Fuel Cell Specification

Control Number: 3309-00046
Version: 1-00
Date: Oct 9, 2012

Coastal and Global Scale Nodes
Ocean Observatories Initiative
Woods Hole Oceanographic Institution
Oregon State University
Scripps Institution of Oceanography

Revision History

Version	Description	Originator	ECR No.	Release Date
1-00	Initial Release, per ECR	R. Petitt	1303-00847	Oct 10, 2012

Table of Contents

1.0 Scope

The specification describes the physical, functional and electrical characteristics of the Fuel Cell for the High Power Surface Buoy Power System. This specification also describes the manufacturing, performance, quality, identification, traceability, handling, packaging, shipping and storage requirements of this component.

2.0 Background

The Ocean Observatories Initiative (OOI) will lay the foundation for future ocean science observations. OOI will enable powerful new scientific approaches by transforming the community's focus from expedition-based data gathering to persistent, controllable observations from a suite of interconnected sensors. The OOI's networked sensor grid will collect ocean and seafloor data at high sampling rates over years to decades. Researchers will make simultaneous, interdisciplinary measurements to investigate a spectrum of phenomena including episodic, short-lived events (tectonic, volcanic, oceanographic, biological, and meteorological), and more subtle, longer-term changes and emergent phenomena in ocean systems (circulation patterns, climate change, ocean acidity, and ecosystem trends).

The OOI will enable multiple scales of marine observations that are integrated into one observing system via common design elements and an overarching, interactive cyberinfrastructure. Coastal-scale assets of the OOI will expand existing observations off both U.S. coasts, creating focused, configurable observing regions. Regional cabled observing platforms will 'wire' a single region in the Northeast Pacific Ocean with a high speed optical and high power grid. Global components address planetary-scale changes via moored open-ocean buoys linked to shore via satellite. Through a unifying cyberinfrastructure, researchers will control sampling strategies of experiments deployed on one part of the system in response to remote detection of events by other parts of the system.

A more detailed discussion of the Oceans Observatories Initiative can be found in the OOI Final Network Design.

3.0 Introduction

Figure 1 below shows a block diagram, which includes all the major components of a Buoy Power System. Power is generated by 4 photovoltaic arrays, dual wind turbines and dual fuel cell systems. A rechargeable lead-acid battery bank stores surplus energy when environmental power is available and supplies energy during periods of peak power demand such as satellite transmissions or Autonomous Underwater Vehicle (AUV) charging. The Power System Controller (PSC) coordinates the energy flow while monitoring and reporting system status. A 380 VDC converter module provides a high-voltage bus for applications that require power transmission to the seafloor. A serial data communications link passes engineering data and commands between the PSC and Communications and Power Manager (CPM).

