Glen Canyon Smooth Water Controller Project Part II Design Progress Report

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Last year…

- ASU Gold team developed a system and design for a environmentally-sensitive non-fossil fuel based motorboat propulsion systems
- It included…
  - Ford Siemens EV Motor
  - Battery pack
  - Controller and inverter
- In the end they had a automotive controller that they were trying to adapt to the marine application.

Changes in Scope

- Assessment of last year's hardware
  - Some batteries were damaged
  - The controller/inverter was damaged
  - Safety
- Initial project goal
  - Repair the inverter
    - Time, Safety, and Cost
- Questions that needed to be answered
  - Is there a motor-controller-battery combo out there somewhere?
  - What is our budget to achieve these things?
  - How can we find a new controller/inverter?

New Direction

- Original
  - Repair inverter
- New Directions
  - Put together a land-based system that can characterize the motor and its performance and allow us to make recommendations for how to proceed with the on-boat prototype.

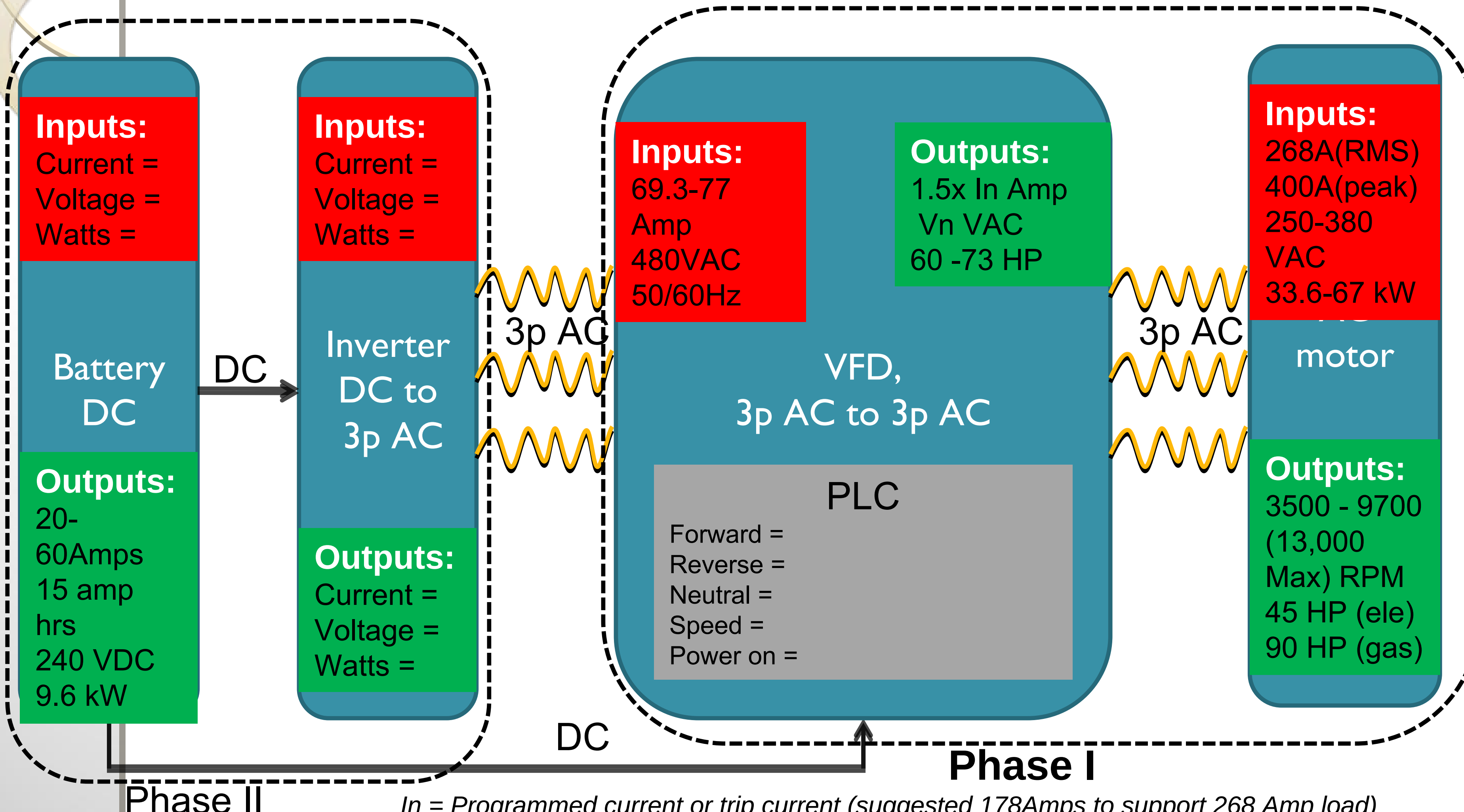
Current Plan Design

Phase I (August 2009 – May 2010)

