

# ISTITUTO NAZIONALE DI FISICA NUCLEARE

Sezione di Milano

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INFN/BE-90/06  
14 Giugno 1990

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**A MIXER UNIT FOR DATA ACQUISITION**

## A Mixer Unit for Data Acquisition

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### ABSTRACT

This analog unit is designed to be used with multiparametric data acquisition systems, and in general with usual MCAs, to reduce the number of ADCs needed and to compact electronic chains. Its main peculiarity consists in capability to accept coincident events too.

## 1- INTRODUCTION

Using multiparametric data acquisition systems, many problems arise. Among them are: the great number of ADCs to be used, the need to collect coincident events and the modularity of the whole apparatus to allow an easy extension or reduction of the number of modules used, depending on the physics of the experiment.

Thinking of the solution for all these problems, we designed, built and tested an analog module, MUDA (Mixer Unit for Data Acquisition) (fig. 1), to be used in data acquisition systems to reduce the number of ADCs needed. Each module, in fact, is provided of eight analog inputs, one independent from the others, one analog output, and proper control signals for connecting with an external ADC. MUDA is also able to collect coincident events, and can be easily combined with other ones to increase the input number. Besides, digital outputs allow to control the Router (4-bit word) and the Pattern (8-bit word), the 2<sup>nd</sup> one foreseen for multiparametric analysis.

## 2- GENERAL DESCRIPTION

As previously said, each MUDA module, properly designed for high speed operations, consists of eight independent inputs, -each one having the analog input section of an ADC (threshold, linear gate, stretcher, holder, etc.)-, an analog multiplexer, and a control unit for handshaking with an external ADC. With a rotary switch on the rear panel it is possible to adjust the subgroup memory range ( $0.5 \text{ K} \div 4\text{K}$ ), allowing to collect up to  $8 \times 4 \text{ K}$  spectra, with proper data acquisition system.

MUDA can accept and process also coincident pulses. In fact each input signal is stretched and held, if necessary, up to several hundreds of  $\mu\text{s}$ , without remarkable change in height [1] until it is processed. Moreover it can be used in list or increment mode for collection of data.

MUDA can work in two different ways:

- a) uncorrelated events,
- b) correlated parameters.

a) In the first case, the 8 inputs are independent one from the others. Each input has its own lower threshold, DC coupling, variable Rise Time Protection (RTP) (2,4,8  $\mu$ s), the same for all the inputs.

Each input, in case of coincident events, waits for its own conversion until the previous one is completed. Namely such possibility -of accepting also coincident events- is the main peculiarity of MUDA, thanks to the analog buffers used for the stretching system.

Labeling of busy inputs is made by means of a 4-bit word Router. ADC is employed in sampling mode, to speed up the collection and to have more reliable conversions.

b) In case of multiparametric events, it is necessary in any time to accept coincident events and to label corresponding parameters of different events.

In all the two previous cases, there are two possibilities of choosing coincidence mode, by means of a toggle switch in the front panel. In COINC, an internal circuit allows a coincidence time from 1 to 16  $\mu$ s, in GATE an external signal is used.

The coincidence circuit works in this way. The coincidence time starts with the threshold of first input, (the priority is not fixed, i.e. it does not depend from the pattern word, for correlated parameters also). During this time the threshold of any other input is open, for collection of connected signals. At the end of this time, each threshold is inhibited up to the end of the event processing.

Instead of the first signal threshold, an external strobe (AUTO/STROBE toggle switch) can be used, so making MUDA a slave unit, waiting for an external trigger, in order to synchronize the MUDA data processing to the requirements of the experiment.

For processing correlated parameters, the router word is not enough for a full identification of one event. For this reason, MUDA also has a PATTERN 8-bit word, to characterize each event.

Two other characteristics must be emphasized: the easy extensibility of the number

of parameters to be detected and its small dead time.

In order to increase the number of parameters to be detected, i.e. to combine several MUDAs, as previously said, only a simple interface is necessary. It works as a control unit, to drive OR of each event start, closure of inputs and specially analog output sequence, ROUTER and PATTERN.

