Design of Mimo Antenna for Wlan/Wimax Applications

D.Sivakumar, J.Sri Arunaa, T N Suresh Babu

Abstract: In the field of wireless communication multiple antennas are gaining increased interests due to their increase in capacity and data transmission compared to that of single antennas. A three element multiple input multiple output (MIMO) antenna model operating in three frequency bands is presented in this paper. The antenna consists of three different patches in the frequency range of 2.4GHz, 3.3GHz and 5.5GHz on a single substrate which is made up of "FR4_epoxy" material. The antenna is designed with the size of about (100 mm x 90 mm) and thickness of 1.6mm. The simulation results are obtained with the help of High Frequency Structure Simulator software (HFSS). In order to improve the performance of the antenna an additional technique known as artificial magnetic conductor (AMC) is introduced. The antenna model consists of another substrate with the air gap of about 1mm between both the substrates and the amc unit cells of different size (5 mm x 5 mm) and (4 mm x 4 mm) are induced in the substrate. Simulation results show it has good operation over the frequency bands of 2.4GHz, (3.3-3.5GHz) and (5.3-5.5GHz) which can be used for WLAN/ WiMAX applications.

Index terms: Artificial magnetic conductor (AMC), High frequency structure simulator (HFSS), multiple input multiple output antenna (MIMO), WLAN/WiMAX.

I. INTRODUCTION

The technology is getting advanced day by day it leads to the advancement of devices and existing wireless systems [1]. Due to this wireless communication system need to operate at more than one frequency [4]. For this purpose MIMO antennas are being preferred compared to the Single Input Single Output(SISO), Single Input Multiple Output (SIMO) and Multiple Input Single Output(MISO) antennas. The rapid growth of wireless communication throughout the world has lead to the popularity of mobile phones and other wireless devices among the people and the market demand is still increasing [1-3]. Over the years there has been huge demand of high data rate and multimedia applications on existing bands [2]. In order to meet these entire requirements MIMO antenna is one of the promising technologies. MIMO is one of the effective technologies to improve the data transmission speed and channel capacity without any additional bandwidth requirement [2]. Several MIMO antennas are reported in the recent years

The MIMO technology needs two to three antenna elements. Most of the handheld and wireless devices have small and limited space the size of the antenna also plays a major role in the design of antennas. But it is not practical to have at least half-wavelength away from each antenna element due to the compact size of the devices [2]. The MIMO antenna design involves several complications to the antenna designers. The need for frequency reduction without the increase of antenna size is also important. Compact antennas are highly preferred for internet of things (IoT) and ultra wide band (UWB) applications [3-7].

In this paper a MIMO antenna model is presented covering three different bands of frequencies. Based on the simulation results the obtained frequency bands are well suited for WLAN/WiMAX applications. The MIMO antenna model is also analyzed under the presence of artificial magnetic conductor unit cells of different sizes to enhance the performance metrics of the antenna. Section II describes the MIMO antenna design; section III represents the results and discussion; section IV describes the conclusion and future work.

Revised Manuscript Received on December 22, 2018.

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II MIMO ANTENNA DESIGN

The proposed MIMO antenna model consists of three different antenna elements covering the frequency range suitable for WLAN/WiMAX applications. The MIMO antenna model is printed on an "FR4_epoxy" substrate with the relative permittivity of 4.4mm and an overall size of (100 mm x 90 mm x 1.6 mm) which is selected in accordance to place the three antenna elements. The preferred unit for antenna design is mm. The substrate of the antenna should lie sandwiched between the ground plane and the patch of the antenna. The ground plane is constructed according to that of the substrate and the ground plane should lie exactly at the bottom of the antenna. The size of patch decreases when the frequency increases. The 50Ω Microstrip feed line is drawn gently to touch the surface of each patch. The patch and microstrip feed line are united using the Boolean operation unite. The antenna is excited using the coaxial cable port. The port is located under each of the patch. The specifications of the designed antenna are given in table I.

