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Design of 2X2 Array Ultra-Small Micro-strip Antenna for Wireless Communication Applications

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ABSTRACT: In this paper, 2X2 shaped rectangular micro strip patch antenna for wireless communication application is presented. Design simulation and optimization processes are carried out with the aid of CST. The antenna offers excellent performance for GSM at centre frequency 1800MHz. Simulated results of the Directivity, return loss, radiation patterns are presented.

KEYWORDS: Micro strip Antenna, CST, Directivity, Return Loss, and Radiation Pattern.

I.INTRODUCTION

An antenna converts the desired signal from a source into electromagnetic radiations and is then radiate into free space. A good antenna transmits the energy in some desired directions and suppresses it in the undesired directions at some desired resonant frequencies. A perfect antenna design improves overall performance of the system which is depending on the physical size of the antenna.

Wireless communication has become an integral part for modern world .the most popular standard for mobile phones in today's world is GSM. The wireless providers use individual radio frequencies multiple times by dividing a service area into separate geographical zones, or cells, each cell requires its own radio transmitter/receiver antenna. GSM networks operate in different frequency ranges in different countries around the world. Most GSM networks operate in the 900 MHz or 1800 MHz bands in Asia and Europe.

Micro strip antennas are perfect choice for GSM application due to following features, low profile, small size and conformability. But micro strip antennas suffer from bandwidth limitations. The bandwidth can be increased by adding lossy elements but it affects efficiency of the antenna. So the better method is to use array antenna.

In this design of rectangular micro strip array antenna for GSM applications, the antenna array is expected to operate with centre frequency 1800 MHz. This antenna array is fabricated in FR-4 substrate constraints relative dielectric constant (εr) to be 4.4 and the substrate thickness (h) to be 1.6 mm.

II. ANTENNA DESIGN METHODOLOGY

Micro strip patch is a rectangular metallic strip of width "W", and length "L" fabricated on a thin insulated dielectric substrate. The thickness of the substrate is denoted as "h" and relative permittivity as "εr".

A. Design Considerations of Patch Antenna

The parameters considered for the design of a rectangular micro strip patch antennae are

• Resonant Frequency of antenna (f_0): The antenna has been designed for GSM applications. The resonant frequency of the proposed antenna is 1.8GHz.

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• Relative Permittivity of the substrate (εr): The substrate material used for the design of the antenna is FR4. It has a dielectric constant of 4.4.

• Thickness of dielectric substrate (h): The thickness of the dielectric substrate is chosen as 1.6 mm which is a standard value.

The values chosen for the antenna design are C = 3×108 m/s,εr =4.4andf0 =1.8GHz.

B. Design Procedure

1. Calculation of Patch Width (W)

The width of the patch element (W) is calculated using the equation,

$$W = \frac{C}{2f0\sqrt{\frac{\varepsilon r+1}{2}}}$$

2. Calculation of Effective dielectric constant (εreff)

$$\varepsilon reff = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}\sqrt{1+12\frac{h}{w}}$$

3. Calculation of the Effective length (Leff)

$$Leff = \frac{C}{2f0\sqrt{\varepsilon reff}}$$

4. Calculation of the length extension (ΔL)

$$\Delta L = 0.412h\frac{(\varepsilon reff+0.3)(\frac{W}{h}+0.264)}{(\varepsilon reff-0.258)(\frac{W}{h}+0.8)}$$

5. The length extension (ΔL)of patch

$$\Delta L = Leff - 2\Delta L$$

The dielectric substrate material used is FR4. FR stands for Flame Retardant. It is easily available in the market. It is very cheap also.

The ground plate all other conducting surfaces are fabricated using PEC (Perfect Electric Conductor). It is an idealized material exhibiting infinite electrical conductivity and zero resistivity. The main advantage is that it will not generate heat.

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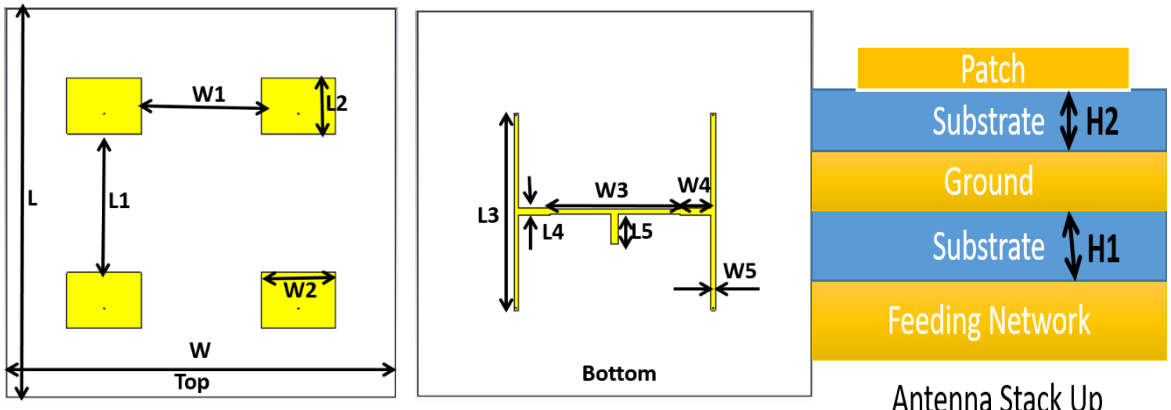

