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SOFTWARE SYSTEM OF THE MAIN RING MAGNET POWER SUPPLY FOR THE 12 GeV PS

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ABSTRACT

The main computer of the multi-microprocessor system have been described on the application softwares and relating peripherals and devices. The computer system covers almost of all digital processing by a time sharing OS compatible tothe unix system III, except the on-line fast real time controls of the hybrid control system for the main ring magnet power supply. Overall response of the system is several tens sec, but powerful utilities are useful to tuning and maintenance of the power system.

Introduction

The replacement of the control computer system had been started on the hybrid system design at the spring in 1983. By the design, the analog control system have to play in main role on real time feedback processes, automatic current regulator (ACR) and minor automatic voltage regulator (MAVR). The digital system covers for fast feedforward pattern control by control clock of 600 Hz and for slow but reliable feedback control loop as the periodic control(1) part of ACR.

As a result, we had adopted H-V90/5 system for the main control computer system which construct reasonably a multi-cpu system, because such a fast feedforward control could not execut by any single microprocessor. The main parts consist of the HD-68000 family LSI components on the industrial standard bus IEEE796 and supported by the unix system III as the software bus and standard peripherals, commercially available or compatible by second source suppliers. Under these circumstances, high level language and powerful utilities support development and maintenance of soft-wares for the flexible pattern control within a reasonable total cost. The main cpu system controls for the slow loops and supports the other tasks and background jobs. For the fast loop, precess controller systems (H-04M) supervised by a on-line real time multi-tasking OS engage exclusively in tasks of which application programs would be described by assembler or macro assembler.

Fig. 1 shows a layout of the new computer system. The system consists of the main cpu system HIDIC-V90/5 and input and output controller HISEC-04M. The distributed three systems are not hierarchical in software, but rather independent even in assembler level between the main and the controller, because the cpu families are different from each other, especially different memory access in address.

General survey of the multi-microprocessor system has been described on someplace(2). The improved analog system will be written on somewhere(3). We report mainly on the application softwares of the main computer system.

H-V90/5 System

Hardware

The system with memory management unit, (MMU), and with DRAM of 4MB on the private bus has floating processor, two loops of local area network based on IEEE 802 (LAN 1 and LAN 2) and standard peripherals- (i.e. 5"-28MB hard disc and 8"-2MB floppy disk drive, two stations of CRT terminal, system typewriter and printer) on the system bus. These resources are supervised by the main OS unix.

The one of two network-loops, LAN 1, engage in exclusive communication to the input or the output controller because of reliable data transfer. The network transfers pattern or logged data between the main and the output or the input controller by the speed 20 kB/sec in a packet of 512B. The speed is rather slow and correspond to a quarter to the one of H-350 by parallel bus. Moreover, the speed is slower in data transfer by the time sharing OS on the system bus. This is one of bottlenecks for high speed response in fine adjusting injection level of the BPS or tracking offset of QPS.

The one local of the two terminals is supported on the system bus through SIO in full duplex, but the other remote is forced to communicate in half duplex operation mode only because of micro-sigma network. The terminal is linked by optical cable to the main and is set in the center control room for 12 GeV PS, since the center is about 350m distant from the power station installed the main system. For the sake of high response of the terminal, the system typewriter works

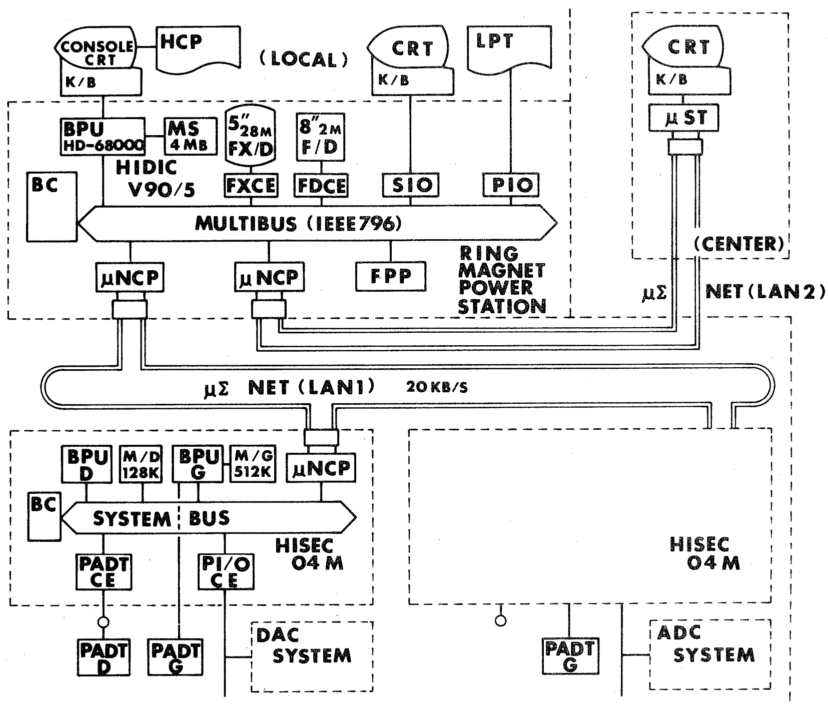

Fig. 1 Multi-microprocessor system

through PIO on the system bus and, therefore, the LAN 2 is private loop of the remote terminal.

