Advanced Direct Methanol Fuel Cell for Mobile Computing

University of North Florida

Jim Fletcher, Ph.D.

University of North Florida

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Project ID # ARRAH2004

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Overview

Timeline

- Start date: January 1, 2010
- End date: December 31, 2011
- Percent complete: 16%

Barriers

Characteristic	Requirement
Specific Power	100 W/kg
Cost	<$3/watt
Lifetime	5000 hours

Budget

- Total project budget $3,054,464
  - DOE share $2,443,441
  - Contractor share $611,023
- Funding for FY10 $3,054,464

Partners

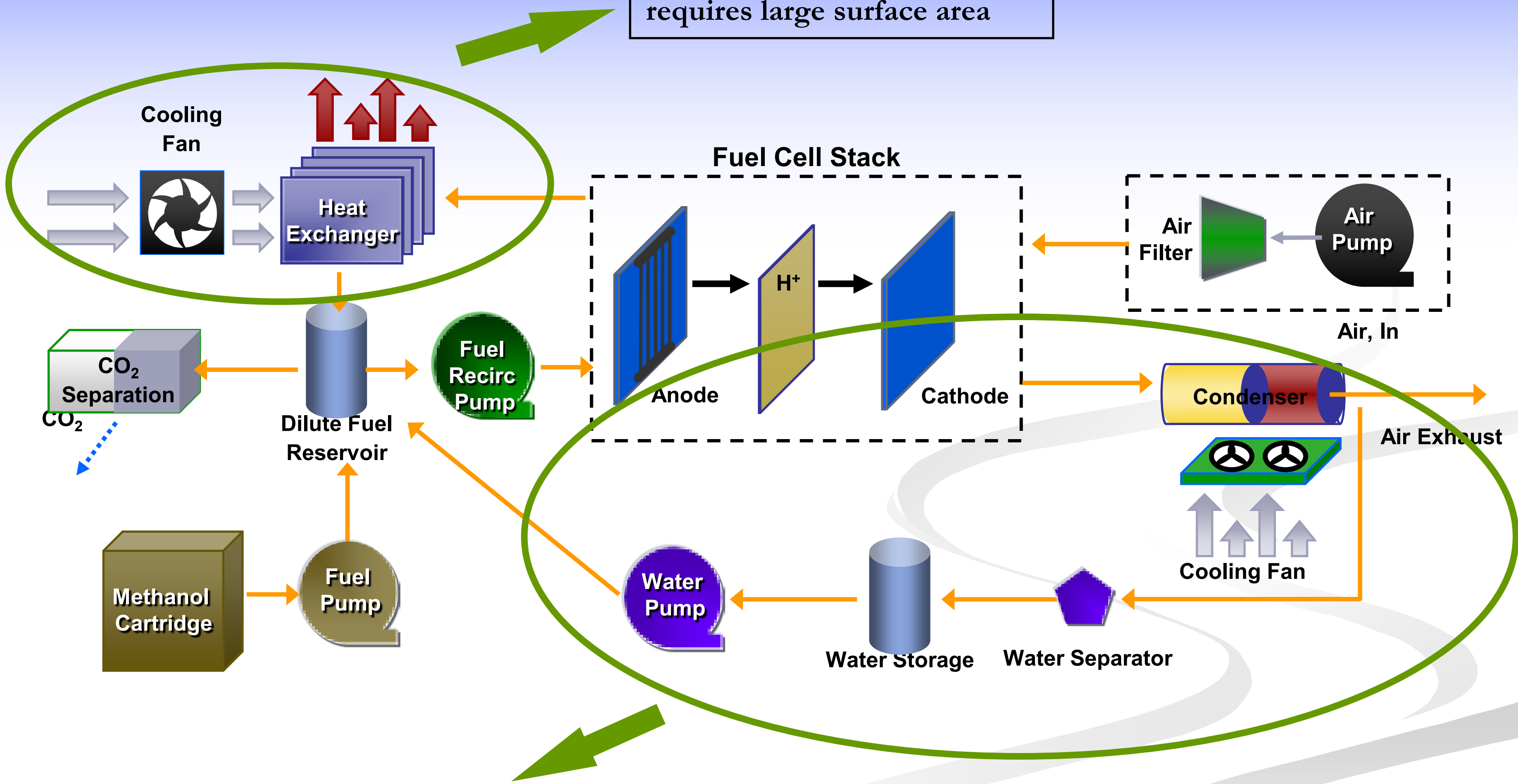
- University of Florida

Relevance: Objective

- The project objective is to develop a DMFC power supply for mobile computing using the novel passive water recycling technology acquired by UNF from PolyFuel, Inc., which enables significant simplification of DMFC systems.
  - The objective of the 2010 effort to date is to define the system concept and develop the required design requirements (system, sub-system, and component) in order to achieve the 2010 Technical Targets.
  - Initial component development effort, based on the CDRs, is nearly completed

