Cameroon Wind Energy Generation

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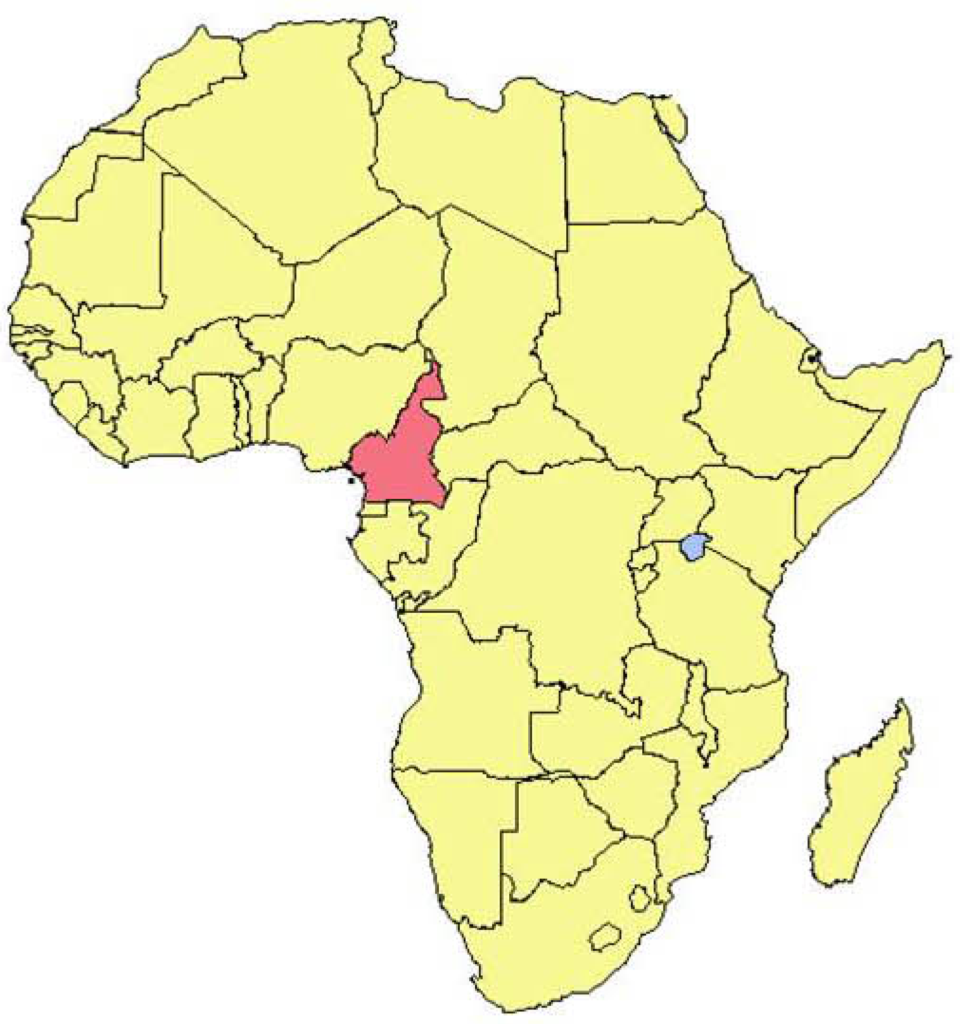


Problem:

The roots of the wind energy generation project are tied back to the African Centre for Renewable Energy & Sustainable Technology (ACREST). The main goal of ACREST is to help Cameroon transition from a developing country to a developed country. ACREST is an organization that works to provide the people of Cameroon with clean renewable energy, in an effort to become a self sustaining country. The purpose of our project is to examine the current power generation situation in Cameroon and develop an improved solution for wind power generation. Important factors in the improved solution are availability of parts, cost of materials, time to manufacture, and part reliability.

Objective:

- Create a design for a wind turbine that can be manufactured in the town using locally available materials.
- The Design must have balanced blade system with mechanism to withstand wind gusts up to 30 mph.
- Design reliable electronic charge controller to prevent overcharging of batteries.

Current Solution:

The current solution in Cameroon Africa is a 3 blade horizontal axis wind turbine. These wind turbines typically stand about 20 feet in the air and have a 6' blade diameter. The current blades are hand carved wooden blades and take approximately 6 hours each to manufacture. The current solution uses a hand made permanent magnet generator to supply power to a bank of 12 volt batteries. The final key to the current solution is the charge controller which prevents the battery bank from overcharging.

