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IMPACT OF SRR ON DEFECTED METALLIC ANTENNA FOR BIOMEDICAL AND WIRELESS APPLICATIONS

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Abstract

Last three decades onwards health care industries are continuously rising and advancing technologies towards implementing more suitable efficient systems for biomedical applications. In this work, a flexible and compact, low-profile defected metallic patch antenna (DMA) is proposed for biomedical and advanced wireless communication applications. This multiband antenna operates at 2.83GHz, 3.73GHz, 4.39GHz, 4.81GHz, 6.25GHz, 8.05GHz, 9.73GHz, 10.84GHz, 11.80GHz and 14.44GHz. The proposed antenna printed on Flame Retardant epoxy glass material with thickness of 1.6mm with a size of $1.45\lambda_g x \;\; 1.45\lambda_g \text{mm}^2$. The simulated electrical and far field characteristics, surface magnitude current distribution are presented in it.

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1. Introduction

The demand for the microstrip patch antenna is increased in the wireless applications. The core areas like satellite and military applications which are operated in multiband range are extensively used the microstrip patch antenna [1- 4]. In modern communication system the low -profile antennas are easily fabricated and integrated. There are some limitations in microstrip patch antenna as bandwidth gain and efficiency. The defected ground structure has introduced in ground plane to improve the performance of antenna. Here by etching a part of the ground in appropriate shape the DGS can be implemented [5-6]. Not only in the wireless applications like Bluetooth / WiFi / WLAN etc., Microstrip antennas at microwave frequencies plays an important crucial role in bio medical engineering. Bio medical devices placed on external to human body. Patch designs are preferred for implantable antenna design, because of their flexibility in conformability and shape. Communication is generally performed in the Medical Implant Communications Service (MICS) band (402-405MHz) and Industrial, Medical and Scientific (ISM) band (2.4-2.48GHz) [7]. Numerical and experimental investigations of implantable antennas have proven to be highly intriguing, and have attracted significant scientific interest. It will not affect to humans but the major requirement in medical cases is miniaturized size and less multipath loss. Here planning how transmitting information from inside of body to external world requires multidisciplinary approach. Here it focused on antennas to be integrated in implantable devices with far field data telemetry capabilities. It allows a clear identification of the main challenges related to implantable antennas [8].

In this paper, microstrip patch antenna designed for Biomedical and advanced wireless applications. Initially star model slot etched on patch element for obtaining the multiple resonances with pyramidal ground structure [9]. For improving the performance of an antenna, more number of self – similar slots removed and additionally single ring resonator (SRR) added in ground plane. Detail discussions about the antenna geometry, design, parameters, electrical 2D characteristics, 3D far field reports, surface current distribution are in followed sections. This work finally concluded with conclusion in last section.

II. Antenna Modeling

II.1 Design Equations:

$$\text{Width of the Patch (1) } (W) = \frac{c}{2f_r \times \sqrt{\epsilon_{eff} + 1/2}} \tag{1}$$

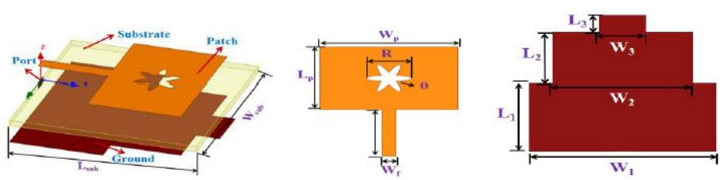
$$\text{Effective dielectric constant } (\varepsilon_r) \ \epsilon_{eff} = \frac{\epsilon_{r+1}}{2}(1 + 0.3 \times h) \tag{2}$$

$$\text{Strip Length } (L_s) \ L_s = \frac{0.42 \times c}{f_r \times \sqrt{\epsilon_{eff}}} \tag{3}$$

$$\text{Ground plane's width } (W_g) \ W_s = \frac{1.38 * c}{f_r * \sqrt{\epsilon_{eff}}} \tag{4}$$

$$\text{Ground plane's length } (L_g) L_g = \frac{0.36 \times c}{f_r \times \sqrt{\epsilon_{eff}}} \tag{5}$$

The designed antenna consists of rectangular microstrip patch antenna with star shaped slot inscribed in it, which is placed on the top of dielectric material FR-4 epoxy with dielectric constant 4.4 and its loss tangent 0.02. Its thickness (h) is 1.6mm. The angle (θ) between two leaves of star model is 60o. For improving the gain and radiation efficiency of designed antenna pyramidal shaped ground is introduced in it. Figure 1 shows the defected metallic patch antenna model. All the design parameters mentioned on the design are represented in table 1.



