A TANGO BASED CONTROL SYSTEM FOR A 3D MEASUREMENT BENCH FOR MAGNETS

D. Beltran[1], F. Becheri[1], R. Butzbach[1], D. Fernandez-Carreiras[1], J. Klora[1], P. Readman[1], E. Taurel[1]
[1]*CELLS (Consortium for the Exploitation of the Synchrotron Light Laboratory), Barcelona, Spain*

ABSTRACT

ALBA is the new light source under construction in Spain. It is situated in the Barcelona area and co-financed by the Spanish and Catalan governments. This 3 GeV third generation source is planned to deliver the first light to the users in 2010. This paper describes the first prototype develop in Tango, which is a control system for measuring magnets in 3D using a hall probe. This system will be used for measuring all the bending magnets for the ALBA facility. The control system has been used as an evaluation of the architecture and components for the ALBA accelerator.

INTRODUCTION

ALBA [1] is the new light source under construction in Spain and it is situated in the Barcelona area. ALBA is a consortium co-financed by two public administrations, the total budget is 187 M€. The storage ring circumference is 268 m, with 16 cells. The main parameters of the machines are the target energy of 3 GeV, the circulating current of 400 mA and the horizontal emittance of 4.3 nmrad. Seventeen straight sections are available for insertion devices. Four straight sections are 8 meters long (one is dedicated for injection), twelve are 4.3 meters long and there are eight short section of 2.6 meters (six are dedicated to RF cavities). The completion of the building design and start of the civil engineering works are scheduled for November 2005, the commissioning is scheduled for 2009. Initially the machine will have the following 7 beamlines: Soft X-ray for polarization dependent spectroscopy and microscopy; Electron and soft X-ray emission spectroscopy; High resolution powder diffraction with micro-focus; High brilliance XAS; Non-crystalline diffraction with micro-focus; Macromolecular crystallography; and X-ray microscopy.

The following picture is a layout of the ALBA facility with its main parameters.

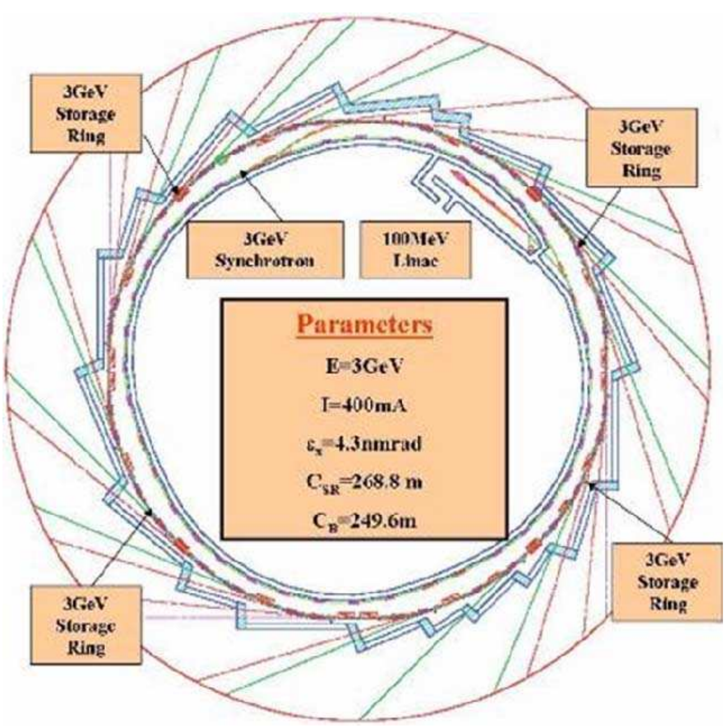

Figure 1: ALBA facility layout.

MAGNETIC MEASUREMENT BENCH

The magnetic system used in particle accelerators designed to provide high brilliance synchrotron radiation needs to be carefully evaluated. In particular, to determine the three-dimensional magnetic field distribution produced by the bending magnets is an essential step in the engineering definition of an accelerator. The magnetic bench [2] of which the control system is described in this paper, is capable of determining the three-dimensional distribution of the magnetic field produced by large-volume bending magnets. Moreover, it will be used to measure the field integral of the insertion devices.

