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A SIMPLE AND ORIGINAL DESIGN OF MULTI-BAND MICROSTRIP PATCH ANTENNA FOR WIRELESS COMMUNICATION

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ABSTRACT

Simulated design and analysis of a new simple multi-band microstrip antenna is presented in this paper. An introduced design covers the requisite bandwidth for GSM/DCS/PCS/UMTS cellular phone system and IEEE Wireless Local Area Network (WLAN) standards: 802.11n, b/g (Wi-Fi), Bluetooth. Light weight, low-cost, plain configuration and multi-band functionality are the advantages. All results of the resonant frequency, return loss, radiation patterns and fields distributions are presented. The simulation analysis was performed using the HFSS software.

Key words: patch antenna, multi-band, multi-standard, wireless communications.

1. INTRODUCTION

Wireless communication system requires low profile, light weight, high gain, and simple structure antennas to assure reliability, mobility, and high efficiency characteristics.
The rapid growth of mobile communication systems has forced to the use of novel antennas for base and mobile station applications. Due to this increase in demand for services and the explosion in the number of users, the future radio systems must implement techniques increasingly sophisticated.
Thus, systems of transmission in free-space using antennas have many advantages. These systems should the constraints of mobility, accessibility and according to frequency used; they can have sufficient reach without amplification. The choice of antenna selection is based on the requirements of the application such as frequency band, gain, cost, coverage, weight, etc.
However, the recent advances in wireless communication systems, such as GSM (Global System for Mobile communication) (880MHz-960MHz) and DCS (Digital cellular system) (1710-1880MHz) in Europe, PCS (Personal Communications Services/System) (1850-1990MHz) in USA, wireless local area networks (WLAN), wireless local loop (WLL), Broadband systems 3G etc, have induced a great interest in microstrip antennas. These have grown tremendously in recent years due to their ability to respond to the particular constraints of size, weight and especially cost imposed by the emerging mobile systems [1]-[2].
Also, these antennas have the advantages of being produced in large quantities and at a very low cost. One of the drawbacks of patch antennas is their narrow bandwidth due to surface wave losses and large size of patch for better performance [3]-[4].
Therefore, interest in multi-band antennas is increasing, especially in order to reduce the number of antennas embedded in combining multiple applications on a single antenna. To answer this, several techniques are used.
Various techniques like using Frequency Selective Surface [5]-[6], using thicker profile for folded shorted patch antennas [7], the use of slots [8], use of thicker substrate[9], E-shaped patch antenna [10], E-shaped with compatible feeding [11] and feeding techniques like L-probe feed [12] are used to enhance bandwidth of microstrip patch antenna. The size of feeding patch and thickness of dielectric should be taken care. This combination of techniques, with the use of the method of the microstrip line [13], which is easier compared to other methods and gives a good overview of the physical operation antenna, allowed us to obtain an antenna capable of covering the GSM standard, so the standard DCS, PCS, UMTS and WLAN applications namely in ISM band used by systems BLUETOOTH (2.4GHz-2.485GHz) and Wi-Fi (2.4GHz for 802.11b/g/n).
In this paper, an internal, low profile multi-band antenna will be designed with the help of several techniques, such as the ones mentioned above. The original design and its effects will be presented in this paper. The operating bands are evaluated by Ansoft HFSS with the criterion of return loss S_{11} less than -10dB. Simulated radiation patterns over the whole frequency bands are acceptable.

2. THE ORIGINAL ANTENNA DESIGN

The 3D perspective of top and side views of the original antenna is shown in figure 1. The antenna is simulated on an FR4_epoxy substrate of 45 ×70 mm^2 with a dielectric constant ε_r=4.4. The thickness of the substrate is H=0.8 mm. A rectangular patch including technical slots with different dimensions shown in Table 1. The ε_r is chosen such that it gives better efficiency and larger bandwidth. The antenna is fed by a microstrip line in order to increase the bandwidth and gain.