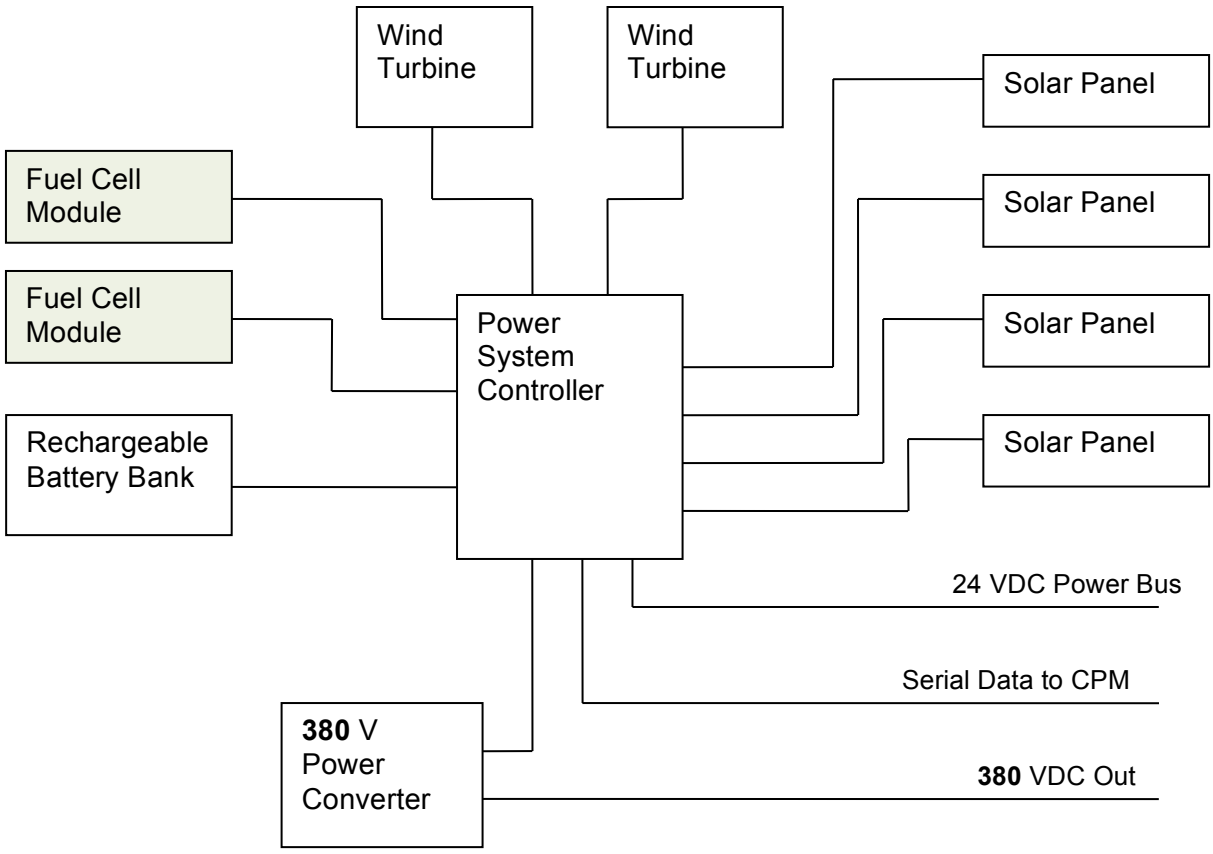

Fig. 1 – Block diagram of the Buoy Power System

Fuel Cell Concept

The CGSN High Power Surface Buoys will be equipped with a Fuel Cell System. This single Fuel Cell system will consist of two Fuel Cell modules which will be installed in cutout spaces in the buoy foam located outboard of the main buoy electronics well (ref. Buoy/Fuel Cell Interface Control Drawing, CGSN drawing number 3701-00313). It is preferable that the Fuel Cell modules be self-contained and autonomous to the maximum extent possible and that interfaces to the rest of the buoy systems be kept to a minimum. However it is understood that the constraints of the system design may dictate that the Fuel Cell modules share an auxiliary system like fuel delivery or air intake. The concept of these Fuel Cell modules is a lightweight box with waterproof electrical connectors, quick-connections for fuel or coolant lines and an accessible control panel with indicator lights. Since the fuel cell modules will be located in the foam insert spaces, all access to the interior of the fuel cell box will be via its top module cover. This drop-in system will allow for convenient replacement of the Fuel Cell modules for maintenance. All components of this fuel cell system will be the responsibility of the vendor.

A block diagram of a concept Fuel Cell module is shown in Figure 2 below. A COTS Fuel Cell unit with additional control electronics provides bulk charging of the internal rechargeable

battery string. During power-up of the fuel cell, surge and startup currents will be drawn from the internal rechargeable battery to avoid excessive loading of the main buoy battery banks. The maximum current drawn by the fuel cell from the PSC should be much less than 10 A. During normal operation, the Fuel Cell units will be continuously connected to the main buoy 24 V bus and will be sourcing current to the bus. During startup and power down periods it might be necessary to disconnect the Fuel Cells from the bus to avoid excessive current draw, which could potentially activate protection devices.

The fuel cell unit will draw ambient air from outside the fuel cell enclosure as an oxygen source. Due to the high salt content of ambient air in a marine environment, an in-line air filtration system will be required to reduce the salt content to an acceptable level. The COTS fuel cell unit will also require a source of forced cooling air to dissipate waste heat generated by the fuel cell to the exterior of the enclosure. This air flow requires some rudimentary filtering for salt and condensed water vapor and a mechanism for preventing intrusion of seawater due to waves breaking on the buoy.

Liquid fuel will be supplied to the Fuel Cell units from 1 or more fuel storage bladders located in the flooded space below the main buoy well.

