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Design of Wideband Antenna Array for WiMax Application

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Abstract: ***The evolution of wireless communication system has led path for innovative antenna design specifically in wideband antenna for WiMax application. In this paper design and simulation of microstrip wideband circular patch antenna array operating between 2GHz to 4Ghz is presented. The circular patch antenna is designed to operate at 3GHz line feed and the ground is itched to achieve required wideband characteristics. The simulation is carried out in EM Flow solver, High Frequency Structure Simulator software. For a single patch antenna, the return loss, lesser than -10dB throughout the bandwidth. Later an*** 1×8 ***antenna array is operating between 2GHz to 4GHz frequency is designed and simulated. The return loss is lesser than -12dBi throughout the band and a peak gain is 14.7dBi.***

Keywords: Microstrip Patch Antenna (MPA), High Frequency Structure Simulator (HFSS).

I. INTRODUCTION

Due to the constantly expanding variety of wireless telecommunication, speech and data transmission applications, there is a lot of interest in the development of ultra-wideband (UWB) communication systems in recent years. WiMax frequency allocation varies from country to country. In India the four frequency ranges are allocated to WiMax and they are 2.5GHz to 2.69FHz, 3.4GHz to 3.6GHz. 2.3GHz to 2.4GHz and 700MHz. Hence in many such communication application requires antennas which operate at wide range of frequencies to support different technologies and standards

There are several papers which assist designing wideband antennas. In paper [1], a U-slot is itched on rectangular patch which helps achieving 1GHz bandwidth and positive gain. To improve impedance bandwidth, a metal-ring superstrate is utilized to load a typical MPA in paper [2] which is successful in increasing bandwidth up to 25%. In paper [3] L-shaped slots are induced on the rectangular patch which aims to reduce the size of the antenna and still be able to achieve wideband properties. The paper referred in this project is paper [4] which uses ground itching technique to achieve wideband characteristics. Gain is a concerned factor in wideband antenna designs, this paper presents a wideband antenna design with positive gain throughout the bandwidth. The gain of the design is positive and return loss is also satisfies the acceptable value throughout the bandwidth. Microstrip patch antennas are a proven EM-waves transmitting and receiving sensors, though the gain of antenna is a concerning factor but with the emergence of various techniques to improve gain, it does serve the system requirements. Adding to its excellent performance is its compact designing flexibility which reduces area occupied by the sensor antennas that in-return reduces the system size. Hence MPA were chosen for receiving the Electro-magnetic signals. A wideband circular patch antenna operating between 2GHz-4GHz frequency was designed and simulated using the HFSS software. Later an antenna array is created and simulated to enhance the gain of the antenna.

In this paper a wideband antenna design for WiMax application is proposed. The design includes a circular patch fed by transmission line feed and a unique ground itching technique to achieve wideband properties is proposed. In section II the design of the proposed antenna is elaborately explained. In section III the simulation results of the design is presented, the simulation results of single patch antenna and 1×8 antenna array is presented in the part A and part B of section III respectively.

II. DESIGN OF WIDEBAND ANTENNA

The proposed design of wideband antenna operating between 2GHz to 4GHz frequency. The design consists of three elements-substrate, patch and ground. The substrate material is FR4-Epoxy with 1.6mm thickness,0.02 loss tangent and 4.4 dielectric constant. The circular patch on top of the substrate is excited by edge/line feeding technique. Below the substrate is the Ground whose dimension are modified to achieve wideband characteristics. The antenna was designed using the standard antenna design equations, the radius of the circular patch was obtained using the following the equation 1:

$$f_0 = \frac{k_{nm} c}{2\Pi a_e \sqrt{\epsilon_e}} \quad [1]$$

Where K is the derivative of Bessel function of order n, $C = 3 \times 10^{10}$ cm/s, ϵ_e is the effective dielectric constant and a_e effective radius.

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When the solution frequency, the substrate specification is known then the effective radius of the patch can be found by the following equation 2:

$$a = \frac{8.791}{\left(f_0\sqrt{\epsilon_e} - h_s\sqrt{\epsilon_r}\right)} \qquad [2]$$

The dimensions of the designed wideband antenna is listed in the following table :

Frequency Range	2GHz to 4GHz
Substrate parameters	Dimensions in cm
Circular patch radius	2.1
Sub width	5.5
Sub length	8.07
Sub height	0.16
Feed width	0.353
Feed length	2.891
Ground width	5.5
Ground length	2.77

III. SIMULATION OF WIDEBAND ANTENNA

The antenna simulations were carried out on the HFSS platform, this section first presents the simulation results of the single patch antenna and next moves on to the creation of 1X8 antenna array and its simulation results...

