



M.KUMARASAMY
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Thalavapalayam, Karur – 639 113.



DESIGN AND DEVELOPMENT OF MICROSTRIP PATCH ANTENNA WITH NANOFERRITE MATERIAL

A MINOR PROJECT-I REPORT

Submitted by

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BONAFIDE CERTIFICATE

Certified that this project report “DESIGN AND DEVELOPMENT OF MICROSTRIP PATCH ANTENNA WITH NANOFERRITE MATERIAL” is the bonafide work of " M.MUTHULAKSHMI(927621BEC130), A.MONISHA(927621BEC129), G.NANDHINI (927621BEC131), S.NAVANEETHA(927621BEC134)”who carried out project work under my supervision in the academic year 2022-2023.

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This Minor project-I report has been submitted for the **18ECP103L – Minor Project-I**

Review held at M. Kumarasamy College of Engineering, Karur on _____

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Mission of the Institution

M1: Produce smart technocrats with empirical knowledge who can surmount the global challenges

M2: Create a diverse, fully engaged, learner-centric campus environment to provide quality education to the students

M3: Maintain mutually beneficial partnerships with our alumni, industry, and Professional associations

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Mission of the Department

M1: Attain the academic excellence through innovative teaching learning process, research areas & laboratories and Consultancy projects.

M2: Inculcate the students in problem solving and lifelong learning ability.

M3: Provide entrepreneurial skills and leadership qualities.

M4: Render the technical knowledge and skills of faculty members.

Program Educational Objectives (PEOs):

PEO1: Core Competence: Graduates will have a successful career in academia or industry associated with Electronics and Communication Engineering.

PEO2: Professionalism: Graduates will provide feasible solutions for the challenging problems through comprehensive research and innovation in the allied areas of Electronics and Communication Engineering.

PEO3: Lifelong Learning: Graduates will contribute to the social needs through lifelong learning, practicing professional ethics and leadership quality

Program Outcomes (POs):

PO 1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO 2: Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO 3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

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PO 6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues, and the consequent responsibilities relevant to the professional engineering practice.

PO 7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO 8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 9: Individual and teamwork: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO 11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO 12: Life-long learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs):

PSO1: Applying knowledge in various areas, like Electronics, Communications, Signal processing, VLSI, Embedded systems etc., in the design and implementation of Engineering application.

PSO2: Able to solve complex problems in Electronics and Communication Engineering with analytical and managerial skills either independently or in team using latest hardware and software tools to fulfil the industrial expectations

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Abstract	Matching with PO,PSO
keywords	PO1, PO3, PSO1,PSO2

ABSTRACT

Microstrip patch antenna is mostly used in modern communication devices over conventional antennas. In this study, novel flexible substrates based on $\text{CuDy}_{0.15}\text{Fe}_{1.85}\text{O}_4$ nanoferrite having an average grain size of 36 nm were prepared using the sonochemical synthesis technique for microstrip patch antenna applications. The synthesized ferrites materials were characterized with X-ray diffractions, scanning electron microscope, dielectric study and vibrating sample magnetometer. Dysprosium doped copper nano ferrite material used as a dielectric material with its dielectric constant = 4.87 which was observed from dielectric study for the prepared material. The rectangular microstrip patch antenna is designed using HFSS software. The designed antenna has a resonating frequency of 2.4 GHz which is applicable to wireless local area network(WLAN).

The studies were taken on the basis of the simulated design in HFSS simulation software. Using ferrite material, the patch size reduced to 37% compare to antenna printed on dielectric substrate. Comparing the values of return loss radiation power, gain, quality factor and VSWR for antenna on ferrite substrate which is better than the antenna on dielectric substrate but the bandwidth and directivity of antenna was much affected negatively. For this work we have synthesized the polycrystalline copper ferrite by the solid-state reaction technique (SSRT) and characterized their electric and magnetic properties.

KEYWORDS: Nanoferrites, HFSS, Microstrip patch antenna, Dielectric constant

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LIST OF ABBREVIATIONS

HFSS	- High Frequency Simulation Software
VSWR	- Voltage Standing Wave Ratio
GHz	- Gigahertz

1. INTRODUCTION

Antennas are key components of any wireless system. An antenna is a device that transmits and/or receives electromagnetic waves. Most antennas are resonant devices, which operate efficiently over a relatively narrow frequency band. An antenna must be tuned to the same frequency band that the radio system to which it is connected operates in, otherwise reception and/or transmission [1].

