CONSOLE OPERATED CONTROL SYSTEM FOR THE RIKEN MUON FACILITY ON ISIS

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ABSTRACT

An integrated control system for operating the RIKEN/RAL Muon Facility has been completed. The system consists of commercially manufactured equipment and this paper describes: how the communications between them is achieved; the hardware and software architecture from console to field equipment via a Programmable Logic Controller (PLC); the subsequent interfaces to operate power supplies for fast kicker magnets, septum magnets, quadrupole and bending magnets, HV separators, beam slit control and vacuum systems.

1 INTRODUCTION

The following equipment required control and monitoring:

- *Magnets and Power Supplies*
  Twenty one Quadrupole; four high voltage Kicker; two Switch Yard; two Septum/Bending and two Crossfield;
- *Vacuum Pumps and control units*
  Eight Turbo Molecular Pumps and forepumps, isolation valves;
- *Beam slits and Blockers*
  Three slits and four blockers;
- *Machine Interlocks*
  Water, Temperature, Vacuum etc;
- *Personnel Interlocks*
  Safety, Radiological etc.

The equipment covered an experimental floor area of 500 sq metres and the power supplies were mostly located on a balcony eight meters above the experimental floor.

Controls for the project were seriously discussed in April 1991 and it was recognised that, to operate a facility with a variety of equipment in beamlines and three experimental areas, it could not be done ad hoc.

A RIKEN control room (RCR) was planned in two sections:

a. an air conditioned, experimental diagnostics room with some dedicated controls for superconducting magnets and their refrigeration control system,
b. an experimental data desk top working area for teams of experimenters.

This paper will describe how the operation and control of the facilities power supplies and control equipment was achieved within these constraints.

2 CONTROL PHILOSOPHY AND CONSTRAINTS

It was specified that:

- Control operations e.g., the setting of current and polarity of magnet power supplies, be carried out from the RCR;
- equipment status information, e.g., the position of vacuum line valves, be available from the RCR;
- in case of RCR control failure, equipment should also be capable of being operated locally;
- the control equipment in the RCR could only take up an area equivalent to that of a desk top PC;
- the system needed to be easy to operate with no specialised personnel training.

3 THE CONTROL SYSTEM

The equipment chosen was a Modicon Video Control Panel (console) and Programmable Logic Controller (PLC). This system provided an economical and flexible alternative to hardwired operator control panels. The console could be connected to higher level systems such as host computers and, via the PLC, to lower level functions such as motor and solenoid valve control.

The PLC layout was designed to keep field wiring lengths to a minimum with Input/Output (I/O) modules located in 'drops' distributed around the beamlines.

3.1 *System Configuration*

The control console, sited in the RCR, and the PLC sited in the experimental hall was linked with a twisted shielded pair cable for communications using MODBUS PLUS (an acknowledged *de facto* industry standard communications network).

The console consists of a NEMA 4/12 sealed front panel and membrane keypad able to work in harsh environments.

3.2 *System Layout*

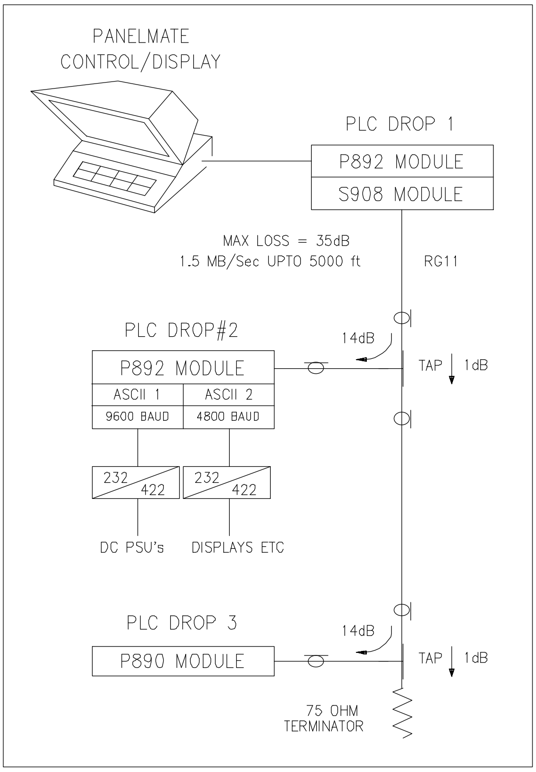

Figure 1 shows the system layout with connecting communications cables.

3.2.1 *Panelmate Plus III (RCR console)*

Users can select and display various screens of templates or graphics from a directory by means of a touch panel, control buttons and numerical keypad.

On screen help messages allow users to rapidly enter and exit relevant pages, to locate sections for display, and carry out on-line operations. A total of 30 pages are available and up to 15 templates per page.

Communication Ports available:

Two RS232 Serial Ports/ Modbus Plus, One Parallel printer port.

3.2.2 *Programmable Logic Controller (PLC-685E)*

The midsized PLC used is a 984-685E (685E) providing large controller power in a modular, expandable architecture. It features 16K words of User Logic and 12.5K words of state RAM (includes storage for 0, 1, 3 and 4XXXX registers) to support 31 Remote I/O drops. A maximum of 1024 discrete I/O points is allowed per drop or can be spread over them all for a total I/O support capacity of 8192 in/8192 out discrete I/O points (any mix). The 685E also supports 9999 registers in 16-bit words.

