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ADG : AN AMPLITUDE AND DELAY GENERATOR

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4.- CONCLUSIONS

The apparatus described in the present paper can be considered an useful instrument for preparation of nuclear physics experiments. In effect in the same module is built not only the energy pulse generator, but also a new instrument able to furnish timing signals of nice quality and delayed of the required intervals, with a good linearity.

REFERENCES

(1) - F.S.Goulding and B.G.Harvey, Ann. Rev. Nucl. Sci. 25, 167 (1975).

(2) - R.Bassini, P.Guazzoni, Qjang Yujun, G.F.Taiocchi and L.Zetta, Report INFN/BE-83/5 (1983).

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ADG : AN AMPLITUDE AND DELAY GENERATOR

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ABSTRACT

We have designed and built a new kind of pulse generator, able to furnish not only two pairs of coincident pulses, with continuously variable amplitude (0-5 V) for each pulse and delay (40-150 μs) between the two pairs - for energy simulation -, but also the corresponding timing signals - for time of flight simulation - with intrinsic variable different delays ranging from 50 ps up to 128 ns, in step of 50 ps, with a proper time resolution better than 15 ps.

1.- INTRODUCTION

The use of pulse generators for simulating true events is universally diffuse. For this reason the variety of pulsers commercially available is very large. But for special purpose it is not so easy to find the particular type of pulser required. In particular, for mass identification of ions, the widely used time of flight technique[1] requires the manipulation of the energy and timing signals arising from a detector telescope, by means of quite complex electronic chains, to be adjusted and calibra-

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ted, every time. So the utility arises to have a proper pulser, able to furnishing to the identification system signals accurately simulated, covering both energy and timing fields.

For this purpose, we have designed and built ADG, an Amplitude and Delay Generator, which is described in the present paper. It can furnish, as output, two pairs of coincident pulses, with continuously adjustable amplitude (0-5 V) and delay between the pairs (40-150 μs), for the energy field. For timing, every energy output (two as ΔE and two as E) is accompanied by a correlated coincident pulse (two as $T_{\Delta E}$ and two as T_E). The peculiarity of the present pulse generator is the presence of an adjustable delay, also between the $T_{\Delta E}$ and the corresponding T_E pulses. It can range from 50 ps up to 128 ns in step of 50 ps. This philosophy allows the instrument to work as a simulator for mass discrimination.

In the Section 2 a general description of the device is furnished. The specifications are given in the Section 3, while the conclusions in the 4th one.

2.- GENERAL DESCRIPTION

The front panel of ADG is shown in Fig. 1. Describing it, wa can summarize the working mode of the generator. The two columns of toggles, located at the edges, allow the adjustment of the partial delay between each $T_{\Delta E}$ and the corresponding T_E. In the middle, in the upper part, four ten-turn potentiometers allow the regulation of the amplitude of the four energy pulses. For ΔE's, two different toggles allow also a x10 attenuation. Under this part, another ten-turn potentiometer allows to adjust the main delay, which value can be seen through the inspection point. Near,two trimmer potentiometers and a switch allow the introduction of a dispersion that can modulate the energy signals to introduce an "experimental" resolution. The working mode of the pulser can be selected by means of a three--position switch: N (the two pairs in output); 1 (only the first one); 2 (only the second one). We can also see, at the bottom: at left, the four BNC connectors for timing and energy outputs; at right, the trigger selection.

