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Flexible Circular shaped dipole antenna on paper substrate

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Abstract*— The paper material is attractive material because of low cost, nature friendly and its flexibility. It is well-suited with direct write, inkjet printing and copper lamination technologies. The paper is natural, easily and broadly accessible. The circular shaped half wave dipole is presented in this paper. The proposed antenna works on 2.35 GHz to 2.77GHz frequency. The antenna is simulated in high frequency structure simulator. The prototype antenna is fabricated and tested using network analyzer. There is good matching observed in simulated and measured results. This prototype provide flexibility. The flexibility test is carried out and it is discussed in the paper.

Keywords— printed dipole antenna, circular shaped dipole, paper substrate, High frequency structure simulator.

I. INTRODUCTION

The paper material is light in weight, low cost, conformable, nature friendly and easily and widely available. It is compatible with direct-write, inkjet printing technologies. Because of these advantages paper become attractive choice for antenna and microwave designer. The paper material is used in many recent application like RFID tags[7], Microwave filters[10],wearable device[9], flexible display[11], wireless sensor networks[4], antennas[13,14] etc.

In [2], a star shaped patch antenna is designed on paper substrate at 2.4GHz. In [3], the Z shape antenna is designed on glossy paper.

In [4], radiating structure was formed by zigzag arrangement of 5 square patches which operates on 2.4GHz and 5.4GHz. In [5], UWB antenna is designed on paper substrate. In [6], U slot monopole antenna is designed using paper substrate which works on 1.57GHz, 3.2GHz and 5GHz.In [7], RFID tag antenna on paper substrate is presented at 915MHz. In [10], inverted-F-antenna (IFA) is designed on a paper substrate at 2.45GHz. In [12], a slot is created in radiator and one additional radiator is added to have frequency operation at 2.4GHz,3.4GHz and 5GHz.

In this paper CPW fed circular shaped dipole antenna using paper substrate is designed at 2.45GHz. The antenna is fabricated and tested. There is good agreement between measured and simulated results. The paper is flexible material. In order to check the effect of bending on antenna performance , flexibility test is carried out. The measured results are slightly shifted to lower side under bend condition.

II. DESIGN

The proposed antenna is CPW fed dipole antenna. The antenna is designed at 2.45 GHz. The dielectric material used for the design is photo paper with dielectric constant of 3.45 [15]. The loss tangent of paper is 0.065 [15]. The thickness of the substrate is 0.1718mm. The radius of circular dipole is 0.55 λ. The width of ground plane 27mm is and length of ground plane is 20 mm. The feed line length is 24.25mm and feed line width is 1.5mm. The gap g is 1mm. The proposed antenna model in high frequency structure simulator is shown in Fig 1(a). Fig 1(b) shows photograph of fabricated antenna.

