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# Radiation Characteristics of Dual Print Microstrip Patch Antenna using IE3D and CST Electromagnetic Simulation Software

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***Abstract*: In this article the radiation performance of coaxial feed dual band dual print microstrip patch antenna using Electromagnetic simulation tool IE3D (Integral Equation Three-Dimensional) and CST-MWS (Computer Simulation Technology Microwave Studio) is offered and discussed. The attempt is made to compare the antenna parameters such gain, impedance bandwidth and radiation pattern from both the Electromagnetic Software. It is observed that both the software has their own pros and cons. However, the features available from the CST make it more feasible in comparison to IE3D. With the presented geometry a wide impedance bandwidth 5.62GHz (1.86-7.48GHZ) with sustained gain is achieved. The antenna radiation parameters are also found as desired. A brief comparison of various EM software is also given for the interest of the readers.***

***Keywords : CST-MWS, Gain, IE3D, Impedance Bandwidth, Microstrip Patch Antenna, Radiation Pattern***

## I. INTRODUCTION

Since the inception of microstrip patch antenna (MPA) it has attained an extreme rise and used in many of the wireless communication device. This all is due to its beautiful features such as low profile, ease of design and fabrication, dual band and dual polarization is easily achievable with single feed. In its most common form it consists of two metallic thin film separated by a dielectric material. The upper metal is commonly known as radiating patch whereas the lower metal is termed as ground. The shape of patch is of any arbitrary shape perhaps it is a key parameter in antenna design, the radiation from antenna depends on its shape [1-2]. However, for ease of mathematical analysis conventional structure such as square, triangle and rectangle is preferred for radiating structures over circle, ellipse, sector etc, since analysis of these shapes involve the Bessel's function, Mathieu functions and more rigorous boundary condition [3-4].

However due to the introduction of new EM (Electromagnetic) tools, nowadays it is convenient to take the unconventional structure as a radiating patch since these tools can solve the Maxwell equation and boundary condition involved with these structures in a quick time. These computational simulations are used to determine that how a designed antenna will function, what will be its frequency range, how its electric and magnetic field vector will behave. There are a few techniques that be able to be utilized for systematic demonstrating and they incorporate the 'Method of Moments (MoM) Technique', 'Finite Difference Time Domain Method (FDTD)', 'Finite Element Method (FEM)' and so forth. There are a large number of EM tools available for the simulation analysis of these geometry among these brief of some of the software for antenna design is elaborated here [5-7].

## II. VARIOUS MOST UTILIZED ANTENNA DESIGN SOFTWARE

### A. ZELAND IE3D

In antenna design industry for designers and manufacturers the ZELAND's IE3D is the ultimate mainstream engineering software because of the overall functionalities provides by a complete IE3D package. The product accompanies the highlights required for circuit 3D Geometry demonstrating, high capacity electromagnetic structure. The highlights, tools and capacities that make it extraordinary incorporates [8]:

- It integrates MoM modelling techniques and it assist the designs importing from different 3 dimensional electromagnetic design software.
- It includes geometry modelling, meshing and simulation of 3D structures
- All the more critically, the instinctive idea of its workspaces wipes out the requirement for a client to have broad information on EM demonstrating to plan a work along these lines rearranging the whole configuration process.

### B. ANSOFT HFSS

For the simple and complex antenna design, RF (Radio Frequency) electronic circuits High Frequency Structural Simulator [HFSS], is an advanced 3 dimensional electromagnetic software.

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The software is additionally furnished with the fundamental highlights and apparatuses for designing and modeling of filters and transmission lines. Some of its features include [9]:

- For design and analysis, it is based on Finite Element Method.
- It incorporates a preset configuration procedure that enables the customer to just indicate the properties of material used for design of geometry and a mesh is created by the software that run into these particulars
- It underpins the structure of linear circuits

### C. CST MICROWAVE STUDIO

CST is a manufactured particularly for the design and simulation of antenna and their dimensional structures, which is basically a CAD (Computer Aided Design) software. With the help of CST one can design antenna for high frequency, filters etc. Due to its high performance it also supports structures include multi-layer. Some of the important features with CST software are [10]:

- To improve the accuracy of design and efficiency of frequency and time domain calculation metrics, CST assimilates features such as Perfect Boundary Approximation (PBA), True Geometry Adaptation and the Thin Sheet Technique.
- It supports the extraction of SPICE parameters which cuts the work period in prototype designing and also supports the import of CAD files from other 3D EM.

