Polarization Reconfigurable Active Antenna

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1. Introduction:

Active antennas (AAs) are a class of radiation system that integrates an antenna and backing active circuits which results in considerable reduction in complexity of the matching networks and filters [1]. This is done by carefully designing the radiating element to provide proper load for active elements. Hummer and Chang have investigated active antenna elements using a microstrip patch antenna and field-effect-transistors (FETs) [2]. Similarly, Ho, Fan and Chang have used FET devices using the simple transmission line method [3]. Reconfigurable patch antenna has also designed with frequency and radiation reconfigurability [4]. Polarization diversity is required for operations under different standards such as GSM, GPS, Wireless Local Area Network (WLAN) to reduce the multi-path fading and co-channel interference. The ability to operate both sense of circular polarization allows the system to reuse frequency and double the system capacity. Moreover, if the antenna can be switched between two senses of circular polarization as well as linear polarization, it will allow the user to roam virtually any existing network [5, 6]. This can be also very useful in RFID system. Polarization switchable active antenna can be used in spatial power combiner in the compact size.

The reconfigurable antenna proposed in this paper operates at the three different polarizations (Linear, RHCP, and LHCP) with the frequency 2.2 GHz. It has been fabricated on low cost substrate. It can switch the polarization using the PIN diode.

2. Antenna design:

The antenna we propose consists of an annular slot in the ground plane fed by a microstrip line as shown in Fig1. The antenna is designed and fabricated on the NELTEC 1000 substrate having the dielectric constant 3.2 and thickness of 0.762 mm. A simple annular slot antenna is linearly polarized. To achieve the circular polarization, two notches are cut along the periphery of the circular patch at the diametrically opposite points. The field of a singly fed annular slot can be resolved into two orthogonal degenerate modes, 1 and 2. Proper perturbation segments will detune the frequency response of mode 2 at the operating frequency; it is of the same amplitude but 90 degree out of phase with respect to mode 1. In the present case, the perturbation is introduced by cutting two notches along the periphery of the annular slot. Length of notch is optimized using CST microwave studio to give the good Axial Ratio at the center frequency.

For the switching between the polarizations PIN diode (HPND4038) has used. When all diodes are in 'Off' state, the structure radiates linearly polarized waves. If one diagonal diode from the each of 'L' type structure is 'On' then the antenna radiates circular polarized waves. Fig. 2 shows the Return Loss $|S_{11}|$ and transmission coefficient $|S_{21}|$ as obtained from the vector network analyzer. In the Fig. 3 & 4, radiation pattern of the antenna has shown which is measured in anechoic chamber. In the Fig. 3a and Fig. 3b show both the X-directed and the Y-directed radiation pattern of circularly polarized antenna. Here, Y–directed is 90 degree rotated with X-directed. Fig. 4a and Fig. 4b show both the Co and Cross polarization of linear polarization. Axial Ratio of the circular polarization is well below the 1 dB.

3. Active Antenna Design:

The active integrated antenna integrates the active devices and passive antenna element on the same substrate. They have advantage of low cost, low profile and light weight. Oscillating active antenna integrates an active devices work as oscillator and a passive antenna work as load as well as radiating element. In this, passive antenna serves as a resonator which will determine the oscillation frequency. For the oscillation, positive feedback method has been used. Antenna has connected through the transmission line. Antenna which has been designed has having multiple bands due to the extra length added in the structure. If amplifier having the large gains at the lower frequency then it will start oscillation at that frequency. Due to this reason, narrow band amplifier has been designed. For the amplifier, NE662M04 device have used with the bias condition 2V and 20mA. For narrow band matching of amplifier two short circuit stub has used.

