Standard Program Package
For 4094 Digital Oscilloscopes
Operation Manual

Nicolet
INSTRUMENTS OF DISCOVERY

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INTRODUCTION

The programs are alphabetically prerecorded on the program diskette. These programs enable the operator to easily perform arithmetic and display manipulations, and are designed for used with the optional F-43 and/or XF-44 Disk Recorders.

The programs contained on this diskette can be duplicated when the XF-44/2 External Disk Recorder is used in conjunction with the DISKETTE COPY program. (Refer to the Dual Disk Recorders section of this manual for additional information.)

IMPORTANT: To enable an easy means by which program results can be compared (and enable both positive and negative program results to be displayed), waveforms will be automatically repositioned to screen center when noted in the selected program's specifications.

In addition, the POSITION control setting is automatically taken into account when the program is executed. If the waveform is not captured at screen center, care must be taken not to exceed the Volts Full Scale setting.

EXAMPLE

The waveform in Figure 1 was acquired with the Volts Full Scale switch in the 10V position and a dc offset voltage present at the input. Therefore the maximum peak voltage may not exceed 10 volts or the resulting waveform will be compressed at the top of the screen (Figure 2). Peak voltages can be verified by positioning the vertical cursor across the waveform while observing the voltage numerics.

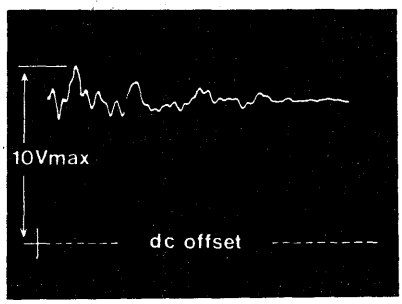


Figure 1

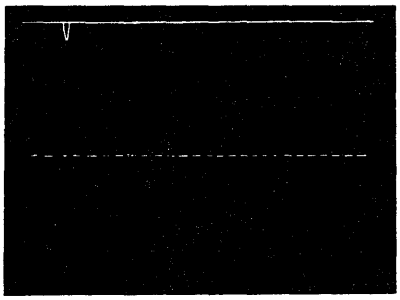


Figure 2

STANDARD PACKAGE INFORMATION

IMPORTANT: The following tabulation of programs (and accompanying descriptions) correspond to the **VERSION 4.x** Program Diskette only. The Version Identification number can be verified by inspecting the label affixed to the diskette.

PART # 177-160100-**4.x**

The Version Identification number also appears at the end of the program titled "CATALOG" when that program is selected for display on the Status Line of the display screen, (e.g., Catalog - 4.x).

Ordering Information

When ordering the Standard Program Package, please use the following part number:

846-000200
4094 Standard Program Package

INSERTING THE PROGRAM DISKETTE

The Program Diskette is inserted into the Disk Recorder in the same manner as previously described under the Disk Recorder tab and the Dual Disk Recorder tab.

IMPORTANT: The drive's door must be closed within 3 seconds after the diskette has been inserted. If the door is not closed within this time limit, the recorder will not recognize the presence of the diskette.

A properly inserted diskette is indicated by an illuminated numerical display with the letter "P" and program "Number."

If the time delay is exceeded before the door is closed, the diskette must be removed and then reinserted.

PROGRAM MEMORY

The Program Memory, located on the I/O board in the third (right hand) bay, stores the selected program.

Once a program has become resident within the memory, it will remain resident until either the power is removed from the 4094 or a new program is entered.

NOTE: If desired and unless otherwise noted in the program descriptions, the Program Diskette can be removed from the disk recorder. No operation will be performed if the operator attempts to execute a program and a program is not resident in the memory.

LOADING A PROGRAM INTO MEMORY

A. Selecting An Unknown Program

This procedure is used to select an unknown program.

#1. Insert the Program Diskette.
   a. A letter "P" and program "number" appears on the numerical display.

#2. Press the Disk Recorder Up/Down buttons until "P01" (Catalog Number) appears on the numerical display.

#3. Press the RECALL button.
   a. The phrase PROGRAM "CATALOG" appears on the status line at the top of the display.
   b. The Catalog Program becomes resident in the Program Memory.

> **NOTE:** The diskette must remain in the disk drive.

#4. FUNCTION switch: PRGM

#5. Press the EXECUTE button.

#6. Press the CURSOR Up/Down button until the desired Program and Program Number appear on the status line. The Program Number will also appear on the recorder's numerical display.

#7. Press the EXECUTE button.
   a. The Catalog Program will be exited.

#8. Press the RECALL button.
   a. The selected Program becomes resident in the Program Memory.
   b. If desired, the Program Diskette may now be removed unless otherwise noted in the particular program description.

#9. Press the EXECUTE button.
   a. The Resident Program manipulates the displayed data, either automatically or via step-by-step instructions to the operator.

B. Selecting A Known Program

This procedure is used to select known program numbers.

#1 Insert the Program Diskette into the disk recorder.
   a. A letter "P" and program "number" appears on the numerical display.

#2. Press the Disk Recorder Up/Down buttons until the desired Program number appears on the numerical display.

#3. Press the RECALL button.
   a. The selected Program becomes resident in the Program Memory.
   b. If desired, the Program Diskette may now be removed unless otherwise noted under the particular program description.

#4. FUNCTION switch: PRGM

#5. Press the EXECUTE button.
   a. The Resident Program manipulates the displayed data, either automatically or via step-by-step instructions to the operator.

DISK PROGRAM GENERAL OPERATION

Programs stored on the diskette can be used in any NICOLET Model 4094 Digital Oscilloscope which has a built-in (F-43) or external (XF-44) disk recorder. The programs are recalled from the diskette in the same manner as waveform data.

The numerical display indicates the program to be recalled (e.g., P01 indicates Program #1). To execute any program, it is necessary to recall it from the diskette, turn the FUNCTION switch to "PRGM," and then press the EXECUTE button.

Operator intervention required by a program will be requested on the display screen. Such requests must be acted upon before the program is allowed to continue. Automatic selection of settings by the 4094 (resulting from previous operator selections or initial program usage) can be altered each time the program is executed.

If the 4094 oscilloscope has a dual disk recorder (XF-44/2), it is possible to keep a program diskette in the other. A single disk recorder (F-43 or XF-44/1) necessitates the removal and insertion of program and data diskettes as required.

Once a program has been recalled from a diskette, it can be used any number of times. It will remain resident in the memory until either a new program is recalled or the oscilloscope is turned off. Program execution, initiated by pressing the EXECUTE button, is indicated by an illuminated green LED above the EXECUTE button.

Operation of the disk recorder is not possible while a program is being executed.

> **NOTE:** Mixed data groups are not acceptable inputs to any program.

Mixed data groups occur when two waveforms on the display were captured using dissimilar sized fractions of memory. Two examples follow:

#1. One waveform is captured in **ALL**. A second waveform is captured in **H2**. Processing is attempted in **ALL**.

#2. One waveform is captured in **H1**. A second waveform is captured in **Q3**. Processing is attempted in **H1**.

Mixed data groups can be avoided by processing waveforms using the fraction of memory where they were captured. Once a mixed data error has occurred, it can be corrected by turning the MEMORY switch to a smaller fraction of memory which contains the necessary waveform.

CATALOG

The CATALOG program contains an alphabetical list of all programs stored on the diskette.

NOTE: The Program Diskette must remain resident in the recorder during execution of the CATALOG Program. In addition, the CATALOG Program does not automatically recall any selected program from the diskette. Once the desired program is located, it is necessary to exit from the CATALOG program and recall the desired new program into memory.

The up/down CURSOR buttons allow the user to sequentially view the title of each program by observing the Status Line located at the top of the display screen. In addition, each program identification number is displayed on the numerical display, allowing a known program number to be easily selected.

The CATALOG program can be exited at any time by pressing the EXECUTE button.

ABSOLUTE VALUE

ABSOLUTE VALUE repositions the selected waveform to screen center, changes the sign of the negative data values to positive, and thus displays the modified waveform.

IMPORTANT: The resultant waveform replaces the original waveform in the memory.

The program prompts the user to select a starting point and an ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if ABSOLUTE VALUE is used repeatedly.

If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be modified, (use Autocenter to make the selection clear). The Plug-in/Channel Identifier indicates which Plug-in/Channel acquired the waveform (for example: 1A = Plug-in #1/Channel A).