(a) 3D view of proposed antenna. (b) DMA. (c) SRR inscribed ground.

Figure 1. Defected metallic patch antenna with pyramidal ground structure.

Table 1. Design parameters of antenna (All are in mm)

Lsub	Wsub	Lp	Wp	Lf	Wf	R	Θ
40	40	20	30	15	3	5	60*o*
L1	W1	L2	W2	L3	W3		
20	40	15	30	5	10		

The simulated return loss characteristics of designed antenna are shown in Figure 2. This antenna resonates at seven multiple resonances. The term return loss is nothing but the ratio of reflected power to the delivered power. Return loss of this antenna is -13.83dB at 4.72GHz, - 18.36dB at 5.59GHz, - 17.41dB at 6.70GHz, - 28.48dB at 8.53GHz - 38.62dB at 46GHz, - 12.99dB at 10.93GHz and -13.80dB at 11.80GHz respectively. The corresponding impedance bandwidths are 130MHz, 150MHz, 290MHz, 560MHz, 360MHz, 350MHz and 330MHz respectively. In this work, return loss values are very less at five resonances. There might be chances to get impedance mismatch losses. To overcome this limitation, another approach introduced in this paper

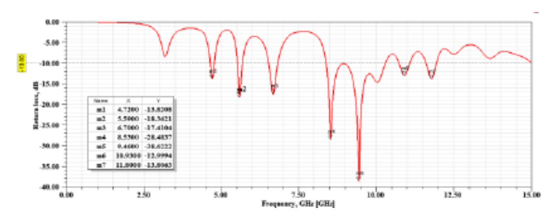
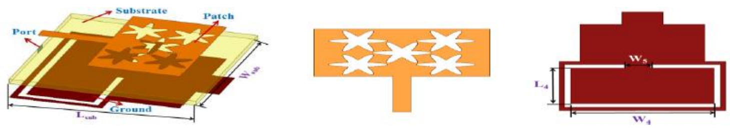


Figure 2. Return loss characteristics of defected metallic patch antenna.

III. Proposed DMA with Single Ring Resonator (SRR) Intended Ground

Figure 3 shows the proposed DMA using SRR inscribed defected ground structure, which is suitable for advanced wireless communication applications. Self-similar star slots are etched on metallic patch as shown in Figure 3(b). The single ring resonator (SRR) is intended here for enhancing the gain and efficiency. Modified ground structure is shown in Figure 3(c). The width of ring is 1.5mm. The inner dimensions of SRR are $L_4 = 14.5\text{mm}$ and $W_4 = 34.5\text{mm}.$ The space between the edges of rings is $W_5 = 6\text{mm}.$



(a) 3D view of proposed antenna (b) DMA (c) SRR inscribed ground

Figure 3. Proposed DMA with SRR affected ground

IV. Simulation Electrical Characteristics

Figure 4 shows the return loss characteristics of proposed antenna. This proposed antenna resonates at ten multiple resonant frequencies. This proposed antenna covers a bandwidth of 410MHz over 2.71–3.12GHz, 60MHz over 3.71–3.77GHz, 130MHz over 4.32–4.45GHz, 110MHz over 4.76–4.87GHz, 230MHz over 6.15–6.38GHz, 320MHz over 7.88–8.20GHz, 420MHz over 9.51–9.93GHz, 580MHz over 10.48–11.06GHz, 290MHz over 11.59–12.28GHz and 650MHz over 14.17–14.82GHz respectively. The corresponding resonant frequency and return loss of this proposed antenna are 2.83GHz and -18.68dB, 3.73GHz and -12.78dB, 4.39GHz and -16.65dB, 4.81GHz and -22.62dB, 6.25GHz and -19.34dB, 8.05GHz and -31.83dB, 9.73GHz and -18.37dB, 10.84GHz and -25.72dB, 11.80GHz and -15.72dB and 14.44GHz and -20.24dB. Figure 5 shows the VSWR characteristics of proposed antenna.

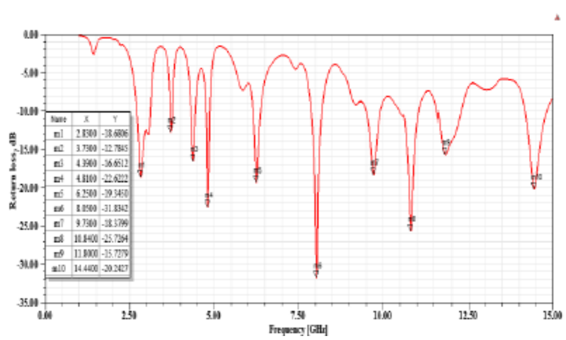


Figure 4. Return loss characteristics of proposed antenna.