After design of amplifier, passive antenna is integrated with the amplifier using the transmission line. The transmission line length of optimized as such that it will satisfy the Barkhausen criteria at the desired frequency. As such design is symmetrical so that it will not show the shift in design frequency for RHCP and LHCP. Fig. 5 shows the fabricated integrated active antenna which is able to reconfigurable in polarization. The measured results of X and Y-directed circularly polarized antenna is shown in Fig. 6 which is measured using the spectrum analyzer. Difference between the power levels of X and Y-directed circularly polarized active antenna is less than 1 dBm so that it will verify that it is working as circularly polarized antenna. Fig. 7 shows the measured results of Co and Cross polarization of linearly polarized active antenna. Here Cross-polarization is well below the 10 dBm from Co-polarization.

4. Conclusion:

The active integrated antenna is a very useful concept in modern microwave and millimeter-wave application systems, especially in the design of planar quasi optical power sources. If we are having the flexibility to reconfigure polarization that will effectively use the antenna. It is foreseen that together with the steadfast progress of MMIC technologies, the active antenna will continue to be a research area of growing interest, contributing to the endless efforts to design compact, light-weight, low-cost and high performance systems for radar, sensing as well as wireless communications.

Reference:

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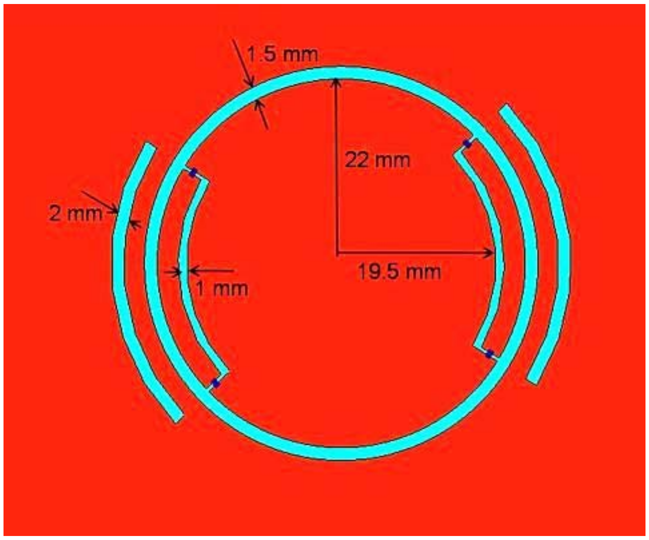

