Driven Shield for a Robust Heart Bio-potential Monitor for Stress and Wellbeing Applications

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Smartbeat is a wearable sensor recording heartrate variability, physical activity, sleep and stress in lifestyle assessments for better wellbeing. To identify and make stress-reducing behavioral changes actionable by the user, data needs to be accurate and available in real time for analysis and feedback. This project developed a technology which combines an innovative electronic circuit with superior EMI and ESD immunity, as well as a Bluetooth Smart connected device optimized for cloud-based computing of context detection and real-time actionable feedback.

Wearable ECG is subject to electromagnetic interference (EMI) and electrostatic discharge (ESD) which limit accuracy of beat-to-beat detection especially when superimposed to motion artefacts produced by intense activities, representing up to 5–7% of monitoring time. Analytics of heartrate variability offer rich and holistic assessment of the wellbeing of the user, therefore increasing the robustness of electronics to perturbations and therefore improving data quality. Furthermore, actionable feedback based on automatic context detection significantly improves the value of this analytics and leads to better user acceptance and market penetration. CSEM together with its finish partner Firstbeat, proposed the Smartbeat concept to address these two issues.

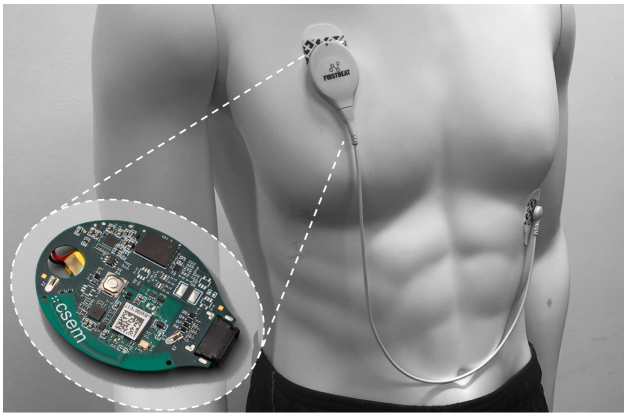

Figure 1: Smartbeat wearable heart rate monitor.

Figure 1 illustrates the miniaturized PCB implementing the driven shield and a Bluetooth Smart communication. The proposed electronic circuit uses two gel electrodes to measure ECG, and a third dry electrode to improve the robustness against EMI generated by various electronic equipment as well as the robustness against ESD events which occur frequently in synthetic sports garments.

Preliminary measurements show a significant reduction of EMI generated by various electronic devices or fluorescent lamps. Figure 2 illustrates the activation of the driven shield and consequent suppression of perturbations on the baseline signal.

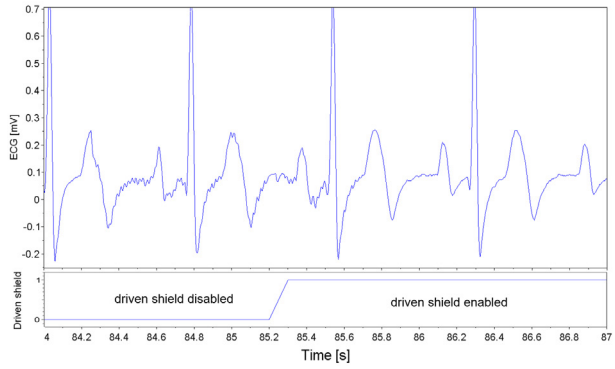

Figure 2: EMI resilience before and after activation of the driven shield.

Additional measurements show the strong attenuation of ESD events generated by synthetic garments. Figure 3 compares the behavior of a commercial device (in red) featuring several "additional" spikes similar to R-peaks, while the driven shield (in blue) absorbs most of ESD events and shows mainly regular R-peaks (green arrows).

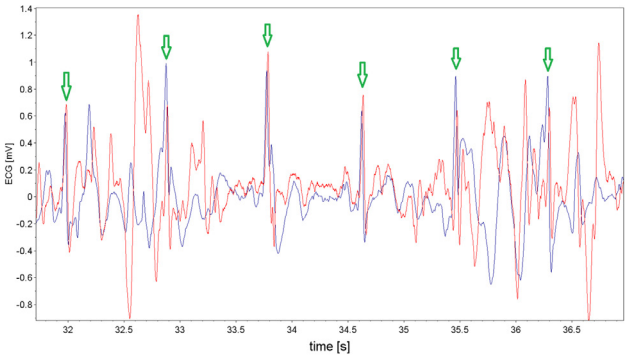

Figure 3: ESD resilience (driven shield in blue, commercial sensor in red).

Special attention has been paid to implement a seamless wireless connection to the cloud via a mobile device. Either live data can be streamed on-demand to a mobile device for instantaneous display, or recorded data can be seamlessly uploaded to the cloud by a background running task (via the mobile device). This synchronization process has been specifically optimized for frequent disconnections between the sensor and mobile device without compromising efficiency and focused to upload most recent data first.

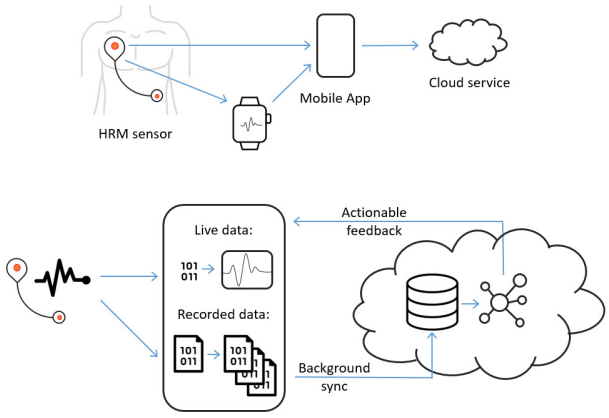

Figure 4: Connected device for actionable feedback.

The sensor developed at CSEM proposes a circuit with very high immunity to EMI and ESD events, and an almost real-time and seamless data upload to a cloud service, enabling a user actionable feedback while maintaining a monitoring autonomy of more than 1 week.

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