EQUATION

Computed Voltages = Original Volts

Computed Time Base = Original Time Base

REQUIREMENTS

a. Mainframe must be in YT.
b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 3.
c. One waveform may be processed at a time.

ADDITION X+Y=Y

ADDITION X+Y=Y moves the selected waveforms (X and Y) to the center of the screen, adds them together, and then displays the answer in the memory locations previously occupied by (Y). The resulting time numerics will be those of waveform (Y).

NOTE: Alignment of the X and Y time bases does not occur before addition. See the HORIZONTAL SHIFT program if time base alignment is necessary.

NOTE: The resultant waveform may not differ dramatically in physical size from the original waveform, but the numerics will be correct.

Waveforms X and Y must be selected by positioning the vertical cursor on the chosen waveform, (use Autocenter to make this clear).

It is important to remember that each waveform must have been captured on the same effective voltage range (voltage range x calibrated probe attenuation).

The time base of the result will be the same as the time base of the original (Y) waveform.

REQUIREMENTS

a. Mainframe must be in YT.
b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 3.

EQUATION

X_n = Voltages on waveform X

Y_n = Voltages on waveform Y

Computed $Y_n = X_n + Y_n$ (See Note 1)

Computed Time Base = Time Base of Waveform Y

Note 1: Vertical resolution is reduced by a factor of 2.

AREA

AREA moves the selected base line for the chosen waveform to the center of the screen, calculates the area between the waveform and the base line, and the displays the area expressed in volt-seconds.

IMPORTANT: The DC shifted waveform replaces the original waveform in the display memory. If the base line coincides with the acquisition zero voltage level, then the original waveform will remain unchanged.

The program prompts the user to select starting and ending points on the chosen waveform. Selection is made by use of the vertical cursor. If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be manipulated, (use Autocenter to make the selection clear).

For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if AREA is used repeatedly.

When AREA is first recalled, the starting and ending points are automatically selected as the first and last points on the chosen waveform.

A base line (level to be taken as zero volts) is also requested by the program. Voltages used in the computation will be taken with respect to the selected base line. Positioning the base line to the actual zero voltage location, (equivalent to ground potential during waveform acquisition) is easily accomplished by momentarily switching the Autocenter switch to the ZERO position.

SPECIFICATIONS

a. Mainframe must be in YT.
b. One waveform may be processed at a time.
c. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 3.

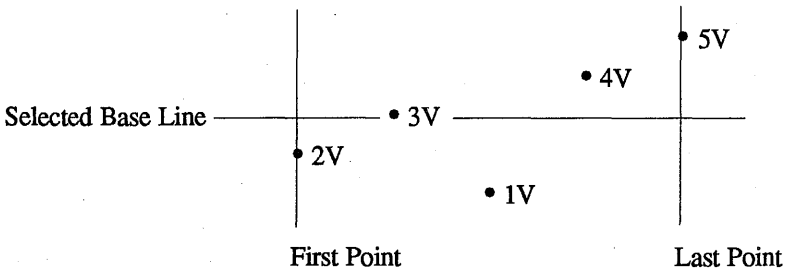
EQUATIONS

V1 = Selected First Point
Vk = Selected Last Point
ΔT = Time Per Point

Area = (V1 + V2 + V3 + ... Vk) x (ΔT)

NOTE: All voltages are measured with reference to the selected base line.

EXAMPLE



Time Per Point (ΔT) = 2 µsec

Area = (-1V + 0V - 2V + 1V + 2V) x (2×10^{-6} sec) = 0 volt-seconds

AVERAGE VALUE

AVERAGE VALUE moves the selected waveform to the center of the screen; computes the average voltage between the selected starting and ending points and stores this value in the last data point of the waveform (far right side of the screen); and then displays the average voltage with the horzontal cursor at the correct level. No other data points are changed.

Positive and negative waveform voltages are taken with respect to the original acquisition zero voltage level. The program requests a starting point and an ending point on the chosen waveform. Each point may be set by correctly positioning the vertical cursor and pressing the EXECUTE button. Selected starting and ending points remain in memory and are automatically recalled if AVERAGE VALUE is used multiple times.

When AVERAGE VALUE is first recalled, the starting and ending ooints are automatically selected as the first and last points on the displayed waveform.

If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be processed (use Autocenter to make this clear).

The Plug-in/Channel Identifier indicates which Plug-in/Channel captured the waveform (e.g., 1A = Plug-in #1/Channel A).

REQUIREMENTS

a. Mainframe must be in YT.
b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 3.

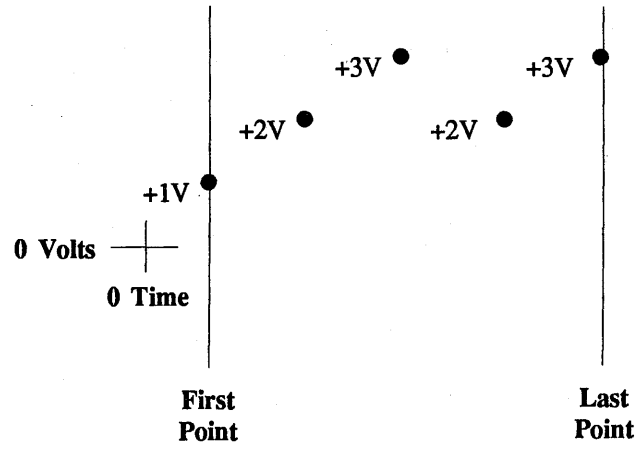
EQUATION

The Computed Average Voltage is stored in the very last waveform address.

V1 = Selected First Point
Vk = Selected Last Point

$$\text{Computed Average Voltage} = \frac{\sum_{n=1}^{k} V_n}{k}$$

EXAMPLE



$$\text{Average Voltage} = \frac{1+2+3+2+3}{5} \text{ Volts}$$

Total Base = Original Waveform's Time Base

AVES., # OF SWEEPS

AVES., # OF SWEEPS is used in conjunction with the plug-in sweep averaging function switch labeled AVERAGE.

If two plug-ins are in use, the displayed count reflects the number of sweeps for the waveform on which the vertical cursor is resting (use Autocenter to make this clear). The Plug-in/Channel Identifier indicates which Plug-in/Channel captured the waveform (e.g., 1A = Plug-in #1/Channel A).

When a plug-in is put into HOLD LAST, the final count is held. Placing the plug-in back into LIVE will reset the count since LIVE initializes the plug-in and allows new incoming signals to be averaged.

Each plug-in (not each channel) operates independently and can be started and stopped without affecting the count for the other plug-in. To exit the program, press EXECUTE.

NOTE: Exiting the program does not affect the sweep counter.

REQUIREMENTS

a. Maximum allowable count is 21,800. If a larger count is attempted, the resulting waveform will deviate from what would be predicted since the sweep count is an important factor in the averaging algorithm.

BIT-MASKING

BIT-MASKING modifies the selected waveform to illustrate reduction of vertical (voltage) resolution.

The primary use of this program is to provide a visual appreciation for resolution expressed in terms of binary bits. The connection between digital resolution and the "real world" can best be understood by using BIT-MASKING on actual waveforms.

IMPORTANT: The resultant waveform replaces the original waveform in the display memory.

This program prompts the user to select the new vertical resolution (in bits). The selection is made by use of the Up/Down cursor control buttons.

The user is also asked to place the vertical cursor on the waveform to be converted. If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be manipulated.

REQUIREMENTS

a. Mainframe must be in YT.
b. One waveform may be processed at a time.

CENTERING, 0 VOLTS

CENTERING, 0 VOLTS moves the zero voltage level of all displayed waveforms to the center of the screen. Centering takes place as soon as the EXECUTE button is pressed.

IMPORTANT: The resultant waveform replaces the original waveform in the memory.

The primary use of this program is to move captured waveforms to the center of the screen so that visual comparisons can be made on waveforms which were captured with different vertical positioning. It may also be used to make X-Y recorder and photographic records more pleasing to the eye.

The voltage and time values remain unchanged by this procedure.

REQUIREMENTS

a. Mainframe must be in YT.
b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 3.
c. All waveforms shown on the screen are processed at the same time. To move only one waveform, the MEMORY switch must be used to show only the selected waveform on the screen.

DATA MOVE

DATA MOVE moves the selected waveform to a new vertical position on the display. The small trigger cursor (zero time, zero volts indicator) is not moved in this process.

IMPORTANT: The resultant waveform replaces the original waveform in the display memory.

This program is equivalent to the front panel function DATA MOVE, except one waveform out of several displayed waveforms can be manipulated.

