Bulgarian Academy of Sciences
Space Research in Bulgaia, 6
Sofia . 1990

Systems for laboratory testing of two-dimensional coordinate-sensitive detectors for charged particles

Peter T. Baynov, Yordanka V. Semkova

Space Research Institute, Bulgarian Academy of Sciences, Sofia

Introduction

Ground-based testing is the primary and important step towards the development of space research instruments. Some specific aspects of the testing are: capacity verification and element characteristics investigation of the detecting devices; — coordination between sensor and electronic block performance, calibration and tuning; development of control-and-measuring equipment; reliability testing, etc.

In order to perform this testing, we need systems of sufficient complexity and methodics, quite often with capacity and requirements exceeding those of the on-board systems. Thus, we provide the possibility of an adequate research of the circuitry potential and its optimisation. In order to obtain and investigate the correlative links and dependencies between the physical model and the experimental results, as well as to find out the virtual criteria of estimating the tests and the extent to which they approximate the actual conditions, we use relatively complicated and powerful soft- and hardware facilities.

The problem

A general purpose testing facility for charged particle detectors is shown in Fig. 1. The tested detecting element is placed into a vacuum chamber together with the charged particle source. The required conditions are transmitted via microcomputer to the controlling block which, in turn, supplies the detector operational parameters and the impact source.

The information obtained from the detector is addressed to the electronic block, where it is subjected to primary processing and read by the microcomputer. Simultaneously, the information from the vacuum chamber and the electronic block is supplied to the control-and-measuring instruments: analog-to-digital analysers, oscilloscopes, etc.

Recently, many laboratory and space research investigations, related to charged particle registration use coordinate-sensitive detectors CSD, since

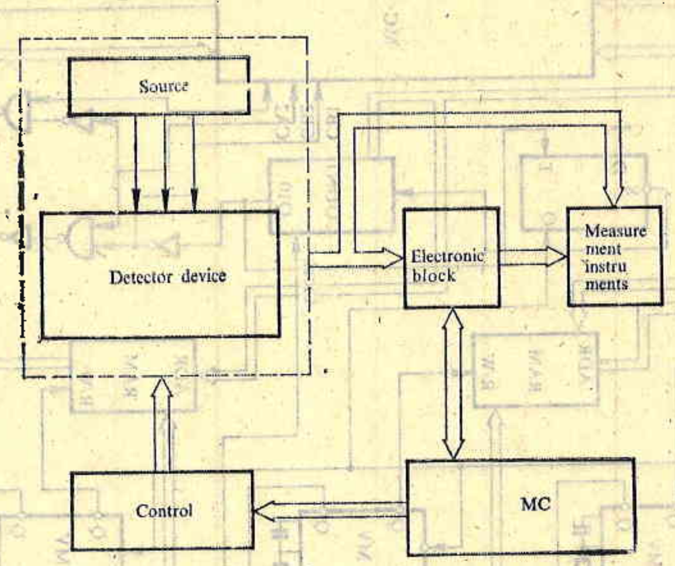

Fig. 1

they provide relatively easy and fast pattern of obtaining information on the particle location. The coordinate-sensitive detectors contain an input charge multiplying element (cascade-connected microchannel plates), and a trapped particle coding anode. Some CSD [1] are known to provide analog coding of the particle locations. There, the anode device divides the output charge from the microchannel plates between the terminals of the individual electrodes with relative amplitudes, depending on the particle location on the CSD. The distribution centroid of this charge and the trapped particle location is measured by the method of analog ratio. Three-electrode anodes are used in the CSD devices, as suggested in [1], for the determination of the trapped particle coordinates, i. e. it is necessary to measure the signals form these electrodes.

The electronic circuit

The block diagram of the electronic system, required for the laboratory testing of coordinate-sensitive detectors (CSD) of the type mentioned above, is shown in Fig. 2. The system is developed as a three-channel version in order to measure the respective CSD outputs.

