ConCyle

Design Document

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Executive Summary

Development Standards & Practices Used

- Lithium Polymer battery - Common battery standard, easy to find schematics/ reference designs
- Molex - connector standard - Common plug type on batteries. Easily available
- Micro USB female receptacle- For connection of components
- Storage - SD card form factor
- I2C/I2S Communication Protocols - Common, well documented Communication standards
- IEEE 829 software documentation standard - Allows better communication, changeability and replicability/Better than nothing
- Tip Ring Sleeve 3.5mm audio jack - Standard size for audio output, for use with headphones or earbuds, ubiquitous

Summary of Requirements

- A colorful pixel-based display system
- A processing/compute subsystem that can handle 60 frames/second rendering of a 2D game with reasonable complexity
- A digital audio system for music and sound effects
- An onboard source of power
- A physical interface
- A method of playing multiple games on the device
- At least 3 games/applications to demo the capabilities of the device
- Hosted on a custom PCB(s)
- A custom enclosure

Applicable Courses from Iowa State University Curriculum

- EE 201: Intro to Circuits
- EE 230: Electronic Circuits
- EE 224: Signals and Systems I
- EE 330: Integrated Circuits
- EE 333: Electronic System Datasheet
- EE 451: Engineering Acoustics
- CprE 281: Digital Logic
- CprE 381: Computer Organization and Assembly Level Programming
- CprE 288: Embedded Systems
- ComS 309: Software Development Practices
- SE 329: Software Project Management
- SE 339: Software Architecture and Design

New Skills/Knowledge acquired that was not taught in courses

- Propeller Tool
- PropellerIDE
- Spin Programming Language
- PASM - Propeller Assembly
- Propeller Microcontroller
- MC34063A Step-up-step-down converter
- MCP4922 Digital to Analog Converter
- LM386 Audio Amplifier
- 74HC165 Parallel-to-Serial Register
- LD117-3v3
- Dual-Gang Resistive Slider
- 24FC512 Serial EEPROM
- Arduino Uno
- SD Card Interface
- SPI Communication Protocol
- FAT16 File System
- NHD-2.8-240320AF-CSXP-F LCD Display
- 3.5mm Headphone Jack with Switch
- SDL
- Game Design Documentation
- SP-1504 Circular Microspeaker
- SP-1511L-2 Rectangular Microspeaker

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1 Team

1.1 Team Members

- Stephen Brooks
- Brandon Xicon
- Julio Torres
- Brady Solomon
- Seth Braddock
- Mitchell Anderson
- Trey Wiegmann

1.2 Required Skill Sets for Your Project

- A colorful pixel-based display system
    - Low-level Embedded Programming
    - Oscilloscope Knowledge
- A processing/compute subsystem that can handle 60 frames/second rendering of a 2D game with reasonable complexity
    - 2D Graphics Expertise
    - Real-time Systems Expertise
- A digital audio system for music and sound effects
    - Audio Theory and Practice Domain Knowledge
    - Circuit Design
    - Frequency Analysis
    - Filter Analysis
    - Oscilloscope Knowledge
- An onboard source of power
    - Circuit Design Knowledge
    - Oscilloscope Knowledge
    - Multimeter Knowledge
    - Cursory Battery Chemistry Knowledge
- A physical interface
    - Ergonomics
    - Serial to Parallel Shift Converters
- A method of playing multiple games on the device
    - SD Card Specification Knowledge
    - SPI Communication Protocol Knowledge
    - Embedded Programming
    - Oscilloscope Knowledge
    - FAT16 File System Specification Knowledge
- At least 3 games/applications to demo the capabilities of the device
    - Game Development Knowledge
        - Map Implementation
        - Level Design

        - Ruleset Creation
    - Understanding of the Rules of Conway's Game of Life
    - Physics Knowledge
    - 2D Graphics Knowledge
    - Music and Audio Design
- Hosted on a custom PCB(s)
    - KiCAD Knowledge
    - PCB Layout Expertise
    - Survey-level Knowledge of PCB Manufacturers
- A custom enclosure
    - CAD Software Knowledge
    - 3D Printer Tuning
    - Ergonomics

1.3 Skill Sets covered by the Team

- Technical Lead
    - Steve
        - High-level programming
        - Low-level programming
        - Firmware development
        - Software optimization
        - Game development
            - Artificial intelligence
            - Animation
            - Physics
            - User Interface Design
            - Tool Creation
            - Game Design
        - Embedded Systems Design
        - PCB design
- Video Display Hardware and Drivers
    - Brandon
        - Embedded systems
        - Some Video Display Hardware Experience
    - Mitchell
        - High-level programming
        - Low-level programming
        - Embedded Systems programming
    - Trey
        - Hardware knowledge of small screens
    - Seth
        - Embedded systems programming
        - Low-level programming
- Power
    - Julio
        - Project experience
    - Trey
        - Battery/Charging projects and experience
- Audio
    - Julio

        - Circuit theory knowledge
        - Data converters circuit design
    - Seth
        - Audio knowledge
        - Circuit design
    - Trey
        - Audio hardware lover
        - Analog amplifier circuit design
- Physical interface
    - Brady
        - Raspberry Pi Projects
        - Robotics Experience
    - Julio
        - Arduino projects
- Game development
    - Brady
        - High-level programming
        - Software Development experience
        - Gamedev experience
    - Brandon
        - High-level programming
        - App development experience
        - Gamedev experience
    - Mitchell
        - High-level programming
        - Physics
    - Seth
        - High-level programming
        - Gamedev experience

1.4 Project Management Style Adopted by the team

AGILE is the management style best suited for this project's needs due to its iterative nature.

1.5 Initial Project Management Roles

- Seth - Communications Director
- Brandon and Brady - Report Managers
- Mitchell - Arbitrator
- Trey - Passive Collector Of Information
- Stephen Brooks - Facilitator
- Julio - Schedule Manager

2 Introduction

2.1 Problem Statement

Gaming is a $156 billion industry worldwide. People desire entertainment. Some of this entertainment takes the form of video games. Our console project provides a source of gaming entertainment. (The project also provides an educational opportunity for the members of the team.)

2.2 Requirements & Constraints

- **A colorful pixel-based display system with**
    - At least 128x128 pixel resolution
    - Color graphics (not grayscale or monochrome)
        - Can be implemented as indexed/palettized
        - No bit depth requirement
    - An update rate of 60 frames per second, minimum
        - Software may run slower or faster than this upper bound
    - *Optional*: No tearing
- **A processing/compute subsystem that can handle 60 frames/second rendering of a 2D game with reasonably complexity**
    - At least one smoothly-scrolling (1-pixel granularity) background layer
    - At least 64 on-screen objects (often called "sprites") of size 16x16
        - Positionable on screen with one-pixel granularity
        - Color keying/pixel transparency (not necessarily translucency/alpha-blending)
            - *Optional*: Alpha-blending
    - An alternative benchmark is a pixel fill rate of 32768 pixels per frame (at 60 Hz)
        - One background layer @128x128 plus 64 16x16 sprites = 16384 + 16384
    - *Optional*: 3D capability (not constrained to 60 FPS)
- **A digital audio system for music and sound effects**
    - Stereo output
    - At least 12 bits of precision per channel (left/right)
    - A playback sample rate of at least 32000 samples per second
    - Can hear the audio without requiring headphones
        - *Optional*: Headphone support
- **An onboard source of power**
    - Prefer rechargeable
- **A physical interface so the user can easily**
    - Turn the device on and off
    - Increase and decrease the audio volume between minimum (silent) and maximum
    - Indicate (to applications) information such as movement direction and commands
- **A method of playing multiple games on the device**
- **At least 3 games/applications to demo the capabilities of the device**
    - Conway's Game of Life plus at least two others
    - No specific operating system, programming language, or library/SDK required

- **Hosted on a custom PCB(s)**
- **Hopefully/probably a custom enclosure (Second semester/492)**
    - Comfortable in a range of hands
    - No bigger than a Nintendo Switch
    - Needs to be 4in tall x 9.4in wide x 1.55in deep
    - Less than 1 pound

2.3 Engineering Standards

What Engineering standards are likely to apply to your project? Some standards might be built into your requirements (Use 802.11 ac wifi standard) and many others might fall out of design. For each standard listed, also provide a brief justification.