Table I- Specifications of designed antenna

PARAMETERS	DIMENSIONS (in mm)
Length of the substrate	100mm
Width of the substrate	90mm
Length of Patch 1	30mm
Width of Patch 1	38mm
Length of Patch 2	21mm
Width of Patch 2	28mm
Length of Patch 3	13mm
Width of Patch 3	17mm

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The infinite ground cut out is induced at ground plane for the purpose of creating the coaxial cable. Then the ground plane and the cut is selected and it is subtracted using the Boolean operation subtract. Next corresponds to the design of outer cylinder, inner cylinder, source and wave ports. For all the three patches the coaxial feed is designed separately and it is placed accordingly. The desired materials such as pec and vacuum are assigned for the coaxial cylinders and copper corresponds for the ground plane. The materials for the substrate, ground and cylinders are selected according to the model and based on designers considerations. The proposed multiple input multiple output (MIMO) antenna model without AMC structure is represented in Fig: 1.

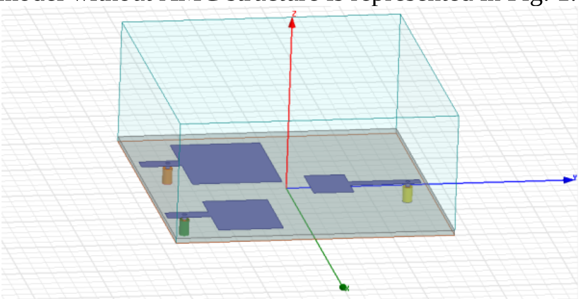
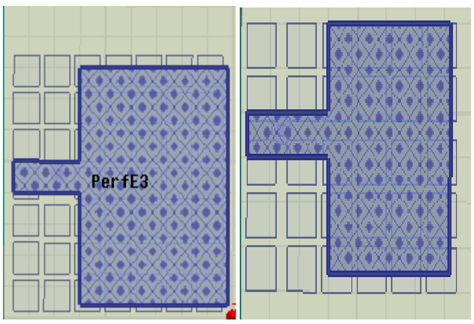


Fig: 1 Proposed MIMO Antenna Model.

The above Fig: 1 represents the proposed multiple input multiple output antenna model without amc unit cells. There are three types of boundary conditions in which the Perfect Electric fields and excitations such as wave ports or lumped ports are assigned according to the model. In HFSS the order of the boundaries is also important. The Perfect E field is also referred to as perfect conductor; it forces the electric fields to be perpendicular to the surface. The Perfect H field is known as perfect magnetic conductor. The finite conductivity boundary defines the surface of the object as a lossy imperfect conductor. In this model boundary (perfect E) fields are assigned to the patches, amc unit cells and for the ground plane. Excitations (wave port) are selected according to the model. The final step in antenna design involves the construction of the radiation box which helps in proper radiation of the antenna without the radiation box the antenna designed is of no use and air medium is assigned to the radiation box. Perfect radiation is assigned to the radiation box. The radiation boundaries are also known as absorbing boundaries. Each of the wave port will be excited individually.



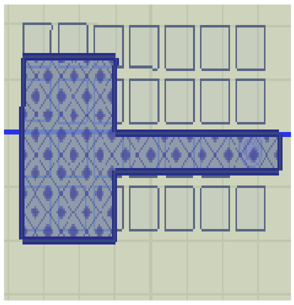


Fig: 2 Representation of Perfect E fields

The above Fig: 2 represent the perfect electric fields for all the three patches and the perfect radiation is represented in Fig: 3.

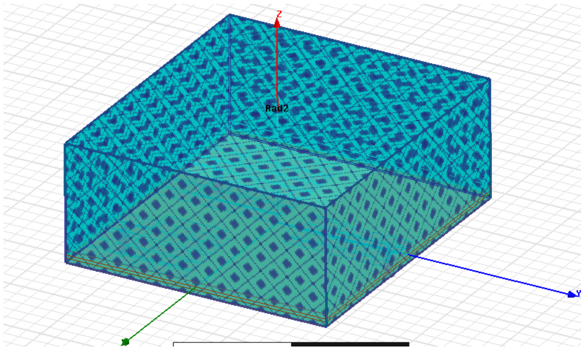


Fig: 3 Representation of Perfect Radiation.

