PRECISION CURRENT MONITOR SYSTEM FOR THE POWER SUPPLIES AT SRRC

Yuan-Chen Chien †, Chen-Yao Liu, Justin Chiou, Kuo-Bin Liu, Jeng Tzong Sheu
Synchrotron Radiation Research Center
No I, R&D Road VI, Hsinchu Science-Based Industrial Park, Hsinchu 30077, Taiwan

Abstract

At SRRC, a precision output current monitoring system is installed to monitor the output performance of all the booster/storage ring power supplies. Accurate DC current transformers (DCCTs) are attached to the output terminal of every power supply system. Each transformer's gain/offset are carefully calibrated against high precision current source and approximated using high-order polynomial curve fitting. The output of each DCCT is connected to multi-channels data logger for real-time data collection, the collected data are calibrated using the interpolated DCCT gain/offset value. A PC station is set up to serve as host to store the current output for real-time monitoring. This monitoring system provide a precise real-time database for rapid fault diagnosing whenever there is malfunction of the beam operation.

1 INTRODUCTION

In this paper, a precision real-time power supply current monitor system is proposed and established. To ensure the stability of light source, it is required to monitor each power subsystem's performance at real-time. The real-time retrieved data not only provide information for instant system fault diagnosis, but the data can also be utilized to evaluate each power subsystem's long-term performance. Based on the retrieved data, decision can be easily made for future system upgrade.

The current outputs are monitored by use of commercial data logger at a user-defined interval. The collected data are transferred instantly to a PC server which stores all the data coming from the data logger. The operator can hook up to this data server at any time from the local site to monitor the real-time power supply subsystem's performance. This monitor system has been proved to be efficient to speed up the fault diagnosis process each time there is a beam lost caused by power supply subsystem's instability.

2 MONITOR SYSTEM ARCHITECTURE

The monitor system architecture is illustrated in Figure 1. Each output of power supply was monitored by Danfysik's high precision DC current transducer, UltraTab 866-300A [1]. This DDCT has linearity performance better than 1ppm and excellent temperature coefficient less than 0.3ppm/ºC. The DCCTs are powered by ±15V and produce 200mA current output at 300A primary current. Vishay's VFP-4 series four terminal high-stability current sensing shunt resistor (with less than ±10ppm/º C temperature coefficient and 25 ppm ΔR change per year) is connected at the output of each DCCT. This further converts the 0-200mA analog output into a 0-1V voltage output signal. The voltage outputs from the shunt resistors are connected by well-shielded twisted pair lines to the multiplexer module of Agilent's 6-1/2 digits HP34970A Data Acquisition/Switch Unit [2] for data logging. A HP34970A is capable of monitoring up to 60 channels of voltage signals. This means that a HP34970A module can monitor 60 power units at the same time.

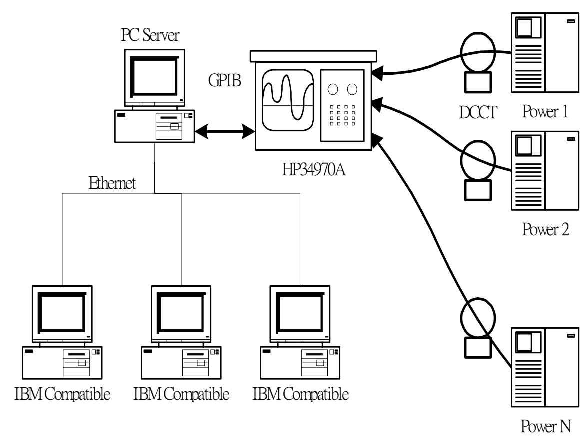

Figure 1: System Architecture Monitor System.

This could largely reduce the overall cost to construct the monitor system.

HP34970A samples each monitor voltage channel at a certain time interval, which is adjustable by the operator. The sampled data are temporarily buffered in the data logger and are later retrieved back to the PC server through GPIB interface. A Labview program is developed to facilitate this process. The program controls the data transfer between the data logger and PC server. Besides, it also converts the sampled voltage reading into the real current output value using the calibrated gain and offset obtained during the DCCT calibration process. This process will be discussed later in the following section.

