NAVAL UNDERSEA WARFARE CENTER

⑪ DECEMBER 1967

⑫ 23p.

⑯ F101 03

⑰ SF1010316

⑥

DIGITAL AXIS-CROSSING INTERVAL AND AMPLITUDE MEASUREMENT SYSTEM (DACIM II)·

⑩

by J. A. Nesheim

San Diego, California

SUBPROJECT NO. SF1010316

TASK NO. 8685

FOREWORD

Part I introduces a Digital Axis-Crossing Interval and Amplitude Measurement System (DACIM II). The introduction includes background, system description and applications.

Part II provides a description of the Interval Timer used in the DACIM System. Measurement modes, major components and Interval Timer specifications are described.

This note has been prepared in the interest of others at NUWC and possibly a few persons or activities outside NUWC who are interested in measuring axis crossing intervals. It presents for information, a small portion of the work being done in the area of sonar signal measurement and analysis. Limited distribution outside NUWC is contemplated.

Specification of DACIM II resulted from the joint efforts of E. G. Jackson, H. Magnussen, L. Mulcahy, J. Nesheim, R. Prager and L. Weill.

ILLUSTRATIONS

TABLES

PART I

INTRODUCTION TO A DIGITAL AXIS-CROSSING INTERVAL

AND

AMPLITUDE MEASUREMENT SYSTEM (DACIM II)

BACKGROUND

After reading the title page of this TN, the reader may immediately ask the question, "What is an Axis-Crossing Interval?" or, "Of what use is it?"

To answer the first question, an axis-crossing must first be defined. Here is where a picture is worth a thousand words-----
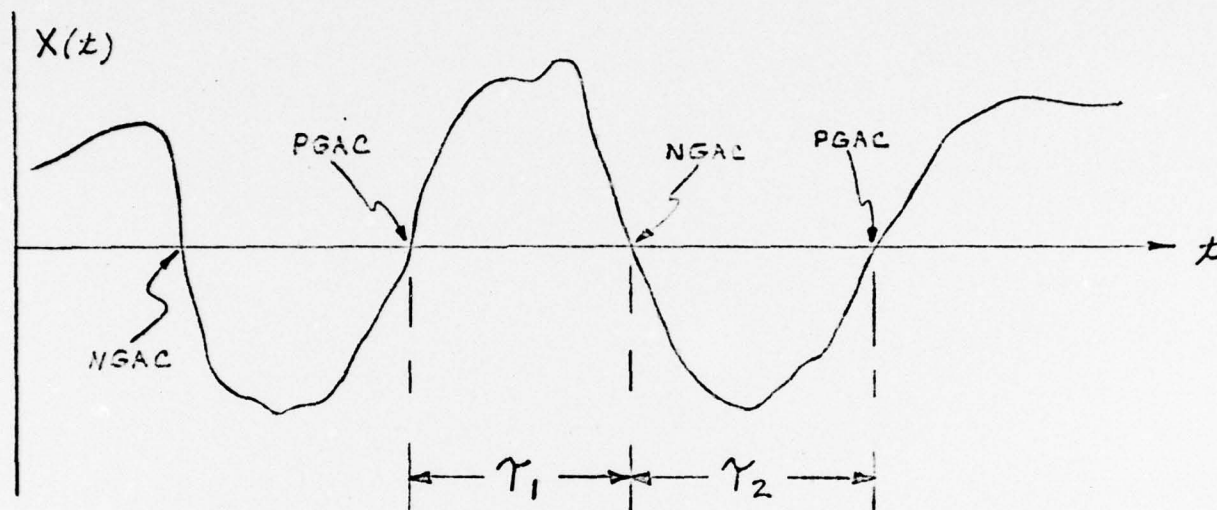
Υ = ONE AXIS-CROSSING INTERVAL

NGAC = NEGATIVE GOING AXIS CROSSING

PGAC = POSITIVE GOING AXIS CROSSING

FIGURE 1, AXIS-CROSSINGS AND AXIS-CROSSING INTERVALS

To answer the second question, axis-crossing intervals yield knowledge of the frequency of a waveform on a cycle-to-cycle basis. Information about cycle-to-cycle phase differences between two waveforms is also obtainable.

