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Improvement of Slotted Patch Antenna Performance for Biomedical Applications

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Abstract: *Patch antenna finds enormous applications in present time as it has lot of advantages. The main advantages are it can be directly printed on the circuit boards, it is in expensive, it can be designed in different shapes, can be designed with less weight and size also. If slots are considered in the patch antenna then the parameters of the antenna like VSWR and Return loss are still more improved. In the present paper patch antenna resonating at bio medical applications (2.45 GHz) with single slot and multiple slots are considered. The performance characteristics are compared with the regular micro strip patch antenna resonating at same 2.45 GHz.*

Keyword: *Implantable antennas, Biomedical applications, HFSS, Slotted Patch Antenna.*

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I. INTRODUCTION

Patch antennas [1-2] have become increasingly important in the advancement of wireless networks in the digital era, GPS, wireless connections, cellular communication systems, and electromagnetic sensors are only a few examples. Microstrip patch antennas have the following advantages over other antennas: small size, low profile, simple manufacturing and integration, and low cost. Microstrip antennas with properly placed slots produce good results in return loss, gain, resonant frequency, impedance, and bandwidth [3-6]. Implanted biomedical antennas are receiving a lot of attention as they try to find solutions to difficult medical problems. Implanted biomedical antennas must be small with good efficiency, and safe, as well as able to operate within appropriate medical frequency bands. Radio frequency/microwave applications now play a significant role in disease prevention, diagnosis, and treatment.

Antennas in and out of the body are required for body centric wireless communications, which reduces patient diagnosis [7-12]. It can interact without a wire penetrating the skin, which prevents infections in medical diagnosis. In the biomedical field, an inductive link and a radio frequency (RF) link are the most common modes of communication. The inductive link, which employs coils for near-field communication, has a low data rate. The RF link is used for far-field communication and has a higher data rate than the inductive link. The objective of this paper is to introduce a small, slotted patch antenna for 2.45 GHz biomedical applications that has a light weight and good performance. The slotted antenna is made by loading unique slots into the radiator of a standard microstrip antenna to improve bandwidth, gain and radiation efficiency. The performance of these antennas is simulated and analysed using HFSS software.

II. MICROSTRIP ANTENNA DESIGN PROCEDURE

The patch, matching element and feed line are all designed as part of the antenna design process. While designing a microstrip antenna, special parameters such as the substrate's dielectric constant (ε_r), height (h), and resonant frequency (f_r) must be taken into account. The main parameters of Dielectric substrate are Substrate: Roger RT 5880, Dielectric Constant: 2.2, Substrate Thickness: 1.6mm, Operating frequency: 2.45 GHz, loss tangent: 0.02. The design equations [1-2] used for the patch antenna design are

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

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{-\frac{1}{2}} \tag{2}$$

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{eff}}} \tag{3}$$

$$\Delta L = 0.421h \frac{(\varepsilon_{eff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{eff}-0.258)(\frac{W}{h}+0.8)} \quad (4)$$

$$L = L_{eff} - 2\Delta L \quad (5)$$

Where
W is width of the patch
ε_{eff} is effective dielectric constant
L_{eff} is effective length
f_0 is the Resonance Frequency
L is the Length of the Patch
h is the thickness
ε_r is the relative Permittivity of the dielectric substrate
c is the Speed of light: 3×10^8

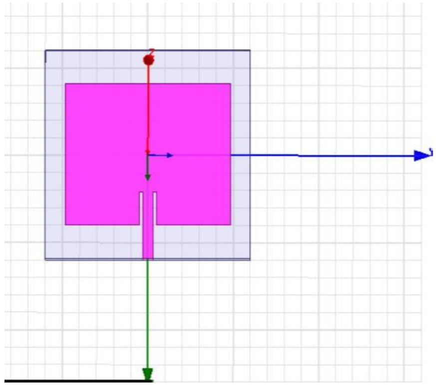

Fig1. Rectangular micro strip patch antenna

Table 1. Antenna Dimensions in mm

Dimensions	(mm)
Patch Width (W_p)	48.4
Patch Length (L_p)	40.48
Length of Feed (L_f)	10.48
Gap between feed and patch (g)	1
Width of feed (W_f)	3

III. Simulation and Results of Antenna

The patch antenna with slots and with out slots has been designed using the equations 1-5 in HFSS software. The parameters of dielectric substrate is presented above. The three-dimensional radiation patterns of antenna without slots, with single slot and with multiple slots are presented in Figures 4, 9 and 14 respectively. The total gain patterns of antenna without slots, with single slot and with multiple slots at 0° and 90° in x-z plane are presented in Figures 5, 10 and 15 respectively.