DAC: Nine sets of DAC work for BPS, that is, six of them serve as reference pattern voltage of the thyristor converter group, two as the dynamic filter detector and one as the reference current for the analog ACR. In the Qf and Qd,respectively, two sets serve for reference voltage and current to the analog loops and one set for dynamic filter.

The system outputs these pattern data to the fifteen sets of DAC in every clock of 1.67ms. The data convert in synchronizing to the zero-cross pulse of six phase ac power line. However, when these control data are output through PIO insulated by photo-couplers, jitters among bits of a PIO and among the ports are not able to neglect compare to 600Hz. We have been used

DAC with buffer resister and conserve the synchronization between analog signal and the clock.

ADC: At every clock, the system reads data of seven sets of 16-bit-ADC with a sample hold amplifier. The calibrated precisions of these sets are estimated at within 6*E-5 corresponded twice times those of single element.

Three sets serve for the DCCT current signal and the others for the dc voltage applied to the B-, Qf- and Qd- magnet in the same clock of the DAC system. The clock synchronizes zero-cross pulse, but has a constant lag of about 100 microsec which is about 2 times of the conversion time. At the edge of clock pulse, ADC sets have ceased their sampling because they had started synchronizing to the zero cross pulse. There are some problems in jitter of the clock induced by disturbances of the ac line. These jitters are fatal to the precision of the whole control system. These problems will be described somewhere.

Software

The system executes almost of all digital controls except fast real time parts undertaken by the input and the output controllers. And supports developments of and file-managements of control programs and data including patterns. These application programs have been described in the system language C and FORTRAN 77. The main tasks are the operation controls including start-stop and status monitoring, calculation of correction pattern by the periodic control and fine adjustments of pattern data for on-line control. As off-line or supporting tasks, the system works on pattern generations, processing of pattern and operation data, control program development, and background processes including communications between the main and input or output controller. Table gives directories of these application softwares.

As design principles of these application programs,

1. magnet functions are static or time independent polynomials based on new measured values.
2. transfer-functions of the magnet systems are described in discrete z-transform.
3. independent variable is Bl, where B and l are flux density and effective length of the bending magnet.
4. in any pattern of Bl(n), Bl(n) and dBl(n)/dn are continuous at arbitrary n, where n is the n-th control clock from the fiducial point, (P0), of pattern.
5. functions used in fine adjustments are the same in the pattern generations.

Fig. 2 gives an algorithm of control pattern generation for reference voltage and current to the analog control system, where {A(n)} denote time serial data file of A(n). $G_L^{-1}(z^{-1})$, m=b, f, d are inverse function of these transfer functions from the reference pattern voltage to magnet input voltage.

$$I_{mR}(n)=\sum_{R=0}^{m_I} a_{mIK}(Bl_B(n))^K$$

$$L_m(n)=\sum_{R=0}^{m_L} a_{mLK}(I_{mR}(n))^K$$

$$G_{vm}(n)=\sum_{R=-1}^{m_G} a_{vmK} V(n+k)$$

$$B'l_{Qm'}(n)=k_{Qm'}(n)Bl_B(n) \quad ,\text{where} \quad m'= f,\ d$$

Fig. 3 and 4 shows excitation curve of B- and Q-magnet. These curves are adjusted by least square method with quadruple precision for estimation of current function. Both current functions are 20 order of magnitude. But at pattern generation, the precision of calculation are double. Other functions are determined by similar process. But G are at present only lag correction.

For BPS, reference voltage pattern is divide and distributed to the reference voltage of 12 pulsed thyristor converter groups in accordance with the desired voltage to reduce generation of reactive power.

These function files are used for fine adjustment of injection level of the bending magnet without tune shift and corrections calculate in the same algorithm of the pattern generation.

