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New Dual-Frequency Microstrip Antennas for Wireless Communication

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Abstract. The investigations on two new short-circuited microstrip patch antennas, which are able to radiate dual frequencies at GPS and Bluetooth frequency bands, are reported. One of these antennas is combination of two square patch sections and the other is combination of two circular patch sections, both of which are grounded by shorted pins. Using these antennas, by properly choosing the positions of shorted pins, good impedance matching can be obtained at both the frequencies. The dual frequency natures of the shorted patchs, theoretically obtained using IE3D software, are verified by measurement.

Keywords: microstrip antenna, short-circuited, dual-frequency, gain, wireless communication.

1. Introduction

The increasing use of wireless communication systems demands the antennas for different systems and standards with properties like compact, broadband, multiple resonant frequencies. Because of many attractive features, microstrip patch antennas have received considerable attention for mobile communication handset terminals. In wireless communications, for different systems and standards different frequency bands are allocated, two of which are Global Positioning System (GPS, 1.575 GHz Band) and Bluetooth (2.4 GHz Band). The challenge is to design reduced size and moderate gain multi-frequency antenna for wireless terminals.

There are several techniques to reduce the size of microstrip antennas at resonant frequencies. Using microwave substrate of high dielectric constant, patch dimension can be reduced, but the antenna shows poor efficiency due to surface wave generation.

Edge-shorted patches using shorting wall or shorting plate can lower the physical dimensions of a microstrip patches. Further lowering of antenna dimension is possible using shorting pin at the proper position and by using shorting-pin loaded technique, antenna size reduction of about 89% can be achieved [11]. Also slot loaded patches are used to design small microstrip antennas.

In this paper, the investigations on two new short-circuited microstrip patch antennas, which are able to radiate dual frequencies at GPS and Bluetooth frequency bands, are reported. The geometry of the short-circuited square microstrip patch antenna and short circuited circular patch antennas are shown in Fig. 1 and Fig. 2 respectively. The theoretical and experimental investigations on this type of rectangular microstrip patch, without short circuiting, has been reported by one of the authors [8] of this paper which can be used for four resonance frequencies. But since the feed position of that patch is fixed, impedance matching for all the four frequencies are very difficult and may not possible. A short circuited microstrip antenna reduces the size of the patch, lowering the gain of the antenna and almost all the characteristics depend on the position of the shorted post [10, 6, 5, 7, 2, 11, 9, 4]. Thus the drawback of impedance matching of the multi-frequency microstrip antenna [8] is solved by using short-circuited posts and varying positions of two shorted posts of the two sections of the patch as shown in Fig. 1 and Fig. 2.

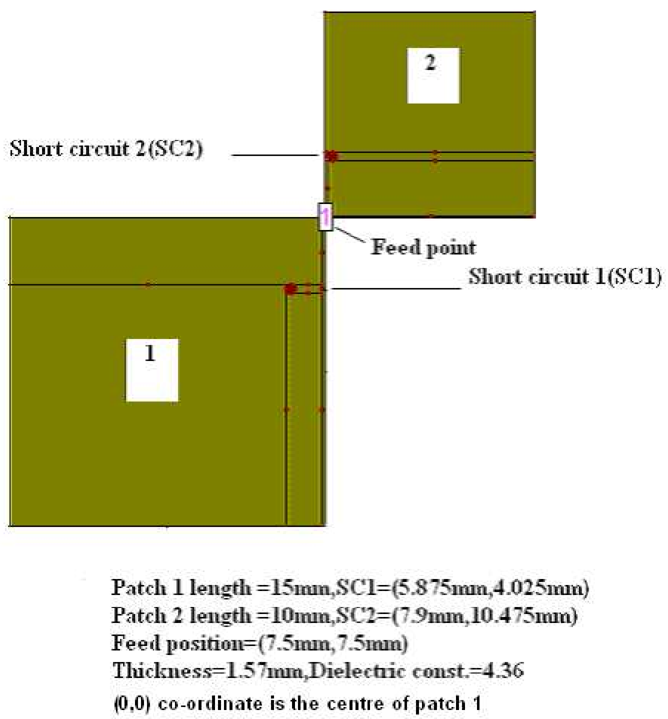

Fig. 1. Short circuited square dual-frequency microstrip antenna.

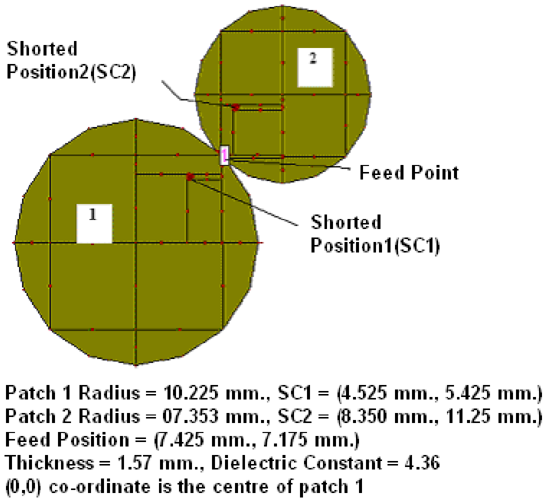

Fig. 2. Short circuited circular dual-frequency microstrip antenna.

