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Wind Turbine Electronic Furling and Yaw Control

Curtis Cole
Lauritzen Inc.
June-2009

Objective:

To control a wind turbine to optimally harvest energy and protect the system components. The system must point the turbine into the wind to collect energy and furl by turning out of the wind when appropriate. The system must be fully accountable and report system failures and faults.

System Description:

A typical wind driven electricity generator has the following components [Figure 1]: a turbine with blades attached to a generator or dynamo to product AC or DC electricity; possibly a rectifier to convert AC to DC; an inverter to convert DC to AC suitable for tying to the grid; and sensors to monitor the turbines speed, direction, and power production. An electronically controlled system also needs an anemometer and wind vane to measure ambient conditions; a motor to point the turbine in a specific direction; and a controller to command the motor based on the sensor inputs and control algorithms.

The controller, motor, and sensors must have a power source independent of the grid power. When the grid power fails, the system must have adequate power to shutdown the turbine and lock it into a stow configuration.

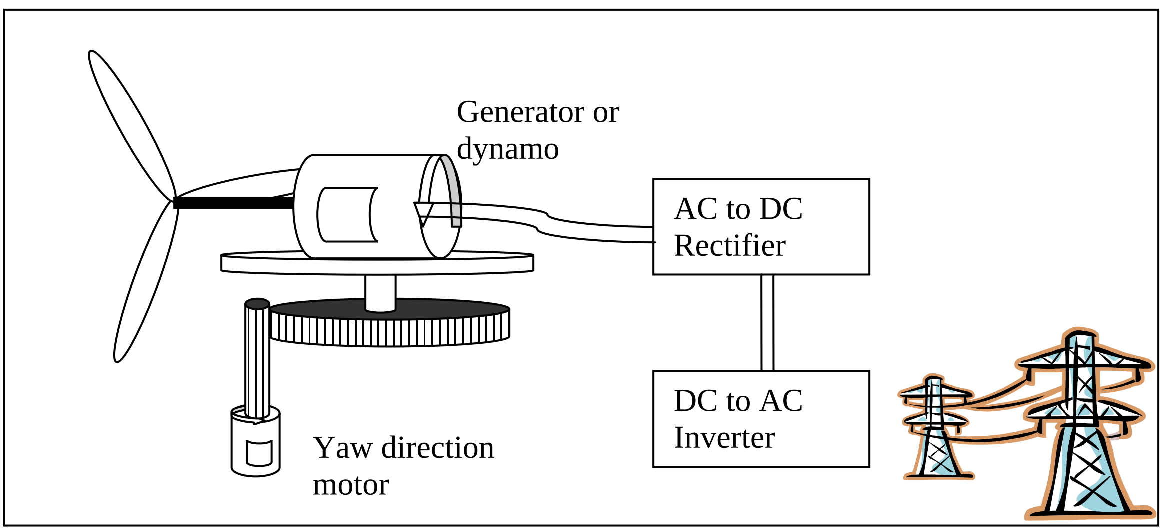

Figure 1: simplified wind turbine

A Lauritzen Inc. Kári Wind Turbine Controller is capable of monitoring and managing the operation of an electronic furling wind turbine. It monitors the turbine RPMs, turbine direction, AC generation, grid-tie and inverter status while also receiving data from weather station component such as an anemometer and wind vane. Kári then drives commands to the turbine's position (yaw) motor.

