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Development of Wearable Antennas with Different Cotton Textiles

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ABSTRACT
Recent advancement in medical applications is wearable antenna. As this is a wearable type it should have low weight, low profile and low cost. In this paper we have designed Microstrip rectangular patch antenna used for this application. Cotton Textiles with different dielectric values are used as substrates for this antenna. The antenna is fed with co-axial feed. Here we have examined the radiation characteristics, return loss and gain which are the critical parameters of wearable antenna for monitoring and diagnosing patient's condition. These are performed by using ANSOFT HFSS.

Keywords - wearable antenna**,** cotton textile, dielectric value, Return loss, gain.

I. INTRODUCTION

With the increasing population there is a great demand for remote health care systems. Even though there are a number of biomedical devices used for these applications, new evolution in Medical applications is wearable antennas. Not only in medical field even for military application also requires the integrating of these wearable antennas on military clothing to enhance the performance of soldier and create awareness, survivability in the time of wars [5]. Flexibility, nominal weight, resistant to shock and vibrations are the main advantages of these body wearable antennas. Inspite of these advantages there are few drawbacks with these antennas. These antennas are having narrow bandwidth and sensitivity to environmental conditions such as humidity and temperature. Dielectric and conductor losses are more for thin patches resulting in degrading the antenna efficiency [2].

Wearable antenna is nothing but a microstrip patch antenna if textile is used as Substrate. The micro-strip patch antenna fabricated on different cotton garments which is wear by the patients was continuously monitored and diagnosed by the doctors in the hospitals remotely. The effect of the user's body on the antenna characteristics are maximum due to the antenna-body coupling and varies between different antennas separation distance and near-field coupling with tissue [7].

Patch: Even though there are different types of patches like rectangular, circular, triangular etc, are available, here we have chosen rectangular type as patch. Because due to its larger physical area, it has higher bandwidth and ease of fabrication when compared to other type of patches [6].

Substrate: Generally for micro-strip antennas the values of substrate dielectric constants are in the range of $2.2 \leq \varepsilon r \leq 12$ [1]. Here we have chosen different cotton textiles like jean cotton, wash cotton, polycotton and curtain cotton as substrates. Care should be taken while choosing these textiles as substrate because radiation parameters greatly depend on them.

Feeding: The antenna is energised by using co-axial feed. Co-axial feeding is used since it has low spurious radiations and also mitigates the other drawbacks when compared to other type of microstrip antenna feedings [2].

II. DESIGN SPECIFICATIONS:

The design specifications for the proposed Wearable antenna are shown in the table.1

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

Table. 1 Design Specifications

The proposed wearable type microstrip rectangular patch antenna has been modelled using Ansoft HFSS.

