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DESIGN OF MICROSTRIP PATCH ANTENNA TO DETECT BREAST CANCER

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Abstract

Breast cancer is an invasive disease in women which needs early detection. There are many techniques like that of magnetic resonance imaging, mammography, digital mammography and computer aided detection as these techniques have their limitations, and an alternative method is implemented and is presented in this paper. Here MSPA (Micro Strip Patch Antenna) is used to detect the tumor in the Breast Phantom. Antenna is designed using computer simulation technology for ISM band (Industrial, Scientific, and Medical) of frequency 2.45GHz. The antenna is fabricated and tested using the Network Analyzer.

Keywords:

Micro Strip Patch Antenna, Breast Phantom and Network Analyzer

1. INTRODUCTION

Cancer is a disease in which abnormal cells divide uncontrollably and destroy body tissue. Among different types of cancers, breast cancer is one of the harmful diseases that kills thousands of people every year. Approximately 40,610 women and 460 men are expected to die from breast cancer in 2017 [1]. Breast cancer has ranked number one cancer among Indian females with age adjusted rate as high as 25.8 per 100,000 women and mortality 12.7 per 100,000 women in 2017 [2]. There are different types of antenna techniques to detect the tumors present in the breast [3].

The performance and advantage of MSPA, namely low cost, low weight, compact design, good gain and low profile make them perfect for communication engineers. These patches are capable to blend with microwave circuits and therefore very well suited for many applications such as cell devices, bio medical applications, WLAN applications, navigation systems and many other.

The MSPA is very simple in the construction using conventional micro strip fabrication technique. Dual characteristics, circular polarizations, frequency agility, dual frequency operation, broad band width, feed line flexibility, beam scanning can be easily obtained from these patch antennas. The MSPA has a ground plane on one side of the substrate. The substrate can be Benzocyclobuten, Rubber, Quartz, etc.

The ground plane on one of the sides is a conducting material, which can be Silver or Copper, Aluminum, etc. [4]. On the other side, we have a patch, which is smaller than the substrate and feed with a Micro strip line. The directivity is independent of substrate thickness. The substrate can be of different shapes, i.e. circular, rectangular, square, and elliptical, depending on the application [3] [4]. The example of the normal antenna with ground, substrate and patch is shown in Fig.1. [5].

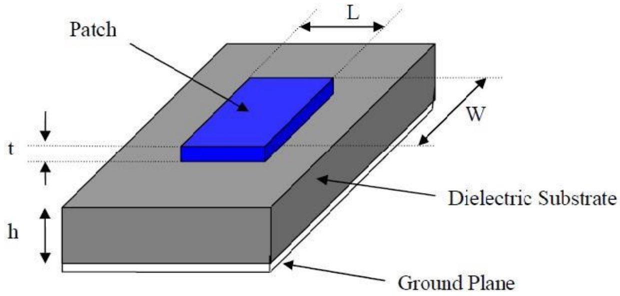

Fig.1. Structure of MSPA

2. ANTENNA DESIGN

The MSPA is a device which has different parts in it namely, substrate, ground, patch, feed line, and source. All those are given certain dimensions for proper radiation of antenna. These antenna dimensions are as mentioned in the Table.1. The antenna is simulated using software called CST (Computer Simulation Technology) for resonant frequency of 2.45GHz. Here, an array of patches in a single antenna are used which resonate for the same resonant frequency. The distance between two patches is d, between patch and the left edge is d', between patch and the right edge is d'' and are equal to 28.75mm, 14.375mm, 14.375mm respectively.

Table 1. Parameters with dimensions of antenna

Parameter	Dimension (mm)
W_p	28.75
L_p	28.75
W_g	115
L_g	57.5
W_f	2.8
F_i	10.79
G_{pf}	1
H_s	1.6

In this antenna design, the patch and ground are made up of copper, substrate is of FR4 epoxy. The feed line is inset fed as it increases the performance of antenna rather than transmission fed. Since, radiation box is responsible for the return loss, the size of it is large enough. Finally, the antenna is fabricated under certain conditions, which is carried out by the fabricating unit. It is shown in Fig.2.

