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Design and performance Micro strip Antenna Arrays MIMO

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Abstract- Micro strip antenna arrays are widely used in wireless communication systems due to their low profile, light weight, and easy integration with planar circuits. Multiple-Input Multiple-Output (MIMO) technology is also an important technique to improve wireless communication system capacity and reliability. In this project, we aim to design and evaluate the performance of microstrip antenna arrays for MIMO applications.The proposed antenna array consists of multiple microstrip antenna elements, which are arranged in a regular grid pattern. Each element is designed to operate at the desired frequency range, and the spacing between the elements is optimized to minimize mutual coupling between them. The antenna array is then fed by a feed network, which applies appropriate amplitude and phase weights to each element, to achieve a desired radiation pattern and to maximize the array gain.To evaluate the performance of the antenna array, we will conduct a series of simulations using commercial electromagnetic simulation software. The simulations will include the analysis of the radiation pattern, gain, efficiency, and impedance matching of the antenna array. We will also investigate the impact of mutual coupling on the performance of the antenna array, and explore techniques to mitigate the coupling effects.Finally, we will assess the performance of the microstrip antenna array for MIMO applications. We will analyze the capacity and diversity gain of the antenna array, and compare the performance of the MIMO system with and without the antenna array. The simulation results will provide insights into the design and performance of microstrip antenna arrays for MIMO applications, and demonstrate their potential for improving

the capacity and reliability of wireless communication systems.

Keywords: ***Patch antenna, Radartechnology, Radiation efficiency, Micro strip***

I. Introduction

Antenna is one of the most important components of any wireless system. An antenna is an electronic device that transmits and (or) receives electromagnetic waves. In most cases, it operates as a resonant device that efficiently operate in a relatively narrow frequency band [1]. For the antenna to work efficiently, its frequency must be tuned to the frequency band of the communication system to which it is connected, otherwise, the signal transmission will be impaired [2]. The receiving antenna is responsible for turning the electrical signal into its original form. In recent years, the development in communication systems necessitates the requirement of low cost, minimal weight, low power, and low profile antennas that are capable of maintaining high efficiency over a wide band of frequencies [3]. A microstrip patch antenna is a single layer design that in most cases contains four main parts the patch, the ground plane, the substrate in between patch and ground, and the feeding port. The design and construction of the antenna are very simple using the conventional microstrip feed line method. The patch can be designed in any shape although in most cases rectangular and circular configurations shapes are more prominent] [7]. The ground plane can be finite or infinite depending on the model (transmission line model, cavity model, full-wave model or method of moments) used for the analysis of dimensions [1]–[8]. Relative permittivity (Єr) and height (h) are the two most important characteristics considered for any antenna type. The substrate, as well as the feeding port, can be microstrip line, coaxial probe, aperture coupled or proximity coupled Feed [5]–[7]. Single microstrip patch antenna presents the advantages of low cost, lightweight, conformal and low profile [9]. The drawbacks are very little which are low gain, low directivity, low efficiency, and narrow bandwidth [10].

II. ANTENNA DESIGN AND SIMULATION

The antenna array was designed and simulated using computer simulation technology (CST) Studio Suit Software. CST is a 3D full-wave electromagnetic field simulator; it uses the finite element method together with adaptive meshing to solve the wave equation. If a 3D model has been made, CST sets up the mesh automatically.

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The CST computes S-parameters can be calculated and plot both the near and far-field radiation. It also computes important parameters such as gain and radiation efficiency. This software was used to vary the sizes of patches, microstrip feed line, and ground plane to come up with the desired results.

A transceiver (a transmission and reception device) with a microstrip antenna transmits and receives electromagnetic waves (waves of electromagnetic radiation). Modern wireless communication systems use transceivers to convert radio frequency fields into induced currents, and vice versa. Thus, an antenna is a conduit for transmitting signals from one part of the electromagnetic spectrum to another [1]. Antennas and other conversion devices are seen schematically in Figure 1.1. When a wave is converted into a current, the arrows in this diagram depict electrical fields that become free space.

