A New Radiation Method for Ground Radiation Antenna

Hongkoo Lee, Jongin Ryu, Jaeseok Lee, *Hyung-Hoon Kim, Hyeongdong Kim
Department of Electronics and Communications Engineering, Hanyang University, 17 Haengdang-Dong, Seongdong-Gu, Seoul 133-791, Korea
*Kwangju Women's University, Korea
E-mail : hdkim@hanyang.ac.kr

***Abstract*- This paper presents a new radiation method for exciting small size Universal Serial Bus (USB) dongle applications. New radiation method is designed on a thin line that fully covers Bluetooth and Wireless Lan (Wi-Fi) services. The simulation of the proposed antenna has a bandwidth of 123 MHz, from 2388 MHz to 2512 MHz under Voltage Standing Wave Ratio (VSWR) = 2 : 1. The proposed antenna consists of a feeding line, capacitor (C) and inductor (L). The basis for radiating USB dongle is to form a resonating structure on a thin line connecting USB dongle and Printed Circuit Board (PCB) ground of an external device, where current is strong. The antenna is designed on a Frame Retardant Type 4 (FR-4) substrate (ε_r = 4.4, tan δ = 0.02) and occupies area of 2.5 X 7 mm^2. New feeding structure was designed on a thin line, which is the USB port of a USB dongle that does not require additional clearance area.**

***Index Terms* – PIFA, Ground Radiation Antenna**

I. INTRODUCTION

Mobile devices currently on the market require both a wide bandwidth capability and a high realized efficiency because of their rapidly increasing data usage requiring high data transfer rates. The many functions of today's mobile devices are capable of require many components; for this reason, the components must be compactly arranged within the handsets and mobile antennas must become ever smaller. Expansion of the impedance bandwidth in an electrically small antenna is difficult because the impedance bandwidth of a small antenna is closely related to its physical volume [1].

According to 'Chu-Harrington limit' [2, 3, 4, 5], the radiation quality factor of an ideal small antenna is approximately inversely proportional to the volume of the antenna in wavelengths and thus its impedance bandwidth is limited by the antenna size. From these reasons, the main challenge in the field of antennas is to make the optimal compromise between their size and performance. Therefore, we need to develop a new radiation method with high performance within allowed volume for the antenna.

Antennas are indispensable components in wireless communication devices. They play a pivotal role in determining the performance of a whole communication system. Recently, the concept of ground radiation is extended by previously published papers [6, 7]. This new radiation technique (so called 'Ground Radiation Antennas') is to utilize the ground plane effectively as a radiator for high frequency applications (Wi-Fi and Bluetooth band). Instead of actual antenna structures, this technique uses only reactive components such as commercial chip-capacitors. In other word, two capacitors replace both matching circuits and antennas typically used in mobile handsets. One of reactive components is inserted in the strip line to connect two ground points. Its value is related to a resonant frequency similar to a branch line length of Planar Inverted F Antenna (PIFA). The other component is located on the feeder and its value is involved with input impedance of antennas.

With the wide increase in the use of mobile devices, Bluetooth service has become an essential component in wireless service. All mobile devices require wireless service that enables communication with other devices.

The mobile devices are becoming smaller day by day and as a result, the area allowed for antenna is also becoming smaller. An obvious way to enhance the performance is to increase the antenna size. However, it is impossible to increase the antenna size. It is becoming difficult for antenna designers to fulfill the performance in a limited given space.

In this paper, a new radiation method to excite USB dongle at Wi-Fi frequency (2.4-2.5 GHz) was proposed. The simulation was performed with the Finite Elements Method (FEM) 3D simulator 'ANSYS HFSS v.13' and measurement data was obtained using network analyzer and three dimensional anechoic chamber.

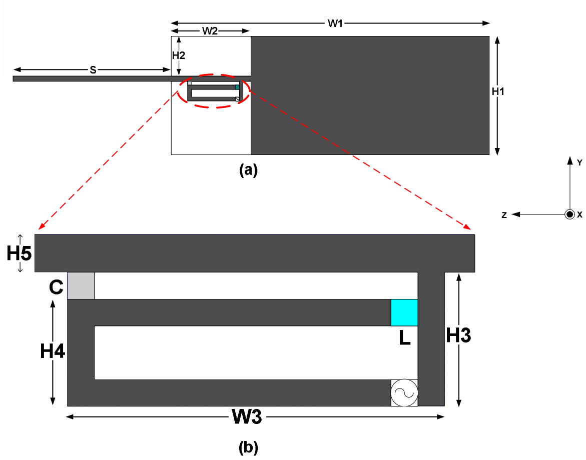

Figure 1. Geometry of the proposed antenna (a) General view; (b) Dimensions of the feeding structure

