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SKIN CANCER DETECTION USING MICROSTRIP ANTENNA

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Abstract - With the advancement in the field of Electromagnetics, there are several medical applications that can be used to detect different diseases. Skin cancer, being one of the most common types of cancer that affects millions of people worldwide, requires early detection to ensure effective treatment and improved patient outcomes. One promising method for detecting skin cancer is by using a microstrip antenna that can analyze the properties of skin tissue. In this paper, we propose a novel technique for detecting skin cancer tissue by designing a Microstrip Patch Antenna with a dimension of length 19.15mm and width 25mm using CST suite tools software. The substrate is made of FR-4 material of relative permittivity 4.3 and a thickness of 1.5 mm. The biological skin tissue is modeled in CST software using the dielectric properties of normal and cancerous tissues. The presence of a tumor causes an increase in the reflection coefficient (S_{11}) and a shift in the resonance frequency, which can be used to identify cancer. We have also ensured that the computed specific absorption rate (SAR) is less than the safety levels, thus making the technique safe to use. This paper proposes a simple and efficient detection technique for skin cancer, which shows promise as a non-invasive, cost-effective, and reliable method for early cancer detection. However, further research and development are necessary to refine the technique and improve its accuracy. This technique has the potential to revolutionize skin cancer diagnosis and treatment.

Key Words: $S_{11,}$ Microstrip patch antenna,VSWR,SAR

1.INTRODUCTION

Modern wireless communication systems require antennas that are low profile, lightweight, high gain, and have a simple structure to ensure reliability, mobility, and high efficiency. One type of antenna that satisfies these requirements is the microstrip antenna. Microstrip patch antennas, in particular, are among the most commonly used antenna types today, especially in the frequency range of 1 to 6 GHz. They are easy to construct, lightweight, low cost, and can conform to the mounting surface or protrude minimally from it.

Cancer is one of the most fatal diseases worldwide, causing nearly 10 million deaths in 2020. Skin cancer, in particular, is the most common type of cancer, with 3.5 million cases of basal cell and squamous cell carcinomas and 76,600 cases of melanoma reported in the United States in 2013. Skin cancer is categorized into different stages based on how far the cancer has spread in the body, ranging from stage 0 to stage IV.

Detection of skin cancer usually involves invasive methods such as shave and punch biopsies, which can be painful for patients. However, recent studies have shown that differences in the dielectric properties of normal and malignant tissues, such as water and protein content, can be used to study their interaction with electromagnetic waves. Knowledge of the dielectric properties of biological tissues is therefore essential in this area of research.

This paper aims to investigate the dielectric properties of normal and malignant skin tissues and their interactions with electromagnetic waves which will help to detect the skin cancer . The results of this study may contribute to the development of non-invasive methods for detecting skin cancer.

2.SKIN ANATOMY AND SKIN CANCER

The skin is an essential organ that provides a physical and chemical barrier against the external environment. It is the largest organ in the human body, covering an average surface area of about 2 square meters in adults. The skin is composed of multiple layers, including the epidermis, dermis, and subcutaneous tissue, each with its specific function.The outermost layer of the skin is the epidermis, which is composed of several layers of cells that continually renew themselves. It serves as the first line of defense against harmful external factors such as UV radiation, bacteria, and pollution. Beneath the epidermis lies the dermis, which contains hair follicles, sweat glands, and blood vessels that supply nutrients and oxygen to the skin cells. The subcutaneous tissue is the deepest layer of the skin, consisting of fat and connective tissue, which provides insulation and support totheskin.Skin cancer is a type of cancer that develops from the skin cells. The three most common types of skin cancer are basal cell carcinoma, squamous cell carcinoma, and melanoma.These cancers can develop from exposure to ultraviolet radiation from the sun or other source such as tanning beds.The stages of skin cancer depend on the extent of the cancer and whether it has spread to other parts of the body. In stage 0, the cancer is only in the top layer of the skin and has not spread to other parts of the body. In stage I, the cancer is small and has not spread to nearby lymph nodes or other parts of the body. In stage II, the cancer is larger and may have spread to nearby lymph nodes but not to other parts of the body. In stage III, the cancer has spread to nearby lymph nodes and may have also spread to nearby tissues and organs. In stage IV, the cancer has spread to other parts of the body, such as the lungs or liver.

