SQUARE SLOT ANTENNA FOR DUAL WIDEBAND WIRELESS COMMUNICATION SYSTEMS

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Abstract—A square slot antenna fed by two orthogonal feedlines is designed for dual polarized applications. The presented antenna has not only a dual operating band, but also a very wide bandwidth. The bandwidth is 91% in the first band and 40% in the second one. It can simultaneously serve most of the modern wireless communication applications that operate at 1.8, 1.9, 2.4, 5.2 and 5.8 GHz and require wideband characteristics. The antenna can also produce circular polarization with wideband characteristics.

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1. INTRODUCTION

In recent years, wireless communications have gained a wider and wider popularity. Presently, the trend is to provide a wireless link to every kind of electronic device. In this framework, Personal Digital Assistants (PDAs), PCMCIA, and cellular phones are becoming constitutive elements of new generation networks. In particular, there is a specific need for greater capacities and transmission speeds, which, together with a growing demand from users for more complicated services, require the design of higher performance systems. In this context, multi- and wide-band antennas are required [1–4]. Many researchers investigated the design of multi-band antennas to cover different frequency ranges [1–9]. Other researchers investigated techniques to improve a single band antenna bandwidth [10–14], where a very good bandwidth with the range of 57% to 70% is achieved.

This paper presents a new antenna design that can simultaneously support operations of dual and wide-band, and dual and circular polarizations. The return loss and far field radiation characteristics of this antenna are presented. The simulation and analysis for the presented antennas are performed using the commercial computer software package, Ansoft HFSS, which is based on the finite element method. Verification for the return loss is performed using the commercial software Momentum of Advanced Design System (ADS) of Agilent Technology, which is based on the method of moments’ numerical technique. Measurements of return loss are also conducted for verification of this new antenna design.

2. ANTENNA GEOMETRY AND DIMENSIONS

The proposed antenna is printed on a Rogers RT/Duroid 6010/6010 LM substrate of a dielectric constant of 10.2 and a conductor loss (\(\tan \delta\)) of 0.0023. The use of high dielectric constant substrate material reduces radiation losses because most of the electromagnetic field is concentrated in the dielectric between the conductive strip and the ground plane. Another benefit of having a high dielectric constant is that the antenna size decreases by the square root of the effective dielectric constant. To minimize conductor loss, the conductor thickness should be greater than \(5\delta\) [15], where \(\delta\) is the skin depth, which is approximately 0.65 \(\mu\)m for the copper. The conductor thickness used in this research is 34 \(\mu\)m. The description of the antenna geometry is introduced in the following section.

The geometry and parameters of the proposed dual-polarized dual-band microstrip-fed printed square slot antenna are shown in
Fig. 1. The antenna consists of a wide square slot sandwiched between two identical dielectric substrates, and fed by two orthogonal identical microstrip-fed-two-arm through rhombus shape microstrip lines, as illustrated in Fig. 1. The square slot is printed on a finite ground plane of a $35 \times 35 \text{mm}^2$ size, and the edge of the square slot is $W$, where $W = 25 \text{mm}$. Each substrate has a thickness $h = 0.635 \text{mm}$ (25 mil). The microstrip-fed-two-arm feedline is placed symmetrically with respect to the centerline of the square slot. The dimensional parameters of the microstrip-fed-two-arm feedline are shown in Fig. 1, where $W_1, W_2, W_3, W_4, W_5, W_6, L_1, L_3, L_3$ and $L_4 = 1.25, 1, 2.25, 1.5, 2, 3.25, 4.25, 1.5, 13.5, \text{and } 1.5 \text{mm}$, respectively, and the width of the microstrip feedline $W_f$ equals 0.6 mm for an approximate
Figure 2. Prototype of the proposed antenna.

Figure 3. Comparison between the measured and computed the return loss in the (a) lower and (b) upper operating band.

characteristic impedance of 50 Ω.