- Lithium Polymer Battery Chemistry
    - Common battery standard
    - Easy to find schematics/reference designs
- Molex Connector
    - Common plug type on batteries
- Micro USB
    - Common Interconnect
- FAT16 File System
    - Most common file system on SD cards
- SPI Communication Protocol
    - Used by SD cards and many ICs
- IEEE 829 software documentation standard
    - Allows better communication, changeability, and replicability
- Tip Ring Sleeve 3.5mm audio jack
    - Common interconnect for audio

2.4 Intended Users and Uses

- Entertainment seekers, electronics enthusiasts, epic gamers, people seeking an escape or diversion or even a challenge.
- They will manipulate the device with their fingers and thumbs and receive audio and visual feedback.
- Users will boot up the device using battery power, enter a game cartridge, and play games on it.

3 Project Plan

3.1 Project Management/Tracking Procedures

We will use the AGILE project management style for this project. The continuous integration and iteration style of AGILE will help with completing the subsystems' goals. It also allows more communication between the client and the team. It gives us the option to make changes to the plans if necessary.

We will use Trello for project managing, and we will use GitHub to keep track of our code.

3.2 Task Decomposition

- **Display System**
  - Choose Display
  - Create Drivers
- **Audio System**
  - Choose DAC
  - Design Amplifier
  - Create Drivers
- **Power System**
  - Design power circuit
  - Choose battery
- **Physical Interface**
  - Input Control
  - Volume Control
- **Storage**
  - Read/Write SD card
  - Multiport Driver
- **Games/Applications**
  - Conway's Game of Life
  - RPG
  - Platformer
- **Custom Enclosure/PCB**
  - Working PCB with all subsystems
  - PCB fits in enclosure
- **Combine All Subsystems**
  - Games Demonstration

3.3 Project Proposed Milestones, Metrics, and Evaluation Criteria

- **Display System**
  - Breadboard Standalone Prototype of Display System

        - Accepts commands from microcontroller, culminating in visible, predictable colors
    - Driver Firmware
        - Software commands such as drawing shapes and rendering images are functional
- **Audio System**
    - Breadboard prototype of amplifier
        - Sufficient volume with low distortion
    - The above works with DAC
        - Plays back microcontroller-synthesized frequencies
- **Power System**
    - Prototype-PCB-based power circuit
        - Power system can meet current demands of entire system
- **Physical Interface**
    - Breadboard Standalone Prototype of Physical Interface System
        - Test program indicates that buttons are read correctly
- **Storage**
    - Breadboard Standalone Prototype of Storage System
        - SD card block reading and writing works
        - FAT16 file reading works
        - (Optional) FAT16 file writing works
- **Games/Applications**
    - Conway's Game of Life is complete
        - Operates following the standard rules of the game
    - Game One Design Document
        - Sufficiently describes game one so that it can be implemented
    - Game Two Design Document
        - Sufficiently describes game two so that it can be implemented
- **Custom Enclosure/PCB**
    - Working PCB with all subsystems integrated
        - Test software still works and power system meets the needs of the system
    - (Optional) Create an enclosure
        - Enclosure securely houses PCB and components

3.4 Project Timeline/Schedule

The individual subsystems will be done by the end of the semester with subtasks being done in the necessary order. The whole system will be integrated by the end of semester two.

https://docs.google.com/spreadsheets/d/1hGsoIBlMNJrxppIyBXG4lZxlZmiQB5Ko7s8y_kccG_M/edit?usp=sharing

ConCyle GANTT CHART

PROJECT TITLE: Concyle DATE: 10/6/21

WBS NUMBER	TASK TITLE	TASK OWNER	DURATION
1	**Display**		
1.1	Choose Display	Display Team	10
1.1.1	Create Drivers	Display Team	100
2	**Audio**		
2.1	Choose DAC	Audio Team	10
2.2	Design amplifier	Audio Team	25
2.3	Write Drivers	Audio Team	100
3	**Power**		
3.1	Design power circuit	Power Team	20
3.2	Choose battery	Power Team	15
4	**Physical interface**		
4.1	Input Control	Interface Team	15
4.2	Volume Control	Interface Team	20
5	**Storage**		
5.1	Read/write SD card	Storage Team	10
5.2	Multiport driver	Storage Team	30
6	**Games/Applications**		
6.1	Conway's Game of Life	Game Team	40
6.2	RPG	Game Team	40
6.2	Platformer	Game Team	20
7	**Custom Enclosure/PCB**		
7.1	Working PCB with all subsystems	Enclosure Team	2nd Semester
7.2	PCB fits in enclosure	Enclosure Team	2nd Semester
8	**Combine Subsystems**		
8.1	Games demonstration	All	2nd Semester

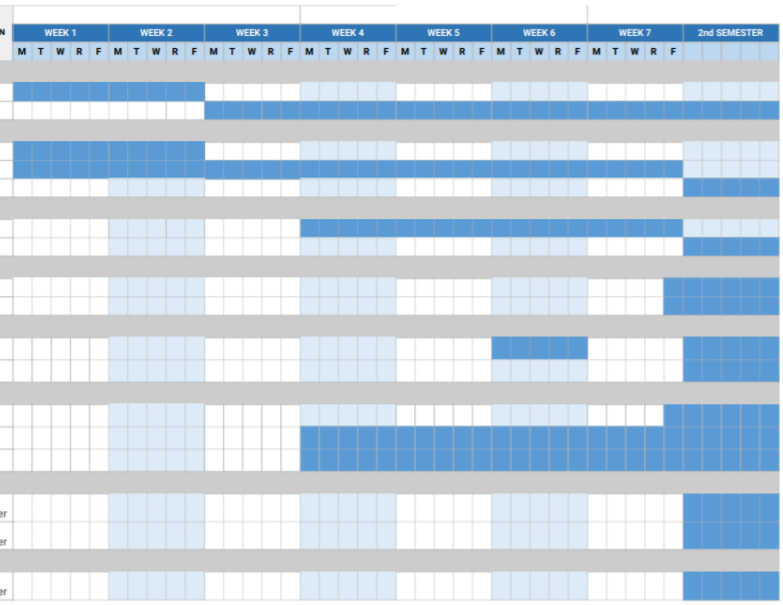

Figure 1. Project Gantt chart

3.5 Risks And Risk Management/Mitigation

- **Display**
  - Obtain Display
    - Shipping delays or stock issues 0.1
- **Audio**
  - Design Amplifier
    - Blow Speaker 0.01
- **Power**
  - Choose battery
    - Battery not in stock 0.1
  - Design power circuit
    - Shorting 0.01
- **Physical Interface**
  - Input Control
    - Can't figure out how to read 8 buttons from 8 I/O pins 0.05
- **Storage**
  - Multiport Driver
    - Too complex to complete before deadline 0.1
- **Games/applications**
  - Games have poor performance 0.01
- **Custom enclosure/PCB**
  - Working PCB with all subsystems
    - Shipping delays 0.1

    - PCB fits in enclosure
        - Run out of time 0.1
- **Combine all subsystems**
    - Games Demonstration
        - System does not work 0.001

3.6 Personnel Effort Requirements

Each task was estimated with the following person-hour count. Higher counts were devoted to high priority items such as the display drivers, power circuit, SD card driver, demo games, and final integration.

