Microstrip Patch Antenna Array for RFID Applications

Smitha J[1], Rajeshwari P[2]

[1]M. Tech Student, ETE, DSCE, Bengaluru
[2]Assistant Professor, ETE, DSCE, Bengaluru

Abstract— **Radio-frequency identification (RFID) is an expanding technology that enables radio detection and recognition of the objects associated with an identification code carried by an electronic chip which is attached to tag. RFID belongs to group of technologies which is referred as Automatic Identification and Data Capture (AIDC). AIDC methods automatically identify the objects, collect the data, and analyze the data from the object. RFID's being extensively used in different kinds of applications and is one of the most promising in the field of IoT (Internet of Things). The design of the RFID system deals with mainly two components which are RFID tag and the RFID reader, both the system contains an antenna in it. The microstrip patch antenna is designed for UHF Gen-2 item-level tagging systems. And it is optimized to read near-field tags placed on products with a variety of packaging options. The microstrip patch antenna array for the RFID applications is designed for a particular range of frequency 865-868 MHz using a tool called CST and it will be fabricated on a Printed Circuit Board (PCB) for the required specifications.**

IndexTerms— **Microstrip Patch array antenna, RFID applications, RFID reader, CST tool, UHF.**

I. INTRODUCTION

The most versatile features of the microstrip patch antennas are its simplicity, lightweight, low fabrication cost and strong ability to integrate into feed network. For an antenna, the patch shapes are chosen accordingly to match the resonant frequency, polarization, signal pattern, and impedance. The distribution of the energy into the various antenna elements can be achieved by different feeding configurations. Improvement of the efficiency, directivity, and gain for the radiating system is achieved by the array arrangements of microstrip antennas. The RFID (Radio Frequency Identification) has become very popular which is an electronic identification technology that uses radio EM waves to exchange data between reader and tag antennas i.e., an object basically used in commercial applications. The common examples are UHF band (840-960MHz) RFID systems becoming more attractive for many applications such as supply chain, tracking, bioengineering, inventory management, large information storage capacity, logistics etc., Generally the UHF tag antennas are linearly polarized but the orientations of tag antennas are random, so actual application and requirement of RFID tag antennas are circularly polarized systems. Microstrip antenna reduces the multipath effect generated by misalignment of reader and tag antennas and becomes most effective and efficient RFID system. Therefore recently, RFID antennas are usually circularly polarized. The total frequency range of UHF band used for RFID system is 840-940 MHz. However, the frequency band for RFID application is different for different countries. In America, operating band is 902-928 MHz, in Europe 865-867 MHz, in India 865-867 MHz, in China 840.5-844.5 MHz and 920.5-924.5MHz, in Japan 952-955 MHz.

II. LITERATURE SURVEY

An innovative technique for attaining high isolation between antenna array elements is presented in this paper. Less than half a wavelength separates the elements of the planned antenna. A slot in the antenna array is utilised to achieve isolation. There are several performance metrics offered, including return loss and mutual coupling. The proposed antenna is appropriate for WLAN application.[1] An "AND gate-shaped" microstrip patch antenna array with several company feeding techniques is shown in this study. This article also includes a comparative examination of these feeding techniques. The suggested antenna can be utilised for RFID applications and is made for 5.8 GHz operating frequency. The outcomes comprise parametric experiments carried out by adjusting the substrate's measurements as well as the ground's length. 5.24 dB of peak gain are provided by this patch antenna at 5.8 GHz resonance.[2] This paper presents the complete design of a rectangular Microstrip Patch Antenna for use in RFID Reader applications that operates at a frequency of 5.8 GHz with two components. With a loss tangent of tan = 9.10-4, a dielectric constant of 2.2, and a thickness of 1.56mm, the patch antenna was created using RT/duroid-5880 material and supplied via a 50-microstrip line. Our antenna was first defined as a single patch with a rectangular shape, but after analysing the results for gain, directivity, and radiation patterns, we changed it to a 2*1 linear array. Enhancing directivity, gain, and radiation patterns is the major goal. [3] Using HFSS simulator software built on the Ansys platform, a 1x2 Circular microstrip patch antenna array operating at 2.4GHz is constructed. It is helpful for Bluetooth, IoT, and many WLAN (wireless local area network) applications. Edge feeding is used to feed the circular patch antenna, which is built on a FR4 substrate with a dielectric constant of 4.4 and a height of 1.6mm. Numerous antenna properties are investigated, including return loss, radiation pattern, bandwidth, directivity, antenna gain, and radiation efficiency. [4] Microstrip antenna is a shaped thin board of antenna and capable for working at high frequencies. A rectangular shape is one of the pattern strip shapes that can be found on microstrip antennas. Microstrip antennas have some drawbacks, including a limited bandwidth and low gain. To address these issues, an array is used to boost the antenna's strength and a u-slot to expand its bandwidth. In this study, the results of an antenna simulation performed using Ansoft HFSS software tools will be discussed, along with how well they adhere to the specifications of the intended antenna. In this article, we examine the outcomes of the design and simulation of a microstrip antenna operating between 2.6 and 2.7 GHz for LTE applications.[5]

