EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

NP INTERNAL REPORT 73-14
August 1973

A MULTI-CHANNEL TIME RECORDER

I. Pizer

1. INTRODUCTION

In experiments where many time-measurements are required, the application of conventional scalers is often complex and expensive. The instrument described below is capable of recording up to 200 time-measurements with a precision of ± 5 nS using 4 scalers and a buffer memory. It has been developed for the new "g-2" experiment but has other applications. (Tradition in "g-2" experiments dictates that this instrument be called a "Digitron".)[6]

2. PRECISION

Timing precision is given primarily by the crystal-controlled 100 MHz clock. In addition, the input signals to be measured pass via Time-Quantizers (sometimes called Derandomisers or Synchronisers) which place them in the nearest 10 nS time-bin. This is a necessary procedure in order to avoid errors (see later). The crystal-clock in the "g-2" application is always running - in other applications the clock could be started in synchronism with a Start pulse.

3. ORGANISATION

The 4 scalers have each 16 bits (4 x 95H16). They are controlled by a recirculating shift-register (95H00) which contains a single 1 bit and three zeros - thus only one scaler counts at a time. Having started the system such that the first scaler is counting the 100 MHz clock pulses, the arrival of a signal to be measured causes the shift register to move on one position, stopping the first scaler and starting the next. To avoid losing a count it is arranged that this shift takes place between two clock-pulses - hence the need for the Time-Quantiser.

As soon as a scaler stops counting, its content is transferred to the M.O.S. buffer and it is then cleared to zero. It takes 500 nS to do this transfer. If, during this 500 nS, two more input signals arrive, the next two scalers also stop counting and the fourth begins. A fourth input stops the fourth scaler and starts the first again (which has been cleared after data transfer to buffer). Should the fourth signal arrive before the first scaler has been cleared, this signal is lost. These losses we call the "Queuing Losses", somewhat analogous to Dead-Time losses; they can be predicted and in most applications will be small.(1)(2)(3) The 500 nS transfer time is a property of the particular MOS memory chosen. Faster buffers would mean even lower queuing losses.

This procedure continues until the buffer of 200 words is full or the measurement is complete.

The times recorded by the scalers represent the time between input signals. To obtain time from a start signal, the recorded times must be added. As an error check, an artificial end signal (marker) may be injected at a known time interval.

4. THE BUFFER

The buffer (MOS static shift register type 2511)[7] has the capacity of 200 words of 24 bits. Sixteen of these bits represent the time-measurement (16 bit binary word representing about 640 μS of measurement time). An additional 8 bits allow any required signals or pattern of signals to be recorded, correlated to the arrival time of the input signal. The size of the buffer could be changed to suit other applications.

The instrument is being constructed as a 3 unit wide CAMAC module and the buffer content may be transferred to a computer, under computer control, with the usual CAMAC functions.

5. THE TIME-QUANTIZER

Basically this is a set-reset device. It is set by an input signal and reset by the next clock. While set, a gate opens, allowing the next clock pulse through. This single gated clock pulse represents the input signal but now synchronised with the clock pulses. One and only one synchronised pulse may be produced for one input signal, and it must always be full amplitude. In the old "g-2" experiment the Time-Quantizer used a Tunnel Diode[4], the present circuits include ECL integrated circuits[5]. The Dead-Time introduced by the Time-Quantizer is 10 nS (for 100 MHz clock) since 2 or more input signals during one 10 nS period can only produce one time-quantized output.

6. QUEUING LOSSES

The prediction of the losses due to the "Queuing effect" caused by using a small number of scalers has been studied. The report by T.K. Alexander et al[1] is relevant. A computer program[2] in BASIC language simulates the system using a Monte-Carlo method and will give results for many differing conditions. A comprehensive paper has been published by H. Øveras[3]. It will be found that in many applications these queuing losses may be neglected. For the present instrument, with 4 scalers and 500 nS transfer time, the queuing losses would be as follows, for various random (Poisson Distribution) input rates:-

Average Input Rate	400 KHz	800 KHz	1.2 MHz	1.6 MHz	2 MHz
Fraction Queuing Loss	.0001	.003	.018	.06	.13

IN CONCLUSION

The instrument or variations of the principles used, can be useful when many times measurements are required. More or less scalers could be used, higher clock frequencies, or variations in the buffer speed and depth.

The present instrument characteristics can be summarized as follows:

- 1 Input for time measurement - NIM
- 8 Label Inputs - NIM
- 4 Scalers, 100 MHz, 16 Binary Bits, used cyclically.
- Buffer - 200 words of 24 bits
- Output - CAMAC
- Resolution - ± 5 nS
- Queuing Losses - depends on input rate.

---

1) CREL-779 Atomic Energy of Canada, Chalk Rever Project, Nov. 1959 (also published as AECL 926).

2) I. Pizer, NP Division "g-2" Note, May 1972.

