Project Report
on
CAPACITIVE COUPLED ELECTROCARDIOGRAPHY MEASUREMENTS EMPLOYING FLEXIBLE ELECTRODES IN A CAR SEAT

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1. INTRODUCTION

Although traffic safety is continuously improving, transportation still causes considerable personal and property damage. The majority of accidents happen because of human error. Monitoring the driver's condition can be a means to reduce such events. Daimler AG is already working towards this subject, e.g. in the BMBF (German Ministry for Education and Research) funded project INSITEX (Aktive *Ins*assensicherheit durch *i*ntelligente *Tex*tilien), the goal of which is to amend driver's safety with intelligent textiles. Here we present a study on the integration of Capacitive Coupled ElectroCardioGraphy (CCECG) into the seat of an upper class model of the Mercedes-Benz S-class to assist in observing the driver's condition without compromising any driving comfort. An electrode employing intelligent textile technology being integrated into the car seat is taken to measure CCECG, enabling to incorporate the measurement set-up into a car seat.

Actual conditions inside a car, like body movement, influence of seat components, and appropriate electrode placement, have been studied to get real life measurements. A car seat of the Mercedes-Benz S-class is considered for the final set-up and the implementation of the CCECG system.

2. MEASUREMENT PRINCIPLE & CONCEPT

The conventional way to measure ECG uses Ag/AgCl electrodes directly attached to the body [1]. Requiring direct skin contact, a more convenient approach for an automotive application is necessary. Non-contact capacitive ECG measurement was first described by Richardson [2], representing a possible solution to this problem. Here electrode plates and skin form a capacitance (C_{el}), through these capacitances an ECG can be obtained from the body with very high input impedance amplifiers (A_1 and A_2) close to the coupling electrodes [3]. Fig.1 shows the schematics of CCECG measurement, the circuit is set up as proposed by Kim et al [4]. The differential amplification of the combined electrode signals provides amplification and reduces the common mode noise. An additional "driven seat circuit" (A_3 et al) corresponding to the classic driven right leg circuit, is implemented to reduce common mode noise further.

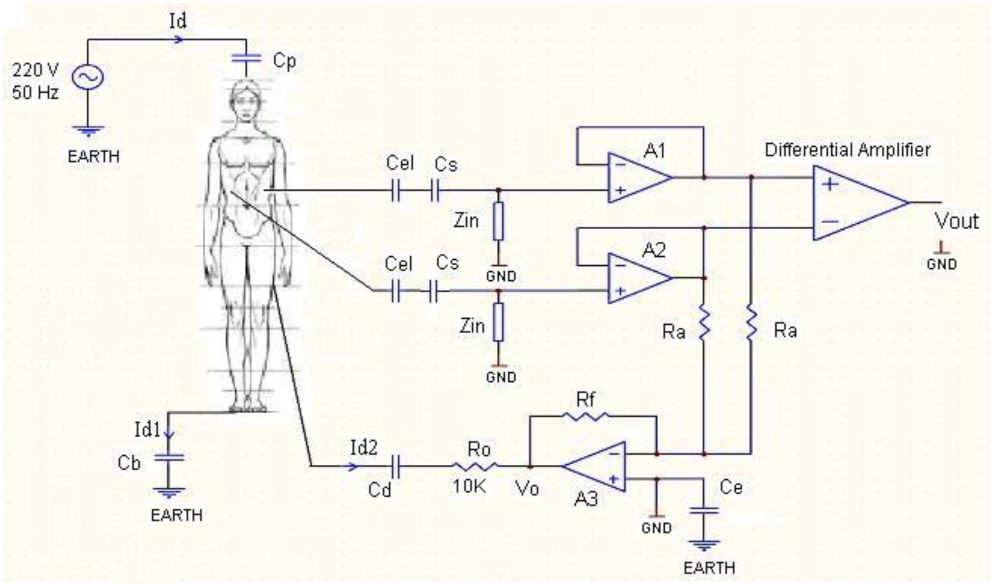
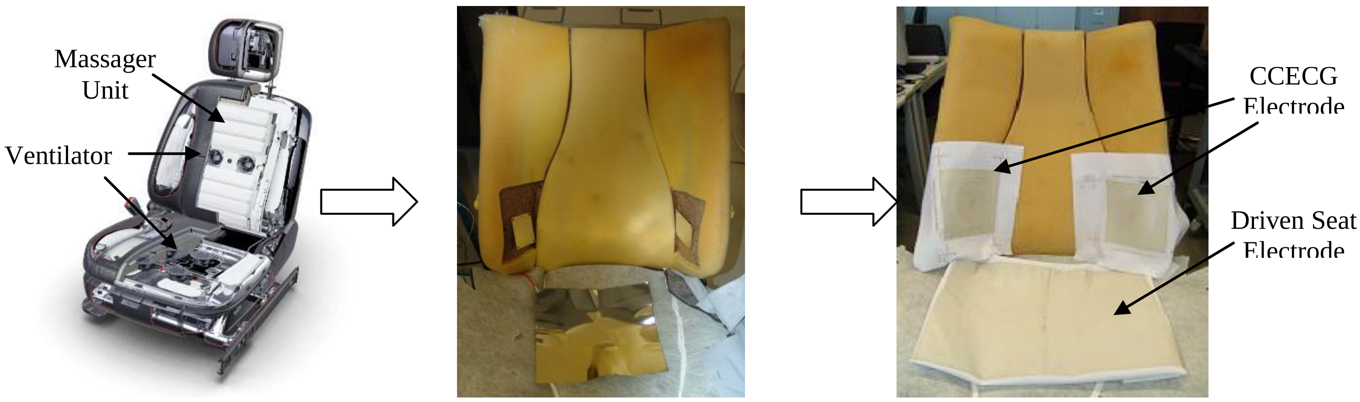


