Australian Journal of Basic and Applied Sciences, 9(2) February 2015, Pages: 260-268

AENSI Journals

Australian Journal of Basic and Applied Sciences

ISSN:1991-8178

Journal home page: www.ajbasweb.com

Performance Evaluation of Dual Band E - Shaped Microstrip Patch Antenna on Different Textiles for Wearable Applications in L & S Bands

[1]Jharesh, A., [2]P. Poorna Priya, [1]Daya Murali, S., [1]Hariharnath, P., [1]Naga Sai, K.P.V.

[1]*B. Tech Scholars, DST-FIST Sponsored ECE Department, KL University, Guntur, A.P, India*
[2]*Assistant Professor, DST-FIST Sponsored ECE Department, KL University, Guntur, A.P, India*

ARTICLE INFO

Article history:
Received 25 October 2014
Received in revised form
26 November 2014
Accepted 29 December 2014
Available online 15 January 2015

Keywords:
Textiles, Microstrip Patch, Return loss, Gain, SAR

ABSTRACT

Microstrip antennas play a significant role in Space, Defence, and Medical Applications. Here we have designed an E- Shaped Microstrip Patch Antenna on different textiles & tabulated the performance characteristics to select the best textile for wearable applications. The proposed Microstrip antenna with coaxial feed resonates at L & S band frequencies and is modelled using a software HFSS.

To Cite This Article: Jharesh, A., P. Poorna Priya, Daya Murali, S., Hariharnath, P., Naga Sai, K.P.V.., Performance Evaluation of Dual Band E - Shaped Microstrip Patch Antenna on Different Textiles for Wearable Applications in L & S Bands. ***Aust. J. Basic & Appl. Sci.,*** *9(2): 260-268, 2015*

INTRODUCTION

As the health conditions of the ever increasing population are deteriorating nowadays, the need for a health care system, which can remotely monitors the health condition of the patients is necessary. To support this need, wearable antennas have evolved. Wearable antennas are used in other applications such as Space, Athletics and Military for monitoring purpose. Light weight, low profile & no maintenance are the major benefits of wearable antennas (Rais, N.H.M., 2009). These antennas integrate fabric & the communication system in between Patient & the medical practitioner (Daya Murali, S.,). Wearable antenna has three layers in its structure namely patch, substrate and ground plane (Balanis, C.A., 1997). Wearable Antennas have narrow bandwidth and are sensitive to environmental conditions like humidity & temperature. For thin patches, the conductor & dielectric losses are higher, which in turn degrades the antenna efficiency (Randy Bancroft, 2006).

Microstrip antennas are planar and are manufactured on Printed Circuit Boards which has made them practical and less difficult to fabricate (Rais, N.H.M., 2009). Microstrip patch antenna with textile substrate is called as Wearable antenna. Wearable antennas are fabricated on various textiles or garments which are worn by the patients. These antennas are useful when the patient has to be regularly monitored by medical practitioners remotely. Because of being hidden and maintaining a low profile of wearable antenna it is convenient for the patient to wear the textile antenna (Rita Salvado, 2012). The patch we have used here is E-shaped Rectangular type in order to achieve circular polarization (www.ansoft-maxwell.narod.ru/en/CompleteMaxwell 2D_V15.pdf.) (https://www.nevaelectromagnetics.com/SurfaceHumanBodyMeshes.html.). Typically, the values of relative permittivity of patch antenna substrates are in between $2.2 \leq \varepsilon r \leq 12$ (Balanis, C.A., 1997).

Conductive textiles like Zelt, Flectron fabrics are generally used as the radiating element (Rais, N.H.M., 2009). The various textiles that we have chosen for substrates are Polycotton, Jean-Cotton, Nylon, Wash-Cotton, Curtain-Cotton, Polyester, Wool and Silk which are non-conductive. Textiles are porous, compressible and anisotropic whose density and thickness varies with lowering pressures. The electromagnetic properties of the fabric antennas are varied with the change in temperature and surrounding conditions (LAPC, 2009).

The ground plane of the wearable antenna is for protecting the body tissues from the radiation effects and for mechanical strength & support (Randy Bancroft, 2006). Although there are various other feeding techniques, in this paper co-axial feeding is used for energizing the wearable antenna because of its minimal spurious radiations, ease of fabrication and ease to match (Sankaralingam, S. and B. Gupta, 2010).

Corresponding Author: Daya Murali, S., B. Tech Scholars, DST-FIST Sponsored ECE Department, KL University, Guntur, A.P, India.
E-mai: murali.singamsetti@gmail.com

Specific Absorption Rate (SAR):

One of the major parameter to look after while designing these types of microstrip patch antennas is SAR. The standard SAR value according to FCC is 1.6 W/Kg whereas according to the European standard it is 2 W/Kg. So it should be as minimum as possible; otherwise it will affect the human body severely. The SAR Penetration will be less for thicker skin layer.

