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DESIGN OF RECONFIGURABLE MICROSTRIP ANTENNA WITH A WIDE TUNABILITY RANGE FOR COGNITIVE RADIO NETWORK

Dr. Ahmed Ghanim Wadday[1] and Dr. Hayder Jawad Albattat[2]

[1] Al-Furat Al-Awsat Technical University, ahmadghw@hotmail.com

[2] Al-Furat Al-Awsat Technical University, saidhaider75@yahoo.com

ABSTRACT

This paper presents two reconfigurable microstrip antennas with different sizes of the patch elements for Cogniative Radio (CR) network. The desired resonant frequencies can be controlled by using smart tunable permittivity materials. The switching among these frequencies depending on the CR requierments. A wide tunability range of switching frequencies covers the bands of Wi-Fi and Wi-Max standards are obtained. This rang of frequencies begin from 1.5 till 5.5 GHz. Variable permittivity concept with respect to (as a function of) external source has been assummed for switching through this study. The two geometry structures for the planner array antenna are investigated and simulated using COMSOL sofware.

KEYWORDS

Microstrip antenna, reconfigurable antenna, cognitive radio network, resonant frequency.

تصميم هوائي شريطي قابل للتكييف ذو مدى التكييف الواسع للشبكات الراديوية الادراكية

د. احمد غانم وداي و د. حيدر جواد البطاط

جامعة الفرات الاوسط التكنولوجية

الخلاصة

يقدم هذا البحث هوائيين شريطيين قابليين للتكيف ذاتي أحجام مختلفة لعناصر الرقعة المشعة. يمكن التحكم بترددات الرنيين المطلوبة بواسطة استخدام مادة ذكية قابلة لتنغييم السماحية النسبية لها.يتحقق الترحيل بين اكثر من تردد وفقا لمتطلبات شبكة الراديو الادراكية. ويغطي معايير شبكات WIFI و WIMAX. أذ أن هذا المدى الترددي يغطي حزمة ممتدة من 1.5 الى 5.5 GHZ . من خلال هذا البحث ولعملية الترحيل تم فرض السماحية النسبية القابلة للتغيير بالنسبة (كدالة) لمصدر خارجي. تم التحقق ومحاكاة عمل التركيبين الهندسيين للهوائيين بأستخدام برنامج COMSOL.

1. INTRODUCTION

Spectrum congestion and renewed spectrum challenges in utilization due to numerous demand on radio spectrum. A new dynamic allocation policies for the spectrum were developed in order to exploit the available spectrum. Cognitive Radio has acquired a great regard in wireless systems because of enormous spectrum improvement [1,2]. In [3], a spectrum sensing survey for cognitive radio strategies is presented. The switching strategy for relaying among the resonant frequencies of the reconfigurable antenna is one of them.

Recently, the frequency range of 200 MHz to 5 GHz has attained the attention of many researchers for use with reconfigurable antenna. These antenna systems integrate a wideband, used for sensing, with a frequency reconfigurable antenna use to communicate [4]. Product limitation of wideband antennas is presented gain-bandwidth, they also demonstrate fluctuations due to a low signal to noise ratio. The performance of the transceiver received a compromise through design for wideband operation, caused by the Radio fequency (RF) front-end components limitations such as mixers, amplifiers, and oscillators [5]. A tunable filter or narrowband reconfigurable antennas appear as the best suitable solution for spectrum sensing and a sloution for all the aforementioned problmes in wideband antennas.

In this paper, reconfigurable microstrip antenna with a very wide tunability range for overlay cognitive radio applications are presented. Section II introduces the design approach of reconfigurable microstrip antenna. Description of smart permittivity material is presented in section III. The simulation results have been discussed in section IV. The paper is concluded in Section V.

