Vertically Polarized Omni-Directional Loop Slot Array Antenna for Mobile Base Station

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***Abstract* – A slim vertically polarized omni-directional feed circuit integrated loop slot antenna for mobile base station is proposed in this paper. Picocell antenna requires a compact and slim structure, because its construction space is limited in urban areas. The proposed antenna consists of loop slots and patches to improve omni-directional pattern and bandwidth. In order to enhance the directivity gain, we arrange two loop slot antennas in vertical plane with microstrip line connecting the slots. The size of antenna is only 0.17λ×1.45λ. This antenna realizes more than 15% relative bandwidth, and an omni-directional pattern in both simulation and measurement results.**

***Index Terms* — vertically polarized, omni –directional, loop slot, parasitic elements, feeding circuit integrated antenna.**

1. Introduction

Picocell antennas require a slim structure and an omni-directional pattern in horizontal plane. A dipole and a monopole antenna are generally used as vertically polarized omni-directional base station antennas [1], [2]. The feeding circuit of linear dipole or monopole array is complicated, then we propose a feed circuit integrated antenna.

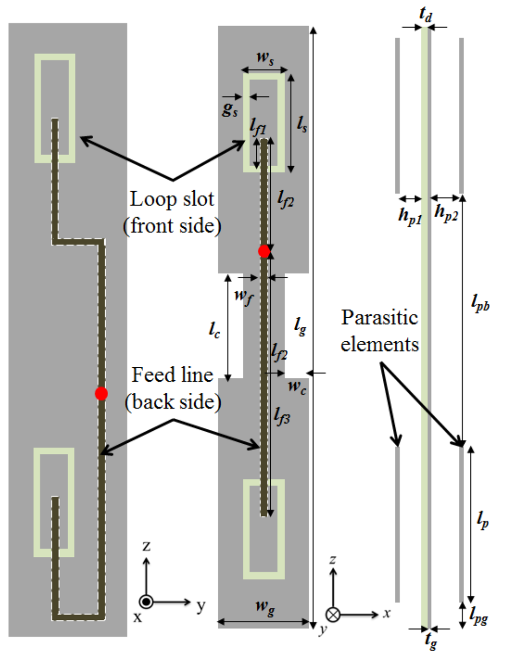
In [3], a vertically polarized omni-directional loop slot antenna was proposed. This antenna consists of the loop slot with parasitic patch and feed lines for multi-band application.

This paper presents a simple array feed network to enhance the directivity in vertical plane and a defected ground plane to suppress unwanted mode radiation in horizontal plane. The proposed antenna geometry is compared with a tournament feed network in simulation and measurement.

2. Antenna Design

We propose an out of phase excitation for the vertically polarized omni-directional loop slot array antenna with parasitic elements. In most applications [4], [5], the tournament feeding circuit is generally used as feeding circuit of array antenna. Fig. 1(a) shows the two-loop slots array antenna using a tournament feeding circuit. One of the problems of this feeding structure is that the antenna width is large because of feeding circuit arranged along the loop slot. The width of the antenna has an influence on radiation pattern in horizontal plane. To reduce the antenna width, we propose a new feeding circuit for loop slot antenna.

Fig. 1(b) shows the geometry of the proposed antenna which has a slim structure (0.17λ×1.45λ). This antenna has two loop slots excited by a microstrip line on the back side of dielectric substrate with a relative dielectric constant of ε_r =2.6. Each slot is located at a distance 0.8λ from each other. Two elements are excited out of phase to excite both antenna elements in phase for the straight microstrip line as shown in Fig. 1 (b). The parasitic elements are placed at both sides of the substrate.



(a) Tournament feeding antenna (b) Proposed feeding antenna

Fig. 1. Antenna configuration.

lg=1.45λ, *wg*=0.17λ, *ls*=0.27λ, *ws*=0.08λ, *gs*=0.01λ, *lf1*=0.08λ, *lf2*=0.29λ, *lf3*=0.61λ,*wf*=0.01λ, *lc*=0.13λ, *wc*=0.06λ, *lpb*=0.50λ, *lpg*=0.11λ, *lpd*=0.36λ, *hp1*=0.06λ, *hp2*=0.05λ, *tg*=0.5mm, *td*=0.8mm

In the first step, the loop slots with a peripheral length of substantially one wavelength are excited by the microstrip feeding line. Then the parasitic elements are excited by the field of the loop slots. At the center of the structure of proposed antenna, two rectangle parts (length=*lc*, width=*wc*) are removed to reduce the unwanted mode radiation. The current distributions are shown in Fig. 3, which shows that the proposed structure helps in removing standing wave on the ground plane.

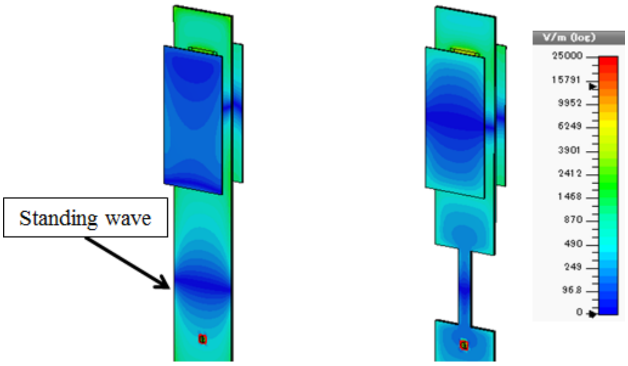
3. Simulation and Experiment Results

In this section, the proposed antenna geometry (b) is compared with a tournament feed network (a) in both simulation and measurement.

