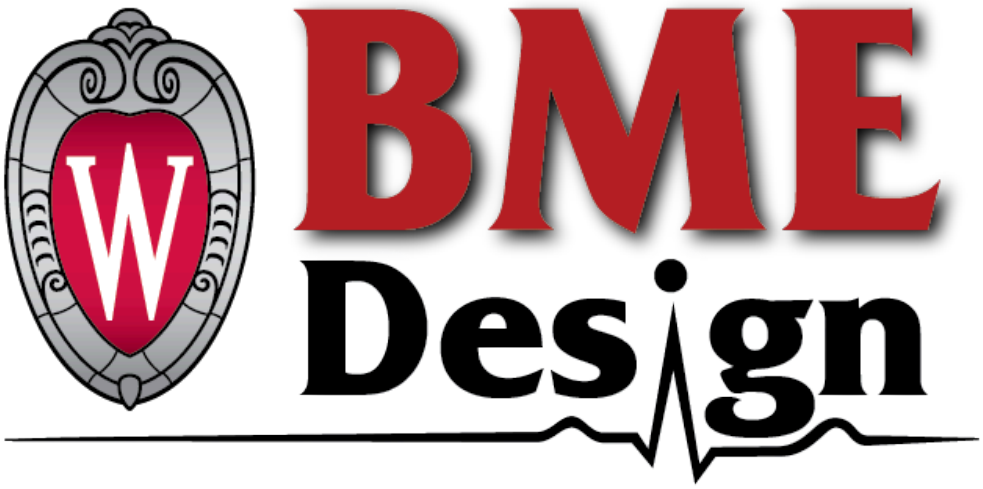

- ChargeForge: Gang Charging System For Newly Developed Physiological Monitoring Device

---

- Preliminary Product Design Specifications
  -
    - *BME 200/300*
    -
    - Team Members:
    - Allison Rausch (Leader)
    - Jake Maisel (Communicator)
    - Yeanne Hwang (BSAC)
    - Luke Blaska (BPAG)
    - Kenan Sirlioglu (BWIG)
    -
    -
    - September 9, 2024

- **Date**: September 18, 2024

- **Project title: ChargeForge Gang Charging System**
- **Group members**
  Leader: Allison Rausch
  Communicator: Jake Mais
  BSAC: Yeanne Hwang
  BWIG: Kenan Sarlioglu
  BPAG: Luke Blaska
- Client: Isabel Erickson
  Advisor: Chris Brace

Function

- A new wearable device for physiological monitoring, specifically designed for occupational safety in environments like heat stress and confined spaces, is currently being developed. The design contains a hard-shelled carrying case which provides protection but lacks trays that can connect physiological sensing devices with charging cables. Thus, the team is tasked to design and fabricate a gang-charging system to help solve this problem effectively and efficiently. Overall, the design should be able to transport, charge, and recuperate 40-50 sensors. The charging system ideally should indicate charge and UV levels. The final design should balance cost, durability, and manufacturability.

Client requirements

- The client primarily requests a tray to be fabricated that is able to charge the devices.
- The client requests ease of removal and insertion of sensors out of the tray.
- The client requests there is a charge indicator on the device.
- The client requests a mechanism for UV disinfection within the device.
- The client requests the device is simple and intuitive, easily operated by a person without an engineering background.
- The client requests the device has internal backup power.

Design requirements

- **Physical and Operational Characteristics**
  - **Performance requirements**
    - It is expected that the tray can hold 40-50 sensors of unspecified dimensions and allow easy removal and insertion of these sensors.
    - The tray must allow constant connection between the sensors and the charging system.
    - A UV disinfection system is preferred within the Pelican Case and should be activated when the case is closed.
    - The model should withstand extensive travel.
    - The device will be exposed to high temperatures, low temperatures, dust, and humidity.
    - The device should be functional when used at Marine training sites, construction sites, and athletic training facilities.
    - The device should be simple enough to be operated by someone without an engineering background.
  - **Safety**
    - Voltage flow and current are concerns in the event of a short circuit, overload, or ground fault in the wiring system.
    - Charging system must follow Intrinsic Safety Standards. [1]

