TRAC

Temperature Regulated Analysis of Coagulopathy

Spring 2021

Development Team

Corbin Jee

Project Lead, PCB + Peripheral Design and Integration

David Mleczko

STM32 Programming, Temperature Control

Lucas Relic

Software, GUI and Algorithm Design

Albert Tran

PCB/Schematic Assistance , Temperature Sensor Protocols

Brycen Westgarth

Firmware Design, Hardware Peripheral Integration

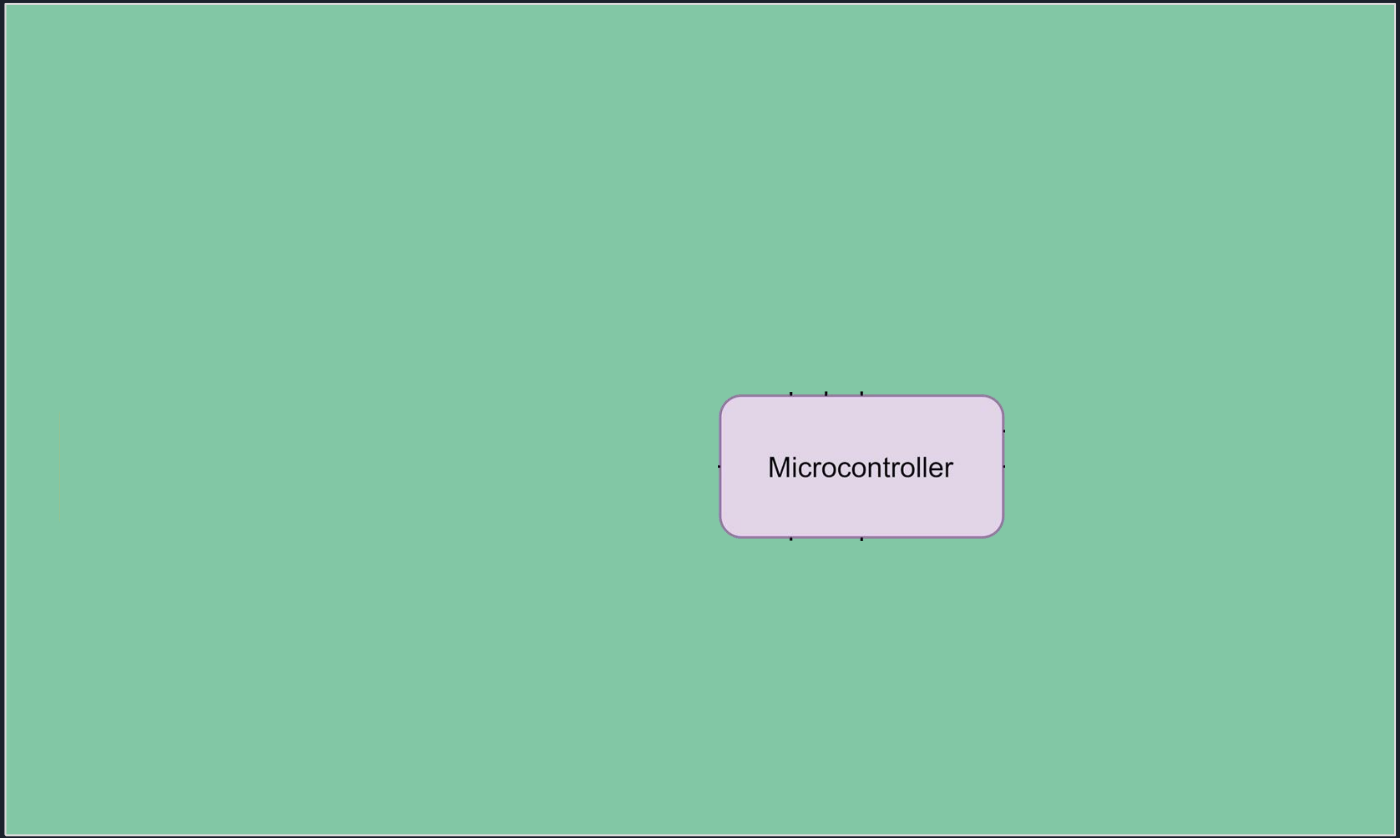
Overview

- Problem Description
- Block Diagram
- PCB Design
- Assembled Device
- Temperature Control
- UI/UX Design
- Firmware

