

Dual Band Planar Antenna for GSM and WiMAX Applications with Inclusion of Modified Split Ring Resonator Structure

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Abstract—This paper presents a dual-band microstrip antenna for Global System for Mobile Communications (GSM) and Worldwide Interoperability for Microwave Access (WiMAX) applications. The split ring resonators structure driven antenna operates at 900 MHz and 3.3 GHz, respectively. Return losses achieved at the two resonance frequencies are 22.26 dB and 18.97 dB, respectively. The proposed antenna is developed on a cost-effective FR-4 substrate with relative permittivity 4.4, tangent loss 0.002, and partial ground plane. The bandwidths of the proposed antenna are 3.01% and 4.26%, respectively. The design and fabrication procedure along with both simulated and measured results are presented and discussed in this paper. Designed antenna delivers good performance and solution for both applications.

1. INTRODUCTION

Global system for mobile is a second generation cellular standard developed to create voice services and data delivery using digital modulation. It is a Time Division Multiple Access-based wireless network technology [1]. The wireless providers use individual radio frequencies multiple times by dividing a service area into separate geographical zones, or cells, each cell requires its own radio transmitter/receiver antenna. GSM networks operate in different frequency ranges in different countries around the world. Most GSM networks operate in the 900 MHz or 1800 MHz bands in Asia and Europe. Global System for Mobile Communication is used with mobile access devices. It is a globally accepted standard for digital communication. European mobile cellular radio system operating at 900 MHz [1, 2].

Physically smaller size of the antenna is the need of recent technologies which enable wireless communication to be fast and cost-effective. Antenna size is obviously a major factor that limits miniaturization. Wi-MAX technology is one of the rapidly growing technologies in the modern wireless communication. This gives users the mobility to move around within a broad coverage area and still be connected to the network. This provides greatly increased freedom and flexibility [3–6]. For a home user, wireless has become popular due to ease of installation and location freedom. A properly miniaturized antenna will improve transmission and reception, reduce power consumption, and improve the marketability of communication devices [6, 7].

Split ring resonators (SRRs) playing a major role for dual frequency band performance with miniaturization [8] of antenna and expected bandwidth requirement at targeted frequencies [8, 9]. Rings of SRR and the size of slots of each ring are restricted to some frequency bands in result [10, 11]. Antennas and metamaterials are always designed and worked separately for the improvement of scattering parameters and radiation of antenna [12, 13]. Slotted electromagnetic band-gap cells are used as a parasitical parameter to improve the gain and bandwidth with a modified structure of patch [14, 15].

The printed planar antenna, which is fabricated on a single sheet of an FR4 substrate, has the advantages of low profile, low production cost, and less complex fabrication. With these advantages,

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the printed planar antenna is an optimal choice for a manufacturer. Hence, microstrip antennas are chosen for GSM application. However, microstrip antennas suffer from bandwidth limitations [16, 17]. The bandwidth can be increased by adding lossy elements, but it affects the efficiency of the antenna [18–20].

In this paper, a dual-band microstrip patch antenna for GSM and WiMAX application is designed and simulated. The proposed patch antenna resonates at the frequencies of 900 MHz and 3.3 GHz, respectively.

2. ANTENNA GEOMETRY

The geometry of the proposed antenna is shown in Fig. 1. The patch is printed on an FR4 epoxy substrate with dimension $50 \text{ mm} \times 40 \text{ mm}$, having relative permittivity 4.4 and thickness 1.6 mm, which is fed using a transmission line having an impedance of 50Ω . Dimensions are tabulated in Table 1. The substrate dimension of the proposed antenna is $50 \times 40 \text{ mm}^2$. The partial ground plane is utilized to increase the antenna bandwidth whose dimension is $25 \times 40 \text{ mm}^2$ shown in Fig. 1(c). Slots in the form of Split Ring Resonators [SRR] are introduced. The dimensions of SRR are shown in shown in Fig. 1(b).

