A Compact Planar Inverted F Antenna for 5G Applications in Biomedical Applications

Debarpita and Nikhil Marriwala

Abstract The aim of this paper is to structure a compact size Planar Inverted F Antenna (PIFA) for 5G applications in biomedical applications. The scale of the antenna is kept as small as possible; here, we have considered 18 × 15 × 2.7 mm and operating frequency of 11.2 GHz. The antenna designed here is probably going to own its applications in wireless communication system. The antenna designed in this project is structured in such a way that it is covering a good wide range of frequency from 10.2 to 12.3 GHz. The radiating patch of the designed antenna is having circular edge on both side of its patch to produce circular polarization. The antenna designed even has partial ground with slot which increases gain, reduces return loss, improves bandwidth, and offers improved VSWR. In this work various parameters like return loss, VSWR, gain, and radiation pattern are also discussed together with comparison of previous work.

Keywords Partial ground · Slot · PIFA · Circular edge · 5G · Return loss · VSWR · Radiation pattern

1 Introduction

The need for portable antenna in modern days are increasing gradually because the size of mobile phone is reducing day by day normal antennas have gotten replaced by PIFA due to its mini size and wide bandwidth [1–5].

The wireless communication is emerging nowadays, and frequencies below 6 GHz have gotten fully occupied due to which the requirement of 5G becomes it improve the speed of working within the hustle lifetime of today's generation. Everyone wants everything to be done at a one tip; thus, 5G comes to save us [6, 7]. 5G works for

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frequency below and above 6 GHz for wireless applications [8]. Many works are still occurring for 5G devices; earlier many antennas are proposed already [9–11]. During this project, I have got tried to structure a compact antenna with improved bandwidth and reduce return loss. **Planar Inverted F Antenna (PIFA) is** basically one of the varieties of microstrip patch antenna. To boost performance of microstrip patch antenna, shorting pins at various locations are employed. It is nowadays widely being employed in mobile phone industry [3]. By doing shorting of pins underneath, advantages are obtained:

- Size is reduced
- Multi-frequency resonance
- Gain improvement
- Desired radiation pattern [3, 5, 11, 12]. During this project, the proposed antenna have a bandwidth of 2.1 GHz and have circular edge with lumped port. And also slot is introduced to boost up gain and reduce return loss as introduction of slot has underneath benefits [13]:
- Obtain broad impedance
- Stability of the radiation patterns
- Improved VSWR [2].

In this paper, partial ground is taken into consideration, which enhanced bandwidth, also improved gain, and helped in reduction of return loss [7].

Also truncated radiating patch is employed to produce circular polarization which provides constant electromagnetic field in all told direction [14].

The PIFA has reduced SAR rate (specific absorption rate) which makes it suitable to be used for biomedical applications as wearable device [5]. This 5G antenna can work as wearable device as it is using dielectric constant material, and it will be beneficial for telehealth where technology meeting healthcare sector for remote sensing as in current scenario people are often restricted to move from one place to another, so this kind of wearable device with 5G speed can help the chronically ill patients and doctors to keep track of those patients without any mobility and with faster speed [15].

The antenna is simulated and designed using the software named HFSS.

2 Antenna Design

The proposed antenna have partial ground plane of dimension 15 × 15 mm. Substrate used here is Rogers Duroid 5889 (Er = 2.2), and resonating frequency is 11.2 GHz. Height of the substrate is kept 0.8 mm. Radiating patch having width is 2.46 mm and length 7 mm with circular edge (truncation). (Circle radius is kept 1.54 mm to provide circular edge.) Feed line for exciting the antenna using lumped port has dimension of 2.7 × 3.5 mm. Shorting pin is kept close to the feed line as 50 ohm impedance is provided and has length and width of 2.7 and 2 mm, respectively. In

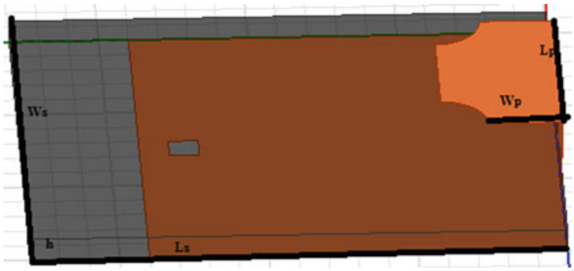

Fig. 1 Side view of antenna in HFSS

Table 1 Designing parameters of desired antenna

Parameter	Value (mm)
Lg	15
Wg	15
Ls	18
Ws	15
Wp	2.46
Lp	7
Lf	2.7
Wf	3.5
Wshort	2
Lshort	2.7
Lslot	1
Wslot	1
H	0.8

this paper, slot is additionally introduced to boost gain and reduce return loss. Slot dimension is (1 × 1) mm (Fig. 1).

