THE RENOVATION OF THE ISOLDE INSTRUMENTATION

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Abstract

The ISOLDE [1] instrumentation [2] is mainly based on mechanical scanners, wire-grids and faraday-cups. Additional items are the “fixed needle beam scanner” (FNBS), the tape-station and a device called the “fast faraday cup”. The control system for these devices is being redesigned and reimplemented in order to be integrated in the standard control system of the CERN accelerators complex. While some devices will still be controlled with "usual" standards (VME), the tape-station and the wire-grids will be controlled using industrial PLC’s. In fact, recently, the automates have become fast enough for these applications. This article will describe the different developments in the control electronics, the improvements of the devices themselves and will finish with a short peek at future projects.

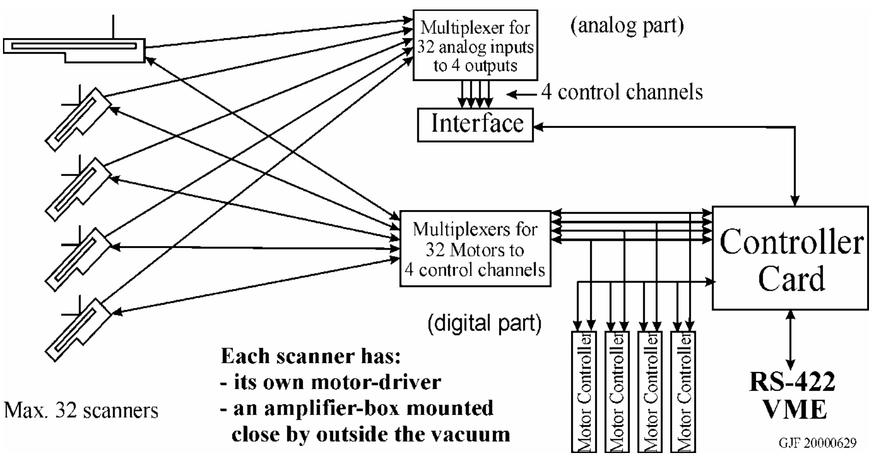

Figure 1: Block-diagram of the ISOLDE Scanner-system

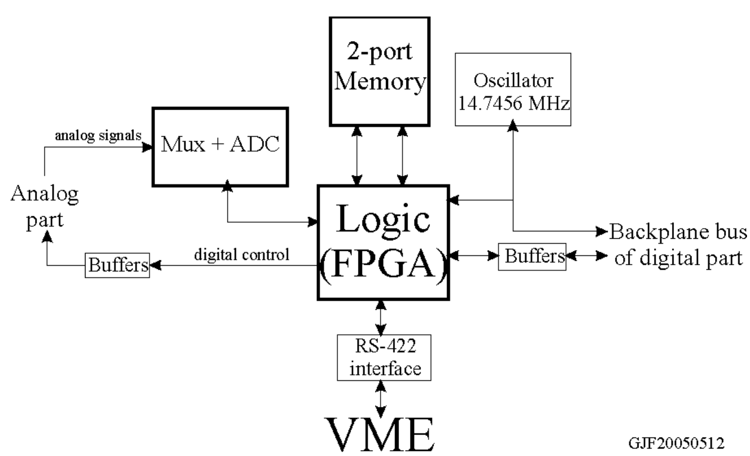

Figure 2: Block-diagram of the RS-422 controller card

SCANNERS

The mechanical scanners as are used at ISOLDE were initially (1992) controlled by a “front-end computer” (FEC) running on DOS [3].

In 1998 a more intelligent electronic card containing an ADC and local memory to store the data was installed. This card was controlled via a 1Mb/s RS422 from a PC, running Windows NT and programmed in Visual Basic. In 2004 this system was ported to Windows XP.

This system is now being ported to the standard CERN control system based on VME and using a slightly improved version of the RS422 card. The front-end software is ready and this upgrade will be finalised as soon as the console-software is ready.

WIRE-GRIDS

Choice of Design

The main part of this article is however about the new controls of the ISOLDE wire-grids as it is based on a (for us) new technique. That is to say it is a new technique for taking data. The previous system was based on an obsolete front-end computer running DOS and should be integrated into the standard CERN control system. Adapting the existing electronics with its ISA-bus interface seemed too difficult and we had to look for an alternative. Siemens has in its Simatic program an ADC that has a 52 s conversion time, which is fast enough to read out the wire-grids. They also have a module called “Boolean Processor”, which is an independently running programmable logic device with a time-resolution of 10 s, good enough for controlling the track-and-hold timing and the integration time of the amplifiers which sit on an external chassis. The use of industrial controls is not new to us; the ISOLDE vacuum-controls were already controlled by Simatic somewhere in the eighties. But using them to replace a PC or VME Front-End Computer for data taking is new to us. It should be noted that it is not possible to use Simatic for the ISOLDE scanners as the Simatic-ADC is far too slow for this purpose.