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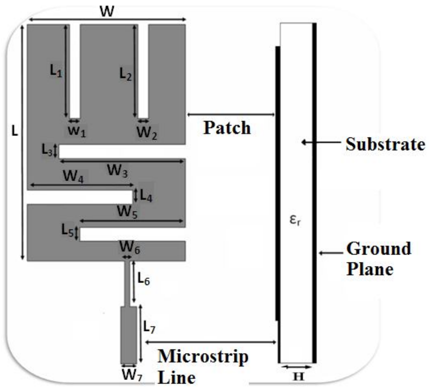

Figure 1: Geometry of the proposed antenna

Table1: Specifications of the proposed antenna

Width	Length
W=30mm	L=41.5mm
W1=W2=2mm	L1=L2=17mm
W3=24mm	L3=2.45mm
W4=W5=20mm	L4=L5=2.45mm
W6=0.925mm	L6=8mm
W7=3mm	L7=10mm

3. RESULTS AND DISCUSSION

3.1 Return Loss

The dielectric constant of substrate material plays an important role in the patch antenna design. A substrate with a high dielectric constant reduces the dimensions of the antenna but it also affects the antenna performance. Thus, there is a trade-off between size and performance of patch antenna. Also, for the microstrip patch antenna to be used in communication systems, it is essential that the antenna is not bulky. Hence, the height of the dielectric substrate should be less.

Figure 2 shows the reflection coefficient of the studied microstrip patch antenna, obtained from the simulation using the HFSS software. It is noted that the resonant is excited with -10dB return loss. For this, the antenna is operating at three resonance frequencies 0.68, 1.88 and 2.5 GHz.

In antenna terminology, the frequency bandwidth of an antenna is generally characterized either with the lower and upper limits of frequency band (f_L and f_u) or the percentage (%) bandwidth for a center frequency, which is given as:

$$\%bandwidth = \frac{f_u - f_L}{f_C} \times 100 \qquad (1)$$

Where f_c is the center frequency of the band as the arithmetic mean of lower and upper frequency limits. The bandwidth of an antenna is defined as the frequency range which the performance of antenna satisfies specified standards of some antenna parameters [14].

For our antenna: The first band allows us to cover the standard GSM. The second allows us to cover DCS/PCS and UMTS and third band for WLAN (IEEE 802.11 b/g/n) applications, especially ISM 2450 frequency bands.

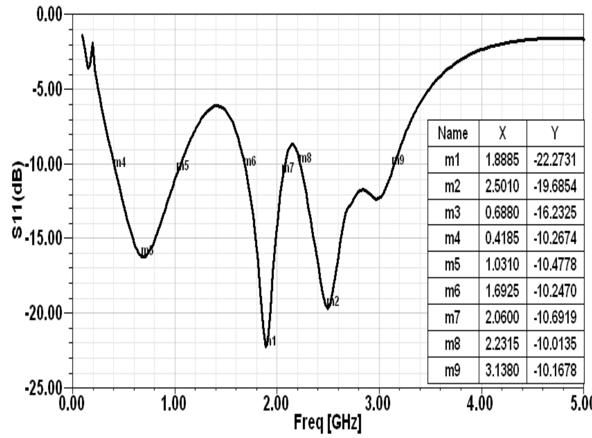

Figure 2: Reflection coefficient of the proposed antenna

Table 2: Frequency and bandwidth of the proposed antenna

Frequency band (GHz)	Bandwidth (GHz)	Percentage bandwidth (%)	S_{11}(dB)	Standard
0.68	**0.42-1.10**	**89**	**-16.24**	**GSM**
1.88	**1.70-2.10**	**19.45**	**-22.28**	**DCS, PCS, UMTS**
2.5	**2.23-3.14**	**36.25**	**-19.70**	**WLAN:ISM band (802.11b/g/n)**

Table 2 presents the frequency bands of the proposed antenna. The simulated bandwidths antenna was 89% for the first band, 19.45% for the second and 36.25% for the third band. In all cases, the antenna offers sufficient bandwidth to cover all the European wireless systems.

3.2 VSWR

The proposed antenna can cover GSM 900, DCS, PCS, UMTS and ISM 2450 frequency bands with constraint of VSWR ≤ 2 as shown in figure 3.

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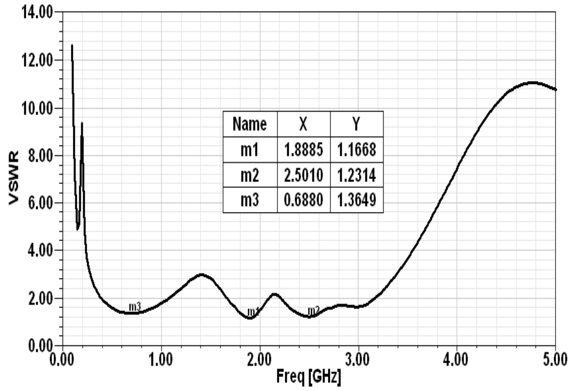
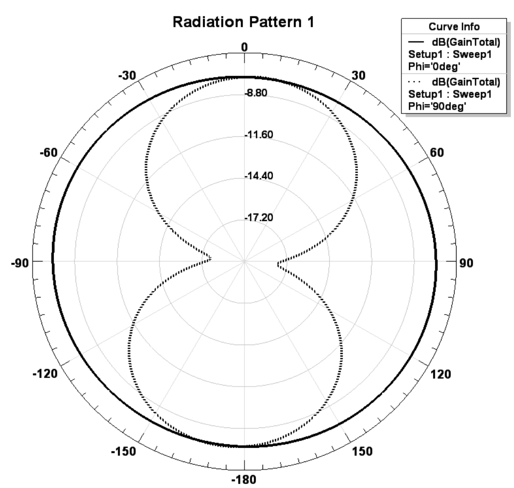


