Design of Base Station Antenna for RF Energy Harvesting

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Abstract— In this paper, a base station antenna changing the backward radiation energy into the renewable RF energy is proposed. The antenna is composed of the array radiator and RF harvesters using slots on the ground plane. The main radiator having a planar dipole type and several RF harvesters on the ground plane are used to renew the RF energy from the main radiators. The several harvesting ports are connected with the RF combiner by coaxial cables and the harvested energy is changed into the DC voltage through the rectifier circuit. Because the surface current on the ground plane flows into the RF harvesting port in the slot, the performance of the main radiator is little disturbed.

As a result, the amount of the harvested energy from this base station antenna is approximately 0.16% of the originally radiated power. The simulated radiation performances of the proposed antenna are almost same with that of the antenna without the harvester.

1. INTRODUCTION

Energy harvesting is the process of accumulating and storing ambient energy from various sources in surroundings to energy storage components. One of the energy harvesting is to use ambient RF energy. However, the RF harvested energy from the mobile communications is about from a 1,000 to 10,000 of other ambient energy sources [1]. Therefore more reasonable solution to harvest RF energy should be needed and developed.

Generally the base stations or repeaters are transmitted with very high power. However, some of the transmitted power is radiated backward and dissipated [2]. In this paper, a base station antenna changing the backward radiation energy into the renewable RF energy is proposed. The antenna is composed of the array radiator and RF harvesters using slots on the ground plane. From the surface currents on the slot, the coaxial ports connected with the rectifier circuit could harvest the RF energy.

2. THE DESIGN CONCEPT OF THE RF ENERGY HARVESTER

Figure 1 shows an element of the base station antenna with the rectangular ground plane and reflector. As shown in Figure 1, the antenna is composed of a dipole type patch and capacitive feeding to enhance the bandwidth characteristics [3]. The dipole antenna has a compact size of 79.2 mm × 70 mm × 34 mm ($W\_a \times L\_a \times H\_a$) to cover Korean LTE band (1.84∼1.87 GHz).

Figure 2 shows the simulated comparison of the radiation patterns between the proposed rectenna and the antenna element shown in Figure 1. The reflector of the ground plane was a height of 12.5 mm (H_g) and used to reduce the back-lobe and increase the gain of antenna [4, 5]. The gain and FBR (Front Back Ratio) of antenna without harvesters are about 10.0 dBi and 23.0 dB, respectively. Even though the reflector such as the vertically side walls on the ground plane to reduce the back-lobe were already presented, the previous side reflector except our research [4] had

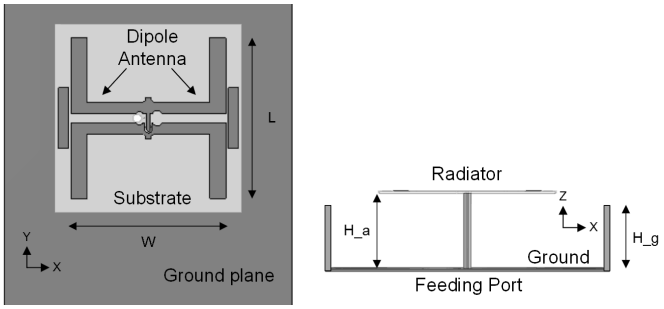

Figure 1: General dipole antenna above a rectangular ground plane. (a) Top view. (b) Side view.

no the harvesting function. To harvest the RF energy and compensate for the gain-loss of antenna, the height of reflector was increased from 12.5 mm to 25 mm.

As shown in Figure 2, the side reflector with slots and harvesting ports are able to suppress and harvest the back-lobe of antenna which has little effect on the forward radiation performance. The gain and lobe-suppression of the proposed model is much improved by 0.3 dBi and 10 dB,

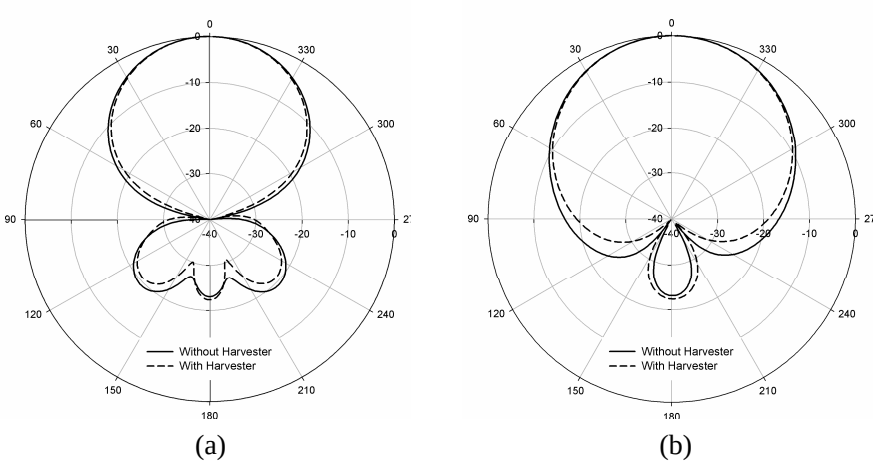

Figure 2: Comparison of the radiation patterns of the proposed array antenna on 1.87 GHz. (a) E-plane. (b) H-plane.