About the Simatic Solution

Simatic PLC's are now an accepted standard for the CERN accelerator control system. But even though the Simatic PLC's connect to Ethernet, the PLC's are not accessed directly by the operators. Operator Consoles connect to a VME-crate acting as a gateway where the data traffic to and from the PLC is treated. Of course the VME may handle many PLC's and this even together with other tasks.

One PLC can handle one amplifier crate with a maximum of 256 input-channels. The system is designed in such a way that it can handle up to 4 Grids.

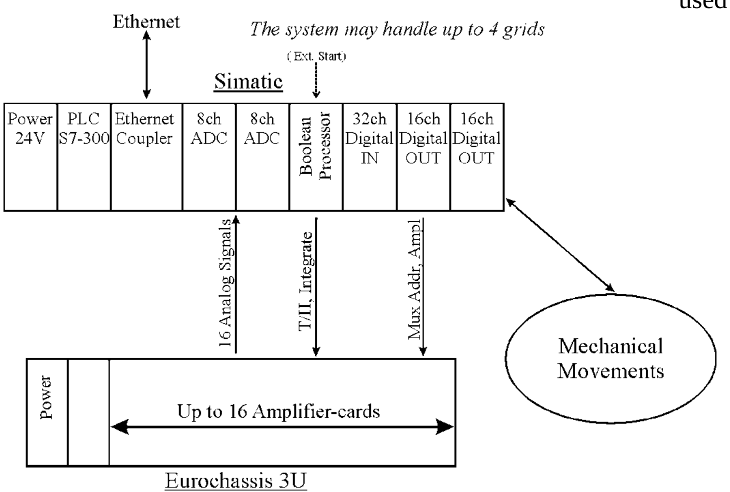

Figure 3: Layout of the wire-grid controls

The system has (up to) 16 amplifier cards and two ADC-modules with 8 inputs each. Each amplifier card is connected to its own ADC-input. In addition each amplifier card has 16 amplifiers and a 16-channel multiplexer. The multiplexers on the amplifier-cards are all controlled in parallel by the same four address-lines. Thus 16 ADC-conversions are necessary to read out all the data.

The ADC's have a conversion-time of 52 s. An ADC-module has 8 inputs; it contains one ADC and an eight-channel multiplexer. An ADC-module will always convert all eight channels (which makes 416 s) and in addition it needs some time to prepare the data before it can be read by the PLC. The result is that conversion takes place with a cycle-time of about 610 s. The ADC-modules cannot be triggered externally and run asynchronously.

The PLC is software based and runs in cycles. At the beginning of a PLC-cycle it reads the input-data, then it executes its program, and finally it refreshes the output-data. When the multiplexers on the amplifier-cards are set to a new address the next ADC-cycle must be discarded! The ADC-modules run asynchronously, so to be sure that they have been able to finish a complete measurement one should wait two times the time of 610 s, i.e. 1.22ms! This necessary delay can be obtained by programming the PLC in such a way that its program skips reading the ADC-data in the PLC-cycle after setting the new multiplexer-address and e.g. checks for mechanical positions or does some other calculations. After this the following PLC-cycle can read the ADC-data and immediately set a new multiplexer-address on the amplifier-cards. As with the used PLC the cycle-time is some 3ms there is no problem, but this means that the 32 cycles necessary to read out all 256 channels take some 100ms.

That is enough for our application, but it isn't really fast. Adding additional software, e.g. for debugging, immediately slows down the system.

The amplifiers have integrators and track-and-hold amplifiers that need a more accurate timing than the standard PLC can offer. Therefore a Boolean processor is used which allows a resolution of 10 s. The Boolean processor contains in fact an FPGA (Field Programmable Gate Array) and is not running in cycles with varying time like the PLC.

Why Use a PLC

The PLC s have slow ADC's and its programming language isn't really made for handling "large" amounts of data. In addition the inputs and outputs work on 24V. This is great for the control of the pneumatic movements, but to control the electronics one will have to convert many signals to and from 5V.

The reason to use a PLC is that we can install it close to the equipment, where space is scarce. If the amplifiers would be made on VME cards we would have been forced to use long cables which would make the system unreliable at low input-currents. And then there is the increase for cabling costs, for the PLC we just need one Ethernet-cable.

The Amplifiers.