Picture from: www.3dcadbrowser.com/preview.aspx?ModelCode=16890

Requested Modifications:

After multiple discussions with ACREST we have determined the most important aspects to the blade design are material availability, cost of material, and time to manufacture the blades. In addition to this they have discussed that they would like a more reliable design for the charge controller and would be interested in being able to use the energy generated when batteries are charged to power an auxiliary function such as a water heater.

Blade Design and Analysis

Horizontal vs. Vertical Axis:

Most wind turbines designed for power generation are of the horizontal axis variety.

The main advantage of a horizontal axis wind turbine is the rotor can easily be made from blades formed with an airfoil shape. This increases the operational efficiency over typical vertical axis turbines which use drag type rotors.

The airfoil shape of the blades is positioned so the lift vector of the blades is parallel to the plane of rotation. Since the velocity of each blade element increases proportionally with radial distance, a twist is designed into the blade to reduce the angle of attack and keep the lift vector pointing in the same plane along the whole blade.

Blade Creation:

The blades for our turbine design are created from large diameter PVC pipe. The pipe is cut into 3 vertical sections, each being 7 ¾" around the circumference of the pipe. A diagonal line is then drawn across the section from 5 ¼" to 2 ½" in circumference.

This method produces two turbine blades out of one section of the pipe, thus enough blades for two turbines (six blades total) can be produced from this one 2' piece of pipe. Therefore, one 10' length of pipe can create enough blades for 10 turbines.

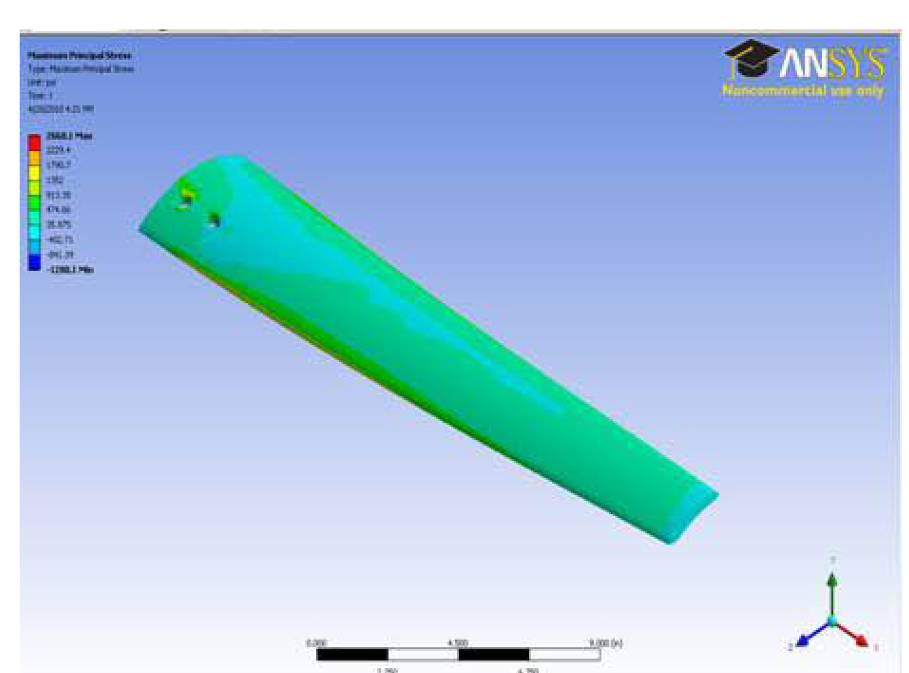
Blade Analysis:

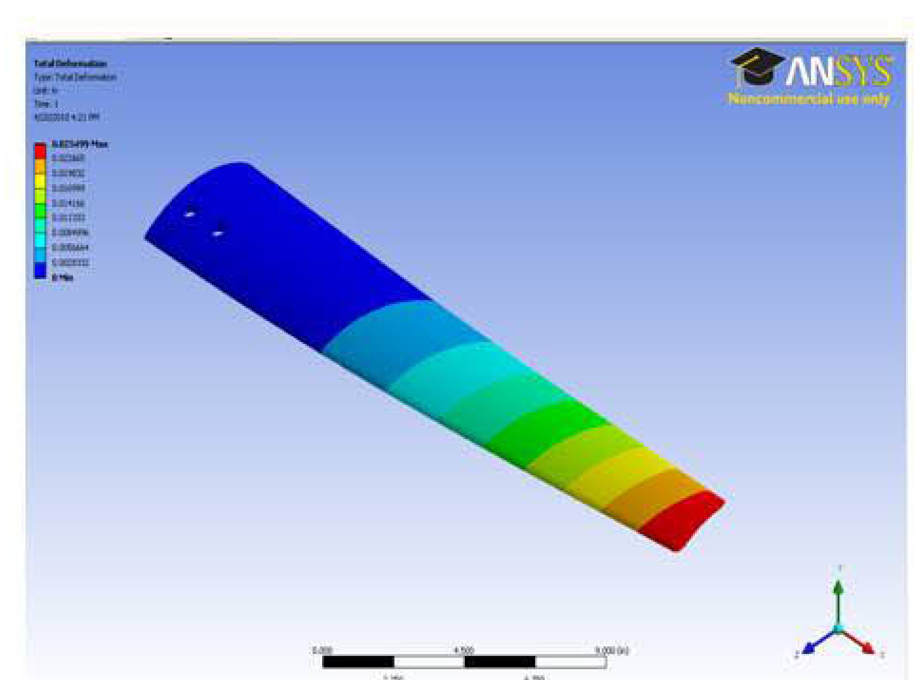
Blade models were created in ProE Wildfire 4.0 and analysis was performed using ANSYS Workbench.