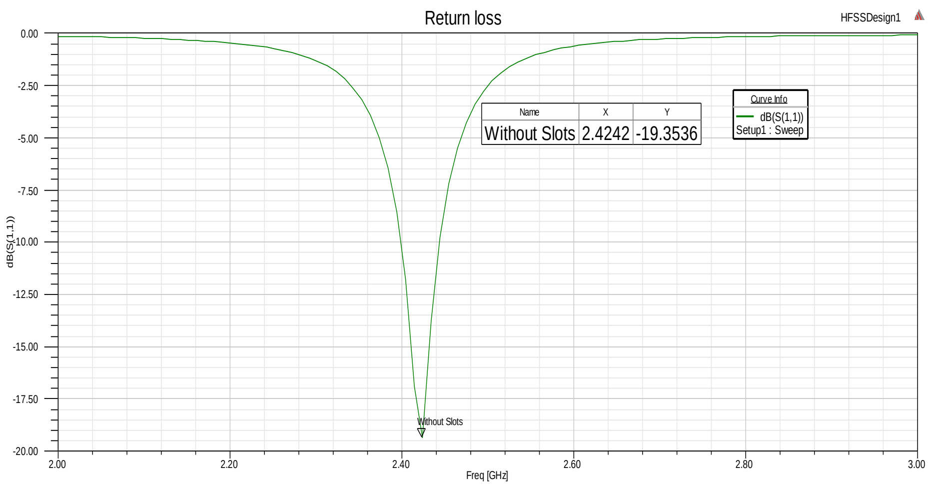

Fig 2. Antenna without slots return loss versus frequency

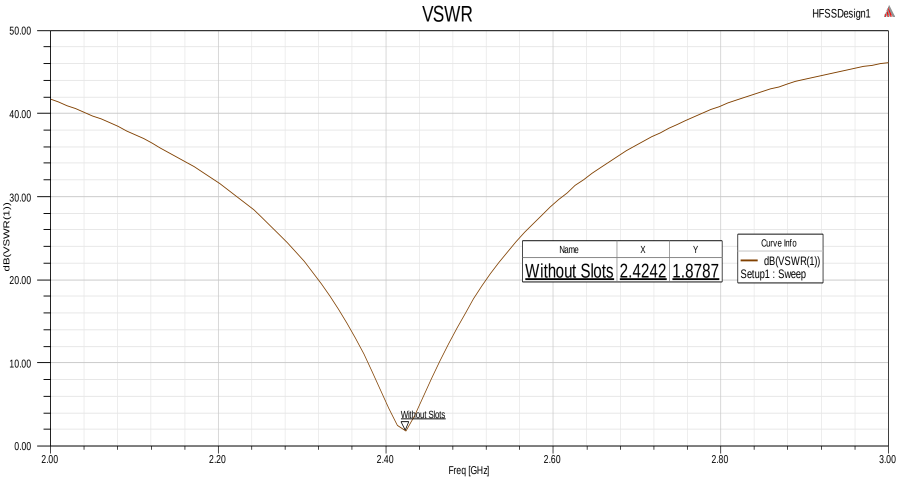

Fig 3. Antenna without slots: VSWR versus frequency

The return loss versus frequency is depicted in Figure 2. The antenna has a return loss of -19.35 dB at 2.42 GHz, based on a -10 dB return loss. The antenna's VSWR versus frequency is 1.87 at 2.42 GHz, as shown in Fig 3.