In order to improve the performance of the antenna an additional technique known as artificial magnetic conductor (AMC) unit cells of different size are induced in the another substrate. The new substrate is also constructed using the same "FR4_epoxy" material and an air gap of 1mm is maintained between both the substrates. The amc unit cells are constructed under each of three patches. A (5mm x 5mm) amc unit cells are constructed under the antenna 1 and (4mm x 4mm) amc unit cells under the antenna 2 and antenna 3. The mimo antenna model with amc unit cells is represented in Fig: 4.

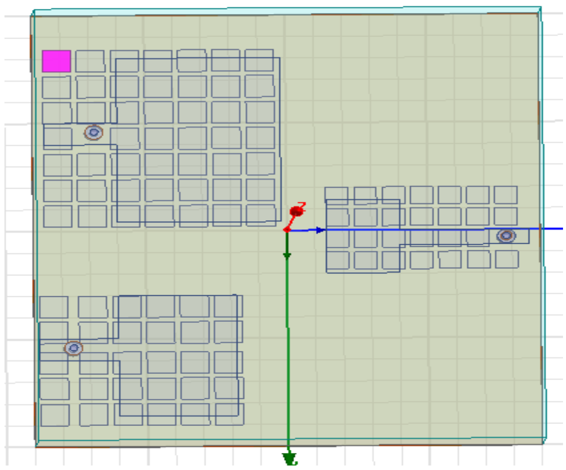


Fig: 4 MIMO antenna model with AMC unit cells

III RESULTS AND DISCUSSION

The HFSS stands for High Frequency Structure Simulator software. It is used for the simulation of the mimo antenna model. The HFSS software has evolved over a period of years got its input from many industries and users. Ansoft HFSS is the preferred tool in research and development.
The return loss has obtained maximum isolation characteristics over 29dB.

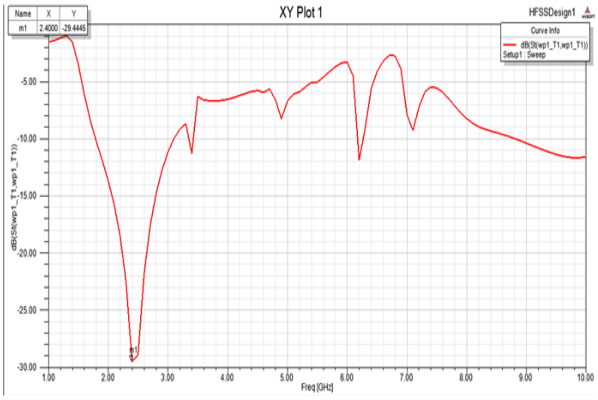


Fig: 5 Return loss for patch 1.

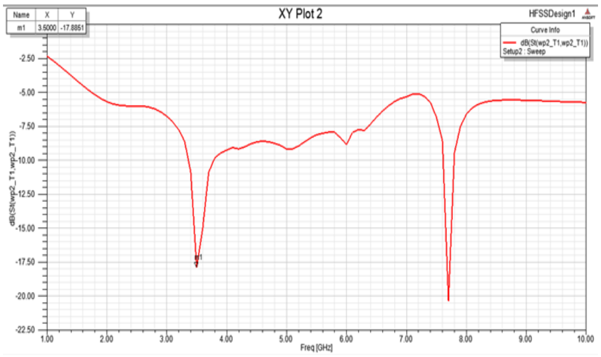


Fig: 6 Return loss for patch 2.

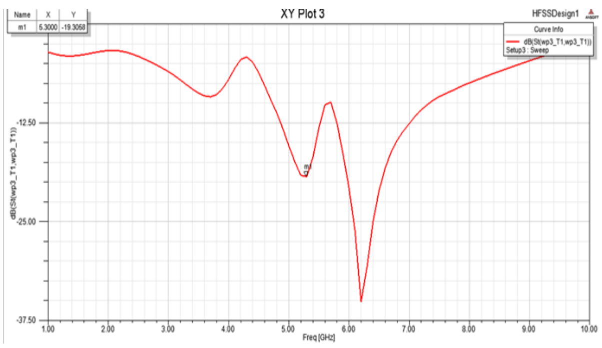


Fig: 7 Return loss for patch 3.

