ARRAY FACTOR IN CURVED MICROSTRIPLINE ARRAY ANTENNA FOR RADAR COMMUNICATION SYSTEMS

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ABSTRACT

This paper presents the designed of varians *array in curved microstripline* antenna *for radar communication. The antenna geometry comprises of three varians in matrics 2x2, 2x4 and 4x4 dimensions. The several array operates in C-Band frequencies (4GHz – 8GHz) and X-Band frequencies (8GHz-12GHz) with a 1.82 VSWR, -18.72dB Return loss,* 0.29 *reflection coefficient, and 5.8dB gain for 2x2 array, 1.64 VSWR, -16.17dB Return loss,* 0.24 *reflection* coefficient*, and 5.4dB gain for 2x4 array, 1.04 VSWR, -37.70dB Return loss,* 0.19 *reflection* coefficient*, and 7.6dB gain for 4x4 array. All of the varians in array elements are feed using a direct feeding technique. This array antenna is suitable developed for use in radar communication systems.*

KEYWORDS

Array, Curved microstripline, Radar communication, C-Band, X-Band

1. INTRODUCTION

Researches on Design of Antenna had conducted previously. The variation of design, the analysis, and the result obtained were not be optimal to be conducted in its application especially in radar communication systems. In this research, 2x2, 2x4, and 4x4 varian arrays in curved microstripline antenna was designed. In radar communications, there is a emphasizing need to minimize the size, weight and power requirments of antenna in array varians. The concept of array antennas with widely separated frequencies bands. Thus, in this research multiband frequencies antenna elements have been designed and fabricated that can potentially to develope radar communication systems. A novel design in microstrip antenna is one type of antenna that is designed using a PCB (Printed Circuit Board). Microstrip antennas are physically components that are designed to emit and or receive electromagnetic waves. In this antenna design also considerated the size of feeding stripline to reach the maximum results in antenna indicator parametric. As a goal of this research is to find the optimum indicator parametric results in S_{11},

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Voltage Standing Wave Ratio (VSWR), Return Loss, Reflection Coefficient and gain that can be develope in radar application communications.

2. THEORIES

2.1 Microstrip Antenna

Microstrip antennas are electrically thin, lightweight, comformable, low cost, easily fabricated and can be connected to Microwave Integrated Circuits (MICs) at various frequencies [1]. There are various types of microstrip antenna designs on the taper section. There is a rectangular, circular, triangle shape according to the empirical analysis of antenna design. The design of the antennas varies with the single side and the double side. This study designed novel curved microstripline antenna with 2x2, 2x4 and 4x4 array, to produce greater gain so that it could be more optimally applied to radar communication systems.

2.2 Array Factor

Microstrip antennas arranged in Array are not only useful for widening bandwidth but also have an impact on the radiation pattern produced. The radiation pattern in the Antenna is generally written with the equation:

$$R\ (\theta,\emptyset)\ \text{with i element in the position of}\ r_i = (x_i, y_i, Z_i)$$

The relationship with the wave emitted from the antenna array (Y) with the multiplier of complex numbers (wi) in the function (θ, Ø), is obtained:

$$Y = R\ (\theta,\emptyset) w_1 e^{-j\,k\,\cdot\, r_1} + R\ (\theta,\emptyset) w_2 e^{-j\,k . r_2} + \cdots R(\theta,\emptyset) w_N e^{-j\,k\, r_N}$$

With k is the wave vector in the incoming wave.
Next can be written:

$$Y = R\ (\theta,\emptyset) \sum_{i=1}^{N} w_i e^{-j\,k\,.r_i}$$

$$Y = (\theta,\emptyset)\ AF$$

$$;AF = \sum_{i=1}^{N} w_i e^{-j\,k\,.r_i}$$

AF = Array Factor (as an Antenna position function).

2.3 Design Overview

Calculation of Antenna Dimensions uses the following steps:

The first calculating is to find the total electricity permittivity (ε_{rtot}) using the capacitor equation:

$$\frac{1}{c_{tot}} = \frac{1}{c_1} + \frac{1}{c_2}$$

$$\frac{1}{\varepsilon_o \, \varepsilon_{r\ tot} \, A / d\,tot} = \frac{1}{\varepsilon_o \, \varepsilon_{r_1} \, A_1 / d_1} + \frac{1}{\varepsilon_o \, \varepsilon_{r_2} \, A_2 / d_2}$$

where ε_{r1} is ε_r for air ($\varepsilon_{r1} = 1$), ε_{r2} is ε_r for substrate (ε_r FR4 = 4.3), d_1 thick of substrate and d_2 distance of substrate to the reflector, with dtot is d_1+d_2.

