International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-8 Issue-11, September 2019

Construction and Implementation of Coaxial Probe Feed Microstrip Patch Array Antenna

B.Siva Sai Reddy,.P.Parvathi,.B.Senthil Kumar

Abstract: ***This project aims for the construction and implementation of the Coaxial probe feed microstrip array antenna for radar applications. As the Continuous Wave Frequency Modulated (CWFM) radar can together transfer and to accept the signals, whatever that can be used for a bistatic radar for consideration of weather and temperature. The single patch, 1x4, 2x2, 4X4 coaxial probe feed is to design at a frequency of 1.48GHz by using RT duriod (ε_r = 2.2) dielectric substrate for a bandwidth of 15MHz. For Microstrip antenna array elements is to connect with inter-component configuration of 0.8λ. in both horizontal and vertical directions. The microstrip patch array antenna was constructed and implemented by using HFSS (High Frequency Structure Simulator) and comparison of various descriptions of array antennas by using feeder network in circuit construction and to check the isolation between the two antennas for bistatic radar.***

Index Terms**:** ***Microstrip patch array antenna, Bistatic radar, isolation, HFSS.***

I. INTRODUCTION

Microstrip antenna performance an important factor in wireless communication systems. Microstrip patch antenna consisting of a transmitting patch on one side of the dielectric substrate that has the ground plane any other wayside. These types of antenna consist of three sheets. The top sheet is radiating patch and the intermediate sheet is a dielectric substance, the bottom sheet is ground plane[2][4]. The material is used for the top and bottom sheets are used for copper material and RT Duriod is used as a dielectric substance.

Based on emission uniqueness of the array antenna is designed. For single antenna emission pattern is extensive and directivity is less[3][4]. To increase directivity narrow beam width array antenna is used.

The coaxial probe feed is one of the most common feeding techniques for microstrip antenna. In this technique, the feed can be located any desired area inside the patch to match the input impedance of the patch antenna. The inner conductor of the coaxial connector is extended through the dielectric is attached to the radiating patch of the antenna that the outer conductor is connected to the ground plane. In these microstrip patch antenna can be used to design by using HFSS and also to check isolation between the two antennas for bistatic radar.

II. MICROSTRI P PATCH ARRAY ANTENNA

In this paper, coaxial probe feed patch antenna array has been designed by using feeder network in circuit design at a center frequency of 1.48GHz using a dielectric substance as RT Duriod with ϵ_r= 2.2 and thickness (h) = 0.3175cm. The dielectric constant is commonly in the length of $2.2 \leq \epsilon_r \leq 12$[4]. The arrays elements are connected with the inner component configuration of 0.8λ in both horizontal and vertical directions. For the design of probed feed microstrip array antenna is used for the transmission line design.

The specifications of the antenna are return loss, bandwidth, VSWR, radiation pattern, gain, directivity and to check isolation between the two antennas are determined by using the High Frequency Structure Simulator. It is used for antenna, antenna arrays, filters and high frequency ranges. An Iterative solver is used for simulation.

A. Design Equations

The expected antenna design can be determined by using the formulas[2] given below.

The width of the patch can be calculated as

$$W= c/2f_r \text{ x } \sqrt{2/\epsilon_r+1} \qquad (1)$$

Where c is the speed of the light, f_r is the running frequency of the antenna, ϵ_r is the constant of the dielectric substrate.

The diameter of the patch can be calculated by using the following equations:

$$\epsilon_{reff} = \epsilon_r+1/2 + \epsilon_r -1/2(1+12\ h/w)^{-1/2} \qquad (2)$$

Where ϵ_{reff} is effective dielectric constant, h is the thickness of the dielectric substrate.

$$L_{eff} = c/2f_r \sqrt{\epsilon_{reff}} \qquad (3)$$

Where L_{eff} is that the effective length of the patch.

$$\Delta L= 0.412xh\ (\epsilon_{reff} +0.3)\ (w/h+0.264)/\ (\epsilon_{reff} - 0.258)\ (w/h +0.8) \qquad (4)$$

Where ΔL is the extended patch length.

$$L = L_{eff} - 2x\Delta L \qquad (5)$$

Where L is the actual patch length.

The location of the feed location can be calculated along x-axis and y-axis were given as

$$X_f = L/2 \sqrt{\epsilon_{reff}} \qquad (6)$$

Where X_f has the desired frequency along X-axis.

Manuscript published on 30 September 2019.

*Correspondence Author(s)
B. SIVA SAI REDDY, Electronics and Communication Engineering, SVEC College of Engineering, Tirupati, India.
P. PARVATHI, National Atmospheric Research Laboratory, Gadanki, Tirupati, India.
B. SENTHIL KUMAR, Electronics and Communication Engineering, SVEC College of Engineering, Tirupati, India.

$$Y_f = W/2 \qquad (7)$$

Where Y_f has the desired frequency along Y-axis.

B. Feeder Network in Circuit Design

The λ/4 transformer is the perfect procedure for impedance is identical[1]. While construction of feeder network plays important for impedance from source to load.

