# Aperture Coupled Technique Using Triangular Shape Patch Antenna for Integration into Different Wearable Textile Substrates

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***Abstract: The rapid development in wireless communication devices is increasing in day to day life, with the advancement of wearable antenna and electronics in civil, medical, sportswear and mainly in medical domains to replace wired communication systems in the near future in which antennas play an important goal. At present scenario, there is a greatest interest in antenna to merge between wearable systems. In this paper a different feeding technique called aperture coupled feeding technique has been implemented with three different substrates like cotton, jean and fleece fabric. The new coupling technique helps to improve the overall performance of textile antenna and among the three substrates cotton achieves maximum efficiency. The designed antenna operates in the frequency of 2.4 – 5.8 GHz of ISM band applications. From this analyzed result the textile antenna is highly efficient, fully flexible, can be easily wearable and it is easily integrated into garments.***
***Key words: Textile antenna, Return loss, Flexibility, Highly Efficient.***

## 1. INTRODUCTION

Wearable textile antenna aim is to improve the quality of human life by enhancing the functionalities of clothing's through a combination of textiles and electronics. This new generation of wearable textile antenna has the ability to monitor the wearer's bio signals and communicate the data to the environment in order to provide continuous information about a person's health. Antennas for wearable applications need to be comfortable too wear and perform their functionalities. Mostly wearable textile antennas are constructed by using commonly available materials like cotton, jean, fleece fabric etc., and conductive materials are preferred solutions as they are flexible and soft.

Antenna with textile also assist the emergency services like fire fighters, detectives and military. It may also provide to establish communication between the soldiers and many other units of the modern battle field including unmanned aerial vehicles. In this paper textile antenna is fully integrated into garments to preserve flexibility and comfort. These antennas have flat, planar structure to be comfortably wearable. These antennae do not disturb while the movement of wearer occurs, since of its light weight and flexibility. An aperture coupled design is proposed for wearable microstrip patch antenna with a slot on the ground plane to improve its performance.

An aperture coupled technique consists of two substrates bonded together with a ground plane in between them. The radiating patch is on the top of the substrate while a microstrip feed line is on the bottom of the feed substrate, A small slot (aperture) on the ground plane to couple energy between the feed line and the patch. Here three different textile substrates with different permittivity is used. In case of wearable antenna their performance varies when they are placed on the human body. This paper also compares the performance of three different textile substrates like fleece fabric, cotton, and jean. The structure of the wearable textile antenna is designed using CST Microwave Studio Package.

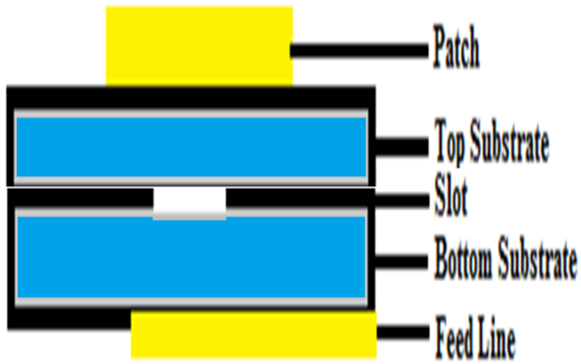


Fig 1: Aperture Coupled Feeding Technique

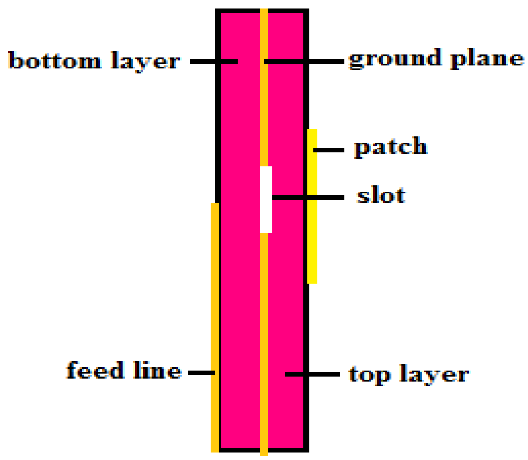


Fig 2: Left Side View of Aperture Coupled Patch Antenna.

