DIRECTLY-COUPLED MICROSTRIP ARRAY ANTENNAS FOR WIDEBAND APPLICATION

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Abstract

A method for increasing the bandwidth of microstrip array antenna by adding additional resonator, which is directly – coupled to the non – radiating edges of a radiating element is narrated. The experimental result of four elements non-radiating edge directly – coupled rectangular microstrip array antenna (FNCRMAA) shows wide band with bandwidth of 15.63 %. Further extending the elements of array to eight elements non-radiating edge directly – coupled rectangular microstrip array antenna (ENCRMAA), the antenna shows improved impedance bandwidth up to 20.76 %. The design specifications, radiation patterns and gain of the proposed antennas are shown and reported.

Keywords*: *Wide band, Non-radiating edge, direct – coupling, corporate feed, microstrip array.

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1. INTRODUCTION

The modern communication system needs multifunction devices, where users can obtain multiple services with only one instrument. In addition, compact technology is commonly demanded for multi-band and wide-band applications. Microstrip patch antennas are broadly used because of their many advantages, such as the light weight, lower profile, and conformity. On the other hand, these antennas have a main drawback by its narrow operating bandwidth [1]. Researchers have made a lot of efforts to overcome this problem and various configurations have been presented to widen the bandwidth. Though, the bandwidth and the size of an antenna have generally mutual conflicting properties, that is, enhancement of one of the characteristics normally results in degradation of the other.

A new configuration has been proposed for wide band operation without increasing the effective area. The concept of direct-coupling is used for designing a single layer four elements array. Further, the study is extended for eight elements array and the obtained experimental results are presented and discussed.

2. DESIGN SPECIFICATIONS

A low cost glass epoxy substrate material is used to design the proposed antennas with the dielectric constant εr = 4.2 and thickness h = 1.6 mm. Fig. 1 shows the geometry of FNCRMAA.

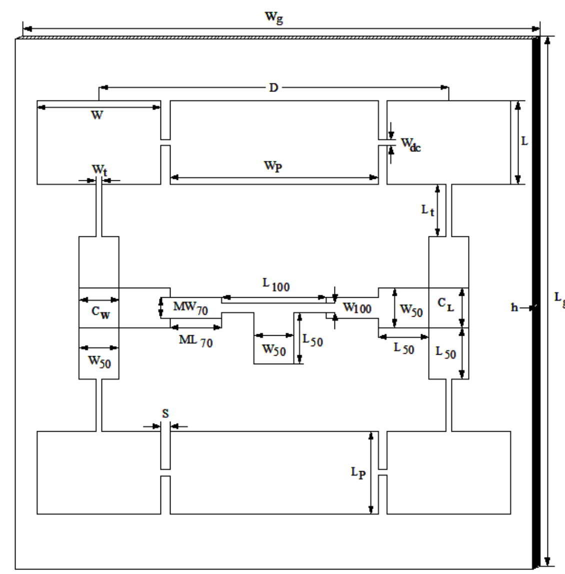

Fig-1: Geometry of FNCRMAA

Radiating patches of array are designed for the frequency of 9.4 GHz with dimensions L = 6.6 mm and W = 9.9 mm. While, for the proposed antenna the radiation pattern is measured with the help of bench and in bench it is observed that the microwave source i.e. Gunn oscillator starts to give more power from 9.4 GHz, hence we have taken 9.4 GHz as the design frequency . An optimized non-radiating element of dimension of length, LP = 6.6 mm and width, WP = 17.2 mm is placed between the radiating elements, which forms the non-radiating edge which is direct-coupled. The distance between parasitic and the radiating element S is optimized and is taken as 0.025 λg, where λg is the operating wavelength in mm [2]. The direct coupling is done through a coupler with width Wdc = 0.4 mm and it is an optimised dimension. The length will be same as S. Length Lg = 48.2 mm and width Wg = 50.5 mm of ground plane of antenna is calculated using the equations; Lg = 6h + L and Wg = 6h + W [3]. The radiating array elements are excited through simple corporate feed arrangement. This feed arrangement consists of matching transformer, quarter wave transformer and coupler for better impedance matching between feed and radiating elements [4].

The two-way power divider of 100 Ω of dimension L100 = 8.3, W100 = 0.7 mm is used between impedances of 70 Ω matching transformer of measurements ML70 = 4.1, MW70 = 1.6 mm and 50 Ω of dimension L50 = 4.1, W50 = 3.1 mm. A link of dimension CL = CW = 3.1 mm is used between 50 Ω microstrip lines to couple the power [5, 6]. The 50 Ω microstrip line is connected at the centre of the driven element through a quarter wave transformer of dimension Lt = 4.1mm, Wt = 0.4 mm for better impedance matching. To the 50 Ω microstrip line feed, a coaxial SMA connector is connected for feeding the power. Elements of array are kept at a distance of D = 27.9 mm from their centre point. This distance is chosen to attain minimum side lobes in the radiation pattern and to add the radiated power in free space [7]. Further, the study is carried out for ENCRMAA. Fig. 2 shows the geometry of ENCRMAA

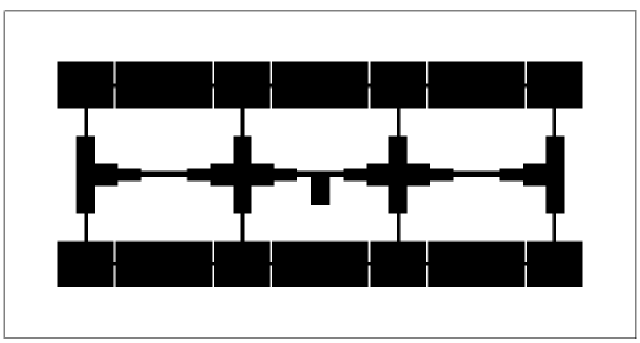

Fig-2: Geometry of ENCRMAA

3. RESULT AND DISCUSSION

Impedance bandwidths for the proposed antennas are measured. The measurements are taken on Vector Network Analyser. Graph of reflection coefficient vs. frequency of *FNCRMAA* and *ENCRMAA* are shown in Fig. 3.

