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Design of a New Model of Multiband Miniature Antenna Near Isotropic

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Abstract

In this paper, we propose a new slotted multiband antennas simulated at different frequencies. The insertion of slots in the patch gives a good adapting frequency with various forms on the radiation pattern. The main feature of the proposed antenna is the capability to generate a near isotropic radiation pattern in different frequencies .The design details of the conceived antenna are presented and discussed. Simulations of the different reflection coefficient and radiation pattern are presented. These were carried out using *CST Microwave Studio*. This model has got numerous applications in network sensors, field measurements and electromagnetic compatibility.

Keywords: *Multiband antenna, slot antenna, miniature antenna, near isotropic coverage, circular polarization.*

1. Introduction

In recent years the rapid growth of wireless communication technologies leads to the great demands in using a multi-frequencies band on one device, because the systems want to operate at multi-frequencies in some applications such as mobile applications, pico-cell base station applications, and Wireless LAN applications. The main purpose is to reduce number of antennas in the systems. The antenna operating in multi-frequency operation band has been invented and it is called a multiband antenna [1]. However, the transmitted signal is expected to be as stable as possible, whatever the orientation of the communicating objects is. For short distance, low cost, low data rate and low consumption applications, that is to say, when an adaptive solution cannot be envisaged, the most straight-forward strategy is to search for an antenna radiating uniformly in all directions, knowing that an isotropic antenna doesn't exist [2].

The geometry and detailed dimensions and the feeding network as well as the far-field pattern results of the proposed antenna are successively presented below.

2. Antenna structure

In this study, we propose two models of geometry with the main difference is the number of slots in the vertical patch .The antenna structure is depicted in Fig1. Six slotted patches are located along the sides of two intersected cylinders, such as, four patches on the horizontal mode and two patches on the vertical mode. As presented the following figure.
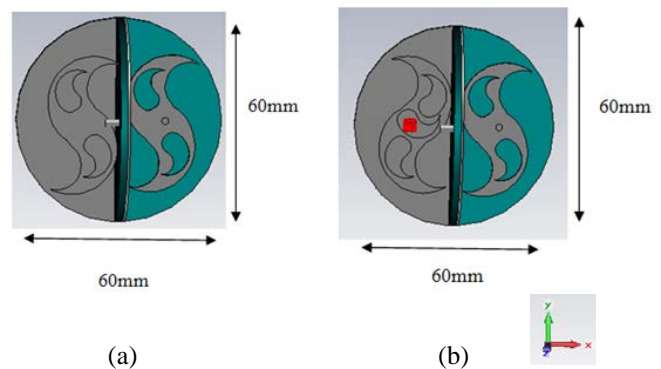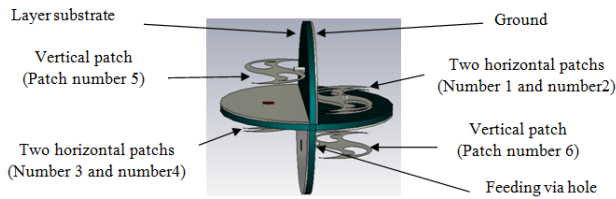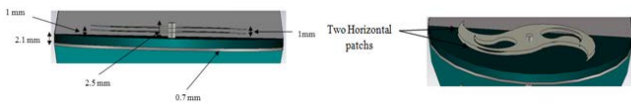

Fig1-(a)Antenna with two slots in the vertical patch,(b) Antenna with tree slots in the vertical patch of the new model

Fig 2(a) illustrate the antenna structure. The green top layer is made of a low permittivity and low-loss substrate, in order to optimize the antenna efficiency and bandwidth, where $\varepsilon_r = 2.33$, $\mu = 1$ and thickness = 2.1 mm. A 0.7 mm thick copper layer is used as a ground plane for the antenna

structure. Fig 2(b) illustrate the horizontal patches structure ,such as, the distance between two patches on each other is 1mm. As presented the Fig 2(b) .

(a)

(b)

Fig 2-(a) Structure of the antenna with six patches, (b) Structure of the horizontal patches.

