Design of a Hybrid Electric People Transporter

December 3, 2004

Objectives

- Complete a 100-mile drive with hybrid transporter
- Redesign Charging Circuit
  - PEM fuel cell is primary power source
  - Li-ion batteries power motor
- Improve Cart Design
- Analysis of Hydrogen Economy
  - Production, Storage, Transportation, Safety
  - Comparison of two hydrogen production methods

Smaller Groups

- Vehicle Design Team
  - Dong Chul Lim
  - Ken Weber
- Battery Team
  - Steven Langel
  - Dong Chul Lim
  - Alison Smith
- Fuel Cell Team
  - Christina Lefief
  - Matt Moy
  - Olatunde Omolaoye
- Faculty Advisors
  - Dr. Said Al-Hallaj
  - Dr. Javad Abbasian
- Hybridization Team
  - Matthew Ayersman
  - Matthew Bachman
  - Olatunde Omolaoye
  - Michael Prince
  - Tanim Taher
- Business Team
  - Vince Aderangi
  - Rita Buresh
  - David Eisenberg
  - Steven Johnson
  - Rick Kraft
  - Christina Lefief
  - Matt Moy
  - Siddha Pimputkar

Battery Team

Steven Langel
Dong Chul Lim
Alison Smith

Objectives for Battery Team

- Status check of batteries for 100 mile drive
- Thermal testing of new carbon material
- Prototype implementing new design
- Construct a spare battery
- Internal resistance measurements
- Connect batteries to new charger

Current battery design

Accomplishments

- All eight batteries functional and charged
- Completion of spare battery
- Work begun on assembling charger

New phase change material

Hybridization Team

- Hybrid Section
  - Olatunde Omolaoye
  - Michael Prince
  - Tanim Taher
- Charger Section
  - Matthew Ayersman
  - Matthew Bachman

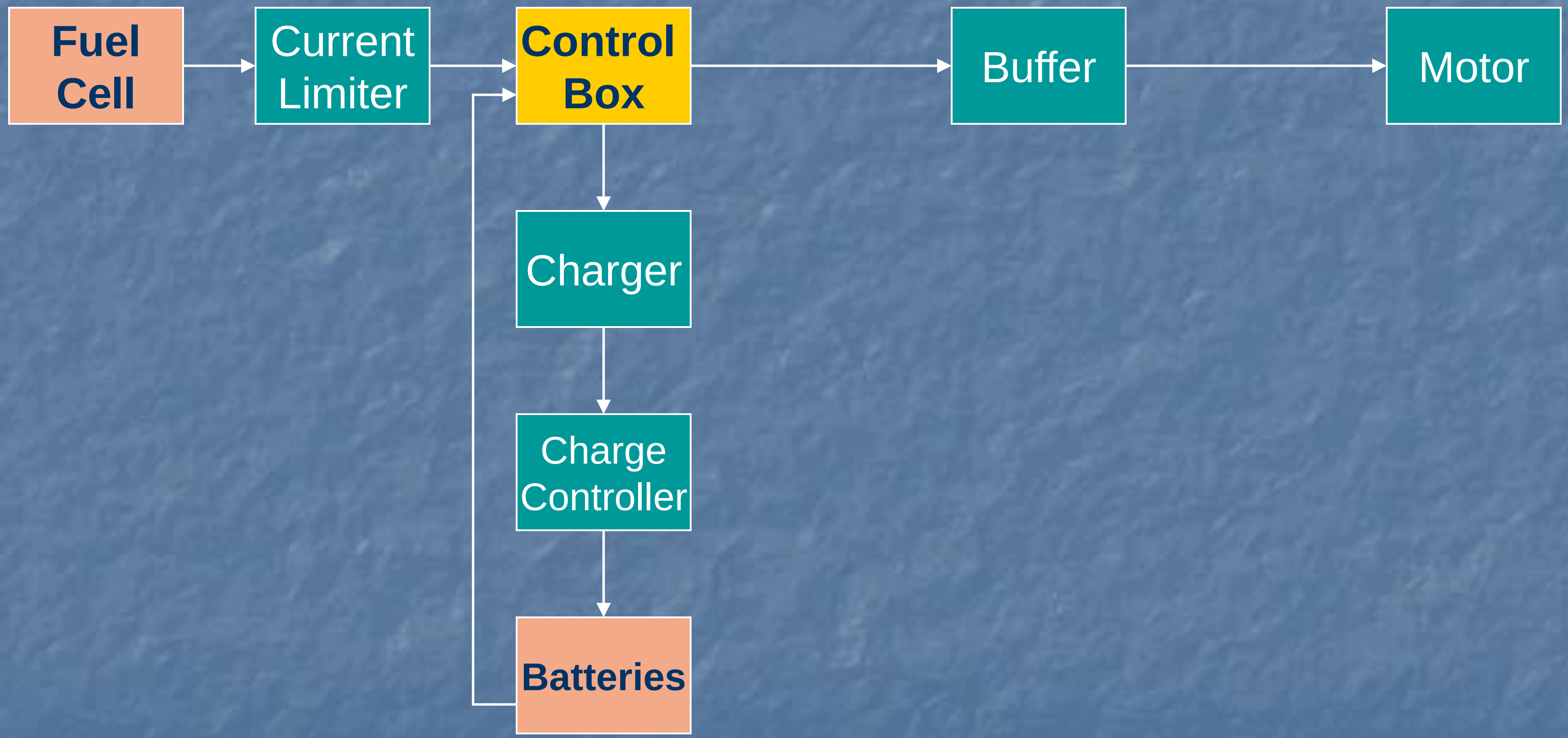
What is a Hybrid System?

