Nome's Child Safety Seat Project

Group 1

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1.0 Executive Summary

Safety features. We hope we never have to use them. We're appreciative when that ding tells us we've left our headlights on or when our seat belt protects us from injury in a crash. So why haven't we as a society taken the opportunity to further protects that which is most sacred to us: Our Children. Each month three to four children are forgotten in their car seats by loving parents and responsible caregivers. The number doesn't seem high but it only represents those incidents reported. Our objective is to create a product that reduces the number of forgotten children significantly. Since 1998 over 700 children have died as a result of being left in their car seats by either someone who will be 'right back' or someone who was sleep deprived, stressed out, or in a hurry. How can that happen? Dr. David Diamond of the University of South Florida continues to research a phenomenon he calls, "Forgotten Baby Syndrome." This syndrome is a, "Failure of prospective memory, which refers to the planning and execution of an action in the future." Ever forgotten your coffee or laptop on the roof of your car? The same process of thought or lack thereof that caused you to forget that thing that's now rolling off the roof onto Main Street also causes perfectly rational, loving parents to simply forget their own children. We intend to reduce this number so that no parent ever has to feel that kind of pain and anguish from a simple mistake for the rest of their lives. Over the past semester we have reviewed countless websites, interviewed parents and medical professionals, and surveyed a hundred parents regarding this issue. We have determined that a simple system can be devised to keep the child safe and cozy as well as to alert their chauffeur of an impending mistake. A system capable of a simple smartphone alert to a complete takeover of the automobile's climate control system and door locks. The Nome's Child Safety Seat is an insert for a child's car seat that allows the monitoring of the child and provides awareness options to remind the vehicle operator not to leave their child in the vehicle. The insert device will communicate with a smartphone application via Bluetooth and provide multiple stages of attention grabbing techniques to the owner. In critical situations the device will assume control of the vehicles onboard features in an attempt to save the lives of the child. Our main goal is to save the lives of endangered and forgotten children so this safety insert will be designed using only the most reliable technology to ensure the success of our device.

2.0 Project Description

2.1 Project Motivation

Frequently in the news are stories where children and infants being accidentally left in vehicles. Severe environmental conditions, including heat, humidity and cold often have a fatal effect on these children. Engineering can help solve this issue with a better designed car seat and better automobile and human interactions. Our goal is to create a child seat that will implement an array of sensors and a control board to ensure that these safety features keep the infant safe. This device will function in situations such as extreme heat and extreme cold where the parent or guardian will be notified and the car be controlled to ensure the child remains safe.

The motivation behind this product is to apply all of our combined engineering knowledge gained from our time here at the University of Central Florida to create a safer environment for children. Our team is the first attempt at creating a working real world project using a mixed majors group of students. The team consists of four industrial engineers, two computer engineers, two electrical engineers, and one business major. Each member of this team has a unique specialty which will be heavily utilized in order to accomplish the full design.

The industrial engineers are in charge of audience identification, obtaining statistical information, and guiding the completion of this project. The computer engineers are responsible for implement their software knowledge to create a working environment. The electrical engineers will use their hardware expertise of analog and digital circuits to create a working platform. Last but not least the business student is required to create advertising, marketing research, and identify where our product will benefit most from our target audience of new mothers.

By successfully developing this product it shows how well the schooling system has prepared us for the real world working environment. The success will also cause similar group combinations to become more main stream during the student’s final semester projects which will have many benefits in the future for well-rounded graduates.

2.2 Objective and Goals

The overall focus of this project is to create a safety device that is easy to install, quickly inserted or removed from the vehicle, and most importantly reliable. Our device consists of a simple insert that connects to a Bluetooth enabled device and monitors the child's environment to ensure the conditions are comfortable for an infant or young child. This insert shall be reasonably affordable and allow the seat to be used throughout the entire stages of the infant's growth process and we plan to add multiple features to ensure this. The seat needs to be lightweight and unrestrictive so parents can easily move the seat from car to car. Possible features the team is considering are a cheaper model that doesn't connect to the car, an application on apple and android devices that can be used to relay device messages, and a more expensive model that will include ease of access options such as a rotating base and more padding so that the seat can get more use as the child grows up.

A hardware goal of this product is to ensure all boards are custom printed circuit boards (PCB) which enables us to become familiar with a circuit board design program and also how to optimize the layout of the physical components to effectively complete the necessary tasks. The device is required to be modifiable by the user to allow multiple features, for example a temperature sensor and a load sensor, to work cohesively and reliably at any given time. To ensure the readiness of the device the power source must be fully functioning and automatically rechargeable at all times to be ready for an emergency. The battery must also be able to function at all the required temperatures ranging from extreme cold to extreme heat without fail.

The software goals include being able to reliably transfer the data via Bluetooth to any device which contains our application. The application will run on all current android devices successfully with iOS support coming in the future. This will require us to learn the software required to develop android applications and how to successfully relay the data between the application and our designed device. All future features shall be able to easily be added to both the base application and data transfer limits of the Bluetooth adapters without fail.

Mainly our goal is to create a base product that is both affordable and reliable to the customer. If this prototype is taken to a manufacturing scale then the device will easily allow additional features to be added to the design. The product will be designed to have many purchasable, but not required, features so the consumer will be able to mix and match their own safety device that specifically applies to their unique situation. Our team chose this approach because our target audiences of new families are not the same in regards to age, income, number of parents or guardians, and even technological knowledge.

2.3 Contributors and Sponsors

Without the assistance of our contributors and sponsors our project would be nothing more than an idea on paper. This section is dedicated to identifying them and how they contribute their knowledge to the project. Below in Table 2.1 will be a description of who they are and what they have done in alphabetical order.

Name	**Description**
The Boeing Company	Approved our funding proposal and decided to provide our team with the appropriate funds required to build and test our design.
Mark Calabrese	Senior Design Professor at UCF acknowledged for his role in the implementation process. He has provided insight into current products and has formulated new ideas with the team.
Matt Civitello	Physical therapist from Nemours Children's Hospital, has been instrumental in the direction of the project by relaying his knowledge of working with children.
Amy Hesse	Works for the Creative School for Children at UCF. She has proven to be essential in the car seat development process and has provided many resources such as connecting the team to parents.
Dr. Kimberly Renk	Special thanks for the knowledge on the psychological aspect she has given.

Table 2.1 Contributors and Sponsors Description

Throughout this project these people will be great assets in the fields in which they are professionals in. The Boeing Company's interest in our project has awarded us with additional funding that will be used for research and development. Dr. Calabrese's industrial engineering knowledge shall provide us with ways to make our project organized and efficient. Mr. Civitello's medical knowledge will assist us in determining safety parameters where the device is needed the most. Mrs. Hesse's access to our targeted audience shall provide critical marketing feedback and targeted audience information. Dr. Renk will help us determine the psychological causes and the types of responses our device shall administer to get the full attention from the parent or guardian.

2.4 Project Requirements Specifications

The Nome's Child Safety Seat must maintain these three requirements: Performance, Mobility, and Ease of Use. Being a safety device it is critical that it is be able to perform reliably under any circumstance. If the device fails the cost could be the loss of a child in the worst case scenario and this is unacceptable. The device shall be lightweight and mobile to ensure the minimum impact on routine while supplying maximum child safety. To ensure all parents or guardians can easily work the device it shall be simple and quick to setup and use. In all future adaptations and modifications of this device these three requirements shall be strictly enforced.

2.4.1 Performance

In all safety devices performance is always the most important requirement. The child seat must be able to function in the extremely hot and cold temperatures that occur inside unattended vehicles. The device is also portable so the device must be durable enough to maintain proper function. Babies and young children are messy by nature and the insert must be able to function in instances of getting wet or dirty as well as after being cleaned. All components must also be durable to withstand any mood the child may be going through.

2.4.2 Mobility

Mobility and Portability are major design focuses for this device. Being able to quickly drop off your child at the daycare and have another parent or guardian pick up the child at a later time and still be able to implement this device is what we aim to accomplish. The insert design allows it to separate from the child car seat for easily installation or removal to and from different vehicles. The wireless peripherals allow for quick access to the devices' features. The application on the user's smartphone is a quick and easy download and takes up absolutely no physical space. With the application the user shall be able to view the status of the insert as well as current temperature all from their mobile device. The future feature of controlling the car in emergency situations is a simple and tiny adapter that is attachable under the steering wheel and does not restrict any movement to the vehicle operator.

2.4.3 Ease of Use

After reliable performance and high mobility the final project requirement shall be ease of use. We aim to create a simple yet effective tool for all parents or guardians to be able to benefit from. This includes both technologically knowledgeable people as well as those who require a little help. The device shall be easily inserted into the car seat using a simple one-step buckle to fasten the device to any car seat on the market. The component housing is to be placed under the child's car seat with no further installation required. After installation of both the insert and component housing all the user needs to do is sync their application and they are ready to go.

Moving on to talking about the application; the device will be able to be synced to the application with a simple button on the applications menu. The application shall be include a simple user interface with few selections to minimize user confusion. Also included inside the application will be a Help menu to instruct any user how the device and application functions. All features of this application, both current and future, shall maintain these basic ease of use requirements to maintain the entire coverage of the target audience.

The end goal is to deliver a very simple to use product that will be able to be used by all age groups because in this day and age you never know who the caregivers or parents will be or on how well they are familiar with safety technology. These requirements also touch on accessibility methods because the parent or guardian may be impaired or have a disability that we need to be able to ensure functionality to. These include clearly visible and audible alerts and application access which would need large clearly defined icons and status updates.

2.5 Component Specifications

To ensure the Nome's Child Safety Seat project requirements of Performance, Mobility, and Ease of Use in the previous section are upheld we are requiring the components used in the design to follow the specifications listed in the section. Each component must meet these minimum specifications to pass both the hardware and software requirements which enable the device to function properly and successfully.

2.5.1 Microcontroller Specifications

The following Table 2.2 contains the specifications for the Microcontroller that controls the communication between all sensors and the data distribution to and from the application. The microcontroller must follow these specifications because all functions of the device must use this component in order to complete their tasks.

Category	**Specification**
Dimensions	Maximum 8 x 8 x 4 inches (L x W x H)
Power Usage	Maximum of 10 V
Power States	Normal and Low Power
Processor Speed	Minimum of 8 MHz
RAM Memory	Minimum of 128 KB
ROM Memory	Minimum of 4 KB

Table 2.2 Microcontroller Specifications

2.5.2 Load Sensor Specifications

Table 2.3 on the following page, contains the specifications for the Load Sensor that is the activation trigger for starting the device. This sensor will be held inside the insert that sits between the child and the child's car seat. Additional specifications are being considered here because of the uniqueness of the situation.

Category	Specification
Sensitivity	Up to a 25lb Child
Length	Minimum of 8 inches
Operating Temp	Must be able to withstand heat of up to 50 degrees Celsius

Table 2.3 Load Sensor Specifications

2.5.3 Temperature Sensor Specifications

The following Table 2.4 contains the specifications for the Temperature Sensor that is the activation trigger for alerting the parent or guardian that the temperature inside the car is too dangerous and unsafe for an infant or small child. This sensor will be placed on the microcontroller board in the component housing under the child's car seat.

Category	Specification
Error Range	Maximum of +/- 5 degrees Celsius
Coverage	0 to 100 Degrees Celsius
Power Usage	Less than or equal to 5 V
Dimensions	Maximum 8 x 8 x 4 inches (L x W x H)

Table 2.4 Temperature Sensor Specifications

2.5.4 Bluetooth Specifications

Table 2.5 contains the specifications for all Bluetooth communications between the microcontroller and the application. This will also be the main communication for any future features we may decide to add. The main receiver is attached to the microcontroller board and is responsible for triggering the alarm and notifications to the application in times of emergency.

Category	**Specification**
Range	Minimum 10m of operation
Speed	Perform up to 1 Mbps
Frequency	Must be 2.4 GHz
Dimensions	Maximum 8 x 8 x 4 inches (L x W x H)

Table 2.5 Bluetooth Specifications

2.5.5 Battery Specifications

The following Table 2.6 contains the specifications for the Battery that is the power source for the microcontroller board and all attached components. Without a reliable source of power the device is dead and therefore cannot warn the parent or guardian that their child is possibly in danger.

Category	**Specification**
Nominal Capacity	Minimum of 1.5 AH
Nominal voltage	Minimum of 3 V
Standard Charge Current	Minimum of 0.2 CA
Max Charge Current	Maximum of 2 CA
Impedance	Maximum of 100m ohms

Table 2.6 Battery Specifications

2.5.6 Solar Panel Specifications

Table 2.7 contains the specifications for the Solar Panel that is the component that replenishes the battery's power. This component will trickle charge the battery so it maintains a safe amount of battery life whenever it may be required.

Category	**Specification**
Charging Method	Must support Trickle Charging
Charging Light	Must be able to charge in low light environments
Dimensions	Minimum length of 8 inches
Operating Temp	0 to 50 Degrees Celsius
Power Output	Minimum of 3V

Table 2.7 Solar Panel Specifications

2.5.7 Application Specifications

The following Table 2.8 contains the specifications for the Application which will be the device's means for communicating with the parent or guardian. The application will receive notifications from the microcontroller in times of emergency via Bluetooth communication. The specifications will include both design and digital requirements the application must be able to supply. Android devices will be the receiving the application first with an iOS version coming sometime in the future.

Category	**Specification**
Compatibility	Version 4.0 or higher to ensure 90% device coverage
Storage Size	Less than 500 mb

Table 2.8 Application Specifications

3.0 Research

3.1 Current State of the Problem

Engineers are natural problem solves, but in order to create a solution they much first fully understand the problem at hand. This section is the sum of all the research our team members have obtained and with it we plan on making the best product we possibly can to ensure the safety of these children.

3.1.1 Statistics

Figure 3.1 below shows the statistics of the cause of vehicular child death over the past 15 years. Before 1998, the main threat was the airbags. The team assumed that 1998 was when automobile industries began to add in air bag safety features, which greatly decrease its killer effect on children. On the other hand, the number of causes for heatstroke has been going up and down since 1994. Three to four times a month a set of loving parents in the United States are horrified to realize that they have forgotten their child in its car seat.

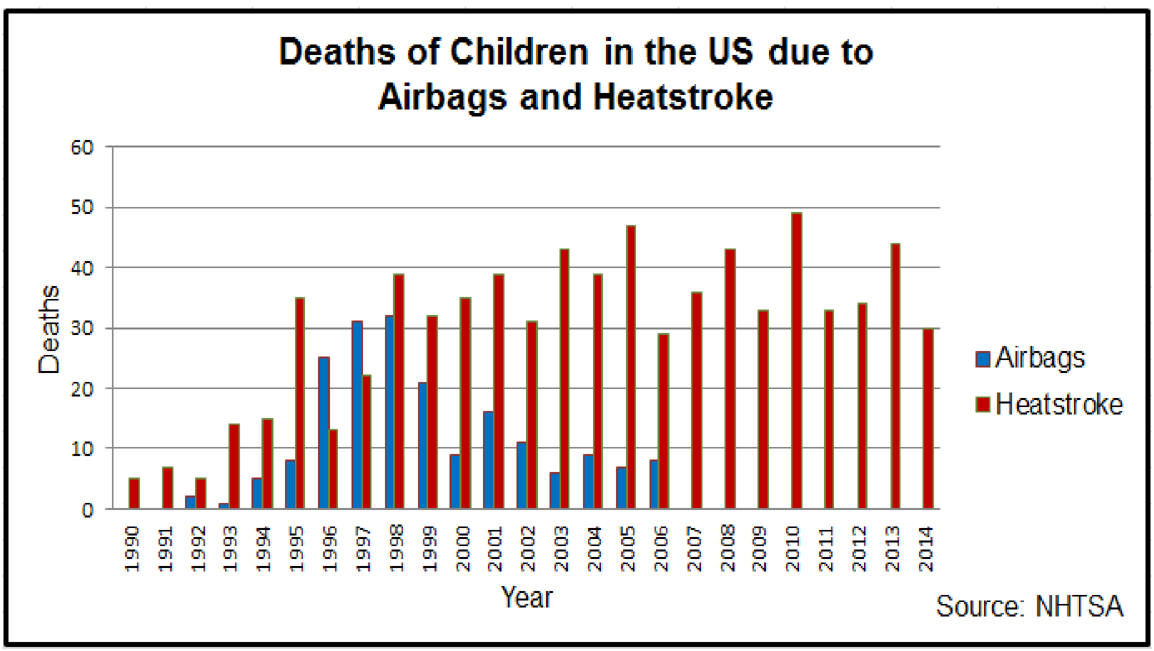

Figure 3.1 Vehicular Child Death Statistics

Data obtained from the NHTSA (see Appendix C).

To date, 719 children have died in heatstroke cars since 1998, ranged in age from 5 days to 14 years. Majority of Children left in car were 1 year old or younger (53%) and jumps to 73% within 2 years included. Table 3.1 below shows the percentage of the causes of children being left in cars that lead to heat strokes. Our project aims to reduce these numbers significantly because as shown from the airbag change it only takes a minor improvement to completely remove the issue from society.

Reason	**Percentage**
Child "forgotten" by caregiver	53%
Child playing in unattended vehicle	29%
Child intentionally left in vehicle by adult	17%
Circumstances unknown	1%

Table 3.1 Causes of Children being left in Cars

Figure 3.2 on the following page shows the average heatstroke distribution in America. Most heating up occurs in first 10-15 minutes. On average, temperature increases at rate of 3.4 degrees (F) per 5 minutes. Temperatures can increase in the range from 9 degrees (F) high up to 19 degrees in the first 10 minutes. Most common heat-caused health effects on children are Dehydration, development of faintness, headaches, extreme fatigue, and shortness of breath. As you can see the most deaths caused by heatstroke occur in the warmest states such as California, Texas, and Florida. We find ourselves beneficial to be conducting our research in Florida because we can get critical data and information from surveying potential customers in the second highest rated state.

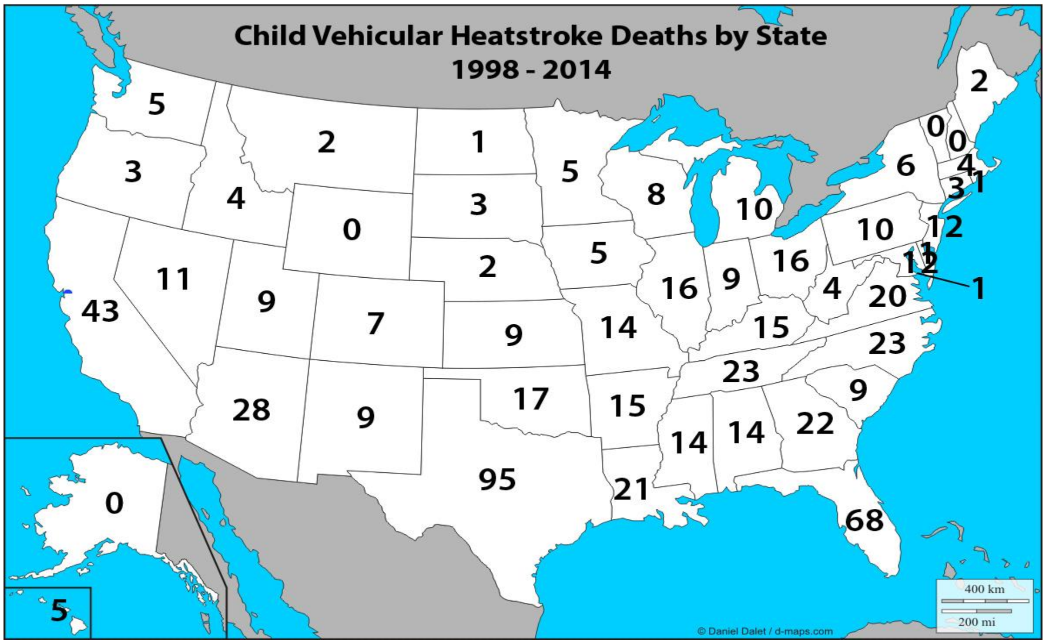

Figure 3.2 Heatstroke Distributions (1998-2014)

Reprinted with permission from ggweather.com – Appendix A

3.1.2 Psychology

The average American is under a tremendous amount of stress. According to Medical News 77% of parents are stressed about money. Add to that the sleep deprivation that parents of newborns and small children experience and you have could have a lethal combination. Dr. David Diamond of the University of South Florida continues to research a phenomenon he calls, “Forgotten Baby Syndrome” (see Appendix B). This syndrome is a, “Failure of prospective memory, which refers to the planning and execution of an action in the future.” In other words, it is indeed possible for people of all ages, incomes, education levels, and genders, to forget their babies in their cars and just go off to the office.

Table 3.2 and Table 3.3, on the following page, shows the causes of stress and the symptoms of stress respectively. These causes and symptoms of stress are mostly unavoidable and to ensure the most satisfaction from our design we have to have the best balance of effectiveness and operation time. We aim to provide a system that can be both inexpensive and also installed without much effort because the highest causes of stress are money and work. Lowering these causes will be beneficial in itself because less stress can lead to a situation where the consumer will not lose their primary focus. Data obtained from American Psychological Association (see Appendix B).

Causes of Stress	Statistics (of 2010)
Money	77%
Work	70%
Family Responsibilities	58%
Relationships(Spouse, Kids, girl/boyfriend)	55%
Personal Health Concerns	52%

Table 3.2 Causes of Stress

Symptoms of Stress	Statistics (of 2010)
Irritability or anger	45%
Lack of interest, motivation, or energy	38%
Feeling nervous or anxious	36%
Headache	36%
Feeling depressed or sad	34%

Table 3.3 Symptoms of Stress

3.1.3 Audience Research

The team's target audiences are caregivers and new families. The team sent out first round of survey to caregivers regarding their experience with their child car seat and what they look for to better a child car seat. The team was able to received 80 responses. The team will be sending out a second round of survey to gather more information that may support the team's design.

Figure 3.3 below is the first House of Quality based on the responses of Survey 1: UCF Nemours Child Car Seat Design Project, which can be found in Appendix C. Having a functional weight sensor is the most important (shown in gold box, scoring the highest out of all requirements) step and the top development priority for the team because it is the baseline of the design.

Requirements								
Category	Statement of Requirement	Importance	Satisfaction with Current Solution	Satisfaction Goal for Our Solution	Improvement Required (Negative Values are Converted to 0)	Impact of Improved Satisfaction	**Development Priority**	**Normalized Priority**
Design	Comfortable cusion	7	7	8	1	1.3	9.10	0.02
Design	Simple and easy to install	8	3	9	6	1.3	62.40	0.11
Design	Easy to clean	4	3	9	6	1.1	26.40	0.05
Finance	Affordability	3	7	8	1	1	3.00	0.01
Funcationality	Functional weight sensor	10		10	10	1.5	150.00	0.26
Functionality	Signal car to turn on cool air when weight sensor detects child is being left in car	10		10	10	1.2	120.00	0.21
Functionality	Send out notification to phone when child is left in car	10		10	10	1.2	120.00	0.21
Psychological	Visual aids in the car	9		9	9	1	81.00	0.14
	Weighted Overall Performance		106	569			571.90	

Figure 3.3 Current Performance Level

3.1.4 Key Variables

The causes of heat and stress discussed in Section 3.1.1 and 3.1.2 are critical factors in the team's designing of a safer child seat. Our inserts are meant to achieve the project goal to ensure a child left in a car can survive and simultaneously alert the parents, and possibly others, about the child being left alone in a potentially deadly environment.

Table 3.4 shown below displays a list of variables the team proposed to incorporate in the design and addition features we expect to be available before mass manufacturing in order to meet the goal. The design enables future safety options to be added to the system quickly and easily so each customer can customize their own child safety seat to their unique situation.

Variable	**Description**
Wireless Awareness Trigger	Creating a sensor to insert into the car seat and an application on the phone to notify caregivers when a child is being left in the car
Car Function Control	Automation control and alarm of the car when temperature exceeds the danger level and the sensor detects a child is being left in the car
Visual Aids	To prevent the psychology of forgetting by providing images of the child to the caregiver
Vehicle Dock Station	This will be placed on the vehicle dashboard and enable a smart device with the application installed to be safely held in place.
Video Streaming	The app will provide a video stream of your child so the driver does not have to turn their head while driving. Combining this with the Vehicle Dock Station provides the best safety option.

Table 3.4 Key Variable Descriptions

3.1.5 Target Performance

The red boxes in Figure 3.4 below are the team's target improvement score, along with the level of impact once the designs are made. We chose this scoring because it allows our design to have the maximum impact on our target audience as well as maintaining our desired affordability and reliability.

Requirements		Importance	Satisfaction with Current Solution	Satisfaction Goal for Our Solution	Improvement Required (Negative Values are Converted to 0)	Impact of Improved Satisfaction	**Development Priority**	**Normalized Priority**
Category	Statement of Requirement							
Design	Comfortable cusion	7	7	8	1	1.3	9.10	0.02
Design	Simple and easy to install	8	3	9	6	1.3	62.40	0.11
Design	Easy to clean	4	3	9	6	1.1	26.40	0.05
Finance	Affordability	3	7	8	1	1	3.00	0.01
Funcationality	Functional weight sensor	10		10	10	1.5	150.00	0.26
Functionality	Signal car to turn on cool air when weight sensor detects child is being left in car	10		10	10	1.2	120.00	0.21
Functionality	Send out notification to phone when child is left in car	10		10	10	1.2	120.00	0.21
Psychological	Visual aids in the car	9		9	9	1	81.00	0.14
	Weighted Overall Performance		106	569			571.90	

Figure 3.4 Target Performance Scoring

3.1.6 Analysis and Findings

The team attempted to apply various quality control tools to the project in order to perform analyses on the research data the team had collected through research and surveys. Due to the nature of the project, it was very difficult for the team to find applicable quality tools to use. The most applicable tool for this project is the Failure Mode and Effects Analyses. The Failure Mode and Effects Analyses, hereafter known as an FMEA, is used to identify where a process step will fail, how it will fail, how impactful this failure is to the process, and the likelihood of that occurrence. The FMEA for our main issue is shown below in Figure 3.5 and represents a sample made by the team that will be used for this project. This figure describes the process of placing a baby into the car along with the potential failures that lead up to the critical situations that can occur when leaving a child in the car. The potential causes, such as fatigue or change in routine, are represented in the table along with a factor showing how often it occurs. Existing controls and procedures are listed as well as some prevention techniques to mitigate the causes and are labeled with a factor representing how you can detect these causes. In conclusion this figure depicts how we will proceed in designing the device to detect the potential causes before any harm is done to the child.

State	Question	Effect
Key Process Step or Input	What is the process step or input?	Putting baby into car and baby is forgotten.
Potential Failure Mode	In what ways can the Process Step or Input fail?	Car temperature is unsafe for the baby to survive
Potential Failure Effects	What is the impact on the Key Output Variables once it fails?	Death of Baby
S E V	How Severe is the effect to the customer? (low 1-10 high)	10
Potential Causes	What causes the Key Input to go wrong?	Parent's Act of Forgetting.
O C C	How often does cause of failure mode occur? (low 1-10 high)	10
Current Controls	What are the existing controls and procedures that prevents failure?	Parent's own attention to detail.
D E T	How well can you detect the cause of the Failure Mode? (low 1-10 high)	10

Figure 3.5 Failure Mode and Effects Analyses Priority Issue

3.2 Existing Products

Prior to beginning development on the Nome's Child Safety Seat's design we found it important to consider alternative and already existing solutions. If a product already exists that is similar to ours and satisfies the goals we have set it may be possible to extract inspiration from their design to better improve ours. Also by examining similar systems we can observe their process, history, and success or failure to help us learn from their design and to avoid similar mistakes in our project. Using this information we can create a highly sought after product that displays the maximum amount of safety with the minimum cost and installation time for the consumer.

3.2.1 Aneiros Vehicle Child Seat Safety System

While conducting research related to similar designs and existing patents our team came across the Aneiros Vehicle Child Seat Safety System. This section is devoted to solely describing how this already existing system functions and the following section will focus on explaining how our system is uniquely different. Figure 3.6 below is the system's product and logo.

Figure 3.6 Aneiros Smart Child Seat System

Permission Pending from Aneiros

The Aneiros Child Seat Safety System is a two part system consisting of a child seat hardwired to the car's processor allowing for full control over the vehicle's systems, such as air conditioning and locks, for times of emergency to ensure the survival of the child. To notify the driver of an emergency the device has three levels of alerts that increase in severity as time passes with no assistance registered to the child even going as far as to contact external help from other people nearby.

The device functions by using weight sensors both in the child's seat and the driver's seat to detect when there is someone present in both seats. This triggers the initial startup of the safety device. If the driver leaves the vehicle the first level of alerts begins as a continuous, soft beeping, alarm to notify the driver they have left their child in the car seat. The alarm will shut off when the child is removed from the seat. If the child is not removed from the seat, then after three minutes of no intervention the second level of alert begins. The second stage alarm accesses the car's alarm system and flashes the car's lights to alert anyone nearby that something is wrong in this vehicle. These two stages are usually enough to notify the driver or anyone nearby and save the child, however Aneiros has implemented an emergency third stage alert for critical situations. This final alert level the system activates the car's air conditioning system to reduce the temperature inside the vehicle and prevent dangerous heat levels. This level also unlocks the car's doors and allows anyone nearby to rescue and remove the child from the heated car.

The Aneiros Child Seat is being planned to be sold directly as a single unit, full sized car seat for the child. Figure 3.7 below shows the model of the Aneiros Child Seat design from three different perspectives. The padding inside will house the weight sensor and a transmitter that will communicate with the hardwired processor and the driver's weight sensor device.

Figure 3.7 Aneiros Child Seat Design

Permission Pending from Aneiros

The car's processor handles all the communication between both the driver and child weight sensors as well as controlling all the vehicle systems. Figure 3.8 below features the full integration between all the devices and is numbered accordingly. The car seat (12) and its enclosed systems are placed in the back seat and wirelessly connected to the processor. The processor is hardwired (38) inside the car (14) to avoid any interference from any other devices that may be within range. The processor then has full control over the following car systems: door lock's (28), car's alarm system (32), the vehicle's ignition switch (34), the vehicle's engine (35), and the air conditioning system (39).

