# TEST BENCH FOR SILICON STRIP DETECTORS TESTING

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*Abstract*

During the next few months more than 400 Silicon Strip Detector (SSD) modules will be tested before and after their installation on the ladders and dispatch to Brookhaven National Laboratory. The requirements for the test bench have been defined and the architectural design of all software components has been completed. The system is distributed and features a client–server architecture. Measurement program has been developed using LabVIEW™ package. The communication server is running under Unix. MySQL™ relational database has been chosen for data storage. Access to data is provided through a JAVA applet, making use of JDBC™ (*JAVA Database Connectivity*) package. Such a solution ensures a fast remote access to data even over the Internet and is virtually independent of hardware and software platforms used.

## 1 INTRODUCTION

The aim of this project is to develop a test-bench for Silicon Strip Detectors (SSD) quality testing before their installation on some kind of mechanical support called *ladders*. The idea behind testing individual SSD modules is to avoid fitting any faulty modules in the ladders. It is also foreseen that the last stage of tests will take place after all mechanical operations have been completed, just before shipment of complete ladders to STAR experiment at BNL. All mentioned SSD modules will be manufactured by French company *Thomson CSF Detexis [1]*.

The core part of an SSD module is a double-sided silicon strip detector. It is wired to *front-end electronics* composed of 12 A128C custom ASICs (6 for each side of detector) and 2 custom chips called COSTAR (1 per side) which can carry out slow control measurements of JTAG-operated detectors. Both A128C and COSTAR have been designed at *Laboratoire d'Electronique et de Physique des Systemes Instrumentaux* in Strasbourg, France [2], [3].

Each A128C chip has 128 channels corresponding to 128 strips of the SSD module. In consequence the whole module contains 12x128=1536 channels and identical number of strips. All these channels and strips must be thoroughly tested and corresponding information stored in database for future use or analysis.

The system has to ensure:

- control over the hardware
- execution of the large number of time consuming measurements
- fast, convenient and reliable access to the measured data
- friendly and intuitive user interface.

The hardware used in the measurement setup includes boundary scan controller PM3705 from JTAG Technologies B.V. and multifunction I/O card PCI 6111E with 5 MHz ADC from National Instruments.

## 2 SYSTEM ARCHITECTURE

### 2.1 General Concept

The general system concept is shown in Figure 1. Measurements are performed on dedicated computer running Microsoft Windows™98 and LabVIEW™from National Instruments. The measured data are transferred over Ethernet network to a computer running LINUX RedHat™6.0. We chose relational database MySQL from TcX AB, Sweden for data storage and maintenance. The LabVIEW™-based measurement program is linked to the database through a communication server written in C. Users can access the measurements by means of a JAVA

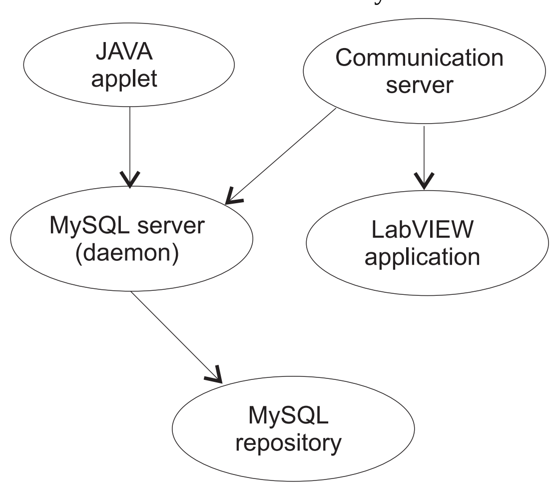


**Figure 1. Dependencies between software modules**

applet. Its graphical user interface makes the construction of complex queries easy even for users with no database experience. Another capability of this applet is the visualization of selected data. The authentication is also supported by our software. It is clear that using JAVA and JDBC allows to access the database over the Internet or local network with user's favorite browser.