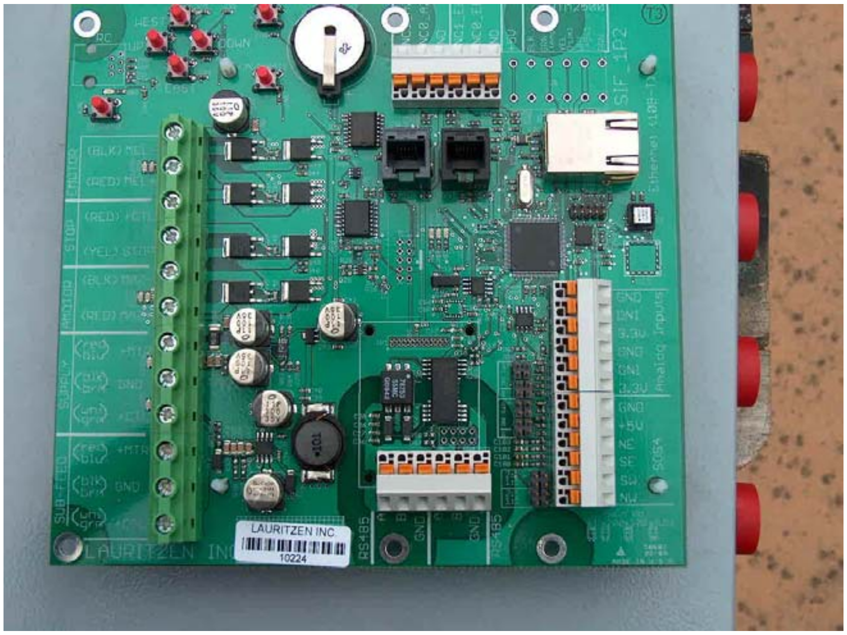

Figure 3: Kári controller

The Kári controller is connected to the Lauritzen Inc. servers through a 10Mb Ethernet cable, and provides periodic updates of system status. Similarly, a connection can be established from the Lauritzen Valhalla server to the Kári controller to provide diagnostics, on-line technician support, as well as remote software updates.

System Operation:

The operation of a typical wind turbine is the same around the clock. It does not show the ephemeral change typical of a PV or thermal hot water system driven by solar radiation. However, winds often do follow a regular pattern over a day.

In the normal operation of a wind turbine, the controller continuously points the turbine directly into the wind to harvest the most energy possible from the wind. System parameters control how often the system will move to chase a new wind direction and require a minimum step size for a move to avoid insignificant adjustments.

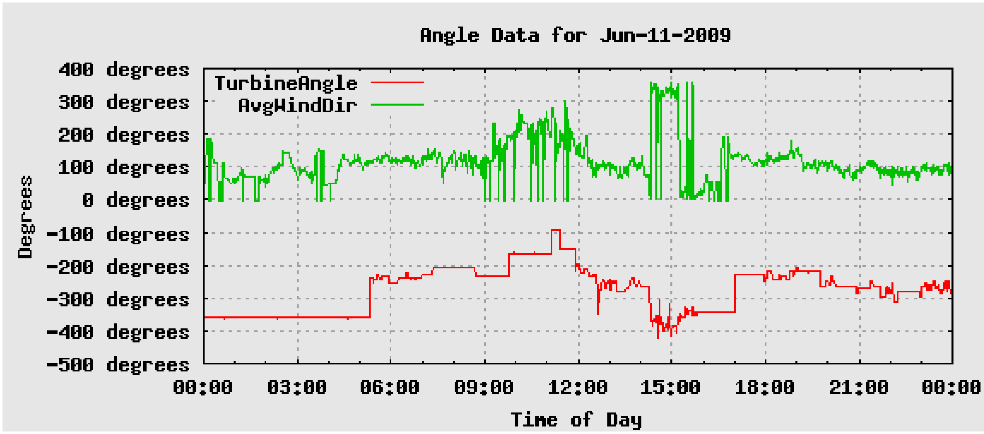

Chart 1: Turbine Angle (range -540 to +540) vs Wind Direction (0-359)

In the lightest of winds, it is not useful to point the turbine into the wind as so little energy is available. So system parameters specify a minimum wind speed to prevent the turbine moving around while there is little or no wind. At the other extreme, since the kinetic energy in wind relates to the cube of the velocity, high winds can damage a turbine and its generator.

