Therapalz Collar

ECE 445 Design Document

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Table of Contents

1 Introduction

1.1 Objective

‘Therapalz’ was a project pitched in class by Ms Fiona Kalensky. It is a a smart therapeutic companion animal which provides both comfort as well as company to patients suffering from Alzheimer's. The original animal has a realistic heartbeat, calming vibrations and makes a purr sound to replicate the behavior of a real cat. However, Ms Kalensky wanted certain external controls on the animal like an on/off button. She also wanted to improve the battery life of the animal. She also wanted a way for caregivers to adjust the settings of the animal as well as have a way to track the animal as Alzheimer's patients have a tendency to hide things. Hence, we propose to work with the existing design to design a smart collar which will have on/off and mute buttons, a tracking mechanism, light sensors which will put the animal to sleep when it is dark in the patient’s room, an accelerometer which will sense the patient’s activity level, a microphone sensor which will change the behavior of the animal based on the loudness/softness of the patient’s voice, and finally a rudimentary app which will help the caregiver adjust the settings of the animal based on his/her need and preference.

1.2 Background

Alzheimer's is the most common form of dementia which causes problems with memory, thinking and behavior. It is a progressive disease with symptoms usually developing slowly before getting worse over time. Patients in early stages, have mild memory loss but as they get older, they begin to lose their ability to respond appropriately to their environment or even carry a conversation [1]. Alzheimer’s affects about 5.5 million people older than 65 every year in the United States. Additionally, about 200,000 people under the age of 65 are affected with early-onset Alzheimer's in the United States. One in ten people age 65 and older have Alzheimer's disease and about one-third of people age 85 and older (32 percent) have Alzheimer's disease [2]. Alzheimer's is also the sixth leading cause of death in the United States [1]. Despite these startling numbers, there is currently no medical cure to Alzheimer's. This is the reason why several organizations and people have dedicated their lives to develop non medical methods to improve the quality of life of these patients to the maximum extent they possibly can.

There are several studies that have proven that pets have a positive impact on patients suffering from Alzheimer's. Pets are a great companion for patients with dementia as they help reduce anxiety, agitation, irritability, depression, and loneliness [3]. However, it is not always feasible or practical to have and look after a pet in a long-term care facility. This is why when Ms Fiona

Kalensky proposed the idea of ‘Therapalz’, a stuffed animal that replicates certain behavior of an actual pet, our team thought this was a perfect solution to the problem.

1.3 High level Requirements List

- **Concealability** : We would like for the buttons to be concealed in such a way such that the patient cannot accidently turn them on or off and mess with the settings of the animal. We propose to have some sort of mechanism similar to that of a locket so the buttons can only be accessed when actually intended too.
- **Sensors :** We would like to make sure that the sensors are strategically located such that they behave as intended. For example, we want the light sensors to be able to detect when the entire room is dark so it can put the animal in sleep mode to both conserve battery as well as to go mute so it doesn't disturb the patient while he or she is asleep.
- **Tracking :** We want to make sure that the animal can be tracked relatively accurately within a room even when faced with obstacles. We also want to make sure that the speaker installed on the collar makes a noise when called so it can help the caregiver locate the animal easily.

2 Design

2.1 Block Diagram

For the collar to work successfully, the power unit, the control unit and the communication system need to work harmoniously. The battery provides the collar with power. The control unit contains all the sensors along with the microcontroller which will behave as described in pre-programmed settings. The bluetooth with the help of beacons will be used to locate the animal as well as to communicate with the app and others part of the animal. Finally the app will be used to track the animal as well as adjust different settings of the animal.