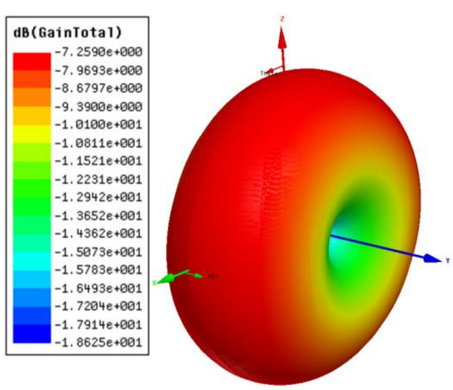
Figure 3: The VSWR of studied antenna.

3.3 Radiation pattern

The term radiation pattern refers to the directional (angular) dependence of the strength of the radio waves from the antenna or other source. Since a microstrip patch antenna radiates normally to its patch surface. The elevation pattern for φ=0° and φ=90° would be important. Figure 4 present the radiation pattern for the proposed patch antenna.



(a)



(b)

Figure 4: (a) 2D Radiation Pattern, (b) 3D-Gain Total

The radiation patterns of the antenna are almost Omni-directional which allows us to use this antenna for mobile applications.

3.4 E-Field distributions

E-field is an effect produced by an electric charge that exerts a force on charged objects in its vicinity Electric fields themselves result directly from other electric charges or from changing magnetic fields [15].

Figure 5 shows the electric field distribution. The maximum value of the E-field obtained is 1.1 10^4 V/m.

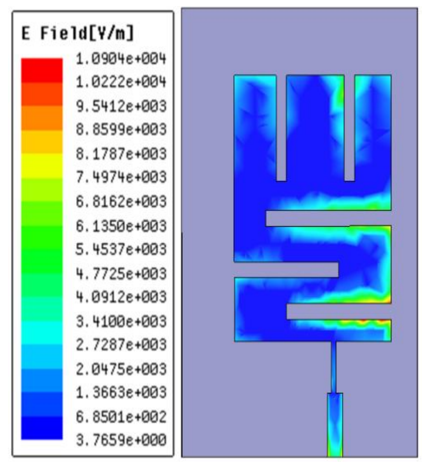


Figure 5: E-field Distribution

3.5 H-Field distributions

It is defined as the measured intensity of a magnetic field at a specific point. Usually expressed in amperes per meter.

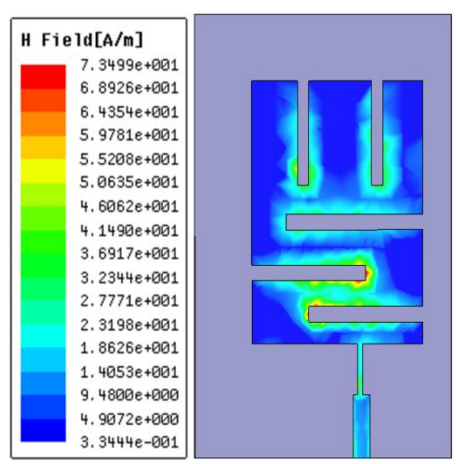


Figure 6: E-field Distribution

The measured intensity of a magnetic field in the patch is shown in Figure 6. The maximum value of the H-field obtained is 73.5 A/m.

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4. CONCLUSION

The analysis and design of a novel multi-band and miniature microstrip antenna for wireless communication is presented. For this antenna, a sufficient band-width was achieved by utilizing various techniques. The designed microstrip antenna is optimized to cover the GSM, DCS, PCS, UMTS and applications in the ISM band used by systems BLUETOOTH and WIFI. The proposed antenna is very compact, very easy to fabricate, and is fed by a 50Ω microstrip line which makes it very attractive for current and future cellular phones applications.

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