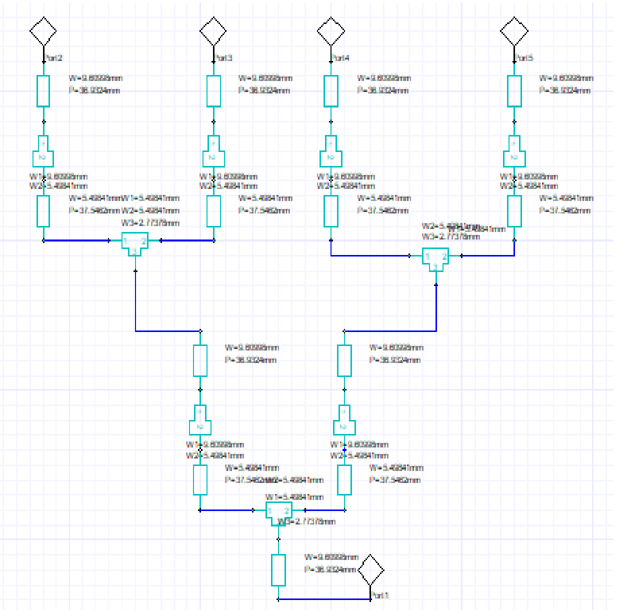

Figure 1: λ/4 of a feeder network in circuit design

III. STRUCTURE OF COAXIAL PROBE FEED MICROSTRIP PATCH ANTENNA CONSTRUCTION IN HFSS

By using HFSS single probe feed, 1x4, 2x2 and 4x4 coaxial probe feed microstrip patch array antenna is constructed. The dimensions and constructions of all these antennas are shown below.

A. Coaxial Probe Feed Patch Antenna Design

1.Single Coaxial Probe Feed Microstrip antenna

In these types of a microstrip patch antenna, the feed can be located inside the patch to match the transmission line of input impedance 50Ω by using an input impedance of the λ/4 transformer.

TABLE 1: Specifications of Single Coaxial Probe feed Patch Antenna

Parameters	Values of Rectangular patch (cm)	Description
H_s	0.3175	The Thickness of substrate
ε_r	2.2	Dielectric Constant
W	8.962	Width of the patch
L	6.43	Length of the patch
D	0.44	Diameter of the inner conductor of probe
d_0	0.127	Diameter of the outer conductor of probe
W_g	16.2	Width of the ground plane
L_g	16.2	Length of the ground plane
f_L	3.29	Feed Length

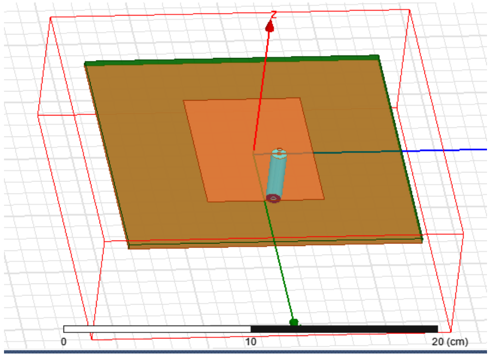

Figure 2: Coaxial Probe Feed for rectangular patch antenna

2. Coaxial Probe Feed Microstrip Patch Array Antenna The microstrip patch antenna is used as single and as well as array elements. The achievement of the antenna character increases like bandwidth, directivity and other specifications that are different from to achieve with a separate element. Rectangular Microstrip Array Antenna has been constructed by using previous single probe feed antenna to achieve better performance. The array has been formed by using corporate feed. The dimensions of the 1x4, 2x2 and 4x4 array antennas are shown in below. To develop the isolation between two antennas with a different distance of the λ values.

TABLE 2: Specifications of Coaxial Probe feed Rectangular Array Antenna

Factors	Values for Array Antenna (cm)	Information
H_s	0.3175	The Thickness of the Substrate
ε_r	2.2	Dielectric Constant
W	8.962	Width of the Patch
L	6.43	Length of the Patch
D	0.44	Diameter of the inner conductor of probe
d_0	0.127	Diameter of the outer conductor of probe
W_g	16.2	Width of the ground plane
L_g	16.2	Length of the ground plane
f_L	3.29	Feed Length
W_{50}	0.960998	Width of 50 Ω λ/4 transformer

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L_{50}	3.69324	Length of 50 Ω λ/4 transformer
$W_{70.7}$	0.549841	Width of 70.7 Ω λ/4 transformer
$L_{70.7}$	3.75462	Length of 70.7 Ω λ/4 transformer
W_{100}	0.277378	Width of 100 Ω λ/4 transformer
L_{100}	3.81825	Length of 100 Ω λ/4 transformer

