University of Central Florida

DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

EEL 4915L: Senior Design II

Final Document

Project: IntelliDate

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1 Executive Summary

The world we live in is always advancing in technology day by day. Our everyday tasks have begun to rely on computers more than they ever have before. Technology is evolving at an exponential rate and we are constantly seeing updates and improvements to the very things that were once seen as a large step forward in our humanity. From the way we travel, to the way we communicate, we have experienced the constantly progressing technology that has become an integral part of our lives.

It is hard to find one thing in our life that does not depend on technology in some way. One example of this is scheduling. In some companies, schedules are still being tracked on white boards and on paper but rely on technology when these schedules need to be communicated to the team. While others have been able to create and track their schedules using software programs, there are many downfalls to the software currently available. With schedules changing just as often as technology, it is important to make sure your tools are not inadequate, which is why we are creating IntelliDate.

IntelliDate is a low-cost, wall-mounted, central hub, in the form of an LCD display panel for common calendar applications utilized by the customer. The panel will display a monthly, weekly, or daily calendar view, combining all events from the customer's linked calendar applications (Google Calendar, iCloud, Outlook) into one wall-mounted display. To maintain a low production cost, the panel will not include touchscreen capabilities, but will instead be paired with the IntelliDate mobile/desktop application, that the customer will utilize to interact with the panel. Our product is a quality-of-life enhancer in the aspect of event organization and adaptive updatability at the changing of logged events.

In this project, our group decided to use a monitor as a display system because it was the perfect size. We wanted the monitor to be transportable depending on the circumstance of the ideal environment our project was put in. one of the group members had an extra monitor to use so it did not cost us a dime. The monitor happened to be an LCD monitor too. Which is a little bit less expensive than the LED that has better contrast and resolution. We also had a few televisions to choose from, but we saw that the televisions were bulkier and more difficult to move from place to place if someone wanted in a different location than before.

After deciding on what display, the next step was how our group was going to create the app. From this part the CE majors did some research on some app making programs.

The next step was to research microcontrollers and choose which one to use. For this our group looked at three different microcontrollers. After looking into each one we had to decide which one was best suited for our project. From looking at similar project like ours most people used the raspberry pi. From this we learned the concept of what we need as far as a microcontroller. So, we decided to use the Arduino, one of the main reasons for the choice over the raspberry pi was because we have not really used the raspberry pi and feel comfortable with the coding aspect of the Arduino.
Then we had to decide if we wanted the controller to be a separate or connected to the monitor. We decided that it would be easier and look better if we connect it to the monitor

unless the customer wants it to be portable and transfer from display to display. So, we will make a portable box out of plastic and put it inside the monitor. On the microcontroller we need a PCB attached to it. In this project we need WIFI, HDMI, and a battery source connected all to the microcontroller. This is where the PCB comes in handy, so we design our own PCB to connect our app to the microcontroller then display it onto the monitor. The microcontroller that our group chose is very slime and will not be too bulky compared to some other.

The last step to our project is deciding how to power everything together. Whether to use a wall outlet or use batteries. So, the group decided that batteries would be the better option because it looks better as a presentation and makes the project more complex in design. Now the problem is what batteries to use, then we must use voltage regulators for the microcontroller since it can only handle from 3.3 to 5 volts input. That is where the PCB comes into play to make a circuit to where the resistors and capacitors if needed help regulate the voltage.

Then we had to read about the standards of each material needed in the project. This is necessary because a project must meet the standards which protects consumers by ensuring safety, durability, and market equity. To touch base on each of those, safety plays a big role in standards, reading about the material and how it can harm the environment and even a human is especially important. Standards help development by ensuring equal opportunities to anyone not just the rich or the poor. They allow information about the product available for the consumer, so they know how it made and what they are getting ahold of.

Finally, is testing the product. The group must get together and make sure the product is working proper and efficiently. Some good advice from the professor is to build the PCB on a bread board and test it to make sure that the circuit works. So that we do not spend tons of money buying multiple PCB or frying the monitor. There is so many reasons to test the product out by using prototypes instead of going all in on the main equipment for the project.

2 Project Description

This section of the project shows the motivation and goals behind the development of IntelliDate. Then talks about the potential marketing of the project and how to market the product to the world. Since the world is in an epidemic the only way right now is to advertise through the internet.

2.1 Motivation

After using a dry-erase whiteboard calendar for several years, common complaints have always been: the lack of space in each day-block for multiple events, the never-ending monthly task of reupdating the calendar's dates, and past-month history being lost upon erasing the whiteboard's contents.

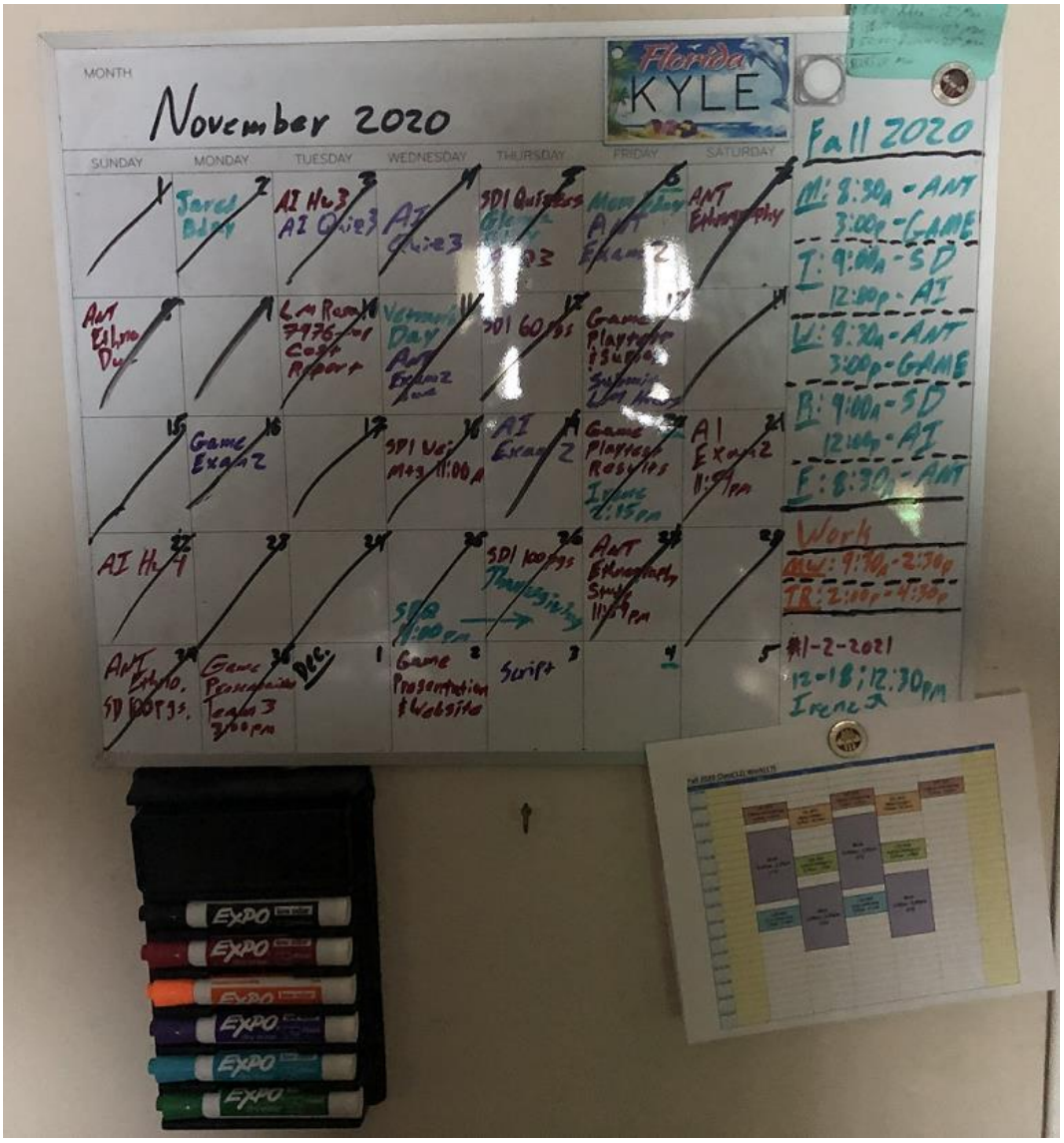


Figure 1: *Dry-erase board calendar*

Having a wall-mounted calendar is much more present than a mobile application yet lacks the ease of update and maintenance that software calendar applications provide. Another issue with the software calendar applications stems from the wide variety of software available, including but not limited to Gmail, iCloud, and Outlook. Though these applications provide methods of linking events between them, the events still reside on an application only viewable with a mobile or desktop device.

As Computer and Electrical Engineering students, we believe this topic will be a perfect project for Senior Design, incorporating Electrical Engineering topics for design and manufacture of the panel, and Computer Engineering topics for design and integration of the display contents and paired application.

There has been time and time again where people get disorganized with their schedule and have a hard time knowing whether they completed the task they set for the day was completed that day. As a student there is so much potential in how this will help having an app that the student can get on with their phone or laptop and update what they need to do. Then it displays on the monitor and it has the perfect size to display. This is so much better than buying a calendar and flipping every month. There is also the amount of space in each box of the schedule. This happens time and time again with the paper calendar and white boards. The person either must write smaller or make a note on the side of it.

Another motivation is in the workplace. People still use paper scheduling. This is outdated when technology is advance at a fast rate. When at work there can be a schedule on the side small enough so customer cannot look at private information but big enough where the employee can see the schedule. The app lets people update in on the spot and this is nice for the environment. Trying to cut back on the paper used every year for calendars and schedules made.

2.2 Project Goals and Objectives

Our goal is to design and manufacture a low-cost display panel that the customer can sync with all calendar applications currently in use. Along with manufacturing the hardware, we will also design and integrate a software application that will be used to communicate with the display (e.g. changing views (monthly, weekly, daily), linking other calendar applications, setting panel brightness level, connecting panel to Wi-Fi network, etc.).

The objective is to make the app user friendly. The way to do this is by making a schedule easily manipulated and made to where the user likes the system. This app should have options to create the schedule how they want it horizontal or vertical the size and type of the font. There should be crossing out of the schedule and other functions to let the user stay organized.

Another objective is to make the right chose on the size of display. The objective is to make it a certain size that it is accessible to see from a certain distance to where the user feels comfortable that others see the screen or if they do not want others to see the screen for personal reasons. This is another conflict that could affect our consumers. The refresh time

could be another issue if people want the application to update immediately when they put the update the schedule.

2.3 Potential Marketing

There are some companies that still use paper as schedules and our project will help the companies get into a technology environment that is simple and easy to use. If they switch to this product it would save them time and save them on spending money on paper and other expensive scheduling devices. There are limitless options the product could do. But first the product will have a schedule, weather, and time on it. This is good enough to go into the market help companies move with the technology times.

The next customer is the everyday scheduler for home. People that like to plan everyday and have their schedule displayed at home and see what's planned out. This will be nice to consumers because it is removable and can change if the customer wants to remodel the living area and move the monitor somewhere else on the wall. Most of the similar products are stuck in one area.

IntelliDate provides the user with a digital central hub for all events that would typically be logged in any other calendar. The ability to sync events from all other calendar applications used by the consumer, along with the presence offered by a wall-mounted device, rather than a mobile or desktop application, will be the selling points that will encourage consumers to purchase IntelliDate.

Aside from personal use in the home, we believe this product would be useful for many other areas of life, including but not limited to restaurant staff scheduling, office-space meetings and due dates, and classroom activity management/communication.
Other companies (DAKboard) have manufactured products like this, but require a premium cost for a simple home appliance. We plan to offer a product that provides a solution to issues raised in our motivation, for a more realistic price, to average customers.

2.3.1 Go-to-Market Strategy

Although many products (95% of them) fail, creating and implementing an effective go-to-market strategy cannot guarantee success, but can certainly increase the chances of a products success, within the marketplace. A go-to-market strategy can be described as follows: "If your product is Point A and your customer is Point Bm then a go-to-market strategy can be described as everything that happens to build a bridge between the two. You have a product and need to find a way to get it in front of the right people. This includes figuring out marketing, a sales method, your ideal customer base, an attractive price, and the unique problem that your product solves or improves."[122]

The seven steps of formulating an effective go-to-market strategy consist of the following: "What are your target markets?", "Who are your target customers?", "What about brand positioning?", "What are you offering?", "What are your channels?", "How will you build your budget model?", "What is your marketing strategy?"[122]

Figure 2: *Seven easy steps to formulate an effective Go-to-Market strategy*[122]

2.3.2 Marketing Strategies

There are many available options for advertising IntelliDate to the public. We plan to take advantage of the massive reachability provided by various social media sites, along with advertisement opportunities offered by popular websites. Right now, the whole world is going through COVID-19 and everyone is on social media because of quarantine. this is where social advertising is booming.

2.3.3 Social Media Advertising

Many products are successful in advertising via social media, including but not limited to: Facebook, Instagram, Snapchat, and Tik Tok. Along with submitting advertisements to the social media company themselves, users on the sites, with large followings, accept payment to create posts advertising certain products. Once a consumer demographic is defined, various accounts that have large followings within that demographic will be approached and offered payment to display ads regarding our product. Along with social media, these same concepts can be implemented into both the YouTube advertisement system, and the various broadcasters that will create a video displaying our product.

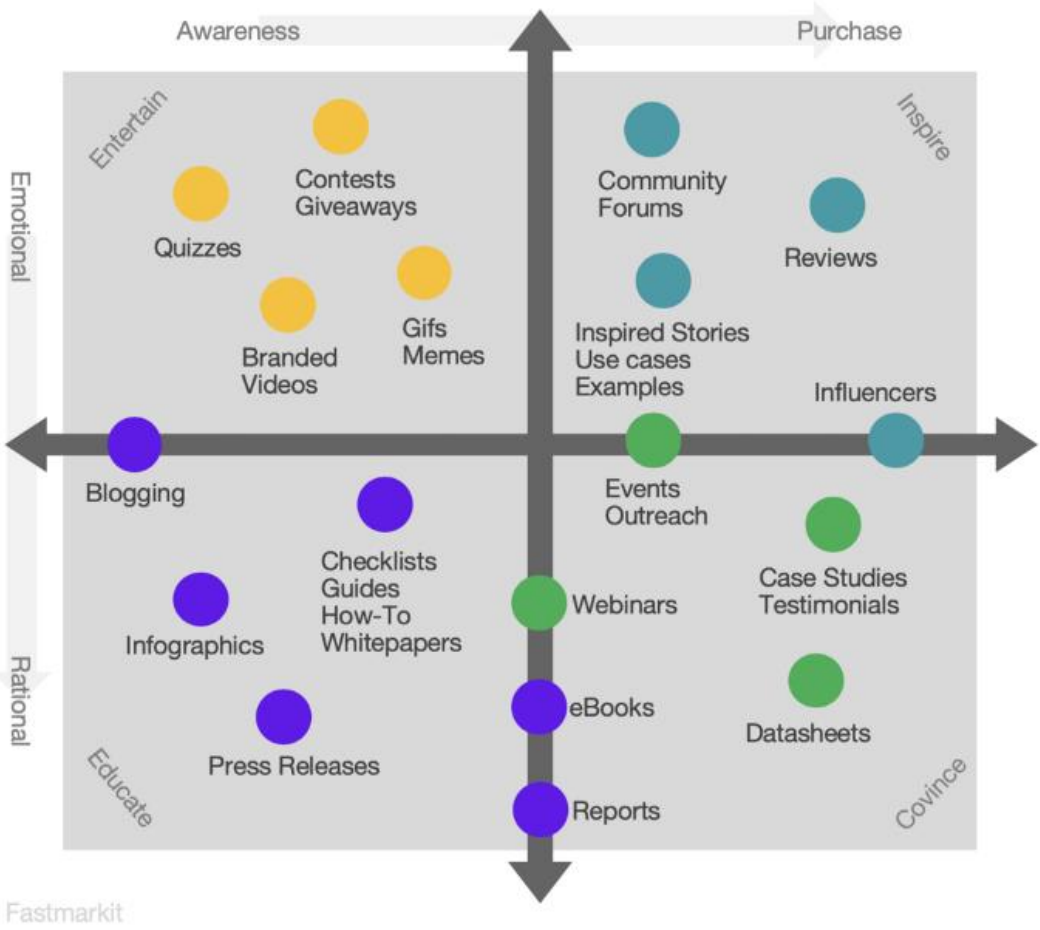


Figure 3: *Creating content to support your product*[122]

2.3.4 Defining the Consumer Demographic

There are many applicable scenarios that highlight the usefulness and desire for a product like IntelliDate. As college students, the most relevant demographic to us would be other college students, as there is a constant feed of events to maintain awareness of, including but not limited to: assignment deadlines, course appointments, social events, exams, registration deadlines, and work scheduling. Although it is evident that college students live with extremely busy schedules, the same could be said for any other working citizen, as it is universal to have work scheduling, health-related appointments, social events, birthdays, holidays, and just about any other event that would require some sort of scheduling.

Aside from personal use, businesses would be able to take advantage of this product as well. Working as a restaurant server for four years, IntelliDate would certainly prove as an efficient tool for restaurants, allowing the consistent updating of all scheduled staff to be displayed on a wall-mounted panel for all employees and managers to view. Working in an office, it can also be assumed that IntelliDate could find its place in an office space, displaying upcoming meetings, deadlines, and special work-related events.

2.4 Engineering Requirement Specifications

Table 1: *Engineering Requirement Specifications*

Specification Number	Specification Description
1	User will utilize sister application on PC and/or mobile device for communication with panel.
2	Display will have a resolution no greater than 1920x1080 pixels. Display will utilize LCD format.
3	Calendar view will update, automatically, upon the addition of events by user and natural transition of month, day and week. Upon the manual addition of an event, panel will take no longer than 10 seconds to display the updated contents.
4	Panel will be battery powered with the option to power/recharge via wall-plug.
5	Panel will have the option to be wall mounted.
6	Panel will connect to Internet through Wi-Fi network.
7	Inner components will communicate with display through HDMI and USB ports.
8	Final product will cost no more than $200 to produce.
9	Display size will lie in the range of 20” to 40”
10	Battery life of panel will be displayed through green, yellow, and red LEDs (Green: 100%-80%; Yellow: 79%-40%; Red: 39%-~0%).
11	Sister application will allow user to set a custom brightness level, as well as set routine times for certain brightness levels to activate.

2.5 Related Work

Digital wall calendar and home information center
This is a similar product we saw online. This product is mounted inside the dry wall. It is made from a 22" LCD television their goal was to make a household item to have everyone schedule instead of buying a wall calendar.

So, their wall mount calendar consists of:

- Calendar from google calendar
- Local weather forecast from forecast.io
- Local traffic map from google maps
- Displays the house temperature, humidity, and house status.
- Monitors the server of the devices of the house.
- Turn off and on
- Small chalk board from google docs
- Microcontroller – raspberry pi

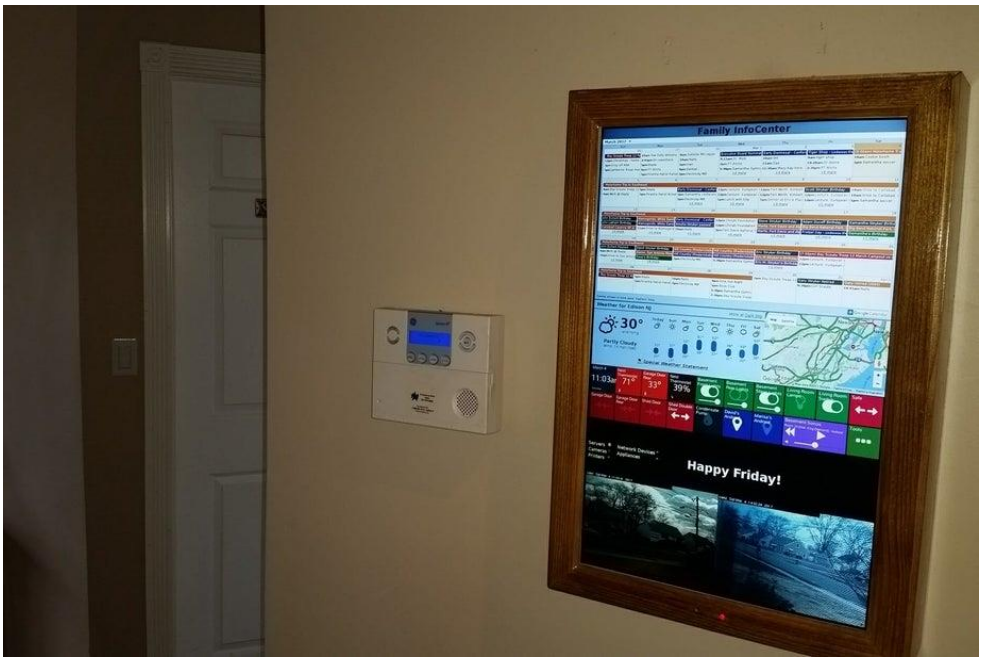


Figure 4: *Digital wall calendar and home information center* [41]

From this we can see that their design is mainly for the house. From our marketing section we are trying to go to the commercial and noncommercial side and just have a calendar and a forecast for the area. We want to create a product that can be moveable from place to place in if needed. Then we want to create our own app that does this without using multiple sites to see different applications. This is basically a tablet on the wall. There is another product that is an adapter like the one we want but charge people to use there service our application will be free of charge.

2.6 DAKboard

The DAKboard is a pre-existing product, currently on the market, very similar to the product we are envisioning with IntelliDate. On the DAKboard website, the product is described as: “a simple and elegant way to display your calendar, photos, weather, and lots more.”[123]

The DAKboard is a wall display that acts as a central hub for the calendar functionalities we plan to implement into IntelliDate, along with other features, such as weather and photos, but for a premium price of $399.95. Though a product of the same nature already exists within the market, we are not discouraged, but in fact even further encouraged, as we plan to introduce a similar product at a much more affordable cost.

Figure 5: *DAKboard wall display*[123]

2.6.1 DAKboard CPU v4

This is another similar product to the one we are trying to make. This device lets the consumer hook up their own monitor or television to this device. As a secondary product from DAKboard, aside from the wall display, the DAKboard CPU can be connected to a separate display, enabling the same functionalities as the DAKboard display, but reducing the cost of the DAKboard product, as a display is to be purchased separately, by the consumer.

The component is powered by the Raspberry Pi 4B. This can display 4k video output. This product connects through WIFI or can connect through the ethernet cable. It weighs about 46 grams. This device is needed to be plugged in to an outlet to keep it running. It also needs a fee monthly for the service which can cost from five dollars to thirty dollars depending on what the customer wants to do with the calendar certain settings.

Figure 6: *DAKboard CPU*[124]

This product contains:[124]

- DAKboard CPU 4 (Raspberry Pi 4B, 2GB) with 16GB Micro SD card installed
- 3 months of DAKboard Plus
- AC Power adapter
- HDMI Cable
- Quick setup instructions
- Dimensions: L 3.5 x W 2.3 x H 0.76 inches
- Power Requirements:120v AC - Includes 5V, 3W micro USB C power adapter. U.S. plug

Our device will be free of charge and the consumer will just need to buy the component and download the app. It will also be battery charged, so there will be no wires hanging out of nowhere to look more professional and cleaner. Our device will be smaller based on the dimension shown above. The similarity to this device is that we have both made our own scheduling and have about the same outlets for connecting the monitor or television to the device. For the components we share HDMI port, USB, and a power supply port.

2.7 Project Block Diagrams

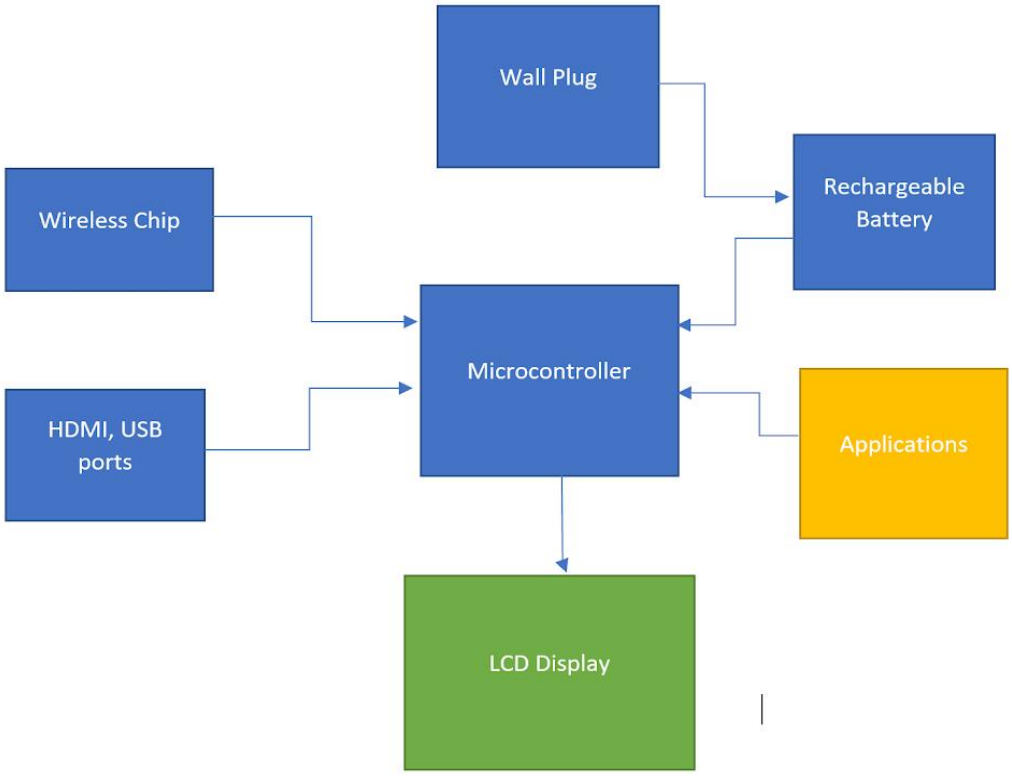


Figure 7: *Project Block Diagram (Technical Components)*

Kory and Dat will oversee the tasks in the blue boxes, while Kyle and Tyler will work on the yellow box which is an application to connect the calendar with devices. Green box indicates final touch where everyone will work together for the final product.

Figure 8: *Project Block Diagram (Functional Components)*

2.7.1 Team Member Responsibilities

Kyle Dennis & Tyler Claitt (CpE)

- Design software application for PC and mobile device
- Configure panel networking capabilities
- Implement customizable brightness setting for display panel
- Design calendar layouts to be displayed on panel
- Integrate other features as they arise (ex. Insertable “Notes” section)

Kory Marks & Dat Tran (EE)

- Physical component design and configuration
- Implement power supply with rechargeable battery
- Integrate battery power level LED indicators

3 Research and Part Selection

3.1 Application Software

Application software is defined as a program or group of programs designed for end users, commonly used to help the users perform a task. Implementation variations of application software include web browsers, media players, digital video games, text processors, media/data sharing, and countless others. In the early stages of application software, common examples of such would include tools like calculators, text processors, and even email. An application program is software that processes data for the user. Except for "system software", which provides the infrastructure for the computer (operating system, utilities, and related components), all software programs are application programs.[4]

Application software has many different implementations amongst various topics. For example, in the world of entertainment, application software refers to games. In the world of business, application programs refer to data entry, update, query, and report programs, acting as the essential building blocks for a business's information system. Application programs can also refer to a generic application, also known as a "productivity program", such as a spreadsheet, Web browser, database, text processor, or email program.[4] Application software can be distinguished into one of two classes: closed source software applications and open source software applications. Of these two classes, application software can be further classified into free or proprietary software applications.

3.1.1 Open and Closed Source Software

Closed source software is software that holds the source code safe and encrypted, meaning, the user can't copy, modify, or delete parts of the code without some type of consequence (be it voiding a warranty or legal repercussions).[14] Open source software is the complete opposite of closed source software, meaning, the user is allowed to copy, modify, or delete parts of the code under their own discretion.[14] With open source software, the user is also allowed to use code from the open source software in their own program with no consequence.[14] Closed source software can also be referred to as proprietary software, or non-free software. Naturally, in converse to closed source software, open source software can be referred to as free software.

3.1.2 Web Applications

As technology developed, applications began to spread into more diverse functionalities, such as the broad topic of web applications. A web application is application software that runs on a web server, for end users to access and utilize via their web browser, with an internet connection to the web server, from which the web application is running. Web applications refer to applications accessed vis Web browser over a network and are developed using browser-supported languages (e.g. HTML, JavaScript).[1]
Web applications refer to websites that have similar functionality to desktop or mobile applications. This definition is what distinguishes a dynamic webpage, of any kind, from a "web application". With HTML5 (an updated version of the HTML programming

language), support for creating applications that are loaded as webpages, but can store data locally and continue to function when offline was introduced.
Some examples of common web applications include online retail stores, online social media sharing, online banking, and second-hand selling.

Figure 9: *Graphical flow diagram of a web-based application*[5]

3.1.3 Client-server model

The client-server model is a distributed application structure that partitions tasks or workloads between the providers of a resource or service, called servers, and service requesters, called clients.[2] Web applications are based on a client-server modeled structure, meaning that the user (client) is able to access and utilize the functionalities provided by the web application through a connection to the separate server from which the application is hosted.

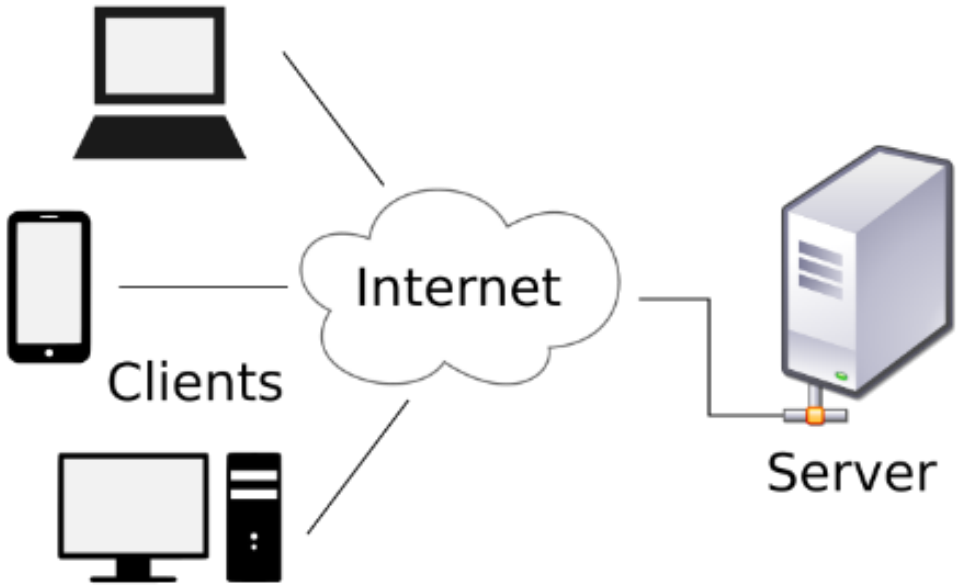


Figure 10: *PC network diagram of clients communicating with a server via Internet* [3]

In a client-server model, servers are classified by the shared services that they provide to clients. Two variations of servers are a web server and a file server. While a web server is responsible for providing web pages to clients, a file server is responsible for providing computer files to clients. The primary benefit of client-server architecture is the sharing of resources from a server, also known as "services". Resources that the server shares with clients consists of the server-machine's hardware and software components, ranging from applications and data to processing power and data-storage capabilities. Service-oriented computing utilizes services as the constructs to support the development of rapid, low-cost, and easy composition of distributed applications.[1]

Primary software, modeled with the client-server architecture, yielded a split in the processing workload between the client end user, using the application, and the server, hosting the application. Applications of this nature would typically include a client program, separate from the server-side of the application, and would need to be installed on the end user's personal computer, acting as a sort of user interface. This early model of client-server software is slightly flawed, as upgrades to the server-side application would require upgrades to the client-side application, decreasing both cost-effectiveness and productivity yielded by the application as a whole. Currently, web application code is executed within the client's Web browser and proves to be an effective offload of required throughput, from the client to the hosting server. Hosting the application on the web server also allows for multiple clients to access and utilize the same application at the same time.

3.2 Types of Web Applications

The base definition of a web application is: "An application in which all or some parts of the software are downloaded from the Web every time it runs."[6] In web applications, the client always requests information from the server, and the client always interacts with the server through a user interface or application on the client side.
The different types of applications are as follows:

1. Browser-Based Web Applications
2. Client-Based Web Applications
3. Mobile Web Applications

3.2.1 Browser-Based Web Applications

Browser-based web applications, commonly referred to as "web applications" are executed entirely within the user's web browser.
Browser-based web applications use a three-tier database architecture, where the tiers consist of:

1. Client Layer (User system interface client environment)
2. Business Layer (Application logic or process)
3. Server Layer (Database management server environment)[7]

In a three-tier database architecture, the application logic or process resides in the tier between the client and server, effectively separated from the user interface and database information. Three-tier database architecture is complex to build and maintain, but offers great security, as the middle application logic and process tier prevents the client from

communicating with the database directly.[7] Three-tier database architecture is much more scalable, robust, and flexible than it's two-tier counterpart, utilized by client-based web applications. Browser-based web applications are hosted on a website, in a browser-controlled environment, by a third-party server, and are accessed via an HTTP (Hypertext Transfer Protocol) address over an active internet connection. Upon accessing the hosting website, JavaScript instructions, contained in the webpages, are retrieved. Within the user's web browser, these JavaScript instructions execute the HTML (Hypertext Markup Language) and CSS (Cascading Style Sheets) code to visually render the webpage. On the server side of the web application, processing occurs to access databases and other support functions. Data for a browser-based web application is stored in either a combination of, or solely on local client-side storage and/or web server-side storage. Browser-based web applications are platform independent, as they only require a web browser to run. In this case, the web browser would be the platform-dependent user interface, utilized by the client to interact with and retrieve information from the third-party server. Browser-based applications do not require any installation, and uses a single-user system, unlike client-based applications, which use two users, consisting of client and server.[8] Examples of browser-based applications would be Facebook(.com), YouTube(.com), or any other website that has similar functionality to desktop or mobile applications.

3.2.2 Client-Based Web Applications

Client-based web applications are applications that run on the client side and access a remote server for information. Client-based web applications are commonly referred to as client/server applications. Unlike browser-based applications, user interaction with the server stems from a client-based application that is always installed on the client's computer.

Client-based web applications use a two-tier database architecture, where the tiers consist of:

1. Client Layer (User system interface client environment)
2. Server Layer (Database management server environment)[7]

In a two-tier database architecture, the application logic or process resides in either a combination of, or solely within the user interface, on the client side, and/or the database, on the server side. In this architecture, the user interface is usually stored on the client's desktop environment, and the database management services are usually in a server that is a much more powerful machine, servicing many clients.[7] Two-tier database architecture is simple to build and maintain, but does not offer as great of security as it's three-tier counterpart, as the client communicates with the database directly.[7] Due to the nature of client-based applications, and the client-side locality of its corresponding user system interface application, client-based applications can be platform specific or platform independent (cross-platform), depending on the programming language used to develop the application. Client-based applications interact with a server on the web using standard web protocols.[6] In client-based applications, the server machine is a host that runs single or multiple-server programs, sharing their resources with clients. Clients always request information from a server without sharing any of its own resources.[8]

Table 2: *Two-Tier and Three-Tier Database Architecture Comparison*[7]

No.	Two-Tier Database Architecture	Three-Tier Database Architecture
1	It is a Client-Server Architecture.	It is a Web-Based Application Architecture.
2	The application logic is either buried inside the user interface on the client or within the database on the server (or both).	The application logic or process resides in the middle-tier. It is separated from the data and the user interface.
3	Consists of two layers : Client Tier and Database (Data Tier).	Consists of three layers : Client Layer, Business Layer and Data Layer.
4	It is easy to build and maintain.	It is complex to build and maintain.
5	Two-tier architecture runs slower.	Three-tier architecture runs faster.
6	It is less secured as client can communicate with database directly.	It is secured as client is not allowed to communicate with database directly.
7	It results in performance loss whenever the users increase rapidly.	It results in performance loss whenever the system is run on Internet but gives more performance than two-tier architecture.
8	Example – Contact Management System created using MS-Access or Railway Reservation System, etc.	Example – Designing registration form which contains text box, label, button or a large website on the Internet, etc.

3.2.3 Mobile Applications

A mobile application is a computer program or software application that runs on a smartphone, tablet, or other portable device.[9] Mobile applications were primarily intended for productivity (email, contacts, calendar, photo organization), but as smartphones became more popular, mobile applications began to skyrocket in development and have since reached out into further categories, such as: ticket handling, social media, games, online shopping, media players, GPS navigation services, and messaging services.

Mobile applications are generally downloaded from a software/application distribution platform (defined as: "A program that installs new applications or application upgrades on client machines throughout the network"[10]) owned and operated by the owner of the mobile operating system on which the mobile device runs (ex. App Store for iOS, Google Play Store for Android). Within the application distribution platform, mobile applications can be downloaded for free or at a charge. For the mobile applications that do not require

a purchase for download, profits are made through advertisements when using the application and/or in-app purchases.

In-app purchases are features that are not included with the native application but can be downloaded and installed if the user pays a premium. It is also common for many products to be sold with the inclination that a free mobile application can be downloaded as a working feature for the product. This marketing and design strategy is used with many products, including smart-home devices, such as Amazon Alexa, Phillips Hue LED Lightbulbs, etcetera.

Figure 11: *Amazon Alexa controlled with free mobile application*[137]

Unlike desktop applications, designed to run on computers, and web applications, designed to run in mobile web browsers, mobile applications are designed to run directly on the mobile device. Mobile applications are incredibly popular among users and continue to grow in popularity as smartphones and mobile devices experience a constant and rapid increase in processing power.

There are three classifications of mobile applications, listed as follows:

1. Native application
2. Hybrid application
3. Web-based application

3.2.3.1 Native Mobile Application

A native application can be defined as: "an executable program coded in the machine language of the hardware platform it is running in. Native applications are compiled into the machine language of that CPU. For example, Windows and Mac executable apps are in x86 machine language, while mobile apps are ARM based."[12] Native mobile applications are all mobile applications targeted toward a particular mobile platform. For example, a native mobile application developed for Apple's iOS will not run on Android devices. Consequently, native mobile applications are generally developed for multiple

platforms to maximize the breadth of targeted demographic. Examples of native mobile applications for Apple would include iMessage, FaceTime, (Apple) Maps, and (Apple) Calendar.

Examples of native mobile applications that have been developed for multiple platforms include Snapchat, Skype, Google Maps, and Google Calendar. Native mobile apps are tailored for a specific platform to achieve the best performance possible.
Contrast to web-based applications that are stored on a server and interpreted one line at a time by the browser's JavaScript and HTML interpreters, a native application will always run faster than the web-based application, because there is no translation taking place.[12]

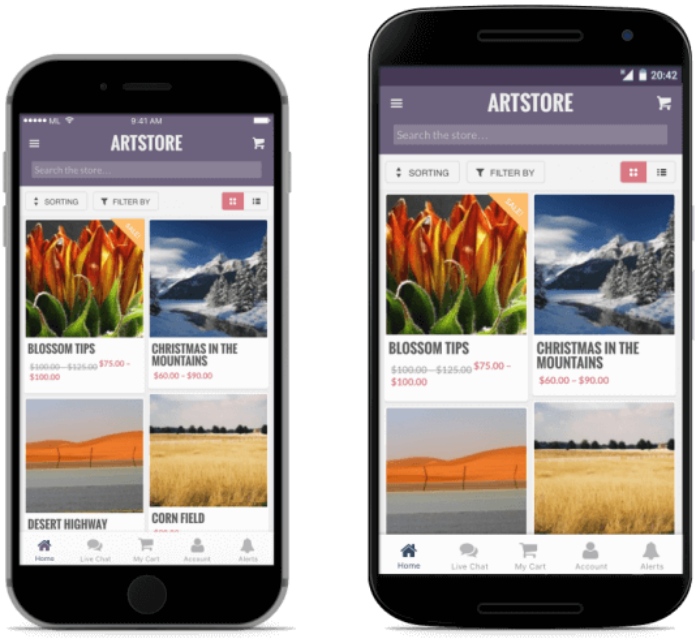


Figure 12: *Two fully separate native mobile applications for iOS and Android*[15]

3.2.3.2 Hybrid Mobile Application

A hybrid mobile application is defined as: "a smartphone or tablet application that is written in the standard Web programming format (HTML, JavaScript and CSS), but the Web elements (the "WebView") are wrapped within a native shell for iOS or Android. The shell allows the app to access inherent functions such as the camera, notifications, GPS receiver and sensors. As with a native app, the hybrid app must be installed and updated from the app store."[13]

The major advantage of hybrid mobile applications, as opposed to native mobile applications, is that the applications are cross platform making them easily changeable, across all platforms. There are also many more Web programmers than there are native iOS and Android programmers.[13] Hybrid mobile applications function much like mobile websites and tend to be more sluggish than native mobile applications, though this concern is appearing to dwindle as mobile devices gain faster hardware performance.[13] For mobile applications that require intricate animation, such as video games that demand complex programming, native programming is the only solution.[13]

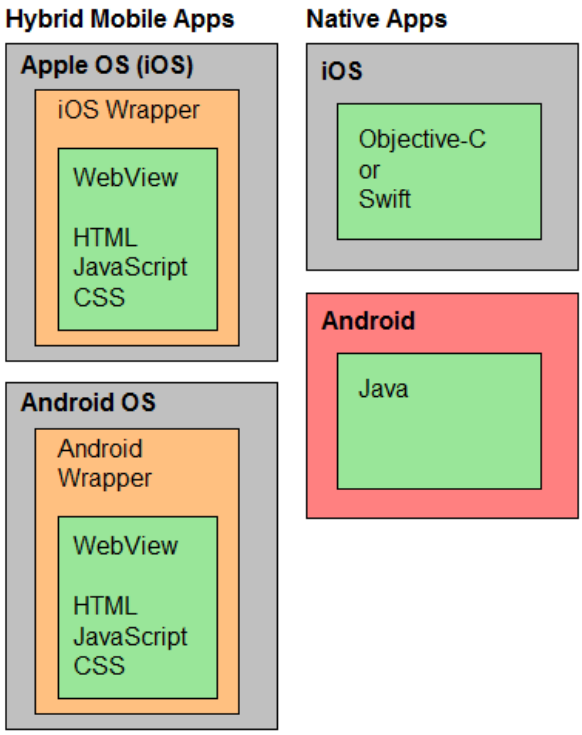


Figure 13: *Hybrid Mobile Application vs. Native Mobile Application*[13]

3.2.3.3 Web-Based Mobile Application

A web-based mobile application is a web-based application that the user accesses through their mobile web browser. Though web-based mobile applications require minimum memory from the mobile devices in which it is running, in comparison to native and hybrid mobile applications, users must have an internet connection to utilize the application and access their data, stored on the third-party hosting server.