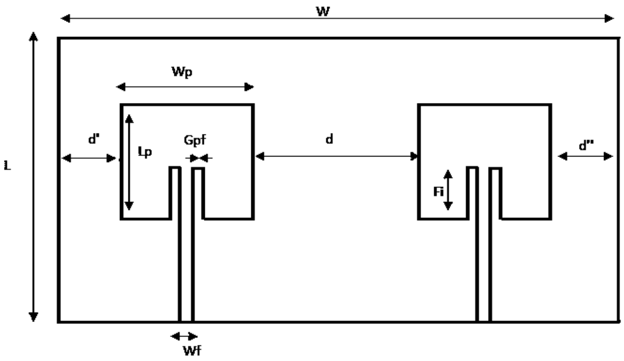

Fig.2. Top view of the designed antenna

2.1 ANTENNA DESIGN EQUATIONS

The equations used for the designing of the antenna are mentioned below. [6] The width and length of the patch are calculated using the following equations where f_r is the resonating frequency, ε_r is the dielectric permittivity of the substrate, μ_o is the permeability of the free space, h_s is the thickness of the substrate.

$$W_p = \frac{1}{2 f_r \sqrt{\mu_o \varepsilon_o}} \times \sqrt{\frac{2}{\varepsilon_r + 1}} \quad (1)$$

$$L_p = \frac{1}{2 fr \sqrt{\varepsilon_{eff}} \sqrt{\mu_o \varepsilon_o}} - 2\Delta L \quad (2)$$

where, ε_{eff} is the effective permittivity of the substrate, which is calculated using the Eq.(3), ΔL is the differential length which is calculated using Eq.(4).

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2\sqrt{1 + 12\frac{hs}{Wp}}} \quad (3)$$

$$\Delta L = \frac{\left(\varepsilon_{eff} + 0.3\right)\left(\frac{W_p}{h_s} + 0.264\right)}{\left(\varepsilon_{eff} - 0.258\right)\left(\frac{W_p}{h_s} + 0.8\right)} * 0.412 h_s \quad (4)$$

Characteristic impedance of the patch can be found,

$$Z_a = 90 \frac{\varepsilon_r^2}{\varepsilon_r + 1}\left(\frac{L_p}{W_p}\right)^2 \quad (5)$$

Impedance of the transition section,

$$Z_T = \sqrt{(50 + Z_a)} \quad (6)$$

The width of the 50Ω micro strip transmission line:

$$Z_o = \frac{120\pi}{\sqrt{\varepsilon_{eff}\left(1.393 + \frac{W_f}{h_s} + \frac{2}{3}\ln\left(\frac{W_p}{h_s} + 1.444\right)\right)}} \quad (7)$$

Length of the micro strip transmission line from the edge of the patch (F_i):

$$R_{in(x=0)} = (Z_o/Z_T) = \cos^2(\pi/L_p)F_i \quad (8)$$

3. BREAST PHANTOM

The structure of the breast phantom is complex and is made up of different tissues. The dielectric properties of skin are mentioned in the Table.2 [7] [8].

Table.2. Dielectric properties of tissues of breast

Tissues	Permittivity (ε_r)
Skin	36
Fatty Tissues	7.2-10.8
Tumor cell	50

3.1 PREPARATION OF PHANTOM

Agar powder was boiled in water for around 30 minutes. The boiled solution was poured into a plastic jar which contained a metal piece, to mimic the tumor. The solution was then allowed to cool down to room temperature. At the steady state of room temperature, the model has the top diameter of 9.8cm and base diameter of 4.9cm with thickness of 3.2cm. The model is shown in Fig.3.

Fig.3. Side view of the breast phantom

3.2 PROPOSED IDEOLOGY

In our designed antenna, we have array of two patches within an antenna. One patch is fed with the source frequency of 2.45GHz. The other patch is connected to the detector probe of VNA. The antenna will be made to revolve around the breast phantom which is prepared from the agar (gelatin) powder [9].

The reflected wave from the phantom will be detected by the antenna. The phantom consists of both the malignant and non-malignant tissues. Thus, the difference in their reflected power will prove the presence of foreign body or tumor cell in the breast region. It can also be implemented over other certain body parts.

4. RESULTS

4.1 ANTENNA SIMULATION RESULTS

A gain for the MSPA obtained is 5.39dB as tabulated in Table.3 in the desired operating frequency of 2.45GHz. The simulated proposed array antenna is as shown in Fig.4. The 3D directivity of the proposed antenna 8.38dB is shown in the Fig.5. The resonant frequency, 2.448GHz, is also satisfied; and VSWR 1.02 shows that there is almost no reflection as shown in Fig.6 [10]. The return loss is -38.4534dB which shows that there is good agreement with theory as shown in Fig.7 [3]. The fabricated antenna is taken for testing as shown in Fig.8.