The timing diagram of the ADG output pulses is shown in Fig. 2. A simplified block diagram of the pulser is represented in Fig. 3. Following

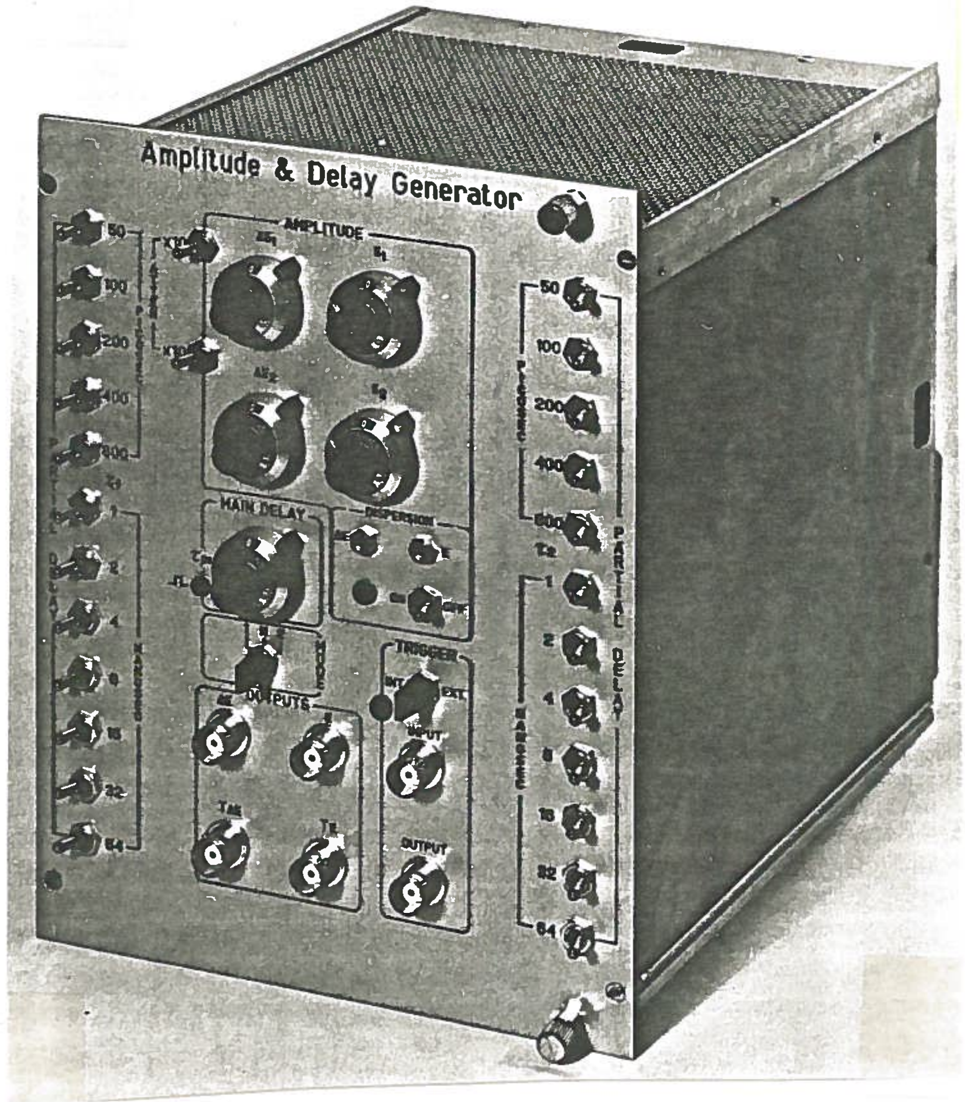

FIG. 1 - Photo of the front panel of ADG.