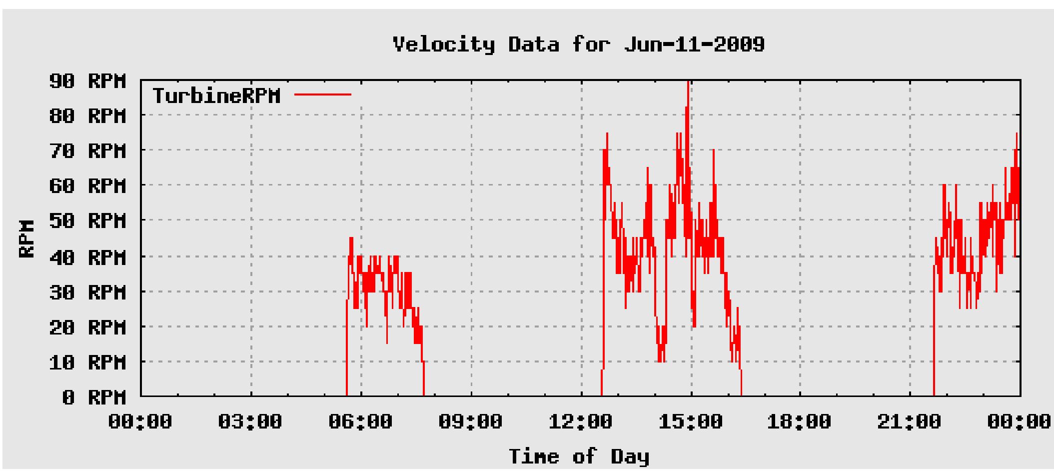

Chart 2: Turbine RPMs

Electronic furling refers to turning a turbine away from the wind to collect less energy and slow the rotation speed. In high winds, or when a generator is turning at a speed above a system parameter, the controller can turn the turbine a number of degrees out of the wind to produce energy at a safe turbine RPM. Under more severe conditions, the system is shutdown by turning 90 degrees to the wind, waiting for the rotation to drop low, and applying a brake to the generator.

Finally, other external effects such as grid failure, inverter failure, or the presence of an operator can require the system to go into a safety shutdown. Control algorithms in the Kári Controller implement these wind following, electronic furling and safety requirements [Figure 3].

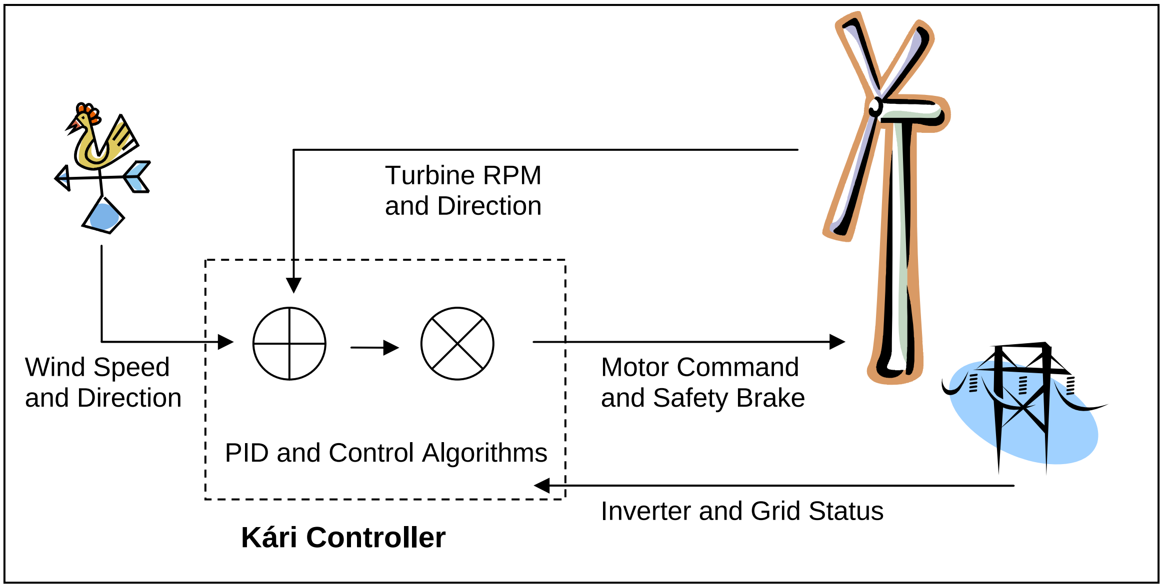

Figure 3: wind turbine control block diagram

The Kári Controller sends sensor data, events, and alarms to the Lauritzen Inc. Valhalla server. Field support teams receive notifications of a turbine's unusual behavior. Through a remote diagnostic session, service technicians can monitor and diagnose many field problems without the expense of driving to a remote wind farm.

In Norse mythology, Kári is the personification of wind.