HEWLETT **hp** PACKARD

Signal Analyzer System
Operating and Service Manual
05480-90021 (Manual)
June 1975

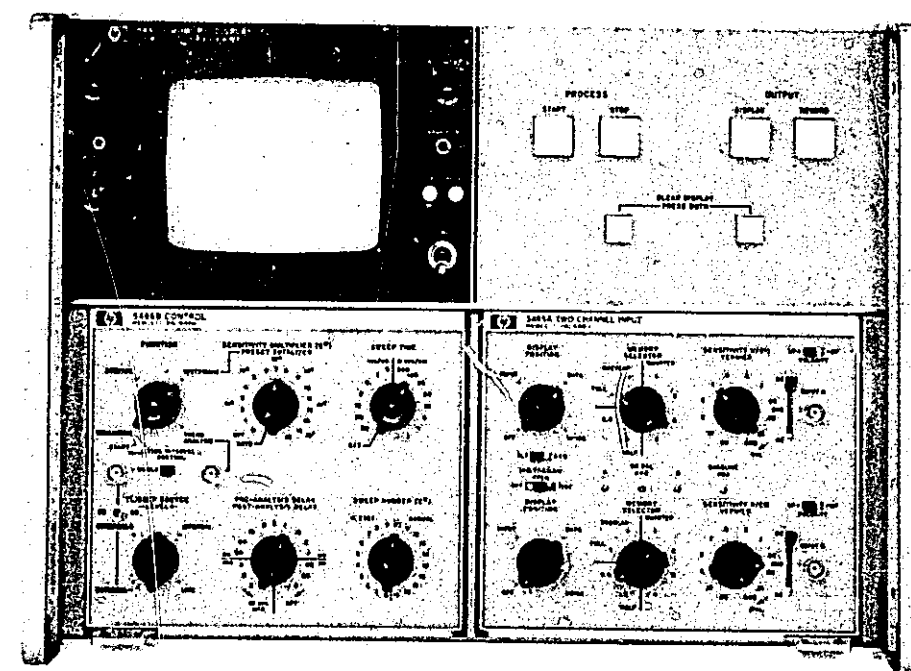Model 5480A/B
Serial Pfx — All
05480-90025 (Fiche)
1 of 5

GENERAL INFORMATION

SIGNAL
ANALYZER
SYSTEM

5480A/B

HEWLETT **hp** *PACKARD*

SIGNAL ANALYZER
5480A/B with 5485A, 5486A/B, 5487A, 5488A PLUG-INS

ALL SERIALS

This manual (including its Backdating Sup-
plement, and Manual Changes sheet, if any)
applied to all standard Hewlett-Packard
Model 5480A/B Signal Analyzer Systems,
as described in Section I of this manual.
Refer to INSTRUMENT IDENTIFICATION,
Subsection 1.4.

SPECIAL INSTRUMENTS

The information required to relate this man-
ual to special modifications is supplied on
special insert sheets. If this information is
missing, contact any HP Sales and Service
Office, giving full specification number,
instrument name, and serial number.

Printed: **MAR 1972**

HEWLETT **hp** *PACKARD*

MANUAL CONTENT AND ORGANIZATION

This manual provides general information required for operating and servicing Hewlett-Packard Model 5480A/B Signal Analyzer Systems. Operating, servicing, and circuit information is organized as follows:

Operating and Service Manual

General System Information

Packaging Information

System Installation

Incoming Inspection Check

Operating Information

System Block Diagrams, including Principles of Operation

Adjustment Procedures

Adjustment and Test Point Locations and Waveforms

Troubleshooting Procedures

Wire Lists and Wiring Diagrams

Operating Information Handbook

A second copy of selected parts of the above book, for use by a person does not need system service information.

Schematic Package

Reprints of the Wiring Diagrams from the Operating and Service Manual

Schematic Diagrams for all 5480A/B, 5484A, 5486A/B, 5487A, and 5488A Boards.

MANUAL AND MANUAL CHANGES
(ORDERING INFORMATION)

This manual provides general information required to operate or service a Hewlett-Packard Model 5480A/B Signal Analyzer System. Manual changes for special instruments will be detailed in special change sheets included with manuals for those systems. If information is missing, it may be obtained by contacting the nearest Hewlett-Packard sales and service office listed at the back of this manual. When requesting information or additional manuals for your system, be sure to include complete Model or Specification number, instrument name, and serial number. (For instrument identification information, see Paragraph 1.5.)

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Figure 1-1. 5480A/B Signal Analyzer System

MODEL 5480A/B
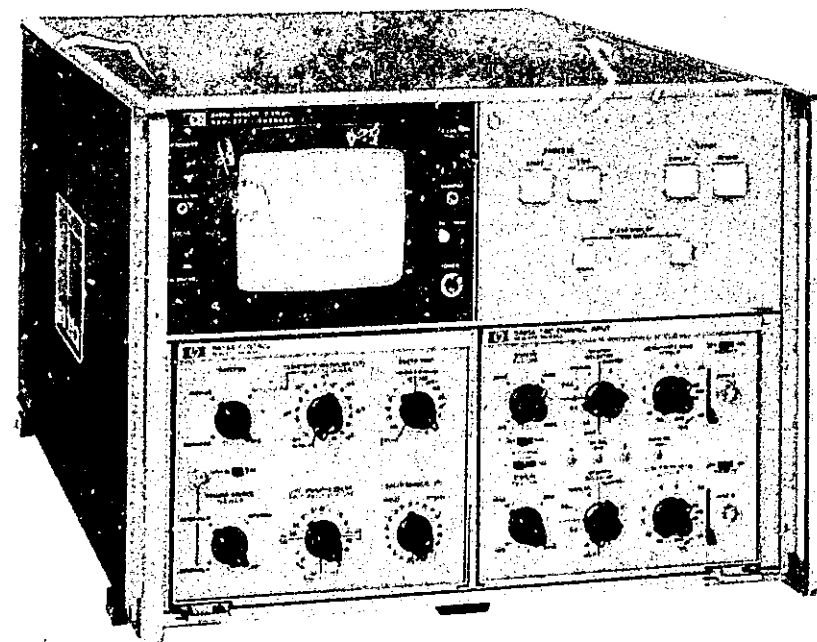
RACK MOUNTING KIT
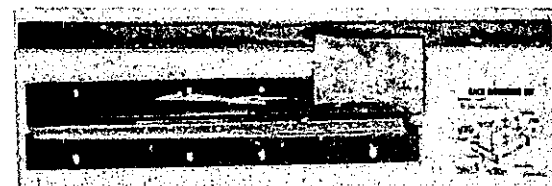
POWER CABLE

EXTENDER BOARDS

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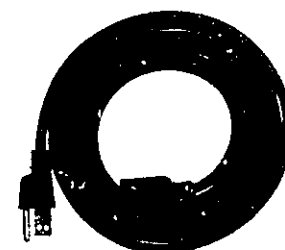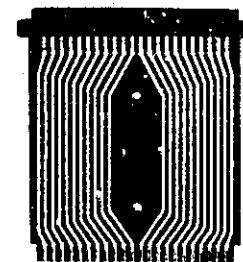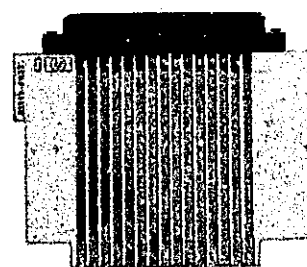
SECTION I
GENERAL INFORMATION

1.1. INTRODUCTION

A Hewlett-Packard Model 5480A/B Signal Analyzer System is best described as either:

a. An Oscilloscope for looking at noisy signals, or

b. A Digital Computer that can perform Averaging, Summation, Time Interval or Frequency Histogramming, or Trend Analysis functions, and display the results on an integral CRT.

In the AVERAGE or SUMMATION function, the 5480A/B can improve the signal-to-noise ratio of a waveform by as much as 1000 times (60 dB). Operating in real time, "on line," the operator can see results while an experiment is in progress, even though the input signal may be so obscured by noise that raw data seem to contain little useful information. Data are accepted in analog form at the input, converted to digital form, processed according to routines selected by the FUNCTION switch, and stored in an internal 1024-word, 24 bits-per-word magnetic core memory stack. The only requirements of the 5480A/B are:

a. The input signal waveform must be repetitive (not necessarily periodic).

b. A sync pulse must be available to signal the beginning of each repetition. In some cases a sync pulse can be derived from a Frequency Synthesizer.

c. The highest frequency component of the input signal must be less than 50 kHz. However, this limit can be extended by using a Sampling Oscilloscope.

In HISTOGRAM and TREND ANALYSIS (formerly MCS) functions, input data are directly processed according to routines selected by the FUNCTION switch.

All system specifications are given in Table 1-1.

1.2. SYSTEM ORGANIZATION

A 5480A/B system consists of a Memory/Display (mainframe) unit, an Analog Plug-in unit and a Logic Plug-in unit. The Analog Plug-in is installed in the mainframe's right-hand plug-in compartment, the Logic Plug-in is installed in the left-hand compartment.

1.3. EFFICIENCY

Efficiency in signal averaging is a measure of the time it takes to obtain a specified signal-to-noise ratio improvement; as efficiency increases, required time decreases. By adding a low-pass filter in series with the Signal Analyzer input, averaging time

can be reduced since high-frequency noise can be removed by filtering instead of by averaging. In many situations, the system of which the Signal Analyzer is a part contains an amplifier which is bandlimited to suit the experiment. The upper cutoff frequency of the amplifier will in many applications provide sufficient filtering so that an added filter will not be required.

Cutoff frequency of the low-pass filter used to improve efficiency of the Signal Analyzer system depends on SWEEP TIME setting and the number of points to be used to represent the sharpest rise time of the input signal under study. The user will rarely choose to study a waveform with a rise time of fewer than five points.

EXAMPLE: SWEEP TIME is 100 msec/cm.

a. One 10 cm sweep takes 1 sec to complete. Since each sweep consists of 1000 points, each point represents 1 msec, and a rise time spanning 5 points in the display is 5 msec.

b. To convert rise time to frequency, divide rise time into "0.35," frequency = .35/rise time. In this example, this becomes: cutoff frequency (highest displayed frequency) = .35/5 msec = 70 Hz. A low-pass filter at the Signal Analyzer input should pass this frequency and cut off all higher frequencies.

1.4. INSTRUMENT IDENTIFICATION

1.4.1 Model Number and Name

Each unit in a 5480A/B Signal Analyzer System is identified by a Model number and a name as a separate instrument, as listed below.

A 5480A Signal Analyzer System consists of:

A 5480A Memory/Display (Mainframe Unit)
A 5486A Control (Logic Plug-in Unit)
One Analog Plug-in Unit from the list below.

A 5480B Signal Analyzer System consists of:

A 5480B Memory/Display (Mainframe Unit)
A 5486B Control (Logic Plug-in Unit)
One Analog Plug-in Unit from the list below.

The Analog Plug-in Units, which may be used in either a 5480A or a 5480B Signal Analyzer System are:

5485A Two Channel Input
5487A Four Channel Input
5488A Average/Correlation Input

1.4.2. Serial Numbers

Each unit in a 5480A/B Signal Analyzer System is identified by its own serial number. The number will

Table 1-1. Specifications

GENERAL SPECIFICATIONS

MODELS

Specifications are for 5480B Signal Analyzer (Memory/Display mainframe), equipped with 5486B Control and 5485A Two Channel Input plug-ins, or for 5480A with 5486A Control and 5485A Two Channel Input plug-ins.

PRIMARY FUNCTIONS

Averaging, 3 methods: Calibrated, Weighted, and Summation

Histograms: Frequency, and Time Interval

Trend Analysis or MCS

Variance, optional on some units.

DIGITAL MEMORY

1024 channels (1000 for data) horizontal, by 24 bits/channel (16,777,216 to 1 range) vertical.

POWER FAIL INDICATION

Momentary power interruption activates PROCESS STOP and RESET lamp, with memory contents protected.

CALIBRATOR

(Output in PROCESS mode): Square wave, alternating between zero (+20 mV - 0 mV) and 1V (±20 mV) every .64 cm, at all SWEEP TIME settings.

OPERATING MODES

SELECTION

By pushbuttons which remain lighted during mode

PROCESS

Input signal is processed into memory at a rate depending on SWEEP TIME setting. START enables PROCESS to begin at next trigger input. STOP immediately terminates any mode.

OUTPUT DISPLAY

Continuously displays data from memory without flicker.

OUTPUT RECORD

Continuous display is suppressed; memory is scanned once, with SWEEP TIME set for desired rate. Simultaneous analog and digital outputs for recording.

Table 1-1. Specifications (Cont'd)

OPERATING MODES (Cont'd)

CLEAR DISPLAY

Erases memory segments in use, resets count of number of sweeps completed. Widely separated buttons must be pressed simultaneously to activate.

COMMON DISPLAY FUNCTIONS

GENERAL

The following display functions do not alter the data processing unless noted.

CRT

Included in mainframe: 8 x 10 cm rectangular display; parallax-free internal graticule, P31 phosphor. Compatible with HP 197A/198A cameras. Adaptors available for other camera systems.

CRT CONTROLS

Intensity, focus, trace alignment, horizontal position and horizontal magnifier (X1 and X5).

CONTINUOUS DISPLAY

Memory contents displayed flicker-free during PROCESS mode for all functions except MCS. Display is interlaced with data processing. Rear panel switch for disabling continuous display.

DISPLAY SELECTION

(Each input channel):

> Data: Displays contents of memory segment in use.

> Input: For all averaging functions, displays sampled input at PROCESS sweep rate during PROCESS mode.

> Noise: (For Calibrated Averaging and Weighted Averaging) Displays difference (NOISE) between sampled input and averaged data in memory during PROCESS mode. Output provided.

> Off: Disables Input channel.

VERTICAL SCALE

Range ±8.38 cm at 10^6 counts/cm. Scale expandable in binary increments up to 2^{15} (to approximately 30 counts/cm). Expansion useable in OUTPUT modes and during PROCESS mode for SUMMATION and HISTOGRAM functions.

VERTICAL DISPLAY RESOLUTION

10 bits, 0.1% of full ±8.38 cm display.

SENSITIVITY VERNIER

(Each input channel): Variable reduction in vertical display by factor of at least 2.5 below calibrated position.

VERTICAL POSITION: (Each input channel). Display level adjustable ±4 cm.

Table 1-1. Specifications (Cont'd)

COMMON PROCESSING FUNCTIONS

GENERAL

The following functions affect data processing as well as display, and their use is common to most of the major 5480 functions and operating modes. Qualifications are noted.

MEMORY SELECTION

(Each Input Channel) Selects memory for data storage, display, or clearing. Contents of unselected segments are unchanged by any operating mode.

HORIZONTAL RESOLUTION

(10 cm trace) 1000 points for FULL memory, 500 (alternate) points for HALF, 250 (every fourth) points for QUARTER.

PRIORITY

Input A over Input B if any mutually selected segments.

OVERLAP DISPLAY

In OUTPUT DISPLAY mode all quarters displayed on four traces vertically separated for comparison. Each Input control positions two traces with 2 cm baseline separations. In PROCESS mode, acts same as FULL memory.

TRIGGER SOURCE

External:	Sweep triggered by an externally applied signal.
Coupling:	AC or DC selectable
Slope:	+ or – selectable
Trigger Level:	-4V to +4V adjustable
Minimum Input:	100 mVrms, Rise time < 10 msec.
Maximum Input:	170V peak
Input Impedance:	1 Meg ohm, shunted by 30 pF.
Internal:	Sweep triggered by internally generated pulse at end of each sweep, after POST-ANALYSIS DELAY.
Line:	Sweep triggered by power line frequency.

SWEEP TIME

1 msec/cm through 50 sec/cm in 1, 2, 5 steps; external at 5 msec/cm or slower.

HORIZONTAL DISPLAY EXPANSION

X5 Magnifier

Table 1-1. Specifications (Cont'd)

AVERAGING

AVERAGING METHODS

Three alternate methods provided are CALIBRATED AVERAGING, WEIGHTED AVERAGING, and SUMMATION AVERAGING.

SIGNAL TO NOISE IMPROVEMENT

Proportional to the square root of the number of sweeps averages. For white gaussian noise the improvement is 3 dB times SWEEP NUMBER setting, N. Up to 60 dB (1000 to 1 ratio) is possible under many circumstances. For a given experiment, the ultimate is determined by the synchronous component of the Noise specification (Calibrated Averaging).

POST-ANALYSIS DELAY

Uncalibrated delay between end of sweep and readiness for next trigger. SYNC OUTPUT pulse, which is derived from trigger, is therefore delayed. Variable between 10 ms and 10 seconds, plus detented OFF position.

PRE-ANALYSIS DELAY

Calibrated delay between trigger and start of analysis sweep. Delays of 0, and 20 μsec to 0.5 sec in 1, 2, 5 sequence, 15 steps, Accuracy ($\pm$0.01%, -0 +10 μsec).

ADC (ANALOG-TO-DIGITAL-CONVERTER)

Sampling Rate:	100,000 samples/sec at 1 msec/cm through 2 samples/sec in 1, 2, 5 steps, on internal time base: 20,000 samples/sec or slower with external base.
Sample Time:	1.2 μsec
Clock Rate:	20 MHz
Resolution:	9 bits, from 50 sec/cm through 5 ms/cm, and external time base; 7 bits at 2 ms/cm; 5 bits at 1 ms/cm.

Calibrated Averaging

SWEEP NUMBER

Number of sweeps to be processed is manually selected in a binary sequence (2^N) from single sweep (0 switch position) to 2^{19} (524,288) sweeps. PRESET used for Calibrated Averaging. When the sweeps counted reaches the SWEEP NUMBER setting the PROCESS mode is terminated and OUTPUT DISPLAY activated.

INPUT CHARACTERISTICS

(For 5485A Two Channel Input)

NUMBER OF INPUTS

Two, may be simultaneously averaged into different segments of memory.

Table 1-1. Specifications (Cont'd)

Calibrated Averaging (Cont'd)

INPUT COUPLING

AC, DC, and ground (disconnected from input), switch selectable.

