



NICOLET 1080 SERIES

DATA ACQUISITION AND PROCESSING SYSTEM

DESCRIPTION AND SPECIFICATIONS

**Nicolet Instrument Corporation
5225 Verona Road
Madison, Wisconsin**

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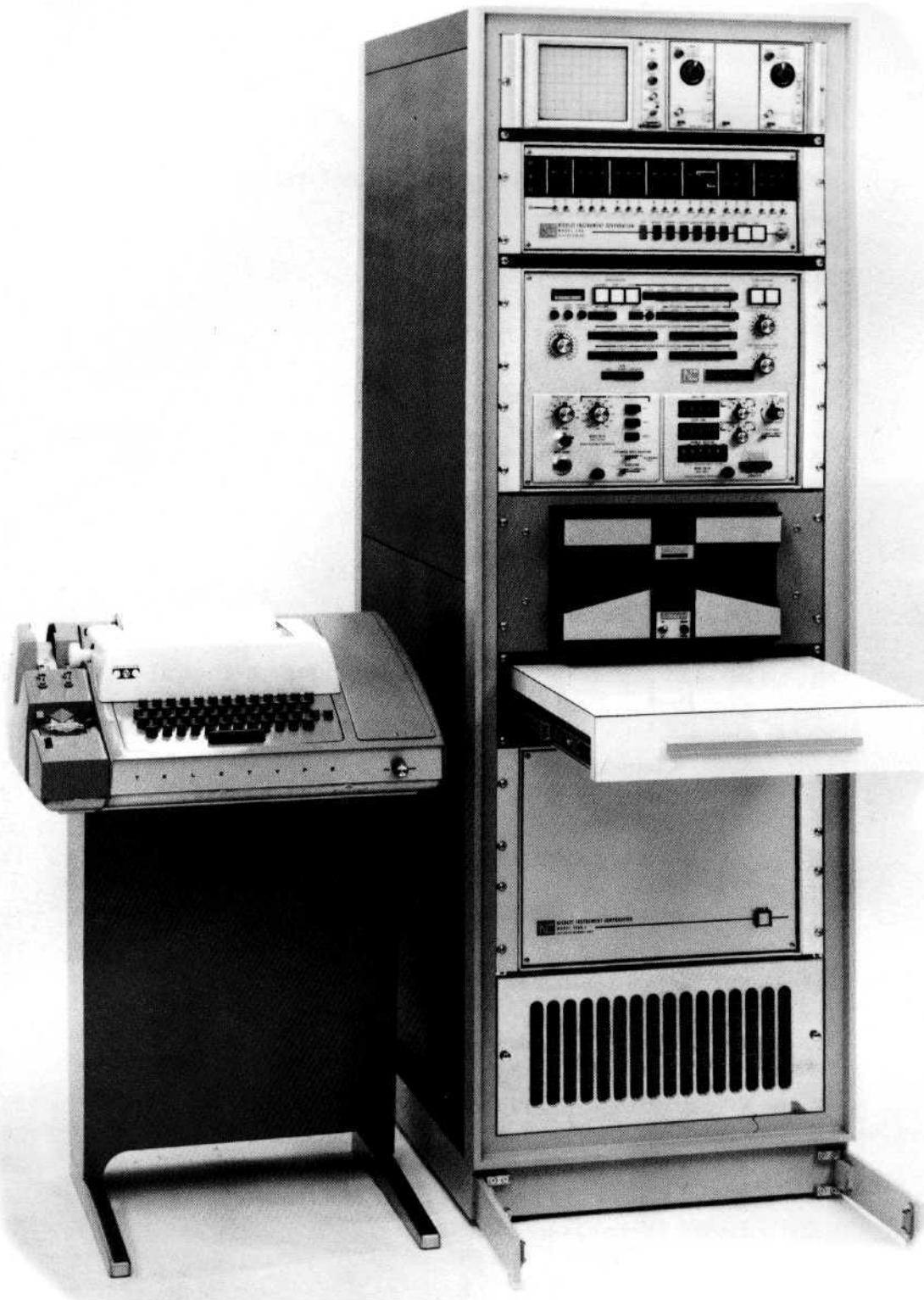


Figure 1. 1085 Data Acquisition and Processing System with High Speed Reader and Rack Cabinet

1080 DATA SYSTEM

I. SYSTEM CONCEPT

A. General

While the 1080 series is a new computer family, its design is a logical extension of the concepts introduced in earlier Nicolet (Fabri-Tek) instrumentation. A major innovation in the 1080 series is the use of a single main frame to perform both stored and wired program computations. The new series is also distinguished by its 20-bit word length, provisions for memory expansion (to 40K words), fast data acquisition rates, and precise control of all timing functions. Each of these capabilities was included to meet specific user requirements in many applications, but specifically Fourier transform and continuous wave nmr spectroscopy were a major consideration.

Like previous Nicolet instrument computers, the 1080 series uses wired programming and conventional instrument controls to regulate such data acquisition parameters as number of sweeps to be averaged, sweep speeds, digitizer sensitivity and dc level, memory storage locations and display ranges. The benefits of this approach are three-fold: (1) it contributes toward on-line processing speed by eliminating time delays while multiple instructions are extracted from memory and executed, (2) it simplifies manual supervision and lessens risk of operator error (controls are functionally labeled and the effects of all adjustments are immediately evident on CRT display), and (3) it minimizes the amount of core memory required for program storage.

Internal stored programming is used for computations too complex or too variable for practical wired programming. Use of the same power supply, memory system, many of the same registers and other hardware in both modes of computation further contributes to the simplicity and economy of the overall system.

B. Significance of Word Length

Many of the difficulties encountered in previous efforts to apply small computer systems to signal averaging and/or Fourier transform spectroscopy have related to the limited storage capacities (both word length and number of words) of such computers.

Whenever the signal-to-noise (S/N) ratio of a time domain signal is low, an accepted method for enhancing its S/N ratio consists of summing repeated measurements coherently in memory (signal averaging). This summation, or ensemble averaging, technique yields an improvement in S/N ratio which is approximately proportional to the square root of the number of repetitive measurements.

Most of the popular mini-computers use either a 12-bit or 16-bit word length, and their limited storage capacity restricts the number of time domain signals which can be summed in memory. Attempts to surmount this restriction have included reducing of digitizer resolution, provision of special algorithms to compute a running averager rather than a sum, and use of double-precision storage configurations.

It can be shown, however, that use of a running average algorithm yields no theoretical advantage over simple reduction of digitizer resolution and straight summation. Implementation of this algorithm will usually reduce the maximum rate at which data can be sampled, digitized and stored in memory, since considerable time may be required for division operations.

Two notable disadvantages are associated with the use of double-precision averaging: (1) the number of memory addresses required for a given frequency resolution is doubled, adding to system cost, and (2) the more complex summation restricts maximum data sampling rates. In some systems, one block of memory is reserved as a buffer for on-line data accumulation, and a transfer is made between measurement sweeps to another block of memory where double-precision summation takes place. While buffering may permit sampling rates comparable to those attainable in a single-precision averaging, it further increases the number of memory addresses required. Another disadvantage is that the time necessary for transferring data from the buffer to the main averaging section of memory for off-line summation reduces the rate at which exciting pulses may be presented to the sample, thereby dissipating part of the time-saving advantage of Fourier transform methods. This "dead time" for transfer and summation between averaging sweeps would be especially objectionable in DEFT or SEFT type nmr experiments where re-focusing of the nuclei is contemplated.

The intent of the 1080 design is to provide adequate word length for dealing with very poor S/N ratios, without restricting the rate at which data can be acquired or at which a sample can be pulsed. Averaging (or more precisely summation) is performed on-line and it is possible to initiate a new averaging sweep immediately on completion of the prior sweep.

C. Sampling Rates, Timing and Transformation Speed

The 1080 system with an SD-81 Signal Digitizer is capable of sampling time domain signals at rates up to 100 kHz, sufficient to permit averaging and transformation of signal frequencies up to 50 kHz with 12 bits of vertical resolution. Regardless of input signal sampling rates or sweep time duty cycles, wired programs provide for real-time display of the averaged data.

The SW-80 Sweep Control provides for a wide range of sampling intervals and for delaying the start of each data accumulation. The sampling interval and delay time can be adjusted from 0 to 9999 microseconds in one-microsecond intervals with five-decade multipliers which extend the range to 99.99 seconds. (The minimum sampling interval with an SD-81 is 10 microseconds.) The sampling interval (DWELL

TIME) and delays are selected by two four-digit thumbwheel switches. The delay may be inserted at the end of a sweep (inhibiting the next trigger) or between the trigger and the start of the sweep or both. When two delays are selected, the second delay is selectable as any integer multiple of the DWELL TIME.

The speed of Fourier transformation is approximately 100 seconds for a 32K transformation, 47 seconds for a 16K, 22 seconds for an 8K, or 10 seconds for a 4K transformation.

D. Experimental Adaptation

A number of special provisions are included in the system to meet future application requirements. The number of words (storage locations) in memory may be expanded in 4096-word increments up to at least 40K.

Command Signals (Flags) are brought out to synchronize laboratory equipment such as pulse sequence generators used in driven equilibrium or partially relaxed nmr experiments.

Particular attention has been given to assuring compatibility with a spectrometer that is sensitive to r-f radiation and with the laboratory environment. To assure minimum electromagnetic interference to the detriment of the experiment either through cables or space, all lines to and from the system are r-f bypassed and no currents circulate through the computer chassis.

A special technique for reducing systematic internal noise is included in the signal digitizer to insure optimum results for large numbers of sweeps.

All power is taken from a 105 - 125 or 210 - 240 volt, 50 - 60 cycle, single phase line. All components will operate under normal laboratory environment, at ambient temperatures between +15°C and +25°C. The basic system, including oscilloscope but excluding the ASR-33 Teletype, will occupy less than 27 inches of vertical space in a standard 19-inch rack for a 12K or smaller memory and less than 40 inches for up to a 40K memory system.

II. SYSTEM FEATURES

A. Composition of the System

The 1080 system includes provisions for both wired program and stored program data reduction.

Wired programming is used for such operations as signal averaging with on-line display where speed is especially important. Stored program computing techniques are employed where greater computational flexibility is needed.

A typical 1080 system includes the following elements:

Model 108N Main Frame. The 108N contains the central processing unit with hardware multiply/divide and a 4096 x N, 20-bit magnetic core memory (N is the number of 4K memory blocks in the system). It also houses the signal digitizer and sweep control plug-in units described below. Up to three 4096-word blocks of memory are located in the primary main frame. For the fourth to tenth 4096-word blocks, a second housing and power supply is automatically included.