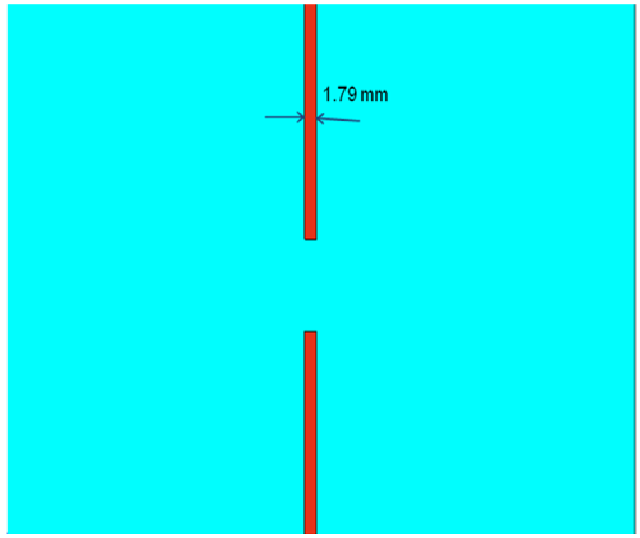

Fig 1: a) Front view of the reconfigurable antenna b) back view of antenna

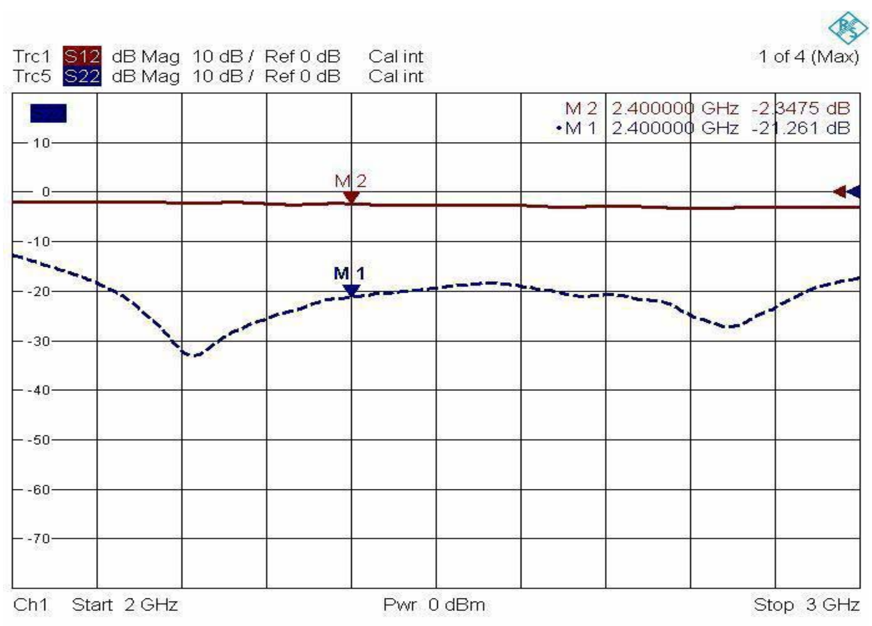

Fig 2: Measured Return Loss and transmission loss

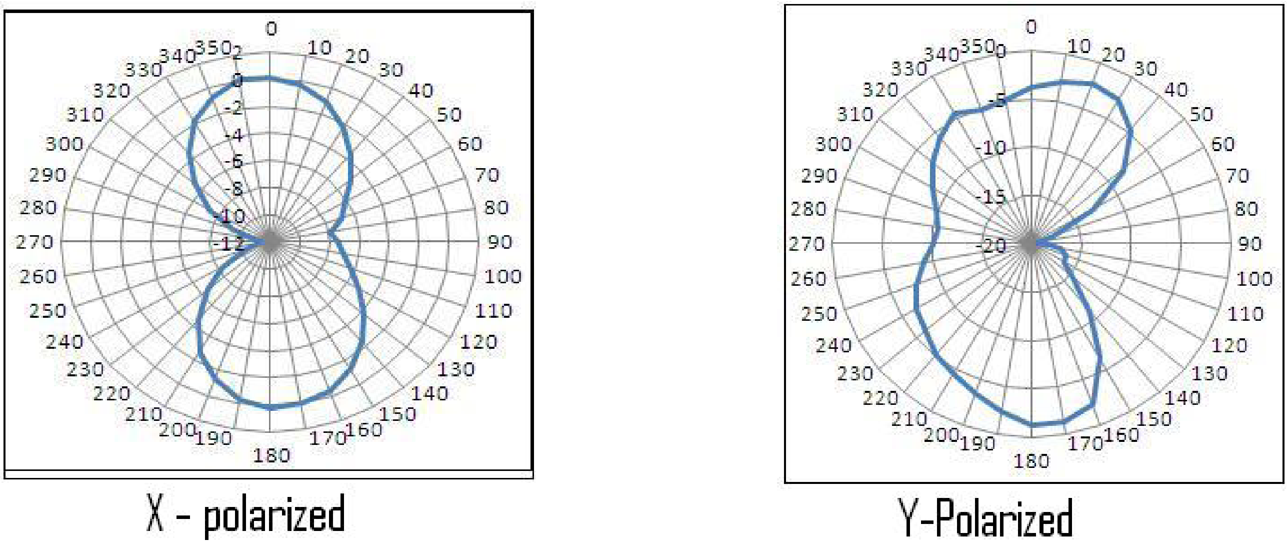

Fig 3: Radiation pattern of antenna when antenna is circularly polarized a) X-polarized b) Y-polarized

