DESIGN AND MODIFICATION IN IMPLANTABLE MICROSTRIP PATCH ANTENNA AT 2.45 GHZ FOR BIOMEDICAL APPLICATIONS

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***Abstract:** As the communication tool, implantable devices have been introduced with great interest. By using wireless link, the vital information (such as blood pressure, temperature, thyroid, cardiac beat, sugar level, cancer identification etc.) can be transmitted from implantable devices to external equipment. Therefore, the research on the implantable devices are very popular. When there is a need for information exchange, ISM band (industrial, scientific and medical band) which is ranges from 2.4 - 2.5 GHz is used. In this paper, a microstrip patch antenna design which is combination of spiral and traditional rectangular geometry is designed, simulated and analyzed. The proposed antenna design operated at the 2.45 GHz band. The antenna design is excited with the strip line feed method and analyzed using different substrate materials (Roger 3010, FR4 epoxy, silicon, alumina). The same antenna design is modified using another feeding method i.e., coaxial feed method. The results of antenna design and modified antenna design are also compare in this paper.*

***Keywords** – Implantable Microstrip patch antenna, Microstrip feed method, coaxial feed method, ISM band.*

1. INTRODUCTION

Microstrip patch antenna is widely used in modern day communication devices due to small size, low weight, and ease of fabrication. In high-performance aircraft, spacecraft, satellite and missile application, where the size, cost, performance, weight and ease of installation are main constraints, low profile antennas are required. Presently many commercial and government application, such as mobile, radio and wireless communication that have similar specification, to meet these necessities microstrip patch antenna can be used [1]. The future trends in communication design is towards compact size. The Microstrip patch antenna have been well known for its advantages and capabilities of dual and triple frequency operations, all these feature attract many researchers to investigate the performance of patch antenna in various applications [2].

Nowadays in the medical device radio communication services, there is growing interest in the devices for biomedical applications. The whole system including the antenna must be as small as possible in order to improve the quality of patient life [3][4]. In the designing of the circular microstrip antenna using rectangular split ring metamaterial unit cell, the author finds the significant miniaturization as compared to conventional circular patch antenna. The bandwidth and gain is also increased by metamaterial structure and this design is well suited for biomedical application wireless device [5].

Various antenna miniaturization techniques have been used by other authors including radiator geometry optimization and high permittivity substrate/superstrate materials [6][7]. The implantable medical devices are the essential part of biomedical telemetry application which helps to improve the comfort of the patient [9] [10]. For the communication between the implanted and external antenna services are used whose frequency range from 402 to 405 MHz and ism band is used for sending wake-up signals for external unit [11] [12].

2. ANTENNA DESIGN

2.1 GEOMETRY OF IMPLANTABLE MICROSTRIP PATCH ANTENNA USING MICROSTRIP LINE FEED METHOD

The antenna design consists of patch that contains the combination of asymmetric spiral and traditional rectangular geometry and it is made of conducting material (copper). The different substrate materials are used to examine the performance of antenna with overall dimension of $24\times 12 \times 2.56mm^3$. The antenna patch and ground plane both are connected through the shorting pin which makes the antenna design as a planar Inverted-F antenna design. The overall dimensions of patch is $8.65\times 9.75mm^2$ and is placed on the surface of substrate. To match 50**Ω** impedance, a microstrip line feed is used with suitable width.

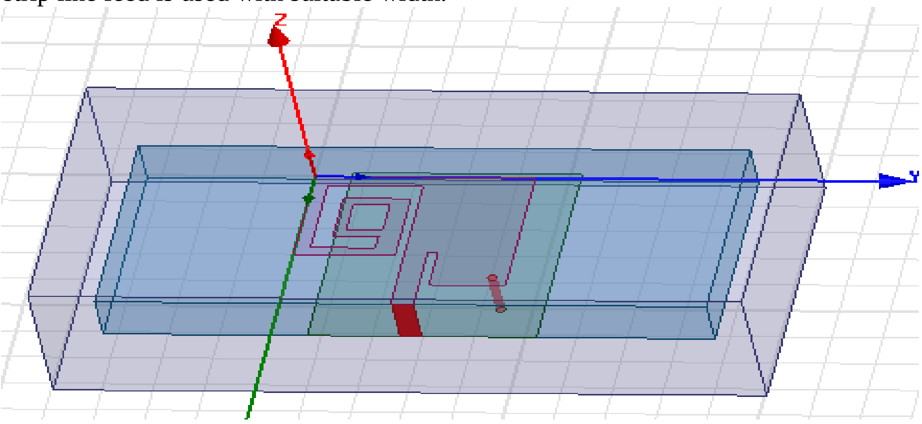


Fig.1.Antenna geometry using microstrip line feed method

The dimension (length, width and thickness) of patch, substrate and ground plane of the antenna design is given in table1.