The measurement system is composed of three Hall Effect magnetometers contained in home made PCB. The probes are supplied in series by a power supply, and the generated voltage is measured with three independent voltmeters. These probes are attached to a high precision mechanical arm (±10 µm) that scans the volume in the three dimensions (500x250x3000 mm). A power converter (1500 A, 100 ppm) feeds the magnet under test. A calibration system has been incorporated, which includes a reference magnet, with its power converter and a NMR system. A pulse generator was incorporated to provide on-the-fly measurements. The probes are maintained at a stable temperature by a PID controller which switches a thermocouple.

All the instruments in the magnetic measurement bench are interfaced through the serial lines, except the magnet power supply of the calibration magnet which is interfaced through GPIB.

The following picture shows the components of the magnetic measurement bench.

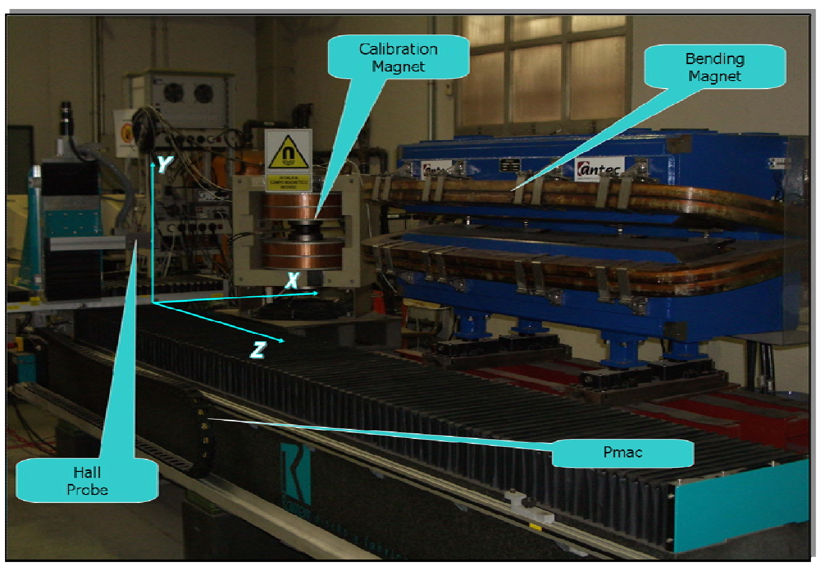

Figure 2: The magnetic measurement bench.

CONTROL SYSTEM REQUIREMENTS

The control system has been designed with the following requirements:

- It has to support three modes of operation: a) calibration of the probes, b) point-by-point measurement; where the magnetic field is measured, stopping the movement at any point, c) on the fly measurements, where the magnetic field is acquired continuously, without stopping the probes .
- The interface with the user has to be friendly (graphical), allowing the user to configure the main parameters of the calibration or the measurement (scanning volume, hall probe temperature). The interface will monitor the main parameters and the status of the acquisition, as well as the percentage of execution.

- A database must be used, to allow the user to select the equipment configuration easily.
- The user has to be able to abort the execution of the measurement at any time, and the data taken up to that moment has to be saved to disk.
- A machine protection system has to be able to automatically shutdown the equipment following a predefined sequence when certain conditions are reached.

At the same time, the control system has been designed as an evaluation of the philosophy and architecture for the ALBA facility.

HARDWARE ARCHITECTURE

The hardware architecture for the magnetic measurement bench acquisition system is based in the standard model for accelerator control. The architecture contains two levels. The first level (a Windows PC) acts as an interface with the operator and runs the Operator Interface (OPI) programs. This PC communicates with the second level through an Ethernet 100T LAN (Local Area Network). The second level consists of an industrial PC (Linux server). This industrial PC is devoted to communications with bench instruments and it also runs the sequencing programs for the measurement and calibration. The RS232 serial line communications are done through a RocketPort PCI board [3], with a rackmount extender, which is capable of interfacing up to 16 devices. The interface with the GPIB instrument is through a National Instruments [4] PCI board. Both cards are supplied with Linux drivers. The Input/Output Controller (IOC) of this industrial PC is a double processor PIII with 1GHz and 1Gbyte of RAM memory. It runs Suse9.3 with kernel 2.6.11.4.