BANDWIDTH

DC Coupled: DC to 50 kHz
AC Coupled: 2 Hz to 50 kHz

SENSITIVITY

5 mV/cm to 20V/cm in 1, 2, 5 steps. Accuracy ±3% at 25°C; Temp. Stability ±.05% per °C.

AVERAGE BASELINE DRIFT

< ±0.2% of full scale/°C for source impedance ≤ K Ohm.

INTEGRAL LINEARITY

±0.2% of full scale

NOISE

Synchronous, RMS < .1% of full scale; Random RMS (will average out) < 1% f.s. at 2 msec/cm and slower, < 3% f.s. at 1 msec/cm.

INPUT IMPEDANCE

1 Meg ohm shunted by 25 pF.

MAXIMUM INPUT

(Linear Operation) Equivalent to CRT deflection of ±5 cm for individual samples.

MAXIMUM INPUT

600V peak, ac coupled; dc coupled, 150V at 5 mV/cm, increasing to 350V at 20V/cm.

POLARITY INVERSION

+UP or -UP selectable.

A+B

Adds Channel B input to Channel A input and sum is fed through Channel A. Polarity of either channel may be inverted to give difference (A - B).

ALT

Processes and displays both channels simultaneously, by means of chopping.

DC BALANCE ADJUSTMENTS

Provided for each input.

Table 1-1. Specifications (Cont'd)

Weighted Averaging

GENERAL

Specifications are the same as for Calibrated Averaging except as follows:

SWEEP NUMBER

NORMAL setting causes Weighted Averaging Function to be automatically entered when selected SWEEP NUMBER is exceeded. This selection determines sweeps averaged, which remains fixed, and averaging is continuous.

Summation Averaging

GENERAL

Specifications under CALIBRATED AVERAGE apply except as follows:

AUTOMATIC SCALING

Display may be automatically scaled down in binary increments until SWEEP NUMBER setting is reached. Display is calibrated at each switching interval and at preset SWEEP NUMBER. Weighted averaging is not possible.

BASELINE

Can be adjusted to zero volts.

HISTOGRAMS

Frequency Histogram

DISPLAY

Relative probability, vertical; frequency, horizontal.

INPUT

At 5486B START/STOP (left-hand) BNC (for serials with prefix 1104A or higher) or at 5486A/B Trigger Source BNC (for serials with prefixes below 1104A)

> Input Frequencies: Rate DC to 1 MHz. Rise time <10 msec. For frequencies below 1 kHz, normally use Time Interval Histogram.

> Other Specs: See Trigger Source (Common Processing Functions)

FREQUENCY RANGES (DISPLAY)

200 Hz/cm through 10 MHz/cm in 1, 2, 5 steps.

MEASUREMENT RATE

Proportional to Frequency Range at one-half the sample rate; approximately 50,000 measurements per second maximum at 10 MHz/cm.

Section I
General

Model 5480A/B

Model 5480A/B

Section I
General

Table 1-1. Specifications (Cont'd)

Frequency Histogram (Cont'd)

PRESET TOTALIZER

Automatically switches from PROCESS to OUTPUT DISPLAY when count in channel with maximum count reaches preset total. Preset values 10^2 to 10^7 in power of 10, and OFF.

CONTINUOUS DISPLAY

During PROCESS mode, for all ranges, except 10 MHz/cm.

Time Interval Histogram

GENERAL

Same as Frequency Histogram, except following:

DISPLAY

Relative probability, vertical; time interval, horizontal.

INPUT (5486B with serial prefix 1104A or higher)

One or two signals, selected by TIME INTERVAL CONTROL switch. SINGLE setting measures time interval between two points on the input signal having the same trigger level and slope. SEP setting measures the time interval between a point on the signal connected to the right-hand (START) connector and a point on a second signal, connected to the left-hand (START/STOP) connector; start trigger point is fixed, as described below, stop trigger level and slope can be adjusted by TRIGGER LEVEL and SLOPE controls.

STOP (START/STOP) Input Characteristics

Same as Frequency Histogram INPUT.

START Input Characteristics (5486B with serial prefix 1104A or higher)

 Input Impedance: 10 KΩ, nominal
 Input Sensitivity: 2V minimum
 Triggers on: positive transition from 0V to 2V
 Maximum input without damage: 40V
 Rise Time: <10 sec.

TIME INTERVAL RANGES (DISPLAY)

1 msec/cm through 50 sec/cm in 1, 2, 5 steps.

COUNTING RATE

Measures every time interval (SINGLE or SEP input measurement) (5466B, serial prefixed 1104A or higher). (5486A/B with serial prefix below 1104A measures alternate time intervals)

MEASUREMENT ACCURACY

±1 channel ±10 μsec

MINIMUM STOP-TO-START TIME (SEP INPUT) (5486B, serial prefixed 1104A or higher)

Minimum time interval between end of one measurement and beginning of next (SEP measurement) is 20 μsec.

TREND ANALYSIS (FORMERLY MCS)

DISPLAY

Counts, vertical; time, horizontal. During the PROCESS mode the continuous display is inactive and the vertical scale is unmagnified.

INPUT

At TREND ANALYSIS (START) BNC on front of 5486B (serial prefix 1104A or higher)
At rear-panel BNC (5486A/B, serial prefixed below 1104A, in 5480A/B, serial prefixed below 1108A)

 Input Frequencies: Pulses; rate: DC to 1 MHz; width 500 nsec, min;
        pulse pair resolution 500 nsec

 Input Impedance: 10K, nominal

DWELL TIME PER CHANNEL

With FULL 1000 channel memory selected, 10 μsec thru 0.5 sec in 1, 2, 5 steps. With external time base, 50 μsec or slower, depends on Sample Input rate. Dwell time is increased X2 using HALF memory, X4 using QUARTER.

SWEEP SHAPE

Sawtooth only (5480B) (Sawtooth or Triangle, 5480A only); External time base input allows rates of 5 msec/cm or slower.

TRIGGERING

External or internal. See TRIGGER SOURCE (Common Processing Functions).
(5480A, external triggering is possible on sawtooth sweep only.)

PRESET SWEEP NUMBER

Sweeps to be processed are selectable in binary sequence (2^N) from single sweep (2^0) to 524,288 sweeps (2^{19}).

TIMING INPUTS AND OUTPUTS

CONNECTORS

Rear Panel, female BNC

SAMPLE INPUT

For external time base. Enabled with SWEEP TIME set to EXT. Requires pulses, 1004/sweep, independent of memory segments in use. < 20 kHz rate, levels 0V or more negative to +2V or more positive. Input impedance > 2K ohms; maximum input 20V.

SAMPLE OUTPUT

One pulse as each memory channel in use is sampled. Pulses per sweep are 1000 for FULL memory, 500 for each HALF, and 250 for each QUARTER, or combinations. Pulse from TTL logic, from > +2.5V to < +0.8V (at 5 mA maximum sinking current); Pulse width 100 nsec.

SYNC OUTPUTS

POSITIVE provides a > +10V, > 0.5 μsec pulse into > 10 k ohm load at start of PROCESS SWEEP, before PRE-ANALYSIS DELAY. NEGATIVE is same, except > -10V.

Table 1-1. Specifications (Cont'd)

ANALOG OUTPUTS

CONNECTORS

Real panel, female BNC, except as noted.

SCALE CALIBRATOR

Switch positions CRT dot to "zero" or "full scale" (4 cm, vertical; 10 cm, horizontal). Equivalent voltages on all analog outputs for calibration. OFF position for normal operation.

CONTINUOUS DISPLAY

Interlace switch IN enables, OUT disables; should be disabled for use of most outputs except for remote CRT. Automatically disabled in OUTPUT RECORD mode.

VERTICAL SCOPE OUTPUT

For remote CRT; same displays and controls as internal CRT except no horizontal magnification. Proportional to CRT display, 1V/cm, -5V to +5V nominal into 10K.

SWEEP VOLTAGE OUTPUT

0 to 1V ramp, proportional to CRT deflection. Output impedance, 400 ohms. Output adjustable by resistor change, up to 10V.

Z AXIS

Blanking pulses for oscilloscope: From TTL logic > +2.4V blank, < +0.8V sinking 10 mA maximum at unblank. Pulse width 5 μsecs nominal.

DAC (DIGITAL-TO-ANALOG CONVERTER) OUTPUTS

Derived directly from digital memory.

HORIZONTAL DAC OUTPUT

0V to +10V nominal into 5 K ohm load, proportional to memory address (CRT sweep); 0.2% linearity.

VERTICAL DAC OUTPUT

-4V to +4V nominal into 5 K ohm load, proporational to CRT display of memory data (relative to cleared baseline) 0.5 V/cm, 0.2% of f.s. linearity.

PLOTTER OUTPUTS (5480B, and 5480A with serial prefix 928 or higher)

For XY recording and instrument interface.

Connector:	Data and control on single connector. Mates with optional 10640B cable (see accessories available) to 7591A Plotting System.
X Axis:	In parallel with Horizontal DAC output.
Y Axis:	In parallel with Vertical Scope Output.
Seek Output:	> 5 V into 1 K Ohm load, > 50 μsec pulse, to point plotter to seek a null.
Plot Input:	> +2V, 200 nsecs pulse, from point plotter after point is plotted. Input impedance 3K Ohms, nominal. External SWEEP TIME setting required for use.
Pen Lift Output:	Contact closure to ground during sweep only, in OUTPUT RECORD mode, lowers pen at start of sweep, lifts pen at end of sweep. 50 mA, maximum current. Parallel output provided on BNC.

Servo Enable/Disable Output: In OUTPUT RECORD mode: > +2.4V from TTL logic during sweep only, for enable; < +0.8V at < 5 mA sinking current for disable of recorder servo.

Table 1-1. Specifications (Cont'd)

ANALOG OUTPUTS (Cont'd)

PLOTTER OUTPUTS (5480A, with serial prefix below 928)

Same as above, except:

Connector:	Each signal brought out (or in) through separate BNC female connector.
X Axis:	Use HORIZ. DAC OUTPUT
Y Axis:	Use VERT. DAC OUTPUT
Seek Output:	+10V, > 50 μsec pulse to tell point plotter to seek a null.
Plot Input:	Same as above, except on BNC connector.
Pen Lift Output:	+5V = pen up; 0V = pen down.

Servo Enable/Disable Output: Not available.

NOISE OUTPUT

(See NOISE, Under Common Display Functions.) During PROCESS mode, output at SWEEP TIME rate as a pulse for each data point; nominal peak amplitude 0.5V/cm deflection of NOISE display on CRT. Provides up to $\pm$4V into 5 K ohm load. Output is same while CRT is displaying INPUT, DATA (with Interlace out), or NOISE. Pulses are coincident with Z axis output which may be used for control of external gating circuitry.

VARIANCE OUTPUT

(With Variance board installed in Analog plug-in.) Output conditions are same as for NOISE OUTPUT. Nominal Calibration in volts is $N^2/32$, where N = noise amplitude in cm on CRT in NOISE display for specific point. Provides 0 to +2V into 10 K ohm load.

DIGITAL OUTPUTS

DIGITAL OUTPUTS FOR COMPUTER

Two 50-pin connectors provide system logic connections for both memory data and control interface to computers. All circuitry and wiring internal to the 5480B are included. Optional 10625A Interface Kit for all HP 2114, 2115 and 2116 series computers includes plug-in boards for computer, interconnecting cable, and software. Standard computer peripherals such as a teleprinter, tape reader, high speed punch, etc., are interfaced through the computer.

Interface, through a coupler, may also be made to a teleprinter tape punch, parallel printer or other computers. Data from the 5480B is 24-bit parallel, twos-complement binary; TTL Integrated Circuit logic levels are used.

PHYSICAL

ENVIRONMENTAL

Operating Range, 0° to 55°C.

POWER

115/230V, 50-60 Hz, 175W with plug-ins.

Table 1-1. Specifications (Cont'd)

PHYSICAL (Cont'd)

WEIGHTS

5480A/B: (Without plug-ins): Net 59 lb (26, 8 Kg), Gross 64 lb (29, 2 Kg)

5485A: Net 8 lb (3, 64 Kg), Gross 13 lb (5, 90 Kg)

5486A/B: Net 9 lb (4, 10 Kg), Gross 14 lb (6, 35 Kg)

ACCESSORIES FURNISHED

Detachable power cord, 7-1/2 feet (230 cm) long, NEMA plug. Rack mount conversion parts. One set of extenders for printed circuit boards. Spare fuse, Manual.

PLUG-INS

Requires two; 5486A/B (see subsection 1.5) and 5485A, or alternates 5487A, or 5488A.

DIMENSIONS: (5480)   (See Outline Diagram below.)

ACCESSORIES AVAILABLE

10640B Cable Assembly (for 7591A Plotting System)
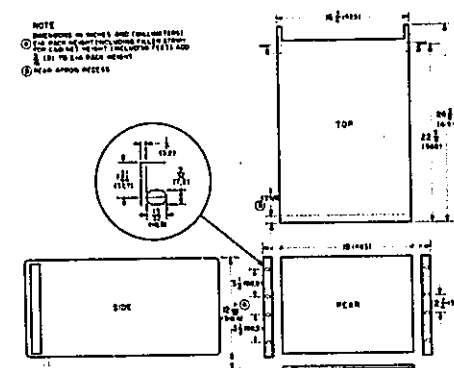
5487A FOUR-CHANNEL INPUT

GENERAL

Alternate to 5485A Two-Input Plug-In. Specifications are the same as for the 5485A, except as follows:

NUMBER OF INPUTS (AVERAGING)

Four. All may be displayed, and averaged simultaneously into different segments of memory, by means of chopping.

INPUT SENSITIVITY

50 mV/cm to 20 V/cm (±3%), in 1, 2, 5 sequence.

BANDWIDTH

Dc to 25 kHz.

Table 1-1. Specifications (Cont'd)

5487A FOUR-CHANNEL INPUT (Cont'd)

MEMORY SELECTION

Same as 5485A, except Histograms can only be done using FULL memory.

MEMORY SELECTION PRIORITY

Input A over B, B over C, C over D, for mutually selected segments.

OMITTED

Polarity reversing and A+B selection.

DIMENSIONS

(Storage space) 6 in. (15, 3 cm) x 7-5/16 in. (18, 6 cm) x 14 in. (35, 6 cm)

WEIGHT

Net, 8 lb (3, 64 Kg); Gross 13 lb (5, 90 Kg).

OPTION 001 (for 5487A) Variance (see Display Outputs)

5488A AVERAGE/CORRELATION INPUT

GENERAL

Alternate to 5485A Two-Input Plug-In. Specifications are the same as for the 5485A except as follows:

FUNCTIONS

Two Channel Input and Correlation

Two-Channel Input

GENERAL

Same as 5485A except:

INPUT SENSITIVITY

50 mV/cm to 20 V/cm (±3%) in 1, 2, 5 sequence.

BANDWIDTH

Dc to 25 kHz

OMITTED

Polarity inversion, and signal addition (A+B).

Table 1-1. Specifications (Cont'd)

Correlation

GENERAL

Cross-correlation between two inputs, or auto-correlation of a single signal, connected to both inputs in parallel.

INPUT CHARACTERISTICS

Same as above, except:

Horizontal Resolution: (Points in correlation function) 1000 for FULL memory, 500 for HALF, 250 for QUARTER.

Delay Increments: (τ) per point, 10 μsec to 0.5 sec in 1, 2, 5 sequence: with external time base, base, 50 μsec and slower.

Delay Offset: 20 μs to .5 sec in 1, 2, 5 sequence, or 0 μs.

Maximum Delay: (1000 increments) 500 seconds: longer with external time base.

Analog-to-Digital Converter (ADC): (For Correlation) 4-bit comparator type with parallel grey code output.

Multiplier: Hardwired digital.

Vertical Calibration: Depends on settings of both input attenuators: $C = 10 \times A \times B$ (volts^2/cm).

DIMENSIONS

(Storage space) Same as 5487A.

WEIGHT

Net, 8 lb (3, 64 Kg); Gross 13 lb (5, 90 Kg).

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be either an eight-digit (000-00000) or a nine-digit (0000A00000) number, located on the serial number plate on the unit's rear panel.

In the eight-digit number, the first three digits are the serial prefix, used to document changes. The five-digit portion of the serial number is unique to each unit with that Model number.

In the nine-digit number, the first four digits are the serial prefix. The alpha character identifies the country of origin, and may be included as part of the serial prefix; A=United States of America, E=England, G=West Germany, J=Japan, U-United Kingdom. The final five digits are unique to each unit with that Model number.

Include the complete Model number, serial number, and instrument (unit) name in correspondence about any unit in your Signal Analyzer System.

1.5. PLUG-IN COMPATIBILITY

The evolution of the 5480A/B Signal Analyzer System has included changes in the Mainframe and Logic Plug-in unit wiring that can prevent complete compatibility between some versions of these units; because of this, certain plug-ins should be used only with certain mainframes, as listed below.

a. Although a 5486A plug-in can be used with a 5480B mainframe and a 5486B plug-in used with a 5480A mainframe, such uses are not recommended. Performance of these combinations is not specified. A 5486A Plug-in should be used only with a 5480A mainframe, and a 5486B with a 5480B mainframe.

b. A 5480B Memory/Display (mainframe) with serial prefix 1108A or above requires a 5486B Control plug-in unit with serial prefix 1104A or above in order to perform TREND ANALYSIS (formerly MCS). The MCS INPUT connector was removed from the 5480B rear-panel beginning with serial prefix 1108A, and the TREND ANALYSIS (formerly MCS)/second HISTOGRAM input connector added to the 5486B at serial 1104A.

c. A 5486B with serial prefix 1104A or above can be used with any 5480B mainframe unit. However, as described in b above, the 5480B's MCS input is not used, since the MCS line in the 5486B is replaced by the front-panel TREND ANALYSIS input.

1.6. CRT WARRANTY

The Warranty and Warranty Claim Form for the 5480A/B CRT are located at the back of this manual. If the CRT should fail within the time specified on the warranty, return it with the warranty form completed.

1.7. UNPACKING AND INSPECTION

If shipping carton is damaged, ask that carrier's agent be present when instrument is unpacked.