NOTE: DATA MOVE is different from the VERTICAL SHIFT program. DATA MOVE causes voltage values to change while VERTICAL SHIFT merely repositions the waveform on the display without changing voltages.

The program prompts the user to select a starting and an endiing point on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if DATA MOVE is used repeatedly.

When DATA MOVE is first recalled, the starting and ending points are automatically selected as the first and last points on the displayed waveform. Points outside of the chosen starting and ending points are left untouched by the operation.

If multiple waveforms are displayed, only the selected waveform will be manipulated (use the Autocenter mode to make the selection clear).

This program will also request a reference point on the waveform and a new level. The reference point is selected by the vertical cursor, and the new level with the horizontal cursor. During program execution, the reference point is shifted to coincide with the new level.

Excessive movement of a waveform (up or down) causes it to "wrap-around" to the opposite side of the screen. The waveform can be recovered by DATA MOVING in the opposite direction.

REQUIREMENTS

a. Mainframe must be in YT.
b. One waveform may be processed at a time.

DERIVATIVE

The DERIVATIVE program finds a value for the slope of a waveform curve at each data point. It is useful in calculating velocity from distance data, and/or acceleration from a velocity waveform. An algorithm has been used which allows the user to compensate for noisy data. The Derivative program should be used on data acquired in a half or quarter of memory.

This program places the original waveform in an associated half or quarter of memory. In this way, both the original waveform and the differentiated waveform may be displayed together.

If data has been acquired in ALL (one channel), the program can be run on only half the data points. Turn the memory switch to H1 or H2 so that every other data point is used in the derivative program.

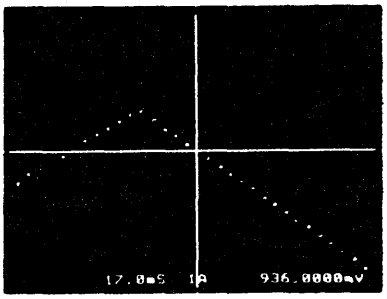
IMPORTANT: Save important waveforms on disk before running this program!

Calculation of the derivative of a waveform is made in the following manner: The slope of the tangent at a particular point, y_n is determined by the method of least squares fit. The user selects a number of points as a window for the least squares fit, from 1 to 45. If the user selects 3, for example, 3 data points to the left and 3 data points to the right of y_n are included in the least squares fit calculation. This process is similar to smoothing - the larger the window, the more smoothing is done.

The examples shown in Figures #1 and #2 should aid in selecting the correct window for your particular data.

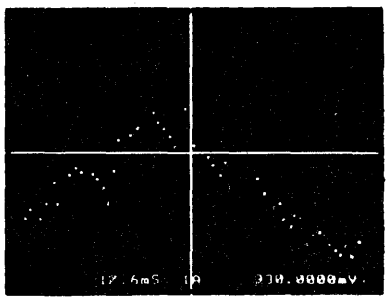
With data that is already quite smooth, select a small window (Figure #1). With data that is noisy, a large window is more suitable (Figure #2).

You will want to experiment by varying the size of the window to suit your data.



Smooth Data - A window of one may be selected

Figure #1



Noisy Data - Large window needed

Figure #2

REQUIREMENTS

a. Mainframe should be in YT.
b. Memory switch must be in a half or quarter of memory.
c. One waveform may be processed at a time.
d. This program destroys data. Be sure to save important waveforms on disk.

READING THE ANSWER

The voltage value at a particular data point represents the slope of the curve in volts per second. If, for example, the voltage reading is 5 millivolts, the slope is 5 millivolts/second.

To give a practical example, if a waveform represents distance or position and you would like to know the velocity, or rate of change of position, the calculation might look like this:

a. Displacement transducer output of 1 volt = .003 meters.

After running the derivative program, the voltage value at a data point is 1.2 volts. This represents 1.2 volts per second.

b. (Velocity in volts/sec) x (Transducer factor) = (1.2 Volts/sec) x (.003 meters/volt), thus - **Velocity** = 3600 meters/sec.

Continued on the next page.

CAUTIONS: When reading values from the oscilloscope screen, note that some values may saturate the screen - that is, when a value is too large or too small to be displayed within the given normalizing range, the data point is shown at the top or bottom limit of the display. This will of course be an incorrect value in the numerics. To check if a point is out of range, move the cursor to the point, turn off AUTOCENTER, and see if you can read values greater than that of the data point (i.e., check if the point is at the absolute top or bottom of the screen). If important data is continually out of range, consider using a larger voltage range when acquiring the data.

NOTE: The waveform may be multiplied by a constant to obtain desired readings by using the MULTIPLY-CONSTANT program.

EQUATION

2w + 1 is the total number of points in the window, w-points to the right of y_n, w-points to the left of y_n.

$$m_n = \frac{\sum_{k=-w}^{k=+w} k * y_{n+k}}{\sum_{k=-w}^{k=+w} k^2}$$

Where: m = slope at y_n.
w = selected number of points in window.

DISKETTE COPY

DISKETTE COPY allows diskette copying in XF44/2 Dual Disk Recorders. The disk recorder on the left should contain the "master" diskette. The right hand disk recorder should contain the "copy" diskette.

NOTE: The "master" diskette should have a protect tab on it, whereas the diskette to be recorded must **not** have a protect tab in place. If a protect tab is found, the numerical display will show "Pro" and the DISKETTE COPY program will be aborted. The title DISKETTE COPY will not be visible after the abort unless the FUNCTION switch is rotated away from "PRGM" and then back again. Absence of the title when the EXECUTE LED is off indicates that the transfer of data has not taken place.

The transfer of data from the "master" diskette to the "copy" diskette takes place even if individual records are protected on the "copy" diskette.

Standard program diskettes are copyable. Attempts to copy other Program diskettes will result in the message: ORIGINAL DISK IS COPY PROTECTED.

Copy errors will give the message: "ABORT" - VERIFY ERROR on the display screen"s status line. All other errors are indicated on the numerical display.

The 4094's plug-in and mainframe remain operational during a diskette copy.

REQUIREMENTS

a. Copying is limited to 4094 data and program diskettes.
b. Copy time for 4094 data diskettes is approximately 6 minutes.
c. Copy time for 4094 Program diskettes varies from 3 to 6 minutes, depending on the number and length of the programs stored on the master diskette.

FREQ = 1/T

FREQ = 1/T calculates the frequency (in Hz) of any waveform based on the user selected period.

The program prompts the user to select starting and ending points on the chosen waveform. Selection is made by use of the vertical cursor. Starting and ending points must be chosen which specify one cycle of the displayed waveform. The calculated frequency will be equal to the inverse of the waveform period specified by the starting and ending points.

For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if FREQ = 1/T is used repeatedly. When FREQ = 1/T is first recalled, the starting and ending points automatically selected are the first and last points on the displayed waveform.

Since the frequency calculation is based directly upon the time spacing between selected starting and ending points, correct cursor placement is critical. If precise frequencies are desired, it is advisable to use horizontal and vertical expansion when locating the starting and ending points.

REQUIREMENTS

a. Mainframe must be in YT.
b. One waveform may be processed at a time.

EQUATION

T1 = Time at chosen starting point.
T2 = Time at chosen ending point.

$$\text{Calculated Frequency} = \frac{1}{T2 - T1}$$

GPIB PLOT

For Plotters with GPIB or HPIB interfaces.

This plotting program labels the horizontal and vertical axes for up to four separate waveforms. The waveforms may be from the Y/T or X/Y display modes. The waveforms are drawn with solid lines and are identified by separate colors. The vertical axis is labelled in volts (mVolts, µvolts, kvolts, etc.). The horizontal axis is labelled in time (seconds, msec., µsec., etc.). Because of the limitless combinations of possible time and voltage, each waveform has its own axes labels. (See example in Figure 2.)

If a title has been added to a waveform, the title is printed at the top of the plot. When two or more titles exist, only the title from the waveform in Q1 is printed.

TYPICAL PLOTTERS

HP 7470, HP 7475, HP 7440A (ColorPro) - with HPIB

REQUIREMENTS

a. Uses IEEE-488 (GPIB) interface on 4094.

b. Requires GPIB Cable connected to plotter's GPIB interface.

c. Plotter must use HPGL language (Hewlett Packard Graphics Language).

Continued on the next page.

GPIB PLOT

HARDWARE SETUP

Plotter

Refer to the plotter manual to set the plotter's GPIB address to 5 (five). (5 is the default HP setting.)