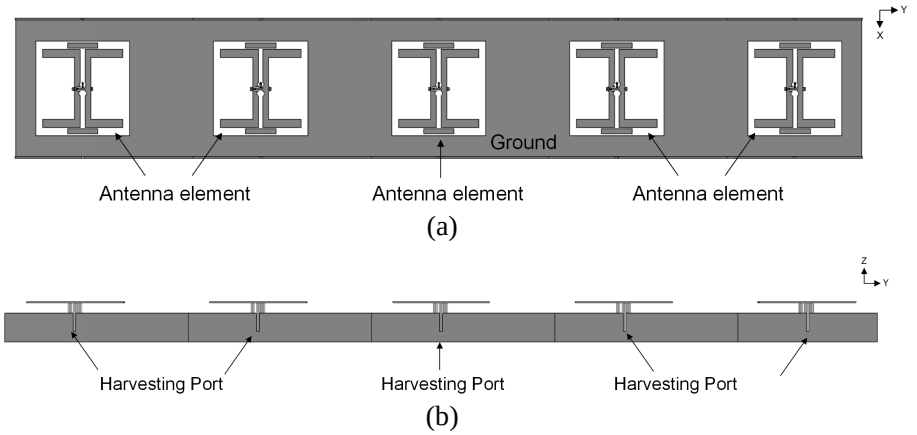

Figure 3: The array antenna with RF energy harvesters. (a) Top view. (b) Side view.

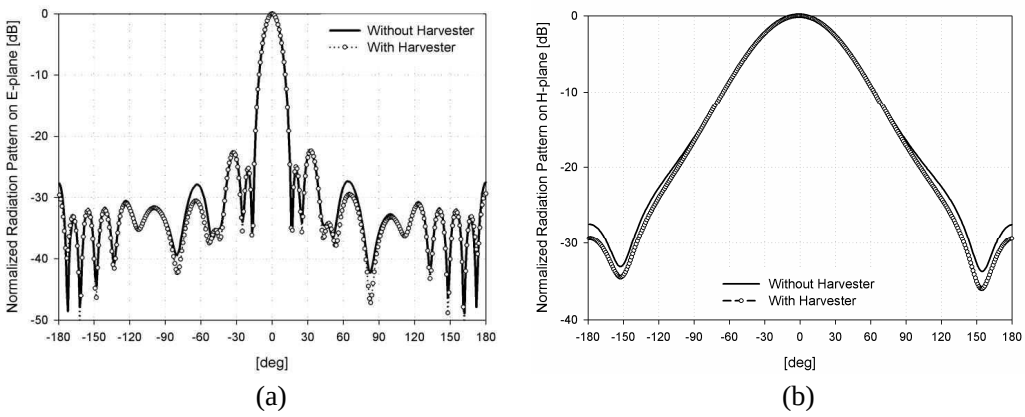

Figure 4: Comparison results of the radiation patterns of the proposed array antenna. (a) E-plane. (b) H-plane.

respectively. However, the height of the reflection should be increased. The coupling between the main radiator and the metallic wall can be controlled by the locations of the slot and walls.

3. THE DESIGN OF ARRAY ANTENNA WITH RF ENERGY HARVESTER

Figure 3 shows the proposed array antenna with RF energy harvesters. The main radiator is composed of five elements and has high gain with vertical polarized radiation performances. And several harvesting ports are arranged with the edge of ground plane shown in Figure 3(b). The coupling factor between the antenna element and the harvesting ports is about 30 dB in the operating band. From Figure 4, the back-lobe suppression on E and H-plane were 4.9 dB and 2.3 dB, respectively, for the absence of the harvesters As a result, the amount of the harvested energy from this base station antenna is approximately 0.16% of the originally radiated power.

4. CONCLUSIONS

This paper presented the array antenna with RF energy harvesters. The slotted ground plane and harvesting ports were used to harvest the non-intentional radiation of the origin antenna. These results show that this proposed rectenna is useful for RF energy harvest applications. In addition, it would be very useful in practical and efficient antenna design.

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REFERENCES

1. Fiorini, P., "Micropower energy scavenging," *Solid-State Circuits Conference*, 2008.
2. Siu, L. and K.-M. Luk, "Unidirectional antenna with loaded dielectric substrate," *IEEE Antenna and Wireless Propagation Letters*, Vol. 7, 2008.
3. Jeong, S. J., "Compact circularly polarized antenna with a capacitive feed for GPS/GLONASS applications," *ETRI Journal*, Vol. 34, Oct. 2012.
4. Moon, J. I., I. G. Cho, S. M. Kim, and Y. B. Jung, "Design of efficient rectenna with vertical ground- walls for RF energy harvesting," *Electronics Letters*, Vol. 49, 1050–1052, Aug. 2013.
5. Wong, T. P. and K. M. Luk, "A wide bandwidth and wide beamwidth CDMA/GSM base station antenna array with low backlobe radiation," *IEEE Trans. on Vehicular Technology*, Vol. 54, 903–909, May 2005.