Temperature Regulated Analysis of Coagulopathy

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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 25°C to 15°C:
- Stable in 20 seconds
- +/- 0.5°C oscillations

Heating from 25°C to 35°C:
- Stable in 5 seconds
- +/- 0.15°C 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
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Questions?