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THE GANIL CONTROL SYSTEM

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1. Introduction

The GANIL[1] control system uses 3 kinds of processors : computers, microprocessors and programmable controllers. These processors are linked one to another via Camac data links. Camac is also extensively used to interface the processors to the heavy ion accelerator. Figure 1 shows the general lay-out of the system.

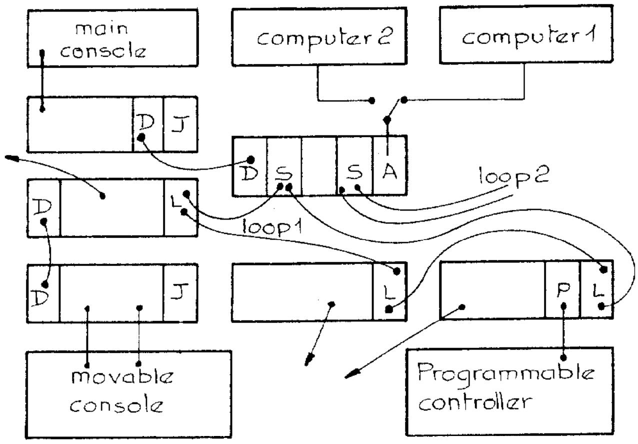

Figure 1

A : type A crate controller
L : type L crate controller
J : autonomous controller
S : serial driver
D : data link between Camac systems
arrows : links to the accelerator
P : data link with programmable controller

1.1 Computers

The computers are 2 french built MITRA 125 computers. One is equipped with 128 K 16 bits words, the other with 192 K words. Normally the smaller one is in charge of controlling the accelerator, the bigger one being available for ancillary tasks like field mapping and software development. Should the first computer fail, the second one is manually switched on. Each computer is equipped with a parallel Camac coupler. The one line computer drives a Camac crate with a type A controller. From this crate are driven 2 serial Camac loops operated in bit serial mode at a 2.5 MHz frequency. Also from this crate data links run to the main console.

Every console is under control of an autonomous crate controller, all the console components being driven by Camac modules.

1.2 Programmable controllers

Programmable controllers are very sturdy equipments used mainly to control the vacuum system and also to interlock security conditions coming from various parts of the accelerator. Programmed in a high level language using boolean equations they replace the traditional cabinets full of relays. 15 of them are used to control the vacuum system, which means performing starting sequences and watching local security conditions. Each programmable controller can handle up to 512 input or output binary informations.

Linked to the Camac system, they receive from the computer orders that will be obeyed only if they are not contrary to the security of the equipments. They send to the computer interrupts to inform the computer that something happened. It is the duty of the computer to read back inside the programmable controller memory to know exactly what happened. In case of a failure of the mains, the programmable controller is programmed to place its output on savety positions and some informations are saved in ferrite memories.

2. Hardware

2.1 Camac

Most Camac modules that we needed have been found directly available from industries, but some have been developped especially for our application.

Camac modules to drive stepping motors do exist from industry, but they usually accept only incremental orders. We wanted a Camac module which would accept absolute orders when associated with an absolute coder. The chosen coder is the one used for the CERN linac[2].

So we devised a special Camac module which includes a microprocessor TMS 9900. As shown on figure 2 the Camac module is a part of a digital servo loop. When the Camac module receives an absolute order, it drives the motor until the coder feeds back the ordered value.

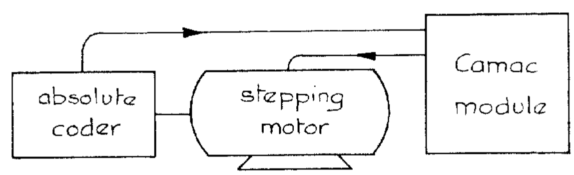

Figure 2

Data links can also be purchased directly from industry but we needed a data link with the following characteristics : a 16 bits word programming, a 512 words buffer to decouple Camac speed and data link speed, a serial transmission at a 1 MHz frequency and a check sum control. Special Camac modules have been made for this purpose. They include an additional interesting feature. When processor 1 sends a message to processor 2, the data link will not accept any other message from processor 1 until processor 2 itself has answered a message which is called the "immediate answer". It may carry data or not, but the important point is that it is the way to let processor 1 know that processor 2 has understood the first message.