Problem Description

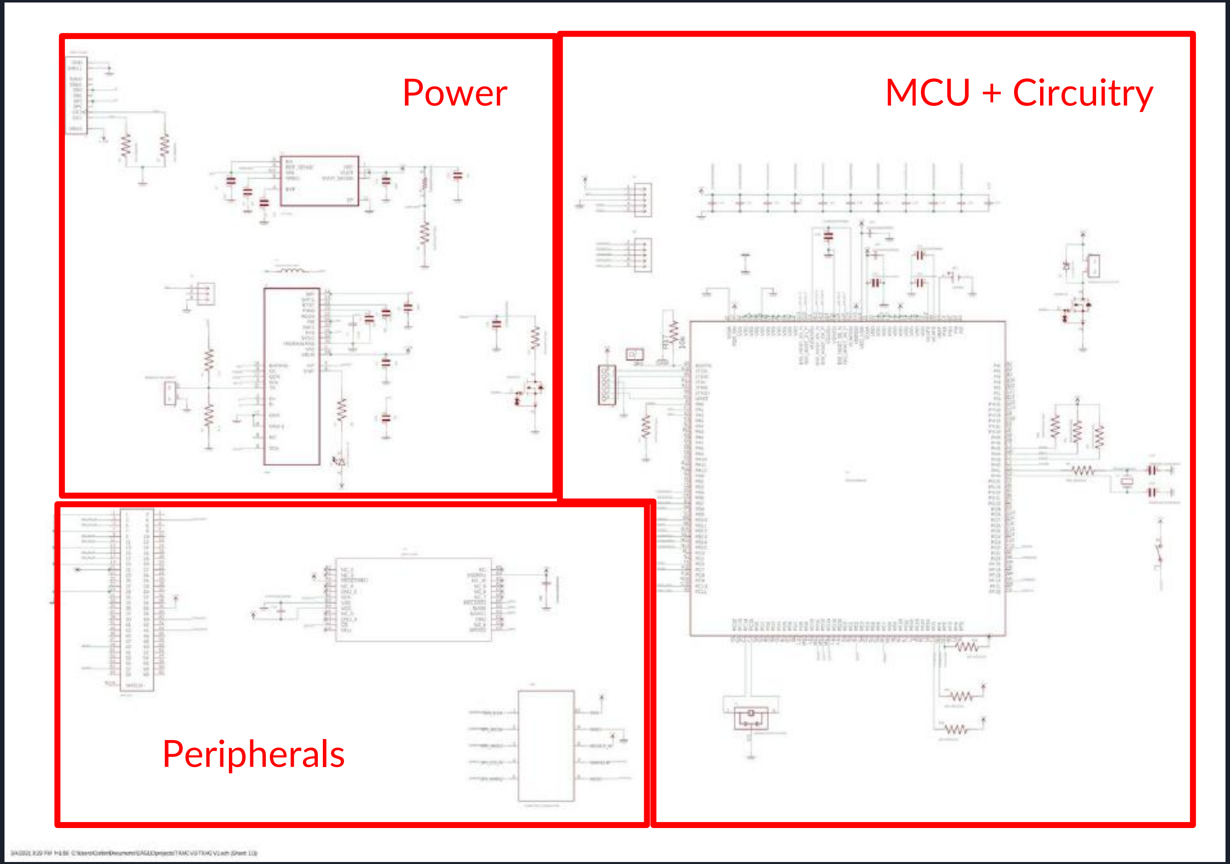
- Trauma-induced Coagulopathy (TIC)
  - Inability to clot blood
  - Occurs in approximately a quarter of trauma patients
- Must be diagnosed and treated as soon as possible
  - 30% of TIC related deaths occur within the first hour
  - Test machines are unavailable on accident scenes