Model SD-82A Signal Digitizer. This plug-in module accepts analog signals from the experiment converting them into digital information with 9-, 7-, or 5-bit (1 part in 512, 128, or 32) resolution at sampling rates up to 50 kHz.

Model SW-80 Sweep Control. Synchronization of data acquisition and experimental operations, including such functions as sweep triggering, sweep delay and sampling rates, is established by this plug-in module. Dwell time selection to 1 part in 10,000 over an 8-decade range allows precise selection of sweep widths in ppm or cps. Delays (either pre- or post-sweep) are also selected with a resolution of 1 part in 10,000 over the same 8-decade range.

Model 290 Display/Control. This unit, in conjunction with a 1080 main frame, serves as a control and display console for stored program operations. Among other functions, it enables the user to observe the contents of the accumulator, program counter and instruction register, to enter data into memory or to step through a program instruction by instruction. The 1080 system power supply is also located in the Model 290.

ASR-33 Teletype, This input/output device is used in loading programs and data into the 1080 memory, reading out information from the memory, and in delivering manual commands to the central processing unit. It includes an alphanumeric keyboard, a paper tape punch and a paper tape reader.

Input Signal Filters. Butterworth 4-pole adjustable low-pass filters are supplied with the digitizer plug-in. The cut-off frequency can be adjusted from 100 Hz to 50 KHz in 29 steps.

Software. The software package includes an assembler, editor, octal debugger, floating point package as well as nmr applications oriented programs for baseline correction, digital filtering, fast Fourier transformation, automatic phase correction, peak integration, peak printout, Teletype driver and loading programs. This software is included in the cost of the 1080 series main frame. (Refer to Nicolet booklets describing software.)

B. Analog-to-Digital Converters

The Model SD-82 signal digitizer with its 50 KHz sampling rate is intended to facilitate examination of a wide range of signals under a variety of experimental conditions. Its 9-bit (amplitude) resolution permits analysis of samples where only a few repetitions need be averaged. Its switch-selectable resolution to 7 or 5 bits and front-panel provisions for input signal attenuation enable measurement of many repetitions without risk of memory overflow. A special technique is included for minimizing

internally generated coherent noise which allows hundreds of thousands of sweeps to be accumulated free of anomalies. Full-scale input sensitivity is adjustable in binary steps from $\pm 1/4$ volt to ± 16 volts. Other forms of signal conditioning include a dc level adjustment and a wide range of active filters.

When greater (12 bits) resolution, 2 multiplexed inputs, or sampling rates to 100 KHz are required, the SD-81 signal digitizer should be selected. The sensitivity, dc level adjustment and coherent noise reduction features are the same as the SD-82A.

The SD-88 plug-in is an interface between a Biomatics (Palo Alto, California) high-speed analog-to-digital converter and the 1080 main frame. This same interface will operate with either the 610B, 802, or 8100 models. The Model 8100 permits sampling rates up to 100 MHz with 2048 data samples.

C. Input Signal Filtering

Included in both the SD-81 and SD-82A digitizers are plug-in filters manufactured by Analog Devices, Inc. These are 4-pole Butterworth filters with cutoff frequencies selected by front panel controls.

Input signal filtering is required for two basic reasons: Due to the extremely broad range of frequencies to which the analog-to-digital (ADC) converter can respond, noise whose frequency spectrum exceeds the Nyquist frequency ($1/2$ sampling frequency) will require longer to "average out" than if a filter whose cutoff frequency is equal to this Nyquist frequency is used. More important, if a coherent signal is present in the input data whose frequency spectrum exceeds the Nyquist frequency, these high signal frequencies will be folded back and distort the true spectrum of the desired signal. This "aliasing" effect is also minimized with filtering ahead of the ADC. Four-pole Butterworth filters are used for input signal filtering since their characteristics represent a good compromise between uniformity in the passband, linear phase response, fast settling time in response to a step function, and sharp cut-off beyond the passband. External filters can also be used since a front panel switch position allows bypassing internal filters completely.

D. Sweep Control Plug-In

The SW-80 sweep control plug-in generates the timing signals which establish the sampling rate of the time domain signal. The sampling rate, in turn, determines the maximum data frequency that can be investigated. A four-digit thumbwheel switch and a five-decade multiplier allow selection of the sampling rate.

A second feature of the SW-80 is the ability to select a delay time between presentation of a trigger signal (either internally or externally generated) and the start of accumulation. Alternatively this delay may be inserted between the completion of sweep and the start of the next. Again, a four-digit thumbwheel switch and a five-decade multiplier provide a range of from 1 microsecond to 99.99 seconds. Rear panel output signals

indicate start of delay period (DELAY FLAG) and start of sweep period (SWEEP FLAG) and may be used for triggering external equipment.

Readout times may also be selected with the Dwell Time thumbwheel switches for reading stored data out to a plotter which has its own internal time base. Alternatively, the readout rate may be established by means of an external clock signal.

Ultra stable trigger threshold circuitry having a 10 millivolt hysteresis characteristic assures precise synchronization of the start of the sweep as well as giving the ability to discriminate against noise present on the baseline of the trigger signal.

Another feature is a five-digit thumbwheel switch allowing the user to intensify an address during CRT readout or to cause a pulse to occur at a specific address during data accumulation. When delays are required both before and after each data acquisition sweep, this thumbwheel is used to select the pre-sweep delay in multiples of the dwell time per address.

E. Front Panel Controls

All data acquisition parameters may be established by the operator by means of conventional instrument controls on the front panel of the system. In addition to the digitizer and timing controls mentioned above (and more fully described in the accompanying specifications), the following are included on the 1080 main frame:

- (a) Vertical display scale selection switch
- (b) Horizontal display scale selection pushbuttons
- (c) Autostop controls
- (d) Electronic (light emitting diode) digital sweep counter display
- (e) Memory allocation pushbuttons for data accumulation and readout (the two functions are independently selectable)
- (f) Wired program and readout mode selection pushbuttons
- (g) Pushbuttons for clearing a selected memory subgroup and/or sweep counter
- (h) Analog readout calibration controls

To guide the operator in adjusting digitizer settings, provisions are made for selection of either a view input, view memory or continuous display mode during measurement. In view input, the CRT display represents the output of the analog-to-digital converter, immediately reflecting the effects of dc level, sensitivity or filter adjustments. In view memory, a live display of updated memory contents is shown. In continuous, a static display of memory contents is interlaced with data accumulation to show the averaged spectrum when sampling rate or sweep repetition rate is too slow for satisfactory representation in the view memory mode.

F. Readout Provisions

Included in the 1080 system are a 6-1/2 inch display oscilloscope for analog readout, plus an ASR-33 Teletype for digital input and output. The Teletype unit is used to execute operator commands, to enter either instructions or data into the system memory, and to read out data from the memory.

Analog outputs are also provided to drive an XY or Y(t) recorder (however, the recorder is not included in the system). Analog readout rate may be selected by means of the dwell time controls on the Model SW-80 sweep control unit.

Provisions are included for interfacing through an appropriate coupler, to a high speed paper tape reader or punch, or to an industry compatible magnetic tape read-in/readout unit.

G. Software

In addition to all the hardware features of the data acquisition section of the 1080 system, the 1080 contains a data processor that can hold its own against any modern mini-computer. Its instruction set, in addition to the usual arithmetic and logical instructions, contains instructions for implementing hardware multiply/divide operations, accessing various controls and registers of the wired-program section of the 1080 (such as instructing the SD-82A when to digitize, controlling the SW-80 sweep ramp, or reading the setting of pushbuttons on the 1080 front panel), and controlling the X and Y display registers for CRT or pen readout.

An assembler program with editor and an octal debugging program are also supplied along with a floating point package which is a compilation of mathematical subroutines useful in scientific computations. Refer to the booklet "Programming the Nicolet 1080 Stored Program Computer" for further details.

Complete applications software for Fourier and cw nmr (including nmr simulation programs) is also included with the 1080 software package. For a complete description, refer to the Nicolet 1080 Series fast Fourier transform program description.

H. Peripherals and Accessories

A very useful option with the 1080 system is a high-speed paper tape reader which permits program tapes to be read into memory at the rate of 300 characters per second. This is an improvement over the teleprinter reader by a factor of 30. The Model NIC-284 plugs into the 1080 rear panel and its interface electronics are self contained. The binary loader program includes provisions for recognizing the high-speed reader. A high-speed paper tape punch (120 characters per second) is also available.

The Model NIC-289 industry compatible magnetic tape option provides the fastest means of reading information into or out of memory. A 7- or 9-track deck with 556 or 800 bits per inch packing density respectively is available. Tape speed can be as high as 25 inches per second. The 1080 software provides for the user being able to identify each readout record with a 6 character tag word and the ability to search for that record when reading back. Starting addresses and block sizes are also selected from the teleprinter keyboard. Longitudinal and transverse parity are hardware generated and recorded on tape. Cyclic redundant check characters (CRCC) can be generated with hardware as an extra cost option.

Also available are rack cabinets for the 1080 system which include blowers, casters, and writing shelf.

III. SYSTEM DESCRIPTION

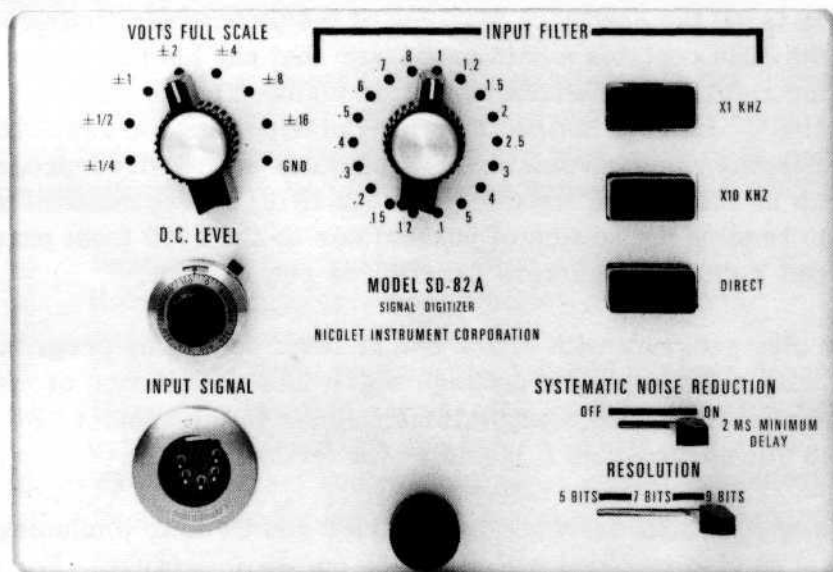


Figure 2. Signal Digitizer Plug-In Model SD-82A

A. SD-82A Signal Conditioning and Analog-to-Digital Conversion Plug-In

1. Connections

The time domain signal is connected to the connector marked INPUT CONNECTOR on the front of the SD-82A. Pins 1 and 3 are the non-inverting and inverting inputs of two operational differential amplifiers whose outputs are fed to a third differential amplifier (see Figure 3). This provides a truly

differential input for eliminating common mode signals (-80 db rejection) that are carried on the analog signal lines. Pins 4 and 5 are "clean" (noise free) common signal ground which should be connected to the input signal reference point. Pin 2 is chassis ground and should be attached to the chassis ground of the input signal source through the shield of the 3-wire shielded cable to eliminate electrical hazards due to metal housings being at different potentials. These connections may vary somewhat depending upon experimental situations.