2. DESIGN APPROACH OF RECONFIGURABLE MICROSTRIP ANTENNA

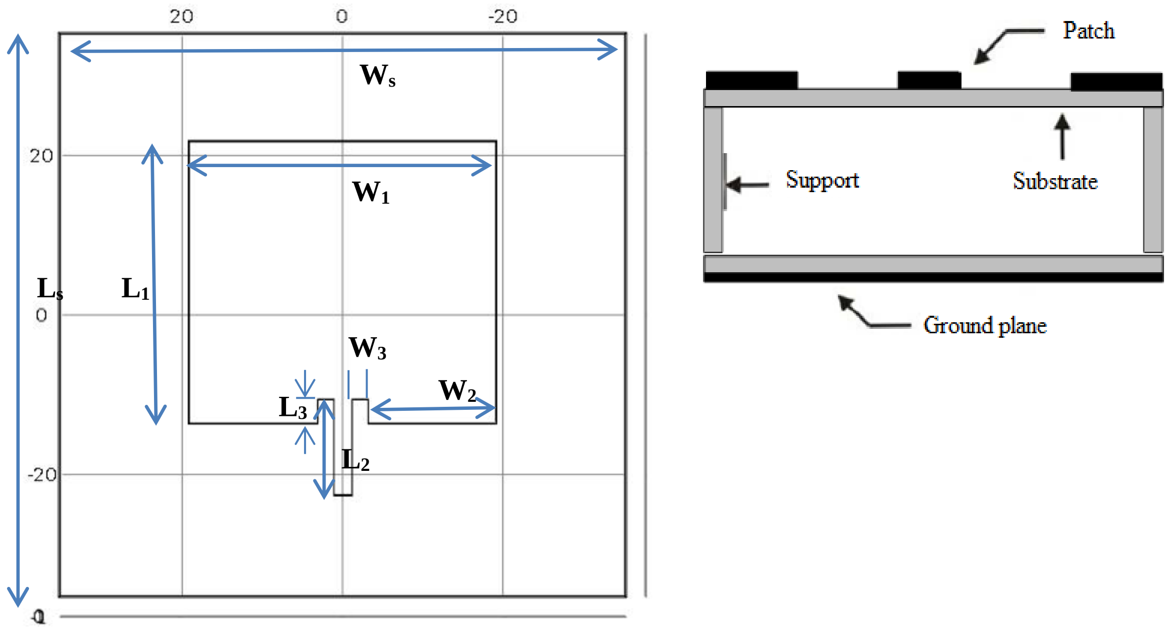
The main properties of reconfigurable microstrip antenna are simple and low-cost to manufacture, low-profile, conformable to planar and non-planar surfaces, low-profile, impedance, polarization, and patterns. Dielectric's length substrate depends on the dimensions (length and width) of the patch. The rectangular patch antenna is designed so as it can operate at the resonant frequency. There are an infinite numbers of resonant modes, sizes and shapes of the patch governe each resonant frequency, the relative permittivity of the substrate ε_r, and to some extent of the substrate thickness. For example, if the patch is rectangular in shape with dimensions *a* (length) and *b* (width), the resonant frequencies are given by [6].

$$f_{mn} = \frac{k_{mn}c}{2\pi\sqrt{\varepsilon_r}} \tag{1}$$

Where: *m* and *n* are mode indices, *c* is the light velocity and

$$k_{mn} = \left[(m\pi/a)^2 + \left(n\pi/b\right)^2 \right]^{1/2} \tag{2}$$

The proposed antenna geometry of this work is shown in Fig. 1.



(a) **(b)**

Fig. 1. (a) The layout of the reconfigurable antenna, and

(b) The sketch related to beside view.

The antennas are simulated using COMSOL program with a relative dielectric permittivity varying from 2.5 to 6.3. This change in the permittivity values were done by assuming there is an external control source. It is made up of a rectangle patch. The characteristic impedance of the feed line of the antenna is fed by a microstrip 50Ω.
The details of parameters for the proposed antennas are shown in Table 1. Then, the dimensions of the next patch are changed to try to study the influence of permittivity changing.

Table 1. Parameters of the antennas

Basic configuration	**Abb.**	**Dimensions (mm)**	
		Ant. No.1	**Ant. No. 2**
Substrate	W_s	80	70
	L_s	80	70
Patch Antenna	L_1	54	33
	L_2	16	12
	L_3	6	12
	W_1	54	38
	W_2	23.5	16
	W_3	2	2
Substrate thickness	H	1.52	3

Where (W) denoted to width while (L) denoted to length

3. SMART PERMITTIVITY MATERIAL

In the last few years, materials have played an important role in the design of antennas [7]. The trends of advanced communication systems are mainly concerned with minor size where the antenna miniaturization is in constant demand. One of the most common miniaturization techniques is the loading of the antenna volume with different materials. Nowadays, using permittivity varying with electromagnetic, photonic and magnetic control beams present a new miniaturization techniques [8, 9]. The structure of the frequency tunable antenna is composed of a microstrip patch antenna, impedance matching network, transmission feed line, and switching tuning circuit may optical, electronic or mechanical. The microstrip antenna is a standard patch antenna with an inset feed to achieve an input impedance of 50Ω. By varying the actuation frequency applied through dielectric and the center conductor, the loading permittivity of the patch antenna can be tuned and hence the resonant frequency. This concept of frequency tuning is employed in this design.

