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A Review on Microstrip Circular Patch Antennas for Wireless Communication

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ABSTRACT

Circular patch micro strip antennas are the light weight, low cost, low volume and easily manufacturable antennas and becoming progressively popular due to their additional advantages of its compatibility with microwave, millimeter integrated circuits (MIC's) and monolithic microwave integrated circuits (MMIC's) because of this reason they are also capable of producing Circular polarization which finds application in airborne and spacecraft application. Changing the design of Circular patch microstrip antenna with respect to its radius, slots and feeding techniques as our motive was to achieve miniature antenna with better results in terms of return loss and bandwidth and impedance matching than conventional antenna's. The solution provided by IE3d which is method-of-moments-based electromagnetic (EM) software. It is analytical and therefore more methodical and accurate than numerical and ray tracing techniques. This paper reviews the performance analysis of A circular patch antenna which provides linear polarization and monopole-like radiation pattern [2016], Circular Array Patch Antenna of 2 × 1 array dimensions with Double Circular Slots [2015], Annular-Ring Slot Antenna for WiMAX and WLAN Applications and giving Circularly Polarization [2014] and Microstrip Antenna of Narrow Half-Ring and Half-Circular Patch giving Dual-Frequency band [2013].

Keywords : Circular Patch, MMIC's , MIC's, Linear Polarization, Low Cross-Polarization, Monopole-Like Radiation Pattern

I. INTRODUCTION

A circular patch antenna is a type of radio antenna with a low weight, low profile, and low cost. It made up of four parts (patch, ground plane, substrate, and the feeding part). The metallic patch which is normally made of thin copper foil plated with a metal which is immune to corrosion, such as gold, tin, or nickel and the feed lines are usually photo etched on the dielectric substrate. A circular patch antenna is a appropriate for WiMAX-WLAN applications, navigation systems and many others [5]. Consider the circular microstrip antenna with radius a, height h and permittivity constant εr and Wavelength in free space λo=c/ fo where c is the velocity of light in air. Therefore the resonant frequencies for the TMmn0 modes can be written as [6],

$$(f_r)_{mn0}=\frac{1\,(X'mn)}{2\pi a\sqrt{\mu\varepsilon\varepsilon}}\ \text{GHz}$$

$$a=\frac{f}{\left\{1+\frac{2h}{\pi\varepsilon r F}\left[\ln\left(\frac{\pi f}{h}\right)+1.7726\right]\right\}^{1/2}}$$

Because of fringing effect antenna looks larger than actual size and therefore a correction in the equation of radius is done by introducing an equation of effective radius a_e

$$a_e = a\left\{1+\frac{2h}{\pi\varepsilon\varepsilon r a}\left[\ln\left(\frac{\pi a}{2h}\right)+1.7726\right]\right\}^{1/2}$$

$$(f_r)_{110}=\frac{1.8412\,v}{2\pi a e\sqrt{\varepsilon r\varepsilon}}$$

II. METHODS AND MATERIAL

Literature Review

The development in the context of Circular patch microstrip antenna is our focus area. This review paper concentrates on the comparative study of four different research works; in a recent study Shuo Liu [1] made a theoretical analysis of A circular patch antenna which provides linear polarization and monopole-like radiation pattern for wireless communication systems. The approach was to first design a circular patch annular ring antenna according to [7] and [8] to produce a single mode and then change its radius r1, r2 for effective result. Figure 1 shows the front view of the Circular Patch Antenna and Figure 2 shows the relationship between the radius r1, r2 and the bandwidth. Note that the impedance bandwidth and return loss is significantly improved when the parameters r1 and r2 are properly adjusted from 3mm to 5mm for r1 and 5.2 mm to 7.2 mm for r2 respectively the frequency alters from 5 GHz to 5.7 GHz and return loss have been achieved −16 dB to −26 dB respectively. Impedance bandwidth of 36.5% at center frequency 5.7 GHz is been achieved. The measured peak gains are 9.7 and 9.1 dBi, respectively.

