BEAM INTENSITY OBSERVATION SYSTEM AT SRRC

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ABSTRACTS

Beam intensity and lifetime measurement system have been implemented at SRRC. The average beam intensity is measured by direct current current transformer. The magnet shielding of DCCT is used to reduce stray magnet field interference, then output signal is digitized by high resolution analog to digital converter on VME crate. In order to be compatible with the data refreshing rate of main control system, which is 10 samples per second, all digitized data are filtered and decimated by digital filter to reduce noise level. The adaptive lifetime calculation algorithm are applied to provide fast time response.

I. INTRODUCTION

Beam intensity is a basic machine parameter should be measured at any time. A commercially available high precision DC parametric current transformer (PCT) has been chosen for measuring the beam current. Beam lifetime is also a significant machine parameter of the storage ring. The beam lifetime is calculated by the beam current measured using PCT. The calculation process of beam lifetime requires precise measuring and quick response of the dedicated system. In the following paragraphs, the hardware and software for beam intensity and lifetime measurement system generating desire result are depicted.

II. INTENSITY MONITOR

The intensity monitor is an commercially available parametric current transformer made by Bergoz. The resolution of the sensor is about 1 μA for 1 second inetgration time. A ceramic break is utilized to couple magnetic field produced by the electron beam on the sensor head. The whole assembled sensor is wrapped by five magnetic shielding layers which are made of highly permeable materials. The shielding effectiveness of the magnetic shield is about 10^3 [1,2,3]. The whole assembled instrument is housed in a Cu-made cover to bypass image current. The ambient magnetic field is about 10 Gauss which is measured by Hall probe.

III. DATA ACQUISITION SYSTEM

The SRRC control system is a two layer hierachical system [4,5]. The upper layer consists of dedicated workstations used as console computers while the lower layer is integrated by VME-based intelligent local controllers (ILC)[4,5] serving
as front end device controllers. Computer systems of both layers are interconnected by Etherenet. Each console layer computer maintains a centrallized control database. Those ILCs refresh transient information of all devices within control database every 100 msec. On one of ILCs, a 16 bit analog-to-digital converting (ADC) channel is used to acquire the current, which is corresponding with beam intensity information, generated by PCT. The necessary hardwares of data acquisition system are shown in figure 1.

The original sampling rate of beam intensity instrument is synchronized with updating rate (10 samples/sec) of main control system, while the sampling rate of new approach is changed to 3.68 KHz.

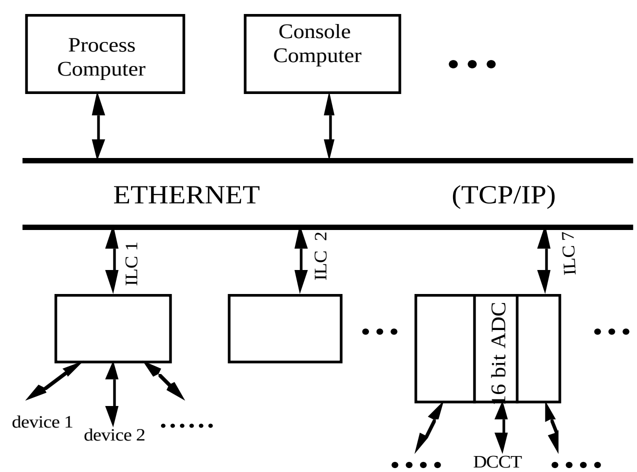


Figure 1. Beam intensity data acquisition block diagram

IV. SIGNAL PROCESSING

The samples obtained by 3.68KHz are reduced to 460 samples per second. A digital filter with respect to decimation is used to reduce noise levels as well as interferences of power systems inherited from the circuitry of ADC. The digital filter is a 20 order low pass finite impulse response (FIR) filter with cutoff frequency at 5 Hz. This process can increase the effective precision of a measurement. Finally filtered values have been decimated to 10 samples per second to fulfill the adopted updating rate of main control system. The flowchart of implementing softwares is shown in figure 2.

