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Research Article

Design of Miniaturized Printed Antenna for Medical Applications

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Abstract

This paper introduces the design, simulation, implementation of miniaturized printed minder line monopole antenna (PMLMA) in medical application. The proposed antenna operates in Industrial, Scientific, and Medical ISM band. Antenna has a compact size of (12.25× 7.81 × 0.8) mm³ with -10 return loss printed on FR4 substrate material with (4.3) dielectric constant and h (0.8) thickness . The proposed antenna is simulated and evaluated using CST microwave studio package. The propose antenna simulation result obtain that antenna operate on 915MHz frequency with less than -10dB return loss (-11.237)dB , gain is -18.23dB, band width 20.546MHz and total efficiency -20.64dB. Results of simulation and implementation show that the proposed antenna possesses an acceptable performances and miniaturized dimensions, enabling their use in medical applications.

Keywords: *ISM band, Medical Application, Compact Size, Meandered Antenna, 915MHz*

1. Introduction

The interest of compact antennas in wireless communication increase to the portability and mobility of the communication devices, The antenna that operate at low frequency include large physical size. performance of the antenna is decrease as the size of antenna decrease. Since medical application deals with low frequency, it will lead to large size of antenna which brings a challenge for the designer to reduce the size of these antennas. There are many techniques used for miniaturized antenna size such as minder line shape (Karacolak ,*et al*,2008& Liu,*et al*,2008), ceramic substrate (Chien,*et al*,2010), different type slot (Zengin ,*et al*,2011& Kiourti,*et al*,2012), split-ring elements (Fernandez,*et al*,2010), and shorting pin between ground and patch. In medical application (wearable and implantable) antenna must have compact size such as antenna used in healthcare application(Smida,*et al*,2020) For example, neural recording(Sharma,*et al*, 2017), endoscopy (Suzan Miah,*et al*,2019), glucose monitoring (Liu,*et al*,2019), and intracranial pressure monitoring (Shah and Yoo,2018), (Khan ,*et al*, 2018).

In (Zhang,*et al*,2017), design circular polarization for biomedical application, the CP operating on ISM band at (915 MHz) with size are (15 × 15 × 1.27 mm³) and high gain -27dB. In (Changrong Liu ,*et al*,2018) a circularly polarization implanted antenna operate in (915MHz)it printed on Rogers 3010 substrate which size of its 153.67 mm³, gain -29 dB and band width (35MHz).

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In(Chang Won,2016).design antenna operate in MedRadio band (401-406 MHz) printed on Flame retardant (FR4) material ,It has the smaller volume of 193.2mm³,band with bandwidth of 10 MHz and gain -20 dBi.In(Li-Jie Xu,*et al*,2017) design miniaturized antenna operating at MedRadio band for medical devices ,it size are170.7 mm³ covers the band from 334 to 441 MHz (107 MHz) .The gain of antenna is -30 dB.

2. Methodology

2.1 antenna design

Fig.1 shows back, front view of proposed antenna. This antenna is configured and simulated by doing various changes in design. Rectangular slots are added into ground plane and minder slot to radiating patch to increasing electrical length for antenna as a result achieving lower frequency band.

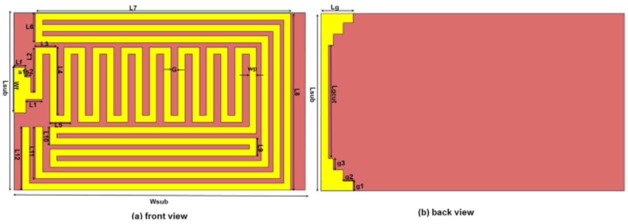

Fig.1 Antenna geometry (Unit: mm). (a) Front view. (b) Back view

This antenna has the rectangular shape smallest size which is 12.25 × 7.81 × 0.8 mm³printed on FR4 substrate ($\varepsilon r = 4.3$) having h (0.8mm) thickness operating on ISM band (915MHz) . A coaxial cable feed by that is normalized to 50 Ω. To get specific resonance frequency, various techniques are used in designing of an antenna. Dimension of proposed antenna illustrate in table 1.

Table 1: dimension of propose antenna

Dimension	Value(mm)	Dimension	Value(mm)
Lsub	7.81	L8	7.8
Wsub	12.25	L9	0.8
Lf	0.5	L10	0.8
Wf	2	L11	2.3
S1	0.42	L12	2.8
S2	0.2	G	0.3
L1	0.7	Wp	0.3
L2	2	g1	0.41
L3	0.9	g2	0.4
L4	3	g3	0.5
L5	0.9	Lgcut	5
L6	1.3	Lg	1.3
L7	10.75	h	0.8

2.2 Modification and simulation result

Fig.2 demonstrates the various procedural steps to achieved miniaturized antenna.

