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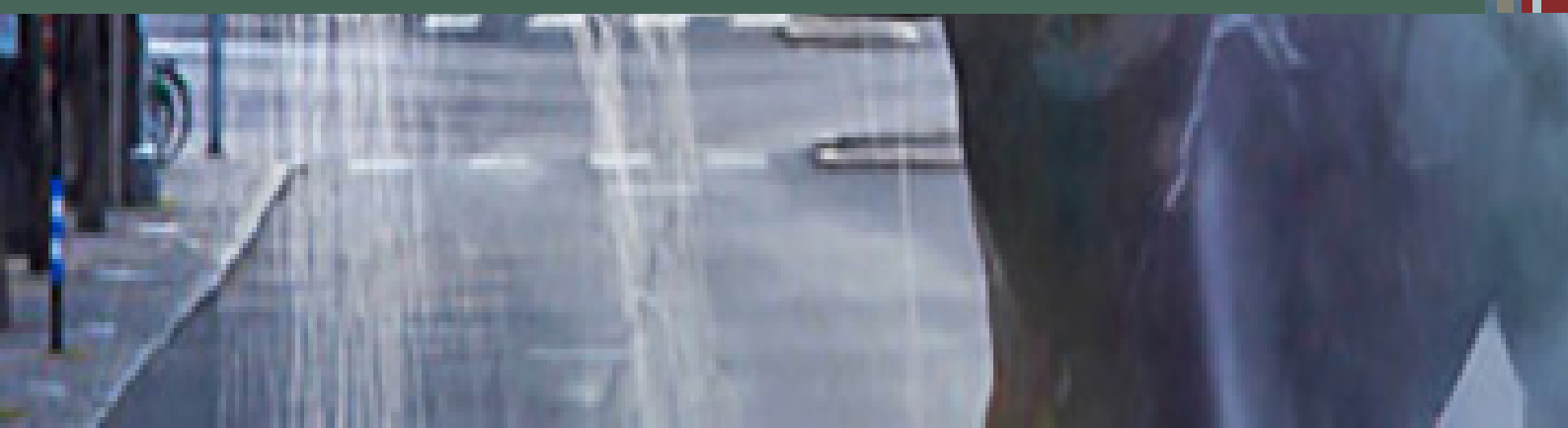

MONITORING OF RESPIRATION AND CARDIAC ACTIVITY BASED ON PIEZOELECTRIC TEXTILE SENSORS

David Wristel[1], Anja Lund[2], Karin Rundqvist[2], Erik Nilsson[1,3], Bengt Hagström[1,3], Leif Sandsjö[2,4]

[1] Chalmers, Göteborg, Sweden. [2] University of Borås, Borås, Sweden, [3] Swerea IVF, Mölndal, Sweden, [4] MedTech West, Göteborg, Sweden

1. Introduction

A piezoelectric material generates an electric signal when a force is applied. Depending on the force that is applied different signal amplitude is achieved [1]. It has been shown that the piezoelectric material PVDF (poly(vinylidene fluoride)) can be incorporated into textiles fibres with preserved textile characteristics [2]. In a recent study it was found that these fibres can stand the force involved in a weaving process, making it possible to manufacture textiles with piezoelectric characteristics [3] and can be used as textile sensors. However, textile sensors based on weaved piezoelectric fibers has limited low frequency response which does not allow to measure static forces. In this study it has been investigated whether it is possible to, electronically, extend the lower end frequency response of the system to be able to record respiration and heart beats.

2. Method

Literature studies indicate that *charge amplifiers* typically are used as a signal conditioning circuit for piezoelectric signals. By creating a measurement setup which can generate repeatable and controllable stimuli it was investigated how component choices in named signal condition circuit alters the response. Using a digital oscilloscope, the signal direct from the textile and the output of the signal conditioning circuit could be compared. By investigating the output signal of mainly three different stimuli; 1) sinusoid, 2) ramp followed by step and 3) single step, different characteristic of the signal conditioning system and the piezoelectric textile sample could be compared. Using the findings it was desired to create a unit which can monitor respiration and cardiac activity live in a computer. The design criteria of the unit was that it should be simple, small and enable tuning to match piezoelectric samples as well as analogue to digital converter (ADC) requirements.

3. Results

It was found that a circuit built on a charge amplifier can be used. The type of circuit enables control of the lower cut off frequency which can extend and enhance the low frequency characteristics of the piezoelectric signal. However, a lower cut off frequency also generates a time lag. Using the test setup it was shown that signal frequencies as low as 20 mHz could be recorded using the system. By considering the trade-off between high and low frequencies a system with the possibility to record respiration could be created. To be able to match interfacing requirements of the sample and ADC both tuneable amplification and offset was built in. The result of the circuit in use to monitor respiration is seen in Figure 1. In the figure a test person is wearing a band around the chest and breathe in different patterns; 1) normal, 2) fast and shallow and 3) deep and slowly. Note how the output follows the breathing patterns, but saturation of the amplifier may occur when taking deep breaths. It was verified that it was possible to alter amplification and offset to match the ADC. It was also verified that it is possible to detect heart beats, as long as other chest movements are limited.

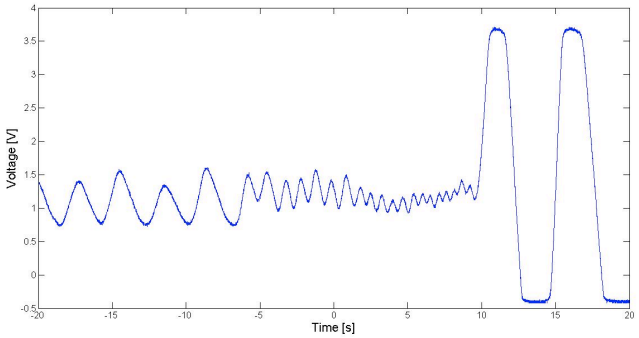

Figure 1: Different respiration patters recorded by the developed system. About 15s normal, 15s shallow and 10s of deep breathing.

4. Discussion

It has been shown that it is possible to design a measurement system for piezoelectric fibres which can handle low frequencies to monitor respiration and heart activity picked up by a weaved piezoelectric textile band to monitor chest movements, and even heart beats if other movements of the body is kept to a minimum. A drawback and limitation of detecting respiration through chest movements is that any chest movements generates signal. In some applications this might be handled, whereas in others such movements need to be discriminated. Further work is needed to optimize the system regarding portability and relevant aspects in relation to the targeted application of the piezoelectric textile fibers.

References

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