Design Status of a Double Array Undulator Control System

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1. Introduction

We are constructing a double array undulator of the APPLE (Advanced Planar Polarized Light Emitter) type[1]. It will be installed at the cell number 23 in the SPring-8 storage ring. This is a new trial to produce a various light polarization in the soft X-ray region. Novel characteristic is to produce any kinds of polarization (horizontally and vertically linear, circular and elliptical) by changing the phase shift of two pairs of permanent magnet arrays. The control system of the undulator and its software is more complicated compared to normal type of insertion devices. Here, we briefly describe the control system and the present status of software development.

2. Machine Control System

The insertion device is 2.5 m in length, 2.2 m in height, 1.22 m in width, and weights approximately 5 ton. Its main components are a steel-made skeleton, two heads (superior and inferior) which slide in the vertical plane and two pairs of permanent magnet arrays running in the horizontal plane. Each magnet array is, in turn, composed of a pair of two magnet rows. The superior and inferior heads are powered by a pulse-motor. Two magnet arrays are driven by servo-motors.

Mechanical movement of the insertion device (ID) consists of (1) gap distance adjust in the vertical plane, and (2) phase adjust in the horizontal plane. The gap distance is altered from 40 mm to 300 mm in order to obtain different harmonic energies of radiation. The energy range is 0.2 keV (6.2 nm) to 3 keV (0.41 nm). On the other hand, the phase shift (relative) can be altered from -120 mm to +120 mm. Different values of phase shift produce different polarization.

At a given gap distance, we can drive the ID in two modes of phase shift; fixed phase drive, and pattern phase drive. At "fixed phase drive", the phase shift do not alter as a function of time. At "pattern phase drive", the polarization alternates periodically (period = 2 sec), for example from right-handed circular (P = +1) to left-handed circular (P = -1) polarization and vice versa, by controlling two servo-motors.

