Smart Antenna Arrays for Advanced WLAN: Performance analysis of Linear and square array approach for adaptivity through phase shifting in antenna feed

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Abstract. The WLAN is operated in some high traffic area where the radiation beam produced by the antenna is to be utilized with optimum efficiency. The aim of those antennas is to produce some directive and switched beams rather than producing Omni-directional pattern since these beam patterns are considered to be wastage in some non-used or low traffic areas. Hence, the antenna systems producing the directive and switched beams should be highly preferred for the WLAN application. A smart antenna array system performs the adaptive beam forming by focusing the beam in the desired direction and creating nulls in other directions to avoid the interference and the wasting of the beams. This is performed by operating the phase shifting in its feed network and different ports. This paper investigates the performance of the different array patterns with different phase shifting for the optimum performance of the WLAN applications in a highly congested indoor environment.

Keywords: Beam forming, array, adaptive antenna, WLAN, Linear array, Square array.

1 INTRODUCTION

In this revolutionary era of communication technology, the WLAN has become intensively popular for the various purposes such as Personal Area Networking (PAN), the high speed internet, the video streaming, multimedia and so on. For the remarkable change of the demand of wireless access in the indoor environment, WLAN has become a giant concern bearing in mind its performance and efficiency. Therefore, to ensure the high data rate and the effective use of the network, the compensation of the multipath effects and the co-channel interference have grown to be a matter of great interest. In addition, the high gain and the high coverage of the WLAN to a desired direction of high traffic with reducing the dead spot in an indoor environment also became a high priority for the researchers.

In earlier version of WLAN, the simple dipole antenna is used which exhibits Omni-directional pattern which means the signal is scattered to all direction with low gain and efficiency and hence the users with high quality signal achieve the small percentage of the signal compared to their demand while the signal is wasted in other areas with low demand. Even boosting the radiation of this antenna, the performance cannot be improved, as the signal being boosted to all directions. The smart antenna array enhances the radiation efficiency by producing the distributed current throughout the whole area. This distributed current produces the directive beams and narrow or pencil beam and those directive beams can be switched towards the desired direction by using the phase shifting technique in its feed network [1].

In this paper, the antenna array is designed with typical micro-strip patch antenna for its compactness and simplicity as the research aims at the compact and low cost design for the WLAN application. These antennas are compatible with MMIC design and exhibit robustness when they are designed on some rigid surfaces [2]. Taking the array into Consideration, the multiple elements can be mounted on the same plane which increases the compactness in terms of thickness of the antenna system for the WLAN. This design does not require any LINC (Linear amplifications with Non-linear Components) Power Amplifier, hence, no risk of imbalance of the gain when practically implemented [3]. Due to simple feed network even with increasing elements, this design is not limited to a 4X4 Butler matrix. [1]. This paper presents a simple linear and planar array system which exhibits a wide range of switching options and that eliminates the requirement of a complicated network such as a hexagonal 7 element array [4].

2 WIRELESS LAN

Because of being unlicensed, the users using the same ISM frequency band may face high level of interference for lower level of separation between the frequency bands which is an obstacle to get higher data rate and overall higher performance [5]. The level of interference severely increases with increment of the level of demand and traffic concentration. To compensate the interference due to same ISM band, the band should be wider with less number of users which is the basic condition of avoiding interference between the channels. To avoid the interference and make directive beams towards the desired direction, there might be necessary several antenna systems with multiple APs or several mechanical systems associated with single AP which is not convenient in terms of design simplicity, cost and efficiency. Some modifications in the physical layer may improve the performance compensating the above limitations [5]. Among a number of solutions, the antenna design is a dominating factor which enhances the performance of the WLAN significantly. Therefore, it is essential to concentrate on the feature of the antenna rather than any other feature of the WLAN.

The IEEE 820.11 standard which includes the WLAN communication is set to be operated at 2.4, 3.6 and 5 GHz frequency. In this paper, the design frequency was selected as 2.4 GHz which is used by the IEEE 802.11b and 802.11g [6]. In WLAN system, the smart antenna array can be implemented as the adaptive antenna having switched beam system. The array of the patch antenna is considered as the four element array with different alignments and feed networking to operate in different phases. The feed network provides the directive beam after the phase is adjusted at different ports. Along with the changing of the phase and amplitude, the pattern, orientation of the elements can be adjusted to investigate the produced directive beam and switching of those beams. The side lobe associated with the main lobe is distributed according the priority of the traffic demand.

3 FUNDAMENTALS OF ANTENNA ARRAY

To achieve the desired directional radiation pattern, multiple radiating elements are needed to be configured providing interconnection between the elements. This arrangement is defined as array antenna, simply, an array. In other words, an array consists of two or more antenna elements that are spatially arranged and electrically interconnected to produce a directional radiation pattern. The interconnection between elements, called the feed network, can provide fixed phase to each element or can form a phased array. [7] Same level of performance of a single large antenna can be maintained by producing an array of many small antennas with the advantage of directivity and electronic scanning of the main beam. According to geometrical configuration basically two types of array are found - the linear array and the planar array. Additionally, phased array can be formed by introducing phase shift to the exciting current of each element of any array. This array is capable of scanning into space [6].

4 THE BEAM SWITCHING CONCEPTS

4.1. Linear Array

For the case of n-element linear array, if the relative phase excitation angle between the array elements is defined as α and the desired angle of the main beam switched to is θ, then,

$$\alpha = -kdn\cos\theta \qquad (1)$$

Where k is the wave number = 2Π/λ, d= inter element distance and n= total number of elements.