2. Computed and Measured Results

The Method of Moment using IE3D software is used for the analysis and design of the short circuited dual-frequency microstrip antenna. The antenna was fabricated on Glass Epoxy substrate with dielectric constant 4.36 and height 1.57 mm and measurement was done using Vector Network Analyzer (N5230A, Agilent Technologies). The antennas were fed by SMA connectors at the common corner of the two patches as shown in Fig. 1 and Fig. 2 and the section 1 and section 2 of the antennas were short circuited using very thin copper wires (of about 0.2 mm diameter). The one end of the shorted wire was connected with the patch and the other end was connected with the ground plane. The positions of the shorting posts were determined using Genetic Algorithm (GA) optimizer of IE3D software.

The computed return losses of dual-frequency shorted square microstrip antenna and shorted circular microstrip antenna are shown in Fig. 3 and Fig. 4 respectively. The size of the antenna structures and the positions of the short circuited posts are adjusted in such a way that both the antennas resonate at GPS (1.575 GHz) and Bluetooth (2.4 GHz) frequency bands. The return losses in these two frequency bands are less than −25 dB and these impedance matching are done by varying the position of shorted posts in the two sections of the patches. The two resonant frequencies are due to the two different resonant frequencies of two square sections (Fig. 1) and two circular sections (Fig. 2) of the antennas having different patch dimensions. The lengths of square section 1 and square section 2 were 15 mm and 10 mm respectively. The computed gains of the antenna at 1.575 GHz and 2.442 GHz were 3.4 dBi and 3.1 dBi respectively. The radii of circular section 1 and circular section 2 were 10.225 mm and 7.353 mm respectively and the computed gains of the antenna at 1.575 GHz and 2.442 GHz were 2.9 dBi and 2.4 dBi respectively. At both the frequencies the antennas show broadside radiation patterns. The antennas are linearly polarized antennas. The gains of the antennas can be improved either by increasing the size of the antenna or by using dielectric layer on the top of the patch [1, 3]. The computed and measured results are compared in Table 1 and in Table 2. As mentioned above, both the square and circular dual-frequency patches, fabricated on glass epoxy substrates, were short circuited using thin copper wires of about 0.2 mm diameter. Using drill machine, very narrow hole was created between radiating patch and ground plane and through the dielectric substrate. Then the copper wire was inserted into the hole, one end of the wire is soldered with the patch and the other end was soldered with the ground plane. The difference between computed and measured results are due to the fact that shorting using thin wire can not be perfect short and practically it is very difficult to short at the exact short circuit positions as obtained by computation.

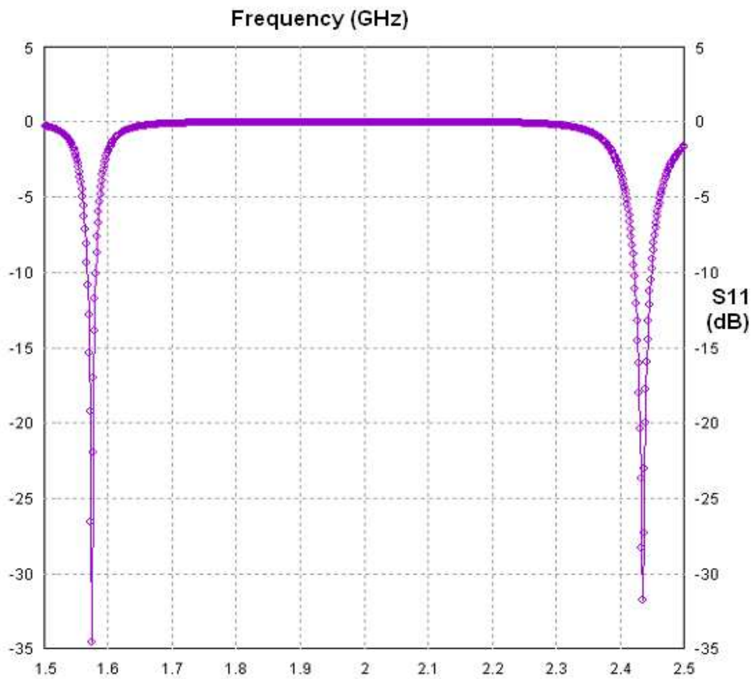

Fig. 3. Computed return loss of square dual-frequency microstrip antenna.

