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Simulation of microstrip patch antenna for detection of abnormal tissues in thyroid gland

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Abstract- An inset feed patch antenna is designed for this application. Polyester with dielectric constant of 1.44 is used as a substrate for the proposed antenna. This antenna is designed at 2.45 GHz frequency, which comes under ISM (Industrial, Scientific and Medical) band of frequency. Since the performance of the antenna is working on ISM band, it is perfectly suitable for biomedical applications. The inset feed improves the impedance matching and return loss. In the proposed antenna, polyester substrate is chosen for implementation because of its flexibility and is placed on the thyroid gland to detect the cancer cells. The performance of the antenna varies when it is placed on the thyroid gland of the human tissue. Tissue properties are considered and analyzed with and without cancer affected areas. Since cancer cells are more water content tissues, the return loss changes for with and without cancer cells. placing the antenna on thyroid gland it is also observed that there is also a change in working frequency of the designed antenna. The results of the proposed antenna have been simulated using HFSS software and results are seen using network analyzer.
Keywords – Dielectric constant, ISM band, Thyroid gland, HFSS

I. INTRODUCTION

The thyroid gland is in the front part of the neck. It is shaped like a butterfly, with two lobes, right and left, joined by a narrow gland called the isthmus. There can be different types of tumors which develop in thyroid gland. Most of these are non-cancerous and some are cancerous, which can spread into neighboring tissues and to other parts of the body, which becomes difficult to treat. Presently, thyroid cancer is diagnosed using biopsy. In this method, cells from the suspected area are removed and looked at under a microscope. Fine needle aspiration (FNA) is used to find out whether a thyroid nodule is cancerous or not. In FNA, a needle is used to draw cells and fluids from a nodule. This is repeated two to three times which is painful. The other methods such as thyroid function tests are expensive and hence not affordable by common people.

Microstrip patch antennas [1] are popular because they are light weight and are easy to fabricate. Due to their planar structure and compactness, these antennas are better to use for biomedical applications. Microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate that has a ground plane on the other side. By making some modifications like slot cut and different shapes, return loss of the antenna can be improved. There are various feeding techniques for an antenna such as co-axial feed, inset feed, edge feed etc. Impedance of patch varies with feeding location like coaxial probe feed patch.

The purpose of this work is to design an antenna with wearable and flexible properties. The substrate chosen is polyester, which is flexible and has a dielectric constant of 1.44. The inset feeding [2] technique is used in the design to improve impedance matching and return loss. The electrical properties of cancerous and non-cancerous cells are different. So when the antenna is placed on the thyroid gland and simulated, it shows a variation in the performance of the antenna.

II. PROPOSED ALGORITHM

2.1 Workflow–

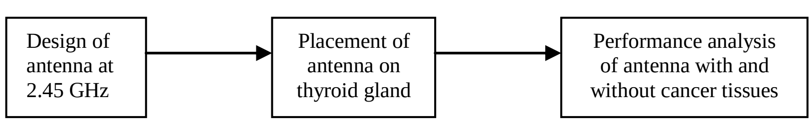

Figure 1 Workflow of the proposed model

The antenna is designed at an operating frequency of 2.45 GHz [4] as it is unlicensed and in the range of ISM [5] band. Polyester is used as the substrate material which has a relative permittivity of 1.44 and loss tangent is 0.01. The patch antenna is fed with an input impedance of 50Ω. The feed used is inset feeding which gives the antenna a planar structure and also provides impedance matching.

This antenna is placed on the human phantom model for both with and without cancer affected thyroid gland and the performance is analysed.

Design Equations:
For the design of the antenna [3], the substrate used is polyster with a dielectric constant of 1.44 and thickness of 2.85mm. The operating frequency is 2.45 GHz.
Step 1: Calculation of width of the patch(W)

$$W = \frac{c}{2f_0\sqrt{(\varepsilon_r + 1)/2}}$$

Where c is the free space velocity of light, fo is the resonant frequency in GHz, εr is the di-electric constant of the substrate kept at 1.44 for polyester. By using these values, the width of the patch of the antenna is 55.43mm
Step 2: Calculation of effective di-electric constant

$$\varepsilon_{reff} = \frac{(\varepsilon_r+1)}{2} + \frac{(\varepsilon_r-1)}{2}[1 + 12\frac{h}{w}$$

Where h is height or thickness of the substrate given as 2.85mm
Step 3: Calculation of length extension

$$\Delta L = 0.412\frac{(\varepsilon_{reff} + 0.3)(\frac{W}{h} + 0.264)}{(\varepsilon_{reff} - 0.3)(\frac{W}{h} + 0.8)}$$

Step 4: Calculation of length of the patch

$$L = \frac{c}{f} \times (\varepsilon_r)^{-0.5} - 2\Delta L$$

Based on the design equations, the dimensions of the patch antenna are as shown in TABLE 1.

