Coupled Data Logger and Analyzer

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Abstract

Many data logging operations collect data for a period of time and then analyze the data that have been collected. Sometimes it is necessary to analyze data while they are being sampled. A recent survey of commercial off-the-shelf (COTS) data logging equipment determined that data loggers that can be configured to analyze data while they are being sampled are scarce and extremely expensive. Exploration of options to consider for developing a data logger that allows data to be analyzed while they are being sampled led to a novel solution.

Introduction

A manufacturer was interested in having a reliability test system that would control power to up to 80 units being tested in an environmental chamber, that would communicate with those units, and that would log RMS input voltage, RMS input current, and chamber temperature for the 30 minutes leading up to a failure of any of the units. Power would be controlled for groups of up to 5 test units. Communication would similarly be for groups of up to 5 test units. The sample rate of the data to be logged for each failure event needed to be at least 10 Hz. A failure is defined as input current out of limit while voltage is being applied.

Tests in the environmental chamber would potentially be run for several months, requiring the failure event detection/data logging system to have a continuous uptime of at least that length of time.

The system would need to be able to maintain sets of control parameters, some related to tests and others related to products being tested. It would need to allow an operator to start, pause, resume, and stop tests. It would also need to be able to monitor the data near real-time. It would need to be able to allow an operator to view failure event data and catalog failure events. It would need to be able to produce test reports. It would need to provide a utility for operating low level control functions.

Argument

For a system with so many functions, an early consideration was to control power to the test units using a PLC, to perform data acquisition and analysis with a computer and to consider using the same computer to communicate with the units while they are powered. This approach would require tight coupling between the PLC and computer. It would also require a computer that is not prone to "crash".

It was determined that the failure event detection/data logging system would function best if the control, data acquisition, and analysis functions were performed on a platform with a deterministic operating system and the operator functions were performed using another platform.

Solution

It was noted that the National Instruments Compact RIO (cRIO) platform has a real-time operating system (either VXWorks or Linux, depending on the model) and allows data acquisition and communication modules to be plugged into its backplane. In addition, it has field programmable gate array (FPGA) that can be programmed for low level processing. The cRIO is programmed using National Instruments LabVIEW development software. LabVIEW provides several interprocess communication libraries that can be used to pass data between sections of software and between programs running on different computers.

The cRIO 9074 was specified for the controller and a touchscreen panel computer was specified for the operator functions. The 9074 runs at 400 MHz. It has 128 MB RAM and a 512 MB Solid State Drive. The touchscreen panel computer had a 1.5 GHz dual core CPU with 2 GB of RAM and a 500 GB hard drive. The environmental chamber temperature is controlled by an internal controller. The environmental chamber controller is programmable so that the chamber temperature can be cycled through a series of setpoints during a run. The environmental chamber controller has a power control relay output that is operated by the chamber profile program. Figure 1 shows the environmental test system components and their connectivity. The cRIO (Data Logger) is responsible for controlling power to the test units during tests, sampling input volts, input current, and chamber temperature, analyzing for failure events, and logging the data leading up to each failure event. The touchscreen panel computer (Panel PC) is responsible for maintenance of test parameters, controlling test execution, and monitoring test data and failure event data.