Return Loss:

Return loss defines the loss of signal power resulting from the back reflection occurs at discontinuities in optical fibre or a transmission line. These discontinuities may be either a mismatch with the load that is terminated or a device inserted in the Transmission line. Generally it is expressed in decibels (dB). Two lines or devices are said to be well matched if the return loss is more. An antenna is said to be perfectly matched if the return loss is of about 10dB.

Gain:

The operational disadvantage with these microstrip patch antennas is low gain. So it is proper to select the high gain antenna for any application. The antenna pattern describes the relative strength of the radiated field in multiple directions from the antenna.

Directivity:

It refers to the direction of the signal radiation. The directivity should be high in forward direction than backward direction for these wearable applications. The most important parameter which determines the directivity of a microstrip patch antenna is εr of the substrate. Since the directivity of the microstrip antenna totally depends on the dielectric constant but not on the ground plane, as dielectric value increases the directivity also increases.

High Frequency Structure Simulator is an Application Software for Electromagnetic (EM) structures which uses Finite Element Method (FEM). For electrical network design, the software has a linear circuit simulator along with integrated optimetrics. HFSS includes a powerful and automated solution process; hence we need to specify geometry, desired output and material properties. Using specified parameters, HFSS generates an efficient, appropriate, and accurate mesh analysis for the specified geometry (Sergio Curto, 2009).

Design Procedure:

The Proposed E- Shaped Microstrip Patch Antenna was designed in HFSS as shown in Figure 2 and specifications are mentioned in the Table 1.

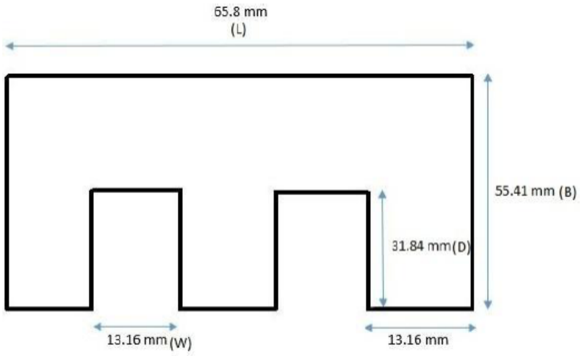

Fig. 1: Schematic of E-Microstrip Patch.

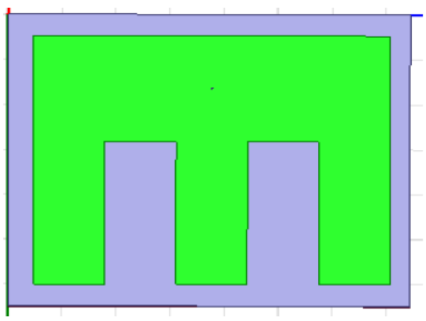

Fig. 2: E-Microstrip Patch in HFSS.

Table 1: Design Specifications for the Proposed Antenna.

Specification	Measurement
Length of Patch	65.80 mm
Width of Patch	55.41 mm
Length of Substrate	74.40 mm
Width of Substrate	65.01 mm
Height of Substrate	1.60 mm
Feed Inner & Outer radius	0.13,0.47 mm
Feed Position	16.446,37.7,0
D	31.84 mm
W	13.16 mm

The proposed E-Shaped Microstrip Patch Antenna was mounted on the Human Body as shown in the Fig 3& 4.

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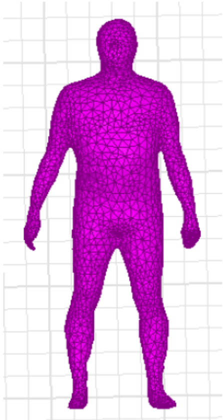

Fig. 3: Human Body Structure.

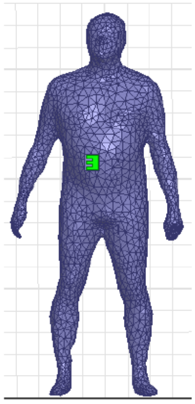

Fig. 4: Proposed Antenna Mounted on Human Body.

Results:

Table 2: Comparison of various antenna Parameters with different textile substrates.

Textile Material	Relative permittivity (εr)	Return Loss (dB)	Gain	Directivity	E-field (V/m)	H-field (A/m)
Wash cotton	1.45	-26.4325	1.6821	1.8838	1.3616e+002	3.2363e+001
Curtain cloth	1.47	-26.5275	1.7310	1.8976	1.8387e+002	3.1942e+001
Poly cotton	1.50	-29.1603	1.8142	1.9159	1.5377e+002	2.4737e+001
Jean cotton	1.59	-41.6028	1.6649	1.7716	1.1691e+002	3.1284e+001
Nylon	4	-15.7895	0.5107	0.5229	2.2203e+002	2.5805e+001
Polyester	3.2	-41.0866	0.4861	0.5475	4.0465e+002	2.1703e+001
Wool	1.865	-26.1334	1.2523	1.3273	1.4298e+002	2.1243e+001
Silk	2.4	-20.8589	0.6622	0.7143	2.5849e+002	3.2301e+001

Return Loss:

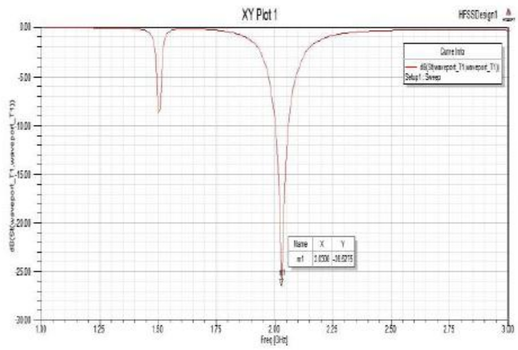

Fig. 5(a): Return loss with Curtain as Substrate.