In conclusion, skin cancer is a serious condition that requires prompt diagnosis and treatment. Understanding the structure and function of the skin and the stages of skin cancer can help individuals take proactive steps to protect their skin and detect any signs of skin cancer early on.

3. PROPOSED STRUCTURE

3.1 ANTENNA DESIGN

The rectangular patch has a simple geometry. The substrate we have used is FR-4 material.The patch dimensions can be calculated using the following equations:

I. Patch width:

$$W = \frac{c}{2f_0\sqrt{\frac{\varepsilon_r + 1}{2}}} \quad \text{........eq(1)}$$

c= Constant speed of light in vacuum

r = Dielectric constant of substrate

f_0 =Operating frequency

II. The effective length:

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{reff}}} \quad \text{........eq(2)}$$

III. The patch length:

The two increments in the length, which are generated by the fringing fields, making electrical length lightly larger than the physical length of the patch:

$$\Delta L = 0.412h\frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \quad \text{........eq(3)}$$

$$\text{........eq(4)} \qquad L = L_{eff} - 2\Delta L$$

IV. The length and width of ground plane (and the substrate), Lg and Wg :

$$L_g = 6h + L \quad \text{........eq(5)}$$

$$W_g = 6h + W \quad \text{........eq(6)}$$

After calculating all the values, the microstrip antenna is modelled using CST microwave suite which is shown in figure 1. In table 1 we have the parameter values which is used to make the antenna design.

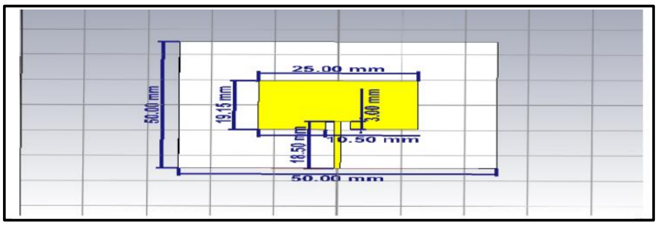

Figure-1: Design specifications of microstrip patch antenna

Table-1: Design specifications of microstrip patch antenna

Parameter	Description	Value (in mm)
Hp	Height of patch	0.035
Hg	Height of the ground plane	0.035
Hf	Height of feedline	0.035
Hs	Height of substrate	1.5
Wf	Width of feedline	2.5
Lf	Length of feedline	17
Wp	Width of patch	17
Lp	Length of patch	19.15
Ws	Width of substrate	25
Wg	Width of ground	50
Ls	Length of substrate	50

