Dual Polarized 16X16 MSPA Antenna Using FR4 Epoxy

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---ABSTRACT--
There are many applications in wireless communication that involve more than one distinct band of frequencies. The present model is a square patch array of 16x16 i.e. 256 elements arranged on the FR4 epoxy substrate material. Dual polarization is obtained at 8 and 13 GHz frequency with return loss of -11.75dB and -18.90dB. The gain obtained from the current model is 22dB. The present work involved the designing of array patch antenna and simulation of the model with Ansoft HFSS. All the output parameters, radiation patterns, axial ratio and directivity are presented in this paper.

Keywords: Dual polarization, MSPA (Microstrip Square Patch Array), FR4 epoxy, Axial ratio.

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1. Introduction:

The attractive features of microstrip patch antenna, such as planar profile, ruggedness and low cost, there has been considerable interest in the development of these antennas to meet dual and multiband frequency specifications. It is sometimes possible that a broadband microstrip antenna can cover the frequencies of interest. However the disadvantage of using a broadband antenna is that it also receives non-desired frequencies unless some kind of filtering network is introduced to reject such frequencies [1-3]. On the other hand, the advantage of a dual and multiband frequency design is that it focus only on the frequencies of interest and is thus more desirable and more efficient [4-8].

Microstrip antenna arrays are attractive for various high gain applications as they can be fabricated by low cost photolithographic technique. The patch is generally made up of with conducting material such as copper with square shape. The radiating patch and the feed lines are photo etched on the dielectric substrate. Microstrip patch antennas generally radiate primarily because of the fringing fields between the patch and the ground plane. In the design of microstrip antenna arrays, mutual coupling between radiating elements is an important factor to be considered. If the mutual coupling between the neighboring elements in an antenna array is small and can be ignored, the input impedance of each element is the same as the individual radiating element. The element spacing of an array not only affects the mutual coupling of the antenna, it also affects the radiation patterns. The beamwidth of the array is reduced when the element spacing is increased and effectively the directivity and gain are slightly increased. The drawback is that a larger spacing between elements produces a higher level of side lobes [9-14].

The proposed antenna is a 16X16 array antenna placed on the FR4 epoxy substrate. The FR4 substrate is having the relative permittivity of 4.4 and dielectric loss tangent of 0.02. Figure (1) shows the 16X16 array Microstrip patch antenna designed on FR4 substrate material by using the advanced antenna designing and simulating tool Ansoft HFSS. The operating frequency range is between 8-14 GHz and this antenna is showing dual polarization at 8.6 and 13.5 GHz.

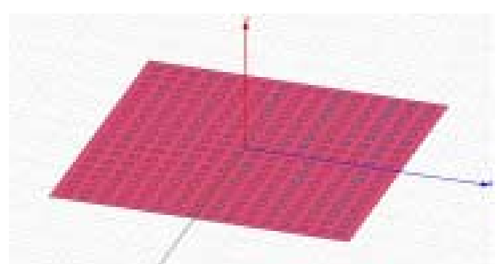

Figure (1) 16x16 array patch antenna

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2. Results and Discussion:

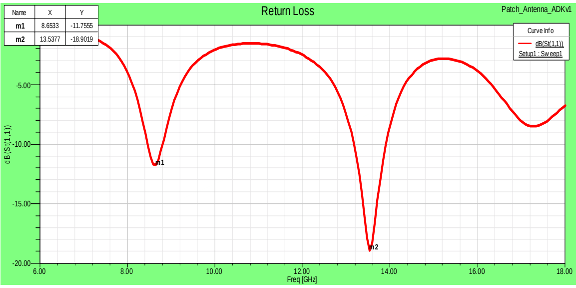

Figure (2) Return loss Vs Frequency

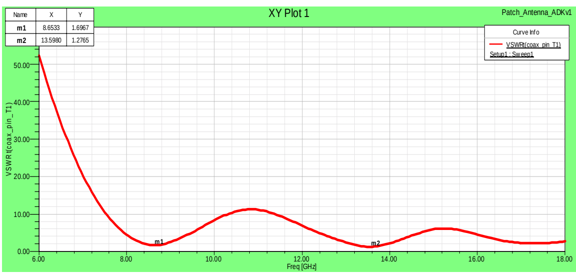

Figure (3) VSWR Curve

Figure (2) and figure (3) are showing the return loss and VSWR curves. From figure (2) we got the dual polarization of the proposed antenna at 8.5 and 13.5 GHz respectively. At 8.5 GHz a return loss of -11.75dB and at 13.5 GHz a return loss of -18.90dB was attained. The figure (3) showing the VSWR curve, which is giving good agreement of 2:1 ratio value. The values of VSWR obtained at both the frequencies are below 2. A VSWR of 1.69 and 1.27 are obtained at 8.5 and 13.5 GHz.

Figure (4) showing the input impedance smith chart curve for the proposed model. From this curve rms of 0.659 and 0.91% of bandwidth values are attained. Gain margin of 11.27 and phase margin of 251.75 and gain crossover of 6 and phase crossover of 8.71 is attained from the current model.

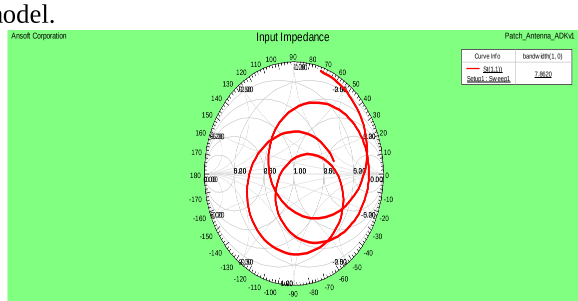

Figure (4) Input Impedance smith chart

Figure (5) shows the three dimensional gain of the present model and a gain of 22dB is obtained from the current design.

Figure (5) 3D Gain

The radiation pattern of an array of antenna elements is different from that of the basic element. It is formed by a combination of the radiated fields from all the antenna elements. The combined radiation pattern is determined by the several factors, including the radiation pattern of single element, element spacing, the number of radiating elements and the amplitude and phase of the excitation of each element.

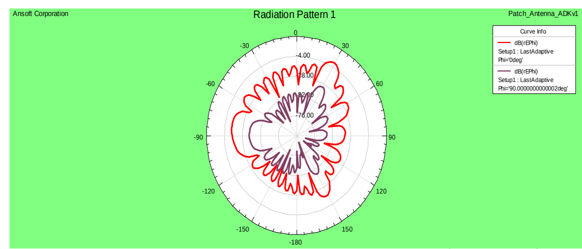

Figure (6) Radiation pattern at phi=0^0 and 90^0

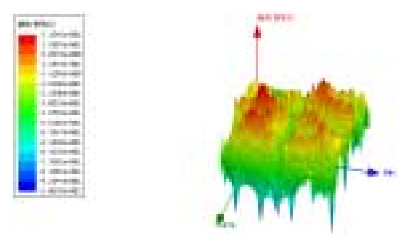

Figure (7) Radiation pattern at phi in 3D

Figure (6), (7), (8) and (9) shows the radiation pattern of the 16x16 square patch array antenna. The far-zone electric field lies in the E-plane and far-zone magnetic field lies in the H-plane. The patterns in these planes are referred to as the E and H plane patterns respectively. Figure (6) shows the radiation pattern of E-plane(y-z plane) in polar coordinates and figure (7) shows the same in 3-Dimensional view.

