Study on the Performance Deterioration of Flexible UWB Antennas

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Abstract — A flexible transparent film uwb antenna for curved surfaces has been designed and developed for wireless communications. The antenna has demonstrated good performance over the entire UWB bandwidth. It can be mounted on any conformal shape by virtue of the film properties of both the antenna as well as the substrate. The radiator and ground are both designed using AgHT-8 while the substrate is of a polymer. The antenna is shown to be able to maintain its performance below the 10dB level throughout the entire UWB bandwidth of 7.5GHz i.e from 3.1 GHz to 10.6 GHz as it is flexed through various radius of curvature thus providing an insight into how to overcome performance deterioration in wearable antennas.

I. Introduction

The recent European Commision's (EC) decision in 2008 to specify the technical conditions under which UWB devices can operate in Europe has spurred a lot of active research in the area of UWB technology. The major interest being in developing small size antennas that are discreet and flexible to enable them to be used in the mass-market consumer electronics applications. UWB devices as per the EC regulations can use the 6.0 to 8.5 GHz band with a maximum mean power density of -41.3 dBm /MHz EIRP. This is the same level as used in the US. The UWB signals must have a minimum bandwidth of 50 MHz. It also states that the 3.4 to 4.8 GHz band may also be used in a similar way. In this paper, a CPW-fed monopole antenna is first fabricated using a copper film and then using an AgHT-8 film to study the effects of singly flexing the antenna through various radius of curvature. Using AgHT-8 for the antenna and ground provide flexibility and discreetness by virtue of the transparent natures of the AgHT-8 material and the polymer.

It known that one of the most challenging aspect of designing wearable antennas is how to overcome its performance deterioration [1]-[2]. The performance study of the copper film antenna and the AgHT-8 antenna is intended to aid the understanding of first, how this deterioration occurs and second, how to overcome it to maintain a reliable performance. A benchmark or comparative CPW-fed monopole antenna was first designed using a copper film for the radiator and ground which was then mounted onto a transparent polymer film substrate. A similar antenna using AgHT-8 for the radiator and ground was then designed. Both antennas were simulated. Initial findings show that the 10dB bandwidth of the copper film antenna reduces as the antenna is flexed more. On the other hand, the AgHT-8 antenna which has a better performance in the planar surface itself maintains its bandwidth below the 10dB line throughout the flexure.

II. Antenna Design

Fig. 1 and Fig. 2 show the structures of the proposed antennas.

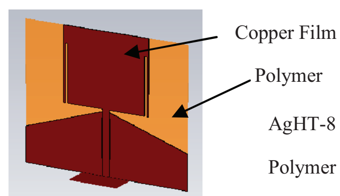

Fig. 1 Copper Film Antenna

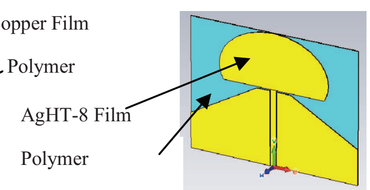

Fig. 2 AgHT-8 Film Antenna

Both antennas are designed for UWB. The copper film comes with adhesive and is attached to the polymer film. The AgHT-8 film is attached in a similar way to the polymer. The dielectric of the polymers were determined using a Split-Post Dielectric Resonator (SPDR) as in the schematic in Fig. 3, and the dielectric was read-off a PNA Network Analyzer that was connected to the SPDR as illustrated in Fig. 4 [3] at the National Physics Laboratory, Teddington, UK. The dielectric data obtained was then used to design and simulate the antennas in Fig. 1 and Fig. 2.