### D. FEKO

FEKO is a comprehensive EM software that includes the most recent procedures in the area of computational electromagnetics. It is intended to give answers for a wide scope of electromagnetic issues radiating from different ventures that utilize Antenna, channels and any device that utilizations time/frequency computations. It functions and features include [11]:

- It employs both MoM and FDTD numerical methods and can handle the analysis of radiation pattern of Patch antenna
- It is equipped with plotting of 2D and 3D models and can export the planned files in different setups
- As other EM tools, it can import and export the CAD files and fitted out with them.

### E. ANTENNA MAGUS

One of the antenna synthesis tool is the antenna magus. It gives data to plan the ideal antenna with certain structure particulars. The magus is recognized for quickening a design procedure by giving the accompanying capacities, for example, Choosing the proper antenna topology, recovering antenna information, approving the structured model and evaluating its presentation. It functions and features include [12]:

- New prototypes can be designs in a quick time with its available existing database
- Different file formats are supported by antenna magus into its workspace
- It likewise takes into consideration the exportation of works done on its interface to other tools

A circular patch dual band dual print MPA is presented and discussed using two well-known EM tools viz IE3D Electromagnetic simulation tool and CST software in this article. Since with the admiring feature of low profile and easy fabrication these MPA suffers with low gain and impedance bandwidth that restrict its application in advance communication systems an attempted is made to enhance its impedance bandwidth with stable radiation pattern.

## III. ANTENNA DESIGN

There are multiple ways by which one can enhance the IBW and gain includes the use of low permittivity substrate [13], by increasing the height (thickness) of substrate material [14], by embedding the proper slot at appropriate location in patch as well as in ground termed as Defected Ground Structures (DGS) [15-16], using PBG or EBG [17], the introduction of parasitic patch in the same plane with the main radiating patch along the radiating or non-radiating edge and in a different plane [18-19], superstrate [20] etc.

In this paper, a dual band double printed circular shape MPA is offered. In this design the ground which is in circular shape isn't simply underneath the patch, perhaps it is set aside on +x – pivot, while the patch is along the - x – pivot. In the present case the balance of the created current flows as for the focal point of the printed antenna is kept up. The feed is symmetric regarding both the coupled patches. Exactly when an extra radiator has been picked, the purpose of the antenna designer is to confirm there is the factual degree of association among these segments with the objective that the introduction of the printed antenna is improved. A critical number of these strategies incorporate adjustment of feed position as well as kind of component used to energize the antenna.

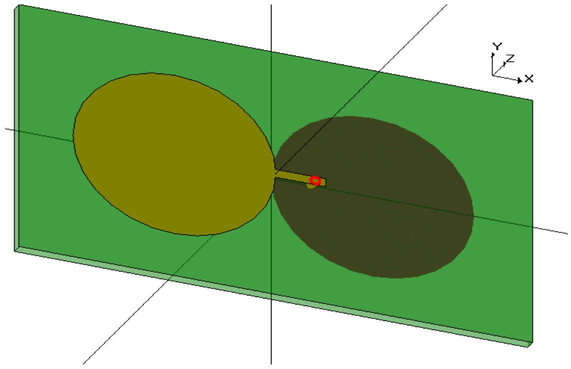


**Fig. 1(a). 3D view of antenna designed with IE3D**

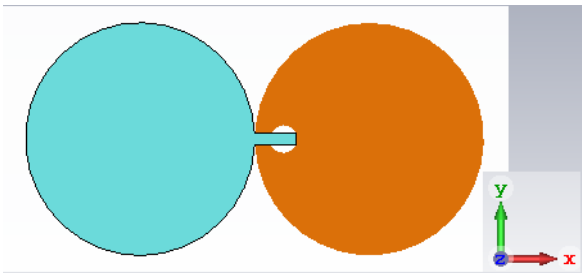


**Fig. 1(b). 3D view of antenna designed with CST**

The geometry of the offered antenna is presented in Fig. 1(a) and Fig. 1(b) with CST and IE3D respectively. The Glass epoxy FR4 substrate is used for the design of antenna having parameters value εr= 4.4, tan δ= 0.025. The left side portion of dual print antenna is made on the top surface of substrate (act as patch) whereas the right side portion of dual print is made on the lower surface (act as a ground). In order to maintain the rotational symmetry, dipole is made up of two circular patches of same radius 'R = 14.2mm' at coordinate (±R, 0) and the feeding point is fixed at ($F_d$, 0). The overall volume of this antenna with CST is 64×32×1.59 $mm^3$ whereas due to the limitation of available IE3D software (does not support finite substrate) the substrate size cannot be defined and it is adjusted by the software itself by assuming infinite substrate size. To excite the patch a feed line of optimum dimension ($L_f$×$W_f$) is connected to upper circular patch, which is fed by SMA connector via lower circular ground.