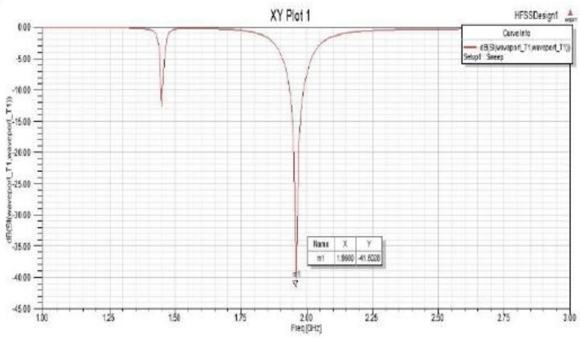

Fig. 5(b): Return loss with Jean Cotton as Substrate.

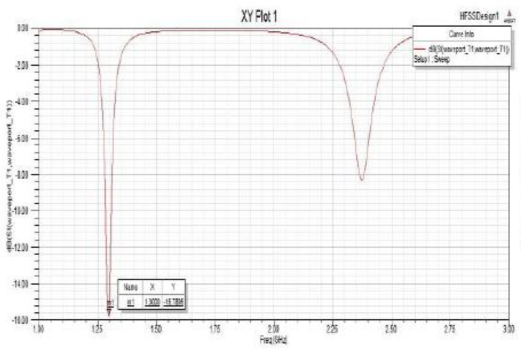

Fig. 5(c): Return loss with Nylon as Substrate.

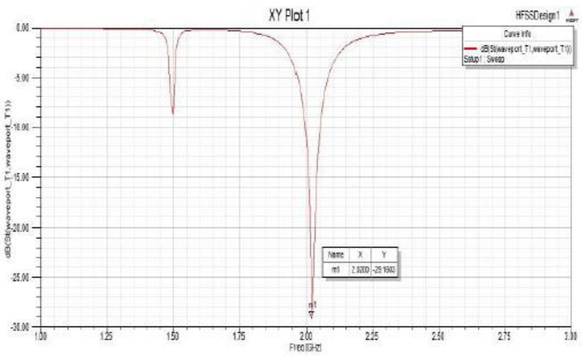

Fig. 5(d): Return loss with Poly Cotton as Substrate.

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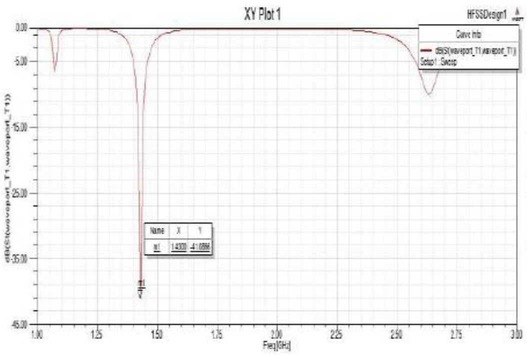

Fig. 5(e): Return loss with Polyester as Substrate.

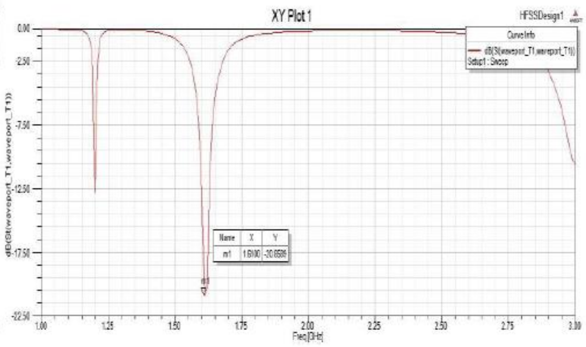

Fig. 5(f): Return loss with Silk as Substrate.

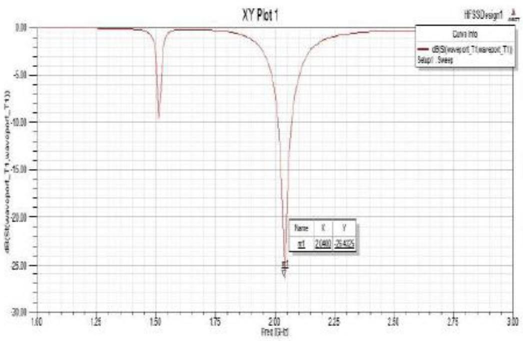

Fig. 5(g): Return loss with Wash Cotton as Substrate.

