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Design of Reconfigurable Annular Ring Coupled Stacked PSI Patch Antenna for Wireless Applications

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ABSTRACT: The proposed project aims to design and fabricate a low-profile miniaturised reconfigurable stacked psi shaped patch antenna with coupled annular ring operating in WLAN/ WiMAX, ISM band and C-band applications. The patch consists of a stacked psi shape with coupled annular ring. The reconfigurable characteristics will be obtained by introducing PIN diodes at required positions of the patch antenna. The model provides both frequency reconfigurability and pattern reconfigurability based on the switching of PIN diodes. The proposed antenna will be designed using CST Studio Suite 2020 and fabricated either on Rogers RT anduroid 5880 LZ R4 substrate with permittivity 2.0 and loss tangent 0.002 or FR-4 Epoxy substrate with permittivity 4.4 and loss tangent 0.02. The proposed antenna will be able to provide better impedance bandwidth, low VSWR, stable radiation patterns and sufficient gains (>= 3 dB) at the desired resonant modes. A good agreement can be seen between simulated and measured values.

KEYWORDS: CST, WLAN/ WiMAX, ISM band and C-band

I. INTRODUCTION

Communication became an essential part of our day-to-day life. The key component in the communication system is the radiating element called antenna used for the transmission and reception of signals of information. The recent challenge aspects in the design and development of an antenna are miniaturization and wide bandwidth. These requirements can be met through the option of microstrip patch antenna (commonly called a patch). The patch antenna design was started since the mid-1950s. Wide bandwidth in a patch can be achieved in two methods. One is through the ultrawideband and other through multiband. These techniques will be depending on various factors like the type of feeding, ground mechanism, structure, or shape of the patch, etc. The performance characteristics like high operating bandwidth and desired gain can be obtained through different structures and slots on patch and ground. In this chapter, a reconfigurable circular ring coupled stacked psi shape antenna with partial ground was designed and simulated in CST Microwave Studio. patch antenna was also fabricated, and the measurements were obtained using Combinational analyser. The antenna can operate in WLAN, ISM Band, C-Band and WiMAX applications.

II. BACKGROUND STUDY

An Antenna can be utilized either as a transmitting receiving wire or an accepting reception apparatus. A transmitting receiving wire is one, which changes over electrical signs into electromagnetic waves and emanates them. An accepting radio wire is one, which changes over electromagnetic waves from the got shaft into electrical signs. In two-manner correspondence, a similar radio wire can be utilized for both transmission and gathering. Receiving wire can likewise be named as an Aerial. Plural of it is, receiving wires or radio wires. Presently a days, receiving wires have experienced numerous changes, as per their size and shape. There are numerous sorts of radio wires relying on their wide assortment of utilizations.

An antenna may be a device for converting electromagnetic wave in space into electrical currents in conductors or vice-versa, counting on whether it's getting used for receiving or for transmitting, respectively. Passive radio telescopes are receiving antennas. It is usually easier to calculate the properties of transmitting antennas. Fortunately, most characteristics of a transmitting antenna (e.g., its radiation pattern) are unchanged when the antenna is employed for receiving, so we frequently use the analysis of a transmitting antenna to know a receiving antenna utilized in astronomy.

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Since the turn of the last century antennas have been commonly used. This field has since under gone extensive work, which has resulted in a broad range of experimental and theoretical expertise alongside various designs and applications. The most punctual radio wire was presented in the late nineteenth century by the German physicist Heinrich Hertz. Hertz's work was trailed by an extraordinary hypothetical examination of the subject during the ahead of schedule to mid twentieth century. This examination continued with the advancement of PC helped plan (CAD) apparatuses during the 1970s-2000s, made conceivable by the improvement of ground-breaking yet moderate PC innovation.