Table1. Dimensions of Antenna design using microstrip line method

Antenna dimensions	Value (mm)
Length of substrate (L_s)	12
Width of substrate (w_s)	24
Thickness of substrate (h_s)	2.56
Length of ground (L_g)	9
Width of ground (w_g)	12.5
Length of patch (L_p)	8.65
Width of patch (w_p)	9.75

2.2 GEOMETRY OF IMPLANTABLE MICROSTRIP PATCH ANTENNA USING COAXIAL FEED METHOD

The radiator design consists of an asymmetric spiral that ultimately combines into a loop, with its right side resembling a traditional rectangular patch. The patch and ground both are of conducting material (copper). The different substrate material with overall dimensions of $10\times 10\times 1.28\text{mm}^3$has been used to analyze the performance of proposed antenna and there also incorporated a shorting pin that couples the antenna radiator and ground plane that producing a planer inverted- F antenna. The geometry of proposed antenna is shown in Fig.2:

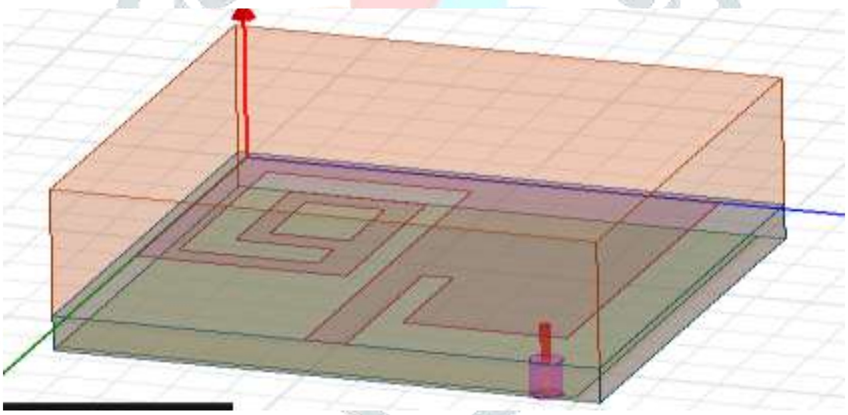


Fig.2 Antenna geometry using coaxial feed method

The dimension of patch of the proposed antenna is $8.65\times 9.75mm^2$ and the patch is placed on the surface of substrate. The microstrip feedline of suitable width has been applied to the patch antenna design to match with 50 ohm impedance.

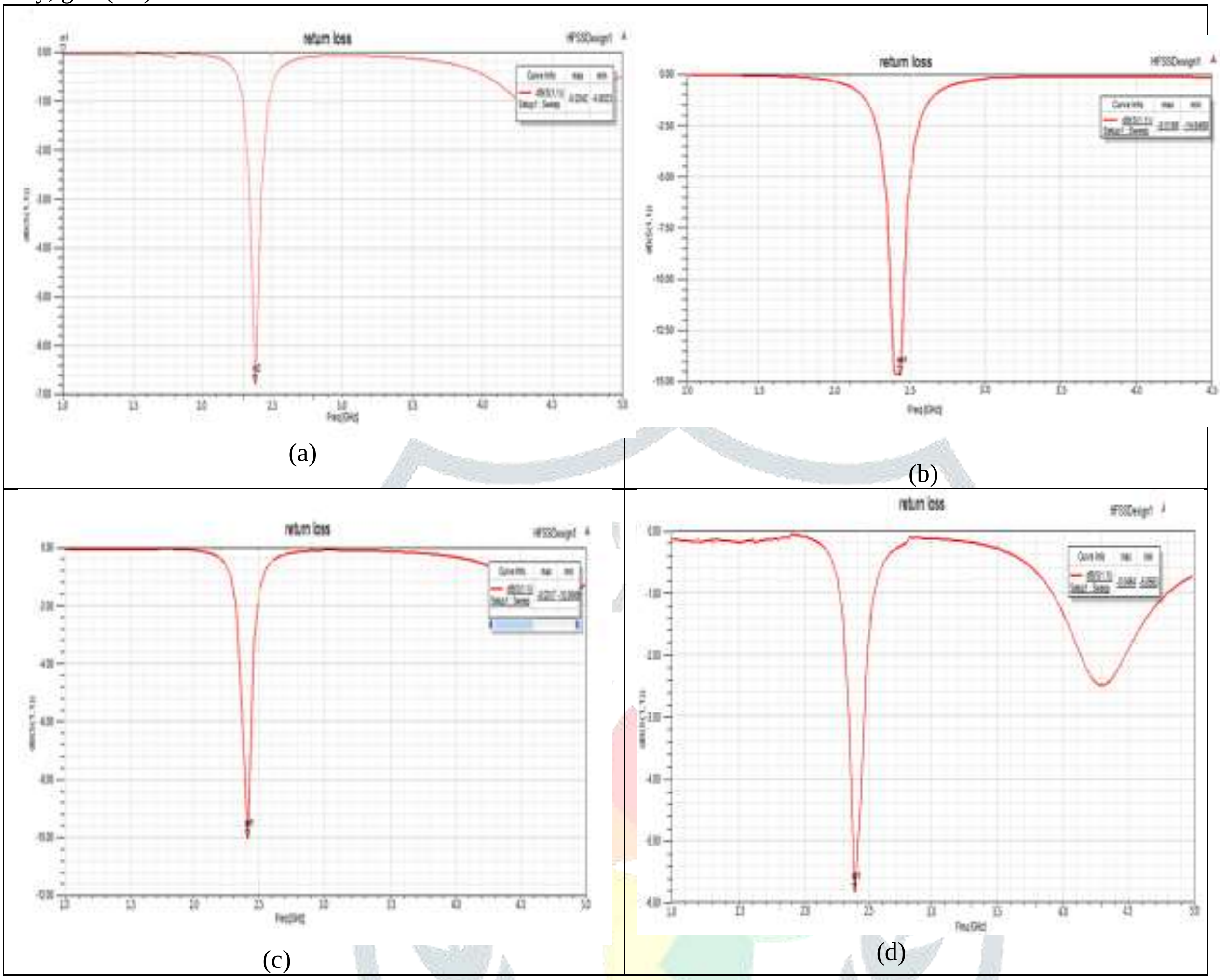
Table 2. Dimension of Antenna design using coaxial feed method

