# A Circuit Technology Platform for Medical Data Acquisition and Communication

## Outline of a Collaboration Project within the Swiss Nano-Tera.ch Initiative


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***Abstract* — Recognizing the importance of interfacing a variety of sensors and networking such sensors around the body area and by cellular services, a Swiss project within the Nano-Tera.ch Initiative is dedicated to developing a platform of circuit technologies for medical data acquisition and communication.**


### I. INTRODUCTION

Aging population and high medical cost in industrialized countries have heightened expectations and demands by governments and public alike that low cost medical devices be developed for better ambulatory health care. Integrated systems, incorporating medical sensors and actuators, miniaturized and low power data acquisition systems, short range wireless link and wide area connectivity to medical centers, play a key role in realizing this new vision of health care provision [1], [2].

The Placitus project investigates the challenges in mixed signal platforms, such as those embedded in biomedical electronics, Microsystems, sensor networks and wireless communications, from both device and systems perspectives. Integrated circuits and demonstrators are targeted that cover generic sensor interface and data acquisition, passive telemetry, wireless body area network, wireless sensor network and wireless wide area networks. The resulting circuit technology platform will benefit other projects in the Nano-Tera initiative in Switzerland focusing more on the sensor/actuator side of health care and environment.

### II. OVERALL SYSTEM VIEW

The Placitus project envisages a system consisting of many sensors and actuators interfaced to micro power data acquisition and driver circuits, respectively. These acquisition circuits can either be powered by battery, or by remote power coupled inductively, for example, from a desktop source. A short range wireless network will link the sensor nodes together and manage the data flow to the outside world centrally. A wide area network wireless modem, with power consumption commensurate with wearable applications, periodically communicates with remote health centers, transmitting data that require analysis and receiving instructions when necessary. This system view is illustrated in Figure 1 below.

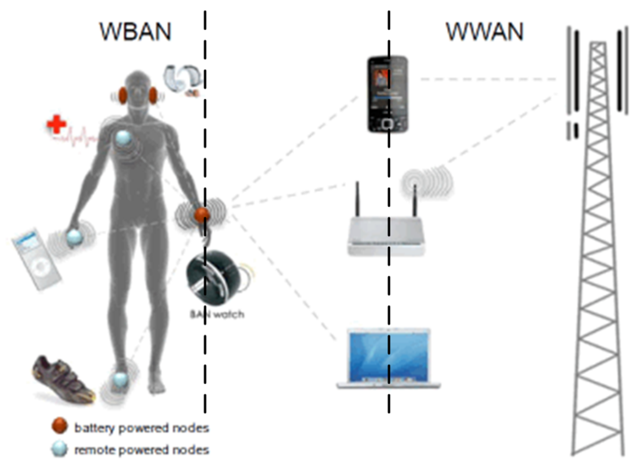


Figure 1 Overall system view of a medical sensor network

The key technologies required to realize the above system have been identified as low-noise, low offset sensor interface electronics, data acquisition systems, power management unit for passive telemetry, short range, low power wireless transceiver and digital modem for body area networks, low power micro controller for network and data flow coordination and elements of wireless transceiver and modem that will make wide area (cellular) network more amenable to wearable, embedded applications.

### III. SENSOR INTERFACE AND DATA ACQUISION

Depending on the biomedical signals being picked up, medical sensors can take the common form of electrodes of varying degrees of sensitivity and miniaturization, resistive and



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capacitive pressure sensors, temperature sensors, or more exotic sensors based on arrays of nano-structures targeting cell level resolutions. Most sensors eventually turn received signals into (differential) voltages or currents and such signals tend to be weak and, not infrequently, accompanied by large common-mode signals and differential offsets. Low noise amplifiers, be it of voltage or current, need to have high common mode rejection ratio, an ability to cancel differential offset from the source, low offset by the amplifier itself, high gain, and low noise. Because biomedical signals tend to be low frequency, flicker noise plays an important role in such low noise amplifiers. In the Placitus project we target interface electronics very close to the sensors, i.e., distributed with the sensors to various parts of the body to minimize the amount of wires across the body. Low power is therefore very important. Ideally as many sensors as possible should work in passive telemetry mode, limiting the total power potentially available to the data acquisition unit altogether. In addition to the low noise amplifiers, filters and analogue to digital converter need to be low power as well. To accommodate multiple sensors, multiplexing may be needed in one form or another, so AD converter bandwidth is not necessarily low. The typical issues above will be investigated during the project.

