BEAM POSITION MEASURING SYSTEM OF THE MICROTRON INJECTOR

Batrakov A.M., Shilo V.V., Shubin E.I., Zinevich N.I.

Budker Institute of Nuclear Physics (BINP), Novosibirsk, Russia

Abstract

The described system is intended for the injector of the microtron-recuperator for Free Electron Laser [1]. The distinctive property of this injector important for the BPM measuring system is that it can work with repetition frequency up to 22.5 MHz. The beam has peak current value of 1.2A and the pulse duration varied from 1.5 ns after the gun to 0.15 ns after the buncher. The measuring system must allow to measure beam position at four points in the whole frequency range of operation.

1. SYSTEM DESCRIPTION

Configuration

Block diagram of the BPM system is shown in Fig.1. It consists of four Multiplexers, the Synchronizer and the four-channel ADC module. Up to four pickups can be connected to the system. The measurement modules are placed in the control room at a distance of ~30 m from injector and work under computer control. The button type pickups with the aperture of 80 mm are used. Each pickup is connected to the system by four coaxial cables of equal electrical length.

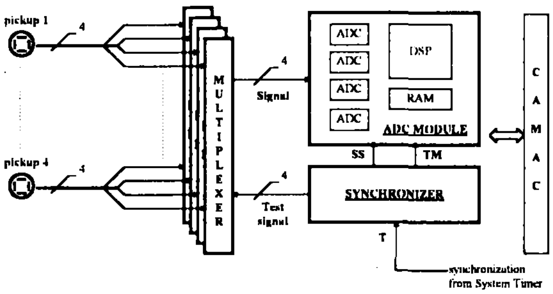

Fig. 1 Block diagram of the BPM system.

Measuring method used in the system is based on simultaneous measurement of pulse signal amplitudes from four pickup electrodes with following processing to obtain the beam position. The beam position is measuring in one of the pickups selected via the Multiplexers. The signals from the pickup's electrodes are amplified by Multiplexers to the appropriate value to fit the effective range of ADC, digitized by four fast ADCs of the ADC module and stored in its memory. After storing the required number of measurements they are sent to computer for final treatment.

The measuring process is synchronized by the signals "start-stop" (SS) and "timing" (TM) from the Synchronizer. This signals are tied to the synchronization pulses (T) from the System Timer, which controls the gun modulator. The delay of synchronization pulses (T) relatively the gun shot can be set with the discrete of 45 ns by the System Timer. More precise delay adjustment is carried out by Synchronizer. The Synchronizer also generates the test signals for the purpose of checking up the system.

Multiplexers

The desired measurement channel is selected by the multiplexer modules. They make the necessary amplifying and filtering of the signals from pickup's electrodes. The simultaneous measurement of the signals from four electrodes of the selected pickup is provided by four identical Multiplexers.

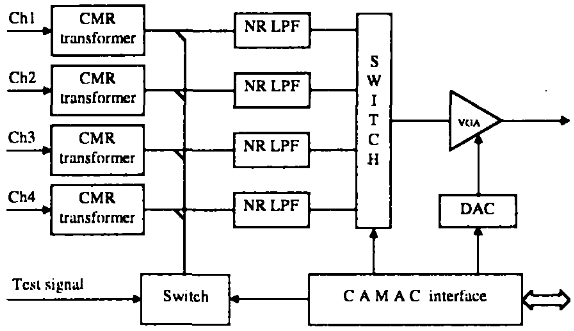

Fig. 2 Multiplexer

Every module (Fig.2) has four switching inputs (Ch1÷Ch4) with common Variable-Gain Amplifier (VGA). The inputs are galvanic isolated by Common Mode Rejection (CMR) transformers, which are loaded by a Non-Reflective 50 Ohm low-pass filters (NR LPF) with cutoff frequency ~27 MHz. The filter's outputs are connected to the VGA input via the GaAs switches. The gain of the amplifier is adjusted by DAC to fit the ADC amplitude range of ±250 mV. The output signals have ~15 ns pulse duration . Test signal (~5 ns duration pulse) passes through the switch to the input of the module. The reflected from the pickup's end of the connection cables signals are used for checking up the system.

Synchronizer

The Synchronizer module generates the "start-stop" and "timing" pulses for ADC module to synchronize the measurements. The module consists of digitally programmable delay generator, start-stop and timing pulses generator, generator of test pulses and CAMAC interface.