Some of the Navy needs to which such information applies are:

(1) determination of sonar Doppler shift relating to

    (a) own ship's motion

    (b) target motion

1

(c) ocean medium effects

(2) more meaningful sonar signal tape recordings through measurement and calibration of flutter, jitter and skew in instrumentation magnetic tape recorders.

(3) improved Sector Scan Indicator, Split Beam Receiver and Correlator designs.

APPROACHES TO THE MEASUREMENT OF AXIS-CROSSING INTERVALS

Some of the early work of measuring sonar signal axis-crossing intervals includes that by W. Rayton and R. Fisher, UCDWR (1944)[1], and the MIT Acoustics Laboratory (1958)[2]. These efforts resulted in the design and fabrication of the Period Meter and the Sonar Signal Analyzer, Q-4X, respectively. More recently, Cook Electric Co., developed the Wave Period Processor (WPP) (1960)[3].

Since 1964, NUWC, Code D-606 (formerly NEL Code 3180) has been conducting investigations of sonar signal amplitude and phase characteristics. This work has involved:

(1) experimentation with 3D, an averaging-type digital axis-crossing interval measurement device (see NEL TM-867).

(2) experimentation with Monoppler, a device which uses phase velocity to estimate Doppler (NUWC TN to be published).

(3) specification of and experimentation with DACIM I, prototype digital axis-crossing detector and interval timer. (NUWC TN to be published). Much of the interval measurement work up to now has involved average measurements; i. e., averaging over a given number of successive intervals using, for the most part, analog instrumentation; e. g., 3D and WPP. DACIM and the Q-4X measure individual intervals.

[1] UCDWR Report No. U 244, Frequency Characteristics of Echoes and Reverberation by W. M. Rayton and R. C. Fisher, 9 August 1944.

[2] Acoustics Laboratory, MIT, Technical Report, Sonar Signal Analyzer, Q-4X, by G. Garrell, Jr., 1 April 1958, for BuSHIPS, Contract NObsr-64653.

[3] A. A. Gerlach, Theory and Applications of Statistical Wave-Period Processing. V. I, II, III, Cook Electric Co., 1967.

Code D-606's current approach is the development of a 2 channel Digital Axis-Crossing Interval and Amplitude Measurement System (DACIM II) to be used in the laboratory and at sea for acquiring, measuring, recording and playing back sonar signal amplitude and phase information, all on a cycle-by-cycle basis (see DACIM Block Diagram, Figure 2).

DACIM II allows for simultaneous measurement of two analog input signals. Signals are first received by the Cycle Analyzers. The Cycle Analyzers produce output pulses which are time coincident with the zeros of the input signals. The Cycle Analyzers also produce binary number representations of the positive peak amplitudes of each cycle of the input signals.

The Interval Timers, one for each channel, receive the zero-crossing marker pulses and measure the time intervals between successive pulses. The time intervals are digitally displayed on the front panels of the Interval Timers and are made available, in binary coded decimal (BCD) form, at rear panel connectors, for subsequent recording.

The Difference Timer receives zero-crossing marker pulses from the two Cycle Analyzers. Pulses from both channels are fed into the Difference Timer where the time difference of pulses in one channel relative the other channel is measured and converted to BCD.

The digitized amplitude information from the Cycle Analyzers and BCD information from both Interval Timers and Difference Timer are fed into a Digital Sonar Data Recording System (DISDRES). Here the data are assembled, formatted and recorded on magnetic tape. DISRES also accepts digital numbers from a Ship's Information Encoder, a unit for use during sea trips, which digitizes ship's pitch, roll, speed and course . Figure 2 illustrates the recording or data acquisition mode, which involves high data rates and high density recording techniques. The DISRES design study, currently underway,

3

includes a playback mode in which the high density tapes are converted to standard digital tapes for computer analysis.

The DACIM Display (contained in DISRES) will allow an observer to monitor the amplitude and time interval information as it is being recorded or played back.

OBJECTIVES

Code D606 is pursuing two objectives involving axis-crossing interval and amplitude measurements:

(1) to investigate the usefulness of phase and amplitude characteristics of sonar signals, as measured on a cycle-by-cycle basis, for target detection and classification.

(2) to provide laboratory and sea data for research on special purpose sonar signal measurement and processing devices and their effects on sonar signals.