Over the past one decade, there is a rapid growth in development of wireless communication applications and the performance of all such wireless systems depends on the design of antennas. Antennas play a major role in such medical monitoring systems since they provide communication between sensor and external equipment. Due to many advantages microstrip antennas are preferred for majority of biomedical applications and it has become a rapidly growing area of research. Their potential applications are limitless, because of their light weight, compact size, and ease of manufacturing. However, the design of such antennas is quite challenging in terms of antenna size, impedance matching, low power requirements, and biocompatibility with the body's physiology [2].

The modern communication systems in civil sector, satellite communication, radar applications etc,.. require size reduction of antennas. Such communication system requires antennas with low weight, low cost, low profile, easy integration into microwave ICs without affecting their antenna parameters. Therefore size reduction or miniaturization has become a very important matter nowadays in the development of patch antennas. The necessary and sufficient characteristics of antennas are small physical size, wide bandwidth and high radiation efficiency [2].

2. LITERATURE REVIEW

A microstrip rectangular patch antenna fabricated on LiTiMg ferrite substrate is presented which has also been compared with same structure of antenna on dielectric. For this work we have synthesized the polycrystalline LiTiMg ferrite by the solid state reaction technique (SSRT) and characterized their electric and magnetic properties. The proposed materials offer tunable dielectric and magnetic properties with soft magnetic behaviours and easy to use where arbitrarily electromagnetic values are required. Moreover, these materials also can be played significant role in flexible microwave field as low cost flexible substrates for compact flexible antennas, metamaterials, absorbers, and sensors applications etc. The lower dielectric losses and magnetic losses for all compositions of ferrite material were useful for miniaturization of antenna. The patches of silver material were printed on fabricated substrates by using screen printing technique. The objective is to achieve matching impedances, low magnetic and dielectric losses ($\tan \delta_\mu$ and $\tan \delta_\epsilon$, respectively), and a relatively large miniaturization factor to reduce antenna size [1].

The ferrites with chemical formulae MgFe_2O_4 , $\text{Mg}_{0.6}\text{Cd}_{0.4}\text{Fe}_2\text{O}_4$ and $\text{Mg}_{0.2}\text{Cd}_{0.8}\text{Fe}_2\text{O}_4$ specified with Ferrite S1, S2 and S3 were prepared by the oxalate co-precipitation method using AR grade sulphates under microwave sintering technique. The single phase cubic spinel structure formation of all the ferrites was confirmed by XRD and FTIR techniques. The dielectric parameters such as permittivity (ϵ_r), dielectric loss tangent ($\tan \delta_\epsilon$), permeability (μ_r) and magnetic loss tangent ($\tan \delta_\mu$) were determined from parameters S11 and S21 by using material measurement software with VNA. The synthesized ferrites S1, S2 and S3 with determined dielectric parameters were used as substrate to design rectangular microstrip patch antenna by simulation using Ansoft Designer SV 2.2. The designed antennas were fabricated by using screen printing technique. The return loss (RL), 10dB % bandwidth and VSWR of these fabricated antennas were measured on vector network analyzer. The simulated and measured values of resonating frequency, return loss (RL), 10dB % bandwidth and VSWR were nearly matched with each other [2].

The magneto-dielectric Mg-Nd-Cd spinel ferrites with chemical formula $\text{Mg}_x\text{Cd}_{1-x}\text{Nd}_{0.03}\text{Fe}_{1.97}\text{O}_4$ ($x = 0, 0.2, 0.4, 0.6, 0.8$ and 1.0) was synthesized by oxalate co-precipitation method under microwave sintering. The electromagnetic input parameters of these ferrites required for design of antennas were investigated in the X-band range. The miniaturization factor found to be highest for composition $x = 0.4$. The lower dielectric losses and magnetic losses for all compositions of ferrite material were useful for miniaturization of antenna. The patches of silver material were printed on fabricated substrates by using screen printing technique. The performance of return loss, % bandwidth and VSWR indicates that Mg-Nd-Cd ferrite substrates with compositions $x = 0.2, 0.8$ will have a strength for application as substrates of MPA in X-band microwave communication [3].