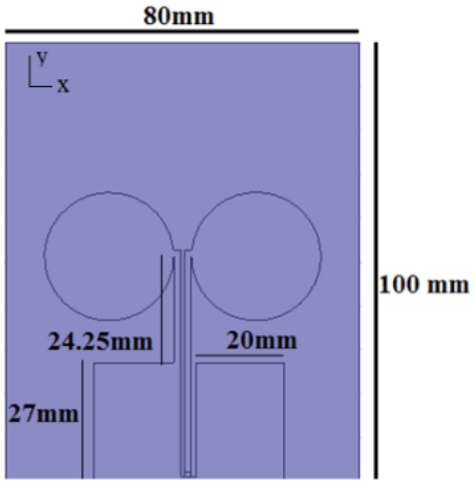

Figure 1(a) circular shaped dipole

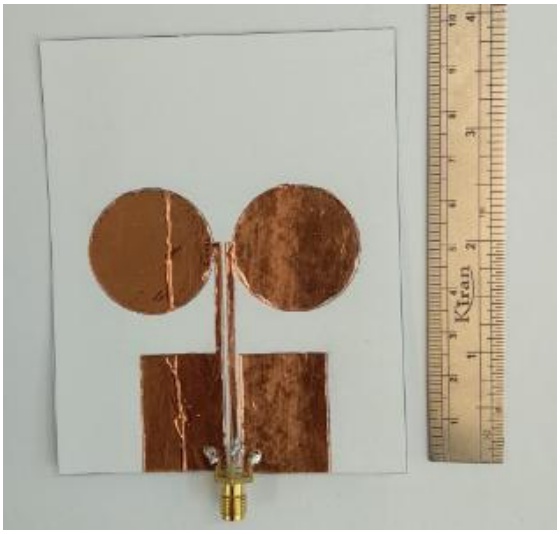

Figure 1(b) Photograph of proposed antenna

Fabrication and related difficulties

The photo paper material is used as dielectric substrate. The single paper thickness is 0.1718mm. The circular shaped dipole and ground plane of the antenna are made up of copper adhesive sheets having thicknesses of 0.05 mm. The copper adhesive tape is manually cut to make dipole and ground plane. The adhesive copper sheets are just fixed on the paper material. Then SMA connector is soldered using normal soldering techniques. There are chances of burning the paper material so special care is taken during soldering. Paper antenna can easily absorb water and moisture which can consequently change the resonant frequency and impedance bandwidth of antennas.

III. RESULTS AND DISCUSSION

The antenna is simulated in high frequency structure simulator. Fig 2 shows comparison plot of simulated and measured reflection coefficient. The simulated reflection coefficient is less than -10 dB for frequency 2.36GHz to 2.77GHz. The measured reflection coefficient is less than -10 dB for frequency 2.34GHz to 2.79GHz as shown in Fig 2. There is good matching observed between simulated and measured results.

The flexibility test of antenna is carried out by fixing the prototype antenna on cylinders of different radius. Fig 3 shows flexibility measurement setup. The antenna is fixed on cylinder such that the antenna bend horizontally and vertically. Fig 4 shows measured reflection coefficient of prototype filter while it is fixed on different cylinders. The measured results are little shifted towards lower side for various curved condition as shown in Fig 4. Fig 5 shows simulated radiation pattern is omni directional. Fig 6 shows simulated peak gain of antenna which 3.9dB at 2.45GHz. Table 1 shows a comparison of simulated peak gain of proposed antenna array antenna with reference papers.