Programmable controllers are equipped with a port normally used to interconnect it to an other programmable controller. We used that port to link the programmable controllers to the main computer. Special Camac modules which include a microprocessor Intel 8080 have been devised for this purpose.

2.2 Interfaces for power supplies

Power supplies are separated in two main classes. Big power supplies usually give the main field in bending magnets. Their stability is in the 10^{-4} to 10^{-5} range. These power supplies are controlled from Camac via a serial data link with galvanic insulation. Inside the power supply a special crate

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is placed, housing decoders and drivers for the data link and also digital to analog and analog to digital converters.

Small power supplies usually feed correction windings and their stability falls to 10^{-3}. Common mode between adjacent power supplies and a Camac crate are not so critical because everything can be gathered in a small area. The chosen solution to control these power supplies is to place the converters inside Camac modules and transmit directly the analog signals with a common mode rejection of a few volts.

3. Microprocessors

3.1 General description

From the hardware point of view, they consist of autonomous crate controllers equipped with an Intel 8080. They are connected to the main computer via the data links described in paragraph 2.1, but they can run in a stand alone mode when this is relevant. Generally speaking, they are used to perform local tasks which would be too time consuming for the main computer. They are divided in two classes : the console microprocessors and the process microprocessors.

3.2 Console microprocessors

There are 6 console microprocessors : 2 for the main console and 4 for the 4 movable consoles. They are used :

first to interpret the operator requests. A single request may involve several actions from the operator (for instance turning pages on a touch panel and pressing a hook button). The microprocessor will interrupt the main computer only when the operator request is fully stated.

second to display informations sent by the main computer. These informations come as crude display lists. It is the duty of the microprocessor to transform these lists in series of Camac orders sent to the relevant Camac display drivers.

3.3 Process microprocessors

These microprocessors either take care of local equipments or perform computations on data coming from beam diagnostic devices.

RF microprocessors. There are 4 of them, one for each cyclotron plus one for the buncher. They are programmed to start a cavity from cold and control its behavior. This includes : tuning the cavity, passing the multipactor, raising slowly the field up to the desired value and taking care of sparkings, at least when they are not too frequent.

Phasing microprocessor. This microprocessor is in charge of phasing the cavities between themselves. The problem arises from the fact that the RF frequency may vary from 6 to 14 MHz. Phasing consists in switching delay lines for coarse phasing and feeding a signal to an electronic phase shifter for fine phasing.

Central phase measurement microprocessor. This microprocessor picks up signals from capacitive probes designed to measure the central phase of the bunches. Here again the microprocessor handles delay lines to take into account the working frequency, but also chooses the amplifier gain according to the magnitude of the picked up signal. Moreover it is programmed to improve the signal to noise ratio by comparing measurements made with and without beam.

Wire chambers microprocessors. Beam transport lines are equipped with about 100 secondary emission wire chambers designed to measure the beam profile at 100 points along the line. When asked to do it, the microprocessor scans all the wires of a given wire chamber, computes the first and second moment of the distribution and answers beam position and beam size.

3.4 Microprocessor software

All the "on line" microprocessors described above are programmed in assembler with a cross assembler runned on the main computer. But some other "off line" microprocessors are used to help the accelerator construction. Among the tasks falling within this scope one may mention magnetic cycling of large magnets and equipment testing. TSTCAM, a Camac oriented high level interpreted language has been devised for this purpose. With this language one can state Camac orders, wait for delays, wait for LAMs, conditionally branch depending on chosen bits in a data. This language turned out to be quite useful and significantly improved the microprocessor conviviality.

4. Consoles

Our consoles have been designed after a careful analysis of what has been done in other laboratories. The CERN linac console design[3] has been especially valuable to solve our problems.

The console system consists of a main console and 4 movable consoles. The main console is shown on figure 3.

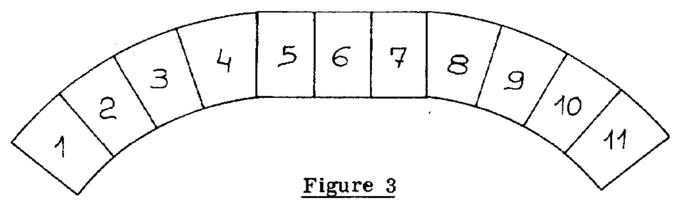

Figure 3

Blocks 1, 2, 3, 4 are identical to blocks 8, 9, 10, 11. Taken as a whole they allow the accelerator control via the computer system. Blocks 5, 6, 7 are devoted to equipments not linked to the computer, such as equipments involving wide band signals.

