

Circularly polarized microstrip patch antenna array for GPS application

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ABSTRACT

The 12 elements antenna array for GPS system having high gain with circular polarization is presented in this paper. The circularly polarized antenna is very suitable for the use of various wireless systems such as Global Positioning System with operating frequency is 1.27 GHz with AR is less than 3 dB between 82° and 140°. The antenna consists of twelve main radiation patches connected in parallel. The antennas array are designed on the Rogers RT5880 substrate with a dielectric constant (ϵ_r) of 2.2 and thickness is 0.787 mm. The antenna is excited with an inset feed line and it operates in L-band with a resonant frequency of 1.27 GHz.

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1. INTRODUCTION

Global Positioning System (GPS) antenna should be an innovative low-profile and lightweight antenna as it has become a crucial component in gaining precise positioning with low acquisition time. The wide range of frequencies and broad radiation beam are required to cover most part of received signal from satellites. Besides, high gain and low axial ratio which is less than 3dB of the GPS antenna is able to reduce multipath error in GPS system. A receiver antenna that functions with multiple GPS frequencies are required to have the above features over a wide bandwidth [1-3].

In this paper, circular polarisation (CP) microstrip patch array antennas have been studied in terms of types of CP microstrip patch array antenna design and feeding techniques. Circular polarization is one of the key features that should be implemented in the GPS system as it is more flexible orientation of transmitting and receiving antenna [4]. Moreover, it can eliminate overcoming multipath effect and enhance weather penetration and mobility [5]. However, it is difficult to build the good and circularly polarized antenna. There are two commonly used CP microstrip patch array antenna, single feed [6, 7] and dual feed antenna [8, 9]. Although the axial ratio of single feed CP antenna is narrow, it become very attractive because the patch elements can be arrayed and easily feed like any linearly polarized antenna.

Microstrip patch antenna array has led to commendable choice in the commercial wireless applications in radar system, satellite communication and global positioning system due to ability to generate circular polarisation. Circular polarisation is performed by arrangements of radiating elements and feeding network structures [10]. Many feed networks structures have been investigated to perform circularly polarized antenna such as Sequentially Rotated Feed [11, 12], H-shaped aperture coupled feed [13], cross

aperture coupled feed [14], and so on. In addition, number of feeding points required to produce circular polarisation waves also has been studied. Two fed network was implemented on two stacked substrates to feed with 180° phase shift to achieve CP [15]. However, single feeding techniques are common with microstrip patch antenna as there are simple, easy to manufacture, compact in structure and low in cost. [16-19].

The dual feed CP antenna require an additional circuit that requires more space and adds more complexity to array designs. Factors required for evaluation of an antenna's performance include radiation pattern, gain, impedance bandwidth and polarization [20]. An antenna polarization is a very imperative consideration when selecting and establishing an antenna. Knowing the difference between polarizations and how to take advantage of their benefit is very significant to the antenna applications. Compared to a linear sensor, a greater amount of information about scenes and targets being imaged would be provided with a circular polarization sensor. In general, microstrip patch antenna array are linearly polarized, but they could be designed to generate circular polarization using some techniques [21]. In general, circular polarization techniques on the number of feeding or the shape of the patch antenna [22]. In this paper, single microstrip antenna, 2x2 microstrip patch antenna array and 6x2 microstrip patch antenna array is proposed. The main objective to design and built a microstrip patch antenna array with circular polarisation by using CST Microwave Studio. The array is connected with single microstrip feedline operated at 1.27 GHz with an impedance of 50 Ω.

2. ANTENNA DESIGN

2.1. Microstrip Antenna

Microstrip patch antenna has become a very important class of antennas since the received attention in the early 1970s. Based on microstrip antenna features such as easy to manufacture, lightweight and compatible with monolithic integrated circuits (MMICs) can produce optimum antenna performance as compact size, low profile and low cost [23]. However, the main disadvantages of the microstrip antennas are not suitable for high power applications, narrow bandwidth of less than 5%, low efficiency, low (RF) power due to the small separation between the radiation patch and the ground plane [24].

The single element design is the microstrip patch with a rectangular with a feedline having a characteristic impedance of 50 Ω the dimension and structure depicted in Figure 1. The single element antenna is proposed by using Rogers RT5880 board which have a dielectric constant of $\epsilon_r = 2.2$ mm with a substrate thickness is 0.787 mm and a 0.035 mm copper thickness.