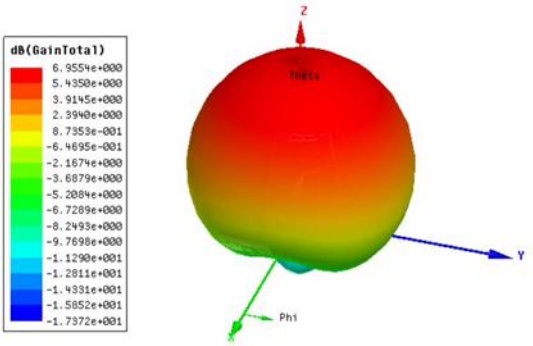

Fig 4. 3D radiation pattern of gain of the Antenna

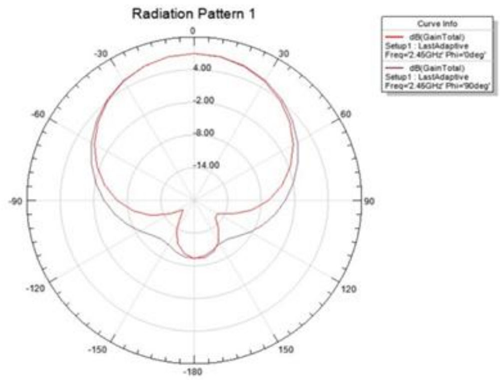

Fig 5. Antenna gain pattern at 2.45 GHz

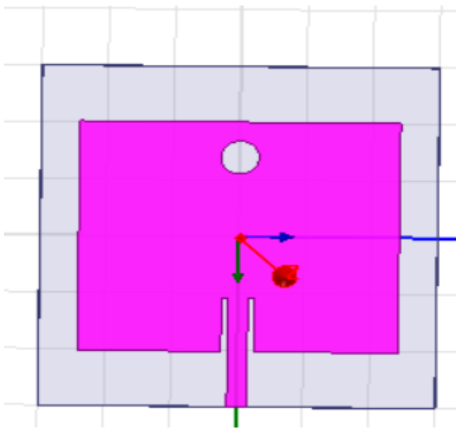

Fig 6. single slot microstrip antenna

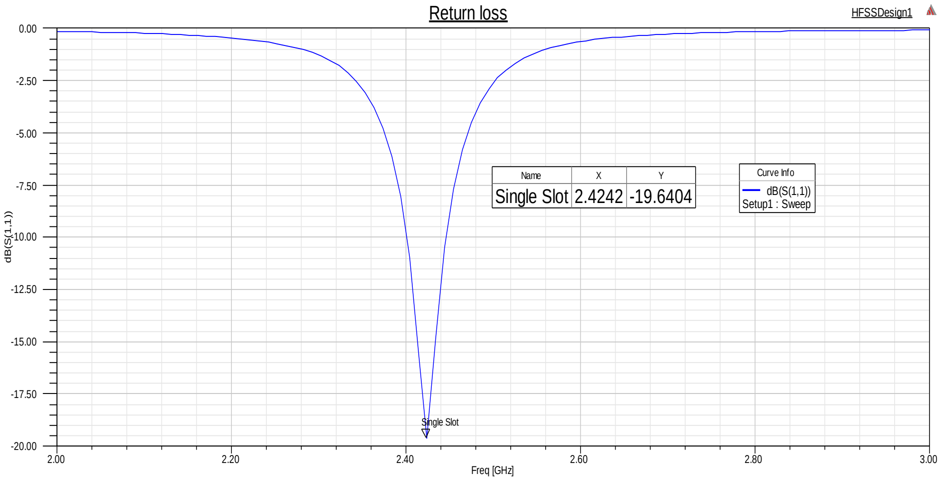

Fig 7. Antenna with one slot return loss versus frequency

A single circle with a radius of 3 mm was slotted into the antenna. Variation of the return loss versus the frequency of the single slot antenna is shown in Fig 7. At 2.42GHz, a return loss of -19.64 dB can be observed. The variance of VSWR with frequency is shown in Fig 8. The VSWR at 2.42 GHz is 1.81, as seen in the diagram.

