Control System of the HIMAC Synchrotron

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Abstract

A control system for the HIMAC synchrotron is being designed.
This report describes an outline of the control system and its main features.

Introduction

The HIMAC synchrotron is a central part of the accelerator complex dedicated to medical use of heavy-ion beam.[1]

As such, 1) the synchrotron must accelerate the beam in a highly reliable and stable manner; 2) the operation has to be carried out by a few operators who do not necessarily have much experience of accelerator operation or background knowledge. On the other hand, a synchrotron itself is a taxing system which necessitates precise and correlated control of numerous devices. Main magnet current, for example, must be controlled to shape a trapezoid-like base-ramp-plateau form repetitively, while Q-magnet currents, RF frequency etc. must keep track of the former. (Hereafter, we refer these wave forms as 'pattern's, for brevity.) Further, since a typical repetition rate of our synchrotron is rather fast to be 0.66 to 2 Hz, a capable real-time system is necessary for synchronized control of devices among whom several tens of 'pattern' output are included.

To meet the challenges characterized above, and to meet requirements of cancer treatment successfully, the control system plays a very important role.

Control System Overview

The system-wide organization of control of the HIMAC complex system is designed in the following way:

Major part of the control is done by each 'sub-system's computer which differs each other in OS, etc. and is operated rather independently, although these computers are networked via Ethernet and supervised by a 'central' computer. This situation may be viewed as a lack of coordination among contractors, but it might serve to construct the system in an 'open' environment and thus enhance the expansibility of the control system. This is also the case in the synchrotron sub-system, where two manufacturers are involved in the ring construction. It could also help deal with devices of different operational characteristics.

Control of the injector sub-system was reported in the previous symposium proceedings[2].

System Configuration

A schematic view of the synchrotron control system is shown in Fig. 1. The control system of the HIMAC synchrotron consists of the following components:

a) A main computer which serves as a man-machine interface coordinator and 'file' server of the synchrotron operation. It controls beam monitor systems via GP-IB and RS232c interfaces. It communicates with the central supervisor computer. Currently we plan to use DEC VAX4000/300 for this purpose under VMS.

b) Operator consoles which provide identical man-machine interfacing (touch panel, rotary encoders, etc.) and common procedure for similar devices with other sub-systems. Two rings are controlled from respective console desks and each console has two VAX Station 3100/76SPX, which also share controlling function with the main computer, and form a cluster-system.

c) Power supply output controllers for ring magnets and static HV devices. Several VME controllers will be installed, which directs and monitors power supply output via Digital I/O units. Besides usual DI and DO unit for DC power supplies, fast DI/DO unit is developed to control those power supplies which operate with 'pattern' output. These FDO units have a dual memory which enables quick change of the patterns. Appropriate real time program will be developed with a workstation and to be downloaded to HIMV controllers which are like MVME174.

d) PLC. To ensure reliable operation of the power supplies, warning signals and on/off control may be communicated through sequence controller which is simpler and thus thought as more robust than micro computers against sarge , noise and so on of the accelerator environment.

e) Timing system. Timing control is a crucial part of the operation and we utilize the above mentioned FDO to deliver timing signals because of the repetitive nature of operation. It also delivers event signals to the Injector and HEBT (High Energy Beam Transport) sub-systems.

f) 'RF' computer. RF cavity and power supplies are controlled, together with beam position monitors of the synchrotron ring, by a dedicated small computer. It is connected to the main computer via Ethernet within the synchrotron sub-system. With the help of a similar work-station as in c) above, RF computer can test RF system independently. The detailed accounts of RF control system will be found in a separate paper[3], as well as of beam position monitor system[4].

g) 'BT' computer. Beam lines between the synchrotron rings and the injector linac, and between the rings and the HEBT channels are also controlled by dedicated computer(s), whose position within the system is similar to that of the 'RF' one.

h) SVC controller. Static Var Compensator and Main magnet power supplies are closely coupled. See Ref.5 for more discussion of this point.

These are major blocks of the synchrotron control system.

