Implementation of Real-Time Controller in the Loop Simulation using RTDS® and NI cRIO

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Abstract

The need for reliable and efficient power systems, that are more actively managed, has increased due to the rapid technological growth our society has experienced in the past fifty years. With the development of unique power system simulators and rapid prototyping systems, it is possible to design and test new control methodologies on system models without actually building the physical systems, providing a cost effective and fast method of designing, testing, and enhancing electrical power systems controllers. The objective of this research was to develop a hardware-in-the-loop system using a real time digital power system simulator and a real-time controller simulator. This implementation was performed using the RSCAD program which runs on the Real-Time Digital Simulator and the National Instruments LabVIEW program which runs on the real-time controller NI cRIO-9004. A simple two bus system with an over-current relay (as the controller) and a two bus system with a voltage regulator (as the controller) were designed, implemented, and tested. Case studies from the two systems are presented to illustrate the controller methods and the real-time functionality of the systems.

RTDS

Real-Time Digital Power System Simulator

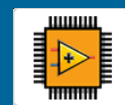
- Is the hardware that takes the power system circuit created in the RSCAD design software and runs it in real-time.
- Sends the Analog/Digital outputs to cRIO.
- Receives Analog/Digital input to determine values needed for the simulation.

Analog-Digital I/O

Analog-Digital I/O

cRIO

Field Programmable Gate Array (FPGA)

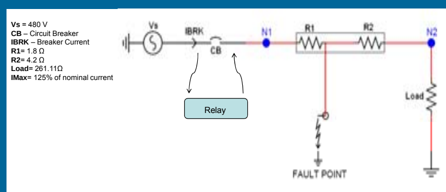


- Reconfigurable chip.
- Processes analog and digital input/output.
- Can be programmed using LabVIEW FPGA tools.

Compact Reconfigurable Input Output

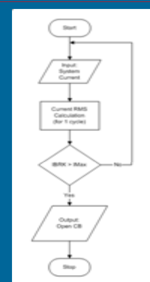
- Features embedded real-time processor for reliable stand-alone or distributed operation.
- Can be used for real-time controller testing, analyses and data acquisition.

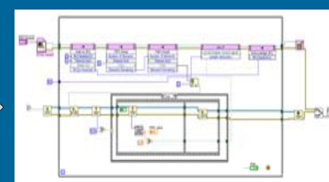
Case 1: Over-current Relay



IBRK (analog signal)

CB (digital signal)



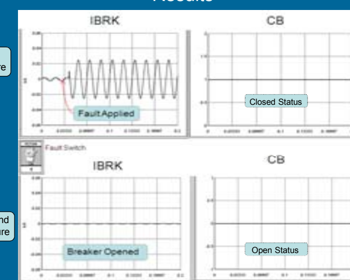


- Single phase power system with an over-current relay that detects when there is an over-current due to a fault, then send a signal to open CB to isolate fault from circuit .

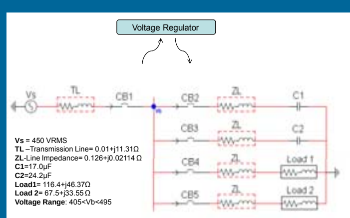
Results

First Capture

Second Capture

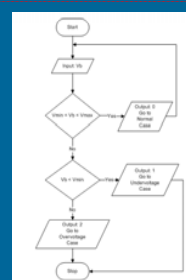


Case 2: Voltage Regulator



$V_b, CB_2, CB_3, CB_4, CB_5$ (analog/digital signals)

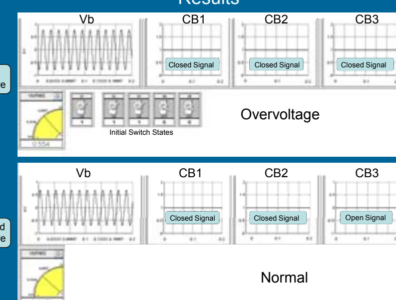
CB_1, CB_2, CB_3 (digital signals)



- Voltage regulator in the single-phase power system monitors the voltage on the load bus, V_b , using two capacitor banks to regulate the voltage within a specified range

Results

First Capture



Second Capture

Conclusions

- Both hardware in the loop simulations worked correctly; this can be confirmed by real-time responses between the systems.
- A look-up table was used in the second case to obtain the voltage output, this constrains the studies that can be done. A DAE solver would provide a controller that could calculate the values for any situation.
- The scale factor of the signal sent from the RTDS influences the precision of the controller in the cRIO.

Future Work :

- Replace DAE look up table with a DAE solver or simulator.
- Increase the complexity of the power systems to better understand hardware in the loop simulation.
- Use different data window sizes for data signal processing.(ie. ½ cycle, ¼ cycle, etc.)

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