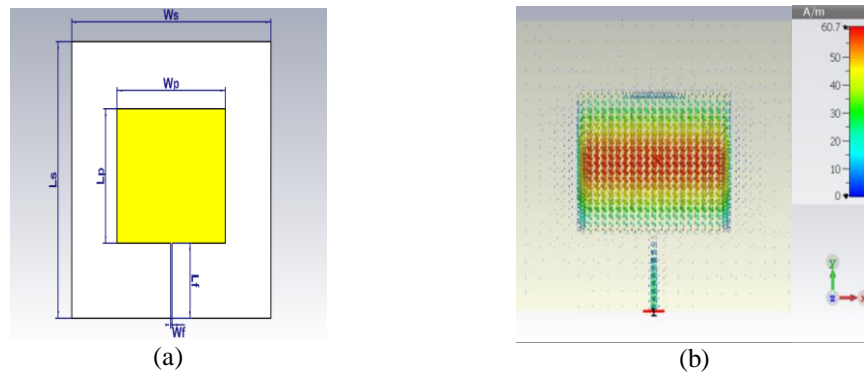


Figure 1. Single Patch Antenna Element (a) antenna design (b) surface current distribution

2.2. Array design

In array design, number of elements in array combination indicates the performance of gain and directivity. More elements are typically performing larger gain as provided by single element. Optimisation of necessary elements depends on the requirement of gain characteristic to minimise the cost. First, the set of 4 element array is combined in parallel with the dimensions of each elements is remained constant as shown in Table 1. Some other consideration must be taken into array design is element spacing. In [25] array element has to be far between two elements to avoid mutual coupling and grating lobes in the radiation patterns. The horizontal distance between the patches is 53.03 mm and the vertical distance between the patches is 62.53 mm as shown in the Figure 2. Corporated feed network with T-junction method is proposed

to control of the feed for each elements. 12 elements antenna array is designed to enhance the gain directivity for GPS system as shown in Figure 3. The dimension for each patch is remained same as show in Table 1.

Table 1. Dimension of Antennas

Parameters	Single Patch (mm)	2×2 Array (mm)	6×2 Array (mm)
Length of the substrate (L_s)	160	360	380
Width of the substrate (W_s)	160	280	775
Patch length (L)	77.92	77.47	76.55
Patch width (W)	86.97	86.97	85.31
Distance ($d1$)	-	53.03	54.69
Distance ($d2$)	-	62.53	63.45

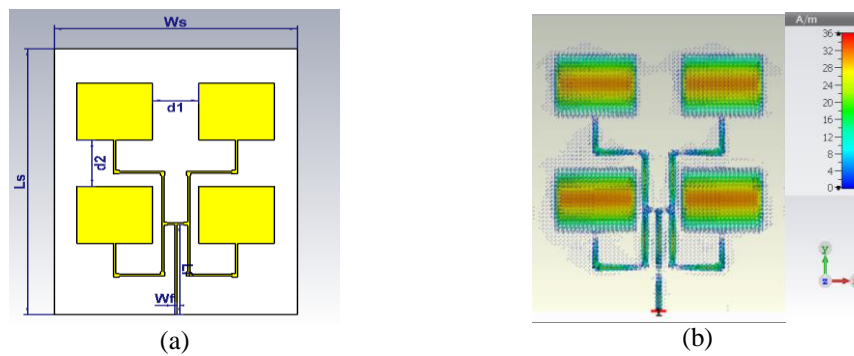


Figure 2. (2×2) Elements Antenna Array (a) antenna design (b) surface current distribution

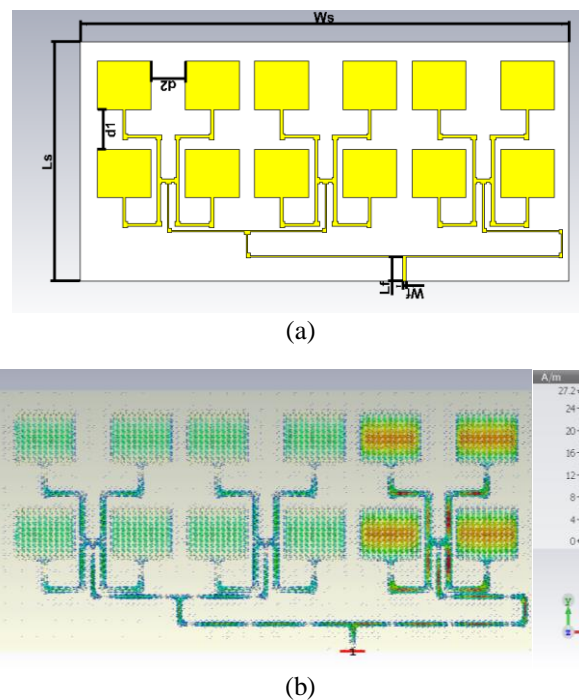


Figure 3. (6×2) Elements Antenna Array (a) antenna design (b) surface current distribution

3. RESULTS AND ANALYSIS

The performances of the proposed antennas have been compared based on the simulated result from three different radiating elements. According to Figure 4, the bandwidth becomes narrow when more radiating patch elements have been employed which is 12 elements. From the single element, microstrip

antenna performed at 1.27 GHz with return loss is -13.11 dB. Reflection coefficient for four elements antenna has performed slightly different as compared to single element which is -12.01dB.