4. RESULTS AND DISCUSSION

Fig.s 2 and 3 show the relationship between the permittivity and the resonant frequencies (Fr_1 and Fr_2) for the first and the seconed antenna structures adopted in this paper, respectively. More than fifteen resonant frequencies were obtained for permitivity values lies between 2.5 to 6.3. It appears that by increasing the permittivity of the substrate, the low resonant frequency has been obtained. These will lead to provide wide range of frequencies which is useful in applications like WiFi and WiMax.
Minimum insertion loss parameters (S_{11}) for each resonant frequency of the first and the second antennas were presents in Fig.s 4 and 5.Through these figures the insertion loss (S_{11}) for each the resonant frequency with respect to permittivity value are descriped. Also, the lower insertion loss for each resonant frequencies can be realized by applying prrimetivety value (ε_r=3.5) for first antenna (-18 dB for second resonant frequency). Minimum insertion loss for second antenna when applying permitivity value at (ε_r=2.7) is -33.5 dB. Fig.s 6 and 7 show the relationship between insetion losses and frquencies at given dielictric permitivity value for the first and second antenna proposed. As it mentioned earlier; the permittivity values (ε_r=3.5 and 2.7) enabled to obtain the lower insertion losses for the first and second antenna, respectively. Then the same geometric structure and without replacing the permittivity or/and the dimension of the patches of antenna can obtained the desired resonant frequencies.

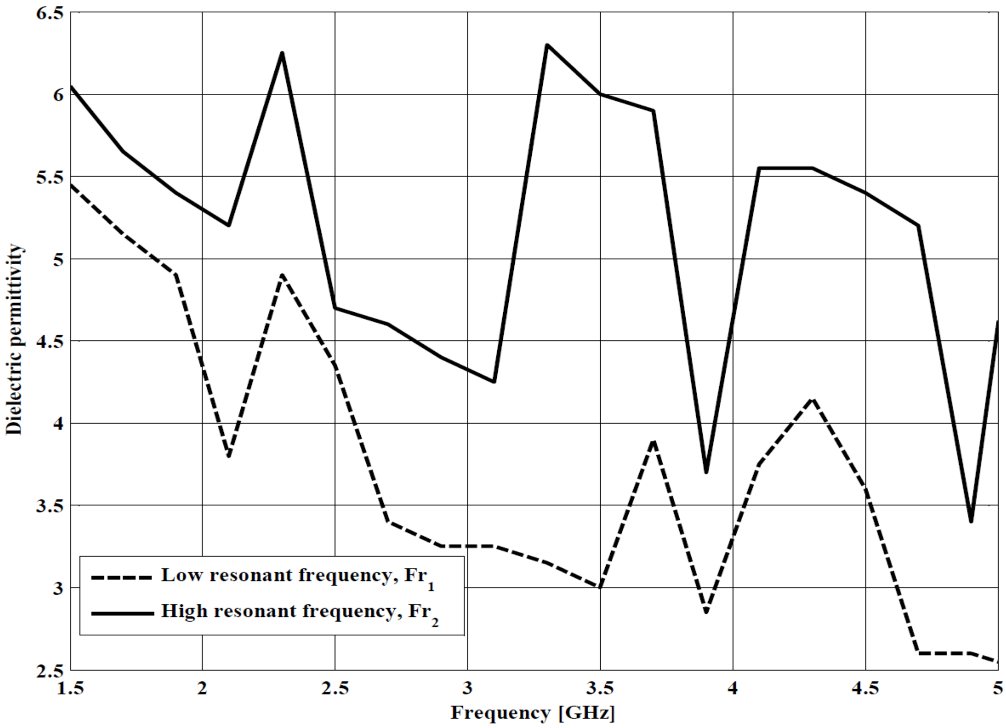


Fig. 2. The relationship between the permittivity and the resonant frequency for the first antenna