Table 1 gives the dimension of the proposed antenna.

Figure 2 shows the feeding technique used for the proposed antenna. In this structure lumped port is used for exciting the antenna.

Figure 3 shows the ground plane structure with slot having dimension 1 × 1 mm, and material used for ground plane is copper which employs infinite conductivity.

3 Simulation Result

The desired antenna is designed using HFSS. The result is simulated keeping operating frequency as 11.2 GHz and certain important parameters like return loss which describes power loss by the antenna, VSWR shows how effectively antenna is working, gain, and radiation pattern as it is used as wearable device having %G characteristics it must be omnidirectional and safe for human body.

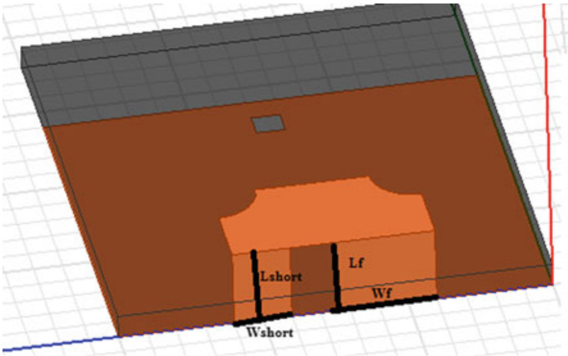

Fig. 2 Structure of feed line in HFSS

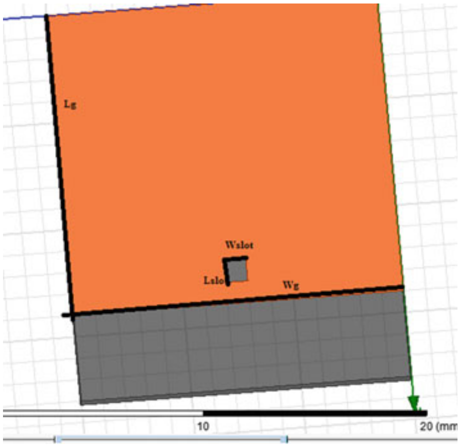

Fig. 3 Ground plane structure

3.1 Return Loss

S11 parameters are checked to observe antenna return loss, as lumped port method is used to excite the antenna, −10 dB is considered as base value for mobile communication. The proposed antenna is showing resonating frequency at 11.2 GHz having return loss of −24.7593 dB (with slot) and −21.7299 dB (without slot) and wider bandwidth of (10.2–12.3 GHz) 2.1 GHz after simulation. The simulation result is shown below in Fig. 4a, b.

3.2 Vswr

We know that for any antenna VSWR must not exceed 3; ideally, it should be 1. In this paper, the proposed antenna shows VSWR (with slot) of 1.0055 and VSWR

