Toothbrush Alarm
ECE 445 Design Document - Spring 2024

Project #67
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Contents

1 Introduction

1.1 Problem

Waking up early in the morning is a challenge that many people face, and conventional alarms fail to provide an effective solution for heavy sleepers or after exhausting nights. Despite setting multiple alarms, people find themselves constantly oversleeping, waking up significantly later than intended. This issue can lead to a range of negative consequences, including disrupted daily schedules, reduced productivity, and increased stress. Traditional alarms tend to lack the ability to ensure that a person not only wakes up but also gets out of bed and starts their day. This is particularly problematic for those with a heavy sleeping pattern or a habit of snoozing alarms.

1.2 Solution

To address this issue, our idea is to create a Toothbrush Alarm. The concept involves an alarm that persists until you get up and spend, for example, 3 minutes brushing your teeth. Once the tooth brushing routine is complete, the alarm automatically stops. This not only ensures a timely wake-up but also promotes a refreshed start to the day after engaging in the morning teeth-cleaning ritual.

1.3 Visual Aid

Figure 1. Rough outline of project

Figure 1 illustrates the basic idea of how the toothbrush alarm works. A wireless alarm is placed near where the user sleeps, and once the user set alarm rings, it will continue to ring until the user gets up and approaches the dock, or until 30 minutes of inactivity has occurred.

1.4 High Level Requirements

1. Alarm will turn off only after the user brushes their teeth for 2 minutes, if the user holds two specific buttons on the dock for 10 seconds, or if the toothbrush is left unattended for 30 minutes
2. Toothbrush can detect if it has been used with ± 2.2 mN (the estimated minimum force the sensor can detect), regardless of direction and orientation
3. Able to detect the presence of human body within 3 m, in a 180° angle in front of the dock

2 Design

2.1 Physical Design

The dock will be a circular plastic disk, around 5 cm in diameter, and 2 cm in height. Inside the dock, a seven-segment display will be installed on the front, mimicking the appearance of a desktop clock. Five control buttons are located on top of the dock on a curve, just above the seven-segment display. Four buttons are the cardinal directions, to control a selector on the seven-segment display. The fifth button is the toggle between three modes, one to display the current time, another to toggle and set the alarm, and the last to determine how long the user must brush their teeth in minutes and seconds, defaulting to 3 minutes. In the center, there will be a hole shaped to fit the toothbrush handle, allowing it to be stored there when not in use. Additionally, the IR distance sensors will detect whether a user is present in front of the dock, presumably to brush their teeth. The entire dock will be encased in a plastic shell, which will house all components, including the microcontroller and power converter. It will be connected to a wall outlet for power.

The toothbrush will hold the accelerometer, which will detect the force used by the user to brush their teeth. For safety, all electrical components, including the microcontroller, transceiver, battery, and accelerometer, will be housed within the toothbrush handle. This ensures that the brush head, the part that enters the user's mouth, remains safe to use. The components will be encased in a plastic housing shaped like a toothbrush handle, allowing for the attachment of the brush head.

The speaker will be placed in the user's bedroom and connected to the dock via Bluetooth. It will be housed in a plastic case along with a microcontroller, transceiver, and power converter. A hole matching the size of the speaker will be cut out to ensure proper functioning.

