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IMPROVEMENT OF TEMPERATURE AND HUMIDITY MEASUREMENT SYSTEM FOR KEK INJECTOR LINAC

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Abstract

A new temperature and humidity measurement system at the KEK injector Linac consists of 26 data loggers connected to around 700 temperature and humidity sensors, one EPICS IOC, and CSS archiver. CSS archiver engine retrieves the temperature and humidity data measured by the data loggers via ethernet. These data are finally stored into the PostgreSQL database system. A new server computer has been recently utilized for the archiver of CSS version 4 instead of version 3. It can drastically improve the speed performance for retrieving the archived data in comparison with the previous system. The long-term beam stability of Linac is getting a quite important figure of merit since the simultaneous top up injection is required for the independent four storage rings toward the SuperKEKB Phase II operation. For this reason, we developed a new archiver data management application software with a good operability. Since it can bring the operators a quick detection of anomalous behaviour of temperature and humidity data resulting in the deterioration of beam quality, the improved temperature and humidity measurement system can be much effective for the daily beam operation. We will report the detailed system description together with the future plan.

INTRODUCTION

The KEK injector Linac is a linear accelerator with a total length of about 600 m, which is composed of the ground floor (klystron gallery) and underground floor (tunnel). Approximately 60 rf sources (high-power klystron and modulator) for accelerating the beam are installed in klystron gallery. The klystron gallery is divided into sectors of about 80 m. A part of device name and EPICS PV name include the corresponding sector name. The klystron gallery is divided into 8 sectors in order from the upstream electron gun to the downstream.

In order to operate the beam of injector Linac stably, the temperature of each subsystem and its surrounding environment are very important information. The stability of the cooling water temperature of the acceleration tube and the SLED should be within 30 ± 0.3 °C in KEK injector Linac. Furthermore, it is necessary to adjust the temperature of klystron within 30 ± 0.5 °C. A change of the room temperature or the cooling water temperature may cause the variation of beam acceleration phase. Eventually, it could result in the change of beam energy. For this reason, the present measurement system has been introduced for monitoring the temperature and humidity [1] in 2006.

In the KEK Linac control system, the version of CSS [2, 3] was updated from version 3 to version 4 in January 2017. In addition, a new server computer based on Linux has been utilized aiming at the improvement of data retrieving speed performance. The SuperKEKB Phase II operation is going to start the early stage of next year.

Since the simultaneous top up injection to the downstream five rings will be carried out, the higher beam stability is strongly required. In such case, the precise temperature and humidity measurements are quite important, and they are required the fine control of them. For this purpose, we developed a new data viewer with a good operability. It can also show the large number of data points with a quick response, and has an alarm function for detecting the abnormal values all the time. We have deployed them for the daily operation. In this paper, we report the details of this temperature measurement system and the alarm display panel.

SYSTEM DESCRIPTION

The temperature measurement system operated at the KEK injector Linac has a total of 720 sensor units consisting of resistance temperature detector (RTD, Pt 100), thermocouple (K), humidity sensor, and 26 data loggers. The resolution of the data logger is 0.01 °C. Its sampling speed and communication rate are 10 Mbps and 56 Hz, respectively. The sensors were installed at the upper side of the klystron gallery in each sector to measure the room temperature. For the cooling water of accelerating structure, each sensor is attached to the input and output ports. Figure 1 shows the pictures of the sensors for the room temperature and cooling water temperature measurements.

Figure 1: Pictures of the temperature sensor in the klystron gallery (left) and for the cooling water of accelerating structure (right).

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We collect data measured by sensor with data logger near sensor and manage with EPICS IOC. Figure 2 shows pictures of the communication unit, power supply unit, and input unit of the data logger.

Figure 2: Picture of the data logger provided with the communication unit, power supply unit and input units.

In each sector, three or four data loggers are installed, and the total number of data loggers is 26 for the temperature and humidity measurements. Table 1 shows the types of objects to be measured and the number of sensors. Figure 3 shows the schematic layout of all 26 data loggers for each installed location at the injector Linac. The names of measured objects are also shown in the same Figure.

