CONTROL SYSTEM OF THE 1 GeV SYNCHROTRON RADIATION SOURCE AT SORTEC

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The system controls the accelerator complex. The central mini-computer for the man machine interface is linked to local microprocessors for the accelerator device interfaces. The softwares of an operation-mode handler, a device handler, a parameter file handler, a supervisor have been installed as basic application softwares indispensable to the operation of the complex. The radiation protection has been realized by a hardwired interlock system and a softwared one.

Introduction

The system controls the accelerator complex consisting of a 40 MeV linac, a 1 GeV synchrotron, and a 1 GeV SR ring, as shown in Fig. 1. The system has worked since June 1989. The operation of the complex started in July.[1] The lifetime at the beam current 200 mA reached 8 hours in December.

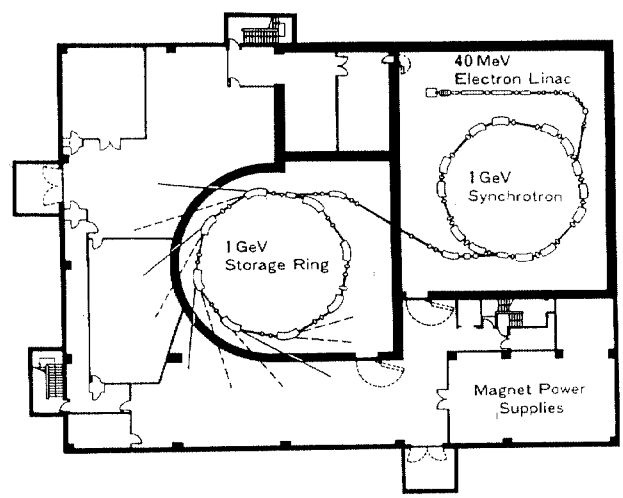

Fig.1 Layout of the synchrotron radiation facility with the control room just on the power supply room.

The control system has been constructed in the following conception:

1) The accelerator complex is operated from starting up to stopping down under the CPU's sequences.
2) The beam tuning is carried out with man-machine interfaces (CRTs, keyboards, and touch panels) at the control console.
3) There are two levels of CPUs. The central mini-computer supports operation of operators, and the local microprocessors carry out data handling with devices.
4) The complex is synchronized with a cycle signal, a clock one, and trigger ones, which are generated from an RF signal.
5) The interlock system protecting persons from the radioactivities has two structures, the one being hardwired and the other softwared.

Hardware

Main control system

Figure 2 shows the structure of the control system. The central mini-computer system, MELCOM70 MX/3000II has 16 MB main memory, 32 KB dynamic and 96 KB static cash memories with a 0.5 GB hard disc. Local processor systems with Intel 80286 or 8086 have access to devices directly with DIOs, ADCs and RS-232Cs. The central CPU issues logical access commands to the local CPU to get or give device's data. On the other hand, the central CPU receives status data from the local CPU without command, as the local CPU detects a change of status to send the data to the central CPU. Interfaces between them are optical RS-232Cs or GP-IBs. An operator can handle any part of the complex with a set of man-machine interface consisting of 2 CRTs, a touch panel and 2 keyboards. Installation of two equal sets of them has maintained flexibility of the operation of the complex.

Four lithography beamlines have been recently built and have worked. The beamline control system is consisting of a computer and a link of programmable sequence controllers (PSC) for each beamline. The computer collects beamlines' status through the PSC link, and is linked with the central CPU through the optical fiber.

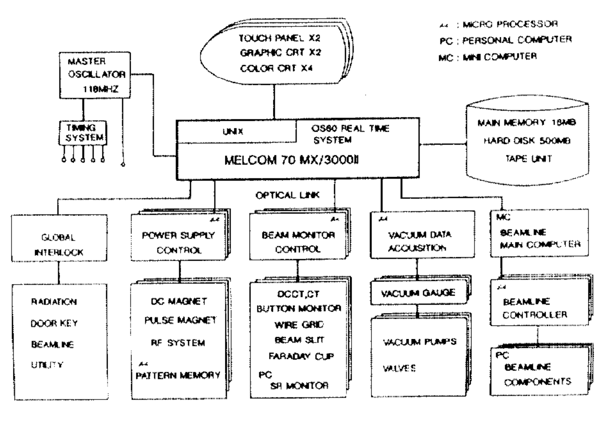

Fig. 2 Structure of the control system.

