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A COMPACT CIRCULARLY POLARIZED SLOTTED MICROSTRIP ANTENNA

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Abstract

Slot antennas are often used at UHF and microwave frequencies. In slot antenna for RFID reader applications the frequency ranges from 902-923MHz to achieve circular polarization. The shapes and size of the slot, as well as the driving frequency, determine the radiation distribution pattern. The proposed compact size circularly polarized slotted microstrip antenna are summarized with design rules. The circularly polarized radiation in square patch antenna can be obtained by perturbation technique with different shapes of slot in the orthogonal direction. A single feed configuration based symmetric slotted microstrip antenna is adapted to realize the compact circularly polarized microstrip antennas. Based on the perimeter, the size of the slot on microstrip slot antenna are studied and compared. The Operating frequency of the antenna is 912MHz that can be tuned by varying the perimeter of the slot while the keeping the circularly polarized radiation unchanged. The schematic and layout are configured by using Advanced Design System (ADS). Return loss, Resonant Frequency, Axial Ratio (AR), and Gain were determined for the proposed system using ADS. A measured 3dB Axial Ratio (AR) bandwidth around 6MHz with 16MHz impedance bandwidth has been achieved for the antenna on a RO3004C substrate with dielectric constant 3.38.

Keywords:

Circular Polarization, Slotted Microstrip Antenna, Axial Ratio, Gain

1. INTRODUCTION

The Ultra High Frequency (UHF) band which uses the Radio Frequency Identification (RFID) system has it gained popularity in many applications, as it provides longer readable range and fast reading speed [1]. RFID technology uses the short-range wireless communications and information in the device (tag) can be read by using the radio frequency. Due to the merits of high data transfer rate and broad readable range, passive RFID systems at the UHF band are preferred in many applications. The RFID system uses 840-960 MHz with total frequency span of UHF band. The system operates at the bands of 840-955 MHz in Asia-Pacific region, 902-928 MHz in America, and 865-867 MHz in Europe. The main contemplation for the Circularly Polarized (CP) microstrip antenna design of handheld/movable RFID reader applications is complete compact size of the antenna.

Compact circularly polarized microstrip antennas (CPMAs) are mostly used in handheld portable devices and in compact portable communication systems. Circular polarization is the most common polarization types used in modern wireless communication systems. Several applications also want compact circularly polarized microstrip antennas where the overall antenna size is a main consideration, such as for mobile wireless, radio-frequency identification (RFID) readers, and portable wireless devices. The compact circularly polarized microstrip antennas are proposed for handheld RFID reader applications. Circularly polarized antennas could be matched in wide range of orientations because the radiated waves oscillate in a circle that is perpendicular to the direction of propagation.

Designing a circularly polarized microstrip antenna is challenging; it requires combination of design steps. The first step involves designing an antenna to operate at a given frequency. In the second step circular polarization is achieved by either introducing a perturbation segment to a basic single fed microstrip antenna, or by feeding the antenna with dual feeds equal in magnitude but having 90° physical phase shift. The shape and the dimensions of the perturbation have to be optimized to ensure that the antenna achieves an axial ratio that is below 3 dB at the desired design frequency.

The Circularly Polarized Microstrip Antenna design which generally uses the single- and dual- feed structure [4]. Single-feed circularly polarized microstrip antennas are more compact when relate to dual-feed circularly polarized microstrip antennas [5]. Single feeding techniques are commonly used because they are simple, easy to manufacture, low in cost and compact in structure. Single fed circularly polarized microstrip antennas are considered to be one of the simplest antennas that can produce circular polarization. For Feeding network circuit (external polarizer) requires larger ground plane area for dual feed structure than the single feed structure. Various techniques have been published [5]–[10] to generate the CP radiation of the single-feed microstrip antennas. The small size of the CPMA can be achieved at the cost of limited gain, and narrow 3-dB AR bandwidth.

For size reduction, the different shapes are slot along the diagonal direction on the microstrip patch radiator. Circular polarization diagonally symmetric slots are studied based on the circular, square, ring and cross shaped two slots and diagonally symmetric slot are circle and cross shaped four slots was studied [1].

In this paper, we propose a method to generate compact size of the square microstrip antenna using a diagonally symmetric slotted microstrip-patch structure for circular polarization. The proposed technique is based on equally embedded slots along the diagonal directions on the microstrip patch antenna. Circularly polarized radiation can be achieved by slightly changing the perimeter of the slots in the diagonal directions of the microstrip square patch. In addition, the proposed method can also be used for circular polarization and size reduction of microstrip antenna. The simulated results are obtained from the ADS (Advanced Design System) commercial simulator.

