A New High Performance Data Acquisition System and Application to a Betatron Oscillation Monitor

J.Kishiro[1], S.Igarashi[1], K.Nigorikawa[1], Y.Takeuchi[2], T.Toyama[1], Y.Yamaguchi[2] , T.Kondo[3].
1 High Energy Accelerator Organization, Japan, KEK, 1-1 Oho Tsukuba, Ibaraki, Japan
2 Yokogawa Electric Corporation, Japan, YOKOGAWA, 2-3-9 Naka-machi, Musashino, Tokyo, Japan
3 Emac Corporation, Japan, EMAC, 4-19-11 Minami-tanaka, Nerima, Tokyo, Japan

Abstract

A new system of a betatron oscillation monitor in the KEK 12GeV proton synchrotron has been developed. System is a combination of a transverse beam kicker, betatron oscillation beam monitor and a fast data acquisition. The circulating beam is transversely kicked by a white noise signal and a digitizer module acquires the detected oscillation signal and automatically FFT analyzed. Noise generator, power amplifier controller, fast digitizer *etc*. are installed in a separated powered chassis and connected each other by employing an optical fiber network. Data acquisition system by a combination of plug-in-modules and chassis is newly developed by Yokogawa electric corporation [1] according to plug-and-play architecture.

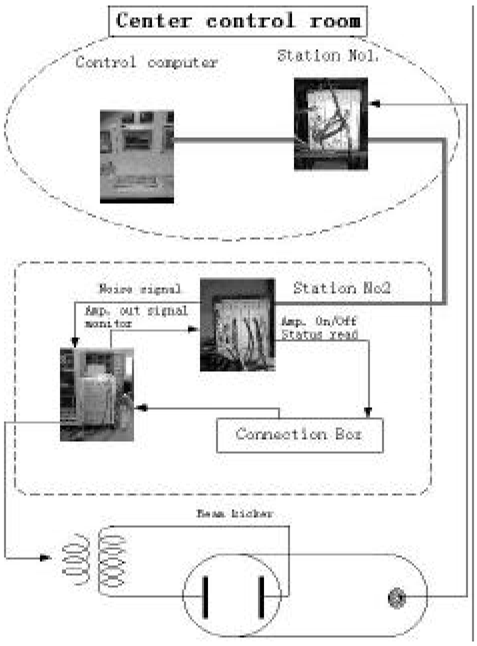

Figure 1. System configuration.

1 Betatron oscillation monitor system.

The betatron oscillation monitor system consists of a white noise generator, transverse beam kicker and fast data acquisition modules. System configuration is depicted in figure 1.

Noise signal bandwidth is controlled so as to include the several spectrums of the betatron oscillation side bands around the revolution spectrum in order to obtain an efficient transverse kick. The amplitude of the beam kick is controlled sufficient but as small as possible for detecting the beam transverse oscillation without any degradation of the beam quality[2]. Figure 2 shows the cross sectional view of the beam kicker electrode.

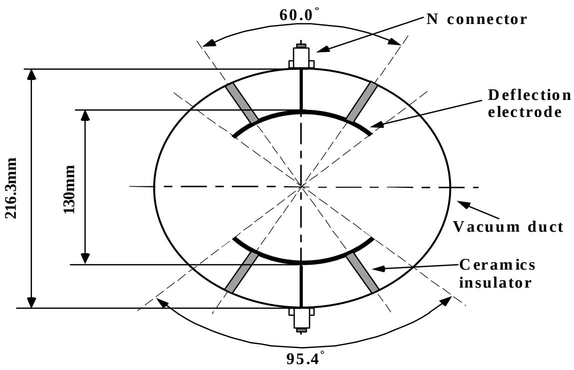

Figure 2. Cross sectional view of the beam kicker electrode.

The data acquisition modules are distributed in two powered chassis, one of which is placed in the accelerator control room and the other is in a satellite room. The chassis and modules are new products and designed to have a dedicated protocol and architecture in order to realize the high speed visualized data acquisition and control (details are described in the following section). The system is connected to one of the 12-GeV accelerator control computer, in which WindowsNT is executing and all of the control and data presentations are developed by Delphi-2. Figure 3 shows the control panel for this system.