With regard to dead time, MUDA can be employed also with very fast successive approximation ADCs ( $3 \mu\text{s}$  conversion time [2]) without any remarkable change in total dead time.

### 3- WORKING MODE

The working mode of MUDA can be understood following both Timing Diagram (fig. 2) and General Schematic (fig. 3).

Each input has an independent lower threshold, with a dynamic of about 1V, and is DC coupled. With threshold, a monostable for RTP starts, together with the coincidence circuit, described in the previous section, whose trigger pulse is the OR signal of the 8 thresholds. The width of the coincidence is infinite, when the switch is OFF.

HOLDER flip-flop starts at the end of RTP. It calls for the conversion, by means of an encoder, used for the handshake with ADC. In fact the encoder, in case of coincident signals, checks the priority, opening in the correct way the analog multiplexers and giving the proper sampling pulse (SAMP) to ADC.

Following input signals, they pass a linear gate, always open, with the stretcher connected in discharge.

Each input has its own RTP, at the end of which HOLDER starts. Before the data processing will begin, it is necessary that all HOLDERS be in order, to avoid priority mistakes.

OR of RTPs signifies that all of them have finished: in fact OR, at the beginning, starts the coincidence time and, at the end, puts out the parameter signals which are present.

All HOLDERS interested are enabled at the end of RTP. The starting of HOLDER switches-off the discharge of the stretcher, to allow level of input signals to stand high. HOLDER closes also input linear gate, to insulate the stretcher after RTP. In coincidence with HOLDER, Data Processing Enable (DPE) starts. It enables priority encoder, for choosing the parameter of highest priority. Consequently CMOS is enabled, in order to put out the signal to ADC. Just after (i.e. the time required for analog outputs to be flat ( $\sim 1.5 \mu s$ )), its SAMP starts. A new output to ADC can be sent only when ADC's RTP is ended. At this moment, in fact, a new pulse starts and is held, up to its own SAMP arrives, in order to enable the conversion. At the end of the connected ADC's RTP, another pulse is put out, waiting for its SAMP, and so on, up to the end of all parameters, for each event. ADC's RTP starts in connection with leading edge of SAMP. The  $2^{nd}$  one will start with  $2^{nd}$  SAMP, etc. At trailing edge of  $1^{st}$  ADC's RTP, ADC will convert the A pulse, while the B one will be converted at the end of the  $2^{nd}$  SAMP, and so on. It is to be noted that a new signal is put out, during the ADC conversion time, and held, up to its own conversion, in order to speed up the process. As to the Router, it can be analog or digital. The analog one (for internal purpose only), connected to A pulse, starts in connection with the leading edge of DPE and goes down with the trailing edge of ADC's RTP. The others, connected with B, and subsequent pulses, start immediately, and go down in the same way.

At the same time, also digital one (i.e. the analog latched) starts, in connection with DPE and ends in coincidence with the trailing edge of ADC Data Enable. For B,.. pulses, on the contrary, it goes up immediately, but in any case always goes down with ADC Data Enable. This philosophy allows to use also fast ADC, with derandomizer [2]. In this case, in fact, ADC stores the data in a latch, after RTP and conversion, waiting for the transmission to MCA, while a new "RTP+Conversion" can start. So the dead time of ADC can be drastically reduced. Before putting out the pulses, it is necessary that each of these has a proper label (coming from the router word) to recognize its own memory subgroup. A shift register allows three different memory range to be chosen (0.5,1,2,4 K). We have

to signify again that only data stored in the memory are transferred to ADC, and not those under processing, to speed up the working mode, with decreasing total dead time.

The Pattern word, foreseen for multiparametric system, should be loaded at the end of RTPs (i.e. at the end of coincidence time, when all possible parameters are accepted). Its output, due to the 3-state component used, is required from the ADC. The PATTERN word represents the HOLDER situation (busy or free).