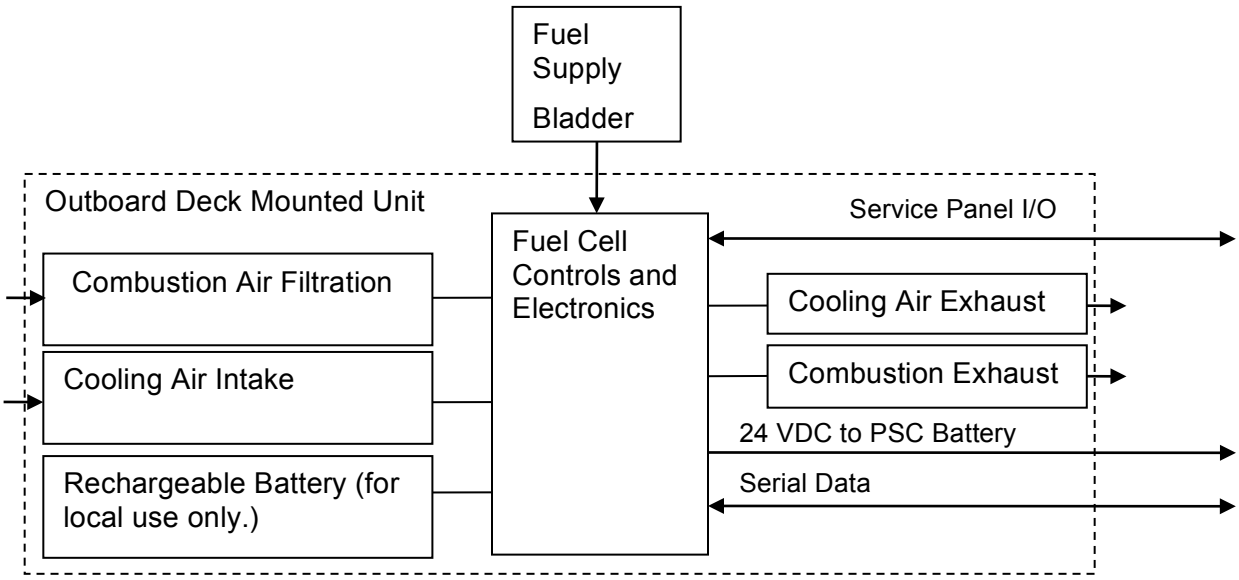

Fig. 2 – Block diagram of the Fuel Cell Module concept

4.0 Documents

The documents listed in this section are for informational purposes only and may not have been referenced in this specification.

Buoy/Fuel Cell Interface Control Drawing, CGSN drawing number 3701-00313

Consortium for Ocean Leadership, Inc. 2010. *Final Network Design.* Washington, DC. [Online] Available: http://www.oceanleadership.org/programs-and-partnerships/ocean-observing/ooi/network-design/

5.0 Definitions

Glossary and Acronyms

- **PSC** – The Power System Controller monitors, controls and reports status of power generation activity, battery charging and power delivery.
- **Deployment Interval** – The period of time between deployment and recovery of the buoy system.
- **CPM** – Communications and Power Manager; The buoy control computer which functions as the central controller of the buoy electrical system.
- **Survive** – Experience an event without major loss of hardware. System may experience loss of functionality requiring repair to return to normal mode functionality. An example of this is knockdown of a global mooring or loss of some part of the mooring resulting in the instrument descending to the bottom. Any internal memory in the instrument shall remain accessible, but the sensors may need to be replaced to return to normal functionality.
- **Sustain** – Experience an event (environmental extreme or condition) without permanent loss of normal mode functionality. System may experience reduction of functionality during event.

6.0 Specifications

Operating Environment

Spec No.	Item	Requirement
OPEN-001	Isolated power outputs	Power outputs from the Fuel Cell System shall be electrically isolated from the buoy hull.
OPEN-002	Resistance to Icing	The Fuel Cell System shall sustain periods of icing.
OPEN-003	Splash	The Fuel Cell System shall be splash-proof

OPEN-004	Submersible	The Fuel Cell System shall survive immersion in seawater to a depth of 5m.
OPEN-005	Maintenance	The Fuel Cell System shall be capable of unattended operation for a period of 7 months with no intervening service visits.
OPEN-006	Operating temperature	The Fuel Cell System shall be capable of operating over the temperature range -10 C to +40 C.
OPEN-007	Fuel cell air intake	The Fuel Cell enclosures and mechanical pass-throughs shall prevent seawater from entering the Fuel Cell System.
OPEN-008	Power system operational tilt	The Fuel Cell System shall remain operational when tilted at all angles up to 45 degrees from vertical.