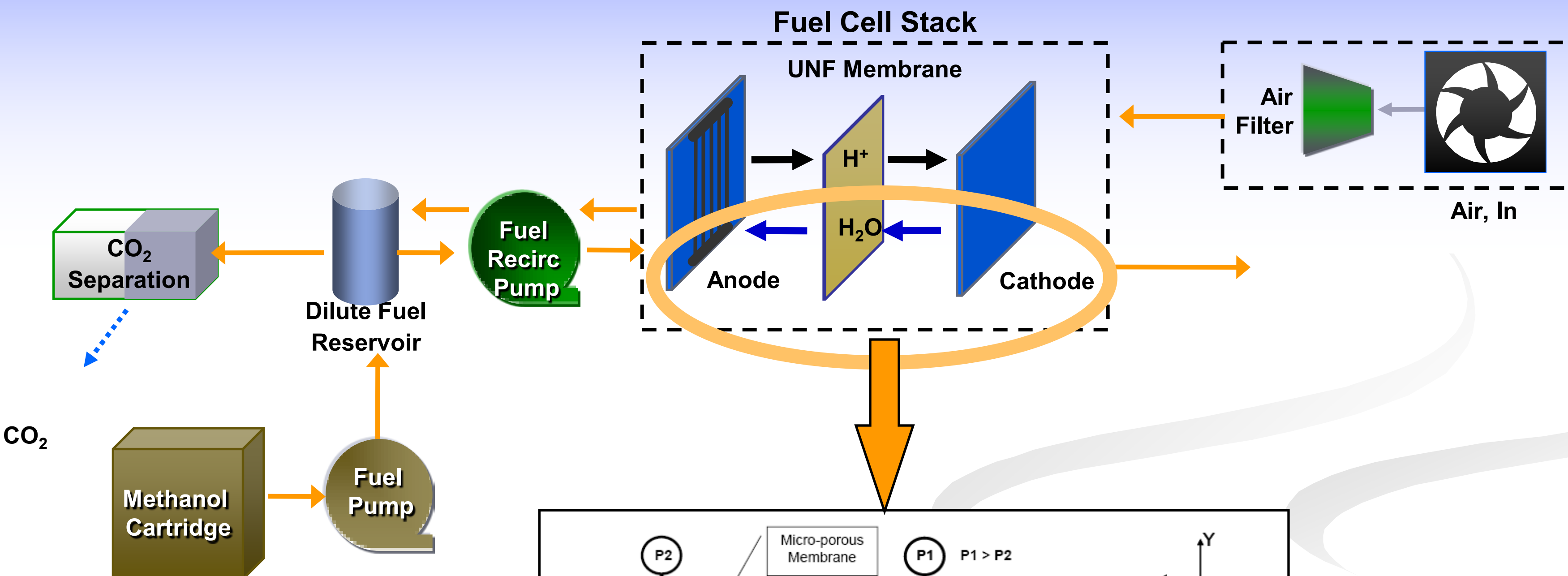
Relevance: Conventional DMFC System

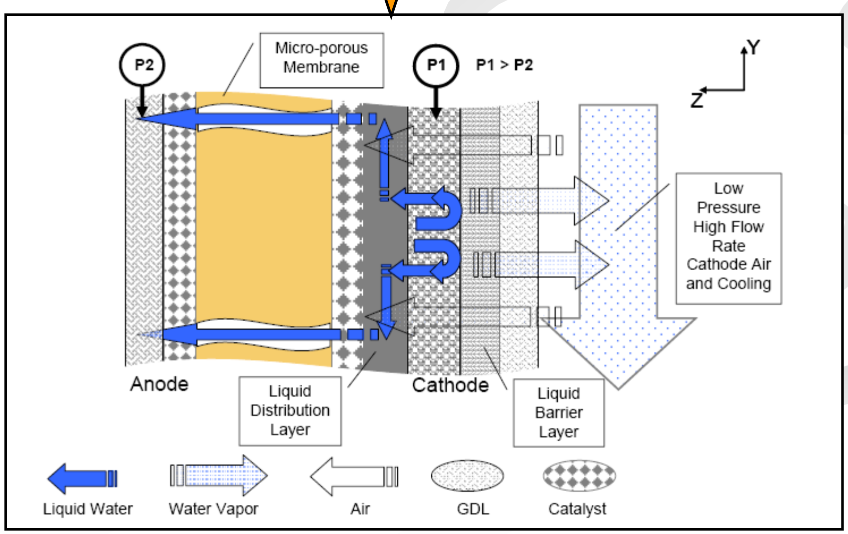
Radiator heat exchanger requires large surface area



Water recovery components are large and cumbersome - also do not directly aid the electrochemical process

Relevance: UNF’s Simplified DMFC System





Novel passive water recovery MEA significantly reduces the number of balance of plant components

Relevance: Impact

- Incorporating the novel passive water recovery technology results in significant reduction in the number of components

Characteristic	Units	UNF 15 W DP3 2008 Status	DOE 2010 Target	UNF Proposed 20W System Design
Specific Power [a]	W / kg	35	100	54
Power Density [a]	W / L	48	100	63
Energy Density	W-hr / L	250 (1 x 100ml)[b] 396 (1 x 200ml)[b]	1000	198 (1 x 100ml) 313 (1 x 200ml) 507 (3 x 200 ml)
	W-hr/kg	155 (1 x 100ml)[b] 247 (1 x 200ml)[b]	N/A	180 (1 x 100 ml) 302 (1 x 200 ml) 532 (3 x 200 ml)
Lifetime [c]	Operating Hours	1,000 hrs in single cell	5,000	2,500 Integrated System
Cost	$ / Watt	11 (est. in volume)	<3	< 10 (est. in volume)

[a] Beginning of life, 30°C, sea level,50% R.H., excluding hybrid battery, power module alone
[b] Normalized from DP3 data from 150 ml cartridge to either 100ml or 200ml for comparison purposes
[c] Lifetime measured to 80% of rated power

Marked improvement on the road towards commercialization.

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Approach: Project Integration

- This project is focused on the balance of plant (pumps, blowers, etc.) development and overall system integration

- This effort is highly integrated with the UNF-led Topic 5A: *New MEA Materials for Improved DMFC Performance, Durability, and Cost* project (DOE funded) which focuses on optimizing the passive water recovery MEA
  - The passive water recovery MEA performance will be improved
  - As part of the Topic 5A program, industry partner Johnson Matthey will apply commercial processes to the MEA production
  - Critical to achieving cost, robustness, and lifetime goals for the DMFC power supply

Integrating the commercially produced MEA into the improved balance of plant is an important step towards commercialization.

