Laboratori Nazionali di Frascati

LNF-59/24 (1959)

A. Alberigi, C. Bernardini, C. Infante and I. F. Quercia: A LOGARITHMIC, CONSTANT PERCENT ERROR, PULSE HEIGHT ANALYZER.

Estratto dal: Nuclear Instruments 5, 120 (1959)

NUCLEAR INSTRUMENTS AND METHODS 5 (1959) 120–123; NORTH-HOLLAND PUBLISHING CO.

A LOGARITHMIC, CONSTANT PERCENT ERROR, PULSE HEIGHT ANALYZER

A. ALBERIGI-QUARANTA, C. BERNARDINI, C. INFANTE and I. F. QUERCIA

C.N.R.N., *Laboratori di Frascati*

Received 5 June 1959

A single channel pulse-height analyzer with a dead time of about 0.15 μsec is described. The channel width is determined by the passive characteristics of a delay line and is a constant percentage of the discriminator setting. An important feature of the device is a paralysis circuit. Circuit diagrams and calibration curves are given.

1. Introduction

The need for fast and drift-free pulse-height analyzers in nuclear physics hardly requires to be stressed: conventional forms of single channel discriminators[1–5]) usually resort to 'kicksorting'': i.e. two threshold discriminators followed by an anti-coincidence, while, of course, defining channel width by means of a standard pulse is also widely employed[6–8]).

The present analyzer differs radically from the above mentioned ones and is a development of the ideas set forth in a recent article[9]): the

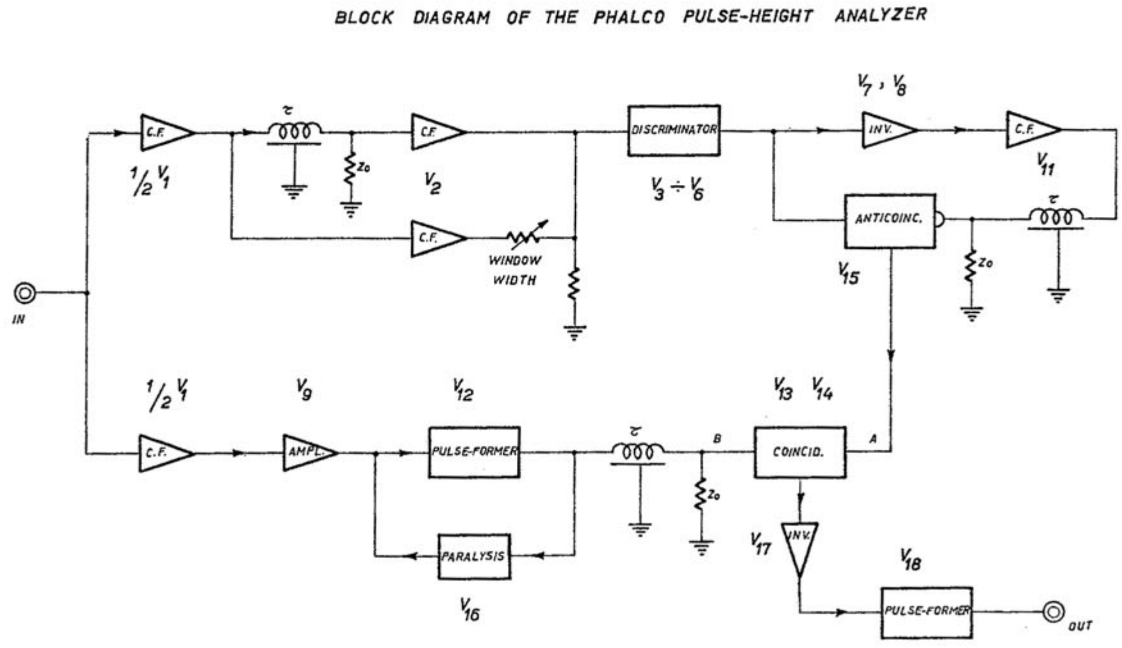

Fig. 1 †

† The abbreviation PHALCO on the headings is short for: Pulse Height Analyzer with Line Coding.

