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Energy-Autonomous Wearable Sensors for Biomedical Sensing

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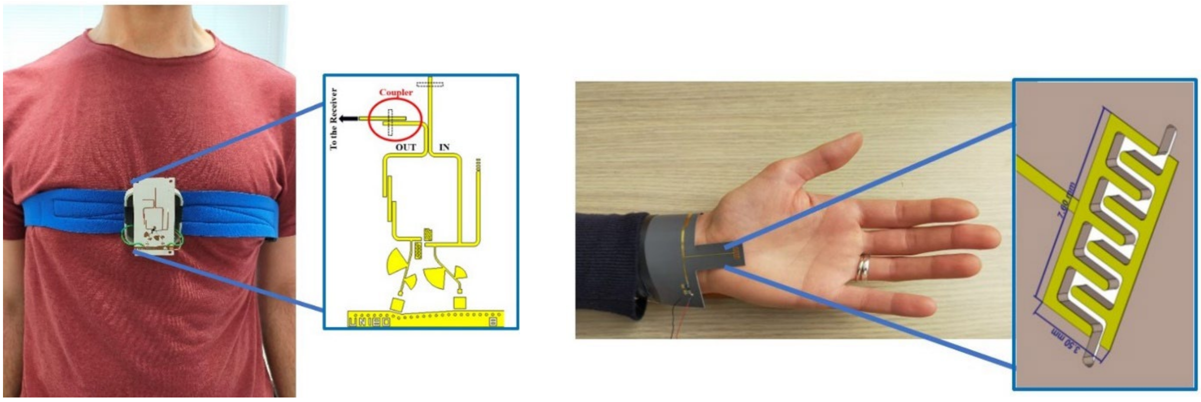
In recent years, energy-autonomous wearable sensors have become a widely spread solution for remote health monitoring thanks to recent advances in wireless and battery-free technologies to generate biocompatible, noninvasive, lightweight sensors for wearable and implantable applications. Radiofrequency (RF) wireless power transmission (WPT) is in this sense a very attractive candidate for reducing size and weight of such devices, and for feeding them wirelessly with enough energy. This tutorial will describe the design implementation of some representative wearable microwave systems for vital signs monitoring a for material detection.

As an example, remote breath rate detection can be implemented in a wearable sensor, working at 5.8 GHz and exploiting the self-injection locking (SIL) radar technique [1]. This sensor allows to detect situations of deep or fast breath occurring for the monitored users, which could be revelatory of dangerous conditions, i.e., tachypnea. This device is small-sized, fully wearable, and should be located at about 2.5 cm from the subject's body at the chest position. The device has on-board a demodulator circuitry that can be exploited as an RF-to-dc rectifier for energy harvesting purposes, e.g., to supply an ultra-low-power transceiver to send wirelessly the acquired data to a laptop or a smartphone.

An energy-autonomous rectifying filtenna (filtering antenna) operating at 2.45 GHz can be worn as a bracelet and used to monitor the presence of ethanol for sanitization surveillance. The system is realized on a Rogers RT/Duroid 5880 substrate, whose flexibility contributes to the sensor wearability. The detection of solutions with different percentages of ethanol is performed thanks to a resonant open stub, loaded by a microfluidic channel whichvaries the filter performance with the ethanol concentration variations. Energy autonomous sensing is obtained by the same circuit simultaneously performing energy harvesting and ethanol detection. [2]



(a) (b)

Figure 1. (a) Breath rate detector placed at the user's chest for breath rate sensing and exploded view of the SIL radar circuitry; (b) wearable microfluidic sensor for ethanol detection, with zoom on the interdigitated capacitor for sensitivity enhancement.

References

[1] G. Paolini, M. Shanawani, D. Masotti, D. Schreurs, and A. Costanzo, "Respiratory Activity Monitoring by a Wearable 5.8 GHz SILO With Energy Harvesting Capabilities," *IEEE Journal of Electromagnetics, RF and Microwaves in Medicine and Biology*, **6**, 2, June 2022, pp. 246-252, doi: 10.1109/JERM.2021.3132201.

[2] F. Benassi, G. Paolini, D. Masotti, and A. Costanzo, "A Wearable Flexible Energy-Autonomous Filtenna for Ethanol Detection at 2.45 GHz," *IEEE Transactions on Microwave Theory and Techniques*, **69**, 9, September 2021, pp. 4093-4106, doi: 10.1109/TMTT.2021.3074155.