Operation Control System for the Storage Ring of SPring-8

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Abstract

The operation procedure and the control system for the storage ring of SPring-8 are reported with focusing on the injection and the storage of the electron beam.

1 Introduction

The construction of SPring-8, a third generation light source facility, was completed in March 1997 and the commissioning of the storage ring started immediately. The facility consists of a 1 GeV linac, an 8 GeV booster synchrotron and an 8 GeV low emittance storage ring. The storage ring has a capability of constructing 61 beamlines, 23 of which are for insertion devices. Two beamlines were constructed at the early stage of the commissioning, other five beamlines were set up three months later.

In this report we describe the way of the operation and the control system of the storage ring of SPring-8. In particular, the injection and the storage of the electron beam are illustrated.

2 The Framework of the Storage Ring Control System

The storage ring control system consists of engineering work stations (EWS), VMEbus systems and optical fiber network (FDDI) system [1]. The remote procedure call (ONC/RPC) is used for the communication between machine control applications over the network. The operation history and the equipment parameters are stored on a database by relational database management system (RDBMS), Sybase.

The structure of the storage ring control system is shown in Fig. 1 [1, 2]. An operator command is issued to the message server (MS) by using a control panel. The MS forwards the received message to the access server (AS) after checking the syntax. The AS resolves the destination of the message and send it to the equipment manager (EM) running on the remote CPU board. There are individual AS's corresponding to the equipment groups, e.g. RF, magnet, vacuum and so on. The EM manages the VME devices connected to equipment controllers. The status data of the equipments are accumulated via another communication path, poller/collector system, and saved on the on-line database by Sybase.

The constituents of the control panels are listed in Table 1, which constitute the hierarchy structure as well as the machine components.S see Fig. 2.

At the first level there is a top control panel operating SPring-8 as a whole. The control panels for the constituent accelerators of SPring-8, the linac, the synchrotron and the

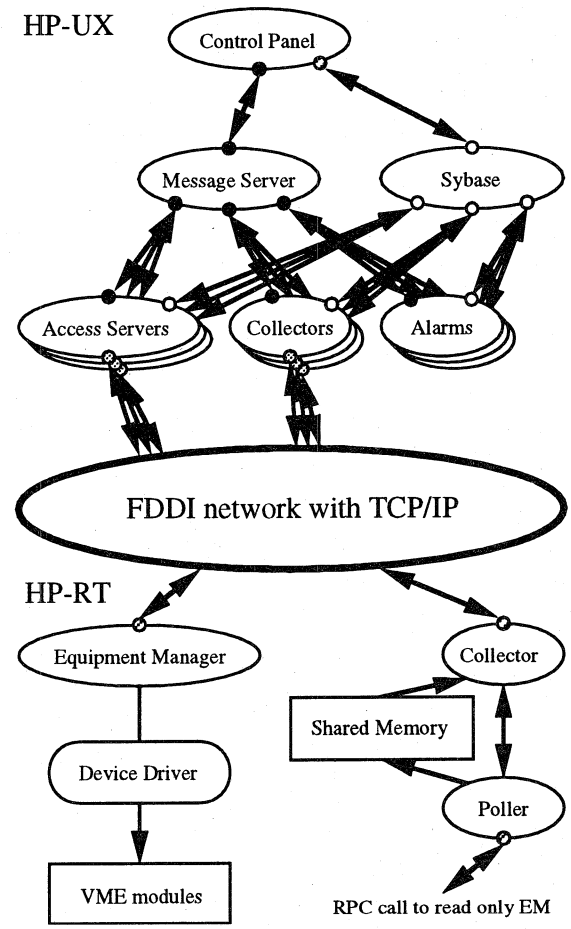

Figure 1: The structure of storage ring control system. The ellipses denote independent processes, respectively.