Inspect instrument for damage (scratches, dents, broken knobs, etc.). If instrument is damaged or fails to operate (see Operating Check, Table 3-2), notify carrier and nearest Hewlett-Packard Sales and Service office immediately. Sales and Service offices are listed at back of this manual. Retain shipping carton and padding material for carrier's inspection. Sales office will arrange for repair or replacement of your instrument without waiting for claim against carrier to be settled.

1.8. INSTALLATION

The 5480A/B is shipped with logic and analog plug-ins installed, and is ready for bench operation when power and signal connections are made. Additional parts necessary for rack mounting are packaged with the system. Rack installation should allow a free flow of cooling air. To convert the Signal Analyzer for rack installation, refer to Figure 1-2 and proceed as follows:

Figure 1-2. Rack Mounting
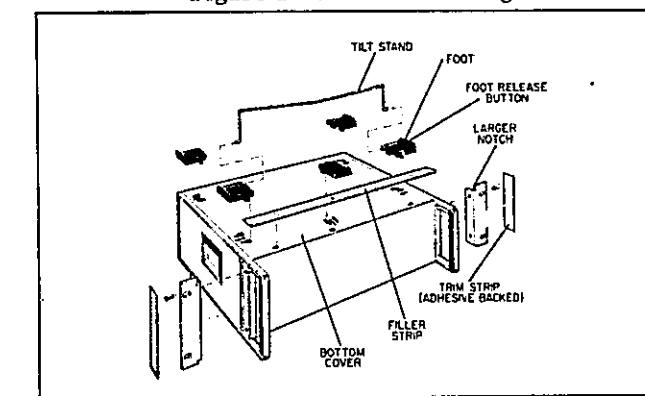
a. Remove tilt stand.

b. Remove feet (press the foot-release button, slide foot toward center of instrument, and lift off).

c. Remove adhesive-backed trim strips at front end of sides.

d. Attach filler strip along bottom edge of front panel.

e. Attach flanges to front end of sides where trim strips were removed (larger corner notch of flange is toward bottom of instrument). The Signal Analyzer is now ready to mount in a standard rack.

1.9. CONNECTIONS

In general, BNC connectors are used for external signal connections to the 5480A/B mainframe and its plug-ins. The primary exception is the 28-pin

ribbon PLOTTER connector used on all 5480B's and on 5480A's having serial prefix 928 and above. Normal signal connections for each FUNCTION are identified in the Operating Plates, Figures 1-4 through 1-16. A more detailed description of the 5480A/B rear-panel connectors, and the signals available there, is given in Table 4-2, Part F, in this manual. Figure 1-3 shows how to connect a Sampling Oscilloscope to increase frequency response of the 5480A/B system.

Figure 1-3. Connection of Sampling Oscilloscope to Extend Frequency Range
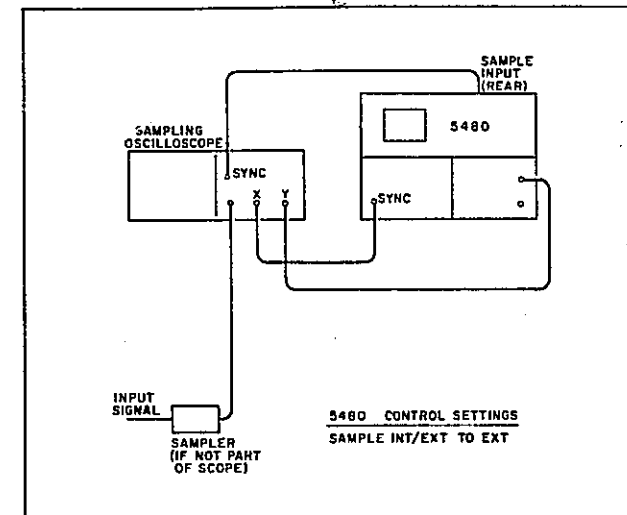
1.10. SERVICE AIDS

1.10.1. Service Kits

This Manual is intended to support the service kits for the HP 5480A/B Signal Analyzers. The kits contain most-often-needed replaceable parts (see lists in Section IV) for the following 5480A/B system units:

> 5480A/B Memory/Display
> 5485A Two Channel Input
> 5486A/B Control
> 5487A Four Channel Input
> 5488A Average/Correlation Input

1.10.2. Board Exchange

Hewlett-Packard provides exchange printed circuit boards for the 5480A/B system units listed in subsection 1.10.1. The board exchange program works as follows:

a. Repair 5480A/B system with Service Kit. Replace faulty boards in system with good boards from kit. Tag bad boards with a description of trouble caused in system.

b. Order rebuilt board(s) from Hewlett-Packard.

c. When a replacement board arrives, place it in the appropriate service kit. Save the box the board came in.

d. The box in which you received your replacement board will also contain an address label to be used for returning the board to the repair center, and a form to provide information about the trouble the board caused. Place the bad board in the box, along with the trouble description form (filled in), and stick the address label over the old address on the box. Send the board to the repair center.

1.11. STORAGE AND SHIPMENT

1.11.1. Packaging

To protect valuable electronic equipment during storage or shipment, always use the best packaging methods available. Your Hewlett-Packard Sales and Service Office can provide packaging material such as that used for original factory packaging. Contract packaging companies in many cities can provide dependable packaging on short notice.

1.11.2. Environment

Conditions during storage and shipment should normally be limited as follows:

a. Maximum altitude: 15K feet (4, 5 km).

b. Maximum temperature: $+149^O$F ($+65^O$C).

c. Minimum temperature: -4^OF (-20^OC).

Figure 1-4. Memory-Display Unit (5480B)
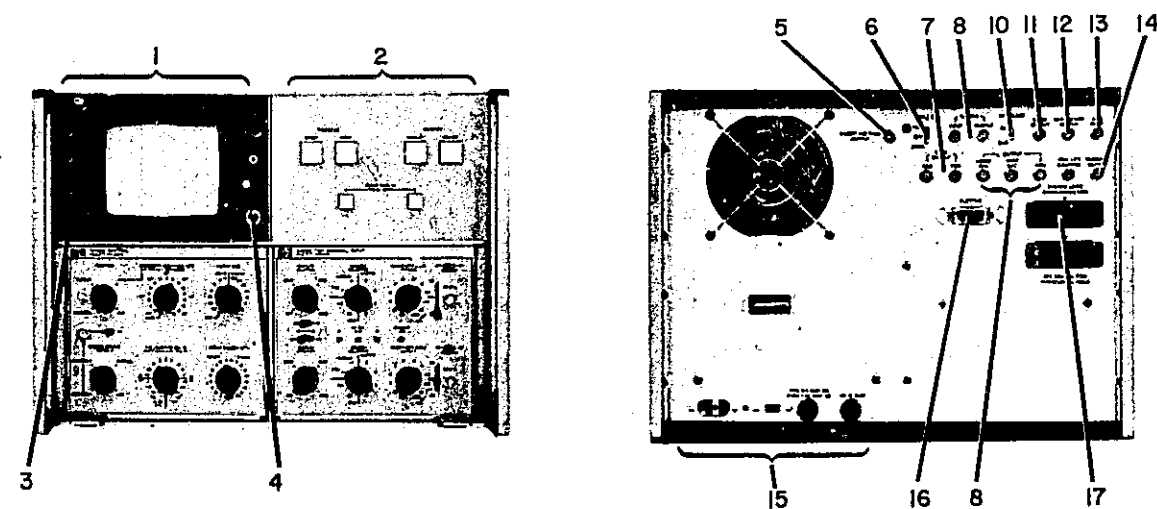
NOTE: Except for identification engraving, 5480B front panel is identical to 5480A front-panel shown above.

DESCRIPTION; Provides memory, logic, power supply, and display output for Signal Analyzer System.

CONTROLS, CONNECTORS, INDICATORS

Front Panel

1. DISPLAY

CRT: Provides visual output from 5480B. See Figures 1-4 through 1-16 for interpretation of display.

INTENSITY: Adjusts CRT trace intensity. Prevent CRT phosphor burns by keeping intensity as low as possible while maintaining good trace visibility.

TRACE ALIGN: Rotates trace for alignment with graticule.

FOCUS: Adjusts CRT focus. Set for smallest spot size.

MAGNIFIER: Expands horizontal display scale by factor of 5 (in X5) to provide increased resolution.

Figure 1-4. Memory-Display Unit (5480B) (Cont'd)

Front Panel (Cont'd)

2. <u>MEMORY</u>

PROCESS and OUTPUT controls are pushbutton switches containing indicator lamps. Lighted switch button indicates which Memory activity is in progress.

PROCESS START: Enables signal processing by Memory. Processing begins at first sync pulse after pushbutton is pressed. If pressed while STOP or DISPLAY button is lighted, processing resumes at next sync pulse. Button remains lighted during signal processing.

PROCESS STOP: Stops signal processing by Memory. No CRT display.

OUTPUT DISPLAY: Causes Memory contents to be displayed on CRT. Stops signal processing if pressed while START button is lighted.

OUTPUT RECORD: When signal processing is stopped, causes 5480B to step through Memory contents once at rate selected by SWEEP TIME control. Memory contents are provided in analog form at rear panel OUTPUT AND PLOTTER connectors (items 9 and 16). Output signal can be recorded by X-Y recorder at rate which recorder pen can follow. (A Pen Lift signal is provided through the PLOTTER connector).

CLEAR DISPLAY: Two pushbutton switches must be pressed simultaneously to erase Memory contents being displayed on CRT. Use of two buttons prevents accidental erasure of Memory contents.

3. <u>CALIBRATOR</u>

Female banana connector. One-volt peak-to-peak squarewave. Output frequency depends on SWEEP TIME to maintain same number of cycles on CRT display regardless of SWEEP TIME setting.

4. <u>POWER</u>

Switch controls ac power to 5480B.

White indicator lights whenever ac power is ON.

Amber RESET lamp lights to indicate that ac power was momentarily interrupted (longer interruptions do not light the lamp). Memory contents are protected against ac interruption, but processing cannot continue until the interruption has been acknowledged by resetting the 5480B by turning ac power off for about one second, then on again.

Rear Panel

5. <u>SWEEP VOLTAGE OUTPUT</u>

Female BNC connector. Provides sawtooth (0V to +1V) signal synchronized with analyzer sweep. Set INTERLACE to OUT when using this connector.

6. <u>SCALE CAL</u>

Provides means for calibrating an X-Y recorder connected at OUTPUT or PLOTTER connectors (items 9 and 16). When analog plug-in DISPLAY control is set to DATA, SCALE CAL operates as follows:

In FULL, a dot appears at upper right corner of CRT; In ZERO, a dot appears at lower left corner of CRT; In OFF, 5480B operates normally.

Figure 1-4. Memory-Display Unit (5480B) (Cont'd)

Rear Panel (Cont'd)

7. SYNC OUTPUTS

Female BNC connectors. POS provides +12V, > 0.5 μsec pulse at end of each sweep (plus post-analysis delay); NEG provides same, except -12V.

8. SAMPLE

SAMPLE INPUT connector. Female BNC. Signal applied here establishes sampling rate when 5486B SWEEP TIME switch is set to EXT. Signal frequency must be less than 20 kHz and levels must vary from 0V or more negative to +2V or more positive.

SAMPLE OUTPUT connector. Female BNC. Up to one-thousand logic level sample pulses per sweep. Output available from either internal or external sweeps. One pulse for each input sample, number depends on MEMORY SELECTOR settings. Can be 0, 250, 500, 750, or 1000.

9. OUTPUT

Female BNC connectors. Provides necessary analog outputs for driving X-Y recorder, point plotter, oscilloscope, or other analog device.

HORIZ DAC provides 0V to +10V ramp, proportional to each Memory address.

VERT DAC provides -5V to +5V, proportional to vertical display.

Z-AXIS provides 2V logic-level signal for oscilloscope blanking.

PEN LIFT CONTROL provides relay closure to ground to lower recorder pen at start of sweep and opens to lift pen at end of sweep.

10. INTERLACE

Controls display sweep. When set to IN, display address register sweeps memory and CRT continuously at 1 msec/cm, providing continuous flicker-free display, regardless of Logic Plug-in SWEEP TIME setting.

When SWEEP VOLTAGE OUTPUT (item 5) is being used, set INTERLACE to OUT. This will make SWEEP VOLTAGE OUTPUT a single ramp for each triggering sync pulse.

11. NOISE OUTPUT

Female BNC connector. Provides difference between sampled input signal and data stored in memory, if 1) PROCESS START button is lighted and 2) INTERLACE is set to OUT, or DISPLAY and ON/ORR switches are set to display INPUT or NOISE from one or more input channels.

12. VERT SCOPE OUTPUT

Female BNC connector. Provides -5V to +5V ac signal (proportional to amplitude of displayed signal) riding on a dc offset voltage that is proportional to setting of Analog Plug-in Vertical POSITION control(s).

13. LOGIC PROBE (5480B, serial prefix 1108A or higher)

Female BNC connector. +5-volt power source for HP 10525A/B Logic Probe.

MCS INPUT (5480B, serial prefix below 1108A)

Female BNC connector. Signal input for MCS (Multichannel Scaling) mode (see Figure 1-16). Requires 5486B with serial prefix below 1104A; 5486B with serial prefix 1104A or higher may be used, except use its TREND ANALYSIS front-panel input instead.

Rear Panel (Cont'd)

14. VARIANCE OUTPUT

Female BNC connector. Provides square of noise only (variance of input signal) when variance board is installed in analog plug-in (see Figure 1-13). By observing this output on an unused 5480B input channel, operator can tell if average waveform is made up of more than one output signal locked to the input sync frequency.

15. POWER

Serials prefixed below 976: connector accepts HP 8120-0078 power cord.
Serials prefixed 976 or higher: connector accepts HP 8120-1378 power cord.

115/230 slide switch allows operation from either 115V or 230V ac lines. Use a narrow-blade screwdriver to slide switch so numbers indicating operating line voltage are exposed. Be sure correct fuse is installed: For 115V, use 2.5A slow-blow, HP Part No. 2110-0015. For 230V, use 1.25A slow-blow, HP Part No. 2110-0021.

5V fuse: For internal +5V supply, use 10A, HP Part No. 2110-0051.

16. PLOTTER

14-pin female ribbon connector. Provides data and control paths between 5480B and point plotter.

17. SYSTEM LOGIC INTERCONNECTION for I/O Coupler or Computer.

The I/O coupler provides for interface connections between the Model 5480B and computer, teleprinter, printer, tape reader, or tape punch.
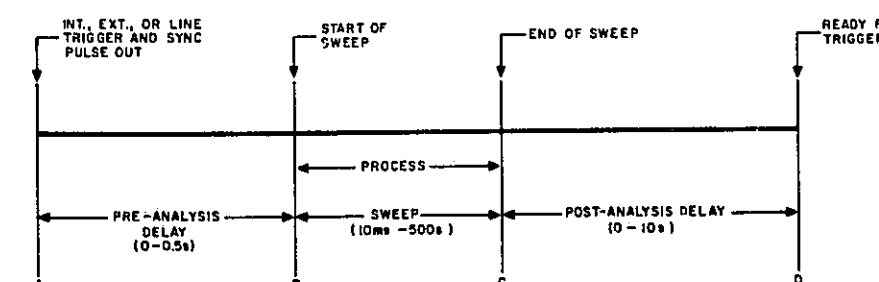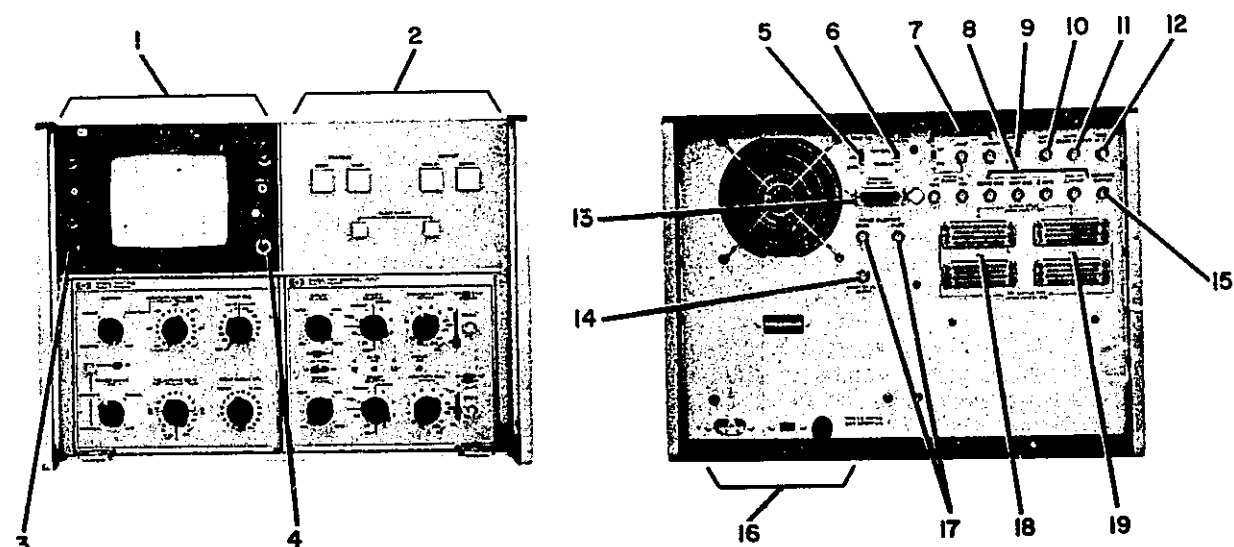
PRE-ANALYSIS AND POST-ANALYSIS DELAYS

1-19

Figure 1-5. Memory-Display Unit (5480A)

DESCRIPTION: Provides memory, logic, power supply and display output for Signal Analyzer System.

CONTROLS, CONNECTORS , INDICATORS

Front Panel

1. DISPLAY

CRT: Provides visual output from 5480A. See Figures 1-11 through 1-16 for interpretation of display.

INTENSITY: Adjusts CRT trace intensity. Prevent CRT phosphor burns by keeping intensity as low as possible while maintaining good trace visibility.

TRACE ALIGN: Rotates trace for alignment with graticule.

FOCUS: Adjusts CRT focus. Set for smallest spot size.

