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BodyPoweredSenSE RTD 2013

FNSNF

Thermoelectric Energy Harvesting for Wearable Medical Devices

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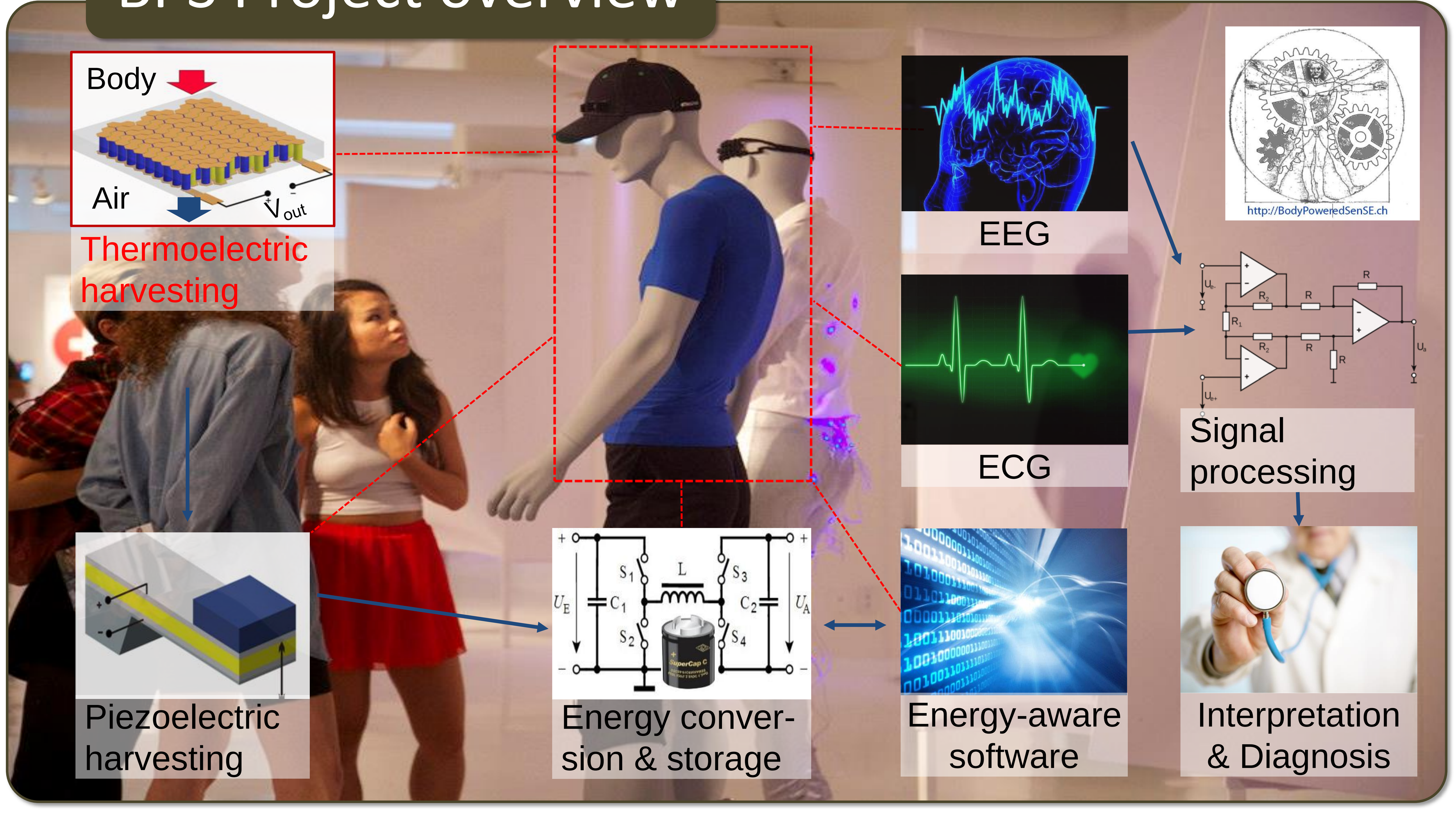
BPS Project overview



Zero-power active biopotential electrode

Motivation: Active amplification and filtering of human biopotentials consumes power in the µW-regime

