USER'S MANUAL

MODEL 1965A
GATED UNIVERSAL COUNTER

SERIAL NUMBERS

This manual applies directly to instruments with serial numbers prefixed **2310A.**
For additional information about serial numbers, refer to INSTRUMENTS COVERED BY MANUAL in Section I.

Operating and Service Manual Part No. 01965-90902
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SAFETY

This product has been designed and tested according to International Safety Requirements. To ensure safe operation and to keep the product safe, the information, cautions, and warnings in this manual must be heeded. Refer to Section I and the Safety Summary for general safety considerations applicable to this product.

CERTIFICATION

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Bureau of Standards, to the extent allowed by the Bureau's calibration facility, and to the calibration facilities of other International Standards Organization members.

WARRANTY

This Hewlett-Packard product is warranted against defects in material and workmanship for a period of one year from date of shipment. During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by HP. However, warranty service for products installed by HP and certain other products designated by HP will be performed at Buyer's facility at no charge within the HP service travel area. Outside HP service travel areas, warranty service will be performed at Buyer's facility only upon HP's prior agreement and Buyer shall pay HP's round trip travel expenses.

For products returned to HP for warranty service, Buyer shall prepay shipping charges to HP and HP shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to HP from another country.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HP SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. HP SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

ASSISTANCE

Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

GENERAL — This is a Safety Class I instrument (provided with terminal for protective earthing).

OPERATION — BEFORE APPLYING POWER verify that the power transformer primary is matched to the available line voltage, the correct fuse is installed, and Safety Precautions are taken (see the following warnings). In addition, note the instrument's external markings which are described under "Safety Symbols."

WARNING

Servicing instructions are for use by service-trained personnel. To avoid dangerous electric shock, do not perform any servicing unless qualified to do so.

BEFORE SWITCHING ON THE INSTRUMENT, the protective earth terminal of the instrument must be connected to the protective conductor of the (mains) power cord. The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. The protective action must not be negated by the use of an extension cord (power cable) without a protective conductor (grounding). Grounding one conductor of a two conductor outlet is not sufficient protection.

If this instrument is to be energized via an auto-transformer (for voltage reduction) make sure the common terminal is connected to the earth terminal of the power source.

Any interruption of the protective (grounding) conductor (inside or outside the instrument) or disconnecting the protective earth terminal will cause a potential shock hazard that could result in personal injury.

Whenever it is likely that the protection has been impaired, the instrument must be made inoperative and be secured against any unintended operation.

Only fuses with the required rated current, voltage, and specified type (normal blow, time delay, etc.) should be used. Do not use repaired fuses or short circuited fuseholders. To do so could cause a shock or fire hazard.

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

Do not install substitute parts or perform any unauthorized modification to the instrument.

Adjustments described in the manual are performed with power supplied to the instrument while protective covers are removed. Energy available at many points may, if contacted, result in personal injury.

Any adjustment, maintenance, and repair of the opened instrument under voltage should be avoided as much as possible, and when inevitable, should be carried out only by a skilled person who is aware of the hazard involved.

Capacitors inside the instrument may still be charged even if the instrument has been disconnected from its source of supply.

SAFETY SYMBOLS

⚠ Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect against damage to the product.

⚡ Indicates hazardous voltages.

⏚ Earth terminal (sometimes used in manual to indicate circuit common connected to grounded chassis).

WARNING The WARNING sign denotes a hazard. It calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in personal injury. Do not proceed beyond a WARNING sign until the indicated conditions are fully understood and met.

CAUTION The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product. Do not proceed beyond a CAUTION sign until the indicated conditions are fully understood or met.

LITHIUM BATTERY SAFETY INFORMATION

To prevent explosion or exposure to hazardous materials, the Lithium battery contained in this instrument must be handled in the following manner:

Do not crush, puncture, or mutilate battery.
Do not incinerate battery.
Do not short battery terminals.

Dispose of battery in a controlled, hazardous waste land fill as designated by your state.

If proper disposal methods are not available or unknown, place insulating, electrical tape over terminals and return to your nearest HP Sales and Service office.

SS-3-9/80

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USER'S MANUAL

INTRODUCTION

This User's Manual will acquaint the operator with the Model 1965A features, controls, and measurement techniques. This User's Manual contains a set of specifications and Operating and Programming information for the 1965A. The information contained in this manual is also available in Section I through Section III and Appendices A through D of the Operating and Service Manual.

This manual has been divided into major sections of Operation by function. All of the major sections are separated by a tab divider. Most of the functional sections are further divided into Detailed Operating Instructions.

The Detailed Operating Instructions contain Local and Remote Operating Instructions and the generic program codes for that operation. There is also a section containing programming examples for the Hewlett-Packard Model 9826 or 9836 Desktop Computers using BASIC programming language.

CAUTION

The 1965A must be calibrated in the 1980 where it is to be used.

DESCRIPTION

The 1965A Gated Universal Counter is a fully HP-IB programmable, gated 100 MHz universal counter. A 1980 with a 1965A installed combines the numerous counting modes and accuracy of a universal counter with the signal conditioning, triggering, signal display and gating of the oscilloscope. The 1965A can measure frequency, period, time interval, and can count events in A[gated], A during B, Ratio A/B, Totalize A, Totalize A+B, and Totalize A−B formats. The 1965A also contains an auto parameters measurement routine. These Auto functions will measure and display rise time, fall time, pulse width, duty cycle, propagation delay, and phase shift measurements.

The 1965A Gated Universal Counter is contained in a 12.95 cm (5.1 in.) high by 6.35 cm (2.5 in.) wide by 25.65 cm (10.1 in.) long package that plugs into the expansion module location of the 1980A/B. The 1965A obtains all its power from the 1980A/B's power supplies and makes use of the 1980's HP-IB and display capabilities.

Local operation of the 1965A is from the front panel. All functions of the gated universal counter can be controlled by the front panel keys and the 1980 control knob. Remote operation of the 1965A is similar to remote operation of the 1980A/B; however, the 1965A has its own set of commands.

In addition, the 1965A has these special features:

* All functions are programmable via HP-IB (HP's implementation of IEEE Std 488) for automatic or semi-automatic measurement applications.

* Calibration can be performed on-site, without removing the 1965A Gated Universal Counter and requires little or no test equipment. Complete, step-by-step instructions are displayed on the CRT.

* Performance verification through front panel selected confidence test and memory checks.

* Uses all 1980A/B functions such as Autoscope and Save-Recall.

SAFETY CONSIDERATIONS

WARNING

To prevent personal injury, observe all safety precautions and warnings stated on the instrument and in the manual.

The 1965A and all related documentation must be reviewed for familiarization with safety markings and instructions before operation. Refer to the Safety Considerations page found at the beginning of this manual for a summary of general safety information. Safety precautions for installation, operation and servicing are found in appropriate locations throughout the Operating and Service Manual. These precautions must be observed during all phases of operation, service and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in the Operating and Service Manual violates safety standards of design, manufacture, and intended use of this instrument. Hewlett-Packard assumes no liability for failure to comply with these requirements.

SPECIFICATIONS

Specifications and supplemental characteristics of the 1965A Gated Universal Counter are listed in Table 1. This instrument will meet the electrical characteristics listed following complete calibration as given in the Adjustments section of the manual. These electrical characteristics apply over the ambient temperature range of 0 to 55° C. Warm-up time for given accuracy is 30 minutes.

Table 1. Specifications

FREQUENCY A

RANGE: 100 mHz to 100 MHz

Note: Refer to Triggering for minimum pulse width requirements.

LSD DISPLAYED:

$$\frac{10\text{ ns}}{\text{sample time}} \times \text{frequency (9 digits max)}$$

UNARMED AND ARMED MODES:

Resolution:

$\pm(2 \times \text{LSD})$

$$\pm 1.4 \times \frac{\text{trigger error†}}{\text{sample time}} \times \text{frequency}$$

Accuracy:

$\pm$ resolution

$\pm$ time base error $\times$ frequency

GATED MODE:

Resolution:

$$\pm \frac{\text{period resolution*}}{\text{period}} \times \text{frequency}$$

Accuracy:

$$- \frac{\text{period accuracy*}}{\text{period}} \times \text{frequency}$$

**Refer to period (gated) specifications.*

PERIOD A

RANGE: 10 ns to 10 s

LSD DISPLAYED:

$$\frac{10\text{ ns}}{\text{sample time}} \times \text{period (9 digits max)}$$

UNARMED AND ARMED MODES:

Resolution:

$\pm(2 \times \text{LSD})$

$$\pm 1.4 \times \frac{\text{trigger error†}}{\text{sample time}} \times \text{period}$$

Accuracy:

$\pm$ resolution

$\pm$ time base error $\times$ period

GATED MODE:

Resolution:

$$\pm \frac{10\text{ ns} + (1.4 \times \text{trigger error†})}{N \times \sqrt{\text{sample time}/(\text{period} \times N)}}$$

Accuracy:

$\pm$ resolution

$$\pm(\text{time base error} \times \text{period}) + \frac{4\text{ ns}}{N}$$

(Where N is the number of cycles gated per sweep)

†Refer to DEFINITIONS

TIME INTERVAL A → B

RANGE: $\pm$ 10 ps to $\pm$ 10 s

LSD DISPLAYED:

$$\frac{10\text{ ns}}{\sqrt{(\#\text{ of averages})}}$$

Number of averages	LSD
1	10 ns
100	1 ns
10,000	100 ps
1,000,000	10 ps

RESOLUTION:

$\pm$ LSD

$\pm$ start trigger error† $/ \sqrt{(\#\text{ of averages})}$

$\pm$ stop trigger error† $/ \sqrt{(\#\text{ of averages})}$

ACCURACY:

$\pm$ resolution

$\pm$ time base error $\times$ time interval

$\pm$ trigger level timing error†

$\pm$ systematic error†

†Refer to DEFINITIONS

Refer to Appendix A for explanation and graphs of the Time Interval Specifications.

RATIO A/B

RANGE: 10^{-9} to 10^{9}

RESOLUTION:

$$\pm \frac{\text{period B}}{\text{sample time}} \times \text{ratio}$$

$$\pm \frac{\text{trigger error†}}{\text{sample time}} \times \text{ratio}$$

ACCURACY: same as resolution

EVENTS A (Gated)

RANGE: 0 to 1000 megabits

EVENTS A DURING B

RANGE: 0 to 1000 megabits

MINIMUM TIME BETWEEN B PULSES: 75 ns

TOTALIZE A

RANGE: 0 to 1000 megabits

LSD: 1 count of input

RESOLUTION: $\pm$ LSD

ACCURACY: same as resolution

TOTALIZE A + B

RANGE: 0 to 2000 megabits

LSD: 1 count of input

RESOLUTION: $\pm$ LSD

ACCURACY: same as resolution

TOTALIZE A – B

RANGE: −1000 megabits to 1000 megabits
DISPLAY: continuous update for input repetition rates up to 5 MHz. Beyond 5 MHz, display is updated when measurement is completed.
LSD: 1 count of input
RESOLUTION: ± LSD
ACCURACY: same as resolution.

AUTO-PARAMETERS

REPETITION RATE: 15 Hz to 20 MHz, such that period − time parameter* >35 ns.

Time parameter for duty cycle is pulse width, and time parameter for phase shift is propagation delay.

MAXIMUM INPUT UNDERSHOOT + OVERSHOOT: 10%.
MINIMUM P-P AMPLITUDE: 3 divisions and 35 mV.
RESOLUTION:
± LSD
± start trigger error† / $\sqrt{\text{(\# of averages)}}$
± stop trigger error† / $\sqrt{\text{(\# of averages)}}$
TIME PARAMETER* ACCURACY:
± resolution
± (time base error × time interval)
± auto trigger error ± systematic error

Note: systematic error for rise time, fall time, pulse width, and duty cycle = 1ns. Systematic error for propagation delay and phase shift = 2 ns.

AUTO TRIGGER ERROR:

$$\pm \frac{\text{1\% of input p-p voltage}}{\text{slew rate at START trigger point}}$$

$$\pm \frac{\text{1\% of input p-p voltage}}{\text{slew rate at STOP trigger point}}$$

ARM DELAY

RANGE: 100 ns to 10 s
RESOLUTION: 100 ps (displayed: 5 digits, HP-IB: 11 digits max)
ACCURACY: ± 10 ns ± 0.1% of reading, within one hour of delay self-calibration and in constant ambient temperature.

GATE WIDTH

RANGE: 200 ns to 10 s
RESOLUTION: 1 part in 10^3
ACCURACY:
± 3% for gate width of 200 ns to 100 ms;
± 4% for gate width of 100 ms to 10 s

TIME BASE

FREQUENCY: 10 MHz
AGING RATE: <1 part in 10^7 per month
SHORT TERM:
<1 part in 10^9 rms for 1 s average
<2 parts in 10^6, 0° C to 55° C
EXTERNAL TIME BASE INPUT: front panel BNC accepts 10 MHz 1 Vrms to 10 Vrms into 500Ω. Time base selected to EXTERNAL via soft key selection.
TIME BASE OUT: 10 MHz, 25 mV p-p into 50Ω via front panel BNC with time base selected to INTERNAL via soft key selection.

Note: external time base input and internal time base output utilize the same front panel BNC.

TRIGGERING

RANGE: −20 divisions × input sensitivity to +20 divisions × input sensitivity.
Example: if input sensitivity is 10 V/div, then maximum range is −200 V to +200 V.
MINIMUM ± PULSE WIDTHS:
main = 5.0 ns (100 MHz max)
delayed = 6.25 ns (80 MHz max)

Refer to Appendix D for graph illustrating typical triggering range.

RESOLUTION: 0.02 divisions × input sensitivity.
Example: if input sensitivity is 2 mV/div, then maximum resolution is 40 μV.
TRIGGER LEVEL ACCURACY: ± 3%
± (0.4 div × input sensitivity)

Note: for further 1980 input characteristics and triggering specifications, refer to the 1980A/B specifications.

CLOCK

A 4-year time/calendar clock, with battery back-up, displays hr/min/day/month/yr.
The timer mode generates SRQs and front panel outputs at programmed times.
TIMER OUT: front panel BNC, TTL signal set by clock in timer mode.

DEFINITIONS

RESOLUTION: smallest discernible change of measurement result that is due to a minimum change in the input signal.
ACCURACY: deviation from the actual value as fixed by universally-accepted standards of frequency and time.
TRIGGER ERROR (RMS):

$$\frac{\sqrt{(0.02 \text{ div} \times \text{sensitivity})^2 + en^2}}{\text{input slew rate at trigger point}}$$

Where en is in the rms noise voltage of the input for a 100 MHz bandwidth.
Refer to Appendix B for measurement of system noise.

TRIGGER LEVEL TIMING ERROR: applies to time interval measurements

$$\frac{(\text{hysteresis}/2) \times \text{input sensitivity}}{|\text{input slew rate at START trigger point}|}$$

$$\frac{(\text{hysteresis}/2) \times \text{input sensitivity}}{|\text{input slew rate at STOP trigger point}|}$$

Note: hysteresis of the 1980 trigger circuits is accessible via HP-IB.

Typical Hysteresis: 0.15 divisions

SYSTEMATIC ERROR: timing error due to propagation delays between START(A) and STOP(B) trigger paths.

Common Source (Main-to-Main, or Delayed-to-Delayed): 500 ps

Dual Source with equal vertical sensitivities: 1 ns

Dual Source with unequal vertical sensitivities: 2 ns

GENERAL

Display: The counter and resolution is displayed on the 1980 CRT on a single line. The counter uses a three letter mnemonic to indicate the function selected. The measurement uses a max. of 9 digits on the CRT, the annunciator displays sec to attosec (s to as), millihertz to megahertz (mHz to MHz). Leading zeroes are suppressed. The clock is displayed on line 3 of the 1980 CRT and is located in the rightmost 13 digits. The reference offset is also displayed on line 3 in the leftmost portion of the CRT.

Overflow: Overflow is displayed on the CRT in inverse video.

Resolution: User may set to 1, 100, 10,000; 1,000,000 averages or 1 µsec, 100 µsec, 10 msec, 1 sec sample time. Auto resolution selects the optimum number of averages/sample time for any particular on screen setup.

Modes: Three user modes. Unarmed, armed, and gated, allows the user to window specific measurements.

Counting Lamp: Indicates when counter is in operation.

Signal Sources: Main and delayed trigger may be independently selected for 1965A source A and B. 1980 specifications apply to channel inputs and trigger setting.

Count View: Displayed as a vertical channel on the CRT to show operator the measurement interval.

Arm View: Displayed as a vertical channel on the CRT to show operator where the arming gate is located on waveform.

HP-IB: All functions can be accessed via 1980 HP-IB system.

Reset: Stops measurement, zeroes display and starts new measurement sequence. If in the "single" mode, then only one measurement will take place between "resets".

Operating Environment: Same as 1980.

OPERATING CHARACTERISTICS

Table 2 summarizes the major operating characteristics of the 1965A Gated Universal Counter. For a complete set of specifications, refer to Table 1, Specifications.

GENERAL INFORMATION

Panel Features briefly describes all controls, connectors and indicators. Front panel features are discussed on page 6.

Detailed Operating Instructions provide a complete operating reference for the measurement system user. They include information about the various measurements that can be made, as well as complete descriptions of all controls and menu functions. The instructions are arranged functionally with index tabs dividing major categories.

Each instruction contains a general description that covers signal levels, ranges, measurement limits, and other general information. Following the description, local and remote operating procedures are explained and an example is given to illustrate the procedures. At the end of each instruction, any special considerations are listed that might aid the user.

Remote Operating Information

Knowledge of local operation is essential for the remote operator to use the full capabilities of the 1965A Gated Universal Counter. Pages containing explanations of HP-IB related operations are noted with the HP-IB symbol. Instructions for HP-IB operation are in the following paragraphs.

Remote Operation, Hewlett-Packard Interface Bus in the 1980A/B Oscilloscope Measurement System Operating and Programming Manual, presents a complete description of the instrument's bus implementation. It covers bus compatibility, HP-IB message response, general Data message (input and output) format rules, and many other basic bus considerations.

Detailed Operating Instructions in this manual explain how to program instrument setups and make bus controlled measurements. Specific format rules and any special programming considerations are described. Each instruction includes programming examples.

HP-IB Codes and Format Summary condenses the programming information for the instrument. It is a quick reference for the experienced remote operator. The summary lists all program codes alphabetically and includes a complete description of parameter range and format. Refer to the 1980A/B Oscilloscope Measurement System Operating and Programming Manual for condensed programming information of the 1980A/B.

Notation Conventions and Definitions explains the syntax conventions used in this manual.

Programming Examples give several examples of typical measurements programs utilizing the 9826/9836 computer in Basic.

OPERATOR'S MAINTENANCE

The only instrument maintenance an operator needs to perform is to occasionally clean the instrument front panel using a soft cloth and either a commercial glass cleaner, or mild soap and water solution.

CAUTION

Do not use chemical cleaning agents or abrasive cleaners that might damage the plastics in this instrument. Recommended cleaning agents are isopropyl alcohol, or a solution of 1% mild detergent and 99% water.

GENERAL OPERATING INSTRUCTIONS

CAUTION

Excessive input voltage will damage the input circuit. Observe the maximum input rating described in Table 1, Specifications.

Switch off instrument power before installing or removing the 1965A Gated Universal Counter, otherwise damage to the 1980A/B or 1965A Gated Universal Counter may result.

