A Small Wind Power Generator System

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12/13/2013
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Introduction

- Wind generation to produce useable electricity is one of forefront choices to alternative energy.

- As climate change pops up in the news, some individuals are taking action to reduce their carbon footprint.

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OBJECTIVE

- The objective for this project is to learn how a wind turbine works to produce electricity from the spinning of the blades to the battery bank to the making a light bulb shine.
- Many ways to construct a wind turbine system
  - Simplest way is to source a PM motor and blades
  - One of the hardest ways is to build everything from the ground up

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RESEARCH

- Two kinds of wind generators
  - HAWT – rotating axis is parallel with ground
    - Produces more power but heavy construction
  - VAWT – perpendicular to ground
    - Potential to produce power with wind coming from all directions

VAWT type

HAWT type

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RESEARCH

Initial questions to ask

- 1) What are my surroundings?
- 2) What is average wind speed?
- 3) On/Off grid?
- 4) Monthly power use?
- 5) Charging voltage?
- 6) Battery bank size?
- 7) What local, state, federal regulations are there for mounting a tower?

These questions will give insight on feasibility

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RESEARCH

- Find wind chart data for your area
  - Through government website or Internet search

http://www.windpoweringamerica.gov/windmaps

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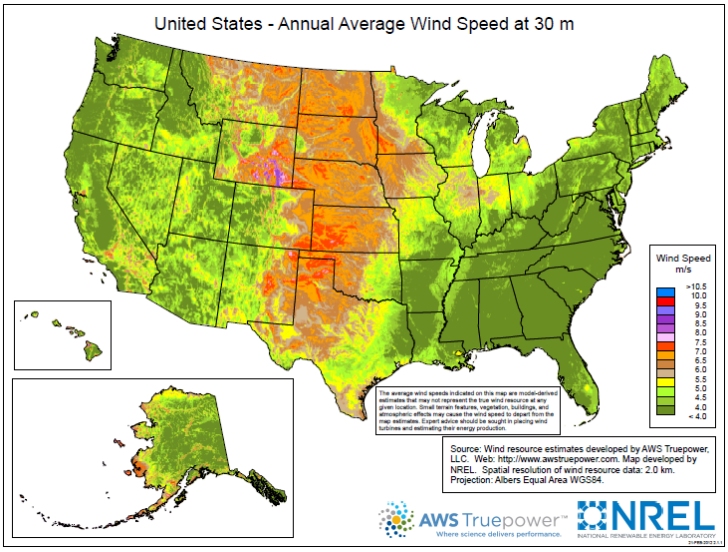
RESEARCH



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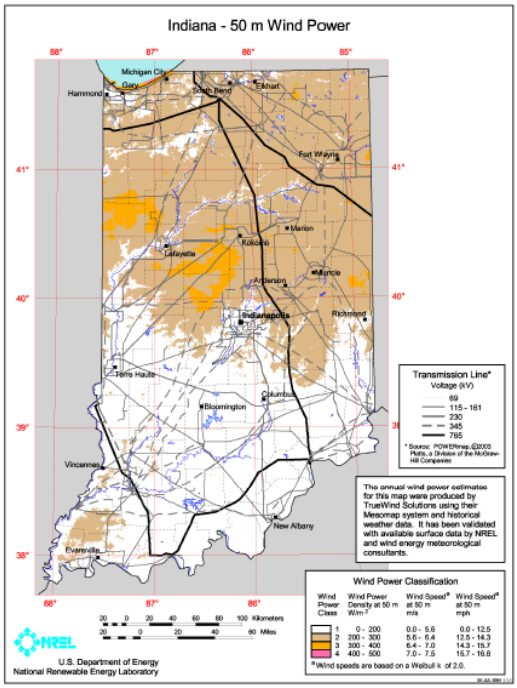
RESEARCH



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RESEARCH

- Internet search for wind turbines
  - Menard's, Lowe's, Cabela's, Northern Tool
- Most range between 600 – 2000 Watt
- Prices easily up to $2,000 plus you will need
  - Charge control, energy dump, wiring
- Additional features = more $$
  - Tail fin, braking (electrical or mechanical)

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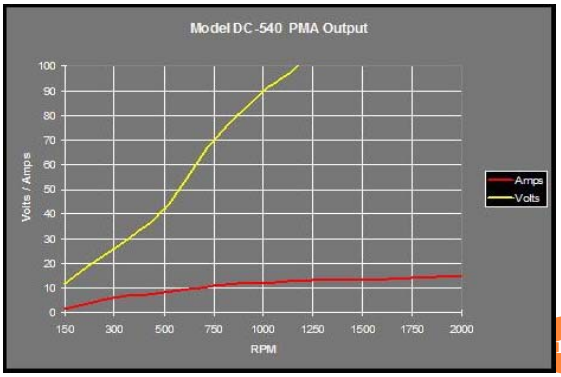
RESEARCH

- The best approach to compare wind turbines is looking at the datasheet
- What is OCV?
- What is SCC?