Task Name	Hours Required
Choose Display	20
Create display drivers	100
Choose DAC	10
Design amplifier	80
Create audio drivers	100
Decide on battery	30
Design power circuit	120
Input control	50
Volume control	50
Read/write SD card	20
Multiport driver	160
Conway's Game of Life	10
RPG	200
Platformer	200
Working PCB with all subsystems	100
PCB fits in enclosure	100
Games demonstration	100

3.7 Other Resource Requirements

- Part datasheets
  - LM386 Audio Amplifier
  - Propeller Microcontroller
  - MCP4922 Dual 12-bit DAC
  - MC34063A Step-Up/Step-Down Converter
  - NHD-2.8-240320AF-CSXP-F LCD Display
  - 24FC512 Serial EEPROM
  - 74HC165 Parallel-to-Serial Shift Register
  - SP-1504 Circular Microspeaker
  - SP-1511L-2 Rectangular Microspeaker
- Testing equipment
  - Oscilloscope
  - Multimeter
  - DC Power Supply
  - Function Generator
  - PC
  - Arduino Uno
  - USB Serial Port
  - Speakers
- Product testers
- Meeting space
  - Senior Design Classroom
  - TLA
  - Student Innovation Center
- Software Tools
  - PropellerIDE
  - PropellerTool
  - SimpleIDE
  - ArduinoIDE
  - Serial Terminal Emulator
  - KiCAD
  - SolidWorks
  - Graphics Drawing Program
  - Music and Audio Editing Software
- Other Documentation
  - SPI Communication Protocol
  - FAT16 File System
  - SDL Documentation
  - SDL Tutorials
  - Step-Up/Step-Down Converter Guide
  - Spin Language Reference
  - PASM Language Reference
  - LM386 Guides
  - Game Design Documents
  - Game Research

4 Design

4.1 Design Context

4.1.1 Broader Context

The project will address societal needs in the following ways:

- This product is designed to provide a safe and portable form of entertainment that exercises the mind, offers bonding experiences for friends and family members, prevents

delinquency, and relieves the user of stress. The product will be user friendly for all age groups.
- This project will use quality, long lasting components to promote the longevity of the system to keep them out of landfills.

Relevant considerations related to the project in each of the following areas:

Area	Description	Considerations
Public health, safety, and welfare	How does your project affect the general well-being of various stakeholder groups? These groups may be direct users or may be indirectly affected (e.g., solution is implemented in their communities)	Games will have a seizure warning at the beginning Reduce stress
Global, cultural, and social	How well does your project reflect the values, practices, and aims of the cultural groups it affects? Groups may include but are not limited to specific communities, nations, professions, workplaces, and ethnic cultures.	In our society, entertainment is highly valued, the gaming industry is an over 170 billion dollar industry Diverse set of game genres
Environmental	What environmental impact might your project have? This can include indirect effects, such as deforestation or unsustainable practices related to materials manufacture or procurement.	Encourage recycling Long product life cycle No planned obsolescence
Economic	What economic impact might your project have? This can include the financial viability of your product within your team or company, cost to consumers, or broader economic effects on communities, markets, nations, and other groups.	If we were to manufacture, our product would be affordable for consumers Long lifespan means consumers don't need multiple copies

4.1.2 User Needs

- Entertainment seekers and epic gamers need a way to entertain, distract, or challenge themselves because they are seeking entertainment.
- Electronics enthusiasts need a way to connect with technology because they enjoy novel devices and creative uses for technology.

4.1.3 Prior Work/Solutions

The following are examples of similar products to the ConCyle. This section discusses their advantages and shortcomings.

There is a DIY Raspberry Pi Zero handheld gaming console on Instructables.com. The creator used an old GameBoy Advance case to house the Pi, power circuit, display, and other components. This project has a similar end goal to ours, although the Pi is significantly more advanced than our MCU.

Reference: https://www.instructables.com/DIY-Raspberry-Pi-Zero-Handheld-Game-Console

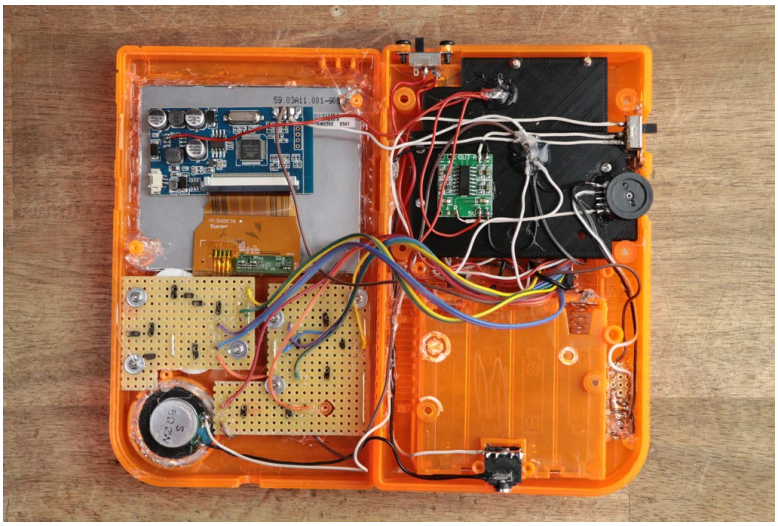

Figure 2. Raspberry Pi GameBoy Console

Another Instructables project does a similar job to the one above with more in-depth peripheral circuitry, also using a Raspberry Pi. This is an example of a very polished product we would aspire to be like with our project.

Reference: https://www.instructables.com/Homemade-Game-Console-NinTIMdo-RP/

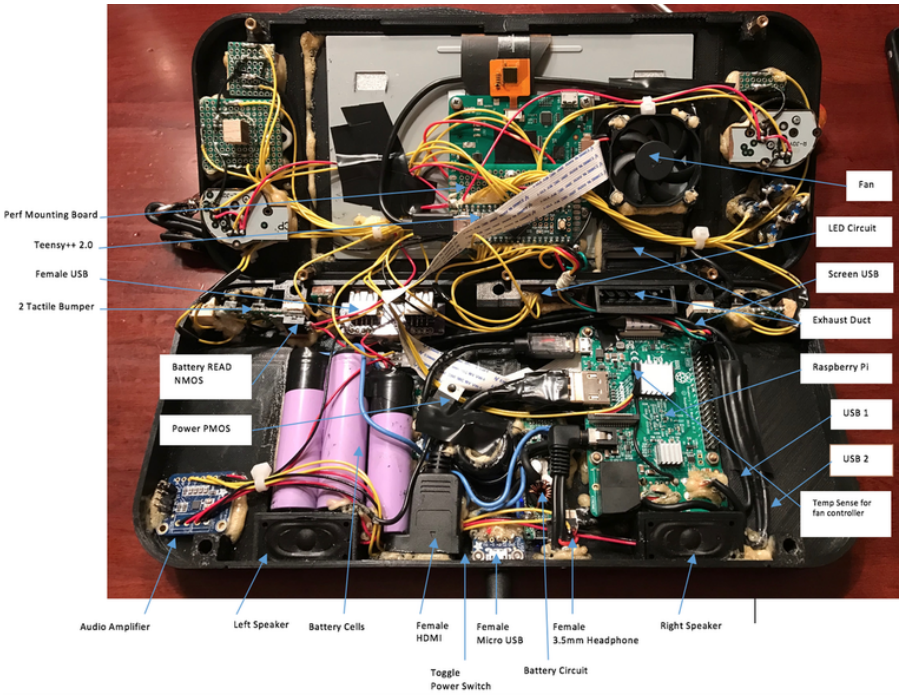

Figure 3. Raspberry Pi Nintendo Switch Clone

4.1.4 Technical Complexity

Provide evidence that your project is of sufficient technical complexity. Use the following metric or argue for one of your own. Justify your statements (e.g., list the components/subsystems and describe the applicable scientific, mathematical, or engineering principles)

1. The design consists of multiple components/subsystems that each utilize distinct scientific, mathematical, or engineering principles –AND–
2. The problem scope contains multiple challenging requirements that match or exceed current solutions or industry standards.

