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Design and Performance Analysis of Corporate Feed Antenna Array for WLAN Application at 2.4 GHz

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***Abstract*: Formation of beam used to access all amplitude and phase of required signals. Current paper describes design and simulation for reduced size of Microstrip patch antenna with parallel power divider operating at 2.4 GHz. Every Wireless LAN Application always demands for increased bandwidth and better quality of service. Because of much more advantages such as less cost, easy fabrication, versatile and flexible, Microstrip patch antennas are widely used. The practical operation of this microstrip patch antenna has been simulated on 4×1 microstrip patch antenna with consists of Power Divider. Results from simulation are observed by Ansoft HFSS version13 software in terms of Return loss, VSWR, radiation and Beam patterns. Microstrip patch antenna with Power Divider has been fabricated on FR4/Rogers PCB. Simulated and measured results show good performance and analysis. The proposed Microstrip patch antenna will be connected by 50 Ω Microstrip feed line. Phased antenna array may be to use a switched radiation pattern or to scan Beam of antenna rapidly in angle of azimuth or elevation. Patch antenna arrays are used in mobile communications.**

***Keywords:* Microstrip patch antenna, Phased antenna array, Mobile communication, 50 Ω feed line.**

I. BASIC INTRODUCTION OF MPA ARRAY WITH POWER DIVIDER

Formation of Beam or filtering of spatial is a signal steering method used in many wireless communication applications to signal transmit and receive accurately. This situations/results are achieved by combining all elements of patch antenna array [1]. So this topic of formation of Beam network using phased antenna array has been more popular and attention because of its wide range of applications and more advantages of Microstrip patch antenna. Formation of Beam systems can be broadly divided into two categories: Adaptive (phased) Beam-former and Switched (conventional) Beam-former [1][3]. Phased antenna array receiving a lot of attention for WLAN applications [1] as they are cost effective design for developing smart antenna system in many applications.

Phased antenna array is a set or bunch of antennas in which the relative all phases of respective signal applying the antennas. The array is designed by four single patched antennas which provide Omni-directional radiation patterns individually. For Microstrip antennas, the range of dielectric constants is basically in terms of $2.2 \leq \varepsilon_r \leq 12$. Dielectric constants the low end of range can give us extra advanced efficiency, better bandwidth. Simulated antennas can be easily fabricated on FR4 (ε_r =4.4), RT/Duroid 5880 (ε_r =2.2) or high dielectric constant of (ε_r =10.2 R03010) material of substrate. Popular Microstrip antenna feeding system is the corporate feeding. Corporate/parallel feed technique is used for good matching impedance at input of radiation elements of Microstrip patch antennas.

II. FORMATION OF BEAM NETWORK USING CORPORATE FEED ANTENNA ARRAY SPECIFICATION AND DESIGNS

Antenna array is in the form of $2^p \times 2^p$ network with 2^p input and 2^p output, $2^{p-1} log_2 2^p$other supplementary networks where p is no. of turns such as hybrid junctions, phase shifters [1]. In this study four array antennas have been designed with same radiation pattern because four Beams are needed. Fig.1 shows the general Block diagram of Feed Network with phased antenna array.

By combining all elements of phased antenna array, array is designed successfully and fabricated on FR4/Rogers substrate with relative permittivity$\varepsilon_r = 4.4/2.2$. Simulated results are obtained from Ansoft HFSS software to analysis the results. The design frequency of required antenna is 2.4 GHz. Required Microstrip patch antenna is connected by 50Ω Microstrip feed line.

Microstrip patch antenna with Power Divider is used to divide power levels of 2^m (i.e. m =2, 4, 8, 16….etc). This is achieved by quarter wavelength impedance transformer or tapered line type of Power Divider [8].