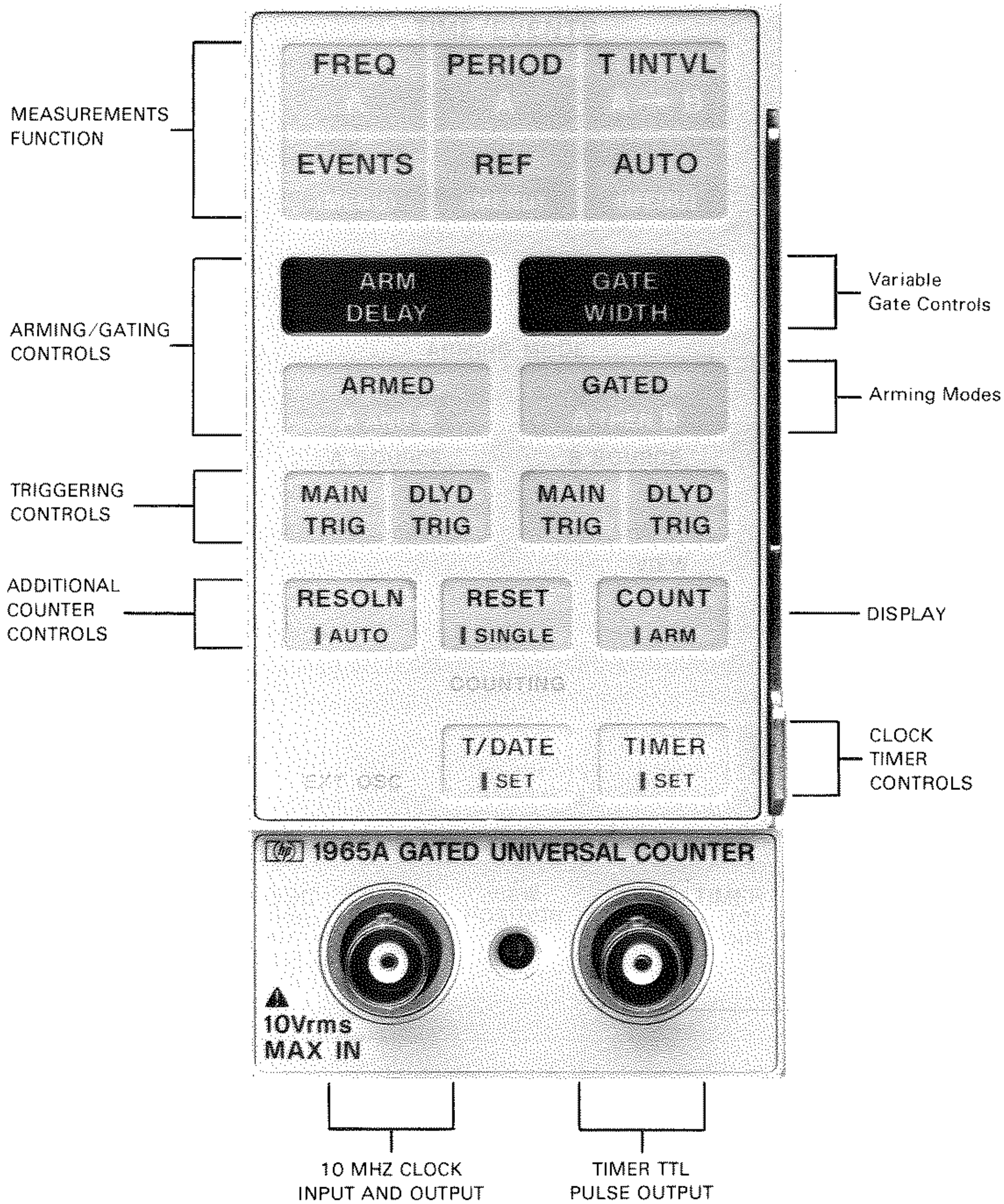
Power-on

Power-on Configuration. The 1980A/B Measurement System and 1965A Gated Universal Counter powers on with the same settings it had before it was switched off (that is, if line power was removed). The primary default conditions after an Autoscope are: Frequency - unarmed - Main Trig - Auto Resolution. If the counter is "on" when the autoscope is performed, then the default mode is as stated; however, if the counter is "off" when the autoscope is performed, then the counter will remain off. After a Preset, the 1965A Gated Universal Counter is turned off.

Power-on Error. If at turn on Err 41 is flashing in the LED display, some calibration factor(s) is not correct. To set the Calibration Factors enter and complete the 1980A/B and 1965A Front Panel Calibration routine. Do not attempt to do a Confidence test as it may or may not fail depending on which Calibration Factor is out of calibration and how much it is out of calibration.

PANEL FEATURES

The 1965A's front panel is logically arranged using the 1980A/B's computer architecture. The top row of keys control the basic measurement functions. The dark keys (arm delay and gate width) assign variable functions to the 1980A/B's control



⚠ 10 V rms Input Signal Maximum
These are not signal inputs.

Figure 1. Front Panel Features

knob. Remaining keys are used to set up the measurement conditions and other modes of the 1965A. At the bottom are two BNC connectors.

CAUTION

10 V rms maximum input.
The BNC connectors on the 1965A are not signal inputs.

FREQ A | PERIOD A

Period and frequency measurements up to 100 MHz can be made with up to eight digits of resolution. Depending on how the waveform is gated, frequency measurements can be made on the ringing of a waveform and on bursts.

T INTVL A→B

The time interval function measures the time between user-defined start and stop points. Typical time interval measurements include the time between edges of a complex pulse train and the propagation delay between a clock and data stream.

ARM DELAY | GATE WIDTH

The gate used by the 1965A is the delayed sweep gate (i.e., the intensified marker). Arm delay positions the start of the intensified marker, and gate width controls the duration of it. These controls are identical to the delay time and delayed sweep speed controls of the 1980A/B, except that gate width is approximately 11 divisions of delayed sweep and the readout of both controls is calibrated to the 1980/1965A system.

ARMED A AND B | GATED A THEN B

The 1965A's three arming modes — unarmed, armed, and gated — are generated using the main and delayed sweeps of the 1980A/B. If neither armed nor gated is selected, the 1965A is in the unarmed mode. Armed mode is used when the measurement is enabled at the beginning of the 1980A/B's delayed sweep. Gated mode is used when the measurement must be made over a specific window. Measurements such as the frequency of a burst, the time interval between edges of a pulse train, or the propagation delay between waveforms on channels one and two can be made using these modes. Examples of measurements that can be made in these modes are covered in the detailed operating instructions in this manual.

MAIN TRIG | DLYD TRIG | MAIN TRIG | DLYD TRIG

The 1965A's counting sources A and B can be assigned to the main or delayed trigger signals. The main trigger signal can be defined as channel 1, channel 2, external, or line. The delayed trigger signal can be defined as channel 1, channel 2, or external.

RESOLN ↑AUTO

The measurement resolution of the 1965A is selectable based on the digits of resolution needed or measurement time allowed. In auto-resolution, the 1965A automatically selects the resolution so that the measurement result is updated every 2.5 seconds or less.

RESET ↑SINGLE

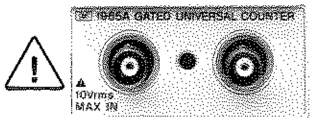
When the 1965A is in single mode, a measurement is made each time the RESET key is pressed.

COUNT ↑ARM

The 1980A/B generates a count view waveform that indicates the interval being measured. ARM view is a waveform showing the position and duration of the delayed sweep.

T/DATE ↑SET | TIMER ↑SET

The 1965A contains a real-time, battery-backed clock that can be displayed on the 1980A/B's CRT and used to document results. The 1965A also contains an alarm timer allowing up to 50 times to be set. When the time displayed by the real-time clock equals an alarm time, the BNC TIMER TTL OUT is pulsed. Additionally, an SRQ can be generated over HP-IB, and a key sequence can be executed using the HP 19811A Plot/Sequence ROM.

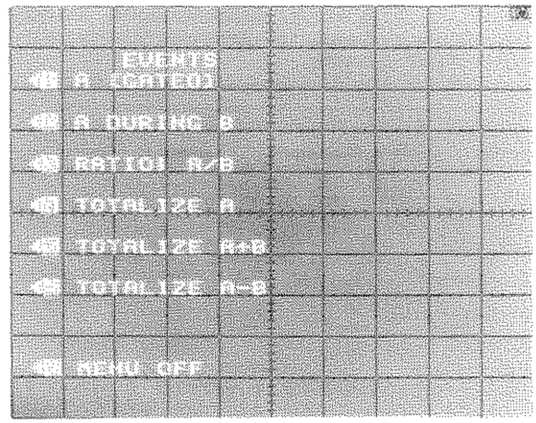


The two auxiliary BNCs are not signal inputs to the counter. The 1965A uses the 1980A/B's main and delayed trigger signals as its counting sources. The BNC on the left is a 10 MHz oscillator input and output. If an external oscillator is being used, EXT OSC is illuminated. The other BNC is a TTL pulse output used by the timer.

SOFT KEY MENUS

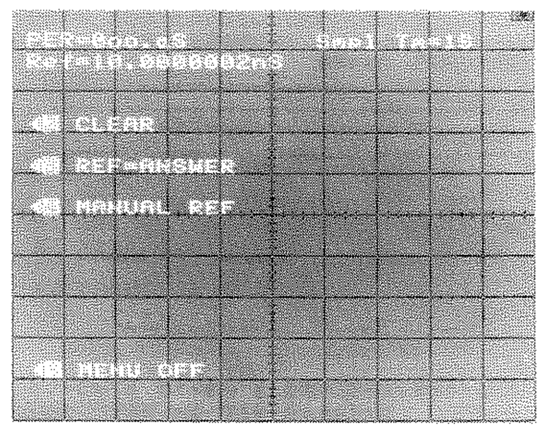
The events functions count the number of occurrences of a signal(s). When the EVENTS key is pressed, a menu is displayed on the 1980A/B's CRT. A specific events function can then be selected through the 1980A/B's soft keys. The events functions are useful in many digital applications that require counting pulses in defined time frames or that require detecting glitches or intermittent pulse occurrences.

EVENTS (MENU)



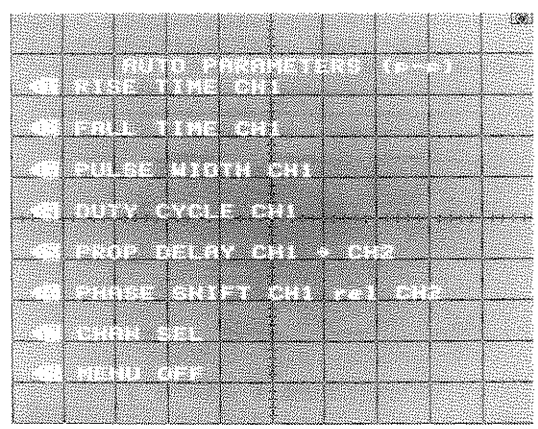
The reference function can null out propagation delays caused by different cable or probe lengths. Also, a known value can be set as a reference for frequency, period, time interval, and events functions. This allows variances and drift to be measured easily.

REF (MENU)



The auto-parameter function makes basic time interval measurements automatically. To use this function, one or two waveforms must be displayed with a stable trigger. For many waveforms, the 1980A/B's Auto-Scope can be used as a single keystroke setup. After the waveform is set up, the auto-parameter functions can be accessed by pressing the AUTO key. A menu on the 1980A/B's CRT lists the automatic measurements that can be performed on repetitive signals. Many applications require basic pulse parameters to be measured, and the 1965A makes these measurements with minimal effort.

AUTO (MENU)



The 1980/1965A makes these measurements by finding the absolute minimum and maximum waveform levels and setting the trigger levels needed for the desired measurement (e.g., 10% and 90% for a rise time). It then uses the time interval function to make the measurement. Rise and fall time measurements cannot be made on waveforms with overshoot + undershoot greater than 10% of the peak-to-peak voltage.

Several of the 1965A's features are accessed through the 1980A/B's option menu. These features perform several self tests; they assist in adjusting the internal crystal oscillator used for the real-time clock; and allow selection of either the internal or an external oscillator for measurements. The user can also select the level of hysteresis used. HIGH hysteresis should be used when operating in a noisy environment.

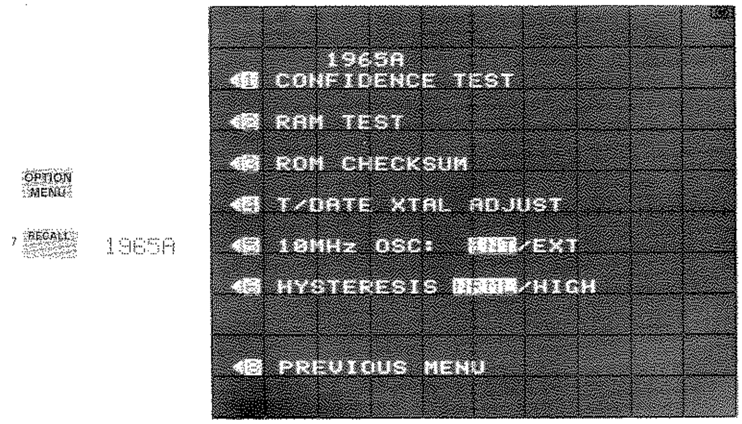


Table 2. Operating Characteristics

Function	Mode	Description	Application
FREQ A/ PERIOD A	UNARMED	Makes measurement asynchronously to the 1980A/B's sweeps.	Characterizing simple periodic waveforms.
	ARMED	Enables measurement at beginning of delayed sweep.	Frequency of startable oscillator.
	GATED	Enables measurement at beginning of delayed sweep. Begins counting at the first trigger occurrence of the A SOURCE, after the beginning of delayed sweep, and stops counting after the first trigger occurrence of the A SOURCE after the end of delayed sweep.	Ringing frequency. Frequency at a point in a swept response. Burst Measurement. Signal coupling.
TIME INTERVAL	UNARMED	Measures the time from the beginning of main sweep to the beginning of delayed sweep. With the delayed sweep mode in TRIG'D or DGTL DLY, time measured will be referenced to trigger points of main and delayed triggers.	Time relative to the first main trigger point on screen. Time interval measurements on complex waveform.
	ARMED	Measures the time interval from the first trigger occurrence of the A SOURCE to the first trigger occurrence of the B SOURCE after the beginning of delayed sweep. Measurement result may be negative.	Rise time of a waveform. Pulse width of a waveform. Two channel propagation delay.
	GATED	Measures the time interval from the first trigger occurrence of the A SOURCE after the beginning of delayed sweep to the first trigger occurrence of the B SOURCE after the end of delayed sweep. Measurement result may be negative.	
EVENTS: A	GATED	Counts the number of times that the waveform is above the trigger level (+ slope) or below the trigger level (− slope) during the delayed sweep gate.	Glitch detection. Digital Waveform analysis.
EVENTS: A DURING B	UNARMED	Counts the number of times that the waveform is above the trigger level (+ slope) or below the trigger level (− slope) while B is true (i.e., above trigger level for + slope, below trigger level for − slope).	Digital Waveform analysis.

Table 2. Operating Characteristics (Cont'd)

Function	Mode	Description	Application
EVENTS: A DURING B	GATED	Same as unarmed except measurement is performed only during the delayed sweep window.	Digital waveform analysis.
EVENTS: RATIO;A/B	UNARMED	Counts the events asynchronously to the 1980A/B's sweeps.	Measuring the harmonic relationship between frequencies.
	ARMED	Counts events after the beginning of delayed sweep.	
	GATED	Counts events during the delayed sweep gate.	
EVENTS: TOTALIZE A	UNARMED	Counts the number of events of the A SOURCE under the control of the START/STOP soft key.	
EVENTS: TOTALIZE A+B, TOTALIZE A–B	UNARMED	Counts the number of events asynchronously to the 1980A/B's sweeps under the control of the START/STOP soft key.	
	ARMED	Measurement enabled by START/STOP key. Begins counting events after the beginning of the delayed sweep and continues asynchronously to the sweeps until the START/STOP key is pressed again.	
	GATED	Counts events during the delayed sweep gate under the control of the START/STOP soft key.	

Display

Active functions and operating modes on the 1965A are indicated by the lighted keys on the front panel and the CRT readout. The answer is displayed in engineering notation on line #2 of the CRT. Any insignificant digits in the answer or reference offset will be indicated by the lower case letter "o". Suffixes range from atto (a), 10^{-18} to Giga (G), 10^{9}. The answer is preceded by a mnemonic indicating the counting function selected.

FREQUENCY A ...... = FRQ
PERIOD A .... = PER
TIME INTERVAL A→B = TI
EVENTS A[GATED]... = [A]
EVENTS A during B .. = A & B
RATIO A/B.......... = A/B
TOTALIZE A .... = A
TOTALIZE A+B ...... = A + B
TOTALIZE A–B....... = A – B
RISE TIME .... = Tr
FALL TIME .... = Tf
PULSEWIDTH .... = PW
DUTY CYCLE .... = Dcy
PROP DELAY .... = PD
PHASE SHIFT .... = ΔΦ

When operating the 1965A from the front panel, the answer will be updated at a maximum rate of 1/2 second which is indicated by the flashing "COUNTING" light on the front panel. When operating remotely, the answer may be updated upon command or by increasing the update rate with the "PU" command.

The selected resolution is also displayed on line #2 of the CRT indicating either a sample time (Smpl Tm) or number of averages (#avg) setting.

If the reference offset is active, it will be displayed on line #3 directly below the answer. Also on line #3 is the time of day and date information if the T/DATE key is lighted. The time of day is displayed in a 24 hour format.

ARM DELAY (ArmDly) and GATE WIDTH (GateWd) are displayed on the bottom two lines of the CRT. Both ARM DELAY and GATE WIDTH displays are multiplexed with the 1980's DELAY TIME (Dly Tm) and DELAYED SWEEP Setting (Dlyd). ARM DELAY and GATE WIDTH variable settings will only be displayed when either the ARM DELAY or GATE WIDTH variable function key is selected.

The 1965A generates two gate type waveforms which can be displayed on screen if either is selected. COUNT VIEW indicates the counting interval of the measurement. ARM VIEW shows the position and width of DELAYED GATE, which is coincident to the delayed sweep (intensified portion). The VIEW may be positioned vertically by a screw adjust on the lower portion of the panel between the two BNCs.

OPERATOR'S CALIBRATION AND ADJUSTMENT

Front Panel Calibration

Description The Front Panel Calibration routine allows the operator to set the calibration factors for Arm Delay, Gate Width, and Internal Delays. With these calibration factors properly adjusted, the errors in the 1980 and 1965A are held to a minimum. The 1980 must be properly calibrated before calibrating the 1965A. It is recommended to always perform a 1980 BALANCE & DELAY SELF CAL prior to calibrating the 1965A.

Gate Width — The Gate Width calibration routine determines calibration factors so that the width of the Delayed Gate received by the 1965A is accurately calculated and may be accurately set up by the user.

Arm Delay — The Arm Delay calibration routine determines calibration factors so that the delay time of the 1980 delay generator is accurately calibrated when referenced to the 1965A.

Internal Propagation Delays — The Internal Propagation Delay calibration routine determines various internal propagation delays for various scope/counter setups. The propagation delays are nulled out every Time Interval measurement so that the true time interval may be obtained.

Procedure To execute the Front Panel Calibration, press the following key sequence:

OPTION MENU

2 CHAR INTER — CALIBRATE & UTILITIES

7 RECALL — FRONT PANEL CAL 1965A

The Front Panel Calibration can be initiated via HP-IB by sending the Data message:

HP-IB

SK0,2,7<CR><LF>

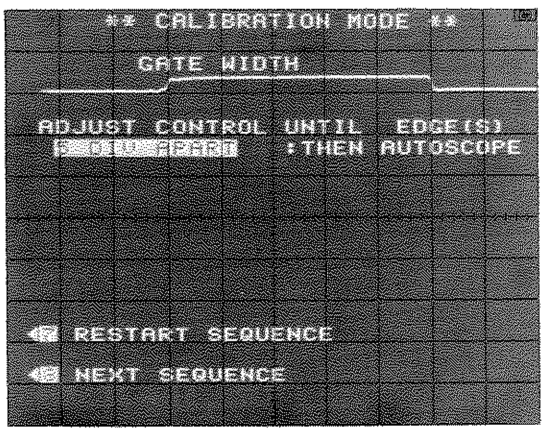
Note

Follow the instructions displayed on the CRT.

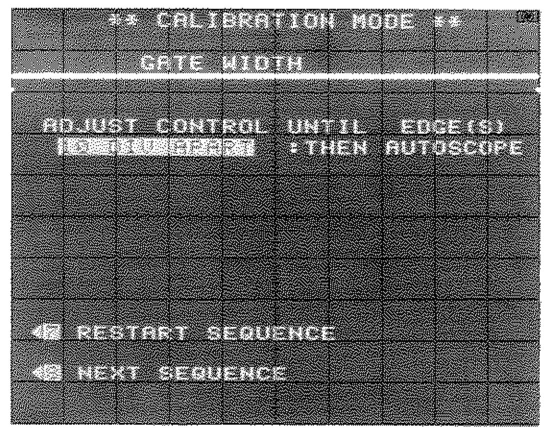
Indication An automatic routine is entered and FINDING HYSTERESIS is flashed on the screen until this routine is completed. Upon completion of the first routine, the Gate Width calibration is entered. The operator must make two pulse width adjustments as requested on the CRT. The internal Delays routine requires a 10 MHz signal be connected to channels 1 and 2 of the 1980A/B. This signal should be connected with a BNC tee and two equal length cables to minimize the difference in cable delays.