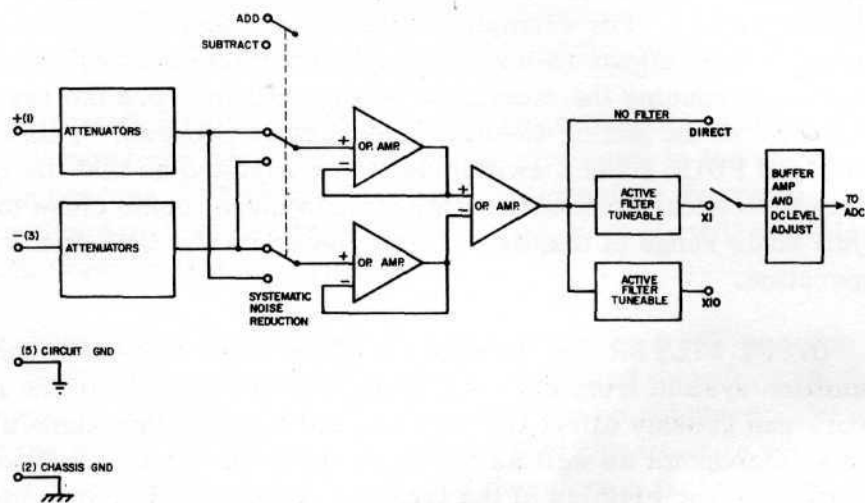


Figure 3. Block Diagram of SD-82A Signal Conditioner

The amplitude of the differential input signal can range from ± 250 millivolts to ± 16 volts for full scale input. The full scale signal voltage should be close to one of the indicated settings of the FULL SCALE VOLTS switch so that the maximum dynamic range of the digitizer is utilized. The differential input will reject common mode voltages which can be up to ± 20 times the full scale input with an absolute maximum of ± 50 volts. The input impedance is 400K ohms balanced or 200K ohms unbalanced. If the input signal is connected in a single-ended, unbalanced manner, the unused terminal should be connected to the common terminal.

2. Controls

VOLTS FULL SCALE ~ This control, variable from $\pm 1/4$ volt to ± 16 volts, determines the maximum input signal amplitude required to produce a full scale number of counts from the analog-to-digital converter. This switch and the RESOLUTION switch determine the relationship between the sampled input voltage and the number of counts representing that voltage and is expressed

$$\frac{\text{Counts}}{\text{Volt}} = \pm \frac{2^R - 1}{\text{VFS}}$$

where R is the number of bits determined by the setting of the RESOLUTION switch and VFS is the setting of the VOLTS FULL SCALE switch. The plus or minus sign is determined by the polarity of the input signal. The GND position of this switch disconnects the input signal and connects the inputs of the operational amplifier to the common terminal.

D. C. LEVEL — This ten turn control permits a dc voltage to be added to or subtracted from the input signal. This allows cancellation of unwanted bias voltages present on the input signal and also provides for offsetting the input signal to permit better utilization of the dynamic range of the analog-to-digital converter. For example, if the input signal is all positive and has a reasonably good signal-to-noise ratio, subtracting a dc voltage from it with this control and reducing the attenuator setting will improve the resolving capability (resolution) of the analog-to-digital conversion process. This control along with the VOLTS FULL SCALE switch should be adjusted so that the maximum positive and negative excursions of the time domain signal come close to but do not exceed the full scale range of the digitizer as viewed on the CRT in the View Input mode of operation.

INPUT FILTER — This is one of the more important controls of the data acquisition system from the standpoint that the selection of the input filtering network can grossly affect the accumulated time domain signals from a signal-to-noise standpoint as well as the effect upon the frequency dependent phase and amplitude characteristics of the transformed data. A sharp cut-off, low pass filter is essential. For optimum results the cutoff frequency of the filter should be set as close as possible to $1/2$ the sampling frequency (i. e. , $1/2 \times 1/\Delta t$ where Δt is the dwell time setting on the SW-80).

The SD-82A contains two tunable 4-pole low-pass Butterworth plug-in filters with controls which allow selection of the cutoff frequency from 100 to 50,000 Hertz in 29 steps. (See Technical Data Sheet C050-50-5/70 of Analog Devices, Inc., Cambridge, Massachusetts for complete description and specifications of filters.)

If an external filter, or no filtering is used the DIRECT mode should be selected.

RESOLUTION — Digitizer resolution can be defined as the smallest voltage difference that will make a one count difference in the voltage/count relationship of an ADC. It is generally expressed in terms of the MI scale number of counts for a full scale input voltage and therefore has a label of bits (binary digits). For example, in the 9 BIT position the SD-82A will resolve an input signal to one part in 2^9 (512). In the 7 BIT position a resolution of one part in 128 is achieved and in the 5 BIT position one part in 32.

In actual operation the setting of this control is determined by the signal-to-noise ratio (S/N) of the incoming time domain signal and the number of sweeps

(repetitions) that are to be made. In general, coherent signals will reinforce with each sweep and will therefore add linearly with the number of sweeps made, whereas non-coherent data will add in proportion to the square root of the number of sweeps made.

In Fourier nmr spectroscopy the highest coherent amplitude of the time domain signal occurs early in time and decays exponentially while the non-coherent component is relatively constant throughout. Therefore the S/N ratio of the time domain signal decreases with time. Since frequency resolution increases with increased observation time, a balance must be struck between digitizer resolution, the number of sweeps, and the dwell time.

The ultimate limiting factors on S/N ratio improvement are the length of each data word and the systematic noise introduced in the analog to digital conversion process. The algorithm used in computing the average, whether it be a normalized method or straight summation method, will not alleviate the restriction imposed by the word length.

By changing the RESOLUTION control from the 9 BIT position to the 5 BIT position, 16 times as many sweeps can be made and therefore, a theoretical improvement of a factor of 4 in the S/N ratio can be achieved. Correspondingly, changing the RESOLUTION switch from the 9 BIT position to the 7 BIT position, 4 times as many sweeps can be made and therefore a factor of approximately 2 improvement in S/N ratio can be achieved.

SYSTEMATIC NOISE REDUCTION — In those applications where an extremely large number of sweeps is to be made, a scheme to reduce coherent noise arising from the digitizing process can be introduced. This technique will only reduce noise generated within the SD-82 and not coherent noise which may be coming from the signal source. The theory on which it operates is quite simple: data presented to the input terminals have their polarity inverted on alternate sweeps by means of reed-relay switches.

At the same time the add/subtract logic is switched between add and subtract on alternate sweeps at the end of each sweep. This means the input signal will always be added to memory totals, but systematic noise arising inside the digitizer, whose polarity does not get inverted, will be cancelled out due to the alternate addition and subtraction operation.

When this technique is used, a minimum delay of 2 milliseconds must occur between successive sweeps. If no external delay between sweeps is provided this delay must be set on the DELAY TIME switches of the SW-80 Sweep Control plug-in. This delay permits the reed relays to "settle down" after being switched.

B. SW-80 Sweep Control and Time Base Plug-In

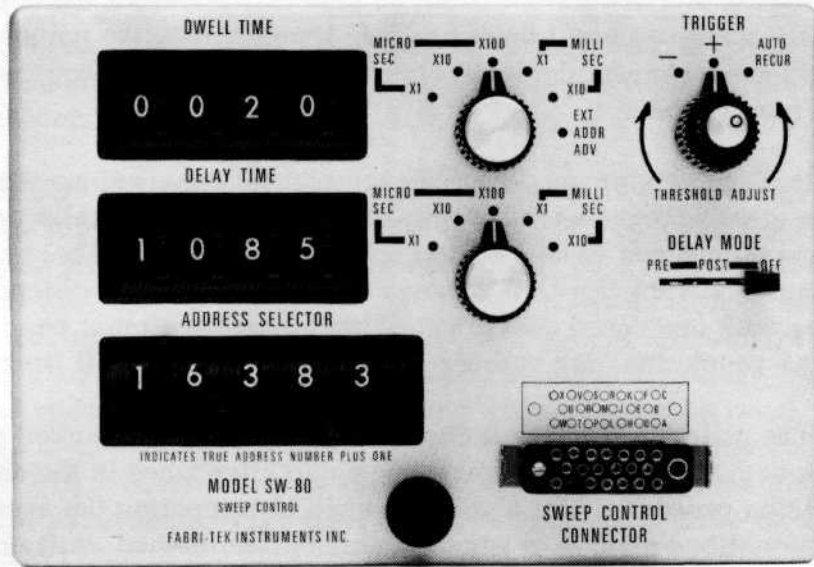
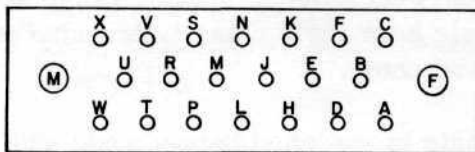


Figure 4. Sweep Control Plug-In Model SW-80

1. Connections

The SWEEP CONTROL CONNECTOR on the front panel of the SW-80 is a female 20 pin AMP Inc. connector. The following is a list of the signals on this connector.