In this paper, design, simulation and optimization study of a 1x2 circular microstrip patch antenna (MPA) array for next generation 802.11ac wireless LAN (WLAN) is presented. The IEEE 802.11ac may be a set of MAC layer enhancements for higher throughput within the 5GHz band. This emerging standard provides wider channels, higher throughput and efficient use of spectrum. The proposed antenna array is intended and simulated using Agilent ADS momentum. The antenna array is meant using the FR4 substrate ($\varepsilon r = 4.6$ and $h = 1.6mm$). the size of the proposed design is calculated using the transmission-line model. An inset-feed with quarter-wave transformer is employed to feed the antenna elements. The proposed design improves the shortcomings of a classical rectangular MPA. Hence, the utmost achieved bandwidth and gain of the 1x2 circular patch antenna array are 292MHz and 5.17dBi respectively. The proposed array is also used as a template to make larger arrays which might be utilized in next generation 802.11ac WLAN [6]

III METHODOLOGY:

The antenna is designed for the operation that enable reading of an Item Level Tag which works with UHF Gen2 RFID tags that incorporate an inductive near-field component with high-performance, low-cost antenna solution which can be mounted top or bottom of the table. The proposed methodology is depicted in the below flowchart, here the Microstrip patch array antenna is designed which operates at the frequency band of 865-868 MHz. The design parameters like length, width and thickness of ground, substrate and antenna are formulated. The orientation, shape and feeding technique of an antenna is designed using CST tool. The designed microstrip patch antenna is then analyzed with respect to VSWR, return loss and other specification required.

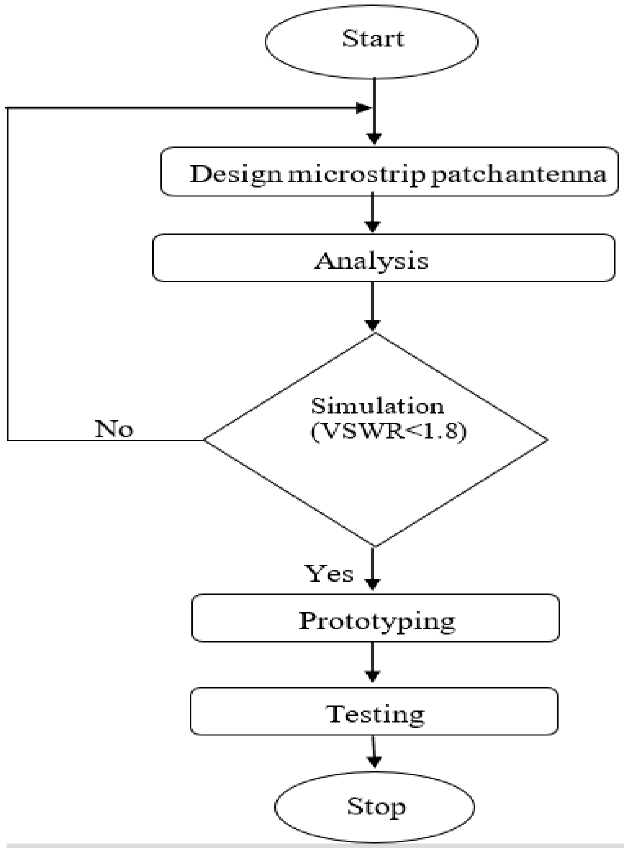

Fig 1: Flow chart of proposed antenna

IV PROPOSED ANTENNA STRUCTURE

Microstrip antennas are very flexible and are used in an array to synthesize a desired pattern which cannot be obtained with a single element. We use an array to extend the performance of the antenna€, scan the radiation pattern beam of an antenna system, enhance the directivity and gain which would be better compared to that of a single element. The elements can be fed by single line or by multiple lines in a feed network arrangement. The important parameter for the design of a microstrip patch antenna is the Frequency of operation (fr). The resonant frequency of the antenna should be chosen appropriately. The RFID frequency range from 865-868MHz. Hence the designed antenna must be competent to function in this frequency range.

