A Printed Multi-Band Monopole Antenna for Wireless Applications

[#]Shih-Ying Sun[1], Sheng-Yi Huang[2], and Jwo-Shiun Sun[2]
[1]Department of Electronic Engineering
[2]Institute of Computer and Communication Engineering
National Taipei University of Technology
1, Sec. 3, Chung-Hsiao E. Rd., 10608 Taipei
s4360361@ntut.edu.tw

1. Introduction

Antenna is one of the most important elements in communication system. They act as transmitting and receiving the electromagnetic (EM) energy. Printed antennas are very favorable candidates for wireless terminal devices application due to such characteristics as low-profile, low-price, and easier fabrication [1-5]. A printed multi-band monopole antenna is designed for *Bluetooth* (BT) band of 2.4 GHz and *Worldwide Interoperability for Microwave Access* (WiMax) IEEE 802.16e band of 3.5 and 5.8 GHz. The impedance bandwidth of the designed antenna of 2.4 – 4.2 GHz and 5.05 – 5.9 GHz is referred to -10 dB *Return Loss* (RL). These covered frequency bands are also for *Wireless Fidelity* (WiFi) 2.4 - 2.5 GHz and 5 - 5.8 GHz and *Wireless Local Area Network* (WLAN) 2.4 - 2.48 GHz, 5.15 - 5.35 GHz, and 5.72 - 5.83 GHz application. The total volume of the antenna is 20 (L) x 7.64 (W) x 0.4 (H) mm^3, which is greatly reduced by 36 % compared to generally internal printed radiators. The ratio of impedance bandwidth of the antenna in relation to central frequencies (3.3 and 5.5 GHz) is 54.5 % and 15.5 %, respectively.

The good performances of the antenna such as wide bandwidth and omni-directional far-field radiation patterns are attainable. The experimental results show fairly good agreement with the numerical data by *High Frequency Structure Simulator* (HFSS).

2. Antenna Design

The small printed monopole antenna is designed for BT/WiMax/WiFi/WLAN bands. The material FR4 is used to be a substrate (SUB) of the antenna. The relative permittivity and volume of the FR4 are 4.4 and 70 (L) x 40 (W) x 0.4 (H) mm^3, respectively. The geometry of the antenna is shown in Fig. 1 with the dimensions of L1 = 1.5 mm, L2 = 18.5 mm, L3 = 17.5 mm, W1 = 0.72 mm, W2 = W3 = 2 mm, and W4 = 7.64 mm. Furthermore, the interval between the 50-ohm feeding line and the ground (GND) is 0.5 mm. The radiator is mounded on the top of the SUB.

The feeding type is by using *Coplanar Waveguide* (CPW) due to having some good performances described in references [6-8]. The 50-ohm SMA is used to connect the PNA Agilent E8362B and deliver the EM energy to the antenna through the 50-ohm micro-strip line.

3. Experiment Results

The far-field anechoic chamber and *Vector Network Analyzer* (VNA) HP 8720C are used to measure the electrical characteristics of the antenna. The experimental results are compared to the numerical simulator HFSS. The *Return Loss* (RL) of the antenna is shown in Fig. 2. It illustrates that the measured impedance bandwidth of the antenna between 2.4 - 4.2 GHz and 5.05 - 5.9 GHz is covered referring to -10 dB RL. These covered frequency bands are able to be applied for BT (2.4 GHz), WiMax (2.5/3.5/5.5 GHz), WiFi (2.4/5.8 GHz), and WLAN (2.4/5.2/5.8 GHz) applications. The ratios of impedance bandwidth of the antenna related to the central frequencies of 3.3 and 5.5 GHz are 54.5 % and 15.5 %, respectively.