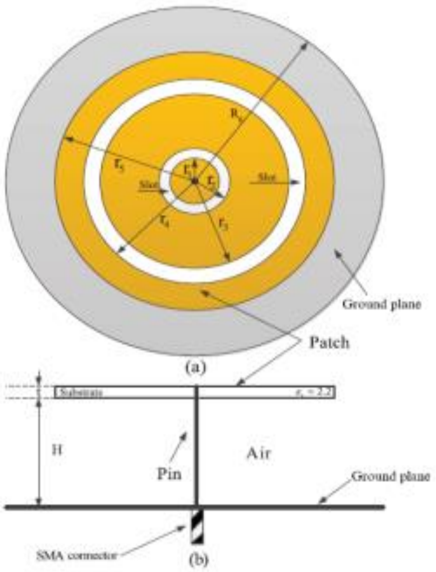

Figure 1. Front view of the Circular Patch Antenna

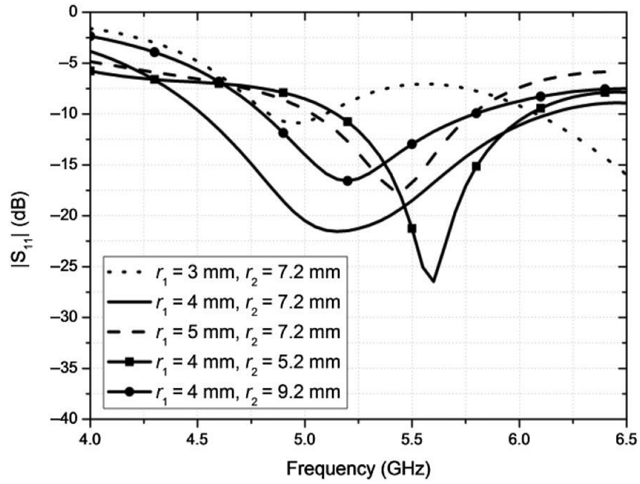

Figure 2. Bandwidth and Return loss performance of the Circular Patch Antenna

Circular Array Patch Antenna of 2 × 1 array dimensions with Double Circular Slots was successfully developed by Nik Muhammad Farid Nik MohdSalleh et al. [2]. Figure3 shows the front view of the 2 × 1 circular patch antennas having double circular slots of radius R1 and R2 with microstrip feeding. The first approach of this design was to create two slots with radius of R1=5.0 and R2=2.1 mm and then change its radius R1 and R2 to control the radiation characteristic. When the radius R1 changes from 4.2 mm to 6.2 mm, the frequency alters from 2.381 to 2.378 GHz and return loss have been achieved −23.803 db to −29.214 db respectively and when radius R2 increases from 2.1mm to 4.1 mm keeping R1 constant, the operating frequency increases from 2.367 to 2.341 GHz and the respective return loss are −18.885 db to −22.716 db as shown in Fig 4 and Fig 5. The impedance bandwidth for this proposed antenna fluctuates around 52 MHz, in the frequency range between 2.375.

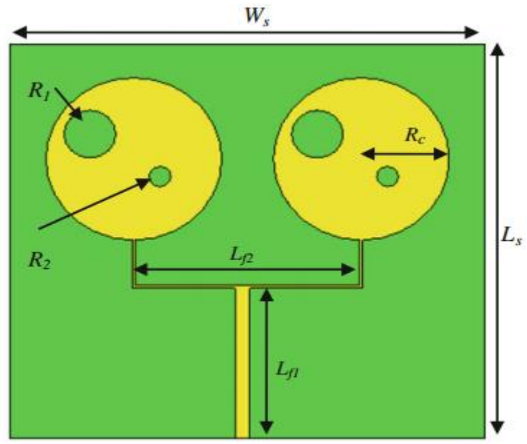

Figure 3. A front view of 2 × 1 circular array patch with double circular slots,

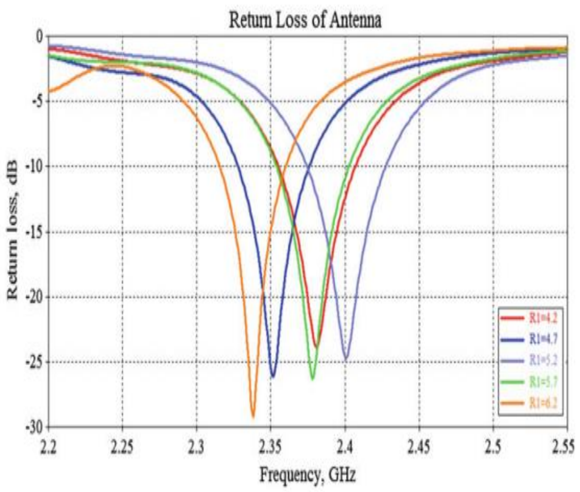

Figure 4. Return loss performance of the 2 × 1 circular array patch antenna with different radius dimension of R1