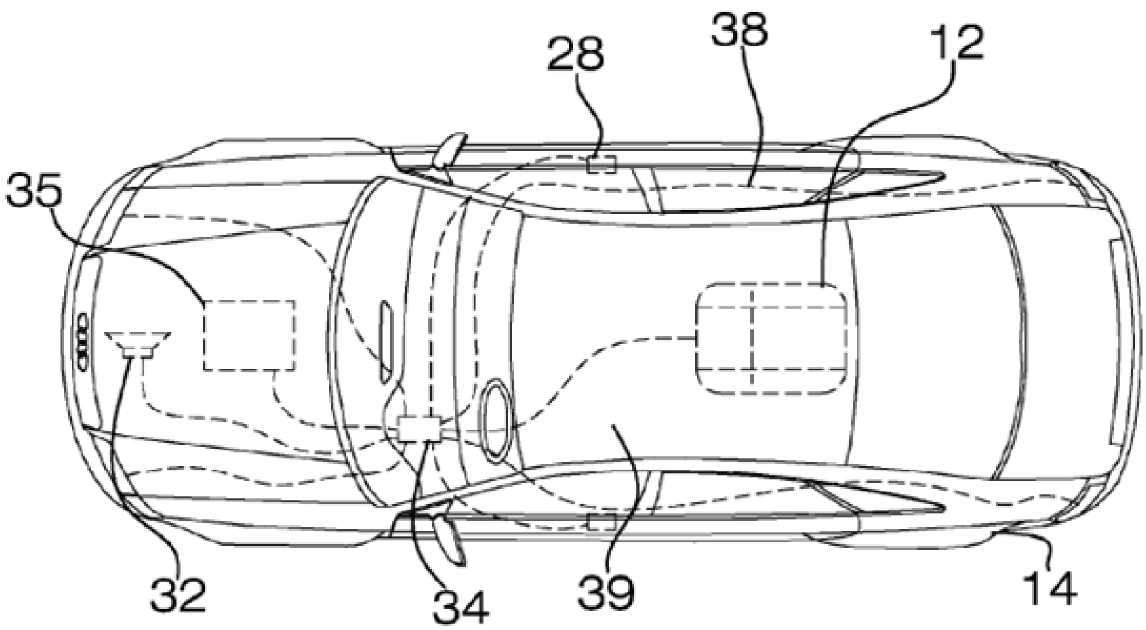

Figure 3.8 Aneiros Car Integration

Permission Pending from Aneiros

3.2.2 Aneiros Comparison and Influences

Using this information we found about the Aneiros design in addition to our results from the surveys we decided that the original car seat design of our product required too much installation time and was not as mobile as the market demanded. In order to adjust our design we now have shifted to a car seat insert that is highly mobile and easily inserted between the child and already existing car seat.

The Aneiros design requires a car to be equipped with network of wires to connect all of their systems of the child car seat, the driver seat, and the car computer together. This design required the car to have a processor not only build into the car but also have access to all the car's features. Usually this level of access is restricted on most vehicles and requires permission from the car distributors to obtain the correct coding which allows the device to communicate with the car. Vehicles are only now being built with computer systems installed and in order to cover as much of the consumer market we want to provide a safety option that can cover both situations reliably.

Our design will be using the freedom of Bluetooth wireless devices to avoid being hardwired into the car. This choice was made because to keep the entire system lightweight, mobile, and quick to install we could not have the parent or guardian waste time laying wires throughout their car so the wireless option is clearly a better choice. Our system will consist of a housing wedge that goes under the car seat that houses all of our electronics to provide the option of a safety device that does not have to be integrated into vehicles and maintains mobility.

Instead of requiring the consumer to have a vehicle with an integrated processor we are shifting our focus to a more hand held option. Our design requires the use of a smart phone and the application will provide information and status of the child safety seat. We decided this option to be the best approach because in this day and age most young adults, who will be starting families soon, have smart phones and are relatively technologically knowledgeable. The vibration alerts, and alarms that smartphones can provide will be highly beneficial to the goal of reminding the parent or guardian that there is a child in the back of the car.

The final comparison derived from the Aneiros design in the difference between car seat and insert. The Aneiros car seat is a full car seat design where the device is built into the car seat and sold as a single unit. We believe this is not the best approach because most families that are looking into better security for their child will already have a car seat from other friends or family via gifts or hand me downs. Our insert design allows it to be easily placed into an existing car seat and be fully functioning and reliable. This design direction is better because it is easily moved from one parent's vehicle to another without having to move the large car seat. Also the insert design will cover areas of the car seat that can become dirty so instead of having the bulk of the mess on the car seat it will be focused on the insert. Then the insert can easily be taken out of the car and cleaned properly elsewhere. This level of mobility is what our design in focusing on and by comparing design techniques with the Aneiros Child Safety System our design has been greatly improved to achieve our main goal.

3.2.3 ChildMinder SoftClip®

While conducting research related to similar designs and existing patents our team came across the ChildMinder SoftClip® developed by Baby Alert International. This section is devoted to solely describing how this already existing system functions and the following section will focus on explaining how our system is uniquely different. Below in Figure 3.9 is an image of the system's product clip and receiver.

Figure 3.9 ChildMinder SoftClip®

Permission Pending from Baby Alert International

The ChildMinder SoftClip® is a two part system consisting of a child seat belt clip and portable key ring alarm system. This device will attach to the child's seat belt harness on any existing child car seat and the key ring will be kept with the parent or guardian. When the key ring is more than fifteen feet away and the clip is fastened the device will begin beeping. This provided an audio reminder that the owner will hear and remind them that they forgot their child in the vehicle. The alarm is then turned off by either unbuckling the seat belt clip or pressing the blue button on the key ring alarm. The alert system is powered by a lithium ion battery with the lifetime of approximately 1 year which allows the system to be functional for a very long time.

3.2.4 ChildMinder SoftClip® Comparison and Influences

Using this information we found about the ChildMinder SoftClip® design in addition to our results from the Aneiros design and surveys we decided that the original car seat design of our product required too much installation time and was not as mobile as the market demanded. In order to adjust our design we now have shifted to a car seat insert that is highly mobile and easily inserted between the child and already existing car seat and decided to use a smartphone application to alert the owner via an audio reminder.

The ChildMinder SoftClip® is only a pre-crash device which means it only functions as an alarm system and has not ability to intervene in an emergency situation to attempt to save the child. The Nome's Child Safety seat will feature a multiple stage intervention system that firsts alarms the owner and in emergency situations will take over the vehicle and adjusts the temperature inside to save the child's life.

An important fact to point out is that by applying the safety clip to the child's car seat harness will also void most of the car seat warranties, which is not something we are aiming to do. Our car seat insert will not infringe on any car seat warranties because if it's insert design.

3.3 Relevant Technologies

To better understand what technologies we would need to use for this project. We first needed to understand what our projects communication requirements would be and what goals we were attempting to accomplish. We needed to ask ourselves if we were going to want to communicate with other devices from the microcontroller and the required sensors. How would we do that? We also knew that we would need a way to talk to the user remotely so that we could alert them to the status of the Car seat. Knowing this we chose to research the following technologies, UART, Bluetooth, GSM/CDMA. These communication protocols would allow for the car seat to communicate on three different levels with the seat. The first being low level with UART, which could be used to talk to the sensors and gain the required information to late transmit to another device. Second being Bluetooth which allows the microcontroller to communicate with a device with an application to notify the user with relevant information. Third being GSM/CDMA to communicate at distances further away than what Bluetooth is capable of. With this brief discussion on the different communication technologies we researched they will be described in more details in the following sub sections.

3.3.1 UART

UART is a way to communicate with the microcontroller from a sensor. It is a two way communication that uses Tx and Rx to send and receive data. UART uses RS-232 standard and is very simple to implement. This method allows for simple communication between the microcontroller and sensors which will allow for an easy way to collect the data and then process it with the microcontroller.

3.3.2 I^2C

I^2C, short for Inter-Integrated Circuit and is a communication interface which may be used to talk between the microcontroller and the sensors. This design respects the master to slave designs and for our project the microcontroller will be acting as the master while the sensors will act as the slaves. This method is advantageous to us because we are able to connect all our sensors, load and temperature, uniquely to the microcontroller via an identification number. This method requires us to include a two wired connection between the microcontroller and each sensor. This design type offers multiple transfer speeds for the data and the transfer speed we may use is the 100Kbps option because not a lot of data will be transferred very often. Data will only be sent when the device notices a change and then becomes active.

Figure 3.10 below shows the master to slave set up and the two wire connection between them.

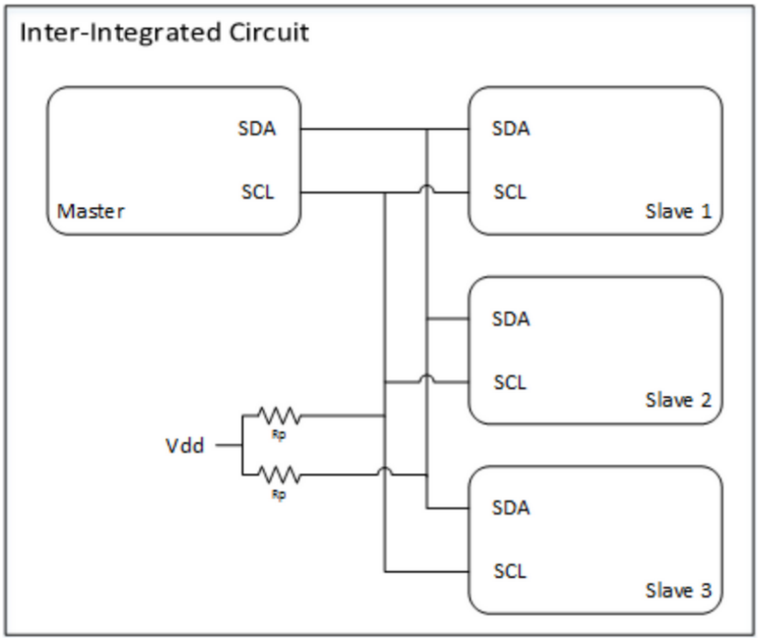

Figure 3.10 I^2C Diagram

3.3.2 Bluetooth

Bluetooth is a wireless standard for exchanging data over short distances. It operates at between 2400 and 2483.5 MHz. Bluetooth provides benefits over other 2.4 GHz technologies due to the implementation of adaptive frequency hopping. This provides it the ability to detect other devices that are using the spectrum and change the frequency to an unused one to avoid any noise. Bluetooth has 79 frequencies that are 1Mhz apart. Bluetooth has a range that is mandated by the specification but there is not a limit on the upward side, and the range can be extended based upon the use case that is needed. Devices are divided into 3 classes shown below in Table 3.5

Class	Description
Class 3 radios	have a range of up to 1 meter or 3 feet
Class 2 radios	most commonly found in mobile devices – have a range of 10 meters or 33 feet
Class 1 radios	used primarily in industrial use cases – have a range of 100 meters or 300 feet

Table 3.5 The Different Classes of Radios.

The IEEE standardized Bluetooth as IEEE 802.15.1 but no longer maintains the standard. The standard is now maintained by the Bluetooth SIG group. There are a number of patents that apply to this technology, and in order to market a Bluetooth device it must both meet the standards set by the Bluetooth SIG group and pay a licensing fee to them. Because of the licensing and certification requirements that the Bluetooth SIG maintains we knew we would be forced to purchase a manufactured Bluetooth radio for our design.

3.3.2.1 LMX5252

The LMX5252 is a compact Bluetooth radio manufactured by TI. This radio integrates a complete Bluetooth Class 2 Transceiver. To comply with the Bluetooth SIG standards it must be paired with a compatible Bluetooth processor. That has been certified. This Bluetooth chip is Bluetooth 3.0 Certified.

In Figure 3.11, on the next page, we can see the flow of the device and all of the sub components. This lets us know the flow that the Bluetooth device will take. It also lets us know where we have to hook up the antenna and the inputs and to the microcontroller. This device uses a receiver, a transmitter, and a synthesizer in order to transmit and receive data.

This radio integrates the receiver, transmitter baluns, antenna switch, and filter together using the voltage-controlled oscillator tank all in one die. The baseband interface is digital which allows it to be compatible with an 8-pin bi-directional BlueRF by using the RXMODE2 configuration. This allows for the device to automatically change the voltage levels with the use of the baseband controllers all independently of the supply voltage.

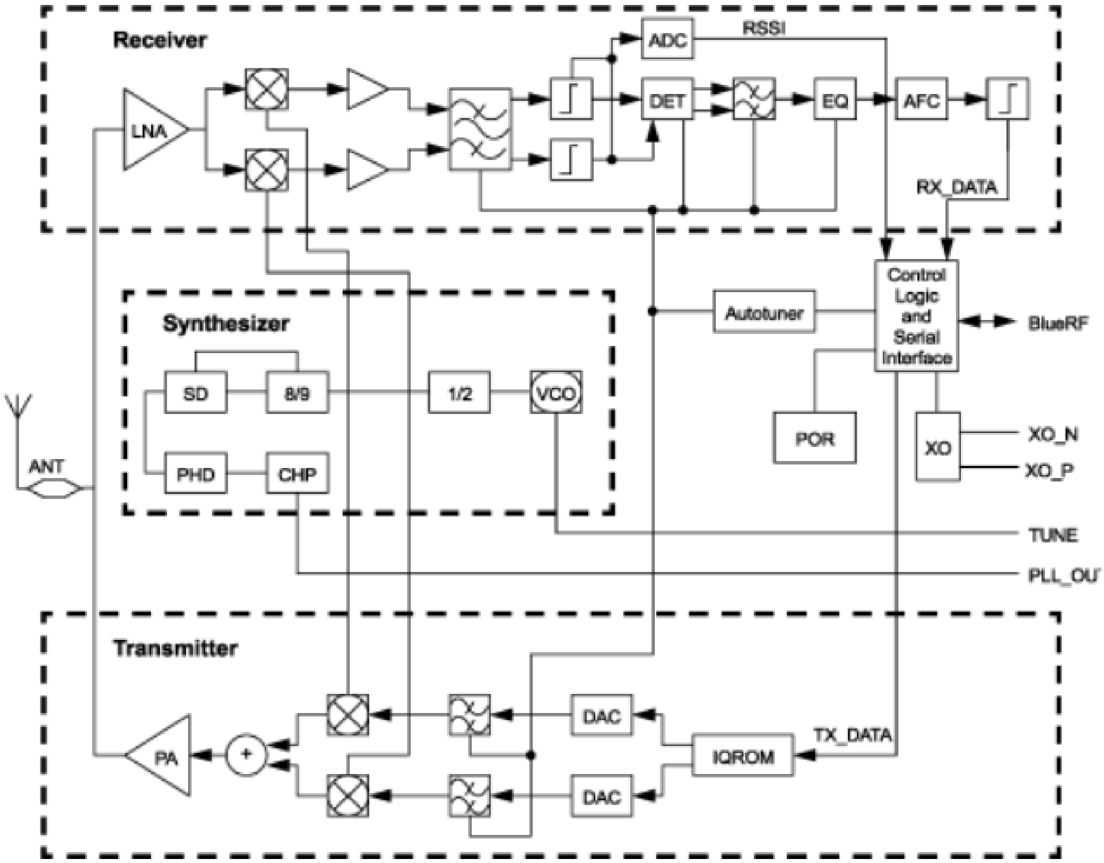

Figure 3.11 Functional Diagram

The LMX5252 in Figure 3.12 below shows the direct pinouts of the device and allows for us to properly be able to integrate this into our PCB and connect it to an antenna. Using the voltage pins we will also have to plan our design around how we will power both the microcontroller and the Bluetooth radio at the same time. Using the above we can plan how we will handle both placement and integration of the device. We have to supply a voltage of -.3 to 3.3 volts to the device. This will also have to be taken into consideration of our design because we need a low power device to be able to properly implement our design into a car that will be portable.

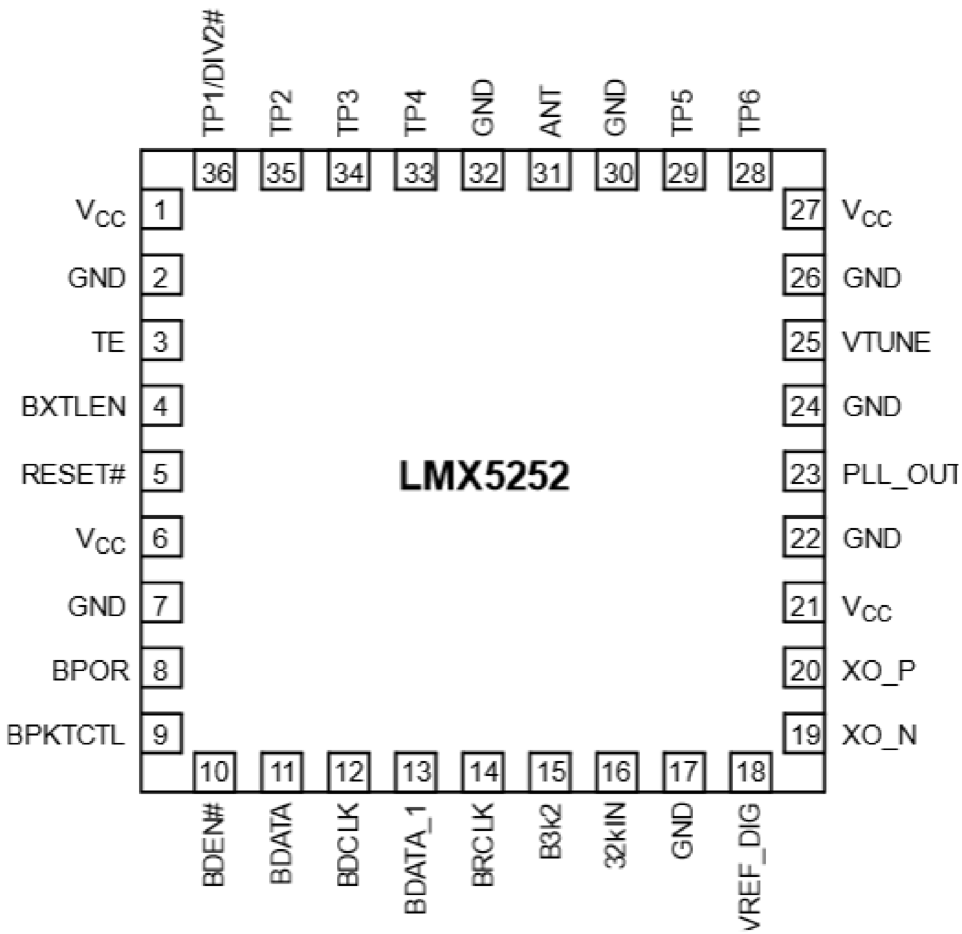

Figure 3.12 Connection Diagram of the LMX5252

With this device we have include a crystal driver circuit into our PCB design. In Figure 3.13 below, we can see that the LMX5252 needs to have a circuit included into the design. This will cause the PCB size to increase. This crystal is vital to the Bluetooth radio because it allows for the frequency to be tuned to each other and for the device to properly function.

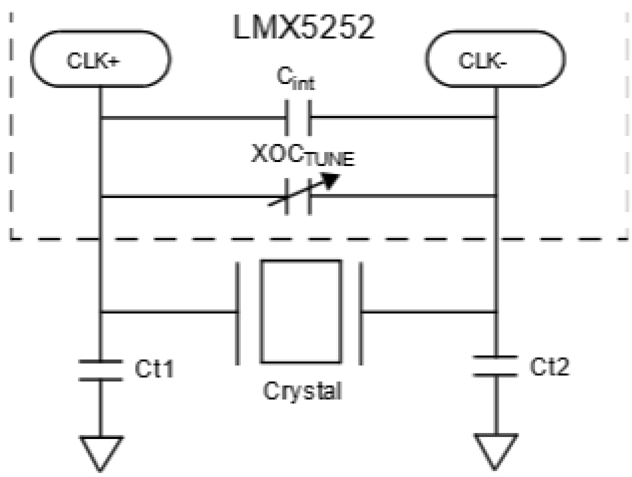

Figure 3.13 Crystal Circuit

In Figure 3.14 on the following page, we can see the order in which the device has to take in order to power on then transmit data. The path that is taken is that the device is in idle, and then the radio will wait for data, after waiting the data will sync, which then the device will power up and transmit the data. The time this takes will have to be taken into consideration when using this device for the programing portion.

With all this taken into consideration we can later decide if this device is one that we would want to implement into our design. We will take into consideration the space requirement, time it takes to sync and turn on data, and the extra power consumption that will be required.

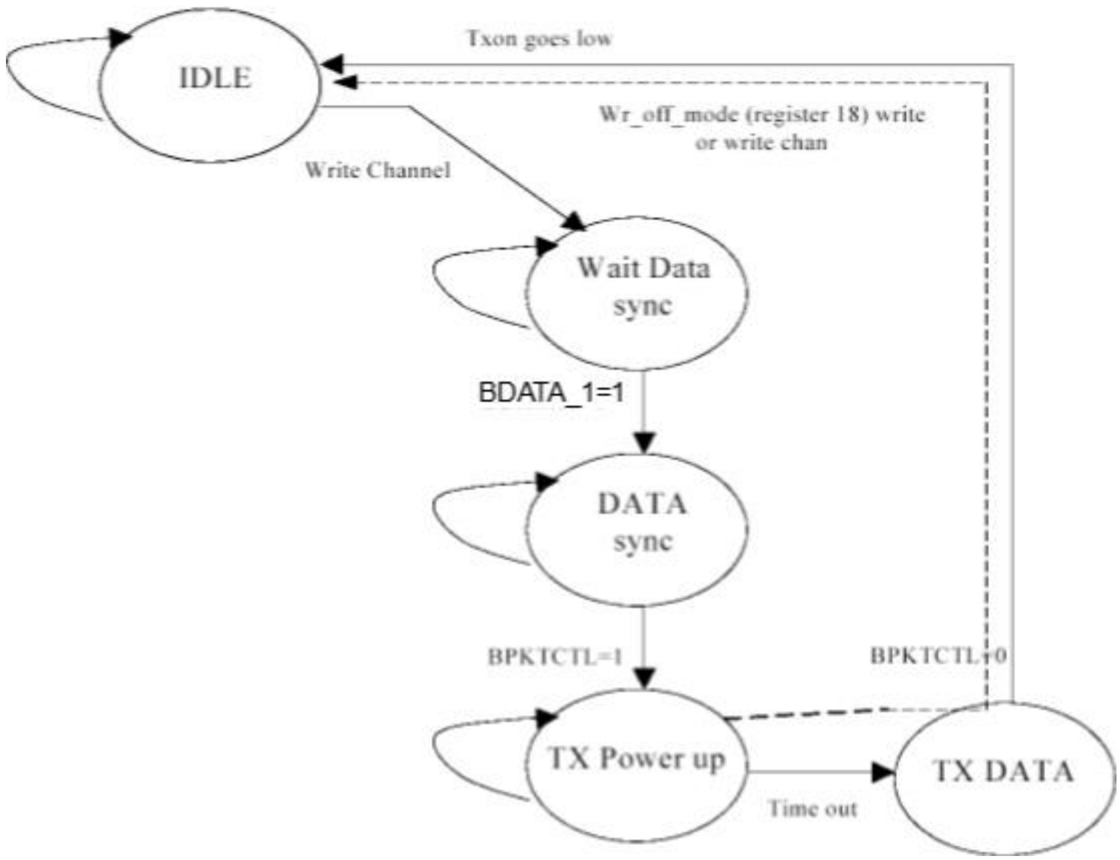

Figure 3.14 Tx-Mode Sequence

3.3.2.2 CC2540T

The CC2540T is a low power Bluetooth Radio also Manufactured by TI. This radio integrates a both the Transceiver and a Bluetooth processor that is Certified by the Bluetooth SIG. This Chip has the benefit that it comes with a Bluetooth Controller that has a software stack created and maintained by TI. Use of this Radio would allow us to bypass writing low level Bluetooth protocols. This chip is certified for Bluetooth 4.0.

In Figure 3.15 on the following page we can see the block diagram of the CC2540T which allows us to understand how the device is operating. This is a complex Bluetooth radio that has low power application and has a processer built on the chip. The CC2540T has a CPU cure which users the crystal clock on the chip to sync the radio to transmit.

The use of this device is a complex design which would include designing our PCB with room for both CPU chips and integrate both of these to the same power source. This would cause for a larger power drain on our battery and we would have to take this into consideration while calculating the amount of solar panels we need to charge. The device uses 2 – 3.6 volts and from 235 micro-amps and 6.7 mill-amps.

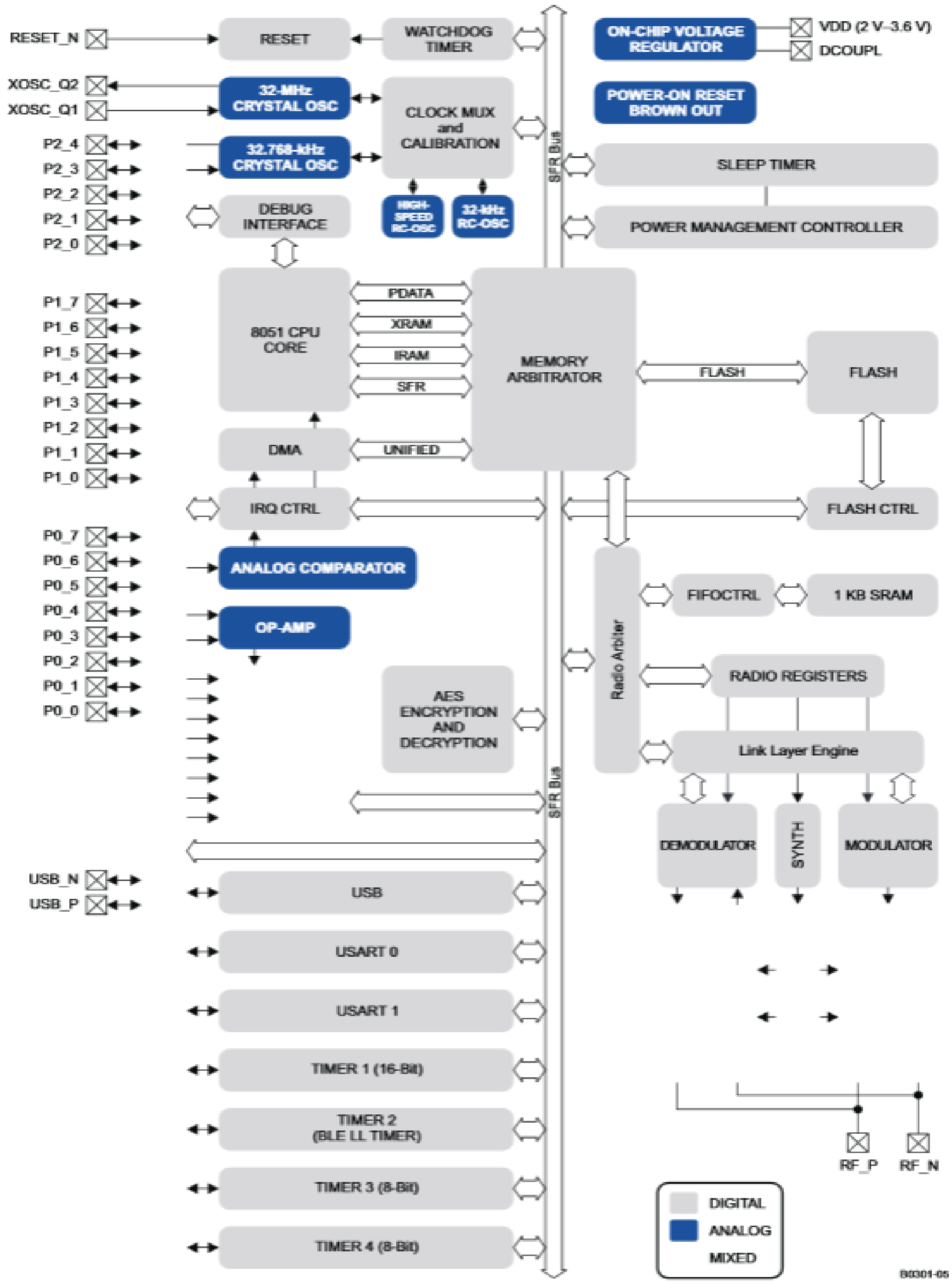

Figure 3.15 Functional Block Diagram of CC2540T

In Figure 3.16 below the pinout of the CC2540T will allow for us to better understand how we have to implement this Bluetooth radio into our PCB design. The CC2504T will need to be supplied to the chip in order to do this we will have to match the CPU to the correct voltage range or use a voltage regulator in order to keep the voltage at the correct value. We can also see how we will have to implement the external crystal connected to the correct two pins and how to implement the correct antenna design. This will allow for correct placement of both the chip and the antenna on the PCB.