And then using the following equation:

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + 10\frac{h}{w}\right)^{-0,555}$$

To calculate the effective permittivity electricity (ε_{eff}). Where ε_r is the same with εr_{tot}, h is d_{tot} and w is the various wide for patch and stripline side.

The following equation is to know the maximum dimension in the patch side (w_1):

$$f = \frac{2c}{3w\sqrt{\varepsilon_r}}$$

$$w_1 = \frac{2c}{3\sqrt{\varepsilon_r}\, f}$$

where c is lightspeed in air, ε_r is electricity permittivity and f is frequency.

And to calculate the effective width stripline side ($W_{2,3}$), using the following figure:

$$W_{2,3} = \frac{1}{2f\sqrt{\mu_0 . Z_o}}\sqrt{\frac{2}{\varepsilon_r + 1}}$$

Where f is frequency, μo is permeability constant and Zo is characteristic impedance.

The calculation wavelength of the substrate (λg), using the following equation:

$$\lambda g = \frac{\lambda}{\sqrt{\varepsilon_{eff}}}$$

From the analysis above we find to fix the parameter of antenna fabrication.

The following figure is the Curved Microstripline Antenna Design in array variant.

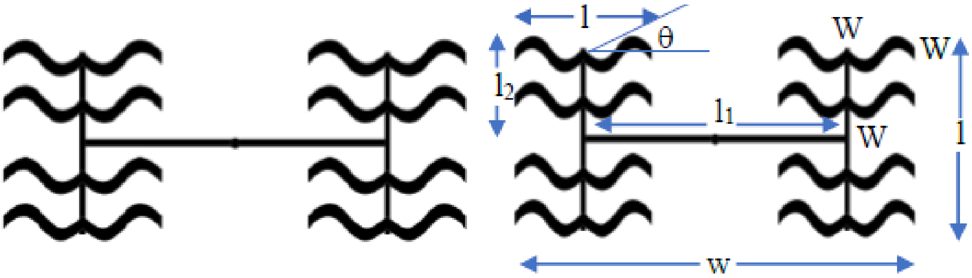


Figure 1. (a) Curved Microstripline 2x2 Array Antenna Design (b) Dimension of Curved Microstripline 2x2 Array Antenna Design.

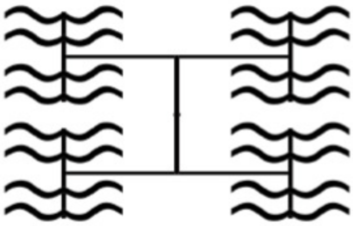


Figure 2. Curved Microstripline 2x4 Array Antenna Design.

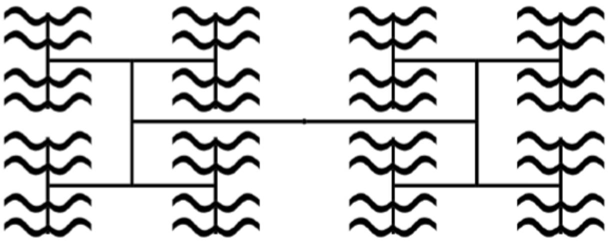
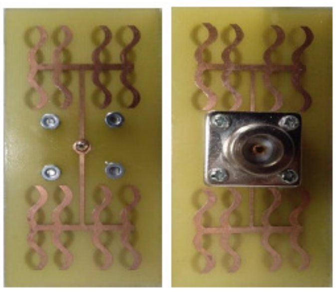


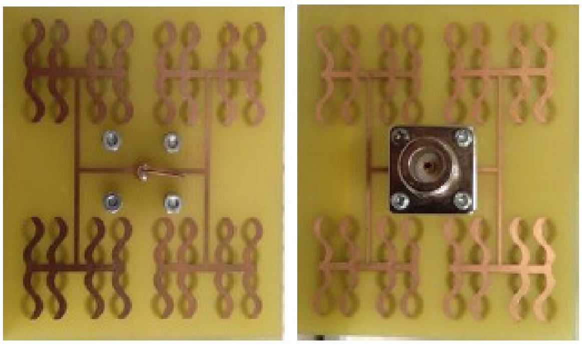
Figure 3. Curved Microstripline 4x4 Array Antenna Design.

