A small and slim printed Yagi antenna for mobile applications

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Introduction

Printed Yagi antennas have been widely used in many wireless communications due to the following advantages: low cost, low profile, easy fabrication and high directivity. The spacing between the Yagi antenna and the reflector normally needs to be about 0.15λ to 0.25λ. However, most mobile systems require a physically smaller antenna size [1].

In this paper, we propose a slim printed Yagi antenna. The length of the proposed antenna is reduced by 43% compared with a typical dipole antenna applying the meander structure. In addition, the spacing between the antenna and the reflector is designed as 0.01λ. A folded dipole and a lumped balun transformer were adopted to compensate the low radiation resistance caused by the reduced spacing [2]. Finally, the performance of the proposed antenna was verified through application on vehicle GPS systems (1.575GHz).

Antenna Design and Analysis

Figure.1 (a) illustrates the block diagram of a navigation system with the proposed antenna for vehicle. The navigation system is composed of an antenna and modules (such as an LCD module, a GPS engine module and a main processor module). Each module is shielded by a shielding box which is connected to the common ground. Therefore, this whole system can be simply implemented as Figure.1 (b).

Figure.2 shows the geometries of the proposed antenna. This antenna was fabricated on a double sided PCB with a 0.76 mm-thickness Taconic substrate. To reduce the antenna length, the antenna was designed as the meander structure. It has the length, l=40 mm, the height, h=4.5 mm, the line width, w=0.5 mm and the gaps of the meander line, d_1=5.5 mm, d_2=4.5 mm and d_3=1 mm. The spacing between a reflector and a driven antenna is g=2 mm (0.01λ), which is much less than that of a typical Yagi-Uda (0.15~0.25 λ) [3]. A folded dipole antenna with high real impedance (about 300 ohm) is used for the driven antenna because it can compensate the real impedance which becomes smaller as the driven antenna is getting closer to the ground reflector [4]. To minimize the antenna height, a folded dipole antenna was designed on the double sided PCB and connected through vias. From this technique, we could make it working with the impedance of around 20 ohm. For antenna impedance matching and feeding, we put the balun transformer composed of lumped L, C elements on the top side. And to tune the center frequency exactly, we inserted the inductor, L_1 on the bottom side.

Figure.3 is the current distribution of the proposed antenna. This result was obtained from simulations with CSTMWS (CST Microwave Studio). It is noted that the strongest current is formed around the center of the proposed antenna. Hence, in order to tune the frequency efficiently, we put the inductor L_1 on the center of the proposed antenna. Figure.4 shows the frequency variation according to L_1. When the L_1 is larger, the frequency is getting lower.

Experimental Results

Figure.5 (a) is the measured return loss of the proposed antenna. The return loss is greater than -10dB from 1.56GHz to 1.59GHz. It has bandwidth about 30MHz. Figure.5 (b) shows the measured radiation pattern of proposed antenna at 1.575GHz. The maximum gain is -1.25dBi. The HPBW (Half Power Beam Width) on the YX-plane is 100 degree and the HPBW on the YZ-plane is 160 degree. And the front-to back ratio is about 15dB.

Conclusions

The slim printed Yagi antenna was proposed in this paper. To make the compact antenna, the meander structure was employed. And to compensate the reduced antenna impedance, the folded dipole antenna with the double sided PCB was used. The proposed antenna can be widely applied to various portable devices which require the low-profile inner antenna.

References

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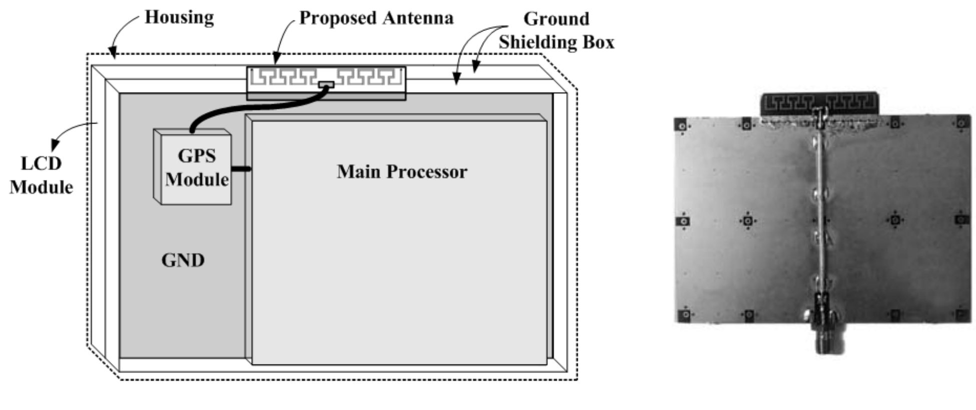
[2] Sungkyun Lim and Hao Ling, “Design of a Planar, Closely Spaced Yagi Antenna” *IEEE AP-S International Symposium*, June, 2007.

