Miniaturized and Multiple-Polarization Ingestible Capsule Antennas

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Implantable and ingestible devices designed to monitor physiological data of the human body have great promises for disease prevention, diagnosis and therapy. Among those devices, the ingestible wireless capsule endoscope (WCE) has appeared as an effective and painless technology to obtain inspections from inside of a human body. The first wireless capsule was invented in the 1950s, but its capabilities are very limited that only the temperature, pH, and pressure of the gastrointestinal (GI) tract could be measured. In 1997, the first several practical prototype of the capsule endoscope system was developed with the implementation of a miniature charge-coupled device (CCD) camera. The first wireless video capsule endoscope system that could be swallowed by patients was developed in 2000 thanks for the introduction of the low-power, complementary, metal oxide semiconductor-based (CMOS-based) image sensor. Since then, significant improvements have been made on WCEs in the performances of image resolution, frame rate and power consumption.

A capsule antenna is a key component in the WCE system and a lot of efforts have been made in these years. As the space of the capsule is limited, antenna miniaturization is crucial. Spiral antennas and meander dipole antennas are the common antenna types in capsule antenna designs. Moreover, the capsule travels in the complex body environment characterized by various permittivity values and a wide bandwidth is typically required. Furthermore, when the capsule is swallowed into the human body, the orientation of the capsule is random, which may lead to possible polarization mismatching and further deteriorate the communication quality. There exist few methods to address the polarization mismatching problem. One is to put multiple antennas in various directions outside the human body, which means the receiving antennas have polarization diversity performance. The alternative way is to design a diverse polarization capsule antenna.

In this work, a multiple-polarization antenna for WCE systems will be presented. By bending a traditional dipole, three orthogonal currents are obtained. Currents in different orientations provide polarization diversity characteristic which can realize the orientation insensitive performance. Communication links between the capsule antenna and an external receiving antenna are evaluated and measured. Measurement results indicate that the proposed antenna shows better direction insensitivity performance when the orientation of the capsule antenna changes.