

CONTROL OF CENTRIFUGALS WITH THE USE OF A PROGRAMMABLE CONTROLLER

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Abstract

Automatic batch centrifugals in the sugar industry are intensive in relay logic and interdependent cycle sequences. Programmable controllers are specifically designed for rapidly performing relay logic and sequence operations and simultaneously providing the reliability that has become synonymous with modern solid state electronics. This paper describes the successful marriage of these two situations at Ubombo Ranches, and discusses some of the principles pertaining to programmable controllers in industry.

Introduction

In this age of computerisation most people have been exposed to automation of varying degrees and such a simple device as a programmable controller (PC) may seem a bit of an anticlimax. However, these devices do have a role to play in process control and offer a degree of simplicity acceptable to plant personnel.

Programmable Controllers

The distinction between PCs and Microprocessors and Computers is becoming more and more vague as technology progresses and in a lot of cases the same basic electronic chip is used throughout and only the level of communication varies. All the above devices rely upon a fundamental principle of considering the electrical state of a circuit and deciding whether it is "ON" or "OFF". Thus all are making a number of YES/NO decisions, the difference lying in the capacity and speed.

Such electronic circuitry lends itself then to an application of logic decision making, and this is exactly what the programmable controller does.

Industrial Application

There are three fundamental elements to any electrical plant. These are control console, relay panel and motor control centre as shown in Figure 1. It must be understood that the PC (or computer) does not provide anything new but merely replaces an existing system with something more reliable.

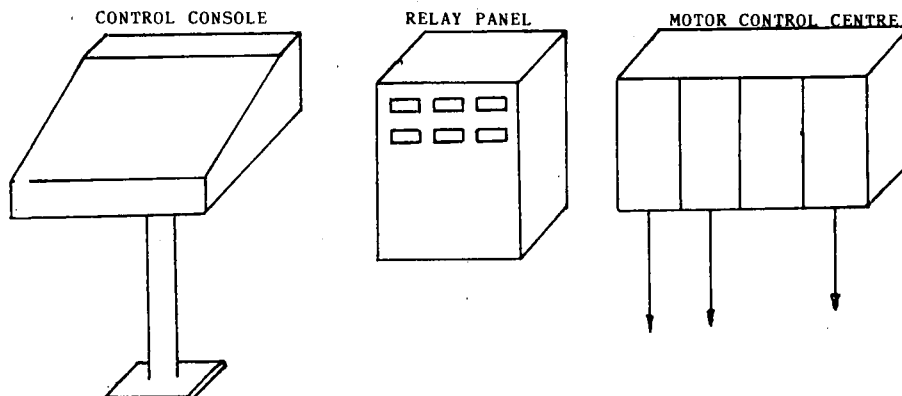


FIGURE 1 Basic elements of electrical plant.

Where then should a PC be used in the sugar industry — if indeed it should be used at all? Look for an application where a number of logical decisions are made, in sequence, with interdependence and with a high degree of repetition. All these conditions are present on an automatic batch centrifugal.

At Ubombo Ranches a bank of five A-centrifugals with sequence controllers, which were a constant source of downtime, and logic relays, that were maintenance intensive, provided ample justification for improvement.

A good deal of thought and as much trepidation went into the decision to overcome the above problems by replacing the out of date equipment with electronics. Ubombo Ranches is not exactly on the doorstep of civilization and must be prepared, in its "modus operandi", for varying degrees of technical ability in its operational and engineering staff. Sophisticated computerisation was discarded and the system decided upon met the following prerequisites:—

1. Inexpensive to purchase.
2. Easy to install.
3. Simple to programme.
4. Ability to commission in stages.
5. Reliable.
6. Does not require specialist maintenance.

The system chosen was a Gould Modicon 484 Programmable Controller¹.

Implementation

The mechanics of purchasing a programmable controller ensure that one does a fair amount of homework before the decision is made. The cost of the system is a function of the amount of programme space required, and this will not be known accurately until the programme is written. Most PCs use a simple electric diagram symbol system to build a programme in the form of a circuit diagram on a VDU screen. Having estimated the programme space required it is then necessary to count up the number of inputs and outputs required. These are simply the number of devices with which the PC must communicate e.g. contractor coils, solenoids, limit switches etc. With this information the order is placed, the goods arrive, the mistakes are

realised and the standard add-on packs are ordered to increase memory size and input/output capacity.

The system chosen for centrifugal control should have the following capabilities :

1. Logic decisions.
2. Sequence control.
3. Timers — externally variable.
4. Counters.

In addition to this the Modicon can also add, subtract, multiply and divide. It has a built in capacity for 8 x 32 step sequences. Timers are used extensively and those required to be adjustable by process staff are "Spin Time", "Wash Water Time", and "Steam Time". This can be achieved in several ways, one of which is to have externally mounted thumbwheels with dialled value read directly in seconds. This can be mounted suitably remote to prevent operators from entering electrical panels, control rooms etc.

