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Research Article

DESIGN OF INTER-DIGITAL E SHAPED ANTENNA FOR BIOMEDICAL APPLICATIONS

***N. Srividhya, I. Dhivyabharathi, A. Jerin, B. Sarathivijayalakshmi**
Department of Electronics & Communication Engineering,
St. Joseph's College of Engineering and Technology, Thanjavur
**Author for Correspondence: srividhyadharmarajan@gmail.com*

ABSTRACT
Wearable systems are a popular and appealing option in health care services because they provide patients with individualised solutions for disease prevention, diagnosis, and treatment. The key component in the wearable systems is the biomedical antennas, which must be portable, low-profile, low power operating, flexible, and have a low Specific Absorption Rate (SAR). In this paper, we propose a suitable Inter-Digital E shaped microstrip patch antenna for biomedical applications operating in the 2.4–2.5 GHz ISM band. The overall dimension of the antenna is $12x11x0.0635mm^3$.This inter digital E-shaped antenna provides a gain of 12.76 dB with low SAR. The magnitude of the return loss is found to be -17.517104dB. The performance of the antenna is analysed in a three layer tissue model using CST (Computer Simulation Technology) Microwave Studio.

Keywords: *Biomedical Antenna, Microstrip patch, SAR, ISM band, Return loss*

INTRODUCTION

Wearable microstrip antennas have become increasingly popular in recent years. The application of antenna technology in every aspect of communication has been steadily rising in recent years. Wireless Body Area Networks (WBAN), which comprise in-body communication, on-body communication, and off-body communication, employ wearable antenna. It is presently employed in a wide range of applications. The inter digital E-Shape antenna is used to monitor the human body, such as glucose monitoring, blood pressure monitoring, heart rate monitoring, temperature monitoring, and live position tracking, among other things. Wearable gadgets range from one-of-a-kind smart rings, buttons, bracelets, and necklaces to smart glasses and watches, as well as smart gloves, socks, and T-shirts, as well as various decorative clothing items or other ornaments, etc... It provides continuous health monitoring of an elderly person or patient without interfering with his daily activities, according to ShahidnM. Ali, Cheab Sovuthy et at (2020). The antenna is a critical component of the communication system for increasing the productivity of medical equipment. It wirelessly transmits the signal. The process of transmitting a physiological signal from one location to another is known as biomedical telemetry. As a result, EMF propagation through the human body has become a vital design of an on-body antenna is very challenging, due to numerous factors that must be considered at some point during the design of an on-body antenna. There are also requirements that must be met before an on-body antenna can be used (Samsul *et al.*, 2020). First and foremost, the antenna's performance near the human body must remain unaltered, and the radiation must be such that hyperlink loss is kept to a minimal. Because these antennas must function on the human body, they confront greater obstacles than standard antennas. The reliable functioning of the human body is one of the primary issues facing the adoption of the wearable antenna.

Wearable antenna, unlike standard antenna, are placed near human tissues under diverse deformation situations. These tissues have a highly dielectric structure, which affects antenna performance parameters like reflection coefficients (S_{11}), bandwidth, gain (dBi), and radiation characteristics. Furthermore, electromagnetic radiation from this antenna must have a Specific Absorption Rate (SAR) of over 10 g and over 1 g, as set by the European Union (EU). It features bands from the industrial, scientific, and medical fields (ISM). A high dielectric constant substrate was used, combined with geometrical and structural changes to the patch and ground plane, to achieve small authorization

The conducting material, which is smaller than the substrate and feeds with a microstrip line, serves as the ground plane on one of the sides. The directivity is unaffected by the thickness of the substrate. In addition, the antenna has a good gain, a wide bandwidth, and a high efficiency in body-worn settings. Furthermore, when installed on the human body, the antenna has a reasonable low SAR value. CST was used to imitate the intended antenna

Medical wearable devices use frequency bands 433.1-434.8 MHz, 868-868.6 MHz, 902.8-928 MHz, and 2400-2500 MHz Industrial, Scientific, and Medical band (ISM) and Medical Implant Communication Systems (MICS) 402-405 MHz, according to ITU-R Recommendation SA.1346.27. Deepak C. Karia, Siddhant Goswami (2019).

