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Right Angle Triangular Microstrip Antenna for Biomedical Application

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Abstract

This paper presents right angle triangular microstrip antenna for biomedical application. The right angle triangular (RAT) microstrip antenna (MSA) has been fed using microstrip line with partial ground. The corners of RAT and partial ground have been rounded to realize wideband response. The proposed antenna is designed and simulated using economical FR4 substrate having dimension of 60 × 50 mm^2 and offers wide impedance bandwidth (VSWR < 2) of 5.61 GHz from 2 GHz to 7.61 GHz. The parametric analysis has been presented to understand the behaviour of wideband response. The proposed antenna can be suitable for wideband biomedical applications such as tumour detection.

Keyword : Right angle triangle; wideband; VSWR

1. Introduction

Increasing demand of handheld biomedical systems has gain popularity. These systems are used to detect the malicious element present inside human body. The system used for tumour detection are seems to be very large and the process is very painful for survivor. Therefore there is need of handheld biomedical systems which can detect the tumour inside human body using non contacting method. This device comprises antennas which radiates the electromagnetic signals on selective area of human body. If the malicious tumour is present inside the body, the reflected electromagnetic signal can be received by the antenna. As the frequency of reflected signal is other than transmitted signal frequency, the antenna used in such biomedical devices need to be wideband. From literature study, it has been studied that the microstrip antennas are suitable element for biomedical applications. However, one of the important limitations of microstrip antenna is narrow bandwidth. The microstrip antennas used for biomedical application need to be compact in size and offer wide impedance bandwidth. Therefore, it is a great challenge for antenna designer to design compact and wideband microstrip antennas for biomedical applications. Various antenna designs from different research groups have been reported.

Flexible antennas for biomedical telemetry application having rectangular slots with modified ground have been reported by A. Smida et al., 2020. The antenna has been fabricated using RT duroid semi-flexible material with compact size of 17 × 15 × 0.787 mm^3. The reported antenna offers 1.38 GHz impedance bandwidth. Two rectangular loop based capsule shaped antenna for wireless endoscopy application has been presented by J. Shang et al., 2019. The antenna uses parasitic coupling with rectangular loop offering wide impedance bandwidth from 1.11 to 6.03 GHz. The conformal antenna structure having maximum size of 10 × 15 mm^2 developed using substrate having dielectric constant of 2.2. The reported antenna has been fabricated and measured impedance bandwidth of 4.9 GHz has been reported.

CPW fed conformal antenna for in ISM band for biomedical application has been presented by K. N. Ketavath et al., 2019. The antenna consists of rectangular and circular ring slots on radiator and ground. The reported antenna has been fabricated using conformal substrate having dielectric constant of 3.5 with dimensions of 24 × 22 × 0.07 mm^3. Two triangular and few parallel rectangular slots cut CPW fed wearable microstrip antenna has been reported by X. Lin et al., 2020. The reported antenna offers wide impedance bandwidth from 1.19 to 4.05 GHz. The overall reported size of antenna is 90 × 40 mm^2. The antenna has been fabricated using thin substrate having thickness of 0.5 mm. N. Ganeshwaran et al., 2020 presented dual band antenna for implantable biomedical application. The presented antenna resonating at 400 MHz and 2.4 GHz dual band ISM application, offering 38.1 % and 17.6 % of bandwidth respectively. The presented antenna has been fabricated using higher dielectric substrate with relative permittivity of 10.2. A. S. M. Alqadami et al., 2020 reported flexible on-body compact, unidirectional, and wideband antenna for electromagnetic biomedical diagnostic systems. The reported antenna has been designed and fabricated on a flexible, low-loss temperature-vulcanizing silicone (RTV) substrate with a size of $0.055\lambda_0 \times 0.055\lambda_0 \times 0.009\lambda_0$. The fabricated antenna exhibits a measured bandwidth from 0.55 GHz to 3 GHz. D. D. Ahire et al., 2018 reported corner rounded wideband microstrip antenna for biomedical applications. The reported antenna exhibits wide impedance bandwidth of 9.51 GHz.

