180° direction is respectively 5 dB and -8 dB at 2.45 GHz. The difference between the simulated realized gain and the measured realized gain is around 0.5 dB. The measurement accuracy of the anechoic chamber (± 0.5 dB) can be responsible for this variation.

3. Antenna with Parasitic Elements

3.1. Antenna with One Parasitic Element

The addition of one parasitic close to the simple printed dipole creates a second resonance frequency (**Figure 7**). The resonant band is obtained through coupling between

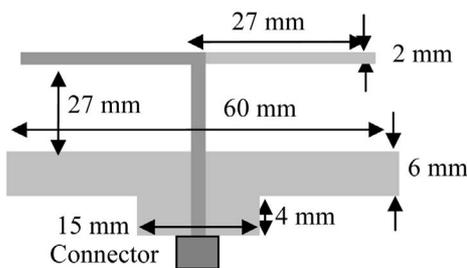


Figure 1. Geometry of the printed dipole antenna with reflector.

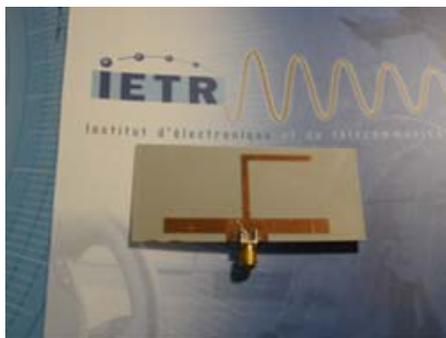


Figure 2. Photo of the printed dipole antenna with reflector.

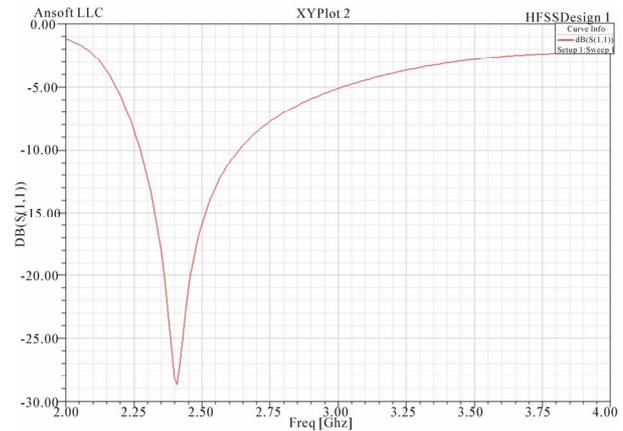


Figure 3. Simulated reflection coefficient of the simple printed dipole.

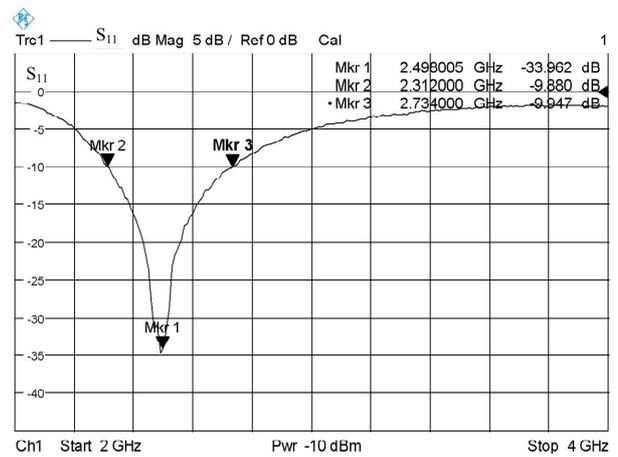


Figure 4. Measured reflection coefficient of the simple printed dipole.