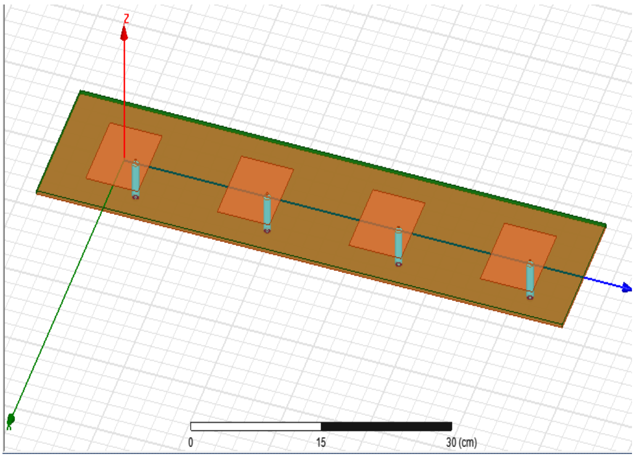

Figure 3: 1x4 Coaxial Probe Feed rectangular patch

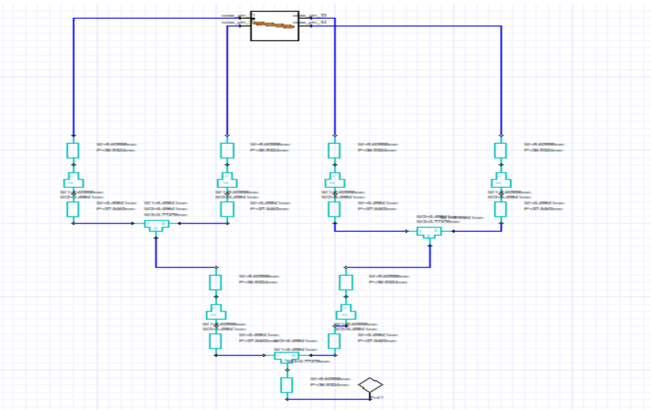

Figure 4: 1x4 Coaxial Probe Feed rectangular patch with feeder network

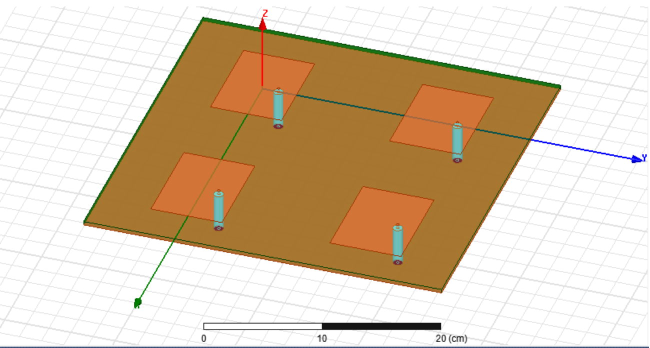

Figure 5: 2x2 Coaxial Probe Feed rectangular patch

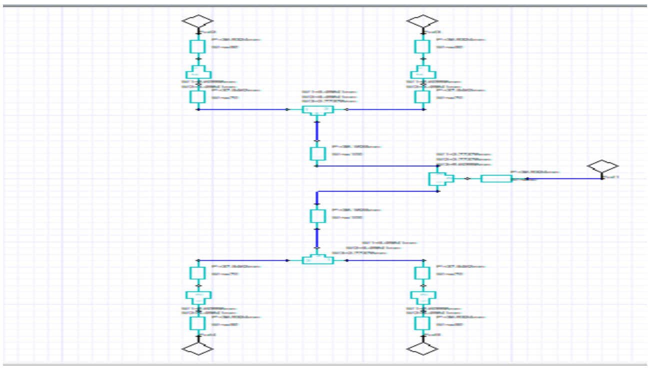

Figure 6: 2x2 Coaxial Probe Feed rectangular patch with feeder network

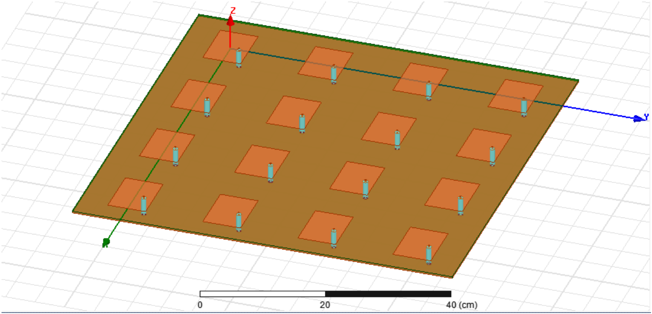

Figure 7: 4x4 Coaxial Probe Feed rectangular patch

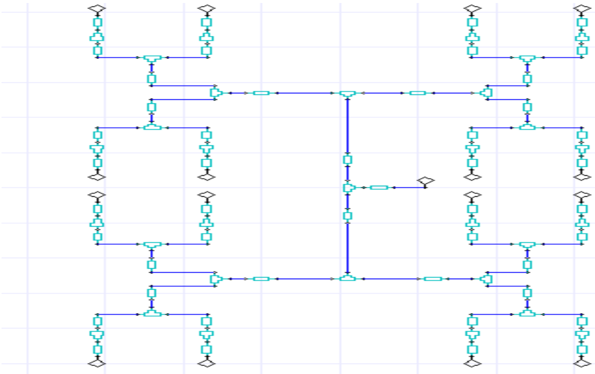

Figure 8: 4x4 Coaxial Probe Feed rectangular patch with
feeder network.

