Firmware Development, Testing and PCB Design for the Analog Front End of Extended Gate Transistor Based Electrochemical Sensing System

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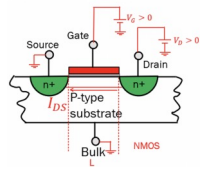
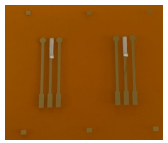
Background

- A **transistor** is a semiconductor device used to amplify or switch electrical signals and power.
- In an extended gate transistor based electrochemical sensing system the change in chemical activity of analyte species can be detected in the form of shift in silicon transistors **current-voltage(I-V) Characteristics.**
- If the transistor gate is connected to an appropriate **electrochemical sensor**, based on the analyte in contact with the sensor, there is a shift in the transistor's threshold voltage.



NMOS Transistor



Printed Differential Electrode Sensor

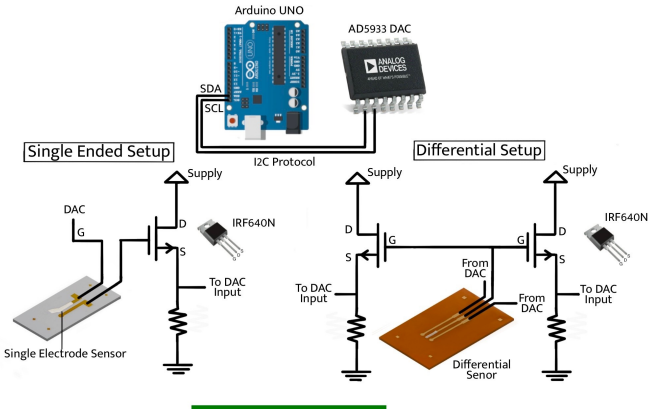
Analog Front End

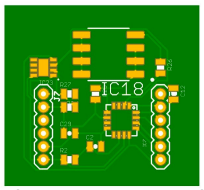
- Collection of electrochemical data requires appropriate analog-to-digital conversion and supply of bias through Analog Front End (AFE).
- AD5933 is a high precision impedance converter that combines an on-board frequency generator with a 12-bit, 1 **analog-to-digital converter (ADC).**
- It can be interfaced with Arduino to control transistors and read the drain-source current.

Motivation

- By designing an **AFE capable of functioning with Arduino**, the cost and complicacy of measurement can be lowered.
- **Printed sensors** represent a highly scalable alternative to conventional electrochemical electrode systems.
- Our goal is **to develop firmware and hardware** for the AFE of extended gate transistor based sensor with differential sensing capabilities and demonstrate its application in Potassium Ion sensing.

System and Methodology

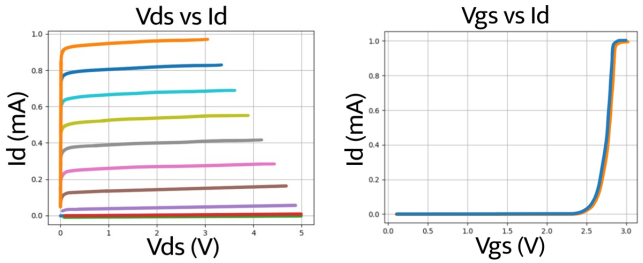




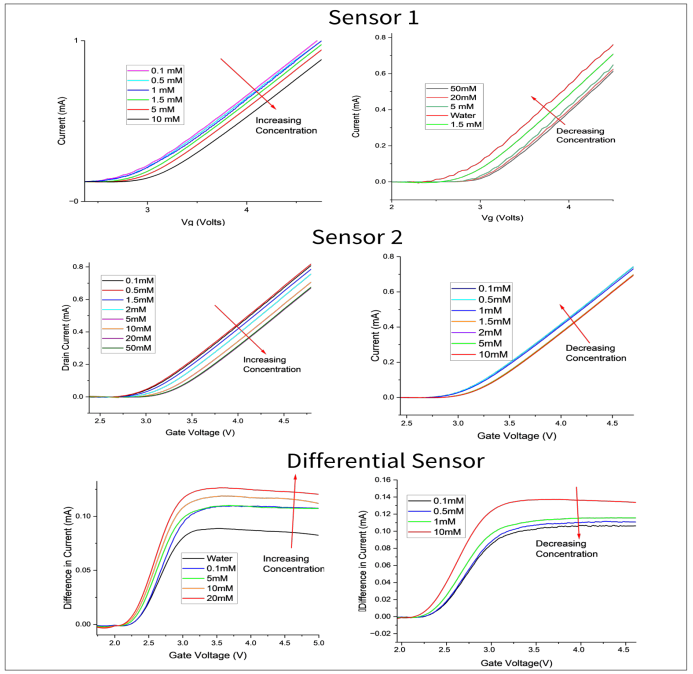
Designed PCB Board Layout

- Development of a firmware to interface the DAC with Arduino and provide bias to NMOS transistors.
- The DAC reads voltage from the transistor's source and converts it to a digital signal.
- The transistor gate is connected to the working electrode of the Single-ended and Differential printed sensors having Gold Working Electrodes and Silver Reference Electrodes.
- A PCB layout of the AFE is designed with multiple analyte sensing Capabilities.

Transistor Characterization



Application of Developed System in Potassium Ion Sensing



Future Work

- The designed PCB will be manufactured, and its functionality will be tested.
- The firmware will be updated for Bluetooth communication between Arduino Nicla Sense and AFE.
- Simultaneous Multi analyte sensing capability will be added.

References & Acknowledgements

Zheng, Youbin, etal."A wearable microneedle-based extended gate transistor for real-time detection of sodium in interstitial fluids." *Advanced Materials* 34.10 (2022): 2108607.

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