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MOSCOW UNIVERSITY RACE-TRACK MICROTRON CONTROL SYSTEM: IDEAS AND DEVELOPMENT.

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Abstract.

Moscow University race-track microtron (RTM) control system is a star-shape network of LSI-11 compatible microcomputers. Each of them is connected with RTM systems via CAMAC; optical fiber coupling is also used. Control system software is designed on Pascal-1, supplemented with real time modules and Macro. A unified real time technique and reenterable data acquisition drivers allow to simplify development of control drivers and algorithms. Among the latter three main types are used: DDC methods, those, based on optimization technique and algorithms, applying models of microtron's systems. Man-machine interface is based on concept of the "world of accelerator". It supports means to design, within hardware possibilities, various computer images of the RTM.

INTRODUCTION.

Moscow University race-track microtron - when it's construction will be finished - is to produce 175 MeV 100% duty factor electron beam with low transverse emittance (0.05 mm*mrad) and up to 0.01% energy monochromaticity [1,2]. To support means for easy programming of microtron's behavior, when being adjusted, and to meet requirements of experimental work, computer-based control system is to be developed. It's configuration is shown on fig. 1

HARDWARE.

Each micro computer of the control system is a 1-PCB LSI-11 compatible machine (EIS,FIS CPU; 1 mips; 56 Kb RAM). In control station it's connected with CAMAC via JCC-11 compatible crate-controller. Among CAMAC modules the following types are used: output and input registers (standard and specialized), FET multiplexers, 13,14,16 bit ADCs, step motor drivers. To prevent inadmissible interference, control system is isolated electrically from accelerator's equipment. For this purpose optically coupled measurement devices are used. Their terminal modules can be of three types: 19 bit TTL transmitter or receiver, 16 multiplexed a dozen bit ADCs or eight 12-bit DACs. Control stations (three of them in operation now) are connected via RS-232C interface in a star-shape network, formed by concentrator station. The latter is also tied with host-machine, used for software development and system loading. Man-machine interface and data-bases station is linked up with network like a control station. Concentrator machine and control stations have no any extra memory storage except CPU RAM. Man-machine and data bases station includes two microcomputers. One of them supports graphics, another handles data bases and communication protocols. This station, as well as host machine, is supplied with disc memory - including electronic one. Alphanumeric displays (VT-100) and some other peripherals are also attached. Among them - RS-232C interface, allowing to link up control system with external computer or network. Man-machine interface will also be supplied with four infinite-turning knobs to facilitate manipulation with one, two or three dimensional objects (control parameters value, terminal cursors etc).

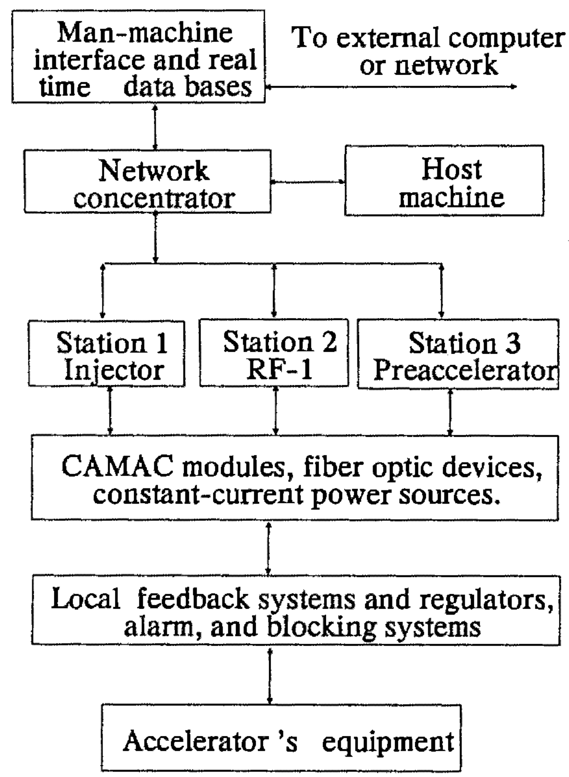

Fig. 1. Block diagram of Moscow University RTM control system.

SOFTWARE.

Compilation tools.

Basic compilation tools are shown on fig. 2. Source Pascal code with Macro insertions is being compiled with Pascal-1. Then a specially designed improver heightens an effectiveness of resulting Macro code. Afterwards, on Macro stage, it's being combined with CAMAC support

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modules. The resulting object code is being linked with Pascal library and the one, containing control system support modules.

