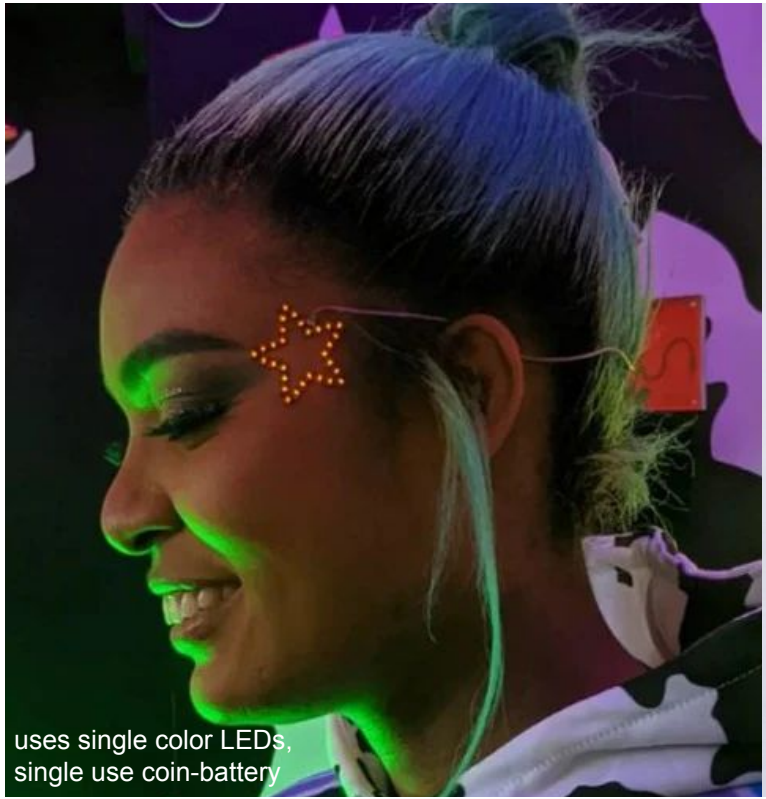
Use Cases for Digital, Customizable Jewelry

Apple Watch Series 8 ($399)

Oura Ring Gen 3 ($299)

Fitbit Luxe ($199)

Use Cases for Digital, Customizable Jewelry



Use Cases for Digital, Customizable Jewelry

HALO-90 open source earrings: uses 90 single-color red 0402 diodes, STM8L151G4 microcontroller, CR2032 coin battery, microphone & button

Purple locket by Artefact (prototype): digital locket, connects via BLE, theoretically uses photos from social media (no specs available)

Use Cases for Digital, Customizable Jewelry

Video pendant: uses ATSAMD21 microcontroller, 0.9" TFT ST7735S screen and LIR1220 battery (8mAh), upload images/gif files by connecting device to computer (no wireless)

Purple locket by Artefact (prototype): digital locket, connects via BLE, theoretically uses photos from social media (no specs available)

Use-Case Requirements: Physical Design

Spec	Requirement	Proposed methods to satisfy requirements
weight	< 20 g per earring	● Manufacture the earring body from a material with a low density ● Employ a simplistic design with minimal details ● Design a hollow earring body, externalize some components to a back-of-ear mounted device (similar to hearing aids)
temperature	< 40 C device temperature	● Manufacture jewelry from body-safe metals such as titanium, surgical steel, platinum etc. ● Coat or plate outside of jewelry in hypoallergenic material ● Use a biocompatible polymer as an alternative to metal ● Integrating current-limiting resistance into circuit design
material	earring post must be skin-safe, hypoallergenic	● Incorporate features for heat dissipation into the earring casing (i.e. heat sinks, holes etc.) ● Avoid manufacturing the earring from a conductive material (steel and bronze have the lowest heat conductivity)

Use-Case Requirements: Functionality

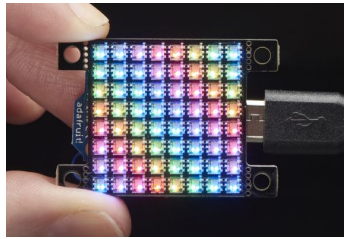
Spec	Requirement	Proposed methods to satisfy requirements
update speed	< 1500 ms to update design	● using BLE for data transfer: considering the resolution of the LCD, average image size will be 40-80 kb and BLE data transfer is 1Mbps ● compressing larger images (within a set range) before sending to device
setup time	< 90 s to scan/pair device and set custom pattern	● not using looped scanning to pair device ● clear, simple UI with preset pattern options ● easy to use pattern customization interface
battery life	3 hr for RGB matrix 45 min for LCD	● design variations to elongate battery life: making the battery external to the earring body to allow for a larger battery (hearing aid type mount) ● optimizing update functions to use minimum power