The project has multiple subsystems, each requiring different engineering principles:

- **Display system**
  - Requires software of sufficient complexity to interface with a multicolor graphical display
- **Digital audio system**
  - Circuit Design
  - Firmware Driver
  - Digital Audio Manipulation and Creation
- **Power system**
  - Circuit Design
  - Voltage Regulation
  - Energy Demand Requirements
  - Power Filtering
- **Physical interface**
  - Input Button Multiplexing
  - Parallel-to-Serial Converter
  - Potentiometer Volume Control
- **Storage medium**
  - SD Card Firmware
  - Multi-Read/Write Ports in Driver
- **Games/applications**
  - Game Physics
  - Human Visual System Concepts
  - Artificial Intelligence
- **Custom enclosure/PCB**
  - 3D printing Technology-Fused Deposition Modeling
  - CAD Tools
  - Ergonomic

4.2 Design Exploration

4.2.1 Design Decisions

The following components have been chosen:

- Microcontroller

    - Parallax Propeller 1
- DAC
    - MCP4922 Dual 12-bit DAC
- Display
    - NHD-2.8-240320AF-CSXP-F LCD Display
- Types of Games
    - RPG
    - Platformer

4.2.2 Ideation

For the brain of the console we had to first decide on a microcontroller or FPGA and decided on a microcontroller due to supply issues and financial constraints. From there, we conducted internet research and brainstormed options such as Propeller 1, Propeller 2, Raspberry Pi, Arduino, ESP32. The Propeller 1 emerged as the most attractive choice based on knowledge, price, and usability.

4.2.3 Decision-Making and Trade-Off

In order to make a decision, we used tournament style comparison between options using price as the chief criterion - We chose the propeller 1 because it was the best value that was desired and has 8 cores for our usage.

4.3 Proposed Design

Progress that has been made so far includes:

- **General**
    - Dev kits have been created with our chosen microcontroller (Propellor 1)
- **Display**
    - LCD has been breadboarded
    - Driver has been started
- **Audio**
    - Amplifier Circuit has been breadboarded
    - DAC has been tested
    - Multiple Speakers have been tested with the Amplifier
- **Power**
    - Potential Circuit Diagram has been created
- **Physical Interface**
    - Block Diagram has been created
- **Storage**
    - SD Card driver has been created
    - Experimental FAT16 Driver has been created
- **Games/applications**
    - PC Implementation of Conway's Game of Life has been completed

4.3.1 Design Visual and Description

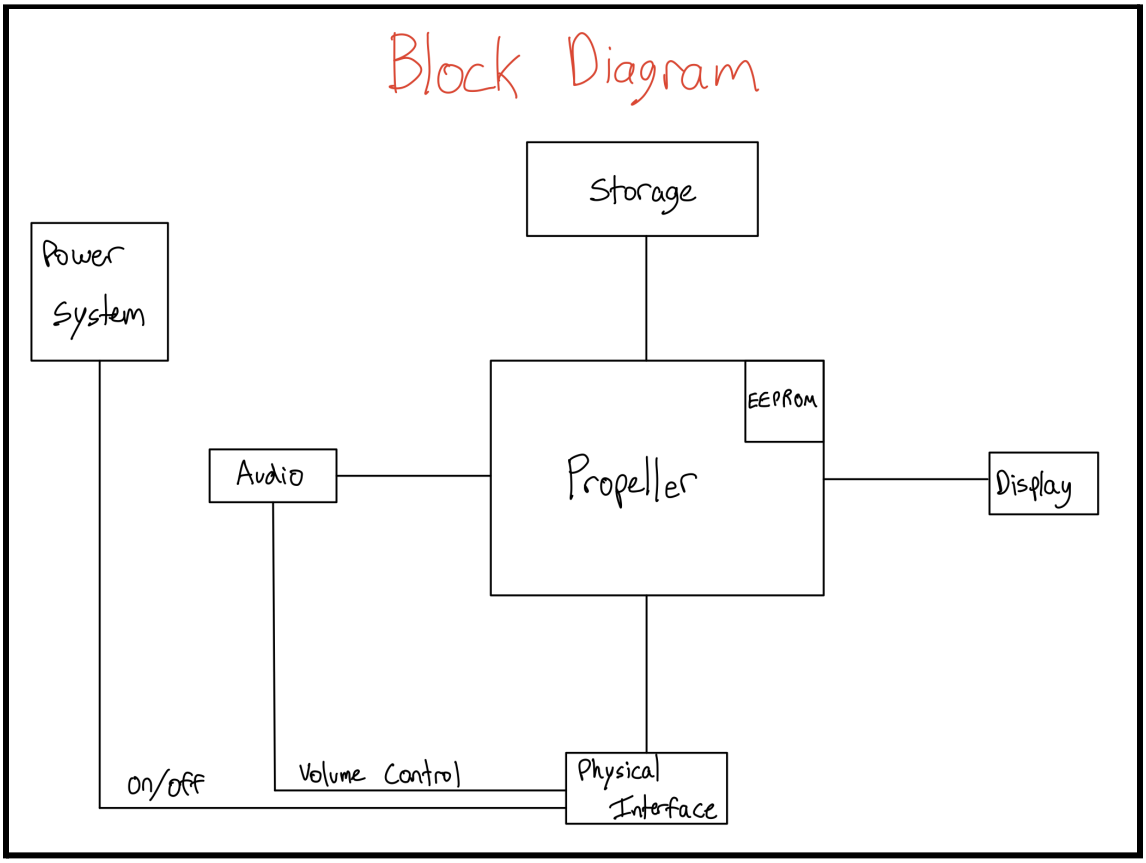

Figure 4. Block diagram overview of design

Our propeller has 8 cores, each will be dedicated to a subsection of the console and holding memory in EEPROM when needed. Storage will be implemented with reading SD cards as our game cartridges, We will read the SD cards to display the game. Display and audio will be connected to the propeller as well as other I/O to control all things needed for the console such as powering the system on, adjusting audio, and playing the different games that are read through the SD.

4.3.2 Functionality

Our design is intended to be operated in both hands of the user and be able to withstand standard stress due to daily use. It is intended to be able to be viewed at a safe distance from the user's eyes and comfortable for the hands and arms with dimensions of around 4inx9.4in x 1.55in and weighing less than 1 pound. Our design will be able to support multiple games on cartridges to give diversity to the type of gamers using our console.

Our design satisfies all functional and non-functional requirements given by our client as shown in our visual and description as well as described in Requirements assignment.

4.3.3 Areas of Concern and Development

Primary concerns we might have are deadlines for individual tasks.

Developing contingencies for risks. For example, we are taking a two stage approach to part selection. We choose a simpler device for a task, learn to interface with it, and when we have mastered it, see if we have enough time to choose a more complicated part.

4.4 Technology Considerations

The following are the strengths and weaknesses of chosen components as well as potential alternatives:

- Propeller
    - Strengths
        - 8 cores
        - 32-bit
        - Ease of use
        - Available
    - Weaknesses
        - No multiplying instruction
        - Language associated (Spin) not mature
    - Alternative
        - 65C02
- LCD
    - Strengths
        - Onboard power circuit
        - Utilizes a relatively small number of pins (13)
        - Communication protocol is simple
        - Available
    - Weaknesses
        - Small size (2.8 inches)
        - Relatively low resolution (240x320)
    - Alternative
        - NHD-3.5-320240MF-ATXL#-1 (3.5 inches, 320x240)
- DAC
    - Strengths
        - Only requires 3 pins
        - Power supply voltage same as Propeller
    - Weaknesses
        - Only a 12-bit resolution
    - Alternative

        - CS4344 (24-bit DAC)
- LM386
    - Strengths
        - Gain is adjustable
        - 20 - 200 gain
    - Weaknesses
        - Requires 9V for the application
    - Alternative
        - LM4889 (1W audio amp)

4.5 Design Analysis

Since the design is to be finalized in the second semester, before final implementation on a PCB. Analysis can be conducted at that time.