Exerting the arbitrary value of α, one can get the desired direction of the main beam of the considered array. Additionally, if the number of array (n) increased, the number of side lobes increase. The width of the side lobe and main lobe can be measured by the following formulae [8].

Width of the main lobe = 4Π/n
Width of side lobe=2Π/n

The above equations demonstrate the width of the lobes increased with decreasing of the number of element and this has got greater impact on the main lobe rather than side lobe.

4.2. Planar or Square Array

For a planar array, α have two dimensions-along x-axis (α_x) and y axis (α_y) where

$$\boldsymbol{\alpha_x = -kd_x\, n\, \sin\theta\, \cos\varphi} \text{ and } \boldsymbol{\alpha_y = -kd_y\, n\, \sin\theta\, \sin\varphi}$$

Here, d_x and d_y are the distance between elements along x and y-axis respectively which are kept in the range of λ/2 and λ/4. The beam directions are characterized by θ and φ. [8]

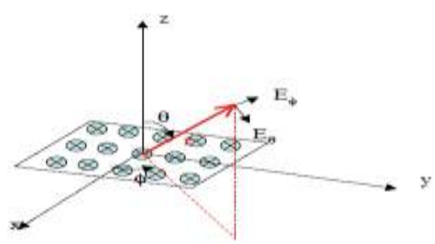


Fig. 1. Planar Array [8]

Hence, the beam can be oriented to the desired angle by adjusting the phase excitation angle (α) between the ports.

5 DESIGN METHODOLOGY OF SMART ANTENNA ARRAY

5.1. Designing the single element

In this paper the smart antenna array for WLAN AP is designed with micro-strip patch antenna. The conventional use of this antenna is in high performance aircraft, spacecraft, satellite and missile applications, where size, weight, cost, installation feature are some main issues to deal with. [2].

The designed frequency to operate the WLAN is 2.4 GHz. (for IEEE 802.11b and IEEE 802.11g). A quarter wavelength section is included for impedance matching between the feeding and the patch. [9] The dimension is nearly $\lambda_{eff}/4$, where λ_{eff}=free space wavelength/ √(dielectric constant) 125(mm)/√2.78 which produces effective wavelength of 74 mm. Hence we determine the length of the quarter wavelength section as 18.5 mm. [10] The width of the quarter wavelength section is approximately 0.65 mm.

The dimension of the patch is selected nearly as 20.25 X 34.8 mm (≈ $\lambda_{eff}/2$). [11] The height of the ground, patch, quarter wavelength section and the feed is 0.1 mm. The width of the feed is 3.5 mm and substrate height is 1.374 mm. The substrate used for the designed antenna is Rogers RT6002 with dielectric constant of 2.94. [12]

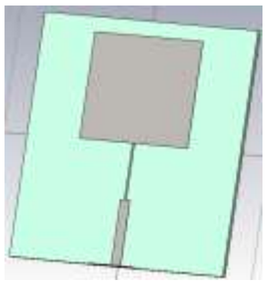


Fig. 2**.** Single patch Micro strip antenna

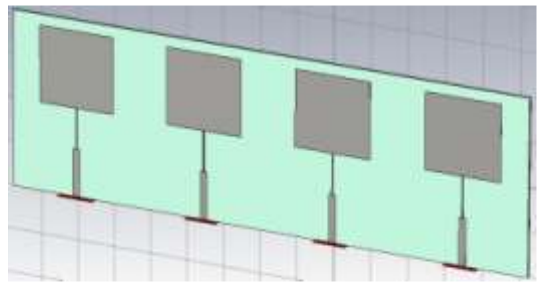
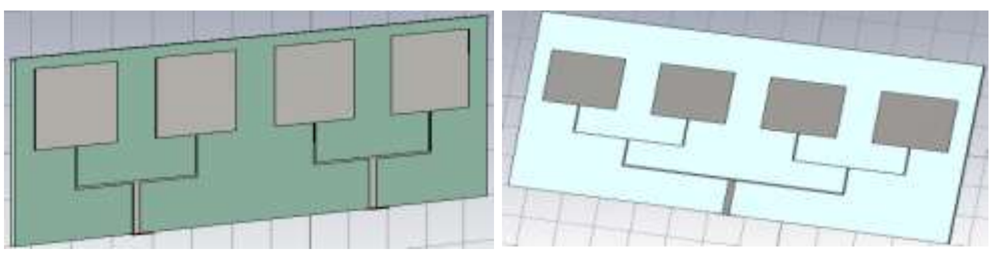


Fig. 3. Linear Array with Individual Feeds

5.2. Designing the Linear Array

The first approach is to design the linear array with four elements at the equal distance of 37 mm ($\lambda_{eff}/4$ <distance < $\lambda_{eff}/2$) by providing the feeds individually with the same ground plane and substrate as shown in fig.3. All the single elements are fed with different phase of current and the beam switching is observed. The same array is fed with two feeds and hence two branch feeds are included with two feeds as demonstrated in fig. 4 (a).



(a) (b)

Fig. 4. The Linear Array with (a) Two Feeds and (b) Single Feed

5.3. Designing the Planar or Square Array

Here, the four elements array is constructed in planar or square form. At first, the array is constructed with four individual elements where the inter element distance is 35 mm. The dimension of each element is the same as the single element. The pairs of the patch are placed opposite to each other with different feeds.

