MICROSTRIP PATCH ANTENNA DESIGN FOR UMTS HANDSETS

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Abstract

In this paper a novel feeding technique is introduced in order to enhance the required bandwidth and reduce the size of a microstrip patch antenna which radiates efficiently in 1900-2200 MHz band for UMTS. Unlike other well-known feeding methods, rectangular radiating patch, which is designed as antenna structure, is fed by coupling of a planar conductive part which shows characteristics of a monopole antenna alone. The designed antenna has 18.3 % (1.88- 2.26 GHz) impedance bandwidth which has the quality of covering UMTS band.

Introduction

UMTS, known as the most popular mobile communication technology, allows high quality sound and data transmission between mobile phones developed for third generation users. Thus, new generation mobile phones provide oral and written communication as well as video calls, video messages, music player, video games, internet, data transfer and even other computer functions as office applications for their users. However, besides these services, the most important feature expected from a mobile phone is being light and low profile. For this reason, the components used in these devices must be designed in small sizes in order not to damage this profile. Since the size of a mobile phone is mostly effected by the antenna type used, mountable antennas are preferred in the technologically improved models. Therefore, microstrip patch antennas (MPA) that can be produced in the intended dimensions with printed circuit board technology are generally used in mobile phones.

In this research, design of a broadband microstip patch antenna which has a resonance around 2.05 GHz center frequency and works efficient in 1900-2200 MHz band for UMTS is achieved. There are several techniques developed to increase the bandwidth of microstrip antennas, such as using a thicker or low dielectric substrate, using some feeding or impedance matching methods[1]. Unlike other well-known feeding methods, rectangular radiating patch, which is designed as antenna structure, is fed by coupling of a planar conductive part which shows characteristics of a monopole antenna alone. Ansoft HFSS software, which is a full-wave electromagnetic field simulation package, is used as a design tool.

Antenna Structure

The complete geometry of the proposed patch antenna is shown in Figure 1, where, an aluminium plate with dimensions of Lg x Wg and thickness of 1 mm is used as a ground plane. A lumped port with 50 Ω impedance is located at equal distance from the side edges and at a distance of L_1 from the shorter edge of the ground plane. Upper

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edge of the lumped port is made touch to the point on a conductive plate with the size of Lb x Wb, while the planar monopole structure, of which dimensions are determined as Lm x Wm, is settled on the edge of this feeding surface perpendicularly, where, Wm is chosen equal to Wb. The distance between ground plane and feeding surface is Hb. In order to achieve coupled-feeding, the rectangular radiating patch with the dimensions of Lp x Wp, is placed above the monopole structure with a distance of Hk. The position of rectangular structure can be shifted along the x-axis by changing the value of L2 parameter. It should be noted that at the first stage of the study a substrate, which is assumed to have the electrical properties of air with relative dielectric permittivity $\varepsilon_{r1} = 1.0006$ and thickness h, is used between radiating rectangular patch and ground plane, then it is changed with FR4 substrate with relative dielectric permittivity $\varepsilon_{r2} = 4.4$ at the second stage of this study in order to reduce the dimensions and thickness, h, of the antenna, which is proportional to the wavelength [2]. The thickness of all conductive sheets at the antenna are about 0.2 mm and copper can be selected as a conductive material. Table 1 indicates the optimized design parameters obtained for the proposed patch antenna with air-like and FR4 substrates.