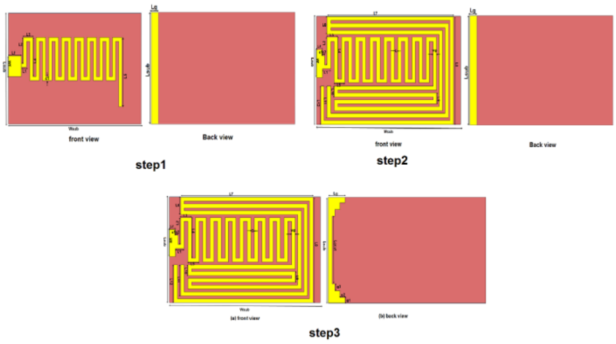

Fig. 2 Designing steps of antenna

step1: primary design gives return loss (S11) <- 10 at 2.75 GHz as shown in Fig. (3) .

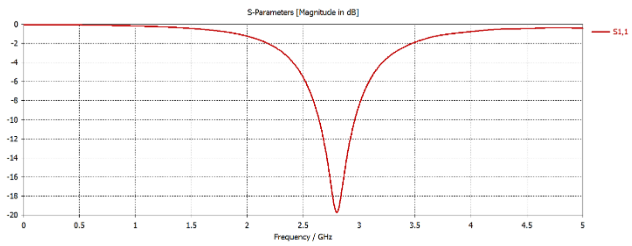

Fig. 3 primary design returns loss PMLMA.

step2: By added extra minder slots to the patch in order shift band to lower resonant frequency give (S11) less than -10dB at 937.11MHz as shown in Fig 4.this result is not the aim of design antenna so we make another modification to achieve the required performance .

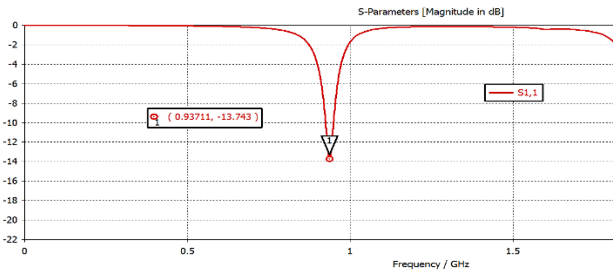

Fig.4 Step2 modification antenna returns loss.

step3: cuts rectangular slots from the ground plane to get required resonance frequency. Final results shows (S11)<- 11.2 at 915 MHz. Reflection coefficient (S11) is calculated in different steps in Fig 5.

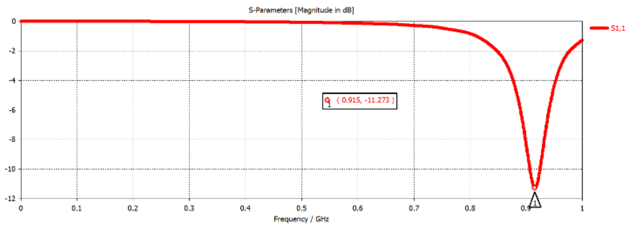

Fig.5 return loss of (step3) propose antenna.

Fig.5 shows the return loss results for the proposed antenna and show that the antenna operate at the required band frequency (915MHz) with return loss less than -10 dB (-11.273dB) antenna has acceptable gain (-18.46dB) , efficiency(-20.53),and bandwidth (20.377MHz) compare with previous design that operate at the same frequency.

Finally, the antenna shows acceptable radiation pattern similar to the Omni-directional radiation for the low frequency as shown in Fig 6 and 7 where these figures display the 2-D pattern of the far field directivity for the proposed antenna.

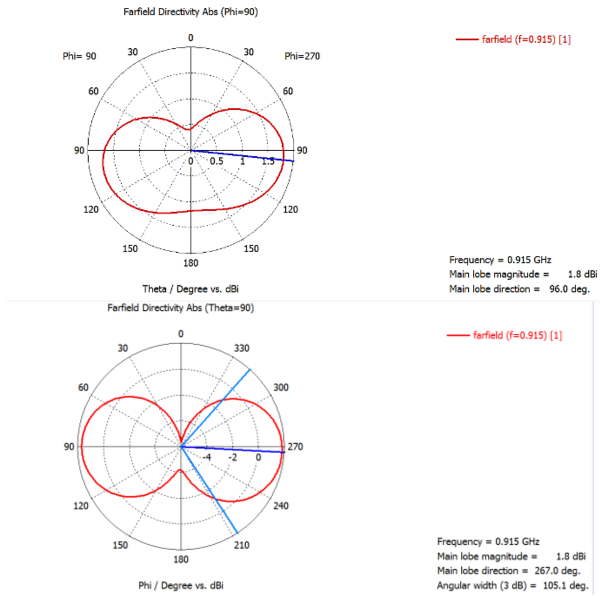

Fig.6 2-D pattern of the far field directivity for the proposed antenna (Phi, Theta = 90).

