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A Raspberry Pi Controlled Antenna System for Switchable Tilted-twin Beams

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***Abstract*—A complete antenna system controlled by Raspberry pi is presented for providing switchable tilted-twin beams. The antenna system is composed of a circular metal disk and sixteen T-shaped parasitic elements which are proximity-coupled to the disk. The open and short states of the T-shaped elements are obtained by using a switching circuit consisting of sixteen Single Pole Single Throw (SPST) switches. The SPST switches are controlled by a Python-based Graphical User Interface (GUI) running on a Raspberry Pi. The antenna provides sixteen switchable tilted-beams by changing the location of the open and short states of the T-shaped elements.**

Keywords—Parasitic elements, SPST switch, Raspberry Pi, tilted-twin beam.

I. INTRODUCTION

With the emerging Fifth Generation (5G) wireless communication system, it is expected that about 30 billion devices will be connected to the network by 2022. The global terrestrial mobile broadband data traffic is expected to increase by tenfold between 2016 and 2022 [1]. The modern wireless transceivers require to install innovative infrastructure technologies, particularly the right antennas to support bandwidth and traffic demands. Traditionally, wireless transceivers such as mobile phones, laptops, tablets and GPS terminals mostly use monopoles/whips [2], patches [3] and Planar-inverted-F antennas [4]. However, these antennas are susceptible to the interferences in a complex electromagnetic environment due to the lack of beam steering capabilities. In recent years, various configurations of switched beam antennas are investigated for achieving beam switching operation [5]-[8]. These antennas direct the radiation beam only toward the intended direction and mitigate the interference signals coming from undesired directions.

In this paper, a complete antenna system is presented that provides switchable tilted-twin beams. The beam switching is achieved by changing the locations of the open and short states of the T-shaped elements [9]. The switching circuit consisting of sixteen SPST switches is controlled by a python-based GUI running on a Raspberry Pi.

II. ANTENNA CONFIGURATION

Fig. 1 shows the perspective and side views of the antenna. A metal disk having a diameter of 70 mm is printed on a FR4 substrate. The disk is placed at a height of 13 mm from the ground plane and fed in the centre by a vertical probe. The sixteen T-shaped elements are circularly arrayed with a radius of 37 mm and space angle of 22.5°. The vertical and horizontal length of the T-shaped element is 13 mm and 10 mm, respectively. The switching circuits is printed on a FR4 substrate and placed beneath the ground plane. Fig. 2 shows the bottom view of the switching circuit. Sixteen SPST switches controls the open and short states of the T-shaped elements. One port of each switch is connected to a T-shaped element and the other port is connected to the ground plane using a cylindrical via.

A raspberry pi is used to control the SPST switches by providing switching control voltages and biasing voltage of 3.3 V. When the switch is 'off', it provides an open circuit between the T-shaped elements and the ground plane, and when the switch is 'on', it makes the T-shaped elements short to the ground plane. The switching voltages are controlled by a GUI programmed using Python. Fig. 3 shows the configuration of the complete antenna system.

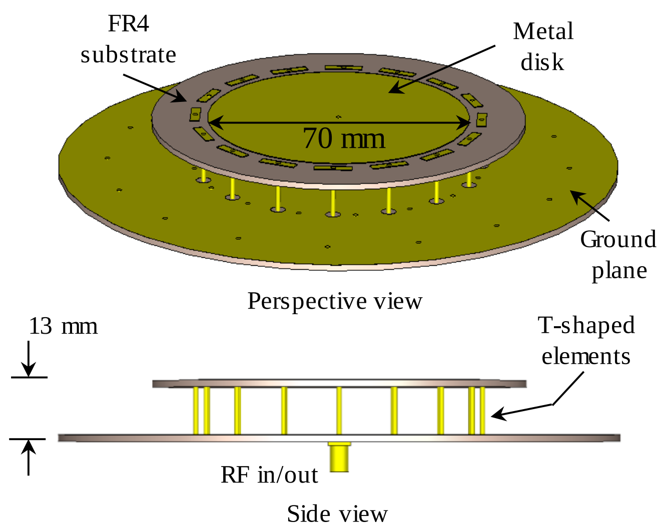

Fig. 1. Perspective and side views of the antenna.

III. RESULTS

When T-shaped elements are organized as 5 shorted elements, 3 open elements, 5 shorted elements, and 3 open elements, the antenna provides a tilted-twin beam. Fig. 4 shows the reflection coefficient of the antenna. The antenna exhibits a reflection coefficient bandwidth of 100 MHz (3.9 GHz to 4 GHz). Fig. 5 shows the radiation pattern of the antenna. The antenna provides a twin-beam, both tilted by θ_{max}=50° from the zenith (Z-axis) and has a gain of 6 dBi in the direction of the maximum radiation. The tilted-beam can be switched around the antenna axis in a space angle of 22.5°. Therefore, the antenna covers 360° in the azimuth plane by using sixteen beams.