Models were created out of 6", 8" and 10" diameter PVC pipe (σ_{UTS} = 7880 psi) in 2' and 3' lengths.

During the analysis the crucial variables that we were examining were the max principle stress and the max deflection in the blade.

Using this analysis we have determined that the 6" PVC doesn't have the strength to withstand a 30 mph wind. We also found that the 3' blades tended to push the outer limits of the material strength at this wind speed.





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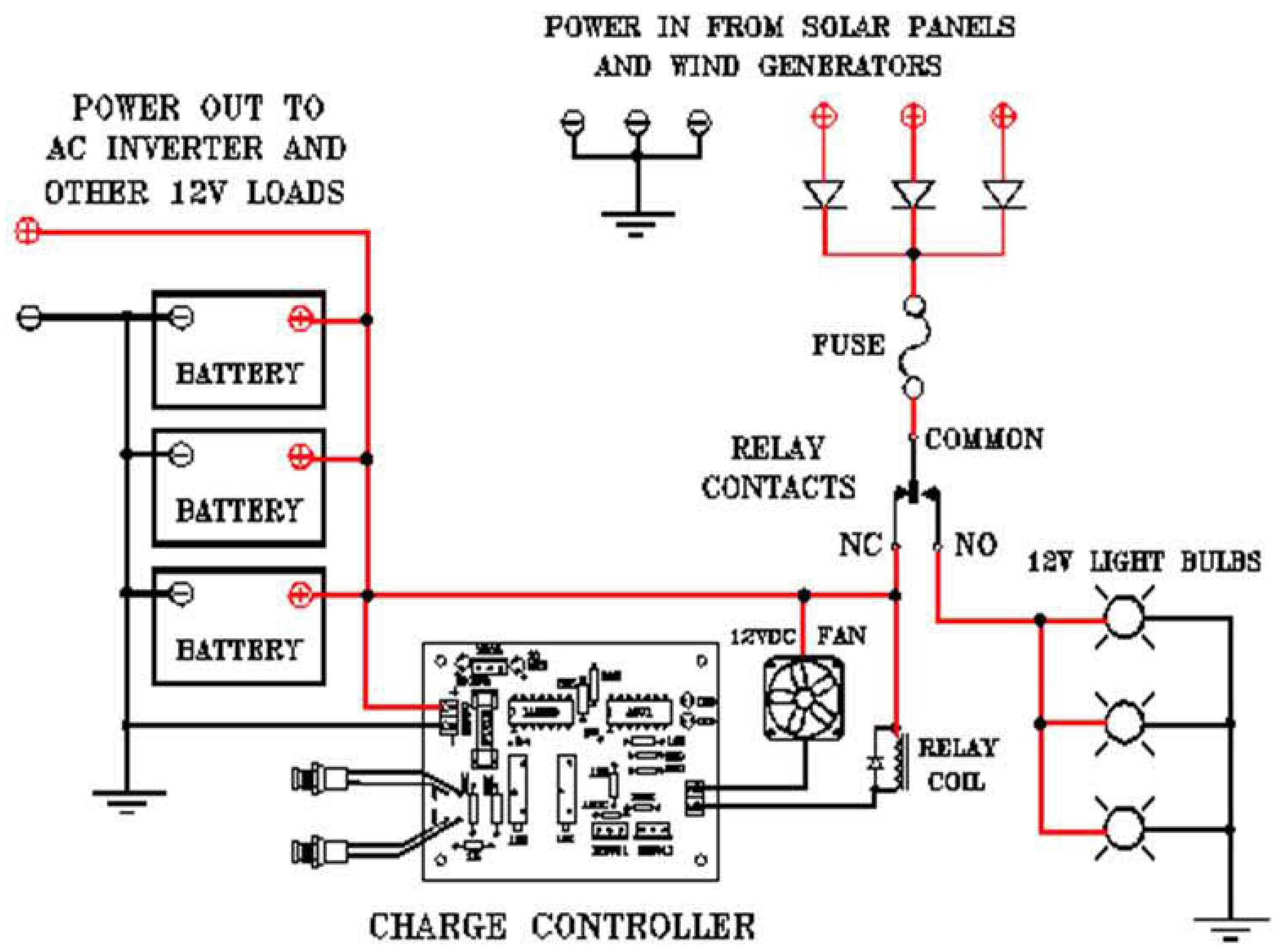
April 20, 2010