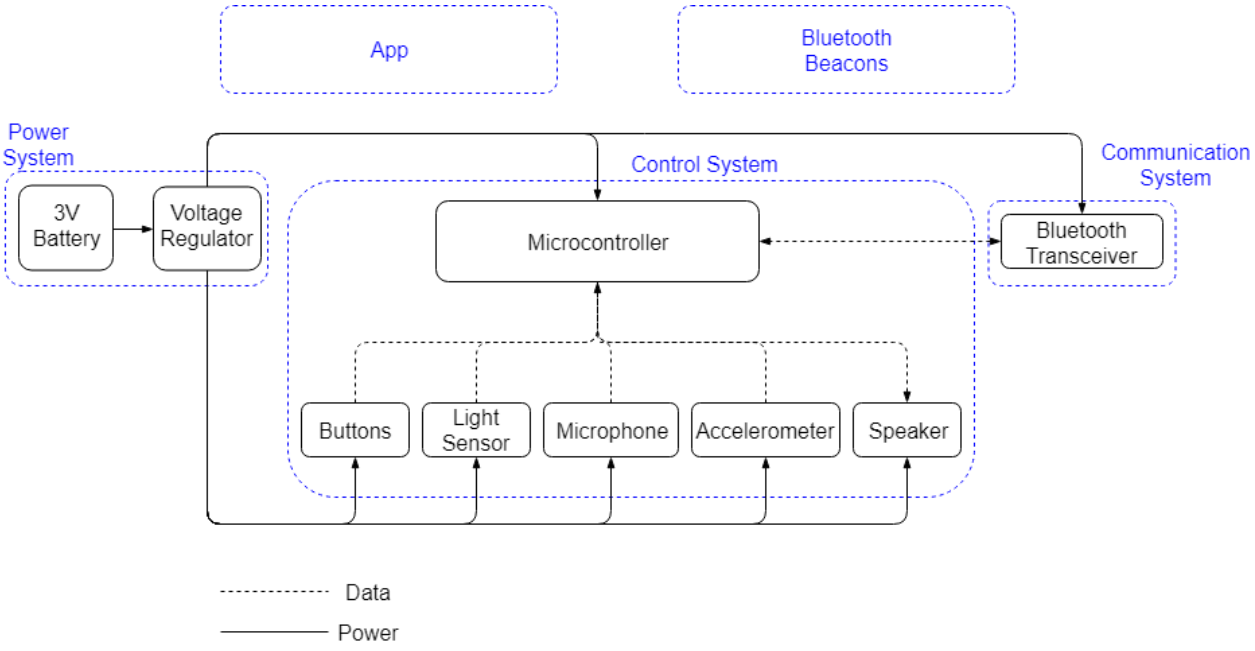

Figure 1: Block Diagram

2.2 Physical Design

This is a schematic representation of what we hope the outer casing of our device will look like.

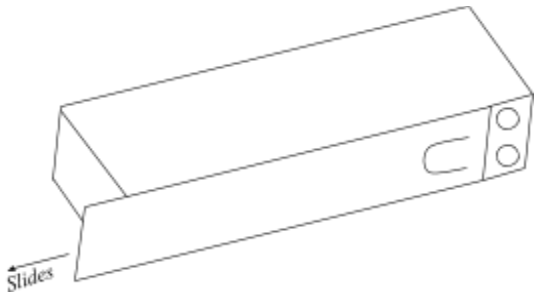

Figure 2: Outside casing of device

2.3 Power System

2.3.1 Battery: The battery we will be using is the CR2032. It supplies power to all of the components of the collar through its daily use. We plan to use 2 3V coin cell batteries to supply power to the device.

Requirement	Verification
Must power the device at a constant 6V±0.6V	Check battery voltage with multimeter in parallel with a resistor for 6V±0.6V
Must keep the device powered for a minimum of 12 hours	Measure voltage after 12 hours of use and confirm that power is still supplied

2.3.2 Voltage Regulator: The voltage regulator keeps the supplied voltage at 3.3V to operate the various components.

Requirement	Verification
Must power the device at a constant 3.3V±0.3V	Check voltage with multimeter in parallel with a resistor for 3.3V±0.3V

2.4 Control System

2.4.1 Microcontroller: The microcontroller we will be using is the ATmega328/P. It will receive inputs from buttons and sensors, as well as use Bluetooth through UART to communicate with the app.

Requirement	Verification
Can be used with Bluetooth module through UART protocols	Check that messages are received from Bluetooth module with <10% packet loss

2.4.2 Light sensor : The light sensor we will be using is the APDS-9301. We will measure the illuminance of the surrounding area and return this lux value as a digital signal to the microcontroller through the I2C communications protocol. We will use this lux value to determine the intensity of the light, and when the conditions indicate it is nighttime the pet will enter a sleep mode to conserve battery.

Requirement	Verification
The lux value recorded for a room at night time should be within a 10% range of 5 lux [4]	Test light sensor in a dark room to simulate a bedroom at night. Confirm lux value is within a reasonable range from 5 lux.

