# Foldable and Stretchable Liquid Hexagonal Antenna

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**Abstract**—*The area of focus in this thesis is to design a flexible antenna that removes the need for antenna designs with exact shape. The main content would be designing an antenna that would not only be used in harsh environments but also as biosensors with better performance as compared to the other metal antennas This paper proposes to design a planar hexagonal wideband microwave frequency antenna with PDMS as the substrate and liquid as conducting medium. This antenna can be folded and stretched in any direction without any damage to the antenna. The antenna is manufactured with a process in which conductors are realized by injecting room temperature liquid metal alloy into micro-structured channels in an elastic dielectric material. The presented antenna has return loss better than 10dB within 3.1-9GHz.This antenna is useful for body-centric wireless network and in applications in harsh environments where mechanical flexibility helps improve durability.[1]*

**Keywords—** UWB, PDMS, body-centric wireless network, Planar hexagonal, omnidirectional

## I. Introduction

In recent advances there has been a growing demand for ultra wide technology as it provides various advantages such as low cost, low complexity, low spectral power density, high precision ranging, low interference and extremely high data rates.[2-9]One of the most promising areas in UWB applications is body-centric wireless networks where various sensors are connected together by UWB devices which have to be low power, low-profile and unobtrusive to the human body.[10,11].Due to the presence of human body the design of ultra-wideband antennas is complicated. Several fundamental requirements such as wide impedance bandwidth, small size and low profile, good on body propagation and radiation characteristics in the proximity of the body have to be fulfilled[10-15Due to the high dielectric and conductivity contrast of metal antennas with respect to most parts of the human body (blood, skin, ), most of the wireless sensors operating in RF and microwave frequencies is limited to 1-2 cm when attached to the body as dielectric constant of liquid is low as compared to metal, this problem can be overcome by using liquid as the dielectric medium[19].Furthermore by using PDMS as the substrate it can be made more flexible which can withstand severe mechanical shock by flexing instead of breaking. The electrical conductivity of liquid depends on temperature of water. The higher the temperature, the more electrical conductivity we have. The electrical conductivity of water increases by 2-3percent for an increase of 1 degree Celsius of water temperature. Adding salt reduces the static permittivity (from 80 down to 30-40 sometimes) of aqueous electrolyte solutions due to several effects. The easiest to conceptualize is solvent dipole density dilution. Solvent (e.g. water) molecules bond to the ions cancelling out their dipole moment. Another effect is the hydrodynamic rotation of the water molecules that results from the ion migration under the influence of the electric field.[19] Principle of Operation: In electrolyte solutions, current is created by ions which migrate under the influence of an electrical field. In the case of an electrolytic liquid filled loop antenna, the voltage gradient is due to the Lorentz force that can be generated by two electrodes connected on opposite sides of the loop, similar to that of a toroid shaped battery. The antenna must be designed and tuned so that the charge-discharge-charge cycle occurs at a specific resonant frequency, that determines the antenna frequency.[19]

## II. Antenna Structure

This paper presents an antenna design using liquid metal for conductors and a stretchable substrate material. A Planar hexagonal wide band microwave frequency antenna for frequency range of 3.1- 9GHz. Its uniplanar structure makes it a suitable antenna type for a design that should be bendable. The ground area should be “infinite”, which in practice means that it should be significantly larger than the radiator. In the 3.1-9 GHz band, the antenna features diverse modes at different frequencies. The antenna radiator is 19.4mm.The omnidirectional pattern of planar hexagonal antenna makes it suitable for body area networks. When realizing this design with liquid metal, the conducting surfaces are replaced with a grid of liquid metal filled channels inside the substrate.

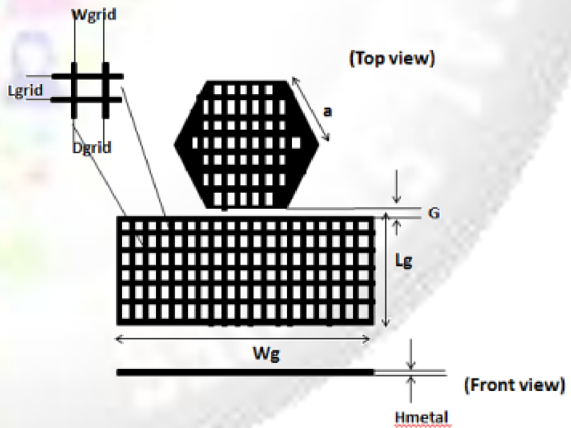


Fig. 1: Geometric configuration of the 2-D stretchable Planar Hexagonal wide band antenna

The antenna is designed on low cost PDMS substrate.Its dimensions are Wgrid=1.5mm, Dgrid=2mm, Lgrid=1.5mm, Lg=25mm, Wg=40mm, W2=1.75mm, W1=1.25mm, R=10.4mm,Hmetal=0.1mm,G=0.3mm.

## III. Simulation Results

The proposed Planar Hexagonal wide-band antenna for IE3D simulation studies is shown in Figures below.

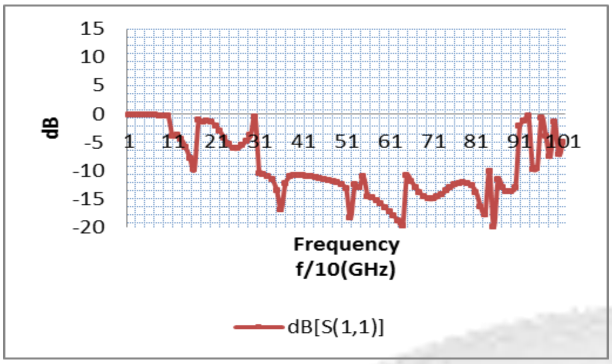


Fig. 1: Simulation result of Planar Hexagonal wide band antenna.

The antenna consists of a radiator and a rectangular ground plane. The antenna is designed on lowcost PDMS-substrates with a thickness of 0.5 mm, a relative permittivity of 3 and optimized in terms of impedance bandwidth (S11 < 10 dB) using IE3D simulation. The conducting liquid(Sodium chloride) medium has relative permittivity of 5.9,having conductivity of 5m/s.

## IV. Conclusion

A highly foldable and stretchable Planar hexagonal antenna with good electrical performance has been presented. The demonstrated planar wide band antenna which fulfills the requirements of UWB applications operating in the 3-9GHz band. The antenna allows stretching , folding and twisting, all without mechanical damage. A wide range of applications can be foreseen in various areas such as wearable computing, healthcare & fitness wireless sensors, and radio frequency identification (RFID) systems.[18]

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