Antenna dimensions	Value (mm)
Length of substrate (L_s)	10
Width of substrate (w_s)	10
Thickness of substrate (h_s)	1.28
Length of ground (L_g)	10
Width of ground (w_g)	10
Length of patch (L_p)	8.65
Width of patch (w_p)	9.75

3. RESULT AND DICUSSION

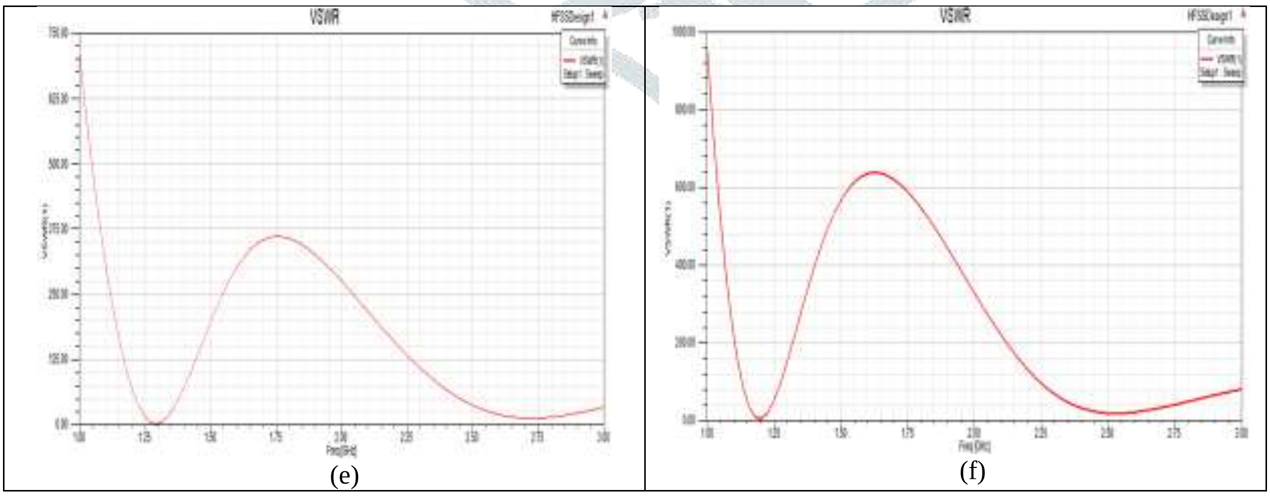
3.1 SIMULATION OF ANTENNA DESIGN USING MICROSTRIP LINE METHOD

The proposed implantable antenna has been designed using HFSS 15.0 Software. The comparative performance of implantable antenna using microstrip line feed method employed with different substrate material and have been analyzed in term of return loss (dB), radiation efficiency, gain(dB) and VSWR.

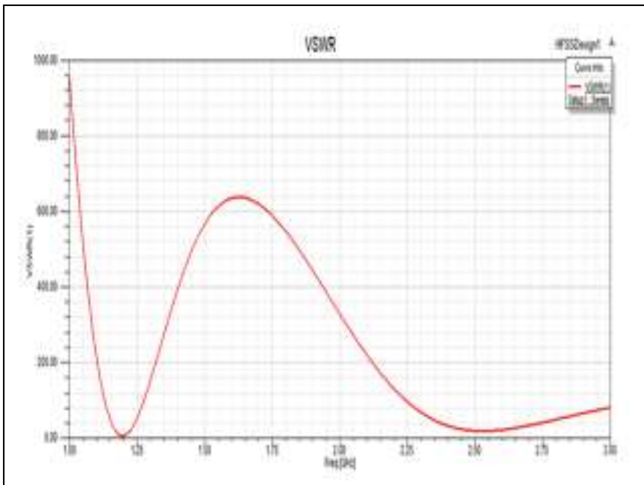


(a) (b) (c) (d)

