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CONTROLS OF FAST KICKERS AND SEPTA BY COMPUTER

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A proposal for an ejection maintenance assistance system has already been made (MPS/SR/Note 71-8). We shall therefore consider more particularly the needs of operation.

It is our belief, however, that during operating time there cannot be a clear-cut separation between the needs of operation and those of hardware maintenance. Information on hardware performance enables the responsible persons to understand better the behaviour of the apparata but at the same time provides the operating crew the means to detect drifts or malfunctions that effect the stability of operation.

The design of a control system should therefore match the needs of operation and maintenance. The fact that a computer will probably form the nucleus of the control system provides sufficient flexibility for the problem to be solved satisfactorily for everyone.

Fast Kickers

The needs of operation are

a) efficient monitoring of kicker performance. High frequency sampling of the current pulse on the front resistors of the delay lines feeding the two kicker units as well as sampling of the Σ output of the pulse balance should be introduced. The samples are to be digitized and acquired by the computer through a special survey program. In particular one wants to know:

- the pulse rise time between 5% and 95% of full current level

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- the stability and accuracy of the pulse flat-top
- the fall time between 95% and 5% peak level
- the current when the preceding and following bunches enter the kicker aperture
- the exact timings of the 5% and 95% levels and their stability with respect to the RF/$_{20}$ pulse train

b) long time scale drifts survey and compensation through control of relevant hardware.

Control is needed on the fine delay lines acting on front and clipping gaps so that an optimization can be possible on the exciting pulse duration and timing with respect to the kicked bunches. Comparison of the sampled signals from the two front resistors for the two kicker units permits adjusting separately the triggers to the front and clipping gap in order to minimize the pulse balance Δ output.

Control of the high voltage on the pulse forming network permits to choose the right voltage in function of extraction energy and to finely adjust it to compensate for beam radial dimension increase due to increase of intensity.

Survey of jitter in current pulse should start at the Marx triggers. One wants to acquire the trigger tension and polarity and to control the pressure of its spark gaps to optimize firing conditions.

The jitter of front and clipping gaps in the storage lines depend essentially on three parameters: the high voltage level, the trigger voltage and the air pressure in the gap. Optimum settings at start-up and continuous survey of jitter ($\pm$ 3 μs in best conditions), which tends to increase with the number of firings, should be provided.
A closed loop control by computer to adjust the air pressure in the gaps in order to follow the bending of the breakdown characteristic would provide better stability and avoid faster deterioration of the surfaces in the gaps.

Control is needed on stroke amplitude in order to compensate for long time scale variations of the beam position in the kicker. This calls for stability of mean radial position and for a better and quantized measurement of the beam position in the kicker. The timings related to kicker motion in and out of the chamber should not be independent of ejection timing. The "flat-top" of the movement should in particular be well defined by two timings so that the ejection always occurs in that time interval

c) easy start-up and programming. The remote control unit in the MCR should be replaced by the computer. This implies that all its functions of interlock checking and programming are taken over by the computer. When all auxilliaries of the kicker magnet, which are in the ring or in the computer room, have been switched on and are operating under normal conditions, the operator chooses by means of the computer: the kicker to be used, the ejection zone, the timing of ejection, the number of ejected bunches and the first bunch to be ejected. The computer then chooses the long or short storage line according to the number of bunches selected, sets the position of the field invertor for right kick polarity, chooses the timing and amplitude of the kicker movement to centre it on the beam, sets the duration of the "flat-top" according to the number of ejections and their timings, sets the voltage to the level necessary for the energy of ejection and the beam radial dimension, sets all timing pre- and post-pulses to the convenient value according to the energy of ejection and the ejection area. The computer checks the validity of the program requested against hardware possible performances and checks that no overlapping occurs in the operation or other incompatibility. Also the sequencing of different operating modes and adjustment of parameters imposed by the sequence can be envisaged by computer

d) acquisition of interlocks and satisfactory information on fault location. The whole interlock chain of the kicker magnet system should be acquired by the computer. When a fault on the chain appears and ejection is cut off, the computer should display a message informing on the location of the fault, whether it is resettable or not and the possible causes. Also special survey programs could be confined to the computer, in particular on faults appearing randomly in time or at long time intervals and acceleration of parameter variations with respect to fault occurence.