ANTENNA DESIGN

Figure 1 depicts the suggested two-bonded E-shape micro strip loaded with four E-shapes. The suggested antenna's overall dimensions are 12x11x0.0635mm3. The antenna has a radiation patch, full ground, and two substrate layers, the first of which comprises patch radiation and the four microstrip E-shape resonators, and the second of which is the superstrate layer. The antenna is fed by a coaxial wire and a shorting pin with diameters of 0.15 mm and 0.1 mm, respectively, and is standardised to 50 ohms. As a substrate and superstrate layer, employed a RO3010 with a dielectric permittivity constant (ϵ = 10.2) and the loss tangent (tan =0.0035) and 0.635 mm thickness. The suggested antenna has a resonance frequency of 2.5GHz. as shown as below fig .1.

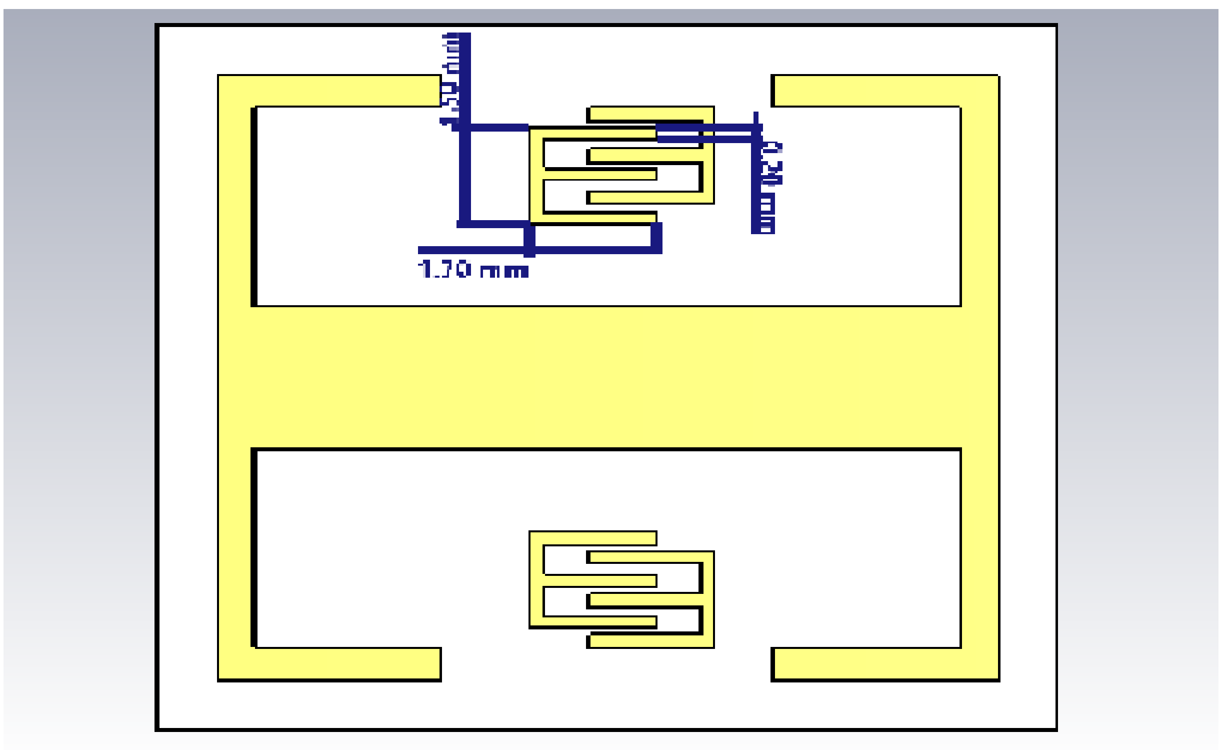


Fig.1.Inter digital E shaped Antenna

S- PARAMETER:

S_{11} (return loss) is the most widely stated and useable antenna characteristic. It represents how much power is reflected from the antenna and is thus known as the reflection coefficient (sometimes written as gamma: or return loss) Wenjing su1,2 ET AL(2020).S_{11} is always the same as the reflection coefficient, S_{11} below -10dB indicates that at least 90% of the input power is delivered to the device and reflected power is less than 10%, in this work the S_{11} value is -17.517104, as shown in fig.2.

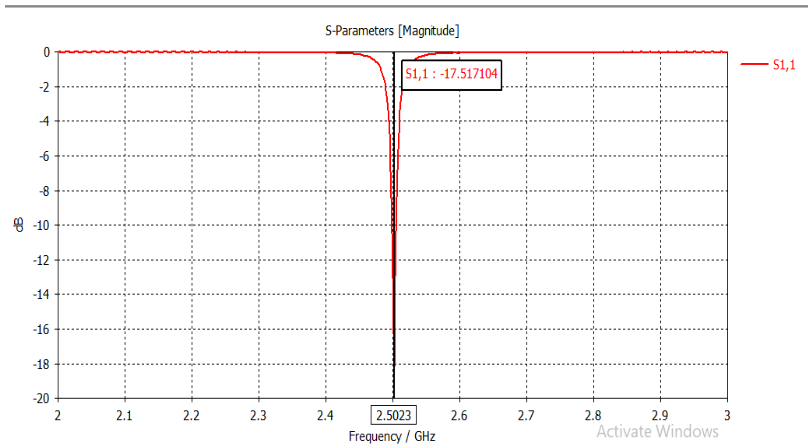


Fig.2.S_{11} parameter

VSWR:

The voltage standing wave ratio (VSWR) is a measurement of how well radio-frequency power is delivered from a power source to a load via a transmission line. In a perfect system, all of the energy is transported. The VSWR in this study is 1.310026, as seen in Fig.3.

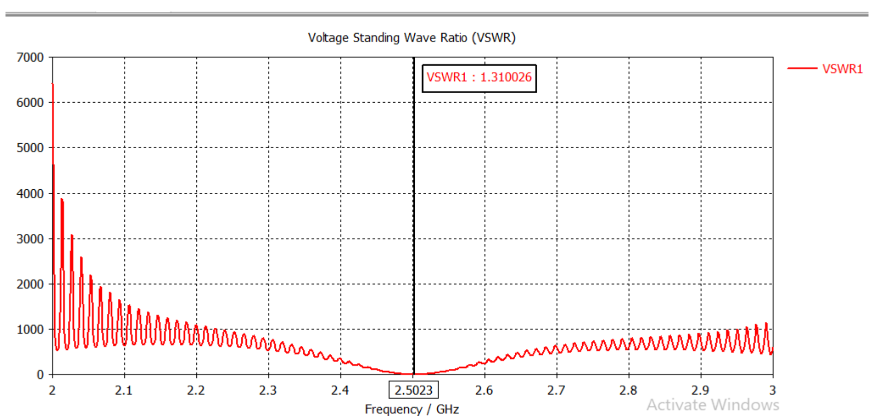
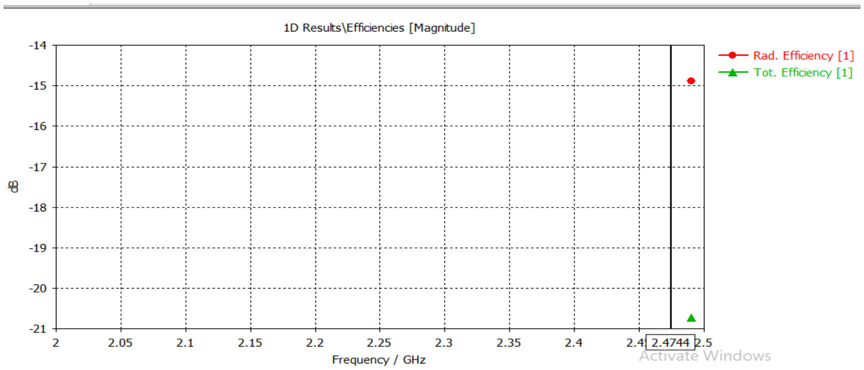


