JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Design of Wearable Textile Antenna for Medical Applications

[1]G. Sai Phaneesh, [2]G. Sree Vanitha, [3]A. Sirisha Reddy, [4]Ch. Chaitanya Krishna

[1]Student, [2]Student, [3]Student. [4]Student
Electronics and Communication Engineering,
R.V.R & J.C. College of Engineering, Guntur, India

Abstract- This paper is proposed to design and implement a wearable miniaturized textile antenna for Industrial, Scientific and Medical (ISM) band applications. The designed antenna is achieved by proper adding of rectangular strips to the inverted E-shaped antenna. The design is simple and compact. Denim fabric with dielectric constant (ε_r) of 1.7 is used as substrate material and the patch is fed by a 50Ω microstrip line. The antenna is analyzed by varying the patch dimensions and changing the substrate materials to achieve better resonant frequency and to observe the parameters like radiation pattern, reflection coefficient(S_{11}) and Gain of the antenna. The antenna is simulated using CST Microwave Studio.

Keywords - Miniaturized antenna, ISM band, Wearable textile antenna, Dielectric constant (ε_r).

I. INTRODUCTION

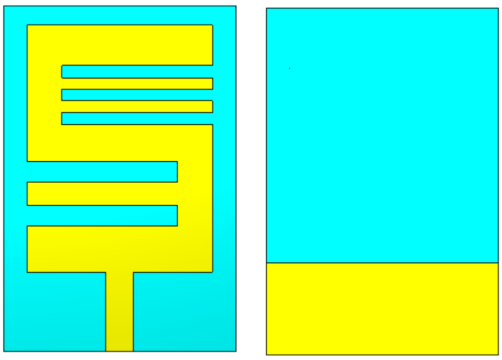
A wearable antenna is one that may be attached to a wireless communication device, such as a smartphone, wristwatch, or fitness tracker, and is made to be worn on the body. These antennas are typically lightweight and small in size. These are used in various applications such as medical devices, sports and smart clothing. They are also used in military and rescue operations. Smart clothing comes under textile antennas, these are embedded into textiles such as clothes, fabric, and other flexible materials. They can be used in a number of wearable devices since they are made to be both flexible and strong. Conductive fibers are frequently used to create textile antennas. Many wireless communication applications, including Bluetooth, Wi-Fi, and cellular connectivity, can be carried out using them. Compared to conventional wearable antennas, the usage of textile antennas has a number of benefits, including increased comfort and durability.

Wearable antenna miniaturization has been a challenging task in recent years. The use of high dielectric substrates, prolonging the current path of the radiator, capacitive loading, shorting pins/walls, inserting tails around the edge, and other methods have all been suggested to reduce the physical size of a patch. These methods result in smaller antennas that operate at lower frequencies, such as the ISM band.

II. DESIGN OF ANTENNA SYSTEM

A. ANTENNA DESIGN

The antenna design was based initially on inverted E-shape antenna with strips and it is designed to operate at 2.4GHz using CST Microwave Studio. Adding additional strip to the antenna [1] and by changing dimensions of the patch, the desired design is achieved. The designed shape of the antenna is shown in Figure-1. The width and length of the antenna are 20mm and



(a) (b)

Figure-1. Patch Antenna (a) Front View (b) Back view

30mm respectively and the ground plane is 8mm long. The conducting material SheildIT is implemented on 0.7mm thick Denim material with dielectric constant (ε_r) of 1.7. The Denim substrate is replaced with Polyester and Leather materials according to their thickness to optimise the performance of the antenna [2–5]. Table 1 gives an overview between them.

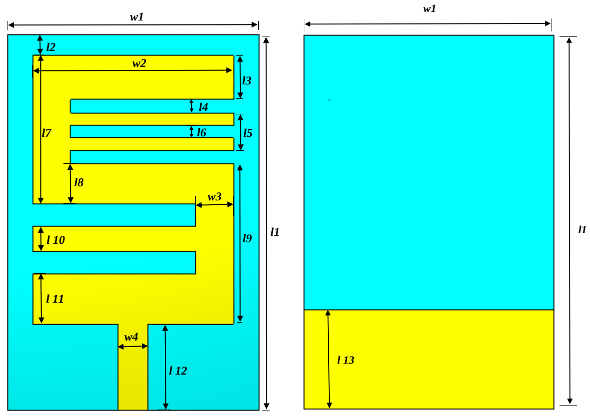
Table-1. Comparison between different substrates

