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Gain Enhancement of Microstrip Antenna through Array method for Bluetooth Application

Rajesh Kumar Raj, Aditya Pareek,H R Choudhary, Vinit Tak

Abstract— In this paper, a four element antenna array has been proposed. The proposed array has been designed over a single sided copper laminated FR4 epoxy dielectric material (low cost).A Wilkinson power divider network has also been designed to feed this array network. The proposed antenna array gives 5.451dB gain. Simulated and Fabricated structure results are in match. The array has been simulated in CST Microwave Studio. It can be used for Bluetooth and Wi-Fi applications also.

Index Terms— Antenna; Array; Bluetooth; Wi-Fi; Wilkinson Power divider; Gain;

1 Introduction

THIS If we increase the length of antenna for required gain and directivity then side lobes, cross polarization have been increased and power loss also, so we use array concept to resolve this problem. Antennas have same size, certain spacing between elements. They give more gain, more directivity, low side lobes and low cross polarization. In recent development this concept are used in wireless technology. Devices give better connectivity results for users for long distance. In this paper designing of an array for Bluetooth application is at low cost. The devices required associated with the technology are increasing with a rapid rate [1]-[4]. Due to rapid growing technology, number of wireless devices increases, it's becoming difficult for an antenna to accommodate a greater number of users within a specified range [5]. To accommodate all the users simultaneously, channel capacity needs to be increased. For enhancing channel capacity either number of antennas to be increased or antenna array to be used. To increase the antennas more cost is needed for installation new antennas they give more side lobe so a cheaper solution is using an antenna array, which increases the gain for the specified range. [6]-[10]

A microstrip antenna array is the simplest, easily manufactured and inexpensive type of aerials available. It comprises a single printed circuit board (PCB), RF connector and sometimes an absorptive load. Microstrip antennas can be manmade on controlled substrate materials which are easily available. The applications of microstrip antennas are fan beams, pencil beams and omni-directional coverage because of its versatility. They can hold both linear polarization and circular polarization. Microstrip feeler arrays are the best example which explained the combined effects of mutual coupling between radiators.[11]-[15]

- *Aditya Pareek is currently pursuing M.Tech in Digital Communication in Govt. Engineeringing College Ajmer. E-mail: adityapareek445@gmail.com*
- *Rajesh Raj, H.R. Choudhary currently Assistant Professor in Govt. Engineeringing College Ajmer.*
- *Vinit Tak is currently pursuing M.Tech in Digital Communication in Govt. Engineeringing College Ajmer.*

In this paper, an array is designed for Bluetooth and WiFi purposes. The proposed antenna has been simulated in electromagnetic solver CST Microwave Studio. Stepwise designing of the antenna array is shown in the section below. Array networks of two antennas and four antennas have been designed and discussed the results in detail.

2. Designing of Proposed Antenna Array

2.1 Designing of Single unit Antenna

Initially, a single unit antenna has been designed as shown in Fig. 1. The proposed structure has been simulated on FR4 epoxy with dielectric constant 4.4 and loss tangent 0.0024 for 2.45GHz.The antenna has been simulated in CST MWS. Dimension of single patch in Table 1.

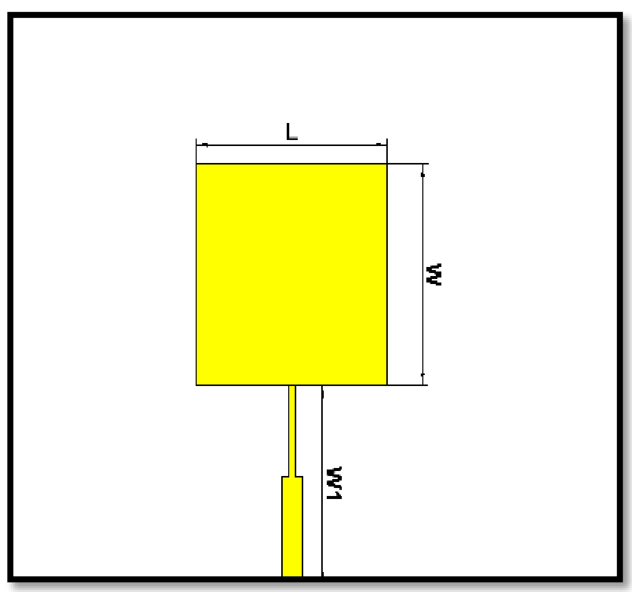

Fig. 1 Single antenna of proposed array

TABLE 1 DIMENSIONS OF SINGLE ELEMENT ANTENNA

Dimensions	Units (mm)
Width of the patch (L)	27.8 mm
Length of the patch (W)	28.6 mm
Length of microstripline (W1)	25.6 mm

Simulated reflection coefficient (S11) of single unit patch antenna is shown in Fig. 2 and gain of single patch in Fig. 3.

