Multi-Band Printed Antenna for Wireless Communication Systems

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Abstract: New design of a printed antenna with simple shape radiator element for multi-band operation of wireless communication system is presented. By using simple design configuration and slot form on printed circuit board, the proposed antenna has the multi-band measured operation for covering the GSM (880-960 MHz), DCS (1710-1880 MHz), PCS (1850-1990 MHz), UMTS (1920-2170 MHz), 2.4-GHz WLAN (2400-2484 MHz), Mobile-WiMAX (IEEE 802.16e in the Taiwan: 2500-2690 MHz), and 5-GHz WLAN (5150-5350/ 5725-5825 MHz) bands. Several properties of the proposed printed antenna for multi-band operation such as impedance bandwidth, radiation pattern and measured gain have been investigated numerically and experimentally in detail.

1. Introduction

Recently, wireless communication systems have been grew up fast and developed widely, which leads to a strong design in low-profile, cost down and multi-band antennas for mobile terminals. Many antennas with broadband and multi-band performances including inverted-F antenna, monopole antenna, planar antenna and slot antenna configurations have been reported in recent years [1-7]. These are printed antennas with moderate radiating characteristics and can be operative at multiple frequency bands. In [1, 2], they can supply a dual-band operation for the application in the wireless local area network (WLAN) communication systems. However, other antenna fabrication designs, they have needed the design of antenna fabrication using a slot patch and a broad ground plane to provide a broadband and multi-band systems including the global system for mobile communications (GSM), the digital communication system (DCS), the personal communication system (PCS), the universal mobile telecommunication system (UMTS), and the 2.4- and 5-GHz WLAN bands. The proposed printed antenna of this letter is presented and experimented by way of arranging for simple configuration and slot form, we could applied to the printed antenna, and a multi-band characteristic with the proposed antenna improves the narrow band of the printed monopole antenna with a ground plane for GSM (880-960 MHz), DCS (1710-1880 MHz), PCS (1850-1990 MHz), UMTS (1950-2170 MHz), 2.4-GHz WLAN (2400-2484 MHz), Mobile-WiMAX (IEEE 802.16e in the Taiwan: 2500-2690 MHz) and 5-GHz WLAN (5150-5350/ 5725-5825 MHz) applications.

2. Antenna Configuration

Fig. 1 shows the geometry of the proposed printed antenna for multi-band applications. It is printed on the 1.6 mm FR4 substrate of relative permittivity 4.4 and has a dimension of 112 × 15 mm^2 in this study. The simple design of printed antenna has a slot form patch, a U-shaped ground plane and the feed microstrip line between patch and ground plane. The length of proposed printed antenna is about less than the half-wavelength measured at the lower frequency operation. The optimal dimensions of proposed antenna are W_1= 3 mm, W_2= 4 mm, W_3= 2 mm, W_4= 1.525 mm, W_5= 2 mm, W_6= 11 mm, L_1= 22.8 mm, L_2= 4.5 mm, L_3= 36 mm, L_4= 1 mm, L_5= 5 mm, S_1= 13.2 mm, S_2= 0.5 mm, and S_3= 3.5 mm. The dimensions of the antenna were firstly studied by Ansoft HFSS simulation electromagnetic software, and then verified by experiment. Details of the proposed antenna and results of the prototypes are discussed.

