Ku Band Microstrip Linear Array Configurations

Mr. Waikar P. D.
Assistant Professor,
Department of Electronics & Telecommunication, Rajendra Mane College of Engineering & Technology ambav, India

Mr. Joshi A. P.
Assistant Professor,
Department of Electronics & Telecommunication, Rajendra Mane College of Engineering & Technology ambav India

***Abstract*— Micro-strip antenna arrays can be used for various Ku band applications. They are relatively inexpensive to manufacture and design because of its simple 2-dimensional physical geometry. The Ku band Micro-strip antennas can be used in light weight radars, ground based fire-detection system & VSAT. In this paper the Design of a Micro-strip antenna for single element and array configurations of 1x2 & 1x4 are presented .Three different configurations are designed and simulated for a single patch, 2 and 4 element arrays at 16 GHz. The substrate used is FR4 of dielectric constant (ϵ_r) of 4.2 and height (h) 1.6 mm. The microstrip corporate feed structure is used for ease of antenna fabrication. All the patches are rectangular in shape with same dimensions. The Simulation of micro-strip antenna array configuration is done by using HFSS (high frequency structural simulator) version 11 and the results are obtained which show increase in gain and bandwidth with the increase in patch elements. S parameters and VSWR of all the configurations are studied in detail.**

Keywords*— *Antenna arrays, Bandwidth, Corporate feed, Ku band, VSWR

I. INTRODUCTION

The three configurations of a single patch, 1x2 & 1x4 are proposed in detail. The increment in the gain, directivity and bandwidth of the microstrip antenna is a primary goal of the presented paper. The operating frequency of microstrip antenna is 16GHz [1] comes under the ku band microwave frequencies used for long distance satellite communication.

The design of three configurations is mainly intended for ku band application requires the high gain, directivity & bandwidth. [2]

II. THEORETICAL FORMULATION

A. Single element microstrip antenna formation

The operating frequency of a single element is 16 GHz. The antenna is simulated on FR4 substrate with thickness of1.6mm and relative dielectric constant of 4.4.The microstrip line feed is used for providing the excitation. The inset feed technique is employed for the impedance matching. The mathematical formulation is done by using the following equations [3]

$$W = \frac{\lambda o}{2}\sqrt{(2/\epsilon r + 1)} \quad (1)$$

$$L = \frac{\lambda o}{2\sqrt{\epsilon reff}} - 2\Delta L \quad (2)$$

$$\frac{\Delta L}{h} = 0.412\frac{(\epsilon reff+0.300)}{(\epsilon reff+0.258)}\frac{(\frac{W}{h}}{(\frac{W}{h}+}\frac{+0.264)}{0.800)} \quad (3)$$

$$\varepsilon_{reff} = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}\left(1+12\frac{h}{W}\right)^{-1/2} \quad (4)$$

The detail dimensions of a single element microstrip patch and transmission lines are shown in the table 1.

Table1
Single patch dimensions

Patch	
length	4.4mm
width	6.4mm
Transmission line 50Ω	
length	3.4mm
width	2.8mm

B. 1x2 microstrip antenna array formation

The 1x2 microstip antenna array is simulated on the similar FR4 substrate with same specification as that of the single element. The microstrip line with inset feed technique is employed for excitation. The detail dimensions of 1x2 array is shown in table2.

Table2
1x2 microstrip array dimensions

Patch	
length	4.4mm
width	6.4mm
Transmission line 50Ω	
length	3.4mm
width	2.8mm
Transmission line 100Ω	
length	6.85 mm
width	0.7 mm

C. 1x4 microstrip antenna array formation

The 1x4 microstip antenna array is simulated on the similar FR4 substrate with same specification as that of the single element & 1x2array.The microstrip line with inset feed technique is employed for excitation The quarter wave transformer of 70 Ω line is used[4] .The detail dimensions of 1x4 array is shown in table3.