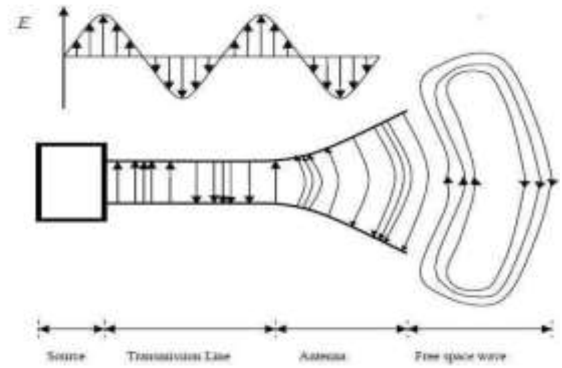

Figure 1: An antenna's structural illustration as a transmission technology.

Antenna performance in a wireless environment is directly related to antenna design [2]. There are numerous applications for microstrip antennas. Mobile telecommunication antennas have evolved over time to include the antenna as an internal feature of the phone. Mobile devices must have antennas that are small and flexible in order to accomplish this goal [3]. To date, the most commonly used tiny mobile terminal antenna types have evolved from the simple to the more complex to the Dielectric Resonator (DR). "Microstrip antennas" are available in a wide range of forms and sizes to meet the needs of a number of wireless applications. The most common antennas found in cell phones will be discussed in this part of the chapter.

III. Literature Survey

Antennas are essential components in wireless communication systems as they

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serve as the interface between the transmitter and the surrounding medium. A wide range of antennas have been developed for various applications, including microstrip antennas, patch antennas, dipole antennas, and many others. In this literature survey, we will review some of the recent advances in antenna technology, with a focus on their structural illustration as a transmission technology.

1) Microstrip antennas (MSAs) have become popular in recent years due to their low profile, light weight, and easy integration with planar circuits. A compact MSA with a fractal-shaped radiating element was proposed by Pandey et al. (2021), which offers improved impedance bandwidth and radiation efficiency. The fractal-shaped radiating element is designed to generate multiple resonant modes, which provides additional bandwidth and improves the radiation efficiency.

2) Patch antennas are another type of microstrip antennas, which consist of a metal patch mounted on a grounded substrate. A circularly polarized patch antenna with an inverted L-shaped feedline was presented by Liu et al. (2020), which offers wide bandwidth and high axial ratio. The inverted L-shaped feedline provides an additional resonance mode, which increases the bandwidth of the antenna. The proposed antenna was also fabricated and measured to validate its performance.

3) Dipole antennas are widely used in many applications due to their simple structure and high radiation efficiency. A compact broadband dipole antenna with a mushroom-shaped ground plane was proposed by Lee et al. (2021), which offers a wide impedance bandwidth and high radiation efficiency. The mushroom-shaped ground plane is designed to provide additional capacitance, which compensates for the inherent inductance of the dipole, resulting in a wider bandwidth.

4) In addition to these types of antennas, other novel antenna structures have also been proposed recently. For example, a compact dual-band antenna with a U-shaped

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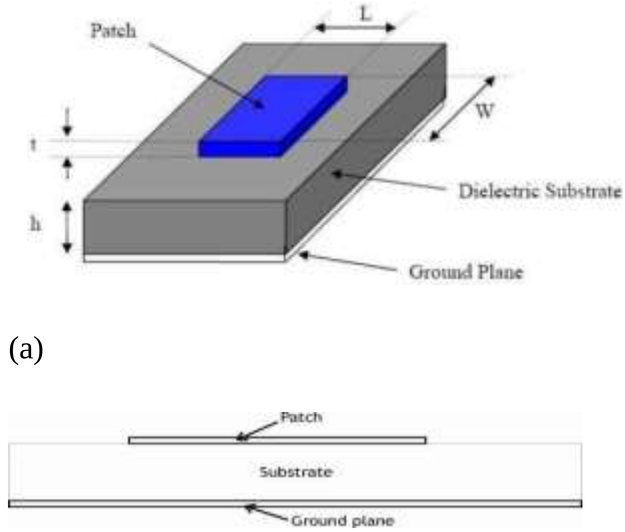
slot was proposed by Feng et al. (2021), which offers a wide impedance bandwidth and good radiation characteristics. The U-shaped slot is designed to provide an additional resonant mode, which increases the bandwidth and improves the radiation characteristics.