2.2 Block Diagram

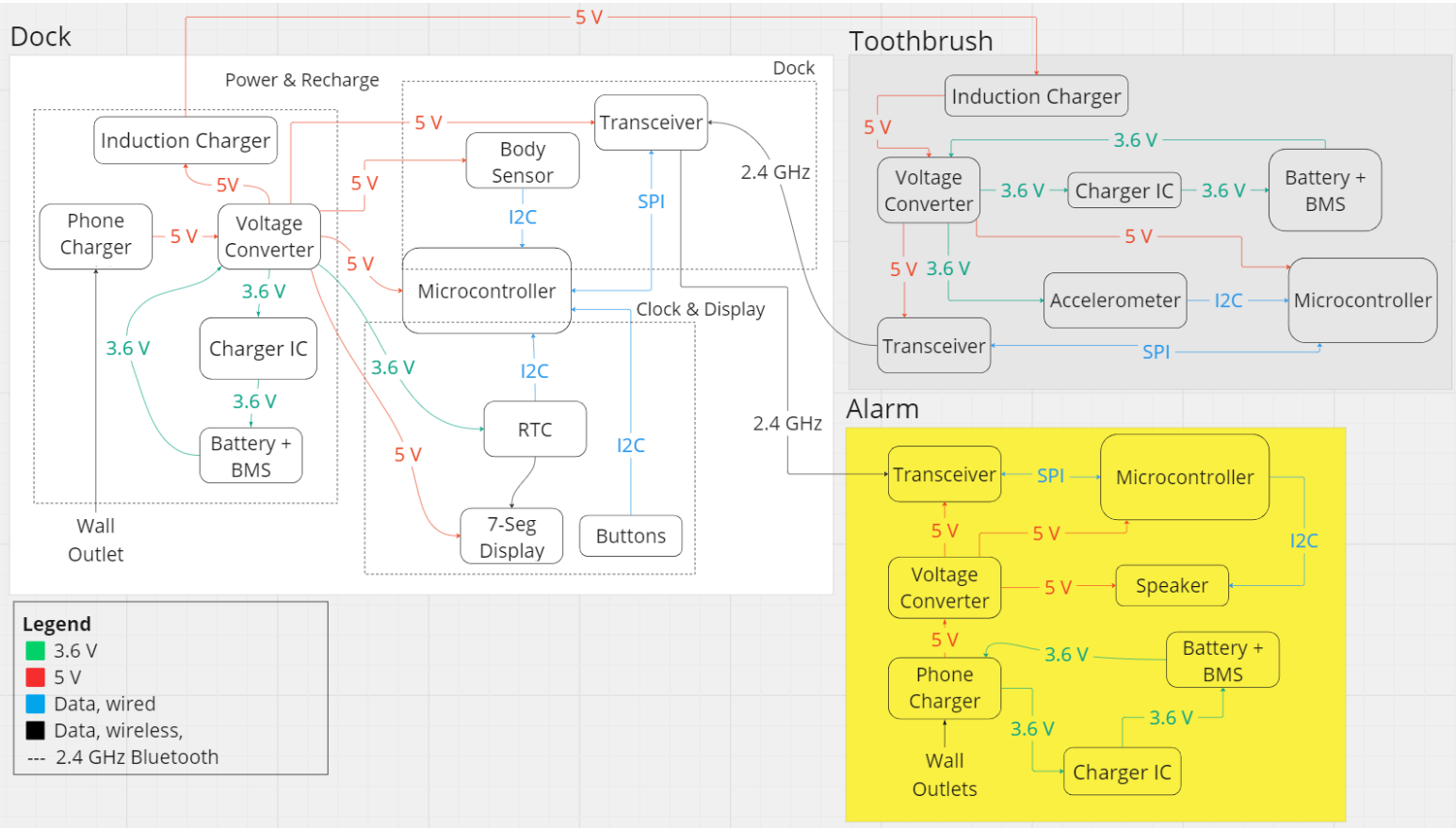

Figure 2. Toothbrush Alarm Block Diagram

2.3 Functional Overview & Block Diagram Requirements

2.3.1 Dock Subsystem

The dock will sense the presence of a user, receive transmissions of whether the user is currently brushing their teeth or not, and send transmissions to the alarm subsystem of when to activate and deactivate. Once the user enters the vicinity of the dock, the IR distance sensors will notice and cause a signal to be sent to turn the alarm off and switch the seven-segment display to its third mode, to display how much time is left for bruising teeth. The user then picks the toothbrush up, and after the user brushes their teeth for their set time, the alarm will remain off after leaving. Should the user leave before their set time is up, the alarm will reactivate. The alarm will continue to sound until either the user completes their teeth brushing or 30 minutes have passed since the alarm activated. The dock will contain our PCB board to contain a number of other subsystems, such as the

clock & display and power and recharge. To ensure the Dock Subsystem is operating to these specifications, a table of requirements and verification are listed below.