3. FABRICATION, SIMULATION AND MEASUREMENTS RESULT

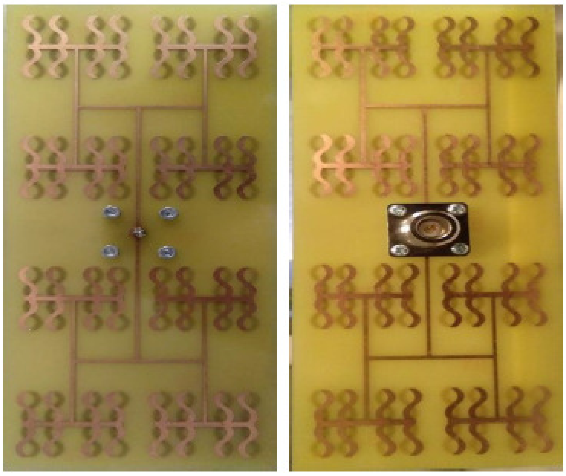
The following figure is the result of fabrication in curved microstripline array varians antenna.



(a) 2x2 Array Varians.



(b) 2x4 Array Varians.



(c) 4x4 Array Varians.

Figure 4. Curved microstripline array varians antenna prototype. (a). 2x2 Array Varians. (b) 2x4 Array Varians. (c) 4x4 Array Varians.

Curved microstripline array varians antenna prototype was fabricated by UV photoresist laminate. In our work, the antenna prototypes are fabricated on Flame Retardant 4 (FR_4) material with 4.3 dielectric constant. The first step in the fabrication process is to generate the photo mask artwork by printing on stabline or rubylith negative film of the desired geometry on butter sheet. Using the precision cutting blade of a manually operated co-ordino graph the opaque layer of the stabiline or rubylith film is cut to the proper geometry and can be removed to produce either a positive or negative film representation of the antenna sketches. The design dimensions and tolerances are verified on a cordax measuring instrument using optical scanning. Enlarged artwork should be photo reduced using a high precession camera to produce high resolution negative, which is later used for exposing the photo resist. The photographic negative must be now held in very close contact with the polyethylene cover sheet of the applied photo resist using a vacuum frame copy board or other technique, to assure the fine line resolution required. With exposure to proper wavelength of light, polymerization of the exposed photo resist occurs making it insoluble in the developer solution. Now, it is then coated with a negative photo resist and exposed to UV-radiation and it is immersed in developer solution up to two minutes through the mask. The exposed photo resist hardens and those in the unexposed areas are washed off using a developer. The unwanted copper portions are now removed using Ferric Chloride ($FeCl_3$) solution. $FeCl_3$ dissolves the copper coating on the laminate except which is underneath the hardened photo resist layer after few minutes. Finally, the laminate is then washed with water and cleaned in acetone solution to remove the hardened negative photo resist. The fabrication process has shown in the following figure.

