Low Carbon Footprint Hybrid Battery Charger

Project Proposal

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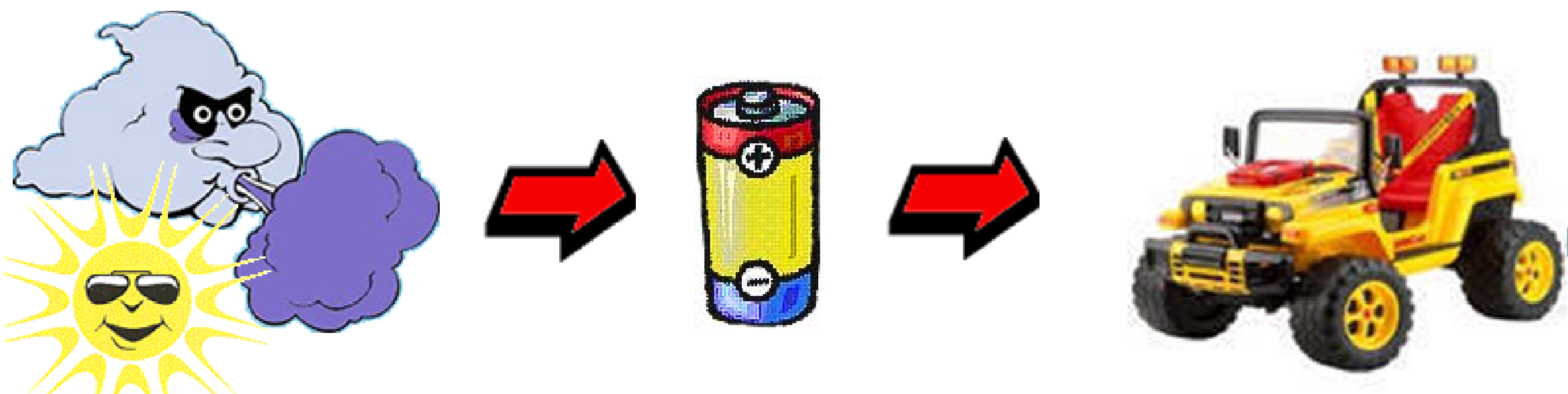
Date: December 11, 2007

Presentation Outline

- Project Summary
- Previous Research
  - Patents and Standards
- Project Description
  - System High Level Block Diagram
  - Subsystem Description and Specifications
  - Software High Level Block Diagram
- Datasheet
- Analytical Evaluations
- Project Equipment
- Project Schedule

PROJECT SUMMARY

- Charge a mobile battery for vehicular applications using renewable energy
  - Photovoltaic arrays
  - Wind turbine
- Develop microcontroller algorithms
  - Three Modes of Operation
- Emphasize efficient energy collection
  - Minimize utility A.C. energy
    - Store renewable energy in power bank until needed



Previous Research

- What has been created by others?
  - Solar powered vehicles
  - Utility A.C. electric vehicles
  - Wind turbine power generation
  - Photovoltaic power generation
  - Wind/Solar hybrid power generation
  - Renewable energy charging a storage bank
  - PWM battery charger

Applicable Patents

Relevant Patents	Description
U.S. Patent #5646507	Battery charger system for electric vehicles with quick charge and safe charge
U.S. Patent #6768285	Power system for converting variable source power to constant load power
U.S. Patent #4024448	Electric vehicle battery charger
U.S. Patent #5144218	Device for determining the charge condition of a battery
U.S. Patent #6204645	Battery charging controller for photovoltaic array using stationary battery and PWM to provide a constant load
U.S. Patent #6677730	Device and method for pulse charging a battery using PWM for photovoltaic applications.