Figure- 1 Schematics of Capacitive Coupled Electrocardiography.

3. IMPLEMENTATION :

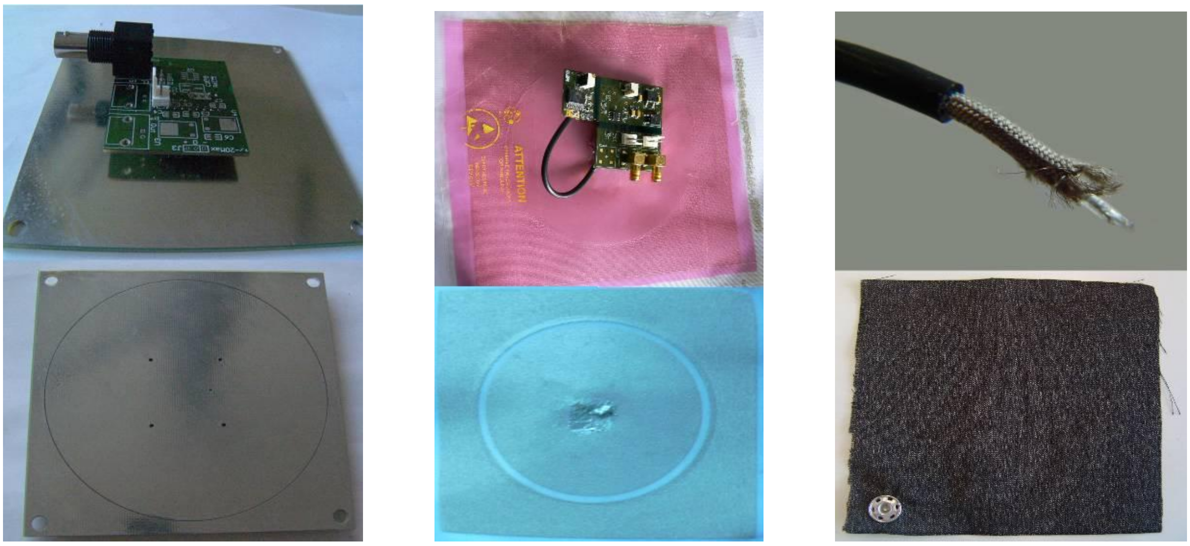
To verify the feasibility to measure CCECG within a car seat, a first study was done with Printed Circuit Board electrodes [5]. After proving the feasibility, further experiments with textile electrodes were carried out. The configuration is shown in fig.2(c), where the conductive textile sheet for the driven seat circuit also can be seen. The electronics is converted to starflex (semi flexible) to cohere the textile electrode shape (Fig3(b)). A seat of the Mercedes-Benz S-class, Fig.2(a) is considered for integration the electrodes. The real implementation is currently done on a special experimental seat, because it allows to quickly implement system changes. Fig.2(b) shows electrodes integrated into that car seat.



(a) **(b)** **(c)**

Figure- 2(a) Seat of series W221, (b) Experimental seat with PCB Electrode and (c) Experimental seat with textile electrodes

The series seat contains a large number of electronic devices, e.g. heater, ventilator, airbag ECU, DC-DC converters, some of which are depicted in fig. 2(a). With all those devices being integrated into the seat, only two positions could be identified for placing the electrodes, presumably being integrated as an intelligent textile. One is at the sides of the backrest and the other is on the seat surface. As an ECG signal led from the thighs provides very small amplitudes, the only possible location to integrate the system into the seat was on the two sides of the backrest, as shown on the right side of fig. 2(b).



