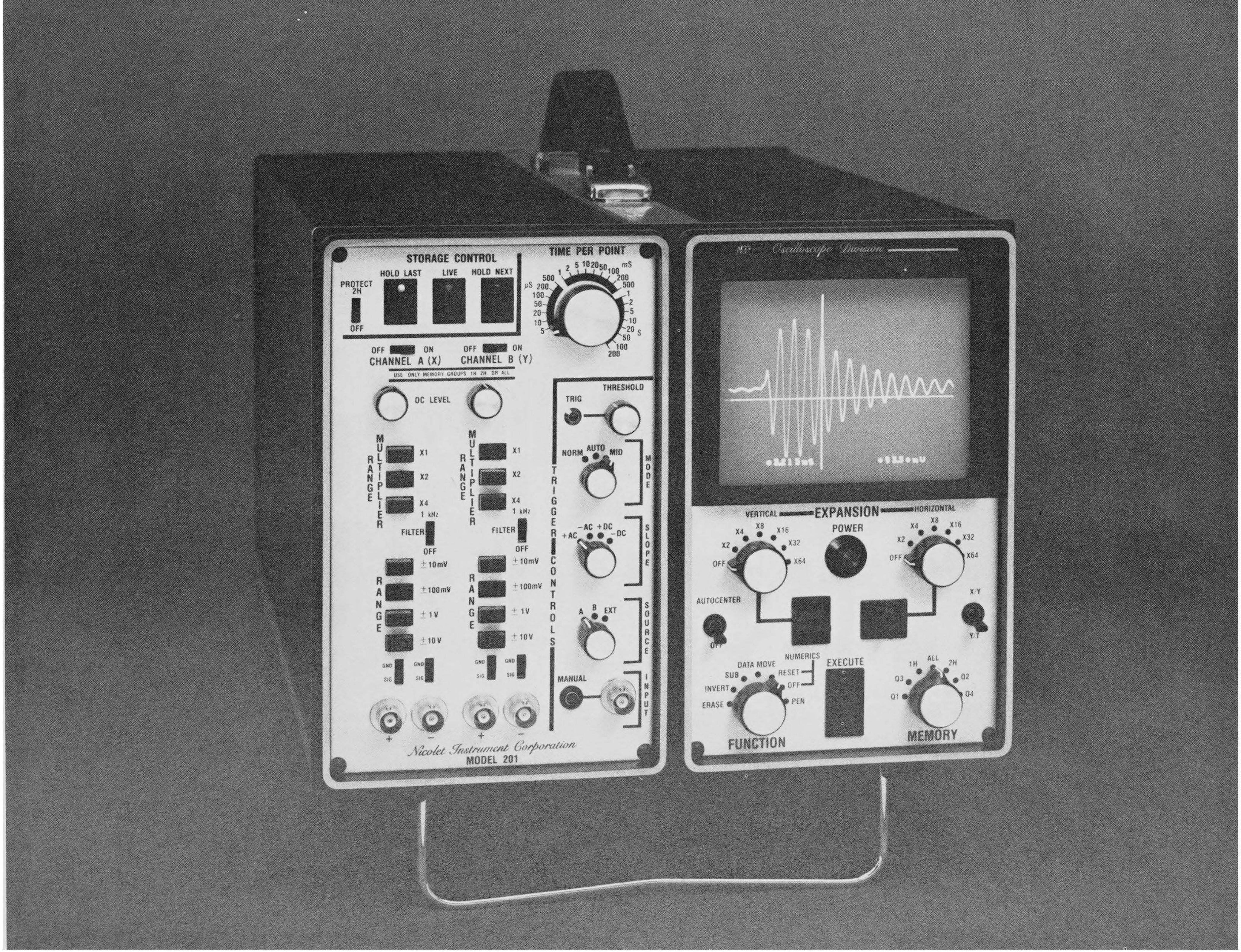
OPERATION MANUAL

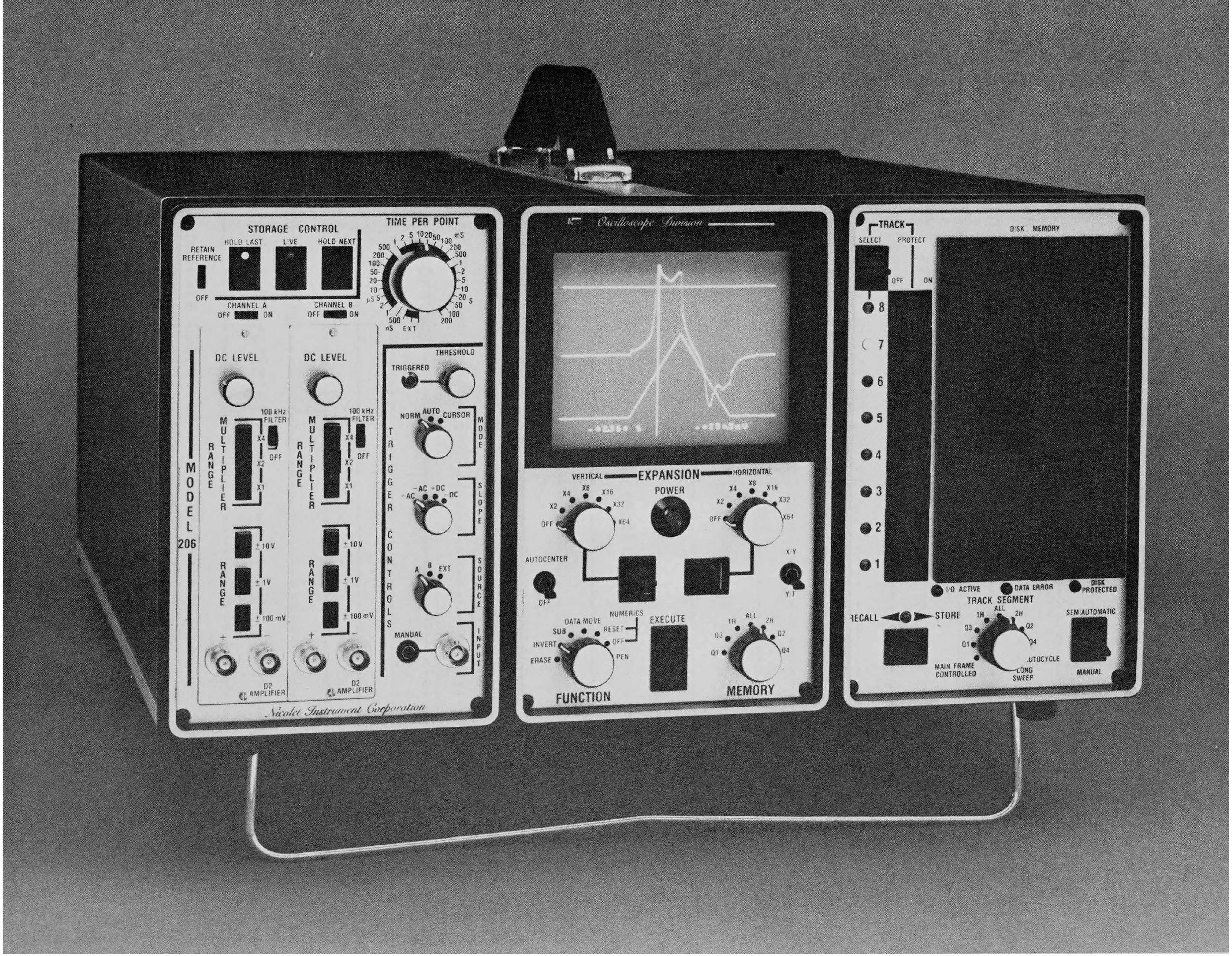
FOR SERIES 2090 DIGITAL OSCILLOSCOPES

NOVEMBER 1981

NICOLET INSTRUMENT CORPORATION
OSCILLOSCOPE DIVISION



STORAGE CONTROL
TIME PER POINT
PROTECT 2H
OFF
HOLD LAST
LIVE
HOLD NEXT
μS
mS
S
CHANNEL A (X)
CHANNEL B (Y)
USE ONLY MEMORY GROUPS 1H 2H OR ALL
DC LEVEL
RANGE MULTIPLIER
X1
X2
X4
1 kHz
FILTER
OFF
RANGE
±10mV
±100mV
±1V
±10V
GND
SIG
THRESHOLD
TRIG
NORM
AUTO
MID
MODE
TRIGGER CONTROLS
SLOPE
SOURCE
INPUT
MANUAL
EXT
Nicolet Instrument Corporation
MODEL 201
Oscilloscope Division
VERTICAL
EXPANSION
HORIZONTAL
POWER
AUTOCENTER
X/Y
Y/T
NUMERICS
RESET
DATA MOVE
SUB
INVERT
ERASE
PEN
EXECUTE
FUNCTION
MEMORY



STORAGE CONTROL
RETAIN REFERENCE
HOLD LAST
LIVE
HOLD NEXT
OFF
CHANNEL A
OFF ON
CHANNEL B
OFF ON
TIME PER POINT
DC LEVEL
DC LEVEL
100 kHz FILTER
MULTIPLIER
RANGE
MODEL 206
D2 AMPLIFIER
D2 AMPLIFIER
Nicolet Instrument Corporation
THRESHOLD
TRIGGERED
NORM AUTO CURSOR
MODE
SLOPE
SOURCE
MANUAL
INPUT
TRIGGER CONTROLS
Oscilloscope Division
VERTICAL EXPANSION HORIZONTAL
POWER
AUTOCENTER
X/Y
Y/T
NUMERICS
DATA MOVE
RESET
SUB
INVERT
ERASE
PEN
EXECUTE
FUNCTION
MEMORY
TRACK
SELECT PROTECT
DISK MEMORY
I/O ACTIVE
DATA ERROR
DISK PROTECTED
TRACK SEGMENT
RECALL
STORE
SEMIAUTOMATIC
MAIN FRAME CONTROLLED
LONG SWEEP
AUTOCYCLE
MANUAL

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I. INTRODUCTION

This portion of the EXPLORER Series Instruction Manual describes the general design and operating characteristics of the EXPLORER II and III Oscilloscopes, as well as the recommended operating procedures. These should be understood by the operator, in order to make full use of the numerous new benefits provided by these instruments. For the most part, operation is conventional, but the nature of the instrument, which is a digital oscilloscope, is such that there are a number of new techniques involved in the operation.

Typically, an experienced analog oscilloscope operator can learn the operating procedures even without consulting this instruction manual. It is nevertheless recommended that this manual be utilized rather than depending upon trial-and-error learning.

II. GENERAL DESIGN

The block diagram of the EXPLORER Series is shown in simplified form in Figure 1. For the case in which a plug-in unit such as Model 206 is in use, the signal information is converted to digital form, stored in a buffer memory, then transferred to the main frame memory for display purposes, the microprocessor controlling the beam of the display cathode-ray tube.

Details of plug-in unit and microprocessor structure and programming are beyond the scope of this discussion, but certain characteristics are of interest and help in understanding the instrument.

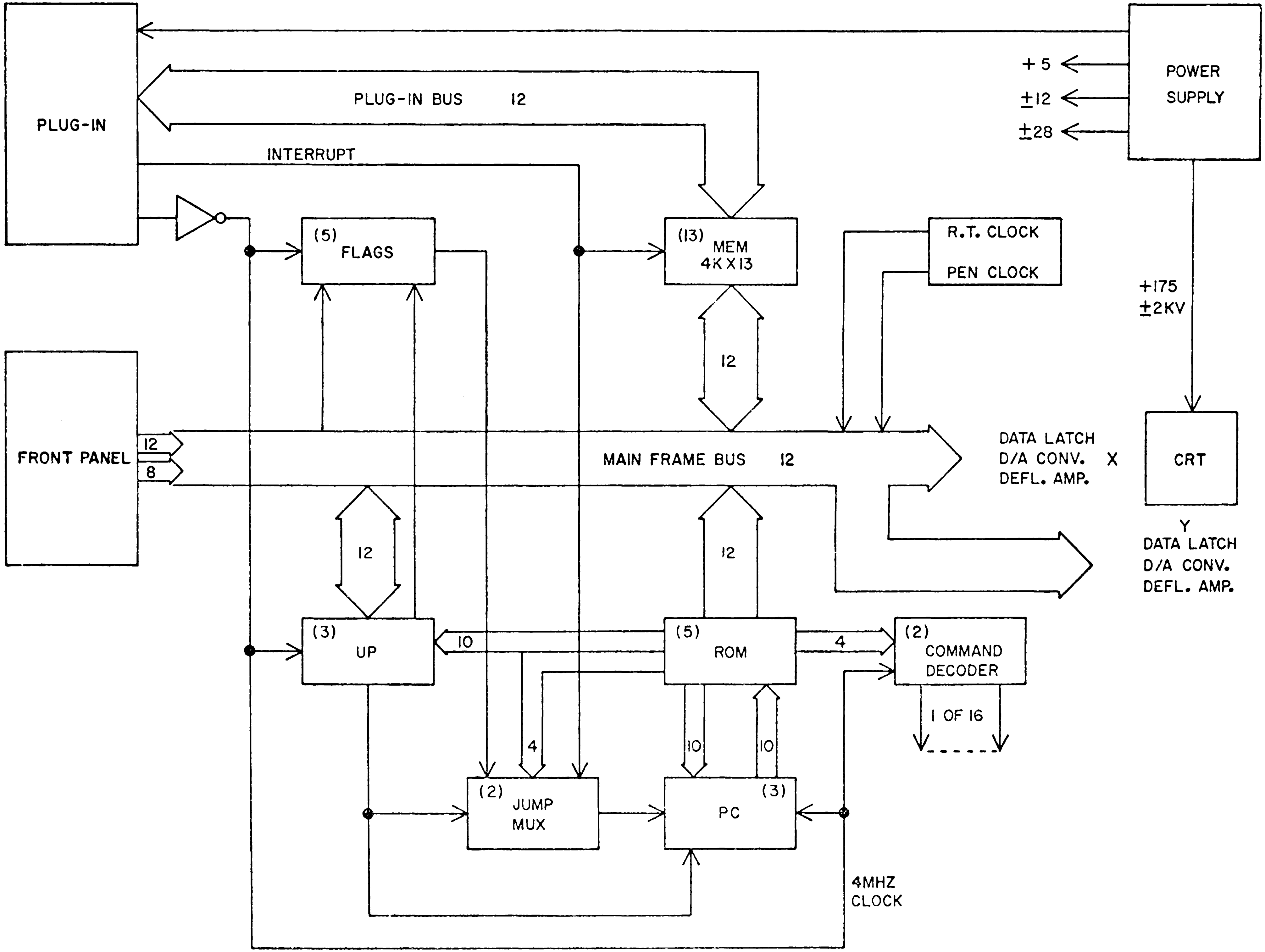
In this manual the term "sweep" is used in a manner analogous to its use in analog oscilloscopes. When a sweep trigger signal is received, the analog-to-digital converter measures the signal at intervals (separated by amounts which depend upon the selected sweep speed) and transfers the information to the buffer memory. Depending upon front panel switch settings, when 1024, 2048, or 4096 measurements have been made, the sweep ends. The information is then transferred from the buffer memory to the main frame memory and the oscilloscope is ready to receive another sweep trigger. In the case of slow sweeps (10 μsec per point or longer) the information is transferred during rather than after each sweep.

The microprocessor continually interrogates the main frame memory and produces the waveform display as well as marker lines (cursors) and numerics.

This is a simplified description of operations. The sequences differ under different conditions, for example, where two signal channels are in use or where "cursor triggering" is in use. The operations described, however, are representative of the manner in which the oscilloscope handles the signal information.

The method differs radically from that used in an analog oscilloscope, which controls the display tube directly from the amplified signal voltages and a sawtooth "sweep" voltage. While in simple, undemanding oscilloscope applications, the operation and appearance of the display are almost indistinguishable from those of analog oscilloscopes, there are fundamental advantages gained.

Descriptions of the controls of the EXPLORER Series, and of specific kinds of measurement given in this manual disclose the usefulness of most of the advantages. To make the best use of these improvements, Section III should be read and understood.



BLOCK DIAGRAM

FIGURE 1

III. INITIAL INSTALLATION

A. Power Requirements

This instrument operates from any one of four AC power source voltages: 101, 115, 202, and 230 volts AC, all ±10%. The power lines frequency allowable is 50-60 Hz ±5%. These must be single phase power sources with neutral wire at or near ground potential, a separate safety ground at ground potential, and the third wire the line wire. See Figure 2 for the position of the neutral, line, and safety terminals at the connector.

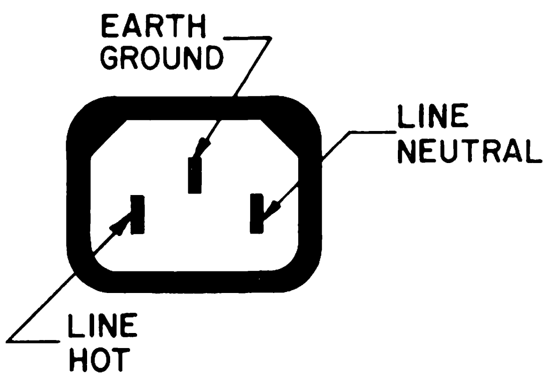


Figure 2

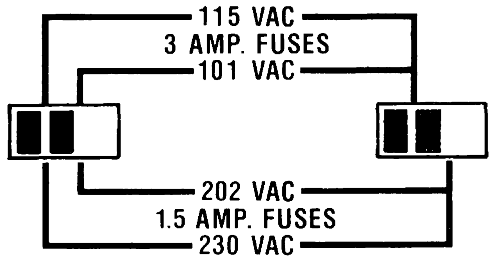


Figure 3

Switches at the rear of the cabinet allow selection of the range. Figure 3 indicates the switch positions which should be used for each of the four voltage ranges. The table below may be used for this purpose also.

Input Voltage Range	Left Switch	Right Switch
101 ±10%	Right Position	Left Position
115 ±10%	Left Position	Left Position
202 ±10%	Right Position	Right Position
230 ±10%	Left Position	Right Position

The fuses used must be 3 ampere slow blow fuses if the input power is either 101 or 115 volts ±10%, and must be 1.5 ampere slow blow fuses for the 202 and 230 volt ±10% ranges.

It is imperative that the switches be in the correct positions for the power line voltage that will be involved, to avoid serious damage to the oscilloscope circuits. Inspect the switches for correctness of settings when the instrument is received. If the switches are changed, double check the correctness of their new settings before applying power.

The power requirement for this instrument is nominally 225 volt amperes. It is higher in the case of operation with some plug-in units than others. It should never require more than 300 volt amperes, average, under worst case conditions.

B. Environment

This instrument may be operated at air temperatures of from 0°C to 33°C. To operate from 0°C to 45°C, reduce the incoming AC voltage 9% from the nominal input. Storage may be at -55°C to +70°C.

C. Thermal Cut-Out

In the event of excessive temperature, power is shut off automatically, and will be restored after the temperature returns to a safe level. This cutoff is slow acting, and will not protect against overheating due to high storage temperatures followed by operation before the chassis has cooled, internally, to near the recommended operating environmental temperature.

IV. OPERATING PROCEDURES

A. "First Time" Procedures

When operating this instrument for the first time, unfamiliarity with the controls will cause a certain amount of difficulty, as with any new instrument of comparable complexity. Use an hour or two to learn the behavior of the instrument. First read this section, then after a few minutes of experimenting, you should take the time to read the remainder of Section IV. It is assumed that the Initial Installation section has been read.

In initial experimenting, to start some "action", place the trigger mode switch to the AUTO position. The sweeps will then occur even in the absence of triggering signals.

Be sure that the TIME PER POINT switch setting is reasonable; if it is in a very slow speed setting, it could be hours before a sweep is completed, and you could conclude that there is a malfunction because whatever you might do with the other controls, you may not see a signal waveform. Use a 1 μsec/point sweep speed setting initially.

Apply a signal, preferably of a few volts amplitude, and experiment just as you would with any new oscilloscope. If you have a two channel plug-in unit, be sure that the channel to which you have applied the signal has been switched "on", and that the other channel is "off".

B. Main Frame Operating Controls

1. Horizontal Display Controls

The EXPANSION switch allows you to select a scale multiplier factor from 1 to 64. The expansion is digitally accomplished and therefore exact.

It is important for you to know that the functions invert, subtract, and data move discussed below, will not take place unless the HORIZONTAL EXPANSION switch is in the OFF position. Erase will work with HORIZONTAL EXPANSION turned on, but only the displayed portion of the waveform will be erased.

When expansion occurs, it occurs symmetrically about the vertical marker line, which you can position left or right by use of the paddle switch below the HORIZONTAL EXPANSION switch.

You will notice when in an unexpanded display mode, that the marker when moved will move at a rate of about a centimeter/ second. This corresponds to up to 400 data points per second. You will not be able to position it easily at an exact location because of reaction time. You can move it one data point at a time, however, by just momentarily operating the switch. If you hold the switch left or right for over 0.6 seconds, the marker will then proceed at 400 data points/ second.

You will also notice that the rate of movement slows, if you have selected an expanded view. This allows "finer" control; using an expansion factor of 16, the marker moves at a rate of approximately 16 points/sec., so you can react quickly enough to control the movement.

Placement of the horizontal position control to the right will cause the waveform to move right during expanded view operation. It will cause the cursor to move to the right when an unexpanded display is in use.

2. Vertical Display Controls

The VERTICAL EXPANSION switch, when "on", expands the display vertically. The expansion is symmetrical about the horizontal marker line. This line may be moved up or down by means of the paddle switch below the VERTICAL EXPANSION switch. That positioning switch isn't used often, for you can instead use the AUTOCENTER feature, which causes that line to be positioned so that it is at the same level as that of the data point intersected by the vertical marker line. This, in expanded views, automatically causes the waveform to pass through screen center. The numerics indicate the voltage and time coordinates for that center point, so you do not lose baseline information, when the autocenter mode is in use. If it is not in use, the numerics indicate the coordinates of the waveform point intersected by the vertical marker line.

3. The MEMORY Selector Switch

The main frame memory can be used in its entirety (4096 addresses), or in groups of 1024 or 2048. You may place a waveform in the 2048 point section referred to as H1, then switch to H2 for observation of live waveforms or for storing another waveform. Later you can switch back to section H1 to examine the waveform you stored earlier. Similarly, section Q1, consisting of 1024 points, may be used to store a waveform, and you can use Q2, Q3 and Q4 for others.

Never switch to a new memory section while in the "Live" mode. Doing so will usually result in that stored waveform being replaced by new signal information.

4. The XY Selector Switch

When this switch is on, two waveforms in memory (or "Live" waveforms) will be displayed as functions of each other. A waveform recorded in Q1 (X) will be plotted as a function of one in Q3 (Y), when the Memory Selector switch is placed in the H1 position. Similarly, waveforms in Q2 (x) and Q4 (Y) will be plotted as functions of each other when the switch is in the H2 position. A waveform recorded in H1 (X) will be plotted vs one in H2 (Y), if the Memory Group Selector switch is in the "All" position.

If the plug-in unit is a two channel unit, the two "Live" signals will be plotted in this way regardless of what memory section is in use.

In the XY mode, placing the AUTOCENTER switch to AUTOCENTER will cause the A vs B function to pass through screen center. In expanded views, use of the Horizontal Position control causes the trace to "move" through that center position so that different points will be centered. The numerics displayed refer to that centered point. The selected point, in unexpanded or noncentered displays, is marked for identification.

You can alter the selection of which point is marked only by using the autocenter mode and the Horizontal Position switch, whether or not expanded display is used.

5. The FUNCTION Switch

This switch provides for pen recording and simple manipulations of information stored in memory. If the function involves alteration of stored data, the HORIZONTAL EXPANSION switch must be set to OFF. All functions are done by pressing the EXECUTE button.

a. ERASE

This is used rarely. It has been included in order to clear "junk" from the screen prior to use of a long sweep, to make it easier to watch the waveform unfold as the sweep progresses. A cleared memory is also useful in the process of adjusting the "zero" position of a pen recorder.

b. INVERT

This causes the voltage values of the waveform stored in memory to be multipled by -1, when the Execute button is depressed.

c. SUBTRACT

When this function is executed, corresponding points of two waveforms are subtracted from each other. Which two this will be depends on the memory switch setting:

If the switch is set at Q1, the waveform in Q1 will be subtracted from that in Q3 and the difference will be placed in Q1.

If the switch is set at Q3 the difference (Q1 - Q3) will be placed in Q3.

If the switch is set at Q2, the difference (Q4 - Q2) will be placed in Q2.

For the setting Q4,(Q2 - Q4) will be placed in Q4.

For a setting H1, (H2 - H1) will be placed in H1.

For a setting H2, (H1 - H2) will be placed in H2.

For the ALL setting there will be no change in the waveforms as this would not be a valid operation.

The original waveform may be recovered by repeating the subtraction step that produced the difference signal.

Difference measurements traditionally have been made by using a differential amplifier. With this oscilloscope they also can be made using just one signal probe, by recording first one waveform, then the other, and subtracting. There is then an assurance that there will be essentially no amplifier DC or AC imbalance, since only one signal channel and attenuator circuit is involved. It also is mechanically easier to do this than to connect two probes. There are, of course, situations in which this is not an allowable procedure, for example, when common mode voltages are present and vary with time.

If it is desired to add two signals, the "subtrahend" of the subtraction operation should first be inverted and then the subtraction process executed.

d. DATA MOVE

When this operation is performed the waveform is vertically repositioned so that the "selected point" intersected by the vertical marker line is raised or lowered so that it appears at the same level as the horizontal marker line, and all other waveform points are shifted by a like amount. This causes loss of baseline information, if this is of importance, make a note of the original voltage level for a selected point. Then the waveform can be "data-moved" back to its original level later.

e. RESET NUMERICS

This operation causes the origin to be changed. Instead of the normal origin of t_0=trigger time and v_0=zero volts, pressing the EXECUTE button causes the origin to change to the present position of the cursor line intersection.

Note that if the AUTOCENTER switch is ON, the horizontal marker line will be at the intersection of the vertical marker, and the waveform. Thus, the new origin is changed to the intersection of the vertical (time) line and the waveform.

To restore the numbers to absolute values, with respect to the time zero, voltage zero "original" origin, turn the FUNCTION switch to some other position. Returning that switch to the RESET NUMERICS position again causes the numerics to be relative to the new origin. This operation can be applied only to stored waveforms, not during "Live" operation. It is not necessary to press EXECUTE.

f. NUMERICS OFF

This is self-explanatory.

g. PEN

Pen recorder drive signals are provided at BNC connectors on the rear of the cabinet. These are designed to operate into high impedance pen recorder circuits (50,000 ohms or higher), and have a range of nominally 0 to 5 volts full scale for both X and Y drives. The pen recorder should have a manually operable pen lift, and it must be an XY recorder rather than a strip chart recorder. It should have a pen slew speed capable of full scale deflection in ten seconds or less.

The readout rate is automatically controlled to take into account the pen slew times; instead of reading data out at a rate of one second per point, it reads it out at a rate which is very high in featureless regions, but slow whenever substantial pen excursions are involved. The basic readout rate can be adjusted by the rear panel pen speed control. This decreases or increases the rate to adapt to very slow recorders or to faster recorders.

Before the pen readout is executed, the pen drive voltages are approximately zero. This corresponds to a vertical negative full scale position on the paper, and the leftmost part of the waveform.

To calibrate the recorder, place a full scale DC level into the oscilloscope. This is done by placing the plug-in in Live, using one channel without an input, and Auto trigger. Turn the channel's DC offset adjust until the offset is at full scale. Now place the plug-in in Hold Last. Initiate a pen recording. The pen recorder will draw a box corresponding to the horizontal and vertical limits of the pen outputs. Adjust the inputs of the pen recorder until the outline is drawn as required. After calibration has been achieved, this box may be drawn for each pen recording so that the horizontal and vertical limits of a recording can be shown with each tracing of a signal.

If the oscilloscope display expansion controls are in use, so that only part of a waveform is being shown, that same part will be recorded in the pen recording operation. You may "compose" the recording, by adjusting the display controls. The recording does not include drawing of the marker lines or numerics shown on the cathode ray tube screen.

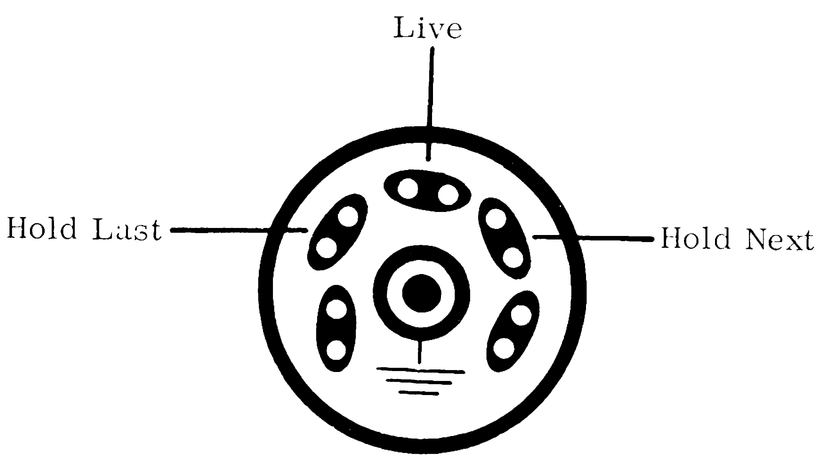
It is best not to attempt to record superimposed waveforms, except by first recording one, then the other. The pen, otherwise, will alternate vertically between one waveform and the next for each point, which is undesirable both because of appearance and because of greatly increased recording time.

6. REMOTE CONTROL Connector

The functions of the two hold pushbuttons and the LIVE pushbutton can be achieved by use of signal inputs provided on the rear panel REMOTE CONTROL connector.

Remote control requires that external commands be generated. The signal needed is an open circuit (or open transistor collector) for no action, with a ground potential applied to cause the action. Remote control can be used in order to take advantage of the high speed of a remote sensor, rather than relying on your reaction time. It can also be used in order to allow you to manually control storage from a location away from the oscilloscope front panel (e.g., a probe pushbutton can be used).

Refer to the following diagram for pin connection details.