5) recent advances in antenna technology have led to the development of various novel antenna structures with improved performance and functionality. These advancements have not only enabled the development of more efficient and reliable wireless communication systems but have also expanded the range of potential applications for antenna technology.

IV. Proposed Methodology

Patch Antennas are illustrated in the following diagram and comprise of a metal part attached to a substrate and a ground plane.



(a)

(b)

Figure2: A diagrammatic "microstrip patch antenna": (a) 3-Dimensional picture; and (b) Adjacent look

The length and width of a Microstrip Patch Antenna can be calculated using the following formulas:

$$L = \frac{\lambda_g}{2} = \frac{\lambda_0}{2\sqrt{\varepsilon_{eff}}} = \frac{c}{2\,fr\sqrt{\varepsilon_{eff}}} \quad (1)$$

$$W = \frac{\lambda_0}{2\sqrt{\frac{\varepsilon_r + 1}{2}}} = \frac{c}{2\,fr\sqrt{\frac{\varepsilon_r + 1}{2}}} \quad (2)$$

Where, (λ_0) is the free space wavelength at operation frequency (*f*).

W = width of the patch antenna

L = length of the patch antenna

ε_r = dielectric constant

For W/h ≥ 1:

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$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + 12\frac{h}{W}\right)^{-0.5} \quad 3$$

$$Z_c = \frac{\eta}{\sqrt{\varepsilon_{re}}}\left\{\frac{W}{h} + 1.393 + 0.677\ln\left(\frac{W}{h} + 1.444\right)\right\}^{-1} \quad 4$$

Where, Z_c = characteristics impedance of the patch antenna, η =120π Ω is the wave impedance in free space. The actual range of parameters for a patch is usually such that $0.25 \leq W/h \leq 2.75$; and $2.5 \leq \varepsilon_r \leq 25$.

The patch antenna can be powered by coaxial cable or microstrip cable, as illustrated in the following diagram [2].

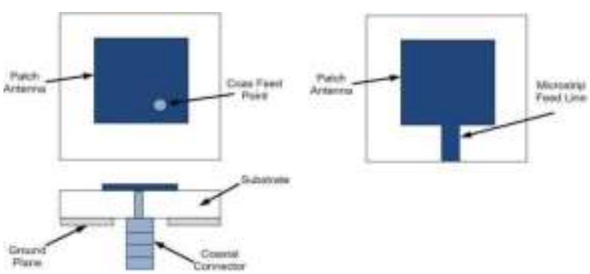

Figure 3: Techniques of feeding

Monopolies Antennas

A “quarter-wave monopole” antenna is one of the simplest and the most fundamental phone antennas [4], as illustrated in the following diagram.

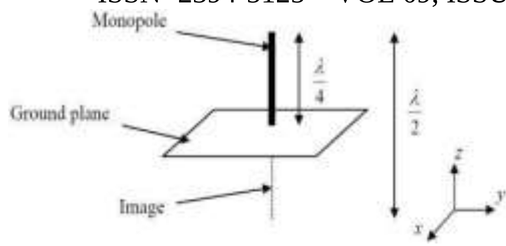

Figure 4: ¼ wavelength monopole antenna

Although the monopole's centre conducts the most current, the antenna's terminal case distributes significantly more currents than the monopole's centre[2]. Therefore, the feed point between the monopole and the monopole has a very low current entering the terminal housing. When a quarter-wavelength monopole is used, a massive amount of current is pumped into the terminal housing.

Planar Inverted-F Antennas (PIFAs)

PIFAs have become increasingly popular as antennas for mobile phones because of their low-profile, lightweight construction, omnidirectional pattern, high radiation efficiency, and ease of integration and manufacture [2]. PIFAs might be seen as a step up from IFAs in this regard. Instead of the IFA's horizontal radiating strip, use a flat plate parallel to the ground plane, as shown in Figure 1.7.