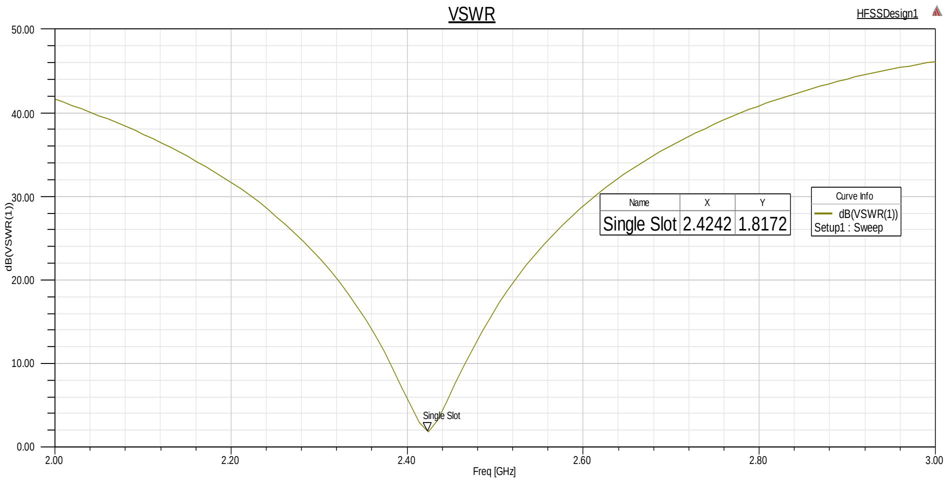

Fig 8. Antenna with one slot: VSWR versus frequency

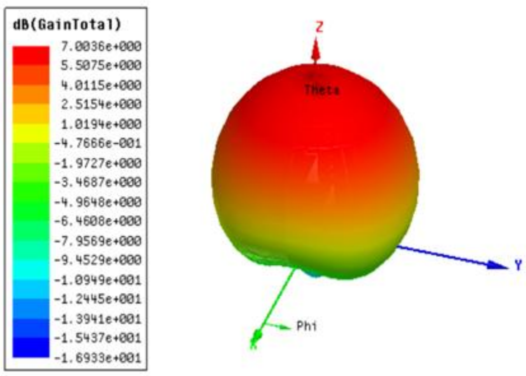

Fig 9. 3D radiation pattern of gain of single slot Antenna at 2.45 GHz.

