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Implementation of the beamline controls at the Florence accelerator laboratory

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Abstract

The new Tandetron accelerator in Florence, with many different beamlines, has required a new organization of all the control signals of the used equipment (slow control).

We present our solution, which allows us the control of all the employed instruments simultaneously from a number of different workplaces. All of our equipment has been designed to be Ethernet based and this is the key to accomplish two very important requirements: simultaneous remote control from many computers and electrical isolation to achieve a lower noise level. The control of the instruments requires only one Ethernet network and no particular interfaces or drivers on the computers.

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Keywords: Ethernet based instrumentation; Microcontrollers; Slow control

1. Introduction

In this paper we describe how the remote controls for all the instruments used in the beamlines of the Tandem accelerator at LABEC (Laboratorio di tecniche nucleari per i Beni Culturali, INFN Florence) have been realized by means of many microcontroller boards, some computers for the user interaction and a completely independent Ethernet network.

The new 3 MV Tandetron accelerator, manufactured by High Voltage Engineering Europe, has been installed in our laboratory in May 2004 [1,2]. This facility is mainly used for ion beam analysis measurements (IBA) and accelerator mass spectrometry (AMS) and was delivered ready for AMS, while the beamlines for IBA were to be realized by the users, together with all the necessary remote controls.

The accelerator and the AMS operation are handled by two *accelerator computers* and two racks of electronic modules. All the signals needed for the beam control and visualization are carried by individual optical fibres to guarantee high electrical insulation from zones where high voltage sparks can occur. This also has the side effect to avoid the ground loops, increasing the S/N ratio for the signals.

The hall hosting the accelerator has a size of (35×15) m^2 with roughly 1/3 of the length reserved for the nine planned IBA beamlines (presently 6). The *accelerator computers* and the other computers, specific to the experiments, are located in nearby rooms.

Along the beamlines a lot of different equipment is needed for the setup and monitoring of the beam; these activities, as usual in these cases, must be performed from remote locations.

Because of the high number of the beamlines, it was impossible to group all the related controls around the *accelerator computers*, so for every line we created an individual control station at a different location, where, in principle, only the data acquisition and beam transport controls for the corresponding beamline are located.

We didn't want however to resign to the added value of having the beam transport controls, for all the beamlines,

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also on the same desk of the *accelerator computers*, so we decided to organize our beamlines satisfying the following rules:

- All instruments must be easily controllable at the same time from several locations.
- Every *control computer* must be connected to the different kinds of equipment with no need of different dedicated interface boards.
- It must be possible to operate the controls from a distance of 50 m or more.
- The connection must guarantee an electrical isolation between the instruments and the control computers.

2. Used instruments

We have many tens of instruments located in the accelerator area to control, falling in the following general categories:

- Motors (both step and DC).
- Beam current monitors (10 pA–10 μA).
- Pneumatic valves.
- Video cameras.
- Radiation monitors.
- Vacuum systems (pumps, roughing and turbo).
- Pressure gauges (low and high vacuum).
- Power supplies (both voltage and current).
- Data acquisition (not discussed in this paper).

Almost all these instruments (mostly commercial) can indeed be equipped with a remote interface to be connected to a single computer, located at a limited distance; the electrical isolation is however not easy to achieve in this situation.

In principle, building up multiple control locations would be possible, but as a consequence we would have too many cables connected to switches in order to give the control to one of many computers; each computer would have to accept all the connections with each instrument type, so the number of hardware interfaces needed for each computer would rapidly became unmanageable.

Another limit of this approach would be that only one computer at a time would control or read a particular instrument.

As stressed before, it is also very important to electrically isolate the detectors and acquisition systems ground from that of the accelerator, in order to reduce the measurement noise: this task would imply the introduction of optical or electrical decouplers along every connection.

In order to satisfy our requirements, we decided to adapt ourselves most of the instruments to our needs and, when not possible, to design and realize new ones.

3. Project architecture

The "slow-control" approach we have used is different from the complex one used in high-energy experiments [3,4] but it starts being adopted in smaller ones [5]. We chose to use exclusively an Ethernet interface to communicate with all the instruments, in order to achieve uniformity and to simplify the connection to the *control computers*, avoiding the use of any "master controller" or VME crate.

The general design layout is shown in Fig. 1.

Every computer (Fig. 1 bottom) can communicate with any number of instruments (Fig. 1 top) using a (dedicated) Ethernet network.

This choice has some important advantages:

- All the recent computers have at least one Ethernet interface, thus no board has to be added in the computer slot, neither driver software must be written.
- All operating systems can be easily supported.
- None of the computers is privileged, and it is possible to connect several of them to the same instrument, at the same time, without any problem.

Furthermore, some of our requirements are automatically granted: firstly, a signal travelling along an Ethernet cable is electrically isolated from the connected board; secondly, the network can be distributed to a number of computers and instruments as large as desired by means of standard and inexpensive hubs.

If a better electrical isolation is needed, it is possible to use a single optical fibre link between the accelerator and the acquisition rooms.

There is no upper limit to the distance between controls and instruments, as long as some delay in the actuation (of the order of some ms) can be accepted.

The approach we propose can also be easily introduced in existing setups, because an Ethernet cable is probably already present nearby, and no further wiring is necessary.

The disadvantages of our choice consist in the intrinsic delay in the execution of any command, which in our case is not important, and in the absence of an Ethernet interface, even as an option, in most commercial instruments.

This implies a relevant work in modifying existing equipment and in designing and realizing new ones. In

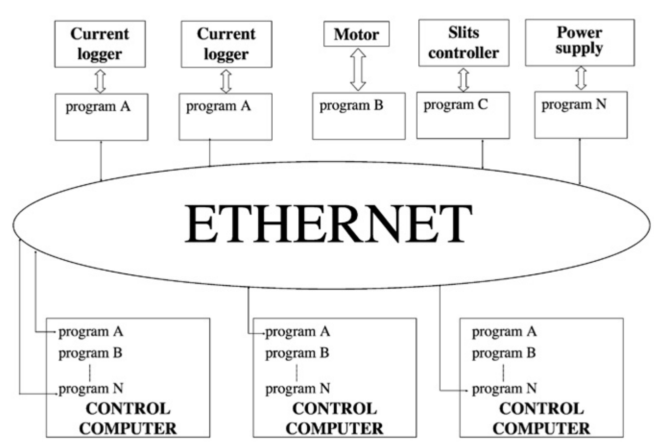

Fig. 1. Sketch of the control structure in the accelerator laboratory.