Front View of
Sweep Control
Connector

<u>PIN</u>	<u>FUNCTION</u>
A	Delay Flag Output
C	External Address Reset Input
D	External Trigger Input
E	Sweep Ramp Output
F	Cursor Reset Input
H	Cursor Output
K	External Address Advance Input
L	External Clock Input
M	Dwell Out
N	Internal Clock Inhibit
P	Measure Address Cursor Inhibit
S	Sweep Flag Output
T	External Stop
U	Readout Trigger
V	Extra Delay Enable
W	Chassis Ground
B, J, R, and X	Circuit Ground

Figure 5. Pin Connection List of SW-80
Sweep Control Connector Cable

Pin Signal Description

- A DELAY FLAG — A +10 volt level (enabled only in the Measure mode of operation) is present on this pin for the duration of the delay period as selected on the SW-80 DELAY TIME and DELAY MODE switches. With the DELAY MODE switch in the PRE position, the delay is inserted between the time of triggering a sweep and the start of the sweep. With the DELAY MODE switch in the POST position the delay is inserted between the end of one sweep and the start of the next. When using External Trigger mode, the first trigger signal that arrives after the end of the post delay period will initiate the next measure sweep.
- C EXTERNAL ADDRESS RESET — A +4 volt pulse applied to this pin will cause the termination of a measurement sweep immediately on completion of the next memory cycle.
- D EXTERNAL TRIGGER INPUT — An external trigger signal of from -5 to +5 volts amplitude applied to this pin will initiate a sweep unless a sweep is currently in progress or post delay time is being counted (in which case it is ignored). The start of the sweep occurs as the trigger signal passes through the threshold level selected by the THRESHOLD ADJUSTMENT control on the SW-80 with a slope selected by either the + or - position of the TRIGGER control.
- E SWEEP RAMP OUTPUT — An analog output voltage proportional to the address number during a measurement sweep is provided on this pin. The voltage can start at 0 or +10 volts at the beginning of a sweep and go to +10 volts or 0 at the end of the sweep, as selected by an internal switch. Another internal switch selects the total number of increments (addresses) that the voltage ramp is to include. Two more internal controls allow dc off-setting of the voltage ramp by as much as $\pm 10\%$ of full scale and trimming the amplitude of the ramp by $\pm 10\%$ of full scale. If fewer than 16K data addresses are used the voltage ramp can be attenuated by setting the internal increment switch to a higher value than the number of addresses actually being used.
- F CURSOR RESET — (See description for pin H) A +5 volt to zero volt pulse applied to this pin causes the cursor output scaler to reset.
- H CURSOR OUTPUT — A +5 to zero volt pulse with a duration of 2 microseconds is presented on this pin when the sweep enters the address selected by ADDRESS SELECTOR thumbwheel switches. This pulse is present during the Measure mode of operation with or without Continuous Display. Connecting pin P of this connector to pin X (ground) will cause the CURSOR OUTPUT signal to be present when the readout address register goes through the selected address number. Instead of a pulse at one address during a measure or readout sweep it is possible to arrange for this pin to provide

a pulse at every n^{th} address where n is the number selected on the ADDRESS SELECTOR switches. To accomplish this, connect the CURSOR OUTPUT signal (pin H) to pin F which is called CURSOR RESET. Again, by connecting pin P to pin X this signal will occur every n^{th} measure address.

- K EXTERNAL ADDRESS ADVANCE — Successive +4 volt pulses applied to this pin will cause the ADC to sample the input signal, convert each sample to a digital value, and add the values into successive addresses of memory. The DWELL TIME decade switch must be in the EXT ADDR ADV position for these pulses to be recognized. The thumbwheel switches will divide the frequency of this signal by the indicated value (range 1 to 9999).
- L EXTERNAL CLOCK — An externally derived clock signal (such as from a frequency synthesizer) can be inserted on this pin. The clock signal will be divided by 10 immediately and can be further divided by the setting of the DWELL TIME thumbwheel switches and decade switch. The actual time between sampling commands will then be equal to 10 times the reciprocal of the divided down external clock frequency. Clock signal should be +5 volts and can have a maximum frequency of 20 MHz. When an external clock signal is used pin N must be connected to ground to inhibit operation of the internal clock.
- M DWELL OUT ~ The internal signal DWELL which tells the digitizer when to sample and convert the input signal is available at this pin. This makes possible the exact synchronization of external timing equipment.
- N INTERNAL CLOCK INHIBIT — If an external clock signal is to be used on pin L, then the internal clock signal must be inhibited. This is accomplished by connecting pin N to pin X (circuit ground). (See pin L description.)
- P MEASURE CURSOR INHIBIT — When this pin is grounded (by connecting it to pin X) the CURSOR OUTPUT signal (pin H) occurs when the readout address equals the number set on the ADDRESS SELECTOR thumbwheel switches.

However, if the Continuous Display mode is selected on the 1080 main frame, and it is desired to intensify the selected address on the CRT display, then pin P should not be connected to pin X (circuit ground). In this case, however, there is no time relationship between the CURSOR OUTPUT signal and the actual measure address. (See pin H for further description.)

- S SWEEP FLAG — A +10 volt level is present on this pin for the duration of a wired-program measurement sweep. (Should a negative level be required consult factory for modification information.)

- T EXTERNAL STOP — Grounding this will initiate Stop in Measure or Readout modes.
- U READOUT TRIGGER — A transition from +5 volts to ground applied to this pin will cause the start of the Real Time Readout mode (either CRT or PEN) when the TRIGGER switch is in either the + or - position. This allows synchronization of the start of a Pen Readout cycle with external equipment.
- V EXTRA DELAY MODE — Grounding this pin, placing the TRIGGER switch in the + or - position, and placing the DELAY switch in the POST position will allow the ADDRESS SELECTOR thumbwheel switches to insert a second delay, i. e. , a pre-delay before the start of data accumulation. This mode would be used when the 1080 is to control the timing of the experiment. (See Figure 6 for timing diagram.) For example, with the ADDRESS SELECTOR switches set at 00004, a DWELL TIME of 100 microseconds, a DELAY TIME of 1804 x 100 microseconds, and 8192 data points (8K) used, the following will be the sequence of events when the MEASURE (WIRED PROGRAM) pushbutton is depressed:

- (1) The SWEEP FLAG signal (pin S) will go high (this can be used to trigger the experiment).
- (2) For exactly 400 microseconds (ADDRESS SELECTOR switch setting multiplied by DWELL TIME switch setting, i.e. , 4 x 100) no data will be accumulated.
- (3) At the end of this delay period data accumulation will start and continue for 819,200 microseconds (number of data points multiplied by DWELL TIME switch setting, i.e. , 8192 x 100).
- (4) At the end of this sweep period, the SWEEP FLAG signal will go to ground and the DELAY FLAG signal (pin A) will go high for 180,400 (1804 x 100) microseconds.
- (5) At the end of this second delay period, the cycle restarts.

When these data are Fourier transformed, the frequency spectra will have an upper frequency value (f_{\max}) of 5 KHz ($1 / 2 \times \text{DWELL TIME}$), and a frequency resolution (Δf) of 1. 2207 Hz ($1 / \text{Number of data points} \times \text{DWELL TIME}$) per data point. The total time of one acquisition cycle is 1 second of which 0. 0004 seconds are used for pre-acquisition delay to permit possible overload conditions to settle down, 0. 8192 seconds for acquisition of the time domain signal, and 0.1804 seconds are used to allow the system to return to equilibrium. Note that this pre-acquisition delay of 400 microseconds will cause a contribution to the frequency dependent phase shift term "B" of 720 degrees (number of sampling intervals of delay x 180 degrees).

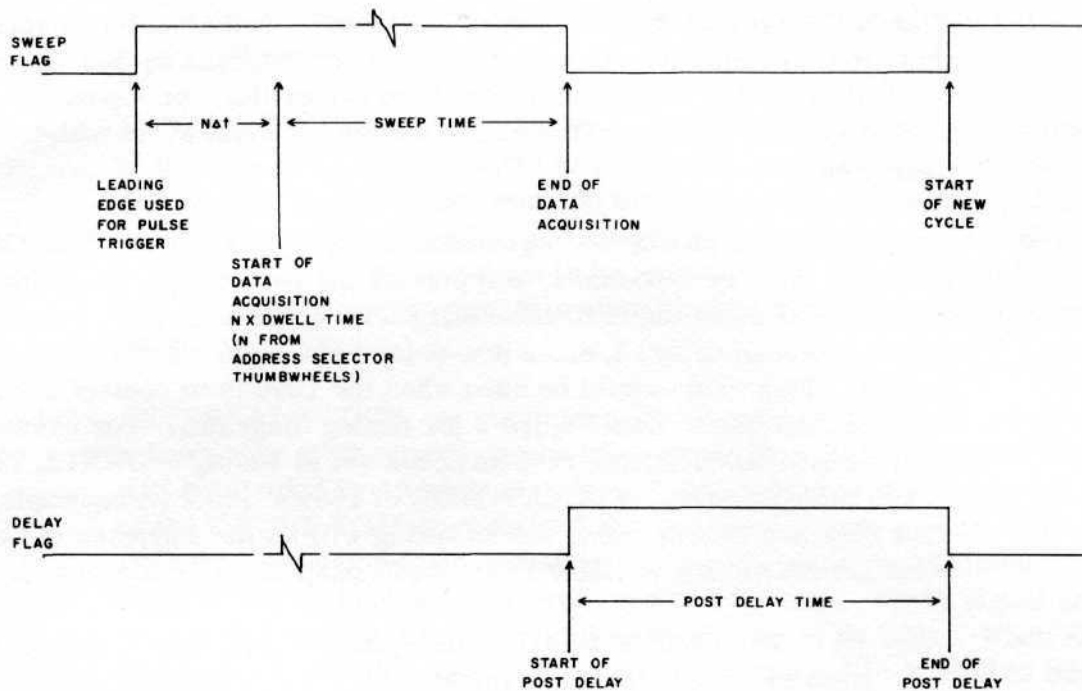


Figure 6. Timing Diagram When Using EXTRA DELAY ENABLE Mode

- W CHASSIS GROUND — This point is connected to the main frame and plug-in metal frame. In general it should not be used as circuit ground for either internally or externally generated signals.
- B, J, R, X CIRCUIT GROUND — All externally applied signals should be referenced to one of these ground connections. All internally generated signals are referenced to these ground connections.

2. Controls

DWELL TIME — Four thumbwheel switches permit selection of the 4 most significant digits of the sampling period Δt . The rotary switch alongside the thumbwheel switches selects the decade multiplier of the thumbwheel switch settings and therefore determines whether the numbers indicate microseconds, tens of microseconds, etc. With the SD-82 Signal Digitizer the minimum setting for the Measure mode is 20 microseconds. (Any setting less than this will not result in a calibrated time base.)