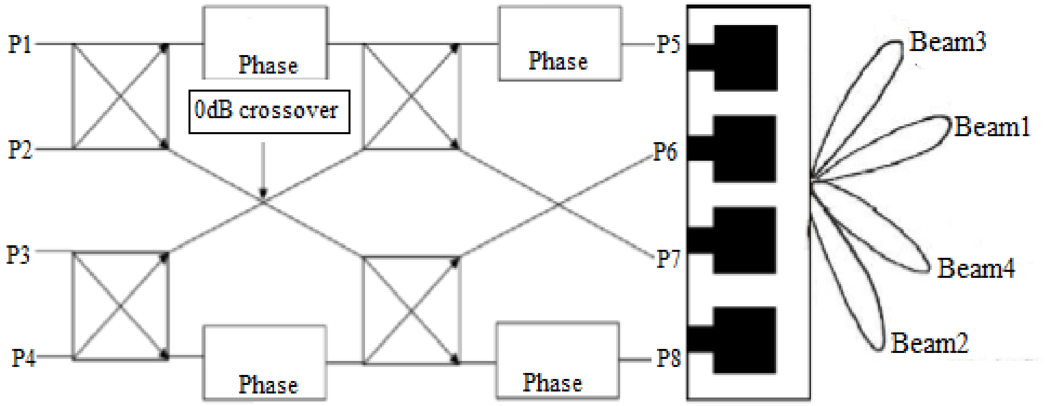

Fig. 1 General Block diagram of Feed Network

III. DESIGN PROCEDURE OF MICROSTRIP PATCH ANTENNA

Microstrip rectangular patch antenna, width as well as length can be measured as follow [3],

$$W = \frac{C}{2 f_r} \sqrt{\frac{2}{\varepsilon_r + 1}} \qquad (1)$$

Where, C = light velocity and ε_r = dielectric constant material, f_r = Resonant design Frequency [3],

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}} \qquad (2)$$

h = 1.67mm height of substrate,

Extended length of patch is [3],

$$\frac{\Delta L}{h} = 0.412 \times \left[\frac{(\varepsilon_{reff} + 0.3)(\frac{W}{h} + 0.264)}{(\varepsilon_{reff} - 0.258)(\frac{W}{h} + 0.8)}\right] \qquad (3)$$

By using above formulas, we can find exact length of Microstrip patch antenna [3],

$$L = \frac{C}{2 f_r \sqrt{\varepsilon_{reff}}} - 2\Delta L \qquad (4)$$

Formulas for ground calculation as follow [3],

$$L_g = 6h + L \qquad (5)$$
$$W_g = 6h + W \qquad (6)$$

We can also calculate array factor for antenna array[3],

$$(FA) = \sin^2(N\pi(d_x/\lambda)\sin\theta))/N^2\sin^2(\pi(d_x/\lambda)\sin\theta) \qquad (7)$$

By using above mathematical computation equation, the patch parameters have been designed for the FR4 substrate. The results are summarized in TABLE I.

IV. ANTENNA ARRAY SPECIFICATION

Microstrip patch antenna structures are describing in figure 2 and figure 3. Simulated antenna will be done by applying FR4 epoxy material on substrate having dielectric constant material 4.4 and the required frequency 2.4GHz is considered. Antenna is connected through 50Ω microstrip feed line. Simulated work is done by using Ansoft HFSS software. All the specifications are given in the table1 (all Llengths and widths in mm and frequency in GHz).

TABLE I: DESIGN DIMENSIONS

SR No.	PARAMETERS	VALUES
I	Resonant frequency(f_r)	2.4 GHz
II	dielectric constant(ε_r)	4.4
III	Substrate height(h)	1.67mm
IV	Patch Length(L)	38.03mm
V	Patch Width(W)	29mm
VI	Effective dielectric constant(ε_{reff})	4.6
VII	Extended length(ΔL)	39.77mm
VIII	Inset fed	1mm
IX	Feed length	3mm

V. SIMULATED RESULTS AND DICSUSION

A. Patch antenna

Low Microstrip patch antenna bandwidth is most important parameter that limits its wide range coverage. In the current work the Microstrip rectangular antenna bandwidth is increased by applying insect feed with patch antenna. Simulated performance of required Microstrip rectangular patch antenna is achieved by using Ansoft HFSS software at selected design of 2.4 GHz frequency. Simulated results like Return loss, VSWR, Total gain, patterns etc. for required antenna are shown in the figures.

