CSE 237D Spring 2025

TONIQ Project Specification

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1. Project Charter

1.1. Project Overview

TONIQ is a smart water bottle that improves the well-being of its users by tracking critical health metrics such as water consumption and water quality, and presents them on an integrated e-ink display. It also features an automated UV-C sterilization system to kill any harmful viruses or bacteria that may be present in the liquid. Additionally, the lid of the bottle (containing the electronics) is fully independent of the bottle itself, and fit to the exact specifications of a standard wide-mouth water bottle opening. This enables it to be easily attached to other water bottle bodies such as a 32 oz. Hydro Flask. Existing smart water bottles have many flaws: they are expensive, inflexible, reliant on a mobile app for tracking, and may require nonstandard charging cables prone to failure. We aim to solve these key issues while maintaining an elegant and user-friendly design in one container: *TONIQ*.

1.2. Project Approach

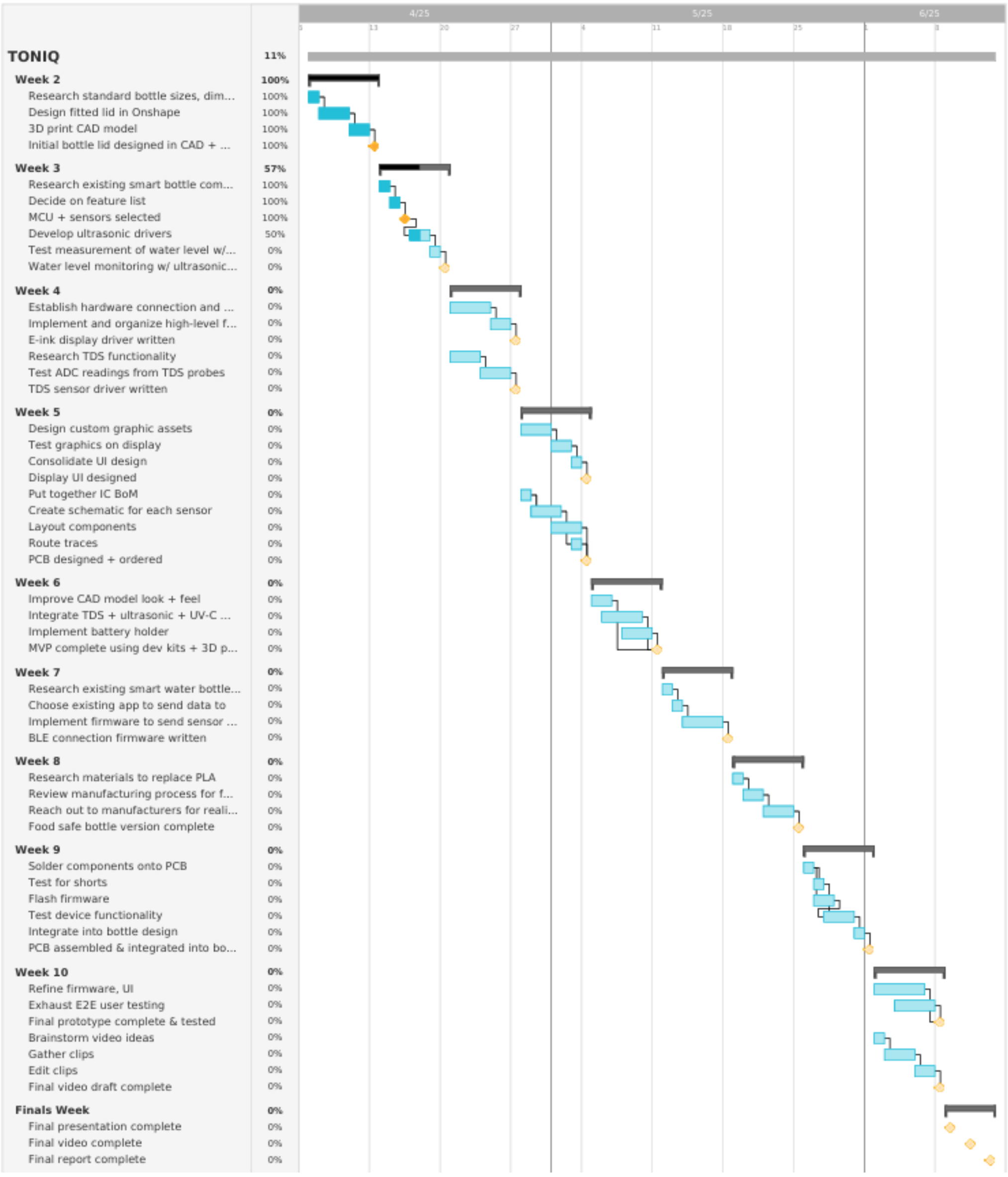
There are four categories to making TONIQ: Mechanical, Electrical, Firmware, and Manufacturing. We split the tasks into these four categories and make progress on each in parallel. If a task has no blocking dependencies, we prioritize it and assign it to a member of our group.