Substrate	ε_r	Thickness(mm)	Band (GHz)	Bandwidth (MHz)	Frequency (GHz)
Denim	1.7	0.7	2.3 - 2.49	190	2.4
Polyester	1.90	0.4	2.35-2.48	130	2.42
Leather	1.8	1.39	2.21-2.4	190	2.3

According to Table 1, even though polyester and denim have a similar operating frequency, denim has a greater bandwidth than polyester. As a result, designing the antenna with denim is preferred.

B. Dimensions Of Antenna

The dimensional view of the antenna is shown in Figure-2 and the values of the parameters are mentioned in the Table-2. Adding additional slots increases current length in the patch that helps in reducing the resonant frequency to 2.4GHz.



(a) (b)

Figure-2. Dimensional view of Antenna (a) Front View (b) Back view

Table-2. Dimensions of the antenna

Parameters	Value (mm)	Parameters	Value (mm)
w1	20	l6	1
w2	16	l7	11.8
w3	3	l8	3.2
w4	2.4	l9	12.8
l1	30	l10	2
l2	1.7	l11	4
l3	3.5	l12	6.9
l4	1.05	l13	8
l5	3		

III. Antenna Performance

A. Return Loss

The designed antenna is simulated using CST Microwave studio. The simulated reflection coefficient of designed antenna is shown in Figure-3 and the antenna operates at 2.4GHz. Also, the S11 value achieved in this design is better than [1], it has a return loss of -63.68dB.

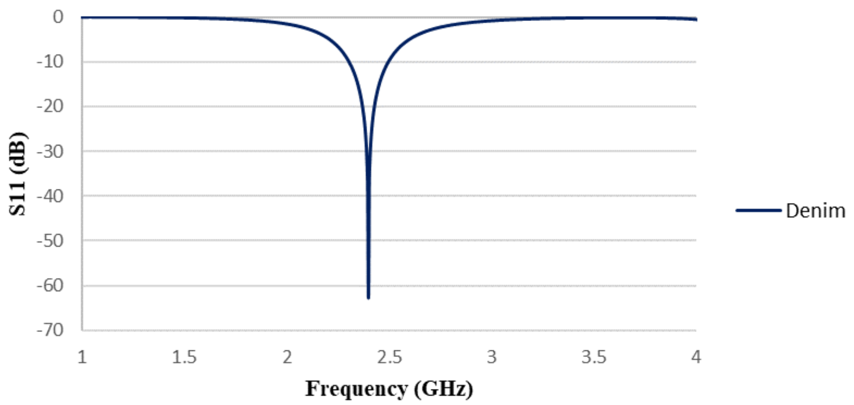


Figure-3. Return loss of designed antenna

VSWR (Voltage Standing Wave Ratio) it is the measure of the efficiency of an antenna. In this design the VSWR achieved is 1.0013 which is close to unity. The bandwidth of the antenna (S11<-10dB) is 190MHz and band from 2.3GHz to 2.49GHz.

B. Surface Current Distribution

As additional strips are added at upper slot, they provide more current deviations at the upper slots, increasing the current length and the surface current distribution of the antenna at 2.4 GHz, as shown in Figure-4.

