Triple band Microstrip Quasi-Yagi Antenna for Mutiband Applications

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Abstract: This paper presents a simple and compact quasi-Yagi antenna for multiband applications. The antenna consisting of a multi-strip quasi-yagi element and a coplanar waveguide to coplanar fed line, the antenna operates in three different frequency bands, namely 3.2, 4.35, and 10.5 GHz. drivers are built with a symmetrical structure based on the classic dipole configuration. The antenna structure design and its multi-band nature with effective radiation make it a good candidate for multi-band applications.

Keywords: Quasi-Yagi Antenna, Multiband Antenna and CPW

NOMENCLATURE

PIFA	Planar Inverted F- Antennas.
UWB	Ultra Wideband
FR4	Dielectric Substrate.
CPW	Coplanar Waveguide.
SMA	A Sub-Miniature Connector.
CST	Micro-Wave Studio Simulator.

1. INTRODUCTION

Wireless communication networks have traditionally used the antennas as the essential element in their applications. While taking into account that the antenna's future lies in its compact size and easy to produce. There are several types of antennas for different fields with promising applications [1], among them are microstrip antennas. They're easy, less expensive antennas. Several geometries have been tested with many features to achieve the desired results.

Enormous progress in multi-band antenna development and design to understand antenna behavior and multi-band functionality. Many techniques have been suggested in this area. Various studies have been carried out on applications and technologies for the design of multi-band antennas, including inverted F-planar antennas (PIFA)[2]-[4], internal compact four-band antenna[5], multi-band antenna with multiple ring in [6] distinct from a wide-band antenna, compact printed triple band-notched Ultra Wideband (UWB) antenna in[7], Multi-band antenna designs are also used to meet the requirements of multi-service and multi-band communication systems, multi-functional antenna design for high-capacity and high-speed transmission rates[8]-[13], ring antennas using fractals can also provide multi-band responses by offering different modes of operation [14]-[15], however the design of the corresponding frequency bands is subject to certain restrictions and the applications are therefore limited. Due to its plane geometry and simplicity in the design process, the Yagi antenna has been commonly used to enhance the directivity [16]-[18]. However the multiband operation targeted by search activities in this category of antennas is still missing. In the reported literature, branch line structures are used in the design of drivers [19]-[20]. This configuration allows the antenna to operate either in single or multiple frequencies, while the antenna gain is disturbed.

A new quasi-Yagi antenna design is proposed and analyzed in this paper; it is optimized to operate at 3.2, 4.35 and 10.5 GHz for simultaneous high gain and multiband operation. It provides good performance in terms of reflection coefficient and also a directional radiation pattern and it can be easily manufactured.

2. ANTENNA DESIGN AND CONFIGURATION

In this section, we describe the geometric antenna configuration for multiband applications and the proposed model specifications. The design concept for this antenna is based on the yagi-shaped structure theory.

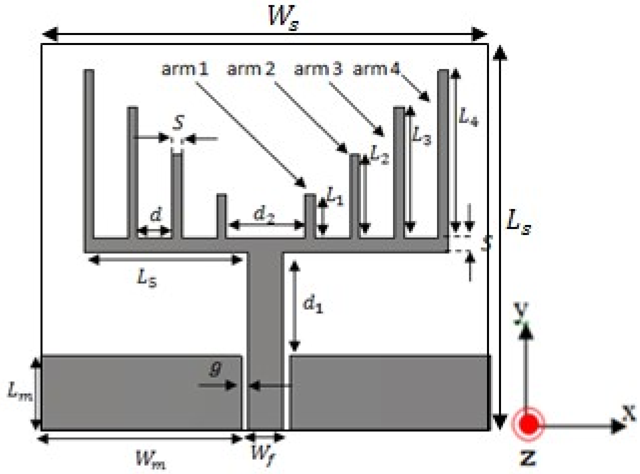


Fig.1: Geometry of the proposed antenna.

Antenna Configuration

Figure 1 shows the proposed antenna structure, it is printed on the front face of FR4 dielectric substrate with relative permittivity ε_r= 4.35, with 1.6 mm thickness and dielectric loss tangent of 0.02, the radiating element is constructed as a quasi-yagi and the total substrate footprint ($L_s \times W_s$) of all antenna is 30x30.8 mm², the CPW coplanar waveguide structure was used to supply this antenna through a sub-miniature SMA connector, characterized by ground length Lm and width Wm, gap distance S between feeding line with dimensions length Lf and width Wf and the two symmetrical rectangles.

