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A CONTROL SYSTEM FOR CRYOGENIC INSTALLATIONS

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Abstract - A modular control system has been developed for the automatization of cryogenic systems. The hardware has been built around a microprocessor; conventional and specific modules for cryogenic applications have been developed. A special software has also been written, the first aim of which being an easy writing and modifying of the process control by the users.

The prototype of this system has been operated for more than a year. The system is now commercially available; it has been used and is under consideration for several cryogenic projects in which the laboratory is involved.

INTRODUCTION

The development of advanced cryogenic systems requires more and more automatization; one or several of the following reasons can justify this affirmation: the complexity of these systems generally increases with their size; they must be very reliable and safe; an industrial development implies that they must work without a skilled staff in non cryogenic surroundings (plants, hospitals, ...) and finally the running cost must be minimized.

The opportunity to develop such a system has been given to Saclay through the construction of a magnetic separator prototype, using a superconducting solenoid. Meant for a plant, this installation must be fully automatized; so, it is equipped with a built-in refrigerator working in closed cycle and with a control system, enabling to run the system in an fully automatic mode, from the cooldown to the keeping of the solenoid under excitation.

After successful tests at Saclay, the licence for this system has been sold by the CEA to the company Mecilec, which now commercializes it under the trademark Syclop.

1 - REQUIREMENTS FOR A FULLY AUTOMATIC CRYOGENIC SYSTEM

The control and monitoring of the different phases of a cryogenic process can be done through:

- on/off inputs and outputs
- analog inputs and outputs, particularly cryogenic ones: temperatures, levels, heaters...
- regulation, supervision and safety functions
- and more sophisticated functions such as counting, temporization, ramp
The aim of the system is to give to the user all these possibilities for a medium size process having a cyclic operation, typically with:

- 100 to 200 on/off parameters
- 50 to 60 analog parameters
- 10 adaptive control loops
- 300 to 500 steps of sequential operation.

II - THE "GRAFCET" EXTENDED TO PROCESS CONTROL

The "grafcet" is a simple and rational method for representation of sequential automatic control systems. (1)

Grafcet basic elements are step and transition:

- A step can:
  - control on/off parameter states, analog parameter values, execution of calculations, execution of instruction programmes, timers and counters
  - modify control constants
  - drive control loops
  - output messages to the printer...

- A transition can be described by a logical combination of tests on on/off parameter states, measured or calculated analog parameter value, time delay durations, counter values, control parameters values, state of a Grafcet step...

Divergences and convergences (and or or) are also possible.

III - HARDWARE

A complete hardware has been designed. The system is build around a S100 (IEEE 696) bus and is monitored by a Zilog Z-80 microprocessor.

The system cards consist of a CPU card and a memory card. A floppy disk controller and two 315K floppies can be added for local software development and loading. The I/O cards are connected to the process via connection boards included in the cabinet.

Card description is given in Table I; special attention has been given to the insulation. Up to 18 cards can be plugged in a chassis. A main DC power supply is connected to the bus while a lot of auxiliary powers provide multiple insulated sources for the cards. Immunity against main power glitches or switch off are provided by an insulated transformer and an uninterruptible power supply.

A display and a line printer can be interfaced. A special asynchronous RS 232 link is reserved to support a local area network used when several systems are needed.

The prototype is shown on Fig 1.
IV - SOFTWARE

The general organization of the software is shown on Fig 2

A special language has been developed for the system; it is based on the grafcet method as indicated before. Its main particularities are:
- each parameter is identified by the name assigned to it by the user.
- programming with words from the natural vocabulary of automation specialists
- PID control loops can be treated
- use of a compiler to translate the program into machine code, to detect errors...
- on and off lines tests possibilities.

![Fig 2 - Software organization](image-url)
V - APPLICATIONS

Installations now in operation:
- Sepma: ore separator prototype using a superconducting solenoid and working in closed cryogenic loop; after the setting, has been periodically in fully automatized operation for more than a year.
- Helium liquefier-refrigerator: in the frame of a collaboration between Air Liquide and Saclay, the system has been put in a modular helium liquefier-refrigerator which can produce between 40 - 70 l per hour. This is the first truly automatic standard helium liquefier - refrigerator (2).
- Gas control and epuration system for the detectors of a very large experience now under installation in the Frejus tunnel, to measure the proton life-time.

Installation under development:
- Test facility for the Tore Supra coils which will be tested two by two before their final installation. The system will control the cryogenic and the electrotechnical processes.
- Post accelerator using superconducting cavities to be put after a Van de Graaf at Saclay; this will be the largest installation to control, with about 500 digital and 150 analog I/O. Five systems will be used in a network: one master, three slaves for the eight cryostat management and one installed in a helium liquefier similar to the one described above.

CONCLUSIONS

A modular process control system has been completely developed. Primitively designed for cryogenic processes, its possibilities are large enough to be now commercialized by a manufacturer which is involved in rather different process controls. Its practical modularity, its industrial design and its plain language make it use very simple.

REFERENCES

(1) See for example: M. BLANCHARD: Comprendre, maîtriser et appliquer le Grafcet - Editions CEPADUES