System overview

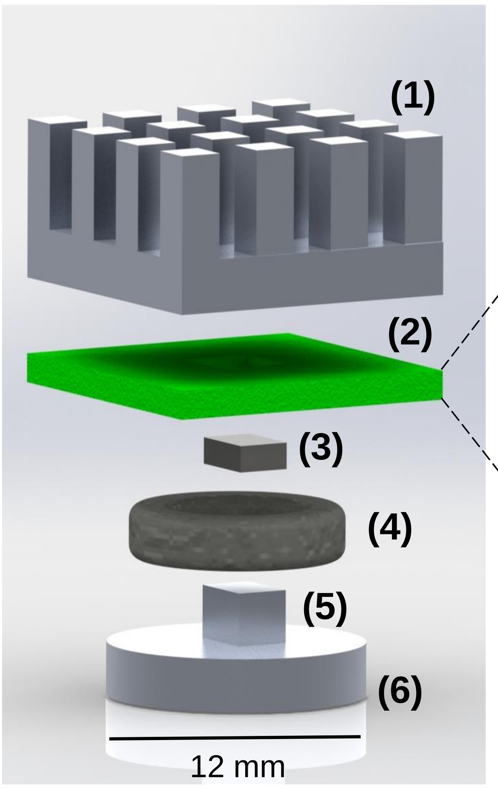
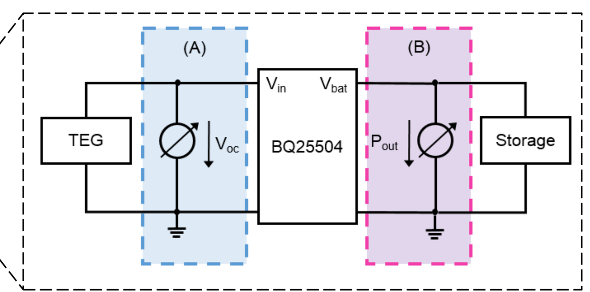


Fig 1 - System overview
(1) Heat sink (R_{th} = 29 K/W) to dissipate heat into the environment. **(2) Circuitry** for power management (TI BQ25504) and signal processing (not included).



(3) Microgenerator (MPG651). **(4) Silicone ring** for thermal isolation and structural stability **(5) Heat transfer structure** to funnel heat to the TEG and prevent parasitic flux **(6)** Electrode surface (e.g. metal, AgCl, polymer)

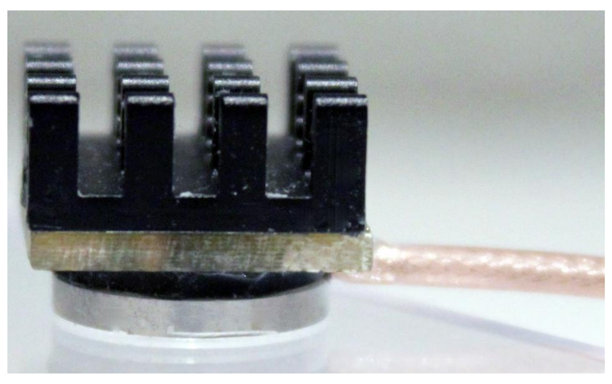


Fig 2: Prototype of zero-power active electrode

Harvester specs
TEG: MPG-651
Rth = 28 K/W
Rel = 210 Ω
RHS = 21 K/W
Ahot = 1.1 cm2