Control station software structure.

The structure is depicted on fig. 3. Feedback control loops include control drivers, algorithms and reenterable data acquisition drivers. Reenterability allows to obtain measurement data by any program module, initiated with interrupt, while the same device is used by another program unit. Control drivers and algorithms are supervised with monitor. Real time processes deal with interrupts, initiated from different sources (network, CAMAC, timer). Network support system handles net protocol; access to data transfer buffer is also reenterable. Low level real time techniques include P-V operations to protect critical resources, repetition of critical section with non-savable resources and counting flags to prevent CPU overload.

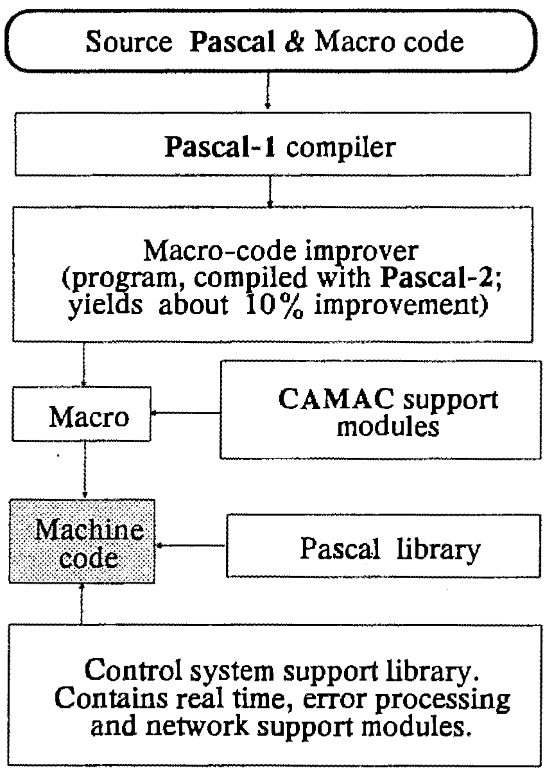

Fig. 2. Basic compilation tools.

Network data communication.

Data transparent network protocol is supported by exchange of byte-serial frames. They include command code, destination and source codes, data counter, unit of data and checksum. Command code indicates function to

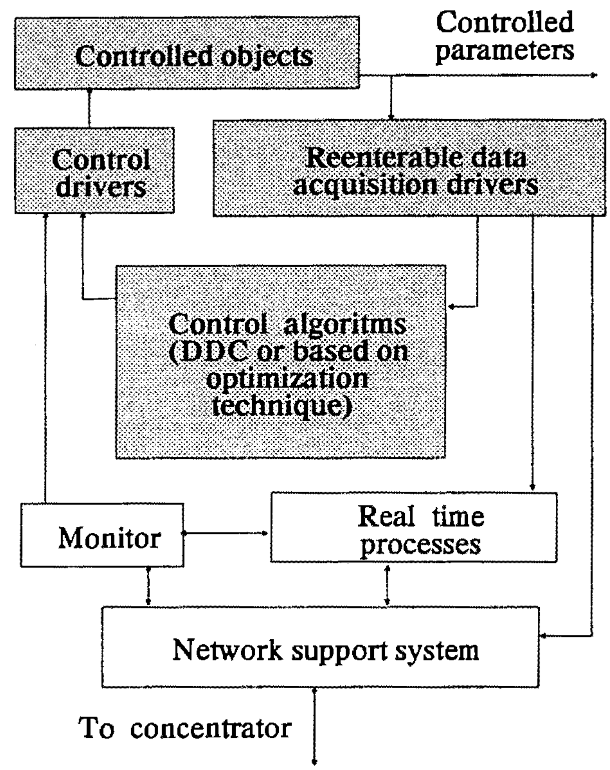

Fig. 3. Control station software structure.

be accomplished with received parameters. These functions include: status of parameter inquiry, control, parameter value acquisition, free coefficients setting (calibration) and implementation of predefined operations. Special frames, consisted of only command code, are used to support network protocol and characterize general subsystem status.

Algorithms.