MAGNIFIER: Expands horizontal display scale by factor of 5 (in X5) to provide increased resolution.

2. MEMORY

PROCESS and OUTPUT controls are pushbutton switches containing indicator lamps. Lighted button indicates Memory activity in progress.

PROCESS START: Enables signal processing by Memory. Processing begins at first sync pulse after pushbutton is pressed. If pressed while STOP or DISPLAY button is lighted, processing resumes at next sync pulse. Button remains lighted during signal processing.

Figure 1-5. Memory-Display Unit (5480A) (Cont'd)

Front Panel (Cont'd)

2. MEMORY (Cont'd)

PROCESS STOP: Stops signal processing by Memory. No CRT display.

OUTPUT DISPLAY; Causes Memory contents to be displayed on CRT. Stops signal processing if pressed while START button is lighted.

OUTPUT RECORD: When signal processing is stopped, causes 5480A to step through Memory contents once at rate selected by SWEEP TIME control. Memory contents are provided in analog form at rear panel OUTPUT connectors (item 8). Output signal can be recorded by X-Y recorder at rate which recorder pen can follow. (A PEN LIFT signal is also provided at rear panel.)

CLEAR DISPLAY: Two pushbutton switches must be pressed simultaneously to erase Memory contents being displayed on CRT. Use of two buttons prevents accidental erasure of Memory contents.

3. CALIBRATOR

Female banana connector. One volt peak-to-peak square wave. Output frequency depends on SWEEP TIME to maintain the same number of cycles on CRT display regardless of SWEEP TIME.

4. POWER

Switch controls ac power to 5480A.

White ON lamp lights whenever ac power is applied.

Red RESET lamp lights to indicate that ac power has been interrupted. Memory contents are protected againstæ interruption, but processing cannot continue until the interruption has been acknowledged by resetting the 5480A by turning ac power off for about one second, then on again.

Rear Panel

Panel illustrated is for 5480A's having serial prefix 852 or 836. Rear panel of 5480A's having serial prefix 928 and above is same as 5480B, shown in Figure 1-4.

5. SCALE CAL

Provides means for calibrating and X-Y recorder connected at OUTPUT connectors (item 8). When analog plug-in DISPLAY control is set to DATA, SCALE CAL operates as follows:

In FULL, a dot appears at upper right corner of CRT.
In ZERO, a dot appears at lower left corner of CRT.
In OFF, 5480A operates normally.

6. HORIZ SWEEP WAVEFORM

Useable in MCS only. Allows operator to select SAWTOOTH or TRIANGLE sweep voltage. In SAWTOOTH, Memory is stepped from 0 (left) to 1000 (right) linearly, jumps back to 0 (left) and steps linearly to 1000 (right) again. In triangle, Memory is stepped from 0 (left) to 1000 (right) linearly, then from 1000 (right) to 0 (left) linearly, then 0 (left) to 1000 (right), etc.

SAWTOOTH gives continual left-to-right sweeps while TRIANGLE gives alternate left-to-right and right-to-left sweeps (steps through Memory).

Rear Panel (Cont'd)

7. SAMPLE

   INT/EXT Switch: In INT, 5480A uses internal 100 kHz time base to establish sampling rate
   In EXT, 5480A uses signal applied at SAMPLE INPUT connector to establish sampling rate.

   SAMPLE OUTPUT connector. Female BNC. One-thousand logic level sample pulses per sweep.
   Output available from either internal or external sweeps.

   SAMPLE INPUT connector. Female BNC. Signal applied here establishes sampling rate when
   INT/EXT switch set to EXT. Signal frequency must be less than 20 kHz and levels must
   vary from 0V or more negative to +2V or more positive.

8. OUTPUT

   Female BNC connectors. Provides necessary analog outputs for driving X-Y recorder, point
   plotter, oscilloscope, or other analog device.

   HORIZ DAC provides 0V to +10V ramp, proportional to each Memory address.

   VERT DAC provides -5V to +5V, proportional to vertical display.

   Z AXIS provides 2V logic-level signal for oscilloscope blanking.

   PEN LIST CONTROL provides logic level signal to drop X-Y recorder pen at start of sweep
   and lift pen at end of sweep.

9. INTERLACE DISPLAY

   Controls display sweep. When set to IN, display address register sweeps memory and CRT
   continuously at 1 msec/cm, providing continuous flicker-free display, regardless of Logic
   Plug-in SWEEP TIME setting. When SWEEP VOLTAGE OUTPUT (item 14) if being used, set
   INTERLACE DISPLAY to OUT. This will make SWEEP VOLTAGE OUTPUT a single ramp for
   each triggering sync pulse.

10. NOISE OUTPUT

    Female BNC connector. Provides noise being removed from data signal. Voltage level is correct
    for that point during time CRT is unblanked (Z AXIS OUTPUT pulse).

11. VERT SCOPE OUTPUT

    Female BNC connector. Provides -5V to +5V ac signal (proportional to amplitude of displayed
    signal) riding on a dc offset voltage that is proportional to setting of Analog Plug-in Vertical
    POSITION control.

12. MCS INPUT

    Female BNC Connector. Signal input for MCS (multichannel scaling) mode (see Figure 1-16).

13. EXTERNAL DATA INPUT

    24-pin connector. Inputs parallel data inputs from Analog Plug-in connector.

14. SWEEP VOLTAGE OUTPUT

    Female BNC connector. Provides sawtooth (0V to +1V) signal synchronized with analyzed
    sweep. Set INTERLACE DISPLAY to OUT when using this connector.

Rear Panel (Cont'd)

15. VARIANCE OUTPUT

    Female BNC connector. Provides square of noise only (variance of input signal) when variance
    option is installed. By observing this output on an unused 5480A input channel, operator can tell
    if average waveform is made up of more than one input signal locked to the input sync frequency.

16. POWER

    Connector accepts flat-connector end of HP Part No. 8120-0078 power cord.

    115/230 slide switch allows operation from either 115V or 230V ac lines. Use a narrow-blade
    screwdriver to slide switch so numbers indicating operating line voltage are exposed. Be sure
    correct fuse is installed: For 115V, use 2.5A slow-blow, HP Part No. 2110-0015. For 230V, use
    1.25A slow-blow, HP Part No. 2110-0021.

17. POINT PLOTTER

    Female BNC connectors. SEEK supplies signal telling point plotter to plot a point.

    PLOT receives signal from plotter, indicating point has been plotted.

    Point plotter X and Y inputs come from HORIZ DAC and VERT DAC OUTPUTs, respectively.
    Logic Plug-in SWEEP TIME switch (see Figure 1-6) must be set to EXT.

18. SYSTEM LOGIC INTERCONNECTION

    For I/O (Input/Output) Coupler. The I/O coupler provides for interface connections between
    the Model 5480A and computer, teletype, printer, tape reader, or tape punch.

Figure 1-6. Control Plug-In (5486A/B)
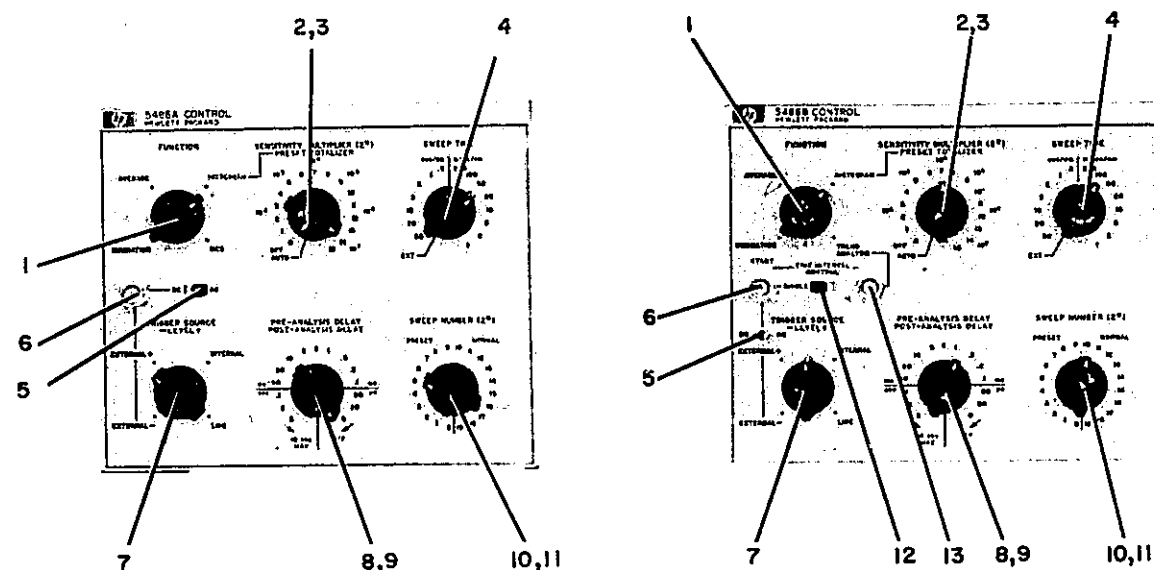
5486A, 5486B (PREFIX BELOW 1104A)

(Note: Except for Model Number engraving, front panel of 5486B with serial prefix below 1104A is identical to 5486A shown above.)

5486B (PREFIX 1104A AND ABOVE)

(Note: TREND ANALYSIS operates exactly as MCS in older units. Generally you may substitute "TREND ANALYSIS" for "MCS" or "Multichannel Scaling" whenever they appear in this manual.)

DESCRIPTION: Selects FUNCTION of Signal Analyzer System. Controls system rate, pre- and post-analysis delays, and amount of processing for each analysis.

N	2^N
0	1
1	2
2	4
3	8
4	16
5	32
6	64
7	128
8	256
9	512
10	1024
11	2048
12	4096
13	8192
14	16384
15	32768
16	65536
17	131072
18	262144
19	524288

Figure 1-6. Control Plug-In (5486A/B) (Cont'd)

CONTROLS, CONNECTORS

1. **FUNCTION**

   SUMMATION: Causes successive repetitions of input signal to be added, keeping a "running total". Vertical display is not calibrated (see Figure 1-14).

   AVERAGE: Keeps "calibrated average" of successive input signal repetitions. Provides continuous calibrated display (see Figure 1-11).

   HISTOGRAM: Creates plot of number-of-occurrences (probability) vertical axis versus frequency or period on horizontal axis. Input signal is applied at input connector (item 6).

   MCS (5486A, 5486B with serial prefix below 1104A): Creates plot of frequency on vertical axis versus time on horizontal axis. Input signal is applied through 5480A/B (serial prefix below 1108A) rear-panel MCS INPUT connector.

   TREND ANALYSIS (5486B with serial prefix 1104A and above - see note under photograph): Creates plot of frequency on vertical axis versus time on horizontal axis. Input signal is applied through 5486B TREND ANALYSIS input connector (item 13).

2. **SENSITIVITY MULTIPLIER (2^N)**

   Multiplies vertical display size by 2^N. Dial is calibrated in N, thus as control is turned clockwise each position doubles display size. In AUTO, vertical display is automatically calibrated in terms of V/cm on the input attenuator setting when signal was being processed in AVERAGE and SUMMATION.

3. **PRESET TOTALIZER**

   When FUNCTION is set to HISTOGRAM, PRESET TOTALIZER specifies number of values to be counted in memory location having greatest number of counts; highest peak in histogram display will have number of counts indicated by PRESET TOTALIZER, other portions of display will be proportional. When PRESET TOTALIZER is set to OFF, histogramming continues until manually stopped by pressing OUTPUT DISPLAY or PROCESS STOP pushbutton.

4. **SWEEP TIME**

   Determines rate at which address register steps through Memory, (processing rate). In EXT, input signal connected through 5480A/B rear-panel SAMPLE INPUT connector is converted to a train of sampling pulses; nearly any periodic waveform may be used for this application.

   In Frequency HISTOGRAM mode, SWEEP TIME control calibrates Horizontal axis (Figure 1-15).

5. **AC/DC**

   Selects ac coupling or dc coupling of input sync signals in SUMMATION and AVERAGE mode.

6. **INPUT CONNECTOR**

   Female BNC.

   5486A, 5486B with serial prefix below 1104A: Sync input for SUMMATION and AVERAGE mode; signal input for HISTOGRAM mode. See Figure 1-9 through Figure 1-15.

CONTROLS, CONNECTORS (Cont'd)

6. **INPUT CONNECTOR** (Cont'd)

    5486B with prefix 1104A or higher: Sync input for SUMMATION and AVERAGE mode; signal input for FREQUENCY HISTOGRAMs and SINGLE input TIME INTERVAL HISTOGRAMs; STOP signal input for SEP input TIME INTERVAL HISTOGRAMS.

7. **TRIGGER SOURCE/LEVEL**

    Operates in SUMMATION, AVERAGE, and HISTOGRAM modes only.

    TRIGGER SOURCE selects triggering signal from: INTERNAL, uses sync signal generated at end of each sweep (5480A/B is free-running). LINE, uses signal derived from power line frequency. EXTERNAL + or -, uses signal at BNC connector (item 6); derives sync pulse from positive or negative signal slope.

8. **PRE-ANALYSIS DELAY**

    Provides calibrated 20 sec to 0.5 sec delay between input sync signal and start of sweep. Conserves memory and increases resolution by eliminating unnecessary front portion of data waveform display.

9. **POST-ANALYSIS DELAY**

    Provides uncalibrated zero to 10 second delay of output sync pulse occurring at end of every sweep. If this sync output is used to start each repetition of an experiment, start of experiment will be delayed by this amount.

10. **SWEEP NUMBER (2^N)**

    Selects number of sweeps or repetitions to be averaged. Dial is calibrated in N, number of sweeps is 2^N. (For example, SWEEP NUMBER 3 causes 8 sweeps to be averaged.) Signal-to-noise ratio improvement in dB is approximately 3N. For example, where N is 3, dB improvement is 9 dB.

11. **PRESET/NORMAL**

    PRESET (AVERAGE): 5480A/B averages number of sweeps selected by SWEEP NUMBER, stops and DISPLAYs result (see Figure 1-11). This is stable averaging.*

    NORMAL (AVERAGE): 5480A/B averages number of sweeps selected by SWEEP NUMBER, and continues averaging with this number of sweeps defining the weighting time constant until stopped manually. This is weighted averaging. (See Figure 1-11.)

    PRESET (SUMMATION): 5480A/B adds number of sweeps selected by SWEEP NUMBER control, stops and DISPLAYS result (see Figure 1-14).

---

* **NOTE:** In PRESET (AVERAGE), PRESET (SUMMATION), or PRESET (MCS), and SWEEP NUMBER is 19, 5480A/B will stop and DISPLAY result after 2^{18} sweeps.

CONTROLS, CONNECTORS (Cont'd)

11. **PRESET/NORMAL** (Cont'd)

    NORMAL (SUMMATION): 5480A/B adds inputs until manually stopped (see Figure 1-14). The AUTO scaling feature of SENSITIVITY MULTIPLIER ceases operation in NORMAL mode during SUMMATION after SWEEP NUMBER has been reached.

    PRESET (MCS): 5480A/B performs Multichannel Scale function for number of sweeps selected by SWEEP NUMBER, stops and DISPLAYs result (see Figure 1-16).

    NORMAL (MCS): 5480A/B performs Multichannel Scale function until stopped by pressing OUTPUT DISPLAY or PROCESS STOP pushbutton.

12. **TIME INTERVAL CONTROL**

    Selects one- or two-input operation of TIME INTERVAL HISTOGRAM FUNCTION. In SINGLE, the inputs are connected to START/STOP input connector (item 6); time intervals are measured between points on the input signal having the trigger level and slope selected by the TRIGGER LEVEL and SLOPE selected by the TRIGGER SOURCE controls. In SEP, one signal input is connected to the START input connector (item 13), and a second signal is connected to the START/STOP input connector (item 6); time intervals are measured between the START input trigger (a voltage transition from 0V to 2V) and the STOP input trigger (selected by TRIGGER SOURCE and LEVEL controls).

13. **INPUT CONNECTOR**

    Female BNC. START input for SEP Input **TIME INTERVAL HISTOGRAMS**; signal input for **TREND ANALYSIS** mode.

Figure 1-7. Two Channel Input Plug-In (5485A)
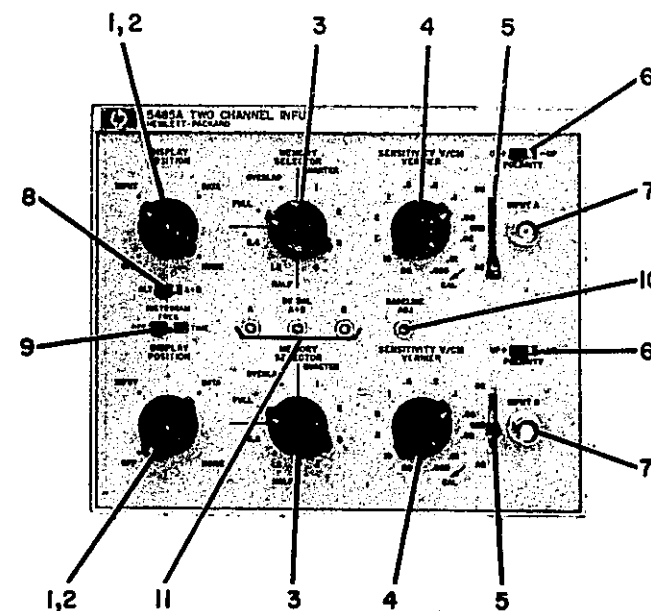
DESCRIPTION: Accepts one or two channels of input data to be presented as vertical portion of Signal Analyzer display.

CONTROLS, CONNECTORS

1. DISPLAY

   Selects CRT display for its channel. INPUT displays raw, unprocessed input signal. DATA displays averaged signal, MCS, or histogram. NOISE displays difference between INPUT and averaged signal. OFF turns channel off (see item 3).

2. POSITION

   Adjusts vertical position of its channel on CRT display.