1) R. D. Amado and R. Wilson, Journ. Sc. Instr. 34 (1957) 205.

2) E. Fairstein and E. M. Porter, Rev. Sc. Instr. 23 (1952) 650.

3) E. Fairstein and F. M. Porter, Rev. Sc. Instr. 27 (1956) 549.

4) F. J. M. Farley, Journ. Sc. Instr. 31 (1954) 241.

5) F. C. Park, Journ. Sc. Instr. 33 (1956) 257.

6) E. Gatti and F. Piva, Nuovo Cimento Ser. IX, 10 (1953) 984.

7) E. Gatti, Nuovo Cimento Ser. IX, 11 (1954) 153.

8) S. Colombo, C. Cottini and E. Gatti, Nuovo Cimento Ser. X, 5 (1957) 748.

9) A. Alberigi-Quaranta, C. Bernardini and I. F. Quercia, Nuclear Instruments 3 (1958) 201.

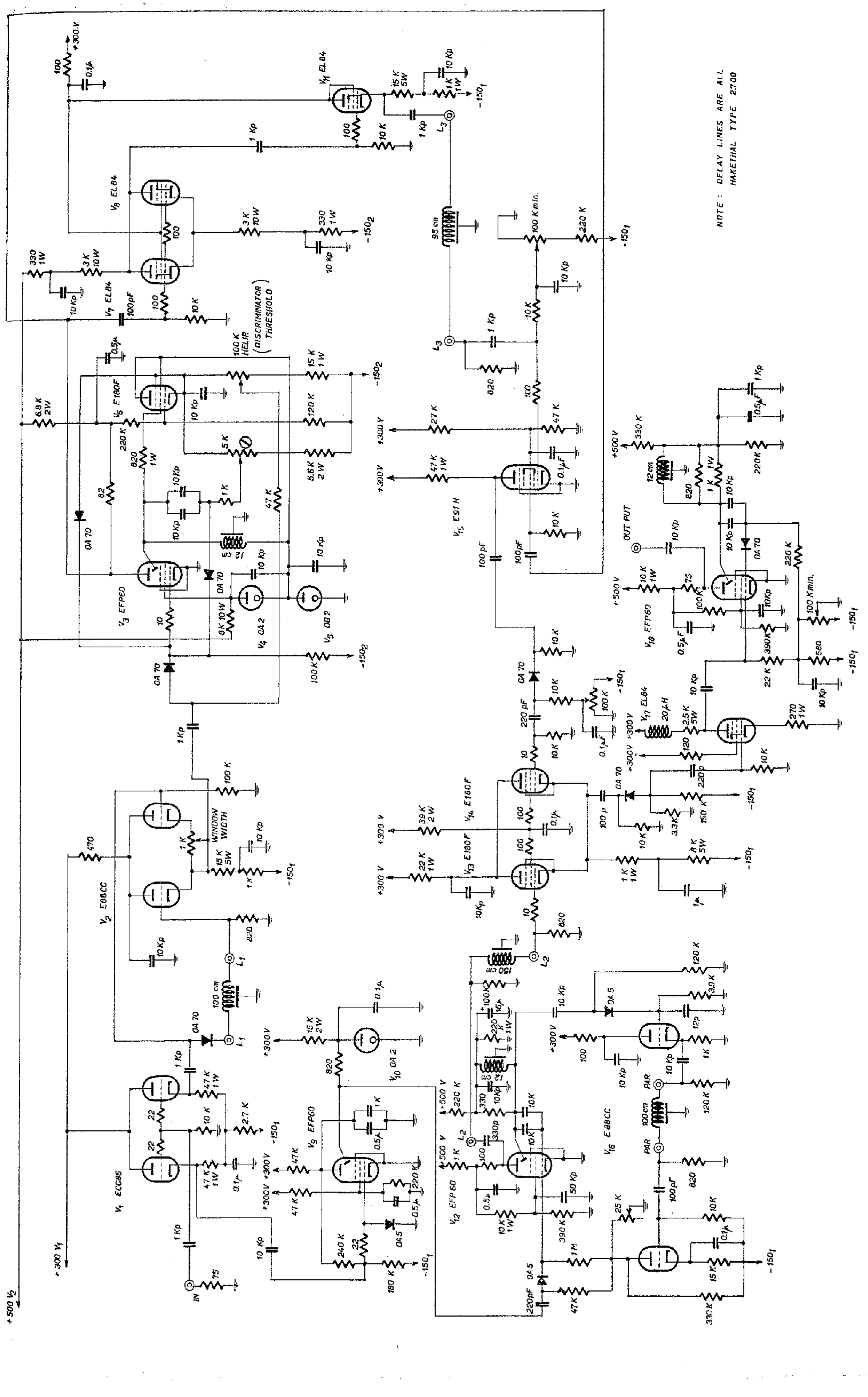

Fig 2

incoming pulse is attenuated and delayed by a matched length of line: both the original pulse and the delayed one are injected into a threshold discriminator: this means that for every input pulse, two pulses are fed to the discriminator at different times: the first pulse of amplitude V_0 at a time $t = 0$, the second of amplitude $V_0 \exp(-\gamma L)$ at a time $T = \tau$, where τ and γL denote delay and attenuation respectively.

