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A SIMPLE BEAM ANALYSER

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Introduction

(ee',p) experiments allows to measure the missing energy distribution as well as the momentum distribution of the extracted proton in the nucleus versus the missing energy. Such experiments are presently conducted on SACLAY's A.L.S. 300 Linac. Electrons and protons are respectively analysed by two spectrometers and detected in their focal planes. Couting rates are usually low and include time coincidences and accidentals. Signal to noise ratio is dependant on the physics of the experiment and the resolution of the coincidence. It is obvious that *if* the true coincidences counting rate *is* proportionnal to the instantaneous incident current i, the accidental rate is proportionnal to i^2. It is madatory to get a beam current distribution as flat as possible.

If N_{true} is the counting rate for true coincidences and N_f for accidentals

$$N_{true} = \alpha Q = \int_o^T \alpha \, i\,(t)dt$$

$$N_f = \int_o^T \alpha \, i\,(t)dt \int_{t-r}^{t+r} i\,(t'-tr)dt'$$

were t_r is a delay for autocoincidence and the coincidence width.

If i(t) is constant $N_f = 2r\,N^2/T$ which is the well known formula for accidentals. It is then interesting to measure the ratio of N_f'/N_f where N_f' is the real accidental counting rate and N_f the counting rate of accidentals for a rectangular beam pulse having the same average current than the one giving N_f'

$$\text{then } f = \frac{N_F'}{N_F} = T\,\frac{\int_o^T i\,(t)^2\,dt}{[\int_o^T i\,(t)\,dt]^2}$$

$$T' = T\frac{N_f}{N_f'} \quad \text{appearing as the real duty cycle.}$$

An apparatus has been designed which allows the evaluation of f. It takes advantage of analog memories capabilities to sample and store analog information corresponding to instantaneous current. The beam pulse is 10 µs wide at a frequency of 1000 Hz which is sufficient provided that the frequency response of the ferrit is in the order of 2 MHz. Analog samples are converted in digital form and the following computation takes place on each sample i_j

1 - Σi_j
2 - $i_j{}^2$
3 - Σi_{j2}
4 - $(\Sigma i_j)^2$
5 - $x\dfrac{\Sigma i_{j2}}{(\Sigma i_j)^2} = f = 1 + \dfrac{1}{x}\,\dfrac{\Sigma (i_j - i)^2}{i^2}$

where x is the number of samples and $i = \Sigma\, i_j/x$ the final result being the relativa variance of the current amplitude.

Computation of f :

The problem to solve is the measurement of the amplitudes of a certain number of samples and to compute the duty cycle value from these measurement.

This operation has to be done for each pulse which is 10 µs wide at a frequency of 1000 Hz.

Provided the experimental set up used for (ee'p) experiments, there is two possibilities to acquire the information.

1 - Paralelling of several sample and hold associated to one or more ADC's. Conversion being done during the beam pulse.

2 - To use analog memories to store the analog informations during the beam pulse and to retrieve and digitalize this information during the interpulse allowing the use of slower ADC's. Fairchild CCD 321 and Reticon SAM 64 types have been considered.

In either case the computation of f could be done by the experiment's on line computer or a specialized unit. The bandwith of the ferrite system delivering the analog signal being 2 MH_z a sampling frequency of that least 4 MH_z is required. The first system has been implemented with a 64 samples/10 µs capacity which is a 6.4 MH_z sampling frequency. The CCD 321 has higher sampling frequency capability around 15 MH_z. At the processing level it is to be pointed that the computation is specific and does not require any programming change. The PDP 15 is fairly busy with the acquisition and processing of the experimental data and cannot absorb this supplementary processing. This has led to the design of a specific unit in charge of the computation of f.

Comparison of the analog memories :

There under are summarized the performances of SAM 64 and CCD 321.

A - **Reticon SAM 64 Serial Analog Memory**

- 64 memory cells (Mos capacitances)
- Independant Read in, Read out.
- Sampling speed from 5 MH_z to 12 MH_z
- Out put capacitance 25 pf
- Clock line capacitance 20 pf
- Dynamic 50 db

B - **Fairchild CCD 321 Analog shift Register :**

- 455 memory cells
- Common read in, read out clock.
- Sampling speed from 20 KH_z to 20 MH_z
- "Square out put signal".
- Clocks capacitance : 30 pf.
- Dynamic : 55 db.

The comparison beetween the two memories shows a higher speed capability for the CCD 321 it is also simpler to use due to the limited number of clocks 2 instead of 4, plus start lines and the possibility to avoid any sample and hold beetween the analog memory and the ADC.

Thus the CCD 321 is certainly a better choice : fig. 1 shows the structure.