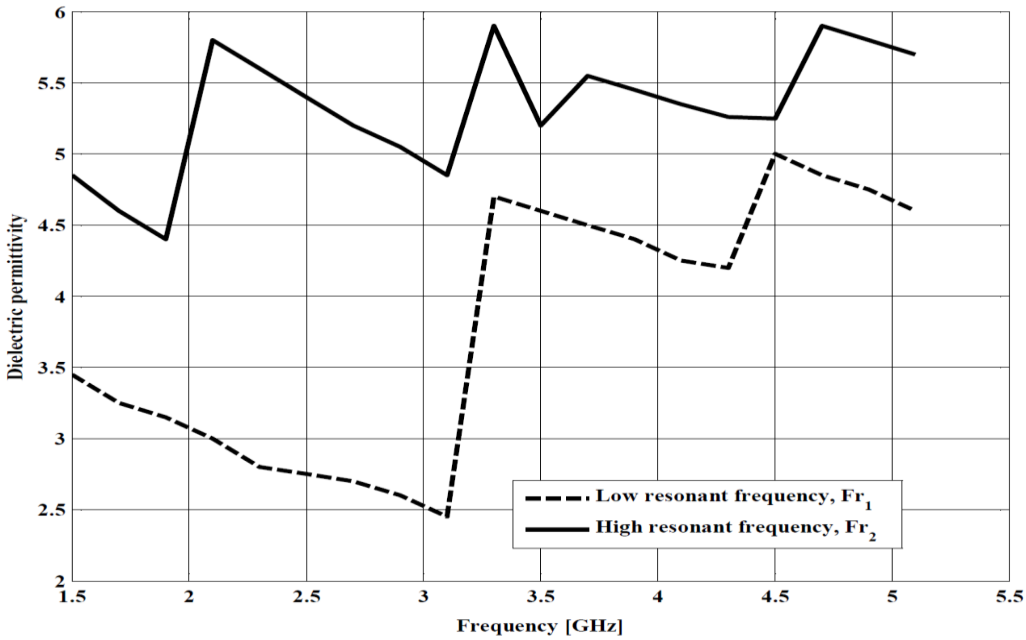


Fig. 3. The relationship between the permittivity and the resonant frequency for second antenna

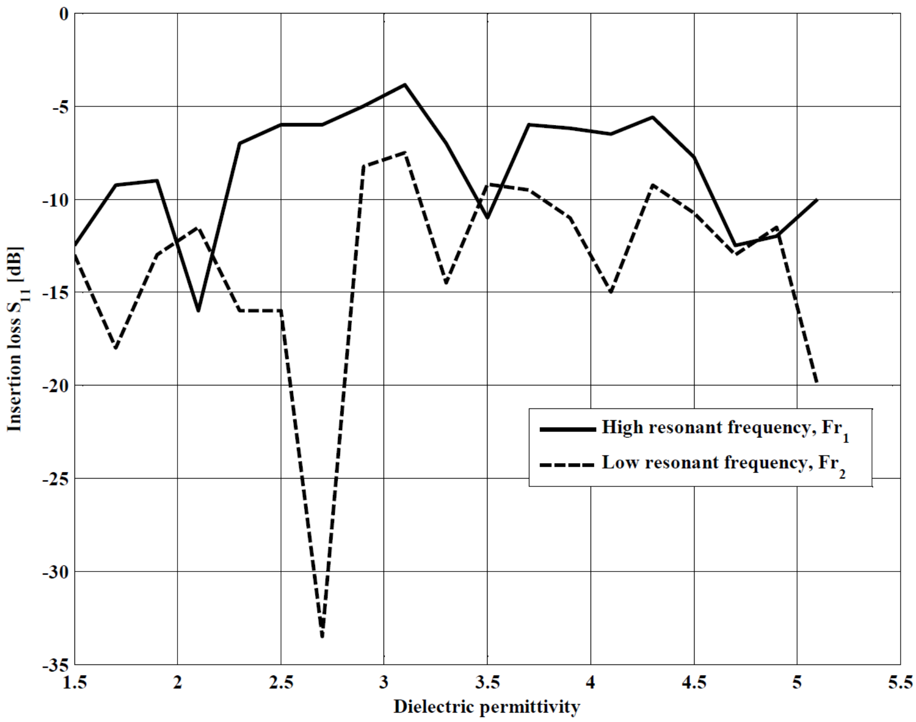


Fig. 4. Minimum insertion loss parameter (S11) for each resonant frequency of the first antenna