The six patches are fed with equal amplitudes. S2 and S3 are fed with the same phase of 90°. There is a phase difference of 90° between S1, (S2,S3) and S4. It presents the advantage of greatly reducing the mutual coupling between patches.

Patch number	1 and2	3and 4	5	6
Amplitude relative to patch	1	1	1	1
Phase delay relative to patch	0°	90°	90°	180°

Table1: Amplitude and phase constraints of the antenna.

3. Vertical patch configuration

3.1 Patch with two slots

Fig3 illustrates the elementary vertical patch are 36.85 mm long, 23.79 mm wide .And two slots of 12.21 mm long,9.35 wide . This patch is made of copper. They are fed via holes of 1 mm wide and 2.5mm long. Via holes are connected to the feeding network.

Fig 3: Vertical patch used with two slots

3.1.1 Radiation properties of antenna

In Fig4, the computed return loss of antenna with two slots in vertical patches. The simulated antenna by *CST Microwave Studio* software is well adapted at five resonant frequencies of 4.7 GHz, 5.5GHz, 6GHz, 7.4GHz and 8 GHz. The reflected power reaches the values of -21.74 dB,-14.5 dB,-18.4 dB,-13.5 dB and –12.83 dB at these resonant frequencies respectively.
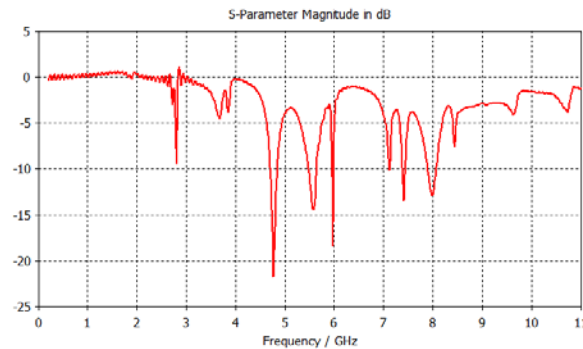

Fig4: Computed return loss of antenna

The main purpose of the antenna is it's near isotropic radiation pattern which allows the communication performances to be uniform between devices whatever are their orientations in several resonant frequencies . The antenna radiation pattern is near isotropic. Fig 5 (a) to Fig 5(o) presents the antenna directivity pattern in two cutting plans at different resonant frequencies.
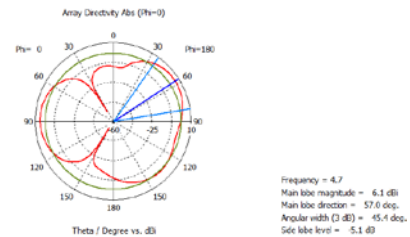

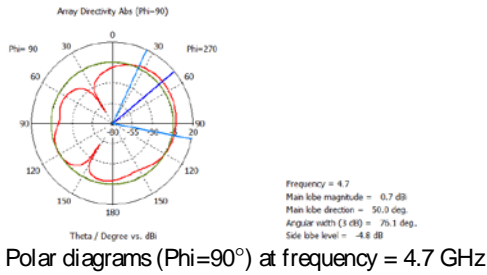Fig 5(a) : Polar diagrams (Phi=0°) at frequency = 4.7 GHz

Fig 5(b) : Polar diagrams (Phi=90°) at frequency = 4.7 GHz
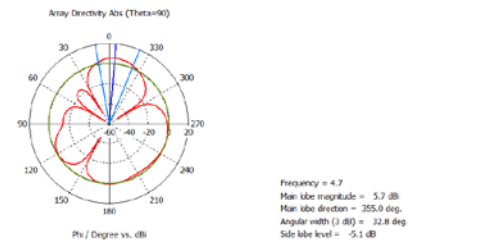

Fig5(c) : Polar diagrams (Theta=90°) at frequency = 4.7 GHz
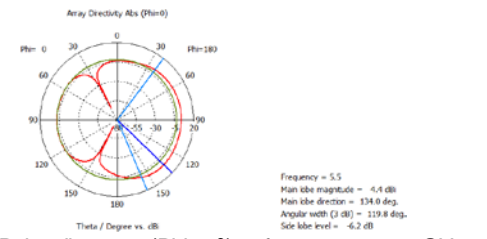