Block Diagram



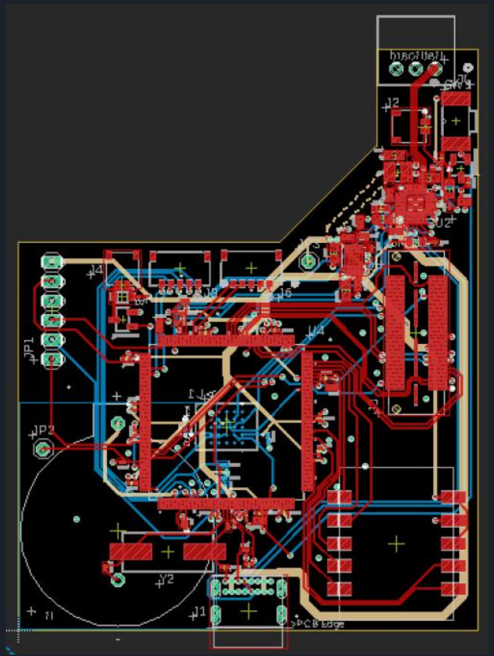
Mainboard Schematic

- Device is broken into multiple boards
  - Layout flexibility
  - Size and complexity constraints
- Features:
  - STM32 + Memory
  - Battery Management System and power regulation
  - Peripheral board connections

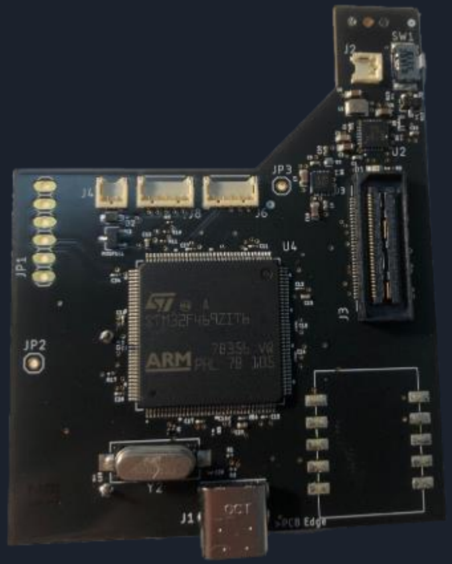


Mainboard Layout

- 4 layer PCB
  - Optimal cost and efficiency
- Separate power plane
- Optional communications PCB attachment point
- Sleep Mode Battery
- Debug and programming port
- Differential pairs routed for MIPI DSI