## *2.2 Measurement Program Architecture*

Taking into account the tremendous amount of measurements which must be performed by our test bench and complexity of suitable software we concluded that the only way to make it reliable and fast is to devise a good architecture. We chose the Windows™ version of LabVIEW as a software toolkit to be used for application development. One can argue, of course, that Windows is not the best operating system platform but we had no choice because of use of PCI 6111E card. It is a relatively new product by National Instruments and the driver API (making use of register level programming) is not documented yet. Due to that we designed our measurement program as shown in Figure 2. It is easy to see the high modularity and clarity of the structure. The role of some modules shown in Figure 2 is shortly described below.

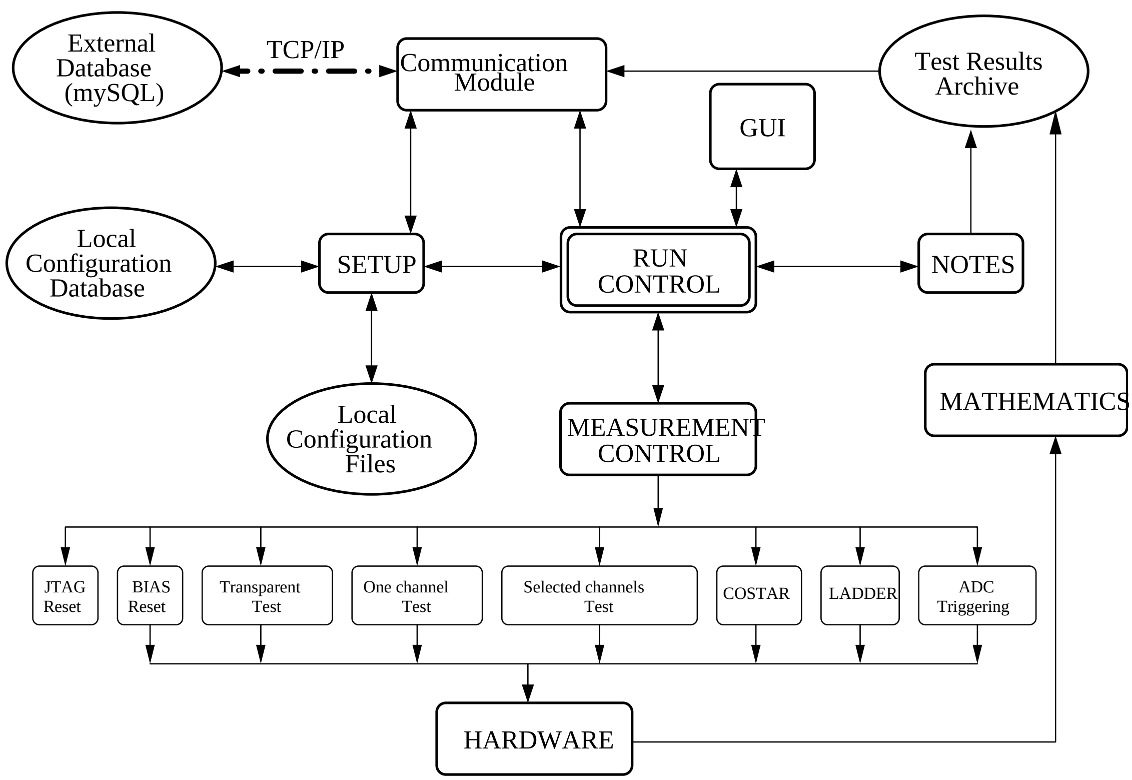


**Figure 2. Measurement program architecture**

**Run Control** module serves as a supervisory unit in the program. It launches other modules and controls the information flow within the program. It is worth noting that almost all modules communicate with each other via the Run Control module and there are no direct connections between them. It also lets keep track of the current state of the experiment. Another important task of the Run Control module is to start the Measurement Control object. It is apparent that the role of the Run Control module is that of an engine that drives the whole measuring system. **GUI** (Graphical User Interface) module provides the human interface for an operator. It employs LabVIEW widgets and windows to create an easy to use, intuitive environment. It handles user input via set of standard mechanisms, such as menus and dialog windows. This way it allows operator to configure and control an experiment with a few keystrokes or clicks of a mouse button. GUI provides a user with the visual information about the current state of the experiment. Experimental data can be viewed as 2D configurable plots when necessary.

