A Reconfigurable Antenna Using Fluorescent Lamps

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Abstract - **Plasma in a discharge tube, such as a fluorescent lamp, conducts electric current below a plasma frequency, and therefore can be used as an antenna element. This paper describes a reconfigurable antenna by combining a quarter-wavelength monopole on a ground plane and an array of U-shaped fluorescent lamps surrounding the monopole. The lamps configure as a square cylinder. When the lamps on adjacent two planes among the square cylinder are switched on, these lamps function as a square corner reflector; and when the lamps on a plane and approximately halves of its adjacent two planes are switched on, these function as a trough (C-shaped) reflector. These configurations yield a 8-multibeam, directional antenna. On the other hand, when all the lamps are switched off, this antenna is omnidirectional. An inexpensive reconfigurable antenna was realized by selecting the lamps to be switched on/off. Absolute gains measured with a prototype antenna were approximately 8.2-9.3 dBi when directional and 1.1-2.3 dBi when omnidirectional. Transient time between the different directivities was found approximately 60 ms, corresponding to the thermal time constant of hot cathodes of fluorescent lamps.**

Index Terms — **Reconfigurable antenna, corner reflector antenna, fluorescent lamps, plasma**

I. Introduction

Plasma in a discharge tube, such as a fluorescent lamp, conducts electric current below a plasma frequency determined by electron density within the tube, and hence can be used as an antenna element. A smart antenna has been proposed by placing a cylindrical array of straight fluorescent lamps around a dipole antenna and switching off one of the lamps to find out a direction of radio wave arrival [1]. Several types of "stealth antenna" have been proposed to hide the presence of antenna by switching off the lamp used as a radiating element [1]. A reconfigurable corner-reflector antenna has also been reported by using an array of fluorescent lamps as reflector grids [2]. We fabricated another corner-reflector antenna to realize reconfigurability either omnidirectional or directional (8-multibeam).

II. Prototype Antenna

A prototype antenna consisted of an array of 20 fluorescent lamps configuring a square cylinder on a ground plane and a quarter-wavelength monopole placed at the center of the cylinder, as shown in Fig. 1. This antenna used U-shaped 28-W fluorescent lamps fed from underneath the ground plane, and thus the feed lines did not block vertically-polarized radio wave. The bases of the U-shaped fluorescent lamp are submerged under the aluminum ground plane. When the lamps on adjacent two planes among the square cylinder (total of 10 lamps) are switched on, these lamps function as a square corner-reflector; and when the lamps on a plane plus approximately halves of its adjacent two planes (total of 13 lamps) are switched on, these function as a trough (C-shaped) reflector. These configurations yield a 8-multibeam directional antenna. On the other hand, when all the lamps are switched off and virtually transparent to the radio wave, this antenna is omnidirectional.

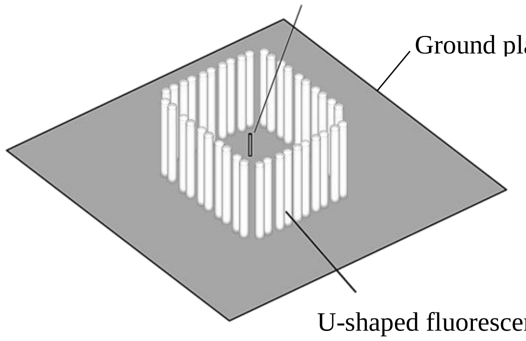

Fig. 1. A prototype reconfigurable antenna.

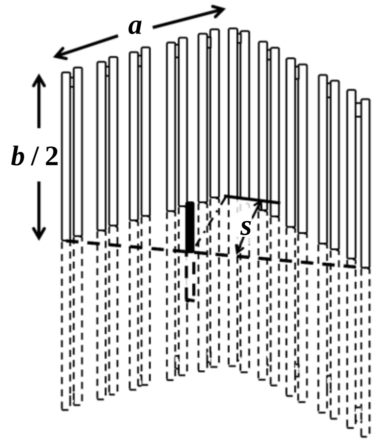

Fig. 2. Dimensions when used as a square corner reflector antenna.

An operating frequency of 750 MHz (wavelength = 400 mm) was chosen, well below the plasma frequency. The distance between the monopole and a vertex of the square is denoted by s; the side of the square a is given by $\sqrt{2}s$; and the height of the lamps above the ground plane by b / 2, as shown in Fig. 2. We selected s = 0.50 λ = 200 mm, a = 0.71 λ =282 mm, and b / 2 = 0.75 λ = 300 mm. The ground plane was 900 mm $\times$ 900 mm. Maximum directivity yielded by these dimensions was expected to be approximately