Fig. 3 shows reflection characteristics. The bandwidth of the proposed antenna is wider than tournament one due to its simple feeding circuit. The relative bandwidth of proposed antenna is more than 15% for the reflection below -10dB in both simulation and measurement. The reflection characteristic shows two resonant frequencies. The first one is excited by parasitic elements coupled with the loop slot, and the other is given by the coupling between the parasitic element on feeding side and the feeding line.

The radiation patterns in horizontal plane are shown in Fig. 3 for two frequencies at 0.93f_0 and 1.10f_0. It shows that the proposed antenna provides omni-directional pattern better than tournament one because the resonance of ground plane is suppressed by the proposed geometry. The simulation results are similar with measurement in reflection characteristics. The radiation from the parasitic element on the feeding side is stronger than the side one at high frequency, then the parasitic element positions are adjusted as h_{p1}=0.06λ and h_{p2}=0.05λ to reduce the pattern deviation in horizontal plane. The radiation patterns in vertical plane are shown Fig. 4. In lower frequency, side lobe of proposed antenna is larger than tournament one due to the radiation by the feeding circuit.

The gain deviations of the proposed antenna in both simulation and measurement in horizontal plane are less than 3 dB for two frequencies. The gain deviations for the simulation in horizontal plane are smaller than the measurement due to the influence of coaxial cable in experimental system.



(a) Original structure (b) Proposed structure

Fig. 2. The current distributions.

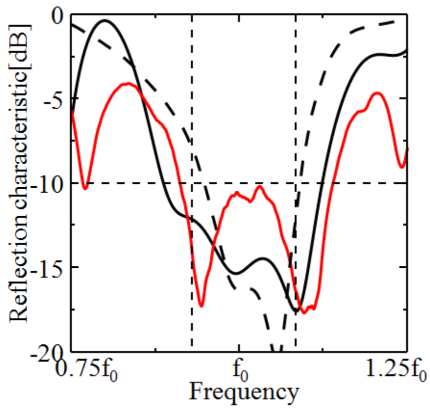
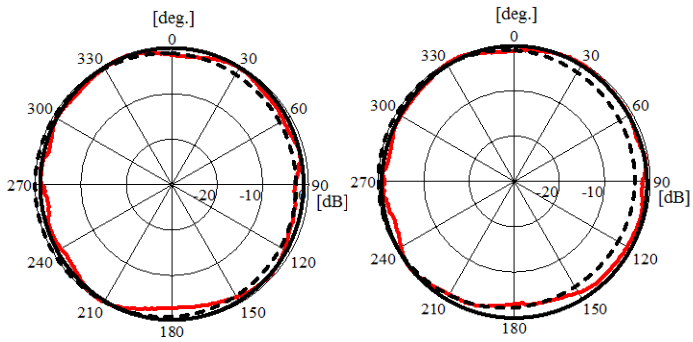


Fig. 3. Reflection characteristic of the proposed antenna.

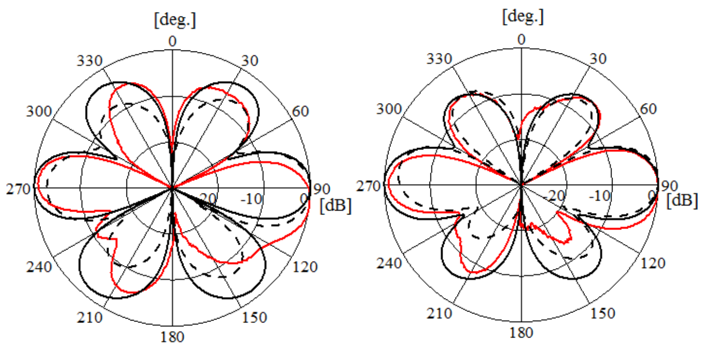
Sim.(a) Sim.(b) Exp.(b)



(a) 0.93f_0 (b) 1.10f_0

Fig. 4. Radiation pattern in horizontal plane (xy-plane).

Sim.(a) Sim.(b) Exp.(b)



(a) 0.93f_0 (b) 1.10f_0

Fig. 5. Radiation pattern in vertical plane (yz-plane).

Sim.(a) Sim.(b) Exp.(b)

4. Conclusion

We propose a slim vertically polarized omni-directional feed circuit integrated array antenna for mobile base station. This antenna has two loop slots and patches excited by a microstrip line on the back side of dielectric substrate. The two elements are excited out of phase to excite both antenna elements in phase for the straight microstrip line.

This antenna provides more than 15% relative bandwidth, and an omni-directional pattern in both simulation and measurement results.

References

[1] H. Kakehuda, A. Shimamura, T. Tanaka, Y. Ebine, "A design method of dual polarized omni-directional antenna for radio blind areas," *Soc. Conf. IEICE.*, vol. B-1-79, 2009.

[2] I. Icgiro and H. Yagi, "2GHz band dual polarized omni-directional antenna," *Soc. Conf. IEICE.*, vol. B-1-149, 2003.

[3] Y. Yokoo and H. Arai, "Multi-frequency loop slot antenna with omnidirectional pattern," *IEICE trans. Comm.*, vol. J88-B, no.9, pp.1718-pp.1727, 2005.

[4] H. D. Chen, C. Y. D. Sim, J. Y. Wu, and T. W. Chiu, "Broadband high-gain microstrip array antennas for WiMAX base station," *IEEE Trans. Antennas Propag*., vol. 60, no.8, pp.3977-3980, 2012.

[5] Chi-Fang Huang and Wei-Yu Chen, "A wideband microstrip array based on air substrate for wireless base-station applications," IEEE *EuCAP*, pp.1268-1271, 2013.