- This phase includes the development planning and integration of the Variable Frequency Drive controller (VFD) with the Siemens AC motor. This phase will also involve the interconnects and programming of the VFD controller to manipulate the performance of the AC motor for unit performance testing.

ASU Glen Canyon II System Diagram

Team: Tyler Wallace, Melissa Martinez, Ryan Schaumburg, Adam Reynolds



In = Programmed current or trip current (suggested 178Amps to support 268 Amp load)
Vn = Programmed Voltage (suggested 240 or 250 VAC)

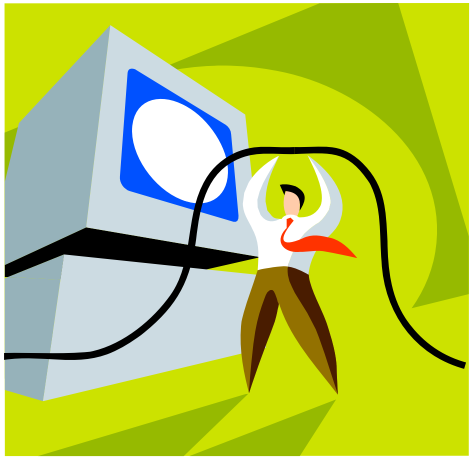
There is a possibility of bypassing the Inverter by connecting the battery to the DC voltage in the VFD.

Main Goal of Phase I

- Find or Repair VFD. (completed)
- Find generator or location that can supply required Voltage and Amperage for VFD. (50% complete)
- Remove bearings from AC motor and replace with sealed ones. (70% complete)
- Connect VFD to AC motor (incomplete)
- Find and/or program PLC (50% complete)
- Test controls by manipulating frequencies (incomplete)
- Test unit performance in and out of water tank (incomplete)
- Attach throttle control and retest (incomplete)

Constraints

- Finding a viable power source for testing the controller. (VFD)
- Actual system performance test results don’t match theoretical values.



Electric motor peak power output needed for plane:

45 hp (ele) → 33.56kW

Theoretical VFD max output:

77 Amps x 480 Volts = 36.9 kW.

Phase II

Scope (Mar. 2010 – May 2010)

- The second phase of the project will consist of researching a viable on-boat prototype power supply and conditioner including:
  - Batteries
  - Inverter and/or a new controller
  - Different motor options