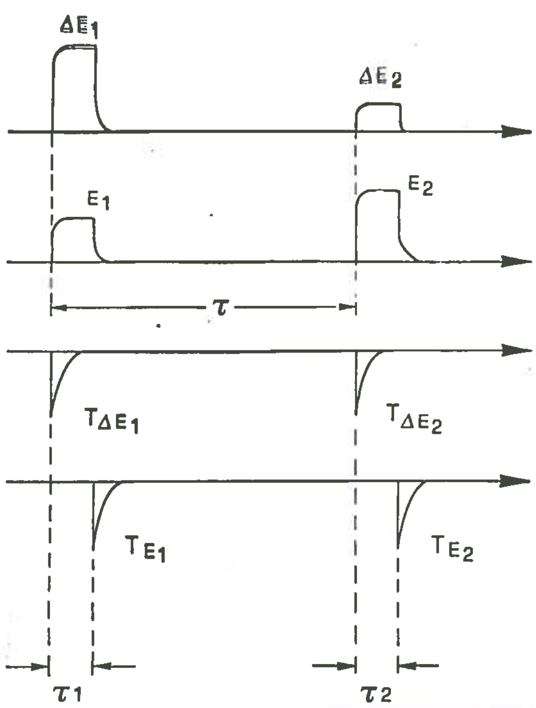

FIG. 2 - Timing diagram of ADG output pulses.

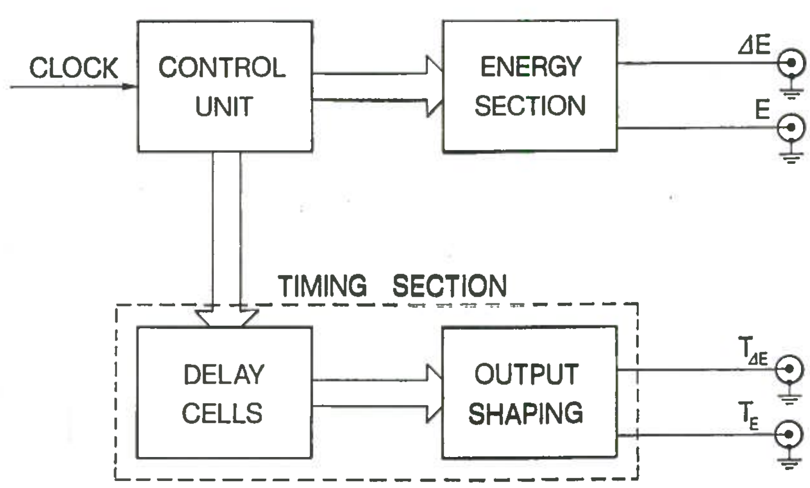

FIG. 3 - Simplified block diagram.

this scheme we can subdivide the module in three different sections: energy section, timing section and control unit.

2.1.- Energy section

It furnishes the two pairs of signals ΔE and E. Its block diagram is shown in Fig. 4. Corresponding to the leading edge of the clock signal,

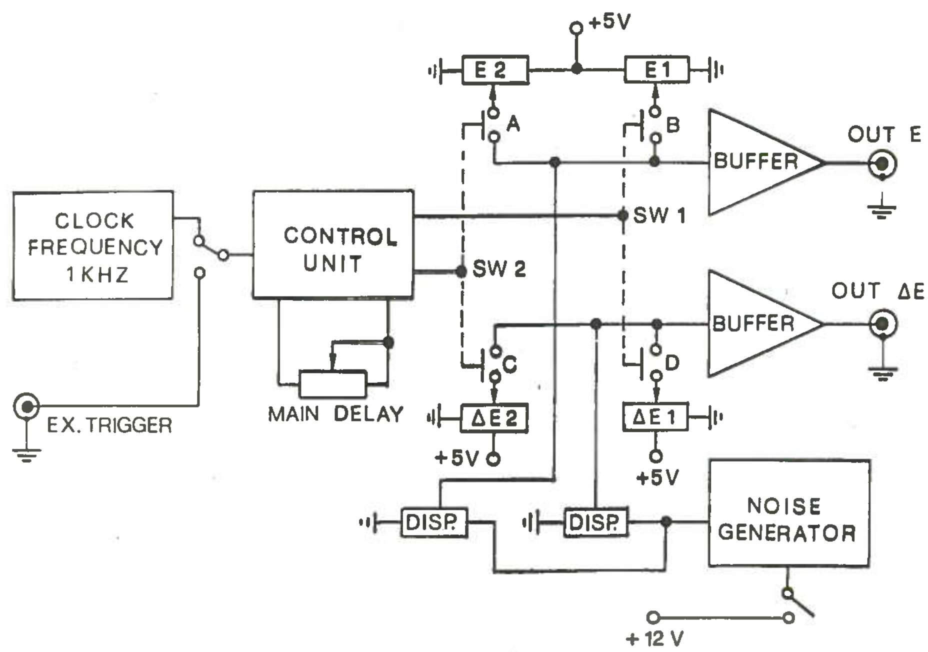

FIG. 4 - Block diagram of the energy section.