3.3 IntelliDate Mobile Application

For our IntelliDate mobile application, we will most likely choose to develop a hybrid mobile application.

Developing a hybrid mobile application will be most beneficial, for our purpose, because the app will be compatible with all mobile platforms, when coded with the webpage programming languages, HTML, CSS and JavaScript. Creating a hybrid application, as opposed to a native application for iOS and Android is also the preferable option, because the knowledge of each platform's code base is not necessary to learn. Though the app will not be as fast as a native mobile application, this difference in speed will be negligible, as mobile device hardware continues to increase in processing power.

Displayed below is a comparison of the three previously covered mobile application classes:

Table 3: *Native Mobile Application, Hybrid Mobile Application, and Web-Based Mobile Application Comparison*

No.	Native Mobile App	Hybrid Mobile App	Web-Based Mobile App
1	Runs in device environment	Runs in device environment, using the mobile platform's WebView (a sort of "mini-browser" that can be configured to run full-screen)	Runs in mobile web browser
2	Developed with code language specific to mobile platform (Objective C or Swift for iOS and Java or C++ for Android)	Developed with webpage programming languages (JavaScript, HTML, CSS), Wrapped within native shell for mobile platform	Developed with webpage programming languages (JavaScript, HTML, CSS)
3	Must have a standalone version for each mobile platform (one for iOS, one for Android)	One version is cross-compatible with all mobile platforms	One version is cross-compatible with all mobile platforms
4	Difficult to update/manage across all platforms	Easier to update/manage across all platforms	Easiest to update/manage across all platforms
5	Lives in mobile device storage	Lives in mobile device storage	Lives in third-party server
6	Faster than Hybrid Apps, Faster than Web-Based Apps	Slower than Native Apps, Faster than Web-Based Apps	Slower than Native Apps, Slower than Web-Based Apps
7	Installed from software distribution platform (App Store)	Installed from software distribution platform (App Store)	No installation necessary; Accessed from web browser
8	Safe and secure, via required approval from App Store	Safe and secure, via required approval from App Store	Does not require approval from App Store
9	Must be updated from App Store, on each user's device	Must be updated from App Store, on each user's device	Updated automatically
10	Can be accessed without internet connection	Can be accessed without internet connection	Cannot be accessed without internet connection
11	Has access to system resources (sensors, camera, GPS, data from other apps)	Has access to system resources (sensors, camera, GPS, data from other apps)	Does not have access to system resources

3.4 Mobile Application Development

Throughout this section, the main topic of focus will lie on Hybrid Mobile Application development, as this is the route we plan to take for our IntelliDate mobile application. When developing applications for mobile devices, certain constraints and features of the devices must be considered. Particular mobile device-specific constraints and features to keep in mind, during development, are as follows:

- Battery capacity
- Processing power
- Various hardware specifications
- Location services
- Camera functionality
- Display size
- Display resolution

Developing a mobile user interface (UI) design is an integral part of the mobile application development process. Mobile user interface design considers constraints, contexts, screen size, screen resolution, input, and mobility as outlines. Centering the design of the user interface around the user, user input focuses on allowing the user to manipulate a system, and device output focuses on allowing the system to indicate the effects of the user's inputted manipulation. The overall goal of an effective mobile user interface is to provide the user with an understandable user-friendly experience. Considerations that increase likelihood of achieving this goal consist of: users' limited attention, minimal keystrokes, and minimal functions of a task-oriented nature. The user interface front-end of the IntelliDate mobile application will be responsible for allowing the user to interact with their IntelliDate panel, in a matter of configuring system settings (brightness controls), configuring network settings (Bluetooth and/or Wi-Fi connection), changing the display of the panel (daily, weekly, monthly, annually), and connecting their various calendar application accounts.

The user interface of a mobile application is referred to as the "front-end". The front-end of an application always relies on the back end to execute the desired functionality of the application. The mobile back-end is responsible for facilitating: data routing, security, authentication, authorization, working off-line, and service orchestration. The mobile backend functionalities are supported by components, located in the middle layer of the application's architecture, composed of a mobile app server, mobile backend as a service (MBaaS), and service-oriented architecture (SOA) infrastructure. The back end of the IntelliDate mobile application will be responsible for executing the desired functionalities, inputted by the user, via the user interface.

3.4.1 Mobile Application IDEs

When developing a mobile application, the utilization of a specialized integrated development environment (IDE) is required. Due to the rapid growth and demand of mobile applications, there are many mobile integrated development environments available for use. When deciding which integrated development environment to use, it is first important to outline what kind of mobile application will be developed. For example, as

explained above, the IntelliDate mobile application will be a hybrid mobile application, rather than a native mobile application. This decision, alone, rules out many available integrated development environments that are all geared towards a specific mobile platform, such as Xcode, Android Studio, and AppCode.[18] Rather, the integrated development environments we are interested in fall into the category of "cross-platform mobile integrated development environments".

With cross-platform mobile integrated development environments, mobile applications can be developed for one or more mobile operating system platforms, simultaneously. This enables developers to use the same codebase for a variety of different mobile operating systems. Though cross-platform mobile integrated development environments can be further categorized into three platforms (coding platforms, low-coding platforms, and no-coding platforms), we will be utilizing a mobile integrated development environment with coding platform development tools.

Coding platforms provide the developer with the most (full) control over the entire mobile application development process, given that the developer has a strong understanding of the coding language being utilized. A few mobile development tools with coding platform development tools to consider include: Appcelerator Titanium, Xamarin, React Native, Unity, and Flutter.

3.4.1.1 Appcelerator Titanium

Appcelerator Titanium is an open-source software development kit for cross-platform mobile development. Appcelerator also provides the Appcelerator platform, which provides cross-platform native mobile application development using JavaScript, mobile backend as a service (MBaaS), mobile test automation, crash detection, performance management, and mobile analytics.

Appcelerator seems like a satisfactory option for our purpose, but offers a free and premium version, with a monthly fee of $199.00, which leads me to believe that another more cost-effective option may be the optimal selection.

3.4.1.2 Xamarin

Xamarin is a Microsoft-owned mobile application development platform that helps designers and developers build native iOS, Android, and Windows applications, using a single shared .NET code base. Xamarin utilizes Visual Studio Tools, an open-source Microsoft owned integrated development environment, to build native mobile applications.

Xamarin and Visual Studio Tools offer many features, including code editing, refactoring, debugging, testing and cloud-publishing. Xamarin requires a monthly premium of $25.00, but also includes a free trial period. Using Xamarin also requires knowledge of the .NET coding language, as opposed to JavaScript.

3.4.1.3 React Native

React Native is an open-source cross-platform mobile application framework, created by Facebook, based on JavaScript technology. React Native is used to develop applications for Android, Android TV, iOS, macOS, tvOS, Web, Windows, and UWP by enabling developers to use React's framework along with native platform capabilities. React Native is virtually identical to React, except that rather than manipulating the document object model (DOM), React Native interprets JavaScript code, in the background, directly on the mobile device and communicates with the native mobile platform vis reformatting the code into instructions native to the device (serialization).

React (also referred to as React.js or ReactJS) is an open-source, front end, JavaScript library for building user interfaces or user interface components. React is responsible for rendering UI components, constructed with HTML code, in the document object model. React allows for the creation of single page applications (SPAs) by interpreting HTML code within the JavaScript code base. This effectively loads and unloads HTML code, within the user interface, dynamically, rather than requiring a new HTML webpage to load with each changing of a component within a webpage.

Some of our team has prior experience utilizing React to create a web-based application, and we will highly consider implementing React components into our user interface for the IntelliDate mobile application.

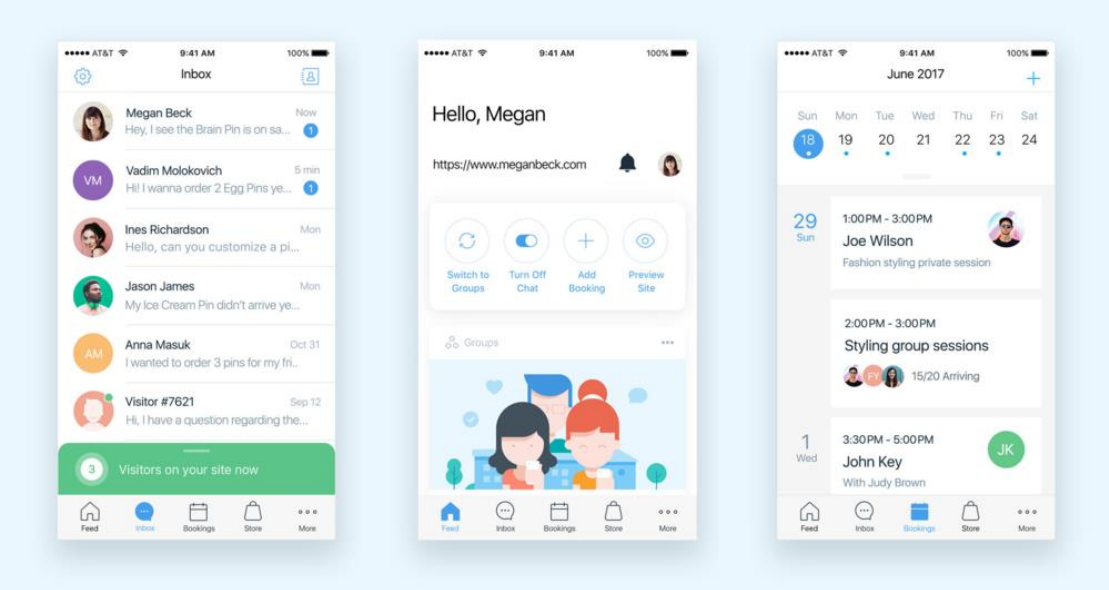


Figure 14: *Example of mobile applications developed with React Native*[19]

3.4.1.4 Unity

Unity is a cross-platform game engine and integrated development environment, developed by Unity Technologies. Unity is used to create three-dimensional, two-dimensional, virtual reality, and augmented reality games, as well as simulations and other experiences for Android, iOS, Windows, consoles, and many more platforms. Though Unity is extremely

useful for game development (and primarily aimed towards such), its use is not limited to games only. Unity can also be used to build tools, utilities, business applications, and more.

One of the major advantages Unity has over previously mentioned development environments is the C# codebase used in Unity to create applications. Unity also offers an exceptionally intuitive and effective user interface. Many operations can be completed by simply drag-and-dropping elements, rather than hardcoding them as you may have to do in another development environment. Unfortunately, along with the various functions Unity offers to assist the developer comes a fair amount of code, required to support them. This will effectively increase the size of the application, which turns many developers away from utilizing Unity for mobile application development.

One of our team members has previous experience with the Unity user interface from developing a two-dimensional Pokémon video game. Through researching, it was found that other methods, like Flutter and Xamarin, are preferred over Unity in the regard of mobile application development; however, due to the prior experience and C# code base, Unity is a viable option that we are considering for the IntelliDate mobile application development process.

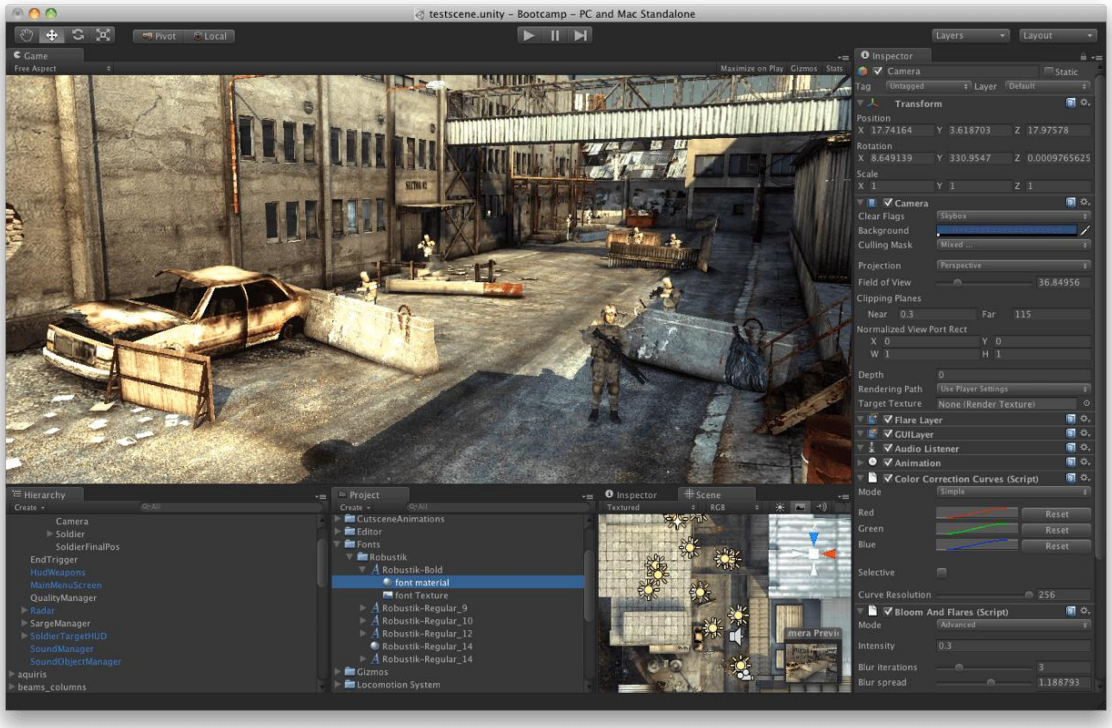


Figure 15: *Unity game engine/IDE user interface*[20]

3.4.1.5 Flutter

Flutter is an open-source user interface software development kit, created by Google, and is used to develop applications for Android, iOS, Linux, Mac, Windows, Google, Fuchsia, and the Web from a single codebase.

Flutter can be distinguished by two important areas:

1. A Software Development Kit (SDK): A collection of tools that assist the developer in the mobile application development process. This includes tools that compile Dart code into mobile platform-specific native machine code (code for iOS and Android).
2. A Framework (user interface library, based on widgets): A collection of reusable user interface elements (e.g. buttons, text inputs, sliders, etc.) that can be personalized to the developer's specific needs.[21]

Flutter applications are written in the Dart language and effectively utilize advanced features offered by the language. The Dart programming language was created by Google in October 2011, and has received many improvements, since then. Dart is an object-oriented programming language, similar to JavaScript syntax, and can be utilized to create both iOS and Android native mobile applications with a single codebase.[21]

There are many advantages to using Flutter for native mobile application development. Flutter is said to be easier to learn and use than other mobile application development methods, such as Java, Swift, or React Native. Google also offers an introductory crash-course of sorts for developers using Flutter for the first time. Along with the crash-course, exceptional documentation is available. Flutter also offers "Hot-Reload", a Just In Time compilation method where the effects of changes in code can be seen during execution.[21] This allows for faster and more efficient debugging, during the development process. Flutter is also available on many integrated development environments, such as Android Studio and VS Code, so long as the proper Flutter and Dart plugins are installed.[21] Flutter will most likely be the user interface development kit that we use for the IntelliDate mobile application.

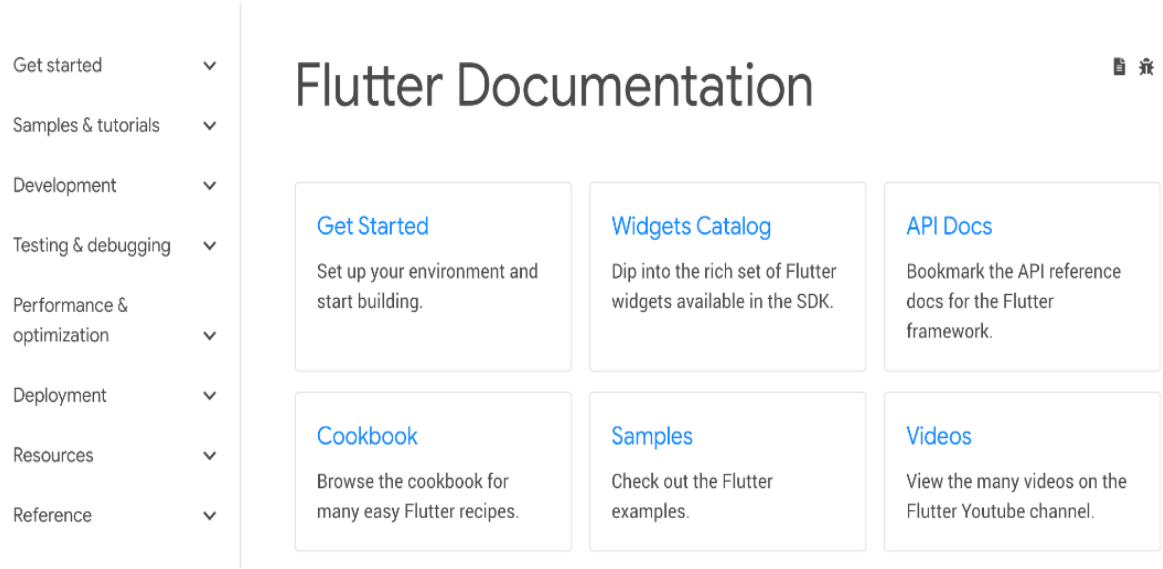


Figure 16: *Flutter Documentation*[21]

3.5 Microcontroller

The microcontroller is an installed CPU that controls most of the electronic devices and apparatuses individuals use consistently, directly from clothes washers to non-freezing stopping devices in vehicles. Presently, how did this thought of a microcontroller arise? What is the innovation story of this amazing chip?

It was during 1970 and 1971 when Intel was dealing with imagining the world's first microchip, that Gary Boone of Texas Instruments was chipping away at a significant comparable idea and developed the microcontroller. Boone planned a solitary coordinated circuit chip that could hold virtually all the fundamental circuits to frame a number cruncher; just the showcase and the keypad were not fused. Shockingly, this uncommon achievement in the field of hardware and correspondence was fairly given an unremarkable name of TMS1802NC. It had 5,000 semiconductors giving 3000 bits of program memory and 128 bits of access memory. Along these lines, it was conceivable to program it to play out a scope of capacities. Requirements and necessities lead to innovations and disclosures.[125]

Business at the Texas Instruments MOS Department was generally a custom business wherein organizations like work area number cruncher producers came to TI with a bunch of explicit necessities. TI changed those determinations over to a chip set, regularly four, five or six chips to execute or actualize the particulars for well-known organizations like Canon, Olympia, or Olivetti. For these organizations, it was truly astonishing that TI offered this extreme assistance of packing endless units on to only four or five or six chips in light of the fact that the recently utilized innovation called the TTL would utilize hundred to two hundred chips.[125]

It was during these occasions that Gary Boone was with a couple of others making broad exploration inside the nation just as traveling to Germany, Italy, and different nations. They were attempting to comprehend the requirements of the new clients and work on it. Boone was in a real sense exhausted in the wake of doing this various occasion. Plus, since their past activities were all effective and they had a herd of fulfilled clients, another arrangement of clients expected them to accomplish a similar work they did to another person the earlier year. In this way, there was a critical interest for increasingly more of these undertakings.[125]

A typical standard at Texas was "one uproar, one officer" which signifies "one chip, one designer." So, Texas Instruments that had around twenty MOS engineers and sent three or four of them on a task. Also, it took around a half year to finish one task. Subsequently, business limit was the quantity of engineers separated by the quantity of chips, once in at regular intervals. Even though the prerequisites of these tasks contrasted regarding subtlety, the significant standard and the general capacity was very indistinguishable. In this way, the architects were truly burnt out on doing these tedious ventures. They were working for extended periods of time and they felt a superior method to achieve these goals should be investigated.[125]

Boone and engineers wound up thinking about a network of client needs one way and pieces of hardware or useful squares the alternate way. Finally, the product TMS 1000 microcontroller chip arrived.[125] The computational force, unpredictability and force utilization maintained on expanding in control to give extreme execution. For a Microprocessor to work, it needs a lot of supporting equipment that can be found on a mother board. The equipment incorporates memory, ICs for fringe gadgets, and so on to start with itself, the Microprocessors capacity to control other electronic hardware like Photocopiers is figured it out. The accentuation here is not on the computational intensity of the Microprocessor but instead on a control component with less mind-boggling equipment and expanded unwavering quality. This prerequisite cleared path for incorporating the base equipment needed for complete working of a Processor on to a solitary chip for example same chip as the processor, to be exact.[126]

This is the ascent of Microcontrollers, an Integrated Circuit, which contains all the capacities and equipment to make a total PC framework. Here, the computational intensity of the gadget is of less significance than the combination of the multitude of parts, including memory.[126] In our project we are going to have to use a microcontroller to be able to connect the Wi-Fi and transmit data from our app to the monitor. What is a microcontroller? A microcontroller is a tiny computer. This device has a CPU that executes programs, we need this in our project to load our app and project it onto the monitor. The microcontroller also contains RAM (random-access memory). RAM is the hardware inside the microcontroller where the operating system stores the programs and data so that the processor can easily reach the processor. RAM improves the systems performance by allowing the microcontroller to hold more information at a time.

The microcontroller has Input/Output pins to communicate with a device such as Wi-Fi, and an output such as a monitor or a display system. People use microcontrollers because they are generally small and cheaper than other components.

Basic components of the microcontroller:

- Central Processing Unit (CPU)
- Program Memory (ROM – Read Only Memory)
- Data Memory (RAM – Random Access Memory)
- Timers and Counters
- I/O Ports (I/O – Input/Output)
- Serial Communication Interface
- Clock Circuit (Oscillator Circuit)
- Interrupt Mechanism

Microcontrollers processors can vary from 4-bit, 8-bit, 64-bit, and 128-bit. They usually run at speeds from 1MHz to 200 MHz, the speeds are slow because they are embedded in other devices that usually need more power. The microcontroller has non-volatile and volatile memory. The volatile memory is memory that stays, such as the RAM. Non-volatile memory which erases after a certain time or when the microcontroller shuts off. Some microcontroller use flash memory to increase the speed of the processor because it only holds information for a certain time. There is some non-volatile memory that will stay

after the component is shut off and it is called EEPROM, but it makes it more expensive than the flash memory.

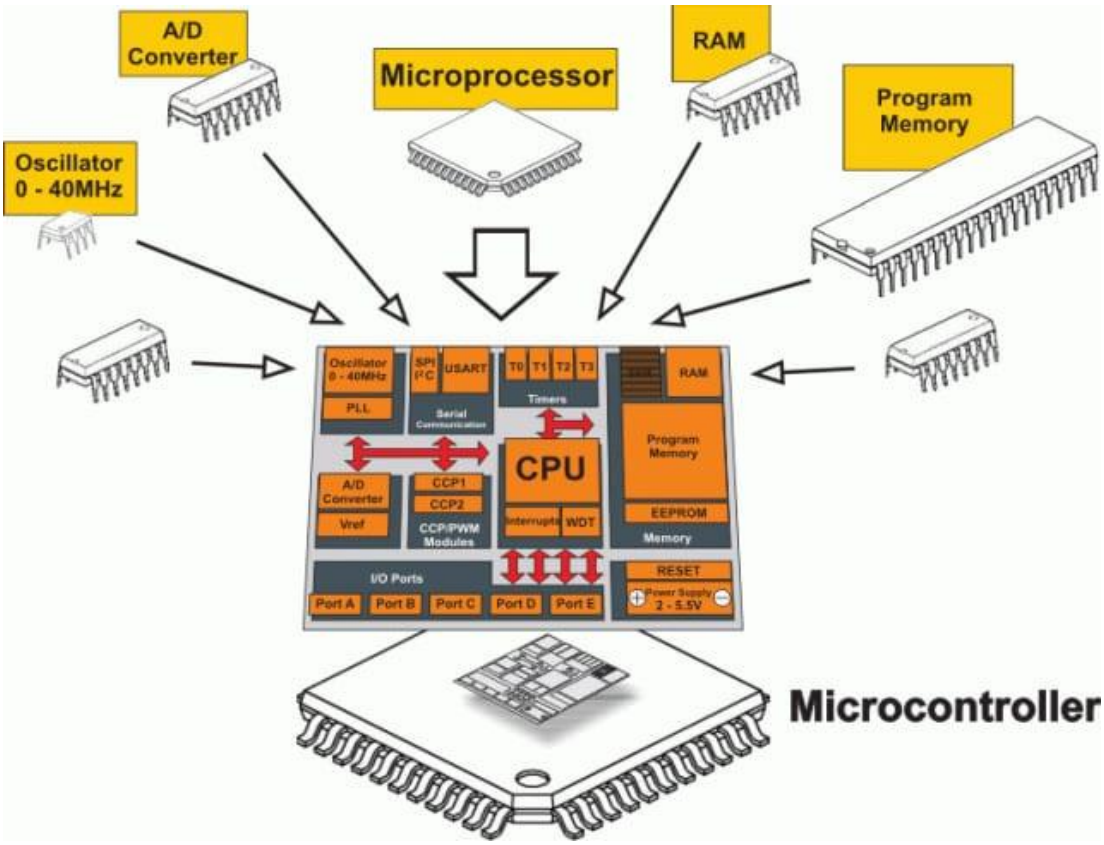


Figure 17: *Microcontroller*

Some more functions of the microcontroller are Serial ports, timers, ADC, DAC and interpret control. Serial ports let the microcontroller connect to other devices such as USB, HDMI, ethernet, and other devices. Timers are usually built into the microcontroller and they control the all the counting and timing operations. The main functions of this is clock and frequency measuring. The ADC (analog to digital converter) is exactly what it says in the parenthesis. Switching to digital signals help determine applications that require to be measured or read off. DAC (digital to analog converter) which is the exact opposite of the ADC, which means it supervises the devices that deal with analog. So now we have some information on what a microcontroller is and how it works my team must figure out what type of microcontroller we want to use for our project.

3.5.1 MSP430FR6989

The first microcontroller we considered was the MSP430FR6989. My group considered the MSP430 because we already had this product in our grasps. We used the MSP430 in multiple labs in embedded systems and in Engineering analysis and computation. This board comes with buttons and LEDs to code for certain concepts. Then it has an LCD display if the projects need to project something on it. “This device has ultra-low power

consumption, 128 KB of embedded FRAM (Ferroelectric Random-Access Memory). This comes with long lasting power supply and speedy writing access.

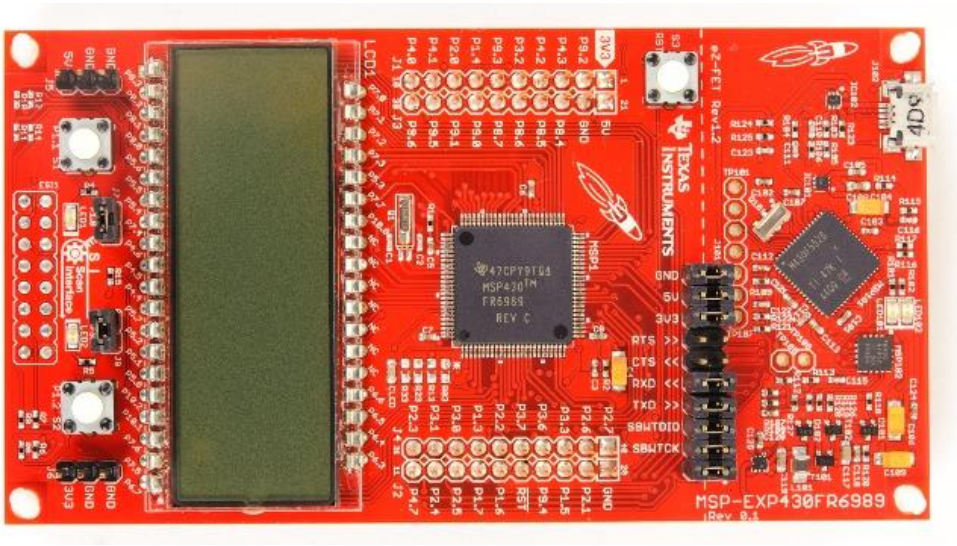


Figure 18: *MSP430FR6989*

The MSP430FR6989 comes with a 40-pin BoosterPack plug-in module connector. This allows the user to stack multiple BoosterPacks on a single launchpad to increase the functions of the design the user wants to create. This includes wireless connection connectivity, environmental sensing, and power sources. This device also contains eZ-FET on-board emulator, which enables debugging/ programming to and from a computer. EnergyTrace Technology is embedded into the device to see the real-time power consumption readings and updates. Also comes with a segmented LCD display that show six alphanumeric characters, six symbols for various applications, and an ultra-low power display.

Some information to take into consideration about the MSP430 uses Texas Instruments Code composer studio to apply programming to the microcontroller. Its power consumption starts at 100 MHz on active mode and can decrease to 350 nA on standby. The architecture is 16-bit RISC and a clock speed of 16 MHz. This product also includes direct memory access and 16 channels 12-bit ADC. To find more specs you can find it on the Texas Instrument webpage.

3.5.2 Arduino UNO REV3

The second microcontroller we decided to investigate was the Arduino UNO REV3. We decided to investigate this product because we need to figure out how we are going to connect our app to the monitor we want to use. Most people start out using Arduino uno to begin practicing coding. The uno board is the first one to have a USB port attached to it. One thing about the Arduino Uno is that you can connect a WIFI shield to connect to the internet. Which we need in our project because we are trying to make an app to connect to the monitor to show a schedule.

Figure 19: *Arduino UNO REV3*

The Arduino WIFI shield lets the user connect to the internet. For the shield to work the user must mount the shield on top of the Arduino Uno board. Once you connect it to the board you must connect it with the computer and program the shield. Then the shield will connect to any open network. The SSID must be broadcast for the shield to connect. If the network is WPA/WPA2 then you will need the SSID and the password to connect to the internet. If the network is WEP the user will need the SSID, the key (which are hexadecimal strings), and the key number. To gain more knowledge about the Arduino WIFI shield go to the Arduino website.

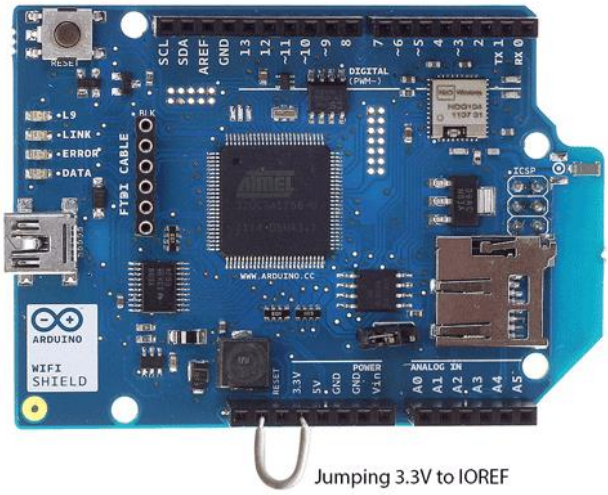


Figure 20: *Arduino Shield*

The Arduino Uno was created on the Atmega328P. This product contains USB port, 14 input/output pins, and six analog inputs. The flash memory is 32 KB, and the user can power it with a battery or an AC-to-DC adapter. The recommended input voltage is between 7 to 12 volts and to operate the device it requires five volts. The SRAM is 2 KB,

and the clock speed is 16 MHz. From this information we gathered from the Arduino uno, it feels like it is more compatible of what we are looking for from the MSP430.

3.5.3 Raspberry Pi Zero W

The last microcontroller we consider was the Raspberry Pi Zero W. This is being considered as our microcontroller because when we first starting with the idea of creating our project we had to look up if anyone else has done this before. We found product that were similar and most of them built the design with a Raspberry Pi. This specific raspberry Pi has built in WIFI, so the user does not have to add an additional chip to it and not to mention has Bluetooth too. This will cut back on having to use an ethernet cable too from out box we are trying to limit the cables and make the back side of the monitor very clean and light weight. This will benefit my group very much because we are trying to make a product that can connect to our scheduling app.

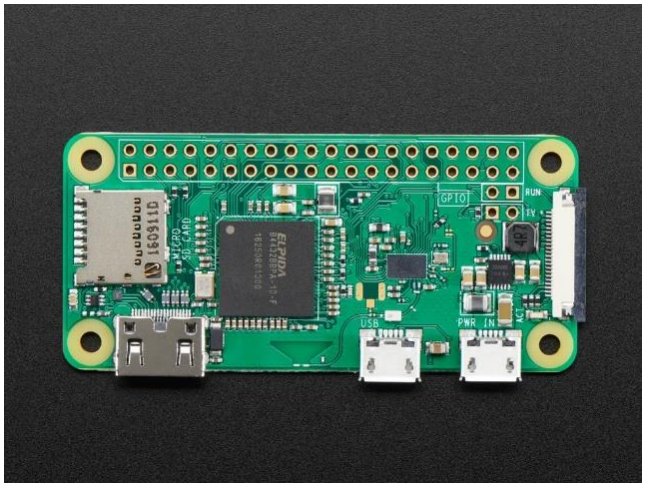


Figure 21: *Raspberry Pi Zero W*

The Raspberry Pi Zero W is very slime and is fully compatible with all other raspberry Pi zeros. To power this device, it needs at least five-volt power supply and comes with a 4GB SD card. It has mini HDMI to HDMI adapter port which allows the user to get up to 1080P video and audio out of the microcontroller. The Bluetooth has two different modes on it from regular Bluetooth 4.1 edition to Low Energy Bluetooth (BLE). It has a 40-pin header and a 1 GHz, single core CPU. The processing power on this device is incredible for its size and price which would help tremendously if we want to add different components to it. Due to watching videos and having other projects on the Raspberry pi.

I have found that the coding aspect is noticeably clear and easy to understand and there are many tutorials out there to help anyone solve a problem. The price of this item is exceptionally low for what it can do for a project. The size of the raspberry pi is one of the biggest things to point out, it can hide well behind a monitor or even inside one.

Table 4: *Microcontroller data*

	MSP430FR6989	**Arduino UNO REV3**	**Raspberry Pi Zero W**
Manufacturer	MSP430FR6989	ATMEGA328P-AU	DEV-14277 ROHS
GPIO	83	20	40
RAM	128 KB	32 KB	512 MB
SPI	2	4	3
UART	2	3	2
Clock speed	16 MHz	16 MHz	1 GHz
Power	100 uA	200 uA	100 mA
Price	$24.00	$23.00	$10.00
Dimensions	196mm x 256mm	68.6mm x 53.4 mm	66.6mm x 30.5mm

3.6 Microcontroller Picked: Arduino UNO REV3

After researching the three microcontrollers my group chose to use the Arduino UNO REV3. This microcontroller was chosen because we have background knowledge of this device and know that its coding language is remarkably simple and easier to look up how to properly code certain functions on the internet. Also, by looking at the specs it has what the project needs as in size and power. The size is perfect because the product needs to be thin. This is because the product must attach to the back of the monitor and be mounted on the wall. The power consumption is the tricky part because it is going to have to use the battery for this microcontroller and the monitor. The product does not need much RAM because the there is only going to be one application. The number of pins needed in our project is limited but this design does not need to use that many pins.

3.7 MSP430FR6989: Programming language

Figure 22: *Code Composer Studio*[73]

The language that this microcontroller uses is C programming. The program used is Code Composer Studio. This is the only code that can communicate with the MSP430, which makes it easy to find help with coding this specific microcontroller. "Code Composer Studio comprises a suite of tools used to develop and debug embedded applications. It includes an optimizing C/C++ compiler, source code editor, project build environment, debugger, profiler, and many other features."[73] "Embedded Coder® connects MATLAB®, Simulink®, and Simulink Coder™ with Code Composer Studio. These products enable integrated algorithm development, analysis, simulation, and code generation. Users include algorithm developers, system designers, embedded engineers, and DSP software developers."[73]

3.8 Arduino UNO REV3: Programming language

The Arduino Uno has many different languages that a person can program. One popular coding programing people use is ArduBlock. This program is quite easy to use to new people that are starting out. Whether than typing the code out, the program allows you to visually program with a snapped-together list of code blocks.

Snap4Arduino is a modification of the Snap! visual programming language that lets you seamlessly interact with almost all versions of the Arduino board. Snap! Is a drag and drop programming language like the ArduBlock. Then the most used one is C and python. These two are mainly used on the Arduino because there is so much more a person can do with these programs compared to the other two mentioned earlier

Figure 23: *Linux programming logo*

Linux is an open source operating system kernel that can be shared and distributed and is also compatible with many programming languages such as C++ and Java. The Linux source code is often copied and changed. “An operating system is the interface that connects users to computer hardware and orchestrates the running of programs and applications.”[75] “The kernel is the core of the operating system because it manages communications between software and hardware components.”[75] Linux handles the most complex and specific data. Linux is widely used in servers, computer architecture, and computer security systems and used in real-time programs and the embedded systems of cell phones. Ubuntu and Mozilla Firefox run on Linux and many applications have resulted from Linux programming. Linux is protected under the GNU Public License, but the source code is widely used in ways that are constantly evolving.

This program is used across the world and people will continue to use this programming and enhance the way to making better coding languages. This being the software where people use the coding programs is immensely helpful in deciding what code to use. The are some main reason this is widely used. Linux has high security to where the user will not get any viruses from using the software. It has high stability, the system will not crash on the user, unlike other software it will run the same speed even if a new device is out that is better and the user does not have to reboot the system every time there is an update. Linux runs on any hardware and is free to use to the public.

3.9 Raspberry Pi Zero W: Programming language

The raspberry Pi default language is Python. “Python is an interpreted, object-oriented, high-level programming language with dynamic semantics. Its high-level built in data structures, combined with dynamic typing and dynamic binding, make it incredibly attractive for Rapid Application Development, as well as for use as a scripting or glue language to connect existing components together.”[74] “Python's simple, easy to learn syntax emphasizes readability and therefore reduces the cost of program maintenance. Python supports modules and packages, which encourages program modularity and code reuse. The Python interpreter and the extensive standard library are available in source or binary form without charge for all major platforms and can be freely distributed.”[74]

Figure 24: *Python programming language*

People become fascinated with Python because of how easy it can create code by telling the code exactly what to do. Since there is no compilation step, this means that the testing cycle is quick. Which means debugging is fast too. Debugging Python program never stops the code from functioning and fulfilling its duty. There will be an error that points to where the code is not working properly and want the user to fix the problem. “When the program does not catch the exception, the interpreter prints a stack trace. A source level debugger allows inspection of local and global variables, evaluation of arbitrary expressions, setting breakpoints, stepping through the code a line at a time, and so on. The debugger is written in Python itself, testifying to Python's introspective power.”[74] The way to solve or debug in python and helpful in other programming is to use print statements. This helps because the user can see all their actions till the point where it will not let them print the statement. This is usually where the error is.

Some main reason people use python is readable and maintainable code. Unlike C, python is quite easy to understand. It has multiple programming paradigms which helps create large applications if needed. Python is compatible with major platforms and has a large standard library to choose from a huge range of modules that have endless possibilities. The open framework and tools help keep the expenses down unlike other programing languages that charge for development.

3.10 Microcontroller Picked: Arduino

After researching the three microcontrollers my group chose to use the Arduino UNO REV3. This microcontroller was chosen because we have background knowledge of this device and know that its coding language is remarkably simple and easier to look up how to properly code certain functions on the internet. Also, by looking at the specs it has what the project needs as in size and power. The size is perfect because the product needs to be thin. This is because the product must attach to the back of the monitor and be mounted on the wall. The power consumption is the tricky part because it is going to have to use the battery for this microcontroller and the monitor. The product does not need much RAM because the there is only going to be one application. The number of pins needed in our project is limited but this design does not need to use that many pins.

3.11 Serial Communication

Serial communication is the process sending information through protocols to the computer to communicate back and forth. The protocols work as channels going to each network to send data. These protocols can be summed in two ways as parallel and serial. Parallel send multiple bits at the same time and serial interfaces send data by sending one bit at a time. Parallel has its pro and cons just like the serial. The pros of the parallel is that it is fast and easy to make. Then the cons are is it takes more input and output pins that is a con because we want to use those pins a few as possible just in case we need to use them for something else. The serial is slower, but it gets the job done and does not have crowded servers and is cheaper.

The way the economy works they want to make product that work efficiently and cheaper, so people make the serial protocols and some interfaces that connect to the serial protocols are USB, internet cord, SPI, and I2C. They can be distinguished by synchronous or asynchronous. Synchronous pairs the information line with the clock signal which makes the serial have the same clock and let the system transfer data faster, but the downside is that it need an extra wire between the device and the source. Asynchronous means that the data is transferred without the clock signal. This method is to use less input and output pins and takes more reliability to send information back and forth. This would be less useful for our project because we need to use Bluetooth or WIFI so it would be difficult to transfer information using that way.

Serial Asynchronous Rules:

- Baud Rate- the speed the data sends over a protocol line. If the speed is too fast than there will be error on the device that the user is trying to send it to. Some common baud rates are 9600 bps (bits per second), 1200, and usually cannot exceed 115200.
- Synchronization bits- these bits are the first and last of a chunk of information going to the receiving data.
- Parity bits- this verify if there is any error in the data transfer by implementing error handling. This slows down how fast the device receives the data but makes sure you receive correct information.
- Data bits- this sends data through the serial ports. They usually send as packets between five to nine data bits at a time.

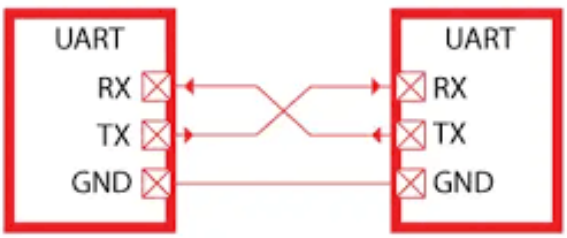


Figure 25: *UART example*

3.11.1 UART

Universal asynchronous receiver/transmitter which is known as UART. It is a block of circuit that oversees sending and receiving data. UART contains eight lines of data and has two serial ports RX and TX to send data back and forth. UART is commonly found in most microcontrollers. In the figure above the left side oversees sending the data to the right side. The way it sends data is by creating packets which consist of 5 to 9 data bits at a time. TX sends the data with timing from an external device since it is asynchronous device and RX lines the rate with the baud rate and then synchronized the bits and relays the data. Some good information to know about UART is that the new ones may have buffers, which stores data until the microcontroller grabs the data and uses it. Buffers can have a few bits or multiple bits depends on how developed the UART is.

The advantages of UART is that it only requires two wires, does not need any clock to send the data, and has parity bits to check the packet bits to make sure that the information has no error. The disadvantages of the UART is that there is a limit on the size of data being sent at a time that is why they send I packet between five to nine. The speed is slower because only requiring two wires. The transmitter and receiver must follow the serial Asynchronous Rules or there will be errors.