It is to be noted that the transfer inefficiencies for the CCD 321, or the signal dispersion from cell to cell for the SAM 64 are sufficiently low, some percents, to keep the accuracy compatible with what is required for f.

Processing unit

Eight bit or sixteen bit monolithic processors would not be sufficiently fast to handle the total volume of processing : 128 addition operations 65 multiplies and a division. It was necessary to use much faster technologies. The 2901 type microprocessor slice has been choosen as the basic element of the processing unit. It must be pointed that recent circuits introductions could simplify and speed up the present structure. However the present system process the data in 750 µs with a basic 200 ns cycle time.

Description (fig. 2)

- 16 bits words
- Microprogramm memory 256 words of 24 bits wide 18 bits of which are for 2901 peripheral control, the 6 other bits control, data transfer to the PDP 15, the accelerator control room and a display.

Processing program (fig. 3)

The sequence is as follows

- Operator initialisation, RAM reset, constants storage during the pulse duration - operator idle
- Acquisition of the digital value of sample i_j, addition of i_j to $\sum_{j=0}^{j-1} i_j$

Computation of i_j2 and addition to $\sum_{j=0}^{j-1} i_j2$

This part of the program is quite time consuming around 10 µs per sample and determine the analog memorie's speed as well as the conversion time of the A.D.C.

Conclusions

Using new technologies, with certainly relaxed requirements, has allowed to monitor in real time the behavior of the beam pulse and determine when the duty cycle can be considered as good on a numerical basis.

It is possible, althrough not done yet but obviously the goal, to use this result either to select flat beam pulses that is with lower coincidental rates or to check the impact of all beam transport parameters on the duty cycle.

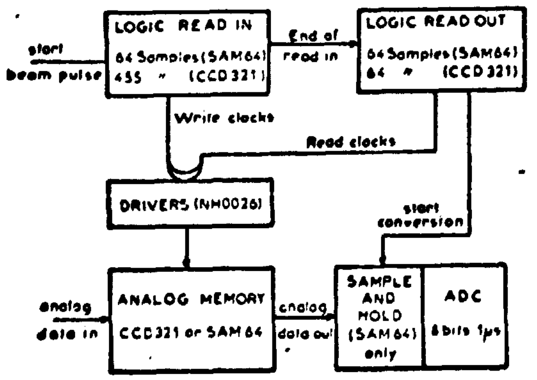

Fig. 1

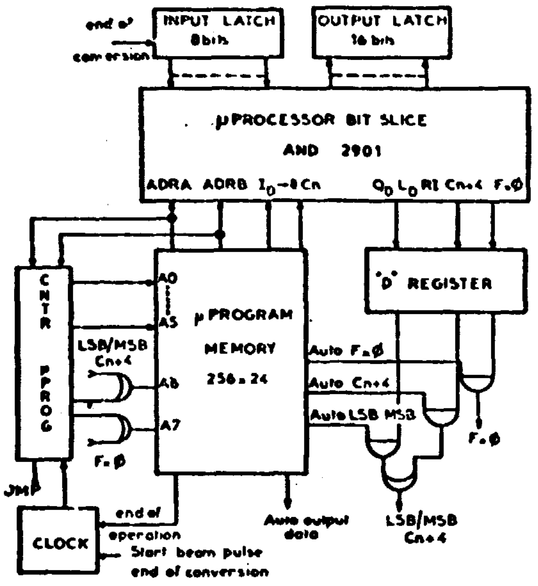

Fig. 2

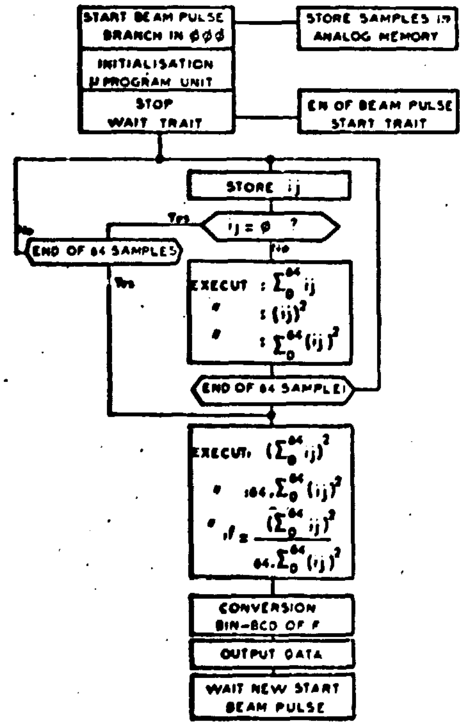

Fig. 3