Parts that are required for this system to work properly are microcontroller, bluetooth transceiver, and the IR distance sensor. The microcontroller, a PIC16F886-I/SO, helps us control the overall operation of the dock system, it processes the inputs, manages communication with other subsystems, and sends out control signals to trigger appropriate actions. The bluetooth transceiver, a TLIN1027-Q1 LIN, plays an important role in facilitating communication between the controller and other components in other subsystems. The IR distance sensor, a HC-SR312 AM312 Mini PIR Human Body Motion Sensor, is embedded in the dock to measure the distance between the user and the dock to ensure the user is present.

Table 1: Dock Subsystem - Requirements & Verification

Requirements	**Verification**
● When the user enters within 3 meters of the dock, the alarm should deactivate, and the clock & display subsystem should display the remaining time left to brush teeth, or brush countdown	● Measure the user is more than 3 meters away from the dock, and check if time display is set to current time ● Then, user approaches and measure distance less than 3 meters away ● The time display should now be set to the time remaining to brush teeth
● When the user enters within 3 meters of the dock, but then leaves before completing their teeth brushing, the alarm should continue, and the brush countdown should remain	● Measure the user is less than 3 meters away from the dock and check if the remaining time to brush teeth is displayed ● While the remaining time is greater than zero, have the user move further than 3 meters from the the dock ● This should cause the alarm to resume, and the time remaining is still displayed
● When the user finishes brushing their teeth, the clock display reverts back to showing the current time, and the alarm remains off	● Measure the user is less than 3 meters away from the dock and check if the remaining time to brush teeth is displayed ● Have the user brush their teeth

	until the time remaining hits zero, for 2 (± 1) seconds ● The display should now show the current time, and moving 3 meters further from the device does not retrigger the alarm
● When the user overrides the alarm, the clock display reverts back to showing the current time, and the alarm remains off	● Measure the user is less than 3 meters away from the dock and check if the remaining time to brush teeth is displayed ● While the remaining time is greater than zero, have the user press the left and right button at the same time for 10 seconds to activate the override protocol ● This should force the display to show the current time, and moving 3 meters further from the device does not retrigger the alarm
● When the alarm has been on for longer than 30 minutes, the clock display reverts back to showing the current time, and the alarm turns off	● The alarm is triggered, but the user does not complete brushing their teeth ● After 30 minutes since the set alarm time, the alarm will automatically shut off

2.3.2 Toothbrush Subsystem

The toothbrush contains an accelerometer that detects whether the user is making appropriate teeth brushing movements, and transmits a signal of whether it is being used to the dock subsystem. While it is possible to simply wave the toothbrush without actually brushing your teeth, the main purpose of the device is to wake up the user, and sufficient physical movement will help, regardless of if it is used to brush teeth or not. The accelerometer will determine the force applied on the brush and how often it switches directions, so it can tell when the user is brushing their teeth. This information is sent back to the dock subsystem to determine whether the brush countdown decreases or not. To ensure the Toothbrush Subsystem is operating within these specifications, a table of requirements and verification are listed below. Specifications for proper use are in the software design section.

Parts that are required for this system to work properly are the accelerometer, rechargeable battery, battery management IC, charger IC, voltage converter, microcontroller, as well as the bluetooth transceiver. Unless specifically stated, the part is the same one listed above. The accelerometer, a MC3416, helps us to detect the brushing activities by measuring the acceleration and orientation of the toothbrush. The induction charger, a 760308101216 (receiver), is to charge the toothbrush without allowing an opening. The rechargeable battery, a PRT-13851, provides power for wireless operation, the battery management IC, a BQ77915, ensures the batteries operation and efficiency, the charger IC, a BQ2409x, manages the charging operation of the rechargeable battery, and the voltage converter, an ADP 5023, adjusts the voltages for each device. The microcontroller controls the operation of this particular subsystem and communicates with other subsystems by using the bluetooth transceiver.

