Design of Planar-Type Modified Folded Loop Antennas

Sung-il Park, *Member, KIMICS*

***Abstract*— This paper proposes the planar-type modified monopole antennas of loop structure. This antenna has an opened center of a conventional closed loop structure with an inside-folded terminal of the loop microstrip line. The size of the proposed antenna was minimized by folding the end of the loop. Also, the reactance value has been minimized by increasing capacitances between the coupled microstrip line. Therefore the proposed antenna has been compacted to about 20% from a conventional loop antenna and has increased its efficiency. The proposed antennas have an omni-directional pattern, the antenna gain was 3.67 [dBi] and the bandwidth was 900 MHz (2.6~3.56 GHz) with VSWR≤2 from the simulated and the measured results. The frequency utilization coefficient was 29.9%. These properties could satisfy the S-DMB band.**

***Index Terms*—folded loop antenna, CPW (Coplanar waveguide), Broadband, Wideband, S-DMB**

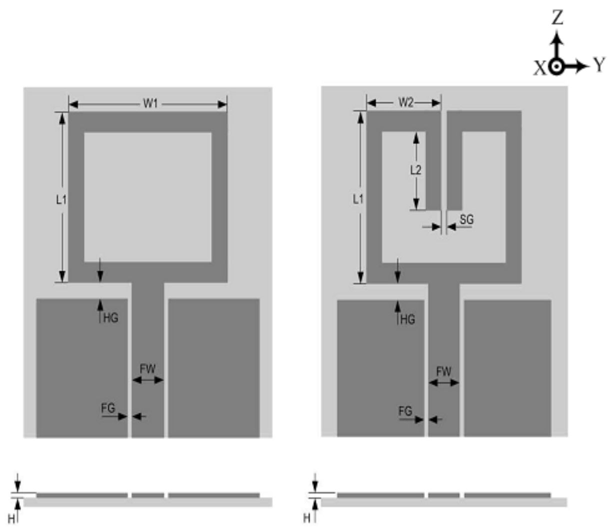
I. INTRODUCTION

These days, with the miniaturization and integration of personal mobile terminals, mobile phone antennas likewise must be small, light, multi-functional, and capable of being mass produced. In today's mobile telecommunication age, monopole and patch antennas are used most as terminal antennas because they are easy to manufacture. Patch antennas are widely used as antenna elements but are problematic because of their narrow bandwidth (approximately less than 10%). In addition, the size of the patch is approximately λ/2 in relation to the wavelength of resonance frequency, which makes these antennas difficult to mount on small portable telecommunication devices[1][2]. This also poses an obstacle to the manufacturing of the diverse designs demanded by today's consumers. This paper proposes to minimize antenna size by folding the loop. The physical size of the antenna is minimized by opening and folding the center of microstrip loop into the radiator. The current at the terminal of the opened and folded loop structure is approximated at zero due to the electromagnetic properties. The antenna efficiency is increased by generating capacitance between the folded microstrip lines. The proposed antenna can be used for the satellite DMB band.

Manuscript received September 15, 2010; revised September 24, 2010; accepted September 27, 2010.

Sung-il Park is with the Department of Engineering Information & Communication, Dongshin University, Naju, Korea (Email: psi@dsu.ac.kr)

II. ANTENNA DESIGN AND MEASUREMENT



(a) (b)

Fig. 1 Geometry of proposed antennas
(a) A closed loop structure.
(b) The coupled loop structure.

TABLE 1
OPTIMAL PARAMETERS OF THE DESIGN ANTENNAS

(a) Parameters of closed loop

Parameter	Value	Parameter	Value
L1	17[mm]	FW	5 [mm]
W1	24[mm]	FG	0.4[mm]
HG	1.4[mm]		

(b) Parameters of with coupled loop

Parameter	Value	Parameter	Value
L1	15[mm]	SG	0.4[mm]
W2	9.6[mm]	HG	1.4[mm]
L2	6 [mm]	FW	5 [mm]

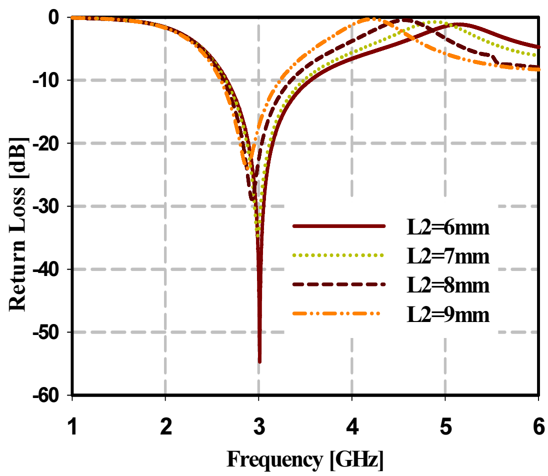


Fig. 2 Return loss against various L2 in (b) of Fig1.