With regard to the second working mode -STROBE- at the arrival of input signals (either to be accepted or to be rejected), thresholds start, followed by RTPs. As a consequence only those HOLDERS will start, that are connected with good inputs. The coincidence time goes up in coincidence with the strobe input. The other signals show the same behaviour as in auto/coincidence mode.

The 3<sup>rd</sup> working mode -GATE- is completely similar to STROBE mode, unless the coincidence time starts with the trailing edge of GATE.

## **4- PERFORMANCE**

### **4-1 Testing**

MUDA was preliminary tested to verify its correct working mode. The first attempt was made in controlling the timing correctness of MUDA. Using the 4-output, multi-pulse DAG generator [3], we checked it, to control the agreement with the theoretical diagram of fig.2. The experimental results are shown in fig. 4.

With regard to stability, a pulse of fixed amplitude, approximately at half of full dynamical range, coming from a BNC-PB4 pulser was sent in parallel to the inputs. The MUDA output was sent to the data acquisition system for a one week test. The result is a stability better than 1 mV/day, for each input.

At the same time, we were able to verify that no worsening is introduced by MUDA in the resolution of collected data. The FWHM obtained is practically the same as for pulser signal separately collected.

With regard to the Holding, pulses can be held up to 100  $\mu\text{s}$  without remarkable decreasing [1].

Moreover, a set of tests was made with the DAG generator, to determine the integral and differential linearity for the full dynamical range, using 39 pulses from 100 up to 3900 mV, in step of 100 mV. The results are, for each section: integral nonlinearity better than 0.0006%; differential nonlinearity  $< 0.1\%$ .

#### **4-2 Experimental results**

MUDA was also used in electronic chain to verify its performance. The block diagram of the chain is shown in fig. 5. One intrinsic Ge detector, high resolution, one photomultiplier, for high count-rate noise generation in the full dynamical range, one PB4 and DAG pulse generators were connected at the same time to MUDA. The data were collected with Silena VARRO (memory cycle  $< 1 \mu\text{s}$ ) MCA and an ultrafast SILENA 7423-UHS successive approximation ADC [2]. The resolution of both pulsers and gamma-source spectra, and the noise are the same as in case of signals directly collected without MUDA, in spite of the high PM count-rate.

In order to better emphasize the MUDA capability to accept also coincident events, the four spectra shown in fig. 6 were collected. In this case the gamma-signal fed both inputs A and B, PM noise D input, while the C one was left free, in order to control that no spurious counts arrived from other inputs. To take a full advantage of the high speed of both MUDA and 7423 UHS ADC, these spectra were collected using ADC derandomizer option.

We can conclude that MUDA can represent a good tool to compact the multiparameter chains and to save the number of ADC used, without changing the quality of collected data and allowing furthermore to collect coincident pulses.