Power output after conversion

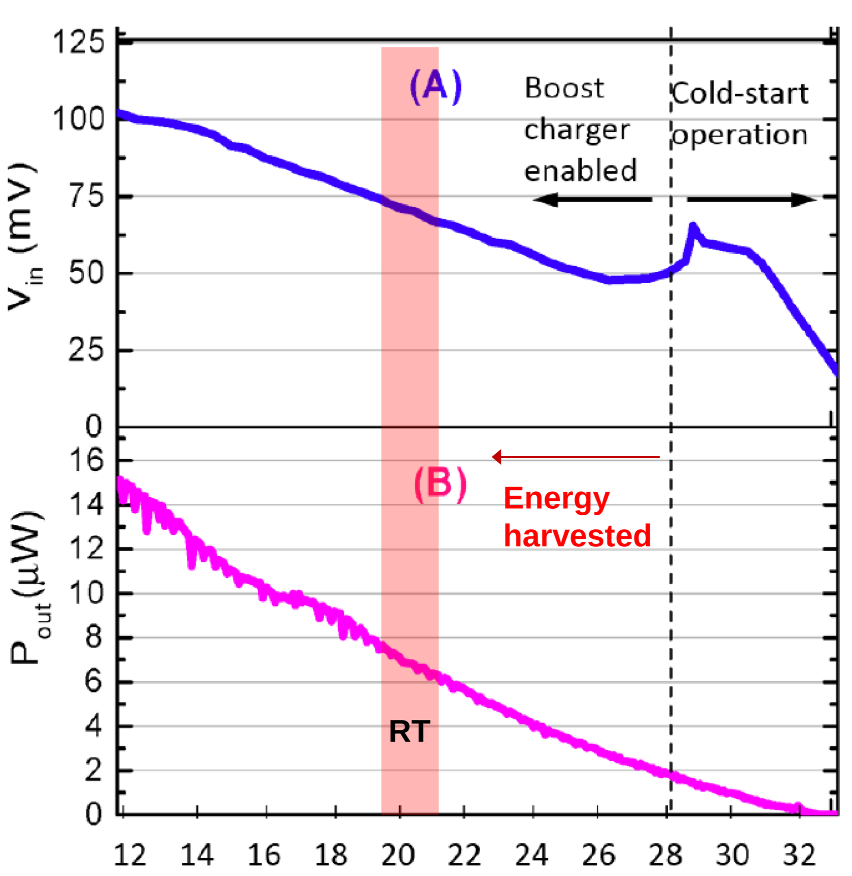


Fig 3: Input voltage at power conversion circuit Vin and power output at 3V in decreasing ambient temperatures (stationary subject).

Measurement of biopotentials

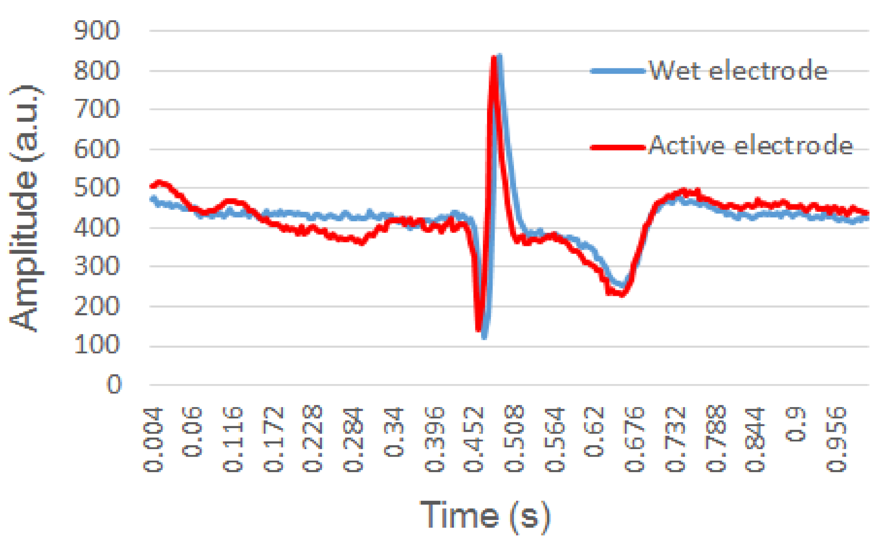


Fig 4: Recording of the electroencephalogram (ECG) using the electrode prototype (red) and a clinical-standard wet electrode (blue). Signals show high correlation and the QRS-complex is visible.

Summary: Sufficient power generation (2-15 µW) to enable energy autonomous biopotential electrodes

Large-are harvester for the forehead

Motivation: Signal processing and the interpretation, storage and communication of data consumes power in the lower mW-regime

System overview

Fig 5: System overview (center), closeup of the harvester module (left) and prototypes (right).
(1) Heat sink (R_{th} = 20 K/W) to dissipate heat into the environment.
(2) Stacked TEGs (RMT, R_{el} = 13.33 Ω, R_{th} = 85 K/W) for power generation.
(3) Hot interface (Al, A = 4 cm²) to increase effective harvesting area.