The setting of these switches is the sole determining factor of the maximum recorded frequency f_{\max} . The relationship is expressed

$$f_{\max} = \frac{1}{2\Delta t}$$

where L_{QV} is in Hertz when Δt is in seconds. Therefore to select the Δt setting given the desired sweep width in Hertz the relationship is

$$\Delta t = \frac{1}{2f_{\max}}$$

The Δt control along with the selection of the number of data points will affect the resolution of the frequency spectra after the Fourier transform operation. This relationship is

$$\Delta f = \frac{1}{N\Delta t}$$

where Δf is the change in frequency from one value of the frequency spectrum to the next adjacent one, and N is the number of data points selected for storage of the time domain signal. Since f_{\max} is the maximum frequency in the spectrum and Δf is the increment in frequency, then

$$\frac{f_{\max}}{\Delta f} = \frac{1/2\Delta t}{1/N\Delta t} = \frac{N}{2}$$

is the number of frequency values that will be computed in the Fourier transformation.

For a given number of points of data storage (N) of the time domain signal, a compromise has to be made between sweep width and resolution. Resolution (Δf) improves with longer observation time ($N\Delta t$) but the maximum observed frequency (f_{\max}) increases with shorter sampling periods (Δt).

Instead of the internally generated time base for sampling the analytical signal it is possible to use an external time base. Two methods are provided for connecting this external time base:

1. The external time base signal can be connected to pin K of the SWEEP CONTROL CONNECTOR and the DWELL TIME decade switch should be put in the EXTERNAL ADDRESS ADVANCE position. The thumbwheel switches will then select the integer by which the input clock frequency will be divided.

2. If the frequency of the external time base signal has to be divided by any arbitrary integer, it can be connected to pin L of the SWEEP CONTROL CONNECTOR. The divisor is selected with the DWELL TIME thumbwheel switches and decade switch. In this case,

pin N must be connected to pin X to inhibit the internal clock. The DELAY TIME thumbwheel and decade switches will now select the number of periods (x 10) of the external clock signal as the delay-time.

DELAY TIME — Four thumbwheel switches permit the selection of the 4 most significant digits of a delay time that can be inserted between the trigger signal and the start of a measurement sweep or between the end of a sweep and the beginning of a new sweep. The rotary switch alongside the thumbwheel switches selects the decade multiplier of the thumbwheel switch settings and therefore determines whether the thumbwheel numbers indicate microseconds, tens of microseconds, etc. up to 99.99 seconds.

DELAY MODE — A selectable time delay may be inserted before the start of a measure sweep or at the end of a measure sweep if this switch is in the PRE or POST positions. If this switch is in the OFF position any setting of the DELAY TIME switches is ignored and a measure sweep begins immediately upon presentation of a trigger signal if the TRIGGER switch is in the + or - position or immediately upon completion of a sweep if the TRIGGER switch is in the AUTO position. (This continues until the preset number of sweeps as set on the main frame AUTOSTOP switch is reached.) Figures 7, 8, 9 and 10 show the timing relationships between the delay and sweep times when using external or autorecurrent trigger and PRE and POST delay modes.

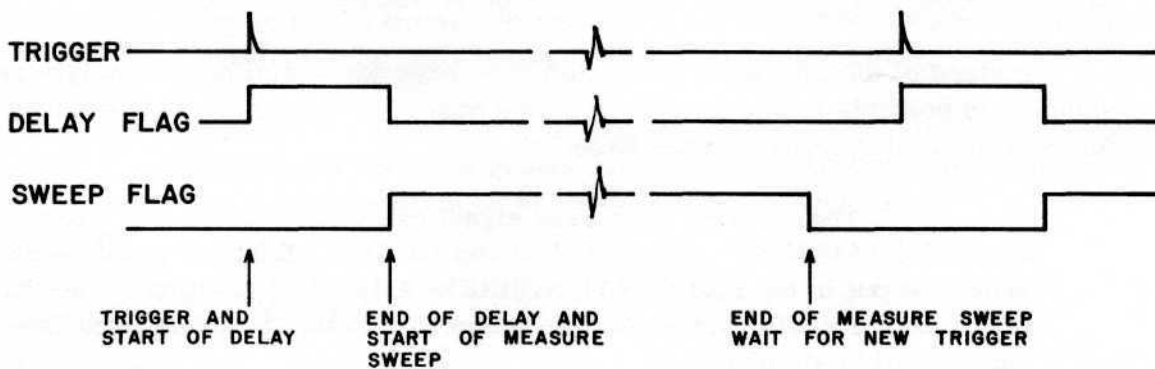


Figure 7. Timing Diagram when Using Delay Time with External Trigger and Predelay Mode

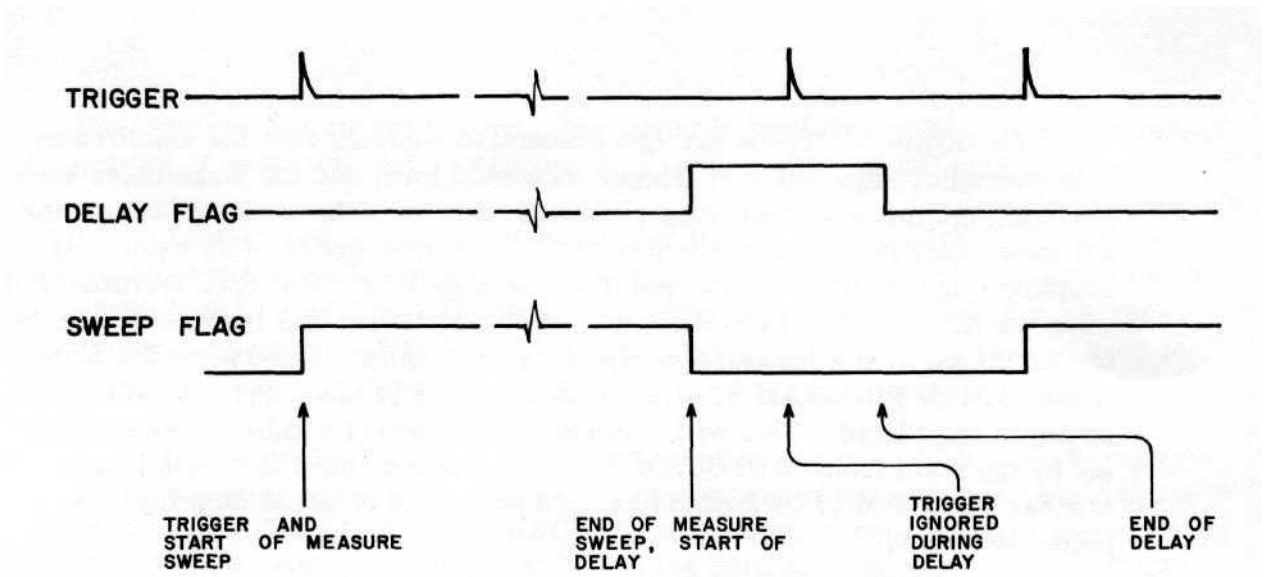


Figure 8. Timing Diagram when Using Delay Time with External Trigger and Postdelay Mode

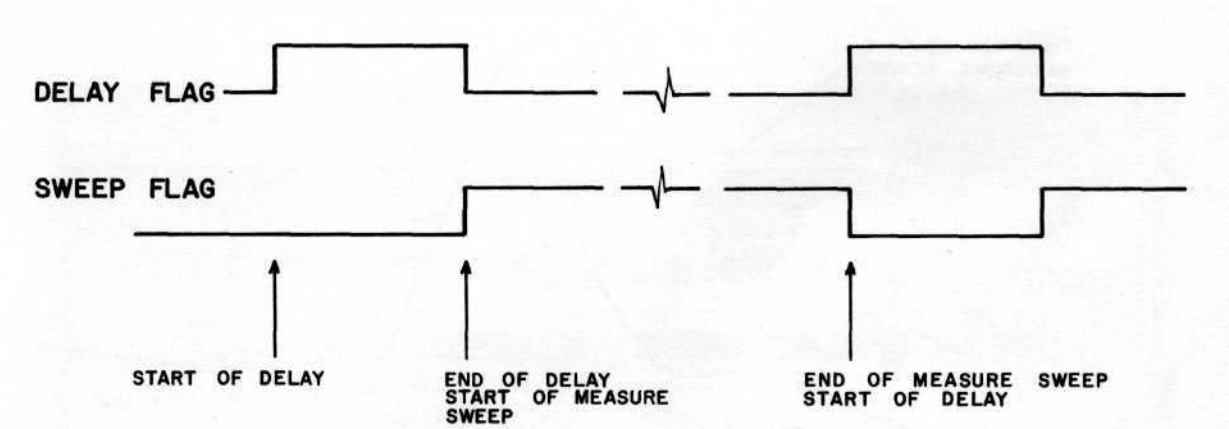


Figure 9. Timing Diagram when Using Delay Time with Autorecurrent Trigger and Predelay Mode

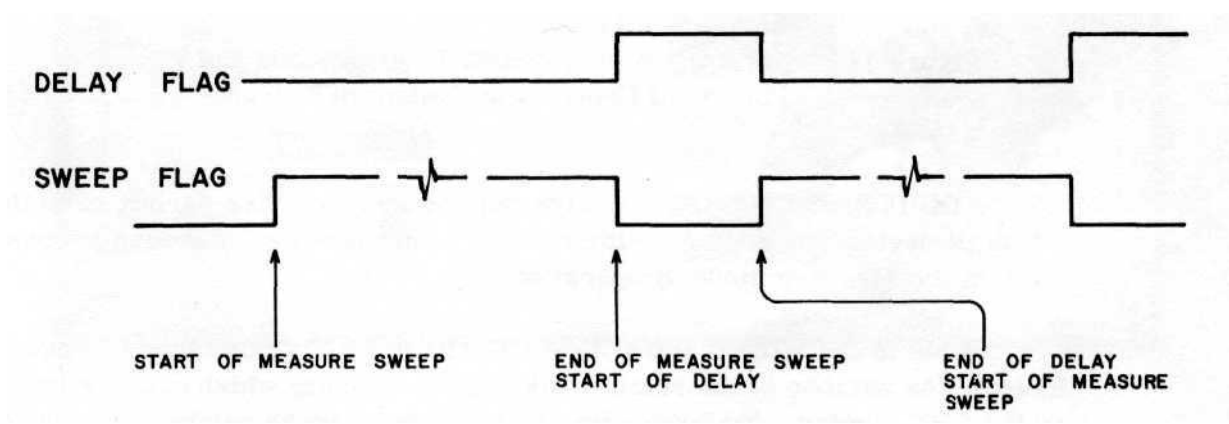


Figure 10. Timing Diagram when Using Delay Time with Internal Trigger and Postdelay Mode

TRIGGER — These are two concentric controls with the small outer knob providing adjustment at trigger threshold level and the large inner knob selecting the mode of triggering a measure sweep. The modes of triggering the sweep may be either on the positive or negative slopes of an externally supplied trigger signal (connected to pin D of SWEEP CONTROL CONNECTOR) when the mode control is in the + or - position. When this mode switch is in the AUTO position a measure sweep is automatically started when the main frame WIRED PROGRAM START pushbutton is depressed and also when a sweep is completed. This will continue until a preset number of sweeps as set by the main frame AUTOSTOP has been made or until the main frame WIRED PROGRAM STOP button has been pushed or external Stop input is pulled to ground.

