DEVELOPMENT OF A UNIT CONVERSION CHANNEL ACCESS SERVER FOR J-PARC LINAC

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Abstract

A unit conversion server has been developed for magnet power supplies at J-PARC LINAC. The server is a separated system from the control system. The server application is written as a Portable Channel Access Server in C++. The conversion function is defined as a 3rd order polynomial functions with 3 ranges in the current so that it can fit well with magnet field measurements and calculations reasonably while the inverse conversion can be solved analytically. The parameters for the polynomial functions and boundary current values, lower and upper limits, and fudge factors are defined as a configuration file which is maintained and automatically generated from a database. The server is applied to about 200 power supplies of quadrupole, steering dipole magnets, and bending magnets of LINAC. During beam commissioning since November 2006, it has been working stably.

INTRODUCTION

In beam commissioning, it is often necessary to control and monitor devices with physics parameters instead of device parameters. In case of magnets, field values of magnet power supplies are designed with beam transport models. The parameters for magnets in the models are magnetic field. On the other hand, in the magnetic power supplies, current values are usually set. Each type of magnet has its own excitation function *B(I)* which connects the above two parameters. Beam commissioning requires a mechanism to convert these two parameters in online for efficient beam tuning.

In J-PARC LINAC, we have designed a system to convert units of parameters from device parameters. Devices are controlled through EPICS records in IOC (Input Output Controller). Requirements for the unit conversion system are summarized as follows.

- Device records for monitoring must be converted to physics records. With event notification in EPICS, each time when values of the device records have changed the corresponding physics records must also be updated.
- Physics records for setting physics parameters to devices must be provided. When a value is set to the record, it is converted to a device parameter value an set it to the corresponding device record.
- For maintenance, the conversion system should be separated from the control system inside IOC's. It should be easy to implement various unit conversion functions for different types of device types. The parameter of the conversion functions must be maintained and should be updated easily.

DESIGN AND TECHNOLOGY CHOICE

We developed unit conversion system of magnet power supplies. First implementation is attempted with subroutine records inside IOC and tested for a DTQ magnet power supply. The test was successful but the following problems have appeared.

- Device records and records for unit conversion are closely mixed. It is not easy to separate the two functions. Also IOC reboot is necessary when modifying unit conversion function.
- The records are linked to each other in a complex way. Thus, it is difficult to maintain the record definition file (the database file).

To resolve these problems the following design was adopted.

- A Portable Channel Access Server, which is a C++ program which creates physics EPICS channels was chosen. An EPICS client function which is connected to the device records has been developed.
- Parameters for unit conversion function are read from a configuration file.

IMPLEMENTATION

A version of Portable Channel Access server developed at SNS was chosen as a base. A major modification has been done to include EPICS client functions for monitoring, reading, and setting a record. Parameters for unit conversion functions for each physics record, and its corresponding device record are defined in a configuration file in CSV format. The configuration file is maintained with the commissioning database and automatically generated. When the configuration file is modified, the record definitions can be updated by setting a value to a special "reset" record also inside the server. The records inside the server can be accessed with high frequency with multi-threading. Monitor records and set records are treated separately. When a monitor (read) record is read, a corresponding current monitor record in unit of current is read and the value is converted to magnetic field with *B(I)* and set to the magnetic field record and then finally the value is sent to the client. The device monitor record is also monitored always via EPICS monitor function and the corresponding magnetic field record is updated each time when the device monitor record is updated. When a value is set to the magnet field set record, the value is converted into current with *I(B)* and set to the corresponding current set record with "caput" function. In case of LINAC magnet power supplies, the conversion function *B(I)* is

parameterized as up to 3rd order polynomials. The reason is that the 3rd order polynomial can be solved analytically to calculate inverse conversion function *I(B)*. Since the 3rd order polynomial is often not sufficient to parameterize field saturation effect, the range of I is divided into 3 regions and parameterized separately with 3rd order polynomials with the boundary conditions that the function is continuous and differentiable. An example of a quadrupole magnet in J-PARC LINAC is shown in Fig. 1.

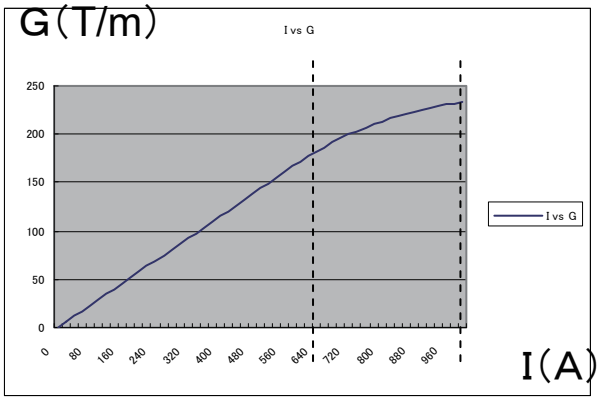

Fig. 1: An example of excitation function of a quadrupole magnet.

RESULTS

The number of monitor and set records of magnet power supplies in J-PARC LINAC are about 400. The server is PC with Linux RedHat Enterprise 4. The CPU is Dual Core AMD Opteron 2212 processor and memory size is 1GB. A typical update frequency of the monitor records is 1 Hz. The frequency of setting parameters is about 5 Hz at maximum. In a bench test, about 2000 channels can be handled without problems. During a beam commissioning since November 2007, the server has been working stably and crashed only a few times. The problems were identified to be due to improper way of unreferenced PV object inside eventCallback function for monitoring of device records. After bug fixes, a crash of the process has been observed only once during 3 months. Also there was a memory leak problem (due to missing deallocation of arrays) and but was repaired. There was a crash when values are set to set frequently (~ 20 records per second), which was repaired.

SUMMARY AND PROSPECTS

A PCAS based online unit conversion system has been developed for J-PARC LINAC. The system provides magnetic field monitor and set records for about 200 magnet power supplies at J-PARC LINAC. The system has worked stably during LINAC commissioning since November 2006. It is planned to implement a mechanism of automatic restart of the server process when it has died.

REFERENCES

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