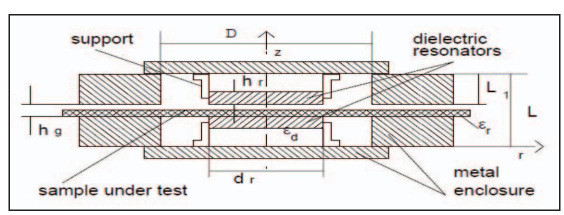

Fig. 3 Schematic of a SPDR in use

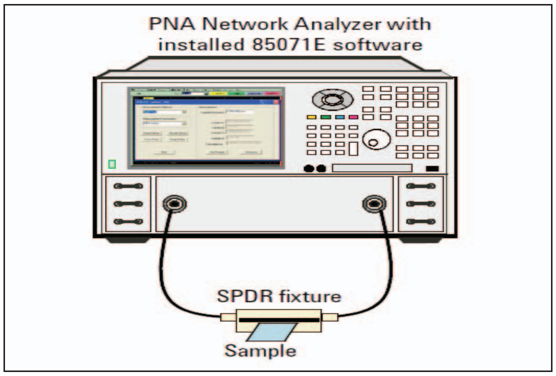

Fig. 4 The dielectric measurements are read-off a Network Analyzer

Both antennas were designed as CPW-fed monopole antennas but with different radiator designs. The copper film antenna had an approximate square patch radiator while the AgHT-8 antenna had a partial elliptical radiator.

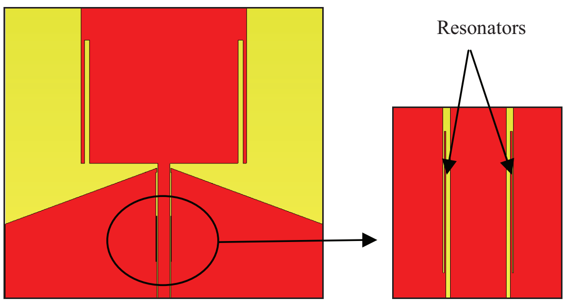

Fig. 5 (a) Resonator s on ground plane of Copper Film Antenna

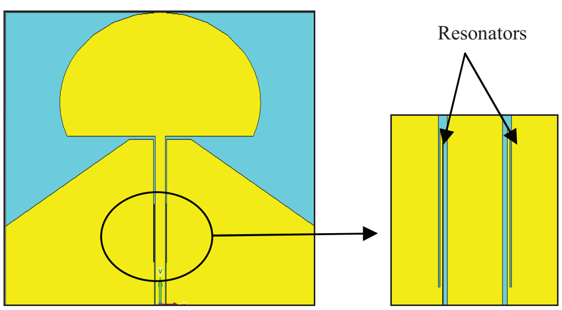

Fig. 5 (b) Resonators on ground plane of AgHT-8 Film Antenna

Both antennas were designed with resonators on the ground plane alongside the feedline as shown in Fig 5 (a) and Fig 5 (b). The resonators help the performance of the antenna. The copper film antenna however, had a 5 GHz band stop notch incorporated [4]. CST 2009 which has new features incorporated to study bending of the antenna and its effect was used to simulate the performance of both the antennas under various radiuses of curvatures. The surface resistance of the AgHT-8 was used to represent its material characteristic in the simulation study.

III. Results

The AgHT-8 antenna showed better S-parameter response compared to the Copper Film antenna for a planar surface, Fig. 6 and Fig. 7.

Initial findings for the antenna designed on the copper film and polymer substrate show that the 10dB bandwidth reduces as the antenna is flexed more as shown in Fig. 8 and Fig 9. This helps to understand why the performance of a wearable antenna deteriorates as it bends or flexed more. The simulation results provided in Fig. 10 and Fig. 11 are for the AgHT-8 film antenna. The simulation shows that this antenna demonstrates a better response as it is flexed through various radius of curvatures.

