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Design of Microstrip Patch Array Antenna for Ku-Band Applications

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Abstract - For satellite communications terminals, this paper deals with the design of a Micro strip Patch Array Antenna for KU-band applications that resonates at 12.3 GHz respectively. The substrate used for design is ARLON AD300N and the software used for simulation is Agilent ADS Momentum. This design expressed the array antenna in 8-element.It approach their corresponding results are validated based on their antenna parameters like VSWR, gain, directivity and power radiated and so on. One of the microstrip antennas (MSA) arrays achieved a radiation efficiency of 100%, which is among the best reported efficiencies for this resonating frequency and class of antennas.

Keywords - Micro strip patch antenna, *coaxial fed and* momentum simulation, advanced design system (ADS).

I. INTRODUCTION

Satellite communications have been developed widely and rapidly in the modern World. This indicates that the future communication terminal antennas must meet the requirements of multi-band or wideband to sufficiently cover the possible operating bands. However, the difficulty of antenna design increases when the number of operating frequency bands increases. In addition, the antenna must also be small enough to be placed inside the system in effective manner. In order to transmit and receive more information large bandwidths are required, and bandwidth enhancement is currently a popular research area. Microstrip patch antennas are increasing in popularity for use in Satellite applications due to their low-profile structure. Therefore they are extremely compatible for embedded antennas in handheld such devices Telephony, satellite TV, Mobile satellite technology, Satellite broadband, etc... The telemetry and communication antennas on missiles need to be thin and conformal and are often Microstrip patch antennas. Some of their principal advantages are Light weight and low volume, Low profile planar configuration which can be easily made conformal to host surface, hence can be manufactured in large quantities, Supports both, linear as well as circular polarization, Can be easily integrated with MICs. In this study, we proposed microstrip patch array antenna is mostly used in recent times to its simple structure, single resonant frequency, low profile, high data rate. In this array antenna, the return loss is reduced at resonant frequency level and also each element of that array antenna have small in size. The antenna constructed radiation pattern, better gain and good efficiency. The size of an array antenna is constructed in 8-element.In literature, some author approach wideband offset slot coupled patch antenna array for X/KU-band application and one more paper are done in design of dual band dissimilar patch size array antenna for wireless applications. In both paper is concentrates on the designing an array antenna (each element) in large size, poor efficiency and return loss is also poor. This papers they used the lossy element (substrate) on it.

II. ARRAY ANTENNA DESIGN

A. ADS Momentum

It provides the simulation tools required to evaluate and design products of modern communication systems. It is an electromagnetic solver in the form of a simulator that computers the S-parameter for general planar circuits which includes microstrip, slot line, strip line, coplanar waveguide and many other topologies. It is a complete tool for prediction of the performance of high frequency circuit boards, antenna and IC. One of the best advantages of this momentum possesses is the 3-dimensional interface that it provides for the user during simulations and results. It is a 2.5D solver that can do both 2Dand 3D computations. For example while computing the antenna parameters, momentum provides both 2D and 3D graphs of the directivity and the far-field radiation patterns of the antenna.

B. Design of array antenna

In this section, an 8-element array antenna is initially designed using common coaxial feed and quarter wave transform as shown in figure: 1 throughout the communication, the configuration is referred to as the "direct fed array". The dimensional parameter of t he array antenna are given by Ls, L1, L2, L3, L4, L5, L6, L7, L8, W1, W2, W3, W4, W5, W6 and Ws as shown in table 1.1 .The substrate chosen for the design is 0.635mm thick, with a dielectric constant 2.2.Given that the four element at the left and another four element at the right, the fed point radiation is placed in common part of the entire 8-element and the input power is act as a quarter wave transform structure. The array antenna is optimized to maximize the gain along the broadside direction and is matched to the system impedance Z0=50Ω .It operates between 12.0GHz to 15.0GHz.