PARAMETERS	VALUES
Operating frequency	2.45 GHz
Width of patch	55.43mm
Length of patch	48.46mm
Substrate thickness	2.85mm
Width of substrate	90mm
Length of substrate	90mm
Inset distance	10mm
Inset gap	2mm
Feed width	3.3mm
Feed length	24mm
Di-electric constant	1.44
Input impedance	50Ω

Table 1. Dimensions of the antenna

2.2 Implementation–
The microstrip patch antenna is designed for the values indicated in TABLE 1. Figure 2 shows the designed antenna. Figures 3 and 4 show the S11 parameter and gain of the antenna respectively.

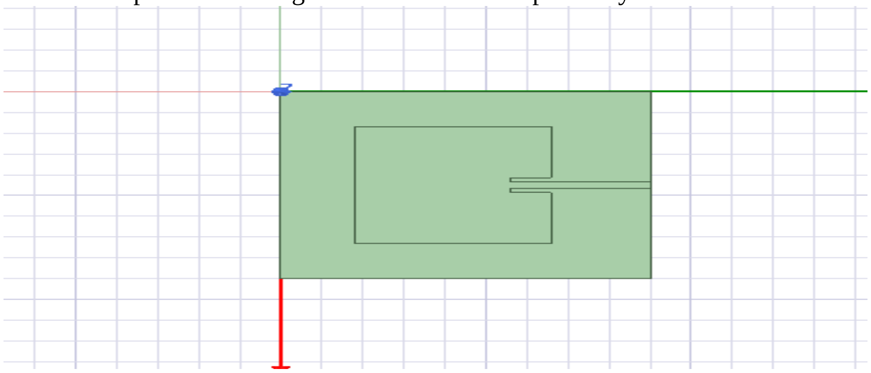

Figure 2 Inset fed patch antenna with polyester substrate

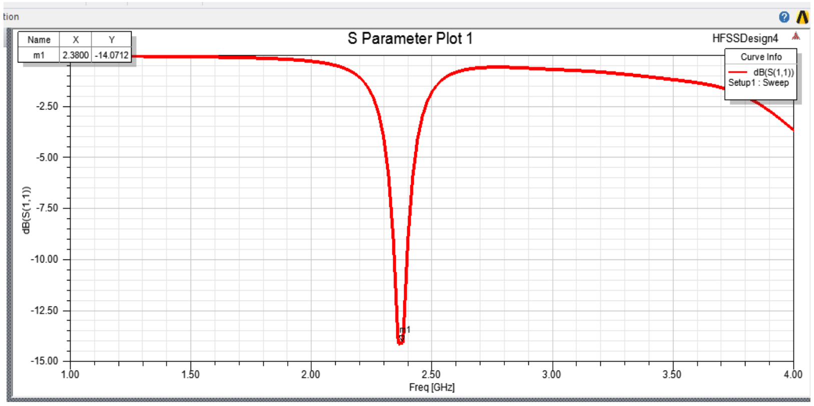

Figure 3 Return loss of the antenna

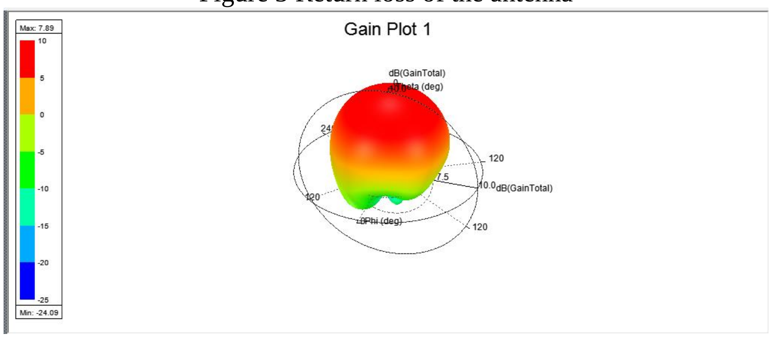

Figure 4 Gain plot of the antenna

2.3 .Design of human phantom model

The antenna is now placed on a 4 layer human phantom model created in HFSS. This 4 layer human phantom model consists of the 4 layers of human body tissues i.e. muscle, fat, skin and thyroid gland. TABLE 2 illustrates the different values of human body tissues that are taken to create the human phantom model. Figure 5 shows the human phantom model.

