DEPARTMENT OF
ELECTRICAL & COMPUTER ENGINEERING

UNIVERSITY OF CENTRAL FLO RIDA

EEL 4914
Senior Design I
Intellaturbine – Group 9

Initial Project Description

Wintel-Group 9

The team consists of four members:

- Dwayne Smith: Electrical Engineer undergraduate at the University of Central Florida. Upon graduation he plans on perusing a career in the Power Generation Industry.
- Jose Dominguez: Electrical Engineer undergraduate at UCF. Interested in DSP and Control Systems.
- Joaquim Thompson: Electrical Engineer undergraduate at UCF. Interested in control systems.
- Timothy Knob: Electrical Engineer undergraduate at UCF. Interested in digital systems and ICs.

Wintel will have one major sponsor/contributor Shaun Dunbar. Shaun is a Mechanical Engineer who currently works in the Power Generation Industry. He has an interest in wind power generation and as such has agreed to be a sponsor/contributor.

Goals and Objectives:

The senior design project chosen by me and my peers is a wind turbine that not only converts wind energy to power, but keeps a running log of the wind activity and power generation from day to day. The largest task we will face as electrical engineers will be the electrical control system, the data logging capability, and converting the energy generated by the turbine into usable electrical power at a reliable and efficient rate.

The objective of this project is to design a wind turbine system for individual home use. The intent is to design and implement the wind turbine system at a low cost where it would be feasible for home owners. With this low cost it should be possible to get many homes off the power grid and going “green” hence doing our little part for the environment. After initial setup the turbine will be self-sufficient requiring little to no interaction from owners. It will however, have user adjustable parameters. These parameters will include: battery charge time, voltage charge level and voltage output level. The turbine will also have ‘smart’ features such as wind speed and direction sensing allowing for optimum use of the wind. Diversion control to prevent overcharging of the batteries and an alternative charging source in the event of there is no wind. For ease of use, the turbine will have a screen display, displaying: turbine voltage for all three phases (A, B, C), DC voltage from rectifier, charging current, turbine shaft speed (RPM), and wind speed. Data access point via USB port for up/down loading data and parameter specifications. Speed control of the turbine will be controlled with pulse width modulation.

Specifications:

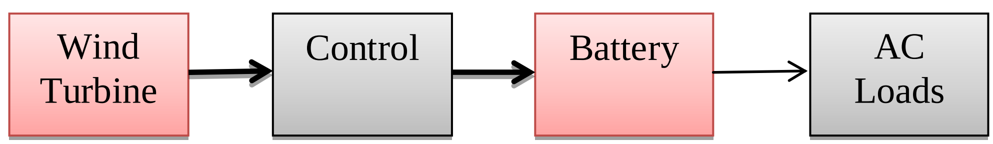
Because wind speed is not a constant this design will employ ‘maximum power point tracking’ (MPPT). In low wind conditions the turbine will produce relatively low voltage, whereas in high wind conditions it has the ability to produce much higher voltage. Using a MPPT converter to change the voltage allowing it to rise in high wind conditions has several benefits.

- Because losses depend on the square of the current, increasing the voltage correspond to a reduction in the current at a given power output which will save energy and avoid overheating.
- Turbines will work best when rotational speed changes in direct proportion to wind speed. Using a constant voltage implies constant speed (not possible) therefore using the MPPT convert allows for a wider range of speed.