The implementation and installation is basically in two phases, which may be carried out simultaneously. Phase 1 is the programming or software work, and Phase 2 is the actual wiring up or hardware work. Software tends to frighten people unnecessarily. Because factory staff are not development personnel, the approach was to reproduce simply the existing circuit diagram in the memory of the PC. Apart from simplifying the programming this has the advantage of keeping the programme in a form with which the fault-finding electricians are familiar. The author programmed the first centrifugal while the factory electricians programmed the remaining four, producing a number of modifications of their own. Figure 2 shows typical programmed networks as they appear on the Visual Display Unit (VDU) screen.

Each centrifugal has its own programme. If changes are required to be made to a particular programme, that centrifugal must be stopped for the few minutes required to make the change; the remaining centrifugals need not be stopped.

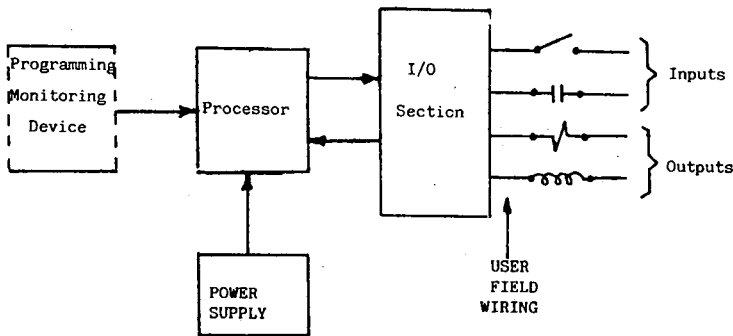


FIGURE 3 Typical programmable controller layout.

System Description

Figure 3 shows a layout of a typical programmable control system.

Practical Aspects

Some concern was felt about putting "all the eggs in one basket", a feature of most computer installations. For this reason initially only one centrifugal was converted without disturbing the old relays. Complete duplication of the Central Processing Unit (CPU) was decided on at Ubombo to allow, in the event of a memory loss, for connection into an alternative CPU. It appears at this stage as though these fears were unfounded and Ubombo will most likely use the spare CPU on some other application — possibly the affination

and refinery centrifugals. The memory of the CPU is protected by a torch cell type battery which will maintain memory for one year without AC power. The battery life is normally five years but a policy of replacing this once a year during off-crop will be adopted.

The unit operates off a 110 volt power supply and accepts $\pm 15\%$ voltage fluctuations. There has been no indication of any problems with the present installation working from the factory's own generated power.

The state of any desired field device (limit switch etc) can be monitored, and controlled if desired, from the VDU programming panel. This has been found in practice to be a most valuable feature for fault finding. Also the state of each field device is permanently displayed in the form of a small light at the input/output modules.

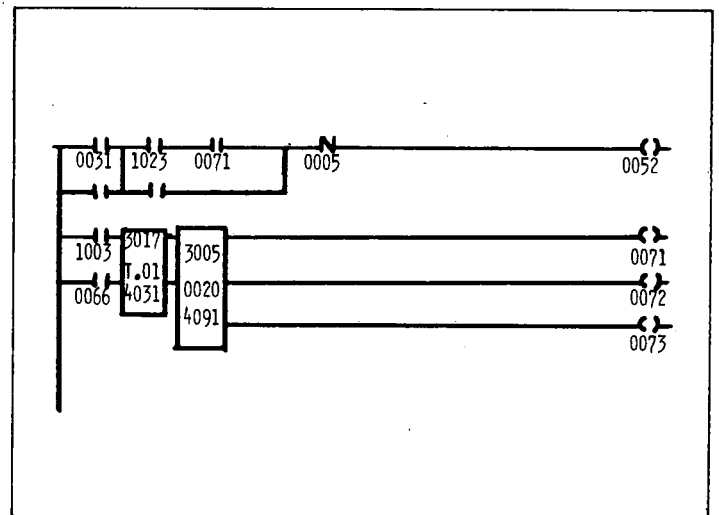
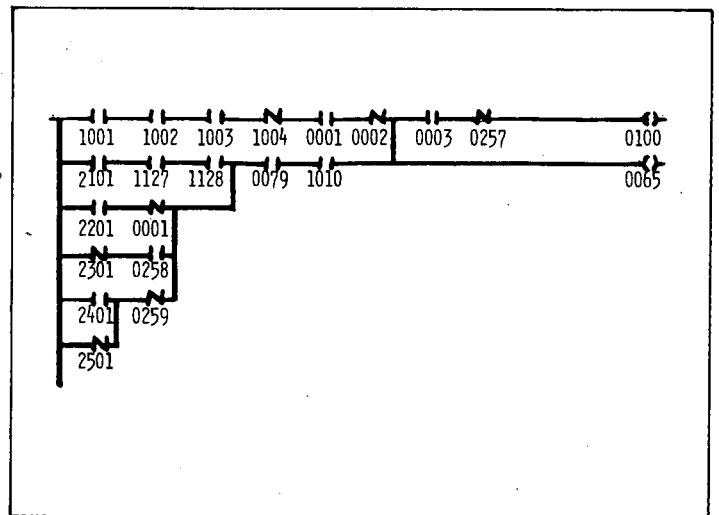


FIGURE 2 Typical programmed networks.