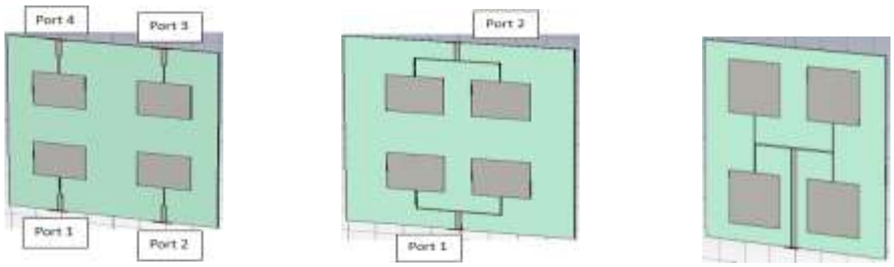


Fig. 5. The Square Array with (a) Four Individual Feeds (b) Two feeds (c) Single Feed

Fig. 5(b) shows the design of the square array with two feeds which involves two branch feeds of 0.96 mm connected to each of the 50 ohm main feed for impedance matching. The concept of this impedance matching is the same as the linear two feed array. Lastly, the square array is fed with single feed as shown in fig.5(c). The impedance is matched by following the same principle of the linear array. The inter element distance is kept in the range of, $\lambda_{eff}/4$ to $\lambda_{eff}/2$. [13]

5.4. The Comparison of phase shifting

In addition to examine the beam switching with different phases, the radiation pattern of the linear array with four feeds and two feeds are compared with the same combination of excitation angle in order to operate the equivalent feed network with less number of ports. For example, in case of individual feeds array, pair of patches are excited by two different angles (0 and 90 degrees) as shown in fig. 6. This result is compared to that of the two feeds array with the same excitation angle as shown in fig.7.

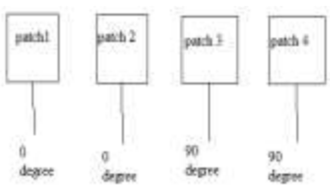


Fig. 6. Exciting the Pair of Patches with Same Angle

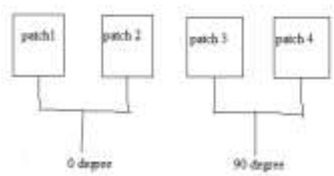


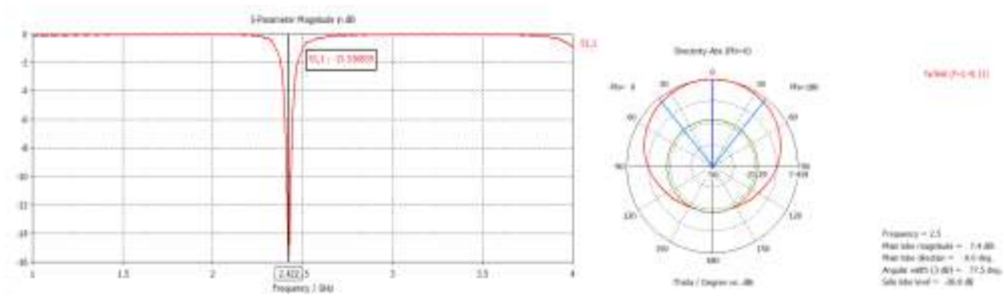
Fig. 7. The Equivalent Model with Two Feeds

The similar approach is taken in case of square array and the pattern is compared with same excitation which is found to be similar unless the phase is changed due to the feed network. For the single feed array, the pattern achieved with a single phase angle is matched with different angles in four feeds array and hence, different excitation angles are found at different elements of the single feed array due to the feed network.

6 RESULTS AND DISCUSSION

6.1. The Single Element

Fig.8a shows the S-parameter of the single element. The reflection coefficient is found as -15.53 dB at the resonant frequency of 2.42 GHz. Fig.11 depicts the radiation pattern of the single patch antenna which is completely directional with a main lobe magnitude of 7.4 dB. The magnitude of the associated side lobe is -26.8 dB.



(a) (b)

Fig. 8. The single element (a) reflection coefficient and (b) radiation pattern

6.2. Linear Array with Individual Feeds

6.2.1. The S-Parameters

The S-parameters diagram are shown below where at the resonant frequency of 2.42 GHz, the antenna exhibits reflection coefficients of -14.35 dB. The minimum isolation between reflection and transmission coefficients is more than 5 dB.

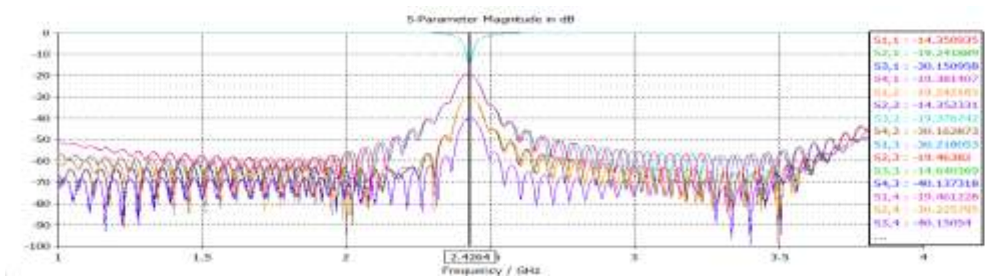


Fig. 9. The S-Parameters for Linear Array with Individual Feeds

6.2.2. *Formation of Switched Beam*

At the very beginning, no phase shift is introduced, which gives the narrow beam along zero degree along with some side lobs as from the equation (1). Here, the inter element distance d is 37 mm and k=wave number, n=number of elements.

Here, as the switched beam angle is 0 degree, the phase difference α is zero. Since the phase of all the ports is equal, there occurs a directive beam along the bore sight angle where there are nulls in all other direction.[14] So, for excitation, the first port is assumed as the left most and that is continued to the rightmost which is the fourth port.