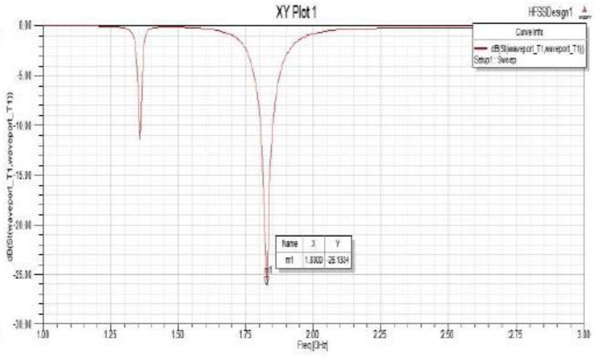

Fig. 5(h): Return loss with Wool as Substrate.

Gain:

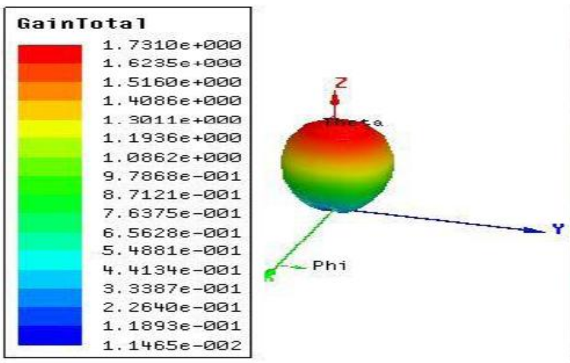

Fig. 6(a): Gain with Curtain as Substrate.

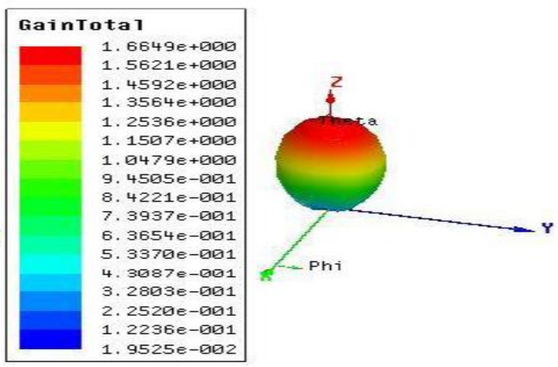

Fig. 6(b): Gain with Jean Cotton as Substrate.

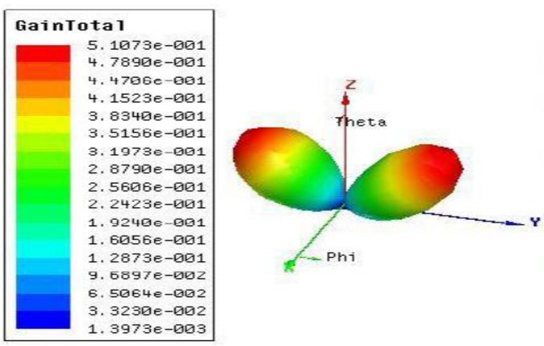

Fig. 6(c): Gain with Nylon as Substrate.

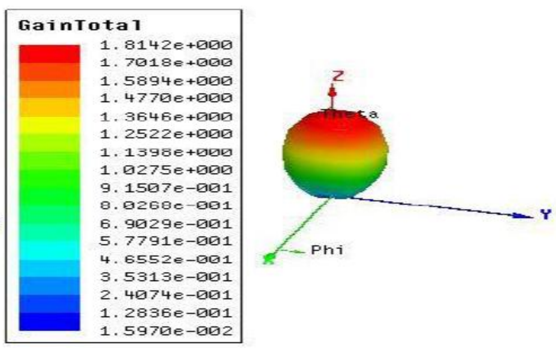

Fig. 6(d): Gain with Poly Cotton as Substrate.

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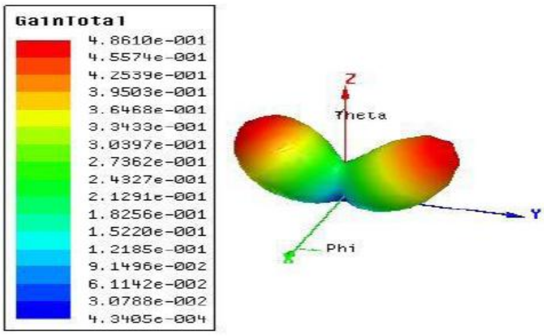

Fig. 6(e): Gain with Polyester as Substrate.

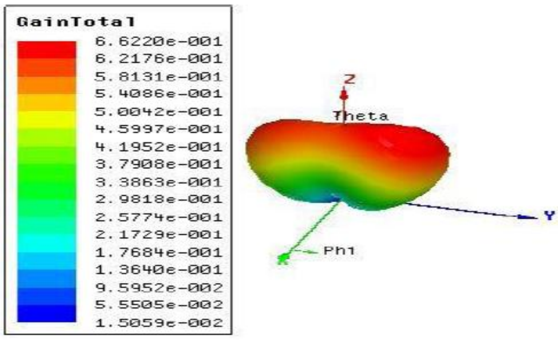

Fig. 6(f): Gain with Silk as Substrate.

