Magnet Information Management System Based on Web Application for the KEK e-/e+ Injector LINAC

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Abstract

The KEK injector LINAC provides e-/e+ beams to four independent storage rings and a positron damping ring. An accurate information management system of accelerator components is very important since it is used for the development of a beam tuning model. In particular, an incorrect magnet database could cause a large deterioration of the quality of beam emittance. At LINAC, a text-based database has long been used for the device information management of magnet systems. It comprises several independent text files that contain master information for generating EPICS database files and other configuration files required for many LINAC control software programs. In this management scheme, it is not easy for common users except a control software expert to access and update any information. For this reason, a new web application-based magnet information management system is developed with the Angular framework and PHP scripts. In the new system, the magnet information can be easily extracted and modified using any web browser by any user. In this paper, we report the new magnet information management system alongside future prospects.

INTRODUCTION

The KEK e-/e+ injector LINAC [1, 2, 3] established the simultaneous top-up injection into five rings in 2019 to support both SuperKEKB particle collider experiments with the DR, LER and HER rings [4], and photon science experiments at the PF ring and PF-AR. Figure 1 shows the layout of LINAC and the lepton accelerator complex. At the most downstream part of LINAC, the third beam switching yard, one LINAC beam line branches to the beam transport lines with the deflecting pulsed bending magnet, as shown in Fig. 2. We succeeded in improving the efficiency of SuperKEKB collision experiments by more than 200% after the introduction of simultaneous top-up injections [5]. This noble injection scheme became indispensable because the beam lifetime of the SuperKEKB ring is quite short, especially at the LER positron ring, which was less than 10 min in 2021. The basis of this operation arrangement, LINAC gradually improved the injection performance and contributed to the achievement of the world-record collision luminosity of SuperKEKB [6].

For the SuperKEKB project, significant updates have been made to the magnet system at LINAC. In 2017, around 120 pulsed magnets were installed together with a new magnet control system [7, 8]. With a total length of 700 m, the injector LINAC currently employs approximately 600 DC and pulsed magnets for the beam operation.

As a tool for magnet system information management, a database using simple text files has been used for many years since the beginning of the KEKB project. The information contained within this database, such as magnet names, corresponding power supply specifications, and excitation curve parameters, has been used for the many different control system software programs based on the Experimental Physics and Industrial Control System (EPICS) [9]. However, the modification of this database is not very easy particularly for non-control software experts. To

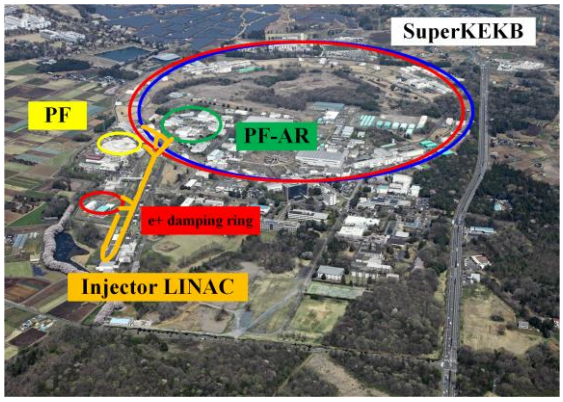

Figure 1: Layout of the KEK e-/e+ injector LINAC and the lepton accelerator complex.

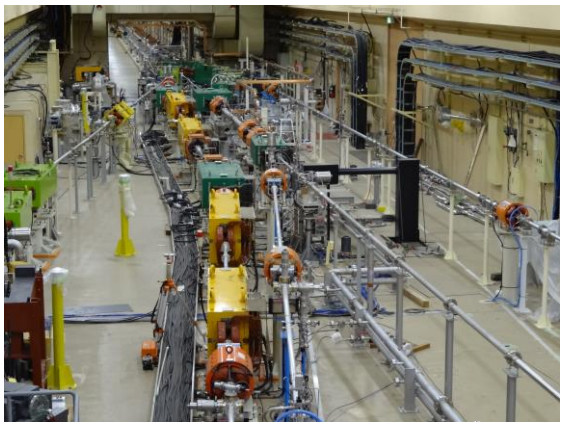

Figure 2: Photograph of the third beam switching yard at the KEK e-/e+ injector LINAC. The LINAC beam line branches to the beam transport lines with the deflecting pulsed bending magnet.

improve the usability of database handling, a new web application with a relational database was developed at LINAC.