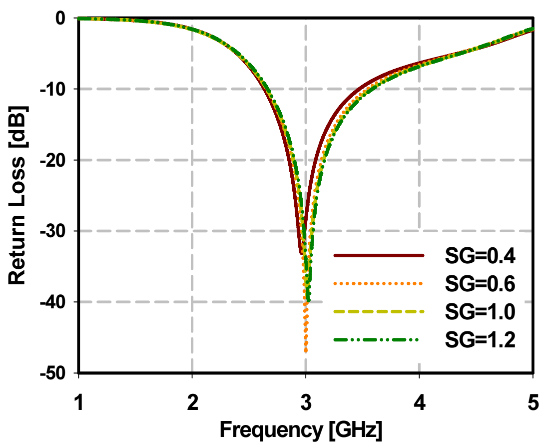


Fig. 3 Return loss against various SG in (b) of Fig1

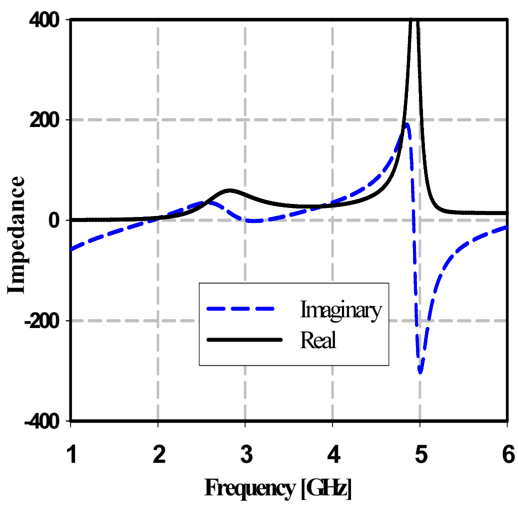


Fig. 4 Impedance characteristic of proposed antenna.

The proposed antennas use a coplanar waveguide (CPW) that can be realized through a single plane, thus allowing for an easy feeding method. Fig. 1 presents the design structure of the proposed antenna. Structure (a) of Fig. 1 represents closed loop antennas. The proposed structure (b) of Fig. 1 represents an opened and folded central loop antenna with electromagnetic properties approximated at zero. The proposed antenna is folded inside the loop to generate coupling between both lines. As shown in the Fig. 1, planar square loop antennas consist of a feeding part and a radiating part according to a CPW with a length of 50[Ω] design[3][4][5].

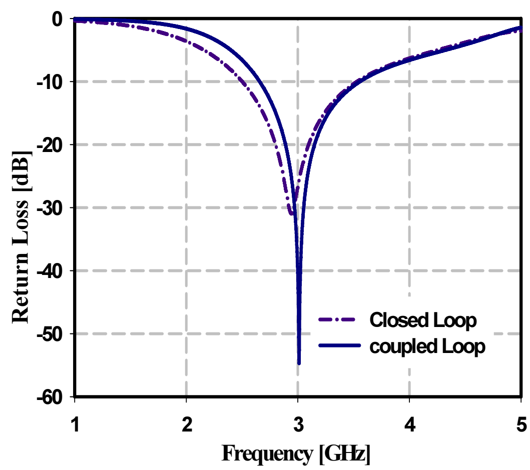


Fig. 5 Return loss of proposed antennas of (b) Fig1.

Table 1 shows parameters of the designed antennas. Here, 'H' is the height of the dielectric board and t is the thickness of the conductor. An RF-4 substrate with relative dielectric constant 4.2 and a thickness 0.8 [mm] was used for designing the proposed antenna. The length of the rectangular loop antenna was optimized from λ/3 to λ/4 of operation frequency[6]. Fig. 2 shows the reflection coefficient according to L2 change in structure (b) of Fig. 1. Here, the maximum resonance properties were obtained at 6 mm when L2 changed from 6 to 9 mm. Accordingly, as the length of L2 increases, the resonance frequency shifted to a lower band, It was in agreement with general antenna theories. Fig. 3 shows reflection coefficients in proportion to SG change in structure (b) of Fig. 1, which is the gap between folded microstrip of loop antenna. When SG changed from 0.4 to 1.2 mm, the resonance frequency didn't shift but the resonance properties changed. This was because resonance conditions were satisfied in consequence of capacitance change due to the SG distance. Fig. 4 shows impedance properties according to a simulation of structure (b) of Fig. 1. Here, when the imaginary value approximated at zero, the effective resistance clearly expressed a characteristics impedance of 50 [Ω]. Fig. 5 shows the reflection coefficients of comparison between a closed loop antenna and the proposed antenna. From Fig. 5 the resonance frequency of closed and folded structures didn't change significantly, but the proposed loop antenna produced better characteristics of reflection coefficients than a closed loop antenna. The total size of both structures were reduced approximately 20% and obtained good results, due to the design of the folded loop antenna.

