Antenna Design for Medical Biotelemetry Applications: Small Antennas for Ingestible Capsules

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The role of wireless electromagnetic devices in the medicinal field has vastly expanded over the recent years. With the latest approvals by the FDA for capsule-based medical devices and the allocation of frequencies for medical telemetry by the FCC, the necessity for a wireless link in medical devices is apparent. For instance, in the application of bio-capsules, real-time data collected through the gastrointestinal tract must be transferred through the body to provide physicians with biological data that can help evaluate patients for conditions like gastroparesis. The challenge is therefore designing a wireless device that is capable of transmitting information through the human body whilst meeting physical size and frequency restraints. Additionally, the antenna must comply with health regulations as it must be bio-compatible with the human body and meet safety levels for human exposure. In order to meet these requirements, it is necessary to not only analyze the effects of the human body on the antenna but the effects of the antenna on the human body. Since measurements of the body effects on the antenna can be complicated, it becomes essential to integrate the effects when simulating the device.

In this paper, a viable antenna design for the application of bio-capsule telemetry is introduced and analyzed through the use of a numerical electromagnetic simulator. The design of the antenna consists of bio-compatible materials that are contained within a digestible bio-capsule. In order to simulate the capsule traveling through the body, a complex body model is utilized to identify the body effects on the antenna. The antenna's radiation characteristics along with the electromagnetic energy exposure witnessed at different locations within the model are produced, demonstrating the effectiveness and safety of the antenna within the human body.

The antenna design takes into account surrounding body tissues so that it is matched at the possible operating frequency range of 400MHz -1.4GHz, complying with the medical bands established by the FCC. To provide realistic physical simulations, the antenna is housed within an acid resistant ingestible capsule measuring 26mmx13mm, slightly larger then that of a multi-vitamin tablet. Using the simulator's body model, the antenna will be characterized taking into account realistic conditions. Inclusive of this, the detuning effects on the antenna within the body will be investigated along with the 1-g averaged specific absorption rate (SAR) as indicated by ANSI/IEEE regulations.