Power producing buoy for strategic applications: Prototype and Testing – Q5 Report

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Report Period:	3/26/2010-6/25/2010

Summary

Activities in the fifth quarter of this project have been heavily oriented toward the design and build of the prototype that will be tested in the lab and at sea during the remainder of 2010. This prototype will demonstrate wave-energy to electrical energy conversion at a scale that is sufficient to validate the previous model estimates and allow the modeling to be used to confidently predict the capabilities of a larger system.

Activities

1. Completed the overall system engineering and architecture design for the prototype system.
2. Completed power take-off system engineering and design.
3. Began power take-off system fabrication, most components have been ordered.
4. Held a design review with Levant that marked the end of the first phase of their effort.
5. Designed and began fabrication of the test facility needed to exercise the power take-off system.
6. Submitted an "add-on" proposal to begin the exploration of AUV docking to the buoy power station in late 2010.

Technical Status and Results

The prototype system that is currently under development will consist of a surface buoy (waterplane area = $5m^2$) connected to a submerged flat plate (area = 10 m^2) through a power take-off system that converts mechanical energy to electrical energy. Figure 1 shows a system level diagram that illustrates how the system is partitioned into several sub-systems. The mechanical components such as the submerged plate, tether and buoy structure are relatively straightforward and borrow heavily from similar oceanographic buoy systems. The controller sub-system is responsible for the overall system monitoring, communications, and data logging requirements of the system. This main controller is comprised largely of off-the-shelf computing and communications equipment and as such is not optimal in terms of performance and power consumption, but does meet the requirements with a minimum of engineering input required. The power take-off system however is the heart of the system and considerable attention has been paid to the engineering of this system.

Figure 2 shows a schematic of the power take-off system mechanical and electrical components. The Levant supplied components (shown in yellow) were reviewed at MBARI during this report period and those reviews cleared the way for Levant to fabricate the device which should be delivered in early August. Also required for the PTO system is a spring element. Several concepts were explored for this important element and a pneumatic spring device has been designed and is under construction at MBARI. Based on a CFD study of the gas dynamics in the device it appears that this will result in an efficient and adjustable spring for the system. The power take-off controller electronics have been designed and are also under construction after design reviews that took place during this quarter. The design of this element includes sufficient instrumentation (pressure sensors, temperature sensors, position sensors, and load cells) to allow the performance of the device to be analyzed and optimized during testing. The controller electronics consist of a microcontroller system that has sufficient computational power to implement any control algorithms for optimizing power take-off that can be reasonably envisioned. This optimization has not been started but will be enabled by the existence of the numerical models developed in the first stage of the project. In that stage no special treatment was given to the exact force/speed characterization of the power take-off system when the power estimates were developed but the existence of an instrumented prototype will allow the exact characteristics of the power take-off system to be incorporated into the numerical model.

Testing of the complete power take-off system will commence in August 2010 on a test facility being developed at MBARI (see below). At-sea testing of the complete device is currently scheduled for October 2010.

Also during this report period, an add-on proposal was submitted to explore the feasibility and challenges of adding an AUV docking component to the floating wave-energy buoy.