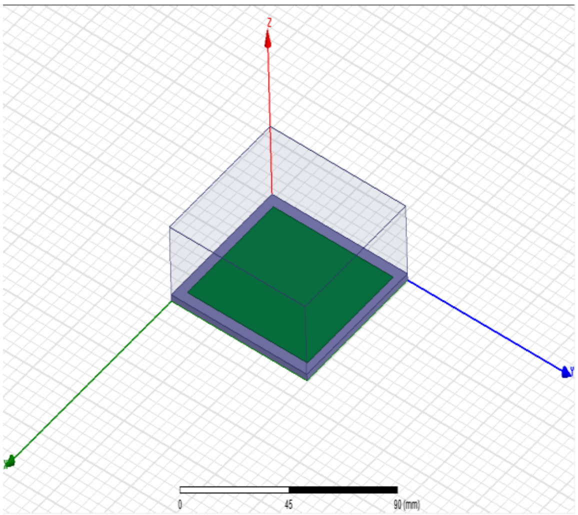


Fig (1) Microstrip Rectangular Patch Antenna

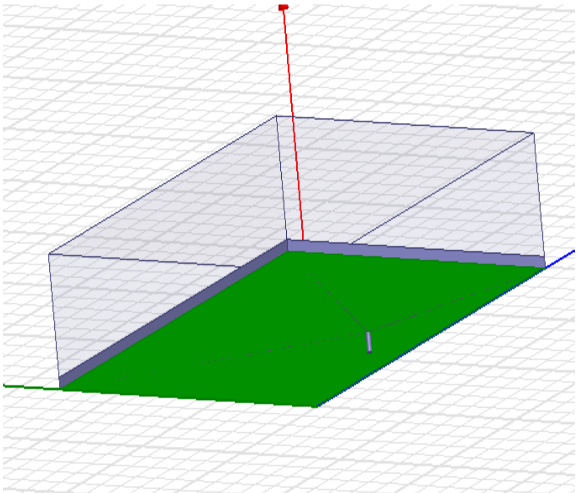


Fig (2) Patch Antenna with coaxial feed

HFSS is a commercial finite element method solver for EM structures. The software has a linear circuit simulator with integrated optimetrics for electrical network design. HFSS incorporates a powerful, automated solution process; hence we need to specify geometry, material properties and the desired output only. Using these, HFSS automatically generates an appropriate, efficient and accurate mesh analysis for the given geometry.[5].

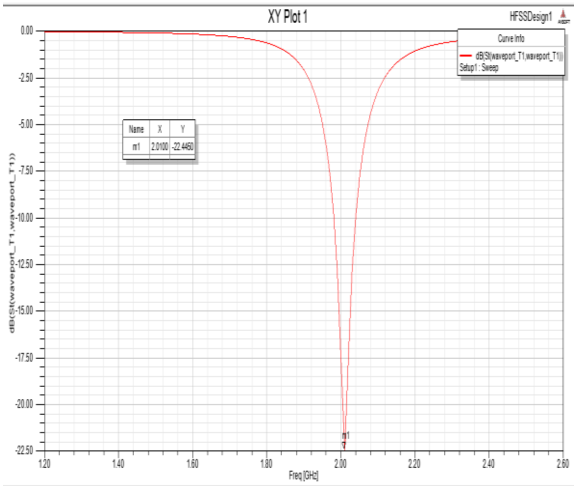
The relative permittivity value of different cotton textiles used as dielectric material for wearable antenna is shown in table 2.

Dielectric Material	ε_r
Wash Cotton	1.45
Curtain Cotton	1.47
Polycotton	1.50
Jean Cotton	1.59

Table. 2 Materials & their dielectric values

III. RESULTS AND DISCUSSIONS:

RETURN LOSS:



Fig(3) return loss with jean cotton as substrate

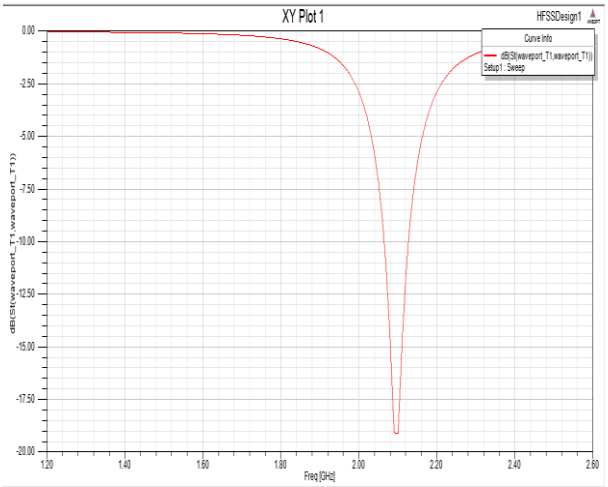


Fig (4) return loss with wash cotton as substrate

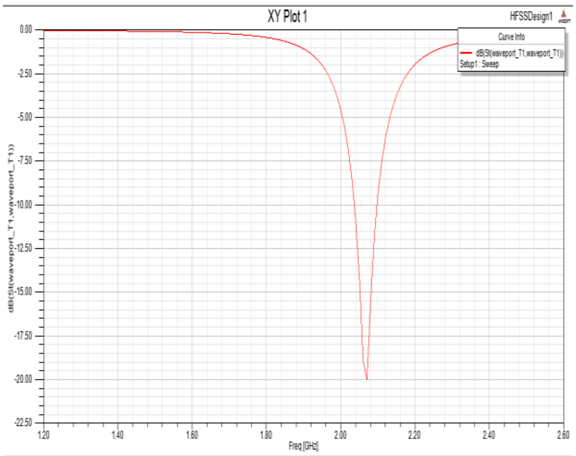


Fig (5) return loss with polycotton as substrate

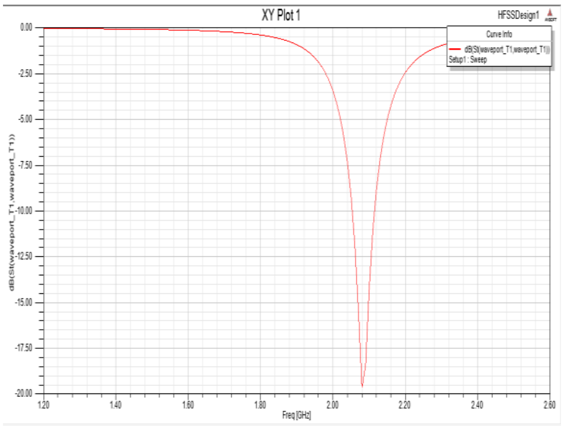


Fig (6) return loss with curtain cotton as substrate

The antenna performance greatly depends on the return loss. If the return loss increases the performance of the antenna also increases. From the table 3 it is clear that the jean cotton has higher return loss when compared to wash, curtain and poly-cotton.

Table. 3 Dielectric Vs Return Loss

Dielectric Material	Return Loss
Wash Cotton	-18
Curtain Cotton	-19
Polycotton	-20
Jean cotton	-22

RADIATION PATTERN: The antenna pattern describes the relative strength of the radiated field in multiple directions from the antenna. It includes both reception and transmission pattern.

2d radiation patterns with different cotton textiles of proposed antenna are shown in the figures (7), (8), (9) & (10).

