Feasibility of Blood Oxygen Saturation Levels using Non-contact Microwave Measurements at 60 GHz

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This paper investigates the feasibility of remotely detecting and monitoring blood oxygen saturation levels in humans. The technique relies on the detection of resonances induced by electromagnetic absorption in the presence of oxygen, which are observed at frequencies around 60 GHz (T. A. Ricard, Ph.D. Dissertation. University of South Florida, 2008). In this paper, we develop an electromagnetic model for the cutaneous blood vessels distributed just beneath the skin layer to investigate the feasibility of detecting resonant responses due to the blood oxygen levels.

The oxygen saturation is an important parameter to measure for human vital signs. If the oxygen levels reach below 90%, this is considered to be hypoxemia. Levels reaching below 80% can cause serious morbidity and mortality secondary to the risk of ischemia and potential end-organ damage thereby critically compromising the function of organs including the brain and heart. Conventionally, a pulse oximeter device is used to measure the peripheral capillary oxygen saturation (SpO_2) by clipping a small device to the finger. However, noncontact measurement for monitoring vital signs are desirable.

In this study, we model cutaneous blood vessels under the skin layer, and study the backscattered fields to determine whether we can detect oxidization levels in the blood vessel. The frequency range of operation is from 59 to 63 GHz, mirroring the range where the oxygen resonance spectra occurs. We use an infinite slab with a thickness of 2mm to model the homogeneous skin. The thickness of the skin is chosen at multiple skin depth values for the frequency range discussed above. The blood vessels are located at a depth of 0.4mm beneath the skin layer. The segments of vessels are distributed in a random fashion on a plane beneath the skin to emulate the web like structure of the vessels.

In this model, we assume that each blood vessel acts as an independent antenna embedded in the skin. The radiated fields from each vessel inside the skin layer is computed using MoM. The total back-scattered field is then calculated from the sum of the back-scattered fields of each blood vessel with the appropriate phase shift. This concept is similar to the concept in the antenna array theory. The coupling effects between the blood vessels are not considered in this paper. The resonances in the scattered field signature will be investigated for potential correlation with resonances due to oxygen absorption and oxygen saturation level.