B. Isolation Between Two Antenna Arrays

3. Microstrip Patch Antenna for Isolation between two Antennas

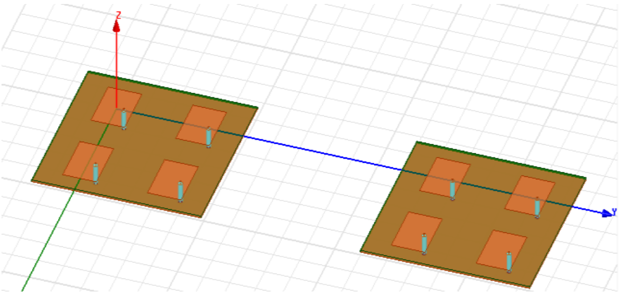

Figure 9: 2x2 Rectangular patch coaxial probe feed antenna with 1.5 λ

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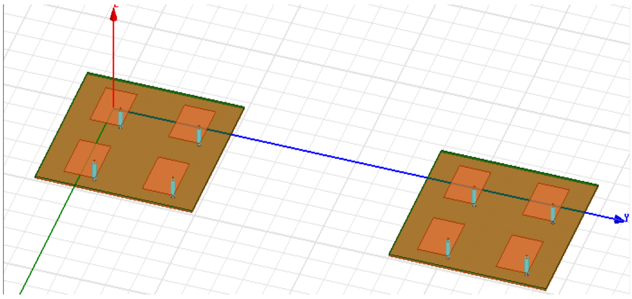

Figure 10: 2x2 Rectangular patch coaxial probe feed antenna with 2 λ

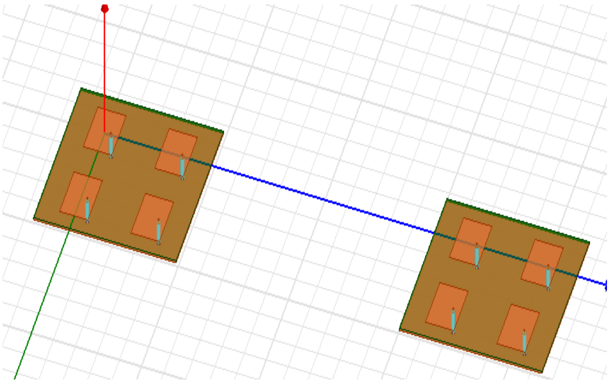

Figure 11: 2x2 Rectangular patch coaxial probe feed antenna with 2.5 λ

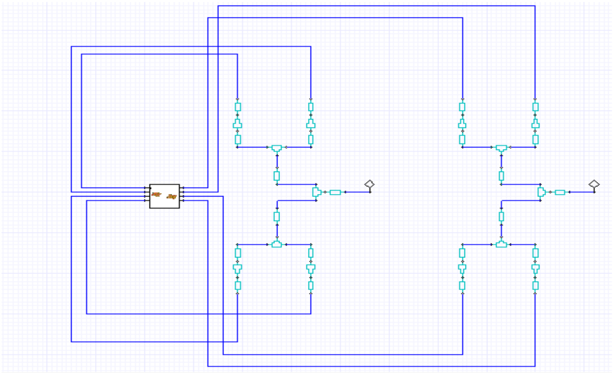

Figure 12: 2x2 probe feed circuit for antenna design for isolation between two antennas is same for 1.5,2 and 2.5 λ Values