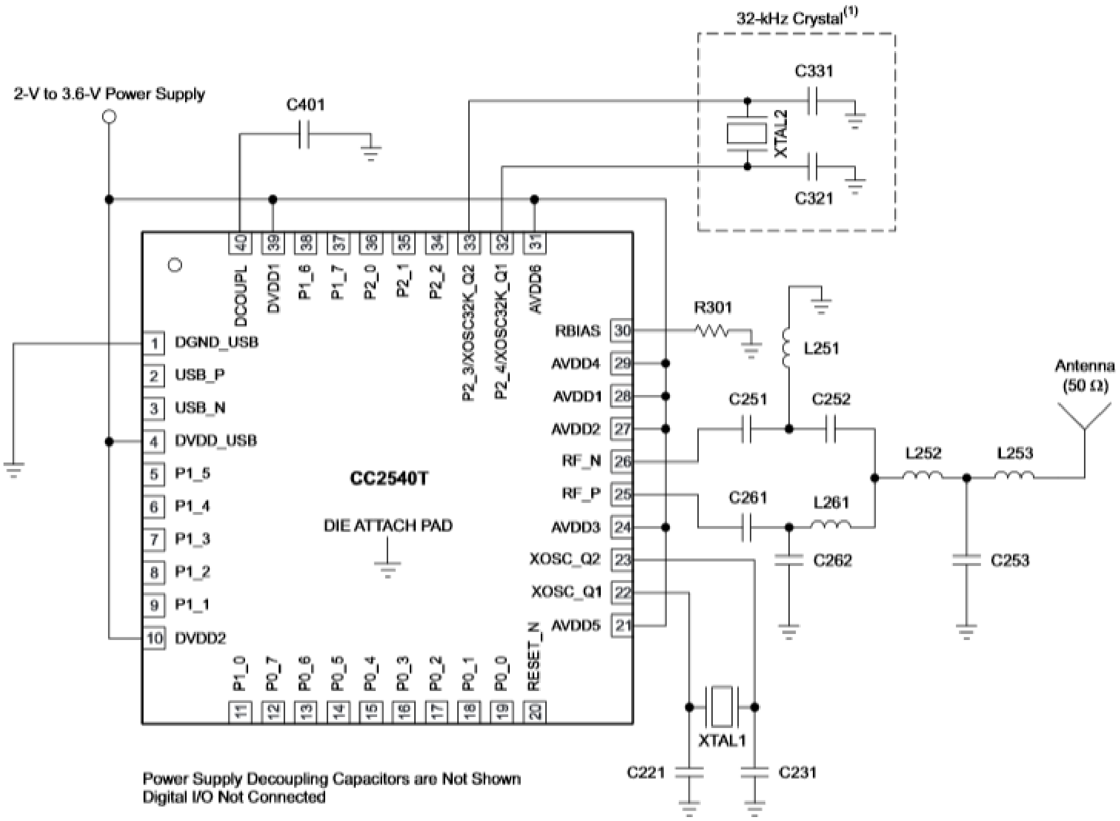

Figure 3.16 Pinout of the CC2540T

3.3.2.3 Bluetooth SOC

Another option for Bluetooth radios is to purchase a SOC that contains both the Microcontroller and the Bluetooth radio integrated into the package. There is a magnitude of these on the market produced by multiple manufacturers that we will review more in the Microcontroller section of this paper. This combination will allow for us to implement on chip with the same voltage onto the PCB. With this we can properly place just one chip and build the antenna and supply the correct voltage to just one device. Since this device is a combination of both microcontroller and Bluetooth radio we will talk more about the specs in the microcontroller section of the paper. This section will take into consideration of the PSOC4 BLE and the NRF51822, since those are the two that we chose to research.

3.3.3 Microcontroller

Before we could begin to research a specific microcontroller that would function for our design, we first need to better understand microcontrollers. For our design we would have to gain information in the form of data that can be analyzed, transmitted and action taken based on the data. This process requires us to use a microcontroller. A few questions we asked ourselves before starting research were what kind of microcontroller would be good for our application? How much processor speed and memory do we need? What power applications do we have?

With these questions in mind we decided to research a few different types of microcontrollers. This would allow us to better understand which kind of microcontroller would be best for our use. Since microcontrollers are made by many different semiconductor manufactures and come with all different feature sets for different usages. After extensive research we narrowed down our choices to the following microcontrollers for comparison shown on the following page in Table 3.6.

	Msp430	Tiva C	AtMega	PSOC4 BLE	NRF51822
Processor	16-bit RISC	Cortex M4	atMega2560	Cortex M0	Cortex M0
Speed				48 Mhz	16 Mhz
Memory	4KB	256KB	256KB	128KB	256KB
Power	2.2 V	0-4V	5V	5V	3.6
Comm Protocol	UART	UART/USB	SPI/Uart/I2C	SPI/I2C/UART/Bluetooth	SPI/I2C/UART/Bluetooth
Low Power State	Yes	Yes	Yes	Yes	Yes

Table 3.6 Microcontroller Comparison

3.3.3.1 MSP430

The MSP430 is one of the options we considered for our project. We took into consideration the total power consumption, the amount of memory, processor, communication, GPIOs, and Hibernation. The processor is a 16-bit RICS architecture, which uses operations other than program flow as register operations. The 16 registers allow for quick execution time. The MSP430 has 4 kilobytes of ROM memory and 256 bytes of RAM. The flash memory is used for programing the CPU by using the UART communication protocol interface. This allows for the CPU to have low power operation because it has less memory, but it still has enough memory for the device to be able to operate correctly.

The MSP430 also allows for different types of modes shown on the following page in Table 3.7. This table allows for us to see how the CPU will act when each power mode is active. When in the active mode the CPU will have full power available to it. Each mode after will decrease the power output of the CPU, because each mode will have different clocks active and will have the CPU in an Inactive (sleep state). The sleep stats are important because we need to be sure that the CPU we choose will have a low power operation mode to save on the batter usage since we are trying to make a device that has mobility.

Power Mode	Active mode	Low Power mode 0	Low Power mode 1	Low Power mode 2	Low Power mode 3	Low Power mode 4
CPU Status	Active	Inactive	Inactive	Inactive	Inactive	Inactive
MCLK	Active	Inactive	Inactive	Inactive	Inactive	Inactive
DCO	Active	Active	Inactive	Inactive	Inactive	Inactive
SMCLK	Active	Active	Active	Inactive	Inactive	Inactive
ACLK	Active	Active	Active	Active	Active	Inactive
Crystal Oscillator	Active full power	Active less power	Active less power	Active less power	Active lowest power	Stopped

Table 3.7 Power modes of CPU

Figure 3.17, on the following page, lets us see the block diagram of the components in the MSP430. Here we can see that the clock connects to the memory, and the CPU. The CPU connects to all of the components of the CPU. This lets us decided if we will be able to use the CPU to implement our design of the safe car seat. The CPU operates on 1.8 to 3.6 volts to power on.

This allows for us to be able to use less voltage and save on battery usage while powering the device. In its low power state we can decrease the power usage as well by lowering the consumption will on to 230 micro-amps, and also allows for a standby mode that operates at .5 micro-amps. In standby the device can wake up in less than 1 micro-second, which is vital to our operation of being able to determine the sensor data in the system.

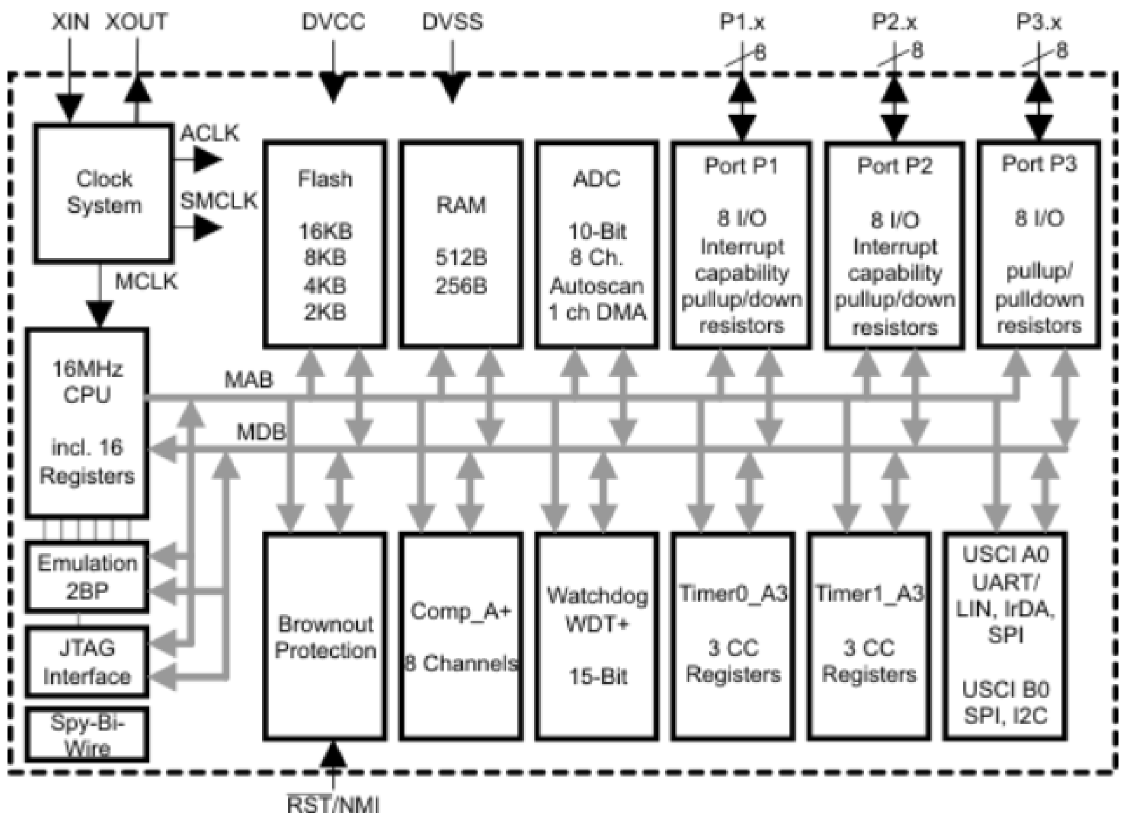

Figure 3.17 Functional Diagram of MSP430

In Figure 3.18, on the next page, we can see the pinout of the MSP430 which will allow us to connect our sensors to the CPU. While choosing which pin to connect the MSP430 to we will have to carefully pick if we do not wish to add more devices to our circuit. We are limited here because multiple pins can be used for multiple different things. This could complicate our circuit because we may have to use one pin for a different device rather than using the pin we want to. Although this is not a huge issue it is something that we have to take into consideration.

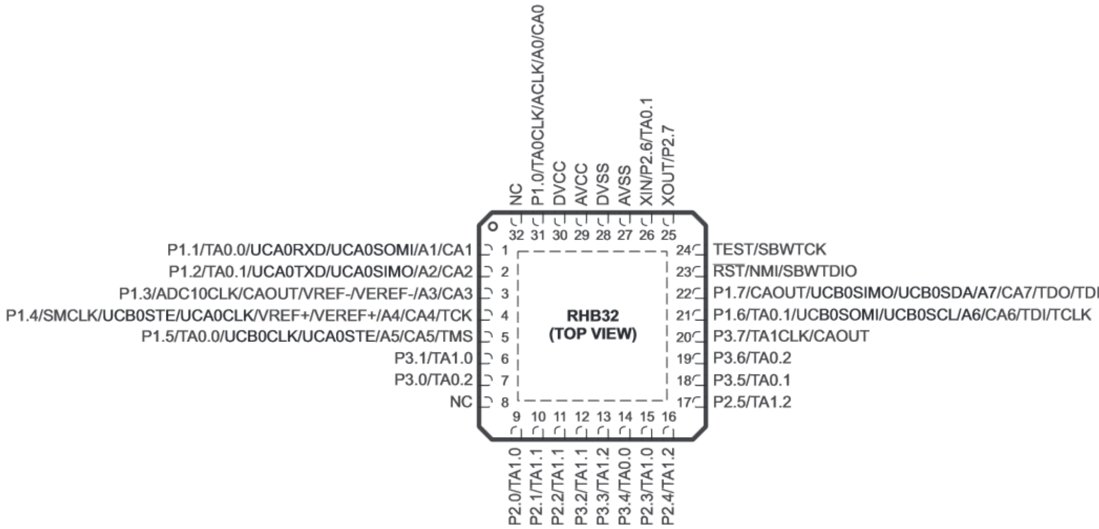

Figure 3.18 Pinout of MSP430

3.3.3.2 TM4C

The TM4C is manufactured by Texas Instruments and is based on the Cortex-M4 processor which is a 32-bit ARM based processor. The processor has an 80MHZ operating frequency and performs at 100 DMIPS. This allows for the processor to be fast and reliable at complex code. It has 256KB of memory which allows for large programs to be loaded to the CPU. This Processor also has an operating requirement of only 58.7mA to be able to provide the 80Mhz. The low power state for this processor uses 6.5 UA.

This processor provides plenty of I/O for our needs. The CPU features of this device provide are listed on the next page in Table 3.8. These features show us what the CPU has in order to determine if it fits within the needs for our project. Here we can see a list format of the amount of the chips internal components that allow for the input sensors and battery control to work.

CPU Features	Details
Universal Asynchronous Receivers/Transmitter	Eight UARTs
Synchronous Serial Interface (SSI)	Four SSI modules
transmission speeds including high-speed mode	Four transmission speeds including high-speed mode
Inter-Integrated Circuit (I2C)	Four I2C modules
Controller Area Network (CAN)	Two CAN 2.0 A/B controllers
General-Purpose Input/Output (GPIO)	Six physical GPIO blocks
Advanced Motion Control	One Advanced Motion Control
Pulse Width Modulator (PWM)	Two PWM modules, each with four PWM generator blocks and a control block, for a total of 16 PWM outputs
Quadrature Encoder Interface (QEI)	Two QEI modules
Analog-to-Digital Converter (ADC)	Two 12-bit ADC modules, each with a maximum sample rate of one million samples/second
Analog Comparator Controller	Two independent integrated analog comparators
Digital Comparator	16 digital comparators

Table 3.8 Features Included in the Cortex-M4

In Figure 3.19 on the next page, we can see the Cortex-M4 CPU in a block diagram which will allow for us to see the architecture of the processor. Here we have a high-performance processor core that uses a three stage pipeline architecture, making it ideal for demanding embedded application. It includes single-precision floating-point computation with a wide range of single cycle, and SIMD multiplication. This processor will allow for us to have fast computation times and still maintain low power consumption.

In Figure 3.20 on the next page, we can see the hibernation block diagram which is a main component of our project as we are looking to save as much power as possible. We can see that the hibernation module features a 32bit real time seconds counter which will allow for fine adjustments to be made while waking up the CPU. It can be powered by a discrete external regulator or the on-chip power control and has a dedicated pin for wake up.

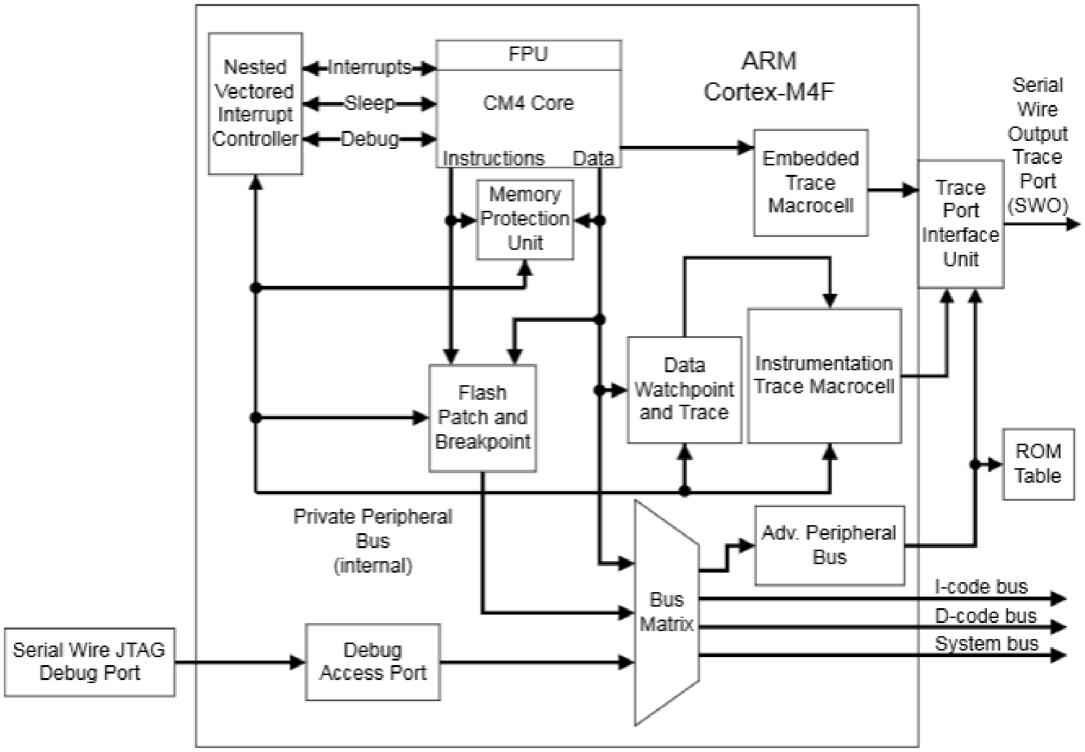

Figure 3.19 Block Diagram of Cortex-M4

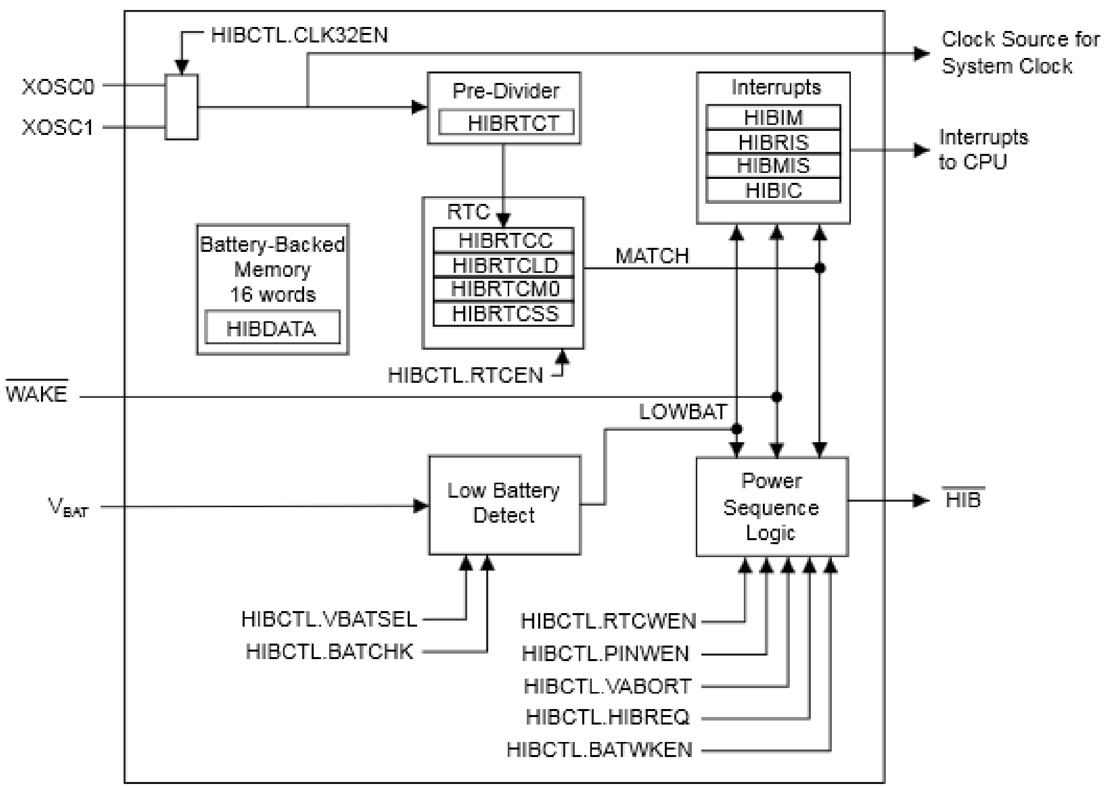

Figure 3.20 Hibernation Module Block Diagram

With this is can use a lower power battery detection signal which allows for the GPIO pins state to be retained while hibernating. With an external pin wake up we will be able to wake up the CPU when weight is detected if we decided to go with this device. This low power hibernation mode allows for battery management which will easily allow us to charge the battery while the system is in the standby mode.

In Figure 3.21 below there is a visualization of how the GPIO's will work. This allows for us to decide how we will go about determining how we will hook up the sensors to the CPU. We will be able to hook up the sensors and use the analog to digital converters to interpret the analog signal and change it to a readable digital output and incorporate it into our application to output the correct value.

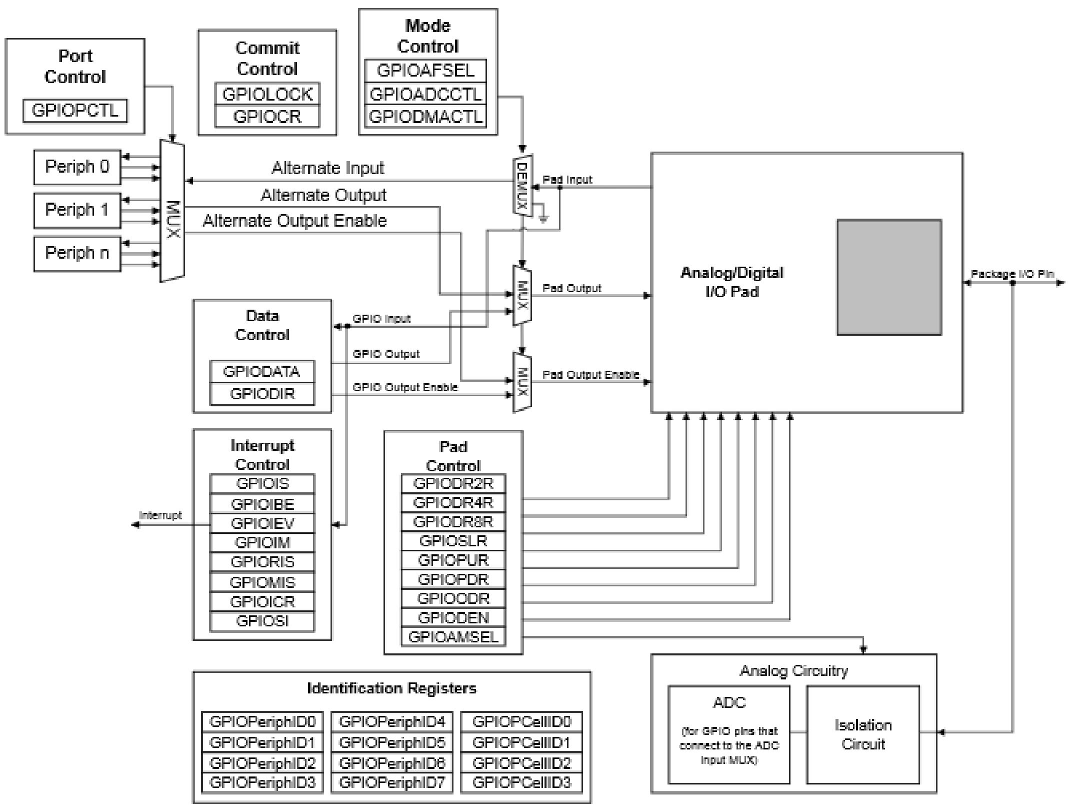

Figure 3.21 Analog/Digital Input Output Block Diagram

Figure 3.22 below, shows the pinout diagram allows us to see the exact pins of the chip. This will allow for us to see the exactly how we have to place the chip on the PCB board and which pins we will have to use to power on the CPU. We can see were we had to hook up our sensors in order to have them operate properly depending on if they are analog or digital. We can also use this to power on the device and ground the pins properly. We can also see all the pins that will have to be uses for syncing and connecting the Bluetooth adapter. With the wide variety of input and outputs to the CPU we can easily implement our project using the TM4C.

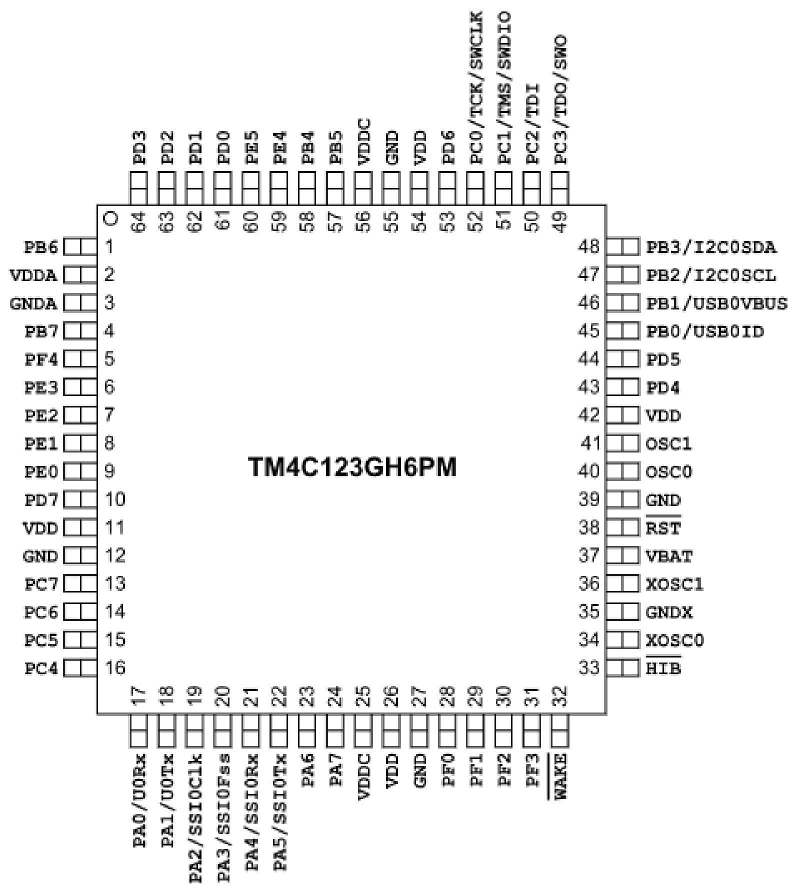

Figure 3.22 Pinout of TM4C

3.3.3.3 AtMega2560

The ATmega2560 is manufactured by Amtel and is based on the 8-bit AVR architecture. This chip contains 256KB of Memory. This Microcontroller operates at 16 mA at 16MHz and provides up to 16 MIPS. The low power state for this Microcontroller operates at 15Ua. This Microcontroller provides the standard communication protocol that we would expect to see in any modern microcontroller and also provides plenty of I/O interfaces to support our optional feature design.

In Table 3.9 on the following page, we can see all of the features that the ATmega2560 offers. This will allow for easy reference to see whether or not this chip falls within our projects scope. The table also shows us that there are plenty of Input output devices which will allow for us to connect the sensors to the CPU. It also includes enough analog to digital converters to allow for the analog signal to be converted to digital which allows for the correct conversion of the sensor which will let us display and act correctly.

CPU Features	**Details**
8-bit Timers	Two 8-bit Timers with Separate Prescaler and Compare Mode
16-bit Timers	Four 16-bit Timers with Separate Prescaler, Compare and Capture Mode
Real Time Counter with Separate Oscillator	One Real Time Counter with a Separate Oscillator
PWM Channels	Six PWM Channels
Programmable Resolution from 2-16 Bits	Twelve Programmable Resolution from 2-16 Bits
Output Compare Modulator	One Output Compare Modulator
10-bit ADC	8/16-channel
Programmable Serial USART	Two/Four Programmable Serial USART
SPI Serial Interface	Master/Slave
2-wire Serial Interface	One 2-wore Serial Interface which is Byte Oriented
Programmable Watchdog Timer with Separate On-chip Oscillator	One Programmable Watchdog Timer with Separate On-chip Oscillator
Analog Comparator	One On-chip Analog Comparator
Interrupt and Wake-up	Interrupt and Wake-up on Pin Change

Table 3.9 List of the ATmega2560 Features

In Figure 3.23 below, we can use the pinout picture to understand where we have to hook up our power, and sensors to the CPU. We can also see where we have to hook up the Bluetooth adapter and sync the clocks to. This allows for us to easily understand where on the PCB we will have to integrate the chip to implement our design without complicating the PCB board. With the pinouts known we can use this to create our PCB in a way that will be able to have quick access to JTAG and UART ports to allow us to easily program the device.

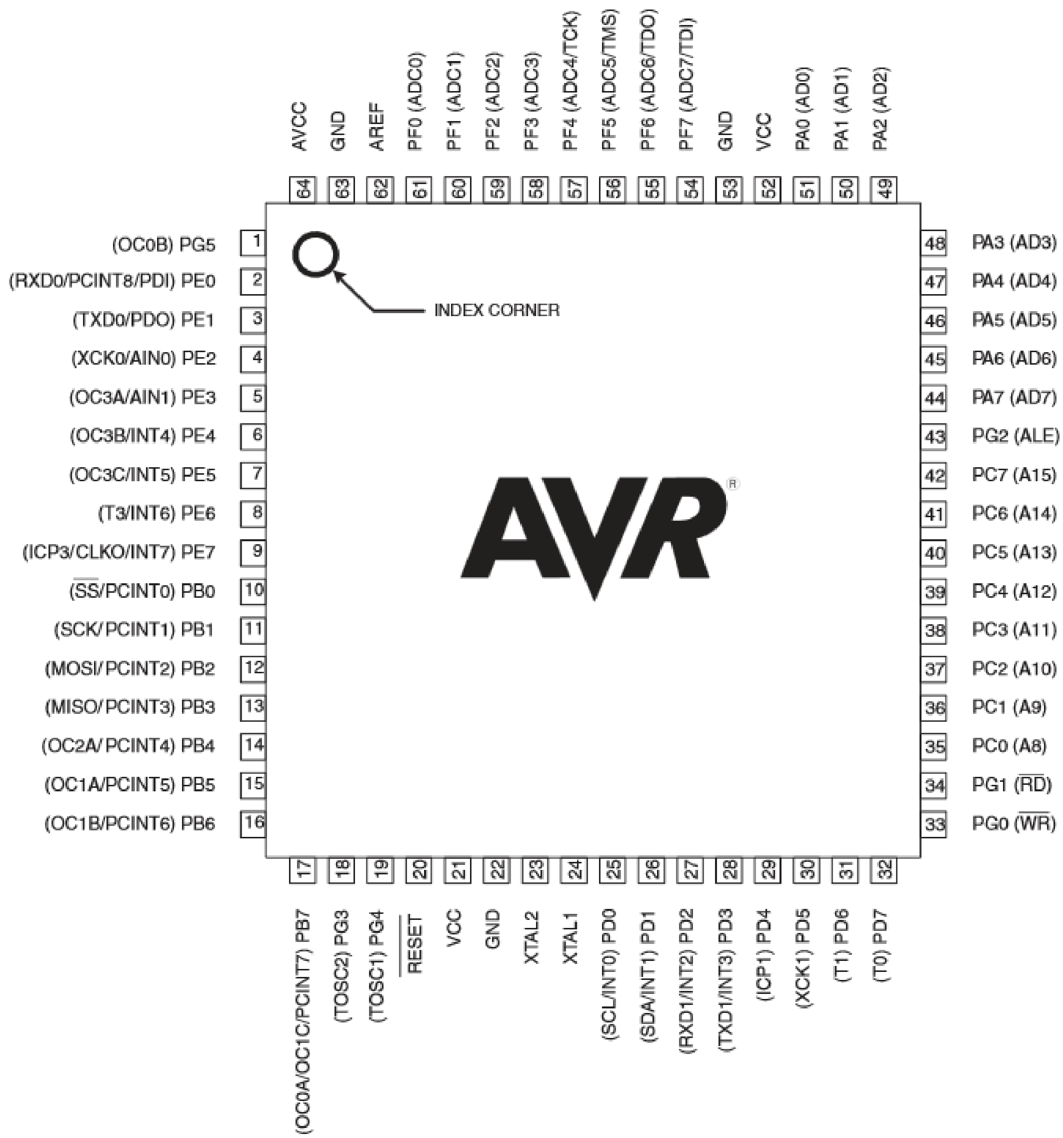

Figure 3.23 Pinout of ATmega2560

In Figure 3.24 below, the block diagram of the ATmega2560 allows us to see how we will use the CPU to calculate and design our sensor input and output display. Here we can see that the ATmega2560 is a high-performance device that allows for easy implementation of input and output while allowing for fast processing of the input data. Allowing for the device to have accurate readouts to the application and being able to act on the input data quickly. With all of this taken into consideration we will be able to decide on if this CPU will fit the needs we desire in order to implement our design with in our set of goals and requirements.

