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Automated Control System Structure of the USSR Academy of Sciences Kaon Facility

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1. Introduction

Up to date at Nuclear Research Institute of the USSR AS (Moscow-Troitsk) it is finished building of Moscow Meson Facility high intensity current proton Linear Accelerator (LA) (beam parameters: energy – 600 MeV, average current – 0.5 mA, pulse current – 50 mA). The LA proposed to serve as Kaon facility (KF) injector which is under working out [1].

Kaon complex, in addition to LA, includes: buster proton synchrotron (BR) with output energy 7.5 GeV, main synchrotron (SR) with proton energy up to 45 GeV and storer-stretcher (SS). The KF is proposed to work at 3 regimes.

At first regime SS follows SR and is used as beam stretcher. KF time work diagram is cleaned by Fig.1a. A half of beam pulses from LA and BR is used at ones for physical experiments. At second regime SS is inserted between BR and SR and works as collector (Fig.1b.). At third regime it is supposed to store in SS 4-6 beam pulses with next fast exit to experiment (Fig.1c). The such kind using allows to receive terra watt power level pulses ($8 \cdot 10^{14}$ particles with 45 GeV energy) with frequency of 1 Hz. There are presented below brief description of KF systems, which are concerned of radiotechnical systems (RTS) control (ACS) and adjusting (AAS).

2. RTS Interaction

KF RTS can be divided on 3 groups.

The first group unites RTS, which take parts immediately in technological process. The systems work in real time scale and are controlled with the help of devices with early loaded programs, which operate according to ACS

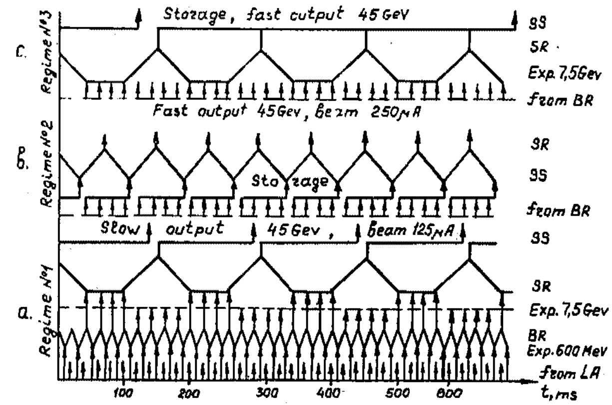

Fig1. Time regimes of Kaon complex Work

system corrections as a result of diagnostics and measurement systems function. Besides of software there are used also hardware AAS with feedback.

The second group unites measurement and diagnostics systems generally.

The third group includes ACS equipment.

The special features of RTS control depends on two KF properties:

1) the complex consists of cascade row with which of cascade been working in different regimes with different time changing characteristics;

2) the accelerators are fast recycling and high intensity beam devices.

High accelerating process velocity demands increasing of RTS measurement and final-control devices fast-responsibility, localizing of control systems near by the first group RTS and using of distributed control systems. These demands are complicated also by high beam intensity: it needs of accelerators resonator beam loading compensation and coherent betatron particles oscillations suppressing.

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3. KF common synchronization system

The system is designed for pulse generation and pulse distribution for LA, BR, SR and SS work synchronization with locking to LA cycle, to BR and SR injection magnetic fields, as well as to BR accelerating field initial frequency and phase. ACS couplings make possible to fulfill corrections at complex work timely. General number of timer pulses is equal 1162 - for BR, 3140 - for SR, 1058 - for SS.