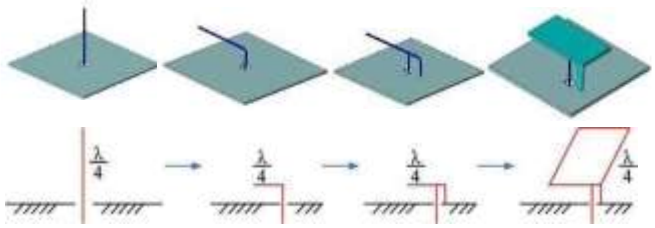

Figure 5: Development of a PIFA from a monopole antenna

A PIFA typically includes a short-circuiting plate or pin, a feeding mechanism, and a rectangular planar component [6].

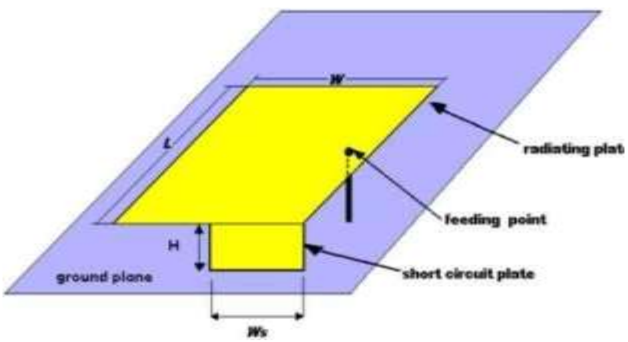

Figure 6: Fundamental structure

The monopole's center conducts the greatest current, yet the antenna's terminal case distributes substantially more currents than the monopole's center does. To put it in a different manner, there is relatively little current flowing through this feed point between two of the monopoles. Terminal housings are subjected to tremendous current when a quarter-wavelength monopole is utilized:

$$\frac{\lambda_0}{4\sqrt{\varepsilon_{eff}}} = (L + H + W - W_s) \quad 5$$

$$fr = \frac{c}{4(L + H + W - W_s)\sqrt{\varepsilon_{eff}}} \quad 6$$

Where, L, W and H are the length, width and height of the PIFA radiator, respectively. W_s is the width of the short-circuit strip.

In the case of $W = W_s$.

$$fr = \frac{c}{4(L + H)\sqrt{\varepsilon_{eff}}} \quad 7$$

In the case of $W_s \approx 0$, this means replacing the shorting plate with a shorting pin as a step to reduce the size of the antenna and the estimated resonant frequency can be determined by:

$$fr = \frac{c}{4(L + W + H)\sqrt{\varepsilon_{eff}}} \quad 8$$

Antenna performance is affected by different variables such as the antenna's impedance, frequency range and bandwidth, feed point position on the dielectric substrate, and the radiator size, shape and height above the ground plane. Below is a summary of the consequences of several PIFA parameters e.g., device's dimensions, feeding position, and shorted pins [7].

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Table Error! No text of specified style in document.**.1 Parameters of PIFA and their effects**

Parameters	Effect
Height	Controls BW
Width	Controls impeding matching
Length	Determines resonance frequency
Width of short strip	Effect on the resonance and increases BW
Feed position from short strip	Effect on the resonance frequency and BW

Using PIFAs comes with several advantages. Because it's so little, unlike other antennas like the rod, whip, or helix, this one may be used with phones that already have cases on them. As a second point, the vertical and horizontal polarization advantages are enormous. With a movable antenna's position, wireless communications can take advantage of a wide range of reflections from different corners of the surroundings [6]. Third, the SAR (Specific Absorption Rate) is decreased, which increases antenna performance and reduces backward radiation. The narrow-band property of PIFAs is a key limitation for commercial use in wireless telecommunication environments.

V. SIMULATION RESULTS AND ANALYSES

The antenna responses were plotted using sigma plot and the following results are obtained.

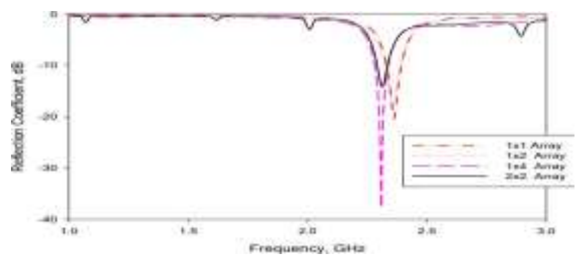
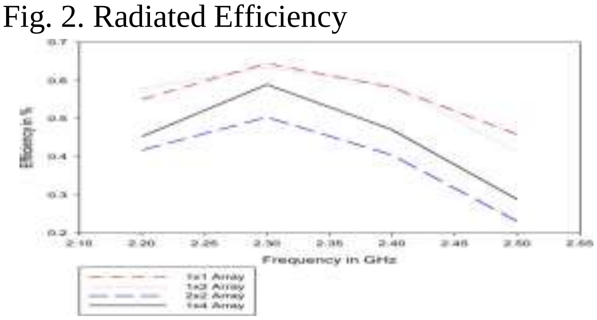