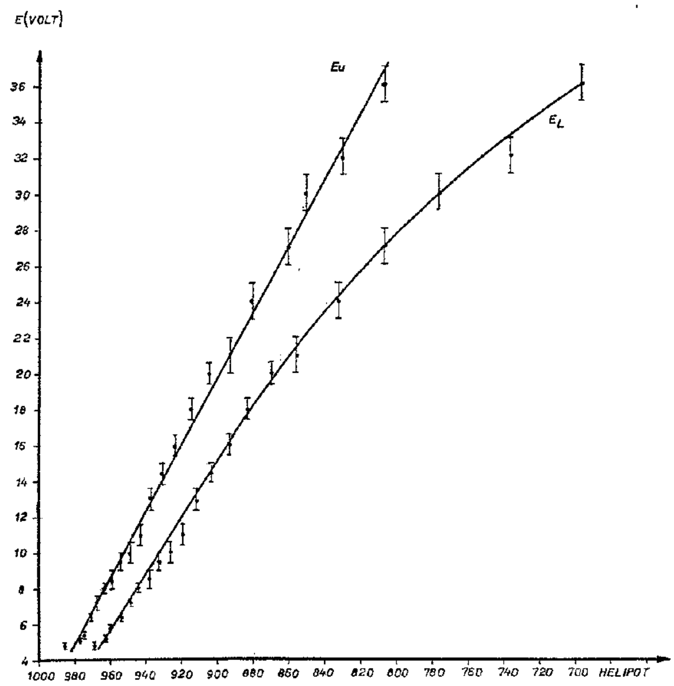

Fig 3

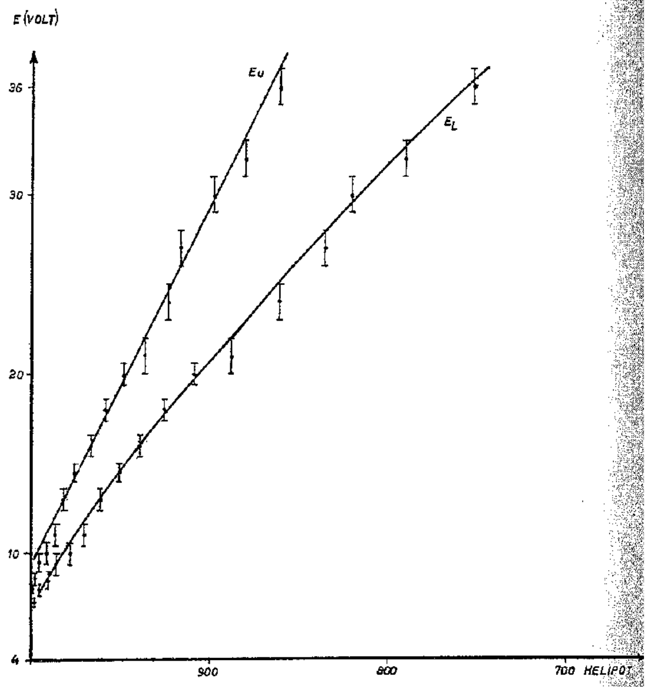

Fig. 4

If we denote the discriminator bias by V_t, the discriminator will trigger

twice if $V_t < V_0 \exp(-\gamma L) < V_0$

once if $V_0 \exp(-\gamma L) < V_t < V_0$

never if $V_0 \exp(-\gamma L) < V_0 < V_t$.

In other words, every time the discriminator fired only once we know that the input pulse had an amplitude V_0 such that $V_t < V_0 < V_0 \exp(-\gamma L)$. Subsequent circuitry is designed to give an output pulse if, and only if, the discriminator fired only once.

2. Circuit Description

The block diagram of the analyzer is shown in fig. 1. Its operation may be summarized as follows: an input pulse reaching IN is cathode followed and delayed reaching the threshold discriminator and is also branched through a variable-gain C.F. so as to control the channel width and again injected in the discriminator; two pulse thus reach the discriminator as outlined previously. The discriminator output is fed to an anti-coincidence circuit both directly and through a delay τ. This insures an output pulse from the coincidence at a time τ after the last pulse coming from the discriminator; i.e. if the discriminator does not trigger there is no pulse in A, if the discriminator triggers once a pulse appears in A a time τ after the input pulse; finally, if the discriminator fired twice a pulse appears in A at time 2τ.

Neglecting the paralysis circuit for the moment, one sees that the input pulse is also cathode followed, amplified, shaped and delayed by τ before it is injected in the coincidence input (point B). The coincidence will therefore produce an output pulse only if the discriminator triggered only once producing a pulse injected at the input A at time τ. The coincidence (resolving power is about 10 mμsec) output is shaped again before being allowed to reach the output terminals.