4094 Oscilloscope

#1. Turn the Function switch to I/O STATUS.

#2. Press EXECUTE. The I/O Status display appears (see Figure 1) and the plug-ins go into HOLD LAST mode.

#3. Using the UP/DOWN cursor buttons, position the small pointer at the right of the screen until it is aligned with the GPIB ON/OFF (top of display).

#4. Select ON by pressing the LEFT/RIGHT cursor buttons.

#5. Position the small pointer to the RS232 ON/OFF parameter. Use the LEFT/RIGHT cursor button to turn OFF RS232.

NOTE: No other Parameters are necessary for a GPIB plot.

#6. Press EXECUTE. The I/O parameters will be saved by the 4094, remaining constant even when the scope is powered off and on.

EXECUTING A PLOT

#1. Press the HOLD LAST button and wait for the sweep to end.

#2. FUNCTION switch: PLOT

#3. Press EXECUTE. The plotter draws a box with tic marks, and a title if present. The plotter pauses for you to select a waveform for plotting.

#4. Select a waveform using the cursors or the MEMORY switch and then press EXECUTE. The plotter labels the voltage and time axes and draws the selected waveform.

#5. If you are plotting more than one waveform, select the next waveform to be plotted. You may plot up to 4 separate waveforms sequentially. The program selects different pens for different waveforms automatically.

#6. To EXIT the program before 4 waveforms have been plotted, turn the FUNCTION switch away from the PRGM position.

GPIB	ON/OFF	OFF <	OFF / ON
	ADDRESS	14	0 - 30
RS-232	ON/OFF	ON	ON / OFF
	BAUD RATE	9600	110, 300, 600, 1200, 2400, 4800, 9600, 19200, 38400
	PARITY	OFF	OFF / EVEN / ODD
	STOP BITS	1	1, 2
PLOTTER	BAUD RATE	9600	110, 300, 600, 1200, 2400, 4800, 9600, 19200, 38400
	PARITY	OFF	OFF / EVEN / ODD
	STOP BITS	1	1, 2
AUX	BAUD RATE	9600	110, 300, 600, 1200, 2400, 4800, 9600, 19200, 38400
	PARITY	OFF	OFF / EVEN / ODD
	STOP BITS	1	1, 2

Mutually Exclusive

Figure 1

Continued on the next page.

USEFUL HINTS

#1. The waveform display may be altered between waveforms using the expansion controls and cursor buttons.

#2. To attain zero volts at the center of the plot (no vertical expansion), use the "Centering Zero Volts" program before running the plot program.

#3. The "tic" marks on the plot are at same location as the GRID lines. To see the grid lines, turn the FUNCTION switch to GRID before entering the plot program.

STANDARD RESOLUTION PLOTS

A maximum on 1024 data points are plotted for any signal. This requires from 40 seconds to 2.5 minutes. Which of a waveform's data points will be plotted is shown in Table 1.

Example

If the MEMORY SWITCH is in the ALL position, one channel on, the waveform contains 15,872 data points. With HORIZONTAL EXPANSION OFF, every 16th point will be plotted. If two channels are on, each waveform contains 7,936 data points, and every 8th point of a waveform will be plotted.

HIGH RESOLUTION PLOTS

All of the selected waveform's displayed data points are plotted, requiring up to 7 minutes for a full 15,872-point signal.

To execute a high resolution plot, press and hold the EXECUTE button, then toggle the AUTOCENTER switch to the "ZERO" position. This action tells the program to plot every data point in the selected signal.

INCREMENTAL SELECTION OF STANDARD PLOT DATA POINTS								
MEMORY SWITCH POSITION	DATA POINTS PER WAVEFORM	HORIZONTAL EXPANSION SWITCH						
		OFF	X2	X4	X8	X16	X32	X64
ALL	15,872	16	8	4	2	*	*	*
	7,936	8	4	2	*	*	*	*
	3,968	4	2	*	*	*	*	*
	1,984	2	*	*	*	*	*	*
H1/H2	7,936	8	4	2	*	*	*	*
	3,968	4	2	*	*	*	*	*
	1,984	2	*	*	*	*	*	*
	992	*	*	*	*	*	*	*
Q1/Q2/Q3/Q4	3,968	4	2	*	*	*	*	*
	1,984	2	*	*	*	*	*	*
	992	*	*	*	*	*	*	*
	496	*	*	*	*	*	*	*

Table 1

(*) All of the selected waveform's displayed data points are plotted.

Continued on the next page.