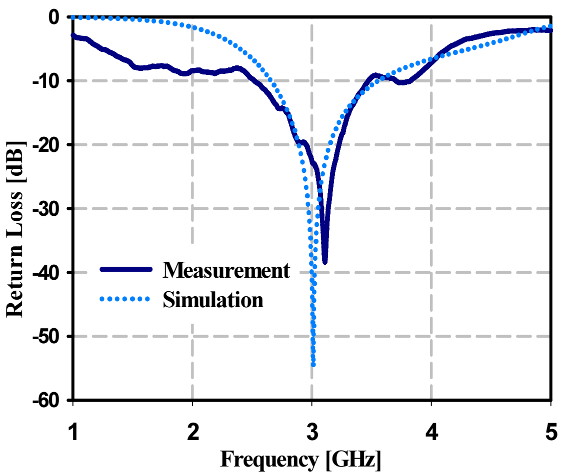


Fig. 6 Impedance characteristic of proposed antenna.

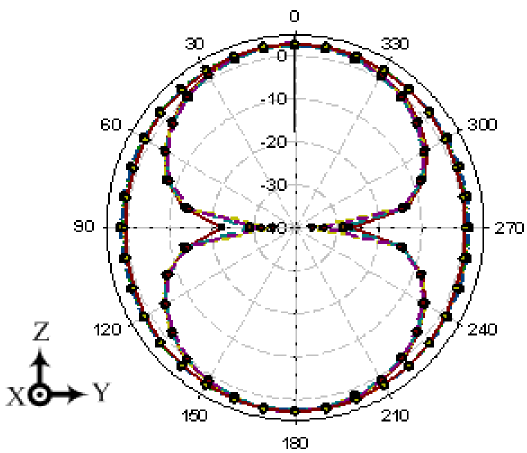
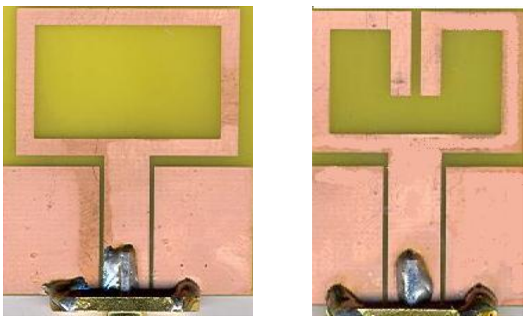


Fig. 7 Impedance characteristic of proposed antenna.



(a) Closed loop type (b) Coupled loop type

Fig. 8 The photographs of manufactured antenna

Fig. 6 shows reflection coefficients of the simulation and the measurement. As shown Fig. 6 reflection coefficients have similar results that were outstanding. Fig. 7 shows the radiation pattern of the proposed antenna. Here, differences in gain properties are extremely negligible, the radiation properties of the electric field and the magnetic field reflected the monopole antennas of omni-directionality. Fig. 8 shows photographs of the manufactured antenna. The third photograph was small because the overall size decreased in comparison with the closed loop antenna.

Ⅲ. CONCLUSIONS

In this paper proposes the use of a modified folded loop antenna with CPW-fed. The proposed structure has an opened and folded center loop antenna. It has been folded inside to generate a coupling between both coupled lines. We analyzed the properties of the proposed antenna according to designing parameter values and manufactured specifications. Antenna gain of 3.67 [dBi] were obtained and from both of the simulation and the measurement results an impedance bandwidth of 900 MHz (2.6-3.56 [GHz]) with VSWR≤2 was obtained. It satisfied the frequency band of satellite DMB (2.6-2.655 GHz). The electric field and magnetic field patterns of the radiation pattern confirmed to approximate an omni-directional pattern.

REFERENCES

[1] W. Menzel and W. Grabherr, "A microstrip patch antenna with coplanar feed line," IEEE Microwave Wave lett., vol. 1, pp. 340-342, Nov. 1991.

[2] W. L. Stutzman, G. A. Thiele "Antenna theory and design," John Wiley & Sons, pp.210-215, 1998

[3] P. L. Sullivan, "Analysis of an Aperture Coupled Microstrip Antenna" IEEE Trans. Antennas and Propagation, Vol. AP-34, No. 8, August 1986.

[4] H. Lee, Y. Lim. "Wide-Band High-Efficiency Printed Loop Antenna Design for Wireless Communication Systems," IEEE

Trans. on Vehicular Technology vol.54, no.3, May, 2005.
[5] K. F. Lee, W. Chen, "Advanced in Microstrip and Printed Antennas," Wiley Inter-science, pp. 71-109, 1997.
[6] K. D. Katsibas, C.A. Balanis, P. A. Tirkas, " Folded loop antenna for mobile communication system," International IEEE Antenna and propagation Symposium Digest. vol. 34, pp1582-1585, Jul. 1996.

Sung-il Park received the B.S., M.S. in Information & Communication engineering from Dongshin University, Naju, Korea, in 2002, 2004, respectively. He also received Ph.D. from Chonnam National University, Korea in 2010. From 2006 to 2009 he was a full-time lecturer in Information & Communication engineering from Dongshin University. Since 2009, he has been a part-time lecturer in Information & Communication engineering from Dongshin University, Naju, Korea.