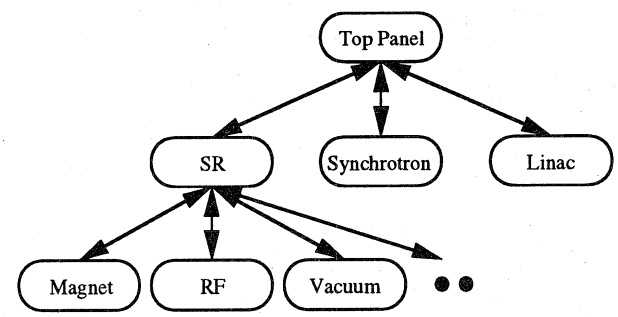

Figure 2: The structure of the control panels. The round squares denote the individual control panels.

Table 1: Major contents of the control panels.

SPring-8 top panel
SR control panel
main magnet control panel
injection magnet tuning panel
steering magnet control panel
RF control panel
BPM control panel
vacuum control panel
injection timing (filling pattern) set panel
injection ready confirm panel
COD correction panel
ring lattice parameter tuning panels
stored current and beam life time display panel
pressure distribution display panel

storage ring, belong to the second level. At present, the control panel of the storage ring can be opened by the top panel, since the linac and the synchrotron are operated by the different control system from that of the storage ring. However, the main parameters, such as current and energy of the linac and the synchrotron, can be acquired and indicated on the SPring-8 top panel. It is planned to integrate them for the sake of operation brevity.

The main panels for the equipment groups, i.e. magnet, RF, monitor and vacuum, are located in the third level of the hierarchy structure. A main panel of equipment groups includes the sub-panels as various needs arise. In addition to the panels for the equipment groups, we have the panels which lighten the operation burden. They are the COD correction panel, the injection timing set panel, the injection ready confirm panel, and so on.

Most of the data of the machine parameters of the storage ring are centrally managed by means of the database. The status data of the equipments on the online database are updated every 5 seconds with some exceptions. Since the repetition rate of the injection is 1 Hz, it is necessary to store the data of the stored current every second. In setting a parameter of an equipment, the control panel updates the data on the parameter database, so that another control panel easily know the set value by the access to the database.

To smoothly tune the storage ring parameters, the online analysis of the data is indispensable. The COD correction panel [3] and the the lattice parameter tuning panel do such analysis and set the resultant machine parameters to the equipments. To help understanding the data intuitively, the tools displaying the data graphically on the widgets made by X-Mate were developed.

We list the major functions of the control panels used in daily operation except for those of the equipment groups.

- SPring-8 control panel
  1. saves operation parameters of SPring-8 accelerator modules as a whole,
  2. opens SR control panel,
  3. displays the status of the constituent accelerators,
  4. displays the operation mode,
  5. limits the stored current,
  6. forbids to inject the electron beam into the storage ring if the condition is not satisfied, and
  7. changes the alarm condition according to the operation mode.
- SR control panel
  1. saves operation parameters of whole storage ring equipments,
  2. manages the control panels and the status display panels for the equipment groups, and
  3. aborts the stored current.
- injection timing (filling pattern) set panel
  1. produces the injection pattern data of the pulse number and the addresses, and
  2. sets the injection pattern data.
- injection ready confirm panel
  1. confirms the ready status of the equipments of the storage ring.

The tasks of the control panels for the equipment groups are to access to the modules and to display the status.

Table 2: Major parameters of the storage ring in daily operation.

stored electron energy	8 GeV
limit current of stored electron beam	20 mA
RF frequency	508.58 MHz
harmonic number	2436
repetition rate of injection pulse	1 Hz
injection pulse length	40 ns

3 The Beam Operation of the Storage Ring

In this section, we illustrate the beam injection into the storage ring as an example of the operation. The ways of starting up the power supplies of the equipments, the magnets and the RF system, are found in [4, 5].

The operation parameters related to the beam injection to the storage ring are listed in Table 2. An injection pulse contains 20 bunches in series, all of which but one are eliminated by RF knock out in synchrotron in the case of single bunch operation [6].