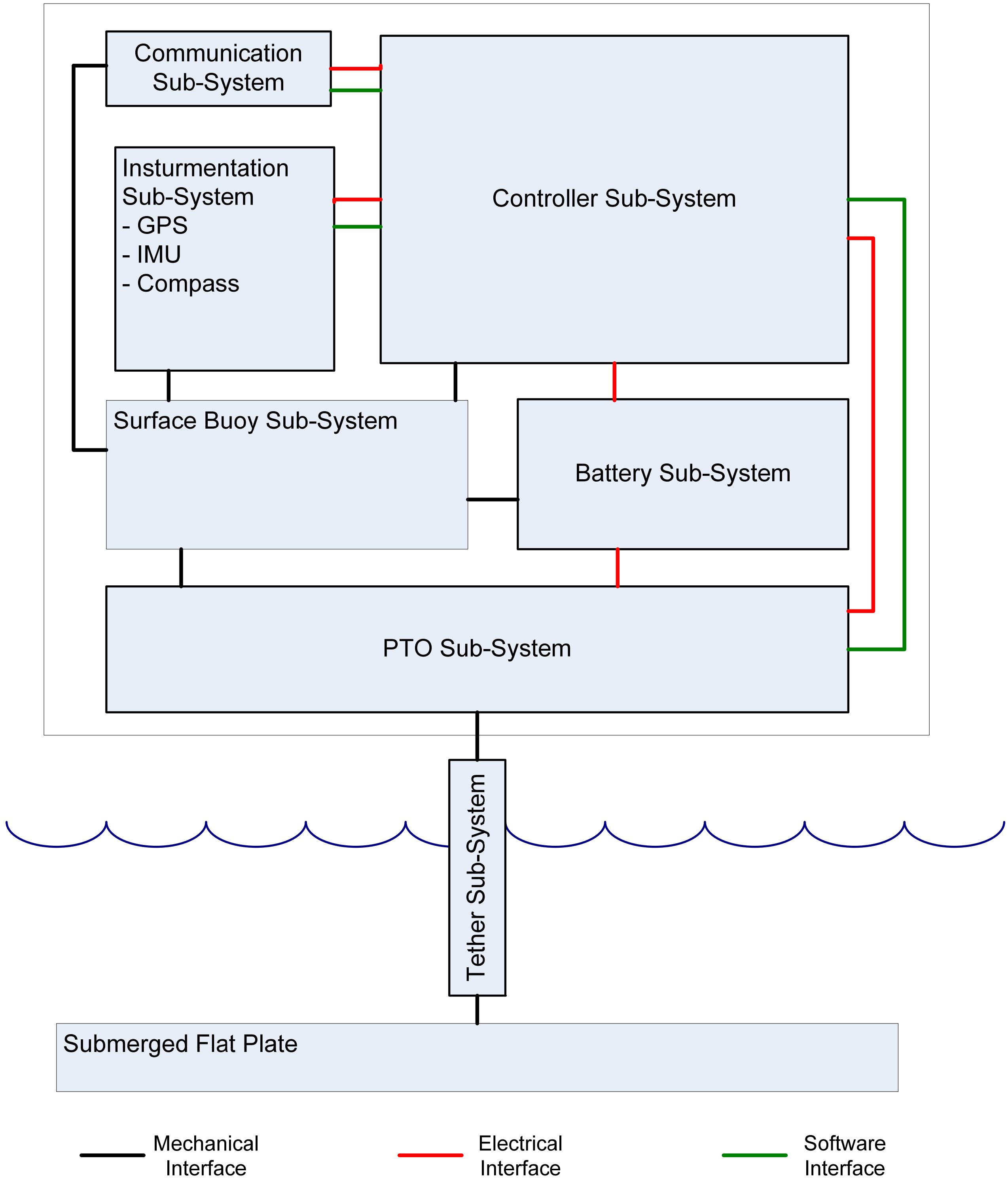

Figure 1: System block diagram for instrumented prototype being developed in stage two of the project.