the control unit closes for a time interval (3 μs) the switches B and D, by means of the control line SW1. In this way the first part (ΔE_1, E_1) of pulses is sent to the energy output connectors. The width of the pulses is adjustable up to 6 μs; their amplitude corresponds to the value chosen on the E_1 and ΔE_1 potentiometers.

After a main delay τ, the control unit closes for the same interval, the other two switches A and C, by means of the control line SW2. After this time the pair ΔE_2 and E_2, of the chosen amplitude, presents itself to the output energy connectors, τ delayed in respect to the first one.

All the energy outputs can also be dispersed, as previously said, to introduce an "experimental" resolution. This happens by means of a dispersion generator. In fact, firstly a Zener diode is used as noise source. Its output, properly amplified by an operational amplifier, becomes the signal used for the dispersion. Finally it reaches a pair of trimmer potentiometers (gain 1-0) that allow to regulate separately the dispersion level in the two channels (ΔE and E).

2.2.- Timing section

This section is the kernel of the pulser and consists of three different blocks: pulser, delay cells and output shaping. Its goal is to furnish a pair of pulses to each of the two T_E and $T_{\Delta E}$ timing outputs. The T_E pulse of each pair is delayed from the corresponding $T_{\Delta E}$ of a proper interval ranging from 50 ps to 128 ns in step of 50 ps.

The behaviour of the timing section can be described following Fig.5.

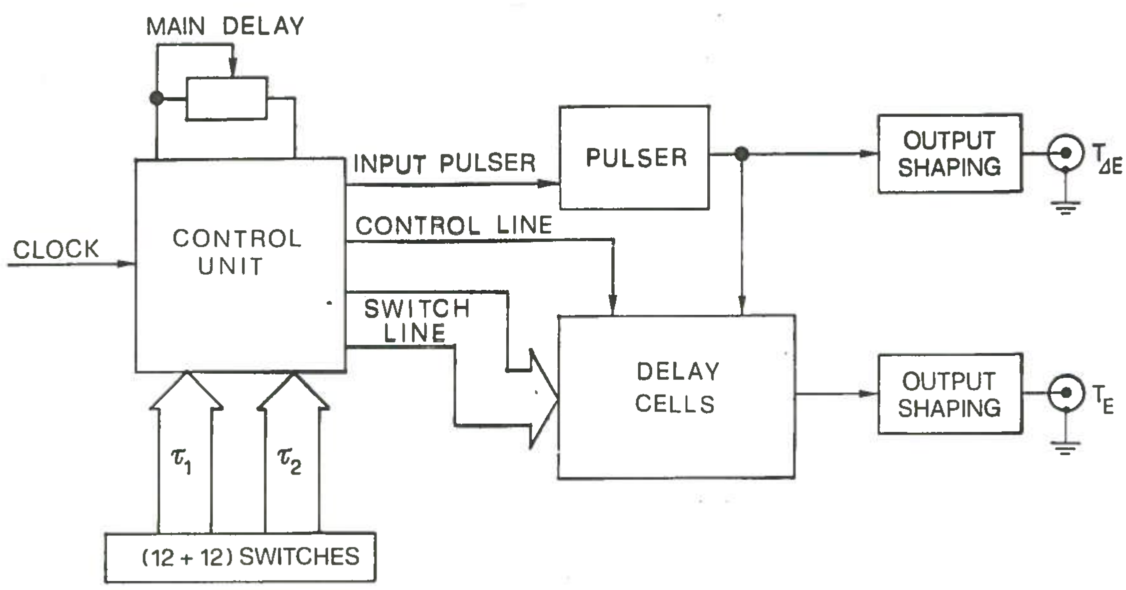

FIG. 5 - Block diagram of the timing section.