## IV. RESULTS

The $S_{11}$ variation of offered antenna with frequency with IE3D and CST are shown in Fig. 2(a) and Fig.2 (b). it is perceived from the figures that for both the tools the fundamental resonant frequency is almost same and it is nearly 2.0GHz. However, Fig. 2 (a) suggest that for IE3D the second resonance is at 4.00GHz with a hump above -10dB at 3.00GHz that restricts its impedance bandwidth, it is perhaps due to the infinite substrate size. With the CST as shown in Fig.2 (b) the second resonance appears at nearly 6.50GHz with a large -10dB impedance bandwidth nearly 5.62GHz band (254% for frequency 2.20GHz and 88.6% for frequency 6.32GHz).

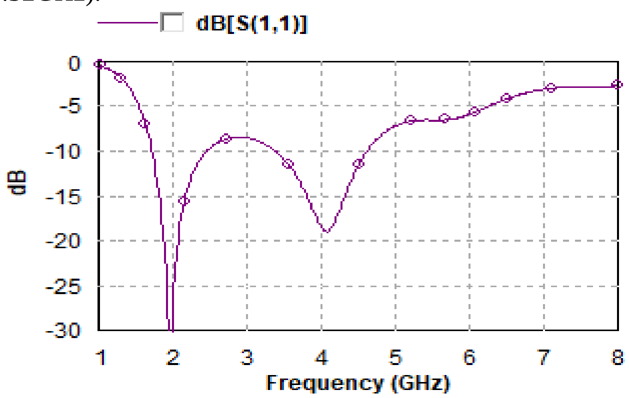


**Fig. 2(a). $S_{11}$ variation with frequency for IE3D**

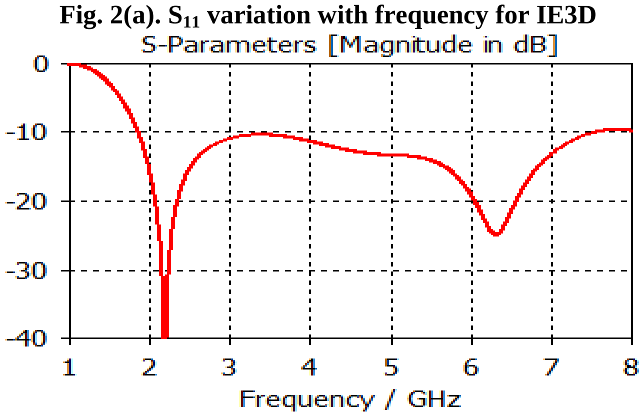


**Fig. 2(b). $S_{11}$ variation with frequency for CST**

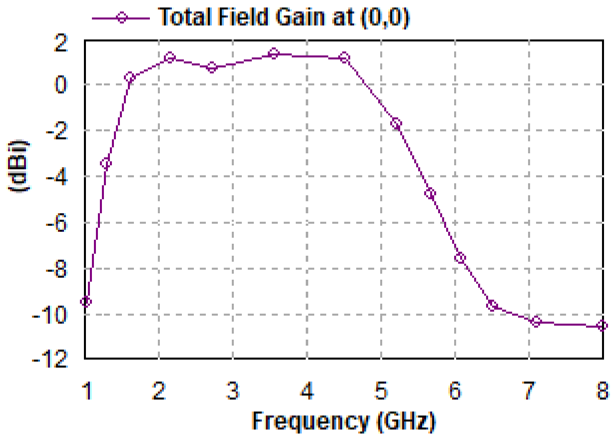


**Fig. 3(a). Variation in gain with frequency for IE3D**

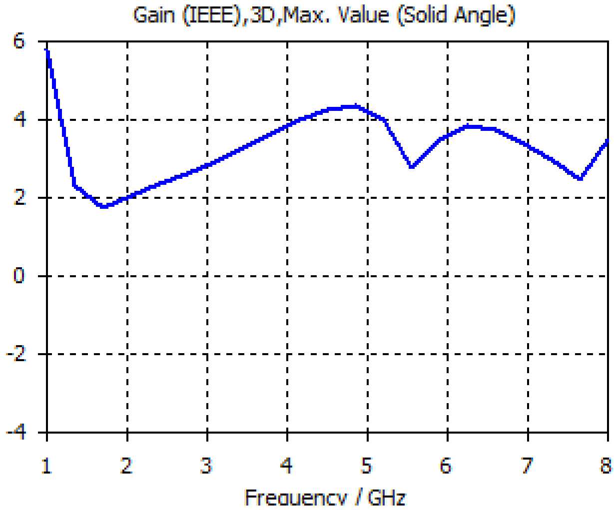


**Fig. 3(b). Variation in gain with frequency for CST**

The gain variation with frequency for IE3D and CST is presented in Fig. 3(a) and Fig. 3(b) individually, it is found that due to the finite size of antenna in CST the gain is almost flat (with a permissible variation of 2dBi) in the interested impedance bandwidth range makes it attractive design. However, for IE3D the gain is dropped down abruptly after 4.52GHz.Two dimensional polar radiation pattern of presented antenna attained from with IE3D software is shown in Fig. 4(a) and Fig. 4(b) whereas Fig. 5(a) and Fig. 5(b) represents the radiation pattern from CST software for their respective first and second resonance frequency. It is found that for both the EM tools the general shape of the radiation pattern for both the frequency is same. However, there is a noticeable difference in other antenna parameter such as the direction and magnitude of main lobe and the 3dB angular width, it is perhaps due to the fact that they are fundamentally function on the different methods. IE3D works on principal of Method of Moments in which the "integral equations are expressed with a full dyadic Green's function and the matrix elements are calculated absolutely numerical in the spatial domain" whereas CST MWS is established on "the finite integration technique (FIT) which agree to decide on the time domain in addition to the frequency domain method". A comparison of various antenna parameter such as frequency, direction and magnitude of main lobe, 3dB angular width is presented in Table – I.

**Table- I: Comparison of different antenna parameter**

| Software | CST | | IE3D | |
|---|---|---|---|---|
| Frequency (GHz) | 2.18 | 6.30 | 2.00 | 4.00 |
| Main lobe direction (degree) | -179.0 | 136 | 30 | 110 |
| Main lobe magnitude (dBi) | 2.67 | 1.60 | 2.86 | 1.93 |
| 3dB Angular width (deg.) | 75.2 | 44.0 | 0.0 | 0.0 |