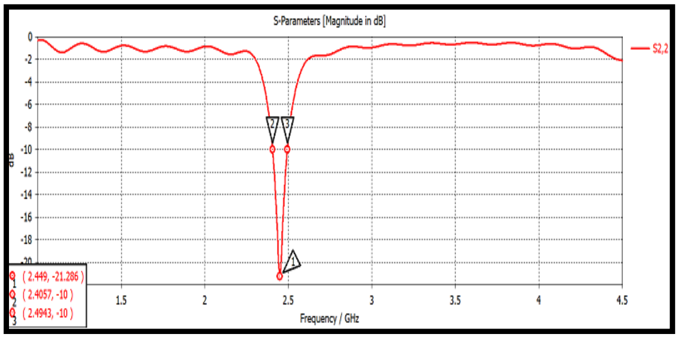

Fig. 2 Single antenna of proposed array.

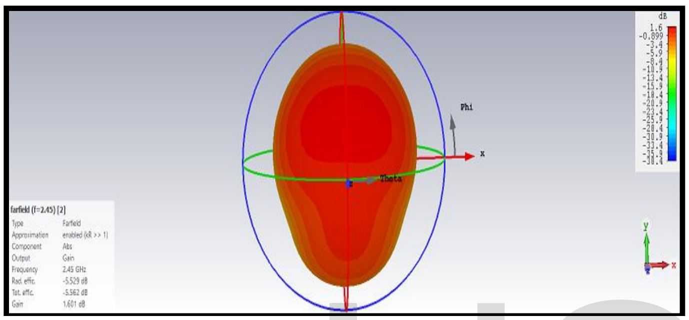

Fig. 3 Gain of patch.

2.2 Designing of Two element Antenna Array

In the second step, a feeding system with power divider has been intended for two antennas. The two-antenna array with power divider has been shown in Fig. 4. The structure has been pretend using CST MWS. Simulated S11 factor of this structure is shown in Fig. 5, which shows that two element array also resonates at 2.4GHz due to proper matching.

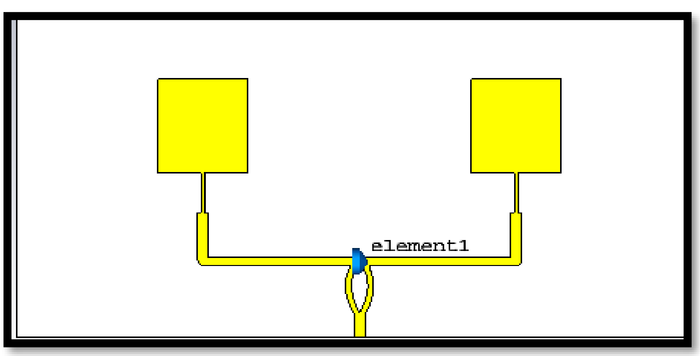

Fig. 4 Two element array of proposed antenna array

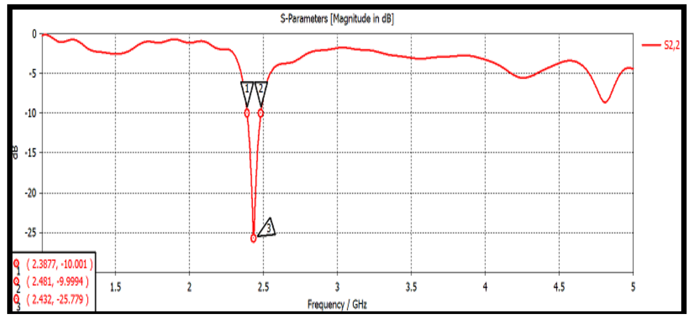

Fig. 5 S22 parameter of two element array of proposed antenna array.

(A) Proposed Microstrip Array Antenna

Proposed 4 element antenna arrays with its dimensions are shown in Fig. 6. The detailed dimension of array is given in Table 2. For feeding all the elements of this array, a feeding network has been designed with three power dividers, which feeds all the four antennas simultaneously for with perfect matching.