3. MEMORY SELECTOR

   Selects portion of Memory to be used for storage, display, or processing. Memory is divided into four quarters. Operator may select memory portions for either channel as follows:

   QUARTER 1
   QUARTER 2
   QUARTER 3
   QUARTER 4
   HALF (QUARTERS 1 and 2)
   HALF (QUARTERS 3 and 4)
   FULL (QUARTERS 1, 2, 3, and 4)

   In OVERLAP all four quarter sections are displayed simultaneously as separate traces. When MEMORY SELECTOR controls are set to cause both channels to be connected to same Memory quarter, A rules. For example, if MEMORY SELECTOR A is set to FULL, no quarter

Figure 1-7. Two Channel Input Plug-In (5485A) (Cont'd)

CONTROLS, CONNECTORS (Cont'd)

3. MEMORY SELECTOR (Cont'd)

   is left for B; or, if MEMORY SELECTOR A is set to QUARTER 1, and MEMORY SELECTOR B set to FULL, Channel A gets QUARTER 1, and Channel B gets QUARTERs 2, 3, and 4.

4. SENSITIVITY/VERNIER

   SENSITIVITY: Attenuates input signal and provides calibration of vertical display axis from 5 mV/cm to 20 V/cm.

   VERNIER: Provides continuous, uncalibrated attenuation of vertical display axis. Does not affect input signal amplitude stored in memory.

5. DC/GND/AC

   Switches from dc coupling, grounding, or ac coupling of input. In GND, input connector is open-circuited, and input to amplifier is grounded to provide a zero reference.

6. UP+/-UP

   Inverts input signal, allowing waveform to be displayed with positive voltage above baseline (UP+) or below baseline (-UP).

7. INPUT

   Female BNC connector. Input for AVERAGE or SUMMATION functions (see Figures 1-11, 1-13, and 1-14).

8. ALT/A+B

   In ALT, two channels operate separately. In A + B, signal at INPUT B is added to signal at INPUT A and sum is fed through Channel A only. Difference between two signals can be averaged by setting one channel to UP+ and other to -UP.

9. HISTOGRAM FREQ/TIME

   If Logic Plug-in FUNCTION is set to HISTOGRAM, FREQ displays a frequency histogram (use above 1 kHz), or TIME displays a period (time) histogram (use below 1 kHz). See Figure 1-15.

10. BASELINE ADJ

    Adjusts baseline to prevent baseline drift during summation.

11. DC BAL CONTROLS

    Compensate for small dc offsets in the input circuits so dc input will be stored as "0" in the memory.

Figure 1-8. Four Channel Input Plug-In (5487A)
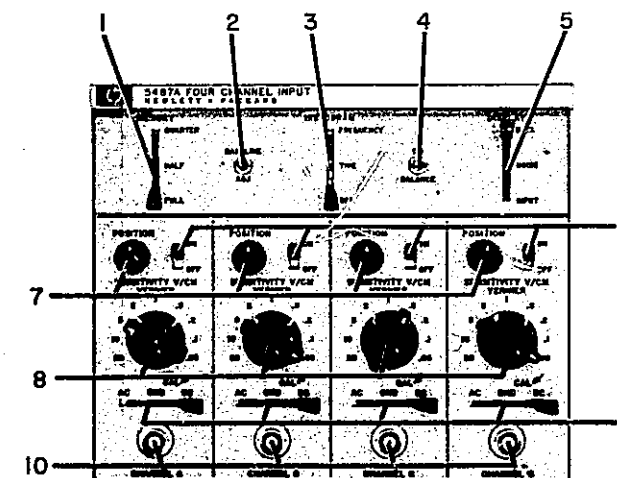
DESCRIPTION: Accepts one to four channels of input data to be presented as vertical portion of Signal Analyzer display.

CONTROLS, CONNECTORS

1. **MEMORY**

   Selects portion of memory to be used for storage, display, or processing by any one channel. The chart below lists memory section-vs-5487A channel allocations.

2. **BASELINE ADJ**

   Adjusts baseline to prevent baseline drift during summation.

3. **HISTOGRAM/FREQ/TIME**

   If Logic Plug-in FUNCTION is set to HISTOGRAM, FREQ displays a frequency histogram (use above 1 kHz), or TIME DISPLAYS A PERIOD (time) histogram (use below 1 kHz). See Figure 1-15.

4. **DC BALANCE**

   Compensates for small dc offsets in the input circuits so dc input will be stored as "0" in the memory.

5. **DISPLAY**

   Selects CRT display for all channels turned ON (see table referenced by MEMORY switch description). INPUT displays sampled input signals. DATA displays averaged signal, MCS, or histogram, NOISE displays difference between INPUT and averaged signal (DATA).

Figure 1-8. Four Channel Input Plug-In (5487A) (Cont'd)

CONTROLS, CONNECTORS (Cont'd)

6. ON/OFF SWITCHES

These switches, plus the MEMORY switch and some internal logic determine which channels will be processed or displayed. The table referenced by the MEMORY switch description provides details. At least one channel must be ON or there will be no processing or display.

7. POSITION

Each control adjusts vertical position of its trace (if channel is being displayed) on CRT screen.

8. SENSITIVITY/VERNIER

SENSITIVITY: Attenuates input signal and provides calibration of vertical display axis from 50 mV/cm to 20 V/cm.

VERNIER: Provides continuous, uncalibrated attenuation of vertical display axis. Does not affect input signal amplitude stored in memory.

9. AC/GND/DC

Switches from ac coupling, grounding, or dc coupling of input. In GND, input connector is open-circuited, and input to amplifier is grounded to provide a zero reference

10. INPUT

Female BNC connector. Input for AVERAGE or SUMMATION functions (see Figures 1-11, 1-13, and 1-14).

CONTROLS, CONNECTORS (Cont'd)

MEMORY switch selects whether any one Plug-in channel will be connected to one (QUARTER), two (HALF), or four (FULL) quarters of memory.

FULL

All four memory quarters are connected to the highest priority channel that is turned "ON". Channel A has highest priority, followed, in order, by B, C, and D.

FULL MEMORY

connected to this channel when Channel is "ON"	Unless
A	----
B	Channel A is ON
C	Channel A or B is ON
D	Channel A, B, or C is ON

HALF

Memory quarters are connected to Plug-In Channels as shown in chart below.

NOTES:

1. Numbers indicated identification numbers for the two memory quarters connected to a channel when that channel is ON.
2. ON/OFF indicates that all memory quarters are taken by higher-priority channels, and it makes no difference whether this channel is ON or OFF.
3. OFF indicates that this channel must be OFF to have this condition.

| A	B	C	D
1,2	OFF	OFF	OFF
OFF	3,4	OFF	OFF
OFF	OFF	1,2	OFF
OFF	OFF	OFF	3,4
*1,2	3,4	ON/OFF	ON/OFF
1,2	OFF	3,4	ON/OFF
1,2	OFF	OFF	3,4
OFF	3,4	1,2	ON/OFF
OFF	3,4	OFF	1,2
OFF	OFF	1,2	3,4

*Recommended usage for two-channel operation.

QUARTER

Each memory quarter is connected to a specified Plug-in channel when that channel is ON. There is no change in quarter allocation when a channel is OFF.

Channel A always gets quarter 1
Channel B always gets quarter 2
Channel C always gets quarter 3
Channel D always gets quarter 4

Figure 1-9. Correlator Input Plug-In (5488A/H01-5485A)
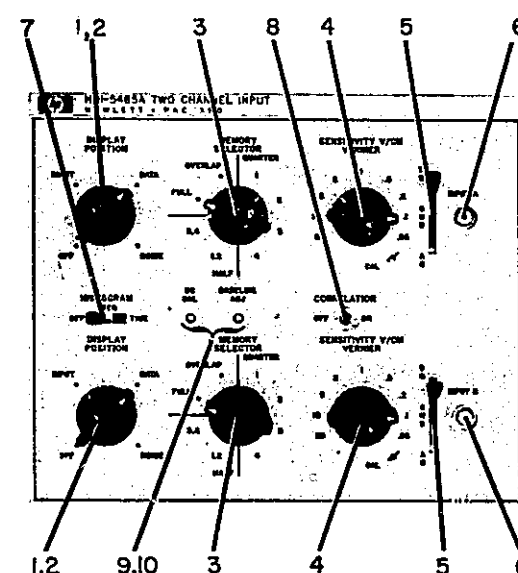
NOTE: Except for minor differences in front-panel engraving and parts numbers, the 5488A and H01-5485A are identical. In general, text will use 5488A terminology and numbers, differences between these and those for the H01-5485A will be described where necessary.

DESCRIPTION: Accepts one or two channels of input data to be presented as vertical portion of Signal Analyzer display. Can perform cross- or auto-correlation function on input signals, in addition to other 5480A/B functions; refer to Figure 1-12 for operating instructions for correlation.

CONTROLS, CONNECTORS

1. DISPLAY

   When MODE (see item 8) is set to AVG, selects CRT display for its channel. INPUT displays raw, unprocessed input signal. DATA displays averaged signal, MCS, or histogram, NOISE displays difference between INPUT and averaged signal. OFF turns channel off (see item 3).

   When MODE is set to CORR, Channel A DISPLAY switch should be set to DATA; displays for other switch positions are meaningless. Channel B DISPLAY switch may be set to any position because Channel B will not be displayed.

2. POSITION

   Adjusts vertical position of its channel when channel is being displayed on CRT.

3. MEMORY SELECTOR

   Selects portion of memory to be used for storage, display, or processing. Memory is divided into four quarters. Operator may select memory portions for either channel as follows:

Figure 1-9. Correlator Input Plug-In (5488A/H01-5485A) (Cont'd)

CONTROLS, CONNECTORS (Cont'd)

3. MEMORY SELECTOR (Cont'd)

   QUARTER 1
   QUARTER 2
   QUARTER 3
   QUARTER 4
   HALF (QUARTERS 1 and 2)
   HALF (QUARTERS 3 and 4)
   FULL (QUARTERS 1, 2, 3, and 4)

   In overlap, all four quarter sections are displayed simultaneously as separate traces.

   When MODE switch is set to AVG and MEMORY SELECTOR controls are set to cause both channels to be connected to the same memory quarter, Channel A has precedence. For example, if MEMORY SELECTOR A is set to FULL, no quarter is left for B; or if MEMORY SELECTOR A is set to QUARTER 1, and MEMORY SELECTOR B is set to FULL, Channel A gets QUARTER 1, and Channel B gets QUARTERs 2, 3, and 4.

   When MODE switch is set to CORR, both MEMORY SELECTOR controls must be set to the same position.

4. SENSITIVITY/VERNIER

   SENSITIVITY: Attenuates input signal and provides calibration of vertical display axis from 50 mV/cm to 20 V/cm.

   VERNIER: Provides continuous, uncalibrated attenuation of vertical display axis. Does not affect input signal stored in memory.

5. DC/GND/AC

   Switches from dc coupling, grounding, or ac coupling of input. In GND, Input connector is open-circuited, and input to amplifier is grounded to provide a zero reference.

6. INPUT

   Female BNC connector. Input for AVERAGE, SUMMATION, or CORRelation functions (see Figures 1-11 through 1-14).

7. HISTOGRAM FREQ/TIME

   If Logic Plug-in FUNCTION is set to HISTOGRAM, FREQ displays a frequency histogram (use about 1 kHz), or TIME displays a period (time) histogram (use below 1 kHz). See Figure 1-15.

8. MODE AVG/CORR (CORRELATION ON/OFF)

   When set to AVG (OFF), 5480A system can perform all normal functions (AVERAGE, SUMMATION, HISTOGRAM, MCS). When set to CORR (ON), and Logic Plug-In FUNCTION switch is set to AVERAGE, the 5480A system performs a correlation function on the signals at A and B INPUTS (see Figure 1-12).

9. DC BAL

   Compensates for small dc offsets in the input circuits so dc input will be stored as "0" in the memory.

10. BASELINE ADJ: Adjusts baseline to prevent baseline drift during summation.

Figure 1-10. Setup and Turn-on

5487A

5488A
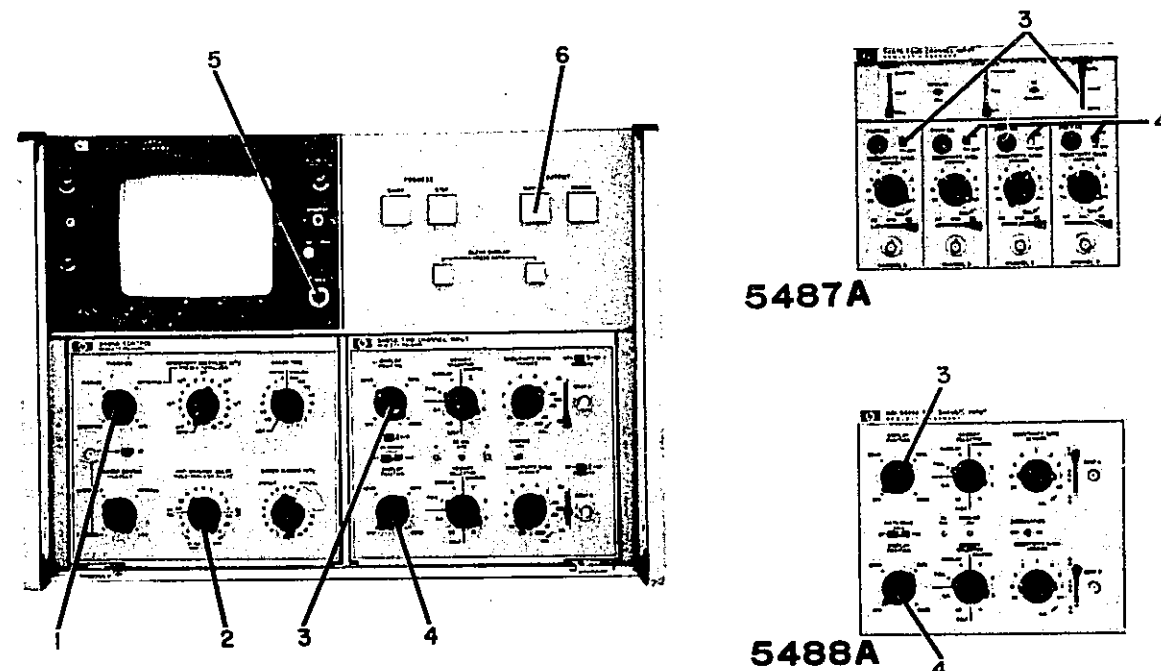
SETUP

Connect input signals and any auxiliary equipment to Signal Analyzer System.

Set 115/230-volt slide switch (see Figure 1-4 or 1-5) so numbers indicating line voltage to be used are exposed. Install correct fuse for this line voltage (use 2.5A slow-blow for 115V; 1.25A slow-blow for 230V).

Connect Signal Analyzer to ac line.

NOTE: Operating instructions and indications below are for standard Signal Analyzer Systems with no auxiliary equipment connected to SYSTEMS LOGIC INTERCONNECTION Connectors. Operating instructions for systems with connections to these connectors are contained in manuals for the auxiliary equipment.

Set controls as listed below:

1. FUNCTION to AVERAGE
2. PRE-ANALYSIS DELAY and POST-ANALYSIS DELAY to "0" and OFF, respectively.
3. Channel A to DISPLAY DATA.
4. Channel B, C, D to OFF

Figure 1-10. Setup and Turn-on (Cont'd)

TURN-ON

5. Turn on ac power. POWER switch (item 5) is near lower right corner of CRT. At turn-on, the white ON and PROCESS STOP switch lamps will light. There will be no CRT display.

6. Press OUTPUT DISPLAY pushbutton. Button will light, and display appear on CRT. Observe CRT display for each of the following Channel A DISPLAY switch positions: FULL; HALF 3, 4; HALF 1, 2; QUARTER 1; QUARTER 2; QUARTER 3; QUARTER 4. Display for each setting represents what was in that portion of memory when Signal Analyzer was turned off. If memory section being displayed is not important, erase it by pressing both CLEAR DISPLAY pushbuttons simultaneously; any quarter or half of the memory being displayed can be erased independently of other memory sections not being displayed.

SELECT OPERATING MODE

Operating mode is selected by FUNCTION switch (item 1). AVERAGE/CORRELATION use AVERAGE (see Figures 1-11 through 1-13), SUMMATION (see Figure 1-14), HISTOGRAM (see Figure 1-15), TREND ANALYSIS or MCS (Multichannel Scaling) (see Figure 1-16).

Figure 1-11. Average
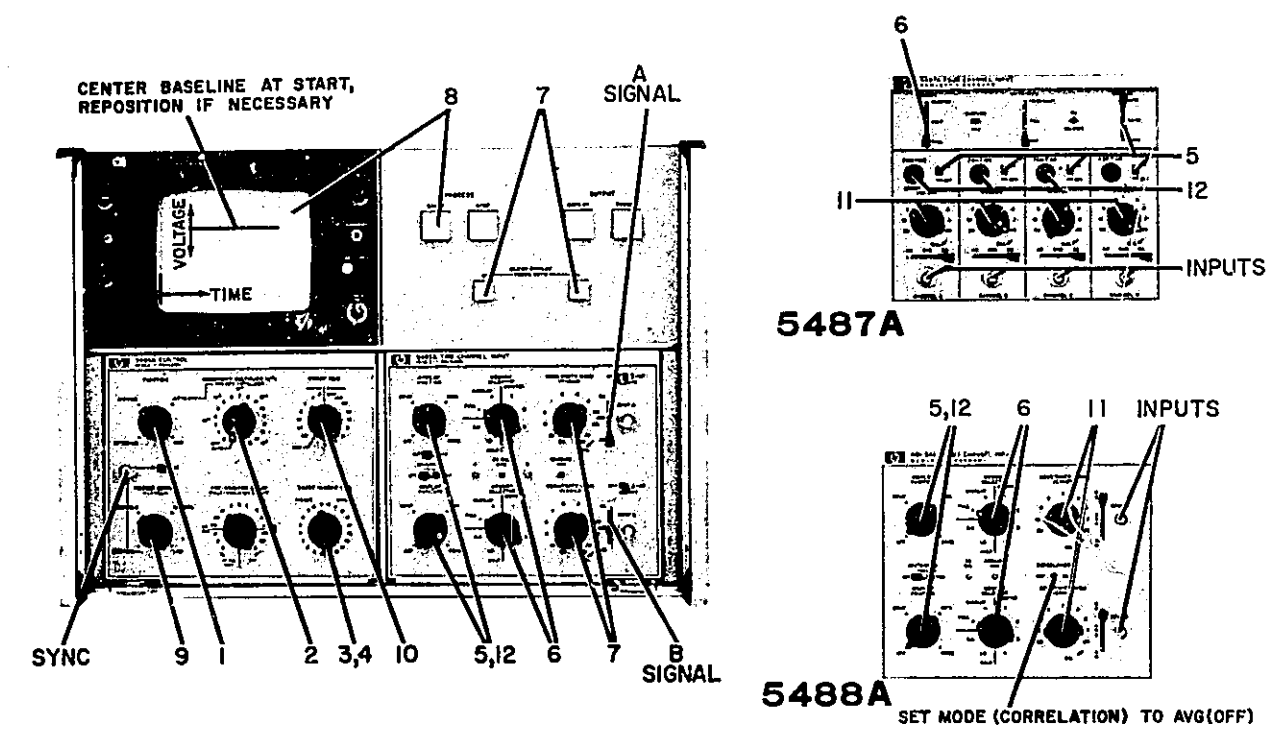
DESCRIPTION: Analyzer performs either weighted or calibrated average. Display resembles oscilloscope presentation of input signal, with noise averaged out. Up to 60 dB of signal-to-noise ratio improvement can be obtained. Vertical display is calibrated in V/cm, noise signal appears at full value and noise is gradually removed, leaving only signal.