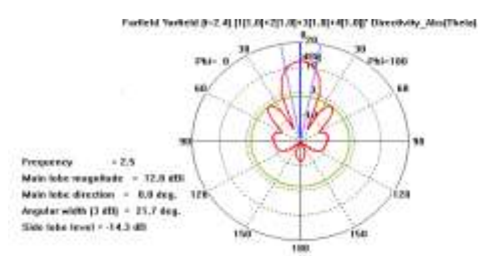
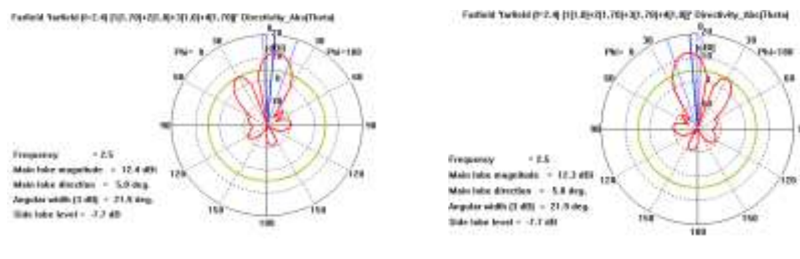


Fig. 10. The Beam Pattern for α=0 for Linear Individual Feed Array

Keeping the first two ports at as reference (0 degree), the other ports were excited with the same phase of 70 degree. So, here, the relative phase shift from 1st pair of patches to 2nd pair is 70. This gives the antenna main lobe direction towards 5 (θ) degrees as shown in fig. 11(a). Beside the 12.4 dBi main beam, the -7.7 dB side lobe is produced which has a direction of 30 degrees.

The main beam can be switched towards 5 degree left to the bore sight angle as shown in fig. 11(b). Here, all four patches have reversed phase shift with respect to first case. As the relative phase shift α is inverted (-70 degrees), the beam angle θ must be changed to another side of zero axis which caused the beam to be switched to 10 degree from previous position. The rotation is shown in (fig. 11).

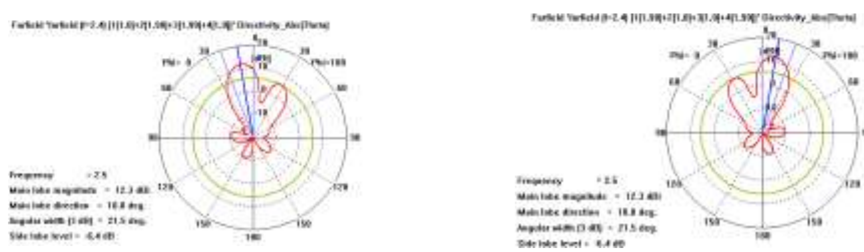


(a) (b)

Fig. 11. The Beam Patterns for (a) 0,0,70,70 and (b) 70,70,0,0 for Linear Individual Feed Array

The width of the main lobe is 4Π/N. Here, N = 4 (four elements). So, width is 22.9 degree (in decibel) after calculation whereas for minor or side lobe width is 4Π/N. Hence, the side lobe width is 19.54 degree.

In the similar way, by changing the phase shift between 0 to 90 degrees at either of the consecutive pair of patches, a 10 degree switching of the main beam for linear patch array about the bore sight angle can be obtained which is shown in fig. 12.

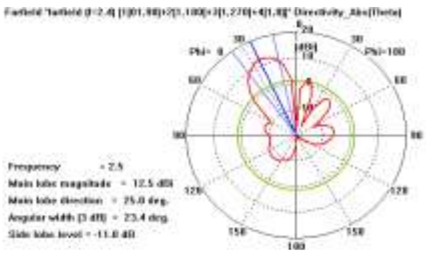


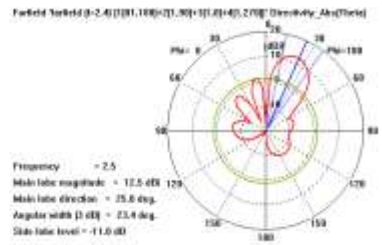
(a) (b)

Fig. 12. The Beam Patterns for (a) 90,90,0,0 and (b) 0,0,90,90 for Linear Individual Feeds Array

The switched beam angle θ is shifted to either side by changing the phase shift angle α (0-0-90-90 to 90-90-0-0). So, for a four elements linear array, with individual feeds, keeping one pair as reference and excitingly the adjacent pair of the patches with the same angle the main beam can be switched randomly to either side of bore sight angle.

Furthermore, exciting the feeds in an increasing order with same difference we get the following patterns. For example, having the consecutive phase of 0, 90, 180 and 270 degrees at four consecutive feeds, the beam switches 25 degrees from its initial position as depicted in fig. 13. If the orders of the phase excitation are reversed, the beam can be shifted to other side of bore sight angle to same degree. It means, we can get an overall switch of 50 degrees of the main lobe by just exciting the feeds with α=90 degrees apart and making the phase shifting in different ports in reverse order.