To fit the physical constraints of our system, we need to choose compact electronic components. For this reason, we are printing a PCB to perfectly fit the unique form-factor of the housing in the bottle lid. This PCB will also allow us to efficiently route data and power between our micro-controller and external sensors without the need for additional components.

With this product, power efficiency is at the forefront of our design. Users shouldn't need to charge their water bottle every night. For these reasons, we have decided to use a CR2450 coin cell battery, which has a relatively high capacity (620 mAh) and allows users to easily replace it as needed. We have also chosen an MCU that is capable of entering an extremely low-power sleep state, as the electronics will remain in a sleep state for the large majority of the time. Our choice to use an integrated e-ink display will also help with this given that it draws effectively no power after it is driven.

1.2.1. Deliverables & Timeline

Responsibility for each deliverable will be determined by the Gantt chart (see image below). Generally, each person will have either device drivers to write, a structural component to design, or hardware circuits to design each week, which can be completed independently. For milestones, the responsibility will be shared between all team members as each milestone will likely involve integrating multiple individual deliverables into the larger system and then testing it (see Section 4).



1.3. Minimum Viable Product

1.3.1. Overview

Our minimum viable product is a smart water bottle which includes at least one of the monitoring or health features that we outlined in our full specification. This means we will have support for one of either water consumption tracking, water quality measurement or water sterilization UV-C. The water consumption will be tracked using an ultrasonic senor which will be pointed down from the lid. For measuring water quality, we will use a TDS (Total Dissolved Solids) sensor.

In addition to the core health functionality, our MVP will include an e-ink display with simple interface. The display's user interface will be sufficient enough to display one of the aforementioned health metrics. The e-ink itself will be physically placed around the ring of the

1.3.2. Implementation

For the MVP, we will aim to manufacture the lid of the water bottle to meet the needs of our product. This means it will need to allocate space for the display, sensors, and other electronic components. For manufacturing the lid, we will start off with 3D printing using a food-safe material. This gives us the ability to rapidly prototype towards the MVP and keep our costs down in lieu of more sophisticated manufacturing techniques.

With regards to firmware, we plan on having the e-ink driver completed with a rudimentary user interface that can at least display one of our health measurements or the UV-C status. This will require us to develop SPI firmware to send commands and data to the display. In addition, we need firmware to interface with one of our health related peripherals to perform either water consumption tracking, water quality measurement or water sterilization with UV-C. Interfacing with the ultrasonic or TDS sensor will require us to interface with our microcontroller's analog to digital convertor (ADC) to read the output from each sensor.

1.4. Constraints, Risk, and Feasibility

There are many risks for each part of the project. Part selection and design was a critical part of scoping this project. We originally intended to use a round e-ink display that looks seamless on the top of the bottle. We discovered that the dimensions and driver board for our form factor do not exist after contacting an e-ink display supplier. By completing the rough mechanical design, locking components selection early on, and freezing the feature set, we have set a reasonable scope for the project. Every design decision creates cascading work in our four categories, so we quickly decided to commit to a maximal feature set that will not change.

