Cotton based head band sensor for osseointegration monitoring in the human forehead

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This paper presents a cotton-based sensor to identify the stages of Osseo integration by monitoring and analyzing the dielectric parameters from the human forehead. A special case of bone implant property variation in the craniotomy scenario of the forehead is selected for this study. Researchers are using microwave energy [1] to identify the bone mineral density by looking at its dielectric properties. The fundamental principle of resonance frequency variation with respect to the effective dielectric constant of a resonator is utilized in this work. The geometry of the resonator along with the top and side view is shown in figure 1. The geometry consists of a microstrip circular loop as a feeding line, which is parasitically coupled to a circular patch on the same plane placed at the center with a small separation gap. The usage of parasitic coupling over direct feeding has been analyzed earlier [2]. The prototype is compact with an overall dimension of 40mm x 40mm. The outer and inner radius of the outside feeding ring is selected for 50 ohm impedance matching. The radius of the circular disc is affecting the coupling of EM energy and resonance. The feeding ring has terminated at a distance D from the feeding line. Skin and bone of specific dielectric properties are used for simulation analysis. Since the radiator is a microstrip geometry, the electromagnetic radiations are mostly directed towards the biological phantom, which is placed in the boresight direction of the device.

The prototype is simulated on a cotton material of dielectric constant 1.7 and loss tangent 0.02 and a thickness of 1mm. Without loading biological samples, the device resonates at a frequency of 4GHz.

It is advisable to design a low gain antenna while designing a prototype for near body wearable sensing applications, since it reduces the impedance matching challenges. Moreover, it should be highly sensitive towards the variation in dielectric properties of the medium in which the device is placed. Low gain nature will reduce the specific absorption rate and will ensure impedance matching in a wide dielectric region. This designed sensor is a bad radiator with low gain and having good impedance matching. When the device is loaded with a material of different dielectric constant the resonant frequency is found to shift corresponding to the variation in effective dielectric constant. Since the dielectric constant is inversely proportional to the resonant frequency, the device operating frequency shifted to the lower region when loaded with a material of different dielectric parameter. Thus, this can be used as a good sensor for analyzing the implant variation.

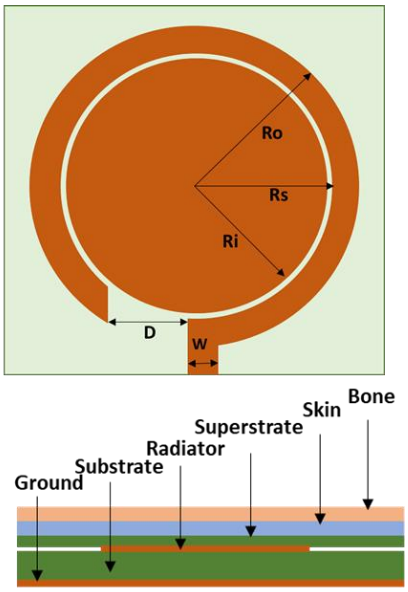

Figure 1. Geometry of prototype.

A rectangular section of 30mm x30mm is selected for the implant location, which is exactly covering the physical geometry of the prototype. The implant property variation from abnormal (Void, Water buildup etc) to normal (converted to normal bone) scenario is analyzed by varying the dielectric property of the area under test. It is found that the prototype is capable of identifying the variation in dielectric properties by looking at the resonance frequency variation.

Acknowledgement- This research is supported by TANSCHE RGP. We thank Vice Chairman and Member secretary of TANSCHE who provided constant support and help for this research.

References

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