Table3
1x4 microstrip array dimensions

Patch	
length	6.4 mm
width	4.4 mm
Transmission line 50Ω	
length	2.7 mm
width	2.4 mm
Transmission line 100Ω	
length	7.9 mm
width	0.7 mm
Transmission line 70 Ω	
length	10.25 mm
width	0.8 mm

III SIMULATION & RESULTS

A. Simulation of a single patch

The simulated model of a single patch in HFSS [5] is shown in Fig.1

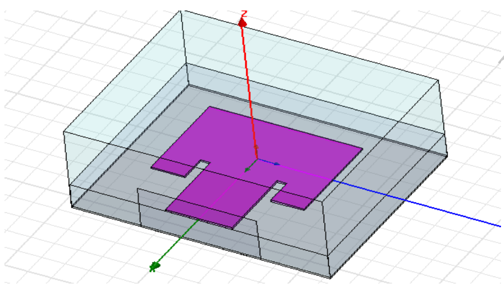

Fig.1: single patch layout in HFSS

B. The HFSS results of a simulated model a single patch

The performance parameter of a single patch is shown in Table4.The VSWR is shown in Fig.2.The 3-D gain is shown in fig. 3. The S_{11} response is shown in fig. 4.

Table4
Single patch performance parameter

VSWR	1.96 at 16 GHz
gain	4.8db
bandwidth	0.650GHz
S_{11} response	-9.88 db at 15.94 GHz

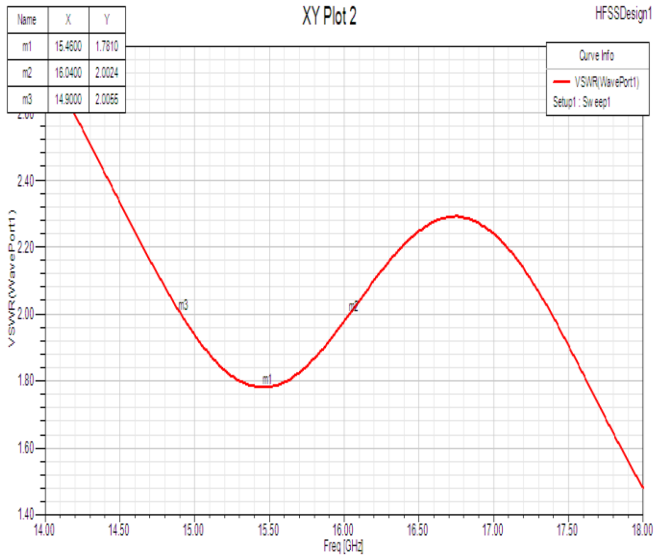

Fig.2: VSWR of a single patch

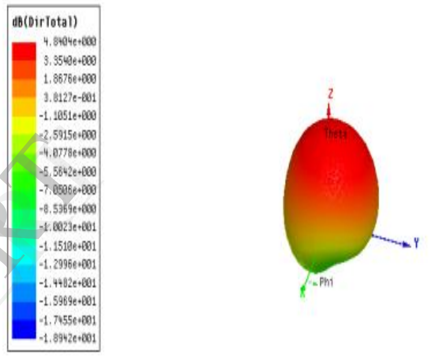

Fig.3: 3D gain of a single patch

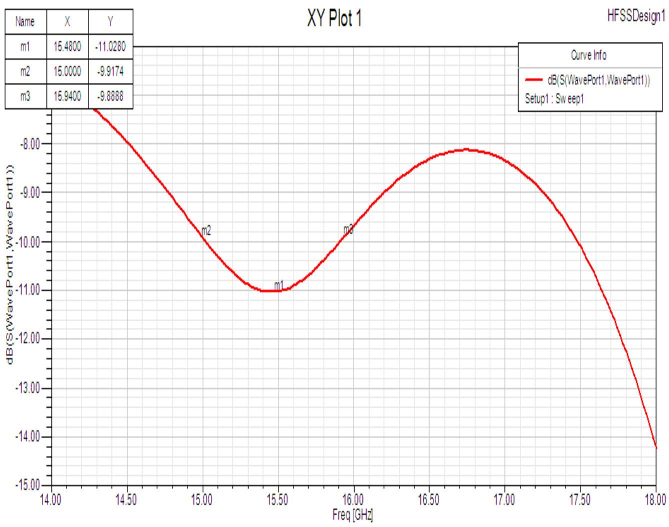

Fig.4: S_{11} of a single patch

C. Simulation of a 1x2microstrip array

The simulated model of 1x2microstrip array in HFSS is shown in Fig.8.

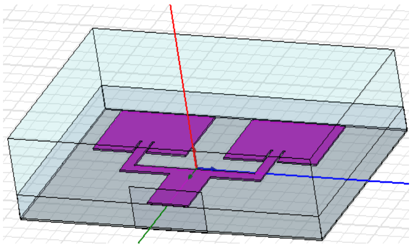

Fig.5: 1x2microstriparray layout in HFSS

D. The HFSS results of a simulated model 1x2 array

The performance parameter of 1x2 microstrip array is shown in Table5. VSWR is shown in Fig.6.The 3-D gain is shown in fig.7. The S_{11} response is shown in fig.9.