The amplitude analysis circuit (AAC) is the unit connected directly with the particle detector, which defines the accuracy and velocity of registration and the consequent identification, processing and control procedures. On the other hand, it should ensure all the necessary conditions of adjusting an asyn-

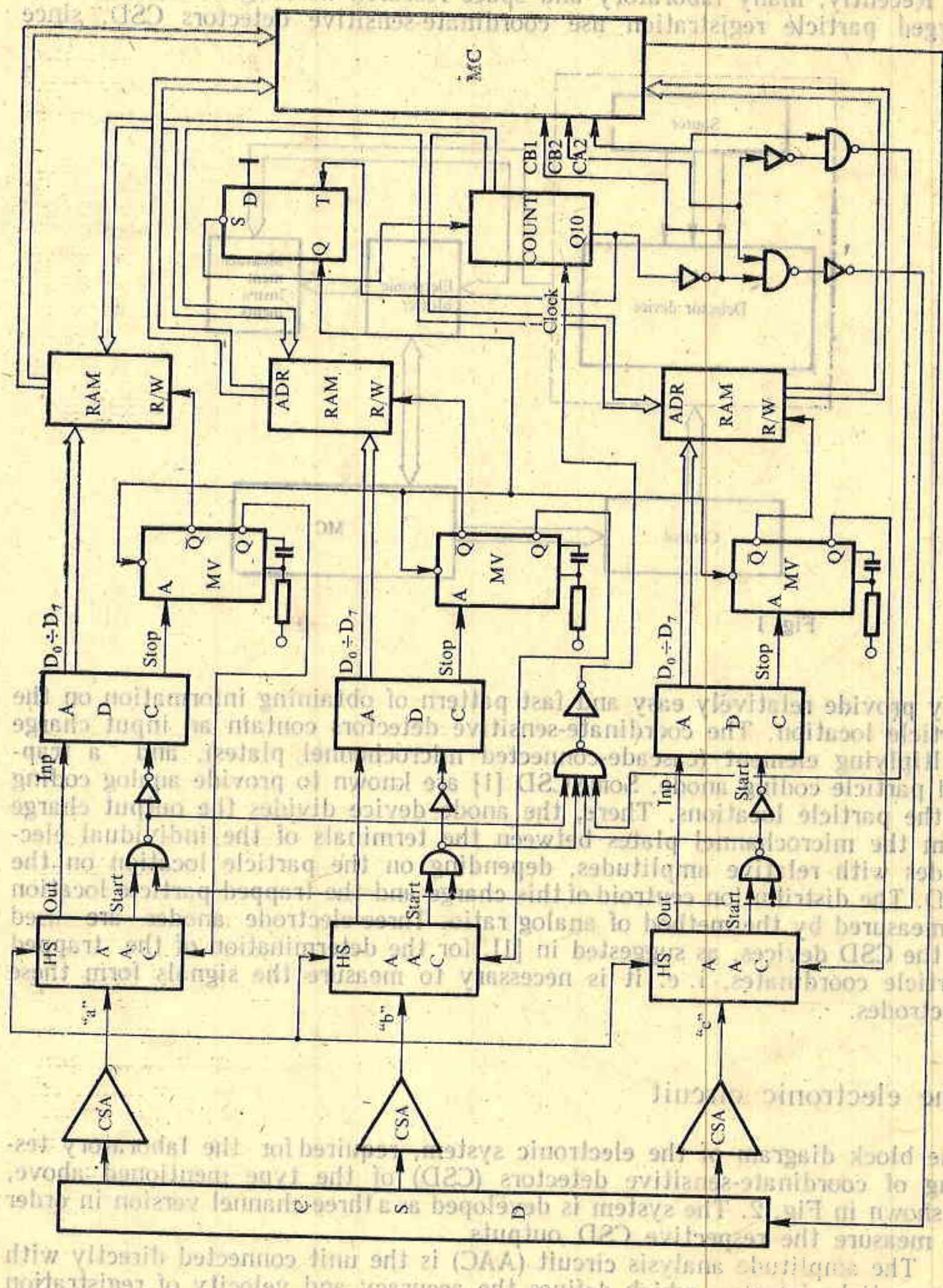
MC
CB1
CB2
CA2
COUNT
Q10
Clock
S
D
T
Q
RAM
R/W
ADR
MV
A
Q
$D_0 \div D_7$
Stop
Inp
Start
Out
HS
C
"a"
"b"
"c"
CSA