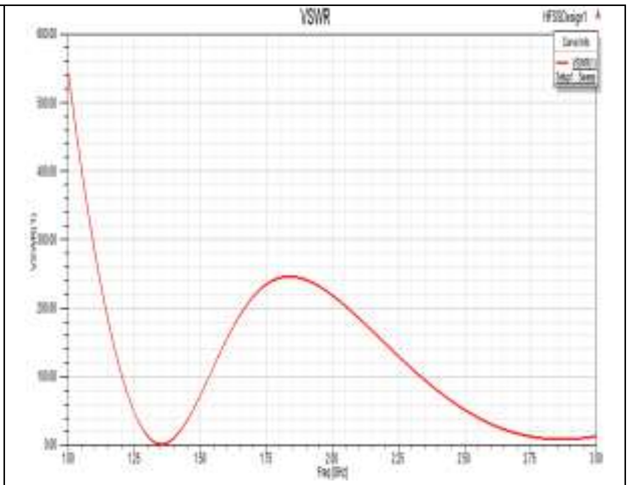
Fig.(a-d) illustrate the graph of return loss versus frequency. These results represent the different values of return loss corresponding to the different substrate materials (Roger 3010, FR4, silicon and alumina). The value of return loss for Roger 3010, FR4, silicon and alumina is -6.8 dB, 14.6 dB, -5.8 dB and 10 dB respectively.



(e) (f)

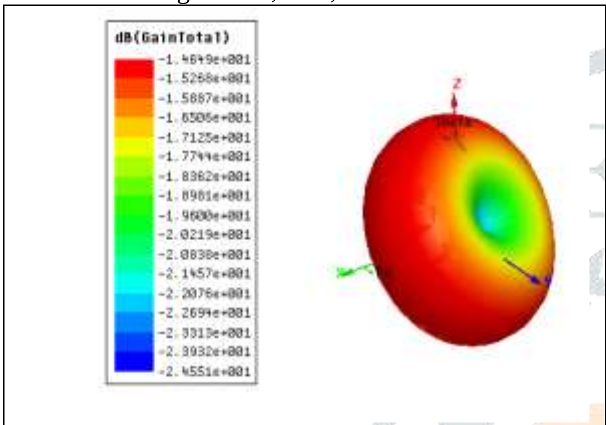


(g)

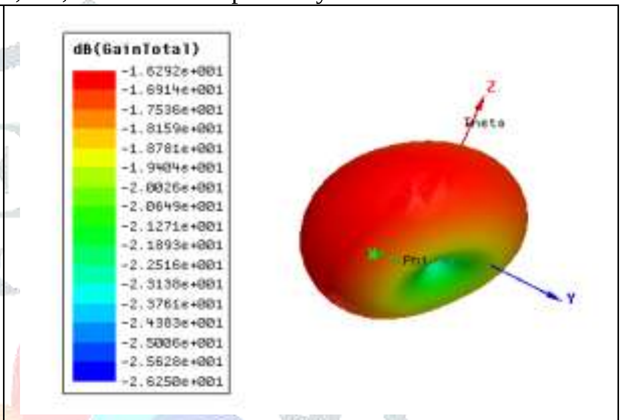


(h)

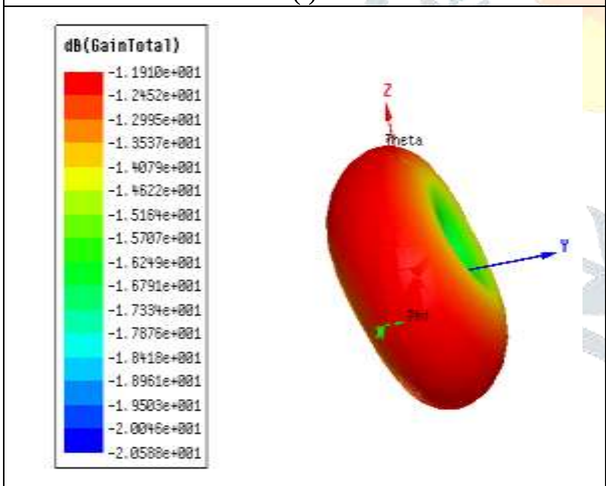
Fig(e-h) illustrate the voltage standing wave ratio (VSWR) for the different substrate materials (Roger 3010, FR4, silicon and alumina). The value of VSWR for Roger 3010, FR4, silicon and alumina is 1.3, 1.2, 1.2 and 1.3 respectively.



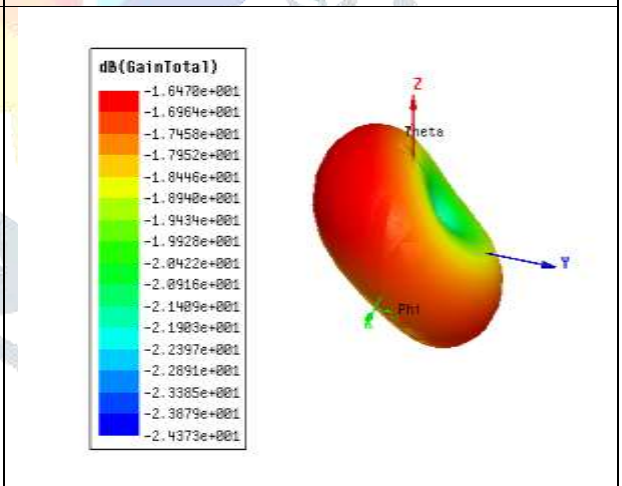
(i)



(j)

