Antenna Design for Ultra Wideband Application Using Stacked Multiresonator Patches

Yashar Zehforoosh
Urmia University
Department of Electrical Engineering
St-y.zehforoosh@mail.urmia.ac.ir

Dr. Changiz Ghobadi
Urmia University
Department of Electrical Engineering
Ch.ghobadi@mail.urmia.ac.ir

Dr. Javad Nourinia
Urmia University
Department of Electrical Engineering
J.nourinia@mail.urmia.ac.ir

Abstract

As wireless communication applications require more and more bandwidth, the demand for wideband antennas increases as well. For instance, the ultra wideband radio (UWB) utilizes the frequency band of 3.1-10.6 GHz .This paper presents some of the work carried out within ULTRAWAVES in the area of antenna design and analysis. Two antennas have been designed, optimized and simulated using Stacked Multiresonator patches. In addition results and conclusions are presented.

1. Introduction

Ultra Wideband Radio (UWB) is a potentially revolutionary approach to wireless communication in that it transmits and receives pulse based waveforms compressed in time rather than sinusoidal waveforms compressed in frequency [1]. This is contrary to the traditional convention of transmitting over a very narrow bandwidth of frequency, typical of standard narrowband systems such as 802.11a, b, and Bluetooth. This enables transmission over a wide swath of frequencies such that a very low power spectral density can be successfully received [2]. The recent allocation of the 3.1-10.6 GHz frequency spectrum by the Federal Communications Commission (FCC) for Ultra Wideband (UWB) radio applications has presented a myriad of exciting opportunities and challenges for antenna designers [3]. Pulsed UWB, by definition, refers to any radio or wireless device that uses narrow pulses (on the order of a few nanoseconds or less) for sensing and communication. This requires sufficient impedance matching, proper return loss and VSWR<2 throughout the entire bandwidth. In this paper, two thin, low profile, small stacked multiresonator microstrip antennas will be presented for UWB application. The bandwidth of a microstrip antenna increases with an increase in substrate thickness and decreases in the dielectric constant also, the bandwidth of the antenna increases when multiresonators are coupled in planar or stacked configurations [6]. In this paper we use a single patch placed in the bottom layer, and multiresonators taken on the top layer. The bottom patch is excited by a coaxial-fed.

2. Effect of Parasitic Patches

A patch placed close to the fed patch gets excited through the coupling between the patches [4][5]. Such a patch is known as a parasitic patch. If the resonance frequencies f_1 and f_2 of these two patches are close to each other, then broad bandwidth is obtained as shown in figure1. The overall input VSWR will be the superposition of the responses of the two resonators resulting in a wide bandwidth [5]. If the bandwidth is narrow for the individual patch, then the difference between f_1 and f_2 should be small as shown in Figure 1. If the bandwidth of the individual patch is large, then the difference in the two frequencies should be large to yield an overall wide bandwidth as shown in Figure2.

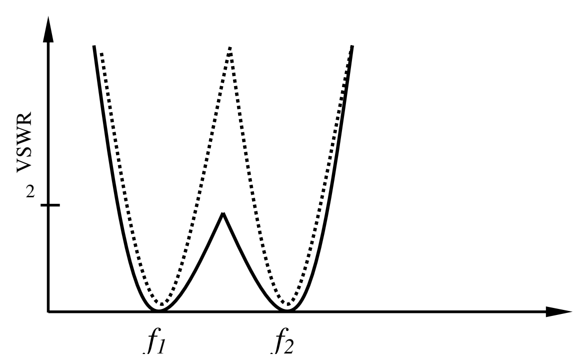

Fig. 1. VSWR plot of two coupled resonators having narrow bandwidth(. . .) individual resonators and(—) overall response

Planar and stacked multiresonators techniques are combined to yield a wide bandwidth with a higher gain. In this paper we use two different configurations for this type of antennas.