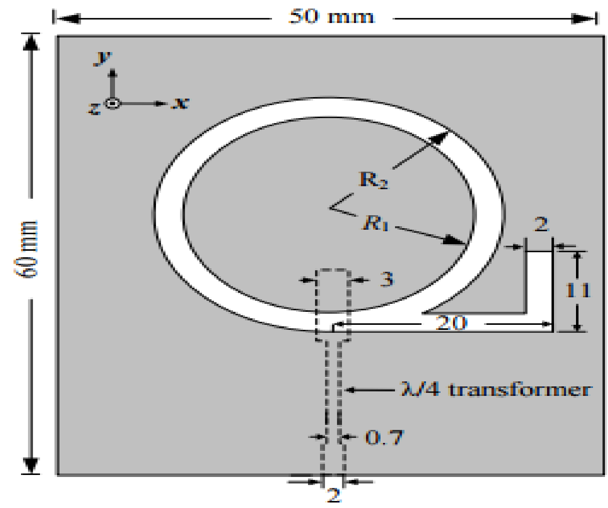

Figure 6. Geometry of proposed ARSA with inverted L-shaped slot

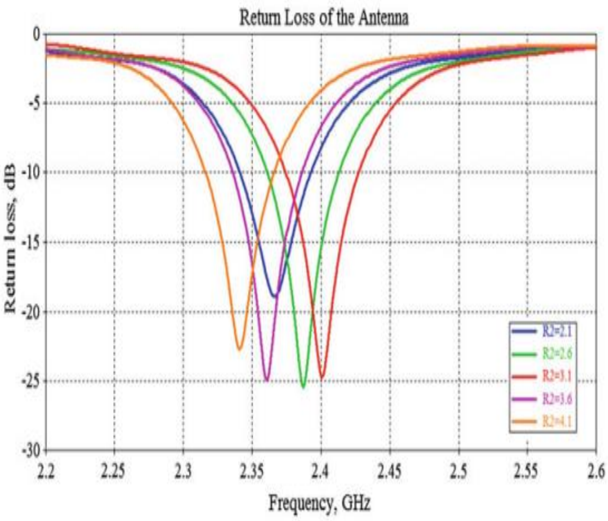

Figure 5. Return loss performance of the 2 × 1 circular array patch antenna with different radius dimension of R2

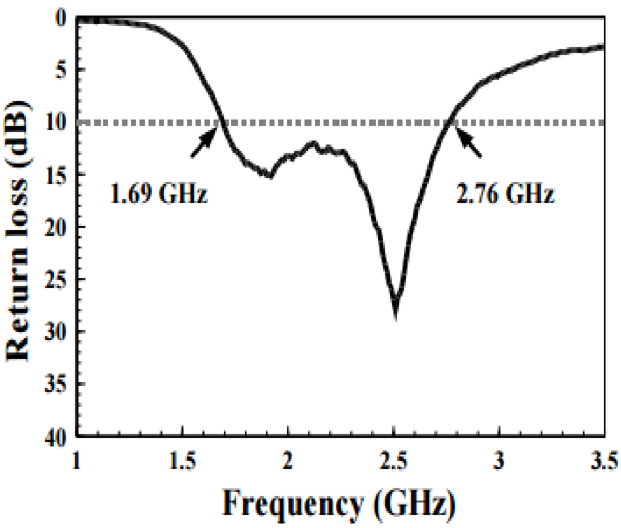

Figure 7. Return loss performance of proposed CP ARSA.

Annular-Ring Slot Antenna for WiMAX and WLAN Applications providing Circularly Polarization is studied by Chow-Yen-Desmond Sim* et al [3]. In this design loading an inverted L-shaped slot into the bottom section of the CP-ARSA is proposed as shown in Fig 6. In Fig 7, the impedance bandwidth of the proposed CP ARSA was measured between 1.69 and 2.76 GHz (48%) and the maximum value of return loss is -28 db. This antenna can cover both the WiMAX 2.3 GHz and WLAN 2.4 GHz operating bands and its corresponding 3-dB Axial Ratio bandwidth was approximately 8% for the band of 2.29–2.48 GHz. Antenna gain varies between 5.06and 5.41 dBic for the frequency band of 2.3 to 2.5 GHz.

Further Xin Hu et al. [4] demonstrated performances of Microstrip Antenna of Narrow Half-Ring and Half-Circular Patch giving Dual-Frequency band. Here the dual-frequency is generated because of half-circular patch element and half-ring which is narrower than the conventional ring antenna structure. Dual band can also be generated using notching or adding the slots [9] and the stubs [10] to patch antennas and by using monopoles [11].