- Comes from Latin word ‘Hybrida’
- Synergistic: Two sources, one task, better performance

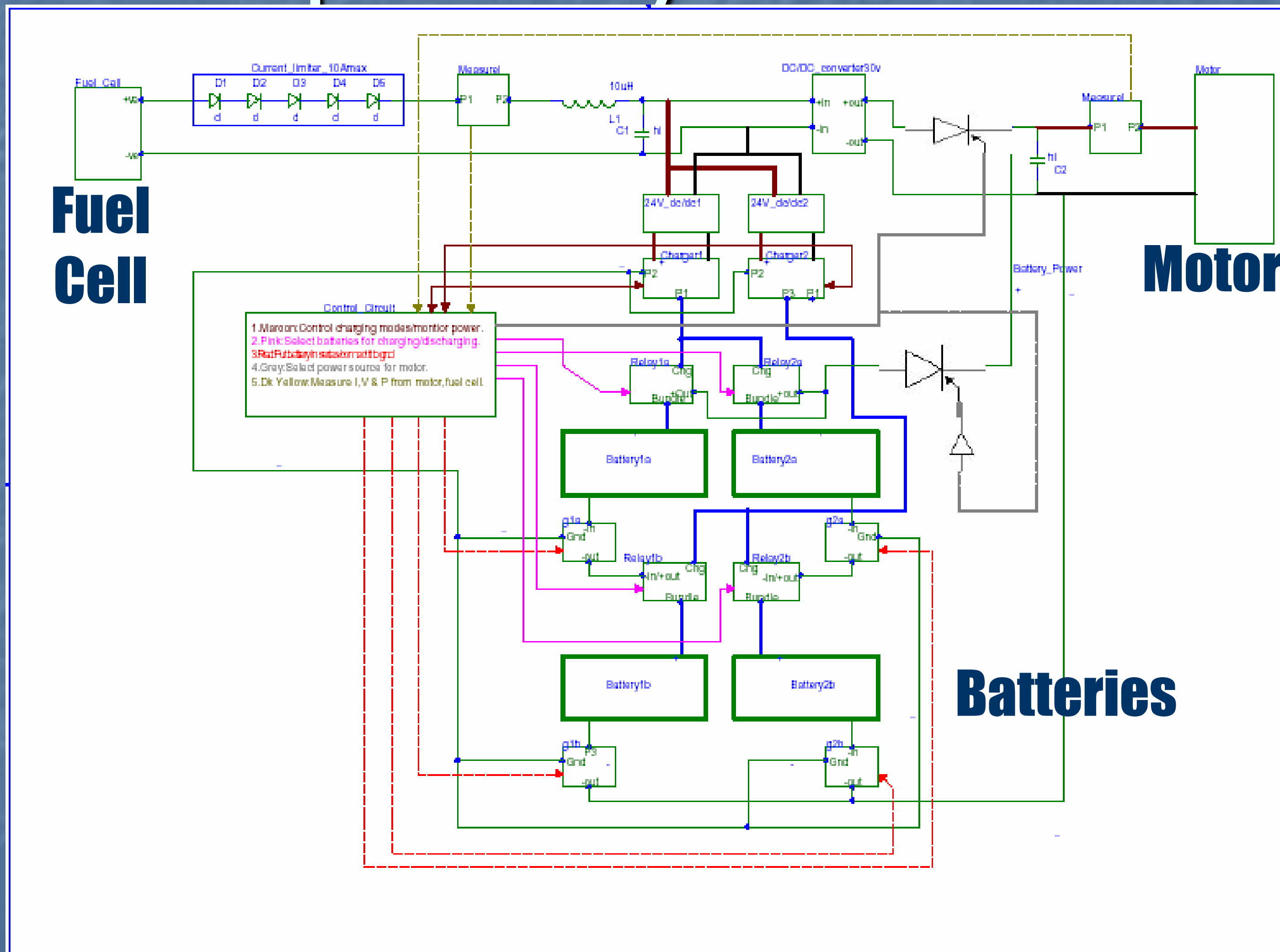
Objectives for Hybrid Section

- Design schematic for hybrid system using components available in lab, as well as those available in industry
- Obtain specifications/data for system components and design accordingly
- Examine functional feasibility of Hybrid Control Circuit