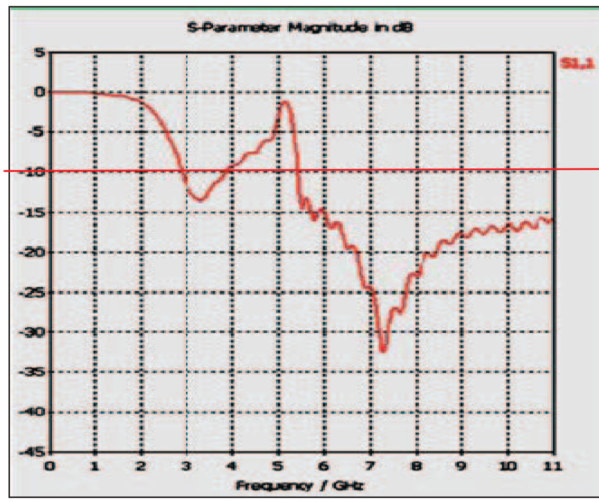

Fig. 6 S_{11} for a planar Copper Film antenna

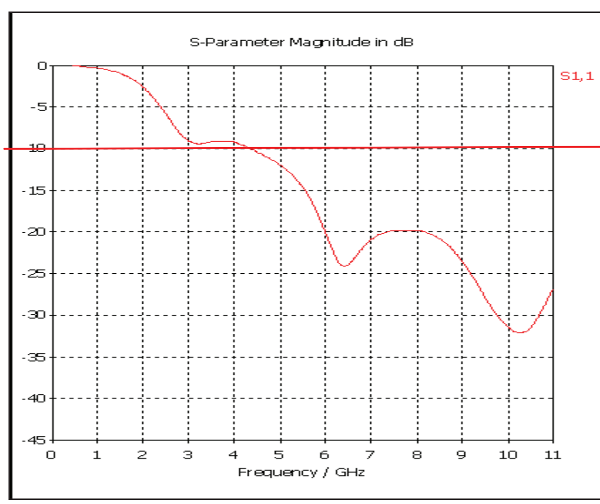

Fig. 7 S_{11} for a planar AgHT-8 Film antenna

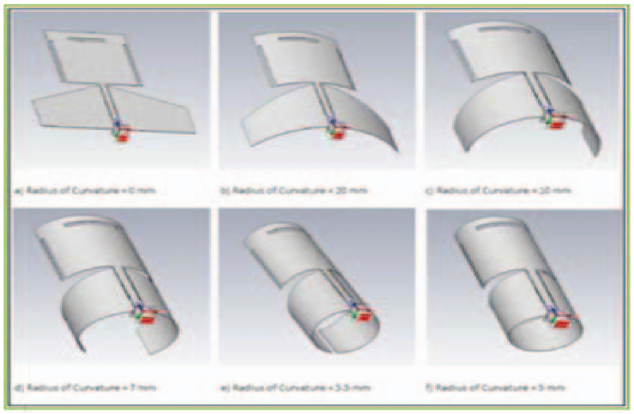

Fig. 8 Copper film antenna being flexed through various radius of curvatures

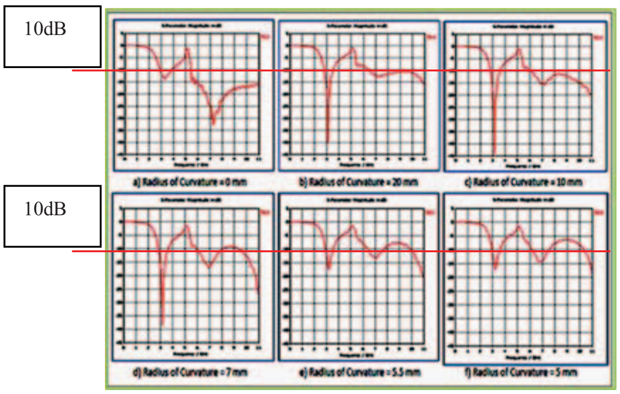

Fig. 9 The 10dB bandwidth reduces as the antenna is flexed through various radiuses of curvatures

The AgHT-8 antenna was able to maintain its performance below the 10dB bandwidth throughout its flexure, . This demonstrates the possibility of using AgHT-8 as a good candidate for wearable antennas to overcome performance deterioration during bending in body motion.

