ASIAN JOURNAL OF PHARMACEUTICAL AND CLINICAL RESEARCH

Special Issue (April)

Online - 2455-3891
Print - 0974-2441

Full Proceeding Paper

MINIATURIZED MULTIBAND MULTIPLE INPUT MULTIPLE OUTPUT ANTENNAS FOR WIRELESS APPLICATION

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Received: 19 January 2017, Revised and Accepted: 20 February 2017

ABSTRACT

The objective of this paper is to design a miniaturized and multiband multiple input multiple output (MIMO) antenna using slotting technique which can be used for many devices such as cell phones and microwave radio relay. The MIMO antenna module consists of four microstrip antennas which are arranged in two MIMO antenna pairs. Reduction in size, multi-broadband, moderation in gain, and good efficiency are obtained. The main aim is to reduce mutual coupling while optimizing the antenna size. The present work would be aimed at designing an antenna which is used mainly for wireless applications

Keywords: Multiple input multiple output, Wireless, Miniaturization, Multi-broadband, Slot.

 DOI: http://dx.doi.org/10.22159/ajpcr.2017.v10s1.19640

INTRODUCTION

Multiple input multiple output (MIMO) technology is widely used for wireless applications. It is an antenna technology which consists of several antennas which are situated on a single motherboard at both the transmitter section and the receiver sections [1-4]. This provides greater capacity for data flow, higher feed, and increased link reliability. With the available bandwidth, MIMO antennas increase the maximum rate, at which data can be sent. This causes it to be breakthrough in the wireless department where increased capacity and spectral efficiency are vital. This article discusses the ways, in which we can incorporate four different frequencies in a single antenna and its effects on the wireless devices. The antenna design proposed here takes in two antennas, each of different designs and incorporates them in a single module to have three to four frequencies radiating from it.

LITERATURE REVIEW

Novel compact and Dual-Broadband Microstrip MIMO antennas for wireless applications: This paper consists of two MIMO antenna modules with one antenna resonating at 5.2 GHz and the other at 5.8 GHz. This is very useful in wireless applications [1]. MIMO antenna using resonance of ground planes for LTE mobile application: use of MIMO antennas for LTE mobile applications using resonance of ground planes [3,5].

Common elements wideband MIMO antenna system for Wi-Fi/LTE access point applications: modification of ground plane of the common elements wideband MIMO antenna system by introducing four slots in each corner of the ground plane thereby reducing mutual coupling [3]. A novel multiband planar antenna for GSM/UMTS/LTE/Zigbee/RFID mobile devices: design of multiband two-strip monopole and meandered antenna which occupies a very compact area but gives −42% at 900 MHz bandwidth and −53% at 1900 MHz [4].

MINIATURIZATION TECHNIQUES

Antenna is a necessary device when it comes to small or hand-held devices form an engineering point of view. However, for the designers, the antenna is a component that must be made as small as possible. Therefore, antenna miniaturization techniques are used to reduce the physical length while increasing or keeping the electrical length constant. It is also used to have higher radiation efficiency and higher bandwidth.

There are three types of miniaturization techniques [5].

Meandering techniques
It is a technique of antenna miniaturization in which are intended to reduce the resonant length of the antenna while increasing the electrical length.

Fractal techniques
It is a miniaturization technique which uses a fractal, a self-similar design to maximize the electromagnetic radiation in the given surface area.

Cutting slots
It is the technique where a hole or a slot is cut from the main patch antenna and the slot radiates the electromagnetic waves in a similar fashion to dipole antennas. The slots determine the driving frequency and the radiation distribution pattern.

EXPERIMENTATION AND ANALYSIS

The following methodology has been used in designing the MIMO antenna:
1. The design for the formal patch antenna is made. Then, the design of first antenna is designed.
2. The design is implemented with the slits and correct length of the feed line to have 50 ohm feed.
3. The design of the second antenna is similarly considered and implemented to work in the desired frequency range.
4. The designs of both the antennas are considered and consolidated and the slits are introduced in the ground plane to direct the flow of the current. The slits are rectangular in shape and very thin.
5. The antenna design is simulated and the results are then taken.