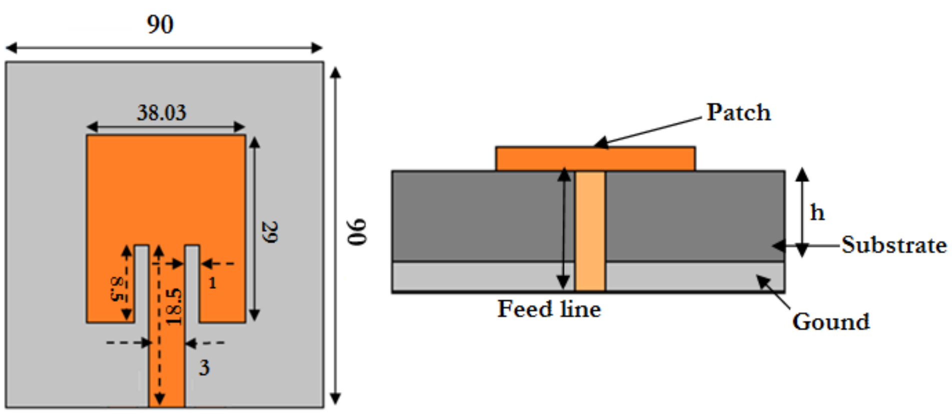

Fig. 2 Top and side view of Microstrip patch antenna

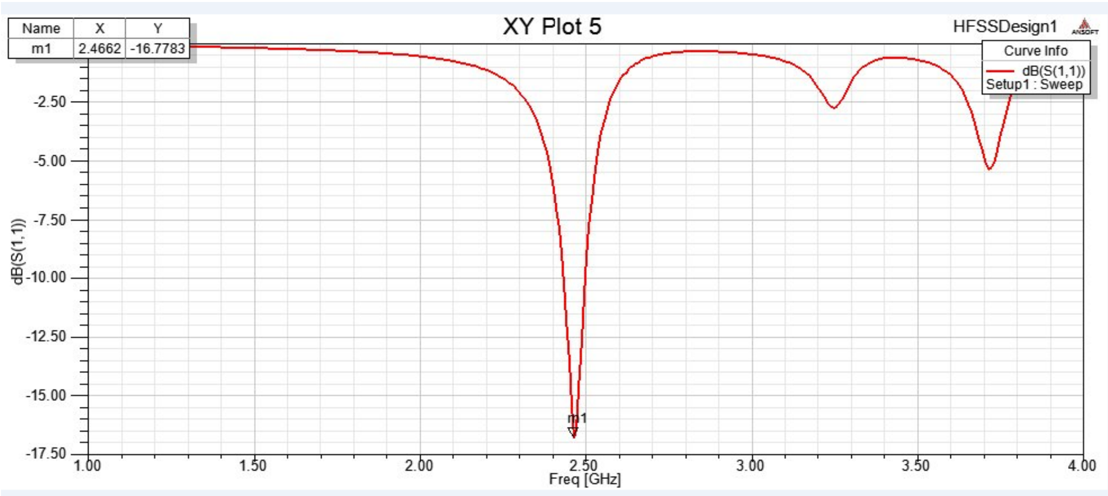

Fig. 3(a) Return loss Vs Frequency plot

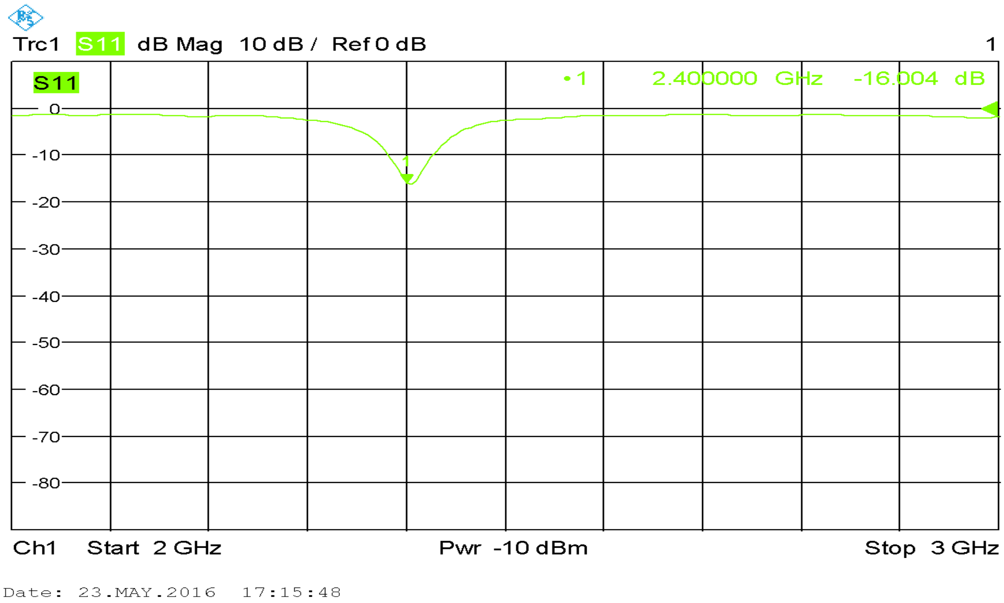

Fig. 3(b) Measured Return loss Vs Frequency plot

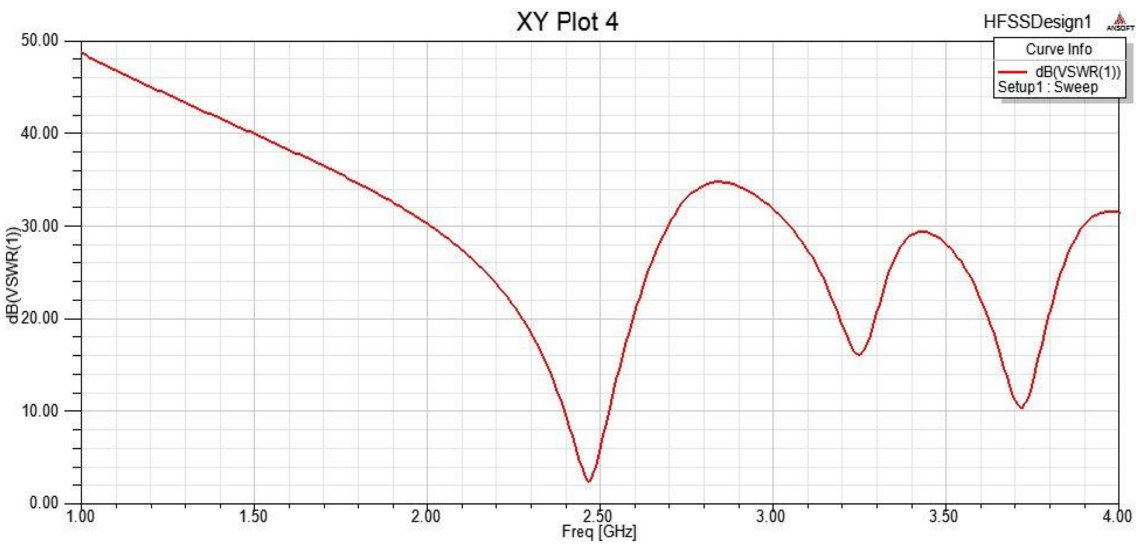

Fig. 4 VSWR Vs Frequency graph

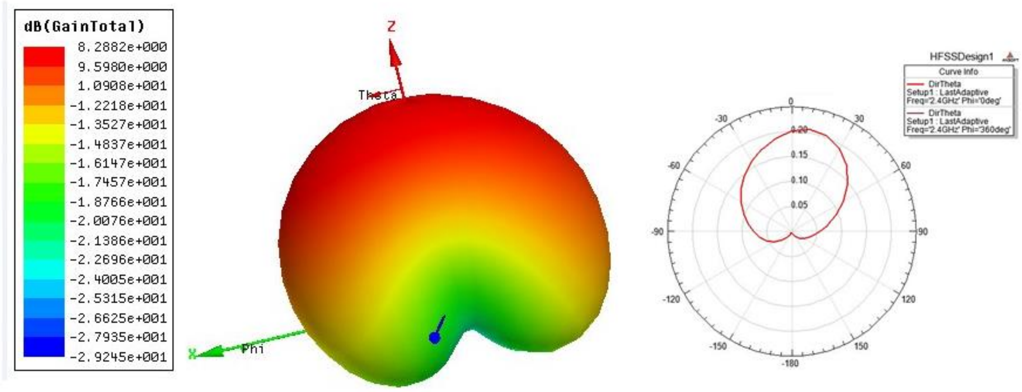