The signals coming from the pulser follow two different paths: in the first one the signal arrives directly to the output shaping and after to the $T_{\Delta E}$ output connector; in the second one it passes through the delay cells, the output shaping and present itself to the T_E output connector.

The two groups of 12 toggles, mounted on the front panel, are used to preset the time intervals τ_1 and τ_2 between the $T_{\Delta E}$ and T_E pulses. To complete this goal, the control unit transfers the logic word of the two sets of switches to the control line bus. In this way, once chosen the different delay values τ_1 and τ_2, the pulser is allowed, by the control unit, to start only when the delay cells are correctly set.

The control frequency and the main delay are the same as those of energy section to obtain coincident signals for energy and timing.

2.2.1.- Pulser

It consists of a fast comparator AM685, drived by the monostable 4 of the control unit (see Sect. 2.3). Its input is the clock signal. The signal coming from this monostable is slow and the goal of AM685 is to speed it up to 5 ns.

After the AM685, a current switch makes again shorter the rise time and assures a better stability of the pulse. Emerging from the comparator the pulse follows the two different paths: prompt and delayed.

2.2.2.- Delay cells

To obtain T_E signals properly delayed in regards to $T_{\Delta E}$ ones, the signal, coming from the pulser and to be delayed, follows different paths depending on the chosen delay. To obtain this, we have built 12 "delay cells" of different delay values ($\Delta\tau_i$ = 50, 100, 200, 400, 800 ps and 1, 2, 4, 8, 16, 32, 64 ns).

Up to 4 ns we have used paths drawn on a printed circuit board, to obtain the different delays (largeness 3 mm, thickness 0.03 mm, propagation time 13 cm/ns) (see Fig. 6). For the other ones we have used coaxial cables of proper lengths (RG174U type, 50 Ω, propagation time 18 cm/ns).

Following Figs. 7 and 8, we can describe the behaviour of the delay cells. Each of the 12 serially connected cells allows a delay equal to zero - with the two switches in position 1 - or equal to $\Delta\tau_i$ - when in position 2. The two switches are driven by the logic state of the control unit. It drives the logic information of the two set of toggles, transferring it to the bus switch line. In this way are selected, at different time, the τ_1 and τ_2 delays (obviously $\tau_{1,2} = \Sigma_i \Delta\tau_i$). To avoid unrequired and dangerous spikes, the T_E line is short-circuited during the commutation between τ_1 and τ_2 delays.

2.2.3.- Output shaping

This section consists of two constant fraction discriminators (CFD), built following the same philosophy of our compact system for timing measuring[2]. Their circuitry consits of two comparators: the first one is constant fraction like, the second one has a variable threshold (0-1). An AND gate accomplishes the logical product between the two outputs of the comparators. The two CFD's are built with ECL components, symmetrical in geometry to avoid different thermal shifts. The delay involved in CFD is T_0=4 ns, obtained with a RG174U cable, Z=50 Ω. In these conditions the integration and attenuation of the signals, due to different paths inside the instrument, are completely avoided.

