VEPP-4 Control System

A.Aleshaev, A.Batrakov, S.Belov, A.Dubrovin, Yu.Eidelman, A.Kalinin, S.Karnaev, M.Kollegov, V.Kozak, E.Kuper, A.Ledenev, B.Levichev, Sv.Mishnev, A.Naumenkov, G.Piskunov, I.Protopopov, D.Shatilov, E.Simonov, V.Smaljuk, A.Smirnov, S.Tararishkin, Io.Zaroudnev
Budker Institute of Nuclear Physics
Prospekt Lavrentjeva, 11, Novosibirsk, 630090, Russia

Abstract

The VEPP-4 control system includes twelve CAMAC-embedded 24-bit in-house developed ODRENOK computers (CC24) [1], interconnected in a star network. The central node provides the boot for the peripheral computers, intertask communications between them and file server functions. Real-time intercommunications between some of the computers are based on point-to-point interfaces. Equipment control electronics is mostly CAMAC (nearly 60 crates). A real time multitasking OS permits running up to 10 tasks with fast dynamic change of core image. Control of VEPP-4 is accomplished by the simultaneous performance of more than 50 tasks. PCs are used as operator consoles, data processing computers, printer servers and back-up systems.

1 INTRODUCTION

The VEPP-4 accelerator facility [2] is composed of a 6 GeV collider VEPP-4M of 365 m in circumference, a 2 GeV multi-purpose storage ring VEPP-3 and a 350 MeV electron/positron injector. The injector consists of a 50 MeV LINAC and a 350 MeV B-4 synchrotron. The LINAC RF is supplied by pulsed GIROCON generator. There are pulsed transfer lines from the LINAC to B-4, from B-4 to VEPP-3 and from VEPP-3 to VEPP-4M (Fig.1).