Applicable Standards

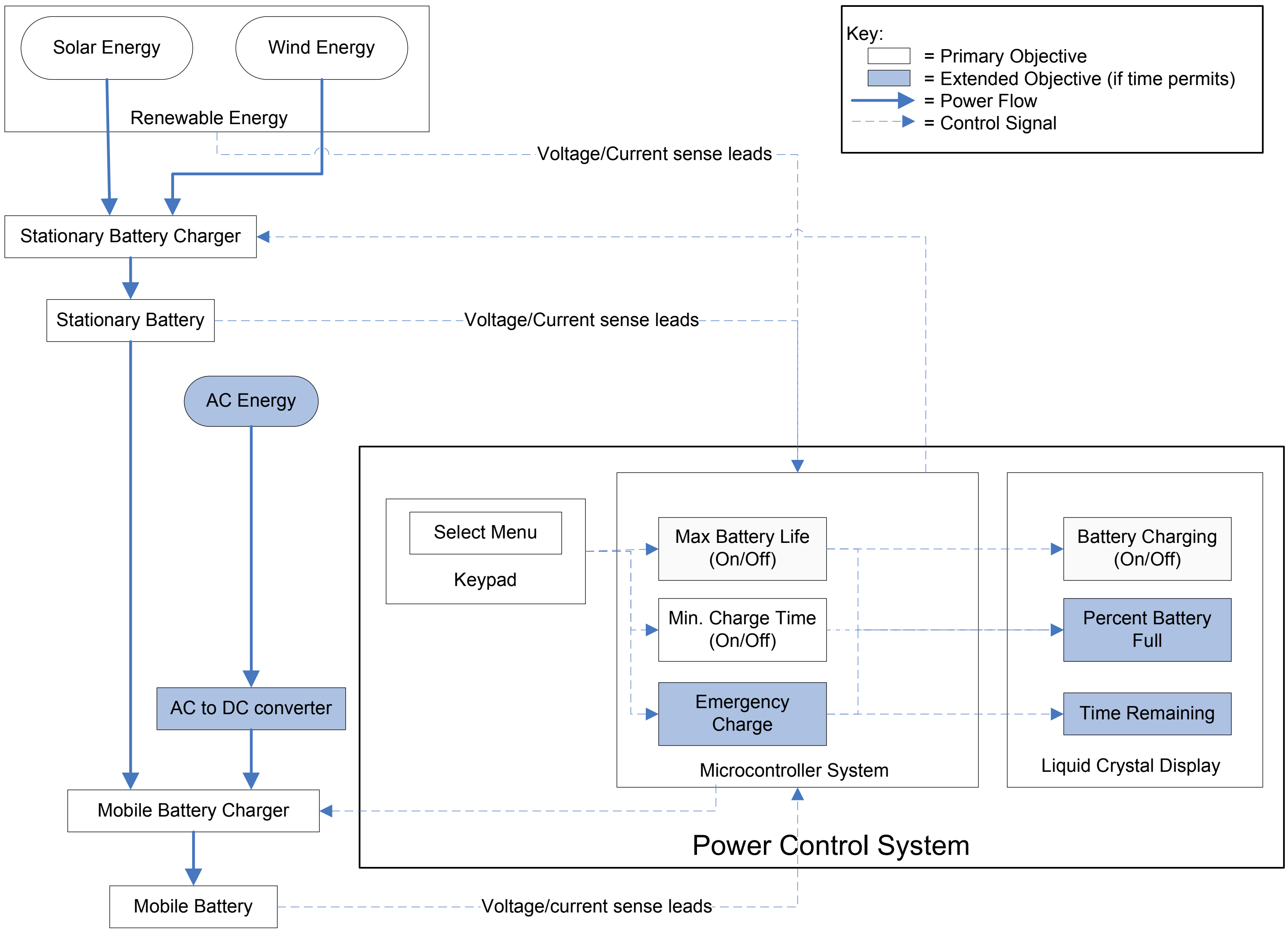
Relevant Standard	Description
IEC 62124	Photovoltaic (PV) stand-alone systems Design verification
IEC 61173	Overvoltage Protection for Photovoltaic (PV) Power Generating Systems
IEEE 1013	Recommended Practice for Sizing Lead-Acid Batteries for Stand-Alone Photovoltaic (PV) Systems
IEEE 485-1997	IEEE Recommended Practice for Sizing Lead-Acid Batteries for Stationary Applications
UL 2202	Electric Vehicle Charging System Equipment
UL 2231-1	Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: General Requirements
UL 2231-2	Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: Particular Requirements for Protection Devices for Use in Charging Systems
UL 2231-2	Plugs, Receptacles and Couplers for Electric Vehicles

IEC- International Electrotechnical Commission

Previous Knowledge Application

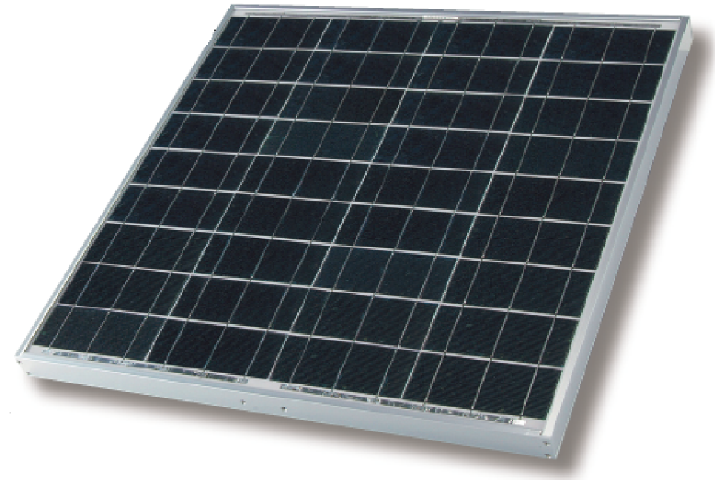
- What is new with our project?
  - All of these systems will be combined to charge a vehicle battery
  - Utilization of battery to battery charging