C. Model 206 Plug-In Operating Controls

1. The Storage Controls

The LIVE pushbutton, when depressed momentarily, allows the instrument to respond to both signal input and trigger input as selected. A valid trigger will cause new information to replace the old.

The HOLD NEXT pushbutton allows one more sweep, only to be triggered, after it is depressed when operation is "Live".

The HOLD LAST pushbutton, when momentarily depressed, allows no further triggering but if a sweep is already in progress, it allows that sweep to be completed.

The RETAIN REFERENCE switch, when "on", prevents new signal information from being entered into alternate memory locations; half the data points then indicate the "Live" ongoing signal waveforms and half represent the older waveform being protected. The effect is to allow waveforms to be compared closely, one of the waveforms being stored, the other "Live".

When operating in the "Cursor Trigger" mode (See Section IV, C.5.b.2) the change to or from the RETAIN REFERENCE mode takes place at the end of a sweep, if the plug-in is kept in Live. Whenever the LIVE button is depressed, the RETAIN REFERENCE mode, either on or off, is entered into the 206 control logic. In other triggering modes, altering the switch position causes this mode to take effect at the beginning of the next sweep and therefore, the protection is effective more immediately.

2. The TIME PER POINT Control

This switch allows selection of sweep speed of 500 ns per point and exact multiples (2, 5, 10 etc.,) of 1 μs, up to 200 seconds per point. You should not change the position of this switch during long sweeps, if you do not wish information to be lost, in part.

3. CHANNEL ON-OFF Switches

The Model 206 plug-in unit can be used as a single channel unit if the unused channel is switched off. Switching off both channels is physically possible, but an incorrect operation. If this is done, the instrument may appear to operate correctly with certain settings of the MEMORY switch and trigger source, but with other settings of these switches the instrument will not operate correctly. Therefore, be sure to have one channel "on".

If you wish to examine only one signal source, you will be using only one amplifier; the other signal channel should be switched off. Even when it is switched off, you may use the second signal amplifier to receive a trigger signal from another source, rather than using the EXTERNAL trigger signal input.

4. TRIGGER THRESHOLD and TRIGGER SLOPE

When the trigger signal voltage crosses the threshold level selected by this control, a sweep is triggered if the oscilloscope is in the "Live" mode. It is a positive transition which causes the sweep to start if the TRIGGER SLOPE switch is in the "AC+ or DC" position" otherwise it is the negative transition.

In the case of positive transition triggering, the trigger signal voltage must recross back below the threshold after the trigger has occurred and must drop below that threshold voltage by an appreciable amount, before another trigger can occur. This requirement is to prevent infinite sensitivity. The same is true for negative transition triggering, but in the opposite direction.

The amount by which the trigger signal must continue beyond the threshold during the recrossing after a trigger has occurred determines the sensitivity. The sensitivity is nominally 0.5 volts for external triggering. It is nominally one tenth of the full scale range selected, for internal triggering.

The AC coupling time constant is 0.1 seconds. The external trigger circuit input impedance is 1 Megohm. The external trigger voltage should not exceed ±25 volts.

5. Trigger Controls

a. TRIGGER SOURCE Selection

The 206 plug-in allows sweep triggering to be initiated by either an externally provided signal, or from the signals from the amplifier of either channel A or B. When internal triggering is in use, for example by means of the signal from the channel A amplifier, the A channel is usually "on" (See Section IV, C.3), and the signal is displayed on the screen. If channel B is also "on", two waveforms are displayed, those applied to each of the two amplifiers.

If channel A is switched "off", the signals applied to it continue to cause triggering, and in this situation the "B" waveform continues to be displayed if the "A" signal continues to provide suitable trigger signals.

This is conventional in modern analog oscilloscopes, also. The purpose in using one channel for triggering, even if its waveform is not displayed, is to allow the signal being used for triggering to be "conditioned", i.e., amplified, attenuated, level shifted, or filtered, by the amplifier. It also allows you to "see" the signal if you temporarily switch that plug-in unit channel "on", thereby allowing you to confirm that what is causing the triggering is really what you want to cause it; and that the trigger threshold is set at a safe level above noise and also safely below the maximum point of the triggering signal feature.

The 206 plug-in unit also provides for manual push-button triggering, which is used when no trigger signal feature is present, such as at the beginning of a long measurement of some variable such as room temperature.

b. The NORM-AUTO-CURSOR TRIGGER MODE CONTROL

1. NORMAL and AUTOMATIC Triggering (206)

Normally, triggering is produced in a conventional manner. The AUTO trigger mode is one in which another sweep is caused to occur automatically, if no trigger occurs within 22 milliseconds after the preceding sweep is ended. The automatic triggering is used principally during set-up procedures.

2. The CURSOR TRIGGER MODE

Cursor triggering is the mode which allows observation of signal regions both preceding and following the trigger time. How much pre-trigger information, and how much post-trigger information will be shown is determined by the position of the vertical marker line (the cursor) displayed on the screen when an unexpected display is in use.

It is ordinarily just as easy to use this mode of triggering as the NORMAL mode. There is one situation which should be kept in mind, however. During the use of very slow sweeps it will be observed that information is not transferred to the main frame for display until the sweep is completed. You might sometimes observe by means of the TRIGGERED led on the panel that a trigger has occurred, yet nothing seems to be happening. You may even suppose that there has been a malfunction, especially if the sweep is very long in duration. It is not a malfunction; when the sweep ends the signal waveform will be displayed.

The CURSOR TRIGGER mode is sometimes referred to as the "mid-signal trigger" mode. It is made possible by recording into the plug-in unit memory continuously, but not transferring that information to the main memory for display until some time after the trigger signal is received. The buffer memory contains past history, therefore, that will be used to indicate the signal waveform that corresponds to the signal that existed before the trigger. In the period before the trigger, the buffer may become "full", after which the oldest information is discarded to make room for the most recent. Usually that buffer contains 4096 data "points", therefore.

When a trigger occurs, this process is allowed to continue for a time, the length of time depending upon the position of the vertical marker line, the cursor. At the end of that time, the contents are transferred to the main memory. The "pre-trigger-time" information is therefore displayed, followed by the "post-trigger" information. The act of transferring information to the main memory consumes typically 2 milliseconds, and for practical design reasons, all information is discarded from the buffer, at that time. This means that the next trigger cannot be allowed to happen until the buffer again contains a sufficient amount of "new" history. If it occurs too soon, it will be ignored by the oscilloscope.

This is an important consideration in the case of very slow sweeps. Suppose, for example, that you want to observe what precedes an event that you expect might happen during the night. You may then select a sweep time of 11.5 hours (10 seconds per point if you are using the full memory and a single input channel). If you need to see what happened before the event, an hour of information for example, you will set the cursor to a position about a tenth of the way from the left of the screen. There must be at least one hour of running before a trigger will then be accepted. You must place the instrument in the CURSOR trigger mode, and press the LIVE pushbutton at least an hour before the event is expected in this case.

6. The DC LEVEL Control

This should normally be set to a position which causes the trace to be at the zero voltage position when the signal probe is removed from any signal source. The numerical voltage value displayed indicates trace level. When measurements require high accuracy, this setting should be checked with appropriate care. DC level drifts of as much as 0.025% of full scale per hour, even at constant temperature, can be expected except in the case of drift-stabilized plug-in units. Furthermore, amplifier gain switch selection changes can introduce DC level offset changes of as much as 0.1% of full scale.

7. External Sweep Timing Control

The Model 206 plug-in unit includes the capability of allowing external control of sweep timing, in place of the internal crystal oscillator control. This feature is referred to as the "External Address Advance" capability.

This capability is provided when the TIME PER POINT switch is placed in one of the three positions counterclockwise from the 500 ns position.

The Model 206 plug-in provides three external timing modes:

MODE 1: This is referred to as the "fast, non-synchronous" mode. In this, the first externally provided timing pulse acts as a sweep trigger pulse and as the first "sample" command.

The following pulses each act as "sample" commands, and when they occur the signal is measured and recorded within 650 ns, until the "sweep" is concluded following 1024, 2048, or 4096 such commands, depending upon the size of the memory group being utilized.

The pulses are applied to the INPUT BNC connector, and it is necessary to use the NORMAL triggering mode, and the EXTERNAL SOURCE triggering mode should be used. The trigger threshold level control, and the polarity and AC/DC coupling controls are used in a normal manner, and control the response to these externally applied pulses.

Use the first position counterclockwise from the 500 ns position, for this mode.

Note that there is limited synchronization of timing. There will be a delay of from 150 to 650 ns following each applied pulse before the signal is actually measured.

In this mode, the timing pulses must not occur with a spacing less than 500 ns.

MODE 2: The Model 206 provides a second external timing mode, with 400 ns delay and 25 ns timing uncertainty, but in which the minimum pulse spacing allowed is 1.5 μsec. The second time base switch position counterclockwise from the 500 ns position is used for this mode.

MODE 3: The third unmarked position counterclockwise, of the Model 206 time base switch, provides a slow, synchronized mode. Minimum external timing pulse spacing is 4 μsec, and time of measurement delay of 400 ns and 25 ns timing uncertainty. Unlike MODE 1 and MODE 2, this mode allows the waveform of the signal being measured to be observed during the sweep rather than afterwards.

NOTE: On units shipped before September 1, 1978, MODE 2, under certain circumstances does not operate correctly. If MODE 2 is required, please consult Nicolet in Madison, Wisconsin. Also, MODE 3 is nonsynchronized on units shipped before September 1, 1978.

D. Model 204-A Plug-In Unit Operation

General

This 20 MHz sampling rate plug-in unit is operated in substantially the same manner as other EXPLORER plug-in units. It is an 8-bit-resolution plug-in unit, rather than 12 bits, and as a consequence you should not need to utilize very high vertical display expansion when viewing waveforms. A x4 vertical expansion, you will find, is about the maximum effective expansion, beyond which the information becomes less, rather than more, meaningful. Experiment with the expansion control, to confirm this.

1. Controlling Storage

Causing the oscilloscope to store a signal is an easy matter; you only need to touch one of the two HOLD pushbuttons to cause either the next or the last preceding signal to be stored.

There are some simple choices to make concerning what part of the memory you will use for storage. The choice depends on what other signals you want to store, if any, and upon whether or not you will want to continue to use the oscilloscope while the stored signal or signals are being held.

The memory may be divided into quarters or halves or you may use the entire memory. Obviously, for a given sweep speed, the more memory you use the longer the signal segment that will be stored, but the fewer the number of signals that you can store. Your measurement situation will determine your choice.

After storage, you may superimpose the stored signal waveforms, or view them singly. To view stored signals superimposed on line signal waveforms, you must use the RETAIN REFERENCE switches. Each of the four switches "freezes" certain coordinate points. Every fourth point starting at the first point is protected against change when the left switch is in the "up" position. The next switch is used to protect every fourth point starting with the second. The next switches protect the 3rd and 4th points, respectively, and every fourth point following.

You can easily test the effects of these switches by using them while watching live signals being displayed. Note how easy it is to accurately compare signal waveforms presently occurring with one or more earlier signals.

2. Remote Storage Control

At the rear of the cabinet is a REMOTE connector, with contacts which allow you to duplicate the functions of the HOLD and LIVE pushbutton switches from a remote location. See Section IV-11 which indicates the contact arrangement. The signals required are contact closures or open-collector TTL logic circuit output signals.

3. Time Per Point (Sweep Speed) Control

The sweep speed selector is calibrated in terms of time units per point rather than time per centimeter. This is because if display expansion is is use, the "per centimeter" term becomes incorrect.

4. CHANNEL ON-OFF Switches

For single channel operation, you should turn off the Channel Selector Switch for the unused channel. The signal amplifier is not turned off by this switch, so you may use that channel for a trigger signal source even though the signal to that channel is not being displayed or stored.

5. Trigger LEVEL, COUPLING, SLOPE and SOURCE Controls

The trigger signal transition across a selected voltage level produces an oscilloscope sweep. The trigger LEVEL control is used to select the threshold level. The SLOPE switch determines whether the transition must be from below or from above the threshold. The SOURCE and COUPLING switches are traditional in function.

When the selected trigger signal has crossed the selected threshold voltage, of course it must re-cross it in the return direction in order that it may again cross it in the selected direction to start the next sweep. The voltage must re-cross past the threshold by a considerable amount, before the trigger circuits again become armed.

This means that very small signals cannot cause triggering. While the signal voltages may cross the selected threshold voltage, and may return back over the threshold, the return may not be far enough to re-arm the trigger circuits. The amount by which the signal voltages must return past the threshold is nominally ten percent of the full scale range in use, for internal triggering, and 0.5 volts if external triggering is in use.

6. Triggering Modes

The AUTO-NORMAL pushbutton switch allows you to operate with or without a trigger source. When in the "out" position a triggering signal from Channel A or B, or the signal applied to the external trigger signal BNC connector, is needed. When in the "in" position, another sweep will occur automatically within 29 milliseconds of the end of the preceding sweep, or if a trigger signal is received before that time.

The CURSOR trigger mode, sometimes called midsignal trigger mode, is one in which the sweep seemingly begins before the trigger signal is received. This seems impossible, at first thought, but is made easy by means of a digital signal delay line. The signal delay, insofar as the display is concerned, has the same effect as if the sweep trigger had been advanced. Thus, the sweep appears to have started before the trigger signal occurred.

The amount of signal delay, in the case of this plug-in unit, is adjustable by moving the vertical marker line on the screen, called the "cursor". To adjust the delay, switch off the horizontal expansion, and position the cursor at the location you wish to correspond to time zero, the time of trigger occurrence. Press the CURSOR LOCK button so that future changes in cursor position won't affect the location of time zero.

7. The DC Offset Control

This should normally be set to a position which causes the trace to be at the zero voltage position when the signal probe is removed from any signal source. The numerical voltage value displayed indicates trace level. When measurements require high accuracy, this setting should be checked with appropriate care. DC level drifts of as much as 0.1% of full scale per hour, even at constant temperature, can be expected. Furthermore, amplifier gain switch selection changes can introduce DC level offset changes of as much as 1% of full scale.

8. Slow Sweeps

During the use of very slow sweeps it will be observed that information is not transferred to the main frame for display until the sweep is completed. You might sometimes observe by means of the TRIGGERED light on the panel that a trigger has occurred. yet nothing seems to be happening. This is not a malfunction; when the sweep ends the signal waveform will be displayed.

9. External Sweep Timing Control

The Model 204-A plug-in unit includes the capability of allowing external control of sweep timing, in place of the internal crystal oscillator control. This feature is referred to as the "External Address Advance" capability.

This capability is provided when the TIME PER POINT switch is placed in any of the three marked positions. All positions operate the same.

The External Address Advance mode is initiated, after the TIME PER POINT switch is moved to the correct position, by a trigger signal. Normally the trigger signal is received through the External Trigger input, but either of the two channels can be used as a trigger. The first trigger pulse acts as a normal sweep trigger and as a "sample" command.

The following pulses each act as "sample" commands, and when they occur the signal is measured and recorded within 100 to 150 nanoseconds with External trigger.

The timing pulses must not occur with a spacing less than 100 ns.

When using the External Address Advance, as when using normal sweep timing, the signal cannot be seen until all needed timing pulses are received.

E. Model 201-2 Plug-In Operating Controls

1. General

This plug-in unit is designed for low frequency measurements, and provides appropriate sensitivity, input impedances, and stability for the majority of such measurements.

In most respects, the operating procedures involved are the same as for the Model 206 plug-in unit, described earlier beginning on Page IV-12.

2. The Amplifier

The plug-in unit utilizes a stable, low noise, low input bias current instrumentation amplifier in each channel. This amplifier has an input impedance of nominally 10^{11} Ω differential and 10^{13} Ω common mode (each input, to ground). The input currents are nominally ± 2 pa, each input, doubling each 10° C. (See paragraph E9, Page 38, for test techniques.)

For the +10 volt sensitivity range, an attenuator is switched into the input circuits, which changes the input impedance to 10^{6} Ω from the + and the - inputs to ground.

Because of the high impedance "floating" inputs, this amplifier must have one input grounded (or tied to a suitable dc reference if the signal voltage is not near ground potential), when operating "single ended". The unused input must be grounded or suitably biased, except for the ± 10, 20, and 40 volt ranges.

Because of the sensitivity and high impedances, reasonable care in shielding should be used in connecting the signal source to the oscilloscope.

Electrostatic and electromagnetic fields, which do not affect other oscilloscopes noticeably, can significantly affect the signals in the case of this oscilloscope. What you see on the screen is what is present between the input terminals; appropriate shielding is needed to insure that only the signal of interest is present.

3. The Storage Controls

The LIVE pushbutton, when depressed momentarily, allows the instrument to respond to both signal input and trigger input as selected. A valid trigger will cause new information to replace the old.

The HOLD NEXT pushbutton allows one more sweep, only, to be triggered, after it is depressed when operation is "live".

The HOLD LAST pushbutton, when momentarily depressed, allows no further triggering but if a sweep is already in progress, it allows that sweep to be completed.

The RETAIN REFERENCE switch, when "on" prevents new signal information from being entered into alternate memory locations; half the data points indicate the "live" ongoing signal waveforms when these are occurring and half represent the older waveform being protected. The effect is to allow waveforms to be compared closely, one of the waveforms being stored, the other "live".

When the retain reference mode is in use, it is always the odd-numbered memory addresses which are protected. These correspond to the "second half" of the memory (H2). When the entire memory is being used, odd numbered points are being protected.

When memory section H1 is in use, none of the data points are protected. When using section H2, all are protected. Thus, there will be a superposition of stored and live waveforms only when using the ALL position of the MEMORY selector switch.

NOTE: The Model 201-2 plug-in should not be operated while using the Q1, Q2, Q3, Q4 positions of the MEMORY selector switch. It is "illegal" to use those positions, except when the oscilloscope is in the "Hold" condition. The oscilloscope will refuse to accept data if that switch is in the wrong position.

4. The TIME PER POINT Control

This switch allows selection of sweep speeds of 5 μs per point and multiples (10, 20, 50 etc.), up to 200 seconds per point. You should not change the position of this switch during long sweeps, if you do not wish information to be lost in part. However, if you wish to end a very long sweep quickly, you may, <u>if you first press the HOLD LAST pushbutton</u>.

5. Channel On-Off Switches

The plug-in unit can be used as a single channel unit if the unused channel is switched off. <u>Switching off both channels is physically possible, but an incorrect operation</u>.

If you wish to examine only one signal source, you will be using only one amplifier; the other signal channel should be switched off. Even when it is switched off, you may use the second signal amplifier to receive a trigger signal from another source, rather than using the EXTERNAL trigger signal input. It is only the digital data which is blocked; the amplified signal may be used for internal triggering when desired.

6. Trigger Threshold and Trigger Signal Coupling

When the trigger signal voltage crosses the threshold level selected by this control, a sweep is triggered if the oscilloscope is in the "Live" mode. It is a positive transition which causes the sweep to start if the Trigger Signal Coupling switch is in the AC+ or DC+ position otherwise it is the negative transition.

In the case of positive transition triggering, the trigger signal voltage must recross back below the threshold after the trigger has occurred and must drop below that threshold voltage by an appreciable amount, before another trigger can occur. This requirment is to prevent infinite sensitivity. The same is true for negative transition triggering, but in the opposite direction.

The amount by which the trigger signal must continue beyond the threshold during the recrossing after a trigger has occurred determines the sensitivity. The sensitivity is nominally 0.5 volts for external triggering. It is nominally one tenth of the full scale range selected, for internal triggering.

The AC coupling time constant is 0.1 seconds. The external trigger circuit input impedance is 1 Megohm. The external trigger voltage should not exceed ± 25 volts.

7. Trigger Selection

a. Trigger Source Selection

The 201 plug-in allows sweep triggering to be initiated by either an externally provided signal, or from the signals from the amplifier of either channel A or B. When internal triggering is in use, for example by means of the signal from the channel A amplifier, the A channel is usually "on" and the signal is displayed on the screen. If channel B is also "on", two waveforms are displayed, those applied to each of the two amplifiers.

If channel A is switched "off", the signals applied to it continue to cause triggering, and in this situation the "B" waveform continues to be displayed if the "A" signal continues to provide suitable trigger signals.

The purpose in using one channel for triggering, even if its waveform is not displayed, is to allow the signal being used for triggering to be "conditioned", i.e., amplified, attenuated, level shifted, or filtered, by the amplifier. It also allows you to "see" the signal if you temporarily switch that plug-in unit channel "on", thereby allowing you to confirm that what is causing the triggering is really what you want to cause it; and that the trigger threshold is set at a safe level above noise and also safely below the maximum point of the triggering signal feature.

The plug-in also provides a choice of direct external triggering, and it also provides for manual pushbutton triggering for use when no trigger signal feature is present, such as at the beginning of a long measurement of some variable such as room temperature, which is not associated with a "start" event.

b. The NORM-AUTO-MID TRIGGER Control

(1). Normal and Automatic Triggering

Normally, triggering is produced in a conventional manner, a sweep beginning within 250 nanoseconds after the trigger has occurred. The AUTO trigger mode is one in which sweeps recur one after another, automatically, even with no trigger signal applied. The automatic triggering is used principally during set-up procedures.

(2) The Mid-Signal Trigger Mode.

In order to observe segments of the signal corresponding to times preceding the trigger signal occurrence, it is necessary to delay the signal information in some way. This "shifts" the position of the waveform to the right from its ordinary position, when viewed on the screen.

The signal is continuously digitized by the plug-in unit, in the "live" mode, and entered into a digital "delay line", using one fourth of the main frame memory as that "delay line". At the moment the trigger signal occurs, that memory section contains one fourth of one "sweep's worth" of signal information.

It is placed in that memory address sequentially, but of course there is no way of knowing at what address the last data point will be entered prior to the trigger occurrence. The data will be automatically rearranged so that the oldest information is in the first address, the latest in the 1024th address, after the trigger occurs. The plug-in unit circuits cause that rearrangement, while post-trigger information continues to be entered in other memory sections. At the end of the sweep, 1024 points of data corresponding to pre-trigger signal information and 3072 points corresponding to post-trigger information have been entered in memory.

If you have depressed the appropriate Hold push-button, the 4096 point waveform is steadily displayed, after the sweep has ended. If you haven't, and operation remains "live", the "delay line" part of the memory immediately begins to receive new signal information. You can see what is being entered by watching the right hand one fourth of the "waveform".

8. XY Operation

The left hand, or "A" channel should be used to receive the "X" variable, for it will determine horizontal position, while the "B" input provides vertical position, for each coordinate point.

The high input impedances make the plug-in especially easy to use for measuring characteristics of solid state devices, for example the input voltage-current characteristics of a transistor where sub-nanoampere currents may be of interest. To measure current, a large resistor (e.g., 10^7 ohms) may be placed between a voltage source, such as a triangular wave generator, and the transistor base (or gate). One channel (channel B, usually) is used to measure the voltage across the resistor. The other channel is used to measure base (or gate) voltage. In this case, the sweep speed should roughly match the triangular wave frequency so that a little more than one cycle occurs per sweep. Use the YT display mode to verify this relationship. It is not harmful to use several cycles per sweep, but if a pen recording is to be made of the data, the pen will "trace" an essentially continuous line, if only one or two cycles of the independent variable have been used. Otherwise it may "jump" from one part of the voltage-current characteristic to another and greatly slow the speed of recording.

Furthermore, since the circuit impedances may be high, the variables may have to be changed slowly, to allow stray capacitances to charge to steady state values. Using several cycles per sweep is unnecessary and may greatly slow the measurement.

The numerics on the screen show the XY values for any selected point. The left number corresponds to the "X" value received from signal channel A, the left channel. The right hand number shows the ordinate, or Y value, received via channel B.

9. Input Bias Current Tests

If a capacitor of about 0.01 μf is connected, with leads as short as possible; from one input to ground, and if the other amplifier input grounded, the bias currents present can be measured by noting the drift in voltage across the capacitor according to the relationship:

(1) $$i = C \frac{\Delta e}{\Delta t}$$

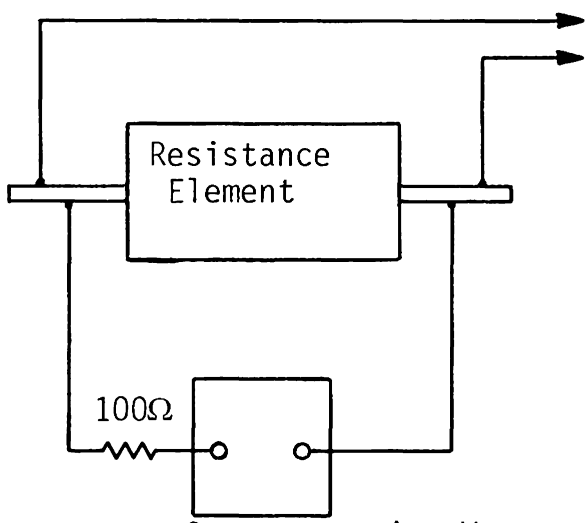
Where i is the bias current, $C = 0.01 \times 10^{-6}$, Δe is the observed voltage change for some convenient time interval Δt.

Use a slow sweep, such as 50 milliseconds per point, start the sweep, then short circuit the capacitor for a few seconds. A bias current of 1 pa will be indicated if the voltage changes at a rate of a millivolt in ten seconds. The capacitor should not be touched by the hands for a few minutes prior to the test because temperature changes can introduce various e.m.f. generating effects, and it may be necessary to keep the capacitor shorted for a few minutes in advance to eliminate "memory" of earlier charges.

This test also discloses the nature of input current "noise" (or random variations with time). It indicates the limits of error involved when very high signal source impedances are involved. With practice, valid tests can be made in two or three minutes, and it is worthwhile making such tests regularly (perhaps once a week) if signal currents are expected to be a nanoampere or so, full scale.

10. Resistance Measurements

Very low resistances, such as contact resistances, printed circuit leads, etc., can be measured by applying a square wave of current through the resistive element. The voltage resulting may be measured, to determine the voltage/current ratio, hence the resistance.



Square or sine Wave
Voltage Generator 10V p-p

This set-up makes resistance measurements independent of the resistances of the various connections used. For example, the clip leads from the current source may be as high as 100 milliohms without affecting the results by more than 0.1%. It is also independent of thermal e.m.f.'s, since those have dc effects, the a.c. peak-to-peak voltage noted across the element is used in determining the resistance, not a d.c. voltage. The resistance, R, is given by:

$$R = \frac{\Delta E_{pp}}{\Delta I_{pp}}$$

Where ΔI_{pp} is in this case 0.1A. Resolution of 1% is provided, using this simple set-up, for resistance values as low as 5 milliohms, when using the most sensitive range of the model 201 plug-in, and as little as 50 micro-ohms can be sensed.

If a slow sweep is used, resistance changes as a function of parameters such as temperature may be observed.

V. SOME OPERATING TECHNIQUES AND SPECIAL FUNCTIONS

A. The Numeric Display

The numbers shown on the photo of Figure 4 correspond to the waveform point intersected by the vertical marker line. That line may be moved to any desired location. In XY display, the numbers correspond to the voltage-voltage coordinate of the brightened point. To move the brightened point, switch to AUTOCENTER and use the horizontal position control. The left number corresponds to ordinate value, the right to abscissa, in XY display.

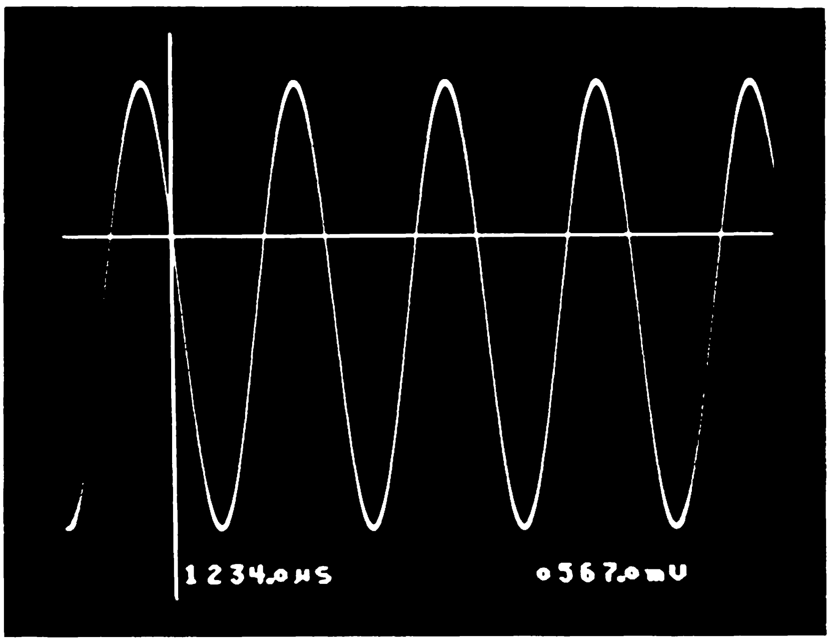


Figure 4

In all cases, normalization of values is according to the control settings used when the signal was measured, whether or not the controls have since been altered.

The voltage values do not take into account DC level control settings. The DC offset voltage produced by that control appear as a component of the signal. For this reason, it is usually preferrable to adjust that offset so that with the signal probe removed from the signal source, the voltage value shown is zero (during "Live" operation and with the sweep triggered continuously).

B. <u>Numerical Display Use When Multiple Waveforms Are Displayed</u>

The numerics indicate the time and voltage corresponding to the intersection of the vertical marker line and the waveform, if one signal trace, only, is involved. There will be two or four such intersections if waveforms are being displayed superimposed. Which of the waveforms corresponds to the numerical information can easily be observed by switching to AUTOCENTER for then the horizontal marker line intersects the vertical marker line at the data point associated with the numerical values shown.

