FESA BASED DATA ACQUISITION FOR BEAM DIAGNOSTICS AT GSI

T. Hoffmann, H. Bräuning, R. Haseitl, GSI, Darmstadt, Germany

Abstract

In view of the upcoming Facility for Antiproton and Ion Research (FAIR) at GSI with its increased complexity in beam control and diagnostics, the decision was taken to use the well-tested CERN made Front-End Software Architecture (FESA) as the lowest level of the new control system [1,2]. In the past years, the current stable FESA framework (Version 2.10) has been adapted and installed at GSI, with the major part of the adaptation being the different machine timing models of GSI and CERN. With a stable environment at hand, all current and new beam diagnostic related data acquisition systems will be implemented with FESA. To demonstrate the suitability of FESA for demanding data acquisition problems with high data rates or large amounts of data, two different projects such as the Tune Orbit and POSition measurement (TOPOS) and the Large Analog Signal Scaling Information Environment (LASSIE) are presented. Experiences with implementing standard interfaces such as CAN, GigE and PLCs in FESA applications as well as a move towards low cost Intel based controllers like the Men A20 VME controller or industry PCs running a real time Linux will be discussed.

THE FESA ENVIRONMENT AT GSI

Besides the development of the next generation FESA 3.0 environment by staff of the GSI controls department in collaboration with CERN CO/FE, the GSI beam diagnostic department (BD), which is responsible for the layout of the FAIR beam diagnostics DAQ system, is developing FESA 2.10 classes for dedicated BD systems. These efforts are made to show the feasibility of all expected data acquisition requirements and to train programming of the front-end part of the new control system for FAIR. At the beginning of 2010 the FESA 2.10 installation and integration at GSI was fully accomplished. The environment resides on a powerful blade system, which is the new mainframe of the GSI control system providing NFS based access to all front-end controllers (FEC) and to all branches of code development. Basic information on FESA is given in [1,2]. The main parts of the FESA systems are:

Operating System

At present the operating system (OS) of the GSI control system is a Red Hat Enterprise Linux Server release 5.5 with kernel 2.6.18-92 - x86_64. The OS for the FECs is Scientific Linux CERN 5.4 with kernel 2.6.24.7-rt27, which contains patches for real-time support.

Supported FEC Hardware

FESA 2.10 provides cross compilers for Intel and PowerPC based CPUs. For maintainability reasons the following FEC systems are supported by GSI:

- Standard Industry PC
- Kontron KISS PCI760 with PXEBoot, diskless, Intel AMT remote management system
- MEN A 20 VME CPU with PXEBoot, diskless.

For applications requiring real time behaviour the CES RIO3 CPUs with Lynx OS can be used as an exception.

For the time being the upcoming xTCA for Physics standard [3] as a new form factor is under evaluation for the usage at FAIR. For the tests an Adlink AMC-1000 CPU in an ELMA xTCA-6 frame were chosen. After integration of the diskless system into the control system, the installation will be tested with high bandwidth applications such as GigE video imaging and analog data sampling.

Timing

FESA 2.10 is strongly dependent on the CERN timing system and its timing receiver hardware, which is different to the existing GSI timing. To gain efficient use of the FESA RT action feature a dedicated FPGA based GSI-CERN timing converter was developed. It allows to use the CERN timing receiver hardware with the GSI timing. Although some purely CERN specific features are not available, this converter allows to trigger RT actions by accelerator timing events in a multiplexed beam operation for all three GSI accelerators (UNILAC, SIS, ESR).

JAVA Graphical user interface

To provide GUIs for the developer as well as for the users such as machine operators or system experts the JAVA based concept of CERN was chosen. It consists of the Java API for Parameter Control (JAPC, [4]) and CERN libraries such as the JDataViewer and the CERN middleware (cmw-rda). Due to the JAVA web-start functionality and the general JAVA platform independence, the GUI may be used at any office at GSI.

TUNE, ORBIT, AND POSITION MEASUREMENT (TOPOS)

The first test project for FESA and its related middleware and GUI solutions at GSI was a development for the tune, orbit and position measurement (TOPOS) at the heavy ion synchrotron SIS in collaboration with Cosylab and Instrumentation Technology, Slovenia. The development of the modular extendible TOPOS was performed also in preparation for the FAIR project and the usage at the FAIR synchrotrons. The data acquisition concept is well described in [5].

This very demanding system, with data rates up to

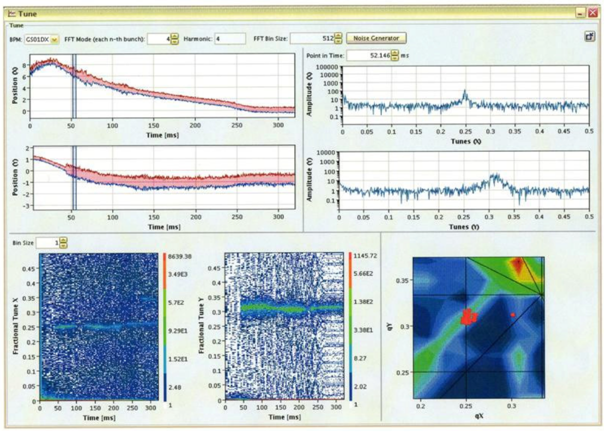

Figure 1: The FESA based TOPOS system showing horizontal and vertical tune measurements on excitation of the beam at $2*10^8$ U^{73+} ions per bunch.

