a07g-exploring-the-CLI

- **Team Number: 18**
- **Team Name: DualCore**
- **Team Members: Peng Su, Yuanchao Zhang**
- **GitHub Repository URL: https://github.com/ese5160/a00g-devices-designs-diagrams-s25-dualcore**
- **Description of hardware (embedded hardware, laptop, etc): (1)Apple M3 Pro, macOS Sonoma (2) Apple M1 Pro - Macbook**

Part 1. Software Architecture

(1) : Update the requirements of HRS & SRS based on the latest modifications

Hardware Requirements Specification (HRS)

HRS 01 – Microcontroller & PCB Base

The project shall be based on a custom PCB integrating a suitable microcontroller (SAM W25). This PCB must provide:

- General-purpose I/O for motor control and sensor data acquisition.
- At least one communication interface (e.g., UART/SPI/I²C) for the LCD screen.
- Wireless connectivity (Wi-Fi/Bluetooth) for smartphone control, or headers for an external module.

HRS 02 – Sensors

The system shall incorporate:

- A **Temperature-Humidity Sensor** (e.g., DHTxx/SHTxx) to measure ambient conditions.
- An **Air Quality Sensor** (e.g., MQ-series, CCS811, or similar) capable of detecting smoke or poor air quality.

All sensors must operate under the expected environmental conditions (e.g., indoor ranges of temperature and humidity) and provide reliable, stable readings.

HRS 03 – Motor Driver & Window Actuator

A motor driver circuit (integrated on the custom PCB or via a module) shall deliver the necessary current/voltage to a DC or Continuous Rotation Servo that adjusts the

window’s opening angle. This includes:

- Support for PWM or position feedback control when we use Continuous Rotation Servo.
- Overcurrent or thermal protection mechanisms.
- Secure mechanical coupling to the window’s frame or rod.

HRS 04 – PDLC Film Power and Control

The PCB shall feature a step-up converter to approximately 48 V DC, plus a DC-to-AC conversion stage, enabling segmented control of the PDLC film for time display:

- Each 7-segment “digit” on the glass must be individually switchable.
- The system shall refresh the displayed time at a minimum of once per minute (using the onboard RTC).
- Safe isolation and protective measures against high-voltage lines are required.

HRS 05 – Switch Reed Integration

The system shall incorporate a reed switch to ensure precise detection of the window’s fully closed state. This includes:

- Interrupt-based or polling-based detection mechanism integrated with the microcontroller.
- Automatic stopping of the servo motor when the closed position is detected.
- Reliable and durable placement to avoid false triggers or misalignment over time.

HRS 06 – Steel Flat-Edge Sliding Window Roller Assembly

- The system shall include a steel flat-edge sliding window roller assembly to ensure smooth and fluent movement during window opening and closing. This includes:
- High-durability rollers capable of supporting the window's weight.
- Minimal friction design for seamless motion.
- Secure mounting and alignment to prevent jamming or misalignment.

HRS 07 – Housing & Mounting

All PCB components must fit within the acrylic window frame enclosure to protect electronics. Additionally:

- Mounting points on the PCB for screws or standoffs to secure it in place.
- The LCD shall be flush-mounted or otherwise integrated into the frame for user viewing.
- Proper ventilation or heat dissipation strategies for voltage regulators and motor drivers.

HRS 08 – Safety & Protection

The hardware design shall include protection features such as:

- Overvoltage/overcurrent safeguards on motor driver and PDLC driver stages.
- Reverse-polarity protection or fuses as needed.
- Adequate insulation for high-voltage lines (48 V AC) powering the PDLC film.

Software Requirements Specification (SRS)

SRS 01 - Window and Environment Data Retrieval:

The system shall enable users to access real-time window status (open/close/angle) and environmental data (temperature, humidity, air quality) via a smartphone app.

SRS 02 - Window Time Adjustment:

The system shall allow users to modify automatic window operating times (e.g., morning open, evening close) through the app.

SRS 03 - Manual Window Opening and Closing:

Node-red Dashboard shall provide a Virtual Button to "Open Window" and "Close Window" or angle adjustment.