The return loss values for all the three operating frequency are given in the table II.

Table II- Representation of Return loss

ELEMENTS	OPERATING FREQUENCY	RETURN LOSS(dB)
Patch 1	2.4GHz	-29.44
Patch 2	3.5GHz	-17.88
Patch 3	5.3GHz	-19.30

The voltage standing wave ratio (vswr) plot for all the three antenna elements are represented in the figure 8, 9 and 10. It is obtained less then 2dB which shows optimal performance of the antenna.

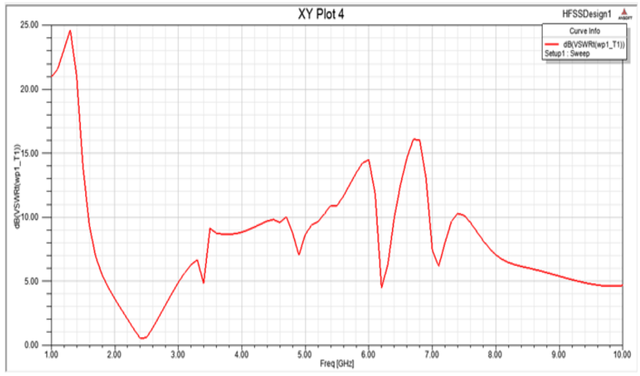


Fig: 8 VSWR for patch 1.

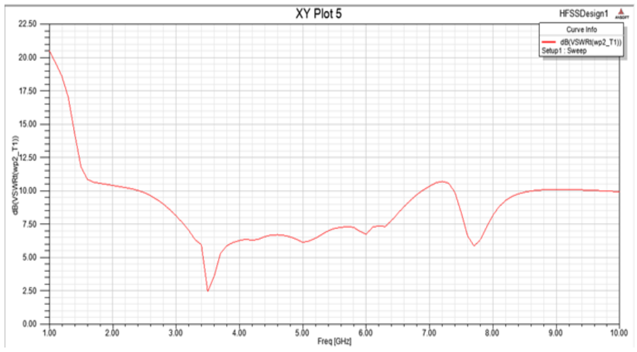


Fig: 9 VSWR for patch 2.

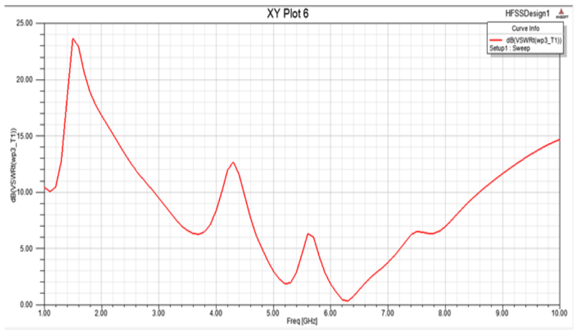


Fig: 10 VSWR for patch 3.

The radiation pattern for the desired range of frequency can be obtained by setting the values for the far field infinite sphere, phi, and theta and step size. The simulated radiation pattern plot for all three patches is represented in the figure 11, 12, and 13.

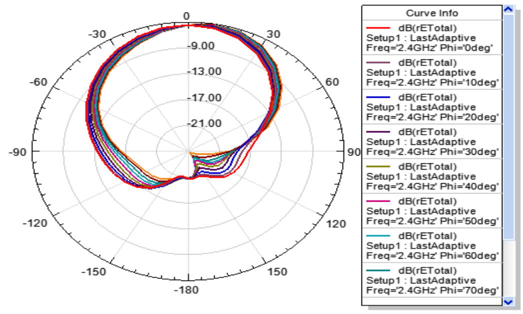


Fig: 11 Radiation pattern for 2.4GHz patch.

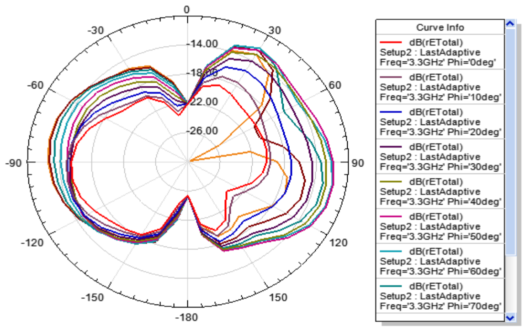


Fig: 12 Radiation pattern for 3.3GHz patch.