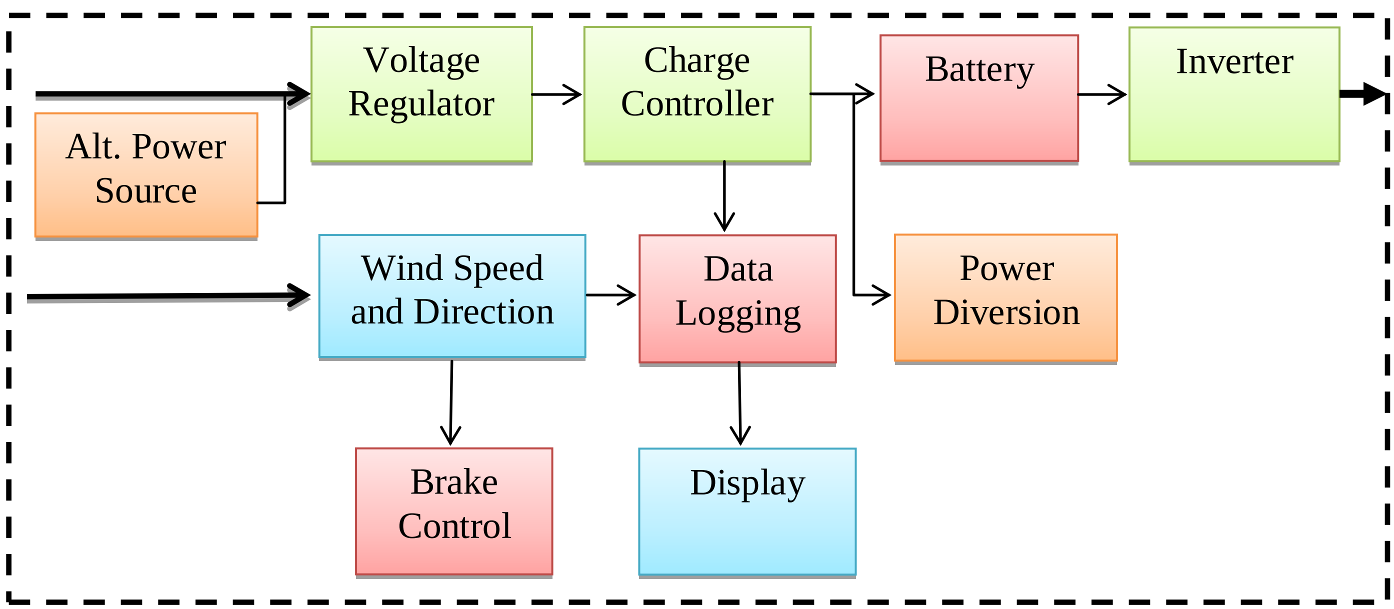
The following are the target requirements for the system:

- Power output: 1kW at 24vDC
- Voltage output range: 24 to 29vDC
- Charge time: 1 to 360 minutes

Wind Turbine Block Diagram



Control Block Diagram



Legend

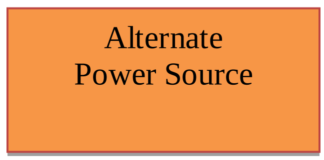
- Dwayne Smith
  - Voltage Regulator – Regulates the voltage for maximum allowable power. Researched.
  - Charge Controller – Checks battery charge and diverts power. Researched.
  - Inverter – Converts current for AC loads. Researched.
- Joaquim Thompson
  - Wind Turbine – 1000kW/24VDC 5 blade turbine. Researched.
  - Brake Control – Prevents over spinning of the rotor. Researched.
  - Data Logging – Saves all important data e.g. wind, battery charge. Researched.
  - Battery – 25V Lead acid flooded battery. To be acquired.
- Jose Dominguez
  - Wind Speed and Direction – Sends wind speed and direction data. Researched.
  - Display – Receives and displays collected data. Researched.
- Timothy Knob
  - Alternate Power Source – Charges battery when turbine is inoperative. Researched.
  - Power Diversion – Diverts power when the battery is charged. Researched.
- N/A

Wind
Turbine

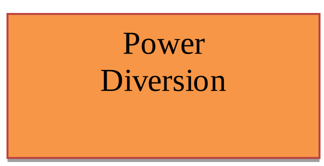
The wind turbine block designates what kind of wind turbine is needed for this project. Specifications for this project determined the wind turbine would produce 1000kW at 24-29VDC. It has no input but its outputs would be the wind speed and direction data to be logged and processed by the other system components as well as the voltage. The output port of the turbine will be R232 or USB for convenience. Since wind speed varies the voltage will output to a voltage regulator to manage power for maximum efficiency. A possible turbine choice is a 1000kW/24V home wind turbine with 5 blades. It will be donated by our sponsor with the details of the design of the system. This turbine has over-speed braking but the project design will implement its own break controller.

Brake
Controller

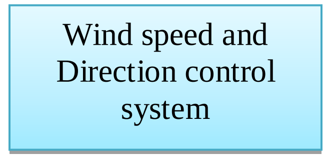
The Brake Controller will be used to maintain the speed safety range of the rotor in the wind turbine. According to the details of this project the turbine must produce energy for a 10-20 mph wind speed. If the rotor spins too fast it will produce too much voltage and damage the circuitry. Inputs from the wind speed and direction controller will engage the brake controller. The primary design approach for the brake controller is still being researched but one concept is a pulse width modulator (PWM). The PWM would be designed to use the three phases of the voltage to attenuate the signal and reduce rotor speed. A design approach for the brake controller is still being researched.