Fig 1: Total Efficiency

Figure 1 shows the S11 parametric response of the configured antenna of different array designs which is the frequency response of the antenna at the giving frequency of 2.4GHz. In Figure 2 the antenna array radiation efficiency is shown. It indicated that antenna 1x1 has the highest radiation efficiency than the other.

Fig. 2. Radiated Efficiency



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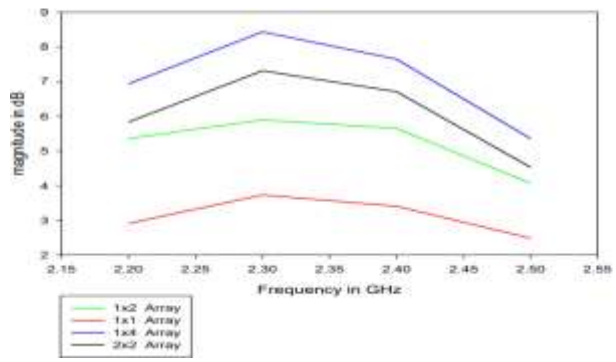

Fig. 3. Maximum Gain

The result in Figure 3 shows the maximum gain of the antenna, which indicate that the antenna 1x4 has a maximum gain. This implies that it will cover a higher distance of receiving and transmitting signals followed by 2x2 then 1x2 and lastly 1x1.

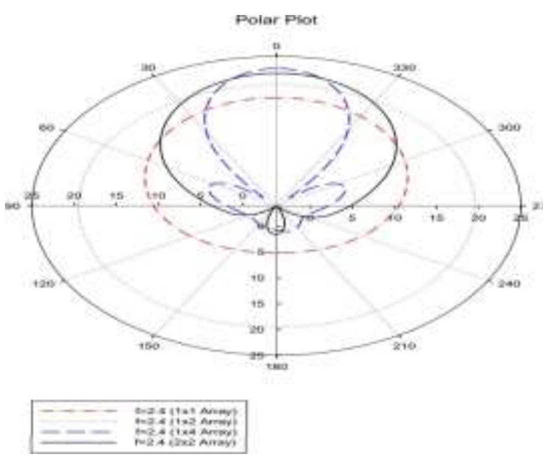

Fig. 4. E-plane

The result in Figure 4 shows the E-plane result of the antenna and the antenna radiate only in one direction towards the main lobes (uni-directional radiation pattern)., The H-plane result of the anenna is shown and the antenna radiates in two direction (in both two main lobes that is bi-directional).

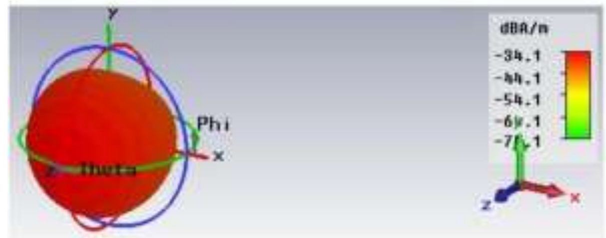

Fig. 5. D Polar plot of 1X1 array

Figure 5 shows the polar plot of the 1x1 antenna and it shows 3D plot of the radiation pattern of that 1x1 antenna.

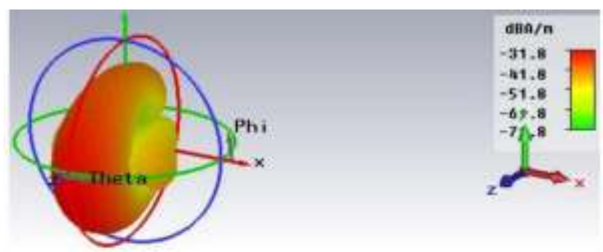

Fig. 6. D Polar plot of micro strip 1X2 array

Figure 6 shows the polar plot of the 1x2 antenna. It shows 3D plot of the radiation pattern of 1x2 antennas.