SRS 04 - Manual Angle Adjustment for Manual Window Control:

Node-red Dashboard shall provide a input function for Angle Adjustment.

SRS 05 - Automated Window Opening by Time:

Users shall be able to set specific times for automatic window opening in the app.

SRS 06 - Automated Window Opening by Smoke:

If the air quality sensor detects smoke or poor air quality, the system shall immediately open the window for ventilation (highest priority).

SRS 07 - Automated Window Closing by Time:

Users shall be able to program specific times for automatic window closure in the app.

SRS 08 - Automated Window Closing by Rain:

When rain or high humidity is detected, the system shall close the window to prevent water from entering. This has a lower priority than smoke detection but higher than standard scheduling.

SRS 09 - PDLC Film Time and Weather Display：

Using PDLC film segments on the glass, the system shall display the current time and weather in a 7-segment style (HH: MM), driven by an internal or external RTC.

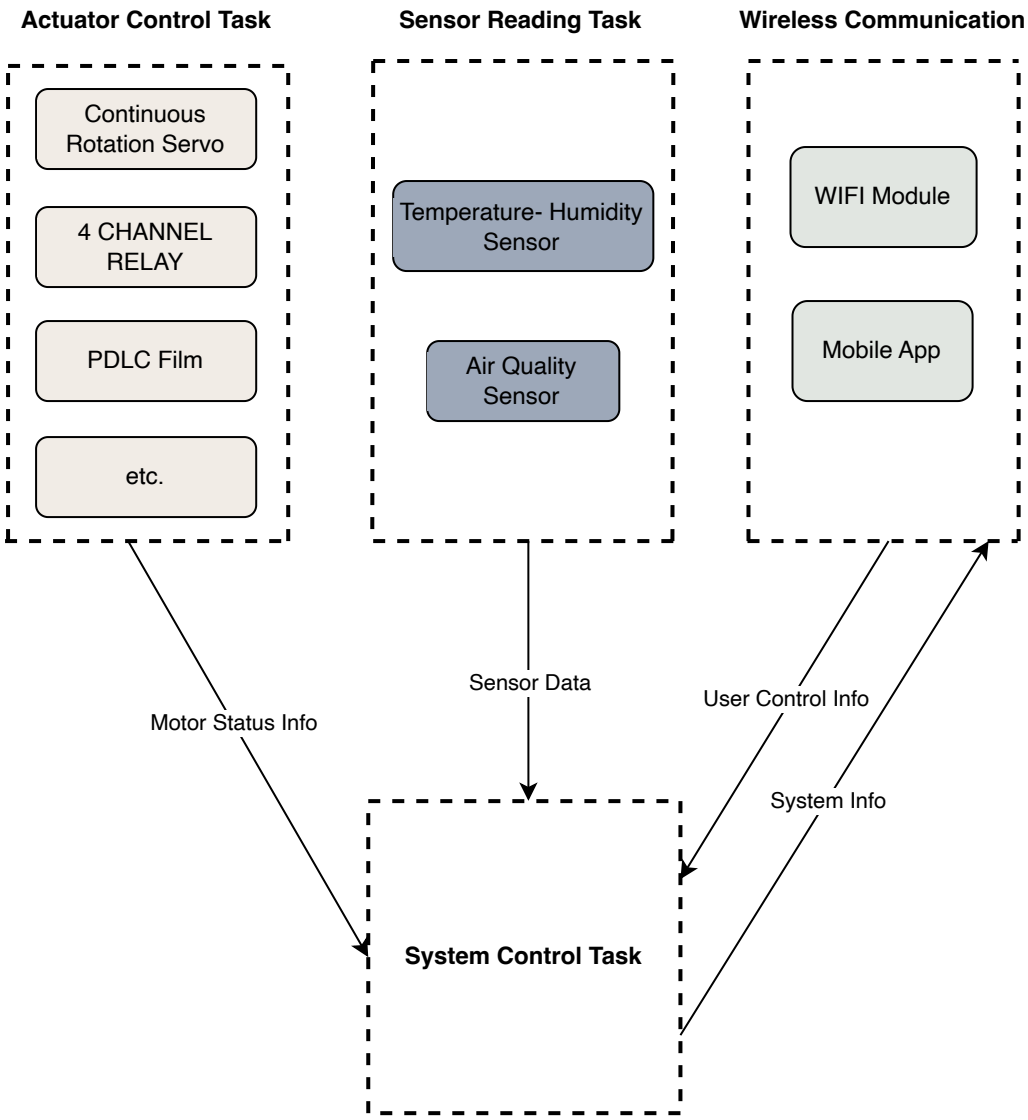
SRS 10 - Voice System / Spoken Alerts:

Node-red Dashboard shall support a Virtual Voice Module to announce time, environmental alerts (smoke/rain), or user notifications.

SRS 11 - Window Opening / Closing Constraints:

The system shall prevent excessive opening or closing if the window is already fully open or closed, avoiding redundant motor actions.

(2) : A block diagram outlining the different tasks (A07G_BlockDiagram.svg):



Part 2. Understanding the Starter Code

(1) `InitializeSerialConsole()` sets up the UART interface by initializing circular buffers (`cbufRx` for received data and `cbufTx` for transmitted data), configuring the USART peripheral, registering callbacks, setting the interrupt priority, and starting an asynchronous read operation. `cbufRx` and `cbufTx` are **circular buffers**, a fixed-size data structure that efficiently manages streaming data using a head and tail pointer, preventing data loss and reducing CPU overhead in serial communication.

(2) `cbufRx` **and** `cbufTx` are initialized in `InitializeSerialConsole()` using `circular_buf_init()`, which sets up circular buffers for receiving and transmitting UART data using `rxCharacterBuffer` and `txCharacterBuffer`, each **512 bytes** in size. These buffers manage UART communication efficiently by storing incoming and outgoing characters. The data type `cbuf_handle_t` and functions like `circular_buf_init()` and `circular_buf_get()` are likely defined in a separate

C file, `circular_buffer.c`, with corresponding declarations in a header file like `circular_buffer.h`.

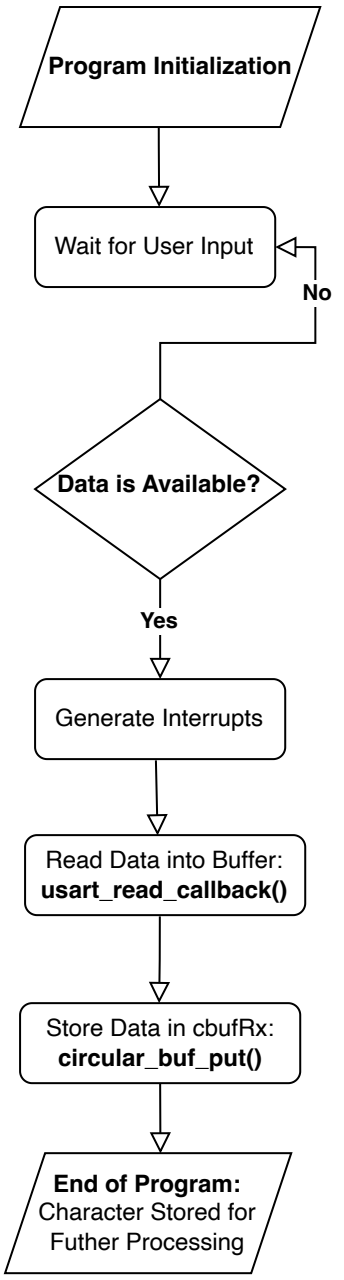
(3) The received (RX) and transmitted (TX) characters are stored in the character arrays `rxCharacterBuffer` (512 bytes) and `txCharacterBuffer` (512 bytes), respectively. These buffers temporarily hold UART data before being processed. While `cbufRx` and `cbufTx` are circular buffer structures, they internally manage data storage using `rxCharacterBuffer` and `txCharacterBuffer`, ensuring efficient handling of streaming data.