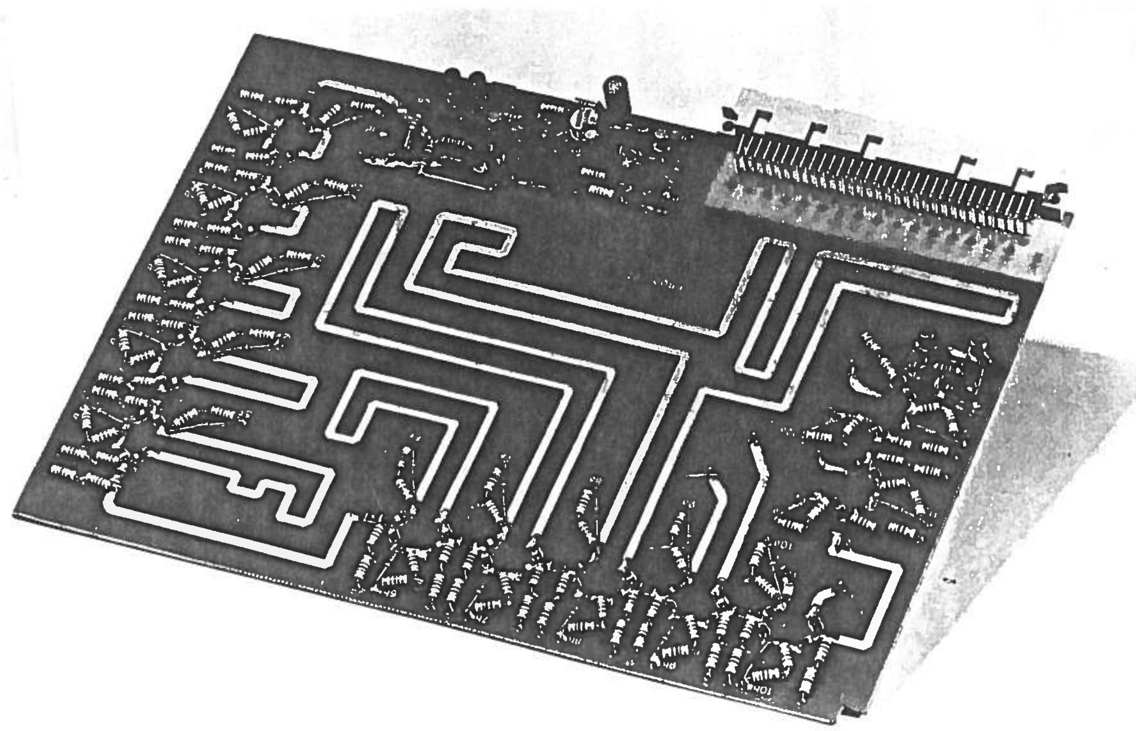

FIG. 6 - Photo of the delay cell printed circuit board.

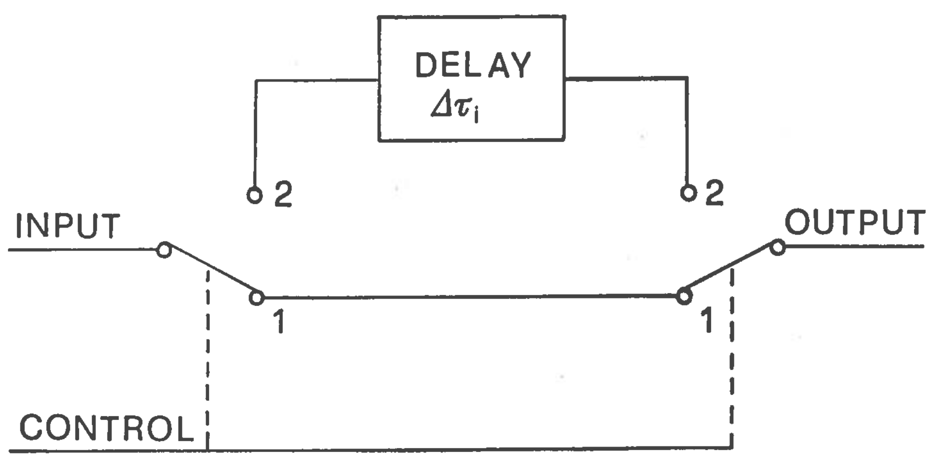

FIG. 7 - Simplified block diagram of a delay cell.