TABLE 2 DIMENSIONS OF FOUR ELEMENT ARRAY ANTENNA

Dimensions	Units (mm)
Width of the patch (L)	27.8
Length of the patch (W)	28.6
Length of microstripline (W1)	25.6
L1	41
L2	61.4
L3	15.4

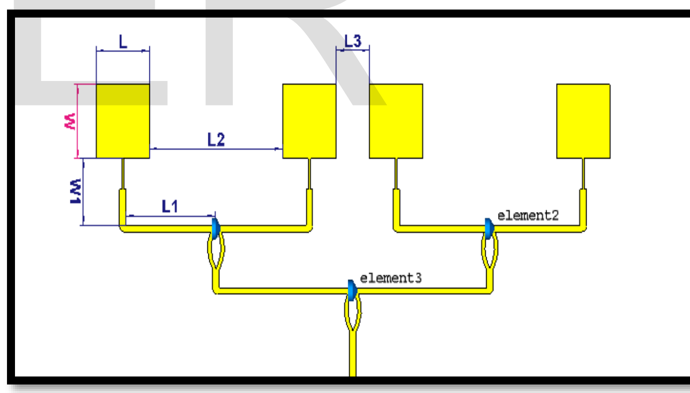

Fig. 6 Two element array of proposed antenna array.

3 RESULTS AND DISCUSSION

All the parameters of characterize antenna is discussed in this section.S11 parameter of proposed four element arrays is shown in Fig. 7. S11 parameter shows that the 4-element mast array also resonates at 2.4GHz, due to perfect matching. The array provides almost 90 MHz bandwidth.

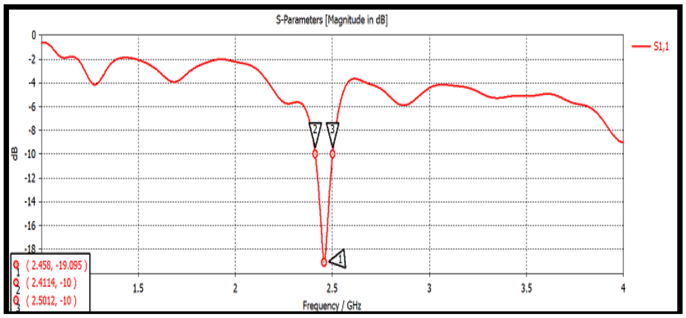

Figure 7. S11 parameter of four element antenna array.

The surface current of 4 component antenna array is shown in Fig. 8. The figure shows current as evenly distributed in all the 4 patches and the feeding network is also evenly distributing the power to all antennas.

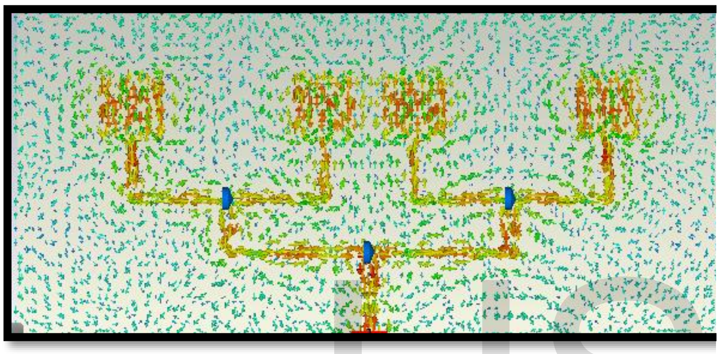

Figure 8. Surface current of proposed four element antenna array

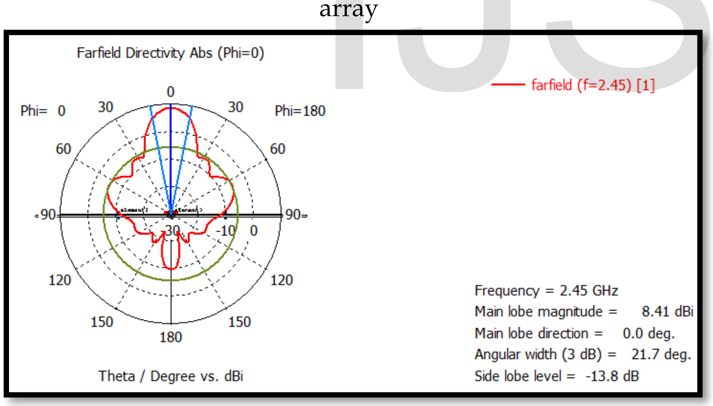

Figure 9. Radiation Pattern of proposed four element array at 2.4 GHz for phi 0 degree.