The resonant frequency chosen for our design is 865MHz. the chosen value of the substrate (FR4 epoxy) relative Dielectric constant (Ɛr) is 4.4 and the substrate thickness (h) is 0.8mm. Then, we evaluated the radius of the circular patch using the formula:

$$a = \frac{F}{\left\{1 + \frac{2h}{\pi \varepsilon F}\left[ln\left(\frac{\pi F}{2h}\right) + 1.7726\right]\right\}^{1/2}}$$

$$where F = \frac{8.791X10^9}{fr\sqrt{\varepsilon}}$$

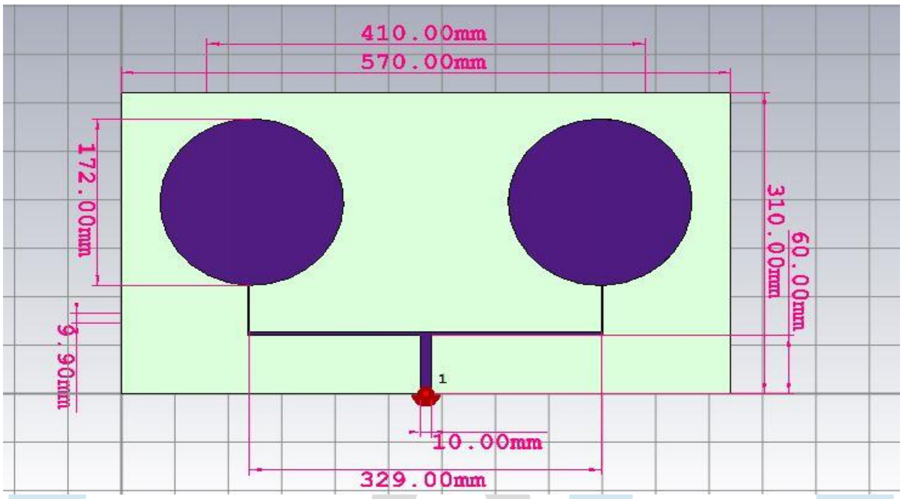

Fig 2: 1x2 microstrip patch antenna

V SIMULATION RESULTS

There are many different aspects from which an antenna can be analyzed. But, the basic parameters which define the antenna performance are gain, VSWR, return loss, band width, input impedance. The simulation is done using the software CST STUDIO. CST STUDIO is a powerful tool for the 3D electromagnetic simulation of high frequency components. CST offered unparalleled performance, making first choice in technology leading research and development departments. And user-friendly and enables to choose the most appropriate method for the design and optimization of devices operating in a wide range of frequencies. It offers accurate, efficient computational solutions for electromagnetic design and analysis.A radio transmitter or a receiver to deliver power to an antenna, the impedance of the radio and transmission line must be well matched to the antenna impedance. The Voltage Standing Wave Ratio (VSWR) is a parameter which measure how well the antenna impedance is matched to the radio or transmission line it is connected. The Voltage Standing Wave Ratio is an indication of the amount of mismatch between an antenna and the feed line connecting to it. VSWR is real and positive number, the smaller the VSWR is the better the antenna is matched and more power is delivered. The range of values for VSWR is from 1 to infinity, but VSWR value below 2 is considered suitable for most applications and the antenna can be described as having a good match.