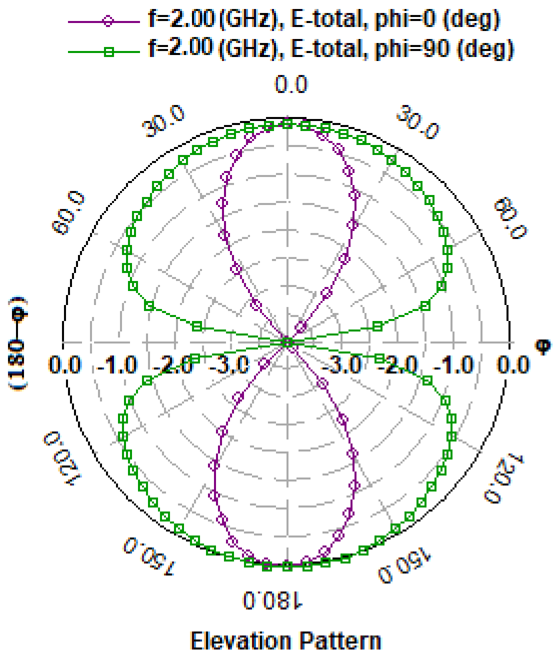


**Fig. 4(a). 2D radiation pattern with IE3D at 2.00GHz**

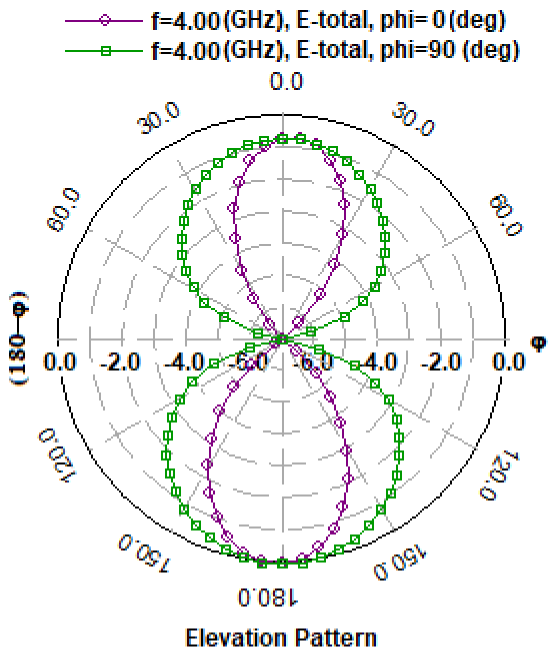


**Fig. 4(b). 2D radiation pattern with IE3D at 4.00GHz**

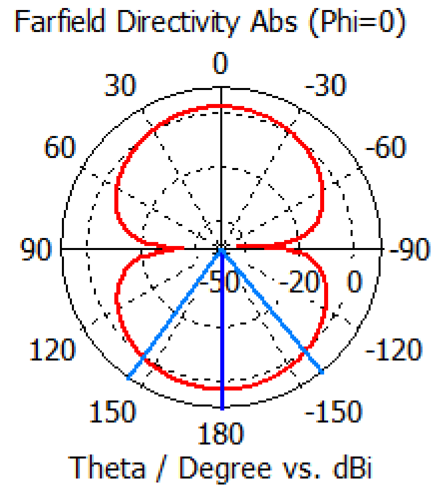


**Fig. 5(a). 2D polar radiation pattern of presented antenna with CST-MWS for frequency 2.18GHz**

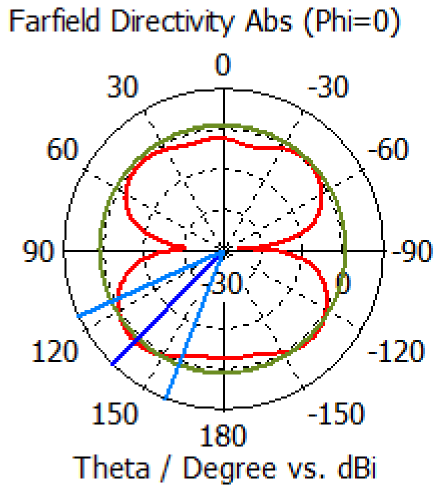


**Fig. 5(b). 2D polar radiation pattern of presented antenna with CST-MWS for frequency 6.30GHz**

## V. DISCUSSION

On reviewing the different available software, it can be stated that all this EM software's have some merits and demerits The geometry of the structure and the necessary precision of the arrangement decides that which software is valuable for the particular case. For instance, ZELAND IE3D depends on MoM explanation of integral equation that has a fantastic precision for frequency domain investigation. Notwithstanding, the interface of IE3D isn't exactly reasonable to remember fine subtleties for the geometry of the antenna. In this way, IE3D would be the finest if the shape is straightforward similar circular or rectangular. Then again, ZELAND Fidelity, depends on FDTD examination. It depends on mix of explicit geometries. However, for large size antenna like reflector antenna or antenna arrays neither MoM nor FDTD are appropriate.

Ansoft HFSS and CST have far improved interface which empower the user to remember fine subtleties for the geometrical shape of simulated design. HFSS depends on Finite Element (FE) approach and CST depends on a technique which is like FDTD.