As shown in Table 2, the performance of 12 elements of antenna array is performed better return loss which is -34.62 dB with the bandwidth 7.3 MHz satisfies the (<-10dB). The gain of 12 elements is increased 28% from 10.2 dB performed by four elements as shown in Figure 5. Moreover, the directivity of 6x2 elements also greater than others which is 23%. The radiation pattern of 12 elements is high directional pattern as compared to 4 elements with 15.9dB of directivity. Axial ratio of 12 elements is shown in Figure 6. According to the graph, AR is less than 3 dB between 82° and 140°. A good directional radiation patterns of proposed antenna is improved as the number of elements is increased as depicted in Figure 7.

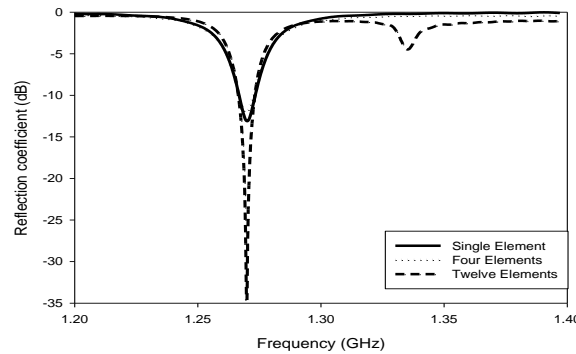


Figure 4. Reflection coefficient curve of proposed antenna

Table 2. Results of Antennas

Parameters	Single Patch	2x2 Arrays	6x2 Arrays
Return loss (dB)	-13.11	-12.01	-34.62
Bandwidth (MHz)	8.2	9.4	7.3
Gain (dBi)	5.38	10.2	13.1
Directivity (dB)	7.82	12.9	15.9
VSWR	1.5	1.7	1.04
Polarisation	Linear	Linear	Circular

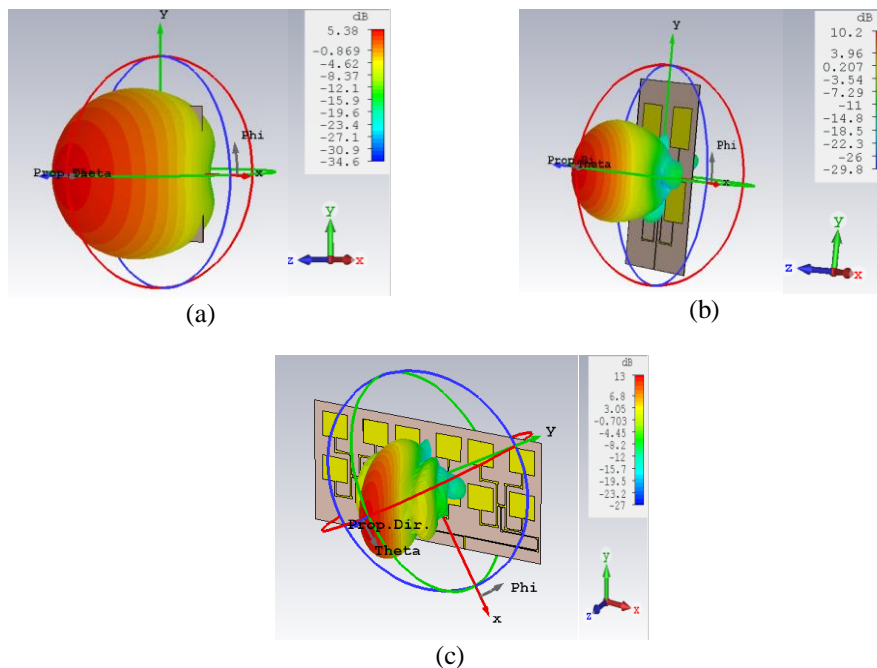


Figure 5. The directive gain from the simulated 3D radiation pattern (a) single element antenna (b) 2x2 elements array antenna (c) 6x2 elements array antenna