**References**

- (1) P. Guazzoni, G.F. Taiocchi and L. Zetta - Nucl. Instr. and Meth. A 278 (1989) 507
  - (2) 7423-UHS ADC: user guide - SILENA Cernusco s/n - Italy
  - (3) P. Guazzoni, P. Michelato, G.F. Taiocchi and L. Zetta - Nucl. Instr. and Meth. 185 (1981) 219
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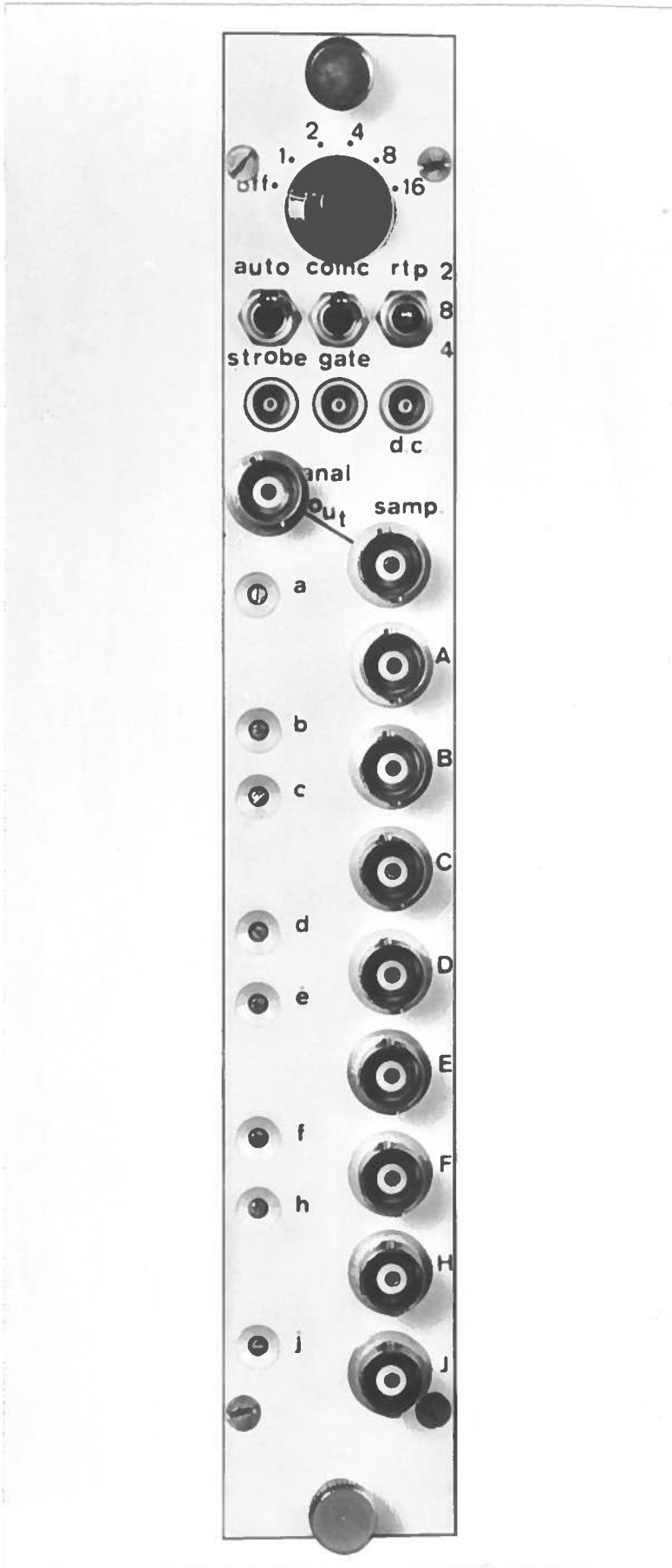