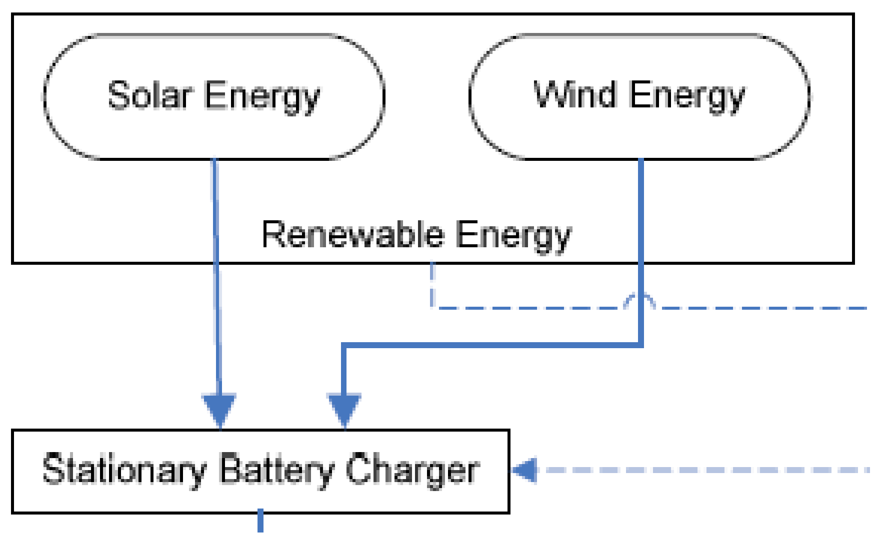
High Level System Block Diagram



Renewable Energy

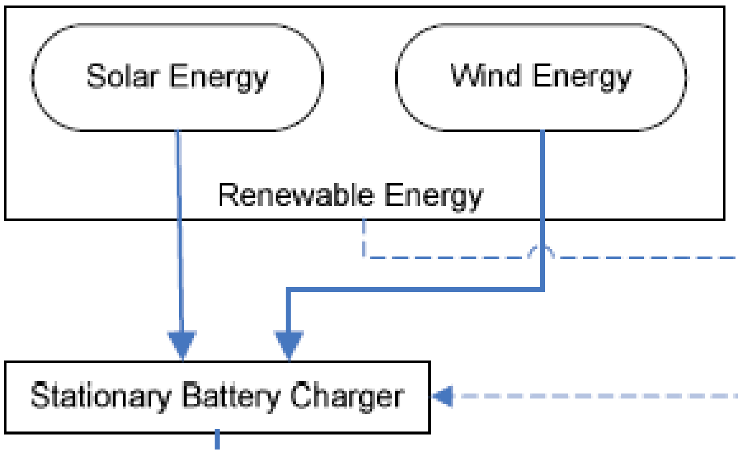
- Photovoltaic (P.V.) Energy
  - Provide sufficient energy to charge the mobile battery given 1.470 sun hours per day
    - May simulate some power with D.C. power supply
  - Plan to use Kyocera KC50T
    - High Efficiency: > 16%
    - Max Power: 54W
    - Competitive Cost





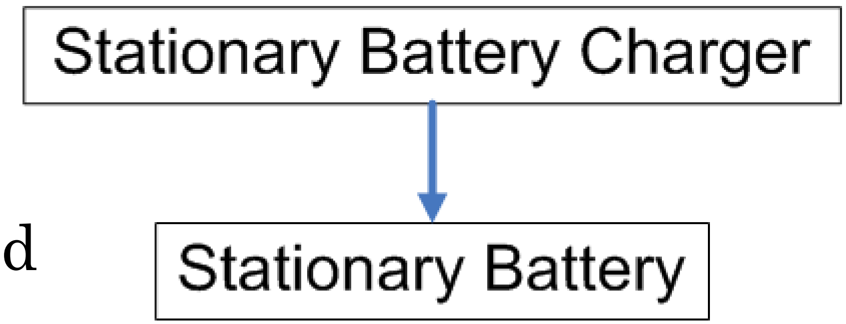
Renewable Energy

- Wind Energy
  - Provides 1.2 kWh/day at a height of 50m
    - May simulate some power with D.C. power supply
  - Plan to use Southwest Wind Power Air-X
    - Start up wind speed: 7 M.P.H.
    - Rotor Diameter: 46 in.
    - Max Power: 400W @ 28 M.P.H
    - Vout= 24VDC
    - Competitive Cost