4.6 Design Plan

In order to make a portable device, we will devise a power system with a battery-based solution. Furthermore, to help reduce environmental waste, we will use rechargeable options. The weight of the battery must be sufficiently small so as to achieve comfortable gripping, toting, and manipulation. The battery should be contained within the device, as opposed to a cumbersome, perhaps wearable, external battery pack tethered to the unit via power cabling. Power system design is to be completed in the second semester.

In order to make a usable device, in addition to the above section on the battery, we will endeavor to choose a readable display, speakers with acceptable fidelity, comfortable and accurate input controls, and standard charging option(s).

The display team has been prototyping with an IPS-rated 2.8" LCD. This display is backlit with high-brightness LEDs and has a very wide viewing angle. The display (240x320, 18-bit RGB color) also meets the requirement for a colorful display system with a pixel resolution equal to or greater than 128x128.

The audio team has started to test candidates for the onboard speakers. Three models have been acquired for testing, two round varieties and one square form factor (as may be found in a cell phone). Evaluation continues in the second semester.

Physical input such as buttons and switches must be comfortable and sturdy. Most off-the-shelf products meet these criteria. Although we have a block diagram, actual design of the physical input system is to be completed in the second semester.

Returning to the topic of power, the charging solution should be one familiar with the user. We have preliminarily chosen the ubiquitous micro USB port as our solution. Completion of the power system is to be completed in the second semester.

5 Testing

Testing our system involves testing each subsystem alone and then integrated with the microcontroller. The overview of the testing strategy involves testing often to ensure compliance with requirements. In our project, many tests will be conducted by a user as opposed to an instrument. Our project involves many subjective testing decisions. Software testing for our project is affected by the fact that the main language of our software is the proprietary spin programming language for our microcontroller.

5.1 Unit Testing

Unit testing software components will occur in the second semester.

5.2 Interface Testing

Interfaces in the design will include software drivers and the application logic. Interface testing will occur in the second semester.

5.3 Integration Testing

What are the critical integration paths in your design? Justification for criticality may come from your requirements. How will they be tested? Tools?

The critical integration paths are shown below. These will be tested by play testers through games/applications..

- Microcontroller to
    - Display
    - Power
    - Audio
    - Storage
    - I/O

This testing topology represents a separable strategy to avoid exponential growth of test cases.

5.4 System Testing

For the project, section 5.3 describes system testing due to the modularity of the project.

5.5 Regression Testing

We will implement a regression test for game software in the second semester. We don't know what critical features that will need to be implemented yet to make sure it doesn't break. This regression testing is not driven by requirements *per se*. It is not yet known what tools will be required.

5.6 Acceptance Testing

We will submit schematics to the client for acceptance. The client will have access to physical hardware.

To demonstrate that the project meets the 12 bit DAC requirements, we will refer the client to the data sheet for our chosen DAC.

To demonstrate that the project meets the 32kHz sample rate requirement,we will refer the client to our documented audio driver software.

The client will have access to game/demo source code.

To demonstrate that the project meets the requirements for a scrolling background and finely positionable objects, we will submit a game that demonstrates these features.

5.7 Results

The results of unit testing are measured on a pass/fail basis. These results show compliance with the requirements by indicating if these units are working or not. When the results indicate the unit is not working, we will make it work.

Our methods for performing interface testing will develop in the second semester.

The results of integration and system testing will ensure the subsystems are able to function cohesively. When all systems work together, the project is closer to meeting the requirements.

Regression testing results will indicate if we have broken a unit during development. When regression testing indicates that a unit no longer functions properly, we will restore functionality. This methodology will ensure that we meet requirements.

The client will give us feedback during the acceptance testing phase if the client is dissatisfied with any aspect of the project, we will correct the issue.

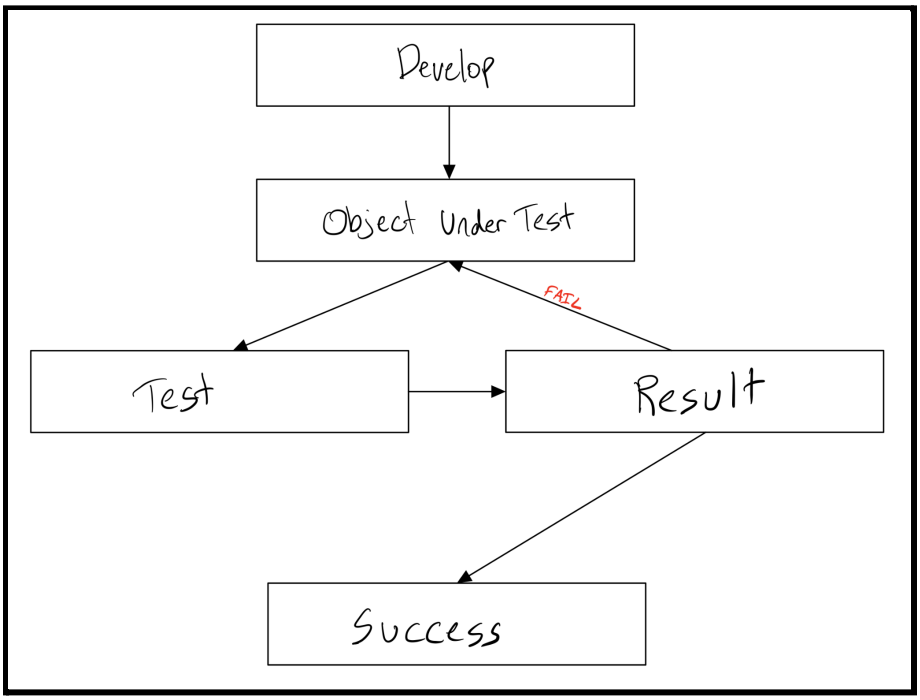

Figure 5. General Testing Flowchart

6 Implementation

Next semester we will integrate all hardware systems (display, audio, storage, power, I/O). Application and software development will begin in earnest in the second semester. With all hardware systems together, the power system can be completed. If time and resources permit, a custom enclosure will be created to house the product.

7 Professionalism

This discussion is with respect to the paper titled "Contextualizing Professionalism in Capstone Projects Using the IDEALS Professional Responsibility Assessment", *International Journal of Engineering Education* Vol. 28, No. 2, pp. 416–424, 2012

7.1 Areas of Responsibility

Our team abides by the IEEE code of ethics. The table below addresses each of the areas of seven professional responsibilities.

Area of Responsibility	IEEE Code of Ethics Relation	Difference from NSPE
Work Competence	Section six indicates a commitment to improve ourselves as engineers and to only offer our services if qualified.	There is no significant difference in the code for this area.
Financial Responsibility	Section four states that bribery should be rejected in all forms, and section three states that claims (such as monetary) should be realistic based on available data.	The IEEE code only emphasizes that engineers shall reject bribery. The NSPE is more specific about engineers not accepting or offering bribes for influence or job opportunities.
Communication Honesty	Section three is a commitment to honesty in stating claims and data-based estimates, and section seven is a commitment to making our collective work as engineers high quality.	NSPE states that engineers are expected to exhibit the highest standards of honesty and integrity which aligns with the IEEE code. The NSPE does give more examples such as they must advise when they believe a project is not successful.
Health, Safety, Well-Being	Section one is a direct commitment to accepting responsibility in making decisions concerning public safety, health, and welfare.	There is no significant difference in the code for this area.
Property Ownership	Section nine specifies that damaging others' property through malicious action is to be avoided.	The NSPE code describes more that the designs given by the client are property of the client and not of the engineer and the engineers' designs referring exclusively to the employer's work are the employer's property. Showing that the NSPE code shows more of the property ownership than the IEEE code.
Sustainability	Section one states that we should accept our responsibility for the actions we make.	The NSPE goes into more detail that the project should show the challenge of meeting human needs for natural resources, industrial products, energy, etc. while conserving and protecting environmental

		quality.
Social Responsibility	Section eight states to treat all persons fairly and not discriminate based on social aspects such as race and religion.	The NSPE does not go as in depth on the social responsibility based on race, religion, sexual orientation etc. as the IEEE standards do. Just noting down to be ethical.

