Design of Switched-Sector Planar Antenna for Wireless LAN

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Abstract

Given the potential market for wireless LAN (WLAN) technology, multiple-sector antenna arrays are known to be able to provide capacity enhancement by means of interference reduction. In this paper, the switched-sector planar antenna will be designed with nine-direction radiation pattern on single PCB board. The kind of antenna can act as an Access Point (AP) in indoor WLAN.

I . INTRODUCTION

The demand for increased capacity in wireless networks motivated recent research toward wireless systems that exploit space diversity [1]. As a result, there are many efforts on the design of antenna arrays. Research on antenna design has focused on the selection of attractive radiating elements and antenna architecture that can accommodate the physical and electrical requirements of the system [2]. This paper presents a comprehensive effort on antenna-array design. The main goal of this paper is to design switched-sector planar antennas operating at a frequency of 6GHz and conform to the geometry of an array architecture that could control the radiation pattern both in azimuth and elevation directions. Consequently, this resulted in the selection of microstrip patches arranged in a planar configuration. In addition, the number of radiating elements was chosen to meet bandwidth requirements while maintaining reasonable costs and complexity for hardware implementation.

II . ANTENNA DESIGN

The type of antenna element considered in this paper is a microstrip antenna (also known as a patch antenna). The microstrip antenna element was designed to operate at a frequency of 6GHz ($\lambda = 5cm$) using a FR4 material with some related parameters shown in Table1.

FR4 parameters	ε_r	loss tangent	substrate thickness	metal thickness
values	4.28	0.0018	1.48 mm	0.04 mm

Table1. Parameters of PCB board FR4

According to formulas of patch antenna, the length and width of single patch are 1.21 cm and 1.92 cm respectively. The bandwidth efficiency of single patch is 3.17%. Thus, the expected bandwidth of single patch is 190.2MHz.

For an $M \times N$ identical elements with uniform spacings dx and dy placed on the $xy-plane$, the array factor is given by [3]

$$[AF(\theta,\phi)]_{M\times N} = \sum_{m=1}^{M}\sum_{n=1}^{N} I_{mn} e^{jk\sin\theta[(m-1)d_x\cos\phi+(n-1)d_y\sin\phi]} \quad (1)$$

where I_{mn} represents the feed current of the mnth individual patch elements and (θ,ϕ) represents the elevation and azimuth angles.

The design objective is to establish nine-directional main beams toward different desired directions on a 8×8 planar microstrip antenna array. The block diagram of the switched-sector planar antenna is shown in Fig1. These antenna elements are spaced at $\lambda/2$ apart in both directions. Each block uses its own feed network to produce a radiation pattern directed to its desired direction. Once the desired direction of each block is defined, the weighting of each element in Eq (1) can be determined, and the feed network of each block can then be designed. In this paper, the feed network was designed with uniform amplitude and constant progressive phase shift and it is to be implemented with microstrip lines.

Since the switched-sector antenna array is to be placed on the center ceiling of a large room, the desired pointing direction θ_0 and ϕ_0 of each block are designed to be at (θ_0=45°,ϕ_0=45°),(θ_0=135°,ϕ_0=45°),(θ_0=-135°,ϕ_0=45°),(θ_0=-45°,ϕ_0=45°),(θ_0=0°,ϕ_0= 45°),(θ_0=180°, ϕ_0=45°),(θ_0=-90°, ϕ_0=45°),(θ_0=90°, ϕ_0=45°),(θ_0=0°, ϕ_0=any value) respectively. Substituting these directions to Eq (1), the required phase of each element can be determined and the feed network of each block can be designed. The result is shown in Fig2. Although there are nine blocks on PCB, it is noted that only four different patterns of feed networks actually need to consider. Blocks (1,2,3,4) have the same antenna array and feed network pattern, but they are oriented with different directions. Blocks (5,6) and Blocks (7,8) are other pairs.

III. SIMULATION AND MEASUREMENT RESULTS

The *Ensemble* simulation tool is used to analyze and simulate the microstrip antenna element and the mutual coupling effects between elements [4]. The software *Ensemble* is also used to adjust the excitation (magnitudes and phases) network.

The PCB layout of the switched-sector planar antenna with radiation patterns of nine directions is shown in Fig2. The measured return losses of different block patterns are shown in Fig3. The respective bandwidths and return losses are shown in Table2.