In this study, novel flexible microwave substrates based on $\text{Co}_x\text{Zn}_{(0.90-x)}\text{Al}_{0.10}\text{Fe}_2\text{O}_4$ nano-powder having an average grain size of 20 nm to 26 nm were prepared using the sol-gel synthesis technique for microstrip patch antenna applications. At first there are three different molecular composition were chosen having the chemical formula of $\text{Co}_x\text{Zn}_{(0.90-x)}\text{Al}_{0.10}\text{Fe}_2\text{O}_4$ and specified as Co20, Co40 and Co60 for $x = 20\%$, $x = 40\%$ and $x = 60\%$ respectively. Then the synthesized ferrites materials were characterized with XRD, FESEM, and VSM analysis, and single-phase spinel with high crystallinity were revealed. Besides, the dielectric and magnetic properties of the proposed Co-Zn ferrites samples were investigated for the affirmations of microwave applications. The values of dielectric constant ϵ_r and loss tangent (T_d) are determined using dielectric assessment kit, and the obtained values are ranges from 3.5 to 4.5 for ϵ_r and 0.002 to 0.006 for T_d for Co20, Co40, and Co60 respectively. Also, the magnetic permeability μ_r and magnetic loss tangent (T_{dm}) values are determined to form the predetermined scattering parameters S_{11} and S_{21} obtained from rectangular substrate pellets and the obtained values of μ_r and T_{dm} are ranges from 0.90 to 1.00 and 0.003 to 0.007 respectively [4].

The effects of Cd^{2+} ions on the microstructure, magnetic properties, and dielectric properties of Bi_2O_3 -added MgFe_2O_4 ferrites ($\text{Cd}_x\text{Mg}_{1-x}\text{Fe}_2\text{O}_4$, $x=0.00, 0.15, 0.30$ and 0.45) are obtained by adopting the solid-state reaction method at a low temperature (910°C). The objective is to achieve matching impedances, low magnetic and dielectric losses ($\tan \delta_\mu$ and $\tan \delta_\epsilon$, respectively), and a relatively large miniaturization factor to reduce antenna size. Experimental results indicate that the cations occupying the tetrahedral (A) and octahedral (B) ion sites are redistributed, resulting in an enhanced super-exchange interaction between the two sublattices. As a result, improved magnetization, including the increase in saturation magnetization (41.74 emu/g) and decrease in coercivity (63.75 Oe), is realized. The real part of permeability (μ') also increases with increasing concentration of Cd^{2+} ions. When x is 0.15 , matching impedances with equivalent μ' and ϵ' values are obtained over a long frequency range ($1\text{--}150 \text{ MHz}$). Moreover, the formation of a dense microstructure guarantees that losses occur at low orders of magnitude ($\tan \delta_\mu \approx 10^{-2}$ and $\tan \delta_\epsilon \approx 10^{-3}$). Accordingly, these properties afford wide application perspectives for the proposed compounds in the high-frequency region, i.e., from high-frequency to very-high-frequency bands [5].

$\text{BaCo}_{1.3}\text{Ti}_{1.3}\text{Fe}_{9.4}\text{O}_{19}$ ferrite was synthesized by solid-state reaction route. Co and Ti ions were substituted for Fe cation to modify the anisotropy field of the ferrite. The effects of B_2O_3 and CuO sintering additives on the phase stability, sintering behavior at 900°C , microstructure development, magnetic and dielectric properties of the ferrite were investigated. The densification of the ferrite at 900°C was found to increase upon B_2O_3 and CuO addition. A permittivity of 19 and initial permeability of 11 was obtained in the ferrite containing 5 wt% B_2O_3 sintering additive. There was a nominal decrease in saturation magnetization of the ferrite with increasing sintering additive. An antenna based on the low temperature sintered ferrite substrate was designed. Antenna parameters such as resonance frequency, return loss, voltage standing wave ratio (VSWR), and bandwidth were simulated and reported [6].

3.METHODOLOGY

The methodology for design and development of microstrip patch antenna depends on various techniques used to simulate different parameters of the antenna. The proposed antenna was designed using Dysprosium copper ferrite substrate. The major performance parameters such as antenna gain, bandwidth and return loss were observed [2].

4.TOOLS USED

Software requirement: HFSS Software

Ansys HFSS is a 3D electromagnetic (EM) simulation software for designing and simulating high-frequency electronic products such as antennas, antenna arrays, RF or microwave components, high-speed interconnects, filters, connectors, IC packages and printed circuit boards [1].