Table 2: Toothbrush Subsystem - Requirements & Verification

Requirements	**Verification**
● When the toothbrush is in proper use, it should relay a signal to the dock system to start decrementing the brush countdown	● The user takes the toothbrush and brushes their teeth properly, which can include up and down, back and forth, and circular movements with sufficient force and frequency. For specifics, see section 2.7.1 In-Use Sensor ● The displayed time should decrement until it hits zero, where it will stop, and after 2 (± 1) seconds the current time will be displayed
● When the toothbrush is not in proper use, it should relay a signal to the dock system to stop decrementing the brush countdown	● The user takes the toothbrush and brushes their teeth improperly, which can include up and down, back and forth, and circular movements with insufficient force and frequency. For specifics, see section 2.7.1 In-Use Sensor ● The displayed time should remain the same until the user begins brushing their teeth properly

2.3.3 Alarm Subsystem

The alarm is wirelessly connected to the toothbrush dock; it starts ringing once the user set time is reached, and will stop ringing once the user approaches the dock. When the user is completely done brushing (the user will set a timer for this and the user themself must follow), but if the user stops brushing halfway (not meeting the requirements), the alarm will start ringing if they leave the dock. In addition, the user may press and hold the override buttons for 10 seconds, or if the alarm has sounded for 30 minutes, the alarm will also turn off. To ensure the Alarm Subsystem is operating within these specifications, a table of requirements and verification are listed below.

Parts that are required for this system to work properly are speaker, rechargeable battery, battery management IC, charger IC, voltage converter, charger block, microcontroller, and the bluetooth transciever. Unless specifically stated, the part is the same one listed above. The purpose of the speaker, a PCB speaker from Sanco, in this subsystem is to provide sound and wake up the user when it is activated. The rechargeable battery provides power for wireless operation, the battery management IC ensures the batteries operation and efficiency, the charger IC manages the charging operation of the rechargeable battery, the voltage converter adjusts the voltages for each device, and the charger block, like the one for typical smartphones, is used to power the subsystem from a wall outlet. The microcontroller controls the operation of this subsystem, managing the activation and deactivation of the alarm, and communicating with other subsystems by using the bluetooth transceiver.

Table 3: Alarm Subsystem - Requirements & Verification

Requirements	Verification
● When real time clock, RTC, matches with the time for the alarm to ring, the alarm should start ringing	● The user sets a time for their alarm ● The RTC time reaches the set time ● This should cause the alarm to start ringing
● When the user enters within 3 meters of the dock, the alarm should stop.	● The alarm is ringing from the time set by the user ● The user then moves to be less than 3 meters away from the dock ● This should cause the alarm to stop ringing
● When the user leaves before completing their teeth brushing, the alarm should resume	● The alarm is ringing from the time set by the user ● The user then moves to be less

	than 3 meters away from the dock, which stops the alarm, but does not complete brushing their teeth properly ● This should cause the alarm to start ringing again
● When the alarm has been on for longer than 30 minutes, the alarm should turn off	● The alarm is ringing from the time set by the user ● The user does not complete brushing their teeth properly for 30 minutes from the time their set alarm time ● This should cause the alarm to stop ringing

2.3.4 Clock & Display Subsystem

The purpose of this clock display is to indicate time. One mode is to display the current time, another to display the time the alarm will go off, and the last so the user can set and keep track of their time while performing the brushing routine. The clock has a seven segment display of the time that the dock has stored. All of these time or alarms can be adjusted by the user by using the cardinal arrow buttons and toggle button embedded in the dock. To ensure the Clock & Display Subsystem is operating within these specifications, a table of requirements and verification are listed below.