Design Procedure

The antenna is a symmetrical structure, construction of its geometry begins with a simple horizontal microstrip line midpoint containing vertical stubs spaced between them with the same distance d, two rectangles of the same size are placed symmetrically with respect to the CPW fed line, figure 1 show the layout of the antenna structure. The distance between the dipole elements d is fixed, arm 1 to arm 4 will be excited at different frequencies as half wave dipoles, while the non excited elements, shorter or longer than the excited element, act as directors or reflectors, respectively, the length of the driver dipole elements, L1 to L4 are approximately equal to λg/4 (λg is the operating wavelength in the substrate) at their resonance frequencies, according to principle of the yagi antenna [16], The final optimal dimension values are obtained after optimization, as shown in Table 1.

Table 1: Optimized parameters of the proposed antenna.

Parameter	Value (mm)	Parameter	Value (mm)
W_m	16.95	L_5	13.92
L_m	6.41	d	2.95
W_f	2.94	d_1	9
L_1	3.75	d_2	6.7
L_2	7.2	S	0.8
L_3	11.25	g	0.3
L_4	14.4		

3. RESULTS AND DISCUSSION

The CST micro-wave studio simulator is used to simulate the proposed antenna, the performance characteristics of proposed antenna are evaluated on basis of parameters such as reflection coefficient, radiation pattern and total gain, The bandwidths of 0.09, 0.12, and 1.82 GHz are achieved for the three bands of 3.22–3.31, 4.31–4.43, and 10.01–11.83 GHz, respectively, with The condition of coefficients performance less than -10 dB.

Reflection Coefficient S11

This section explores and analyzes in detail the effect of the geometric parameter for a reflection coefficient S11. It is apparent that the resonant frequency varied according to the antenna's geometric parameters, they are adjusted in length and width in order to see the effects of different parameters on the frequency, and the goal is to find suitable parameters to satisfy the resonance frequency requirements.

Figure 2-a shows the results obtained by simulating the reflection coefficient S11 characteristic according to L1 geometry shift while constants are preserved for all other parameters, High resonant frequencies shift to the lower frequencies as the value of L1 increases. Thus, by increasing the length of arm 1, the electrical current on arm1 is extended, causing the resonant frequency to decrease, with a good impedance matching when L1 equal to 2.75 mm. Consequently, arm1 is mainly responsible for controlling the third 10.5 GHz frequency band and this assumption is supported by the current distribution in Figure 3-c.

A recapitulation analysis on the following points to prevent redundancy

- Frequency band (4.31 - 4.43 GHz): L2±1mm, Figure 2-b.

- Frequency band (3.22– 3.31GHz): L4±1mm, Figure 2-c.

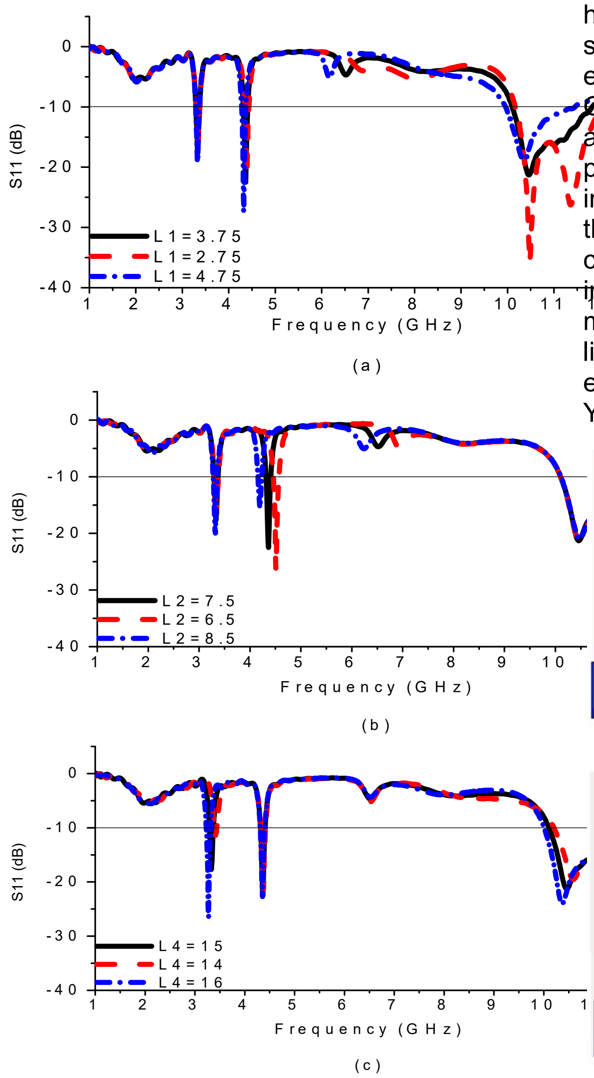


Fig. 2 influence of geomety parametres for S11, (a) S11 versus Frequency on the influence of L1, (b) L2, (c) L4.