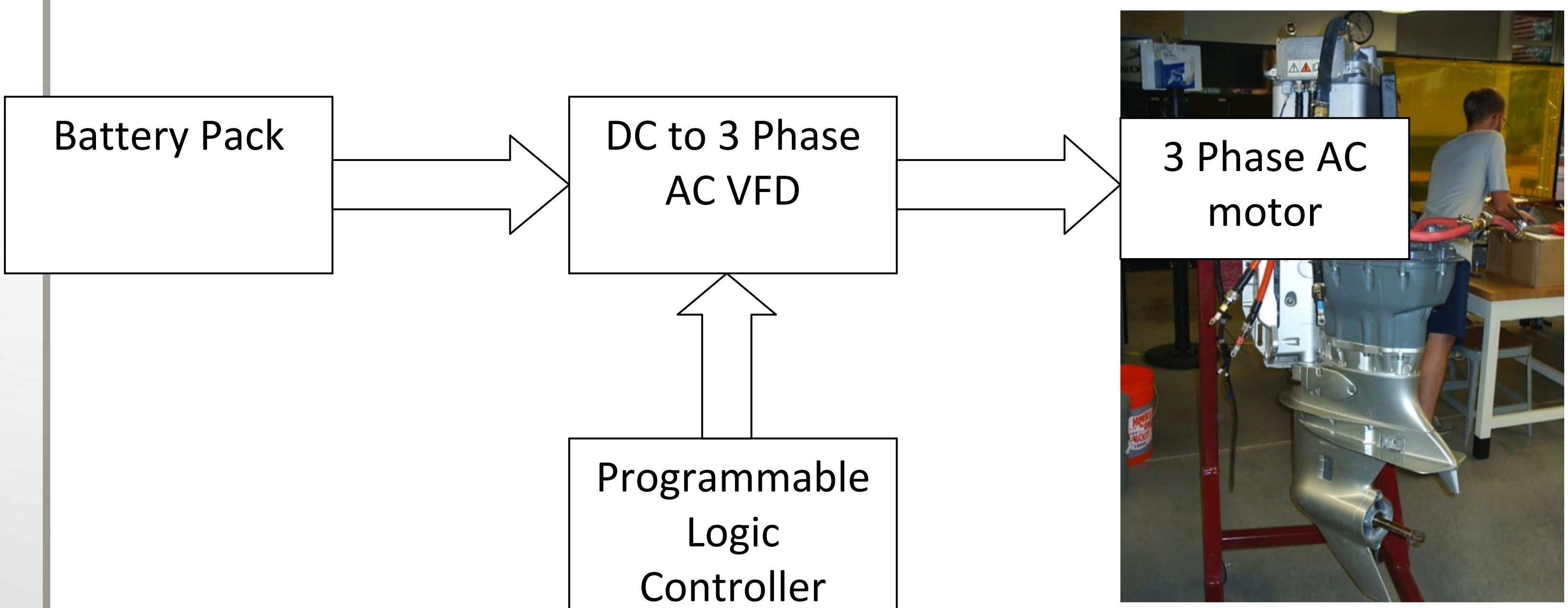
Future Goals

- Find high energy density batteries capable of operating at a high discharge rate
- Determine appropriate number of batteries capable of providing all power for the duration of the trip
- Find or construct appropriate circuitry and enclosure for battery system that fulfills all safety requirements
- Find or construct appropriate inverter circuitry and VFD controller capable of full aquatic operation at a size and weight that keeps all equipment from being intrusive
- Develop the monitoring and gauge system required both by GCROA and required to meet safety requirements
- Develop a charging system that meets the limited window required to both charge the batteries and to get the boat back in the water for the next trip
- Install entire system to meet high safety standards to run small and large scale trial runs

Implementation

- How is the device physically going to be connected?
- How will it be powered?
- What tests will be performed?
- Two versions of Implementation
  - On-boat prototype
  - Proof of Concept

On-boat Prototype Connections
(Phase II)



On-boat Prototype (Phase II)

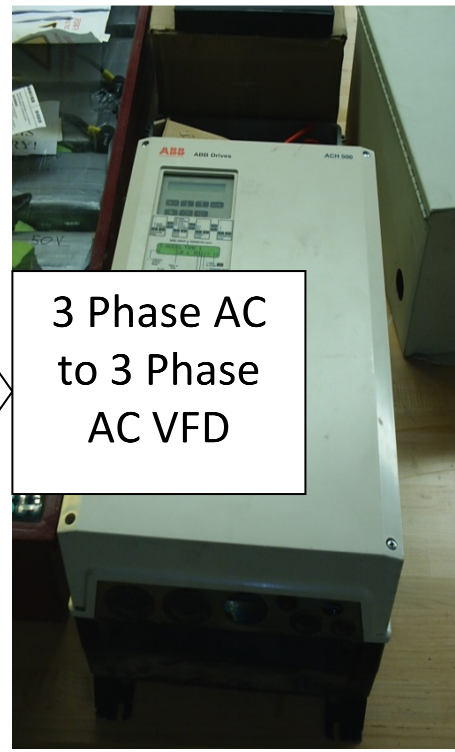
- Battery pack to power VFD to drive AC motor
- Batteries are not rated high enough for application
- Require DC to 3 Phase AC VFD
  - Too expensive for budget

