A High Gain Flexible Antenna for Full Duplex System at 5.8 GHz with Defected Ground Structure

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***Abstract*—A novel high gain full duplex flexible antenna using PET paper and foam is presented for 5.8 GHz. Two rectangular patches are placed on top layer whereas bottom layer has defected ground structure printed on it. Patches are fed with inset line feeding. This antenna works effectively from 5.75GHz to 5.81 GHz for full duplex purpose while maintaining a radiation efficiency of 98.6% and peak gain of 8.78 dB at 5.8 GHz. This antenna is believed to be first proposed antenna which is flexible and full duplex with such high gain while working at 5.8 GHz. It also has simple structure, low cost, light weight along with good isolation and gain, which eventually makes it a good candidate for 5.8 GHz full duplex applications.**

I. Introduction

With the booming usage of internet based devices, spectrum for connecting these devices is becoming limited. To solve this problem, we have to efficiently use the spectrum as it is limited. Using a device for transmission and reception on the same frequency at the same time theoretically doubles the spectral efficiency [1]. Main problem of implementing full duplex system is self interference which means that receiving signal getting interfered with the transmitting signal. This self interference can be cancelled in three stages: digital domain, analog circuit domain and propagation domain. In order to facilitate this cancellation, it is very important to design a low cost, low power antenna with high isolation and high gain which will eventually reduce the complexity of other stages of cancellation operation. Moreover, with the happening of fourth industrial revolution, demand for wearable and implantable devices which are mostly flexible are increasing [2]. Flexible antenna is an essential part of a flexible device. In [3], a flexible full duplex antenna is proposed for 2.45 GHz over a textile material. In this paper, PET paper and low loss flexible foam is used for designing the proposed antenna. This antenna works at 5.8 GHz which is commonly used for WiFi. WLan, WiMax applications. We also use defected ground structures(DGS) for improving impedance matching and isolation between TX and RX ports by distirbuting surface current distribution on the ground plane [4]. Two rectangular shape DGS is placed right under two feeding line. Other five rectangular shape DGS are placed in between two patches. Detail description of the proposed antenna and simulated results are presented in subsequent sections.

II. Antenna Design

The proposed antenna is made with three flexible layers with dimensions 42 x 125 x 1.83 mm^3. Top layer is PET paper over which two exact similar patches are printed. One patch is used for transmission and another one is used for reception. Two patches are placed 84 mm apart with 180° rotation. Both patches have corner cut in all four corners with

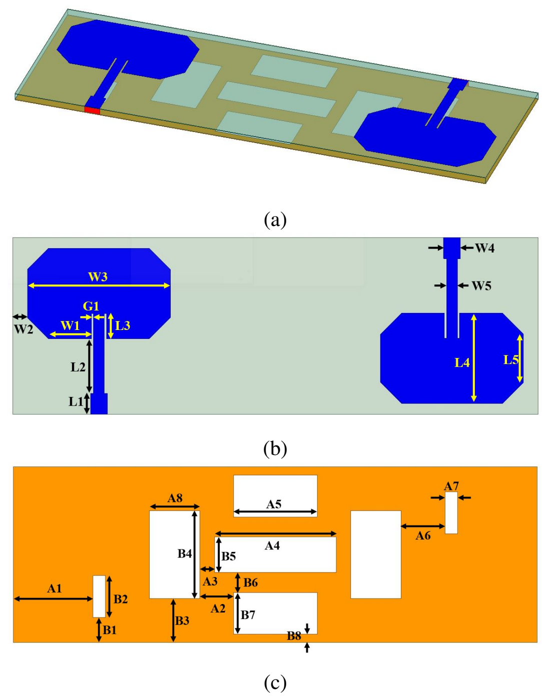

Fig. 1: Proposed full duplex patch antenna. (a) Trimetric view, (b) Top view with detailed parameter marking, (c) Bottom view with detailed parameter marking.

TABLE I: OPTIMIZED DESIGN PARAMETER OF THE ANTENNA

Dimensions	Value, mm	Dimensions	Value, mm
W1	10.2	L1	5
W2	3.5	L2	12.93
W3	34	L3	6
W4	4	L4	21.5
W5	2.6	L5	11.5
A1	19	B1	6
A2	8	B2	10
A3	3.5	B3	10.5
A4	29	B4	21
A5	20	B5	8.5
A6	10.5	B6	4.75
A7	3	B7	10
A8	12	B8	2
G1	0.5		

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same dimension. This PET paper layer has height of 0.135mm with relative permittivity 3.2 and loss tangent 0.022. Middle layer is of foam from Cuming Microwave with thickness of 1.6 mm. This foam layer is used for providing better structural stability while not effecting any antenna properties. Relative permittivity of foam layer is 1.06 and loss tangent 0.0001. Ground layer is also made using PET paper and has same height and properties like the top layer. Defected ground structure is printed on the bottom of this layer. The antenna is designed and optimized using ANSYS HFSS. Fig. 1 shows trimetric view along with detailed top and bottom view for optimized parameters. Optimized parameters are listed in Table 1.