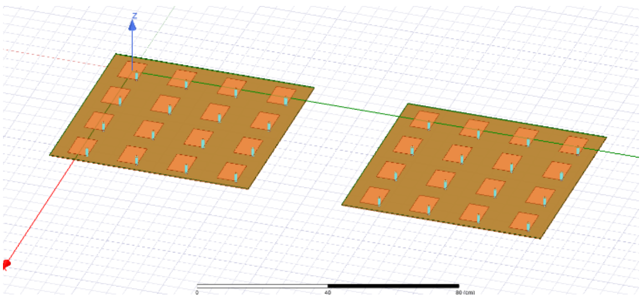

Figure 13: 4x4 Rectangular patch coaxial probe feed antenna with 1.5 λ

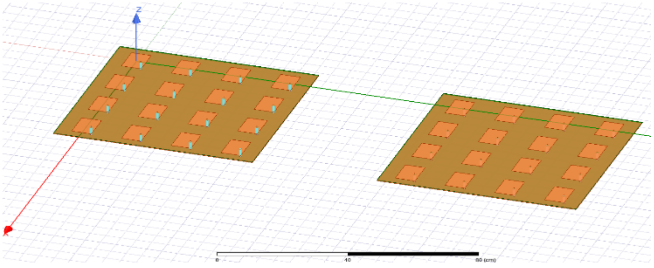

Figure 14: 4x4 Rectangular patch coaxial probe feed antenna with 2 λ

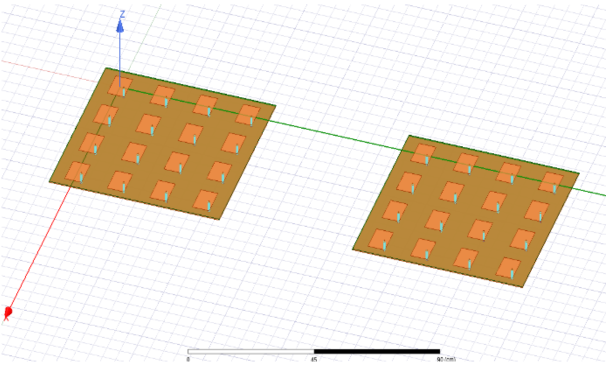

Figure 15: 4x4 Rectangular patch coaxial probe feed antenna with 2.5 λ

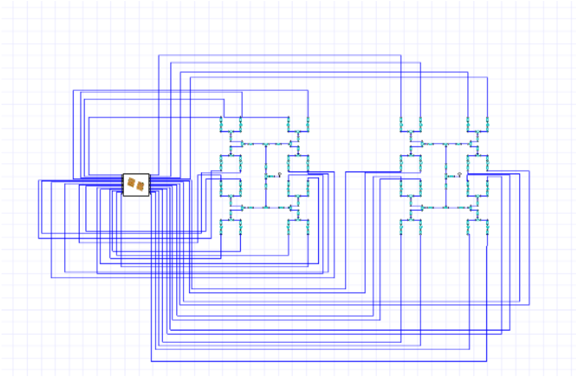

Figure 16: 4x4 probe feed circuit for antenna design for isolation between two antennas is the same for 1.5, 2 and 2.5 λ values

IV. SIMULATION RESULTS

Using High Frequency Structure Simulator (HFSS) the coaxial probe feed microstrip array antennas are constructed and implementation results are displayed below.

A. Coaxial Probe Feed Patch Antenna Construction Results

1.Single Coaxial Probe Feed Microstrip antenna:

For single coaxial probe feed microstrip antenna for Return loss (S_{11}) of -22.4713dB and bandwidth of 20MHz can be achieved.

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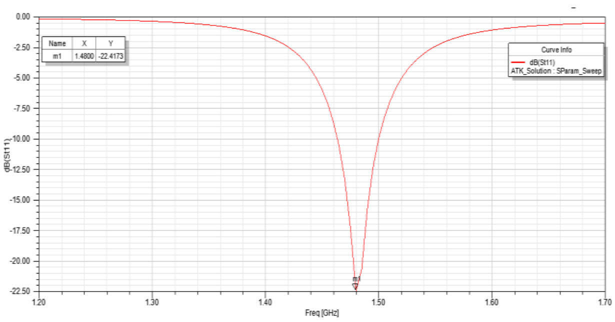

Figure 4.1: Return loss

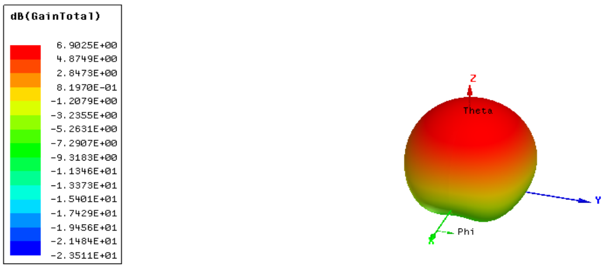

Figure 4.2: 3D Radiation pattern

2.1x4 Coaxial Probe Feed Microstrip Array Antenna

For 1x4 coaxial probe feed microstrip antenna for Return loss (S_{11}) of -19.9063dB and bandwidth of 20MHz can be achieved

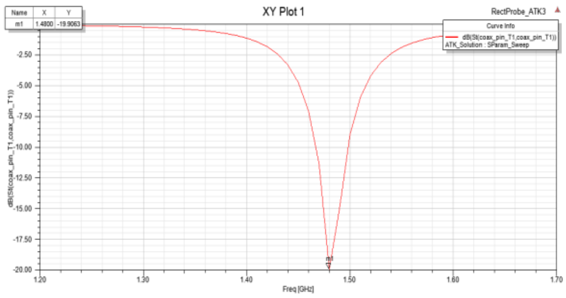

Figure 4.3: Return loss

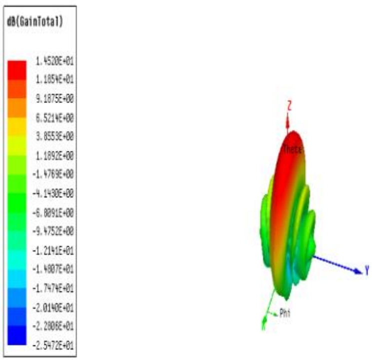

Figure 4.4: 3D Radiation pattern

3.2x2 Coaxial Probe Feed Microstrip Array Antenna

For 2x2 coaxial probe feed microstrip antenna for Return loss (S_{11}) of -72.555dB and bandwidth of 20MHz can be achieved

