# New Reconfigurable Power Divider Based on Radial Waveguide and Cylindrical Electromagnetic Band Gap Structure for Low Power and Low Cost Smart Antenna Systems

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***Abstract*—A new low power and low cost technique is proposed for designing agile antennas by using a reconfigurable radial waveguide excited by a central probe and feeding multiple radiating elements. The power distribution of the radiating elements is controlled by a cylindrical Electromagnetic Band Gap structure with PIN diodes allowing azimuth beam steering and multiple-beams. The proposed technique permits any polarization and it can be used for beam steering in both azimuth and elevation by adding control circuits in the radiating elements. Numerical and experimental results are presented for validation.**

## I. Introduction

Cylindrical Electromagnetic Band Gap (CEBG) structures were first proposed and analysed in [1-2]. In [2-3], CEBG structures made of metallic wires periodically loaded with PIN diodes were proposed to be used for designing base stations agile antennas. In these designs, the EBG structures were acting as reconfigurable parasitic reflectors and a single radiator was located in their center. This technique can have several drawbacks: it can require more than 10V DC voltage because of the number of PIN diodes in each wire, it can present prohibitive cost and loss because of the total number of diodes, it can be used only for vertical polarization and it is limited to azimuth beam forming.

In this work, we propose a new concept for designing an agile antenna with lower cost and better performance. The proposed technique consists of using a radial waveguide, a CEBG structure made of loaded wires and transitions from the radial waveguide to radiating elements. With this concept, it is possible to control the beam forming with a DC voltage lower than 1V. Also, any polarization can be obtained and the number of diodes is minimized. Furthermore, the proposed concept can be extended to azimuth and elevation beam steering by adding control circuits in the radiating elements. Using such reconfigurable antennas, it is possible to increase the communication capacity thanks to interferences mitigation or media-based modulation [4].

The remainder of the paper is organized as follows. In Section II, the concept is described. Section III presents results for the reconfigurable power divider and the full antenna. Finally, concluding remarks are given in Section IV.

## II. Proposed Concept

The proposed concept is illustrated in Fig. 1. A periodic structure made of metallic wires is integrated in a radial waveguide. The metallic wires are loaded with PIN diodes (or MEMS) controlled by a DC circuit. The radial waveguide is excited by a coaxial probe which couples to radiating elements arranged around the periphery of the periodic structure.. The pass-bands and stop-bands characteristics of the periodic structure, which is called Cylindrical Electromagnetic Band Gap (CEBG) structure, can be analyzed by using the techniques described in [1-2]. Using these techniques the parameters (periods and wire diameter) of the CEBG structure are optimized for operating at 5.8 GHz.

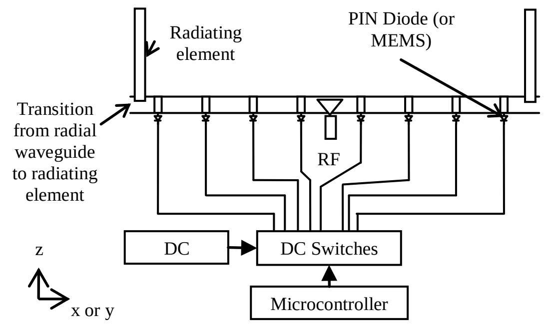



Fig. 1 Principle of proposed smart antenna

## III. Radial power divider and agile antenna

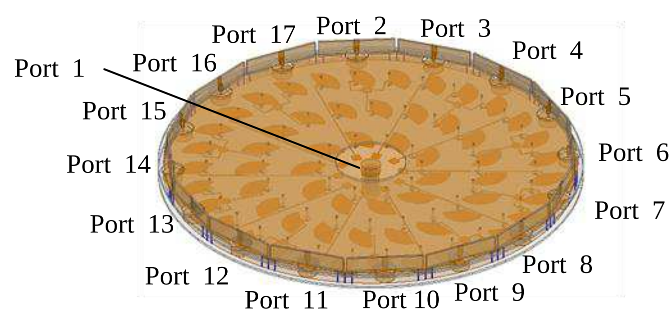



Fig. 2 17 ports reconfigurable radial power divider

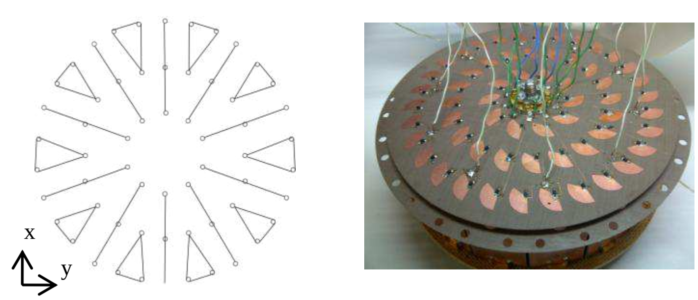



Fig. 3 Diodes assembling (20 groups) and photo of fabricated reconfigurable power divider showing the DC control circuit

Using the technique described previously, a reconfigurable power divider with 17 ports and operating at 5.8GHz has been designed (using HFSS software) and fabricated. Figs.2-3 show the design and photo of fabricated prototype. Since there are 20 groups of diodes, there are $2^{20}$ different possible states.

Fig. 4 shows photo of the S parameters measurement setup and Fig. 5 presents simulated and measured S21 and S101 parameters for State 1 shown in Fig. 8. One can note that a good agreement is observed between theoretical and experimental results. Also, one can note that there is more than 30dB difference between S21 and S101 at 5.8GHz. At this frequency, S11 is below -12dB (not shown here).

