Dual Polarized Patch Antenna with High Inter-Port Isolation for 1GHz In-Band Full Duplex Applications

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***Abstract*—This paper presents the design and implementation of dual port, orthogonal polarized single microstrip patch antenna with high interport isolation to realize 1GHz In-band Full Duplex (IBFD) wireless communication using single antenna. The implemented antenna provides 66dB isolation between transmit and receive ports at centre frequency. The interport isolation is better than 40dB for 22MHz antenna 10 dB input impedance bandwidth.**

Keywords*—*High Isolation antennas, IBFD, full duplex antenna, feed forward loop

I. INTRODUCTION

As demonstrated in [1], the data throughput of wireless communication system can be doubled if the wireless transceiver is enabled to transmit and receive simultaneously at the same radio frequency. Such In-Band Full Duplex (IBFD) wireless communication operation can be realized by suppressing the Self Interference (SI) at the receiver that is caused by coupling from its own transmitter. The required amount of SI suppression depends on the transmitted power and signal bandwidth. Generally, the SI should be suppressed to RF transceiver noise floor and normally SI suppression of approximately 100 dB or more is required for IBFD operation.

To achieve this amount of SI suppression, the SI suppression mechanism is normally implemented at three stages across the IBFD transceiver and they are known as antenna cancellation, RF/analog cancellation and digital base-band cancellation [2]. Most of the SI suppression is achieved at antenna stage to relax the required amount of SI cancellation at the rest of two stages. Antenna stage SI suppression techniques target to minimize the inherent mutual coupling between transmit and receive ports of antenna by firstly employing cross polarization for transmit and receive operation and then use external circuitry to achieve additional isolation. For example, the reported antenna in [3] uses orthogonally polarized single antenna with improved feeding method to achieve high isolation between transmit and receive ports.

Our implemented microstrip patch antenna achieves more than 66dB isolation between transmit and receive ports. The antenna's polarization diversity (orthogonal polarization) provides 45dB interport isolation and additional isolation is achieved by external loop between transmit and receive ports.

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II. 1GHZ ANTENNA WITH FEED FORWARD LOOP

Initially, a dual port orthogonal polarized 1GHz square microstrip patch antenna was simulated using Agilent Advanced Design System (ADS) Momentum. The design was simulated for different feeding locations of Port 2 on respective antenna edge to optimize S12 for required operating frequency and optimized S12 was obtained when both antenna edges are centre fed from respective edge as shown in Fig.1

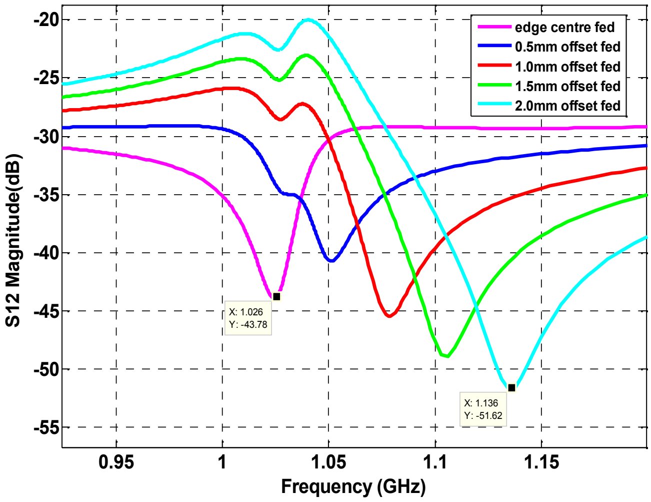

Fig. 1. Interport isolation variations vs port 2 feed distance w.r.t edge centre

The antenna was implemented on FR-4 substrate (with ε=4.5, tangent loss =.01, thickness (h) =1.6mm).After analyzing the performance of two port patch antenna, external feed forward loop between transmit and receive ports was implemented to improve the interport isolation. Two RF couplers (ZEDC-15-2B and ZEDC-10-2B) are used to sample signal from transmit and receive antenna ports to add them after adjusting phase and amplitude so that they cancel each other. ZFAT-R512 and SPHSA-152+ from Mini-circuits were used as digital step attenuator and voltage variable phase shifter, respectively to adjust the amplitude and phase of the sampled signal. The complete constructed antenna system is shown in Fig.2.