At present in communication field, the wireless is the advanced technology used. Wireless communication began with the invention of radio at the turn of the twentieth century. There are numerous uses of wireless communication, such as telecommunication networks, that can provide stable connections between electronic devices in almost every location. They transmit data between two or more places without requiring any physical contact. WLAN (Wireless Local Area

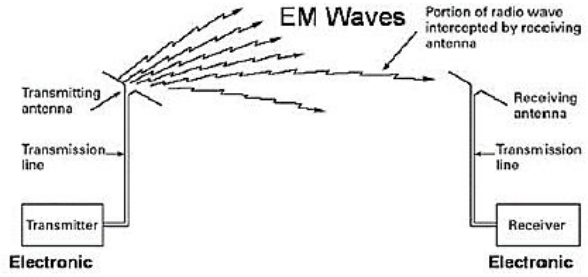

Fig. 1: Wireless communication system

III. RELATED WORK

ARCSP patch antenna was analyzed to attain the reconfigurable properties for the frequency applications like WLAN, C-band, and ISM band applications. The Annular Ring Coupled Stacked Psi Shape Patch antenna which was designed was modified by placing the PIN diodes at the relevant positions on the patch antenna and a partial ground. Three different positions were chosen for obtaining reconfigurable property by placing PIN diodes between the stacked psi shape and the feed line, feed line and left portion of the coupled annular ring as well as feed line and right port of the coupled annular ring. The designed antenna has provided a good performance characteristic. The prototype of the patch antenna was fabricated, and the simulated results provided a good consistency with measured results.

IV. ANTENNA DESIGN AND GEOMETRY

The Reconfigurable Circular Ring Coupled Stacked Psi (RCRCSP) patch antenna structures comprises of the overlapped dual circular ring structures with a stacked psi shape placed inside the circular ring structures. To obtain reconfigurable property, PIN diodes were placed at the various positions of the structure to obtain the reconfigurable property. Depending on the switching of the diodes, the patch antenna undergoes the frequency as well as pattern reconfiguration. The patch dimensions are maintained at 3.5*2 cm2 (L*W). A partial ground was placed with a 0.35 cm length below the feed line. A slot width of 0.07 cm was etched from the structure to keep the PIN diodes. The geometry of the patch antenna was shown in fig 4.1. The positions of the PIN diodes on the patch antenna are shown in fig. 4.2. the PIN diodes are represented as PIN_0, PIN_1, PIN_2 and are placed as follows. PIN_0 is placed between Stacked psi shape and the feed line, PIN_1 is between the right longitudinal half of the dual overlapped circular ring and feed line and finally PIN_2 is placed between the left longitudinal half and the feed line. The geometry variables and their values of the patch antenna are shown in fig.4.2.2 and table 4.1. The switching combination of the PIN diodes provides the required frequency or pattern reconfiguration. With three PIN diodes, eight switching combinations were evaluated for the design in CST studio suite.

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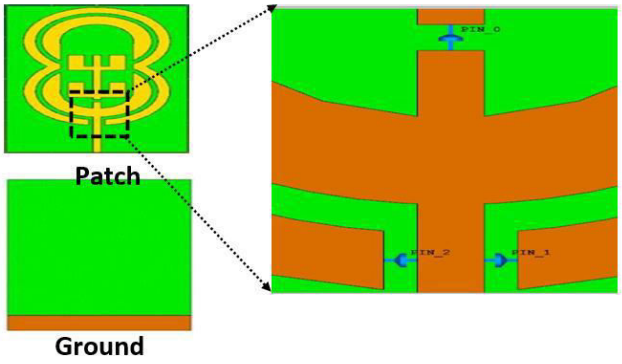

Fig2.: PIN diode positions on RCRCSP patch antenna

V. ANALYSIS AND DISCUSSIONS

CST Studio Suite is a computational electromagnetics tool developed by Dassault Systems Sissmulia. It contains several different simulation methods. Including the finite integration technique (FIT), finite element method (FEM), transmission line matrix (TLM), multilevel fast multipole method (MLFMM) and particle-in-cell (PIC), as well as Multi physics solvers for other domains of physics with links to electromagnetics. The software was initially developed for particle accelerator laboratories, it found application in microwave engineering, and so FIT was implemented in CST Microwave Studio (CST MWS) in 1998, which became CST Studio Suite in 2005.CST was acquired by Dassault Systems in 2016, and since then CST Studio Suite has been a product of Simulia the time domain FIT method uses a proprietary meshing technique called perfect boundary approximation (PBA)to represent curved surfaces in a hexahedral mesh ,and there is also a frequency domain FEM solver. Other methods include the MLFMM and shooting boundary ray EM solvers. There are also Multiphysics solvers such as PIC, wake field, thermal and structural mechanics.

