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# Three-Dimensional Self-Complementary Antenna

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## 1. Introduction

It has been reported by the present authors that the input impedance of a planar antenna composed of conducting plate and slot on a flat surface, which are self-complementary structures each other, is independent of frequency. Recently, we studied three-dimensional self-complementary antennas composed of the combination of flat conducting plates, and it has been proven theoretically and experimentally that the input impedance is constant with respect to frequency.

## 2. Main text

### (i) Theory

Let us consider an antenna shown in Fig. 1 as the three-dimensional self-complementary antenna. The currents on the conducting plates are divided into the currents on the head and the tail surfaces as shown in Fig. 2a. The complementary antenna to that of Fig. 2a is the antenna shown in Fig. 2b, and the relations among the voltages and the currents are derived using the symmetric geometry as

$$\begin{Bmatrix} V = V_1 = V_2 = V_3 = V_4 = V_0 \\ I = 4I_0, \quad I_1 = I_2 = I_3 = I_4 = I_0 \end{Bmatrix}, \quad \begin{Bmatrix} V' = V_1' = V_2' = V_3' = V_4' = V_0' \\ I' = 4I_0', \quad I_1' = I_2' = I_3' = I_4' = I_0' \end{Bmatrix}$$

In the above equations, $V_0, I_0, V_0'$ and $I_0'$ are the voltages and the currents of wedge of one quarter space. In the same manner to the planar self-complementary antenna, the relations

$$V_0' = Z_0\, I_0^2, \quad I_0' = V_0,$$

are used and we have

$$Z' = \frac{V'}{I'} = \frac{V_0}{4I_0'} = \frac{Z_0^2 I_0}{4V_0} = \left(\frac{Z_0}{4}\right)^2 \frac{I}{V} = \left(\frac{Z_0}{4}\right)^2 \frac{1}{Z},$$

where $Z_0$ is the intrinsic impedance in vacuum space. Since $Z = Z'$ in the case of the self-complementary antenna, the value of $Z$ is derived as

$$Z = Z_0 / 4 \cong 30\pi \cong 94.2\,\Omega\,.$$

### (ii) Experiment

Antennas shown in Fig. 3 were fabricated and the input impedance was measured. The results are shown in Table. The radiation pattern of antenna shown in Fig. 3b was also measured and the results are illustrated in Fig. 4, which is almost the same to theoretical results.

3. Conclusion

It has been shown that the input impedance of three-dimensional self-complementary antenna shown in Fig. 1 is $30\pi \cong 94.2\,\Omega$ theoretically and the measured results almost agree with the theoretical value. We expect that the three-dimensional self-complementary antennas become practicable broadband antennas.

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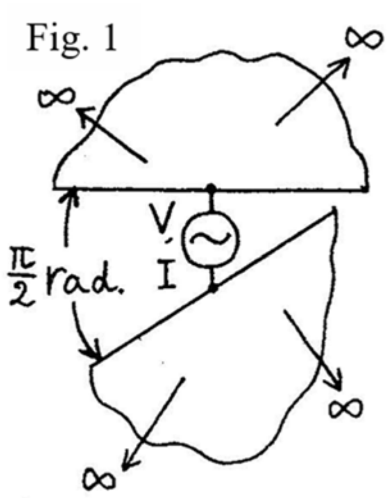