APPLICATIONS

DACIM II will be applied to the investigation of:

(1) signal conditioning and processing techniques, such as:

    (a) filtering

    (b) modulation

    (c) correlation

    (d) split-beam processing

    (e) analog magnetic tape recording

(2) effects of the ocean medium on sonar signals.

(3) effects of ship motion on sonar signals.

Existing laboratory computer facilities will be used for data analysis, which will include determining the statistical characteristics of axis-crossing

4

intervals and investigation of relationships between axis-crossing intervals and envelope amplitudes.

STATUS

Further laboratory investigations with Monoppler and DACIM I are currently in progress.

The Cycle Analyzer, Interval Timers and Difference Timer have been specified and are now under construction. All units are scheduled for delivery by April 1968.

Specifications have been written and a contract awarded for a design study of the Digital Sonar Data Recording System (DISRES). The Ship's Information Encoder will not be required until later in this program.

Computer simulations of DACIM-type instruments and of Monoppler are being conducted as a means of investigating how such devices should operate and for comparison with physical measurements.
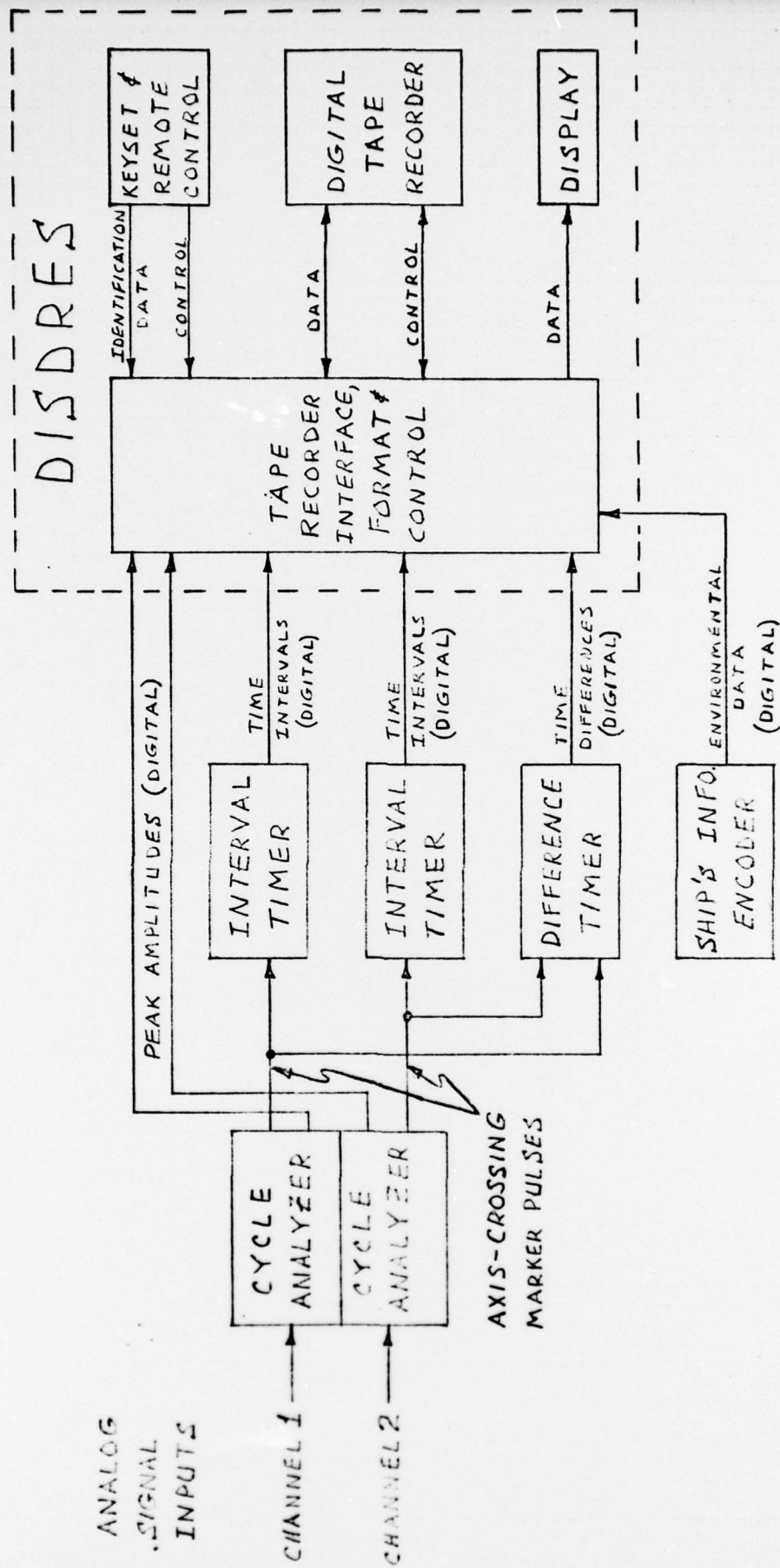
FIG. 2 DACIM SYSTEM BLOCK DIAGRAM