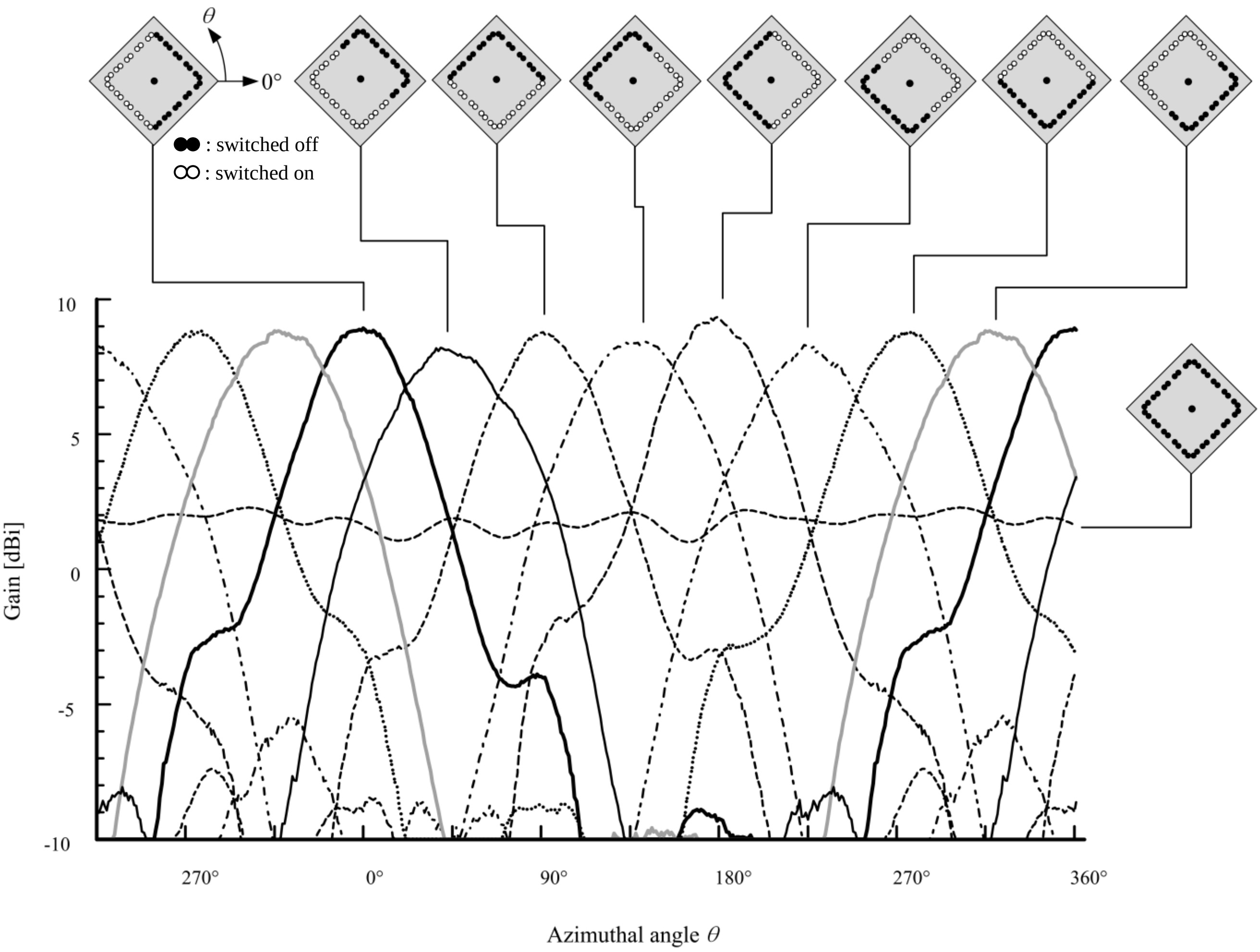

Fig. 3. Measured radiation patterns corresponding to the selection of the fluorescent lamps to be switched on/off.

10 dB [3], if the reflector planes were made of perfect electric conductor (PEC).

III. Measurement Results

The voltage standing wave ratios were 1.5 and 1.1, when the 10 lamps on the adjacent two planes were switched on and all the lamps were switched off, respectively. The azimuthal radiation patterns were measured corresponding to the selection of on/off states of the lamps, as shown in Fig. 3. Maximum gains ranged from 8.2 to 9.3 dBi for the 8 multibeams in a 45° -interval–from 8.8 to 9.3 dBi for the square corner reflectors and from 8.2 to 8.4 dBi for the trough reflectors. Crossover levels between the 8 multibeams ranged from 6.4 to 7.4 dBi. Maximum gains and front-to-back ratio of the directional beams were lower than the values expected when using PEC planar reflector, since the conductivity of the plasma is considerably lower than the PEC. The gain fluctuated from 1.1 to 2.3 dBi when all lamps were off.

Transient time between the different directivity was found approximately 60 ms, which was attributed to the thermal time constant of hot cathodes of fluorescent lamps.

IV. Conclusion

A reconfigurable 8-multibeam and omnidirectional antenna was realized with use of a monopole antenna on a ground plane and an array of fluorescent lamps configuring as a square cylinder. Fast switching, however, is unfeasible for the lamp's thermal time constant. Frequent switching is also impractical for the reason that it reduces the lifetime of the lamps. Nevertheless, this combination yields an inexpensive reconfigurable antenna, since fluorescent lamps are far less expensive than common radiofrequency devices, such as switches and phase shifters.

References

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