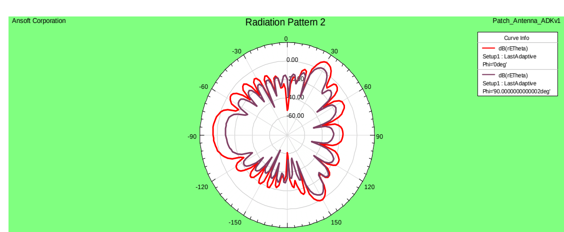

Figure (8) Radiation pattern at theta=0^0 and 90^0

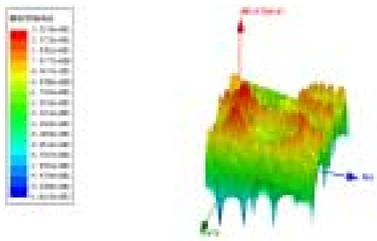

Figure (9) Radiation pattern at theta in 3D

Figure (8) shows the radiation pattern of H-plane (x-z plane) in polar coordinates and figure (9) represents the same in 3-Dimensional view.

Quantity	Value / units
Max U	3.0377 w/sr
Peak Directivity	316.44 dB
Peak gain	224.36 dB
Peak realized gain	98.773 dB
Radiated power	0.12063 w
Accepted power	0.17014 w
Incident power	0.38647 w
Radiation efficiency	0.70902
Front to back ratio	63744

Table (1) Antenna parameters

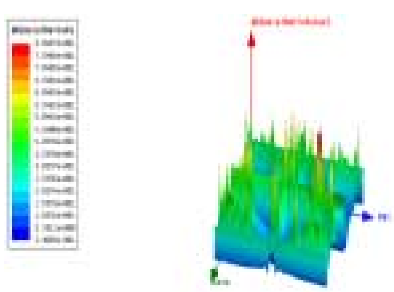

Figure (10) Axial ratio

The axial ratio is a parameter which measures the purity of the circularly polarized wave. The axial ratio will be larger than unity when the frequency deviates from f_0. Figure (10) shows the axial ratio for the current model in 3-Dimensional view.

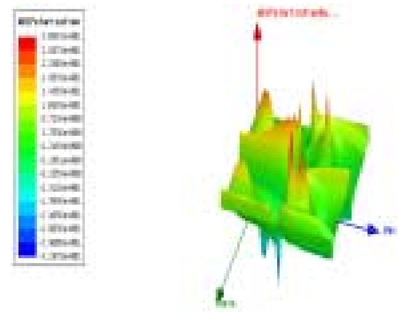

Figure (11) Polarization

Figure (11) is giving polarization plot of the 16X16 patch array antenna in three dimensional view. Table (1) and table (2) giving the antenna parameters and maximum field data.

rE-Field	Value / units	At Phi	At Theta
Total	47.858	45 deg	44 deg
X	33.359	45 deg	44 deg
Y	13.472	45 deg	44 deg
Z	32.688	45 deg	46 deg
Phi	15.043	45 deg	44 deg
Theta	45.442	45 deg	46 deg
LHCP	30.699	45 deg	46 deg
RHCP	36.936	45 deg	44 deg

Table (2) Maximum field data

3. Conclusion:

16X16 array patch antenna was designed and simulated using Ansoft HFSS. The proposed model was designed on FR4 epoxy substrate material with patches arranged in linear array setup. The current dual polarized model is giving 22dB gain and VSWR of 1.69 and 1.27 at desired frequencies. The bandwidth of 0.91% improvement is obtained. The entire antenna output parameters and maximum field data presented in this paper is giving good encouragement for the future work regarding the substrate material selection in the array antennas designing.

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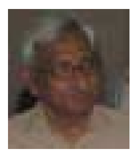
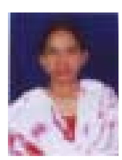


Prof. VGKM Pisipati was born in India, A.P, in 1944. He received his B.Sc, M.Sc and PhD degrees from Andhra University. Since 1975 he has been with physics department at Acharya Nagarjuna University as Professor, Head, R&D Director. He guided 22 PhDs and more than 20 M.Phils. His area of research includes liquid crystals, nanotechnology and liquid crystals applications. He visited so many countries and he is having more than 310 International research publications. He served different positions as academician and successfully completed different projects sponsored by different government and non-government bodies. He is having 5 patents to his credit.



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