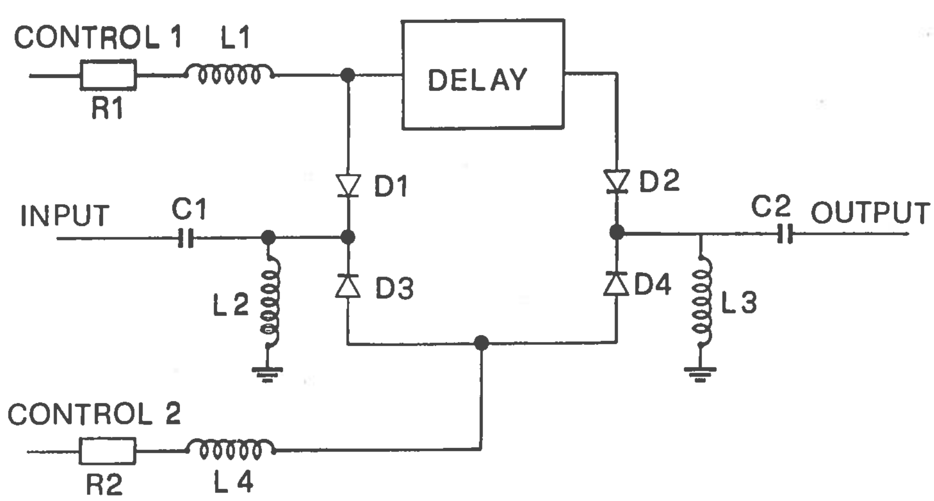

FIG. 8 - Block diagram of a delay cell.

2.3.- Control unit

Its goal is to drive the whole system, furnishing the right timing to the different sections.

As shown in Fig. 9, its circuitry consists of 6 monostables, 1 flip/flop, some logical gates, 1 multiplexer, 12 inverters and 24 power-switches. Five monostables provide a sequence of signals necessary for the apparatus working; the sixth one is used only to visualize the trigger signal with a

