Demonstration of a Proprietary Chip for Dry-electrode ECG and Impedance Measurements

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Classical approaches to make high-quality ECG measurements require the use of shielded cables connecting gel electrodes to a central unit. Moreover, impedance measurement requires at least two additional electrodes for current injection. CSEM has developed a concept based on dry-electrode sensors able to simultaneously measure ECG and thoracic impedance. Prototypes with discrete components were built to validate the correctness of CSEM approach [1]. Following this, an ASIC was realized in order to drastically reduce the system size. The small system size (56×25×5.5mm) and the simplicity of the cabling (only one unshielded and possibly uninsulated wire) make the system highly wearable and easy to integrate in a garment, thus improving the patient comfort. A demonstrator was realized in order to assess the ASIC performances in real life scenario. This paper presents the results of this development.

The developed demonstrator measures one ECG lead and impedance (real and imaginary components). Figure 1 (left) shows the typical sensor placement on a woman garment, whereas Figure 1 (right) shows the developed prototypes which contains the dedicated ASIC. The system is made of two sensors (active electrodes) connected together with one simple unshielded wire, each sensor having two dry-electrode contacts with the skin. With only two sensors, this patented technologies allows one to get ECG with a quality equivalent to three-electrode systems and impedance measured with the tetrapolar approach requiring four electrodes. The small and thin form factor allows one to wear the device under a simple garment. In order to further improve the patient comfort, the sensors were molded into soft silicon. Each sensor contains its own electronics (including the dedicated ASIC) and power supply (battery).

Figure 1: Sensors positions on the body.

In addition to ECG and impedance measurements, the system has additional sensing functionality, namely an inertial motion unit (IMU) for measuring body movements of the wearer.

The system includes a flash storage device allowing for the recording of the measured signals without any need of external device. Data can be downloaded afterward for further analysis. A Bluetooth 4 (BLE) connection integrated in the system allows transmitting in real time a set of signals to an external device for monitoring or post-processing purpose.

The final demonstrator dimensions are 56×25×5.5 mm^3, including an 80 mAh battery. The battery allows a 24 hours of continuous measurement.

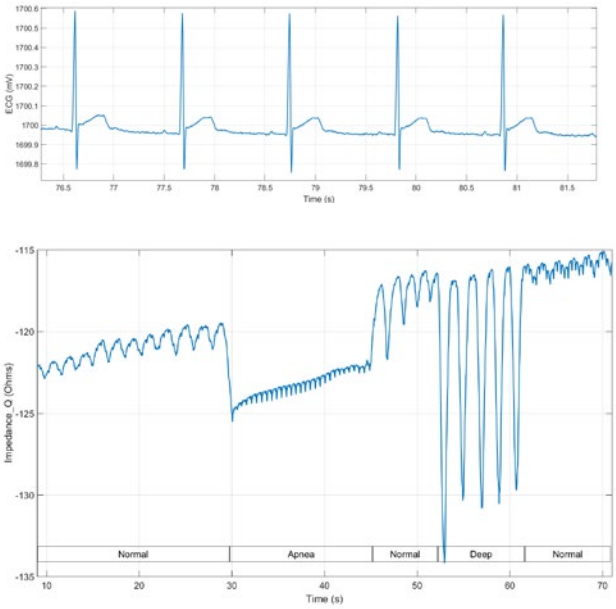

Figure 2: Typical ECG and impedance measurements.

The first tests conducted have shown good results of the system. The chip is fully operational. As shown in Figure 2, the ECG is clearly visible and complies with the medical standard for Holter devices, namely EN 60601-2-47.

The impedance signal shows that the respiration is visible during normal and deep respiration phases. Note that the impedance amplitude is much bigger during the deep phase, as expected.

The apnea phase shows that the signal is bound to the heart volume changes and/or pulmonary arteria distension. This is interesting for devices able to measure cuff-less blood pressure. It can also be extracted during the other phases with appropriate signal processing.

This demonstrator shows that the developed ASIC can be implemented in products that are compliant with medical standards and that require one-lead ECG and impedance measured with dry electrodes and simplified cabling.

[1] O. Chételat, *et al.*, "A Highly Integrated Wearable Multi-parameter Monitoring System for Athletes," 15th Nordic-Baltic Conference on Biomedical Engineering and Medical Physics, pp 148-151 (2011).