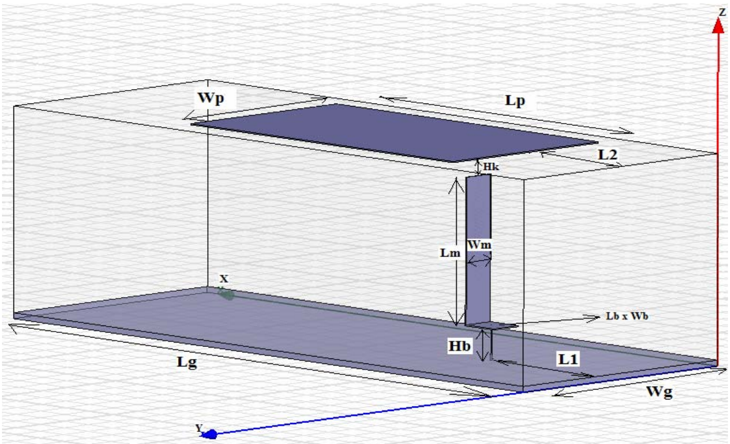


Figure 1: 3D geometry of proposed microstrip patch antenna

Table 1: Design parameters of the proposed microstrip patch

Design Parameters	Values [mm] (with air-like substrate)	Values [mm] (with FR4 substrate)
Lg	107	51*
Wg	40	19*
Hb	5.5	2.5*
L1	27.1	27.1
Lb	6	2.4*
Wb	7	2.4*
Lm	23	6*
Wm	7	2.4*
Lp	54	28.2*
Wp	26	13.3*
Hk	0.8	0.2*
L2	21	4.8*
h	29.3	8.7*

Simulation and Measurement Results

The proposed antenna geometry is designed by using Ansoft HFSS which is a full-wave finite element electromagnetic (EM) simulator [3]. Firstly, the return loss variations obtained via HFSS and by measurement for antenna with air-like substrate are plotted in Fig. 2a and 2b, respectively and as it is clearly observed that the results have similar caharacteristics. Then in Fig. 3 the return loss variation obtained via HFSS for antenna with FR4 substrate is plotted. As it can be seen from the Fig. 2, microstrip patch antenna with air-like substrate exhibits wideband characteristic from 1.49GHz to 2.28 GHz (41.9% impedance bandwidth) for S11 ≤ -10dB threshold level and it covers whole UMTS band (1.9-2.2GHz). However, it is large in size with the dimensions of 107mm x 40mm x 30.5mm and not practical for UMTS mobile handsets. On the contrary, microstrip patch antenna with FR4 substrate covers UMTS band with the operational bandwidth from 1.88GHz to 2.26GHz (18.3% impedance bandwidth) as shown in the Fig. 3 and also has the suitable size of 51mm x 19mm x 9.9mm for mobile handsets.

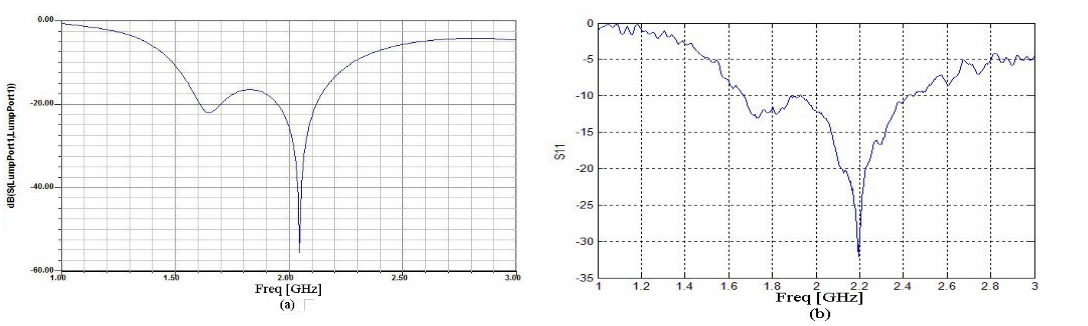


Figure 2: Return loss variations obtained for antenna with air substrate (a) HFSS results (b) Measurement results