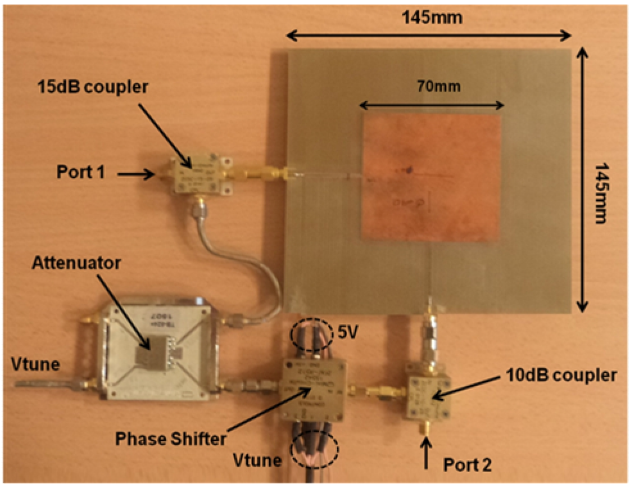

Fig. 2. Implemented dual port patch antenna with feed forward loop

III. TEST AND MEASUREMENT RESULTS

As seen in Fig. 3, the measured return loss (S11& S22) and interport isolation (S12) are 20.36 dB and 45dB respectively at centre frequency without feed forward loop. Then, phase shifter and attenuator were tuned to obtain additional isolation and measured interport isolation is 66.1dB at centre frequency. The interport isolation is better than 40dB for 22MHz 10dB impedance bandwidth in both cases so antenna interport isolation bandwidth is not reduced with feed forward loop.

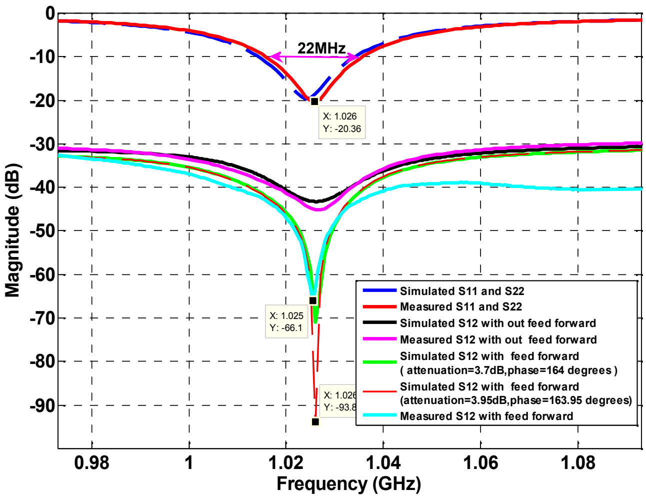

Fig. 3. Simulated and measured S11, S22 and S12 parameters

The interport isolation is very sensitive to even slight changes in loop attenuation and phase shift. As shown in Fig.3, simulated interport isolation is more than -94dB at 1.026GHz (with 3.95dB and 163.950) but reduces to -70dB at 1.026GHz (with 3.8dB and 1640).More precise variable attenuators and phase shifters are required to get very high isolation notch. Also, as shown in Fig.4, measured maximum interport isolation notch frequency can be tuned on any required frequency with in antenna 10dB input impedance bandwidth.

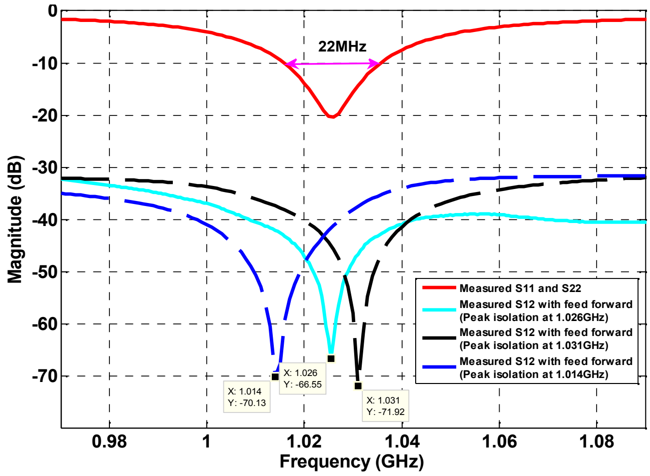

Fig. 4. Measured S12 with shifted port isolation notch frequency

The radiation pattern for each port was measured by exciting one port and terminating other port with 50 ohms. Measured results are for 2D normalized Eco are shown in Fig.5

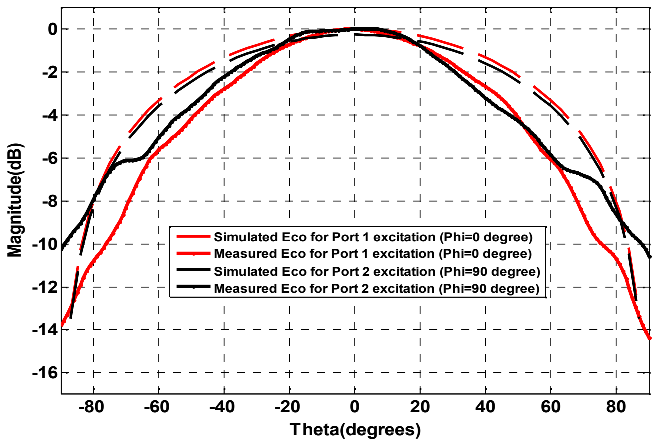

Fig. 5. 2D Normalized Eco Pattern of dual port implemented antenna

IV. CONCLUSION

The implemented antenna is well suited to realize 1GHz full duplex communication link using single antenna and as an array element for 1GHz retrodirective antenna array for mobile applications as demonstrated in [4]. It eliminates the power loss caused by circulator used for duplex operation.

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