From figure 3, it is observed that *FNCRMAA* offers wide band in the range 9.32 to 11.70 GHz, resonating at 11.08 GHz, with magnitude 1740 MHz (15.63 %). When compared to the single radiating element (2.85 %) the bandwidth is 5.48 times more than the proposed antenna. Although the patches are calculated for 9.4 GHz frequency, the proposed antenna is resonating near to 11.08 GHz. This may be due to parasitic patch with longer width compared to the width of designed patch. The together resonance of each element with parasitic coupling results in the improvement of impedance bandwidth [2]. The minimum reflection coefficient is measured and is found to be -26.40 dB.

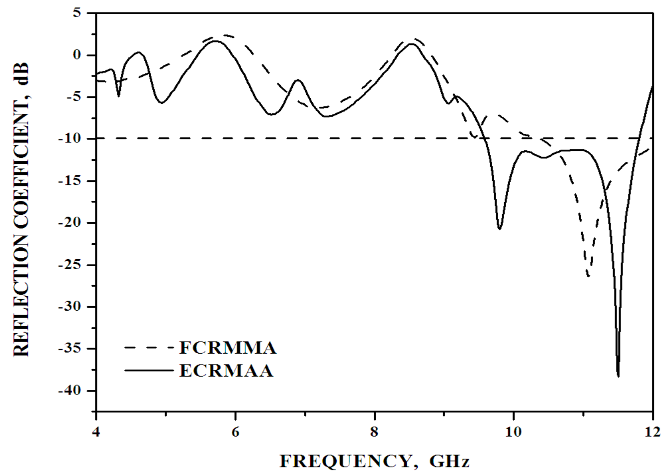

Fig-3: Graph of reflection coefficient versus frequency of FNCRMAA and ENCRMAA

Again, from the graph it is apparent that ENCRMAA is resonating for single wide band with a magnitude of 2220 MHz (20.76 %). When compared with FNCRMAA the impedance bandwidth of ENCRMAA is 1.32 times more. The minimum reflection coefficient in this antenna is found to be -38.34 dB at 11.50 GHz.

The H-plane co-polarization and cross-polarization radiation patterns of *FNCRMAA* and *ENCRMAA* are measured at resonating frequency with minimum return loss and are shown in Fig. 4 and 5. It is clear from these figures, that both the antennas are showing broad side radiation characteristics in nature with lower cross polarization level which are less than -11 dB and -16 dB for *FNCRMAA* and *ENCRMAA* respectively.

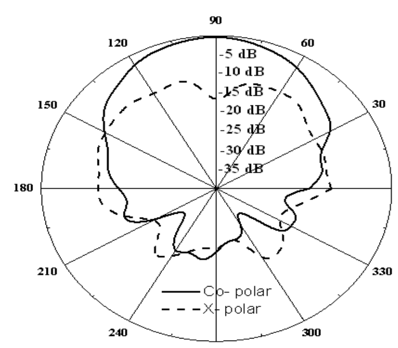

Fig-4: Radiation pattern of FNCRMAA at 11.08 GHz

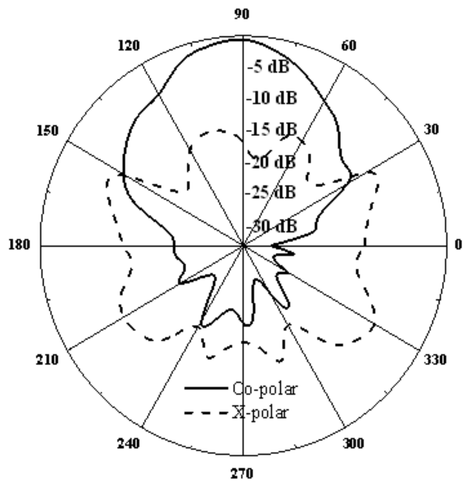

Fig-5: Radiation pattern of ENCRMAA at 11.50 GHz

HPBW's of *FNCRMAA* and *ENCRMAA* are calculated and are found to be 62^0 and 39^0 respectively. When compared to [8, 9], the HPBWs of the proposed antennas are improved.

The gain is measured, the power transmitted (P_t) by the pyramidal horn antenna and the power received (P_s) by *FNCRMAA* and *ENCRMAA* are calculated separately. With the help of obtained data, the gain of antenna under test (G_T) in dB is calculated using the equation [9],

$$(G_T)_{dB} = (G_s)_{dB} + 10 \log (P_t/P_s)$$

Where, *Gs* is the gain of standard pyramidal horn antenna. It is seen that the gain of *FNCRMAA* and *ENCRMAA* are 2.14 dB and 2.45 dB respectively. When compared with *FNCRMAA*, the gain of *ENCRMAA* is improved by 1:1.14 ratios. It is clear that by using array configuration and direct – coupling technique, the gain of the antenna also improves considerably [10].

4. CONCLUSIONS

The experimental study reveals that, the antennas are simple in fabrication and design as well as quite good in improving the impedance bandwidth and give better gain with good broadside radiation pattern at the resonating frequencies. The wide-band microstrip patch array antenna can provide an option to large bandwidth planar antennas, in applications in which large bandwidths are needed for operating at two separate transmit-receiver bands. Moreover, the antennas are also better as they use single layer low cost substrate material and find vast applications in modern communication system, microwave wireless communication system and in radar communication systems.

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