(a) (b) (c)

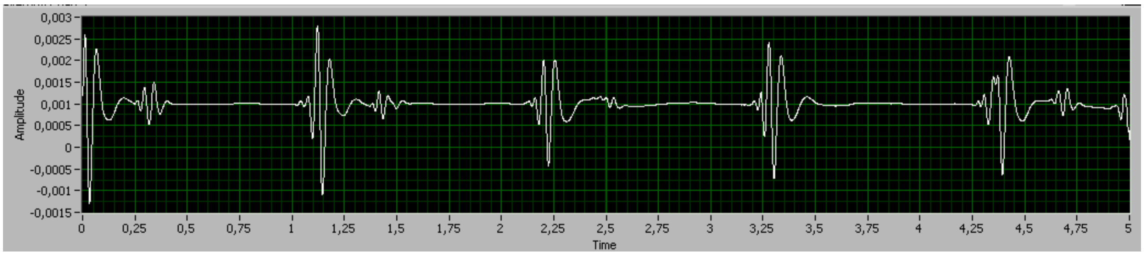
Figure- 3 (a) CCECG PCB Electrode and its electronics (b) CCECG Textile electrode with semi flexible electronics (c) Textile Coaxial cable and Driven seat electrode from eBlocker

Now it would be interesting to see a transformation from the hard PCB (Printed Circuit Board) structure, fig.3 (a), into a flexible structure (fig.3 (b)). A textile coaxial cable is implemented with the help of TITV "TextilforschungsInstitut Thüringen-Vogtland" in Greiz. We used a conductive textile fabric dubbed "E-blocker" from Novonic GmbH in Weiler-Simmerberg, as a driven seat electrode. Fig.3(c) shows the textile coaxial cable and E-blocker fabric. The CCECG electrodes are made up using printed textile technology. The photos show the transformation from the hard system to the flexible one. The electrode has 2 layers and contains a guarding layer to avoid any parasitic effects. Patent of the electrode is pending.

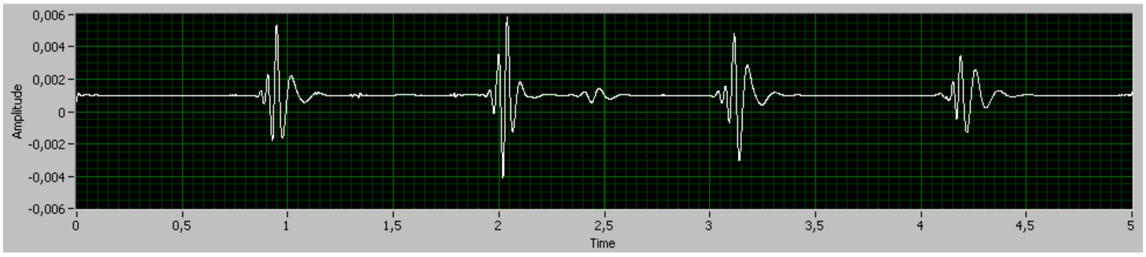
4. RESULT AND DISCUSSION

The differential signal from the CCECG system (through an anti aliasing filter) is fed to DAQ system (NI USB-6215) to digitize it. This signal is processed with LabVIEW for analysis and display. The signals are filtered with an algorithm, being developed in house. The algorithm is designed to extract the Heart Rate (HR) out of a very noisy Capacitive ECG signal.

Fig. 4(a)&(b) show a measurement with the textile electrodes. The Heart Rate can be determined from the measured results, which was the aim of this very project. Heart rate in fig.4 (a) is 60 beats/min, while 40 beats/min can be seen in fig.4 (b).



(a)



(b)

Figure 4 (a) & (b) Capacitive coupled ECG with the textile electrode

5. CONCLUSION AND OUTLOOK

This work shows promising results to integrate a CCECG system into the car seat. The achieved results demonstrate the possibility to determine Heart Rate from measured signals. However being a first attempt with textile electrodes only, the quality of the signal needs to be improved. Furthermore the problem of body movements has to be considered and solved.

Further work comprises aspects to convert the system into a practical set-up, e.g. tests with various intelligent textile technology approaches, integration into the car seat comprising all necessary components, as well as the influence of the seat environment on the chosen intelligent textile. Reproducibility and robustness has to be verified in order to use the system flawlessly. Finally the system has to be examined in a real car environment.

6. ACKNOWLEDGEMENT

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