Compact Triple Band Slotted Microstrip Patch Antenna

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Abstract — This paper presents a compact triple band slot microstrip patch antenna for 1.7/2.92 GHz WLAN applications. The radiating element of the proposed antenna consists of Swastika symbol slot operating at 1.8 GHz, 2.09 GHz, and 2.92 GHz bands. The antenna size is very compact (50 mm x 50 mm x 1.6 mm) and covers 1.8 GHz to 2.92 GHz and can be used for AMPS, GSM and WLAN applications. The antenna is fed from a single 50 Ω coaxial cable. Using IE3D software package of Zeland, according to the set size, the antenna is simulated. The composite effect of integrating these techniques and by introducing the novel slotted patch offers a low profile, wide bandwidth, high gain and compact antenna element. The computer simulation results show that the antenna can realize wide band characters with each band having good impedance bandwidth (VSWR ≤ 2) for all the three resonant frequencies.

Keywords— Microstrip antenna, triple-band, slot, IE3D.

1. INTRODUCTION

The rapid development of wireless communication systems has increased the demand for compact microstrip antennas with high gain and wideband operating frequencies. Microstrip patch antenna has advantages such as low profile, conformal, light weight, simple realization process and low manufacturing cost. However, the general microstrip patch antennas have some disadvantages such as narrow bandwidth etc. Enhancement of the performance to cover the demanding bandwidth is necessary [1]. There are numerous and well-known methods to increase the bandwidth of antennas, including increase of the substrate thickness, the use of a low dielectric substrate, the use of various impedance matching and feeding techniques, and the use of multiple resonators [2-6]. To overcome the above problem, a microstrip antenna structure with a typical Swastika symbol shaped slot is proposed which exhibits three bands with good impedance bandwidth.

In this paper a printed multi-band antenna fed by a coaxial probe is presented. The antenna is simulated using IE3D, 12.32 version of Zealand. The results show that the impedance bandwidth has achieved a good match. Besides to make sure that the antenna designed in this paper can be applied into practice a slot of Swastika symbol is cut to generate lower frequency. Hence it can be applied for AMPS, GSM WLAN etc.

2. ANTENNA DESIGN

The dielectric constant of the substrate is closely related to the size and the bandwidth of the microstrip antenna. Low dielectric constant of the substrate produces larger bandwidth, while the high dielectric constant of the substrate results in smaller size of antenna. A trade-off relationship exists between antenna size and bandwidth [7]. The resonant frequency of microstrip antenna and the size of the radiation patch can be similar to the following formulas [8].

\[ f \approx \frac{c}{2L\sqrt{\varepsilon_r}} \] (1)
\[
W = \frac{2}{f_r} \left( \frac{\varepsilon_r + 1}{2} \right)^{\frac{3}{2}}
\]
(2)

\[
L = \frac{c}{2f_r \sqrt{\varepsilon_r}} - 2\Delta l
\]
(3)

Where \( f \) is the resonant frequency of the antenna, \( c \) is the free space velocity of the light, \( L \) is the actual length of the current, \( \varepsilon_r \) is the effective dielectric constant of the substrate and \( \Delta l \) is the length of equivalent radiation gap.

The antenna geometry is shown in figure 1. All the dimensions are in mm. First a square microstrip patch antenna is designed based on standard design procedure to determine the length (\( L \)) and width (\( W \)) for resonant frequency. For this the ground plane is kept finite and is of the size 50 mm x 50 mm. The size of the square patch is 45 mm x 45 mm. Inside this square patch two rectangular slots of size 30 mm x 10 mm and centered at (22.5 mm, 22.5 mm) of the square patch are cut. Each arm of the above slots is extended at right angles with size 10 mm x 5 mm and hence resulting into a typical Swastika symbol slot. In between the patch and ground plane there is a substrate called glass epoxy whose dielectric constant is 4.2 and the height of which is 1.6 mm.

Reducing the size of the antenna is one of the key factors to miniaturize the wireless communication devices. However, reducing the antenna size will usually reduce its impedance bandwidth as well. Therefore designing a small antenna operating at multi-frequencies with a wide impedance bandwidth which satisfies future generation wireless application is a challenging work, especially having stable radiation patterns across the operating frequency band [9-10]. In this paper coaxial probe feeding, multiple slots on the patch provide the wide bandwidth and gain enhancement.
3. RESULTS AND DISCUSSIONS

Fig. 2. Simulated return loss of the proposed antenna.

Fig. 3. Radiation pattern of the proposed antenna.
The performance of this antenna was simulated and optimized by “IE3D” 12.32 version of Zeland. This was used to calculate the return loss, impedance bandwidth and radiation pattern. The simulated -10 dB return loss of the proposed antenna is shown in the figure 2. The simulated result shows that the first band resonant frequency locates at about 1.8 GHz with the -10 dB impedance bandwidth from about 1.7 GHz to 1.9 GHz. The second band resonant frequency locates at about 2.09 GHz with the impedance bandwidth from about 2.04 GHz to 2.104 GHz. The third band resonant frequency locates at about 2.92 GHz with the impedance bandwidth from about 2.89 GHz to 2.962 GHz. The antenna covers a frequency range from 1.8 GHz to 2.92 GHz with 1120 MHz bandwidth (-10 dB return loss). The -10 dB return loss impedance bandwidths for first, second and third band are 11%, 3% and 2.5% respectively. The radiation pattern of the proposed antenna is shown in figure 3. The simulated current distribution on the patch and impedance Smith circle diagram are illustrated in figure 4 and 5 respectively.

4. CONCLUSION

A novel compact triple-band slot microstrip antenna for 1.7/2.92 GHz is presented. The proposed antenna has a compact size of 50 mm x 50 mm x 1.6 mm and it can effectively cover the AMPS, GSM and WLAN applications. Good antenna performance and impedance matching can be realized by adjusting the probe position and the dimensions of the patch.

References

Biographical notes

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