Fig5(d) : Polar diagrams (Phi=0°) at frequency = 5.5 GHz
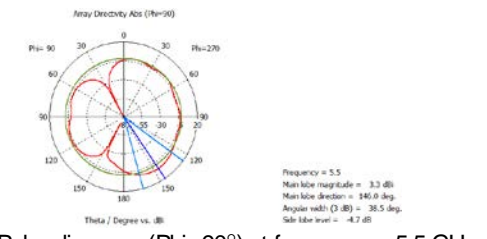

Fig5(e) : Polar diagrams (Phi=90°) at frequency = 5.5 GHz
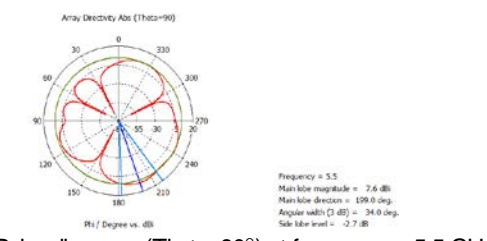

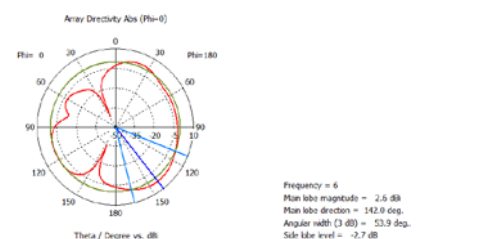Fig5(f) : Polar diagrams (Theta=90°) at frequency = 5.5 GHz

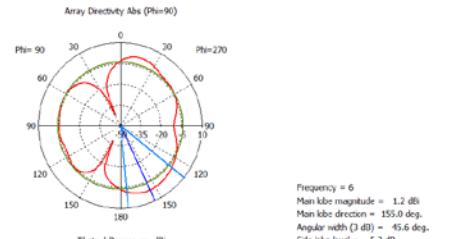

Fig5(g) : Polar diagrams (Phi=0°) at frequency = 6 GHz

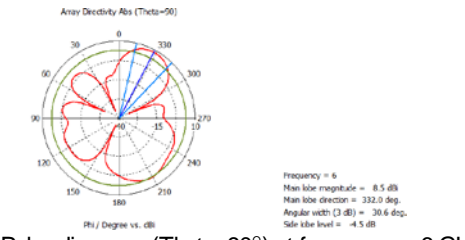Fig5(h) : Polar diagrams (Phi=90°) at frequency = 6 GHz

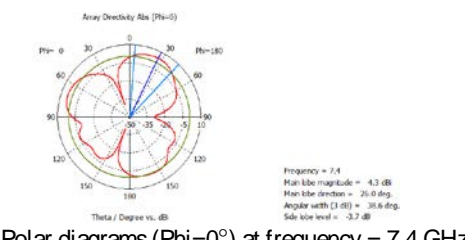Fig5(i) : Polar diagrams (Theta=90°) at frequency = 6 GHz

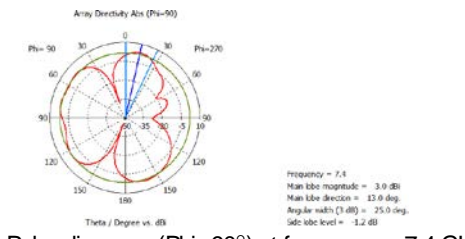Fig5(j) : Polar diagrams (Phi=0°) at frequency = 7.4 GHz

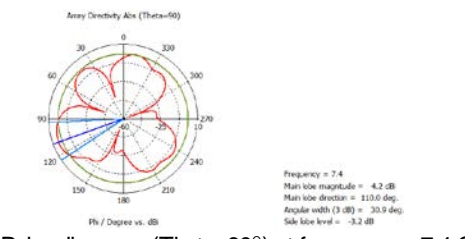Fig5(k) : Polar diagrams (Phi=90°) at frequency = 7.4 GHz

