High Isolation and High Gain Planar Patch Array for In-Band Full-Duplex Applications

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***Abstract*—This study proposes a dual polarized planar patch antenna array with high gain and high isolation between transmission and reception ports for full-duplex applications. The antenna system contains two arrays, each of which is composed of four identical single-ended microstrip rectangular patch antennas operating at 12.2 GHz. The first array is fed using corporate feeding technique, while series-fed method is used to feed the second array. The simulated bandwidths of transmit and receive operations are 1260 MHz and 810 MHz, respectively. The simulated results show good isolation, S_{21}, reaching – 60 dB at the center frequency. The design also maintains peak realized gain from 6.7 dB to 7.6 dB through the entire band of interest. The high isolation characteristic of the antenna is suitable for cancelling the interference of transmitter on the receiving port. The antenna array also exhibits low cross-polarization, compact size, and good impedance matching.**

I. Introduction

As the novel 5G is the next generation of wireless technology, standard spectrums become limited. Most of the current wireless communication systems operate in half-duplex mode, where the transmission (TX) and reception (RX) operate on the same channel, but not simultaneously [1]–[2]. New wireless spectrum standards are exploring to address over the current crowded spectrum. Full-duplex system appears as an excellent candidate for this backhaul connection, which enable transmit and receive operations on the same frequency at the same time [3]. The significant challenge to realize full-duplex operation is the high level of self-interference, where the undesired signals have stronger power than the targeted signal [4]. Hence, the received signal of interest may become unrecognizable and distorted due to RF leakage between TX and RX ports. This project focuses on designing a dual polarized two-port planar patch antenna system that offers high gain and high isolation between two operations. Microstrip antenna arrays play an important role and are being widely used in various practical applications [5]–[6]. In addition, the antenna separation technique is employed in order to achieve a high level of cancellation. The antenna design is optimized to operate on the target frequency of 12.2 GHz and sustains high level of isolation. The proposed system provides the coverage for common applications in satellite communications, or multichannel video and data distribution service (MVDDS).

II. Antenna Design Process

In this work, two microstrip rectangular patch arrays are designed each having four identical elements. The low-cost FR4 substrate has a thickness, h_1, of 1.4 mm, a dielectric permittivity, ε_r, of 4.4, and dielectric loss tangent, $\tan\delta$, of 0.02. By using these parameters, the width, *W*, and the length, *L*, of each rectangular patch are computed [7].

Fig. 1(a) depicts the geometry of the entire antenna array. Fig. 1(b) and (c) illustrate the front view and side view of the antenna. Table I shows the optimized dimensions of the array. Here, we assign port 1 as TX port and port 2 as RX port. The TX and RX arrays are separated by an optimized distance, *D*, of 0.558 λ, where λ is the wavelength of the center frequency. This design provides orthogonal linear polarizations on the same radiating structure. The spacing between two arrays is crucial because it impacts the mutual coupling between TX and RX ports. It also affects beam direction of the entire antenna array.

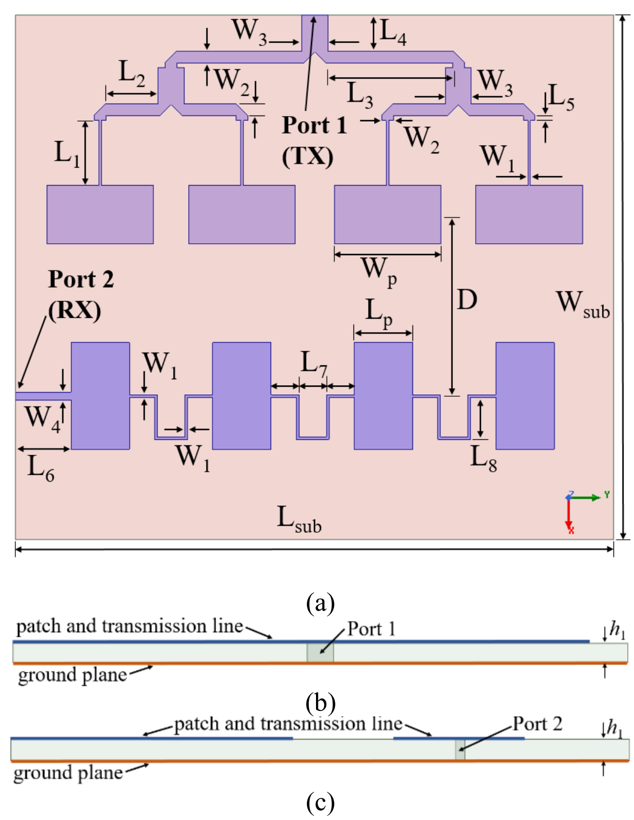

Fig. 1. a) The geometry of array; b) Front-view of the antenna; c) Side-view of the antenna.