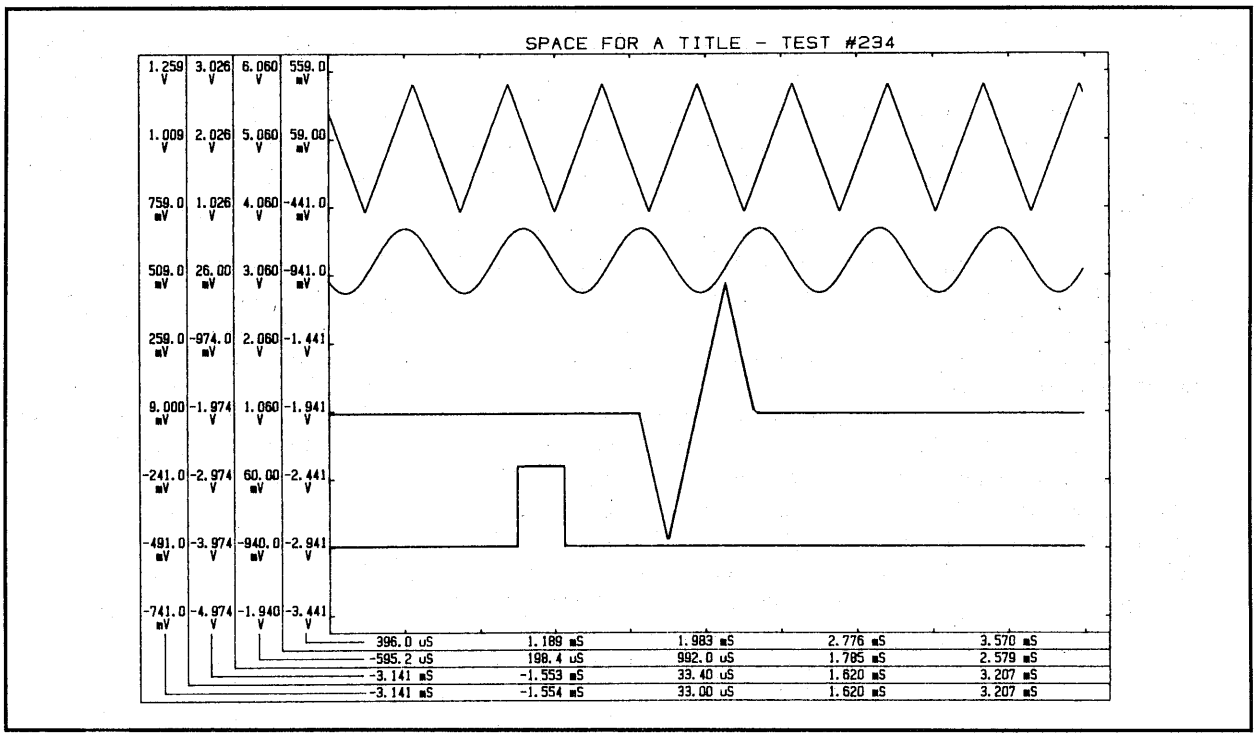


Figure 2 - Y/T Plot of Four Waveforms

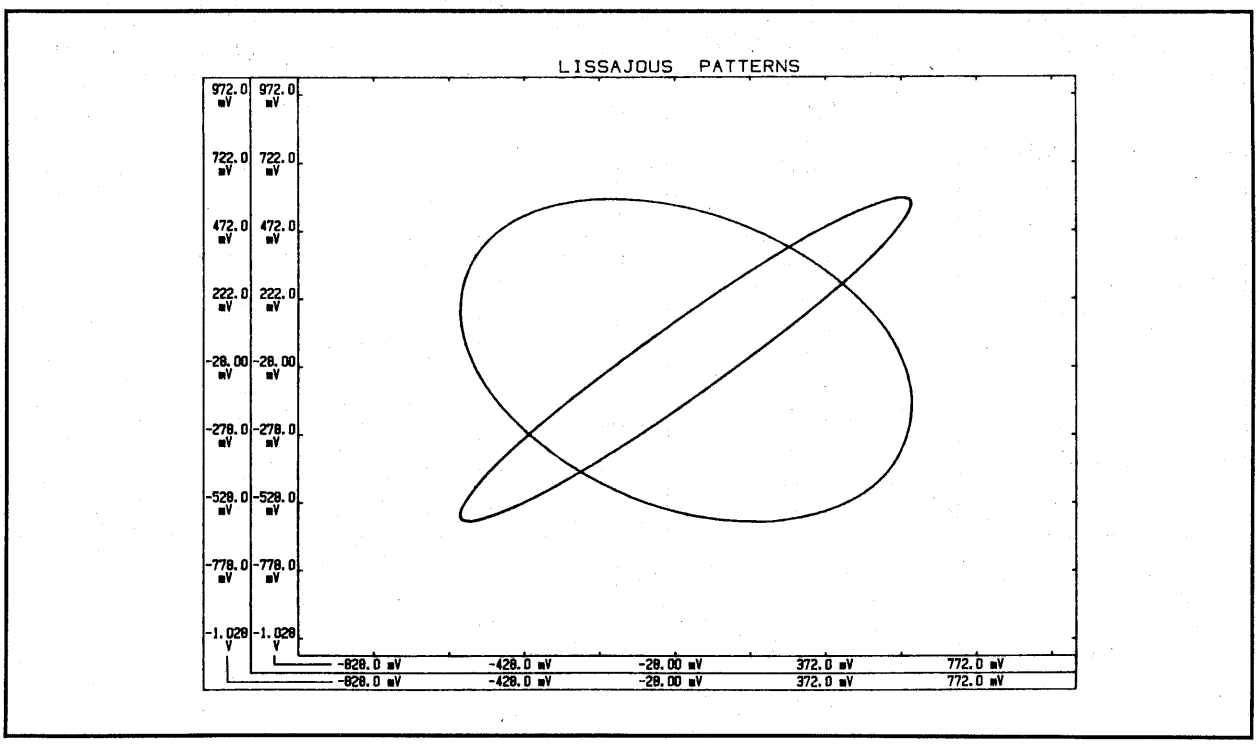


Figure 3 - X/Y Plot of two Lissajous Patterns

HORIZONTAL SHIFT

HORIZONTAL SHIFT is used to move a captured waveform in either a left or right direction along the time axis. The time value associated with each point is not changed in this process. This is equivalent to changing the trigger location before waveform acquisition.

IMPORTANT: Portions of a waveform shifted off the screen are lost and cannot be recovered by shifting the waveform back. The corresponding data points will be represented by a flat line on the left or right side of the screen.

The program prompts the user to select starting and ending points on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if HORIZONTAL SHIFT is used repeatedly.

If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be shifted (use Autocenter to make the selection clear). The Plug-in/Channel Identifier indicates which Plug-in/Channel captured the waveform (e.g., 1A = Plug-in #1/Channel A).

The location of the starting point will be moved to the location of the ending point upon program execution. All other points on the waveform are shifted accordingly.

REQUIREMENTS

a. Mainframe must be in YT.
b. One waveform may be processed at a time.

INTEGRATE X*Y

INTEGRATE X*Y moves the selected X and Y waveforms to the center of the screen, multiplies them together, displays the result along with the original "X" waveform, and then integrates the resultant waveform between the chosen limits.

IMPORTANT: The original Y waveform is replaced in the memory by the multiplication result. If a single waveform is used for both X and Y, the waveform will effectively be squared and the result replaces the original waveform in the memory. The integrated waveform replaces the product in the display memory.

The program prompts the user to select X and Y waveforms for multiplication. Each waveform is selected by positioning the vertical cursor on the waveform, (use Autocenter to help make the selection clear). The entire X and Y waveforms will under go multiplication. If the same waveform is used for X and Y, then it will be multiplied by itself.

After the multiplication step is complete, the program requests the selection of starting and ending points for integration, (usually on the waveform resulting from the multiplication operation). The program also requests the selection

of a base line using the horizontal cursor. The base line will be used as "zero volts" in the integration procedure. Positioning the base line to the actual zero voltage location, (equivalent to ground potential during waveform acquisition) is easily accomplished by momentarily switching the Autocenter switch to the ZERO position. During integration, the waveform will be moved so that the selected baseline lies at the center of the screen.

Points outside of the chosen starting and ending points are zeroed after integration is completed. The final integrated waveform is scaled to fit on the display screen and the voltage numerics are modified accordingly.

The following will be displayed at the top of the screen:

AREA = XXXEXX VOLT-SECONDS

This is the total area from the start point to the end point.

A computed result which lies along a slope merely indicates that a constant voltage was systematically added across the entire waveform. Careful positioning of the base line will be necessary if DC voltage offsets are to be avoided. Even very small voltage offsets will greatly affect the final result. It should be noted that duty cycle variations and the chosen starting and ending points can dramatically change the final result.

REQUIREMENTS

a. Mainframe must be in YT.
b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 3.

Voltage Prefixes

10^{-6} = μ (micro)
10^{-3} = m (milli)
10^{0} = blank
10^{3} = k (kilo)
10^{6} = M (mega)
10^{9} = G (giga)
10^{12} = T (tera)
10^{15} = P (pata)
10^{18} = E (exa)
10^{21} = ?
10^{24} = !

Continued on the next page.

EQUATIONS

Multiplication Step

X1 X2 X3 X4 X5 --- etc.
• • • • •

Y1 Y2 Y3 Y4 Y5 --- etc.
• • • • •

New Y1 = X1 x Y1,
New Y2 = X2 x Y2,
New Y3 = X3 x Y3, etc.

Integration Step

V1 = Selected First Point
Vk = Selected Last Point

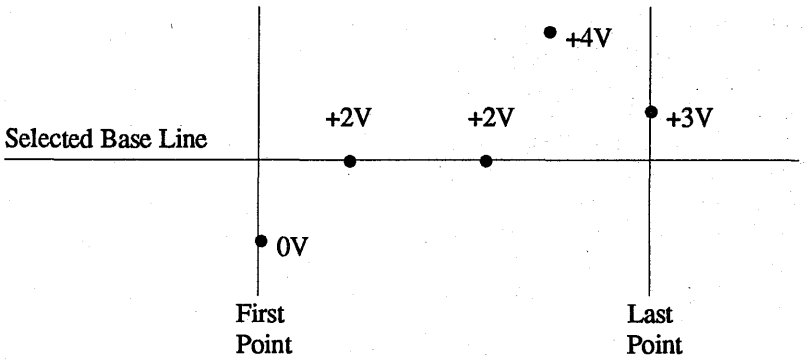
Computed $Vn = (Vn + Vn\text{-}1 + Vn\text{-}2 + \ldots\ldots V1)\ \Delta t$

Where -
$(1 \leq n \leq k)$
Δt = Time Per Point

NOTE: All voltages are measured with reference to the selected base line.

Time base, result = Time base, original

INTEGRATION EXAMPLE



Time Per Point = 1 second

Computed Volts at third point = -2V + 0V + 0V = -2 Volt-seconds

Computed Volts at last point = -2V + 0V + 0V + 2V + 1V = 1 Volt-seconds

INTEGRATION

INTEGRATION provides an instantaneous integral of a selected waveform and a read-out of the total area under the curve between start and stop points.

IMPORTANT: The resultant waveform replaces the original waveform in the display memory.

The user is prompted to select starting and ending points on the chosen waveform using the vertical cursor. If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be manipulated (use AUTO-CENTER or MEMORY switch to make the selection clear).

For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if INTEGRATION is used repeatedly.

When INTEGRATION is first recalled, the starting and ending points automatically selected are the first and last points on the displayed waveform.

A base line (level to be taken as zero volts) is also requested by the program. Voltages used in the computation will be taken with reference to the selected base line.

Positioning the base line to the actual zero voltage location, (equivalent to ground potential during waveform acquisition) is easily accomplished by momentarily switching the Autocenter switch to the ZERO position.

During INTEGRATION, the waveform will be moved so that the selected base line lies at the center of the screen.

The resultant area from the start to stop point is displayed at the top of the screen upon completion of the program. In addition, when the cursor is placed at any point on the integrated waveform, the voltage read-out at the lower right of the screen indicates the area under the curve from the start point to the cursor-selected point. Although the alphanumerics are designated as volts, they should be understood as volt-seconds.