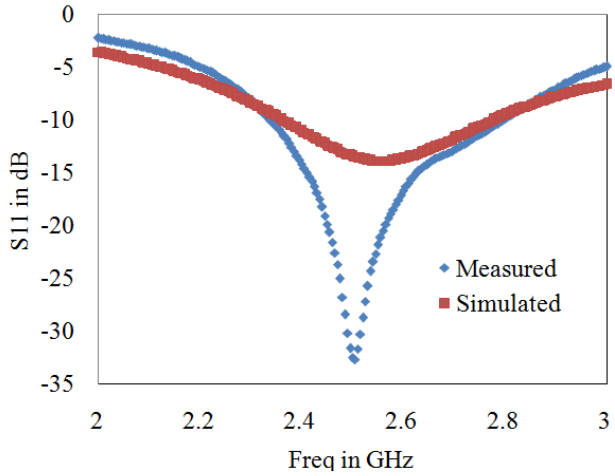

Figure 2 Comparison plot of simulated and measured reflection coefficient

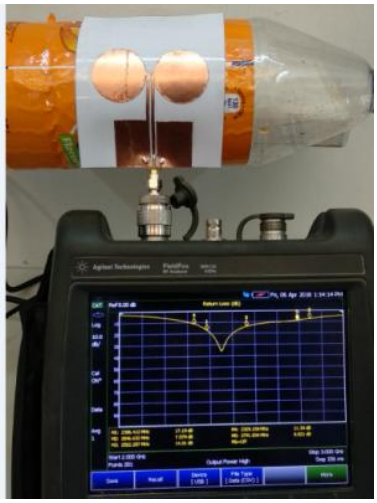

Figure 3 Flexibility test setup

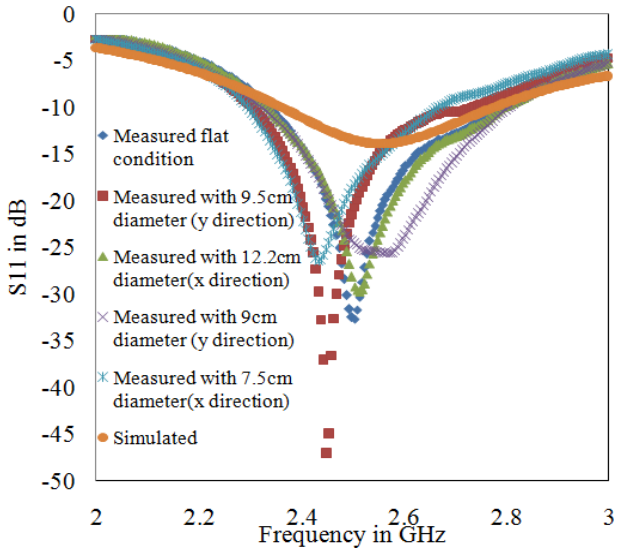

Figure 4 Measured reflection coefficient of fabricated filter for different curved conditions

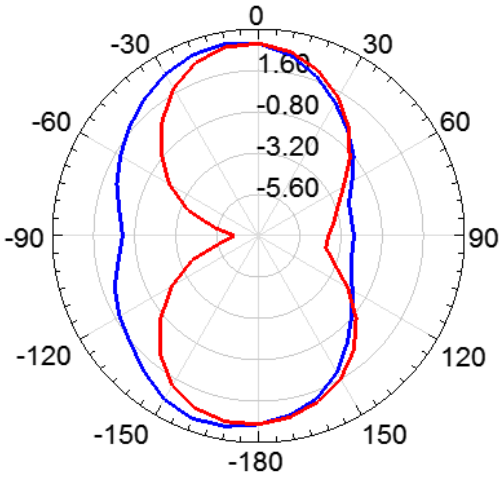

Figure 5 Simulated Radiation pattern

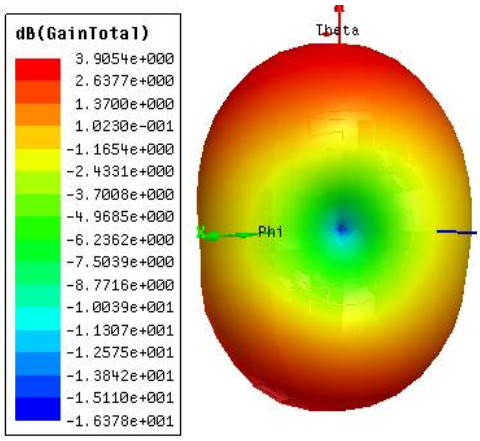

Figure 6 Simulated 3D gain plot

Table 1: Table 1. Comparison of gain with reference papers

Reference paper	Frequency of operation	Simulated Peak Gain
[2]	2.4GHz	1.8dBi
[4]	2.4GHz	2.1dBi
[6]	1.57GHz, 3.2GHz, 5.4GHz	Up to 2dBi
[7]	915MHz	1.8dBi
[9]	2.3GHz - 2.6GHz	-12dB to 2dBi
[11]	2.45	1.43dBi
[12]	2.4GHz, 3.4GHz, 5GHz	0.2dBi, 2.45dBi, 2.36 dBi
[13]	2.4GHz	3.04dB
Proposed antenna	2.4GHz	3.9dB

IV. CONCLUSION

The design of CPW fed circular shaped antenna on paper substrate is discussed in this paper. The prototype antenna is fabricated and tested. There is good agreement observed in simulated and measured results. Since the photo paper is used as substrate it provide flexibility. The flexibility test of antenna is carried out. The results are slightly shifted towards lower side for various bend condition. The proposed is light in weight ,low cost and also provide broad band width.

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