Printed Ring Monopole Antenna for Medical Application

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***Abstract*—The Ring printed monopole antenna has been proposed for broadband application. The printed monopole ring microstrip line feed antenna is simulated on IE3D and its impedance matching bandwidth and the return loss and current distribution are shown, along with radiation pattern. The bandwidth measured in the laboratory is in the range of 1.87 to 4.6GHz. The proposed antenna has achieved fractional bandwidth of 167%.**

Keywords— Ring microstrip line feed antenna, VSWR, return loss, impedance bandwidth, current distribution.

I. INTRODUCTION

In medical field many advance technologies are available for detection of breast cancer like mammography, computer tomography etc. Breast cancer is more common disease found in women worldwide and its treatment process is very painful [1]. Breast cancer affects many women and hence its detection should be fast and accurate. To detect cancer in early stage is very important. Some of methods for breast cancer detection are X-ray mammography, MRI and ultrasound [2]. However, they have some limitations. Microstrip antenna is used to detect breast cancer is a promising method and there are many works in this area. There are many ways of Breast cancer identification such as Mammogram, X-ray, ultrasound, tomography and MRI [3]. However, this technique has some undesired results and is not preferred by younger age group. These techniques were overcome to some extent by recent growing techniques and technologies such as microwave imaging, wireless monitoring system [4]. Early diagnosis is the most important parameter to detect and interfere with cancer tissue. Some of methods for breast cancer detection are X-ray mammography, MRI and ultrasound [5]. However, they have some limitations. For example; between 4 to 34% of all breast cancers are missed because of poor malignant/benign cancer tissue contrast. Microwave imaging to detect breast cancer is a promising method and there are many works in this area [6].

The tissue with malignant tumour has higher water content than the normal breast tissue, hence they have higher dielectric properties than the normal tissue which have low water content, therefore strong scattering take place when the microwave hit the tissue with malignant tumour [7].

Microstrip line feed printed monopole antenna is used for breast cancer detection, it is easily used technique because of light weight, low cost, easy to fabricate. [8-9].

The basic idea of using microwave imaging system for breast cancer detection is to transmit electromagnetic waves from a transmitting antenna to the breast and receive the scattered waves at a receiving antenna. Differences between electric field and magnetic field are important to identify cancerous tissue's position and volume etc. Many types of microstrip antennas are used for breast cancer detection like rectangular, circular, antenna with array, UWB (Ultra Wide Band), Vivaldi etc. [9]. The printed monopole antennas are easy to fabricate on any substrate like fabric, sheet, paper, foil etc. by taking these advantages into consideration researchers design flexible antennas which can be implemented on jacket or cloth, can be conformal [10]. The proposed antenna covers ISM (Industrial Scientific Medical), which covers medical applications and as well as GSM (Global system for Mobile)/DCS (Distributed Control System) /PCS (Personal Communication Services)/UMTS (Universal Mobile Telecommunications Service) and WLAN (Wireless Local Area Network) [1-11].

II. ANTENNA DESIGN

The printed monopole antenna are low profile, light in weight, easily maintainable antennas. The printed monopole antenna has simplest design with conducting material on one side of the substrate as radiating patch and partial ground plane on other side of that. These antennas are available in various shapes such as circular, rectangular, ring, semi-circular etc. The printed monopole is equivalent to the cylindrical monopole antenna [11].

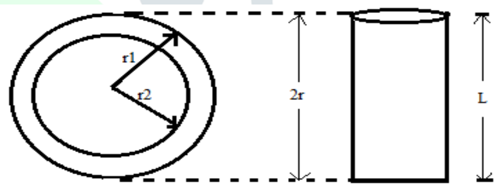


Fig.1 Printed Ring monopole antenna.

The area of cylindrical planar antenna is

$$W=2\pi r \qquad (1)$$

Where,

W is a width of antenna.

