MONITOR OF SEISMIC VIBRATION FOR THE KEK LINAC

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Abstract

A real-time monitor of seismic vibration has been developed at the KEK Linac. The monitor comprises a VME-bus-based computer as a front-end interface, an Ethernet as a high-speed communication network, and a Unix-based workstation as a host computer. The purpose of the monitor is to provide basic knowledge concerning seismic vibration at the KEK Linac, which will be important for a precise alignment of the accelerator components needed for any future upgrade of the Linac.

1 Introduction

The influence of vibration is one of the crucial problems regarding future large-scale accelerator design, since vibrations may cause emittance growth or a reduction in the luminosity at collision points [1]. It is therefore important to study the seismic vibration around KEK, since knowledge concerning vibration is indispensable for a precise alignment of the accelerator components needed for any future upgrade of the KEK Linac.

Some studies have already been carried out at KEK. A building distortion caused by thermal stress due to solar irradiation was reported at the ring of the Photon Factory [2]. Ground motion in the frequency range between 10 mHz and 100 Hz was measured in relation to an active supporting table for the Accelerator Test Facility (ATF) [3]. In 1992, we also carried out an investigation of environmental vibration with respect to the Linac beam characteristics. Seismic vibrations in the range between 0.1 Hz and 100 Hz were measured in collaboration with the University of Tokyo [4].

After the collaboration was finished, we have experienced that it is important to have a real-time monitor for vibrations which is always available at the KEK site. Continuous observation is essential in order to determined the origin of vibration noise. In this article, we report on details concerning the real-time monitor of seismic vibration which we have developed. A discussion regarding instrumental aspects is also presented.

2 Real-time Monitor of Seismic Vibration

2.1 Setup of the monitor

A commercially available seismic probe (RION LS-20C, an accelerometer with a sensitivity of 3 mV/gal) is used for the monitor. Two probes, one for the horizontal (X) and the other for the vertical (Z), were set on the floor of the Linac tunnel [4]. We selected the frequency range to be from 1 to 10 Hz. A low-pass filter at 10 Hz is used to cut out the higher frequency region.

A schematic view of the monitor system is shown in Fig. 1. Since the observation site is in the Linac building, it is convenient for us to utilize the resources of the Linac control system (networks, communication software, etc.) [5, 6, 7]. It comprises three parts: a VME-bus-based computer as a front-end interface, an Ethernet as a high-speed communication network, and a Unix workstation as a host computer. We are currently using a Force computer (25MHz 68040, OS-9) for the front-end, and a Sparc2/IPX for the host, respectively. It is worth noting that the front-end and the host computer are physically separated, and that both are interconnected by a communication network.

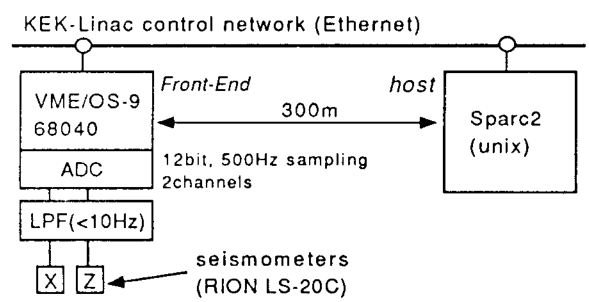

Figure 1: Schematic view of the monitor for seismic vibration.

2.2 Data-taking processes

The flow of signals along with the corresponding data-taking processes is given in Fig. 2. Signals from two probes are fed into the VME 12-bit ADCs. A sampling frequency of 500 Hz is to be used for a future upgrade of the monitor (see section 3.3), though it is not necessary for the frequency region of current interest (1–10 Hz). Digitized data are buffered once on the memory at the front-end VME computer, and then transferred to the host at intervals of every 32 ms. Data transfer relies on the network communication library [5] based on the TCP/IP socket functions.

All of the subsequent processes take place in the host workstation. The received binary-data is converted into ASCII streams, then reduced by the appropriate ratio (in our case 25) to be recorded in a raw-data file. As a matter of fact, the raw-data file contains vibration signals digitized using the 20-Hz sampling frequency.

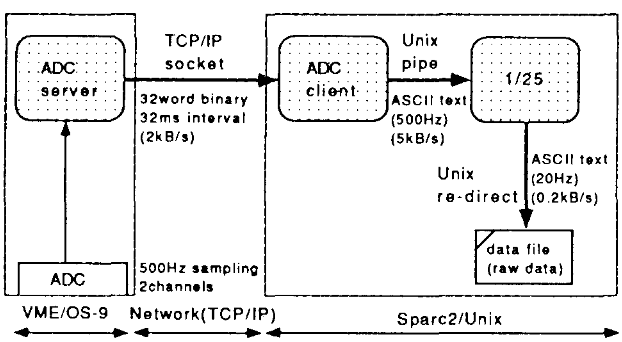

Figure 2: Data-taking processes. Finally digitized signals are saved in a raw-data file.

2.3 Data analysis and display

A procedure for data analysis is given in Fig. 3. During the usual operation, a raw-data is created at intervals of every 102.4 seconds; then, the power-spectrum density (PSD) is calculated. The old files (raw-data and PSD) are kept in a scratch disk for a while for later analysis.