2. VARIOUS TECHNIQUES

Different techniques are published in the literature for single-feed circularly polarized microstrip antenna. In 1983, rectangular

slot embedded at the square patch center and truncated corner method was proposed by Sharma and Gupta [6]. For Circular polarized microstrip antenna truncated corner method did not provide any size reduction [1]. Then, in 1996, Cross slot embedded at the centre of the circular patch was explained by Iwasakli [7]. But the feeding technique was proximity feeding. The circular polarization microstip antenna which uses the tuning stub [9] to achieve the circular polarized radiation. However the circular polarized microstrip antenna design the tuning stub was not useful for size reduction.

3. ANTENNA CONFIGURATIONS

For circular polarization, radiation with compact antenna size is proposed. Diagonally symmetric slotted microstrip antenna has to support two orthogonal modes with a 900 phase shift. At 450° axis of the feed location the diagonally symmetric slotted microstrip antenna, perturbate along the axis are excited at the orthogonal modes. By using the perturbations technique along the orthogonal axis, the 900 phase shift can be achieved using the two orthogonal modes. The location of the two slots and four slots are located on the diagonal direction. The coaxial feed location is at 450° on the *x* axis form the arbitrarily shaped slots on the patch radiator. The slots in the diagonal direction help to change resonant length in the diagonal direction by changing the perimeter of the slots; the circular polarization radiation can be achieved. The perturbations can be loaded along the two slots and four slots along the diagonal direction on the microstrip patch radiator. For four slots asymmetric slots are embedded in the orthogonal direction.

The proposed square patch diagonally symmetric slotted microstrip patch antenna is discussed in this paper. The antennas were designed to operate around 900 MHz. The proposed diagonally symmetric slotted microstrip-patch antennas were designed on an RO3004C substrate (with a thickness of H = 4.572 mm ($0.0137\lambda_0$), a dielectric constant of 3.38, and a loss tangent of 0.0027). The feed which uses the coaxial feed is on the *x* axis. The overall antenna size was designed for the handheld/portable RFID reader applications. The input and radiation performance of the diagonally symmetric slotted microstrip antenna was studied based on the area of the square patch radiator and fixed overall volume of the antenna.

4. ANTENNA BASED ON TWO SLOTS

The Fig.1(a) shows the two slot diagonally symmetric Slotted Microstrip Antenna. Diagonally symmetric slotted microstrip antennas based on two slots are illustrated in figure. The dimensions of the diagonally symmetric slotted microstrip antenna are design is in mm. The perimeter of the slot should be greater than zero, to achieve the circular polarized radiation. The perimeter of the slot is 138 mm, for good circularly polarized radiation.

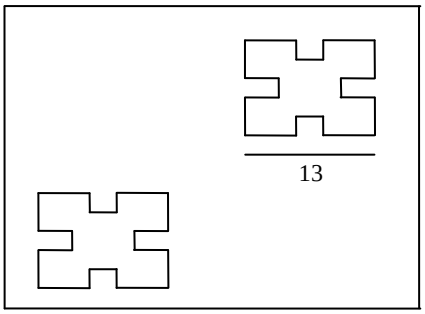

Fig.1(a). Two Slot diagonally symmetric Slotted Microstrip Antenna

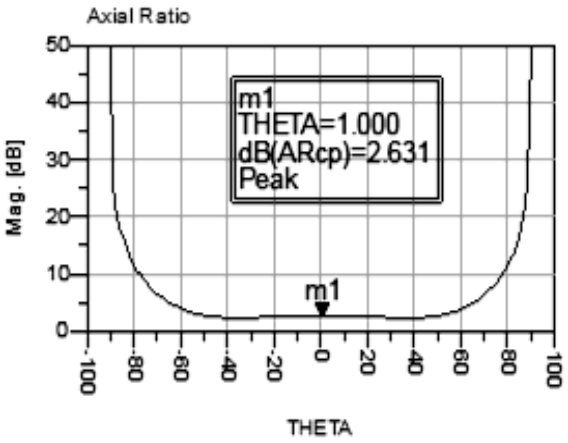

Fig.1(b). Two Slot Simulated Axial Ratio

The Axial Ratio of the two slot antenna has 2.631 dB. The simulated axial ratio at the boresight, return losses, gains at the boresight of the diagonally symmetric slotted microstrip patch antenna are shown in Figs.1(b, c & d) respectively. The two slot diagonally symmetric slotted microstrip antenna has lowest resonant frequency and circular polarized (minimum axial ratio) was achieved. The resonant frequency was dependent on the perimeter of the slots. The square shape slot is for good circular polarized radiation [1]. The resonant frequency of the antenna two slot antennas has 984 MHz. The gain of the antenna is 6.273 dB which is shown in Fig.1(d).