Fig. 1 Front panel

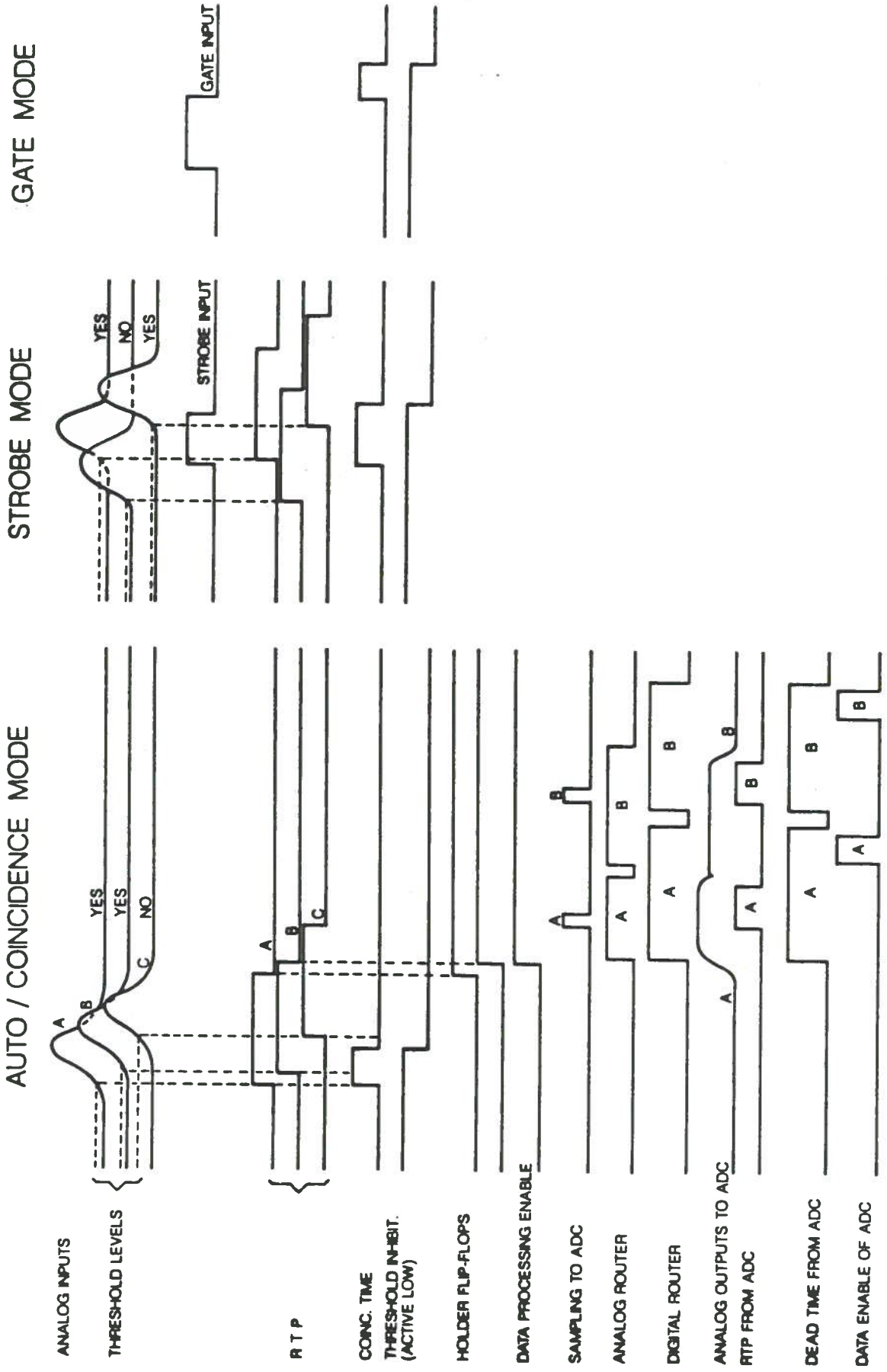


Fig. 2 Timing diagram