Table 1. Comparison between computed and measured results for square dual-frequency microstrip antenna (Fig. 1)

	Reso. Frequency [GHz]	1:2 VSWR Bandwidth	Reso. Frequency [GHz]	1:2 VSWR Bandwidth
Computed Results	1.575	20 MHz	2.442	35 MHz
Measured Results	1.510	30 MHz	2.410	42 MHz

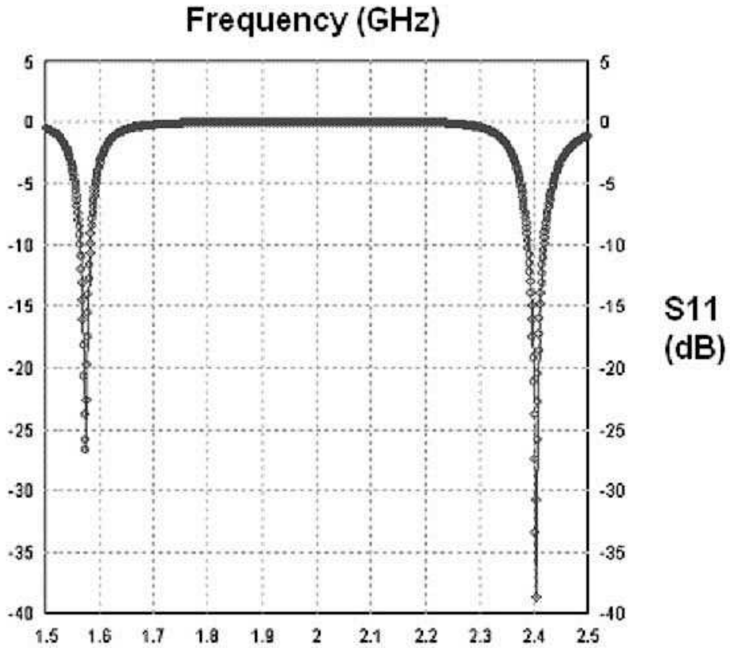

Fig. 4. Computed return loss of circular dual-frequency microstrip antenna.

Table 2. Comparison between computed and measured results for circular dual-frequency microstrip antenna (Fig. 2)

	Reso. Frequency [GHz]	1:2 VSWR Bandwidth	Reso. Frequency [GHz]	1:2 VSWR Bandwidth
Computed Results	1.575	18 MHz	2.442	28 MHz
Measured Results	1.525	27 MHz	2.415	36 MHz

The computed radiation patterns of shorted circular microstrip antenna at 1.575 GHz band and 2.4 GHz band are plotted in Fig. 5 and Fig. 6 respectively.

3. Conclusion

Theoretical and experimental investigations on new short-circuited dual-frequency microstrip antennas are reported. The resonance frequency and impedance matching depend on the positions of shorted posts. The results are supported by measurements. The antennas can be used for multi-band wireless communications.

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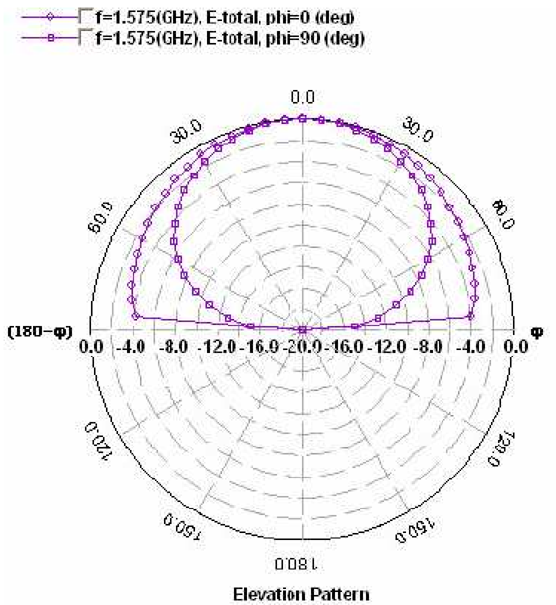

Fig. 5. Computed radiation pattern of circular dual-frequency microstrip antenna at 1.575 GHz band.

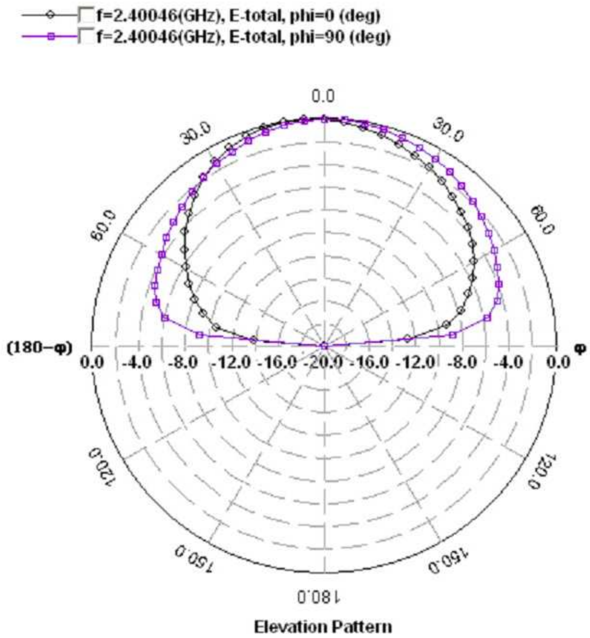

Fig. 6. Computed radiation pattern of circular dual-frequency microstrip antenna at 2.4 GHz Band.

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