Operation Scheme

To quickly achieve a reliable daily operation, we adopt following scheme; i.e., parameters such as current values, timing relation, various patterns etc. are to be saved as a 'file' in the main computer, together with other operating conditions. Operation will be relying on these files as a reference data base. To ensure reproducibility of the parameters, we plan to take an initialization procedure for magnet excitation, including 'pattern' magnets. As we mentioned, 'pattern' control, including generation and modification of wave form and its monitoring, is a characteristic and determining ingredient of the synchrotron operation. Therefore, we need to prepare special handling

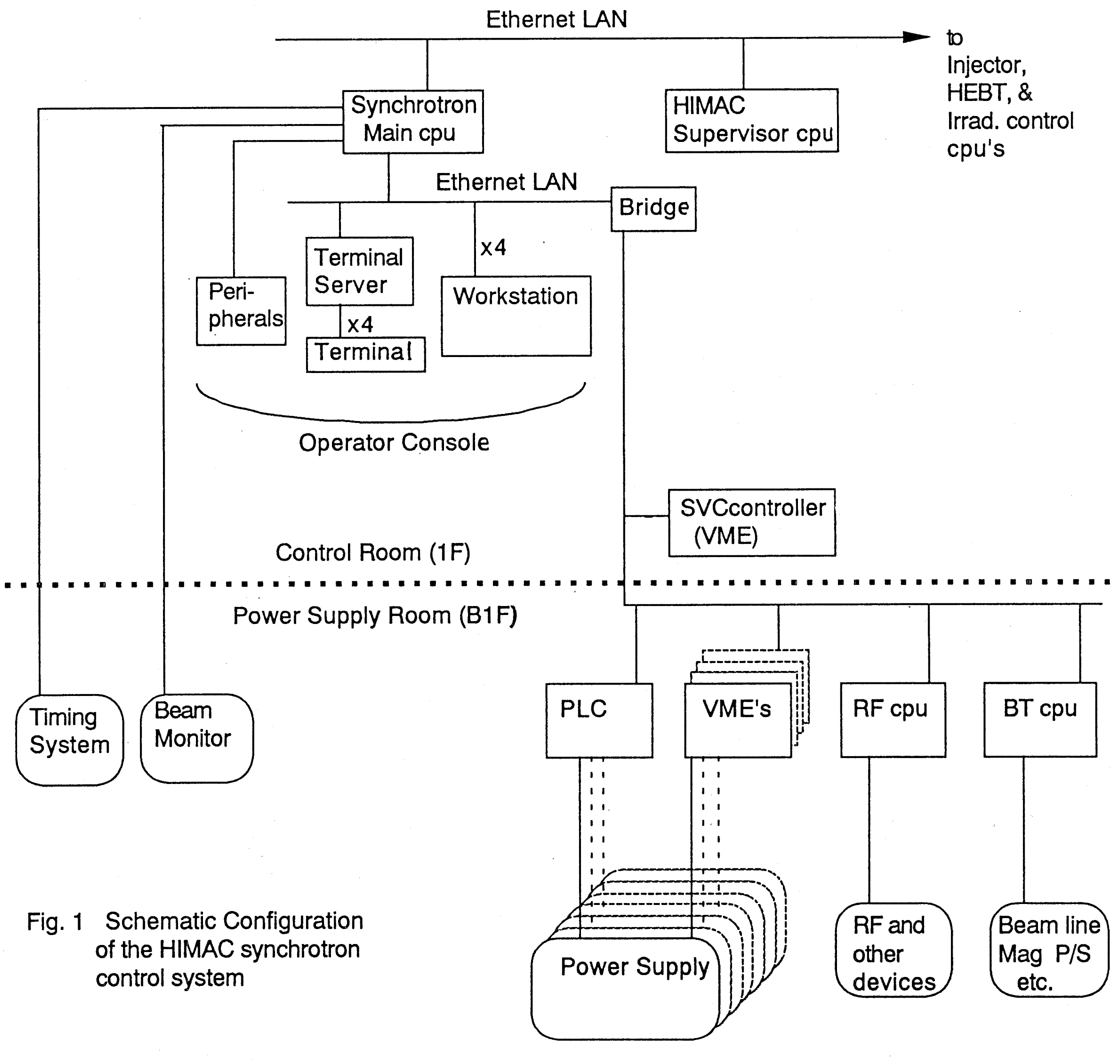

Fig. 1 Schematic Configuration of the HIMAC synchrotron control system

tools for both generation and modification, which perform basic conversion and necessary correlating change of patterns.
In pursuit of quick and systematic tuning of the machine, we employ common convention to other sub-systems for operator procedure, so that an operator can control the HIMAC complex in a simplified manner.
Detail of monitoring method of those patterns is still under study, while exhaustive monitoring may not be necessary nor possible in the present system. Instead, Beam Diagnostics (Intensity, COD, TUNE, BMP-orbit) and adjustment of a few key parameters of crucial pattern must be easily carried out. Also Beam characteristics such as chromaticity, emittance, life, etc. should be able to be evaluated from the measured data.
These measurements and relevant corrections might need an additional cpu, which is not within the cluster.

Safety Consideration

A global interlock system which supervises safety for human exposure to the beam is prepared separately and controls crucial beam shutters. Critical faults of devices also triggers the interlock system.

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