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**A CAMAC HIGH RESOLUTION
TIME INTERVAL METER**

J. D. Wiedwald

June 13, 1972

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A CAMAC HIGH RESOLUTION
TIME INTERVAL METER*

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ABSTRACT

A four channel Time Interval Meter (TIM) with one-quarter-nanosecond resolution was designed and packaged in a triple width CAMAC module. The TIM has a common Start and four Stop inputs with a total range of 65 536 nanoseconds plus an overflow bit, with basic accuracy dependent on an internal 125 MHz crystal controlled clock.

*Work performed under the auspices of the United States Atomic Energy Commission.

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447-1100, Author is a member, IEEE.

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TIME INTERVAL METER*

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SUMMARY

Background

Many measurements made by the Lawrence Livermore Laboratory involve large numbers of channels where the parameters of interest are the time intervals among various events. Often the sequence of these events is not accurately known beforehand and, though the intervals themselves may be small, they might occur within a relatively wide time frame. Historically, these measurements have been made with wideband oscilloscopes but this method requires very careful (and time consuming) setup and human or sophisticated machine intervention to digitize the trace. Resultant accuracy is typically not better than a couple of percent, a figure that the experimenters find inadequate for present work.

Several time digitizers of high resolution are available but typically suffer from one of two failings; high cost for less than desired resolution or inadequate dynamic range. Because of the large number of channels required, a modular system with a single readout mechanism was considered feasible, and the CAMAC system was chosen as the means for implementation.

Solution

A four-channel Time Interval Meter (TIM) with the specifications listed in Table I was developed. It is of the counter with interpolation variety with a basic clock frequency of 125 MHz and interpolation to 1/8 nanosecond. Since interpolation is performed upon both starting and stopping the net resolution is $\pm 1/4$ nanosecond. There is a unique feature which allows, in case of a failure in the system preceding the start input,

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for the first stop input to start the remaining three channels. The channel which started the unit then reads zero and the other channels are referenced to it. The block diagram for a single channel of the TIM is shown in Figure 1.

Operation

The six least significant bits are obtained by taking the difference of the start interpolation and the stop interpolation and then adding the contents of the ripple counter (LSB weight of 8 nanosecond). The "Start/Stop Logic," "Counter First Stage," "End Counting," and "Start and Stop Interpolators" are totally MECL III using 30 integrated circuits for the four channels. These are mounted on a four layer PC board which is in turn mounted on a standard CAMAC board. The Start and Stop "Time Stretchers" are of the run up/run down type with a stretching ratio of 256:1. Because of delays in the MECL section required to assure jitter free operation, the pulse width into the pulse stretchers ranges between 12 and 20 nanoseconds and this offset must be removed by biasing in the Time Stretchers. All additional circuitry is TTL, with some of it S series (Schottky) for high speed segments and some low power MSI. In order to conserve power, the arithmetic section is multiplexed among the four channels using the CAMAC A busses for addressing.

Conclusion

As of June 1, 1972, a single channel with 12 bits range, had been breadboarded and checked using a PDF-8 as a multi-channel analyzer. The results showed 1.2 channel standard deviation (300 picoseconds) and 100% of 9500 measurements were within 12 channels (± 1.5 nanoseconds). Nearly all of the jitter was determined to be due to crosstalk between synchronous and asynchronous signals on the breadboard, and is anticipated to be greatly reduced on the multi-layer board. The prototype module is scheduled for completion in August, 1972.

TABLE I

Specifications

ONE-QUARTER-NANOSECOND
TIME INTERVAL METER

Number of Channels	4
Number of Start Inputs	1
Number of Stop Inputs	4
Input Signal Levels	NIM Fast
Input Resistance	50 Ω
Input Protection	$\pm$ 200 V Pulse
Resolution	1/8 Nanosecond
Accuracy	1/4 Nanosecond + 0.003% of measurement

Readout: Sub addresses 0 through 3 give
16 least significant bits
appropriate measurement. Sub-
address 4 gives 3 most significant
bits plus overflow bit for each
of the four channels.

Power: $\pm$ 6 V, $\pm$ 24 V; ~ 20 watts

Packaging: Triple width CEMAC module

Additional Feature: If a Stop pulse arrives prior to the Start input,
that pulse will start the other three channels giving a
measurement relative to that channel. The initiating channel
will read zero.

FIGURE 1 - BLOCK DIAGRAM