Fig5(l) : Polar diagrams (Theta=90°) at frequency = 7.4 GHz

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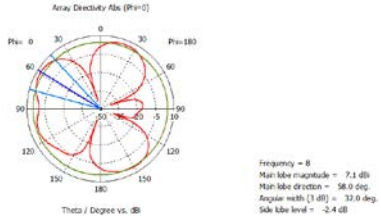ISSN (Online): 1694-0814
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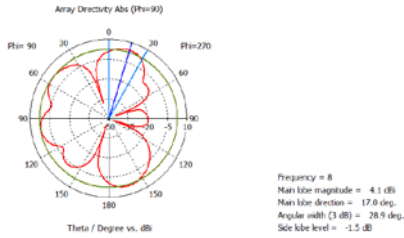Fig5(m) : Polar diagrams (Phi=0°) at frequency = 8 GHz

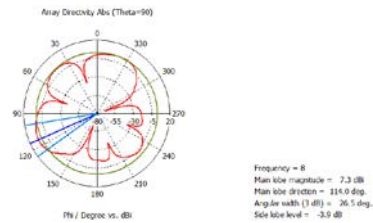Fig5(n) : Polar diagrams (Phi=90°) at frequency = 8 GHz

Fig5(o) : Polar diagrams (Theta=90°) at frequency = 8 GHz

3.2 Patch with tree slots

Fig6 illustrates the elementary vertical patch are 36.85 mm long, 29.79 mm wide .And tree slots of 12.21 mm long,9.35 wide . This patch is made of copper. They are fed via holes of 1 mm wide and 2.5mm long. Via holes are connected to the feeding network.
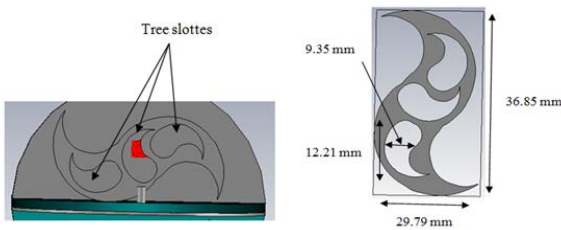

Fig 6: Vertical patch used with tree slots

3.2.1 Radiation properties of antenna

In Fig7, the computed return loss of antenna with tree slots in vertical patches. The simulated antenna by *CST Microwave Studio* software is well adapted at four resonant frequencies of 4.7 GHz, 5.6 GHz, 6GHz, and 7.4GHz. The

reflected power reaches the values of -27.75 dB,-24.6 dB,-15.5 dB and -12.5dB at these resonant frequencies respectively.
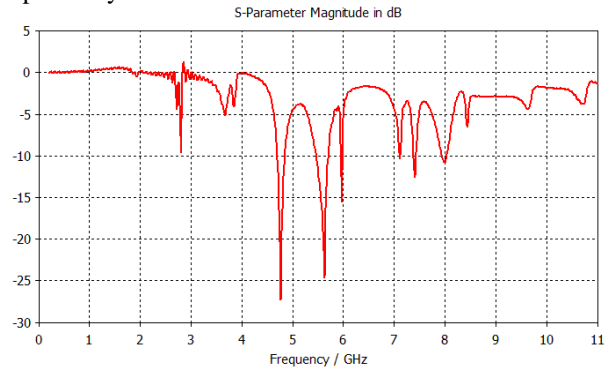

Fig7: Computed return loss of antenna

Fig 8 (a) to Fig 8(o) presents the antenna directivity pattern in two cutting plans at different resonant frequencies.
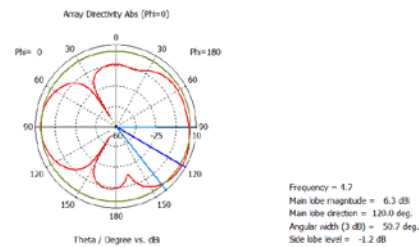