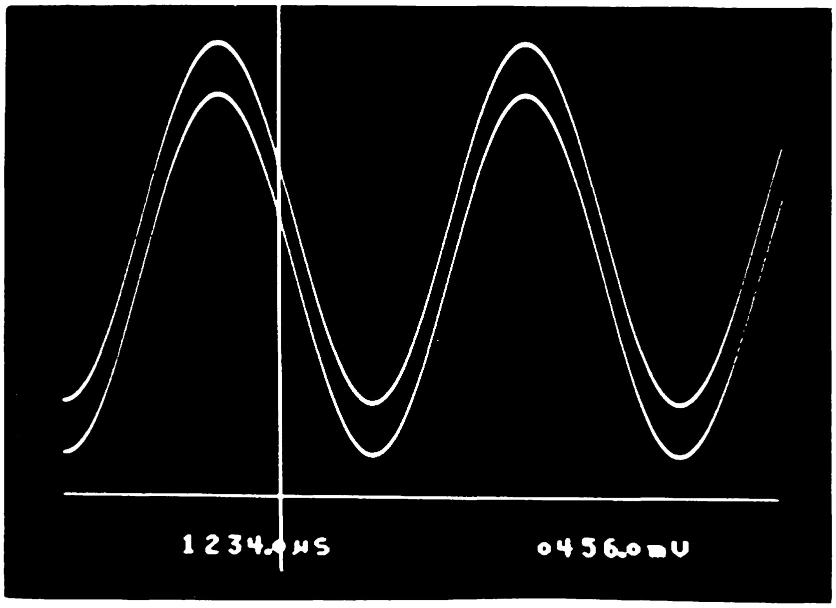


Figure 5
When autocenter is not used, there is no simple indication of which of the two waveforms shown here corresponds to the numerical voltage and time display.

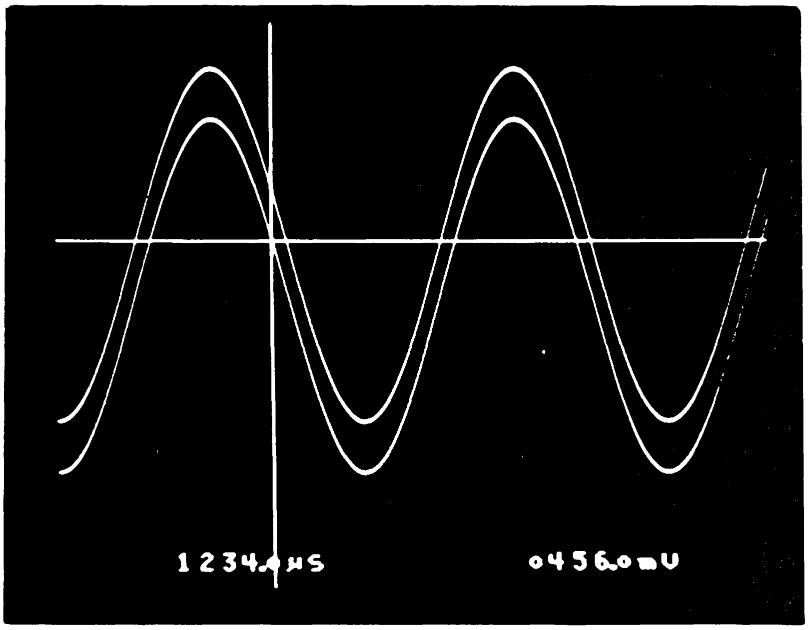


Figure 6
When autocenter is used, the horizontal and vertical marker intersection is at the data point corresponding to the numerical values shown.

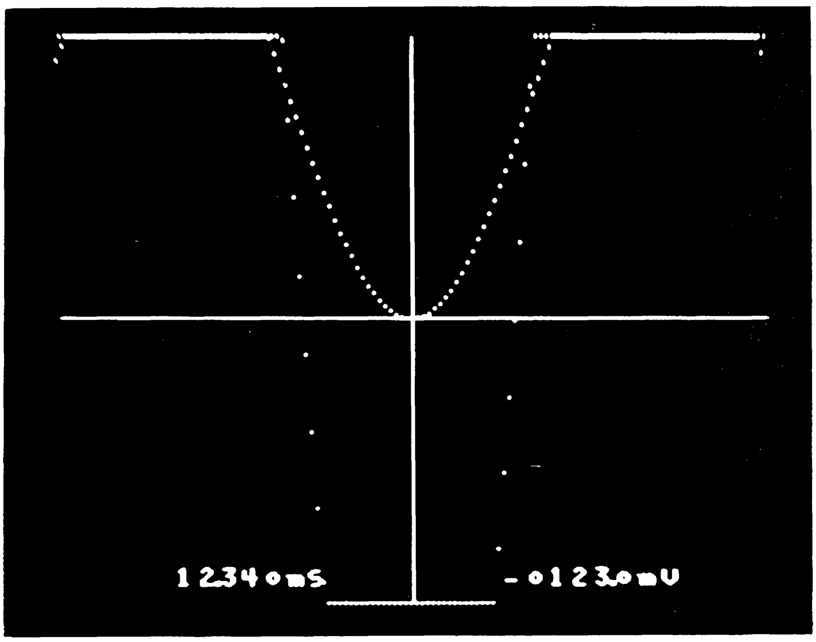


Figure 7
When multiple waveforms are shown superimposed, with display expansion and autocenter in use, the intersection of the two marker lines is at screen center, and the numerics correspond to the data point at the intersection.

C. Very Low Speed Sweeps

Operation, when long sweeps are involved, is the same as otherwise. An indirect effect occurs, however. There is no instant visual "feedback" to you that indicates that your set-up procedures were correct. If the measurement is an overnight measurement, you may discover in the morning that you had used the wrong amplifier gain, or the wrong memory size, or some such thing. Because such a mistake can be costly, it is best to use certain advance precautions.

1. Make the same measurement, in practice, using a moderate sweep speed, for example, a total sweep time of about 20 seconds. This faster rate is slow enough to let you see the consequences of an error, such as failure to depress the HOLD LAST pushbutton after the sweep is triggered, or failure to switch the correct signal channel "on", or other errors.

2. Be careful in selecting the correct sweep speed. A one second per point sweep speed results in roughly one hour total sweep duration when the ALL position of the MEMORY switch is in use, and one signal channel is being used. For an overnight measurement, therefore, you should then use a 20 second per point sweep speed. This will give a 23 hour long measurement.

Remember that if two signal channels are in use, each trace will contain only 2048 points. A 20 second per point sweep will last 11.5 hours.

3. In some cases, you may wish to prematurely end the sweep. The measurement may have proceeded from five o'clock p.m. for example, and 15 hours later at eight a.m. you may have returned and do not want to wait eight more hours for the sweep to end.

The correct way to end the sweep is to depress the HOLD LAST pushbutton, and keep it depressed, then touch the LIVE pushbutton. The data are then preserved properly. This action must result in the green "Live" light being "off". If it isn't, repeat the premature-stop procedure.

It is tempting instead to merely switch to a faster sweep speed, which also will end the sweep as rapidly as you wish, but there are two possible bad effects in doing that. One is that the oscilloscope may enter the wrong normalizing constant into its memory, so the numerical display will show incorrect times for the data. Another is that unless you had been careful to depress the HOLD LAST pushbutton another sweep might occur, and all of the signal information obtained during the night will be erased by this possible spurious sweep.

Practice ending rather long sweeps prematurely the correct way to ensure that the procedure, as you follow it, produces the desired effect.

As a precaution, switch the trigger selector to EXT, and remove all inputs to the External Trigger BNC connector, when using very long sweeps. This is simply to assure that in the event you do forget to depress the HOLD LAST pushbutton after the sweep begins, another sweep will not begin when the first one ends. Start very long sweeps by using the MANUAL Trigger pushbutton, only, as a precaution.

4. After taking all of the above precautions, erase the "junk" contents of the memory, just so you can more easily see the signal of interest as it "unfolds" on the screen. Then start the sweep in the usual manner by touching the "Live" pushbutton, the MANUAL trigger pushbutton, then the HOLD LAST pushbutton.

If you have done all of these things, you should be able to leave. It is reassuring, however, to take a look, using high display magnification, at the first data points. Every 20 seconds, if that's the sweep time in use, a new point should be plotted. Seeing these tells you that a sweep has really started, that you have in fact selected the desired sweep speed, and that some sort of signal is present of reasonable appearance. Take a last look at the HOLD LAST pushbutton red light, to be sure it is "on", and leave.

NOTE: It is a characteristic of this instrument that numeric normalizing information is not transferred to the main frame microprocessor until late during a sweep, in "Live" operation. This is of no practical consequence except during the use of very low sweep speeds. During those sweeps the numerics will initially be normalized incorrectly;

if the TIMER PER POINT or voltage range switches have been changed since the previous sweep, the numerics will be in error by an indefinite amount, until the sweep has progressed to at least memory address.

This is an inconvenience only rarely. If it is of importance to have meaningful numbers during the long sweep, however, a helpful procedure is to set the controls first, as desired for the long sweep. Then switch to a sweep speed 1000 times faster and trigger one sweep. Then return to the required slow sweep speed, and when ready, start the sweep. The numerics will be correct, except the alphabetical time multiplier (ms, s) will be indicated as 1000 times less than it should, an easy thing to keep in mind, and hardly likely to be misinterpreted. Later in the sweep, the correct normalizing will be transferred, so the alphabetical character will be correct.

If this procedure is not followed, none of the numerical or alphabetical information will be predictable, for either voltage or time, during as much as five eights of the long sweep.

D. Capturing Single Events

When the HOLD NEXT pushbutton is depressed, following your pressing of the LIVE pushbutton, one sweep, only, will occur. A single signal can be captured in this way.

If the single signal you wish to capture is of special interest or value, some advance precautions should be taken, to avoid a mistake. It is, of course, entirely a function of how rare or valuable the signal information is, that determines how much care you use. If the information is both rare and valuable, you should:

1. Confirm the safety margins in the trigger sensitivity setting by advance practice runs.

2. Confirm proper amplifier, sweep speed selections, and other oscilloscope and external apparatus adjustments by practice runs.

3. Never fail to depress the HOLD NEXT pushbutton after switching to LIVE operation for the final measurement.

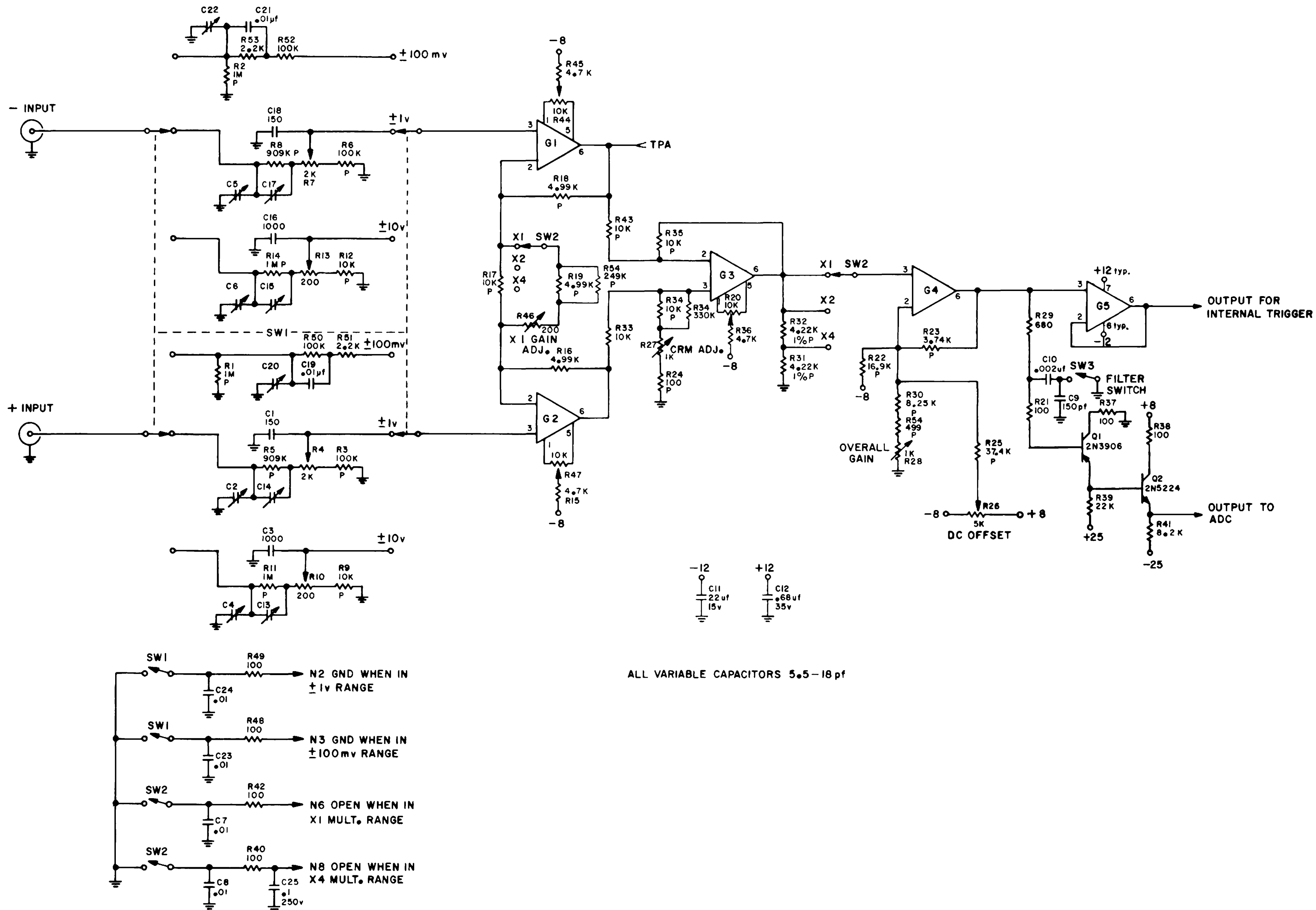
4. Do not use the RETAIN REFERENCE mode when capturing valuable information, because the data points will be lost in that mode, simply because half the memory is utilized to hold previous signal information.

E. The Type D-2 Amplifier Overload Characteristics

The drawing of Figure 8 shows the input circuit schematic of the Type D-2 Amplifier. The type CA3140 operational amplifier has a high input impedance, with a bias current of 10^{-10} amperes typically. Under over-voltage conditions, the input circuits of that device saturate and much greater currents are involved. Saturation occurs at a voltage of approximately 8 volts if the overvoltage is applied to one signal terminal, only.

For this reason, a protective resistor of 10^5 ohms, paralleled by a 0.01 nf capacitor, and another series resistor of 2200 ohms have been included to limit the current during overload. Those protective resistors allow DC overload voltage of ±100 volts to be applied without damage, even when the sensitivity range selected is ±100 mv. Voltages of greater than ±150 volts DC are likely to cause damage to the input circuits if applied for more than a few seconds, when the most sensitive ranges are in use.

For the ±1 volts and ±10 volt ranges damage is possible if voltages much in excess of ±200 volts are applied.



NICOLET INSTRUMENT CORP
D2 AMPLIFIER
000-9010-04 LEK 9-26-78

F. <u>The Type D-3 Amplifier</u>

The D-3 differential amplifiers allow the oscilloscope to display the differences between the voltage values applied to the (+) and (-) input BNCs.

The amplifiers can also be used as single-ended amplifiers when the unused input BNC is grounded.

WARNING: Ground all unused D-3 differential amplifier inputs. An unused, ungrounded amplifier input may cause erroneous measurements during single-ended amplifier applications because the input may "float" at some unknown voltage value instead of remaining at ground potential.

Place the SIG/GND switch, adjacent to the (-) input BNC, to the GND position if input signals are being applied to the (+) input BNC during single-ended amplifier measurements. Place a grounding cap over the (+) input BNC if input signals are being applied to the (-) input BNC during single-ended amplifier measurements.

VI. THE MAGNETIC DISK MEMORY

A. General

The magnetic disk has a storage capacity of 32 kilobytes, each byte having 13 bits. Twelve of these are used for numerical information, and the 13th is used for recording of code words indicating the settings of the oscilloscope controls that existed when each measurement was made.

The disks are removable, by opening the door at the front panel. They must be inserted right-side-up, with the small rectangular notch at the top. This notch may be covered with tape, supplied with the disks. When covered, previously recorded data are protected from being written over unintentionally, which makes it safer to use them as reference signals or for repeated study. When protected, the indicator led labelled DISK PROTECTED is energized. An alternative method of protecting is by use of the eight front panel TRACK PROTECT switches. (These do not energize the DISK PROTECTED lamp.)

The Disk is divided into 8 "tracks", each of these having a capacity of 4096 data points. To confirm with the main frame memory, which can be divided into quarters and halves, each track can also be divided into segments of 1024 storage locations each. For convenience these are named Q1, Q2, Q3, Q4 as are the main frame memory groups. These are referred to as H1 and H2. For engineering reasons, Q1 and Q3 comprise H1, and Q2 and Q4 comprise H2.

B. Track Addressing

The front panel TRACK SELECT switch may be used to step to the track location to be used next. The 8 indicator lamps show which track will be used for the next storage or recall operation. At the end of each such operation (with one exception, to be discussed in the next section) the disk controller increments the track selector. As you may have noticed, when incrementing beyond track 8, track 1 is selected next. When storing a "waveform", and a track has been protected by the TRACK PROTECT switch corresponding to that track, the selector circuits skip the protected track.

C. Segment Addressing Principles

In most store operations the entire main frame memory content is recorded, and an entire track therefore is utilized. Segments are automatically addressed, and in recall, later, the data are placed in memory just as they were recorded. Segment addressing is then of no concern to the operator.

There are circumstances in which this is not the case. For example, a disk may contain a number of waveforms* of 1024 points each, and it may be desired to retrieve one wave-from only, and to place it into a particular quarter of the main frame memory. Another example is the case in which it is desired to place into the disk memory just one 1024 or

*Obviously the disk contains no "waveforms", but rather sets of digital information representing waveforms. For the sake of brevity the word waveform alone will be used in reference to information pertaining to an individual waveform.

2048 point waveform, the remainder of the main frame memory containing information of no interest. A particular section of the main frame memory must be selected, and a particular segment, or segments, of the disk may be selected, as will be described later.

(It is usually desirable to keep a log of what waveform has been placed in the memory, and its location. Sometimes that is unnecessary, if storage is to be needed for only a short time, because some waveforms are identifiable on sight, and no log is then needed.)

The disks have a large amount of storage space, and they are not expensive. It may be elected to never store more than one set of information on one track (a single waveform or a set of related waveforms), leaving in some cases part of the track blank. The waste of storage space is sometimes preferable to making the segment addressing and logging complicated by using every available segment on every track.

If that technique is used, it is preferable to avoid recording "junk" on the disk. If the main frame contains one interesting waveform, and the rest is "junk", erase the useless information and then record the entire memory content onto the selected track. This guarantees that "junk" on the disk will be replaced by the zeros in the erased portions of the main frame memory and by the interesting waveform. Leaving old information of no future interest on the disk can cause future confusion.

D. <u>The Mechanics of Segment Addressing</u>

1. "Normal" Operation

When the TRACK SEGMENT switch on the disk control panel is in the counterclockwise position, the disk addressing is controlled by the main frame MEMORY selector switch. The selected main frame waveform will be placed in the corresponding segment or segments of the track in use during a recording operation.

If only part of the main frame memory is to be recorded (for example, Q1 and Q3), the remainder of the track segments (Q2 and Q4) will be undisturbed on the disk.

Similarly, in a recall operation, if the Main Frame switch is in the H1 position (Q1 and Q3 are in H1), and the TRACK SEGMENT switch is in the counterclockwise position, Q1 and Q3 will be read from the disk and the remainder of the main frame memory will be undisturbed.

2. Separate Selection of Main Frame Group and Track Segments

Placing the TRACK SEGMENT Selector switch in the Q1, Q3, H1, H2, Q2 and Q4 position assures that the next recall or recording will involve only the segment or segments corresponding to that switch position. The main frame MEMORY selector has no control, then, upon which disk segment(s) will be involved; it controls where it will be placed or read from the main frame memory, only.

Always use equal-sized groups for the main frame and the disk. Don't use the H1 position for the main frame, and Q3 for the disk, for example.

3. Automatic Sequencing of Segments

The AUTOCYCLE setting of the TRACK SEGMENT switch causes both segment and track selection during recording to be automatically sequential. Starting at track 1, the addressing occurs segment by segment and track by track, until the disk is full. The "size" of the recordings (1024, 2048 or 4096 points) is determined by the main frame MEMORY switch. If the size is 1024 points, the segments are addressed in sequence, so a total of 32 waveforms will be recorded.

If the AUTOCYCLE switch position is used during recall operations, the main frame switch governs what will be seen. If in the Q3 position, for example, only segment Q3 of each track will be recalled, just as for the counterclockwise setting of that switch. It is usually preferable, when viewing information that has been automatically sequenced, to use the "ALL" position of the main frame Memory switch, so that all of the waveforms will be seen.

In the AUTOCYCLE recording mode, signal waveforms will be recorded one after another, until the disk is "full". The disk control circuits cause the main frame to switch between "Live" and "Hold", with the "Hold" mode continued long enough to record the waveform on the disk, and each "Live" mode lasting until a sweep trigger has occurred and the signal received. When the disk is full the process ends.

A special sequence is necessary to start a recording in the autocycle recording mode. It is preferable to select track 1, initially. Then switch the main frame to the "Live" mode. When ready to begin, press the HOLD NEXT pushbutton on the plug-in unit. The process then starts.

Usually, prior to actually starting the autocycle sequence, you will be "setting up" the oscilloscope to confirm proper triggering, sweep speed, etc. The oscilloscope is in the "Live" mode during this. By chance, a signal that is very interesting may occur. To save it, quickly depress the HOLD LAST pushbutton. This temporarily protects it. To record this "waveform" and also start the autocycle mode, depress the HOLD NEXT button, after the plug-in went into "Hold". To record this "waveform" and not start autocycle, manually store the waveform. You may now continue from where you left off.

The autocycle mode is useful for obtaining waveform records in rapid sequence, for such situations as during rather rapid changes in conditions within the signal source. It is also useful for obtaining a number of signals in circumstances in which they occur quite infrequently, for example once an hour. You need not be present during the several hours it takes to obtain several signals.

The recordings require no more than two seconds, most of which time involves the start-up time for the disk drive motor. The motor does not stop at once, after each recording, but is allowed to run for several seconds. In the case in which small (1024 point) recordings are involved, the recording time is ½ second and no motor start-up time is involved if the signals occur in rapid sequence. As many as 32 records may then be obtained in a 17 second period. (The first recording involves a one second start-up delay.)

4. The LONG SWEEP Mode (Normal Trigger Only)

If the oscilloscope includes an I/O option (2090-3C), it is possible in the case of low measurement sweep speeds to store possible in the case of low measurement sweep speeds to disk, and to obtain as many as 32,768 data points for the signal, rather than the usual 4096 maximum. The segment and track addressing for the disk proceeds segment by segment until the disk is "full". In this mode, sweep speeds must be 500 μsec/point or slower for single channel or 1 msec/point or slower for 2 channels. The "waveform" can, of course, only be recalled in 4096 point increments at a time for viewing.

LONG SWEEP is selected by setting the TRACK SEGMENT switch to LONG SWEEP, the main frame MEMORY switch to ALL and the plug-in speed is set as desired. The LONG SWEEP is started by pressing STORE on the RECALL-STORE switch. The plug-in may be in "Live" or "Hold". The plug-in speed must be set correctly or inaccurate information will be placed on the disk. If the main frame switch is not in ALL, LONG SWEEP will not function. NOTE: LONG SWEEP will not operate with the 204 plug-in.

When the STORE lever is pushed, the plug-in must receive a trigger within 5 seconds if the plug-in is set for 500 μsec (single channel) or 1 msec (2 channel). The trigger can be received at any time if any other slower speed is selected.

If it is desired that a LONG SWEEP be shorter than a 32,768 point "waveform", a track other than 1 should be selected. Tracks after the starting track should not be "write protected".

When the "waveform" is recalled, the main frame MEMORY switch must be placed in ALL, as when storing.

There are two major events that happen when the "waveform" is recalled from the disk. They are described as follows:

a. A shifted "waveform" can be displayed by holding the RECALL switch. A shifted "waveform" contains part of one tracks "waveform" and part of the next tracks waveform. If the recall started at track one, the first recall would display all 4096 points of that track. If the RECALL switch is held, one second after finishing the transfer of track one, the disk will transfer the last 3 segments of track one (3072 points) and the first segment of track 2 (1024 points). If the RECALL switch is still held, one second later, the disk will transfer the last 2 segments (2048 points) of track one and the first 2 segments (2048 points) of track two. This process will continue until the RECALL switch is released which upon completion of the transfer will cause the illuminated track "led" to advance to the next track. This whole procedure allows recalling of 4096 points of the "waveform", 1024 points further along in time, in order that portions of 2 tracks can be viewed as a continuous "waveform". The only exception is when track 8 is reached. Upon completion of recalling all of track 8, the disk will advance to track 1 in its entirety.

b. A non-shifted "waveform" can be recalled by pressing the RECALL switch and then releasing it. On completion of the transfer, the disk will advance to the next track. This mode can be selected, in the above described shifted mode, by releasing the RECALL switch any time after a transfer of a "waveform" has started, or during the one second wait period.

If the oscilloscope does not have the I/O option, but does have the disk (2090-3B), a LONG SWEEP can be recalled that was recorded on another oscilloscope having the I/O option (2090-3C). A LONG SWEEP cannot be recorded on an oscilloscope not having the I/O option. (Recalling of LONG SWEEP "waveforms" can only be done on 2090-3B oscilloscopes shipped on or after January 6, 1978. If this feature is required, consult the factory or your local representative.

E. Initiating Recordings

Ordinarily, single recordings are made by momentarily moving the RECALL STORE switch to the STORE position. If you wish, you may cause a recording to be made each time you press one of the plug-in units HOLD pushbuttons, by placing the right hand switch in the SEMIAUTOMATIC position. When the plug-in unit exits from the "Live" mode to the "Hold" mode, a recording on disk is made.

This, in some cases, is a convenience since it means that the STORE switch need not be actuated. Another use is in the case in which remote control of the plug-in unit is in use, since no operator action is needed in order to obtain several waveform recordings on the disk.

Unlike the autocycle mode of recording, the process does not end when the disk is "full", (when track 8 has been reached) the disk's track is addressed next, and the tracks are incremented in sequence again. The tracks are incremented after each recording, even if the records are only 1024 points long.

F. The Indicator Lights

1. The STORE-RECALL Led

This indicates that a store, or a recall, command has been received. It ordinarily extinguishes within 2 seconds, when the recording or recall operation has been completed. If it does not, this is an indication of a malfunction of some kind:

a. There may be no disk in the recorder.

b. The plug-in unit is in the "Live" mode.

2. I/O ACTIVE Led

This indicates that the I/O circuits of the oscilloscope are busy, and that the disk cannot be manually operated.

3. DATA ERROR Led

The disk control circuits include bit count circuits, and other circuits for sensing data errors. When an error is sensed the indicator lamp is energized. Not all data errors are detectable. Valuable data, when recorded, should be tested after recording, for visual examination, when practical. Data errors are very rare. If one occurs, it may be advisable to replace the disk.

4. DISK PROTECTED LED

When a disk has been protected by covering the rectangular slot with tape this indicator is energized. It is not energized when the track protection switches are "on".

5. Unlabelled Indicator Led

An indicator on the disk drive is energized when it is in the process of storing or recalling.

VII. EXPLORER III DIGITAL I/O

A. General

The EXPLORER III Digital I/O contains all the logic needed to transfer the display memory of the EXPLORER to an external device or to receive data from the external device and place it into the EXPLORER display memory. Operation of the EXPLORER Floppy Disk system and EXPLORER plug-ins can be accomplished from an external device through the Digital I/O.

Data format is in a 12 bit, two's complement, binary form, with a 13th bit for data normalization. Full handshaking capabilities are included with various inputs and outputs being used for Floppy Disk and plug-in operation.

An explanation of all signals follows. All definitions are written in positive logic, i.e.; 1=True, 0=False. Signals on the actual I/O pins are in negative logic, i.e.,; a logic 1=0 V (Ground) =True, a logic 0=5 V = False. Conversion from negative to positive logic may be required. Consult the manual on your external device.

B. I/O Control Signals

1. I/O ACTIVE (27B) (To EXPLORER)

When this signal is true, it indicates that the EXPLORER III is being controlled by an external device. Manual and external operation of the Floppy Disk Recall and Store is blocked. Manual and external track selection on the Floppy Disk can still be accomplished. When I/O Active is false, it allows manual and external control of the Floppy Disk Recall and Store.

2. DISABLE DATA OUT (28B) (To EXPLORER)

When true it disables data and normalizing output information. Disabling the data out allows wire-oring of the data out lines with other data out lines or connecting data out and data in to a bidirectional data bus.

3. DISK/PL (21B) (To EXPLORER)

a. Disk Mode, DISK/PL=1

When true, it allows operation and monitoring of the Floppy Disk as follows: (Also reference Disk Memory section).

1. RECALL:HOLD LAST (18B) (To EXPLORER)

A true pulse on this pin places the Floppy Disk into the RECALL mode.

2. STORE:HOLD NEXT (20B) (To EXPLORER)

A true pulse on this pin places the Floppy Disk into the STORE mode.

3. ATRK:RELSW (19B) (To EXPLORER)

A true pulse on this pin will advance the Floppy Disk track by one.

4. $T^2:G^2$; $T^1:G^1$; $T^0:G^0$ (20A,19A,18A) (From EXPLORER)

A binary output to indicate which track the Floppy Disk is currently on. Track one is equal to a binary count of 0 and track 8 is equal to a binary count of 7.

NOTE: The minimum pulse width on pins 18B, 19B, 20B (RCL, ATRK, STO) is 600 µs. A pulse of shorter duration may be missed by the Floppy Disk control circuits. After pulsing ATRK, a wait of 8 ms is required before checking the 'T's".

b. Plug-in --- Main Fame Mode, DISK/PL=0

When false, it allows operation of the plug-in and monitoring of the main frame MEMORY switch.

1. RECALL:HOLD LAST (18B) (To EXPLORER)

A true pulse on this pin places the plug-in in HOLD LAST.

2. STORE:HOLD NEXT (20B) (To EXPLORER)

A true pulse on this pin places the plug-in in HOLD NEXT.

3. ATRK:RELSW (19B) (To EXPLORER)

A true pulse on this pin places the plug-in in LIVE.