Surface Current Distribution

Figure 3 displays the surface current distributions at three different resonant frequencies to further explain the antenna operating mechanism. it shows Current distribution graduation at three frequency bands on the antenna radiating elements. Note that, the current density at each resonant frequency is indeed higher on the certain part of the antenna compared to the other part whose dimensions are supposed to control that particular frequency. the distribution of the surface current at the frequency band centered at 3.2 GHz, is shown in Fig. 3-a, and so are the frequencies of 4.43, and 10.5 GHz in Fig. 3-b and Fig. 3-c respectively. at the radiating elements, It is clearly shown that at the center frequency of the corresponding operating band there is a greater concentration of current distributions, however, the surface current is guided in the same directions, suggesting that the elements actually work as half-wave dipoles. On the other side, the current distributions are lower at the non-excited elements as a parallel stubs open-circuit and their input impedance is infinite, however, it is clear that there is still a considerable distribution current on the unexcited element, which is induced by the driver dipole element. This means the non-excited elements behaves like the parasites. Therefore, the radiation elements of the antenna were based on the Yagi antenna principle.

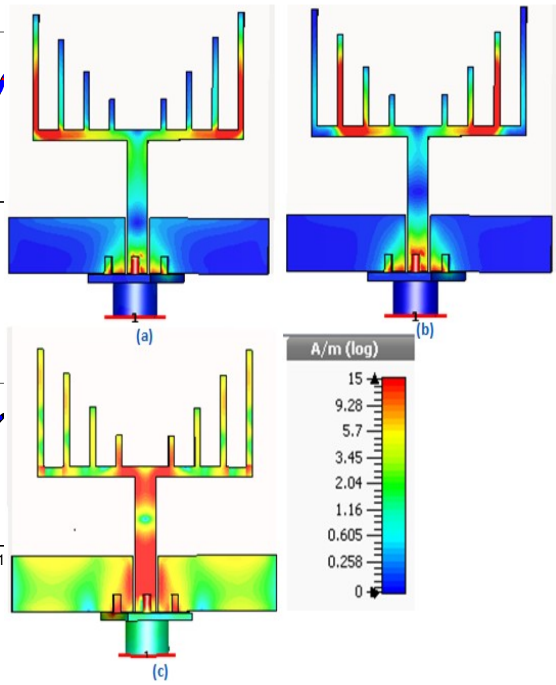
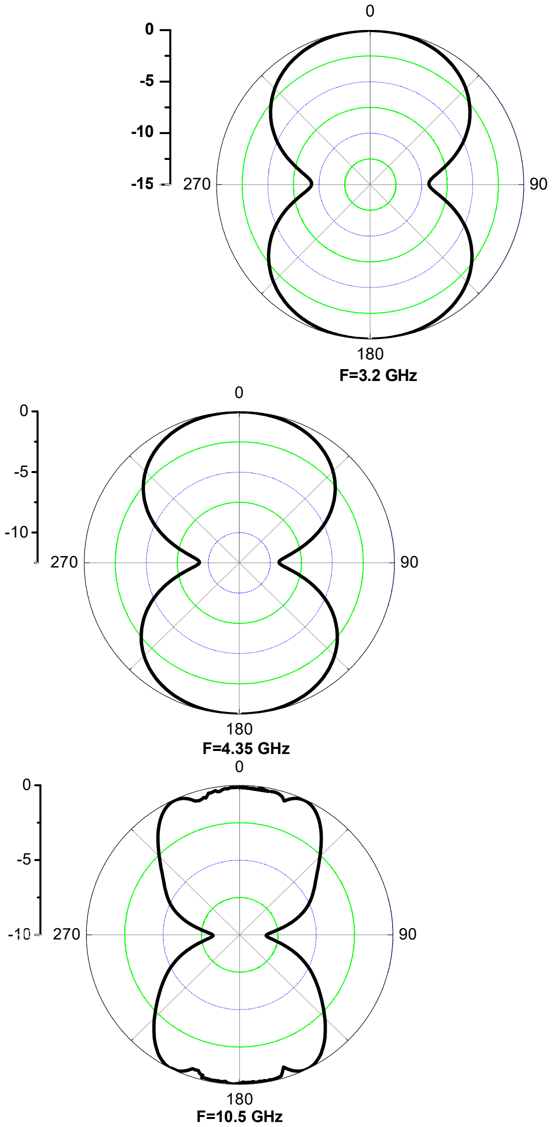