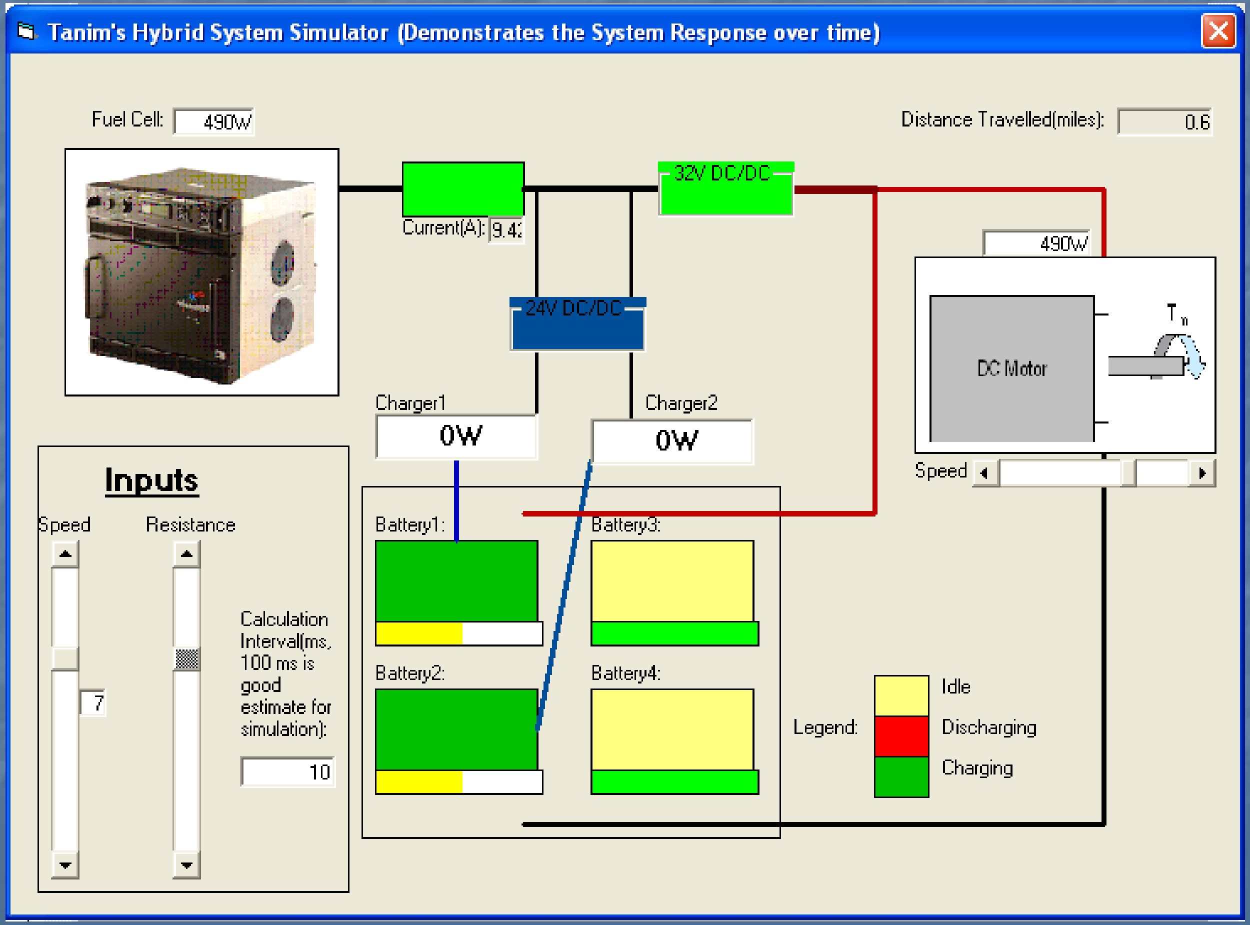
Hybrid Circuit Block Diagram



Complete Hybrid Circuit



Simulation



Tanim's Hybrid System Simulator (Demonstrates the System Response over time)
Fuel Cell:
490W
Distance Travelled(miles):
0.6
Current(A):
32V DC/DC
490W
24V DC/DC
DC Motor
Charger1
0W
Charger2
0W
Speed
Inputs
Speed
Resistance
7
Calculation Interval(ms, 100 ms is good estimate for simulation):
10
Battery1:
Battery3:
Battery2:
Battery4:
Legend:
Idle
Discharging
Charging

Accomplishments

- Examined various modes for hybridizing the system
- Based on our research, we designed schematic for a working Hybrid System
- Made considerable progress simulating the Hybrid System