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Timing System

The complex is synchronized through the timing system which generates an 11.8 MHz clock signal, a cycle one, and trigger ones from a 118 MHz RF signal. Both RF systems of the synchrotron and the SR ring share the RF signal in order that the beam from the synchrotron is injected to the SR ring phase to phase. Figure 3 shows the structure of the timing system.

The cycle time and the delay times are programmable in the unit of 84.7 nsec. The start/stop of outputting each signal of the cycle and triggers is programmable. The signals are delivered to devices through optical fiber cables:

1) Trigger signals are delivered to beam monitors, and injection/ejection devices.
2) The cycle signal and the clock signal are delivered to the pattern generator which gives reference patterns to AC power supplies.

Delay circuits in the unit of 1 nsec are equipped with some of the injection devices.

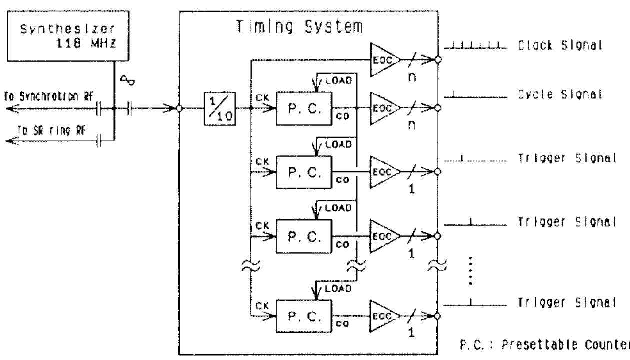

Fig.3 Structure of the timing system.

Global Interlock System

The system which protects persons from radioactivities has been dually realized by a softwared interlock system and a hardwired one. Both of them have the same logic as shown in Fig. 4, but the latter has been made from relays and the former programmed in the central CPU. When the system works, the latter inhibits the linac from ejecting the beam, and the former issues commands to stop the trigger signal used for the ejection as well as to inhibit the linac from ejecting.

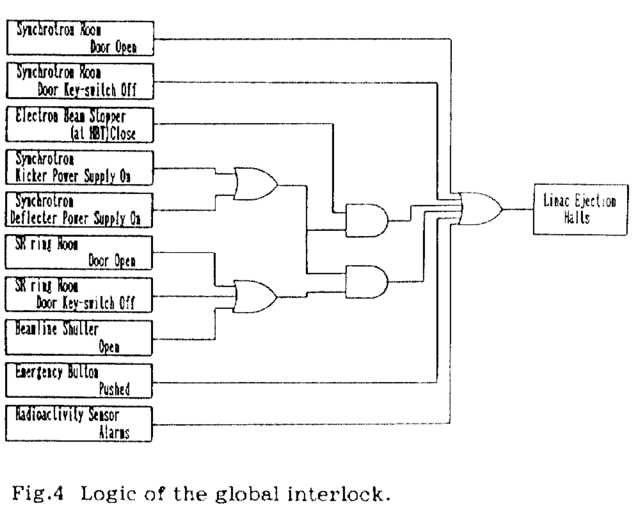

Fig.4 Logic of the global interlock.

Software

The central CPU has two operating systems, UNIX* and the real time operating system OS60. Application softwares are executed under UNIX, and tasks of device access under OS60.

The basic application softwares indispensable to the operation of the complex were prepared before the 1st operation. They are an operation-mode handler, a device handler, a parameter file handler, and a supervisor, with which operators are interactive mainly through the 14" CRT, the touch panel, and the keyboard. Application softwares have been made by users.

