Design and Testing of a Galvanic Skin Response Sensor Circuit

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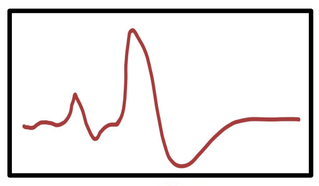
Background

- **Galvanic Skin Response (GSR):** the change in skin conductance due to external stimuli
- Caused by **sweat gland activation** from the sympathetic nervous system
- Indicator of **emotional arousal**



Signal characteristics

- Biphasic or triphasic
- Very low frequency (0.05Hz to 2Hz)
- Skin resistance depends on type of electrode used (~1kΩ to 10MΩ)

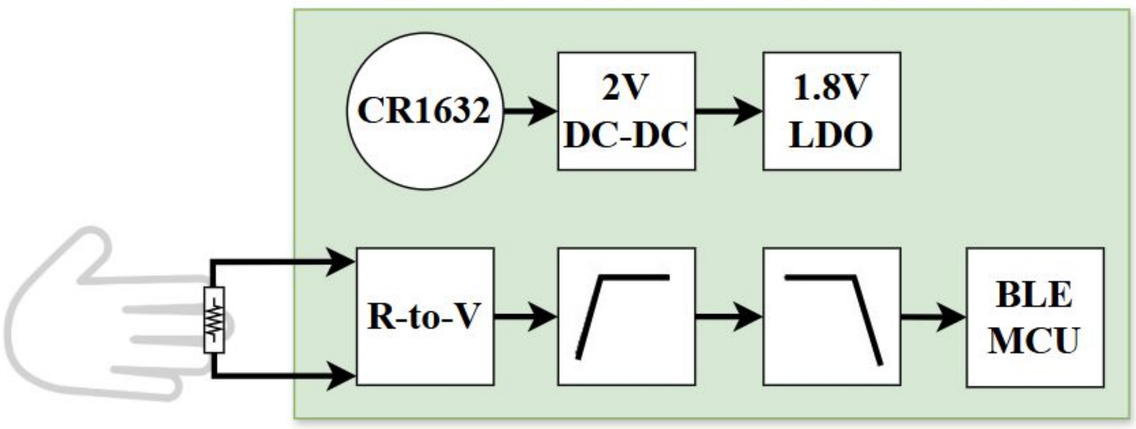
Research Overview

- **Objective:** design a circuit that measures skin conductance and isolates the GSR component

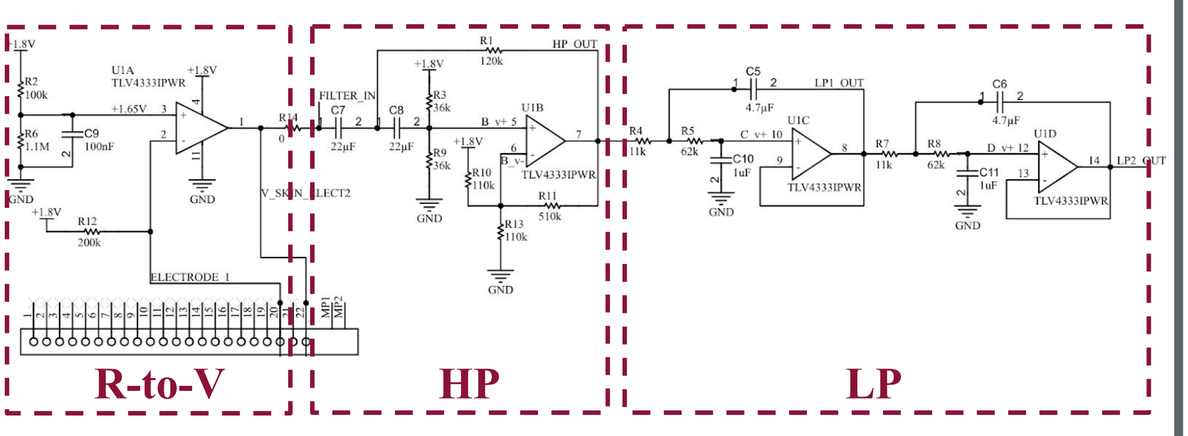
- **Considerations**
  - Single-supply, low-power
  - Op-amp specifications (low-noise, RRIO)
  - Active filters (max amplification of 20 dB)

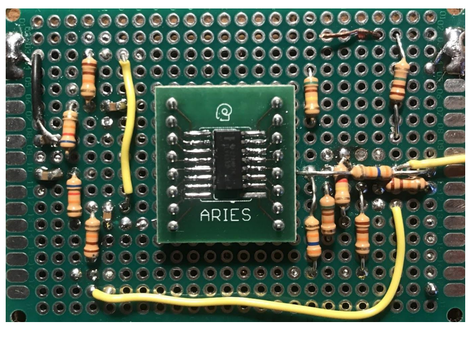
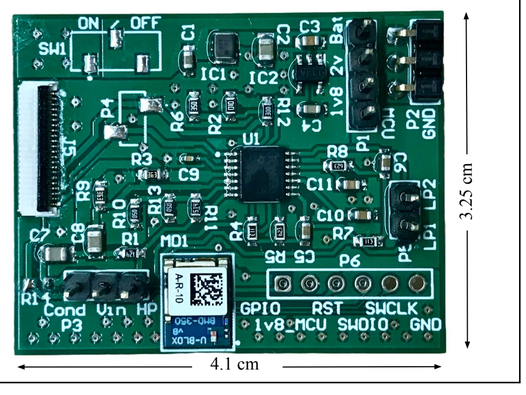
PCB Design