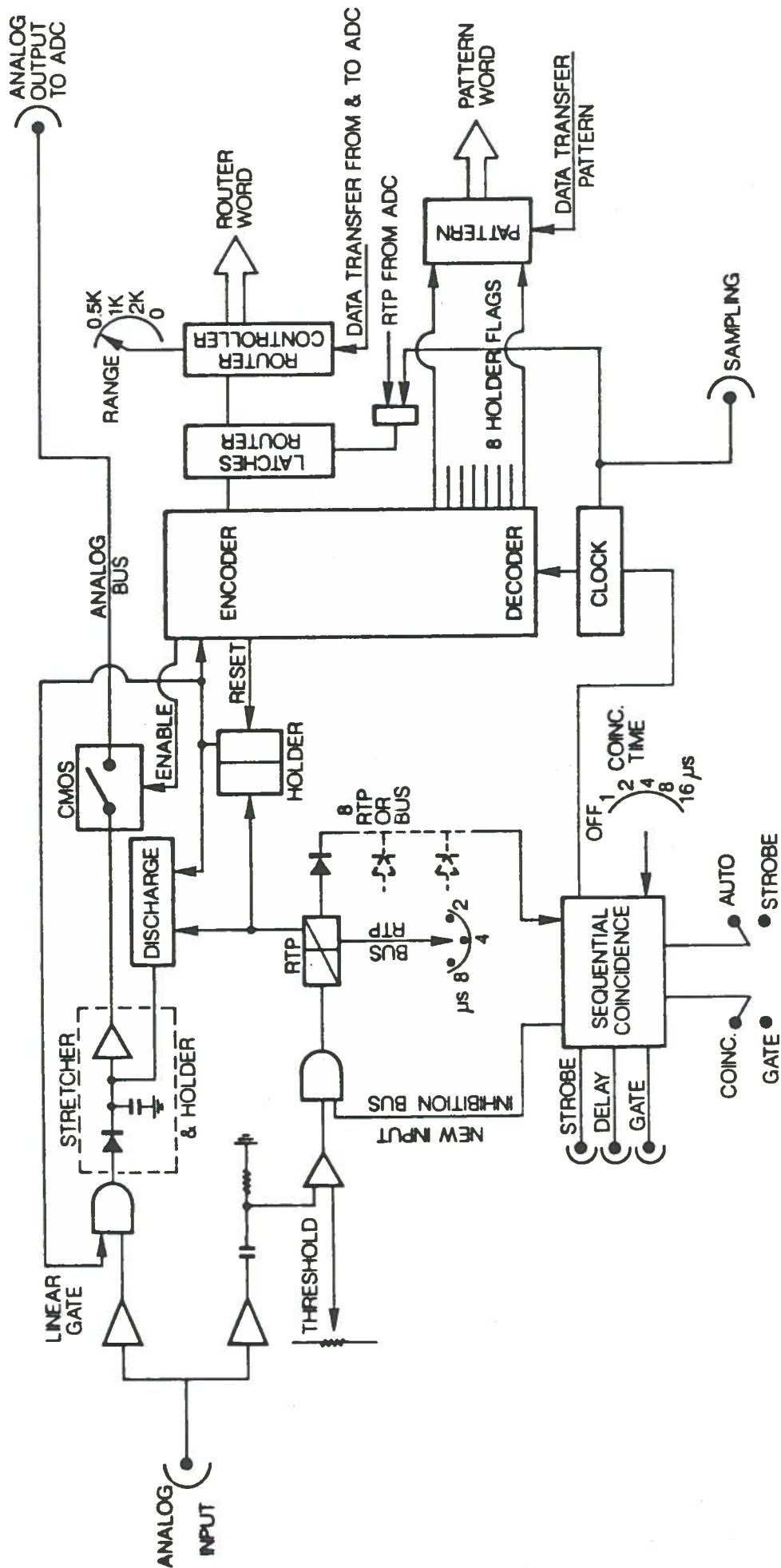


Fig. 3 General schematic

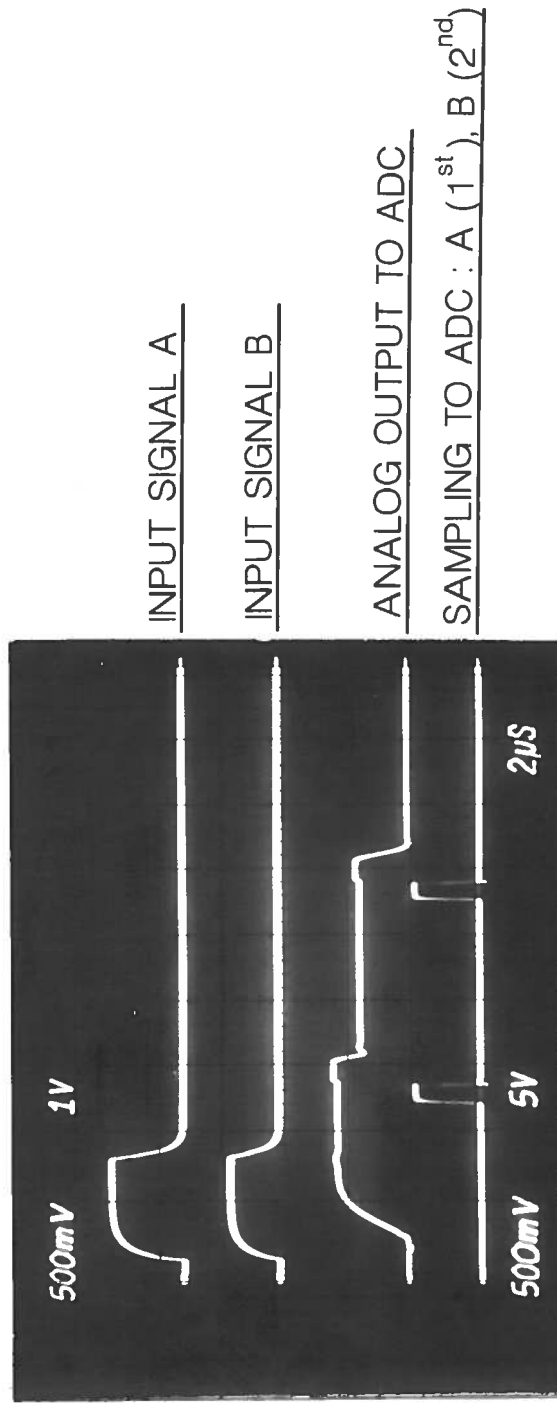