3.2.3 *I/O Drops and Modules*

Drop 1 contains the following :

980-685E PLC with CPU and memory.
S908 remote I/O module to communicate with I/O in drop 2 through the P892 interface, and I/O in drop 3 through the P890 interface.
Discrete I/O, 9 input modules/3 output modules
Analogue I/O, 1 input module /1 output module

Drop 2 contain the following:

P892 power module and ASCII comms
Discrete I/O, 5 input modules/2 output modules
Analogue I/O 1 input module

Drop 3 contains the following:

P890 power module
Discrete I/O , 4 input modules/2 output modules
Analogue I/O, 1 input module

Types of I/O modules in the drops:

24V discrete, 32 way input and output,
240V discrete, 16 way output,
0-10V Analogue input and output,
8 way Volt free dry contact.

3.2.4 *ASCII Communications*

Drop 1 PLC module, two ASCII ports are available for communications between dedicated programming devices or PC derived software.

In drop 2 the ASCII ports are used to communicate with power supplies, slit control units and kicker magnet timing modules distributed around the facility as shown in Fig 2.

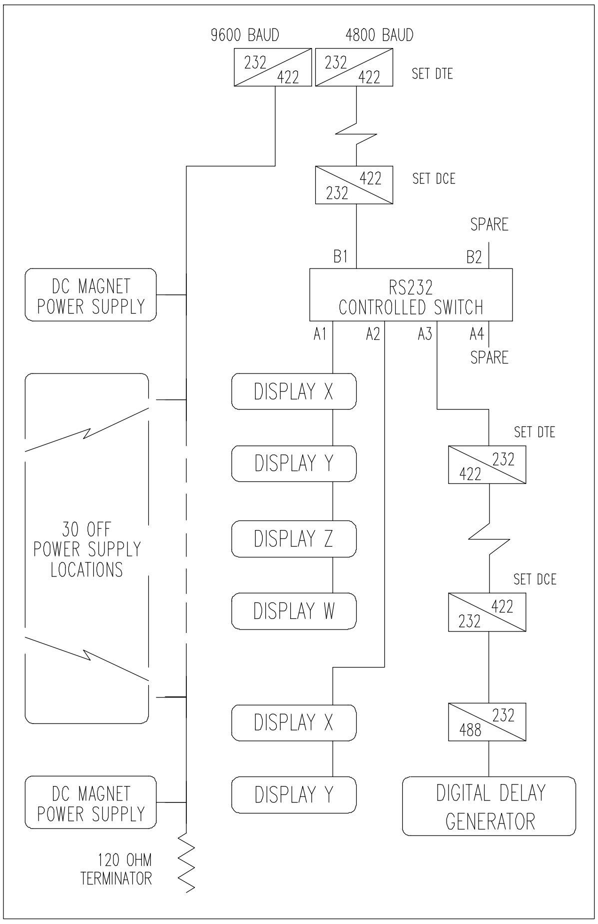

Fig 2. ASCII distribution

Port 1 is set to operate at 9600 Baud and communicates to most of the power supplies. Port 2 is set to 4800 Baud since this is the fastest speed at which the beam slit communications operates.
The RS232 serial comms is converted to RS422 for longer distance operation.
Fifteen of the power supplies were manufactured by Danfysik (Jyllinge, Denmark), most of the remainder are old power supplies with new installed Danfysik control electronics with RS232/RS422 as their standard communications.
The kicker timing generator has IEEE-488 comms with an RS422/IEEE-488 converter interfaces.

3.3 *PLC Software*

The language used is Ladder Logic and is incorporated in the Modicon Modsoft software package.
Ladder Logic Language is incorporated in a Modsoft software package operating from a laptop PC. The logic is made up of nodes, networks and segments,
Contacts are discrete inputs referenced as 1XXXX numbers and a 32 input module could be referenced 10001 to 10032 inclusive.
Discrete outputs and internal coil contacts are referenced 0XXXX numbers,
Analogue inputs are referenced 3XXXX numbers,
Analogue outputs and internal holding registers are referenced 4XXXX numbers.

A network displayed on the PC screen has seven horizontal lines with up to 11 nodes in a line reading from left to right. The last node(11) on the RHS has to be a coil.
The logic is scanned vertically, down the LHS nodes in the network, then proceeds on the top line to the next node until all nodes are scanned before moving to the next network.
All networks in a segment are scanned before moving to the next segment.

It is possible to choose to miss out a segment during the scan and therefore leave unimportant inputs and outputs to less frequent updating and therefore decrease scan times for essential functions.

The types of nodes are wide and varied from normally open (NO), normally closed (NC), fleeting contacts, coils for output operation, or coils for internal expansion of the ladder logic. The same references can be used as a node many times with the exception of output coils which can only be used once.
Networks can be programmed with counters (up and down) or timing blocks to control the delay of operations.
More specialised blocks are available to carry out mathematical functions of adding, subtracting, multiplication and division.
For example an input analogue 3XXXX reference variable voltage can be subtracted from a constant value and output coils operated if the difference is greater than, less than or equal to the constant.
It is possible to take a register that receives an input or a stored value and transfer it to another register for storage. Conversely it is possible transfer a table of registers of stored values into a single register.

4 CONCLUSIONS

In September 1994 beamline elements were adjusted to run the first muon beam.

At approximately 0900hrs the final beam blocker was opened and after some minor tuning adjustments at 0920hrs muons were observed at experimental port 2. It was originally thought that this first step would take several days.

The ease and speed with which this was done amply demonstrates the control and flexibility of the system.