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SPECIFICATIONS

Rated Power	100 W
Blade Rotor Diameter	5-6 ft
Rated average wind speed	5-15 mph
Max RPM	up to 300
# of blades	up to 5
Blade material	Aluminum/Wood
Charging Voltage	12Vdc
Suggested Battery Capacity	>30 A/hr
Rated Load Current	Up to 8 A

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CALCULATIONS

- Watts = ½*air density*swept area*wind velocity^3
- Air density = 1.23 kg/m^3 at sea level
- Swept area = πr^2
- Wind velocity is in meters per second
  - 1 m/s = 2.237 mph
- Expected Watts uses the Betz Limit of 59.3%
  - Small turbines will be up to 35%

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CALCULATIONS

- Tip speed ratio (TSR) = $\frac{\text{Tip speed of blade}}{\text{wind speed}}$
- Wind speed (V) = $\frac{2\pi r}{Time\ (T)}$

# of Blades	Optimum TSR
2	~6
3	~4-5
4	~3
5-6	~2-3

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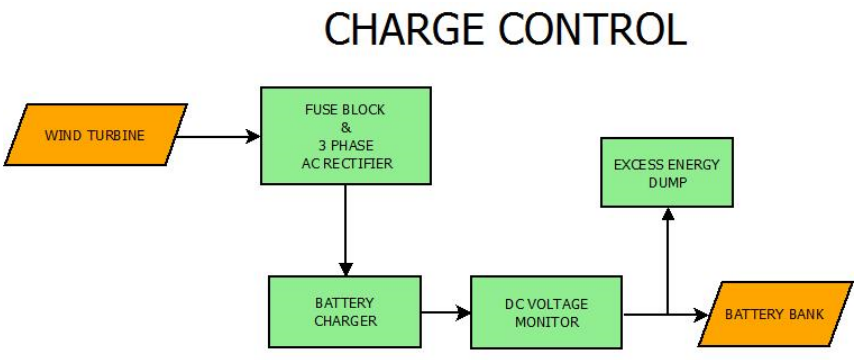
BLOCK DIAGRAM



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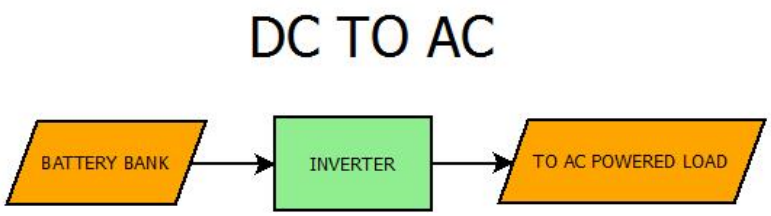
Block Diagram



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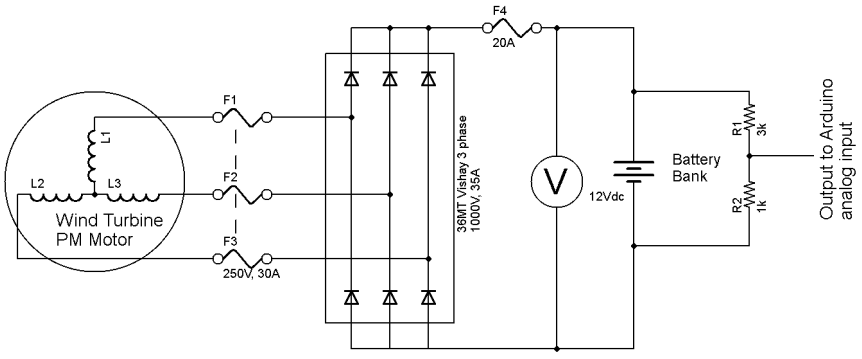
Hardware design – AC to DC conversion



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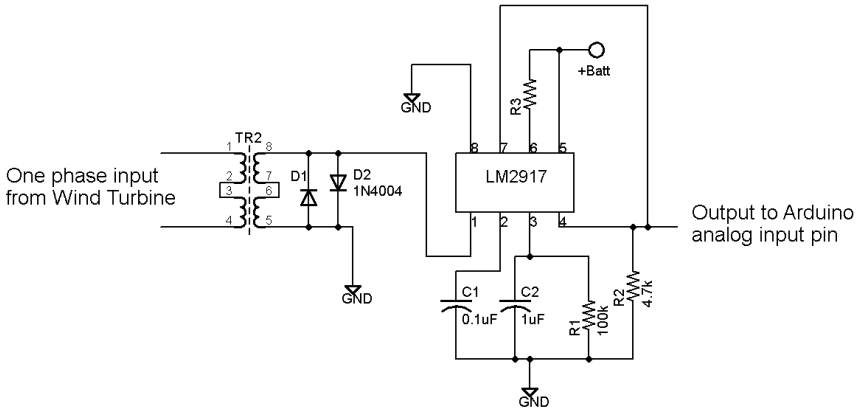
HARDWARE DESIGN – RPM MEASUREMENT



