# Fuel Cell Monitor

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# CONCEPT OF OPERATIONS

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# CONCEPT OF OPERATIONS
FOR
# Fuel Cell Monitor

TEAM 38

APPROVED BY:

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T/A Date

# Change Record

| Rev. | Date | Originator | Approvals | Description |
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| **1** | [09/15/2022] | Fuel Cell Monitor System | | Draft Release |
| **2** | 10/02/2022 | Russell Wells | | FSR, ICD attachment |

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# 1. Executive Summary

A single fuel cell is an easy power source to monitor, but to achieve any level of real usable power they must be connected in a stack which provides a usable amount of power. Our fuel cell monitor will be focused on the integrity of individual cells. The proposed device will monitor individual voltages on a real time basis, transmit the data via Wi-Fi to a mobile app which will have a graphical display of the individual cell voltages.

# 2. Introduction

Fuel cell monitor is used to measure the efficiency and electrical characteristics of fuel cells [2]. A Fuel cell is an electrochemical energy conversion device where it utilizes hydrogen and oxygen to generate electricity, heat, and water [3]. The fuel cell monitor that will be created will provide real-time monitoring of every cell in each fuel stack. This monitor will be able to communicate via Wi-Fi to transfer the data from the cell to an application. The purpose of this monitor is to track the fuel cells to see if they fail at some point.

## *2.1. Background*

Fuel cells are not new technology, and neither are fuel cell monitors. However, with the more recent push for clean and renewable energy, different types of fuel cells have become much more prevalent in research as well as personal use of recreational equipment. Some of the fuel cells take hydrogen and use it to generate electricity. The fuel cell monitor will be used to track these voltages. The monitor will have a microcontroller unit which will be used to store the data from the fuel cell.

## *2.2. Overview*

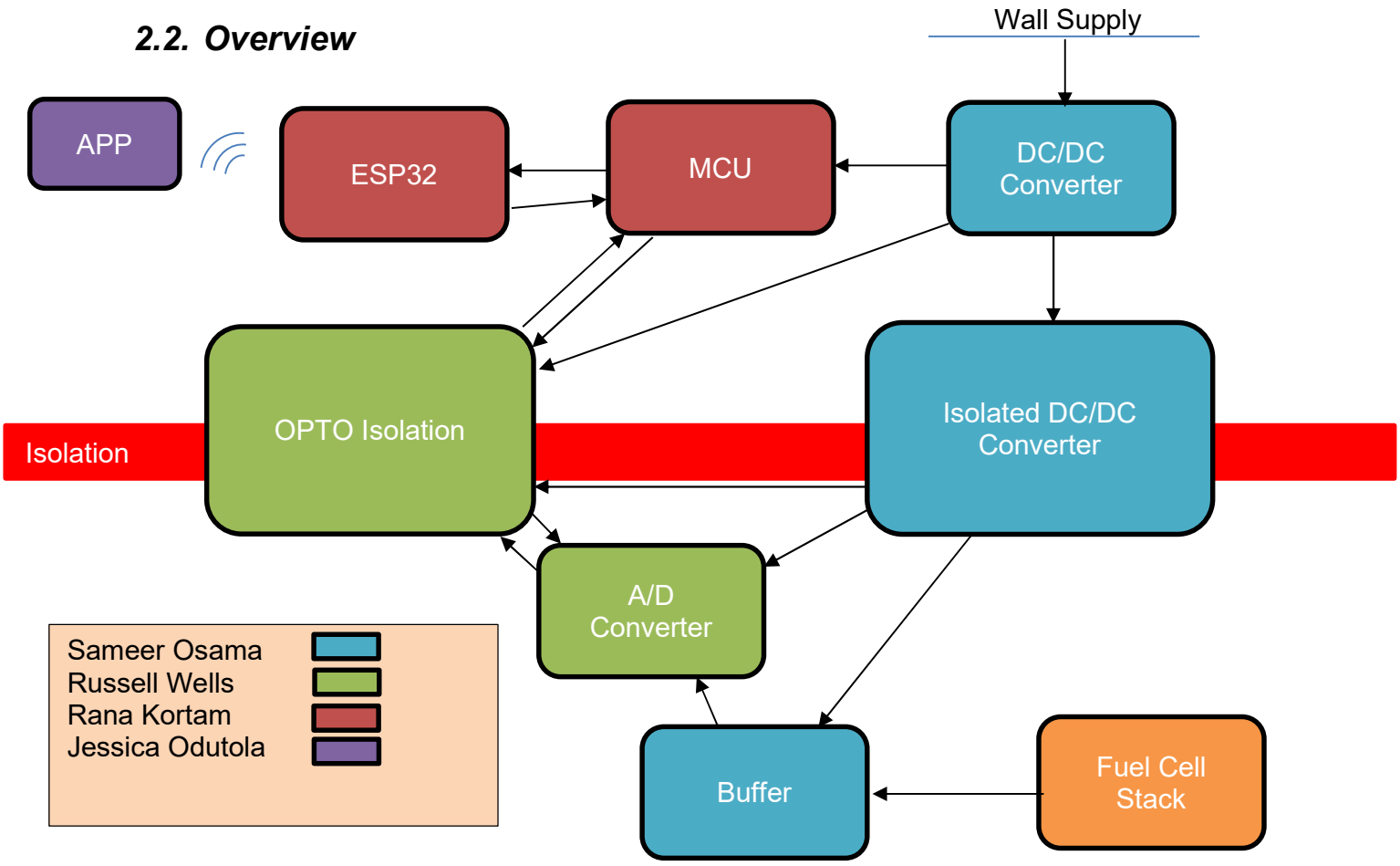


***Figure 1: Fuel Cell Monitor Block Diagram***

The proposed device is not intended as a replacement for a more robust control system such as SCADA but is intended as an affordable, low maintenance, mobile, voltage monitoring and alarm system. The system will display real-time voltages on the app and push notifications to the user via the app when a cell is not operating within expected ranges. The monitor will not have a control aspect but will send a warning to the owner/operator when action is required to preserve fuel cell integrity.