Basic antenna design and description
The conventional patch antenna is shown in Fig. 1. This antenna patch is mounted on an FR-4 substrate. Patch and substrate sizes are chosen to be small in size. The patch and the ground plane are reconfigured and resized to tune to the desirable frequencies. Here, two different designs of the conventional antenna are shown.

$$Z_0=\begin{cases}-\dfrac{60}{\sqrt{\mu_e}}\ln\left(\dfrac{8d}{W}+\dfrac{W}{4d}\right)\text{for } W/d\le 1\\ -\dfrac{120\pi}{\sqrt{\mu_e}\left[W/d+1.393+0.667\ln(W/d+1.444)\right]}\text{for } W/d^{3}1\end{cases}$$

$$\mu_e=\frac{\mu_r+1}{2}+\frac{\mu_r-1}{2}-\frac{1}{\sqrt{1+12d/W}}$$

Height of substrate = 1.6 mm
Height of patch = 0.035 mm
Permittivity = 4.8 [5].

Antenna design I

The first antenna is a conventional antenna with a rectangular slot in the patch for the antenna to work in the desirable frequency range. The radiating edge of the patch is symmetric. The design and dimensions are chosen to be useful for applications in higher frequency [6-8]. The feed provided is 50 ohms and the length of the feed is adjusted accordingly as shown in Fig. 1.

Antenna design II

The latter antenna module design consists of a conventional antenna with a rectangular slit in the ground plane to reduce the physical length of the electrical path while keeping the effective path essentially the same [9,10]. Another rectangular slit along non-radiating edge has been introduced in the patch through slotting techniques which would allow the electrical length to increase while keeping the physical length same as shown in Fig. 2.

Final antenna design

The final MIMO antenna module design consists of both the former designs consolidated into one single antenna unit. Each antenna is placed orthogonal to each other and thin rectangular slots have been introduced in the ground plane so to increase the electrical length as shown in Fig. 3.

RESULTS AND DISCUSSION

The results are that the first antenna module operates at two frequencies and the second also at two frequencies. The S parameters are observed and optimized. The entire MIMO antenna resonates at four frequencies. It can be plainly seen that the current occurs on near the slot in the patch due to skin effect. It has also been noticed that the effect of digging slots in the ground plane results in the reduction of frequency range which is what is required for the antenna to be operational in the desired frequency range (Figs. 4-6). The current density distribution is also presented here. The current distribution is shown in Figs. 7 and 8.

Current density

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Frequency analysis

Results from the Figs. 4 and 5 are tabulated below in Table 1.

