Wireless RF Digital System for Mouth-Embedded Multi-Sensor Communication

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Introduction: This paper will lay the framework for a design to provide digital wireless transmission for multiple sensors, embedded in dental implant or on teeth to monitor the mouth condition Models of EM antenna radiation patterns are used along with circuit designs for analog to digital conversion and digital transmission to realize this system of communication.

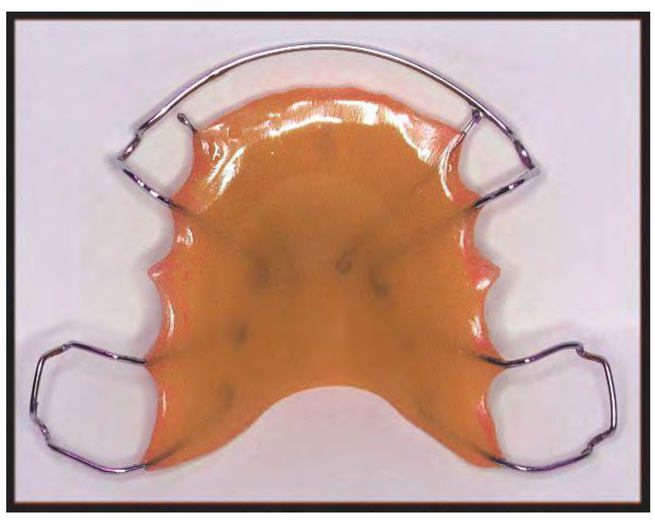


Figure 1. Hawley retainer to be placed into the top of the mouth and fits snugly behind the teeth, where ICs will be placed. Antenna is placed behind the teeth.

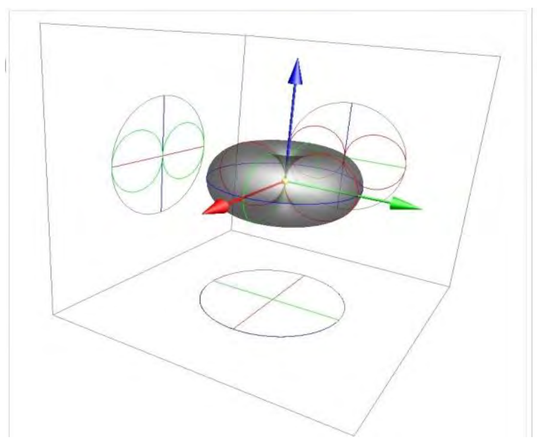


Figure 2. COMSOL Simulation of the electromagnetic radiation in wolfram. Simulation is done at .5λ, but a .47λ would be nearly visually identical. Antenna is parallel to the z-axis, thus there is no radiation in the <0,0,1> direction.

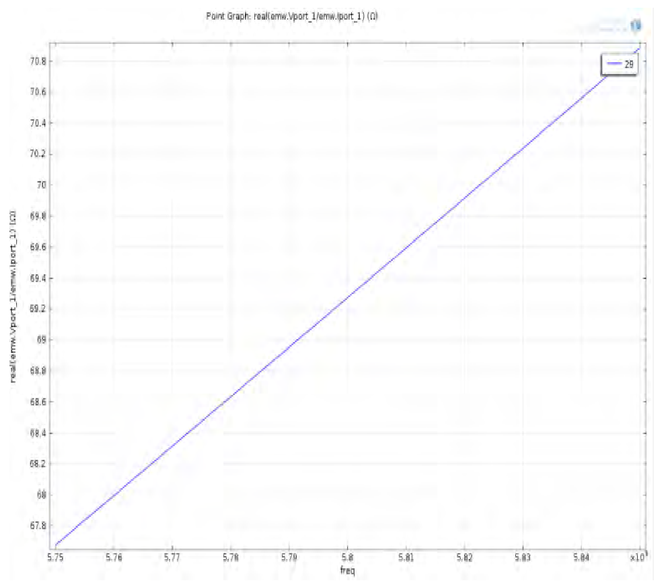


Figure. 3. COMSOL plot of the impedance of the antenna and port at a range of 5.75 to 5.85 GHz. At the center frequency of 5.8 GHz, there is an impedance of 69.3Ω.

Results:

Skin depth is calculated from:

$$\delta = \left(\frac{1}{\omega}\right)\left\{\left(\frac{\mu\epsilon}{2}\right)\left[\left(1+\left(\frac{1}{\rho\omega\epsilon}\right)^2\right)^{\frac{1}{2}}\right)-1\right]\}^{-\frac{1}{2}}$$

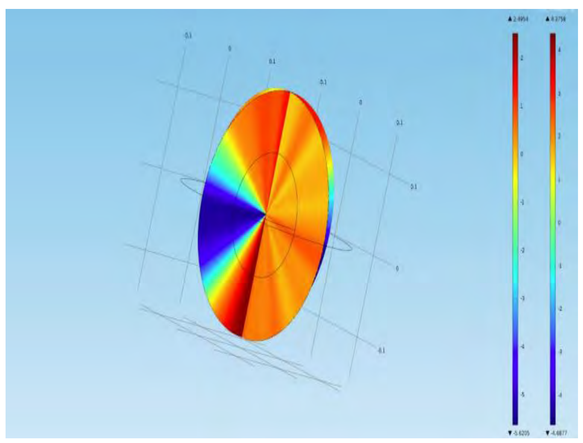


Figure 4. A COMSOL rendering of antenna radiation with four front teeth behind the antenna. Signal in front of teeth is approximately 1.9 norm dB, while signal behind teeth ranges from -2 to -6 norm dB.