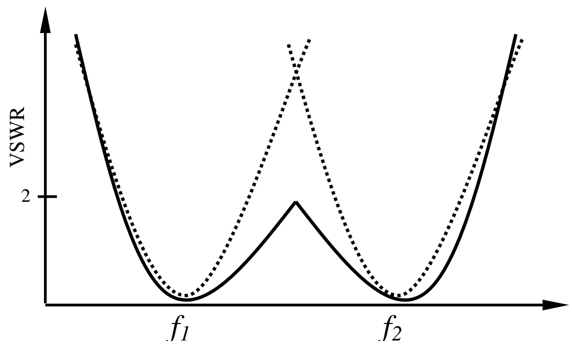

Fig. 2. VSWR plot of two coupled resonators having wide bandwidth (. . .) individual resonators and (——) overall response.

In first antenna we used a configuration with two dielectric layer and placed three patch on the top layer and one patch at the bottom of the top later(shown in Figure3) and in the second antenna we placed four patches on the top layer and one at the bottom of the top layer(shown in Figure7).

3. Antenna design

In this paper we introduce two microstrip patch antennas use stacked multiresonator patches. The first antenna has one rectangular patch at the bottom and three patches on the top exciting the bottom patch by coaxial feed. The second one has one rectangular patch at the bottom and four patches on the top exciting the bottom patch by coaxial feed.

3.1 Three rectangular patches on the top and one at the bottom

In this antenna three patches are stacked on the other patch to increase the bandwidth. Only the bottom patch is fed and the top patches electromagnetically coupled as shown in Figure 3. The patch on the bottom layer is shown in dotted lines and the patches on the top layer are shown in solid lines. For the parasitic patch length L_1 =14.4 mm, dielectric thickness between the fed patch and the parasitic patch h = 3 mm, L= 18 mm, h_2 =5 mm, and x= 7.5 mm, the simulated VSWR plot, return loss and gain plots are shown in figures 4, 5 and 6.

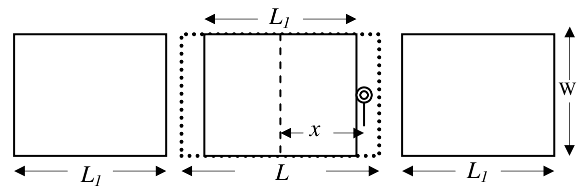

Fig. 3. One patch on bottom layer and three rectangular patches on the top layer

3.1.1 Simulation and Results

The bandwidth of the antenna is 2.05 GHz (40%). The radiation is in the broad side direction, and the variation in the pattern is very small over the entire bandwidth. At 5.07 GHz, the gain is 8.1 dB. As shown in plots the bandwidth and return loss are proper for ultra wideband applications and antenna dimensions are suitable for mobile devices.
The related figures and plots are shown below.

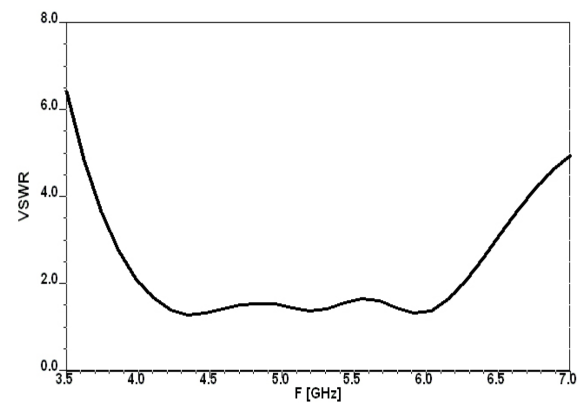

Fig. 4. VSWR plot of antenna with three patches on top layer.

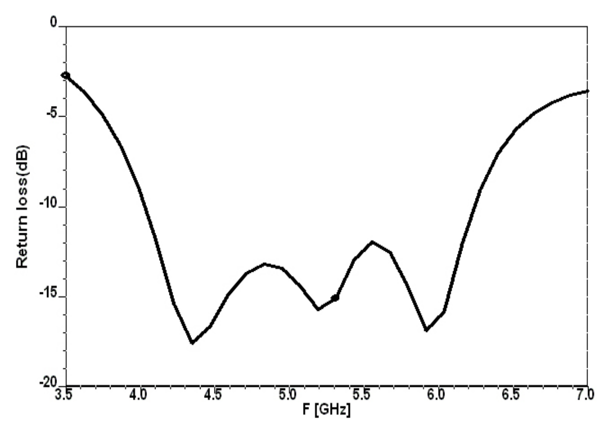

Fig. 5. Return loss plot of antenna with three patches on top layer.