(4) The **UART character received** and **UART character sent** interrupts are handled in the callback functions `usart_read_callback()` and `usart_write_callback()`, respectively. These functions are registered using `usart_register_callback()` inside `configure_usart_callbacks()`, ensuring they are triggered when a character is received or transmitted. The interrupts are then enabled using `usart_enable_callback()`, allowing asynchronous UART communication.

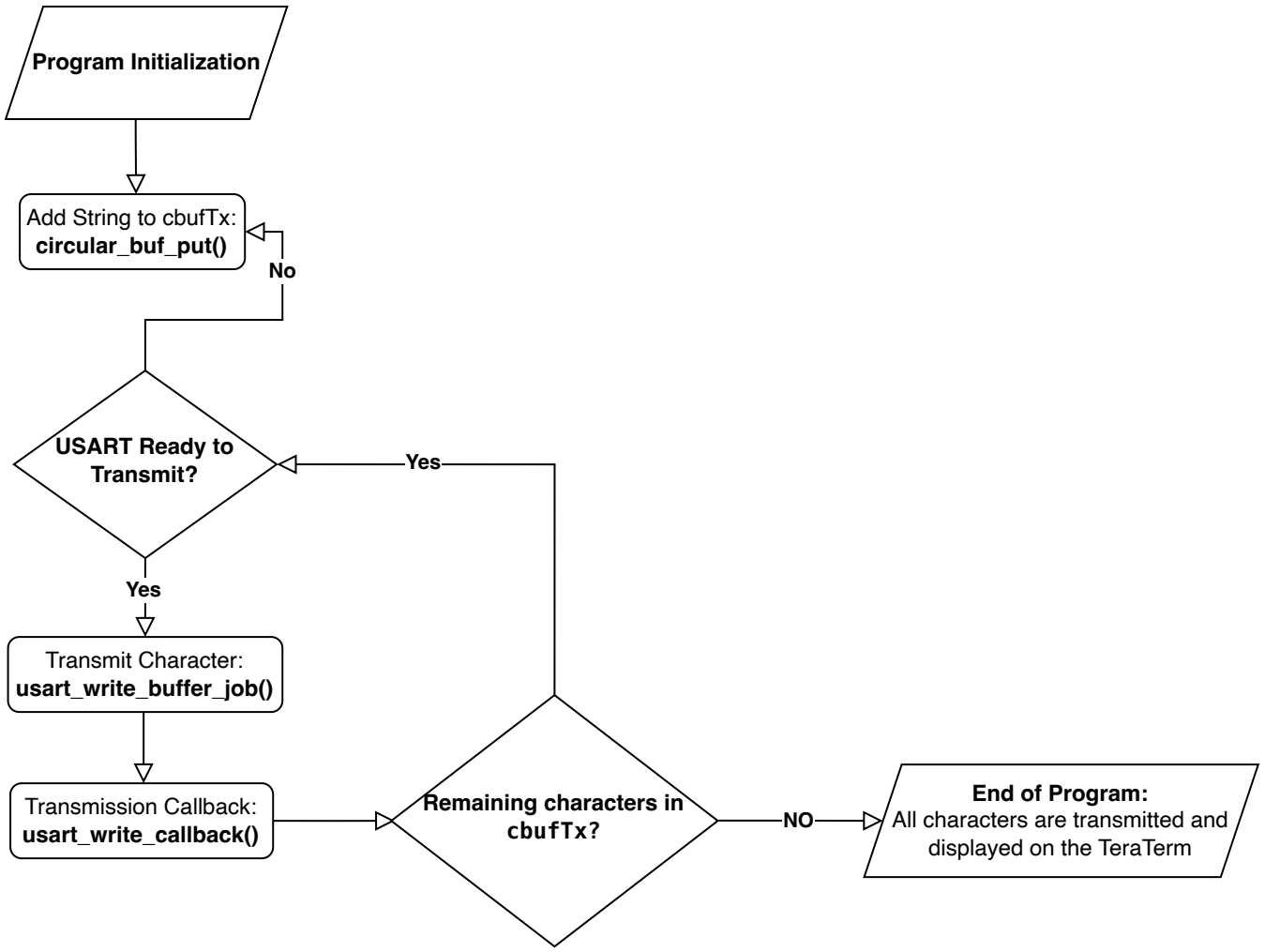
(5) The callback function `usart_read_callback()` is triggered when a character is **received (RX)**, while `usart_write_callback()` is called when a character has been **sent (TX)**. These callbacks are registered inside `configure_usart_callbacks()`, linking them to the USART interrupt system. This setup ensures efficient handling of UART communication by automatically responding to character transmission and reception events.