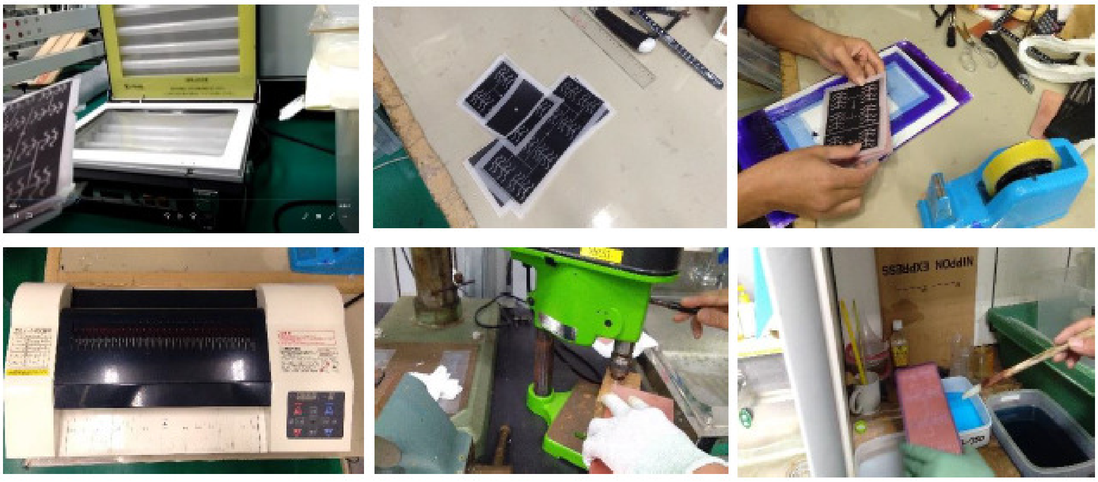
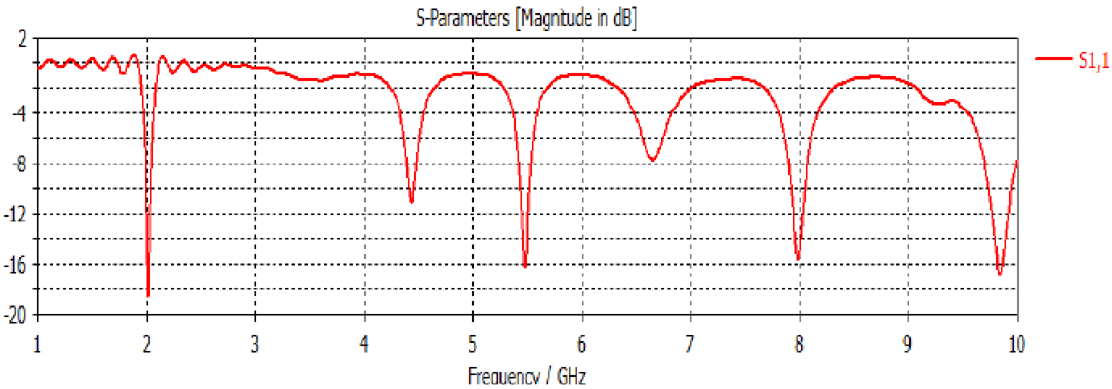
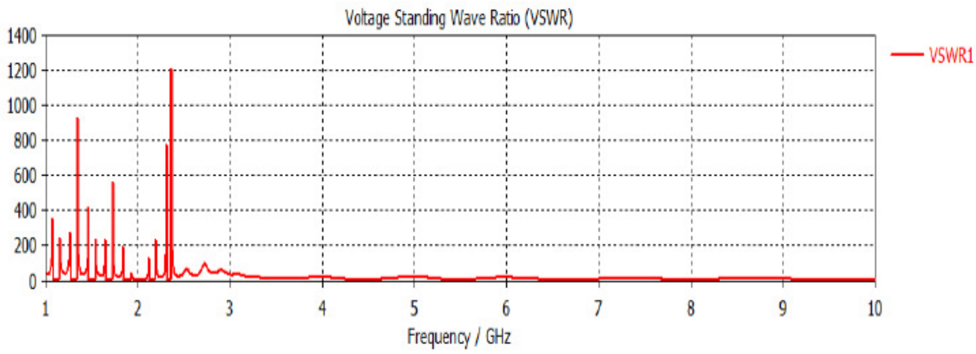
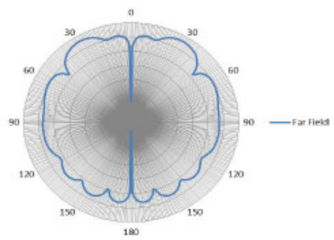


Figure 5. Fabrication Process.

The curved microstripline array varians antenna shown in Figure 6 has been modeled in CST programme to determine S_{11} parameter, Voltage Standing Wave Ratio (VSWR), Return Loss, Reflection Coefficient and Radiation Pattern.