REQUIREMENTS

a. Mainframe must be in YT.
b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 3.
c. One waveform may be processed at a time.

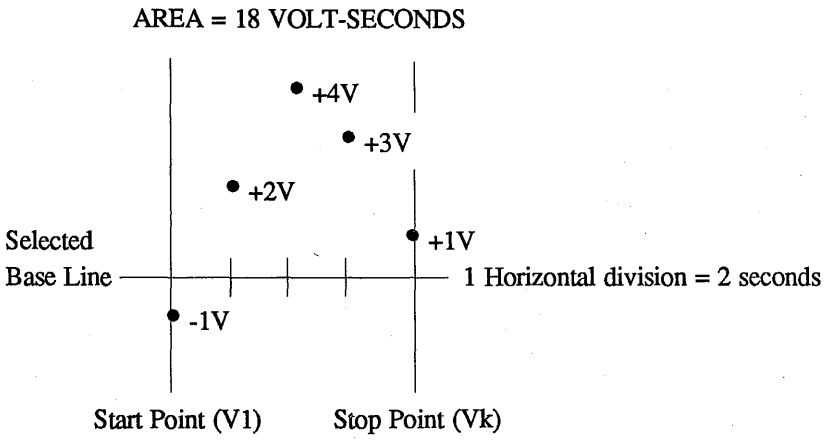
EQUATION

V1 = Selected Start Point
Vk = Select Stop Point

Computed Vn = $\left[Vn + Vn{=}1 + Vn{-}2 + \ldots V1\right] \Delta t$

Where Δt= Time Per Point, and $(1 \leq n \leq k)$

EXAMPLE



AREA at last point = (+1+3+4+2-1) volts * 2 seconds = 18 volt-seconds

AREA at fourth point = (+3+4+2-1) volts * 2 seconds = 16 volt-seconds

INTEGRATION (AC)

INTEGRATION (AC) is very similar to INTEGRATION. The only difference is that the average voltage is computed between the starting and ending points and subtracted from every point. This is used to remove unintentional DC voltage offsets which may exist on an acquired waveform.

IMPORTANT: The resultant waveform replaces the original waveform in the memory.

For the computed average to be equal to the DC voltage offset, it is essential that an integral number of cycles lie between the starting and ending points. DC offsets which vary over the sweep time are not successfully removed. Refer to the INTEGRATION program for the operation specifics.

REQUIREMENTS

a. Mainframe must be in YT.
b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 3.
c. One waveform can be processed at a time.

EQUATION

$$V_{ave} = \frac{\sum_{n=1}^{k} V_n}{k}$$

V_1 = Selected First Point
V_k = Selected Last Point
Δt = Time Per Point

$$\text{Computed } V_n = \left[(V_n - V_{ave}) + (V_{n-1} = V_{ave}) + (V_{n-2} - V_{ave}) + \ldots (V_1 = V_{ave})\right] \Delta t$$

INVERT

INVERT moves the selected waveform to the center of the screen, multiplies each data point value by (-1), and displays the result.

IMPORTANT: The resultant waveform replaces the original waveform in the memory.

The program prompts the user to select starting and ending points on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if INVERT is used repeatedly.

Whe INVERT is first recalled, the starting and ending points automatically selected are the first and last points on the displayed waveform.

If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be inverted (use Autocenter to make the selection clear). The Plug-in/Channel Identifier indicates which Plug-in/Channel captured the waveform (e.g., 1A = Plug-in #1/Channel A).

The program INVERT is different than the function INVERT present on the FUNCTION switch. Program INVERT rotates the waveform about zero volts (ground) while FUNCTION switch INVERT rotates the waveform about screen center (digital zero), which may or may not coincide with zero volts.

REQUIREMENTS

a. Mainframe must be in YT.
b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 3.
c. One waveform may be processed at a time.

EQUATION

V1 = Selected First Point

Vk = Selected Last Point

Computed Vn = -1(Vn)
where $(1 \leq n \leq k)$

MAX/MIN

MAX/MIN scans a waveform for the maximum positive (or minimum negative) data point and the minimum positive (or maximum negative) data point, and displays each data point extreme. The Δvoltage-Δtime (DV - DT) differences between maximum and minimum are also made available.

The program prompts the user to select a starting and an ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if MAX/MIN is used repeatedly. When MAX/MIN is first recalled, the starting and ending points automatically selected are the first and last points on the waveform. If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be manipulated, (use Auto-center to make the selection clear).

When the maximum and minimum data points are displayed, the cursors are positioned on the calculated point so that normal time and voltage numerics give the max/min readings. The time and voltage differences between the maximum and minimum data points can be viewed while in RESET NUM. The only original waveform data which is modified by running MAX/MIN is the data displayed in RESET NUM.

REQUIREMENTS
a. Mainframe must be in YT. b. One waveform may be processed at a time.

MULTIPLY

MULTIPLY moves the selected waveforms (X and Y) to the center of the screen, multiplies them together, and displays the result along with the original waveforms. The result is stored in both the second half of the original X and the second half of the original Y data point locations. Half of the original X and Y data points remain untouched.

The primary reason for storing the resulting waveform, as described above, is so that "original vs. results" can be compared. For example, since (voltage x current = power), these comparisons can be made:
voltage vs. power
current vs. power

The original X and Y waveforms may be acquired on any voltage range or time base. The time base of the result will vary depending on which half is viewed. The half associated with X will have the X time base. The half associated with Y will have the Y time base. Note that the time resolution of the original and resultant waveforms is reduced since each waveform has given up half of the captured data points.

Waveforms X and Y must be selected by positioning the vertical cursor on the chosen waveform (use Autocenter to make this clear). The Plug-in/Channel Identifier indicates which Plug-in/Channel captured the waveform (e.g., 1A = Plug-in #1/Channel A).

REQUIREMENTS

a. Mainframe must be in YT.
b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 3.

EQUATION

X_n = Voltages on waveform (X)
Y_n = Voltages on waveform (Y)

Original Waveforms = X_1 Y_1 X_2 Y_2 X_3 Y_3 X_4 Y_4 ⟶ etc

Calculated $X_2 = Y_2 = (X_1) \times (Y_1)$
Calculated $X_4 = Y_4 = (X_3) \times (Y_3)$
Calcualted $X_6 = Y_6 = (X_5) \times (Y_5)$

MULTIPLY-CONSTANT

MULTIPLY-CONSTANT moves the selected waveform to the center of the screen, multiplies it by a constant number, and displays the resulting waveform.

IMPORTANT: The resultant waveform replaces the original waveform in the display memory.

A common use for this program is to modify experimental results to reflect a transducer scaling factor, (e.g., 3.142 psi = 1 volt).

NOTE: MULTIPLY-CONSTANT is different from SCALE 0-200% in that the scale factor is numerically selected rather than visually selected.

The program prompts the user to select the numerical multiplier by use of the Up/Down and Left/Right cursor control buttons. The digit being selected is marked by an underline. After the entire number is chosen, press the EXECUTE button.

The program also requests the selection of starting and ending points on the waveform to be multiplied. Selection is made by use of the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if MULTIPLY-CONSTANT is used repeatedly.

When MULTIPLY-CONSTANT is first recalled, the starting and ending points are automatically chosen to be the first and last points on the displayed waveform. If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be processed, (use Autocenter to make the selection clear).

Before a multiplication factor is entered, it is important to understand how the display will be affected by the chosen factor. The actual size of the displayed waveform is multiplied by the four digit number selected. The voltage numerics are affected by both the four digit multiplier and its exponent.

REQUIREMENTS

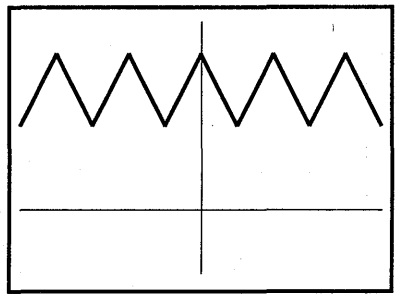
a. Mainframe must be in YT.
b. One waveform may be processed at a time.
c. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 3.

Continued on the next page.

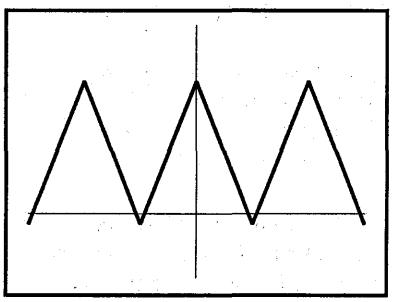
EXAMPLE

From the example below, it can be seen that 3.000E+00 is NOT equivalent to 0.300E+01. In example (A), the display size is multiplied by 3.000 while in example (B) the multipler is 0.300. In either case the voltage "numerics" will be correct even though the displays are of different sizes.