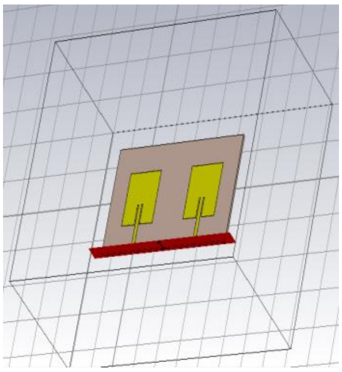

Fig.4. Proposed simulated antenna

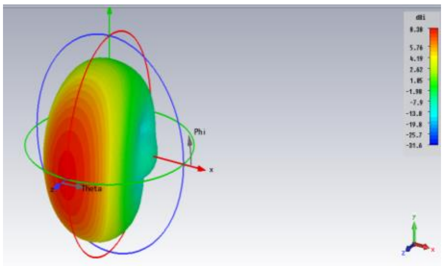

Fig.5. 3D representation of Directivity

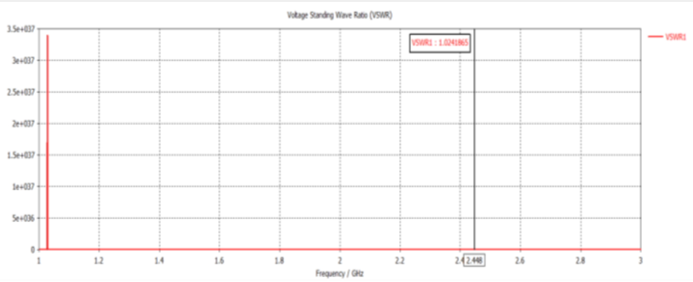

Fig.6. VSWR at the operating frequency 2.45GHz.

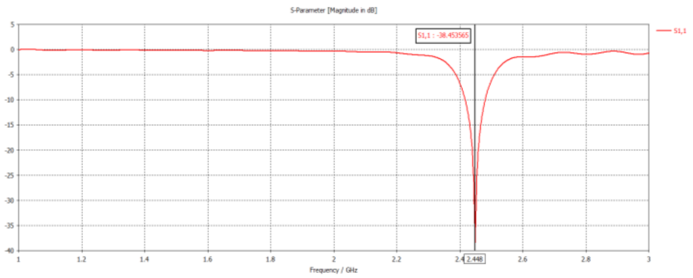

Fig.7. Return loss at the operating frequency 2.45GHz

Fig.8. Proposed fabricated MSPA

Table 3. Simulated results of proposed antenna

Parameters	Results
Antenna Frequency	2.45GHz
Substrate	FR4 Epoxy
Height of Substrate	1.6mm
Size of Patch	28.75×28.75
Dielectric Constant	4.4
VSWR	1.02
Return loss	-38.45
Gain	5.38dB
Directivity	8.38dB

4.2 TEST RESULTS THROUGH VNA

The fabricated MSPA is kept 1.5cm away from the phantom and practical values are measured through Network Analyzer. Return loss without tumor S_{11} is -24.46dB and with tumor (small metal piece kept in phantom) return loss S_{11} is -18.91dB is shown in Fig.9 and Fig.10 respectively. The results show that the reflection occurs because of tumor increases the return loss S_{11} tumor to -18.91dB as tabulated in Table.4. The results clearly confirm the presence of foreign body in the phantom.

Table.4. Test results of tumor detection in breast

Condition	Obtained Value
S11 output without tumor	-24.46dB
S11 output with tumor	-18.91dB
VSWR output without tumor	1.11
VSWR output with tumor	1.45

Fig.9. S_{11} output without tumor

The Fig.11 and Fig.12 show the VSWR parameters of phantom without and with tumor respectively as 1.11 and 1.45. The measured values of VSWR through Network Analyzer with tumor shows that the reflection increases because of the tumor in phantom as in Table.4.

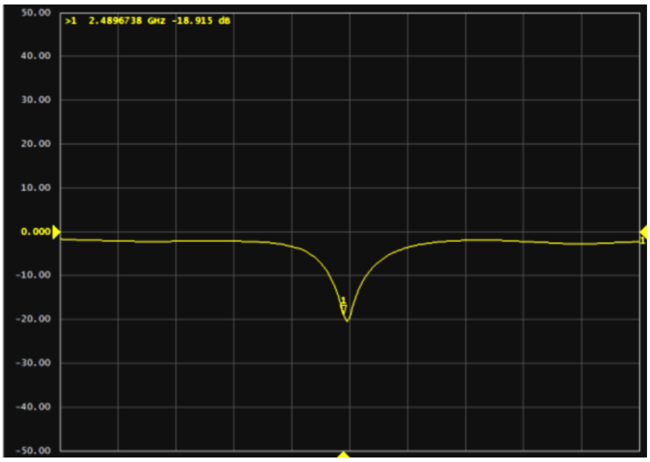

Fig.10. S_{11} output with tumor

Since the testing is done with the breast phantom which was prepared to match the dielectric properties of a breast and as the tumor used is not as malignant as cancer affected tissue, the experiment has limitations. This can be directly experimented on patients for proper reflected power for both normal tissues and tumorous tissues.