Parts that are required for this system to work properly are 7-segment display, real-time clock, and the buttons. The 7-segment display, a TDCG1050M, will display the current time and alarm time to the user. The real time clock, a bq32000, provides accurate timekeeping functionalities for the clock within this particular subsystem. The buttons, TS02-66-55-BK-100-LCR-D, allows user to adjust the settings, such as the current time, overall brushing time, and alarm time

Table 4: Clock & Display Subsystem - Requirements & Verification

Requirements	Verification
● When real time clock, RTC, matches with the time for the alarm to ring, the alarm should start ringing	● The user sets a time for their alarm ● The RTC time reaches the set time ● This should cause the alarm to start ringing
● When the user enters within 3	● Measure the user is more than 3

meters of the dock, the clock & display subsystem should display the brush countdown	meters away from the dock, and check if time display is set to current time ● Then, user approaches and measure distance less than 3 meters away ● The time display should now be set to the time remaining to brush teeth
● When the user is properly brushing their teeth, the brush countdown should be decrementing	● The user takes the toothbrush and brushes their teeth properly, which can include up and down, back and forth, and circular movements with sufficient force and frequency. For specifics, see section 2.7.1 In-Use Sensor ● The displayed time should decrement until it hits zero, where it will stop, and after 2 (± 1) seconds the current time will be displayed
● When the user is not properly brushing their teeth, the brush countdown should be remain constant	● The user takes the toothbrush and brushes their teeth improperly, which can include up and down, back and forth, and circular movements with insufficient force and frequency. For specifics, see section 2.7.1 In-Use Sensor ● The displayed time should remain the same until the user begins brushing their teeth properly
● When a button is being pressed, the clock display or the alarm time should be modified according to its function.	● Press the button and observe the displayed time or the alarm time. Verify that the display time is accurate. ● The left and right buttons cycle through the numbers on the display, acting as a selector. The selected number blinks at a regular interval, and stops blinking after a period of inactivity ● The up and down buttons increment and decrement the value

	selected. These buttons are to adjust the time ● The toggle button cycles through the three modes of the display. First is the RTC, the current time, displayed as hour-minute-second-AM/PM. Second is the alarm time, with the same display as RTC. Last is the time brush countdown, displayed as blank-blank-minute-second

2.3.5 Power and Recharge Subsystem

This subsystem is responsible for providing power to the entire system and managing the rechargeable battery. The purpose of this is to ensure that the system remains operational and can recharge its power source efficiently and safely.

Parts that are required for this system to work properly are rechargeable battery, battery management IC, charger IC, induction charger, and the charger block. Unless specifically stated, the part is the same one listed above. The induction charger, a WRSC-7R2K-32 (transmitter), is to charge the toothbrush without allowing an opening. The rechargeable battery provides power for wireless operation, the battery management IC ensures the batteries operation and efficiency, the charger IC manages the charging operation of the rechargeable battery, the voltage converter adjusts the voltages for each device, and the charger block is used to power the subsystem from a wall outlet.

Table 5: Power and Recharge Subsystem - Requirements & Verification

Requirements	Verification
● When the dock, alarm, or toothbrush is charging, an LED should indicate that it is charging to the user	● The user plugs in the device to charge ● A green LED will light up to indicate the device is charging, and will turn off once it is fully charged
● Each cell is recharged so that the voltages of each cell maintains the same proportions (± 0.1 V)	● With the batteries at full capacity, measure and record the voltage of each cell

2.4 Hardware Design

2.4.1 Operating Voltage

All the components: the PIC16F886-I/SO microcontroller[2], the IR distance sensor[8], the accelerometer[4], the transreceivers[3], the RTC[10], the seven-segment display[9], and speaker[7] are able to be operated at either the 5 V from the phone charger brick[12], or the 3.6 V from the battery[5]. For ease of design and construction, these will be the only voltages used. Though this is up for change as the design is developed and finalized.

2.4.2 Battery Management System

The use of lithium ion batteries was chosen to help facilitate its use in travel settings, where after exhaustive trips to destinations, the user will need an extra measure to make certain they wake up on time for whatever task they need to complete. The specific 1000 mAh was chosen because of its decent battery life and size that could be easily fit in a handheld device for the toothbrush. All separate systems: the Dock Subsystem, the Toothbrush Subsystem, and the Alarm Subsystem, use the same battery for ease of design. To ensure the safety of the product and ease of use for the user, there is also a battery management IC, BQ7790518PW. This battery management chip will monitor and protect the batteries voltage, current, and temperature.[5][6]

2.5 Software Design

2.5.1 Dock & Speaker Control

Since we keep track of time in the dock, the speaker is controlled by the dock to sound the alarm or not. When it is the set time of the user, the dock will send a signal to the speaker via bluetooth, and the alarm will sound until it receives another signal from the dock to tell it to stop.