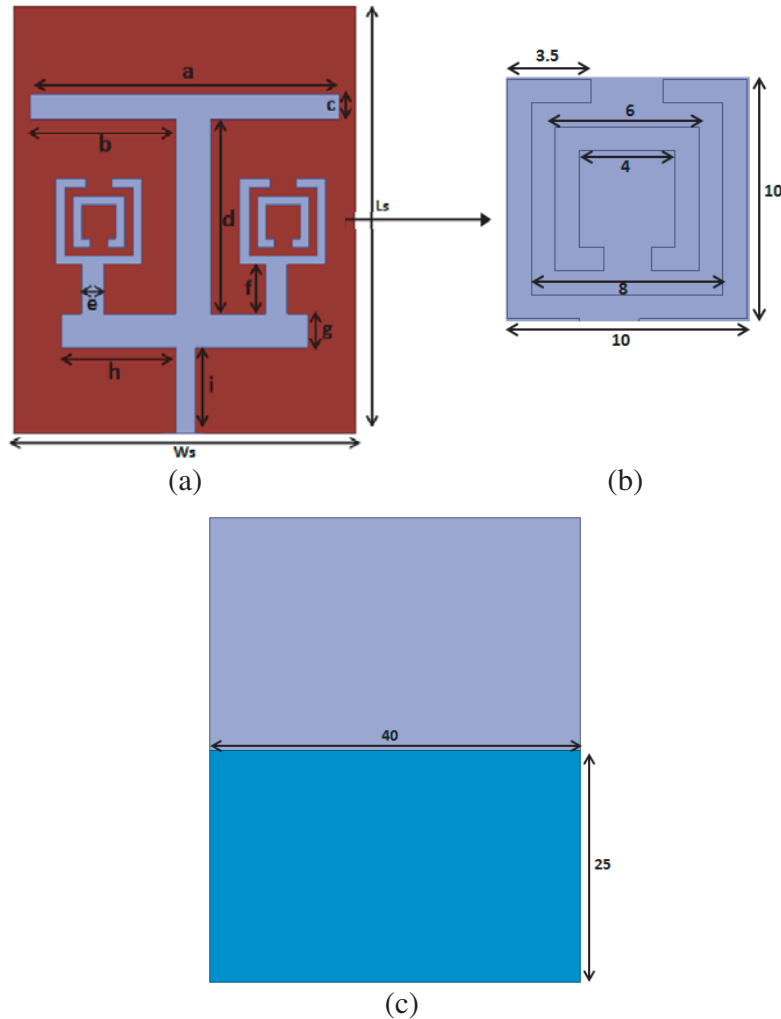


Figure 1. Geometry of proposed antenna. (a) Microstrip patch. (b) Unit cell. (c) Partial ground plane.

Table 1. Antenna physical dimensions (All dimensions are in mm).

L_s	W_s	a	b	c	d	e	f	g	h	i
50	40	36	16	3	22.8	2.5	5.8	4	13.3	10.1

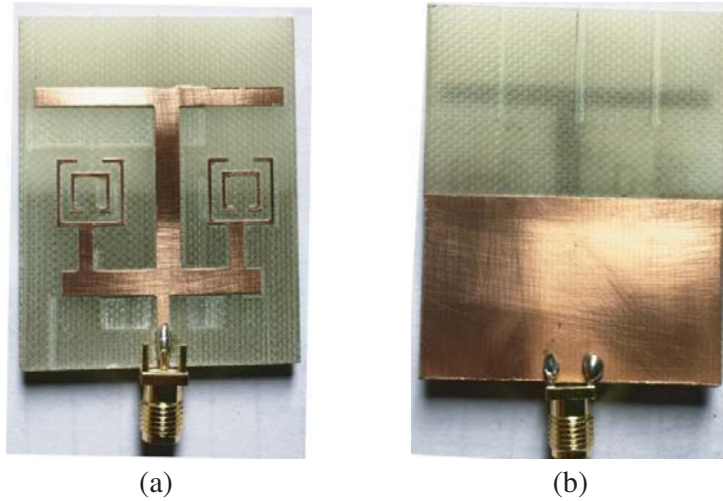


Figure 2. Fabricated prototype of proposed antenna. (a) Top view. (b) Bottom view.

Figure 2 illustrates the fabricated prototype of proposed antenna using a PCB fabrication machine. Patch in the top view and partial ground plane are clearly visible on the fabricated prototype antenna.

3. RESULTS & DISCUSSION

The antenna parameters are analyzed using FEM based HFSS Simulator. Return loss measurement of the antenna is measured using Keysight Vector Network Analyzer N9912A, and radiation pattern measurement is carried out in an anechoic chamber.

Figure 3 illustrates simulated and measured return losses at 900 MHz which are 22.26 dB and

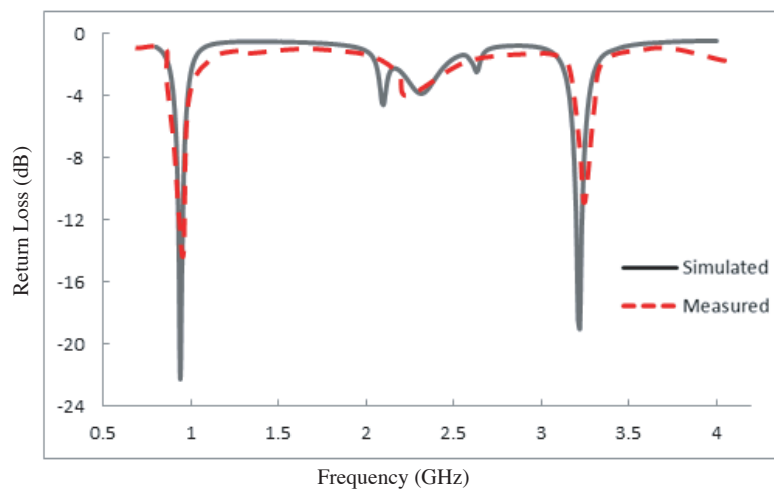


Figure 3. Simulated and measured return loss.

