ANALOG I/O MODULE TEST SYSTEM BASED ON EPICS CA PROTOCOL AND ACTIVEX CA INTERFACE

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Abstract

Analog input (ADC) and output (DAC) modules play a substantial role in device level control of accelerator and large experiment physics control system. In order to get the best performance some features of analog modules including linearity, accuracy, crosstalk, thermal drift and so on have to be evaluated during the preliminary design phase. Gain and offset error calibration and thermal drift compensation (if needed) may have to be done in the implementation phase as well. A natural technique for performing these tasks is to interface the analog I/O modules and GPIB interface programmable test instruments with a computer, which can complete measurements or calibration automatically. A difficulty is that drivers of analog modules and test instruments usually work on totally different platforms (vxWorks VS Windows). Developing new test routines and drivers for testing instruments under vxWorks (or any other RTOS) platform is not a good solution because such systems have relatively poor user interface and developing such software requires substantial effort. EPICS CA protocol and ActiveX CA interface provide another choice, a PC and LabVIEW based test system. Analog I/O module can be interfaced from LabVIEW test routines via ActiveX CA interface. Test instruments can be controlled via LabVIEW drivers, most of which are provided by instrument vendors or by National Instruments. Labview also provides extensive data analysis and process functions. Using these functions, users can generate powerful test routines very easily. Several applications built for Spallation Neutron Source (SNS) Beam Loss Monitor (BLM) system are described in this paper.

INTRDUCTION

The BLM system of SNS facility, which is being built at Oak Ridge National Laboratory, needs a wide bandwidth (>= 35kHz), high resolution (>= 21 bits digitizing range) data acquisition system to sample and process beam loss signal [1]. During the design phase of this data acquisition system a considerable amount of discussion centered on the choice of ADC module. Comparing specifications of commercial products is an easy and reasonable method of comparison. However, not all vendors provide detailed documentation, which includes all key factors we felt were important for the BLM system. In addition, to achieve high absolute accuracy, the gain, offset and their thermal drifts of signal condition circuit and ADC modules have to be calibrated before installed into final location. Therefore a custom designed analog I/O module evaluation environment is required. This system will be used to test the performance of ADC candidates in the design phase and collect system calibration data for global engineering database in the installation phase. For PC based system we can build such system easily with Windows resources and third party software. However, the VME bus architecture of BLM system makes this work a little more complicated. The VME bus computer, in which the analog I/O modules reside, is unsuitable as main testing computer because of poor user interface and few signal analysis functions of vxWorks.

With the presence of ActiveX Channel Access (CA) interface [2] we find another solution for this kind of cross platform testing system. Since analog I/O module data can be collected via calling ActiveX CA interface in LabVIEW, this engineer style graphical programming language becomes the primary choice of test routine developing tools kit.

BASIC CONCEPT

System diagram

Figure 1 shows the system schematic diagram, which consists of three parts: Windows based Main Computer (MC), EPICS residential I/O Controller (IOC) and commercial Test Instruments (TI). The communications between MC with EPICS IOC is implemented using CA protocol via Ethernet. There are several supported mechanisms for interfacing the MC with TI, including Ethernet, GPIB, or RS232 serial link.

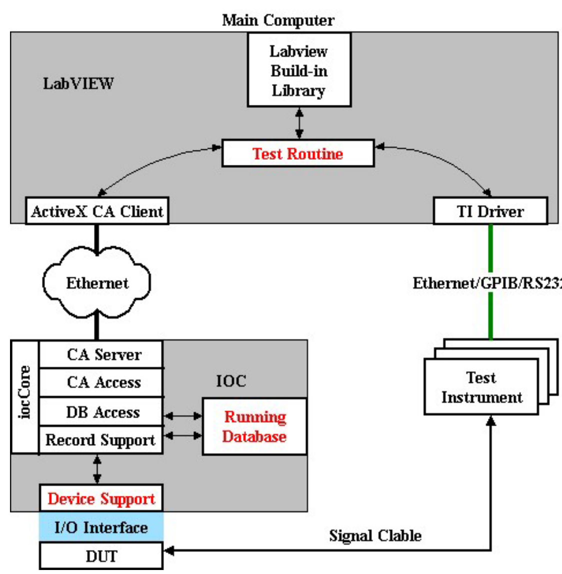

Figure 1: Cross platform analog I/O module test system

MC provides developing and executing environment for specific test routines, which collects data together from the Device Under Test (DUT) and TI then analyzes them to present some datasheet or graphical results to users. ActiveX CA interface is used to send/receive data to/from EPICS IOC. Since the test routine is typical a data consumer that never accepts data requests from other routines, we just need to use the ActiveX CA client library but not the ActiveX CA server.

Test instruments are used to provide stable, precise test signals to DUT (voltage or current source), accurately measure output signals of DUT (multi meter), or record some environment variables such as temperature and pressure. Most of test instruments are commercial products which LabVIEW driver is provided by vendor.