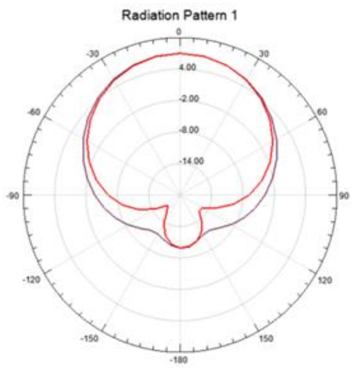

Fig 10. Antenna gain pattern of on slot at 2.45GHz

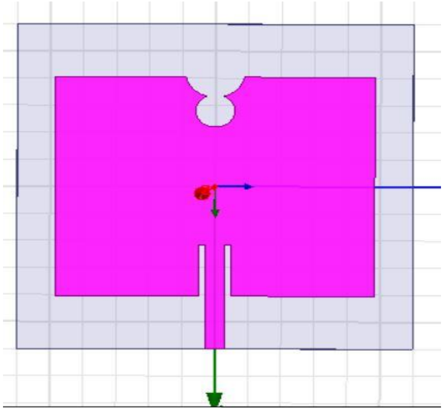

Fig 11. Microstrip antenna with two slots

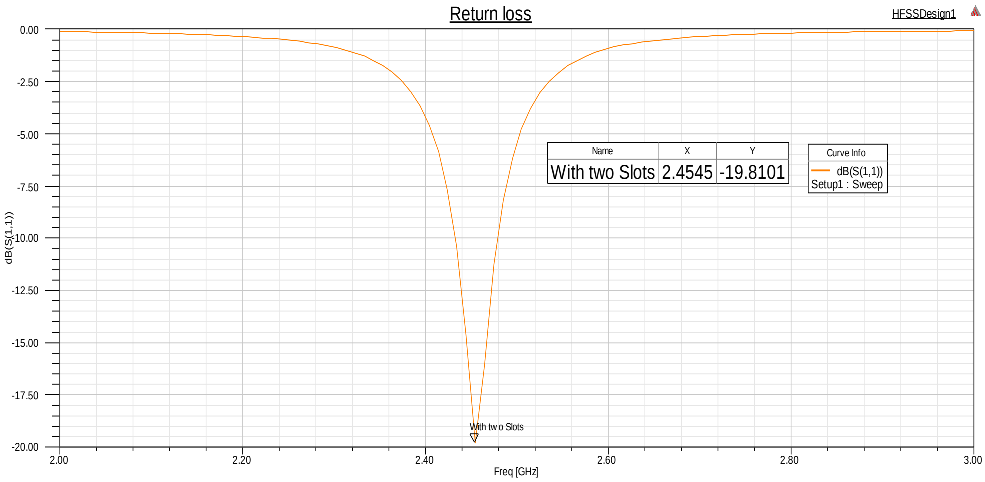

Fig 12. Antenna with two slots return loss versus frequency

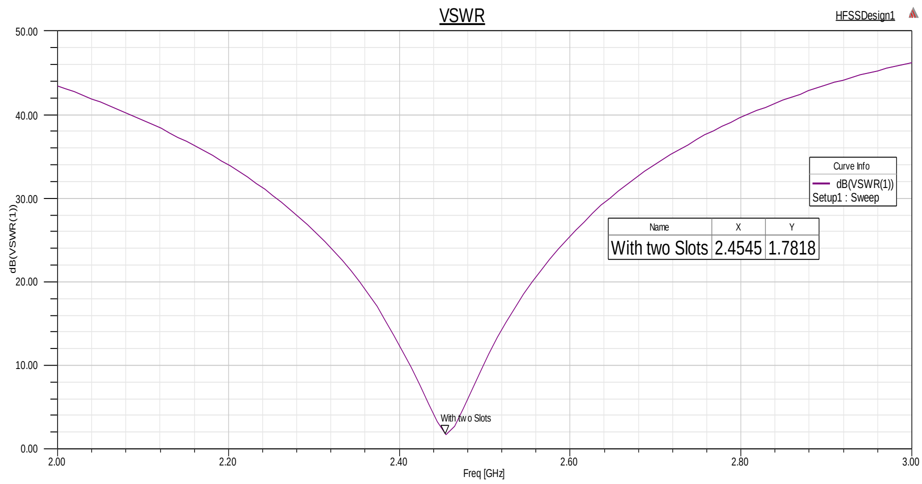

Fig 13. Antenna with two slots: VSWR versus frequency

The antenna was slotted with two rings, circle1 with a radius of 4.5 mm and circle2 with a radius of 3 mm. The slotted antenna's return loss as a function of frequency is shown in Figure 12. The return loss at the resonant frequency is -19.81 db. Figure 13 shows the variation of VSWR with frequency. As shown in the diagram, the VSWR is 1.78 at 2.45 GHz. Slotted antennas and traditional rectangular antennas are compared in terms of parameters and is presented in table 2. It is evident from the table that a slotted antenna outperforms a rectangular antenna.

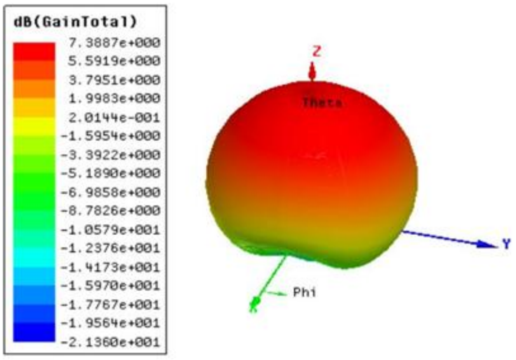

Fig 14. 3D Radiation pattern of gain of Antenna with two slots at 2.45 GHz.