700MByte/s, showed good results with respect to performance, stability, and usability. After benchmarking tests with the former beam position monitoring (BPM) system it will be raised to operational status at GSI. Fig. 1 gives an impression of the online tune measurement.

LARGE ANALOG SIGNAL SCALING INFORMATION ENVIRONMENT (LASSIE)

LASSIE is the new FESA based DAQ project to distribute and analyze a large quantity of beam diagnostic related analog and digital signals. It consist of FESA based data acquisition classes and JAVA GUIs. Recently the readout of a scaler array with 192 channels for SIS and connected beam line data was implemented in FESA. It is based on a VME system with six SIS3820 Multiscalers [6] and a dedicated timing receiver board. Scaler input consists of signals from beam loss monitors, experiment counters and other data like accelerator rf, current transformers etc. via a voltage-to-frequency converter. The scalers can be latched with a frequency of up to 1 MHz which provides fine-grained information about the spill structure. The GUI framework provides general GUI and non-GUI components like for example data structures, settings manager and a help system for rapid application development. Current applications include integrated counter values between selected machine events, spill structure analysis and trending.

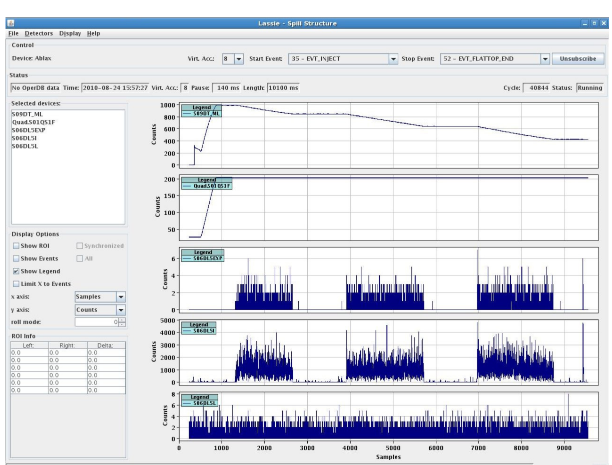

Figure 2: LASSIE: FESA based spill structure analysis of synchrotron signals (from top to bottom: current transformer, quadrupole ramp and beam loss monitors).

The system is now accessible from the accelerator control room for testing and will replace the Kylix based ABLASS [7] system with all functionalities. At typical scaler latching frequencies for normal operation around 100 to 1000 Hz, the FESA class can easily handle the readout of all 192 scaler channels. Using two memory banks, the FESA class allows GUIs to access the data of the just completed spill while acquiring the data for the current spill. In order to reduce the network load, the GUI applications use the filter mechanism of FESA to request for example the spill structure of only those channels which are displayed.

Another bottleneck for high latching frequencies is the transfer of data via the VME backplane. According to the SIS3820 specifications [6], the transfer rate via the VME backplane is limited to about 50 MByte/s for MBLT64 block transfer. To compare the rate capabilities of the older PowerPC based CES RIO3 CPUs and the new Intel based Men A20 CPUs, a test system with a single 32 channel scaler and a virtual machine cycle of 2000ms runtime and 150ms pause was set-up. Figure 3 shows the maximum number of scaler channels which could be read

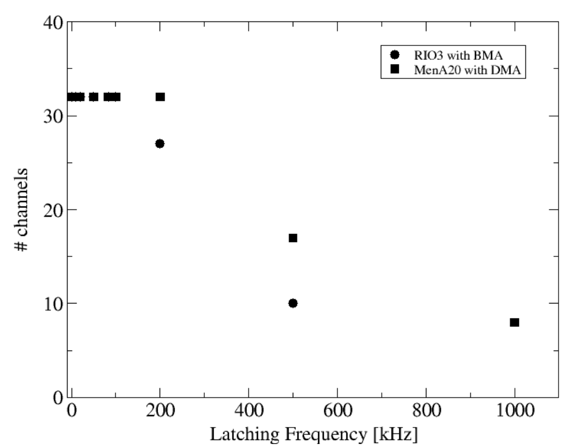

Figure 3: Number of scaler channels which can be readout as a function of the latching frequency.

out by the FESA class without any connected GUI clients as a function of the latching frequency. Scaler access was done via block transfer (BMA) on the RIO3 and DMA on the Men A20. The Men A20 board consistently has a higher data throughput with a maximum measured rate of 34 MBytes/s. A total CPU load of only 10% indicates that this rate is limited by the transfer from the scaler module to the memory and not by data handling in the FESA class. In contrast, a maximum data rate of 22 MBytes/s was measured with the RIO3. This is accompanied by a strong increase in the CPU load, which indicates that the processor power is the limiting factor. However, it must be noted that this superiority of the Men A20 is only valid in the case of DMA usage. For direct access of a single register, the RIO3 has a slight advantage with a measured data rate of 1.4 MBytes/s as compared to 1.2 MBytes/s for the Men A20 board. In addition, setting up the DMA transfer takes some time and is thus suitable only for the transfer of large blocks of data via the VME bus.