## 2. SUBSTRATE MATERIAL SELECTION

The permittivity of the material is usually given relative to that of the free space which is known as relative permittivity or dielectric constant. Different substrates having different dielectric constants affect the antenna performance in various ways. Here, Fleece Fabric $\varepsilon r = 2.22$ with a tangent loss of 0.0015, Cotton $\varepsilon r = 1.54$ with a tangent loss of 0.058, and Jean $\varepsilon r = 1.6$ with a tangent loss of 0.0019 are used as antenna substrates. Selection of material for designing the antenna is unique in this paper.

Table 1: Dielectric Constant of Different Wearable Textile Substrates

| S:NO | MATERIAL | DIELECTRIC CONSTANT | TANGENT LOSS |
|---|---|---|---|
| 1 | Jean | 1.6 | 0.0019 |
| 2 | Cotton | 1.54 | 0.058 |
| 3 | Fleece fabric | 2.22 | 0.0015 |

## 3. WEARABLE MATERIALS CONCERNS

Textile materials that are used as an antenna's substrates can be divided into two main categories, natural and man-made Fibers. Synthetic Fibers are an interesting subcategory of man-made Fibers being polymers from their molecular structure. On the other hand, textile materials generally have a very low dielectric constant, which reduces the surface wave losses and improves the impedance bandwidth of the antenna. In comparison with high dielectric substrates, textile antennas are physically larger. However, several wearable antennas aspects contribute in the overall design features of the antennas. These aspects can be concluded as follows:

- Movement of Human Body
- Bending
- Wetness

## 4. ANTENNA DESIGN AND IMPLEMENTATION

In order to design a patch textile antenna, a selection of suitable conducting and non-conducting material is required conducting materials is applied for both the patch and the ground plane, while non-conducting textile is applied for the antenna substrate layer. For antenna substrate Fleece fabric, Cotton and jean is chosen because of its high thickness and low permittivity, which are excellent properties of textile antenna design. The top Substrate with a dimension of 98 x 98 mm with a thickness of 2.86 mm and the bottom substrate with a dimension of 98 x 98 mm with a thickness of 1.15 is used, while the ground plane with a dimension of 80 x 80 mm with a thickness of 0.0354 mm. The triangle patch is the radiating patch with a thickness of 0.0354 mm. The 50$\Omega$ micro strip feed-line is excited with a SMA connecter. Figure shows the combined results of patch textile antenna designed using CST software.