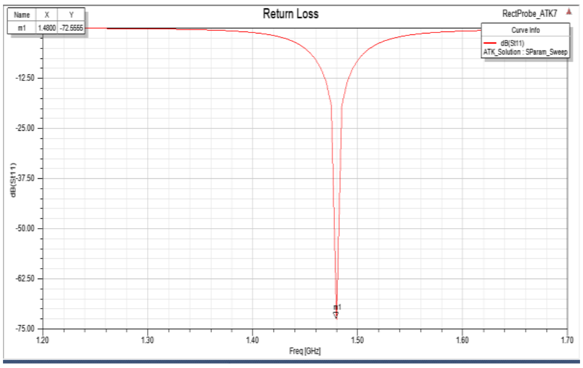

Figure 4.5: Return loss

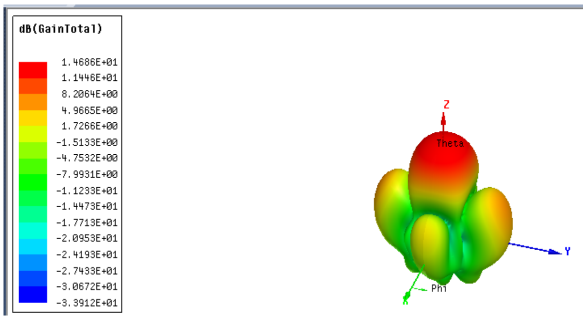

Figure 4.6: 3D Radiation pattern

3.4x4 Coaxial Probe Feed Microstrip Array Antenna

For 4x4 coaxial probe feed microstrip antenna for Return loss (S_{11}) of -22.4052dB and bandwidth of 20MHz can be achieved

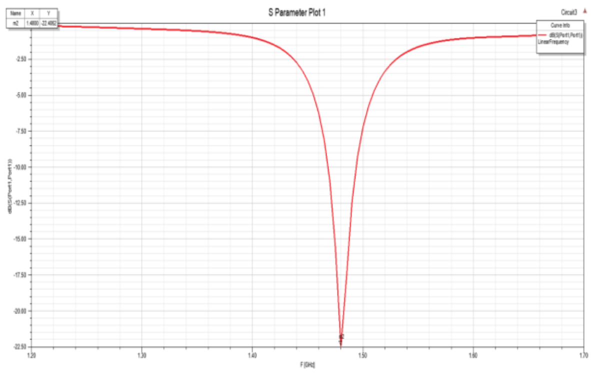

Figure 4.7: Return loss

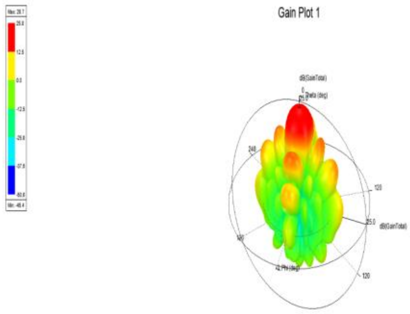

Figure 4.8: 3D Radiation pattern

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B. Isolation Between Two Antenna Arrays Results