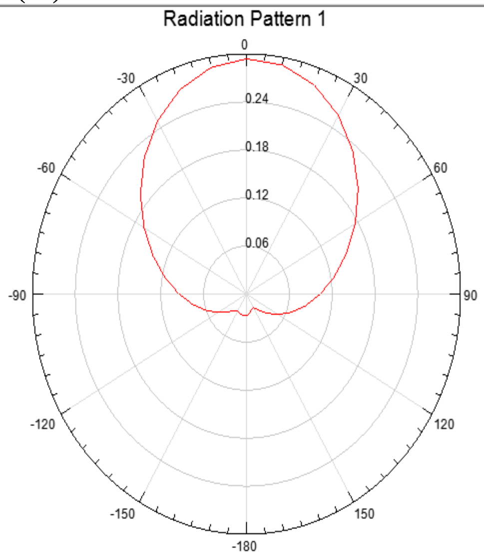


Fig (7) 2d pattern with jean cotton as substrate

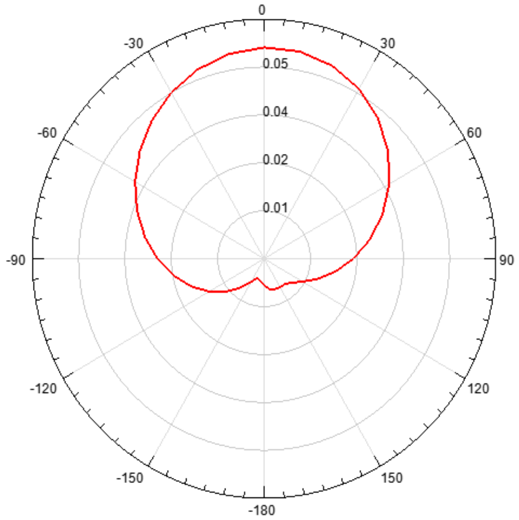


Fig (8) 2d pattern with wash cotton as substrate

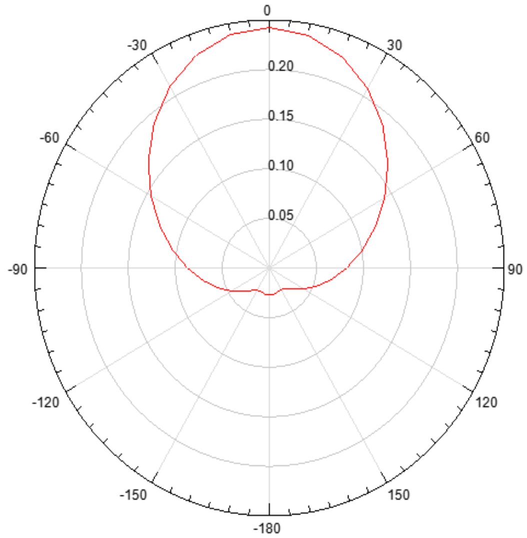


Fig (9) 2d pattern with polycotton as substrate

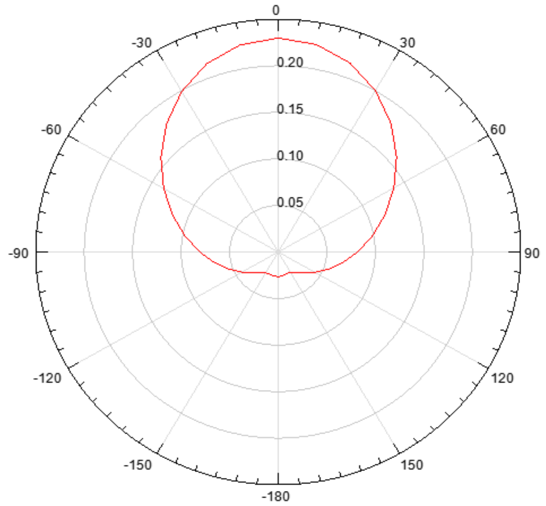


Fig (10) 2d pattern with curtain cotton as substrate

From the above 2d-radiation patterns of rectangular microstrip wearable antenna it is clear that we have achieved linear polarization. But once if this antenna was fabricated on the patients cloth there is no guarantee that patient was stable, he or she may move so it is better to achieve circular polarization to cover patient's body in 360 degrees.

Dielectric	ϴ=0	ϴ=90
Wash cotton	Mag=0.05	Mag=0.02
Curtain cotton	Mag=0.22	Mag=0.081
polycotton	Mag=0.24	Mag=0.082
Jean cotton	Mag=0.29	Mag=0.10

Table. 4 Dielectric Vs magnitude

As shown in the table. 4 with the increase in dielectric values for different cotton textiles like wash cotton, curtain cotton, polycotton and jean cotton the magnitude of the 2d radiation also increases in the direction of 0 and 90 degrees of ϴ.

3D-RADIATION PATTERN:

3d radiation patterns of wearable antenna with different cotton textiles are shown in the figures (11), (12), (13) & (14).