Table 1: Type and Number of Measuring Object for the Temperature and Humidity Measurement System

Measurement object	# of measurement points
Klystron Modulator	244
Timing System Rack	15
RF Window	66
SLED	66
Sub-Booster Klystron	9
Thermostatic Chamber	91
Thermostatic Chamber (humidity)	11
VXI	67
ACC Cooling Water	43
SLED Cooling Water	16
Klystron Cooling Water	61
Gallery	8
Tunnel	8
Klystron Test Hall	2
Klystron Test Hall (humidity)	2
Outside	4
Gun	7
ALL	720

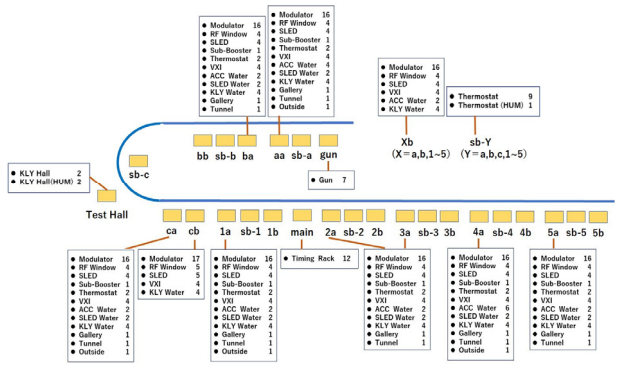

Figure 3: Schematic layout of data loggers for the temperature and humidity measurement system at the KEK injector Linac.

DATA ACQUISITION SOFTWARE

The KEK accelerator facility uses the control system software framework called Experimental Physics and Industrial Control System (EPICS) [4] for the accelerator control. EPICS is a tool kit for implementing the control system that began to be developed mainly in the US Los Alamos National Laboratory and Argonne National Laboratory. Today, it is being developed as collaborative research of research facilities around the world. CSS is a set of control system tools for operating and monitoring a large scale control system such as accelerator, which was developed by DESY based on EPICS and Eclipse IDE. Currently, it is jointly developed by many research institutes, and it can be operated on multiple OS such as Linux, Windows, and Macintosh. CSS has abundant tools for accelerator control, data collection tools, GUI, alarm system, and so on. This alarm system is composed of the multiple software components, and it has been already utilized in the injector Linac.

The data collection software is built on CSS archiver, which is a standard tool for data logging in EPICS control system framework [5]. Figure 4 shows an overview of the data collection software for the temperature measurement system in the injector Linac.

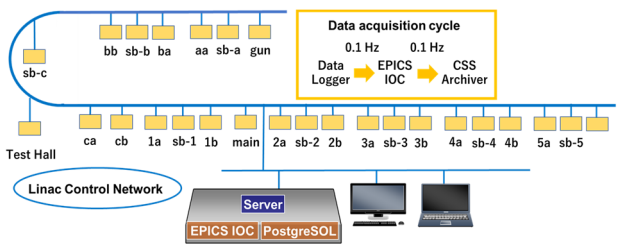

Figure 4: Schematic layout of data acquisition software for the temperature and humidity measurement system at the KEK injector Linac.

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The temperature and humidity measurements via all 26 data loggers are managed by the only one EPICS IOC running on the Linux computer. The measurement data obtained by each sensor is firstly collected by the data logger. The EPICS IOC was developed by using the EPICS driver for PLC called NetDeV. The measured data by the data logger can be read via EPICS PV from the client software. The CSS archiver engine acquires the EPICS PV data and records them into PostgreSQL which is a Relational Database Management System (RDBMS). We developed the web application using AMFPHP for displaying the CSS archiver data. This web application can be operated on all platforms with Adobe Flash Player being available.

VIEWER AND ALARM SYSTEM

Conventional Measurement System

In the conventional temperature measurement and alarm system, only the limited number of measurement points has been monitored by the temperature sensors. In the conventional alarm system, the threshold value to each data point is set as the appropriate value with the predetermined nominal value. The CSS alarm framework has been used for the injector Linac control system. So far, we set the alarm threshold values to the limited number of EPICS PVs. We have developed a web application that can display the archiver data according to the selected period and EPICS PV [6]. Figure 5 shows the screen shot example of the CSS archiver viewer for displaying the data of the temperature sensor installed in the injector Linac. However, it takes relatively long time to display the large number of data points. For this reason, a new software is strongly required to reduce the consumed time for archiver