Tissue	Permittivity (εr)	Conductivity (S/m)	Loss tangent (tan σ)	Density (Kg/m3)
Skin	31.29	5.0138	0.2835	1100
Fat	5.28	0.1	0.19382	1100
Muscle	52.79	1.705	0.24191	1060
Thyroid	1.5	1.469	-	1050
Tumor	4.5	6	-	2050

Table 2. Properties of human layers

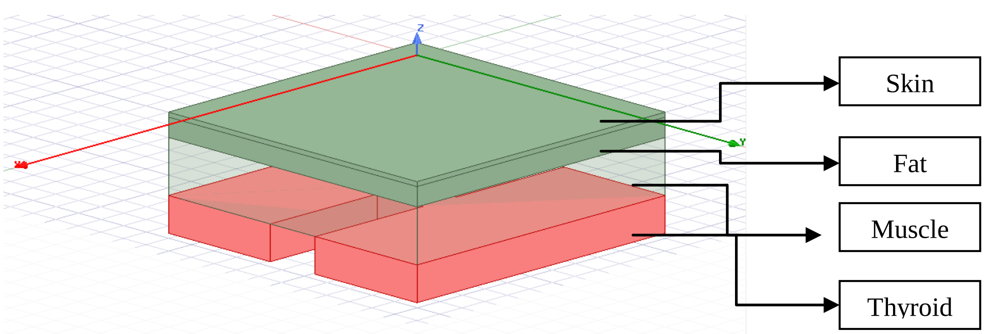

Figure 5 Human phantom model

III. EXPERIMENT AND RESULT

The antenna is characterized by 50Ω input impedance and is simulated using HFSS tool. The return loss and the gain of the antenna is illustrated in Figures 3 and 4 respectively. The return loss of the antenna is -14 dB at 2.45 GHz and gain is 7.89 dB. This antenna is placed on the human phantom model and is simulated for both thyroid without and with tumor. Figures 6 and 7 illustrate the antenna placed on human phantom model which is not affected by cancer and the corresponding return loss respectively. The return loss is -11.84 dB and the working frequency is shifted to 2.4 GHz.

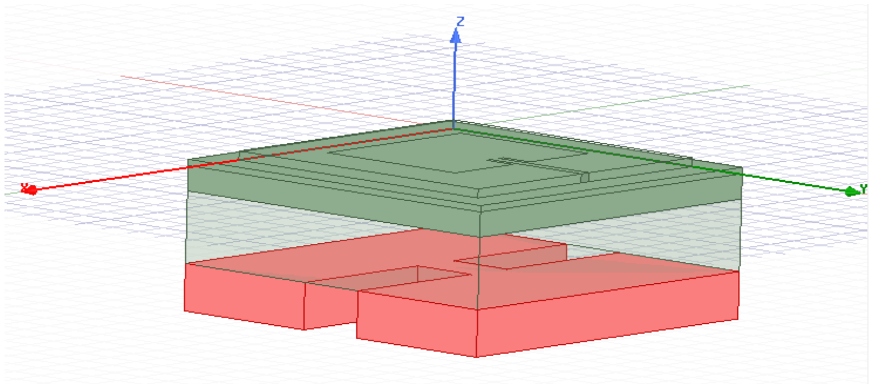

Figure 6 Antenna placed on the model without cancer(Ɛr=1.5)