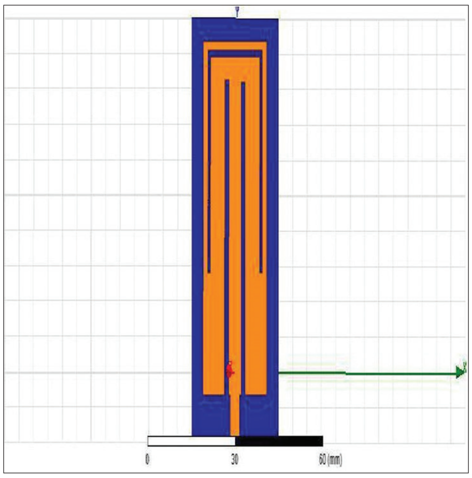

Fig. 1: Antenna design I

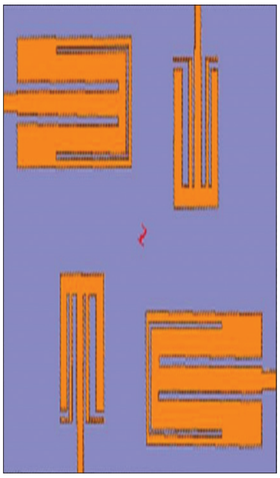

Fig. 3: Final antenna design

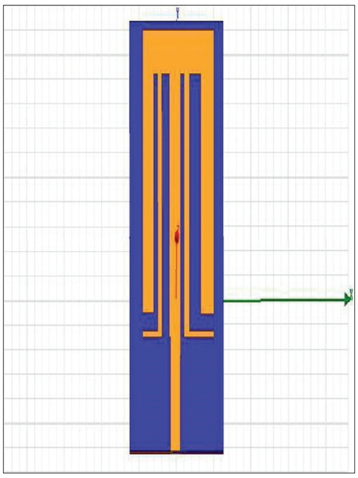

Fig. 2: Antenna design II

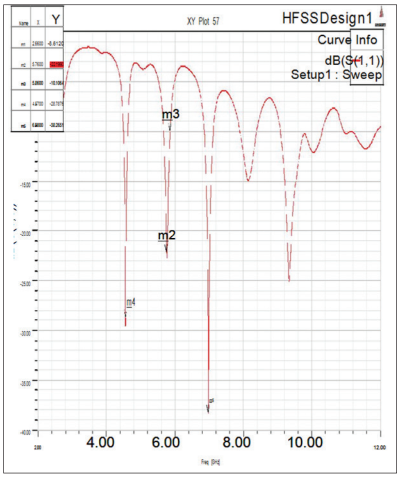

Fig. 4: S (1,1) of the first antenna

Table 1: List of frequencies and their applications

Frequency (GHz)	Application
2.6	Weather radar
3.4	WiMAX
5.8	Mobile, FS, Wi-Fi
6	FS, FSS

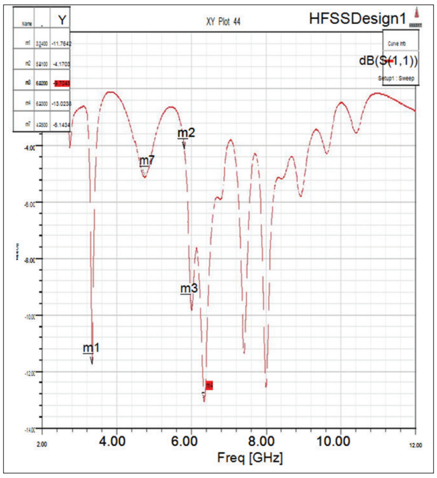

Fig. 5: S (1,1) of the second antenna

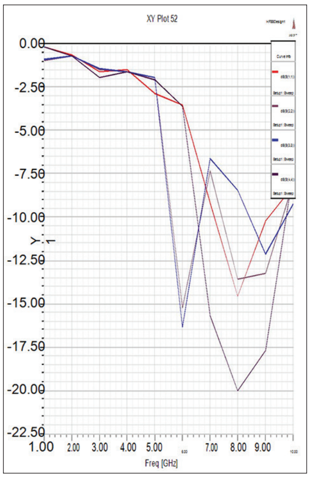

Fig. 6: S parameters of all the four antennas

The frequencies of the final antenna consist of merging of the initial two designs of antenna, where each one of them is placed in an orthogonal way so as to reduce the mutual coupling. After combining and optimization, the result is shown in the form of graph where the S parameters of all the individual antennas are plotted, especially the S (1, 1) parameters.

CONCLUSION

It is found that the first antenna structure in the MIMO setup has higher frequencies when compared to the second antenna structure and the entire module operates at different frequencies. The MIMO structures have been designed in such a way so as to resonate in multiple frequencies. This is particularly useful for wireless devices, such as Zig bee and Wi-Fi, which operate at lower frequencies and for whether and radar satellites which operate at the frequencies in higher spectrum.

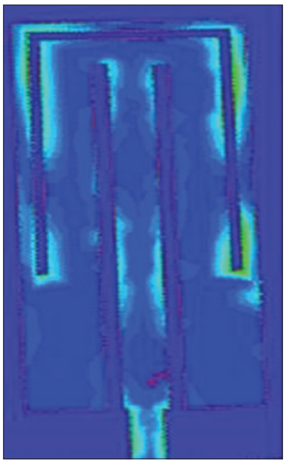

Fig. 7: Current density distribution of the first antenna design at 5.8 GHz

Fig. 8: Current density distribution of the first antenna design at 3.4 GHz

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