Multiband Tuneable Antenna for Mobile Global Roaming Terminals

Jun-Mo Jung Jae-Hoon Jo Yoon-Ho Kang Byung-Je Lee

Department of Radio Science and Engineering, Kwangwoon University

447-1, Wolgye-Dong, Nowon-Gu, Seoul, 139-701, Korea

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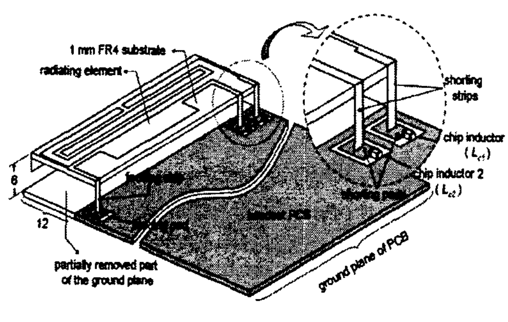
CONTENT

I. INTRODUCTION

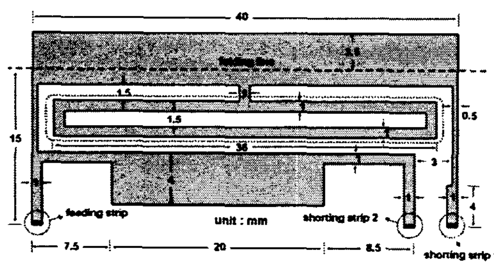
Demands for mobile global roaming terminals, which can use various networks with the only one phone not dependently on what country or region the user is, are increasing. An antenna, especially an internal antenna, with a multi resonance and wide bandwidth is very important for realizing an upcoming global roaming terminal. Many studies and works have been performed to obtain multi-frequency operation of single-fed shorted microstrip antennas which is a major candidate of internal antenna[1]. However, it is still difficult to improve bandwidth since antenna bandwidth is related to the volume of the space which the antenna occupies and it is very restrictive within a mobile handset. Although several meaningful studies have been reported for improvement of the antenna impedance bandwidth, they are not also tolerant of trade-off relations between the bandwidth and efficiency[2,3]. Frequency changeable antenna is brought up as a good solution because if can realign the antenna available band to recently usable network for handset user [4-6]. In conventional frequency changeable antenna, the most noticeable problem is that each frequency band is not independently tuneable. This means that it is very difficult to obtain perfectly matching of two resonant frequencies to meet the desired system bands in case of dual frequency antenna operation. In this letter, a novel multi-band internal antenna with capability of independent frequency shift is proposed. The antenna consists of combing two half-wavelength loaded line structures covering different frequency bands. Detailed characteristics of the proposed antenna are discussed on analysing experimental results.

II. ANTENNA DESIGN

Figure 1 shows the geometry of the proposed multi-frequency antenna mounted on the top portion of system PCB (44 × 85 × 1 mm^3), and the antenna occupies the volume of 40 × 15 × 6 mm^3. Two shorting strips of the antenna are connected to shorting pads on PCB. There are gaps between the shorting pads and PCB ground plane, and chip inductors (L_{c1}, L_{c2}) are added as a connectingbridge between them. Figure 1 (b) shows the layout of the antenna radiating element and remarkably, there are two resonant current paths on the radiating element. One is a path from the feeding strip to shorting strip 1, and the other is a path to shorting strip 2. As shown in figure 1, an end of the half-wavelength microstrip line forming one current path is fed by feeding strip and the other end is connected to the ground by inductively or capacitively loaded element. In this work, this structure is defined as HWLLS (half-wavelength loaded line structure) for brevity. An inductively loaded HWLLS lowers the resonant frequency as the loaded inductance values, compared without loading. This is because that the HWLLS has the only one electric field maximum area and it is shifted to the end of the half wavelength microstrip line as increasing the loaded inductance. The proposed antenna consists of two HWLLS, which operates independently in each lower frequency and higher frequency band. Radiating stub, a rectangular part indicated by a dotted line in Figure 1 (b), reduces the resonant frequency and includes the main radiating area in lower band. Figure 2 and 3 show the simulated dB magnitude of S_{11} for the proposed antenna against varying values of inductances (L_{v1} is an inductance value of L_{c1}, and L_{v2} is an inductance value of L_{c2}) using the dimensions shown in Figure 1. In the simulation, HFSS, as known as a full-wave analysis tool, is employed [7].