We mitigated risks to mechanical design by removing all moving components in the lid. Everything is integrated into the same piece, except for a removable battery on the top. We ensured the electrical and firmware parts would be easier by choosing a standard Nordic NRF-5x chipset. Using common hardware makes it most likely for the firmware to work with the hardware, and we can be certain the Zephyr RTOS SDKs are well-supported. In addition, using a Nordic chip means that the wireless hardware is built-in and we do not have to undergo any FCC certification in the case of Bluetooth functionality.

2. Group Management

2.1. Team Members

- Cody Rupp
- Samir Rashid
- Kyle Trinh
- Anthony Tarbinian

2.2. Communication

Our decisions are made by consensus before deadline. We whiteboard decisions, weigh all options, and commit to a choice for every aspect of the product. All of our meetings happen in person.

A member sends meeting notes after and lists remaining tasks before the next meeting. We use our timeline to ensure we are staying on track. If a blocking task is behind schedule, then we all focus on unblocking it. Making the bottle requires having everything working well before the end of the quarter, so we mix the aspects that we work on. This shared responsibility means that we do not have strict separation of concerns between members. Ultimately, everyone is responsible for meeting all milestones on time.

2.3. Scheduling

We have allocated Monday 2-6PM and Wednesday 5-9PM as our scheduled meeting times. When unavoidable events happen in our lives, that obstruct our meetings, we will communicate with our team beforehand to appropriately alter meeting goals.

It is vital that absent members consult with the rest of the team to catch up on milestone discussions and project decisions.

3. Project Development

3.1. Team Roles

Cody, Samir and Anthony will focus on the mechanical design. Cody will focus on PCB design. Anthony, Samir and Kyle will focus on firmware.

With this being said, all of us will collaborate and share responsibilities across the project. We have a dynamic environment where everyone is expected to touch all aspects of the product.

3.2. Hardware/Software Tools

Our hardware is a NRF52840 chip which runs the e-ink display and the water sensors. The firmware runs on the Zephyr RTOS. We have already bought all the components and will need to integrate them into a PCB once we have a working prototype.

Bill of Materials:

Item	**Cost**
E-ink display	$20
E-ink driver board	included
Lid polypropelene	$0.1
Lid gasket	$0.1
Coin cell battery	$1
PCB	$5
Ultrasonic sensor	$5
UV-C LED	$2
Vacuum sealed bottle	$2
SUM	**$35.2**

3.3. Testing and Documentation

We are testing the sensors by hand with breadboarded electronics. We are rapidly prototyping the hardware by 3D printing the chassis pieces before working on the mass manufactured version.

We will make a usage manual for consumers of the product. The firmware will have source code comments and our CAD files have labeled variables and transformations. We also maintain a log of progress in an internal Google Doc.

4. Project Milestones and Schedule

The larger, more deliverable milestones are listed below. For lower-level milestones, refer to the Gantt chart above. Since these will all involve integrating multiple smaller tasks (completed by individuals), all members will be responsible for each of these critical milestones.

Week	Milestone
2	Initial bottle lid designed in CAD + 3D printed (4/13)
3	MCU + sensors selected, water level monitoring implemented (4/16, 4/20)
4	Firmware drivers for e-ink display, TDS sensor written (4/27)
5	Display UI designed, PCB designed + ordered (5/4)
6	MVP complete using dev kits + finalized 3D print model (5/11)
7	Firmware for BLE connection to smartphone health app written (5/18)
8	Food safe bottle version complete (5/25)
9	PCB assembled + integrated into bottle (6/1)
10	Final prototype complete & tested, drafts of final video complete (6/8)
Finals	Final video + presentation + report complete (6/9-6/13)