PART II

AN AXIS-CROSSING INTERVAL TIMER FOR DACIM II

INTRODUCTION

The Interval Timer is a modified CMC Model 800 A electronic counter, speci-[1]fied by NUWC Code D-606 and constructed by Computer Measurements Co.,[2] San Fernando, California, under contract No. N123(953)55127A.

The function of the Interval Timer within the DACIM II system is to measure, display and output in binary coded decimal form, the time between successive axis crossings of the DACIM II input signal. The Interval Timer receives from the Cycle Analyzer, marker pulses which are time coincident with the axis-crossings of the DACIM II input signal and measures the time intervals between successive pulses.

DESCRIPTION, GENERAL

The Interval Timer (see Figure 3, Interval Timer Block Diagram) is made up of three major components, which together form a counter system that measures and displays the duration of time between points on the same or different wave forms. The three major components are:

1. Electronic Counter, CMC Model 800A-3007
   (modified CMC Model 800A)

2. Range Module, CMC Model 803A-3007
   (modified CMC Model 803A)

3. Axis-Crossing Interval (ACI) Function Module,
   CMC Model 2774A ACI
   (replaces counter-timer function module, CMC Model 833A)

The Interval Timer is a portable, solid-state instrument which measures electrical quantities selected by the ACI Function Module. The Range Module determines the frequency range. Both modules plug into areas provided within the counter to form a counter system. Selection of the desired measurement mode is controlled by a switch on the Function Module, and is based upon the nature of the DACIM system analog input signal and/or the definition of the experiment for

---

[1] NEL Specification No. 3180-64-1

[2] Operation Manual, CMC Model 800A-3007 Electronic Counter

which the measurement data are required.

The six measurement modes that can be selected are:

1. Single ACI, internal clock

2. Single ACI, external clock

3. Multiple ACI, internal clock

4. Multiple ACI, external clock

5. Continuous ACI, internal clock

6. Continuous ACI, external clock

MEASUREMENT MODES

1. Single ACI Measurement Mode with Internal Clock:

In this mode, the system counts a manually selected internal clock signal for a single interval, starting upon receipt of a start pulse and stopping upon receipt of the first stop pulse following the start pulse . The start and stop signals may be manually selected as points on the B-input signal, on the C-input signal, or the start pulse may be on the B-input signal and the stop pulse on the C-input signal. The output count is displayed on the Counter Display tubes with an automatically-positioned decimal point. Display zero reset is performed manually.

2. Single ACI Measurement Mode with External Clock:

In this mode, the system counts the number of pulses of an external clock signal applied to the A-input of the Range Module, starting upon receipt of a start pulse and stopping upon receipt of the first stop pulse following the start pulse. The start and stop signals may be manually selected as points on the B-input signal or on the C-input signal, or the start pulse may be on the B-input signal and the stop pulse on the C-input signal. Display zero reset is performed manually.

3. Multiple ACI Average Measurement Mode with Internal Clock:

In this mode, the system counts 1 mc., 10 mc., or 100 mc. for a selected

8

number of intervals, starting upon receipt of a start pulse and stopping upon receipt of the first stop pulse after the selected number of start pulses have occurred. The frequency counted and number of intervals are both manually selected. The start and stop signals in this mode are both on the same input signal for either the B or C channel, as manually selected. The display is in microseconds, with an automatically positioned decimal point. Display zero reset is performed manually.