The microcontroller in the dock will have data from the pressure sensor and the body motion sensor wired, and receive accelerometer data from the toothbrush wirelessly. It will determine if the user is up and brushing their teeth.

The dock will tell the alarm to stop when the body motion sensor detects the presence of a human and the pressure sensor no longer senses the weight of the toothbrush, indicating the user picked it up.

After five minutes, if the user fails to meet the set conditions of brushing their teeth and is not actively brushing, the dock will once again tell the speaker to sound the alarm until the user meets the criteria.

The set condition for the alarm to stop is the user brushing their teeth for over two minutes and putting the toothbrush back into the dock. The way we determine teeth brushing is by having an accelerometer in the toothbrush handle. If it detects ± 2.2 mN force, regardless of direction and orientation, for over two minutes cumulatively, the toothbrush will send a signal to the dock via bluetooth to tell it that the user has "brushed their teeth". We will also use the accelerometer to determine if the user is actively brushing their teeth. When the accelerometer detects any movements, the toothbrush will send a signal to the dock to indicate it.

2.5.2 Override Situations

There are override conditions set to stop the alarm in case the user was in a hurry or having other situations.

Situation 1: Pressing two specific buttons on the dock for 10 seconds
The dock will detect button presses, and track how long they are held down for while the alarm is sounding. We have not yet finalized our button design, so we will decide which two buttons specifically at a later stage. Once the condition is met, the dock will send a signal to stop the alarm.

Situation 2: The toothbrush is left unattended for 30 minutes
The toothbrush will send a signal to the dock indicating when it is in use, so when the dock has not received this signal from the toothbrush for 30 minutes, and the alarm is still sounding, it will send a signal to stop the alarm.

2.5.3 Transceiver Communication

The transceivers in the dock will send out signals to the speaker, and receive signals from the toothbrush. While the toothbrush will only send signals, and the speaker will only receive signals.

Since both the dock and the toothbrush will send out signals, and we plan on broadcasting the signals, to avoid confusion, we will use different bits in the signal to indicate its meaning.

User Brushed Teeth	Toothbrush in Use	Alarm Off	Alarm On
Bit 3	Bit 2	Bit 1	Bit 0

Table 6. Transceiver Bit Scheme

For example, if the signal sent out from the transceiver is 4-bit in length each time, we will dedicate the lower 2 bits to the speaker. When bit 0 is 1, it tells the speaker to sound the alarm; when bit 1 is 1, it tells the speakers to stop the alarm. The upper 2 bits will be dedicated to the toothbrush. When bit 2 is 1, it tells the dock that the toothbrush is in use and not unattended; when bit 3 is 1, it tells the dock that the user has met the teeth brushing condition of 2 minutes cumulatively.

The dock and the speaker will use bit mask and bit shift to read their respective bits, and ignore the irrelevant bits. When never a bit is 0, it means no change or the signal is sent by a device that does not regulate that condition.

2.5.4 Accelerometer Threshold

The threshold we will use for detecting toothbrushing is 2.2 mN, as derived from our calculations in section 2.7.1. This estimate represents the minimal force that must be detected and that the user needs to apply in order to brush their teeth effectively. Thus, we establish a threshold that accommodates cases where the user applies very little force.

