Breathing measurement system based on capacitive technology

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1. Introduction

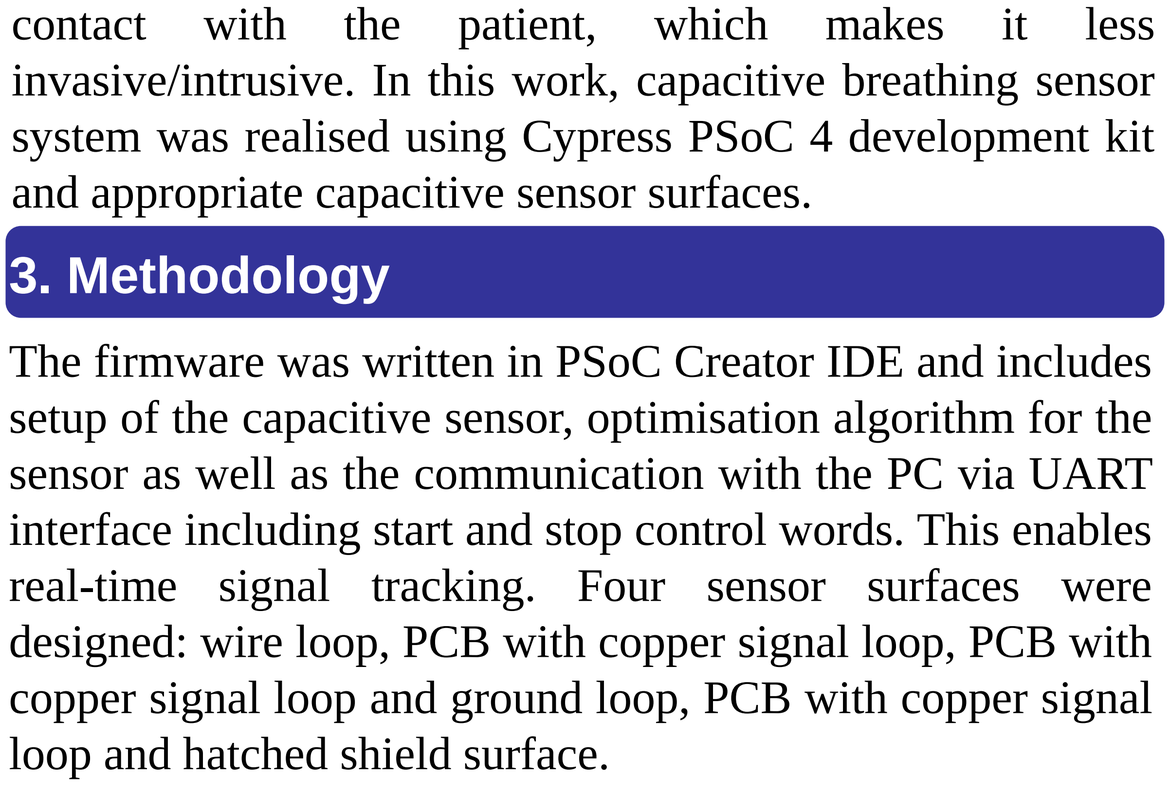
Capacitive technology is very popular choice for uses in various sensor applications, such as measurement of pressure, distance, force, humidity and acceleration. They usually provide a way of minimally invasive or completely non-invasive measurements, while remaining easily integratable and reliable. One interesting application is breathing measurement.

2. Problem description

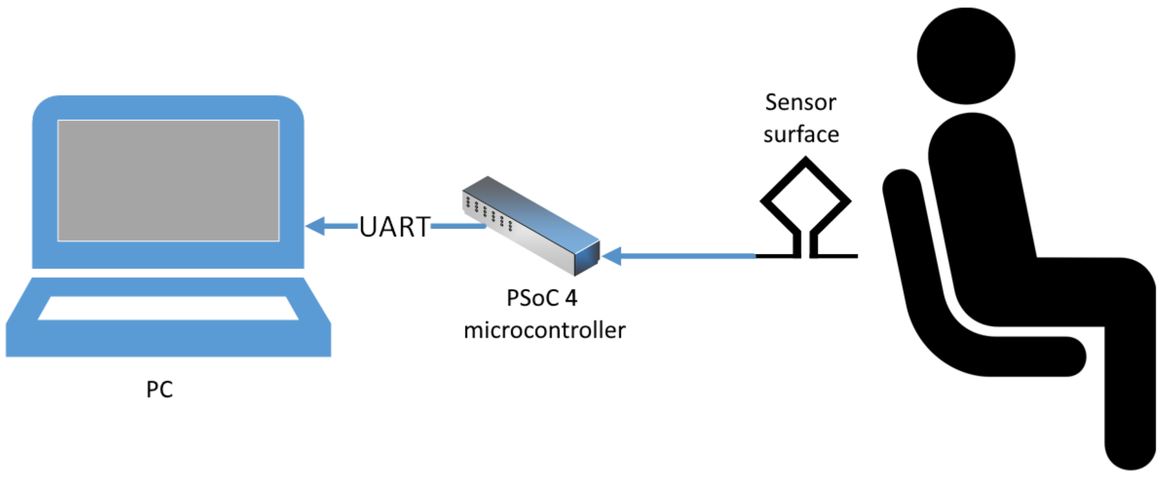
Breathing measurement is commonly done via invasive or intrusive sensors such as turbine flow meters or strain gauges. Capacitive breathing sensor does not require a direct contact with the patient, which makes it less invasive/intrusive. In this work, capacitive breathing sensor system was realised using Cypress PSoC 4 development kit and appropriate capacitive sensor surfaces.