## IV. Power Management for sensor circuits

Like most autonomous electronic circuits, power supplies for distributed biomedical sensor networks need to be regulated to provide reliable operation with a relatively small overhead in current consumption. Power domains need to be carefully partitioned to avoid interference with sensitive signal paths, be they low frequency sensor signals or high frequency wireless reception. In passive telemetry, power itself is transmitted to the sensor node, for example, by inductive coupling. The amount of power receivable depends on the way power is coupled through, frequency at which power is transmitted, physical area dedicated to collecting power and the efficiency with which received AC power is converted to DC and regulated to a usable level to power the electronic circuits attached to it. In the Placitus project power management will be investigated holistically from system concepts to actual realization of efficient power management units.

## V. Wireless body area network

Many standards exist today for personal area or body area wireless networks. It is nonetheless a challenging task to put a realistic concept forward for minimizing wired connections between a portable electronic unit and sensors or electrodes placed at where the signals need to be picked up. Power consumption is still too high for most radio transceivers to be operating without a battery. Even with a battery, a wireless modem needs to have intelligent scheduling in order to operate at low duty cycle. Depending whether a sensor or group of sensors need to be monitored continuously or only intermittently upon demand, the wireless transceiver/modem of moderate data rate can be complemented by a wake-up radio operating at extremely low power consumption, and a system scheduling concept that ensure flexible use of the system.

From a circuit design point of view, the potential to improve power efficiency for short-range radio is far from exhausted. In addition to low power circuit techniques, novel components based on special process technologies can also help improve power efficiency. FBAR technology, for example, can be used to realize resonators of very high quality factor. Front-end filters and oscillators are examples where FBAR resonators help improve current efficiency.

## VI. Elements of Wireless Wide Area Network

Wireless wide area networking via a cellular modem provides considerable added value to a sophisticated body area medical sensor network. Elderly patients can be monitored in the relative comfort of their own homes by miniaturized sensors and wearable electronics, alarms and data requiring analysis can be sent via the cellular network to health centers or their own physicians automatically or on demand. Low cost ambulances can be equipped with simple and wearable sensor networks and vital signs of patients being transported can be transmitted to awaiting doctors at the emergency hospital ahead of arrival, in real time.

Unlike a smartphone, a cellular modem intended as part of a medical sensor network does not have to have the same user interface, application software or choice of ringtones. Instead, miniaturization of the core modem, low power consumption, multi-standard support for several cellular services may be more important to ensure even better user portability, wearability, and service reliability than a mobile phone. Standby time and talk time may also follow a different pattern from the average phone user. Optimization of key elements of a multi-standard RF transceiver and digital modem for such medical use is an unexplored field, which is partially taken up in the Placitus project.

## VII. Partners and Status

The project Placitus was approved in late 2009 by the Swiss Nano-Tera.ch Initiative and started in summer 2010. Three leading Swiss centers of mixed signal analog, digital and RF integrated circuits are represented in the project, with EPFL focusing on sensor interface, data acquisition and remote powering, CSEM on wireless body area networking and ETH on elements of cellular RF transceivers. All three partners have considerable prior experience in the areas discussed in this paper. Considerable efforts have so far been invested into planning of system concept, identifying key challenges and planning. The design of some of the key elements has commenced recently and we expect the first batch of circuit results to be available by early 2012.

## References


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