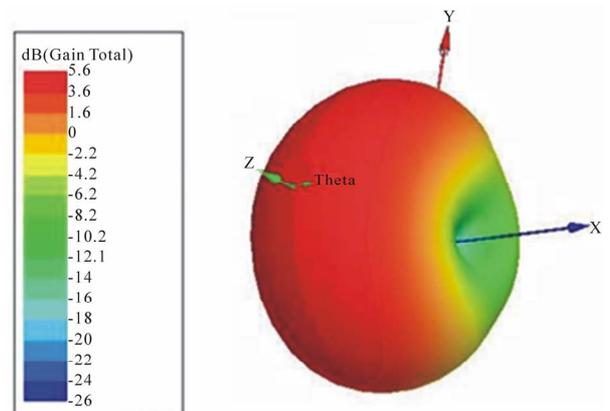


Figure 5. Simulated 3D radiation pattern of the dipole antenna with reflector.

the dipole arms and the parasitic strip. This frequency is determined by the length of the parasitic around $\lambda_0/2$. We have optimized the distance between dipole and reflector, the distance between dipole and parasitic strip (2 mm).

The distance between the dipole arms and the parasitic dipole is very short because the coupling between them is capacitive. The realized antenna is shown in **Figure 8**.

The simulated and measured S_{11} of this antenna is plotted in **Figure 9**. The addition of one parasitic close to the simple printed dipole permits to increase the bandwidth of the antenna. We note a good similarity between measurement and simulation. We obtain with this antenna around 1 GHz bandwidth for a $S_{11} < -10$ dB (2.3 GHz - 3.3 GHz).

We present the measured radiation pattern at 2.45 and 3 GHz. The maximum value of measured realized gain of the antenna with one parasitic is 5 dB in $\theta = 0^\circ$ (**Figure 10**). In the **Figure 11**, we can see the measured maximum gain versus frequency. We observe a flat gain over the frequency band 2.3 GHz to 3.3 GHz at the value around 5 dB. The efficiency of this antenna is greater than 75% over the frequency band.

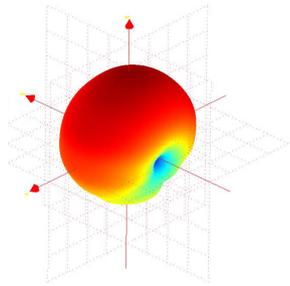


Figure 6. Measured 3D radiation pattern of the dipole antenna with reflector.

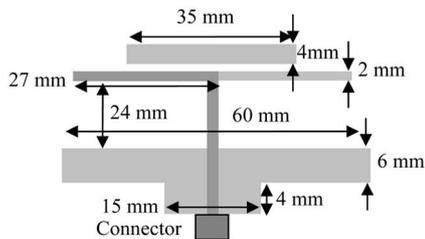


Figure 7. Geometry of the quasi-Yagi antenna with one parasitic.

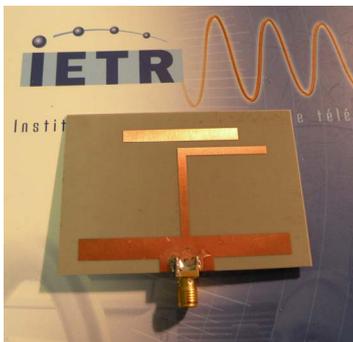


Figure 8. Photo of the quasi-Yagi antenna with one parasitic.