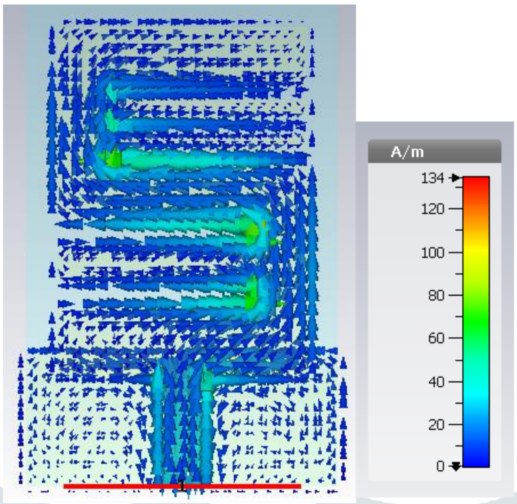
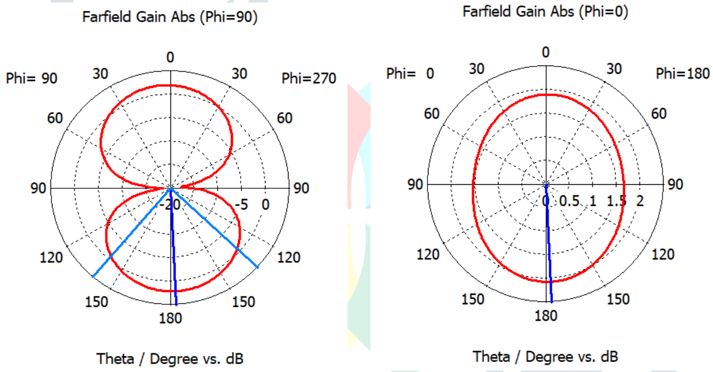


Figure-4. Surface current distribution of antenna

C. Radiation Pattern

The far-field radiation pattern of antenna in the E-plane and H-plane is shown in Figure-5. Moreover, a bidirectional radiation pattern in the E-plane and an omnidirectional radiation pattern in the H-plane are achieved. The gain and directivity of the antenna design are 2.086dB and 2.176dBi, respectively.



(a) (b)

Figure-5. Simulated radiation pattern of the designed antenna (a) E-plane (b) H-plane

D. SAR Analysis

SAR- Specific Absorption Rate, it is a measure of the rate of Radio Frequency energy absorption by the body from the source being measured. A multi-layered human body is being developed. It is a combination of four layers: skin, fat, muscle, and bone. Table-3 lists the thickness, permittivity, conductivity, and density values.

Table-3 Multi-layer Human body [5]

Layer	Thickness(mm)	ε_r	Conductivity (S/m)	Density (Kg/m^3)
Skin	2	37.95	1.49	1001
Fat	5	5.27	0.11	900
Muscle	20	52.67	1.77	1006
Bone	13	18.49	0.82	1008

The CST Microwave Studio's IEEE C95.1 standard is the base for the SAR calculations. The SAR must not exceed 2 W/kg averaged over 10 g and must not exceed 1.6 W/kg averaged over 1 g of human tissues, according to the FCC and CNIRP guidelines. The SAR for the designed antenna is 0.185 W/Kg for 10g of tissue and 0.515 W/Kg for 1g.

IV. Conclusion

A miniaturized antenna is designed for ISM applications at 2.4GHz. The efficiency of the developed antenna is 95.86%, and its gain is 2.08 dB. The designed antenna's compact size, good radiation performance, and bandwidth makes it as a good choice for ISM applications. By integrating antennas into clothing and textiles, we can create new possibiities for communication and data exchange. By integrating antennas into clothing and textiles, we can create new possibiities for communication and data exchange. Although textile antennas are still in their development, we may expect more applications in the future with further research and development.

V. References

[1] Adel Y. I. Ashyap, Zuhairiah Zainal bidinsamsul, Haimi Dahlan, Huda A. Majid, Waddah A. M. A, Muhammad Ramlee Kamarudin, George Adeyinka Oguntala, Raed A. Abd-Alhameed and James M. Noras, "*Inverted E-Shaped Wearable Textile Antenna for Medical Applications", IEEAccess* 10.1109/ACCESS.2018.2847280

[2] Bahaa Almohammed , Alyani Ismail and Aduwati Sali, "*Electro-textile wearable antennas in wireless body area networks: materials, antenna design, manufacturing techniques, and human body consideration*", Textile Research Journal, July 2020, DOI: 10.1177/0040517520932230

[3] Ifrat Ahmed, Musfiqur Rahman, "*Design and optimization of a textile antenna for wearable communication*", Researchgate 320584254

[4] Seema Dhupkariya, Vinod Kumar Singh, Arun Shukla, "*A Review of Textile Materials for Wearable Antenna*", ISSN: 2349-900, Volume 1, Issue 3

[5] A. Y. I. Ashyap et al., ''*Compact and low-profile textile EBG-based antenna for wearable medical applications*,'' IEEE Antennas Wireless Propag. Lett., vol. 16, pp. 2550–2553, 2017.