(6) In `usart_read_callback()`, when a character is **received (RX)**, it is added to the `cbufRx` circular buffer, allowing the system to store incoming UART data efficiently. Similarly, in `usart_write_callback()`, when a character has been **sent (TX)**, the next character is retrieved from `cbufTx` and transmitted via `usart_write_buffer_job()`, ensuring continuous data transmission. These callbacks manage UART communication asynchronously by using `cbufRx` and `cbufTx` to buffer received and transmitted characters, preventing data loss and reducing CPU overhead.

(7) UART Receive Flowchart:



(8) UART Transmission Flowchart:



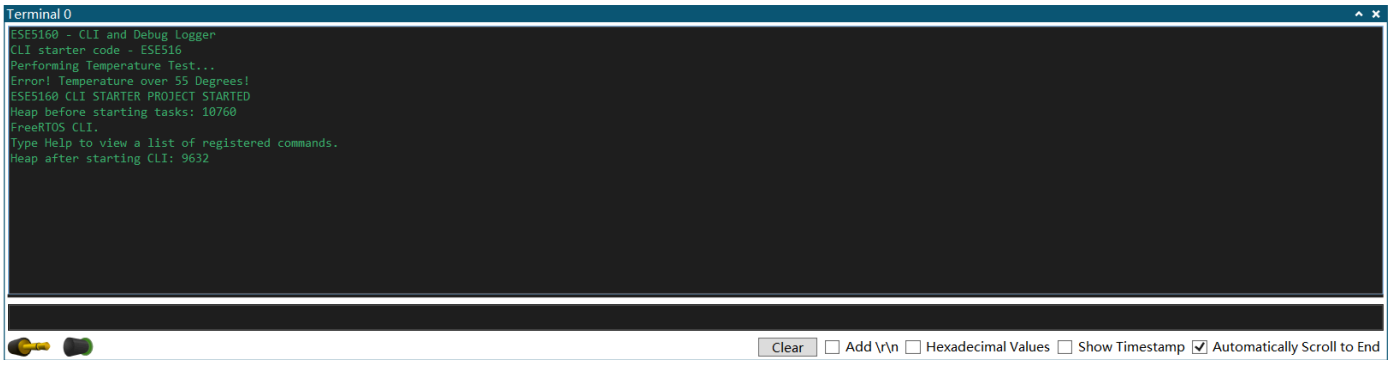
(9) The function `StartTasks()` initializes system tasks and prints the available heap memory before and after task creation. It starts the **Command Line Interface (CLI) task** using `xTaskCreate(vCommandConsoleTask, "CLI_TASK", CLI_TASK_SIZE, NULL, CLI_PRIORITY, &cliTaskHandle)`. If the task creation fails, an error message is printed. Based on the provided code, only **one thread (CLI task)** is explicitly started in this function.

Part 3. Debug Logger Module

Link of Debug Logger Module in Github Repository (A07G Debug Logger Module):

https://github.com/ese5160/final-project-a07g-a14g-t18-dualcore/tree/main/A07G%20Debug%20Logger%20Module

Output of Debug Logger Module (A07G_DebugLogger_Output.png):



Part 4. Wiretap the convo!

1. Submit Our Answers to Github Repository:

(1) The **UART communication** between the **SAMW25** and **EDBG IC** occurs on **SERCOM4**. To capture data using the Saleae Logic 8, attach the logic analyzer as follows:

- **TX (SAMW25 → EDBG)**: → `Channel 0`
- **RX (EDBG → SAMW25)**: → `Channel 1`
- **GND**: Connect to board ground.