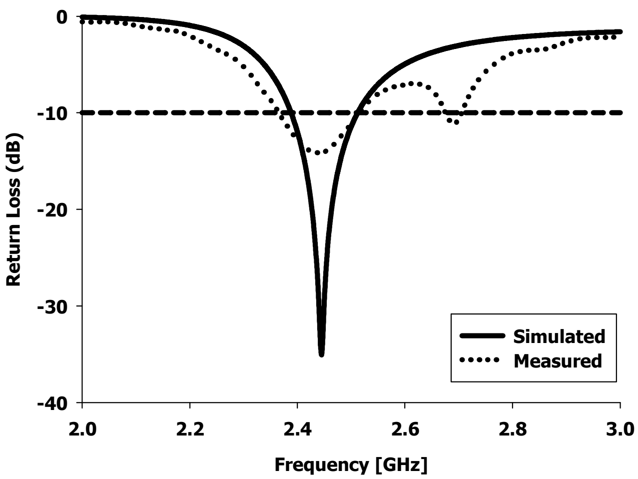

Figure 2. Simulated and measured return loss

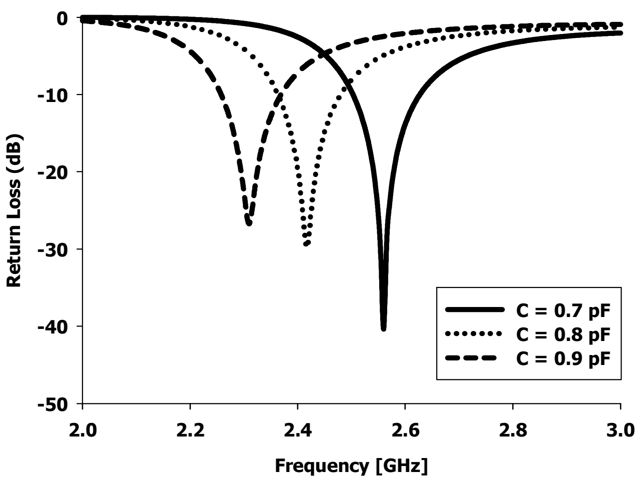

Figure 3. Return loss with C variation

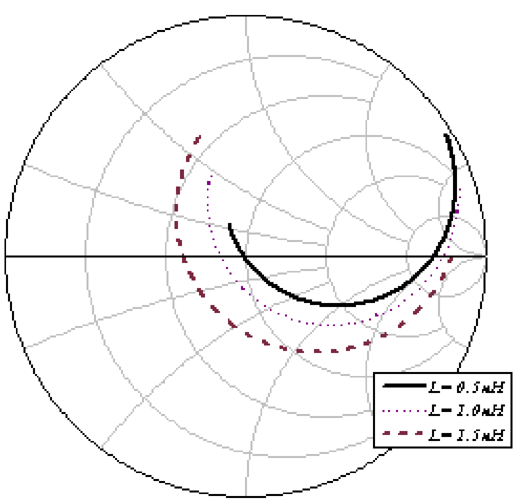

Figure 4. Input impedance with L variation

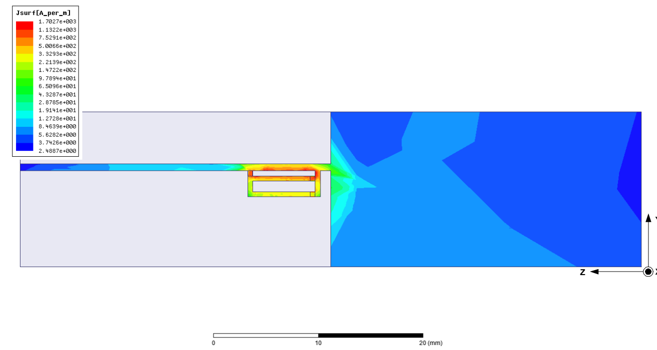

Figure 5. Computed surface current density

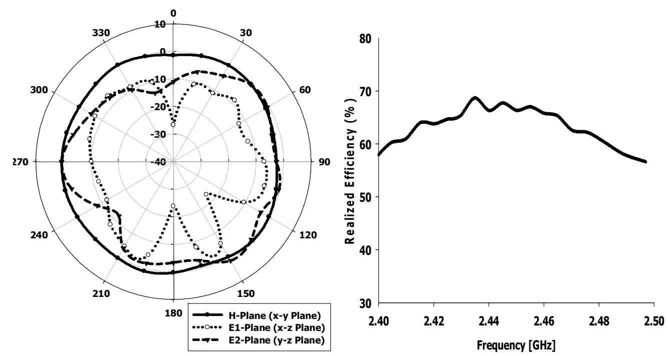

Figure 6. Measured radiation patterns and realized efficiency

II. ANTENNA DESIGNS AND ANALYSIS

The geometry of the proposed antenna is shown in Figure. 1. The optimized design parameters for the proposed antenna are: H1 = 15mm, H2 = 5 mm, H3 = 2.5 mm, H4 = 2 mm, H5 = 0.7 mm W1 = 40 mm, W2 = 10 mm, W3 = 7 mm, S = 20 mm, thickness = 1.2 mm, L = 0.4 nH and C = 0.775 pF.

Technique for controlling resonance frequency is shown in Figure. 3. Resonance frequency can be lowered by increasing the values of C. Figure. 4 shows how the impedance matching can be achieved by controlling the value of L. Figure. 5 is computed surface current density, implying strong current on the thin line of the USB dongle. Figure. 6 is the measured radiation patterns and realized efficiency.

The resonator forms a feeding loop exciting the thin line where current is strong, with magnetic coupling. This coupling can be controlled by variation of L and the resonance frequency can be controlled by variation of C.

III. EXPERIMENTAL RESULT AND DISCUSSION

The proposed antenna has been successfully simulated and constructed. The proposed antenna was simulated and measured. It can be seen from Figure. 2 that the proposed antenna fully satisfies the Wi-Fi bandwidth in both simulation and measured results. Figure. 2 illustrates return loss of simulated and measured results, showing similar pattern at