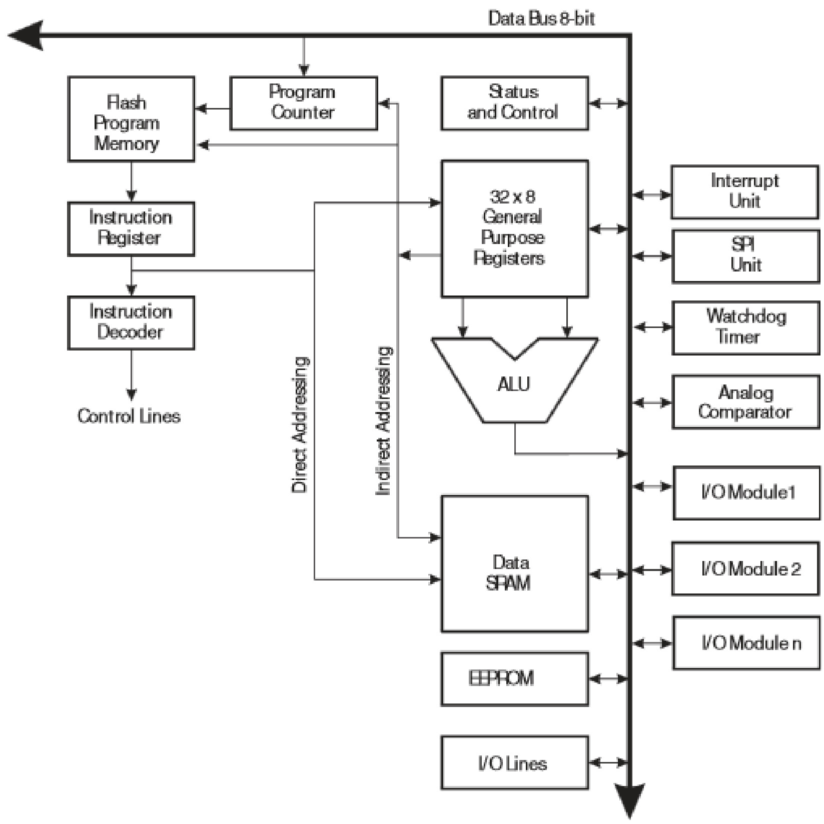

Figure 3.24 Block Diagram of the ATmega2560.

3.3.3.4 Atmel SAM3X8E ARM Cortex-M3

The Atmel SAM3X8E ARM Cortex-M3 microprocessor is different than the Atmega2560 because it has a 32-bit core and an 84 MHz CPU frequency. The microcontroller has 54 digital I/O pins. 12 of the 54 I/O pins are Pulse Width Modulated (PWM) outputs. The Atmel SAM3x8E comes with 512 KB of flash memory, 4 USARTs, and 1 UART. In Table 3.10 we can see all of the features that the Atmel SAM3X8E offers. This will allow for easy reference to see whether or not we will have a need to use this CPU. The table also shows us that there are plenty of Input output devices which will allow for us to connect the sensors to the CPU. It also includes enough analog to digital converters to allow for the analog signal to be converted to digital which allows for the correct conversion of the sensor which will let us display and act correctly.

Features	
Core	
	ARM Cortex-M3 revision 2.0 running at up to 84 MHz
	Memory Protection Unit (MPU)
	24-bit SysTick Counter
	Nested Vector Interrupt Controller
System	
	Embedded voltage regulator for single supply operation
	Power-on-Reset (POR), Brown-out Detector (BOD) and Watchdog for safe reset
	Quartz or ceramic resonator oscillators: 3 to 20 MHz main and optional low power 32.768 kHz for RTC or device clock
	Up to 17 peripheral DMA (PDC) channels and 6-channel central DMA plus dedicated DMA for High-Speed USB Mini Host/Device and Ethernet MAC
Low-power Modes	
	Sleep, Wait and Backup modes, down to 2.5 μA in Backup mode with RTC, RTT, and GPBR
I/O	
	Up to 103 I/O lines with external interrupt capability (edge or level sensitivity), debouncing, glitch filtering and on-die Series Resistor Termination
	Up to six 32-bit Parallel Input/Outputs (PIO)

Table 3.10 Features of the Atmel SAM3X8E

In Figure 3.25 the block diagram shows us how the processer is laid out and will allow for us to understand how to properly implement this into our project. Here we can see that the processor is complex and can be used for intensive need areas. This will allow for proper on the go processing and for all the sensor data and actions over Bluetooth to work properly.

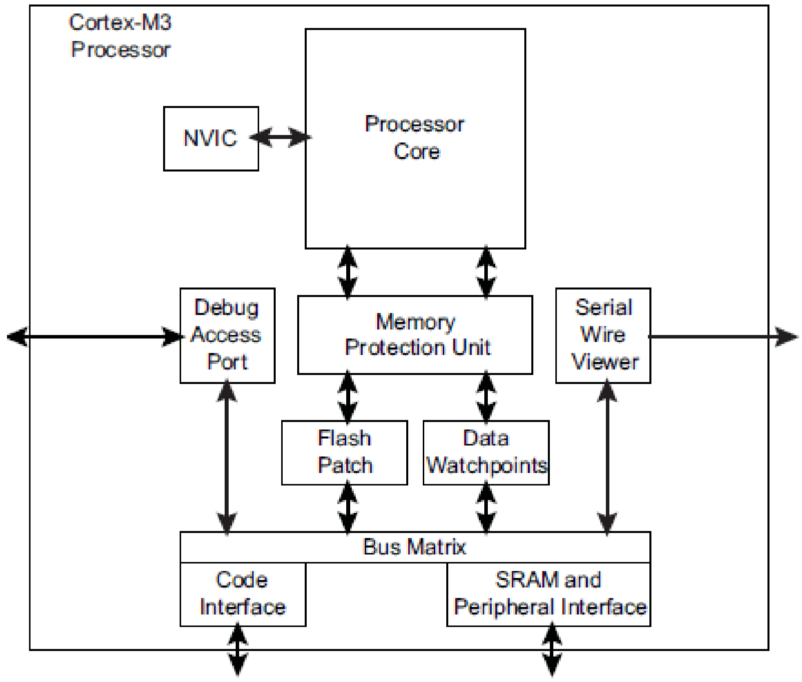

Figure 3.25 Block Diagram of AMTEL SAM3X8E

The AMTEL SAM3X8E uses -0.3 to 4.0 volts to power the device on. In this range the VDDCORE cannot exceed 2.0 volts and the VDDIO cannot exceed 4.0 volts. The microprocessor uses up to 150 mili-Amps which in our case could allow for it to be power off of a battery. This device also allow for a sleep mode which will turn the core clock off to save power when it does not need to be uses. In this state the microprocessor can use as low as .025 mili-Amps but the clock will have be running at 0.032 MHz.

In Figure 3.26 we can see the diagram of how the general purpose I/O lines integrate into the microcontroller. All of the I/O lines have this embedded On-Die Termination meaning that they consist of internal series impedance to prevent signal reflection. The internal series resistor will reduce the IO switching current and reduce its EMI.

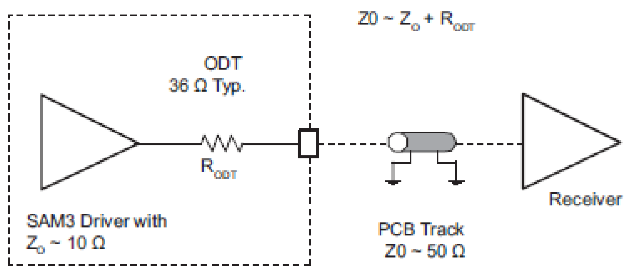

Figure 3.26 On-Die termination of input output lines.

This will call for more accurate results by decreasing overshoot and undershoot. Knowing this allow for us to be able to implement our input device with the microcontroller properly, which means that we will be able to obtain the results we want from the microcontroller without having to worry about the device outputting skewed results. This is beneficial to us because we are having the car act based on the values of out sensors. Knowing all of this will allow us to properly choose our device.

3.3.3.5 PSOC4 BLE

The PSOC4 BLE Series from Cypress Semiconductors is a Complex SOC Microcontroller. This Microcontroller is based on the Low Power ARM Cortex M0 CPU and operates at 48 MHZ while providing plenty 128KB Flash Memory. This Processor is designed for specifically for low power applications and only draws 13.4 mA and will draw as low as 150 nA in hibernation mode. This Microcontroller also provides an integrated Bluetooth communication at 2.4 GHz RF with a 50 OHM antenna drive. This Microcontroller also provides us with plenty of analog and digital I/O’s

In Table 3.10 below it shows the different available devices within the CPU that allow for the input and output devices. It also allows for using deep-sleep mode and also allowing for us to use the analog to digital converters. This devices uses and ultra-low power within deep-sleep to save on power which would be key for us with a battery and a solar charger; it also shows that there are plenty of options when it comes to documentation which allows for the provided coding program to be used with the devices. Since we have decided to use this device it will further be explained in the hardware section of the report.

Programmable Analog	**Details**
Four opamps	Reconfigurable high-drive external and high-bandwidth internal drive, comparator modes, and ADC input buffering capability; can operate in Deep-Sleep mode
1-Msps SAR ADC	1-Msps SAR ADC, 12 bit with differential and single-ended modes; Channel Sequencer with signal averaging
Two current DACs (IDACs)	General-purpose or capacitive sensing applications on any pin
Two low-power comparators	Operate in Deep-Sleep mode
Programmable Digital	**Details**
Four programmable logic blocks	Universal digital blocks, (UDBs), each with eight macrocells and datapath
Coding	Cypress-provided peripheral component library, user-defined state machines, and Verilog inputs

Table 3.11 Different between Analog and Digital Devices

3.3.3.6 NRF51822

The NRF51822 Microcontroller from Nordic Semiconductors is also Complex SOC Microcontroller and is based on the Low Power ARM Cortex M0 CPU. It operates at 16 MHZ while providing 256KB Flash Memory. This processor is designed uniquely for Low power applications while drawing 4.1 mA and even as low as 0.6 MicroA in hibernation mode. This Microcontroller also provides an integrated Bluetooth at 2.4 GHz RF with a 50 OHM antenna drive and also provides us with both analog and digital I/O’s shown in Table 3.11 below.

I/O	Features
GPIO	
	Flexible GPIO pin configuration
	31 GPIO
	Up to 4 PWM
Digital I/O	
	Digital interfaces -SPI Master/Slave, 2-wire, UART
	Quadrature decoder
Analog I/O	
	8/9/10 bit ADC - 8 configurable channels
	Low power comparator

Table 3.12 NRF51822 I/O's

In Figure 3.27 on the following page, the pinout of the NRF51822 allows us to understand where we will place the NRF51822 on our PCB. This will allow us to properly position the chip to easily integrate the sensors and power to the CPU. It will allow us to plan how to connect the sensors to the CPU and how to connect the Bluetooth antenna to the CPU. This chip has the Bluetooth integrated into the chip which allows for simple PCB design.

With the integration of the Bluetooth into the CPU we can easily just power one chip and have the clocks already synced. The 2.4 GHz radio will allow for us to be able to have the correct range with a minimum antenna design. We should be able to correctly transmit the data from the Bluetooth on the chip to the Bluetooth on the device. This also allows for the chip to be able to use less power than having to power both independently.

This chip only requires 1.8 to 3.6 volts and the current to be between .6 and 470 micro-amps. The low power will allow for the battery that will run the CPU to be able to charge with just the use of a few solar panels rather than creating more cost and room by adding more solar panels to design. With this in mind we will be able to decide on if we should use this CPU chip or not.

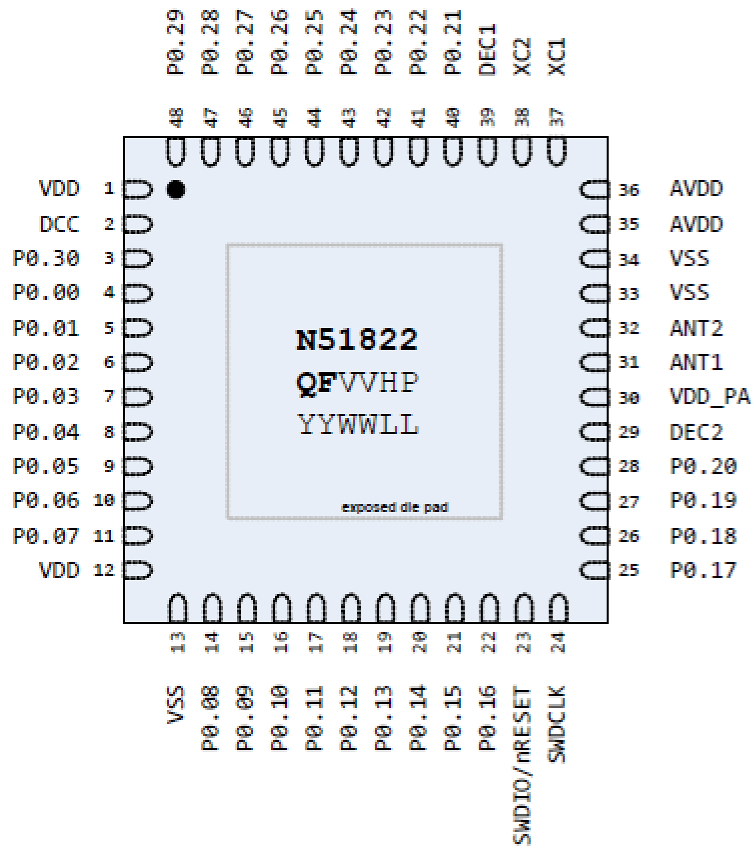

Figure 3.27 Pinout of NRF51822

3.4 Safety Triggers

This product features mainly as a safety system and thus we need to determine when this system needs to become active. There are two ranges we need to discuss and examine, the first scenario is when the temperature in the vehicle becomes two hot and the child is at risk of succumbing to heatstroke. The second scenario is when the temperature becomes too cold for the child and hypothermia sets in. The temperature range values of hot and cold need to be determined for our device to function reliably.

3.4.1 Heat

The main problem this device is needed for is heat stroke because it is the main killer for babies left in vehicles in hot weather. The determined unsafe internal body temperature for a child in 104 degrees Fahrenheit; if this temperature is reached the baby would then require immediate medical attention. Therefore the device needs to activate before such a temperature is reached.

Heatstroke is when the body cannot rid itself of heat faster than the body's temperature is raising. This occurs when someone is stuck in a heated environment, like a vehicle, with no cool airflow to allow the body to cool down. This raising of body temperature can cause fatal damages to the child's organs and even cause death.

Our goal is to stop heatstroke from progressing to deadly levels and thus during the third alarm stage if the vehicle's temperature has reached 110 degrees Fahrenheit the device's emergency state will activate. Upon activation the car will turn on and begin cooling the vehicle using the vehicle's air conditioning system. This will remain active until the child is removed from the seat and vehicle. This temperature was chosen because it takes time for the child to heat up to the vehicles car level and this value is the maximum risk we are willing to allow to ensure the survival of the child.

3.4.2 Cold

The cold temperature environment is much more difficult to calculate than heat because it is highly dependent on the other factors than just temperature. Some factors include how well the child is dressed, how old the child is, and whether or not there is a wind chill factor.

The two common cold related injuries are hypothermia and the neonatal cold syndrome. Hypothermia is the opposite of heatstroke where the person's body temperature drops at a very dangerous rate and cause damage to internal organs. Neonatal cold syndrome causes the infants vital body functions to slow down and become lethargic, which prevents the child from crying for help.

To ensure neither of these medical problems occur we are setting the third stage alarm to activate if the temperature inside the car has dropped to 50 degrees Fahrenheit. This temperature was chosen because cases of hypothermia are recorded to start when the child's internal temperature drops below 94 degrees Fahrenheit and we are assuming the child is decently clothed to mitigate some of the cold weather.

4.0 Related Standards

4.1 Bluetooth

The standard for Bluetooth is 802.15.1-2002 IEEE Standard for Telecommunications and Information Exchange between Systems which is a standard that allows for the wireless connection between short ranges. Bluetooth uses RF based connectivity for portable personal devices which will allow for the car seat to talk with the phone. This standard will include medium access control (MAC) which includes, logical link control and adaptation protocol (L2CAP), link manager protocol (LMP), Baseband, physical layer (PHY), logical link control (LLC), protocol implementation conformance statement (PICS), and specification and description language (SDL). This standard will allow for us to use the Bluetooth in our device.

4.2 JTAG

The standard for JTAG is IEEE Standard 1149.1 (JTAG) which allows for the CPU to use the test access port (TAP) which are four pins TMS, TCK, TDI, and TDO to communicate with the CPU. This allows for the pins to act as regular 1/0s and JTAG pins. The TAP controller uses 16 states which receives two control inputs TMS and TCK which generate control and clock signals for the other test logic. It also includes an instruction register which consists of five IR cells what have shift-register stage and a latch stage. This allows for the data to be shifted up toward the TDO. This standard is important because it will allow for us to program the device without incorporating a USB interface.

4.3 Java Standards

With multiple people submitting java code for the application it is required that there be a coding standard to ensure all code looks and runs as if completed by a single person. For this reason we have chosen to follow the Java coding standards from IEEE. The software quality must reflect functionality, reliability, usability, efficiency, maintainability, and portability. File structure for our source code will be used to place all our files under a single location that is easy to access and efficient for the entire group. Our architectural structure will follow a modular flow to represent a monolithic flow. Variables will be uniquely defined and only used for a single instance and then not repeated. When a function is no longer used it shall be removed completely so there are no ghost functions residing in the final installation of code. A change long will be recorded to keep track of the development of the project.

All functions shall be properly commented to completely describe the function or code section in question. Java supplies us with a single environment so our individual sections will work on everyone’s systems without any errors. This project will adopt the Java Code Conventions that will make sure all programmers are using the same style guidelines which include naming, organization, indentation, comments, declarations, statements, white space, and naming conventions.

4.4 C/C++ Standards

The coding that is to be run on the microcontroller will also need specific standards to deliver a professionally coded program. The standard template library (STL) offers the fundamental abstracts for containers, algorithms, and iterators. Incorporating the STL with C/C++ will allow our program to follow the guidelines of a standard that has grown to an internationally recommended standard. By conforming to these existing standards it will ensure that our code delivers on portability which will guarantee that no matter where the code is compiled it will provide one hundred percent success. This also included virtual machine environments where some of our testing can be competed in. While C and C++ are becoming the generic coding language we can be sure that even at higher levels of programming we do not sacrifice any efficiency with these standards.

5.0 Design

With all of the necessary research done, in the design section we will discuss the basic design of the PCB, application, and user interface, and chosen hardware. With this we will be able to implement the chosen parts to create this child seat. We will also talk about how we plan to put all of these parts together to implement a full design.

5.1 PCB

5.1.1 Requirements

We require a small compact PCB that will have the microcontroller and Bluetooth on it. Here we will have to implement a design on the board to allow us access to the programing pins of the microprocessor, supply power to the microprocessor, and transmit over Bluetooth with an antenna. Here we will also have to create the PCB so that the board fits behind the car seat in a location that will allow for the Bluetooth communication not to be blocked.

5.1.2 Hardware Configuration

For the Hardware configuration we have to take into consideration all of the components of the system. Here we will have to make sure that everything can fit onto the PCB board and still be small enough to fit on the car seat. The hardware configuration will take into consideration the placement of the microcontroller so that all the requirements above can be met and so that there is ample room for the battery to be able to sit close to the PCB. To do this we will design a PCB using Eagle to customize the location of resistor networks and microcontroller placement allows for the PCB to be to correct size.

5.2 Microcontroller

The Microcontroller that we are going to be using for this project is the PSOC4 BLE. The microcontroller is crucial for the system to work so we will have to implement the controller onto the board in such a way that the microcontroller can be the central unit in the system. This microcontroller allows us to implement the needed features on a small PCB. The reason that we chose to use the PSOC4 BLE is that it allowed us to use super low power allowing for the battery to last longer and for the solar panels to have less work when charging the batter.

Another huge benefit of using the PSOC4 BLE is that it has a Bluetooth chip embedded, allowing for us to keep the PCB small. The PSOC4 BLE uses an Arm M0 processor which allows us to gain experience in using Arm devices. We will learn how to embed the chip onto a PCB board and how to program the Arm chip. This is a plus because experience in arm processers will be very useful in the workplace.

In Figure 5.1 below, we can see a block diagram layout of the processor. This allows us to easily visualize the components of the processers that we will need. In this figure we can see that we have multiple different power modes allowing for us to be able to design our safety child car seat with using the least amount of power as possible.

We can also see that the Bluetooth subsystem is built in, but will go in more details on this in the Bluetooth section. We can also see that all 36 of the GPIO's are connected to a high speed bus meaning that we can select anyone of the GPIO pins when implementing this chip which is helpful when we design the PCB board. The CPU allows the user to set what each GPIO does while programing.

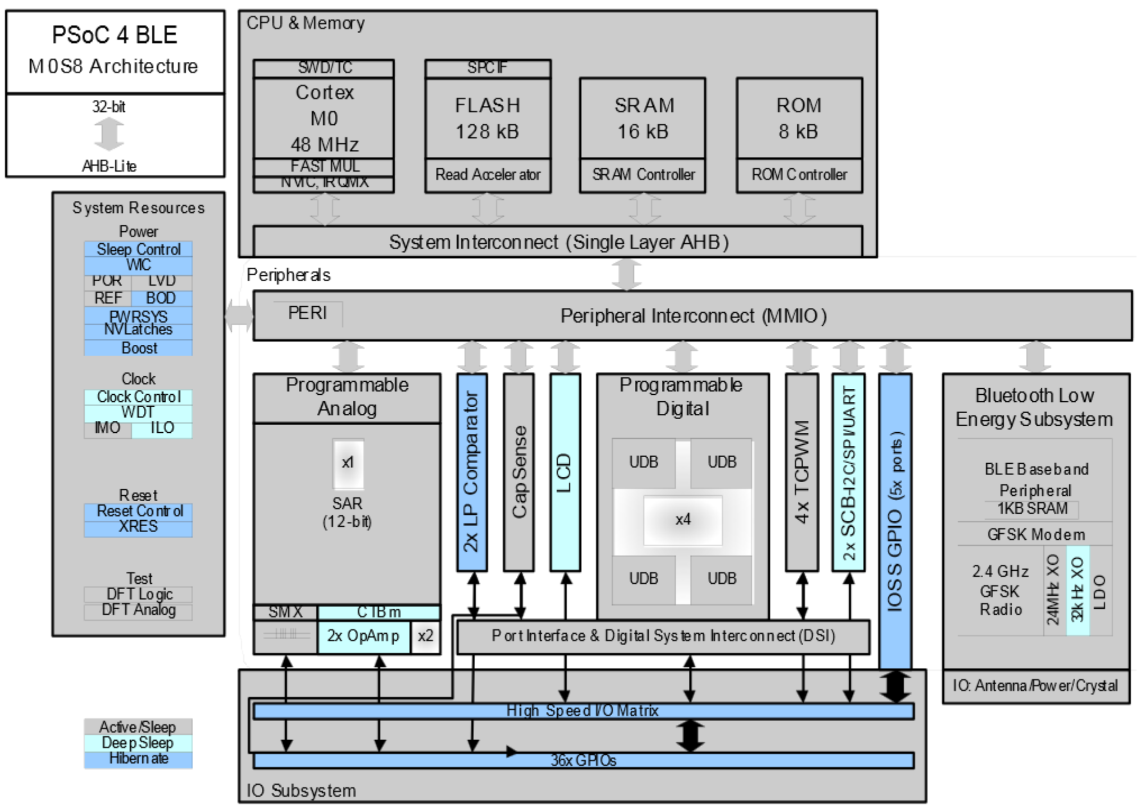

Figure 5.1 Block Diagram of the PSOC4 BLE

The PSOC4 BLE will take in our sensor data and process the results and output them to the application. It has 48 MHZ and 128KB of flash memory which is plenty of speed and memory for our application. With this we will be able to collect the sensor data quickly and then reliably and quickly process the data and output the results to the application. We need to use inputs in order to collect the data for the sensors. To implement this into our design we will have to look at the schematic Figure 5.2 below.

In this figure we can see all the pinouts offered by the PSOC4 BLE. Here we will use this when we create the PCB board by implementing the schematic correctly allows us to embed this processor on to PCB when we create it we will be able to design the board in such a way that we can use any GPIO pin allowing for easy organization of the PCB board. Using any GPIO pin we can connect the temperature sensor and load sensor because the PSOC4 BLE lets us define the GPIO pin this will also allow us to use the analog to digital converters inside that way we can read the values of the analog devices as digital readouts.

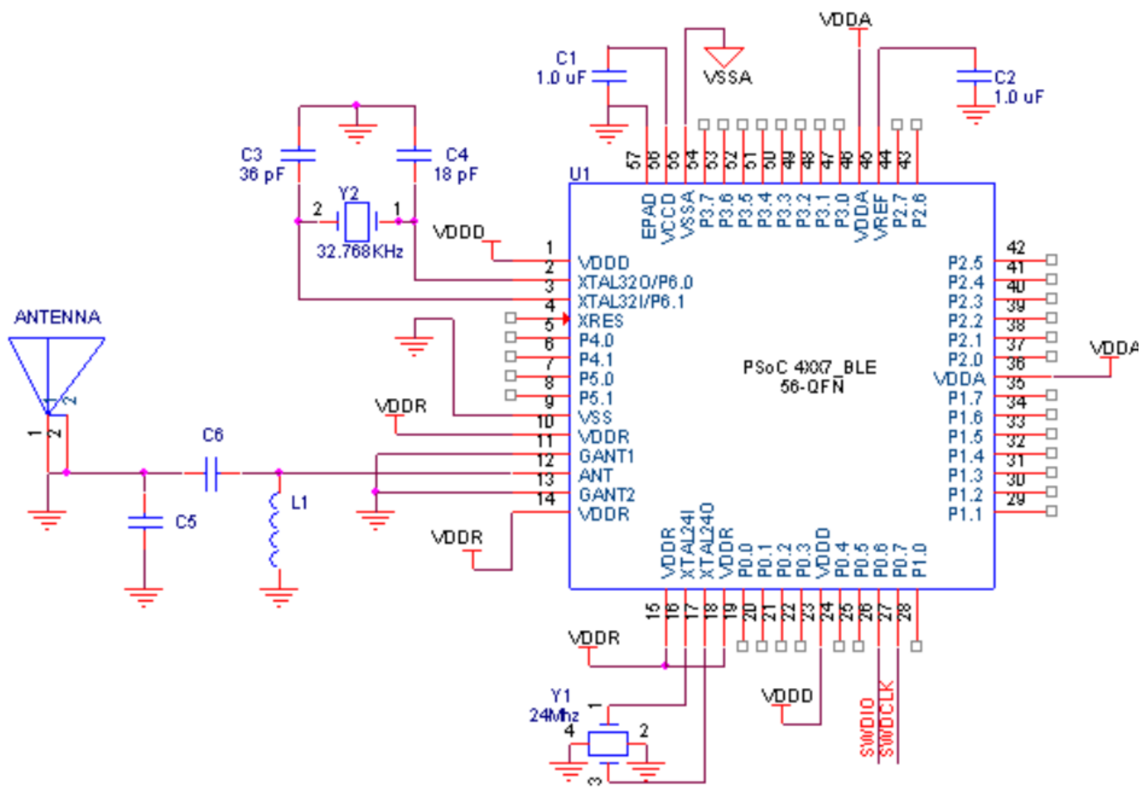

Figure 5.2 Pin Layout for the PSOC4 BLE

For using the analog and digital Figure 5.3 shows us how the Clock is implemented in the PSOC 4 BLE. This design uses an internal main oscillator, internal low speed oscillator, 24-Mhz external crystal oscillator, and a 32-kHz watch crystal oscillator. With these clocks the PSOC4 allows for all subsystems to be able to switch between different clock sources without causing glitches. The standard clock rate in the internal main oscillator is 24-Mhz which can be changed between 3-MHz and 48-Mhz in increments of 1-MHz.

This allows for a wide variety of options when we implement the reading of data. If we do not need to use the full clock speed we can save on power allowing for us to use less of the battery, which will make it easier for the solar panel to keep the battery charged. The analog clock leads the digital clock which will let us get data from the sensors before the digital clock cycle takes place.