(2) Pin Mapping

Signal	SAMW25 Pin	Logic Analyzer Channel
UART TX	PB10	CH0
UART RX	PB11	CH1
GND	GND	GND

From `SerialConsole.c`, the TX (SAMW25 → EDBG) is mapped to `PB10`, and RX (EDBG → SAMW25) is mapped to `PB11`.

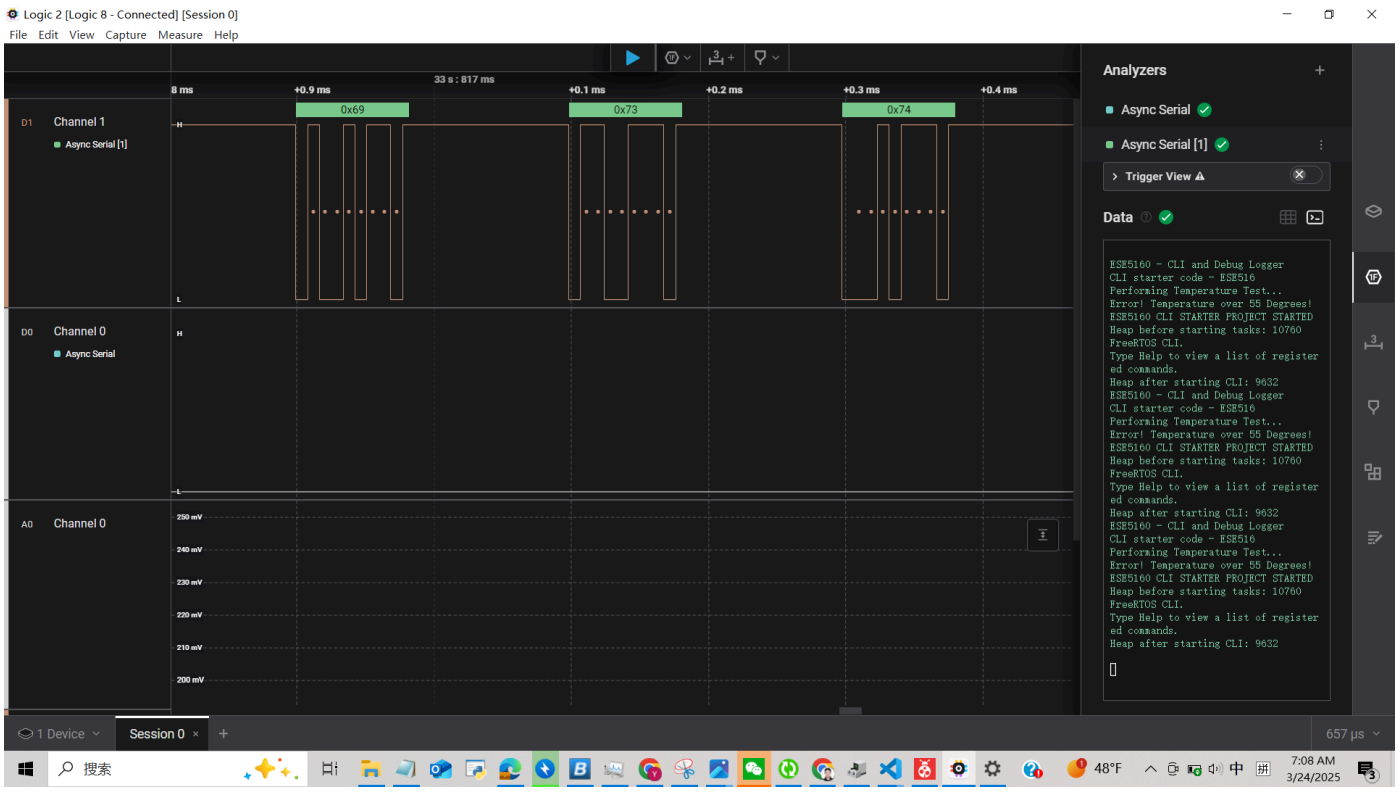
- **TX (SAMW25 → EDBG)**: `PB10` → `Channel 0`
- **RX (EDBG → SAMW25)**: `PB11` → `Channel 1`
- **GND**: Connect to board ground.