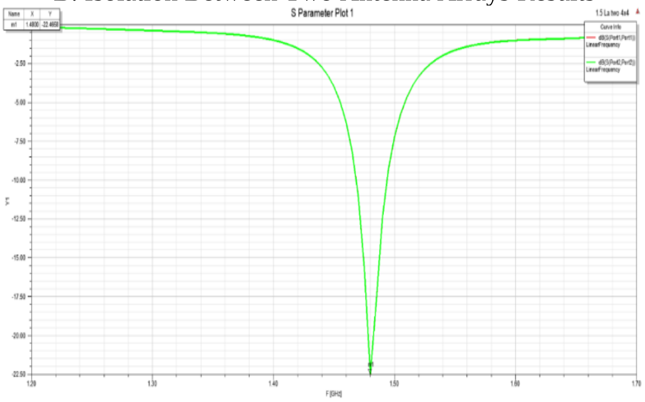

Figure 4.9: Return loss of 2x2 antenna with a distance of 1.5 λ

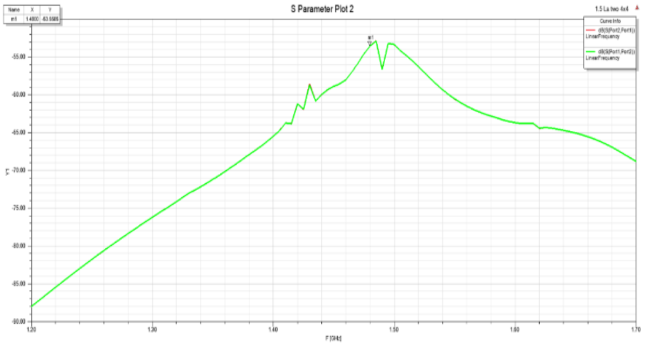

Figure 4.10: Isolation of 2x2 antenna with a distance of 1.5 λ

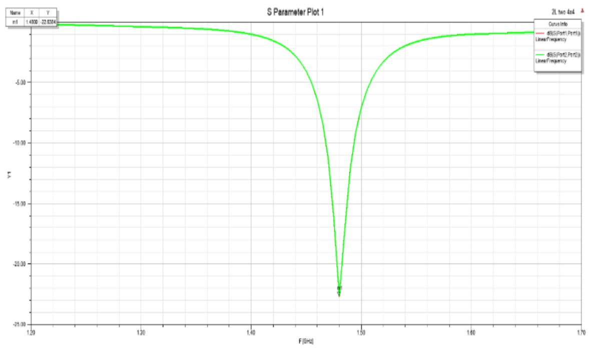

Figure 4.11: Return loss of 2x2 antenna with a distance of 2λ

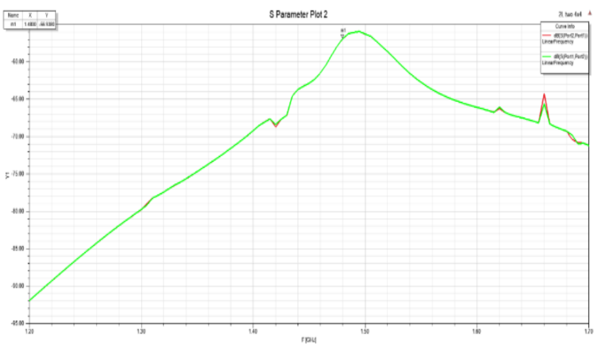

Figure 4.12: Isolation of 2x2 antenna with a distance of 2 λ

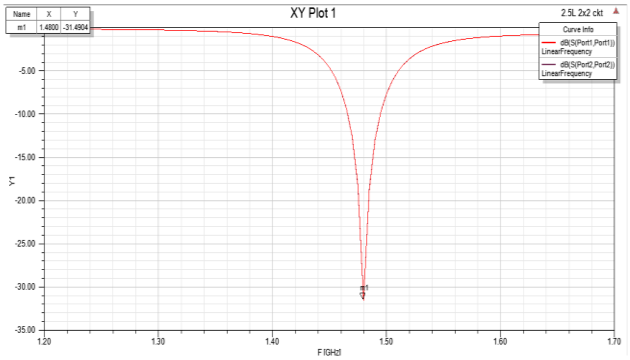

Figure 4.13: Return loss of 2x2 antenna with a distance of 2.5 λ

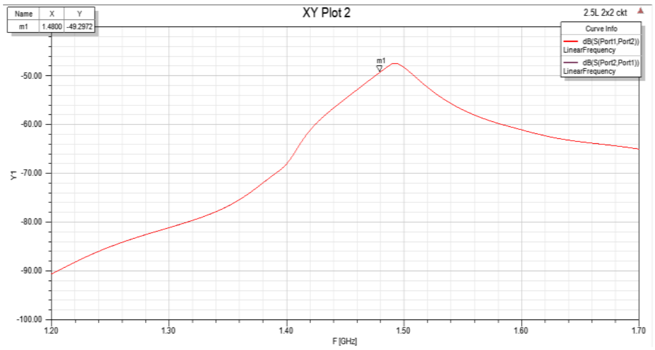

Figure 4.14: Isolation of 2x2 antenna with a distance of 2.5 λ

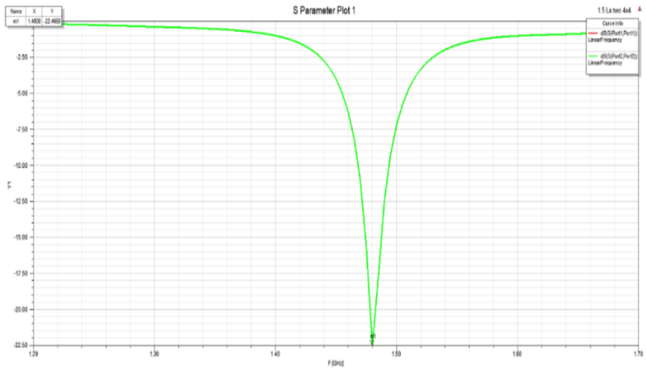

Figure 4.15: Return loss of 4x4 antenna with a distance of 1.5 λ

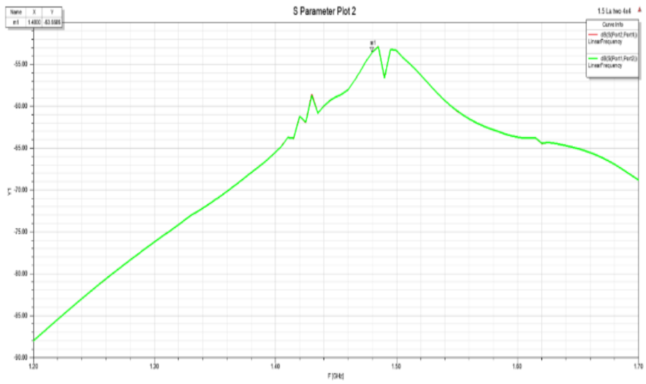

Figure 4.16 Isolation of 4x4 antenna with a distance of 1.5 λ

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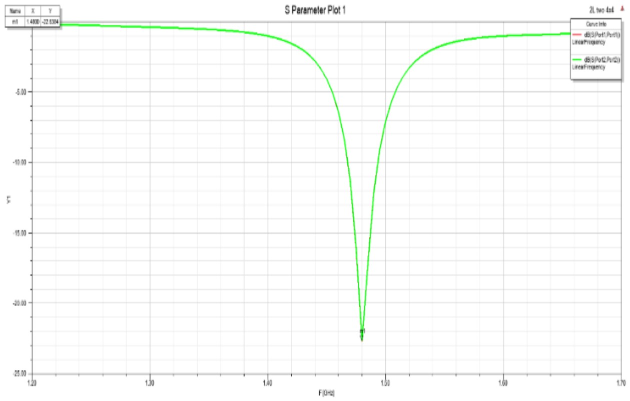