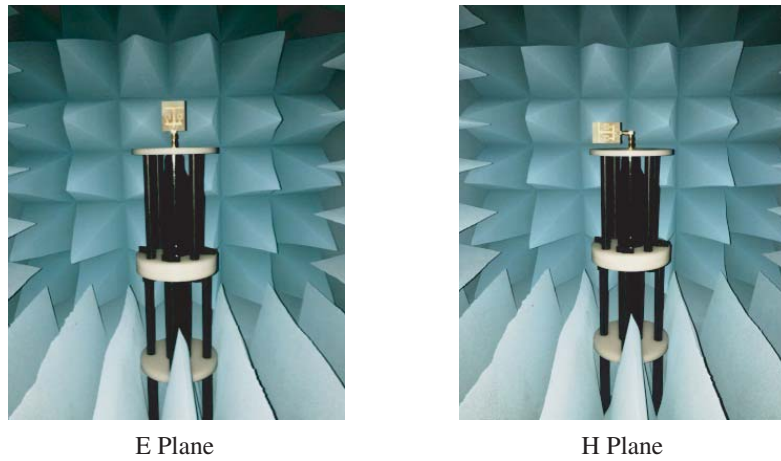


Figure 4. Antenna measurement in anechoic chamber.

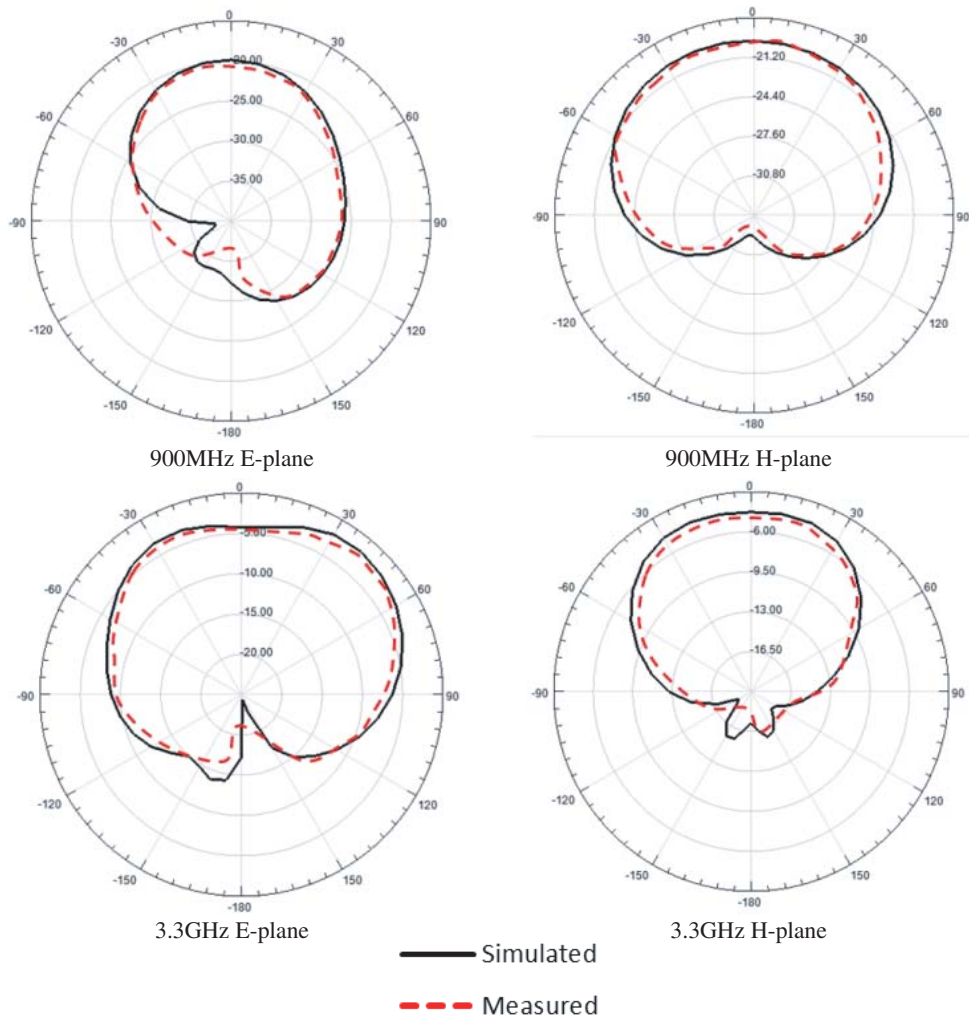


Figure 5. Radiation patterns at resonance frequencies.