Perform SETUP and TURN-ON procedure described in Figure 1-10.

CONTROL SETTINGS

1. FUNCTION to AVERAGE.

2. SENSITIVITY MULTIPLIER fully CCW.

3. SWEEP NUMBER to about 6.

4. PRESET/NORMAL to NORMAL.

5. Each channel to DISPLAY DATA (or OFF, if channel is not used).

6. MEMORY SELECTOR. As desired.

   a. Larger memory sections provide more signal resolution.
   b. A processed signal can be stored in one memory section while processing is done in another section.
   c. (5485A or 5488A) If MEMORY SELECTOR controls are set to feed A and B to same quarter section of memory, A overcomes B. 5487A, refer to Figure 1-8.
   d. Signal processing occurs only 1) in memory sections selected by MEMORY SELECTOR and ON/OFF switches, 2) when PROCESS START button is lighted, and 3) when sync signal is received by Logic plug-in.

Figure 1-11. Average (Cont'd)

CONTROL SETTINGS (Cont'd)

7. Clear display by simultaneously pressing both CLEAR DISPLAY buttons. OUTPUT DISPLAY button will light, and CRT will display a horizontal line.

8. Press PROCESS START pushbutton. Button will light, and OUTPUT DISPLAY light will go out. Display will show signal processing.

9. If necessary, select TRIGGER SOURCE and adjust LEVEL to initiate processing. Ordinarily, best triggering is obtained using an external triggering source locked in frequency to the signal to be observed. See Correlation, Figure 1-12.

10. Adjust SWEEP TIME for best display of input signal. Press both CLEAR DISPLAY buttons and PROCESS START button each time SWEEP TIME is changed.

11. Adjust VERTICAL SENSITIVITY for each displayed input channel to provide best CRT display of input signal.

12. Use POSITION controls to separate or center signals vertically.

The above procedure provides a means for obtaining a rough measurement of signal amplitude and frequency, and positioning display. Information below enables refinement of measurement.

SIGNAL-TO-NOISE RATIO IMPROVEMENT VS RESPONSE TO INPUT SIGNAL CHANGES

Signal-to-noise ratio improvement can be determined approximately by SWEEP NUMBER setting, and can be expressed in dB as $3N$, where N is SWEEP NUMBER. For example, where N is 10, signal-to-noise ratio improvement is 30 dB (after 2^N, or 1024 sweeps).

Higher SWEEP NUMBER settings result in greater signal-to-noise ratio improvement.

Lower SWEEP NUMBER settings enable faster response to input signal changes or changes in Signal Analyzer control settings when PRESET/NORMAL switch is on NORMAL.

NOTE: To prevent invalid readings, the following SWEEP NUMBER and SWEEP TIME combinations should not be used:

SWEEP TIME	SWEEP NUMBER
1 msec/cm	19 (PRESET) see NOTE under NORMAL VS PRESET
2 msec/cm	19, 18
5 msec/cm or slower	19, 18, 17, 16

If the above limits are not observed when using a 5486A, data will overflow available memory bits and will be lost. The 5486B automatically limits the SWEEP NUMBER used in averaging to 19 in 1 msec/cm, 17 for 2 msec/cm, and 15 for 5 msec/cm and slower sweep times. The 5485A modification described below will have no effect in systems containing the 5486B logic plug-in.

This SWEEP NUMBER limitation (except 1 msec/cm) is directly related to the 5-, 7-, or 9-bit resolution of the Analog-to-Digital Converter (depending on SWEEP TIME). If input signals are so noisy that 2^{15} sweeps are not sufficient (2^{17} sweeps at 2 msec/cm), the modification below may be made to the 5485A Dual Channel Input plug-in; the modification restricts resolution to 5 bits for all SWEEP TIMEs.

Modification to 5485A for decreased resolution:

1. Remove connecting wires from SZ3(2) and XA3(3).

2. Tape ends of wires removed in step 1.

3. Ground pins XA3(2) and XA3(3) by connecting them to XA3(17).

NORMAL VS PRESET

NORMAL

Signal Analyzer averages all sweeps until it completes 2^N sweeps. After this number of sweeps is completed, averaging process continues, except that previous information is weighted exponentially with a time constant equal to the time required to take 2^N sweeps. Averaging continues until PROCESS STOP (no CRT display) or OUTPUT DISPLAY pushbutton is pressed.

PRESET

Signal Analyzer averages all sweeps until it completes 2^N sweeps.* After this number of sweeps is completed, averaging process stops and Analyzer automatically switches to OUTPUT DISPLAY. Note that the value of 2^N increases very rapidly (see table in Figure 1-4), and large values of 2^N can result in very long experiment times. As with NORMAL, averaging process can be stopped at any time by pressing PROCESS STOP or OUTPUT DISPLAY button.

CRT DISPLAY

Signal is displayed full-scale and noise is reduced with each sweep.

Vertical calibration for displayed channel is determined by SENSITIVITY V/CM control.

Horizontal calibration is determined by SWEEP TIME and X1/X5 switch.

In OUTPUT DISPLAY, vertical display can be expanded by changing setting of SENSITIVITY MULTIPLIER. MULTIPLIER.

VERNIER of displayed channel provides for uncalibrated reduction in display size (does not affect input SENSITIVITY).

For PRE-ANALYSIS DELAY and POST-ANALYSIS DELAY information, see Figure 1-4.

*NOTE: Except for N = 19. In PRESET, N = 19 and N = 18 are same, 5480A sweeps for 2^{18} sweeps, then DISPLAYs result.

See also correlation, Figure 1-12, and Variance, Figure 1-13.
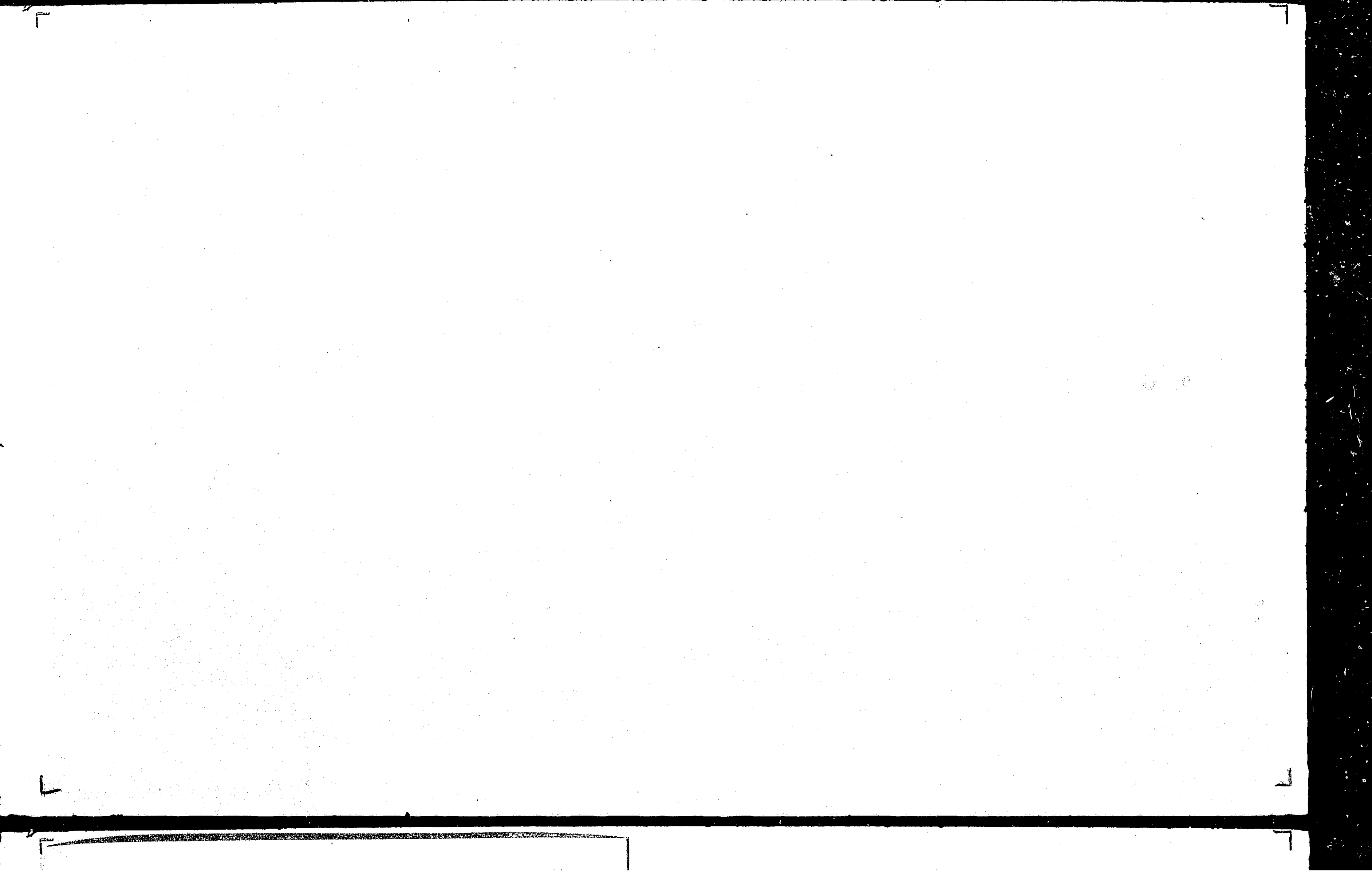
Figure 1-12. Correlation
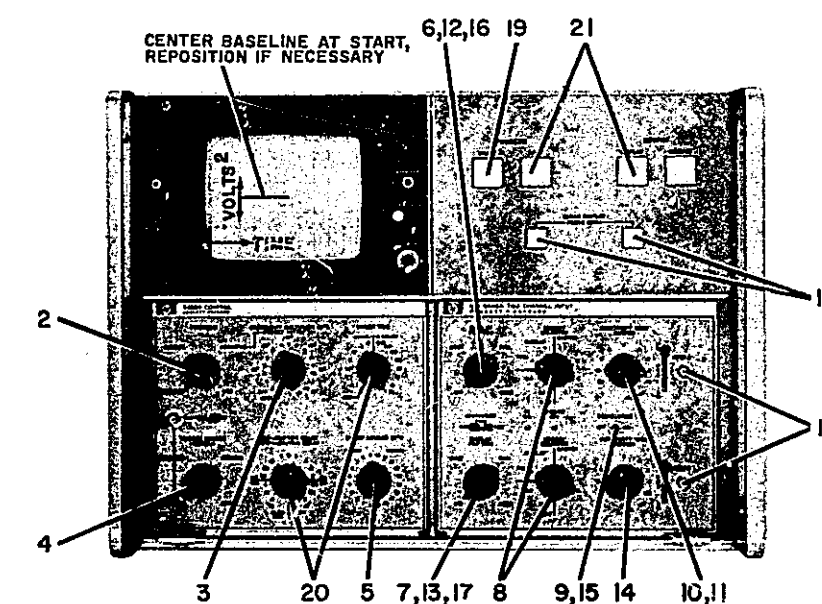
DESCRIPTION: Correlation is a measure of the similarity between two waveforms. The 5488A plug-in allows the 5480A/B system to perform cross- or auto-correlation of signals connected to its A and B INPUTs, when the MODE (CORRELATION) switch is set to CORR (ON). When the plug-in MODE (CORRELATION) switch is set to AVG (OFF), the 5488A allows the 5480A system to function normally, making the measurements described in Figures 1-11, and 1-13 through 1-16.

Correlation is computed by multiplying the two input waveforms ordinate-by-ordinate and finding the average product. Finding the correlation function of two different signals is cross-correlation; finding the correlation function of a signal with itself is auto-correlation. Auto-correlation can be used to determine if there is any periodicity in an unknown input signal; the period of the auto-correlation function is the same as the period of the original input signal. Cross-correlation is used to show how closely two "independent" signals are related.

Some uses of cross- or auto-correlation are:

System Identification: determination of the laws which relate the outputs of a system to its inputs.

Noise Source Direction Finding

On-site measurement of Acoustic Absorption Coefficients: when designing special acoustic environments

Cross-correlation of Electromyograms: medical research

Measurement of Torsion in rotating shafts

Contactless Velocity measurements

Speech Research

Radio Astronomy

Determination of Noise Transmission Paths

Figure 1-12. Correlation (Cont'd)

Figure 1-12. Correlation (Cont'd)

Perform Setup and Turn-on Procedure described in Figure 1-9.

CONTROL SETTINGS

To obtain a valid correlation function, the input signals must not be "clipped". Steps 1 through 14 of this procedure assure proper settings of the Channel A and B attenuators.

1. To perform cross-correlation, connect each of the two input signals to one of the 5488A INPUT connectors. To perform auto-correlation, connect the single input signal through a "T" connector to both inputs.

2. FUNCTION to AVERAGE

3. SENSITIVITY MULTIPLIER fully CCW

4. TRIGGER SOURCE to INTERNAL

   NOTE: Correlation requires that sampling pulses not be sync'ed to either input signal. Random triggering is most easily achieved by setting TRIGGER SOURCE to INTERNAL.

5. PRESET/NORMAL to NORMAL

6. Channel A DISPLAY to INPUT

7. Channel B DISPLAY to OFF

8. MEMORY SELECTOR switches for both channels to the same setting. FULL provides greatest resolution; correlation functions can be stored for comparison by processing in HALF or QUARTER and changing MEMORY SELECTOR settings before next processing.

9. MODE (CORRELATION) to AVG (OFF)

10. Channel A SENSITIVITY VERNIER fully CCW, to display full signal on CRT.

11. Press PROCESS START button. Starting from 20 V/cm, rotate Channel A SENSITIVITY control until you see clipping of INPUT signal. Go back one switch position; this is maximum sensitivity for SENSITIVITY that can be tolerated without clipping.

12. Set Channel A DISPLAY to OFF.

13. Set Channel B DISPLAY to INPUT.

14. Repeat steps 10 and 11 for Channel B SENSITIVITY control.

5480A/B system is now set for maximum sensitivity, without clipping.

Do not change SENSITIVITY control settings; Channel A VERNIER can be set for larger picture without disturbing processing.

15. Set MODE (CORRELATION) to CORR (ON).

16. Set Channel A DISPLAY to DATA.

17. Set Channel B DISPLAY to OFF.

18. Press both CLEAR DISPLAY pushbuttons.

19. Press PROCESS START button.

CONTROL SETTINGS (Cont'd)

20. Rotate SWEEP TIME and PRE-ANALYSIS DELAY switches as necessary for best presentation of correlation function. SWEEP TIME determines delay (time offset) between input signals, PRE-ANALYSIS DELAY determines delay in sampling of both input signals. For principles of operation, refer to Section II.

CRT DISPLAY

The signal at INPUT A is sampled once, at the beginning of each process sweep. The value of its amplitude is digitized and stored in a buffer register in the 5488A. Signal B is sampled 1000 (or 500 or 250) times during each processing sweep. Each signal B sample is digitized and stored in another buffer register in the 5488A. The contents of the two buffer registers are multiplied, and the product converted to an analog value. The analog value of the signal product is compared with the analog value of the memory contents for the same point; the analog difference is digitized and added to the memory contents to form the new correlation value for that point.

On the next sweep, the next point of the INPUT A signal is sampled, digitized, stored, and multiplied by all digital values of Signal B, as described above. Thus, after some number of sweeps, the value of the correlation signal is built up in the 5488A memory. This is the signal displayed on the 5480A/B CRT.

Amplitude and polarity of the correlation function depend on amplitude and relative phase (polarity) of the two input signals. Positive points of correlation function mean that input signals are in phase (have same polarity), negative points of correlation function mean that input signals are out-of-phase.

The autocorrelation function of a periodic signal will have the same period as the input signal. A sync signal with this period may be used when the input signal is being averaged.