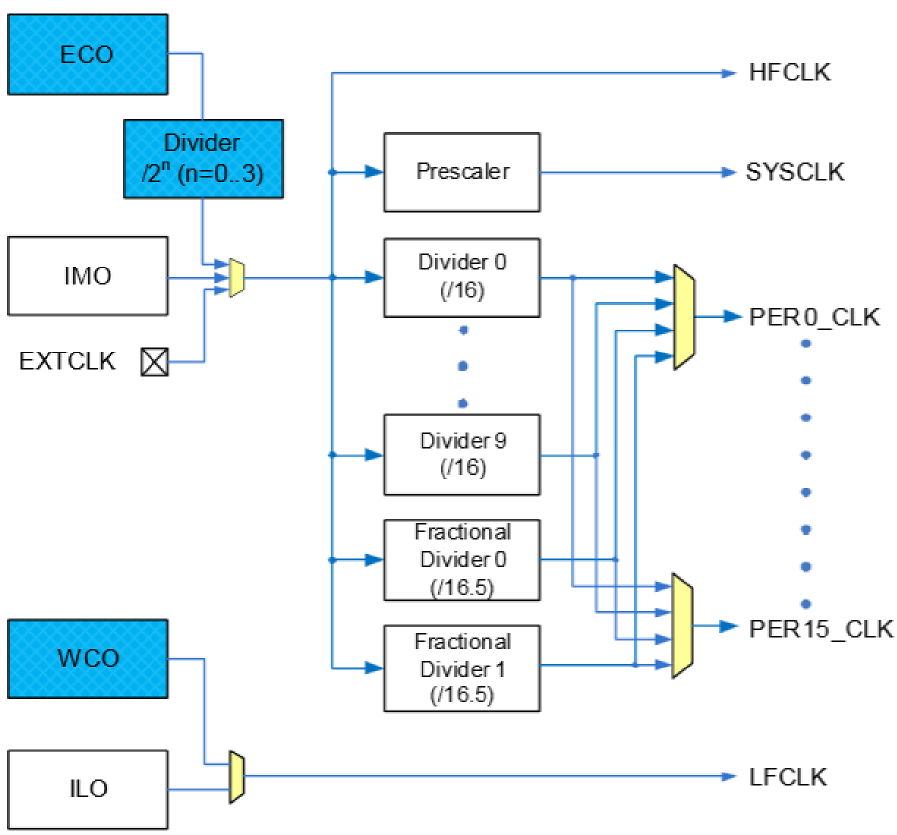

Figure 5.3 Clocking Architecture

For analog to digital we will have to use the successive approximation analog to digital converter which is an analog to digital converter that takes continuous analog wave and converts it into a digital representation by using a binary search through all possible quantization levels before finally coming to conclusion where there is a digital output for each conversion. The successive approximation analog to digital converter can be seen below in Figure 5.4 is a block diagram representation of how the successive approximation analog to digital converter works. Using this device will allow us to be able to accurately convert our analog signals from our sensors to digital accurately. The POSC4 BLE also has four op-amps which allow for these analog to digital conversions to be done on the chip rather than having to implement a circuit for these on the PCB board. This is helpful because it allows us to keep our circuit board design as small as possible. Table 5.1 below shows how to implement the bypass capacitors on the required pins.

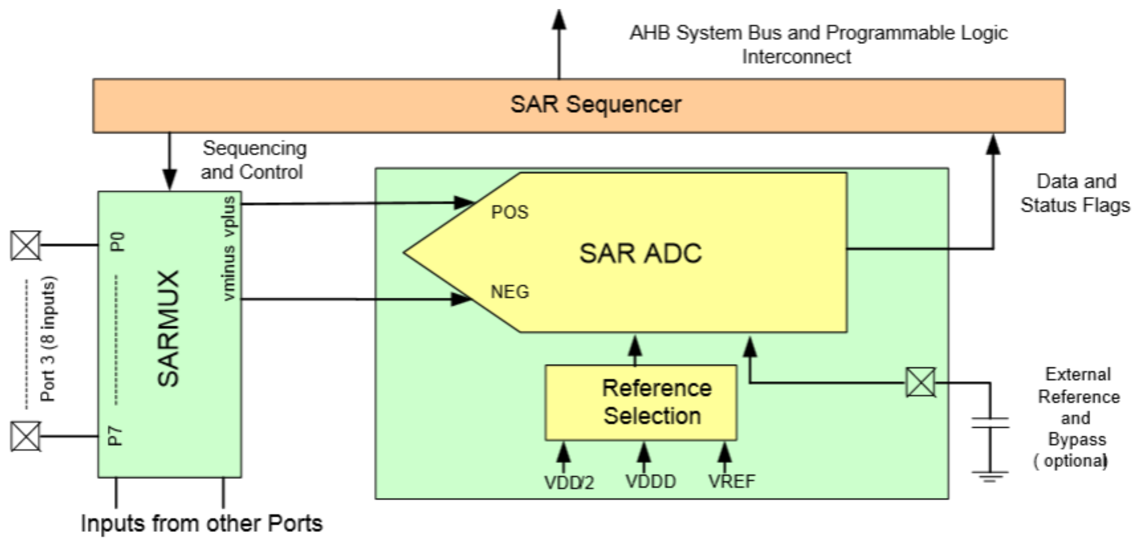

Figure 5.4 Successive Approximation A/D Converter Block Diagram

Power Supply	Bypass Capacitors
VDDD	0.1-µF ceramic at each pin plus bulk capacitor 1 µF to 10 µF.
VDDA	0.1-µF ceramic at each pin plus bulk capacitor 1 µF to 10 µF.
VDDR	0.1-µF ceramic at each pin plus bulk capacitor 1 µF to 10 µF.
VCCD	1-µF ceramic capacitor at the VCCD pin.
VREF (optional)	The internal bandgap may be bypassed with a 1-µF to 10µF capacitor.

Table 5.1 Power Supply Bypass Capacitors

The PSOC 4 BLE can have its voltage input be supplied from a range of 1.9V to 5.5V and connecting this directly to the digital supply (VDDD), analog supply (VDDA), and radio supply (VDDR) pins. This device has internal LDOs which allow the device to regulate the supply voltage for the correct blocks. The PSOC 4 BLE also has separate regulators for the deep-sleep and hibernation modes which allow it to consume less power. The radio turns off at 1.9V but the device is able to continue working as low as 1.71 V without the RF enabled. In Table 5.1 we can see the different allowed values for each voltage supply points bypass capacitor. These are necessary to remove noise from the voltage line to the device.

5.3 Bluetooth

Since we chose the PSOC 4 BLE microcontroller we are able to use the embedded Bluetooth chip on this device this helps us to implement our design by reducing the amount of hardware on the PCB board and lets us easily use the Bluetooth stack that comes with chip. It is also good from a production standpoint as the manufacturer will only have to purchase one chip that has both devices on it allowing for the overall design to save on production cost. The implantation of the Bluetooth will be relatively easy as all we have to do is build and antenna for the Bluetooth radio and connect it to the correct pins in Figure 5.2 above.

To understand how to design the antenna I will briefly discuss the theory of building one. The antenna is one of the most important parts of the Bluetooth radio. The design of the antenna can cause the Bluetooth to operate at different ranges, so in order to get a good short range antenna we have to apply some antenna theory. The antenna is an exposed conductor and if the length of the conductor reaches a certain resonance the electrical energy from the antenna will radiate into free space. The most important part of this diagram is to note the length and Antenna Feed are the most important part for the antenna design.

Which is a great way to go about implementing an antenna but for PCB there is a better way of creating an antenna called the quarter wave antenna, which uses a $\lambda/4$ as the length of the wire and a copper ground plane. We will have to determine important things to consider when designing this are the antenna length, antenna feed, and the shape and size of the ground plane and return path. We have decided to use a chip antenna that will allow for us to implement our design while using the least amount of PCBs room. This will allow for the device to have a well build antenna and for us to be able to create a small PCB board. The small chip antennas have many applications because of their size. As recommended by the Cypress documentation we will being using the Johanson Technology 2450AT18B100E chip antenna, which is the exact part we will implement.

5.4 Hardware Block Diagram

One of the design factors that must be considered is the kind of power supply that must be used to power the Nome's baby car seat. There were numerous ways to power the device, since the device is in initially in a sleep state and consumes a minimal amount of power when in operation from the device being turned on. In the case of this project the micro controller unit is the main device being powered and the two systems of the temperature sensor and Bluetooth adapter will be powered off of the board. The block diagram shown below in Figure 5.5 is the basic layout of the hardware design that will be used for Nome's baby car seat. The power supply consists of a 3.3V battery, charge controller to regulate power and a solar panel that will trickle charge the battery in a time span of 6 hours when exposed to sunlight. The power supply will generate power to a micro controller unit that is inside the wedge housing with the printed circuit board, temperature sensor and other electronic components. The micro controller will initially be in a sleep state and then will be operational when a pressure sensor is activated within the car seat itself. When the car seat is operational the car seat is within communication with car through the OBD link and is in direct communication with the user through a phone application via Bluetooth.

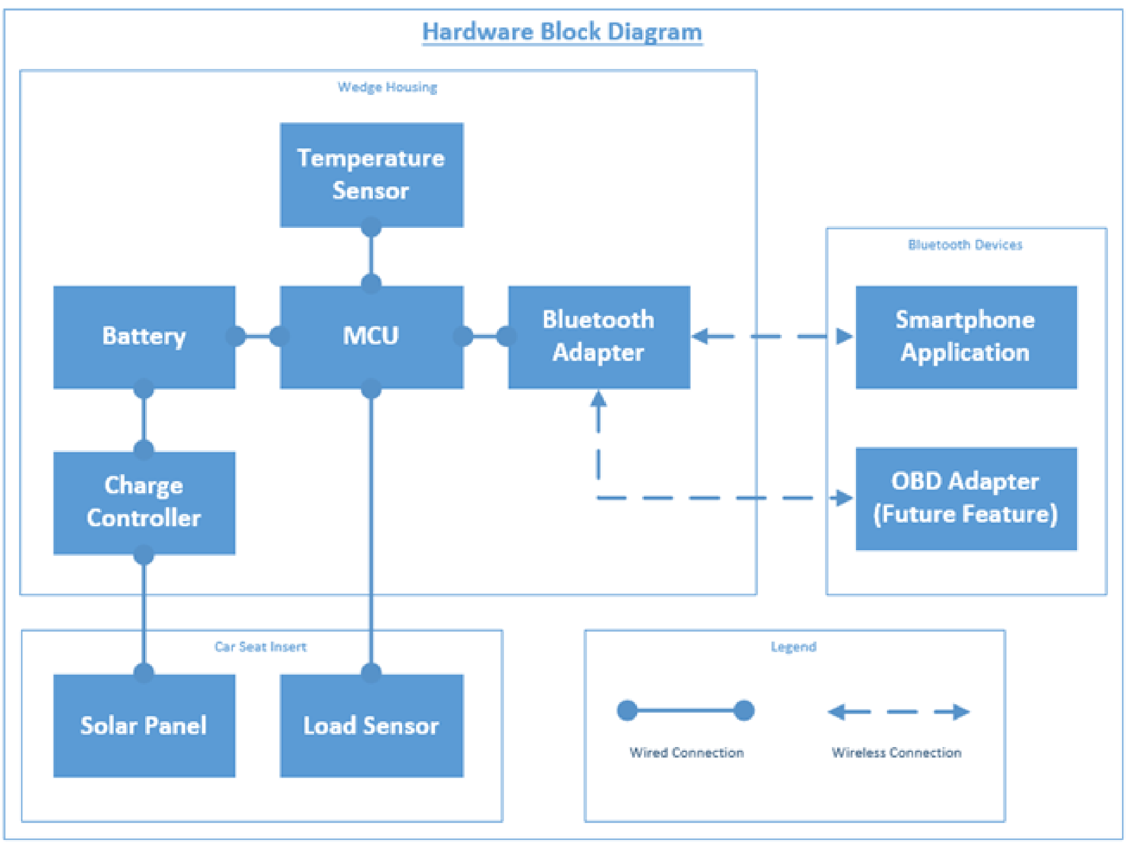

Figure 5.5 Hardware Block Diagram

5.5 Hardware Subsystems

Each subsystem in this section consists of parts that are currently ordered so that they match the specifications and requirements set by the team. The objective that the device fulfills is stated, and then the function and design of the parts shown.

5.5.1 Temperature Sensor

The temperature sensor allows the Nome's baby car seat to have knowledge about how high or low the ambient temperature in the car is in order to activate preemptive measures such as activated the car and notifying the parent through the application to save the child's life. The information of knowing the ambient temperature is crucial because it will determine the activation of the subsystems of the project to save a child's life. The main conditions that this subsystem needs to accomplish are listed in Table 5.2 below.

Condition	Details
1	Measure the ambient temperature of the car
2	Send the information of the ambient temperature sensor voltage to the micro controller
3	Be able to measure the ambient temperature within the car to an acceptable accuracy within 3% error.

Table 5.2 Temperature Sensor Conditions

Table 5.3 below shows the specifications for which the temperature sensor must maintain while in operation.

Specification	Value
Measurement	Temperature (°C)
Accuracy	± 3°C
Total Lifespan	5 years
Max Operating Voltage	5 V
Max Operating Current	10 mA
Temperature Range	0°C- 40°C

Table 5.3 Specifications for Temperature Sensor

Table 5.4 below shows an itemized list of the part to be used in the baby car seat with power subsystem. The temperature sensor that has been chosen is built by Texas Instruments and the temperature sensor chosen reaches a temperature range of -40°C to +125°C and has a temperature accuracy of ±.5°C which is in are required specifications for this project. Cost was an important factor also when choosing this temperature sensor since the group wants to make sure the project is within a $300 build cost.

Part	**Description**	**Cost**
Texas Instruments TMP112	The TMP112 device is a digital temperature sensor ideal for NTC/PTC thermistor replacement where high accuracy is required. The device offers an accuracy of ±0.5°C	$1.79

Table 5.4 Temperature Sensor Itemized

5.5.2 Solar Panel

There were many considerations that were taken into account when choosing the solar panel design and they are listed in Table 5.5 below. These conditions were considered for the power subsystem for the Nome's baby car seat.

Design Conditions:

Condition	**Details**
1	Power output in Watts to charge battery in 12 hour time
2	Compact Size to fit the wedge housing
3	Cost effective
4	Be able to sufficiently charge even when in indirect sunlight.

Table 5.5 Solar Panel Conditions

In this project the solar panel has become an important part of the project because it is charging the lithium ion 3.3V battery that is powering the micro-controller unit which is controlling all other subsystems in the project. The solar panel chosen was matched correctly with the battery that is used to power the system which is 3.3V and 1750 mAh in our project. The solar panel must be at least 1 Watt to be able to fully charge the battery in the time frame allocated of 12 hours.

After looking through a couple of solar panels the group has found one that is flexible and gives a charge time to the battery of 6 hours. The solar panel must produce enough power to keep the battery from discharging below the 50% capacity because this will shorten the life of the battery. The solar panel is waterproof also by having epoxy on the back contacts which will help and account for spills of liquids. The dimensions of the solar panel are 3in by 5in and can fit safely between the arm and wedge housing on the car seat. The solar panel will be able to fully charge the lithium ion battery during the day and is a 3.3V and 1750 mAh battery.

The solar panel will be mounted to the side of the baby car seat using epoxy adhesives since it will hold up against extreme heat conditions and will protect and make the solar panel waterproof. The solar panel must have the back contacts covered in this epoxy to withstand rigorous conditions that might occur from the child or extraneous conditions such as rain. Solar panels are mounted in a similar way to withstand liquid problems.

The main objective is to get the solar panel in a position on the car seat so that it receives the maximum amount of sunlight while the car seat is docked in the base. The solar panels will be placed under the armrest of the car seat to ensure they are out of contact with the child and to receive the maximum amount of sunlight to charge the battery. There are many epoxy adhesives that are on the market that could be used to secure the solar panel onto the car seat. In order to also angle the solar panels at a 45° angle to induce the maximum amount of sunlight a plastic resin base is created in order to angle the solar panel at the right angle.

The solar panel is connected into the power subsystem which is the solar panel, battery and charge controller used to power the system of the device. The main objective that must be achieved for the solar panel is to provide enough solar energy to trickle charge the battery so that the device can run in a continuous matter without having the battery drain and the system become inoperable. This requires that the solar panel to be large enough to fully charge the battery in the 12 hour period of sunlight time and the battery must have a large enough capacity to keep the device powered. This was ensured by the choices in battery and the fact that the system draws energy in the nano watt range.

5.5.3 Charge Controller

The design conditions for the charge controller under consideration are listed in Table 5.6 below. The group took into account these conditions when choosing a design for the charge controller.

Design Conditions:

Condition	Details
1	State of charge management
2	Efficiency
3	Voltage and Current Regulation
4	Maximum Power Transfer

Table 5.6 Charge Controller Conditions

In this project the charge controller is a vital part of the power system because it will be used to make sure the battle does not overcharge and manages that the battery does not fall below the 20% threshold. The charge controller is located in between the solar panel and the battery and is attached into the wedge housing. The charge controller will communicate with the state of charge of the battery in order to change the state of the charge controller to keep the battery from overcharging.

In the first stage which is a DC/DC converter stage which is required to change the power from the solar panel to the load. This stage is used in the charge controller circuit to decrease or increase the voltage for the power coming from the solar panel into the battery based on the state of charge of the battery if it is at the point of being overcharged or close to the lower threshold of needing a charge. The objective for the DC/DC stage is to change the voltage level coming into the circuit to a different value. The charge controller from Texas Instruments will be implemented on the micro controller which will be able to read the state of charge of the battery and accurately produce the correct response of lowering or increasing the voltage coming from the solar panel to the batter itself. This will be done reading inputs into the micro controller from the charge controller circuit when it is connected to the battery. On the next page Figure 5.6 is an example of the operational flow chart that will be used to perform the charge reaction between the battery, solar panel and charge controller.

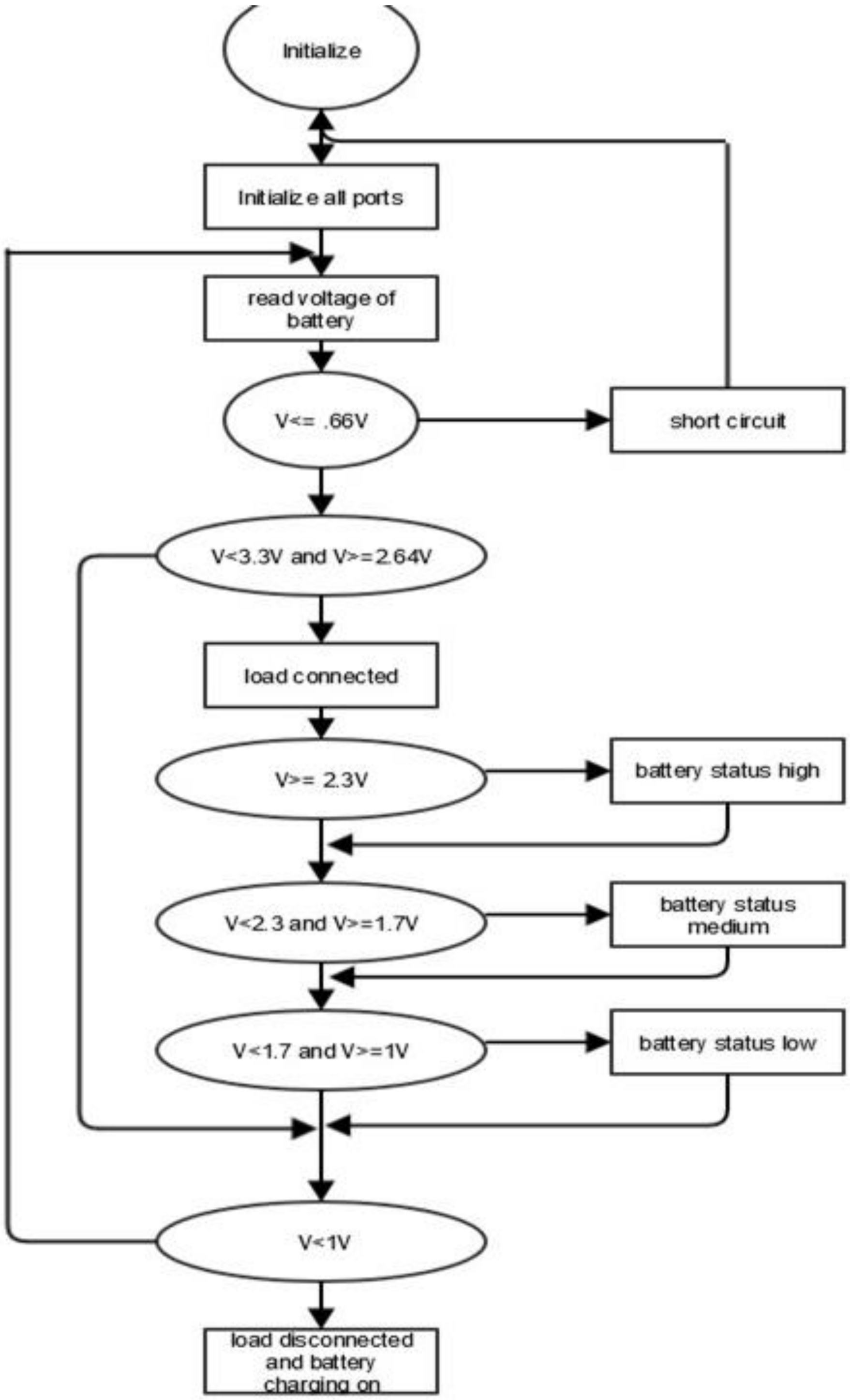

Figure 5.6 Operational Flowchart for Charge Controller

The micro controller will be able to evaluate the solar panel and battery voltages during the initialization of the device the idea breakdown of the process presented below in the flow chart can be summarized in Table 5.7 below.

Voltage	Description
<= .66V	The micro controller will determine the system is in a short circuit condition and the load is disconnected immediately to begin charging of the battery via the solar panel.
<1V	The micro controller turns on the battery charging and the load is disconnected until a charge of 2.3 V is reached to extend the batteries life cycle.
> 3.3V	The battery is now in the overcharging state and the micro controller will turn off the battery charging between the solar panel and battery via the charge controller.
>= 2.3V	The battery is above the 80% threshold of charge capacity and will charge slowly until the optimal 3.3V is reached or comes close to it.

Table 5.7 Charge Controller Operation Description

5.5.3 Battery

Under consideration for the design conditions for the battery are in Table 5.8 below. These conditions were taken into account when the group was choosing a battery design for the Nome's baby car seat.

Design Conditions:

Condition	Details
1	Battery Capacity in Units of Ah or Wh must meet at least a 2V minimum to power the entire system.
2	Nominal Voltage Rating
3	Product must not be too costly as to remain under the $300 budget limit of construction
4	Small loss in charge with high energy density

Table 5.8 Battery Design Conditions

The battery is also a key component in the power subsystem that is created for the project because it will be the main power source for the Nome's car seat during daylight hours and times of no sunlight. A lithium ion battery was chosen for this project because we wanted the capability of a rechargeable battery with a small loss in charge over time. The battery will not need a high capacity do to the low powered nature of the system.

The battery will provide the power for the entire system as well as be charged via a solar panel. Another complication that needed to be overcome was portability of the device so the choice of a lead acid battery was excluded since they are heavier than other forms of batteries. The size of the battery was also a factor since the battery must fit into the wedge housing of the car seat and must not overburden and add to the weight of the car seat. The OEM Samsung EB-L1F2HVU meets all specifications that were set by the group and is a 3.3V battery with a 1750mAh capacity. The battery will meet the requirements for use in the power system for the baby car seat.

The charge controller will be placed in the circuit along with the micro controller to prevent overcharging of the battery. The battery, solar panel and the charge controller system only have to accomplish the goal of preventing overcharging and to maintain the battery life to support the system and to make sure the system does not fail. The lithium ion battery is physically mounted inside the wedge housing with the hardware components and will be encased in a plastic resin mounting to protect it from water damage. It will be accessible if replacement has to occur for the battery and overall the area in which the battery is located is in a compact area. On the following page is Figure 5.7 which is a drawing of the battery that displays its size.

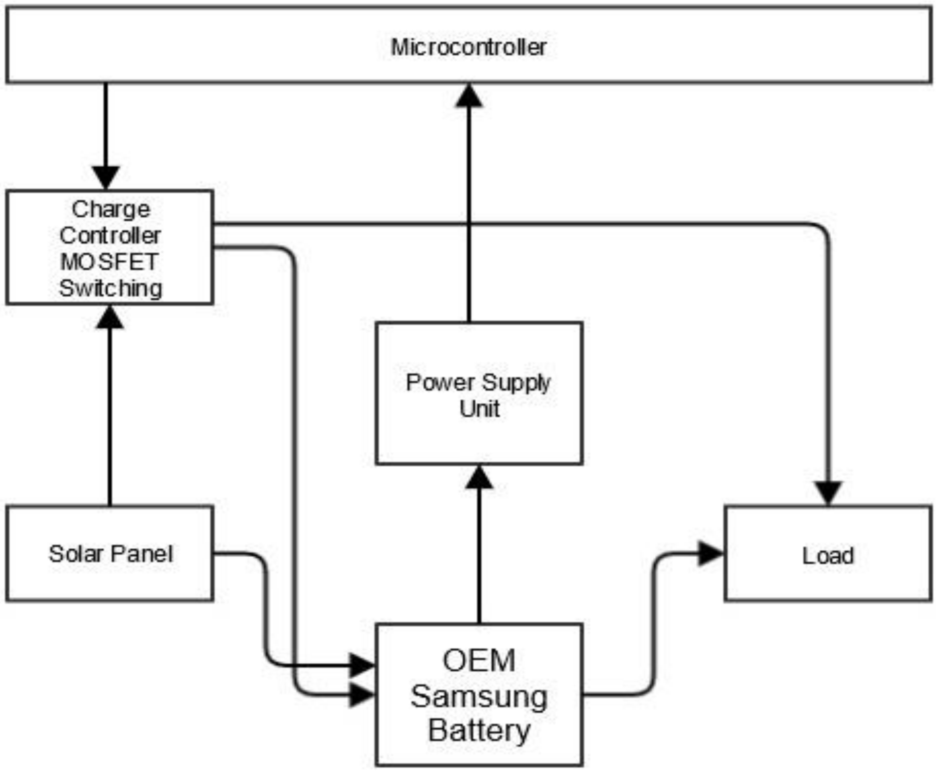

Figure 5.7 Part Connection

5.5.4 Load Sensor

There were many considerations that were taken into account when choosing the load sensor design and they are listed in Table 5.9 below. These conditions were considered for the power subsystem for the Nome's baby car seat.

Design Conditions:

Condition	Details
1	Be able to sense weights from 0- 20 lbs
2	Compact and flexible Size to fit the seat lining
3	Cost effective

Table 5.9 Load Sensor Conditions

The weight sensor is the starting mechanism for the entire system to come out of a hibernation state. When the presence of any weight is felt in the car seat by the load sensor the load sensor will communicate with the micro controller to activate the system and link with the car as well as the application placed on the phone. For this project the load sensor needed to be flexible to fit the lining of the car seat as well as be shaped to the shape of the seat to cover as much area as possible for when a child is placed in the seat.

The Flexiforce 25lb load sensor made by Tekscan fit all of our requirements but has the only drawback of not having a large area sensor pad to cover the seat. This problem was promptly solved by ordering more of the sensors since they are relatively inexpensive. The Flexiforce sensor will be behind a washable cushion that is a part of the seat. The diagram for the Flexiforce sensor is in figure.

5.6 Software

The software section covers the state diagram, block diagram, application user interface designs, and class diagrams for both the microcontroller and application.

5.6.1 Microcontroller State Machine Diagram

Figure 5.8 below represents the microcontroller's states of operation and the flow of the how the device will function depending on the applied inputs.

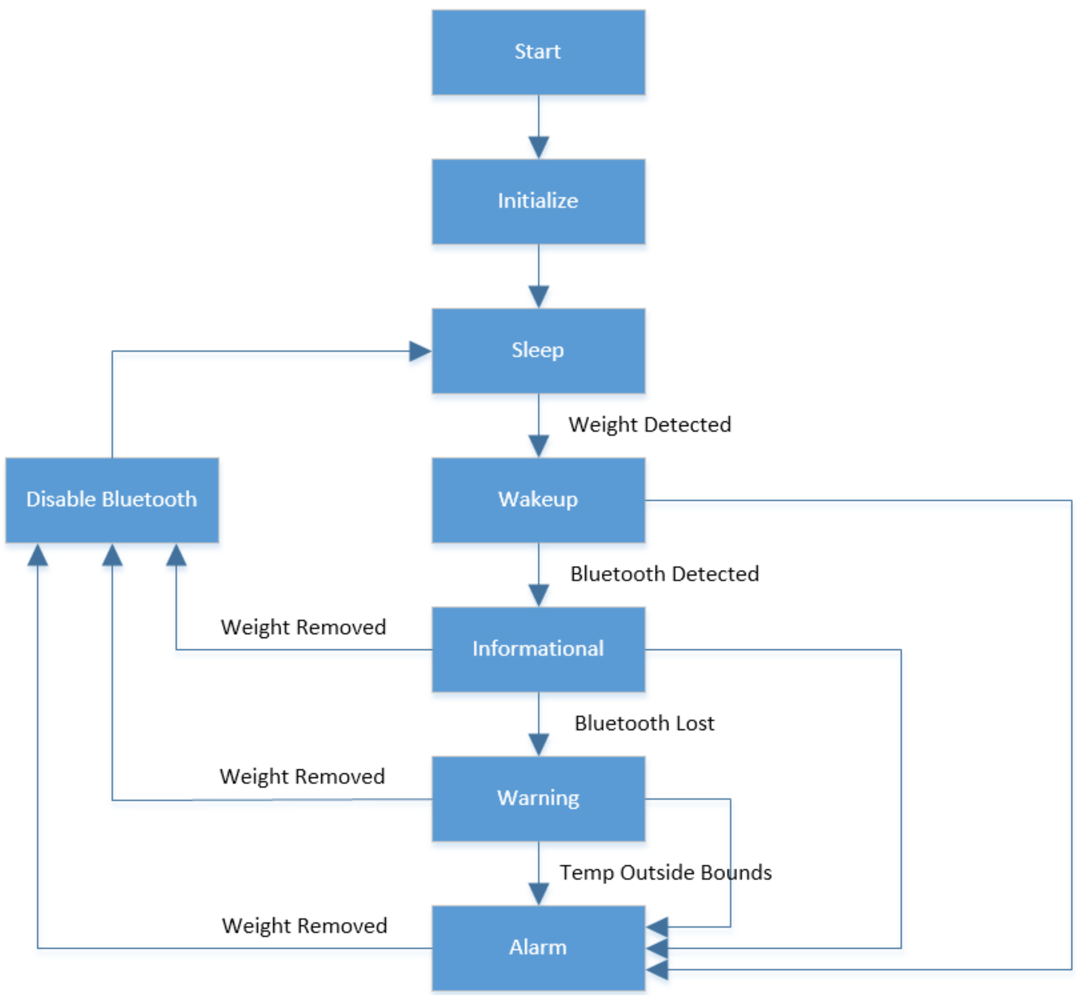

Figure 5.8 Microcontroller State Machine Diagram

5.6.1.1 Initialization State

When the device is powered on this is the first state that occurs. In this state the microcontroller will initialize its system and make any configurations necessary then begin to listen for the weight sensor. Once it has finished all initializations, it will continue to the Sleep state.