2.5.5 Pseudocode

Toothbrush:

```
IF (accelerometer detects force above threshold):
        IF (it is the first detect of the day):
                reset Brush Time Count
        send Toothbrush in Use signal to dock
        cumulate Brush Time Count

        IF (Brush Time Count reaches 2 minutes):
                send User Brushed Teeth signal to dock
```

Speaker:

```
IF (receive Alarm On signal):
        sound alarm
IF (receive Alarm Off signal):
        stop alarm
```

Dock:

```
IF (time is set alarm time):
        send Alarm On signal to speaker via bluetooth

IF (motion sensor detect human AND pressure sensor does not detect toothbrush):
        send Alarm Off signal to speaker via bluetooth
        Brushed = False
        start timer

        WHILE (NOT Brushed):
                IF (receive User Brushed Teeth signal from toothbrush):
                        Brushed = True
                        send Alarm Off signal to speaker via bluetooth
                IF (timer reachers 5 minutes AND pressure sensor does not detect toothbrush
AND NOT Toothbrush in Use):
                        send Alarm On signal to speaker via bluetooth
                IF (NOT receiving Toothbrush in Use signal for 30 minutes OR two designated
buttons on the dock are pressed together for 10 seconds):          # override
                        send Alarm Off signal to speaker via bluetooth
                        Brushed = True
```

2.6 Commercial Component Selection

2.6.1 Battery & BMS

For our battery, we will be using the 3.7V 1000mAh 523450 Rechargeable Dash Camera Lithium Polymer Battery Length from YDL. We chose this specific battery because it has a very compact size, rechargeable battery, and provides suitable voltage and capacity. The battery from YDLis known for its small form factor, making it ideal for space constrained applications like ours. It is also rechargeable, which reduces overall operational cost due to no need for frequent maintenance, making it cost-effective. Lastly, the battery provides a suitable voltage of 3.7 volts and a capacity of 1000 mAh, which fit the requirement of our design. [5]

2.6.2 Microcontroller

For our microcontroller, we will be using the 8-bit CMOS microcontroller from Microchip. We chose this specific microcontroller because it is very cost-effective, low power consumption, and easy to use. Since our designs are only required to operate in 8-bit, this makes our microcontroller more cost-effective compared to higher-bit counterparts such as the 16 and 32 bit microcontroller. CMOS is typically associated with lower power consumption, making it suitable for battery application like our toothbrush alarm. Lastly, the PIC microcontroller from MicroChip is popular due to their comprehensive development ecosystem and has so many user-friendly features, making it easy to assemble as a user. [2]

2.7 Tolerance Analysis

2.7.1 In-Use Sensor

From the datasheet, the user may exert 2.2 mN of force at minimum (F_{min}) to brush their teeth

$$(minimum\ acceleration\ resolution)\ *\ (mass\ of\ toothbrush) = minimum\ detectable\ force \rightarrow$$
$$((2\ *\ 9.8\ m/s)\ /\ 16384\ LSB)\ *\ (18\ g)\ =\ 2.197265625\ mN/LSB\ (1)$$

and our testing indicates the average user brushes their teeth at a frequency averaging 5 Hz and not exceeding 10 Hz (f_{brush_max}).

Given our microcontroller, PIC16F886-I/SO, will be running at 20 MHz (f_{clock}) , and the accelerometer can output data at 1 MHz (f_{accel}), there will be no issue detecting the change in direction. [4]

2.7.2 Proximity Sensor

From the datasheet, the IR distance sensors have a sensor range of a 100° cone (θ_{range}) centered from itself. In order to ensure a reasonable range of detection, two of these sensors will be used, with a 100° difference to minimize overlap. This is sufficient because

$$2\ *\ \theta_{range} = \theta_{range\_total} \rightarrow 2\ *\ 100° = \theta_{range\_total} \rightarrow \theta_{range\_total} = 200°\ (2)$$

Since the total range is now greater than 180°, it is reasonable to assume any approach from the front will be detected, so the toothbrush alarm may function properly. [8]