These PSD files are converted to a graphic screen on an X-window with a general-purpose graphic tool.[1] In addition, the raw-data files are used to provide a time domain display. An example of monitor display is presented in Fig. 4.

[1] We currently use "gnuplot".

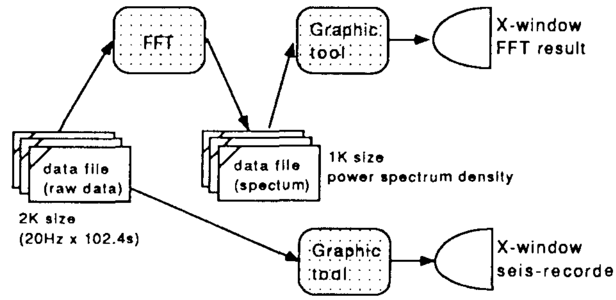

Figure 3: Processes for data analysis and display.

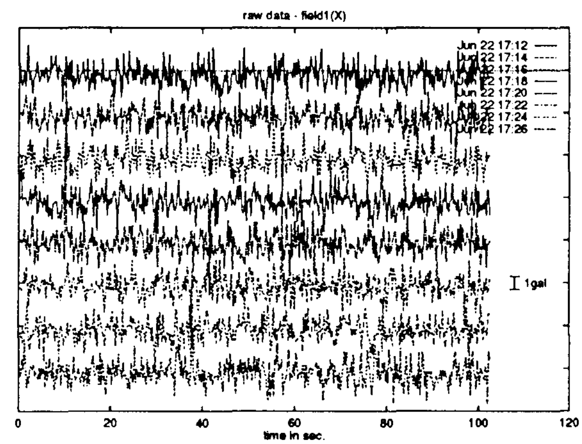

Figure 4: Example of seismic-vibration (horizontal signal only) raw data. Eight successive intervals (819 seconds in total) are shown.

3 Discussion

3.1 Data transfer through an Ethernet

We use a conventional Ethernet (10BASE5) as a data-transfer network. The overall transfer rate is roughly 2 kB/s, which is two orders lower than the maximum capacity of an Ethernet. This fact tells us that more channels (currently two) can be transferred.

The typical transfer time for the present 64-byte data has been evaluated to be 5 ms. Taking into account a random delay caused by a packet collision, the transfer time is sufficiently short to ensure a repetition with a 32 ms interval.

3.2 Real-time display

The refresh rate of the screen is set to be typically 10 seconds, which is sufficiently frequent compared with the data-file renewal interval. However, a faster refresh rate is desired in the future, especially for the raw-data display. Since general-purpose graphic tools involve overhead to fit our real-time requirements, a dedicated program for a real-time presentation is desired.

3.3 Future directions

At present, we have only one monitoring station. It is apparent that the observation of a few points separated from each other along the Linac is necessary for investigating the origin of vibration and the location dependence. It could be easy to extend the present system to have more observation points by introducing copies of the front-end system, and connecting them with the communication network.

The present probe (LS-20C) is insensitive for investigating the frequency region below 1 Hz. In addition, a displacement sensor is suitable for studying the effect of vibrations on the accelerator characteristics. In any case, other types of sensors should be considered at any future extension of the system.

The standard interpretive shell programming technique, such as pipe and re-direction, is used in the host computer (Fig. 2). It is especially convenient at the development stage of the system. Moreover, it enables us to utilize various conversion programs available at Unix workstations. It is possible to monitor two frequency regions at once by dividing the single ASCII stream into two. For example, one stream can be used for the 0–250 Hz range, and another for the 0–10 Hz, for the case of the present monitor.

4 Acknowledgement

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References

[1] For instance, U. Amaldi, Symp.on Critical Issuers in the Development of New Linear Colliders, Madison, WI, August 1986, (Madison Accelerator Symp. 1986), (CERN-EP/86-210) p.413

[2] T. Katsura, et.al., Proc. of the 3rd European Particle Accelerator Conference (EPAC92), Berlin, Germany, March 1992, p1631

[3] S. Takeda, K. Kudo, Y. Funakoshi, A. Akiyama and Y. Kanazawa, submitted to the 4th European Particle Accelerator Conference (EPAC94), London U.K., June 1994; KEK Preprint 94-48

[4] Y. Ogawa, K. Furukawa, N. Kamikubota, Y. Saito, T. Shidara, I. Sato, A. Asami, A. Araya and K. Tsubono, 1992 Linear Accelerator Conference Proceedings (LINAC92), Ottawa, Ontario, Canada, August 1992, p.743

[5] N. Kamikubota, K. Furukawa, K. Nakahara and I. Abe, Proc. Int'l Conf. on Accelerator and Large Experimental Physics Control Systems (ICALEPCS'91), Tsukuba Japan, November 1991, p.318

[6] N. Kamikubota, K. Furukawa, K. Nakahara and I. Abe, Nucl. Instr. Meth. A(1994) in press; KEK-Preprint 93-137

[7] N. Kamikubota, K. Furukawa, K. Nakahara and I. Abe, "New Control System for the KEK Linac", submitted to this conference, KEK-Preprint 94-73