An important feature of this circuit is a "paralysis" device which shuts the analyzer off during its dead time (about 0.15 μsec). This proves useful in analyzing random pulses because the discriminator might not be able to differentiate between an artificially delayed pulse and a second input pulse occurring soon after the first one. Accurate knowledge of dead time is also of help in making theoretical corrections. Paralysis is introduced in the nonlinear channel by V_{16} in the following manner: positive pulses coming from the dynode of V_{12} are stretched, cathode followed, delayed and inverted by V_{16} and subsequently applied to the grid of V_{12}: the latter is thus kept well below cut-off during dead-time and consequently will not respond to any further input pulse.

The complete diagram of the discriminator is shown in fig. 2.

3. Performance

As a threshold discriminator, the Moody circuit[10]) was found to give stable and reliable operation: the linearity of the single-channel discriminator is evident from the calibration curves, (figs. 3–4) where one can also see that the fractional channel width of the analyzer is constant as was shown in[9]).

Drift of the discriminator threshold was about 0.1 V, while drift in channel width was much smaller than this figure. Dependence in pulse shape and rise time are slight, while calibration of the single-channel analyzer does depend on pulse duration between 10 and 100 mμs as evidenced by the calibration curves. The analyzer as a whole is, of course only as good as its threshold discriminator; the same principle of operation could be used to build a faster analyzer as soon as faster threshold discriminators become available.

[10]) N. F. Moody, G. J. R. MacLusky and M. O. Deighton, Elec. Engng. 24 (1952) 214.