5.6.1.2 Sleep State

The device will spend most of its time in this state awaiting a signal from either the operation or the weight sensor. In this state the microcontroller will stop most processing and wait for the weight sensor to reach a specified limit indicating that a child has been placed into the seat. During this state the microcontroller should be using the minimum quantity of power.

5.6.1.3 Wakeup State

This state is used to initialize the Bluetooth controller and attempt to connect to a Bluetooth device that is assumed to be near the parent (typically a phone). There are two ways to exit this state, either the Bluetooth device is connected or the temperature reaches a point outside of the desired range. The second condition is set to allow the parent to forget their phone in the car without preventing the system from reacting to the extreme temperatures.

5.6.1.4 Informational State

This state is used to inform the parent that the child is in the car. No alarms are being set off and the system will attempt to lower its power usage since no processing needs to be done besides the occasional Bluetooth ping. The application owner may also request the current temperature values inside the car through the application. When this request is made the device will ping the app with very little information only containing the temperature value.

5.6.1.5 Warning State

This state is initiated when the Bluetooth device is lost. When this condition is met, it is assumed that the parent has left their child in the car. The microcontroller itself will not do anything except attempt to reconnect to the Bluetooth device and monitor the weight sensor. During this state the application will be warning the operator that they have left their child inside the vehicle. A prolonged duration in this state will cause the Alarm state to trigger in attempt to save the child.

5.6.1.6 Alarm State

This is a state that is triggered when the child has been left in a car for so long that the temperature becomes unsafe. During this state the microcontroller will attempt to make use of any systems it can to remediate the problem (cool down the car) or alert anyone it can (sound the car horn and make use of a GSM radio to send text messages and/or make phone calls). These capabilities are tied to features that will not be in the base model. This is for future expansion.

5.6.1.7 Disable Bluetooth State

This state is used to disable the Bluetooth adapter to save power when the child is removed. It is assumed that when there is no weight, the child has been removed. This state causes the other state to cease such as the warning and alarm states. This state then refers back to the sleep state where the device will await for use.

5.6.2 Microcontroller Software Block Diagram

The software block diagram for the microcontroller is shown in Figure 5.9 and represents the specific events which will trigger the states in sequence. This also displays the overall triggers in which the microcontroller will contact the application.

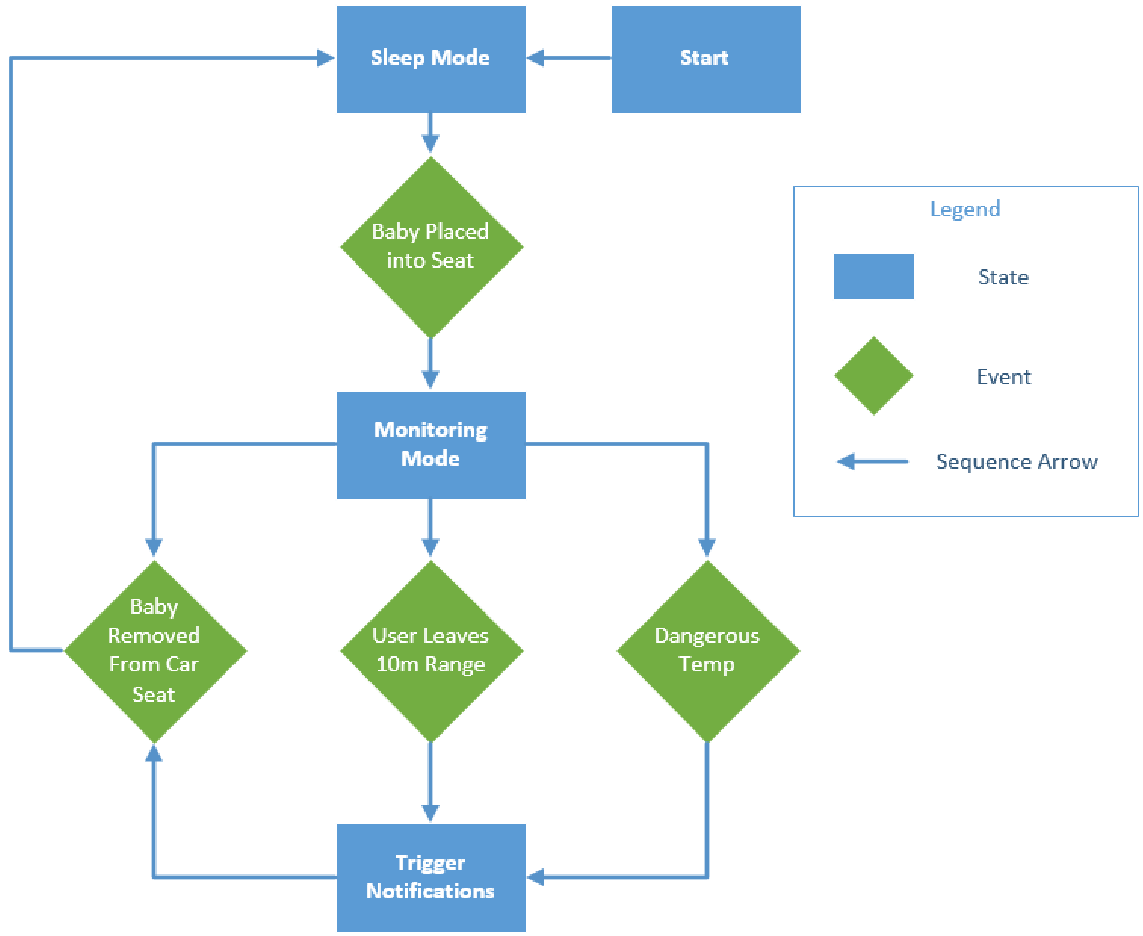

Figure 5.9 Microcontroller Software Block Diagram

The device starts by initializing the sensors and verifying functionality, afterward the device enters the sleep state where it waits for the parent or guardian to place a child inside the car seat. When a child is placed inside the device enters the monitoring mode where it looks for three events. If the baby is removed from the car seat then the device returns to sleep mode. For instances where the temperature becomes dangerous or the application operator leaves the range of the device without taking their child then the device will start to trigger notifications and alarms to the application. For the notifications and alarms to cease the child must be removed from the car seat, then the device will return to sleep mode.

5.6.3 Application User Interface Design

This section is about the organization and design of the applications user interface. Each screen of the application will be shown and described in detail. The diagrams in this section all follow the same format so please refer to Figure 5.10 below to better understand what each symbol means for the application design.

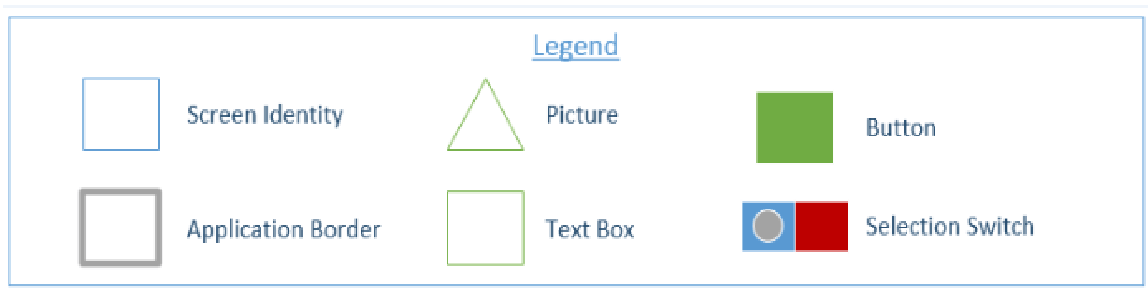

Figure 5.10 Legend for Application User Interface

5.6.3.1 Application Icon

All applications require an icon on the smartphones application menus. The icons can be seen in Figure 5.11 below. Our team decided to go with a simple design of the team's logo with a simple white background. The reasoning behind our decision is "less is more" and this icon is easily distinguishable at any resolution.

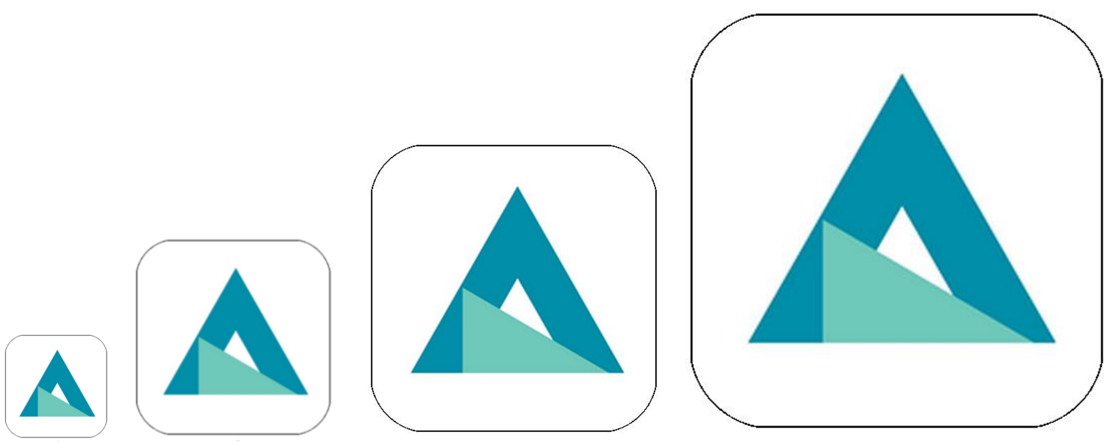

Figure 5.11 Application Icons

5.6.3.2 Loading Screen

Upon starting the application the first screen the user will view is the loading screen, shown below on the left side in Figure 5.12, where the application will gather and organize initial data. This screen contains the application's logo as well as the applications name centered on the screen in a large readable font. There will be a loading bar at the bottom representing the current status of initialization process. This bar will be animated showing a colored bar progressing across the screen as well as a numerical percentage to provide an accurate measure of completion.

5.6.3.3 Main Menu

The Main Menu screen, shown below on the right side in Figure 5.12, is the hub of operation for this application. Other than the name of the application this screen displays a status field for messages from the system and buttons to functions. The status bar shall display whether or not a device is connected nearby. If a device is not connected the user may press the "Quick Sync" button to quickly sync a nearby device. This menu also contains the buttons to the Temperature Details, About Us, and Settings which will be talked about more in depth in their respective sections.

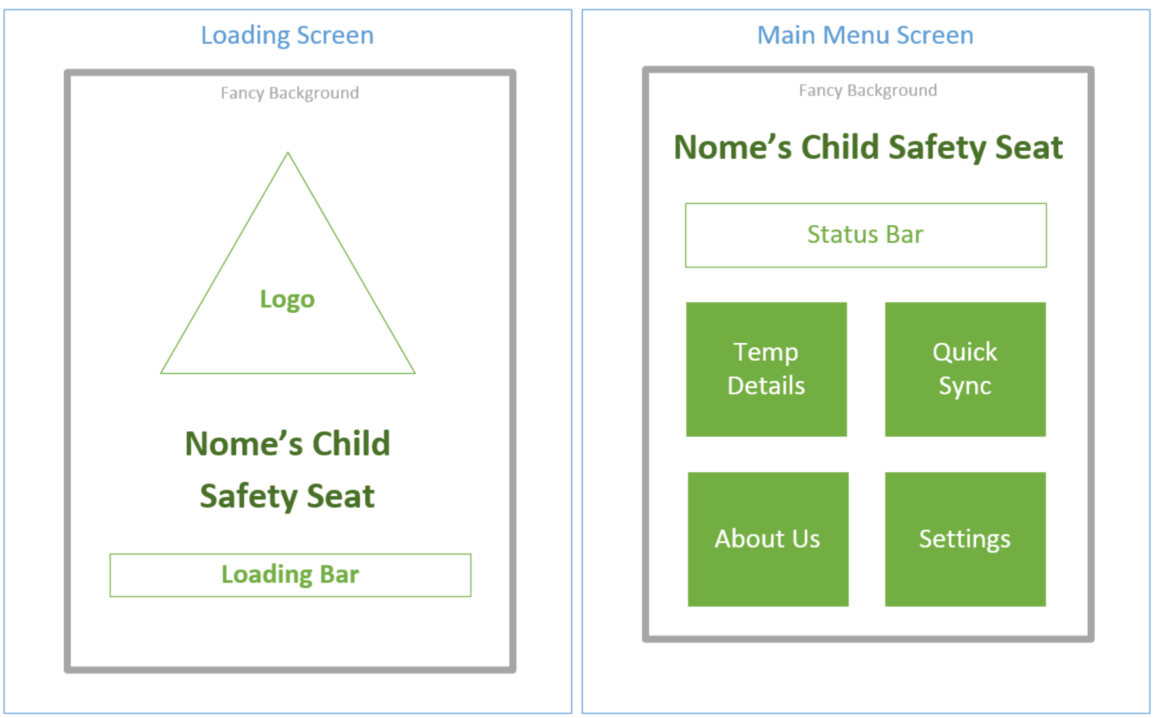

Figure 5.12 Loading Screen and Main Menu

5.6.3.4 Temperature Details

The first button on the main menu leads to the Temperature Screen shown below on the left side in Figure 5.13. This screen contains the Temperature details the system is currently experiencing. The current temperature will be displayed in the center of the screen. Below this reading will be a small graphic showing the safe temperatures recommended for child safety as well as when the safety system will trigger. The last button on this screen will take the user back to the main menu.

5.6.3.5 About Us

Pressing the About Us button takes you to the screen shown below on the right side in Figure 5.13. This screen is very simple and will allow the user to read all about our application a child car seat design. The text will include information such as a small bio about the origin of the company and product, an email for contacting support, and Copyright information. The last button on this screen will take the user back to the main menu.

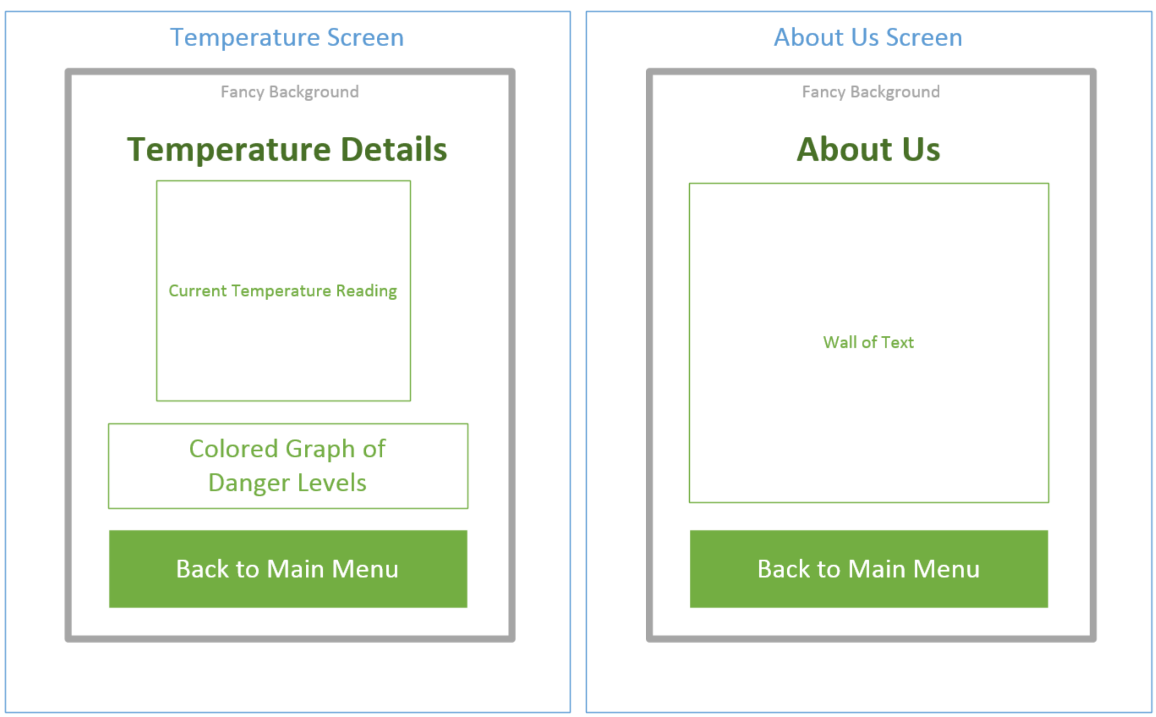

Figure 5.13 Temperature Details and About Us

5.6.3.6 Settings

The image on the left side in Figure 5.14 below shows the Settings Menu. This is another hub menu which redirects the user to other screens to adjust their settings. It includes three buttons what will take the user to change their notification configuration, choose to add, remove, or modify current synchronized devices, and request assistance from the help menu. The last button on this screen will take the user back to the main menu.

5.6.3.7 Notifications

The notification menu, shown below on the right side in Figure 5.14, allows the user to customize their alarm experience. These choices are not the final options. The user will be able to switch each option on or off using an on/off switch. The basic options that may be included are vibration, alarm, and permission to sound even when device is locked and/or on silent, and a snooze feature to remind them at a later time. The button at the bottom will bring the user back to the Settings menu.

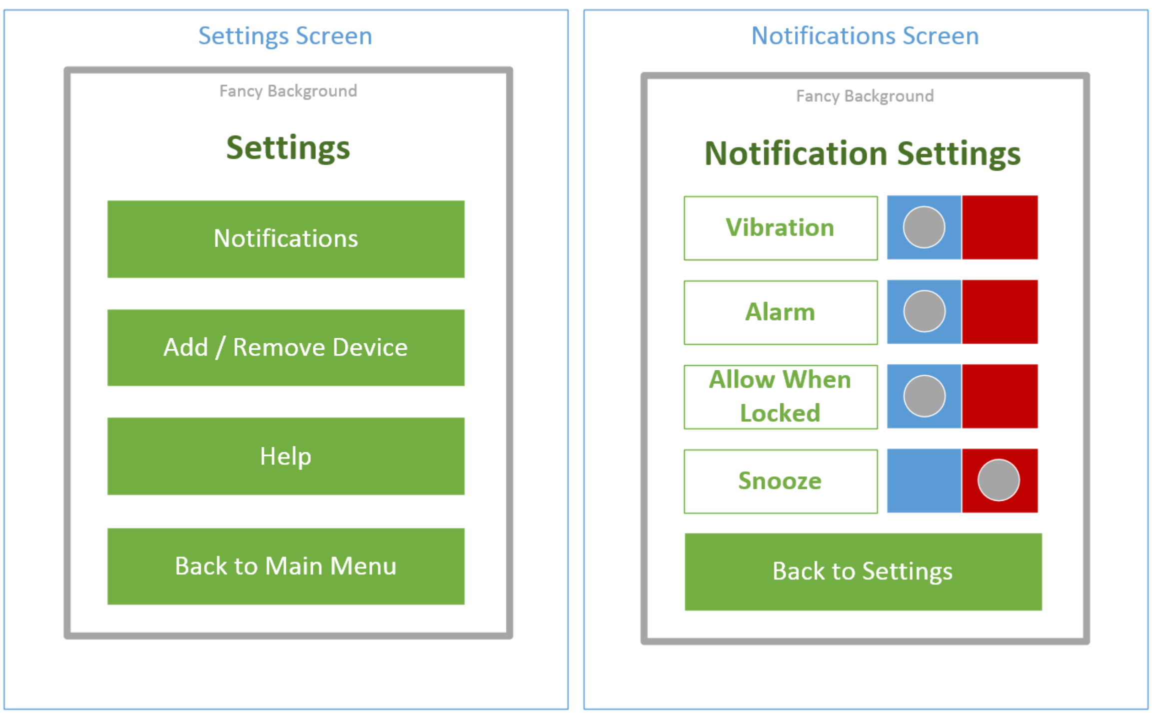

Figure 5.14 Settings and Notifications

5.6.3.8 Add / Remove Device

The Add / Remove device menu, shown on the left side in Figure 5.15 below, displays the current sync status of the user's application to a specific device. From this menu the user can Add, Remove, or even Modify devices synchronization settings. The button at the bottom will bring the user back to the Settings menu.

5.6.3.9 Help

The image on the right side in Figure 5.15 contains the layout for the Help menu will include information to assist the user. This may include an FAQ, a user manual, or a support contact email or phone number. The button at the bottom will bring the user back to the Settings menu.

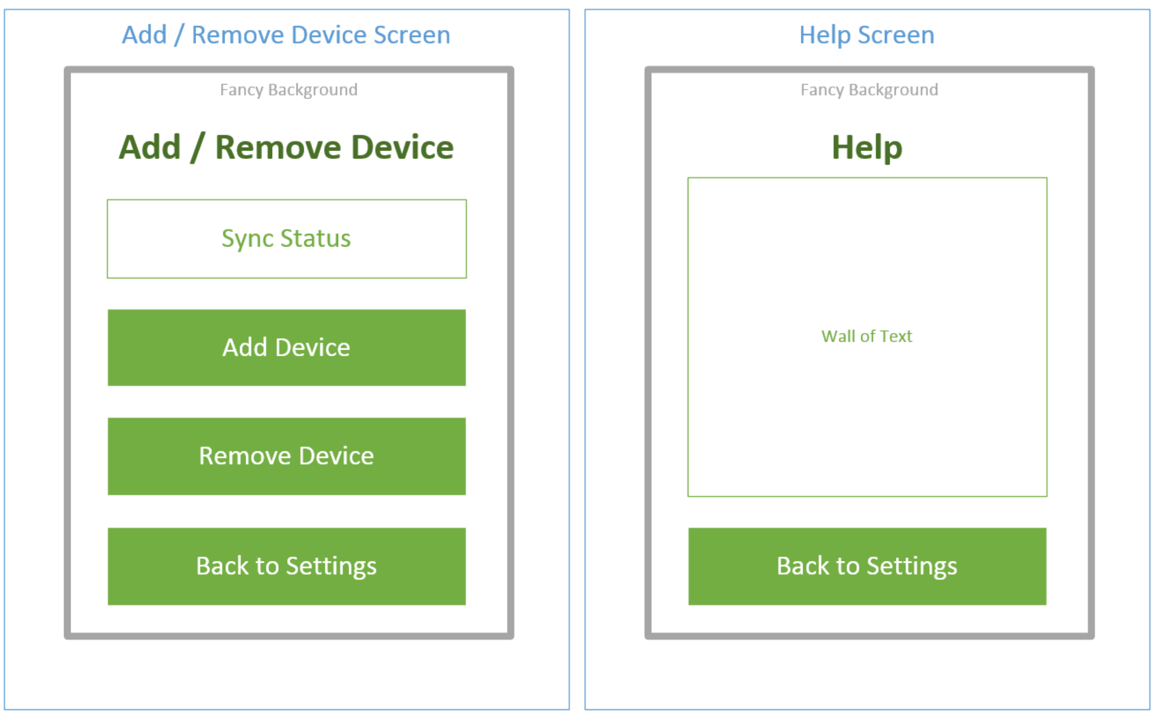

Figure 5.15 Add / Remove Device and Help

5.6.4 Application Class Diagram

Figure 5.16 below shows the different classes that will be created in the program running on the microcontroller. Each class acts separately and is in control of one item except Main.

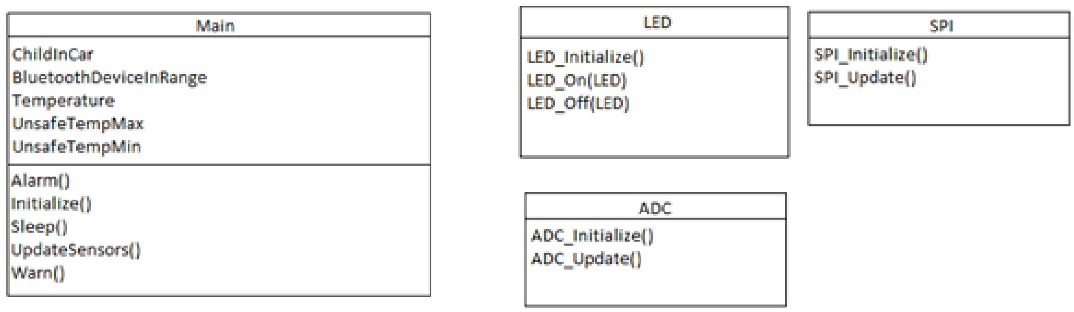

Figure 5.16 Application Class Diagram

5.6.4.1 Main

Main is the primary class and will overlook everything. It will keep track of the current state as well as have the basic information about the states. This design was used so glancing at the Main class would allow someone to get an overview of what would happen in the program.

5.6.4.2 LED

LED will control the LEDs located on the board. These LEDs will be used to show the state that the system is currently in as well as show when the Bluetooth adapter is in pair mode. When the system first turns on it will enter the initialization state. During this state the LED will blink green. If there is an error, it will blink red. Once initialization has completed, the LED will change to off to signify that it has reached the sleep state. This will conserve the most power. Once a weight has been applied, the light will start flashing green signifying that the system is waking up. The system will then turn the light solid green when it is ready to monitor the Bluetooth range and temperature. If the Bluetooth goes out of range before the weight is removed, the light will change to solid yellow. This is the warning state. If during any of these states the temperature rises above a preset limit, the system will immediately change to the alarm state which is signified by a solid red LED.

5.6.4.3 ADC

ADC, which stands for Analog to Digital Converter, will be a class dedicated to monitoring the ADCs within the microcontroller. Only one will be used though. This ADC will be attached to the flex sensor that will be located below the child in the insert. Whenever the Main class determines that the sensor needs to be monitored, it will call the ADC_Update function that will poll the sensor for its value.

5.6.4.4 SPI

SPI, which stands for Serial Peripheral Interface, will be used to monitor the temperature sensor. This sensor will be used to monitor when the car has reached a temperature that warrants changing to the alarm state. In addition to the Main class being able to force an update, the sensor we are using is also capable of setting a trigger point. This will allow us to let the microcontroller handle everything else and have an interrupt handle the temperature reaching too high. Due to our app being able to read the temperature when it is in range, the sensor must be able to be polled.

5.6.5 Software Environment

The software environment in which we will be developing the android application will be the free Android Studio version 1.1.0, which is the most up to date version. This software allows us to easily create an application with multiple tools available to us. When creating a new application you may select any version of android you wish and the software will notify you of the statistics of users you will be able satisfy. Our team has decided to use Version 4.0.3 which will cover about 90% of the android market allowing us to provide the maximum coverage with maximum efficiency.

Tools available to us include a text view of all of the languages you will need to create a user interface and background programs such as XML and Java. Android Studio also includes a design view of your application which allows for a visual editor where you can easily set relative parameters for where object will appear on the user interface. The design view lets you easily add functions such as buttons, images, progress bars, text fields, and much more to your application.

Figure 5.17 on the next page is an example of the design view which you can see shows the user interface for the application. The properties menu on the right side of the picture provides the programmer with features such as layout dimensions, on click references, background color, text size, text color, and much more. Using these properties we plan on creating a creative and simple application for the customers to be able to use with ease.

The most powerful feature of this application is the built in emulator. The emulator provides an interactive testing environment for the application where the programmer can actually test in real time on a real android device. The programmer's mouse acts as the click feature on an android device so they can navigate their application. The emulator allows us to test features such as transitions and popups without actually having to download the application to a real smartphone or android device. On the following page in Figure 5.18 there is an example screenshot of the emulator running and a demo of the pop up feature we will be implementing in our application.

We chose this software because of its full range of features that will undoubtedly be very beneficial in the building phase of the application. Android Studio's ease of access and single download will also provide a simple platform for us to design our application on.