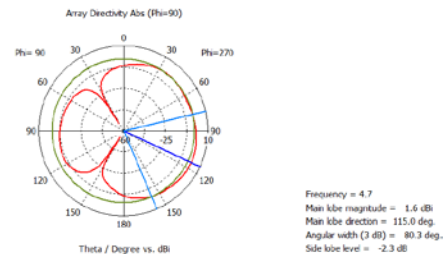Fig8(a) : Polar diagrams (Phi=0°) at frequency = 4.7 GHz

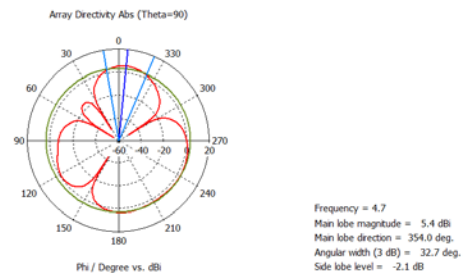Fig8(b) : Polar diagrams (Phi=90°) at frequency = 4.7 GHz

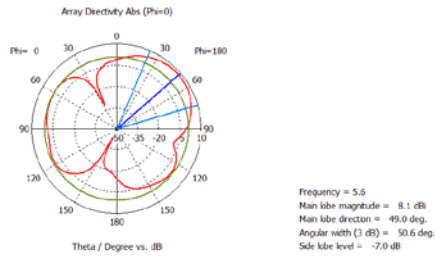Fig8(c) : Polar diagrams (Theta=90°) at frequency = 4.7 GHz

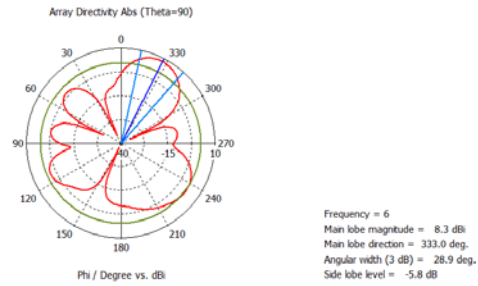Fig8(d) : Polar diagrams (Phi=0°) at frequency = 5.6 GHz

Fig8(e) : Polar diagrams (Phi=90°) at frequency = 5.6 GHz

Fig8(f) : Polar diagrams (Theta=90°) at frequency = 5.6 GHz

Fig8(g) : Polar diagrams (Phi=0°) at frequency = 6 GHz

Fig8(h) : Polar diagrams (Phi=90°) at frequency = 6 GHz

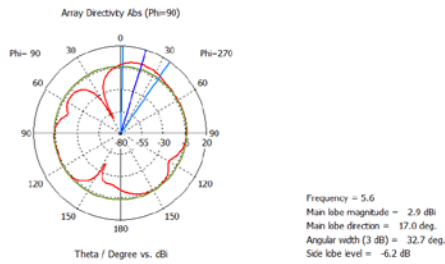Fig8(i) : Polar diagrams (Theta=90°) at frequency = 6 GHz

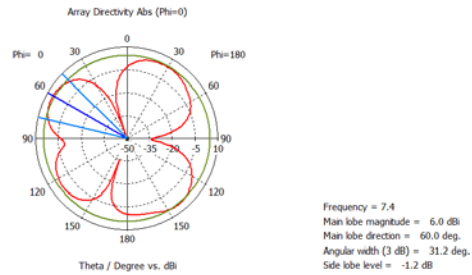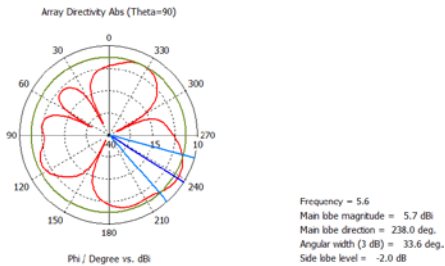Fig8(j) : Polar diagrams (Phi=0°) at frequency = 7.4 GHz