Fig. 4 Photo of the timing of four significant pulses

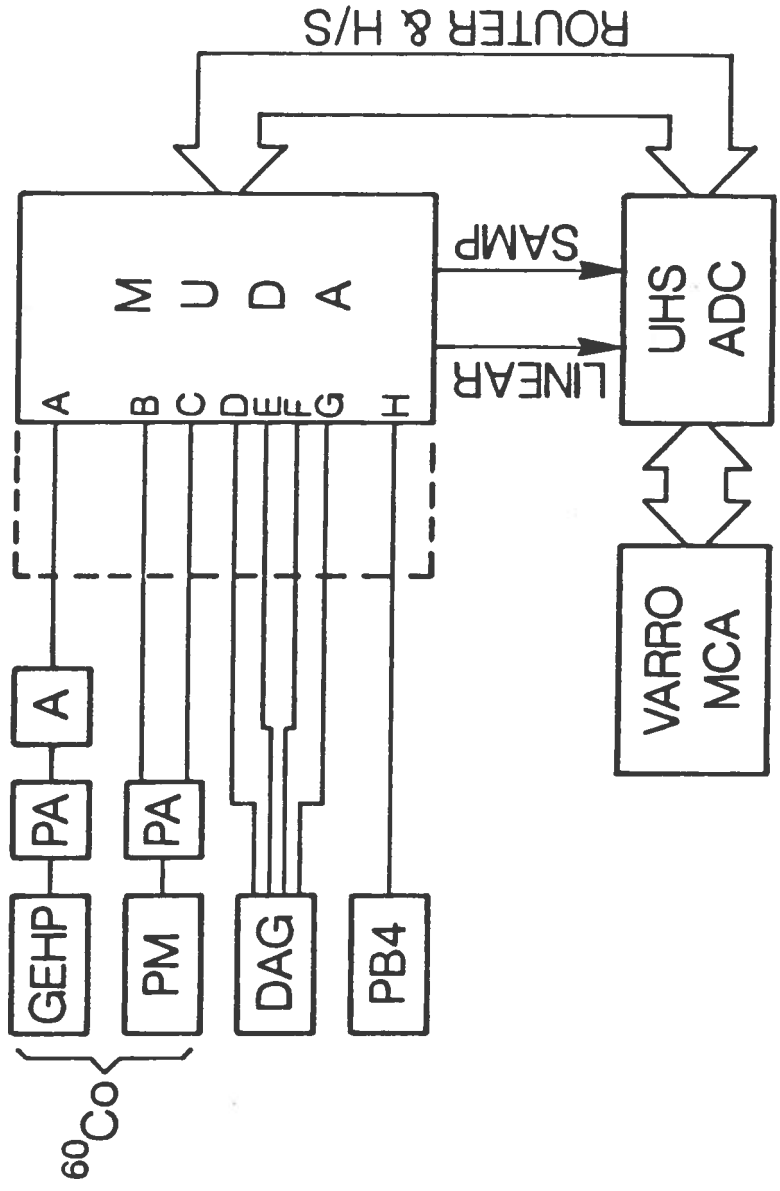


Fig. 5 Testing chain