The operator can access the data recorded in the PC server at any time through the SRRC intranet.

† ycchien@srrc.gov.tw

3 DCCT CALIBRATION

To ensure the measurement precision, every DCCT attached at the output terminal of each power unit has to be calibrated against a known measurement standard. Danfisik's UltraTab 860R+860S range selector, which exhibits very low initial offset < 2 ppm and offset drift < 0.5 ppm/º C is chosen as the standard measurement device. The measured current of each DCCT plus current at sensing shunt resistor to be calibrated were compared such that a calibration curve was obtained. Then optimally fit the relation between output of the measurement standard and that of the DCCT plus current sensing shunt resistor at each power supply unit's output terminal. The calibration set-up is illustrated in Figure 2.

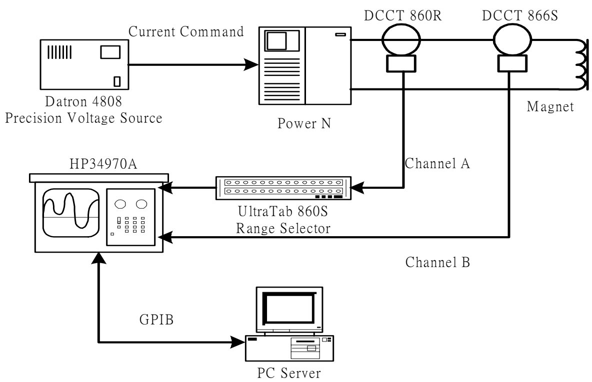

Figure 2. calibration Set-up of Measurement device.

The Calibration process is listed as follows:

1. Calibrate Datron 4808 precision calibrator in the beginning. This precision calibrator is employed to set current command to the power unit in the calibration set-up.
2. Connect the output from both the standard measurement device and the measurement device to be calibrated to HP34970A.
3. Slowly ramp the current output from 0A to the rated maximum value of the power unit. There are total 41 current steps. The readings from both the measurement devices at each current step are recorded and stored in the PC.
4. Repeat the process until all measurement device to be calibrated has gone through all the process.

Since it is impractical to calibrate the measurement device in all current command setting, it is required to find the mathematical formulation between the standard device's output and the measurement device to be calibrated by utilizing the 41 pairs of recorded data. Linear least-square data fitting [3] is employed here to find this relation. 1st order to higher order fitting has been tried and evaluated to verify the accuracy of data fitting. Figure 3 shows the difference between the standard measurement output and the UltraTab 866 measurement output with 1st order and 4th order polynomial curve fitting respectively. Both show excellent result. The difference is less than ±5ppm.

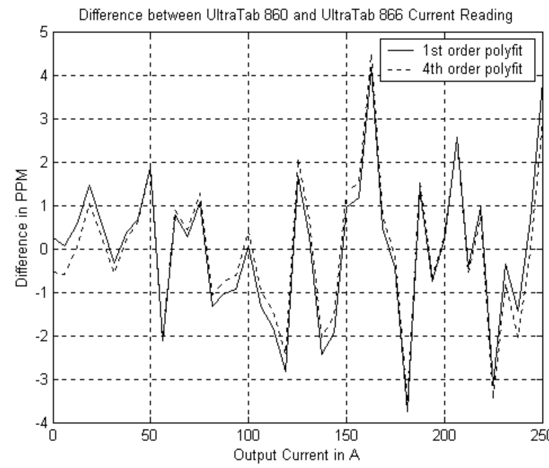

Figure 3. Current difference between standard device and device to be calibrated.

Because 1st order fitting is accurate enough, it is chosen as the conversion formula from the 0-1V voltage reading value of UltraTab 866 to the actual current output value of the corresponding power unit. The 1st order polynomial is represented by :

$$y_i = A \times t_i + B$$
$$y_i : UltraTab\,860\ Output$$
$$t_i : UltraTab\,866\ Output$$

A and B denote current gain and offset respectively. The gain and offset values of all the measuring DCCT devices are input to the monitor program. The monitor program uses the gain and offset values to convert the collected voltage value into actual current value.