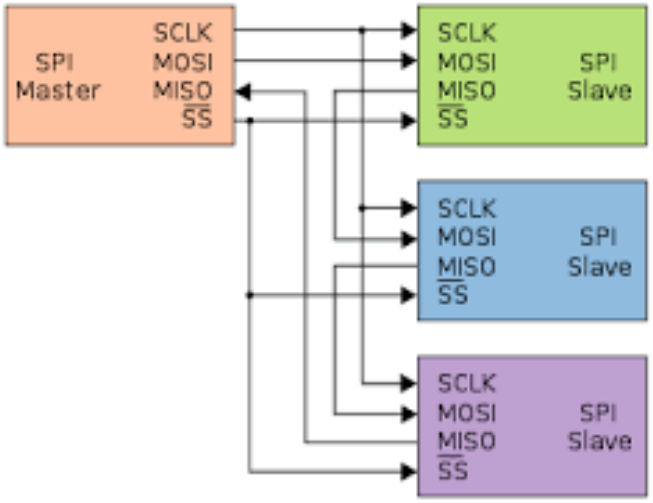


Figure 26: *SPI example*

3.11.2 SPI

Serial Peripheral Interface which can be abbreviated as SPI, one of the main reasons to use the SPI is that it transfers data without interruption. The bits are not limited like the UART. The start and stop of the transfer of bits is taken at the beginning of the cycle so it does not stop until it is complete. From the figure above the SPI shows how the circuit works it is a master to slave relationship. The master controls all the data transferring to each one of the slaves and they listen to the master.

- MOSI- (Master Output/Slave Input) master sends the messages to the slave input.
- MISO- (Master Input/Slave Output) slave sends the message to the master input
- SCLK- (Clock) this is where the SPI has a common clock signal to time the data
- SS- (Slave Select) master selects who to send the message to.

The way the SPI uses the clock is by synchronizing the data bits from the master tot the slave bits. To determine the speed of transferring the data depends on the frequency of the clock signal. There is a way to modify the clock speed in the SPI, the way to change the clock speed is by changing the clock polarity and the clock phase. They way to change the clock polarity is by using the master setting and pick whether to the output of the bits is from the rise or fall of the clock cycle. Then the clock phase can be changed by making the master pick if the first edge or second edge of the clock cycle to start counting the bits.

SPI can operate with just a master and one slave or it can have multiple slaves but there can only be one master. There are two way the master can be connected to multiple slaves; the first way is in parallel or it can be connected as a daisy chain. The MOSI sends information bit by bit to the most significant slave first and can either send back to the master or go straight to another slave. the data sent back to the master is sometimes the least important bit first. The advantages of SPI are that there are no interruptions with sending the data and this is almost double the speed as the I2C that I am about to talk about. The MISO and MOSI are separate wire so it can receive and send information simultaneously.

The disadvantages of the SPI are that it takes up more wires than both the I2C and the UART. To be exact it takes up 4 wires which is crucial if you want to save the input and output pins for some other device needed. It also does not let the sender know when the data have fully been sent to the receiver, it only starts and stops. The last two disadvantages are that it is not about to check for error within the data bit so if there are error there is no way to tell and there can only be one master.

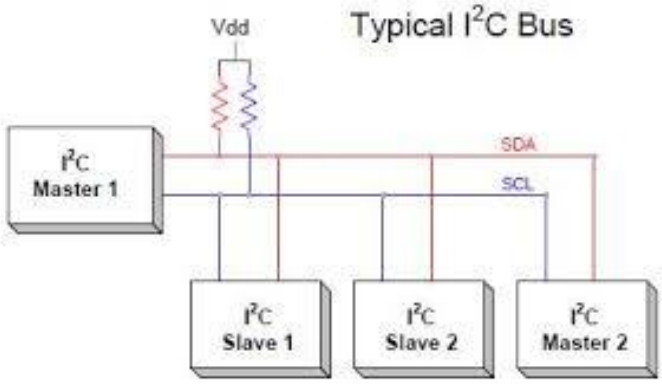


Figure 27: *I2C example*

3.11.3 I2C

Inter-integrated circuit which is known as I2C is probably the best serial communication out of the three. It has the best characteristics from SPI and UART. So, it allows the sender to multiple masters and multiple slaves and this is very usefully if the user has to more than one microcontroller and therefore it is better than SPI. It has the same number of wires as UART, which was 2 wires coming from the master.

- SDA – (Serial Data) master sends data to the slave to output the data.
- SCL – (Serial Clock) this line contains the clock signal.

I2C is remarkably like SPI they both are serial communication, and this means they are synchronous and send data bit by bit instead of mass packets. They both send bits using the clock signal. In I2C messages are divided into frames. The message includes bits from the slave component and the start and stop conditions. There are start and stop conditions, the start condition is that SDA starts at high voltage and goes to low while the SCL goes from high to low as well Then the end condition the SDA starts at low voltage and ends in high and the SCL starts from low to high. The frames usually consist of about seven to ten bits unlike the packet containing about five to nine bits.

There is a read/write bit that travels from the master to the slave that is either sending data or trying to receive data. Each frame has an ACK/NACK bit, this bit goes to the slave and lets the master know if the information was received or not. The address frame is always at the start of sending a new message. This is basically like a messenger sending a message to a person to let them know they are going to receive information the person accepts the message and compares the data to its own. If the address does not match the slave does nothing and then that should raise a red flag to tell the master that there is an error.

I2C acts like the SPI when it has one master and multiple slaves the only difference is that it has a 7-bit address and a read/write bit to tell if the slave is communicating. Now we are getting into the difference between SPI and I2C. I2C can have multiple masters and can connect to a single slave or multiple slaves. Since there are multiple master there might be a confusion on how they will transfer data through the wire, but this is how it works, each master must detect the voltage going across the SDA. The way they take turns is if the volage is low that means the line is busy and if the voltage is high then they can transfer data. This is basically like if you are a stop sign with another person the first one there gets to go first and then the next one there gets to go.

The advantages of using I2C are that the circuits only use two wires and can handle multiple master and slaves. There is a way to make sure that the receiver gets the information through ACK/NACK. The circuit is less difficult to read than UART. This is the most popular serial communication used around the world. The disadvantages of I2C is that it is slower data transfer that both SPI and UART. The data frames are limited like SPI and it takes more components to implement what the SPI is doing.

From researching the three different microcontrollers, the group have found out that we most likely will use either the Arduino uno REV3 or the Raspberry PI zero W. we have decided on this because the coding aspect will be a lot easier and those two have WIFI already. They both are smaller than the MSP430. The only thing is that our group has the MSP430, but from the price range of the Arduino and the raspberry pi it is very affordable. The Raspberry pi takes up more power than the Arduino and has a faster clock speed, but the Arduino has more RAM than the raspberry pi. So, based on how big our app takes up and how much RAM our group will need to be able to have project work properly will determine which microcontroller we are going to use. The Arduino only has 20 pins, so I feel like the raspberry pi will be a better choice in case we want to add more components because it has 40 pins. Coding wise the Arduino has more codes out in the internet to help us code the app easier to the microcontroller compared to the raspberry pi but from the

research we found about similar projects they have used the raspberry pi and the code might be similar.

3.12 Display

For our project it is required we need a display to show the schedule. So, we had to do some research on some television or monitors to see what the best fit for our project is. We must keep in consideration on the size because we want it to be able to move and not stay in one place the whole time. Another thing to consider is how much room is in the back of the monitor or television to be able to hold the microcontroller. For this project we want the customer to be able to see the schedule nice and clear but not to big to give away confidential information. Some displayed to look at for the project were LCD and LED. Then to determine whether a monitor or television would be better.

3.12.1 LED and LCD

An LED TV is an LCD TV, this is true because the LED is a specific kind of LCD. Not all LCD are LEDs. LCD stands for liquid crystal display and both use this type function to create an image. A liquid crystal is a substance that has both properties of a solid and a liquid. Pixels are the main source of a digital image. "A pixel is minute area of illumination on a display screen, one of many from which an image is composed. Every pixel is composed of three-color filters, which are called "subpixels." There is a red, blue, and green subpixel for every pixel."[34]

Figure 28: *How LED work in a monitor*[42]

"The way an LCD display works is that every pixel is composed of two glass sheets and the outermost sheet has the subpixels. The liquid crystals are sandwiched between the two sheets."[34] "LCD monitors have backlights behind the screen that emit white light, and the light cannot pass through the liquid crystals while they are in their liquid arrangement. But when the pixel is in use, the monitor applies an electric current to the liquid crystals, which then straighten out and allow light to pass through them."[34]

The main thing to focus on these different types of displays is that LED are better if it is a full panel of LED if it is only on the outer rim then the LCD is way better. Then other things that come into play is the resolution and refresh rate. "Resolution is the number of pixels inside the display. The more the pixel the more dynamic your composition of colors

can be." [pixel]. The main one for our project will be the refresh time. The refresh time is how fast the display updates the information from the computer or app to the display.

Table 5: *LED vs. LCD*[72]

	LED	**LCD**
Design Flexibility	Design freedom	Limited Flexibility
Display Function	Uses a liquid-crystal display with an LED backlight.	Uses a liquid-crystal display with a fluorescent backlight.
Energy Usage	Energy Efficiency 1. LEDs use less energy	Uses more energy 1. Fluorescent uses more energy than LED.
Weight	Lightweight 1. Edge-lighting provides a lighter and thinner TV Set	Weighs more 1. Fluorescent backlight adds weight and bulk
Expense	More expensive	Less expensive
Image Quality	Pixel pitch range: 0.9- 20 mm 1. Deep saturated colors No screen gap or bezel	Pixel pitch range: 0.5- 0.6 mm 1. Standard contrast and resolution 2. Screen gaps and bezels
Reliability	No image retention 1. 100,000 hrs to half brightness 2. 24/7 performance	Image retention can happen 1. 30,000-50,000 hrs 2. Usually not 24/7 performance

3.12.2 Display: LCD Monitor

The LCD monitor was chosen for this project because one of the group members had one that they were not using. The LCD will work perfectly fine because people can still see the screen fine. Even know the spec all point towards the LED, as a group we decided that the LCD was best option for now due to expenses and what inventory we have available now. As our group is trying to make this product the least expensive to help our consumers that can afford high-end product but still want the same outcome. The choice of a monitor was quite simple. It is lightweight and very portable unlike a television. That was the biggest reason for choosing the monitor. It also helps that one of team members had one, so we did not need to use any of our expenses and use it on other material. With the display can be easily changed because the product can be removed and put into new displays easily.

3.12.3 Monitor or Television

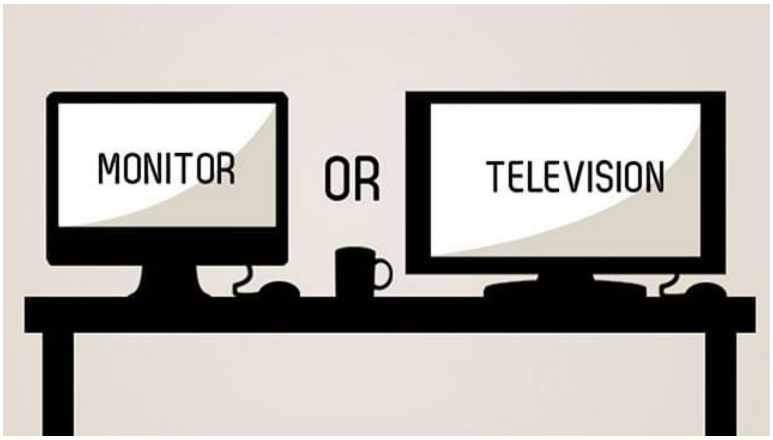


Figure 29: *Monitor or television*

For the decision between Monitor or television, the group had to put into perspective on who was going to see and if we want other people to see it. So, the size of screen comes into play and the mobility of the tv being hung up. However, the refresh rate and screen resolution come into play as well. Also, the monitor has more other connections to support other devices.

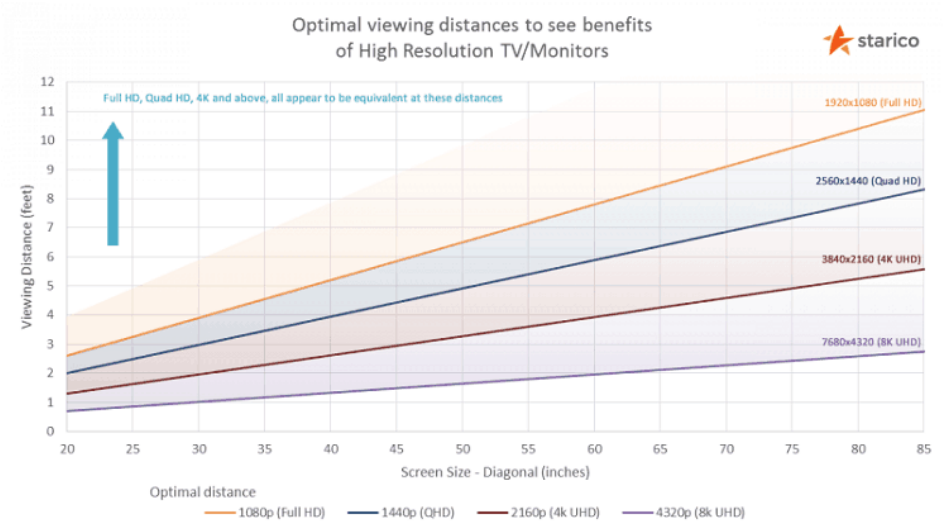


Figure 30: *Viewing distance from Television/Monitor*[33]

From the figure above shows the ratio of screen to resolution. From this graph you see how far away from the screen you can see an image. They figured this out because the low pixel density makes the images look blurry. A 21-inch monitor is perfect for what our group is looking for because we want a light object to be able to move freely easily. Televisions are usually heavier than monitors. A monitor is more private to the environment and most people do not want to show the whole world their schedule.

3.13 Lighting

To indicate the power of the device, there are two options of light that was taken into consideration which were LED and incandescent. The project needs to use these lights to indicate the power and performance of the system. Therefore, a few factors will consider such as cost efficiency, power used, reliability.

3.13.1 Incandescent

The incandescent light is a classic bulb that was always use in houses. This is the first bulb that was very used the electricity to heat up the wire filament. The light will be generated once the wire reaches a requirement temperature. These filaments surrounded by a translucent vacuum glass. The cost to manufacture this traditional bulb is very cheap, so the cost of purchasing this bulb is really low (around one or two dollars).

Company has a long experience with manufacturing these bulbs, therefore they have a very stable performance with either AC or DC supply. These bulbs have been around long enough so that they have a very large range of input voltage and current. However, lifespan is the only drawbacks of this type of lights. For a standard 60-W lamp, it can last up to 1000 hours. This is a very limited lifespan in the modern world.

3.13.2 LED

LED stands for Light Emitting Diode. In 1962, applying the use of semi-conductor materials, Scientist Nick Holonyak, Jr., invented the first visible LED at the age of thirty-three. Holonyak was trying to create the light that could eventually replace the incandescent bulbs. The idea of LED has been around since that time, but there was any significant use of LED until around twenty year ago. Professors Isamu Akasaki, Hiroshi Amano and Shuji Nakamura invented the first ever blue LEDs in the early 1990s; however, the new generation of LED has not started until 2014. The 2014 Nobel Prize for physic was awarded to a Japanese and American scientist for inventing the blue LED. The red and green LED has been around for an exceptionally long time, but the white lamp can only be created with blue LED. In the new 21st century, LED has changed the light industry completely. LEDs give a brighter light and much longer life span. The table below will compare the cost and lifespan of the LED with the classic bulb.

Table 6: *Power usual*

Lumens (Brightness)	**LED Watts**	**Incandescent Watts**
400 – 500	6 – 7W	40W
650 – 850	7 – 10W	60W
1000 – 1400	12 – 13W	75W
1450-1700+	14 – 20W	100W
2700+	25 – 28W	150W

From the table, the LEDs requires a much smaller amount of energy to get to the same brightness level with the incandescent bulbs. The cost of using these two bulbs also taken into the blow table to compare for the cost efficiency:

Table 7: *Total cost in 20 years*

LED vs CFL vs Incandescent Cost	**Incandescent**	**LED**
Watts used	60W	7W
Average cost per bulb	$1	$4 or less
Average lifespan	1,200 hours	25,000 hours
Bulbs needed for 25,000 hours	21	1
Total purchase price of bulbs over 20 years	$21	$4
Cost of electricity (25,000 hours at $0.15 per kWh)	$169	$30
Total estimated cost over 20 years	$211	$34

Although the cost of purchasing the LEDs is more expensive than the incandescent bulbs. The power usual by LEDs is a lot less than the incandescent bulbs and the lifespan of the LED is much higher than incandescent bulbs. Therefore, the LEDs will save consumer a lot more money in the long run.

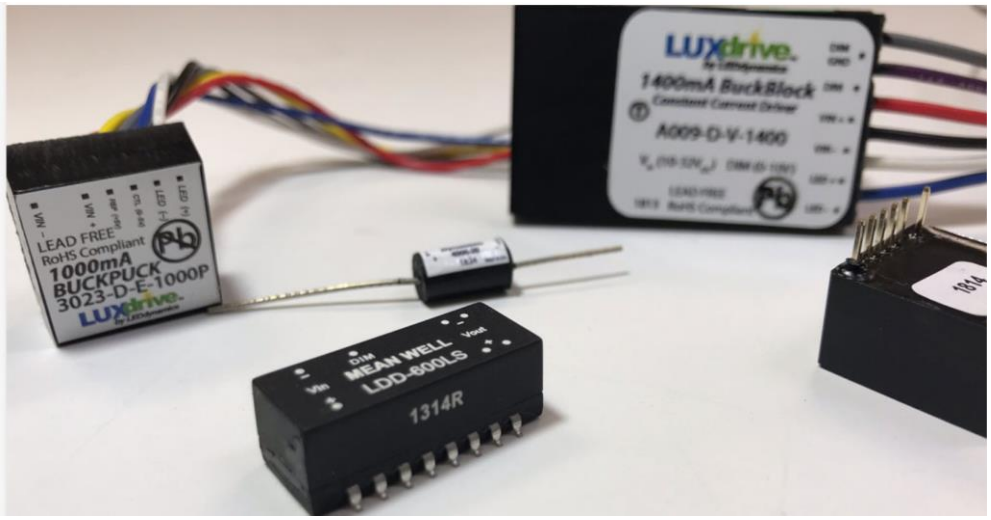


Figure 31: *LED driver*

3.13.3 LED Drivers

LEDs market has become a large varieties choice for users. It is very important to understand the LED driver to choose the right one for the project. Each application requires a different type of LEDs, therefore understand all the factor of LED drivers will help users make a right selection. It has become a usual where people replace their house light bulbs with the LED. However, there are some important information that users need to be aware of when replacing these bulbs. Each LED has their own turn-on voltage (Vf), so these voltages can damage the LED if it is too high. This voltage is being affected unproportionally with the temperature cause the LED draw more and more current. LED has its own tolerance of input current and when it reaches the limit, the LED will be burned. This is where the LED driver come in handy, the driver will control the input current so that it makes sure the LED is being supplied with a constant current for a stable performance.

3.13.4 DC Dimming

Some application requires the LED dimming. This can be easily achieved using the potentiometer. This can be used for one or more than one driver in the circuit. For more than one driver, the value of the potentiometer can be calculated as (Kohm/N) where K is the number of potentiometer and N is the number of drivers which being used in the circuit. There is also a better way of using a driver call A019 Low Voltage Dimming Control. This operates in the range from 0 to 10V. This DC voltage can work with multiple drivers at the same time. Therefore, this is a common use once more than one driver is being used in the circuit.

3.13.5 AC Dimming

There are quite a few ways for dimming using AC power drivers. It is commonly use drivers such as Mean Well or Phihong LED drivers to dim the LEDs. This will allow LED to have a very stable performance with AC supply.

3.14 Plastic cover

With all the components and power running in the design. Safety is always the from concern of any project. It is important to have an insulator cover for the box so that if any electrical problem occur in the box. It will minimize the chances of users getting electric shocks. There are a lot of insulating material but for the purpose of cost efficiency as well as the look of the design. It is clearly the PVC plastic is best option in this design.

Figure 32: *PVC Plastic box*

The picture is an example of a junction box using PVC plastic material. This is a great material that usually companies use to cover router or cable boxes. These can be easily order with customized size to suite user's requirement.

3.14.1 Polyethylene (PE)

Polyethylene is a type plastic that is used worldwide, with almost 80 million tons of polyethylene produced each year. It was created in 1939 and was made for packaging, such as plastic bags, films, and bottles. Polyethylene can be made into different forms and types. PVC is extraordinarily strong and rough but, PE is fragile and smooth. "It makes up for that by having high ductility (the ability to be stretched into wire) and impact strength (the ability to withstand a suddenly applied impact). This flexible and malleable material has a slightly higher temperature rating than PVC, softening at 176 degrees. Different density PE will have different melting points. The higher the density, the higher the melting point." PE is resistant against water and even gas and water vapors have a hard time penetrating. If the PE is left out in the sun it can become very wea k and break easily. PE is a good electrical insulator but can easily become a conductor if it is not treated with the right material. PE can look clear or impossible to see through depending on how thick the material is.

3.14.2 Polystyrene (PS)

PS is also widely known and used around the world in many shapes and sizes. In 1931, PS was made into Styrofoam, plastic tableware, disposable cups, disposable plates, and CD cases.PS is really bad for the environment because it takes years to biodegrade. This product can be found in the ocean and wash up onshore and hurt animals. If it is recycled it can be great use and made into other products but some cases it gets littered and hurts the environment. "PS has a higher melting point than PVC at around 464 degrees but will start decomposing at lower temperatures. It is classified as a highly flammable or "easily ignited" material and is thus prohibited in any exposed building construction uses if the material is not flame-retardant. It must be concealed behind drywall, sheet metal, or concrete."

3.15 PVC plastic material

PVC plastic stands for Polyvinyl Chloride plastic. This is a high strength thermoplastic material that can be used to insulate electricity. There are a lot of application using these materials such as pipes, medical devices, and car equipment. There are a few different versatile properties that this material contains such as lightweight, durable, and low cost. PVC plastic is also available in powder, granules, or solid piece of plastic. Due to its characteristics and coming a lot of difference form. PVC becomes one of the most popular plastic that is used in almost every industry.

3.15.1 Basic Forms of PVC

The various basic forms of basic Polyvinyl Chloride plastic (PVC) are listed and described below:

- Plasticized or Flexible PVC (Density: 1.1-1.35 g/cm^3): Flexible PVC is formed by adding the plastic PVC with crystallinity. This material has an exceptionally low tensile strength. This combination is sometimes called as PVC-P.
- Unplasticized or Rigid PVC (Density: 1.3-1.45 g/cm^3): It is a much harder and more expensive plastic compare to PVC-P. This usually make for construction or any kind of environment activity that can handle the impact of bad weather. This type of PVC is also known as uPVC.
- Chlorinated Polyvinyl Chloride or perchlorovinyl: this product is set in PVC resin and this increases the durability, and chemical stability. CPVC can resist higher temperature more than regular PVC
- Molecular Oriented PVC or PVC-O: this substance can be created by rearranging the amorphous structure of PVC-U into a layered structure. Bi-axially oriented PVC has greater strengths as in being hard to break and lightweight but able to withstand enormous amounts of pressure.
- Modified PVC or PVC-M: It is an alloy of PVC that increased the strength of material to withstand heavy pressure on the material itself.

3.15.2 How does PVC manufacture

Vinyl chloride monomer the companion product between chlorination of ethylene and pyrolysis of the resulting ethylene dichloride (EDC) is call PVC plastic material. The following formula show how this material was formed.

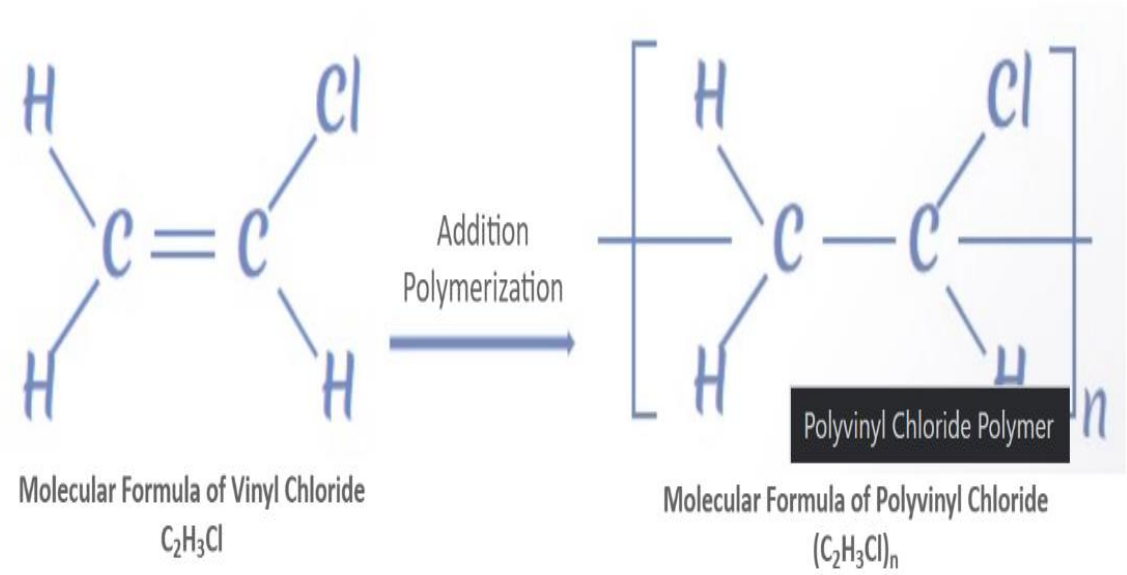


Figure 33: *PVC chemical bond*

3.15.3 Key Properties of PVC Polymer

PVC plastic is a very cost-efficient material that is used by many different companies to make either insulating products or water pipes. Is has a lot of special properties:

- PVC is a particularly good insulating material that can be uses in a lot of electrical appliances.
- PVC is resistant to a lot of hard conditions such as weather, oxygen rotting and electric shock.
- PVC is also a good self-extinguishing material due to the high chlorine content in the atoms. PVC plastic uses a lot in fire recruit departments.
- Due to those above properties, PVC is a long-lasting material with a low-cost manufacturing.
- PVC is a lightweight and tough material so it can be used in a mechanical or industrial field.
- PVC also use a lot in the medical field since it has a property of resisting against inorganic chemicals.

3.15.4 Recycling of PVC

In this modern world, people are pay more attention to the natural. one of the most important topics of the world is how to recycle the plastic so that the environment will not get much more damage. PVC products meet this requirement of the market where all of the products that made by PVC is one hundred percent recyclable. The recycling code for PVC material is #3

Figure 34: *Recycling category*

Adopting the important of recycling plastic could bring a lot of positive affect to the environment not only for these current years but also for year to come. The next generation will have a much cleaner natural. There are many programs were created to recycle these plastics.

- Mechanical Recycling: this is the process of recycling that refers to PVC waste is treated through shredding, sieving, and grinding. After separating these mechanical compounds, there are few techniques that can be used such as granulated and powder. The results will also depend on the compound of the PVC materials.

- Chemical Recycling: this is the process of breaking up PVC material into the monomers and any other substances which is contains in the materials. The new Chlorine in the RVC will be set free and form HCL. This new compound has a hard property that can be used in a lot of chemical applications.
- Feedstock Recycling: this process will generate hydrogen chloride that could be eventually used to make a new PVC plastic.

3.15.5 Why use PVC for the design?

The main property that was taken into consideration of choosing this for the cover of the project is insulating property. The fact that PVC does not have election moving around in the compound. They will not be able to ever conduct electricity which make them become a good insulator.
The cost-efficient is also another greater factor to choose this PVC material over the plastic one. Minimizing the budget is one of the key factors of this project. Therefore, this add a great protection value to our design at low cost.
Lifespan is also important about this PVC material. As the IntelliDate box runs, it will generate a decent amount of heat. Having the property of tolerating the heat will help the product expend its lifespan.

3.16 Wireless Connection

With current technologies, devices with wireless communication has become an essential feature for most users. Bluetooth and Wi-Fi are the two options that were taken into consideration. The following information about Bluetooth and Wi-Fi provides all the advantages and drawbacks of both in order to decide the best solution for the connection.

3.16.1 Bluetooth

Bluetooth was developed in the 1989 by Nils Rydbeck, CTO at Ericsson Mobile in Lund, Sweden. The development was initially named as “short-link ratio technology” and late changed to Bluetooth. The purpose of the technology was to solve short-range distance wirelessly connection between devices. The fundamental concept of Bluetooth is to use ratio frequencies rather than the infrared spectrum which was use in the most of traditional technology. As the result, Bluetooth was able to solve the wired connection problem and still maintaining a clear signal for the communication.

3.16.1.1 How Bluetooth works

Bluetooth operates base on frequency-hopping spread spectrum radio technology. The technology divide signal into a packet-based structure in a master-slave arrangement. With this technique, information is transmitting by packets and the master device will indicates which devices is communicating with.
All of the information is sent between the master and slaves at the given time of the commands and all of them was done using radio frequencies in the industrial, Scientific and Medica (ISM) 2.4Ghz range. For this connection to be done with a clear signal it is required a radio line of sight, which can pass through most of non-metallic objects. The

Bluetooth use low-powered signal which will results in the difference range of signal be capture from shortest to longest. The variation of the power will be from 1mW to 100mW for the range from 1m to 100m.

3.16.1.2 Frequency-Hopping

The Industrial Scientific and Medica (ISM) 2.4Ghz band is 2400Mhz to 2483.3 Mhz. There are 79 radio frequency channels that can be used in this band with a difference of 1Mhz for each channel.

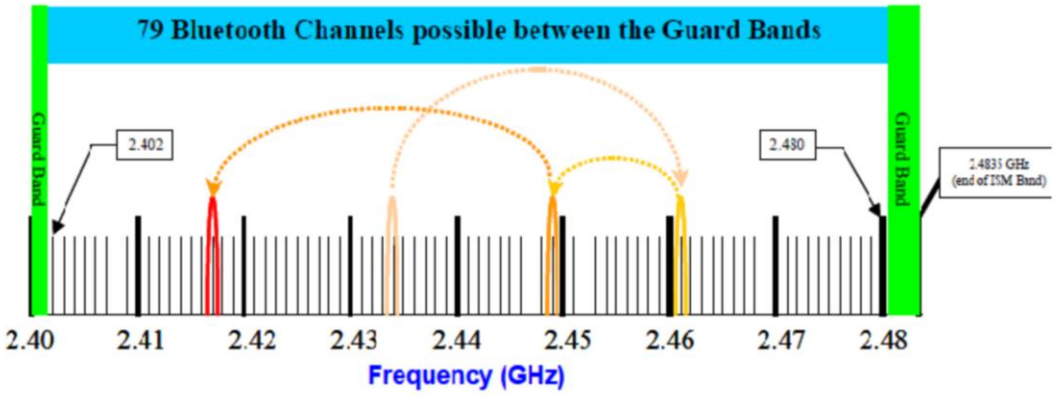


Figure 35: *Bluetooth Channels*

The signal is transmitting with a rate of 1600 hops per second. There are a few difference techniques for hopping frequency. Gaussian frequency-shift (GFSK) was initially used but the most common type of hopping is frequency-shift keying. Given all of these techniques, Bluetooth device is very useful to replace the wired connect; however, there will be some problem with the transfer rate when the information is a large data. The transition rate will be decreased dramatically due to Bluetooth using the same pattern to transfer data as well as disrupt the data.

3.16.1.3 Different Types of Bluetooth

There are varies choices in the market when it comes to Bluetooth chips. It depends on the user requirements and budges to choose which one is the best option to use. Since 1999, there multiples version of Bluetooth has been introduced to the market. It ranges from Bluetooth 1.x to Bluetooth 5.x.

3.16.1.3.1 Bluetooth 4.2

This is an updated version with a faster speed to the Bluetooth Core Specification for the Bluetooth Smart technology. There are some key features and benefits that this new update will bring to users. This new update changes the Bluetooth industry with a faster and smarter technology for the Internet of Things (IoT). This gives user a flexibility internet connectivity option. The security is also improved in this chip. It prevents the Bluetooth device being tracked by LE privacy 1.2 technique and using this feature to save energy unseal for the device. With the LE Secure Connections, the device that has this chip will

use the encryption feature to make sure that the data being protected. The throughput of this version also increases 2.5x faster due to the size of the packet is a lot bigger (10x times) compare to the previous versions.

3.16.1.3.2 Bluetooth 5.2

This is the latest version of Bluetooth industry. Bluetooth 5.2 was introduced in January 2020. A new feature of isochronous channels (ISOC), LE Power Control (LEPC), and Enhanced Attribute Protocol (EATT) were added to this version. This update brings a lot of new feature to the market. The new update of power control gives the device a better control over the quality of the signal, reducing the error during the transmitting and receiving data, and improving the coexistence with other signals in the 2.4Ghz band. The new EATT feature requires the encryption of the connection between two Bluetooth devices which will provide more secure connection compared to the previous one.

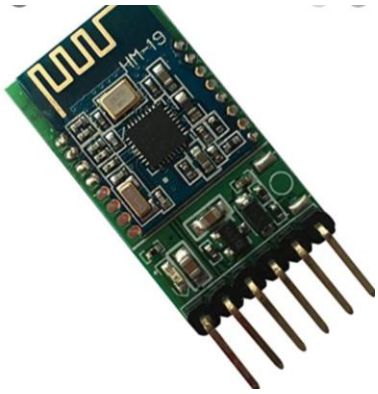


Figure 36: *5.0 Bluetooth chip*

Table 8: *Bluetooth version comparison*

Versions	Basis rate	Data rate	High Speed	Low-powered	Description
Bluetooth 1.x	Yes	No	No	No	This is the most basic Bluetooth that was widely used back in 2003. The hopping frequency technique help this chip to avoid contrast with Wi-Fi, but the data transmission speed was not great.
Bluetooth 2.x	Yes	Yes	No	No	This is an updated from the previous version of Bluetooth. Data rate was improved, and less power technology was implemented in this chip. A secure feature was also added to this version
Bluetooth 3.x	Yes	Yes	Yes	No	In 2009, A high speed Bluetooth was introduced to the market. The high speed was achieved by transmitting data using Wi-Fi but remain connection as Bluetooth.

Bluetooth 4.x	Yes	Yes	Yes	Yes	One of the most advanced versions of Bluetooth was invented in 2010, this version has solved most of the previous issues with old generation. As technology developed rapidly during this period of time, low-powered chips become the talk of many companies purposely save the energy of devices using these Bluetooth. The low-powered feature was introduced in this version. It was yet to be one of the most efficient, but it was a start for one of the most advance Bluetooth versions that is currently use today.
Bluetooth 5.x	Yes	Yes	Yes	Yes	In 2016, the most advanced Bluetooth version was introduced to the market. Every aspects of the Bluetooth chips were implemented greatly in this version. The generation increase the data rate greatly by communicate with the client and hub at the same time in result of improving the data rate compare to all the previous version. The range was also improved from 50 to 800 meters. Low-energy feature was also improved in this version so that this was widely use by a lot of big mobile phone company for example Samsung and LG.

With all the information from the table above, Bluetooth 5.0 and Bluetooth 4.2 seen to be two of the best option for the IntelliDate. Both have all of the modern features that would help the performance of the IntelliDate.

These new Bluetooth chips have one thing in common that they use Wi-Fi to transfer data from one device to another. Technically speaking, it is possible to transfer data without using Wi-Fi; however, the transmission speed will be decrease dramatically. Another factor on top of that is that a lot of modern devices does not work without the Wi-Fi signal. So, this is a drawback about using Bluetooth connection for the smart calendar.

3.16.2 Wi-Fi Connection

Wi-Fi is currently one of the most popular networking technologies with a high-speed connection. “The Wi-Fi was invented by NCR corporation/AT&T in Netherlands in 1991. By using this technology, we can exchange the information between two or more devices.” With the leading technology of wi-fi connection, a lot of mobile applications and smart TVs are utilizing the advantages of fast speed to enhance the customer experiences. Wi-Fi is normally called wireless “local area network” (LAN), which Wi-Fi allow all devise in the local network communication wirelessly. An antenna from the router will get all of the signal information from users and send it to the desired IP addresses. Most of the TV, monitors, and micro-processor come with a Wi-Fi card nowadays.

Figure 37: *Wi-Fi connection*

The figure is implementing for the Wi-Fi connection. Wi-Fi has the flexibly of having many devices in the same network communicate directly with each other. All of the data information will be transmitted from the antennas and router to the devices which contain the Wi-Fi cards. The Wi-Fi signal is depending on the range as well as the environment. The router also plays an important role in the Wi-Fi connection. Theoretically speaking, the closers devices get to the router the faster connection it will receive from the router.

The Wi-Fi has a lot of the leading technology for connection; however, there also a draw in the security factor. Wi-Fi is a wireless connection, so there will be a lot of people could login to the Wi-Fi. Some of these users might accidentally download viruses to damage the whole network. Therefore, it is very necessary that the user has to provide a security for each device using the Wi-Fi network.

3.16.2.1 Types of Wi-Fi Technologies

In a remarkably similar way with Bluetooth, there are currently five different types of major Wi-Fi technologies available in the market:

- Wi-Fi-802.11a
- Wi-Fi-802.11b
- Wi-Fi-802.11g
- Wi-Fi-802.11n

3.16.2.1.1 Wi-Fi-802.11a

This is one of the first Wi-Fi standard that was introduced to the market. It provided a raw data transition speed of 54Mbps within the bandwidth of 5GHz. This is one of the most expensive technology. It also has a problem with connectivity since it is hard to operate a 5GHz bandwidth.

3.16.2.1.2 Wi-Fi-802.11b

802.11b is an updated version from Wi-Fi-802.11a in which this new chip supports bandwidth 11mbps. The signal is now much easy to operate with frequency spectrum around 2.4 GHz. This is much cheaper to generate compare to the Wi-Fi-802.11a. It works great with home appliance and phone. This type of Wi-Fi is utilizing a lot in home system.

3.16.2.1.3 Wi-Fi-802.11g

The world always comes up with new technology. In 2003, the newest Wi-Fi card at that time was a combination technology of 802.11a and 802.11b. The new Wi-Fi card support bandwidth up to 54mbps and it use a 2.4 GHz frequency. This provided a great connection as well as a reasonable range for data transmission due the small bandwidth. The speed of this card is a lot faster but it a trade of the cost of the card since it is higher than the previous versions.

3.16.2.1.4 Wi-Fi-802.11n

Tech leading company has come with the most advantage Wi-Fi card, 802.11n. The new card was designed to improve on 802.11g. The bandwidth is supported by multiplying the wireless signals and antennas. The new technology help keep the pace with rapidly increasing speed using Ethernet. Another new feature added to this card was a low-powered technology, this help devices save a lot of energy while operating this card.

3.16.3 Which one is more suitable for IntelliDate?

After taking the two connection options into a very close consideration. Wi-Fi card is a better option for IntelliDate due to its flexibility and up-to-date technologies. The best option of using Bluetooth for the IntelliDate will be the 4.2 and 5.0 Bluetooth. However, these two chips also need Wi-Fi to work with other devices or to achieve a desired data speed. Therefore, using Wi-Fi is the most suitable option that can be used for the IntelliDate. One of the key factors of make the IntelliDate is to keep the low budget so that every user can get that easily. So, the 802.11g will be the best Wi-Fi option to choose.

3.17 Power Supply

All over the world electricity is used to power different devices. While many of those devices use just electric power from the mains supply, more and more we see devices that need more than just the basic supply of power from a wall outlet. Some places require wind turbines and others just the sun and some solar panels. Some applications require an even more reliable source of power or backup power like emergency generators or backup batteries. All these things are great but useless if the devices that need them cannot even use the supplied power. We realize that the unique application that we are implementing requires a sound solution for power and because of this we have explored many different options of powering it. This being said, we ultimately decided that we would try to integrate the power that is inherently supplied to the screen from a single linear regulated power supply that can supply enough current to comfortably run the screen and auxiliary components.

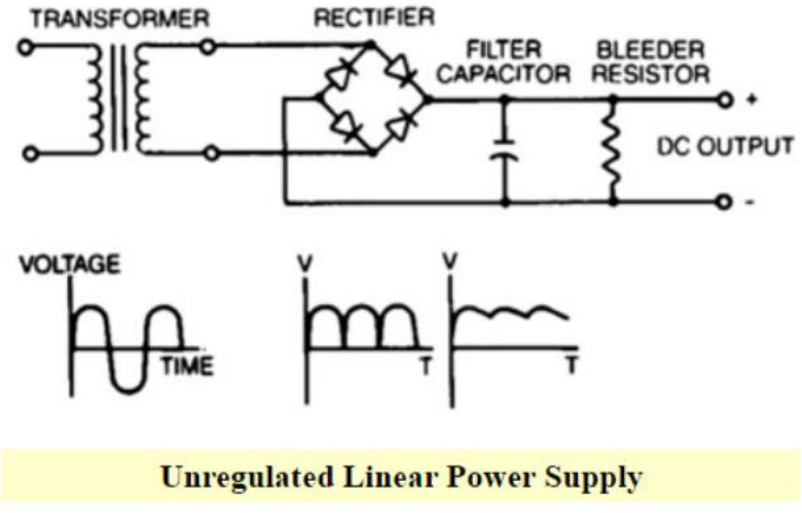
Rather than buying a power supply that has multiple outputs, this will be achieved with the use of a buck/boost converter which will allow for enough current to allow our chipset to perform while regulating the voltage within the desired tolerance level. Along with this we also decided that we would like to try to implement a battery into our design that way if the device ever needed to be mobile for a short period it could still stay connected. These

decisions were all made based on the following factors and more: efficiency, cost, and safety.

3.17.1 Linear Unregulated Power Supply

A linear unregulated power supply is a power supply that does exactly as the name implies, it does not actually regulate the voltage. In layman's terms what this means is that any fluctuations in the input voltage will directly affect the output voltage. This happens because of the composition of the linear unregulated power supply. It is generally made with a transformer to step down the voltage, a rectifier which changes the AC voltage to a DC voltage, a bleeder resistor which is used for drain the capacitor's charge, and a filter capacitor which helps to smooth out the ripple affect caused by the input voltage. This type of power supply can be very finicky because the currently and voltage are inversely connected. These types of power supplies thrive on homeostasis which pretty much means they do not like change. This being said it will always try to supply the same amount of power so if the load that gets connected to it is rated to use more current, the power supply will actually supply a lower voltage. This can be dangerous to devices because it can cause a device that uses less than the rated current to get too high of a voltage and fry it. These types of power supply are general safe these days as long as the manufacturer put a quality resistor in them, so the filter capacitor does not retain its charge. Linear unregulated power supplies are the cheapest types of power supplies because they go through less stages of transformation and therefore have less parts.

As far as safety goes these power supplies can end up being a shock hazard and dangerous. This is because the power supply uses that filter capacitor at the load end and if for any reason the resistor fails the capacitor can be left in a high charge state. So, if someone touches a bare lead, they run the risk of shock. In most cases this very unlikely to happen because these types of power supplies are normally in sealed casings for consumer products.