3. RESULTS OF ONE ELEMENT

The proposed antenna is simulated using Ansoft HFSS and ADS Momentum. In addition, the antenna is fabricated and a prototype is shown in Fig. 2. Figure 3 shows the measurement and simulation
results of the return loss. Good agreement between the results is obtained, which verifies the performance of this antenna. The difference between the results of HFSS and ADS is due to the difference in the simulated geometries. In HFSS, the exact geometry of the antenna is simulated with a finite substrate and ground plane of a $35 \times 35 \text{mm}^2$ size. In ADS Momentum, an infinite substrate and ground plane are considered. On the other hand, the differences between the simulation and measurement results are mainly due to the effect of the SMA connector. Both the simulation and measurements show that the antenna operates in two wide frequency bands in the range from 1 to 8 GHz. The first operating band spans from around 1.2 to 3.2 GHz, with a very wide bandwidth of 91%, and the second band spans from around 4.8 to 7.25 GHz, with a wide bandwidth of 40%.

Since the available anechoic chamber is not operating in the proposed frequency ranges for the antenna, HFSS is used to compute the radiation patterns. The 3D and 2D radiation patterns for the proposed antenna are computed at 1.9, 2.4, 5.2, and 5.8 GHz with only Port 1 excited. Fig. 4 shows the 3D patterns, and Fig. 5 shows the 2D patterns in the $E$ and $H$-planes ($yz$ and $xz$, respectively), where the lower half of all patterns is cropped because they are almost symmetrical. The $E\phi$ component tends to have spherical shape (uniform amplitudes in all directions), which is clear at 1.9 and 2.4 GHz, and distorted at 5.2 and 5.8 GHz. The $E\phi$ component is omnidirectional, which is also clear at 1.9 and 2.4 GHz, and distorted at 5.2 and 5.8 GHz. However, the maximum radiation is in the $z$-direction at all frequencies. The antenna produces high cross polarization level, but this is not a problem when being used in personal communications at the proposed frequency ranges. The aforementioned results show that the antenna is a very good candidate for the modern wireless communication applications that require wideband characteristics. Using this antenna gives these systems the ability to serve simultaneously the frequency bands of the GSM 1800 and GSM 1900, and both industrial, scientific and medical ISM band around 2.4 GHz, in addition to WLAN and Bluetooth applications operating at 2.4, 5.2 and 5.8 GHz.

4. RESULTS OF CIRCULARLY POLARIZED ANTENNA

In many wireless communication applications, circularly polarized antennas have received increasing attention because of their insensitivity to the orientation between the transmitter and receiver. By exciting the two orthogonal ports, Port 1 and Port 2, shown in Fig. 1, a circular polarized pattern can be obtained. To prove that, the radiation pat-
Figure 4. Computed 3D radiation patterns at (a) 1.9, (b) 2.4, (c) 5.2, and (d) 5.8 GHz, for the antenna when only Port 1 is excited.
Figure 5. Computed 2D radiation patterns at (a) 1.9, (b) 2.4, (c) 5.2, and (d) 5.8 GHz, for the antenna when only Port 1 is excited.

terns and the axial ratios are calculated at 0.9, 1.4, 1.9, 2.4, 2.7, and 3.1 GHz, with both ports excited. The axial ratio is computed at 1.9, 2.4, 5.2, and 5.8 GHz and presented in Fig. 6. The antenna has an axial ratio less than 0.5 dB in the $z$-direction, which is the main direction of radiation. The 3 dB beamwidth in the $xz$ plane is 94, 108, 27, and 27° at 1.9, 2.4, 5.2, and 5.8 GHz, respectively, while in $yz$ plane, it is 114, 111, 34, and 33° at 1.9, 2.4, 5.2, and 5.8 GHz, respectively.
Figure 6. Computed axial ratio in the (x-z) and (y-z) at (a) 1.9, (b) 2.4, (c) 5.2, and (d) 5.8 GHz, for the antenna when Ports 1 and 2 are excited.

5. CONCLUSION

A wideband dual-polarized dual-band antenna is designed and presented for wireless communication applications at 1.8, 1.9, 2.4, 5.2 and 5.8 GHz. The antenna has a relatively small size, and operates over two wide bands with bandwidths of 91% and 40%. Circular polarization can be obtained by this antenna in the forward direction at all the proposed frequencies.

REFERENCES


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