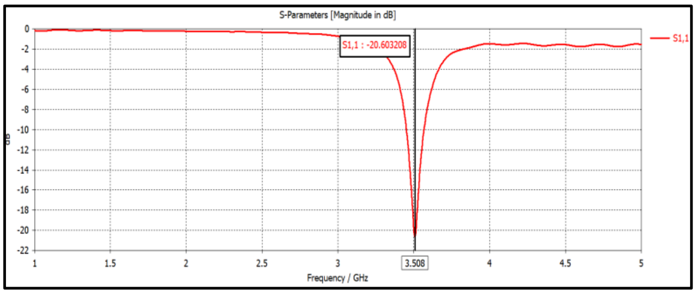

Fig-2: S-Parameter

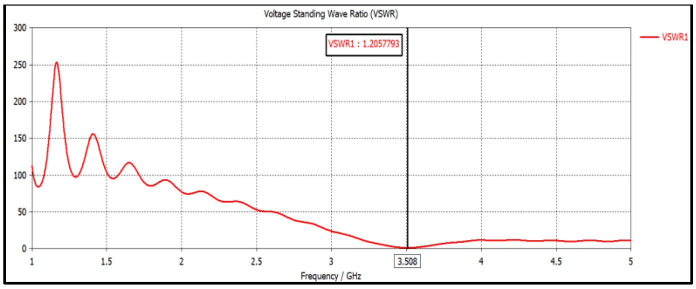

Fig-3: VSWR

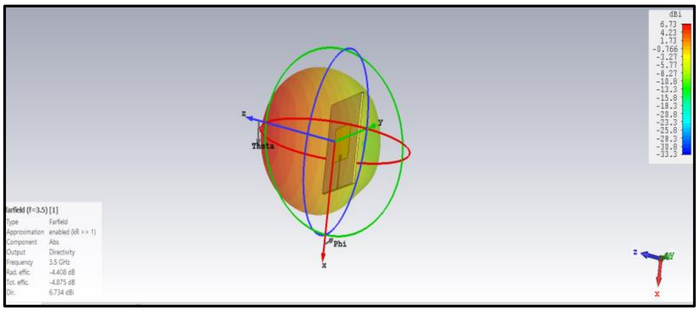

Fig-4: FAR FIELD

3.2 ANTENNA CHARACTERISTICS

The design antenna is simulated, and the S-Parameters, VSWR and Far field results are shown below in figure 2 ,figure 3 and figure 4. In figure 2 the simulated result of antenna is S-parameter which is -20.603 dBi at frequency 3.5GHz, and in figure 3 the simulated result of antenna is VSWR which is 1.205.The far field of an antenna is generally considered to be the region where the outgoing wave front is planar and the antenna radiation pattern has a polar variation and is independent of the distance from the antenna.The far field directivity of antenna which is shown in figure 4 results is 6.73 dBi(max) with red portion.

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3.3 SKIN DESIGN

I. Without Tumor

The skin is an important organ that serves as a protective barrier between the body's internal organs and the external environment. It is the largest organ of the human body, covering a total area of around 20 square feet. Here we have developed a microstrip patch antenna that can be used to detect the presence of skin tumors. The antenna is placed at a 20mm distance on a small patch of skin with a density of 1100 kg/m3. The design of the skin is illustrated in Figure 5, and the parameters used for its creation are listed in Table 2.

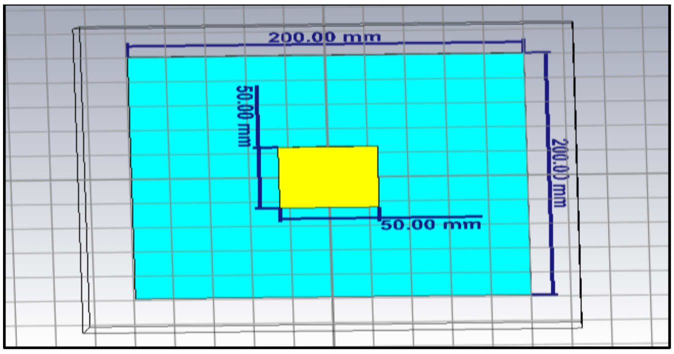

Figure-5: Design specifications of Skin without tumor

II. With Tumor

Cancer is a disease that occurs when healthy cells in the body begin to change and grow uncontrollably, forming a mass called a tumor. Tumors can be either benign or cancerous. In this study, a skin model with a tumor was created using a density of 1058 kg/m3, as shown in Figure 6. The parameters of the tumor are listed in Table 3.

Table-2: Parameter specifications of skin without tumor

PARAMETER	Values
Epsilon	43.75
Mu	1
Electric conductivity	0.856 S/m
Thermal conductivity	30 W/K/m
Heat capacity	3.5 kJ/K/kg
Blood flow coefficient	9e+03 W/K/m^3
Material density	1100 kg/m^3

