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## **Antenna Systems for Wireless Capsule Endoscope: Design, Analysis and Experimental Validation**

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In this paper, we provide novel small antenna solutions of a wireless capsule endoscopy system operating at 433 MHz ISM band. The in-body capsule transmitter is an ultrawideband conformal loop antenna, whereas the on-body receiver is a monopole antenna with a partial grounding. The in-body antenna occupies the outer-wall of the capsule while keeping a camera sight clear so that the inner space of the capsule is available for the other components of endoscope modules. The capsule antenna has a 10 dB impedance matching from 300 to 875 MHz. The ultrawideband characteristic enables the capsule antenna to overcome the detuning effects due to electronics modules in the capsule and proximity of the capsule to various different tissues in gastrointestinal tracts. The on-body antenna is numerically optimized on single tissue and multi-layer tissue phantoms, followed by in-vitro and ex-vivo measurements for the validations. The on-body antenna shows 10 dB impedance matching from 390 MHz to 500 MHz. Finally, this paper reports numerical and experimental studies of path loss for radio links between an in-body capsule transmitter and an on-body receiver using our antenna solutions. The path loss is less than 56 dB regardless of the capsule orientations.

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