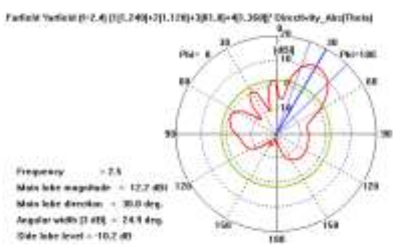


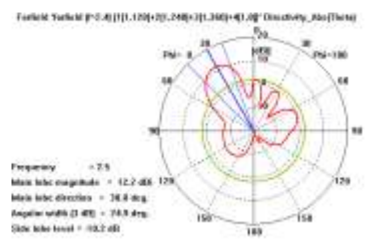


(a) (b)

Fig. 13. The Beam Patterns for (a) 180,270,90,0 and (b) 0,90,270,180 for Linear Individual Feed Array

If we increase the α, the θ will be increased as well that means the overall switching can be increased as shown in (fig. 14). The relative phase angle is set 120 degree (0,120, 240, 360/0), which produces a 30 degree directive beam and inversely, setting the as 360, 240, 120, 0 (α) produces the beam shifted to 30 degrees to the left of bore sight angle. So, the overall shifting of the beam is 60 degrees.





(a) (b)

Fig. 14. The Beam Patterns for (a) 0,120,240,360 and (b) 360,240,120,0 for Linear Individual Feed Array

6.3. The Linear Array with two feeds

6.3.1. S-Parameters

This array gives more reflections to the current and hence causes to be degraded as it propagates. The reflection coefficient not improved compared the individual feed array which is -9.145 dB at the resonant frequency of 2.418 GHz, with a separation of about 15 dB with transmission coefficients.

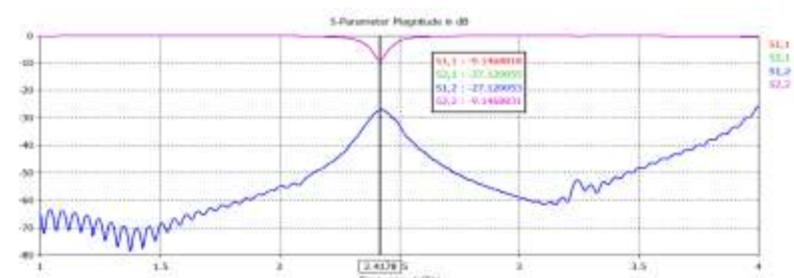


Fig. 15. The S-Parameter for Linear Array with Two feeds

6.3.2. Formation of Switched Beam

At first, the two ports are excited with similar angle (here α = zero) as before. So, the beam will be along bore sight angle with the maximum amplitude (17 dBi) which is shown in fig. 16. The null occurs at 30 degrees with a side lobe level of -14.1 dB. This side lobe appears for the individual element pattern with different phase shifting.

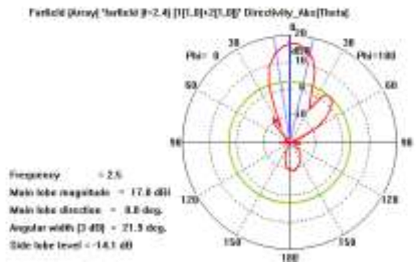
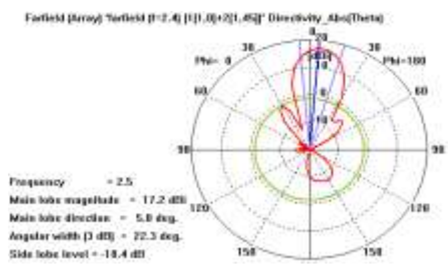
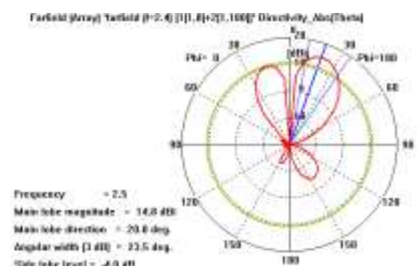


Fig. 16. The Beam Pattern for α=0 for Linear Two Feeds Array

For the case of phase excitation of 45 degrees, the main lobe becomes directive to 5 degrees as shown in fig. 17(a). If we change the phase excitation= -45, the direction of the beam can set to other side of the 0 degree angle axis with same angle.



(a)



(b)

Fig. 17. The Beam Patterns for (a) 0,45 (α=45) and (b) 0,180 (α=180) for Linear Two Feeds Array

After an increment of relative phase excitation (180 degrees), the pattern in fig. 17 (b) is found which exhibits the directive beam towards 20 degrees with a lower level of 14.8 dBi and a minor lobe of -4 dB.

The associated side lobe tends to be increasing with a null at 0 degree. The phase difference of 180 degrees causes a null at the bore sight angle which means the phase of current meets destructively at the bore sight angle. Any phase shift of 180 degrees will produce the same pattern for this array. Fig. 18 depicts the following pattern where the phase excitation is 270 degree with a directive beam at 5 degree angle. Here, the destructive phasing currents occur at around 15 degree as shown in the pattern.

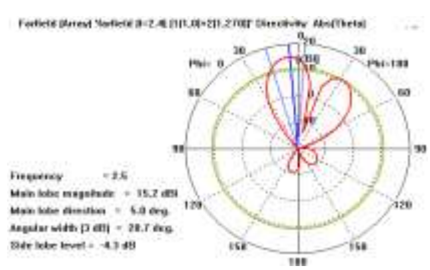


Fig. 18. The Beam Pattern for 0,270 (α=270) for Linear Two Feeds Array

6.3.3. A Comparison with previous result of Array with Individual feed

A closer look to the previous array pattern as in fig. 12 (b) with individual feed with the phase excitation angle 0 degree at the first pair of patches and 90 degrees to the next pair reveals almost the same pattern as depicted in fig.19 where the beam angle is 10 degree. This is because of the same excitation angle is being exerted to different elements. The each branch feed for each couple of patches for the two feed array is producing a phase difference of 90 degrees in current for each pair which is equivalent to create the phase excitation angle as 0, 0, 90 and 90 in the case of previously discussed individual feed array.