Table5
1x2 microstrip array performance parameter

VSWR	1.49 at 15.86 GHz
gain	6.5db
bandwidth	1.8GHz
S_{11} response	-26.80 db at 16.52GHz

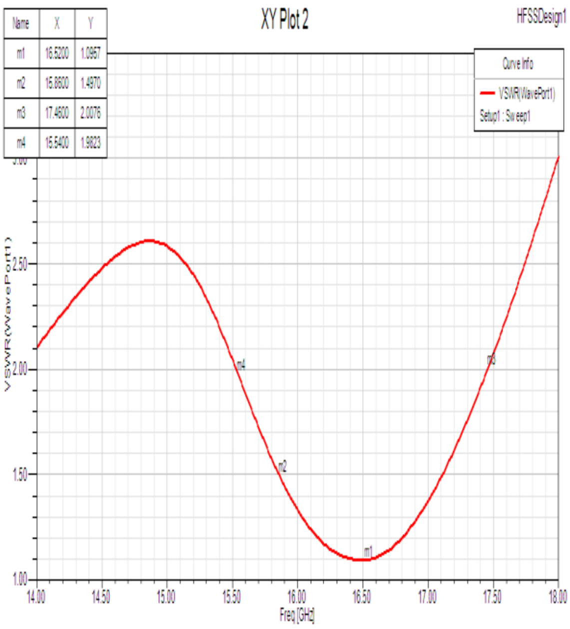

Fig.6: VSWR of 1x2 microstrip array

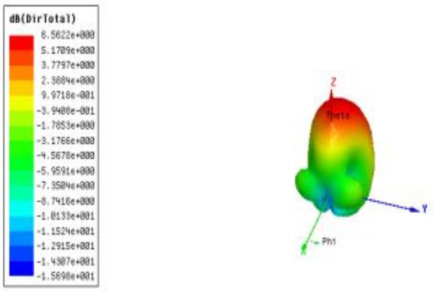

Fig.7: 3D gain of 1x2 microstrip array

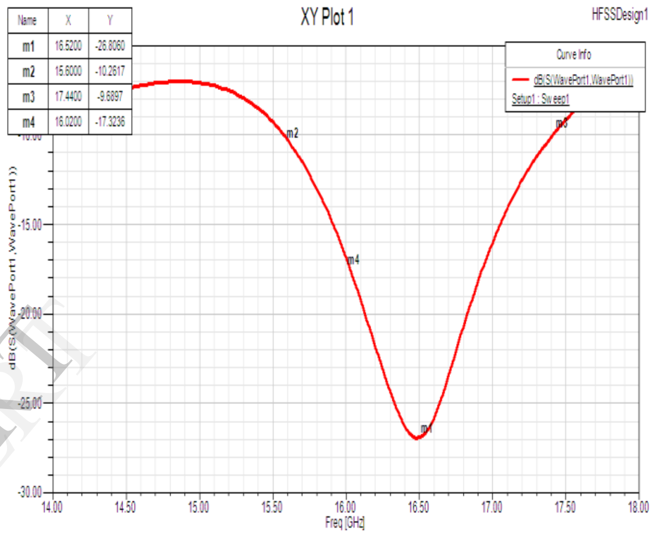

Fig.8: S_{11} of 1x2 microstrip array

E. Simulation of a 1x4microstrip array

The simulated model of 1x4 microstrip array in HFSS is shown in Fig.9

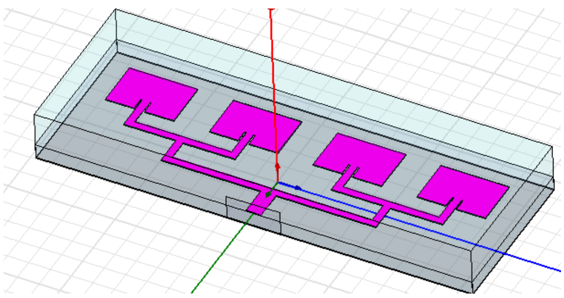

Fig.9: 1x4microstriparray layout in HFSS

F. The HFSS results of a simulated model 1x4 array

The performance parameter of 1x4microstrip array is shown in Table6. VSWR is shown in Fig.10.The 3-D gain is shown in fig. 11. The S_{11} response is shown in