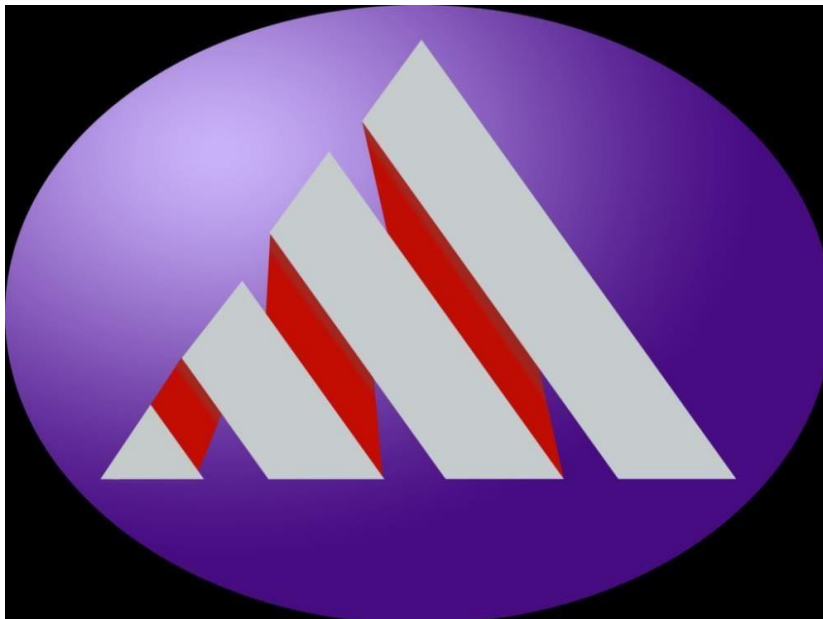


Fig.no.4.1 HFSS LOGO

Engineers use Ansys HFSS primarily to design and simulate high-speed, high-frequency electronics in radar systems, communication systems, satellites, ADAS, microchips, printed circuit boards, IoT products, and other digital devices and RF devices. The solver has also been used to simulate the electromagnetic behavior of objects such as automobiles. ANSYS HFSS allows system and circuit designers to simulate EM issues such as losses due to attenuation, coupling, radiation and reflection. The benefits of simulating a circuit's high frequency behavior with high accuracy on a computer reduces the final testing and verification effort of the system as well as mitigating the necessity of building costly multiple prototypes, saving both time and money in product development. HFSS captures and simulates objects in 3D, accounting for materials composition and shapes/geometries of each object. HFSS is one of several commercial tools used for antenna design, and the design of complex radio frequency electronic circuit elements including filters, transmission lines, and packaging [1].

HFSS software is little difficult to understand but once you design few basic filters or antennas, it will be easy for you to design further implementations. The HFSS integral equation (HFSS-IE) solver uses the method of moments (MoM) technique to solve for the sources or currents on the surfaces of conducting and dielectric objects in open regions. HFSS-IE is effective for radiation and scattering studies of large, mostly conducting structures [2].

5.EXPERIMENTAL TECHNIQUES

The structural parameters of rectangular microstrip antenna obtained on the basis of theoretical rectangular wave guide model which is one of the finest models for the explanation of the working for this type of antenna structures. With the theoretical calculation antenna has been simulated and optimized by EM Talk Microstrip Patch Antenna and Microstrip Line calculator [6].

Table:5.1 Design parameters of microstrip patch antenna

Height	1.6 mm
Dielectric constant	4.87
Dielectric loss tangent	6.21
Relative frequency	2.4 GHz

The design of antennas was explained in following steps. First step was to choose the operating frequency (f_r) at which the microstrip patch antenna to be designed. In present investigation, the proposed microstrip patch antenna was designed at operating frequency 2.4 GHz. The second step was selection of substrate material with required values of input design parameters such as permittivity (ϵ_r), dielectric loss tangent ($\tan\delta_e$), to miniaturize size of antenna with increased performance. The ground is used in telecommunication ,a ground plane is a flat or nearly horizontal surface that serves as part of an antenna ,to reflect the radio waves from the other antenna elements. The substrate properties such as its dielectric constant of material ,loss tangent have good effect on the antenna characteristics. The Patch antenna is mainly practical of microwave frequencies. It is widely used in portable wireless devices because of the ease of fabricating it on printed circuit board [7].