A machine protection system has been implemented independently of the acquisition and control system. The interlocks generated in the system are handled by a PLC (Programmable Logic Controller), shutting down the system. The current system reads the temperature of the magnet cooling water by means of two Pt100 sensors located at the inlet and outlet. When any of the temperatures are higher than a threshold, the PLC opens a switch. The condition is detected immediately by the magnet power converter, and the magnet current output is switched off. It is also planned to install a water flow sensor, which will generate an interlock if the cooling system fails and thermal switches in the magnet coils, which open if the temperature is higher than a threshold. We also would like to incorporate a safety shutdown of the system when a power cut is detected.

The following picture shows the hardware architecture for the measurement bench.

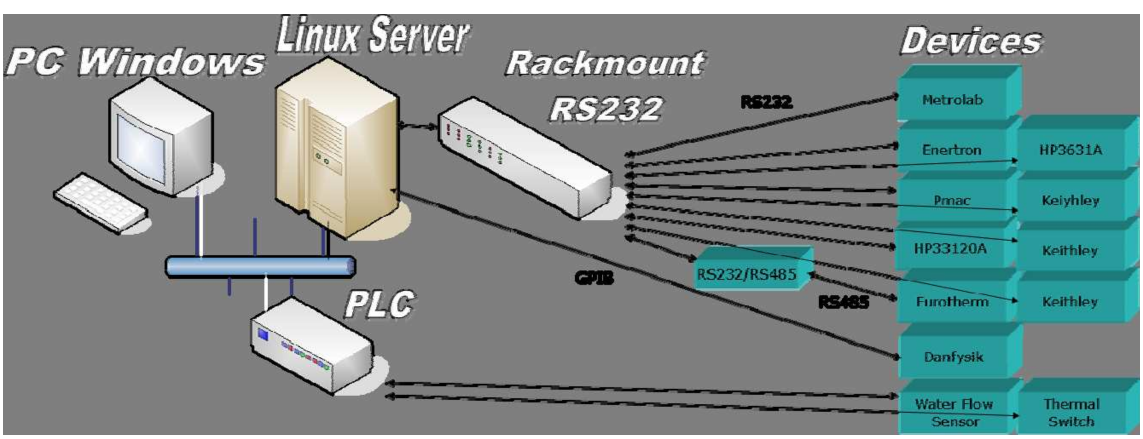

Figure 3: Hardware architecture for the magnetic measurement bench.

The devices in the magnetic bench are mostly controlled by RS232 serial lines. Although some of the devices could be controlled by other fieldbuses, we tried to minimize the number of buses used in this control system. The Eurotherm temperature controller has a RS485 fieldbus so a commercial RS232 to RS485 adaptor was added.

SOFTWARE ARCHITECTURE

ALBA has adopted Tango [5] as the control system toolkit. Tango is an object oriented control system toolkit based on CORBA (Common Object Request Broker Architecture). It was created at the ESRF (European Synchrotron Radiation Facility) and was later adopted by Soleil, Elettra and now ALBA.

The software architecture is also distributed, and it is Tango based. The next picture shows the software architecture.

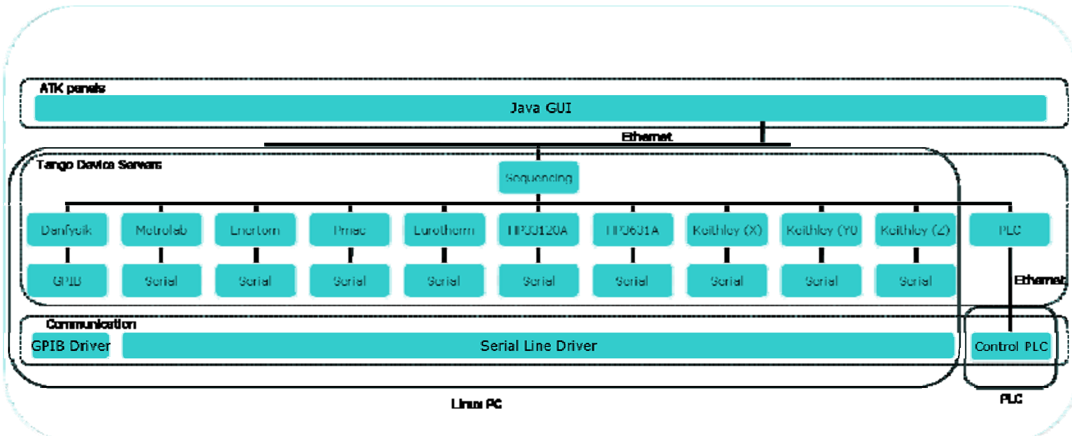

Figure 4: Software architecture for the magnetic measurement bench.

