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A STATISTICAL EQUALIZATION METHOD IN TPHC[†]

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A statistical equalization method to improve the differential performances in time to pulse height converters is described.

The main problem in time to pulse height converters (TPHC), like in all systems which operate linearly on a signal distribution, arises from the request of good integral and differential linearity performances. These are improved by a very careful circuitry, but a substantial progress with statistical equalization methods is possible[1–3]).

Here we illustrate the application to the THPC of our equalization method, previously used in analog to digital converters[4]), in order to improve their differential linearity performances. We will deal with two of possible realizations of this method: the first allows the improvement of the differential linearity; the second too allows a reduction of the time of analysis associated with the multichannel pulse height analyzer.

Method description: The basic idea is not to convert directly the time interval T (defined by the START and STOP pulses), but to obtain its conversion by the algebraic sum of the two levels relative to the conversion of two uncorrelated time intervals T_1 and T_2. These are generally different, also for time intervals that will be classified in the same channel; in this way we obtain a statistical equalization of the channel width.

Let us see now how the two time intervals may be generated.

T_1 is bounded by the START pulse and by an external random stop pulse (RSP). The second interval, T_2, must be realized in two ways according to the arrival order of the RSP and STOP pulses: if the RSP is coming before the STOP pulse T_2 is bounded by the RSP and STOP; in this case T is the sum T_1+T_2 (fig. 1a). On the contrary the boundaries are inverted and now T is equal to T_1-T_2 (fig. 1b).

Some schemes of method realizations: Many circuits may be suggested to perform the measurement with statistical equalization as described before.

In fig. 2 we show a block diagram of the first suggested system. The RSP pulse is obtained by a time interval random generator. The T_1 interval is converted by the C_1 converter. Let us suppose that, at the beginning, the logic gates G_1 and G_2 are opened while G_3 and G_4 are closed by means of the FF1 and FF2 flip-flop triggered by the STOP and RSP pulses.

When RSP is coming before the STOP the time to height conversion of T_2 is carried out by the C_2 converter because G_3 is now closed and G_2 opened by the FF2 commutation; then the next pulse (the STOP) will feed C_2. In the second case (the STOP coming before the RSP) the T_2 conversion is carried out by the C_3 converter.

The C_1, C_2 and C_3 outputs are algebraically added

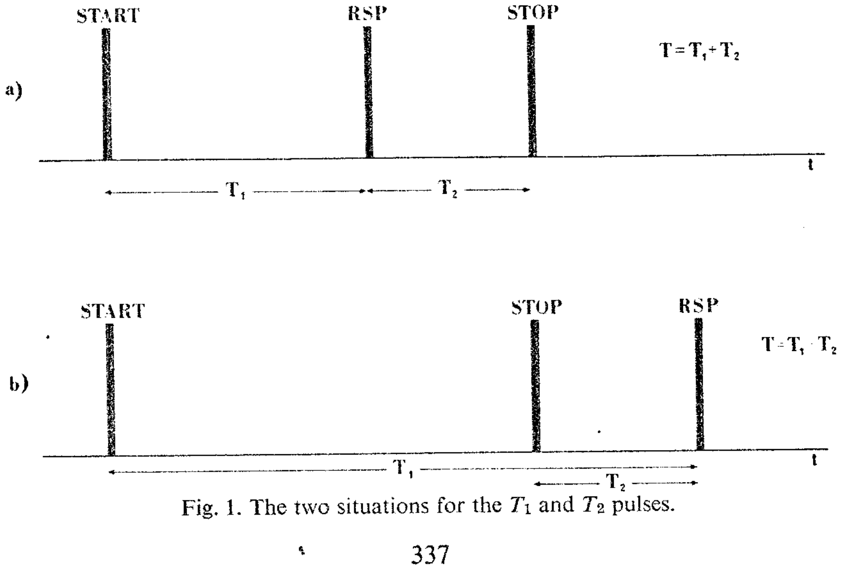

Fig. 1. The two situations for the T_1 and T_2 pulses.

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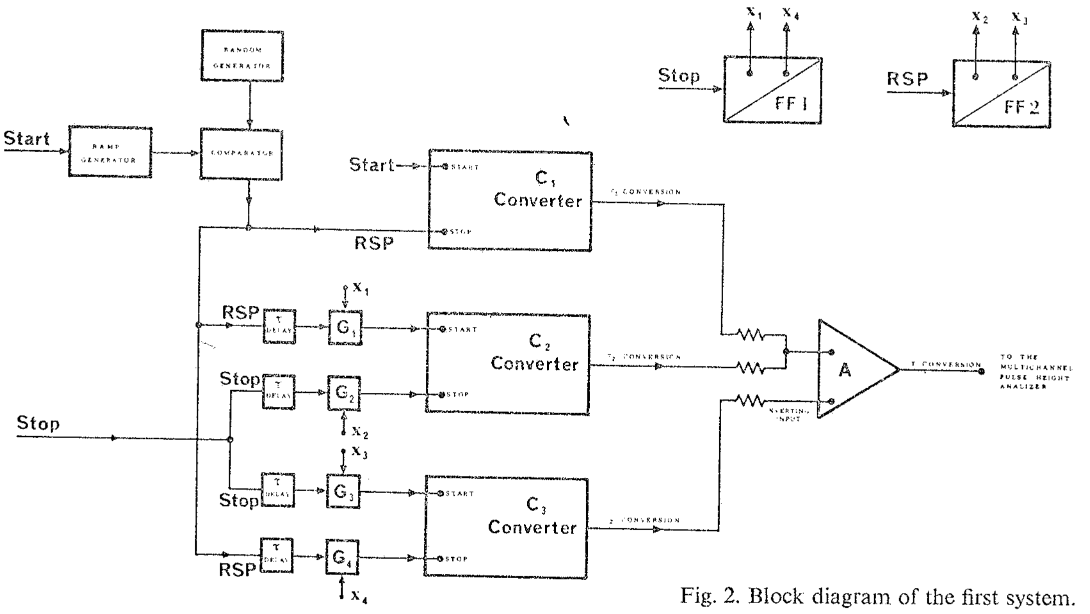