A. Simulation Of Single Circular Patch Wideband Antenna

The antenna was designed to operate between 2GHZ to 4GHz solution frequency. Firstly, the antenna was designed to operate at 3GHz frequency using the equation [2] mentioned in the section II. In order to achieve wideband characteristics in reference to the paper [4] the ground dimension of the design is modified. The designed antenna is showed in the following Fig.1:

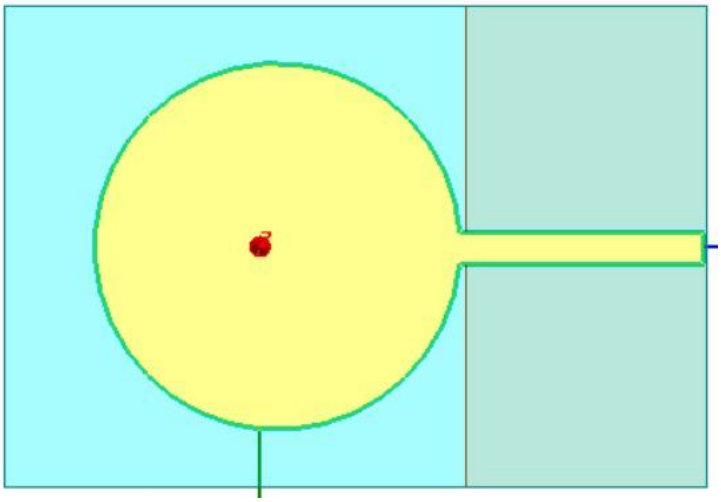


Fig.1. Top view of wideband antenna

The ground is cut to more than its half-length as shown in the above figure. This is also the technique used in paper [3] in order to achieve wideband characteristics. The patch is fed by transmission line feeding technique. The length of the transmission line is almost same as that of ground length. A small rectangle is cut near the joining of the transmission line and circular patch which help enhance the gain of the design. The dimension of the rectangle is about 0.353cm in width and 0.65cm in length. The length of the rectangle was varied to optimize the design and it finally it was fixed to 0.65cm. A aluminum plate of 5mm thickness and dimension equal to that of ground is used on top of the circular patch at a distance of 7mm.

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This aluminum plate was used to achieve unidirectional radiation pattern. The simulation results of the single patch antenna are as following:

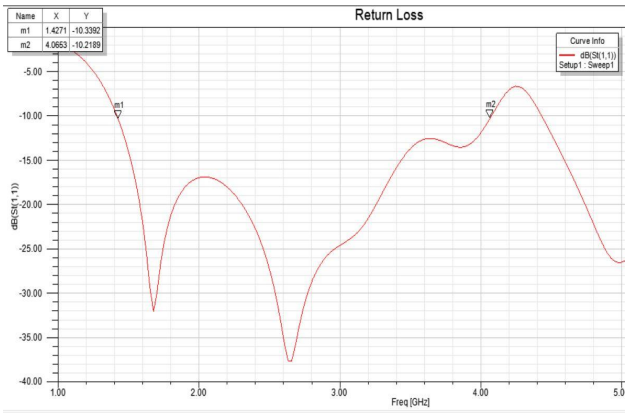


Fig.2: Return loss < -10db from 1.42GHz to 4.06GHz

The above Fig.2 is the return loss of the antenna and it is evident from graph that the return loss is lesser than -10dBi from 1.42GHz frequency till 4GHz frequency which satisfies than wideband characteristics.

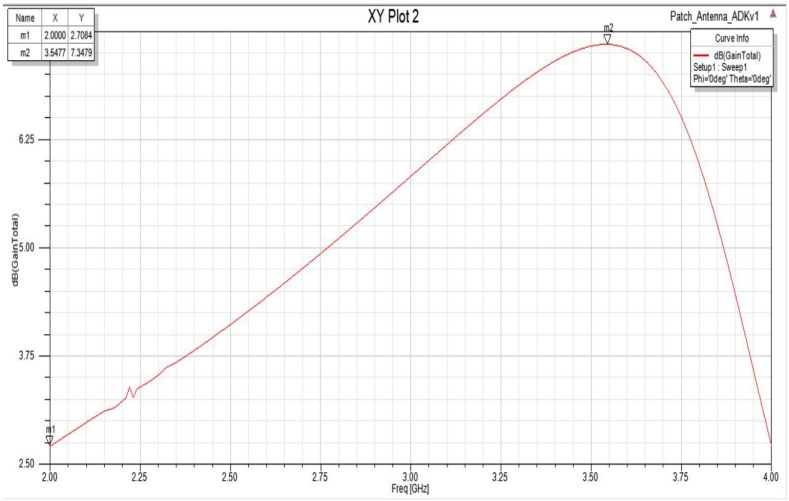


Fig.3: Gain of the wideband antenna

The above Fig.3 is the gain plot of the antenna. According to the above graph the gain of the antenna is positive and ranges from 2.7dBi to 7.53dBi which again satisfies the wideband characteristics. The radiation pattern of the antenna is shown in the Fig.4.