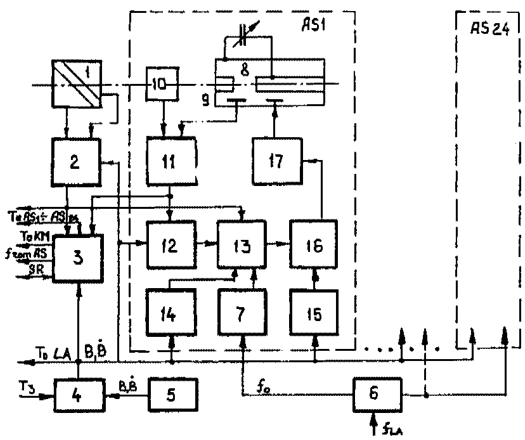

Fig 2. BR frequency control system
1. Beam radial position pick-up. 2. Δr correction signal generator. 3. Cascade-to-cascade beam drive system. 4. B-timer. 5. Primary standard electromagnet. 6. Initial frequency and phase former. 7. Initial frequency phase shifter. 8. Accelerating resonator. 9. Accelerating voltage detector. 10. Beam intensity pick-up. 11. Phase system processing device. 12. ΔΦ-correction signal generator. 13. Defining generator. 14. Frequency programmer. 15. Amplitude modulation programmer. 16. Amplitude modulator-manipulator. 17. Resonator HF supply system.
f_{LA}-Signal with LA accelerating voltage frequency, B,Ḃ-signals, that are proportional to magnetic field value and its derivative, A_S-accelerating station, T_3-start pulse, KM-kick magnets, T_{0LA}-start pulse LA.

4. KF Accelerating Stations (AS) frequency control system

The system structure for BR is shown at Fig.2. Frequency control complex supplies generation of signals with frequency, phase and amplitude adjusting in accordance to given lows. The signals are used as input AS signals. BR frequency control system concerns with LA frequency, because of "zero"-frequency at injection time must be determined by LA beam bunch following frequency. Block 6 transforms 198.2 MHz signal to 30.03 MHz signal. The last is used both for synchronization of 13 generators in each of 24 BR AS, and for control of chopper, which cuts out of LA beam each sixth bunch. It makes possible to optimize putting of injected from LA bunches in BR separatrix along phases and momentums. Before injection beginning controlling generator 13 output signals are directed by modulator-manipulator 15 to AS HF amplifiers 17 inputs. After injection synchro-pulse is switched off and further up to beam injection time in SR work of BR is fulfilled in standard way under programmed frequency control, which is concerned with magnetic field and with frequency correction on base of data about beam radius and phase (there is use beam feedback).

SR and SS frequency control principles are near to that has been described for BR.

Common each cascade (BR, SR, SS) feedback loop with using information about beam radial position (blocks 1 and 2) and partial feedback loops with using data of beam phase position (blocks 10 and 11) are used for slow synchrotrons oscillations suppressing.

5. Accelerating Stations (AS) Automatic Adjusting Systems (AAS)

Salient features of AS AAS and ACS concern with high velocity of accelerating process, large beam loading (the beam taken off power is 4-5 times above resonator loss power), very high RF power levels, which are required for KF cascades work [2].

So, for KF work supporting it needs to supplv SR accelerating resonators with 16.5 MW of summary average power (64 AS with 400 kW of maximum power per unit). At the same time AAS must have increased speed of response and large adjusting range.

Common (for SR, BR and SS) AS structure is presented at Fig.3. It consists of some AAS in combination with programmed devices. They support beam and RF accelerating voltage synchronism and maintain longitudinal beam stability. For this reason AS resonator RF voltage is adjusted by AAS of amplitude (AAA) and phase (AAP), as well as natural resonator frequency is adjusted by AFA with fast acting varactor tuner.[1] To maintain stable interaction of all

1) It is discussed now opportunities to use varactor tuner for high intensity accelerated beam instability suppressing.

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the systems in condition of large beam loading a large amount of RF feedback applied to RF generator and resonator. For transient beam loading compensation during bunched beam injection and because of empty separatrisses (for kick magnets switching) it is suggested to use broadband adjusting loop with beam envelope feedback and one turn delay.

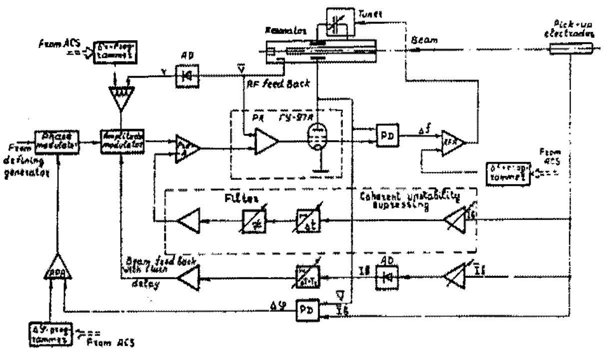

Fig 3. Structure of Accelerating Station with high speed Automatic Adjusting Systems
PA-power amplifier; Pr-A-prime amplifier; PD-phase detector; AD-amplitude detector; I_B-beam current; V-accelerating voltage;

are connected in local ring network of each cascade.