Fig8(k) : Polar diagrams (Phi=90°) at frequency = 7.4 GHz

Fig8(l) : Polar diagrams (Theta=90°) at frequency = 7.4 GHz
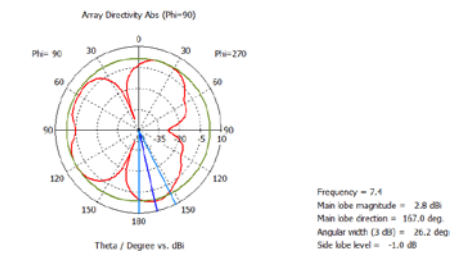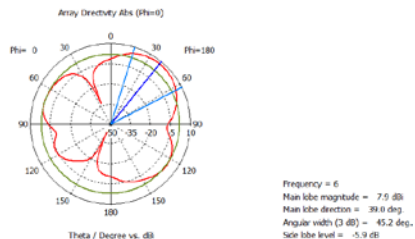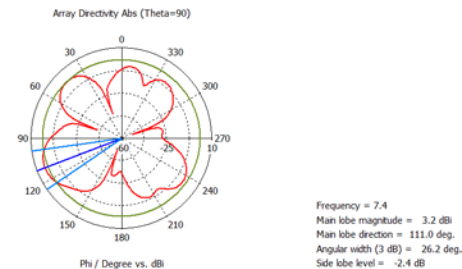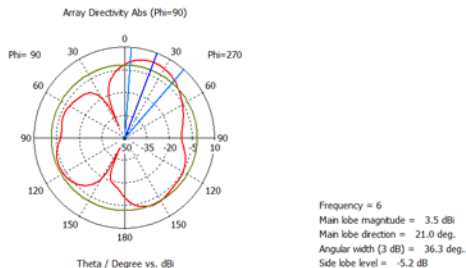
4. Feeding network

In this section, we propose a microstrip network of the antenna with two 90° hybrid couplers and one 180° hybrid coupler are located in the bottom side of the PCB. As presented the following figure.
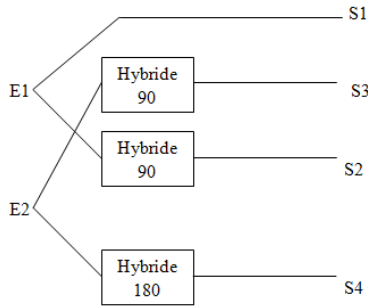
Fig9: Schematic of the feeding network [3]

The circuit layout, as illustrated in Fig 10, was designed using ISIS Proteus. The components are ultra small SMT. The input network is connected through two U-fl coaxial connectors (E1 and E2).
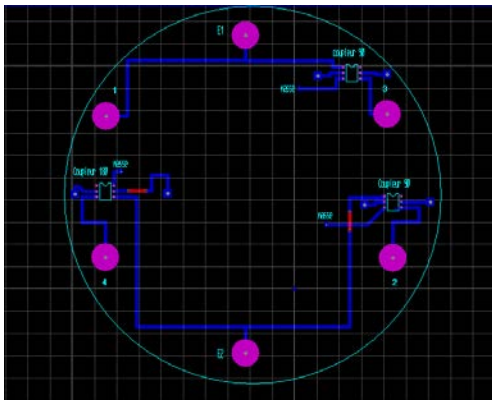

Fig 11: Layout of the microstrip network [4].

The antenna will be positioned in a vertical mode on the PCB.

5. Conclusion

A small multiband miniature antenna with slots on the patches is presented for different application. The simulated results were conducted using the CST Microwave Studio. Furthermore the proposed antenna has a near isotropic pattern for several frequency bands signifying that the proposed antenna is suitable for using in different field in communications. In addition, key advantage of the proposed antenna is simplicity of designing, simple structure, and cost-effective to manufacture.

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Noureddine Boukli-Hacene was born in 1959 in Tlemcen, Algeria. He received his Diplome d'Etudes Approfondies in microwave engineering (DEA Communications, Optiques et Microondes) and his Doctorate Degree in electrical engineering from Limoges University, France and from the National Center of Spatial Studies (Centre National d'Etudes Spatiales) in Toulouse, France, in 1982 and 1985 respectively. Recently, he was appointed as a lecturer at the University of Tlemcen. His research interests include, among others, microstrip antennas and microwave circuits.