[3] Warren L.Stutzman,”Antenna Theory and Design”,Chapter 5.4.Yagi-uda antenna

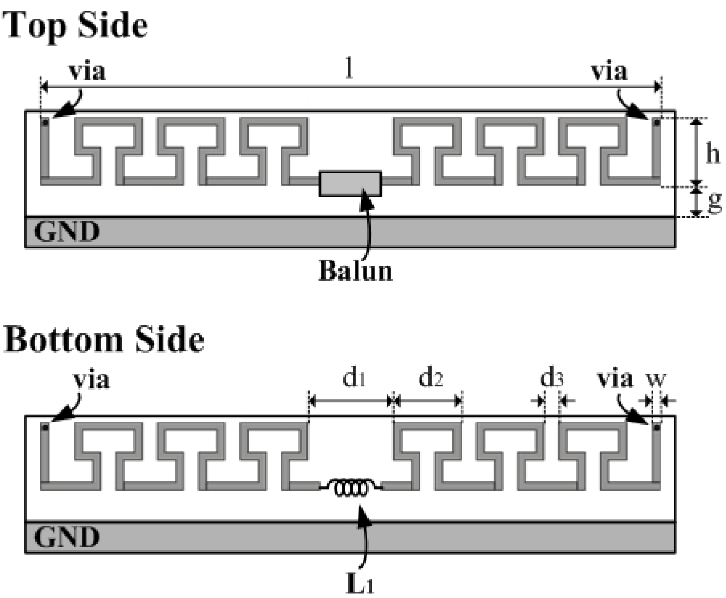
[4] Hossein Mosallaei, ”Antenna Miniaturization and Bandwidth Enhancement Using a Reactive Impedance Substrate” *IEEE Transactions on Antennas and Propagation*, vol.52, No.9, September 2004.

Figures



(a) (b)

Figure 1. Navigation system with the proposed antenna
(a) Block diagram and (b) Implemented antenna



l	**40mm**
h	**4.5mm**
g	**2mm**
w	**0.5mm**
d_1	**5.5mm**
d_2	**4.5mm**
d_3	**1mm**

Figure 2. Geometry of the proposed antenna

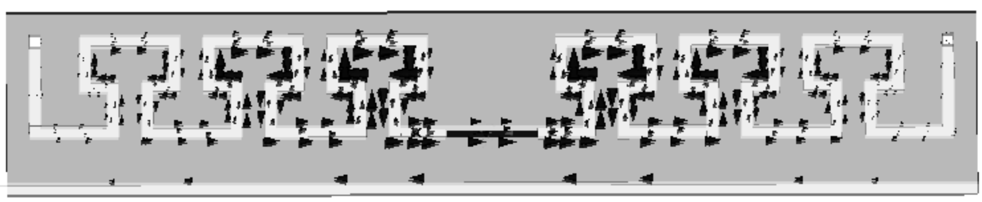


Figure 3. Current distribution of the proposed antenna (by CSTMWS)

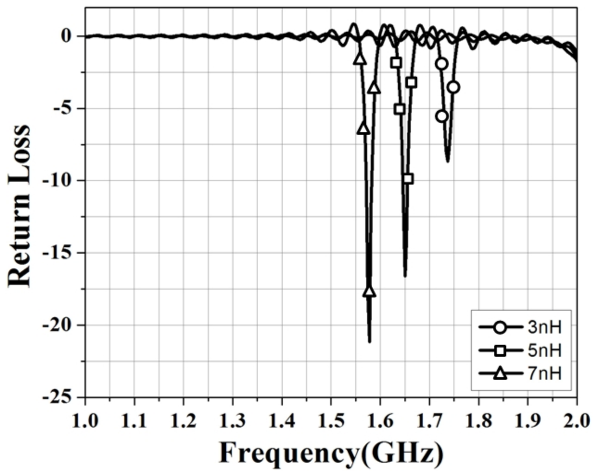
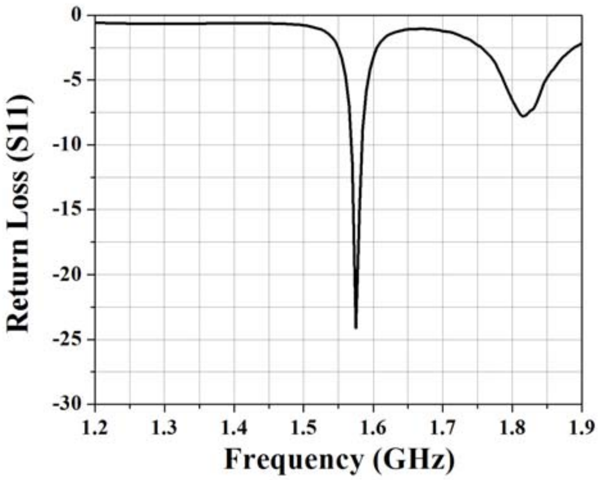
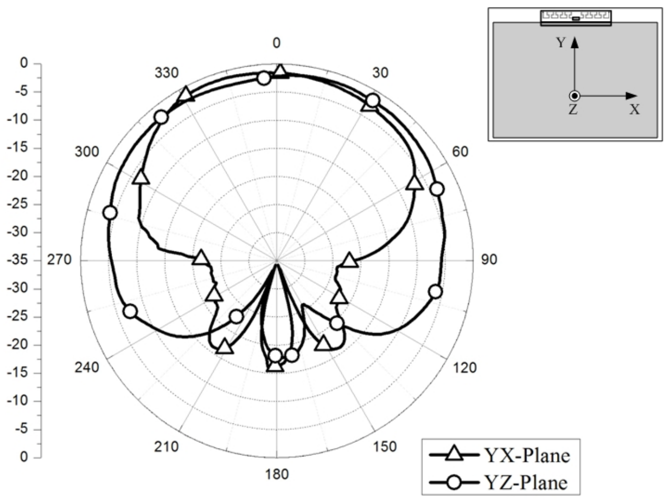


Figure 4. Frequency variation according to L_1 (by CSTMWS)



(a)



(b)

Figure 5. Measured results (a) Return loss and (b) Radiation pattern