As an electromagnetic design tool, CST Studio Suite is chiefly used in industries such as telecommunications, defence, automotive, aerospace, electronics and medical equipment. One application of CST Studio Suite is the design and placement of antennas and other radio-frequency components. The antenna systems on the Bepi Colombo Mercury Planetary Orbiter were developed using CST Studio Suite to investigate their radiation pattern and possible electromagnetic interference. Electromagnetic compatibility (EMC) is the ability of electrical equipment and systems to function acceptably in their electromagnetic environment, by limiting the unintentional generation, propagation and reception of electromagnetic energy which may cause unwanted effects such as electromagnetic interference (EMI) or even physical damage in operational equipment.

VI. FABRICATION

By utilizing photolithographic limits, the reception apparatus is manufactured in this postulation. The pointless metal locales of the metallic layer are disengaged by utilizing this procedure. This is a compound carving process which can be utilized to get planned locale. Single side or double side, uniplanar or biplanar substrates are reused, in view of structure of the part. The key piece of the radio wire configuration is the determination of fitting substrate material. The planned receiving wire created by thinking about dielectric steady, misfortune digression, homogeneity and dimensional quality of the reception apparatus. Particularly at high frequencies, the high misfortune digression substrate contrarily influences the productivity of the radio wire. Based on specifications of radiation characteristics, applications of the antenna the substrate dielectric constant will be selected. Low bandwidth performance along with surface wave excitation is obtained by using high dielectric constant substrates. Photolithographic methods need UV light with relevant wavelength and photo resist which is conscious to this wavelength. There are 2 types of photo resist materials positive and negative. A computer aided design of the geometry is originally made in photolithographic process. On a butter paper a negative mask of the geometry is printed. Due to impurities the discontinuities take place in fabrication design, in order to avoid them on a single side and double-sided copper substrate with sufficient dimensions is accurately cleaned by using acetone and dried. By using dip coating. method, a negative photo thin layer is coated and it is dried which is resolved to UV light and positioned on photo resist. For some time, the layer of photo resist material is placed in the developer solution after the appropriate UV exposure.

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For designing a micro strip antenna there involves an easy process. The above flow chart represents the procedure of fabrication. After the removal of nonessential metal areas, of metallic layer is done by employing chemical etching process. For suggested antenna design, the appropriate substrate material is utilized. To connect feed and ground a SMA (sub miniature version A) connector is used and contributes electrical achievement of an antenna. The SMA connector attempts constant 50ohms impedance with fewer reflections.

VII. PHYSICAL MEASUREMENTS

1. Vector network analyser

Depending on frequency conversion, vector network analyser (VNA's) is used for wide band vector measurements. On a specific dielectric material, if the specific antenna is fabricated, we can measure the antenna parameters such as VSWR; return loss etc., by using the measurement setup of antenna and network analyser. Classification of analysers are of two types: scalar and vector network analyser. Scalar network analyser is used to measure reflection coefficient and magnitude of transmission line. For measuring both magnitude and phase of antenna parameter, vector network analysers are generally used. Commonly, a vector network analyser contains signal processor, microwave source, digital unit and calibration kit. By utilizing digital processor and plotting tools of these devices the output is attained in the form of graph or data