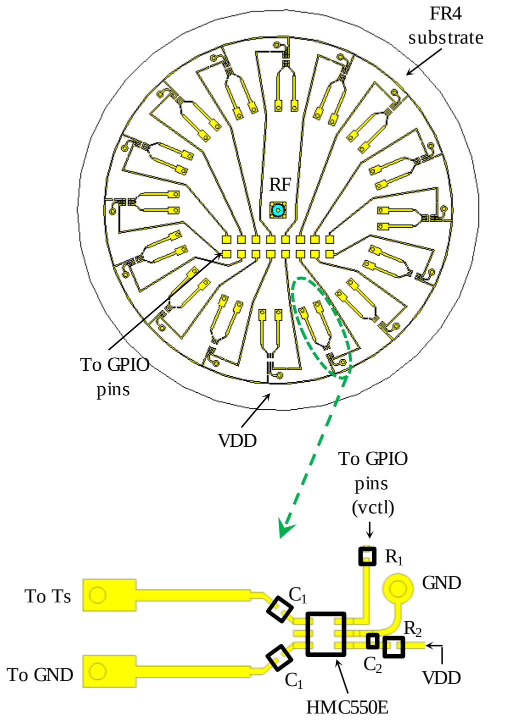

Fig. 2. Bottom and expanded view of the switching circuit.

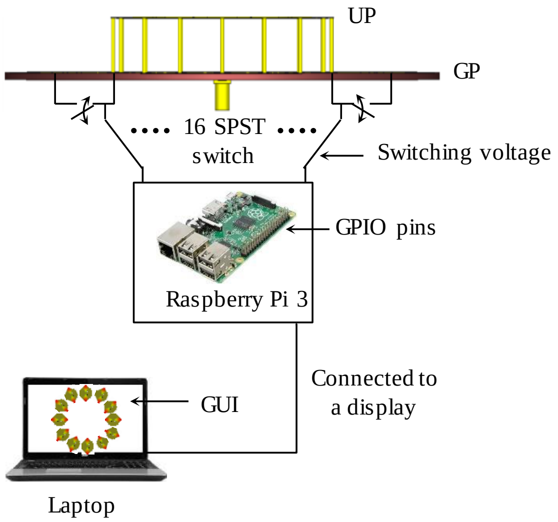

Fig. 3. Complete antenna system. UP: upper metal disk. GP: ground plane.

IV. CONCLUSION

A Raspberry Pi controlled antenna system is presented for generation of sixteen switchable tilted-twin beams. The antenna system is composed of a circular metal disk and sixteen proximity-coupled T-shaped parasitic elements. The open and short states of the T-shaped are obtained using 16 SPST switches. By changing the location of the open and short states of the parasitic elements the tilted-twin beam is switched around the axis of the antenna system.

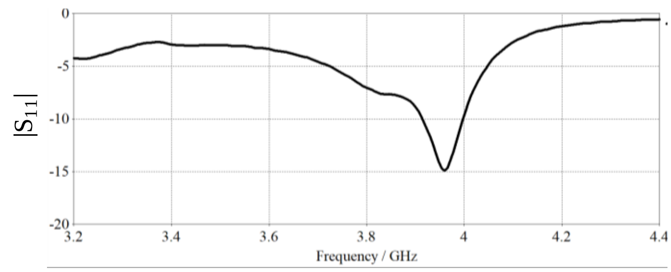

Fig. 4. Reflection coefficient of the antenna in tilted-twin beam configuration.

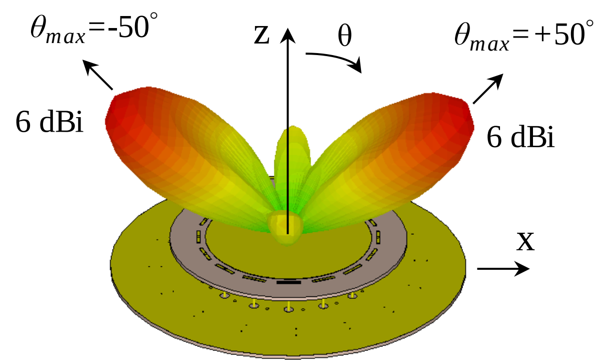

Fig. 5. Radiation pattern of the antenna.

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