Objectives for Charger Section

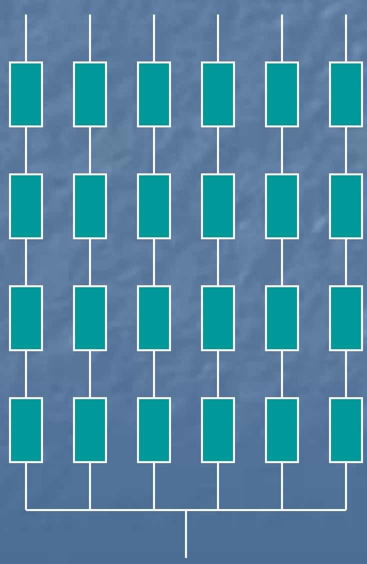
- Design system to charge half of the batteries while the other half power the motor
  - Inventory current equipment
  - Obtain DC/DC converters to power charging circuit with fuel cell
  - Design switching network to connect batteries to motor and chargers
- Create design such that charging components can be reused in hybrid design
- Implement Design

Batteries

Cell

3-4.2 V
2.2 A hours

Brick



12-16.8 V
13.2 A hours

String

12-16.8 V
2.2 A hours

Motor/Charger Requirements

Motor Requirements

- Constant Voltage Load
- 24V
- 12.5 A average current
- 60 A peak current

Solution (4 Bricks)