The horizontal display axis is calibrated by the SWEEP TIME and X1/X5 switch settings. The period of the correlation function may be calculated as follows:

$$\text{Period} = \text{distance between corresponding points (cm)} \ \times \ \frac{\text{SWEEP TIME}}{\text{X1/X5 setting}}$$

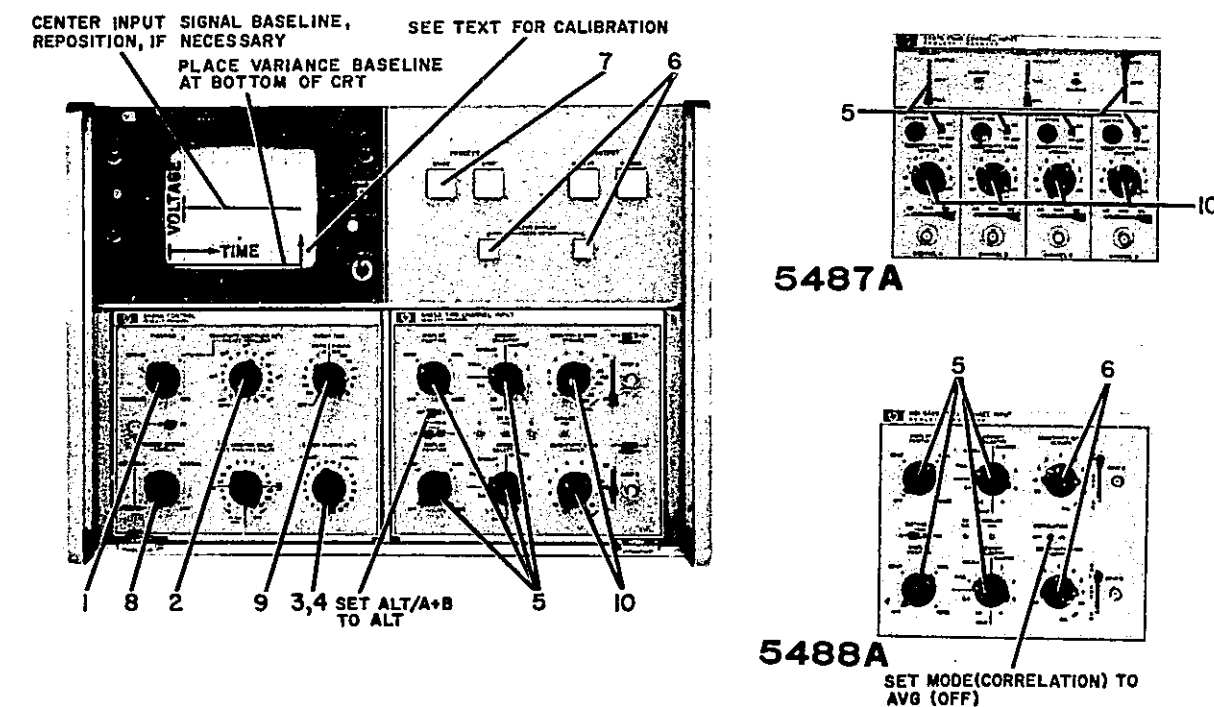The vertical display axis is calibrated by settings of both Channel A and Channel B SENSITIVITY controls. The vertical signal units are volts-squared, calculated as follows:

10 x Vertical deflection from baseline (cm) x SENSITIVITY A x SENSITIVITY B

Example: Vertical point 2 cm above baseline, when A SENSITIVITY is .1V/cm and B SENSITIVITY is .2V/cm is: $10 \times 2 \times .1 \times .2 = .4V^2$

Vertical accuracy is ±5%.

Figure 1-13. Variance

CENTER INPUT SIGNAL BASELINE,
REPOSITION, IF NECESSARY

SEE TEXT FOR CALIBRATION

PLACE VARIANCE BASELINE
AT BOTTOM OF CRT

5487A

5488A

SET MODE(CORRELATION) TO
AVG (OFF)

1 8 2 9 3,4 SET ALT/A+B   5   10
              TO ALT

DESCRIPTION: This feature, abailable for the 5485A, 5487A, and 5488A plug-ins, enables use of the 5480A rear-panel VARIANCE OUTPUT signal to check validity of the averaged signal. For the averaged signal to be valid, the input signal must: 1) repeat itself, 2) always be present, and 3) always be synchronized to the sync pulse. If any of these conditions is not met, an indication can be provided in the Variance Output.

On early 5485A (serial numbers below 964-00201), 5487A (serial numbers below 920-00111), and 5488A (serial numbers below 948-00047) Plug-ins, the Variance function was available as . Option 001; on later units it was a standard feature. Field installation of the Variance function consists of replacing the Switching Logic B Assembly (05485-60010) with Switching Logic B Assembly (05485-60020); no wiring changes are required for this change.

As the input waveform is processed, its average pattern is stored in the Signal Analyzer's memory. The Variance Output signal represents the difference between the sampled input signal and the previous value for the same point, stored in memory. The variance 'race can be used to identify points in the averaged waveform where there is additional activity of.ier than that added simply by random noise.

CONTROL SETTINGS

1. FUNCTION to AVERAGE

2. SENSITIVITY MULTIPLIER fully CCW

3. SWEEP NUMBER to 0 for first sweep, then increase to desired value.

4. PRESET/NORMAL to NORMAL

5. MEMORY SELECTOR, ON/OFF, and DISPLAY switches to display processed input signal and variance signal traces (DATA).

Figure 1-13. Variance (Cont'd)

CONTROL SETTINGS (Cont'd)

NOTE: Because the VARIANCE OUTPUT signal represents the square of the difference between the averaged input signal stored in memory, and the noisy input signal, the variance signal is mostly noise. To obtain meaningful information, the variance signal, too, must be averaged.

The variance signal processed in any memory quarter is the variance of the memory quarter immediately preceding it, as listed below:

Variance processed in
Memory Quarter listed
below . . . . is always variance of
                                             noisy input signal
                                             processed in memory
                                             quarter listed below

1	4
2	3
3	1
4	2

Where possible, the noisy input signal should be put into memory quarters 1 and/or 2, and the variance signal into memory quarters 3 and/or 4.

6. Clear display by simultaneously pressing both CLEAR DISPLAY buttons. OUTPUT DISPLAY button will light, and CRT will display two horizontal lines.

7. Press PROCESS START pushbutton. Button will light, and OUTPUT DISPLAY light will go out. Display will show signal processing. Several processing sweeps will be required for a good enough average to be stored in memory to get meaningful results from the variance output display.

8. If necessary, select TRIGGER SOURCE and adjust LEVEL to initiate processing. Ordinarily, best triggering is obtained using an external triggering source having the same frequency as noisy signal to be observed. See Correlation, Figure 1-12.

9. Adjust SWEEP TIME for best display of input signal. Press both CLEAR DISPLAY buttons and PROCESS START button each time SWEEP TIME is changed.

10. Adjust VERTICAL SENSITIVITY for each displayed input channel to provide best CRT display of input signal.

CRT DISPLAY

The averaged variance output represents differences in the input signal other than random noise.

If the variance trace is a straight line, then the averaged waveform is the result of a single repetitive input which was time-locked to the synchronizing pulse (except for the special case where the absolute deviation of the spurious input from the average is the same at all points on the waveform).

If the leading or trailing edge of a pulse or square wave is jittering (or appears to be jittering due to a jittering trigger signal), the variance trace will not be a straight line (thus indicating that there was something in the signal besides noise and data).

If the input signal waveform changes, the variance will not be a straight line, but will have a shape of its own, reflecting the signal change.

CRT DISPLAY (Cont'd)

The variance trace is also useful for detecting when a signal is not present during the entire analysis interval, by showing the difference between the averaged signal and the missing input signal. All that would happed to the averaged trace is that its amplitude would shrink slightly (depending on number of sweeps that had been averaged).

The variance signal output is always positive, so the variance channel baseline may be set on the bottom line of the CRT graticule (unless the input is AC coupled).

VARIANCE CALIBRATION

I. Given noise, a voltage is provided at the rear panel:

$$V = \frac{N^2}{32}$$

where N = value of noise in centimeters, as displayed on CRT

                V = voltage provided at rear panel.

example: If the noise causes a ± 2 cm deflection on CRT, then the voltage at the rear panel will equal +125 mV ($2^2/32$).

II. Given a relative variance display on the CRT, an absolute value can be determined as follows:

1) Note deflection D in centimeters of the variance display.

2) V represents the relative variance in volts^2, according to the variance attenuator setting.

$$V = D \cdot A_v \text{ in Volt}^2$$

example: If $D = +3$ cm

                and $A_v = 50$ mV/cm

                then $V = 50 \cdot 3 = .150 \text{ Volt}^2$

3) Determine the relative noise N (in cm) that could cause this deflection.

$$N = \sqrt{32V}$$

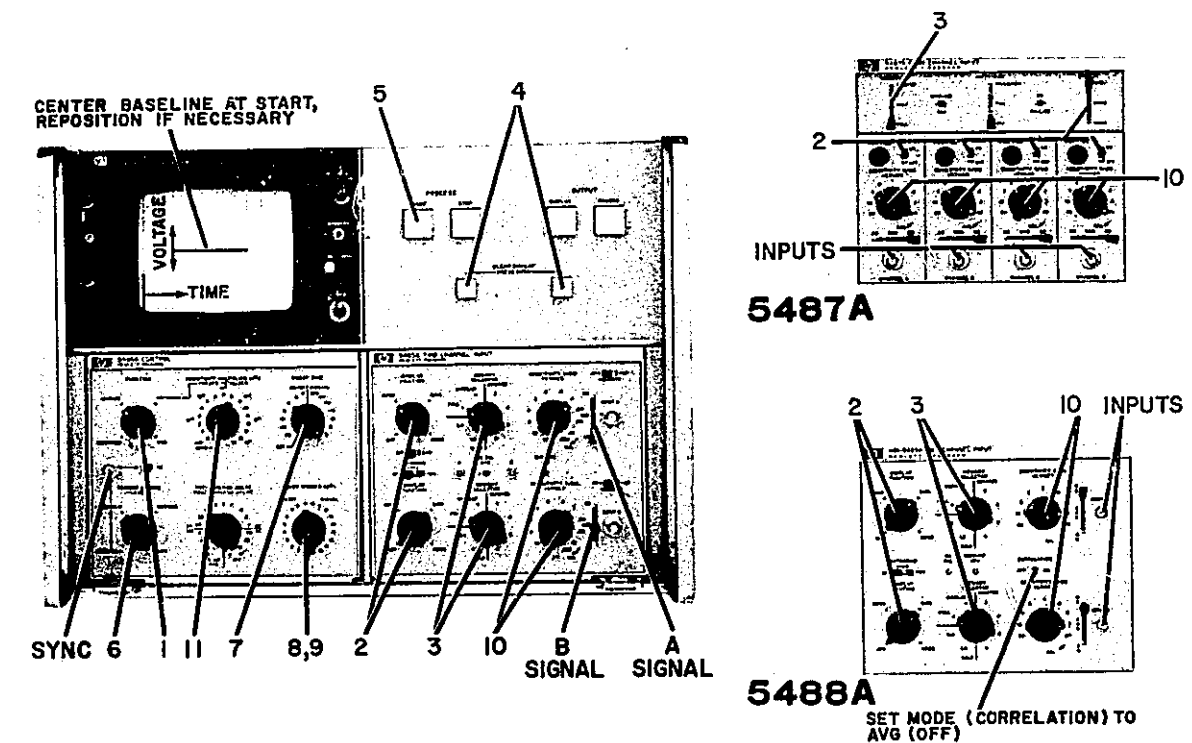example: $N = \sqrt{(32)(.150)} = 2.19$ cm

4) Determine the absolute noise, according to the signal attenuator setting:

$$N_A = N \cdot A_s$$

example: If $A_s = 2$V/cm

                then $N_A = (2.19)(2)$ For additional information, refer to
                                                            Figure 1-11, Average.

                                = 4.38 Vrms

Figure 1-14. Summation

DESCRIPTION: Analyzer adds successive repetitions of noisy input waveform, resulting in an uncalibrated display which is proportional to averaged signal. Display resembles oscilloscope presentation of input signal, growing with each successive sweep; display can be halved automatically when it reaches some predetermined size, to keep it on screen.

Perform SETUP and TURN-ON procedure described in Figure 1-10.

CONTROL SETTINGS

1. FUNCTION to SUMMATION.

2. Each channel to DISPLAY DATA (or to OFF, if channel is not used).

3. MEMORY SELECTOR. As desired.

    a. Larger memory sections provide more signal resolution.
    b. A processed signal can be stored in one memory section while processing is done in another section.
    c. (5485A or 5488A) If MEMORY SELECTOR controls are set to feed A and B to same quarter section of memory, A overcomes B. 5487A refer to Figure 1-8.
    d. Signal processing only occurs:
        1) In memory sections selected by MEMORY SELECTOR and ON/OFF switches.
        2) When PROCESS START button is lighted.
        3) When sync signal is received by Logic plug-in.

Figure 1-14. Summation (Cont'd)

CONTROL SETTINGS (Cont'd)

4. Clear display by simultaneously pressing both CLEAR DISPLAY buttons. OUTPUT DISPLAY button will light, and CRT will display a horizontal line.

5. Press PROCESS START pushbutton. Button will light, and OUTPUT DISPLAY light will go out. Display will show signal processing.

6. If necessary, select TRIGGER SOURCE and adjust LEVEL to begin processing. Ordinarily, best triggering is obtained using an external triggering source having same frequency as noisy signal to be observed.

7. Adjust SWEEP TIME for best display of input signal. Press both CLEAR DISPLAY buttons and PROCESS START button each time SWEEP TIME is changed.

8. SWEEP NUMBER to 19.

9. PRESET/NORMAL to PRESET.

10. Adjust SENSITIVITY for good display

CRT DISPLAY

Signal starts at zero amplitude and grows with each sweep as Signal Analyzer totalizes input sweeps. Rate of vertical presentation growth depends on settings of SENSITIVITY for each displayed channel and SENSITIVITY MULTIPLIER. To keep growing display on-screen, SENSITIVITY MULTIPLIER setting is decreased manually or automatically, as described below.

Vertical display is not calibrated.

Horizontal display is calibrated by SWEEP TIME and X1/X5 settings.

SENSITIVITY MULTIPLIER

Controls vertical display size.

When set to AUTO (and SWEEP NUMBER set to 19):

1. Vertical display is cut in half at end of every 2^N (first, second, fourth, eighth, etc.) sweep.

2. Display continues growing at half of previous rate until it is again cut in half.

3. Unless SUMMATION process is stopped (by pressing PROCESS STOP or OUTPUT DISPLAY pushbutton), vertical display is divided in half through the N = 15 sweep; after N = 15, display keeps growing.

NOTES:

1. SENSITIVITY MULTIPLIER and SWEEP NUMBER switches interact, most noticeably at low SWEEP NUMBER settings. When SENSITIVITY MULTIPLIER is set to AUTO, display is cut in half every 2^N sweeps until N is same number set by SWEEP NUMBER switch. From this time on, no additional AUTO scaling is provided, CRT display grows and must be manually scaled using "N" SENSITIVITY MULTIPLIER SETTINGS.

2. SENSITIVITY MULTIPLIER can be set to any N number from 1 to 15. If setting is changed during a sweep, display size will change at end of that sweep.

Figure 1-14. Summation (Cont'd)

SENSITIVITY MULTIPLIER (Cont'd)

NOTES: (Cont'd)

3. SENSITIVITY MULTIPLIER can be switched from AUTO to any N number and back to AUTO, and will resume AUTO scaling without loss of count of sweeps.

4. To prevent invalid readings, the following SWEEP NUMBER and SWEEP TIME combinations should not be used when SENSITIVITY MULTIPLIER is in AUTO:

SWEEP TIME	SWEEP NUMBER
1 msec/cm	19 (PRESET) see NOTE under NORMAL VS PRESET
2 msec/cm	19, 18
5 msec/cm or slower	19, 18, 17, 16

If the above limits are not observed when using a 5486A, data will overflow available memory bits and will be lost. The 5486B automatically limits the SWEEP NUMBER used in summation to 19 in 1 msec/cm, 17 for 2 msec/cm, and 15 for 5 msec/cm and slower sweep times. The 5485A modification described below will have no effect in systems containing the 5486B logic plug-in.

This SWEEP NUMBER limitation (except 1 msec/cm) is directly related to the 5-, 7-, or 9-bit resolution of the Analog-to-Digital Converter (depending on SWEEP TIME). If input signals are so noisy that 2^{15} sweeps are not sufficient (2^{17} sweeps at 2 msec/cm), the modification below may be made to the 5485A Dual Channel Input plug-in; the modification restricts resolution to 5 bits for all SWEEP TIMEs.

Modification to 5485A for decreased resolution:

a. Remove connecting wires from XA3(2) and XA3(3).

b. Tape ends of wires removed in step 1.

c. Ground pins XA3(2) and XA3(3) by connecting them to XA3(17).

5. If power is lost following summation, and instrument is in DISPLAY, automatic scaling associated with AUTO may be lost and display will not be calibrated. (This happens because the AUTO scaling factor is stored in an active register.) Display calibration can be regained, however, by setting SENSITIVITY MULTIPLIER to: 24 - (SWEEP NUMBER + number of bits).

Number of bits = 5 in 1 msec/cm SWEEP TIME

= 7 in 2 msec/cm SWEEP TIME

= 9 in 5 msec/cm or slower SWEEP TIMEs.

Example: SWEEP NUMBER is 6, SWEEP TIME is 10 msec/cm. Set SENSITIVITY MULTIPLIER to 24 - (6 + 9) or 9.

NORMAL VS PRESET

NORMAL: Set SWEEP NUMBER to 19. Analyzer totalizes until manually stopped by pressing PROCESS STOP or OUTPUT DISPLAY pushbutton. AUTO scaling feature of SENSITIVITY MULTIPLIER ceases operation in NORMAL mode during SUMMATION after SWEEP NUMBER has been reached.

PRESET: Set SWEEP NUMBER to number of sweeps to be totalized. Signal Analyzer will totalize this number of sweeps*, stop processing, and display result.

*NOTE: Except for N = 19. In PRESET, N = 19 and N = 18 are same, 5480A sweeps for 2^{18} sweeps, then DISPLAYs result.