Operation-mode handler

Operators easily operate the complex through the operation-mode handler. The handler carries out sequences to lead the complex to the selected mode. Figure 5 shows the transition of the modes of 3 subsystems(the linac and the low energy beam transport line(LBT); the synchrotron; and the high energy beam transport line(HBT) and the SR ring), which mean the following states:

Halt: all power supplies are still switched off, except for vacuum devices,

Power On: the state after the sequence to switch all power supplies on,

Parameter Set: the state after the sequences of loading the parameter file selected by the operator, initializing DC magnet's magnetizations, and setting devices by reference values registered in the file. No trigger signal is output to an injection/ejection device.

Ejection: the state after the sequence to output the trigger signal to the linac. The beam is ejected from the linac. No injection device runs in the synchrotron.

Acceleration: the state after the sequence to output the trigger signals to the linac and the injection device in the synchrotron. The beam is accelerated cycle by cycle. No ejection device runs in the synchrotron.

Accumulation: the state after the sequence to output the trigger signals to all injection/ejection devices. The beam from the linac via the synchrotron is accumulated in the SR ring.

Radiation: the state after the sequence to stop all trigger signals used for the injection/ejection. SR lights are available.

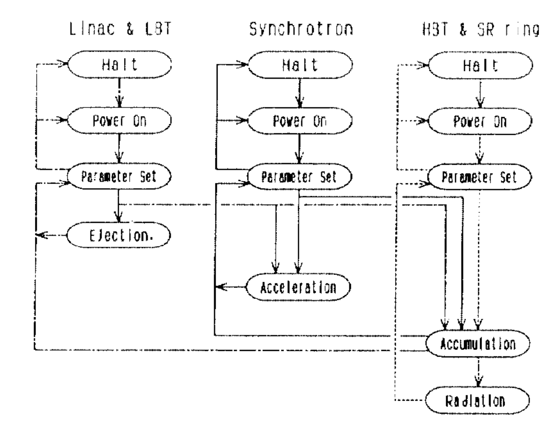

Fig.5 Transition of the operation-mode.

Device Handler

Operators handle any device, opening one of pictures made by the handler on the 14" CRT:

1) Through a picture 'device', all operations(on, off, set, monitor) of a device are possible. Such a picture has been prepared for every accelerator device except for the switch to inhibit the linac from ejecting.

*UNIX is a registered trademark of AT&T Bell laboratories.

2) Through a picture 'block', it is possible to set devices of a block by new reference values.

On the 20" graphic CRT, data of a monitor are displayed by selecting the item from the display-menu of beam monitors, vacuum pressure monitors and others.

Operators carry out the beam tuning interactively with the handler.

Parameter file handler

Through the parameter file handler, operators save reference values presently given to devices, and create patterns for AC power supplies:

1) All reference values presently given to devices and names of pattern files in use are saved in the character code into a new parameter file, for example, after the beam tuning is carried out well. The saving is done for a subsystem. (A parameter file is loaded only in the sequence for 'Parameter Set' through the operation-mode handler.)

2) Patterns of reference values given to an AC power supply are created or modified according to points(time, reference value) input by the operator. The patterns can be output to the AC power supply through the pattern generation. The points can be saved in the character code into a pattern file. (Of course, pattern files are loaded in the sequence for 'Parameter Set'. Patterns are generated and output to the devices, too.)

Parameter File

The parameter file contents following information in the character code, as shown in Fig. 6:

1) device name (NAM=XXXX),

2) reference value given to the device (SET=NNNN), or pattern file name(FIL=XXXX)

3) if the initialization of the device is carried out or not(INT=1/0),

4) loop number(LOP=NNNN) and half time[sec] took by a loop(TIM=NNNN) for the initialization,

5) if the device is supervised by the supervisor or not(SUP=1/0).

Operators can edit parameter files with a full screen editor, if necessary.

```
      TITL   SAMPLE OF PARAMETER FILE OF A SUBSYSTEM

  C             dipole
      PARM  NAM=BM,      SUP=1, SET=1321.5, INT=1, LOP=5, TIM=20
  C             steerer1
      PARM  NAM=STH1,    SUP=1, SET=20.2,   INT=1, LOP=5, TIM=5
  C             bump1
      PARM  NAM=BMP1,    SUP=1, SET=2.854,  INT=0
  C             AC power supply
      PARM  NAM=AC,      SUP=1, FIL=PATTERNAC, INT=0
  C             trigger for the linac
      PARM  NAM=TLINAC, SUP=1, SET=234000, INT=0
                :
                :
                :
      END
```

Fig. 6 Sample list of the parameter file.