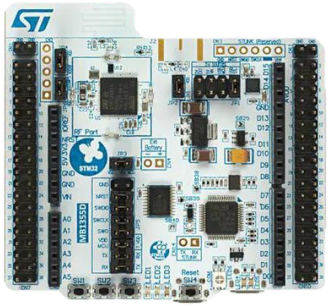
Technical Challenges

- Physical shape and design of device casing to contain, protect and withstand the operating conditions of all components: controller, sensors, power supply
  - dependent on weight and material constraints
- Careful PCB design to make sure microcontroller, screen, and battery can be integrated within the earring size requirement
  - The size of the earring should be no bigger than the screen itself, all electrical components should be hidden under the screen
- Consistent Bluetooth pairing with user mobile and successful image transmission via BLE
  - impacts speed and usability
- Power-aware hardware and software designs that maximize the battery life
  - Energy consumption should be taken into consideration
- Software algorithms that allow aesthetically pleasing moving patterns
  - Good algorithm design that ensures quick computation of the pixel value update

Solutions Approach: Hardware

- Microcontroller: STM32WB55RGV6
  - Matter connectivity. Has both built-in BLE to communicate with user mobile and SPI peripheral to interface with the screen
- Development Board: P-Nucleo-64
  - ultra-lower power, BLE compatible, easy to program. For firmware and software development purposes.
- LED panel: Adafruit DotStar RGB Pixel Matrix
  - 8x8 RGB DotStar pixels, individually addressable
- Screen: Non-Touch Graphic LCD Display Module
  - 128x128 RGB pixels, TFT type
- Button: KXT311LHS
  - low actuation force
- Casing for electronics:
  - 3D printed manufacturing: 316L grade Surgical Steel (Markforged), Silicon (Formlabs)