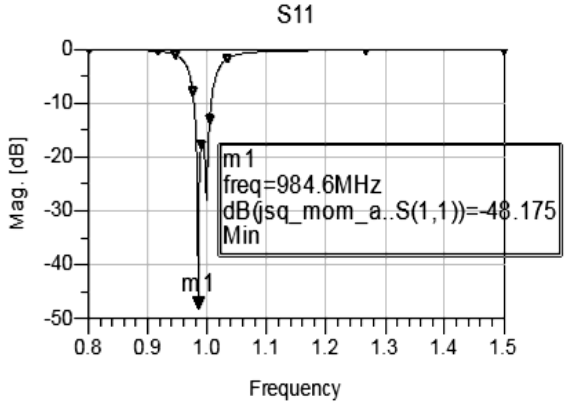

Fig.1(c). Two Slot Resonant Frequency

The proposed system is based on the square shaped slot to get the good circular polarized radiation and resonant frequency.

The center frequencies of the diagonally symmetric slotted microstrip antenna for circular polarization are obtained. The axial ratio was obtained at the center frequency. The resonant frequency of the antenna and circular polarization of the diagonally symmetric slotted microstrip antenna are shown in Fig.1(c).

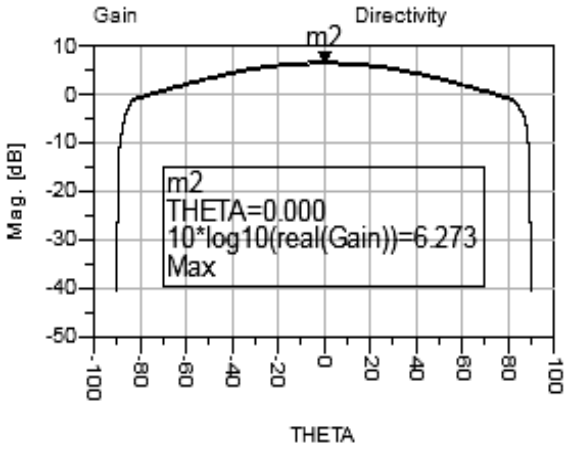

Fig.1(d). Two Slot Simulated Gain

5. ANTENNA BASED ON FOUR SLOTS

The proposed diagonally symmetric slotted microstrip antenna based on four slots is shown in Fig.2(a). For good circular polarized radiation and minimum axial ratio the perimeter of the slot should be very larger than the two slot diagonally symmetric slotted microstrip antenna.

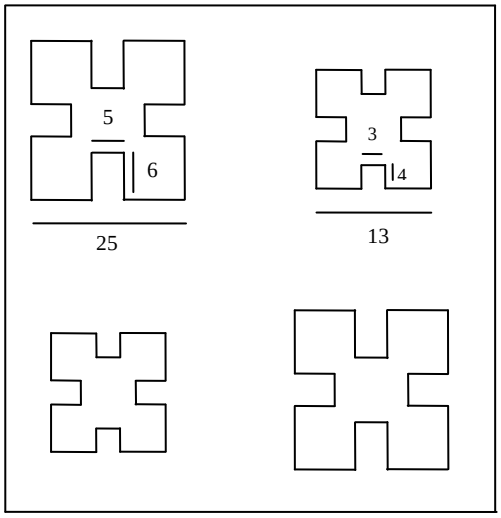

Fig.2(a). Four Slot Diagonally Symmetric Slotted Microstrip Antenna

The resonant frequencies of the four slots diagonally symmetric slotted microstrip antenna are 912 MHz. The Resonant Frequency of the antenna is shown in Fig.2(b).