ORIGINAL SYSTEM

At LINAC, the information of various devices, including magnets, beam diagnostics, timing systems, and RF systems, is managed using simple text-based database files. In particular, the precise control of magnets is very important for achieving good beam quality. The original magnet information management system comprised several independent database files. These database files are simple text files. The database file names and their contents are listed in Table 1.

The contents of these database files are the magnet names, corresponding power supply specifications, controller information, excitation curves, and others. During the maintenance in the summer of 2017, a substantial number of pulsed magnets were installed for simultaneous top-up injections. At LINAC, the database files were updated by control software experts, although the original device information has been managed by hardware experts. Consequently, since the process of database modification is not very simple, it takes time and could include incorrect parameters. To improve these inconveniences, a new web application was developed to consolidate the magnet information previously scattered across multiple database files into a unified database. Using the new web application with good usability, even non-control software experts can also easily modify the magnet information database.

Table 1: Text-based Database Files for Previous Magnet Information Management System

File name	contents
mgtbl.tbl	DC magnet controller (PLC) information
mgbasetbl.tbl	Pulsed magnet controller (PXI) information
mgpvtbl.tbl	Magnet name/EPICS PV name table
mgbtbl.tbl	DC magnet excitation curve (magnetic field)
mgktbl.tbl	DC magnet excitation curve (k value)
mgbptbl.tbl	Pulsed magnet excitation curve (magnetic field)
mgbftbl.tbl	DC magnet fudge factor
mgbfptbl.tbl	Pulsed magnet fudge factor

NEW SYSTEM

System Outline

The new magnet information management system has been implemented as a web application to ensure easy access by any application user including non-control software experts. Figure 2 shows the software structure of the new system. Angular is used for the implementation of the frontend. Angular is a widely used open-source single-page web application framework developed by Google [10]. At LINAC, Angular has already been used for the electronic operation logbook and archive viewer web applications.

The web server using Apache HTTP is running on HPE SimpliVity as high-availability server computers. PostgreSQL is also running on the HPE SimpliVity server as the backend database. Data communication among the web server, frontend, and backend database components is conducted using PHP scripts, a widely used programming language for server-side web application development. It enables easy access to the database.

Features

The access permission to this system is fully controlled through by the username and its corresponding password.

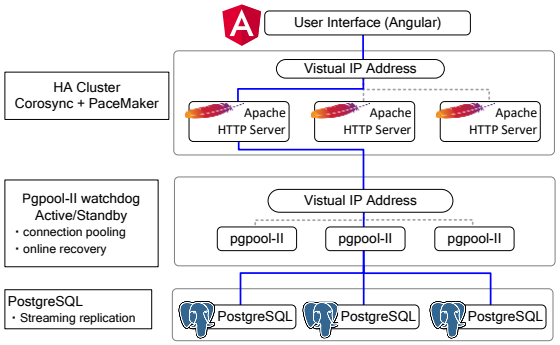

Figure 2: Software structure of the new magnet information management system at the KEK e-/e+ injector LINAC.

Figure 3: Login page screenshot of the magnet information management system.

For each user, a specific permission can be assigned such as read only or read-and-edit access. The access control of the database can be managed using the already existing Lightweight Directory Access Protocol (LDAP) server at LINAC. After authenticating by the username and password through the login screen as shown in Fig. 3, users can access the operational interface of the system. A screenshot image of the main page that appears after user authentication is shown in Fig. 4.

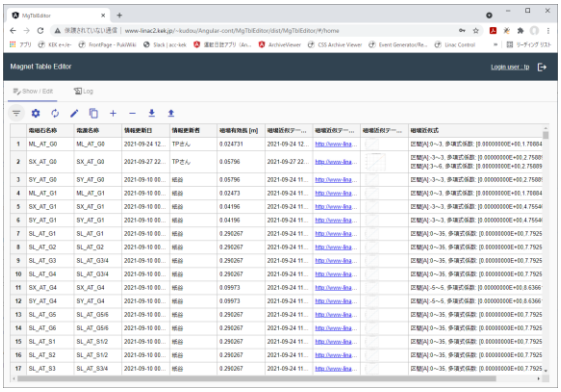

Figure 4: Main page screenshot of the magnet information management system.