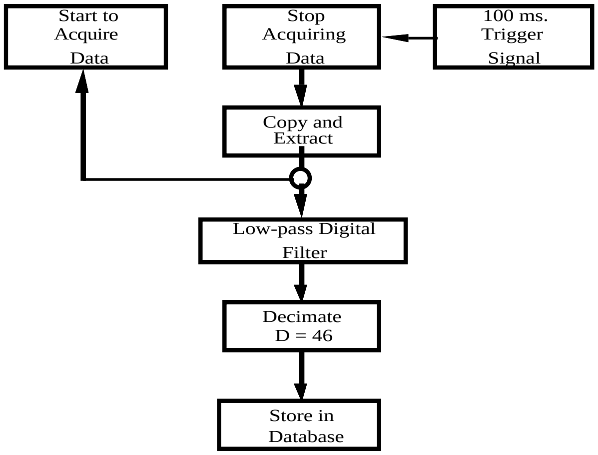
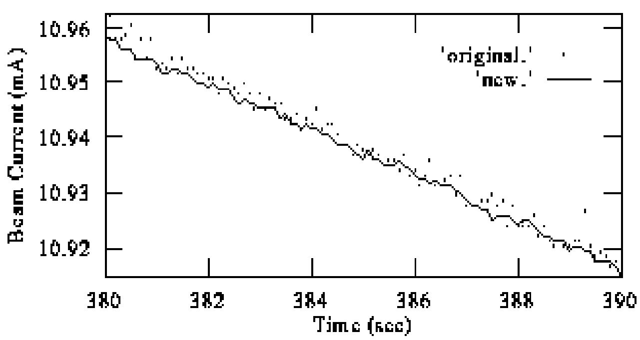
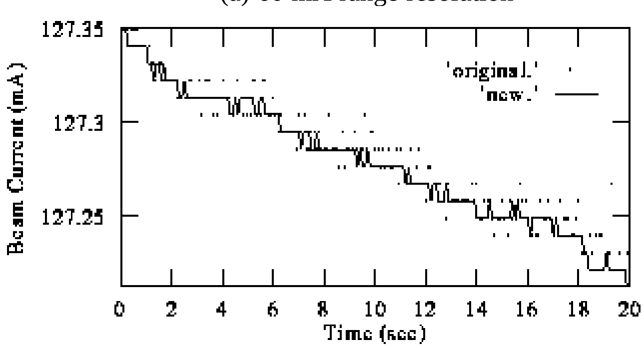


Figure 2. Software flowchart



(a) 60 mA range resolution



(b) 600 mA range resolution

Figure 3. Beam intensity readings

Comparisions between the original measurement system and the new approach can be observed in figure 3. The resolution of PCT can be better than 1 μA with 1 second integration time, besides the 1 KHz bandwidth of PCT. Since the ADC channel is with high bandwidth, the original system is interfered with the line frequency; also due to 10 Hz sampling rate, there are some aliasing effects existed. It is obvious that we can't remove both interferences in old system. The new approach, which resides on the ILC, increases the sampling rate and filters out the interferenece by the digital filter. As shown in the figure, the peak variation of beam intensity is about 60 μAp-p. Hence, the new system is much better than the old one.

The resolutions of beam currents generated by new approach are also shown in figure 3. The beam current sensor is with two ranges of full scales (60 mA or 600 mA). From the figure, it is easy to identify that the resolution of beam current is approaching 1 μA for 60 mA range and 10 μA for 600 mA range.

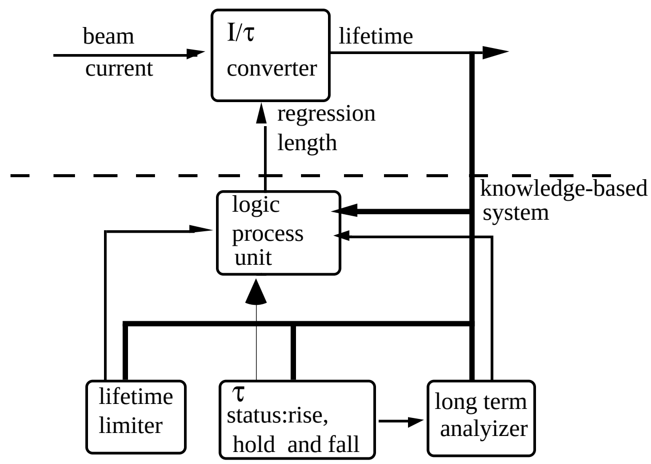


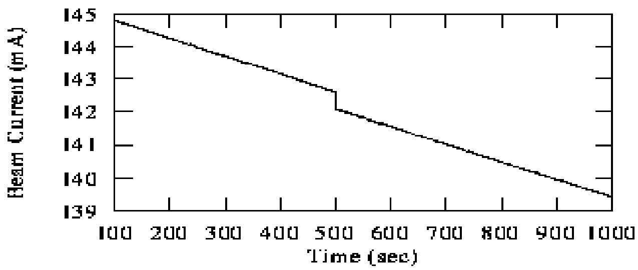
Figure 4. Lifetime calculation algorithm