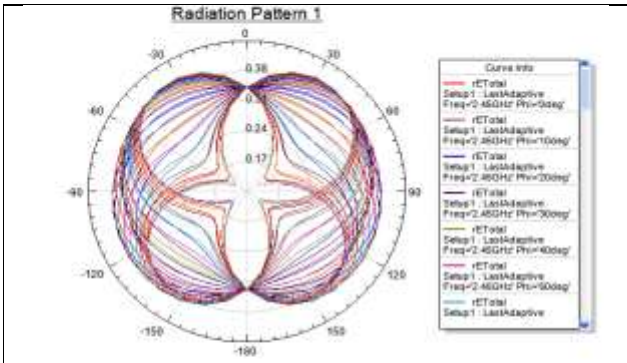


(k)

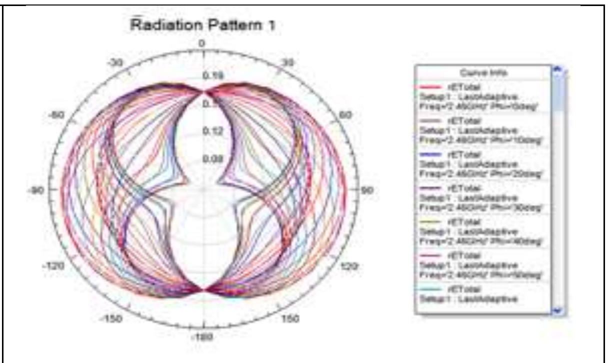


(l)

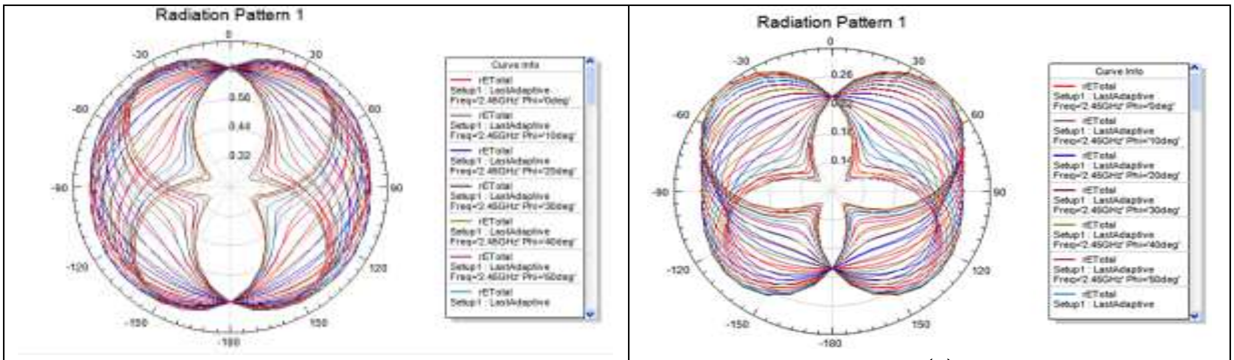
Fig.(i-l) represents the gain of proposed antenna for different substrate materials (Roger 3010, FR4, silicon and alumina). The gain for the Roger 3010, FR4, silicon and alumina is -1.46 dB, -1.62 dB, -1.19 dB and -1.6 dB respectively.



(m)



(n)

