FPGAs Go Green in Wind Turbine Control

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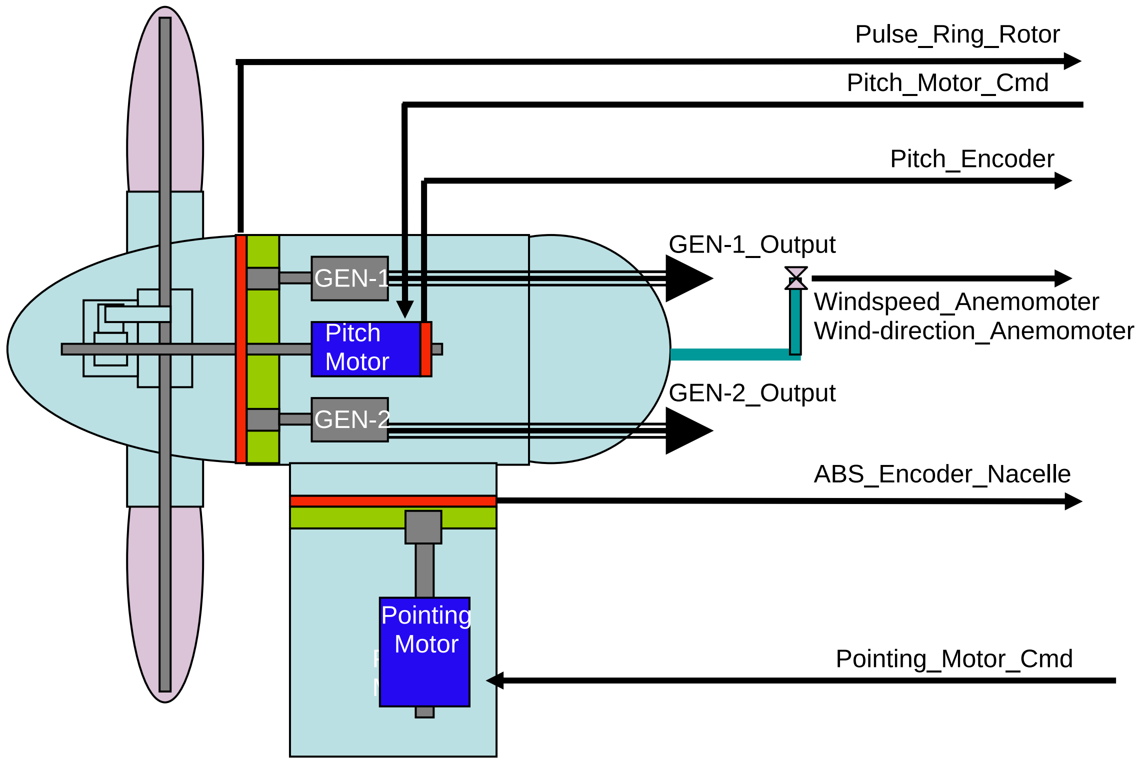
Energy conservation is ever-growing in importance, both from environmental and personal perspectives. Using less energy will preserve resources and reduce consumer costs provided appropriate low-energy devices are made available, reliable, and put into commonplace use.

Successful green power generation requires that:
a) more power is produced than is consumed in generating the power, and
b) the mechanisms and control apparatus deployed yield sufficient payback to recapture the overall investment made for installation and a lifetime of maintenance.