Fig. 5 Directivity of required antenna plot

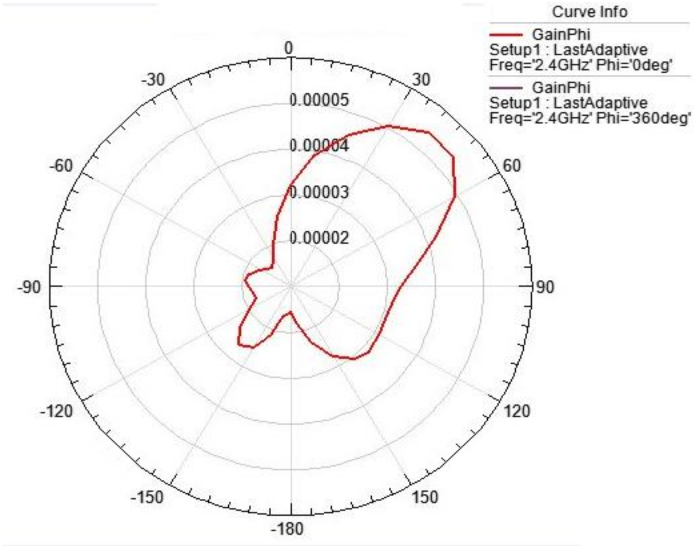

Fig. 6 Gain of required antenna

Simulated and measured Return Loss of the antenna is -16.77 dB and -16.004 dB respectively as shown in Fig. 4,5. Gain and directivity of the antenna are 8.282 dBi and 0.20 dBi respectively. Antenna return loss is -10dB or lower from 2.437 GHz to 2.462 GHz, so this can be used in 2.4 GHz band WLAN system.