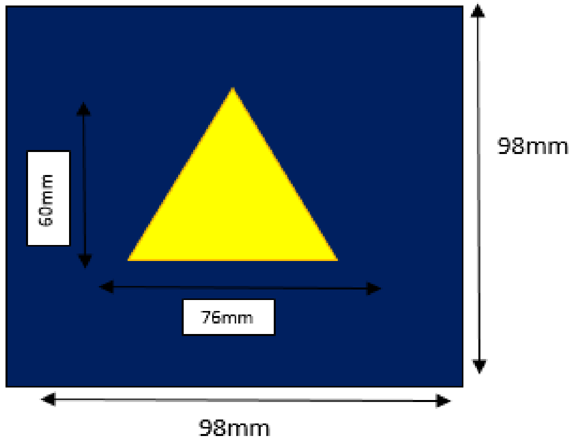


Fig 3: Top layer of textile antenna

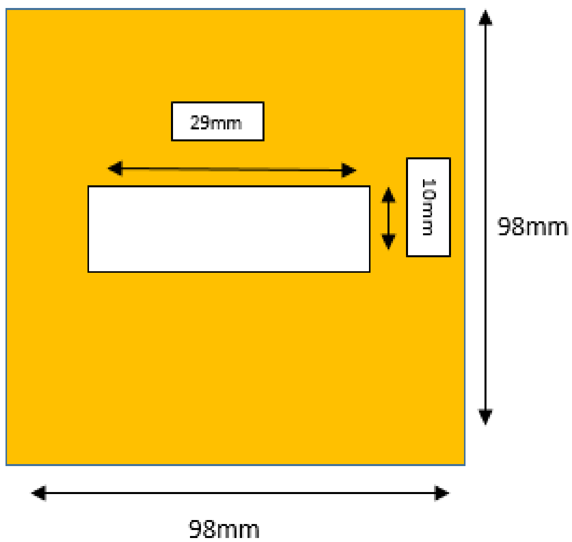


Fig 4: Ground Plane of textile antenna

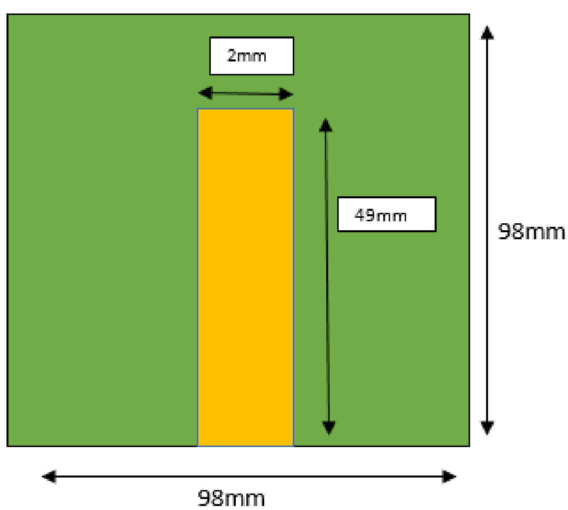


Fig 5 :Bottom layer of textile antenna

The top substrates are varied by using fleece fabric, cotton and jeans while the bottom substrate is kept constant as felt since to overcome the disadvantage of flexibility. The conductive material will be self-adhesive copper foil tape with a thickness of 0.0354 mm. The bottom substrate felt is selected because of hard nature so that flexibility, dimension inaccuracy can be overcome. The small rectangular slot is etched on top of the ground plane which is used to radiate the waves and to activate the top layer. The slot dimensions are 10× 29mm. The slot is positioned at the center of ground plane in order to produce the maximum coupling, so that direct electrical connections between the feedline and the top radiating patch. It conducts by means of a small aperture slot in the ground plane.

## 5. ANALYSIS OF APERTURE COUPLED WEARABLE MICROSTRIP PATCH ANTENNA USING CST

The designed wearable textile antenna is simulated using CST Microwave studio and there corresponding results are analyzed and shown below Figure shows the S-parameter results with good impedance matching where fleece fabric achieves return loss of -31.906 dB with voltage standing wave ratio of 1.05 while cotton substrates achieves a return loss of -29.604 dB with a VSWR of 1.06 and Jean substrates achieves a return loss of -39.772 with a VSWR of 1.02.