2.4.3 Accelerometer: The accelerometer we will be using is the MMA8452Q. It will measure the acceleration of the pet as it is used throughout the day as a digital output to the microcontroller using the I2C communications protocol. When the pet is unused for a specified amount of time, indicated by a prolonged period of acceleration less than $1 m/s^2$, the pet will go into a sleep mode to conserve battery life. At sudden rises in acceleration during sleep mode, the pet will resume normal operation.

Requirement	Verification
Accelerometer can accurately detect sudden rises in acceleration.	Move pet suddenly, and confirm that accelerometer data correctly records the movement.
Sensor can detect no motion	Leave pet stationary, and confirm that accelerometer data correctly records a lock of movement

2.4.4 Power/Mute buttons: Allow caregivers to easily change important settings, must not be easily accessible to patients (turn on/off and mute). The outer casing having a sliding door is meant to keep patients from accessing buttons.

Requirement	Verification
Power button turns animal on/off	Button sends signal when pressed
Mute button turns off sound in animal	Button sends signal when pressed

2.4.5 Microphone: The microphone we will be using is the ADMP401. The microphone will simply listen to the patient, and depending on the frequency response in dB the pet is to use one of a set of pre-programmed settings for vibration and purring.

Requirement	Verification

Differentiate between normal talking (~60 dB) and raised voice (~70 dB) [5]	Take measurements at these noise levels and compare frequency responses

2.4.6 Speaker: The speaker we will be using is the TDS SuperSonic Small Sugar Cube Speaker. Should the pet be lost or hidden, the caretaker is given the option of pressing a distress button on the app, which triggers the speaker to emit a sound which would help locate it.

Requirement	Verification
Can produce sound at least 70 dB	Measure output of speaker volume and verify that it is at least 70 dB

2.5 Communication System:

2.5.1 Bluetooth Transceiver: The Bluetooth module we will be using is the Texas Instruments CC2564MODA. The Bluetooth module will be used to track the location of the stuffed animal as well as send/receive data from caregiver through associated app.

Requirement	Verification
Can receive data to and from up to 6 devices (beacons, app, other sections of pets)	Connect devices consecutively and see if any become disconnected/interfere with any and other.

2.5.2 Bluetooth Beacons: The Bluetooth beacons we will be using are the RadBeacon Dot. We will use them to track the location of the collar by sending out signals at regular intervals, and once received by the collar, the signal strengths will be compared to one another to get relative distances from each beacon.

Requirement	Verification
Maintain constant transmission interval of 10 sec. or less	Check that a signal is received from beacons at set rate of 10 sec. or less

3 Cost & Schedule

3.1 Cost

Our labor costs are estimated to be about $50/hour, 10 hours/week for 3 people. There are 16 weeks in this semester.

3 x 50/hr x 10 hrs/week x 16 = $24000

Part	Cost ($)
Buttons	2.00
Light sensor	2.91
Microphone	3.95
Accelerometer	2.64
Battery x 2	8.60
Speaker	6.95
Bluetooth beacons x 4	56
Bluetooth Module (including Antenna)	20.77
Microcontroller x 2	4.00
Voltage Regulator x 2	3.00
3-D Printed Case	5.00
Total	115.82

Hence our total cost is estimated to be labor + cost of parts = $24,115.82

3.2 Schedule

Week	Tanvi	Benjamin	Bernardo
10/1	Design Document - Introduction, Objectives, Power System, Tolerance Analysis	Design Document- High level Requirements, Control System,, Tolerance Analysis	Design Document- Cost & Schedule, Beacons, , Tolerance Analysis, Ethics
10/8	Purchase Parts - Micro-controller, Batteries, buttons, beacons	Start Circuit Design- Preliminary circuit design	Purchase Parts- Sensors, bluetooth module, voltage regulator
10/15	Test Sensors- Light, microphone, accelerometer, speaker	Start PCB Design- Initial PCB Design	Test Sensors/ PCB Design- Divide time with testing and PCB design
10/22	Begin Prototype Sensor Implementation- Implement initial prototype	Finalize PCB design-Finalize PCB Design	Finalize PCB Design -Finalize PCB Design
10/29	Initial Algorithms for bluetooth to find location	Finalize power system	Finalize Prototype Sensor Implementation
11/5	Finalize algorithms	Design Physical Case	Start software work for sensors
11/12	Final Assembly - Power system	Final Assembly - Control System	Final Assembly- Communication System
11/19 (Thanksgiving Break)	Software for Bluetooth & beacons	Finish software for Bluetooth	Finish Software for Microcontroller and Sensors
11/26	Testing - Power system	Testing - Control System	Testing- Communication System
12/3	Demo Work on final paper and slides as a team	Demo Work on final paper and slides as a team	Demo Work on final paper and slides as a team
12/10	Final Paper & Presentation Lab checkout	Final Paper & Presentation Lab checkout	Final Paper & Presentation Lab checkout

