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Electromagnetic Biosensing of Respiratory Rate

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Continuous monitoring of respiratory rate is crucial in forecasting health crises and other major physiological instabilities. Current respiratory monitoring methods limit the mobility of the patient or require cooperation from the subject. Wireless, wearable technology can collect continuous physiological data without immobilizing or inconveniencing patients, but require regular battery replacement – this creates a barrier for compliance and wide adoption of the technology, and the disposed batteries create an environmental hazard. Human energy harvesting can be used to power these wearable sensors.

In this paper, we explore this zero-net energy biosensor concept through simultaneous sensing and harvesting of respiratory effort. An off-the-shelf DC brushed motor was modified into a chest belt, and tested on a mechanical chest simulator as well as on 20 human subjects, using a spirometer as a respiratory rate reference. Respiratory rate was detected from the Fast Fourier Transform of the electromagnetic biosensor output, and the harvested power was calculated from the voltage across a load resistor between the motor terminals.

The electromagnetic biosensor was used to successfully harvest 7-70 microwatts from human subjects. On the mechanical chest, respiratory rate was detected with a mean absolute error of 0.00027 breaths per minute with a standard deviation of 0.00019 breaths per minute. For human subjects, respiratory rate was detected with a mean difference of 0.36 breaths per minute with a standard deviation of 2.83 breaths per minute (sitting), 0.23 breaths per minute with a standard deviation of 2.64 breaths per minute (standing) and 0.48 breaths per minute with a standard deviation of 3.06 breaths per minute (walking).

Keywords: biosensor; respiration; electromagnetic; harvesting