

A Profibus-based Control System for Nuclear Physics Applications



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Introduction



- **Remote control system based on ProFiBus technologies used for the remote control of experimental nuclear physics apparatus.**
- **Two different applications :**
 - **Remote control of a multidetector (made up of a bidimensional array of CsI scintillators) used to detect light nuclear particles, as protons and/or light ions.**
 - **An implementation of the control of a vacuum system suitable for a special chamber used for the development and testing of particle detectors operating in vacuum conditions.**

New techniques and methodology in process control: problematics



- The demand for distributed process control involves intelligent systems, control devices and measurement systems able to communicate through the network.
- It means -> reduction in connections, thus simplifying system management and decreasing maintenance problems.
- A new solution is provided by FieldBuses systems which are widely applied in experimental research in nuclear physics.

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Experimental research in nuclear physics: problematics

- Distributed remote control apparatus capable of working in very hard operating environment (strong electromagnetic fields, damage by radioactive particles, low temperatures etc.);
- At the same time meeting the necessary safety, reliability and simplicity requirements;
- Large number of devices;
- Many devices must be controlled locally and this requires frequent access to the site of the experiments (not safe environments).



- The use of a FieldBus is a valid solution since it provides tools for implementing a remote control system;
- The ProFiBus (Process FieldBus) is a communication system widely used in the world of industry and is highly suitable for this aim.

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REMOTE CONTROL IN NUCLEAR PHYSICS EXPERIMENTS

- The types of information present in nuclear physics experiments is often complex and generally fall into two different categories of data:
 - **plant supervision and control data.** It allows operators to introduce system modifications without the need to remain in the measuring area. dynamic is relatively modest, therefore it can be handled via remote control by using distributed systems ;
 - **data obtained via measurements carried out during the experiment itself.** The signals are usually obtained at an aleatory frequency and have a very short duration (not suitable to be transferred via Bus-Based communication systems).

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The experimental setup

- Is a system designed to study heavy ion reactions, disposed in the "**Neutron Hall**".
- This structure is managed by the C.H.I.C.(Collaboration for Heavy Ion Collisions) research group and is located at the Laboratori Nazionali del Sud in Catania, property of the I.N.F.N.(Istituto Nazionale di Fisica Nucleare).
- The laboratory comprises a series of airtight chambers, with observation windows, in which nuclear interferometry experiments are carried out.
- A beam of intermediate energy heavy ions (10-50 MeV/A) is deflected in the vacuum and conveyed towards the reaction chamber by means of magnetic bending.
- The beam impinges on nuclear targets and the collision products are recorded by various detectors and the data are acquired and analyzed by human operators for off-line handling.

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Neutron Hall



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Observations

- Currently most of the support equipment is activated manually and located close to the structure;
- During each experiment the presence of radiation that is harmful for both humans and the electronic instrumentation requires the experimental cave to be put under safety control;
- All connections between the cave and the acquisition rooms are dedicated point-to-point connections (potential radiation leakage point).

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- Key points in the setup where the traditional solution introduced a number of problems and prolonged measurement times:
 - ***The support system for a multidetector apparatus comprising 13 CsI light ion detectors***, which has to be moved during the various phases of the experiment in order to stay at the different best position both in the calibration and data taking runs.
 - ***The vacuum chamber***, which is an essential component of the research since the beam of particles has to move in the vacuum, and heavy ion products are degrading their energy in air.

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Main advantages introduced by a fieldbus system in the experiments

- Savings in cabling and installation costs ;
- Easy addition or removal of system devices without the need for new cables for additional devices;
- A reduction in the number of connections for devices mounted on mobile parts;
- A saving in cable weight;
- A reduction in installation errors;
- A reduction in documentation costs;

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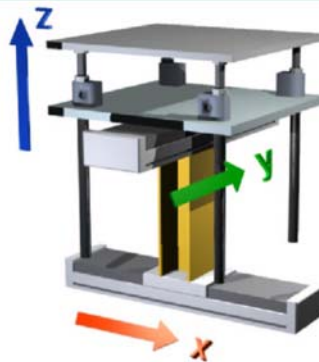
FieldBuses present typical features that have been optimized for the specific field of application

- FieldBus also provides one-to-many (multicast) or one-to-all (broadcast) connections according to the type of information being handled.
- A FieldBus makes it possible to synchronize activities carried out by physically distinct devices connected via the Bus;
- A FieldBus has to guarantee data quality;
- A FieldBus can operate in particularly difficult climatic, electromagnetic and radiation damage conditions.

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THE MOTION CONTROL APPLICATION

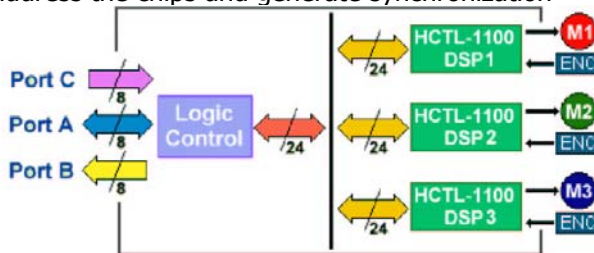
- Remote control of a movement system with three degrees of freedom for the micrometric positioning of a multidetector including 13 CsI light ion detectors.
- Each track is activated by a *brushless* electric motor with a pulse encoder and a gear reduction unit;
- At the end of each track there are limit switches to detect the maximum stroke.