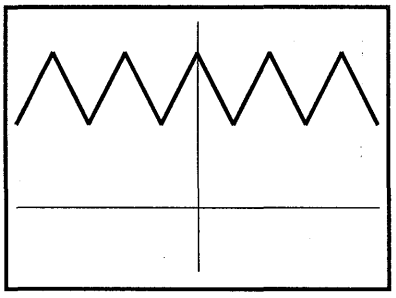
If the four digit multiplier is made too large, the waveform will be clipped at the top or bottom of the screen. Portions of data that have been clipped cannot be retrieved by further multiplications.



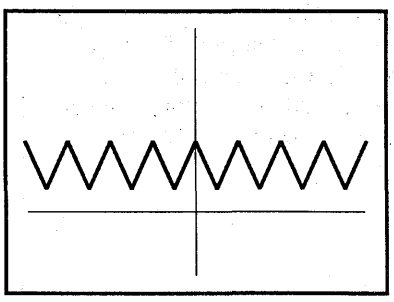
times +3.000E+00 equals



Example A



times +0.300E+01 equals



Example B

MULTIPLY X*Y=Y

MULTIPLY X*Y=Y moves the selected waveforms (X and Y) to the center of the screen, multiplies them together, and displays the result in the memory locations originally occupied by waveform Y.

IMPORTANT: The resultant waveform replaces the original Y waveform in the memory.

NOTE: MULTIPLY X*Y=Y differs from MULTIPLY in that the resulting waveform contains the same horizontal (time axis) resolution as the original waveforms. This feature means, however, that one of the original waveforms must be destroyed.

The program prompts the user to select X and Y waveforms for multiplication. Each waveform is selected by positioning the vertical cursor on the waveform, (use Autocenter to help make the selection clear). The Plug-in/Channel Identifier indicates which Plug-in/Channel acquired the waveform, (e.g., 1A = Plug-in #1/Channel A).

EQUATION

X1 X2 X3 X4 X5 ⟶ etc.

• • • • •

Y1 Y2 Y3 Y4 Y5 ⟶ etc.

• • • • •

Calculated Y1 = X1 x Y1,
Calculated Y2 = X2 x Y2,
Calculated Y3 = X3 x Y3, etc.

REQUIREMENTS

a. Mainframe must be in YT.
b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 3.

PLUG-IN DELAY

PLUG-IN DELAY provides a simple procedure to set multiple channels to the same trigger locations in time. This program is particularly useful when trigger locations must be the same in three or four channel measurements.

The program prompts the user to select the trigger location for Plug-in #1/Channel A by using any of the trigger set-up procedures described in the Plug-ins section (Tab 8) of this manual.

NOTE: Plug-in #1 is located in the left bay of the oscilloscope.

After the trigger is located for channel 1A, press EXECUTE to move the triggers of all other active channels to the same point.

IMPORTANT: Each channel that is to be set for a delay must be turned on before pressing the EXECUTE button.

In addition, if the 4094 is configured with two plug-ins and both plug-ins are to be set for a delay, an equal number of channels for each plug-in must be activated in order to set equal delays.

For example, if one channel is activated on each plug-in, the delay for each plug-in will be equal. Likewise, if both plug-ins have two activated channels, the delay will be equal.

However, if three channels are activated, the plug-in with the single activated channel will be set to twice the delay of the plug-in with two activated channels. This is because the plug-in with the single channel has twice the number of data points to be acquired for display than the plug-in with two activated channels.

RISE TIME

RISE TIME calculates the time and voltage difference between two points on the rising or falling slope of a waveform.

IMPORTANT: Execution of this program destroys the original time and voltage numerics.

The program prompts the user to select a starting and ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in the memory and are automatically recalled if RISE TIME is used repeatedly.

When RISE TIME is first recalled, the starting and ending points are automatically selected as the first and last points on the displayed waveform. Typically, the chosen points should lie on a peak and a trough on each side of the slope in question.

RISE TIME calculates 10% and 90% of the voltage difference between the chosen data points. Upon program execution, the plug-in crosshair and the cursor are moved to points near the calculated 10% and 90% values.

The actual points picked are:

#1. Rise time calculation.
   a. Crosshair at first point greater than 10%.
   b. Cursors at first point greater than 90%.

#2. Fall time calculation.
   a. Crosshair at first point less than 10%.
   b. Cursors at first point less than 90%.

The time and voltage between the 10% and 90% data values is immediately available on the numeric display after completion of RISE TIME. The accuracy of RISE TIME is dependent on the time resolution of the data and signal-to-noise ratio. Ideally, calculations should be done in areas with plenty of data points and low noise.

REQUIREMENTS

a. Mainframe must be in YT.
b. One waveform may be processed at a time.

RMS

RMS moves the selected waveform to the center of the screen, computes the Root Mean Square (RMS) between the selected start and ending points and stores this value in the last data point of the waveform (far right side of screen), and then displays the average voltage with the horizontal cursor at the correct level. No other data points are changed.

NOTE: Positive and negative waveform voltages are taken with respect to the original acquisition zero voltage level.

The program prompts the user to select a starting and ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in the memory and are automatically recalled if RMS is used repeatedly.

When RMS is first recalled, the starting and ending points are automatically selected as the first and last points on the displayed waveform.

If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be processed (use Autocenter to make the selection clear). The Plug-in/Channel Identifier indicates which Plug-in/Channel captured the waveform (e.g., 1A = Plug-in #1/Channel A).

The calculated RMS voltage is dependent on all characteristics of the waveform including the DC offset, symmetry, duty cycle, and number of cycles chosen, (integral number or non-integral number).

REQUIREMENTS

a. Mainframe must be in YT.
b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 3.
c. One waveform may be processed at a time.

EQUATION

V_1 = Selected First Point
V_k = Selected Last Point

$$\text{Computed } V_{RMS} = \sqrt{\frac{\sum_{n=1}^{k} (V_n)^2}{k}}$$

SCALE 0-200%

SCALE 0-200% moves the selected waveform to the center of the screen and increases/decreases the displayed waveform's size according to the levels set by the user. This action effectively allows waveforms to be multiplied/divided by a constant.

IMPORTANT: The resultant waveform replaces the original waveform in the memory.

The program prompts the user to select a starting and ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if SCALE 0-200% is used repeatedly.

When SCALE 0-200% is first recalled, the starting and ending points are automatically selected as the first and last points on the displayed waveform.

If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be processed (use Autocenter to make the selection clear). The Plug-in/Channel Identifier indicates which Plug-in and Channel acquired the waveform (e.g., 1A = Plug-in #1/Channel A).

The program will also request selection of a reference point and a new level. These are set by correctly positioning the vertical and horizontal cursors (Autocenter must be switched off). A reference point chosen outside of the selected start/end range can still be used to scale, but it will not be affected by the scaling action.

NOTES

#1. If a scaling factor of more than 200% is requested, a scale factor of 200% is used and the reference point voltage is doubled.

#2. If the reference point and the new level are of opposite sign, the scaling factor will be calculated on the absolute value of the two voltages. This permits the reference point to be scaled up/down, but it will not be moved to the new level specified since the sign is incorrect.

REQUIREMENTS

a. Mainframe must be in YT.
b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 3.
c. One waveform may be processed at a time.

N-POINT SMOOTH

N-POINT SMOOTH reduces the high frequency noise on an acquired waveform. It calculates a weighted running average of the data points in a selected waveform section.

IMPORTANT: The resultant waveform replaces the original data in memory. Save the original on disk if it is needed.

Running the Program

After downloading the program, press execute to begin. When prompted, select a starting and stopping point on the waveform using the vertical cursor. Press execute after each selection. Start and stop points remain in memory if the program is run repeatedly.

The 3rd prompt calls for selection of "N", the number of data points to be used for the running average. Use the left/right cursor buttons to select the units, tens, or hundreds position. Use the up/down buttons to scroll through the digits until the desired number appears. Any odd number from 1 to 499 may be selected. The chosen N-value remains in memory for multiple program runs.

REQUIREMENTS

a. Mainframe must be in YT.
b. One waveform may be processed at a time.