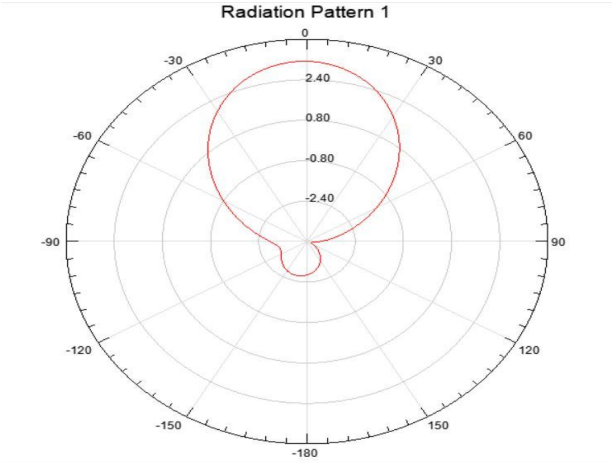


Fig.4: Radiation pattern of the antenna

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B. Simulation Results Of 1x8 Antenna Array

The single wideband antenna that was designed in previous section was used to create an array of eight elements. The single element was repeated eight times to form 1X8 antenna array. The antenna element separation is half wavelength distance which constitutes to be 5cm for 3GHz central frequency of the designed antenna. Fig.5 represents the top view of the designed 1X8 antenna array.

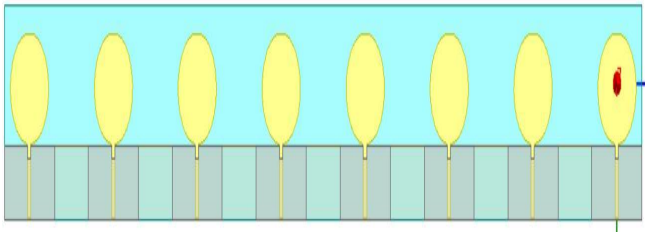


Fig.5: Top view of 1X8 antenna array

The dimension of 1×8 antenna array is 8 cm in length and 70 cm in width. Each element in the 1×8 antenna array is fed by transmission line feed. The simulation results of the antenna array are as following:

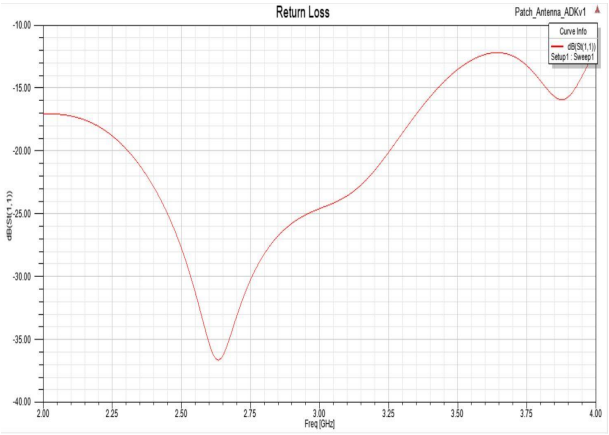


Fig.6: Return Loss of the 1X8 antenna array

Above Fig.6 is the return loss of the antenna array and it is evident that return loss of the antenna is lesser than -12dBi.Thus the 1×8 antenna array is said to have wideband characteristics.

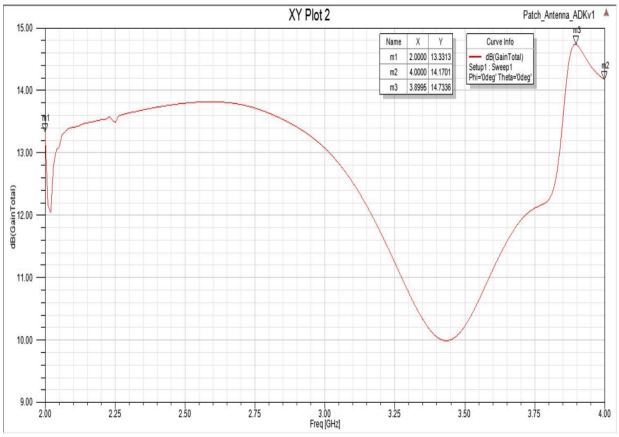


Fig.7: Gain of the 1X8 antenna array

The simulation result show that the gain of the antenna is over 10dBi gain throughout the bandwidth and as a peak of about 14.7dBi which is depicted in Fig.7. Thus, the simulation results suggest that the 1×8 array is a wideband antenna array.