Figure 4 shows an enlarged view of blocks 1, 2, 3, 4. From a logical point of view these blocks can be divided in 4 areas α, β, γ, δ .

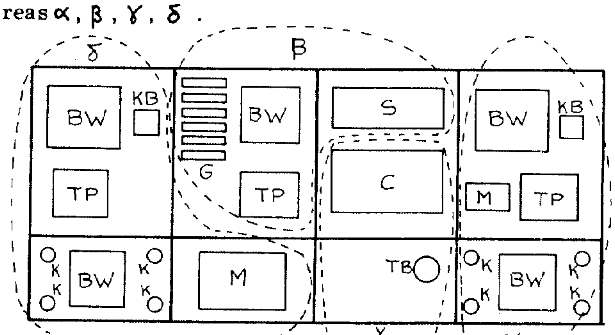

Figure 4

BW	:	black and white TV monitor
K	:	knob
TP	:	touch panel
S	:	scope
C	:	color TV monitor
G	:	galvanometer
TB	:	track ball
KB	:	key board
M	:	memoscope

Area β is related to analog signals to be displayed either on galvanometers or on oscilloscopes. The desired signal can be chosen by turning the pages of an analog-signal tree on the touch panel. Analog signals are collected along the accelerator via a signal observation system (SOS) built on CERN specifications[4] that CERN kindly allowed us to use.

Area γ is mainly used to display schematics of subsets of the accelerator. Color is particularly useful for such an application ; the shape of the drawing gives the status of the equipment (on/off, opened/closed) while a color code indicates if this situation is to be considered as normal or not. Areas α and δ are logically identical. Movable consoles are exactly identical to area α . From such an area one can control any of the equipments linked to the computer system (excepted analog signals). One can work either at the elementary level or at high level.

At the elementary level the control system behaves as a multiplexer. At this level one can handle one by one the equipments designated by their "operational names" on an operational name tree displayed on the touch panel. The equipments can be hooked one by one to any of 4 knobs. When an equipment is hooked, its actuel value and its status are displayed on the black and white TV monitor associated with the knobs.

It is at the high level that one can take full benefit of the control system. At this level one can run tasks chosen on a task tree displayed on the touch panel. The upper black and white monitor, key board, knobs and memoscope are input/output peripherals for the tasks. Several tasks at a time can share the input/output peripherals of a same α type area.

5. Computer software

Computers have been delivered with a standard multitask monitor. On this basis has been built what is called Ganiciel, which is mainly all the software we needed to drive the consoles and to interface the various components of the accelerator. All this software is written in LTR, a structured real time language similar to Pascal. Figure 5 shows a simplified block diagram of the Ganiciel.

The console control module deals with the operator requests such as hook such equipment to such knob, or start such task.

The alarm control module handles interrupts coming from line surveyors Camac modules. Usually this indicates that a power supply has been turned off. If this is not consecutive to an order sent to the equipment , it means that it tripped. An alarm message is built ; it will be edited by the alarm editing task.

Handlers are pieces of software dedicated to specific equipments. All the equipments interfaced to the computer in the same way (for instance all the stepping motors) are driven by a single handler. This approach has the advantage of allowing to start running the system with some handlers, and to add others afterwards. Associated to each handler is an equipment table in the data base. This table has an entry for each equipment driven by the associated handler. Equipments are numbered sequentially in each equipment table. They are known inside the Ganiciel by their "equipment names". An equipment name consists of a couple : handler number, equipment number.

The equipments are known outside the Ganiciel by their "operational names". Only these names have to be used by the operators and the application programmers. The name translator module translates an operational name into its associated equipment name.

Example : C1.IN.SM1 may be the operational name of the Septum Magnet 1 belonging to the INjection system of Cyclotron 1. If this septum magnet is fed by power supply number 12 in the class operated by handler 4, its associated equipment name will be : 4, 12.

The external messages management modules is in charge of sending and receiving messages travelling through the data links labeled D on figure 1.

The internal messages management module allows the exchange of messages between tasks inside the computer.

The microprocessor driver modules play the role of handlers for the equipments controlled by the process microprocessors.

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Figure 5