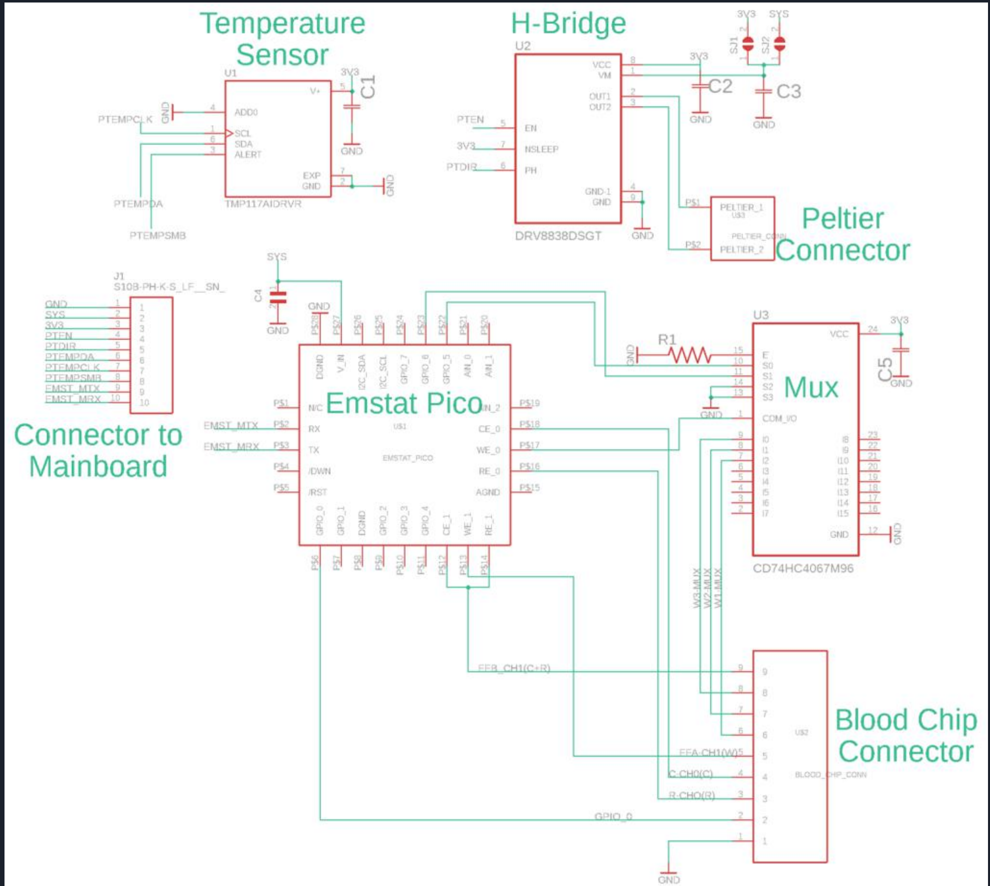


*Ground and Power Planes removed



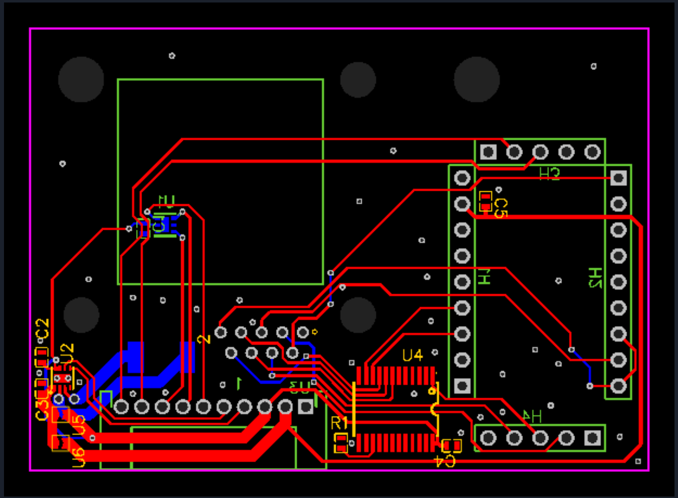
Peripheral Board Schematic

- **Temperature Sensor:** Gets reading from surface of Peltier
- **H-Bridge:** Switch between heating and cooling
- **Emstat Pico:** Conducts blood chip test
- **Mux:** Test point selection
- **Mainboard Connector:** Power and communications



Peripheral Board Layout

- Two layer board
- Holes drilled for Peltier and heatsink mounting
- Copper-Free Area where Peltier Module gets mounted for better thermal insulation
- Emstat Pico sits on headers for easy removal



Electrochemical Analysis

Emstat Pico

- Potentiostat module that performs the electrochemical measurement procedure developed by Aptitude
- Measures the concentration of fibrinogen, a crucial blood protein that aids in coagulation
- Fully capable MCU on board capable of controlling gpio pins and executing measurement protocols written in MethodSCRIPT

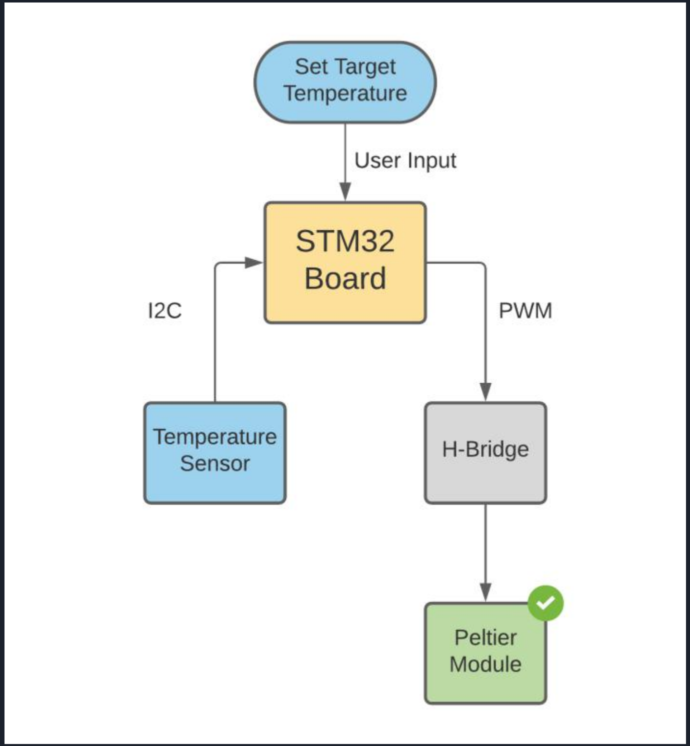
Assembled Device

- USB Type C port at the bottom for charging
- Aptitude blood chip is inserted at the top of the device
- Peltier heatsink dumps heat out left side
  - Fan pulls air in from rear
- Large 4” Touchscreen interface
- Rear Access and debug ports