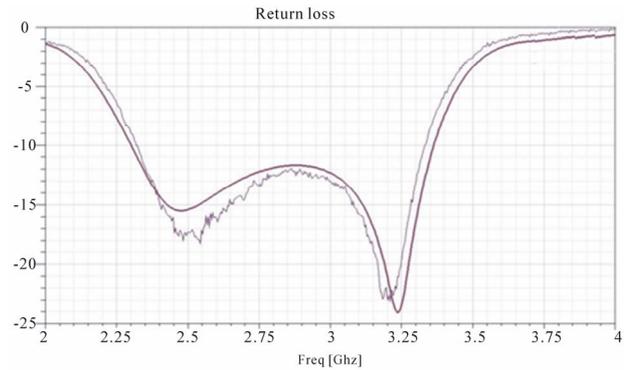
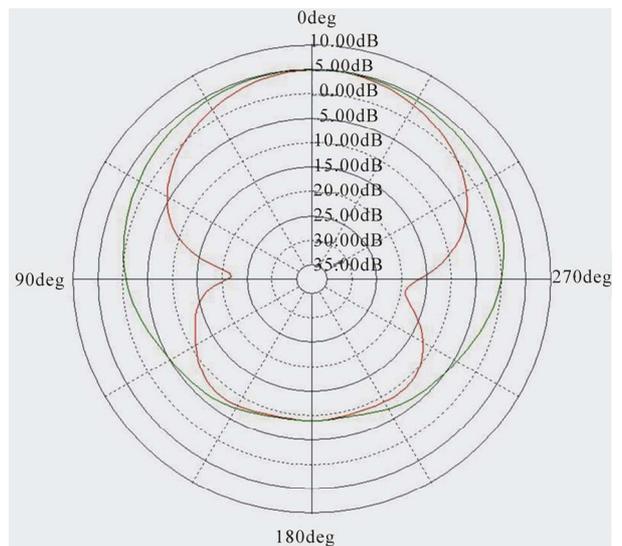
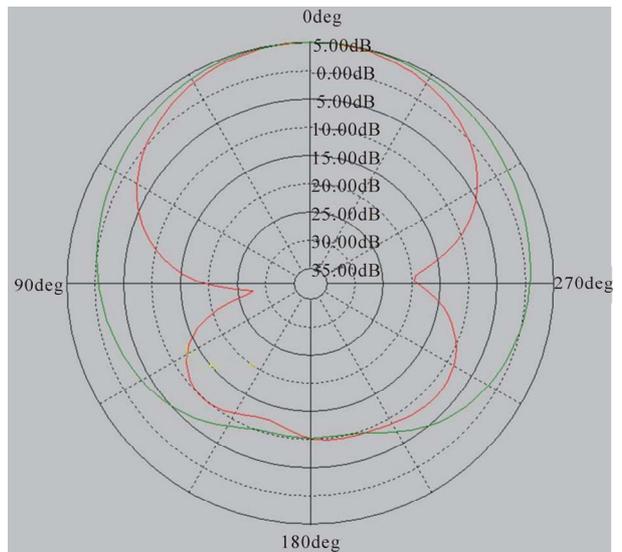


Figure 9. Simulated and measured return loss of the antenna.



(a)



(b)

Figure 10. Measured radiation pattern (red curve: E plane; green curve: H plane) of the antenna at 2.45 GHz (a) and 3 GHz (b).

3.2. Antenna with Three Parasitic Elements

In order to increase more the antenna bandwidth (for WiFi and WiMax applications), we have added three parasitic elements on the bottom side of the substrate where one dipole arm; the reflector and the ground plane were printed (**Figure 12**). Each parasitic element should be shorter than the length of the two dipole-arms for create a resonances greater than the resonance of dipole antenna. Three parasitic elements are sufficient to cover the WiFi and WiMax bands. The antenna is designed using the same size of the prototype described in 3.1, with the new parameters of the three parasitic elements. The lengths of these parasitic elements are: 32 mm, 29 mm and 27 mm. The width is 4 mm. The distance between them is 2 mm. The tested antenna is shown in **Figure 13**.

The broadband printed quasi-Yagi antenna is matched in simulation over the operating frequency bandwidth. The return loss of the tested antenna is presented in **Figure 14**. The level of measured S_{11} is lower than -10 dB over the operating frequency bandwidth (2.3 GHz - 3.8 GHz). We note a good similarity between measurement and simulation. We obtain a bandwidth of 1.5 GHz (around 50%).

Figure 15 presents the measured radiation pattern at 2.2 GHz, 3 GHz and 3.8 GHz. We observe a very stable radiation pattern with less than -10 dB backside radiation versus the bore sight direction.