6.MATERIALS AND METHODS

Antennas can be designed with different substrates to achieve the desired performance. The substrates are chosen taking into consideration the ease of fabrication and its biocompatibility when compared to other semiconductors. The selection of height and dielectric constant of the substrate helps in achieving high directivity and better radiation efficiency. One among such antennas are nanoferrite based patched microstrip antennas which are used for applications at 2.4GHz. For performance, predictions and simplified analysis, a rectangular shaped microstrip patch antenna operating at 2.4GHz is proposed. The dimensions of the microstrip patch antenna were designed using the approximation equation below [1].

1.The Patch Width, W

$$W = c/2f_0\sqrt{(\epsilon_r+1)/2}$$

2.Effective Dielectric Constant, ϵ_{eff}

$$\epsilon_{eff} = \epsilon_r + 1/2 + (\epsilon_r - 1/2)[1 + 12 h/w]^{-1/2}$$

3.Effective Length, L_{eff}

$$L_{eff} = c/2f_0\sqrt{\epsilon_{eff}}$$

The patch of the antenna is electrically longer than the physical dimension due to fringing factor. This factor is subtracted from the effective length to give the actual length of the patch which is given by:

$$\Delta L = 0.412h(\epsilon_{eff}+0.3)(W/h+0.264)/(\epsilon_{eff}-0.258)(W/h+0.8)$$

4. Ground plane dimensions

$$W_g = 6h + W$$

$$L_g = 6h + L$$

Where W_g is the width of the ground plane in mm, L_g is the length of the ground plane in mm. In this project, inset fed antenna structure as a rectangular microstrip patch antenna is used. It shows proposed antenna structure and the names of its dimensions.

