Beam Position Measurement System for SRRC

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Abstract

The beam position monitors, processing electronics and VME crate based data acquisition system have been designed and implemented recently in SRRC. The beam position monitor is composed of four button-type electrodes mounted on skew position of vacuum chamber. The switched detector processing electronics and the high speed data acquisition system were chosen for fast beam position measurement due to the requirement of the global harmonic orbit correction and the local beam position feedback system. The beam position measurement system will be provided fast and accurate beam position information for the 1.3 GeV storage ring.

REQUIREMENT OF BEAM POSITION MONITORING SYSTEM

The beam position measurement system should be fulfilled the following goals:

* First turn beam trajectory measurement with accuracy ± 1 mm to aid commissioning of the storage ring.
* Accurate beam position measurement for closed orbit correction.
* Provide fast beam position information for global harmonic feedback and local feedback purpose.
* High dynamic range, working form 0.2 mA to 200 mA of beam current with small current dependent accuracy.
* To aid lattice function measurement.

To meet above stringent requirements, all elements and modules in beam position measurement system should be carefully designed and implemented.

BEAM POSITION MONITOR

There are 47 sets of beam position monitor (BPM) to provide beam position information for the 1.3 GeV electron storage ring [1], each BPM is composed of four button type electrodes with SMA feedthrough connectors that are welded on the vacuum chamber directly as shown in Figure 1. The BPM will mount on the BPM fixture which is fixed on the magnet support near the quadrupole magnet via an aluminum frame block. The adjustment mechanism of BPM are used to adjust the position of BPM. The frame block fixes tightly with BPM and provides reference planes for BPM calibration before installation, and also provides reference plane for alignment with quadrupole bore after being installed. The setting error of BPM will be measured by dimensional measurement

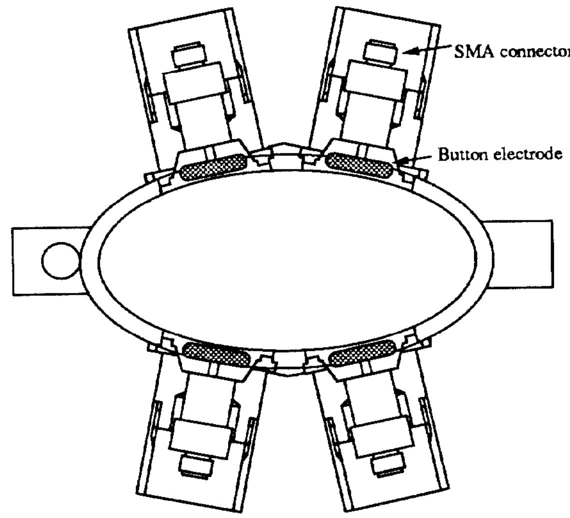

Figure 1. Beam position monitor.

equipment. The setting offset of each BPM will provide the correction information for beam position measurement.

The sensitivity of the BPM is about 7.5% and 6% change in signal strength near the center of the BPM in horizontal and vertical direction respectively. The calibration coefficient for nonlinearity correction are find out from the data of the BPM calibration measurement.

PROCESSING ELECTRONICS

The global harmonic feedback and the local beam position feedback plays an important role in the low emittance synchrotron light source. The high speed processing electronics for the beam position monitor are highly desirable.

Processing electronics is shown in Figure 2 which is slight modify from the design of NSLS [2]. There are several synchrotron radiation facilities [3,4,5] which are under construction will build the similar system. This approach uses solid state switch as RF multiplexer to select signal pickup by the button electrode. The selected signal is sent to the IF module by a 20-50 meter high quality coaxial cable. The IF module is a high dynamic range superheterodyne receiver turned at the 200th harmonic of the revolution frequency (500 MHz) to amplify and to detect the beam signal. The processing electronics are packaged in Eurocard bin. The signal from the BPM is connected to the front panel and the processed

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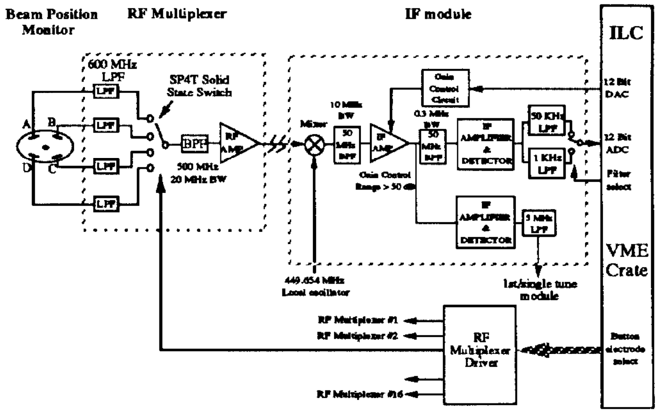

Figure 2. Functional block diagram of the processing electronics.

signal is send to VME crate based intelligent local controller (ILC) via backpanel DIN connector.

The beam signal from four button electrodes are read into ILC sequentially. The detected signal of processing electronics for four electrodes will be added, subtracted and normalized to obtain normalization horizontal and vertical signal by ILC. The beam position can be obtained by using suitable algorithm. The nonlinearity of BPM can be also linearized by appropriate linearization method.