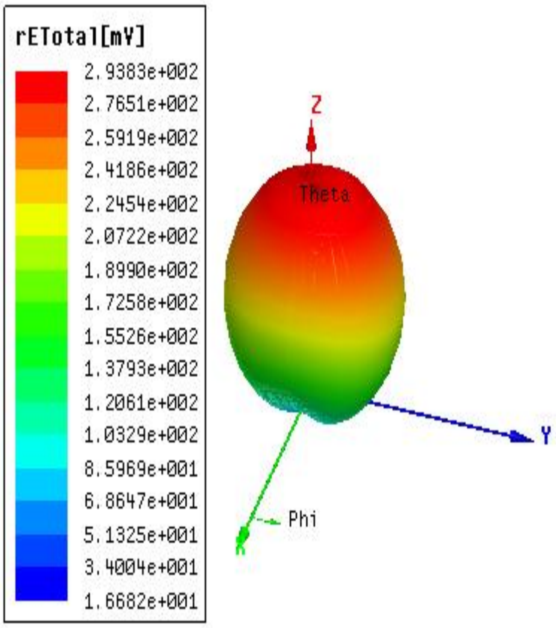


Fig (11) 3d radiation pattern with jean cotton as substrate

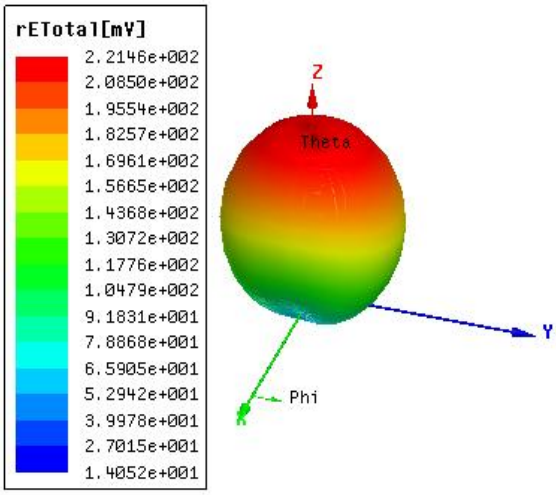


Fig (12) 3d radiation pattern with wash cotton as substrate

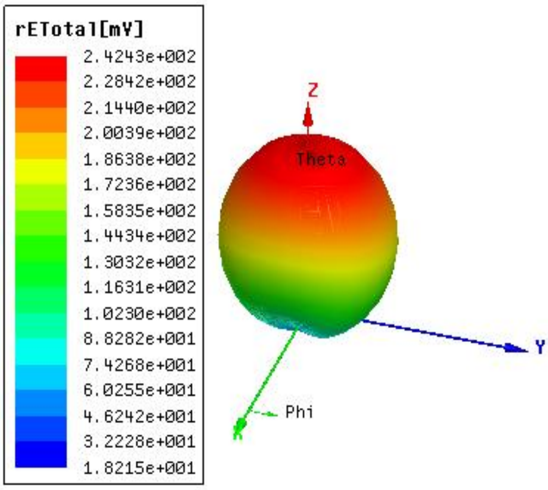


Fig (13) 3d radiation pattern with polycotton cotton as substrate

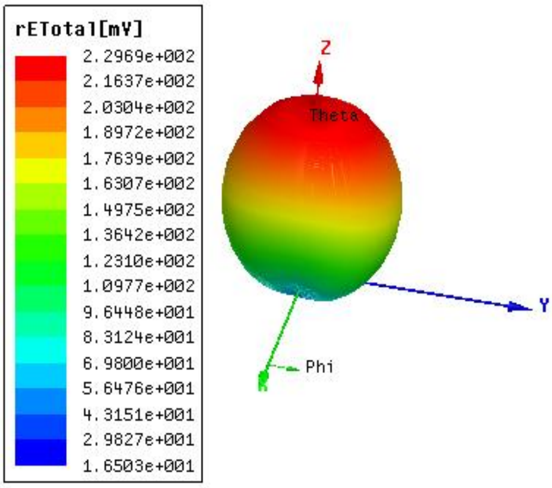


Fig (14) 3d radiation pattern with curtain cotton as substrate

The operational disadvantage with these microstrip patch antennas is low gain. So it is proper to select the high gain antenna for any application. As shown in the table. 4 if the dielectric value increases the gain also increases. So for the best suitable in medical applications it is better to use jean cotton as substrate for this microstrip antenna.

Table. 5 Dielectric Vs Gain

Dielectric Material	Gain(dB)
Wash Cotton	2.21
Curtain Cotton	2.29
Polycotton	2.42
Jean Cotton	2.93

Directivity: The most important parameter which determines the directivity of a microstrip patch antenna is the relative dielectric constant 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.

E-FIELD CHARACTERISTICS:

E-field characteristics of the proposed antenna are shown in the figures (15), (16), (17) & (18).