Figure 1-15. Histograms
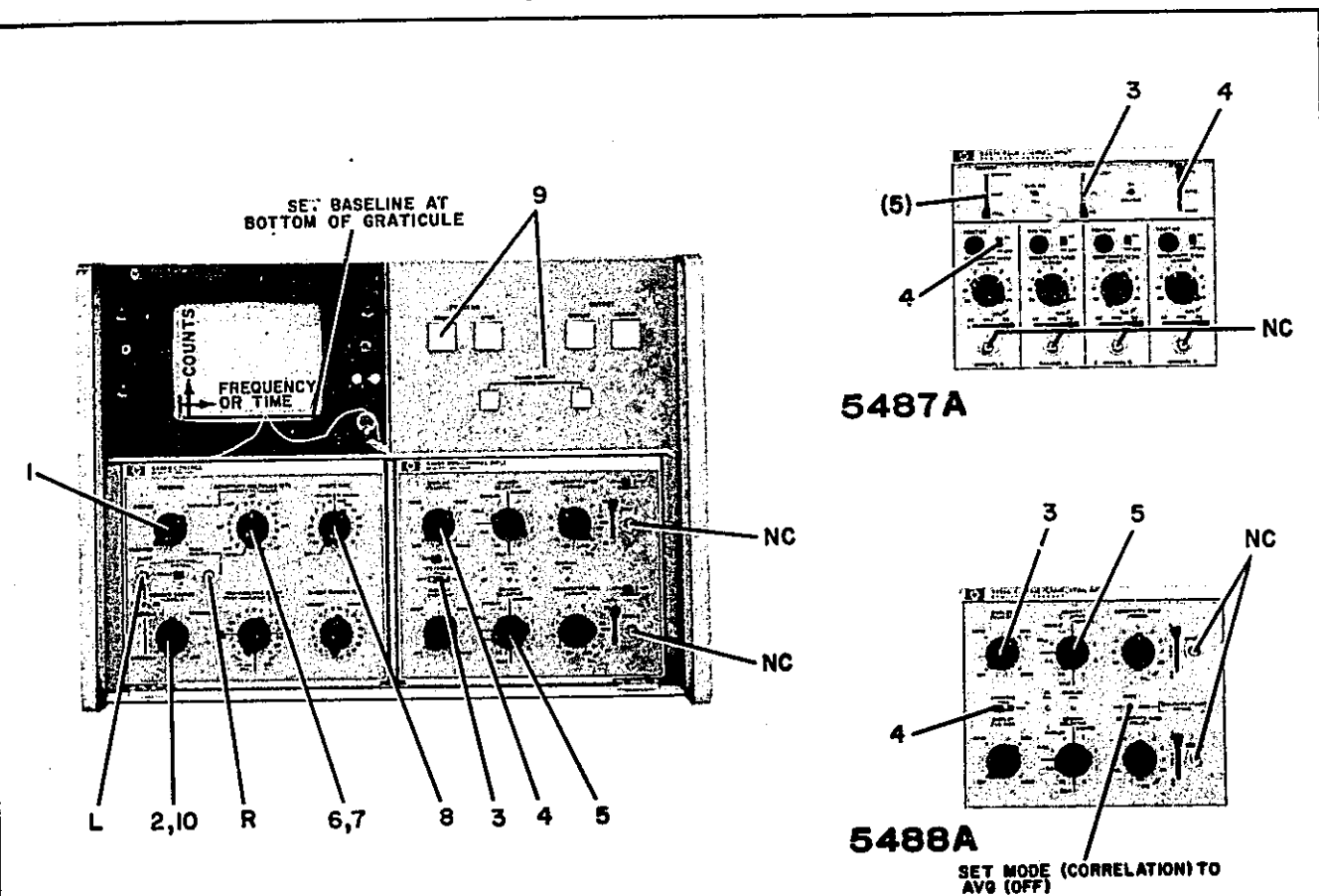
HISTOGRAM	INPUT
FREQUENCY	L
TIME-SINGLE	L
TIME-SEPARATE	R-START L-STOP

DESCRIPTION: Analyzer displays a probability-versus-frequency (or time interval) plot. Number of incoming pulses during a set gate time determines memory location into which a count is placed. After several gate times, a distribution results.

FREQUENCY HISTOGRAMS

In FREQ HISTOGRAMS, the 5480A/B accumulates histogram counts during alternate time periods, as shown in the example below. The number of counts received at the SYNC/START/STOP (left-hand) input connector determines the address which is incremented.
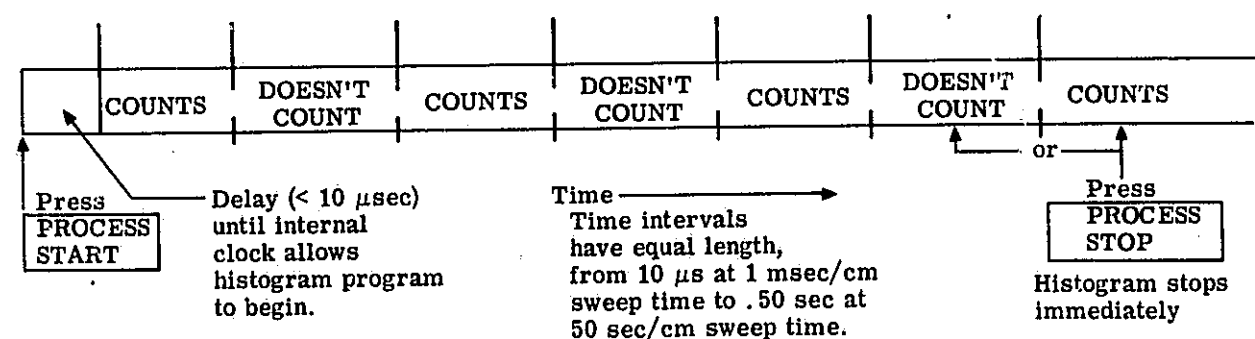
Figure 1-15. Histograms (Cont'd)

DESCRIPTION (Cont'd)

TIME INTERVAL HISTOGRAMS

In TIME HISTOGRAMS, a 5480B with a 5486B having serial prefix 1104A or higher will accumulate histogram counts during all time periods; the chart below will apply if you cross out the word "DOESN'T" in the places labeled "DOESN'T COUNT". When the TIME INTERVAL CONTROL is set to SINGLE, the number of counts accumulated between any two successive pulses at the START/STOP (left-hand) connector determines which address is incremented. When the TIME INTERVAL CONTROL is set to SEP, the number of counts accumulated during the time between a pulse at the START (right-hand) input connector and a pulse at the STOP (left-hand) connector determines which address is incremented.

In TIME HISTOGRAMS, a 5480A/B with a 5486A or a 5486B having a serial prefix lower than 1104A will accumulate histogram counts during alternate time periods, as shown in the chart below. The number of counts accumulated between any two successive pulses at the SYNC connector determines which address is incremented.
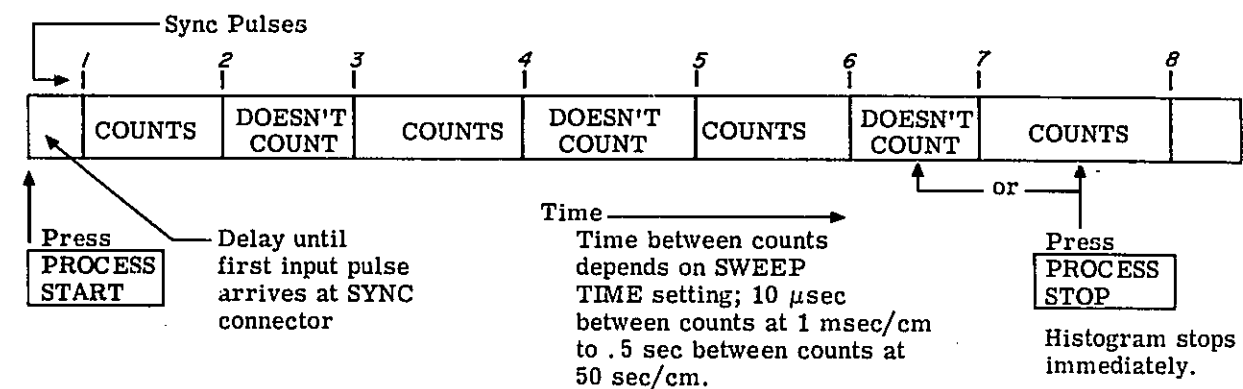
Perform SETUP and TURN-ON procedure described in Figure 1-10.

For 5486B with serial prefix 1104A and above (two input connectors on front-panel), perform the following steps; for older units, go on to CONTROL SETTINGS, below.

Connect input signal(s) to appropriate connector(s) and set TIME INTERVAL CONTROL to SINGLE or SEP as desired.

For FREQ HISTOGRAMS, connect the single input signal line to the left-hand (START/STOP) connector. The TIME INTERVAL CONTROL has no effect for FREQ HISTOGRAMS.

For single-input TIME INTERVAL HISTOGRAMs, connect the single input signal line to the left-hand (START/STOP) connector. Set TIME INTERVAL CONTROL to SINGLE.

For separate-input TIME INTERVAL HISTOGRAMS, connect the signal that is to start the time interval measurement to the right-hand (START) connector, and connect the signal that is to stop the time interval period to the left-hand (START/STOP) connector. Set TIME INTERVAL CONTROL to SEP. START trigger level and slope are fixed as the positive-going transition from 0V to 2V. STOP trigger level and slope are adjustable by TRIGGER SOURCE and LEVEL controls. Note that the START and STOP trigger signals may come from a single line, connected to the two inputs through a "TEE".

Figure 1-15. Histograms (Cont'd)

CONTROL SETTINGS

1. FUNCTION to HISTOGRAM

2. TRIGGER SOURCE to either EXTERNAL position.

3. HISTOGRAM to: FREQ for input signals between 1 kHz and 1 MHz TIME for input signals below 1 kHz.

4. One Channel to DISPLAY DATA.

5. MEMORY SELECTOR:

   5485A or 5488A: Use CHANNEL A MEMORY SELECTOR to select one QUARTER, one HALF or FULL memory for processing. NOTE: If A DISPLAY is OFF, use B MEMORY SELECTOR as above.

   5487A processes in FULL memory only, MEMORY switch has no effect in HISTOGRAM.

6. SENSITIVITY MULTIPLIER to 15.

7. PRESET TOTALIZER to OFF, or to number of events to be accumulated.

8. SWEEP TIME to 2 msec/cm.

9. Press both CLEAR DISPLAY buttons, then PROCESS START.

10. Adjust TRIGGER LEVEL, if necessary, to enable triggering.

CRT DISPLAY

SWEEP TIME may be adjusted for best display.

Horizontal baseline calibration is as follows:

For TIME HISTOGRAMS, read calibration directly from SWEEP TIME setting. Max Time Interval is 10 times SWEEP TIME, or overflow will occur, causing erroneous reading.

CRT DISPLAY (Cont'd)

For FREQ HISTOGRAMS, convert SWEEP TIME to frequency/cm, using chart below:

| SWEEP TIME SETTING	DISPLAY CALIBRATION	MAX INPUT FREQUENCY	USABLE HORIZ RANGE
1 msec/cm	10 MHz/cm	1 MHz	0.1 cm
2 msec/cm	5 MHz/cm	1 MHz	0.2 cm
5 msec/cm	2 MHz/cm	1 MHz	0.5 cm
10 msec/cm	1 MHz/cm	1 MHz	1.0 cm
20 msec/cm	500 kHz/cm	1 MHz	2.0 cm
50 msec/cm	200 kHz/cm	1 MHz	5.0 cm
100 msec/cm	100 kHz/cm	1 MHz*	10.0 cm
200 msec/cm	50 kHz/cm	500 kHz*	10.0 cm
.5 sec/cm	20 kHz/cm	200 kHz*	10.0 cm
1 sec/cm	10 kHz/cm	100 kHz*	10.0 cm
2 sec/cm	5 kHz/cm	50 kHz*	10.0 cm
5 sec/cm	2 kHz/cm	20 kHz*	10.0 cm
10 sec/cm	1 kHz/cm**	10 kHz*	10.0 cm

* Maximum frequency that can be displayed, without overflow
** For frequencies below 1 kHz, use TIME HISTOGRAM mode.

Overflow occurs when the process address register in the 5480A/B accumulates more than 1024 counts during either FREQ or TIME HISTOGRAM processing. When more than 1024 counts have been accumulated, the process address register automatically returns to address 0000 and continues counting; at the end of processing, address x (which really should be 1024 + x) is incremented (causing an error in the display). Overflow problem is eliminated by proper setting of SWEEP TIME control.

Figure 1-16. TREND ANALYSIS (formerly MCS)

5487A

5488A

SET MODE (CORRELATION) TO
AVG (OFF)
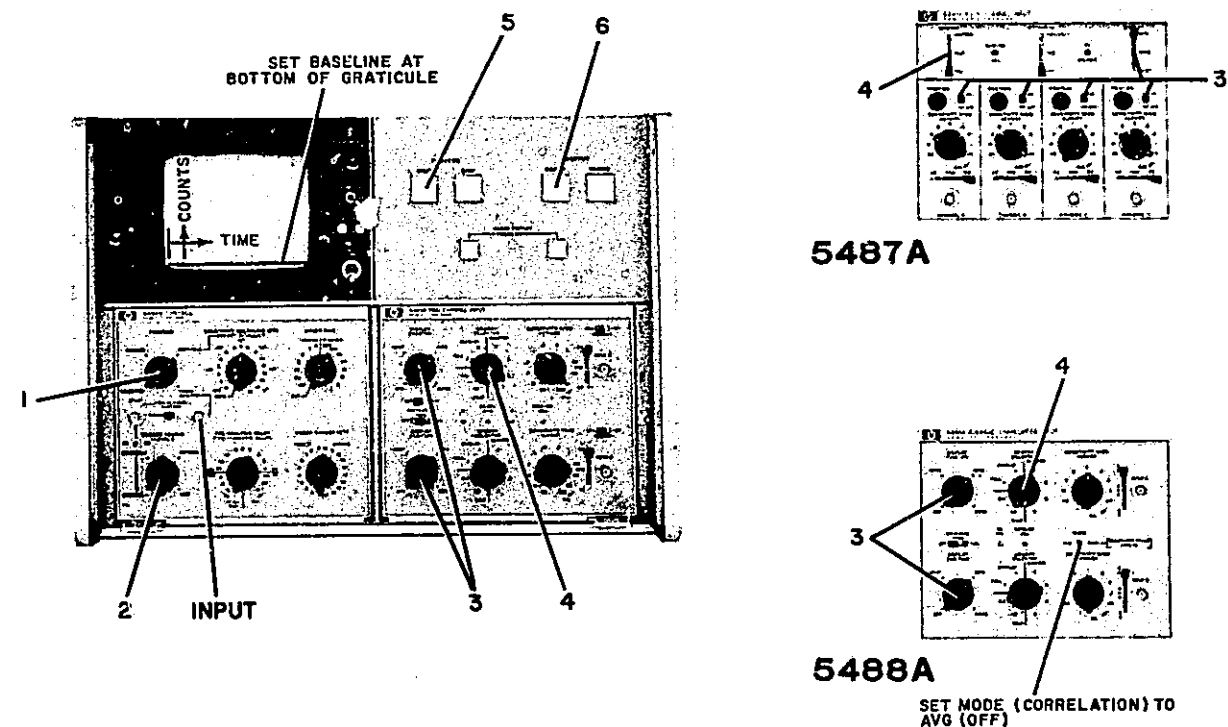
DESCRIPTION: Analyzer displays a plot of frequency-versus-time. Analyzer sweeps through its memory, remaining at each location for a set gate time. Number of counts placed in each location is determined by number of input pulses during gate time for that location.

NOTE: TREND ANALYSIS and MCS are the same. Generally, "TREND ANALYSIS" may be substituted wherever "MCS" or "Multichannel Scaling" are used.

COMPATIBILITY: The MCS INPUT via the 5480A/B rear panel was removed from the 5480B beginning with serial prefix 1108A, and from the 5486B beginning with serial prefix 1104A; it was replaced by the TREND ANALYSIS input on the 5486B front panel, beginning with 5486B serial prefix 1104A. Thus, a 5486B with serial prefix 1104A or higher may be performed TREND ANALYSIS in any 5480B; a 5486B with serial prefix below 1104A requires a 5480B with serial prefix below 1108A (in order to have a MCS INPUT), and vice-versa.

Perform SETUP and TURN-ON procedure described in Figure 1-10.

CONTROL SETTINGS

1.   FUNCTION to TREND ANALYSIS (formerly MCS)

2.   TRIGGER SOURCE as desired.

3.   DISPLAY to DATA (Channel A), all other channels OFF.

4.   5480B System: MEMORY SELECTOR as desired
      If system contains 5487A, refer to Figure 1-8 for memory allocations.

      5480A System: MEMORY SELECTOR A to FULL
      If system contains 5487A, set A ON/OFF to ON, all others to OFF.

Figure 1-16. TREND ANALYSIS (formerly MCS) (Cont'd)

CONTROL SETTINGS (Cont'd)

5.   Press PROCESS START button.

6.   After desired processing interval, press OUTPUT DISPLAY button. 5480B/5486B only: if desired, set SWEEP NUMBER to number of sweeps desired (2^N), and PRESET/NORMAL to PRESET. 5480B system will perform preset number of MCS processing sweeps and stop automatically, displaying result on CRT.

      NOTE: (5480A only) If PROCESS STOP is pressed, memory contents of point being processed are lost (cleared), and this point will appear as "0" on display.

CRT DISPLAY

During processing, CRT display is only a dot moving across screen at rate determined by SWEEP TIME control. When OUTPUT DISPLAY is pressed, processing continues until end of sweep, then display appears.

Display represents number of counts received at each horizontal position as memory is stepped through all 1000 points. There are no "holes" in processing when 5480B/5486B MEMORY SELECTOR switch is set to process in QUARTER or HALF of MEMORY; the memory sections addressed are addressed for a longer period than they would be during FULL memory processing, each memory point accumulating the total number of counts that would have been placed in all the points it is replacing.

If display is not satisfactory, try a different SWEEP TIME setting. Be sure to clear display after changing SWEEP TIME.

Vertical display is not calibrated, however number of counts in any one channel can be calculated using the information presented below, when OUTPUT DISPLAY button is lighted.

SENSITIVITY MULTIPLIER SETTING	CALIBRATION (COUNTS/CM ON VERTICAL AXIS)
15	31
14	61
13	122
12	244
11	488
10	976
9	1,953
8	3,906
7	7,813
6	15,625
5	31,250
4	62,500
3	125,000
2	250,000
1	500,000
0	1,000,000

Horizontal display is calibrated by SWEEP TIME. Either the HORIZ DAC or SWEEP VOLTAGE output (available at rear-panel connectors) may be used to control input source, to relate input signal frequency to horizontal channel being scaled, instead of the more usual time variation.