A DIAGNOSTIC SYSTEM FOR MEASURING PROFILE OF THE BEAM LINES

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ABSTRACT

In this paper, a diagnostic system for measuring profile of the beam lines of the Heavy Ion Research Facility in Lanzhou (HIRFL) has been introduced . A secondary emission multi-wire chamber as a detector of the profile of the beam lines has been used. The current coming from the wires will be sent to I/V or I/F convertors in which they will be digitized. Then the distribution spectrum of the beam in the direction X and Y can be obtained by a computer. The principle of an integrated operational amplifier package which is used in I/V or I/F convertors has been briefly introduced.

INTRODUCTION

In order to monitor the profile of the beam lines of accelerator, the secondary emission multi-wire chamber is usually used as a detector in the nuclear experiment. By measuring about one hundred weak current signals, which are extracted from the wires of chamber, the distribution spectrum of the beam in the direction X and Y can be obtained and the central position of the beam can be found out. It is obvious that the accurate and relatively consistent measurement of every current coming from the wires is the key to efficiently monitor the profile of the beam lines, so the sections of detectoe and convertor in the diagnostic system are very important.

SECONDARY EMISSION MULTI-WIRE CHAMBER

A secondary emission multi-wire chamber has been employed in monitoring the profile of the beam lines of HIRFL.[1)] The chamber consists of two orthogonal wire-planes, three high voltage rings and a fitting plate. 47 parallel tungsten wires, which have been covered with gold, have been used on each plane. These wires, whose diameter is 25 µm each and all, are isolated each other and separated by a space of 1.0mm. The current are extracted from the wires.

I/V AND I/F CONVERTORS

The current signals coming from the wires will be sent to 47 channels' I/V or I/F convertors. Every unit of the I/V converters is made by using an integrated operational amplifier with high input impedance and low input-point leakage current which is linked as a close loop by a sampling resistance. It can change I into V from 10^{-7} to 10^{-11} ampere. Sometimes the I/V convertor needs changing the sampling resistance so that it can be used to diagnose more extensive current, so we also adopt I/F convertor because it can conveniently change I into F from 10^{-6} to 10^{-16} ampere without switchers. By the way, the I/V convertor needs a A/D convertor behind it to digitize the voltage signals coming from the I/V so that they can easily be treated by a computer. But the I/F convertor does not need A/D because the current signals have already been changed to frequency—it is a digitized signal— while the current throughout the I/F convertor.

The principle block diagram of the I/F convertor is shown in Fig.1 . In the I/F

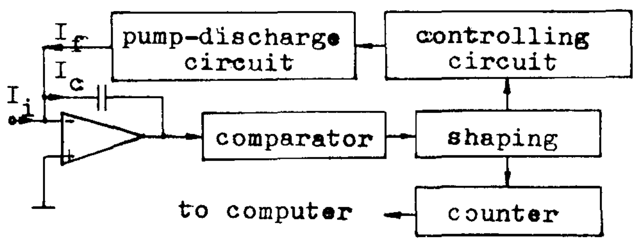

Fig.1 The block diagram of the I/F

convertor we have employed an integrated operational amplifier package linked as a current-integrator. When the voltage of the integrator arrives at the open gate voltage domain, the comparator which is composed of MOS NOR gate will turn over and give out a pulse signal. On the one hand, the pulse signal is sent to a counter so that the computer can compute the measured current according to the number of the pulses. On the other hand, the signal is also sent to a controlling device which controls a pump-discharge circuit so that the charge of the integrator's capacitance can be pumped off a small part. It is obvious that the pump-discharge circuit works by on-off state. Because the time of discharging charge in pump-discharge is shorter than 7.5μs, the controlling pulse's breadth, which is controlled by another logic-circuit, must be less than 7.5 μs.

USING A COMPUTER TO TREAT THE DATA

The data coming from the A/D convertor or the I/F's counter will be sent to a computer. The diagnosed data of the beam line profile, which are treated and controlled by the computer, will be printed out by a printer, or drawn out a distribution spectrum of the beam in the direction X and Y by a plotter, or shown the diagram on CRT. The logic diagram of the diagnostic system is shown in Fig.2.

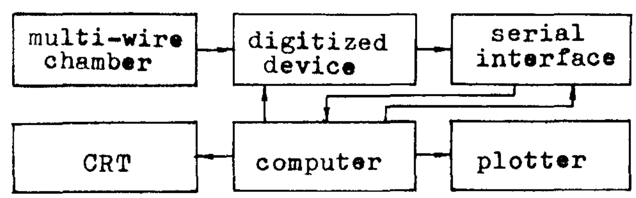

Fig.2 The logic diagram of the diagnostic system

INTEGRATED OPERATIONAL AMPLIFIER PACKAGE

The most important part in the diagnostic system is the integrated operational amplifier package. In order to obtain a package whose input-resistance is higher and input point leakage current is lower enough to be used, we have to make it by ourselves. A pair of MOS-FET whose G-point leakage current is less than 10^{-15} ampere have been used in the package and linked as a differential amplifier which is the input-stage of the package. Another IC's operational amplifier has been linked with the stage. This package's input characteristic is nice enough to be used, but it is easy to be harmed. So we have used a relay, whose normally closed contacts have been linked with FET's grid and source.

When the voltage-source does not work, the FET can not be damaged by static electric field induction because it has been protected by a relay. When the voltage-source works and at the same time the I/V or I/F have been switched on, the relay's normally closed contacts have been opened and the FET can not be damaged, too, because there are these or those sorts of electric lopps which will confine the voltage brtween grid and source. In this way, a good character's package can be obtained, its input resistance is higher than 10^{14} ohms and its grid leakage current is also less than 10^{-15} ampere.[2] Besides this, it is not easier to be damaged. By the way, the package is compatible with other integrated operational amplifiers.

MULTI-CHANNEL MEASURING COINCIDENCE

There two method which can get higher measuring accuracy for the 47 channels. One of them is how to exactly measure the high value of sampling resistances which are used in the I/V convertors or measure the value of integrator's capacitances in the I/F convertors. The value of the sampling resistances can be accurately measured by using a standard resistance R which will compare with the sampling resistances on a voltage follower. The follower is composed of the package done by ourselves.[3] It is not difficult for the sampling resistances to gain better accuracy than 1% in the measurement.[4] Just as the same princille, the value of integrated current-integrator's capacitances can be measured, too.

Another method of accurate measurement is only using one I/V or I/F convertor for the 47 channels by adopting the computer-controlling relaies which switches on only one wire of the profile-detector every time. There is not the problem of coincidence because only one I/V or I/F convertor has been used in the diagnostic system, but its converting speed is slower than the speed of using 47 convertors at the same time. Slower as it is, it is enough to be used because the current signals coming from the profile of the beam lines are slow changing signals.

THE PERFORMANCE OF THE BEAM DIAGNOSTIC SYSTEM

The performance of the beam diagnostic system has been tested at the 1.5 meter cyclotron of HIRFL, and the better distribution spectrum of the beam in the direction X and Y has been obtained. The system is simple to contrive or construct and easy to operate. Its performance is stable and reliable.

REFERENCES

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