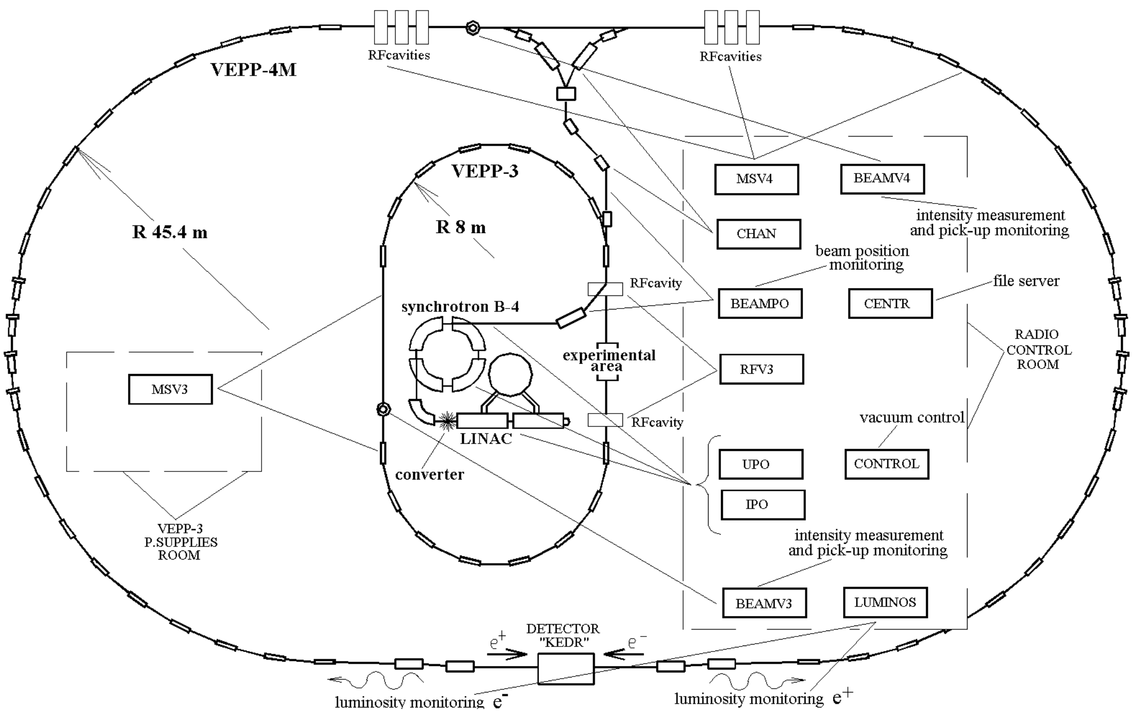

Fig.1 *VEPP-4 facilities and control computers layout.*

The collider provides the experiments with electron/positron beams, back-scattered Compton g quanta and synchrotron radiation. VEPP-3 is an injector into VEPP-4M and is used simultaneously for experiments with synchrotron radiation and a polarized gas internal target.

The up-to-date control system has been developed since 1986 at the same time as the upgrading of the VEPP-4M main ring. All hardware and software have been developed and produced in the Budker Institute of Nuclear Physics.

2 ARCHITECTURE

2.1 Structure

The control system has three levels: the central node, the local computing layer and the equipment layer.

The local computing layer is composed of 11 intelligent CAMAC crates containing ODRENOK computers which are interconnected in a star network. All computers are connected to the central node via 250 kbit/s serial-links. The node provides for the initial downloading of the computers, file service and “slow” interprocess communications via a mail box. Special point-to-point 1.5 Mbit/s serial-links are employed for high-speed intertask communications in different local computers.

Usually each subsystem of the accelerator facility is controlled by its personal ODRENOK. An overview is shown schematically in Fig.2. All the active crates and the central node are located in a control room, except for the computer which controls the VEPP-3 magnet system. Table 1 presents the up-to-date configuration.

The front end electronics is mostly distributed among passive CAMAC crates connected to the active crates through serial-link drivers and controllers [3]. The distance between the active and the passive crates is up to 150 m. Special serial controllers are employed for connections with non-CAMAC electronics, used for control of the RF-systems and for beam diagnostics in the transfer lines. Coaxial cables are used for all links. The equipment control layer is dispersed around the facility.

The magnetic system of the VEPP-4M ring is controlled by distributed intelligent controllers [4] connected with CAMAC by MIL-1553-B links (Fig.2). The use of these controllers gives us improved control of the magnet system during the rise of the beam energy from 1.8 GeV to 6 GeV.