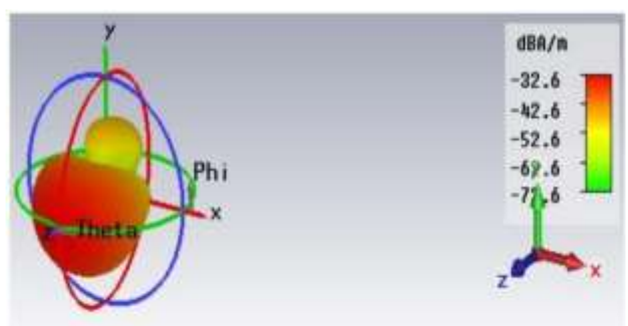

Fig. 7. D Polar plot of 2X2 array

Figure 7 shows the polar plot of the 1x24 antenna and it shows the 3D plot of the radiation pattern of the 1x4 antenna.

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VI. CONCLUSIONS

In this project, we have designed and evaluated the performance of micro strip antenna arrays for MIMO applications. We have proposed an antenna array consisting of multiple micro strip antenna elements, which are arranged in a regular grid pattern and fed by a feed network to achieve a desired radiation pattern and maximize the array gain.Through simulations using commercial electromagnetic simulation software, we have analyzed the performance of the antenna array, including the radiation pattern, gain, efficiency, and impedance matching. We have also investigated the impact of mutual coupling between the antenna elements and explored techniques to mitigate its effects.Our simulations have shown that the proposed micro strip antenna array can significantly enhance the capacity and diversity gain of the MIMO system. The simulations have also demonstrated that the proposed antenna array can achieve high gain, low cross-polarization, and good impedance matching characteristics.In conclusion, the design and performance evaluation of micro strip antenna arrays for MIMO applications are crucial for improving the capacity and reliability of wireless communication systems. The proposed antenna array has shown promising results, and further research is required to explore its potential for practical applications.

REFERENCES

[1] B. Ramya, C. Supratha and S. Robinson, “Design and Analysis of microstrip patch array antenna for WLAN applications,” ICTACT Journal of microelectronics, vol. 3, Issued on 4 Jan., 2018.

[2] J. Vijayalakhmi, V. Dinesh and S. Rubasri, “Design and Analysis of high gain circular patch antenna arrays for 2.4GHz,” IJSTR vol. 9, ISSN 2277-8616, Issued on 4 April, 2020.

[3] M. T. I. Huque, et al., “Design and Performance analysis of microstrip array antennas with optimum parameters for X band applications”, International Journal of Advanced Computer Science and Applications, vol. 2, no. 4, 2011.

[4] A. Balanis, “Antenna theory: Analysis and Design/Constantine,” third edition, Hoboken. NJ. Wiley, 2005, ISBN 047166782X (hbk).

[5] J. L. Volakis, “Antenna engineering handbook,” 4 th Edition, McGraw-Hill 207 ISBN 0071475745/1475747.

[6] M. A. Douglas (B. Ed.(Sci)), “Design and Analysis of microstrip antenna for

ISSN- 2394-5125 VOL 09, ISSUE 05, 2022

2.4GHz applications," Master's thesis, School of pure and applied science of Kenyatta University. (August, 2019).

[7] O. Barrou, A. El Amri, A. Reha, "Microstrip patch antenna array and its application: a Survey," (IOSRJEEE), e-ISSN: 2278-1676, p-ISSN:2320-3331, vol-15, Issued on Jan-Feb, 2020, pp 26-38, University of Casablanca, Morocco.

[8] Dr. A. K. Gautam, "Antenna and wave propagation," Dept. of electronics and communication engineering, G.B. Pant, Engineering College, Daryaganj New-Delhi.

[9] H. Singh, "Electromagnetics and Antennas," College of Engineering and Technology Tangori, Mohali (Punjab), New-Delhi.

[10] R. Garg, P. Bhartia, I Bahl and A. Ittipiboon, "Microstrip Antenna Design Hand Book" New Edition, Artech House, 2010.