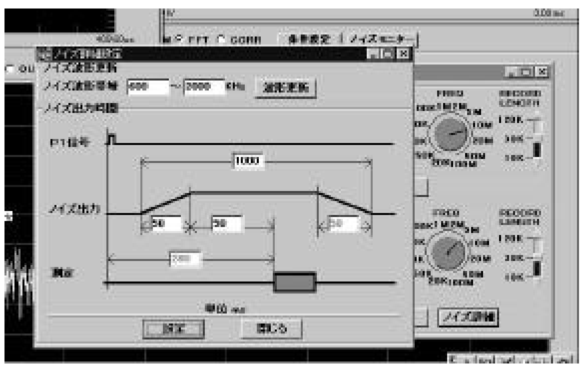

Figure 3. System control panel.

On the control panel, several control knobs are configured to adjust the data acquisition timing, acquisition gain and kicker power *etc*. The signal of the beam oscillation monitor is automatically acquired and those are also automatically analyzed by means of a software fast Fourier transformer (FFT). The software program looks for the fundamental revolution frequency and the betatron side band around that. Thus the betatron tune is automatically displayed on the panel. A typical example of the display of this monitor system is depicted in figure 4.

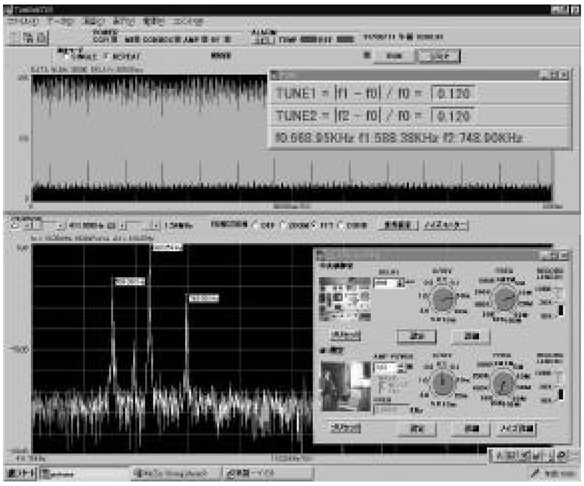

Figure 4. Monitor display.
Analyzed spectrum and automated tune display are shown.

The system development is completed. This system enables an automatic betatron tune measurement and continuously operated on the accelerator console.

2 New data acquisition system

For the betatron oscillation monitor system the followings are requested:

a. 100k word data should be acquired and analyzed during the accelerator operation period of 4s.
b. Control and data presentation panel should be developed by only employing GUI builder software.
c. The system should have device or module independent architecture.
d. The system components can be distributed by an optical fiber network.

In addition, KEK has now a new project of a high intensity proton synchrotron called JHF (Japan Hadron Facility). For an accelerator control and data acquisition, KEK is investigating the available interface hardware. JHF has a rapid cycle accelerator (25Hz repetition rate) so that the most serious requirement is the fast and large amount of data transfer on the control network. And a control panel should be easy to develop by employing a user friendly visual objectives.

We take a WE7000 system for the betatron oscillation monitor and reliability test for the new accelerator control is undergoing.

WE7000 is a newly developed by Yokogawa electric Corporation [1] intending to an extremely fast data acquisition system, which is basically a PC base network data acquisition system distributed some powered chassises (called Station) and those are interconnected by employing two optical fibers. Yokogawa also develops a dedicated protocol for WE7000 (WE-Link) and, by this protocol, all of the controls both for the station and for the modules are realized.

This system is composed of some (maximum 127) powered chassis (stations), control/acquisition computers and optical fiber network. The optical fiber network has a large capacity to transfer the data rate of up to 250Mbps and connected by the chain style. The station has four or eight slots in which any kind of modules, such as digital scope module, digital/analogue I/O modules, function generator modules *etc.*, are installed (as shown in figure 5). And the station itself is equipped a RISC micro processor chip by which the network and station bus control are handled. This RISC computer automatically compresses data taken by some modules so that the network load is easy to reduce. Also some pre-processor software is possible to down load into this RISC computer.