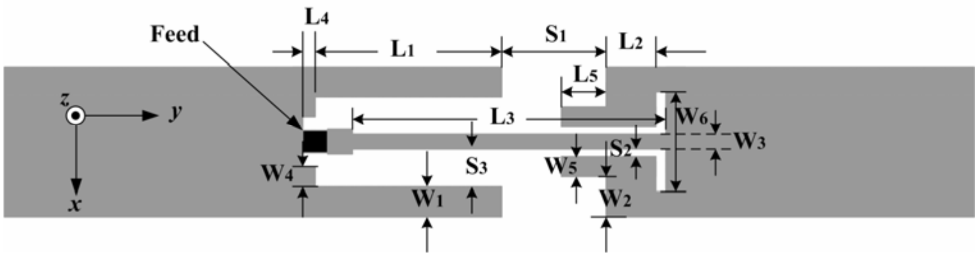


Figure 1: The geometry of the proposed antenna

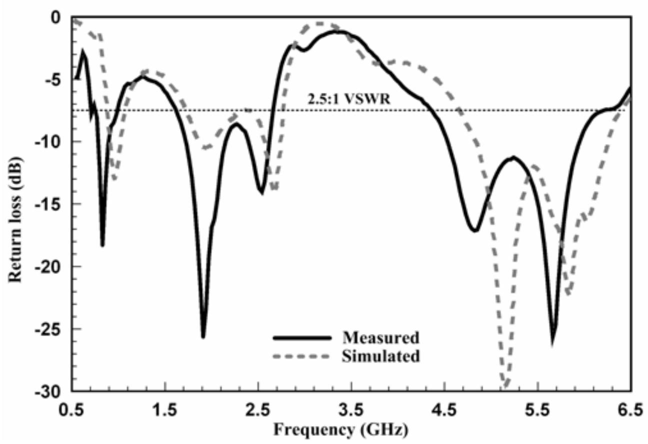


Figure 2: The simulated and measured return loss curves

3. Results

Fig. 2 shows the simulated and measured return loss of the proposed printed antenna with simple and low profile structures for multi-band applications. It shows the measured return loss and it is noted that five distinct resonant modes at around 900, 1900, and 5800 MHz are excited with 2.5:1 VSWR. It is shown that the different resonances occur in the simulation and the measurement, but it is not apparent, which could be due to the effect of the SMA port. It shows the significant effects on the bandwidth. The measured return loss of operation bandwidth portion has a 220 MHz within 760 MHz ~ 980 MHz at first resonance mode. Nevertheless, this resonance bandwidth has the signification operation on the GSM system between 880 MHz and 960 MHz. The slot form on radiator patch shows the signification factor on the variation of second and third resonances mode of 1070 MHz within 1620 MHz ~ 2690 MHz, which cover the DCS (1710-1880 MHz)/ PCS (1850-1990 MHz)/ UMTS (1950-2170 MHz)/ 2.4-GHz WLAN (2400-2484 MHz)/ Mobile-WiMAX (IEEE 802.16e in the Taiwan: 2500-2690 MHz) bands, and it influences first low band operation of the proposed antenna also. The two higher resonance modes exhibit bandwidth of 1840 MHz from 4370 MHz to 6210 MHz, covering the 5-GHz for WLAN operation (5150-5350 MHz and 5725-5825 MHz). The measured bandwidth of proposed antenna is covered five resonance modes, 25.3 % on first mode for GSM system, 49.6 % on second and third modes for DCS/ PCS/ UMTS/ 2.4-GHz WLAN/ Mobile-WiMAX systems, and 34.8 % on fourth and fifth modes for 5-GHz WLAN system, respectively. Figure 3 and 4 have been shown in the simulation that the operating bandwidth and the impedance match of the proposed antenna is critically dependent on the slot form and U-shaped ground plane. So these parameters could be optimized for multi-band operation. We studied to modify dimension of the width of U-shaped ground plane and obtained the results in Fig. 3. Other parameters are fixed at the optimized state. If the antenna has completed the width of U-shaped ground plane, the performance of impedance bandwidth and impedance match will be optimum situation. However, Fig. 4 shows the return loss curves for different slot length of proposed antenna with their respective optimal designs. It is observed that higher resonant frequency bandwidth changes with the variation of the length of the proposed antenna.

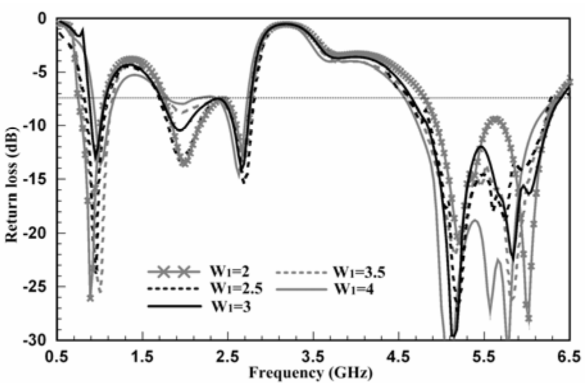


Figure 3: The return loss curves for different widths on ground plane of the proposed antenna

