Smart Electrodes for Vital Sign Monitoring

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CSEM has designed several vital sign monitoring systems based on different technologies and topologies, either with centralized electronics and distributed passive electrodes, or smart electrodes with embedded electronics. The advantage of the integrated electrodes is that they no longer require a separate electronic box. However, the main challenges are weight, size, user comfort and, as a consequence, autonomy. Other issues are sealing, biocompatibility, easy-to-use interface and smart power management to reduce the energy consumption, when not used.

In the framework of European, CTI and industrial projects, CSEM is developing a new family of smart electrodes for the vital sign monitoring. Metrology and signal processing tasks remain a priority, because they impact on the final signal quality. Nevertheless, other aspects, like wearable comfort, biocompatibility and/or ergonomics are important factors to be taken into account. The targeted application with different constraints and expectations is also an important factor.

The basic functions of Smart electrodes are highlighted in Figure 1.

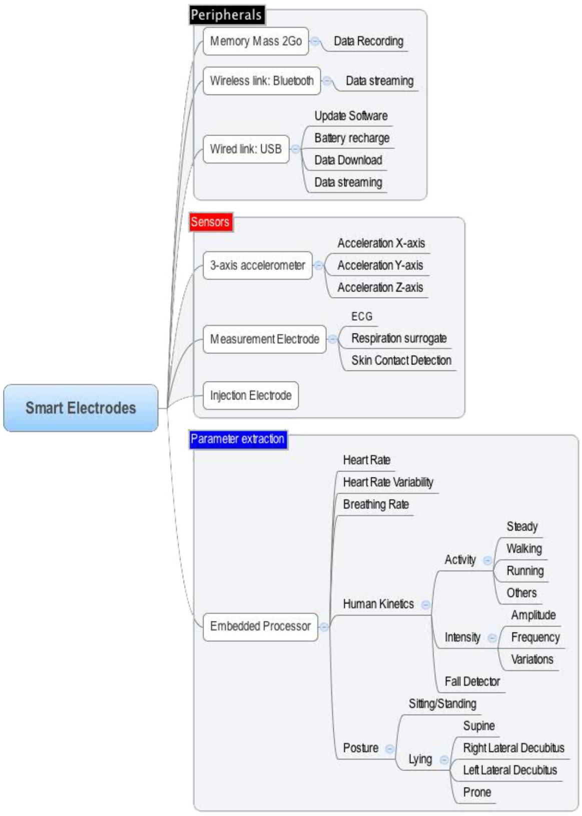

Figure 1: Diagram of the smart electrode features

In smart electrodes, the core of the monitoring system consists of embedded sensors, ultra-low power microcontroller, power computation capability, and user peripherals. Features such as medical quality, comfort and autonomy allow using the system for many continuous monitoring applications such as:

- Elderly in independent life
- Disease management solutions for cardiac patients
- Leisure and professional sports

In order to manage easily a user monitoring session, an important feature is an automatic contact detection of the electrodes when placed on the skin. Then, a wireless link with a smartphone, PDA, tablet or PC is automatically opened. For this wireless link, several possibilities exist which may make interoperability an issue. The implementation based on Serial Port Profile is supported by a lot of handheld operating systems but not iOS using PAN profile. Moreover, the market entry of the Health Device Profile (IEEE 11073) and Bluetooth LE must be considered.

Charging the battery requires a connector socket, which can also be used for data exchange, such as for instance data download from the memory mass or a firmware update. In previous designs, a micro USB was used, inducing three issues, namely size, reliability, and sealing. To solve them, metallic pads integrated in the housing have now replaced the connector. Another alternative is to use inductive charging systems, which allow recharging the battery without any pads. Such systems make the verification of the compliance with the medical safety requirements (IEC 60601-1) trivial, since no current can accidentally flow from the device to the body.

In any case, the removal of the USB connector imposes the use of a specific device, the so-called cradle (see Figure 2). The main function of the cradle is for battery charging, but it can also be used to download data and update the firmware with a wired connection as a faster alternative to the wireless link.

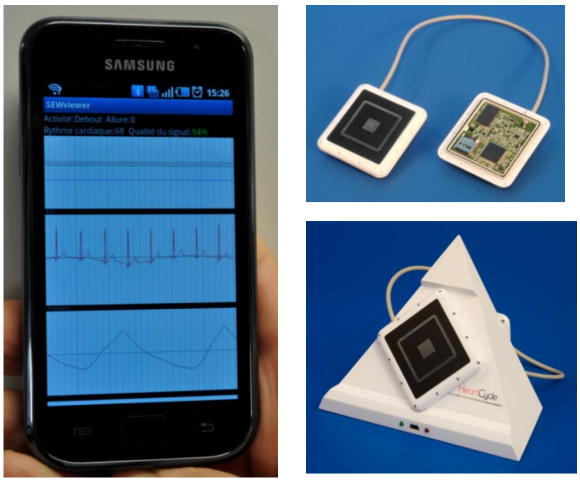

Figure 2: User Interface and smart electrodes

Systems like smart electrodes are required to address many aspects, sometimes unexpected such as the water tightness of a simple USB connector. Several iterations of design and detailed prototyping enabled CSEM to gain a precious experience in this promising technology.