Supervisor

When the supervisor detects failure of accelerator devices, peripheral ones, the microprocessor systems, and others, it displays alarm messages on CRTs temporarily. If the failure happens with beam on or the global interlock works, the supervisor stops the trigger signal used for the ejection from the linac and inhibits the linac from ejecting. It lets the operation-mode handler change 'mode with beam on' into 'mode with beam off'.

Opening the pictures 'Status' or 'Alarm List', operators can know which devices are or were in failure, respectively. When a device does not have to be supervised, operators teach the supervisor not to supervise it. After then, the device is not a object of the sequences of the operation-mode handler, either.

Application Softwares

Tune correction: At present, the tune values of the operating point are measured manually by spectrum analyzing the signal from the pickup monitor. The task of the correction can shift the operating point from the present point to the desired one by adjusting once the exciting currents of the quadrupoles(Q_f and Q_d).

Tune diagram display: A present operating point on the tune diagram is displayed on the CRT, as shown in Fig. 7. The point is calculated from the deviations of the present exciting currents of the dipole and quadrupoles from the currents at which the tune values were measured.

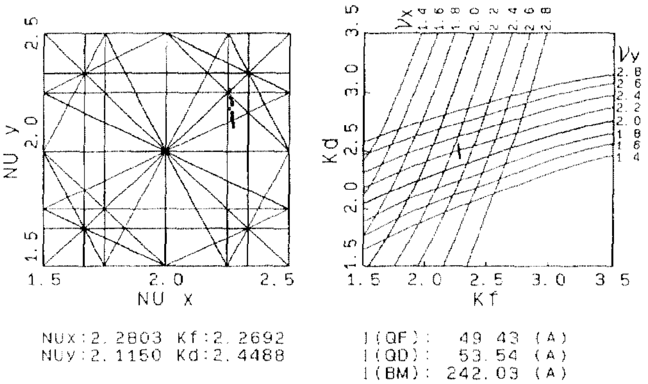

Fig.7 Tune diagram. The latest operating point is added continually.

COD correction: The 8 beam positions in the SR ring are measured with the signals from the 8 pickup monitors via the super-heterodyne circuits. The task of correction makes the deviation of the positions less by adjusting the exciting currents of steerers. The task iterates the measurements and the adjustments until the deviation becomes about 0.1 mm/point.

Figure 8 shows an example of the correction.

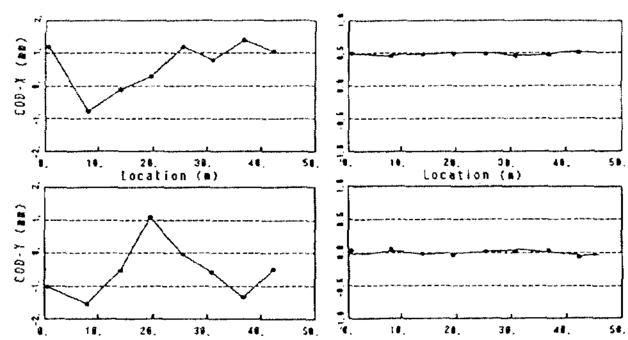

Fig. 8 COD correction. The left pictures are for before the correction, and the right for after the correction.

Deceleration: The full energy injection method has been adopted in the SR ring. For the study of characteristics of the ring at the low energies, the beam deceleration is realized by sending the reference values to the power supplies step by step and by keeping the operating point constant. The deceleration from 600 MeV to 100 MeV takes about 15 minutes.

Beam re-filling: The beam re-filling is carried out automatically under the mode transition between 'Radiation' and 'Accumulation' in order that the stored beam current in the SR ring is kept over the given level.

References

[1] S.Nakamura, et al., "Present Status of the 1 GeV Synchrotron Radiation at SORTEC", this proceedings.