Potentiostat-Based Glucometer Proposal

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Project Overview

The increasing prevalence of diabetes necessitates the development of reliable, accessible, and accurate glucometers. This project aims to develop a low-cost, potentiostat-based glucometer prototype that employs amperometry for glucose quantification. The system will be validated against standard glucose solutions to ensure accuracy and reproducibility, paving the way for further refinements in electrochemical biosensing technology.

Project Objectives

01	Calibration	Development of sufficient redox-mediated calibration between glucose concentration and electrochemically produced measurement appropriate for instrumentation.
02	Hardware development	Ensure compatibility between all components through various prototyping stages.
03	User-friendly design	Design an easy-to-use, durable, portable glucometer.
04	Experimental validation	Final product performs similarly compared to current available second generation glucometer.

Working Schedule

TASK NAME	STATUS	ASSIGNED TO	START DATE	END DATE	DURATION in days	Need to submit:	COMMENTS	Schedule
Planning	In Progress	All	01/27	1/31	5	For presentation and in february		internal schedule
Introducing Theertha to the Project	Complete	Kayla, Paulina	01/27	01/27	1		Show what we did last semester to Threetha so she knows our base line	
3-D printing	Complete	All	01/27	01/30	4	group assignment, (print one item per group), individually CAD files and		
3-D CAD files test	Complete	All	01/27	01/30	4	Have files ready by lab meeting on Thursday	CAD and slicing done for nameplates, box with sliding lid and UNO Case.	class schedule
3-D printing (test)	Complete	All	01/27	02/06	11	Have files ready by lab meeting on Thursday		class schedule
Writing	Complete	All	02/03	02/07	5	Compling Preliminary Design Presentation on team GitHub page		class schedule
Electrochemistry reactions and analytical methods	Complete	Kayla	02/03	02/07	5			class schedule
Firmware development	Complete	Kayla	02/03	02/07	5			
Product standards research	Complete	Kayla	02/03	02/07	5			
Project scope: Minimum and maximum expectations	Complete	All	02/03	02/07	5			class schedule
Materials; costing and sourcing	Complete	Paulina	02/03	02/07	5			class schedule
Getting proposal into github	Complete	Paulina	02/03	02/07	5			
Design principles outlined	Complete	Theertha	02/03	02/07	5			class schedule
Market research	Complete	All	02/03	02/07	5			class schedule

Materials and Components

Calibration and Testing

- AimsStrip Plus Mini glucose test strips ($15.15 for 50 strips)
- **d-Glucose stock solution** (250 g/L in PBS)
- PBS for dilution preparation

Hardware Components

- **IO Rodeostat**
- Accompanying Adafruit ItsyBitsy Board (MC)
- **Electrode wire connector (adjusted for test strips) and shim**
- Adafruit Li Battery Backpack

Display Screen Options

- Arduino Display (available on eBay for $55)
- IO Rodeostat-compatible display ($35)
- Adafruit Display ($24)

Purchased, Needs to be purchased

TO BUY (please & Thank you) :

Arduino Display

Sold out in: Arduino USA,
Available: in eBay for $55
In Arduino Europe

Microcontroller

Adafruit ItsyBitsy M4 - $15, purchasing 2

Glucose Test Strip

AimsStrip, Amazon, $15.15 for 50 strips

PBS

For this experiment so we do not use CBE 4800.

Battery Backpack

Adafruit LiIon/LiPoly Backpack

$4.80 (buy 3)

(as many as possible Dr. Huff can by for us at once)

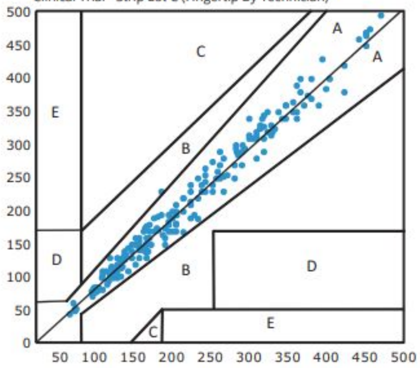
AimStrip Plus Glucose Meter

- Reliable, Accurate Results in 10 Seconds
- Only 1μL Blood Sample Required from Fingertip or Forearm Testing
- Single Code Chip for the Life of the Meter
- Memory Allows up to 300 Records with Date and Time
- English & Español Instructions

https://www.germainelabs.com/wp-content/uploads/2020/08/AimStrip-Plus-BG-Flyer-02-19.pdf

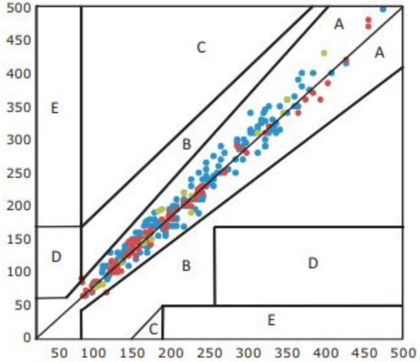
Accurate Fingertip Testing

Error Grid Analysis
Clinical Trial - Strip Lot C (Fingertip By Technician)