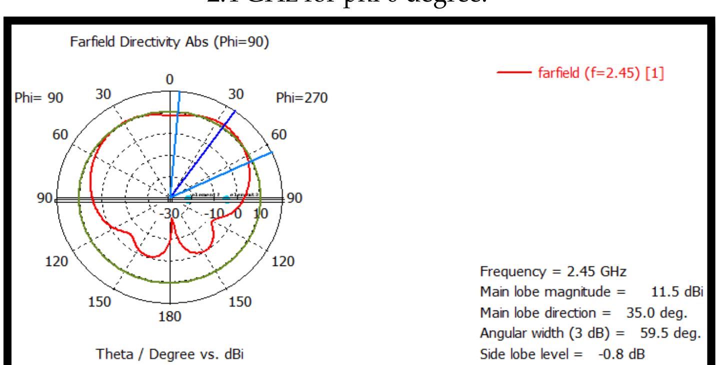

Figure10. Radiation Pattern of proposed four element array at 2.4 GHz for phi 90 degree

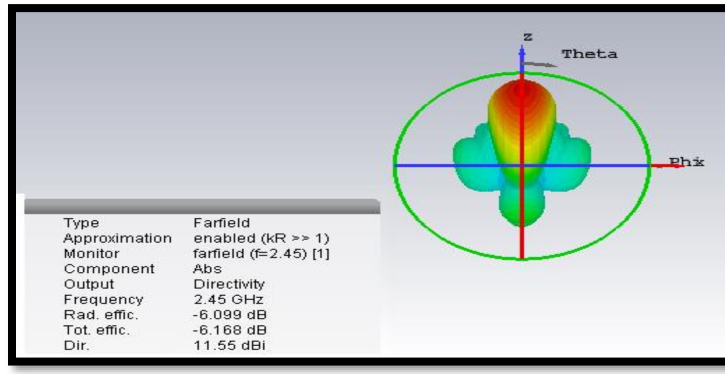

Figure 11. 3D radiation Pattern of proposed four element array at 2.4 GHz

Simulated radiation outline at 2.4GHz is shown in Fig. 9 and Fig. 10. The radiation pattern for four element arrays has been shown at phi 0 degree and 90 degree which shows the directional pattern with wide bandwidth. As evaluate to single antenna and 2 elements array the pattern of 4 element arrays is better in terms of directivity and gain. At phi 0 degree, pattern shows directivity of 8.41dBi while at phi 90 degree it shows directivity of 11.5dBi. The radiation outline of array shows better radiation outline than single element, 2 element array with directivity 11.5dBi and its more directional. 3D radiation pattern of the proposed 4 element array is shown in Fig. 11, which shows that the directivity is very high and backlobes are very less means it will radiate more in desired direction.

TABLE 3. COMPARISON RESULTS BETWEEN SINGLE PATCH UNIT ,TWO AND FOUR ELEMENT ARRAY ANTENNA

Properties	**Single Patch Antenna**	**Two element Array**	**Four Element array**
Gain	1.601 db	2.628 db	5.451db
Directivity	7.130 dbi	8.998dBi	11.55 dbi
Bandwidth S_{11}(Blow -10db)	88.6 MHz 2.4057 to 2.4943 GHz	93.3 MHz 2.3877 to 2.481	89.8MHz 2.4114 to 2.5012 GHz
S11 peak	-21.286 db at 2.449 GHz	-25.779db at 2.432 GHz	-19.095 db at 2.458 GHz

On comparing the outcome of solitary patch unit, 2 element array and 4-element array aerial, it is find that the Beamwidth of array is equal with the single unit of the antennas and there is drastic improvement ingain and directivity of the feeler, which is as shown in 2-D representation graphs figure 12 and Fig. 13

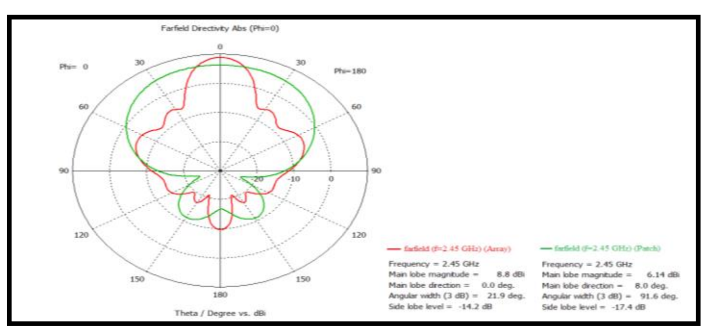

Figure 12. 2-D Radiation pattern at Phi=0 for both patch and array antenna.