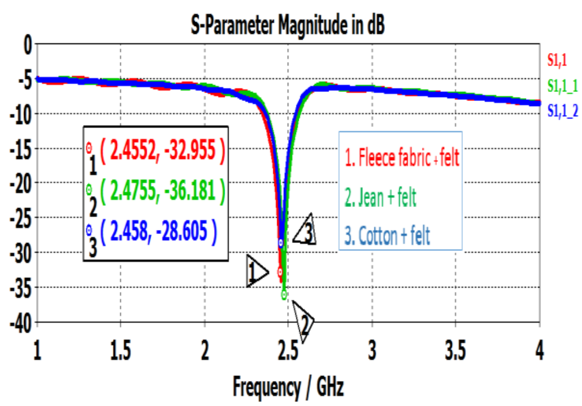


Fig 6: Comparison of Return loss of different textile substrates

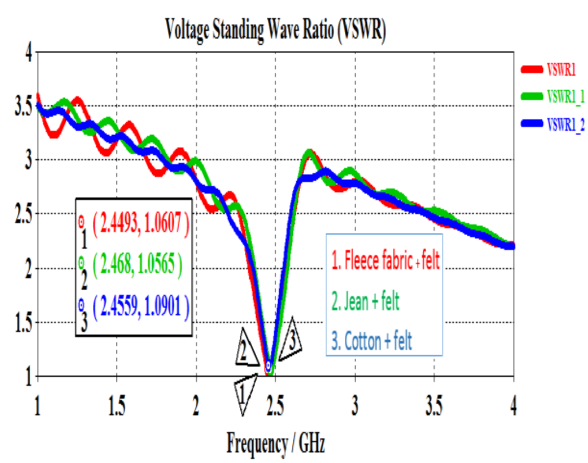


Fig 7: Comparison of VSWR of different textile substrate.

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Table 2: Comparison of return loss and VSWR of different textile substrates

| S:NO | TOP SUBSTRATE | BOTTOM SUBSTRATE | FREQUENCY (GHz) | RETURN LOSS (dB) | VSWR |
|---|---|---|---|---|---|
| 1 | Fleece Fabric | Felt | 2.45 | -32.95 | 1.06 |
| 2 | Jean | Felt | 2.47 | -36.18 | 1.05 |
| 3 | Cotton | Felt | 2.45 | -28.60 | 1.09 |

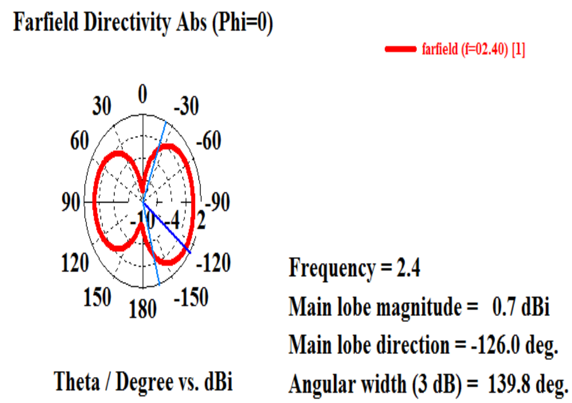


Fig 8: Directivity of Fleece Fabric at frequency

**2.4 GHz**

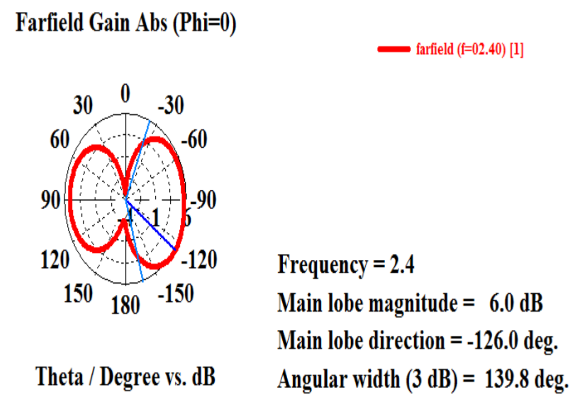


Fig 9: Gain of Fleece Fabric at frequency 2.4 GHz

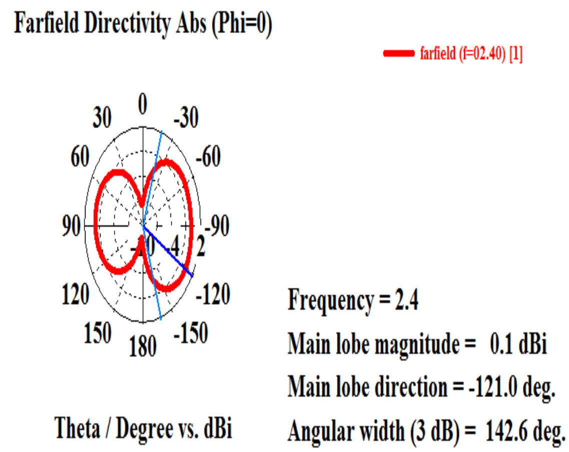


Fig 10: Directivity of Jean at frequency 2.4 GHz.