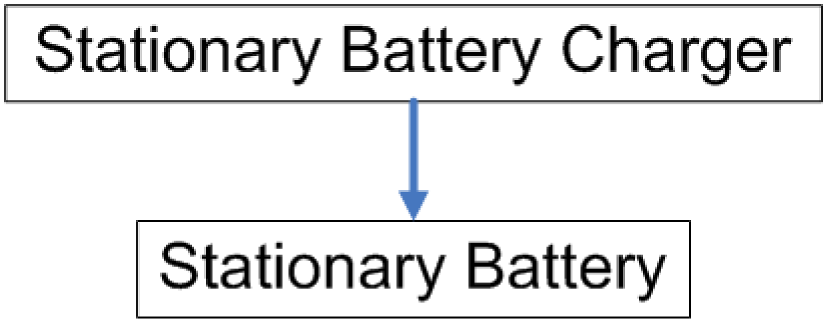
Stationary Battery Charger

- Integrates wind and P.V. energy to charge stationary battery
- Must accept max input values
  - Voltage: 24V
  - Current: 42A
- Output specifications dependent on stationary battery
- Charges stationary battery to maximize life
- Charging Scheme to be determined
- Monitors voltage and current characteristics of renewable energy and stationary battery



Stationary Battery

- Stores renewable energy to maximize energy collection when mobile battery is not charging
- Reduces mobile battery charge time
- Capacity needed determined by:
  - What is practical from cost standpoint
  - Stationary battery decay vs. mobile battery
  - Must be at least 180Wh
- Battery chemistry to be determined



Stationary Battery

- Possible battery choices

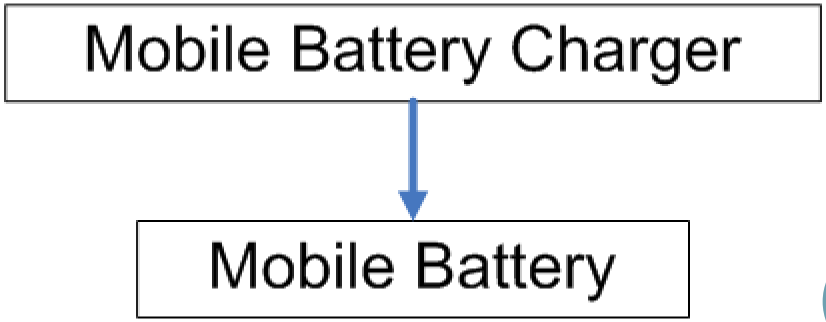
	Optima Lead Acid	Li-Ion	Ni-CD	Ni-MH	Sealed Lead Acid
Temperature Range (C)	130 to -30	50 to -20	45 to -40	50 to -20	60 to -40
Calendar Life (years)	?	2 to 5	2 to 5	2 to 5	2 to 8
Max Charge Cycles	300+	1000+	300 to 700	300 to 600	250 to 500
Discharge Profile	Flat	Slope	Flat	Flat	Flat
Self Discharge Rate @ 20C (% /mo)	Very Low	2	15 to 20	15 to 25	4 to 8
Memory Effect	No	No	Yes	Yes	No
Ability to Trickle Charge	Yes	No	Yes	Yes	Yes
Charging Characteristic		2 stage			
Deep Discharge	Yes	Yes	Yes	Yes	No
Relatively Quick Charge	Yes	Yes	Yes	Yes	No
Constant Voltage Or Current Charge	Voltage	Voltage	Current	Current	Voltage
Relative Expense/ Capacity	Cheap	Expensive	Moderate	Moderate	Cheap
Approx Expense (dollars)	150	< 600	300	350	80

Stationary Battery

- Li-Ion Eliminated
  - No Trickle Charge
- Sealed Lead Acid Eliminated
  - Low charge cycles
- Ni-Cd eliminated because similar to Ni-MH
  - Ni-MH has less memory effect
  - Ni-MH has higher energy density
- Optima Lead Acid vs Ni-MH
  - Optima
    - less charge cycles
    - significantly lower cost
    - no memory effect.
- Conclusion
  - Trade off between charge cycles and cost
  - Will probably choose Optima Lead Acid battery