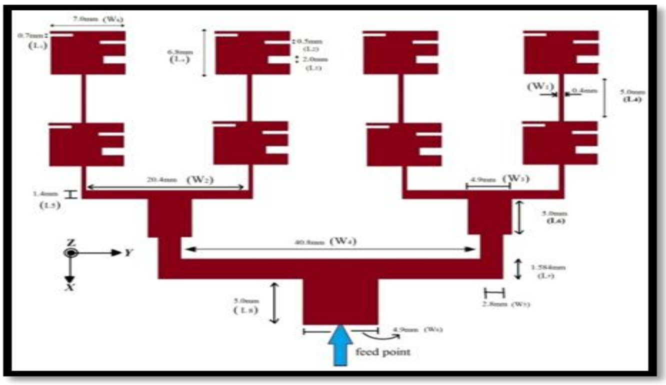

Fig.1. Proposed array antenna structure

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The practical width and length can be calculated by the transmission methods, as shown in below

$$W = \frac{c}{2.fr\sqrt{\mu o.\varepsilon o}}\sqrt{\frac{2}{\varepsilon r + 1}} \quad (1)$$

The length of the rectangular patch antenna is

$$L = \frac{c}{2.fr.\sqrt{\varepsilon eff}\sqrt{\mu o.\varepsilon o}} - 2\Delta l \quad (2)$$

Where, length extension of the patch antenna

$$\Delta L = 0.412h\frac{(\varepsilon_{eff} + 0.3)(w/h + 0.264)}{(\varepsilon_{eff} + 0.258)(w/h + 0.8)} \quad (3)$$

A microstrip patch array antenna (8-element) is designed in ADS tool as shown in figure: 2.This is one of the easier methods to fabricate as it is a just conducting strip connecting to the patch and therefore can be consider as extension of the patch. This input impedance Zin can be altered by selection of the Z1, so that Zin = Zo and the antenna is impedance matched. The parameter Z1 can be altered by changing the width of the quarter-wave length strip. The wider the strip is, the lower the characteristic impedance (Zo).

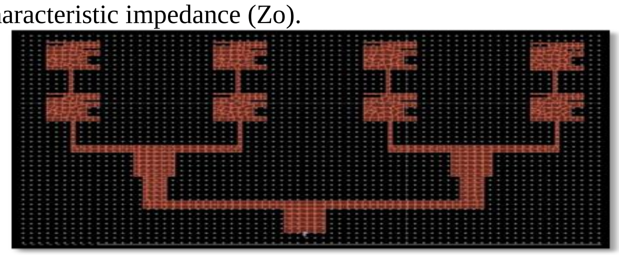

Fig.2. An array antenna design in ADS tool

TABLE I. OPTIMIZED ANTENNA DIMENSIONS

S.No	Parameter	Value(in mm)
1.	Ls	6.8
2.	L1	0.7
3.	L2	0.5
4.	L3	2.0
5.	L4,L6,L8	5.0
6.	L5	1.4
7.	L7	1.584
8.	Ws	7.0
9.	W1	0.4
10.	W2	20.4
11.	W3	4.9
12.	W4	40.8
13.	W5	2.8
14.	W6	4.9

The goal is to match the input impedance (Zin) to the transmission line (Z0).If the impedance of the antenna is ZA, then the input impedance viewed from the beginning of the quarter-wave length. These array antenna input is performed as a quarter wave impedance transform between antenna and feed line (50 Ω) for loss less power transmission. These are also called as input impedance. Antenna pre-amplitude powered (30v DC) through coaxial feed .These pre-amplitude has electrostatic discharge protection and RF gain control.

III. MEASUREMENT RESULTS OF MICROSTRIP PATCH ARRAY ANTENNA

This microstrip patch array antenna was designed in ADS momentum. After design, the patch was simulated and to get the directivity, the gain, returns loss along with the 3D visuals of the far field radiation and the 3D view of the designed patch array antenna.

TABLE II. RESULT OF THE ARRAY ANTENNA

S.No	Parameters	Output values
1.	Power radiated(Watts)	5.63
2.	Directivity(dBi)	8.90
3.	Gain(dBi)	8.89
4.	Resonant frequency(GHz)	12.29
5.	Radiation efficiency (%)	100

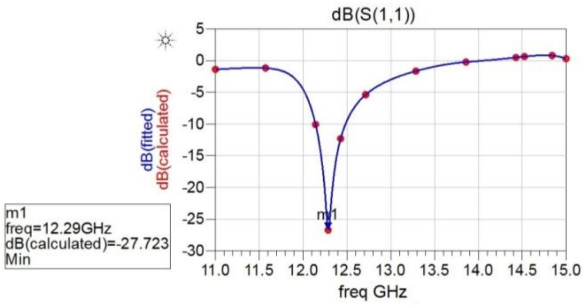

Fig.3. Simulation results

Figure. 3 shows the Simulation results of the microstrip patch array antenna in ADS momentum (Return loss Vs resonant frequency). Table: 1.2 shows the Result of the array antenna (far field antenna parameters). One of the main features of the ADS momentum is that it can give us both 2D and 3D graphs of the gain, return loss and Phase S (1, 1) and etc..The electric field radiation pattern of the 12.29GHz microstrip patch array antenna designed by us is shown in figure.2. The various parameters like, Directivity, Gain, Resonant frequency (GHz), Radiation efficiency (%) etc.. are output required form the microstrip patch array antenna (Figure.2) .