Moreover, the Men A20 CPU with its 1000 Mbit/s Ethernet interface also allows a higher data transfer rate to the GUI application as compared to the RIO3. Thus the RIO3 CPU has been phased out in beam diagnostics applications and is replaced with the Men A20 CPU.

Future applications of the LASSIE system may include direct readout of ADCs for pulse-height analysis or TDCs for even more detailed spill structure analysis. For FAIR it is estimated that more than 1000 channels, distributed over the complete campus, will have to be read out. Preparatively the current system will be used as a test setup for a distributed DAQ system for proper intra-cycle data correlation.

SCADA APPLICATIONS

In addition to sophisticated DAQ systems, beam diagnostic devices depend strongly on technical subsystems such as pressurized air actuators, stepper motors, gas flow meters, high voltage power supplies and remote control operations. Such control requirements are also to be handled with FESA as the connector between the device and the GUI.

For devices like actuators, flow meters and such, a field-bus system will be established. For the time being the Programmable Logic Controller (PLC) Simatic S7-300 from Siemens is under evaluation. A description of the system and the connected beam induced fluorescence (BIF) measurement is given in [8]. Essential for this PLC setup was the interfacing with FESA, which was achieved using the IEPLC tool [9] from CERN. It creates Simatic code for data block exchange via Ethernet, which exchanges data with a predefined FESA 2.10 PLC class. The handling of the BIF system, e.g. control power for micro channel plates and camera iris regulation by use of FESA is now operational. The required calls to get and set data from the FESA class are implemented in a QT [10] based GUI.

The integration of the multi-channel high-voltage power supplies like the CAEN SY1527 into the control system is a must. A FESA class was developed which accesses the SY1527 system via Ethernet connection. The FESA class provides access to all channels at once for e.g. shutdown procedures, but also single channel access from application GUIs, where only a subset has to be controlled. This is achieved by extensive use of the filter mechanism provided by FESA for its properties. Safety is easily enhanced by the FESA class included monitoring, logging and alarm options.

A strict demand for all FAIR DAQ systems is the remote control access to all crates and systems, preferably via Ethernet. In some cases hardware has to be used, which allows only CAN bus access, for which a FESA class was developed.

OUTLOOK

In preparation for the FAIR project and the realization of the beam diagnostic DAQ system, all significant BD requirements, such as readout of high data rates, video imaging, distributed systems, slow controls, etc. were realized with FESA. The results are very satisfying and give confidence for the usage of FESA at FAIR. All new BD-DAQ systems for the existing accelerators will be realized with FESA to train developers and operators on the new technology. The new FESA Version 3.0 is expected to be released soon. By separating the FESA framework into a general and a lab-specific part, the new version will accommodate the GSI environment more suitably. As soon as a production quality will be reached, the current BD FESA classes will be ported to the new version. Although some differences between the current and the new FESA version exist, no major problems are visible at the moment.

The next important development will be the DAQ for the beam position monitoring in the UNILAC at a cycle frequency of 50 Hz to demonstrate the real-time performance of FESA.

REFERENCES

[1] T. Hoffmann, "FESA – The Front-End Software Architecture at FAIR", PCaPAC 2008, Ljubljana, Slovenia.

[2] T. Hoffmann, M. Schwickert, G.Jansa, "FESA at FAIR", PAC 2009, Vancouver, Canada., to be published

[3] www.picmg.org xTCA for large scale physics applications, PICMG-no.: phyTCA

[4] V. Baggiolini et al, “JAPC - the Java API for Parameter Control”, ICALEPCS’2005, Geneva, Italy

[5] G. Jansa et al., "A New DAQ Installation for the SIS18 Beam Position Monitoring System at GSI", ICALEPCS2009, Kobe, Japan

[6] www.struck.de

[7] T. Hoffmann, P. Forck, D. A. Liakin, “New spill structure analysis tools for the VME based data acquisition system ABLASS at GSI”, BIW’06, Batavia (USA), p. 343-350.

[8] R. Haseitl, C. Andre, .H. Bräuning, T. Hoffmann, R. Lonsing, "Integration of Programmable Logic Controllers into the FAIR Control System using FESA", PCaPAC2010, these proceedings

[9] Frank Locci, BE/CO/FE, CERN, Switzerland

[10] http://qt.nokia.com/