Indian Institute of Technology Delhi

School of Interdisciplinary Research (SIRe)

SIRe Project Number

2025-01-18

(will be assigned by SIRe)

Project Proposal for Ph.D.

Project Details (The research problem must clearly indicate the need for an interdisciplinary approach)	
Project Title	High data-rate, Low Power Nanoscale Transceiver Integrated Circuit for Wireless Capsule Endoscopy Utilizing Ingestible Antenna
Project Summary (Minimum 500 and maximum 2000 characters)	This research is focused on the design and development of ingestible capsule prototype (ingestible for humans and implantable for animals that can range in size from a mouse to a cow) as a transceiver using intelligent co-design approach for designing subsystems (conformal antenna and CMOS transceiver IC) in a wireless capsule endoscopy (WCE) system and subsequently, characterize the system as follows: **1. Design and Implementation: Conformal Antenna (part of capsule)** • Design and modelling of the conformal antenna as per ANSI and FCC medical guidelines. • Analytical and numerical approach for designing biocompatible conformal antenna suitable for the frequency bands licensed for medical applications, followed by its commercial fabrication. • Develop tissue phantom model and characterization of its electrical properties for the measurement of conformal antenna (develop link-margin between designed antenna embedded in phantom and commercially available standard base-station transceiver system outside phantom). **These objectives would be accomplished through supervisor-1 (Dr. Vikrant Kaim).** **2. Design and Implementation: Nano Scale CMOS Transceiver (part of capsule)** • Design and analysis of CMOS based signal processing unit (i.e. Front-end transceiver: pulse generator, pulse modulator and demodulator with power amplifier & LNA) on a single platform in order to achieve a high data-rate and Low power. • Layout and tape-out of front-end transceiver using 180nm CMOS process. • Integration and synchronization of signal processing unit with commercially available products (biosensor and camera). **These objectives would be accomplished through supervisor-2 (Dr. Sandeep Kumar).** **3. Development of Prototype and Physical Experiments: Integrated CMOS transceiver and Conformal Antenna (capsule prototype)** • Commercial fabrication of custom made capsule shell using bio-compatible flexible material with the help of Co-PIs (medical professionals). • Integrate the contacting pads of conformal antenna and signal processing unit using electronic microscope and micro tools. • Physical experiments for data telemetry (real-time wireless transfer of recorded biological data (pressure and temperature of the muscles in the vicinity of capsule, using biosensor) and captured images (using camera) of the muscles through *in-vitro* (muscle phantom) and *in-vivo* (rodent) measurements) will be executed from the implanted developed prototype to the commercially available external base-station system while performing verification and validation of the results with the help of medical professionals. • Physical experiments for power telemetry (real-time wireless power transfer for both *in-vitro* and *in-vivo* measurements) will be executed from external base-station system to the developed prototype. **It is to be noted, the proposed applications to be carried out with the help of ingestible and implantable capsule is diagnosing the complete gastrointestinal tract (GIT) of human but, in order to develop the proof-of-concept, the performance validation of the capsule prototype would be done through implantation in the stomach of a mouse, rabbit, pig,**

	sheep or cow (*in-vivo* measurement). The animal subject for the measurement may vary depending on the availability during measurement. **4. Data Processing at the base station** • Installation of base station near the subject so as to receive data transmitted by transceiver resting within capsule. • Processing the data received using image processing techniques. This research problem critically needs an interdisciplinary approach because it involves expertise in three domains as follows: - Ingestible capsule based antenna design and biological phantom based measurement. - Design of low power IC chip specifically for WCE application. - Signal (image/videos) processing of human's GIT.

Ph.D. Supervisors
(Supervisor 1 and Supervisor 2 cannot be from the same department of IITD)

Role	Name of Faculty	Academic Unit in IITD/Institute/University	Email ID (Official)
Supervisor 1	Vikrant Kaim	CARE, IIT Delhi	vkaim@care.iitd.ac.in
Supervisor 2	Sandeep Kumar	Special Centre for Nanoscience, JNU, Delhi	skamera@jnu.ac.in

Project requirements (Student qualifications, experience required, etc)
***The candidate will be shortlisted based on common shortlisting criteria decided by ScRC (SIRe)**

- Student should have done BE/B.Tech degree in electronics/electronics and communication/EEE whereas, master's degree in core RF and microwave engineering or equivalent.
- Exposure in antenna design and circuit simulation would be preferred.

Source of fellowship/funding and project number
(CSIR/UGC/DBT/ICMR/ICAR/NEET-PG/DST-INSPIRE/IRD/FITT Project details, if any)

Candidate with his/her own fellowship

Role of Faculty Members involved:

Supervisor-1	• Robust ultra-miniaturized wireless power-based antenna platform in the vicinity of electronic circuit models will be designed under the supervision of Dr. Vikrant Kaim. • Further, realistic models of GI tract phantom and electronic circuit components of WCE system will be investigated, develop and characterized to facilitate the design and operation of antennas for real time applications. It will include the investigation of optimal location inside the biocompatible capsule shell to overcome tissues and electronic components' electromagnetic interference (EMI) on antennas' radiating power.
Supervisor-2	• Design and implementation of circuit design with proposed techniques will be done on Analog virtuoso cadence platform using 180nm CMOS commercial process. • Observing new parameters and improves high data-rate and lower power consumption with existing ones for WCE applications. • Develop new tools/methods for sensing physiological signals. • Develop an electromagnetic compatibility of designed IC with antenna units using

	analytical and fundamental. • Fabrication and measurement of co-design approach (circuit model with antenna) would be conducted.