The user interface, running on the windows PC, is in the highest layer of the architecture. In our case, it consists of several “screens” which allow the operator to control data acquisition as well as its on line visualization. The screens also display an alarm condition in case of malfunction and identify the device responsible for it. The screens have been developed with ATK, which is Tango tool to develop graphical user interface panels in Java. The following picture shows the main control panel.

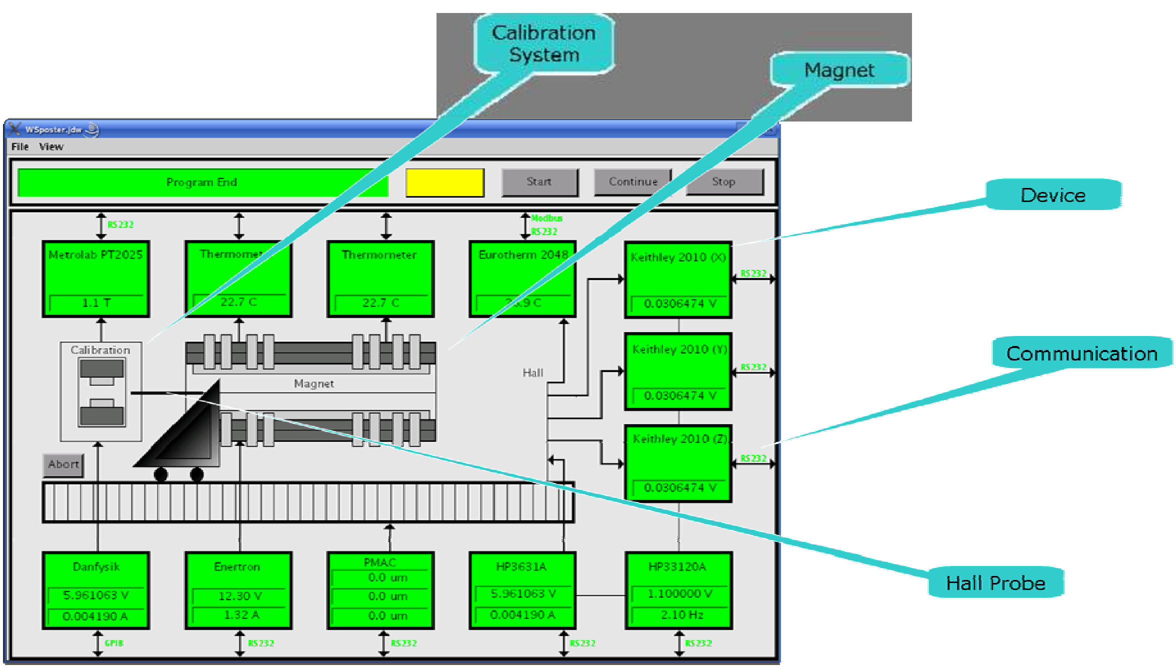

Figure 5: Main screen for controlling the magnetic measurement bench.

Tango (see figure 4) provides transparent LAN communications, between the graphical user interface running the windows PC and the sequencing application running in the Linux server. The Linux server has a separate Tango device server for handling the communication with any instrument. These Tango servers have been developed on top of existing device servers for the serial line, GPIB and socket communications. This approach allows a software re-use, minimizing the manpower and increasing the reliability. The developed device servers implement particular commands from the devices, whilst the fieldbus details are implemented in the existing servers, shared in the Tango collaboration. All the device servers are written in C++.

The co-ordination and acquisition sequence is done by another device server (Sequencing server in figure 4). This device server executes the machine state presented in the following picture.