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Approach: Milestones

25% Complete

- **Component Engineering**
  - CDRs Revised
  - Component DFMEAs
  - Key Subsystems – Prototypes
  - Shell Body and Interface Prototypes
  - Fuel Cartridge Prototype

15% Complete

- **Component/Subassembly Testing**
  - Component Performance & Durability
  - Integrated Subsystem Testing

25% Complete

- **System Engineering**
  - Concept Design
  - DFMEA, DFMA of System
  - Brassboard Assembly & Testing
  - System Assembly & Testing

10% Complete

- **Control System Development**
  - Rest /Rejuvenation Protocol Optimization
  - Start-up & Shut-down Protocol
  - Operating Protocol Tuning Revised System

10% Complete

- **System Validation Testing**
  - Test Plan Released
  - Operating and Storage Durability Testing
  - Ex-Situ System Testing
  - In-Situ System Testing

- **Program Management**
  - Quarterly & Annual Report
  - Go /No-Go Decision
    - Specific Power: 40 W/kg
    - Power Density: 55 W/l
    - Energy Density: 575 W·hr/l

    (3 x 200 mL cartridges)

The project is on schedule.

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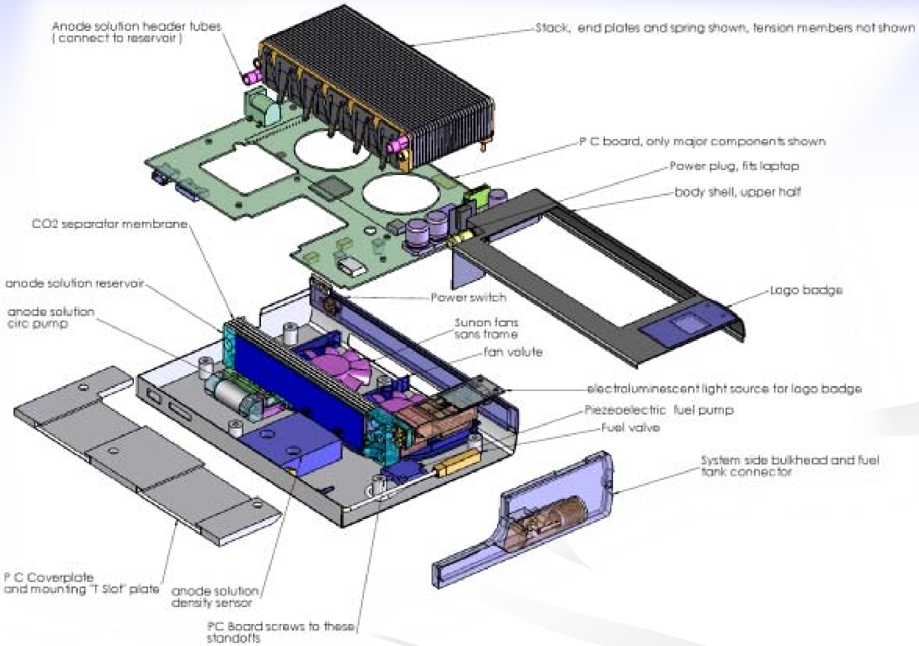
Previous Accomplishments: Existing DP3