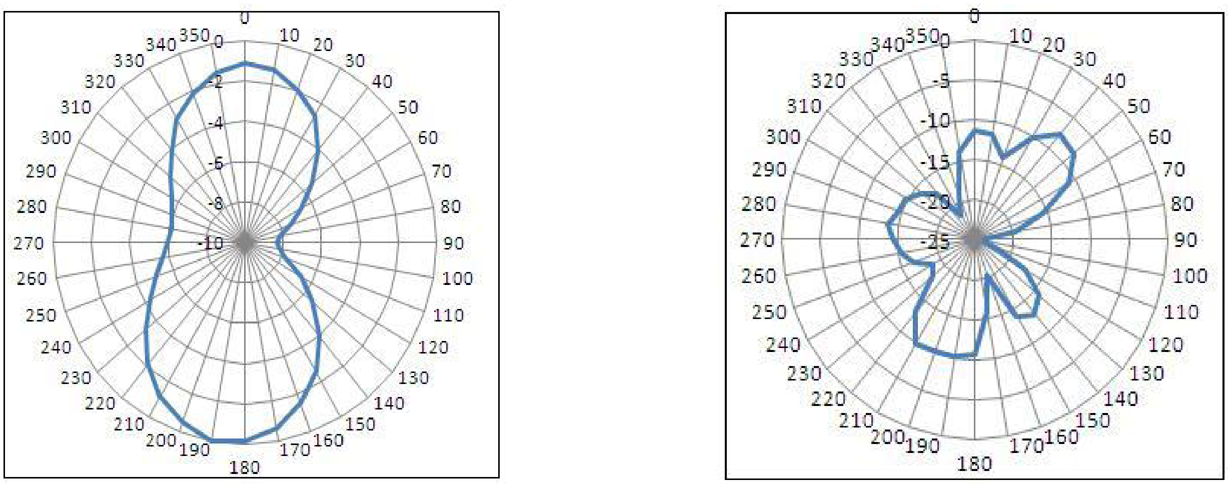

Fig 4: Radiation pattern of antenna when antenna is linearly polarized a) Co-polarization b) Cross polarization