Figure 1. Proposed Structure of 1800 MHz Antenna

III. RESULTS AND DISCUSSION

Figure 1 shows it contains 4 patch element are used and each element has same dimensions as mentioned in Table I in order to increase the antenna performance. The antenna structure contains 5 layers which has feeding network, 2 FR-4 substrate layers contains the thickness 1.6 mm and ground plane and four patch elements.

The feeding network will be connected using via to four elements to match the impedance of each element. Simulation is carried out using CST MICROWAVE Studio 2019. Figure 2. Depicts that Reflection coefficient of proposed antenna

Table I. Dimensions of the Proposed Antenna

Parameters	L	L1	L2	L3	L4	L5	H1	H2
mm	266.5	95	38.2	133.24	5.3	20.96	1.6	1.6
Parameters	W	W1	W2	W3	W4	W5		
mm	266.5	82	51.15	88.2	20.96	3.1		

which shows good impedance matching. Figure 3. Shows the VSWR of the proposed antenna which is covering frequency range of 1.795 – 1.825 GHz is less than 2.

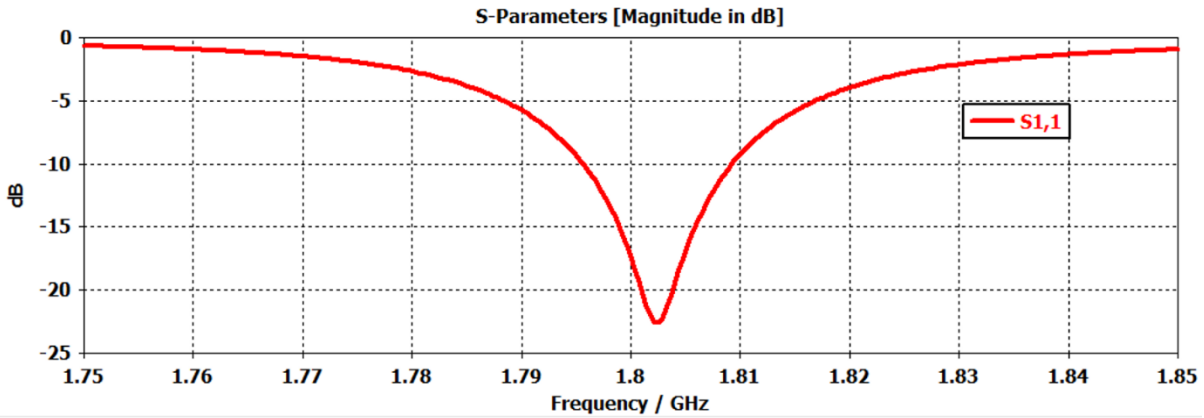

Figure 2. Reflection coefficient of Proposed Antenna

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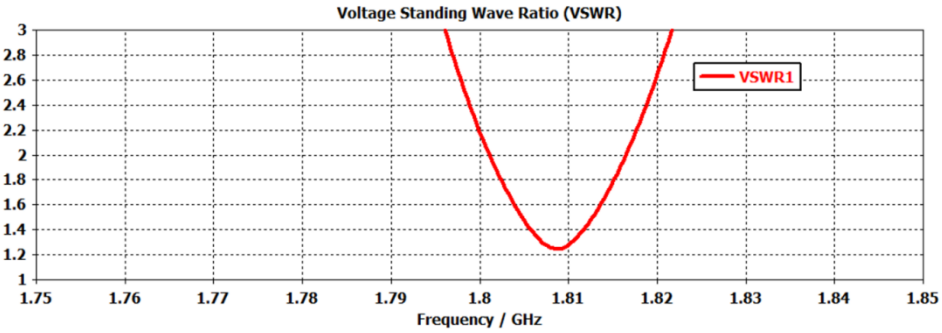