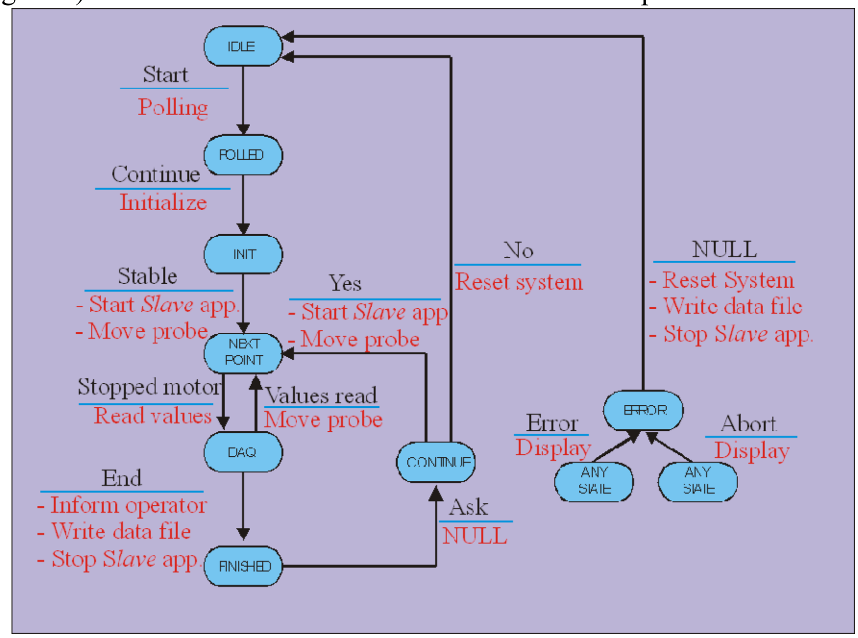

Figure 6: Magnetic measurement point-by-point state machine.

When the user starts the acquisition, all the instruments are polled. If all the instruments are present, the application waits until the user introduces the parameters for the acquisition (temperature probes, magnet current, and magnetic field mapping). The application is then in a loop and the motor is moved to the next point. When this position is reached, the motor is stopped, and the point is acquired. This sequence is repeated until all the points in the mapping are acquired. At this stage, the data is saved in a file, and the application requests the user if a new measurement should be done, or if the system has to be shutdown.

This is the machine state for a magnetic measurement point-by-point. Similar machine states are executed for the calibration and on-the-fly measurements.

NEXT STEPS

Currently the calibration and the magnetic measurement point-by-point are running whilst the on-the-fly measurements are still under development. The on-the-fly measurement is done in a straight line, with the probes moving at a constant speed. An external generator will be used, and it will generate a pulse (frequency 0.5 Hz) when a point has to be acquired. The pulse will trigger an acquisition in the three voltmeters, and in the motor controller to store the current position. The control system will read these values before the next acquired point.

The machine protection system is still under development. We are evaluating different PLC manufacturers (Siemens, ABB, Allen-Bradley, Wago). As part of this evaluation, the machine protection system will be initially implemented for the magnetic measurement bench.

We are developing a Tango Python script executer, as a part of the Tango collaboration. The idea is to have a Tango Python server that executes python scripts. These scripts will communicate with the graphical interfaces and with the underlying devices. This will allow the users to modify the execution sequences easily. The Python device server will replace the current C++ device server for sequencing the magnetic measurement bench.

CONCLUSION

We have presented and described the current status of the Tango control system for the magnetic measurement bench. This control system is used as an evaluation of the architecture and the devices for the ALBA control system. We have made full use of commercial products, supplied with their Linux drivers; we have simplified the number of fieldbuses and have used fieldbuses that will be used in the ALBA facility. As part of the Tango collaboration, we have benefited from the code already developed, and designed our control system taking this into account. We have also used the different Tango tools for the control system development (Jive, Astor, Pogo, Atk Synoptic). We would like to contribute to the Tango collaboration with the Python server, for the execution of python scripts.

By the end of year we will provide a control system for measuring large magnetic structures, using point-by-point and on the fly measurements. This system will be used in the ALBA facility for the characterization of the bending magnets for the accelerator and the field integral of the insertion devices.

REFERENCES

[1] www.cells.es
[2] D. Beltran et al., "An instrument for precision magnetic measurements of large magnetic structures", NIMA 489, 285-294, 2001
[3] www.comtrol.com
[4] www.ni.com
[5] www.esrf.fr/tango