4. T^2:G^2; T^1:G^1; T^0:G^0 (20A,19A,18A) (From EXPLORER)

An output to indicate the position of the main frame MEMORY switch. The following is a table of the G outputs:

	G^2	G^1	G^0
Q1	0	0	0
Q2	0	0	1
Q3	0	1	0
Q4	0	1	1
H1	1	0	0
H2	1	0	1
ALL	1	1	0

NOTE: The minimum pulse width on pins 18B, 19B, 20B (HOLD LAST, RELSW, HOLD NEXT) is 1 μs. If the Floppy Disk selector is in the AUTO-CYCLE position, the minimum pulse width on pin 20B (HOLD NEXT) is 600 μs.

4. I/O STEP (22B) (To EXPLORER)

A true pulse on this pin initiates a data transfer, with one I/O STEP pulse being needed for each data word to be transferred and the false to true edge of the pulse starting data transfer. (Also consult Timing Diagram.)

a. Writing Data to EXPLORER III

The data word being sent to the EXPLORER III should be ready 500 ns before I/O STEP and should be held until the I/O FLAG goes READY. (See I/O FLAG.) The D-W/R line must be true.

b. Reading Data From the EXPLORER III.

Data will be ready on the output lines when I/O FLAG goes READY. An I/O STEP pulse must be given in order to receive a data word. The D-W/R line must be false.

5. I/O RCS (17B) (To EXPLORER)

Nicolet use only. Wire pin to +5V.

6. DISK ERROR (21A) (From EXPLORER)

When true, it indicates a disk system error. This signal should be monitored after every external disk RECALL. Consult Disk Memory Section for further details.

7. I/O FLAG (22A) (From EXPLORER)

Used to indicate the status of an I/O operation. When true it indicates that the EXPLORER III is BUSY with an I/O operation. When false it indicates that the EXPLORER III is READY to receive another word of data, or a word of data was placed on the data output bus when I/O FLAG went READY from BUSY.

8. DISK ACTIVE (23A) (From EXPLORER)

When true, it indicates that the Floppy Disk system is doing a RECALL or STORE operation.

9. LIVE (24A) (From EXPLORER)

When true, it indicates that the plug-in is in the LIVE mode. Consult the section for plug-in operation. When false, it indicates that the plug-in is in a hold condition.

Before any I/O operation is started the following signals should be checked:

I/O FLAG - False

DISK ACTIVE - False

LIVE - False

The minimum signals required for data transfer are I/O STEP, I/O FLAG, D-W/R and AC1. Consult various sections and Timing Diagram for operation.

C. DATA, ADDRESS & NORMALIZING FORMAT

1. Data

The data points are 2's complement binary representations of voltage magnitudes shown on the oscilloscope screen. There are 12 output data lines and 12 input data lines. At the I/O connector both of these are negative true logic. (0v = logic 1; 5v = logic 0).

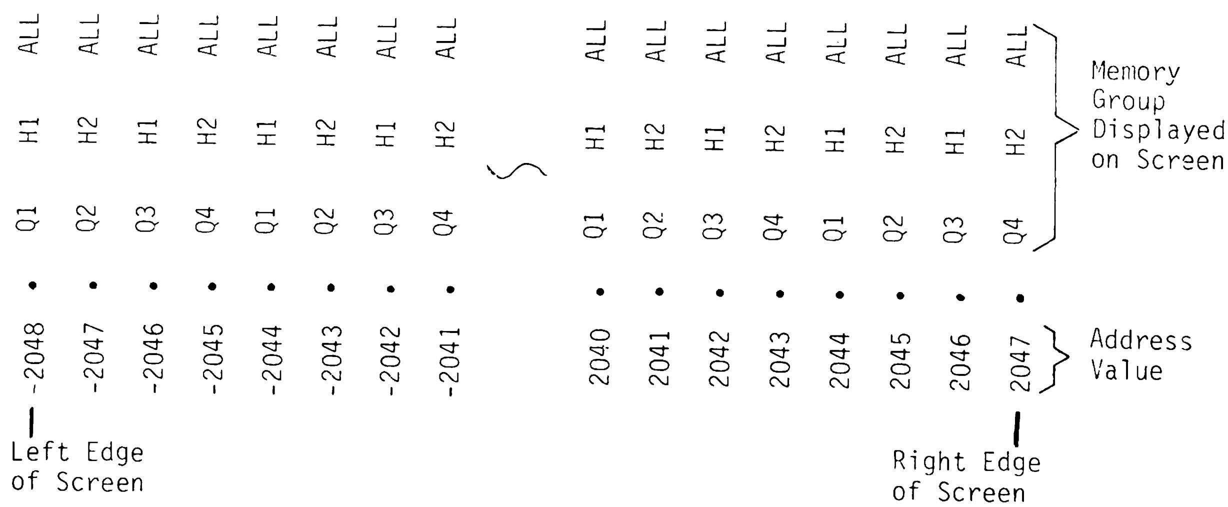
The voltage range, in binary form, is from -2048 to +2047, which is bottom screen to top screen, respectively.

2. Address

The address of the data point is proportional to the time at which the data point was measured. If the load address mode is used, the 12 input data lines are used to transfer the address to the address counter. The address is in the form of 2's compliment. "ALL" of memory has an address range of -2048 to +2047, which is left screen to right screen, respectively. At the I/O connector, it is negative true logic.

Throughout this section the address bits and words will be described using the term XAn, where n is equal to the binary bit, i.e., XAØ = LSB and XA11 = MSB. When n is missing, the binary value for XA will be listed with XA.

OSCILLOSCOPE SCREEN WITH ADDRESS VALUES SHOWN



The memory address counter is designed so only the displayed memory group can be accessed for data transfer. If a non-displayed memory group is addressed, the counterpart in the displayed group will be transferred. For example, if H1 is addressed and H2 is displayed, the data points of H2 will be transferred or if Q1 is addressed and H2 is displayed, the data points of Q2 will be transferred.

3. Normalization

The numerical information displayed on the oscilloscope screen is decoded from normalizing constants which are stored as part of the display memory. The normalizing constants are stored serially as a 13th bit that rides along with the 12-bit data words.

The normalizing bit is addressed in the same manner as the data words. The only difference is that complete normalizing information is contained in the addresses starting at 0 and ending at 1023. The addresses from 0 to 511 contain the original plug-in normalization and the addresses from 512 to 1023 contain the "NUMBERS RESET" normalization. (Numbers reset is a feature on the EXPLORER that allows a new time zero and/or voltage zero value to be selected by the operator.) The bit format for both the original and numbers reset are identical. The values for the normalizing words are identical until numbers reset is activated.

The basic normalizing format consists of four 16-bit words. The first word is the time value information which will be called "HORZ-NORM". HORZ-NORM contains three types of information about the time axis:

a. Time per point switch setting.

b. Memory group location.

c. Whether or not the time units being displayed should be normalized.

The second word is the voltage value which will be referred to as "VERT-NORM". VERT-NORM contains two types of information:

a. Voltage per level value.

b. Whether or not the voltage units being displayed should be normalized. The voltage per level value and the voltage full scale switch setting are not the same thing but they are directly related. To find the voltage per level value just divide the voltage switch setting by 2000. Any units not being normalized will display a binary value only.

The third word called "HZERO" contains the address of the data point which is considered to be time equals zero. This address is in the lower 12-bits of the 16-bit word and the upper 4 bits are zero. When "NUMBERS RESET" is used, "HZERO" contains the address of the horizontal cursor (vertical marker line).

The fourth word called "VZERO" contains a binary value of zero. When "NUMBERS RESET" is used, "VZERO" contains the binary value of where the vertical cursor (horizontal marker line) is located.

This set of four 16-bit words is needed for each waveform stored in the EXPLORER display memory. This occurs when four, two channel measurements are made with the MEMORY switch set to a quarter for each measurement. Usually there are not eight waveforms in memory so the same pattern is duplicated and if a single waveform is stored in of memory the eight normalizing sets will be identical. HNORM, HZERO and VZERO can only have four different possible normalization values as both channels, in 2 channel, use the same time per point and numbers reset values.

If more than one waveform is in memory, the data points are alternated on the display screen. This is also true of the four normalizing word-sets.

Normalizing must be thought of as 64 16-bit words multiplexed in serialized form in memory as one bit, where 8 different Nx's are stored before Nx+1 is stored. This multiplex scheme has, for example, all 8 NØ's stored in one area of memory for a given word before the 8 N1's are stored in memory. This multiplexing scheme can be seen in TABLE 1.

Following are three tables which describe the normalizing constants. TABLE 1 shows the memory address location for each normalizing bit. TABLE 2 shows the normalizing value for HORZ-NORM & VERT-NORM in abreviated form. TABLE 3 shows HORZ-NORM & VERT-NORM as stored as a 16-bit normalizing word.

TABLE 1

NORMALIZING WORD ADDRESS BIT = XA

XA11 = XA10 = 0

XA9	
0	Plug-in Original
1	Numbers Reset

XA8	XA7	NORM. WORDS
0	0	HORZ NORM
0	1	VERT NORM
1	0	HZERO
1	1	VZERO

XA6	XA5	XA4	XA3	NORM BIT
0	0	0	0	N0 LSB
0	0	0	1	N1
0	0	1	0	N2
0	0	1	1	N3
0	1	0	0	N4
0	1	0	1	N5
0	1	1	0	N6
0	1	1	1	N7
1	0	0	0	N8
1	0	0	1	N9
1	0	1	0	N10
1	0	1	1	N11
1	1	0	0	N12
1	1	0	1	N13
1	1	1	0	N14
1	1	1	1	N15 MSB

XA2	XA1	XA0	MEMORY GROUP Where N's are Stored		
0	0	0	Q1-ChA	H1-ChA	ALL-ChA
0	0	1	Q2-ChA	H2-ChA	ALL-ChB
0	1	0	Q3-ChA	H1-ChB	ALL-ChA
0	1	1	Q4-ChA	H2-ChB	ALL-ChB
1	0	0	Q1-ChB	H1-ChA	ALL-ChA
1	0	1	Q2-ChB	H2-ChA	ALL-ChB
1	1	0	Q3-ChB	H1-ChB	ALL-ChA
1	1	1	Q4-ChB	H2-ChB	ALL-ChB

Note: that if a single channel measurement was made,

Ch-A and Ch-B, shown above, will contain the same information.

TABL[illegible]

NORMALIZING WEIGHT FACTOR FOR HORZ-NORM & VERT-NORM

N12 = N13 = N14 = N15 = 1 for not normalized

$4096 \div 2^n$ data points		Memory Group During Measurement
N11	N10	
0	0	ALL
0	1	H's
1	0	Q's
1	1	8th's

$x2^n$		$\div 2^n$		
N9	N8	N7	N6	MULT.
0	1	1	0	X0.5
0	1	0	1	X 1
0	1	0	0	X 2
0	0	1	0	X0.25
0	0	0	1	X .5
0	0	0	0	X 1

$X10^{-3n}$		$X10^n$		$\div 10^n$		
N5	N4	N3	N2	N1	N0	DECADE
1	1	1	0	0	0	100 nano
1	0	0	0	0	0	1 micro
1	0	0	1	0	0	10 micro
1	0	1	0	0	0	100 micro
0	1	0	0	0	0	1 milli
0	1	0	1	0	0	10 milli
0	1	1	0	0	0	100 milli
0	0	0	0	0	0	1
0	0	0	1	0	0	10
0	0	1	0	0	0	100

For HORZ-NORM the result of MULT X DECADE equals the time per point.

For VERT-NORM the result of MULT X DECADE equals the voltage per level.

For all plug-ins designed to date note that:

HNØ = HN1 = Ø; HN8 = 1
VNØ = VN5 = VN7 = VN9 = VN10 = VN11 = Ø
VN1 = VN4 = 1
N13 = N14 = N15 will follow (=) N12

0.25 mult. is not implemented in main frames shipped to date

TABLE 3

VOLTAGE

Range	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
10 mv	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0
20 mv	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
40 mv	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0
100 mv	0	0	0	0	0	0	0	0	0	1	0	1	0	1	1	0
200 mv	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0
400 mv	0	0	0	0	0	0	0	1	0	0	0	1	0	1	1	0
1 v	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0
2 v	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0
4 v	0	0	0	0	0	0	0	1	0	0	0	1	1	0	1	0
10 v	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	0
20 v	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0
40 v	0	0	0	0	0	0	0	1	0	0	0	1	1	1	1	0
							X 2^n		÷ 2^n		X 10^{-3n}		X 10^n		÷ 10^n	
	$\overline{\text{NORM}}$				MG		MULT				DECADE					

Norm bit: 15

TIME

Range	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
50 ns	0	0	0	0	χ	χ	0	1	1	0	1	1	1	0	0	0
100 ns	0	0	0	0			0	1	0	1	1	1	1	0	0	0
200 ns	0	0	0	0			0	1	0	0	1	1	1	0	0	0
500 ns	0	0	0	0			0	1	1	0	1	0	0	0	0	0
1 µs	0	0	0	0			0	1	0	1	1	0	0	0	0	0
2 µs	0	0	0	0			0	1	0	0	1	0	0	0	0	0
5 µs	0	0	0	0			0	1	1	0	1	0	0	1	0	0
10 µs	0	0	0	0			0	1	0	1	1	0	0	1	0	0
20 µs	0	0	0	0			0	1	0	0	1	0	0	1	0	0
50 µs	0	0	0	0			0	1	1	0	1	0	1	0	0	0
100 µs	0	0	0	0			0	1	0	1	1	0	1	0	0	0
200 µs	0	0	0	0			0	1	0	0	1	0	1	0	0	0
500 µs	0	0	0	0			0	1	1	0	0	1	0	0	0	0
1 ms	0	0	0	0			0	1	0	1	0	1	0	0	0	0
2 ms	0	0	0	0			0	1	0	0	0	1	0	0	0	0
5 ms	0	0	0	0			0	1	1	0	0	1	0	1	0	0
10 ms	0	0	0	0			0	1	0	1	0	1	0	1	0	0
20 ms	0	0	0	0			0	1	0	0	0	1	0	1	0	0
50 ms	0	0	0	0			0	1	1	0	0	1	1	0	0	0
100 ms	0	0	0	0			0	1	0	1	0	1	1	0	0	0
200 ms	0	0	0	0			0	1	0	0	0	1	1	0	0	0
500 ms	0	0	0	0			0	1	1	0	0	0	0	0	0	0
1 sec	0	0	0	0			0	1	0	1	0	0	0	0	0	0
2 sec	0	0	0	0			0	1	0	0	0	0	0	0	0	0
5 sec	0	0	0	0			0	1	1	0	0	0	0	1	0	0
10 sec	0	0	0	0			0	1	0	1	0	0	0	1	0	0
20 sec	0	0	0	0			0	1	0	0	0	0	0	1	0	0
50 sec	0	0	0	0			0	1	1	0	0	0	1	0	0	0
100 sec	0	0	0	0			0	1	0	1	0	0	1	0	0	0
200 sec	0	0	0	0	↓	↓	0	1	0	0	0	0	1	0	0	0
							X 2^n		÷ 2^n		X 10^{-3n}		X 10^n		÷ 10^n	
	$\overline{\text{NORM}}$				MG		MULT				DECADE					

Norm bit: 15

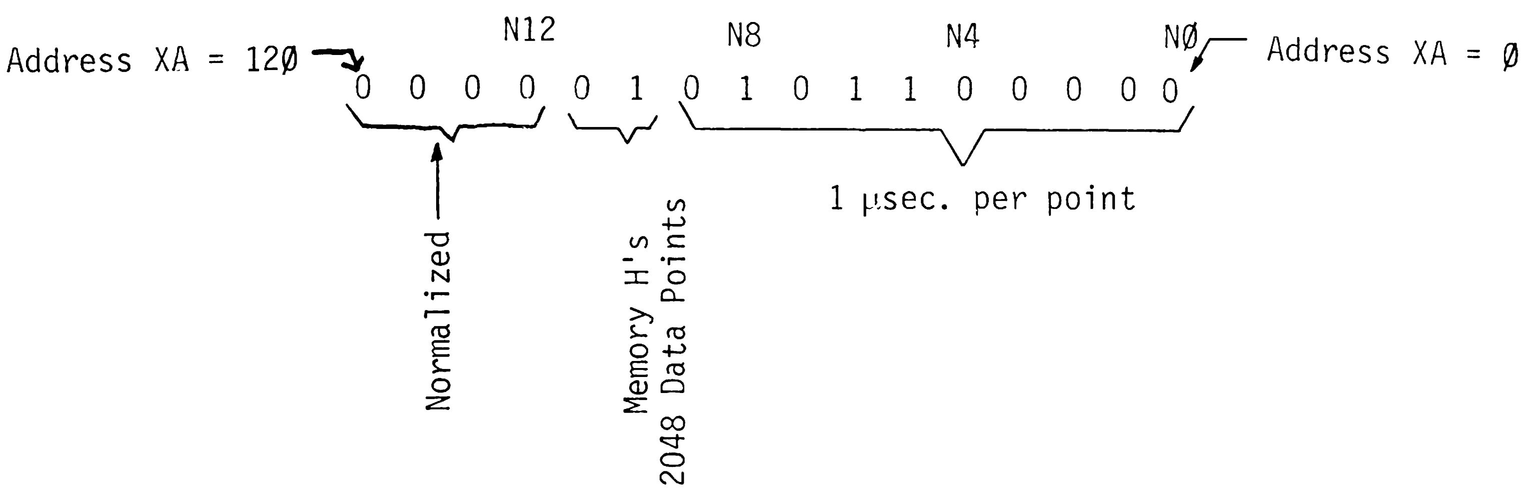
Normalizing Example:

A measurement was made in H1 and it was done with only one channel on. The plug-in switch settings are 1 µsec per point, 1V, and normal trigger. The first bit, NØ, of HORZ-NORM is located at address, XA = Ø. This first bit. NØ, is also duplicated at address 2, 4 and 6.

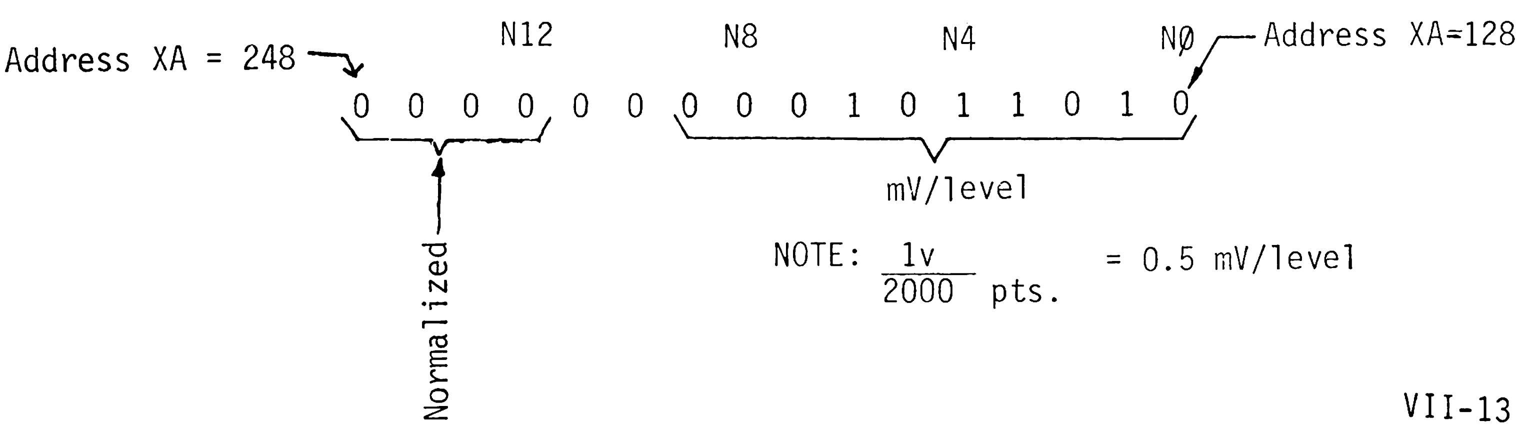
The first bit, NØ, for VERT-NORM is located at address 128, 130, 132 and 134. The addresses listed below are for the original plug-in values, if the numbers reset is to be addressed just add 512 to these addresses.

The next normalization bit in each word will be XA + 8 higher than the previous bit.

HORZ-NORM



VERT-NORM



HZERO

Address XA = 376 → N12 N8 N4 NØ ← Address XA=256

0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0

-2048 address is time zero
for normal trigger

VZERO

Address XA = 5Ø4 → N12 N8 N4 NØ ← Address XA=384

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

The plug-in sets zero
voltage to be at the center
of the screen.

The normalizing information can be transferred simultaneously with the data points or it can be transferred separately.

A minimum of 16, 16-bit words, or registers, will be required to store all possible combinations of normalization constants for the original plug-in normalization. They break down as follows:

8 - VNORM	4 - HZERO
4 - HNORM	Ø - VZERO (always equal to Ø)

A minimum of 20 more words, or registers will be required for the NUMBERS RESET normalization, if used. The extra 4 words are for VZERO, which can be other than zero. A maximum of 64 words, 32 for each section of plug-in normlaization, will be needed if each of the normalization words are stored by the user's equipment.

5. Memory Read or Memory Write Selectors for Data and Normalizing Transfer

D-W/R	N-W/R	Data	Normalizing
0	0	Read	Read
1	0	Write	No Operation
0	1	No Operation	Write
1	1	Write	Write

These Read-Write selectors allow the Data and Normalizing information to be transferred independently.

When a memory address is loaded into the address counter it is not necessary to change the Read-Write selectors. This means the Read-Write selector states are only applicable during a data or normalizing transfer operation.

Memory Addressing Modes: (Controlled by AC1 and AC2)

AC2	AC1		
0	0	Load Address	Immediately after this mode is entered the address counter is cleared and the load address state is set. Clearing the address counter operation is used in conjunction with the Advance Address modes. When the load state is set, the first information that is transferred to the I/O interface is the memory address. A data point can then be transferred in or out of the memory location that was addressed. The alternating address and data process repeats as long as the load address mode is selected.

When a new I/O transfer sequence is initiated in the load address mode, the load address mode should be entered from another mode (usually advance address by one). This will insure that the first information transferred is interpreted by the I/O interface as an address and not data.

AC2	AC1		
0	1	Advance Address by One	This mode automatically advances to the next memory address after a data point is transferred. The starting address can be set in one of two ways. The load address mode is entered from some other mode. This does two things; it sets the load address state and resets the address counter to the left edge of the oscilloscope screen. If the mode is now changed to Advance Address by one the first data point transferred will be on the left edge of the screen. If an address is entered before the mode is changed to Advance Address by One the first data point transferred will be located at the address which was loaded in.

AC2	AC1		
1	0	Advance Address by Quarters	This mode is similar to the Advance Address by One mode. The only difference is that it automatically advances by Quarters count instead of by one. Quarters Count: All, advances by four. H's advances by two. Q's advances by one.
AC2 1	AC1 1	Hold Address	This mode is used to hold the address counter at a particular location. When this mode is entered no address can be loaded and no automatic address advance will take place. Data transfers will occur at the same address location until a different mode is selected.

D. TRANSFER HANDSHAKE OPERATION

Two I/O signals are allocated for Address, Data and Normalizing transfer operations. An input signal labeled I/O-STEP is used to pulse the I/O circuits to initiate an I/O transfer. This transfer operation may be an Address input, a Data input or output, and/or a Normalizing input or output. The output signal labeled I/O-FLAG can be used as a status line to inform the user's external device that the EXPLORER III is ready for a data transfer. (Ready=0, Busy=1). The I/O-FLAG goes to busy immediately after the I/O-STEP lines goes from 0 to 1, unless the DISK ACTIVE signal is true. When an address is transferred into EXPLORER III, I/O-FLAG will stay busy for 1.25 μs. When data or normalizing is transferred, I/O-FLAG will stay busy for 2 μs if the plug-in is in a hold condition. If the plug-in is LIVE, I/O-FLAG will go busy and stay busy until the plug-in goes to hold and the I/O transfer can go to completion. The plug-in delays the I/O transfer because the plug-in and the I/O exchange data with the display memory on the same data bus.

It is unusual for the plug-in to be in LIVE and for an I/O transfer to be in progress because the plug-in will change the data stored in the display memory.

If the user knows the plug-in will not be activated during an I/O transfer, the I/O-FLAG line need not be monitored as long as the I/O-STEP pulses are a minimum of 3 μs apart. If the user wishes to monitor the I/O-FLAG line, a circuit should be implemented to sense the busy to ready (1 to 0) transition of the

I/O-FLAG. This transition will tell the user's sytem that the I/O transfer is complete.

Beware that if the user's system does not activate the I/O-ACTIVE line for the I/O transfer the disk could be manually operated and destroy the I/O data. If this sequence occurs the I/O-FLAG will go to ready even if the I/O transfer is not complete.

Write to 2090-III Display Memory (Load Address)

1. Set I/O ACTIVE.
2. Wait until disk is not active & plug-in is not Live.
3. Set Load Address mode on A.C. lines (pulse from another mode if in load).
4. Set N-$\frac{R}{W}$ and/or D-$\frac{R}{W}$ to write.
5. Ready input Address
6. Pulse - I/O STEP
7. Check I/O FLAG (1.25 μsec.) OPTIONAL
8. Ready input Data
9. Pulse - I/O STEP
10. Check I/O FLAG (2.0 μsec.) OPTIONAL

No — Last Data Point (No: return to step 5)

Yes

11. Disable I/O ACTIVE

Read From 2090-III Display Memory (Load Address)

1. Set I/O ACTIVE.

2. Wait until disk is not active and plug-in is not Live.

3. Set Load Address mode on A.C. lines (pulse from another mode if in load).

4. Set N-$\frac{R}{W}$ and D-$\frac{R}{W}$ to read.

5. Ready input address.

6. Pulse-I/O STEP

7. Check I/O FLAG (1.25 μsec.) OPTIONAL

8. Pulse - I/O STEP

9. Check I/O FLAG (2.0 μsec.) OPTIONAL

10. Output Data Available

Last Data Point — No → return to step 5; Yes ↓

11. Disable I/O ACTIVE

Write to 2090-III Memory (Advance After Each Data Point)

1. Set I/O ACTIVE

2. Wait until disk is not active and plug-in is not Live.

3. Set Advance Address mode on A.C. lines (go to load address to clear address counter).

4. Set N-$\frac{R}{W}$ and/or D-$\frac{R}{W}$ to write.

5. Ready input Data

6. Pulse - I/O STEP

7. Check I/O FLAG (2 μsec.) OPTIONAL

Last Data Point — No → return to step 5; Yes ↓

8. Disable I/O ACTIVE

Read From 2090 III Memoery (Advance After Each Data Point)

1. Set I/O ACTIVE.

2. Wait until disk is not active and plug-in is not Live.

3. Set Advance Address mode on A.C. lines (go to load address to clear address

4. Set N-$\frac{R}{W}$ and D-$\frac{R}{W}$ to read.

5. Pulse - I/O STEP

6. Check I/O FLAG (2 μsec.) OPTIONAL

7. Output data available.

Last Data Point — No → (return to step 5)

Yes ↓

8. Disable I/O ACTIVE

E. I/O - LINE DRIVERS & RECEIVERS

1. I/O Output Lines

These signals are driven by open-collector TTL gates, 7438, capable of sinking 48mA. The suggested line termination for each output signal is a 220Ω resistor to +5 and a 330Ω resistor to ground.

2. I/O Input Lines

These signals are terminated, on the Option 002 and 003 board, with a 220Ω resistor to +5V and a 330Ω resistor to ground. These signals are received with Schmitt Triggers for better noise immunity. These lines should be driven with a device having a minimum sink current of 21mA.

F. RECOMMENDED DRIVERS & RECEIVERS

For a users system that has a positive logic internal bus structure the 74LS240 can be used to drive and receive. The 74LS240 has the advantage of hysteresis inputs for increased noise immunity as a receiver and it has 3-state outputs for the user's system bus multiplexing. It also does the negative to positive logic inversion for the drivers and receivers.

For a users system that has a negative logic internal bus structure, the 74LS244 can be used with the same advantages as the 74LS240. Here the driver and receiver logic inversion is not needed.

DATA & NORMALIZING READ-WRITE CONTROL

(25B) N-W/R	(26B) D-W/R	Normalizing	Data
0	0	Read	Read
0	1	No Operation	Write
1	0	Write	No Operation
1	1	Write	Write

Read-Data and/or normalizing is taken from the 2090 display memory and latched onto the DO and/or NO signal lines.

Write-Data and/or normalizing is taken from the DI and/or NI signal lines and stored in the display memory.