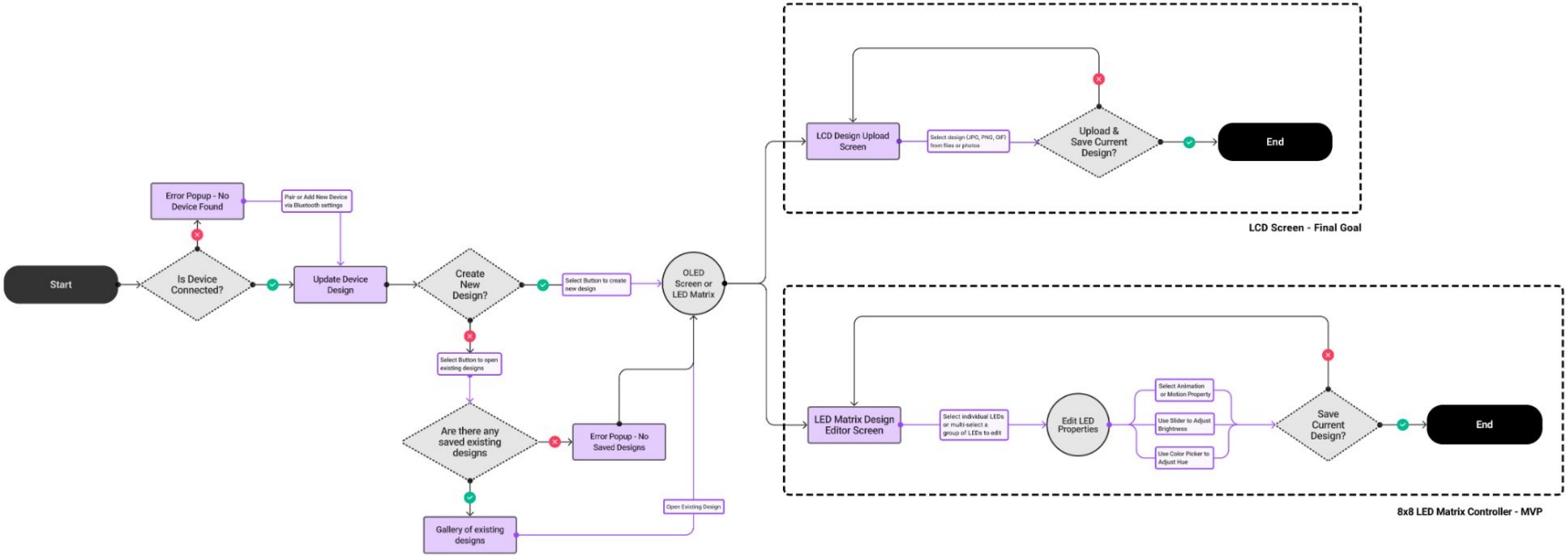
Solutions Approach: Firmware

- Communication Protocol: BLE (Bluetooth Low-Energy)
  - used in smart watches, smart home light bulbs
  - no IP addressing, designed to use smartphones as the gateway
  - data transfer speed is ~1Mbps
  - Existing libraries: react-native-ble-plx, react-native-ble-manager
    - works with iOS and Android, iOS is simpler, Android has more flexibility
- Interface with screen using SPI peripheral
  - Use the SPI 4-wires peripheral to interface pixel data with AFK128128A0 TFT LCD screen
  - HAL library peripheral driver eases the development and testing of SPI peripheral
  - Saleae logic analyzer for debugging and SPI peripheral driver
- Develop on nucleo development board
  - Use STM32WB55 Nucleo for developing the BLE and SPI firmwares
  - Get the full stack working on nucleo and breadboard first before assembling the actual physical design

Solutions Approach: Software

- Application Platform: iOS 16
  - Meets user needs of convenience and accessibility
- UI/UX: Figma
  - Intuitive views design and cloud sharing across team members
- SDK: SwiftUI
  - Optimised for iOS 16 Development
- Peripheral Interface: Core Bluetooth
  - Inherent Swift framework that enables foreground & background communication with BLE devices
- Data Management: Core Data