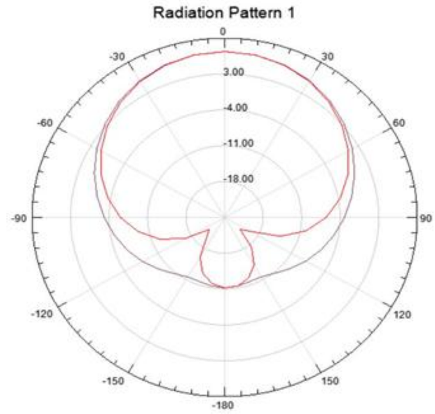

Fig 15. Antenna gain pattern of two slots at 2.45 GHz

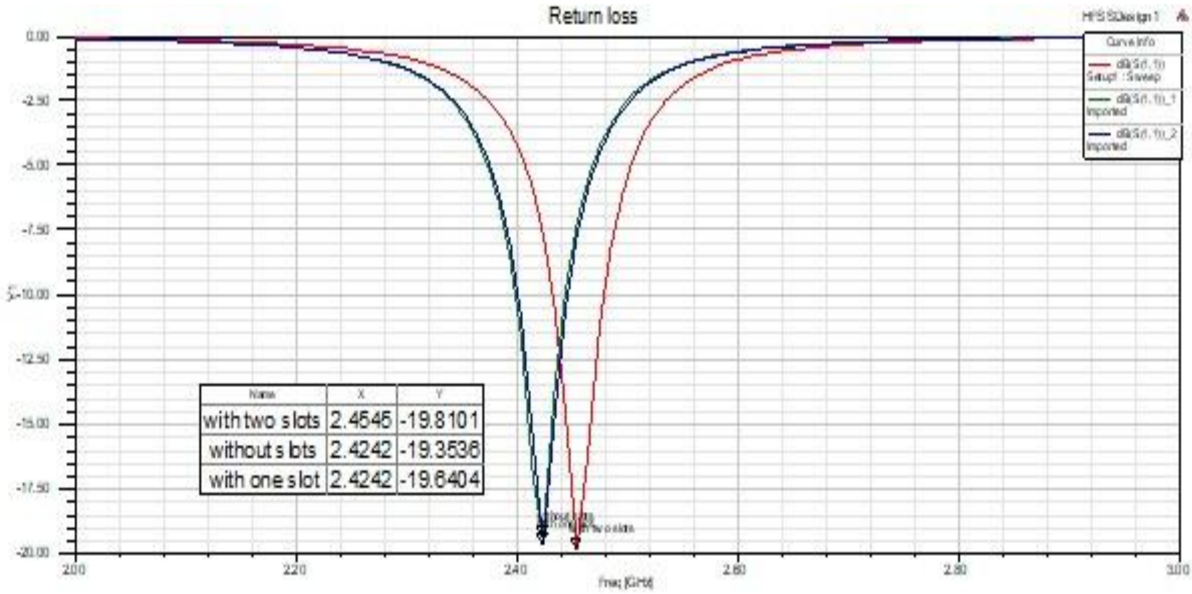

Fig 16. Comparison of Return loss considering all three Antennas

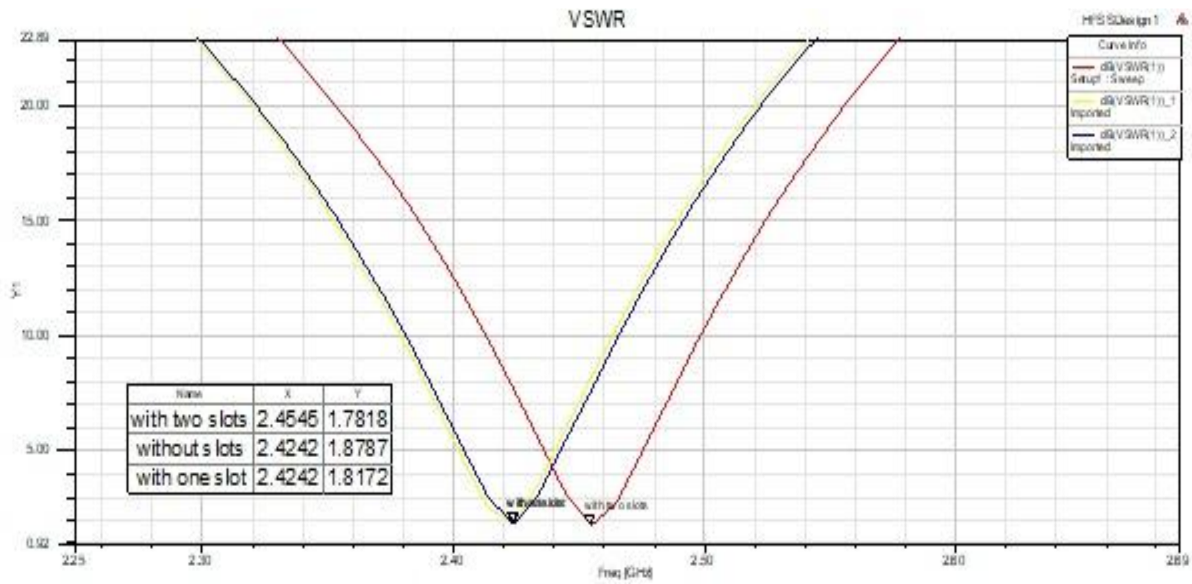

Fig 17. Comparison of VSWR considering all three Antennas

Table 2. Antenna parameters at 2.45 GHz

Parameters	Antenna without slots	Antenna with Single Slot	Antenna with Two Slots
Radiation Efficiency (%)	97.17	97.72	98.35
Return Loss (dB)	-19.35	-19.64	-19.81
VSWR (dB)	1.87	1.81	1.78
Peak Gain (dB)	6.95	7	7.38
Peak Directivity (dB)	7.08	7.1	7.46

IV. Conclusion

In this paper, by adding slots in the patch antenna, a closely-packed microstrip antenna with slots operating at 2.45 GHz for Biomedical applications is developed. According to the simulation results, the suggested slotted antenna is portable and has a simple design., and it operates at 2.45 GHz, which covers the (2.4 to 2.5 GHz) band, with a radiation efficiency of 98.35, a VSWR of less than 2, and a return loss of more than -10dB. In comparison to a traditional microstrip antenna, the slotted antenna has better radiation characteristics. Its radiation efficiency is increased by 1.18% and parameters like radiation efficiency, return loss, VSWR, peak gain, peak directivity are also improved. Therefore, the proposed slotted antenna has a strong presence in the desired band (2.4–2.5 GHz) and can be used effectively for Biomedical Applications.

References

[1] Balanis, C.A, Antenna Theory: Analysis and Design. 2nd Edn., John Wiley and Sons, New York 1997.
[2] John D Kraus, ―Antennas and Wave Propagation, Tata McGraw Hill Education Pvt.Ltd, New Delhi.