Fig. 1

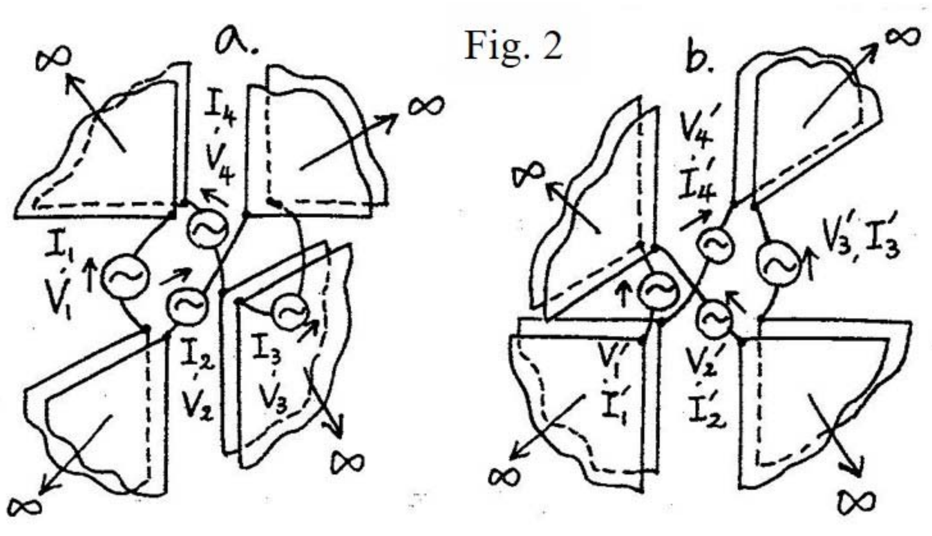


Fig. 2

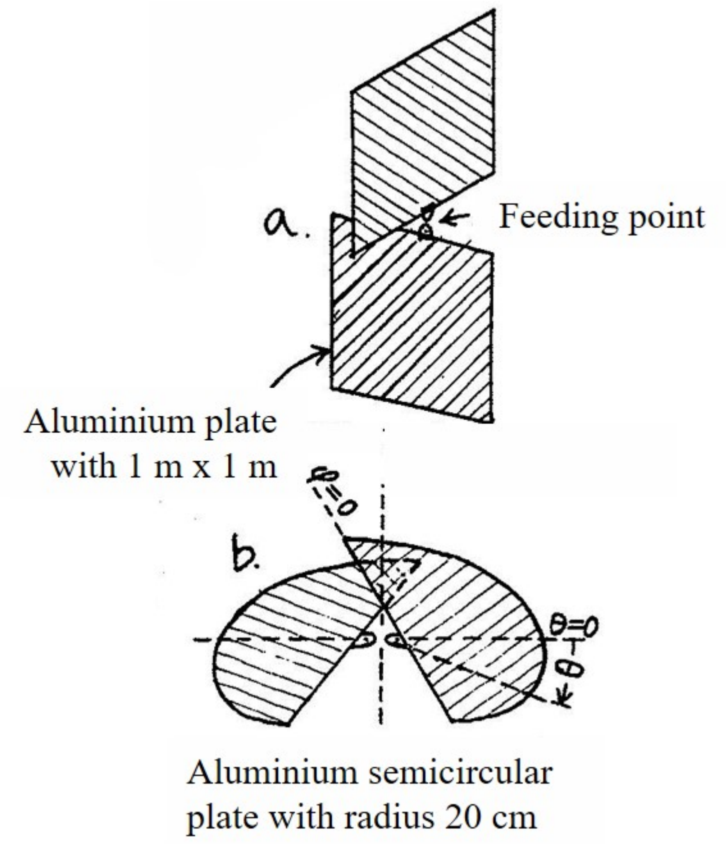


Fig. 3

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Frequency (MHz) | 550 | 600 | 680 | 700 | 725 | 750 | 810 | 850 | 900 |
| Impedance of *a* | 88 | 76.5 | 105 | 100 | 90 | 105 | 95 | 119 | 150 |
| Frequency (MHz) | 700 | 720 | 740 | 760 | 780 | 800 | – | – | – |
| Impedance of *b* | 100 | 85 | 94 | 84 | 105 | 110 | – | – | – |

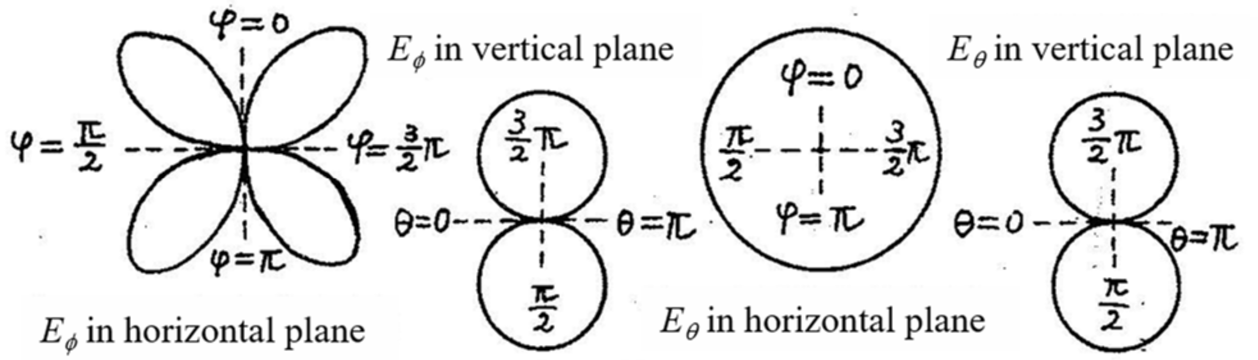


Fig. 4