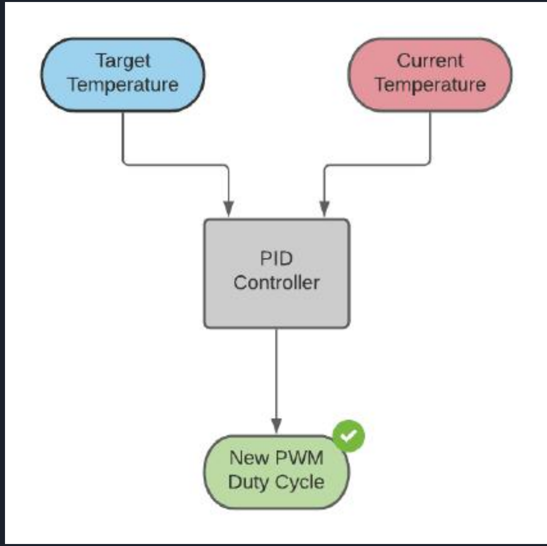
Temperature Control

Peltier Control Background

- MCU sends a PWM signal to the H-Bridge
- Duty cycle of the PWM signal controls how hot/cold the Peltier gets
- Given a target temperature, the MCU changes the duty cycle so the Peltier converges to the target

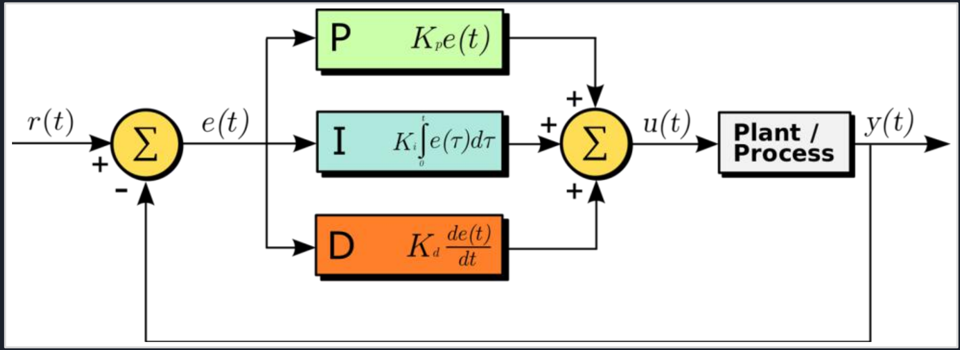


Temperature Control



PID Controller Basics

- Closed-feedback loop that uses error to apply a correction to an output
- Uses Proportional, Integral, and Derivative terms to calculate a new duty cycle
- The controller is configured using three constants: Kp, Ki, and Kd



Temperature Control

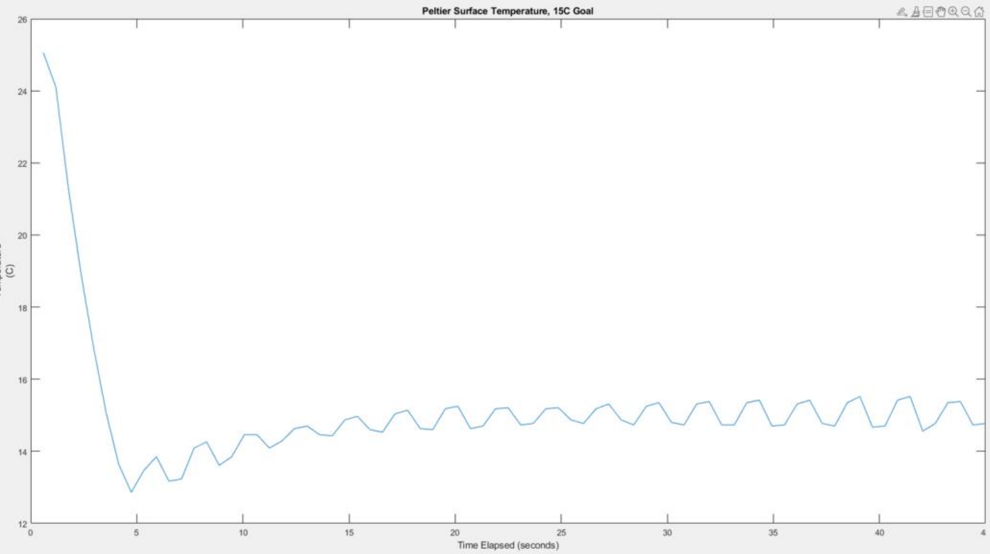
Temperature Control with Decent PID Tuning:

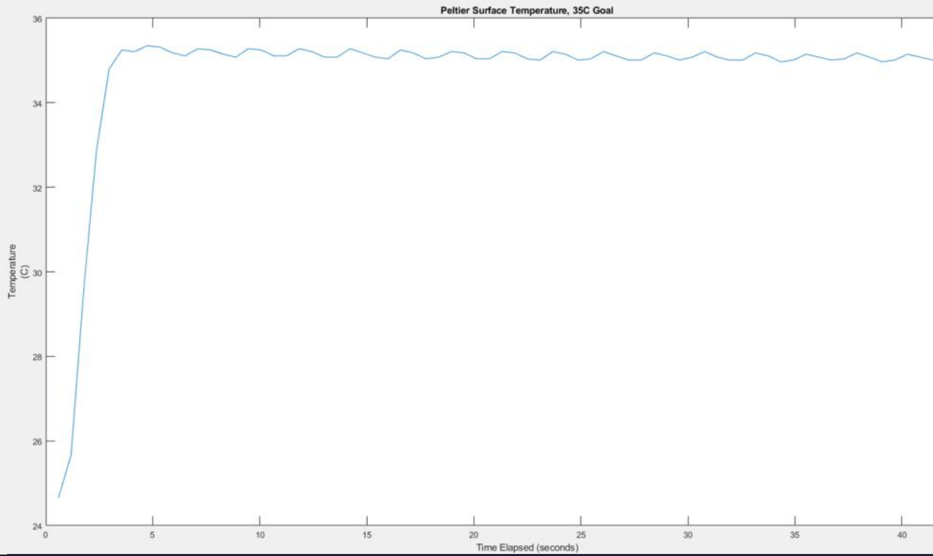
Cooling from 25C to 15C:

- Stable in 20 seconds
- +/- 0.5C oscillations

Heating from 25C to 35C:

- Stable in 5 seconds
- +/- 0.15C oscillations



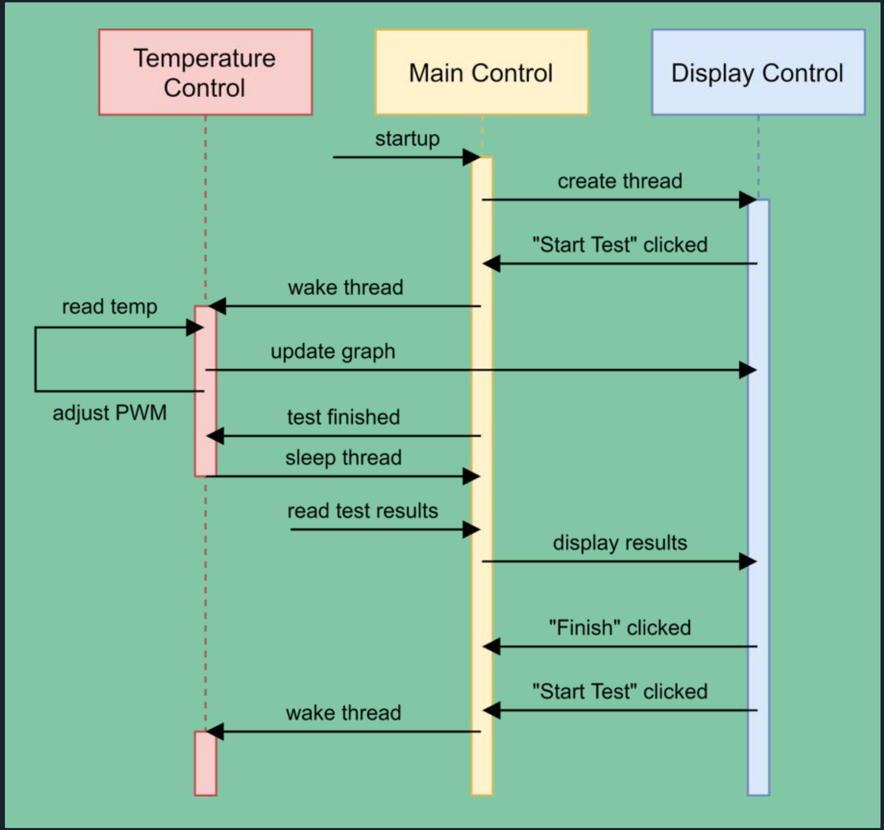


Software Overview

- Three main functions:
  - Control and communicate with peripherals
  - Generate and display the results of the test
  - Host a graphical touchscreen interface application
- All software is executed by our MCU running FreeRTOS in order to properly schedule tasks

Software Architecture

- Three-threaded design
  - One thread per function
- Threads sleep when not in use
- Mutexes for shared data
  - Temperature reading
  - Test results

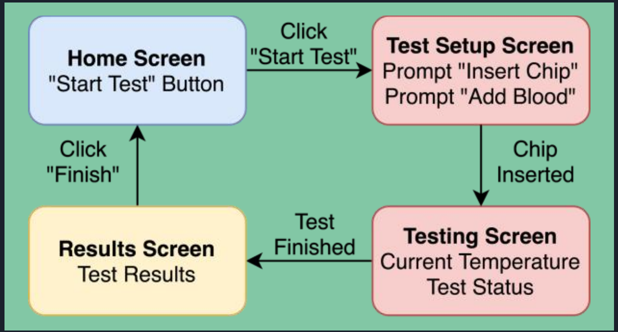


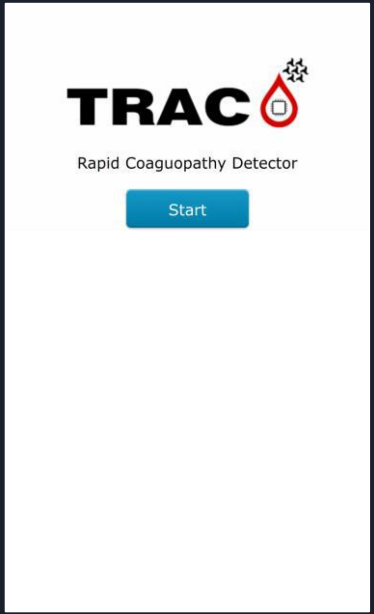
Firmware

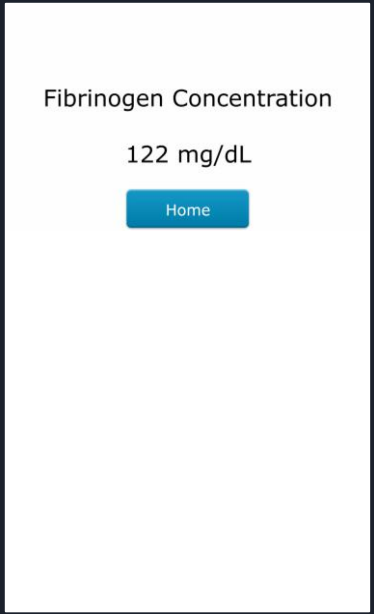
- MIPI DSI Driver
  - OTM8009A custom host driver
  - Controls drawing of framebuffer and display
- Touch Control Driver
  - FT6x06 custom ic driver
  - Detects and notifies rest of system of user touch
- Peripheral control
  - Serial communication with the Emstat Pico and temperature sensor
  - PID controller implementation
- Backend communication with the application
  - RTOS messages and queues for passing data and receiving instructions
  - Test procedure scheduling

User Interface

- Straightforward interface
  - Easy to use in stressful medical scenarios
- Automatic progression through testing sequence







Acknowledgements:

- Dr. Yogananda Isukapalli, CE Capstone Project Instructor
- Trenton Rochelle, TA
- Boning Dong, TA
- Aptitude, Project Sponsor
- Tyler Chozinski, Aptitude Contact

Thank You

Questions?