24-33.6 V
24.6 A hours

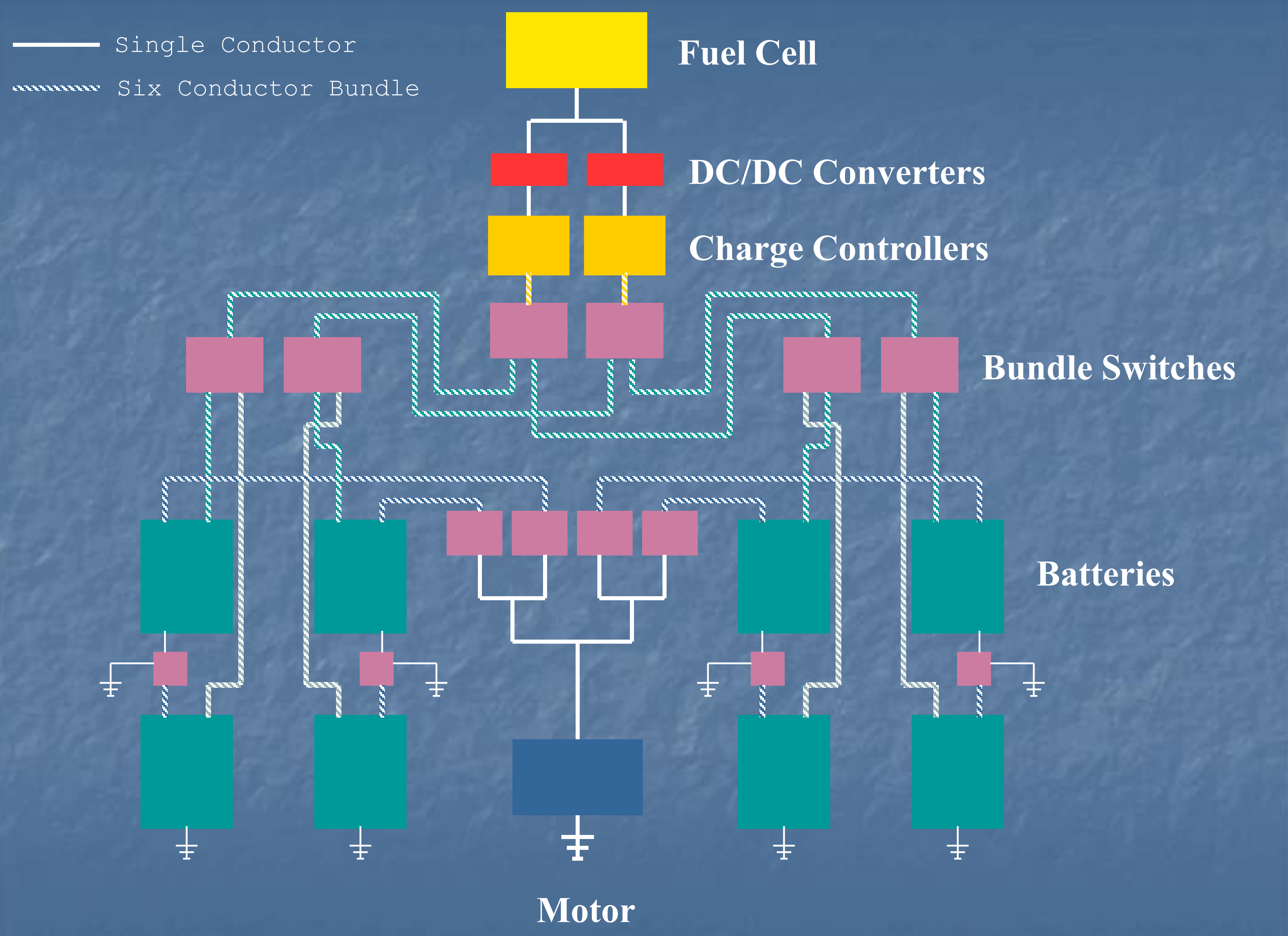
1.97 hours
at 12.5 A

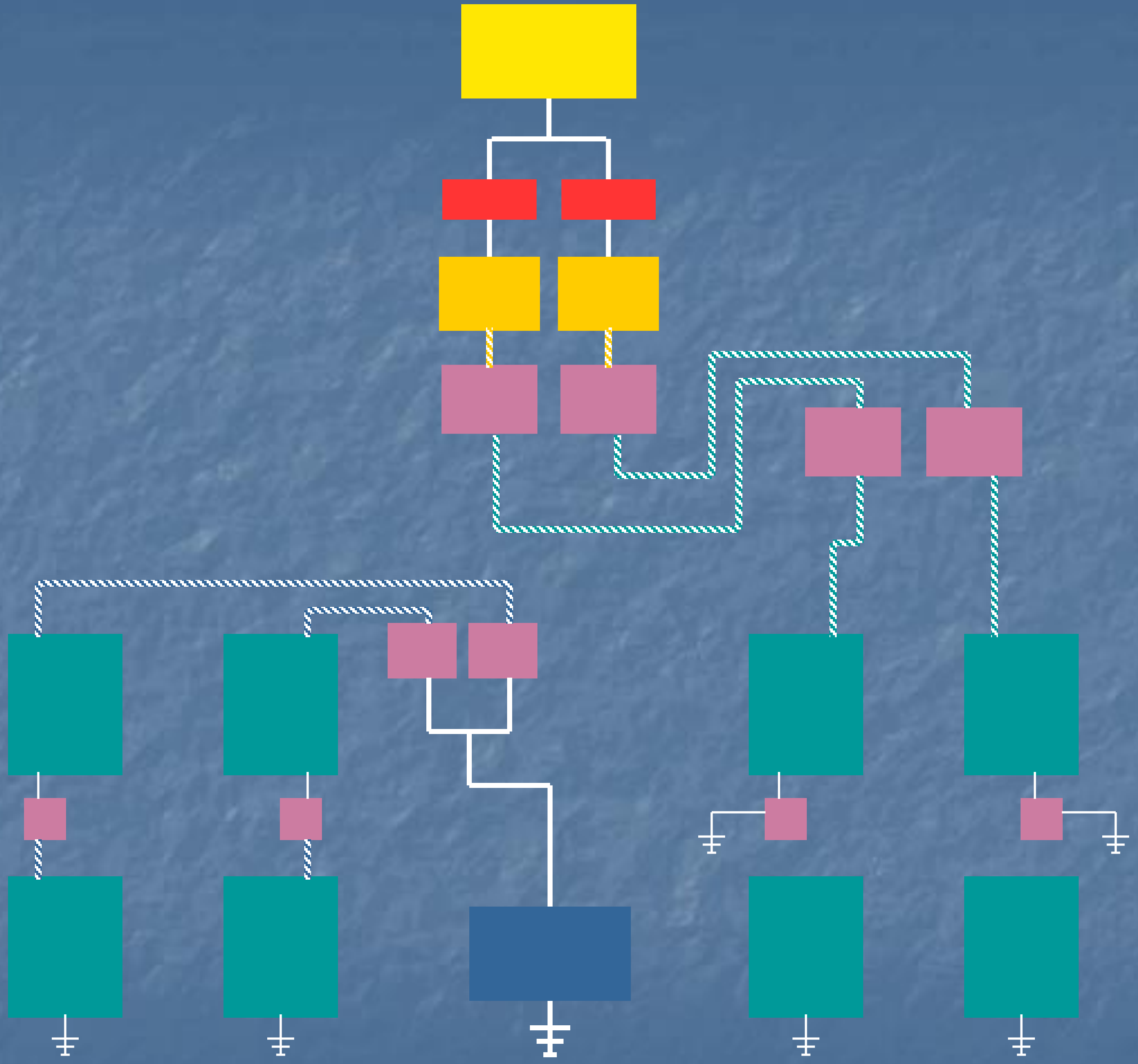
Charger Requirements

- Two units
- 24V
- 10A each

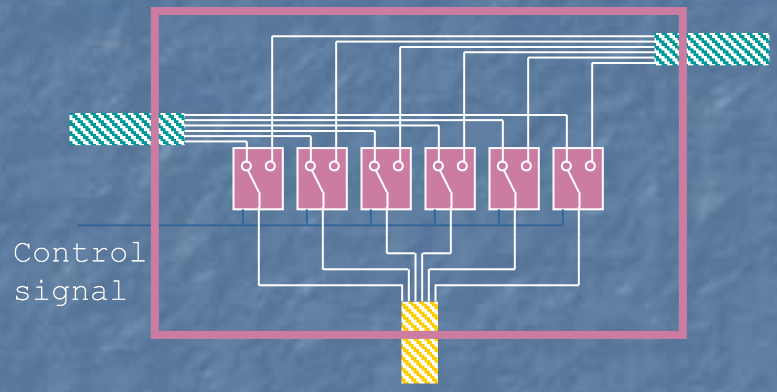
Solution

Two DC/DC converters from Pico Electronics

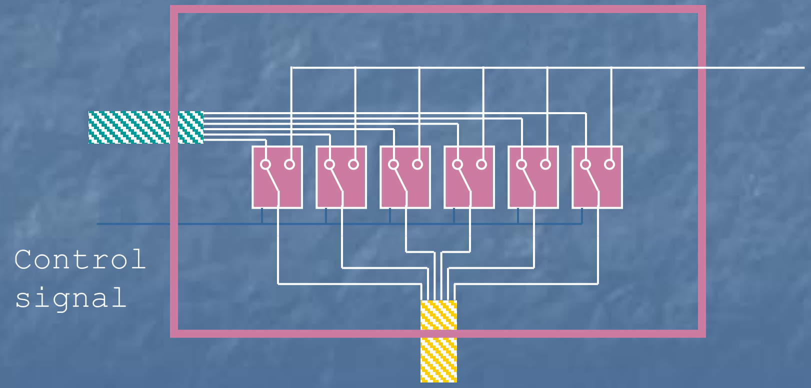

Single Conductor
Six Conductor Bundle
Fuel Cell
DC/DC Converters
Charge Controllers
Bundle Switches
Batteries
Motor



Bundle Switch Example



Switch
(bundle > bundle or bundle)



Switch
(bundle > bundle or single)

Implementation

- Relays used for all switches
- 4PDT units used (4 switches per unit)
- All relays housed in one enclosure with standard D-Sub 9 connectors
- 2 manual switches control charging/discharging state
- Gauges used to monitor current battery charge levels

Business Team