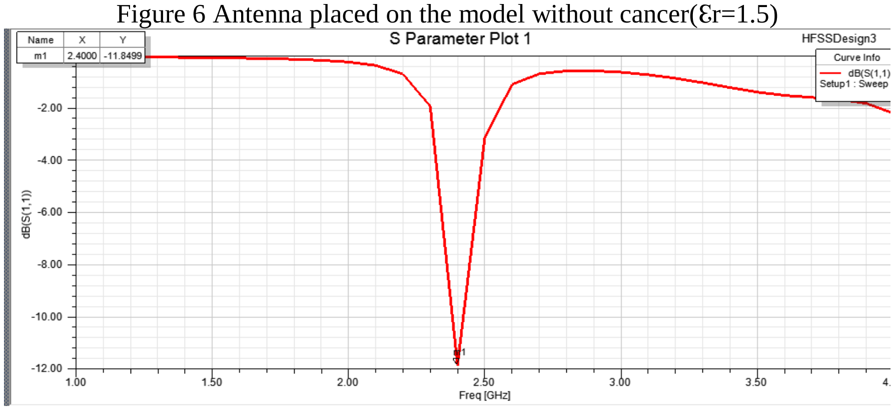

Figure 7 Simulated return loss on cancerless gland

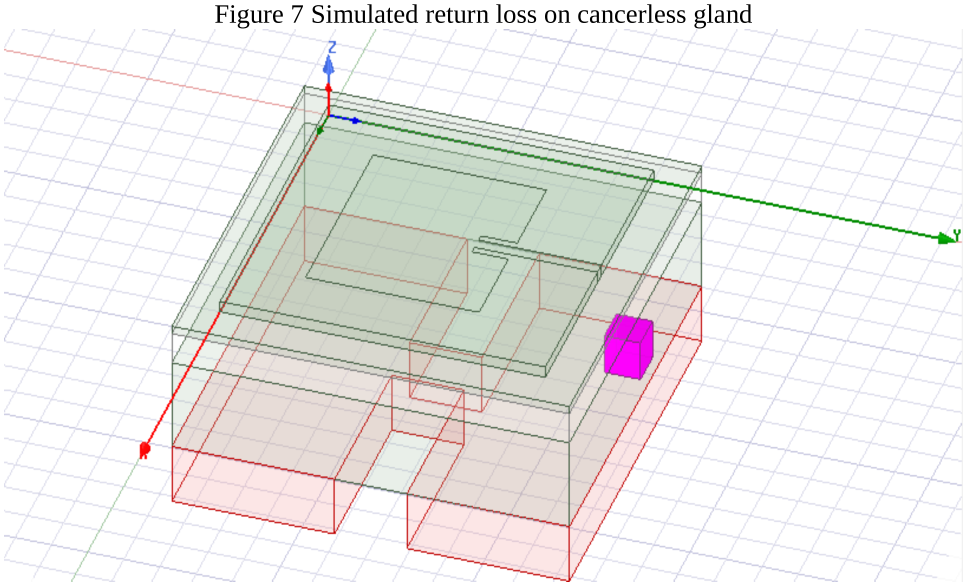

Figure 8 Antenna placed on the model with cancer tumor(Ɛr=1.5) in right lobe of thyroid

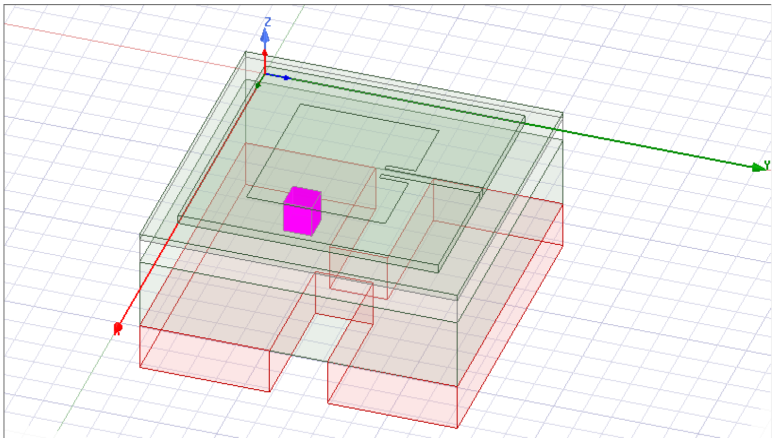

Figure 9 Antenna placed on the model with cancer tumor(Ɛr=1.5) in left lobe of thyroid