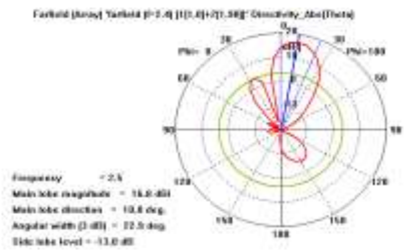
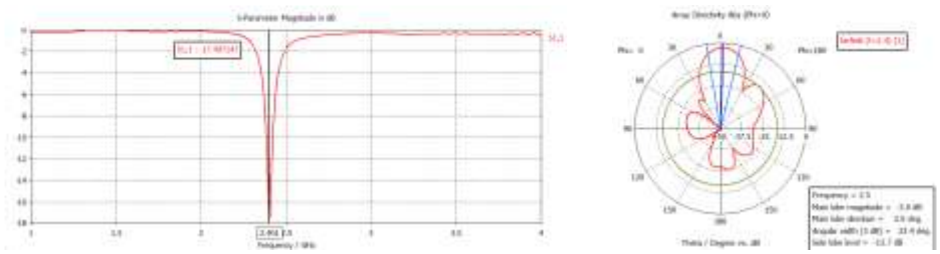


Fig. 19. The Beam Pattern for 0,90 (α=90) for Linear Two Feeds Array

6.4. The Linear Array with Single Feed

6.4.1. S-Parameter and Radiation Pattern

The single feed linear array shows the reflection coefficient -17.48 dB at a resonant frequency of 2.403 GHz as shown in fig.20 (a).



(a) (b)

Fig. 20. (a) S-Parameter and (b)Beam Pattern for Linear Array with Single Feed

For single feed, there is only one port; hence, it is not possible to change the relative phase excitation angle (α). For α being zero, the resultant beam will not be steered rather it will remain in the zero angle which is evident from fig. 20 (b). A side lobe level of -12.7 dB is due to some mutual coupling of current between the elements.

6.4.2. Comparison with Individual Feeds

However, comparing with the pattern for individual feed linear array (shown in fig. 10) with zero degree relative phase excitation, we get the same pattern as shown in fig. 20 (b). Similarly, introducing α = zero at the first pair and 90 degrees to other pair, the beam can be directed towards 10 degrees left to the main beam angle (0) (shown in fig. 12) which means, if we keep a single port and want to obtain the same result, later pair of the patches of the array must be provided with 90 degree relative phase angle of current relative to the first pair. Referring to fig. 13, to make a directive beam of 25 degree angle, the patches of single feed array must be provided with gradually increasing of 90 degrees phase angle (0, 90, 180 and 270) to each patch.

6.5. Square Array with Individual Feed

6.5.1 The S-Parameter

The square array with individual feed shows a reflection coefficient of -19.726 dB at the resonant frequency of 2.42 GHz which is better than that of linear array. The separation between the reflection and transmission coefficient is approximately 3 dB.

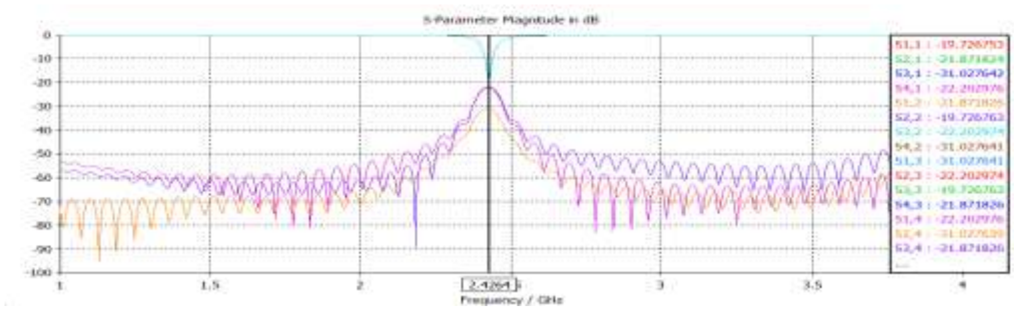
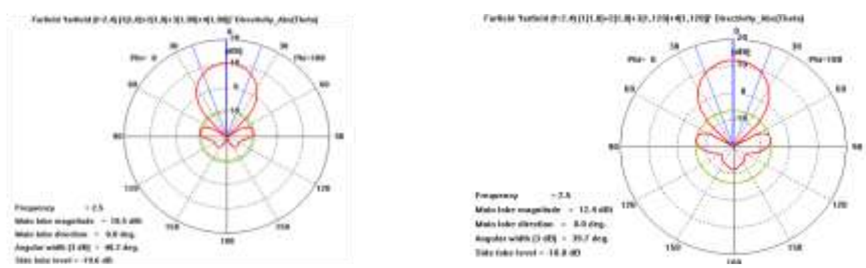


Fig. 21. The S-Parameters for Square Array with Four Feeds

6.5.2 Formation of Switched Beams

Here, the azimuth coverage and direction is considered for planar array and hence, the beam is considered to be varied along θ axis. Exciting the array as $\boldsymbol{\alpha_x = 0}$ and $\boldsymbol{\alpha_y = 90}$ the following pattern depicted by fig. 22(a) is produced where the phase angle of one side is 0 degree and the other side is 90 degree. Here, the two pairs of patches radiate independently for individual feed and as the relative phase angle in each pair is zero, the overall array pattern exists along main beam angle. As further observation, the pattern with relative phase excitation of 120 degree between pairs of both the sides is shown in fig. 22(b).