TABLE I. GEOMETRY OF THE PROPOSED ANTENNA ARRAY.

Symbol	Dimension (mm)	Symbol	Dimension (mm)
L_1	5	L_{sub}	46.02
L_2	4.05	W_{sub}	40.35
L_3	9.76	W_1	0.1
L_4	2.8	W_2	0.9
L_5	0.4	W_3	2
L_6	4.25	W_4	0.6
L_7	2.13	W_p	8.2
L_8	3.23	L_p	4.5
h_1	1.4	D	13.95

III. RESULTS AND DISCUSSIONS

The antenna array is designed and simulated by using ANSYS HFSS. Fig. 2 presents the simulated S-parameters of the entire antenna. The corporate-fed method provides the 10-dB bandwidth of 1260 MHz for TX mode, S_{11}, while, the series-fed technique gives the 10-dB bandwidth of 810 MHz for RX mode, S_{22}. In addition, the antenna maintains good simulated isolation between two operations, $S_{21} < -40$ dB, reaching as low as – 60 dB.

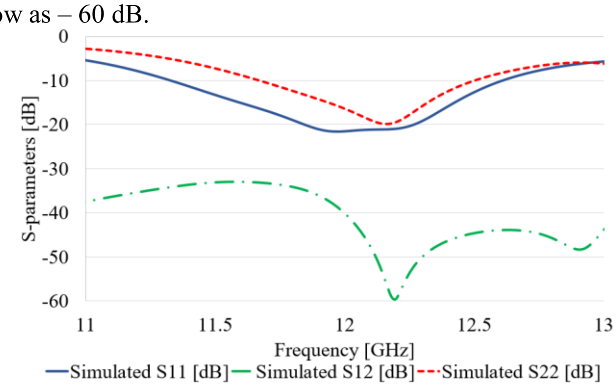

Fig. 2. Simulated S-parameters results of the antenna array.

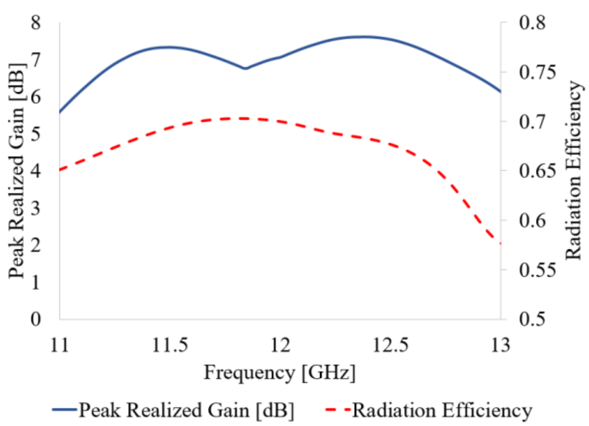

Fig. 3. Simulated peak realized gain and radiation efficiency of the array.

In Fig. 3, the simulated peak realized gain is sustained from 6.7 dB to 7.6 dB, while, the simulated radiation efficiency is more than 65 % through the band of interest which is good for satellite communications. Fig. 4 illustrates the simulated radiation pattern of the antenna array when both TX and RX operations are activated. At Phi = 0º (x-z plane), the co-polarization is near 32 dB larger than the cross-polarization at the boresight when two modes are activated. Similarly, this value is close to 33 dB on the y-z plane (Phi = 90º).

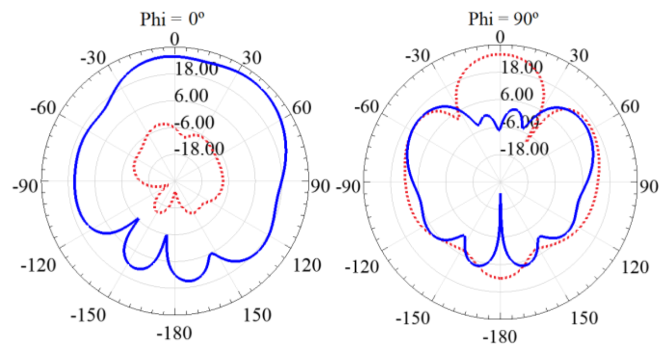

Fig. 4. The simulated radiation pattern of the array at Phi = 0º and Phi = 90º.

IV. CONCLUSION

This letter presents a high isolation and high gain planar microstrip rectangular patch antenna array for full-duplex applications. The proposed design has two patch arrays for TX and RX operations. The structure attains the isolation greater than 40 dB around the center frequency. Good simulated radiation pattern with low cross-polarization values can be observed. The combination of corporate-fed and series-fed techniques make the antenna more compact and suitable for satellite communication systems. A prototype will be fabricated and tested for the future work.

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