Figure 3. VSWR of Proposed Antenna

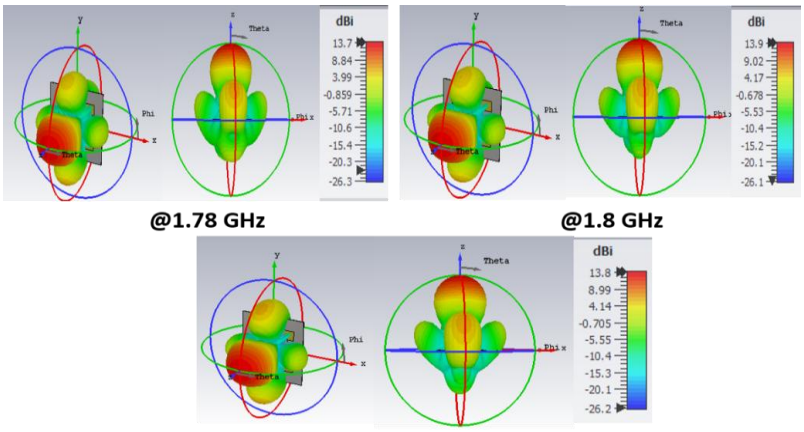

Figure 4. 3dD Radiation Pattern of Proposed Antenna

Figure 4 and Figure 5 shows the 3 dimensional and 2 Dimensional view of the radiation pattern of the proposed antenna in both E and H Plane. The pattern is observed is directional pattern and it has aggregate of large gain of 13.9 dBi, which will suit for base station antenna applications and GSM applications.

Figure 6 shows the directivity of the proposed antenna, which shows the large gain greater than 13.67 dBi throughout the operating band.

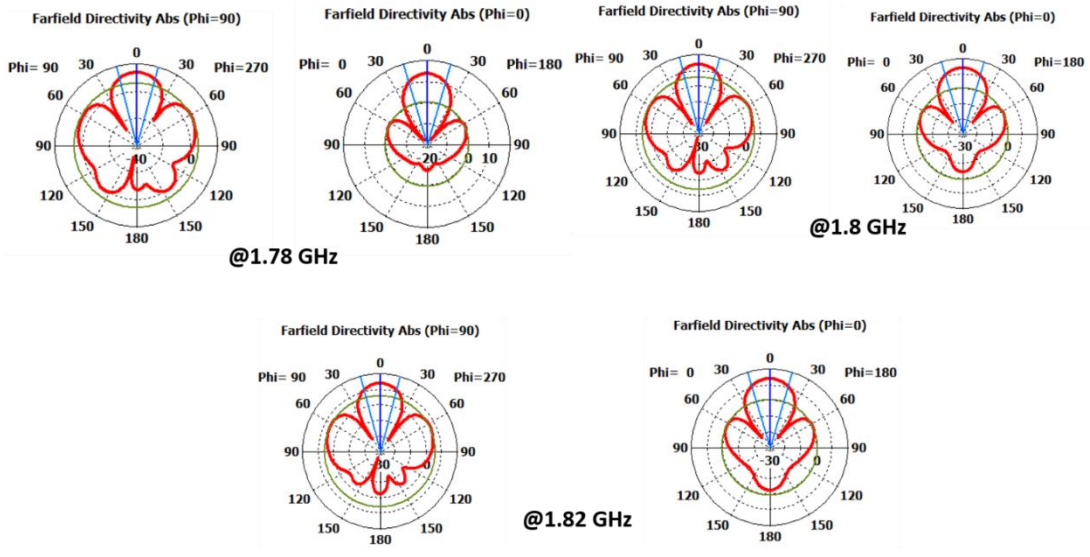

Figure 5. 2D Radiation Pattern of Proposed Antenna

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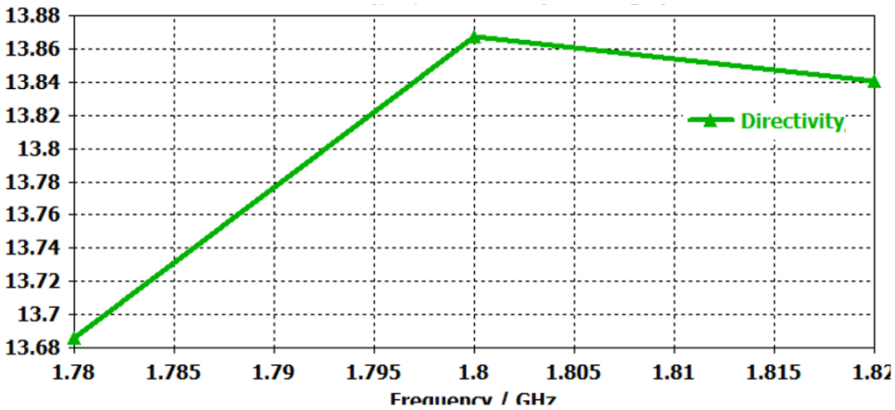

Figure 6. Directivity of the Proposed Antenna

IV.CONCLUSION

A 2x2 rectangular micro strip phased array antenna has been successfully designed. Here micro strip feed technique is used to feed single patch antenna. And corporate feed technique is used for 2X2 array antenna. S parameter calculation has been performed for the designed antenna. From the graph, it is clear that the designed antenna has been radiated in the prescribed range of frequencies defined for GSM application. The solution frequency which is used is very much important for this network and by designing such antenna we are going to improve the efficiency and desired output power. This pattern of antenna can used in GSM application because of array formation it gives better radiation and return loss. The future work is to design 4x4 and 8x8antenna array and square shaped conformal micro strip phased array antenna for GSM application.

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