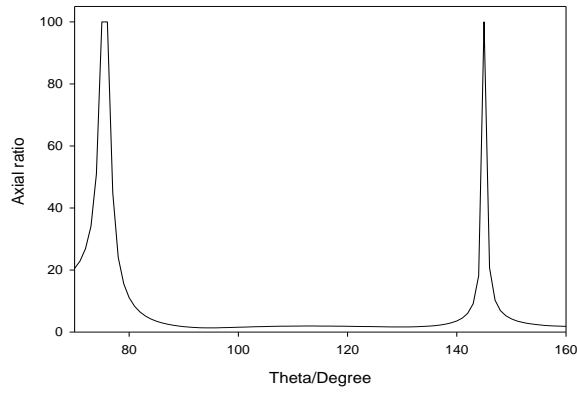


Figure 6. Axial Ratio for 6x2 elements antenna array

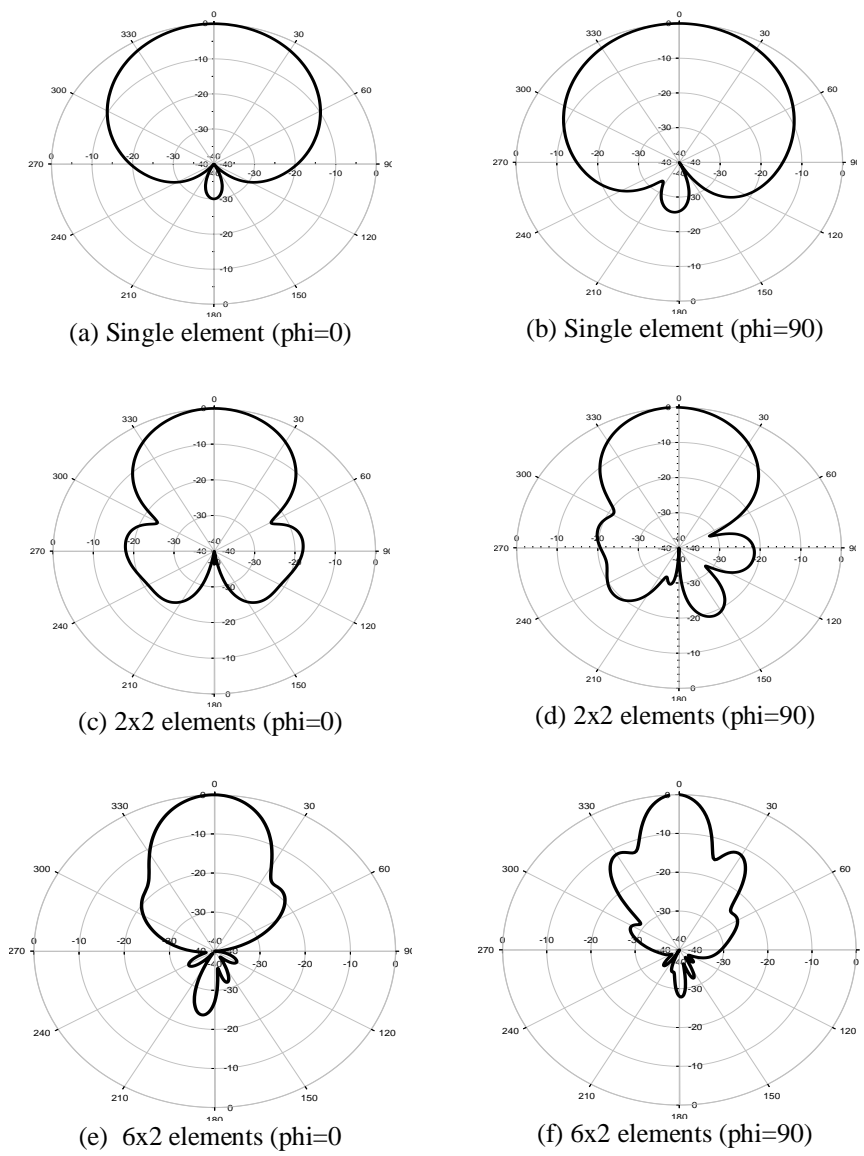


Figure 7. Radiation pattern for H-plane and Eplane

4. CONCLUSION

A 12 elements antenna array has been proposed for GPS applications. More radiating elements antenna array helps to achieve circular polarization and high gain to mitigate multipath fading. It is observed from antenna performance that the proposed antenna achieved low axial ratio with wide angular range. As the result, there is 28 % increment of gain after 8 elements of proposed antenna is added. For directivity, the proposed antenna performs 23% increased with high directional pattern of radiation pattern.

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