THE PROCESS CONTROL COMPUTER AT THE CERN PROTON SYNCHROTRON: ITS APPLICATION IN THE OPERATION OF A FAST EJECTED BEAM

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Summary

An IBM 1800 has been installed at CERN to assist and improve operation of the Proton Synchrotron (CPS). This paper describes the three main tasks performed in the operation of ejected beams: logging of ejection parameters, monitoring of the beam transport currents and optimization of the ejected beam position on the external target. An account is also given of the hardware installed, the main features of the software and the operational facilities offered.

Hardware

The main characteristics of the process control computer are listed in Fig. 1, showing the framework of the installation.

Acquisition and Control

Two data acquisition systems, driven by the computer, are used: one a multiplexed digital transmission system, able to transmit words of 16 bits over 2 km telephonic cable at a rate of 70 000 words per second and providing galvanic isolation. This system, STAR[1], covers the whole useful area of the CPS and uses the cycle stealing facility for self-synchronization. The other uses DAS[2] for analog acquisition and multiplexes analog information by RF carrier multiplexer to a central digital voltmeter.

An elementary control system (designed at an early stage of this project) was installed to act in parallel with the existing installation for the remote control of beam transport currents and to allow settings through the RF carrier MPX on dc motors.

A fast digital control system is now being tested and will improve the speed of control.

Operation

A push-button program request unit enables the operator to call or stop the programs required. Information is given by TV, showing the screen of a memoscope driven by the computer. A small program plots curves or writes messages on the scope. Information to be retained is printed out on the computer typewriter.

An alphanumeric display with external memory, monoscope and keyboard is used to exchange messages with the computer.

Software Organization

We use the Time Sharing Executive System (TSX) provided with the computer. With adequate organization of the process programs, this system is very useful for updating them.

The fixed part of the memory includes all the main IBM subroutines and input/output programs, a data bank which is refreshed regularly and interrupts servicing routines; these, by means of various flags, bring in information on the CPS cycle and, when necessary, branch onto process programs.

On request, process programs are transferred from the disk unit into the variable core memory for execution. The system is designed in such a way that this part is not used by the computer every cycle. After completion of the required programs, the computer is free for non-process jobs. The on-line system has only 5 K available for process core-loads, written in Assembler language, which does not include I/O routines. For special applications using Fortran treatment programs, a system is being designed with fewer facilities but 10 K variable memory.

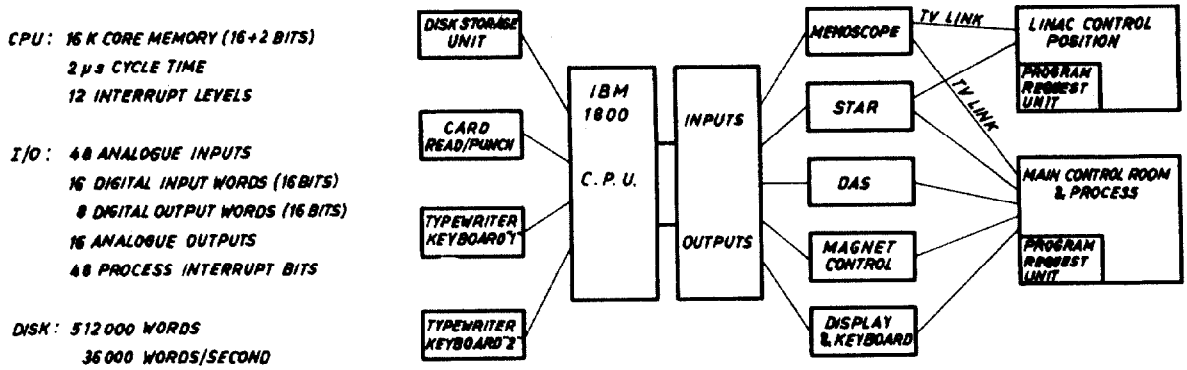

Figure 1.

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Tasks Performed on the Ejected Beam

Logging of Ejection Parameters

Using the two acquisition systems and some direct inputs, the computer can record the main parameters concerning ejected beams (74 analog and 50 digital values). The data are printed out after proper conversion and stored on the disk as a reference with date and time of the record.

The operating staff can also request a "Variations Log": the same acquisition is performed but data are compared with the reference stored on the disk. For each parameter a permissible jitter is specified: if the difference is greater, the variation is printed out; the references are not altered but are updated after each normal log.

Monitoring of Beam Transport Currents

This program is brought in core regularly (now every 100 CPS cycles: 3 - 4 minutes). The values of all the currents are compared with a reference table and re-adjusted, if necessary. A warning message appears if this is not possible. The user can stop the running of this program to try to find a better tuning of a beam and restart it, with or without a refresh of the reference table. With such a feature, the operator is not obliged to check the monitored values regularly, which may lead to less strict specifications of long-term stability for the power supplies.

Ejected Beam Position Optimization

To obtain the highest secondary particle production, the primary beam must hit the centre of the external target. This tuning is cumbersome to do manually and would require hardware to normalize and average the observations. The computer checks ejection conditions, scans the radial and/or vertical plane, records the data, then chooses the best point and places the beam on it.

The computer changes the vertical (radial) steering magnet current to scan at six points, with specified step sizes, on either side of the initial beam position. In case of equipment failure, special exits are provided.

When the current is set properly, the computer reads the charge induced on the external target, the secondary flux and intensity of the ejected beam. If the latter value is too low, the reading is rejected and another acquisition requested; if it is correct, the data are stored. An average is made over a specified number of cycles. The induced charged and secondary fluxes, normalized to the primary intensity, are kept for the optimization process and displayed to allow the operator to follow the process. A new scanning step then takes place. Here too exits are provided in case of malfunctioning.

After completion of the scanning, the normalized results are analysed. If the beam is smaller than the target, the curve depicts one minimum between two maxima (Fig. 2); if larger, one maximum only, the centre of the target corresponding to the minimum and maximum respectively[3]. The program scans for higher or lower values if necessary and when the best point is found sets the current of the steering magnet to the corresponding value and checks the results. The same procedure can take place with another steering magnet and another step size.

Operational Use of Programs

To request the ejection log, variation log or beam transport monitoring, the operating crew has only to press labelled push-buttons to select one or more programs and warn the computer by an interrupt.

For optimization of the ejected beam position, many options are possible; this is why a discussion program is used first. It displays the specifications used the previous time and asks if they are still valid. If yes, the operator writes this and sends it back to the computer, which starts the sequence of operations. If the data are no longer valid, the operator writes "no" and changes them and the new specifications are checked (as far as possible) by the computer. In case of errors, valid information is retained and a new message displays the number and location of the faults, enabling the operator to correct them. At any point in the operation, optimization can be stopped by releasing the request push-button.

The same program can be used for optimization of any magnet if the same criteria of optimization are valid.

References

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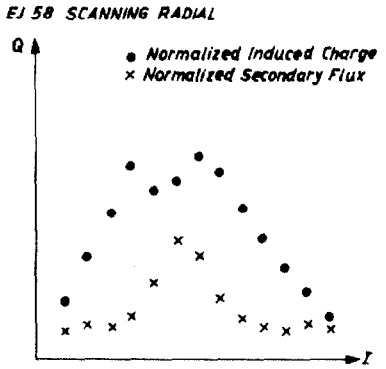

Figure 2.