Table Directories of the application software system (blocks)

/hitachi/bin	592	/users/cfil	2704
/etc	48	/cltest	896
		/cmfile	2752
/kek/bin	192	/dfil	1888
/command	1696	/fcl	1008
/include	160	/ffal	784
/mrps	592	/ffa2	432
/wk	128	/ffa3	432
		/ffa4	880
/lib/ccom	133484	/ffa5	432
/cpp	26064	/fifo	160
/crt0.o	215	/fpc	976
/fl	63352	/fpg	2256
/f77passl	131696	/frs	480
/libF77.a	4526	/kek	160
/libFDUX.a	17334	/log	80
/libGPUX.a	13666	/logf	64
/libI77.a	70338	/lost+found	288
/libc.a	77596	/lstout	1150
/libcrs.a	10944	/man	80
/libg.a	195	/pfil	384
/libkek.a	97354	/sfil	2560
/libm.a	32084	/ufil	1552
/libmrs.a	14202		
/mcrt0.o	646		

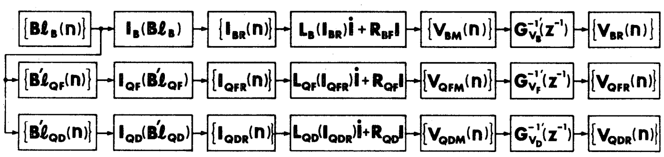

Fig. 2 Algorithm of reference patterns

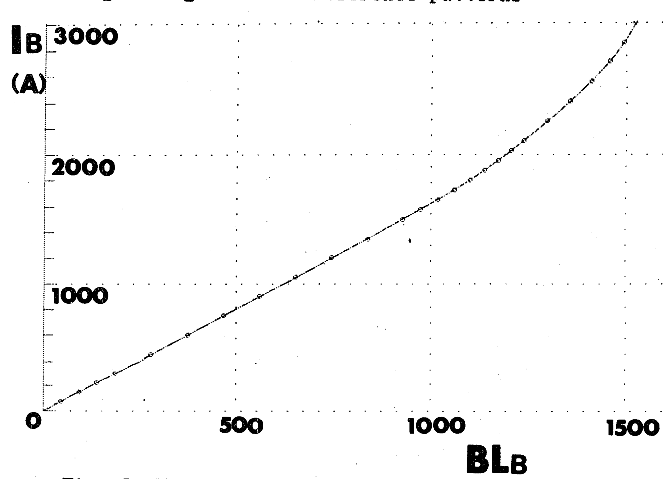

Fig. 3 Measured excitation curve of B-magnet

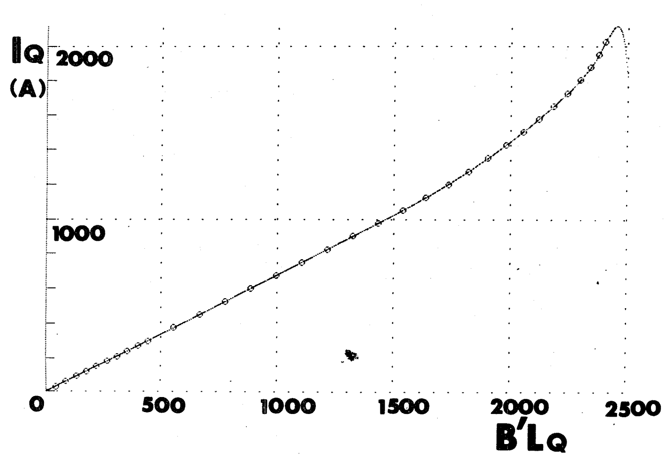

Fig. 4 Measured excitation curve of Q-magnet

There are tracking offset calculations in the similar situation at injection correction, that is, by given or calculated offsets correction of reference voltages are computed in the same scheme as pattern generation.

In both fine adjust, a step variation is smoothing by optimum polynomials in a fixed interval.

Man-machine-IF: Main parts of the programs are described by the FORTRAN and subroutines by the FORTRAN and the C. The programs make parameter files on a CRT of teminals to communicate with control programs. Powerful utilities of the unix are very useful not only program developments but also maintenance of the application programs, controlling and monitoring the whole system by file management, screen editor and shell command etc., as long as slow response(a half minute or more) is allowable. However, fine adjustment of injection or tracking is required higher response. These programs have been optimized and sophisticated less than a half minute or less by supress for file access, by FIFO file for communication among tasks etc.. These necks would be improved by version up of the main system in hardware and in software

In Fig. 5, impulse response of periodic current are given as linear vector modified one of H-350. Upper part means a impulse and bottom is the response of the transferfunction. By the function, correction patterns are calculated. Fig. 6 shows for an ACR deviation of B-magnet to be converging stable by correction times of the periodic current control, since initial pattern calculation.

Fig. 7 gives for typical all voltage and tracking patterns of a routine 12 GeV operation on the slow beam ejection. And the measured current deviations and magnet voltage (measured) are indicated.