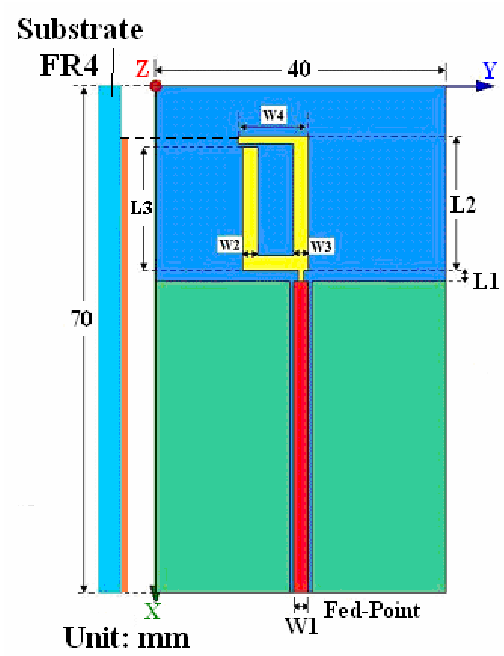

Figure 1: Geometry of the antenna

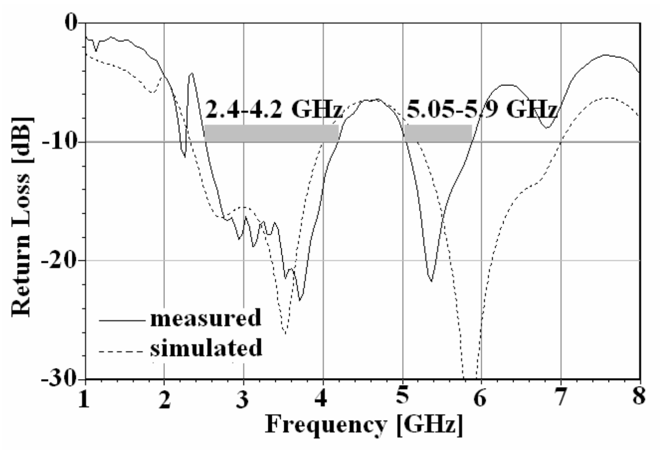

Figure 2: Return lose (RL) of the antenna

The far-field radiation patterns of the antenna at these resonant frequencies of 2.4, 3.5, 5.2, 5.5, and 5.8 GHz are shown from Fig. 3 to Fig. 7. The values of peak gain of the antenna on the azimuth (H_plane) at these resonant frequencies of 2.4, 3.5, 5.2, 5.5, and 5.8 GHz are -2.06, 0.78, 1.6, 3.07, and 1.49 dBi, respectively. The values of peak gain of the antenna on the elevation (E_plane) at these resonant frequencies of 2.4, 3.5, 5.2, 5.5, and 5.8 GHz are -3.1, -0.04, 3.05, 4.67, and 3.21 dBi, respectively.

4. Conclusions

A printed monopole antenna is presented for wireless terminal devices application. It has the good characteristics of omni-directional radiation patterns and very wide impedance bandwidth. The antenna works in BT (2.4 GHz), WiMax (2.5/3.5/5.5 GHz), WiFi (2.4/5.8 GHz), and WLAN (2.4/5.2/5.8 GHz). The total volume of the antenna is 20 (L) x 7.64 (W) x 0.4 (H) mm^3, which is greatly reduced by 36 % comparing to generally internal printed radiators. The experimental results show fairly good agreement with the numerical data by HFSS. It demonstrated the potential for commercial applications.

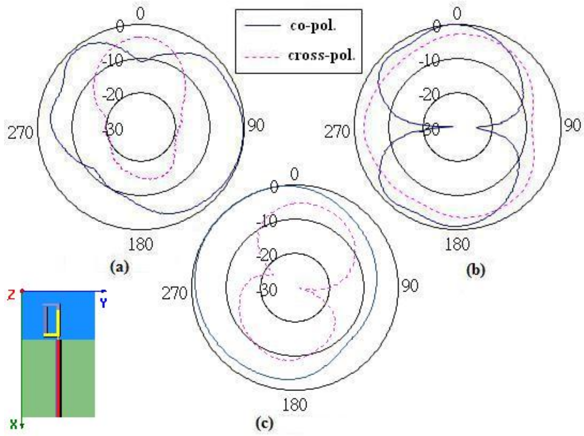

Figure 3: Measured radiation patterns of the antenna at 2.4 GHz (a) x-y, (b) z-x, and (c) y-z plane