Bluetooth and Wi-Fi bands. Fig. 2 shows simulation result with bandwidth of 123 MHz (2388 - 2512 MHz) and the measured result with bandwidth of 149 MHz (2365 - 2514 MHz) under VSWR = 2 : 1. It shows overall realized efficiency of 63.21% at 2400 MHz to 2500 MHz and omnidirectional pattern.

IV. CONCLUSION

The proposed antenna was designed and achieves sufficient bandwidth covering Bluetooth and Wi-Fi service. It forms a feeding structure on a thin line, where the current is strong. The proposed feeding method occupies area of 2.5 X 7 mm^2.

This makes it possible to apply the proposed feeding structure in various devices that include a connection through a thin line because it does not require additional clearance area on the PCB ground.

ACKNOWLEDGMENT

This research was funded by the MSIP (Ministry of Science, ICT & Future Planning), Korea in the ICT R&D Program 2013.

REFERENCES

[1] McLean, J.S.: 'A re-examination of the fundamental limits on the radiation Q of electrically small antenna', *IEEE Trans*. Antennas Propag., 1996, 44, (5), pp. 672-676.

[2] H.A.Wheeler, 'Fundamental limitations of small antennas,' *Proc. IRE*, Vol. 35, No. 12, pp. 1479-1484, Dec. 1947.

[3] H.A.Wheeler, 'Small antennas,' *IEEE Transactions on Antennas and Propagation*, Vol. AP-23, No.4, pp. 462-469, Jul. 1975.

[4] R.E.Collin, 'Minimum Q of small antennas,' *Journal of Electromagnetic Waves and Applications*, Vol. 12, No. 10, pp. 1369-1393, Dec. 1998

[5] R.F.Harrington, 'Effect of antenna size on gain, bandwidth and efficiency,' *Journal of Research of the National Bureau of Standards- D. Radio Propagation*, 64D, pl-12, Jan-Feb. 1960.

[6] O. Cho, H. Choi, and H. Kim, 'Loop-type ground antenna using capacitor,' *Electronic Letters*, Vol. 47, No. 1, pp. 11-12, Jan. 2011.

[7] Y. Liu, X. Lu, H. Jang, H. Choi, K. –Y. Jung, and H. Kim, 'Loop-type ground antenna using resonated loop feeding, intended for mobile devices,' *Electronics Letters*, Vol. 47, No. 7, pp. 426-427, Mar. 2011.