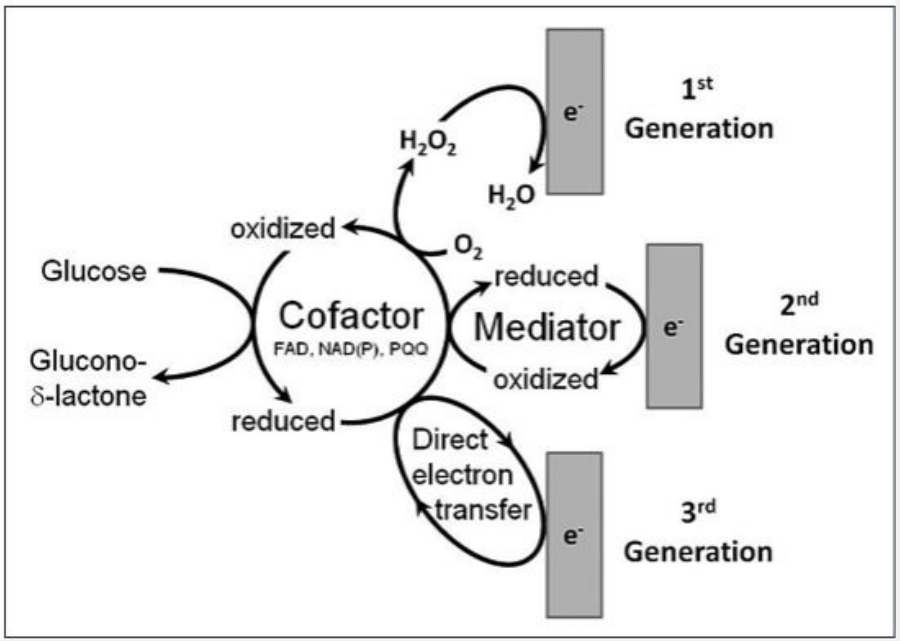


Patients can Perform a test as well as a trained technician

Error Grid Analysis
Clinical Trial - Strip Lot A, B, C (Fingertip)



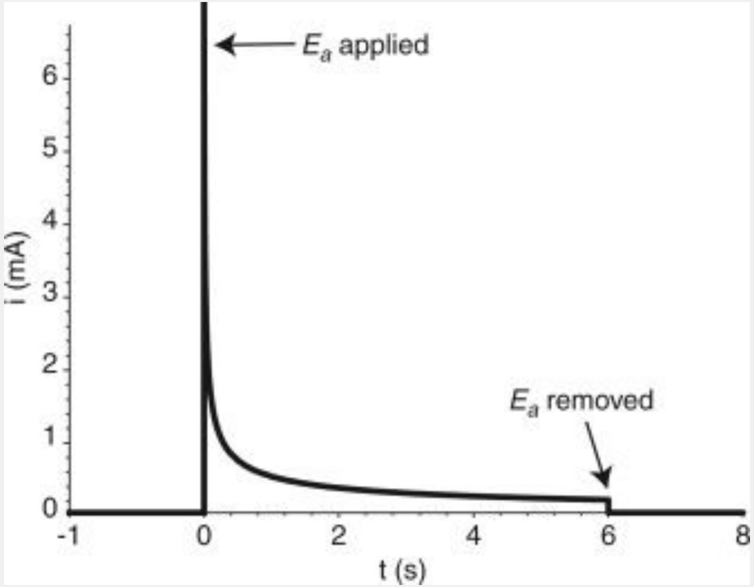
Electrochemical Reactions in Glucometers



https://doi.org/10.1177/193229681100500507

- Primary reaction is aerobic oxidation of glucose with glucose oxidase (GOx)
- Redox-mediated electron transfer introduced to improve efficiency, accuracy
- AimStrip Plus Strips
  - GOx/FAD
  - Ferri/ferrocyanide mediator
  - 10 sec response time

Analytical Methods



https://doi.org/10.1016/B978-0-12-802993-0.00004-6

- Amperometric analysis
- Experimentally determine
  - Appropriate step potential for selective oxidation of Fe(II) back to Fe(III)
  - Lag time (steady-state)
- Get linear calibration between current and concentration from **Cottrell equation:**

$$i = \frac{nFAc_j^0\sqrt{D_j}}{\sqrt{\pi t}}$$

Engineering Design Considerations

01

User Interface

Intuitive Design: Simple navigation with clear icons and minimal steps for testing.

High-Contrast Display: Ensures readability for users with visual impairments.

Backlit Screen: Allows visibility in low-light conditions.

Buttons: Evaluating the type of buttons based on user preference and cost.

02

Power Supply

Batteries: Evaluating lithium-ion vs. disposable options based on cost and user convenience.

Low-Power Components: Selecting energy-efficient microcontrollers and displays to extend battery life.

Power Indicator: Clear battery status display to alert users when charging or replacement is needed.