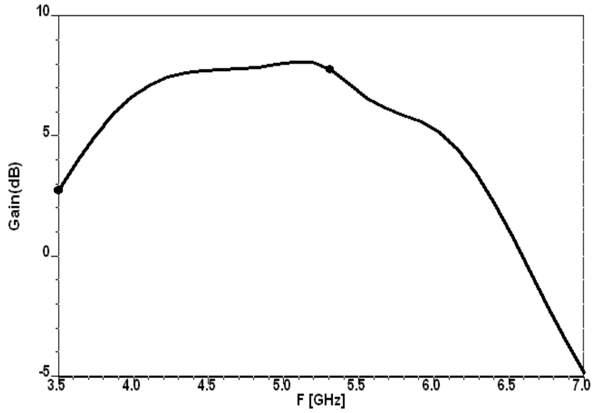

Fig. 6. Gain plot of antenna with three patches on top layer

3.2 One Rectangular Patch at the Bottom and Four Patches on the Top

Instead of three rectangular patches on the top layer, four patches on the top layer are considered as shown in figure 7. Two patches of the top layer of the antenna are displaced from the feed axis along the width of the fed patch, and another two patches are symmetrically with respect to the feed axis. All the top four patches are chosen to be identical for a symmetrical radiation pattern. Also, the width W1 of the top patches is reduced as compared to the bottom patch. Because the top patches are getting fed along the diagonal from the bottom patch, and if W1 is comparable to L1 then the orthogonal mode of the top patch will also get excited. The number of parameters that are to be optimized are increased; these are length *L1* and width *W1* of the top patches and offsets along the *x*- and *y*-axis.
The optimized values of the antenna are given in table 1.

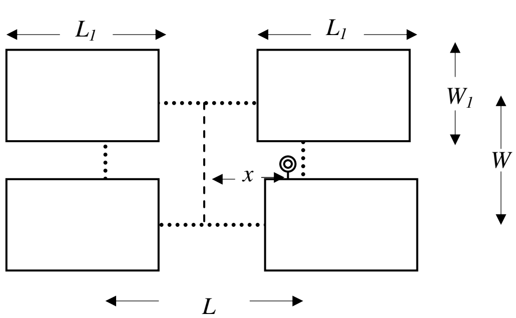

Fig. 7. One rectangular patch on the bottom layer and four patches on the top layer

3.2.2 Simulation and Results

The bandwidth of the antenna is 3.21 GHz and the return loss in 4.21GHz is –22dB. Other information are shown in the plot below.

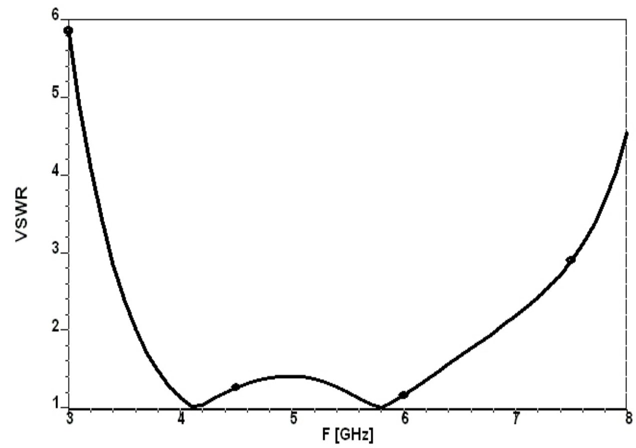

Fig. 8 VSWR plot of antenna with four patches on top layer.