ADDRESS MODE CONTROL

AC2(24B)	AC1(23B)	
0	0	Load Address
0	1	Advance Address + 1
1	0	Advance Address + Q
1	1	Hold Address

DISK & PLUG-IN CONTROL

DISK:PLUG-IN

DISK/PL=1 DISK/PL=0

EXPLORER III - I/O - SIGNAL LISTING

I/O CONNECTOR, OPTION 002 and OPTION 003

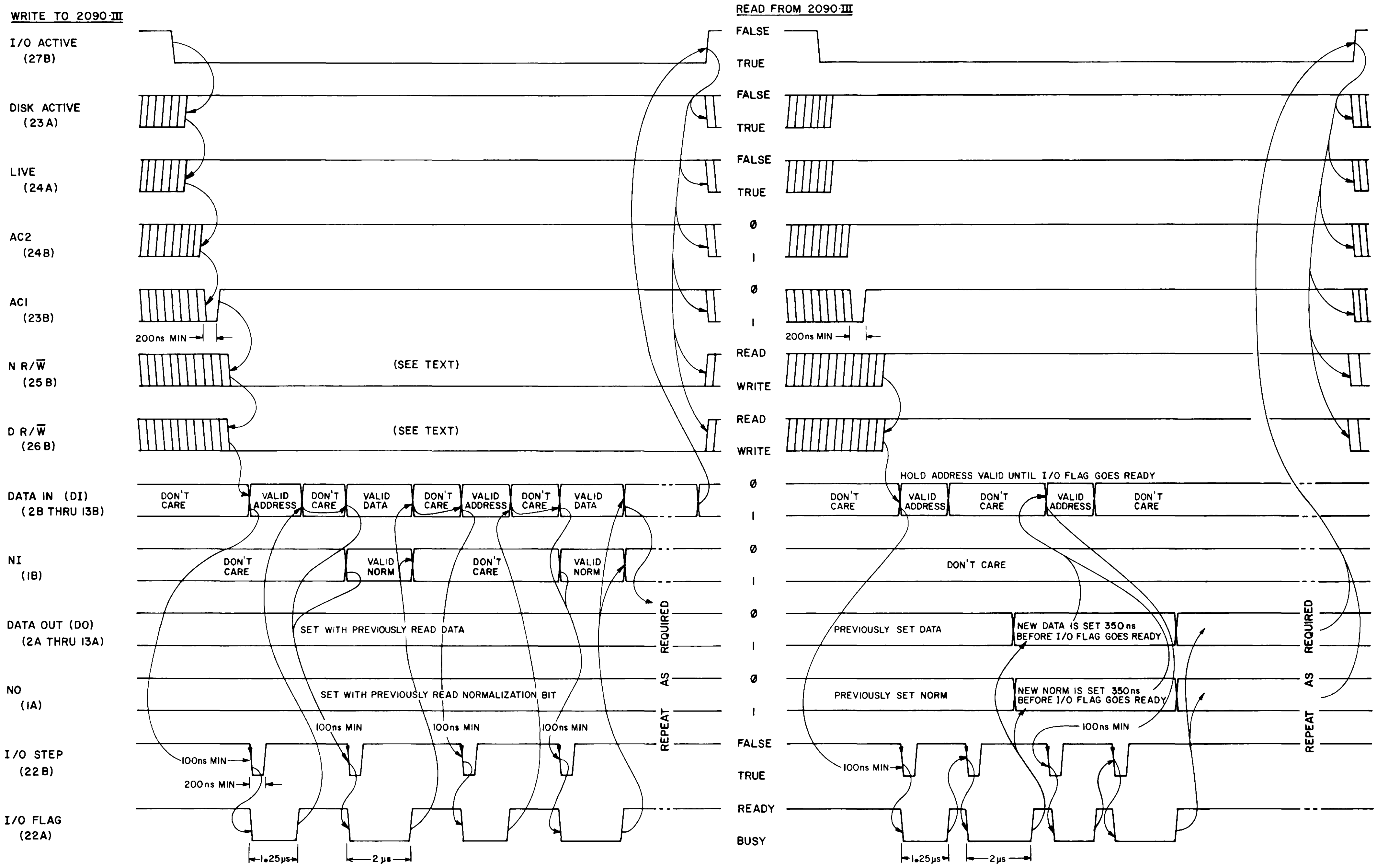
I/O-Board Connector Pin No.	OUTPUT SIGNAL	OPTION 003 LOWER CABLE Twisted Pair Wire Color	Cable Connector No.
1A	NO	1	1
2A	DO 0 (LSB)	2	3
3A	DO 1	3	5
4A	DO 2	4	7
5A	DO 3	5	9
6A	DO 4	6	11
7A	DO 5	7	13
8A	DO 6	8	15
9A	DO 7	9	17
10A	DO 8	0	19
11A	DO 9	1	21
12A	DO 10	2	23
13A	DO 11 (MSB)	3	25
14A	GND	-	
15A	GND	-	
16A	GND	-	
17A	NC	4	27
18A	T0:G0	5	29
19A	T1:G1	6	31
20A	T2:G2	7	33
21A	DISK ERROR	8	35
22A	I/O-FLAG (Busy=1)	9	37
23A	DISK ACTIVE	0	39
24A	LIVE	1	41
25A	NC	GND 2	43
26A	NC	GND 3	45
27A	NC	GND 4	47
28A	NC	GND 5	49

I/O-Board Connector Pin No.	INPUT SIGNAL	OPTION 003 UPPER CABLE Twisted Pair Wire Color	Cable Connector No.
1B	NI	1	1
2B	DI 0 (LSB)	2	3
3B	DI 1	3	5
4B	DI 2	4	7
5B	DI 3	5	9
6B	DI 4	6	11
7B	DI 5	7	13
8B	DI 6	8	15
9B	DI 7	9	17
10B	DI 8	0	19
11B	DI 9	1	21
12B	DI 10	2	23
13B	DI 11 (MSB)	3	25
14B	+5	-	
15B	+5	-	
16B	+5	-	
17B	I/O-RCS	4	27
18B	RECALL:HOLD LAST	5	29
19B	TRK-FORWARD:RELSW	6	31
20B	STORE:HOLD NEXT	7	33
21B	DISK/PL	8	35
22B	I/O-STEP	9	37
23B	AC1	0	39
24B	AC2	1	41
25B	N-W/R	2	43
26B	D-W/R	3	45
27B	I/O-ACTIVE	4	47
28B	Disable Data Out	5	49

Negative true logic; 2's compliment;1 = ground; 0 = +5V; ground/+5V

Cable Connector - tan color and even pin numbers are twisted shield.

LOAD ADDRESS MODE

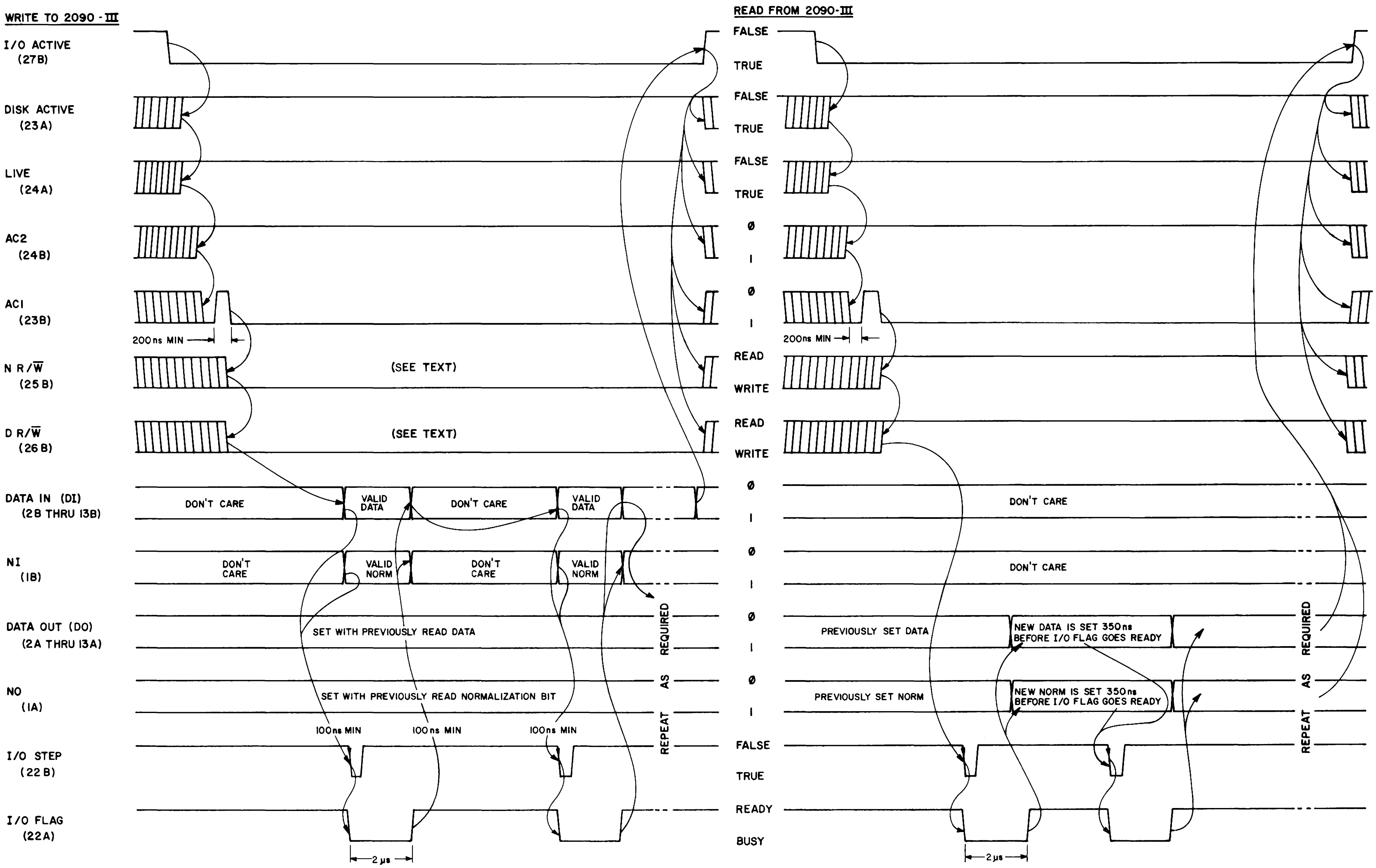


THIS TIMING DIAGRAM SHOWS SIGNAL LEVELS ON THE PINS OF THE 2090·III I/O CONNECTOR

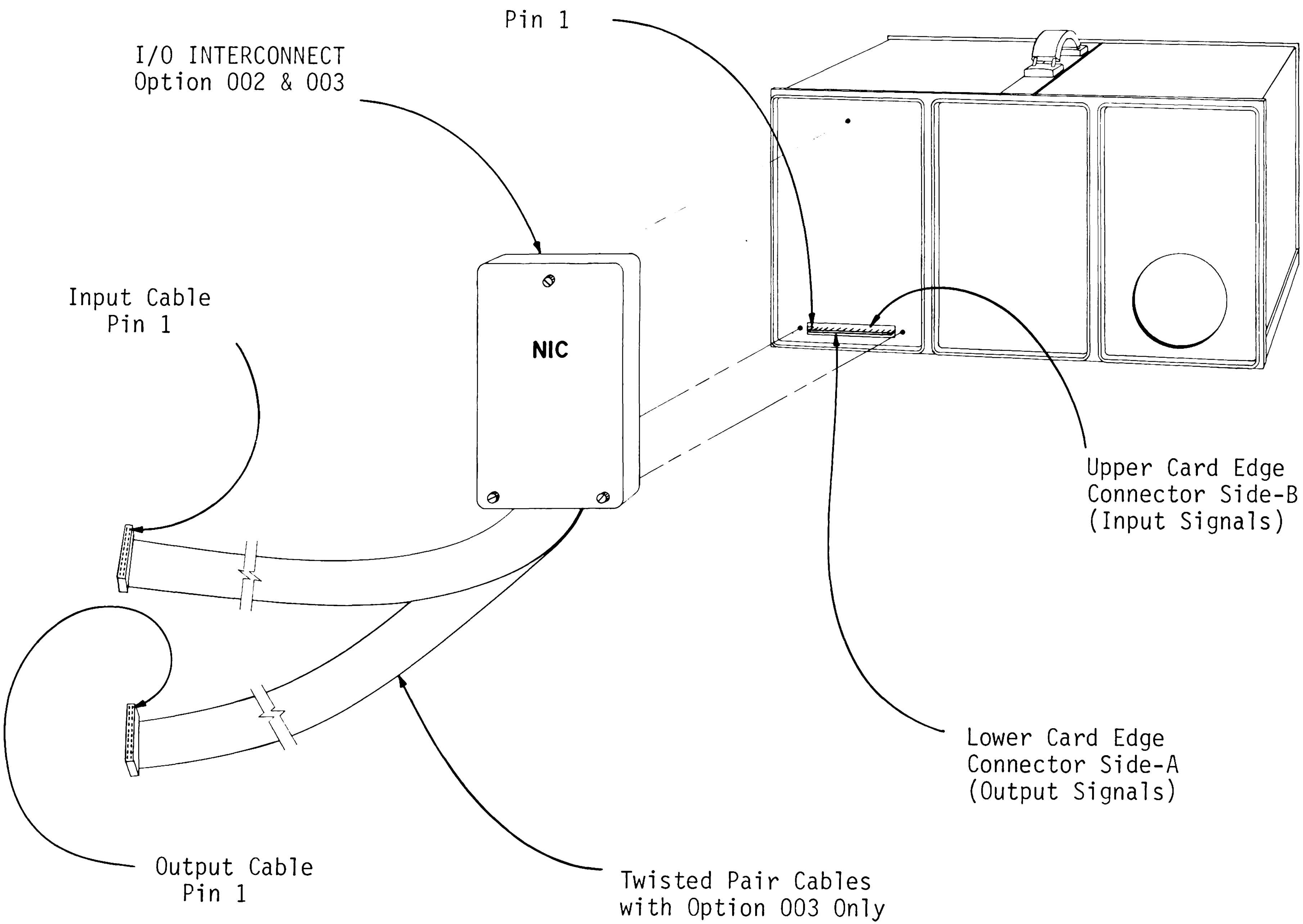
FALSE = +5 v = LOGIC Ø, TRUE = Øv = LOGIC 1

UNLESS OTHERWISE STATED, RELEASE OR HOLD TIMES ARE Ø µs.

ADVANCE ADDRESS MODE



THIS TIMING DIAGRAM SHOWS SIGNAL LEVELS ON THE PINS OF THE 2090-III I/O CONNECTOR
FALSE = +5v = LOGIC Ø, TRUE = Øv = LOGIC I
UNLESS OTHERWISE STATED, RELEASE OR HOLD TIMES ARE Ø μs.



NICOLET INSTRUMENT CORP

TITLE		
DRAWN	SIZE C	DWG. NO.
CHECKED		
APPROVED	SCALE	

2081

IEEE-488/GPIB INTERFACE TO NICOLET OSCILLOSCOPE

CONTENTS

GPIB/IEEE-488 GLOSSARY OF TERMS

2090	Model number of Nicolet oscilloscope mainframes.
2081	Model number of Nicolet GPIB interface option.
Address	A number which represents the location in memory of a specific data point. Also used to represent a device attached to the GPIB.
ASCII	American Standard Code for Information Interchange. A seven bit system of representing characters such as numbers, letters, math symbols, etc.
BASIC	A high level programming language.
Bit	A single digit in the base two numbering system. A bit is either "0" or "1". Groups of bits (8 bits = 1 byte, 4 bits = 1 nibble, unspecified number of bits = 1 word) are used to encode data used in digital electronic systems.
Bus	Wires used to transmit groups of bits. Buses can be internal or external to a machine.
Byte	A group of eight bits.
CAMAC	The IEEE-583 interface standard. Primarily used in the nuclear industry in place of the GPIB.
Carriage Return	A computer terminal key which causes the printing head or cursor to return to the start of the line.

Character	Standard symbols such as: A-Z, a-z, 0-9, +, -, etc.
Controller	A device connected to the GPIB which commands, addresses, and polls other devices on the GPIB.
DIP	Dual In-line Package. Standard physical structure of integrated circuits. Two rows of pins are attached to the IC body.
FORTRAN	A high level programming language.
GPIB	General Purpose Interface Bus. Specified by IEEE-488.
HPIB	Hewlett Packard Interface Bus. Essentially the same as the GPIB/IEEE-488. Devices with the HPIB are compatible with the GPIB.
Handshaking	The process of synchronizing communications between devices. A system of questions (Ready?) and replies (Yes) are used to make sure sender and receiver are properly prepared.
IEEE	Institute of Electronic and Electrical Engineers
IEEE-488	The IEEE specification for the GPIB.
I/O	Input/Output
Interface	The circuitry and programming necessary for the interconnection of electronic devices.
LSB	Least Significant Bit. In most cases the LSB is a bit representing 2^0 or 1.

Linefeed	A computer terminal key which causes the paper or cursor to advance one line.
MSB	Most Significant Bit. The bit in the highest binary location in a binary number.
Noise	Unwanted signals. Interface noise is usually caused by radio frequency interference on connecting cables.
Negative Logic	A low voltage represents a binary "1". This is the convention used by the GPIB.
Octal	Base eight number system.
Positive Logic	A high voltage represents a binary "1".
Word	A group of bits of arbitrary length which form a single binary value. 2090 words are 12 bits long.

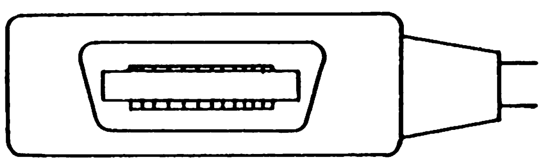
ASCII CODE CHART

BITS			2^6	0	0	0	0	1	1	1	1
			2^5	0	0	1	1	0	0	1	1
			2^4	0	1	0	1	0	1	0	1
2^3	2^2	2^1	2^0								
0	0	0	0	NUL	DLE	space	0	@	P	`	p
0	0	0	1	SOH	DC1	!	1	A	Q	a	q
0	0	1	0	STX	DC2	"	2	B	R	b	r
0	0	1	1	ETX	DC3	#	3	C	S	c	s
0	1	0	0	EOT	DC4	$	4	D	T	d	t
0	1	0	1	ENQ	NAK	%	5	E	U	e	u
0	1	1	0	ACK	SYN	&	6	F	V	f	v
0	1	1	1	BEL	ETB	'	7	G	W	g	w
1	0	0	0	BS	CAN	(	8	H	X	h	x
1	0	0	1	HT	EM	)	9	I	Y	i	y
1	0	1	0	LF	SUB	*	:	J	Z	j	z
1	0	1	1	VT	ESC	+	;	K	[	k	{
1	1	0	0	FF	FS	,	<	L	\	l	¦
1	1	0	1	CR	GS	-	=	M	]	m	}
1	1	1	0	SO	RS	.	>	N	^	n	~
1	1	1	1	SI	US	/	?	O	_	o	delete

GENERAL OVERVIEW - IEEE-488/GPIB

The General Purpose Interface Bus (GPIB) has been widely accepted since April 1975 when IEEE-488 was published. The GPIB offers interface compatibility which was previously unavailable. Since 1975, thousands of GPIB compatible products have been introduced on the market.

Figure 1 shows the layout of the standard GPIB cable and connector.



D8	pin 16	(MSB)
D7	pin 15	
D6	pin 14	Bidirectional
D5	pin 13	Data Lines
D4	pin 4	
D3	pin 3	
D2	pin 2	
D1	pin 1	(LSB)
NDAC	pin 8	Data Transfer
NRFD	pin 7	Control Lines
DAV	pin 6	(Handshaking Lines)
ATN	pin 11	
IFC	pin 9	General Control
SRQ	pin 10	Lines
REN	pin 17	
EOI	pin 5	

Pins 12, 18, 19, 20, 21, 22, 23, 24 at ground potential.

Figure 1

Physical limitations

1. No more than 15 devices on one GPIB.
2. No more than 2 meters of cable between any two devices or more than 20 meters of cable in total, whichever is less.
3. Maximum data transfer rates are set by the slowest device involved in the data transfer. Computer program execution speed is an important factor in data transfer rates.

GPIB Pin Explanations as they relate to the Nicolet 2081

D1 through D8	Carry data into or out of the 2081. Carry addresses into the 2081. Carry specialized controller commands into the 2081.
NDAC - Not Data Accepted	When "1": 2081 ready to accept data.
NRFD - Not Ready For Data	When "1": not OK to send data.
DAV - Data Valid	When "1": data valid on data lines.
ATN - Attention	When "0": data lines have data. When "1": data lines have address or GPIB command.
IFC - Interface Clear	When "1": "unaddresses" all devices attached to the GPIB so that they are off the GPIB.
SRQ - Service Request	When "1": tells the controlling computer that some device on the GPIB has information to be released. To locate the device, a serial polling operation would have to be conducted by the computer.
REN - Remote Enable	When "1": all devices on the GPIB will ignore their front panel controls and operate strictly under GPIB control. Not supported in the 2081.

EOI - End Or Identify	When "1": indicates to the device receiving information that the last information to be transmitted is on the data lines. Not supported in the 2081.

"1" is represented by a low voltage (approx. 0V).

"0" is represented by a high voltage (approx. 3V).

Addressing

Each device connected to the GPIB must be assigned one or more addresses (decimal numbers) so that it can be distinguished from other devices also on the GPIB. Each device may have a "talk" address for outputting data and a "listen" address for inputting data. It is possible for a single device to have multiple talk or listen addresses for different modes of operation.

The 2081 interface requires two listen addresses and one talk address. These addresses are used for the following:

1. One listen address and one talk address are used for inputting or outputting sample point data, normalizing data, and data addresses.
2. One listen address is used to send commands to the 2081 to carry out various operations.

Many computers will simplify programming by allowing the programmer to refer to a single address. The computer will correctly translate this into a talk or listen address depending on the program statement. A "PRINT" statement in BASIC infers that a listen address is required. An "INPUT" statement in BASIC would indicate that a talk address is needed. The programs shown at the end of this interfacing section show practical examples.

The 2081 addresses are set using a DIP switch concealed inside the back cover which houses the 2081. After turning the oscilloscope OFF, remove the back cover and use Table 1 to set the DIP switch to the chosen addresses (decimal 0 through decimal 29). The address set on the DIP switch is the data input/output (talk and listen) address. DIP switch setting plus 1 is the command input (listen only) address. Example: DIP switch setting = decimal 14, DIP switch setting plus 1 = decimal 15. Neither address should be used by any other device on the GPIB.

NOTE: Depress the ON side of a rocker switch to turn it ON

Depress the OFF side of a rocker switch to turn it OFF

DIP Switch (1)	(2)	(3)	(4)	(5)		GPIB Address Decimal	Octal	Listen Address Decimal	ASCII	Talk Address Decimal	ASCII
ON	ON	ON	ON	ON		0	0	32	space	64	@
OFF	ON	ON	ON	ON		1	1	33	!	65	A
ON	OFF	ON	ON	ON		2	2	34	"	66	B
OFF	OFF	ON	ON	ON		3	3	35	#	67	C
ON	ON	OFF	ON	ON		4	4	36	$	68	D
OFF	ON	OFF	ON	ON		5	5	37	%	69	E
ON	OFF	OFF	ON	ON		6	6	38	&	70	F
OFF	OFF	OFF	ON	ON		7	7	39	'	71	G
ON	ON	ON	OFF	ON		8	10	40	(	72	H
OFF	ON	ON	OFF	ON		9	11	41	)	73	I
ON	OFF	ON	OFF	ON		10	12	42	*	74	J
OFF	OFF	ON	OFF	ON		11	13	43	+	75	K
ON	ON	OFF	OFF	ON		12	14	44	,	76	L
OFF	ON	OFF	OFF	ON		13	15	45	-	77	M
ON	OFF	OFF	OFF	ON		14	16	46	.	78	N
OFF	OFF	OFF	OFF	ON		15	17	47	/	79	O
ON	ON	ON	ON	OFF		16	20	48	0	80	P
OFF	ON	ON	ON	OFF		17	21	49	1	81	Q
ON	OFF	ON	ON	OFF		18	22	50	2	82	R
OFF	OFF	ON	ON	OFF		19	23	51	3	83	S
ON	ON	OFF	ON	OFF		20	24	52	4	84	T
OFF	ON	OFF	ON	OFF		21	25	53	5	85	U
ON	OFF	OFF	ON	OFF		22	26	54	6	86	V
OFF	OFF	OFF	ON	OFF		23	27	55	7	87	W
ON	ON	ON	OFF	OFF		24	30	56	8	88	X
OFF	ON	ON	OFF	OFF		25	31	57	9	89	Y
ON	OFF	ON	OFF	OFF		26	32	58	:	90	Z
OFF	OFF	ON	OFF	OFF		27	33	59	;	91	[
ON	ON	OFF	OFF	OFF		28	34	60	<	92	\
OFF	ON	OFF	OFF	OFF		29	35	61	=	93	]
ON	OFF	OFF	OFF	OFF	Do Not Use						
OFF	OFF	OFF	OFF	OFF	Do Not Use						
							Unlisten/Untalk	63	?	95	_

TABLE 1

Table 1 also equates the DIP switch address (and DIP switch plus 1) to the corresponding talk and listen addresses. These may have to be used if the computer does not automatically do address conversions. Consult your computer manual to find out if talk and listen addresses must be specified. Note that talk and listen addresses are expressed in decimal numbers and their ASCII character equivalents. These represent binary numbers which are derived from the DIP switch address setting by turning on bit 6 or 7 in addition to the five bits already shown on the switch. A DIP switch OFF represents a binary 1. Switch 5 is the most significant bit. Example: binary 00001 = decimal 1, add bit 6 = 1; binary 100001 = decimal 33 =! in ASCII.

Unlisten and untalk addresses cause all devices on the GPIB to be removed as a listener or a talker.

Specialized Commands

Several front panel controls and input/output functions are controllable by sending commands on the GPIB. Each command described below is sent on data lines D1 through D8 in ASCII code. In most programming situations these commands will be sent out as character strings. Only the commands listed below can be used. Upper case (capital) letters must be used. Ø = zero.

Front Panel Manipulation

LØ - LIVE	Plug-in goes into "LIVE". A service request (SRQ) is sent out if the plug-in is manually taken out of "LIVE".
HØ - LIVE/HOLD NEXT	Plug-in goes into "LIVE" and "HOLD NEXT". A service request (SRQ) is automatically sent out when the plug-in goes out of "LIVE".
H2 - Abort	Cancels the sweep in progress. Plug-in goes out of "LIVE". No service request is sent.

NOTE: Service requests are not sent out by the 2081 when strictly manual changes are made on the front panel switches.

Disk Recorder Manipulation

Note: As always, be careful to have the MEMORY switch and the TRACK SEGMENT switch in compatible positions.

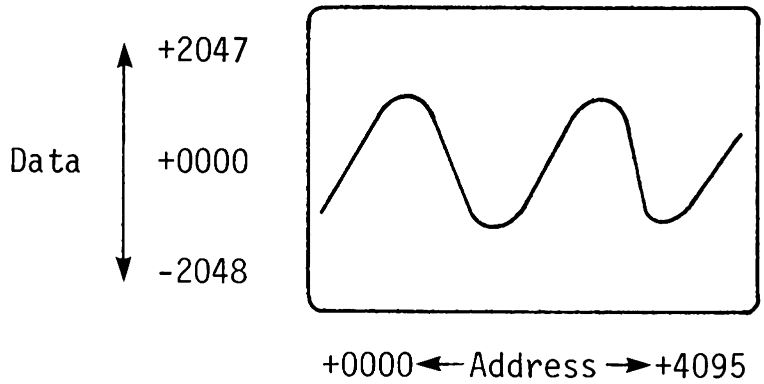
H3 - Autocycle	Activates autocycle mode if the front panel switch is already in the autocycle position. A service request (SRQ) is sent out when autocycle is completed.
Rn - Recall Track "n"	Track number n (1 through 8) will be recalled. RØ will recall whichever track is indicated on the front panel. A service request (SRQ) is sent out when the recall is completed.
Sn - Store on Track "n"	Displayed data will be stored on track number n (1 through 8). SØ will store data on whichever track is indicated on the front panel. A service request (SRQ) is sent out when the store is completed.
Tn - Select Track "n"	Disk recorder will be set to track number n (1 through 8). TØ leaves the disk track position unchanged. No service request is sent.

Data Transfer Commands

DØ - Auto Address Advance Data in ASCII code	Commands the 2081 to input or output data in ASCII code. An internal address counter will automatically count ahead to the next address. The start up address of the counter will be random if it is not reset. The command sequence D1DØ will cause the counter to start at address 0000. Address 0000 is at the left edge of the screen.
D1 - Load address Data in ASCII Code	Commands the 2081 to input or output data in ASCII code for addresses specified. Each address must be sent to the 2081 in ASCII code. The 2081 will immediately respond with the data value at the given address.
D2 - Auto Address Advance Data in binary form	Similar in function to DØ except that data is in binary code and not in ASCII code. See the explanation on pages 12, 13 and 14 concerning high and low bytes. The command sequence D3D2 will cause the address counter to start at address 0000 (the left edge of the screen).

D3 - Load Address Data in binary form	Similar in function to D1 except that data and selected addresses are in binary code and not in ASCII code. See the explanation on the next page concerning high and low bytes.

Address and Data Format



ASCII Data Transfer (commands DØ and D1)

1. 5 ASCII characters are needed for each data point.

   Examples: +1362 or b̸1362, -0492 (b̸=space=+)

2. 5 ASCII characters are needed for each address.

   Examples: +0126, +4024

Binary Data Transfer (commands D2 and D3)

1 byte = 8 bits

Data and addresses are transferred as two bytes, high byte first then low byte.

Example: Data = 234
Binary Format: 00000000 (High Byte) 11101010 (Low Byte)

Data = -234
Binary Format: 11111111 (High Byte) 00010110 (Low Byte)

Binary Data

When binary data transfer commands D2 and D3 are used each data value is transmitted as two eight bit bytes. Each high byte is transmitted first followed by the corresponding low byte. High and low bytes must be correctly combined in order to form a single binary value which can be treated as a data point value. Likewise, binary data sent into the 2081 must be transformed into high and low 8-bit bytes for transmission. A scheme to combine high and low bytes is given below.

1. Multiply the high byte by decimal 256 and add the result to the low byte. This operation sets the high byte to the correct binary significance and combines the high and low bytes. The resulting binary number is a standard 16-bit 2's compliment representation of a single data point.
2. Since standard computer word lengths vary considerably it should be noted that it may be necessary to extend the sign bits (bits 2^{11} through 2^{15}) to fill the remaining bit positions. This can be done in one of two ways:
   a. Check the value of bit 2^{15} and set the remaining unspecified bits to equal bit 2^{15}.

      Example: Computer word length=20 bits

      ```
                 1111111100010110=data from 2081
      bit 2^15 __↑
                      ←extend sign bits
             11111111111100010110
                 20-bit word
      ```

b. Check the value of bit 2^{15} and if "1" then subtract decimal 65536(2^{16}). This effectively extends the sign bits out to the most significant place.

Example: Computer word length=20 bits.

```
     1111111100010110= data from 2081
+ 11110000000000000000  add -65536
  11111111111100010110
       20-bit word
```

Status Information

D4 - Status ASCII Coded	Commands the 2081 to output two ASCII coded decimal digits: 1. Disk track number (1 through 8) 2. MEMORY switch setting number (table)

Example: 24
- 2 — Disk track
- 4 — MEMORY switch (see table)

MEMORY Switch Setting	Status Number
Q1	0
Q2	1
Q3	2
Q4	3
1H	4
2H	5
ALL	6

NØ - Normalization Data ASCII Coded	Commands the 2081 to output standard normalization data sets. When NØ is used to input normalization data to the 2081 both standard and reset locations will be filled.
N1 - Standard Normalization ASCII Coded	Input or output standard normalization data only.
N2 - Reset normalization ASCII Coded	Input or output reset normalization data only.