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The two methods are as yet appropriate for little or moderate items contrasted and the working wavelength. As the CST works in time domain it is easy to achieve wide band with it. The precision of Finite Element is marginally not exactly the exactness of MoM. This is the fact that why there is a little distinction in results among HFSS and Zeland IE3D for standard shapes like triangular or rectangular antenna. For this situation the consequence of IE3D is the more precise outcome. Notwithstanding, for entangled geometry, the exactness of HFSS and CST are obviously superior to IE3D because of the approximations taken in the geometry of the structure. HFSS and CST can be utilized to simulate large structures relying upon the accessible equipment assets.

FEKO has two principle solvers, one depends on ‘MoM and another dependent on GTD (Geometrical Theory of Diffraction)’. The piece of FEKO which depends on GTD can't be supplanted by Zeland, HFSS or CST since it is fundamentally appropriate for enormous structures like reflector antenna. Taking everything into account, a great planner ought to have the option to utilize distinctive CAD devices with profound comprehend of cut-off points of their numerical procedures and modeling interface.

## VI. CONCLUSION

In this article the evaluation of radiation characteristics of a coaxial single fed circular MPA with two electromagnetic software IE3D and CST-MWS is presented. It is observed that both the software gives nearly the same outcomes, however a little variation is observed which may be perhaps due to the two different methodology belongs to the software. It may be due to the version of IE3D software available since with this ground structure is made finite however the software does not support the finite substrate. This issue is not arising in CST due to its compatible environment. A large impedance bandwidth is obtained with the presented antenna with sustained gain and radiation pattern with CST.

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