Controls of Septa for Fast Ejection

Computer control is needed on septa positions and angles and on their power supplies. One wants to switch on the power supply, set the current level and timings to the right values, acquire and survey the interlock conditions. The current pulse is to be measured and acquired at timings of ejections. Losses on septa should be detected by a fast loss monitoring system which would gate the measurement to separate losses due to the kicked and ejected bunches from those caused by the circulating beam.

The other elements of fast extraction are essentially the bump coils and the beam. The control by computer of an operation should survey all parameters which influence the behaviour of the operation. Therefore the bump coils power supply should be computer controlled and the current level acquired and surveyed particularly in the case of double ejection (see MPS/CO Note 71-30). The parameters of interest with respect to the beam are (at the timing of ejection) beam intensity and energy, horizontal and vertical dimensions, bunch length, mean radial position, radial Q value, orbit of kicked bunches, orbit of circulating beam, position at the septum entry and exit of the kicked bunches, efficiency of extraction, intensity of kicked bunches in the ring and intensity of the same in the outer channel.

Controls of Septa for Slow Extraction

For the new slow extraction system a proposal exists already (MPS/CO Note 71-15). We shall stress here:

- for the electrostatic septum one needs control on:
  position of the cathode
  position and angle of the anode
  tension.

Acquisition of current and detection of sparks is to be envisaged to permit an analysis of their frequency and time distribution within the cycle. A particular program could be introduced for the constant current formation of the septum.

For the magnetic septa we again require control on their positions, angles, currents and power supplies.

CONCEPTIONS DU CONTROLE

1. But

Pour les lignes qui suivent nous nous proposons de mentionner succintement quelques aspects particuliers du contrôle. Dans cet esprit nous éviterons les contrôles pour lesquels des solutions ont déjà été établies.

2. Considérations générales

L'emploi d'un ordinateur satellite de l'IBM 1800 a fait l'objet d'une autre proposition. En conséquence les présentes suggestions supposent que l'ordinateur satellite soit en mesure de pourvoir, entre autre, au contrôle des "kickers" et "septa".

3. Kickers rapides

Le problème particulier qui a retenu toute notre attention est celui de l'échantillonage du courant. Une étude plus détaillée mérite d'être entreprise afin de conclure à la solution électronique la plus adaptée.

Dans la mesure où la reconstitution de la courbe (avec la précision voulue) est acquise les programmes correspondants semblent classiques. Hormis le fait que l'ordinateur satellite ait l'acquisition de données complémentaires (train RF, position faisceaux, par exemple) il est à noter que certains calculs peuvent être menés en virgule flottante.

Les programmes d'affichage et de surveillance exigent une liaison rapide avec l'opération donc avec l'IBM 1800.

4. Septa

La position des "septa" semble devoir, à l'avenir, être controllable par ordinateur. Dans cet esprit nous proposons que l'intervention de l'ordinateur se fasse au niveau d'une tension continue.

Dans le cadre de l'extraction lente, la détection des claquages du septum électrostatique semble présenter des problèmes électroniques. Le problème est d'ailleurs celui de la détection des pertes aléatoires. Tout dépend à ce niveau de la rapidité des acquisitions et des caractéristiques de l'ordinateur choisi.

Conclusions

Il nous apparaît que certains problèmes électroniques, et celui de l'échantillonage en particulier restent en suspens. Ils méritent des études plus approfondies avant de pouvoir se prononcer.

Hormis le fait d'une acquisition supplémentaire des paramètres liés aux programmes proposés, la liaison IBM ↔ satellite devra être relativement élaborée, en vue de rendre l'opération efficace.