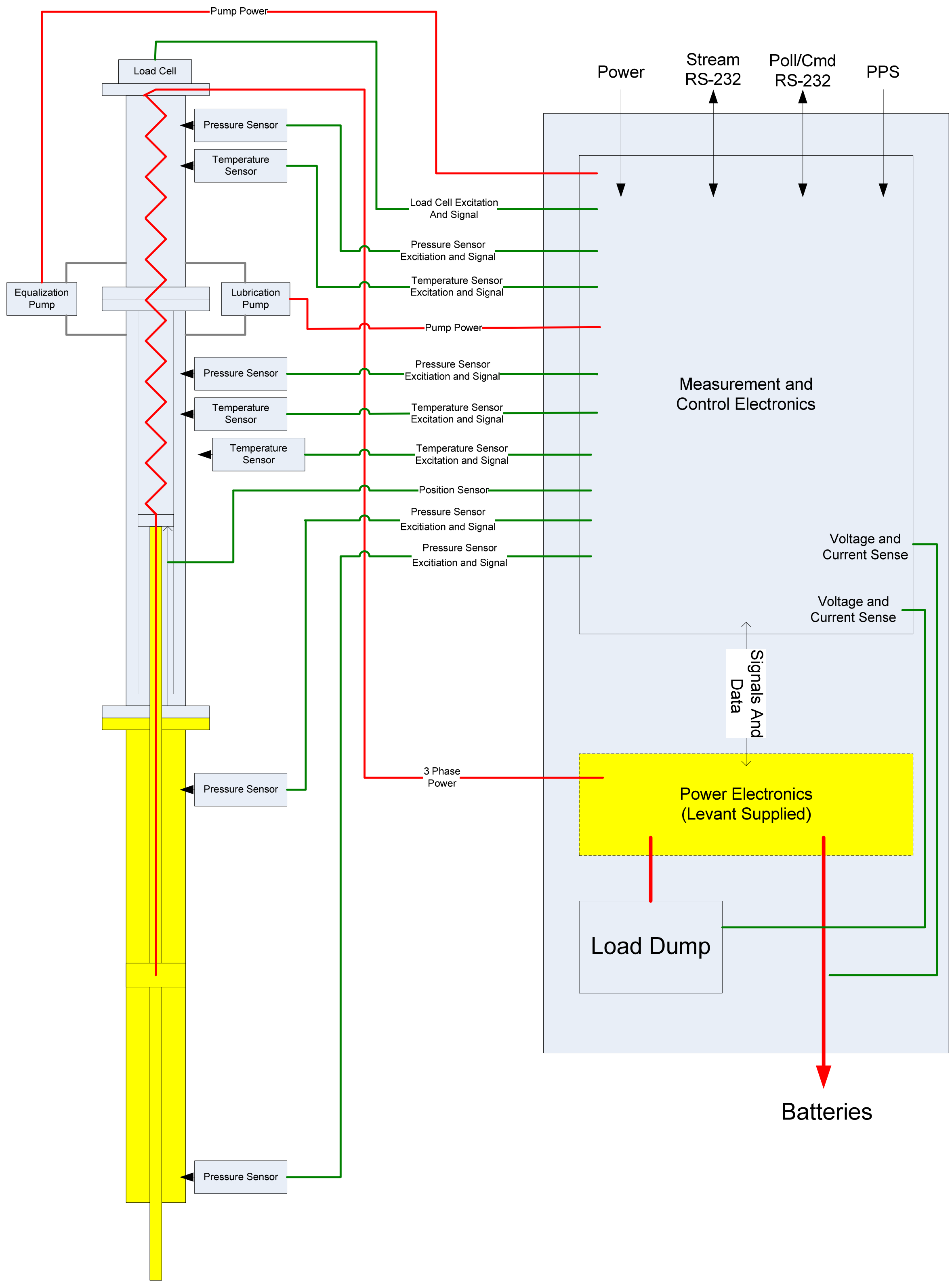

Figure 2: Power take-off system block diagram. Items colored in yellow will be provided by Levant.

In order to test and characterize the power take-off system in the lab, a test facility is under construction that will allow the power-take off system to be subjected to the same forces and speeds that are expected based upon the numerical modeling elements. Figure 3 show a rendering of the test facility that has been designed and is under construction. In this image the buoy power take-off system is on the right hand side and is connected through a load cell to a driving hydraulic ram that is controlled by an electronic motion controller and proportional servo valve. For this system the peak expected forces and speeds for this prototype are about 7500lbs at up to 2 m/s. The relatively large size of the test bed will support these requirements (and more) without significant deflections that would compromise the integrity of the system under test. This equipment will be built and operated at MBARI.