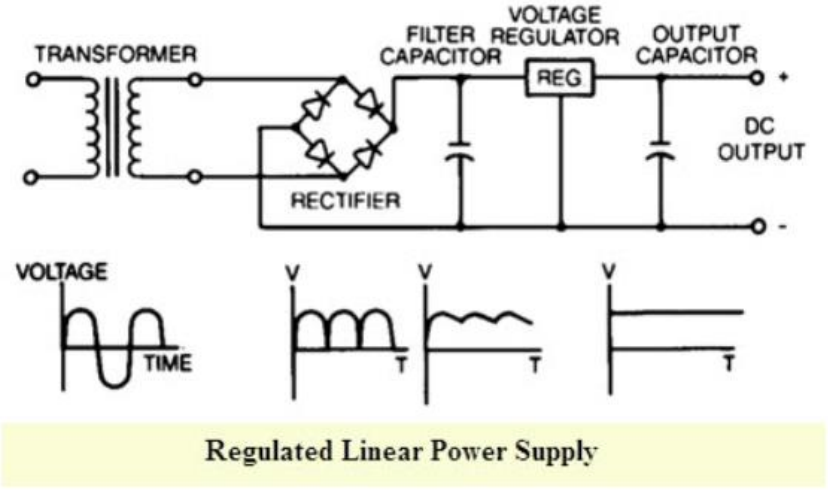
Unregulated Linear Power Supply

Figure 38: *Unregulated linear power supply*[76]

3.17.2 Linear Regulated Power Supply

A linear regulated power supply is a power supply that is again fairly straightforward in its function in that it is a power supply in which power is regulated. This power regulation is what filters the output signal to be consistent and smooth. Looking at the parts and pieces of a regulated power supply we can see that is almost the exact same configuration as an linear unregulated power supply with the exception that it has a voltage regulator in place of the bleeder resistor. This being said the configuration is usually as follows: a step down transformer to bring the voltage down to a usable number, a rectifier to convert the voltage from AC to DC, a filter capacitor in order to try to smooth the rectified voltage to a more consistent voltage and a voltage regulator which ultimately allows the power supply to deliver a consistent voltage across different types of loads by turning the voltage into a constant smooth stream. This is an important feature to have because it now allows for the potential to use this power supply with other devices without the worry of either destroying the device with too high of a voltage, or not being able to power the device because it requires a higher current and the voltage becomes too low. This fact alone makes this type of power supply just slightly more efficient than the first, linear unregulated power supplies.

The linear regulated power supply itself is not the most efficient power supply made being only about 20%-25% efficient regularly but it makes up for this fact in other areas like reliability and size. As I stated before the parts for both linear regulated and unregulated power supplies are remarkably similar, so it should not be a surprise that their price points are very similar. The linear unregulated power supply is, for the most part, cheaper than the linear regulated power supply but in many cases not by much. This leads me to my last point, safety. The linear regulated power supply is in most cases on the same level as the linear unregulated power supply when it comes to safety. This is due to the fact that it still has the filter capacitor at the output.



Regulated Linear Power Supply

Figure 39: *Regulated linear power supply* [77]

3.17.3 Linear Power Supplies

As we can see from above linear power supplies have a simple model and therefore are low cost options when trying to power devices. They each have pros and cons, like the fact that unregulated power supplies can't be used with sensitive equipment such as x-ray machines or some computers etc., or the fact that linear power supplies can be very robust in their applications, but at the end of the day they just might not cut it for some applications. Many times, for our everyday electronics we will use a regulated linear power supply but that is because for our most used electronics (Cellphone, Tablet, Television) the power constraints are relatively low.

When we start to see a need for reliable power at higher levels, we will realize that the linear power supplies just won't cut it because of their restraints and that's where another type of power supply comes into play.

3.17.4 Switching Power Supply

The next type of power supply is a switching power supply which is quite different than the previously discussed power supplies because of not only its components but just the way it functions in general.

A switching power supply does still have some of the same components, but they are used in a different way. Some of the parts include a bridge rectifier which are a few diodes placed in a way that no matter if the input AC voltage is on the positive or negative leg of the sine wave the output of the rectifier will be a positive almost constant voltage, a filter capacitor to try to smooth that voltage even more, a transistor that is connected to a feedback regulator which will act as an on and off switch to make sure that the end voltage stays as constant and consistent as possible, a transformer which will take the switching signal from the transistor and transform it to a lower voltage, another bridge rectifier that again makes sure that the resulting voltage coming from the transformer is only able to be positive, a filter capacitor which now doesn't have to have too high of a value because of the efficiency of the rectifier, and a bleeder resistor to discharge the capacitor in the off state of the power supply. The end result of this configuration is a power supply that is very versatile and able to supply very concise and copious amounts of power.

The separate stages of this power supply cause the efficiency of these switching power supplies to go up exponentially in comparison to the two linear power supplies that were previously discussed. In many cases the efficiency will be as high as 96%. These power supplies are also able to be a lot lighter and smaller than their linear counterparts because the parts they use allow for the transformer to be smaller. Now all of this sounds great but what does this mean for my pocket you may ask, well more features and a higher efficiency equals, you guessed it, higher costs. As far as safety goes these switching power supplies are on the safer end because the filter capacitor does not have to be as large as it has to be in it linear counter parts because the other components do a lot of the filtering already.

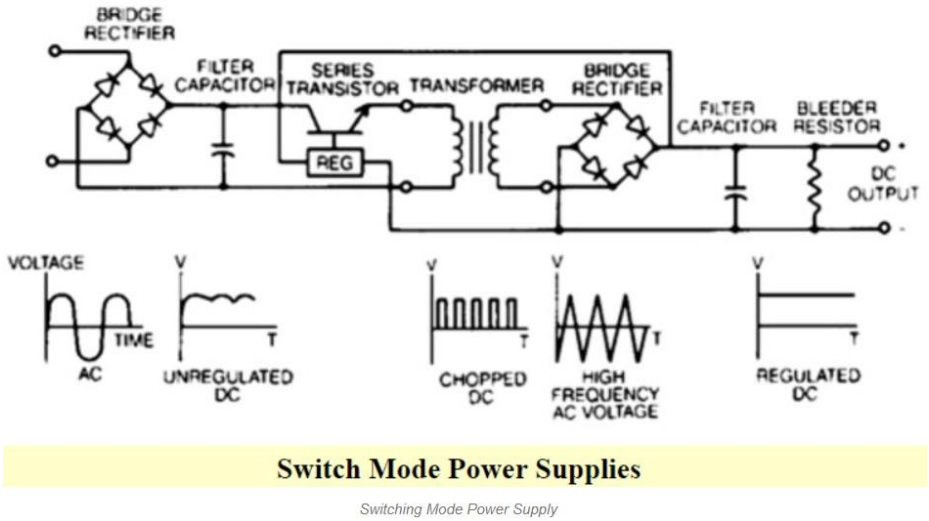


Figure 40: *Switching Mode Power supply*[78]

3.17.5 Uninterrupted Power Supply

The uninterrupted power supply is a power supply that uses an AC voltage just like all of the other power supplies mentioned before this, but it has another portion to it that allows it to stay on in the event of a power failure. In many cases the uninterrupted power supply is used in conjunction with the other power supplies because it will normally supply an AC voltage as the output rather than the DC voltage all of the other power supplies supply. The uninterrupted power supply usually uses a 12-volt battery built into it that is connected to an inverter which transforms that 12 volts into 120 volts or 240 volts depending on where in the world you are. Most uninterrupted power supplies also have a built-in surge protector to help protect and sensitive devices that may be connected to them from sudden surges in power. Many times people will use these devices on things like computers and modems because it will allow them to save their work if they suddenly lose power, and that is a feature that can be useful to someone who wants to use our device because there may be sometimes when the system is either updating or the user is updating their calendar and if there was a power loss they could brick their system. These devices tend to be very efficient in their conversions of power.

Figure 41: *Uninterrupted power supply*[79]

3.17.6 DC power supply

There is also the DC power supply which is normally not something that you will power most electronic devices with. They tend to be used for troubleshooting electronics and prototyping. When it comes to DC power supplies, they usually are able to be controlled by both variable voltage and or variable current.

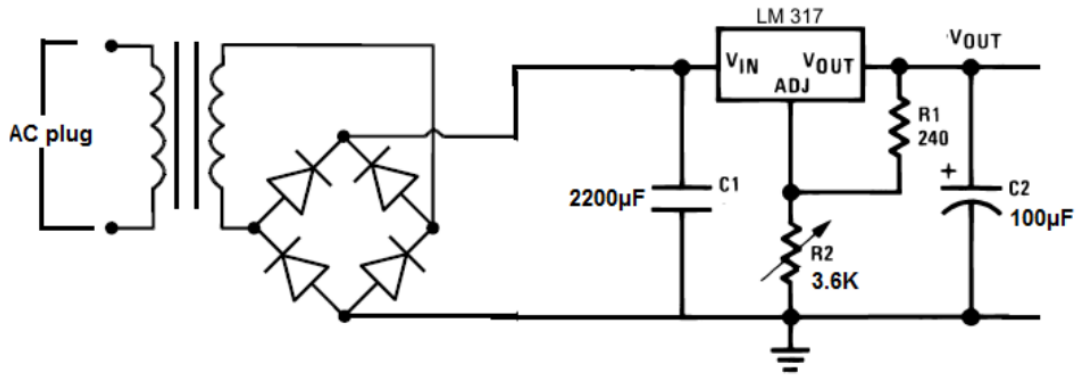


Figure 42: *DC Power Supply*[80]

3.17.7 Power Supply Conclusion

So, after careful consideration of each of the possible options, we decided on using a linear regulated power supply and here is why. The unregulated power supplies are the cheapest, but their efficiency is very horrible and as far as safety goes, they are possibly the most dangerous of all the power supplies. Now when you look in terms of danger none of these are inherently dangerous because they are consumer projects that are sealed in casings but when compared to each other certain ones have more safety features than others. The switching power supply is one of the most efficient and cost-effective power supplies, but it is also on the more expensive side of things. Being that it has more premium parts it also is more safe than linear supplies. The uninterrupted power supply wouldn't easily be incorporated into our product because the size of the power supply wouldn't be able to fit into the casing of the screen but it is something that might possibly help to ensure that we get consistent activity. We chose the linear regulated power supply because it is still cheap but in comparison to other power supplies and it's very reliable. When you put a load on it, you can still get the voltage rated for it and not have to worry about pulling too much current.

Table 9: *Power Supply Comparison*

No.	Linear	Switching	Uninterrupted	DC
1	Light Weight	Medium weight	Light weight	Heavy
2	Cheap	Cheap	Semi	Expensive

3	Small	Small	Medium	Medium
4	Simple	Complex	Complex	Simple
5	Robust in applications	Primarily for computers and servers	Used in hospitals and telecommunication	Low voltage applications
6	Not good for sensitive equipment	Good for sensitive equipment	Great for sensitive equipment	Not good so sensitive equipment
7	Not the most reliable	Reliable	Very Reliable	Reliable enough
8	Not safest	safe	Safe	Not safest

3.18 Voltage Regulator

After the power supply passes power to the screen then we need to transform that power to match the criteria and power the board and other electronics. To do this we have a few different things at our disposal such as a buck converter, boost converter, or a buck-boost converter, but ultimately these are all just types of voltage regulators.
A voltage regulator is a device that takes an input voltage that can be large or small and creates an output voltage that is one steady number. Whenever you need a non-fluctuating voltage a voltage regulator is the best bet.

3.19 Linear Regulator

Just as there are linear regulated power supplies there are also linear regulators. These regulators are quite simple in that they act as a voltage divider by design. What this means is that when you apply a voltage to your device and it gets to the regulator, the voltage is then forced through some type of resistor and then out to the load. Causing the voltage to first go through this resistor creates a drop in the supplied voltage to the load effectively regulating the voltage to a lower value. The issue with this approach is that the voltage will not always be the same when using this regulator with this device. There is also an issue with the fact that this device dissipates through the use of a resistor which pretty much drops the efficiency of the device down exponentially because the resistor drops the voltage by producing heat and in turn a lot of energy is wasted as heat in the system.

Figure 43: *Linear Regulator*[81]

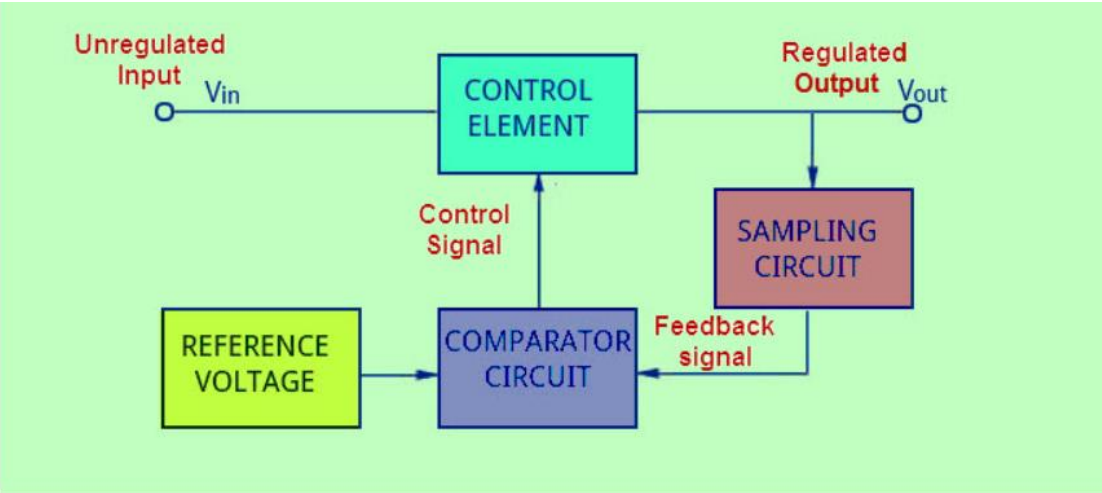
3.20 Shunt Regulator

One of the types of linear regulators is a shunt regulator. Shunt regulators provide a single path from the supply voltage to ground through a variable resistor, which then causes the voltage to drop to a degree depending on what the resistance is. This characteristic is a form of voltage divider as discussed above which can be fine-tuned by varying the resistance of the regulator verses the resistance of the load. Doing this can allow us to be very precise in low current situations because once the regulator is tuned to the device that it is paired with, there would not be much deviation in the required specifications. The shunt regulator is therefore mostly used in applications that require small currents. This is because there is such a big waste of power due to heat.

3.21 Series Voltage Regulator

Another type of Liner voltage regulator is the Series Voltage Regulator which works in somewhat of a similar way to that of a Shunt Voltage Regulator. A Series Voltage Regulator uses a variable resistor placed in series with the load to regulate the amount of voltage that goes to the load. In this case, a voltage divider is not necessarily created but Ohm's Law is put directly into effect. Ohm's Law states that the voltage will be equal to the current multiplied by the resistance and the two resistors in series essentially split the amount of voltage available proportionally to their size. Using this example, the variable resistor being put in series with the load essentially treats the load as another resistor. This method will also generate a decent amount of heat because of the use of a resistor to dissipate part of the voltage.

Conversely to the Shunt Voltage Regulator, the Series Voltage Regulator does not dissipate any of the current when in series with the load, allowing the load to receive the full current that is originally supplied. Even if the load if no longer attached the Series Voltage Regulator does not dissipate all the current and therefore is more efficient than the Shunt Voltage Regulator.



Series Voltage Regulator

Figure 44: *Series voltage regulator*[82]

3.22 Switching Voltage Regulator

A switching voltage regulator uses the mechanism of rapidly turning on and off to regulate the voltage. This mechanism can change the voltage by varying the duty cycle and setting the amount of charge that is transferred to the load. Switching Voltage Regulators have feedback systems to help control the duty cycle. These feedback systems sense how high the average voltage is and tells the system when to turn on and turn off. This type of voltage regulator is a lot more efficient than a Linear Voltage Regulator because it is either all the way on or all the way off and the variable resistor must dissipate a lot less power. This process is so efficient that these regulators are even able to generate voltages higher than the input source voltage.

Table 10: *Regulator Type Comparison*

No.	Linear	Shunt	Series	Switch
1	Light Weight	Light Weight	Light Weight	
2	Cheap	Cheap	Cheap	
3	Small Size	Small Size	Small Size	
4	Brings down Voltage	Brings up Voltage	Bring up or down voltage	
5	> 90% efficiency rate	90%-96% efficiency rate	90%-97.6% efficiency rate	
6	Variable voltage output	Variable voltage output	Variable voltage output	
7	Adjustable current limit	Adjustable current limit	Adjustable current limit	

3.23 Buck Converter

A Buck Converter, also known as a Step-Down Converter, is one type of a Switching Voltage Regulator that lowers the input voltage. It uses pulse with modulation to create a signal that will mimic a certain voltage. If this output waveform is analyzed on an oscilloscope, we will see a ripple in the waveform. Buck Converters normally consist of at least three main parts: a diode, a capacitor, and an inductor. Many times, it will also include a switching transistor and bridge rectifier to aid in the feedback circuit. With that in mind, sometimes it is ok to use AC or DC power with these devices as long as they are isolated properly. For the Buck Converter to maintain a continuous output, the circuit uses the

energy stored in the inductor during the on periods of the switching cycle, during the off periods of the switching cycle.

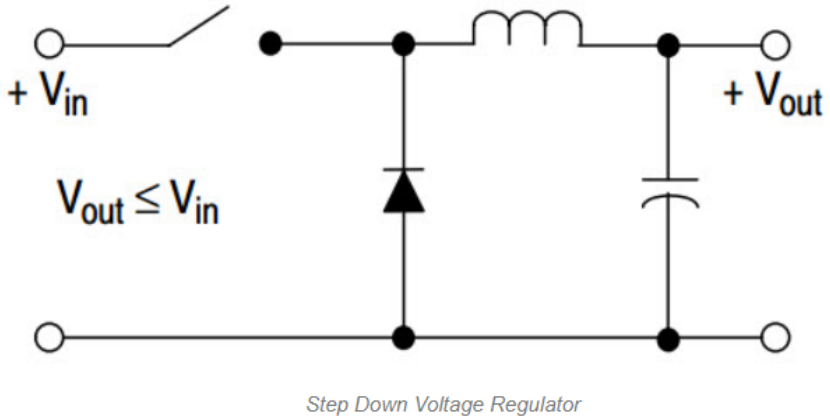


Figure 45: *Step Down voltage Regulator*[83]

3.24 Boost Converters

The boost Converter also known as the step-up converter is also a type of Switching Voltage Regulator. Its main function is to take a voltage that's normally a DC voltage and boost it to a higher voltage this process is done by using four basic elements: an inductor, a diode, a capacitor, and a transistor in a different configuration than that of a Buck Converter. But do not worry this device does not defy the laws of physics in that the boost of voltage has an inverse effect on the current passing through the device. In other words, the amount of power that can be supplied by the Buck Converter versus the amount of power that was supplied to the Buck Converter both remain the same. A Buck Converter in its basic function is practically the same as a DC transformer but in many cases, it is smaller and lighter.

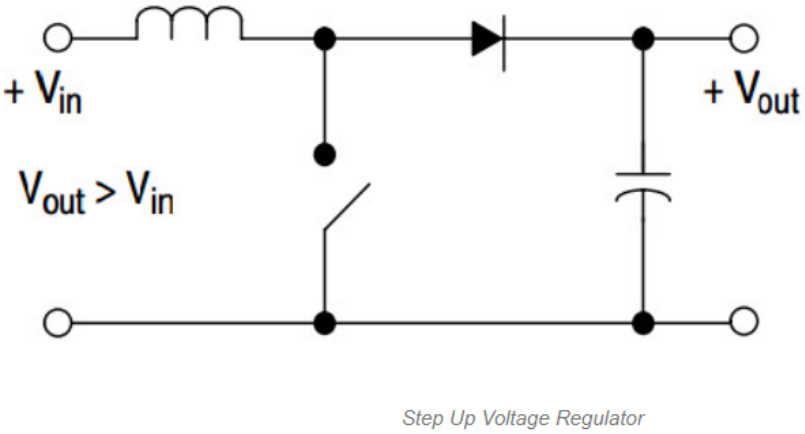


Figure 46: *Step up voltage regulator*[84]

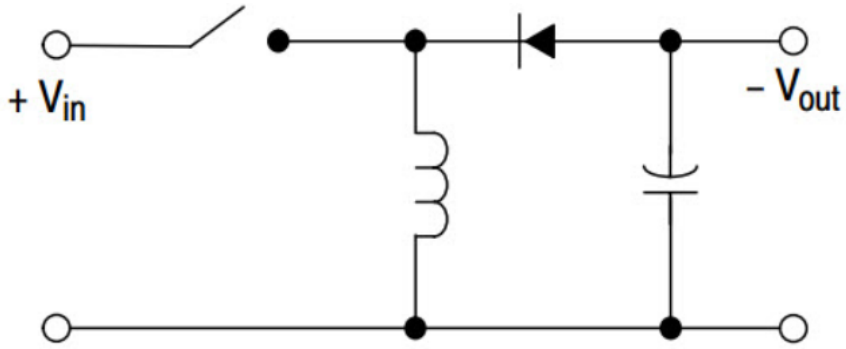
3.25 Buck-Boost converters

A Buck-Boost Converter also known as a step-up step-down converter, is yet another type of Switching Voltage Regulator that combines the principles of both the Buck Converter

and the Boost converter into one single circuit. It is also sometimes referred to as a voltage inverter. This combination can be very useful especially in battery powered applications because of the unique characteristics. For example, in our application we are seeking to integrate a battery to power a device. At full charge, a battery may be at a higher voltage that what is needed but as time progresses the battery will eventually pass a threshold in which the voltage is lower than what is required for proper operation.

If we use a Buck-Boost Converter to regulate that voltage, we would be able to get an extended life from that battery because we can step down the voltage when the battery is charged as it passes the lower threshold, we can then step up the voltage without having to charge the device. Both Buck and Boost Converters use remarkably similar if not the same parts and therefore creating a Buck-Boost Converter is just a matter of correctly rearranging those parts.

The cost of creating a Buck-Boost Converter is actually similar and, in some cases, even cheaper than creating one or the other. Along with a low price point, a Buk-Boost Converter is very efficient sometimes with rates as high as 97.6%.



Step Up/Step Down Voltage Regulator

Figure 47: *Step up/ step down voltage regulator*[85]

Table 11: *Switching Regulator Type Comparison*

No.	Buck	Boost	Buck/Boost
1	Light Weight	Light Weight	Light Weight
2	Cheap	Cheap	Cheap
3	Small Size	Small Size	Small Size
4	Brings down Voltage	Brings up Voltage	Bring up or down voltage
5	> 90% efficiency rate	90%-96% efficiency rate	90%-97.6% efficiency rate

6	Variable voltage output	Variable voltage output	Variable voltage output
7	Adjustable current limit	Adjustable current limit	Adjustable current limit

3.26 Battery Types

As we discussed the plans for our project, we toyed with the idea of using a battery powered power supply in order to offer some form of portability and also give a cleaner overall look if the device is mounted on a wall. Due to this fact, we investigated different types of batteries that are available on the market and compared them to each other. The types of batteries that we decided to discuss below are: Lithium Ion, Lithium Polymer, Ni-Cad and Lead.

3.26.1 Lithium Ion

The Lithium Ion battery is a type of rechargeable battery that has been around since 1985. We see them everywhere today mainly in electronic devices like cell phones and other portable electronics. Unfortunately, not all lithium ion batteries are made equal and many of them are more likely to combust, explode, or leak due to overcharging, over draining, and /or overheating. If we look at some of the pros though we can see that the Lithium Ion battery is a dense and rechargeable battery that is also lightweight relatively, allowing it to be used across many platforms. There are many different types of styles of the Lithium Ion but for now we will just discuss the 18650 cells.

Figure 48: *Lithium Ion Battery*[86]

3.26.2 18650 Cells

The 18650 Cell battery is a standard size battery that has been adopted by manty different industries. These cells can be seen in many different devices such as portable chargers, battery banks for solar arrays, flashlights, electric bicycles, electric longboards and many

more. Why does this cell have so much popularity? Well for many reasons. For one it is a cell that is relatively dense in energy storage in comparison to its weight. What this means is that a consumer will be able to go longer without having to recharge these batteries than with let's say a NIMH battery because it is able to store more energy in a smaller place (volume). This energy density is not only important to the frequency of charge and discharge but also for the allowance of high current drain. Another pro of these cells is that they are very low maintenance. In comparison to cells that are made from Ni-cad, which require a user to periodically drain and then recharge a cell to maintain its integrity, these batteries are the best because nothing of the sort is needed. These cells also have a very low self-discharge rate on standby with as little as 1% every month. A very big advantage that these cells have over other cells is the voltage of these cells. The resting mid voltage of these cells is around 3.6 volts, with cells being fully charged at 4.2 volts. When we look at other batteries that are similar in size, they only measure about 1.5 to 2 volts that can be supplied, which in comparison shows a very big difference in ability. That means that in some cases it would take twice as many other batteries to get the job done that an 18650 cell could take care of. Probably a very big deal for many people is the fact that Lithium Ion batteries in general are just available in so many different ways, such as this 18650 style and not only that but in the way that they are able to fit in cellphone, home phones, computers and more. Now it is not all just rainbows and sunshine over here either, there are a few cons with these cells as well. One being they are costly to make and therefore costly to buy. In comparison to Ni-Cad batteries these are typically 40% more to manufacture. Also, the transportation of the cells sometimes can be a negative affected because many airlines will only transport of certain number of batteries at any given time. That makes you wonder why right? Well one of the reasons is the actual chemical makeup of these batteries. You see the batteries themselves have a very flammable electrolyte in them. What this means is that any imperfection or mishandling of these cells can cause the battery to catch fire or even worse explode.

Figure 49: *18650 Battery*[87]

3.26.3 Lithium Polymer

When it comes down to a battery that is very innovative and flexible both literally and figuratively the Lithium Polymer battery stands out the most. In recent years there have been a spike in hobby grade unmanned aircraft for consumers all over the world. Although the entire industry has seen a spike in numbers, I am more referring to the hobby grade

and/or professional grade (drones) quadcopter. This spike in sales and interest was actually a huge help to the battery industry when it came to the lithium polymer batteries because that actually gave the boost in interest in order for the further research to be done on the development of those batteries. But what is so special about these batteries? Well they are also a very dense battery which allows them to be useful for so many other things such ask, cameras, phones, watches, and laptops just to name a few. One of the key differences between a Lithium Ion battery and the Lithium Polymer battery is the fact that the Lithium Polymer battery can be made into practically any shape. Another key difference is the fact that Lithium Polymer batteries are made with a polymer electrolyte which helps with their flexibility to shape. Another pro of the Lithium Polymer battery is that the voltage at which these cells perform is the same as with the 18650's in that they run at about 3.6 volts - 4.2 volts. One of the cons of this battery though is that it is not very safe. When these cells get overcharged the begin to swell and this swelling can actually lead to catastrophic failure and cause the cell to possibly catch on fire or explode. This was one of the more serious considerations that were had to make while trying to choose a battery for our product. We wanted to maintain a sense of safety when consumers use our product for a couple reasons, one being their well-being and two being legalities.

Figure 50: *Lithium Polymer Battery*[88]

3.26.4 Lead

Lead batteries power the automobile industry as we know it but with those batteries tend to be very robust. The lead battery is a battery that can supply large amounts of power through bursts and sustained methods and yet be able to fit in a relatively small area. Many Lead batteries can have large capacities to be able to be sufficient enough to supply different devices with power for relatively long times without having to recharge them. This means that consumers get more uninterrupted time to do whatever it is that they need to do. This battery is not all carefree though, there are a few cons to having a lead battery. One would be that those batteries can get very heavy amazingly fast. This means that even if we were able to get the battery in a case with our screen, we would still have an issue with the assembly being heavy, possibly too heavy to hang. Another issue we might run

into is the fact that lead batteries are not super low maintenance. This means that the batteries would still need to be accessible enough for the user to maintain them by adding distilled water when needed and cleaning the terminals.

Figure 51: *Lead Battery*[89]

Table 12: *Battery Type Comparison*

No.	Lithium Ion	18650	Lithium Polymer	Lead
1	Medium weight	Medium weight	Light weight	Heavy
2	Cheap	Cheap	Semi	Expensive
3	Medium size	Smaller than a C battery	Any size/ shape	Large size
4	Low Maintenance	Low Maintenance	Low Maintenance	High Maintenance
5	Combust/ Leak	Flammable	Flammable/ Explode	Flammable
6	Small Capacity	Medium Capacity	Medium Capacity	Large Capacity

3.27 Hardware Components

As with any other electronic product there are many different components in different combinations that are needed in order for proper function to occur. These components include but aren't limited to capacitors, resistors, inductors, diodes, and IC chips. For some of these products the sensitivity of parts are not direly important because the product itself is not one using sensitive parts or having very strict standards to up hold. Our product

however does have some rather sensitive parts to it and fairly strict requirements as far as standards go to ensure proper function. When considering which of the lower level components are needed one might be inclined to think that all components of one type are created equal but that is where they are wrong.

3.27.1 Capacitors

Let us take capacitors for example, there are many different types of capacitors and each one has its' strengths and weaknesses even though they all for the most part have the same basic kind of makeup. A capacitor has a few different uses, but when it really boils down to it the two reasons to use a capacitor are either as filter to help clean up voltage or to store power.

3.27.1.1 Dielectric Capacitors

The first type of capacitor is the Dielectric Capacitor. This type of capacitor is known to be as part of the variable type of capacitor because it is commonly used in devices such as transistor radios and transmitters. It works by having multiple plates inside, some that move and some that do not, and when the moving plates get closest to the stationary ones the capacitance goes to its maximum.

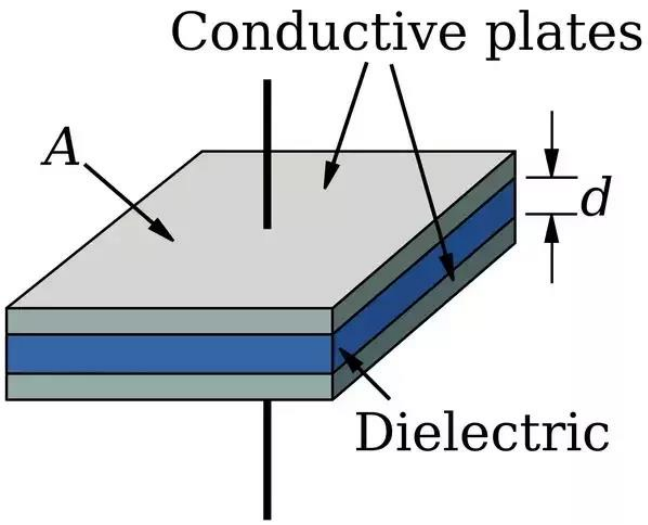


Figure 52: *Dielectric Capacitor*[96]

3.27.1.2 Film Capacitors

This next type of capacitor sometimes goes by different names such as metallized film capacitors, plastic film capacitors, polymer film capacitors, and even film dielectric capacitors. Even with all of these different names the main concept is still the same, these capacitors use a plastic film as insulation and also use it as the dielectric in the capacitor. These capacitors are actually very robust in their application, having an approximate range of between 100s of picofarads to 10s of microfarads. Although this may not seem like a lot, it is for the most part more than enough for most applications. This capacitor is also special in that it is not polarized. What this means is that no matter the orientation the

capacitor will still work just fine. This is one of the reasons why it is also considered one of the more robust capacitors on the market because it is one of the perfect candidates for filtering AC signals and power from mains voltage. This type of capacitor can be found in many applications that include power electronics, X-rays, fluorescent lights, and even audio crossovers. This is a very reliable type of capacitor because it is built to last. It retains its rated value longer than other capacitors and ages generally slower than other capacitor types. This means that their shelf life and service life are prolonged and also that the rate of failure is reduced. Even with these exciting facts the capacitor can still fail and when this happens if can literally be explosive and/or cause a fire so we must be careful in our designs to make sure that we don't overload the capacitor.

Figure 53: *Film Capacitor*[97]

3.27.1.3 Ceramic Capacitors

The Ceramic capacitor also known as disc capacitors are on the smaller side of the spectrum but don't let the nickname fool you, they come in many different shapes and sizes. True they do have a decent range of capacitance values, ranging from picofarads to microfarads but they have a relatively low tolerance for voltages and therefore are not nearly as versatile as the film capacitors. That still does not stop this capacitor from being one of the most widely used capacitors to date. This capacitor like the film capacitor is unpolarized. This means that in any orientation the capacitor will work, and it also makes it ideal when working with AC signals. The downside though is that because this capacitor is not usually able to withstand higher voltages it is not the go to choose when dealing with mains voltage. For the disc looking ceramic capacitors the rating of the actual capacitor is written on it, this helps to ensure that the correct capacitor is used during assembly of a product. The value is usually given with the use of three numbers. The first two numbers are the leading values whereas the last number is usually the amount of 0's for follow. These values are given in picofarads. For example, let's take the number 145, this would be interpreted as 14 followed by 5 0's so 1,400,000 picofarads or 1.4 micro farads.

Figure 54: *Ceramic Capacitor*[98]

3.27.1.4 Electrolytic Capacitors

Electrolytic capacitors are probably the capacitors that most people think of when they hear the word capacitor. These capacitors are able to achieve very high capacitances due to their chemical setup but unfortunately because of this same reason they are subject to some downsides. The electrolyte that is used in these capacitors is not able to maintain its chemical integrity as well as a solid-state dielectric would which means that these capacitors don't have lifespans that are as long as their solid-state counterparts. We also have to worry about large leakage currents and ESR's (Equivalent Series Resistance). These capacitors are also polarized so the orientation when placing them actually matters. This means that they aren't always the ideal component when dealing with AC voltage because the current is only meant to flow one way. Now don't get me wrong there are some very special nonpolarized electrolytic capacitors for use with AC signals out there, but they are not to be confused with just a regular old electrolytic capacitor. Reason being if a polarized capacitor receives a reversed signal from what it is supposed to get, it could have a potentially catastrophic failure that ends in explosion.

Figure 55: *Electrolytic capacitor*[99]

Table 13: *Capacitor Type Comparison*

No.	Dielectric	Film	Ceramic	Electrolytic
1	Through hole	Through hole	Surface mount and through hole	Through hole
2	Cheap	Cheap	Cheap	Cheap
3	Small	Small	Tiny/ SMD	Bigger than most others
4	Low Maintenance	Low Maintenance	Low Maintenance	High Maintenance
5	Combust/ Leak	Flammable	Flammable/ Explode	Combust/ Leak
6	Small Capacity	Medium Capacity	Small - Medium Capacity	Large Capacity

3.27.2 Resistors

Resistors are a very important part of almost any project because they one of the base components for power which ensures for are able to get the voltages you need when and where you need them. For us it was important to make the right choice in our resistors so that we could ensure a long-lasting product. Just as before with the capacitors, there are also a lot of different types and sizes of resistors available.

3.27.2.1 Fixed Resistors

When people are first introduced to resistors 9/10 times it is the fixed resistor. These are the most common type of resistor and as the name would imply they are “fixed” in their resistance value. Fixed resistors are classified as a linear resistor. They are normally fairly cheap and actually happen to be reliable but along with that they are unfortunately not very stable because the heat coefficient is high. These resistors being the most popular have a through hole mounted version and also a surface mounted version which allows it to use in a wide variety of applications.

Figure 56: *Fixed Resistor*[100]

3.27.2.2 Variable Resistors

Variable resistors differ from fixed ones in that they in most cases have a mechanical moving part to them. This is in order for them to have a varying resistance function. One very common subtype of the variable resistor is the potentiometer. A potentiometer normally has 3 terminals which are connected to circuits in a way to create a voltage divider with itself. This allows for different values to get through to a circuit inevitably changing the characteristics of how the circuit performs. Generally, a variable resistance has a higher tolerance than that of a fixed resistor.

Figure 57: *Variable Resistor*[101]

3.27.3 Thermistor

This is a specialized type of resistor in which the resistance changes in respect to the temperature. There are currently two different types of these resistors, the negative temperature coefficient and the positive temperature coefficient. When dealing with the negative temperature coefficient (NTC) the relationship is an inverse relationship meaning that as the temperature goes up the resistance decreases and when the temperature decreases the resistance increases. The PTC on the other hand works in the exact opposite manner, it is directly related to the temperature. These resistors are best used in applications that require temperature to be used as an input, such as an AC system with an auto set feature or in situations where you need an auto shut off for a system when it begins to overheat. These parts tend to be fairly expensive in respect to fixed resistors because of their specialized function.

Figure 58: *Thermistor Resistor*[102]

3.27.4 Varistor

Another Specialized type of resistor is the Varistor. It is a non-linear resistor that reacts to changes in voltage with changes in resistance. The main point of a varistor is that as the voltage across it increases the resistance decreases at a non-linear rate. This characteristic actually makes it great at being able to protect equipment for high surges of voltage because it absorbs those surges. The was this works is as the voltage gets higher and begins to pass a threshold the resistance of the varistor begins to rapidly drop, this drop in resistance then begins to make the varistor begin to seem like a short circuit. So, when the varistor is put in parallel with a device that receives a voltage surge, it essentially acts as a short circuit to avoid the voltage entering the device. This is something that well protected devices will include and incorporate on some level. For the terms of our project this would be most beneficial in our power supply before any filtering is done, but would not necessarily be required because the DC part of the power supply would be sufficiently isolated and the filter capacitors at the beginning of the circuit would be able to handle the higher voltages.

Figure 59: *Varistor Resistor*[103]

Table 14: *Resistor Type Comparison*

No.	Fixed	Variable	Thermistor	Varistor
1	Surface mount and through hole	Through hole	Surface mount and through hole	Surface mount and through hole
2	Cheap	Expensive	Expensive	Medium
3	Tiny/ SMD	Medium	Tiny/ SMD	Tiny/ SMD
4	Low Maintenance	Low Maintenance	Low Maintenance	Low Maintenance
5	One value	Multiple Values	Multiple Values	Multiple Values

3.27.5 Inductors

Inductors are passive electrical devices which store energy by utilizing the magnetic field in a wire coil that is caused when an electric field is applied to that wire. There are many

types of inductors but for the most part inductors serve one great purpose which is to store energy. Essentially inductors are made of insulated wire being wound around some type of core into s coil.

3.27.5.1 Air-Core Inductor

The air core inductor is a lot more common than I originally thought. For the most part, it uses nothing but air at its core and the times that it doesn't it has a piece of ceramic or plastic. Doing this allows for the minimal loss of signal and it also ensures that nothing is lost as long as we have a strong magnetic field.

Figure 60: *Air-core Inductor*[104]

3.27.5.2 Iron-Core Inductor

An Iron-Core Inductor is named that way because at the core of its coils it has an iron piece. This core is very important to the practicality of the inductor because it actually increases the overall inductance of the inductor. These inductors tend to only work well at lower frequencies because once they start crossing over into high frequencies they will start to suffer from core losses and energy losses.

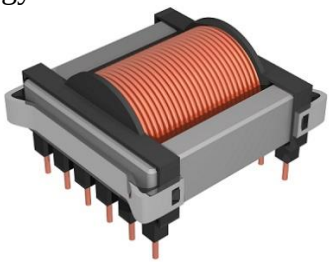


Figure 61: *Iron-core Inductor*[105]

3.27.5.3 Laminated Core Inductor

The Laminated core inductors work differently from the other previously discussed Inductors because it doesn't even have coils. Essentially this inductor uses laminated plates

that are stacked on top of each other to minimize the loop action. This is important because the more of a loop action that there is, the higher the energy losses. So this method instead allows us to minimize the energy loss and increase the efficiency.

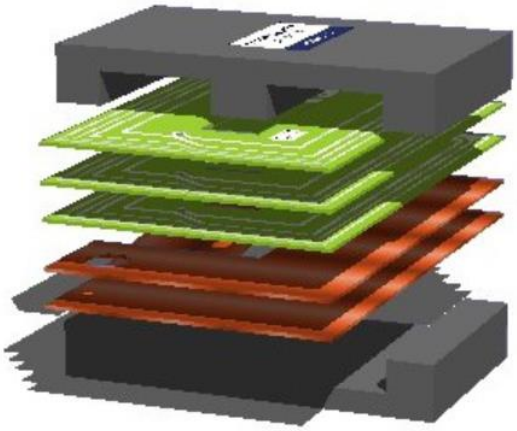


Figure 62: *Laminated core Inductor*[106]

3.28 Printed Circuit Board (PCB)

For this project we are going to need to make a PCB. PCB stands for Printed Circuit Board. The first printed circuit board is traced back to the early 1900s. Before there were printed circuits, they had point-point construction which means they were heavy and huge designs with sockets. Those types of circuits would need to be replaced often. In the 1920s, they started to get more common and where in radios and gramophones. Then in the start of the 1960s a person named Gordan E. Moore made up a law about microchips. This law says that the speed and capability of computers can be expected to double every two years, because of increases in the number of transistors a microchip can contain.

Figure 63: *PCB*

The next impact was of the printed circuit was when they started testing different materials and started using resin and the wiring would be printed on one side and the electrical components would be on the other side. This made it a lot easier because it was bulky as

before, but it still had to be replaced periodically. In 1956 when the U.S. Patent Office granted a patent to a small group of scientists representing the U.S. Army for the "Process of Assembling Electrical Circuits." At the time, the process involved drawing the wiring pattern and then photographing it onto a zinc plate. This plate could then be used to create a printing plate for an offset printing press. This is what was used to print the wire in acid resistant ink on the copper foil, which could then be etched by an acid solution. [PCB] After this the development of the PCB increased to where they could make multilayer and connect PCBs.

Why are people using PCB? It is very convenient and light weight and takes up less space and exceptionally reliable. Surprisingly, it is usually cheaper than making a wired circuit. PCB are everywhere including in the medical, aerospace, military, industrial, and commercial. Mostly all PCB are custom to fit the design a specific device need. A way to design a PCB and have it printed is by going a design website called eagle. We have used this website before in junior design were, we had to build a PCB and have it made and work as a product. This software allows the user to make schematics of the circuit and then make a BOM spreadsheet that lets the user know how much the parts are and if they are in stock for use on the PCB. It has some nice feature to where it will auto route the wires for you on the circuit board.

Figure 64: *Software for printing PCB* [40]

Different types of layered PCB:

- Single-sided PCB- this PCB consist of a one-sided circuit board. It is layered with substrate and coated with a thin layer of copper usually for a conductor. This single-sided PCB is what we are going to use in our project for the HDMI and for the USB and the WIFI.
- Double-sided PCB- this PCB consists of a double layer where circuits are on both sides the components are usually on the surface and use the through hole method to be soldered on.
- Multi-layer PCB- this is an improvement form of the double-sided PCB. So there can be components on both sides and there are multiple of the double-sided PCB connected together. These are used for very advance devices such as GPS and satellites.

Different types of PCB:

- Rigid PCB- This PCB is very sturdy given the name rigid. The only con is that it is not flexible and once it is been made it cannot be changed or the PCB will not work anymore. One known rigid PCB is the motherboard on the computer that holds everything together for the computer.