Note

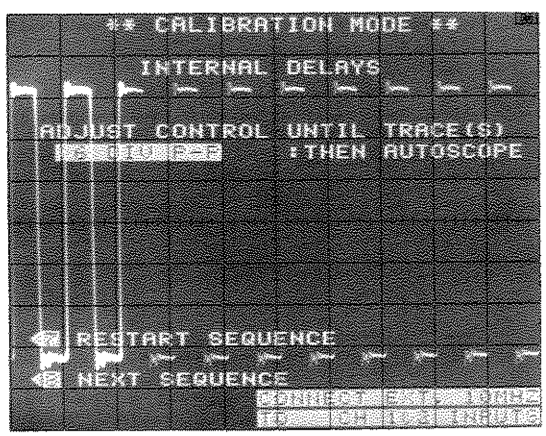
The signal from the OSCL BNC may be used to calibrate the 1965A; however, an external fast rise time signal is recommended.



a. Gate Width Step 1



b. Gate Width Step 2



c. Internal Delays

Figure 2. Calibration Setups

Response If an error condition is encountered or a calibration factor is not accepted, the instrument should be checked by qualified service personnel.

Operator's Checks

Operator's checks allow the operator to make a quick evaluation of instrument operation. The following checks are provided:

Confidence Test is a menu function that assures most of the instrument is operating properly.

RAM TEST is a menu function that verifies operation of RAM memory. No additional equipment is required.

ROM CHECKSUM is a menu function that verifies the content and operation of ROM memory. No additional equipment is required.

HP-IB I/O Check in the 1980A/B Oscilloscope Measurement System Operating and Programming Manual, confirms that the Measurement System responds properly to all HP-IB messages. This check assumes that local operation has been verified with the Confidence Test and Memory Check procedures. An HP-IB controller, interface and connecting cable are required.

GETTING ACQUAINTED EXERCISE

This exercise will aid the first time user in becoming familiar with the 1965A and its operation.

1. Make certain that your 1965A module has been calibrated in the 1980 in which it is to be used. If not, do a Front Panel Calibration prior to proceeding with this exercise.

2. Power up the 1980 and connect the calibrator signal from the 1980 rear panel to the channel 1 input.

FREQUENCY MEASUREMENTS

3. Press AUTO-SCOPE on the 1980 control panel.

4. Select the following modes on the 1965A front panel:

   FUNCTION: FREQ A
   ARMING MODE: UNARMED (neither ARMED nor GATED selected)
   A SOURCE: MAIN TRIG
   RESOLUTION: AUTO

   The counter should now be measuring the frequency of the calibrator signal which is 1.860...kHz. The answer is displayed on line two of the CRT. Sample time is also displayed on line two and should indicate one second. Sample time determines the degree of resolution of the resultant measurement.

5. Press the RESOLN key on the 1965A front panel one time. The sample time will change to 1 μs and the number of digits in the answer displayed will be three. Toggle through the various resolution settings (four discrete selections) by pressing the RESOLN key and observe the number of digits displayed in the answer.

6. Select AUTO Resolution once again by pressing the blue shift key on the 1980 Voltage Panel and then press RESOLN on the 1965A front panel. In AUTO-RESOLUTION the 1965A automatically selects the optimum resolution so that the user or controller does not wait more than 2.5 seconds for an update of answers. The usefulness of this feature will become more obvious in gated measurements.

Gated Frequency Measurement

7. Press the INTEN by delayed key on the 1980 main time panel. The intensified portion (delayed sweep indication) should appear. All ARMED and GATED measurements require that the delayed sweep in the 1980 be on. In addition, in order for the 1965A to measure DLYD TRIG, delayed sweep must be turned on. It is good practice to always turn on the delayed sweep (INTEN by dlyd) whenever operating the 1965A.

8. Adjust main sweep SEC/DIV to 500 μs/division.

9. Press the ARM DELAY key on the 1965A front panel and adjust the Control Knob until ARM DELAY is approximately equal to 900 μs. The ARM DELAY setting is indicated on the CRT (lower right) and is also indicated in the LEDs. Arm delay controls the delay time of the 1980 delayed sweep referenced to the first trigger event on screen.

10. Press the GATE WIDTH key on the 1965A front panel and adjust the Control Knob for approximately 2 ms. Gate width controls the duration of the delayed sweep.

11. Set the arming mode to GATED on the 1965A front panel.

12. Turn on the View select to COUNT VIEW.

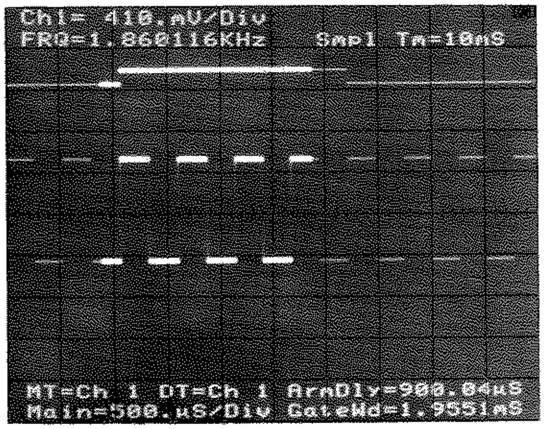


Figure 3. Example of Gated Frequency Measurement Setup

The 1965A is now measuring the frequency in the gated mode. Measurement data is collected by the counter from the first rising edge after the beginning of the intensified portion to the first rising edge after the end of the intensified portion. This is indicated by the count view display which should be "popping" up and down over the measurement interval.

13. The 1965A has automatically selected 10 ms as the sample time. For a better display of COUNT VIEW, press the RESOLN key once. The sample time will now be one second and the measurement update will be approximately every five seconds. Select AUTO-RESOLUTION once again.

14. Adjust ARM DELAY and GATE WIDTH to various settings and observe the position and duration of the intensified portion versus the measurement interval (indicated by COUNT VIEW).

    Applications for gated frequency measurements include: ringing frequency, burst measurements and swept response measurements.

PERIOD MEASUREMENT

15. Select PERIOD A on the 1965A front panel. The 1965A actually performs period measurements for both PERIOD A and FREQ A. A reciprocal operation is performed in order to display the answer in the frequency format.

ARMED TIME INTERVAL

16. Press AUTO-SCOPE on the 1980 Control Panel to return the 1980 and 1965A to an initial setup state.

17. Turn on the delayed sweep by pressing the INTEN by dlyd key on the 1980 main time panel.

18. Adjust main sweep's SEC/DIV to 200 µs/div.

19. Press VOLTS/DIV (channel 1) key and adjust for 200 mV/division.

20. Select the following modes on the 1965A front panel.

    FUNCTION: T INTVL A→B
    ARMING MODE: ARMED
    A SOURCE: MAIN TRIG
    B SOURCE: DLYD TRIG
    RESOLUTION: ▯ AUTO
    VIEW: COUNT

Rise Time

21. Press ARM DELAY on the 1965A front panel and adjust for approximately 500 μs.

22. Press GATE WIDTH and adjust for approximately 100 μs.

23. Select ▯ TRIG VU on the Main time panel.

24. Press the TRIG LVL key on the main time panel and adjust main trigger level for −2.00 divisions (readout in LEDs). Observe the position of the waveform on trigger view. Center screen defines the triggering point. With a trigger level of −2.00 divisions, main trigger will be triggering at approximately 10% on the rising edge (_/‾).

25. Select ▯ TRIG VU on the delayed time panel.

26. Press the TRIG LVL key on the delayed time panel and adjust delayed trigger level for +2.00 divisions. Observe the position of the waveform on trigger view. Triggering should now be at approximately 90% on the rising edge (_/‾).

27. Turn off delayed ▯ TRIG VU and observe COUNT VIEW.

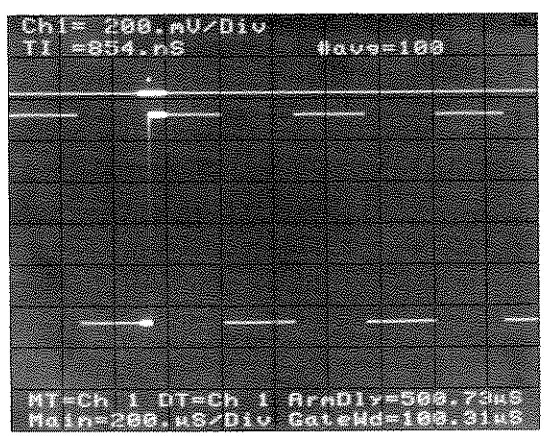


Figure 4. Example of Rise Time Measurement Setup

The 1965 is now measuring the rise time of the 1980's calibrator signal. COUNT view should show a narrow "blip" indicating that the measurement is being taken on the 2nd rising edge of the input. The 1980's calibrator signal rise time may vary from instrument to instrument.

COUNT view should be difficult to see since the rise time relative to the period of the waveform is extremely fast. For a better display of the rising edge and COUNT view, press DLY'D on the delayed time panel.

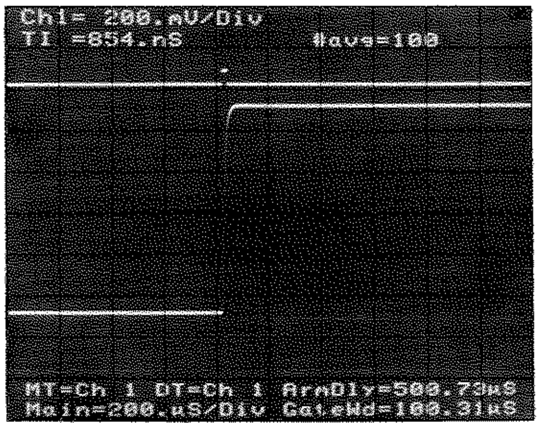


Figure 5. Example of Rise Time Measurement Setup with Delayed Selected

28. With AUTO-RESOLUTION selected, the display on line two of the CRT should indicate "#AVG=100". As in sample time, there are four discrete selections in number of averages. Toggle through the four selections and observe. In this particular measurement, 10,000 averages will take approximately 60 seconds for an answer, and 1,000,000 averages will result in a measurement "OVERFLOW" after approximately 75 seconds. The user may not wish to wait for these conditions to occur. More averaging may be used on signals with faster repetition rates. Re-select AUTO-RESOLUTION.

29. Press the INTEN by dlyd key on the main panel.

30. Press ARM DELAY and adjust for 1.02 ms. The 1965A will now be measuring the rise time of the 3rd rising edge displayed on screen. The ARM DELAY adjustment is not a very critical adjustment. In order to measure the rise time on the 3rd rising edge ARM DELAY could have been set anywhere from approximately 550 µs to 1.07 ms. The beginning of the delayed sweep must occur after the 2nd rising edge and before the 3rd rising edge.

31. Press GATE WIDTH and adjust for any value. Notice that the duration of the delayed sweep does not affect the measurement. In TIME INTERVAL ARMED, the 1965A will measure from the first trigger occurrence of A SOURCE (MAIN TRIG @ 10% in this case) after the beginning of the delayed sweep to the first trigger occurrence of B SOURCE (DLY'D TRIG @ 90%) after the beginning of the delayed sweep. The beginning of the delayed sweep arms both the A and B trigger sources at the same time, therefore the measured time may be negative if the B trigger occurrence arrives before the A trigger occurrence.

32. Change A SOURCE on the 1965A front panel to DLYD TRIG and B SOURCE to MAIN TRIG. The 1965A should now be measuring the time from the 90% point to the 10% point on the rising edge, which is negative in time.

Fall Time

33. Change the slope selection on both the main time panel and delayed time panel to falling (⌝_). The 1965A will now measure the fall time of the calibrator signal.

Note

When changing trigger conditions such as slope settings on the delayed time panel, an advisory message "DLY'D SWEEP IN AUTO" is displayed. This advisory is for the 1980 user and should be ignored when using the 1965A.

Pulse Width

34. Press TRIG LVL on the main time panel and adjust to 0.00 divisions (LEDs). Main trigger will now be triggering at approximately 50% of the waveform.

35. Press TRIG LVL on the delayed time panel and adjust to 0.00 divisions. Delayed trigger will now be triggering at approximately 50% of the waveform.

36. Change the slope selection on main time panel to rising (_⌐). Slope selection for delayed trigger should remain falling (⌝_).

37. Change the A SOURCE to MAIN TRIG and B SOURCE to DLY'D TRIG.

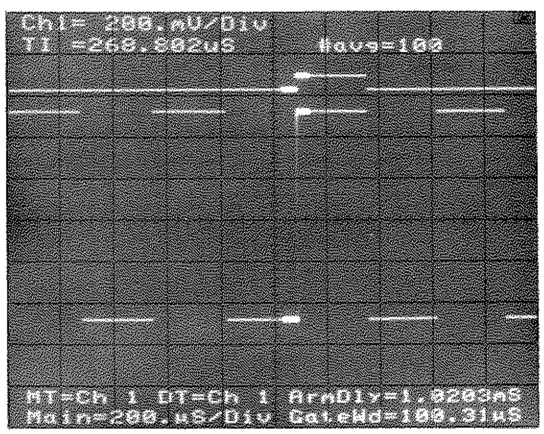


Figure 6. Example of Pulse Width Measurement Setup

The 1965A should now be measuring the pulse width of the 3rd positive going pulse displayed on screen.

38. Press ARM DELAY and adjust for any value. Observe COUNT VIEW and the answer. If the beginning of the delayed sweep precedes a rising edge, then the time interval measured is a positive pulse width. If the beginning of the delayed sweep precedes a falling edge, then the time interval measured is the negative time of a negative pulse. In order to measure the negative pulse width with the correct sign, reverse the A and B SOURCE to A SOURCE = DLYD TRIG and B SOURCE = MAIN TRIG and set the ARM DELAY so that the delayed sweep precedes a falling edge.

There are many other applications for ARMED TIME INTERVAL measurements, including two channel measurements such as propagation delays, in which case main and delayed triggers would be assigned to different channels of the input (i.e. MT=CH1, DT=CH2).

GATED TIME INTERVAL

39. Press AUTO-SCOPE on the 1980 control panel.

40. Turn on the delayed sweep by pressing the INTEN by dlyd key on the 1980 main time panel.

41. Adjust main SEC/DIV to 200 μs/div.

42. Select the following modes on the 1965A front panel:

    FUNCTION: T INTVL A→B
    ARMING MODE: GATED
    A SOURCE: MAIN TRIG
    B SOURCE: MAIN TRIG
    RESOLUTION: ▮ AUTO
    VIEW: COUNT

43. Press ARM DELAY and adjust for approximately 400 μs.

44. Press GATE WIDTH and adjust for approximately 400 μs.

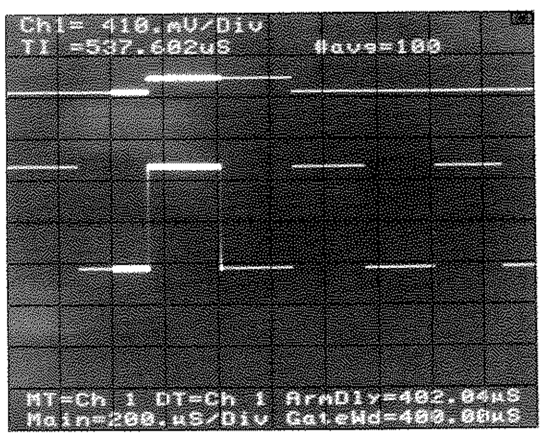


Figure 7. Example of Gated Time Interval Measurement of One Period

The 1965A should now be performing a gated time interval measurement. COUNT view should indicate that the interval measured is the period of the 2nd cycle on screen. In the gated mode, time is measured from the first trigger occurrence of the A SOURCE after the beginning of the delayed sweep to the first trigger occurrence of the B SOURCE after the end of the delayed sweep. The beginning of the delayed sweep arms the A trigger source, while the end of the delayed sweep arms the B trigger source.

45. Adjust GATE WIDTH to approximately 800 μs. The 1965A should now be measuring the time interval of two cycles of the input.

46. Change the B SOURCE to DLYD TRIG.

47. Change the slope selection on the delayed time panel to falling (⌄).

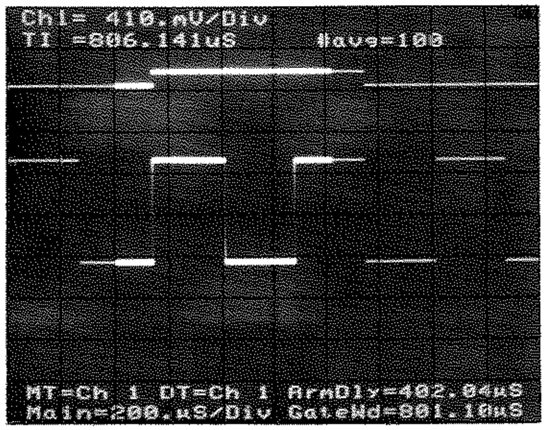


Figure 8. Example of Gated Time Interval Measurement of 1-1/2 Periods

The 1965A should now be measuring 1-1/2 periods of the input. The time measured is from the 2nd rising edge on screen (1st A trigger after beginning of delayed sweep) to the 3rd falling edge on screen (1st B trigger after end of delayed sweep).

48. Adjust ARM DELAY and GATE WIDTH to various settings and observe the various time intervals measured.

With the ARMED and GATED measurement techniques of the 1965A, numerous measurements can be performed upon simple waveforms.

UNARMED TIME INTERVAL

49. Press AUTO-SCOPE on the 1980 Control Panel.

50. Turn on the delayed sweep by pressing the INTEN by dlyd key on the 1980 Main Time Panel.

51. Adjust main SEC/DIV to 200 μs/div.

52. Select the following modes on the 1965A front panel:

FUNCTION: T INTVL A→B
ARMING MODE: UNARMED (neither ARMED nor GATED)
RESOLUTION: AUTO
VIEW: COUNT

Note: Source selections cannot be made.

53. Press ARM DELAY and vary the arm delay value. Observe the time interval measurement.

Time Interval in the UNARMED mode measures time from the beginning of the main sweep to the beginning of the delayed sweep. With the delayed sweep mode in AUTO, TIME INTERVAL UNARMED is an accurate measure of ARM DELAY.

54. Adjust ARM DELAY for approximately 100 μs.

55. Select the delayed sweep mode to be TRIG'D on the Delayed Time Panel. The 1965A should now be measuring the period of the 1st cycle on the screen.

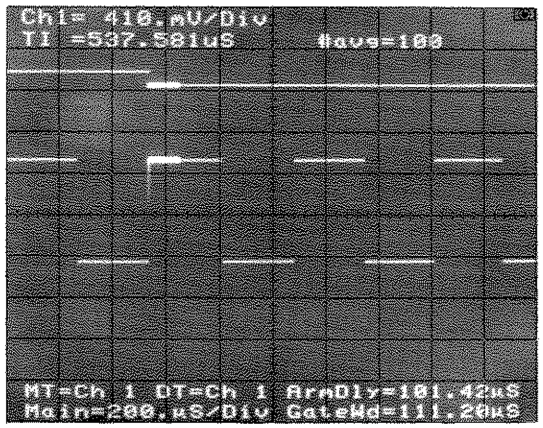


Figure 9. Example of Unarmed Time Interval Measurement of the 1st Cycle

56. Change the slope selection on the delayed time panel to falling (⌝_).

The 1965A should now be measuring the pulse width of the first positive pulse displayed on screen. When it is imperative that a time interval measurement be performed relative to the first trigger occurrence on screen, the UNARMED mode must be used. Time interval measurements in the ARMED and GATED modes are measured upon triggers that occur after the beginning of the main sweep. Since the first trigger event on screen occurred before the beginning of the main sweep, it is impossible to detect it in the ARMED or GATED modes.

57. Press the REF(menu) key on the 1965A front panel. A reference offset menu will be displayed on screen. Press soft key #3 (REF=ANSWER). All subsequent answers will be offset by this value, which is displayed on line #3 of the CRT. Press soft key eight (menu off).

58. Change the slope selection on the Delayed Time Panel to rising (_⌐). The 1965A should now be measuring the negative pulse width of the first cycle displayed on screen. COUNT view will indicate the true measurement without the reference offset.

Time Interval in the UNARMED mode has many applications in measurements involving complex waveforms. In order to obtain a stable 1980 sweep, a sync signal must be provided for Main Trigger. All timing measurements must then be performed upon the delayed trigger, which must be triggering upon the complex waveform. Any measurements outside of a simple gated measurement requires that the UNARMED mode be used utilizing REFERENCE offset in a two step process. In addition, the delayed sweep must be either in DIGITAL DELAY or TRIG'D.

AUTOMATIC PARAMETERS MEASUREMENTS

59. Press AUTO-SCOPE on the 1980 Control Panel.

60. Press the AUTO (menu) key on the 1965A front panel. A menu should be displayed on screen with six parameter measurement selections and a channel selection.