4 Tolerance Analysis

One of the most critical components of our design is the voltage regulator, since all of our components require a constant voltage. Our coin batteries power the device at a constant 6V which needs to be pulled down to 3.3V so it is within voltage range for our sensors and bluetooth module. The microcontroller requires an input voltage of 5V to run at 20 MHz (see Figure 4), so we need another voltage regulator to step down the 6V supply from the batteries to the required 5V. The voltage regulator will ensure that the components of the device are protected, maintains a current limit and protects the device from short circuiting.

5 Ethics and Safety

We plan to conform to and follow the IEEE Code of Ethics in order to preserve the health of our product's users and their privacy, as well as to disclose potential dangers our project might pose to the users [6].

5.1 Potential Hazards

Alzheimer's, also known as senile dementia, is a form of dementia. A common consequence to this is that there is often an increased sensitivity towards noise that is often overlooked. Our feature of using noise to locate the pet in the case that it becomes lost is similar to that of an alarm or a pager, sources of noise that are recommended to keep at a minimum [7]. In order to try to keep the emotional health of our intended users in mind, we have incorporated the idea of using tracking via Bluetooth, so that resorting to the noise method is only applicable in extreme scenarios.

In addition to this we must take care to develop the noise we use for locating the pet to be distinct yet unobtrusive. As such it is important to understand a certain constraint on the decibel levels of said sound. Nearing dB levels of 100, exposure for longer than 15 mins can cause possible damage to the patient's hearing [8].

Another potential hazard is as a result of having a battery in a product where the stuffed animal is in part sufficiently flammable, it is a concern to make sure the battery is never damaged in such a way that could lead to it catching on fire. Care must made to make sure the battery is not put into conditions that might result in extended overheating, which could also lead to fires.

5.2 Potential Privacy and Security Infractions

The use of accelerometer and Bluetooth data in tandem can be used to track the motion the user as they move throughout their rooms, and as such poses a significant breach of privacy. This is especially a concern considering this data will be sent through Bluetooth to the phone app. What we propose to do is to encrypt the data being sent and received with private keys for the sake of the prototype.