Mobile Battery Charger

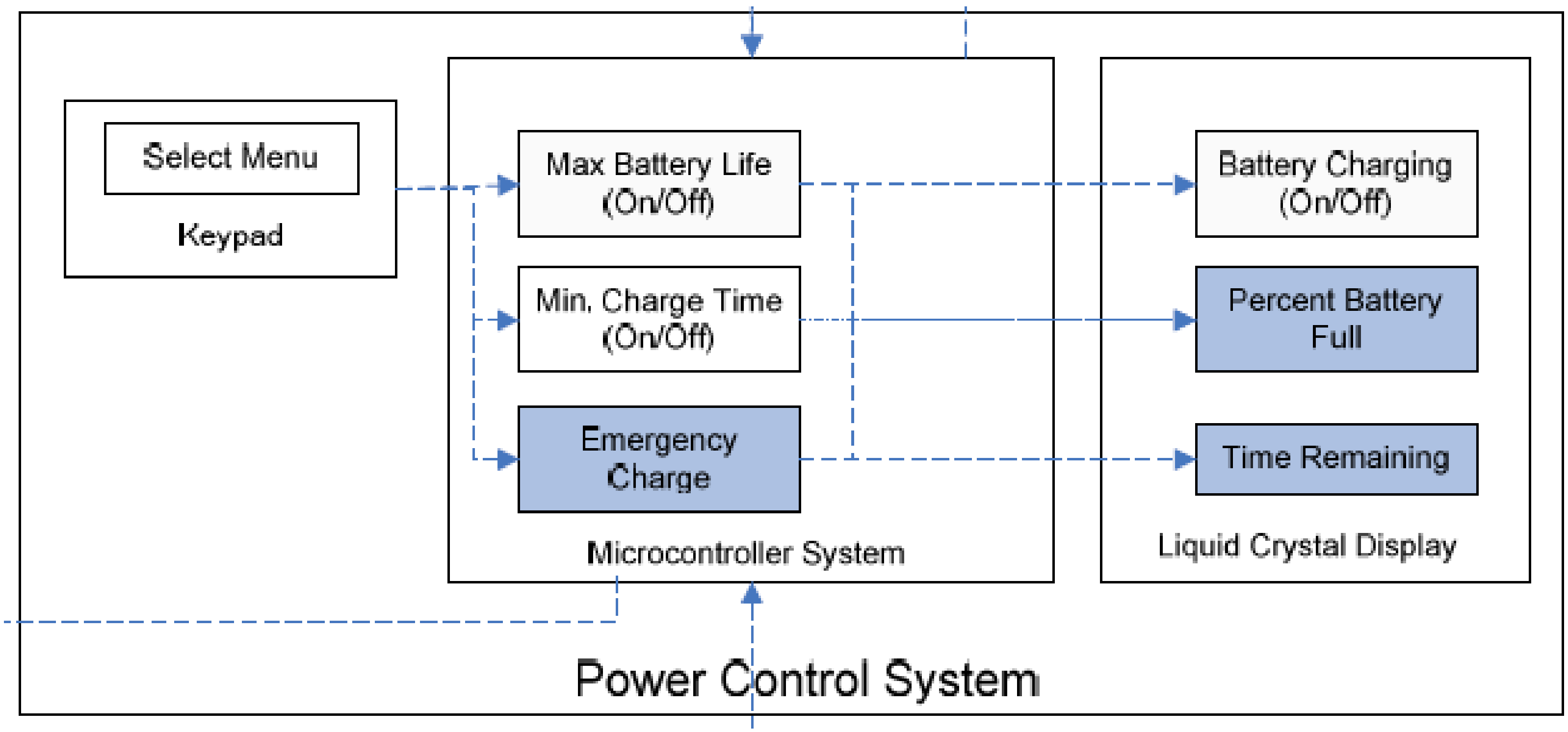
- Accepts energy from stationary battery
- Must accept max input values based on stationary battery specifications
- Must be capable of outputting
  - Voltage: 14.9V
  - Current: 4.8A
- The mobile battery charger shall be capable of charging the mobile battery within at least 12 hours



Mobile Battery

- Panasonic LC-RA1212P for Gaucho
  - 12V lead-acid battery
  - Rated capacity: 12Ah
- Minimal charge time
  - 2 hours 39 minutes
- Maximum battery life
  - 2-8 years
  - 250-500 charge cycles
- Constant Voltage Charge