The cylindrical antenna height is equal to the circular patch antennas diameter [12].

$$L=2(r_1) \qquad (2)$$

But, the inner part of circular radiator is minimal of current vectors, so it does not take part in radiation. Therefore the area πr_2^2 has been removed.

Therefore,

$$r_1 = \frac{L}{2} \qquad (3)$$

According to Fig.1 planar antenna area is equal to annular ring patch area.

$$=\pi(r1-r2)^2 \qquad (4)$$

According to Fig.1 the surface area of cylindrical monopole antenna is equal to

$$= 2\pi r \times L \qquad (6)$$

Equating the value of equations (4) and (5)

$$2\pi r \times L=\pi \times L^2/4 \qquad (7)$$

Then

$$r=L/8 \qquad (8)$$

The effective radius of cylindrical monopole antenna is equal to circular planar antenna [12]:

$$f_L = 7.2/ (L+r+p) \quad (9)$$

Because of the fringing edge of the circular monopole antenna on dielectric substrate the lower edge frequency is reduces the formula become:

$$f_L = 7.2 / (L+r+p)k \quad (10)$$

Where, k is a correction factor for FR4 K=1.15 [11].
Substituting value of k in equation (10)

$$f_L= 7.2 / (L +L/8 +p)k \quad (11)$$

Printed monopole circular ring microstrip antenna:

Fig.2 Ring line feed antenna implemented on FR4.

The circular ring microstrip line feed printed monopole antenna is implemented practically by using FR4 glass-reinforced epoxy laminate material.FR4 has dielectric constant 4.4 with thickness of 1.59 mm and loss tangent tanδ = 0.02. It consists of four parts: a patch, a partial ground plane, a substrate and feed line part. The outer radius of ring is 25mm and inner radius of the ring 20mm. the feed line is 1.44mm.

II. Results and Discussions

Simulation is carried out from frequency range from 1GHz to 5GHz.
The following figure shows the impedance matching bandwidth of antenna. The ideal value of VSWR (voltage Standing Wave Ratio) is unity but for printed monopole antenna below 2:1 value is desirable. Fig. 3 shows impedance matching bandwidth, frequency range is 1.87GHz - 4.6 GHz that is bandwidth of 2.73GHz. The measured values are shown in corresponding fig.4 and fig.5.

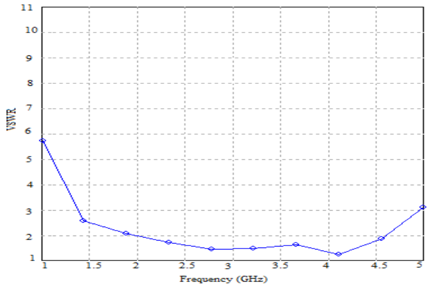


Fig.3 Printed ring monopole antenna simulation result

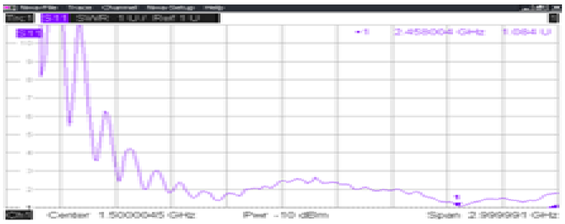


Fig.4 VSWR result of Printed ring monopole antenna

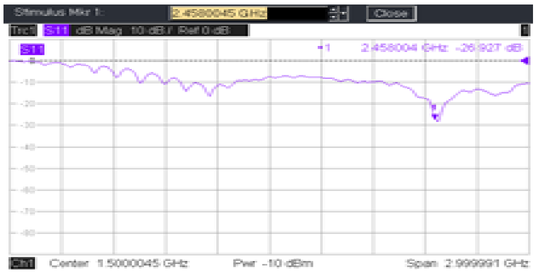


Fig.5 Return loss in printed ring monopole antenna

The maximum gain is above 2dBi in the needed frequency range from 1.87GHz to 4.6GHz.