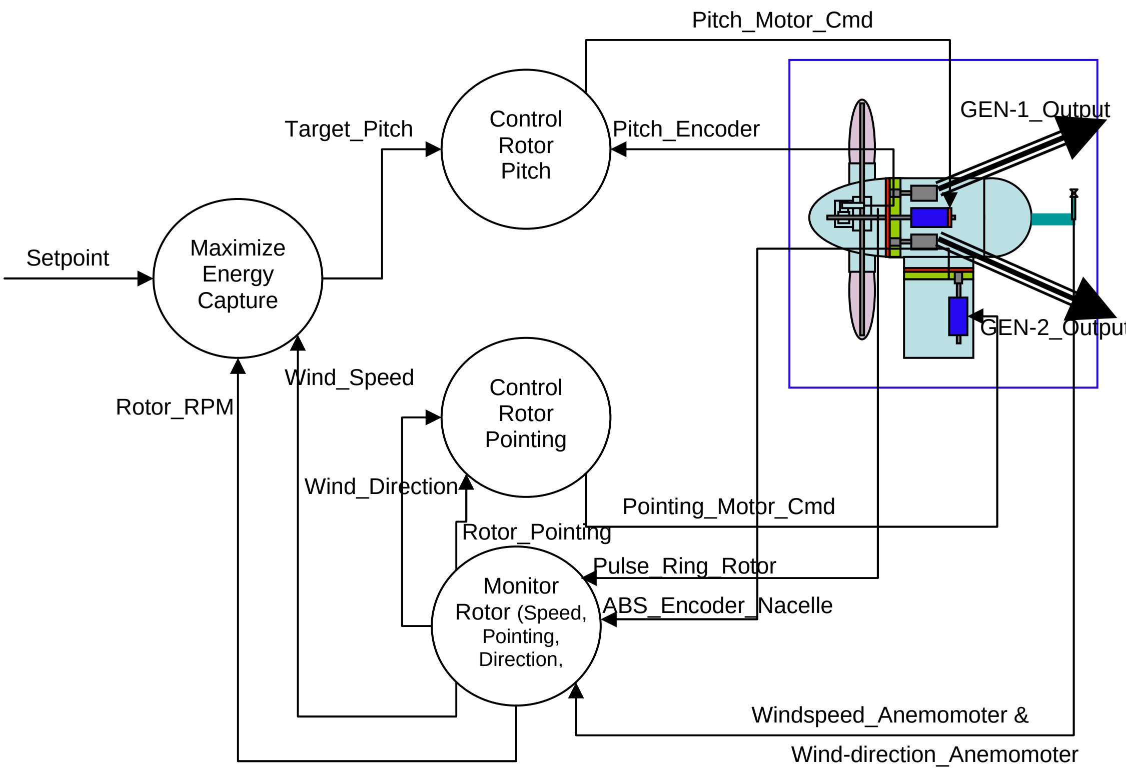
Field Programmable Gate Array (FPGA) technology is currently playing a significant role in energy conservation. Wind turbine control is just one application where PMC modules with reconfigurable FPGAs are being used in renewable energy ventures.

Figure 1: A typical rotor turbine head



The basic components of a control system to maximize energy capture from a wind turbine include: rotor pointing, blade speed regulation, minimization of pointing and pitch control, and the mitigation of disturbances (i.e. excessive rotor speed, wind gusts, etc.). See Figure 1. Additionally, the environment inside the rotor head, or nacelle, is very hostile. Any control device used in this environment must be self-diagnostic, re-bootable, extreme temperature tolerant, vibration tolerant, and of course, affordable.
There are many methodologies that will be or are currently being implemented. Many of these approaches will share the basic control architecture components of Figure 2 below.

Figure 2: Typical control architecture components



Acromag PMC FPGA modules provide a unique combination well-suited to the application's requirements. Conduction cooling and wide ambient operating ranges help withstand the extremes temperatures. High channel density with up to 97 single-ended I/O points on the front edge and up to 64 single-ended I/O points on the rear connector enables monitoring and control of many components. Logic is stored in re-programmable flash memory, available in variable capacities, and is re-bootable at any time. The PMCs are able to generate and monitor high speed serial communications. They can simplify the capture of encoder and position feedback, as well as facilitate driving stepper motor systems and closing servo loops. And finally, the capability to execute the RTOS of choice on top of either a soft of hard PowerPC foundation makes the selection of PMC FPGA modules very popular for wind turbine control and similar green applications.

In Figure 2 above, the Setpoint would include items such as the Target_RPM at which the rotor most efficiently generates power and any boundary conditions (pitch, RPM, rate of movement for pitch and pointing correction, etc.). Based upon wind speed and direction information from the anemometer attached to the turbine head's nacelle, it is possible to determine the ideal Target_Pitch for the rotor turbine blades. The Pitch_Encoder data provides present position information and the Pitch_Motor_Cmd is generated to acquire Target_Pitch. Similarly, using wind direction information from the anemometer, rotor pointing is adjusted for optimal use of the prevailing wind source. Capturing sensory information, executing algorithms to maximize energy capture, and generating commands to address circumstantially ideal rotor pointing and blade pitch positioning are simple tasks for robust PMC FPGA modules. In fact, PMC modules, such as Acromag's PMC-VFX70 with a Virtex-5 FPGA and PowerPC core can be solely tasked to this undertaking in standalone configurations. No in-rotor or in-nacelle computer is required.