Implementation of Basic Control Procedures for SIBERIA-2 Storage Ring by Object-Oriented Programming Methods.

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Abstract

Object-oriented approach for programming of basic control procedures for 2.5 GeV synchrotron radiation source SIBERIA-2 -- accumulation, ramping, orbit correction, etc. -- is described. Class libraries support network channel access, data base exchanges, graphical environment. The kernel of software implementation is beam object's class libraries, which allows to control (in beam terms) orbit position, betatron tunes, chromaticity, etc. These beam objects combine on-line modelling, beam monitoring and functional control of groups of low-level equipment.

1. INTRODUCTION.

The SIBERIA accelerator complex includes a 80 MeV electron linac, a 450 MeV booster storage ring, a main 2.5 GeV storage ring and two transport lines for electron beams. Now SIBERIA facility transits from construction phase into commissioning/operation phase. Electron beam was accelerated in booster ring up to 450 MeV and extracted into transport line to main ring. Main ring was assembled completely. The SIBERIA control system can be classed into 3 level. The PC-network presents upper level for usage in the control rooms. The single PC makes possible the interconnection between the console network and the second level of real-time control. 24-bit CAMAC-oriented computers are used in this level of the control system. Here we have 8 computers in service. Each computer controls the specific part of accelerator complex (injection, main ring) or specific system (vacuum, beam diagnostic, termomonitoring, etc.). The I/O data acquisition and controlling CAMAC hardware is the low level of the control system.

Software also consists of three levels: console level, networking level and real time level. Lower level programs run in CAMAC computers under real-time operating system ODOS and controlling CAMAC equipment. Networking level programs provide interconnections between console network and real-time network. Console applications interact with an operator.

2. DATABASE AND EQUIPMENT ACCESS LIBRARIES.

Database describes control system of accelerator complex and consists of main file and channel's families' description files. Each record in main file includes name of channel's family, name of description file and comments. Hence a number of records is equal to a number of channel's families. Family's description files describe channels of the same type. For instance, family of control channels for power supplies, family of monitoring channels for temperature sensors, family of measuring channels for digital oscilloscopes, etc. Channel description represents a record in corresponding file, which contains static information -- names, coefficients, hardware addresses, comments, etc. Channels of different type can have records of different structure. Number of records in family description file is equal to a number of channels with this type. Channels have not to be linked to hardware channels of ADC or DAC, but can be designed for to transmit instructions for real time operating system or to produce some mathematical calculations and so on. For example, BeamEnergy channel can be a result of processing of current values in bending magnets. To database access and mapping in computer memory object oriented library was developed (Figure.1).

```
TDataBase
TFamily
TChannel
TData
    TOscArray
    TOsccontrol
    TThermo
    TDir
    ...
TStaticData
    TStatThermo
    TStatOsc
    TStatDir
    ...
```

Figure 1. Library classes for database access and mapping.

Class TDataBase represents concept of database as container of channel's families in a form of array. It encapsulates also methods for database reading from persistent memory and data member's construction.

Similarly, TFamily implements concept of family as array of channels. TChannel contains an array of dynamic data (TData) and static data (TStaticData) from database. TData and TStatData are abstract classes, which includes all necessary methods for information treatment. They implement methods suitable for data of any type. Methods which are different for different data types are presented as pure virtual functions. Classes derived from TData or TStaticData define implementation of these methods. These are methods of interpretation of database information, treatment of information from low level control system, execution of requests from console level programs, methods of graphical representation of data.

Library for network and internet exchanges contains classes for communication to control computer's network. TExchange implements hardware level of information transmission and decoding. TZone executes link between particular real-time control program and channels (TChannel). TSocket connects a console level application with database server program. Data exchange between high level applications uses NetDDE protocol (Network Dynamic Data Exchange) [1].