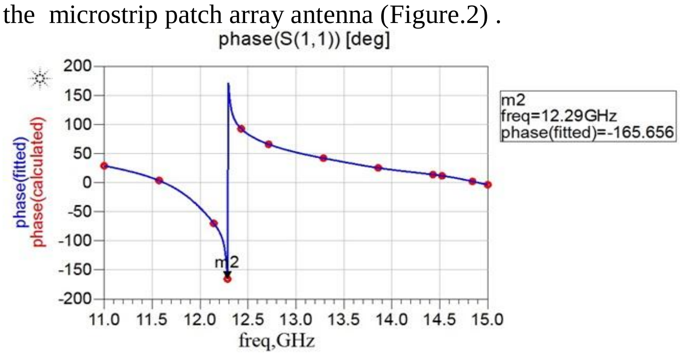

Fig.4. Antenna output: S (1, 1) [deg]

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Figure: 4 show the Antenna output: S (1, 1) [deg] (Phase S (1, 1) Vs resonant frequency). This graph shows the fitted (phase) value of -165.656 and the overall performance is expressed their better gain and directivity of the microstrip patch array antenna.

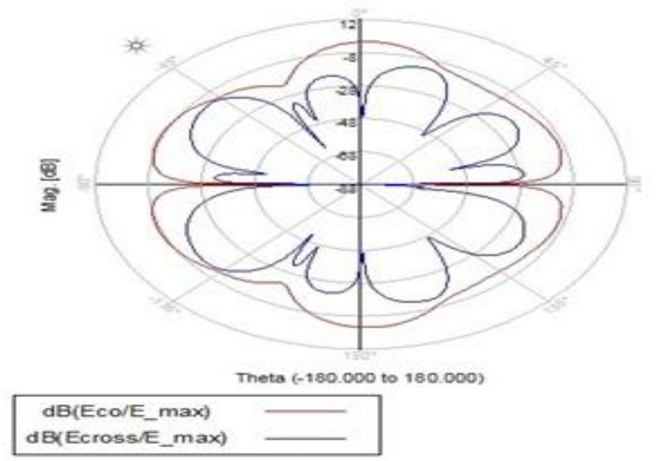

Fig.5. Linear polarizations of the array antenna

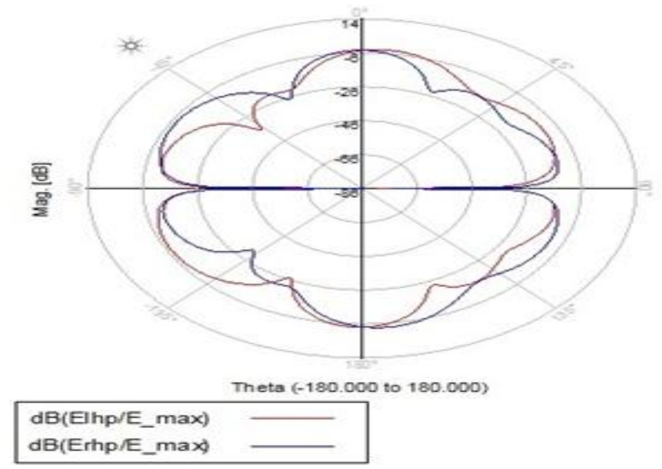

Fig.6. Circular polarizations of the array antenna

IV. CONCLUSION

A Wideband Microstrip Patch Array Antenna with a very compact area of only (6.8mm * 7.0mm) with eight elements Using 25 mil ARLON AD300N substrate, common and coaxial feed MSA array has been designed and using ADS tool computer simulation and measurement. This array antenna provides a promising way to minimize the each element size and demonstrates that a Microstrip patch antenna .this is a feasible and effective solution for low cost, low profile, high gain. The Array Antenna resonating frequency was obtained at 12.29GHz with return loss -27.7dB.The S11, radiation pattern, gain and efficiency all have been studied.The author would like to thank the anonymous reviewers of this paper for their valuable comments and suggestions, which have greatly improved the quality of this paper.

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