7.RESULTS AND DISCUSSION

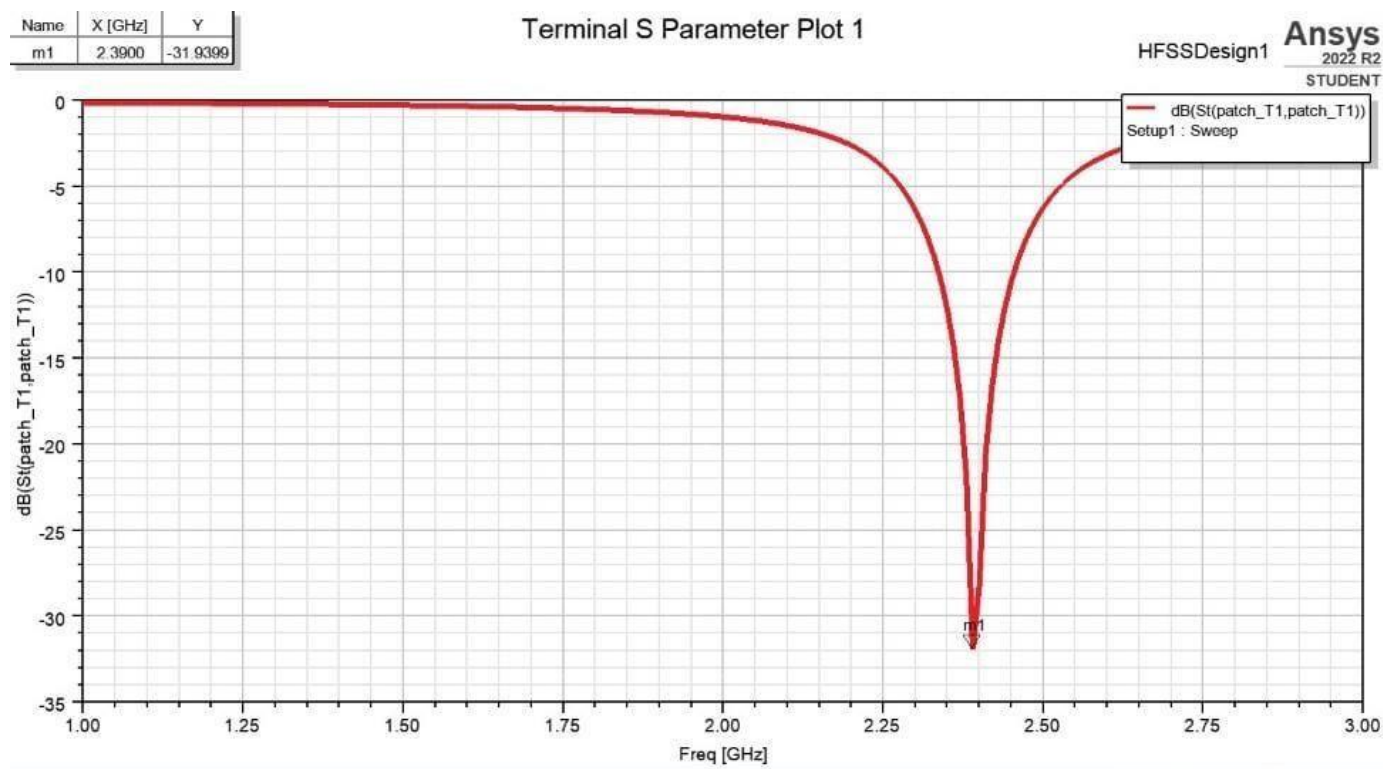


Fig.no.7.1 S Parameter of Dy doped copper nanoferrite

Fig no.7.1 shows that the S parameter of Dy doped copper nanoferrite which indicates that the parameter plot at exactly at 2.4GHz frequency. S parameter indicates the return loss value from 0 to 60 dB [3].

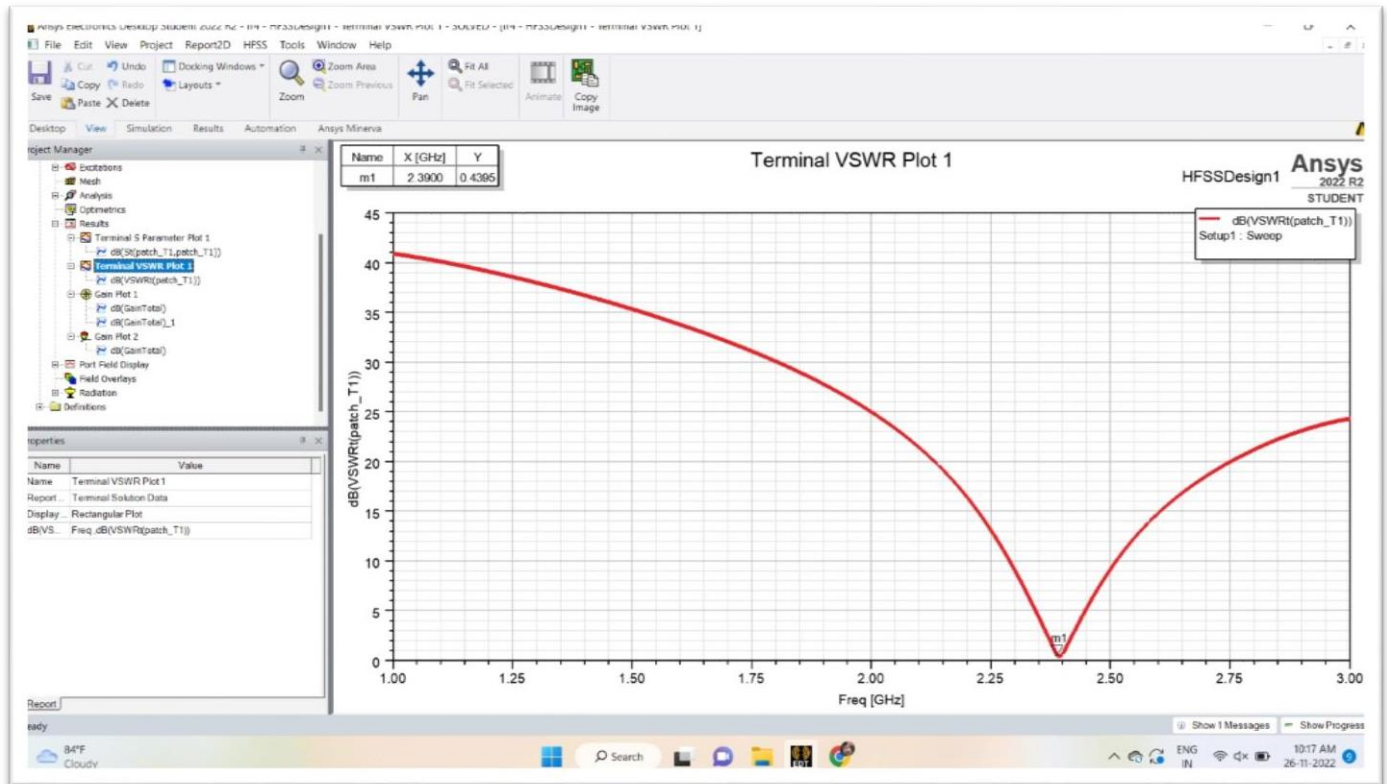


Fig.no.7.2 Terminal VSWR of Dy doped copper nanoferrite

VSWR is a measure of how efficiency ratio frequency power transmitted from a power source through a transmission line into a load [3].