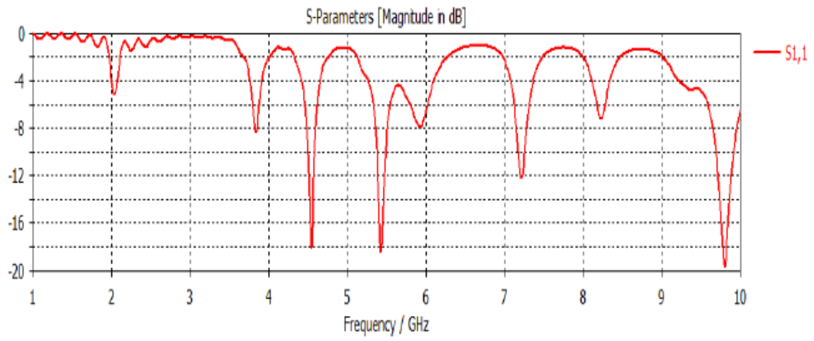


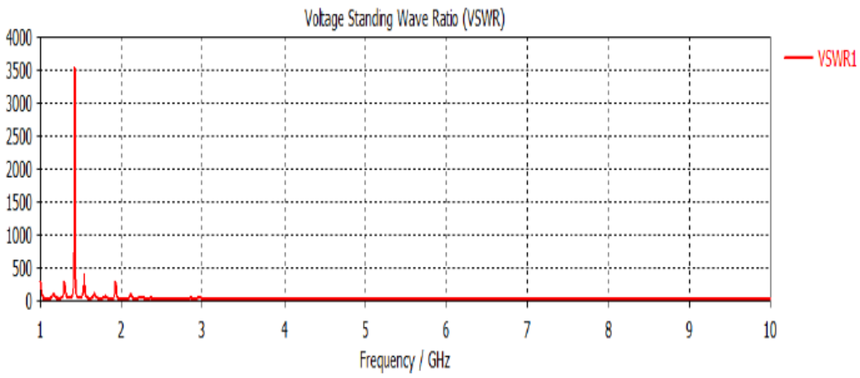


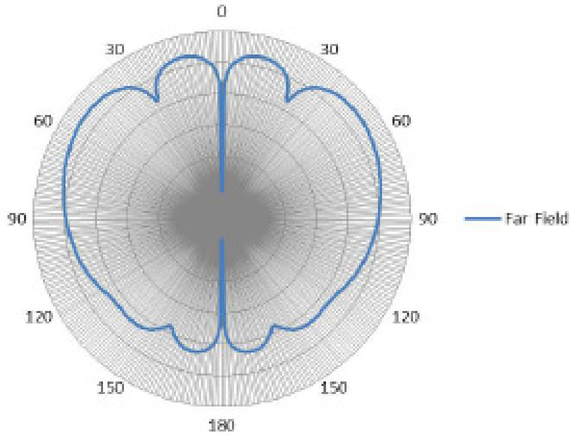


(a) S_{11} Parameter. (b) VSWR. (c) Radiation Pattern.

Figure 6. Curved microstripline 2x2 array varians antenna simulations. (a) S_{11} Parameter Simulation. (b) VSWR Simulation. (c) Radiation Pattern Simulation.