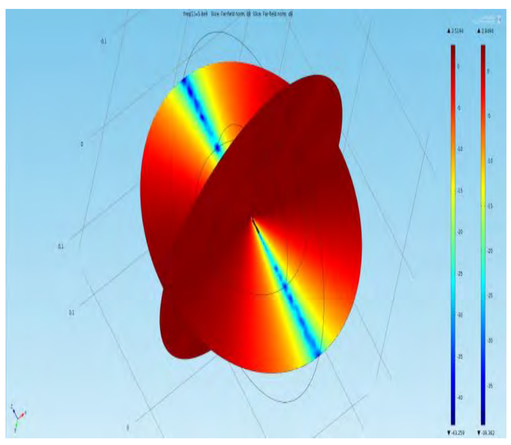
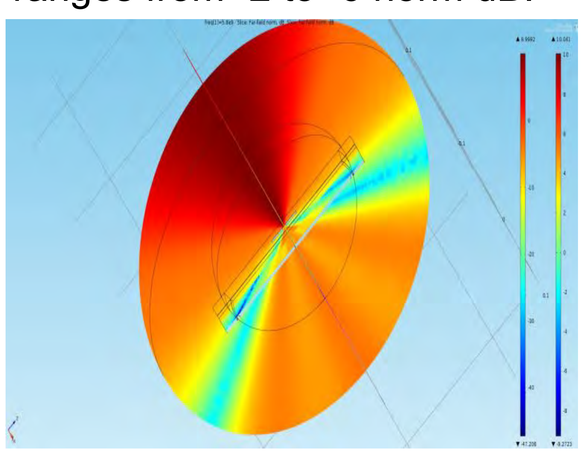
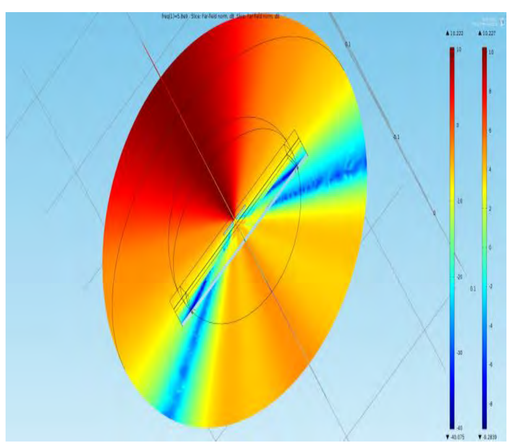


Figure 5. A COMSOL rendering of antenna radiation at 5.8 GHz using a dipole antenna.



(a)



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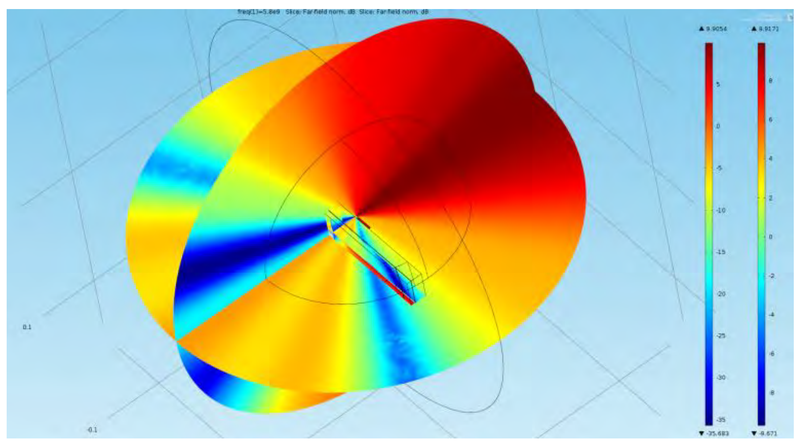

(c)

Figure 6.Radiation from antenna with different tissues behind. (a) for 2600 μm of skin with 1 cm of fat tissue stretched across the antenna. Ranges of -3.1 to -7.3 norm dB, (b) 2900 μm of skin with 1.1 cm of fatty tissue stretched across the antenna. Ranges of -3.4 to -8 norm dB, and (c) 3100 μm of skin with 1.1 cm of fatty tissue stretched across the antenna. Ranges of -3.9 to -8.5 norm dB.

Conclusions: The study proves that EM waves at 5.8 GHz can be transmitted through the lip tissues without significant attenuation. Antennas using this frequency can be used to communicate data from and to the mouth to read embedded sensors in the teeth or dental implants.

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