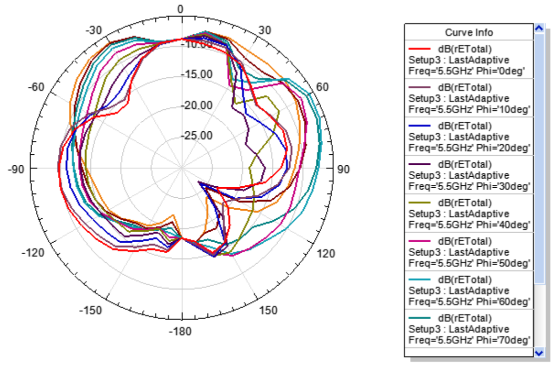


Fig: 13 Radiation pattern for 5.5GHz patch.

The gain and directivity of the MIMO Antenna model is represented in the figure14 and 15. The gain of the above antenna is found to be -1.74dB.

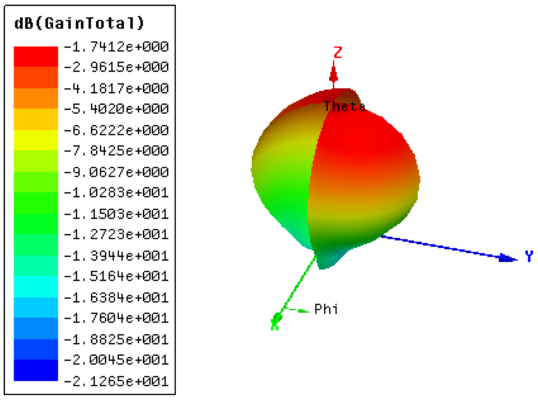


Fig: 14 Gain of the antenna.

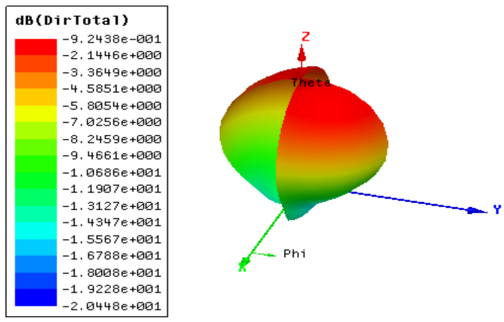


Fig: 15 Directivity of the antenna.

IV CONCLUSION AND FUTURE WORK

A MIMO antenna model with three operating frequency bands is proposed and discussed. The antenna consists of three different patches in the frequency range of 2.4GHz, 3.3GHz and 5.5GHz in a single "FR4_epoxy" substrate. The performance of the antenna is improved by the addition of another "FR4_epoxy" substrate in which AMC unit cells of different size are induced under each of the three patches. The obtained simulation results are performed with the help of HFSS software and they are well suited for WLAN/WiMAX applications. The future work involves the fabrication and testing of the designed MIMO antenna model.

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I have about 66 research publications in reputed international journals and about 75 conference proceedings. I have authored book pertaining to Information Technology. I have served as a doctoral level research supervisor in Anna University and Sathyabama University, Chennai. I have produced three Ph.D. holders so far. I am also a doctoral committee member in these universities.

I serve as a reviewer for the reputed Elsevier International Journal of Mobile Communication and china communication journal. I have filed two patents in the area of Antenna design and analysis. I have conducted many workshops, seminar and both international and national conference. I have got best paper presenter award at International Conference received from Computer society of India during CSI convention digital connectivity-social impact, outstanding faculty award in the field of wireless mobile Adhoc networks for my constant research contribution since 2004. Award has been given by Venus International Research Foundation during contemporary academic meet VICAM 2016 and got award for getting maximum project funding from Central Government of India at Adhiparasakthi Engineering College during 2010-2011.I am a recipient of the AICTE's research funding of INR 18 lakhs to do the active research in the area of wireless networks.

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