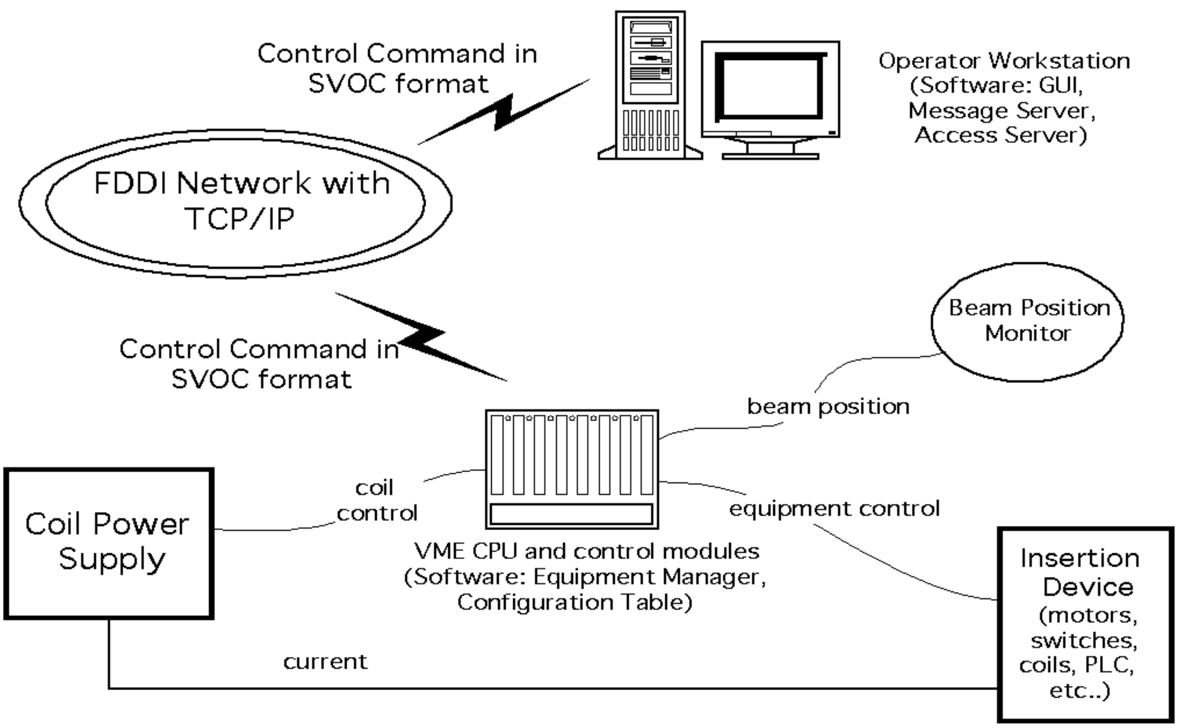


Fig.1 Control System for APPLE Type Insertion Device

When the gap distance is closed down or the phase shift is changed, the magnetic field integral on electron beam orbit will vary. So, the gap drive and phase drive cause electron beam orbit distortion (COD). The COD correction is achieved by a pair of steering long coils which are located between the gap of undulator. In addition, the COD and the photon (X-ray) beam fluctuation are corrected in detail by four steering coils, two located upstream and other two downstream of the undulator. The beam position signals are transmitted to the ID local processor. This calculates a correction feedback factor at a rate of 100 Hz.

3. Control Hardware

The ID local processor is VME bus based CPU (100 MHz of clock rate, 64 Mbytes of RAM and 20Mbytes of Flash ROM). CPU, VME modules (equipment interface boards), motor controllers, programmable logical controller and all peripherals are enclosed in a rack-type control panel (Fig.1). The operating system for this VME processor is real time HP-RT. DC power supplies for the ten steering coils are enclosed in other control panel. These power supplies are connected to VME modules by optical fiber RIO (Remote I/O). Optical fibers are electrically noise free. Beam position monitor equipment is arranged in another control panel.

The local VME processor will be connected to the ID operator console located at central control room. The operator console is an UNIX workstation equipped with a CPU of 100 MHz of clock rate, 64 Mbytes of RAM and 1 Gbyte of Hard Disk. The operating system is HP-UX Ver 9.07. The VME processor is linked to the UNIX workstation via FDDI(TCP/IP) network which has a data transmission rate of 100 Mbps. The control data is transmitted along that one named "machine loop" among several loops consisting the FDDI network.

Because of the "event-driven" criteria, the command system is flexible enough to resist any possible ID operation situation. The command rule for communication between UNIX workstation and VME local processor is one named SVOC format originally developed in SPring-8. From the point of view of client/server system, the SVOC format allows an abstraction of actual equipments to be controlled. The SVOC was introduced with the objective of facilitate the posterior and independent improvement of hardware and software[2].

Two video cameras will be installed close to the ID in order to monitor gap and phase shift movements during machine maintenance. The CRT monitors will be installed on the VME control panel and another in the experiment station.

4. Software Configuration

The computer logic adopted in SPring-8 is an event-driven triggered client/server system. The characteristic of "event-driven" is that it is sensible to any malfunction that will occur in the system. This is an advantage over the "loop" control system.

4-1 Software on local processor

When a SVOC command is emitted on UNIX workstation, this command is transmitted to the local VME processor via TCP/IP network. The application software running on the VME processor is the one named equipment manager (EM), which is linked to the network through remote procedure call (RPC). EM is in charge of interpret SVOC commands, control VME modules and collect status data of equipments such as coil power supplies, motor controllers, programmable logic controller, ion pumps, etc. EM controls equipments based on the control data defined on machine configuration table. Control data defined on configuration table are the address of equipments, the set value of equipments and the status data to be collected from equipments. The configuration table is stored on the memory of local processor. The equipment's status data collected by EM are temperature, vacuum level, limit switch status, alarms, etc. of the undulator system.

In addition, EM is responsible for calculating steering coil currents for COD correction. When the gap distance adjust heads move, for instance from 40 mm to 300 mm, EM calculates the quantity of current to activate the COD correction steering coils. Similarly, EM corrects COD deviation occasioned by the movement of two pairs of phase shift permanent magnets. Signals from beam position monitor are used to calculate coil currents for the electron beam and X-ray beam position correction.