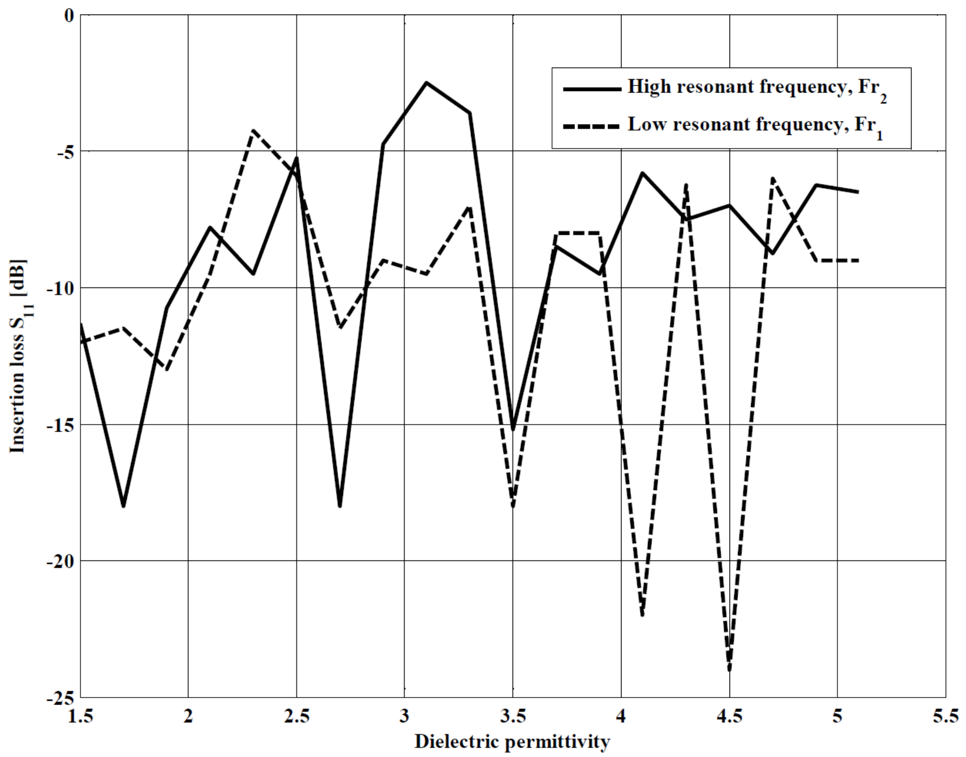


Fig. 5. Minimum insertion loss parameter (S11) for each resonant frequency of the second antenna