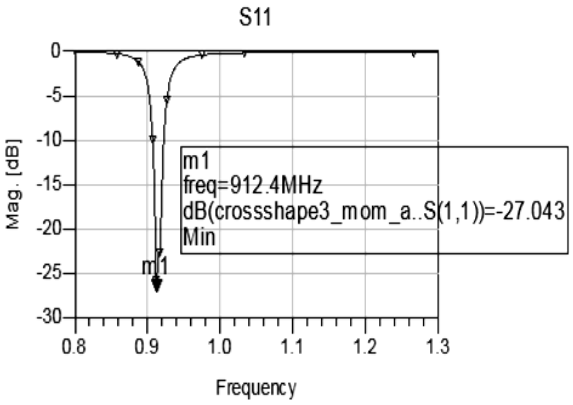

Fig.2(b). Four Slot Resonant Frequency

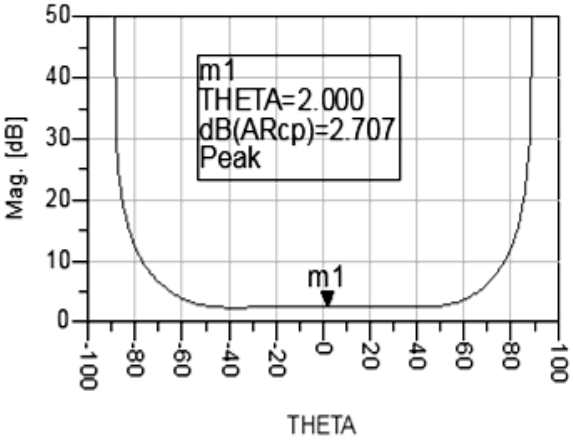

Fig.2(c). Four Slot Axial Ratio

The axial of the four slot diagonally symmetric slotted microstrip antenna are given by 2.707 dB. The minimum axial ratio frequency was also compared with the two slots diagonally symmetric slotted microstrip antenna. The minimum axial ratio frequency of the four slots diagonally symmetric slotted microstrip antenna was 912 MHz. The perimeter of the four slots was larger when compared to the two slot diagonally symmetric slotted microstrip antenna.

As a result, the boresight gain of the four slot diagonally symmetric slotted microstrip antenna was lower. Also, the operating frequency of the four slots diagonally symmetric slotted microstrip antenna was also lower. The perimeter of the slot in orthogonal direction for circular polarized radiation is not same in the diagonally symmetric slotted microstrip antenna. The bandwidth and gain of the diagonally symmetric slotted microstrip antenna are the function of overall size, so electrically smaller antenna has narrow bandwidth and lower gain.

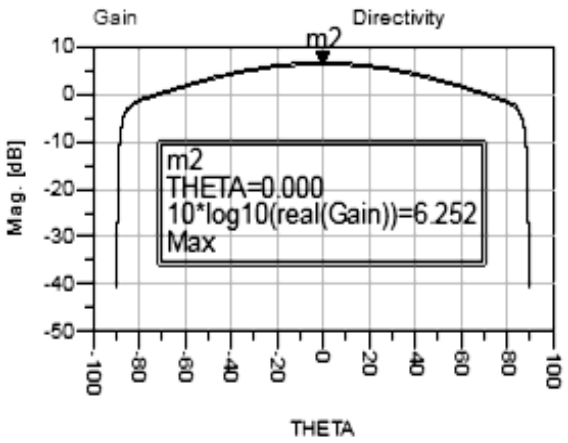

Fig.2(d). Four Slot Simulated Gain

The four slots gain of the antenna is shown in Fig.2(d). The gain of the antenna is 6.252 dB. The four slot diagonally symmetric slotted microstrip antenna had the lowest operating frequency and minimum axial ratio compared to the two slots diagonally symmetric slotted microstrip antenna.

6. TUNING THE OPERATING FREQUENCY

The operating frequency of the antenna can be tuned by varying the perimeter of the slot in the diagonal direction of the smaller and larger slot length of the diagonally symmetric slotted microstrip antenna. The relative size of the slot decreases the operating frequency increases. The operating frequency decreases the slot perimeter increases on the radiating patch. The slot perimeter increases the maximal axial ratio frequency also decreased. The antenna operating frequency can be tuned by varying the perimeter of the slot. The axial ratio was not affected by varying the perimeter of the slot. The gain of the antenna slightly decreased with an increase in the relative size of the slot. The proposed four slot antenna is designed to tune a desired UHF frequency band for RFID readers by changing the relative size of the slot without affecting the circular polarization.

7. CONCLUSION

The diagonally symmetric slotted microstrip antenna with compact size are studied and presented. An arbitrarily shaped slot can used to achieve circularly polarized radiation with an antenna of compact size.

In general, the antenna has larger perimeter and has more size reduction. The circular polarized radiation can also achieve with increase in perimeter of the slot. It has been shown that by changing the relative size of the slots, the operating frequency band of the antenna can be tuned with good circular polarized radiation for desired operating frequency. The designed antenna can be cover one country RFID UHF frequency band.

The proposed antenna can be used for RFID reader system. The proposed technique to generate circularly polarized radiation is useful for compact circularly polarized microstrip antenna designs.

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