Table-3: Parameter specifications of Skin with tumor

PARAMETER	VALUES
EPSILON	18
Mu	1
Material density	1058 kg/m^3

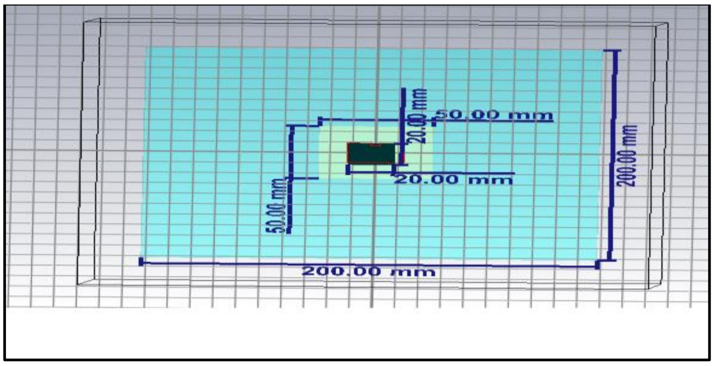

Figure-6: Design specifications of Skin with tumor

4. SIMULATED RESULTS

The study aimed to investigate various parameters of the Skin (with and without tumor) and microstrip patch antenna setup, including Electric Field Intensity (E-field), Magnetic Field Intensity (H-field), Specific Absorption Rate (SAR), VSWR, S11, Far field Directivity and Gain, Surface Density, Current Density, and Power Loss Density through simulations. The electric field refers to the space surrounding an electric charge where its influence can be felt. Electric field intensity, expressed in volts per meter (V/m), is the force that a unit positive charge placed at a specific point experiences. The maximum E-field for skin with and without tumors at 3.5 GHz frequency was calculated using the formula E = √30∗∗V/m, where 'Pt' is the Transmitter radiated power in dBm, 'Gt' is the Gain of Transmitter Antenna in dBi, and 'd' is the Receiver distance in km. The E-field value for skin without a tumor was 12320 V/m , while the value for skin with a tumor was 13731 V/m (table 4) . These findings suggest that placing skin with a tumor in proximity to the antenna can lead to an increase in the E-field.

In this study, Magnetic Field Intensity was analyzed for both skin with and without a tumor in the microstrip patch antenna setup at a frequency of 3.5 GHz. Magnetic Field Intensity is the part of the magnetic field in a material that arises from an external current and is not intrinsic to the material itself. It is expressed as the vector H and is measured in units of amperes per meter (A/m). The formula used to calculate H-field is H = A/m, where E is the Electric Field Intensity and Z is the impedance with a standard value of 377 ohms. The maximum H-field values obtained were 43.6 A/m for skin without a tumor and 44.5 A/m for skin with a tumor (table 4 and 5). These results indicate that placing skin with a tumor near the antenna can cause an increase in the H-field.

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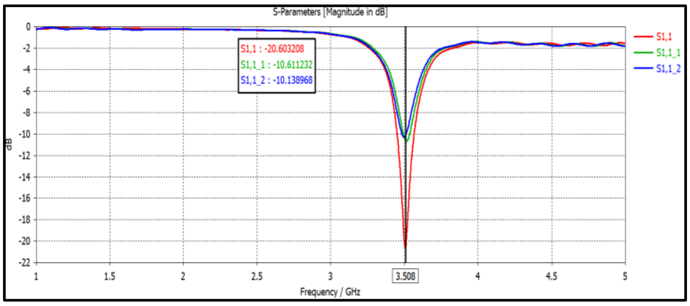

Figure-7: Combined S-Parameter

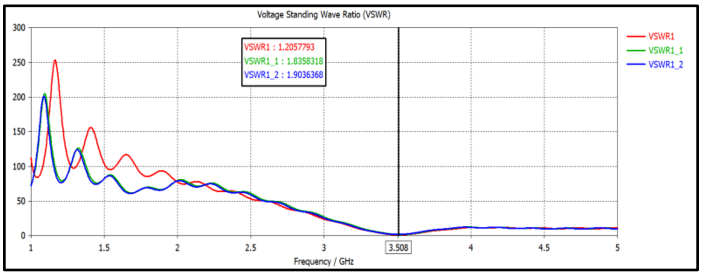

Figure-8: VSWR

Here in figure 7 and figure 8 is the result of combined S-Parameter and VSWR of antenna and skin (with tumor and without tumor).The S1,1 and VSWR1 is of antenna and S1,1_1 and VSWR_1 is of skin without tumor and S1,1_2 and VSWR_2 shows skin with tumor.