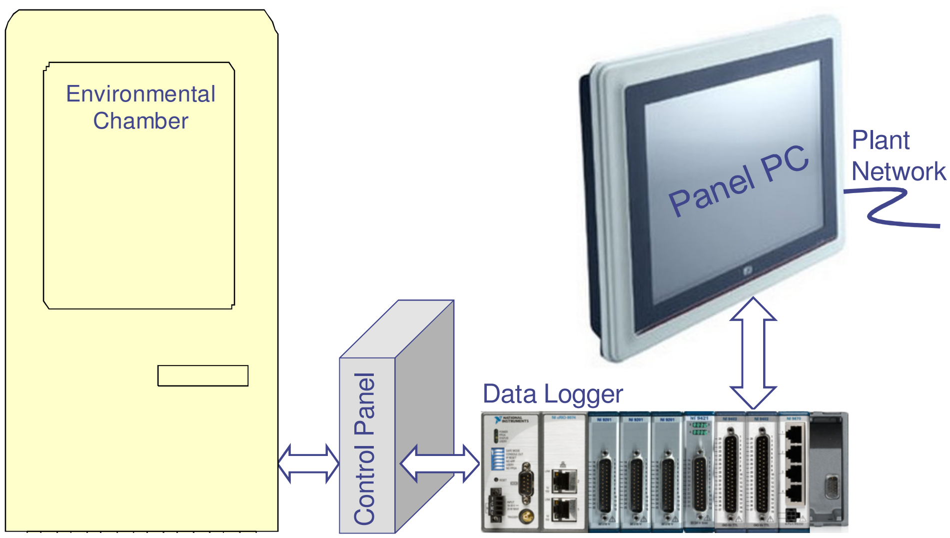

Figure 1. Environmental Test System Components and connectivity

The test unit input currents are measured using circuits that contain DC to RMS conversion in hardware. The FPGA in the cRIO can be programmed to convert the signal, but lack of familiarity with the tool to program the FPGA led to the decision to perform the conversion using a printed circuit card.

The block diagram of Figure 2 is a result of architecting the system software. The block diagram indicates the functions performed on the real-time controller (cRIO) and those performed on the panel PC. The major software sections are labeled in rectangles and data flow between these sections is represented as arrows. Interfaces with external components (relays, dimmers, and transducers) and data (raw data, event data, and event packages) are identified.

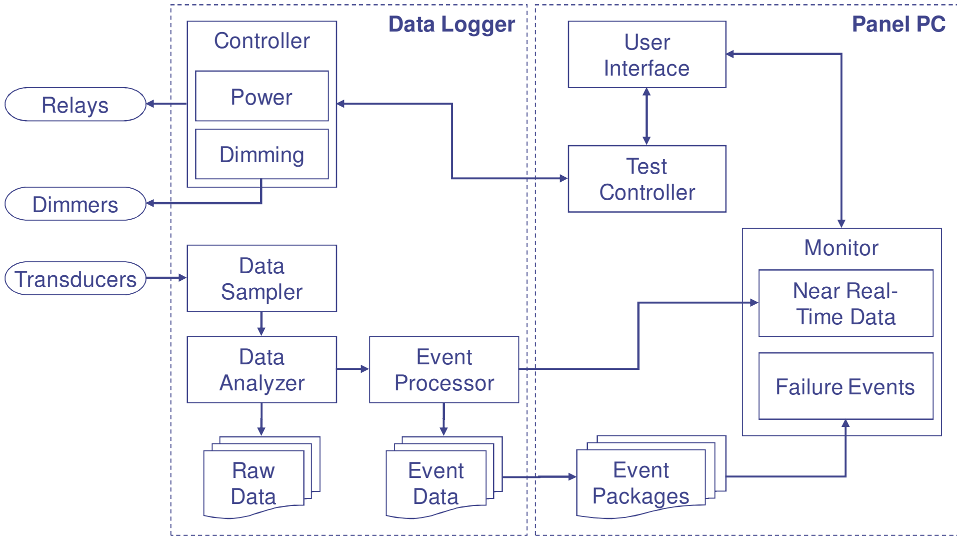

Figure 2. Environmental Test System Block Diagram

Data flow between the Data Logger and the Panel PC are accomplished using mechanisms built into LabVIEW. Commands and state information are shared between the Data Logger and the Panel PC using network published shared variables. The shared variable engine is hosted on the Data Logger so the Data Logger can continue to operate even when the Panel PC is disconnected from the Data Logger. Near real-time raw data are transmitted to the Panel PC using network streams. Test parameters are transferred to the Data Logger and failure event data are transferred to the Panel PC using ftp.