- Cost Analysis
  - Vince Aderangi
  - Steven Johnson
- Liaison
  - Siddha Pimputkar
- Safety & Economics
  - Rita Buresh
  - Rick Kraft
- Hydrogen Production
  - David Eisenberg
  - Christina Lefief
  - Matt Moy

Hydrogen Production/Economics

- Analysis of cost of production, storage, and delivery
  - Production: Most economical is ~2X of natural gas
  - Storage: New technologies required – automobiles
  - Delivery: Hydrogen infrastructure needed
- Production Design
  - Design of practical natural gas reforming plant
  - Design of futuristic sulfur/iodine thermochemical cycle powered by nearby nuclear plant

Can a hydrogen economy succeed?

- Energy Security
  - 25 kg H_2 displaces 1 barrel of petroleum
- Source Flexibility
  - Non-traditional resources
- Environmental
  - Air quality improvement
- Global Climate Change
  - Reduce greenhouse gas emissions

Is hydrogen a safe fuel?

Yes

- Low explosive energy and density
  - 20 times less damaging than gasoline
  - Dissipates quickly, reducing risk of fire or explosion

No

- Colorless and odorless
- Invisible flames in daylight
- Causes hydrogen embrittlement of most metals

What did we learn?

- Hard work pays off
- Projects are not always what they seem
  - Real world projects have numerous unknowns
    - Difficult to continue someone else's project
  - Cannot just drive cart to Milwaukee
- Large groups can be difficult to coordinate

Thank you

- Mohammad Saad Alam
- Shabab Amiruddin
- Curtis Cox
- Adekunmi Keleko

ReliOn Hydrogen Fuel Cells

All Cell Technologies

MicroSun Technologies, LLC

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