In this research work, right angle triangular microstrip antenna has been fed using microstrip line. The antenna design uses partial ground plane. The designed geometry of right angle triangular antenna has been simulated using CAD Feko antenna simulator.

2. Antenna Design

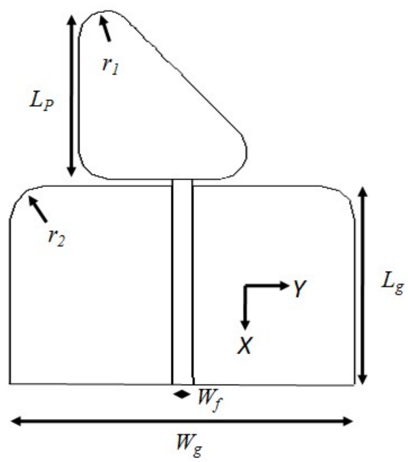


Figure 1. Design Geometry of RAT MSA

Figure 1 depicts design geometry of right angle triangular (RAT) shaped microstrip antenna (MSA). The side length L_P of RAT is calculated using equation (1) (Olaimat and Dib).

$$f_{(m,n)} = \frac{c}{2L_P\sqrt{\varepsilon_r}}\sqrt{m^2+n^2} \tag{1}$$

In equation (1), $c = 3 \times 10^8$ m/s, ε_r is dielectric constant of substrate considered and m, n are the operating modes of respective patch. The RAT shaped patch is designed to operate at 2.45 GHz resonant frequency having fundamental TM_{10} mode. The dielectric substrate considered to design this antenna is economical FR4 substrate having relative permittivity of 4.3 and thickness of 1.6 mm. The estimated value of length of RAT patch is L_P = 30 mm. The antenna has been feed using microstrip line having length of 30 mm and width of 3 mm. The width of microstrip line W_f is considered equal to 3 mm so that maximum matching of 50 Ω impedance can be achieved. The partial ground having dimension of L_g = 29 mm and W_g = 50 mm is considered for obtaining better impedance bandwidth. This antenna structure has been simulated using CAD Feko antenna simulator and its VSWR response has been noted. Further, to improve the bandwidth of proposed antenna, the corners of RAT and ground plane have been rounded. The values of r_1 and r_2 have been taken as 4 mm and 5 mm respectively. The detailed simulation results have been studied and presented in following section.

3. Results & Discussion

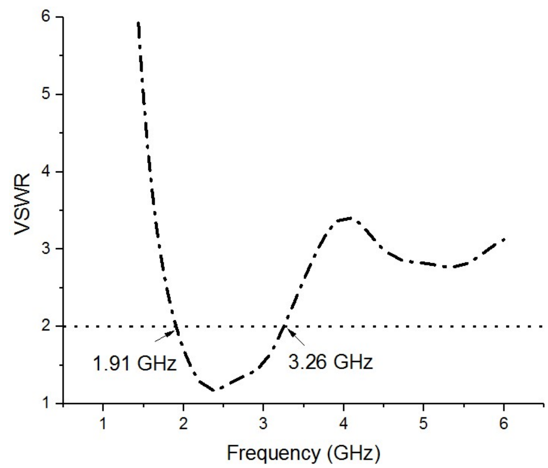


Figure 2. VSWR plot of RAT antenna without rounded corners

Figure 2 presents VSWR plot for RAT MSA without rounded corners. The observed impedance bandwidth (VSWR < 2) for this antenna structure is from 1.91 – 3.26 GHz i.e. 1.35 GHz. The antenna has been resonating at its fundamental TM10 mode having center frequency of 2.45 GHz. Further, to enhance the impedance bandwidth the three corners of RAT patch and top two corners of partial ground plane has been rounded with values of r_1 and r_2 respectively. The observed simulated impedance bandwidth for rounded corner RAT MSA is from 2 GHz to 7.61 GHz. This obtained impedance bandwidth is of about 5.61 GHz which is wider as compared to initial design. The VSWR plot of corner rounded RAT MSA is depicted in Figure 3.