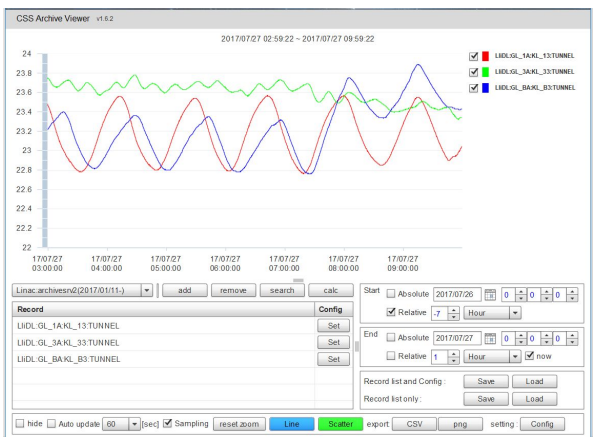

Figure 5: Image example of the web application as CSS archiver viewer for the KEK injector Linac.

data retrieving. It could be effective for enhancing the beam commisioning productivity.

New Measurement System Software

We developed a new software panel for temperature measurement system. The new software is based on the Python scripting language and the matplotlib library which is a standard library for drawing graphs in Python. We also use Tkinter, a standard library for building and manipulating GUIs in Python, and use Linacmenu class library developed in injector Linac for conveniently creating Tkinter menu bars. In addition, the Readarchiver_CSS module developed in Linac is utilized for reading CSS archiver data via Python. With this new software, the temperature and humidity data acquired by CSS archiver can be always packed as one text formatted file in every hour. The data retrieving speed performance of the new software is much faster in comparison with the original CSS archiver viewer. Moreover, we have greatly improved the operability for multiple data display over a long period of time due to the data selection functionality of the filtering option by the type and installed location.

New Alarm System Software

Figure 6 shows the image example of the new archiver data viewer and alarm display panel for managing the temperature and humidity at the KEK injector Linac. These software panels provide an easy operability and the fruit

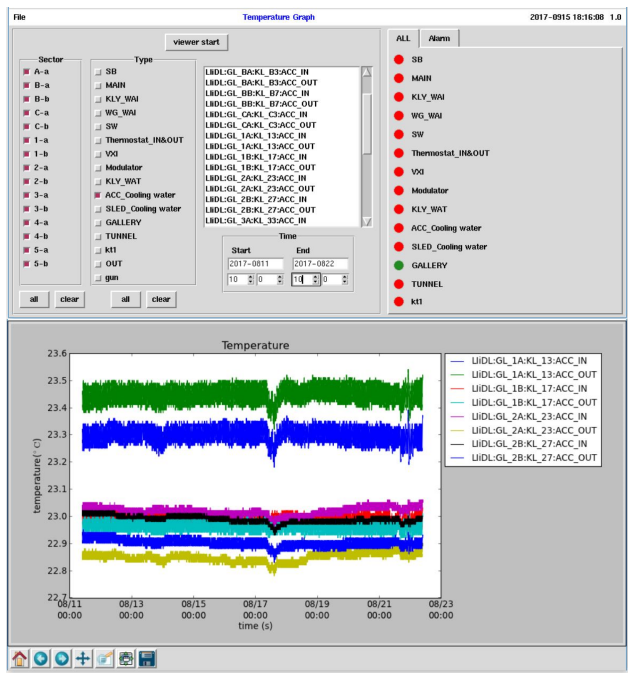

Figure 6: Image example of the new archiver data viewer (top) and alarm display panel (bottom) for managing the temperature and humidity at the KEK injector Linac.

functionality.

The new alarm system can easily determine the threshold value by calculating the standard deviation value from the measured data during a certain period. This threshold can be set in the alarm field of EPICS PV. In every 10 seconds, the CSS alarm monitors whether the current measurement data is anomalous value in comparison with the threshold calculated above scheme.

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SUMMARY AND FUTURE PLAN

By using the newly developed software, we can monitor the temperature and humidity of various devices affecting the beam operation of the KEK injector Linac. The software can quickly detect the defects of the measured temperature and humidity data. In addition, the usability of the software panel is also drastically improved.

In the near future, we have a plan to watch the anomalous value by using this new alarm system, not only for the temperature and humidity data but also for the status value of other subsystems like rf phase, magnet excitation current, timing signal delay, and so on. Regarding the calculation scheme of the threshold setting value, it is planned to decide a more appropriate threshold value by using the result of machine study soon. The new developed software has a good operability and a rich functionality. It can enable us for the quick detection of the anomalous data behaviour. Such function will be resulting in the grate contribution to the stable beam operation in the KEK injector Linac.

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