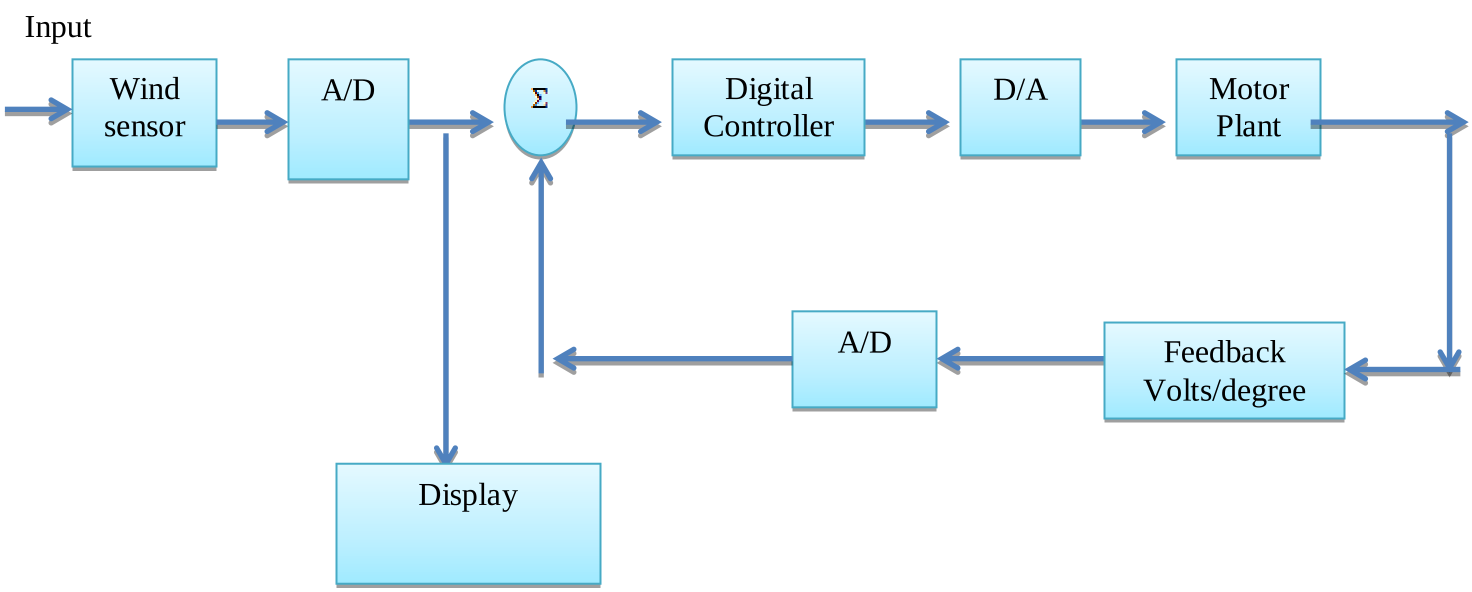
Since wind is not 100% reliable the turbine requires an alternate power source for when the wind dies down. Project parameters do not specify what kind of power source but the usual alternate source of power for a wind turbine is a solar panel. The system will be able add sources at the users will. This block is currently being researched.



Use of Power Diversion for the system is enabled when the battery is fully charged to prevent destruction of the battery. The primary power diversion technique for a wind turbine is to use dump loads. A charge controller is the input to the power diversion block and it determines when to switch from the battery connection to the dump load. Dump load systems are determined by the electrical specs of the system which are mainly battery voltage and how many amps the wind turbine will produce at maximum power. The two values are then used to calculate the values of the resistor in the dump load and how many dump loads will be needed. This block is still being researched.

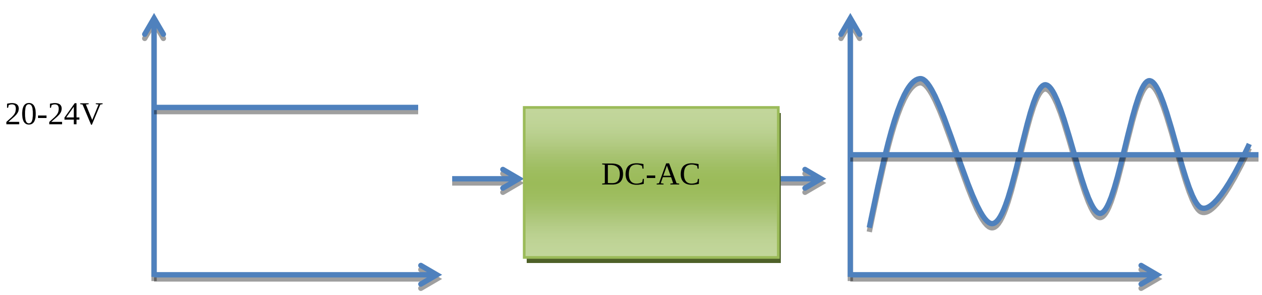


- The group member responsible for this block diagram is Jose Dominguez.
- Block status: To be acquired.
- The inputs associated with this block diagram are:
  - Wind direction.
  - Wind speed.
- The outputs associated with this block diagram are:
  - Wind speed measured in miles per hour.
  - Desired position for maximum power generation measured in degrees.