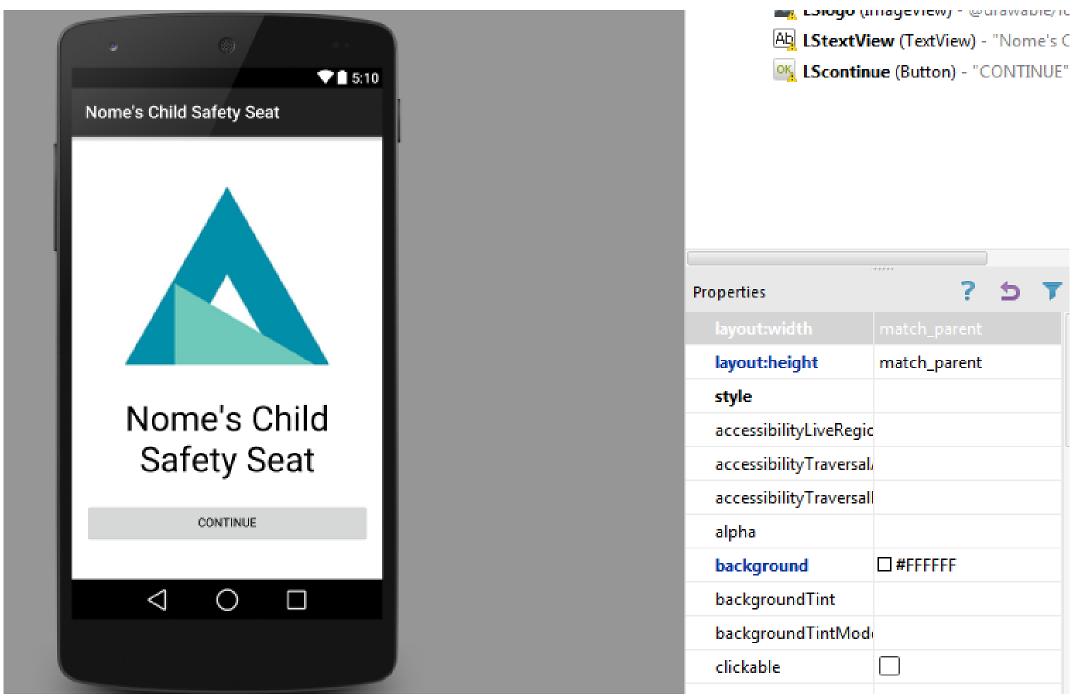

Figure 5.17 Application Design View

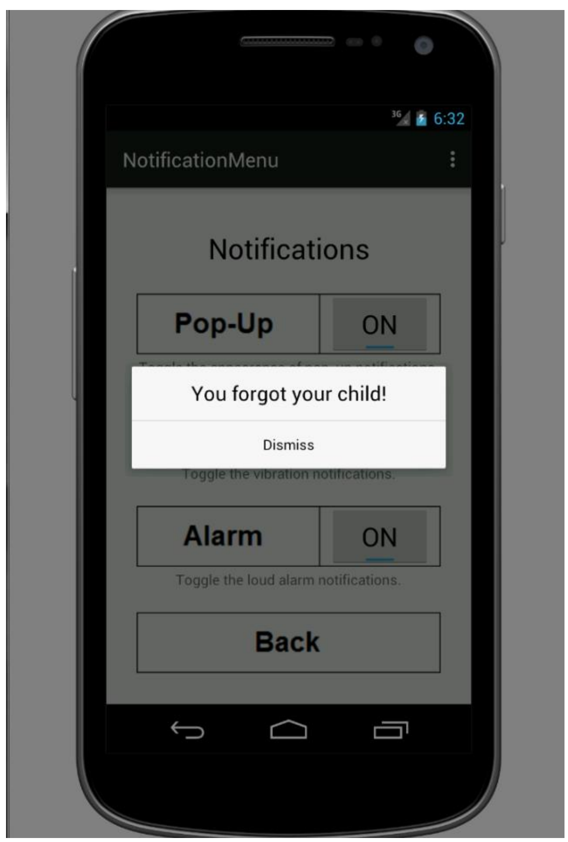

Figure 5.18 Android Studio Emulator

6.0 Prototype Assembly

After the discussion of the initial design of the Nome's baby car seat complete this section will cover the next stage which is product development of the initial prototype. This section will detail out the parts and how many there will be, where parts will be connected an implemented and where all part come from with their cost. This will include all of the hardware subsystems and main printed circuit board, as well as the considerations on how software will be written and implemented into the device.

The prototype construction chapter includes the following sections shown below in Table 6.1.

Section	Details
1	The plan for implementation of each part and how it will be mounted.
2	How parts will be acquired, including distributors and stores where components are purchased.
3	A plan for how the software will be written, including the micro controller and web server programming.

Table 6.1 Section Details

6.1 Microcontroller

In order to prototype the microcontroller, a TIVA-C was used to test a basic outline of the code. This allowed us to test the states and ensure that all of our cases were handled properly. Once the code was decided, the microcontroller was ordered. The code can then be transferred with minimal effort due to the test board and the final processor both being an ARM processor. The eventual prototyping will include a development board for the correct processor where the code will be fully tested with proper sensors and then the a new microcontroller will be ordered that can be soldered to our PCB

6.2 Battery

The battery will be the OEM Samsung EB-L1F2HVU 3.3V and 1750 mAh power source that will be mounted in a plastic resin case that will be the dimensions of 3in x 5in and will be placed in the wedge housing and secured using an adhesive epoxy that will make the battery case waterproof from accidental spills that may occur. The battery will be placed inside this plastic resin case and the case will have 1mm diameter holes drilled into it to allow access of wiring between the solar panel, load and the charge controller. The case will have clip access which will allow the replacement of the battery if the battery is ever damaged or needs replacement done. The plastic resin case will be bought from home depot and will only cost $3.89 which is crucial to stay under are budget limit. Below is a diagram of figure 6.1 the battery case and the how the battery will be situated in the wedge housing. Also how the battery case will be constructed to allow easy access to the battery.

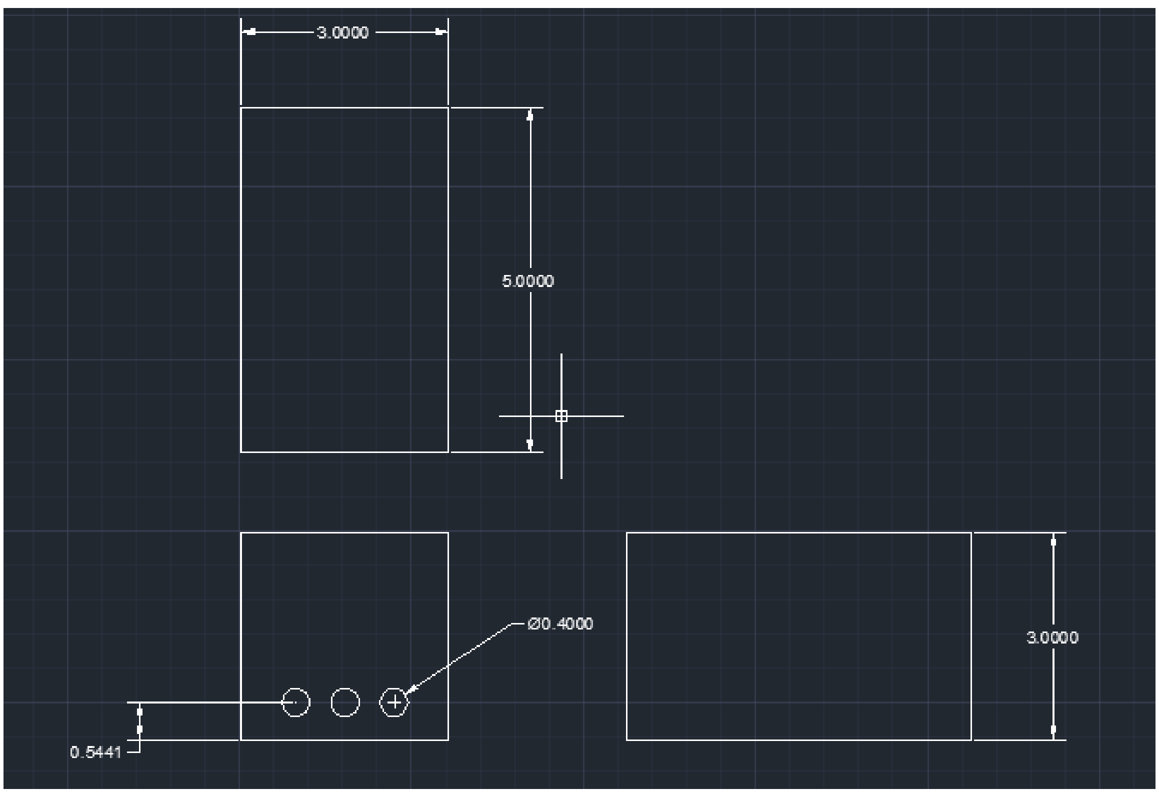

Figure 6.1 Battery Case

6.3 Charge Controller

The charge controller will be placed on a metal platform within the wedge housing and will be connected through wiring to the solar panel and the battery. In order to prototype the charge controller a BQ25504 charge controller will be used and will be in direct contact with the micro controller in order to determine when to send charge from the solar panel to the battery.

Some methods that will be implemented on the charge controller will a voltage in and voltage out function and a battery check function that will monitor the capacity of the battery. The voltage in function will record the amount of charge coming into the system and will communicate with the micro controller to keep a constant reading of the input voltage and the voltage output which is recording the voltage coming out of the system. Finally the charge controller will check the battery capacity and return the status of the battery and this will be indicated by a set of bits that will indicate the batteries charge from 20% to 100%.

6.4 Housing

The environment in which the Nome's baby child seat will be operating is in a housing wedge. The wedge housing will be able to sustain the system in hot, dry climates or humid, cold climates and any other climates. The housing will make the system waterproof, and protect the system from surge shocks that could occur if the system was drop.

6.5 Solar Panel

The solar panels will be on the outside of the baby car seat along the sides to be in the angle of the sunlight. To make the panels face at a 45° angle a plastic resin base will be attached along the side of the baby car seat using an epoxy adhesive. To test out the solar panels from Adafruit there a power resistor will be placed in parallel with a multimeter. The voltage can be found across the resistor and therefore the current could also be found.

The solar panel has a main variable of sun exposure which plays a main priority if the battery will charge in the designated time of twelve hours, to ensure that the panels absorbed enough sunlight even when in direct sunlight or shade. Once the solar panel is placed on the car seat the plastic resin base will be able to pitch in order to receive the maximum amount of sunlight. After the panels are mounted in the right position the test will be ran to ensure maximum exposure by testing the incoming voltage and to see when the voltage drops when the cells are covered by shade and to identify bad cells within the solar panel.

A Figure 6.2 presented below will show how the solar panel will have its connections to a resistor and multimeter to test voltage being drawn into a battery. Another variable that would be tested when this solar panel is implemented will be temperature. Solar panels have different efficiencies at different temperatures and will vary the voltage. The solar panel will be tested in hot and cold climate.

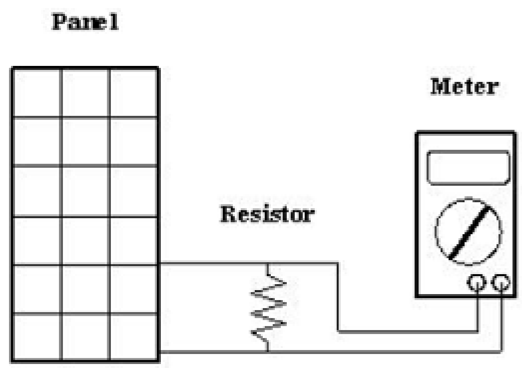

Figure 6.2 Solar Panel Connections

6.6 Load Sensor

The load sensor is combined with the system to bring the system out of the initial state of being in sleep and will activate the micro controller unit to be able to realize the ambient temperature in the car. The load sensor will deliver the message to the micro controller to wake the system. The load sensor will be along the back spine rest of the baby car seat and in the seat rest of the baby car seat and will have its wiring encased in a flexible 1mm tubing to protect from damage of the wires. The load sensor will measure the weight from the child in lbs. and this will be transmitted to the micro-controller as a digital signal or an analog signal.

The load sensor is going to be integrated on the circuit board and send its readings to the micro controller which will be programmed to start the system. All together the devices send their weight readings to the micro controller and these are converted to digital signals. The load sensor is able to sense a minute weight as low as .01% of a pound and will allow the initiation or deactivation of the system. The figure 6.3 on the following page shows the integration of the load sensor into the system

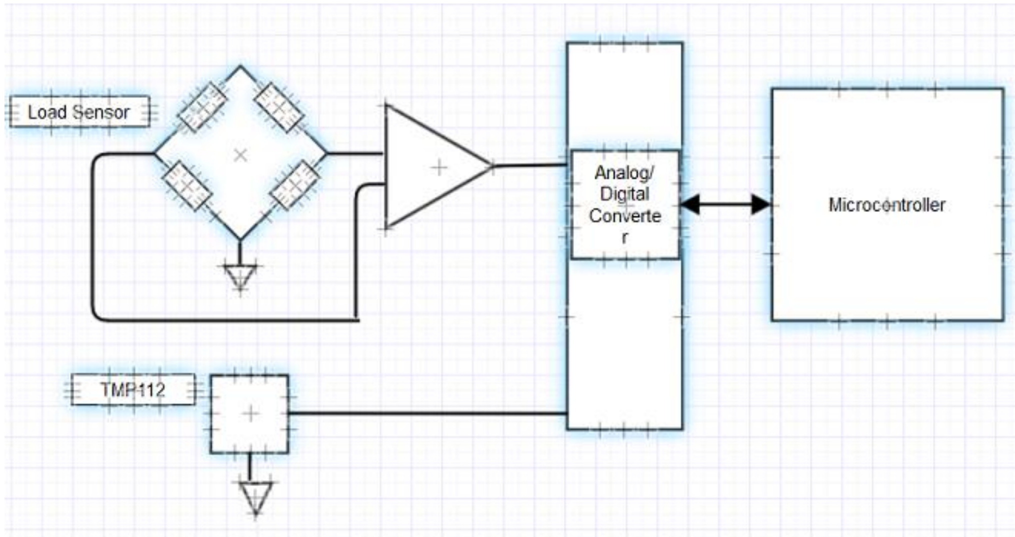

Figure 6.3 Load Sensor Integration

6.7 Temperature Sensor

The temperature sensor is combined with the system to monitor the ambient temperature in the car and determine when the micro controller should communicate with the car to turn on the A/C unit if the cars temperature reaches above 90 degrees making the temperature drop and then notifying the parent through the application to retrieve the child. The temperature sensor will be located in the wedge housing of the seat and will be detecting the temperature within a ±.5 degree error.

The temperature sensor is going to be integrated on the circuit board and send its readings to the micro controller which will be programmed to the Bluetooth of the system to send signals to the application and the car. All together the devices send their temperature readings to the micro controller and these are converted to digital signals. The load sensor is able to sense a minute temperature as low as -155 degrees Celsius and will allow the initiation of the application and the car.

6.8 PCB

The PCB was originally tested using a solderless breadboard. This included connecting the test components to the board and running the program. Once the paths have all been determined and tested, a PCB will be printed. The PCB will be designed in EAGLE since most companies will accept a design that was made using that product. An additional step that may be used will be for us to use a toner transfer method to print our own PCB. The toner transfer method is a relatively simple method used for rapid prototyping.

The process begins by printing an inverted image of the traces. Then the printout is placed on a blank PCB and heat is applied so the toner transfers from the paper to the blank PCB. Once all of the traces have been applied, the blank is submerged in a chemical that will remove any copper that is not coated with toner. Once that process has completed the board will have the proper traces but with toner covering them. A second chemical will be used to remove the toner. Once that process has completed, the board will be ready for the holes to be drilled and then used.

7.0 Hardware Comparisons

Before that process can be done a quick overview of compared hardware is completed below of why certain parts were chosen for the design.

7.1 Temperature Sensors

Before the group could begin to research a specific temperature sensor that would be adequate to read the ambient temperature and would function for the design, the group had to first research various temperature sensors to learn about them. In the design the ambient temperature of the car needs to be recorded in order to trigger a state in the micro-controller when a certain threshold for temperature is reached. A few different temperature sensors were studied to see which would fit the specifications and would be better for our design. After examining some parts these are the temperature sensors that were chosen and are compared below in Table 7.1.

	LM35	**TMP112**	**MAX1617**
Operating Temperature	-55°C to +150° C	-40°C to +125°C	-55°C to +125°C
Output Interface (Digital/Analog)	Analog Output	Digital Output: SMBus, Two-Wire and IC Interface Compatibility	Digital Output: SMBus, Two-Wire Serial Interface
Supply Range (VDD Range)	1V to 6V	1.4V to 3.6V	3V to 5.5V
Temperature Accuracy	± .2°C	±.5°C	±2°C

Table 7.1 Temperature Sensor Comparison

7.1.1 LM35

The LM35 is one of the temperature sensors being considered for the project. For consideration temperature accuracy, supply range, type of output interface and cost, this temperature sensor is one of three and the only one that has an analog interface and has the lowest temperature error accuracy of .2°C. This temperature sensor requires no calibration and due to its wafer level trimming design makes the overall design low cost. With the low output impedance and linear output makes the interfacing of the temperature sensor easy. Due to the design this has been the temperature sensor that was chosen by the group due to its cost effectiveness, operating temperature, easy interfacing and low temperature error. The analog LM35 temperature sensor does not require the extra components of a resistor network and analog and digital converter adding to the cost and footprint of the temperature sensor problem. Figure 7.1 below shows the diagram for the LM35 from Texas Instruments.

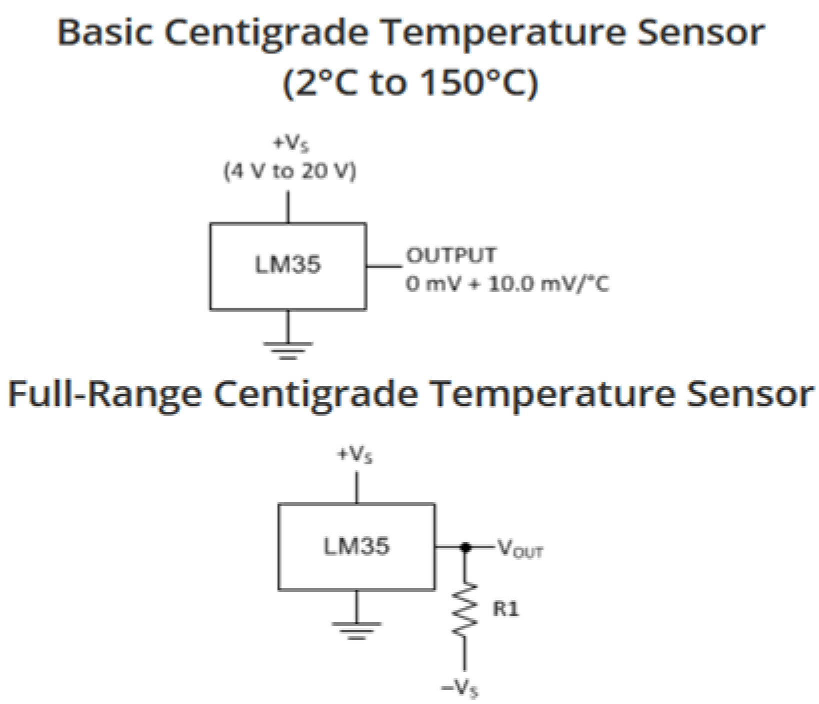

Figure 7.1 LM35 Temperature Sensors

Awaiting Permission from Texas Instruments

7.1.2 TMP112

The TMP112 is manufactured by Texas Instruments just like the LM35 except the output interface is a digital output that uses a SMBus, two-wire and IC compatibility. The TMP112 has an improved accuracy feature that allows it to make its temperature accuracy from ±.5°C to ±.17°C giving it a better accuracy than the LM35. The TMP112 temperature sensor has an operating temperature range of 40°C to 125°C which is well within the specified temperature ranges needed to detect and activate the next state machine which is the MCU to activate the Smart phone app to notify the parent. The TMP112 has a chance of increased temperature error at low and high temperatures causing the output voltage vs Temperature(°C) to saturate due to the low resolution to detect the change in output voltage per degree Celsius. This problem is not seen the analog LM35 temperature sensor since it has a virtually linear output. To fix this problem a high resolution analog to digital converter (ADC) would have to be implemented causing the implementation of this device to be tedious. Figure 7.2 below shows the schematic for the TMP112 from Texas Instruments.

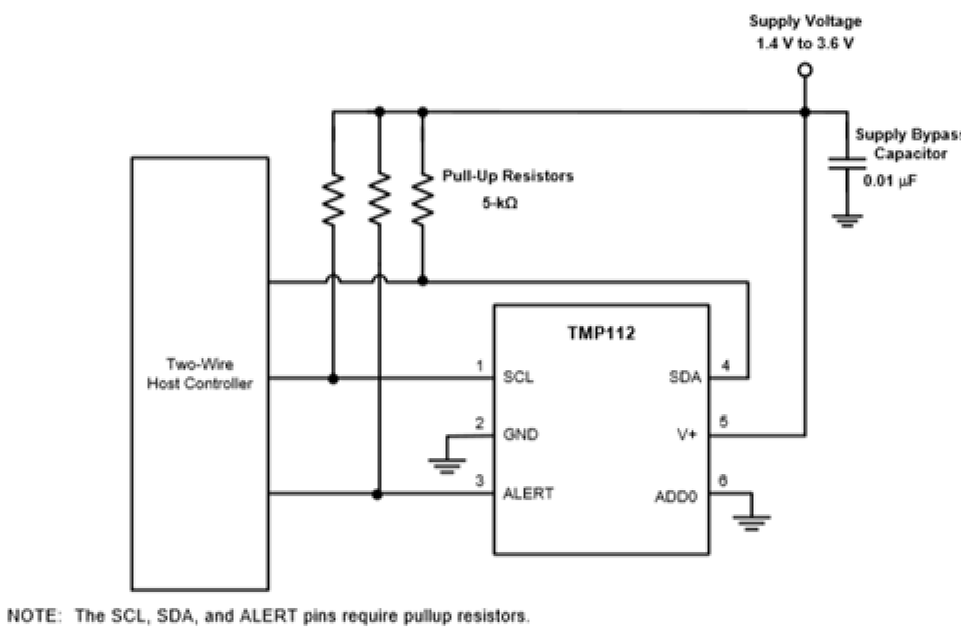

Figure 7.2 TMP112 Temperature Sensor

Awaiting Permission from Texas Instruments

In Figure 7.3 the internal block diagram of the TMP112 will let us further understand how the device functions. Here we can see that the temperature sensor is compiled of diode temperature sensor, A/D converter, OSC alert, control logic, serial interface and a configure register. This will allow for us to properly connect the component and gather accurate results. Once the results are gathered they can be processed by the microcontroller, be acted upon by communicating with the car, and then displayed properly on the application.

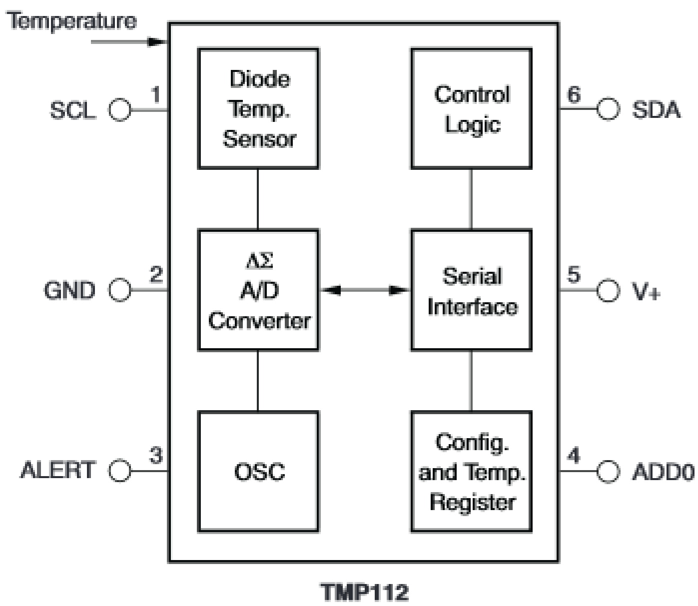

Figure 7.3 Internal Block Diagram of TMP112

7.1.3 MAX1617

The MAX1617 is manufactured by maxim integrated and is also a digital thermometer like the TMP112, but has a fairly larger temperature error of ±2°C. A great quality of the MAX1617 is that it can also measure the temperature of the MCU and other devices while also monitoring the ambient temperatures. The operating range of the temperature sensor is -55°C to 125°C which is still under performing compared to the LM35 analog sensor, but the ambient temperature being analyzed will not reach those extremes before the MCU is triggered to alert the parent. Although the MAX1617 doesn't suffer the same drawback as the TMP112 of needing the higher resolution analog to digital converter for the thermistor the cost of the thermometer is still higher than the LM35 and will still need calibration in order to bring the output voltage vs temperature to be more linear, hence the slightly larger temperature error. The Figure 7.3 below displays the design schematic for the MAX1617.

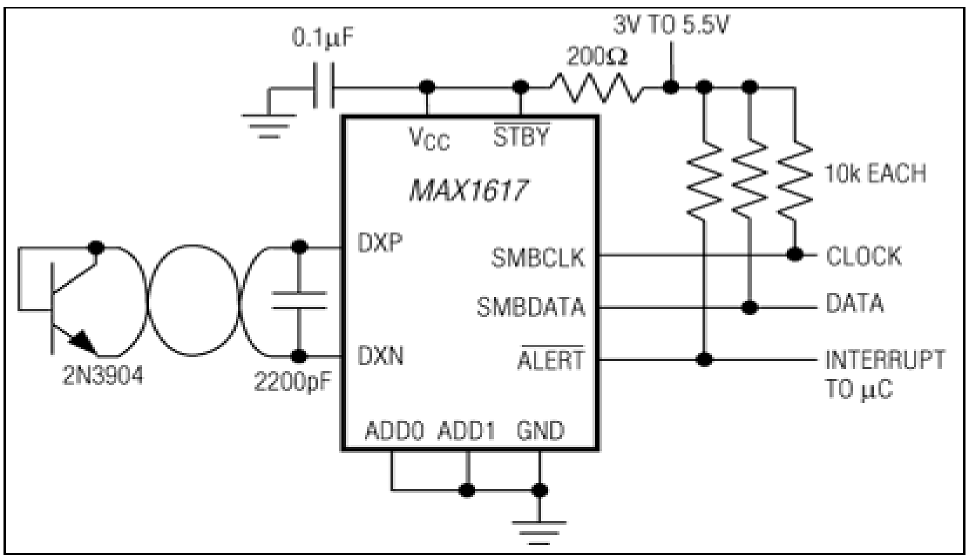

Figure 7.4 MAX1617 Temperature Sensor

7.2 Load Sensor

The Load sensor chosen for the project is a Flexiforce pressure sensor that is a piezoresistive force sensor from Tekscan. The sensor ranges from 0-25 pounds of pressure with a response time of 5 microseconds which is the time required for the sensor. This force sensor has a ±3% linearity error for the volt per force from a 0 to 50% load. The force reading on the sensor only changes by .36% per degree of temperature which is in our guideline specifications of 3% read error from the sensor. The load sensor features a 1 inch diameter head that acts as the pressure pad that will relay the weight information to the MCU to bring the system out of sleep mode notifying that there is a child and guardian present in the vehicle. Figure 7.5 below shows the schematic for Flexiforce Load Sensor.

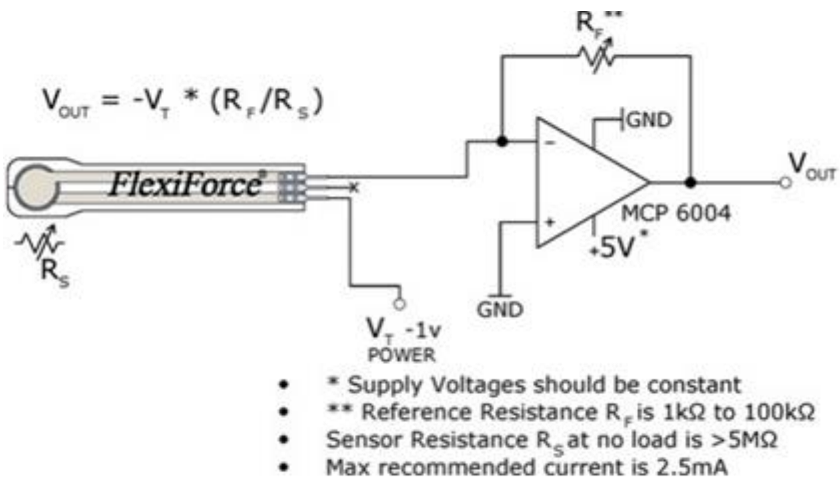

Figure 7.5 Flexiforce Load Sensor

7.3 Solar Panels

Since the device will be in some form of natural light a solar panel is used to harness that power. There are some great capabilities that come about when solar panels are used in the overall design. The entire system could be powered with a solar panel due to the low powered nature of the system, but considering the locations the design could be used at there might not be adequate sunlight. Without implementing a solar panel to power the subsystems the device will have to be plugged into an outlet to charge the battery. This would limit the overall flexibility of the system. When choosing solar panels we wanted the panels to be able to flex to the base of the car seat as well as be able to trickle charge the APC unit that will be powering the micro-controller, temperature sensor, and load sensor.

The solar panel needed to fit the requirement of charging the battery in 12 hours or less and be able to support the power demand of the car seat. The group decided on a solar panel from Adafruit that has 6V 1W of power and through calculation of using the equation Hours= Watts/Watt hours we have decided that a total of four solar panels will be used in order to achieve 11.45 hours of charge and will cover no more than 9 square inches of the base. This fits both requirements the group was aiming for and provides a sustainable source of energy for the car seat. This will be able to charge the nano watt power consuming MCU and the rest of the elements in the design.

7.4 Power Supply

Due to the nature of the device not being primarily powered by solar panels the idea of using an APC battery was decided and to use the solar panels to trickle charge the battery. Due to the low energy of the car seat itself because of the seat being in a natural sleep mode until the load sensor is triggered causing the micro controller unit to be activated the battery needed would not have to be high powered. The battery itself would need to be a low weight and not excessively huge in size, and be able to fit the criteria of being trickle charged by the solar panel under a twelve hour period. Table 7.2 below contains the list of batteries that were examined that fit the criteria of what was needed to power the system.

	APC RBC35	**WKA12-8F2**	**DURA6-10F**	**Samsung EBL1F2HVU**
Weight	2.9 lbs	5.6 lbs	3.9 lbs	0.06 lbs
Voltage/Amp Hours	12V/3.5AH	12V/8AH	6V/10AH	3.7/1.75AH
Time to Charge	11.45 hours	12.25 hours	12.5 hours	6 hours
Product Dimensions	2.6 x 2.28 x 5.28 inches	8.5 x 6 x 2.3 inches	8.5 x 7 x 3.3 inches	2 x 3 x .25 inches

Table 7.2 Battery Comparison

7.4.1 APC RBC35

The APC RBC35 has a time to charge of 11.45 hours and holds enough battery capacity to fully power and operate the entire car seat system. This is a little under the constraint of a charge time of 12 hours that the car seat requires in order to trickle charge it. The size of the APC RBC35 is also very suitable and can be housed in the base of the car seat without adding much weight t the overall design in the car seat. The battery uses F2 connections which are slightly flatter and wider than the F1 terminals used by the WKA12-8F2 and the DURA6-10F.

