

DEVELOPMENT OF OPERATOR INTERFACE USING ANGULAR AT THE KEK e-/e+ INJECTOR LINAC

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Abstract

At the KEK e-/e+ injector LINAC, the first electronic operation logbook system was developed in 1995 using a relational database. This logbook system can automatically record the detailed operational status. In addition, operators can manually input detailed information about operational problems, which is highly helpful for future troubleshooting. In 2010, the logbook system was improved with the implementation of a redundant database, an Adobe Flash-based frontend, and an image file handling feature. In 2011, we started using the CSS archiver system using PostgreSQL as a backend database and a new web-based archiver viewer developed by Adobe Flash. However, with the discontinuation of Adobe Flash support at the end of 2020, it became necessary to develop a new frontend without Adobe Flash for both the operation logbook and archiver viewer systems. For this purpose, the authors adopted the Angular framework, which is widely used for the development of web applications using JavaScript. In this paper, we report the development of operator interfaces using Angular for the injector LINAC.

INTRODUCTION

The KEK e-/e+ injector LINAC [1, 2] established the simultaneous top-up injection to five independent rings in 2019 to support both the SuperKEKB particle collider experiment with DR, LER and HER rings [3], and the photon science experiment at the PF ring and PF-AR, as shown in Fig. 1. It succeeded in improving the efficiency of the SuperKEKB collision experiment more than 200% before and after the introduction of the simultaneous top-up injection [4]. This noble injection scheme became indispensable because the beam lifetime of the SuperKEKB ring is short, especially at the LER positron ring, which was less than 10 min in 2021. On the basis of this operation arrangement, the injector LINAC has gradually improves the injection performance and contributed to the achievement of the world-record collision luminosity of SuperKEKB [5].

At the injector LINAC, the beam operation status and its history have been automatically recorded with an electronic operation logbook system. In 1995, the first operation logbook system was developed with Microsoft Access (MS-ACCESS) and Microsoft SQL (MS-SQL) on the Windows 2000 server because of the easy database management and development of the user interface. MS-ACCESS is a frontend component, and it decreases the CPU load of

MS-SQL. The console PC and MS-SQL are connected through Open Database Connectivity (ODBC), and an operator can enter the current operation status of LINAC in the Japanese language. After 1999, the beam injection into the KEKB ring started and the data size markedly increased. After that, the electrical operation logbook system has been gradually improved. Finally, the backend database was replaced with PostgreSQL, and the frontend component, which operates within web browsers, was developed using Angular [6], a well-known web application framework, in addition to React. Additionally, the viewer web application for the data archiver system was also developed and has been operated using Angular.

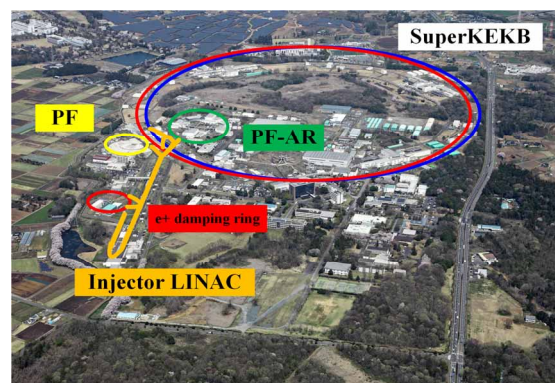


Figure 1: Layout of the KEK e-/e+ accelerator complex with beam properties from the injector LINAC to five independent rings.

PREVIOUS OPERATOR INTERFACE

In injector operations, following the transformation of the electronic operation logbook system into a web application in 2010 [7], Adobe Flash was extensively employed in the frontend of web applications. Flash applications offered enhanced usability and expressive capabilities compared with simple HTML-based pages. They could run on computers with Flash Player, regardless of the operating system, and being web applications, they facilitated easy redistribution, significantly reducing operational complexity compared with native applications that required installation. These applications had been stably operated since their development. However, with the discontinuation of Adobe Flash Player support by major web browsers in 2020, a transition to a new framework became imperative.

At the injector LINAC, Angular emerged as a promising framework to replace Adobe Flash. Angular is a web application framework developed by a community led by

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Google, and it is well suited for building Single Page Applications (SPAs). SPAs operate swiftly, much like native applications, as they transmit and receive only the necessary data without performing full-page reloads.

NEW OPERATOR INTERFACE

Electronic Operation Logbook System

The electronic operation logbook system comprises a database component, an automatic operation information recording component, a user interface (UI) component, and a web page generation component for delivering operation information. From the viewpoint of affinity with the existing LINAC operation software, this system was developed as application software on the Linux operating system. PostgreSQL is used as the backend database component. The system employs a redundant configuration with three database servers, as shown in Fig. 2. For the redundant operation, we adopted the replication feature of PostgreSQL and Pgpool-II, which is a middleware that works between PostgreSQL servers and a PostgreSQL database client. Communication between the database servers and the UI component is facilitated with PHP scripts.