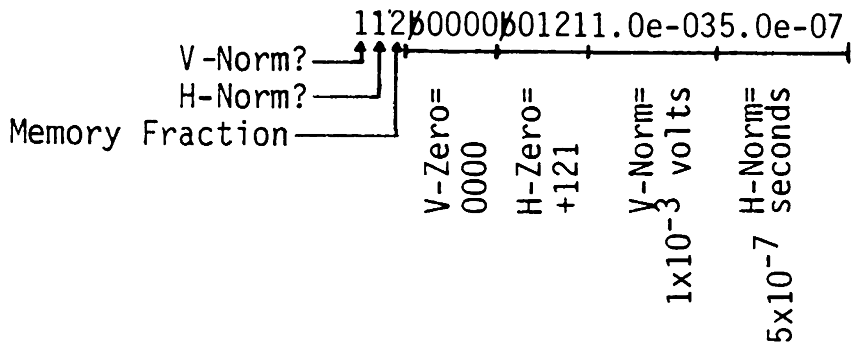
Normalization data is covered in depth on the next page.

Normalization Data

Normalization data is required if the actual voltage and time for each sample point needs to be known. Unnormalized data values range from -2048 to +2047 regardless of any front panel setting. Normalization allows data values to be converted into voltages, and addresses into time values. "Standard" normalization reflects the original front panel settings during signal acquisition. "Reset" normalization values come into existence when the front panel function RESET is used. RESET causes the zero time, zero voltage location to be changed on the display thus requiring new normalization. Standard and reset normalization data exist for every waveform in memory. If RESET has not been used, standard normalization will be found in both standard and reset locations in memory.

The maximum number of waveforms that can be stored in memory at one time is eight (2 channels x 4 quarters). Because of this, a total of eight standard normalization "sets" and eight reset normalization "sets" are stored in memory. A "set" contains all the normalization information required for a single waveform. If fewer than eight waveforms are stored in memory then some of the normalization sets will be duplicates. When inputting normalization sets, all eight sets (eight standard or eight reset) must be sent to the 2081, even if they are duplicates.

A Single Normalization "Set"



ƀ = blank space = +

Note: A single normalization set contains 27 ASCII characters.

1. V-Norm?, H-Norm? — If "1" then data normalization has occurred. If "0" then data is not normalized. Normally these will be "1" for all normalizations sets. Use of external address advance would cause H-Norm to be "0".

2. Memory Fraction — The increment needed to find the next point on a given waveform in memory. This varies depending on the position of the MEMORY switch during signal capture and the number of channels used. To calculate the memory fraction:

(M) x (no. of channels used) = mem. fraction

MEMORY Switch	M
ALL	1
1H or 2H	2
Q1, Q2, Q3, Q4	4

Note: (4094 points) x $\left(\frac{1}{\text{mem. frac.}}\right)$ = no. of points per waveform

3. V-Zero — The data value (a number between -2048 and +2047) where zero voltage is located. This is always 0000 for standard normalization. Use of RESET would allow this to range from -2048 to +2047 for reset normalization only.

4. H-Zero — Similar to V-Zero except that it relates to the horizontal zero time location ranging from 0000 to 4095. Use of cursor triggering could give a non-zero value for H-Zero in standard normalization sets.

5. V-Norm — Equal to the voltage between data point values when the waveform was captured.
Example: The voltage between +0000 and +0001. If a given data point value (-2048 to +2047) is multiplied by V-Norm the result will be the actual voltage at that point. The data value (V-Zero) where voltage equals zero should be taken into account when using reset normalization. The DC LEVEL knob may have to be adjusted to position ground potential at 0000 if the data values are supposed to represent the voltage from ground. The letter "e" precedes the exponent value. V-Norm is related to the voltage range setting on the front panel.

$$\text{V-Norm} = \frac{\text{Voltage range setting}}{2000}$$

6. H-Norm

Equal to the front panel TIME PER POINT setting (in seconds) when the waveform was captured. Addresses multiplied by H-Norm will yield the actual time at that location. The address location (H-Zero) where time equals zero should be taken into account. Use of cursor triggering will result in a time = zero somewhere other than at address 0000. The letter "e" preceeds the exponent value.

Delimiters

E∅ - CR/LF — Delimiter used will be carriage return/line feed.

E1 - CR — Delimiter used will be carriage return only.

Delimiters are ASCII characters which show the end of a group of related ASCII characters. By looking for delimiters the controlling computer is able to spot groups of ASCII characters that belong together (such as the five ASCII characters +2047). Two delimiters, carriage return (CR) and carriage return/line feed (CR/LF) are used by the 2081. The receiving computer must be able to correctly interpret these characters or problems will result. The delimiter which will be used, unless otherwise specified, is CR/LF. Transmissions containing binary data (high and low bytes) must not have delimiters as they will be misinterpreted as data bytes.

GPIB COMMANDS

These commands vary in purpose but are all standard to the GPIB. Not all controllers are capable of transmitting all commands. The ones listed below are able to be used by the 2081 in addition to the standard talk, untalk, listen, unlisten, and handshaking functions. These were described in the general overview of the GPIB. It may be necessary to consult the computer manual on the availability of these functions.

Device Clear (DCL)	This command returns all devices capable of responding to their predefined states. For the 2081 this predefined state is: unaddressed on the GPIB, the internal address counter set to 0000. In ASCII, DCL is represented by "DC4". This command is not addressed to specific devices.
Selected Device Clear (SDC)	Similar to DCL except that it affects only the devices addressed. In ASCII, SDC is represented by "EOT".
Interface Clear (IFC)	See the general discussion of the GPIB. This command has a separate line on the GPIB. Look for computer statements such as "INIT" in BASIC to switch on the interface clear.

Serial Poll Enable (SPE)

Serial Poll Disable (SPD)

The 2081 is capable of participating in a serial poll conducted by the controlling computer. A serial poll is a method by which the controller sequentially addresses each device on the GPIB to find one with a request for service (RQS). Each device returns its "status byte" which contains the necessary information.

2081 Status Byte

D8	D7	D6	D5	D4	D3	D2	D1
0	RQS	0	0	Disk Error	Interface Error	Disk Active	Live

1. RQS = 1 if the 2081 is requesting service.
2. Disk Error, Disk Active, and Live indicate the actual state of the indicator lights on the front panel.
   Light ON = 1
3. Interface Error = 1 indicates that the communication was terminated prematurely due to an error. Check for noise introduced into the interface cable by outside sources.

EXAMPLE: Status "64" (01000000) means the 2081 is requesting service, no errors have been detected, the disk is not in use, and the plug-in is not in LIVE.

IEEE-488 Function Subsets

SH1	Source Handshake - complete capability
AH1	Acceptor Handshake - complete capability
T6	Basic talker, Serial poll, & Unaddress if MLA
L4	Basic Listener & Unaddress if MTA
SR1	Service Request - complete capability
RLØ	Remote Local - no capability
PPØ	Parallel Poll - no capability
DC1	Device Clear - complete capability
DTØ	Device Trigger - no capability
CØ	Controller - no capability

SAMPLE PROGRAMS

TEKTRONIX 4052 COMPUTER

Program 1:

```
100 DIM B(4096)
110 PRINT @ 15: "D1DØ"
120 FOR I=1 TO 4096
130 INPUT @ 14: B(I)
140 NEXT I
150 PRINT B
160 END
```

Line By Line Explanations:

100 Dimension array B to 1 X 4096.

110 Output the ASCII coded commands D1DØ to GPIB address 15.

120 While incrementing I from 1 to 4096, input data from GPIB address 14 into

140 the computer array B.

150 Display the data values of array B.

160 End of program.

Description - A total of 4096 data points are transferred to the TEK 4052 using the auto address advance input/output command DØ. The data is displayed in four columns on the TEK 4052. To receive all 4096 points, the MEMORY switch should be in ALL. Note the use of addresses 14 and 15 in lines 110 and 130. The DIP switch in the 2081 is set at decimal 14.

Program 2:

```
100 DIM B(4096)
110 PRINT @ 15: "D1DØ"
120 FOR I=1 TO 4096
130 INPUT @ 14: B(I)
140 NEXT I
150 STOP
160 FOR J=1 TO 4096
170 PRINT @ 14: B(J)
180 NEXT I
190 END
```

Line By Line Explanations:

100 Dimension array B to 1 X 4096.

110 Output the ASCII coded commands D1DØ to GPIB address 15.

120 While incrementing I from 1 to 4096, input data from GPIB address 14 into

140 computer array B.

150 Pause during program execution until a restart command is given (RUN 160).

160 While incrementing J from 1 to 4096, output the data in array B to GPIB

180 address 14.

190 End of program.

Description - This program is similar to program 1. A total of 4096 data points are transferred to the TEK 4052 using the auto address advance input/output command DØ. After the data is transferred, the computer will stop at statement 150 so that the user can have time to erase the data on the oscilloscope screen using the FUNCTION switch. When the data is erased, the statement RUN 160 should be entered on the TEK 4052. The TEK 4052 will send the data back to the oscilloscope to be displayed.

Program 3:	Line By Line Explanations:
100 DIM B(4096)	100 Dimension array B to 1 X 4096.
110 PRINT @ 15: "D1DØ"	110 Output the ASCII coded commands D1DØ to GPIB address 15.
120 FOR I=1 TO 4096	120 While incrementing I from 1 to 4096,
130 INPUT @ 14: B(I)	↓ input data from GPIB address 14 into
140 NEXT I	140 computer array B.
150 PRINT @ 15: "NØ"	150 Output the ASCII coded command NØ to GPIB address 15.
160 INPUT @ 14: A$	160 Input one normalizing set into character string variable A$.
170 LET C$ = SEG(A$,5,4)	170 Make character string variable C$ equal to a 4 character segment of A$ beginning at the 5th character in A$.
180 LET D$ = SEG(A$,10,4)	180 Similar to line 170.
190 LET E$ = SEG(A$,14,7)	190 Similar to line 170.
200 LET F$ = SEG(A$,21,7)	200 Similar to line 170.
210 LET C = VAL(C$)	210 Set C equal to the numeric value of the character string C$.
220 LET D = VAL(D$)	220 Similar to line 210.
230 LET E = VAL(E$)	230 Similar to line 210.
240 LET F = VAL(F$)	240 Similar to line 210.
250 FOR J=1 TO 4096	250 Increments J by one on each pass from line 250 to 310.
260 Y = (J-D-1)*F	260 Calculate the equivalent time of

	each data point address (0 through 4095). D is equal to H-Zero. F is equal to H-Norm.
270 B(J) = (B(J)-C)*E	270 Calculate the voltage of each data point. C is equal to V-Zero. E is equal to V-Norm.
280 L = J-1	280 Compute the address of each data point (0 through 4095).
290 PRINT USING 300: Y;"SECS";L;B(J);"VOLTS"	290 Display the time, voltage, and address of each data point.
300 IMAGE 4D.9D,2X,5A,5D.7D,2X,5A	300 Specifies the format for PRINT statement 290. Each number tells how many spaces are required. D is used to specify numeric data. Decimal points separate whole and fractional portions of a number. X is used for spaces. A is used for character strings.
310 NEXT J	310 End of the loop (lines 250 to 310).
320 END	320 End of the program.

Description - Data points and normalization data are sent to the TEK 4052 using input/output commands DØ and NØ in lines 110 and 150. The normalization data is used to scale the data point values so that they are displayed in volts. Address locations of data points are translated into time in seconds.

Program 4:

```
100 DIM B(4096)
110 PRINT @ 15:  "D3D2"
120 WBYTE @ 78:
130 FOR I=1 TO 4096
140 RBYTE H,L
150 B(I)=256*H+L-65536*(H=>128)
160 NEXT I
170 WBYTE @ 63,95:
180 PRINT B
190 END
```

Line By Line Explanations:

100 Dimension array A to 1 x 4096.

110 Output the ASCII coded commands D3D2 to GPIB address 15.

120 Address the GPIB at 78. Number 78 is the talk address for the device at GPIB address 14.

130 Increment I from 1 to 4096 while looping from line 130 to line 160.

140 Read a high byte (H) and low byte (L) off the GPIB.

150 Convert each byte to the correct numeric value and add together. Since the data is in two's compliment form, the section "-65536*(H=>128)" extends the sign of the calculated numeric value.

160 End of the loop (statements 130 to 160)

170 Address the GPIB at 63 and 95. Use of the unlisten and untalk addresses (63 and 95) causes previously addressed devices to be removed from the GPIB.

180 Display the data in array B.

190 End of program.

Description - A total of 4096 data points are sent to the TEK 4052 in binary form by use of the auto address advance input/output command D2. H and L represent the high and low bytes of data. Line 150 computes the integer equivalent of the combined high and low bytes. The data points are displayed on the TEK 4052 in a manner similar to the display on program 1. The program statements involving WBYTE are addressing and unaddressing (untalk and unlisten) the 2081. WBYTE is only needed on the TEK 4052 when binary data is transferred.

Program 5:	Line By Line Explanations:
100 DIM B(4096)	100 Dimension array B to 1 x 4096.
110 PRINT @ 15: "D3D2"	110 Output the ASCII coded commands D3D2 to GPIB address 15.
120 WBYTE @ 78:	120 Address the GPIB at 78. The number 78 is the talk address for the device at GPIB address 14.
130 FOR I=1 TO 4096	130 While incrementing I from 1 to 4096,
140 RBYTE H,L	input high and low bytes of data into
150 B(I)=256*H+L-65536*(H=>128)	H and L, combine H and H, compute the
160 NEXT I	160 numeric equivalent, and store in array B.
170 WBYTE @ 63,95:	170 Address the GPIB at 63 and 95. Use of the unlisten and untalk addresses (63 and 95) causes previously addressed devices to be removed from the GPIB.
180 PRINT @ 15: "NØ	180 Output the ASCII coded command NØ to GPIB address 15.
190 INPUT @ 14: A$	190 Input one standard normalization set from GPIB address 14 into character string A$.
200 LET C$=SEG(A$,5,4)	200 Make character string variable C$ equal to a 4 character segment of A$ beginning at the 5th character in A$.
210 LET D$=SEG(A$,10,4)	210 Similar to 200.
220 LET E$=SEG(A$,14,7)	220 Similar to 200.

230 LET F$=SEG(A$,21,7)	230 Similar to 200.
240 LET C=VAL(C$)	240 Convert the number represented in a character string into a number which can be used in math operations.
250 LET D=VAL(D$)	↓
260 LET E=VAL (E$)	↓
270 LET F=VAL(F$)	270
280 FOR J=1 TO 4096	280 Increment J from 1 to 4096 while looping from line 280 to line 340.
290 Y= (J-D-1)*F	290 Calculate the equivalent time of each sample point address (0 through 4095). D is equal to H-Zero. F is equal to H-Norm.
300 B(J)=(B(J)-C)*E	300 Calculate the voltage of each data point. C is equal to V-Zero. E is equal to V-Norm.
310 L=J-1	310 Calculate the address of each data point (0 through 4095).
320 PRINT USING 330: Y;"SECS";L;B(J);"VOLTS"	320 Display the time, voltage, and address of each data point.
330 IMAGE 7D.9D,2X,5A,5D, 5D.7D,2X,5A	330 Specifies the format for PRINT statement 320. Each number tells how many spaces are required. D is used to specify numeric data. A is used for character strings. X is used for blank spaces. A decimal point is used to separate whole and fractional portions of numeric data.

340 NEXT J	340 End of the loop (280 to 340).
350 END	350 End of the program.

Description - This program is similar to program 3. Normalization data is transferred to the TEK 4052 and used to scale the data points so that they are displayed in volts. Address locations of data points are translated into time in seconds. All data points are transferred in binary form. H and L represent the high and low bytes of data.

Program 6:

```
100 PRINT @ 15:  "N1"
110 INPUT @ 14:  A$,B$,C$,E$,
    F$,G$,H$
120 PRINT A$,B$,C$,D$,E$,F$,G$,H$,
130 END
```

Line By Line Explanations:

100 Output the ASCII coded command N1 to GPIB address 15.

110 Input eight standard normalizing sets from GPIB address 14 into character strings A$ through H$.

120 Display the character strings.

130 End of program.

Description - This short program transfers eight normalization sets to the TEK 4052 and displays them. The normalization input/output command N1 specifies that standard normalization sets will be transferred. Command N2 would cause reset normalization sets to be sent out.

HP 85 COMPUTER

Program 1:

```
10 DIM A$[8200]
15 OUTPUT 715; "D3D2"
20 IOBUFFER A$
25 TRANSFER 714 TO A$ FHS;
   COUNT 8192
30 CLEAR 7
35 DISP "END"
40 FOR I=1 TO 8191 STEP 2
45 P=256*NUM(A$[I])+NUM(A$[I+1])
   -65536*(NUM(A$[I])>128)
50 PRINT P
55 NEXT I
```

Line By Line Explanations:

10 Set the length of string variable A$ to 8200 characters.

15 Output the ASCII coded commands D3D2 to GPIB address 15. The HP-85 select code is 7.

20 Assign A$ to the input/output buffer.

25 Transfer data from GPIB address 14 to the HP-85 (select code 7) using the fast handshake mode. A total of 8192 bytes are transferred.

30 Send a Device Clear (DCL) signal on the GPIB to remove all devices presently addressed.

35 Display the word END on the HP-85 screen.

40 While incrementing I from 1 to 8191, combine the high and low bytes and calculate the numeric equivalent. The combined bytes form a 2's compliment binary data word. Each value is printed on the HP-85 printer.

55

60 END	60 End of program

Description - A total of 4096 data points are transferred to the HP-85 in binary form. Since each data point is composed of a high byte and a low byte, the total number of bytes transferred is 8192. Line 45 puts the high and low bytes together and calculates the integer equivalent. When all data has been transferred to the HP-85, "END" will be displayed. Note that the HP-85 select code is 7 and the 2081 address DIP switch is set on 14. Addressing can be seen in lines 15 and 25.

Program 1 modification: 50 DISP P, I/2-.5. The data and address location will be displayed in the scroll mode on the HP-85 display.

Program 2:

```
10 DIM A$[8200]
20 OUTPUT 715; "D3D2"
30 IOBUFFER A$
40 TRANSFER 714 TO A$ FHS;
   COUNT 8192
50 CLEAR 7
60 PAUSE
70 TRANSFER A$ TO 714 FHS
80 CLEAR 7
90 END
```

Line By Line Explanations:

10 Set the length of string variable A$ to 8200 characters.

20 Output the ASCII coded commands D3D2 to GPIB address 15. The HP-85 select code is 7.

30 Assign A$ to the input/output buffer.

40 Transfer data from GPIB address 14 to the HP-85 (select code 7) using the fast handshake mode. A total of 8192 bytes are transferred.

50 Send a Device Clear (DCL) signal on the GPIB to remove all devices presently addressed.

60 Pause during program execution until CONT key is depressed.

70 Transfer data from A$ to GPIB address 14 using the fast handshake mode.

80 Send a Device Clear (DCL) signal on the GPIB.

90 End of program.

Description - Using the binary data auto advance command D2, this program transfers 4096 data points (8192 bytes) into the HP-85. When line 60 is reached the HP-85 will pause. During the pause, erase the oscilloscope display using the FUNCTION switch. The data can be returned to the oscilloscope screen by pressing the CONT key on the HP-85.

Program 3:	Line By Line Explanations:
10 DIM A$ [8200]	10 Set the length of string variable A$ to 8200 characters.
20 OUTPUT 715, "D3D2"	20 Output the ASCII coded commands D3D2 to GPIB address 15. The HP-85 select code is 7
30 IOBUFFER A$	30 Assign A$ to the input/output buffer.
40 TRANSFER 714 TO A$ FHS; COUNT 8192	40 Transfer 8192 bytes of data from GPIB address 14 to the HP-85 (select code 7) using the fast handshake mode.
50 CLEAR 7	50 Remove all devices presently addressed by issuing a Device Clear (DCL) on the GPIB.
60 DISP "END"	60 Display the word END on the HP-85 screen.
70 SCALE 1, 4096, -2048, 2047	70 Set the minimum and maximum values of the data in the X and Y dimensions.
80 XAXIS -2048, 1024	80 Draw the x-axis on the HP-85 screen.
90 YAXIS 1, 1024	90 Draw the y-axis on the HP-85 screen.

100 FOR I=1 to 8192 STEP 2	100 While incrementing I from 1 to
110 P=256*NUM(A$[I])+NUM(A$[I+1])	8192 in steps of 2, combine the
-65536*(NUM(A$[I])>=128)	high and low bytes and calculate
120 PLOT .5*I+.5,P	the numeric equivalent. Plot
	each data point on the HP-85
	screen. The section ".5*I+.5"
	corrects the value of I
130 NEXT I	130 to the range of 1 to 4096.
140 END	140 End of program.

Description - Data transfer in this program is similar to program 2. When the data transfer is complete, "END" is displayed on the HP-85 screen. A scaled plot of the data will be shown on the HP-85 screen.

Program 4:

Line By Line Explanations:

```
10 DIM B$[280], A$[8200]
```

10 Set the lengths of string variables B$ and A$.

```
20 OUTPUT 715; "NØ"
```

20 Output the ASCII coded command NØ to GPIB address 15. The HP-85 select code is 7.

```
30 IOBUFFER B$
```

30 Assign B$ to the input/output buffer.

```
40 TRANSFER 714 to B$ FHS;
   COUNT 230
```

40 Transfer 230 bytes of normalizing data from GPIB address 14 into B$ using the fast handshake transfer mode. Each normalizing set contains 27 ASCII characters. Eight sets of characters and delimiters results in a maximum of 232 transfers. The last delimiters are thrown out resulting in 230 transfers.

```
50 CLEAR 7
```

50 Remove all devices presently addressed by issuing a Device Clear (DCL) on the GPIB.

```
60 VØ = VAL(B$[5,8])
```

60 Assign the numeric value of characters B$[5]through B$[8] to VØ. VØ equals the V-Zero portion of the first normalization set.

```
70 HØ = VAL(B$[10,13])
```

70 Similar to line 60. HØ equals H-Zero.

80 V1 = VAL(B$[14,20])	80 Similar to line 60. V1 equals V-Norm.
90 H1 = VAL(B$[21,27])	90 Similar to line 60. H1 equals H-Norm.
100 OUTPUT 715; "D3D2"	100 Output the ASCII coded command D3D2 to GPIB address 15.
110 IOBUFFER A$	110 Assign A$ to the input/output buffer.
120 TRANSFER 714 TO A$ FHS; COUNT 8192	120 Transfer 8192 bytes of data from GPIB address 14 to A$ using the fast handshake mode.
130 CLEAR 7	130 Issue a Device Clear (DCL) on the GPIB.
140 FOR I=1 to 8191 STEP 2	140 On each pass from 140 to 210 increment I by 2. I ranges from 1 to 8191.
150 P= 256*NUM(A$[I])+NUM(A$[I+1]) -65536*(NUM(A$[I])>=128)	150 Combine the high and low bytes and calculate the numeric equivalent.
160 J=I/2-.5	160 Calculate the address of each data point (0 through 4094).
170 V=P*V1	170 Calculate the voltage at each data point
180 T=(J-HØ)*H1	180 Calculate the time at each address. HØ is the "time equals zero" address.
190 DISP USING 200; T; "SECS"; V; "VOLTS"	190 Display the time and voltage of each data point.
200 IMAGE DDD.DDE,5A,DDD.DDE,5A	200 Display format for line 190.
210 NEXT I	210 End of the loop (line 140 to line 210).

```
220  END                              220 End of program.
```

Description - This program transfers binary data and standard normalization to the HP-85. The binary data is converted into its equivalent integer form and normalized so that each data point is equated to a voltage. Addresses are convereted into time in seconds. Each normalized data point is displayed on the HP-85 screen.

Program 5:

```
10 DIM A$[280]
15 OUTPUT 715; "NØ"
20 IOBUFFER A$
25 TRANSFER 714 TO A$ FHS;
COUNT 230
30 CLEAR 7
35 DISP "END"
40 PRINT A$
45 END
```

Line By Line Explanations:

10 Set the length of string variable A$.

15 Output the ASCII coded command NØ to GPIB address 15. The HP-85 select code is 7.

20 Assign A$ to the input/output buffer.

25 Transfer 230 bytes of normalization data from GPIB address 14 into A$ using the fast handshake transfer mode.

30 Remove all devices presently addressed by issuing a Device Clear (DCL) on the GPIB.

35 Display the word END.

40 Print out all the normalization data contained in A$.

45 End of program.

Description - This program transfers eight standard normalizing sets to the HP-85. The normalizing sets are printed out on the HP-85 printer. Use of normalization input/output command N2 would allow reset normalization to be transferred.

2082

RS232C INTERFACE TO NICOLET OSCILLOSCOPE

CONTENTS

RS-232C GLOSSARY OF TERMS

2090	Model number of Nicolet oscilloscope mainframes.
2082	Model number of Nicolet RS-232C interface option.
Address	A number which represents the location in memory of a specific data point.
ASCII	American Standard Code for Information Interchange. A seven bit system of representing characters such as numbers, letters, math symbols, etc.
BASIC	A high level programming language.
Baud	Bit serial data transmission rate measured in bits per second.
Bit	A single digit in the base two numbering system. A bit is either "0" or "1". Groups of bits (8 bits = 1 byte, 4 bits = 1 nibble, unspecified number of bits = 1 word) are used to encode data used in digital electronic systems.
Bit Serial	Data transmitted one bit at a time.
Byte	A group of eight bits.
Carriage Return	A computer terminal key which causes the printing head or cursor to return to the start of the line.
Carrier Freq.	A frequency which is modulated to carry binary information.
Character	Standard symbols such as: A-Z, a-z, 0-9, +, -, etc.
Data Set	See Modem.
DIP	Dual In-line Package. Standard physical structure of integrated circuits. Two rows of pins are attached to the IC body.
EIA	Electronic Industries Association

Echo Check	A transmission error detection procedure in which the receiving device repeats everything back to the sender for verification.
FORTRAN	A high level programming language.
FSK	Frequency Shift Keying. Each binary state, 1 or 0, is represented with a single frequency. These two tones are transmitted over telephone lines in standard RS-232C communications. See Carrier, Modem.
Full Duplex	Communications which can take place in two directions simultaneously.
Half Duplex	Communications which pass in only one direction at any given time.
Handshaking	The process of synchronizing communications between devices. A system of questions (Ready?) and replies (Yes) are used to make sure sender and receiver are properly prepared.
I/O	Input/Output
Interface	The circuitry and programming necessary for the interconnection of electronic devices.
LSB	Least Significant Bit. In most cases the LSB is a bit representing 2^0 or 1.
Linefeed	A computer terminal key which causes the paper or cursor to advance one line.
Local Echo	The process of sending characters typed on a computer terminal keyboard to the computer terminal screen for display.

MSB — Most Significant Bit. The bit in the highest binary location in a binary number.

Modem — Modulator-demodulator. A device used to transmit and receive binary data on telephone lines. Each binary "1" or "0" is represented with a specific signal frequency.

Noise — Unwanted signals. Interface noise is usually caused by noisy telephone lines or radio frequency interference on connecting cables.

Negative Logic — A low voltage represents a binary "1". This is the convention used by RS-232C.

Parity Bit — A parity bit is an extra bit added to a binary word to create an even or odd number of binary bits equal to "1". By counting the number of 1's in a word and knowing whether the total should be even or odd, the receiving device can detect most errors due to interface noise.

Positive Logic — A high voltage represents a binary "1". This is the convention used by RS-232C handshaking lines.

RS-232C — Recommended Standard 232C. An EIA specification which defines bit serial data communications.

Serial Data — See Bit Serial.

Simplex — Similar to half duplex communications except that communications can travel only in one direction. It is impossible to transmit anything back to the sender.

Start Bit — A bit which precedes the eight bits (7 bits plus parity bit) representing an ASCII character. The start bit is a warning to the receiver that data will follow immediately. Start bits are at logic "0".

Stop Bit — The bit(s) which immediately follow the eight bits (7 bits plus parity bit) which compose an ASCII character. The stop bits (1 or 2) define the minimum spacing between characters. Stop bits are at logic "1".

Word — A group of bits of arbitrary length which form a single binary value. 2090 words are 12 bits long.

ASCII CODE CHART

BITS 2^3 2^2 2^1 2^0 \ 2^6 2^5 2^4	0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
0 0 0 0	NUL	DLE	space	0	@	P	`	p
0 0 0 1	SOH	DC1	!	1	A	Q	a	q
0 0 1 0	STX	DC2	"	2	B	R	b	r
0 0 1 1	ETX	DC3	#	3	C	S	c	s
0 1 0 0	EOT	DC4	$	4	D	T	d	t
0 1 0 1	ENQ	NAK	%	5	E	U	e	u
0 1 1 0	ACK	SYN	&	6	F	V	f	v
0 1 1 1	BEL	ETB	'	7	G	W	g	w
1 0 0 0	BS	CAN	(	8	H	X	h	x
1 0 0 1	HT	EM	)	9	I	Y	i	y
1 0 1 0	LF	SUB	*	:	J	Z	j	z
1 0 1 1	VT	ESC	+	;	K	[	k	{
1 1 0 0	FF	FS	,	<	L	\	l	¦
1 1 0 1	CR	GS	-	=	M	]	m	}
1 1 1 0	SO	RS	.	>	N	^	n	~
1 1 1 1	SI	US	/	?	O	_	o	delete

INTERFACE 2082

RS-232C

GENERAL

The Electronic Industries Association (EIA) Recommended Standard 232C has become the accepted bit-serial data transmission specification. Bit-serial interfacing was primarily developed for long distance communications over telephone lines. Widespread acceptance of RS-232C has prompted its use in non-telephone data transmissions as well. Figure 1 shows the layout of the standard RS-232C cable and connector.