III. Simulated Results

Fig. 2 shows the simulated S parameters of the proposed antenna. Reflection coefficients (S11 and S22) for both ports S overlap completely so that antenna can be used in same frequency range for transmission and reception. This antenna have used inset line feed to get a bandwidth of 400 MHz from 5.6 GHz to 6 GHz. The antenna also maintains a bandwidth of 60 MHz from 5.75 GHz to 5.81 GHz for isolation (S21) parameter under -45 dB. S21 is around -46dB at 5.8 GHz while reaching as low as -59 dB at 5.75 GHz. In Fig. 3, a comparison between S parameters for the defected ground structure is presented. S11 parameter shifts left with a bandwidth of 250 MHz from 5.87 GHz to 6.12 GHz. Isolation is also improved which is under -45 dB for 250 MHz from 5.77 GHz to 6.03 GHz. DGS structure makes the antenna working at 5.8 GHz without adding any circuital complexity, extra space and manufacturing cost. Fig. 4 shows peak gain and radiation efficiency of the proposed antenna. Proposed antenna has a radiation efficiency over 89% for 5 GHz to 6.5 GHz whereas it has a efficiency of 98.6% at 5.8GHz. Peak gain is over 6.35 dB for 5GHz to 6.5 GHz whereas it is 8.78 dB at 5.8 GHz.

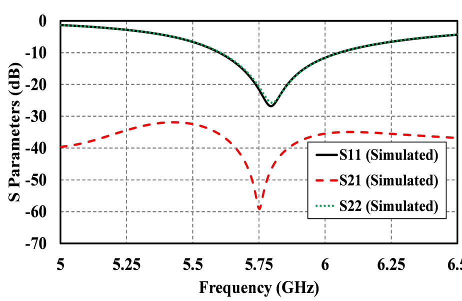


Fig. 2: S parameters of the proposed antenna

Fig. 5 shows the radiation pattern in x-z (ϕ = 0°) and y-z (ϕ = 90°) planes. Co-polarized field is around 25dB higher than cross-polarized field in θ= 0°direction for x-z plane, whereas for y-z plane co-polarized field is around 35dB higher than cross-polarized field in same direction.

IV. Conclusion

In this paper, a high gain flexible antenna is presented which can be used for 5.8 GHz full duplex communication. As the continuation of the work, this antenna will be fabricated using inkjet printing technology. This antenna will then be measured to compare with simulated results. Additionally, bending test and on body characterization will be performed as a future work.

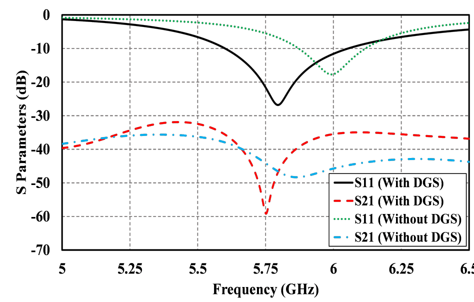


Fig. 3: Comparison of S parameters with and without defected ground structure

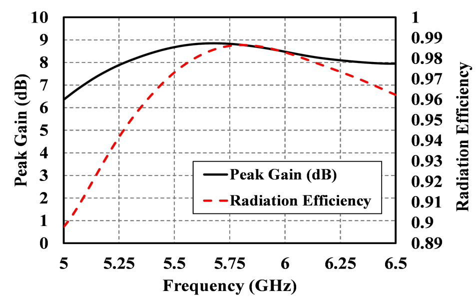
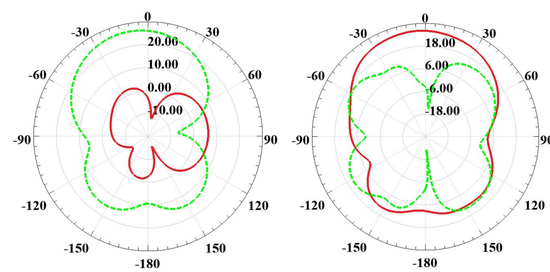


Fig. 4: Peak gain and radiation efficiency of the proposed antenna over the frequency



(a) (b)

Fig. 5: Radiation pattern of the antenna at 5.8 GHZ where (a) ϕ = 0°, (b) ϕ = 90°, Green line is for E_θ and Red line is for E_ϕ.

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