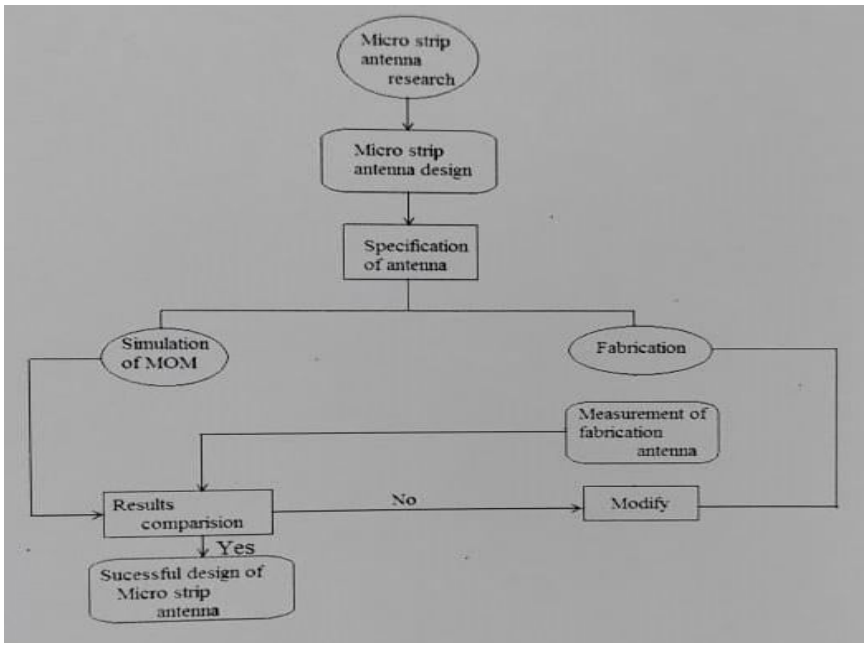

Fig.3.: Design methodology of fabrication process

VIII. CHALLENGES AND GAPS

Results and Conclusion

The RCRSP patch antenna with partial ground was designed and simulated in CST Microwave studio 2020. Various performance parameters considered for analysis are Return Loss (S11), Radiation Patterns, VSWR and Surface currents. The patch antenna prototype was fabricated, and the parameters are measured using combinational analyzer.

4.3.1 Return Loss (S11)

The characteristics between the reflection co-efficient and the frequency was observed for the RCRSP patch antenna with various PIN diode switching combinations. As we are using 3 PIN diodes, 8 switching combinations were obtained and analyzed. The return loss characteristics with respect to frequency is shown in fig.4.3(a).

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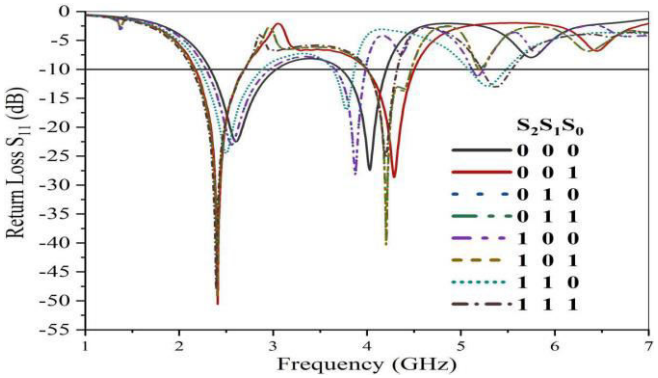

Fig. 4.(a): Return Loss (S11) characteristics for the RCRSP Patch antenna

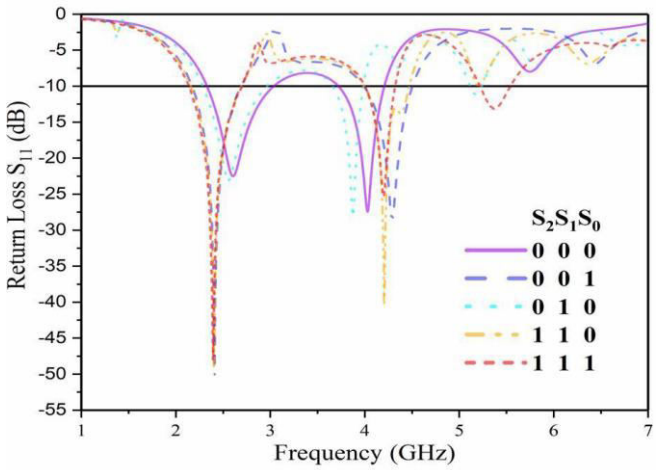

Fig.4.(B): Return loss characteristics of the RCRSP patch antenna for frequency reconfigurable PIN diode switching combinations

IX. CONCLUSION

Antenna design for modern commercial applications is proposed, using annular ring-based structures. There are many challenges in the design of antenna which can work in commercial frequencies like WLAN, WiMAX, ISM Band and C- band Applications. The antenna which can increase channel capacity and can give access to several other users is a best choice to take up. Discussions are made covering the entire operations of the antenna and their performances. The antennas are designed that they can cover irregularities present in modern commercial applications. The antenna is modified with different types of techniques to get required parametric results and providing performance improvement.

X. FUTURE SCOPE

Future works can be based on different types of techniques which are used on the antenna to enhance its performance. The different types of MIMO antennas and its techniques are going to be investigated. The isolation methods and techniques, placement of patch elements in different orientations and different positions, which can enhance the performance of antenna. Main future work will be on the performance of MIMO antennas and its techniques. Investigation was done on only two patch elements furthermore investigation is going to be on multiple patch elements and techniques for placement and isolation reduction. Investigations on compactness of the MIMO antenna for different sizes along with the placement and isolation reduction, it is because as the antenna gets compact the isolation is one of the major problems in MIMO antennas. placement is also a factor which need to be considered where the placement also gets complicated in the antenna design. The working performance will change accordingly with size. So, Investigations to be made are different and versatile in nature due to complications being faced in the field of MIMO antennas. Many more advances are going on like fractal, reconfigurable, conformal will be taken into consideration and lay path towards achieving it.