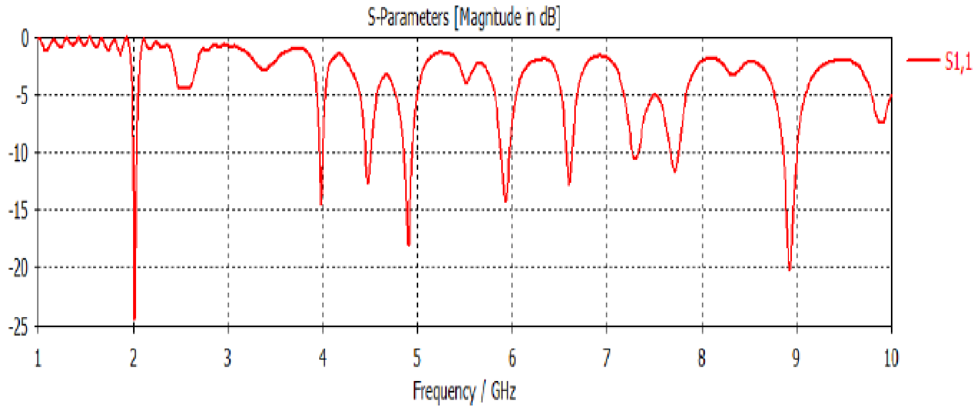


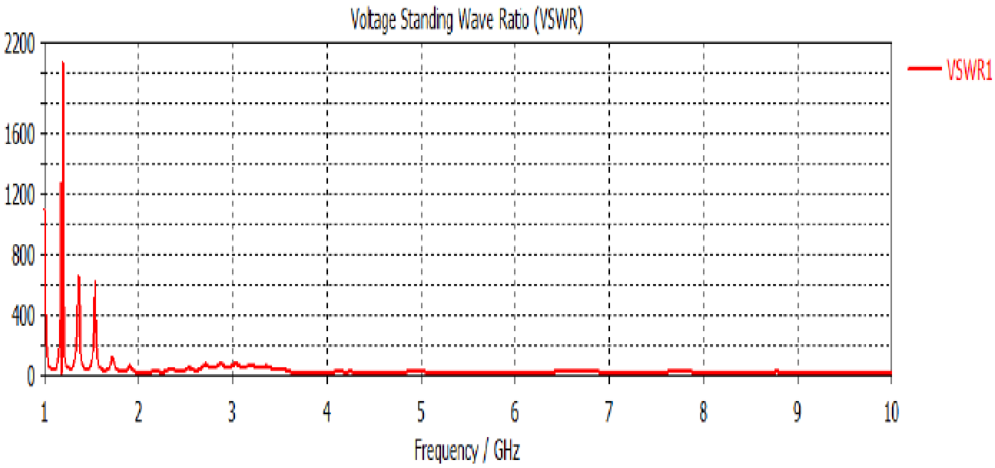


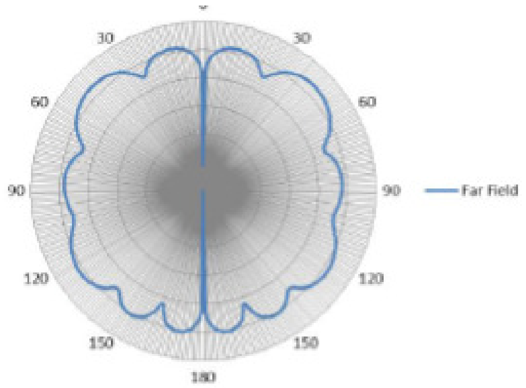


(a) S11 Parameter. (b) VSWR. (c) Radiation Pattern.

Figure 7. Curved microstripline 2x4 array varians antenna simulations. (a) S_{11} Parameter Simulation. (b) VSWR Simulation. (c) Radiation Pattern Simulation.



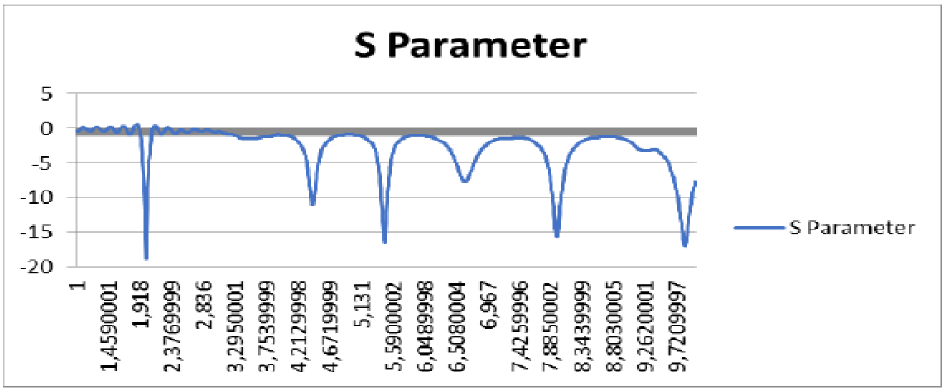




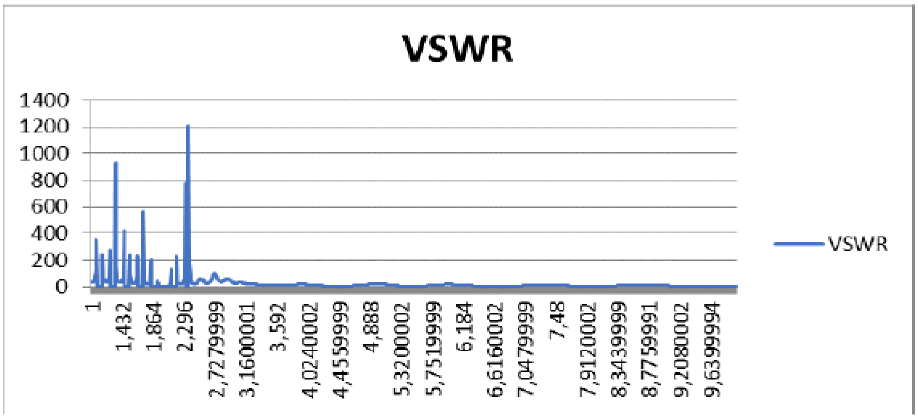
(a) S_{11} Parameter. (b) VSWR. (c) Radiation Pattern.

Figure 8. Curved microstripline 4x4 array varians antenna simulations. (a) S_{11} Parameter Simulation. (b) VSWR Simulation. (c) Radiation Pattern Simulation.