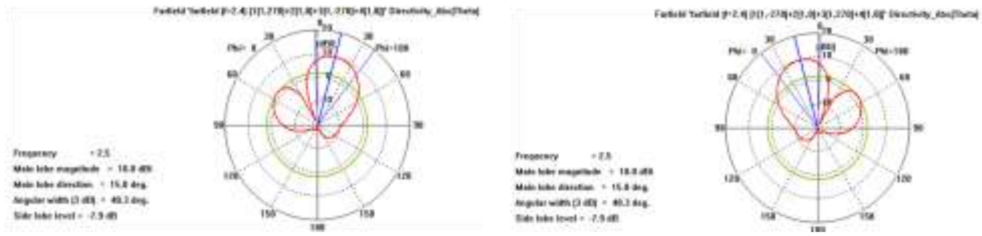


(a) (b)

Fig. 22. The Beam Pattern for (a) 0,0,90,90 and (b) 0,0,120,120 for Square Array with four Feeds

Additionally, it can be observed that, the main lobe magnitude increases form 10.5 dBi to 12.4 dBi as the difference between α_x and α_y increases. In case of square individual feed array, if any pair of patches in each side of the array is excited with $\alpha = 0$ degree, θ is always observed as zero.

Setting the phase difference between the pair of patches of one side as -270 and the other side as 270 degree, the main beam switches to 15 degree to the right of the zero degree angles. The null occurs at 30 degrees due to destructive phase of the current. The angular width of the main lobe is 40.3 degree, which is much more compared to that of the linear arrays.

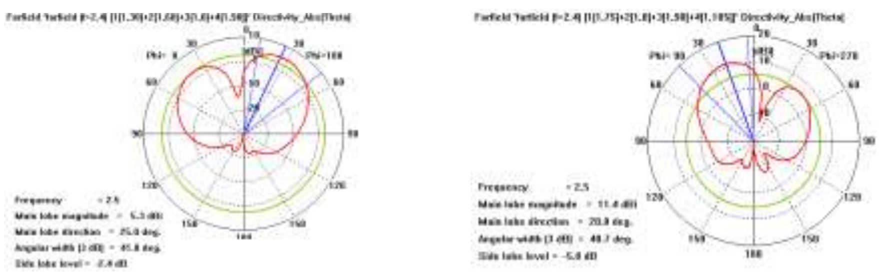


(a) (b)

Fig. 23. The Beam Pattern for (a) 270,0,-270,0 and (b) -270, 0, 270, 0 for Square Array with four Feeds

Fig. 23b demonstrates that by changing α as 270 and -270 degrees (inverse to the -270 and 270 degrees), the beam can be shifted by 15 degree to the other side keeping the width and side lobe same as before. Therefore, the beam can be switched in this manner just by changing α at each side of the patches.

By varying relative phase angle α for each pair of the patches in each side, the beam can be moved from its zero degree position. This observation is demonstrated by the following patterns.



(a) (b)

Fig. 24. The Beam Pattern for (a) 30,60,0,90 and (b) 75,0,90,105 for Square Array with four Feeds

Fig. 24a depicts that comparing to the case of α = 270 and -270 degrees at each pair of both sides, we get larger switching angle (25 degrees) with larger width of main beam and side lobe for the case of α = 30 at one side and 90 degree at other side. For, α = -75 degree and 15 degree, the main beam is directed towards 20 degree which is evident from fig. 24b. Symmetrically, the beam can be rotated by 40 degrees (20 degrees to the right side of main beam angle) by changing α to 75degree from -75 degree and -15 degree from 15 degree.

6.6 Square Array with Two feeds

6.6.1 The S-Parameters

For the square array with two feeds, the reflection coefficient decreases to -11.28 dB and the separation becomes 10 dB. The resonant frequency is 2.42 GHz which is the design frequency.

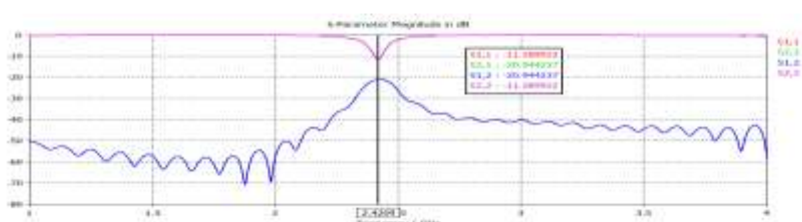
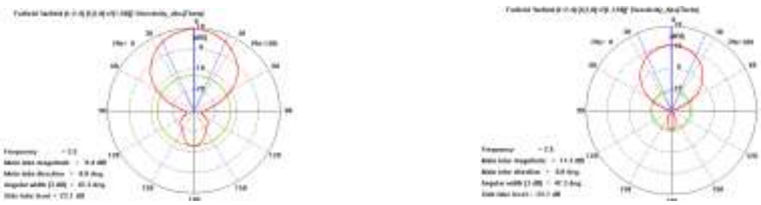


Fig. 25. The S-Parameter for Square Array with Two Feeds

6.6.2 Formation of Radiation Pattern

In this array pattern, there is only one value for α_x and α_y each. As α_x and α_y is always zero, the beam exists along the zero angle direction which means switching cannot be provided with this array. For example, if α_x =0 (patch 1=0, patch 2= 0 degree) and α_y=0 (patch 3 = 90 and patch 4= 90 degrees), the following pattern depicted in fig. 26(a) is produced.



(a) (b)

Fig. 26. The Beam Pattern for (a) 0,90 (α=90) and (b) 0,120 (α=120) for Square Two Feeds Array

The patches connected with each port will have the 0 degree phase excitation irrespective of whatever the value for relative phase angle α is. This phenomenon is shown in fig. 26(b).