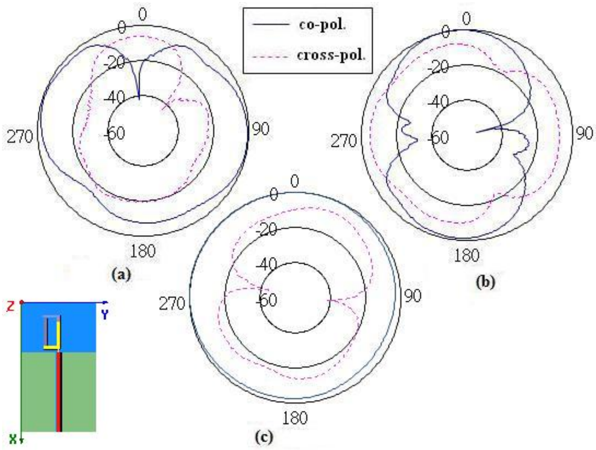

Figure 4: Measured radiation patterns of the antenna at 3.5 GHz (a) x-y, (b) z-x, and (c) y-z plane

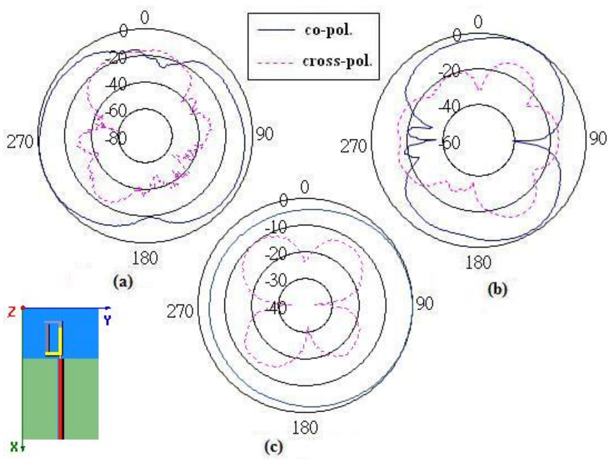

Figure 5: Measured radiation patterns of the antenna at 5.2 GHz (a) x-y, (b) z-x, and (c) y-z plane

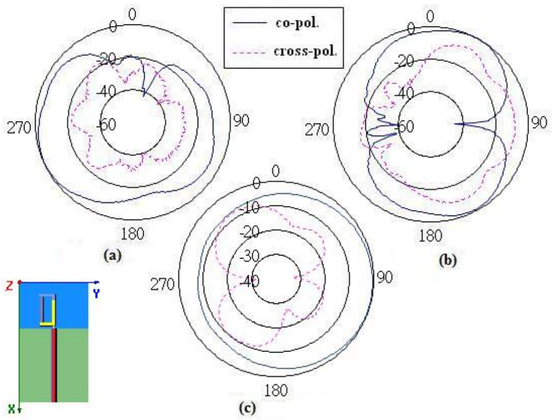

Figure 6: Measured radiation patterns of the antenna at 5.5 GHz (a) x-y, (b) z-x, and (c) y-z plane

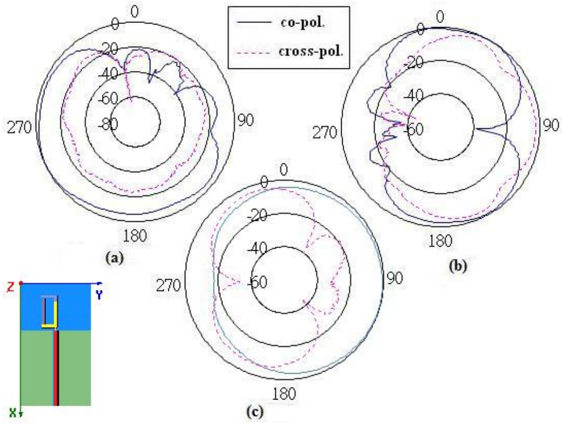

Figure 7: Measured radiation patterns of the antenna at 5.8 GHz (a) x-y, (b) z-x, and (c) y-z plane

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