The beam injection control system is shown in Fig. 3. The electron gun at the linac is fired only by the beam on-switch on the beam control panel hardwired to the gun. Although the linac gun trigger is turned off by pushing the beam off-switch

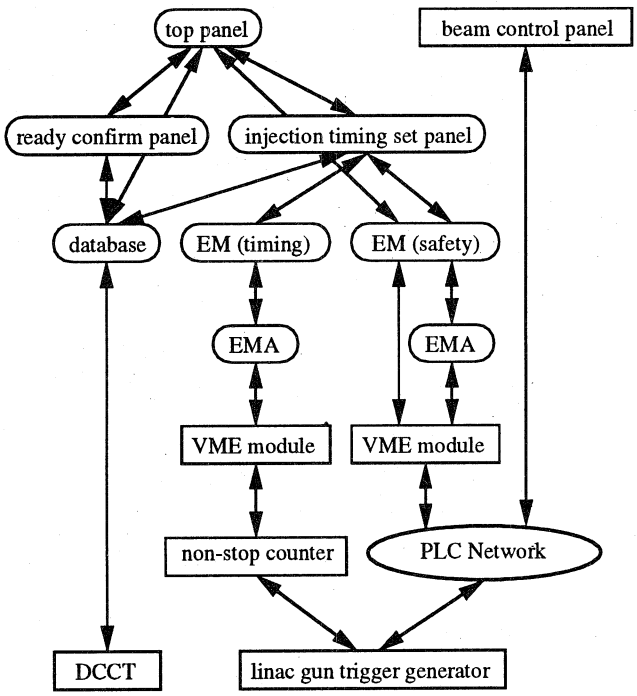

Figure 3: The electron beam injection control system. The round squares indicate the software applications and the rigid ones the hardware modules.

on the beam control panel, the operation control applications can issue the linac gun-off request to the PLC system managing the radiation safety. Once the gun-off request is issued and if not reset, the beam on-switch is immediately turned off by the PLC.

The RF bucket, where the top bunch of the injection pulse is located and which is called the address, is determined by the non-stop counter of 508.58 MHz [6]. In the operation with high current, the beam is injected into the storage ring with varying the address, since we should retain the peak current of the stored electron in the low level because of the beam instability. The injection address is managed by the process, or EM agent (EMA), running on the VME directing the timing system. In a similar manner the injection pulse number is controlled by another EMA on the VME communicating with the radiation safety system.

The beam injection is managed by the following two regulations, (a) the injection pulse number limit and (b) the current limit. For the limit (a), the safety EMA watches the on/off status of the beam switch with 10 ms period. If the beam switch is turned on, the EMA starts to count down the injection time and, after the injection pulse number reaches to the limited value, the EMA gives the command of turning off the linac gun to the safety PLC. As a backup to the process, the top panel also count down the beam injection time. Provided the process fails to stop the beam injection, the top panel issues the gun-off command a few second after the expiration of the injection time.

For limit (b), the stored current measured by the DCCT is monitored by the top control panel through the on-line database. When the stored current amounts to the set value, the top panel stops the beam injection by issuing the gun-off request command. In the case that the stored current data are not updated due to the failure of the data taking system, the beam injection is stopped by the software interlock supplemented to the top panel. As a last resort of limiting the stored current, we set up the beam abort module hardwired to the DCCT. If the stored current measured by the DCCT exceeds the threshold, the module sends the beam abort signal to the RF system and the gun-off signal to the safety PLC.

Besides, there is the case that the control panel issues the gun-off request. If the injection ready conditions, as shown in the following list, become to be not satisfied, the gun-off request is issued.

1. The power supplies of the magnets have the fixed values.
2. The RF system has the fixed accelerating voltages with the fixed phases.
3. The check of the DCCT is completed.
4. The gate valves at photon-beam extraction ducts are opened.
5. The gaps of the insertion devices are fully opened.
6. The main beam shutters of the beamlines are closed.

The gun-off state demanded by the top panel is reset by the panel itself after the conditions are made prepared and the stored current falls below the threshold.

4 Conclusions

The first stage of the commissioning of the storage ring is just finished, which is successfully accomplished by the help of the control panels. The flexibility and the expansibility of the control panels made the commissioning to go on smoothly.

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