Charge Circuit Design and Analysis

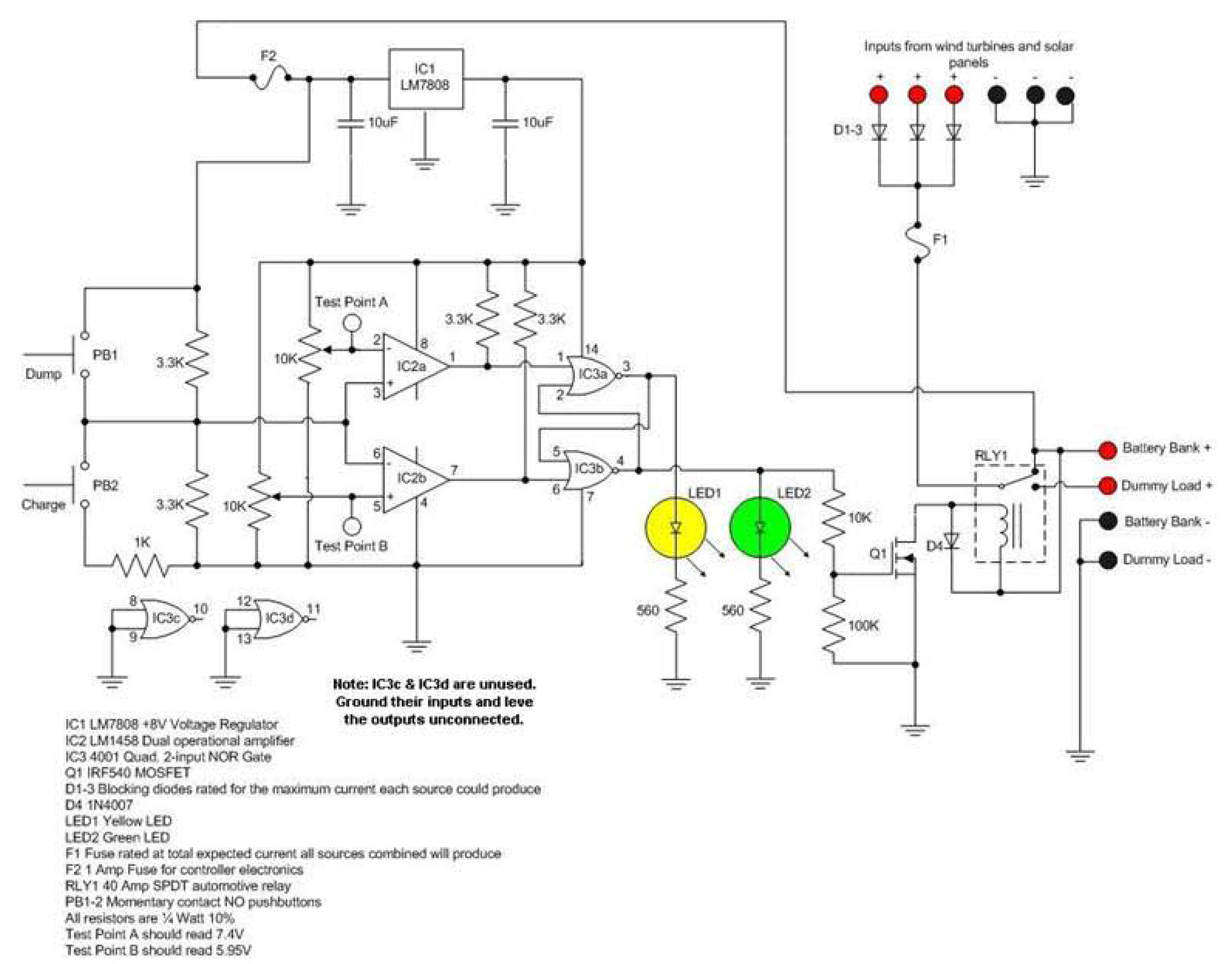


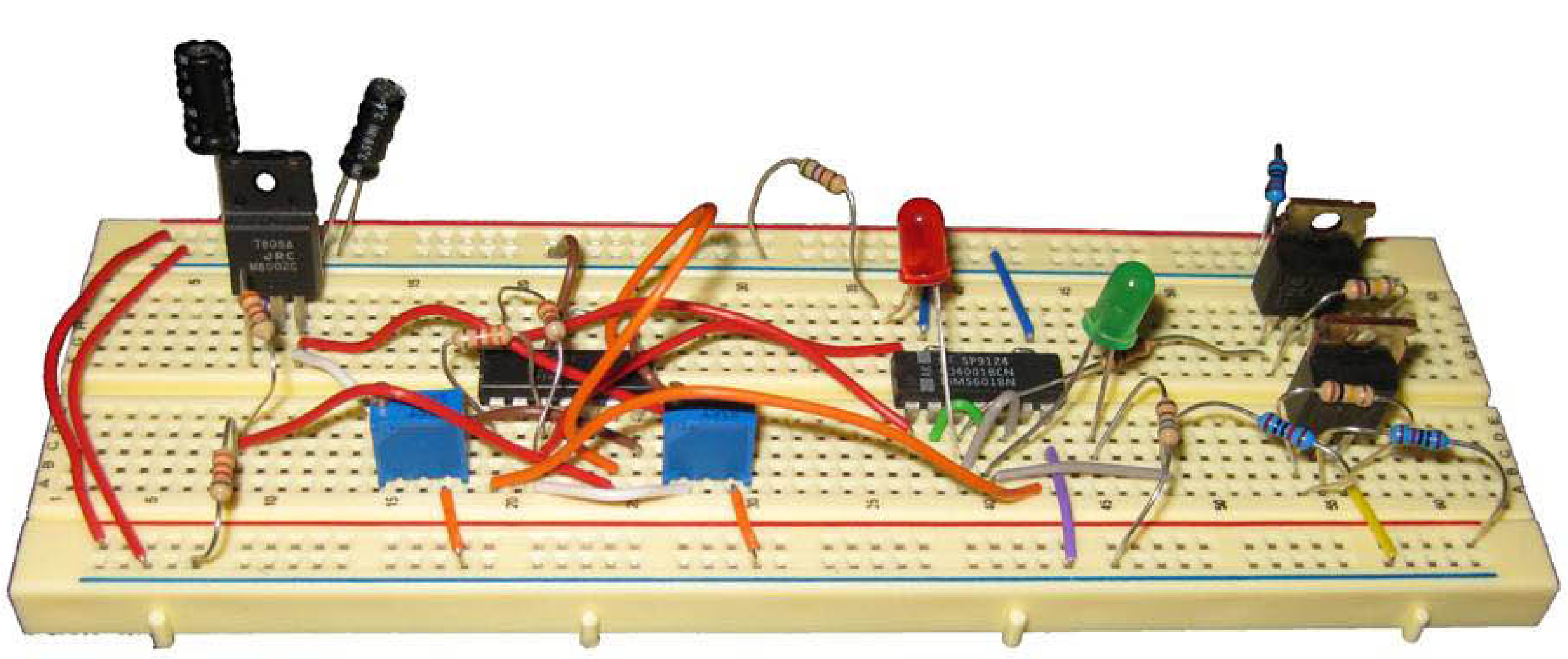
Purpose:

The purpose of the of the charge controller is to manage and control the battery charging system. The importance of this system is to prevent the battery bank from overcharging, thus decreasing the life of the batteries. As you can see in the figure to the left, the positive lead from the generator of the wind turbine is shared with the input side of the charge controller and the positive side of the battery bank. On the output side of the controller, you can see another positive connection to the battery bank and a common connection to ground. This set-up allows the controller to monitor the batteries' voltage and charge the bank when necessary or dump excess power.

Function:

The charge controller takes the voltage input from the battery bank and compares it to the cut-in voltage that we set using the potentiometers (~10V). If the value is below this preset threshold, the controller will activate the charging circuit and the yellow LED will illuminate. This branch of the circuit will remain active until the battery voltage reaches the cut-out voltage (~14V). At this time, the controller will re-route the power from the charge circuit to the dump circuit (represented by the bank of 12 V light bulbs above). The dump circuit will remain active until the battery voltage drops below the cut-in voltage and charging of the battery system will resume.





Dump Circuit:

The dump circuit can be used to power any number of 12V devices that do not require personal supervision. The solution we have proposed to ACREST is to connect a 12V submersible electric hot water heater element. This can be used to help heat water for cooking or bathing, reducing the need to burn other fuels.

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