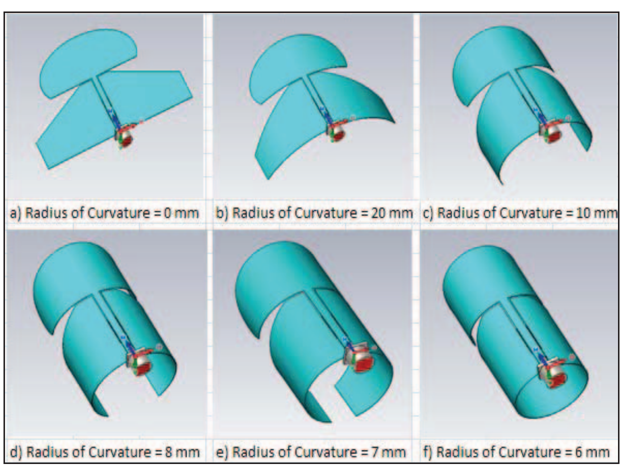

Fig. 10 AgHT-8 film antenna being flexed through various radius of curvatures

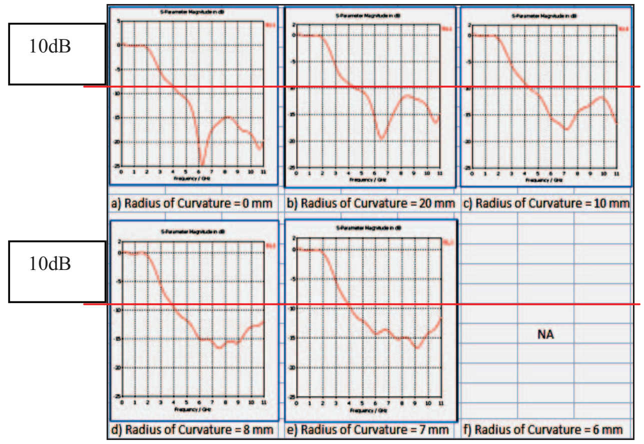

Fig. 11 The 10dB bandwidth is maintained as the antenna is flexed through various radius of curvatures. The result for the 6mm radius is invalid as the edges of the ground plane are touch ing.

Figures 12 to 16 show the simulated co-polarization and cross-polarization radiation patterns for the AgHT-8 antenna at frequencies, 3.1 GHz, 4 GHz, 5 GHz, 7 GHz and 10 GHz. The radiation patterns are similar and are stable across the frequency range of operation. However, the maximum simulated gain is only around 2dBi across probably due to the lossy nature of the AgHT-8 material. Design improvements will be looked into to improve the gain in future works.

