Generator Control Simulator

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Abstract

The objective of this project was to program a generator control simulator in Rockwell Studio 5000, and emulate a PLC on a laptop. A key part to the success of this project was the Generator Control Simulator to receive commands at individual stages for each operational state, and provide feedback that the present stage has been achieved. There are three states for this Control Simulator. The starting state brings the generator/turbine from a stopped state to an online state. Starting state interacts with auxiliary systems, master circuit, brakes, governor system, excitation system, exaltation system, and the closing of the breaker. Each system is in a stage or step in the startup sequence. The Online Control State consists of three control modes. The three modes are: Megawatt control, Gate control, Forebay Level control modes. Each mode will monitor the gate position, forebay level, and MW output. The Shutdown State will take the generator/turbine from an online state to a complete stopped state. The shutdown state will send the gate control to zero immediately beginning the shutdown sequence. Shutdown state interacts with auxiliary systems, master circuit, brakes, governor system, excitation system, and opening the breaker. Each system will be a stage or step in the shutdown sequence.

Design

Ladder Logic Overview

Ladder Logic consists of a series of rungs that close and open contacts to perform computing logic.

Function Block Diagrams

Function block diagrams in Rockwell are useful when computing via non-Boolean values. They allow the user to compute and analyze data based on functions in the ladder logic itself or other function block diagrams. The block diagrams run off Boolean algebra as well as comparators, timers, and counters.

System Diagram

Snead, AVR: Automatic Voltage Regulator
MW: Mega Watt
Governor: Manages the speed of the rotor, as well as rotor stability
For a future iteration the team would recommend taking an input of the excitation
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Bose.

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Future Work

Starting State: For a future iteration the team would recommend taking an input of the excitation current into the system that can directly represent the voltage level, and as fluctuation occurs the team can adjust the current accordingly so as to monitor the voltage to the grid.

Online State: In a future iteration the forebay would likely need to be reconfigured to work off of very specific values of gate and megawatt output, this comes from the fact that most dams operate at a forebay level within a very small error margin.

HMI Touchscreen: A future iteration would almost certainly utilize multiple screens, as well as a table where all elements can be monitored in one screen for optimized operability.

Glossary

- PLC’s and Touchscreens make the panel more compact, allowing it to be much smaller. They also clean up various wire connections.
- Many operators are used to operating a panel with switches, changing over to a HMI touchscreen can be a slow process.
- Having a PLC lab allows Avista to test their code before implementing it to the field, where before they couldn’t test until it was in their system.
- As demand for power grows over time PLC control in hydro-generator facilities will need to be commonplace for the most efficient control of power flow.

Results

After the user toggles the start button via a touch screen or mouse, the program enters the starting state.
The Simulation indicates when the various systems have been checked, via the green lights.
The speed, voltage, and frequency are tracked until the desired setpoint is reached.

HMI Interface Design

The interface used to communicate the response of the generator control simulation is a touchscreen built through FactoryTalk View. The HMI display allows the user to control the generator simulation from a singular window. The display shows the SNL, AVR, frequency, contact states, and gate, MW, and forebay levels, through a plethora of options of buttons, lights, and gauges.

Broader Impacts

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