The primary function of this control system is to monitor the wind direction for maximum power generation from the wind turbine. The wind sensor will take the wind direction as an input and give and output voltage that's proportional to the wind direction measured by the sensor. That output voltage will be the reference input voltage to the control system. For better versatility and flexibility we have decided to digitally control the system. Digital control systems offers many advantages over analog systems because they are easy to configure and reconfigure through the usage of software and because they are less prone to parameter changes in the system due to environment conditions such as temperate. The input reference voltage will be converted to a digital signal thru the analog to digital converter box. That signal will be feed to the digital controller for compensation purposes and then converted back to an analog signal to be used by the motor. The output of the motor will be feedback as digital signal to the system for stability purposes. As long as the feedback voltage of the system is not equal to the input reference voltage, the control loop will keep on going until the feedback voltage equal the reference input voltage. Once the system reaches that condition it will become stable and the motor shaft will be at the desired angle for maximum power generation from the turbine. The wind direction and wind speed will be re-routed to be displayed on some displaying device and saved in a data-logging device.

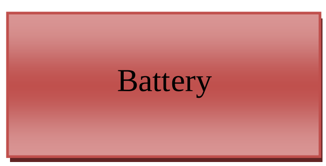
- The group member responsible for this block diagram is Dwayne Smith.
- Block status: To be acquired.
- The input associated with this block diagram is:
    - DC voltage source
- The output associated with this block diagram is:
    - AC voltage source



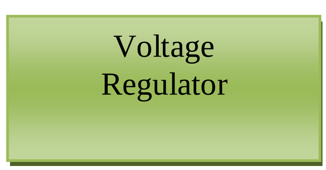
An inverter is an electrical device that converts direct current (DC) to alternating current (AC); the converted AC can be at any required voltage and frequency with the use of appropriate transformers, switching, and control circuits. For our purposes, the wind turbine generates 1KWatts of power at 24V DC. That power will be used to charge up a 24V battery. To use the energy stored in the battery in a home, we have to convert from DC to AC because most appliances use AC current to operate.

- The group member responsible for this block diagram is Dwayne Smith.
- Block status: To be acquired.
- The input associated with this block diagram are:
    - Output from the voltage regulator.
- The outputs associated with this block diagram are:
    - DC voltage to the battery and data to be logged.

The charge controller is an electronic voltage regulator that is used to limit the rate at which electric current is drawn in or out of the batteries. The simplest charge controllers turn off the charge when the battery reaches the optimum charging point and turns on when it goes below certain level. It fully charges the battery without permitting overcharge while preventing from reverse current flow. The overcharge or overvoltage may reduce the battery performance or lifespan and may pose a safety risk. Some charge controllers can show system operation parameters, battery status and protection from over discharging.

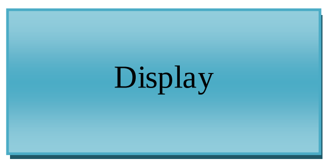


The battery that will be used in this project will be lead acid flooded and will be 24V. Voltage from the battery will be used to power the components of the control system as well as the main load. Four large 6V batteries will be used. This block is being researched.



Three voltage regulators will be used in the design. The first will be connected to the turbine to maintain a safe voltage. Our sponsor has suggested using maximum power point tracking (MPPT) to allow for the maximum output of power from the turbine. The second one will be used to step down the 24V from the battery to 5V for the control systems. The final regulator will be used to regulate the voltage for the AC load.

The system will save voltage and wind readings for analysis. Inputs to the data block are wind speed and direction and voltage inputs. The info will be logged for user access via USB. Data that is accessed also outputs to a display



A display will show the data collected from the system. The data that is going to be displayed are also the inputs which are the turbine voltage for three phases, the DC voltage from the rectifier, the changing current, turbine shaft speed, and wind speed. Display design is being researched.

Budget and Financing:

- PMA Alternator: At a cost of $1570.00, this is the most expensive part of the project.
- Rectifier kit: $70.00
- DC meters (Amps &Volts): $40.00
- Circuit board work: $100
- Blade system (for low wind speed): $498.00
- Center shaft: $20.00
- 4 Batteries: $350.00 each
    - **Estimated Total**: $3698.00