The Controller section of the Data Logger software controls test execution and turns test units on and off and changes power level (normal or dim). Power and power level schedule are determined from test parameters. Power can be controlled by the environmental chamber power control relay or by timing parameters of the test.

The Data Sampler is configured to acquire data from all transducers at a rate of 10 Hz and put the data into a real-time FIFO (queue) shared variable. The Data Analyzer pulls the data off of the queue, analyzes the data to determine if a failure event has occurred, and puts the data into a ring buffer. If a failure event has occurred, the channel (any of 80) and the timestamp are placed in a failure event queue. The ring buffer contains the most recent input volts for all 16 groups, the input current for all 80 test units, the chamber temperature, and the timestamp for each timepoint of data. The data from the ring buffer are transmitted to the Near Real-Time Data monitor using a network stream. The Event Processor retrieves the next failure event (if any) from the failure event queue, extracts the data for that test unit from the ring buffer, and writes the failure event data to a text file.

A test unit experiences a failure event when its input current is out of bounds (less than its lower limit or greater than its upper limit). The input current cannot respond instantaneously when voltage is applied. The input current limits for normal power and for dim power can be different. Therefore the input current is not monitored for failure for a short time after power is applied and for a short time after a change of power level. The amount of time after power on and power level change are parameters that are dependent on the test model.

The Panel PC software is used to maintain test parameters, control test execution, monitor near real-time and failure event data, view test reports, and monitor and control Data Logger inputs and outputs. Figure 3 is a screenshot of the Panel PC main screen. Navigation is provided by the buttons along the left side of the screen. Currently executing tests are listed in the Tests column. Power and power level state are indicated along with the failure state of each unit in the group. External input states are indicated in the lower right corner of the screen.

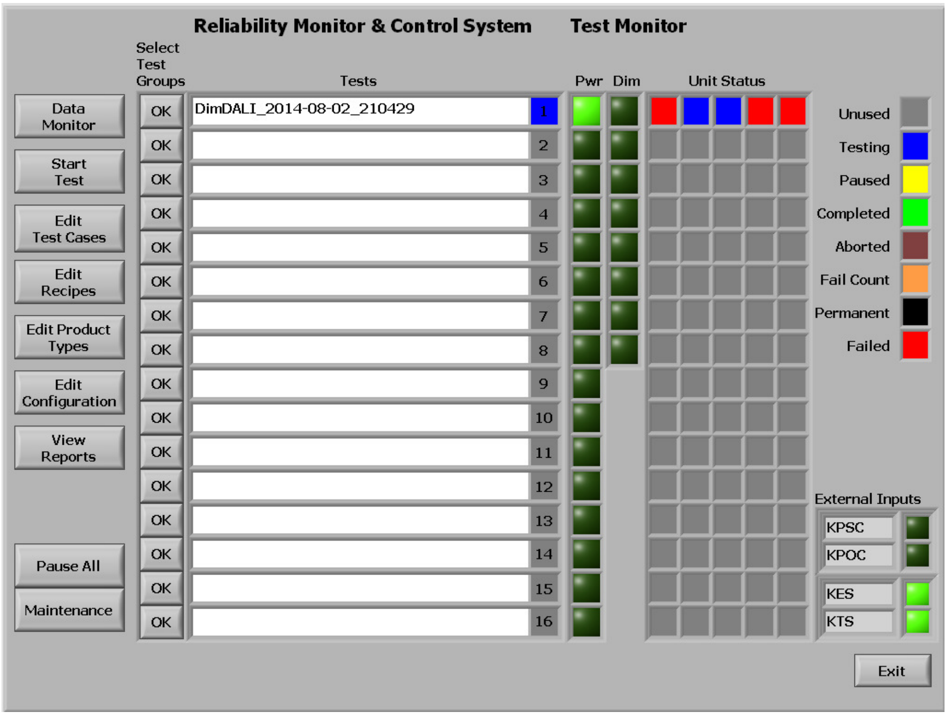

Figure 3. Panel PC operator interface main screen

The Raw Data Monitor presents the near real-time data for a test group. This consists of the input volts, 5 input currents, and chamber temperature. The Raw Data Monitor is shown in Figure 4.