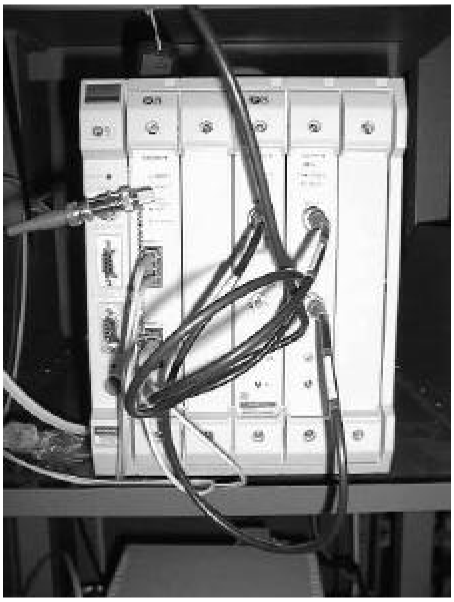

Figure 5. WE7000 station.
From left, station power supply and RC232C interface, optical fiber network in/out and four modules.

One of the excellent features of this system is that the individual driver software is already implemented in the module itself, and the installation of the module concerned is automatically recognized according to the plug-and-play architecture. This driver software is not only the hardware interface software but also includes the visual interface. Thus a user is free from the control and display software coding.

Some API (application program interface) are also supplied by Yokogawa so that any kind of control/acquisition program is easy to develop. A typical system configuration is a chain style multi station as shown in figure 6.

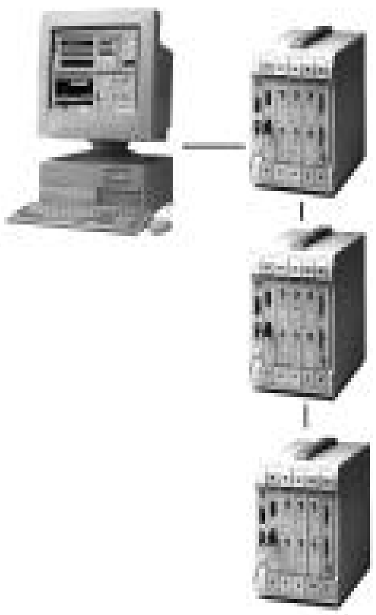

Figure 6. Single chain multi station configuration.

Not only a single chain but also a multi chain connection is possible through the computer network by the Ethernet *etc.*, one of an example is shown in figure 7.

3 Conclusion

A betatron oscillation monitor has been successfully developed and continuously operated during any period of acceleration. The beam is transversely kicked by a white noise signal, which is extremely sufficient to excite the beam betatron oscillation even when the betatron tune is dynamically changed. And the beam degradation by the kick is unobservable. Automate tune measurement provides very efficient tool to study the beam dynamics during the acceleration.

The development of a new fast measurement system was tested of its reliability and feasibility by adopting it to the betatron oscillation monitor. The architecture of WE7000 hardware and software were examined from the viewpoint of accelerator control, and provides excellent performances.

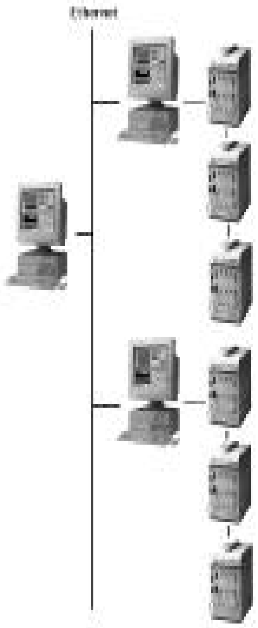

Figure 7. Multi chain, multi station.

References

[1] Yokogawa Internal report.
[2] Toyama, private communication.