        - In the event of using UV-curable resins, the user must wear chemical-resistant gloves that are not made of latex. Nitrile and neoprene gloves are best suited for handling. Parts should also be washed after being cured using the solvent that is compatible with the chosen resin. [2]
        - Trays should not contain sharp edges or protruding pieces that are sharp enough to penetrate the user's skin.
        - There will be no materials that will require labeling as toxic or harmful material.
        - All corners must be rounded or filed down to prevent shearing and/or slicing injuries to handlers.
        - Tray must clamp and attach to the Pelican Case tightly without counteracted bending moments.
    - **Accuracy and Reliability**
        - Charging cables must be functional for 24 hours at a time.
        - The UV disinfection system must prevent contagion between multiple users and disinfect devices.
        - Client requires the charge display must have a ±5% error from true charge values.
        - The tray device must remain accurate when exposed to high temperatures, low temperatures, dust, and humidity.
    - **Life in Service**
        - The device should be able to operate for 24 hours at a time.
        - The sensors must remain in contact with the charging system at all times during usage.
        - The tray should have a life span of approximately 10 years.
            - The tray should be easily repaired.
            - The tray should remain functional after 100s of uses.
        - The UV light within the disinfection system should have a lifespan of approximately 8,670 - 14,00 hours. [3]
    - **Shelf Life**
        - The storage facility where the device will be kept has a temperature range from 68°-75° Fahrenheit.
        - The device will be stored in a facility with a relative humidity level of 55-40.[4]
    - **Operating Environmen**t
        - The gang charging device should ideally operate in many different environments. The device will mainly be used on Marines training sites, construction sites, and athletic training sites.
        - The device must withstand very high temperatures of over 100° Fahrenheit.
        - The device should be able to withstand very low temperatures. There are US military bases in very remote areas that reach temperatures as low as -25° Fahrenheit [5]. The device must remain operable after being exposed to such a temperature.
        - The case must be rugged enough to withstand other environmental factors including sand, wind, and dust.
        - The case must be able to withstand heavy transportation and long times in transportation. During this process, the device has to remain intact and not break the internal devices.
    - **Ergonomics**
        - Many people will be tasked to operate the device, including engineers, trainers, military personnel, etc.
        - The device should be easy enough to be operated by a person in any occupation.
        - The process of using the device should be very simple allowing it to be operated by only one person.
    - **Size**
        - The smallest pelican case that can be used to fit 40-50 devices is a 13 in x 11 in x 6 in case with an interior dimension of at least 12 in x 9 in x 5 in. The small size of this case allows the operator to carry and move the device.

        - The largest pelican case recommended is a 33 in x 18 in x 11 case with an interior dimension no larger than 30 in x 16 in x 10 in. This case has wheels and a handle allowing the user to transport the device.
    - **Weight**
        - The client prefers that the device is under 30 pounds.
    - **Materials**
        - Body materials need to be shock-resistant, sturdy, elastic, and durable like high performance resin.
        - It needs foam that can protect the device while charging: polyester foam will be ideal.
        - Pin and latches of the pelican box shouldn't be rusted easily, so it would be ideal to use materials like Stainless Steel.
        - Light charging ports are needed.
    - **Aesthetics, Appearance, and Finish**
        - The client prefers the color of the final product is black or US Navy colors (Navy Blue and Gold).
        - Hard and rough texture that can absorb shock.
        - Cube shape that is stable and resistant to tipping or shaking.
- **Production Characteristics**
    - **Quantity**
        - A single successful working prototype is the goal of the project
        - It would be ideal if the design is easy to repeat and implement into other pelican cases so it can be effectively used on a large scale for the Marine Corps
    - **Target Product Cost**
        - The initial budget for the project is $300, and this will be the target cost. Additional funds will be offered by the client if necessary.
        - The pelican case will cost either $120 or $406 depending on the size chosen, but this will be provided by the client and not factored into the budget.
- **Miscellaneous**
    - **Standards and Specifications**
        - The National Electrical Code(NEC) is a set of standards for safe electrical design and installation. Much of the NEC is focused on 600V or less, which will be relevant for this design as wall outlets use around 120V [6].
        - Some of the more applicable codes include Article 250.52, which prevents electrical shocks and hazards due to faulty or wet wiring via proper grounding. This must be factored into the design as the devices may be wet when placed into the case [6].
        - Article 300 details the minimum allowed wire coverings for buried wires to ensure no moisture exposure [6].
        - Article 210 specifies minimum wire size and ampacity for varying circuits[6]
        - Many further standards in the NEC can be examined for certain scenarios.
        - In the case that UV is used in the design, there are several UV standards to be adhered to. ASTM(American Society for Testing and Materials) E2297-23 details proper sensitivity range and calibration for UV use[7]. ASTM G154-23 details the standard practice for operating UV lamps and exposure of materials, which has important implications for what material is chosen[8].
    - **Customer**
        - Understanding the customer's preferences is vital in ensuring that the ChargeForge Gang Charging System is both functional and appealing.