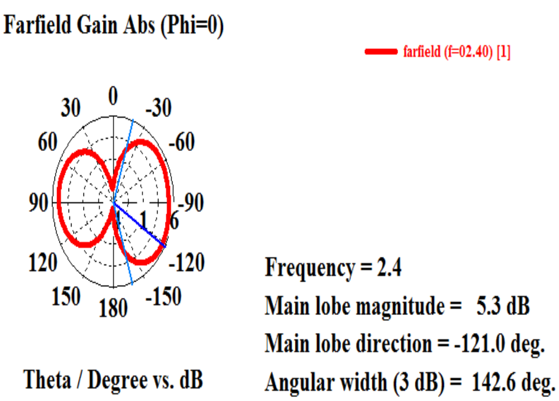


Fig 11: Gain of Jean at frequency 2.4 GHz.

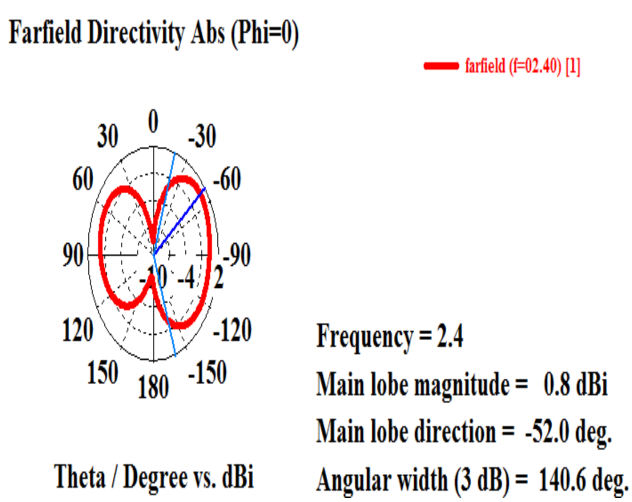


Fig 12: Directivity of Cotton at frequency 2.4 GHz

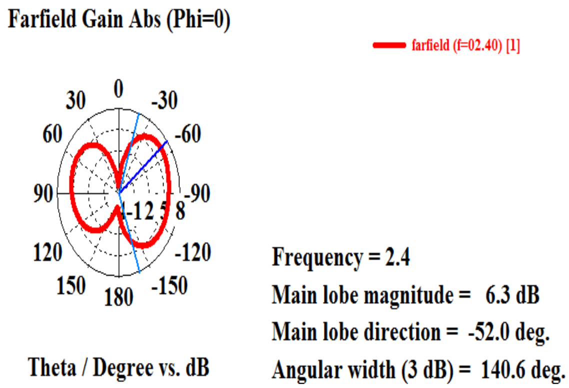


Fig 13: Gain of Cotton at frequency 2.4 GHz.

Table 3: Comparison of gain and directivity of different textile substrates

| S:NO | TOP SUBSTRATE | BOTTOM SUBSTRATE | GAIN (dB) | DIRECTIVITY (dBi) | EFFICIENCY (%) |
|---|---|---|---|---|---|
| 1 | Fleece Fabric | Felt | 8.552 | 3.306 | 62 |
| 2 | Jean | Felt | 8.496 | 3.327 | 69 |
| 3 | Cotton | Felt | 9.442 | 3.526 | 75 |

## 6. CONCLUSION

The main aim of this paper is to observe the performance and characteristics of different textile antenna with an integration of aperture coupled technique for ISM band (2.4 – 5.8 GHz) applications and to overcome difficulties like dimension inaccuracy and flexibility by using hard textile substrate felt at the bottom substrate as constant. From these observed results it shows that cotton achieves maximum efficiency of 75 % when compared with the other textile substrates.

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