4. Multiple ACI Measurement Mode with External Clock:

In this mode, the system counts the number of pulses of an external clock signal applied to the A-input starting upon receipt of a start pulse and stopping on receipt of the first stop pulse after the manually selected number of start pulses have occured. The start and stop signals in this mode are both on the same input signal for either the B or C channel, as manually selected. Display zero reset is performed manually.

5. Continuous ACI Measurement Mode with Internal Clock:

In this mode, the system counts the number of pulses of a manually selected internal clock signal for every interval, starting upon receipt of a start pulse and resetting automatically upon receipt of each succeeding stop pulse. To allow for reset time, 1000 counts of the time base signal selected are registered after the closing of the count gate and before the opening of the subsequent count gate. In this mode, the Memory switch must be set to on. The start and stop signals are on the same waveform, either the input to the B channel or to the C channel, as manually selected.

6. Continuous ACI Measurement Mode with External Clock:

In this mode, the system counts the number of pulses of an external clock signal applied to the A-input for every interval, starting upon receipt of a

9

start pulse and resetting automatically upon receipt of each succeeding stop pulse. To allow for reset time, 1000 counts of the A-signal are registered after the closing of the count gate and before the opening of the subsequent count gate. In this mode, the Memory switch must be set to on. The start and stop signals are on the same waveform, either the input to the B channel or to the C channel, as manually selected.

DESCRIPTION of MAJOR COMPONENTS

ELECTRONIC COUNTER MODEL 800A-3007

The CMC Model 800A-3007 is designed to operate only with a model 803A-3007 Range Module and a Model 2774A ACI Function Module or Model 833A Counter-Timer Function Module. The counter circuits in the Model 800A-3007 have a fast reset time to permit time interval measurements using the same signal pulse as a stop pulse for the current count and a start pulse for the next count (see Figure 3, Interval Timer Block Diagram).

The results of all measurements are displayed by 8 illuminated digits with an automatically positioned decimal point. The digital display may be reset to zero at any time with a local switch.

The time during which the count gate is open is indicated by the illumination of the gate lamp. Automatic or manual control of the count gate is set by a local Gate switch. The Gate lamp remains on, when the switch is set to "open" and cycles on and off when set to "Auto".

Indication of power supply cycling to a crystal oven is provided by an illuminated Oven lamp.

The display time is variable, independent of gate time. Choice of either a change of display each time a count is completed, or a continuous display of changing count is provided by a rear-panel Memory switch.

The time base used is obtained from either a 1 mc. internal crystal oscillator or an external 1 mc. signal, as selected by a rear-panel switch. Time base frequencies, scaled down in decade steps, are selected by a local or remote Time Base switch. These frequencies are available at the rear-panel Time Base Osc. connector during the Single and Mult. ACI (internal clock) modes of operation. Also available at the connector, during Mult. mode, are scaled down frequencies of the input signal. The 1 mc. time base oscillator output and a 10 mc. output signal are available at rear panel connectors.

Two connectors are provided on the rear panel for supplying digital outputs. Count Output 1 connector provides a four-line binary coded decimal (BCD) output, decimal point output, reset inhibit and end-of-count signals. Count Output 2 connector provides the complements of connector 1 outputs with the exception of the decimal point and reset inhibit signals. Connector Output 2 replaces the Model 800A Remote connector and remote control capability.

RANGE MODULE MODEL 803A-3007

The CMC Model 803A-3007 Range Module is a plug-in unit for operation with a CMC Model 800A-3007 Counter and a CMC Model 2774 ACI Function Module or a CMC Model 833A Counter-Timer Function Module. (See Figure 4, Range Module Logic Diagram).

The Range Module plug-in permits both direct counting of signals up to 110 mc. and period or time interval measurements up to a resolution of 10 nanoseconds.

Included in the Range Module are the A-input connector, an input amplifier, 10 mc. and 100 mc. multipliers and a 100 mc. decade counting unit. Also included are various gating circuits which are actuated by signals as determined by the Function Module and Counter control positions.

11

The Range Module has an input impedance of 10K ohms times the attenuator setting. Attenuator settings (determined by the position of the Attenuator switch) are 1, 3, 10, 30, 100. Input sensitivity is 0.1 volts RMS; 6 db/octave rolloff below 10 cps.

AXIS-CROSSING INTERVAL FUNCTION MODULE MODEL 2774A ACI

The CMC Model 2774 ACI Function Module is a plug-in unit for operation with a CMC Model 800A-3007 counter and a CMC Model 803A-3007 Range Module. (See Figure 5, ACI Function Module Block Diagram.)