Parameters	Right_Top3x3	Center2x2	Right2x3	Bottom3x2
BW(MHz)	160 MHz	160 MHz	210 MHz	290 MHz
Return Loss(dB)	-24.3 dB	-14.9 dB	-18.6 dB	-37.7 dB

Table2. Measurement results of switched-sector planar array

The measured radiation patterns of different blocks are shown from Fig4 to Fig11. These figures illustrate measurement results of switched-sector planar antenna at angles $\phi=0°$ and $\phi=90°$ with both vertical and horizontal polarizations [5]. The individual 3D radiation pattern of each block on switched-sector planar antenna is measured in an anechoic chamber using a Vector Network Analyzer.

IV. CONCLUSIONS

The design of switched-sector planar antenna with radiation patterns of nine directions has been presented. There is an isolation of at least 15dB within the 3dB beamwidth between the vertical and horizontal polarization at $\phi=0°$ and $\phi=90°$. The results obtained in this paper can provide certain guidelines for the measurement of wireless LAN environments.

In the future, this switched-sector antenna will be used to measure the channel characteristics in WLAN environments. It is expected that the multipath delay spread will be reduced if a sector antenna is employed. Consequently, the guard interval required in the OFDM signals can be smaller and the permissible data rate can be increased.

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V. REFERENCES

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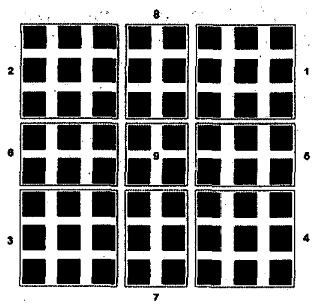

Fig1. Block Diagram

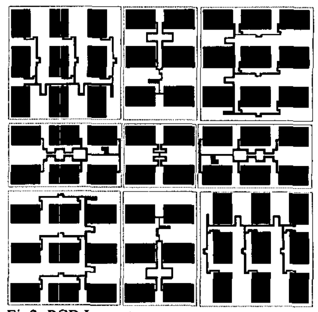

Fig2. PCB Layout

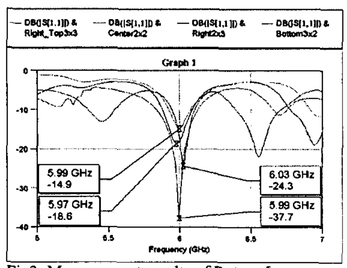

Fig3. Measurement results of Return Loss

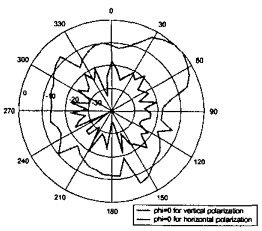

Fig4. Radiation pattern of Block1 at Phi=0°

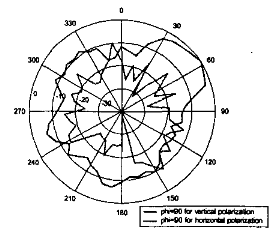

Fig5. Radiation pattern of Block1 at Phi=90°

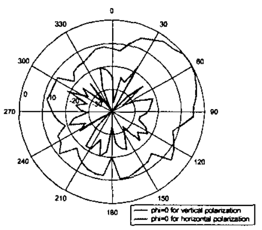

Fig6. Radiation pattern of Block5 at Phi=0°

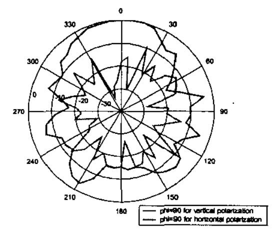

Fig7. Radiation pattern of Block5 at Phi=90°

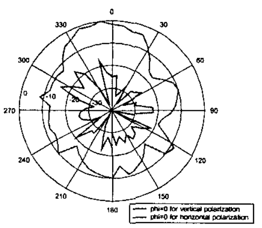

Fig8. Radiation pattern of Block7 at Phi=0°

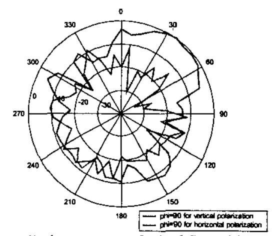

Fig9. Radiation pattern of Block7 at Phi=90°

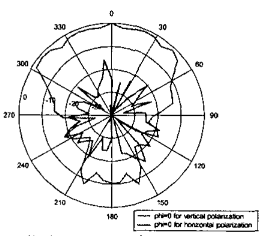

Fig10. Radiation pattern of Block9 at Phi=0°

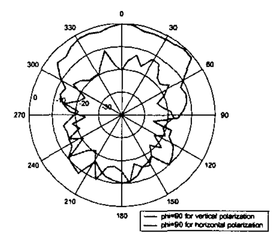

Fig11. Radiation pattern of Block9 at Phi=90°