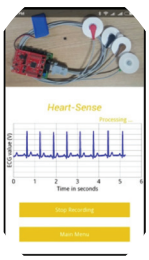
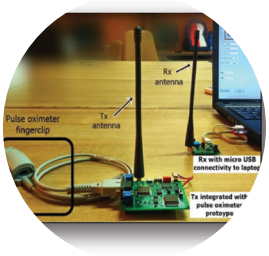
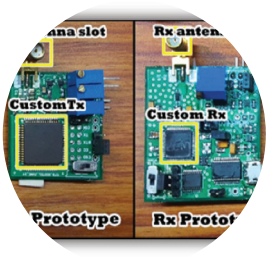
Biomedical instruments of the Internet-of-Things (IOT) era







With the recent thrust in the Internet-of-Things and wearable electronics, it is expected that all the conventional medical instruments would be highly unobtrusive as well as connected to the internet in near future. However, this imposes several fundamental challenges in their design like low-power consumption, low-noise design, EMI immunity, motion artifact tolerance, low radiation bio-signal communication.

One aspect of our research is the development of ultra-low noise instrumentation amplifiers (INA) as plug-in solutions that can be used to record various bio-potentials as well as signals from bio-sensors. We have successfully demonstrated a complete ExG measurement system prototype built using our CMOS custom designed application specific integrated circuit (ASIC). The user interface for this prototype is developed in Python programming language for both PCs and android based smartphones. For the ECG recording application, to make the recording over a long time possible in an unobtrusive manner, we have also developed an ECG patch. We have also developed an ultra-low power pulse oximeter (PO) ASIC suitable for application in wearable platforms with tolerance to the unavoidable finger movements. To demonstrate the functionality of the custom designed PO ASIC, we have made a fully functional pulse oximeter prototype, OxiSense. The user interface is developed in Python for PC and android based smartphone. By virtue of its unique signal processing algorithm, the PPGs acquired by OxiSense is relatively immune to minor motion artifacts like shivering and finger movements which are unavoidable in many patients.

We have also developed a wireless telemetry system (Bio-WiTel) for wearable/implantable medical devices. This system can be used for diagnostic and therapeutic purposes such that a large population can get quality medical assessment by the virtue of remote health monitoring techniques. Various wireless communication technologies have been evaluated in this work. As per the recommendations of Federal Communication Commission (FCC), USA and Wireless Planning Commission (WPC), India, Medical Device Radiocommunication (MedRadio) band in 401-406 MHz frequency range has been selected for wireless communication of bio-signals. Low power wireless transmitter (TX) and receiver (RX) systems for bio-signal communication over a short range (up to 3 m) have been also proposed for MedRadio band and custom CMOS integrated circuits (ASIC) for TX and RX have been designed, fabricated and tested. This is one of the unique full system solutions for MedRadio band reported till date. The specifications match the FCC recommendations. The bio-signal communications has been successfully demonstrated at home and hospital environments by using these custom telemetry ICs. A miniaturised ($14 \times 14 \times 2.45$ mm^3) MedRadio band micro-strip antenna has been also designed for implantable applications. In-vitro characterisation of the antenna has been performed and the gain was measured as -40 dBi.

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