Power Control System

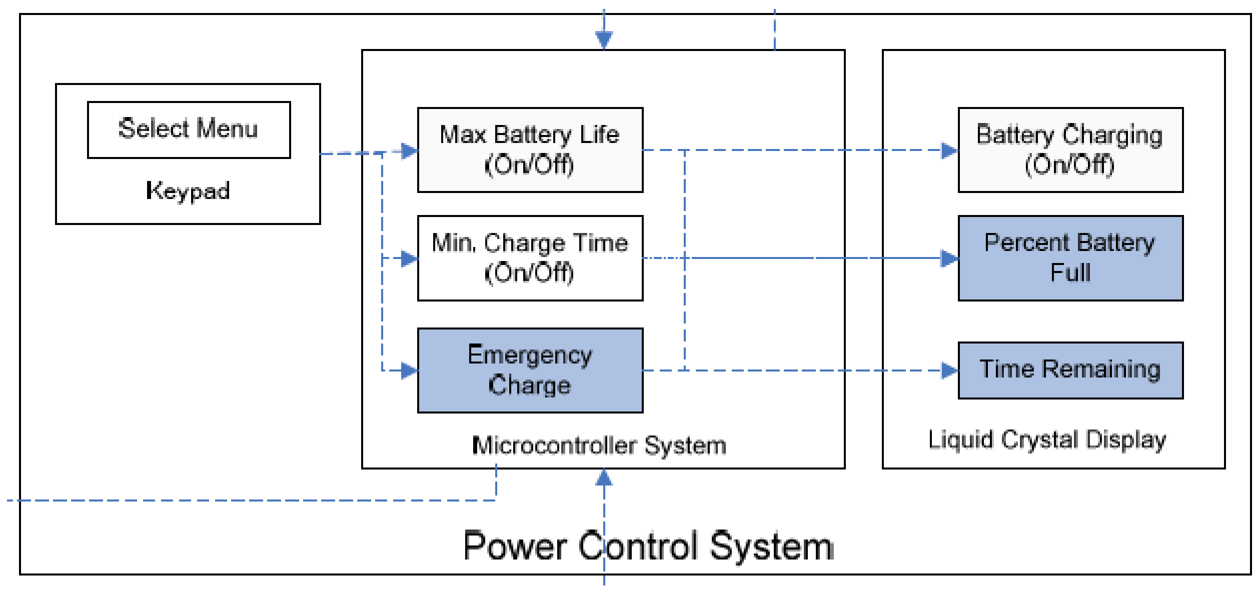


Power Control System

- Power control system switches charging modes of mobile battery charger
- Three modes of charging
  - Maximum battery life
  - Minimum charge time
  - Emergency charge (Extended Objective)
- Monitors voltage and current characteristics of stationary battery and mobile battery
- Operational between 0C and 45C for battery protection

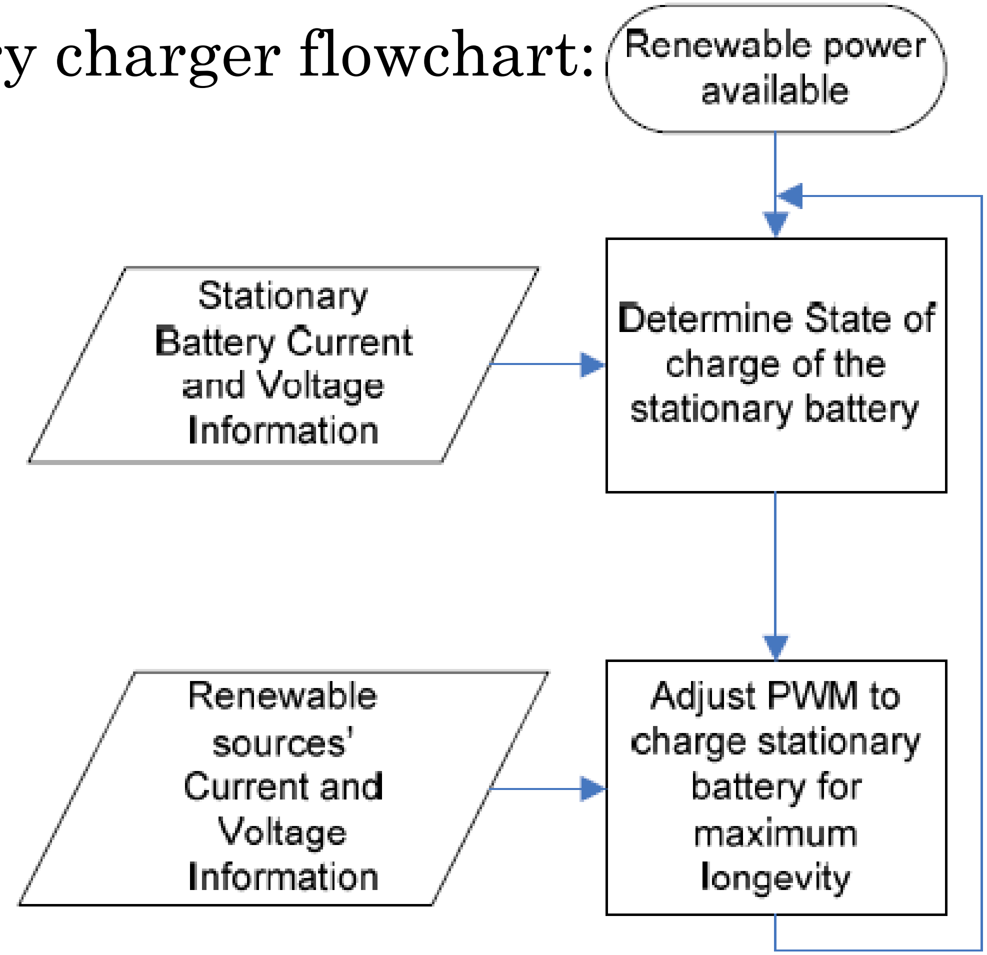
Power Control System

- Power control system is user interface
- Keypad input
  - User selects mode of charge
- L.C.D. output
  - Battery charging indicator
  - Battery charge percentage indicator
  - Time remaining until battery charged indicator