3. SOFTWARE SUPPORT FOR ENERGY RAMPING PROCESS.

The working energy of SIBERIA-2 storage ring is more than 5 times greater than injection energy, so a lot of attention must be paid to ramping process. Ramping should not be too slow because there is a minimum of a beam lifetime in energy region about 1 GeV. Do not lose more than 5% of stored current of 300 mA, ramping time should be less than 10 minutes. From the other hand, ramping velocity is restricted by very different time constants of power supply for quadruples and bending magnets. This leads to betatron tune shift and beam loss due to nonlinear resonances. Another problem is saturation processes in iron of magnet elements that begin from energy near 1.6 GeV, when magnetic field becomes not proportional to current of power supply. All these problems require careful design of software for ramping support.

One of the tool for solving these tasks is so called overcontrol coefficient. The overcontrol coefficients are different for magnetic elements with different time constants. On every step of ramping control process the desired current increment multiplies by this coefficient. This leads to leveling of field increasing velocities in different elements and strongly decreases possible ramping time.

Another tool ramping support is concept of regime of storage ring. Regime represents a collection of settings for control channels. Each regime may be saved in file and edited by special program. Ramping process consists in loading a set of regimes for different energies consequently. During transition from one regime to another settings in control channels behave linearly. If any channel is not presented in given regime the set of this channel is not updated during regime loading.

4.BEAM-OBJECT CLASS LIBRARY.

At present in accelerator control systems program complexes are often used, which support control and modeling procedures simultaneously[2-4]. We've tried to design object-oriented library that combines control methods for specific equipment (power supplies, pulse generators, etc.) with control methods in beam terms -- coordinate, angle, betatron tunes, chromaticity, energy.

To control magnet system of beam transport line or storage ring we use classes: TMSControlChannel - magnet elements control, TPSControlChannel - power supplies control, TBMChannel - virtual beam-channels control. These classes are derived from class TChannel described earlier.

```
TChannel
   TMSControlChannel
      TMSGroup
         TLineGroup
            TRingGroup
         TMultGroup
   TPSControlChannel
   TBMChannel
THandle
   TMatrixHandle
      TControlHandle
         TSimpleHandle
         TMSHandle
            TQXZHandle
            TSXZHandle
            TCorHandle
               T2CorHandle
                  TX2CorHandle
                  TZ2CorHandle
                  T3CorHandle
                     TX3CorHandle
                     TZ3CorHandle
                  T4CorHandle
                     TX4CorHandle
                     TZ4CorHandle
```

Figure.2 Hierarchy of beam-object class library.

Class THandle and its derivatives are used to provide linking between control channels of different types. Objects of this class convert beam parameters (for example coordinate and angle deflection of electron beam at given accelerator azimuth) to control influences for magnetic elements (i.e., correctors' magnetic fields) and then to appropriate power supply settings. Hierarchical class structure is shown on Figure 2.

To realize control procedures in beam terms on-line information about magnetic structure of accelerator is necessary, that is transport matrix, input/output Twiss parameters for every element of the structure, etc. Class TMSControlChannel represents all necessary methods for such on-line modeling. Class TMSGroup is a set of magnetic elements (i.e., objects of TMSControlChannel class) and from the other hand is a magnetic element itself, for which all the necessary modeling procedures are realized. Thus we can build beam transport line or storage ring structure and get information about machine functions and update it after any variation in settings of magnet elements in real-time.

Let's consider an example of control procedure. When we construct an object of TX4CorHandle class the information about magnetic elements (4 X-correctors and virtual beam position control channel) is used and objects of TMSGroup class are constructed to calculate transport matrix between elements. When executing SetValue() procedure of beam position control channel to change beam coordinate TMSControlChannel::Control() method involves appropriate methods of TX4CorHandle. Then necessary simulation information is calculated (transport matrix and matrix binding beam coordinate and angle with forces of correctors in this case). After that we can execute Control() procedure for these correctors. This procedure uses objects of TSimpleHandle class for binding to specific power supply control channels.

5.REFERENCES

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