The first turn trajectory measurement is helpful for the machine commissioning. Six special VME modules will be used to support the first turn and next 10^3 turns beam position measurement. This module have eight channels with 8 bits video analog-to-digital converter, each channel has 1 kbyte dual-port memory. The signal form each processing electronics are digitized and stored at memory for analysis. Since, the processing electronics is an multiplex system, only one signal is selected for each injection cycle. Hence, four injection cycle in needed to complete data acquisition sequence on the basis that cycle by cycle variation of injection condition is not change drastically. This special VME module with larger memory also will be used with the single turn position measurement electronics which will be installed conjunction with one or two BPM to provide a useful tool for machine study.

ORBIT ACQUISITION SYSTEM

The major role of orbit acquisition system is to collect electron beam position information. The measurement system of the electron orbit is composed of three set of electronic racks which are located at three locations at the inner area of the storage ring. Each BPM has its own processing electronics. Each set of electronic rack will handle the 16 BPMs of two superperiods as shown in Figure 3. The ILC are based on the Motorola MVME-147 CPU board with a 68030 microprocessor and a 68882 floating-point coprocessor, 4 Mbyte on board memory and etherne interface. The pSOS $^+$ real time kernel with network support pNA $^+$ was chosen for ILCs. The

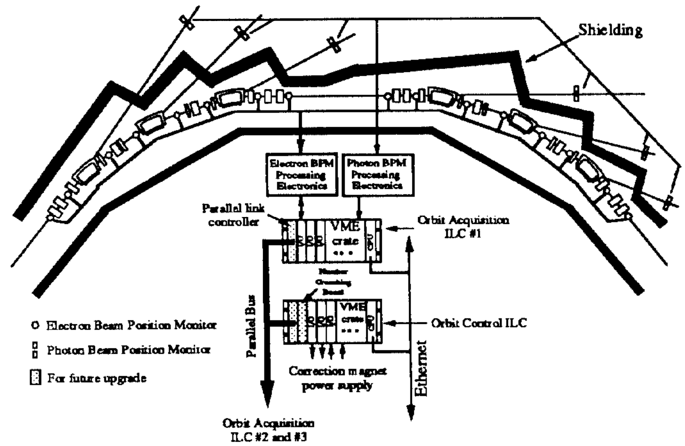

Figure 3. Beam position monitoring and beam position feedback system.

development environment is based on the Microtec cross development tools under VAX/VMS over a TCP/IP network. The software components at the ILCs for the beam position acquisition are composed network server, computation server, and I/O tasks.

The measurement system of the beam position performs as an orbit server. The high precision beam position information can be sent via ethernet to process computer or workstations for the use of the closed orbit correction or the other purpose. The nonlinearity of BPM is corrected by suitable algorithm [6,7], which is also done by the local orbit acquisition system. The orbit acquisition system also provide fast beam position information for real time beam position feedback system.

BEAM POSITION FEEDBACK SYSTEM

The global harmonic feedback and the local feedback will enhance the performance of the storage ring [8,9,10], provide a good stability for photon beam line, especially for the beam line of insertion devices.

Most of the existing global or local beam feedback systems were implemented by analog circuit, mainly because they were designed for operating machines and use small number of position monitor and corectors. It is difficult to implement analog global beam position feedback system at the third generation synchrotron radiation facility because these machine use a lot of BPMs and corectors to maintain its beam quality. All digital methods are more flexible and easy implement for a complex system than analog method.

The beam feedback system needs information of electron beam position and photon beam position. In order to damp fast beam motion due to unavoidable noise, beam position monitoring system should have fast response. The processing electronics of the BPM and the orbit acquisition ILCs can provide about 500 beam position reading per second.

At early operation stage of storage ring, position feedback is not necessary. In order to improve the performance of storage ring, the position feedback system will be implemented after machine commissioning. The beam position feedback system supports the global harmonic feedback mode or the local feedback mode as well as the combine of both approach.

Since speed is critical at the application of real time beam position feedback system, the beam position feedback will be done by a dedicated orbit control VME crate. The orbit control ILC is composed of CPU boards, number crunching boards and various input/output boards as shown in Figure 3. Since all equipments are installed at the inner side of the storage ring, the distance between three set orbit acquisition ILCs with orbit control ILC is within 100 m, commercially VMEbus multi-crate link with reflective memories will be adopted to transmit data between three BPM system's ILCs to orbit control ILC rather than develop a special module like fast interface module (FIM) [11] of ELETTRA due to limited time available for the project. The transfer rate requirement for fast beam feedback is about 1 Mbyte/sec (send 192 byte within 200 μsec) which is beyond the capacity of ethernet. When the CPU of orbit acquisition system write to the reflective memory, beam position information are transparently up-dated into the memory of orbit control ILC. This link will transfer the electron beam position and the photon beam position information to orbit control ILC. There are many choice about number crunching board on VMEbus system which is under evaluation, such as most advanced VMEbus based RISC processor board or digital signal processing board, all of these number crunching board support more than several tenth MFLOPS computing horsepower (such as Intel i860 can be provided 80 MFLOPS peak computing power, Motorola M96002 DSP chip can provide near 50 MFLOPS computing power, ...etc.). To speed up the system, orbit control ILC has analog output to control steering power supply directly to avoid additional delay through communication network. For a careful design, large than 50 Hz closed loop bandwidth of position feedback is easily achievable.

SUMMARY

The processing electronics and the VMEbus based fast orbit acquisition system for the beam position measurement system is under development. The system can be provided high accuracy beam position for the upper layer beam dynamic related applications. The orbit acquisition rate is about 500 orbit/sec, this rate satisfied the requirements of the fast beam position feedback system for the storage ring of SRRC which is also under intensive study.

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