[3] S. W. Lu, T. F. (1999). CPW-fed slot-loop coupled patch antenna on narrow substrate. Electronics Letters, 682-683.
[4] Yen, P. H.-F. (2001). Analysis of a cpw-fed slot ring antenna. Proc. APMC2001 International Conference, 1267-1270.
[5] H. Tehrani, K. C. (2002). Multi frequency operation of microstrip-fed slot-ring antennas on thin low-dielectric permittivity substrates. IEEE Transactions on Antennas and Propagation, 1299-1308.
[6] J.S. Chen, H. C. (2003). Dual-band characteristics of annular-ring slot antenna with circular back-patch. Electronics Letters, 487-488.
[7] Jaehoon Kim, R.-S. Y. (2004). Implanted Antennas Inside a Human Body: Simulations, Designs, and Characterizations. IEEE Transactions on Microwave Theory and Techniques, 1934-1943.
[8] Chen., J.-S. (2005). Studies of CPW-fed equilateral triangular-ring slot antennas and triangular-ring slot coupled patch antennas. IEEE Transactions on Antennas and Propagation, 2208-2211.
[9] Yuce., M. R. (2010). Implementation of wireless body area networks for healthcare systems. Sensors and Actuators A: Physical, 116-129.
[10] J. Gemio, J. P. (2010). Human body effects on implantable antennas for ism bands applications: models comparison and propagation losses study. Progress In Electromagnetics Research, 437-452.
[11] Samal., S. (2012). A Microstrip Patch antenna for biomedical applications at 2.45 GHz. 5th International Conference on Computers and Devices for Communication (CODEC).
[12] Al-Shaheen., A. (2012). New patch antenna for ISM band at 2.45 GHz. ARPN Journal of Engineering and Applied Sciences.

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