6.6.3 Comparison with Individual Feed Square Array

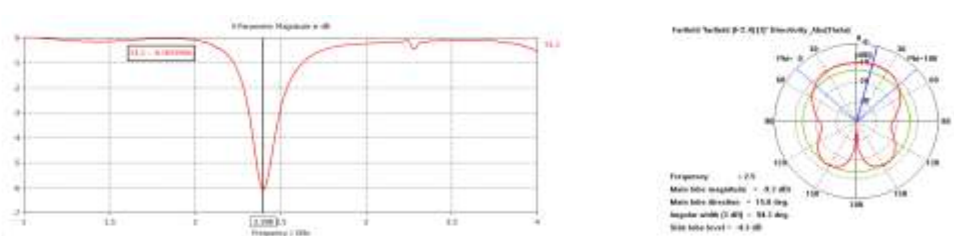
The above pattern at fig. 26 (a) resembles the pattern of the individual feed square array with the excitation 0,0,90 and 90 degrees depicted by Fig.22 (a).

As far as the patterns for individual feeds are concerned, it can be noted that it is possible to generate similar patterns with equivalent phase excitation by using the feed network with two ports. For example, in fig. 23 (b), the phase difference between port 1 and port 2 is 270 degree while it is -270 degree between port 3 and port 4 which provides a switched beam with 15 degree angle. The same degree of angle can be attained here by using two feeds, by exerting the phase difference of 270 degree between the pair of patches connected with port 1 and -270 degree to the other pair of patches connected with port 2. However, in order to incorporate such relative phase angle, the patches need to be physically excited by an external phase shifter. Fig. 26 shows, in this case, the magnitude of the main lobe increases with the increment of relative phase excitation angle between the patches which is similar to that of the individual feed square array depicted in Fig. 22.

6.7 Square Array with Single Feed

6.7.1 The S-Parameters and Radiation pattern

In case of the single port the level of return loss is very poor (-6.064 dB) with the resonant frequency at 2.39 GHz. The long feed, the branch feeds and the quarter wave length section affect the propagation of current significantly with several losses. [11]



(a) (b)

Fig. 27. Square Array with Single Feed (a) The S-Parameters (b) The Beam Pattern

6.7.2 Formation of the Pattern

In this case, all the four patches experience the same phase excitation angle and hence, the beam should be at the bore sight angle. However, the pattern shown in fig. 27 (b) depicts that the main beam is directed towards 15 degree, which is caused by the phase shifting of the current in the feed network. The large angular width of 94.3 degree arises due to the significant amount of mutual coupling between the elements and complex feed network of the array. The design structure of this array causes a very little current propagation delay to any of the patches which can reduce the side lobe level.

6.7.3 Comparison with four feeds Array

Fig. 27 (b) shows a 15 degree switched beam, which can also be produced by exciting the ports 1, 2, 3 and 4 respectively at a phase angle of 270, 0, -270 and 0 degree in four feeds array shown in Fig. 23 (a). This refers to the fact that it is possible to provide the relative phase angle of that of the four feeds array to each element of a single feed array by the feed network. The relative phase angle between the patches can be controlled to produce some switched beams from the single feed array by adding some quarter wave length sections which give 90 degree phase shift. However, this gives rise to a great complexity in the feed network.

7 CONCLUSION

In this paper, two types of arrays are designed: the linear and the planar or square and their performances are investigated with different feeding network. The relative phase shifting at different ports produces the directive beam towards the desired direction with the main lobe while some side lobes are also associated, which is the common phenomenon of an array system. However, the according to the demand and traffic concentration in the indoor environment, the side lobes and main lobe can be distributed on the basis of their strength rather than wasting them. Beside the main lobes, the side lobe can be focused to less number of users with less demand.

The investigation of two forms of array indicates that the linear array shows better performance compared to that of the square array. It is simpler to configure and the inter element distance is easily reconfigurable. The planar array requires complex and long feeding network which affects the current propagating through it and hence the radiation pattern may not be achieved as desired. As the proper orientation of the patches of a planar antenna requires complex feeding, sometimes it is difficult to design in terms of simplified WLAN. Furthermore, it is not always necessary to scan at the back of Access Point (AP) and it is needed to scan E-plane horizontally with an angular range of 0 to 180 degree. The linear array is able to meet that requirement. However, planar array can provide scanning up to 360 degree and to extend the range, the linear array needs some mechanical shifting.

For design simplicity, the numbers of feeding ports are reduced for both types of array. To examine the performance with less number of feeding port, some comparisons are made between the array with individual ports for each patch and that with less number of ports. It has been observed that the array with less number of feeds has less option to exert different phase excitations to each element. However, by changing the feed network or introducing some external phase shifter, the equivalent relative phase angle and consequently the same beam direction of an array having more feeding ports can be obtained with less ports or even single port. Although, the single feed arrays are preferred for simplicity, this requires a complex feeding network to make it equally efficient as the individual feed antenna. Due to the close proximity of the elements in the orientation, the mutual coupling is quite high in case of square array. Additionally, for a single feed, the long feed line along with the increased feeding complexity introduces a current propagation delay which degrades the performance of this array antenna compared to that of the linear array.

Typical Omni-directional antenna exhibits good coverage, large bandwidth which is not the essential feature for WLAN systems. Larger bandwidth and whole area sometimes cause the interference from neighboring WLANs and the signal can be received by some unwanted third party which affects the security system. The designed smart antenna array is the possible solution to avoid security breach, waste of bandwidth and some radio wave propagation constraints.

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