BE-SAFE

Battery Event Safety Alarm FixturE

ELECOMP Capstone Design Project 2020-2021

Sponsoring Company:

EaglePicher Technologies
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Company Overview:

EaglePicher Technologies is a leading producer of batteries and energetic devices. For more than 75 years, we have been serving the mission-critical aerospace, defense, aviation and medical battery markets. EaglePicher's batteries are a key component of the U.S. space program; our batteries provided the emergency power that successfully brought the Apollo 13 crew home. Today, EaglePicher batteries power the International Space Station, Mars Rovers, commercial jets and helicopters, life-saving medical implants and more than 85 percent of U.S. missile platforms.

Technical Directors:

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Project Motivation :

Battery designs trend toward ever increasing energy which often pose unique safety challenges during manufacturing, transportation and use. EaglePicher Technologies (EPT) is developing high energy batteries that eclipse the capacity of most common electric vehicles. Recognizing inherent hazards, EPT is committed to providing the safest possible environment in the manufacture of these potentially very dangerous batteries. In emergencies, equipment connected to utility AC power lines can be rendered safe by switching power off from a safe distance. Batteries in contrast can pose deadly and undetectable hazards that persists when all other hazards have been removed. Additionally, sprinklers and other fire suppression steps may dramatically increase the risks associated with large batteries. While live AC power lines can be detected with the use of devices carried by most firemen and utility workers, detecting the DC voltage of a charged, high voltage battery, from a distance is a problem. A battery, soaked in fire suppressing water, could under some circumstances, electrocute a person without warning. A similar situation can be envisioned for a battery in a partially flooded naval vessel. The motivation for this project is to determine if an effective method for detecting shock hazards in proximity to high energy batteries can be identified and second, develop a monitoring device to provide an early warning that such a hazard exists.

Anticipated Best Outcome:

A) Identify methods to detect hazardous conduction paths in proximity to high energy batteries that have been drenched or submerged in water.
B) Develop an early warning device to alert personal and first responders to the existence of shock hazards in proximity to a drenched or submerged battery.

Project Details:

To be electrocuted by a battery, a body needs to complete a circuit between the positive and negative terminals of the battery. Under normal dry conditions, the safety precautions are straight forward. Don't touch anything. However, in the case where a battery has been immersed or drenched, a conduction path may be present through the enveloping water. A person traversing near a compromised battery may present a better conduction path than the water, and be electrocuted. This is especially true if the chassis or craft is at the battery negative (ground) potential. This is often the case in military vehicles.

Pure water is a poor conductor of electricity. However, the water used to suppress fires is essentially, if not in fact, pond or sea water. The contaminants in pond water produce a solution that will conduct electricity to some extent. Sea water which contains salt will conduct much more readily. To provide a comparative study of various detection methods for this project, it is desirable to establish a "Pond Water" standard and a Rhode Island "Sea Water" standard for conductivity.

The batteries EPT is developing will be assembled on mobile work stands. During the manufacturing process these batteries and work stands will be repositioned several times to perform successive assembly and test operations. A key result of this project is to define a hazard radius around these work stands which have been inundated. Using the standards described above, create a scale model workstation, and scale model battery (Not Very Dangerous), to examine the hazard radius.

Having established a test setup, various detection techniques can be compared. First responders carry "Hot Sticks" to detect the presence of live AC wires. These devices light up when brought near a live wire without having to make contact, even through walls. These devices rely on principles of electromagnetic theory. If a conductor is placed near an Alternating Current, a detectable signal is induced in the conductor. The DC current produced by batteries in our scenarios are not known to generate a dynamic signal and therefor are much more difficult to detect.

Is there a detectable dynamic in the conductive pool of pond water?

Can a device be placed in on a battery line that creates a detectable signal? Can an electric or other type of signal be introduced to the pond water enveloping a battery to render hazardous conditions more detectable? (i.e. does a signal react differently in presence of a DC voltage field)

At the successful completion of this project, the battery work stands will be equipped with a shock hazard warning system/device. This device could be either portable or hardwired.

The ideal solution will be unobtrusive, automatic and easily identifiable when activated. Like a fire alarm that goes unnoticed until a fire occurs, the ideal embodiment of this investigation will generate a unique signature warning that a hazard exists.

Hardware/Electrical Tasks

1. Create a system requirements specification based on the outline description
2. Define the physics of the problem.
3. Define the risk level and risk radius for various common battery voltages
4. Establish Project Safety Rules and Requirements
5. Determine feasibility and methodology steps to validate the concept
6. Create analytical or experimental test models per feasibility study
7. Identify and develop experimental hazard detection circuits
8. Determine the best candidate circuits based on performance, cost, and complexity
9. Identify a suitable controller to process detection signals
10. Design an intuitive user interface with displays, indicators or annunciators
11. Design a power system for standalone operation
12. Generate schematic diagrams
13. Create a Bill of Materials
14. Determine manufacturing costs
15. Create assembly drawings
16. Determine service or calibration requirements
17. Create a user manual

Firmware/Software/Computer Tasks

1. Identify key requirements
2. Create software specification documents
3. Create system flow and state diagrams
4. Generate pseudocode task outlines
5. Validate that the selected hardware will meet the performance requirements
6. Set up software development tools for the selected controller (IDE)

Composition of the Team:

3 Electrical Engineers & 1 Computer Engineer. ***US Citizenship Required; Background Checks will also be conducted before the first kick-off meeting with the Technical Director.***

Skills Required:

Electrical Engineering Skills Required:

- Circuit simulation
- Data analysis
- Electrical Safety knowledge and awareness
- Analog circuit design
- Digital circuit design
- Low Power circuit design
- Knowledge and use of common lab equipment
- PCB layout (experience or enrollment in Mike Smith's class this semester)
- Soldering, Troubleshooting, Repair
- Physics minor, electromagnetics background, or diagnostic experience would be highly desired.

Computer Engineering Skills Required:

- Embedded software development
- IDEs / Debuggers
- Algorithm development
- Analog Signal processing
- Digital Signal processing and Filters
- Test, Debug and Validate code

Anticipated Best Outcome's Impact on Company's Business, and Economic Impact

If successful, the deployment of the Battery Monitor will result in no accidents, injuries or lost time and lost revenue due to unseen or undetectable shock hazards in the manufacture of large dangerous batteries.

Broader Implications of the Best Outcome on the Company's Industry:

Creating enhancements to safety in the battery industry will stimulate growth by eliminating risks associated with manufacturing and handling of large high capacity batteries.

Hazards:

The health and safety of every team member will be paramount throughout this project; **safety & security training will be conducted at the kick-off meeting.** No team member will be subjected to any of the conditions being studied during the course of this project. This program intends to detect electrical voltages and currents that are hazardous to human life. These dangerous conditions must be created in laboratory settings for experimentation purposes. Little is known or quantified about the level of risk that exists when people and high voltage batteries share a common wet environment.