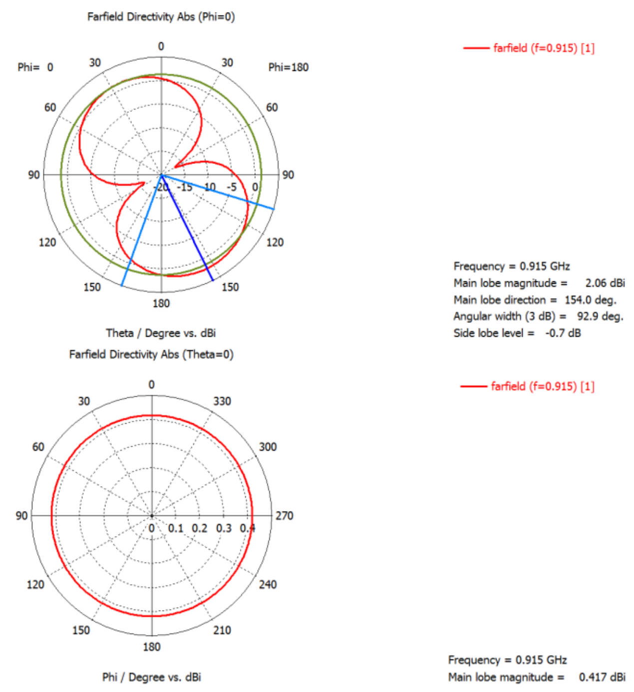

Fig.7 2-D polar pattern of the far field directivity for the proposed antenna (Phi, Theta = 0).

Fig 8 shows 3-D pattern of the far field directivity for the proposed PMLMA and as for the 2-D patterns the antenna has radiation similar to the Omni-directional radiation for the low frequencies. While Fig 9 shows the surface current distribution for fundamental frequency and higher order harmonics.

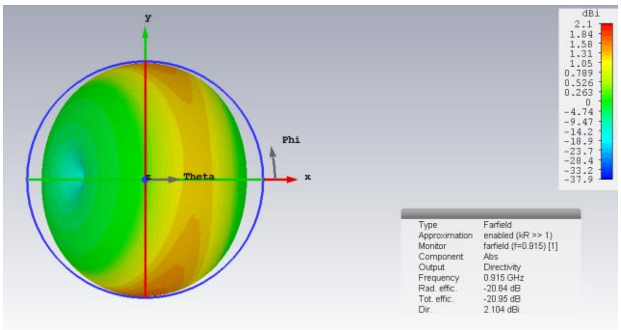

Fig.8 3-D pattern of the far field directivity for the proposed antenna.

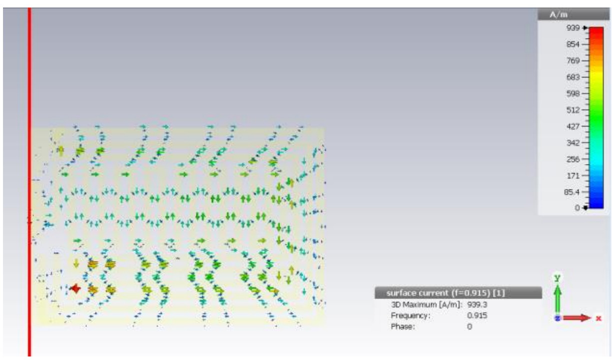

Fig.9 surface currents for the purpose antenna.

3. Measured result

The prototype of the propose antenna are Laboratory manufactured and measured as shown in Fig10. Antenna characterization has also been described in this section with the measurement setup shown in Fig 11, it acceptable result camper with simulation result. its measured by network analyzer and 50 Ω SMA connector probes are used for measurement. An experimental setup is done by linking a coaxial cable probe with the feed line and the ground plane because the antenna size is very small compared to the connector port as well.

(a)front view (b)back view

Fig.10 The fabricated PMLMA.

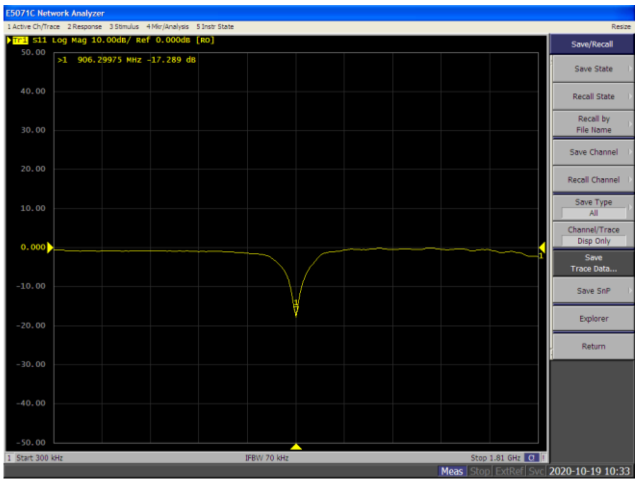

Fig.11measured return loss

Conclusions

In this paper, a miniaturized printed antenna is proposed for medical application. The printed minder line monopole antenna (PMLMA) characteristics can be achieved by a simple modification to the patch antenna and ground plane. It's compact size compare with previous design. Due to the small size of the antenna, it can be applied in human body implantation.as a result propose antenna operate at ISM band (915MHz) loss less than -10dB, gain-18.46dB, efficiency (-20.5dB) and band width (20.377MHz).

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