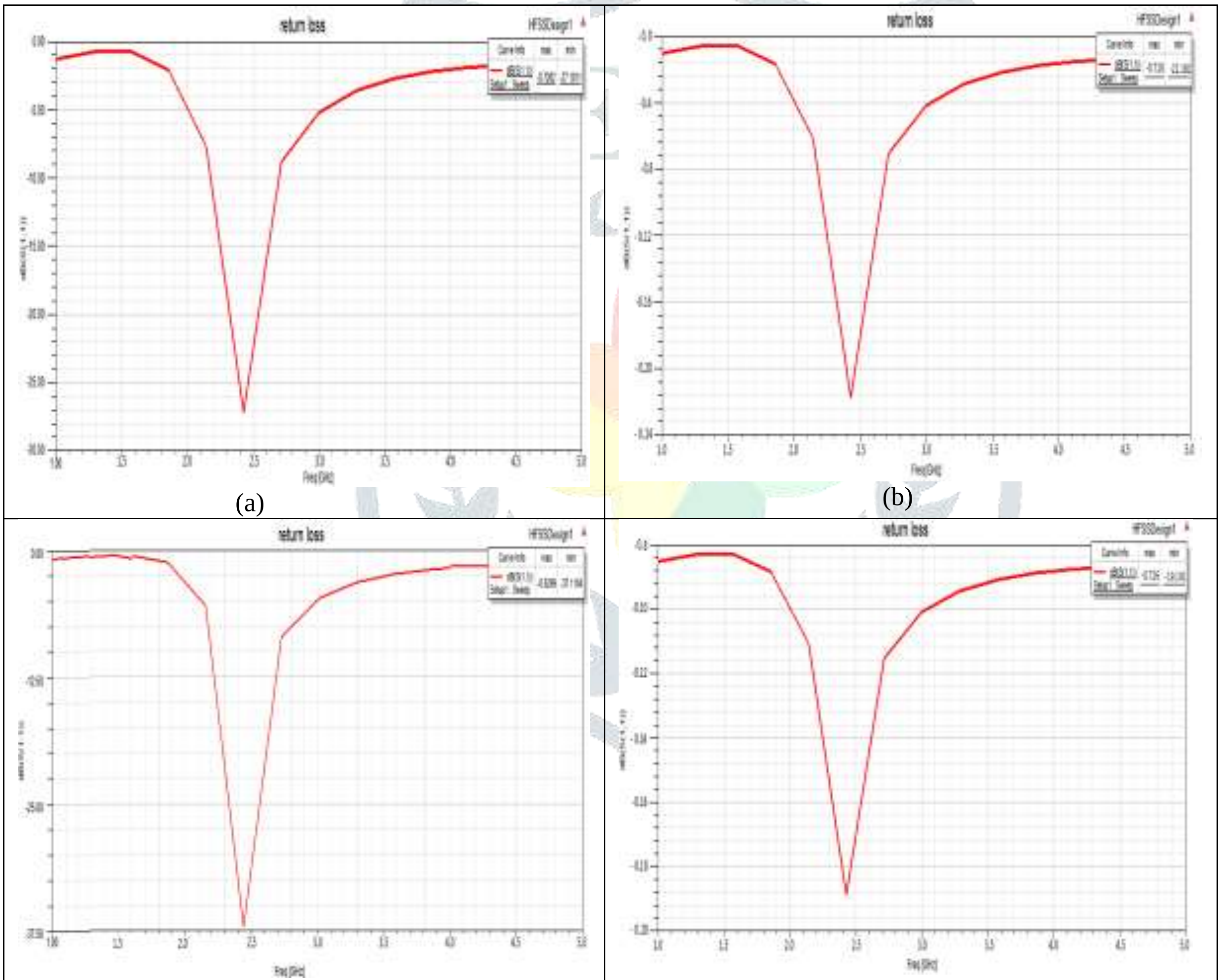


(o) (p)

Fig.(m-p) illustrate the radiation pattern of antenna design for different substrate materials (Roger 3010, FR4, silicon and alumina).

3.2 SIMULATION OF ANTENNA DESIGN USING COXIAL FEED METHOD

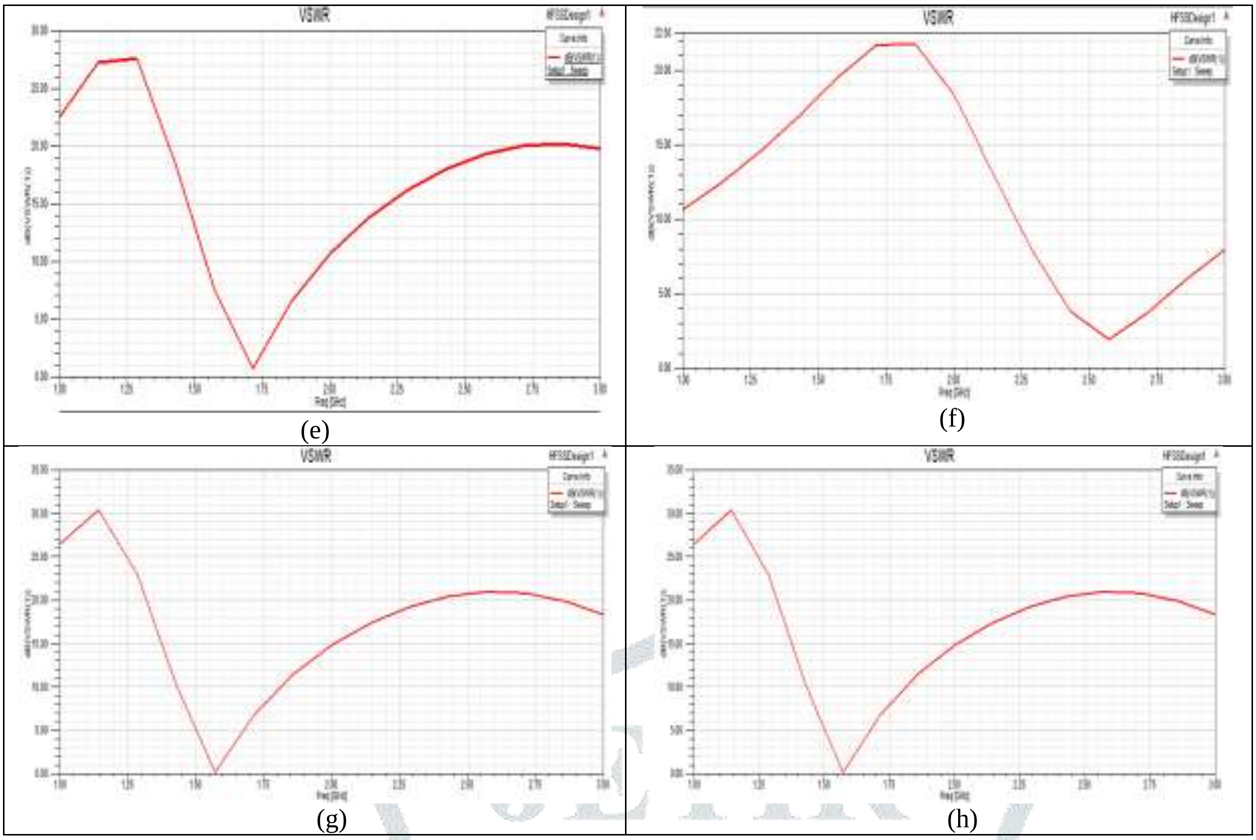
The proposed implantable antenna has been designed using ANYSIS HFSS 15.0 Software. The comparative performance of implantable antenna using Coaxial feed method employed with different substrate material and have been analyzed in term of return loss (dB), radiation efficiency, gain(dB) and VSWR.