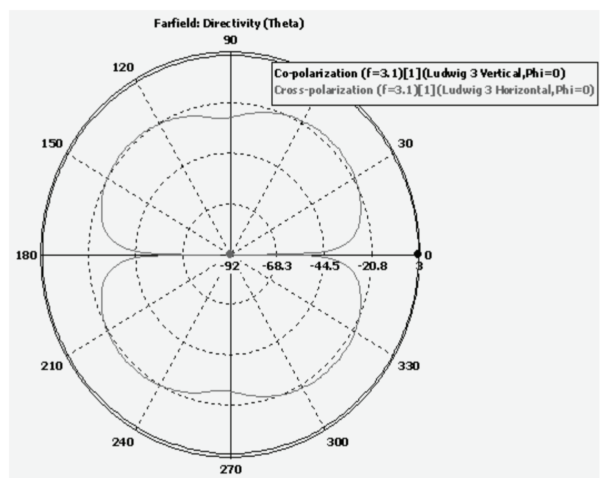

Fig. 12 Radiation pattern at 3 GHz

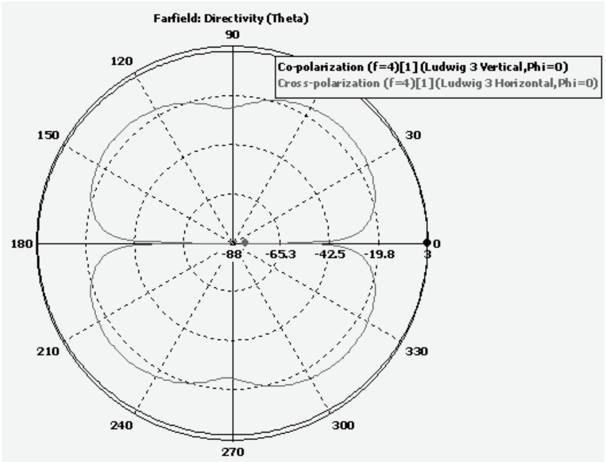

Fig. 13 Radiation pattern at 4 GHz

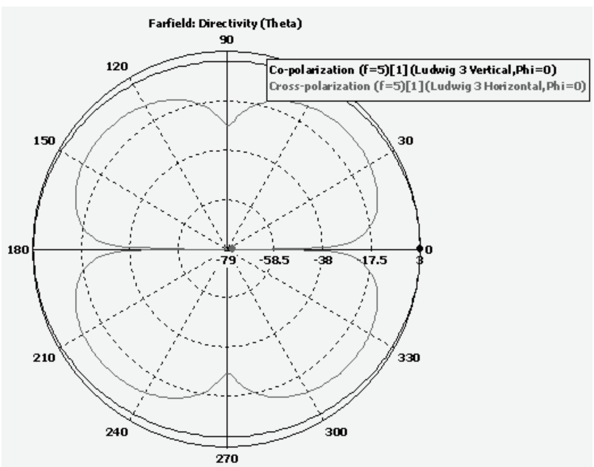

Fig. 14 Radiation pattern at 5 GHz

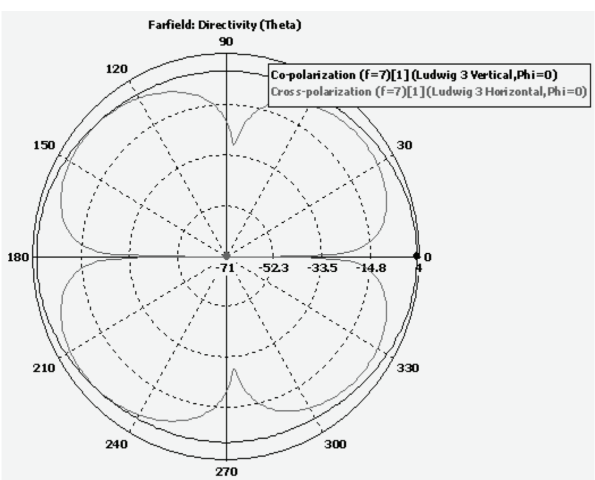

Fig. 15 Radiation pattern at 7 GHz

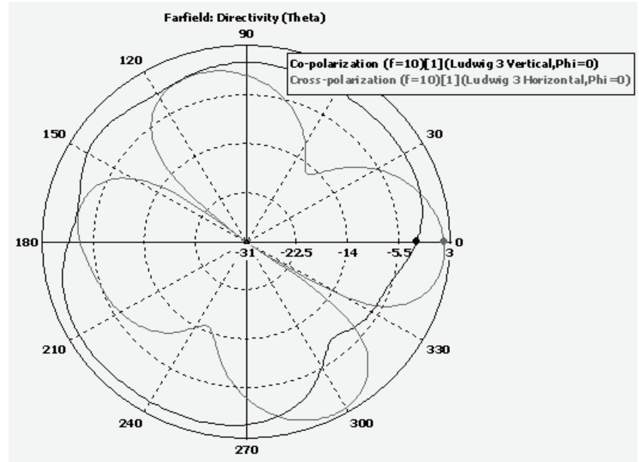

Fig. 16 Radiation pattern at 10 GHz

IV. CONCLUSIONS

The simulation study shows that performance of a flexible antenna deteriorates as it bends. Experimental results will be presented in a separate paper later. Understanding this issue could help us look into using antenna material like AgHT-8 that will have less impact on performance with bending and consequently improve its performance. The study could also help us to determine the maximum flexure possible for acceptable antenna performance when designing RFID antennas which is also gaining popularity. Providing transparency besides flexibility to both wearable and RFID antennas makes them more discrete and of low visibility; a feature which would be greatly favoured and welcomed by industry.

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