In terms of levels (**Figure 16**), the measured realized

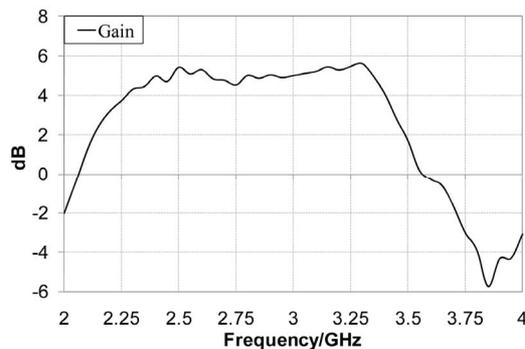


Figure 11. Measured gain versus frequency.

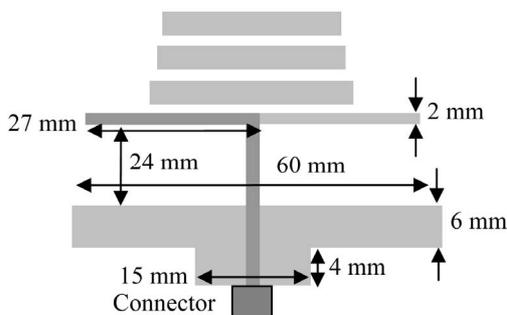


Figure 12. Geometry of the quasi-Yagi antenna with three parasitic elements.

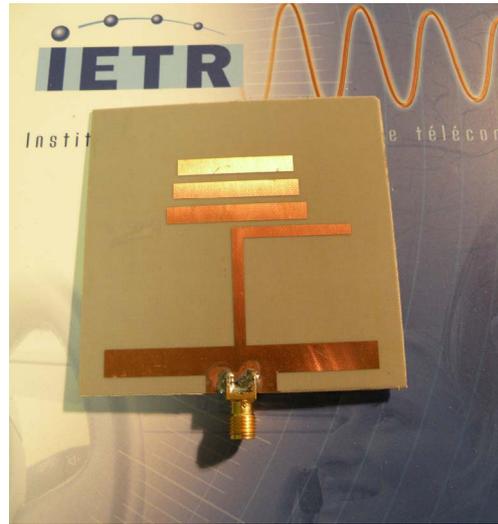


Figure 13. Photo of the quasi-Yagi antenna with three parasitic elements.

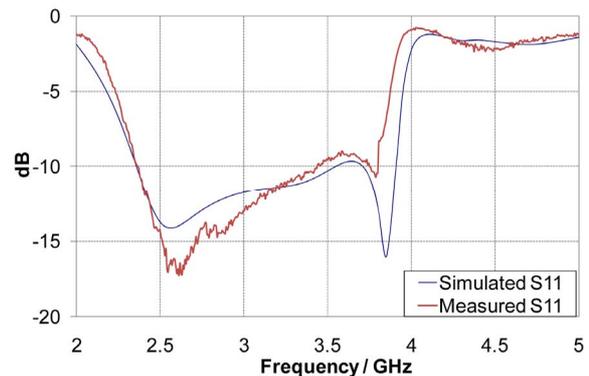


Figure 14. Simulated and measured return loss of the antenna.

gain at $\theta = 0^\circ$ is higher than 5 dB over the band [2.3 - 3.8] GHz. We can observe from the **Figure 16** that the gain is flat over the frequency band 2.3 GHz to 3.8 GHz. The efficiency of this antenna is greater than 70% over the frequency band.

4. Conclusion

In this paper, we have presented the design and the results obtained with broadband quasi-Yagi antenna. As a first step, a printed dipole was designed. As a second step, in order to increase the bandwidth of antenna, we have studied a printed dipole antenna with one parasitic element. Finally, we have developed a special broadband antenna for WiFi and WiMax applications. All the designed antennas were simulated, realized and characterized by measuring their return loss, radiation patterns and gain. We obtain good comparison between simulations and measurements. The proposed antenna operates from 2.3 GHz to 3.8 GHz. The average measured gain in this band is about 5 dB, and the antenna can achieve wide