Fig. 2. Block diagram of the first system.

by the adder A whose output is then the T conversion.

The minimum time interval that can be converted is equal to the switching time T_s of FF1 and FF2; in order to reduce that interval four equal delays τ are introduced. If the STOP and RSP widths are greater than $T_s-\tau$ and $\tau < T_s$, the time resolution is now $T_s-\tau$.

The second scheme we propose is shown in fig. 3. The RSP pulse is obtained by the digital to analog conversion (DAC) of the bidirectional register of the multichannel analyzer which holds the measure of the previously analyzed time interval T. This is to be considered as the T_1 measure.

At the beginning G_1 and G_2 are opened and G_3 and G_4 closed. By means of the logic already explained in

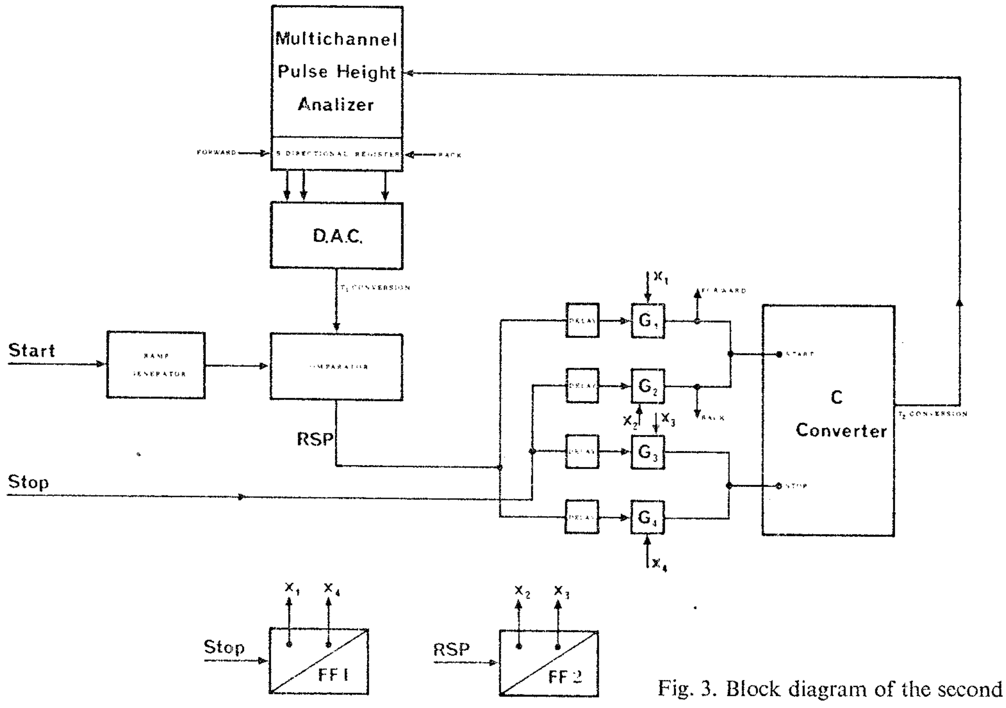

Fig. 3. Block diagram of the second system.

the previous scheme we obtain, from C, the T_2 conversion independently from the arrival order.

The C output feeds the multichannel analyser and its analog to digital conversion is added or subtracted to the bidirectional register content according to the pulse to the C converter "start" input comes from the gate G_1 or G_2.

In this case we generally perform, besides the statistical equalization of the T conversion, a reduction of the analysis time if one uses a Wilkinson type analog to digital converter. For instance, if the time interval spectrum is uniform, we have a reduction of the analysis time equal²) to $\frac{1}{3}$.

We can note that in both schemes the statistical equalization leads to a more complex circuitry and it requires a more flexible instrumentation as, for example, a bidirectional register in the multichannel analyser. This fact is not a heavy problem owing to the present tendency towards more flexible systems.

Moreover, optimized systems can be studied following the method proposed. For example, in the scheme of fig. 2 the C_3 converter can be substituted by a logic able to choose the inverting or non-inverting input of the final adder. Furthermore, the scheme of fig. 3 can be rearranged substituting the DAC with an analog memory.

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