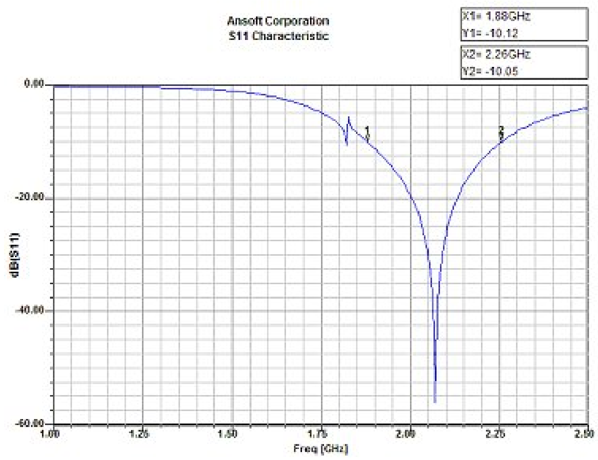
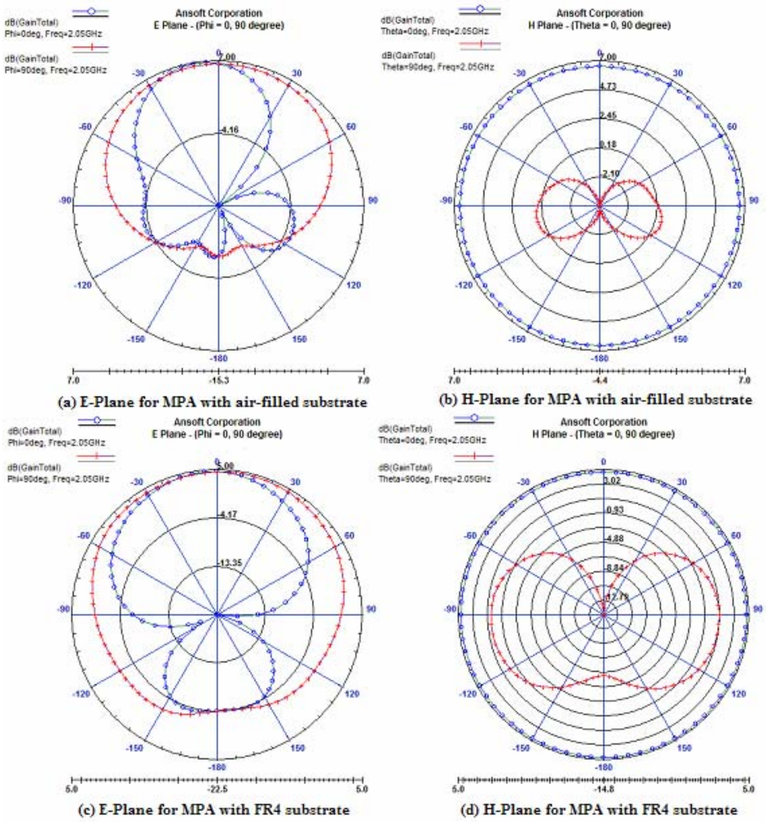


Figure 3: Return loss variation obtained for antenna with FR4 substrate

In Fig. 4 the simulated radiation patterns at the center frequency, $f_c = 2.05GHz$, on E and H planes, are plotted. According to the Fig. 4, both microstrip patch antennas produces a good broadside radiation pattern at 2.05GHz and the peak gain is obtained to be around 6.91dB for the one with air-like substrate and 4.67dB for the other one with FR4 substrate. Furthermore, half-power bandwidths are calculated for E-Plane, where $\varphi = 0^0$ and for H-Plane, where $\theta = 90^0$. Regarding to the microstrip patch antenna with air and FR4 substrates, $HPBW \approx 60^0$ on E-Plane, $HPBW \approx 115^0$ on H-Plane, $HPBW \approx 85^0$ on E-Plane and $HPBW \approx 90^0$ on H-Plane respectively.



(a) E-Plane for MPA with air-filled substrate (b) H-Plane for MPA with air-filled substrate

(c) E-Plane for MPA with FR4 substrate (d) H-Plane for MPA with FR4 substrate

Figure 4: Radiation patterns of proposed antennas

Conclusion

In the present study, broadband microstrip patch antenna design is successfully achieved by introducing a novel feeding method to be able to cover whole UMTS bandwidth. In addition to that, expected size reduction is also succeeded with the change of substrate material in order to make this antenna suitable for UMTS handsets.

Even tough conventional patch antennas can be only designed with the maximum bandwidth of 5% [4], it is improved to 18.3% by using a monopole feeding structure as presented in this research and microstrip patch antenna with the dimensions of 51mm x 19mm x 9.9mm is obtained.

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