- Flexible PCB- are PCB that are flexible and can be easily be able to bend and flex. They can be single, double, or multilayered. These are used mostly in laptops, LEDs, and cellphones.
- Rigid-flex PCB- this is a combination of the two PCB I talked about above. this design is well known and widely used because it is the best of both worlds. They are usually compact and have very sleek and lightweight design. Some devices that use this PCB are camera and pacemakers
- Metal Core PCB- This PCB is containing a metal core that is usually copper or aluminum for the conductivity. The aluminum is less expensive compared to the copper and it is environment friendly. The metal core is used to help heat transfer. If the PCB gets too hot, then the aluminum transfers the heat away from the components.

3.29 Wall Mount

For this project, we want to be able to be portable so it might be necessary for a built-in wall mount. For our final design we will have a wall mount installed. There are many specifications needed to find the right wall mount and this goes for both monitors and televisions. Check out the features of the display. Get a wall mount that is compatible with the display exact requirements. Most wall mounts are intended to suit the display of a particular size and weight. If you can only accommodate up to a 32-inch wall mount on it and attempt to put a larger size on it there is a fair risk that your expensive display will fall to the floor. Make sure that you review the details on the packaging of the wall mount and purchase one that can support your height and weight. Choose the pivot number. Decide whether you want to swivel or sit stationary on your wall mount. Either of these two functions can be done by most wall mountings. While getting a display that sits on the wall and does not move can be great, a swivel mount would be ideal for circumstances where you need to point the display in another direction to hide from customers or show other people the information on the screen that cannot see it well enough.[130]

Figure 65: *Arm-mounted display*

Decide if the consumer wants an arm-mounted mount. Some wall mounts, like a picture frame, hang the display close to the wall. Other wall mounts have an arm that holds the

display a few inches from the wall's surface. Decide which of these two strategies in your home would work better. So, for our design we want the wall mount close to the wall but are considering a movable arm. Consider the cost. While that cheap wall mount might seem like it will do the job as well as any other mount but if the mount cannot hold up the display and breaks the display then it will look bad for our project. For our project we are trying to make it affordable as possible and not overpay for wall mounting, but do not use cheap materials at the same time.[130]

Figure 66: *Vesa wall mount*

For the close to the wall mount. This project must make the box for the battery and the PCB slim to make able to mount. Many manufacturers' stock display stands are barebones, lacking options for both viewing and ergonomics. Some knowledge about the monitor needs to be known is that the monitor needs to be VESA compliant to use virtually any third-party stand or install. That means having regular mounting holes drilled into the back, usually directly into the monitor itself steel frame, enabling any suitable mount to be screwed in. The VESA 100 (with a square hole pattern 100 mm wide on each side) is the norm, although there may be greater specifications for certain super-sized monitors over 35 inches. There might not be many smaller, cheaper, or thinner monitors must be VESA-compatible, and will only work with the manufacturer's custom stands.[131]

The consumer needs to specify the type of wall you're going to attach it to after you've finished measuring where to attach the mount. The most popular walls are wood stud, metal stud, and concrete/block or stone. A different approach is needed for each form:

- Wood stud wall – Wood Screws or Lag Bolts
- Metal Stud wall – Toggle Bolts
- Concrete/block or brick wall – Tapcon anchors or Red Head wedge anchors

After finding out what kind of wall it is, ensure that the screw will not touch any plumbing or electrical runs inside or on the opposite side while drilling into the wall. Check for nearby outlets and switches and also search for water fixtures... Place the wall mount on the wall after it is safe to mount, and mark where you want your anchors to be. Always make sure you have at least four good anchors in the studs, and six to eight or more if you have a bigger/heavier display. Drill and affix a pilot hole, after ensuring it's straight, affix the wall bracket to the wall.[132]

3.30 3D Printing

People think that 3D printing was recently invented in the 2000s, but 3D printing actually started in the 1980s. It began in 1981 with Dr. Hideo Kodama's patent application for a rapid prototyping device. Due to certain issues of funding he was unable to complete the process before the deadline. Then, Jean-Claude André, Olivier de Witte, and Alain le Méhauté came along and Le Méhauté shared his problem with de Witte, who was working for a subsidiary of Alcatel. Having worked with lasers, de Witte knew about liquid monomers that could be cured to solids with a laser. This opened the way to building a rapid prototyping device.[127] The three brought it to the National Center for Scientific Research but were later turned away because the board did not feel it had enough areas to apply this project in the world. Then in 1984 Charles "Chuck" Hull made a patent for a technology called stereolithography. Charles' stereolithography patent marked the beginning of the 3D printing industry.

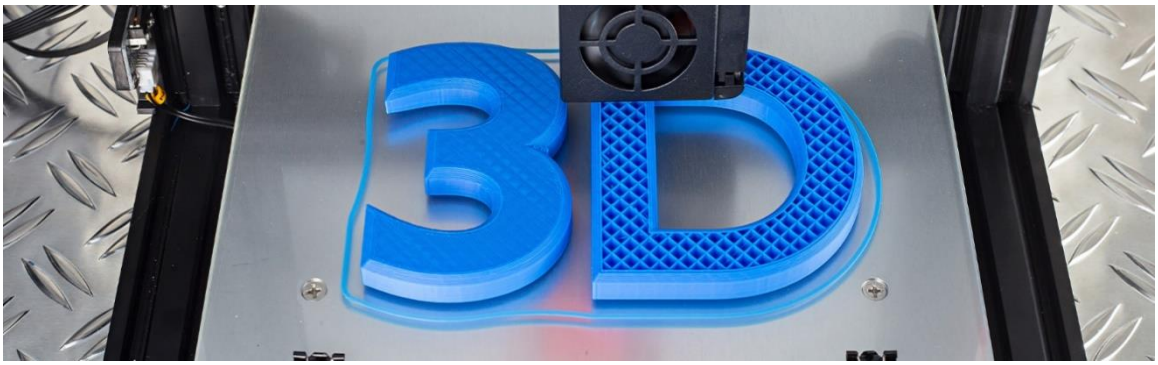


Figure 67: *3D printing*

"The key to stereolithography is a kind of acrylic-based material known as photopolymer. Hit a vat of liquid photopolymer with a UV laser beam, and the light-exposed portion will instantly turn into solid piece of plastic, molded into the shape of your 3D-model design. This new technology was big news to inventors, who could now theoretically prototype and test their designs without having to make a huge upfront investment in manufacturing. Then after a few years his company made the world's first stereolithographic apparatus (SLA) machine, which made it possible to fabricate complex parts, layer by layer, in a fraction of the time it would normally take. That same year, startup DTM produced the world's first selective laser sintering (SLS) machine—which shoots a laser at a powder instead of a liquid."[128]

In the 2000s, the democratization of fabricating had captured the public's creative ability, as had the thought of mass customization. The primary SLS machine got to be commercially practical in 2006, which opened the entryway to on-demand fabricating of mechanical parts. 3D-printing startup Objet (presently combined with Stratasys) built a machine that may print in numerous materials, which permitted a single part to be manufactured completely different forms, with distinctive fabric properties.[128] Present day, 3D printing is booming! People do not have to only use plastic to create the design they want. People can use metals, glass, and other materials. This is helping the economy and speed of production of items.

3D printing is a method of manufacturing in which material is laid down to form a three-dimensional structure, layer by layer. Although 3D printers use a variety of materials such as plastic or metal) and techniques, they share the ability to transform three-dimensional data-containing digital files into physical objects, whether generated on a computer-aided design (CAD) or computer-aided manufacturing (CAM) software, or from a 3D scanner. Files in what is called the STL format are supported by almost all 3D printers. Most CAD applications, from costly commercial packages such as AutoCAD to free or open-source apps such as Google SketchUp and Blender, can generate these types of files. Fused deposition modeling (FDM), also known as fused filament production, is the most widely recognized (FFF). In it a filament is melted and deposited in layers by a heated extrusion nozzle made of acrylonitrile butadiene styrene (ABS), polylactic acid (PLA) or another thermoplastic.[129]

Figure 68: *3D printed box (PCB and Microcontroller Inside)*

Designers have the potential to rapidly convert designs into 3D models or prototypes (a.k.a. "rapid prototyping") through 3D printing and make rapid develop adjustments. This allows manufacturers to produce goods on demand rather than in large runs, enhancing inventory control and reducing storage space. Objects that would otherwise be inaccessible to them can be made by people in remote locations. 3D printing will save cash and material versus subtractive processes from a practical point of view since little raw material is lost. And it aims to alter the design of output, essentially enabling consumers to download files to print even complex 3D objects. [129]

For the project we need to design a plastic covering for our PCB and microcontroller design. Measurements are needed for the hole space for each component that needs to be plugged into the PCB. These components consist of power supply, connecting to the monitor and other connects to connect to other screens if necessary. This plastic box must be slim because it needs to be hidden behind the monitor and be able to not affect the wall mount. The next box that could be made is for the battery, this is considered because we want the back side of the monitor to look professional and not show to much of inner

components. 3D printing can be expensive, luckily for our group we have someone that can do it for cheap and only charge for material cost.

4 Standards

Standards provide a framework for shared understanding for individuals and organizations and are used as instruments to promote correspondence, measurement, trade and manufacturing. Standards are everywhere and play an important role in the economy, promoting business engagement through relationships with the consumers. There are many different standards need to take into consideration when a new system or project is built. All of the following standards are done based on the research about the American standard. There are more than 100,000 recognized standards. These requirements will strictly apply to the design in this project in order to maintain the safety for user as well as builder.

Types of standards:

- Voluntary Consensus Standard (VCS): a type of standard developed or adopted by voluntary consensus standards bodies, using a voluntary consensus standards development process
- American National Standard (ANS): a VCS developed in accordance with the "ANSIEssential Requirements: Due process requirements for American National Standards" and subject to ANSI's unique: 1) accreditation of consensus procedures; 2) neutral oversight; 3) approval process; 4) appeals process; and 5) procedural audit.
- De facto (Ad Hoc) standard has become a standard because it is widely used, not necessarily because it was officially approved by some standards organization or government
- Consortia Standards have a broad category of standards – some consortia procedures reflect criteria like those associated with an American National Standard
- Regulatory Standards are written or adopted by government agencies
- Other is made by Corporate or company standards

4.1 ANSI Standard (LED datasheet)

The American National Standard Institute (ANSI) is currently working on a standard datasheet for white LEDs used for general illumination. White LED becomes very popular to everyone nowadays. A lot of companies develop and manufacture these LED to the market. The only communication way that they have between manufacturers have users is through the data sheet. LED color can be change depending on the voltage and devices. So, the datasheets cannot provide a consistent information of the color of the LED between devices. The develop of this standard is to express the issue of lack of comparison and helping user to pick the color of LED. ANSI LED datasheet standard has updated their sheet, so that there will be a fair comparison can be made by users.

For operational, the datasheet has provided some operating limits of voltage, current and temperature for users to follow. In order to help user with connecting LED, a physical and electrical connection diagram also provided in the datasheet. Connecting LED incorrectly could result on impacting the overall system. For example, LED usually used

to indicate a message to the user. Connecting this wrong will result in a wrong message to the user, which could result in some bad experience. Therefore, the intent of the ANSI LED standard is to provide an accurate and reliable information to the users, and that all parties will get the same benefits of the standardization.[107]

4.2 Sensor Standards

In most modern systems, sensors are used to help gather data and render smarter devices capable of improving task efficiency through automation. This project will most likely include various sensors that will need to have certain standards met. We will also use sensors that can meet the industry standards for reading and outputting the different voltages and data. Our sensors will also need to be suited for use in the United States, and be able to follow all the other standards listed throughout this document.

4.3 Electromagnetic interference (EMI) standards

When dealing with electronics and electrical systems, electromagnetic interference is possible. As a radio frequency wave, electromagnetic interference may pass through the air or can be produced by conductors that are active. This type of interference can result in poor performance of nearby electronic devices or loss of operation. As a result, companies and government groups have partnered together to establish guidelines for electromagnetic interference for electronic devices that are required. Our Project may utilize different ways to wirelessly communicate with electrical devices, so following and incorporating electromagnetic interference standards into our project will benefit us in eliminating potential intermittent problems.[108]

4.4 Federal Communications Commission

The Federal Communications Commission or FCC, which is a government agency that oversees all information networks and any communication system. Radio frequency equipment and electromagnetic interference standards are protected by Section 15 of the federal communications commission. Section 15 is divided into eight subparts, we will mainly focus on the parts A, B and C. Which focuses on general radio frequency, with intentional and unintentional emissions. In order to avoid interference with nearby electrical devices, all steps will be taken to minimize and provide the least potential radiation and emissions of radio frequency signals and noise. This project will be using some sort of wireless communication, whether it is a Bluetooth module, WIFI or some other type of wireless transmission we need to stay within the standards outlined in this section.[108][109]

4.5 ANSI C63.4

The ANSI C63.4 tends to be associated with part 15 of the federal communications commission and includes the testing requirements required to comply with it. This research standard involves radio frequency emission testing methods for electronic devices and components operating in the 9 kHz up to 50 GHz frequency band. This test standard refers to the commercial and residential use of electronic devices, with the goal

of varying the frequency from 9 kHz to 50 GHz and of measuring the emission of electric fields and the emission of magnetic fields. For this project, this standard refers to measuring the emission of electromagnetic interference from the electronics used.[110]

4.6 IEC EN61000

The International Electro-technical commission or commonly known as IEC, it is the responsibility of the organization to establish the specifications needed for all electrical devices and electronic technologies. IEC 61000 is part of the common specifications for electromagnetic compatibility, covering the emission standards for residential, commercial and light industrial settings for electromagnetic compatibility (EMC). This six-sub part standard covers various situations of frequency bands. The immunity for residential, commercial and light industrial environments operating from 0Hz to 400Hz is protected by IEC 61000 6-1. This section refers to this project since the project is often used between the specified frequencies in a residential area, the standard states that there is no test required if there is no emission requirement. IEC 61000 6-3 is applicable because it covers emission requirements for commercial, residential and light industrial environments and states that testing is not needed for emissions unless a requirement is specified. Electromagnetic interference should not be an issue with our project.[111]

4.7 IEC Standards

The International Electro-Technical Commission has developed guidelines that address the safety of sensors from the intrusion of water and dust into the system while in operation. IPXX is also referred to as this standard, where the 'X's denote numbers, the first number is how dustproof the sensor is. Dust proofing varies from 0 to 6 on a scale of 6, meaning the sensor is fully dust-proof. In the model, the second digit reflects water safety and ranges from 0 to 9k, with 9k indicating that the sensor is fully protected against water at high pressures and high temperatures. The sensors used in this project comply with these requirements and are covered by the ranges specified in this standard against dust and water, while our project might not be fully dustproof and waterproof, we will meet the IEC standard.[112]

4.8 Printed Circuit Board Standards

A printed circuit board or commonly called a PCB typically is a flat board that can be in a variety of shapes. They can be made of various materials, which have pathways that are etched to allow the flow of electricity. Mainly all electronic devices now utilize some sort of printed circuit board. This allows many electronic devices to become more compact, streamline and have a modern look. Utilizing a printed circuit board in our project will give us a more modern look by slimming down the entire project. We will be able to solder parts directly to it to give a more secure connection. The printed circuit board will also act as a way for users or technicians to easily access parts in one layout if any devices need to be serviced.[113]

4.9 Institute of Printed Circuit Boards IPC-2152

The Institute of printed circuit boards or IPC-2152. This is a standard built for a PCB's current carrying power. To allow proper current flow, this standard was put in place to correctly size traces within PCBs. This standard says that the cross-sectional area determines the size of a conductor within a PCB. The current in the conductor also increases as the cross-sectional area increases. This standard also specifies that the conductor width should be maximized for production and the spacing requirements of the conductor should be met. The minimum conductor width specified in this specification is 0.1 mm wide, and thus retaining spacing, the maximum width is as broad as the PCB can allow.[113]

4.10 Soldering Standards

Soldering is a process used to tie electrical components together and the printable circuit board (PCB) would use solder joints to install and attach components of the circuit for this project. Soldering is a very useful tool when done correctly following the proper placement of the components to the flux, and type of solder required. If soldering is not done correctly, it can lead to premature failure, intermittent failure and a device that could end up useless. Soldering will be used on the printed circuit board to safely and securely attach our components, to give us the most longevity out of the unit.[113]

4.11 IPC J-STD-001 & IPC-A-610

IPC stands for institute for printed circuits and is responsible for most of the standards that PCB design and manufacturing require. IPC-J-STD-001 is a specification that is important for production in terms of content and processing specifications. The tools, methods and verification requirements for the production of high-quality solder interconnections are included in this standard.[113]

4.12 Insulated Conductors Standards

It will be very necessary to select the correct conductors for our smart calendar because this will modify the amount of electricity running through it. We would need to think if additional addons or accessories can be made to the unit, either giving users an additional USB power port to charge other devices, or if the calendar itself utilizes external sensors such as a temperature sensor, or photo sensors to detect changes in the rooms lighting atmosphere. Choosing the correct size conductors and the right materials will give us an industry standard whether our smart calendars are placed in low and high temperatures. The calendar should also be able to have a strong connection in all external ports for longer life of connecting and reconnecting power plugs, USB cables and other necessary cables. Looking at the chart below can help us determine which type of conductor and conductor coating will suit our application best.[114]

Table 15: *Conductor Coatings Comparison Chart*

Comparison of Conductor Coatings			
Characteristics	Tin Plate	Silver Plate	Nickel Plate
Life Stability	Conductivity and solderability deteriorate with heat aging at rated temperature due to migration of tin and copper and tin oxidation	Excellent - No loss of conductivity with heat aging at rated temperature. Solderability shelf life remains good.	Conductivity remains stable with heat aging at rated temperature.
Crimp Terminability	Good - But contact resistance increases with time and can be variable.	Excellent - Contact resistance remains low.	Good - But contact resistance may vary with time. Use plated steel terminal in some cases.
Solder	Good originally. Deteriorates with shelf life.	Excellent.	Requires active Flux.
Service Temperature	150°C	200°C	250°C

4.13 LED Light Flickering and Potential Health Concerns

In 2010 IEEE advised the lighting industry of the IEEE PAR1789, which involved LED flickering and the health concerns it had on people. In essence, the health effects of flickering can be divided into two categories: instant symptoms or long-term exposure effects. Symptoms of epileptic seizures can be the main immediate effect of only a few seconds of exposure, while symptoms such as headaches, migraines, and reduced vision function are the effects of long-term exposure. Currently 1 in 4000 people suffers from photosensitive epilepsy, and if LED's are not within standards it could initiate a seizure by having a repeatedly rapid change from 3 Hz to 70 Hz. LED controllers and drivers need to be able to eliminate such frequencies that can affect individuals who can be a victim. If the LED has to stay in the working range of 3 Hz to 70 Hz, flickering must be avoided, reduced greatly or eliminated completely.[115]

4.14 Bluetooth Standards

Our smart calendar will mainly use some type of wireless communication, if we choose to go with a Bluetooth connection we must follow the safety and standards set in place. The actual term Bluetooth is a trademark name, and any Bluetooth device needs to be tested and qualified by the Bluetooth Special Interest Group (SIG), previously managed by IEEE 802.15.1. Bluetooth SIG allows companies to manufacture Bluetooth devices sold to the public. For our project, the Bluetooth device will be purchased through a reputable source where we can be assured it has met safety standards.[116]

4.15 Wi-Fi Standards

Wi-Fi standards are under IEEE 802.15 and allow usage for Wireless Personal Area Network or WPAN. Wi-Fi standards need to follow IEEE required specifications. These standards will try to prevent someone from tampering with or to prevent someone from gaining access to the data transmitted. The Wi-Fi standards also need to follow the IEEE specification for SOC TCP/IP. TCP/IP is a layered model that includes the Application Layer, Transport Layer, Internet Layer, and Network Layer. This is a common specification built to cohesively and simplify connectivity through Wi-Fi networks across devices so that each vendor does not have its own framework that must be converted.[117]

4.16 Lithium-ion Battery Standards

Several standards have been developed to test and install the lithium-ion batteries for the design around the world. It is priority to have the safety feature on top of the concern list for every project. There always a risk when dealing with batteries since it contains a decent amount of power. "The internationally recognized standards listed in this section have been created by the International Electrotechnical Commission (IEC), Underwriters Laboratories (UL), the Japanese Standards Association (JSA), and others. The internationally recognized standards listed in this section have been created by the International Electrotechnical Commission (IEC), Underwriters Laboratories (UL), the Japanese Standards Association (JSA), and others."[118]

4.17 International Electrotechnical Commission

Performance standard is based on the IEC 61960 "secondary cells and batteries containing alkaline or other non-acid electrolytes - Secondary lithium cells" and there are two cell which are Prismatic and cylindrical lithium are made from them.[118]
Safety requirement of the battery are standardized with IEC 62133-2:2017 and IEC 62281:2019 these two standards are for the safety of the batteries during transport.
Testing battery are standardized in IEC 61959:2004 "Secondary cells and batteries containing alkaline or other non-acid electrolytes - Mechanical tests for sealed portable secondary cells and batteries"

4.18 RFID Standards

There are a lot of difference standard when it comes to RFID. The standard solution is depending on the type of RFID transmitter/receiver combination. It also depends on what RFID system is using for and at what frequency does the system generated at. There are 5 class for RFID.
Class 1: simple, passive programable nonvolatile memory
Class 2: tag up to 65 KB of read and write memory
Class 3: semi-passive with up to 65KB read and write memory
Class 4: active tag that us built-in battery to run the chip
Class 5: active RFID that can be communicated.
There is another standard for RFID called ISO Standard. "ISO has developed RFID standards for automatic identification and item management. This

standard, known as the ISO 18000 series, covers the air interface protocol for systems likely to be used to track goods in the supply chain. They cover the major frequencies used in RFID systems around the world." [119]

4.19 Receptacle and Connector Standards

The IntelliDate design will have battery charger connecting to the outlet, therefore it is very essential to have a correct outlet mated to the correct connector. A receptacle is a voltage supply device for common household to supply 15 and 20 amps current. So, the 15- and 20-amp plugs will fit into a 20-amp receptacle.

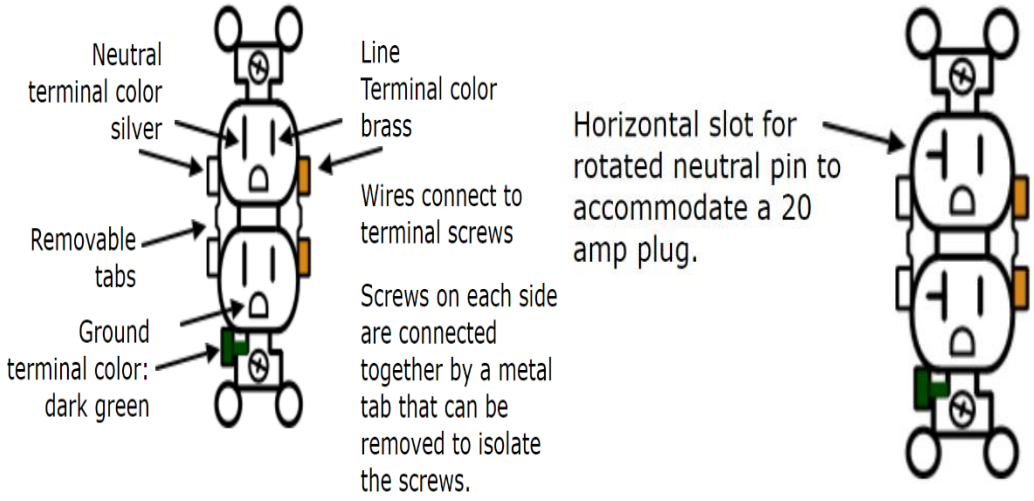


Figure 69: *15-amp and 20-amp Receptacle*

The image above is an example for the two type of receptacle that can be used for our design. The feature of having two different outlet sources help us have a better choice for our design since the IntelliDate box will most likely utilize the most suitable current outlet for the needed inputs.[120]

4.20 Power Switchgear, Circuits and Fuses Standards

All of the circuit design required an Electrical Protection. The main factor of long-lasting product is to have a good protection system. The IntelliDate will run in a system of various voltages. The range of this voltage will run from 5V to 120V. Therefore, it is very important to design an electrical switchgear. This switchgear will act like a voltage regulator to ensure a stable voltage supply for the whole system. A key factor of keeping the profit for business is to have a good monitor and control of every single aspect. It is common problem with every circuit design that there might be a chance of the system get overloaded because of the extra power being generated sometimes. The important of using a correct outlet is very essential in design a circuit. The overload will most likely occur somewhere in the design. Therefore, it is important that the switchgear is used to

protect all other components. Having this system can save user from catastrophic consequences in the chain of component and devices.

Switchgears are usually made from switches, fuses, and circuit breakers. These components work together to achieve a protection system for the design, so the nightmare where the whole chain devices get damaged because of overloaded will not happen. The charging panel of the IntelliDate will connect with circuit protection for each the low voltage and high voltage area. There are some advantages and disadvantage from using fuses and breakers.

Table 16: *Comparison between Fuses and Breakers*[1214]

	Fuses	**Breakers**
Advantages	Cost efficient	Single-phasing
	Great protection feature	Easier to diagnose
	Safety due to the fuses changing the requirement for the overload	Easy to reset
		Multiple uses
Disadvantages	One time use only	Less protection
	More expensive	"visible break" to see voltage isolation is not available
	Created a potential shock due to contacting with the energy	Slower current interruption devices
	Required a professional test once need to be replaced	

4.21 ISO/ASTM 52915:2013

"Describes a framework for an interchange format to address the current and future needs of additive manufacturing technology. For the last three decades, the STL file format has been the industry standard for transferring information between design programs and additive manufacturing equipment. An STL file contains information only about a surface mesh and has no provisions for representing color, texture, material, substructure, and other properties of the fabricated target object. As additive manufacturing technology is quickly evolving from producing primarily single-material, homogenous shapes to producing multilateral geometries in full color with functionally graded materials and

microstructures, there is a growing need for a standard interchange file format that can support these features."[133]

4.22 VESA Standard

Standards for mounting interfaces on monitors and TVs are specified by VESA©. There are several benefits of the VESA mount standard: it enables low-cost monitor installation in a wide variety of applications while positioning displays for improved versatility and ergonomic advantage. Use this guide to evaluate the VESA compatibility of your monitor to check that it will be connected to a VESA Mount product. On the back of the displays and the screws used to suit those holes, the VESA norm specifies the dimensions of the four-hole connection interface. The location of the hole pattern on the display often determines it. Ideally, the hole pattern should be based on the back of a display for attachment to VESA mounts. A center-positioned pattern minimizes the torque forces applied to the mount, which allows a heavier load to be carried.[134]

4.23 FTC Act Sec. 5: Unfair or Deceptive Acts or Practices

"Section 5(a) of the Federal Trade Commission Act (FTC Act) (15 USC §45) prohibits "unfair or deceptive acts or practices in or affecting commerce." This prohibition applies to all persons engaged in commerce, including banks. The Board has affirmed its authority under section 8 of the Federal Deposit Insurance Act to take appropriate action when unfair or deceptive acts or practices (UDAP) are discovered. On March 11, 2004, the Board and the Federal Deposit Insurance Corporation (FDIC) issued a joint statement (Joint Statement) regarding the agencies' responsibilities to enforce the prohibitions against unfair or deceptive trade practices as they apply to state-chartered banks. The Joint Statement contains a discussion of managing risks relating to UDAP and general guidance on measures that state-chartered banks can take to avoid engaging in such acts or practices, including best practices."[135]

4.24 IEEE 830

The IEEE 830 standard, recognized as the Recommended Practice for Software Requirements Specifications (SRS), sets out a guide for companies and developers to set practical targets and outline what software needs to be produced. The SRS is a report outlining the features and criteria of a software application with particular functions. The methods detailed in the standard aid in the process of brainstorming and providing you with the tools to pick various software products for your intended purpose. In our case, our team created a phone device application that displayed the measurement of glucose concentration communicated through Bluetooth and several features of a good SRS mentioned were considered in the IEEE 830 standard to build this software.[136]

Producing a good SRS:[136]

1. Nature (goals) of SRS
    - Functionality, interfaces, performance, qualities, design constraints
    - This design consists of a way to making scheduling easier and more efficient for the consumer. The design is an application that connects to a display and

shows the schedule of what the consumer wants. This project will only have one fee from purchase and no continuous fee after that like other similar designs.

2. Environment of the SRS
   - Where does it fit in the overall project hierarchy
   - This application will be used at home or in a commercial use, to explain if the employer wants the employee to see their schedule and can be updated at any time through the app with Wi-Fi or Bluetooth.
3. Characteristics of a good SRS
   - Generalization of the characteristics of good requirements to the document
   - The application specifications that are produced must be right, simple, succinct, and complete. In addition, the specifications for the development of usable applications, as indicated in the design constraints, must be modifiable and verifiable.
4. Evolution of the SRS
   - Implies a change management process
   - Because of unexpected challenges or situations, the software may normally need to adapt as the software is created and built. For that purpose, our requirement requirements will be broad and modifiable so that it is possible to foresee the evolving software aspects. Also, by looking at the previous steps taken, recording a trace of the various steps taken to modify the program can assist us to understand the final application product.
5. Prototyping
   - Helps elicit software requirements and reach closure on the SRS
   - If the program reaches a satisfactory service, the first step in evaluating the progress of the software as well as its inconsistencies and problems would be prototyping. The system is analyzed as a whole when prototyping the software and is decided whether the software meets an end user's requirements and whether there are any unanticipated effects from the system's actions. Noting these differences will direct us to return and provide a solution for the initial problem.
6. Including design and project requirements in the SRS
   - Focus on external behavior and the product, not the design and the production process

4.25 Ethics

Ethics is based on well-founded standards of right and wrong that prescribe what humans ought to do, usually in terms of rights, obligations, benefits to society, fairness, or specific virtues. This project is ethical because we are only charging for the product and everything else comes free. The application is free with the purchase of the product. This product will save tons of paper because people will not have to print out the schedules. Companies will just have to hang it on the wall or put it on a desk. The application is very friendly to where you log in with a username and password and create their own schedule they need. All electrical parts will be hidden from harming the consumer and the only thing electrical they must deal with is the battery aspect.

4.26 Social and Political Effects

The project we designed does not affect the social or political views, because this project only deals with scheduling and displaying the schedule on a monitor.

4.27 Health and Safety Constraints

This project has some health and safety constraints. These constraints consist of safely putting the wall mount in the correct spot because if it is not It could fall and injury the consumer. The health aspect is the LCD can cause damage to the eyes as all screens can.

5 Design and Testing

5.1 IntelliDate Software Application

5.1.1 IntelliDate Software App: Web-Based or Mobile?

After researching and documenting the differences between mobile and desktop software applications, we have decided to implement a mobile application, to be utilized by the IntelliDate customer. We have chosen to implement a mobile application, because the majority of people (especially people willing to buy a commodity, like a wall-mounted calendar display) own smartphones, and would consider a mobile application more accessible than an application only accessed via their desktop. We have decided to create a mobile application, rather than a web application, for many reasons. Some of these reasons are listed below:[90]

- *Mobile applications can run faster than web-based applications.* While web-based applications use JavaScript code to execute functions, in the web browser, mobile applications use frameworks that can execute functions at a much faster rate than that of web-based JavaScript.
- *Mobile applications usually store data locally, on mobile devices, in contrast to a website that stores data on the web server in which the website is hosted.* One of the main goals when designing and creating IntelliDate is to create a low-cost product. An efficient method of driving cost down is to offload as much work as possible to pre-existing available resources. An example of this is not including touchscreen capabilities with the IntelliDate panel, and instead offloading the task of communication with the display to the user's mobile device, via a free software application. In the case of choosing a mobile application over a web-based application, the storage required for the user's settings and preferences is offloaded from a web server to the user's local device storage.
- *Mobile applications are more personalized than web-based applications.* Mobile applications provide the user with the ability to store preferences on their own device, allowing the application to take proactive actions on the user's behalf. Implementing an application that is "owned" by the user provides a more personalized experience than that of web-based applications.

Figure 70: *Mobile Application personalization capabilities (via preferences)*[91]

- *In contrast to a web-based application, accessed via the user's mobile web browser, a mobile application can utilize resources from the mobile device.* These resources can include the camera, location services, contact list, photos, activity tracking, and notifications. Mobile applications can be used to track user engagement and use it to offer custom recommendations and updates to the users.
- *Mobile applications can function offline, while mobile websites require an internet connection.* Though mobile applications may not provide full functionality when offline, basic features may still be offered. In the case of the IntelliDate mobile application, though features of the application will be discussed at a later point, a simple example of an offline feature would be controlling the brightness of the IntelliDate display.
- *Through notifications, mobile applications provide an easier, less intrusive way of communicating with the user.* Rather than communicating with a user via email or SMS text messages, mobile applications provide the ability to communicate with a user via in-app or push notifications. While in-app notifications can be received by the user only when the app is opened, push notifications can be received by the user at any time, regardless of any activity currently being performed on the device.
- *Users spend more time on mobile applications than web-based applications.* It has been noted that mobile users spend 86% of their time on mobile applications, and just 14% of their time on mobile web-based applications.[92]

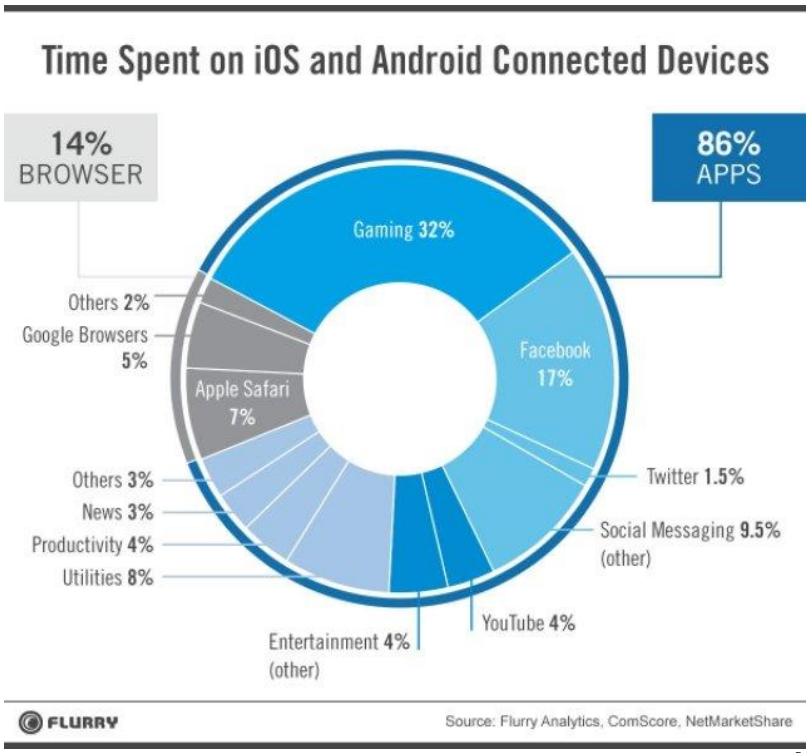


Figure 71: *Time Spent on iOS and Android Connected Devices*[92]

- *Mobile applications offer the branding opportunity of brand presence.* Users will constantly see the IntelliDate logo and name on their mobile device, as opposed to only seeing the brand when visiting the mobile website. Though for each customer, the IntelliDate product is a one-time purchase, keeping the brand as present as possible with each user will increase the chances that users will recommend the IntelliDate product to other people, and will increase the chances of them purchasing future products, manufactured under the IntelliDate brand.

Figure 72: *Example of brand presence offered by mobile applications on an Android Connected Device*[93]

Though implementing the IntelliDate software application through a web-based channel would allow for users to access the application with a mobile or desktop device, for all of the reasons listed above, we believe that developing a mobile application instead of a web-based app is the more effective plan of action. Implementing the IntelliDate software application through a native mobile application will introduce certain challenges and drawbacks that would not be present if we were to create a web-based application, however. Creating a native mobile application will require approval from each mobile platform, in order to upload the mobile application to each mobile-operating-system-specific software distribution platform. On top of working to gain approval from each mobile operating system, creating a native mobile application, as opposed to a web-based application will require knowledge and learning of uploading and maintaining a mobile application on a mobile software distribution platform. Hosting a mobile application on such software distribution platforms will, however, enable the feasibility of automatic updates for all users with the application currently installed on their device(s).

For reasons other than reducing cost, many other products use this same method of user-to-device communication via a mobile application. A prime example of this, mentioned earlier in the document, would be the Phillips Hue Smart-Light application. In this scenario, the user connects lightbulbs to their "network of lights" by entering a bulb's physical serial number into the application. The application then locates the light bulb, adds a widget for the bulb to the user's application interface, and allows the user to manipulate the brightness, power settings, and color of the bulb, all within the application. Phillips Hue utilized a mobile application as a means of user-to-device communication in lieu of a

physical remote, both reducing product cost and allowing for the dynamic addition and subtraction of devices, or bulbs, into a user's "network". Utilizing a mobile application, rather than a physical remote, also allows for updates to the application user interface, potentially giving the user further controls of the bulbs in the future. This technique also offloads the work of controlling the bulbs from a physical remote, with batteries, to the user's mobile device. The user can also install the Phillips Hue application on multiple devices, allowing for a potentially unlimited number of lightbulb controllers. Finally, having the Phillips Hue application on a user's mobile device keeps the Phillips Hue brand present with the user, potentially motivating them to buy more Smart-Bulbs in the future.

Figure 73: *Phillips Hue LED Lightbulbs controlled by free mobile application*[11]

5.1.2 IntelliDate Mobile App: Development Tools

After researching the various types of mobile applications, along with the various tools available for creating mobile applications, it has been decided that the IntelliDate mobile application will be a native mobile application, developed with Google's Flutter mobile application software development kit and framework. It was originally assumed that the IntelliDate mobile application would be that of a hybrid mobile app, where the chosen programming language, for the application to be written, is JavaScript.

Creating a hybrid mobile application would give us the ability to create a mobile application, for all mobile platforms, with a single code base. These sorts of hybrid applications as previously explained, are then wrapped in a native mobile platform-specific wrapper for each mobile platform the app is to be hosted on. In a sense, we are still employing this method, with Flutter, as applications created in Flutter are written with the Dart programming language. When applications written in the Dart programming language are compiled, Dart compiles to native machine code for mobile and desktop, and JavaScript for web browsers.
The Dart programming language has received many updates as of recent, and is an open-source language, providing plenty of user-support, additions, and documentation. There are also many notable applications that have been created with Flutter, including but not limited to: eBay, Google Ads, Groupon, and Capital One. Knowing that many predominant applications have already been created with Flutter is a promising note to developers new

to Flutter, like ourselves, when deciding to use this software development kit to create our mobile application.

Figure 74: *Example applications created with Flutter*[94]

5.1.3 IntelliDate Mobile App: Functionality

It has been my personal experience that when creating a project, before any sort of aesthetic planning is to be implemented, clear guidelines for functionality should be outlined (the simple rule of "Functionality First"). Therefore, before defining the appearance of our user interface, or the aesthetic design of our application, this section will outline and describe the desired functionalities of our application.

The IntelliDate product will consist of a physical display, showing the user a calendar, with events compiled from all other calendar applications utilized by the user. In order to maintain a low production cost, the display will not include touchscreen capabilities. In lieu of touchscreen capabilities, the user will interact with the display via a mobile application. The IntelliDate mobile application will act as the communication gateway between the user and the IntelliDate display.

Some functionalities of the IntelliDate mobile application are listed as follows:

- Connect to IntelliDate display, via device-specific serial number
- Configure IntelliDate display Wi-Fi/Bluetooth connection settings
- Link accounts and sync events from other calendar applications via software-specific login credentials
- Access IntelliDate contents via IntelliDate-specific login credentials
- Create, edit, and remove events to IntelliDate display calendar with an event addition/edit/removal feature
- Change active view of calendar display (daily, weekly, monthly, etc.)
- Configure brightness settings of IntelliDate display
    - Change brightness level manually or set routines to change brightness level at desired times.
- Lock/unlock IntelliDate display
- Send push notifications to the user, reminding them of upcoming events

As soon as a user purchases an IntelliDate display, they will be prompted to download the IntelliDate mobile application, from instructions that will be included in the packaging. Immediately following the installation of the IntelliDate mobile application, the user will be prompted to create an IntelliDate account or sign in to a previously created IntelliDate account.

The user's IntelliDate account will store:

- The user's IntelliDate device information (registered IntelliDate devices)
- All of the user's events (created within the IntelliDate application)
- The user's IntelliDate device configurations (network settings, brightness levels, routines, etc.)
- The user's linked miscellaneous calendar application credentials

5.1.3.1 IntelliDate Mobile App: Create/Edit/Delete Event

Once the user has signed in to their IntelliDate account, if this is the first time the user has signed in to their account (on any device), they will be prompted to "Add an IntelliDate device", where they can enter the serial number (located on the physical IntelliDate display) to add the display to their account. This option will always be available to users, in the case that they choose to purchase multiple IntelliDate displays. Once the display has been added to the user's account, the user will then be able to select a "Create Event" option to begin adding events to their calendar. Adding an event will be very similar to the user interface seen on many predominant calendar applications (Outlook, Google Calendar, Apple Calendar, etc.).
The user will have the ability to:

- Title the event
- Add a location
- Set begin and end times
- Set begin and end dates
- Set a Repeat option for events that occur on multiple occurrences

As events are added to the calendar, via the IntelliDate application, the IntelliDate display will update to reflect these additions, if the added event takes place in the current timeframe shown on the current calendar view (e.g. if the user adds an event that takes place in three months, but the current calendar-view is set to show the current month, the display will not reflect this change; however, if the user adds an event that does take place in the current month, while the calendar-view is set to this current month, the IntelliDate display will automatically update to reflect the event's addition, upon the user pressing "Submit" in the "Create Event" interface. Along with the "Create Event" option, there will also be an "Edit Event" option. This option will allow the user to edit the details of a previously added event. A "Delete Event" option will also be available, allowing the user to remove a previously created event.

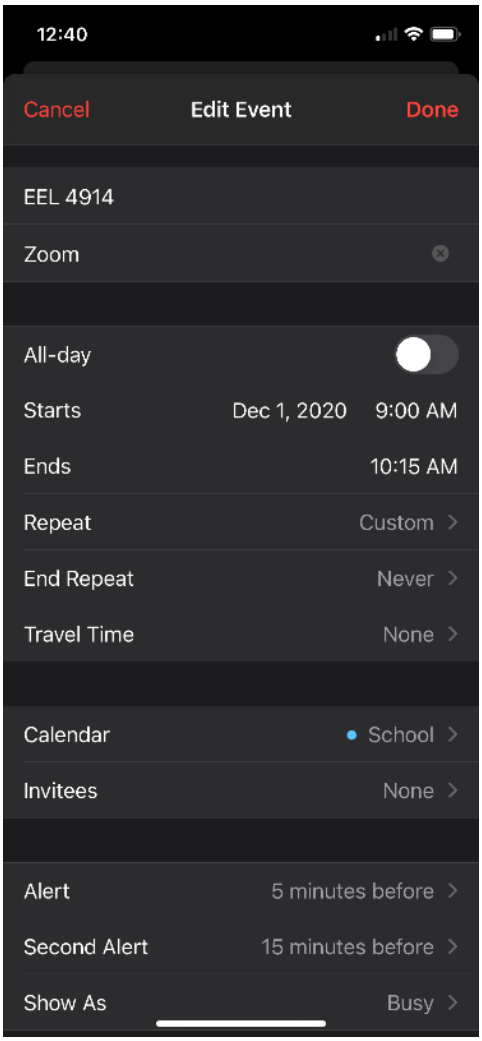


Figure 75: *Example of "New Event"/"Edit Event" interface from Apple Calendar application*

5.1.3.2 IntelliDate Mobile App: Settings

In the mobile application, along with event-management actions ("Create Event", "Edit Event", "Delete Event"), the user will also have the option to select a gear icon, to access the settings. Inside of the settings interface, the user can do all functions that aren't related to managing the contents of events created within the IntelliDate application. It is in the Settings area where the user will be able to:

- Configure IntelliDate display network settings
- Add miscellaneous email-software accounts
- Modify brightness level of IntelliDate display
- Lock/Unlock IntelliDate display
- Create brightness/lock/unlock routines
- Configure IntelliDate calendar view (daily, weekly, monthly, etc.)