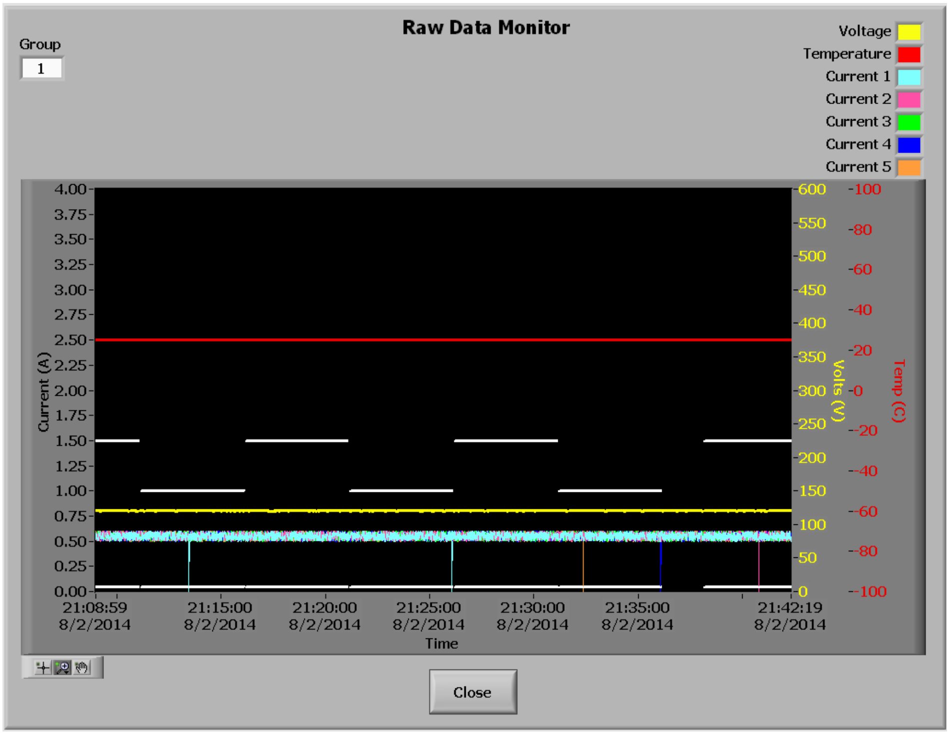

Figure 4. Raw Data Monitor

Monitoring of Data Logger discrete and analog inputs and control of Data Logger discrete outputs is accomplished using the Maintenance screen. The Maintenance screen is divided into two portions: the analog monitoring and the discrete monitoring. Discrete control is available on either view.