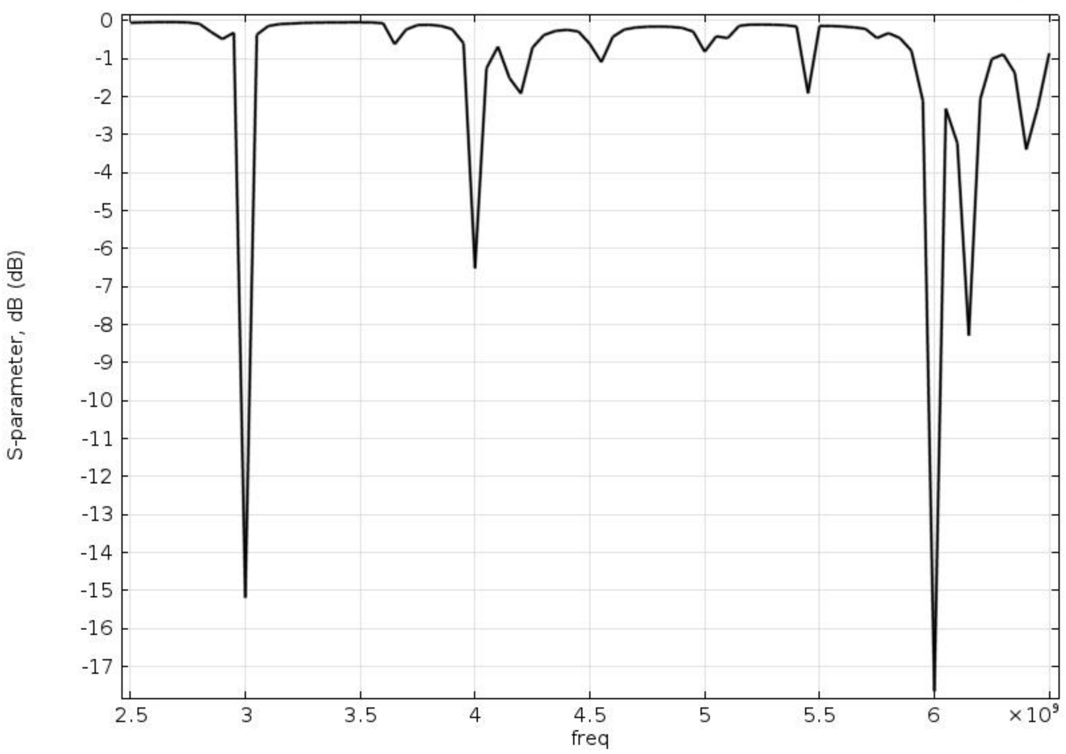


Fig. 6. Insertion loss versus resonant frequencies for the first antenna structure at (ε_r=3.5)

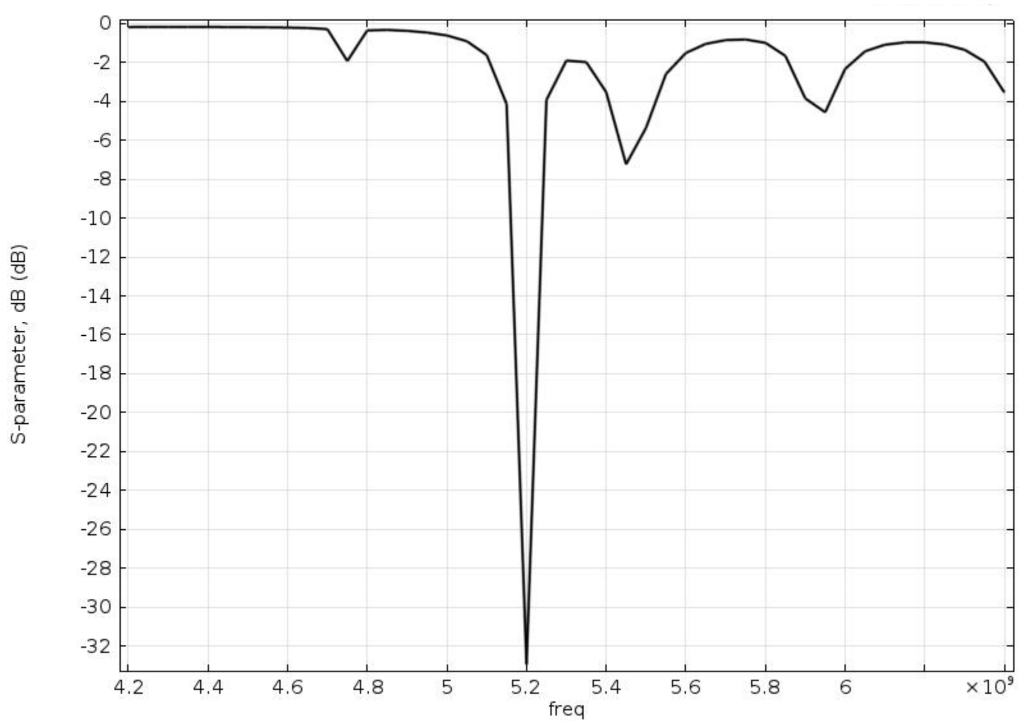


Fig. 7. Insertion loss versus resonant frequency for the second antenna structure at (ε_r=2.7)

5. CONCLUSION

In this paper, two geometric structures of microstrip antenna are designed. Each structure has a single patch with a fixed special layout. The desired resonant frequency can be get by controlling the substrate permittivity. The range of permittivity are varied between 2.5 to 6.3. The results show that changing the permittivity over the range mentioned produces more than fifteen and twenty resonant frequencies for the first and second antenna, respectively. The range of obtained frequencies lie between 1.5 to 5.5 GHz which cover the WiFi, WiMax network standards and cognitive radio applications.

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