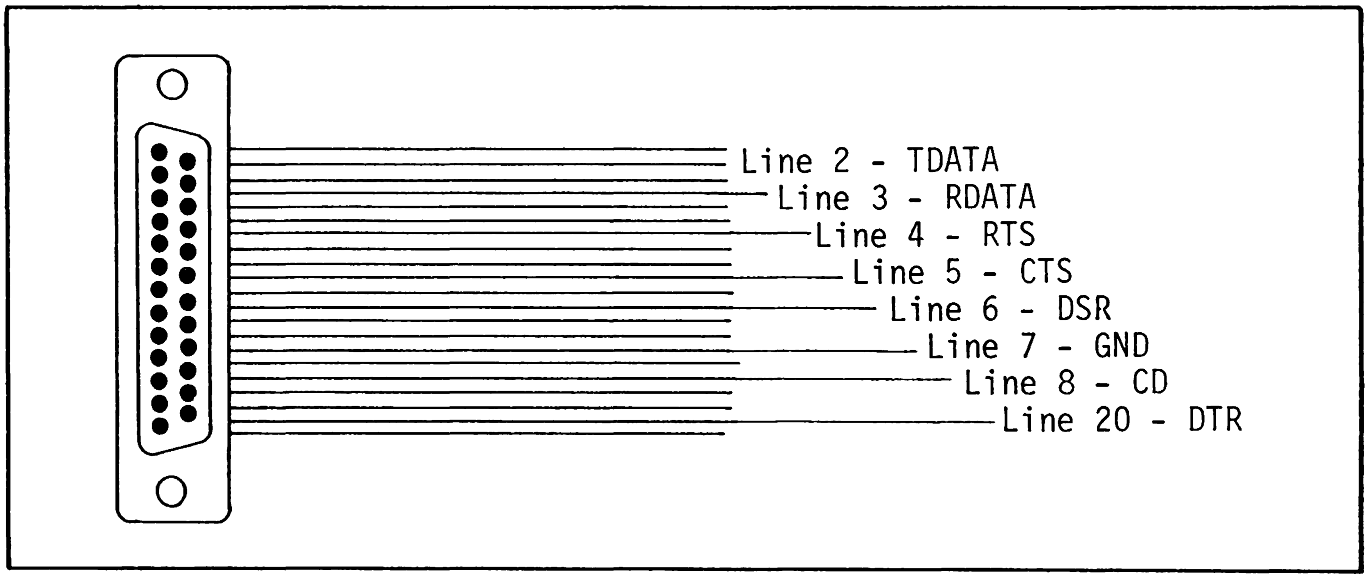


Figure 1

Physical Limitations

1. The maximum transmission distance is unlimited if telephone lines are utilized. Direct cable link-ups are limited to 50 feet.
2. The maximum data transfer rate is set by the allowable baud rates (bits per second) of the communicating devices. The Nicolet 2082 can run at 110 to 9600 baud.

RS-232C lines as they relate to the Nicolet 2082. Lines not not discussed are not supported by the 2082.

#1	Protective Ground	
#2	TDATA - Transmitted Data	Path for outgoing data.
#3	RDATA - Received Data	Path for incoming data.
#4	RTS - Request to Send	Activated by the sending device to tell the sending modem to get ready for data transmissions.
#5	CTS - Clear to Send	Activated by the sending modem to tell the sending device that it is ready for transmissions. The 2082 will pause during data transmissions if this line is turned OFF (-10V). Data transmissions from the 2082 will resume as soon as this line is turned ON (+10V). No characters will be lost.
#6	DSR - Data Set Ready	A data set is a modem. This line is activated by the sending modem to tell the sending device that it is ready for a Request to Send.
#7	Signal Ground	
#8	CD - Carrier Detected	Activated by the receiving modem to tell the receiving device that a carrier signal has been detected and data will soon follow.

#20 DTR - Data Terminal Ready	Activated by the sending device to tell the sending modem that it is ready to send data.

Voltage	Status (for handshaking lines)	Binary (for data)
-3 volts to -25 volts	OFF	1
+3 volts to +25 volts	ON	0

START-UP PROCEDURE

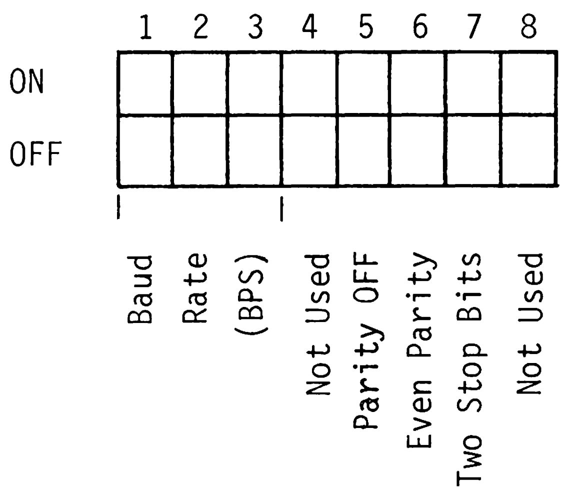
Several manual switch settings must be made before the 2082 interface can be put into service. These settings are used to select baud rate, parity, and number of stop bits. The 2082 interface must have settings which match the connected device specifications. Factory settings are as follows:

a) 300 baud

b) no parity check

c) one stop bit

The above settings may be changed with the DIP switch concealed inside the back cover which houses the 2082. After turning the oscilloscope OFF, remove the back cover and use the following information to set the switch.



NOTE: Depress the ON side of a rocker switch to turn it ON.

Depress the OFF side of a rocker switch to turn it OFF.

1. Set the baud rate (bits per second) to match the baud rate of the connected device.

Baud Rate	Switch		
	1	2	3
110	OFF	OFF	OFF
150	OFF	OFF	ON
300	OFF	ON	OFF
600	OFF	ON	ON
1200	ON	OFF	OFF
2400	ON	OFF	ON
4800	ON	ON	OFF
9600	ON	ON	ON

2. Set the parity. The parity bit is an eighth bit sent with each group of seven bits (each ASCII character). By checking parity bits the receiving device can determine when transmission errors have occurred. If parity is turned off, parity bit checking will not be done. Transmissions from the 2082 will have the parity bit set at "1" if parity is turned off.

   Switch 5

   ON - Parity checking turned off.

   OFF - Parity checking turned on.

   Switch 6 (only used if switch 5 is OFF)

   ON - Even parity.

   OFF - Odd parity.

3. Set the number of stop bits. Each ASCII character (seven bits plus a parity bit) transmitted is preceded by a start bit and ended with one or two stop bits. Communicating devices must agree on the number of stop bits to be used.

   Switch 7

   ON - Two stop bits.

   OFF - One stop bit.

After setting switches 1 through 7 the back cover should be put back in place.

4. The 2082 interface should be switched ON LINE if it is expected to participate in any communications. The ON LINE switch controls pin 20 (DTR) on the TO MODEM connector, the TO TERMINAL connector is unaffected by this switch.

5. The RS-232C connectors on the back of the 2082 are standard 25 pin, D subminiature rectangular connectors (such as Cannon DB-25S, DB-25P, DBSP-25S, and DBSP-25P). The TO MODEM connector is the input/output port for the 2082. The TO TERMINAL connector allows both the 2082 and a computer terminal to communicate with a computer connected to the TO MODEM port. Commands sent in the TO TERMINAL connector will not directly control the 2082. Any device expected to input to the 2082, or receive data from the 2082, must be connected to the TO MODEM port.

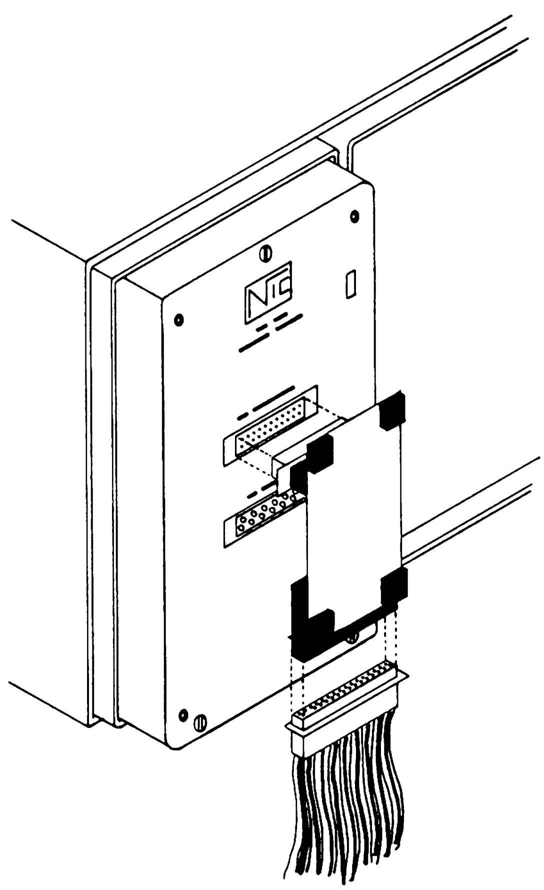
   The TO MODEM port is designed to transmit and receive to/from modems and computer input/output ports configured for use with terminals. Direct connection of the TO MODEM port to computer terminals, teletypes, and non-terminal configured computer ports will necessitate use of the Nicolet null modem printed circuit board supplied with the 2082 (supplied starting Oct. '81). The null modem board is attached to the 2082 as shown in Figure 2. The null modem board provides the following.

   a. Cross-connections of the transmit and receive lines.
   b. Access to control lines so that specialized handshaking can be patched in if desired. For example, a computer which

can control its Request To Send (RTS) line could control the 2082 data output. The computer's RTS could be patched together with the 2082 Clear To Send (CTS) so that the computer can control the 2082. When the computer RTS turns the 2082 CTS line OFF (-3 to -25 volts) the 2082 data transmission will cease. Transmissions will resume as soon as the 2082 CTS line is turned ON (+3 to +25 volts).

c. Access to all 2082 supported RS-232C lines for test purposes.

d. Interconnection of handshaking lines so that each device will "think" that it is connected to a modem providing standard handshaking functions.



Null Modem Connection
Figure 2

6. The 2082 can be used in either full or half duplex without adjustment. However, the 2082 will produce an "interface error" on the status byte and cease transmissions if any characters are sent to the 2082 while it is outputting data. Only a CTRL C (ETX) can be sent to the 2082 during a transmission. ETX will cause an immediate transmission abort without an "interface error". It should be noted that prompters (such as "CR/LF?" and echo checking sent to the 2082 while the 2082 is transmitting data will cause a similar interface error. Echo checking is a method of error detection in which a computer repeats all communications back to the sender for verification. Echo checking and prompters must be eliminated from the computer transmissions.

2082 OPERATIONS

Enable/Disable Commands

SOH or CTRL A

NOTE: SOH and CTRL A are equivalent ASCII characters. An SOH or CTRL A is generated when the CTRL Key and the A Key on a standard keyboard are depressed simultaneously.

Enables the 2082 interface. The indicator light labeled I/O ACTIVE will turn on when this command is received. Other commands will not be accepted if the I/O ACTIVE light is not on. Failure of the I/O ACTIVE light to turn on indicates that the SOH has not been received due to an error in start-up. The start-up procedure must be followed with care. EXCEPTION: If the 2082 is set up for Digital Equipment Corporation computers, the enable command is DC1 instead of SOH.

STX or CTRL B

NOTE: STX and CTRL B are equivalent ASCII characters. An STX or CTRL B is generated when the CTRL Key and the B Key on a standard keyboard are depressed simultaneously.

Initiates all data transfers from the 2082 to outside devices. Data input/output commands are necessary and are specified on Page XI-14. EXCEPTION: If the 2082 is set up for Digital Equipment Corporation computers, the ASCII character DC2 is used instead of STX.

ETX or CTRL C NOTE: ETX and CTRL C are equivalent ASCII characters. An ETX or CTRL C is generated when the CTRL Key and the C Key on a standard keyboard are depressed simultaneously.	Disables the 2082 interface and turns off the I/O ACTIVE indicator light. If ETX is sent to the 2082 while it is transmitting data, the transmission will be aborted. EXCEPTION: If the 2082 is set up for Digital Equipment Corporation computers, the ASCII character DC3 is used instead of ETX.

Several front panel controls and input/output functions are controllable by sending commands into the 2082. Each command described below must be sent in ASCII code. Only the commands listed below can be used. Upper case (capital) letters must be used. Ø = zero.

Front Panel Manipulation

Front panel manipulation commands cannot be chained together. Only ETX may follow these commands without causing an error termination.

LØ - LIVE	Plug-in goes into "LIVE".
HØ - LIVE/HOLD NEXT	Plug-in goes into "LIVE" and "HOLD NEXT".
H2 - Abort	Cancels the sweep in progress. Plug-in goes out of "LIVE".

Disk Recorder Manipulation

Disk recorder manipulation commands cannot be chained together. Only ETX may follow these commands without causing an error termination.

NOTE: As always, be careful to have the MEMORY switch and the TRACK SEGMENT switch in compatible positions.

H3 - Autocycle	Activates the autocycle mode if the TRACK SEGMENT switch is already in the autocycle position.
Rn - Recall Track "n"	Track number n (1 through 8) will be recalled. RØ will recall whichever track is indicated on the front panel.
Sn - Store on Track "n"	Displayed data will be stored on track number n (1 through 8). SØ will store data on whichever track is indicated on the front panel.
Tn - Select Track "n"	Disk recorder will be set to track number n (1 through 8). TØ leaves the disk track position unchanged.

Input/Output Manipulation

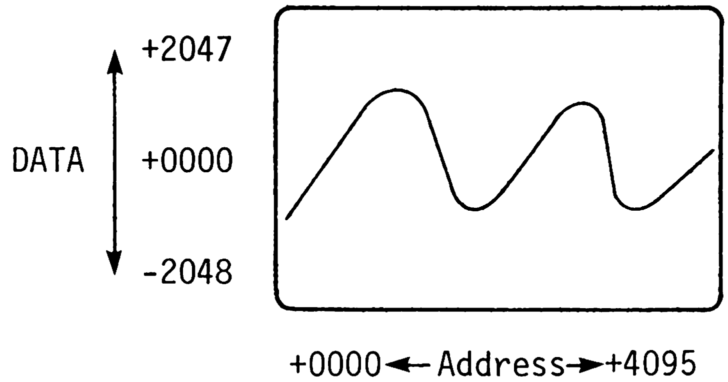
Input/output manipulation commands may be chained together in any order or combination.

DØ - Auto Address Advance Data in ASCII Code	Commands the 2082 to input or output data in ASCII code. An internal address counter will automatically count ahead to the next address. The starting address of the counter will be random if it is not reset. The command sequence D1DØ will cause the counter to start at address 0000. Address 0000 is at the left edge of the screen.
D1 - Load Address Data in ASCII Code	Commands the 2082 to input or output data in ASCII code for addresses specified. Each address must be sent to the 2082 in ASCII code. The 2082 will immediately respond with the data value at the given address.
D2 - Auto Address Advance Data in Printable Binary	Similar in function to DØ except that data is in binary code converted into a printable ASCII character. See the explanation on pages 16, 17 and 18 concerning high and low bytes, and number conversions. The command sequence D3D2 will cause the address counter to start at address 0000 (the left edge of the screen).

D3 - Load Address Data in Printable Binary

Similar in function to D1 except that data and selected addresses are in binary code converted into printable ASCII characters. See the explanation on pages X16, X17 and X18 concerning high and low bytes and number conversions.

ADDRESS AND DATA FORMAT



ASCII Data Transfer (commands DØ and D1)

5 ASCII characters are needed for each data point.

Examples: +1362 or ɓ1362, -0492 (ɓ = space = +)

5 ASCII characters are needed for each address.

Examples: +0000, +0126, +4024

Binary Data Transfer (commands D2 and D3)

1 byte = 8 bits

Data and addresses are transferred as two bytes, high byte first then low byte.

Example: Data = 234

Printable ASCII, Binary Format = #J

High Byte → #

Low Byte → J

Data = -234

Printable ASCII, Binary Format = \6

High Byte → \

Low Byte → 6

Printable Binary Conversion

Printable binary data must be converted into standard binary form before it can be numerically handled by a computer. Likewise, data to be sent from a computer to the 2082 must undergo a conversion into printable binary if I/O commands D2 or D3 are to be used. The conversion scheme to transform printable binary into standard binary is given below.

1. Convert the printable ASCII characters (printable binary) into their binary equivalents. See the ASCII chart on page 1. Ignore parity bits (bit 2^7) included during transmission.

   #=0100011   \=1011100

   J=1001010   6=0110110

2. Subtract binary 32 (0100000) from each binary number. Binary 32 was added to the original data to bring it into the range of printable ASCII characters.

   ```
   #    0100011    \    1011100
       -0100000        -0100000
        0000011         0111100

   J    1001010    6    0110110
       -0100000        -0100000
        0101010         0010110
   ```

3. Multiply the high byte by decimal 64 and add the result to the low byte. This operation sets the high byte to the correct binary significance and combines the high and low bytes. The resulting binary number is a standard 12-bit 2's compliment representation of a single data point.

   ```
   |←—12 bits—→|          |←12 bits—→|
   0000011101010          0111100010110
   (derived from #J)      (derived from \6)
   ```

4. Since standard computer word lengths vary considerably, it should be noted that it may be necessary to extend the sign bit (bit 2^{11}) to fill the remaining bit positions. This can be done in one of two ways:

   a. Check the value of bit 2^{11} and set the remaining unspecified bits to equal bit 2^{11}.

      Example: Computer word length=16 bits

```
                 0111100010110=data from 2082
      bit 2^11 ───↑
                 ←────── extend sign bit

              1111111100010110
              |←16-bit word→|
```

   b. Check the value of bit 2^{11} and if "1" then subtract decimal 4096(2^{12}). This effectively extends the sign bit out to the most significant place.

      Example: Computer word length=16 bits

```
                 0111100010110=data from 2082

          +1111000000000000  add -4096
          -----------------
           1111111100010110
          |←16-bit word→|
```

D4 - Status

ASCII Coded

Commands the 2082 to output an ASCII character which, when translated into its binary form, gives status information.

Status Bits

2^6	2^5	2^4	2^3	2^2	2^1	2^0
1	0	Request Service	Disk Error	Interface Error	Disk Active	Live

1. Request Service

   It is not possible to detect a Request Service using command D4. See Input/Output Termination on page XI-28.

2. Disk Error, Disk Active, and Live indicate the actual state of the indicator lights on the front panel.

   Light ON = 1

3. Interface Error

   It is not possible to detect an Interface Error using command D4. See Input/Output Termination on page XI-28.

D5 - Full Status ASCII Coded

Commands the 2082 to output 3 ASCII characters giving status information as follows:

1. Disk track number (1 through 8).
2. MEMORY switch setting (table).
3. Status character (Same as in command D4).

Example: 35@

```
         35@
         ↑↑↑
         ||└Status (See Command D4)
         |└MEMORY switch (See Table)
         └Disk Track
```

MEMORY Switch Setting	Status Number
Q1	0
Q2	1
Q3	2
Q4	3
1H	4
2H	5
ALL	6

NØ - Normalization Data ASCII Coded

Commands the 2082 to output standard normalization data sets. When NØ is used to input normalization data to the 2082 both standard and reset locations will be filled.

N1 - Standard Normalization ASCII Coded — Input or output standard normalization data only.

N2 - Reset Normalization ASCII Coded — Input or output reset normalization data only.

When sending normalization sets into the 2082 at high baud rates each set must be allowed enough time to be accepted by the 2082. It is necessary to program the computer to wait a given time interval before sending out the next normalization set. Delimiters count as part of the normalization set. The waiting times for each Nn command are as follows:

Baud Rate (bps)	NØ Wait	N1, N2 Wait
2400	20 ms	(no wait)
4800	10 ms	2 ms
9600	10 ms	4 ms

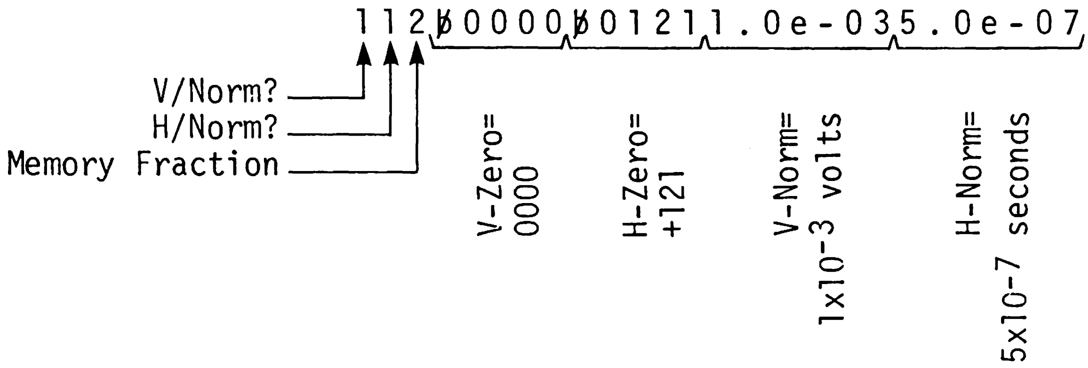
Normalization data is covered in depth on the next pages.

NORMALIZATION DATA

Normalization data is required if the actual voltage and time for each sample point needs to be known. Unnormalized data values range from -2048 to +2047 regardless of any front panel setting. Normalization allows data values to be converted into voltages, and addresses into time values. "Standard" normalization reflects the original front panel settings during signal acquisition. "Reset" normalization values come into existence when the front panel function RESET is used. RESET causes the zero time, zero voltage location to be changed on the display thus requiring new normalization. Standard and reset normalization data exist for every waveform in memory. If RESET has not been used, standard normalization will be found in both standard and reset locations in memory.

The maximum number of waveforms that can be stored in memory at one time is eight (2 channels x 4 quarters). Because of this, a total of eight standard normalization "sets" and eight reset normalization "sets" are stored in memory. A "set" contains all the normalization information required for a single waveform. If fewer than eight waveforms are stored in memory then some of the normalization sets will be duplicates. When inputting normalization sets, all eight sets (eight standard or eight reset) must be sent to the 2081, even if they are duplicates.

A Single Normalization "Set"



b = blank space = +

Note: A single normalization set contains 27 ASCII characters.

1. V-Norm?, H-Norm? — If "1" then data normalization has occurred. If "0" then data is not normalized. Normally these will be "1" for all normalizations sets. Use of external address advance would cause H-Norm ? to be "0".

2. Memory Fraction — The increment needed to find the next point on a given waveform in memory. This varies depending on the position of the MEMORY switch during signal capture and the number of channels used. To calculate the memory fraction:

(M) x (no. of channels used) = Mem. Fraction

MEMORY Switch	M
All	1
1H or 2H	2
Q1, Q2, Q3, Q4	4

Note: (4094 points) x $\left(\frac{1}{\text{Mem. Fraç.}}\right)$ = no. of points per waveform

3. V-Zero — The data value (a number between -2048 and +2047) where zero voltage is located. This is always 0000 for standard normalization. Use of RESET would allow this to range from -2048 to +2047 for reset normalization only.

4. H-Zero — Similar to V-Zero except that it relates to the horizontal zero time location ranging from 0000 to 4095. Use of cursor triggering could give a non-zero value for H-Zero in standard normalization sets.

5. V-Norm — Equal to the voltage between data point values when the waveform was captured.
Example: The voltage between +0000 and +0001. If a given data point value (-2048 to +2047) is multiplied by V-Norm the result will be the actual voltage at that point. The data value (V-Zero) where voltage equals zero should be taken into account when using reset normalization. The DC LEVEL knob may have to be adjusted to position ground potential at 0000 if the data values are supposed to represent the voltage from ground. The letter "e" precedes the exponent value. V-Norm is related to the voltage range setting on the front panel.

$$\text{V-Norm} = \frac{\text{Voltage range setting}}{2000}$$

6. H-Norm

Equal to the front panel TIME PER POINT setting (in seconds) when the waveform was captured. Addresses multiplied by H-Norm will yield the actual time at that location. The address location (H-Zero) where time equals zero should be taken into account. Use of cursor triggering will result in a time = zero somewhere other than at address 0000. The letter "e" preceeds the exponent value.

Input/Output Manipulation (continued - Delimiters)

EØ - CR/LF	Delimiter used will be carriage return/ line feed.
E1 - CR	Delimiter used will be carriage return only.
E2 - CR/LF (once)	The carriage return/line feed delimiter will follow only the last data point transferred. This delimiter does not apply to normalization data.
E3 - CR (once)	The carriage return delimiter will follow only the last data point transferred. This delimiter does not apply to normalization data.

Delimiters are ASCII characters which show the end of a group of ASCII characters. By looking for delimiters the controlling computer is able to spot groups of ASCII characters that belong together (such as the five ASCII characters +2047). Two delimiters, carriage return (CR) and carriage return/line feed (CR/LF), are used by the 2082. The receiving computer must be able to correctly interpret these characters or problems will result. The delimiter which will be used, unless otherwise specified, is CR/LF.

Innnn - Input

All commands in which data of any sort is sent into the 2082 must include Innnn to specify the total number of transfers. An address followed by a data point counts as two transfers. Therefore, commands D1 and D3 must have nnnn equal to twice the number of data points transferred.

Example: I0001 - one data point or one normalizing set is transferred.

Onnnn - Output

Commands which result in the 2082 sending out data must include Onnnn to specify the total number of transfers. An address sent out followed by a data point counts as two transfers. Therefore, commands D1 and D3 must have nnnn equal to twice the number of data points tranferred. Commands D4 and D5 do not require Onnnn.

Example: O0001 - one data point or one normalizing set is tranferred.

Input/Output Termination

After completing an operation, the 2082 sends out the ASCII character "|", a status character, and a delimiter. Immediately following transmission of the delimiter the I/O ACTIVE light will turn off and communications will cease. A new SOH must be issued for the interface to turn back on.

The status character is an ASCII character which gives status information after being translated into its binary form. The termination status character is defined the same as the status character given by command D4.

Status Bits

2^6	2^5	2^4	2^3	2^2	2^1	2^0
1	0	Request Service	Disk Error	Interface Error	Disk Active	Live

1. Request Service = 1 when the following situations occur:
   a. Plug-in goes out of LIVE
      (Excluding sweep abort by command H2)
   b. Autocycle initiated by H3 is completed.
   c. Disk recall, store, or track selection initiated by Rn, Sn, or Tn is completed.
2. Disk Error, Disk Active, and Live indicate the actual state of the indicator lights on the front panel. Light ON = 1.
3. Interface Error = 1 indicates that the communication was terminated prematurely due to an error. If interface errors are consistently present, the start-up procedure was probably completed incorrectly.

Non-Error Termination Results From:

1. Input ETX to the 2082.
2. Completion of a requested operation.

Error Termination Results From:

1. Start-up procedure error.
2. Any characters sent after commands LØ, Hn, Tn, Rn, or Sn except ETX. These commands cannot be chained together with other commands.
3. Use of commands LØ, Hn, or Tn while the disk recorder is active.
4. Use of commands Rn, Sn, Innnn, Onnnn, or STX when the disk recorder is active or the Plug-in is in LIVE.
5 Receiving a character containing a parity error, if parity check is turned on (switch 5 inside 2082 cover).

COMMAND EXAMPLES

The following examples illustrate command sequences necessary for useful RS-232C interfacing. It is not intended to show all possible combinations of commands for all applications. Instead, these examples should be used along with the written explanations on pages XI-10 through XI-27 to put together a complete understanding of command usage. These examples are not computer programs but merely show what communications the actual computer programs must guide.

A. SOH
LØ
ETX

Plug-in goes into LIVE.

B. SOH
R6

Disk track 6 is recalled.

Note: Plug-in must be in HOLD LAST.

C. SOH
EØ
D1
DØ
OØØ1Ø
STX

The first ten data point values (addresses +ØØØØ through +ØØØ9) are sent out by the 2082 with a CR/LF delimiter between each value.

D. SOH
EØ
DØ
OØØ1Ø
STX

Ten data point values are sent out by the 2082. If command sequence C was just completed then the ten data points will be from addresses +ØØ10 through +ØØ19. The address counter was left on +ØØ1Ø by sequence C. If the oscilloscope was just powered up the ten data points transferred will be any ten sequential data points chosen at random.

E. SOH — Ten data point values (addresses +ØØØØ through +ØØØ9) encoded in printable binary are sent out by the 2082.

EØ
D3
D2
OØØ1Ø
STX

F. SOH — A total of ten data point values are sent out by the 2082 for the ten addresses sent to the 2082. Immediately after each address is sent to the 2082 the data point will be transmitted. The next address should not be sent to the 2082 until the data point is fully transmitted and received.

EØ
D1
OØØ2Ø
STX

Data Addresses:

+ØØØØ CR/LF
+ØØØ1 CR/LF
+ØØØ2 CR/LF
.
.
.
.
+ØØØ9 CR/LF

G. SOH — The first (addresses +ØØØØ through +ØØØ9) ten data points shown on the oscilloscope screen are changed to the data values sent to the 2082. Note that the specified delimiter follows each transmitted data point.

```
        E1
        D1
        DØ
        IØØ1Ø
        STX
Data    +ØØØØ CR
Values  +ØØ1Ø CR
        +ØØ2Ø CR
        +ØØ3Ø CR
          .
          .
          .
          .
        +ØØ9Ø CR
```

H. SOH — All eight standard normalizing sets are sent out by the 2082.

```
        EØ
        N1
        OØØØ8
        STX
```

I. SOH — All eight reset normalizing sets are sent out by the 2082.

```
        EØ
        N2
        OØØØ8
        STX
```

NIC-2085N INTERFACE

I. Description

The Nicolet 2085N option allows exchange of data between the Nicolet 2090-3A or 3C and the Hewlett-Packard 9825A, 9835 and 9845 desk top computers. Data can be transferred using different methods which include high speed, one word at a time, addressed or auto addressing.

II. Desk Top Computer Requirements

The minimum requirement for the HP-9825A is the HP-98212A Plotter - General I/O ROM. This does not allow transferring all of the 2090-3 memory into the HP-9825A. In order to transfer all of the 2090-3 memory and using high speed transfers, the following are required on the HP-9825A: Option 001, 8192 bytes of memory (15036 bytes total); 98210A, String-Advanced Programming ROM; 98213A, General I/O-Extended I/O ROM.