Proposed iOS Application User Flow



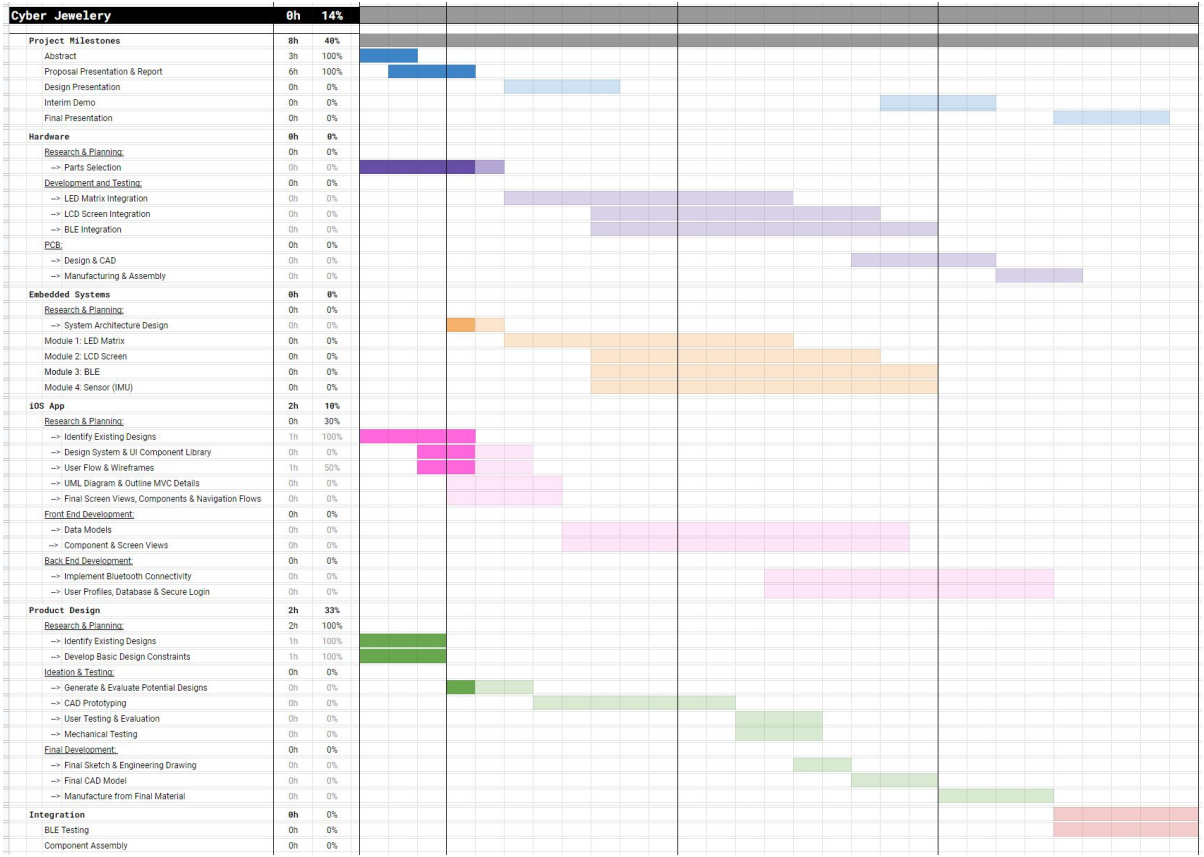
Testing, Verification and Metrics

Requirement	**Testing/Verification Method**
Weight	- Beyond weighing the device, we will survey users on the comfort of a heavier earring and measure the length of time it can be worn comfortably
Temperature	- Run the pattern update loop as close as possible to the data transfer limit for the device (~1Mbps so maybe 2-3 times per second for images, more for RGB matrix patterns) and track heat increase from the processor - User testing for comfort while the processor is operating at higher speeds
Material	- Provide a sample to several users to ensure the device can be comfortably worn without irritating skin - Stress testing: dropping the device, high/low weather temperatures

Testing, Verification and Metrics

Requirement	**Testing/Verification Method**
Update Speed	- Timing tests: pre load a series of patterns to user interface end, time the length it takes for device to respond and execute a pattern switch
Setup Speed	- Time from opening the app to setting a pattern; includes BLE scanning, pairing, naming device (optional) and rendering the pattern control UI - Individually time subprocesses (scanning/pair/UI) to find weaknesses
Battery Lif	- Time length of constant usage from full charge or new battery until device dies - Time required to charge fully

Schedule (Gantt Chart)



Cyber Jewelery	0h	14%
Project Milestones	**8h**	**40%**
Abstract	3h	100%
Proposal Presentation & Report	6h	100%
Design Presentation	0h	0%
Interim Demo	0h	0%
Final Presentation	0h	0%
Hardware	**0h**	**0%**
Research & Planning:	0h	0%
--> Parts Selection	0h	0%
Development and Testing:	0h	0%
--> LED Matrix Integration	0h	0%
--> LCD Screen Integration	0h	0%
--> BLE Integration	0h	0%
PCB:	0h	0%
--> Design & CAD	0h	0%
--> Manufacturing & Assembly	0h	0%
Embedded Systems	**0h**	**0%**
Research & Planning:	0h	0%
--> System Architecture Design	0h	0%
Module 1: LED Matrix	0h	0%
Module 2: LCD Screen	0h	0%
Module 3: BLE	0h	0%
Module 4: Sensor (IMU)	0h	0%
iOS App	**2h**	**10%**
Research & Planning:	0h	30%
--> Identify Existing Designs	1h	100%
--> Design System & UI Component Library	0h	0%
--> User Flow & Wireframes	1h	50%
--> UML Diagram & Outline MVC Details	0h	0%
--> Final Screen Views, Components & Navigation Flows	0h	0%
Front End Development:	0h	0%
--> Data Models	0h	0%
--> Component & Screen Views	0h	0%
Back End Development:	0h	0%
--> Implement Bluetooth Connectivity	0h	0%
--> User Profiles, Database & Secure Login	0h	0%
Product Design	**2h**	**33%**
Research & Planning:	2h	100%
--> Identify Existing Designs	1h	100%
--> Develop Basic Design Constraints	1h	100%
Ideation & Testing:	0h	0%
--> Generate & Evaluate Potential Designs	0h	0%
--> CAD Prototyping	0h	0%
--> User Testing & Evaluation	0h	0%
--> Mechanical Testing	0h	0%
Final Development:	0h	0%
--> Final Sketch & Engineering Drawing	0h	0%
--> Final CAD Model	0h	0%
--> Manufacture from Final Material	0h	0%
Integration	**0h**	**0%**
BLE Testing	0h	0%
Component Assembly	0h	0%

Task Areas and Division of Labor

Task Area	Madi	Saniya	Shize
Hardware Design & Assembly			x
PCB Development			x
Software: Firmware		x	x
Software: iOS Application	x	x	
Software: UI/ UX	x		
Product / Jewellery Design	x	x	x
Assembly & Testing	x	x	x
Parts Ordering & Inventory		x	
Gantt Chart & Meeting Notes	x		