EPICS IOC maintains a running database containing Process Variables (PV) and provides a platform independent interface to access these PVs via CA server. Data and status of the DUT is mapped to these PVs through device support module and record support module. The CA server receives data requests from test routine and calls CA access and DB access functions to get/set related PV value. Then PV linked device support routines and record support routine will be activated to access DUT via I/O interface. This IOC can be a VME bus industrial computer, a PCI bus personal computer, or any other types of computer on which EPICS iocCore can execute. Choosing which type of computer as IOC depends on what device will be test. Usually we implement CPU module and DUT on the same platform because it will simplify interface software development of DUT.

Advantages

The analog I/O module test system based on EPICS and ActiveX CA interface has following advantages:

- *Comprehensive system.* Any kinds of I/O module can be test with this system since choices of IOC type (VME, PCI, etc) and I/O interface type (backplane bus, field bus, or custom-design interface) are flexible.
- *Minimal software development.* Developing tools kit already includes GUI, signal process library, TI drivers and communication between MC with IOC. The only things users need to care are designing a good test method in test routine and writing a device support module for DUT.
- *Reusable code.* Test routines read/write DUT data via PV name, which is hardware independent. So the same test routine can be used for different types of I/O module with replacing deice support module.
- *Friendly user interface.* LabVIEW provides a graphical, engineer-style, easy to learn and use human interface.

APPLICATIONS

Several applications based on this structure have been built to evaluate VME bus I/O module performance or collect calibration data during design and implementation phase of BLM system at BNL. They include an ADC evaluation system, a BLM Analog Front End (AFE) module test system and a digitizer calibration system.

ADC evaluation system

In order to directly compare commercial VME bus ADC modules to find a most suitable digitizer for SNS BLM system, we built an ADC evaluation system in preliminary design phase. The hardware setup of this system is shown in Figure 2.

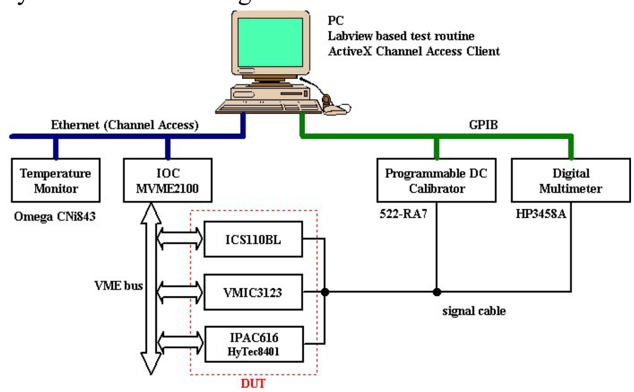

Figure 2: ADC evaluation system

The VME-based MVME2100 was selected as the IOC because all DUTs (ICS110BL, VMIC3123 and HyTec8401 plus IPAC616) work on VME bus. Obviously I/O interface is VME crate backplane. Three types of test instruments are used: EDC 522-RA7, which is a GPIB programmable DC voltage & current calibrator, provides accuracy testing voltage signal for DUT; HP3458A, which is a GPIB programmable 8 ½ digits multi meter, measures actual value of input signal; OMEGA CNi843, which is an embedded Ethernet server for iSeries monitor/controller, acts as a network accessible temperature sensor here. With this configuration some key factors like read back distribution, gain, offset and their thermal drifts have been measured.

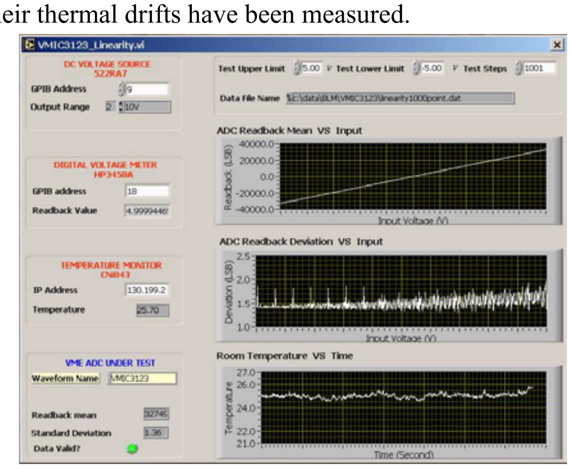

Figure 3: Software panel of ADC evaluation routine

These different ADC modules can share same test routines because we use PV names to access ADC data, which is hardware independent. On the other hand vxWork driver and device support modules of VMIC3123 and HyTec8401 are shared source in EPICS collaboration. So all software we need to write is a waveform device support module of ICS110BL and a group of LabVIEW ADC evaluation routines. Figure 3 shows front panel of one of these evaluation routines: linearity test routine.