The relationship between the + and - slope control and the threshold control is shown in Figure 11.

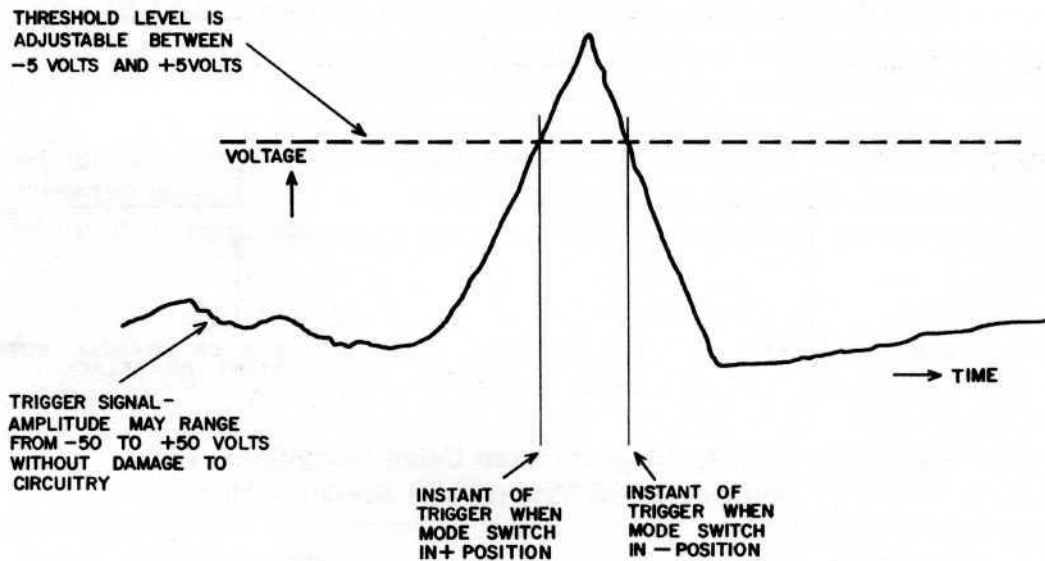


Figure 11. Illustration of Effect of Trigger Mode and Threshold Controls on Instant of Trigger

ADDRESS SELECTOR -- Five thumbwheel switches permit selection of a 5-digit decimal number for either display purposes or for timing purposes when in the Measure mode of operation.

When in the WIRED PROGRAM CRT READOUT mode, these switches will indicate the number of the relative address in memory which is being intensified on the CRT display. To determine the absolute address number, the number of addresses as indicated by the STARTING READOUT MEMORY ALLOCATION switch on the main frame must be added to the indicated number on the thumbwheel switches. There is a one address discrepancy due to the fact that when

the switches are all set to zero, this signal is inhibited. That is, a thumbwheel setting of 00001 will select address 0, a setting of 00002 address 1, etc.

Another use of these switches is for timing signals when in the WIRED PROGRAM MEASURE mode of operation. A +5 volt pulse will appear on pin H of the SWEEP CONTROL CONNECTOR when the sweep reaches the address number indicated by the thumbwheel switches. This pulse can then be used for external timing purposes.

If it is desired to have a pulse output after every n addresses after starting a measurement sweep, this can be accomplished by connecting pin J to pin F of the SWEEP CONTROL CONNECTOR and the output pulse again appears on pin H of this connector. In this case "n" is the number selected by the ADDRESS SELECTOR thumbwheel switches.

3. 1080 Main Frame Controls

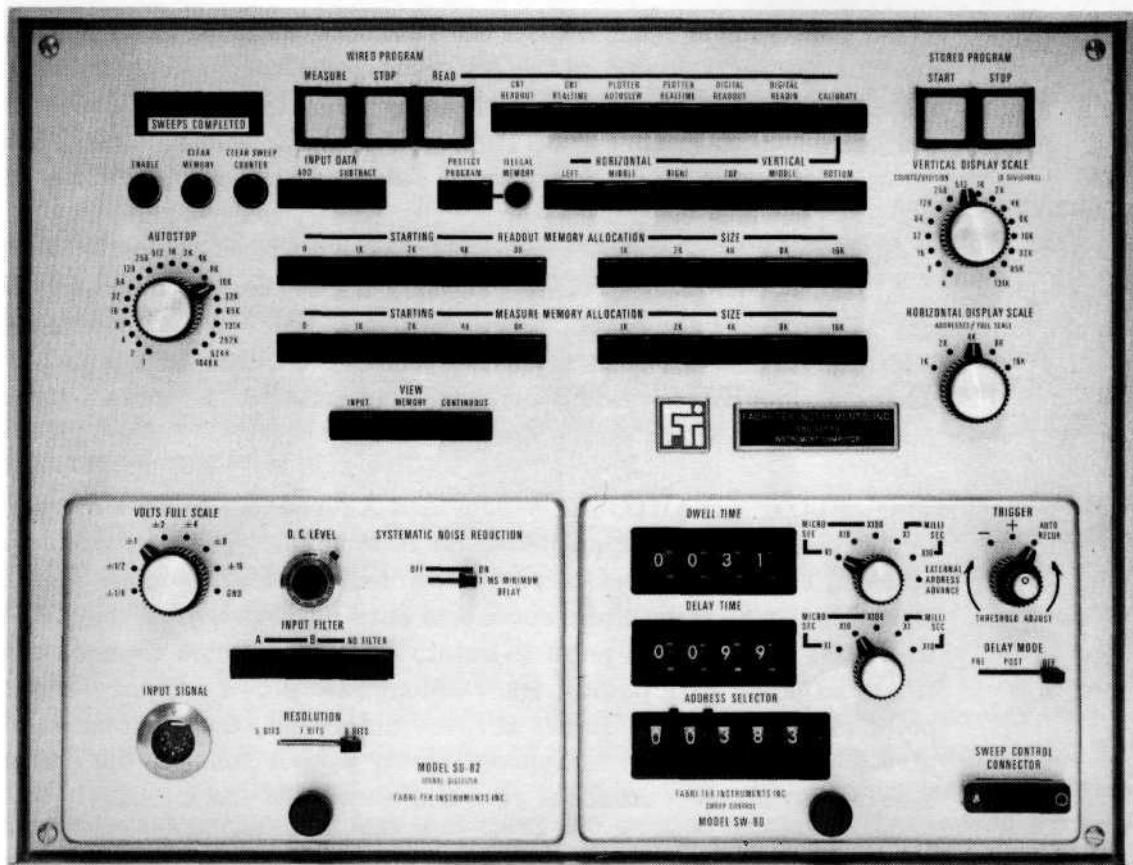


Figure 12. 1080 Series Main Frame with Plug-Ins

SWEEPS COMPLETED — An electronic (light emitting diode), seven-digit decimal display indicates the number of measurement sweeps completed. Display is updated at the beginning of each sweep. (Maximum count is 9,999, 999.) Once this counter has reached the preset value (see AUTOSTOP control) continued measurement sweeps cannot be accomplished until the counter is reset by means of the CLEAR SWEEP COUNTER control or until a higher value is selected on the AUTOSTOP control.

WIRED PROGRAM — MEASURE, STOP and READ pushbuttons select the basic mode of wired program operation. The MEASURE button starts the wired program measurement operation. The STOP button will stop the wired program measurement after completion of the sweep in progress or will stop the wired program readout mode. The READ button initiates one of the following wired program readout operations.

Wired Program READ Modes:

CRT READOUT permits linear CRT display of data stored in memory.

CRT REAL TIME allows the CRT readout rate to be selected by the DWELL TIME controls on the SW-80 Sweep Control plug-in. Minimum DWELL TIME setting is approximately 10 microseconds and depends upon the setting of the VERTICAL DISPLAY SCALE switch. Dwell times of 20 microseconds or slower may be selected at any VERTICAL DISPLAY SCALE switch setting.

PLOTTER REAL TIME provides XY readout of data stored in memory to pen recorder output jacks on rear panel. In this mode, rate of address advance (X-axis scan) is determined either by DWELL TIME setting of the SW-80 Sweep Control or by external address advance commands applied to the sweep control unit.

PLOTTER AUTOSLEW provides XY readout of data stored in memory to pen recorder output jacks on rear panel. In this mode, rate of address advance is controlled by an internal readout clock. Readout rate is nominally 10 points per second in data regions where there is no change in Y-axis values from point to point, but where large changes occur between adjacent data points, the readout rate slows to approximately one point in two seconds. Between these extremes, the time between successive address advances is approximately proportional to the change in deflection voltage. Readout rate and slew rate are internally adjustable.

DIGITAL READOUT is available for initiating wired program digital readout.

DIGITAL READ-IN is available for initiating wired program digital read-in.

GENERAL: All of the above wired program read operations will operate only on the section of memory selected by the READOUT MEMORY ALLOCATION STARTING and SIZE pushbuttons.

CALIBRATE facilitates calibration of X and Y inputs to analog read-out devices. HORIZONTAL pushbuttons permit selection of zero (LEFT), center (MIDDLE) or full-scale (RIGHT) X-axis outputs. VERTICAL pushbuttons permit selection of plus full-scale (TOP), zero (MIDDLE) or minus full scale (BOTTOM) Y-axis outputs. Any of nine possible combinations of these X and Y outputs may be selected. Selected deflection voltages appear on both PEN and CRT output jacks on rear panel. The 1080 must be in the WIRED PROGRAM STOP mode for calibration voltages to be enabled.

STORED PROGRAM — START and STOP pushbuttons allow initiation and termination of operation under stored program control. (See Stored Program Operation section.)

ENABLE — This pushbutton when depressed in conjunction with the CLEAR MEMORY and/or CLEAR SWEEP COUNTER pushbuttons will clear the section of memory being displayed and/or the SWEEPS COMPLETED indicator. The purpose of this pushbutton is to prevent accidental erasure of valuable information.

CLEAR MEMORY — When this pushbutton is depressed simultaneously with the ENABLE pushbutton, the contents of the memory subgroup selected by the READOUT MEMORY ALLOCATION pushbuttons only will be erased. Operable only in CRT READOUT mode.

