A Compact planar antenna for modern microwave communication systems

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Abstract

This paper presents the development of a compact antenna suitable for a range of frequency bands which are widely used in modern microwave communication systems. The proposed antenna incorporates a modified Finite Ground CPW (FGCPW) fed strip monopole with a flaring and an embedded sleeve to implement dual band operation. Software simulations are carried out using FEM based commercial simulation package, Ansoft HFSS to investigate the effect of each antenna element over the antenna characteristics. Finally, the optimized antenna is prototyped and the experimental results are observed to be in good agreement with the simulated ones. Experimental results show a 2:1 VSWR bandwidth of 24% at the centre frequency of 2 GHz for the first resonant band and 56.3% bandwidth at the centre frequency of 4.5 GHz in the second resonant band. The surface current in the antenna is computed in order to identify the contribution of each antenna elements at the resonant bands and to identify the frequency determining element at each resonant band. The proposed antenna is then simulated to verify frequency tuning by varying appropriate element in each operating band. Measured radiation patterns reveal nearly omnidirectional behavior with average gain of better than 3.5 dBi and 2.5 dBi and efficiency of 79% and 68% in the first and second resonant bands respectively.

1. Introduction

The wireless communication industry has witnessed a drastic development in the field of low power, short range microwave communication gadgets like mobile phones and PDAs. Federal Communications Commission [1] has released many unlicensed bands such as Advanced Wireless Systems (AWS), WiBee, and ZigBee to provide wireless connectivity between handheld devices such as mobile phones and computers. Moreover, Manufacturers of recent communication devices are integrating a number of applications which provide ease of connectivity between the systems. Therefore a compact antenna serving the needs, such as omnidirectional radiation coverage, multiband operation and frequency tunability, is a good candidate. Monopole antennas [1-4] are notable for their omnidirectional radiation characteristics with compact and simple design.

In this paper the authors present a modified FGCPW fed strip monopole antenna for the purpose of DCS-1900/PCS/PHS (1850-1990 MHz), WCDMA/UMTS (1920-2170 MHz), Digital Cordless Phones (1880-1900 MHz), AWS-2 (2110-2117 MHz) and WLAN (5150-5350 MHz). The proposed antenna is developed from a conventional FGCPW fed strip monopole antenna by modifying the monopole. A number of simulation studies are systematically carried out to determine the effect of each antenna element over the antenna characteristics. Finally the optimized antenna is prototyped and experimentally verified. Details of the antenna design, simulations and experimental results are discussed and presented.

2. Antenna Design

Fig. 1. depicts the geometry of the proposed dual band antenna fabricated on an FR4 substrate with dielectric constant, \( \varepsilon_r = 4.4 \) and thickness 1.6mm. The antenna consists of a FG CPW feed line designed for an impedance of 50 \( \Omega \) with ground dimensions 10x15mm\(^2\) which couples energy to the radiator through an SMA connector. As the first stage of the design, an FGCPW fed strip monopole antenna (Fig.1a) is simulated using Ansoft HFSS and compared the result with a flared monopole antenna. (Fig.1b) A strip monopole with dimension \( L_m = 25\text{mm}(\sim 0.25\lambda_g) \) is flared with a flaring length of 10 mm which results resonance at a frequency much lower than that of a conventional strip monopole Antenna. A sleeve with dimension \( L_s = 15\text{mm}(\sim 0.33\lambda_g) \) with same flaring angle of the flared monopole is embedded to the monopole for dual band operation where \( \lambda_g \) and \( \lambda_{eg} \) corresponds to the effective wavelengths for the first and second resonant frequencies respectively. In addition, the sleeve is loaded with a slot of dimension 1 mm to enhance the bandwidth of the second resonance band (Fig.1c).


3. Results and Discussion

The development of the proposed antenna is depicted in fig.2. It is seen from the plot that the seed point for this work is a conventional FGCPW fed monopole antenna and by introducing a flaring in the monopole results shift of the resonance to a lower frequency region without much change in the bandwidth. It is also clear from the plot that the introduction of a sleeve generates a second resonant band at a higher frequency and loading the sleeve with a slot results drastic improvement in the bandwidth of the second resonance. The optimized antenna is prototyped and measurements are carried out using Agilent E8362B Precision Network Analyzer. Fig.3 demonstrates both simulated and experimental VSWR characteristics of the proposed antenna. Good agreement between simulated and measured results is observed.

The influence of finite-size ground is studied through software simulation. Effect of ground plane length, Lg is exhibited in fig.4.a. It is observed that smaller values of Lg result in poor matching in the second resonance band while higher values make poor matching in the first band. Therefore, an optimum value of Lg = 15mm is chosen for the proposed antenna. Fig.4b. depicts the variation with ground plane width Wg. It is observed that first resonant band has good matching and wide bandwidth for an optimum value of Wg = 10mm.
The plot of surface currents on each antenna elements for the optimized design is plotted using simulation software and shown in fig. 5. It is clear from the plots that the flared monopole contributes for the radiations in the first resonant band while the sleeve for that of second band. The frequency tuning element for both the bands are identified and verified by plotting the variation of resonant frequency for different values of $L_m$ and $L_2$ which is depicted in fig. 6.

Fig. 4. Effect of finite ground plane dimensions on return loss (a) $L_g$ ($W_g = 10\text{mm}$) (b) $W_g$ ($L_g = 15\text{mm}$)

Fig. 5. Simulated surface current density plots of the proposed antenna. (a) 2.1 GHz (b) 4.5 GHz

Fig. 6. Tuning of first and second resonant bands (a) $L_m$ variation (b) $L_2$ variation
Radiation pattern in the two principle planes are measured at different frequencies and plotted in fig. 7. It is clear from the plot that the antenna exhibit nearly omnidirectional radiation coverage in both the bands which is highly suitable for the modern wireless communication gadgets.

The measured peak gains of the proposed antenna at both the resonant bands are depicted in fig.9. It can be seen that an average gain of 3 dBi and 2.5dBi is obtained for first and second resonant bands respectively. Efficiency of the antenna is measured using Wheeler-Cap[5] method and found that the antenna exhibits an average efficiency of 79% and 68% in the first and second bands respectively.

4. Conclusion

A compact multiband antenna is developed from the conventional FGCPW fed strip monopole antenna for the purpose of DCS-1900/PCS/PHS, WCDMA and WLAN systems. The proposed antenna provides an impedance bandwidth better than 24% and 56% in the first and second resonant bands respectively. Omni directional radiation coverage along with moderate gain and efficiency makes the antenna suitable for the proposed applications.

References