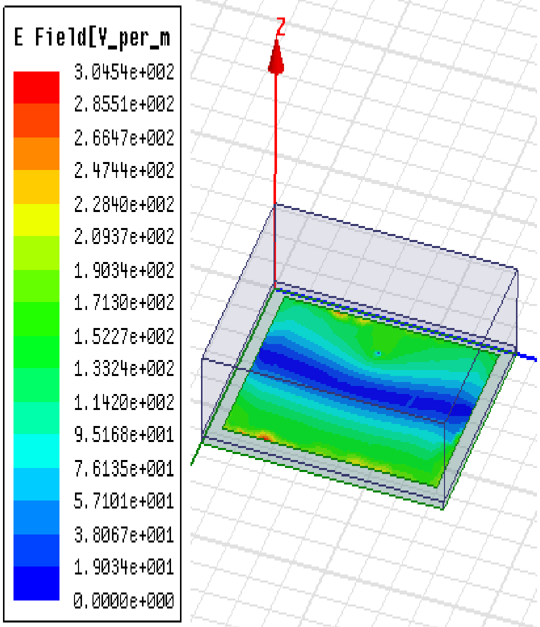


Fig (15) E-Field pattern with jean cotton as substrate

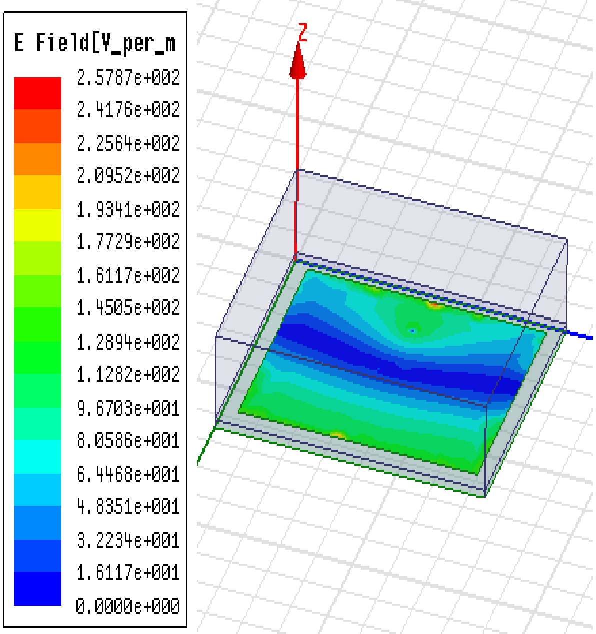


Fig (16) E-Field pattern with wash cotton as substrate

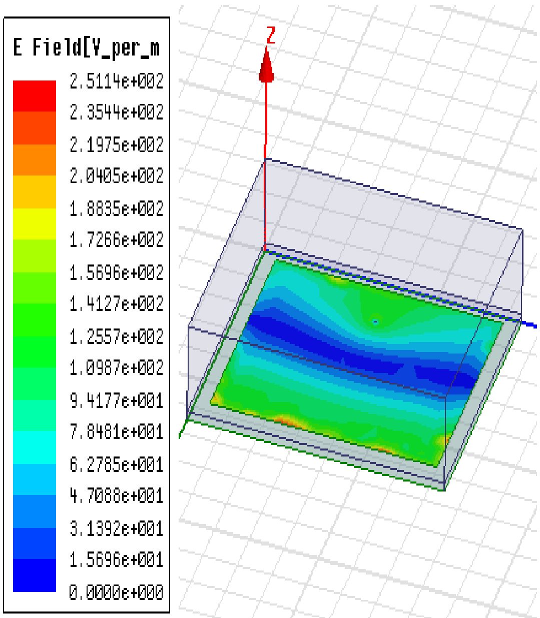


Fig (17) E-Field pattern with polycotton cotton as substrate

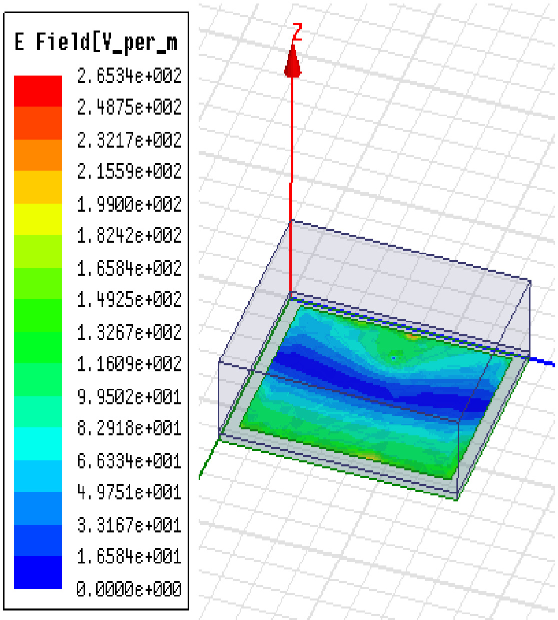


Fig (18) E-Field pattern with curtain cotton as substrate

H-FIELD CHARACTERISTICS:

H-field characteristics of the proposed antenna are shown in the figures (19), (20), (21), (22).