The Function Module allows measurements to be made in 6 modes of operation. Controls include Function switch, input selector switch, clock frequency selector switch. Front panel switches are also provided to select either the front panel B and C input connectors or rear panel B and C input connectors.

Input signals to the Interval Timer are applied to the B-input and/or C-input connectors located on both the front and rear of the ACI Function Module. One or two input signals may be applied at any one time dependent upon the selected measurement mode.

INTERVAL TIMER SPECIFICATIONS

Input Channels:

    A-channel (on Range Module) connected with external clock modes.

    B-channel (on Function Module)

    C-channel (on Function Module)

Start/Stop:

1. When separate channels are used in single interval measurement mode, B-input is Start and C-input is Stop.

2. When a common channel is used in any mode, either B or C channel input is both Start and Stop.

12

Frequency Counted with Internal Clock:

1. Single or Continuous ACI: 100 mc. to 1 cps. in decade steps.

2. Multiple ACI Average: 1 mc., 10 mc., 100 mc.

Measurement Range:

1. Internal clock measurements: 10 nsec. to 10^8 sec.

2. External clock measurements: 1 to 10^8 counts.

Accuracy:

± 1 count ± time base accuracy or external clock accuracy.

Readout Units:

1. Internal clock, single or continuous ACI: micro-sec, msec., sec; automatic decimal point.

2. Internal clock, multiple ACI Average: micro-sec; automatic decimal point.

3. External clock: none.

External Signal Inputs:

1. A-INPUT: MAXIMUM INPUT FREQUENCY, 110 mc

Attenuator position	Max. input (V rms)
1	10
3	30
10	100
30	250
100	250

2. B and C inputs: rectangular pulses; 0 V-off; -9 V-on; rise time $<$ 10 nsec; duration at least 100 nsec. B and C channel input impedance $\approx$ 1 K ohms.

Internal Time Base Stability:

1. Aging: $<$ ±3 parts in 10^9/24 hours

2. Temperature: $<$ ±2 parts in 10^{10}/°C

3. Line Voltage (±10%): $<$ ±5 parts in 10^{10} for 10% change.

MODE SELECTION

The Function Switch selects the mode by which the measurement is to be made. Table 1 lists the Function Switch positions and respective measurement mode descriptions.

INPUT SELECTION

The Input Select switch selects the start and stop pulse source. See Table 2 for listing of Input Select switch positions and respective pulse sources.

14

FUNCTION SWITCH POSITION	MEASUREMENT
SINGLE	Single ACI mode measurement with internal clock; manual reset.
$\frac{A}{SINGLE}$	Single ACI mode measurement with external clock; manual reset.
MULT	Multiple ACI average mode measurement with internal clock; manual reset
$\frac{A}{MULT}$	Multiple ACI average mode measurement with external clock; manual reset.
CONTINUOUS	Continuous ACI mode measurement of every interval with automatic reset upon receipt of stop pulse.
$\frac{A}{CONTINUOUS}$	Continuous ACI measurement with external clock of every interval with automatic reset upon receipt of stop pulse.