7.2 Project Specific Professional Responsibility Areas

The following table emphasizes how the project's professional context applies to the professional responsibility areas in the previous table and how the team is performing in each area.

Area of Responsibility
Work Competence ● This area applies to our project because we all have to learn new skills and knowledge to meet the project requirements. ● Our team is performing HIGH in this area: we are each learning about our project areas and contributing to the final product.
Financial Responsibility ● Our project doesn't have any financial constraints, so this category is N/A.
Communication Honesty ● Our team has been advised to come to the client with any concerns. ● Our team has been advised to seek parlay with the team TA or advisor if they do not feel comfortable with public redress or with interfacing individually with a party with which there is dispute. ● Therefore our team is performing HIGH in this category.
Health, Safety, Well-Being ● This applies to our team because it's important for the team members to feel safe with each other so we can collaborate as a unit and perform at our best. ● Our team is performing HIGH in this area. Everyone accepts and respects each other's opinion.
Property Ownership ● This applies because team members have dev kits that they are responsible for and often interact with other team members' dev kits and must treat them with care. ● Our team is performing HIGH in this area; no dev kits or other hardware have been damaged or mishandled

Sustainability • This applies to our project because we will be using rechargeable batteries in our product to eliminate battery waste and we will use recycled filament to create the case for the product. • Our team is performing HIGH in this area because we have not produced any waste and have plans to keep future waste as low as possible.
Social Responsibility • This applies to our project because we do not want to have any games that promote discrimination on our console. • Our team is performing HIGH in this area as we are making sure any software on the console takes into consideration for social aspects.

7.3 Most Applicable Professional Responsibility Area

Our team has selected 'Work Competence' as our specific area. As indicated above, we perform HIGHly in this category.

In order to complete our project, each team member must display workplace competence in that he must one, increase his skill set; two, attain domain knowledge.

Members of hardware-related subteams have read datasheets to extract interface information for different ICs and electronic components. The display and audio teams have increased their microcontroller coding skills by creating microcontroller code that interfaces to an LCD or DAC. The audio and power teams have been researching voltage converters, amplifiers, and DACs via datasheet information to pick the most-suitable components for the project and are increasing their skills with new circuit designs topologies. The game development team is increasing their knowledge of object physics, graphics and animation, and game logic/rule sets.

These skill and knowledge enhancements will allow us to complete the project effectively.

8 Closing Material

8.1 Discussion

The project is still in progress so there are no main results. The project is to be completed in the second semester.

8.2 Conclusion

We have subsystem prototypes in various stages of development. We were initially slow to start, in part due to a two-week shipping time on our first order. Subsequent orders have been timely and we are progressing well. At times it is difficult to coordinate seven busy students, but we have

persevered. The team seems to be on track for successfully completing the project next semester. Whether or not we complete an enclosure is TBD.

(See section 4.3 for progress thus far.)

8.3 References (IEEE style)

Martin, J., 2021. Propeller Manual v1.2. p.17.

New Haven Display International,, "IPS TFT Liquid Crystal Display Module" NHD-2.8-240320AF-CSXP-F datasheet, Jan. 2019 [Revised Dec. 2019].

How to use MMC/SDC. Available: http://elm-chan.org/docs/mmc/mmc_e.html

About SPI. Available: http://elm-chan.org/docs/spi_e.html

FAT16 File System. Available: http://www.maverick-os.dk/FileSystemFormats/FAT16_FileSystem.html

FAT File Systems. FAT32, FAT16, FAT12. Available: http://ntfs.com/fat_systems.htm

8.4 Appendices

Any additional information that would be helpful to the evaluation of your design document.

If you have any large graphs, tables, or similar data that does not directly pertain to the problem but helps support it, include it here. This would also be a good area to include hardware/software manuals used. May include CAD files, circuit schematics, layout etc,. PCB testing issues etc., Software bugs etc.