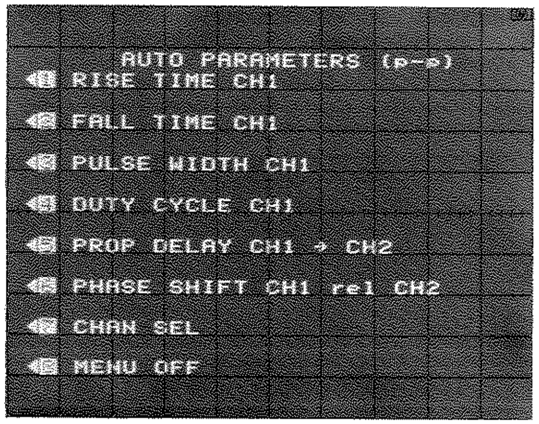


Figure 10. Automatic Parameter Measurement Menu

61. Press soft key #7 (CHAN SEL) and observe. Set the channel select so that the RISE TIME is designated CH1.

62. Press soft key #1 (RISE TIME CH1). The 1965A will automatically rescale the vertical sensitivity of channel 1 so that the waveform will be approximately 16 divisions peak to peak. This is done so that trigger levels can be set with maximum resolution and accuracy. The 1965A then searches for the absolute maximum and minimum of the waveform and sets trigger levels of main and delayed triggers at 10% and 90% based upon the peaks (the 1965A automatically compensates trigger levels due to hysteresis. The rise time measurement is then performed automatically and the answer is displayed on screen with the return of the AUTO-PARAMETERS menu.

Note

Maximum undershoot + overshoot may not exceed 10% of the peak to peak waveform for rise and fall time measurements.

63. Select the remaining single channel automatic parameter measurements. PROP DELAY and PHASE SHIFT require two inputs.

EVENTS MEASUREMENTS

64. Press AUTO-SCOPE on the 1980 Control Panel.

65. Turn on the delayed sweep by pressing the INTEN by dlyd key on the 1980 Main Time Panel.

66. Adjust main sweep SEC/DIV to 200 μs/div.

67. Press the EVENTS (menu) key on the 1965A front panel. A menu will appear on the CRT with six EVENT function selections.

68. Press soft key #1 (A[GATED]) .

69. Select the following modes on the 1965A front panel:

    A SOURCE: MAIN TRIG
    RESOLUTION: AUTO
    VIEW: COUNT

70. Press the ARM DELAY key and adjust to approximately 400 μs.

71. Press the GATE WIDTH key and adjust to approximately 1 ms.

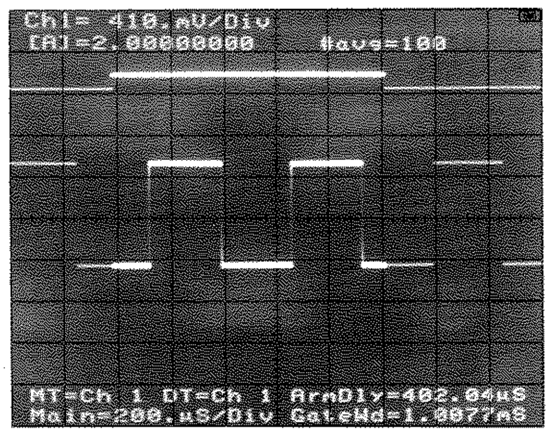


Figure 11. Example of Events A[GATED] Setup

The answer should read 2.000.... A[GATED] counts the number of events of the A SOURCE that occur during the delayed sweep. The measurement may be averaged in which case it is a good tool for glitch detection. Refer to measurement functions section of the Detailed Operating Instruction for an example of glitch detection.

72. Press the ARM DELAY key and adjust to approximately 160 μs.

Notice that the answer is now 3.000.... A[GATED] does not count trigger occurrences of the A SOURCE, but counts true level occurrences of the A SOURCE. Refer to the Detailed Operating Instruction for further information.

73. Press the EVENTS (menu) key. Soft key selection number two is A during B, which requires two inputs to demonstrate. A during B is very similar to A[GATED] except the primary gating signal is now an input which defines the B SOURCE. Refer to the Detailed Operating Instructions.

Ratio A/B measures the ratio of frequencies of two inputs. Applications include measuring harmonic relationships between two signals. Since RATIO A/B requires two inputs, RATIO A/B will not be demonstrated in this exercise.

74. Press soft key #4 TOTALIZE A.

Totalize A counts the number of trigger occurrences of the A SOURCE between user defined START and STOP.

75. Press soft key #7 START/STOP. The 1965A will begin counting "on the fly".

76. Press soft key #7 START/STOP. The 1965A will stop counting.

77. Press soft key #7 START/STOP. The 1965A will continue counting "on the fly".

78. Press soft key #7 START/STOP. The 1965A will stop counting once again.

79. Press RESET on the 1965A front panel. The count will be zeroed.

80. Press the EVENTS (menu) key. The last two selections are TOTALIZE A+B and TOTALIZE A-B. They operate very similar to TOTALIZE A except they require two inputs.

81. Press the EVENTS (menu) key once again. The menu will go off and the 1965A will be shut down.

Things You Must Know About the 1980/1965A System

1. Never operate the 1965A with the 1980 display mode in CHOP.

2. The two BNC connectors on the 1965A module are not inputs for counting.

3. Main trigger must always be triggering on a simple part of the waveform. To insure a stable sweep, main trigger cannot be triggered on ringing. Complex signals require an external sync.

4. Nearly all 1965A measurements require that the delayed sweep be on. This is accomplished by turning on either INTEN by dlyd, DLY'D, or DUAL. The most common and useful operating mode is INTEN by dlyd.

Note

AUTO-SCOPE will turn the delayed sweep off.

5. All time interval measurements with averaging must be performed on screen. Increase SEC/DIV if necessary.

6. Time Interval measurements will OVERFLOW on slow repetition rate signals with a high number of averages selected. Use AUTO-RESOLUTION when in doubt.

7. ARM DELAY and GATE WIDTH must not be setup such that arming points are closer to the desired triggering point than the ARM DELAY or GATE WIDTH specification allows.

8. The 1965A will count and give answers when EXTERNAL oscillator is selected, even if the proper signal is not applied to the OSC BNC (10 MHz, 1 Vrms to 10 Vrms).

9. Never use the PO2 command to enter data for any of the TOTALIZE functions. Use the PO1 command. Refer to "Information Output" in the Additional HP-IB Control section of the Detailed Operating Instructions.

10. When using the PO2 command, beware that if the 1980 is not triggering or sweeping, the 1965A may not return an answer to the controller. The 1965A will hold up the bus until the measurement is complete. If the measurement never completes, then the bus will be held up indefinitely. This can be remedied by using a TIME-OUT routine in the program whereby if any line of code takes more time than a user specified time, then the program can recover by executing a device clear command.

11. Overshoot plus (+) Undershoot may not exceed 10% of the peak to peak waveform when performing rise and fall time measurements under AUTO-PARAMETERS.

12. The TIMER should be turned off when setting the TIMER.

Things You Should Know About the 1980/1965A System

1. It is good practice to use HF REJ on main and delayed triggers for slow slew rate signals under 1 kHz.

2. HIGH hysteresis can be a useful tool for increasing the 1980's noise immunity.

3. For most accurate answers in TOTALIZE, execute a STOP command (PO8) prior to entering data with the PO1 command.

4. Most common measurements require that the delayed sweep mode be in AUTO.

5. Most Time Interval UNARMED measurements will require that the delayed sweep mode be in TRIG'D or DGTL DLY. Digital Delay can be extremely useful in characterizing unknown waveforms, however, digital delay is limited to approximately 15 MHz.

6. Gated TIME INTERVAL and FREQUENCY do not measure only during the delayed sweep. The measurement interval is always to the next trigger occurrence after the end of the delayed sweep.

7. Count view should not be used for accurate setup of trigger levels.

8. On fast main sweep speeds (<1 μs/div), ARM DELAY and GATE WIDTH should be used for accurate setup of the delayed sweep. On fast sweep speeds, the intensified portion is relatively undefined and inaccurate.

9. When operating over the HP-IB, the user must fully understand the use of ARM DELAY and GATE WIDTH. If the signal under test is unknown, there are various techniques for characterizing the waveform such as: FREQ/PER, TIME INTERVAL UNARMED using digital delay, the 1980 waveform storage, etc.

10. Confidence Test is not a complete test of all functions and modes. If the test passes, then user should have a high level of confidence in the instrument. If the test fails, the instrument should be calibrated or repaired.

11. The user should understand the A SOURCE and B SOURCE signal path diagram in the triggering section of the Detailed Operating Instructions.

DETAILED OPERATING INSTRUCTIONS

Using the Detailed Operating Instructions

The Detailed Operating Instructions contain all the information needed to operate the 1965A. The detailed Operating Instructions are arranged in functional grouping with tabs.

The following considerations should be remembered when using the Detailed Operating Instructions.

* The procedures and examples for HP-IB operation include only the program codes (device dependent commands) needed for remote operation. The HP-IB command mode messages (such as REN, MLA, MTA, and UNL) that are required in bus data transfers are not listed.

* HP-IB program codes are listed in ASCII code.

* The notation conventions used to describe HP-IB codes are defined in Notation Conventions and Definitions at the end of this section.

Table 3. Detailed Operating Instructions Index

NOTES

MEASUREMENT FUNCTIONS

The following is the list of counter functions discussed in this section of the Detailed Operating Instructions. Many of these include examples of specific applications.

FREQUENCY A
- UNARMED
- ARMED
- GATED

PERIOD A

TIME INTERVAL A→B
- UNARMED
- ARMED
- GATED

EVENTS A[GATED]
EVENTS A during B
RATIO; A/B
TOTALIZE A
TOTALIZE A±B

AUTO-PARAMETERS
- RISE TIME
- FALL TIME
- PULSE WIDTH
- DUTY CYCLE
- PHASE SHIFT
- PROPAGATION DELAY
- CHANNEL SELECT

Frequency A

Description The FREQ A and PERIOD A counter functions are identical in their physical measurement. The 1965A incorporates the reciprocal counting technique in order to measure the period of signal "A". With a SAMPLE TIME of one second, resolution of 1 part in 10^8 can be obtained. The 1980 microprocessor system merely performs a reciprocal operation to give results in the frequency format. FREQA/PERA may be measured in any of the three arming modes.

UNARMED: The unarmed mode is the default mode when neither ARMED nor GATED are selected. The measurement is performed asynchronous to the 1980 sweep cycle/gates. Frequency or Period in the UNARMED mode is basically the same measurement a stand alone counter would perform. The A SOURCE must be selected to be either MAIN or DLYD TRIG. Refer to the Programming Examples section. Programming Example # 1 will execute an unarmed frequency measurement.

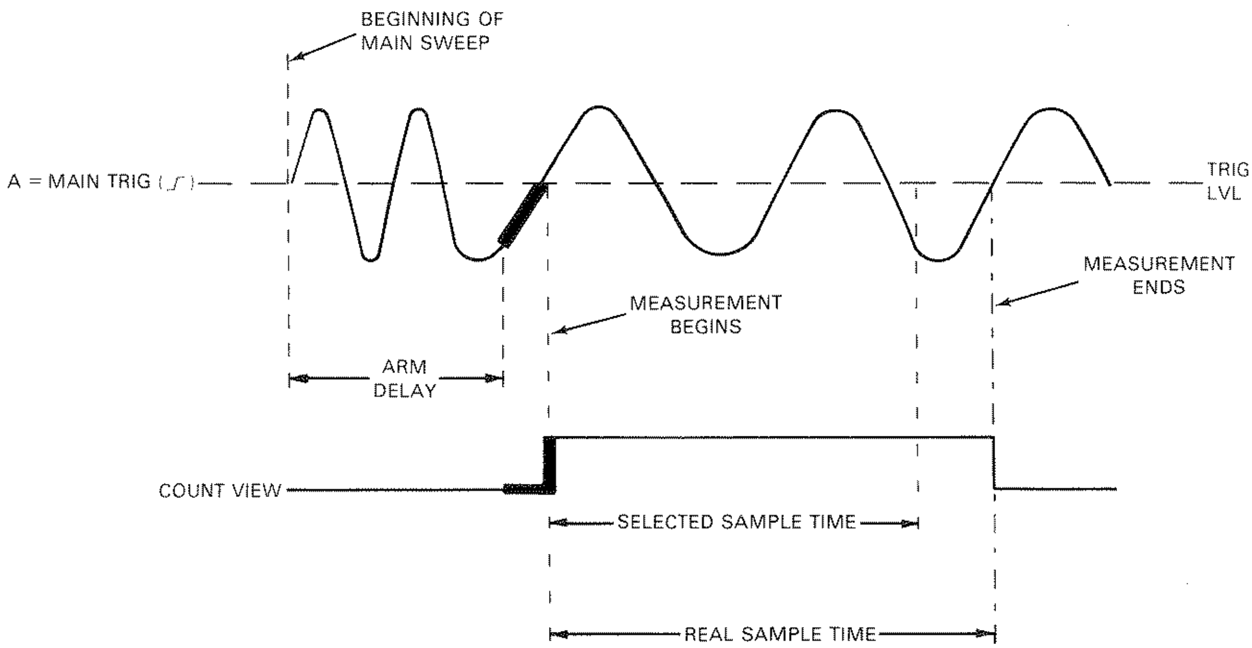
ARMED: In the ARMED mode of operation each measurement is started synchronous with the 1980 sweep cycle. The measurement is armed at the beginning of the delayed sweep (ARM DELAY) and actually begins counting on the very next trigger occurrence of the A SOURCE. A typical application would be to measure the frequency of a startable oscillator where it is desired to hold off the measurement until a specified settling time is satisfied. Once the measurement begins, it will continue counting until the first trigger occurrence of the A SOURCE after the sample time has been satisfied. The complete measurement could involve several sweep cycles, in which case COUNT view would not be as shown in figure 12.

GATED: The GATED frequency/period measurement enables the 1965A to perform measurements only on user defined portions of a waveform. The gated frequency/period measurement begins on the first trigger occurrence of the A SOURCE after the beginning of the delayed sweep (ARM DELAY). The measurement stops on the first trigger occurrence of the A SOURCE after the end of delayed sweep (GATE WIDTH). The measurement will repeat the above sequence each 1980 sweep cycle until the sample time is satisfied. Sample time is accumulated only during each measurement cycle. For example, if performing a gated frequency measurement upon a 1 kHz signal with only three cycles of the signal under measurement then 3 ms of sample time will be accumulated each 1980 sweep cycle. With a sample time of one second selected, it would require 334 sweep cycles to complete one gated measurement.

There are various applications for gated frequency/period measurements.

1. Ringing frequency — to determining a system's resonant frequency.
2. Signal coupling — to determine the source of an unknown asynchronous coupling signal.
3. Burst measurements.
4. Swept frequency — to determine the frequency response of a system.

Frequency A (Cont'd)



Function: FREQ A

Arming Mode: ARMED

A source: MAIN TRIG

B source: Not selectable

RESOLN: 1 μs, 100 μs, 10 ms, 1 s, or AUTO (recommended)

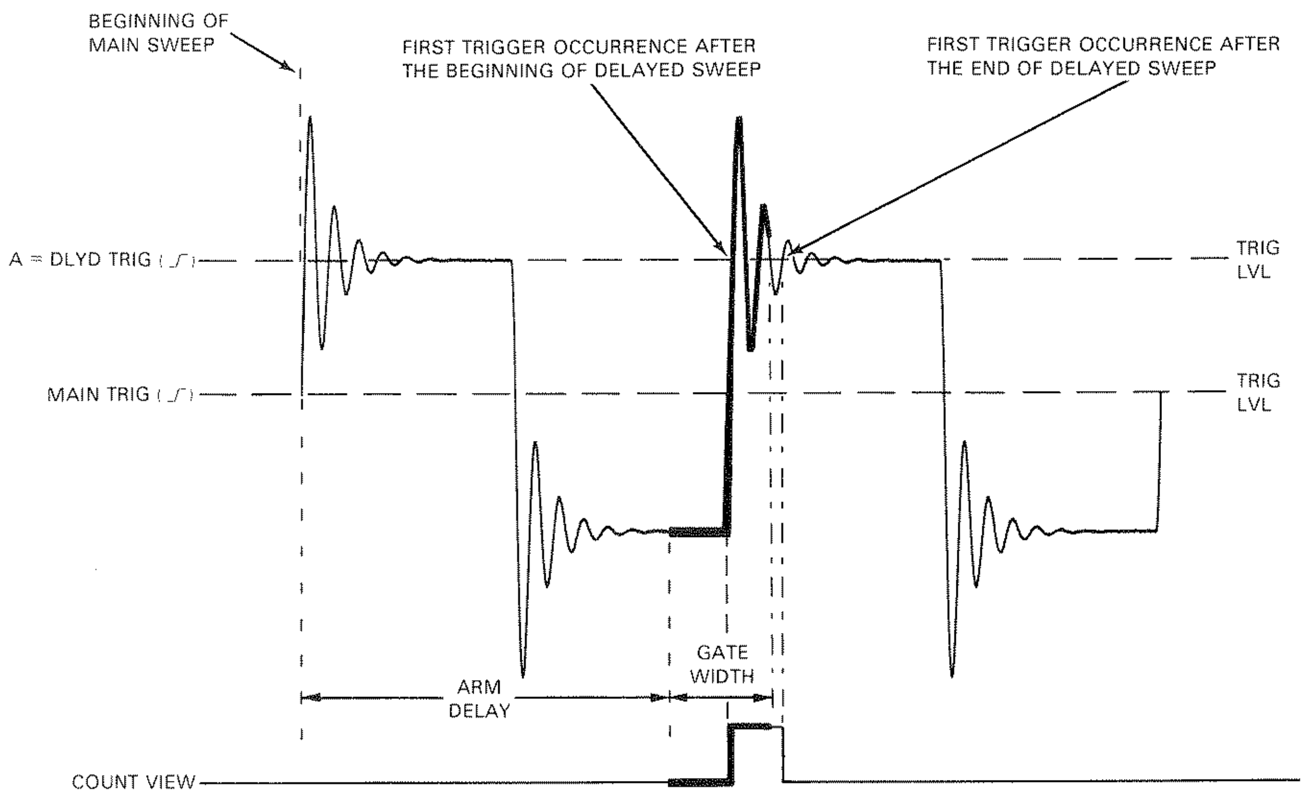
ARM DELAY: Settling Time of the Signal

GATE WIDTH: May be set, but not used in this measurement

Main Sweep Mode: TRIGGERED

Delayed Sweep Mode: AUTO

Figure 12. Frequency Measurement of a Startable Oscillator Using the ARMED Mode



Function: FREQ A

Arming Mode: GATED

A Source: DLYD TRIG

B Source: Not Selectable

RESOLN: 1 μs, 100 μs, 10 ms, 1 second or AUTO (recommended)

ARM DELAY: Set such that the measurement is armed before the first overshoot pulse on the second main cycle of the fundamental waveform.

GATE WIDTH: Set such that the delayed sweep ends before the third overshoot pulse.

MAIN TRIGGER: Must be either triggering upon the fundamental waveform or triggering upon a stable external signal.

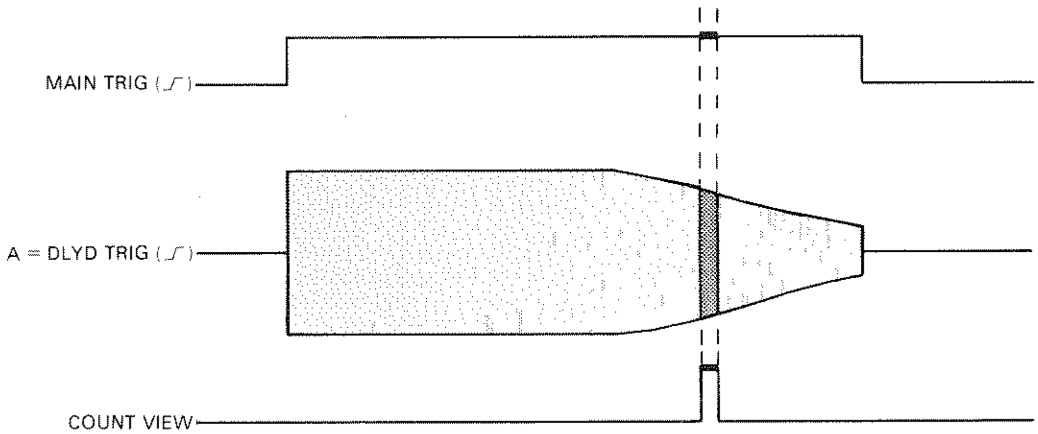
DELAYED TRIGGER: Must be triggering upon the ringing portion of the waveform. Input signal conditioning may be required in order to assure trigger sensitivity (make volts/div smaller).

Delayed Sweep Mode: AUTO

COUNT view: May be selected to show the actual counting interval which for this example would be two cycles of the ringing waveform.