(3) Critical Settings for the Logic Analyzer

- **Baud Rate:** 115200
- **Data Bits:** 8
- **Parity:** None
- **Stop Bits:** 1
- **Inverted Signal:** No
- **Triggering:** "Start Capture on UART Activity" (Edge trigger on TX)

2. Photo of Our Hardware Connections (A07G_Logic8_Hardware.png):

3. Screenshot of the Decoded Message (A07G_Logic8_DecodedMessage.png):



4. A Small Capture File of a Wiretapped Conversation (Logic8_DecodedMessage.sal):

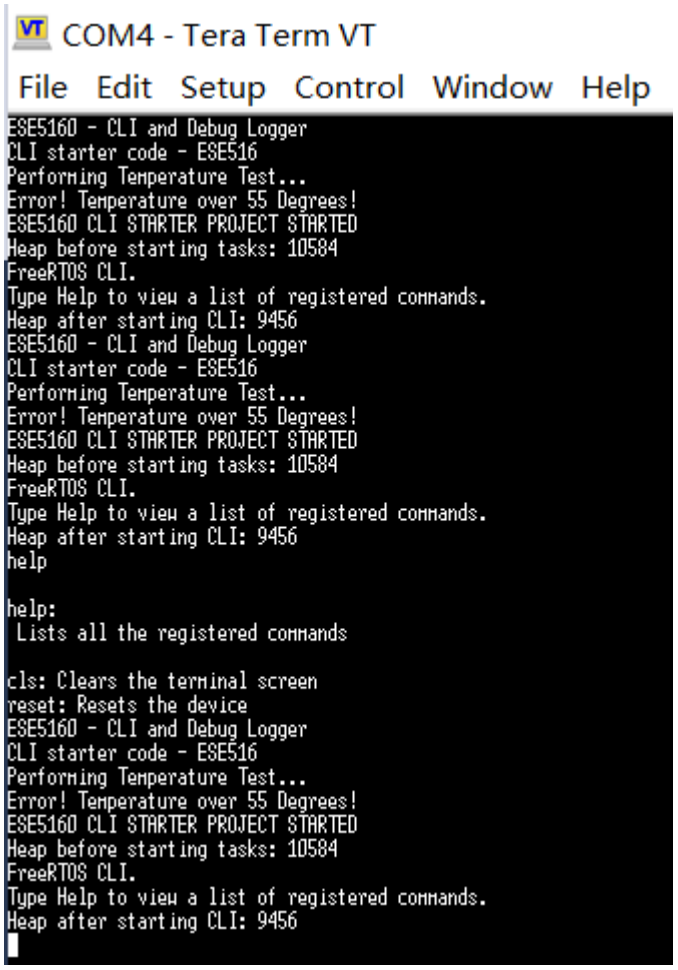
https://github.com/ese5160/final-project-a07g-a14g-t18-dualcore/blob/main/Logic8_DecodedMessage.sal

Part5: Complete the CLI

Link of Completed CLI Codebase in Github Repository (A07G Completed CLI):

https://github.com/ese5160/final-project-a07g-a14g-t18-dualcore/tree/main/A07G%20Completed%20CLI

Screenshot of Completed CLI Codebase:



Part6: Add CLI Commands

Video of This Functionality in Google Drive (A07G_Part6.mp4):

https://drive.google.com/file/d/16XTh9HimEZRzcR5HKSWC8RlalymCl6Ff/view?usp=sharing

Video of This Functionality in Github Repository (A07G_Part6.mp4):

https://github.com/ese5160/final-project-a07g-a14g-t18-dualcore/blob/main/A07G_Part6.mp4

Codebase of Added CLI Commands in Github Repository (A07G Added CLI Commande):

https://github.com/ese5160/final-project-a07g-a14g-t18-dualcore/tree/main/A07G%20Added%20CLI%20Commands