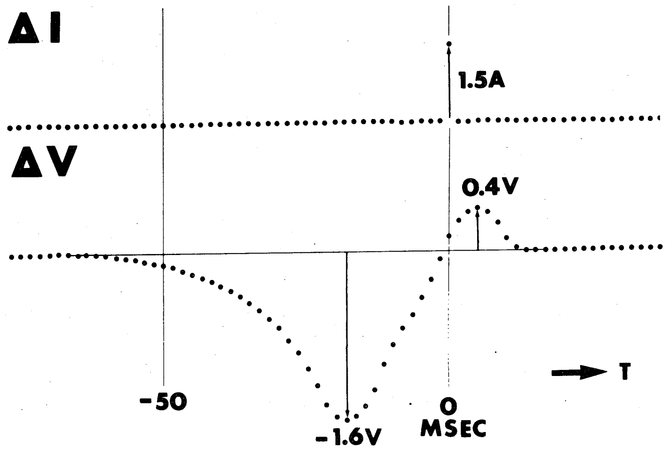

Fig. 5 Impulse response of the periodic current transfer function

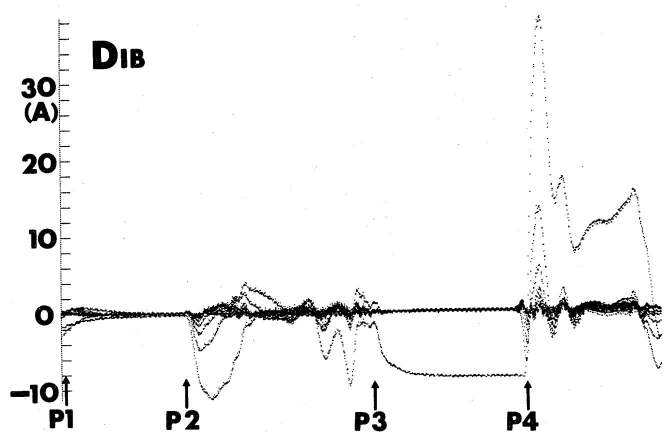

Fig. 6 Typical converging process measured current deviations of B-magnet by periodic control

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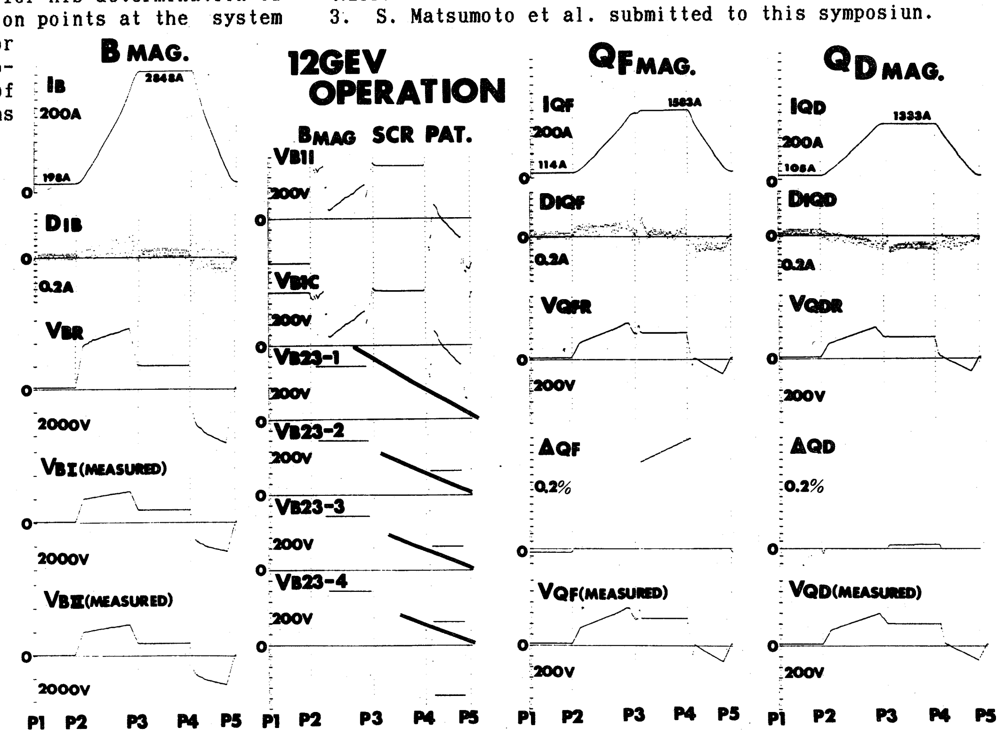

Fig. 7 Typical slow beam extraction pattern on 12 Gev operation