Figure 13. Frequency Measurement of Ringing Using the Gated Mode

Frequency A (Cont'd)



Function: FREQ A

Arming Mode: GATED

A Source: DLYD TRIG

B Source: Not Selectable

RESOLN: 1 μs, 100 μs, 10 ms, 1 second, or AUTO (recommended)

ARM DELAY: Set such that the delayed sweep is positioned to measure at the desired attenuated level.

GATE WIDTH: The narrower the width, the more discriminate the measurement will be, however, a minimum of one trigger occurrence of the A SOURCE must occur during the delayed sweep.

MAIN TRIGGER: Must be triggering upon a sync signal.

DLYD TRIGGER: Should be triggering at the center of the swept response signal.

Delayed Sweep Mode: AUTO

COUNT view: Shows the counting interval and in this example will appear to be coincident with the intensified marker (Delayed Sweep).

Figure 14. Swept Frequency Measurement

Frequency A (Cont'd)

Procedure To select the Frequency function press FREQ A; to select Arming Mode press ARMED A AND B or GATED A THEN B for desired mode.

HP-IB **Program Codes**

Select the Frequency function and one of the Arming modes.

PF[<mode>]

mode::= **0** Unarmed
1 Armed
2 Gated

Example Set 1965A to Frequency function and Gated Mode.

LOCAL (keys)	FREQ A GATED A THEN B
REMOTE (codes)	PF 2 <LF> <CR> identifier (PF) — mode (2) — EOS (<CR>)

Indication FREQ A and GATED A THEN B are lighted. If an input signal is connected, the FREQ display on the CRT will change.

Comments To manually set the Arming mode to unarmed, press ARMED A AND B or GATED A THEN B until neither key is lighted.

Period A

Description Sets the 1965A to the Period function, and allows the selection of an arming mode. Period is the mathematical inverse of frequency. Refer to FREQUENCY A in this section of the Detailed Operating Instructions for a complete description with examples. Examples 2, 3, and 5 in Programming Examples show how to program the Period function and use the resultant answer in order to quickly characterize a waveform to set up Arm Delay and Gate Width for subsequent time interval measurements.

Procedure To select the Period function press [PERIOD A] ; to select Arming mode, press [ARMED A AND B] or [GATED A THEN B] for desired mode.

HP-IB **Program Codes**

Select the Period function and one of the Arming modes.

PP[<mode>]

mode::= **0** Unarmed
1 Armed
2 Gated

Example Set the 1965A to Period function and Armed mode.

LOCAL (keys)	[PERIOD A] [ARMED A AND B]
REMOTE (codes)	**PP 2** <CR> <LF> identifier: PP; mode: 2; EOS: <CR> <LF>

Indication Period A key and Gated key are lighted. If an input signal is connected, a period value is displayed on the CRT. If no input is connected all zeros are displayed.

Comments To manually set the arming mode to unarmed, press [ARMED A AND B] or [GATED A THEN B] until neither key is lighted.

Time Interval A→B

Description The Time Interval function measures the time from the A SOURCE to the B SOURCE. With averaging selected, a resolution of 10 ps can be obtained with a range from ±10 ps to ±10 seconds. For a discussion of the time interval specification, refer to Appendix A which includes graphs for easy interpolation of worst case errors.

Note

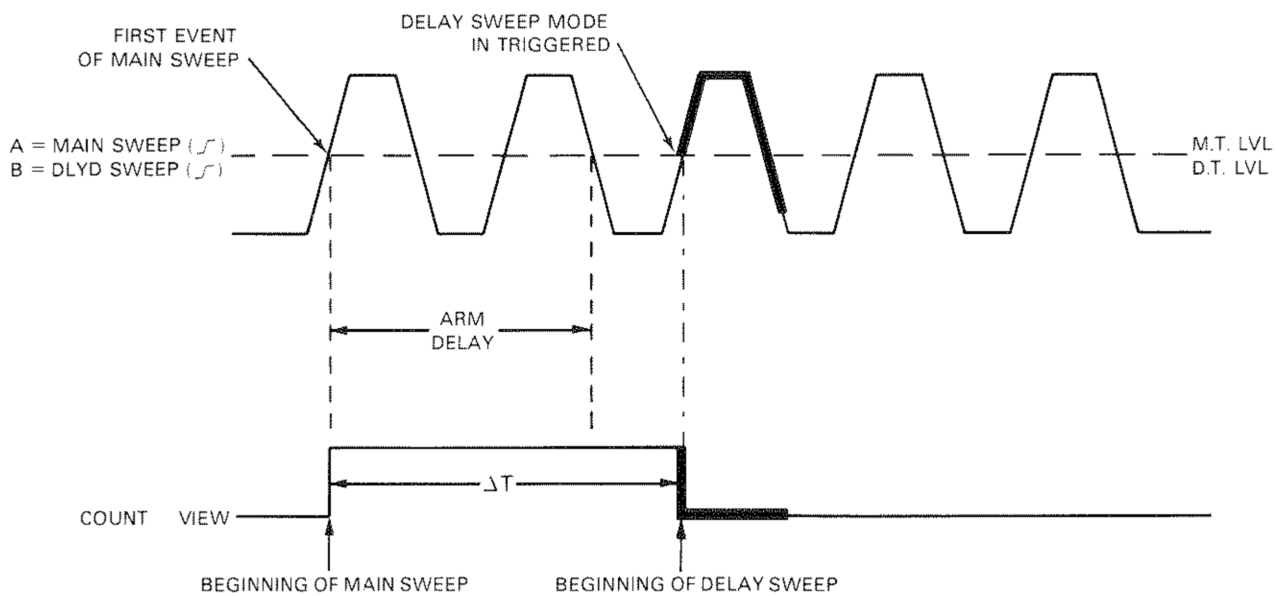
All time interval measurements must be performed on screen. Increase SEC/DIV if necessary.

UNARMED: The unarmed mode gives the time from main sweep to delayed sweep. Trigger source selection is not required and is defaulted to main and delayed sweeps. Most common time interval measurements fall under the ARMED and GATED modes, however, the unarmed mode does have some unique applications.

An UNARMED Time Interval measurement is a very accurate measure of ARM DELAY with the delayed sweep mode in AUTO. ARM DELAY can be set with an accuracy of ±0.1% ±10 ns. ARM DELAY can be measured to an accuracy of ±1 ns. For a very sensitive setup, the unarmed mode can be used to measure and compensate for error in ARM DELAY.

If the user desired to measure time relative to the first event on screen, it is imperative that the UNARMED mode be used. Main trigger generates the main sweep, which will be slightly delayed from main trigger. All ARMED and GATED measurements begin counting after the main sweep begins; therefore, it is impossible to measure time relative to the first trigger event on screen. The solution is to use Time Interval in the UNARMED mode where time is measured relative to the beginning of the main sweep, which is calibrated with the 1965A propagation delay calibration factors so the resultant answers are referenced to the first main trigger event on screen. If the delayed sweep mode is TRIGGERED or in DIGITAL DELAY, then time will be measured from the first trigger point on MAIN TRIGGER to the first trigger point on DELAYED TRIGGER after ARM DELAY.

Time Interval A→B (Cont'd)



Function: T INTVL A→B

Arming Mode: UNARMED

A Source: Main Sweep (not selectable)

B Source: Dlyd Sweep (not selectable)

Resolution: 1, 100, 10,000, 1,000,000 averages, or AUTO (recommended)

ARM DELAY: Set to be greater than 1 period of the input but less than 2 periods of the input.

GATE WIDTH: May be set, but not used in this measurement.

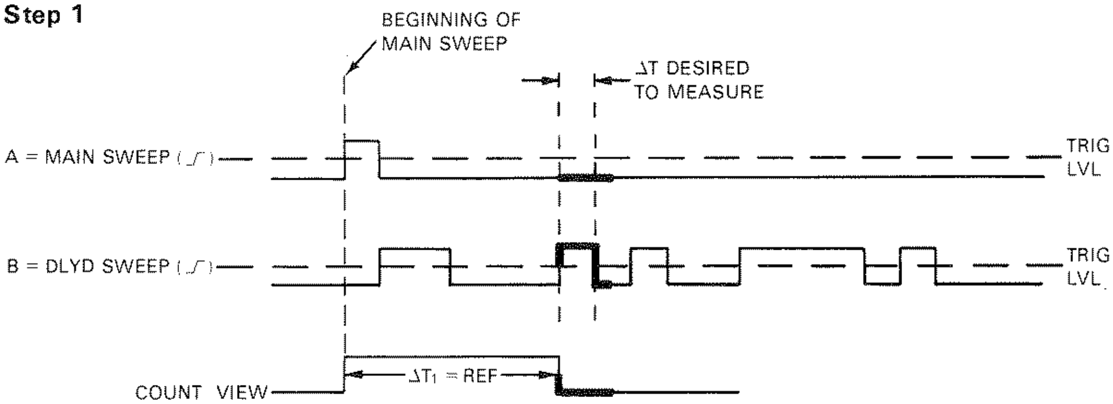
Delayed sweep mode: TRIG'D

COUNT view: May be selected to show actual counting interval which for this example would be the interval between the first two periods shown on screen.

Figure 15. First Event Measurement

Time interval measurements on complex waveforms may require utilizing the unarmed mode in a two-step process using REFERENCE OFFSET. To trigger the 1980 requires a sync pulse for main trigger; therefore, only delayed trigger is available for any timing measurements on the complex pulse string. If the user desires to measure from a rising edge to a falling edge on a single waveform, the unarmed mode is the solution. Example #5 in Programming Examples illustrates this technique over the HP-IB. The following is an example of a pulse width measurement on a complex waveform.

Step 1



Step 1

Function: T INTVL A→B

Arming Mode: Unarmed

A Source: Main Sweep (not selectable)

B Source: Dlyd Sweep (not selectable)

RESOLN: 1, 100, 10,000, 1,000,000 averages, or AUTO (recommended)

ARM DELAY: 2 (In the digital delay sweep mode, delayed sweep will begin on the second trigger occurrence of delayed trigger).

GATE WIDTH: May be set, but not used in this measurement.

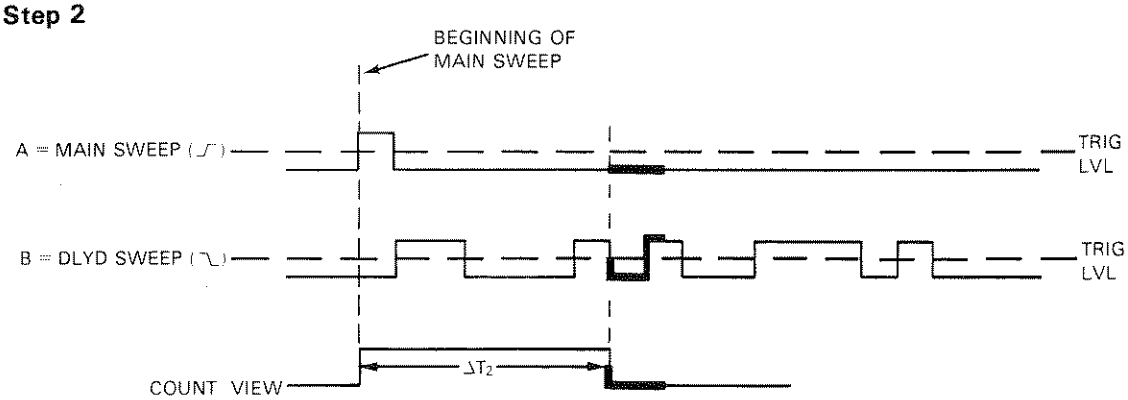
Delayed sweep mode: DGTL DLY

Main Trigger: triggering on sync pulse.

Delayed Trigger: rising (⌐) at 50% point on a complex waveform.

Reference: Set REF=ANSWER. This will define the time interval datum to be at the 50% point of the second rising edge of the complex waveform.

Step 2



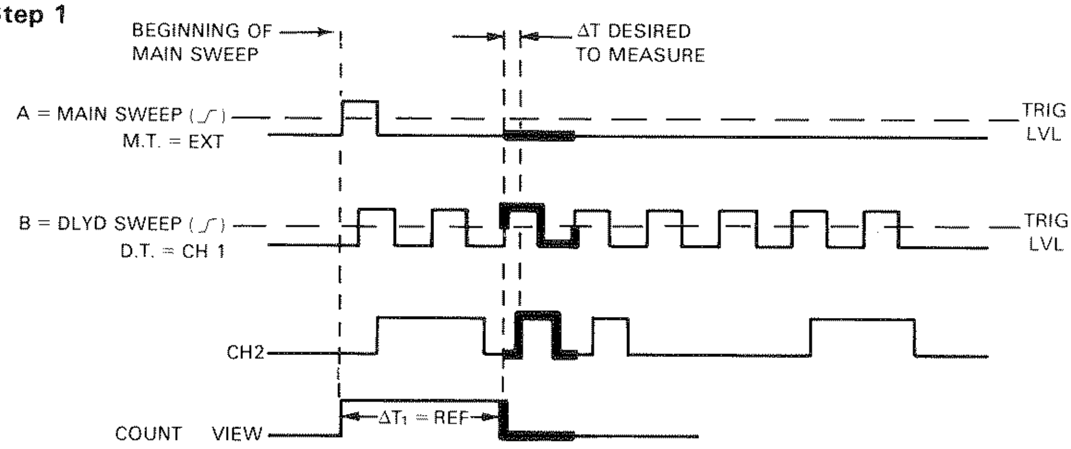
Step 2

Change the Delayed Trigger Slope to falling (¬). The time interval measured will be the pulse width of the second pulse in the complex waveform.

Figure 16. Pulse Width Measurement on a Complex Waveform

Time Interval A→B (Cont'd)

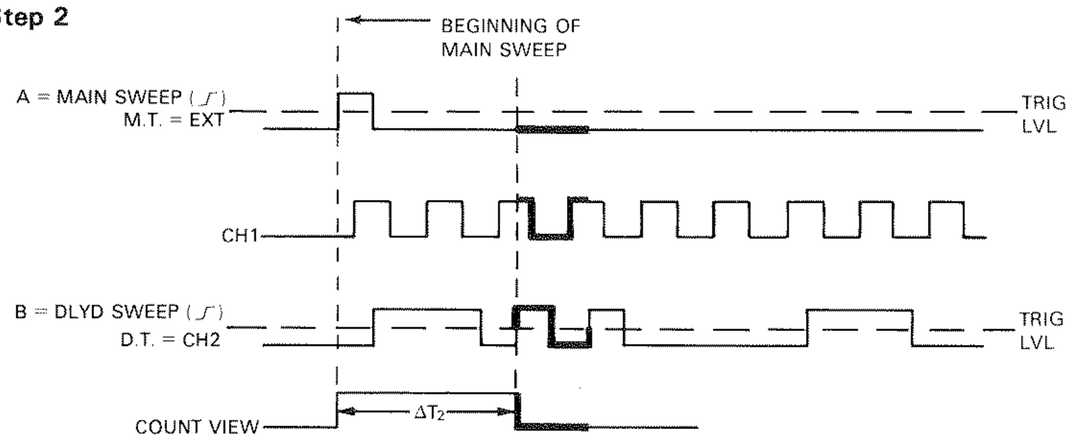
Step 1



Step 1

Function: T INTVL A→B
Arming Mode: UNARMED
A Source: Main Sweep
B Source: Dlyd Sweep
RESOLN: 1, 100, 10,000, 1,000,000 averages, or AUTO (recommended).
ARM DELAY: 3 (In the digital delay sweep mode, delayed sweep will begin on the third trigger occurrence of delayed trigger).
GATE WIDTH: May be set, but not used in this measurement.
Delayed Sweep Mode: DGTL DLY.
Main Trigger: External sync. pulse
Delayed Trigger: Channel 1, 50% rising (_/‾).
Reference: SET REF=ANSWER. This will define the time interval datum to be at the 50% Point of the third rising edge of channel 1.

Step 2



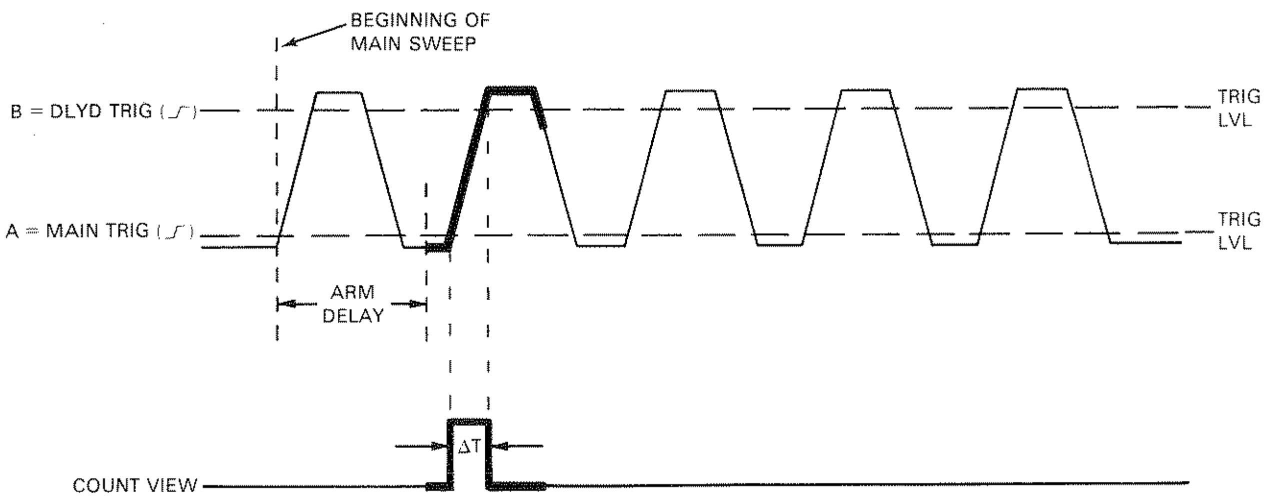
Step 2

Delayed Trigger: Channel 2, 50% rising (_/‾).
ARM DELAY: 2 (In the digital delay sweep mode, delayed sweep will begin on the second trigger occurrence of delayed trigger).
The time interval measured will be the propagation delay between the rising edge of the third pulse on channel 1 and the rising edge of the second pulse on channel 2.

Figure 17. Measuring the Propagation Delay on a Complex Waveform

Time Interval A→B (Cont'd)

ARMED: The ARMED time interval measurement gives the time between the first A SOURCE trigger point to the first B SOURCE trigger point after the beginning of the delayed sweep (ARM DELAY). Time may be positive or negative and source selections are required. Typical applications include: Rise Times, Pulse Widths, and Propagation Delays. Example #3 in Programming Examples shows how a pulse width measurement can be executed using the armed time interval function over the HP-IB.



Function: T INTVL

Arming Mode: ARMED

A Source: MAIN TRIG

B Source: DLYD TRIG

Resolution: 1, 100, 10,000, 1,000,000 averages, or AUTO (recommended)

ARM DELAY: Set to occur before the main trigger point on the second pulse, but after the delayed trigger point on the first pulse.

GATE WIDTH: May be set, but not used in this measurement. The intensified marker does not need to cover the rising edge of this signal.

Main Trigger: Set to the relative 10% level of waveform on the rising edge (⸍).

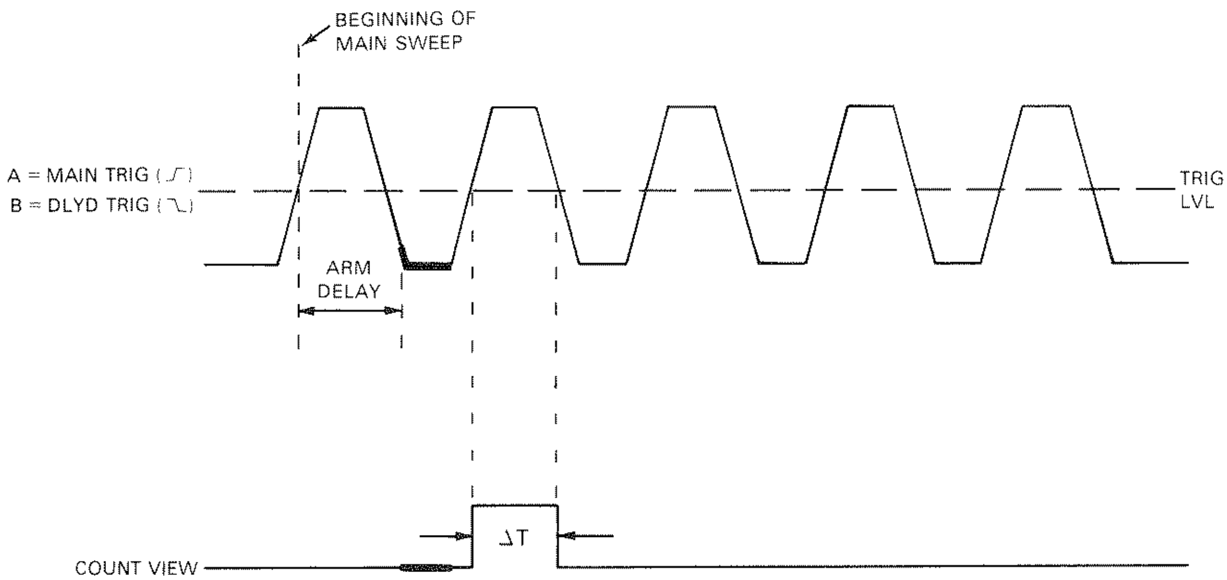
Delayed Trigger: Set to the relative 90% level of waveform on the rising edge (⸍).