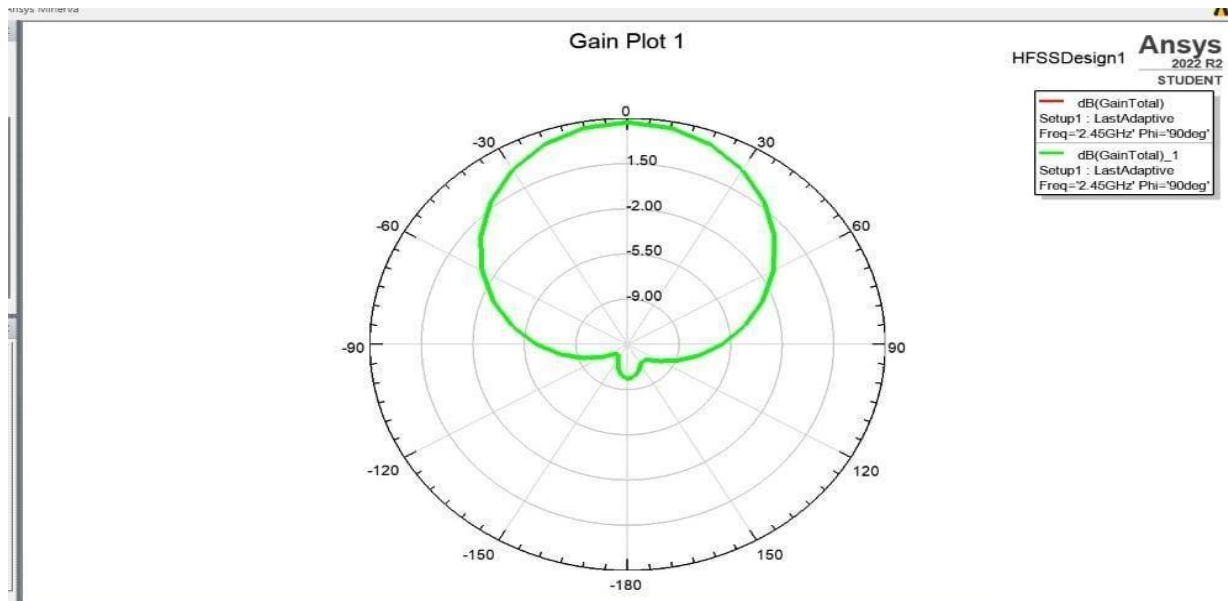


Fig.no:7.3 Radiation Gain pattern of Dy doped copper nanoferrite

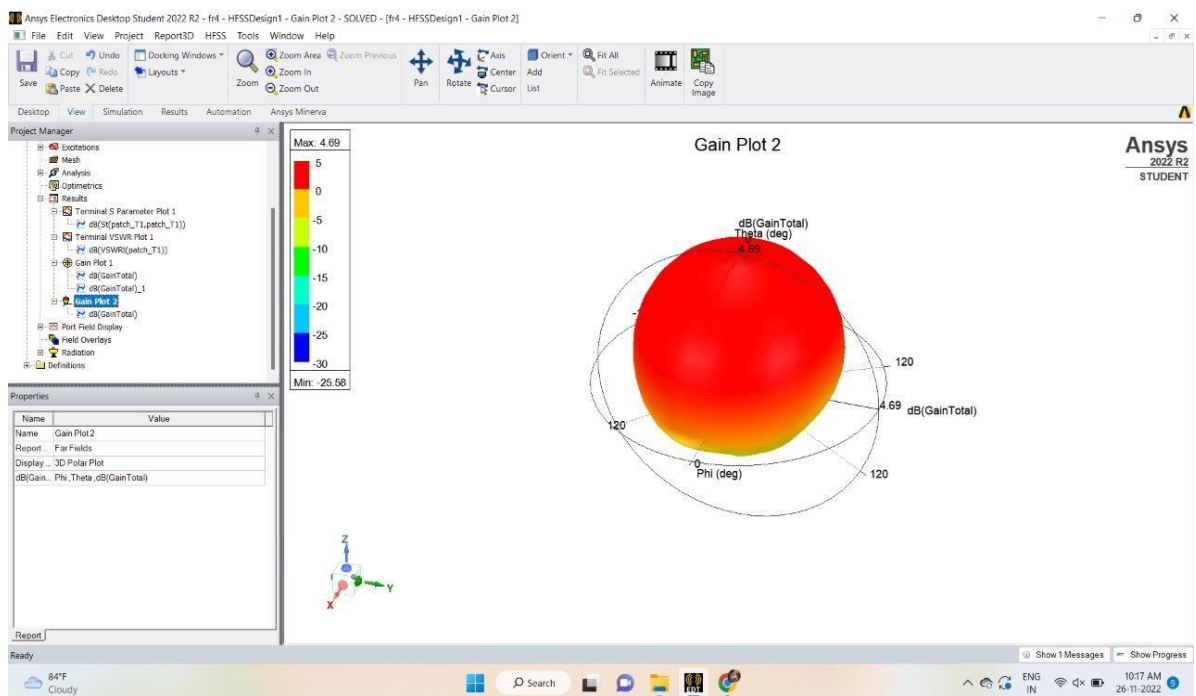


Fig.no.7.4 Polarisation Gain of Dy doped copper nanoferrite

Gain: The radiation pattern of an antenna gives us information about its receiving and transmitting properties in different directions. The radiation pattern of an antenna is one of its basic property [4].

8.CONCLUSION

From the above results we get antenna which is operating at 2.4 GHz frequency. In world 2.4 GHz frequency applications are connect devices for low bandwidth activities like browsing the internet model aircrafts, model boats and toys and many radio controlled drones. On the 2.4 GHz band, you can connect upto devices depending upon the bandwidth usage of the device. If the Bluetooth technology uses the 2.4 GHz ISM spectrum band. Many of cordless telephones and body monitors are used in USA and Canada use the 2.4 GHz frequency.

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**DESIGN AND DEVELOPMENT OF MICROSTRIP PATCH ANTENNA WITH
DYSPROSIUM DOPED COPPER NANO FERRITE MATERIAL**

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ABSTRACT

Microstrip patch antenna is mostly used in modern communication devices over conventional antennas. In this study, novel flexible substrates based on $\text{CuDy}_{0.15}\text{Fe}_{1.85}\text{O}_4$ nanoferrite having an average grain size of 36 nm were prepared using the sonochemical synthesis technique for microstrip patch antenna applications. The synthesized ferrites materials were characterized with X-ray diffractions, scanning electron microscope, dielectric study and vibrating sample magnetometer. Dysprosium