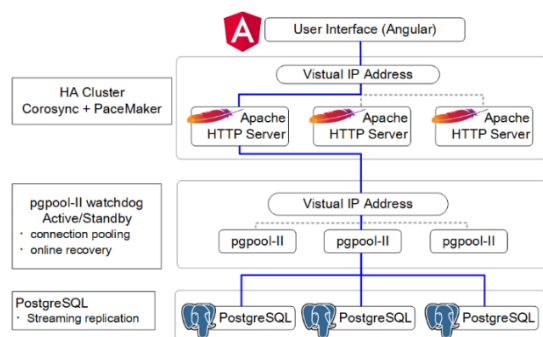


Figure 2: Software block diagram of the electronic operation logbook system.

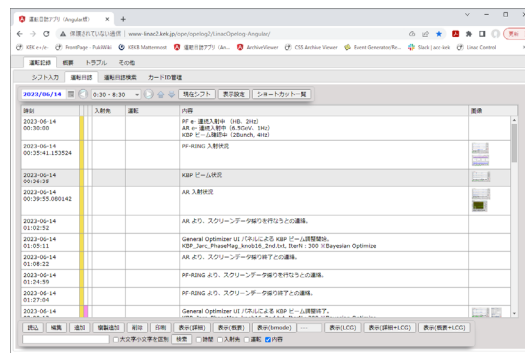
The total number of application screens developed using Angular is nine. These application screens cover functions such as the input/edit of operation logs, the input/edit of troubleshooting information, information retrieval, and uploading image files. As the system is constructed as an SPA, the transition between different screens is sufficiently fast, which is very important for the usability of software.

As shown in Fig. 3, during input/edit operations, the dedicated dialogs pop up. In this popup dialog screen, the operator can upload files such as images, videos, and URLs, or enter the detailed event contents.

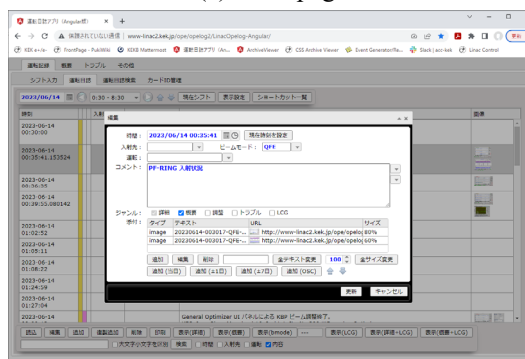
Archive Viewer Web Application

The injector LINAC control system has been developed using the Experimental Physics and Industrial Control System (EPICS). As a machine parameter archiving system, the Channel Archiver, one of the EPICS tools developed at the Spallation Neutron Source in 2004, was introduced. However, because of the discontinuation of the Channel Archiver development, the CSS Archiver [8] was adopted in 2011, and the Archiver Appliance (AA) was introduced in 2019, subsequently facilitating its operation [9].

Although both CSS Archiver and AA packages include graphing tools for archived parameters, their functionalities are limited. To improve the usability of viewer functionality, an Archive Viewer web application was developed.



(a) Main page



(b) Edit dialog

Figure 3: Screenshot of the web-based electronic logbook user interface.

This application has the functionalities such as keyword searches for recorded EPICS process variables (PVs), plotting multiple PVs on a single screen, plotting calculated values from retrieved data, zooming via mouse interaction, and toggling the visibility of individual PVs. It supports up to 10 independent vertical axes, each of which can be customized with titles, font colors, sizes, and logarithmic scaling. An example utilizing five vertical axes is illustrated in Fig. 4. In addition to line graphs, scatter plots can also be plotted, facilitating the easy examination of correlations among different PVs.

Data retrieval periods are not only specified by the exact date and time but also allow for relative time specifications. Through its auto-screen-update feature, the application can automatically display the most recent historical information. It can easily work as a simple real-time monitoring tool for the selected PVs. Moreover, since these settings can be saved into files, application users can significantly reduce the detailed configurations.

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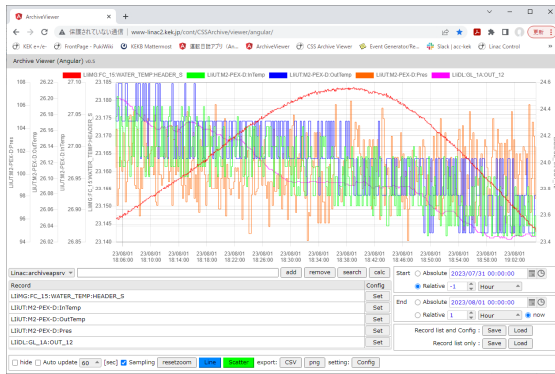


Figure 4: Screenshot of archive viewer web application. Archive data are plotted with five independent vertical axes.