Fuel cartridge and power section

DP3 System with comparable battery energy



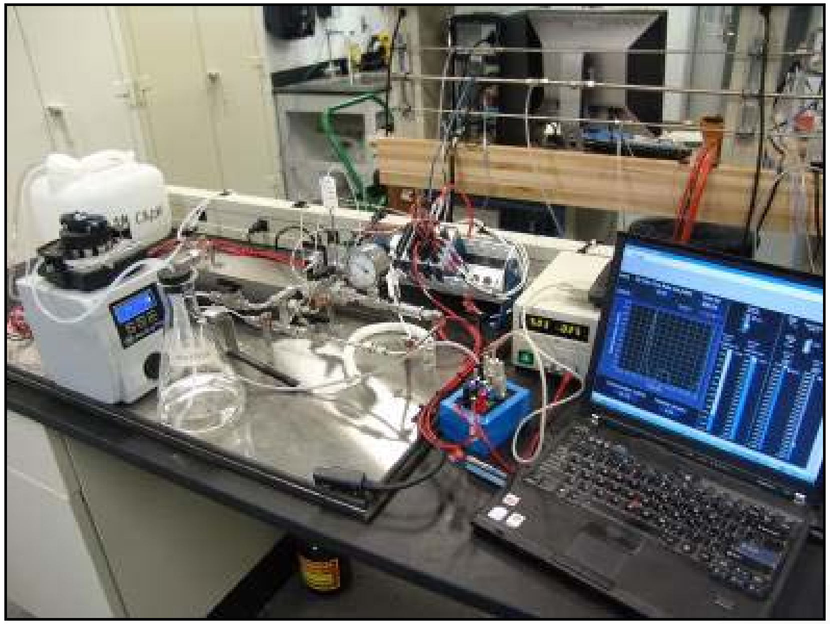
DP3 Exploded View

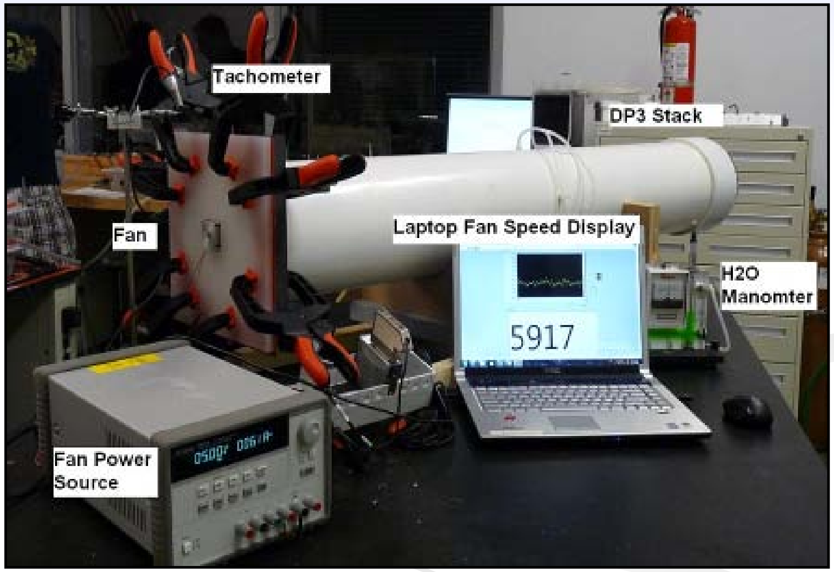
DP3 was a successful proof-of-concept design.

Technical Accomplishments: Component Test Stands

Test stands will be used for each component to insure the component design requirements are met

Methanol Sensor Test Stand: Used to measure the accuracy, transient response, and robustness of various methanol concentration sensor technologies





Cooling Fan Test Stand: Used to measure the performance and efficiency of small-scale motor-blower combinations

Accomplishments: Design Requirements

OVERVIEW								
System Requirements							CDR	
Power Section Requirements						CDR		
Fuel Cell Stack					CDR			
MEA								
Bipolar plate								
Stack ancillaries								
Air Management					CDR			
Thermal								
Noise / filtration								
Fuel Subsystem				Analysis	CDR			
Recirculation Pump								
Gas-Liquid Separator								
Reservoir isolation system								
Methanol conc. Sensing								
Fuel feed subystem					CDR			
Feed pump, isolation valve								
Fluid & mechanical interface								
Fuel Cartridge (Energy Storage)						CDR		
Fluid containment								
Mechanical								

- CDRs are 75% complete at time of submission for merit review

Robust engineering design and development process.