Just like in other predominate calendar-applications, the user will be able to select a "calendar-view" for their IntelliDate display, choosing between a daily, weekly, monthly, or yearly view.

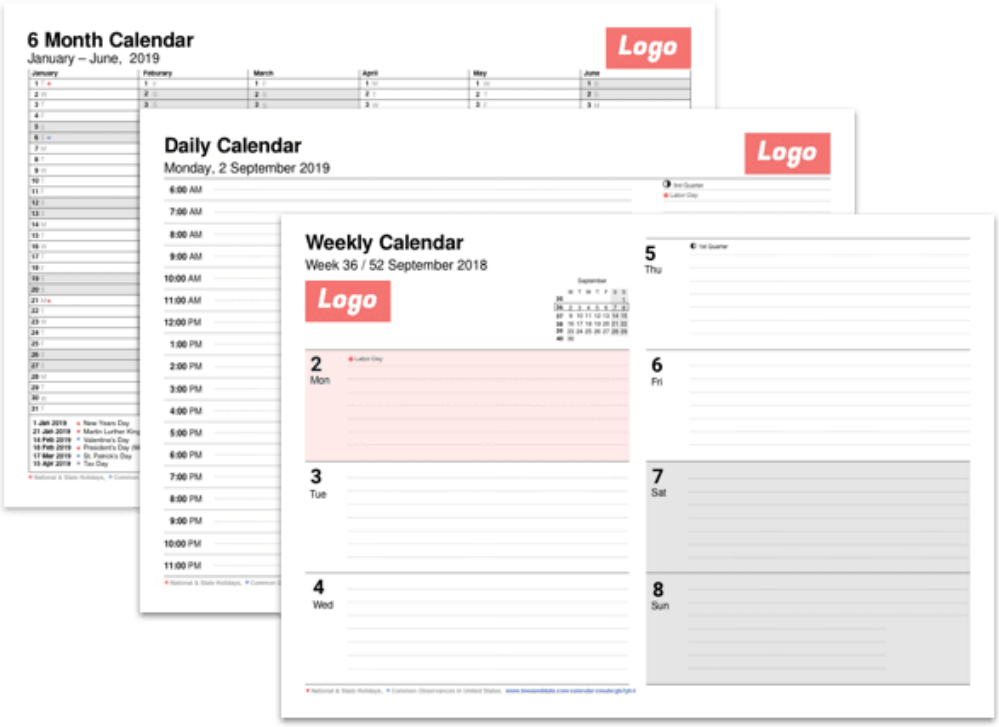


Figure 76: *Example of monthly, daily, and weekly calendar-view*[95]

5.1.3.3 IntelliDate Mobile App: Brightness Controls

Brightness-level control is a feature that we feel is a necessity, for a wall-mounted display. In the scenario that the display is mounted in the user's bedroom, it would be ideal for the user to have some sort of control over the brightness of the display, in order to prevent an unwanted bright screen in an unlit room, when the user is going to sleep. Adjusting the brightness can also save power consumption of the display, introducing a financial selling-point to potential customers.

5.1.3.4 IntelliDate Mobile App: Routines

Rather than having the user manually adjust the brightness every night, when they go to bed, and every morning, when they wake up, it is much more convenient to also include a "routine" functionality in the application, (similar to routines users can create and utilize with Amazon Alexa), allowing the user to set specified times for the IntelliDate display to operate on user-specified brightness levels (e.g. set IntelliDate display brightness-level to 0/100 at 9:00$_{PM}$, and set IntelliDate display brightness-level to 100/100 at 6:00$_{AM}$). A real-world example of this concept can be highlighted with the example of creating an Amazon Alexa routine to, at 9:00$_{PM}$, turn all Phillips Hue Smart Lightbulbs off, and at 6:00$_{AM}$, turn all Phillips Hue Smart Lightbulbs back on.

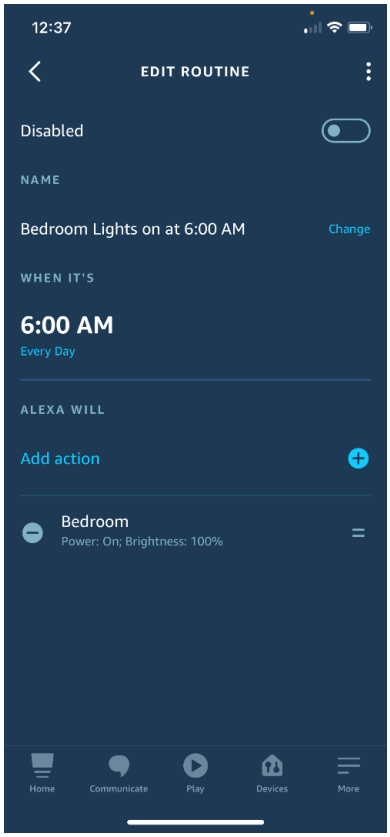


Figure 77: *Amazon Alexa routine (powers Phillips Hue Smart Lightbulbs ON, at 6:00$_{AM}$)*

5.1.3.5 IntelliDate Mobile App: Lock/Unlock Feature

Similar to brightness-level controls, a "lock/unlock" feature will also be included in the application, allowing the user to essentially set the brightness-level of the IntelliDate display to 0/100, instantaneously, if they are in a position where they do not want the contents of the IntelliDate display to be seen by others until they choose to unlock it. Though the action of "locking" the IntelliDate display will simply set the brightness-level of the IntelliDate display to 0/100, it will also disable all routines to further modify the brightness-level until the IntelliDate display has been "unlocked", by the user. There will also possibly be a "lock" icon that dimly displays on the IntelliDate display, while it is "locked".

5.1.3.6 IntelliDate Mobile App: Offline Features

While the IntelliDate mobile application will use internet connectivity, from the mobile device, to sync events from various calendar applications, certain features of the application will be made available when an internet connection is not present. One of the key advantages of using a mobile application in place of a web-based application is the ability to use the application without an internet connection. Adding, editing, and deleting events, created within the IntelliDate application, will be one feature made available in offline mode. The user will also be able to control brightness settings and lock/unlock their IntelliDate panel without an internet connection.

5.1.4 IntelliDate Mobile App: UI Schematics

Though later on in design, software tools that assist in mobile application development will be utilized, to design the mobile application user interface, prototype user interface diagrams were created in Microsoft PowerPoint. The following user interface prototypes are shown below:

Figure 78: *IntelliDate mobile app Login Screen*

This will be the initial screen that the user sees when they open the app for the first time. There will be an option to either create a new account ("Sign up") or log in with an existing account if they have used the IntelliDate app before.

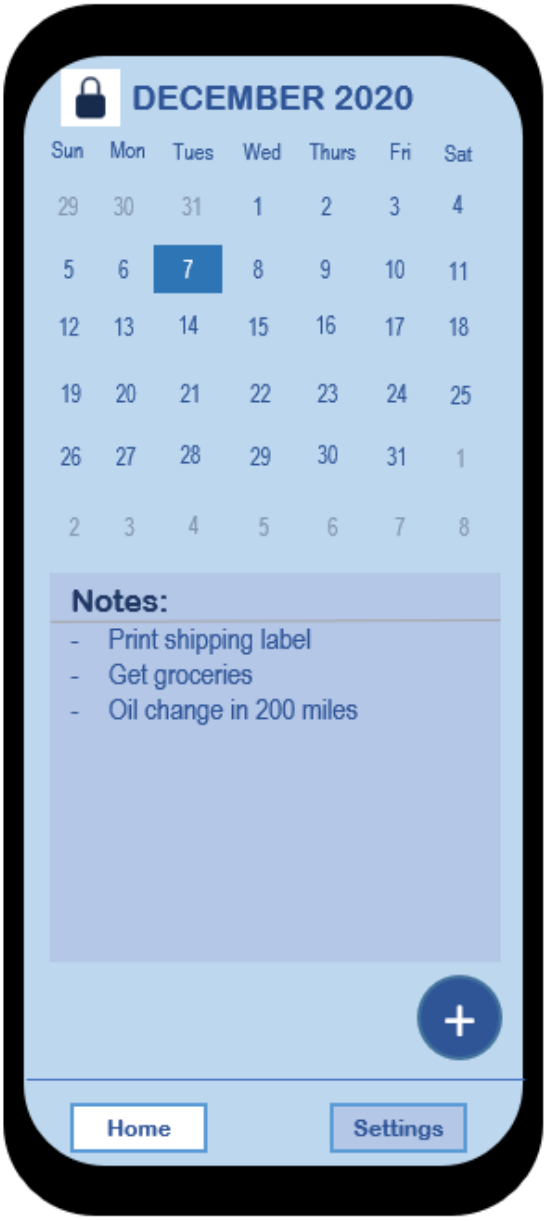


Figure 79: *IntelliDate mobile app Home screen*

Shown above is the Home screen, one of the two main screens in the application. Upon logging in, the user will be greeted with the Home screen. On the Home screen, the user can see, in the top left, if their IntelliDate display is locked or unlocked. In the current view, the IntelliDate display is locked. Tapping the lock icon will unlock the IntelliDate display and change the icon to an opened lock. Next to and under the lock icon is the calendar view for the current month. Each day, represented by a number, can be tapped to view and/or add events for that specific day. Events can also be added by tapping the plus (+) icon in the bottom-right of the screen, above “Settings”. Under the monthly calendar is a “Notes” text area, where the user is free to type notes that will be reflected on the IntelliDate panel, if they choose to show the “Notes” section.

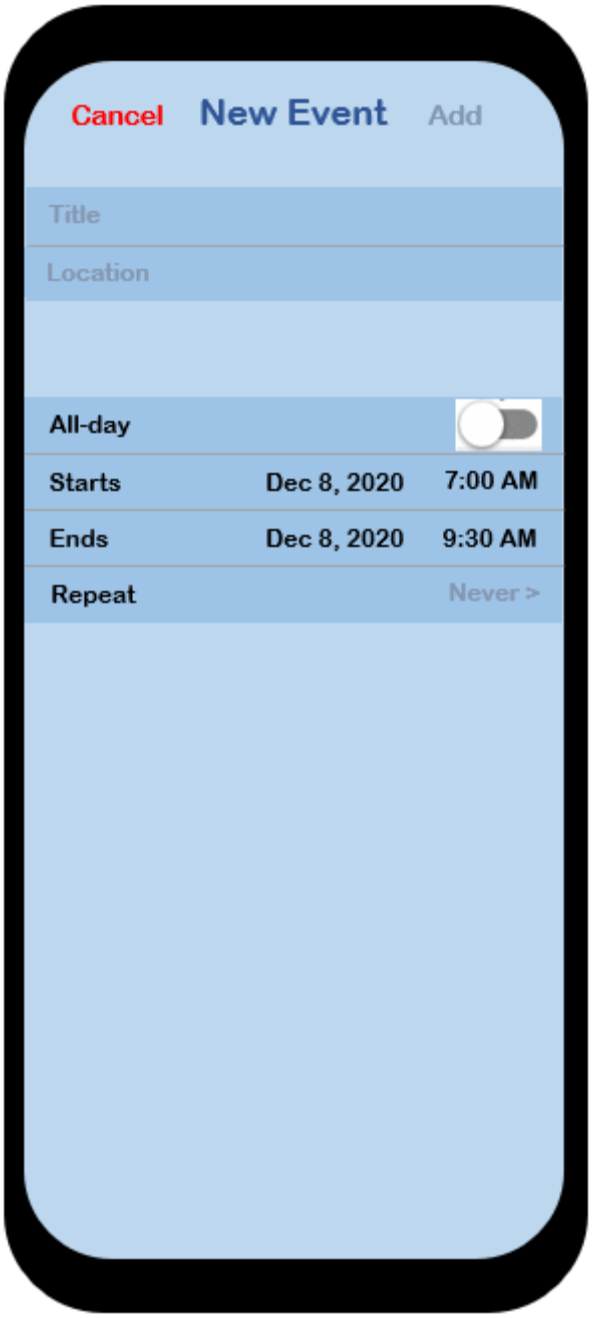


Figure 80: *IntelliDate mobile app New Event screen*

Upon tapping the plus (+) icon or a specific day, on the home screen, the user will be able to create an event to be added to the calendar. Show above is the screen users will be able to interact with, when creating events. This interface allows the user to title an event, set a location for the event, choose if the event happens within a timeframe or lasts for the entire day, set the begin and end time/dates for the event, and select an option to have the event repeat on future dates. The user cannot add the event until it is given a title. This is why the “Add” option, in the top-right of the screen, is currently greyed out. Once a title is given to the event, the “Add” option will have its font color changed to red.

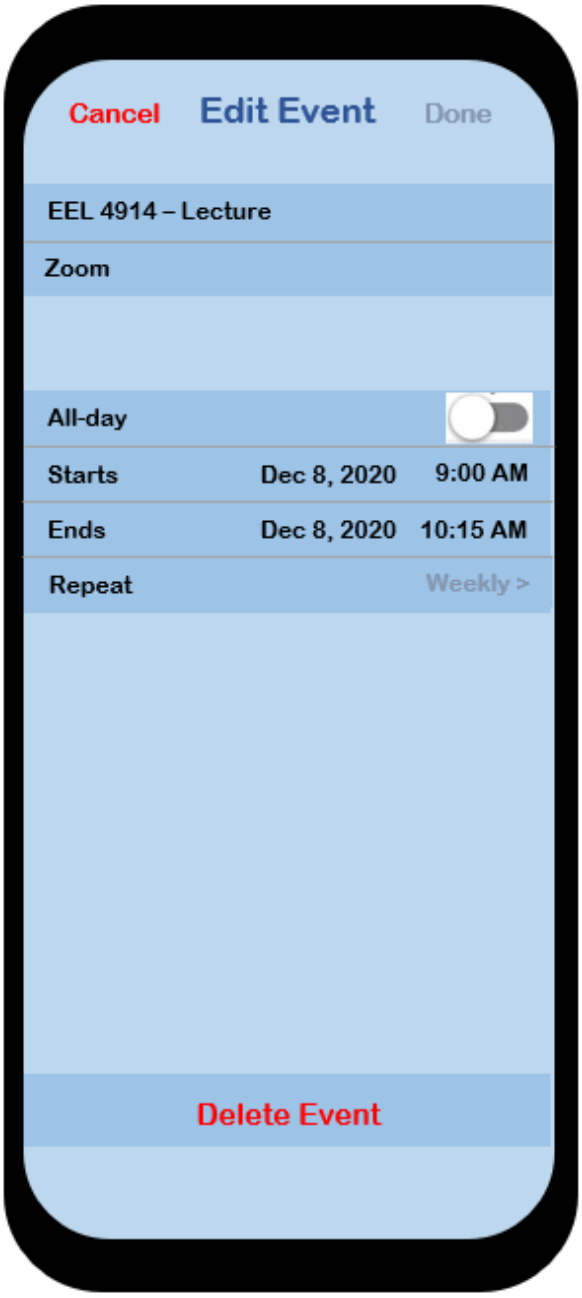


Figure 81: *IntelliDate mobile app Edit Event screen*

Shown above is the screen users will see when they wish to edit or delete an event from their calendar. At the bottom of the screen is the "Delete Event" option, which will first prompt the user to confirm their decision before deleting the event. The "Done" option, in the top-right corner of the screen, will not be selectable and will have grey-colored font until the user makes changes to the original event. Once the user has made some sort of change, the "Done" option will have its font color changed to red. In this example, the event being shown is a lecture, occurring on Tuesdays and Thursdays, from $9{:}00_{AM}$ to $10{:}15_{AM}$. While making this event, the user can select the "Repeat" option to have the event automatically populate on every Tuesday and Thursday, in future weeks to come.

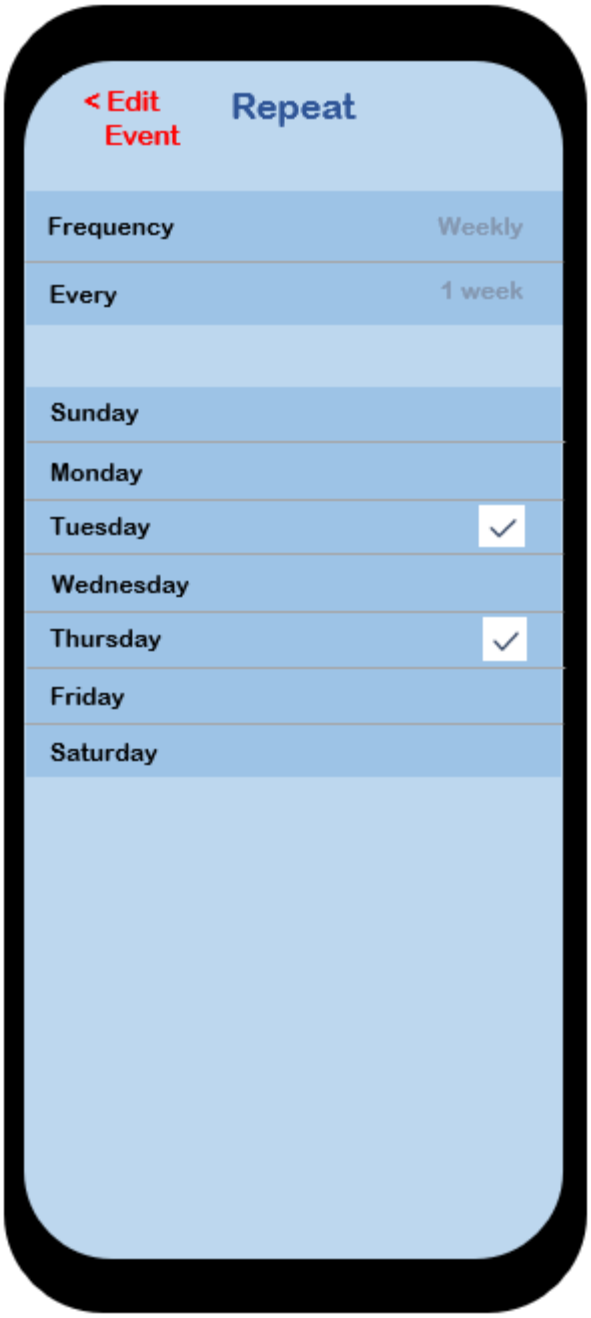


Figure 82: *IntelliDate mobile app Repeat screen*

Shown above is the “Repeat” screen, from which the user can access by tapping the “Repeat” option, in either the Create Event or Edit Event screen. Within the “Repeat” screen, the user can select which days to have the even repeat itself, and on which basis to do so. Another example of the “Repeat” function would be setting an event, titled “Payday” to occur on every other Friday. In this case, “Friday” would be the only day selected (represented with a checkmark, as seen next to Tuesday and Thursday in the figure), “Frequency” would be set to “Weekly”, and “Every” would be set to “2 weeks”. As seen previously, in the Create Event figure, the user can choose to set “Repeat” to “Never”, in the case that the event being added does not occur on future dates.

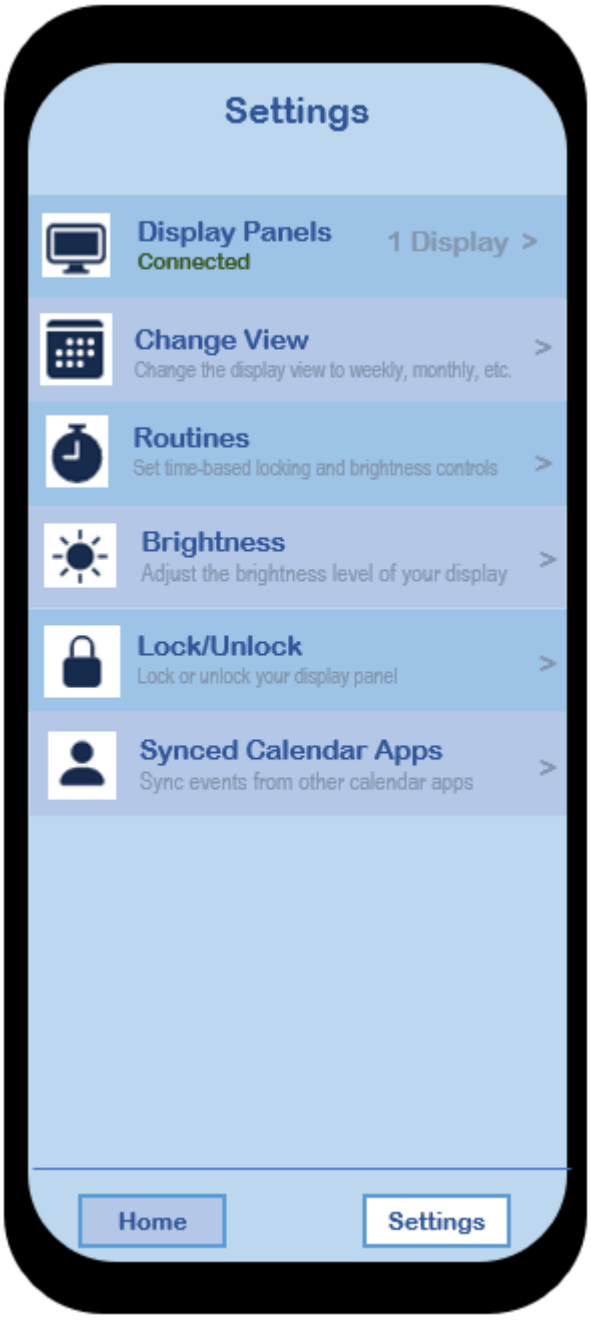


Figure 83: *IntelliDate mobile app Settings screen*

Shown above is the second main screen of the IntelliDate mobile application. The Settings screen allows for the user to connect IntelliDate displays, change the calendar view, create, edit, and delete routines, adjust the IntelliDate display brightness, lock and unlock the IntelliDate display, and sync events from various calendar applications. As this diagram is a preliminary prototype of what the final Settings user interface will look like, certain options may be combined with others, removed, or added to the Settings screen, as the teams sees fit, during design and development.

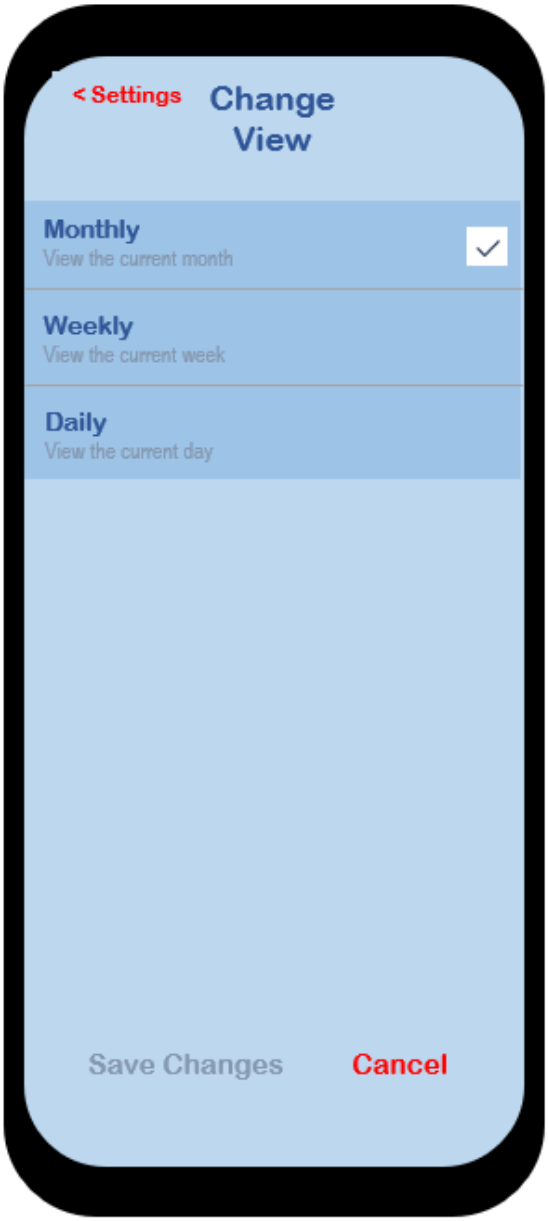


Figure 84: *IntelliDate mobile app Change View screen*

The Change View screen is accessed by tapping the "Change View" option, in the Settings screen, shown above. It is in the Change View screen where the user can select which calendar-view they want to see on their IntelliDate display. The monthly view, currently selected in this example of user interface prototype images, shows the current month on the IntelliDate display. The selected option will have a checkmark icon next to it, just as various days of the week have on the "Repeat" screen, when creating or editing events. If the user chooses the "Weekly" view, their IntelliDate display will show the days of the current week, and all events that coincide with them. Selecting the "Daily" view will show only the current day of the week, with a further detailed breakdown of each event added to the current day. If the user changes the calendar-view from its original state, upon selecting the "Change View" option, from Settings, they must select "Save Changes" in order for

the IntelliDate display to reflect these changes. The “Save Changes” option will change from a grey-font state, that cannot be selected, to a red-font, selectable state, once the user changes the view from its original state. The user can exit this screen, without making any changes, by selecting “Cancel”, in the bottom-right of the screen, or “< Settings”, in the top-right of the screen.

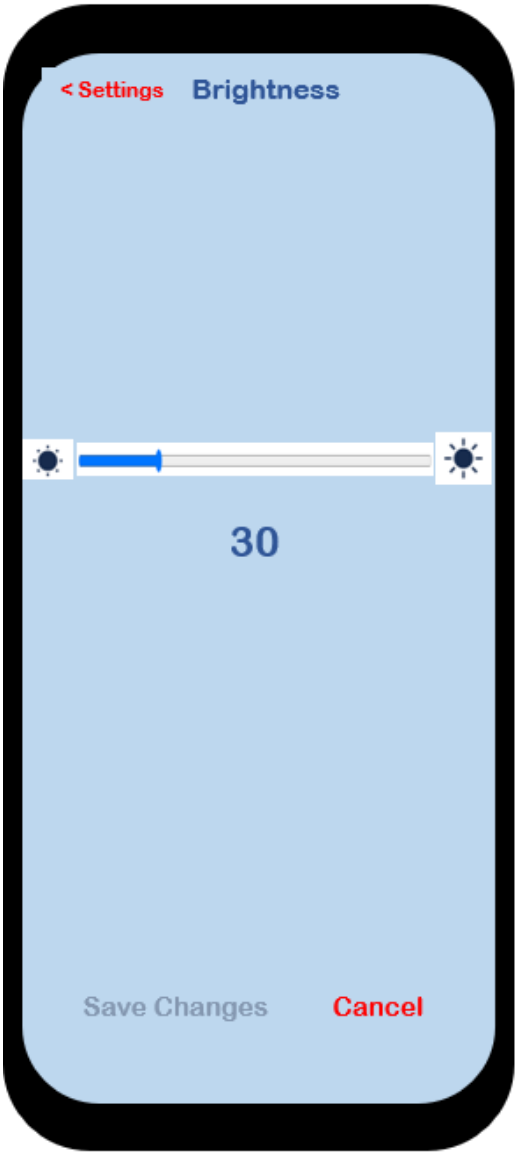


Figure 85: *IntelliDate mobile app Brightness screen*

Shown above is the “Brightness” screen, accessed from the Settings menu, by tapping the “Brightness” option. A slider component will be implemented in this screen, allowing the user to dynamically adjust the brightness level of the IntelliDate display. The brightness level will also be reflected to the user, as a numeric value, between 0 and 100, right under the slider bar. During development, we may choose to implement a vertical slider component, rather than a horizontal slider, as shown in the current prototype, in order to fill the screen of the phone more effectively.

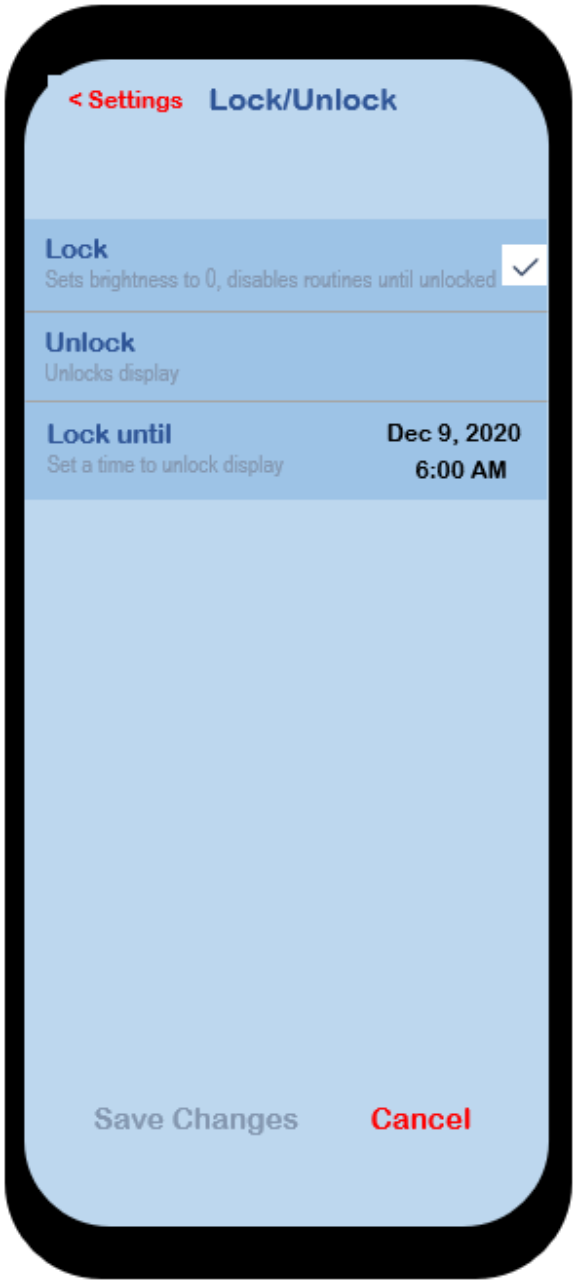


Figure 86: *IntelliDate mobile app Lock/Unlock screen*

Shown above is the “Lock/Unlock” screen, accessed from the Settings menu, by tapping the “Lock/Unlock” option. In this screen, the user can select options to lock or unlock their IntelliDate display. When locked, the IntelliDate display will have its brightness level set to 0, and the user can choose to have their IntelliDate display unlock, automatically, at a specified date and time. The user can also choose to not have their IntelliDate display unlock automatically, but instead require a manual unlock, via the mobile application. While the IntelliDate display is locked, routines will not affect the brightness of the display, and the closed-lock icon will display on the Home screen. Conversely, when the “Unlock” option is selected, the “Lock Until” option will not be selectable, and an open-lock icon will display on the Home screen.

5.2 Design Ideas: IntelliDate Box

After doing a lot research on the market for smart calendar there are two way of design the IntelliDate were taken in to consideration.

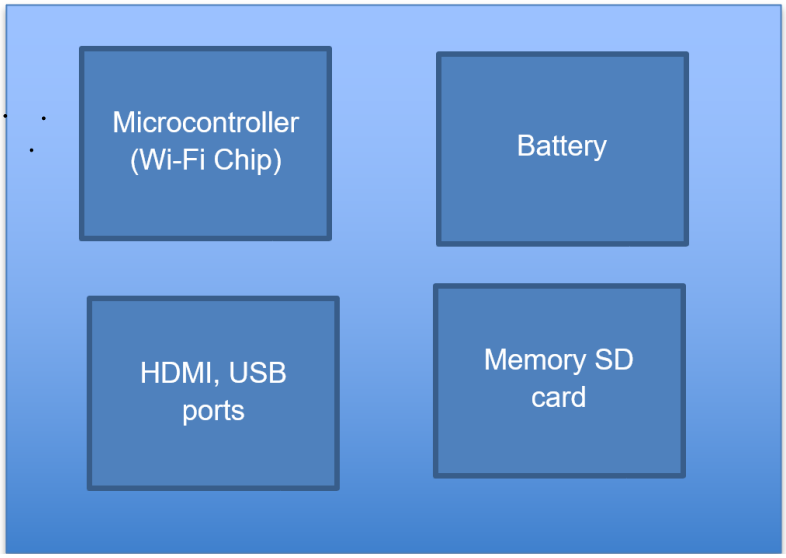


Figure 87: *IntelliDate Box*

This is the first idea of the design where the IntelliDate box will be implemented. This design based on the convenient factors since the box contains all the components needed. It becomes like portable device that can be use transfer to multiple places. The only requirement of this design is to have a separate TV or monitor to turn this on using the HDMI cable.

Another factor added to this design is the cost. The box will be more cost efficient for buyer to buy since the screen is not integrated with the design, so buyer has a choice between using the old monitor or any kind of TV that they have in the house for the IntelliDate box.

5.3 Integrated IntelliDate screen

Another the great idea of the design is to build everything into a whole system with a screen and power supply. This design will look more like a Television system where the Micro-processor will be integrated in TV. This is a great design for office uses. It does not have the flexibility compared to the box, but it will give user a stable system.

This is the system is more for restaurants or offices use to display their calendars or schedules. This system will use the AC power supply to run the whole TV screen and the box. With a stable connection and power, the Integrated IntelliDate screen will perform much more stable than the box since all of the application will be updated simultaneously without worry about losing power.

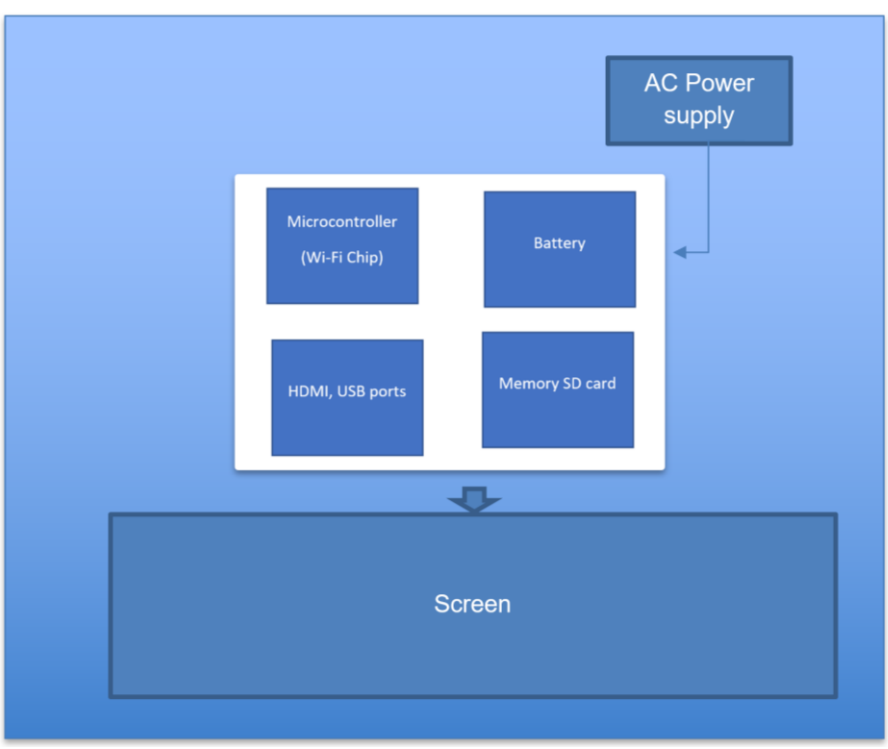


Figure 88: *Integrated IntelliDate screen*

With today technology keep developing, it is always good for customer to have options when they purchase any devices. These two designs have its advantages and disadvantages. Customer can always look at them and decide which one will fit their needs the most. The comparison table below will show all the key difference between the two designs:

Table 17: *Design comparison*

	Advantages	**Disadvantages**
IntelliDate Box	Flexibility	Require a screen to work
	Cost efficiency	Need a separated power supply
	Portability	Harder for application update
	Easy for warranty	
Integrated IntelliDate screen	User friendly	More expensive
	1 power supply needed	Not portable
	Stable performance	Harder to do warranty

5.4 PCB Design

It is very essential for every design that the initial design was sketched first before any further action taken into place. There are a lot of available software for PCB design in the market. The discussion below is to find out which one is the best solution for the PCB initial design.

5.4.1 Autodesk EAGLE

The software was initially found by Rudolf Hofer and Klaus-Peter Schmidinger in 1988 to develop EAGLE, a 16-bit PCB design application for the design. Eagle is a scriptable electronic design (EDA) application with schematic captured and printed circuit board layout. “Originally, the software consisted of a layout editor with part libraries only. An auto-router module became available as optional component later on. With EAGLE 2.0, a schematics editor was added in 1991. The software used BGI video drivers, and XPLOT to print. In 1992, version 2.6 changed the definition of layers, but designs created under older versions (up to 2.05) could be converted into the new format using the provided UPDATE26.EXE utility.”

There are two version of the EAGLE available which are standard and premium. The is a subscription required for users. However, there is also a student version which is free of charge for engineering students whose need to use the software for PCB design. There are some benefits for subscribers:

- Regular updates and new features and bug fixes
- No payment for support a maintenance

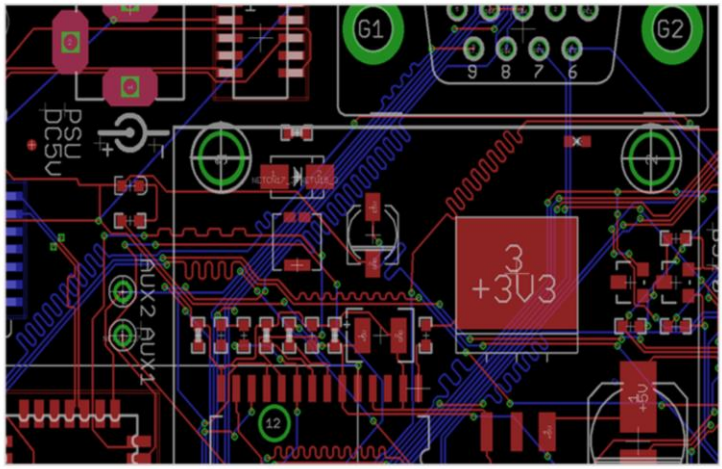


Figure 89: *Example Layout of PCB*

The image is the sample of how the PCB design will look in a schematic mode. There are a lot of features that Eagle Autodesk would provide to the users. Eagle has a feature in which the user could use the library to add components. “Included with EAGLE is an impressive list of part libraries, which you can explore in the Control Panel view. There are hundreds of libraries in here, some devoted to specific parts like resistors, or NPN transistors, others are devoted to specific manufacturers. This is an amazing resource! But it can also be a bit overwhelming. Even if you just want to add a simple through-

hole electrolytic capacitor, there are dozens of libraries and parts to sort through to find the right thing."

5.4.2 Protel (Altium Designer)

Protel company was introduced to the circuit industry in around late 80s, 20th century. Protel has been used for PCB design all over the world as well as in the teaching technologies for a lot of universities. Protel is one of the first PCB design tools created for personal and commercial computer. Protel today call Altium Designer has a lot of advanced legacy compared to other software. Protel is a very powerful PCB design platform. "To give you the power that you need as a PCB designer for today's challenging designs, Altium Designer has been rebuilt from the ground up. Now structured on a 64-bit multithreading system's architecture, Altium Designer is ready to put its power to work for you." Protel provided a better solution for new design structured that required 64 bits architecture.

Altium designer is enquired with the following system requirement:

- 64-bit multithreading architecture
- Altium designer's unfiled design environment
- Schematic capture editor

Protel also has a great feature for beginner which it allows new users access to the software easier with detailed instruction. "With smart placement algorithms, you will be able to quickly organize and position your components for the most optimum placement." With the 3D technologies, users can check the component placement and imported into the mechanical design to check for other features.

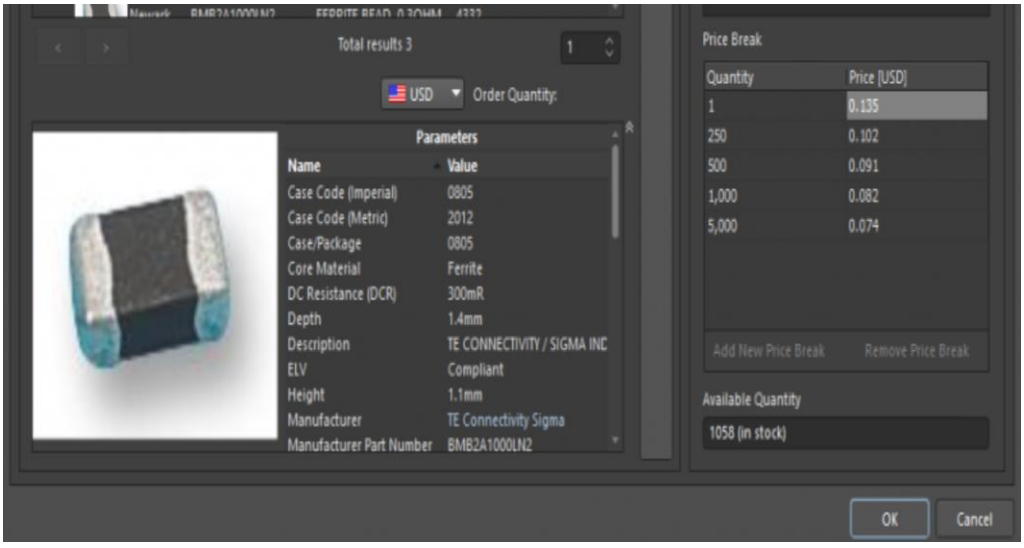


Figure 90: *3D component*

The image shows the 3D component of a resistor with Protel design. With today technology, being able to capture a schematic is no longer up to date. New machines and technologies required software has to do more in order to server user's needs. "To stay competitive, you need to up-to-date component information, advanced auto routing tools, and automated PCB file creation utilities to name a few of today's requirements. Altium

knows this and has been enhancing its software for years in order to add the tools and functionality that you need into Altium Designer."
Altium Designer also come with an Active BOM, which is a bill of material management tool that would give user data portal into the design. With this BOM user has the ability to access the component data directly and select them for the schematic design.