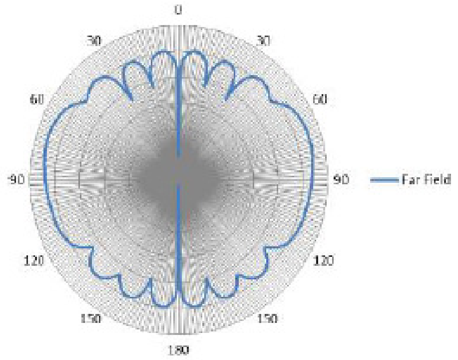
Antenna measurement using a Network Analyzer type device the Agilent 8510 Vector Network Analyzer. With result:



(a)



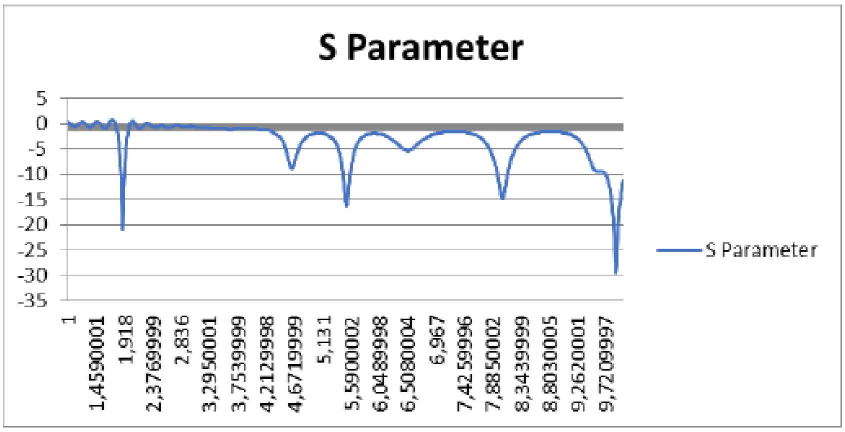
(b)



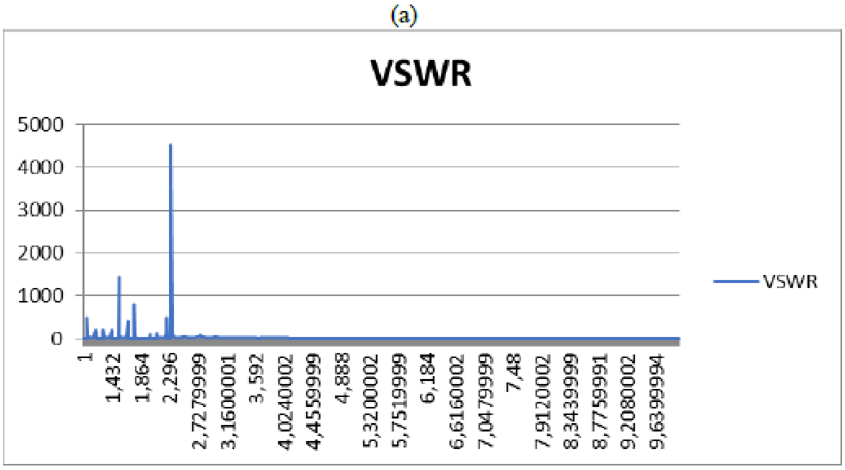
(c)

(a) S_{11} Parameter. (b) VSWR. (c) Radiation Pattern.

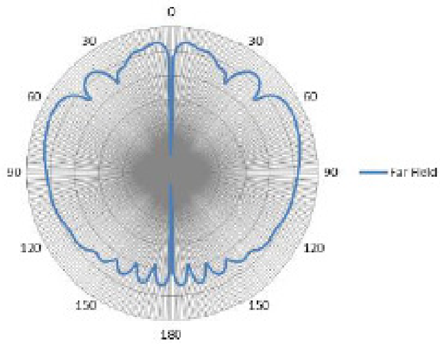
Figure 9. Curved microstripline 2x2 array varians antenna measurements. (a) S_{11} Parameter Measurement. (b) VSWR Measurement. (c) Radiation Pattern Measurement.