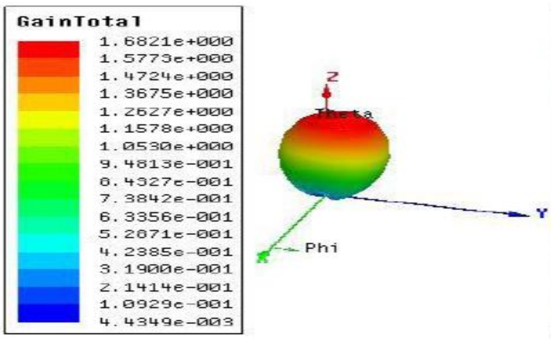

Fig. 6(g): Gain with Wash Cotton as Substrate.

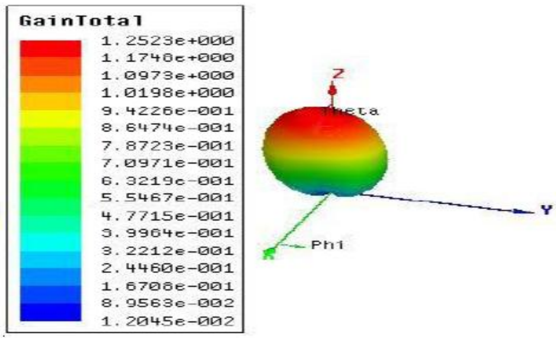

Fig. 6(h): Gain with Wool as Substrate.

Directivity:

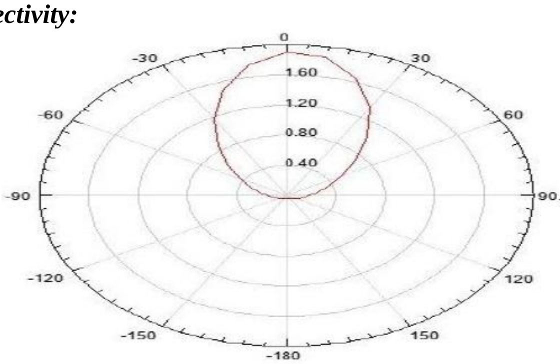

Fig. 7(a): Directivity with Curtain as Substrate.

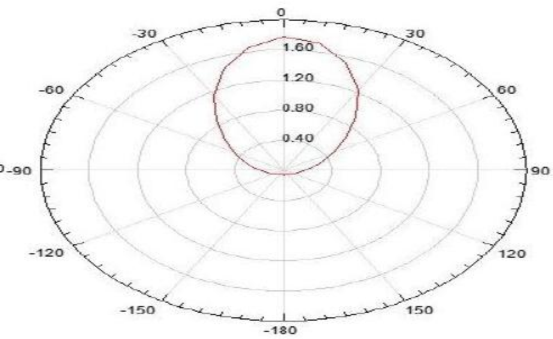

Fig. 7(b): Directivity with Jean Cotton as Substrate.

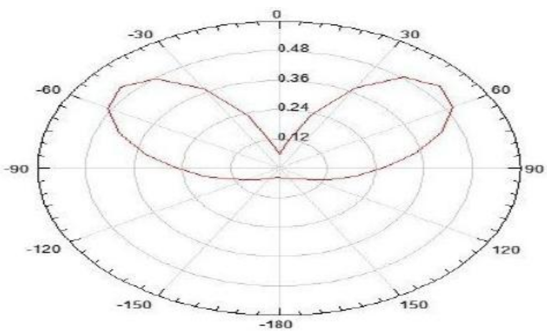

Fig. 7(c): Directivity with Nylon as Substrate.

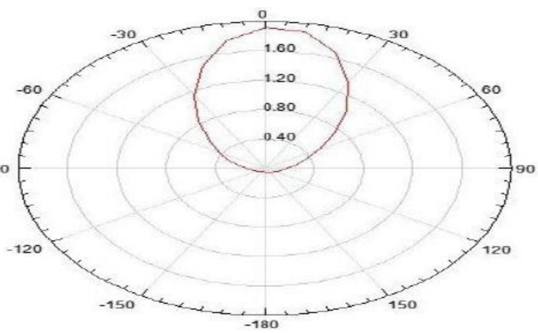

Fig. 7(d): Directivity with Poly Cotton as Substrate.

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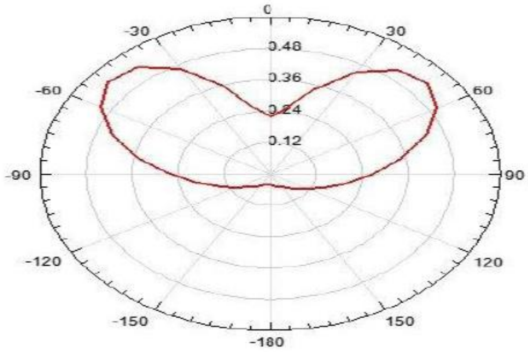

Fig. 7(e): Directivity with Polyester as Substrate.