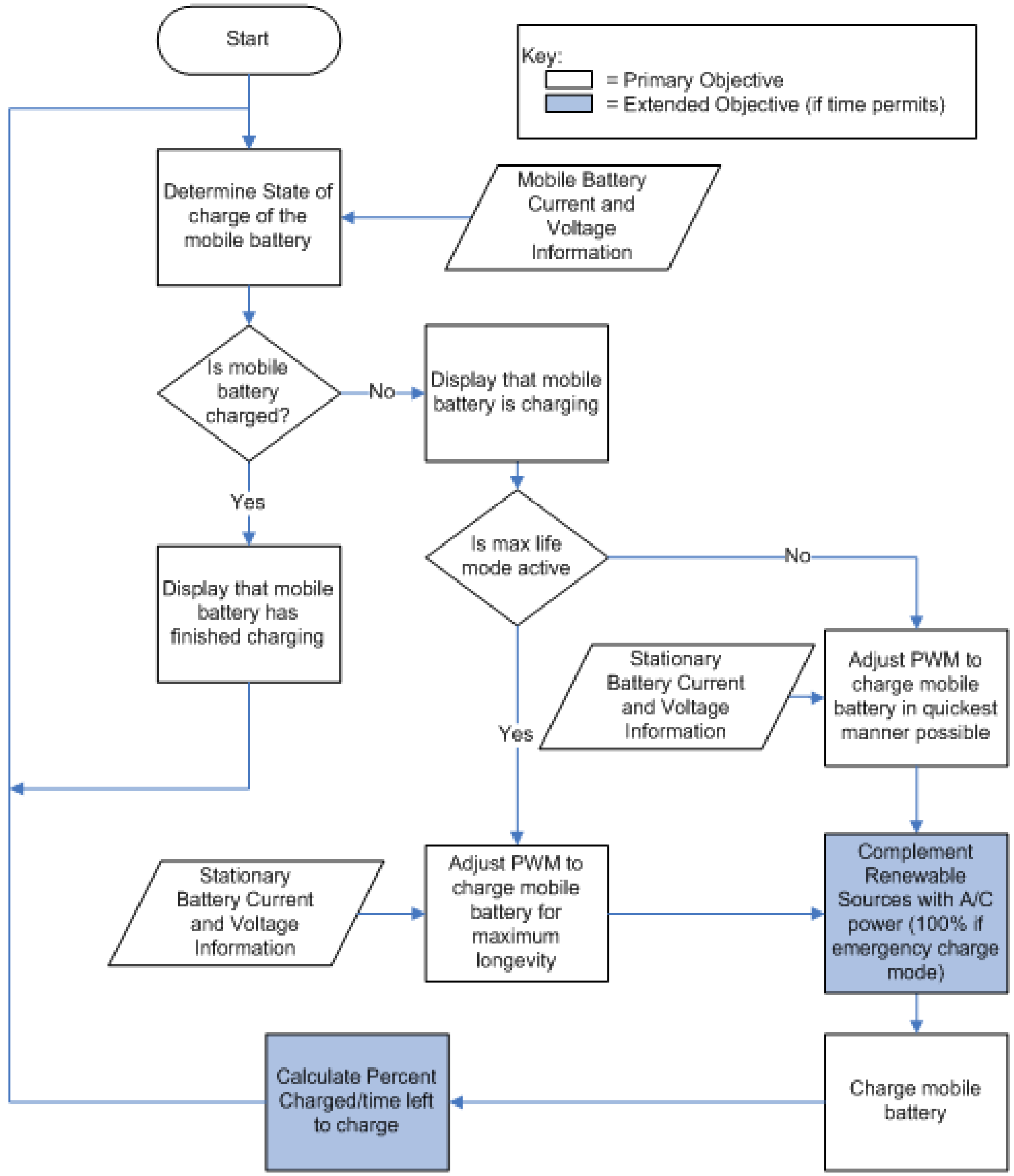


Power Control System Software

- Microcontroller software necessary for user input/output and switching charger modes
- Stationary battery charger flowchart:



Mobile Battery Charger Flowchart



System Datasheet

	Minimum	Maximum	Units
Sun Hours	1.47	--	KWh/(m^2*day)
Wind Speed	7	28	MPH
Stationary Battery Capacity	180	--	Wh
Mobile Battery Charger Output Voltage	14.5	14.9	V
Mobile Battery Charger Output Current	--	4.8	A
Temperature	0	45	C
Time for mobile battery to charge	2.7	12	Hrs

Analytical Calculations

- Load Calculation
  - Capacity 12V*12Ah=144Wh
  - 144 W*3600 sec*1.25 = 648000 J

- Solar Power Calculation
  - Efficiency*Area*Sun hours*3600 seconds
  - Maximum Spec 54W=194400 J/hour
  - Worst Case for Chicago = 285768 J/day