Algorithms, realized in RTM control system, can be divided into three groups: dynamic methods, functioning under strict time conditions, and two groups of quasistatic algorithms, where timing is not essential. The latter are based either on optimization technique or apply physical models of microtron's systems. Control system itself executes only dynamic and optimization methods. Dynamic ones include DDC methods both for logical control (switches) and analog algorithm simulation. The latter one (PI method) is used for temperature stabilization of accelerating sections [3]. Optimization algorithms are realized in one and two dimensional modes. One dimentional algorithm is based on "regula falsi" method and is used for fine tuning of various control parameters. in particular, to stabilize reference frequency generator. Two dimensional algorithm is used to steer electron beam via collimators by minimizing it's leakage current. The method deals with approximately symmetric goal function with flat bottom and uses non-derivative direct searching algorithm. At first stage steering algorithm scans with beam, using spiral trajectory, to find out goal function

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position. Model algorithms are not immediately supported by control system. They can be carried out with the help of any external computer, interfaced with control system. For this purpose man-machine interface computer also handles remote terminal protocol, allowing to inquire and set new values of any controlled parameter or to activate predefined functions.

Software development technique.

A considerable number of controlled parameters (about 400 now) requires definite technique to develop software. The development cycle is shown on fig. 4. It allows to avoid discrepancies between expression of requirements and actual control station program. During the cycle parameters data base is being corrected and supplemented. This base is used later to develop man-machine and "external world" program interfaces.

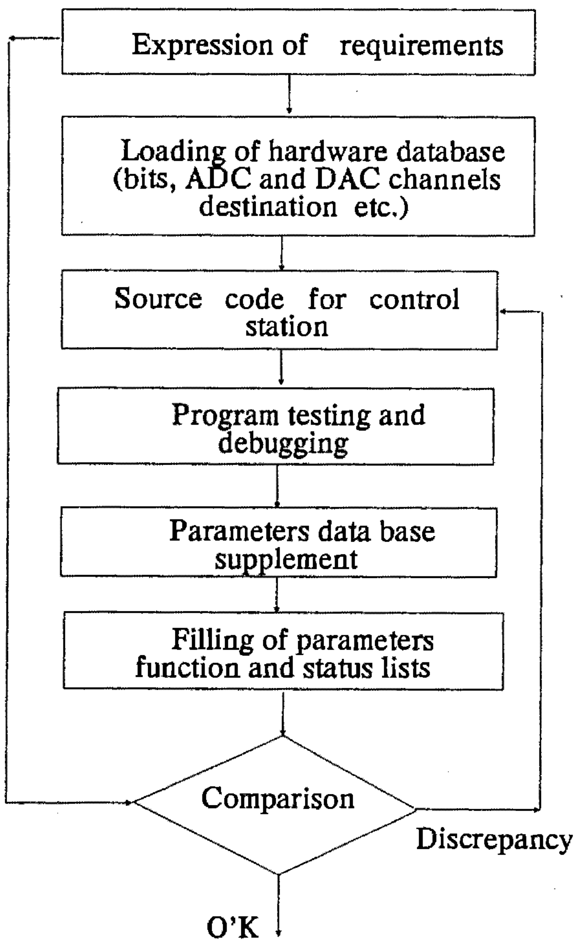

Fig. 4. Software of control station development cycle.

Man-machine interface and external world communication.

Man-machine interface software is based on approach, which gives means for operator to design - within hardware possibilities - his own computer images of the accelerator. It is supported by several types of windows and a list of their names (menu), allowing to activate any window. Special program supports creation of menu and windows. Graphical window can be chosen among several predefined types, which include those, representing several two-dimensional curves and the windows, which support an amplitude analyzers mode. Operator is not able to change geometrical shape of a window, but have a possibility to set colors, inscriptions and some other attributes. Any graphical window can then be loaded in a graphics support computer. Alphanumeric windows contain a set of parameters, extracted from parameters data base. Their values are represented on a terminal in any chosen position. Operator can previously fill the window with an arbitrary text. One type of alphanumeric windows is used to set constant parameters of accelerator (calibration coefficients etc). Their values are defined during a window's editing and transferred to subsystems when it's activated. Another type of windows - a working ones - support actual interaction with control system. They inquire and represent current values of parameters on a display. Operator is able to set a new value of any window parameter or initiate predefined control procedures. To adjust microtron's systems, it's possible to scan with any parameter (time among them), while others are represented graphically or (and) listed in a data-storage file. Working windows automatically support local data base files. Parameter's values are stored there before exit and extracted from the file when window is activated. There are also several windows, which are not programmable and are used to support system functions (time setting, password etc). Statuses of parameters, obtained from control stations, are stored in a special data base and can be displayed by operator's request. As mentioned above, man-machine computer also supports "external world" interface with a required data communication protocol.

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