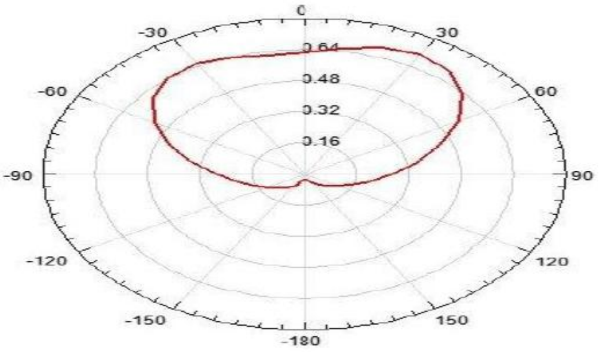

Fig. 7(f): Directivity with Silk as Substrate.

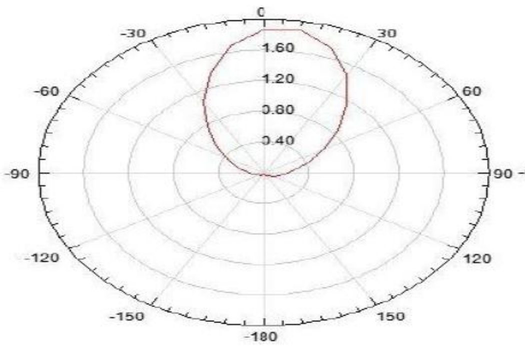

Fig. 7(g): Directivity with Wash Cotton as Substrate.

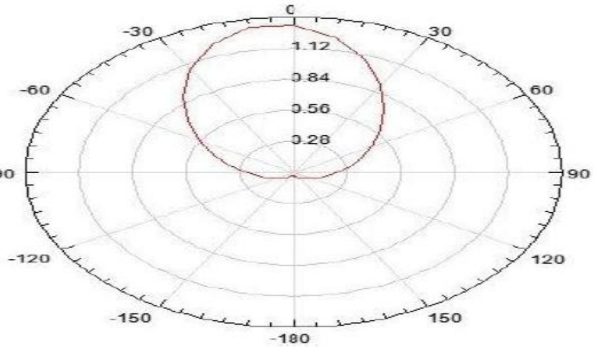

Fig. 7(h): Directivity with Wool as Substrate.

E-Field Distributions:

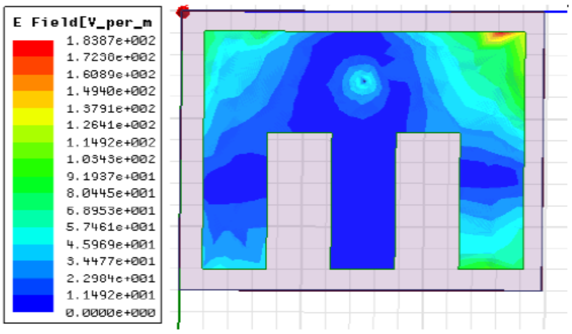

Fig. 8(a): E-field with Curtain as Substrate.

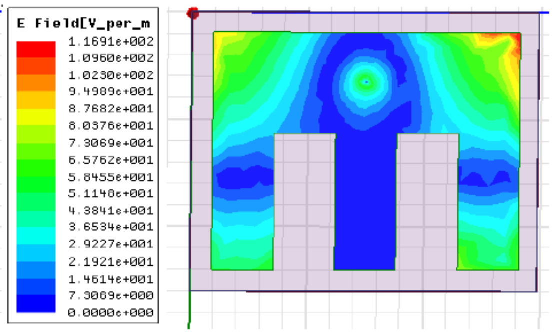

Fig. 8(b): E-field with Jean Cotton as Substrate.

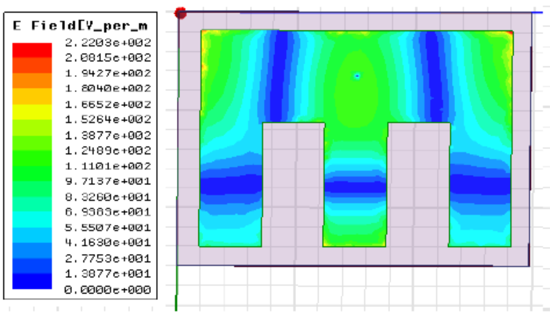

Fig. 8(c): E-field with Nylon as Substrate.

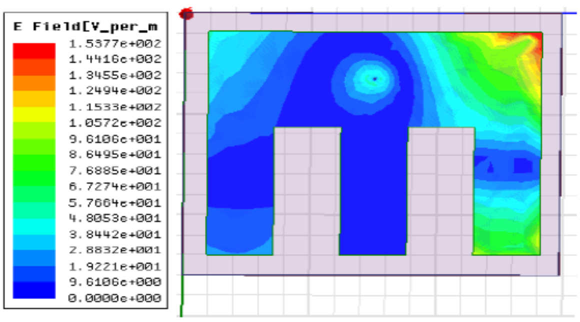

Fig. 8(d): E-field with Poly Cotton as Substrate.