Fuel Cell System Operational

Spec No.	**Item**	**Requirement**
FCEL-001	Fuel cell minimum power rating	Each Fuel Cell Module shall have a rated output power of no less than 150 W
FCEL-002	Fuel Cell output voltage	The Fuel Cell System shall have a nominal output voltage of 24 VDC. (bulk charging up to 28.6V, above which it will provide constant voltage charging until the current level drops to 3.1A)
FCEL-003	Fuel Cell System energy capacity	The Fuel Cell System shall produce no less than 800 kW-hr of electrical energy over the course of a 7 month deployment interval.
FCEL-004	Fuel Cell Module physical volume	The Fuel Cell Modules shall fit within the two allocated foam cutout volumes of 0.5 m length, 0.3 m width and 0.5 m height (ref. Buoy/Fuel Cell ICD, drawing # 3701-00313).
FCEL-005	Fuel Cell service life	The Fuel Cell System shall be capable of operation for two, 7 month deployment intervals with an intervening factory refurbishment.
FCEL-006	Fuel Cell Module operating hours	Each Fuel Cell Module shall be capable of operating for a total of 3000 hours during a single deployment interval.
FCEL-007	Fuel Cell power cycles	Each Fuel Cell Module shall be capable of being restarted 100 times, from a powered down state, during a single deployment interval.
FCEL-008	Fuel cell liquid fuel	The fuel used by the Fuel Cell System shall be an atmospheric pressure liquid such as methanol. Safety and hazardous material shipping and environmental information shall be documented by the manufacturer.
FCEL-009	Fuel storage capacity	The Fuel Cell System fuel storage system capacity shall be no less than 1000 liters.
FCEL-010	Fuel cell oxygen	The oxygen for operation of the Fuel Cell System shall be

	source	drawn from ambient air external to the buoy.
FCEL-011	Fuel storage seawater intrusion	The Fuel Cell System fuel storage system shall be designed to prevent intrusion of seawater during the entire deployment interval.
FCEL-012	Fuel storage fuel leak	The Fuel Cell System fuel storage and distribution system shall be designed to prevent leakage of fuel to the environment during the entire deployment interval.
FCEL-013	Fuel cell exhaust	The Fuel Cell System waste heat and exhaust shall be dissipated in such a way as to have minimal impact on environmental science measurements.
FCEL-014	Fuel Cell power control	The Fuel Cell System power state shall be controllable by a logic level signal or contact closure.

Fuel Cell System Engineering Data

Spec No.	**Item**	**Requirement**
DATA-001	Serial interface	The communication interface between the Fuel Cell System and the PSC shall be full duplex serial.
DATA-002	Engineering data	The Fuel Cell System shall have the ability to provide power system engineering data to the PSC
DATA-003	Fuel Cell data rate	The Fuel Cell System engineering data interface shall be capable of a refresh rate of 1Hz.
DATA-004	Fuel Cell system continuous data mode	The Fuel Cell System data interface shall support a push or continuous data mode.
DATA-005	Fuel gauge	The Fuel Cell System shall be capable of monitoring and reporting quantity of fuel remaining.
DATA-006	Bus voltage	The Fuel Cell System shall be capable of monitoring and reporting output bus voltage.
DATA-007	Bus current monitoring	The Fuel Cell System shall be capable of monitoring and reporting output bus current.
DATA-008	Battery voltage monitoring	The Fuel Cell System shall be capable of monitoring and reporting internal battery voltage.

Quality Requirements

Manufacturing

QUAL-001: The Fuel Cell System shall be manufactured in accordance with the manufacturer’s best practices. Records of quality assurance tests and inspections shall be available for review by the purchaser.

Certificate of Compliance

QUAL-002: A certificate of compliance shall be provided with each delivered unit. The certificate of compliance shall be supported with copies of the Factory Acceptance Test report and calibration records (if applicable) for each unit.

Materials

QUAL-003: The materials used in construction of the Fuel Cell System and the Power System Controller module and associated equipment shall be chosen and treated in such a way as to reduce the levels of wear, corrosion and deterioration to allow multiple deployments of each unit.

Identification and Traceability Requirements

Power System marking

IDNT-001: Each Fuel Cell System shall be marked on an exterior surface with indelible ink. Marking shall include;

- Manufacturer's part number
- Unit serial number
- CGO part number: P/N 3309-00046-00001 for Fuel Cell System

Transportation case marking

IDNT-002: Transportation cases for the Fuel Cell System shall have external labels specifying safe handling precautions

Handling, Packaging, Shipping, and Storage Requirements

Storage temperature range

SHIP-001: The Fuel Cell System shall be capable of being stored between 0 F and 120 F for periods of up to 1 year.

Transportation environment

SHIP-002: The Fuel Cell System transportation case must survive shipping conditions defined by ASTM D4169 truck assurance level 1. [RQ-84]