Figure 4.17 Return loss of 4x4 antenna with a distance of 2λ

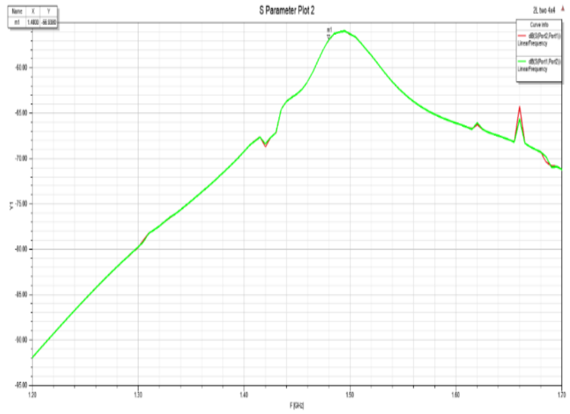

Figure 4.18 Isolation of 4x4 antenna with a distance of 2 λ

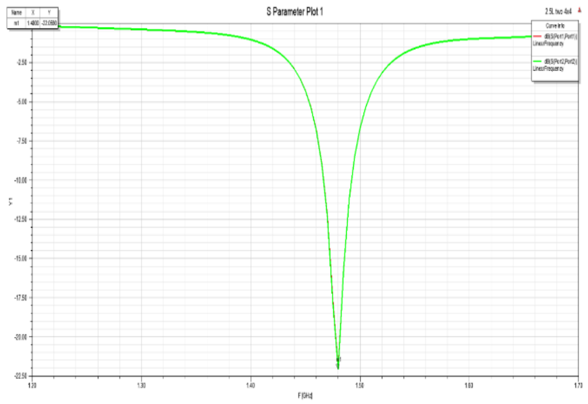

Figure 4.19 Return loss of 4x4 antenna array with a distance of 2.5 λ

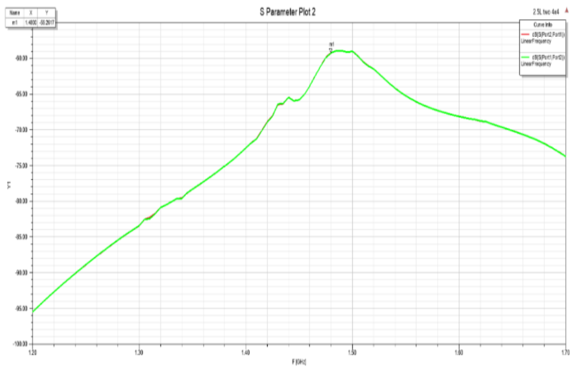

Figure 4.20 Isolation of 4x4 antenna array with a distance of 2.5 λ

TABLE.3: Specifications of Single, 1X4, 2X2 and 4X4 Microstrip patch array antenna

Parameters	**Single Rectangular patch**	**1x4 Rectangular patch**	**2x2 Rectangular patch**	**4x4 Rectangular patch**
Return loss	-22.417	-19.906	-72.5555	-22.4052
VSWR	1.3177	1.7620	0.0041	0.1274
Bandwidth MHZ(at-15dB)	20	20	20	20
3dB beam width(deg)	72.034	15.639	29.8760	15.7461
Directivity	6.9981	14.576	14.7392	20.8024

The suggested antenna is simulated using HFSS. The achievement specifications of single, 1x4, 2x2 and 4x4 coaxial probe feed patch array antenna. Arrays are reproduced, and measured results are shown in above table 3. It is by incrementing the no. of factors in an array the directivity is increases and beamwidth is decreased.
The 4x4 array the maximum directivity is 20.8024dBi, return loss of -22.4052 and beam width of 15.7461 deg. That satisfies for bi-static radar applications

TABLE.4: Specifications of isolation for 2X2 and 4X4 patch antenna arrays

Parameters	**2x2**	**4x4**
Return loss(S11) (1.5 λ)	-31.0772	-22.4658
Isolation (1.5 λ)	-42.7525	-55.5585
Return loss(S11) (2λ)	-29.0076	-22.6384
Isolation (2 λ)	-46.0818	-56.938
Return loss(S11) (2.5 λ)	-31.4904	-22.0590
Isolation (2.5 λ)	-49.2972	-59.2617

V. CONCLUSION

The microstrip patch array antenna is constructed by using coaxial probe feed for radar applications. The various specifications such as return loss, VSWR, bandwidth, directivity of arrays is simulated using HFSS and to check the isolation for bi-static radar. As the sum of arrays are developed the directivity also increases and distance between two antennas increases the isolation is also increases for which are suitable for bi-static radar.

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AUTHORS PROFILE

B. SIVA SAI REDDY currently pursuing Master of Technology in Digital Electronics and Communication Systems from Sree Vidyanikethan Engineering College Tirupati and his research interests includes on Embedded systems, IoT and Communication based Education, and he is a member of IAE.

P.PARVATHI Scientist/Engineer-SE, National Atmospheric Research Laboratory, Gadanki, Tirupati, Andhra Pradesh, India.

B. SENTHIL KUMAR currently working as Associative Professor of Electronics and Communication Engineering in Sree Vidyanikethan Engineering College Tirupati, he has more than 10 years of Academic experience and 15 Research publications to his credit. His research interests include Cognitive radio networks, WSN and MANET.

Retrieval Number: K14900981119/19©BEIESP
DOI: 10.35940/ijitee.K1490.0981119
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)