6 Supporting Material

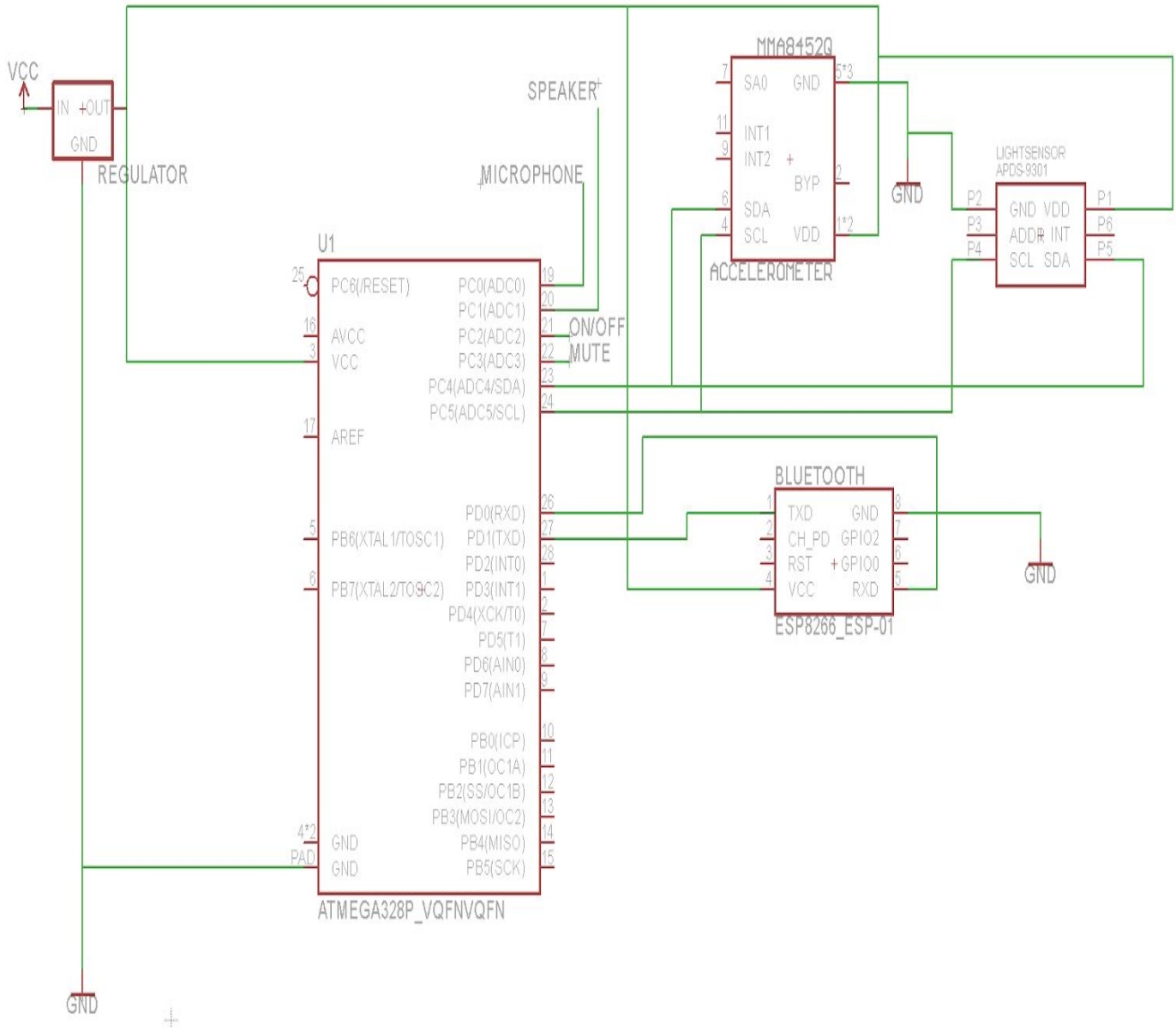

Figure 3: Design Schematic

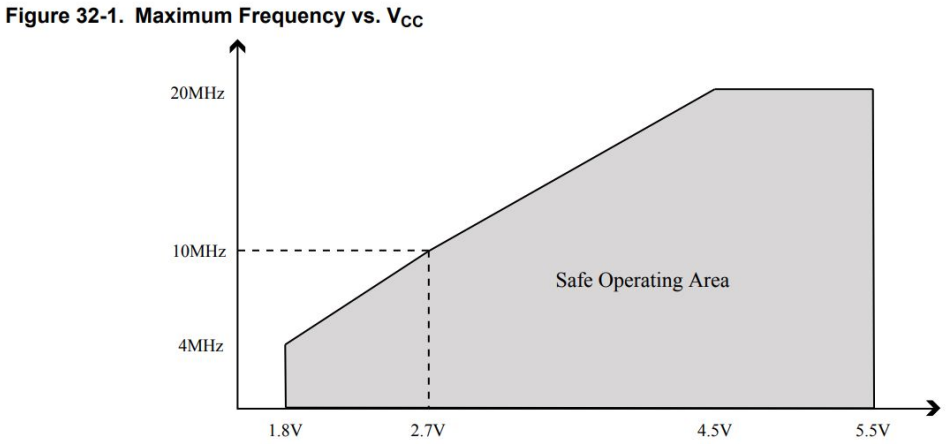

Figure 4: Speed grade for microcontroller [9]

7 References

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[8] “Decibel Exposure Time Guidelines” *Dangerous Decibels.* [Online]. Available: http://dangerousdecibels.org/education/information-center/decibel-exposure-time-guidelines/. [Accessed September 19, 2018]

[9] “ ATMega328/P Datasheet” [Online]. Available: http://ww1.microchip.com/downloads/en/DeviceDoc/Atmel-42735-8-bit-AVR-Microcontroller-ATmega328-328P_Datasheet.pdf