CLEAR SWEEP COUNTER — When this pushbutton is depressed simultaneously with the ENABLE pushbutton, the contents of the SWEEPS COMPLETED indicator is set to zero.

INPUT DATA — ADD/SUBTRACT pushbuttons determine whether digital data acquired under wired program control are to be added to or subtracted from prior contents of memory (if any) in MEASURE mode.

PROGRAM PROTECT ~ When this button is depressed the ILLEGAL MEMORY warning lamp is illuminated when operator selects for display or data storage a non-existent section of memory or the portion of memory in which the stored program instructions are located. It is good practice to keep this button depressed except to display the section of memory reserved for program storage.

VERTICAL DISPLAY SCALE — Selects the 12 most significant bits of memory contents to be presented to the digital-to-analog converter. The converted analog signal is used for both the Y-axis CRT display and the Y-axis

PEN output. Vertical display scale ranges of 4, 8, 16, 32, 64, 128, 256, 512, 1K, 2K, 4K, 8K, 16K, 32K, 65K or 131K counts/division (8 divisions) are switch selectable. This in effect is a digital attenuator control on the displayed data. Memory contents are not affected by the position of this control, only the manner in which they are decoded. It may be used in both wired program and stored program display modes, but must be programmed to be used during stored program operations.

READOUT MEMORY ALLOCATION — Two banks of pushbuttons permit selection of STARTING address (0, 1K, 2K, 4K or 8K) and SIZE (1K, 2K, 4K, 8K or 16K) of memory subgroup to be used for data readout in any of the wired program READ modes of operation. (For Models 1089 and 10810, pushbuttons select STARTING address of 0, 2K, 4K, 8K or 16K and SIZE of 2K, 4K, 8K, 16K or 32K.) More than one STARTING address pushbutton may be pushed in order to select a starting address additively up to 15K (30K in Models 1089 and 10810). These switches also select the section of memory that will be operated on during stored program operation.

AUTOSTOP — Permits preselection, for automatic stop, of a number of measurement sweeps equal to 2^n , n being any integer from 0 to 20. (Autostop range is selectable from 1 to 1,048,576 in powers of two.) An OFF position enables continuous sweeping until manually stopped. The number of sweeps completed is stored in an auxiliary register and is displayed on the SWEEPS COMPLETED numerical display.

MEASURE MEMORY ALLOCATION -- Two banks of pushbuttons permit selection of STARTING address (0, 1K, 2K, 4K or 8K) and SIZE (1K, 2K, 4K, 8K or 16K) of memory subgroup to be used for data storage in wired program MEASURE mode of operation. (For Models 1089 and 10810, pushbuttons select STARTING address of 0, 2K, 4K, 8K or 16K and SIZE of 2K, 4K, 8K, 16K or 32K.) Two or more STARTING address pushbuttons may be depressed to select any starting address in integral multiples of 1K up to 15K (30K in Models 1089 and 10810).

HORIZONTAL DISPLAY SCALE — Selects the portion of memory to be displayed over full scale horizontal deflection of CRT. Horizontal display scale ranges of 1K, 2K, 4K, 8K and 16K (2K, 4K, 8K, 16K and 32K in Models 1089 and 10810) are switch selectable, and can affect both wired and stored display operations without programming.

VIEW INPUT/MEMORY/CONTINUOUS — Three pushbuttons allow selection of digitized input signal (INPUT), live display of accumulation of data in the memory addresses (MEMORY) or continuously updated display of entire contents of all addresses in the selected memory subgroup (CONTINUOUS) for presentation on the CRT during wired program MEASURE mode of operation.

IV. SYSTEM SPECIFICATIONS

A. Series 1080 Main Frame

<u>Memory:</u>	Model 1081:	magnetic core, 4K words x 20 bits
	Model 1082:	magnetic core, 8K words x 20 bits
	Model 1083:	magnetic core, 12K words x 20 bits
	Model 1084:	magnetic core, 16K words x 20 bits
	Model 1085:	magnetic core, 20K words x 20 bits
	Model 1086:	magnetic core, 24K words x 20 bits
	Model 1087:	magnetic core, 28K words x 20 bits
	Model 1088:	magnetic core, 32K words x 20 bits
	Model 1089:	magnetic core, 36K words x 20 bits
	Model 10810:	magnetic core, 40K words x 20 bits

Typical Systems:

- Model 1082, for 4K Fourier transform (2K data points in frequency domain)
- Model 1083, for 8K Fourier transform (4K data points in frequency domain)
- Model 1085, for 16K Fourier transform (8K data points in frequency domain)
- Model 1089, for 32K Fourier transform (16K data points in frequency domain)

Memory Allocation: Any portion of memory may be allocated for either data or program storage. Normally, 4096 words are assigned for program, look-up tables, etc. in fast Fourier transform applications. The remaining (4096 words in a Model 1082, 8192 words in a Model 1083, etc.) are allocated for data storage.

Memory Subgroups: For Models 1081 to 1088 subgroups for data storage or readout may be independently selected in blocks of 1K, 2K, 4K, 8K or 16K starting at any address from 0 to 15K in 1K steps. It is possible to display one subgroup on CRT while accumulating in a different subgroup. For Model 1089 or 10810 data storage or readout is selected in blocks of 2K, 4K, 8K, 16K or 32K starting at any address from 0 to 30K in 2K steps.

Cycle Time: 2.0 microseconds full cycle (Read, Update, Write).

Access Time: 400 nanoseconds.

Add or Subtract Time (Stored Program Operation): 4 microseconds.

Multiply or Divide Time (Stored Program Operation): 20 microseconds.

Add or Subtract Time (Wired Program Operation): 200 nanoseconds.

Y-Axis D/A Converter: Decodes the selected 12 most significant bits of data stored in memory to a linearity of $\pm 0.025\%$ of full scale and furnishes Y-axis deflection voltage of 0-10 volts to both the CRT output jacks and the PEN recorder output jacks. 5K ohm minimum source impedance.

X-Axis D/A Converter: Decodes the memory address to 12-bit resolution with $\pm 0.025\%$ of full scale linearity and furnishes X-axis deflection voltage of 0-10 volts to both the CRT output jacks and the PEN recorder output jacks. 5K Ohm minimum source impedance.

Sweep Flag: A +10 volt (nominal) level is provided at the beginning of each sweep and returns to ground at the end of the sweep. (Can be supplied as -10 volt level if requested.)

Delay Flag: A + 10 volt level is provided at the beginning of each delay period, returning to ground at the end of the delay if internal trigger and sweep delay are used.

Input Power: System (exclusive of ASR-33 Teletype) operates from 105 to 125 volts or 210 to 230 volts, 50 or 60 cycle, single phase line supply. Power consumption is less than 200 VA (excluding ASR-33 Teletype). Power supply located externally (in Model 290 Display/Control). ASR-33 Teletype can be supplied for 115 volt - 60 Hz, 115 volt - 50 Hz operation at no extra charge or for 220 volt - 50 Hz operation at extra cost.

Size: 1080 Series main frame: approximately 16-1/2 inches wide x 12-1/2 inches high x 24 inches deep.
1080E memory extension (required for memories of 16K words and larger): approximately 16-1/2 inches wide 12-1/2 inches high x 24 inches deep.
Model 290: approximately 16-1/2 inches wide x 6-1/2 inches high x 19 inches deep. Available with brackets for 19-inch rack mounting.
Tektronix oscilloscope: 19 inches wide x 5-1/2 inches high x 20 inches deep.

Weight: 1080 Series main frame (including signal digitizer and sweep control plug-ins): approximately 75 pounds. Exact weight varies somewhat with size of memory.
1080E memory extension: approximately 70 pounds to 90 pounds depending upon size of memory.
Model 290 (including system power supply): approximately 25 pounds.
Tektronix oscilloscope: approximately 27 pounds.

General: Internal circuitry is electrically isolated from instrument case. To prevent r-f passage through space, no currents are allowed to circulate through case. All lines to and from main frame and plug-ins are bypassed.

B. Model SD-81 Two Input, 12-Bit Signal Digitizer

Inputs: Two inputs, each balanced, 5-wire XLR-5 connectors. Minimum input impedance 400K ohms balanced, 200K ohms unbalanced. 20 x full scale input common mode voltage with maximum of 50 volts.

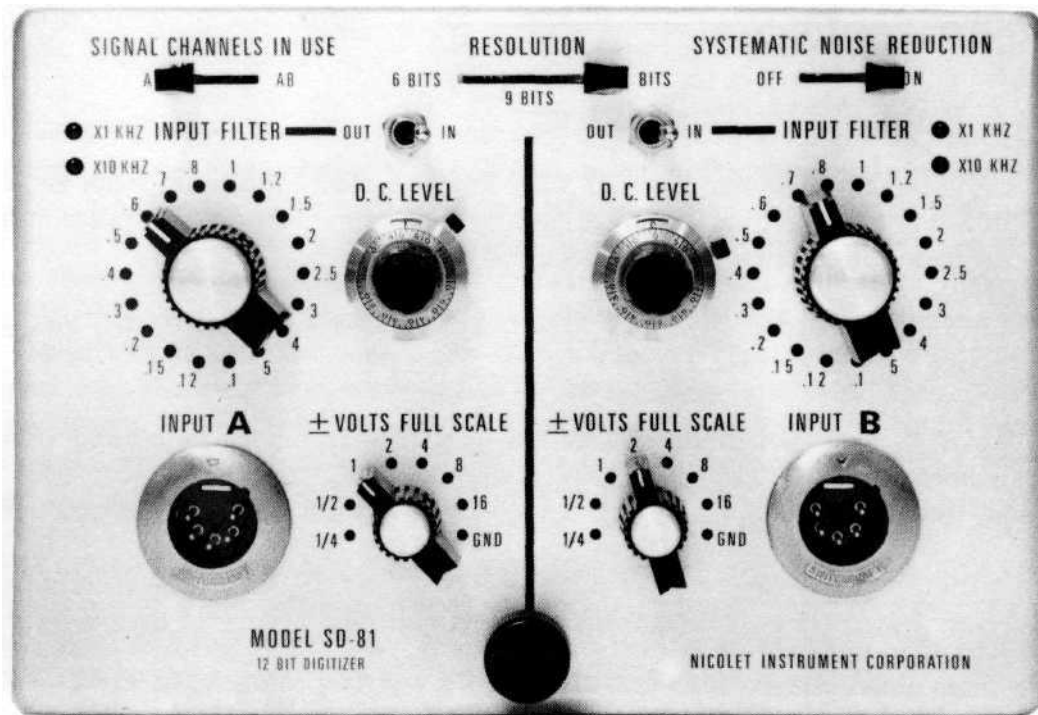


Figure 13. Two Input, 12 Bit Signal Digitizer, Model SD-81

Input Signal Range; $\pm 1/4$, $\pm 1/2$, ± 1 , ± 2 , ± 4 , ± 8 , ± 16 volts full scale, switch selected each input.