The System 35 (9835A or B) minimum requirement is the 98332A General I/O ROM.

The System 45 (9845A or B) minimum requirement is the 09845-65518 and 09845-65519 I/O ROMS.

III. Operation

This test assumes a 98032A select code of 4. Examples use the HP-9825A language, unless noted. In the examples the HP-9825A assignment operator is shown as a right bracket. An example is

0}A.

A. Addressing Modes

1. Advance Address

This mode is activated with a **wtc 4,34**, command. When this command is executed the I/O address count is set to zero. The first data point transferred will be located at the left edge of the 2090 display screen. After each transfer the I/O address counter is advanced to the next data point shown on the display screen.

2. Load Address

This mode is activated with, **wtc 4,34;wtc 4,35**, commands. When these commands are executed the first data sent to the 2085N will be interpreted as a memory address and the second as a data point. This pattern is continued until the data transfer is complete.

When the address is sent from the computer to the 2090, the address must be multiplied by 2; **wtb 4,2A**.

Write Control (wtc) Table

wtc 4, value	2085N
35	load address
34	advance address
33	plug-in "Live"
32	plug-in "Hold Next"
0	idle

Load Address Value Table

Memory Group	Start Address	Address Increment	End Address
ALL	-2048	1	2047
H1	-2048	2	2046
H2	-2047	2	2047
Q1	-2048	4	2044
Q2	-2047	4	2045
Q3	-2046	4	2046
Q4	-2045	4	2047

When the data transfers are complete a **wtc 4,0** should be executed to tell the 2090 that the I/O operation is finished. This action also extinguishes the I/O ACTIVE LED. If the unit is a 2090-3C, the floppy disk will not operate unless the I/O ACTIVE LED is off.

B. Read Status

This allows the computer to check the status of the plug-in, i.e., to "see" if it is in "Live" or "Hold" and also to check the status of the disk, i.e., to "see" if it is doing an operation. The following table shows the values received when a **rds(4)** is done in the 9825A.

rds(4) value	Plug-In 'Live"	Disk "Active"
288	no	no
289	yes	no
32	no	yes
33	yes	yes

C. <u>Data Format</u>

Data and normalization are transferred together as one word. The 2090 12-bit data word is the top 15 bits of the 98032A. The top 4 bits of the 98032A are the 2090 sign bit. The 2090 normalization bit is the LSB of the 98032A.

When data only is needed, the data word placed into the calculator must be divided by 2. This procedure gets rid of the normalization bit; **int(.5rdb(4))}D**.

2090 - 98032A Format Table

	MSB															LSB
98032A Data Bits	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
2090 Data Bits	11	11	11	11	10	9	8	7	6	5	4	3	2	1	0	N

N = Normalization bit

D. <u>Normalization</u>

Before reading further, read the following section of this manual:

DIGITAL I/O; Section C.3; DATA, ADDRESS & NORMALIZATION FORMAT, Normalization; pages VII-7 through VII-14

A good understanding of the above section of the manual will help in the understanding of what follows.

A note of caution at this point. Whenever data is read from the 2090, it must be placed back into the 2090 with normalizing. The data may be changed to reflect a mathematical result. If the normalization is not placed back in the 2090 correctly, erroneous results may appear on the 2090 time and voltage readout. Various sample programs will follow that show how to operate with the normalization.

In order to operate with normalizing on the HP-9825A, the General I/O-Extended I/O ROM must be installed. The **shf** (shift) and **rot** (rotate) functions are used, which are obtained from the Extended I/O ROM command subset.

1. Normalization Read

The normalization is read in as you would read in data. The normalization bit must be stripped off the data word. Different ways of doing this are:

```
shf(shf(rbd(4),-15),15)
rdb(4)mod2
shf(shf(itf(X$[I,I+1]),-15),15)
```

Example a) shifts out the 15 data bits. The **rbd(4)** brings in the data from the 2090.

Example b) uses the remainder of a divide to get the normalization bit.

Example c) is like a), but the data were brought in previously using the buffered I/O. Buffered I/O is explained later in the samples.

After the normalization bit is extracted it must be placed somewhere in order to build up the complete array of normalization N-Sets. A good place is to store the N-sets into an array. In this example and other examples the array **B[2,4,8]** will be used. The array is defined as follows:

first variable - (X will be used in this position)

1 - Original normalization.

2 - Reset numbers normalization.

second variable (Y will be used in this position)

1 - HNORM; Horizontal normalization.

2 - VNORM; Vertical normalization. Value is in volts per level, not the range value indicated on the switch.

3 - HZERO; Binary value of where trigger occurred or the value of the Horizontal cursor position when Reset Numbers was executed.

4 - VZERO; Binary value of where the voltage baseline is or the value of the Vertical cursor position when Reset Numbers was executed.

third variable (Z will be used in this position)

This number indicates which N-Set is being used. The maximum number of N-Sets is 8. The minimum number of N-Sets needed is 1.

The following is an example of how to transfer normalization from the 2090 to the HP-9825A.

```
0: fxd 0;wtc 4,34;wtc 4,35;0}A;dim B[2,4,8]
1: for X=1 to 2;for Y=1 to 4;for B=1 to 16;for Z=1 to 8
2: wtb 4,2A;ior(shf(rdb(4),-15),B[X,Y,Z])}B[X,Y,Z];A+1}A
3: if B#16;rot(B[X,Y,Z],1)}B[X,Y,Z]
4: if B=16;if Y=3 or Y=4;shf(shf(B[X,Y,Z],-4),4)}B[X,Y,Z]
5: if B=16;if Y=3 or Y=4;if B[X,Y,Z]>2047;-4096+B[X,Y,Z]}B[X,Y,Z]
6: next Z;next B;next Y;next X;wtc 4,0
*24907
```

Program Comments:

Line 0 - Sets fixed format, dimensions the B array, enables the 2090 load address transfer mode and the beginning address for normalization transfer.

Line 1 - Sets the for/next loops in order to transfer the norm bit into the array. Variable B is used to keep track of which bit of a N-Set is being transferred.

2 - Writes the address (A) to the 2090. Reads the data from the 2090, gets shifted so that the norm bit is in the sign bit position. This procedure allows building up of the norm N-Set. As each bit is shifted into place, it is inclusive ORed with the corresponding N-Set. The address in incremented by 1.

3 - If the last bit of the N-Set has not been read, shift the N-Set so that the next N-Set bit may be added.

4 - If the last bit of the N-Set has been transferred and the N-Set is HZERO or VZERO, shift out the top four bits to eliminate any false bits that may arrive from the 2090. False norm bits do not affect the 2090.

5 - If the last bit of the N-Set has been transferred and the N-Set is HZERO or VZERO and the N-Set is greater than 2047, add -4096 to the N-Set to correct for the sign bit to make the N-Set into a two's complement number.

6 - Do the next N-Set, do the next bit, do the next N-Set type, do Reset numbers next. When done, reset the 2085N and turn off the I/O ACTIVE LED.

When this program is completed, the array will contain all the possible N-Sets. But the values in the array variable Y= 1 or 2 will be a binary encoded equivalent of HNORM and VNORM.

The binary values must be converted to a floating point value that the computer can use to calculate time and voltage values from the data that are read. For this another array is created. The new array will be **N[2,3,8]**. The array is defined as follows: (X, Y & Z will be used here also.)

first variable

1 - Original normalization

2 - Reset numbers normalization

second variable

1 - HNORM

2 - VNORM

3 - Memory fraction

third variable

Number of the N-Set being used.

Another value that must be converted from the binary value in the B array is the memory fraction. The N array is similar to the B array, so that easy conversion from one array to another is possible. The only exception is the memory fraction. But for conversion, Y in the B array is always 1 and Y in the N array is always 3.

The following is an example of how to convert the B array into the N array:

```
0: dim N[2,3,8]
1: for X=1 to 2;for Y=1 to 2;for Z=1 to 8
2: shf(shf(B[X,Y,Z],-6),12)→B;int(B/4)-Bmod4→P;2^P→M
3: shf(shf(B[X,Y,Z],-10),10)→D
4: Mtn^(-3int(D/16)+int(Dmod16/4)-Dmod4)→N[X,Y,Z]
5: if B[X,Y,Z]<0;0→N[X,Y,Z]
6: next Z;next Y;next X
7: for X=1 to 2;for Z=1 to 8;2^shf(shf(B[X,1,Z],-4),14)→N[X,3,Z]
8: next Z;next X
*27124
```

Program comments:

Line 0 - Dimension the N array

1 - Set up for/next loops.

2 - Shifts the array that the N9, N8, N7, N6 bits are in the 4 LSBs. N9, N8 has N7, N6 subtracted from it so that a power is left over. Two is raised to the power (P) to create the multiplier (M). The mod (modulus) command is used to get the remainder portion of a division.

3 - Shifts the array so that the N5, N4, N3, N2, N1, N0 bits are in the 6 LSBs. The shifted result is placed in the register called "decade" (D).

4 - This line takes -3 times the binary value of N5, N4; adds the value of N3, N2 then subtracts the value of N1, N0. Integer (int) and modulus (mod) are used instead of shifting as less programming is required to obtain the results. A careful study of the N positioning and this program line will show how the 3 binary values are obtained. M is then raised to the power of ten using the result computed earlier in this line. That total result is placed into the N array. The value in the N array is now an understandable number which can be used by the computer.

5 - If the binary value of HNORM or VNORM is less than 0, the value for H or VNORM was not normalized in the 2090. A 0 is placed into the N array to indicate a not normalized value.

6 - Next set of values.

7 - Set for/next loop to convert the memory fraction value. N11, N10 is shifted so that the bits are in the 2 LSBs. Since the binary value of N11, N10 is only the power of 2, 2 is raised to the shifted value to get the memory fraction value.

8 - Next set of values.

2. Using the Normalization with Data

After the normalization arrays are built from the raw normalization bits, they can be used with the data to tabulate actual time and voltage values instead of binary values.

Since there can be 8 different N-Sets, it must be determined which N-Set to use with a particular data point. Under normal operating conditions, the selection process is simple. If ALL of memory, single channel, is being used, only one N-Set has to be used. All 8 N-Sets will be the same. If 2 channel ALL was used, only 2 N-Sets are used; i.e., N-Set #1 and 2. But it is possible to get a N-Set configuration that may not make any sense. This possibility arises when different sections of memory were updated when a larger memory was used initially and a smaller unit of memory was used for new data. The memory address is used for determining which N-Set to use for a particular data point.

If data are read into the computer and that data value is operated on immediately and that result is sent to a logging device (printer, etc.) an address scheme of 0 through 4095 can be used to determine the time value of the data point and can be used to determine which N-Set to use.

The time value is determined by taking the data point location, dividing it by 8 then add 1 to the remainder result, i.e., **Amod8+1}Z.** A is the address value and Z will be the N-Set variable. The HNORM value is now located in **N[X,1,Z]**. The X variable will be 1 or 2 depending on if you want the Original or Reset Numbers normalization values. Now that the HNORM value has been located, it is multiplied by the integer of the address divided by the memory fraction. The memory fraction is located in **N[X,3,Z]**. The time number is now equal to this equation:

```
N[X,1,Z](int(A/N[X,3,Z]))
N[X,1,Amod8+1](int(A/N[X,3,Amod8+1]))
```

The voltage can now be determined as the Z value has already been determined. The read data point is now multiplied by the VNORM value which is located in the array value **N[X,2,Z]**. The data value can be computed with the following equation.

```
N[X,2,Z](int(.5rdb(4)))
N[X,2,Amod8+1](int(.5rdb(4)))
```

If all of the 2090 memory is to be stored in the computer, it is suggested (especially for the HP-9825A) that the data be stored in integer form. Examples of storing integer data are shown later. To determine the address time value of an integer value, use the following equation: (I = for/next loop register value).

int((I-1)/2)}A (A will equal 0 through 4095)

When 1H or 2H memory is used, the 0 to 4095 addressing scheme is still used, but instead of incrementing each point by 1, increment by 2. If Q1, Q2, Q3 or Q4 are used, increment by 4.

3. Normalization Write

When data are read from the 2090 and later written back into the 2090, the normalization must be written as well or unpredictable results will be obtained on the 2090 time and voltage display.

If the data were stored into the computer and care was used so that the normalization bit of each data word was not lost, the data in the stored file can be written back to the 2090 without any problems. When the data in the file are operated on and the results are placed back in the same or a different file, it would be a good practice to keep the normalization bit for that particular data word intact.

If the normalization bit was lost, the normalization arrays must be structured for regenerating the normalization bit. If the B array was left intact, the only conversion needed is to make the top 4 bits of HZERO and VZERO equal to 0. That is accomplished using the following program:

```
0: for X=1 to 2;for Y=3 to 4;for Z=1 to 8
1: shf(shf(B[X,Y,Z],-4),4)}B[X,Y,Z]
2: next Z;next Y;next X
*1925
```

Program comments:

Line 0 - Set up for/next loop for HZERO and VZERO.

1 - Shift out the top 4 bits.

2 - Next word of array.

If the B array was damaged or changed so that the values for HNORM and VNORM are no longer valid, or if user values of H or VNORM are needed, the B array must be reconstructed. The N array is used for this prupose. The floating point numbers in the N array must be converted into the binary form that is used by the 2090. The following program is used to do the conversion.

```
0: dim W$[10]
1: for X=1 to 2;for Y=1 to 2;for Z=1 to 8;flt 1;str(N[X,Y,Z])}W$;fxd 0
2: if N[X,Y,Z]=0;-1}B[X,Y,Z];gto "next"
3: val(W$[1,4])}M;val(W$[6,8])}E;if M>2;.1M}M;E+1}E
4: log(M)/log(2)}P;0}B[X,Y,Z];if Y=1;1024(log(N[X,3,Z])/log(2))}B[X,Y,Z]
5: if P=1;256+B[X,Y,Z]}B[X,Y,Z]
6: if P#1;64abs(P)+B[X,Y,Z]}B[X,Y,Z]
7: if E>0;4E+B[X,Y,Z]}B[X,Y,Z]
8: if E<0;16int(abs(E)/3)+abs(E)mod3+B[X,Y,Z]}B[X,Y,Z]
9: "next":next Z;next Y;next X
*19976
```

Program comments:

Line 0 - Dimensions W$ for use later.

1 - Sets up for/next loop. Stringing the N array into W$ allows the easy retrieval of the digits of the floating points number.

2 - If the N array is equal to 0, a non-normalized value was obtained. Placing -1 into the B array sets the not normalized bits of the word so that the 2090 will not normalize the display for this N-Set. Also skips the rest of the conversion.

3 - The multiplier is placed in M. The exponent is placed in E. If M is greater than 2, divide M by 10 and add 1 to E. M must be .5, 1 or 2 only.

4 - Turn M into a Power (P) of 2 for 2090 use. Clear out the B array. If HNORM is being converted, change the memory fraction into a power of 2 and place the result in bits N11 and N10. This result could have been shifted, but the multiplication by 1024 has the same result.

5 - If the power equals 1, add 256 (N8) to the B array.

6 - If the power is other than one, add 64 times the absolute value of P (N7, N6) to the B array.

7 - If the exponent is greater than 0, add 4 times E (N3, N2) to the B array.

8 - If the exponent is less than 0, add the following results to the B array: 16 times the integer of the absolute of E divided by 3 (N5, N4); the remainder of the absoluite value of E divided by 3 (N1, N0).

9 - Next set of values to be converted.

Once the B array has been converted, the data and normalization can be written into the 2090. If the data have already been written into the 2090, the following program shows how to add the normalization bits to that data:

```
0: wtc 4,34;wtc 4,35;0}A
1: for X=1 to 2;for Y=1 to 4;for B=-15 to 0;for Z=1 to 8;wtb 4,2A
2: shf(shf(rdb(4),1),-1)+shf(shf(B[X,Y,Z],B),15)}D;wtb 4,2A;wtb 4,D
3: A+1}A;next Z;next B;next Y;next X;wtc 4,0
*26192
```

Program comments:

Line 0 - Sets to load address mode and initializes the address register with the start address of normalization.

1 - Sets up for/next loops to transfer the N-Set bits. B will be used to keep track of which bit is being sent and how much shifting is required to get that bit. The address is also written to the 2090.

2 - The data are read from the 2090, the old normalization bit is shifted out and that result is added to the new shifted bit of normalization. The new normalization bit is shifted into the LSB with the other 15 bits equal to 0. The result is placed in the data register (D). The address is re-sent to the 2090, then the data with the new normaling are written to the 2090.

4 - The address is incremented. The next N-Set bit is sent out. When completed, the I/O ACTIVE LED is turned off.

E. Data Without Normalization

If the data are to be used without the normalization, the data are read using the following program statement:

```
int(.5rdb(4))
```

If the data are to be written into the 2090 without normalization, the following program statement would be used:

`wtb 4,2D` where D = data word

When the above program statement is used, the 2090 will display 1 second per point and 1 volt per level (2000 v. range). Time 0 will be in the center of the screen.

If a program was written using the read-alter-write technique the normalization bit can set a flag which is used later to reconstruct the normalization. Shown below is a method of using read-alter-write:

```
0: cfg 0;rdb(4)}D;if Dmod2=1;sfg 0
1: int(.5D)}D;int(.1D)}D
2: wtb 4,2D+flg0
*5966
```

The above example divides the data (D) by 1/10.

F. Sample Programs For HP-9825A

The sample programs shown below assume a 98032A select code of 4 and a Memory Group of "ALL".

1. This program shows how to store all 4096 data points in the calculator using a string variable as a fast read/write buffer. This program also can be used to record waveforms on tape or load them from the tape cartridge back into the 2090. To transfer the waveform to the calculator press "RUN". The waveform is now in the string variable Y$ and it can be recorded on tape. Press the ERASE pushbutton on the 2090 and then press "CONTINUE" on the calculator. This step brings back a stored waveform from the calculator.

To load a waveform from the tape cartridge into the 2090-3, press "RUN" and then load the string variable, Y$, with the data points from the tape. Then press "CONTINUE" and the recorded waveform will appear on the screen of the 2090-3.

Enter the following program into the 9825A:

```
0: dim Y$[8208]
1: buf "data",Y$,2
2: eir 4,34
3: tfr 4,"data",4096
4: wtc 4,0;stp
5: eir 4,34
6: tfr "data",4,4096
7: wtc 4,0;end
*19497
```

Program comments:

This section reads the data from the 2090-3.

Line 0 - Dimension a string variable, Y$, for 8208 bytes. This is for 4096 16-bit words plus 16 bytes of overhead for the fast read/write buffer.

1 - Allocate a buffer called "data" which has also been dimensioned as a string variable, Y$. The 2 stands for the type of buffer, i.e., a fast read/write buffer with a data format of 16-bit words.

2 - Activate advance address mode. "eir" is used instead of "wtc" because the "tfr" statement will reset the "wtc" to zero.

3 - Transfer 4096 data points from the I/O card with select code 4 to a buffer called "data".

4 - Set idle mode for 2085N and stop program.

This section writes the data into the 2090-3 when "CONTINUE" is pressed.

5 - Activate advance address mode.

6 - Transfer 4096 data points from a buffer called "data" to an I/O card with select code 4.

7 - Set idle mode for 2085 and end program.

2. This program stores all 4096 data points and has the same features as program "1", listed above, but this program uses the binary read and write statements for data transfer.

Enter the following program into the 9825A:

```
0: dim X$[8192]
1: wtc 4,34
2: for I=1 to 8192 by 2
3: rdb(4)}N
4: fti (N)}X$[I,I+1]
5: next I
6: wtc 4,0;stp
7: wtc 4,34
8: for I=1 to 8192 by 2
9: wtb 4,itf(X$[I,I+1])
10: next I
11: wtc 4,0;end
*29623
```

Program comments:

This section reads the data from the 2090-3.

Line 0 - Dimension X$

1 - Set advance address mode.

2 - Set up a for/next loop for 4096 data points read a data point from 2090-3 into N.

3 - Read the binary data from I/O card 4 to register N.

4 - Convert the number in N from full precision to integer precision and store the two-byte number in the string X$, at locations I and I + 1.

5 - End of the for/next loop.

6 - Set 2085N to idle and stop program.

This section writes the data into the 2090-3 when "CONTINUE" is pressed.

7 - Set advance address mode.

8 - Set up for/next loop.

9 - Convert the integer stored in the string X$, at the location I and I + 1 back to full precision. Write that data point into the 2090-3.

10 - End of the for/next loop.

11 - Set 2085N to idle and end program.

3. This program divides the waveform in Q3 by 2. It also shows how to use the load address mode.

Enter the following program into the 9825A:

```
0: wtc 4,34;wtc 4,35
1: for I=-2046 to 2047 by 4
2: wtb 4,2I
3: cfg 0;rdb(4)}D;if Dmod2=1;sfg 0
4: wtb 4,2I;int(.5D)}D
5: wtb 4,2int(.5D)+flg0
6: next I
7: wtc 4,0;end
*29388
```

Program comments:

Line 0 - Set load address mode.

1 - Set up for/next loop so I will only address Q3.

2 - Write address to 2085N.

3 - Read data point from 2085N and sfd 0 if norm bit = 1.

4 - Write address to 2085N and get rid of norm bit,

5 - Multiply data point by ½ and write the result into 2085N. The norm bit is added to the result.

6 - End of for/next loop.

7 - Set 2085N to idle and end program.

G. Test Programs for HP-9825A

1. The following is a program that reads the normalization, prints the N-Sets on a printer and then sends the normalization back to the 2090. A select code of 2 is used for the printer. A printer is required to run this program.

After the program listing is an example of the printout.

```
0: wti 0,2;wti 6,1;wtc 2,1;wtb 2,39;wtc 2,0
1: dim W$[10],B[2,4,8],N[2,3,8]
2: "*****This section reads the Normalization":
3: fxd 0;wtc 4,34;wtc 4,35;0}A
4: for X=1 to 2;for Y=1 to 4;for B=1 to 16;for Z=1 to 8
5: wtb 4,2A;ior(shf(rdb(4),-15),B[X,Y,Z])}B[X,Y,Z];A+1}A
6: if B#16;rot(B[X,Y,Z],1)}B[X,Y,Z]
7: if B=16;if Y=3 or Y=4;shf(shf(B[X,Y,Z],-4),4)}B[X,Y,Z]
8: if B=16;if Y=3 or Y=4;if B[X,Y,Z]>2047;-4096+B[X,Y,Z]}B[X,Y,Z]
9: next Z;next B;next Y;next X;wtc 4,0
10: "*****This sections converts the binary normalization":
11: "*****  to floating points numbers":
12: for X=1 to 2;for Y=1 to 2;for Z=1 to 8
13: shf(shf(B[X,Y,Z],-6),12)}B;int(B/4)-Bmod4}P;2^P}M
14: shf(shf(B[X,Y,Z],-10),10)}D
15: Mtn^(-3int(D/16)+int(Dmod16/4)-Dmod4)}N[X,Y,Z]
16: if B[X,Y,Z]<0;0}N[X,Y,Z]
17: next Z;next Y;next X
18: for X=1 to 2;for Z=1 to 8;2^shf(shf(B[X,1,Z],-4),14)}N[X,3,Z]
19: next Z;next X
20: "*****This section prints the normalization":
21: wrt 2,".....";fmt 1,5/,c50,3/;wrt 2.1,"2090 NORMALIZATION PRINTOUT"
22: wrt 2,"ORIGINAL NUMBERS";wrt 2;-2048}A
23: for X=1 to 2;cll 'Heading'
24: for Z=1 to 8;fmt 3,c7,c10,z;fmt 4,c16,c18,z;fmt 5,3c7
25: wrt 2.3,str(A),str(Z);flt 1
26: wrt 2.4,str(N[X,1,Z])&" s/pt",str(N[X,2,Z])&" v/level";fxd 0
27: wrt 2.5,str(B[X,3,Z]),str(B[X,4,Z]),str(N[X,3,Z])
28: A+1}A;next Z;if X=1;fmt 5,3/,c,/;wrt 2.5,"RESET NUMBERS"
29: -2048}A;next X;fmt 5,9/;wrt 2.5
30: wrt 2,"Data Address is the beginning address for data."
31: wrt 2,"If HNorm or VNorm = 0.0e 00, that Norm value was not normalized."
32: wrt 2,"Memory Fraction indicates how much to add to the address."
33: wrt 2,"  The next address must have the same Memory Fraction"
34: wrt 2,"  or incorrect data will result.";wrt 2
35: "*****This section clears the normalization in the 2090":
36: wtc 4,34;wtc 4,35;for A=0 to 1023;wtb 4,2A
37: shf(shf(rdb(4),1),-1)+1}N;wtb 4,2A;wtb 4,N;next A;wtc 4,0
38: "*****This section computes the norm N-Sets":
39: for X=1 to 2;for Y=1 to 2;for Z=1 to 8;flt 1;str(N[X,Y,Z])}W$;fxd 0
40: if N[X,Y,Z]=0;-1}B[X,Y,Z];gto "next"
```

```
41: val(W$[1,4])}M;val(W$[6,8])}E;if M>2;.1M}M;E+1}E
42: log(M)/log(2)}P;0}B[X,Y,Z];if Y=1;1024(log(N[X,3,Z])/log(2))}B[X,Y,Z]
43: if P=1;256+B[X,Y,Z]}B[X,Y,Z]
44: if P#1;64abs(P)+B[X,Y,Z]}B[X,Y,Z]
45: if E>0;4E+B[X,Y,Z]}B[X,Y,Z]
46: if E<0;16int(abs(E)/3)+abs(E)mod3+B[X,Y,Z]}B[X,Y,Z]
47: "next":next Z;next Y;next X
48: for X=1 to 2;for Y=3 to 4;for Z=1 to 8
49: shf(shf(B[X,Y,Z],-4),4)}B[X,Y,Z]
50: next Z;next Y;next X
51: "*****This section writes the normalizing":
52: wtc 4,34;wtc 4,35;0}A
53: for X=1 to 2;for Y=1 to 4;for B=-15 to 0;for Z=1 to 8;wtb 4,2A
54: shf(shf(rdb(4),1),-1)+shf(shf(B[X,Y,Z],B),15)}D;wtb 4,2A;wtb 4,D
55: A+1}A;next Z;next B;next Y;next X;wtc 4,0
56: dsp "********* PROGRAM DONE *********";end
57: "Heading":fmt 2,c,c7,c11,c17,c11,c7,c10
58: wrt 2.2,"Data Address","N-Set","HNorm","VNorm","HZero","VZero","Fraction"
59: ret
*24912
```

A copy of this program may be obtained from NICOLET. See the section, Obtaining Test Programs for the HP-9825A.

2090 NORMALIZATION PRINTOUT

ORIGINAL NUMBERS

Data Address	N-Set	HNorm	VNorm	HZero	VZero	Fraction
-2048	1	5.0e-07 s/pt	5.0e-05 v/level	-2048	0	8
-2047	2	1.0e-06 s/pt	1.0e-04 v/level	-1231	0	8
-2046	3	2.0e-06 s/pt	2.0e-04 v/level	-150	0	8
-2045	4	5.0e-06 s/pt	5.0e-04 v/level	755	0	8
-2044	5	5.0e-07 s/pt	1.0e-03 v/level	-2048	0	8
-2043	6	1.0e-06 s/pt	2.0e-03 v/level	-1231	0	8
-2042	7	2.0e-06 s/pt	5.0e-03 v/level	-150	0	8
-2041	8	5.0e-06 s/pt	1.0e-02 v/level	755	0	8

RESET NUMBERS

Data Address	N-Set	HNorm	VNorm	HZero	VZero	Fraction
-2048	1	5.0e-07 s/pt	5.0e-05 v/level	-888	319	8
-2047	2	1.0e-06 s/pt	1.0e-04 v/level	-55	319	8
-2046	3	2.0e-06 s/pt	2.0e-04 v/level	878	319	8
-2045	4	5.0e-06 s/pt	5.0e-04 v/level	1319	319	8
-2044	5	5.0e-07 s/pt	1.0e-03 v/level	-888	319	8
-2043	6	1.0e-06 s/pt	2.0e-03 v/level	-55	319	8
-2042	7	2.0e-06 s/pt	5.0e-03 v/level	878	319	8
-2041	8	5.0e-06 s/pt	1.0e-02 v/level	1319	319	8

Data Address is the beginning address for data.
If HNorm or VNorm = 0.0e 00, that Norm value was not normalized.
Memory Fraction indicates how much to add to the address.
The next address must have the same Memory Fraction
or incorrect data will result.

2. The following program can be used to test the 2090-3 and the 2085N. This program will write a 4K ramp into the 2090-3, then read it back to see if it was stored correctly or if there are any bit errors. If any bit errors appear, it will print which bit is in error, then it will continually write the 4K ramp so that the bad bit may be found and corrected. If no errors are found, the program will stop.

Enter the following program into the 9825A:

```
0: dim E$[13]
1: fxd 0;dsp "NIC-2085N READ/WRITE TEST"
2: cfg 3;wtc 4,34;for I=-2048 to 2047;2I}D;if Imod2;D+1}D
3: wtb 4,D;next I
4: wtc 4,34;0}E
5: for I=-2048 to 2047;rdb(4)}J;band(J,8191)}J;2I}D;if Imod2;D+1}D
6: band(D,8191)}K;if K#J;ior(eor(J,K),E)}E
7: next I;if E#0;sfg 3
8: for I=12 to 0 by -1
9: if E>=2^I;E-2^I}E;"1"}E$[abs(I-13),abs(I-13)];jmp 2
10: "0"}E$[abs(I-13),abs(I-13)]
11: next I;prt "BAD BITS ARE 1","","11","109876543210N";spc 1
12: prt E$;spc 3;if not flg3;wtc 4,0;end
13: wtc 4,34;for I=-2048 to 2047;2I}D;if Imod2;D+1}D
14: wtb 4,D;next I;jmp -1
*4035
```

H. Obtaining Test Programs for the HP-9825A.

A copy of the test programs for the HP-9825A and the NIC-2085N will be copied free of charge if a blank HP-9825A data tape is sent to:

NICOLET INSTRUMENT CORPORATION
MANUFACTURING ENGINEERING MANAGER
OSCILLOSCOPE DIVISION
5225-2 VERONA ROAD
MADISON, WI 53711

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