The American University in Cairo

School of Sciences and Engineering

Computer Science and Engineering

CSCE 4301 - Embedded Systems - Fall 2023

Project report

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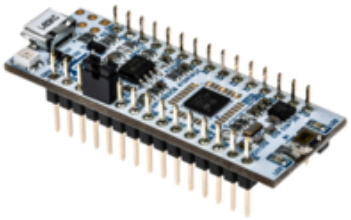
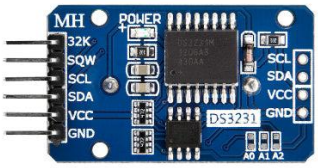
1. Introduction

Our project is primarily a Smart water bottle, an implementation of the embedded systems principles that we have learned and applied throughout the semester. Beyond its conventional function as a hydration vessel, our Smart Water Bottle is an integration of cutting-edge sensors, microcontrollers, and efficient communication protocols. One notable feature of our smart bottle is its ability to alert the user when the bottle is empty. This is achieved by activating a buzzer with a specific frequency, accompanied by a message displayed on the Teraterm application. Moreover, the system provides reminders to drink when the bottle is within a range considered to be full, employing a different frequency for the buzzer and displaying corresponding messages on Teraterm. Adding to its functionality, our Smart Water Bottle constantly displays the water temperature on Teraterm, providing users with real-time information about the contents of their bottle.

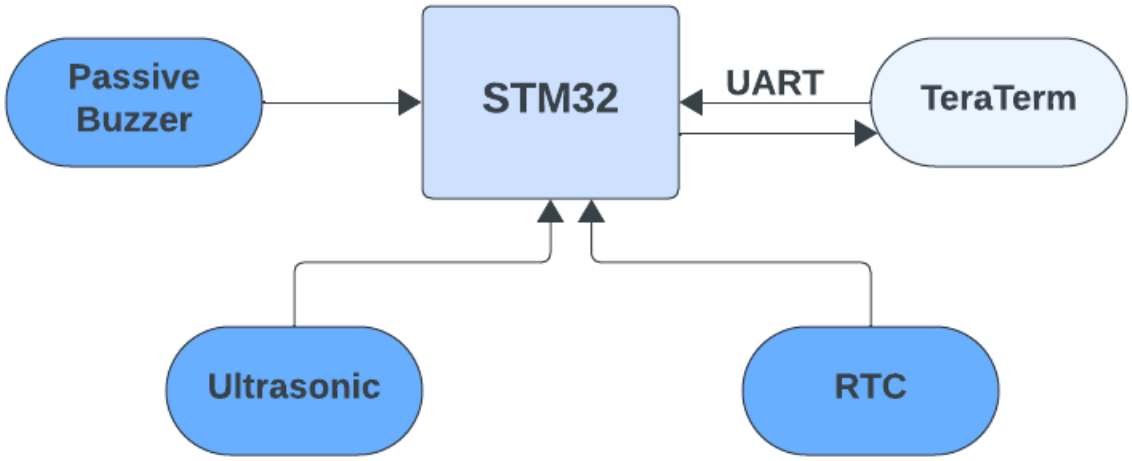
2. Components

Component	**Image**	**Description**
Nucleo STM32 (MCU)		The brain of the system which controls the data flow for the ultrasonic sensor, RTC, and passive buzzer.
Ultrasonic Sensor		The sensor emits high-frequency pulses toward the water level. Then it calculates the time taken for the echo back. Thus providing almost precise data for the small distance of the water level.

RTC		The RTC module, here, is used as a temperature sensor for measuring the temperature of the water. The sensor converts the analog temperature data into a digital format that can be easily read and used by the MCU.
Passive Buzzer		The passive buzzer applies the PWM function to sound different alerts based on certain frequencies. For example, if the water level falls under a predetermined threshold it notifies the user using a certain sound different from the one used to notify the user to drink water.

3. Diagram

This is a diagram of the used components that were discussed in the above section:



4. Financial Study

We conducted a financial analysis in USD for our final product of the project, evaluating the price of each of the components used and comparing it to existing smart water bottles available in the market. The results of the financial analysis favored our project significantly, revealing that our smart water bottle costs about $20 while all the similar products currently in the market are priced between $40 and $60.

	Market Price / Piece	**Links**
RTC	2.50$	RTC
Ultrasonic	2$	HC-SR04 Ultrasonic Module
Nucleo MCU	11$	NUCLEO-L432KC STMicroelectronics| DigiKey
Passive Buzzer	0.33$	Passive Buzzer – Electroslab
Other Components	5$	
Total	**20.83$**	
Other Competitors	40-60$	Smart Temperature Display Flasks

5. Challenges

During our work on the project, the major challenge we faced was how to set up the ultrasonic sensor. The way it operates is that we have to send a signal to the sensor as a starting signal. Then after a certain period of time, we have to send another signal as a stop signal. The time between these two signals must be calculated too because that is how we obtain the distance. It took several tries and multiple setups to make the ultrasonic sensor function properly and provide us with the correct data.

Another challenge we faced was how to place all of the project's components inside a water bottle and ensure that no water would come in contact with them so they don't short-circuit. Our solution was to create a hollow chamber under the storage of the water within the bottle and all the components will be placed there except for the

ultrasonic sensor, it will be placed on the bottom of the lid, and covered with a thin protection layer.

Moreover, this protection layer will have two holes around the sender and the receiver so that the signal doesn't bounce off of it. This solution is done on paper, nevertheless, we couldn't implement it due to the 3D printers not functioning properly.

6. Future Work

For our future work, we will provide the design of our water bottle to get it 3D printed, and prepare a prototype. As discussed above, we were able to think of a design but it was never tested, so testing that design will be our next step.

Then, we will add extra sensors such as Gyroscope and movement detection sensors to stop any measurements taken if the water bottle is moving or tilted as it will provide wrong and inaccurate data. This will increase our accuracy. Another improvement to be added is to make the water bottle vibrate as it currently doesn't vibrate when a notification is sent to the user. In addition, we are thinking of adding a GPS to the bottle to be always aware of its location.

We also want to substitute the TeraTerm with a real mobile application of our development in order to track the status of the bottle with all the data it provides such as the amount and temperature of water, whether the bottle is tilted, moving, or not, and the location of the water bottle itself.

Finally, we want to prepare our marketing plan and discover how our product can enter the market and become the number one water bottle purchased in Egypt.