Fig 2

chronous system to a synchronous, fast-performance system for processing and control. The amplitude analysis circuit determines to a great extent the adequate transformation of the particle spectrum into a signal spectrum, i. e. there is a possibility for the reverse process: reconstruction of the initial spectrum with sufficient accuracy. The analog signal shape of the detecting system and the specific requirements quite often determine a mixed type of structural-informative organization of the amplitude analysis systems under maximum requirements for real time performance.

The development and the operational capacity of the amplitude analyser is based on the technical capacity and characteristics of the detector. The two cascade-connected microchannel plates, which are the main element of the position-sensitive detectors, have amplification of 10^6-10^7 electrons per event and are specified with large spatial resolution, fast performance and low background signal. These major characteristics, together with the characteristics of the charge-sensitive amplifiers connected to the anode, define the cycle and the dynamics of the amplitude analysis, the main characteristics of which are:

— high resolution including processing of pulses of a width larger than 200 ns;

— fast performance, defined exclusively by the transformation time in the analog-to-digital converter ADC. For ADC of parallel conversion of time 100 ns (for 256 discretion levels), the time for the amplitude analysis is 400-500 ns per pulse, implementing TTL digital IC of 54. . . . . series;

— high precision and reliability of measurement, defined by the principle of net pulse measurement (guaranteed measurement from "zero" level of the input signal), by the lack of frequency correcting and tuning circuits etc.

The main operational modes in testing CSD are set up by the microcomputer MC, and measurement, analysis and processing are time-separated operations. This is required by the necessity of a detailed investigation of the CSD's capacity and characteristics under the effect of a controllable physical system, where much time and profound analysis are requested. The measurement cycle starts with the definition of the CSD parameters and the setting-up of the system into initial state. The pulses from the outputs of the respective CSA are fed to the inputs of the respective amplitude analysers AA. AA, in turn, memorize the maximum amplitude pulse values and shape signals for driving ADC. The first "start" signal enhances the counter (COUNT) content by a unit. The counter content determines the sequential cells of the RAM memories for the two channels, which registrate the digital code of the maximum amplitude value of each pulse. The measurement cycle is rejected when the memory is filled by the counter signal and the microcomputer shifts to a processing mode. For the purpose, it transfers the content from the two memories of the testing system into its own operational memory. The processing of these data is based on criteria and algorithms defined by the physical set-up of the measurements. Such a processing, for example, is the yield of the ratio $2a, (a+b+c)$ and $\frac{2b}{a+b+c}$ from the maximum amplitude values of the pulses from the three CSD outputs, obtained for the same time interval. The program realization comprises two parts. The first represents an assembling programme and refers to the experiment control, while the second relates to the computation of the upper ratios, the visualization and the graph display of the results, and to the amplitude and time distribution of the registrated signals, i. e. it is obviously developed on a higher level.

The entire system is specified with large dynamics and flexibility. It is both hard- and software opened and assumes expansion of instrumental and program functions and potential. The use of personal computer provides a possibility for long-term reliable testing and complex investigation of similar instruments and systems.

References

1. Martin, C., P. Jelinsky, M. Lampton, N. O. Anger. — Rev. Sci. Instr., 52, 1981, 1067.

Система лабораторных испытаний двухмерных координатно-чувствительных детекторов заряженных частиц

П. Т. Байнов, Й. В. Семкова

(Резюме)

Описана система для лабораторных испытаний и калибровки двухмерных координатно-чувствительных детекторов заряженных частиц. Детектор состоит из микроканальных пластин, связанных шевронно, и анода, осуществляющего аналоговое кодирование местопопадания частиц. Характеристики детектора измеряются в вакуумной камере при помощи электронного пучка. Электронная система определяет центроиду распределения заряда на детекторе, визуализирует полученные данные и управляет процессом измерения. Система включает персональный компьютер.