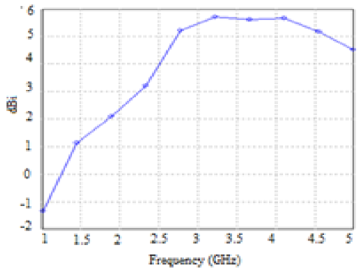


Fig.6 Antennas Max Gain Vs Frequency

Antenna radiation efficiency is more than 80% for the needed frequency band from 1.87GHz to 4.6 GHz.

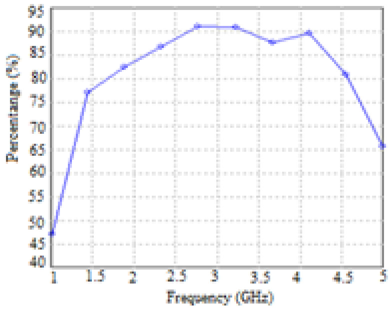


Fig.7 Antennas Efficiency Vs Frequency

The fig.8 shows the vector current surface distribution at 3.66GHz. The current vector distribution is minimum for inside circle as compare outside circle.

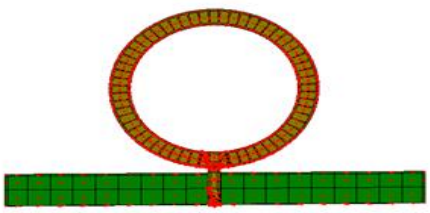
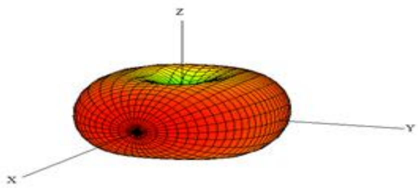
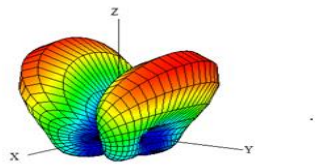


Fig.8 Current Distribution in Printed ring monopole antenna

The simulated vector current density is shown in fig. 9, which justifies the enhancement of bandwidth. The maximum radiation is shown by red color that is only at the edges of an antenna and at the center of antenna minimum radiation is present.



a)



b)

Fig. 9 The simulated 3D Radiation pattern of Printed Ring Monopole antenna at a) 1.44GHz b) 3.22GHz

The measure elevation plane shown in fig.10, it shows figure of eight. There are few nulls that is due to manual measurement in the laboratory.

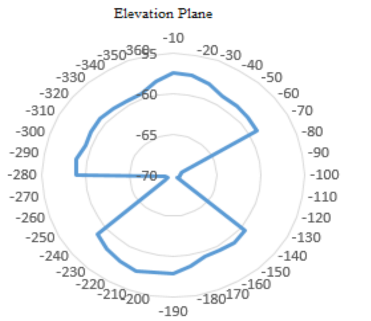


Fig.10 Elevation Plane of Printed Ring Monopole antenna

The azimuthal plane as shown in fig.11 is close to omnidirectional for overall bandwidth.

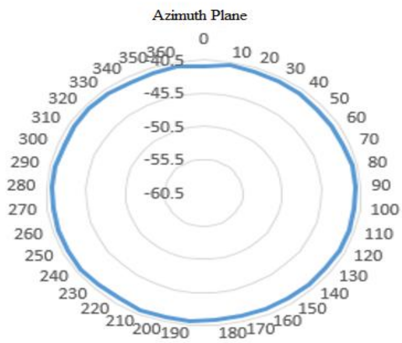


Fig.11 Azimuth Plane of Printed Ring monopole antenna

Conclusion:

The printed monopole microstrip ring antenna provides ISM band for medical application like breast cancer detection. When the antenna radiation is used for detection of cancerous cells, it has been observed that the return loss deteriorate and with this observation it can be conclude that return loss parameter of PMA with microstrip line feed antenna can be used in medical science for detection of breast cancer.

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