Table6

VSWR	1.72 at 16 GHz
gain	9.16db
bandwidth	1.1GHz
S_{11} response	-27.95db at 16.42

1x4 microstrip array performance parameter

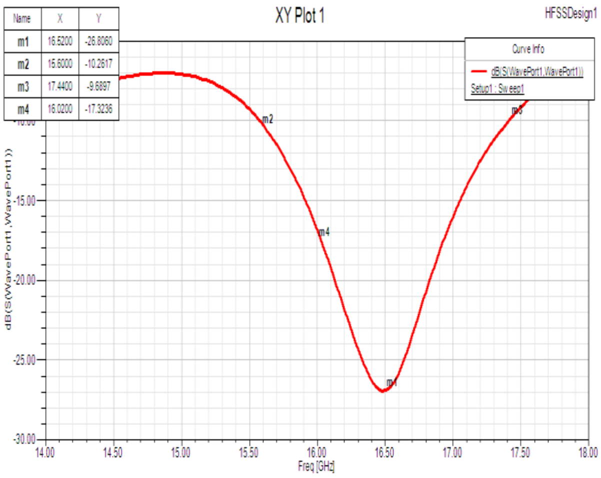

Fig.10: VSWR of 1x4 microstrip array

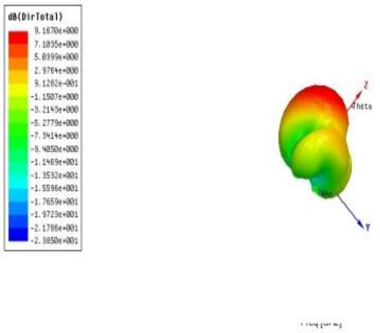

Fig.11: 3D gain of 1x4 microstrip array

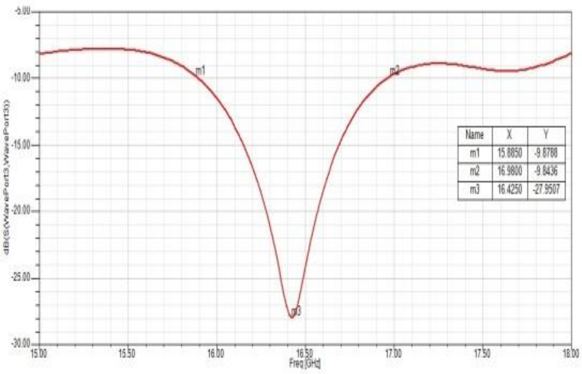

Fig.12: S_{11} of 1x4 microstrip array

III Comparison & Conclusion

The comparative summary of all configurations is represented inTable7.It shows gain increases with increase in patch elements. The VSWR value for a single patch is 1.96 and for 1x2 arrays it is 1.49 at 15.86GHz which indicates less ohmic loss in the feed network. The improved bandwidth of 1.8GHz is useful for high frequency ku band radar application..Future work will include higher array configurations like 2x2 and 2x4 microstrip arrays for higher gain and bandwidth operated at ku band.

Table7

Comparative summary of all configurations

Antenna parameter	Single patch	1x2 array	1x4 array
gain	4.8db	6.5db	9.16db
VSWR	1.96 at 16 GHz	1.49 at 15.86 GHz	1.72 at 16 Hz
bandwidth	0.65 GHz	1.8 GHz	1.1GHz
S_{11} response	-9.88 db at 15.94 GHz	-26.80 db at 16.52 GHz	-27.95db at 16.42 GHz

REFERENCES

[1] Omar Masood Khan, Shahid Shafique, Dr Qamar ul Islam and Amjad Jamal Ghouri, Comparison of 16 GHz Microstrip Patch Antenna Array Configurations *Proc. of International Conference* Islamabad, 2009, 978-969-8741-075/ *IEEE*

[2] Omar Masood Khan, Zaid Ahmad, Dr Qamar Islam, Ku Band Microstrip Patch Antenna Array *Proc. of Emerging Technologies, International Conference* Islamabad, 2007, 1-4244-1494-6/07/IEEE.

[3] Constantine A. Balanis, Arizona StateUniversity, *Antenna Theory: Analysis and Design* 3rd Edition, John Wiley & Sons, Inc.2005

[4] Ramesh Garg, Prakash Bhartia, Inder Bahl, Apisak Ittipiboon, *Microstrip Antenna Design Handbook*, *Artech House*, Norwood, May 2001

[5] HFSS Help, Ansoft HFSS Version 11.