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BEAM-CURRENT MONITORING SYSTEM AT THE KEK ELECTRON/POSITRON LINAC

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Abstract A new automatic beam-current surveillance system was constructed to enable smooth operation of the KEK 2.5-GeV electron/positron linac. It was intended that it shares the signal lines from the wall- and core-current monitors with the oscilloscope monitoring system while not interfering with each other. Information is collected by a minicomputer several times a second through the CAMAC serial highway and then averaged, calibrated and displayed graphically in the operator's console room. Data can be saved for later reference and can also be transferred to the main console computers so that control programs for the linac can also have access.

INTRODUCTION

The 2.5-GeV electron/positron linac of KEK provides beams to both TRISTAN and the Photon Factory ring.[1] It usually serves TRISTAN with short-pulse electron/positron beams and the Photon Factory with a short-pulse positron beam. A long-pulse beam is sometimes used for klystron phasing or other accelerator studies.[2] It takes about thirty minutes for one of these rings to accumulate a beam; if there is a failure during injection to one accelerator, the other must await.

Beam-current monitors are the basic components for accelerator operators to obtain beam information. In the 2.5-GeV linac wall-current monitors and core-current monitors have been employed for short- and long-pulse beams, respectively. However, its read-out system was not well prepared. Operators of the accelerator usually have selected a signal from current monitors, one-by-one, through signal selectors, observed the waveform with an oscilloscope and calculated the current value with a calibration table.

In order to make the beam manipulation easier simultaneous beam monitoring along the linac has been necessary. An automatic beam-current surveillance system is also required by other systems, such as beam-energy analyzing stations.[3] Thus, a new read-out system for the current monitors has been developed.

SYSTEM DESCRIPTIONS

It is intended that the new system does not interfere with the previous monitoring system, involving an oscilloscope which is required for observing waveforms. It must read about thirty wall-current monitors or about twenty core-current monitors along the 500-meter-long linac. Since the repetition rate of the linac is 50 pulses per second, the read-out system need not be faster than this value. In order to utilize the results, the system must be connected to the accelerator control system directly and function as a sub-control system. It has been designed to be extended easily.

Hardware

Before being transmitted to data-acquisition modules, signals from monitors are processed respectively. First a signal from a monitor is divided into two identical signals by a power splitter, allowing it to be shared with one of the signal selectors connected to the operator's console. On the output to the signal selector a buffer amplifier is used to isolate the signal so that no interference takes place. The other output is then divided again by a 180-degree out-of-phase power splitter in order to obtain two signals of opposite polarities. Because positron and electron beams give different polarities, these two signals are needed for with unipolar converters. One of the divided signals is used for the electron beam. The other is amplified by a fast 20-dB amplifier, and is used when the positron beam is accelerated since the signal is ten-times smaller than that from the electron beam.

Since short-pulse beams have a width of about two nanoseconds, it is difficult to digitize the waveforms. Thus the total charge of the beam pulse has been digitized employing a charge-integration-type analogue to digital converters (ADC). Each signal is fed into a separate ADC input.

In order to acquire the correct charges and to avoid noise from klystron modulators, precise gate timings are adjusted by computer-controllable delay generators. A block diagram of signal-processing scheme for the short-pulse beam is presented in Figure 1.

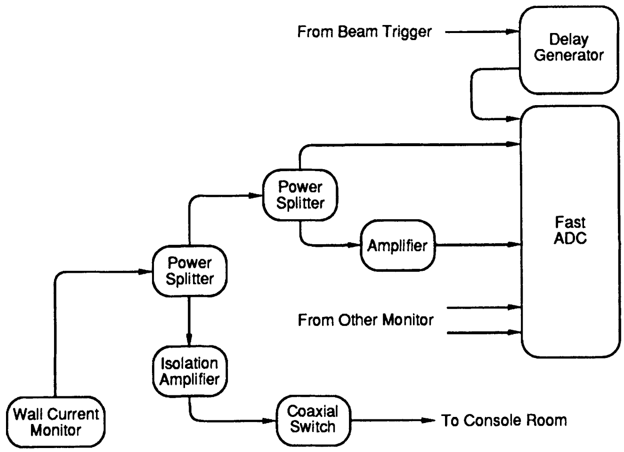

FIGURE 1 Block diagram of signal processing scheme.