        - The primary customer is the U.S. Marine Corps, represented by the client, Isabel Erickson. The system must meet their operational needs, which involves functioning in extreme environments like marine training sites and construction fields.
        - The Marines require a durable device capable of withstanding rough handling, varied temperatures, and dust. Additionally, the device must be simple to use, intuitive for personnel, and integrate easily into their current workflow.
        - Color preferences have also been noted, with a strong preference for a black or Navy Blue and Gold design, aligning with Marine Corps branding. Meeting these aesthetic and functional expectations is essential for customer satisfaction.
    - **Patient-related concerns**
        - Although this device is primarily aimed at occupational safety rather than direct patient care, certain patient-related concerns remain relevant.
        - An example of important patient-related concerns is the gang charging system must ensure that the sensors, used to monitor physiological conditions, are properly disinfected between uses to prevent cross-contamination.
        - Incorporating UV light for this purpose offers an efficient, low-maintenance method for disinfection, ensuring compliance with hygiene standards, especially when multiple users share the same sensors.
        - Additionally, the storage of personal data may be a concern, as physiological sensors might gather sensitive health data. Therefore, the device should comply with data privacy regulations, ensuring that any data stored is confidential.
    - **Competition**
        - After analyzing the competition for gang-charging systems, few are tailored specifically for tough, military-grade environments that require both charging and disinfection capabilities.
        - Competing products usually focus on either charging or storage but lack the UV disinfection and extreme durability that this system offers.
        - This system differentiates itself by integrating durability, ease of use, and UV disinfection in a compact, portable form, meeting the specific needs of Marines operating in challenging conditions.
        - For example, Masimo Corp filed a patent on a physiological device charging station. This design includes a multiple-level system that holds the trays for the devices. The design has a charging port that protrudes from the bottom of the station to provide charge to the devices. However, this design is very large and not made for easy transportation [9]. One of the main requirements for the design is that it is very easy to transport.

References:

- [1] C. Crouse-Hinds, “AN9003 - A Users Guide to Intrinsic Safety.” [Online]. Available: https://www.mtl-inst.com/images/uploads/datasheets/App_Notes/AN9003.pdf
- [2]“Safe Handling of 3D Printing Resins | RadTech.” Accessed: Sep. 19, 2024. [Online]. Available: https://radtech.org/safe-handling-of-3d-printing-resins/#:~:text=Do%20not%20touch%20the%20resin
- [3] U. S. Office of Water, “Wastewater Technology Fact Sheet,” Sep. 1999. [Online]. Available: https://www3.epa.gov/npdes/pubs/uv.pdf
- [4] O. of the U. S. of D. for A. and Sustainment, “DOD SUPPLY CHAIN MATERIEL MANAGEMENT PROCEDURES FOR STORAGE AND MATERIAL HANDLING.” Oct. 12, 2017. [Online]. Available: https://www3.epa.gov/npdes/pubs/uv.pdf
- [5] Quartermaster Research & Engineering Command, “FREQUENCIES AND DURATIONS OF HOURLY TEMPERATURES FORT GREELY, BIG DELTA, ALASKA.” [Online]. Available: https://apps.dtic.mil/sti/tr/pdf/AD0234283.pdf#:~:text=This%20report%20presents%20in%20detail%20the%20frequency%20and
- [6]National Electrical Code, NFPA 70, 2023 ed., National Fire Protection Association, Quincy, MA, 2023.https://link.nfpa.org/publications/70/2023
- [7]Standard Guide for Use of UV-A and Visible Light Sources and Meters used in the Liquid Penetrant and Magnetic Particle Methods, ASTM E2297-23, ASTM International, West Conshohocken, PA, 2023.https://compass.astm.org/document/?contentCode=ASTM%7CE2297-23%7Cen-US
- [8]Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials, ASTM G154-23, ASTM International, West Conshohocken, PA, 2023.https://compass.astm.org/document/?contentCode=ASTM%7CG0154-23%7Cen-US
- [9] M. Corp, “Charging Station for Physiological Monitoring Device” [Online]. Available: https://www.freepatentsonline.com/y2023/0147750.html#google_vignette