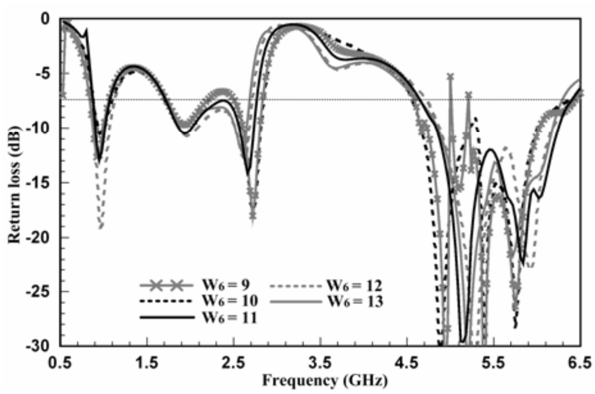
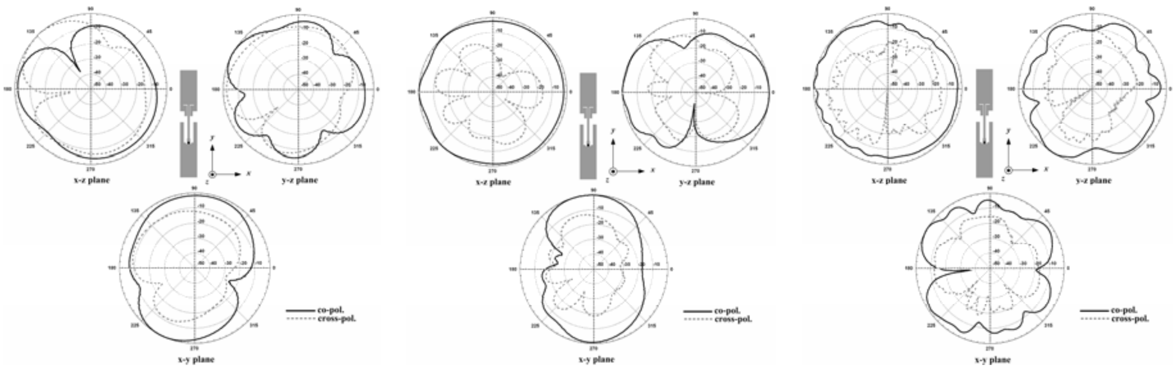


Figure 4: The return loss curves for different slot lengths of the proposed antenna

The measured radiation patterns of the proposed printed antenna at 900 MHz, 1900 MHz and 5800 MHz are illustrated with Fig. 5, respectively. It is noticed that the radiation patterns in three planes at 1900 MHz operation is conventional dipole antenna of the same. The x-z plane radiation pattern is omnidirectional pattern at 1900 MHz operation and distorted slightly at 5800 MHz. So the radiation patterns are generally omnidirectional over the entire bandwidth, similar to a conventional dipole antenna. The variation ranges of maximum measured gain at all radiation planes are varied from -3.2 dBi to -5.7 dBi within 800 MHz ~ 1000 MHz at first operation frequency band, from 1.6 dBi to 6.3 dBi within 1700 MHz ~ 2700 MHz at second and third operation frequency bands and from 1.6 dBi to 4.2 dBi within 5100 MHz ~ 5900 MHz at fourth and fifth operation frequency bands, respectively. Through proposed antenna measured results to display, not only have multi-band effect but also reach the operating applications of the wireless communication systems.



(a) (b) (c)

Figure 5: Measured radiation patterns of the proposed antenna

(a) 900 MHz (b) 1900 MHz (c) 5800MHz

4. Conclusion

A printed antenna has been developed and could achieve multi-band operations. From the investigation of printed antenna, it is found that the simple design structure make a strong effect on the antenna's operating resonance mode. Experimental results show that by using simple design with slot form patch and U-shaped ground plane and tuning their dimensions, operating bandwidth, measured gain and radiation patterns can be obtained for GSM/ DCS/ PCS/ UMTS/ 2.4-GHz WLAN/ Mobile-WiMAX/ 5-GHz WLAN applications.

References

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