Input Filtering: Four-pole Butterworth low-pass filters having selectable cutoff frequencies of 100, 120, 150, 200, 300, 400, 500, 600, 700, 800, 1000, 1200, 1500, 2000, 2500, 3000, 4000 and 5000 Hz with multipliers of x1 and x10 each input.

Analog-to-Digital Converter; Resolution of 12, 9 or 6 bits, switch selectable. Signal conversion time, 10 microseconds maximum. Linearity better than $\pm 0.025\%$ of full scale.

D. C. Level Adjustment: Permits a d. c. bias voltage of $\pm 100\%$ of full scale to be added to each input signal. Level selected by means of a ten-turn precision potentiometer. Drift less than $\pm 0.05\%$ of full scale per hour at constant temperature.

Systematic Noise Reduction: Reduces internally generated coherent noise to permit a very large number of accumulations to be made.

General: Mounts in 1080 series main frame. Draws required power from system power supply.

C. Model SD-82A Signal Digitizer

Input: Single input, balanced, 5-wire XLR-5 connector. Minimum input impedance 400K ohms balanced, 200K ohms unbalanced. 20 x full scale input common mode voltage with maximum of 50 volts.

Input Signal Range: $\pm 1/4$, $\pm 1/2$, ± 1 , ± 2 , ± 4 , ± 8 , ± 16 volts full scale, switch selected.

Input Filtering: Four-pole Butterworth low-pass filters having selectable cutoff frequencies of 100, 120, 150, 200, 300, 400, 500, 600, 700, 800, 1000, 1200, 1500, 2000, 2500, 3000, 4000 and 5000 Hz with multipliers of x1 and x10.

Analog-to-Digital Converter: Resolution of 9, 7 or 5 bits, switch selectable. Signal conversion time, 20 microseconds maximum. Linearity better than $\pm 0.25\%$ of full scale.

D. C. Level Adjustment: Permits a d. c. bias voltage of $\pm 100\%$ of full scale to be added to the input signal. Level selected by means of a ten-turn precision potentiometer. Drift less than $\pm 0.05\%$ of full scale per hour at constant temperature.

Systematic Noise Reduction: Reduces internally generated coherent noise to permit a very large number of accumulations to be made.

General: Mounts in 1080 series main frame. Draws required power from system power supply.

D. Model SD-88 High Speed Buffer Interface

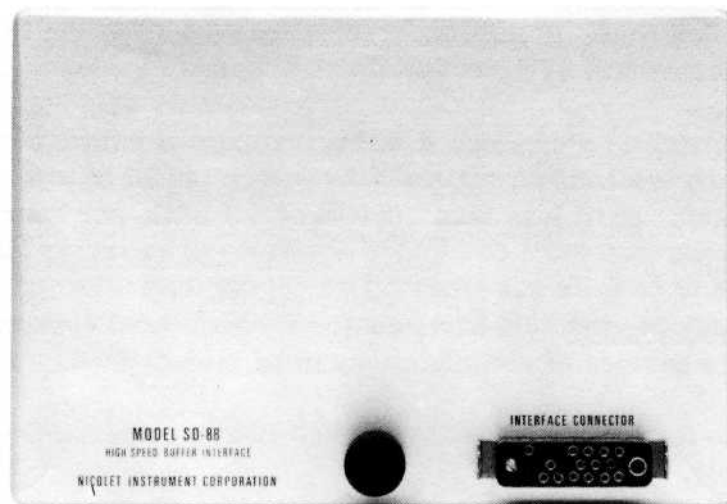


Figure 14. High Speed Buffer Interface, Model SD-88

The SD-88 High Speed Buffer Interface is designed to interface the NIC-1080 Series signal averaging system to the transient recorder manufactured by Biomation, Palo Alto, California. The transient recorder accumulates data at a high rate of speed (up to 10 nanoseconds per point with the Biomation Model 8100) and then transfers the data which have been accumulated to the NIC-1080 memory. Upon completion of the transfer, the transient recorder is enabled and a new accumulation sweep of the input signal will be initiated upon arrival of the next trigger signal. This sequence continues with the data from each sweep of the transient recorder being totaled in the 1080 memory. Data will be accumulated until the measurement is interrupted by depressing the STOP pushbutton on the 1080 or the number of sweeps made reaches the number which has been preset on the AUTOSTOP switch on the 1080.

Sampling rates are selected on the transient recorder front panel and range from 100 ns to 0.5 ms/point for the Models 610 and 610B, 0.5 usec to 0.02 sec/point for the Model 802 and 10 nsec to 10 sec/point with the Model 8100. Transfer rates to the 1080 are 20 usec/point with the Models 610 and 610B and 10 usec/point (depending on the Vertical Display Scale switch setting on the 1080) with the Models 802 and 8100.

See Biomation data sheets for specifications on analog-to-digital conversion.

E. Model SW-80 Sweep Control

Dwell Time Selection: A four-digit (0000 to 9999) decimal thumbwheel switch with x1 usec, x10 usec, x100 usec, x1 msec and x10 msec multipliers provides a choice of dwell times from 20 usec to 99.99 seconds per address. Crystal oscillator timed. Accuracy within 0.02% of indicated time setting. Stability within one part per million per day at constant temperature.

Readout Rate Selection: In REAL TIME READOUT mode, DWELL TIME switches determine pen readout rate.

Trigger Mode Selection: AUTO RECURRENT: Causes recurrent sweeps following the DELAY value selected.

"+": An external trigger signal of from -5 to +5 volts amplitude can initiate a sweep unless a sweep is currently in process. Start of sweep occurs as the signal passes through the selected threshold level with a positive slope.

"-": Same as "+" except that start of sweep occurs as signal passes through threshold level with a negative slope.

Trigger Threshold: Continuously adjustable over a range from -5 to +5 volts by means of a single turn potentiometer.

Sweep Trigger Input: Accepts external trigger signal. Trigger signal amplitude may range up to ± 50 volts without damaging circuitry. Input impedance 10K ohms.

Delay Time Selection: A four-digit (0000 to 9999) decimal thumbwheel switch with x1 usec, x10 usec, x100 usec, x1 msec, and x10 msec multipliers provides a choice of delay times from 1 usec to 99.99 seconds, crystal oscillator timed. Time jitter $\pm 1/10$ usec. Stability within one part per million per day at constant temperature.

Address Advance Selection: INTERNAL: Address advance in MEASURE or REAL TIME READOUT mode occurs at the rate selected by the DWELL TIME switches. EXTERNAL: Address advances one unit for each pulse applied to the EXTERNAL ADDRESS ADVANCE input connector. Pulses should be positive, 2 to 10 volts. Input impedance 10K ohms minimum. Maximum external address advance rate is 50,000 addresses per second when SD-82A signal digitizer is used.

Address Selector: Intensifies a data point in the CRT Readout mode or causes a pulse to occur at the indicated address in the Measure mode.

General: Mounts in 1080 series main frame. Draws required power from system power supply.

Specifications subject to change without notice.

V. STATEMENT OF WARRANTY

Nicolet Instrument Corporation, hereinafter referred to as NIC, warrants this instrument to be free of defective material and workmanship for a period of one year from date of delivery to the customer. The warranty is valid only when the instrument is returned (with prior authorization repair number) to the factory, or is serviced by an NIC authorized field representative. The instrument, if returned, must be packed in packing equal to or better than the original carton to assure proper handling by common carriers.

All peripheral equipment associated with the instrument and not manufactured by Nicolet is subject only to the warranty stated by the supplying manufacturer.

The NIC warranty is invalid if any unauthorized servicing, tampering, or modification is applied to the instrument. Minor adjustment by skilled personnel following manual procedure will not invalidate the warranty.

Upon receipt of the instrument at the NIC factory, it will be inspected for damage and misuse. The customer will be advised concerning the condition of the instrument and responsibility for repair or replacement.

The instrument will be fully inspected, repaired, and tested to the original factory specifications before return to the customer. NIC will assume return shipping costs.

No other warranties expressed or implied shall be applicable to NIC instruments.



SALES OFFICES

New England Area

Bruce Hervey
Nicolet Instrument Corporation
2120 Commonwealth Avenue
Auburndale, Mass. 02166
(617) 969-7420
TWX: 710-335-1954

New York, New Jersey, Penn.

Bernard Conti
Nicolet Instrument Corporation
P. O. Box 36
Old Bethpage, New York 11804
(516) 249-6360

Mid-Atlantic Area

Dick Brown
Nicolet Instrument Corporation
1010 Rockville Pike
Rockville, Maryland 20852
(301) 762-8440

Chicago and Midwest Area

Robert E. Penrod
Nicolet Instrument Corporation
500 East Higgins Road
Elk Grove, Illinois 60007
(312) 956-0404
TWX: 910-222-5999

Southeast and South Central Area

Jerry A. Meyer
Nicolet Instrument Corporation
P. O. Box 973
St. Charles, Missouri 63301
(314) 723-2031

West Central and Southwest Area

Bruce B. Lent
Nicolet Instrument Corporation
6023 South Lamar Drive
Littleton, Colorado 80123
(303) 798-3561

California and Northwest Area

Michael F. Schmitt
Nicolet Instrument Corporation
363 Taaffe Avenue, Suite 220
Sunnyvale, California 94086
(408) 739-8842
(213) 776-6430 (Los Angeles Area)

Canada

Joe Paul, Peter Fedak
Ahearn and Soper Limited
844 Caledonia Road
Toronto 19, Ontario
(416) 789-4325

Al Cornish
Ahearn and Soper Limited
1680 Gilmore Avenue
Burnaby 2, B. C.
(604) 291-0214

Gerald Ferris
Ahearn and Soper Limited
280 Albert St., Suite 1016
Ottawa, Ontario
(613) 232-4518

Marcel Bourcier
Ahearn and Soper Limited
3300 Cavendish Blvd., Suite 220
Montreal, Quebec
(514) 482-9750

European Countries

Dr. Peter Langner
Nicolet Instrument GmbH
6000 Frankfurt am Main
Eschersheimer Landstr. 34
West Germany
0611/551883 Telex: 841/416169

Japan

M. Umino, Takashi Chihara
Nisso Koheki Company Ltd.
Yoyogi-Eki-Mae Building
Tokyo 151, Japan
(03) 379-2471