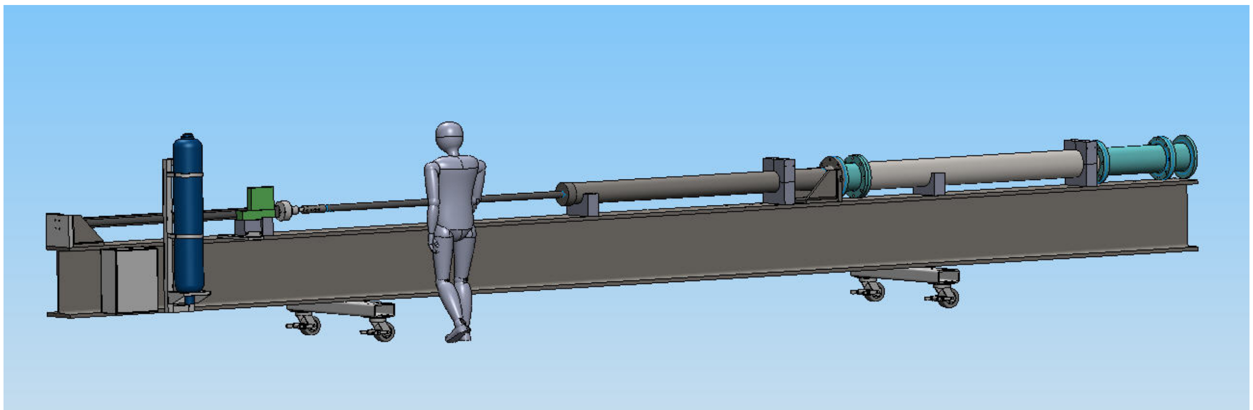

Figure 3: Illustration of test machine, the buoy power take-off system is shown on the right and the driving hydraulic components are shown on the left.

Figure 4 is a schematic showing the electro-hydraulic control system for the driving ram side of the test machine. Two of the main components in this system are MBARI owned assets; the HPU is a 30HP hydraulic power unit, the control system is an appropriate hydraulic control system used on another project and is also an MBARI asset that will be on loan to this project. The driving ram itself belongs to this project and was used at sea in the initial model validation tests in 2009. The accumulator, proportional valve, and steel structure have been specified and purchased for this project. Construction of this system is underway.

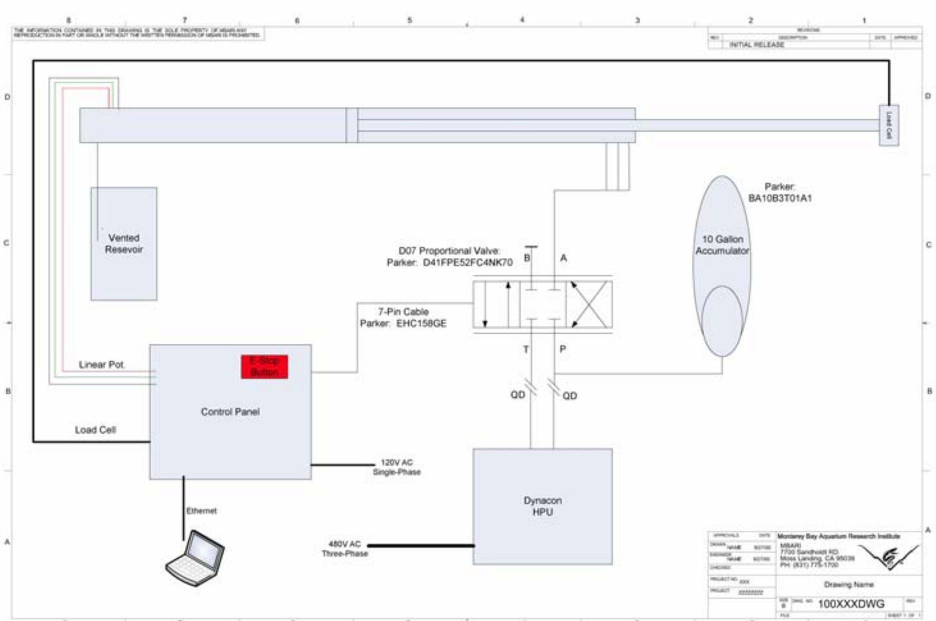

Figure 4: Test machine electro-hydraulic control system schematic

Budget and Spending

As shown in the attached report, at this point 45% of the funds budgeted for the first two years of the project have been spent. This is almost exactly on target relative to the original budget and planned spending profile. In the plan, 48% of the first two years budget was to have been spent at this point.

Attachments

1. MBARI Grant Status Report