(a)



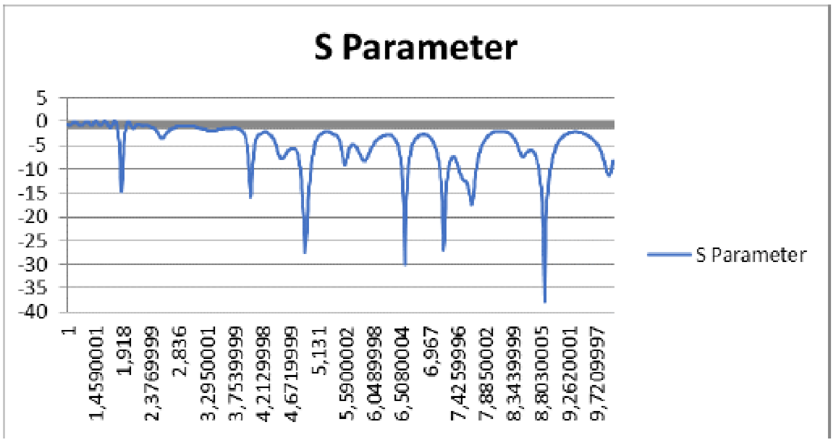
(b)



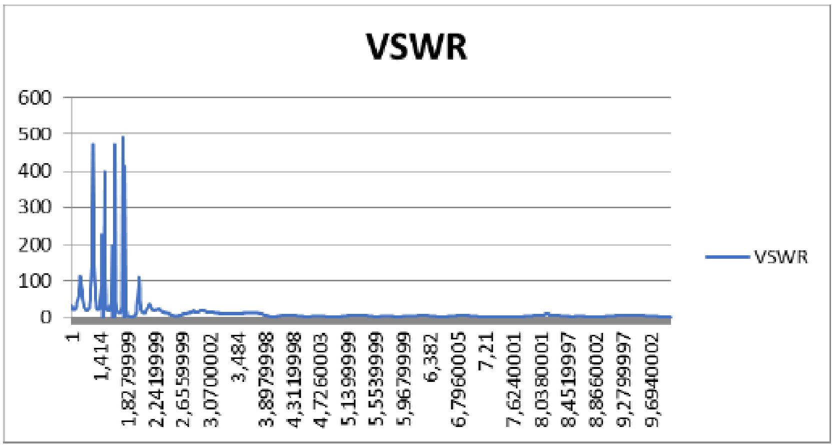
(c)

(a) S_{11} Parameter. (b) VSWR. (c) Radiation Pattern.

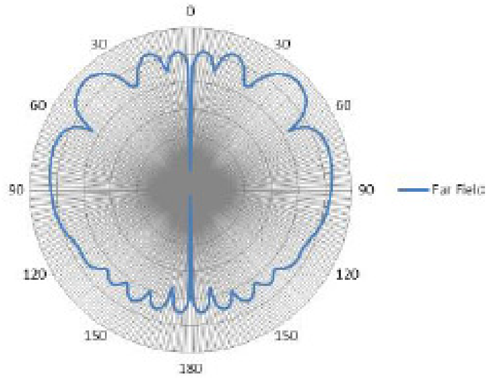
Figure 10. Curved microstripline 2x4 array varians antenna measurements. (a) S_{11} Parameter Measurement. (b) VSWR Measurement. (c) Radiation Pattern Measurement.



(a)



(b)



(c)

(a) S_{11} Parameter. (b) VSWR. (c) Radiation Pattern.

Figure 11. Curved microstripline 4x4 array varians antenna measurements. (a) S_{11} Parameter Measurement. (b) VSWR Measurement. (c) Radiation Pattern Measurement.

In general, base on the simulation and the measurement results, curved microstripline array varians antenna has the optimal parametric characteristic as a good requirements antenna that can be develop in radar communication applications. The characteristics of Curved microstripline array varians antenna can be described in the following table.

Indicator	Value	Standard Parametric
VSWR	Array 2 x 2 1.82 Array 2 x 4 1.64 Array 4 x4 1.04	1 < VSWR < 2
Return Loss	Array 2 x 2 -18.72 Array 2 x 4 -16.17 Array 4 x4 -37.70	≤ - 10 dB
Reflection Coefficient	Array 2 x 2 0.29 Array 2 x 4 0.24 Array 4 x4 0.19	Close to 0
Gain	Array 2 x 2 5.8 Array 2 x 4 5.4 Array 4 x 4 7.6	> 4dB

Table 1. Curved microstripline array varians antenna characteristics.

4. CONCLUSION

Adding Arrays to the Curved Microstripline Antenna gives more optimal results especially in the range of working frequencies (bandwidth) and also the resulting gain. The results indicate that the antenna is able to apply in multiband frequency. The radiation pattern produced in this design is Omnidirectional in linear polarization. The band frequencies array in this design is capable to develope in radar application communication systems.

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