BLM AFE module test system

AFE module is a customer designed signal condition board used in BLM system [3]. This board consisting pre-amplifier, low-pass filter, main amplifier, integrator and control logic, converts ion chamber output current signal (~pA) into ADC readable voltage signal (~V). So gain, offset, noise level, pulse response and control logic of AFE module have to be test before implementation, some of them also will be used to calibrate BLM system in software.

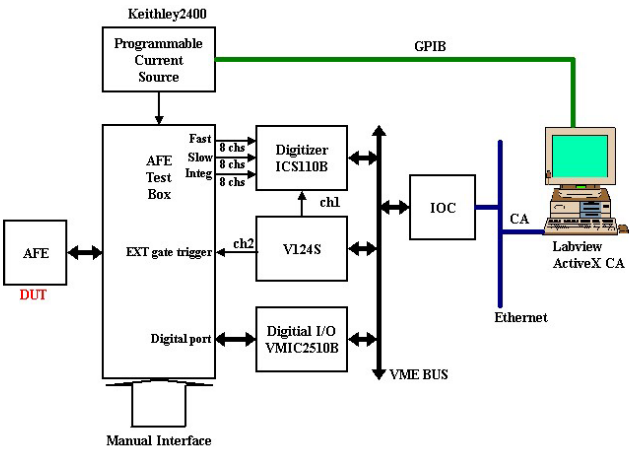

Figure 4: BLM AFE test system

Figure 4 shows hardware configuration of AFE module test system. 24 bits digitizer (ICS110BL), trigger module (V124S), digital I/O module (VMIC2510B) and specific AFE test box combine into DUT I/O interface. A programmable pA current source (Keithley2400) acts as test instrument providing input signal. MC and IOC are configured as same as ADC evaluation system.

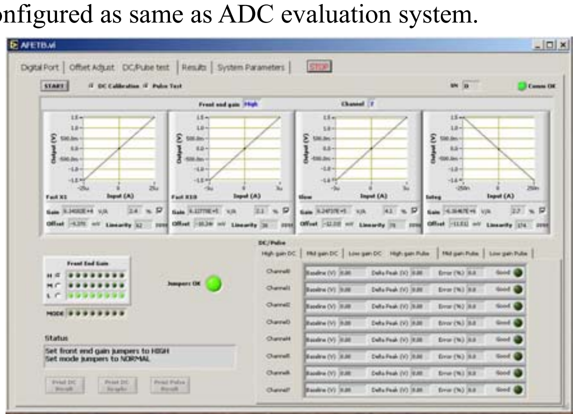

Figure 5: Software panel of AFE test routine

AFE test software includes three sub routines: control logic test, offset adjustment and DC/pulse response test. Figure 5 shows the panel of DC/pulse response test routine.

Digitizer calibration system

After evaluation an ADC with 32 individual channels with 24 accuracy (ICS110BL) was chosen as the digitizer of SNS BLM system, which output curve can be exactly described by a third order polynomial. So a digitizer calibration system is requested to measure these polynomial parameters and log them into global engineering database. These calibration data will be used to correct read back data online or offline later.

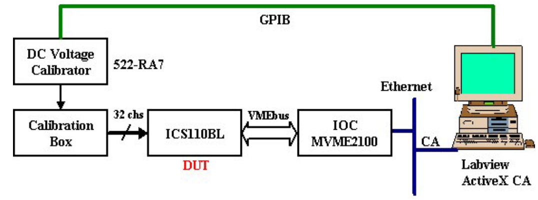

Figure 6: Digitizer calibration system

Hardware configuration of digitizer calibration system (shown in Figure 6) is a subgroup of ADC evaluation system except a specific calibration box was added to connect all 32 channels to voltage source.

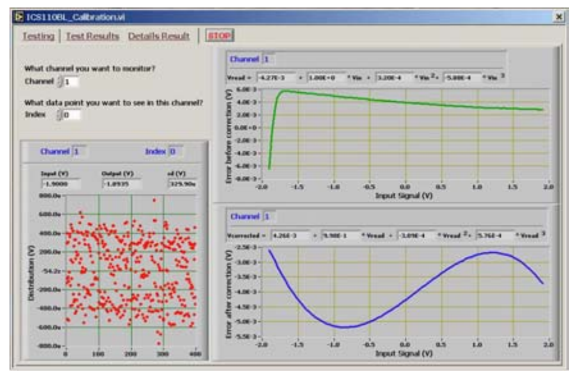

Figure 7: Software panel of digitizer calibration routine

Digitizer calibration routine is modified from the ADC evaluation routine. Many components are reused. Figure 7 shows calibration results display.

SUMMARY

Presence of CA ActiveX interface provides a new way for LabVIEW to share running data with EPICS based system. The combination of EPICS and LabVIEW makes cross platform test system easy to build and maintain. Built-in signal process functions of LabVIEW and extensive EPICS support for hardware reduce software development to minimum.

ACKNOWLEDGMENTS

The authors would like to thank the many BNL colleagues without their contributions this work could not have been accomplished.

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