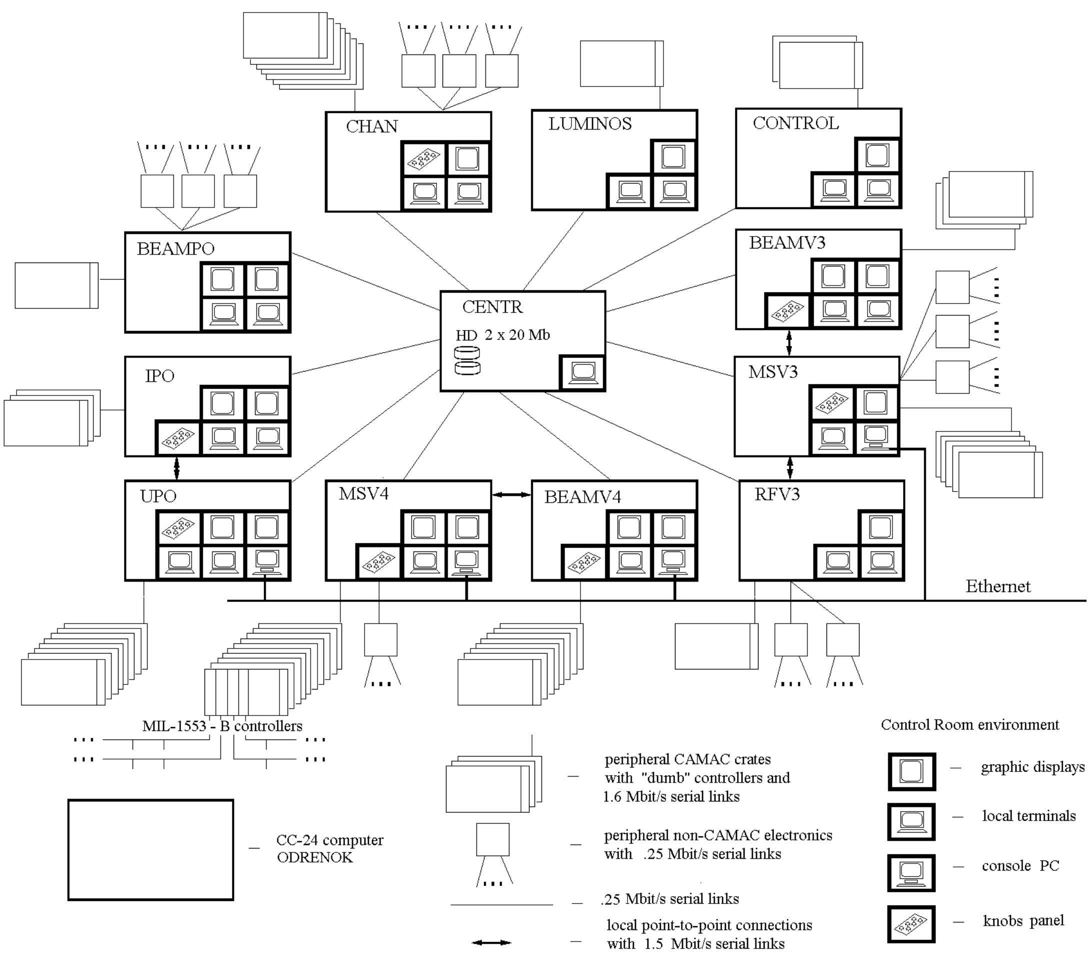

Fig.2 *VEPP-4 control system architecture.*

Table 1
VEPP-4 control system configuration.

	ODRENOK name	Allocation	CAMAC crates	Number of CAMAC modules	outputs	inputs
1	MSV4	control of VEPP-4M	12	70	370	950
2	BEAMV4	beam diagnostics at VEPP-4M	9	50		280
3	MSV3	control of the magnetic system of VEPP-3	5	49	125	290
4	RFV3	control of the RF system of VEPP-3	2	21	30	15
5	BEAMV3	beam diagnostics at VEPP-3	4	32		100
6	UPO	control of the pulse injector	9	75	135	30
7	IPO	pulse injector monitoring	4	47	10	110
8	CHAN	control of VEPP-3 - VEPP-4M transfer line	8	65	135	110
9	CONTROL	vacuum system monitoring	3	24		150
10	LUMINOS	luminosity monitoring at VEPP-4M	2	10		40
11	RADIAC	radiation monitoring	3	24		36
		Total	61	467	805	2111

2.2 Local computing layer

The local computer layer is based upon the CC24-computer, named ODRENOK. This computer was designed in 1983-1985 as an autonomous CC24 crate controller emulating the instruction set of ODRA-1300 (a clone of the ICL-1900 series mainframes) computer. The main features of ODRENOK are as follows:

- word length 24 bit;
- address space 4 M words;
- RAM size 64K 24-bit words;
- performance 0.5 MIPS;
- hardware implementation of floating point operations;
- USER/SYSTEM modes, multitasking support, virtual memory;
- extensions to the initial ICL-1900 architecture: firmware implementation of OS kernel, CAMAC-oriented instructions, vector instructions;
- 2M CAMAC module installed in the controller position;
- microprogram implementation on the AMD 2900 bit-slices

Each active crate has a four-port RS232 module for connection of up to four alphanumeric terminals, a number of color graphic display controllers, a RAM-emulated module (768 kb or 1.5 Mb), a network interface, and peripheral crate drivers. Now the alphanumeric terminals are gradually being replaced by IBM PCs, which are used as operator interfaces and supplementary disk machines.