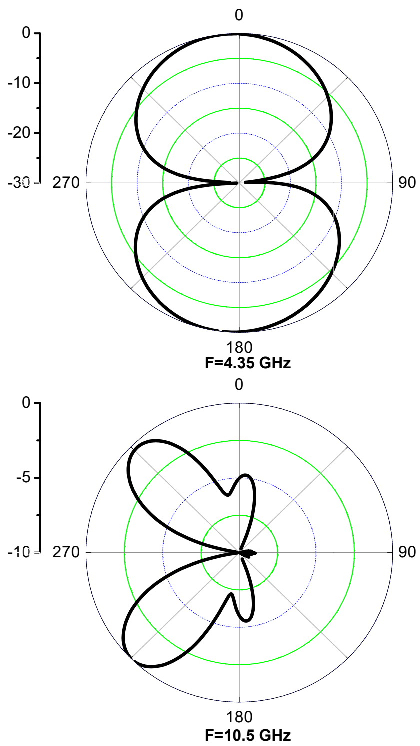
Fig.3. Current distributions in three different frequency bands, (a) at 3.2 GHz, (b) at 4.35 GHz and (c) at 10.5 GHz.

Radiation Pattern

Figure 5 indicates that the antenna radiation patterns at 3.2, 4.35 and 10.5 GHz in the E and H planes. This result confirms that the antenna radiates bidirectional energy mainly. At targeted frequencies, the front-to-back ratios are approximately above 10 dB and the main beams are in the direction of the endfire, which indicates the spatial radiation property of the proposed antenna.



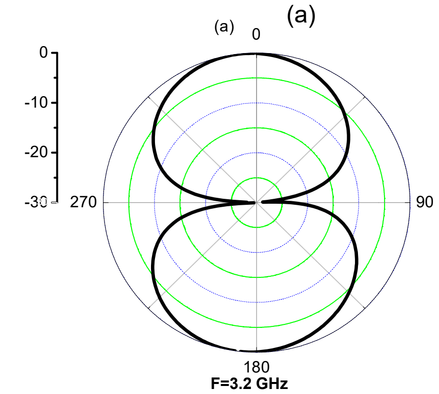
(a)

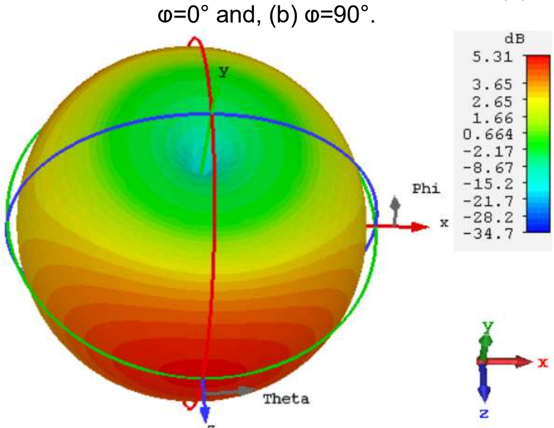


(b)

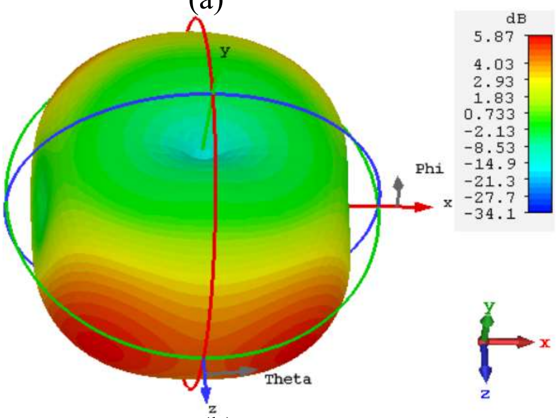
Fig.4: 2D Radiation patterns of the presented antenna at different frequency bands in planes (a) φ=0° and, (b) φ=90°.

(a)

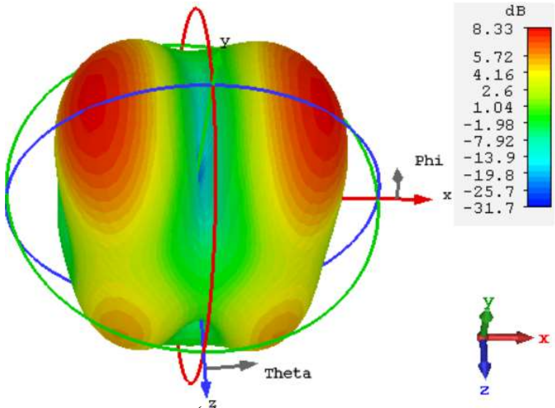




(a)



(b)



(c)

Fig.5: 3D Radiation patterns of the presented antenna at different frequency bands. (a) at 3GHz,(b) at 4 GHz and (c) at 10 GHz.

4. CONCLUSION

In this paper, a coplanar microstrip fed line quasi-Yagi antenna is proposed to achieve multiband characteristic and directional radiation patterns across the entire operating bandwidth and relatively good directional characteristics. The proposed antenna structure is also easy to manufacture and is ideal for WLAN and other communication bands.

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