Delayed Sweep Mode: AUTO

COUNT view: Shows the counting interval between the 10% and 90% points on the second pulse.

Figure 18. Rise Time Measurement

Time Interval A→B (Cont'd)



Function: T INTVL

Arming Mode: ARMED

A Source: MAIN TRIG

B Source: DLYD TRIG

Resolution: 1, 100, 10,000, 1,000,000 averages, or AUTO (recommended)

ARM DELAY: Set to be less than one period of input, but greater than the pulse width.

GATE WIDTH: May be set, but not used in this measurement.

Main Trigger: Set to the relative 50% point of the waveform on the rising edge (_/¯).

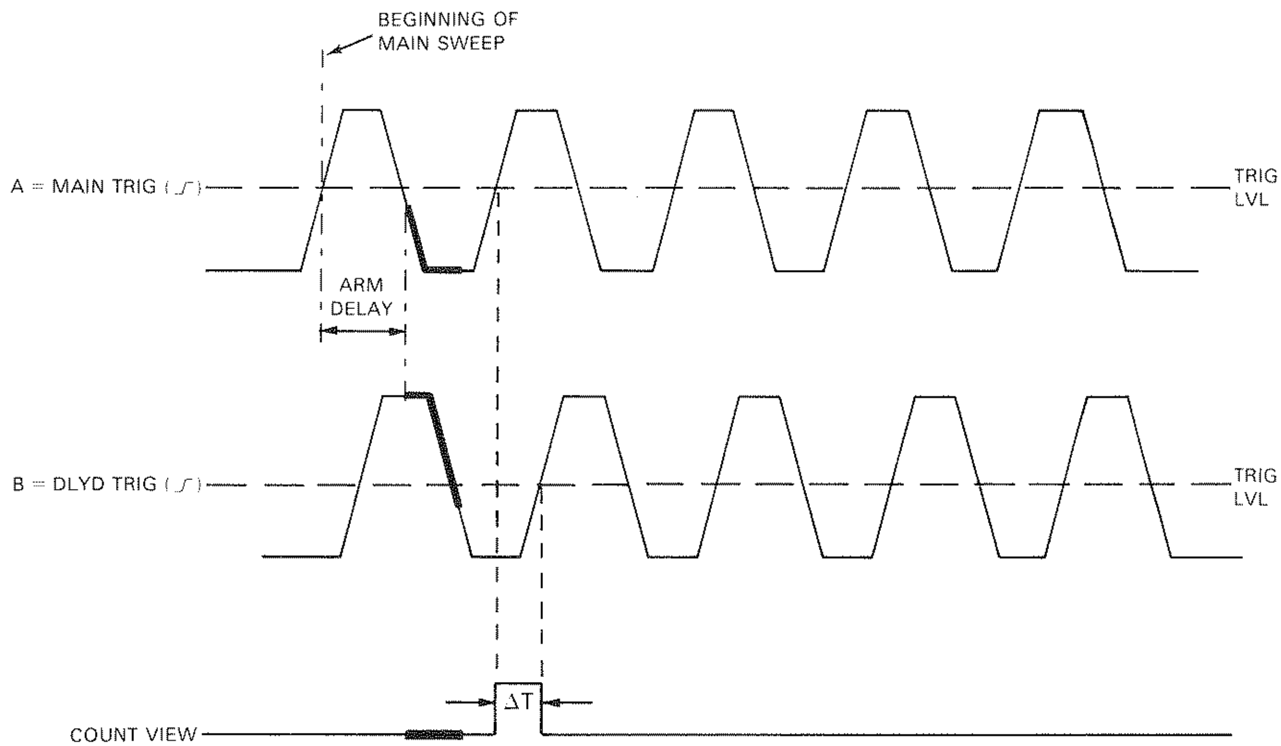
Delayed Trigger: Set to the relative 50% point of waveform on the falling edge (¯_).

Delayed Sweep Mode: AUTO

COUNT view: Shows the counting interval as the pulse width of the second pulse.

Figure 19. Pulse Width Measurement

Time Interval A→B (Cont'd)



Function: T INTVL

Arming Mode: ARMED

A Source: MAIN TRIG

B Source: DLYD TRIG

Resolution: 1, 100, 10,000, 1,000,000 averages, or AUTO (recommended)

ARM DELAY: Set to occur after the first rising edge of delayed trigger and before the second rising edge of main trigger.

GATE WIDTH: May be set, but not used in this measurement.

Main Trigger: Set to 50% point on the rising (⟋) edge of channel 1.

Delayed Trigger: Set to the 50% point on the rising (⟋) edge of channel 2.

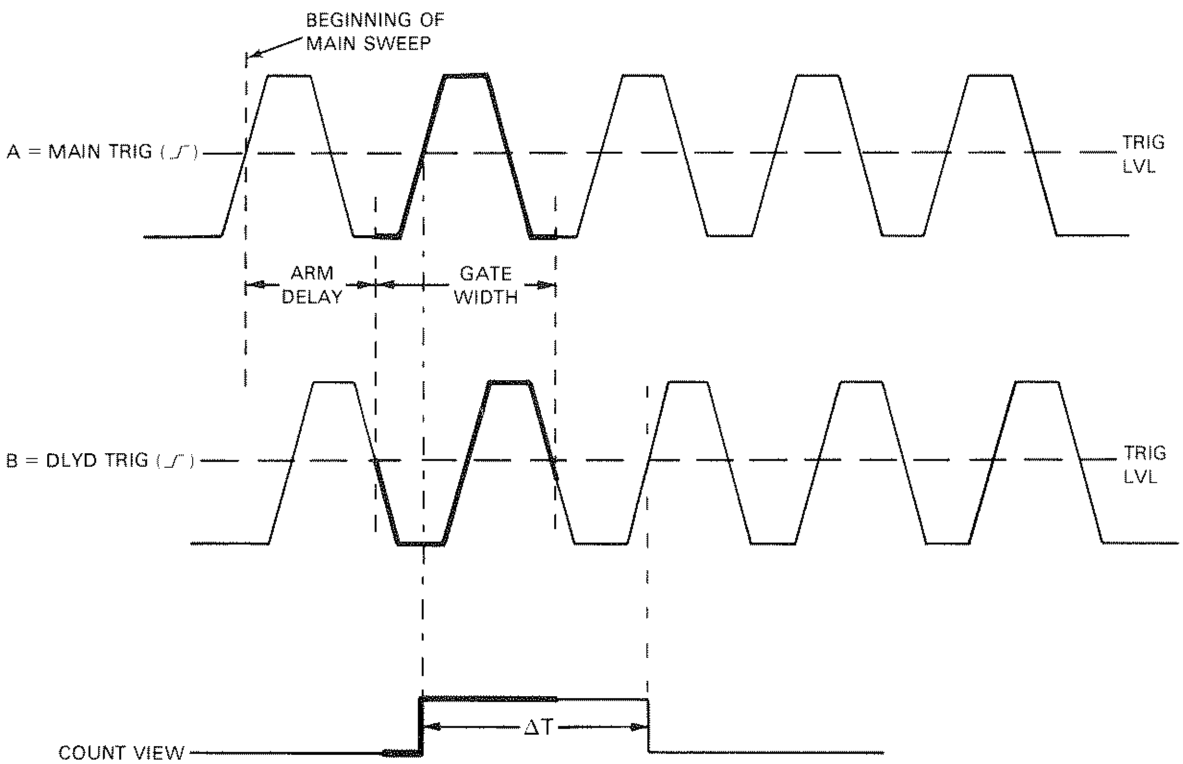
Delayed Sweep Mode: AUTO

COUNT view: Shows the counting interval as the propagation delay between the second pulse of channel 1 and the second pulse of channel 2.

Figure 20. Propagation Delay Measurement

Time Interval A→B (Cont'd)

GATED: The GATED time interval measurement gives the time between the first A SOURCE trigger point after the beginning of delayed sweep (ARM DELAY) to the first B SOURCE trigger point after the end of delayed sweep (GATE WIDTH). Time may be positive or negative and source selections are required. Example #2 in Programming Examples shows how to set up a gated time interval measurement over the HP-IB. The following is an example of a gated time interval where it is desired to measure from the second rising edge on channel 1 to the third rising edge on channel 2. (The second rising edge of channel 2 will be gated out.)



Function: T INTVL

Arming Mode: GATED

A Source: MAIN TRIG

B Source: DLYD TRIG

Resolution: 1, 100, 10,000, 1,000,000 averages, or AUTO (recommended)

ARM DELAY: Set to occur before the second rising edge of main trigger.

GATE WIDTH: Set such that the delayed sweep ends before the third rising edge of delayed trigger.

Main Trigger: Set to 50% point on the rising (_/‾) edge of channel 1.

Delayed Trigger: Set to 50% point on the rising (_/‾) edge of channel 2.

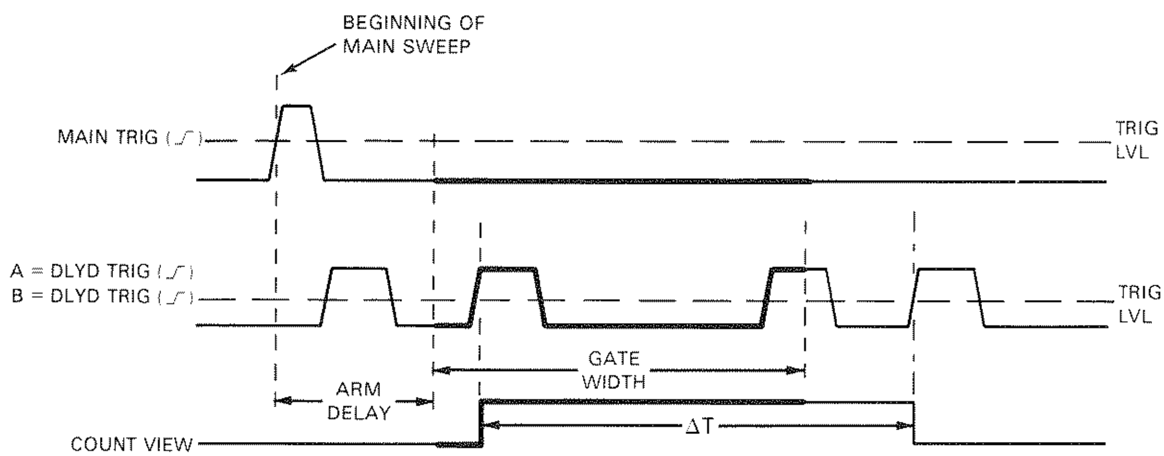
Delayed Sweep Mode: AUTO

COUNT view: Shows the counting interval between the desired START (A SOURCE) and STOP (B SOURCE) trigger points.

Figure 21. Gated Time Interval Measurement

Time Interval A→B (Cont'd)

Time interval measurements on complex waveforms are also possible in the GATED mode. As discussed in applications for the UNARMED mode, the 1980 requires a sync signal for its main trigger, which leaves only delayed trigger for timing measurements. If the user desires to make a time interval measurement from common trigger points on one waveform, then the gated mode easily performs the measurement in one step.



Function: T INTVL

Arming Mode: GATED

A Source: DLYD TRIG

B Source: DLYD TRIG

RESOLN: 1, 100, 10,000, 1,000,000 averages, or AUTO (recommended)

ARM DELAY: Set to occur between the first and second rising edges of the complex waveform.

GATE WIDTH: Set such that the end of the delay sweep occurs between the third and fourth rising edges of the complex waveform.

Main Trigger: Sync pulse

Delayed Trigger: Complex waveform.

Delayed Sweep Mode: AUTO

COUNT view: Shows the counting interval as being one period of the complex waveform.

Figure 22. Measuring the Period of Complex Waveform

Time Interval A→B (Cont'd)

Procedure To select the Time Interval mode press T INTVL A→B, then an arming mode may be selected by pressing ARMED A AND B or GATED A THEN B for desired mode.

HP-IB **Program Codes**

Select the Time Interval function and one of the arming modes.

PT[<mode>]

mode::= **0** Unarmed
1 Armed
2 Gated

Example Set 1965A to Time Interval function and Unarmed mode.

LOCAL (keys)	T INTVL A→B ARMED A AND B or GATED A THEN B (if lighted)
REMOTE (codes)	**PT 0** <CR> <LF> identifier — PT; mode — 0; EOS — <CR> <LF>

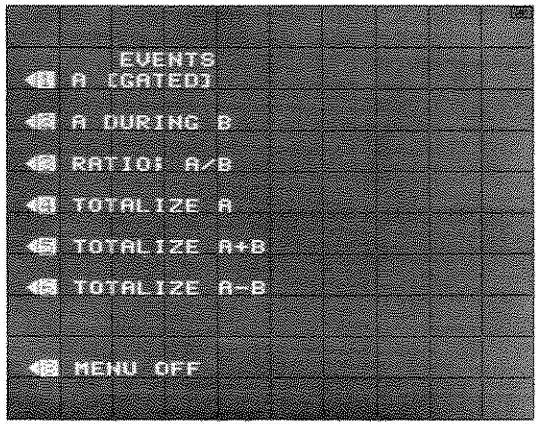
Indication T INTVL key is lighted and neither ARMED nor GATED is lighted. A time interval value is displayed on line two of the CRT.

Comments To trigger the oscilloscope requires a repetitive waveform. This inhibits the measurements of true single shot events. Appendix C gives two techniques for measuring time intervals of single-shot events.

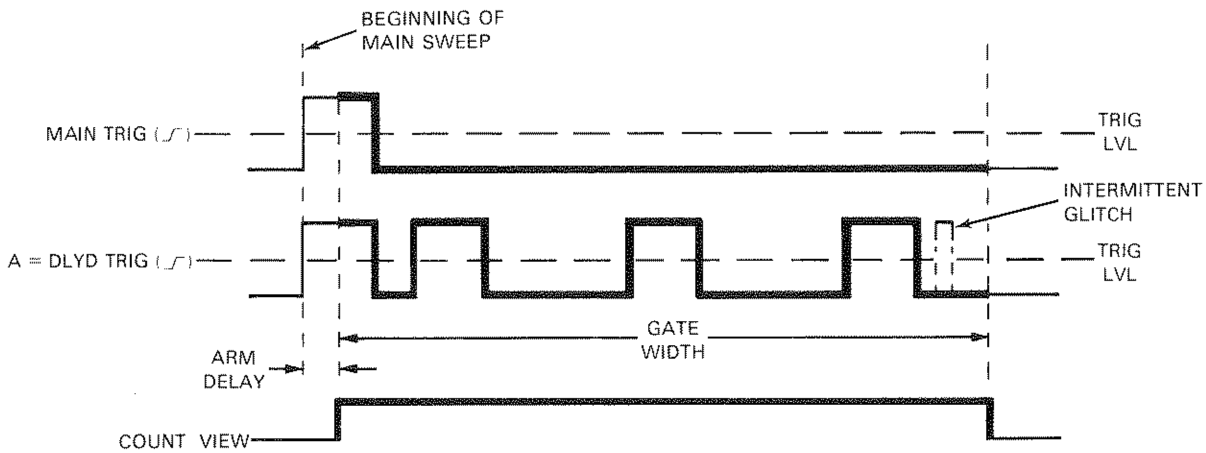
Events

Description Selects one of the events functions and starts or stops the totalizer if in a Totalize function.

Procedure To call the events menu, press EVENTS (MENU) on the 1965A, then press the Soft Key corresponding to the desired Events function. A short description of each of the events follows:



A[Gated] — Counts the number of events of the A SOURCE occurring during the delayed sweep. An event of "A" is defined as a "true" level of A. A "true" level is any time the A SOURCE is above its trigger level if the slope selection is rising (_/¯) or any time the A SOURCE is below its trigger level if the slope selection is falling (¯_). A[GATED] does not count edges of the A SOURCE. If the A SOURCE is already "true" when the delayed sweep begins, then one count will be recorded at the beginning of the delayed sweep. The 1965A defaults to the GATED mode when A[GATED] is selected and measurements may be averaged. This Events function has many digital applications and can be used for detecting intermittent occurrences of signals or glitches. The following example shows how to detect on intermittent glitch that occurs following the fourth pulse on screen.



Function: EVENTS A[GATED]
Arming Mode: GATED (default)
A Source: DLYD TRIG
B Source: Not Selectable
RESOLN: Averaged

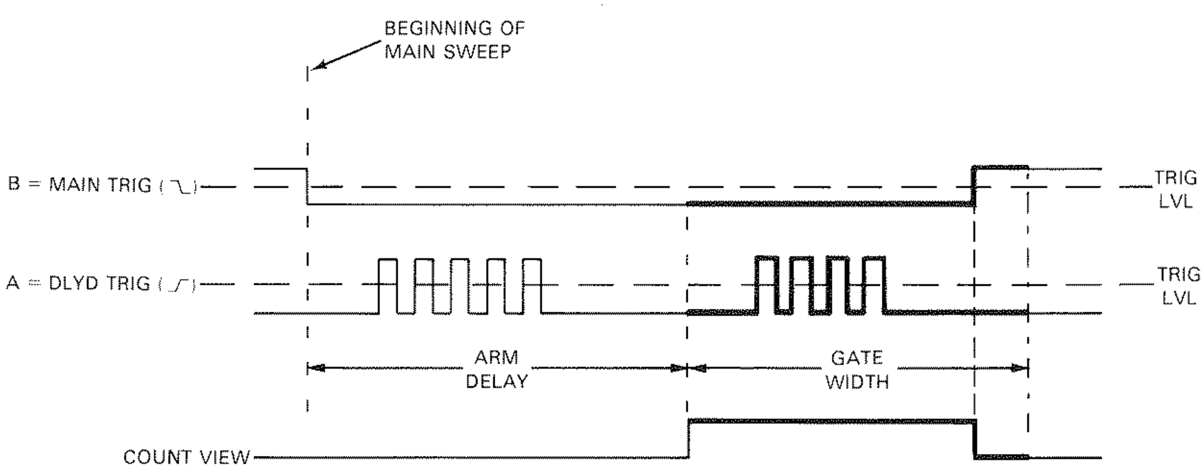
Figure 23. Glitch Detection

Note

To detect intermittent glitches, the user should select the 1965A to average. In this example, if the suspected glitch never occurs, the answer will be "4". If the glitch always occurs, the answer will be "5". If the glitch is intermittent, the answer will contain a fractional count such as 4.00025.

Events (Cont'd)

A during B — Counts the number of events of the A SOURCE occurring during the time the B SOURCE is "true". A "true" level of the A SOURCE and the B SOURCE is as defined in A[GATED]. A during B is very similar to A[GATED] and can be thought of as A gated by B. In addition, A during B may also be gated which results in A gated by B gated by the delayed sweep. A during B may be averaged, whereby one event of B constitutes one average. This Events function may be operated in the UNARMED and GATED modes, but not in the ARMED mode. The following example shows how to measure the number of events that occur during the second burst of a pulse string.



Function: EVENTS A during B
Arming Mode: GATED
A Source: DLYD TRIG
B Source: MAIN TRIG
RESOLN: May be averaged

Figure 24. Burst Events Measurements

Note

If there are no intermittent pulses, then the suggested number of averages for fast through-put is "1". The answer will always be 4 regardless of how many averages are performed. If the UNARMED mode had been selected for this example, the answer would be "9".

RATIO; A/B Counts events of the A SOURCE and events of the B SOURCE for a selected sample time, then calculates the ratio of A to B. Unlike A[GATED] and A during B, Ratio counts slope defined transitions rather than levels. Applications include measuring harmonic relationships between two input signals. The A SOURCE and the B SOURCE do not have to be synchronous to each other. The following is a brief description of each arming mode for A/B.

Events (Cont'd)

UNARMED — Measurement begins asynchronous to the 1980 sweep cycle and continues counting until the selected sample time is satisfied. The measurement will always begin on a trigger occurrence of the A SOURCE and end on a trigger occurrence of the A SOURCE.

ARMED — Measurement begins on the first trigger occurrence of the A SOURCE after the beginning of delayed sweep (ARM DELAY) and continues counting until the selected sample time is satisfied, ending on a trigger occurrence of the A SOURCE.