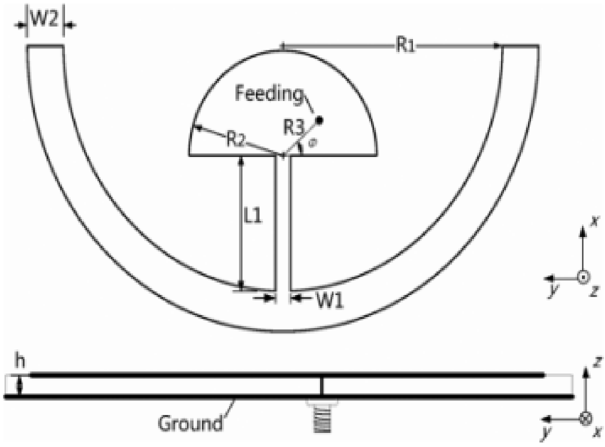

Figure 8. Layout of the dual-frequency microstrip antenna of Narrow Half-Ring and Half-Circular Patch

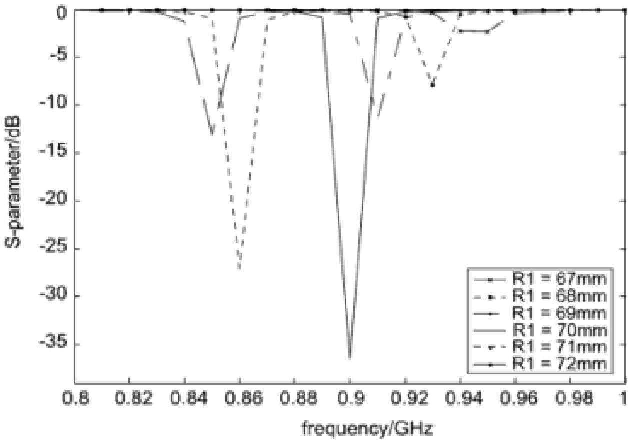

Figure 9. Simulated S_{11} with different $R_1$for Narrow Half-Ring and Half-Circular Patch

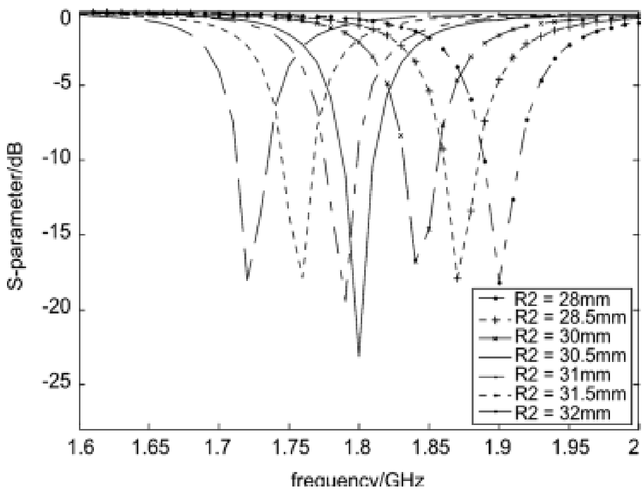

Figure 10. Simulated S_{11} with different R_2 for of Narrow Half-Ring and Half-Circular Patch

III. RESULTS AND DISCUSSION

This section concentrates on structure of the narrow ring. For the feeding process a microstrip line is used. Figure 9 illustrates the layout of the proposed microstrip antenna. In the designing process when the radius of the half-circular patch R1 changes from 67 to 72 mm, the frequency alters from 0.95 to 0.86 GHz and when radius of the half circular patch R2 decreases from 32 to 28 mm keeping R1 constant, the operating frequency increases from 1.72 to 1.91 GHz, and max return loss have been achieved −36 db to −23 db respectively according to the principle the larger the radius, the lower the resonant frequency, and vice versa as shown in Fig 10 and Fig 11. The measurements results show that on the two resonant frequencies 0.9 and 1.8 GHz, the proposed antenna has a gain of 4.83 and 3.26 dBi respectively.

Table I. Literature Review

Years / Antenna parameters	2016	2015	2014	2013
No. of Band	**Single band**	**Dual band**	**Single band**	**Dual band**
Frequency range (GHz)	5 to 5.7	2.387 to 2.378 and 2.367 to 2.345	1.69 to 2.76	.95 to .86 and 1.72 to 1.91
Center frequency (GHz)	5.7	2.337 and 2.387	2.5	.9 and 1.8
Return loss (dB)	-16	-29.2141 and -25.2	-28	-365 and -23
Gain (dBi)	9.1	–	5.06 and 5.41	4.832 and 3.26
Bandwidth	36.5%	-	48%	-

IV. CONCLUSION

The comparative study of the different dimension for radius is also shown in this paper. The right dimension of radius can affect the location of the resonant frequency of the antenna which further improved its performance in terms of return loss -36 dB and bandwidth 48%. This review provides an insight in enhancing the performance of the Circular patch micro strip antennas by introducing annular-ring patch antenna in place of conventional circular patch antenna. It results high gain 9.1 dBi and high impedance matching and by using the single model excitation, the low cross-polarization can be achieved for a wireless communication system. The introduction of circular patch array technique also gives rise to a dual-frequency band.

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