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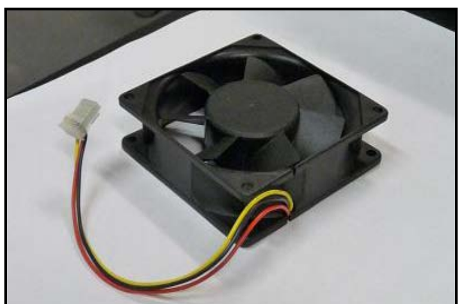
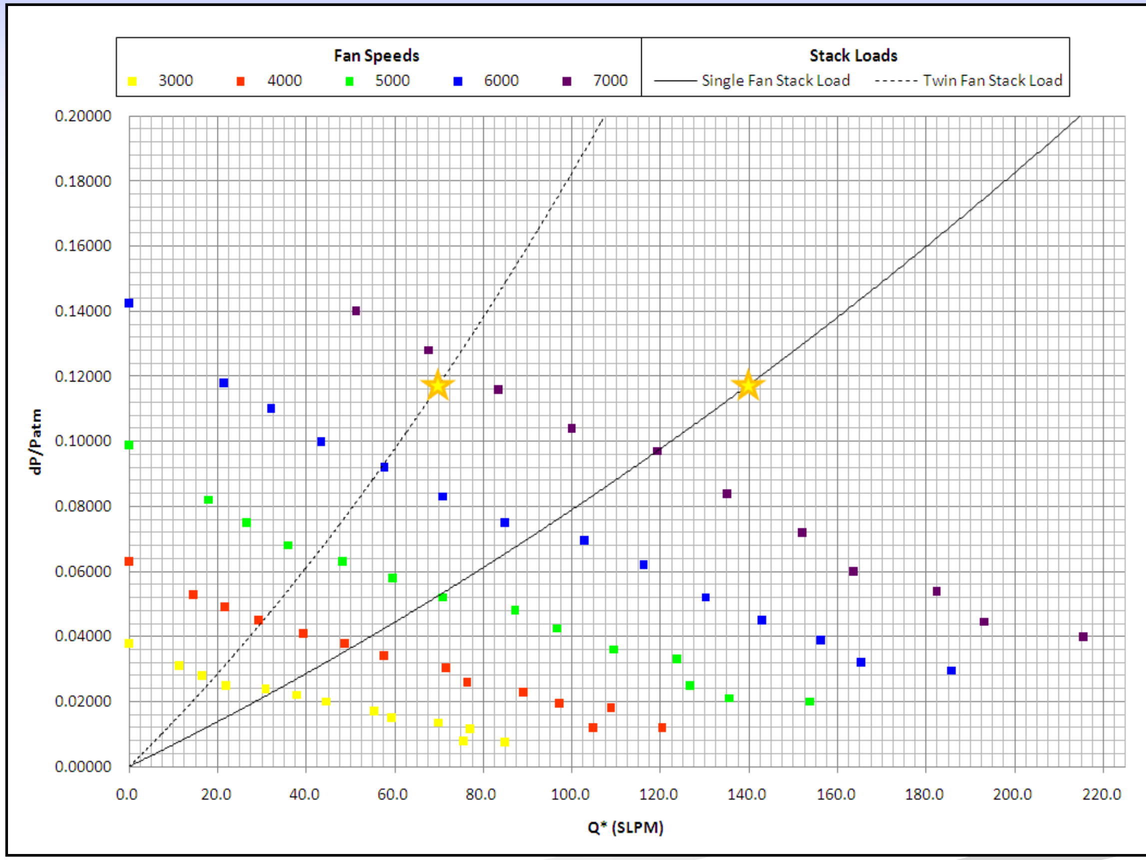
Accomplishments: Fan Test Results

Fan	Peak Efficiency
Adda AD4505HX-K90	5.2
Sunon GB0545AFV1-8	6.0
OLC CFR3B5H	2.0
Sunon KDE1204PKVX	4.3
Y.S.Tech YW0401000-5BH	3.0