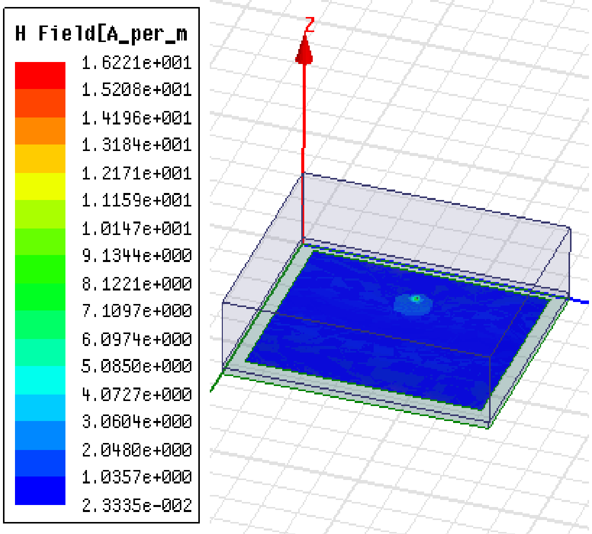


Fig (19) H-field with jean cotton as substrate

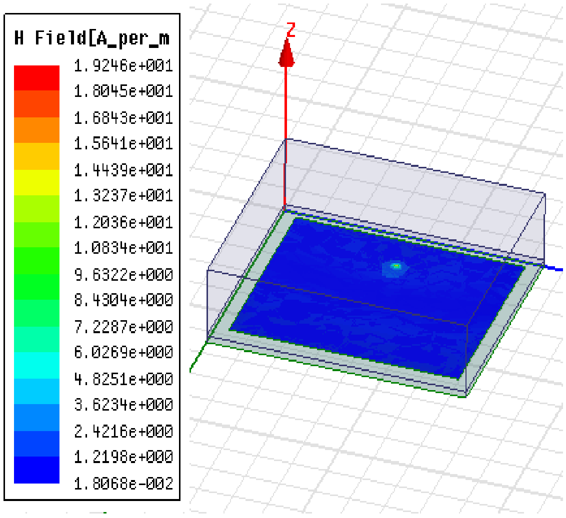
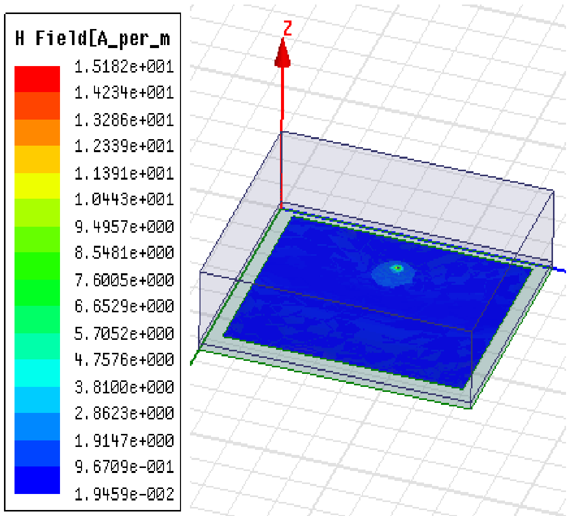


Fig (20) H-field with wash cotton as substrate



Fig(21).H-field pattern with polycotton as substrate

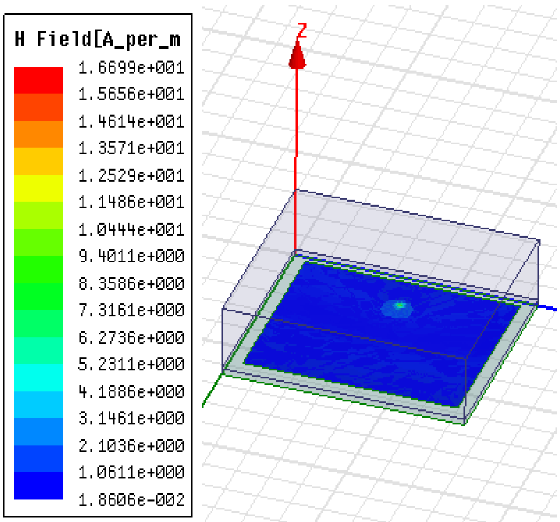


Fig (22) H-field pattern with curtain cotton as substrate

IV. CONCLUSION

The results obtained from the proposed Microstrip rectangular patch antenna with different cotton textiles like jean cotton, wash cotton, polycotton and curtain cotton as dielectric material enhances the use of wearable antennas in medical applications. Particularly choosing jean cotton as substrate is more appropriate textile than other cotton textiles for wearable antennas.

V. FUTURE SCOPE:

This idea can be further extended to achieve circular polarization which has a greater advantage than linear polarization particularly in the field of medical applications for monitoring and diagnosing patient condition appropriately.

VI. ACKNOWLEDGEMENTS

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