For long-pulse beams waveforms are digitized by transient digitizers with a sampling rate of 100 MHz. Several signals are multiplexed into an digitizer input with a signal multiplexer.

Electric modules, such as ADC's, are accommodated in one of the six CAMAC crates distributed along the 500-meter linac and the positron generator. These crates are connected to a data-acquisition computer through a fiber optic CAMAC serial highway with U-port adaptors in an enhanced byte serial mode of 5 megabytes per second. It provides maximum data transmission rate of 1.7 megabytes per second.

A MicroVAX computer is employed as a data-acquisition computer. It has an enhanced serial highway driver which interconnects the computer bus and the CAMAC serial highway. This driver has the capability of the list mode DMA, which enables a direct memory transfer in which many CAMAC commands can be achieved. This capability is important for the process like this system which carries many different CAMAC commands sequentially. This computer is also connected to the main console stations for accelerator controls through network so that other programs for consoles can refer the results.

Software

Software was prepared to read out ADC's or transient digitizers according to accelerated short- or long-pulse beams, process data and to display the beam-current along the accelerator. Detailed tasks are the following.

At first the programs read predefined parameters for this system such as the mode of the beam, attributes of monitors, schemes for data-acquisition and specifications for the display. All parameters are stored in common memory and can be readily modified with control-panel programs at one of the computer terminals. A set of these parameters can be saved to (and loaded from) a disk file.

One ADC or transient digitizer in each crate is read out at a time, although each CAMAC crate deals with several monitors, since the delay timings are different. A delay timing parameter is set to each delay generator in six crates. After the beam comes and the "Look at Me" signals from the ADC's are generated, the program reads out and clears all of the data in the ADC's. It repeats this sequence at a rate of about ten times per second.

Then, the next program determines moving averages of the data over cycles in order to reduce fluctuation of the beam itself and noise from klystron modulators, and to convert the units into milliamperes with calibration coefficients. The results are displayed on a graphic display at the operator's console room. Figure 2 shows a display of the current distributions along the linac. Refreshing of the display once every two

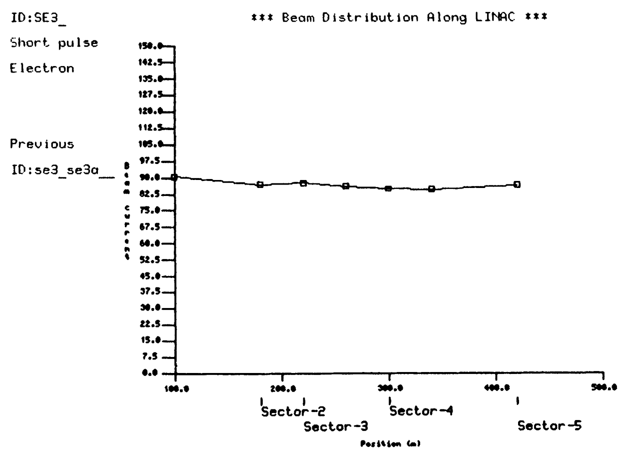

FIGURE 2 An Example of the display of beam-current distribution.

seconds is possible. They can be stored on the disk file by a request from a operator for the later reference.

APPLICATIONS

This system was planned and built last year and put into use this year. So far, operators tended to manipulate the accelerator equipments while observing the current monitor just downstream. This process may cause problems in beam tuning of the accelerator. A beam-current distribution graph along the accelerator displayed at the operator' s console room helps operators to adjust the beam.

Currently, operators must change the set of parameters on the control panel of this system when the mode of accelerator operation is changed, for example from positron beams to electron beams. This is modified to follow the acceleration mode.

For beam-energy analyzing stations operators must adjust the parameters for the analyzing magnets and slits, and must also read the present current manually. Thus, an automatic system for an energy-analyzing station is also planned. The program changes the field of analyzing magnets gradually and reads the analyzed beam current from this current monitoring system simultaneously. With this system the energy spectrum of the beam can easily be acquired.

Since the results from this system can be read from other control computers, some other applications are possible. For example, it is feasible to measure the emittance of the beam in conjunction with slits and focusing magnets. An automatic beam-tuning system may also be possible with some intelligent programs or an expert system. For this purpose, nondestructive beam-position monitors will be required which are not presently installed in this accelerator.

REFERENCES

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