Here we can see that when antenna S-parameter is -20.603 dBi and when the antenna is taken near the normal skin which is without tumor then s-parameter is increased to -10.611 dBi and when antenna is place near the skin having tumor then further s-parameter is increased to -10.138 dBi. and for VSWR the value of antenna is 1.205 and when the antenna is taken near the normal skin then the value is 1.835 and with skin having tumor value is 1.903. Here we notice that as the normal skin and skin having having tumor is placed near the antenna the value is different ,so from this difference of skin properties it is easy to detect the skin having tumor.

Specific absorption rate is the amount of energy absorbed by the body when exposed to radio frequency electromagnetic field. Here we have calculated for 1g mass of tissue of human skin model without and with tumor. According to Federal Communication Commission, FCC (USA), the effect of SAR is supposed to be less than or equal to 2.0 W/Kg for 1 g tissue of a skin model.Here in figure 9 shows the simulated results of SAR that skin without tumor with antenna is 1.04338 W/kg and skin with tumor the SAR value is 2.06534 W/kg is shown in figure 10.

But we know that according to Federal Communication Commission, FCC (USA), the effect of SAR is supposed to be less than or equal to 2.0 W/Kg,taking this consideration we have simulated the skin (with or without) tumor by keeping skin behind the antenna so that SAR value remains less such that harm cause by the radiation of antenna should not harm the skin.

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===========================================================================
SAR Calculation Results
===========================================================================

Powerloss density monitor used: loss (f=3.5) [1] at 3.5 GHz
Power scaling [W] :             None
Stimulated Power [W] :          0.5
Accepted Power [W] :            0.454025
Average cell mass [g]:          0.000217818
Averaging method:               IEEE/IEC 62704-1
Averaging mass [g]:             1

---------------------------------------------------------------------------
Entire Volume:

Min (x,y,z) [mm]:               -124.983, -124.983, -26.5177
Max (x,y,z) [mm]:               124.983, 124.983, 49.9827
Volume [mm^3]:                  4.77995e+06
Absorbed power [W]:             0.273263
Tissue volume [mm^3]:           200000
Tissue mass [kg]:               0.22
Tissue power [W]:               0.014224
Average power [W/mm^3]:         7.112e-08
Total SAR [W/kg]:               0.0646545
Max. point SAR [W/kg]:          2.64543

Maximum SAR (1g) [W/kg]:       1.04338
Maximum at (x,y,z) [mm]:       -0.303704, 6.325, 20.2778
Avg.vol.min (x,y,z) [mm]:      -7.0457, -0.416999, 20
Avg.vol.max (x,y,z) [mm]:      6.43829, 13.067, 33.484
Largest valid cube  [mm]:      0
Smallest valid cube [mm]:      0
Avg.Vol.Accuracy     [%]:      0.0001

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Calculation time [s]:       276
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Figure-9: Report of SAR calculation– without Tumor

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===========================================================================
SAR Calculation Results
===========================================================================

Powerloss density monitor used: loss (f=3.5) [1] at 3.5 GHz
Power scaling [W] :             None
Stimulated Power [W] :          0.5
Accepted Power [W] :            0.453068
Average cell mass [g]:          0.000168973
Averaging method:               IEEE/IEC 62704-1
Averaging mass [g]:             1

---------------------------------------------------------------------------
Entire Volume:

Min (x,y,z) [mm]:               -124.983, -124.983, -26.5177
Max (x,y,z) [mm]:               124.983, 124.983, 49.9827
Volume [mm^3]:                  4.77995e+06
Absorbed power [W]:             0.290108
Tissue volume [mm^3]:           201200
Tissue mass [kg]:               0.22127
Tissue power [W]:               0.01622
Average power [W/mm^3]:         8.06163e-08
Total SAR [W/kg]:               0.0733042
Max. point SAR [W/kg]:          5.52568