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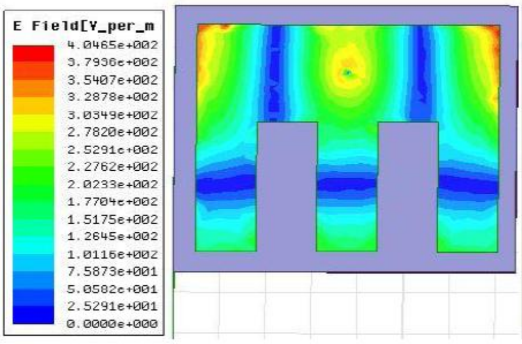

Fig. 8(e): E-field with Polyester as Substrate.

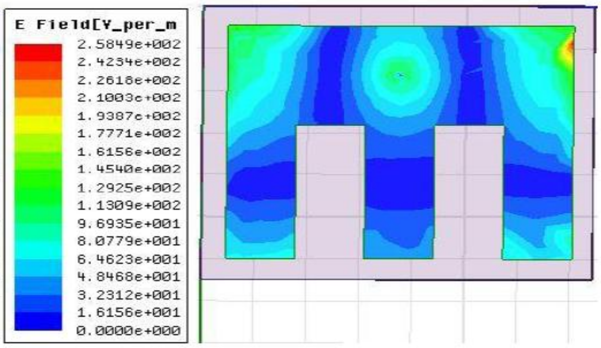

Fig. 8(f): E-field with Silk as Substrate.

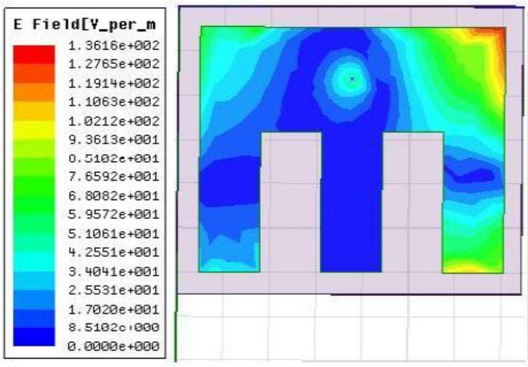

Fig. 8(g): E-field with Wash Cotton as Substrate.

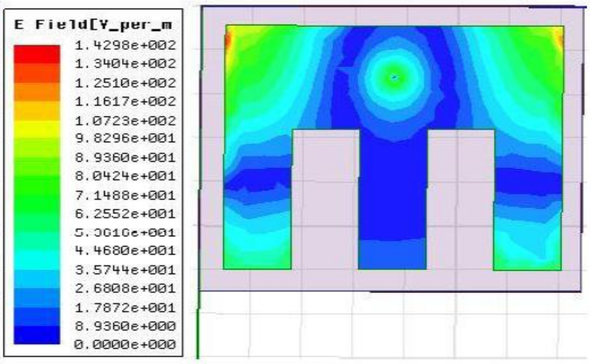

Fig. 8(h): E-field with Wool as Substrate.

H-Field Distributions:

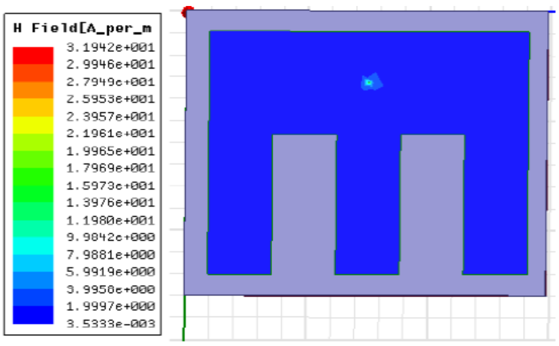

Fig. 9(a): H-field with Curtain as Substrate.

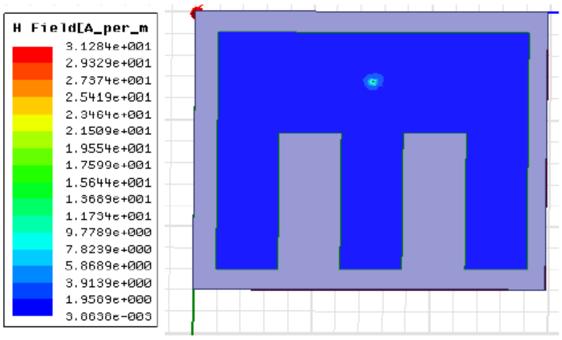

Fig. 9(b): H-field with Jean Cotton as Substrate.

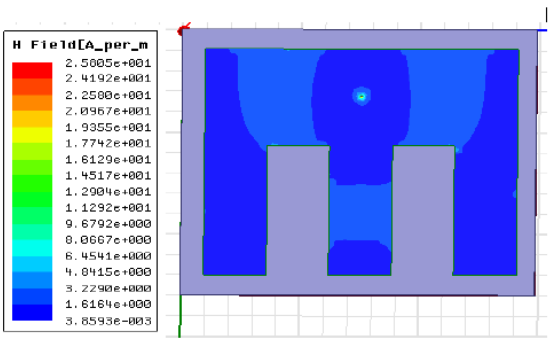

Fig. 9(c): H-field with Nylon as Substrate.