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Dedicated control system

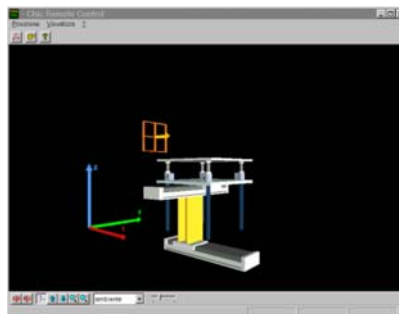
- It comprises a backplane on which 3 control boards are mounted, each using a specialized chip (**HP HCTL-1100**) for the control of brushless or stepping motors.
- The backplane interface provides 3 8-bit ports: port **A**, which is two-way, is dedicated to the exchange of data from and to the control chip registers, port **B**, an input port, is used to read the limit switch, and finally port **C**, the output port, is used to address the chips and generate synchronization signals.



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Graphic interface

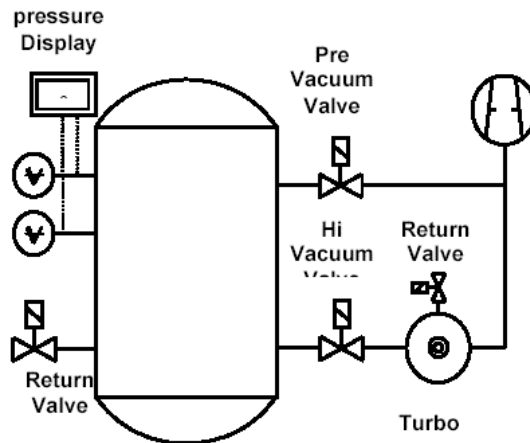
- The central part of the interface provides a realtime vision of the status of the moving platform.
- The position and values of the three Cartesian axes are visible.
- The lower part of the interface provides some commands for the control of the platform according to three degree of freedom.



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REMOTE SYSTEM FOR VACUUM GENERATION

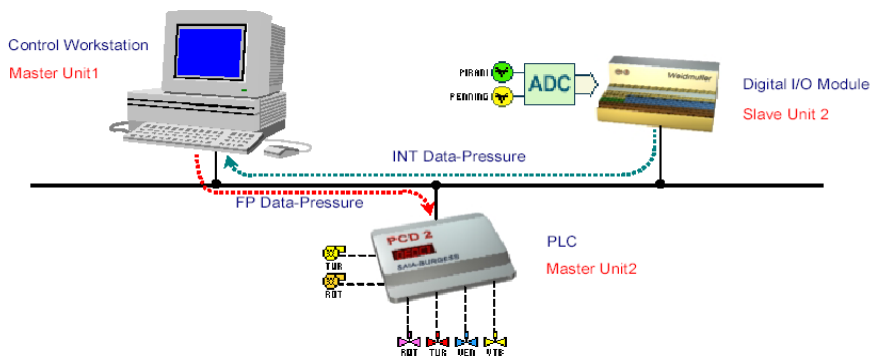
- Research support system for the development and tuning of particle detectors;
- Two pressure transducers for values ranging between $1 \cdot 10^{-3} \div 1 \cdot 10^3$ mbar and $1 \cdot 10^{-9} \div 1 \cdot 10^{-3}$ mbar.



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Remote control tasks

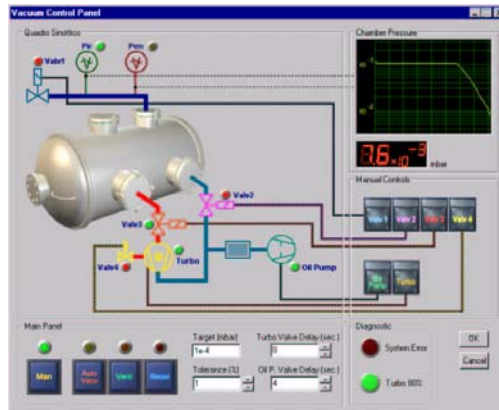
- Monitoring and automatic regulation of the pressure in the chamber on the basis of a pre-established target;
- The possibility of remote intervention on any of the activation devices .



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Command Interface

- The central part of the control panel reproduces a scheme of the plant, together with the operating indicators;
- The two pressure sensors have two indicators;
- On the top right-hand side there is a panel with two displays showing pressure measuring;
- The Main Panel contains a number of buttons, one for each control state of the local algorithm.



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Conclusion

- In this paper we presented the results obtained through the use of the Fieldbus Technology in Nuclear Physics research.
- In particular we have studied how to integrate distributed control systems through the Profibus for two specific applications:
 - The remote control of a complex detector (made up of a dimensional array of detectors) used to detect flows of light ions. This system must be moved in real time, with very high precision in three different directions, requiring the control of three electrical motors that move the detectors.
 - An implementation of the control of a vacuum system suitable for a suitable chamber used for the development and testing of particle detectors.

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Future Developements

- Improve the network speed (the data rate of Profibus can be increased up to 12 Mbps) and in this way a wider bandwidth is available, in order to accommodate a larger number of devices.
- Make an interface between this system and the local Ethernet networks in way to share the application panel.
- Introduce a Fieldbus camera systems that is able to capture images from the acquisition room.