03

Material Selection

Housing: Lightweight, durable, and chemical-resistant (ABS, Polycarbonate, Medical-Grade Silicone).

PLA: Easy to print but lacks high durability. (This is what we use in CBE lab) Resin (SLA):

High precision but more fragile than thermoplastics. (Can use FormLabs Printers in Towne or Biotech Commons)

04

Test Strip Design

Insertion Accuracy: Ensures proper alignment with the sensor for reliable readings.

Durability: Resistant to contamination and frequent use.

Ease of Use: Designed for effortless insertion and removal.

Engineering Design

Prototyping and Testing

3D Printing

Utilize fused deposition modeling (FDM) for quick and low-cost prototyping using PLA or ABS materials. This approach allows for rapid iterations in design before final production.

Material Testing

Conduct drop and stress testing to ensure durability for everyday use. The goal is to verify that the device withstands typical handling and potential impacts.

Chemical Resistance Testing

Verify the material stability against blood and cleaning agents. This ensures that the device remains functional and safe for users in real-world scenarios.

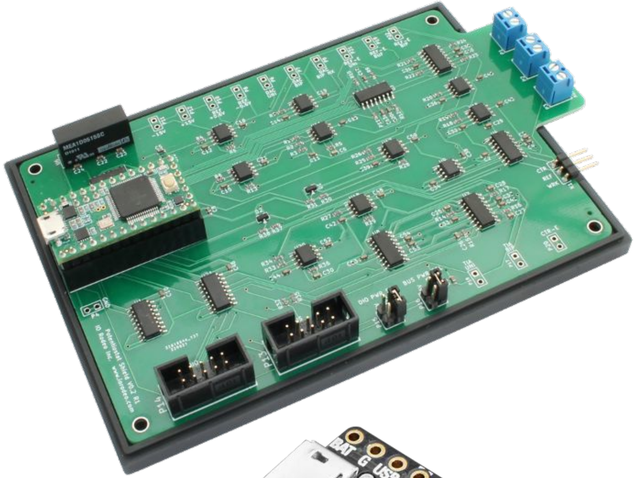
User Ergonomics Evaluation

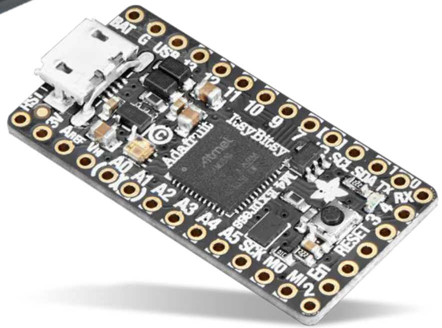
Assess handling ease, readability, and button placement to ensure the glucometer is user-friendly and accessible, particularly for users with visual impairments.

https://iorodeo.com/products/rodeostat

Development

Soft-/Firmware Development Plans





Power Management Features

Time-out response to conserve battery life

Analyte Detection

Implement automatic sample detection

Memory Function

Date/time syncing and storage of past readings for user convenience

Noise reduction

Possibly add supported filtering for noise reduction and/or baseline correction

User Interface

Buttons/display/user input

Powering glucometer, menu selection

Display of glucose reading, battery life

Project Scope

Minimum Viable Product

- Functional potentiostat using IO Rodeostat.
- Basic glucose detection with standard calibration.
- Python-based data output (no external display required).
- Single-user operation without long-term data storage.
- Acceptable margin of error

Main Goals

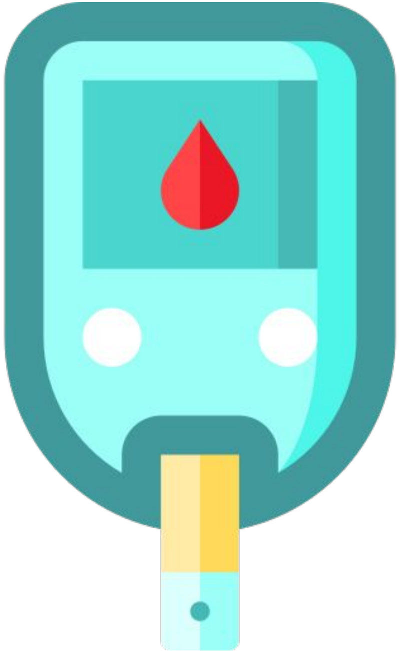
- User-friendly design and ISO-approved accuracy
- Store and analyze user data for long-term tracking.
- Incorporate date/time functionality for better monitoring.
- Portable and durable design

Expected Challenges

- Product build
  - Test strip connection to potentiostat
  - Durability
- Calibration
  - Large error
  - Batch-to-batch test strip inconsistencies
- Firmware integration
  - User-friendly interface

Summary

Conclusion and Next Steps



Develop a user-friendly, low-cost, amperometric-based glucometer to enhance ease of glucose monitoring for individuals with diabetes.

Next steps include:

- Familiarization with IO Rodeostat and completed calibration function
- Design parts purchases
- Outline for prototype-circuit and continued research into circuit design

Thank you! Questions?