GATED — For each main sweep of the 1980, the measurement begins on the first trigger occurrence of the A SOURCE after the beginning of delayed sweep (ARM DELAY) and ends on the first trigger occurrence of the A SOURCE after the end of delayed sweep (GATE WIDTH). The measurement will continue this process for each successive 1980 sweep cycle until the total sample time has been satisfied.

Note

If no trigger occurrences of B SOURCE occur during the measurement, the answer will read "OVERFLOW".

TOTALIZE A — Counts the total number of triggers of the A SOURCE that occur between user-defined START and STOP. The answer is updated "on the fly" and may be read over the bus at any time using the PO1 command; however, for most accurate results, a STOP command should be executed prior to the PO1 and read. After the first START/STOP cycle is performed, each successive START command is actually a CONTINUE. To zero the count a RESET must be performed. The UNARMED mode is the only valid arming mode for TOTALIZE A. Example #8 in Programming Examples section shows how to execute a Totalize A measurement over the HP-IB.

TOTALIZE A±B — Counts the total sum or difference of triggers of the A SOURCE and the B SOURCE that occur between user-defined START and STOP. The answer is updated "on the fly" and may be read over the bus at any time using the PO1 command; however, for most accurate results, a STOP command should be executed prior to the PO1 and read. TOTALIZE A±B may be used in all three arming modes of operation. When operating over the HP-IB, the START command and STOP commands must not be on the same program line.

Note

The display will not update "on the fly" in TOTALIZE A–B if either A SOURCE or B SOURCE repetition rates exceed 5 MHz. This is due to "roll-over" conditions.

Note

Never use the PO2 command to input data for any of the TOTALIZE functions.

Events (Cont'd)

HP-IB **Program Codes**

Select an Events Function and one of the Arming modes.

PE<Function>,[<Arming Mode>]

Function::=**1** A(GATED)
2 A during B
3 A/B
4 Totalize A
5 Totalize A+B
6 Totalize A–B
7 Totalize Start
8 Totalize Stop

Arming Mode::= **0** Unarmed
1 Armed
2 Gated

Example Enter the events menu, then select Totalize A+B, Unarmed, and start totalizing.

LOCAL **(keys)**	EVENTS (MENU) 5 TOTALIZE A+B ARMED A AND B or GATED A THEN B (only if lighted) 7 RECALL START/STOP
REMOTE **(codes)**	**PE 5 , 0 ; PE7** <LF><EOS> identifier [PE] · function [5] · arming mode [0]

Indication Start/Stop is displayed on the CRT next to Soft Key 7. "A+B" is displayed on the second line of the CRT along with a number that is incrementing if an input signal is present.

Comments If in any of the Totalize functions, the resolution is not selectable.

Auto-Parameters

Description

Auto Functions perform an automatic parameter measurement. The Auto key selection enables the Auto parameters menu. Each measurement can then be made by selecting the Soft Key (1-6) corresponding to the desired measurement.

In Auto Parameters the 1965A expands the waveform for maximum resolution and searches the particular waveform for the absolute maximum and minimum peaks. Trigger levels are then set to the appropriate levels based upon the absolute peaks as 0% and 100%. The 1965A automatically compensates for hysteresis in the triggering with each trigger point set accurately to within ±1% of the peak-to-peak waveform.

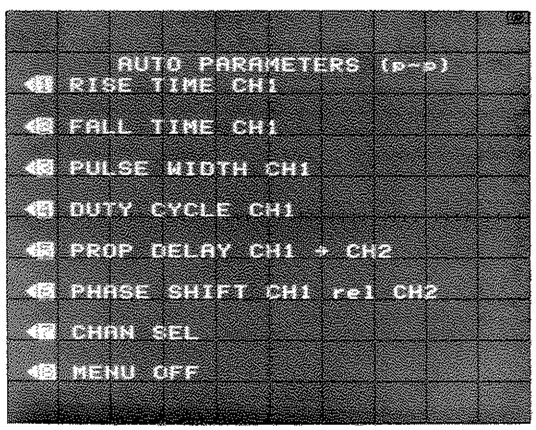
Note

Peak-to-peak perturbations (undershoot + overshoot) must not exceed the relative value set (10% for rise and fall times, and 50% for all others).

The measurement is performed once and the 1980/1965A setup is returned to the original state. Example #4 in the Programming Examples section shows how a Rise Time, Fall Time, and Pulse Width measurement can be executed over the HP-IB.

Procedure

To call the Auto Functions menu, press AUTO (MENU) on the 1965A, then press the Soft key corresponding to the desired Auto Function.



An automatic measurement will be made based upon absolute maximum and minimum of the signal. The parameter value is displayed on the second line of the CRT.

Rise Time — Measures and displays the Time Interval between the 10% and 90% points on a rising edge of a repetitive waveform.

Fall Time — Measures and displays the Time Interval between the 90% and 10% points on a falling edge of a repetitive waveform.

Pulse Width — Measures and displays the Time Interval between the 50% point of the rising edge to the 50% point of the falling edge of a repetitive waveform.

Duty Cycle — Measures and displays the ratio of Pulse Width to Period.

Auto-Parameters (Cont'd)

Phase Shift	Finds the Time Interval between the 50% points of the rising edges of the two inputs. The 1965A then performs a ratio of that Time Interval to the period and displays the Phase after conversion to degrees ranging from −180° to +180°.
Propagation Delay	Finds and displays the Time Interval between the rising edges at the 50% point of the two signals.
Channel Select	Selects the input channel for the automatic measurements to be made or reverses the relationship of the channels for two channel measurements.

HP-IB **Program Codes**

Make an auto parameters measurement.

PA<code>[,<channel>]

code::=
- **1** Rise Time
- **2** Fall Time
- **3** Pulse Width
- **4** Duty Cycle
- **5** Prop Delay
- **6** Phase Shift

channel::=
- **1** Channel 1 or 1 → 2 or CH1 relative to CH2
- **2** Channel 2 or 2 → 1 or CH2 relative to CH1

Example Make a Pulse Width measurement of the channel 2 signal automatically.

LOCAL **(keys)**	AUTO (MENU) 3 CHAR ON/OFF PULSE WIDTH (CH2)
REMOTE **(codes)**	**PA 3 , 2** <CR> <LF> identifier (PA), code (3), channel (2), EOS (<CR> <LF>)

Indication An automatic pulse width measurement takes place and when complete the Pulse Width value is displayed on the second line of the CRT along with the number of averages.

Comments The Auto functions expect the operator to have a waveform that is triggering in Main and >3 div on the screen. This can be accomplished by pressing AUTO-SCOPE prior to performing the auto parameter measurement.

If an optional channel selection is not made when sending the measurement command, the measurement will be made on the channel currently displayed in the menu.

NOTES

ARMING/GATING

This section of the Detailed Operating Instructions includes a discussion of the three arming modes and the variable gate control.

- ARMING MODES
  - UNARMED
  - ARMED
  - GATED

- GATE CONTROL
  - ARM DELAY
  - GATE WIDTH

Arming Modes

There are three modes which can be used to control the measurement arming technique. They are 1) UNARMED, 2) ARMED, 3) GATED. The arming modes may be selected either from the front panel or via the HP-IB as a qualifier with a valid counter function command. The following is a brief description of each mode. Refer to the counter function descriptions for a more detailed explanation of the specifics of each arming mode.

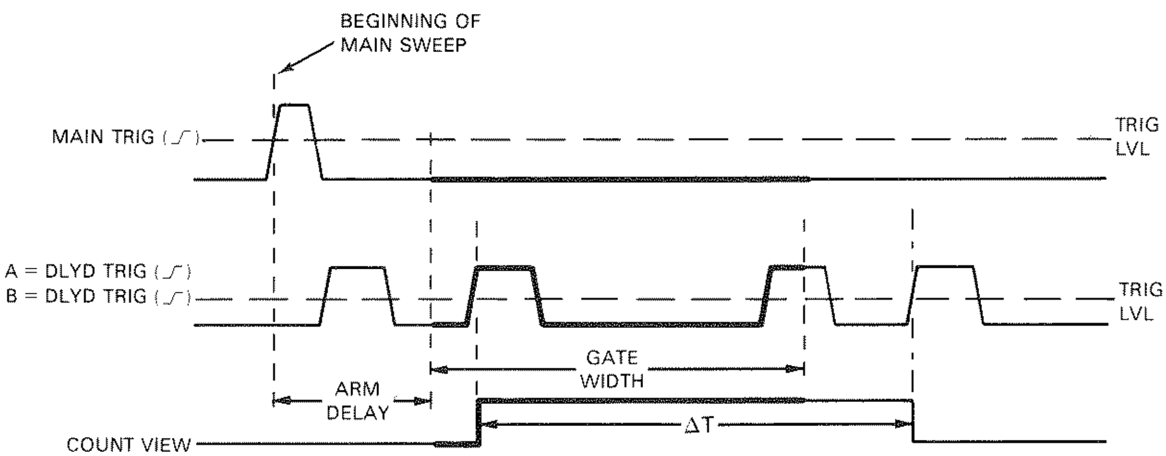
UNARMED: For all functions, except Time Interval, measurements are made without sychronization to the 1980 sweep cycle. In Time Interval, the unarmed mode is defined to measure the time from the beginning of MAIN SWEEP to the beginning of DELAYED SWEEP.

ARMED: In the ARMED mode, all measurements are enabled to begin counting after the beginning of the delayed sweep.

GATED: In the GATED mode, the delayed sweep defines a measurement window for each sweep cycle of the 1980. Coincident with the delayed sweep (intensified marker) is a signal called DELAYED GATE which is the Gating signal for the 1965A. This Gating signal may be viewed by selecting ARM VIEW. The Delayed Gate is calibrated to the 1965A module and is accurately controlled by ARM DELAY and GATE WIDTH.

Arm Delay

Description The time delay from the trigger point on the signal that triggered MAIN SWEEP to the start of the DELAYED GATE (with the delayed sweep mode in AUTO). Both ARM DELAY and the 1980 DELAY TIME control the position of the delayed sweep. ARM DELAY is calibrated to the 1965A module. DELAY TIME is calibrated to the CRT. The intensified marker on screen is a close approximation of the location of the gating signal (DELAYED GATE) to the 1965A. When operating manually with the main sweep speed faster than 1 μs/div, ARM DELAY read out should be used rather than visually positioning the intensified marker. The intensified marker typically precedes the DELAYED GATE coming to the 1965A by approximately 60 ns. ARM DELAY is expressed in seconds and can be set from the front panel using the control knob or from a controller via the HP-IB. Examples #2, 3, and 5 in Programming Examples section show how Arm Delay may be specified as a variable over the HP-IB.



Arm Delay Characteristics

Range: 100 ns to 9.9999 s

Resolution: 100 ps maximum Front panel: 5 digits displayed

Accuracy: ±10 ns ±.1%

Arm Delay (Cont'd)

Procedure To enter a delay value press [ARM DELAY] and rotate the Control Knob.

Press [FINE] to select step resolution for arm delay time entry.

Set the delay value to mimimum by pressing [AV AT ZERO].

HP-IB **Program Codes**

Enter Arm Delay time value.

PD<value>

value::= exponential

[dd]d.[d...]{e | E}-[d]d | +0

100 ns to 9.999 999 999 9 s

maximum 11 digits resolution; 5 digits displayed

Example Enter an Arm Delay value of 450 μs.

LOCAL (keys)	[ARM DELAY] ([FINE]) (Control Knob) 450.00-6
REMOTE (codes)	**PD 450.0E-6** <CR> <LF> identifier: PD; Arm Delay value: 450.0E-6; EOS: <LF>

Indication When the Control Knob is assigned to Arm Delay, [ARM DELAY] is lighted and the Arm Delay value is displayed in the LED readout and on the CRT. Arm Delay values are displayed as exponential numbers.

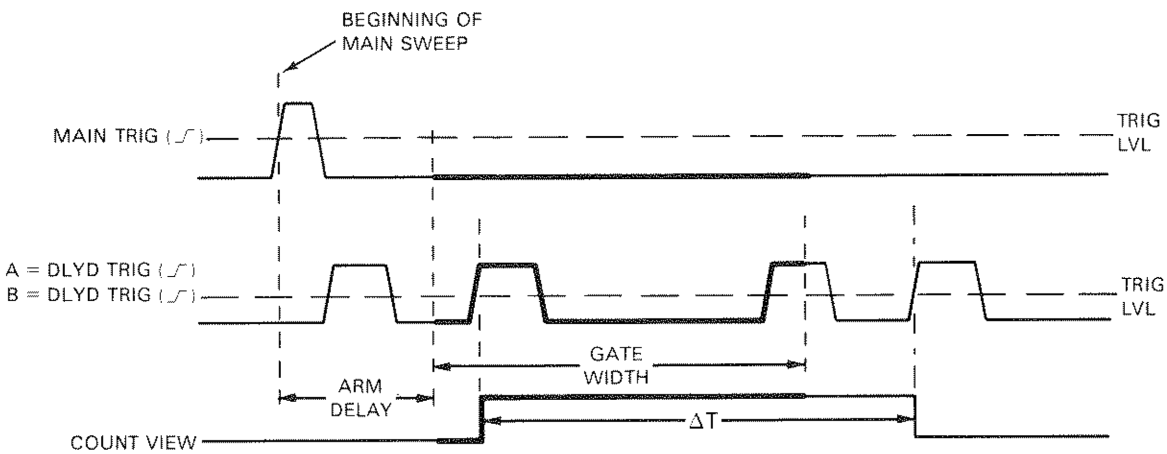
Comments A minimum Arm Delay value is unique to each 1980A/B and 1965A and is determined as a result of the Front Panel Calibration of the 1965A. The minimum value can be read in the LED display by pressing [ARM DELAY] and rotating the Control Knob for the minimum reading in the LED display.

The minimum programmable ARM DELAY is 100 ns.

Gate Width

Description Gate Width is the duration of the gating signal received by the 1965A. The gating signal is known as DELAYED GATE and is generated by and is coincident to the delayed sweep (intensified marker). GATE WIDTH is calibrated from the front panel and is an accurate technique for setting up gated-type measurements either manually or over HP-IB. DELAYED GATE may be viewed by selecting ARM VIEW on the 1965A front panel.

The Gate Width time can be set from the front panel using the Control Knob or from a controller via the HP-IB. Example #2 in Programming Examples section shows how the Gate Width may be specified as a variable over the HP-IB.



Gate Width Characteristics

Range: 200 ns to 9.9999 seconds

Resolution: 1 part in 10^3

Accuracy: ±3% for gate width of 200 ns to 10 ms
±4% for gate width of 100 ms to 10 s

Gate Width (Cont'd)

Procedure To enter a Gate Width value press GATE WIDTH and rotate the Control Knob.

Press FINE HOLD to select step resolution for Gate Width time entry.

HP-IB **Program Codes**

Enter Gate Width time value.

PW<value>

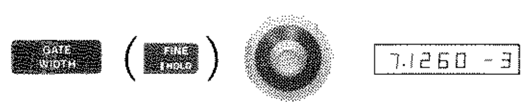
value::= exponential

|dddd|d.|d...|{e | E}−|d|d | +0 | 0

200 ns to 9.9999 seconds

greatest value must be <10 seconds

Example Enter a Gate Width value of 7.126 ms.

LOCAL (keys)	
REMOTE (codes)	**PW 7.1260E-3** <CR> <LF> identifier — PW; value — 7.1260E-3; EOS — <LF>

Indication When the Control Knob is assigned to Gate Width, GATE WIDTH is lighted and the Gate Width value is displayed in the LED readout and on the CRT display. Gate Width values are displayed as exponential numbers.

Comments A minimum Gate Width value is unique to each 1980A/B and 1965A set. The minimum value can be read in the LED display by pressing GATE WIDTH and rotating the Control Knob for the minimum reading. The minimum value is determined by the Front Panel Calibration. The minimum programmable Gate Width is 200 ns.

Since the Gate Width is derived from DLYD SECS/DIV which has a resolution of 3 digits, a value that is entered over the HP-IB may be different than the actual value displayed in the lower digits.

NOTES

TRIGGERING

This section of the Detailed Operating Instructions includes a discussion of trigger source selection (A SOURCE and B SOURCE) and conditioning. Trigger hysteresis calibration and control is also discussed in this section.

- SOURCE SELECTION
  - A SOURCE
  - B SOURCE
- HYSTERESIS CONTROL
  - CALIBRATION
  - AMPLITUDE CONTROL

Trigger Source Selection

Description All counter functions, except TIME INTERVAL UNARMED, measure parameters upon user-defined A SOURCE and B SOURCE triggers. Since the 1965A does not have any of its own inputs, all triggering is derived from the 1980. The 1980 has two independent triggers: MAIN TRIGGER and DELAYED TRIGGER. These triggers may be derived from several different sources.

MAIN TRIGGER	DELAYED TRIGGER
Channel 1	Channel 1
Channel 2	Channel 2
Main External	Delayed External
Line (60 Hz)	

The 1965A's A SOURCE and B SOURCE may independently be selected to be MAIN TRIG or DLYD TRIG. This gives the 1965A much flexibility in triggering since the originating source of MAIN and DLYD TRIGGERS has a multiple of possibilities.

As an example, assume that the 1965A's A SOURCE is set to MAIN TRIG and B SOURCE is set to DLYD TRIG, and the 1980's MAIN TRIGGER is set to be internally triggering on channel 1, with the 1980's DLYD TRIGGER internally triggering on channel 2 (indicated near bottom of CRT: MT=CH1, DT=CH2). If the function selected is T INTVL A→B ARMED, then a time interval propagation delay will be measured from channel 1 to channel 2.

Trigger levels (in divisions) and slope selection (⟋ ⟍) are set and controlled from the 1980 front panel and trigger views may be displayed to show where on a waveform the 1980 is triggering. Main trigger must always be triggering on a simple part of the waveform. To insure a stable sweep, main trigger should not be triggered on ringing or on a complex waveform. An external sync pulse should be used for complex waveforms.

Examples #2 and 3 in Programming Examples section show how source selections are executed over the HP-IB.

Figure 25 is a simplified functional diagram illustrating the 1965A's triggering capability and selection.

Procedure To select the counting source press [MAIN TRIG] or [DLYD TRIG] for A SOURCE and B SOURCE until desired trigger is selected.

HP-IB **Program Codes**

Set the A SOURCE and the B SOURCE to MAIN or DELAYED trigger signals as desired.

PS <(A)source>[,<(B)source>]

source::= **0** No Change
1 main trigger
2 delayed trigger

Trigger Source Selection (Cont'd)

Example Set the B SOURCE to delayed trigger and leave the A SOURCE where it was.

LOCAL (keys)	DLYD TRIG (B source)
REMOTE (codes)	**PS 0, 2** <CR> <LF> identifier (PS) — A source (0) — B source (2) — EOS (<CR> <LF>)

Comments When changing delayed trigger slope (⁄ ∖) from the front panel while the delayed sweep mode is in AUTO, an advisory message will be temporarily displayed on screen indicating that the delayed sweeps is in AUTO. This message is intended for the pure 1980 user; not the 1965A user. This advisory message is not generated over HP-IB unless the 1980 is being programmed with the key commands (KY).