With the assistance of the Synchronizer the precision time synchronization is carried out. Timing pulses generated by Synchronizer have adjustable delay in the interval of 90 ns concerning synchronization pulses from System Timer module. Time delay is regulated with the discrete of approximately 0.3 ns. supplementary to 45 ns step of the System Timer. The individual time delays for every channel must be previously determined. The measurement cycle is initialized by CAMAC command, after which N "timing" pulses sequence (N=1÷127) provided with "start-stop" pulse is generated . The beginning of the sequence is tied to the nearest synchronization pulse from Timer. The frequency of timing pulses is half the synchronization pulses frequency.

ADC Module

The module is destined for synchronous measurement of the signals from four Multiplexer modules. It is similar to that, described in [2], and consists of four fast ADC, memory (32 kWords per each ADC channel) and CAMAC interface. It can be equipped, as shown in Fig.1, by daughter board of digital signal processor (DSP) if necessary. Every channel has a fast ADC with 8 bit resolution. The input stage of each ADC channel consists of input amplifier and track and hold amplifier. The input signals voltage range is set to ±250 mV.

The signals "timing" and "start-stop", coming from the Synchronizer module, are used for synchronization of the measurement process with beam moving.

2. RESULTS

The injector is under commissioning now, so the measurement results of the BPM system are preliminary.

At present three of four desired pickups are installed, because the injector works without the bending magnet, needed for the microtron-recuperator.

The resolution of the measurement system for the test signal applied is demonstrated in fig.3 and fig.4. The histograms of the vertical and horizontal coordinate distribution were measured at the frequency equivalent to ~3 MHz beam repetition frequency. The amplitude of the signal was ten times less, then that of the real beam. Every count was averaged over 100 measurements. The resulting resolution for this case was 30 mkm and 50 mkm for horizontal and vertical respectively.

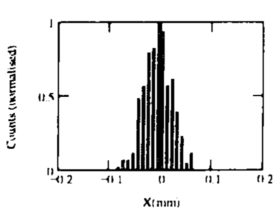

Fig. 3 Distribution of horizontal coordinate.

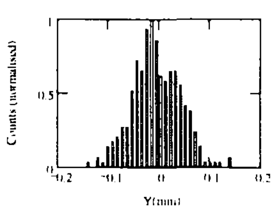

Fig. 4 Distribution of vertical coordinate.

The BPM measurement system was tested with the real beam as well. Dependence of the measured coordinates upon the repetition frequency for the pickup 1 is shown in Fig.5 and Fig.6. The measurement conditions were as follows: the beam peak current was about 1.2A and the data processing was similar to that for the test signal . The curves represent the offset and RMS of the measured coordinates for the frequencies from 0.35MHz to 17.8MHz. It can be seen, that for the lowest frequency the resolution is better, then that for test signal (≤25mkm for both coordinates). With the frequency increase there appears the offset of about 150÷200 mkm and RMS increases to ~150 mkm. This effect can be caused by instrumental error as well as by beam movements and it will be the matter of further consideration.

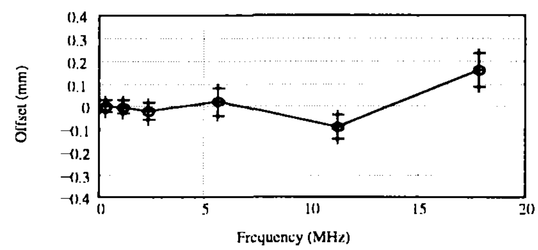

Fig. 5 Frequency dependence of vertical offset.

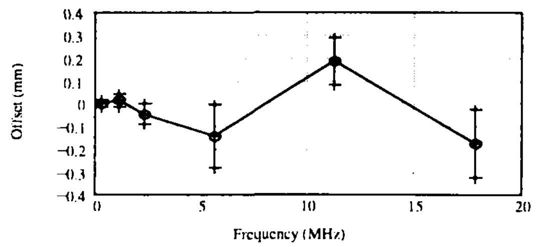

Fig. 6 Frequency dependence of horizontal offset.

3. SUMMARY

The BPM system has now three measuring points, the resolution about 150 mkm at high frequency. The obtained parameters of the measurement system are sufficient for injector diagnostic needs, nevertheless they will be improved in future.

4. REFERENCES

[1]. N.A. Vinokurov et al., 'The Project of High Power Free Electron Laser Using Race-Track Microtron-Recuperator', Proc. of EPAC94, v.1, p.858-860.

[2]. A. Batrakov et al., 'Beam Position Monitor with the Digital Signal Processing', Proc. of EPAC96, v.2, p. 1579-1581.