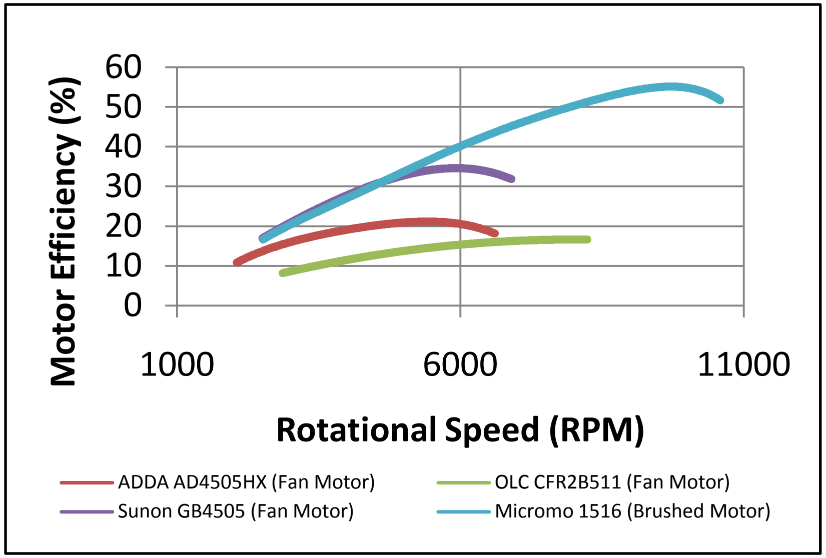


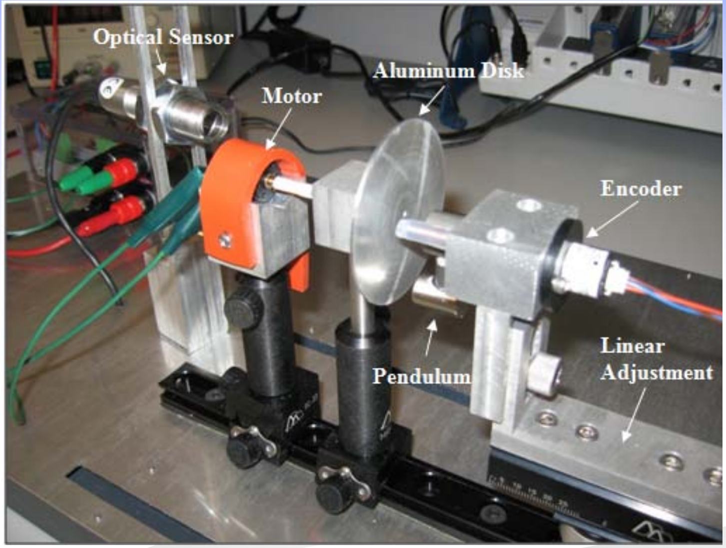


A dual fan configuration meets the design requirements.

Accomplishments: Fan Test Results

Component	Power Budget (mW)
Methanol Injection Pump	50
Fuel Supply Solenoid Valve	100
Anode Recirculation Pump	1000
Cooling/Oxidant Fans	**2000**
Methanol Sensor	200





Testing showed motor-fan assembly efficiency typically 2-6%. Small motor dynamometer was developed to separate motor and fan efficiencies

Important to minimize the parasitic load to meet efficiency and run-time goals.

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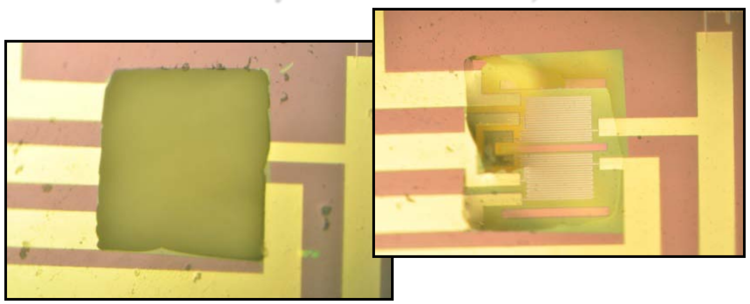
Methanol Concentration Sensor Testing

Siargo FSC-2000 and ISSYS sensors.