LM2917 is a frequency to voltage IC

- output is a linear representation

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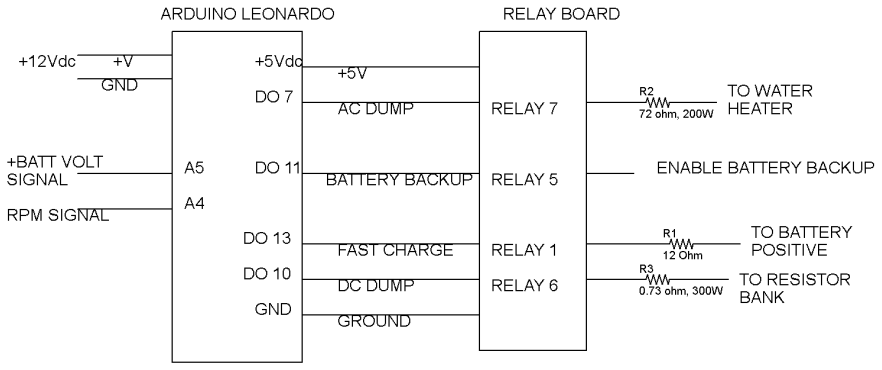
HARDWARE DESIGN – CHARGE CONTROL & ENERGY DUMP WITH THE ARDUINO



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Hardware Design

- Wind Turbine and blades
  - Bought in a kit from www.windbluepower.com
  - Model # DC-540
  - Aluminum blades
- Volts to RPM ratio
  - DC-540 delivers 350V at 2500 RPM = 0.14
  - Rule of thumb what voltage will be at each RPM

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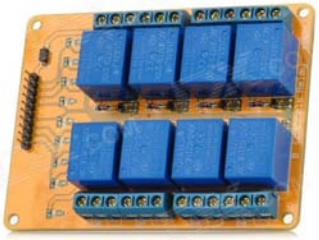
Software Design

- Arduino Leonardo
  - 13 digital out pins
  - 6 analog input pins
- Arduino controls 5Vdc relay board
- When battery voltage reaches:
  - 10.6Vdc – Battery backup
  - 11.0 to 11.5Vdc – Fast Charge
  - 11.5 to 11.9Vdc – Trickle Charge
  - 12.4Vdc – all relays off
  - 13.5Vdc – Energy dump



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System Integration

- Items needed are various hand tools and a voltmeter
  - An oscilloscope is great to see waveforms
- Assemble wind turbine & blades – make sure it spins
- Measure voltage coming from 3 phase harness
- Close fuse block and measure rectified voltage
- Wire up battery & charge controller

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System Integration

- Test software & modify
- Cordless drill and socket to spin blades

Green are calculated values

Batt Volts	ADC # Equiv
13.5	730
12.5	680
12.3	640
12.2	635
12	625
11.9	600
11.8	583
11.7	575
11.5	565
11.4	555
11	540
10.5	515

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BUDGET

WIND TURBINE PROJECT				
		PRICE	QTY	SUB TOTAL
PM motor & blades kit		$ 485.00	1	$ 485.00
Display		$ 40.00	1	$ 40.00
3 PH Rectifier				
	3 PH fuse block	Borrowed	1	Borrowed
	3 PH AC Rectifier	Sample	2	Sample
	Heat sink	$ 25.00	1	$ 25.00
Excess Energy Dump				
	LM2917	Sample	3	Sample
	Transformer	Sample	3	Sample
	Misc Components	$ 10.00		$ 10.00
	Resistor Bank	$ 39.00	1	$ 39.00

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BUDGET

Arduino	$ 36.00	1	$ 36.00
Relay Board	$ 16.00	1	$ 16.00
DC Voltage Monitor	$ 10.00	1	$ 10.00
Battery Bank, 12Vdc	$ 53.00	1	$ 53.00
Inverter, 12Vdc to 120Vac	$ 38.00	1	$ 38.00
Base and stand	$ 19.00	1	$ 19.00
		Total	$ 752.00

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Lessons Learned

- How a wind turbine system works
- What the individual components are
- How to program the Arduino
- Calculations are a must from wire sizing to resistor banks to expected power from the wind turbine
- How to read a wind turbine datasheet

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Conclusion

- Deeper understanding how wind turbines work
- Understanding how system is put together
- Arduino provides great flexibility and ease of use
- Make sure to use the Betz Limit when calculating

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Recommendations

- Utilize the Arduino to implement a wireless telemetry system
- Look into developing an Arduino package that would require less power to run for off the grid
- Display the RPMs of the wind turbine
- Place the electronics into a Nema 4 enclosure to provide easy access and a way to mount everything to the stand

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Recommendations

- Increase the charging voltage to 24Vdc or 48Vdc to provide a more efficient way to charge batteries and require smaller gauge wiring
- Safety factors will need to be addressed if this system is to be mounted on a tower
- Thorough research will need to be done to ensure that no local, state, or federal laws/codes are violated if pursuing to erect wind turbine system

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QUESTIONS/COMMENTS

- Does anyone have any questions or comments

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DEMONSTRATION

Unit demonstration

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