4 MONITOR PROGRAM

There are two programs developed in this power supply current monitor system:

1. Data Archiving Control Program: As mentioned early, this Labview program is executed on the PC server to control the HP34970A and is responsible for storing and converting the retrieved data. The control panel is shown in Figure 4. There is a data window on the panel, which can be used to monitor a current channel on site. On the control panel, user can adjust the data acquisition interval, total sample count and the directory to store the collected data. Before this Data Archiving Control Program is run, user has to define first which acquisition channel a specific power unit/measurement unit to be monitored is

connected to and then input the gain and offset values associated with that specific power unit/measurement unit. During the program's execution time, it is allowable for the user to select a specific power unit and view its real-time performance on site from the Monitor Windows.

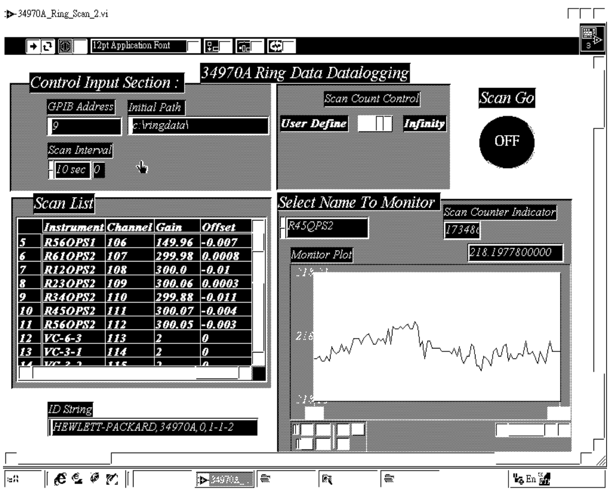

Figure 4. Data Archiving Control Program Display

2. History Archiving Program: This window-based program, developed by Accelerator Operation Group of SRRC, is to offer a easy-to-use environment for viewing the real-time data from all the monitor systems at SRRC. This program can be installed on the PCs whether in the office or in the control room. The operator or any person can access and view the real-time current data at any time inside the SRRC facility. Figure 5 demonstrates the display of History archiving program.

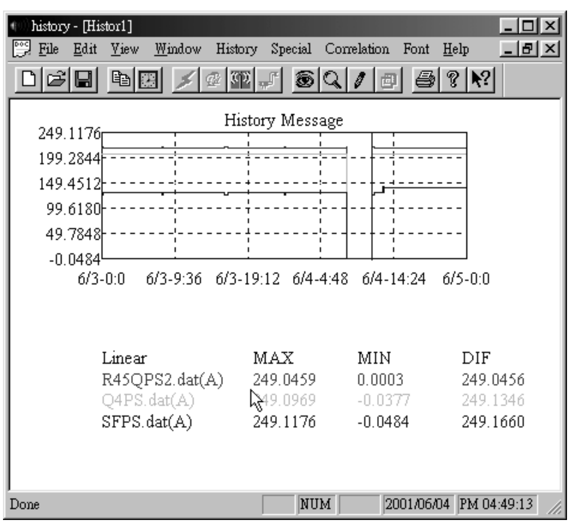

Figure 5 : History Archiving Program Display

5 SUMMARY

A real-time current monitor system has been established at SRRC to monitor the output performance of the booster and storage ring DC/AC power supplies. The combination of low cost DCCT and shunt resistor and commercial multi-channel data logger have been proved to be capable of delivering excellent measurement accuracy. It is shown that, with the calibration process performed, the current measurement accuracy is very close (less than ±5ppm deviation) to that of a high-precision standard measurement device.

Besides, monitor programs are also developed. Through the monitor programs and intranet, it is very convenient for the operator to instantly fault-diagnosis the beam instability problem caused by malfunction of the power supply units.

6 REFERENCES

[1] Danfysik, "Current Transducer Program," 1997.
[2] Angilent, "HP34970A Data Acquisition/Switch Unit User's Guide".
[3] David Kahaner, Cleve Moler and Stephen Nash, "Numerical Methods and Software," Prentice-Hall Inc., 1989, pp190.