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IV. CONCLUSION AND FUTURE SCOPE

This paper discussed in detailed the design and simulation of wideband Micro strip patch antenna array. The design included a circular patch fed by Transmission line feeding and the ground was itched in order to obtain wideband characteristics. The antenna operates between 2GHz to 4GHz frequency bandwidth and was simulated using HFSS software. The simulation results showed return loss of lesser than -10dBi and positive gain throughout the bandwidth with peak gain of 7.34dBi gain.

Similarly, an antenna array of 1×8 was designed for the same frequency bandwidth. The antenna elements had half wavelength separation. The array of antenna was optimized to wideband characteristics employing ground itching technique and the simulation results for 1×8 antenna array showed return loss lesser than -12dBi and positive gain throughout the bandwidth with peak gain of 14.7dBi. Hence wideband antenna design was complete.

The future scope of this paper would be to fabricate the designed wideband antenna. And then the fabricated antenna could be tested in the anechoic chamber. If the antenna simulation results match the physically tested results, then the antenna can be applied in communication applications.

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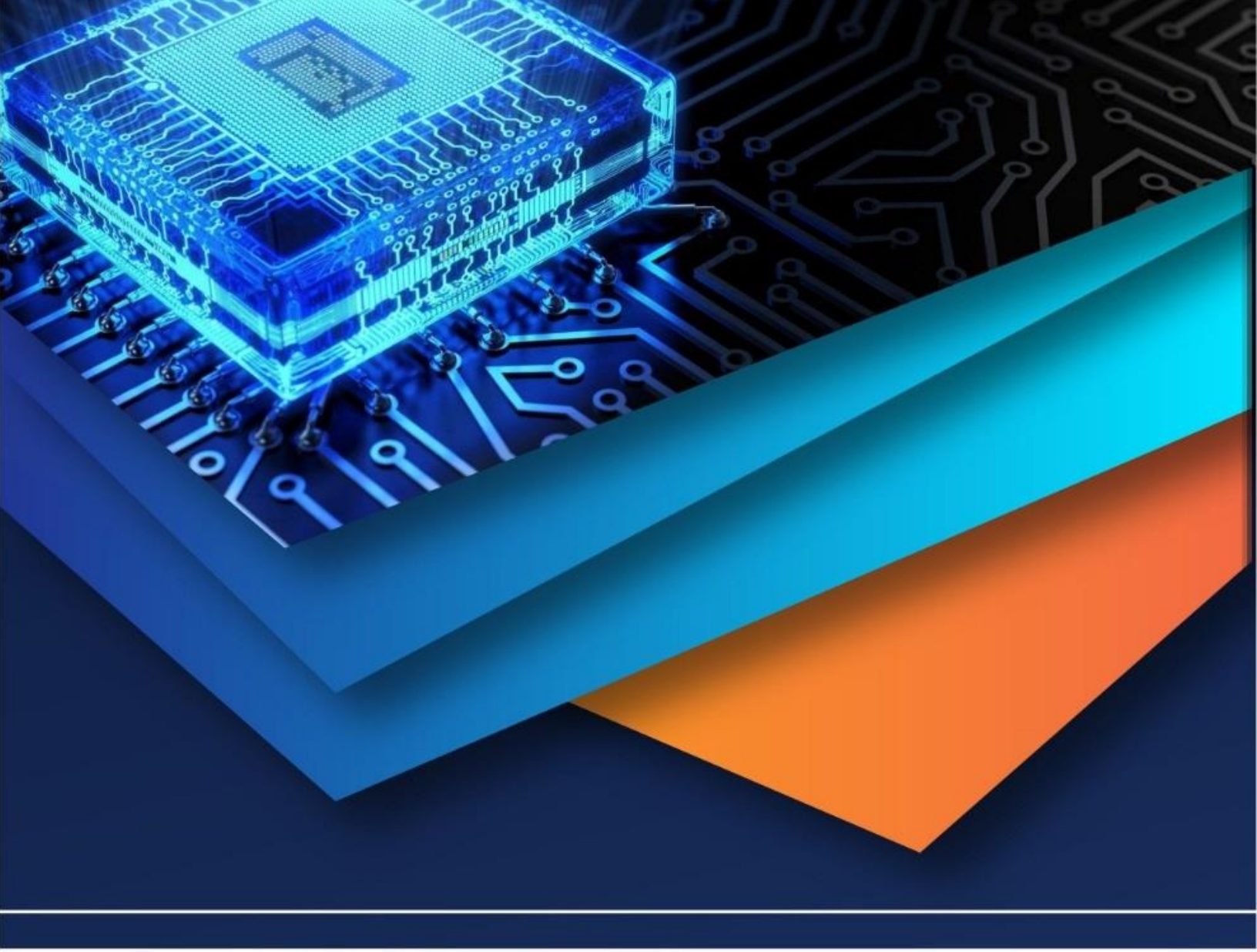
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