Maximum SAR (1g) [W/kg]:       2.06524
Maximum at (x,y,z) [mm]:       6.3375, 1.0842e-16, 20.25
Avg.vol.min (x,y,z) [mm]:      -0.464699, -6.8022, 20
Avg.vol.max (x,y,z) [mm]:      13.1397, 6.8022, 33.6044
Largest valid cube  [mm]:      0
Smallest valid cube [mm]:      0
Avg.Vol.Accuracy     [%]:      0.0001

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Calculation time [s]:       658
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Figure-10: Report of SAR calculation– with Tumor

The result of SAR when we calculated by keeping the skin(with or without) behind the antenna the SAR value we got is 0.04506 W/kg for normal skin and for skin having tumor the SAR value we got is 0.051875 W/kg. is shown in figure 11 and 12.

As we can see that the SAR value is less that the 2W/kg,means harm cause by antenna to skin is very less.SAR is calculated by the formula: $SAR = \sigma |E|^2/\rho$ where, E is the maximum electric fifield in (V/m), σ is the electric conductivity of the tissue in (S/m), and ρ is the mass density of the tissue in Kg/m3.

Table 4 and 5 above presents a comparison between skin is kept in front and behind the antenna used for skin cancer detection, and and comparison shows that keeping the skin behind the antenna is good for skin.

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===========================================================================
SAR Calculation Results
===========================================================================

Powerloss density monitor used: loss (f=3.5) [1] at 3.5 GHz
Power scaling [W] :             None
Stimulated Power [W] :          0.5
Accepted Power [W] :            0.48648
Average cell mass [g]:          0.000217818
Averaging method:               IEEE/IEC 62704-1
Averaging mass [g]:             1

---------------------------------------------------------------------------
Entire Volume:

Min (x,y,z) [mm]:               -124.983, -124.983, -49.9827
Max (x,y,z) [mm]:               124.983, 124.983, 36.8977
Volume [mm^3]:                  5.42852e+06
Absorbed power [W]:             0.226084
Tissue volume [mm^3]:           200000
Tissue mass [kg]:               0.22
Tissue power [W]:               0.0021031
Average power [W/mm^3]:         1.05155e-08
Total SAR [W/kg]:               0.00955952
Max. point SAR [W/kg]:          0.105055

Maximum SAR (1g) [W/kg]:       0.04506
Maximum at (x,y,z) [mm]:       10.4692, 0.25, -24.7222
Avg.vol.min (x,y,z) [mm]:      3.72723, -6.492, -25
Avg.vol.max (x,y,z) [mm]:      17.2112, 6.992, -11.516
Largest valid cube  [mm]:      0
Smallest valid cube [mm]:      0
Avg.Vol.Accuracy     [%]:      0.0001

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Calculation time [s]:       539
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Figure-11: Report of SAR calculation without Tumor

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---------------------------------------------------------------------------
SAR Calculation Results
---------------------------------------------------------------------------

Powerloss density monitor used: loss (f=3.5) [1] at 3.5 GHz
Power scaling [W] :              None
Stimulated Power [W] :           0.5
Accepted Power [W] :             0.481568
Average cell mass [g]:           0.000168973
Averaging method:                IEEE/IEC 62704-1
Averaging mass [g]:              1

---------------------------------------------------------------------------
Entire Volume:

Min (x,y,z) [mm]:                -124.983, -124.983, -49.9827
Max (x,y,z) [mm]:                124.983, 124.983, 36.8977
Volume [mm^3]:                   5.42852e+06
Absorbed power [W]:              0.234767
Tissue volume [mm^3]:            201200
Tissue mass [kg]:                0.22127
Tissue power [W]:                0.00215921
Average power [W/mm^3]:          1.07316e-08
Total SAR [W/kg]:                0.00975826
Max. point SAR [W/kg]:           0.166308

