

Design Issues of Wearable Antennas

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Abstract: *Wearable antenna is an antenna that is designed to be integrated as a part of a garment and to be worn on the body. Wearable antennas are designed to work in the complicated body centric environment. The objective of this work is to find out different designing issues for wearable antennas and to find out most effective solution of designing issues of wearable antennas and make trade off with different designing issues of wearable antennas.*

Keyword: Wearable antenna, Bent antenna, Antenna performance under wet condition, Biological effect of wearable antenna, antenna cover

1. Introduction

Wearable antennas are meant to be worn on human body so that it must be light weight, low profile, flexible, unobstructive and rugged. To fulfill these requirements, textile materials are used to make wearable antennas. Electrical and dielectric properties of these textile materials are not readily available. Unlike, antennas embedded in portable devices, wearable antennas are designed to work in the complicated body-centric environment. Antenna performance near to human body is different than antenna placed in free space. Environmental effects and water absorption also affect antenna performance.

2. Design Issues of Wearable Antennas

2.1 Designing challenges from materials

In the conventional antennas, conventional rigid materials are used which are dis-comfortable and not suitable for wearable antennas [1]. To overcome this problem, textile materials can be used. The conductive textiles have the anisotropic and non-perfect electric conductor (PEC) properties so their conduction characteristics are different from conventional conductors. Another issue regarding materials is that electrical and dielectric properties of materials are not readily available [1].

2.2 Design challenges from human body

When antennas are placed close to human body, their performance is influenced by human body. Antennas that are near to the body have different resonance frequency than resonance frequency in free space. Changes in Resonance frequency, Impedance bandwidth, Gain, directivity and radiation pattern is observed when it is placed close to human body [2].

Furthermore, the movements of the person and posture will result in bending or twisting of flexible wearable antennas. Geometry changing on the electric plane of patch antenna has larger effects on the antennas performance [3].

In addition, some of radiated energy is absorbed by human body. Antenna efficiency and radiation pattern are directly affected because of this absorbed energy. The specific absorption rate (SAR) is used to specify the power absorbed per the unit mass of tissue [4]. In America, the Federal Communications commission (FCC) requires the SAR level to be below 1.6 W/kg average over 1 g and in the Europe Union sets SAR value at 2 W/kg averaged over 10 g.

2.3 Other Issues of Wearable Antennas

- 1.Environmental effects: The temperature tolerance of materials, the durability against frequent bending, physical abrasion and the stress caused by the operational environment can affect performance of wearable antennas [6].
- 2.Water absorption: Textile antennas can easily absorb water and moisture. It results in change in the resonant frequency and impedance bandwidth of an antenna [5].

3. Techniques to Minimize the Designing Issues of Wearable Antennas

3.1 Electrical and dielectric properties of textile material of wearable antenna is a major issue from materials. Electrical and dielectric properties of textile materials are not readily available. Many researchers have studied the dielectric properties of textile fibers. The methods of measurement and the measuring conditions were different in different cases. The various measurement techniques are discussed in [7].

3.2 When antennas are placed close to human body, their performance is influenced by human body. Good isolation between antenna and human body is required to minimize human body effect on the antennas. Good isolation is produced by adding conductive layer between antenna and human body [8]. Size of conductive layer also affects antenna performance. Absorption loss is greatly decreased by adding conductive layer between antenna and human body. It is shown that by putting ground plane with patch, detuning effects of human body can be minimized [9].

3.3 Insertion of felt layer is increase the distance between antenna and human body. By insertion of felt layers

between antenna and human tissue, efficiency can be improved. [9]

3.4 Textile based wearable antenna can absorb liquid material around it. Dielectric constant of absorbed material can affect the resonant frequency. This effect can be minimized by choosing appropriate material for antenna design. Performance of Antenna made with shield it conductive fiber is better than antenna made with copper conductive sheet [5].

3.5 EBG based antennas have more advantages than conventional ground plane antennas. Surface waves can be decreased by EBG based ground plane. So, radiation in backward direction is decreased. And because of it, SAR is decreased. Bending and crumpling effect in EBG based antenna is lesser than conventional antennas [10].

3.6 Requirements for the materials for wearable antennas in real life system are the temperature tolerance, durability, physical abrasion, water absorption, and stress with the structural characteristics of the fabric to maintain the electrical functionality under the environmental condition. Textile cover can be used to protect antenna in real life system [11].

3.7 By adding conductive layer or developing antenna based on EBG ground plane, we reduce radiation in backward direction. So, multiple antennas can be located around the body to get radiation in all direction.

3.8 When high performance is required in terms of antenna gain and radiation pattern, multi antenna system can be used. Automatic tunable circuits and reconfigurable antenna could be implemented in wearable antenna to minimize detuning effect.

Table 1: Comparison of patch antenna with conventional ground plane, patch antenna with EBG based ground plane and patch antenna with EBG based ground plane with dielectric cover.

Issues	Patch antenna with conventional ground plane	Patch antenna with EBG based ground plane	Patch antenna with EBG based ground plane with dielectric cover
1. Dielectric properties of material	Not improved	Not improved	Not improved
2. Return loss characteristics and radiation characteristics near human tissue	Good isolation	Better isolation	Better isolation
3. Antenna performance under bent condition	Not solved	Less effect	Less effect
4. SAR and temperature value	Good reduction	Better reduction than conventional ground plane antenna.	Better reduction than conventional ground plane antenna.
5. Antenna performance under wet condition	Not solved	Performance is Partially affected.	Performance is less affected than other antennas.
6. Environmental effects	Not solved	Not solved	Better performance than other antennas.

4. Conclusion

Conventional techniques for the designing and characterization of antenna should be modified. Design challenges of wearable antennas are need to consider at the time of antenna design. Good isolation between antenna and human body is produced by EBG based antenna. A textile cover on antenna also can be placed to make antenna water proof and save antenna from environmental effects. When high performance is required in terms of antenna gain and radiation pattern, multi antenna system can be used. For the long term reliability of textile, washing and dry cleaning should be further improved. Automatic tunable circuits and reconfigurable antenna could be implemented in wearable antenna to minimize detuning effect.

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