doped copper nanoferrite material used as a dielectric material with its dielectric constant = 4.487 which was observed from dielectric study for the prepared material. The rectangular microstrip patch antenna is designed using HFSS software. The designed antenna has a resonating frequency of 2.4 GHz which is applicable to wireless local area network (WLAN).

Keywords: WLAN, X-ray, Antenna



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CERTIFICATE OF PARTICIPATION

This Certificate is awarded to Dr/Mr/Ms Manisha A of M. Kumarasamy College of Engineering for presenting a paper entitled Design And Development of Microstrip Patch Antenna with Dispersion Doped Copper Nano Ferrite Material in 2nd National Conference on Recent Innovations in Mechanical Engineering (RIME'2K22) Organized by the Department of Mechanical Engineering on 18th November 2022.

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Dharapuram Road, Avinashipalayam, Tirupur - 638 660.

Department of Mechanical Engineering

in technical association with



BARANI GROUP COMPANIES, COIMBATORE

CERTIFICATE OF PARTICIPATION

This Certificate is awarded to Dr /Mr /MsNavarhini S.....of
.....M. Kumarasamy.....College.....of.....Engineering.....for presenting a paper entitled
Design AND Development OF MICRORAP PATCH ANTENNA WITH DIAPHRAGM DOPED COPPER NANO FERRITE MATERIAL
in 2nd National Conference on Recent Innovations in Mechanical Engineering (RIME'2K22)
Organized by the Department of Mechanical Engineering on 18th November 2022.

Prof. S. Karthikeyan Prof. P. Rajkumar
Coordinators

Dr. R. J. Golden Renjith Nimal
Convenor

Dr. C. Rameshkumar
Principal



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