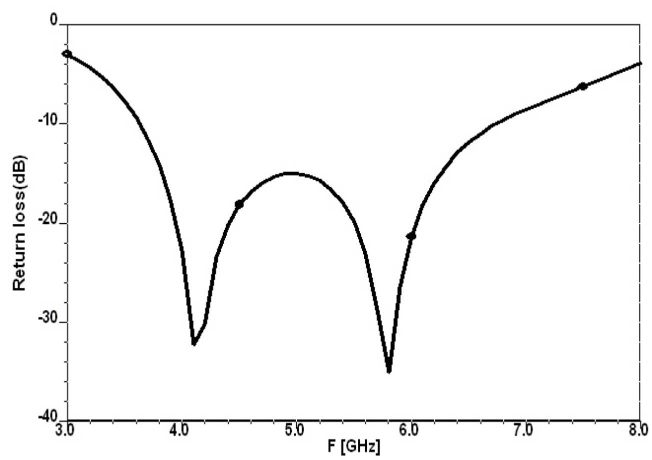

Fig. 9 Return loss plot of antenna with four patches on top layer

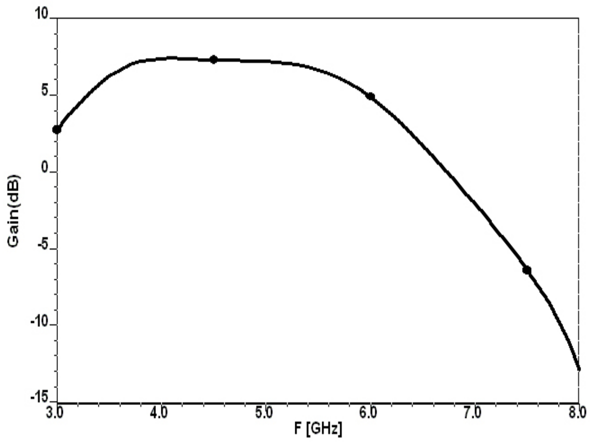

Fig. 10. Gain plot of antenna with four patches on top layer

4. Discussions

In this paper two different multilayer antennas are presented and their results and charts are mentioned. As you can see different bandwidths, return loss, and VSWR are obtained. Also different dimensions have been used for these antennas that prepare them for mobile applications. By a simple comparison between these two antennas this table will be derived:

Table 1
Comparison between two antennas

Antenna	Antenna with Three Parasitic Patches	Antenna with Four Parasitic Patches
Thickness	9.9 mm	11 mm
VSWR (bandwidth)	2.05 GHz	3.2 GHz
Dielectric	Rogers RT	Duroid
Max Gain	8.1 dB	7.4 dB
Physical Profile	47mm×11mm	41mm×22mm

Future work with regard to Ultra wideband antenna design includes reducing size and obtaining bandwidth up to 6 GHz with larger gain and lower VSWR.

5. Conclusions

In this paper, two new small stacked multiresonator microstrip antennas for ultra wideband applications are designed, simulated and compared. There was a great success in finding a suitable structure for mobile applications. Also obtaining bandwidth about 50% and maximum gain about 8 dB shows that this structure can be mentioned as a useful design for ultra wideband products. However acquired results show that the antenna design and structure need more refinement in order to achieve the ultimate design with a smaller physical profile and better performance.

9. References

[1] G. R. Aiello and G. D. Rogerson, "Ultra Wideband Wireless Systems," *IEEE microwave magazine*, pp. 36-47, June 2003.
[2] H. L. Bertoni, L. Carin, and L. B. Felsen,Eds., *Ultra-Wideband, Short-Pulse Electromagnetics*. New York: Plenum, 1994.
[3] First Report and Order (FCC 02-48). Action by the Commission February 14, 2002. New Public Safety Applications and Broadband internet access among uses envisioned by FCC authorization of Ultra-Wideband Technology.
[4] Stutzman, Antenna Theory and Design, 2nd ed., Wiley, New York, 1998
[5] G. Kumar, K.P. Ray, "Broadband Microstrip Antennas" *, Artech House, Inc*., Boston, 2003.
[6] J. R. James, and P. S. Hall, Handbook of Microstrip Antennas, vol. 1, London: Peter Peregrinus Ltd., 1989.