RF Conditioning Status Recording System

During a certain period following a prolonged machine maintenance as in the case of the summer shut down, the injector LINAC conducts RF conditioning. To monitor and record the status of 60 klystrons, an RF conditioning status recording system was developed. Similarly to the electronic operation logbook system, this system employs PostgreSQL as the backend database component and Angular as the frontend UI component.

This system can manage various items, including the currently automatically updated klystron setting voltage and manually input conditioning target values from the UI. When the current setting voltage reaches the target value, the background color of the corresponding klystron changes to enhance the visibility of the RF conditioning progress. Moreover, application users can fill in a detailed description, such as the reason for changing the target values. As shown in Fig. 5, the dedicated dialogs pop up for input/edit operations.

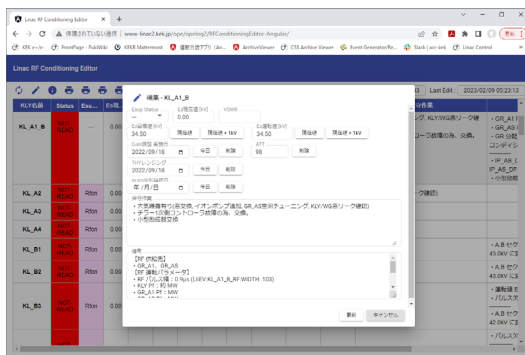


Figure 5: Screenshot of RF conditioning info editor.

Web Application for Magnet Information Management

The injector LINAC comprises approximately 600 electromagnets. The detailed device parameters such as an excitation curve and the corresponding power supply specifications were previously managed using a database based on simple text files. Since there were several different database files in the previous system, database update work required much effort. To simplify the updating database

work, a web application based on a relational database for magnet information management was developed and launched for operation in 2022 [10].

This system, similarly to the electronic operation logbook system, employs PostgreSQL as the backend database component and Angular as the frontend UI component. Access to the system is restricted by usernames and passwords, allowing for varying attributes to be set per user, such as read-only access or both read and edit access. User management is integrated with the existing LDAP system already operating at the injector LINAC. The main page screenshot is shown in Fig. 6. It appears after user authentication.

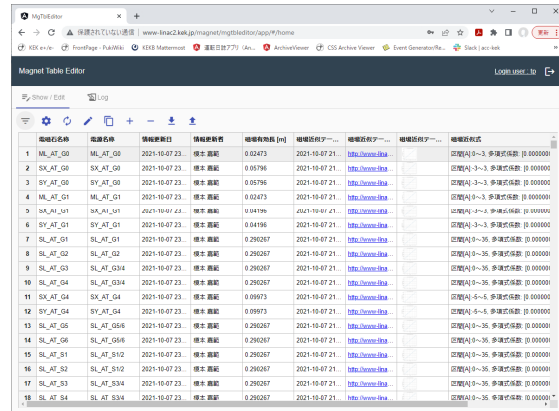


Figure 6: Main page screenshot of magnet information management system.

In this system, approximately 100 different types of data can be managed for each electromagnet, including the name of the electromagnet, the corresponding power supply specification, and the coefficients of the polynomial fit for the excitation curve. Application users can freely customize the items displayed on the web browser and extract data through filtering by combining multiple keywords as desired. In addition to the operations of editing, adding, and deleting items directly on the web browser, the system also implements the import and export functionalities via the CSV file format. This feature significantly reduces the time required for updating a large amount of data.

The previously used text-based database employed file headers to record update histories. However, owing to manual updates, there was a risk of incorrect or missing entries. To avoid inaccurate historical information, the system has a feature for easily comprehending update histories. Figure 7 shows a screenshot of the information update history page. Since this function automatically records the detailed update histories, the historical information is more reliable than that of the previous software.

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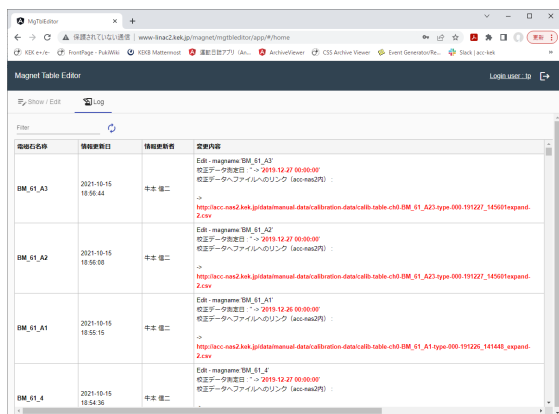


Figure 7: Changelog page screenshot of magnet information management system.

SUMMARY

At the KEK e-/e+ injector LINAC, the web applications with Adobe Flash were developed for operator interfaces, including the electronic operation logbook system, and had been operated for a decade. However, because of the discontinuation of Adobe Flash Player in 2020, the transition to a new framework became an urgent necessity. Therefore, at the injector LINAC, new web applications are developed using Angular, a web application framework developed by a community led by Google. These applications have been stably used for daily machine operations. In the near future, we will expand the software with the similar structures to other device management software such as an accelerating structure, a klystron, and a beam monitor.

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