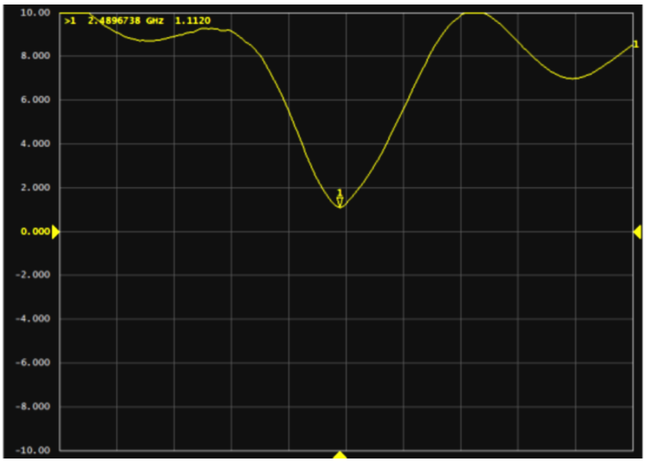

Fig.11. VSWR output without tumor

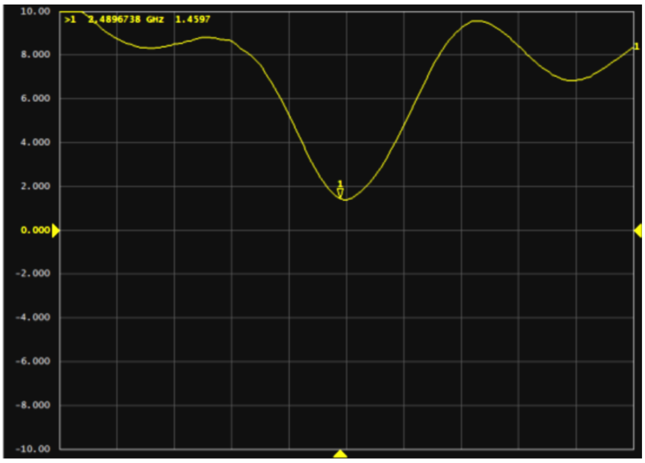

Fig.12. VSWR output with tumor

5. CONCLUSION

A rectangular MSPA is designed, simulated, fabricated and validated in the proposed configuration. The rectangular MSPA, which is the simulated and fabricated antenna, is kept 1.5cm away from the phantom. The phantom is measured through network analyzer to detect the foreign body present in it by capturing the values of return loss S_{11} -18.91dB with the foreign body and the return loss S_{11} -24.46dB without the foreign body. As measured through the network analyzer, the VSWR of a phantom without and with tumor are 1.11 and 1.45, respectively. The measured results of the proposed design are in good compliance with the simulated results and theoretical values.

REFERENCES

[1] Medical News Today, "Breast Cancer: Symptoms, Risk Factors, and Treatment", Available at: https://www.medicalnewstoday.com/articles/37136#causes

[2] S. Malvia, S.A. Bagadi, U.S. Dubey and S. Saxena, "Epidemiology of Breast Cancer in Indian Women", *Asia-Pacific Journal of Clinical Oncology*, Vol. 13, No. 4, pp. 289-295, 2017.

[3] K. Vidyasree, T.S. Nagaveni, M. Manisha and B.M. Nandini and H Vinod Kumar, "Breast Cancer Detection using Microstrip Patch Antenna", *International Journal of Advance Research, Ideas and Innovations in Technology*, Vol. 4, No. 3, pp. 1378-1379, 2018.

[4] Antenna Theory, Available at: http://www.antenna-theory.com.

[5] Shivam Mokha, Shubham Jangir, Shreyas Pimple and Sumeet Bandhaokar, "Design of Flexible Microstrip Patch Antenna of 2.4GHz Operation Frequency using HFSS", *International Research Journal of Engineering and Technology*, Vol. 3, No. 5, pp. 638-644, 2016.

[6] C.A. Balanis, "*Antenna Theory, Analysis and Design*", 3rd Edition, John Wiley and Sons, 2005.

[7] K. Ouerghi, N. Fadlallah, A. Smida, R. Ghayoula, J. Fattahi and N. Boulejfen, "Circular Antenna Array Design for Breast Cancer Detection", *Proceedings of International Conference on Sensor Networks Smart and Emerging Technologies*, pp. 1-8, 2017.

[8] M.H. Bah, J.S. Hong, D.A. Jamro, "Study of Breast Tissues Dielectric Properties in UWB Range for Microwave Breast Cancer Imaging", *Proceedings of International Conference on Computer Information Systems and Industrial Applications*, pp. 1122-1128, 2015.

[9] K. Ouerghi, A. Smida, R. Ghayoula and N. Boulejfen, "Design and Analysis of a Microstrip Antenna Array for Biomedical Applications", *Proceedings of 3rd International Conference on Advanced Technologies for Signal and Image Processing*, pp. 22-28, 2017.

[10] Sakshi Bohra and Tazeen Shaikh, "UWB Microstrip Patch Antenna for Breast Cancer Detection", *International Journal of Advanced Research in Electronics and Communication Engineering*, Vol. 5, No. 1, pp. 1-13, 2016.