In this system, it is possible to manage approximately 100 data column components for each magnet, including the magnet name, corresponding power supply specifications, controller information, and excitation curve. The items listed in the web browser can be freely modified by the user via the popup dialog box. Furthermore, these data can be edited, added, and deleted directly within the web browser by the allowed users. A screenshot of the data editing page is shown in Fig. 5.

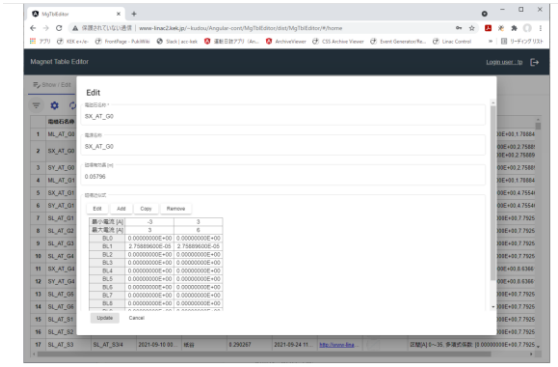

Figure 5: Edit page screenshot of the magnet information management system.

At the initial operation of this new system, many data entries should be imported to the database. Performing such tasks one by one through a web browser takes considerable amount of time and labor. Therefore, the bulk import feature is implemented for handling a large number of data by batch processing with the CSV file format. In addition, all data or the selected data can also be exported to the CSV file for some other purposes.

Currently, the database of this system contains the information of 591 magnets at LINAC. The magnet types are the DC steering, DC bending, DC quadrupole, DC sextupole, pulsed steering, and pulsed quadrupole magnets. Since the total number of registered data is large, the user can show only specific data by filtering against specific criteria. In this filtering feature, the user can use multiple keywords for a quick search of the desired results. A screenshot of the page with filter condition settings is shown in Fig. 6.

In device information management systems, one of the key issues is to maintain a database with correct contents. After the modification of the beam line, the updated information should reflect the contents of the database as quickly as possible. Since some parts of the database contents are used by other control software programs and beam simulation models, wrong contents of database cause severe operational problems and the deterioration of beam quality. Hence, the quality control of the database contents is one of the critical issues. In this new system, the user can easily check the database change log as shown in Fig. 7. In the previous system, the database change log was manually documented in the file header part of the database files. However, since it may lead to incorrect contents, the new system can automatically update the database change

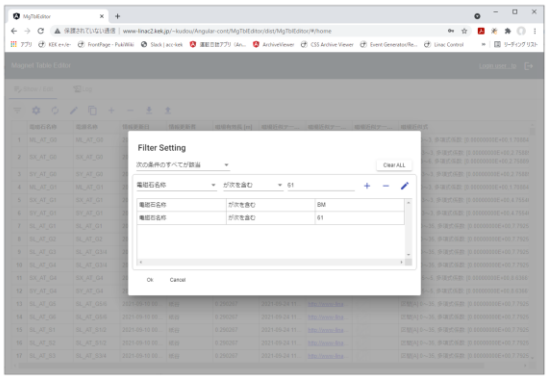

Figure 6: Filter settings page screenshot of the magnet information management system.

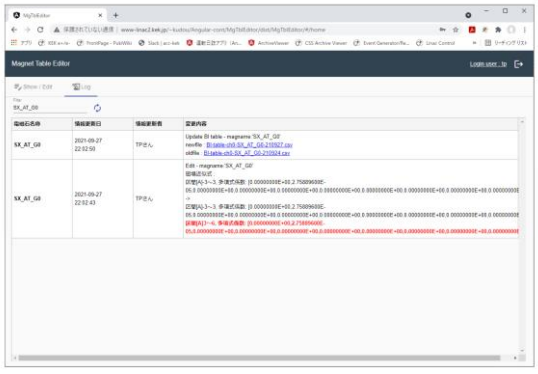

Figure 7: Database change log page of the magnet information management system.

log to maintein the correctness and reduce the user labor of manual input by user.

SUMMARY

At LINAC, the new web application has been developed and implemented for the management of magnet information. In the previous system, several independent text files were used as the backend database. Using these database files, shell or Python scripts can automatically generate the files required for the EPICS database and configuration of various operation software programs. In the new system, since multiple database files are consolidated using PostgreSQL, the complexity of managing these database files is markedly reduced. In addition, even non-software experts can easily modify the database using the operational interface of the web application. In the near future, we will expand this software framework to the information management of other devices, such as an accelerating structure, klystron, and a beam monitor.

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[10] Angular; https://angular.jp/.