- Worst Case Number of Solar Modules
  - 648000 J/285768 J= 2.267 P.V. Modules

Analytical Calculations

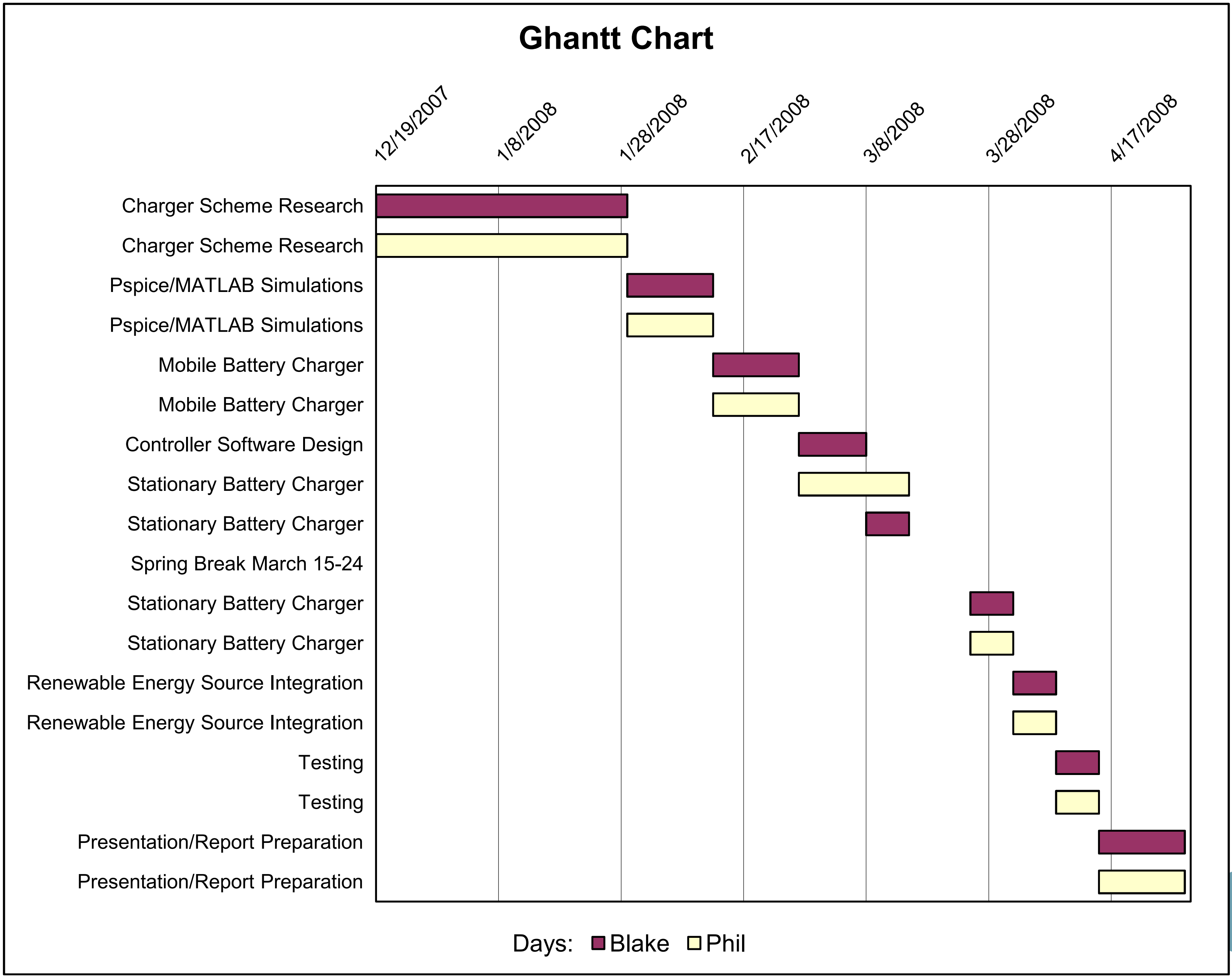
- Load Calculation
  - Capacity 12V*12Ah=144Wh
  - 144 W*3600 sec*1.25 = 648,000 J

- Wind Power Calculation
  - @ 12 M.P.H. 1.2 kWh/day generated
  - @ 12 M.P.H. 4,320,000 J/day generated
  - Average in Peoria, IL 14.3-15.7 M.P.H.

Equipment List

Equipment	Quantity	Estimated Unit Cost	Estimated Total Cost
Kyocera KC50T Photovoltaic Module	3	$299.00	$897.00
Southwest Wind Company 400W Air-X Wind Turbine	1	$555.00	$555.00
Mast for Wind Turbine	1	$130.00	$130.00
Optima D35 Lead-Acid Battery	1	$178.95	$178.95
Micropac535 Development Board	1	$0.00	$0.00
Total:			$1,760.95

Power electronics will be purchased after schematic finalization.



Ghantt Chart
12/19/2007
1/8/2008
1/28/2008
2/17/2008
3/8/2008
3/28/2008
4/17/2008
Charger Scheme Research
Charger Scheme Research
Pspice/MATLAB Simulations
Pspice/MATLAB Simulations
Mobile Battery Charger
Mobile Battery Charger
Controller Software Design
Stationary Battery Charger
Stationary Battery Charger
Spring Break March 15-24
Stationary Battery Charger
Stationary Battery Charger
Renewable Energy Source Integration
Renewable Energy Source Integration
Testing
Testing
Presentation/Report Preparation
Presentation/Report Preparation
Days:
Blake
Phil

Questions?