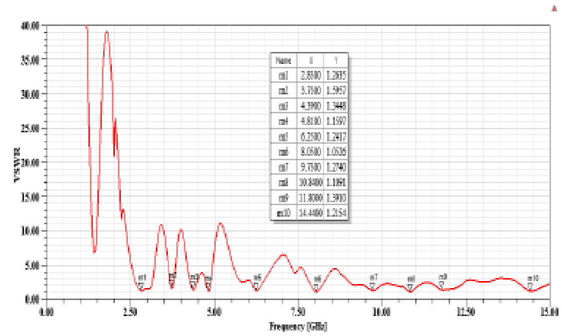


Figure 5. VSWR characteristics of proposed antenna.

V. Far Field Characteristics of Proposed Antenna

The gains of proposed antenna at multiple frequencies are 2.89dB, 5.38dB, 2.85dB, 0.86dB, 3.08dB, 2.77dB, 5.73dB, 4.79dB, 3.70dB and 2.74dB. The gain radiation characteristics of proposed antenna at multiple frequencies are shown in Figure 6. The Co polarization and Cross polarization of proposed antenna in both E-plane and H-plane are represented in Figure 6.

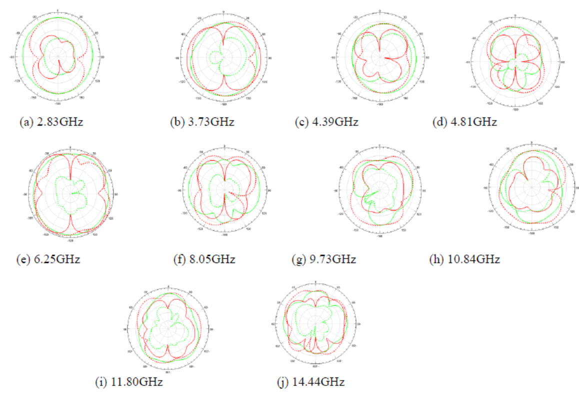


Figure 6. Co-Polarization and Cross-polarization radiation characteristics of proposed antenna (Red line-Cross pol. in E-plane, Red dotted line-Co pol. in E-plane, Green line-Co pol. in H-plane, Green dotted line-Cross pol. in H-plane).

VI. Current Distribution of Proposed Antenna

Figure 7 shows the magnitude surface current distribution of proposed antenna at four resonant frequencies. Current flowing in metallic patch varies depends on the resonant frequencies.

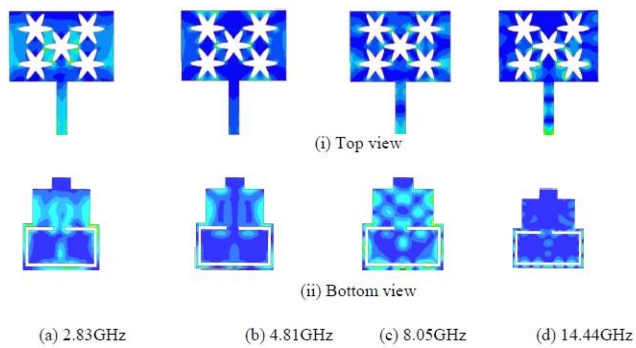


Figure 7. Magnitude surface current distribution of proposed antenna at multiple frequencies.

Table 2. Comparison of results with other implanted Antennas.

Reference	Dimensions (mm)	Gain (dB)	10dB Bandwidth
[1]	15 x 24	- 16	12
[2]	13 x 16	- 25	100
[3]	15 X 8	- 8	120
[4]	13 X 4	- 12	140
[5]	1.45λX1.45λ	- 20	180

VII. Conclusion

A defected metallic microstrip patch antenna with SRR intended pyramidal ground structure is proposed using Ansys HFSS simulation tool. This antenna resonates at ten multiple frequencies with good impedance matching conditions. This antenna covers multiple frequencies within range of 2.5 - 15GHz, which is suitable for S-band, C-band, X-band and Ku-band applications. Due to its high gain and low radiation efficiency properties, this antenna can easily place on human body. At low frequencies this antenna can be used in health monitoring systems like glucose monitoring, digestive morning and weight monitoring devices. At high frequencies this antenna can be opted for wireless network applications.

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