TCIPG Phasor Measurement Unit Demonstration

Karl Reinhard, Michael Quinlan, Keehoon Yoon, Kenta Kirihara, Bogdan Pinte

Problem Statement

To build a working open-box Phasor Measurement Unit (PMU) using National Instruments FPGA module.

Context

- Smart Grid initiatives, started in 2007, envision very reliable synchrophasor data
- PMUs promise to provide near-real time, time-stamped, state-variable field measurements with millisecond-level resolutions
- Phasor Data Concentrators (PDCs) receive data from multiple PMUs and enable monitoring :

  ➢Phase and power angles
  ➢System oscillations that threaten system stability
  ➢Voltage stability
  ➢Line Thermal conditions

Measurement Objectives

Global Positioning System Timing Data

To detect, interpret, and use GPS timing signals to provide a precise time reference for each synchrophasor data set calculation. The timing signal consists of a signal precisely marking the start of each second and each second's time stamp. The GPS timing pulse's leading edge is timed to be accurate within 1µs of the GPS second mark provided by the Naval Observatory's atomic clocks.

Power System Voltage and Current

To filter, sample, and measure single voltage and current readings from the 120V distribution level electric power system.

Results

- Frequency, amplitude and phase are acquired from the sample voltage and are used to build the voltage waveform displayed on the front panel
- Time stamp for the sampled voltage waveform is obtained using the GPS signal

Equipment

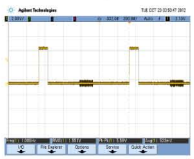
Voltage is measured using a National Instruments LabVIEW software, Compact-RIO (Compact Re-configurable Input-Output) system, and Global Positioning System Timing Signal composed of the following components:

•C-RIO 9025 Real-time Controller
-Used to run LabView

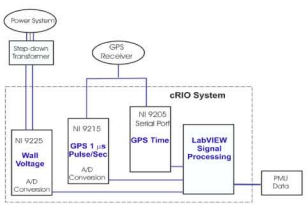
•Virtex-5 LX30 CompactRIO Reconfigurable chassis
-The FPGA module that holds data modules

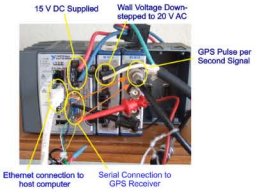
•Data Modules :
- •NI 9225 3- Channel 300 Vrms Analog Input Module 300 Vrms measurement range
- •NI 9215 4-channel, 100KS/x/ch 16 bit +- 10V Analog

•The Garmin 18x LVC GPC antenna and receiver
- Provides the 1µs accurate time pulse

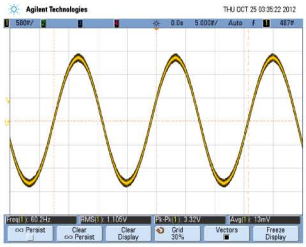


Garmin 18x LVC GPS timing pulse (left) which marks the start of each second has a data within the signal (right). The date and time data extracted for the synchro-phasor data time stamp, read by Putty terminal, is highlighted.

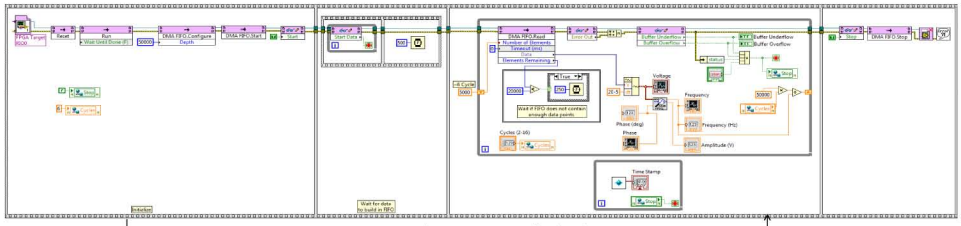




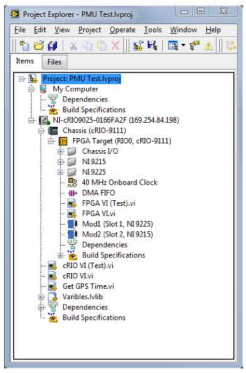
The two figures above show component interconnection (left) and physical connection (right)



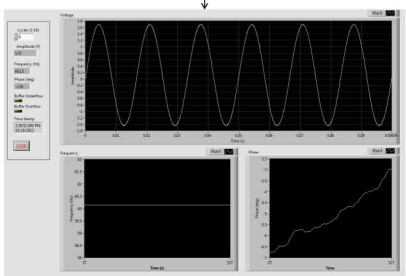
Sample Voltage Waveform (60 Hz)



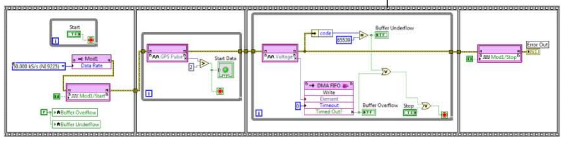
LabVIEW PMU Block Diagram



The Project Explorer shows relationships between the Virtual Instruments (VIs), cRIO Controller, and data acquisition modules that must be established to create a functioning system



LabVIEW Front Panel of simulated PMU system



LabVIEW FPGA Block Diagram. This subVI is part of the PMU Block Diagram

Future Efforts

- Revise the PMU to fit IEEE standards
- Place a more precise time stamp
- Sample distribution currents via c-RIO system
- Extend the work to include 3 phase PMUs and generate a 3-phase balanced composite phasor