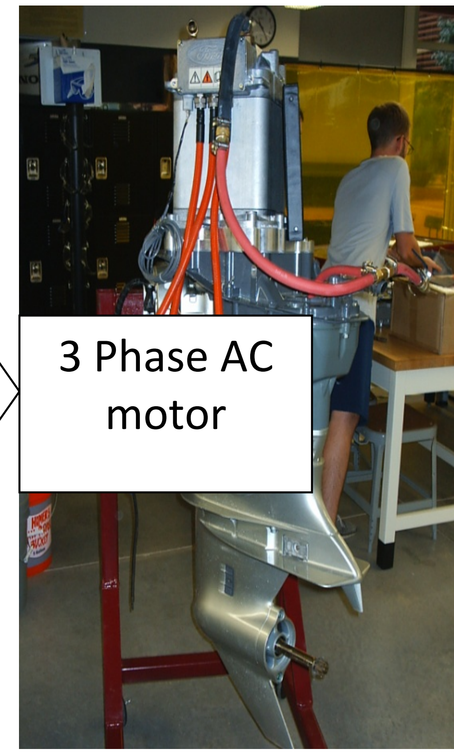
Proof of Concept

- 3 Phase AC generator power supply
  - 3 Phase supply at ASU
  - 3 Phase generator
- 3 Phase to 3 Phase VFD with controller
- Will be able to run and test the motor for specifications for future use
  - Torque, Speed, Power, etc…

Proof of Concept Connections

3 Phase AC generator → 3 Phase AC to 3 Phase AC VFD → 3 Phase AC motor





Desired Deliverables (Phase 1)

- Have an AC motor with sealed bearing.
- Have a controller that is properly connected to the AC motor and a viable power source
- Have the PLC programmed and working the AC motor in all operation possibilities with a throttle.
- Provide test results for torque, power, etc.

Aquatic Vessel Safety Requirements

CODE OF FEDERAL REGULATIONS

Title 46 – Shipping
Chapter I – Coast Guard, Department of Homeland Security

Part 176 – Inspection and Certification
Part 182 – Machinery Installation
Part 183 – Electrical Installation
Part 184 – Vessel Control and Miscellaneous Systems and Equipment

Section	Description
176.806	Electrical Equipment Inspection
182.710, 720	Piping for Vital Systems
183.200	General Design, Electrical Installation
183.210	Protection from Wet Environments
183.220	General Safety Provisions
183.310	Power Sources
183.320	Generators and Motors
183.330	Distribution Panels and Switchboards
183.340	Cable and Wiring Requirements
183.350	Batteries (General)
183.352, 354	Battery Categories and Installation
183.372	Equipment and Conductor Grounding
183.378	Ungrounded Systems
183.380	Overcurrent Protection
183.390	Shore Power
184.620	Propulsion Engine Control Systems

REQUIREMENTS FOR ALL SYSTEMS

Affected Sections:

176.806
183.200
183.210
183.220
183.330
183.340
183.372
183.378
183.380

Required for All Systems
Conductor and Fuses Chosen to Allow Correct Operation
Electrical Discharge Through Conducting Paths
Accessible for Inspection
Clear and Accurate Labeling
Weather Proof and Water Tight
Survive Normal Operating Movements
Distribution Panel for Power System Connection
Ground Detection System
Overcurrent Protection with Disconnects

BATTERIES

Affected Sections:
183.310
183.350
183.352
183.354
183.390

Safety Requirements Specific to Batteries
Chemical Corrosion of Battery Components
Proper Size To Operate for Three Hours
Proper Ventilation to Release Fumes
Separate Dedicated Enclosure for Batteries
Properly Built Charging Station

INVERTER

Affected Sections:

No Sections Specific to Inverter Design

Safety Requirements Specific to Inverters
No Specific Requirements for Inverter Design

The inverter will need to be paired for the incoming and outgoing current and power requirements

VFD

Affected Sections:
184.620

Safety Requirements Specific to VFDs

Two Separate Control Systems Required to Control Engine Speed, Direction of Shaft Rotation, and Engine Shutdown

MOTOR

Affected Sections:
182.710
182.720
183.320

Safety Requirements Specific to the Motor
Coolant system hoses must meet standard SAE J-1942
Coolant system fittings must meet standard SAE J-1475
Must have Voltmeter, Ammeter, and Oscilloscope or other frequency measuring device

Acknowledgements

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ViaSol
ENERGY SOLUTIONS

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ON

ON Semiconductor

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Department of Engineering Technology

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Department of Engineering Technology

Conclusion

2nd Semester Goals

- Have a working prototype
- Power to the VFD
- Be able to demo and give recommendations to GCROA

Any Questions???