B. Corporate Feed Network

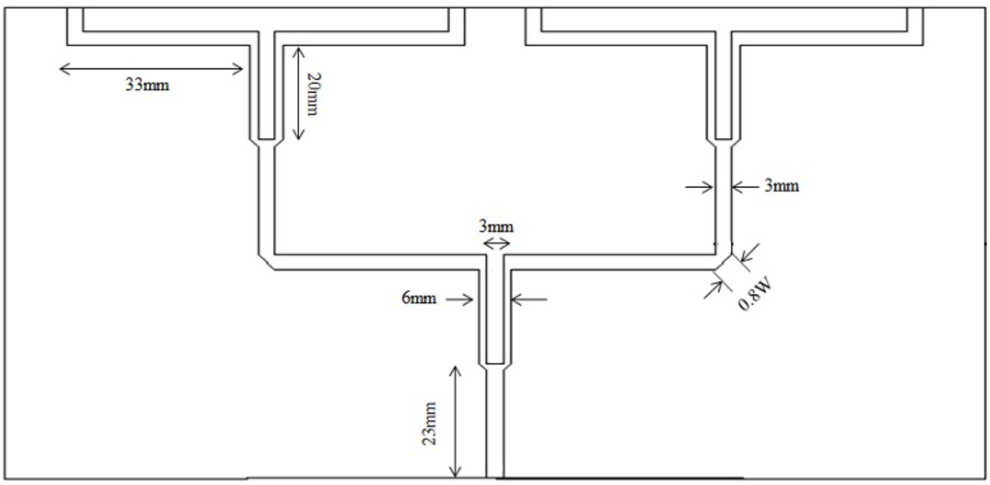

Fig. 7 Schematic diagram of Power Divider

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Corporate feed arrays are general and versatile. This method has more control of the feed of each element and is ideal for scanning phased arrays, multi Beam arrays.