2.3 Equipment control layer

A basis for the equipment control layer is a series of CAMAC modules developed at BINP. The series includes different types of DACs and ADCs [5], switches, etc. Tables 2 and 3 list the main parameters of some modules. Sixteen-output switches with electromagnetic relays are used to turn on and turn off power supplies and for interlocks. This type of CAMAC module has a 1ms switching time.

Table 2
Parameters of CAMAC embedded ADCs

Type of ADC	20-256	101-SK	850-SK	ZIIS-4M
Conversion type	integration	fast	fast	fast
Conversion time	2 - 240 ms	1 ms - 2 ms	50 ns - 2 ms	< 2 ms
Scale (binary)	13-20	12	8	10
Input voltage (V)	± 8	± 1.2 - ± 10	± 1.2 - ± 10	± 2
Number of inputs	1, MUX control	4	4	4
On-board memory (kbytes)	3	12	3	-
Module width	1M	2M	2M	1M

Table 3
Parameters of CAMAC embedded DACs

Type of DAC	CAP-16	CAP-20	GVI-8M	PKS-8
Type of output	analog	analog	delay pulse	pulse-width
Scale (binary)	16	19 + sign	16	16
Output range	± 6.5V	± 8.2V	0 - 838 ms	0 - 6.55ms
LSB	200 mV	15.6mV	.1 ms - 12.8 ms	.1ms
Number of outputs	16	1	8	8
Module width	2M	1M	2M	2M

3 SOFTWARE

3.1 Program environment

A multitasking real-time Operating System (OS) ODOS [6] was specially designed for ODRENOK. It enables us to run up to 10 independently-compiled memory-resident tasks. This OS supports intertask synchronous and asynchronous message transfers, remote file access, connection of up to 4 local terminals and one “system” virtual terminal attached through the network. The OS permits independent dynamic loading, running and termination of tasks.

TRAN (FORTRAN version) with an in-house developed compiler is used for application programs. Under ODOS its features fit well for memory mapping and real-time module control.

3.2 Data-base organization

The DataBase (DB) contains all the information about the devices of the accelerator complex. It has static and dynamic parts. The static database is stored in RAM-modules and on the hard disk of the central node. The dynamic database is a number of arrays in the Resident Executive Programs (REPs). DataBase Editing (DBE) programs provide access to the static database, for saving the operation modes and modifying the data files.

The organization of the static database is illustrated in Fig.3. The lower layer of the “topology” and “devices” branches is a linear array of text, integer and real variables, which includes names, addresses, status flags and calibration parameters. The “setting” branch includes the files, which are the operation modes for different parts of VEPP-4 accelerator facility.