3. Methodology

The firmware was written in PSoC Creator IDE and includes setup of the capacitive sensor, optimisation algorithm for the sensor as well as the communication with the PC via UART interface including start and stop control words. This enables real-time signal tracking. Four sensor surfaces were designed: wire loop, PCB with copper signal loop, PCB with copper signal loop and ground loop, PCB with copper signal loop and hatched shield surface.

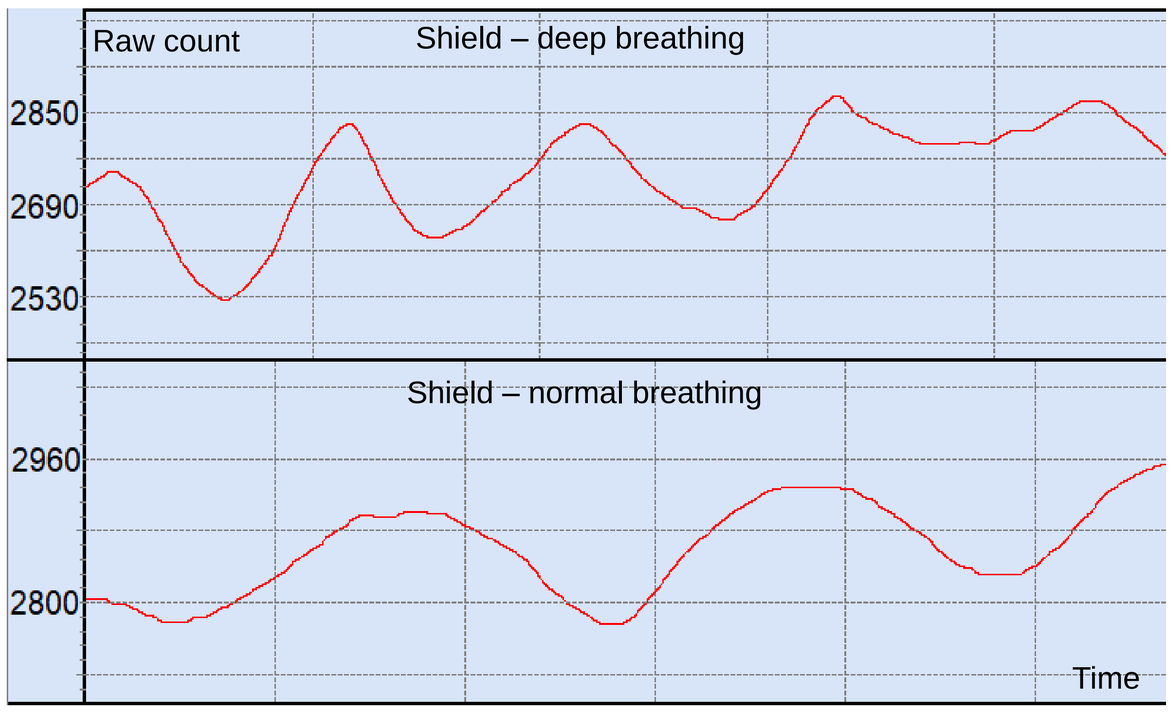


Ground loop reduces noise and improves ESD resistance, while hatched shield surface reduces parasitic capacitance and isolates signal loop from foreign objects. The microcontroller performes filtration of the signal using 1st order IIR filter and the ALP filter. All sensor surfaces can detect movement at 20 cm distance.



4. Results

For every sensor surface, signal and noise levels as well as high and low limit for the ALP filter needed to be optimised. Waveform of deep and normal breathing was recorded.



Sensor surface	*Peak-to-peak* signal level for deep breathing	Peak-to-peak signal level for normal breathing
Wire loop	160	30
PCB with loop	240	100
PCB with ground	160	140
PCB with shield	160-240	120

PCB with loop and PCB with shield provided best results - high sensitivity and low noise. System is sensitive to small movements - the patient is required to sit still.

5. Conclusion

All PCB surfaces are useable (depending on the requirements) due to small differences in achievable peak-to-peak signal level. Realised system can display the measured breathing in real time. Recorded waveforms can provide breathing frequency.