(a) Overall view

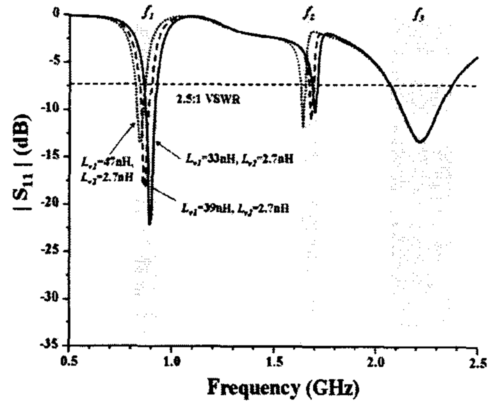


(b) Detail view of the radiating element with dimensions

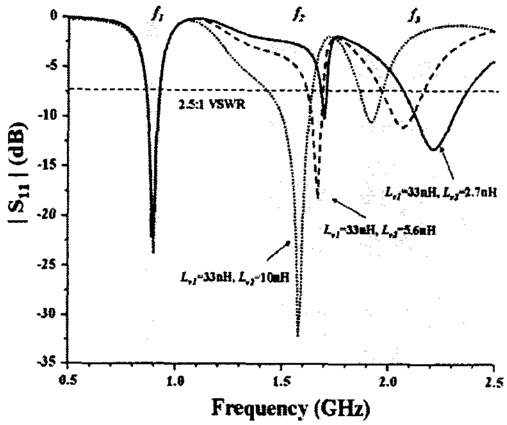
<Figure 1> Geometry of the proposed antenna

III. SIMULATION

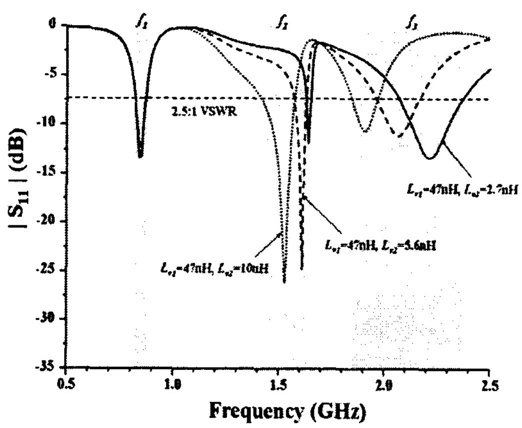
Figure 2 shows the dB magnitude of S_{11} when L_{v2} is fixed at 2.7 nH and L_{v1} takes values of 33 nH, 39 nH, and 47 nH. The regions of f_1, f_2, and f_3 indicate the available frequency band within VSWR of 2.5. The first resonant frequency (f_1) of HWLLS, which is a fundamental mode with a current path from the feeding strip to shorting strip 1, is 0.895 GHz at 33 nH of L_{v1}, 0.862 GHz at 39 nH, and 0.845 GHz at 47 nH, respectively. However, variation of the third resonant frequency (f_3) of HWLLS, which is a fundamental mode with a current path from the feeding strip to shorting strip 2, is very small. Figure 3 (a) and (b) illustrate the dB magnitude of S_{11} varying with the value of L_{v2} when L_{v1} is fixed at 33 nH and 47 nH. In figure 3 (a), when L_{v1} is 33 nH, the resonant frequency (f_3) goes to 2.22 GHz at 2.7 nH of L_{v2}, 2.07 GHz at 5.6 nH, and 1.92 GHz at 10 nH, respectively. In this situation, variation of the third resonant frequency (f_3) is much more dominant than that of f_1. Figure 3 (b) shows the dB magnitude of S_{11} when L_{v1} is replaced 33 nH with 47 nH. Variation of f_2, which is the first higher mode of f_1, and f_3 is very similar to that of figure 3 (a). Results, as shown in figure 2 and 3, mean that the lower and higher frequency of the proposed antenna is independently changeable.



<Figure 2> Simulated dB magnitude of S_{11} with various values of L_{V1} when L_{V2} is 2.7 nH



(a) L_{V1} = 33 nH

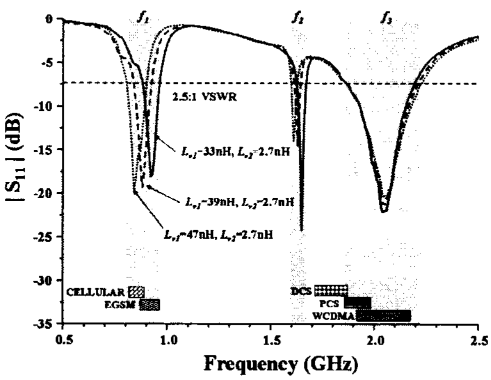


(b) L_{V1} = 47 nH

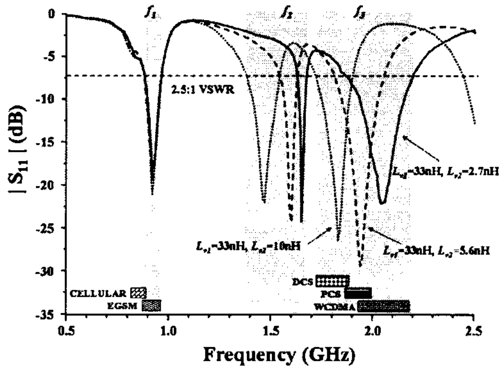
<Figure 3> Simulated dB magnitude of S_{11} with various values of L_{V2}