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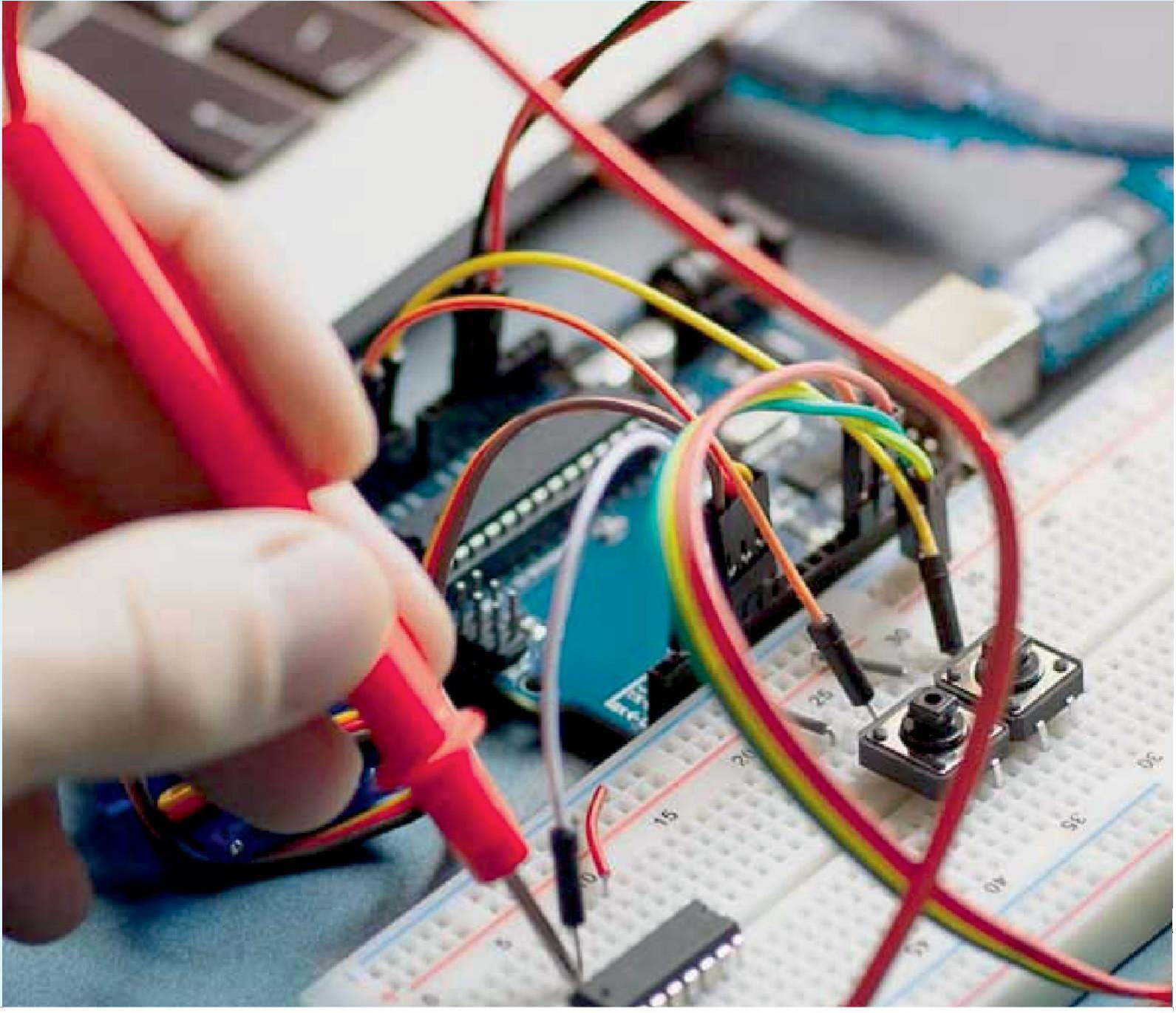

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