The time out period for RPC is set at 25 sec. So, the gap adjust is performed in time steps shorter than 25 sec each step. Thus, in our case the ID operator emits SVOC commands consecutively in a loop of period of 2 sec. This period of 2 sec can be considered as a practical value since the time necessary inside the network is approximately 20 msec.

Several UNIX processes, such as gap drive, fixed phase drive, pattern phase drive, COD correction, X-ray correction, run on EM. The COD correction is performed according to a correction table of magnetic field integral obtained by field measurement and also on the performance of COD correction.

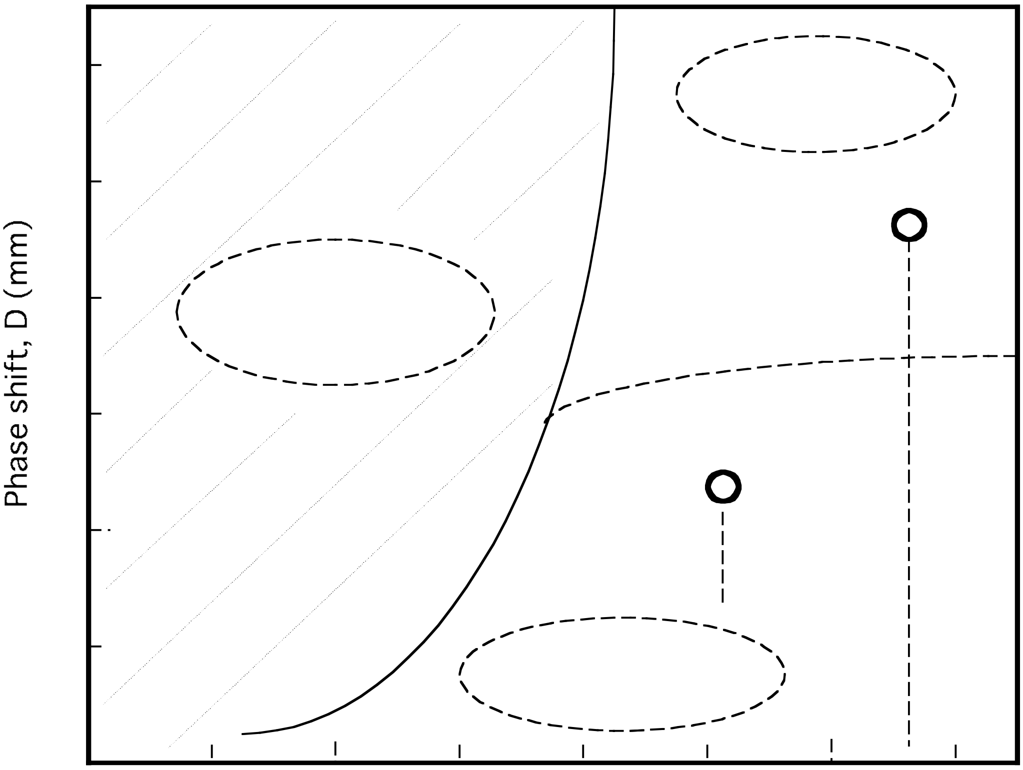
For "pattern phase drive", we prepare several patterns of table for different phase shifts. EM recognizes these patterns by interpreting the "complement C" of the SVOC command. The complement C defines a set value of the equipment. In this manner, the ID operators can obtain their desired polarization pattern just emitting corresponding SVOC commands.

4-2 Software on operator console

The application software running on the operator console are graphical user interface (GUI) to emit control commands, message server (MS) to recognize and classify the type of commands and access server (AS) to call the corresponding EM for the emitted command. The above mentioned correction table of magnetic field integral is edited here on the operator console. The SVOC commands can be emitted either by character mode, or by mouse clicks on GUI mode. The ID operator can obtain his desired photon energy and polarization either by setting values of gap distance and phase shift, or by setting values of photon energy and polarization.

Fig.2 shows the operation range of the insertion device. The photon energy is greater for greater gap distance. According to the value of phase shift D, one can obtain X-ray with different polarization like linear, elliptical, circular, etc. X-ray obtained on point A is vertically linear polarized and on point B the polarization is horizontally linear.

The software development activity is on schedule and site install of the entire system is planned to be in August of 1997.



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References

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