Fig.3.VSWR

RADIATION EFFICIENCIES:

An antenna's radiation efficiency is defined as the ratio of the power given to the antenna to the power radiated by the antenna. The majority of the power present at the antenna's input is radiated out in a high efficiency antenna. The majority of the power is absorbed as losses within the antenna or reflected away due to impedance mismatch in a low-efficiency antenna. The radiation efficiencies of the proposed antenna is 2.47 are shown in Fig.4 in this work.



FFig.4 Radiation Efficiencies

GAIN:

The term antenna gain refers to the amount of power transmitted from a peak source to an isotropic source in the direction of peak radiation. The term "antenna gain" is used more frequently than "directivity." A transmitting antenna with a 3dB gain receives 3dB more power than a lossless antenna with the same input power. With rising frequency, the overall radiation efficiency and maximal gain show an increasing trend. Nikolay Atanasov1,2 and Gabriela Atanasova*1 (2020)The proposed antenna gain is -12.76dB, Radiation efficiency-15.62dB.as seen in fig.5.

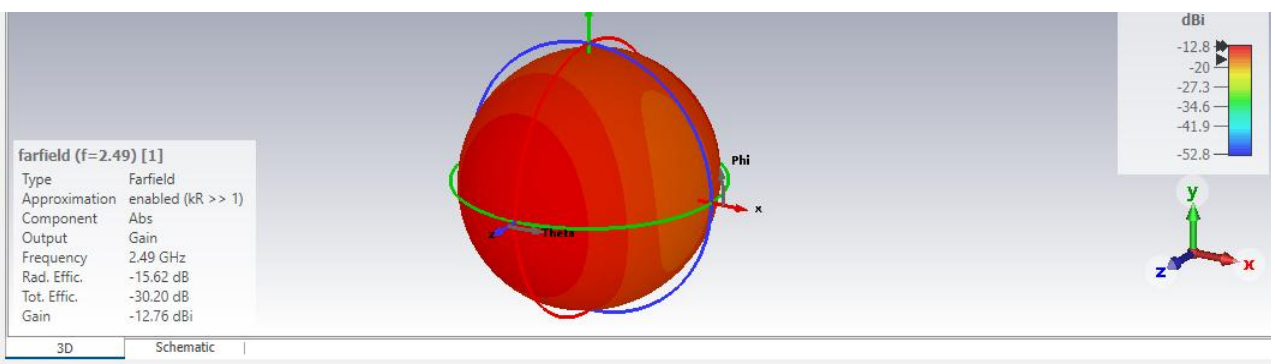


Fig.5. GAIN

RADIATION PATTERN :

The term radiation pattern (or antenna pattern or far-field pattern) refers to the directional (angular) dependence of the strength of radio waves from the antenna or other sources in the field of antenna design. An antenna radiation pattern, also known as an antenna pattern, is a mathematical or graphical representation of the antenna's radiation qualities as a function of coordinates. The radiation pattern is usually determined in the far field and represented as a function of the direction coordinates .The main lobe magnitude at 2.49GHz shows good agreement **Srividhya *et al.* (2021)** as seen in fig.6.