Ⅳ. EXPERIMENTAL RESULTS

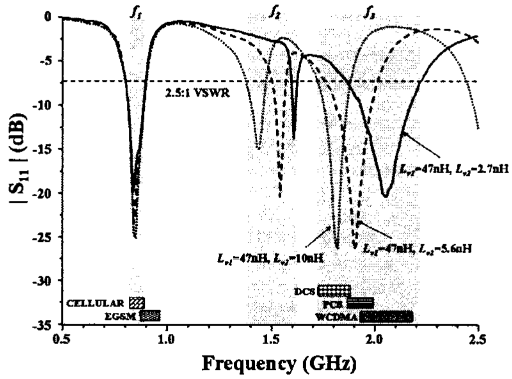
Figure 4 shows the experimental dB magnitude of S_{11} when L_{v2} is fixed at 2.7 nH and L_{v1} takes values of 33 nH, 39 nH, and 47 nH. The first resonant frequency (f_1) is 0.924 GHz at 33 nH of L_{v1}, 0.882 GHz at 39 nH, and 0.848 GHz at 47 nH, respectively. In this situation, variation of the third resonant frequency (f_3) is only 6 MHz. Figure 5 (a) shows the experimental dB magnitude of S_{11} when L_{v1} is fixed at 33 nH and L_{v2} takes values of 2.7 nH, 5.6 nH, and 10 nH. The third resonant frequency (f_3) is 2.054 GHz at 2.7 nH of L_{v2}, 1.944 GHz at 5.6 nH, and 1.828 GHz at 10 nH, respectively. And variation of f_3 is almost not observed. As shown in figure 5 (b), results of when the L_{v1} is 47 nH are very similar to that of figure 5 (a). For global roaming, the antenna has to cover the CELLULAR (824 - 894 MHz), GSM (880 - 960 MHz), DCS (1710 - 1880 MHz), PCS (1850 - 1990 MHz), and WCDMA (1920 - 2170 MHz) bands. In proposed antenna, the frequency band covering GSM, DCS, PCS, and WCDMA can be obtained within 2.5:1 VSWR when L_{v1} is fixed at 33 nH and L_{v2} takes values of 2.7 nH, 5.6 nH, and 10 nH (see figure 5 (a)). Also the antenna covering CELLULAR, PCS and WCDMA band can be realized when L_{v1} is fixed at 47 nH and L_{v2} takes values of 2.7 nH and 5.6 nH (see figure 5 (b)). Figure 6 (a) is a graph of the antenna maximum gains in lower frequency band when L_{v2} is fixed at 2.7 nH and L_{v1} takes values of 33 nH and 47 nH. The maximum gain is 1.768 dBi at 0.88 GHz with L_{v1} of 33 nH, and 1.534 dBi at 0.84 GHz with L_{v1} of 47 nH. Figure 6 (b) shows the maximum gains in higher frequency band when L_{v1} is fixed at 33 nH and L_{v2} takes values of 2.7 nH, 5.6 nH, and 10 nH. Variations are within 0.54 dBi as varying the loaded inductance. Results shown in Figure 6 (b) are consistent with that in Figure 5 (a).



<Figure 4> Measured dB magnitude of S_{11} with various values of L_{v1} when L_{v2} is 2.7 nH

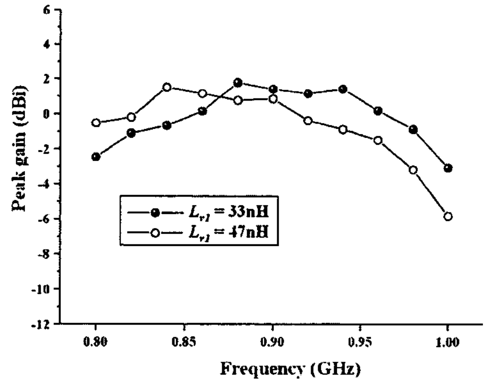


(a) L_{v1} = 33 nH

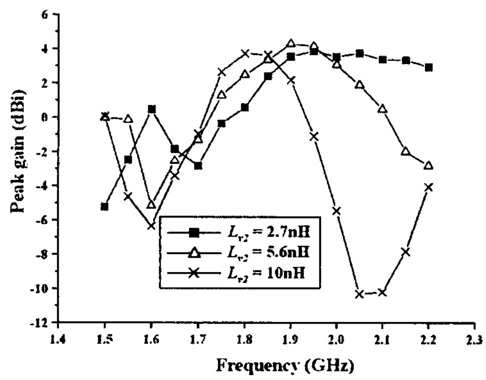


(b) L_{v1} = 47 nH

<Figure 5> Measured dB magnitude of S_{11} with various values of L_{v2}



(a) The lower band (L_{v2} = 2.7 nH)



(b) The higher band (L_{v1} = 33 nH)

<Figure 6> Measured peak gain

V. CONCLUSION

An internal antenna, which is able to cover CELLULAR, GSM, DCS, PCS, and WCDMA, is successfully designed and realized in this work. In future, a mobile handset will become and develop as a single integrated handset available to offer various services rapidly. The antenna is studied and proposed as a good sample in a new design concept. Also it is available for a general-purpose antenna of the present mobile global roaming terminals whose frequency bands are easily tuned as various shapes and types. Tuning of the frequency is realized by lumped elements in the proposed antenna, but it does not perfectly match for an application of the integrated handset. For this, in next work, an antenna with active variable elements will be studied for an electrically active coverage of the desired frequency bands.

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