$$\text{VSWR} = \frac{1+\Gamma}{1-\Gamma}$$

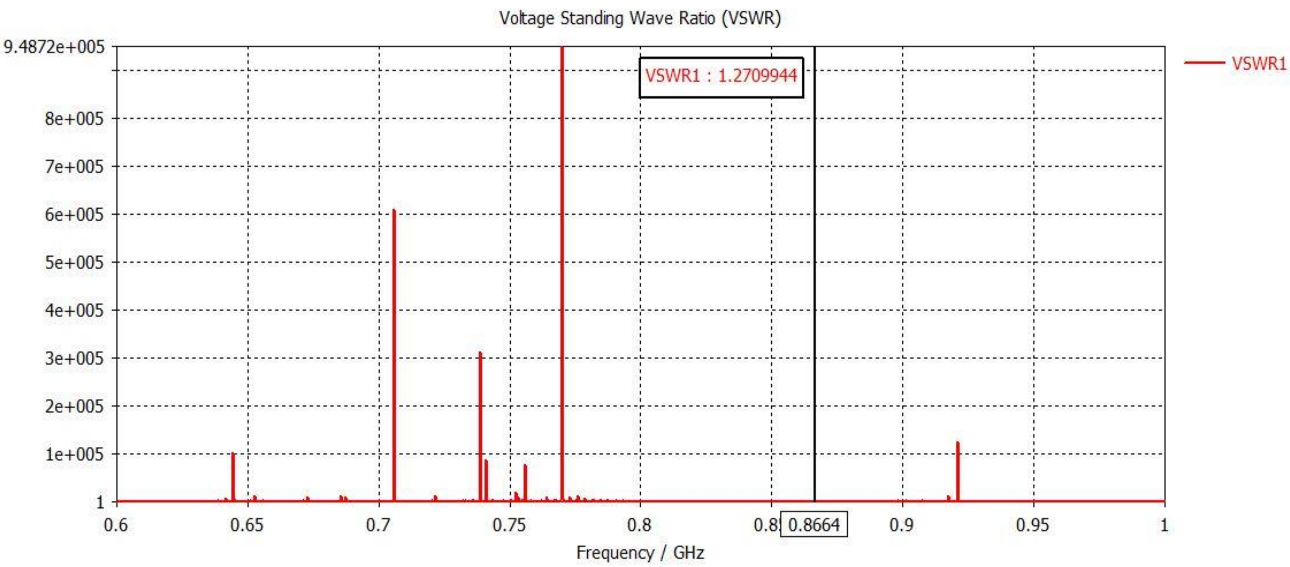

Fig 3: Voltage Standing Wave Ratio

Return Loss (RL)is another specification of interest for an antenna design that indicates the proportion of radio waves arriving at the antenna input that are rejected as a ratio against those that are accepted. It is specified in decibels(dB).

$$r = \frac{VSWR - 1}{VSWR + 1}$$

$$RL = -20Log_{10}(r) \quad \text{Where } r = \frac{VSWR-1}{VSWR+1}$$

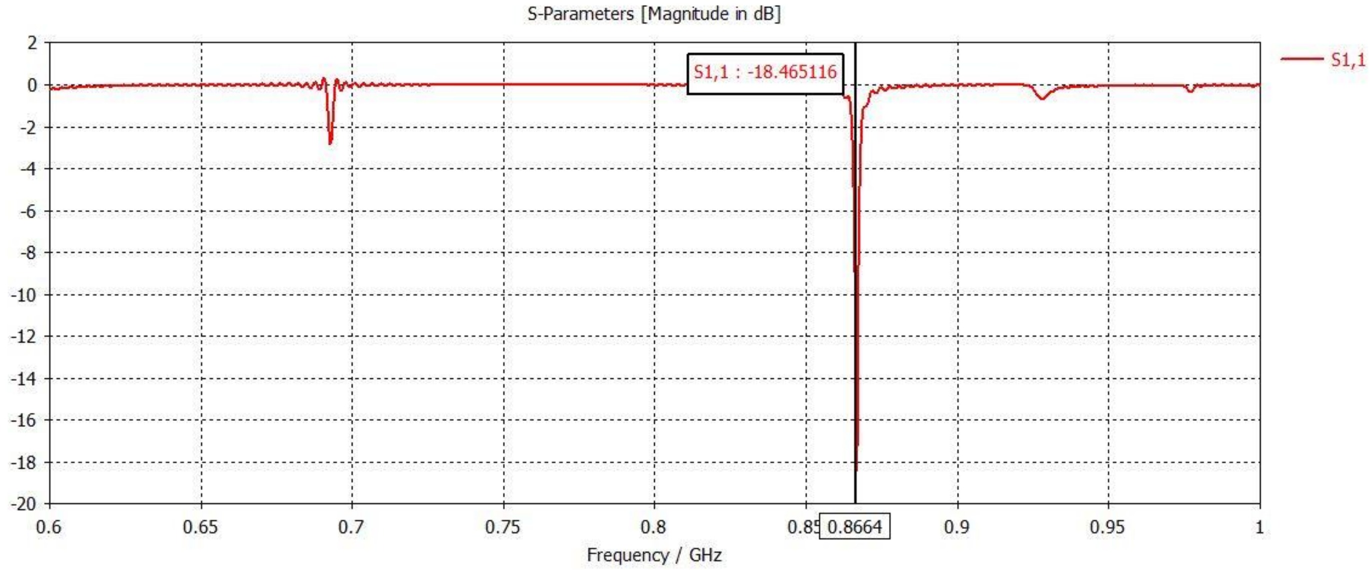

Fig 4: Return Loss(dB)

VI CONCLUSION

The microstrip patch array antenna for RFID application for the range of 865-868MHz with VSWR 1.27 and return loss of -21.24 dB is designed using CST tool and it is analyzed using network analyzer. The designed antenna will be developed on a PCB and tested further.