System-level diagram



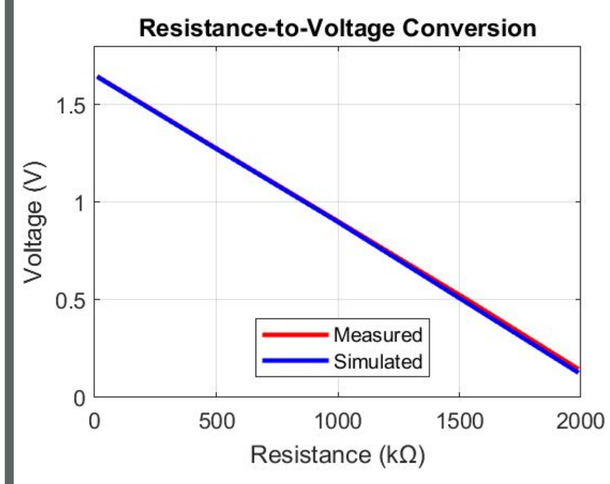
Resistance-to-Voltage Converter and Filtering Circuitry

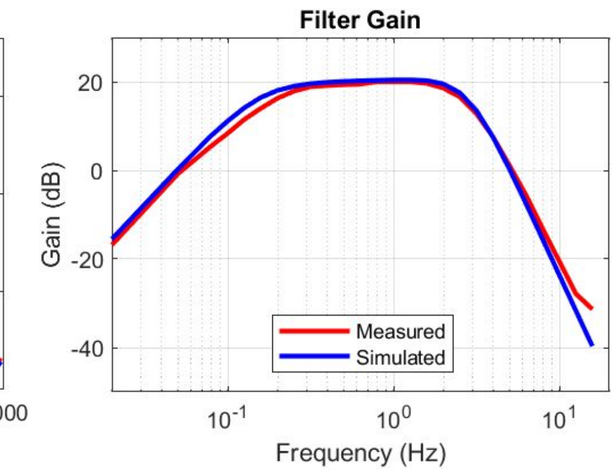


Prototype	PCB
	

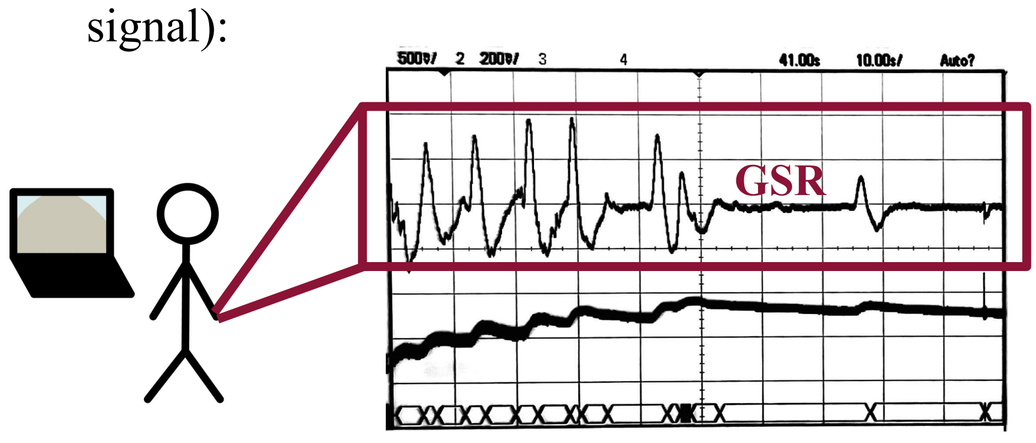
PCB Testing

1) **Board validation**
   - Power: < 1 mA @ 1.8V
   - Measuring different resistors and filter gain:



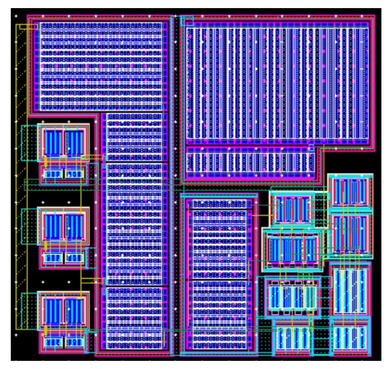


2) **Testing on subjects**
   - Dry Ag/AgCl electrodes secured on two fingertips
   - Rock-climbing video used as visual stimuli
   - The raw skin conductance (bottom signal) was filtered and amplified to obtain the GSR (top signal):



Chip Design

Chip design is currently ongoing.



- TSMC 180nm CMOS
- **Programmability:** sensitivity/gain
- **GΩ pseudo-resistors:** to achieve low cut-off frequencies in filters
- **Significant area improvement:** e.g., 0.005mm² on chip vs 25mm² on PCB for R-to-V circuitry

Summary and Future Work

- A low-power PCB for Galvanic Skin Response sensing was designed, validated, and used to record real GSR signals.
- The chip will be designed and sent for fabrication by December 2024. Testing will be done in Spring 2025.

Acknowledgments

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