3) H. Øveras, Nuclear Instruments and Methods 104 (1972) 85.

4) M. Moore, H. Verweij - unpublished - but see P391, Il Nuovo Cimento, Vol. 9A N4, 21 Guino 1972.

5) to be published.

6) K.A. Lundy, Rev. Sci. Instrum. 34 146 (1963).

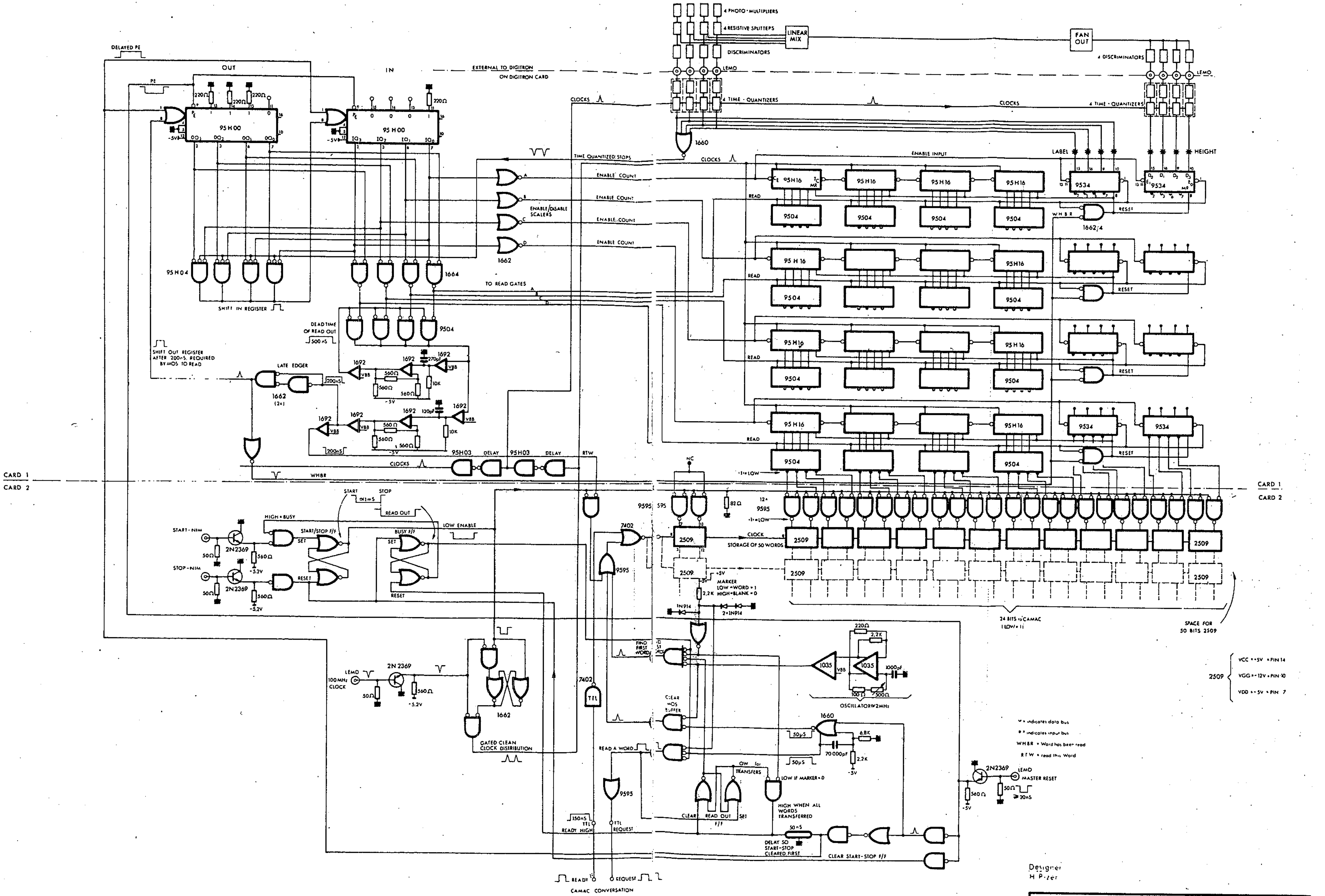
7) 2511 by Signetics.

NOTES REFERRING TO THE "DIGITRON" DIAGRAM 3213-1-A1

1) The actual instrument 3213 does not include the Time-Quantizers shown at the top of the diagram.

2) Time-Quantizers are instrument No. 3214 and will be reported later, as will the Control System 3215.

3) The 16 bit scaler consists of 4 X 95H16 integrated circuits. The 8 input bits are stored in 9534 quad latches. The MOS buffer shown are 2509 blocks which contain dual 50 bits static shift-registers. The final instrument uses dual 200 bit blocks type 2511.



-DIGITRON-

CERN-NP GENEV

3213-1-A1