The app is going to allow real-time monitoring as well as provide historical trend data that can be used to diagnose current issues and anticipate future failures based on past experiences.

## *2.3. Referenced Documents and Standards*

[1] Marsh, Jane. "5 Hydrogen Fuel Cell Environmental Impacts." *Environment Co*, 19 Nov. 2020, https://environment.co/hydrogen-fuel-cells-environmental-impacts/.

[2] "Fuel Cell Monitor Pro 4.0." *Fuel Cell Store*, https://www.fuelcellstore.com/fuel-cell-monitor-pro-3-u103.

[3] "Fuel Cell Basics." *Fuel Cell & Hydrogen Energy Association*, https://www.fchea.org/fuelcells.

# 3. Operating Concept

## *3.1. Scope*

The scope of this project is to provide a monitor that will be able to transfer all relevant parameters to track fuel cells. The exact deliverables for the scope of this project are as follows:

- Power system development
- Internal signal transfer and manipulation development
- Microcontroller development
- Application development

Documentation for the design, construction, and programming of the units will be provided for all parts of the project.

## *3.2. Operational Description and Constraints*

The fuel cell monitoring system is intended for use in a controlled laboratory or secure location. The system will include Wi-Fi-enabled data transfer from the device to a user's cell phone.

Constraints:

- The device is not intended for use outdoors or in harsh environments
- The device requires a 110Vac wall outlet for power

## *3.3. System Description*

- Power System: A wall wart power supply will be used to convert the AC voltage to DC voltage. This DC voltage will be passed through multiple DC/DC converters to bring the voltage down to different levels. The new lower voltage levels will be supplied to the microcontroller, the opto-isolator, and the isolated DC/DC converter. The isolated DC/DC converter is used to pass power over the isolation line and provide power to the op-amps and the ADC.

- Internal Signal manipulation and transfer: The voltages from the fuel cells will be passed through an op-amp buffer to an analog to digital converter. The converter will send the digital signal to an opto-isolator which will transfer the signal as a scaled current that is representative of the differential voltage.

- Signal Processing: The signal from the opto-isolator will be sent to the microcontroller unit where the data will be stored. Then, the microcontroller will be connected to another microcontroller, ESP32, with a UART where the data will be transferred to the application.

- Application and graphical display: The application will display the voltages in the form of a graph of each fuel cell in the stack to the user. The user will be able to navigate to the fuel cell of their choice and/or the fuel cell stack to view the voltages.

## *3.4. Modes of Operations*

- Normal Operating Mode: All cells are within a preset range and the data is displayed graphically on the App.
- Cell Alarm Mode: One or more of the cells have fallen below threshold voltage or spiked above. App will display the faulty or over loaded cell as defective.
- System Alarm Mode: The app no longer receives information from the system outside of normal disconnect.

## *3.5. Users*

- Initial Installer: An electrician or fuel cell technician should conduct the initial installation and test.
- General Operator: The normal operator of this device will not require training. Anyone with access to an android smartphone will be able to connect to the device through the app and monitor the system.
- Maintenance Technician: Maintenance on the device, beyond.

## *3.6. Support*

User will be given a parts list with all replaceable parts outlined for purchase. These parts would include the wall power supply, type and quantity of external signal wires, and a component list for all major PCB components. The program for the microcontroller and App will not be supplied

# 4. Scenario(s)

## *4.1. Experimental Lab Equipment*

Our project, although not all inclusive, will be relatively inexpensive and less concerning when connected to experimental fuel cell systems. The use of the application as a monitoring system will also allow the user to monitor the fuel cells and maintain historical data even if left alone for an extended period.

## *4.2. Personal or Home Power Generation*

The system could be used by a homeowner or non-commercial entity where an individual would like to be able to monitor a fuel cell stack.

# 5. Analysis

## *5.1. Summary of Proposed Improvements*

An improvement that the proposed system will provide is the mobile app connectivity. Another improvement is cost efficiency.

## *5.2. Disadvantages and Limitations*

The limitations of the Fuel Cell Monitor include:

- The app used to monitor and display the voltages for each individual fuel cell is only available on Android devices.
- To use our monitor, it is necessary to be near an outlet.
- The monitor cannot be used outdoors.

## *5.3. Alternatives*

- Full monitor and control system would be an alternative. A PLC cabinet with SCADA control nodes for back pulse and temperature regulation as well as full power monitor would be an alternative and would do the job of our proposed device but at a much higher cost to the client in both initial implementation as well as annual maintenance.

## *5.4. Impact*

[1] Fuel cells, depending on where the hydrogen is extracted, have a positive impact on the environment. Hydrogen can be found in most things in nature; therefore, hydrogen fuel cells are a renewable resource. The ubiquity of hydrogen in nature means that the fuel cells are also a sustainable resource. The use of hydrogen fuel cells significantly reduces carbon emissions. In comparison to their alternatives, fuel cells are the best option for the environment. Being able to monitor the levels of the fuel cells ensures that the negative effects on the environment are limited.