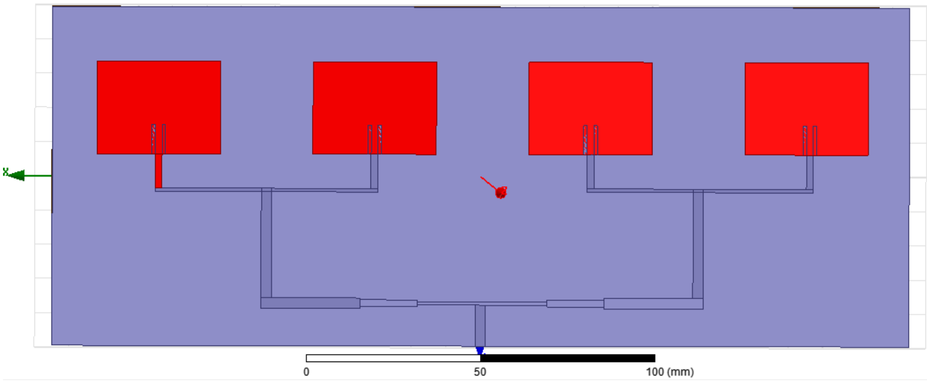

Fig. 8 Corporate Feed antenna array

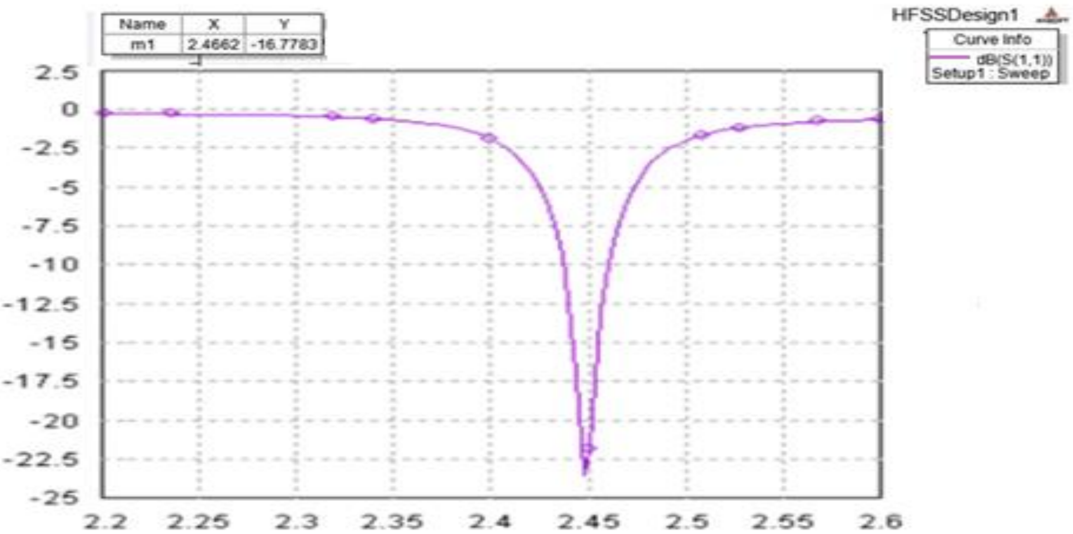

Fig. 9 Return Loss Vs Frequency plot

Fig. 9 shows Return Loss of Four-Patches Rectangular Microstrip Antenna Array (Corporate feed) is -16.7783 at f_r = 2.4 GHz

Name	Theta	Ang	Mag
m1	360.0000	-0.0000	4.4848
m2	314.0000	-46.0000	-7.5607
m3	46.0000	46.0000	-6.9600
m4	178.0000	178.0000	-22.0513

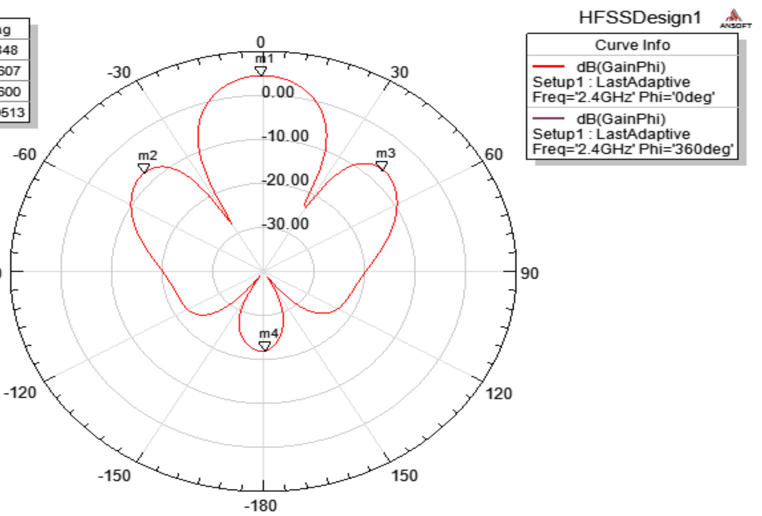

Fig. 10 Beam formation of Corporate Feed antenna array

Gain of the antenna is 4.4848 dB. Side lobe label is -7.5807 dB and -6.9600 dB lower than main lobe is shown in Fig. 10. Antenna Return Loss is -10 dB or lower from 2.437 GHz to 2.462 GHz, so this can be used in 2.4 GHz band WLAN system.

We implement this antenna for performance evaluation. Measured radiation pattern and VSWR of an antenna are not satisfactory; side lobe label is -7.5 dB lower than main lobe and VSWR is more than unity. This is because of fabrication and measuring equipment limitation.

VI. CONCLUSION

Formation of Beam network is used to steer antenna beams accurately. These types of antennas are linear so these types of antenna control the antenna patterns in single plane. This antenna array is fabricated to study about patterns of various radiations over frequency range of WLAN applications 2.4 GHz. Return loss, VSWR and total gain of antenna are obtained using the basic elements of antenna array. Radiation characteristics are verified between simulated and measured results. Microstrip patch antenna bandwidth is gained by 5%.

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