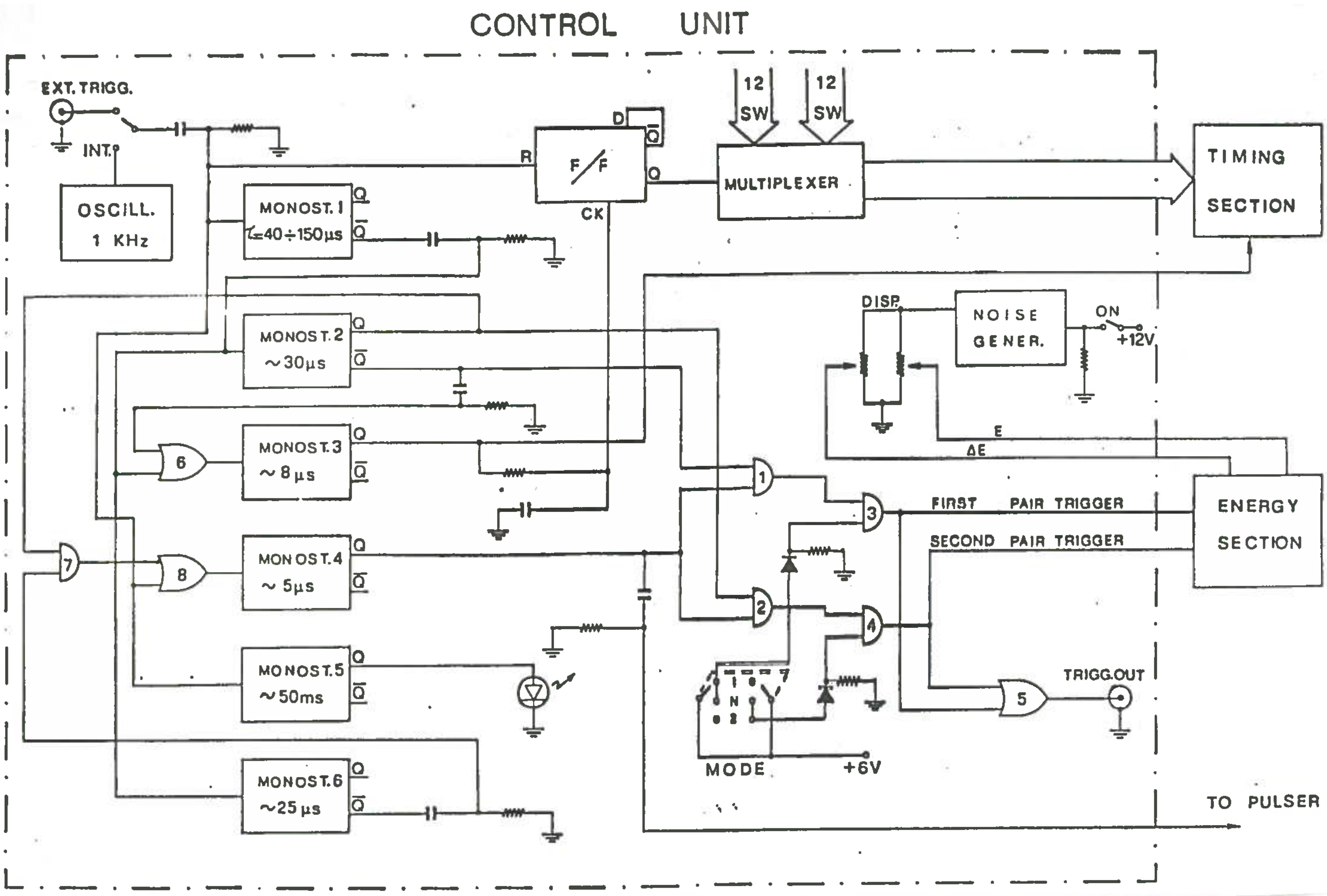

FIG. 9 - Block diagram of the control unit.

LED. The 12 channels and 2 positions multiplexer is used to present as output each digital word (12 bits) representing the proper delay chosen on the front panel toggles. As previously shown, the working modes of the pulser can be selected by means of the three position switch, wich properly sets the relative circuitry. Following Fig. 9 we can see that the two AND's 3 and 4 furnish the proper positive level for the energy pairs, depending on the switching mode selection. The AND 1 is driven by the trailing edge of the main delay negative pulse and the AND 2 by the leading one; while AND's 3 and 4 are directly driven by the working mode switch.

3.- SPECIFICATIONS

Repetition rate:

1 kHz (internal trigger);
0-15 kHz (external trigger, with the main delay at minimum).

Trigger:

external input: amplitude >1.5 V; width >1 μs;
output: positive, + 5 V amplitude, 5 μs width.

Energy pulse:

shape: flat top, positive; 6 μs width;
amplitude: 0-5 V, positive, continuously variable;
attenuation: 2 toggles, x 10, for ΔE pulses.

Main delay:

40-150 μs, continuously variable.

Timing pulses:

amplitude: 1.5 V negative;
rise time: 5 ns.

Timing pulses delay:

integral nonlinearity: $\pm$ 0.06%;
differential nonlinearity: $\pm$ 0.4%;
values: 50 ps-128.55 ns; step 50 ps.

Stability:

timing: 0.05%/°C;
energy: 0.005%/°C.

Output impedence:

for all signals 50 Ω.

Resolution (FWHM):

timing: 15 ps;
energy: 1 mV (dispersion off); adjustable up to 60 mV (dispersion on).

Power required:

+ 6 V - 290 mA; - 6 V - 350 mA;
+ 12 V - 100 mA; - 12 V - 220 mA.

Mechanical dimensions:

quintuple-width, standard NIM module.

4.- CONCLUSIONS

The apparatus described in the present paper can be considered an useful instrument for preparation of nuclear physics experiments. In effect in the same module is built not only the energy pulse generator, but also a new instrument able to furnish timing signals of nice quality and delayed of the required intervals, with a good linearity.

REFERENCES

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