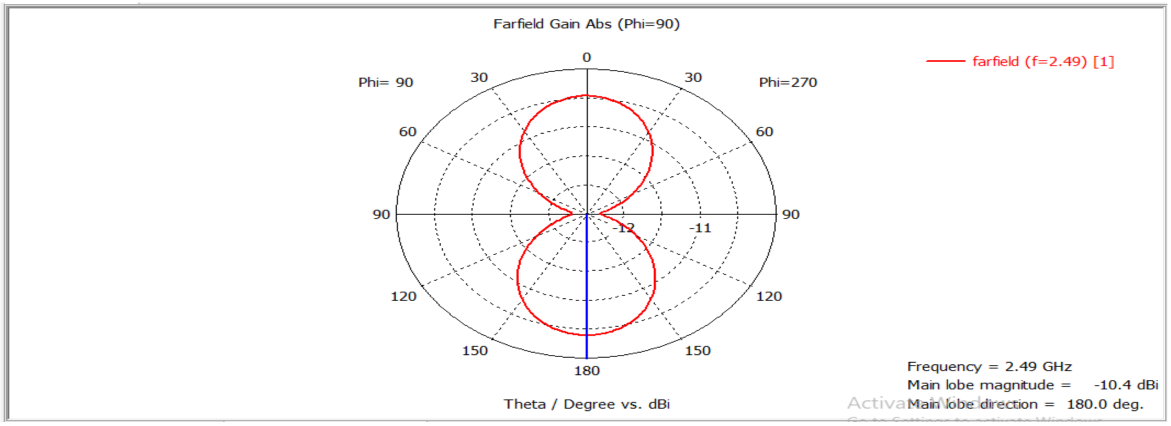


Fig.6. RADIATION PATTERN

SPECIFIC ABSORPTION RATE (SAR):

To determine the sensitivity of human tissues to electromagnetic energy using the specific absorption rate (SAR), the maximum permissible input power to the antenna must be specified. The IEEE C95.1:1999 SAR limit is 16.9 W/kg in a SAR 1-g average mass, but IEEE C95.1:2005 has been revised to 2 W/kg in a 10-g averaging mass SAR.

$$SAR = \frac{\sigma}{\rho} |E|$$

σ = conductivity of material
E = electric field
ρ = density
where E is the root mean square RMS of the induced electric field (V/m) and Kg/m3 is the tissue mass density as shown as below figure.7.

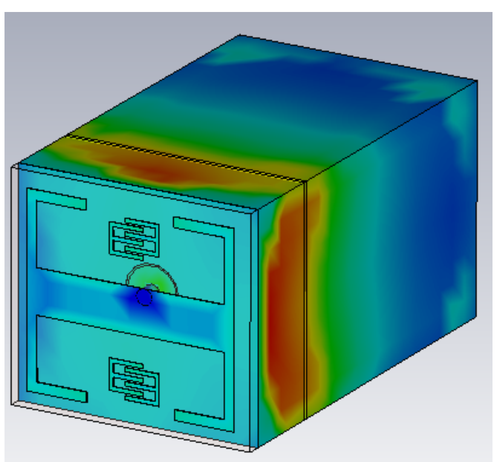


Fig.7. SAR

RESULTS AND DISCUSSIONS

The proposed interdigital E shape antenna parameters are listed in the table below. The gain, directivity, VSWR and SAR are well suited for the biomedical applications. The antenna simulates is performed well by using the CST software. The parameters and the results is shown as below table 1.

PARAMETERS	RESULTS
Antenna Frequency	2.5 GHZ
Substrate	Rogers RO 3010(lossy)
Height of substrate	1.27mm
Dielectric Constant	10.2
VWSR	1.310026
Return loss	-17.517104dB
Gain	-12.76 Db
Directivity	
SAR	1.7w/kg

Table 1

CONCLUSION

The proposed antenna is shown in this work with two alternative metamaterial resonators, one with four E-shapes resonators and the other with E-interdigital resonators. The antennas have an overall size of $12x11x0.0635mm^3$ that operates at 2.5 GHz. The simulation results are reasonable, and two stimulators are used to confirm them. Because of their lossy character, the gain value of the suggested antennas is reduced from open space to the human body. The SAR values stimulated by CST shows good agreement as permitted by IEEE C95.1: 1999.

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