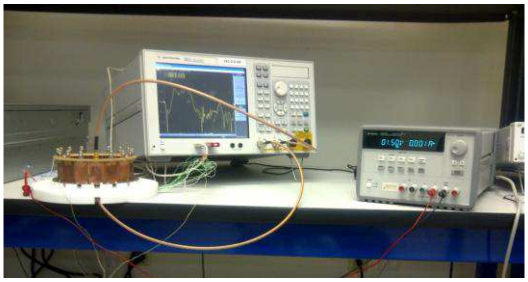


Fig. 4 S parameters measurement setup for the power divider

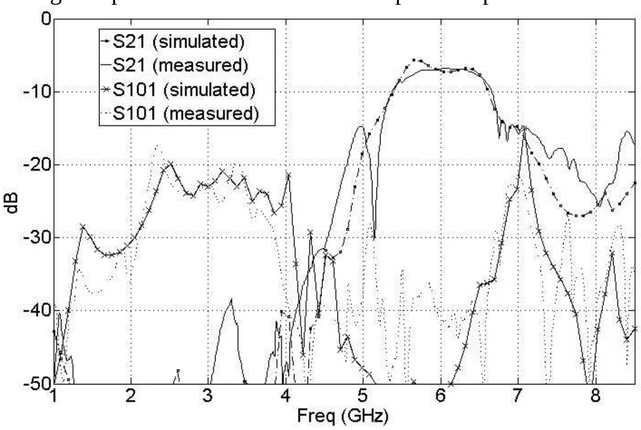



Fig. 5 S21 and S101 for State 1 (see Figs. 2 and 8)

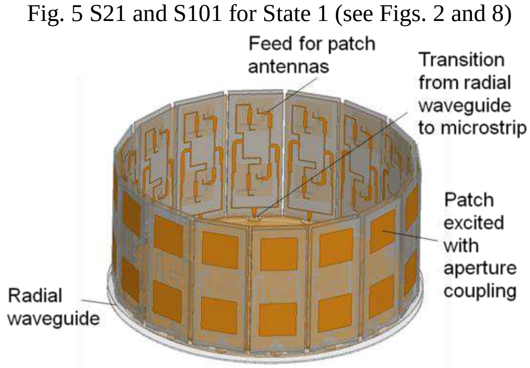



Fig. 6 Reconfigurable antenna with circular polarization

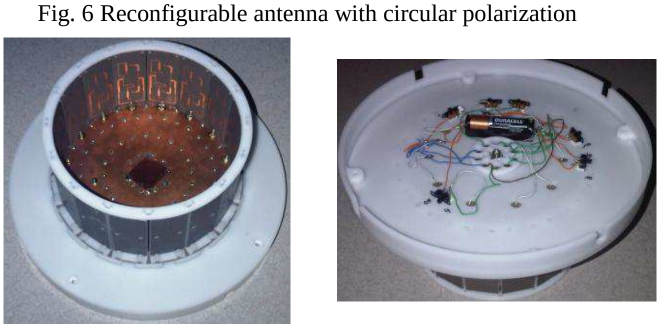


Fig. 7 Photos of reconfigurable antenna prototype

Based on the previous reconfigurable power divider, a circularly polarized reconfigurable antenna has been designed (using HFSS) and fabricated as shown in Figs.6-7. Full-wave simulation results of 3-D radiation patterns at 5.8GHz for different states are presented in Fig.8.

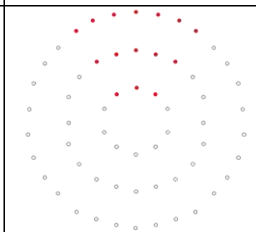
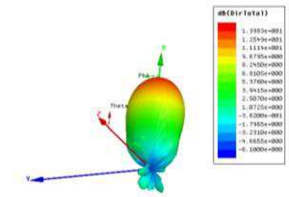
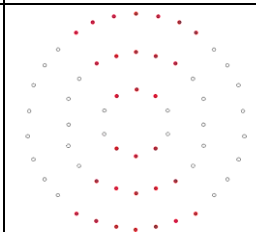
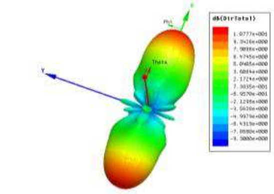
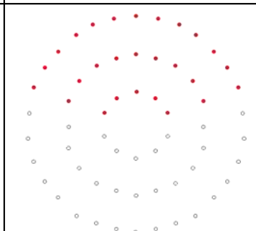
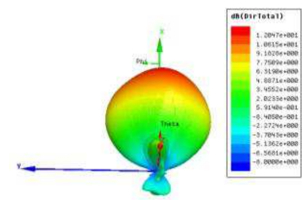
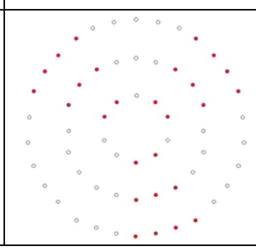
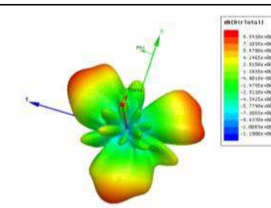
| State | Configuration of diodes | 3-D radiation pattern at 5.8GHz |
|---|---|---|
| 1 |  |  Directive beam (Dir=14dB) |
| 2 |  |  Two beams |
| 3 |  |  Wider beam |
| 4 |  |  Three beams |

Fig.8 Examples of antenna states and corresponding simulated antenna radiation patterns (PIN diodes in red are in ON-state).

## IV. CONCLUSION

A new technique has been proposed for designing agile antennas by using a cylindrical EBG structure integrated in a radial power divider. More details on the performance of these types of antennas will be presented during the conference.

## REFERENCES

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