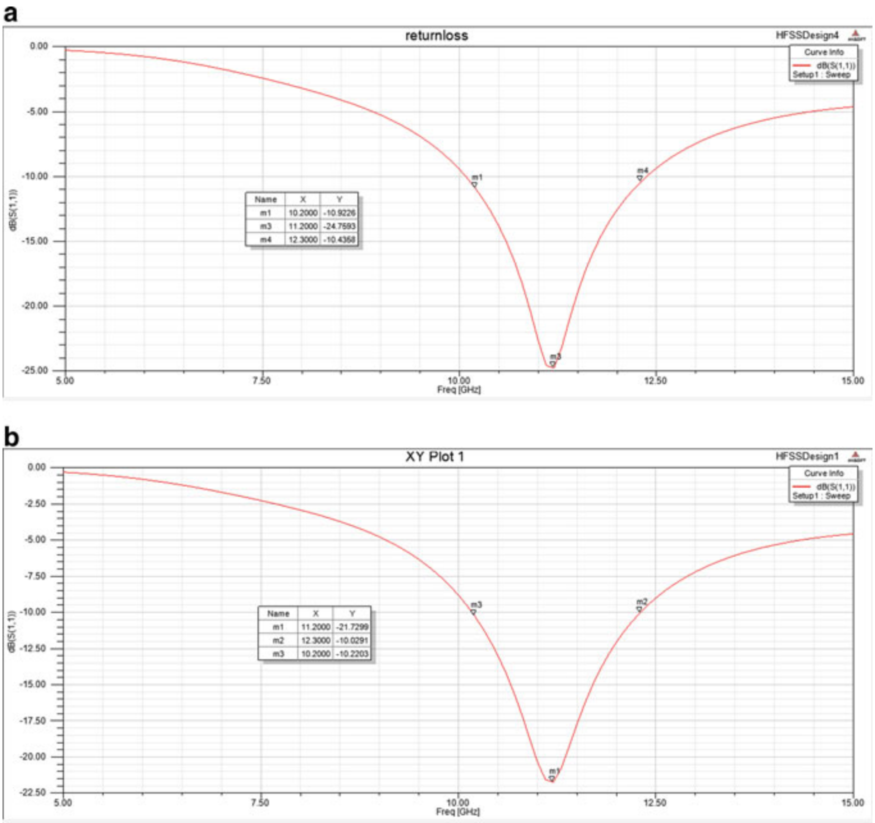

Fig. 4 **a** Return loss (S11) (with slot), **b** Return loss (S11) (without slot)

(without slot) of 1.42 which is close to 1 and is obtained at 11.2 GHz. The simulation result is shown below in Fig. 5a, b.

3.3 Gain Pattern

Efficiency of any antenna is determined by its gain parameter, and in proposed antenna design, gain of 5.0423 dB with slot and without slot 4.8404 dB is obtained well for Planar Inverted F Antenna (PIFA). The simulation result is shown in Fig. 6a, b.

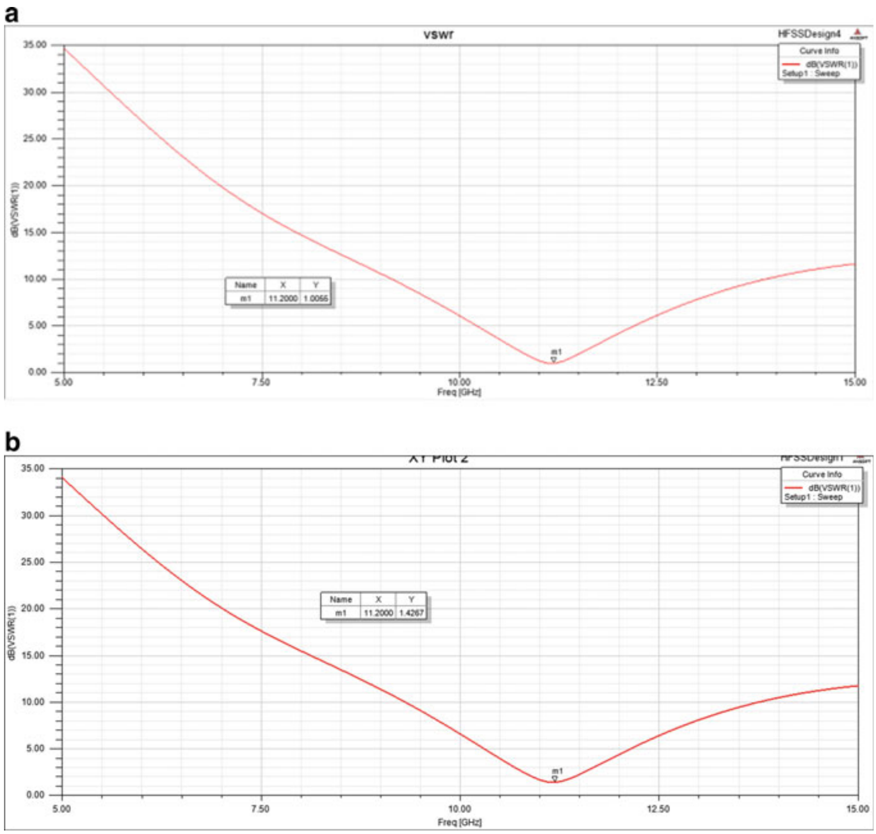

Fig. 5 **a** VSWR (with slot), **b** VSWR (without slot)