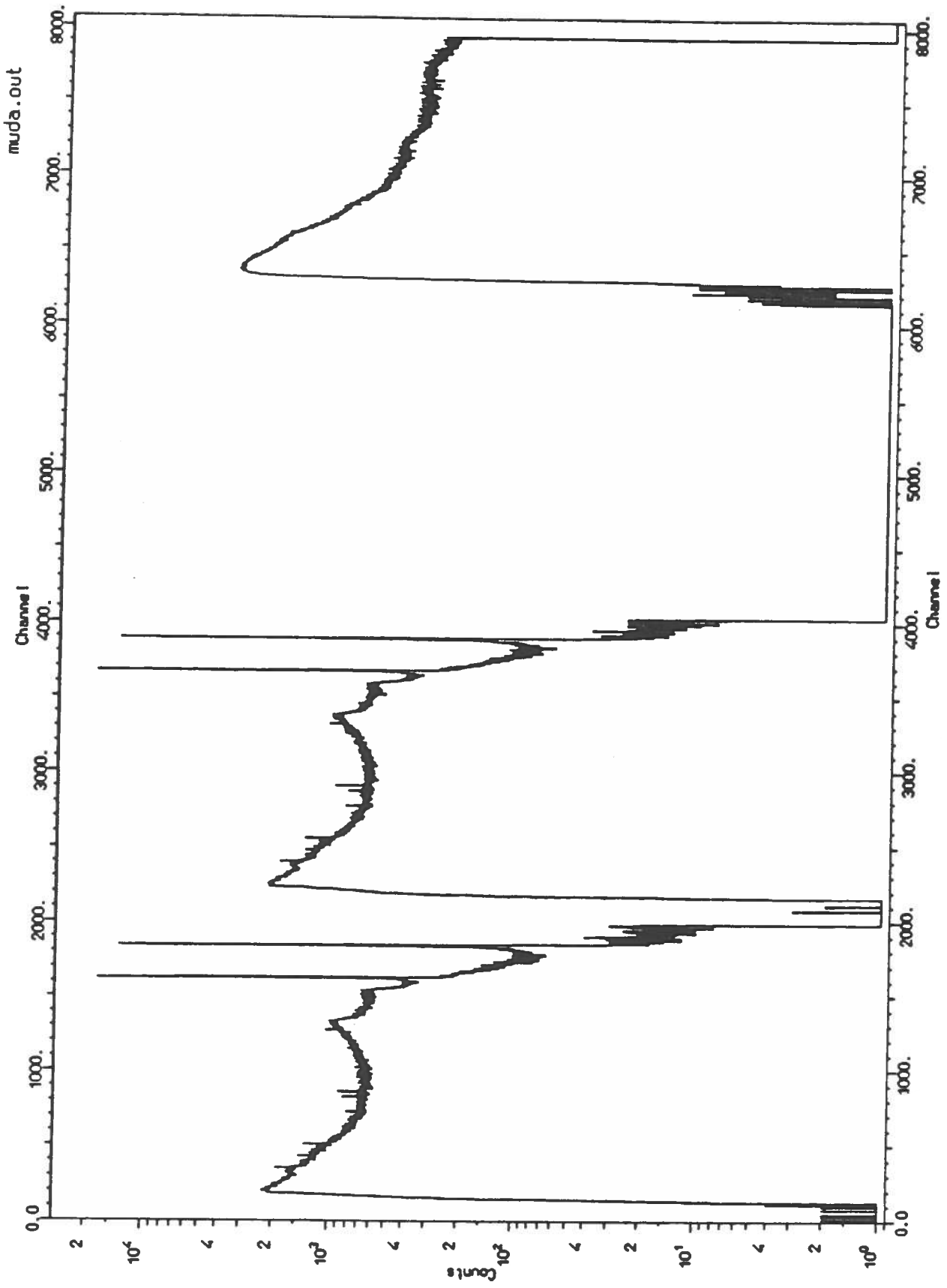


Fig. 6 Multiple spectra obtained using MUDA (see text)