(a) (b)

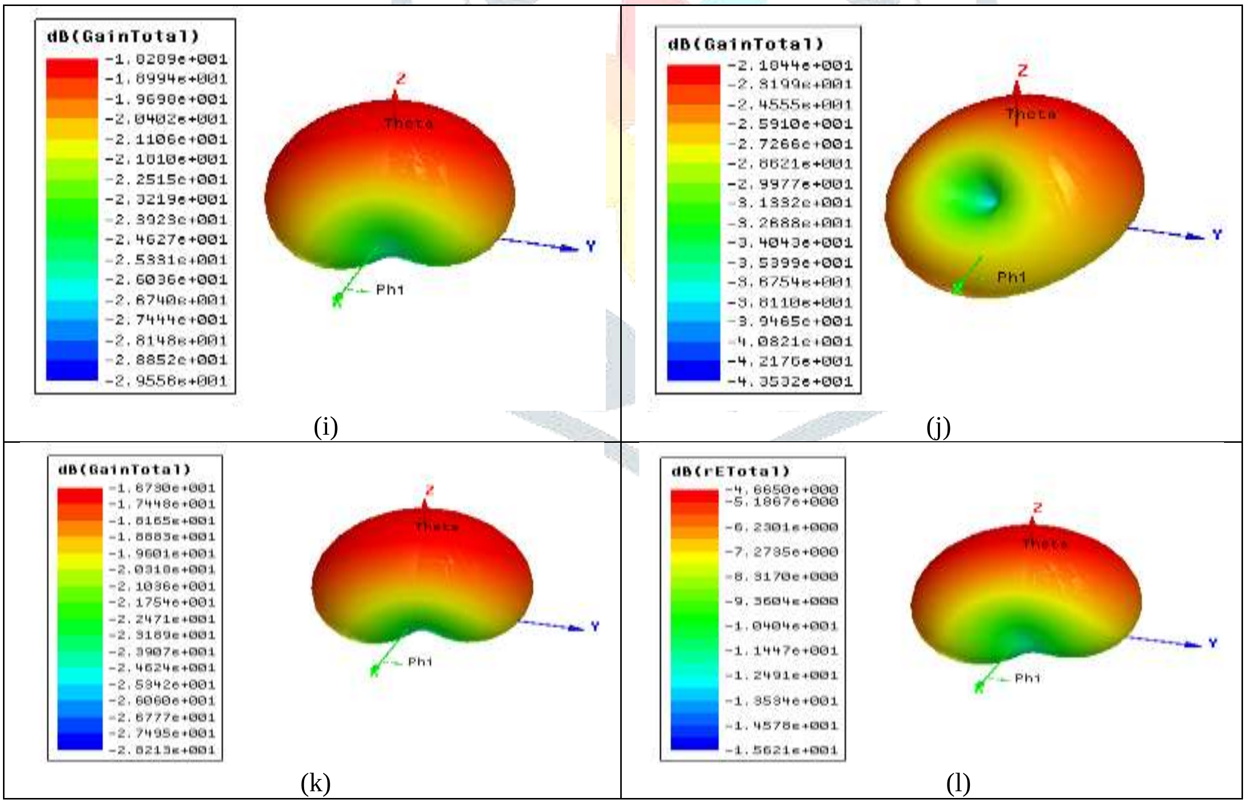
(c) (d)

Fig.(a-d) represents the return loss using Roger 3010 substrate, FR4 epoxy substrate, Silicon substrate and Alumina substrate. The return loss for the different substrates (Roger 3010, FR4 epoxy, Silicon and Alumina) corresponding to the resonant frequency dip at 2.45 GHz is -27 dB, -22 dB, -37dB and -19 dB respectively.



(e) (f) (g) (h)

Fig.(e-h) illustrate the voltage standing wave ratio (VSWR). The value of VSWR should be less than 2. The value for Roger3010, FR4, silicon and alumina is 1.7, 2, 1.55 and 1.57 respectively.



(i) (j) (k) (l)

Fig.(i-l) represents the gain of antenna for different substrate materials such as Roger3010, FR4, silicon and alumina. The value for the four materials is -1.8 dB, -2.1 dB, -1.67 dB and -4.66 dB respectively.