V. LIFE TIME CALCULATION

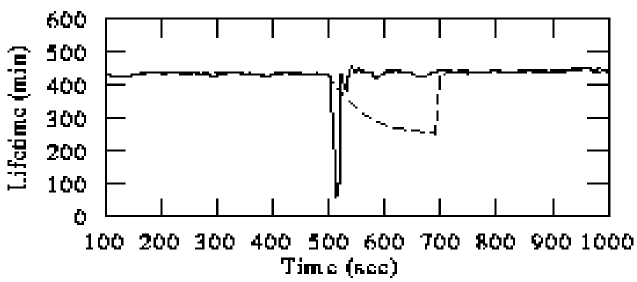
There are two algorithms have been used to compute beam lifetime. Both algorithms are based on typical regression process.

The approach which we currently use is the fixed length regression procedure. This procedure runs on a console level computer, and the regression length is selectable from 100 seconds to 200 seconds. It may happen that the response rate of beam lifetime calculation is not fast enough to show instant changes of beam currents, if longer regression length selected. Another drawback occurs in need of long-term and stable lifetime calculation. In that case, the fluctuating range of lifetime calculation may be enhanced if the selected regression length is not long enough.

The method which is under developing now will be deemed as adaptive and will be done at VME layer in the future. It is shown in figure 4. The new regression length can vary adaptively with respect to time. The longer length of regression is adaptively applied for the case of needing slow response rate in lifetime calculation, while shorter length of regression is for needing fast response rate category, respectively. Advantages over varied regression length are twofold - one is its fast response time for instant changes of beam currents, shown in figure 5(b); another is smaller fluctuation for long-term and stable lifetime calculation, shown in figure 6(b).

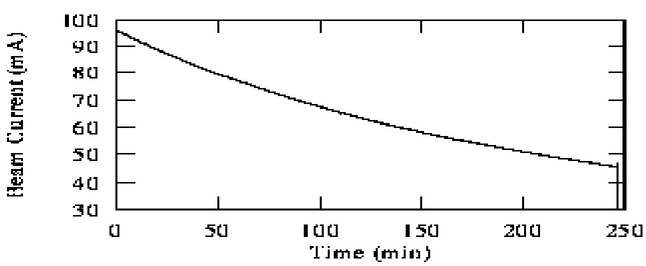


(a) Beam current

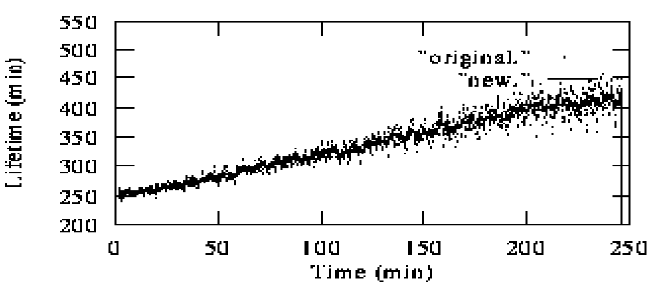


(b) Lifetime calculation

Figure 5. Lifetime calculation with instant beam current drop



(a) Beam current



(b) Lifetime calculation

Figure 6. Long-term lifetime calculation

Comparisions of response times between two methods can also be observed in fig 5(b). The beam current is real beam intensity data, and the sink of beam current is intentionally generated in order to compare performances of both methods of lifetime calculations. The response time of fixed length method is about 200 seconds ,while of adaptive regression length method is about 5 seconds. There are some overshooting effects nearby the recovery period in lifetime calculation; those phenomena are nature, and won't affect anything of applications.

VI. CONCLUSIONS

First, speed up the sampling rate of intensity data. Then, sampled raw data are processed by digital signal processing technique to remove the interference inherited from ambience. The lifetime calculation utilizing adaptative regression length method is introduced. Also improvements in precisions of beam intensity observation, and the response time of beam lifetime calculation are demonstrated.

VII. ACKNOWLEDGEMENTS

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VIII. REFERENCES

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