Most suppliers^{1, 2} offer a free one-day course on their product, and the advantages of the purchaser doing his own software and hardware are considerable. This was certainly the case with Ubombo Ranches. The programmable controller has replaced at each centrifugal 19 relays, 4 timers, 1 "Burrel" process timer and 1 rotary sequence controller.

Those responsible for maintenance in this section of their plant may appreciate the significance of this reduction in equipment. The total cost of purchased equipment

was R16 536,00 which is equivalent to R3 307,00 per centrifugal. The breakdown of these costs is given below in Table 1

TABLE 1
Breakdown of material costs

Item	No. off	Unit Price	Value
Central Processing Unit	1	5 830,00	5 830,00
Input/Output Housing (I/O)	8	250,00	2 000,00
Input Modules	32	63,00	2 016,00
Output Modules	32	95,00	3 040,00
Multiplexer Housing	1	175,00	175,00
Register Multiplexer	1	520,00	520,00
Ducting	1	125,00	125,00
Thumbwheels	15	22,00	330,00
Cabinet	2	1 000,00	2 000,00
36 Core Cable	100 m	5,00	500,00
			16 536,00

This represents a short payback period on maintenance costs alone. Note that these costs do not include installation and labour costs. The financial benefits of decreased downtime and improved productivity are left to the judgement of the reader.

Electronic component are not as susceptible to extreme temperatures as they used to be, and this PC has an operating temperature range of 0°C-60°C. This makes it unnecessary to aircondition the room in which it is housed, although this was done in the case of Ubombo Ranches.

Memory is protected by an ON/OFF key and even with memory protect off there is a specific sequence of commands to perform before any programme memory can be altered, so accidental alteration of programme memory is virtually impossible.

The processor is the brain where all decisions are made and from where all instructions emanate. The I/O section is merely a communication media between the processor and the user's equipment. It converts all field information into the digital language that the processor understands and vice versa.

The processor scans all information at the I/O section very rapidly, presents this to its programmed memory, which makes all appropriate decisions and returns these to the I/O section. Each scan time is in the order of milliseconds and consequently this appears to the observer as a continuous response to process changes.

Programming is achieved from a programming panel which is a plug-in peripheral with a Cathode Ray Tube (CRT) screen. The bottom line of the screen is reserved for status and assembly display whilst the remainder of the screen is available for building a network of circuit elements in any configuration possible. There is no restriction to paralleling elements, the only limitations being the number

of elements that will fit on the screen in one display, which is 70. Errors can easily be removed and alterations made, making de-bugging a simple task.

The system as installed at Ubombo Ranches has used 7 450 words of memory out of a maximum 8 200. It has used 125 inputs and 125 outputs out of a maximum of 128 each.

It is roughly estimated that some 3,5 km of small core cabling was used between the PC and the centrifugals panels.

Fifteen BCD coded thumbwheels supply the settings, read in seconds, of the "Spin Time", "Wash Water Time" and "Steam Time". These have been grouped together on a common panel placed convenient to the process operating personnel. The PC used at Ubombo normally accepts this sort of information through its multiplexers from 9's complement thumbwheels. However, as BCD thumbwheels are more readily available, these were chosen, and a very simple programme was used to convert the BCD code to 9's complement.

Figure 4 shows a schematic of the Ubombo system.

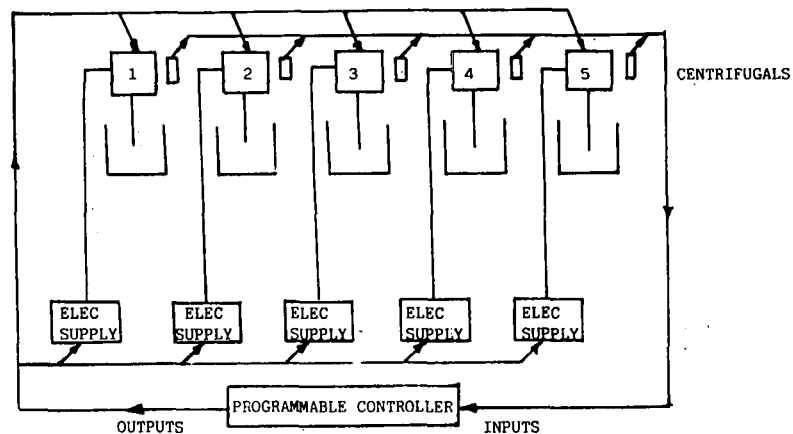


FIGURE 4 Schematic layout of Ubombo Ranches "A" Centrifugals.

Conclusion

The project described above has been so successful that Ubombo Ranches is contemplating applying programmable controllers to further automatic batch centrifugals. Also the conversion of existing sem-automatic batch machines to full automation will be investigated during the 1982 season.

Acknowledgements

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REFERENCES

1. Gould Inc. (1980). Modicon 484 User's Manual.
2. Bateman, E. L. (1980). Modicon 484 Training Course Notes.