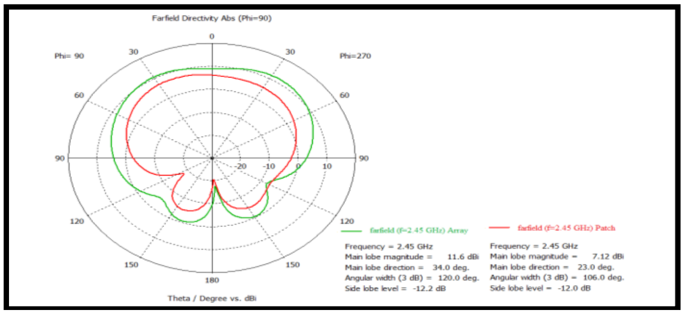

Figure 13. 2-D Radiation pattern at Phi=90 for both patch and array antenna

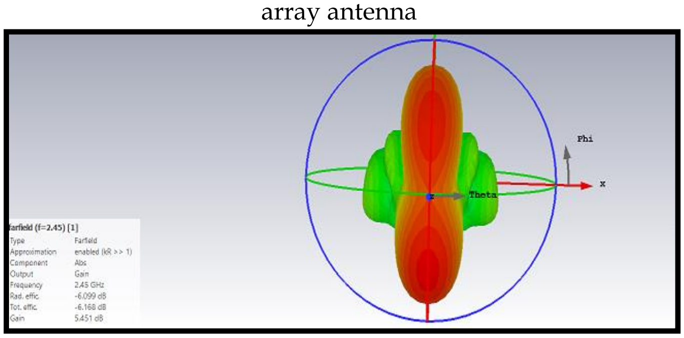

Figure 14 Gain pattern of 4 element array.

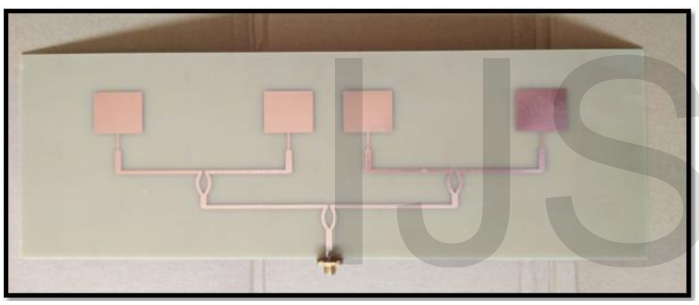

Figure.15 Fabricated four element array.

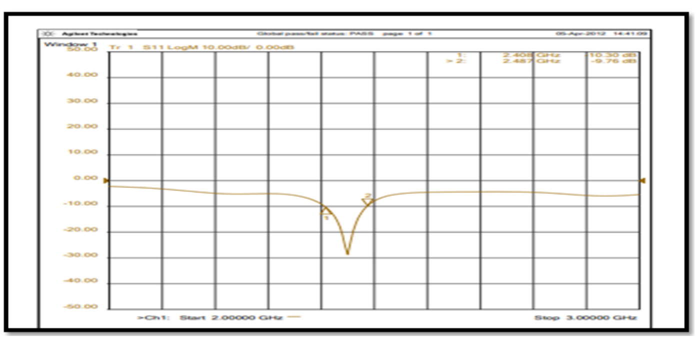

Figure 16. Measured S11 parameter of proposed Antenna array by VNA

TABLE 4. FOUR ELEMENT ARRAY ANTENNA COMPARISON RESULTS BETWEEN SIMULATED AND FABRICATED

Properties	**Simulated array**	**Fabricated array**
Bandwidth S_{11}(Blow -10db)	89.8MHz, 2.4114 to 2.5012 GHz	89MHz, 2.40 to 2.489 GHz
S_{11} peak	-19.095 db at 2.458 GHz	-29 db at 2.45GHz

The antenna array has been fabricated through photolithographic process and fabricated structure is shown in Figure 13. The fabricated structure has been measured using Vector Network Analyzer and measured S11 is shown in Fig. 14, S11of fabricate array shows the same results as simulated array so it is big achievement for ours and it show fabrication process was perfect .

4 CONCLUSION

The 4-element proposed microstrip antenna array has been simulated and fabricated also. A good Wilkinson power divider feeding network has also been designed for two antenna and four antenna array. Wilkinson power divider used for perfect impedance matching between patches and feeding port All the result shows that 4 element antenna array has improved gain and also directivity as compared to single element and 2 element array. The gain of antenna array increases as the number of elements increases in array. The proposed array can accommodate a greater number of users simultaneously. The proposed array has achieved 5.45db gain and11.55dBi directivity. This array can be used for many purposes such as Bluetooth and Wi-Fi purpose in different devices.

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