Maximum SAR (1g) [W/kg]:        0.051875
Maximum at (x,y,z) [mm]:        4.4375, -2.23529, -24.75
Avg.vol.min (x,y,z) [mm]:       -2.37575, -9.04854, -25
Avg.vol.max (x,y,z) [mm]:       11.2508, 4.57796, -11.3735
Largest valid cube [mm]:        0
Smallest valid cube [mm]:       0
Avg.Vol.Accuracy     [%]:       0.0001

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Calculation time [s]:        744
```

Figure-12: Report of SAR calculation with Tumor

Table-4: Overall results(Skin is kept in front of antenna)

Parameter	Only Antenna	Antenna with normal skin	Antenna with cancerous skin
VSWR	1.205	1.828	1.882
S11(dBi)	-20.603	-10.663	-10.278
E-Field(V/m)	10225	121320	13731
H-Field(A/m)	44.9	43.6	44.5
Farfield Directivity(dBi)	6.73	6.1	6.16
Gain(dBi)	2.33	-1.97	5.11
Surface Current(A/m)	40.4	43.5	44.
Power Loss Density(W/m³)	5.83e+05	6.09e+05	6.74e+05
SAR(W/kg)	-	1.0433	2.06534

Table-5: Overall results(Skin behind antenna)

Parameter	Only Antenna	Antenna with normal skin	Antenna with cancerous skin
VSWR	1.205	1.39	1.43
S11(dBi)	-20.603	-15.68	-15.02
E-Field(V/m)	10225	11538	12716.2
H-Field(A/m)	44.9	40.2	40.71
Farfield Directivity(dBi)	6.73	7.97	7.99
Gain(dBi)	2.33	3.26	3.24
Surface Current(A/m)	40.4	40.2	40.7
Power Loss Density(W/m³)	5.83e+05	6.2e+05	5.47e+05
SAR(W/kg)	-	0.0451	0.0519

5. CONCLUSION

This study provided information on a technique for finding skin tumours. The antenna microstrip design has been completed effectively and its different features evaluated. It will be used for analysing variation in antenna performance to compare the electrical characteristics of malignant and normal tissues. S_{11}, Far field, SAR, E-field, H-field, and other scattering parameters are used to investigate the differences between malignant and healthy skin. We will be able to see that these parameter values are different for normal and cancerous tissues. Here in this paper we have also consider the parameter value by keeping the skin in front and behind the antenna so that harm cause by antenna to skin should be less. Despite these challenges, microstrip antenna technology holds promise as a non-invasive and low-cost method for skin cancer detection. With further research and development, it could become a valuable tool for early cancer detection and treatment.

REFERENCES

1. Rabia Top , Yaşar Ünlü , Seyfettin Sinan Gültekin and Dilek Uzer's,"Microstrip Antenna Design with Circular Patch for Skin Cancer Detection" in AdvancedElectromagnetics, vol. 8, no. 2, March 2019.

2. Reza Aminzadeh , Mehrdad Saviz , Amir Ahmad Shishegar's , "Dielectric Properties Estimation of Normal and Malignant Skin Tissues at Millimeter-Wave Frequencies Using Effective Medium Theory".

3. Anamika Mani Tripathi, Praveen Kumar Rao and Rajan Mishra's ,"An AMC Inspired Wearable UWB Antenna for Skin Cancer Detection".

4. M.Leeban Moses, C.Raju and Ajin R Nair's,"Detection of skin cancer using PIFA antenna."

5. Sameer Alani , , A. Ahmad's, "Miniaturized UWB elliptical patch antenna for skin cancer diagnosis imaging". DOI: 10.11591/ijece.v10i2.pp1422-1429

BIOGRAPHIES

Dr. N Shesha Prasad currently working as an Associate professor in the Department of Electronics & Communication Engineering at BNMIT has over 23 years of experience in teaching and industry together. He did his B.E and M.Tech and PhD from BMS College of Engineering, Bangalore. His thesis is in the area of Microstrip antennas for Human Body Communication. He was the Best outgoing student in BE and received Silver medal from VTU for securing Second rank in M.Tech (Electronics). He is also leading the Cultural Club and Nature Club at BNMIT. Sheshaprasad is a trained classical singer and has secured 1st Rank in the Music Exams.

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