15.87 dB while at 3.3 GHz they are 18.97 dB and 11.71 dB, respectively.

The radiation patterns were measured in an anechoic chamber environment as illustrated in Fig. 4 for both E and H planes. The anechoic chamber is $3\text{ m} \times 3\text{ m} \times 3\text{ m}$ in size. Due to electrical compactness of the proposed antenna, this chamber is suitable for radiation pattern measurement. The simulated and measured radiation patterns for the proposed antenna at the target resonant frequencies, with and without presence of split ring resonator, are shown in Fig. 5.

The radiation characteristics of the proposed antenna are studied through simulator. The simulated radiation patterns at the frequencies 900 MHz and 3.3 GHz are shown in Fig. 6. The simulated results show good similar radiation pattern in the E and H planes.

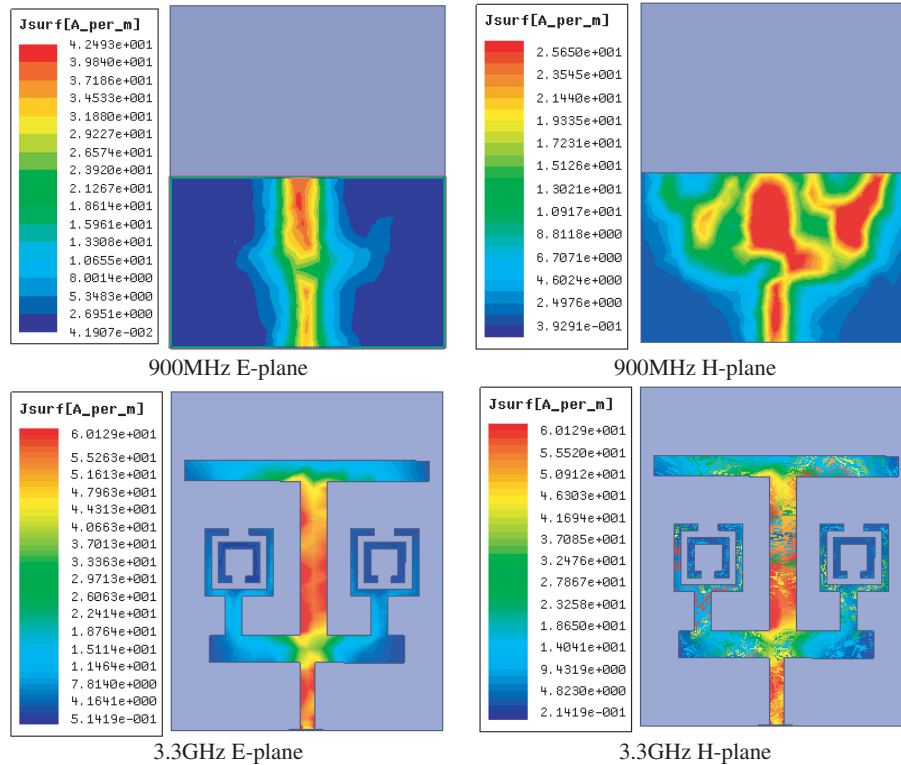


Figure 6. Current distribution at resonance frequencies.

The figure illustrates the current distribution at the partial ground plane and at microstrip patch antenna. At the front side where modified SRR is placed, a higher amount of current density is visible due to lossy nature of SRR.

Table 2. Comparisons of Antenna parameters at resonance frequencies.

Parameters	Return Loss		Impedance Bandwidth	
	Simulated	Measured	Simulated	Measured
900 MHz	22.26	15.87	2.01	1.86
3.3 GHz	18.97	11.71	2.12	1.62

Table 2 shows the comparisons of a few antenna parameters at targeted frequency for simulated and measured results. Due to complex mechanical structure of antenna, a slight difference in the measured results occurs.

4. CONCLUSION

Antennas should have adequate gain and bandwidth for optimal performance of wireless communication devices. The proposed antenna possesses an adequate application for GSM at 900 MHz and for WiMAX at 3.3 GHz target resonance frequency. Satisfactory performance has been achieved in terms of other antenna parameters like return loss, radiation pattern, and current distribution. In addition, the gain and directivity also show good agreement for GSM and WiMAX applications. Partial ground plane plays a major role in higher bandwidth achievement. Modified Split Ring Resonator based microstrip patch offers good current density in the patch region.

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