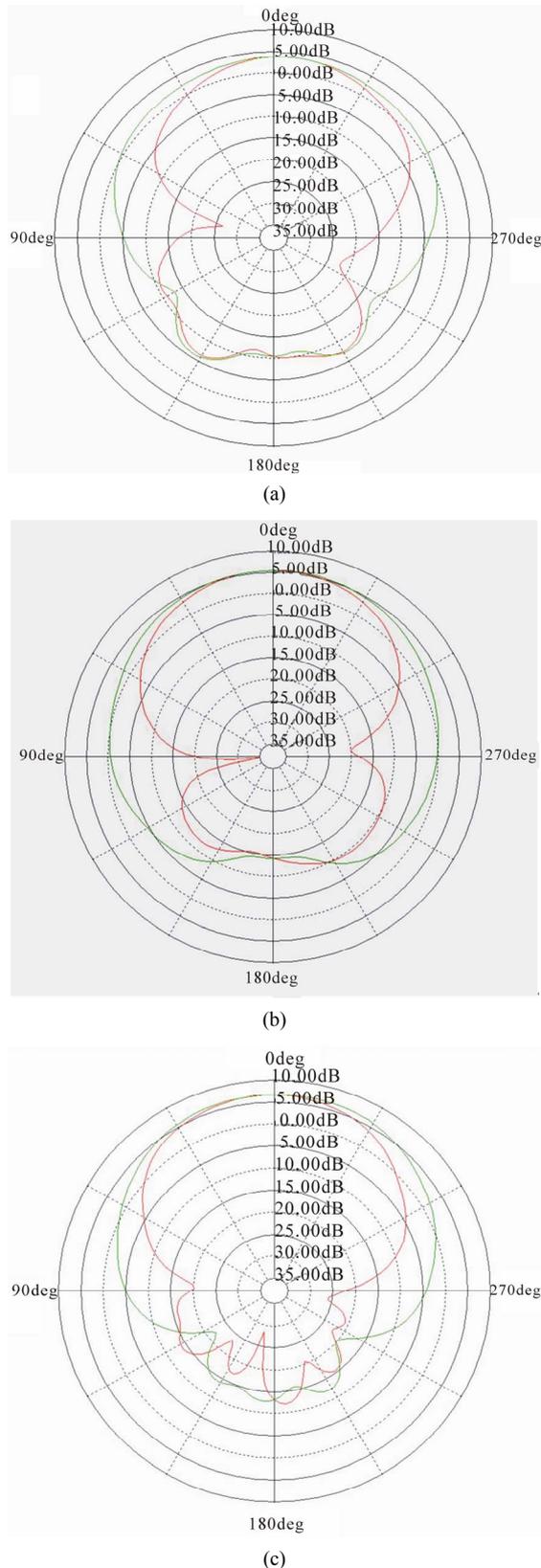


Figure 15. Measured radiation pattern (red curve: E plane; green curve: H plane) of the antenna at 2.2 GHz (a), 3 GHz (b) and 3.8 GHz (c).

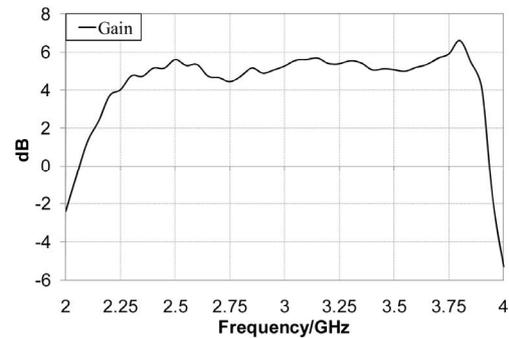


Figure 16. Measured radiation results (realized Gain) versus frequency of the broadband quasi-Yagi antenna.

impedance and gain bandwidths (50%). At the same time, this antenna possesses low profile and miniaturization characteristics. Furthermore, the wide beamwidth and high gain can promise the antenna to be widely applied in many communication systems.

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