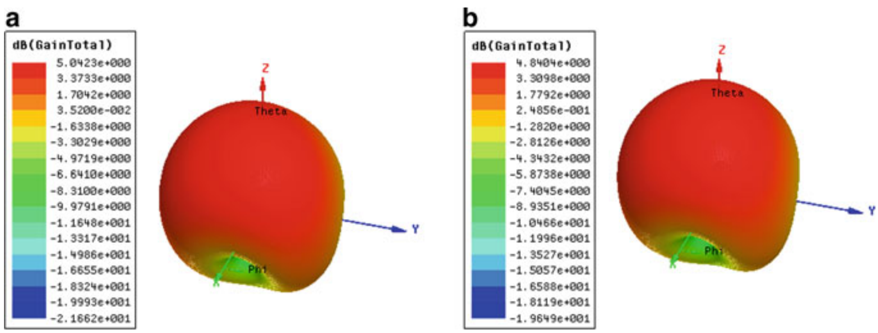

Fig. 6 **a** Gain (with slot), **b** Gain (without slot)

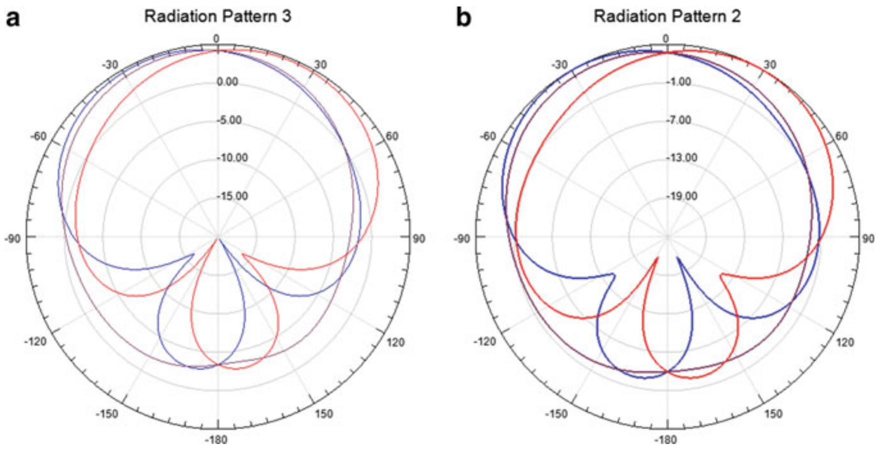

Fig. 7 **a** Radiation pattern (with slot), **b** Radiation pattern (without slot)

3.4 Radiation Pattern

The radiation pattern achieved shows that it is omnidirectional, has good radiation pattern of 2.1 GHz good for 5G applications, and has high-speed transmission. The simulation result is shown in Fig. 7a, b.

4 Comparison Table

This comparison is done in order to increase the bandwidth for our required purpose as form the previous work done the bandwidth is of 1.8 GHz which is improved in this project by employing partial ground and slot having bandwidth 2.1 GHz much greater and improvised version of previous one along with high gain and return loss is close to −30 dB which means less power loss during transmission. This comparison is given in Table 2.

In Table 3, the comparison of my proposed work is done on the basis of providing slot.

5 Conclusion

In this work, a compact edge fed Planar Inverted F Antenna has been proposed. The antenna resonates at 11.2 GHz with a return loss of −24.7593 dB which is often utilized in future 5G wireless devices and for healthcare devices too. The designed

Table 2 Comparison of my work with previous work [5]

Parameter	My proposed work	Previous researched work (without slot and partial ground)
Substrate dielectric constant	2.2	2.2
Substrate height	0.8	0.8
Dimension of ground plane	15 × 15 (mm)	18 × 10 (mm)
Dimension of substrate	18 × 15 (mm)	18 × 10 (mm)
Feed height	2.7 mm	3.5 mm
Shorting pin width	2 mm	2 mm
Bandwidth	2.1 GHz	1.8 GHz
VSWR	1.005	2.31
Gain	5.0423 dB	4.27 dB
Return loss	−24.7593 dB	−17.62 dB
Resonating frequency	11.2 GHz	10.61 GHz