Siargo FSC-2000 MEMS Sensor

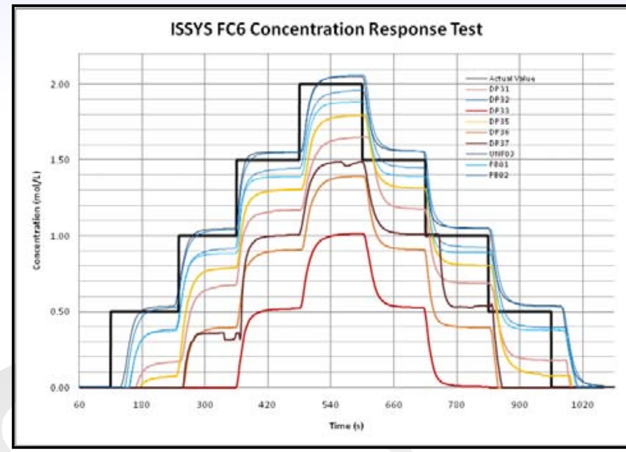
(Thermal Conductivity → Concentration)



Siargo FSC-2000 susceptible to stress cracking due to thin sensor membrane

ISSYS FC6 MEMS Sensor

(Density → Concentration)



ISSYS FC6 sensitive to mechanical shock and accuracy drift.

No current methanol concentration sensor meets the CDR. Other sensing technologies must be investigated (Viscosity, Crossover CO_2, Acoustic Wave, etc.)

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Hydrogen Safety Plan

- **All laboratories are outfitted with gas detection systems to alarm researchers in the event of a hydrogen leak.**

- **The hydrogen safety plan has been submitted and is under review.**

Hydrogen Sensor Probe: The small hydrogen detector is installed at several remote locations providing gas detection at levels greater than 100 ppm.

KnowzNet Gas Detection System: The 8 channel gas detection system works in conjunction with the hydrogen sensor probes in order to provide gas monitoring and alerts at various locations.

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Collaborations

- University of Florida (Academic)
  - Dr. Bill Lear leads the effort to develop critical components including the fuel pump, the recirculation pump, and the CO_2 removal membrane
  - Dr. Oscar Crissale leads the effort to develop the overall control strategy
- The DOE funded project (UNF Prime) *New MEA Materials for Improved DMFC Performance, Durability, and Cost* includes the following collaborators:
  - University of Florida (Academic): Focus on manufacturability and advanced catalysis
  - Johnson Matthey (Industry): Integration of commercial processes into the MEA manufacturing
  - Northeastern University (Academic): Advanced catalysis focused on ultra-stable ruthenium catalyst

The University of North Florida (Prime) and the University of Florida also collaborate on a U.S. Army CERDEC funded project to develop a militarized version of the DMFC laptop power supply

Proposed Future Work

- Remaining FY2010:
  - Complete design requirements and DFMEAs (UNF)
  - Complete component development (UNF, UF)
  - Brassboard (unpackaged) system testing (UNF)

  - KEY Milestone: Demonstrate component performance meets requirements

- FY2011:
  - Complete development of advanced control strategies (UF)
  - Integrate components and sub-systems into packaged unit (UNF)
  - Extensive system testing including performance, robustness, and lifetime (UNF, UF)

  - KEY Milestone: Compare system attributes (power density, expected lifetime, etc.) versus DOE requirements.

Project Summary

- **Project Relevance:** The novel passive water recovery MEA technology allows for simplified balance-of-plant which results in a DMFC power supply approaching the DOE 2010 Technical targets
- **Approach:** Cascade-down design requirements to each component resulting in a robust design. Integrate the balance-of-plant with the optimized passive water recovery MEA
- **Technical Accomplishments:** Design requirements completed and initial component development underway
- **Collaborations:** Technical expertise at UF focused on component development and robust control system.
- **Proposed Future Work:** Complete component development in 2010. System integration and testing (including advanced MEA) in 2011

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