Long-term measurement results

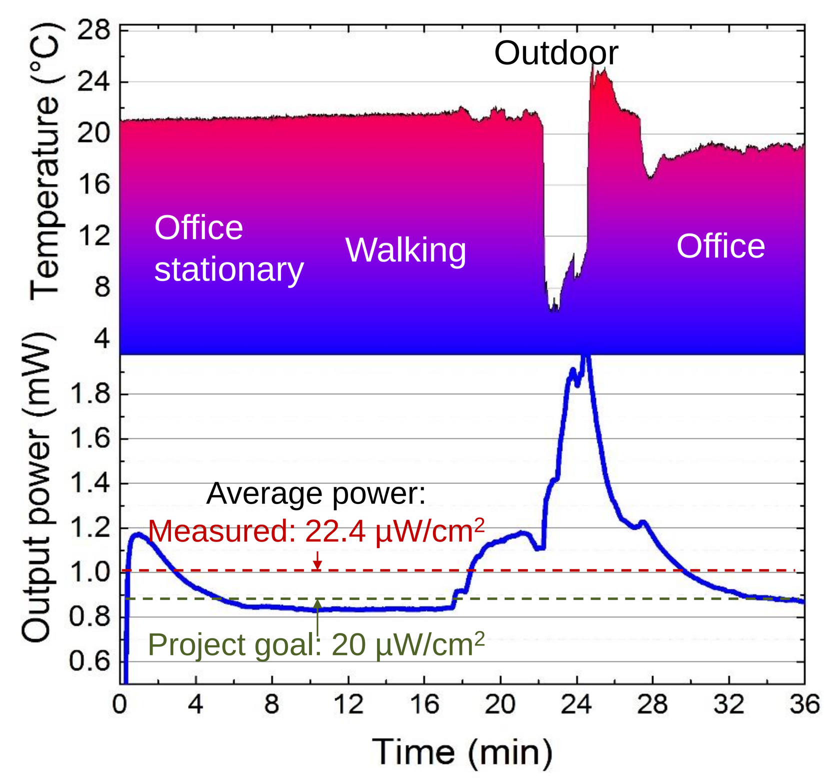


Fig 6: Long-term measurement with harvester prototype (Version 1) in varying environmental conditions. Dashed lines show project goals (green) and mesured average (red).

Fig 7: Child and adult test subjects wearing a harvester prototype during different everyday activities-

Comparison with State of the Art

(1) Leonov, V., et al., *THERMINIC 2009. 15th International Workshop on*. IEEE, 2009

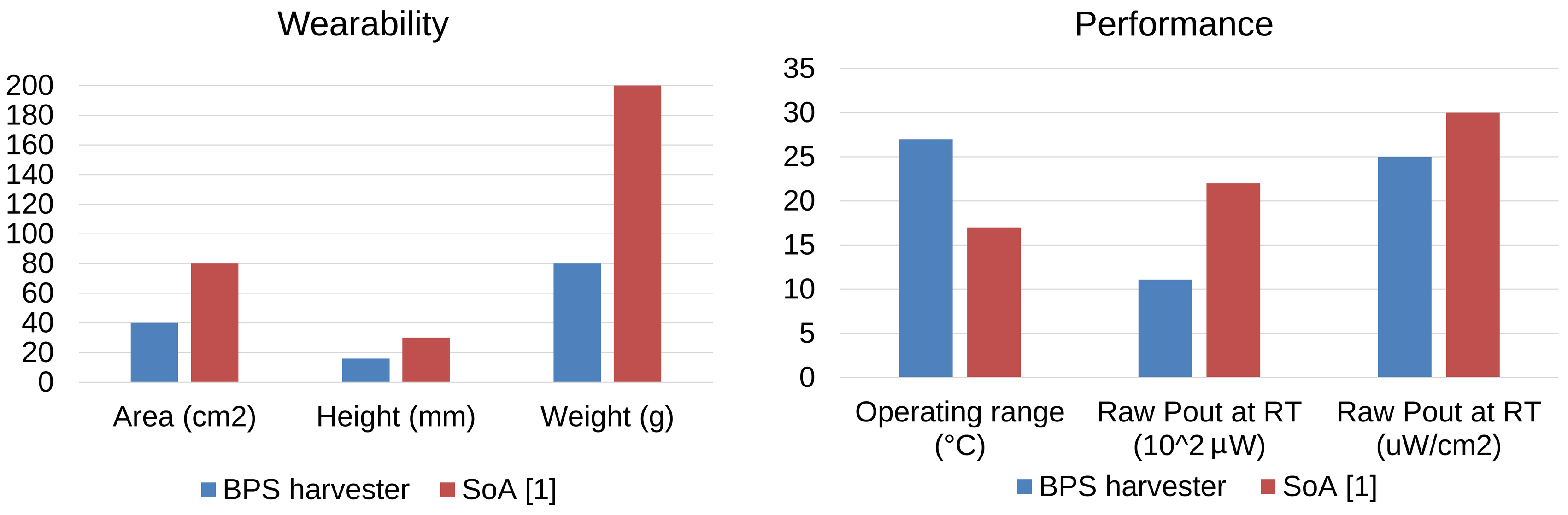


Fig 7: Comparison with SoA. Left: Wearability defined by total area, height and weight of the harvester. Right: Performance including usable temperature range, and output power.

Summary: Generated power-per-area similiar to the SoA with strongly reduced form factor → Towards true wearability

Findings and outlook

Highlights

- First energy autonomous biopotential electrode
- mW power generation from system with high wearability

Outlook

- Integration with other BPS components

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