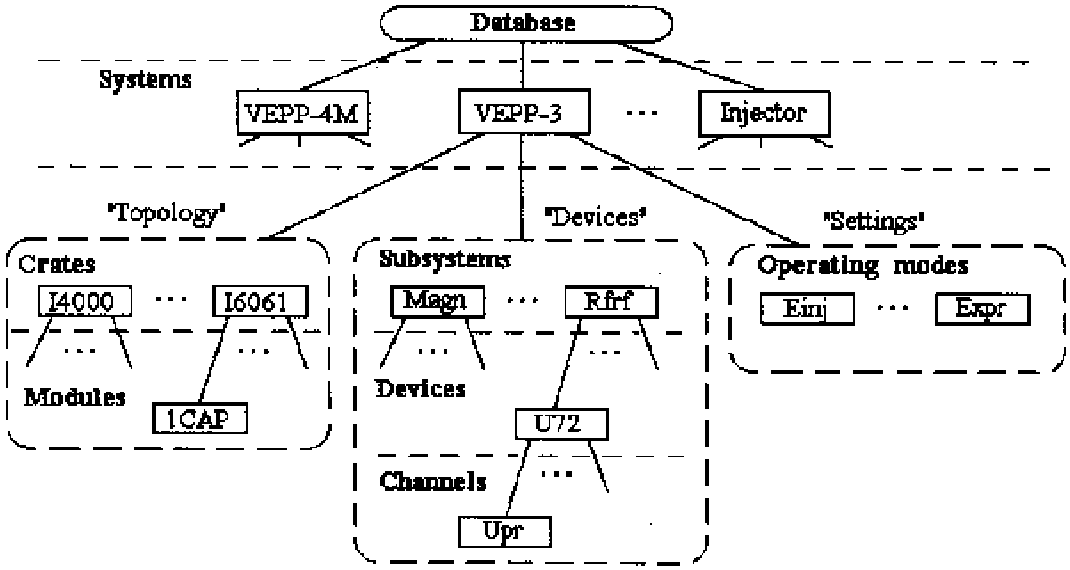

Fig. 3. *Static database organization*

REP is the resident modular program in each local computer (Figure 4). It contains the data, control algorithms and carefully optimized communication subroutines. All front end electronics are controlled by REP which protects the system from improper operation. Any newly developed electronics can be easily added to the program as plug-in modules. Control actions are performed by writing the required values into the dynamic database. REP allows us to have about 2000 - 4000 accesses/s to CAMAC modules.

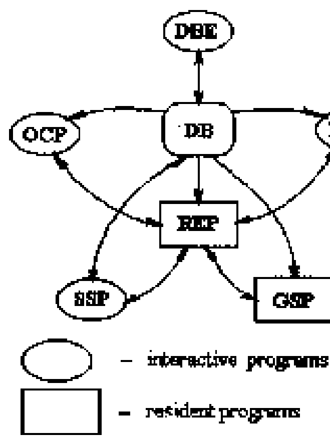

Fig. 4. *Diagram of basic control software in the ODRENOK computer.*

3.3 Applications

All applications were developed by the VEPP-4 staff requiring about 15 person-years. In addition, a large amount of time was spent on the development of special tools for commissioning and modeling programs.

The Operator Control Programs (OCPs) are implemented to handle the devices of the facility. Control values are entered from the keyboard, data are displayed as a column of digital values of device parameters. Saving and Setting programs (SSPs) save/set the operation modes.

Graphical Surveillance Programs (GSPs) display the parameters to be monitored in an illustrative color form. It allows the operator to identify easily any deviations from the assigned operation parameters. The status of the facility is shown in specially-configured graphical display images.

High-level Control Programs (HCPs) provide the automatic operation of VEPP-4 without operator intervention. HCPs perform:

a) electron and positron beam accumulation and acceleration in the storage ring;
b) beam transport to the collider from VEPP-3;
c) the rise of beam energy in VEPP-4M from 1.8 GeV to 6 GeV.

A mailbox in the central computer is responsible for connections between the HCPs in different computers. The mailbox consists of a number of modules, each of them corresponding to a particular ODRENOK. Each module contains status information about the subsystems controlled by that ODRENOK ("operational ready", beam energy, beams current, etc.) and includes control commands for other computers (for example, "reverse polarity", "rise energy", etc.)

4 CONCLUSION

Although the present control system successfully provides for the operation of VEPP-4, it is obvious that an upgrade is necessary. The first goal is the installation of ethernet links between the local process controllers. This will allow us to use a top level based on workstations with standard software without loss of functionality. The second goal is wide use of distributed processors at the lowest control level.

5 REFERENCES

[1] G.Piskunov, Autometria, N4 (1986), p. 32-38 (in Russian).
[2] 1994 BINP Yearly Report, BINP, Novosibirsk (1995), p. 81-87 (in Russian).
[3] V.Kozak, Preprint INP 88-24 (in Russian).
[4] S.Karnaev et al., Control of VEPP-4M Magnetic System, these Proceedings.
[5] E.Kuper, A.Ledenev, ICALEPCS 1991, KEK, Tsukuba, Japan, p. 382-385.
[6] A.Aleshaev, Preprint INP, Novosibirsk (1989) 88-24 (in Russian).