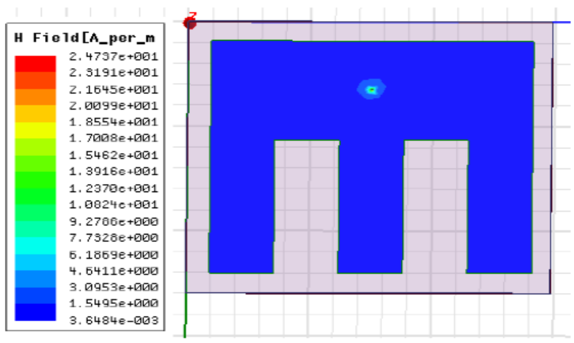

Fig. 9(d): H-field with Poly Cotton as Substrate.

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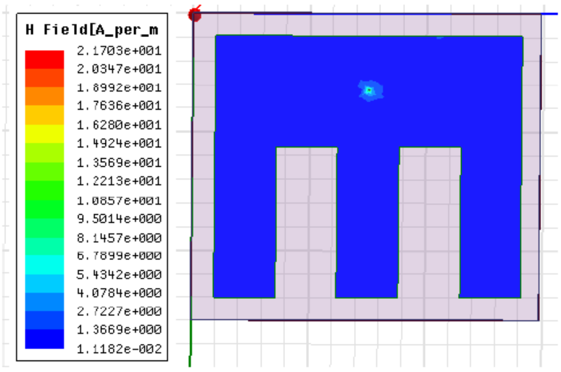

Fig. 9(e): H-field with Polyester as Substrate.

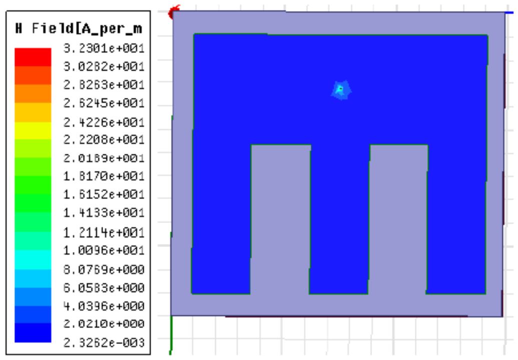

Fig. 9(f): H-field with Silk as Substrate.

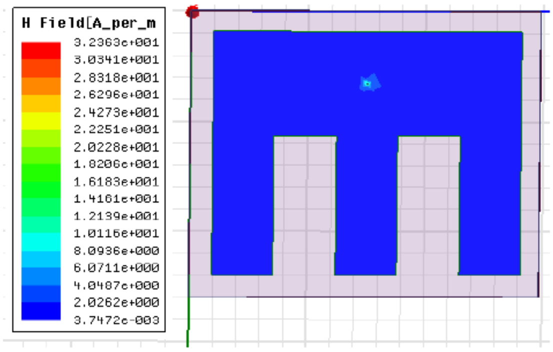

Fig. 9(g): H-field with Wash Cotton as Substrate.

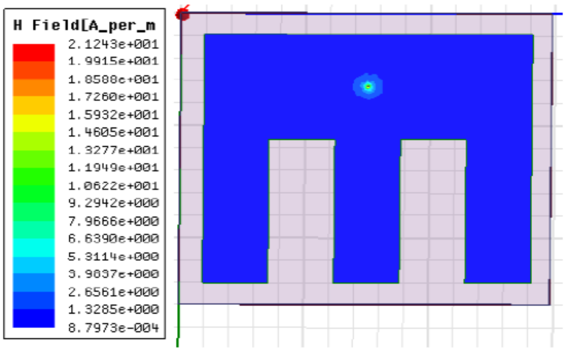

Fig. 9(h): H-field with Wool as Substrate.

Discussions:

Jean cotton has the minimum return loss i.e, -41.60dB when compared to other textiles. Since the main parameter for wearable antennas is gain, of all the textiles Polycotton has the highest gain of 1.8142. In order to cover the human body in 360 degrees the polarization should be circular, here this is nearly achieved with Nylon textile.

Conclusions:

From the above results it is clear that there is a trade off among the resultant parameters for the designed E-Shaped Microstrip Patch antenna. For Medical Applications Gain and Return loss are the major constraints. So based on the required parameter the textile should be selected.

Future Scope:

This work can be further extended to increase the gain, directivity to increase the efficiency the antenna and to make it independent on surrounding conditions like Temperature, Humidity & Pressure.

ACKNOWLEDGEMENT

Authors would like to express their indebtedness to the Department of Science and Technology through SR/FST/ETI-316/2012 FIST program. Authors would also like to convey their deep gratitude towards the Department of Electronics and Communication Engineering and the management of K L University for their support and encouragement during this work.

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