2.8 Cost Analysis

Description	Manufacturer	Quantity	Total Price	URL
8-bit CMOS Microcontroller [2]	Microchip	**3**	**$10.80**	**Link**
Bluetooth transceiver [3]	Texas Instrument	**3**	**$3.00**	**Link**
3-Axis Accelerometer [4]	Memsic	**1**	**$1.61**	**Link**
Rechargeable Battery [5]	YDL	**5**	**$21.35**	**Link**
Battery Management IC [6]	Texas Instrument	**3**	**$5.16**	**Link**
Charger IC [14]	Texas Instrument	**3**	**$3.78**	**Link**
Induction charger (receiver) [15]	Würth Elektronik	**1**	**$8.80**	**Link**
Induction charger (transmitter) [16]	Signal Transformer	**1**	**$5.54**	**Link**
Speaker [7]	Sanco	**1**	**$2.10**	**Link**
IR distance sensor (Pack of 5) [8]	Nanyang Senba Optical and Electronic	**1**	**$9.98**	**Link**
Clock Display [9]	Vishay Semiconductor Opto Division	**2**	**$6.30**	**Link**
Real-Time Clock [10]	Texas Instruments	**1**	**$1.61**	**Link**
Oscillator [13]	Abracon LLC	**1**	**$0.84**	**Link**
Tactile Switch [11]	CUI Devices	**10**	**$1.00**	**Link**
Wall Charger Adapter [12]	AILKIN	**1**	**$11.99**	**Link**

Table 7. Cost Breakdown

2.9 Risk Analysis

Integrating an alarm within a toothbrush system embodies inherent challenges and necessitates meticulous attention to ensure both functionality and user safety. Each component, especially those engineered by our team, plays a pivotal role in the system's integrity. Since the dock, alarm, and body sensor do not move, they inherently pose minimal safety concerns. The primary safety

concern for them is potential harm if they fall on the user. Therefore, we will ensure their exteriors are free of sharp edges or spikes that could cause injury. The sensors integrated into the toothbrush operate at low voltage, and we will also ensure they are watertight to mitigate the risk of electric shock during use.

2.10 Schedule

Week	Task	Person
Feb. 26 ~ Mar. 3	Order parts	All
	Start prototyping	Carl
	Design Review	All
Mar. 4 ~ Mar. 10	Start board assembly	Laurenz
	Start software design	Eric
Mar. 11 ~ Mar. 17	Spring Break	All
Mar. 18 ~ Mar. 24	Start PCB Design	All
Mar. 25 ~ Mar. 31	Work on power and recharge subsystem	Laurenz
	Work on toothbrush subsystem	Carl
	Work on alarm subsystem	Eric
Apr. 1 ~ Apr. 7	Work on clock subsystem	Eric
	Work on dock subsystem	Carl
	Work on the sensor detection	Laurenz
Apr. 8 ~ Apr. 14	Testing subsystems	All
	Finish PCB	All
	Finish Assembly	All
Apr. 15 ~ Apr. 21	Integrated testing	All
	PCB, assembly Revision	All
	Mock Demo	All
Apr. 22 ~ Apr. 28	Debug any bug presented	All
	PCB, assembly Revision	All

	Mock Presentation	All
Apr. 29 ~ May 5	Final Presentation	All
	Final Paper	All

Table 8. Project Schedule

3 Ethics and Safety

Our project is committed to the highest safety standards, placing safety as our foremost priority. Given that the toothbrush will be used inside the user's mouth, it is crucial that it remains safe under rigorous scrutiny. Designing a device for personal hygiene, we prioritize the safety and health of the users above all, aligning with IEEE's Code of Ethics Section I.1, to “hold paramount the safety, health, and welfare of the public.” [1]

Understanding the potential hazards associated with electrical devices, particularly those in close contact with water, we have designed the components on the toothbrush to be enclosed within the handle and water-tight to prevent potential harm to the user. This design choice minimizes any risk of electric shock, making the device safe for everyday use in a bathroom environment.

Moreover, batteries catching on fire has long been a public safety concern, and we take good notes of that. Our BMS will constantly monitor the condition of our batteries, and regulate the charging and discharging cycles to prevent accidents caused by overcharging.

During the execution of the project, we will maintain our work environment according to Section II, to “treat all persons fairly and with respect, to avoid harassment or discrimination, and to avoid injuring others.” Additionally, as stated in Section III, we will support and assist each other as needed. [1]

References

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