REFERENCES

[1] Sharan J S, Sphoorthi A Banakar, Sujith B K, Veena N B, Pramod V Rampur "Design of 1X2 Microstrip Array with High Isolation" IRJMETS-2021.
[2]Deepesh Chandwani, M Chaitanya Sai, Runa kumari- "Microstrip patch antenna array for RFID Application"-IEEE International Conference on Electronics and Communication-2019.
[3]O.Ouazzani,.D.Bennani, M.Jorio "Design and Simulation of two elements rectangular Microstrip Patch Antenna at 5.8 GHz for RFID Reader Applications with high Directivity and Gain" IEEE-2018.
[4] Shanthi P , Yashvi Mehul Shah, Siddharoodha C A
"Design and Analysis of 1x2 Circular Patch Antenna Array for 2.4 GHz Applications"- International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-8 Issue-4, November 2019.
[5] P. Daud, Sri.H, D.Mahmudin , T.T.Estu, A.A.Fathnan, Y.N.Wijayanto, N. Armi "1x2 Array of U-Slotted Rectangular Patch Antennas for High-Speed LTE Mobile Networks"- IOP Conf. Series: Materials Science and Engineering 2016.
[6] Kinza Shafique, Asghar A. Razzaqi, Muhammad Mustaqim, Bilal Muhammad Khan, Bilal A. Khawaja "A 1x2 Circular Patch Antenna Array for Next Generation 802.11ac WLAN Applications"
[7] Pundaraja, Kavya M, Dr. Srividya B V & Sandeep Vedagarbham. Near-Field Antenna for RFID Applications. International Journal for Research in Applied Science and Engineering Technology.1012-1015. 10.22214/ijraset.2019.6174.
[8] Dr.S.Sathiya Priya, A.Supriy, B.Meena Shivani "Analysis and gain enhancement of Different Shapes of Microstrip patch antenna". International Research Journal of Engineering and Technology (IRJET)-2017.
[9] K. Prahlada Rao, Vani R.M and P.V.Hunagund -"Design of 2×1 Square Microstrip Antenna Array" International Journal of Engineering and Manufacturing Science. 2018
[10] Hsien-Wen Liu, Chung-Hsun Weng, Chang-Fa Yang, Yu-Shu Lin, Fu-Syuan Chen, Yu-Cheng Huang Che-Wei Hsu "Design of RFID Near-Field Focusing Circular Patch Array Antenna at 2.4GHz with Applications".IEEE-2010
[11] M. K. A. Rahim, A. Asrokin, M. H. Jamaluddin, M. R. Ahmad, T. Masril and M. Z.A. Abdul Aziz "Microstrip Patch Antenna Array at 5.8 GHz for Point to Point Communication" International RF and Microwave Conference Proceedings. 2006
[12]Yahya S. H. Khraisat, "Design of 4 Elements Rectangular Microstrip Patch Antenna with High Gain for 2.4 GHz Applications," Modern Applied Sciences, Vol. 6, No. 1, January 2012.

[13] Ayyappan, Manoj. B, Jagadish Chadran, “Design and Analysis of Circular Microstrip Antenna at 5.8GHz with Fr-4 Substrate,” International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 5, Special Issue 4, March 2016.
[14] Keshav Gupta, Kiran Jain, Pratibha Singh, “Analysis and Design of Circular Microstrip Patch Antenna at 5.8 GHz,” International Journal of Computer Science and Information Technologies, Vol. 5 (3), 2015, 3895-3898.
[15] S. Whitehead, “Adopting Wireless Machine-to-Machine Technology,” IEEE Journal of Computing and Control Engineering, vol. 15, no. 5, pp. 40-46, Oct-Nov. 2004.
[16 Ken Paramayudha, AriefBudi Santiko, Yuyu Wahyu, Folin Oktafiani, “ Design and Realization of Circular Patch Antenna for S-Band Coastal Radar” (2016).
[17] Togcuoglu, N. B., Albayrak, Y., Saylik, M. N., Daye, M. A., Bal, M., Imeci, M., & Imeci, T, “Circular patch antenna with circular and rectangular slots”, 25th Signal Processing and Communications Applications Conference (SIU) 2017.
[18] A.V. Ponkia, V.V Dwivedi, J.P. Chaudhari, "Dual Band Circular Shaped Slotted Microstrip Patch Antenna", Inventi Journals on Antenna and Propagation, 2012.
[19] N. Boskovic, B. Jokanovic, F. Oliveri, D. Tarchi, "High Gain Printed Antenna Array for FMCW Radar at 17 GHz", 2015.
[20] Shanthi.P, Soundarya.S,Meghana.S,"Design of Dual Band Microstrip Antenna for 2.4 GHz and 3.6 GHz" , International Journal of Recent Technology and Engineering (IJRTE) ,Volume 8(1),Pp.no.2402-2406.