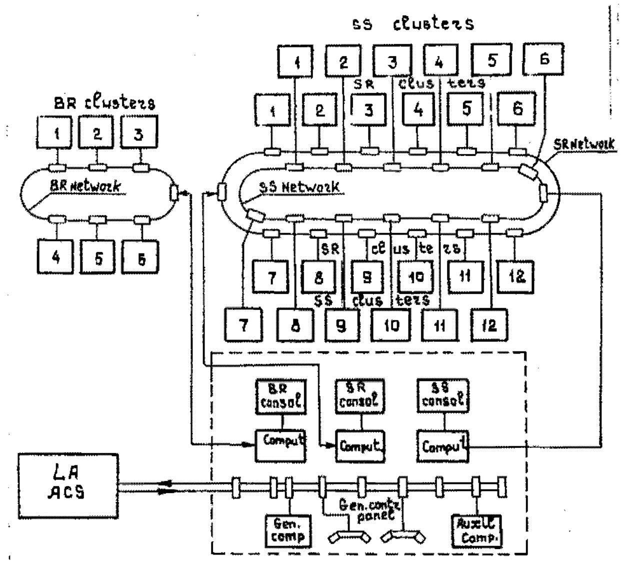

Fig 4. Kaon facility ACS structure

6. KF RTS Automatic Control System (ACS)

It is suggested to build ACS in such way, that each of KF cascade will have an opportunity to work both in autonomy, and in complex. ACS divided on sectors (clusters) by territorial (for distributed RTS) and functional (for localized RTS) attributes. Cluster can contain separate high productivity microcomputers or computer processor stations of bus-module system crates. Number of connected with ACS information and final-control points is evaluated as ~ 30000. KF ACS structure is shown at Fig.4.

The upper system level furnishes: user access to processors and complex equipment, fulfilling of difficult calculations, that connect with process modeling, work regime resetting of complex on the whole, refusal and failure situations prediction; data base management for complex on the whole; overlapping of current tasks solving with soft- and hard-ware development. The level will be created on base of 2 super-mini computers, for example VAX. These computers are connected to ring network as well, as computers for KF cascade control maintaining. Cluster computers of BR, SR, SS are based on microcomputers, which

7. Linear Accelerator ACS

LA ACS is built in another way then other KF cascade ACS, because of it has been designed at well earlier time and now it is using already during setting up work on meson facility LA. The system is designed to have 2 hierarchical levels radial network (Fig.5.) [3]. The first (upper) level represents 5 computers of CM-1420 type with standard hardware, coupling and synchronization box equipment and central control console (CCC). By their function keys the computers may be divide on central (the main control computer complex), CCC servicing, library keeping and storing, program debugging and network front-ending (for mutual communication between separate LA ACS computers). The second (cluster's) level is divided by territorial attribute on 5 sectors, which cover LA injector (sector1), LA initial part (sector2) and LA main part (sectors 3-5). Each sector control computer complex is based on CM-1420 computer type also. These complexes are connected with technological equipment through Object Coupling Devices (OCD). As a rule, each of OCD operates by corresponding part of LA technological system (for example, one resonator with RF amplifier channel and

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AAA, APA, AFA).

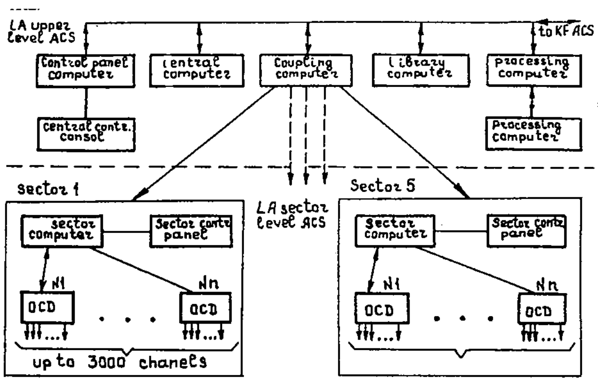

Fig 5. Linear Accelerator ACS structure
OCD- object coupling device

It should be noticed, that some automated LA work control tasks - such, as technological equipment turn-on/-off and bringing to given work conditions, synchronizing processes and setting procedures, - are fulfilled by ACS equipment on real time scale.

8. Conclusion

In conclusion it should be noticed, that up to now there have been worked out the main RTS devices and defined ACS structure and components. In MRTI there are developing full scale brass board models of AS for BR and SR, including ACS and AAS equipment.

Introduction in AS components of new fast-acting varactor tuner, which is able to control high reactive power flows, gives presumptions to use the tuner not only for resonator auto tuning, but and for high intensity beam instability depressing.

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