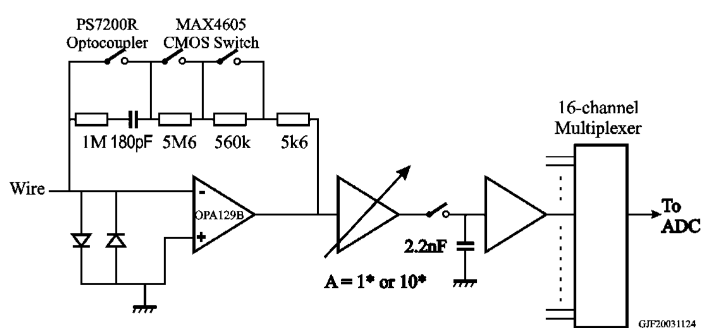

Figure 4: Schematic diagram of the Wire-grid Amplifier

Each channel of the amplifier-card includes a track-and-hold amplifier. There are 16 amplifiers on one Europe-size PCB of 100 by 160mm. For higher currents the amplifier is used as a simple current-to-voltage converter and for smaller currents as an integrator. The reason for this is that precision resistors are easy to find, even in SMD, but not capacitors, especially at large values. For small input-currents it is important to integrate in order to reduce the effect of noise. This integration should preferably be done with a multiple of 20ms to filter out any 50Hz component. To larger currents the noise-problem is less important and therefore don't need as much filtering. The input-current range is very large: from less than a pA up to 2mA.

The MOSFET opto-coupler used to discharge the integrating capacitor is a delicate issue. It must have a very low “on”-resistance to minimise the amplification-error at 2mA input-current. Most of these switches have 25pF capacitance or more from which the tolerance alone will be too large to be used in parallel with the 180pA capacitor. Then of course the switch should be sufficiently fast. The PS7200R from “Californian Eastern Laboratories” has a capacitance of only 1.1pF, an “on”-resistance of 10 , it switches off in some 0.3ms and even the isolation capacitance is low with 0.3pF. Unfortunately the European distributor (NEC) is not interested to deliver these devices, but thanks to our American colleagues from BNL we could get them.

Due to its special characteristics the switching of the PS7200R isn’t that smooth. The light-sensitive switch is made with two MOSFET’s. After switching off, the two MOSFET’s both create a short discharge. Though these two discharges are of different sign, they don’t occur at exactly the same time and are usually not the same size. Tests with a 100pF capacitor in parallel with the switch showed induced voltages of up to 33mV just by switching off the PS7200R. By adding the 1M resistance part of the short discharge-peaks are dissipated lowering the 33mV to a more reasonable 12mV. The final amplifiers show a worst error equivalent to an input-current 0.8pA. (This is with an integration-time of 5s.) This error of maximum 0.8pA is not very repeatable though, it isn’t possible to compensate with a constant value. We found the solution in taking two measurements, one just after switching “off” the PS7200 and one at the end of the integration-process. By subtracting the first value from the second we obtain a remaining error of maximum 200fA, which is close to the resolution of 50fA that we have with our ADC.

THE FIXED NEEDLE BEAM SCANNER (FNBS)

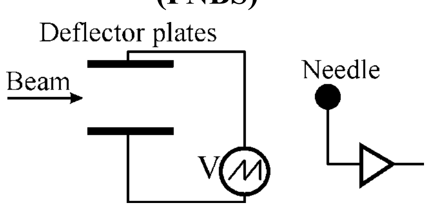

Figure 5: The principle of the FNBS.

The Fixed Needle Beam Scanner is a device where, instead of moving a needle mechanically the beam is deflected electrostatically to a maximum of ±5mm. The needle (actually a 0.1mm wire) doesn’t move during the measurement, but can be taken out altogether with a pneumatic movement. The absence of mechanical movement during the measurement allows obtaining higher precision and eliminates the noise caused by microphonics. The FNBS (there is only one at ISOLDE) is still controlled by a DOS-PC. This device will be ported to the new control system and will also be controlled with Simatic. Once the new control system working, we will extend it with a motor-controller and use it to control an Allison Emittance Scanner [4] that will replace the FNBS at a later date.

FUTURE

With the Isolde Tape-station radioactive nuclei can be collected from the beam and measured nearby. This allows to measure beam-intensities of radioactive isotopes too small to be measured otherwise, which allows optimising the Isolde target. Another feature of this device is the measurement of half-lives. The Tape-station has electronics that dates from 1974. The timing control is modern though with a Simatic PLC and “Boolean Processor”, but the mechanics and its electronics will be redesigned and replaced.

The Fixed Needle Beam Scanner will be replaced by an Allison Emittance Scanner.

The existing Faraday-Cup measurement system controlling a few dozen of Faraday-Cups is built up with a Keithley Electrometer and a Keithley “Scanner”-box. In the environment of switching over between Faraday-Cups having different input-currents and long cables the readout is not always accurate enough. We will look for a solution to improve this system, either by incrementing the number of Electrometers or by building small local amplifier-boxes controlled by Profibus.

CONCLUSION

The Control of the Isolde Instrumentation is slowly being converted to the standard Control system. The main item of this article is the controls of Grids and FNBS by Simatic. This experience shows that it is possible to use this technique and allows putting the controller close to the equipment. As a drawback the programming of the PLC costs more time than expected.

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