Comments

High N-values cut out greater amounts
of noise, but may distort the signal significantly. Also, the length of time needed to run the program increases with increasing N-values. It may be necessary to experiment with various values to meet the requirements of a particular application.

EQUATION

m = The middle point, or median from 1 to N.
At any point V_0, the smoothed voltage value is calculated by the following equation.

$$V_0 = \frac{1}{m^2}\left[1(V_{1\text{-}m}) + 2(V_{2\text{-}m}) + 3(V_{3\text{-}m}) \cdots m(V_{m\text{-}m}) + \cdots 3(V_{m\text{-}3}) + 2(V_{m\text{-}2}) + 1(V_{m\text{-}1})\right]$$

EXAMPLE

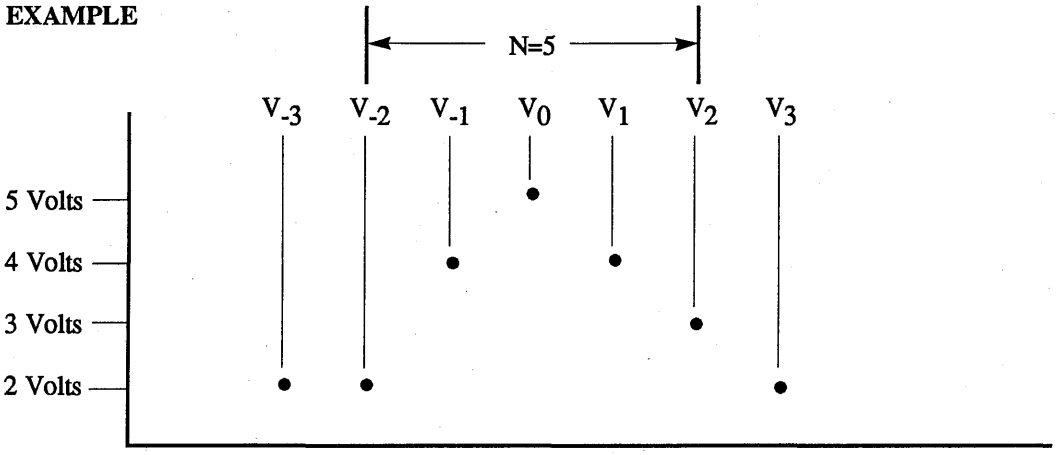


Figure 1

For the waveform points in Figure #1, given a N of 5, m=3:

$$V_0 = \frac{1}{m^2}\left[1(V_{-2}) + 2(V_{-1}) + 3(V_0) + 2(V_1) + 1(V_2)\right] = \frac{1}{9}\left[(2 + 8 + 15 + 8 + 3)\right] = 4V$$

SUBTRACTION X-Y=Y

SUBTRACTION X-Y=Y moves the selected waveforms (X and Y) to the center of the screen, subtracts them, and then displays the answer in the memory locations previously occupied by (Y). The resulting time numerics will be those of waveform (Y).

NOTE: Alignment of the X and Y time bases does not occur before subtraction. See the HORIZONTAL SHIFT program if time base alignment is necessary.

NOTE: The resultant waveform may not differ dramatically in physical size from the original waveform, but the numerics will be correct.

Waveforms X and Y must be selected by positioning the vertical cursor on the chosen waveform (use Autocenter to make the selection clear).

It is important to remember that each waveform must have been acquired on the same effective voltage range (voltage range x calibrated probe attenuation).

The time base of the result will be the same as the time base of the original waveform.

The SUBTRACTION program is substantially different from SUB position on the FUNCTION switch. The SUBTRACTION program manipulates waveforms with respect to zero voltage as shown by the crosshair location. The FUNCTION switch position SUB manipulates waveforms with respect to the center of the display screen (digital zero) which may or may not coincide with zero voltage.

REQUIREMENTS

a. Mainframe must be in YT.
b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 3.

EQUATION

X_n = Voltages on waveform X
Y_n = Voltages on waveform Y

Computed $Y_n = X_n - Y_n$ (See Note 1)

Computed Time Base = Time Base of Waveform Y

Note 1: Vertical resolution is reduced by a factor of 2.

SUBTRACTION X-Y=Y - Blank

TITLE

TITLE allows the user to create up to four unique titles (T1, T2, T3, and T4) and store them in the display memory locations (Q1, Q2, Q3, and Q4, respectively). The titles can contain up to 32 characters each and will appear on the Status Line at the top of the display screen.

Titles written on the Status Line are stored into memory after exiting from the program. In addition, the titles saved in memory can also be stored on diskettes and be recalled along with normal waveform data. The titles can also be included with digital plots of waveform data.

Titles are written by manipulating the horizontal and vertical CURSOR control buttons. The left/right buttons position the "underline" to the next character location. The up/down buttons allow character selection. Holding the AUTOCENTER switch in the spring loaded "ZERO" position while moving the cursor allows rapid erasing of existing titles.

The completed title can be moved, as a unit, left/right by switching into DATA MOVE (while still executing the TITLE program) and manipulating the left/right CURSOR buttons. Care should be taken, however, since titles moved off the display to the left or right are lost from memory.

After completion of a title, use the MEMORY switch to determine which title locations are to be updated with the new title before exiting the program via the EXECUTE button (see Table #1).

Memory Position at Exit	New Title Location
ALL	T1, T2, T3, T4
H1	T1, T3
H2	T2, T4
Q1	T1
Q2	T2
Q3	T3
Q4	T4

Table #1

The completed title can be seen when the FUNCTION switch is moved away from "PRGM." The relationships between title location in memory and where the title can be viewed is shown in Table #2.

Title	Memory Position Where the Title is Visible
T1	ALL, H1, Q1
T2	H2, Q2
T3	Q3
T4	Q4

Table #2

Titles saved in memory are not lost by the actions required to take in new waveforms. Titles can be destroyed only by:
a. Purposely erasing them, or
b. Turning off the oscilloscope, or
c. Recalling new ones from a diskette.

It is possible, therefore, to title experiments, dates, etc., and have the title appear with all new waveforms without the necessity of rewriting them each time. Titles will be stored on the diskette if the FUNCTION switch is not in the "PRGM" position; otherwise blanks will be stored in the title position on the diskette.

When storing titles and waveforms on the disk recorder, all titles (even those not visible) will accompany their corresponding waveforms.

Example

Assume Q1, Q2, Q3, and Q4 each contain a unique waveform and title.

All four waveforms and titles can be stored on a single diskette record if the MEMORY switch is placed to the "ALL" position during a diskette recording.

Transferring Titles

Since the title location is determined by the position of the MEMORY switch when exiting the program, it is possible to transfer a title (either verbatim or modified) form one memory location to another.

Example

The title "EXPERIMENT #1" is stored in Q1 and it is desired to title a waveform in Q2 as "EXPERIMENT #2." To accomplish this:

#1. MEMORY switch: Q1

#2. Enter TITLE program.

#3. Alter "EXPERIMENT #1," displayed on the Status Line, to read "EXPERIMENT #2."

#4. MEMORY switch: Q2

#5. Press the EXECUTE button:
   a. The waveform stored in Q2 is now titled "EXPERIMENT #2."

VERTICAL SHIFT

VERTICAL SHIFT is used to move a captured waveform either up or down on the display screen. The voltage associated with each data point is not changed in this process. This is equivalent to changing the POSITION control before waveform acquisition.

IMPORTANT: The resultant waveform replaces the original waveform in the memory.

Portions of a waveform not chosen to be shifted will have voltage values changed since the zero voltage location has been shifted along with the shifted portion of the waveform.

The program prompts the user to select a starting and ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if VERTICAL SHIFT is used repeatedly.

If multiple waveforms are displayed, only the waveform on which the vertical cursor is resetting will be shifted, (use Autocenter to make the selection clear). The Plug-in/Channel Identifier indicates which Plug-in/Channel acquired the waveform,(e.g., 1A = Plug-in #1/Channel A).

The program will also request a reference point on the waveform and a new level. These are set by positioning the vertical and horizontal cursors, (Autocenter must be switched off).

The selected reference point is shifted to coincide with the new level during program execution. A reference point lying outside of the chosen starting and ending points is acceptable, but will not be shifted.

Excessive movement of a waveform, up or down, will cause it to "wrap-around" and appear on the opposite side of the screen. A waveform that has wrapped-around can be recovered by an additional vertical shift in the opposite direction.

REQUIREMENTS

a. Mainframe must be in YT.
b. One waveform may be processed at a time.