7.4.2 WKA12-8F2

The WKA12-8F2 has a time to charge of 12.25 hours and holds enough battery capacity to fully power and operate the entire car seat system. This is over are constraint of a charge time of 12 hours that the car seat requires in order to trickle charge it. This battery was promptly dismissed after that factor. The size of the WKA12-8F2 is also a bit large in size and cannot be discretely hidden in the base of the car seat. The robust nature of the battery also adds a weight of 5.9 pounds which breaks the design constraint of weight minimization that the group has set. The battery uses F1 terminals just like the DURA6-10F connections.

7.4.3 DURA6-10F

The DURA6-10F has a time to charge of 12.5 hours and holds enough battery capacity to fully power and operate the entire car seat system. This is over are constraint of a charge time of 12 hours that the car seat requires in order to trickle charge it. This battery was promptly dismissed after that factor. The size of the WKA12-8F2 is also a bit large in size and cannot be discretely hidden in the base of the car seat. The battery however does not add much weight to the design while giving an excellent amount of power. The battery uses F1 terminals just like the WKA12-8F2 connections.

7.4.4 OEM Samsung EB-L1F2HVU

The battery chosen that fit all requirements was the OEM Samsung EB-L1F2HVU which satisfied the criteria of a time to charge of 6 hours and holds enough battery capacity to fully power and operate the entire car seat system. The size of the OEM Samsung EB-L1F2HVUis also very suitable and can be housed in the base of the car seat without adding much weight to the overall design in the car seat. The battery uses pin connections that are plus, minus and a third pin for an internal temperature sensor.

The main feature that the Nome’s car seat must acquire is a system that is portable. The system should be self-sustainable in power and should not feature any cables that will make the system portable for the user. The power supply must also be portable, instead of being powered by an outlet in the car. The system will be powered by OEM Samsung EB-L1F2HVU a single lithium ion battery that will power the micro-controller, temperature sensor, load sensor, and charge controller. The battery will be able to recharge by the use of a solar panel that will accomplish a charge time of around 5.54 hours. The battery has a standard 3.7V standard output that will be more than enough to power the overall low powered system.

7.4.5 Specifications

The battery currently selected will be a 1750mAh lithium ion battery. Table 7.3 below shows the specifications of the selected battery. Referring to the specifications section of the report you can verify that this battery meets the initial requirements.

Category	Specification
Nominal Capacity	1750mAh
Nominal Voltage	3.7V
Standard Charge Current	0.2CA
Max Charge Current	1 CA
Impedance	<50 m ohms

Table 7.3 Lithium Ion Battery

8.0 Hardware Project Prototype Testing

The following section contains an overall look at the hardware testing plan, in order to ensure that the final prototype's hardware subsystems achieve all objectives and fits all specifications that have been designed. The Nome's Child Safety Seat Project will strive to thoroughly test its iterative prototyping phases that increasingly functional systems. A system will be generated from the knowledge of constructing the device and testing each subsystem of the device. In the section following, testing procedures are detailed in a user friendly format with an explicit procedure and pass/fail expected result for each test.

8.1 Testing Environment

There are two primary locations for the hardware testing of this baby car seat system. The first is the senior design lab that contains electrical equipment that can be used to debug any errors with the electrical connections and interfacing of devices with the micro-controller. The second location of the test on the system will be done a computer system that will mimic the computer system that is accessed through the OBD port of a car.

While running tests on the hardware subsystems, the two environments will be controlled and not have any outside influences that will affect data and deviate from the test plan. The hardware environment must contain the following constraints listed below.

- Isolate the device from weather conditions that exceed designed limits of the device, such as extreme temperatures that are out of the operating values of the subsystems.
- Provide an adequate amount of sunlight that might be seen as a standard amount of sunlight received in a general area according to test plan.
- Supply a stable power supply and make sure the computer system mimics the environment from the car.

8.2 Subsystem Unit Testing

The following section has a detailed subsystem test plan summary to ensure each device subsystem is working properly.

8.2.1 Power Supply

To ensure that the finished product will work the way it was intended to function product testing is used an essential tool. To develop a successful test plan for the power system, the overall objective of system must be considered. In this design the power system will provide energy to all of the other subsystems which include the micro-controller, load sensor, and the temperature sensor. In maintaining the battery the battery must not be overcharged or deep discharging the battery. The charge controller will operate to turn off the current from the solar panel once the battery has reached an optimal charge which is around 80% of its capacity to extend battery life.

The battery, charge controller and solar panels will be connected together to test the power system for the car seat. When the battery has reached the optimal charge as explained the charge controller will shut off the charge coming from the solar panel to the battery.

To test the solar panel and to make sure that it is operating properly during normal operation in direct sunlight it must output a 6V during this time to effectively charge the battery in the power system. This factor is easily tested by setting the solar panel in direct sunlight outside and measuring the voltage of the solar panel which should be giving off 6V consistently if working properly. Since the power system will not be on constantly due to the built in nature of the system being sleep with no weight present to trigger the system there is no need for an extensive 24 hour period of testing the battery. In the need that this needs to occur the battery is left fully charged alone for a 24 hour period and when returned to the battery should still output 3.3 V with an error of no more than 5% due to discharge.

Once all the components are connected together the current and voltages of the battery and the solar panel can be connected and the charge controller can be tested if it is operating properly. When tested there should be a flow of current going into the battery verifying that the solar panel is charging the battery correctly.

The charge controller is the next item to be tested since it will regulate the charging capabilities of the battery ensuring that it does not discharge or be overcharged by the solar panel. When the device is started the charge controller should check the status of the charge on the battery and determine if it is below the 80% charging threshold before it begins to charge the system. So input power into the solar panel side of the circuit is applied and the micro controller unit is turned on which will tell the charge controller what to do. If the battery is below the 80% threshold the charge controller should turn on to charge the battery from the solar panel. This can be verified by using a multimeter to measure current flow of both situations to see if it charge controller is functioning accordingly.

If current flowing into the battery then the charge controller should be on and the battery should be charging. After the battery has reached the optimal charge current should stop and battery will stop being charged. This should happen when the battery reaches the optimal charge of 3.7 V. When the battery begins to discharge and reach below the threshold the charge controller should begin charging the battery again. This will conclude the testing on the charge controller, battery and solar panel that make up the power system for the car seat. These tests will ensure that the prototype power system is functioning correctly and no more testing will be needed. A listed user friendly design procedure is below to test the power system of the design.

8.2.2 Design Procedure

1. The solar panels are placed in direct sunlight to produce enough charge to fully charge the battery. If the voltage of 6V is produced by the solar panel than the solar panel is working.

2. The battery is tested to provide the regulated time of 24 hours after being fully charged. Measure the voltage on the battery while being discharged slowly.

3. After these two tests the solar panel, battery and charge controller are connected.

4. Test the charge controller by leaving the battery below threshold and ensuring that charge controller turns on to start charging the battery via the solar panel.

5. Once the battery is fully charged ensure that the charge controller turns off after recognizing that the battery is fully charged by measuring current flow with a multimeter.

8.2.3 Battery

The battery being used is a 3.7V rechargeable battery, and certain things need to be considered in order to make sure that the device is working properly. Some things that need to be considered when testing a battery are:

- How much charge is currently in the battery and is there any electrical noise in the battery?

- Can the device fully charge and can it maintain the same charge and performance over an amount of time?

- How many cycles will the battery last through before it is degraded and the battery has to be replaced?

- Are the safety components of the battery in working proper condition and within manufacture specifications that were set for the device?

As explained earlier through research it is found that are measures that can be taken to preserve the life of the battery such as only charging a battery to a threshold of 80% and to not let the battery fall below 23% before charging it. To test the stress of the battery one method is to measure the state of charge of the battery but by doing this test it requires that the battery to be fully discharges and to measure the energy output. This in turn damages the battery after multiple tests so to better measure there are parameters that can be examined about the battery. These parameters are shown in Table 8.1 below.

Parameter	**Description**
Internal Resistance	Determines the power loss that will occur in the battery
Open Circuit Voltage	This parameter helps to determine the internal resistance of the battery.
State of Charge	This is the amount of energy remaining in a battery.
State of Health	Measures the response of the battery, and how long the battery will last.

Table 8.1 Battery Parameters

When these specifications are inadequate and do not match are specifications a different battery is used that closely matches the groups requirements for the car seat. The one battery that currently matches are specification is the CEL 0135 battery but this battery has been known to overheat and have a moderate state of health. If this battery does not pass the APC RBC35 will be used due to its higher state of health although size and weight will be the direct sacrifice to design.

8.2.4 Solar Panel

To test the 6V 1W solar panels that will be used for the design of the project the DC voltage and Amperes must be measured and verified to the specifications of the project.

- DC Voltage – When the solar panel is placed in direct sunlight, a DC voltage should be generated that should be measured with a multimeter to make sure it falls in line with specifications. Another test is then run when the solar panel is placed in inadequate sunlight to test the amount of volts generated for the battery. This will ensure that when the solar panel is placed in poor lighting the charge given to the battery is at least 70% of the optimal charge to remain in a 10-12 hour charge time.

- Amperes – When testing for the current of the system it is important to note that the test should not be done in direct sunlight, because this will damage the solar panel while measuring. Attach the multimeter first to the solar panel and then proceed to move the solar panel to direct sunlight to measure the current generated from the solar panel.

8.2.5 Charge Controller

The charge controller used for the car seat is acting as a regulator for the current that comes from the solar panel to the battery. To test this charge controller and the solar panel should be connected to the battery and to see the response. The device must be measured and the parameters listed below should be measured and examined.

- Operating Current- The operating current of the device should be measured with a multimeter while the battery is fully charged to see if current flow is occurring and while the battery is below the threshold to make sure current flow is happening and the battery is being charged via the solar panel.
- Operating Voltage- The voltage of the device is also measured using a multimeter to make sure the battery voltage is being regulated.

8.2.6 Temperature Sensor

The temperature sensor chosen for this project is the Texas Instruments LM35 which is an analog signal device that generates a linear voltage vs temperature (°C) that can be measured on an oscilloscope or digital multimeter. The device should be mounted and installed with connections to the micro-controller that was chosen to verify that the temperature sensor is returning proper values.

8.2.7 Load Sensor

The load sensor in the design will trigger the MCU to bring it out of the sleep state. The load sensor is one of the most vulnerable because of damage from electric surges, moisture or simply an internal component malfunction. To test to make sure the load sensor is within the correct specifications digital volt and ohmmeter to measure the accuracy of the integrity bridge which should be within ±0.5 ohms and ±0.1 mV of the specifications. The load sensor should be trialed run through possible situations that could occur such as an overload, moisture problem or a simple failed electrical connection. To test this, the device should be mounted and installed with connections to the micro-controller that was chosen to verify that the load sensor is returning proper values.

8.3 Software Testing

The tables below describe the sensor states that were tested and what state the program decided on. After the testing was completed, we determined that the program was able to select the proper state in each situation.

Test 1, shown in Table 8.2, below consists of the child not being in the seat, the temperature being safe, and the Bluetooth not in range. The result of these conditions would be to remain in the sleeping state, because there is no child in the seat.

Sensor	Value
Child in Seat	0
Temperature	70
Bluetooth In Range	0
State	Sleeping

Table 8.2 Software Test 1

Test 2, shown in Table 8.3, consists of the child not being in the seat, the temperature being safe, and the Bluetooth being inside range. The result of these conditions would be to remain in the sleeping state, because there is no child in the seat.

Sensor	Value
Child in Seat	0
Temperature	70
Bluetooth In Range	1
State	Sleeping

Table 8.3 Software Test 2

Test 3, shown in Table 8.4, consists of the child not being in the seat, the temperature in an unsafe range, and the Bluetooth not in range. The result of these conditions would be to remain in the sleeping state, because there is no child in the seat.

Sensor	Value
Child in Seat	0
Temperature	110
Bluetooth In Range	0
State	Sleeping

Table 8.4 Software Test 3

Test 4, shown in Table 8.5, consists of the child not being in the seat, the temperature in an unsafe range, and the Bluetooth being inside range. The result of these conditions would be to remain in the sleeping state, because there is no child in the seat.

Sensor	**Value**
Child in Seat	0
Temperature	110
Bluetooth In Range	1
State	Sleeping

Table 8.5 Software Test 4

Test 5, shown in Table 8.6, consists of the child being in the safety insert, the temperature being safe, and the Bluetooth being inside the range. The result of these conditions would be to enter the information state, where the device will begin monitoring.

Sensor	**Value**
Child in Seat	1
Temperature	70
Bluetooth In Range	1
State	Information

Table 8.6 Software Test 5

Test 6, shown in Table 8.7, consists of the child being in the safety insert, the temperature being safe, and the Bluetooth exiting the range. The result of these conditions would be to enter the warning state, where the device will begin to notify the parent or guardian that they have forgot their child.

Sensor	**Value**
Child in Seat	1
Temperature	70
Bluetooth In Range	0
State	Warning

Table 8.7 Software Test 6

Test 7, shown in Table 8.8, consists of the child being in the safety insert, the temperature entering an unsafe range, and the Bluetooth exiting the range. The result of these conditions would be to enter the alert state, where the device will enter the second stage or third stage of alarm to notify the parent or guardian that they have forgot their child and save the child.

Sensor	Value
Child in Seat	1
Temperature	40
Bluetooth In Range	0
State	Alert

Table 8.8 Software Test 7

Test 7, shown in Table 8.9, consists of the child being in the safety insert, the temperature entering an unsafe range, and the Bluetooth entering the range. The result of these conditions would be to enter the alarm state, where the device would assume the parent or guardian has returned to the vehicle, but not yet removed the child.

Sensor	Value
Child in Seat	1
Temperature	110
Bluetooth In Range	1
State	Alarm

Table 8.9 Software Test 8

9.0 Administrative Content

9.1 Project Milestones

The following milestones are designed to guide the building process of the prototype and final design of the product. This timeline is created prior to the construction phase of the project and will be used to reflect our progress. The senior design course for electrical and computer engineers is broken up into two semesters named Senior Design I and Senior Design II.

The objective of Senior Design I is to form a team, determine a project, obtain funding/sponsors, meet with sponsors to discuss budget, and design requirements, conduct research, design your project on paper, and submit a Final Project Design Report by the end of the course.

The goals of Senior Design II is to implement and build the designed project from Senior Design I, add features if there is time, and present a working product to the student board. Table 9.1, on the following page, lists on a monthly basis, the progress milestones our team has agreed to abide by over the two semesters. Please note this report is to be submitted before the second semester begins so any milestone requirement stated after April is subject to change by the team's discretion.

Month	Milestone Requirements
January	• Team Assignments • Determine a project • Meet with sponsors and discuss design and ideas
February	• Initial Project Document Due • Specification Requirements Research • Sensor Event Trigger Research • Market and Audience Research • Research and Design Begins • Meet with IE group for weekly status update
March	• Client meetings to review research and design • More Research and Design • Meet with IE group for weekly status update • Obtain test boards for Research • Table of Contents Draft Due • IE AS-IS Presentation
April	• Rough Draft Paper Due • Order Necessary Parts • IE Final Presentation • Final Project Design Paper Due • Senior Design I ends • Part testing • Research Additional Features
May	• Senior Design II Begins • Start assembling parts together • Print PCB • Configuration testing • IE Team handoff of leadership
June	• Assembly and Testing • Finalize base design • Additional Features Research • Additional Features Implementation • Additional Features Testing
July	• Finalize Features • Finalize Testing • Presentation & Demonstration • Senior Design II Ends

Table 9.1 Nome’s Child Safety Seat Project Milestones

9.2 Budget and Financing

This is a sponsored project that is gaining popularity very quickly and our sponsors have originally agreed to a project budget of five hundred dollars. However after applying for additional funding The Boeing Company has decided our project qualified for more support and has added six hundred to the budget.

This project has a total budget of one thousand and one hundred dollars but after researching parts and testing our equipment we have created Table 9.2 shown on the following page which states the parts we have chosen along with how much they cost. Also included below are any miscellaneous costs and fees that have appeared over the duration of this project. Please note that this report is being written before actual assembly is being started and these values may not perfectly reflect the final cost of the project and the parts are subject to market fluctuation and the values may not exactly match the current price.

Description	Component Name/Number	Qty.	Unit Price (USD)	Subtotal Price (USD)
Microcontroller with BLE	CY8CKIT-042-BLE	2	48.88	97.76
Battery	GT-i9250 EB-L1F2HVU	1	14.87	14.87
Battery Charger	BQ25504	1	5.51	5.51
Temperature Sensor	TMP112	1	1.79	1.79
Load Sensor	Flexiforce 25 lbs	1	21.95	21.95
Solar Panels	Flexible 6V 1W Solar Panel	2	24.95	49.9
LED	LTST-C191KGKT	3	0.3	0.9
Pair Button	D6R90 F2 LFS	1	1.09	1.09
OBD Link	OBDLink MX Bluetooth		100.91	100.91
PCB	Printed Circuit Board	1	50.00	50.00
Board Components	Wires, Resistors, etc.	-	10.00	10.00
Car Insert Materials	Padding	-	50.00	50.00
-	-	-	**Total Cost:**	**404.68**

Table 9.2 Nome’s Child Safety Seat Budget

9.3 Single Unit Manufacturing Estimates

The previous section reflects on how much it is going to cost our team to build a single unit, which is not the correct amount for marketing manufacturing. Furthermore, these prices are for creating and designing a single unit so the prices are very high. With the bulk manufacturing the prices of each part are drastically reduced making the unit very profitable. Also we have included parts that are strictly for experimentation and there are better units available for mass production purposes.

Table 9.3, on the following page, represents the manufacturing price of a single unit for the real world market. This includes only the required components to have the device function. The price is reduced because when components are bought in bulk they usually have reduced prices. This applies to the smaller components, the padding, and the wedge materials. Also noticeably cheaper are the board and processor which when bought instead of created can be purchased for almost one fourth of the price.

Single Completed Unit Price			
Component	**Quantity**	**Price**	**Sub Total**
Processor	1	6.53	6.53
Battery	1	14.87	14.87
Battery Charger	1	5.51	5.51
Temperature Sensor	1	1.79	1.79
Load Sensor	1	17.95	17.95
Solar Panels	2	24.95	49.9
LED	3	0.3	0.9
Pair Button	1	1.09	1.09
OBD Link	1	100.91	100.91
Board Components	-	5.00	5.00
Car Insert Material	-	10.00	10.00
Total Cost	-	-	**214.45**

Table 9.3 Single Unit Manufacturing Price Estimate

10.0 Conclusions

10.1 Project Summary

The Nome's Child Safety Seat is an insert for a child's car seat that allows the monitoring of the child and provides awareness options to remind the vehicle operator not to leave their child in the vehicle. The insert device will communicate with a smartphone application via Bluetooth and provide multiple stages of attention grabbing techniques to the owner. In critical situations the device will assume control of the vehicles onboard features in an attempt to save the lives of the child.

Our team reached this design though multiple forms of research and data gathering from our future consumer market. The industrial engineers and business team developed statistics and marketing surveys to identify the need for such a safety device. Upon reviewing the statistics our team concluded that the main problem was not only saving the children but also that the parent or guardians were actually forgetting their children on a psychological level. Now that we clearly identified the problems we were facing we were able to identify and create a targeted performance platform for which to begin further design. After reviewing current safety systems on the market we developed features that would not only make our product stand out but that were better suit the targeted consumer audience.

With a clear design in mind we began comparing components looking for the specific part that this design required. Parts were chosen based on their functionality and reliability under the situations that they will be required to work in. Being a safety system we spent extra time making sure that the parts were indeed reliable because if the system fails to trigger it could mean losing a life. The device will alert the owner in three increasing stages of alerts. The first alert is via the smart phone application where will alert the parent or guardian via text, noise, and vibration to remind them to go back. The second stage of alert involves honking the car horns, and alarms to alert nearby people. The final stage is for emergency situations when the temperature reaches dangerously hot or cold for the infant and the system will turn on the vehicle and use the air conditioning to raise or lower the temperature inside the vehicle accordingly.

Extensive research and collaboration from both teams are combined in the project to ensure that we are able to deliver a successful system. We believe there is a great need in the market for this device because it is designed to be responsive and mobile to provide the best security measures possible while also maintaining an easy to use user interface.

10.2 EE/CpE Personal Reflections

10.2.1 Matt Bivona

While progressing though the electrical engineering courses in college I have been able to learn how to engineer both hardware designs and software applications. These courses were demanding and required a lot of concentration, but by remaining studious I have been able to complete these difficult courses. I finally had a chance to apply my knowledge that I have learned from these courses as an engineering student. I was proud to notice that I was able to successfully cooperate with a team to create such a complicated design which has to function as a safety system. The team has proven to be both reliable and resourceful allowing for us to be able to research parts, cooperate with the four other industrial engineers and one business major, and combining our knowledge to create a complex product. Looking ahead into the next semester I am excited to finally construct this project and turn it into a reality instead of just a concept design. This project has been very interesting to research and I am willing and ready to create this great project to try and help save children.

10.2.2 Michael Covitt

Progressing though the computer engineering courses has allowed me to learn how to engineer both hardware designs and software applications. The courses were not easy and I had to learn a lot of material over a short period of time, but I remained confident and studious. Over the last semester I finally had a chance to really apply my knowledge learned from these past years as an engineering student. I was proud to notice that I was able to successfully lead a team to create such a complicated design which has to function as a safety system. My team has proven to be both reliable and resourceful which has allowed us all to combine our knowledge efficiently and create a great product.

Looking ahead into the next semester I am excited to finally construct the safety insert. I am eager to witness the process of bringing something our team has created on paper and bring it into the material world where it will be used to save the lives of young children. Now this project was a first test to determine if making senior design a mixed major class was a good idea and I can conclude that while it is a good idea some modifications should be made. The two senior design classes should be merged into an actual class not just sticking two groups together with a similar product because the IE and EE teams had completely different deliverables and not much information could be shared between the teams. Will all this being said I still believe this project has great potential and I will to my very best to make sure it is a successful product.

10.2.3 Jason Nagin

I have always enjoyed learning something new and then putting it into practice. This project has allowed me to learn the necessary skills to program on an ARM microcontroller. It has also allowed me to learn about the SPI protocol and more detail about ADCs. This new knowledge should allow me to create more advanced system in the future. I'm also glad I got a chance to create something that could potentially save lives and am excited to see if a commercial product is sold in the future using this system as a baseline.

10.2.4 Donnell Robinson

As I have been going through the Electrical Engineering courses in college I have learned a lot about how to build hardware systems and design software. The classes have taught me that not only learning the concepts of how things are applied is important but also the hands on experiencing is important when it comes to actually troubleshooting certain problems that might arise while building a prototype or device. Each course although very taxing and demanding with studying has taught me valuable concepts that will help me with my future engineering profession.

The team has proven to be fully competent and we have come together to complete a successful prototype and great design that seems straightforward to implement. Being able to cooperate with other engineering professions has helped me to be able to accomplish cooperation with other engineering professions just like in the workplace. I have worked with other electrical engineers, computer engineering, and industrial engineers. The next semester will be great since the project construction will be under way and the project is an extremely great concept idea. This project has been very interesting and will save many lives in the long run.

10.3 IE/BS Personal Reflections

10.3.1 Gabrielle Edelmann

The redesigning of a safer car seat has been a comprehensive project that included industrial engineering leanings, design skill, electrical expertise, and marketing finessing. I learned that each member of the team brought a unique perspective whether it was with innovation, design, production, etc. I found working with other disciplines made for a nice exit out of the engineering program and into the real-world, where we will be working with others that have different education backgrounds.

I believe the simulation of the application is very user-friendly. With the addition of the Snooze Button, I think the overall product will appeal to more audiences because those parents that leave their children in the car, with the door open to put away groceries, will now be able to have the option to deny the car alarm sounding. This is a great idea because every 10 minutes (or however long) the Snooze Symbol re-pops up to remind the parent about their child. My future expectations include this button as well as inserting the electrical components into actual car seat cushion pieces. In addition, for the higher level security option, car companies will need to provide our team with the programming necessary to override the system. I look forward to the final result!

10.3.2 Ching Fang Chang

Senior design has been a great experience for me. This project has allowed me to apply my knowledge from the previous years which has been both exciting and rewarding. I have met a lot of reliable colleagues and friends during this class and I hope the best for them as they graduate. I will use the skills I learned of team building, time management, and detailed research during my upcoming graduate classes while I get my master's degree. I believe this project has great potential to save lives in the real world and I wish it great success in the building phase next semester.

10.3.3 Eliezer Lorenzo

The need for a security feature in car seats is an undeniable in demand today. There are hundreds of reported cases of deaths of recent years, and countless more than have not been recorded. This project has enlightened our team the importance of a safety precaution in car seats in regards to forgotten infants in vehicles.

The future of this project has multiple applications along with multiple paths. This project was made to spark an idea that would take the security and convenience of infants in car seats. I expect this idea to continue to grow into a product that will be a standard in car manufacturing just like a seat belt in cars today. The project has not only informed me greatly on the issue at hand but how to create an idea to a project and with proper team work that anything is possible.

10.3.4 Rewel Maldonado

From this senior design project, the most important concept I learned was the importance of collaborating with everyone on a team, specifically people that are not familiar to you. What I mean by this is that in the real world workforce, whatever company you work for will not segregate the business based on what degrees were achieved while in college. Businesses are generally broken up into functional departments, and in this project's case, we had a similar structure in our team. It allowed all team members to collaborate together and contribute towards this project.

I believe this project is incredibly useful to people around the world, and I feel it will escalate into something that everyone involved with the team can reflect and feel that made an impactful difference on the world for safety. I expect that this project will end up being marketed to vendors and sold in stores within a few years at the latest. The knowledge I learned from this project will definitely be useful in my future work life, specifically being able to collaborate with other people to create good ideas together for the good of whatever company I happen to be working for at the time.

10.3.5 Jodi Sweatland

As an Accounting student who volunteered to help out with Senior Design, I learned to work with a cross functional team of several types of engineering students. The project took us in several different directions. The team was able to work together to solve problems and improvise at a moment's notice. This project has been an emotional roller coaster for me. Since research is a large part of the Industrial Engineer's portion of the project, we researched a number of sad stories that involve children's deaths which were described in heart-wrenching detail. Those stories gave me the drive to work harder for a solution. I personally am looking forward to see the build of this project. As a business student, we rarely see a project that we have dreamed up come to life. It's exciting to be part of such a unique team.

Appendix A - Copyright Permissions

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ANEIROS - STATUS: PENDING APPROVAL

aneiroschildseat@gmail.com

To Whom it may concern,

I am a student at the University of Central Florida. My group and I are designing a child safety system for our senior design project. During our research we found your design very interesting and with your consent, we would like to include some information and visuals from your website and patent in our paper. This data will be used to describe your design and explain the differences between both of our designs. Please let us know if you have any questions.

Thank you for your time.

Michael Covitt

UCF Student

BABY SEAT INTERNATIONAL - STATUS: PENDING APPROVAL

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To Whom it may concern,

I am a student at the University of Central Florida. My group and I are designing a child safety system for our senior design project. During our research we found your design very interesting and with your consent, we would like to include some information and visuals from your website and patent in our paper. This data will be used to describe your design and explain the differences between both of our designs. Please let us know if you have any questions.

Thank you for your time.

Michael Covitt

UCF Student

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You have permission to use information from my site with attribution. I also suggest that you read item #4 on my FAQ page (http://ggweather.com/heat/faq.htm).

Regards,
Jan Null

Certified Consulting Meteorologist
Golden Gate Weather Services
Phone: (408) 379-7500
Email: jnull@ggweather.com
Web: http://ggweather.com
Twitter: @ggweather

From: Michael Covitt [mailto:mike.covitt@knights.ucf.edu]
Sent: Monday, March 30, 2015 8:21 AM
To: jnull@ggweather.com
Subject: Copyright Permission

To Whom it may concern,

I am a student at the University of Central Florida. My group and I are designing a child safety system for our senior design project. During our research we found your heat statistic maps very interesting and with your consent, we would like to include some information and visuals from your website in our paper. This data will be used to describe the need for our child safety seat design. Please let us know if you have any questions.

Article Link: http://www.ggweather.com/heat/
Requested Visual: Child Vehicular Heatstroke Deaths by State
Visual Link: http://www.ggweather.com/heat/state_totals.jpg

Thank you for your time.
Michael Covitt
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My group for senior design are considering using your Tiva C chip, MSP430, LMX5252,and CC2540T for our senior design project at University of Central Florida, and we were wondering if we could have permission to use diagrams and information from your data sheet and antenna document in our project paper.

Thanks,
Matthew Bivona]
[Category: eStore]

Appendix B - Works Cited

Diamond, D. (2014, July 12). *Op-ed: Can parents really forget kids in cars?* Retrieved from HLN: http://www.hlntv.com/article/2014/06/30/cooper-harris-child-dies-hot-car-why-parents-forget

NHTSA Child Seat Research. (n.d.). Retrieved March 30, 2015, from http://www.nhtsa.gov/Research/Child+Seat+Research

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Appendix C - Research Surveys

Survey 1: UCF Nemours Child Car Seat Design Project

1. **Gender:**
- ❑ Male
- ❑ Female

2. **Age:**
- ❑ Under 25
- ❑ 25-35
- ❑ Over 35

3. **Marital Status:**
- ❑ Married
- ❑ Single

4. **Do you work? Yes No**
- ❑ Number of hours:
- ❑ Under 20
- ❑ 20-30
- ❑ 30-40
- ❑ More than 40

5. **How many kids to you have?**
- ❑ 1
- ❑ 2
- ❑ 3
- ❑ More than 3

6. **Have you had any of the following issues in the last 12 months?**
- ❑ Death of a loved one
- ❑ Divorce
- ❑ Move to a new City
- ❑ Major Illness or you or a loved one
- ❑ Job Loss
- ❑ None of the above

7. **Do you use smoke detectors in your home?**
- ❑ Yes
- ❑ No

8. **Do you wear a seatbelt while in a motor vehicle?**
- ❑ Yes

- ❑ No

9. Do you think Car Seat Safety is important?

- ❑ Yes
- ❑ No

10. Research states that there is a syndrome called "Forgotten Baby Syndrome" Basewhereby overstressed individuals forget their children in their car seats as easily as one could misplace their car keys or forget their coffee on the roof of their cars. Would you purchase a device that would help to prevent such happenings?

- ❑ Yes
- ❑ No