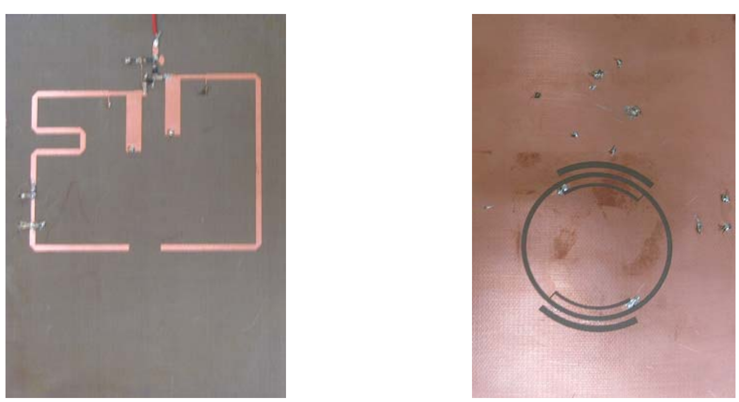

Fig 5: Fabricated Reconfigurable Active Antenna

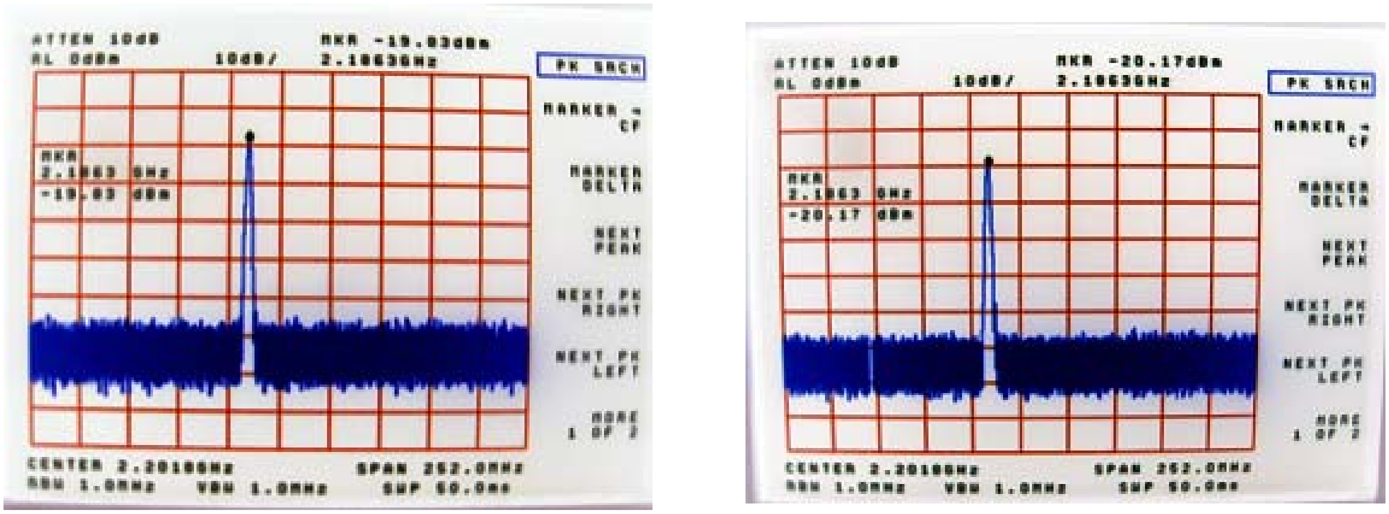

Fig 6: Frequency spectrum of active antenna for circular polarization (X and Y directed)

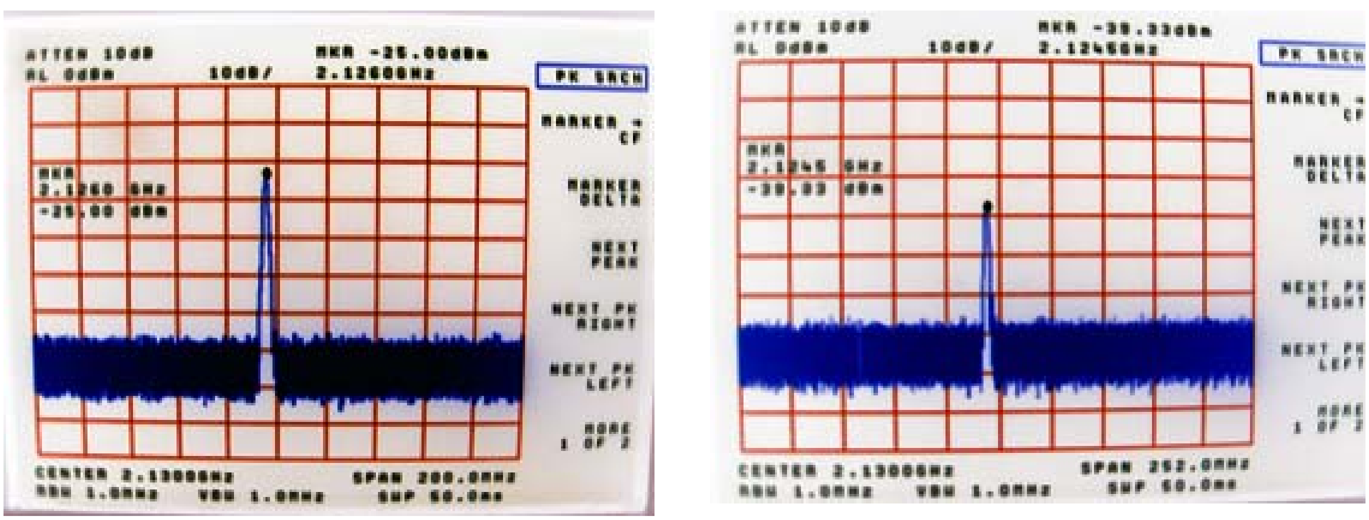

Fig 7: Frequency spectrum of active antenna for linear polarization (Co and Cross polarization)