5.4.3 Ultiboard

The is another the command type of circuit designs software that a lot of engineers use for their designs. Ultiboard is printed circuit design and schematic layout that integrated with Multisim. One of the main focus of this software is Real Time Design Rule check. Ultiboard was originally found by a company named Ultimate Technology. This company focused on design a 3D PCB viewing system, which can be captured using Multisim. "Seamless integration with Multisim software provides simple schematic transfer to PCB, and forward and backward annotation ensures design iteration management." Despite the that there are a lot of benefits for this software the price for one-year subscription for this design is very high.
The following table is the comparison of these three software:

Table 18: *Comparison of EAGLE, Protel, and Ultiboard*

	EAGLE (Autodesk)	**Protel (Altium Design)**	**Ultiboard**
Advantages	Cost efficient	High quality 3D schematic design	User friendly
	Variety libraries	Advanced filtering	
	Auto-router	Offline version to use without license	
	Add-on program languages	Add-on programs	
	Copper pouring	Input helper	
Disadvantages	Poor navigation design	Expensive	Expensive
	Not user friendly	Not user friendly	

After taking all the advantages and disadvantages of those three software designs for the PCB. It turns out that the EAGLE AutoDesk and Protel are the two-best solution for our design. However, due to the budget of the project as self-support. The EAGLE is the best solution for this project since it has a free version for student and contains most of the feature that will help for the design.

5.5 Testing Product

When we start building the product, we are going to have to make prototypes. So, for testing we have a bunch of old televisions and monitors we do not use anymore so we have a set monitor we want to use. So that will be the final design. We must take apart the backs of the televisions and see where we can implant our device to television to make the back look nice and to see if it properly works. Then we are going to test how to mount the monitor on the wall. So, we are going to test some mounts to put on the back of the monitor that will hold the monitor in place without knocking something off. We must take in consideration of the weight of the monitor and to not make it look cheap.

5.5.1 PCB Testing

After we find the spot, we can implant the device we also got to make sure that our PCB is correct, or we can fry the microcontroller and the television and then was our time and money. So, testing the product should be tested on a small breadboard before implementing it on the actual microcontroller to see we are short circuiting anywhere. Lucky for us one of the group members has a small breadboard and a location to you a voltage source. When the time comes, we will be able to test the circuit then we will use eagle and implement the design and print out our PCB.

5.5.2 Battery Testing

While the PCB is getting made, we will see how to implement the battery because we do not want to look cheap with wires hanging out everywhere if it is not necessary. For battery we must make sure that it can keep the voltage where it can keep the monitor and the microcontroller working for a certain length of time before it must be recharged. If the voltage is too high, it can fry the microcontroller and if the voltage is too low it will not power anything.

5.5.3 Mobile Application Testing

Within the integrated development environment, mobile applications can be tested through use of mobile simulators, commonly referred to as mobile emulators. A mobile emulator is: “software in a computer or on a website that simulates a mobile app, running in a variety of smartphone hardware.”[16] Mobile emulators can be used to test in-development mobile applications within the integrated development environment. Mobile app testing refers to “testing activities for native and Web applications on mobile devices using well-defined software test methods and tools to ensure quality in functions, behaviors, performance, and quality of service, as well as features, such as mobility, usability, connectivity, security, and privacy.”[17] Mobile applications include many unique requirements to test. Mobile applications must function properly across all platforms that have different operating systems, display sizes, processing power resources, and battery life.[17]

5.6 Schematic

Our initial thoughts when deciding to create this project were that we would be able to use the lowest priced parts in order to achieve our goal. However, after doing the research we soon realized a lot more would have to be put into the process of part picking than just the cost. For example the Arduino Uno has an ATmega328P chip as it's main brains and can support many functions including an Ethernet interface to have networking capabilities, but these functions in many cases are very limited for this chip and if we were to proceed with this idea we would not be able to complete our project because the ATmega328P would be pushed past its limits. This realization was the driving force behind our research for the design of our product. That being said we have decided that the best way to proceed forward would be for us to take not only price into account but also limitations, availability, and compatibility of each part. For some of the parts of the circuit this was fairly straight forward because of the wide ranges of use cases. For example the power circuits; as long as we designed something that would give us our desired voltage and maintain enough current to supply all necessary parts with enough power, we could use any chipset with it because power is not chip specific.

Another issue that we ran into was the fact that many of the Wi-Fi modules seemed to be very promising but after looking into them we realized that they had been discontinued for one reason or another. This was very frustrating because we need the chips to also have working modules or prototyping boards that are compatible with the chipset that we decide to use and because we were leaning towards the Arduino, an Arduino shield would be perfect for the job. Sadly the more we investigated it the more apparent it became that we would not be able to use the Arduino Uno (chipset) as we had originally planned due to many reasons but the biggest being that it does not have enough memory or processing power to interface with the Wi-Fi chip and micro SD card circuit simultaneously. So once we realized this the next step we took was looking for another microprocessor chip that would work and fortunately there was another part of the Arduino family that would do the trick, the Arduino Zero built around the ATSAMD21G18 chip.

So, in the end, we decided to go with the following parts:

- The ESP8266EX – Wi-Fi
- The ATSAMD21G18A – CPU
- The 74LVC125A – Level Shifter

These parts were chosen mainly because of their low costs and compatibility with each other. Below I will describe the schematic that we plan on implementing.

5.6.1 Wi-Fi Module

The ESP8266EX comes as a basic Microchip without any other needed peripherals such as the power supply chips, or antenna. This being said we have to create those circuits ourselves, so to go about the process I went to the datasheet of the chip to see what was needed for proper function. The following image of the ESP8266EX chip allowed me to see the available pinout and made it easier to be able to map out where we needed connections. All of the connections will not be needed and therefore some of the pins were left unused.

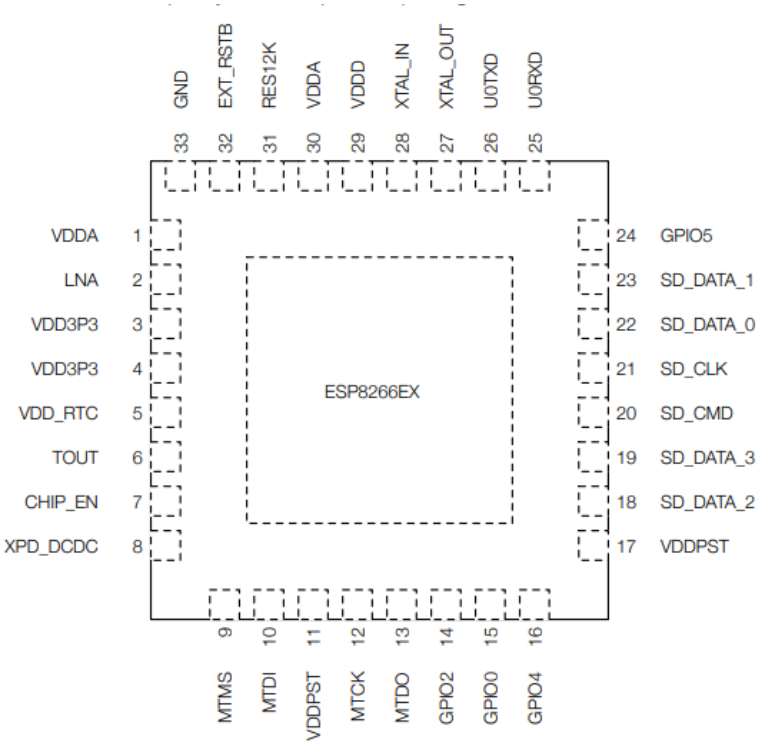


Figure 91: *Taken from ESP8266EX datasheet*[155]

The following table outlines the ESP8266EX pinout and functionality:

Table 19: *ESP8266EX Pinout*[143]-[147]

Pin	Function
1	Analog Power 2.5V – 3.6V
2	RF Antenna
3	Amplifier Power 2.5V – 3.6V
4	Amplifier Power 2.5V – 3.6V
6	ADC pin
7	Chip Enable pin – Active high
8	Deep sleep wake up
11	Digital/IO Power Supply 1.8V – 3.6V
14	UART TX during flash prog
15	SPICS2
17	Digital/IO Power Supply 1.8V – 3.6V
18	SPIHD
19	SPIWP
21	SPICLK
22	SPIQ/MISO
23	SPID/MOSI
25	UART RX during flash prog
26	SPICS1/ UART TX during flash prog
27	Connect to crystal oscillator output

28	Connect to crystal oscillator input
29	Analog Power 2.5V – 3.6V
30	Analog Power 2.5V – 3.6V
31	Serial connection with a 12 kΩ resistor and connect to the ground
32	External reset signal – Active Low
33	GND

Following the ESP8266EX pinout and functionality, the following figure depicts the hand drawn ESP8266EX schematic:

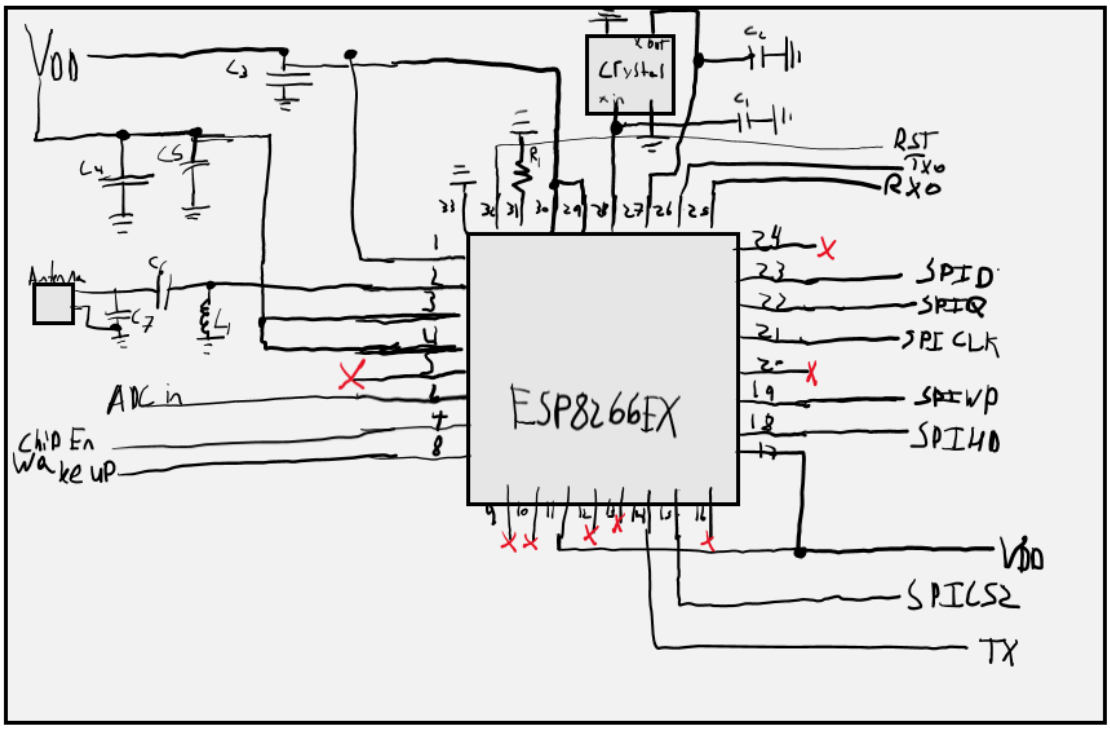


Figure 92: *ESP8266EX Schematic*[143]-[147]

For the Wi-Fi Module to actually work properly the antenna has to be far enough away from the CPU otherwise it will get interference. With configuration that is set above the chip will be set to use the SPI protocol. There are other possibilities, but this is the fastest that is supported by each of the devices involved.

5.6.2 Micro-SD Card Reader

The Micro SD Card reader circuit is actually very simple in design. It too uses the SPI protocol for communication with the microprocessor which is where some of the initial compatibility issues were exposed. The simple design of this module was part of the reason it was chosen. It consists of the card reader, a 3.3V voltage regulator, and a logic level shifter. The components listed are normally needed because Arduinos are 5V devices, but SD/micro SD cards are 3.3V devices. Actually, they cannot even accept any voltage above

3.6V otherwise the cards will incur damage. So, the Voltage regulator makes sure that no matter which voltage is supplied (within reason) it will give the correct output voltage of 3.3V. This is true for the power pins but what about the data pins? Well they require something a little more special because they need to be able to work in both directions. That's where the logic level shifter comes in, its job is to take any signals coming in and make sure they are 3.3V but then it also has to make sure that all signals going out are at the original 5V. The following image, in conjunction with the table it is followed by, shows the pinout of the micro SD card. The actual card reader itself just mimics the output of the SD card pins.

Figure 93: *SD card*[154]

Table 20: *Pinout of the SD cards*[149]-[154]

Pin	Function
1	NC
2	Chip Select
3	Master-out, Slave-in
4	VDD
5	CLK
6	GND
7	Master-in, Slave-out
8	NC
9	NC

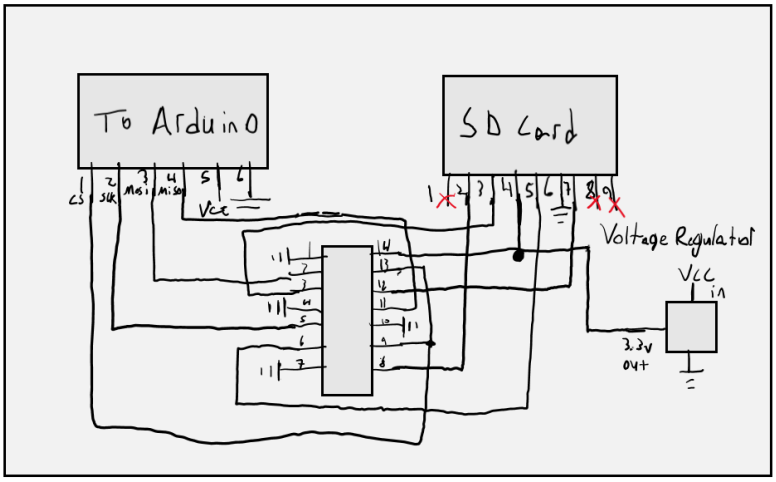


Figure 94: *SD card circuit schematic*[149]-[154]

5.6.3 CPU

Some of the limitations of the Arduino Uno were the fact of too little memory or even the use of only one SPI line, but these and more issues are all addressed in the Arduino Zero. The ATSAMD21G18A chip has a whopping 6 serial communication modules that can all be used at once. This means that we can have multiple peripheral devices running at the same time all interacting and being powered by this one chip.

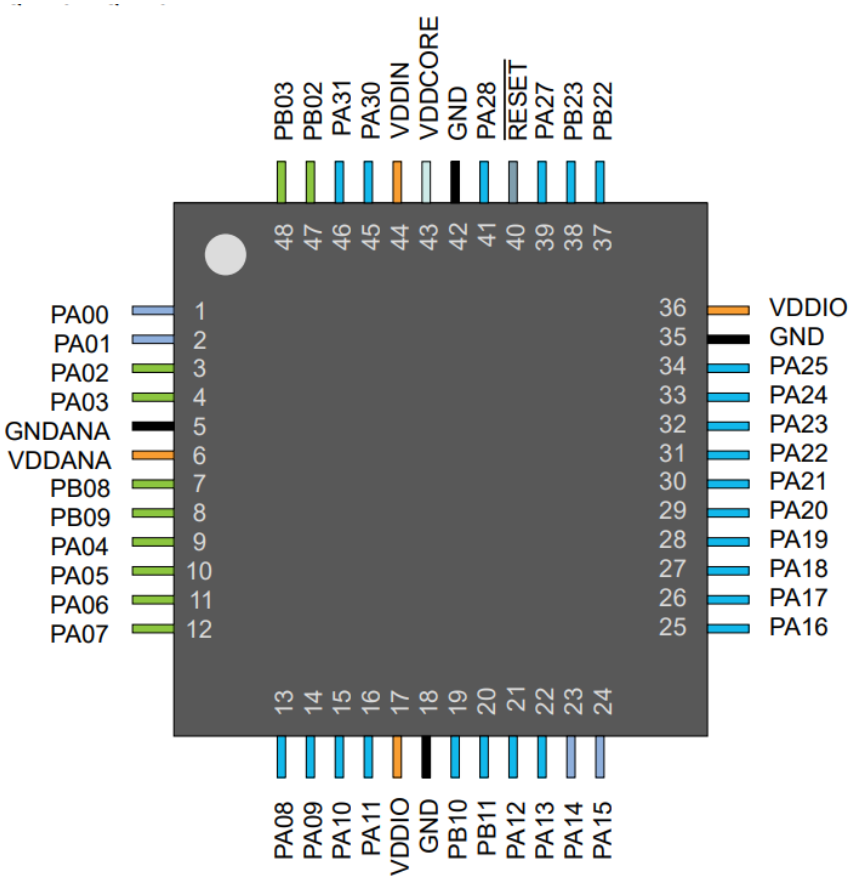


Figure 95: *ATSAMD21G18A Diagram*[148]

Table 21: *ATSAMD21G18A Pinout*[139]-[142]

Pin	Function
1	Crystal in
2	Crystal out
5	GND
6	VDD
15	TX
16	RX
17	VDD
18	GND
19	MOSI – SPI

20	SCK – SPI
21	MISO – SPI
23	Crystal in
24	Crystal out
25	MOSI
26	SCK
27	SS
28	MISO
30	Antenna
31	SDA
32	SCL
35	GND
36	VDD
40	RST
42	GND
43	Vout
44	VDDin

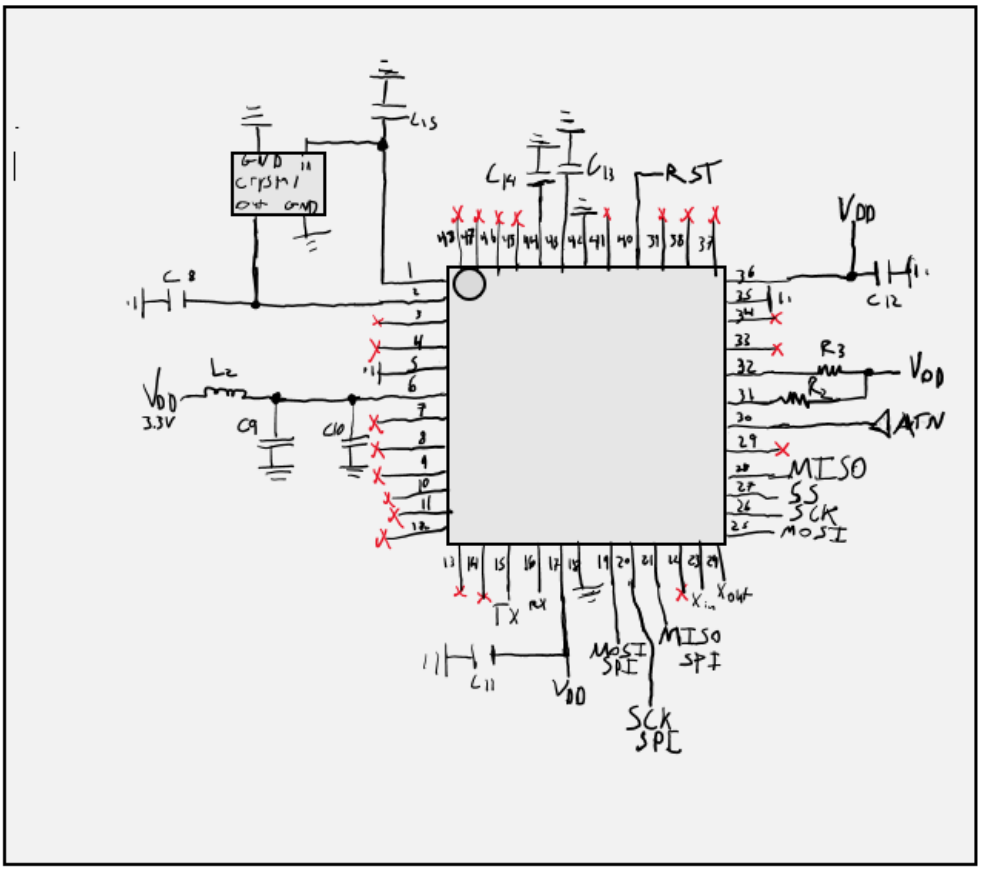


Figure 96: *ATSAMD21G18A Schematic*[140]-[142]

5.6.4 Power Supplies

Once we were able to figure out what chipset we would use and what the circuits would be looking like, we were then able to move to the next step which was designing a proper power supply option. For this task we used TI Webench because of its efficiency in designing power options with a variety of constraints. In order to make sure we have sufficient power for our project we decided to use a 3.3V 2A power solution for the 3.3V rail and a 5V, 2A power solution for the 5V rail. At the center of the 3.3V circuit we have the TI TPS563209DDCR chip which is a buck converter. For the 5V circuit we are using the TI TPS62143RGTR chip which is another buck converter.

Table 22: *TPS563209DDCR Pinout*[158]

Pin	Function
1	GND
2	SW
3	Vin
4	VFB
5	EN
6	VBST

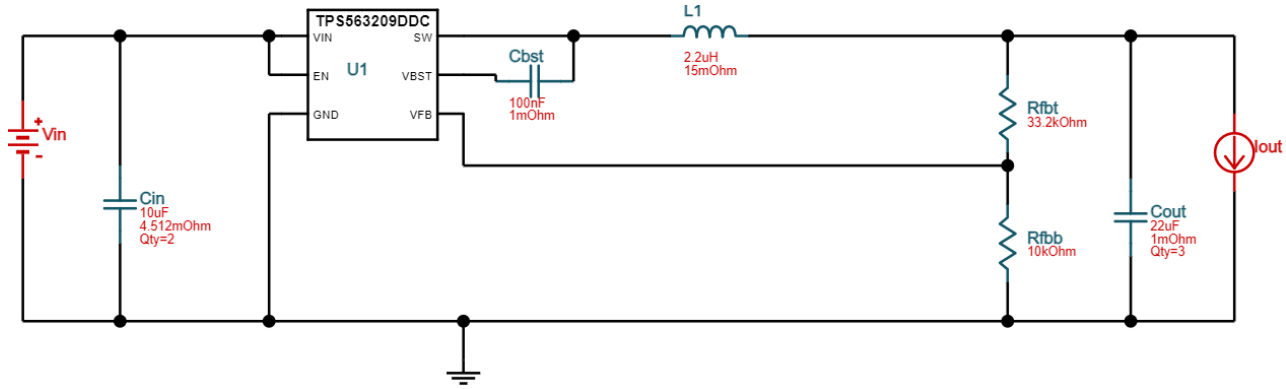


Figure 97: *TPS563209DDCR Schematic*[157]

Table 23: *TPS62143RGTR Pinout*[138]

Pin	Function
1	SW
2	SW
3	SW
4	PG
5	FB
6	AGND
7	FSW
8	DEF
9	SS/TR
10	AVin
11	PVin

12	PVin
13	EN
14	VOS
15	PGND
16	PGND

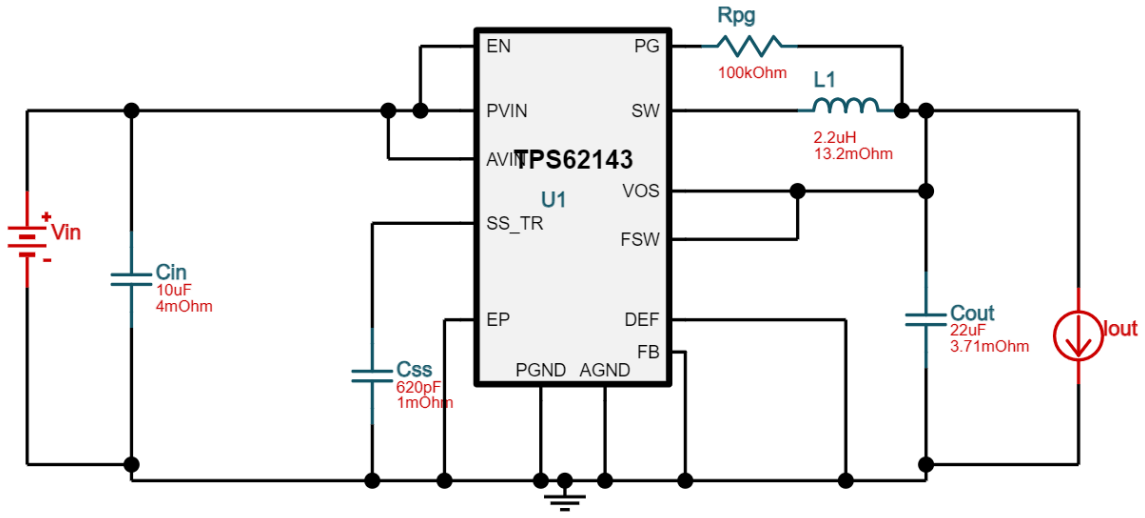


Figure 98: *TPS62143RGTR Schematic*[156]

6 Conclusion

6.1 Estimated Project Budget and Financing

Table 24: *Parts List with costs and lead time*

Part	**Price**	**Lead Time**
LCD Screen	Free-Already have one $50 on eBay	0 Days 30-60 days
Processor -MSP430FR6989 -ATMEGA328P-AU - Atmel SAM3X8E ARM Cortex-M3 CPU	 Free-Already have one $2.01+$7.99 shipping mouser $40.30 $1.76 + $7.99 shipping mouser	 0 Days 1-5 Days 1-5 Days
12v 3A power supply	Free-Already have one	0 Days
Wi-Fi Adapter	$6.65 + $7.99 shipping	1-5 Days
Ethernet Adapter	$1.24 + $7.99 shipping	1-5 Days
Wall mount	$10	0 Days
PCB		
HDMI Ports	$2.61 + $7.99 shipping	1-5 Days
VGA Ports		
18650 Battery	Free-Already have one	0 Days
Lipo Battery	Free-Already have one	0 Days
BMS	Free-Already have one	0 Days
LED’s		
Capacitors/Resistors	$10	1-5 Days
Total		

6.2 Final Project Schematic

A final, cumulative schematic was designed, in EAGLE. The schematic is as follows:

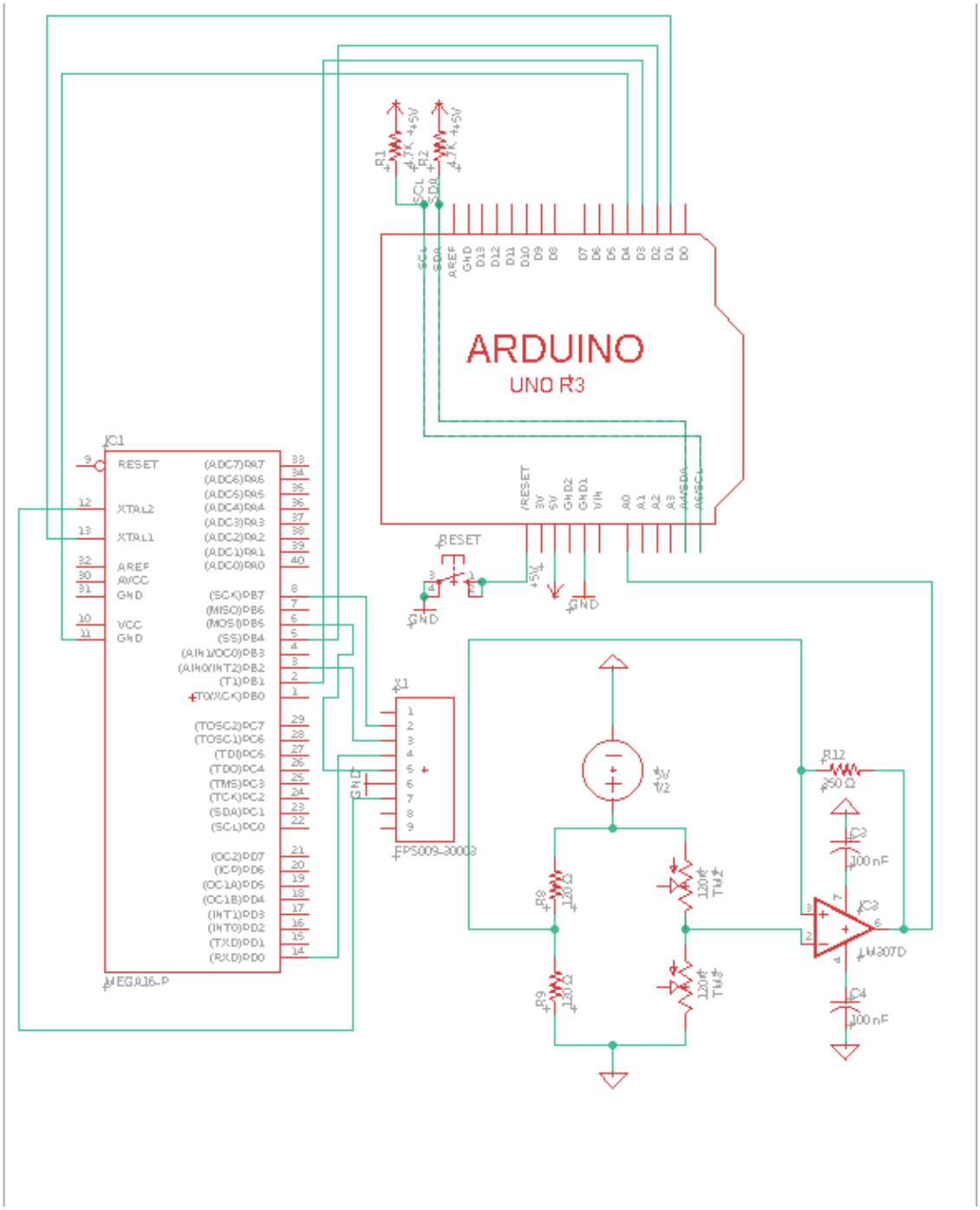


Figure 99: *Final Project Schematic (Designed in EAGLE)*

6.3 Initial Project Milestones

6.3.1 Senior Design I - Fall 2020

September 2020

- Submit project idea D&C outline (9-18)
- Review and reshape project outline with Dr. Wei (9-23)

October 2020

- Design digital layouts for various calendar views (monthly, weekly, daily)

November (1st half) 2020

- Define concrete parts list
- Explore options for pairing-application (platform, web-based, etc.)
- Identify possibilities for syncing events from mainstream calendar applications (Google, iCloud, Outlook, etc.) with a self-made calendar application

November (2nd half) 2020

- Begin ordering parts
- Begin pairing-application development

December 2020

- Submit 120-page report
- Be prepared for development

6.3.2 Senior Design II - Spring 2021

- Design and produce display panel with components
- Complete pairing-application development
- Link pairing-application with panel

6.4 Project Conclusion

As we designed and developed the IntelliDate, many obstacles crossed our paths but as a group of four members, we have been able to overcome most of them. With the information we obtain, we created a design that uses an app to connect to a monitor to display a schedule. This design will not be too expensive and will be easy to install and create a schedule with ease. Even though the user will have to put up the wall mount themselves everything comes prepared unless they only want the microcontrollers.

The reason we chose to do this project is not only to challenge ourselves to find a better solution than having a whiteboard or a paper schedule but to also prove that it is more environmental friendly and easier to make and use. Our objective was to incorporate the making a schedule into a portable device that can be easily carried around and transferable to place to place if needed. The different components required for this project were strategically chosen for cost savings and efficiency purposes.

Using a microcontroller that can communicate through Wi-Fi to a mobile application that can be installed on any mobile device, the software elements of the project would not only be the simplest to implement, but the most user-friendly, depending on how the user would most likely want to operate their system. Wi-Fi is a system that most smartphone owners

are already familiar with using, so it is only normal that the device would be designed to communicate with the home Wi-Fi or Bluetooth link of the user.

We hope that the user will discover that the mobile application management of the system will be comparable to how many other "smart devices on the market allow the user to control their systems. As long as it is fair to enforce the user interface that has been mocked up under Design, the user should have no trouble finding and choosing their preferred IntelliDate choices. The monitor display will give the user the opportunity to see their choice of schedule visibly in action through the display and The display of the monitor will give the user the opportunity to see visibly through the display and application their schedule option in action and serve as an indication of the product working as expected.

7 Senior Design II

After one year of hard work, our group was able to successfully finish the IntelliDate project, with the Printed Circuit Board working corresponding to the software application. This sections below will show what we have done for this project. There were some specifications that our group could not meet due to the difficulty of budget and the COVID-19 pandemic.

7.1 Web Application

In order for the user to interact with the Panel, a web application was developed with the MERN stack (MongoDB, Express.js, React.js, Node.js).

The web application:

- Enables communication between the user and their Panel from any physical location
- Can be accessed on any device with a web browser and active internet connection
- Was deployed with Firebase (frontend) and Heroku (backend)
- Can be used as a scheduling software, even without an attached Panel

The web application allows the user to:

- Create a user account
- Add/remove IntelliDate Panel to/from account
- Configure lock/unlock status of Panel
- Configure calendar view of Panel (monthly, weekly, daily, agenda)
- Create, edit, and delete calendar events and notes that are reflected on the IntelliDate Panel

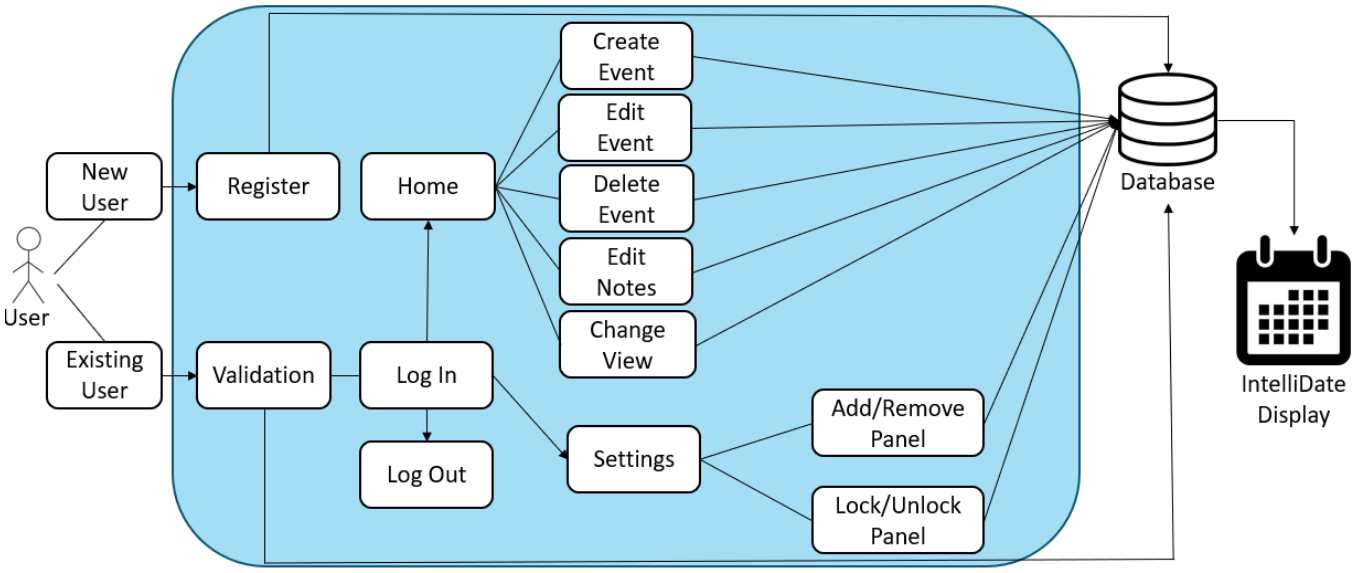


Figure 100: *Web Application Use Case Diagram*

7.1.1 Home Screen

The web application consists of two main pages: the Home screen and the Settings screen. The Home screen is the first initial page that the user sees, when they log in. The Home screen contains the main calendar and the notes section. The calendar contains a navigation bar, along with various controls that allow the user to create new events, edit existing events, navigate through the calendar, and update the current calendar-view that is shown on the Panel.

7.1.1.1 Calendar Views

The home screen, along with various views of the calendar can be seen in the following images:

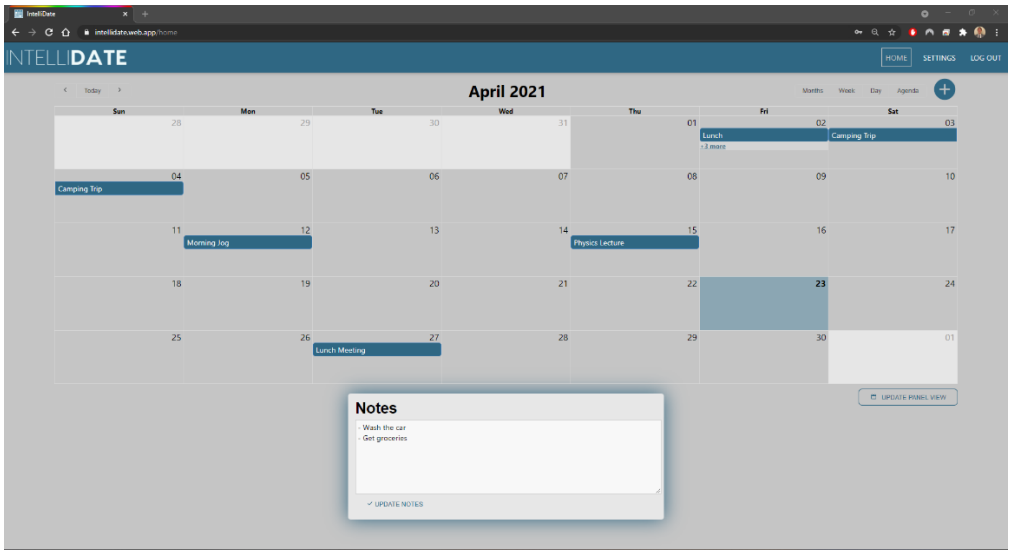


Figure 101: *Month View*

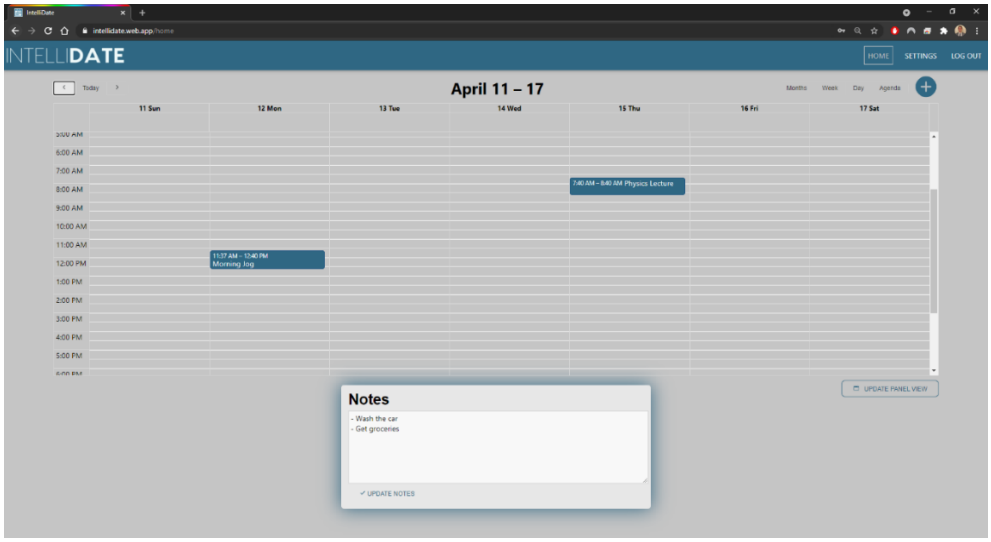


Figure 102: *Week View*

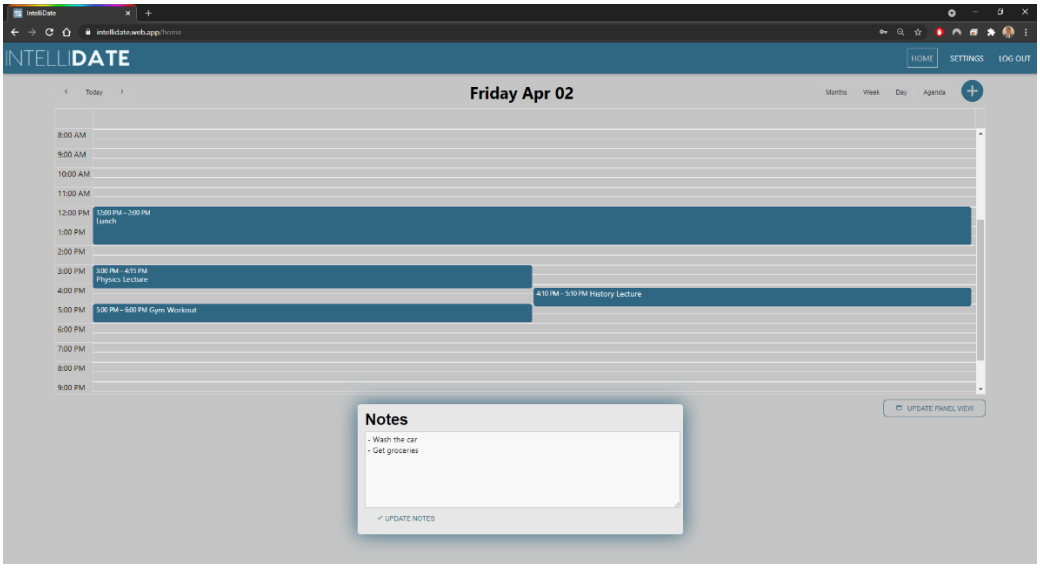


Figure 103: *Day View*

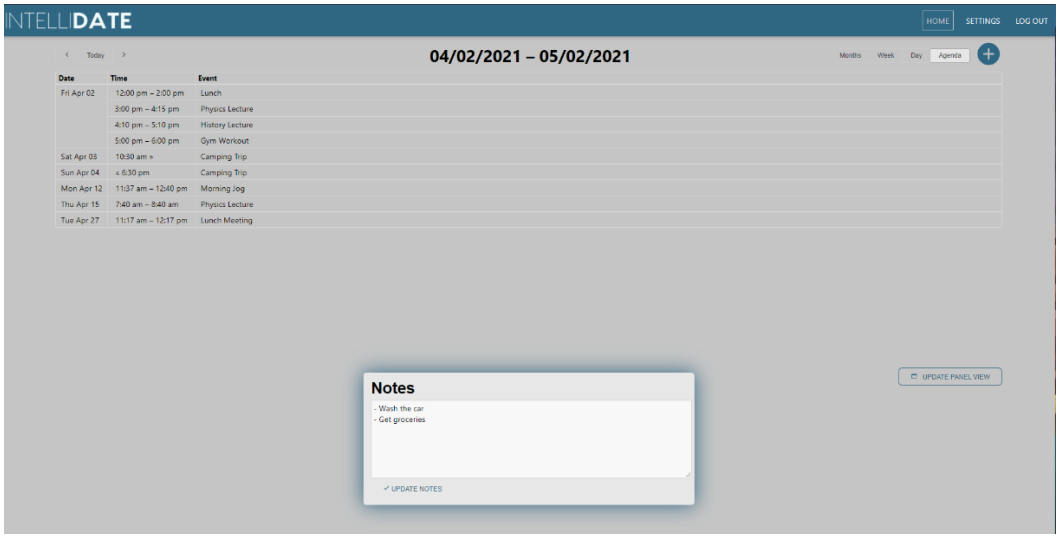


Figure 104: *Agenda View*

7.1.1.2 Creating, Editing, and Deleting Events

In the home screen, the user can also manage their events and notes, via creating/editing/deleting events and notes. Images of the Add Event and Edit Event screens are shown below:

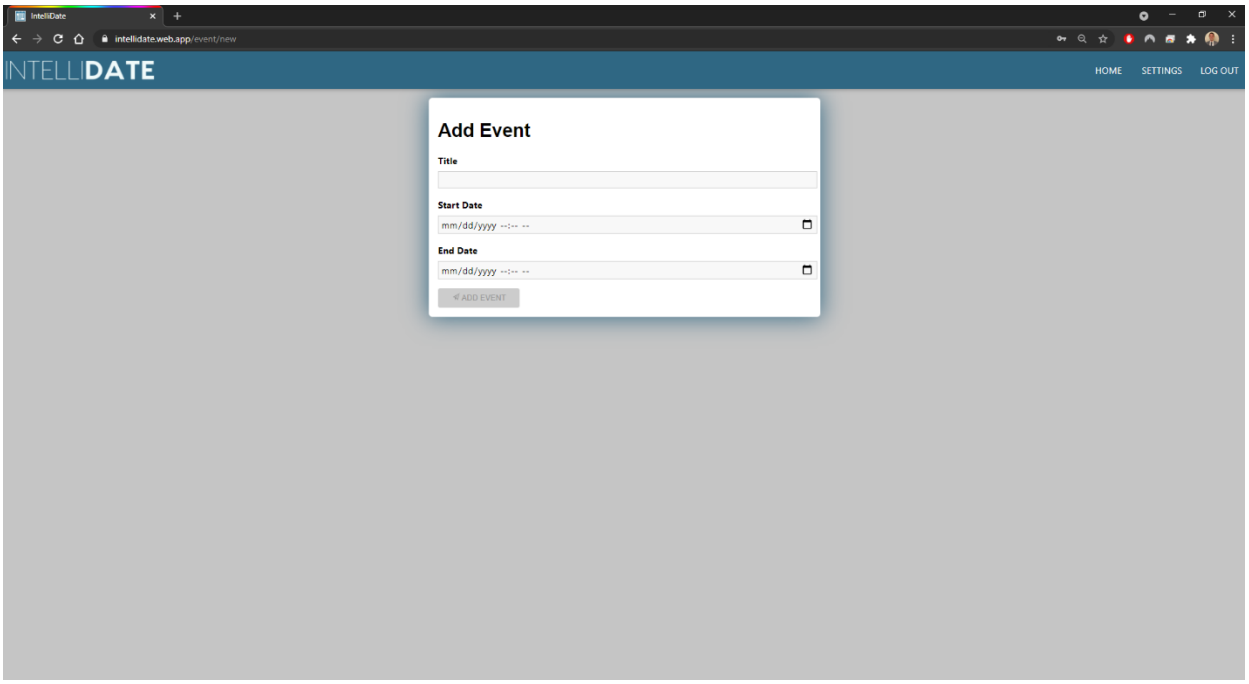


Figure 105: *Add Event*

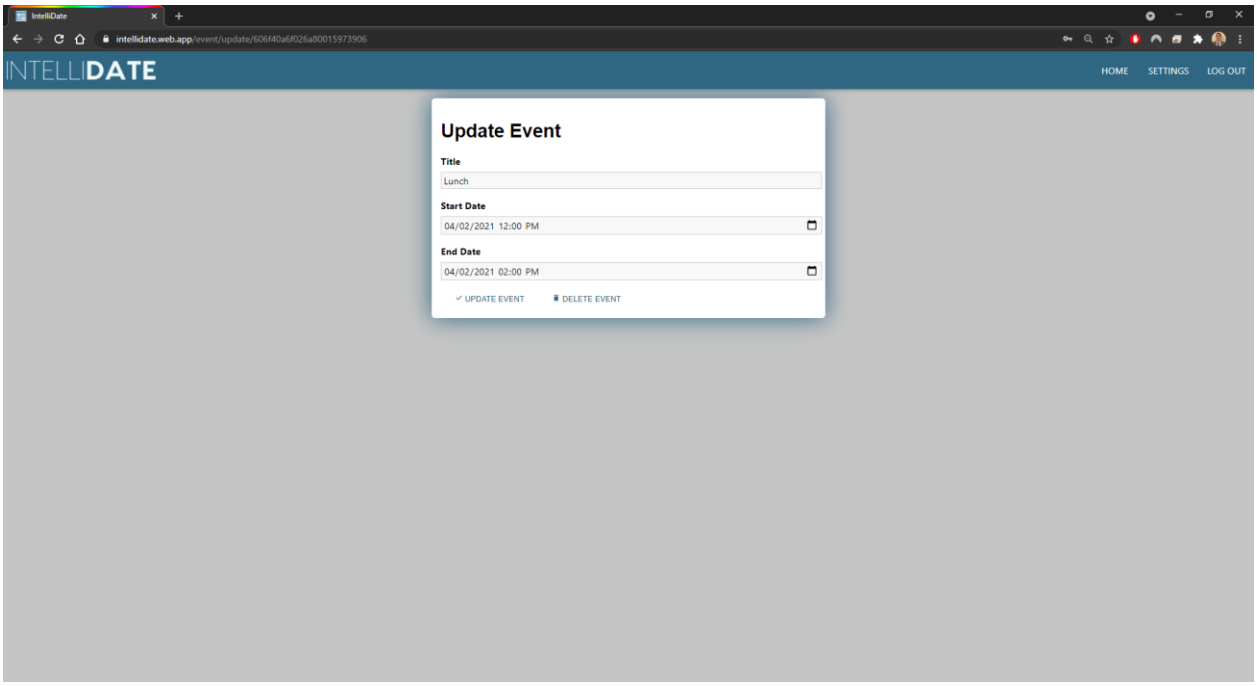


Figure 106: *Update/Delete Event*

7.1.2 Settings Screen

The Settings screen is where users can add a Panel to their account, remove a Panel from their account, and lock/unlock their panel. The Settings screen has two different displays, depending on whether the user has an attached Panel to their account. These views, along with the lock/unlock mechanism, is shown below:

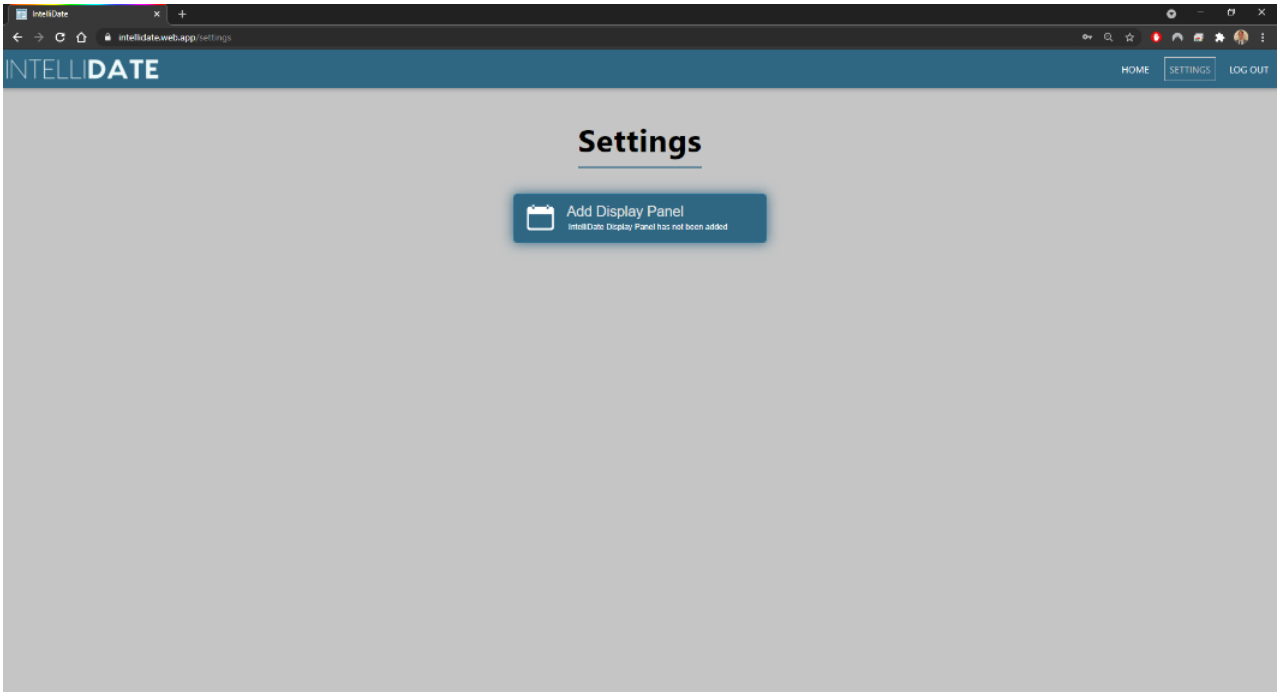


Figure 107: *Settings (without attached Panel)*

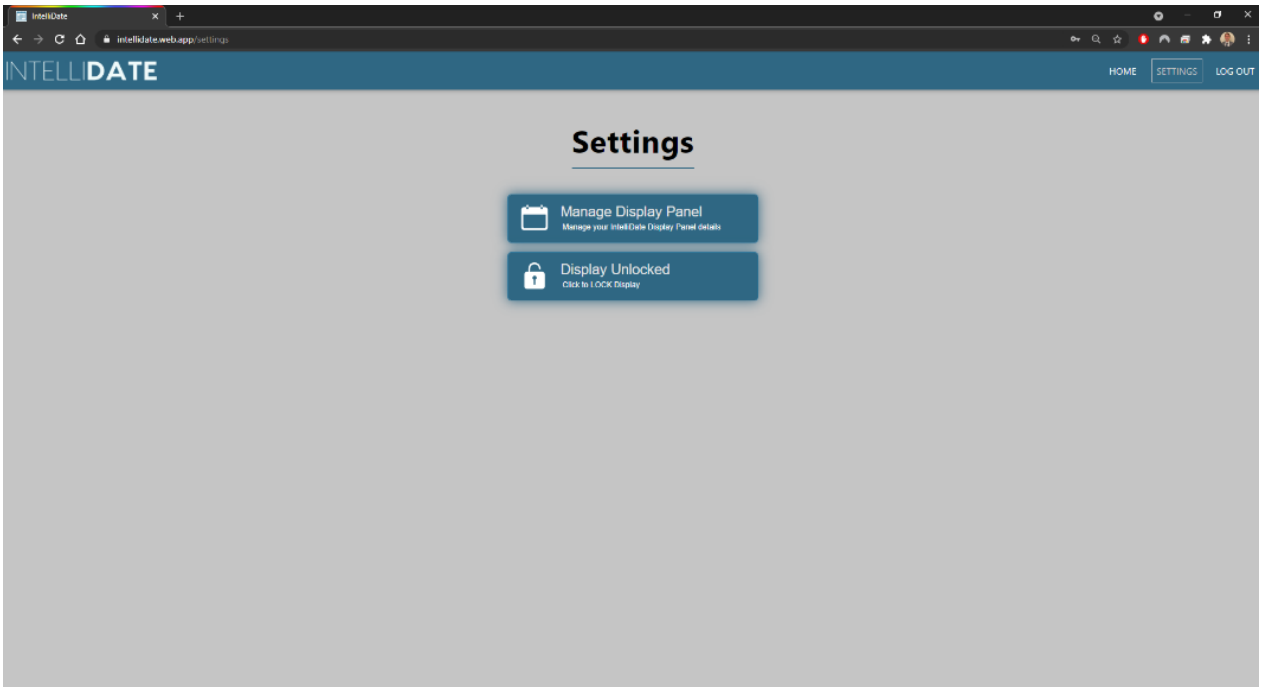


Figure 108: *Settings (with attached Panel - Unlocked)*

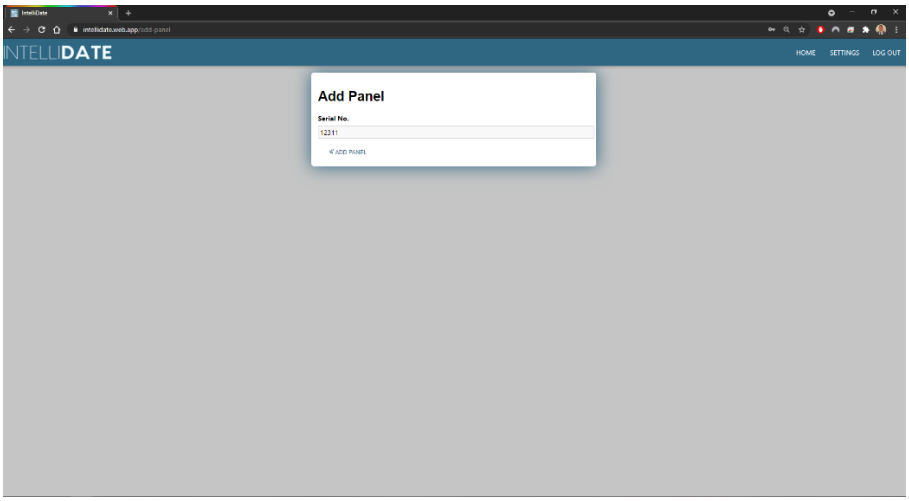


Figure 109: *Add Panel screen*

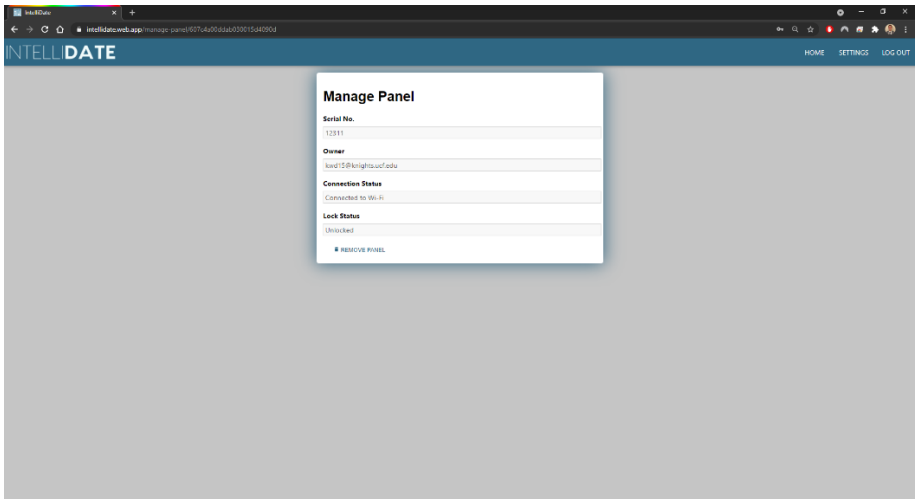


Figure 110: *Manage Panel (Unlocked)*

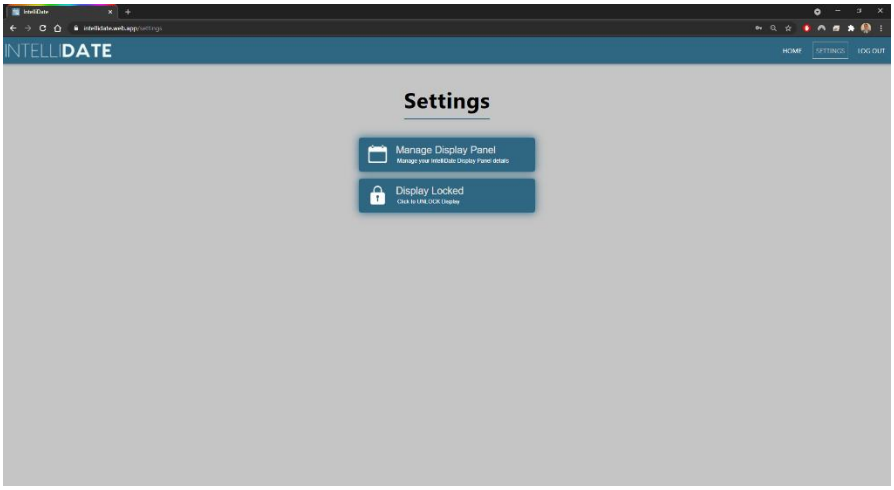


Figure 111: *Settings (with attached Panel - Locked)*

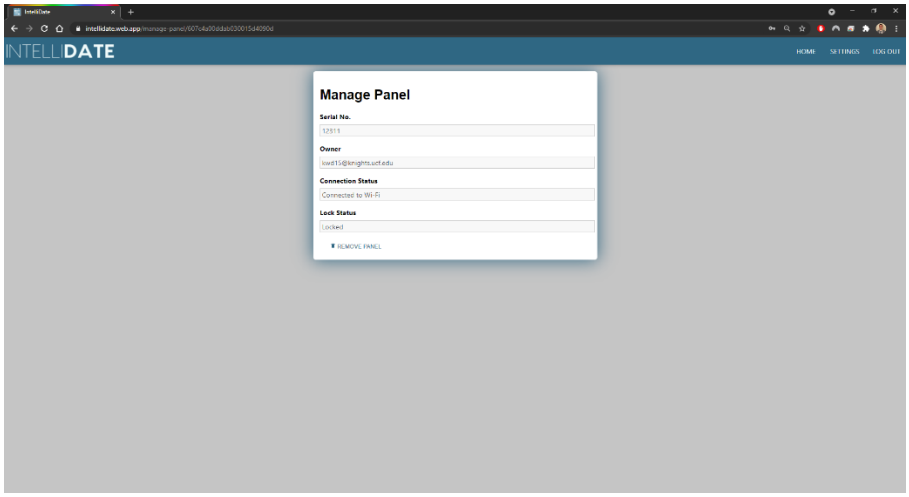


Figure 112: *Manage Panel (Locked)*

Figure 113: *MongoDB Panel Object (Unlocked)*

Figure 114: *MongoDB Panel Object (Locked)*

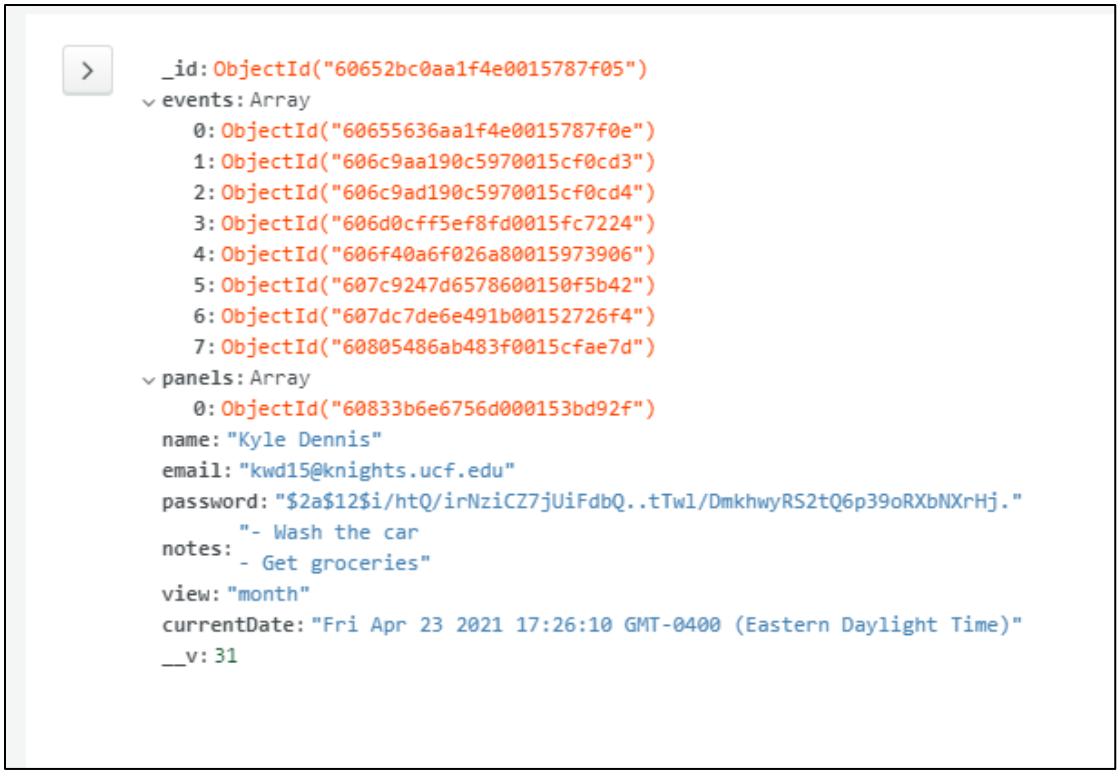


Figure 115: *MongoDB User Object*

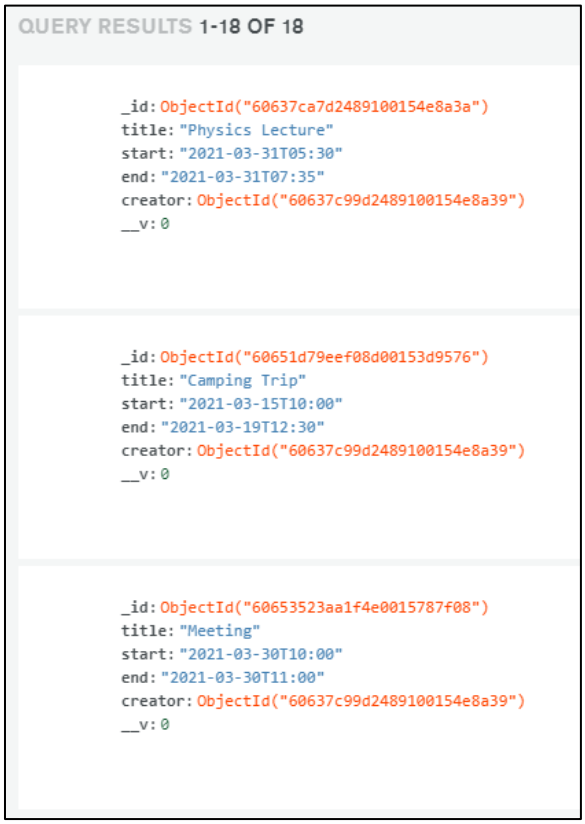


Figure 116: *MongoDB Event Objects*

7.2 Panel Application

The Panel consists of a Raspberry Pi connected to a computer monitor via HDMI connection. The Raspberry Pi continuously executes a desktop application, constructed with React.js and Electron.js. Electron.js is an external library that allows for JavaScript code to execute outside of the browser, effectively allowing JavaScript code to be utilized for a Native Desktop Application. The Panel Application looks very similar to the web application, but there are certain components that were left out, such as the Login Screen, page-navigation bar (Home, Settings, Log-Out), and all buttons that the user clicks on the web application to submit changes (e.g., CHANGE PANEL VIEW, CHANGE NOTES, etc.). The Panel Application also has additional pages that the web application does not have, including a ConnectHelp screen and a Locked screen. The ConnectHelp screen displays when the system is not connected to Wi-Fi. The ConnectHelp screen displays instructions for the user to connect their Panel to Wi-Fi and will be replaced with the Home screen when the Panel is successfully connected. The Lock screen replaces the Home screen whenever the Panel is Locked on the web application. The Panel application reads information from a local text file and updates its contents accordingly every second.


```
{"isLocked":"false","notes":"- Wash the car\n- Take out trash\n- Sweep
garage\n","view":"month","currentDate":"Tue Apr 06 2021 19:09:02 GMT+0000
(Coordinated Universal Time)","events":[{"_id":"60655636aa1f4e0015787f0e",
"title":"Physics Lecture","start":"2021-04-02T15:00",
"end":"2021-04-02T16:15","creator":"60652bc0aa1f4e0015787f05","__v":0,
"id":"60655636aa1f4e0015787f0e"},{"_id":"606c9a8490c5970015cf0cd2",
"title":"Board Meeting","start":"2021-04-02T10:00","end":"2021-04-02T11:00",
"creator":"60652bc0aa1f4e0015787f05","__v":0,
"id":"606c9a8490c5970015cf0cd2"},{"_id":"606c9aa190c5970015cf0cd3",
"title":"Gym Workout","start":"2021-04-02T17:00","end":"2021-04-02T18:00",
"creator":"60652bc0aa1f4e0015787f05","__v":0,
"id":"606c9aa190c5970015cf0cd3"},{"_id":"606c9ad190c5970015cf0cd4",
"title":"Camping Trip","start":"2021-04-03T10:30","end":"2021-04-04T18:30",
"creator":"60652bc0aa1f4e0015787f05","__v":0,
"id":"606c9ad190c5970015cf0cd4"}]}
```


Figure 117: *Example of local JSON text file contents*

7.3 Printed Circuit Board

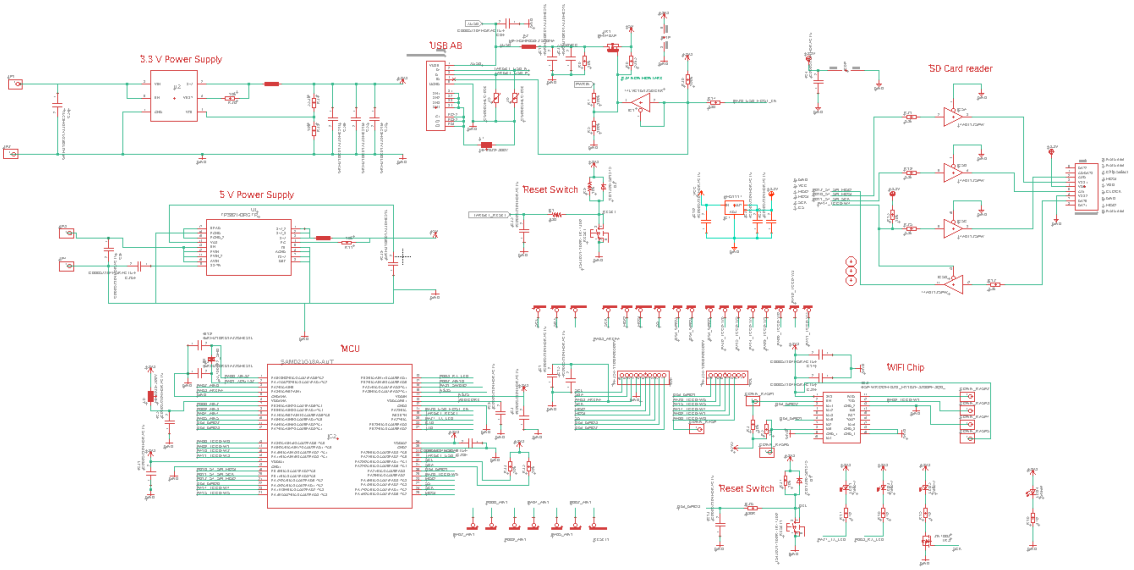


Figure 118: *Final PCB Schematic*

This is our initial schematic design for this project; we have a SAMD21 Chip connected to the ESP 8266 Wi-Fi module. Our thought was to have ESP request user data from the database, then the SAMD21 will pull that data from the Wi-Fi module and save it on the SD card. The information was then sent to the Raspberry Pi and displayed on the screen panel; however, as we are developing our protocol design, we realized that there were a lot of unnecessary circuits and components in our design. We had come to a most sufficient design that we needed for our project. The schematic of all the used components and circuit will be displayed below:

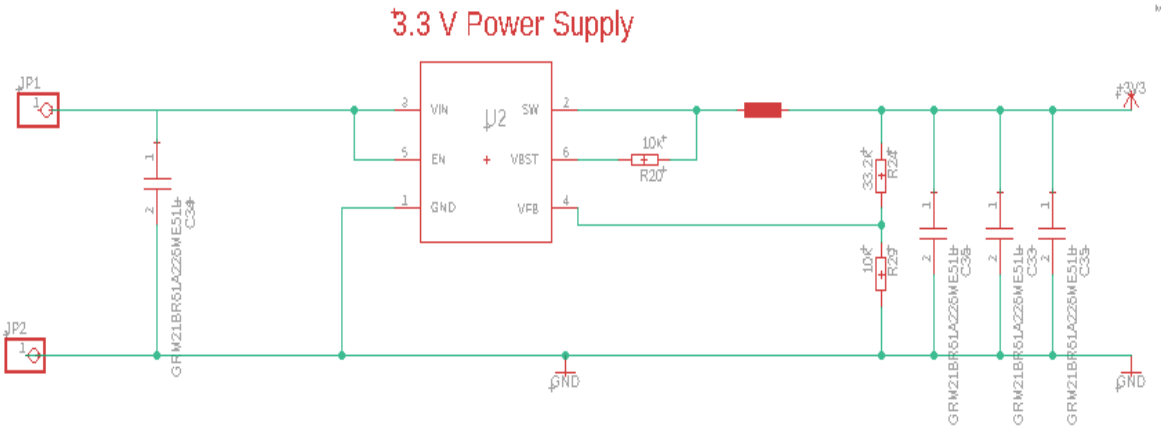


Figure 119: *Power Supply Schematic (3.3V)*

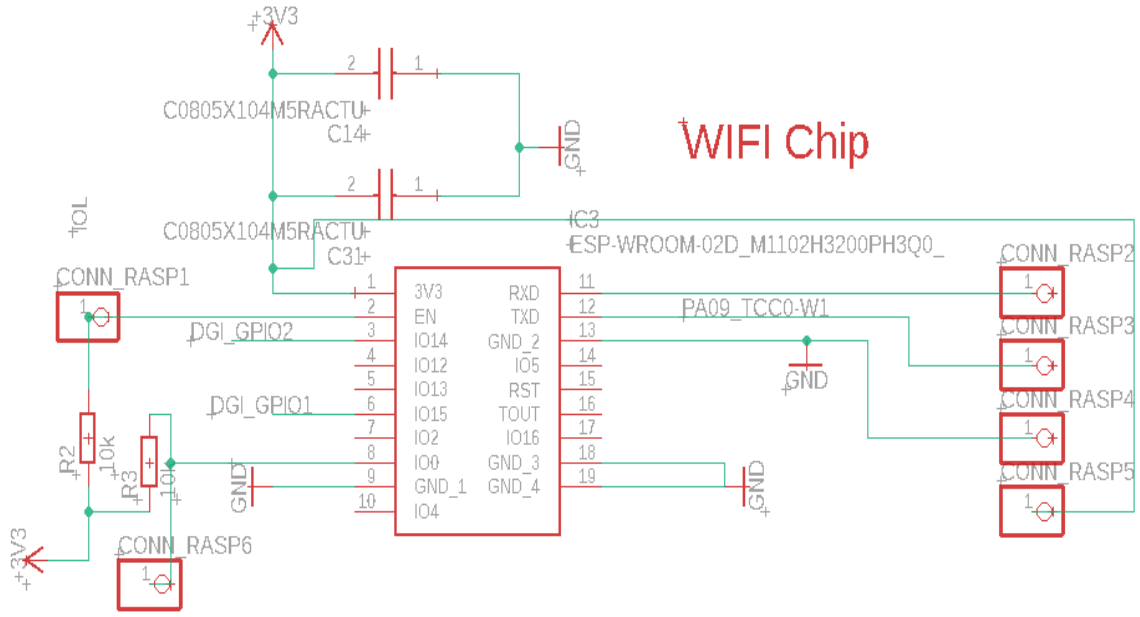


Figure 120: *ESP 8266 Schematic*

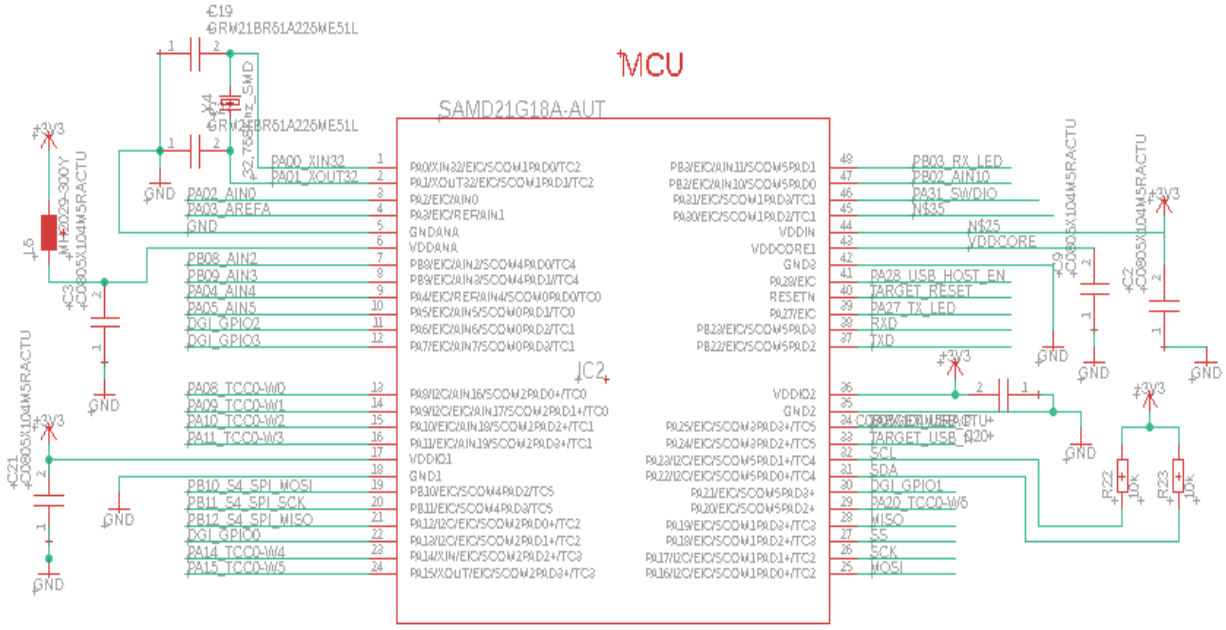


Figure 121: *SAMD21 Schematic*

Our design narrowed down into ESP 8266 Wi-Fi Module, SAMD21 chip and a 3.3V power supply due to the fact our ESP 8266 and SAMD21 use the same voltage supply 3.3V. The PCB we have on our final video included everything due to the time pressure and the delay shipment from Covid-19. Our group was not able to order a second design board. Therefore, we used the same first design PCB. The following image is a screenshot of our PCB layout design:

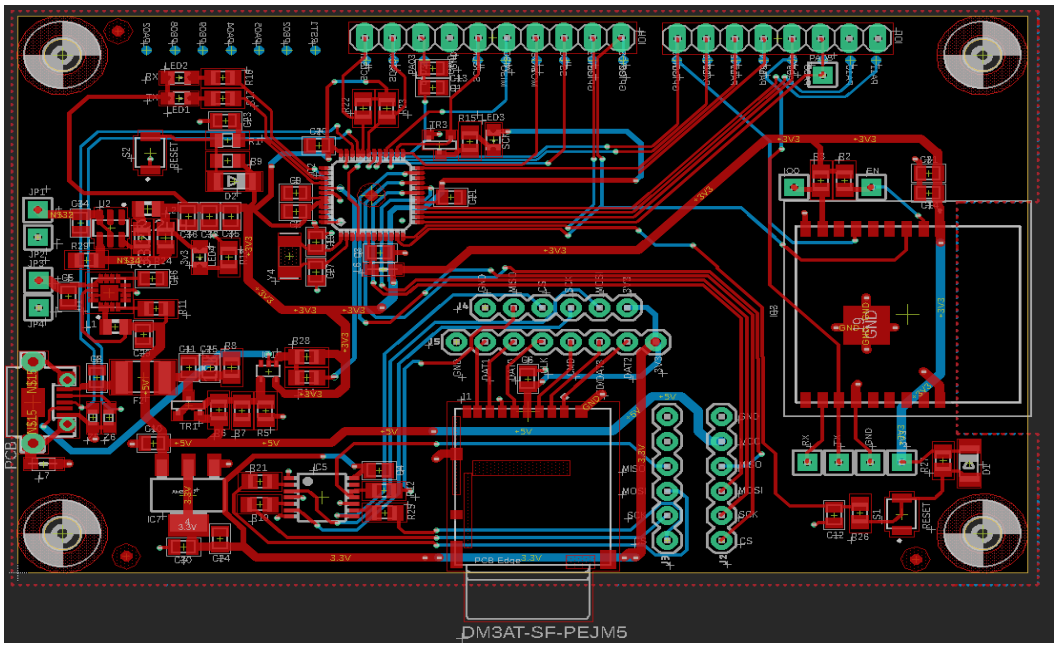


Figure 122: *PCB Layout*

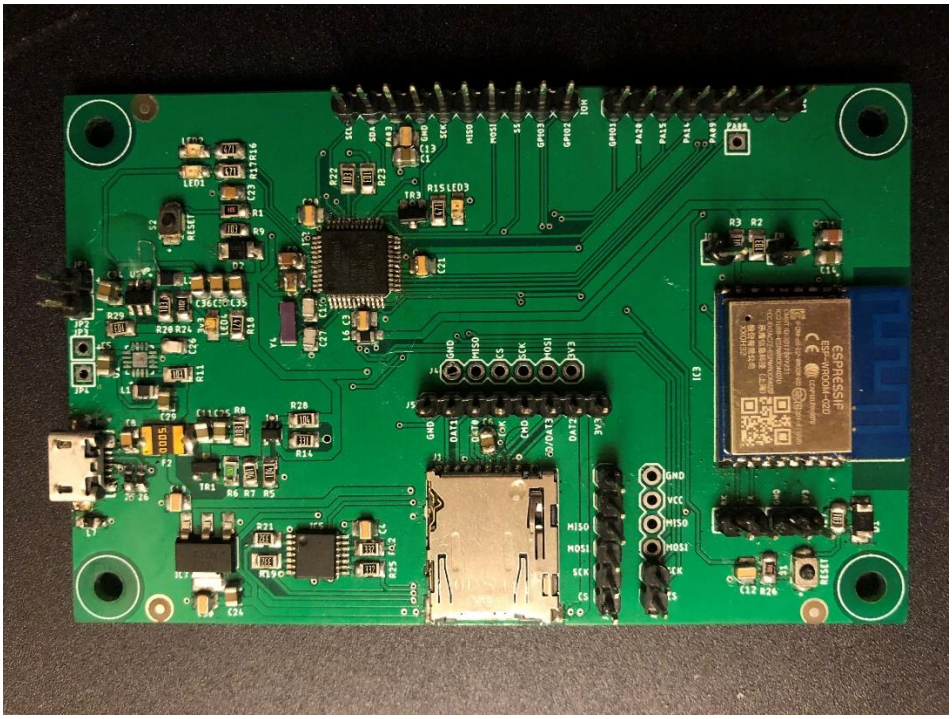


Figure 123: *Final PCB (Product)*

Viewing this PCB layout design, there were a lot of extra parts that we did not need for this project; however, due the time pressure as well as the difficulty of shipping time during the pandemic, our group was not able to design a new PCB to fit our project better. For future design, this PCB could be a lot cleaner where we could take the SD card and the 5V power supply of the chart.

7.4 System Enclosure

While developing our PCB, it was very essential to have an enclosure case for the PCB and the Raspberry Pi. After researching the material as well as the modern design of devices, we came to a conclusion of using clear acrylic case. Our case had dimensions of 2in H x 4in W x 5in L. The front and left side of the case has some cutout for ports connection and power supply. All devices generate heat while they are running; therefore, we incorporated a 5V fan on the top of our case to help the system cool down while they are operating.

Figure 124: *System Enclosure (Empty)*

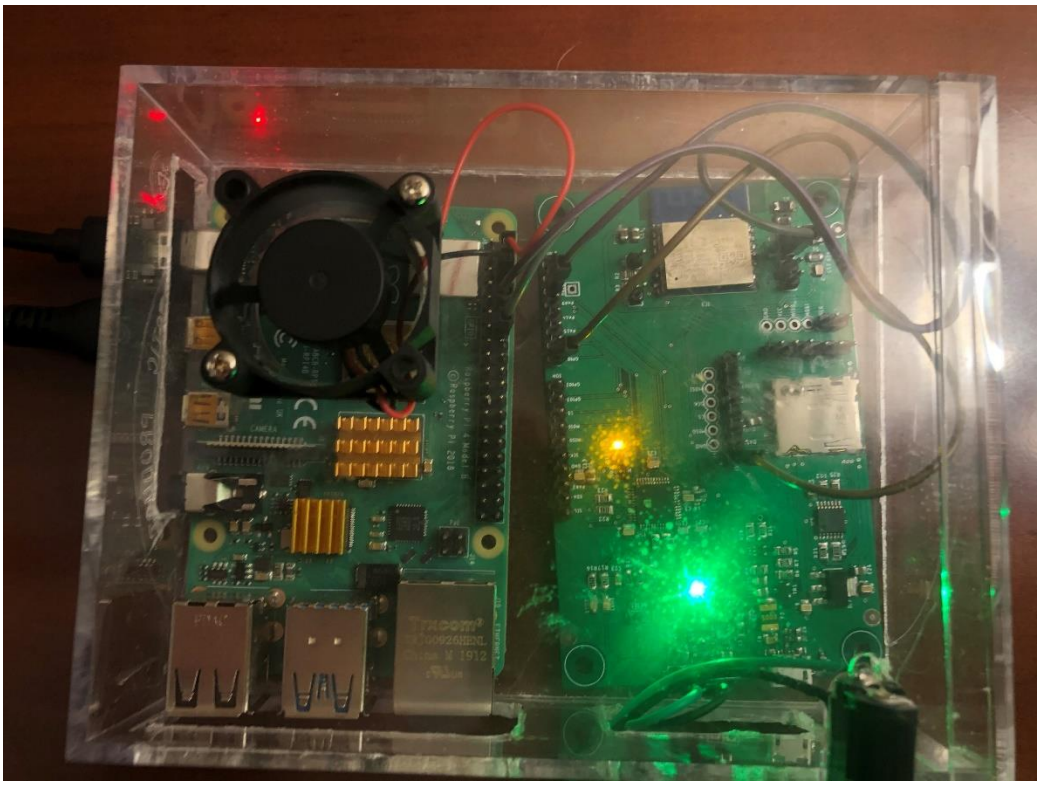


Figure 125: *Final System with Enclosure*

7.5 Conclusion

The IntelliDate project was a success, effectively combining a web application with a Raspberry Pi 4 and a custom PCB to deliver a digitally updateable calendar that a user can edit via a free-to-use web application.

Figure 126: *Final IntelliDate System*

One of the project's main goals was to remain low-cost, as the main competitor product has a market-cost of $399.95 with a $5.00/month service fee. As seen below, the total production cost for IntelliDate was $155.00.

Table 25: *Final IntelliDate Budget*

Item	Quantity	Price
Monitor	1	-
Printed Circuit Board	1	$20.00
Raspberry Pi 4	1	$40.00
PCB Components	82	$60.00
Arduino M0	1	$10.00
ESP8266	1	$10.00
System Enclosure	1	$15.00
Total Price		**$155.00**

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