Table 1. ACI FUNCTION SWITCH/MEASUREMENT MODE

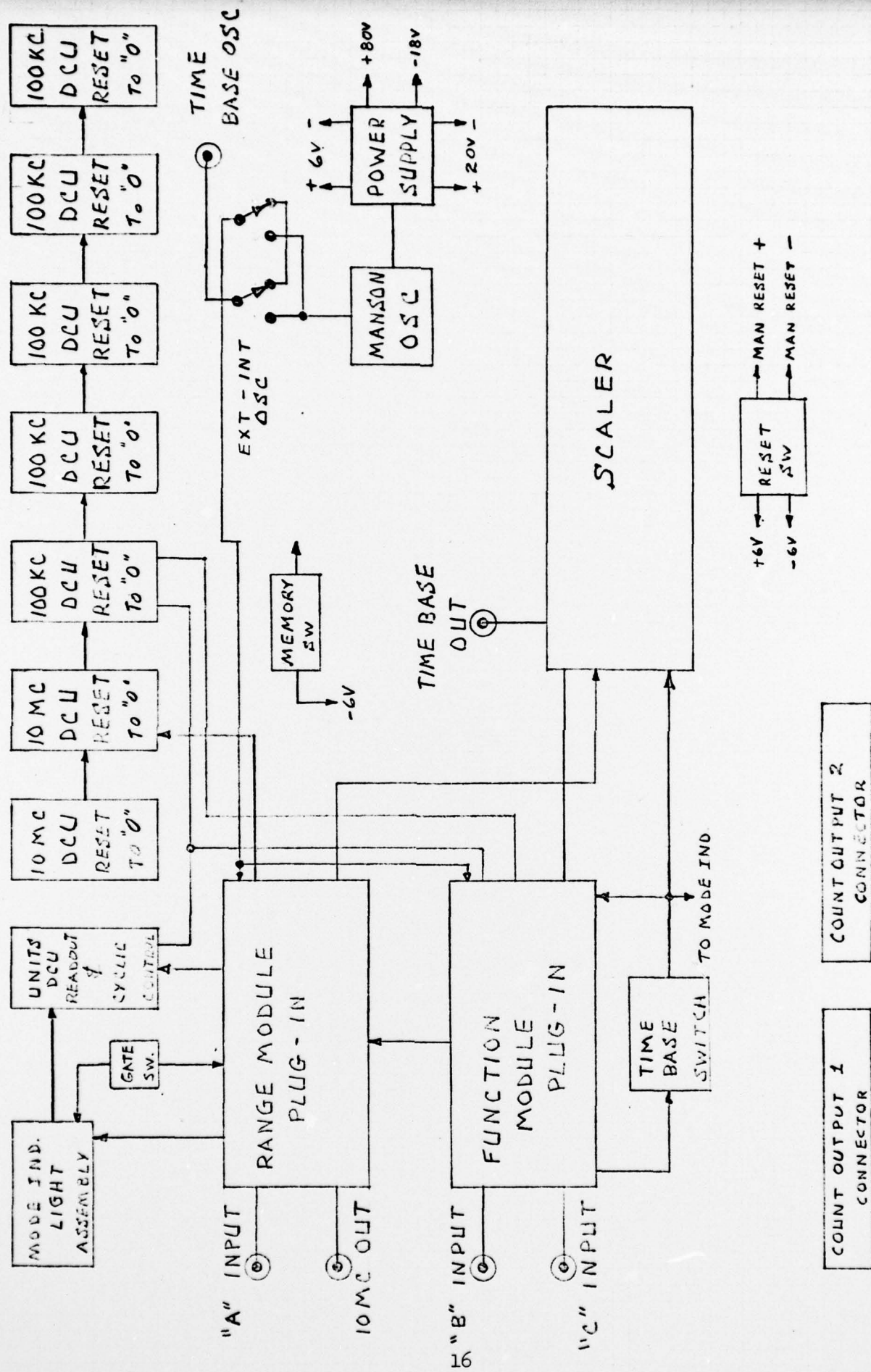| SWITCH INPUT SELECT POSITION	START AND STOP PULSE SOURCE
START/STOP B	B-channel signal starts and stops count.
START/STOP C	C-channel signal starts and stops count.
START B/STOP C SINGLE ONLY	B-channel signal starts count, C-channel signal stops count; for signal ACI mode measurements only.

Table 2. INPUT SELECT SWITCH/PULSE SOURCE

15

FIG. 3 INTERVAL TIMER BLOCK DIAGRAM

16

100 KC DCU RESET TO "0"

100 KC DCU RESET TO "0"

100 KC DCU RESET TO "0"

100 KC DCU RESET TO "0"

100 KC DCU RESET TO "0"

10 MC DCU RESET TO "0"

10 MC DCU RESET TO "0"

TIME BASE OSC

EXT - INT OSC

POWER SUPPLY
+80v
-18v
+6v -
-6v -
+20v -

MANSON OSC

MEMORY SW
-6v

TIME BASE OUT

SCALER

RESET SW
+6v → MAN RESET +
-6v → MAN RESET —

UNITS DCU READOUT & CYCLIC CONTROL

MODE IND. LIGHT ASSEMBLY

GATE SW.