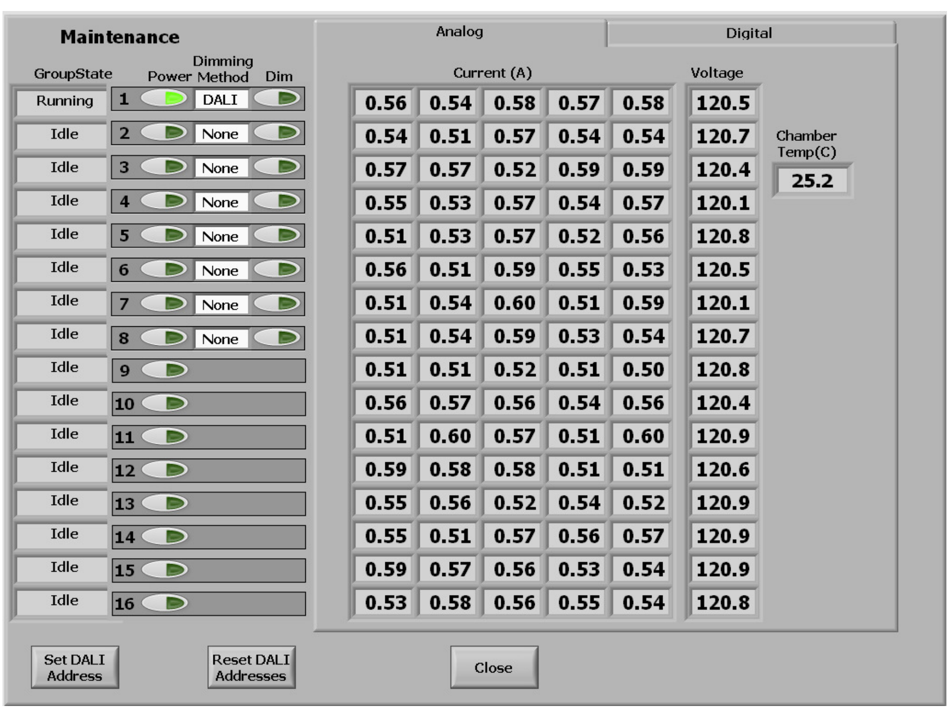

Figure 5. Maintenance screen analog inputs

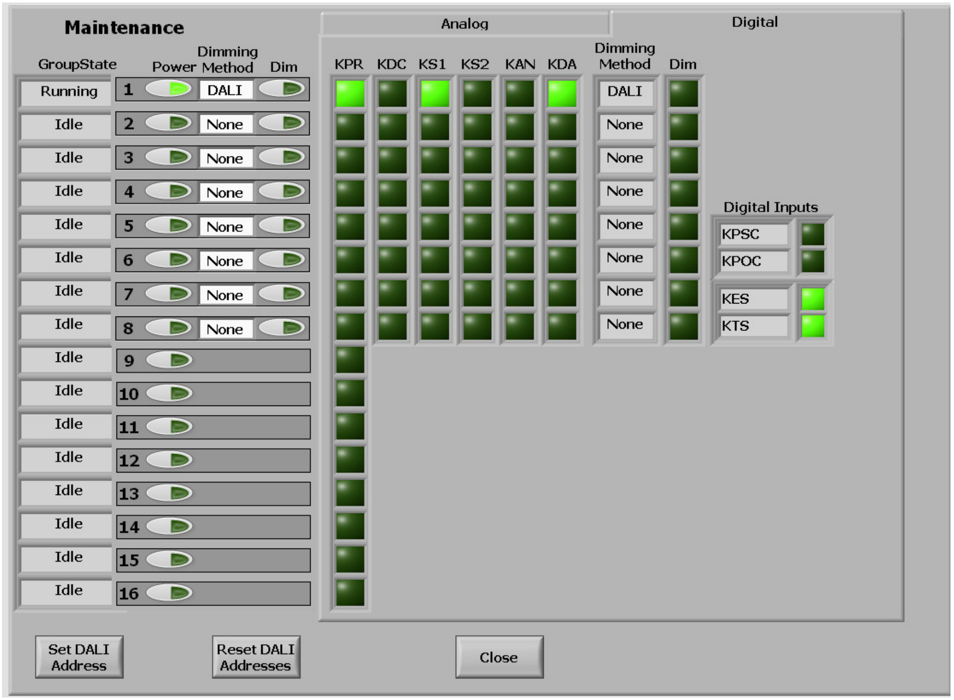

Figure 6. Maintenance screen discrete inputs and outputs

Conclusion

The National Instruments Compact RIO provides a highly reliable, deterministic platform for developing a moderate speed, high data count data logging system for controlling relays, acquiring measurements, analyzing measured data while the data continue to be acquired, and logging data to solid state disk. National Instruments LabVIEW can be used to develop software for a Windows desktop or laptop computer that, when connected to the cRIO, can be used to control operation of the system and monitor the system state. Additionally, high speed operations can be implemented in the cRIO FPGA to extend capability without loading the CPU.

The cRIO is a modular computing platform. The software developed for this application has been developed as a set of modules so that it can be readily modified for use in other applications.