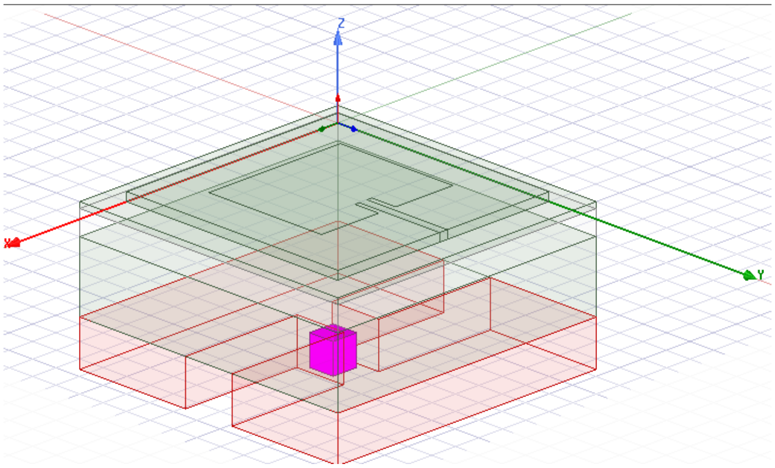

Figure 10 Antenna placed on the model with cancer tumor(Ɛr=1.5) in isthmus

Figures 8,9 and 10 illustrate the antenna placed on cancer affected model with the tumor present in the right lobe,left lobe and isthmus of the thyroid gland respectively. The obtained return loss for different positions of the antenna is found to be -3.1 dB and the working frequency is shifted to 2.5 GHz as illustrated in Figure 11.

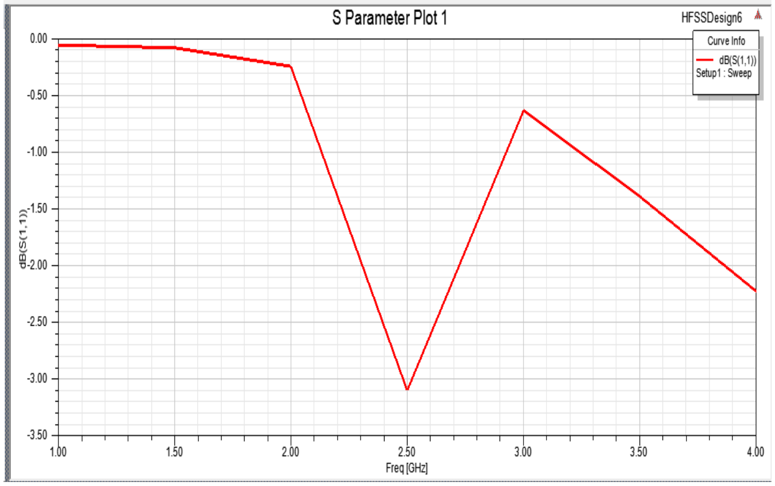

Figure 11 Simulated return loss on cancerous gland

IV. CONCLUSION

An inset fed microstrip patch antenna with polyester as the substrate is used to detect abnormalities in the thyroid gland. The relative permittivity of polyester is 1.44 and loss tangent is 0.01. Due to the low relative permittivity, there is a reduction in surface wave losses. Also, polyester is more flexible compared to other substrate materials making it suitable for biomedical applications. The operating frequency of the antenna is 2.45GHz which is in the range of the ISM band.

The designed antenna is placed on human thyroid gland to detect whether tumor is present or not. Parameters like return loss is considered and accordingly the presence of thyroid tumor is detected. Due to the presence of high water content in cancer cells, the permittivity between cancer and normal cells vary, due to which the performance of the antenna changes consequently. When the antenna is placed on normal and cancerous tissues, the return loss changes from -11.84 dB to -3.1 dB respectively. Also, the change in operating frequency of the antenna is observed from 2.5 GHz to 2.4 GHz for with and without tumor respectively. By using this proposed antenna on human body and analyzing the results, the presence or absence of thyroid cancer can be detected.

V. REFERENCES

[1] Rexiline Sheeba I, Jayanthy T, “Design and implementation of flexible wearable antenna on thyroid gland in the detection of cancer cells” in Biomedical Research,2018; Vol.29:Issue.11: 2307-2312.

[2] Jaget Singh, “Inset Feed Microstrip Patch Antenna” in International Journal of Computer Science and Mobile Computing, 2016; Vol.5: Issue.2: pg.324 – 329.

[3] Dhara Patel, Falguni Raval, “Design and Cavity Model analysis of Inset Feed Rectangular Microstrip Patch Antenna” in V. T. Patel Department of Electronics and Communication Engineering, 2012;2375-1282.

[4] Kukunuri Suraj, Neelaveni Ammal M, “Design and Development of Microstrip Patch Antenna at 2.4 GHz for Wireless Applications” in Indian Journal of Science and Technology, 2018;Vol.11: Issue.23: 0974-6846.

[5] Pankaj KS, Subodh KT, Rahul S, Ashok K. “Design & simulation of microstrip antenna for cancer diagnosis” in IJSER 2009; 824-659.

[6] Rexiline Sheeba I, Jayanthy T, “ Design and Analysis of a low cost, flexible softwear antenna for an ISM band working in different bending environment” in Springer, 2016.