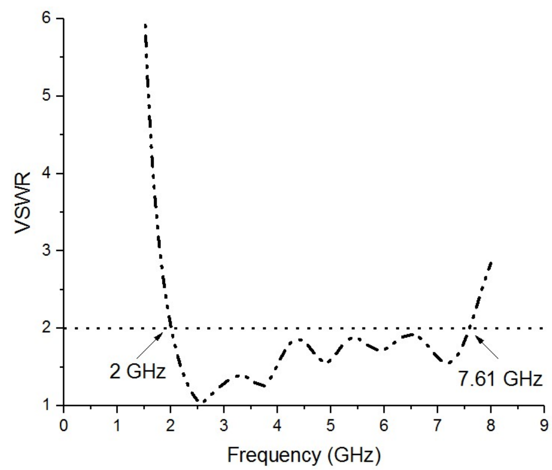
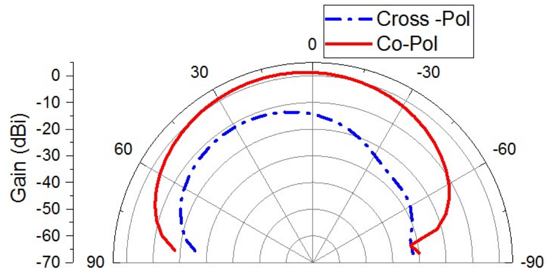
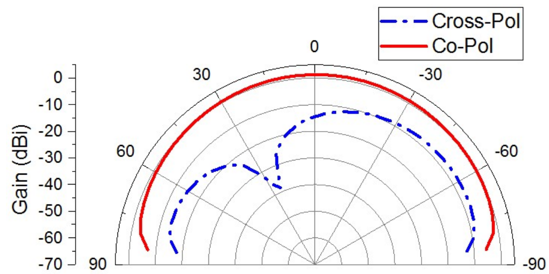


Figure 3. VSWR plot of RAT antenna with rounded corners

The radiation pattern of proposed antenna has been studied and presented in Fig. 4 (a –b). The antenna exhibits the broadside radiation pattern in both E- and H- planes having peak gain of 1.66 dBi. The cross polarization level in both planes is well below -15 dB.

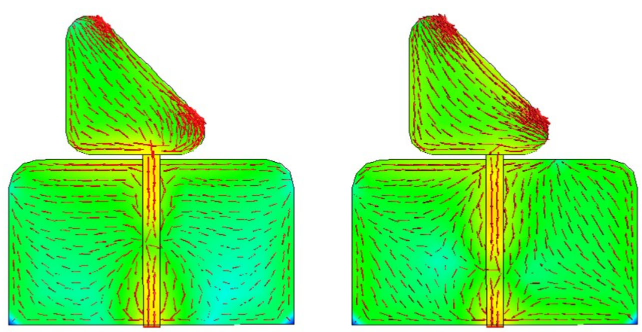


(a)



(b)

Figure 4. Radiation pattern at 2.58 GHz (a) E –Plane (b) H- Plane



(a) (b)

Figure 5. Surface current distribution (a) 2.58 GHz (b) 3.75 GHz

Figure 5 depicts surface current distribution of RAT MSA at 2.58 GHz and 3.75 GHz. It can be observed from Fig. 5 that, maximum current density has been oriented near the rounded part inside RAT patch. Also at fundamental mode the current at the partial ground plane has been out-warding in opposite direction. This clearly describes the low values of cross polar radiations of proposed right angle triangular microstrip antenna. At higher resonating frequencies the observed maximum current density inside the radiating patch is around the corner. Therefore, the rounded corners are eligible for the enhancement of impedance bandwidth.

4. Conclusion

This paper presents design and simulation of corner rounded right angle triangular microstrip antenna for biomedical applications. The proposed antenna design exhibits wide impedance bandwidth of 5.61 GHz having fractional bandwidth of 116%. The designed antenna is radiating in broadside direction with peak gain of 1.66 dBi. As the proposed antenna offering wide bandwidth the antenna can be a suitable element for biomedical applications.

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