RANGE MODULE PLUG - IN

FUNCTION MODULE PLUG - IN

TIME BASE SWITCH

TO MODE IND

"A" INPUT

10 MC OUT

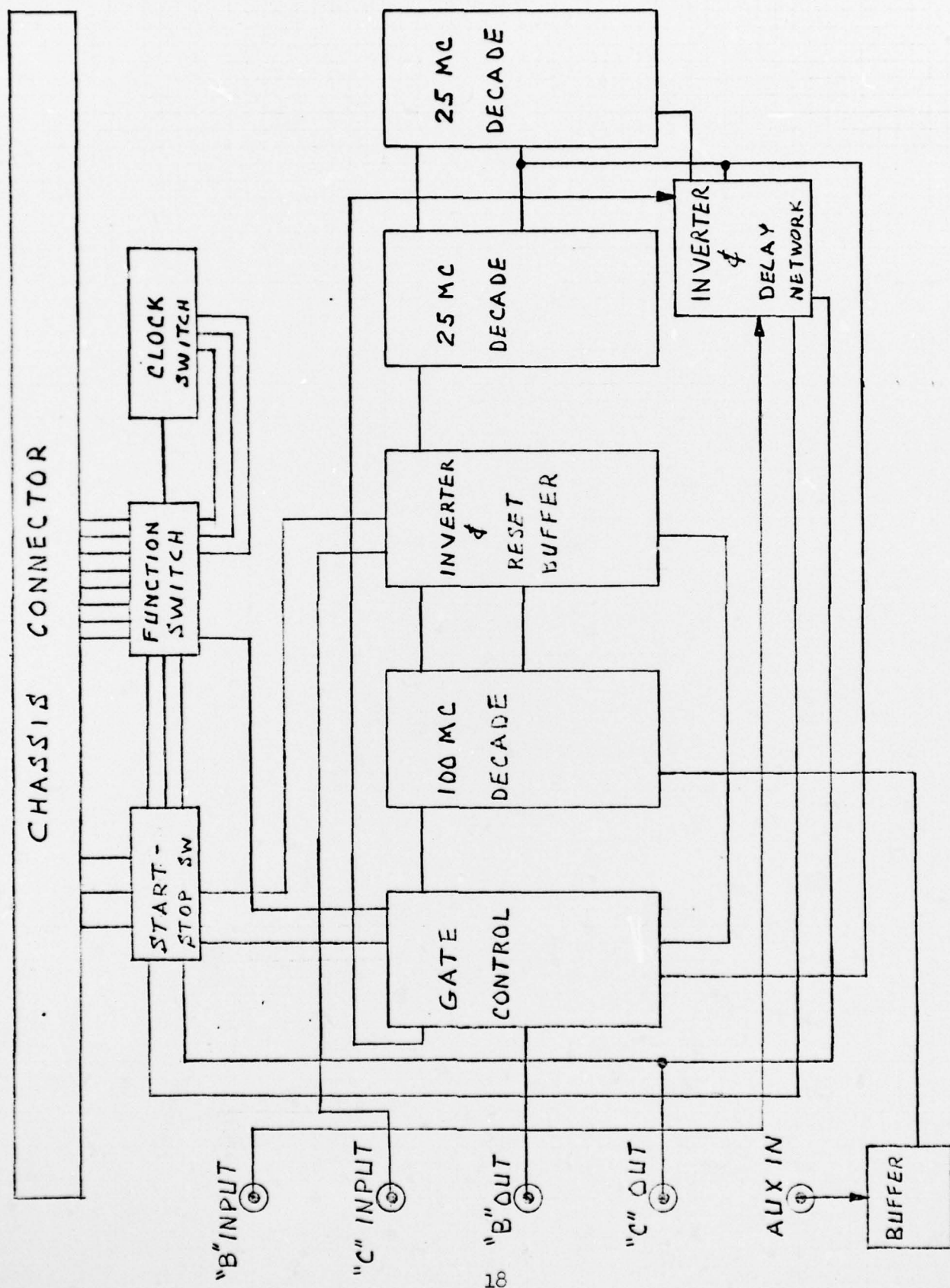"B" INPUT

"C" INPUT

COUNT OUTPUT 1 CONNECTOR

COUNT OUTPUT 2 CONNECTOR

FIG. 4 RANGE MODULE LOGIC DIAGRAM

FIG. 5 FUNCTION MODULE ACI 2774A

18