**Setup** module takes care of the experiment configuration. The actions and measurements which can be made by the test bench are following: reset of JTAG controller, bias setting, enabling of chosen A128C chips, transparent test of channels, pedestal and noise determination and test of selected or all channels and strips as well as gain determination. Operator must have the possibility to decide which of those measurements are to be performed during the run. He can also configure every experiment, for instance specifying a set of channels to be included in measurement, etc. The user interface part is provided by the GUI, but the underlying logic is the responsibility of the Setup module. Current setup can be stored and extracted from the Setup module.

It can store a set of frequently used configurations in the local configuration database. Setup can be reconfigured during the run of the experiment and it immediately applies to the measurements that have not been made by that time.

**Mathematics** module is responsible for all calculations needed for quantitative determination of such detector characteristics as noise mean values and dispersions for all strips as well as the whole detector, pedestals, their minimal values for *p-side* and *n-side* of the module *etc*.

### *2.3 Database*

It is an essential part of the whole system, as usually when the meaningful amount of data is obtained as a result of the measurements and these data must be used in the future for some purposes. Our choice is MySQL, well known and popular database from Swedish company TcX AB. This database is free for non-commercial applications, assures very fast access to data. MySQL is a multi-user and multi-threaded database server with a client/server implementation. Its main component is the server daemon *mysqld*. In addition it provides many client programs and libraries. It should also be stressed that MySQL is an SQL server that means one can use this language to store, update and access information. SQL is the standardized language in the world of databases. It is also very intuitive and easy to learn.

The database browser has been built with typical JAVA tools: *JAVA Development Kit* (JDK) and JDBC. Such a solution gives the possibility of WWW access. Our browser consists of a few panels: *SQL Builder Panel, Result List Panel, Detector Panel and Module Panel.* If someone wants to analyze the data from database, he can do it in a very simple manner. First one has to authenticate to the database. Then, in the Queries Builder one must choose which fields will be selected. The construction of query criterion is based on the creation of logical sentence with *AND* and *NOT* operators only. When the logical sentence is ready, it is converted into an SQL query. The response is displayed in *Result List Panel*. Selection of key parameter (for example SSD module, date of measurement, name of operator) can be made by writing a text pattern with wild characters or by selection from the list with a mouse click. If operator is not satisfied by the result obtained then the next clause with more detailed constrains can be added.

## 4 HARDWARE AND MEASUREMENTS

### *4.1 Hardware Used*

The main parts of hardware in our measurement test bench are: PM3705 Boundary Scan Controller connected to Parallel Port of computer and 6111E PCI Multifunction card with 5 MHz ADC. JTAG bus is used for control and configuration of A128C chip as well as of COSTAR chip (dedicated for slow control). 6111E card is used for triggering and analog signals sampling.

A128C ASIC is 128 channels front-end readout chip designed for SSD. Each SSD module has twelve such chips: 6 on p-side and 6 on n-side. Two COSTAR ASICs are also implanted on each SSD module. A128C and COSTAR chips can be considered the Device Under Test (DUT) in our setup.

### *4.2 Measurements*

Each measurement begins with sending a RESET sequence to selected Test Access Port (TAP) of JTAG controller. This is an important operation because it guarantees that the state of JTAG will match the state of DUT (i.e. A128C). Measurement program can work in manual mode or automatic mode, according to preferences of operator or current needs. One of the most essential tests is the so called transparent test using internally generated pulse (by A128C). The goal of transparent test is to tune seven parameters essential for correct work of SSD, namely: preamplifier biasing current, preamplifier feedback resistor, shaper biasing current, shaper feedback resistor, intermediate buffer biasing current, output buffer biasing current and LVDS2CMOS converter biasing current. The optimization of this set is not trivial and we’ve chosen minimization capabilities provided by CERN’s ROOT to resolve this mathematical task. The resolution is stored in database for proper setting up of the detector during real experiment in the future.

Test of all channels/strips of the SSD module is performed in steps including measurements for 32 channels, every second strip.

## 5 WORK IN PROGRESS

At the moment the project is in the final stage. The only part of the whole system which is still under development is the module that will permit to test SSD’s already fitted on a ladder (there will be 16 SSD’s per ladder). To achieve this not only some coding is necessary, also some additional switching electronics must be developed.

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