Table 3 Comparison of my work with and without slot

Parameter	My proposed work	My proposed work (without slot)
Substrate dielectric constant	2.2	2.2
Substrate height	0.8	0.8
Dimension of ground plane	15 × 15 (mm)	15 × 15 (mm)
Dimension of substrate	18 × 15 (mm)	18 × 15 (mm)
Feed height	2.7 mm	2.7 mm
Shorting pin width	2 mm	2 mm
Bandwidth	2.1 GHz	2.1 GHz
VSWR	1.005	1.42
Gain	5.0423 dB	4.8404 dB
Return loss	−24.7593 dB	−21.7299 dB
Resonating frequency	GHz	11.2 GHz

antenna shows good radiation pattern and good gain of 5.0423 dB. The structure of the antenna is extremely compact, i.e., 18 × 15 × 2.7 mm, and can be easily placed in the housing of the wireless devices [5].

References

1. Wong H, Luk KM, Chan CH, Xue Q, So KK, Lai HW (2012) Small antennas in wireless communications. Proc IEEE 100(7):2109–2121. https://doi.org/10.1109/JPROC.2012.2188089
2. Sharma A (2017) Design and analysis of planer inverted-F antenna (PIFA) with electromagnetic bandgap structures
3. Rhee E (2020) Miniaturized PIFA for 5G communication networks. Appl Sci 10(4). https://doi.org/10.3390/app10041326
4. Rappaport TS et al (2013) Millimeter wave mobile communications for 5G cellular: It will work! IEEE Access 1:335–349. https://doi.org/10.1109/ACCESS.2013.2260813
5. Loharia A, Rana SB, Kumar N A novel miniature edge fed planar inverted-F antenna (PIFA) for future 5G wireless devices I. http://www.samsung.com/global/
6. Anouar M, Larbi S (2018) PIFA antenna for future mobile 5G. https://doi.org/10.1145/3286606.3286808
7. Aziz MAA, Seman N, Chua TH (2019) Microstrip antenna design with partial ground at frequencies above 20 GHz for 5G telecommunication systems. Indones J Electr Eng Comput Sci 15(3):1466–1473. https://doi.org/10.11591/ijeecs.v15.i3.pp1466-1473
8. Kaur A, Kaur B, Pasricha R (2019) Planar antenna covering sub-6 GHz for 5G enabled mobile devices worldwide. Int J Innov Technol Explor Eng 8(11):1549–1554. https://doi.org/10.35940/ijitee.K1817.0981119
9. Cheung CY, Yuen JSM, Mung SWY (2018) Miniaturized printed inverted-f antenna for internet of things: a design on PCB with a meandering line and shorting strip. Int J Antennas Propag 2018. https://doi.org/10.1155/2018/5172960
10. El Kilani S, El Abdellaoui L, Zbitou J, Errkik A, Latrach M (2019) A compact dual band PIFA antenna for GPS and ISM BAND applications. Indones J Electr Eng Comput Sci 14(3):1266–1271. https://doi.org/10.11591/ijeecs.v14.i3.pp1266-1271
11. Gao GP, Yang C, Hu B, Zhang RF, Wang SF (2019) A wide-bandwidth wearable all-textile PIFA with dual resonance modes for 5 GHz WLAN applications. IEEE Trans Antennas Propag 67(6). https://doi.org/10.1109/TAP.2019.2905976
12. Haraz OM, Ashraf M, Alshebeili S (2015) Single-band PIFA MIMO antenna system design for future 5G wireless communication applications. In: 2015 IEEE 11th international conference on wireless and mobile computing, networking and communications, WiMob 2015, pp 608–612. https://doi.org/10.1109/WiMOB.2015.7348018
13. Nasimuddin, Chen ZN, Qing X (2013) Slotted microstrip antennas for circular polarization with compact size. IEEE Antennas Propag Mag 55(2):124–137. https://doi.org/10.1109/MAP.2013.6529322
14. Mak KM, Lai HW, Luk KM, Chan CH (2014) Circularly polarized patch antenna for future 5G mobile phones. IEEE Access 2:1521–1529. https://doi.org/10.1109/ACCESS.2014.2382111
15. Ahad A, Tahir M, Sheikh MA, Ahmed KI, Mughees A, Numani A (2020) Technologies trend towards 5G network for smart health-care using IoT: a review. Sensors (Switzerland) 20(14):1–22. https://doi.org/10.3390/s20144047