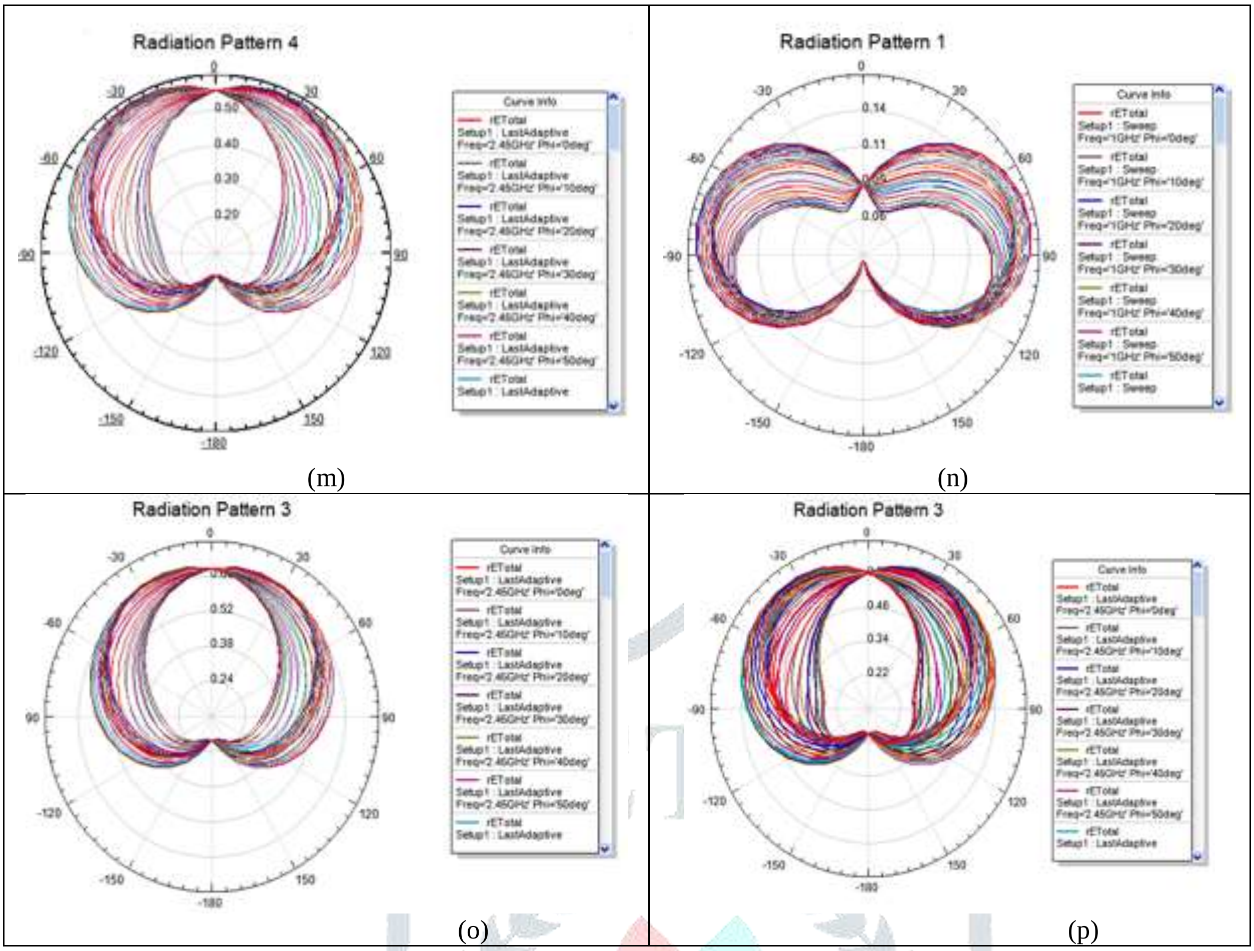


Fig.(m-p) represents the radiation pattern of antenna design for different substrate materials (Roger 3010, FR4, silicon and alumina).

Table 3. Comparison of Antenna geometries

PARAMETERS (MICROSTRIP LINE FEED METHOD)	**Roger RO3010 ε_r =10.2**	**FR4 ε_r=4.4**	**Silicon ε_r=11.9**	**Alumina ε_r=9.9**
Return loss	-6.8 Db	-14.6 Db	-5.8 dB	-10 Db
Gain	-1.8 Db	-2 Db	-1.55 dB	-1.57 Db
Radiation efficiency	76%	58%	88%	61%
VSWR	1.3	1.2	1.2	1.3
PARAMETERS (COAXIAL FEED METHOD)	**Roger RO3010 ε_r =10.2**	**FR4 ε_r=4.4**	**Silicon ε_r=11.9**	**Alumina ε_r=9.9**
Return loss (dB)	-27	-16	-37	-16
Gain (dB)	-1.8	-2	-1.6	-4.6
Radiation efficiency	97%	88%	98%	89%
VSWR	1.7	2	1.55	1.57

4. CONCLUSION

The antenna simulation is done using high frequency structure simulator (HFSS) version 15. In this paper, the implantable microstrip patch antenna is designed using microstrip line feed method and the performance of antenna is analyzed using different substrate materials such as Roger 3010, FR4 epoxy, Silicon and alumina. In the modified antenna design, the implantable microstrip patch antenna is designed using coaxial feed method and also the performance is analyzed using different substrates. The comparison of the two proposed design is also given this paper. From the comparison, it is found that silicon material give the best results as compared to the other material and the antenna design using coaxial feed method is efficient than the first one. Further we can enhance the performance of modified antenna design by varying the dimensions of antenna elements.

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