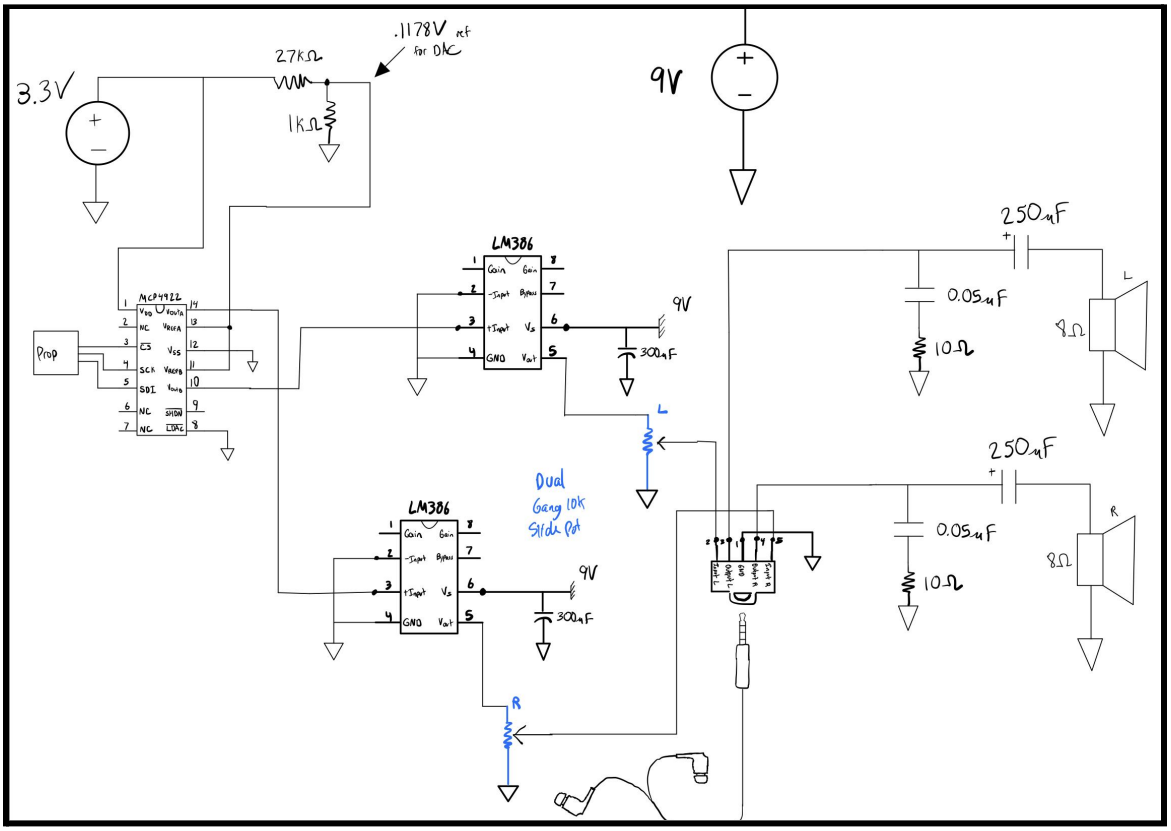

Figure 6. Audio Amplifier Schematic

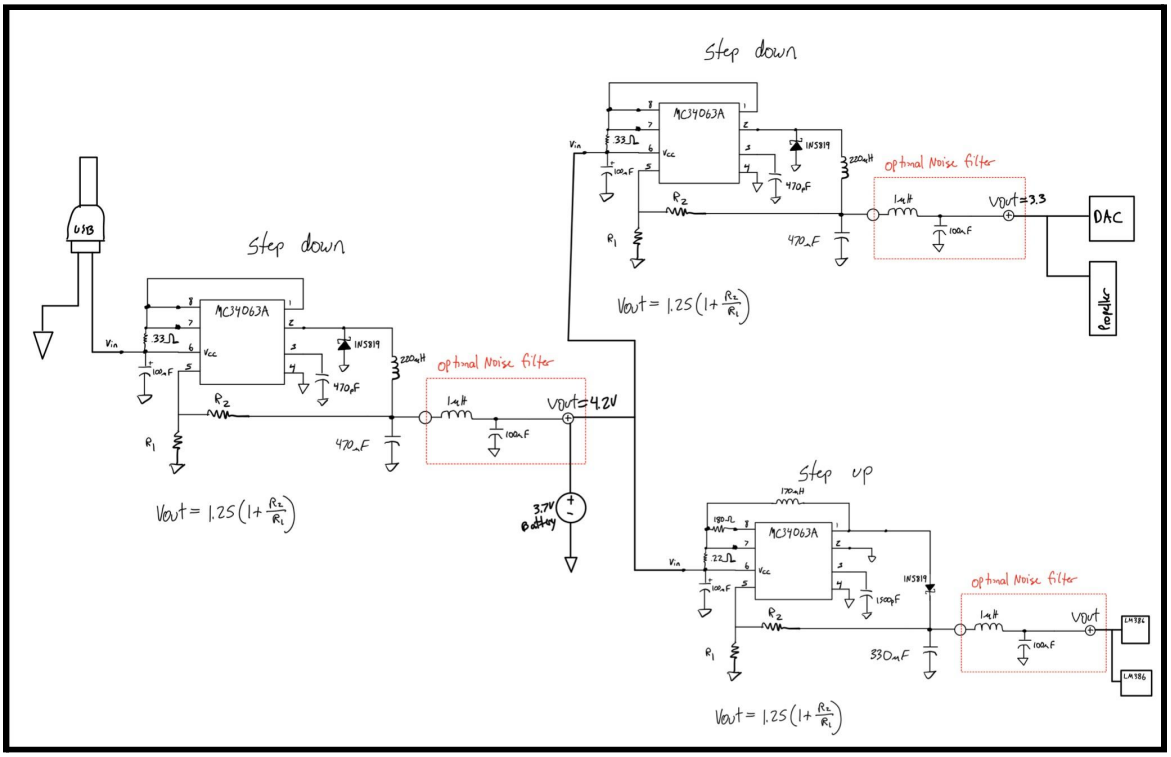

Figure 7. Power Busses Schematic

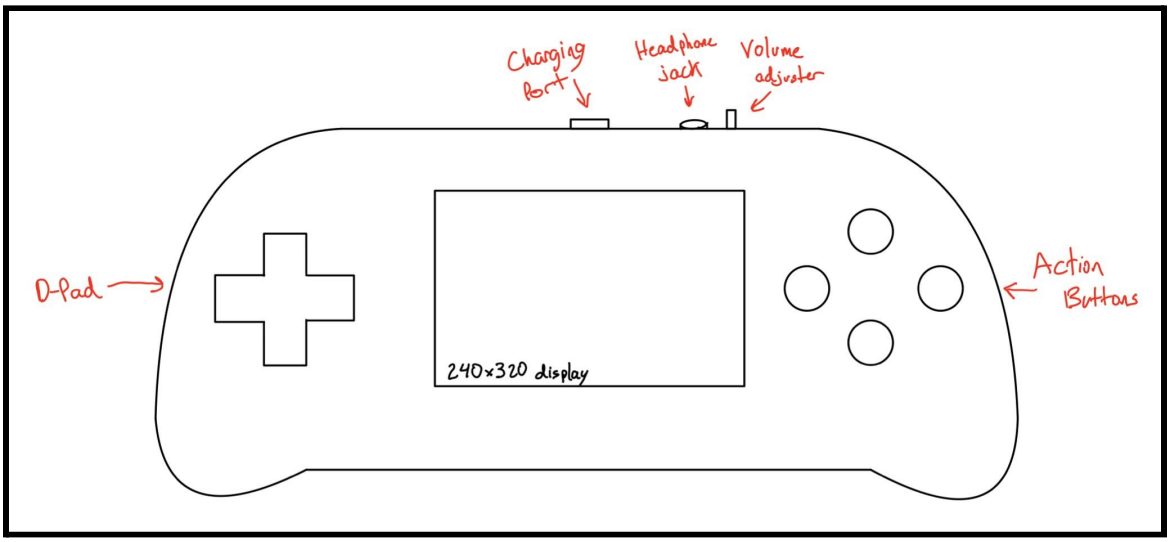

Figure 8. Enclosure Mock-Up

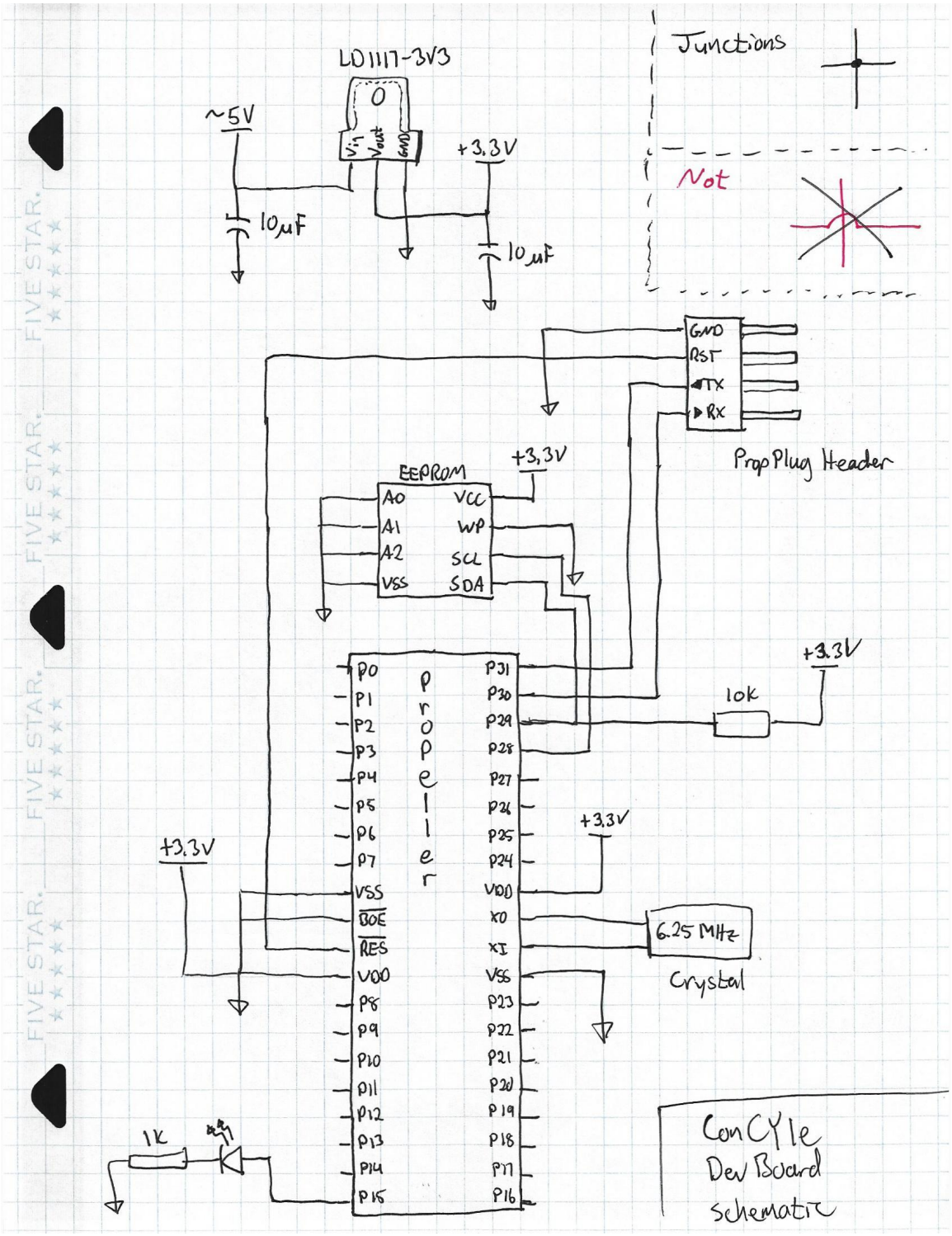

Figure 9. Devkit schematic

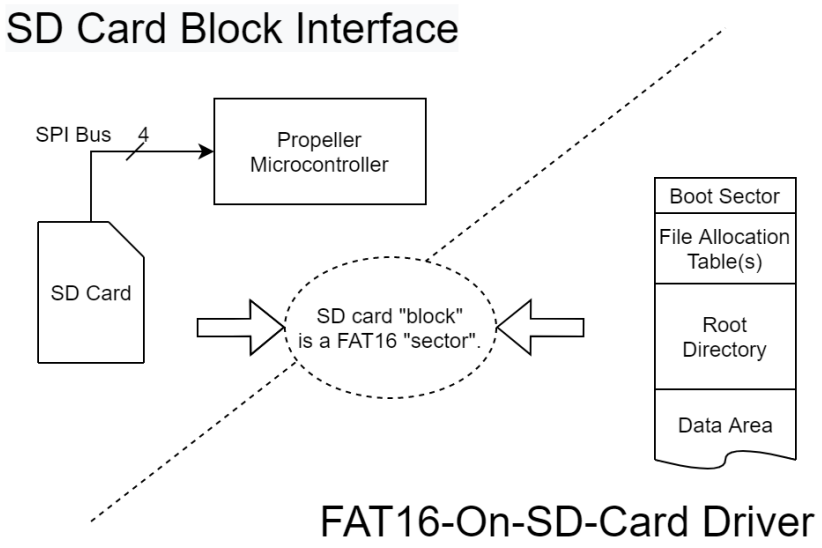

Figure 10. SD Card interface slide from presentation

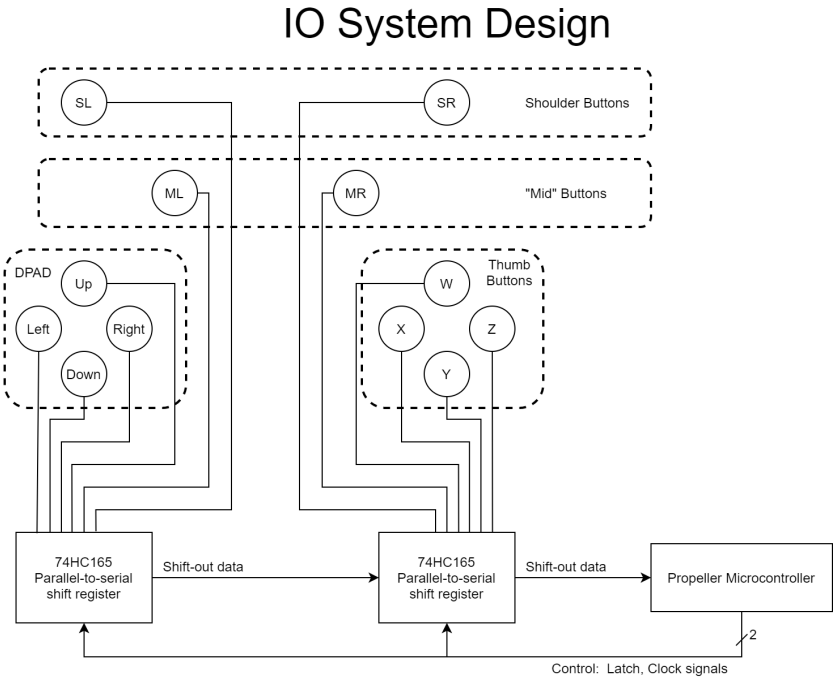

Figure 11. Button input slide from presentation.

8.4.1 Team Contract

Team Members:

1) __Trey Wiegmann_____ 2) __Stephen Brooks_____

3) __Julio Torres_____ 4) __Mitchell Anderson_____

5) __Seth Braddock_____ 6) __Brady Solomon_____

7) __Brandon Xicon_____ 8) _____

Team Procedures

Day, time, and location (face-to-face or virtual) for regular team meetings:

- Senior Design - Wednesday at 6:10 pm in the Student Innovation Center (face to face)
- Audio/Power Team - Wednesday at 5:00 pm in the TLA (face to face)
- Display Team - Thursday at 4:00 pm in the Senior Design Classroom (face to face)
- Game Development Team - Thursday at 7:00pm (virtual)

2. Preferred method of communication updates, reminders, issues, and scheduling (e.g., e-

mail, phone, app, face-to-face):

- All Communication is done in Discord

3. Decision-making policy (e.g., consensus, majority vote):

- Majority vote

4. Procedures for record keeping (i.e., who will keep meeting minutes, how will minutes be

shared/archived):

- Our Passive Collector Of Information, Trey, keeps meeting minutes???

Participation Expectations

All team members are expected to attend every meeting unless they have a reasonable excuse. They are expected to notify the rest of the group if they are unable to attend. All team members are expected to complete their assigned objectives on time and to communicate with the team when they cannot do so. All team members are expected to be committed to completing the project on time.

Leadership

1. Leadership roles for each team member (e.g., team organization, client interaction, individual component design, testing, etc.):

Seth - Communications Director
Brandon and Brady - Report Managers
Mitchell - Arbitrator
Trey - Passive Collector Of Information
Stephen Brooks - Facilitator
Julio - Schedule Manager

2. Strategies for supporting and guiding the work of all team members:
   Sharing information, progress, and issues with the team for feedback on the topics. The objective is to create an environment where team members are comfortable with asking questions, giving and receiving feedback.
3. Strategies for recognizing the contributions of all team members:
   Sharing information, progress, and issues with the team for feedback on the topics. The objective is to create an environment where team members are comfortable with asking questions, giving and receiving feedback.

Collaboration and Inclusion

1. Describe the skills, expertise, and unique perspectives each team member brings to the team.

See section 1.3.

2. Procedures for identifying and resolving collaboration or inclusion issues (e.g., how will a team member inform the team that the team environment is obstructing their opportunity or ability to contribute?) - First, ask your sub-team member; second, bring it up in the team meeting; third, ask Christopher; and finally Zambreno for help. If bringing it up with the team isn't wanted, we can go right to Christopher.

Goal-Setting, Planning, and Execution

1. Team goals for this semester: Complete documentation and prototypes for individual systems.
2. Strategies for planning and assigning individual and team work:
   Break into subgroups depending on related skill for client requirement subcategories.
3. Strategies for keeping on task:
   Team meetings will help us keep on task. We will disclose what we have done and what we have to do. This will keep us on task.

Consequences for Not Adhering to Team Contract

1. How will you handle infractions of any of the obligations of this team contract?
   By referring to Zambreno or Christopher Peterson
2. What will your team do if the infractions continue?
   We will talk to Zambreno about the issue.

****

a) I participated in formulating the standards, roles, and procedures as stated in this contract.

b) I understand that I am obligated to abide by these terms and conditions.

c) I understand that if I do not abide by these terms and conditions, I will suffer the consequences as stated in this contract.

1) ___Trey Wiegmann_____ DATE _____

2) ___Stephen Brooks_____ DATE _____

3) ___ Julio Torres _____ DATE _____

4) ___Mitchell Anderson_____ DATE _____

5) ___Seth Braddock_____ DATE _____

6) ___Brady Solomon_____ DATE _____

7) ___Brandon Xicon_____ DATE _____