Trigger Source Selection (Cont'd)

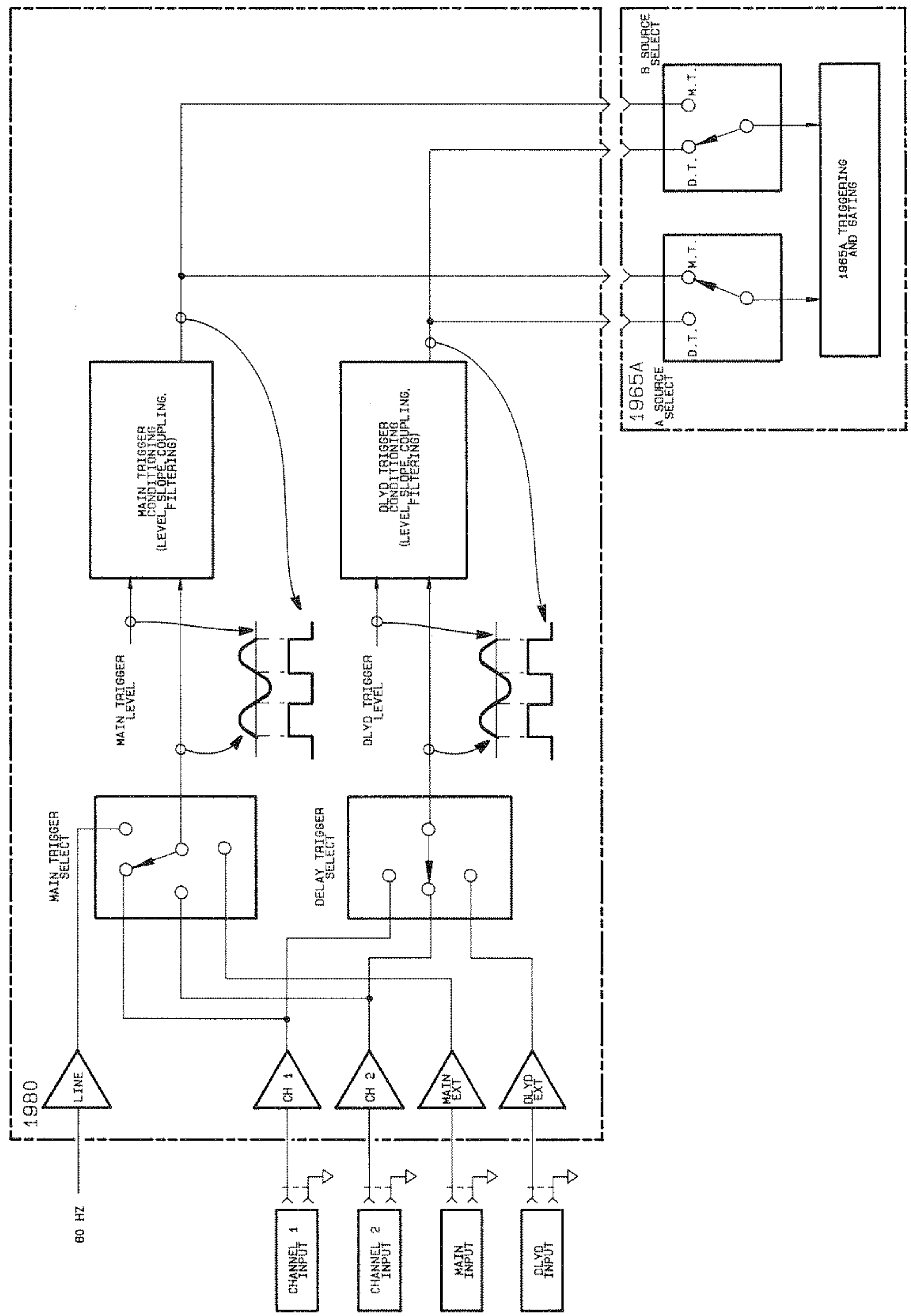


Figure 25. Simplified Functional Diagram Illustrating the 1965A's Triggering Capability and Selection

Hysteresis Control

Description Sets the trigger hysteresis to the normal value or high value (~2 times normal value). In addition, Hysteresis values for various setups may be calibrated and stored in internal RAM and may be accessed and output over the HP-IB.

Hysteresis is typically 0.15 divisions on screen. In noisy environments, it may be desirable to increase the 1980's noise immunity. This may be accomplished by selecting HIGH hysteresis.

When performing a front panel calibration, the 1965A will automatically measure and store away values of hysteresis and trigger level offset for various 1980 setups. The user may also request the 1965A to perform the hysteresis/offset calibration over the HP-IB. This is accomplished with the "PH3" command.

The 1965A's AUTO-PARAMETERS use hysteresis values to automatically compensate for errors in triggering due to hysteresis. The user also has the ability to access the values of hysteresis and offset over HP-IB with the PO8 command (refer to INFORMATION OUTPUT detailed operating instructions in this manual). These values may be used for compensating trigger levels due to error induced by hysteresis and offset. This technique is discussed in Appendix A under Trigger Level Error. Example #9 in Programming Examples section shows how hysteresis and offset values are entered over the HP-IB using the PO8 command.

Procedure To set the Hysteresis control enter the 1965A base menu and press 6 SAVE HYSTERESIS NRML/HIGH.

HP-IB **Program Codes**

Set hysteresis control:

PH<status>

status::= **1** Normal Hysteresis
2 High Hysteresis
3 Perform Hysteresis/Offset Calibration

Example Set Hysteresis control to High hysteresis.

LOCAL (keys)	OPTION MENU 7 RECALL 1965A 6 SAVE HYSTERESIS NRML/HIGH
REMOTE (codes)	**PH 2** <CR> <LF> identifier (PH), status (2), EOS (<CR> <LF>)

Indication The current setting is indicated in inverse video.

Comments To perform the Hysteresis/offset Calibration, the rear "Cal Enable" switch must be in the enabled position.

DISPLAY

This section of the Detailed Operating Instructions includes a discussion of the 1965A waveform display capabilities and the reference offset feature, which offsets an answer in the display and memory. In addition, the display update rate control which is operated only from the bus is discussed.

View Selection

Description The 1965A generates two bi-level waveforms that may be displayed on the CRT.

Count view shows the counting interval over which measurements are taken. When the waveform is high, measurement data are being collected. This is an extremely useful tool when manually operating the instrument. It gives the user a high level of confidence in determining whether or not a measurement is set up properly. Count view is typically delayed from trigger events on screen by 60 ns. This becomes obvious on fast sweep speeds. Also, the leading and trailing edges of count view display what appears to be 10 ns of jitter when operating in Time Interval. This shows that true averaging is taking place.

Arm View shows the position and duration of the delayed sweep.

Procedure To toggle Count View on or off, press COUNT / ARM.

To toggle Arm View on or off, press ▮ COUNT / ARM.

HP-IB **Program Codes**

Select Count View or Arm View:

PV<code>

code::= **0** Views off
1 Count View
2 Arm View

Example Display the Arm View signal.

LOCAL (keys)	▮ COUNT / ARM
REMOTE (codes)	PV 2 <CR> <LF> — identifier (PV), status (2), EOS (<CR> <LF>)

Indication When Count View or Arm View is displayed the corresponding key is lighted.

Comments Only one special view (Count or Arm) can be displayed at one time.

Reference Offset

Description Defines a reference offset value to be subtracted from subsequent measurements. The offset value can be cleared, set to the current displayed answer, or set to a value defined by the user.

REFERENCE OFFSET can be extremely useful in nulling out systematic errors or in measuring drift. It is also a tool to use in making two-step measurements. Refer to the examples showing the use of REFERENCE in the UNARMED mode of TIME INTERVAL in the Measurement Functions section of the Detailed Operating Instruction. Example #5 in Programming Examples shows how a reference offset can be specified over the HP-IB. Note that when setting "reference=answer", whatever is presently in the display will be used as the answer. If a measurement has just been initialized, the program must wait until the measurement is finished before executing the PN1 command. This has been accomplished in example #5 by executing the PO2 command and ENTER prior to the PN1. The ENTER holds up the program until an answer is ready.

Procedure Clear the reference offset by pressing , REF (MENU) then 2 CHAR INTEN CLEAR .

Set the reference to current measurement value by pressing REF (MENU) , then 3 CHAR ON/OFF REF ANSWER .

To set the reference to any desired value, press REF (MENU) , 4 MANUAL REF , and rotate the Control Knob until the number is displayed on the 3rd line of the CRT. 5 COARSE/MEDIUM/FINE can be used to select digits to be changed.

HP-IB **Program Codes**

Enable the reference offset and enter a value.

PN<status>[,<reference>]

status::=	**0**	Clear reference
	1	Set reference equal to current answer displayed.
	2	Set reference as defined
reference::=		exponential
		{+ | −}n.[dddddddd]E[−d]d
		1.00 p(units) to 999.999 M(units)

Reference Offset (Cont'd)

Example Enter a reference of 109.82 kHz.

LOCAL **(keys)**	REF (MENU) 4 MANUAL REF 5 COARSE/MEDIUM/FINE (as required) (For a display reading of) REF=109.82000 kHz
REMOTE **(codes)**	**PN 2, 1.0982E5** <CR> <LF> identifier (PN), status (2), reference (1.0982E5), EOS (<CR> <LF>)

Indication Reference value as sent is displayed on the left side of the third line of the CRT and is subtracted from the reading.

Comments Output value units can be any unit depending upon what measurement setup is in use.

Reference values may be output to a controller with the information output command, PO3.

Update Rate

Description Selects the rate at which the display is updated. This command allows the measurements to be calculated and displayed as soon as they are completed or at a maximum update rate of 1/2 second.

Procedure Update Rate can only be changed via the HP-IB.

HP-IB **Program Codes**

Select display update rate:

PU<code>

code::= **0** No wait for update
1 Normal 1/2 second update rate

Example Set Update Rate to "No wait for answers".

REMOTE (codes)	PU 0 <CR> <LF> identifier (PU), code (0), EOS (<CR> <LF>)

Comments This command can be used with the PO1 (Information Output) command, since PO1 does not restart the counter. The PU (Update Rate) command will allow the measurement answer to be refreshed as quickly as possible. Power up will reset the 1965A to the normal 1/2 second rate of update.

If a PUO command is executed the other functions of the 1980 system may be slowed down (pressing keys, turning the Control Knob, etc.) due to the time the system must take to constantly update the 1965A display.

ADDITIONAL COUNTER CONTROLS

This section of the Detailed Operating Instructions includes a discussion of additional counter controls. They include the following:

RESOLUTION SELECTION
- SAMPLE TIME
- AVERAGING

MEASUREMENT RESET

SINGLE MEASUREMENT MODE

OSCILLATOR SELECT
- INTERNAL TCXO
- EXTERNAL

Resolution

Description Selects the degree of resolution to which the counter will perform measurements. There are four discreet selections that the user may select and are in the form of either "SAMPLE TIME" or "NUMBER OF AVERAGES". The resolution setting is displayed on line two of the CRT.

Sample time is what most counters refer as "Gate Time" and can be set to 1 μs, 100 μs, 10 ms, or 1 second. One second results in the answer with the highest resolution. Sample time applies to the following functions: Frequency A, Period A, Ratio: A/B.

Averaging may be selected to be 1 (no averaging), 100, 10,000 or 1,000,000 with the highest resolution obtained using 1,000,000 averages. Averaging applies to the following functions: Time Interval A→B, Events A(GATED), Events A during B, and Auto-Parameters.

If AUTO-RESOLUTION is selected, the 1965A will select the optimum resolution depending upon the 1980 sweeps cycle time and the 1965A set up. For an on-screen measurement, the 1965A will select the highest resolution so as not to exceed 2.5 seconds in the update display. The 1965A can output to a controller the current resolution setting by executing the command, PO7 (refer to the INFORMATION OUTPUT Detailed Operating Instruction).

Example #2 in Programming Examples section shows how resolution is selected over the HP-IB. The program selects a sample time of 1 μs for a period measurement and then changes the resolution to automatic for a gated time interval measurement.

Procedure To change the resolution setting of the counter, press RESOLN AUTO until the desired resolution is displayed on line 2 of the CRT display. To select Auto Resolution press ▮ RESOLN AUTO.

HP-IB **Program Codes**

Set the resolution of the counter.

PR<code>

code::=

0 Automatic
1 1 μs, or 1 average
2 100 μs, or 100 averages
3 10 ms, or 10,000 averages
4 1 s, or 1,000,000 averages

Resolution (Cont'd)

Example Set the Counter Resolution to 10 ms, or 10,000 averages.

LOCAL (keys)	RESOLN AUTO (until display reads desired value)
REMOTE (codes)	PR 3 <CR> <LF> identifier: PR; code: 3; EOS: <CR> <LF>

Comments The higher the selected resolution, the longer the user or controller must wait for an answer. When averaging or when making gated measurements, the measurement time is directly related to the 1980 sweep cycle time. One average is taken each sweep of the 1980. On slow sweep speeds, measurement updates may take a long time if a high degree of resolution is selected. In addition, the measurement may "overflow" if too high of a resolution is selected. For this reason, it is recommended that the user select AUTO-RESOLUTION.

Reset/ Single

Description Resets the counter and restarts a new measurement. It also clears all 1965A Service Requests.

If the SINGLE mode is selected, then only one measurement will be taken and the answer will remain in the display on the CRT. To initiate a new measurement, the RESET key may be pressed.

Procedure To reset the counter and restart the measurement, press RESET / SINGLE.

Program Codes

Reset the counter:

PZ

Example Reset the 1965A counter.

LOCAL (keys)	RESET / SINGLE
REMOTE (codes)	**PZ** <CR> <LF> — identifier: PZ; EOS: <CR> <LF>

Indications The current reading is reset and all 1965A Service Requests are cleared.

Oscillator Select

Description Selects either an internal or external 10 MHz signal as the 1965A reference oscillator. If EXTERNAL is selected, the 1965A indicates this by lighting a front panel light any time a counter function is active. The user is required to connect the external 10 MHz reference clock to the "OSC" BNC with a minimum signal of 1 V rms and maximum of 10 V rms. The 1965A will "step-up" the 10 MHz clock to 100 MHz (10 ns) as its system reference time interval. A Confidence Test may be performed to verify that the external signal applied is sufficient.

Procedure To select the 10 MHz reference oscillator, enter the 1965A menu then press 10MHz OSC: INT/EXT .

HP-IB **Program Codes**

Select 10 MHz source for counter.

PX<source>

source::= **1** internal 10 MHz time base (TCXO)

2 external 10 MHz source

Example Select the external input as the 10 MHz source.

LOCAL (keys)	OPTION MENU 7 RECALL 1965A 5 10MHz OSC: INT/EXT
REMOTE (codes)	**PX 2** <CR> <LF> identifier (PX), source (2), EOS (<CR> <LF>)

Comments Refer to Specifications for EXT time base requirements. If EXT is selected the 1965A will count and give answers regardless whether or not the proper external 10 MHz signal is connected.

OPERATOR'S CHECKS AND MESSAGES

This secton of the Detailed Operating Instructions includes various checks and error messages that allow the operator to make a quick evaluation of instrument operation. In addition, various advisory messages may be generated due to improper setups and are discussed in this section.

Operator's Checks

Description Operator's checks are 1965A self-diagnostic tests that allow the operator to make quick evaluations of instrument operation. These tests may be performed either from the front panel, via the 1965A main menu, or over the HP-IB with the PQ commands. Three operator's checks are provided:

1. Confidence Test
2. RAM Test
3. ROM Checksum

The confidence Test confirms that the internal 1965A hardware and software is functional. This test does not verify that the 1965A is operating to all specifications. The Confidence Test may be used to verify that the Internal or External oscillator is functioning properly.

The RAM Test assures that the 1965A RAM memory is operating properly.

The ROM Checksum verifies the content of each of the 1965A ROMS.

Procedure Select one of the Operator Checks by pressing

OPTION MENU 7 RECALL 1965A,
1 INTEN PANEL CONFIDENCE TEST
2 CHAR INTEN RAM TEST
3 CHAR ON-OFF ROM CHECKSUM

HP-IB **Program Codes**

Select one of the Operator's Checks.

PQ <code>

code::= **1** Confidence Test
2 RAM Test
3 ROM Checksum

Indication If the instrument passes any of the Operator's Checks, the PASSED TEST advisory message is displayed on the CRT.

If the instrument fails any of the tests, the advisory FAILED TEST is displayed on the CRT and an error number is displayed in the LED display.

If operating remotely, following the PQ command would be the OQ4 output command which sets up the 1980 to output error analysis information. When a controller read occurs, the 1980 returns data indicating either PASSED or FAILED. Refer to ERROR MESSAGES (table 4) which includes LED and HP-IB codes for various error conditions.

Operator's Checks (Cont'd)

Response If a failure is detected by the Confidence Test, the operator should check that the proper 10 MHz source is selected [10MHz OSC:INT/EXT], complete a 1980 front panel Balance and Delay Self Cal, and perform a 1965A front panel calibration. If the instrument still fails the Confidence Tests, it requires servicing.

If the instrument fails the RAM TEST, it might be usable, but it does require servicing.

If the instrument fails the ROM Checksum, it must be serviced.

Comments After a Confidence Test has been executed, the 1965A performs a preset operation which leaves the 1965A off.

The 1965A automatically performs a cal factor checksum test at instrument power up.

Error Messages

Description Table 4 is a summary of the various 1965A error messages. Error messages are displayed in the LED's and may also be read over the HP-IB using the OQ4 command. These messages are generated as a result of operator's checks. Refer to Operator's Checks in this section.

Table 4. Hardware Error Codes

LED Code	HP-IB Code (ASCII) OQ4)	Error Description
	24	PASSED TEST (NO ERROR)
Err -37	63	CONFIDENCE TEST FAILED
Err -67	93	RAM TEST FAILED
Err -16	42	ROM CHECKSUM FAILURE (A4U11)
Err -21	47	ROM CHECKSUM FAILURE (A4U10)
Err -41	67	CAL FACTOR CHECKSUM ERROR

Advisory Messages

Description The 1965A generates advisory messages to indicate incorrect key entries, and special operating information. The messages are displayed on the CRT in inverse video. They can also be reported via the HP-IB. The advisories can be disabled if desired.

Table 5 lists the 1965A advisory messages and describes the conditions which cause them.

Indication When an error condition exists, the advisory will be displayed on the CRT.

Comments At power-on, the advisories are enabled as a default condition. Advisories may be disabled by entering the 1980A/B Calibrate and Utilities menu.

In remote operation, advisory messages can be programmed to issue a service request. This capability is independent of whether the advisory display is enabled or disabled. The advisory messages for the 1965A can be read via the HP-IB using the "OQ6, Plug In Option Code" command. Refer to "Service Request Conditions" Detailed Operating Instruction in this manual.

Table 5. Advisory Message Description

Advisory Message Description	HP-IB Code (OQ6)
FAILED CAL — if the instrument fails the hysteresis calibration.	1
TURN COUNTER VIEW OFF — if attempting to digitize with the count view or arm view waveform displayed.	2
MODE NOT VALID — when selecting invalid modes.	3
COUNTER IS OFF — selecting any counter keys when a valid counter function is not selected. Also when selecting any non-function counter keys if in Auto or Events menus.	4
ABORT — when Auto-parameter measurement is aborted because of time out (30 seconds), probably due to a repetition rate that is too low or because of a 1965A key closure during a measurement.	5
SIGNAL NOT FOUND — if signal is not properly triggered when beginning an Auto-parameters measurement.	6
LIMIT ERROR — if signal has too much DC offset or if signal is removed during an Auto-parameter measurement. **Note** AC coupling MAIN and DLYD triggers is recommended for signals with DC offset.	7

ADDITIONAL HP-IB OPERATION

This section includes various HP-IB control commands which do not relate to front panel use. Some of these commands, such as information output, are essential and must be understood in order to operate the 1965A from the bus.

INFORMATION OUTPUT
SERVICE REQUEST CONDITIONS
LEARN MODE
INITIALIZE COUNTER
MODULE OFF
KEY

Information Output

Description Various information/data (answers, setup, etc.) can be output to a controller from the 1980/1965A system. To set up the 1965 to output the desired information, one of the information output commands must be executed followed by one or more read operations. The 1965A's information output command for each parameter is described below.

PO1 — LAST ANSWER — Sets up the 1965A to output the last answer (current displayed reading) when a controller read occurs.

PO2 — NEW ANSWER — Instructs the 1965A to restart the counter and take a new measurement and "hold" the answer until a controller read occurs. After the controller read, the 1965A will begin cycling at its normal update rate. If the controller read occurs before the new measurement is complete, the 1980/1965A system will "hold-up" the controller on the present read command until the measurement is complete. Several examples in the Programming Examples section demonstrate the use of this command.

Note

If the measurement never completes, probably due to improper triggering, then the HP-IB will be held up indefinitely. This can be remedied by using a TIME-OUT routine in the program, whereby if any program line takes more time than a user specified time, then the program can recover by executing device clear command.

An alternative to momentarily "holding-up" the bus with the read command is to execute a PO2 command and program the controller to periodically monitor the 1980's status byte (serial poll) or read the 1980's status byte once after an interrupt. The 1965A will generate a service request upon completion of a measurement after a PO2 command by setting bit 6 (value of 32) high on the 1980 status byte. If bit 6 is properly unmasked, then a controller will detect this bit on a serial poll operation (refer to SERVICE REQUEST CONDITION in the 1980 Operating and Programming Manual). There are several 1965A conditions which will set the plug-in option request bit high, so the "Plug-In Option Status" command (OQ6) should be executed and a read performed to enter the specific interrupt condition generated by the 1965A (refer to 1965A SERVICE REQUEST CONDITIONS). A value of "32" returned to the controller indicates that the measurement is finished. A PO1 command must then be executed in order to read the last measurement. Example #6 in Programming Examples section shows this method of inputting data.

If the user is certain that the only conditions which could possibly generate a "Plug-In Option Request" are "measurement finished" or "measurement overflow", then upon detecting the "Plug-In Option Request" (bit 6 high in the 1980 status byte), the controller could immediately execute the read and receive the answer. An answer of 9.9999...E9 is an indication of a hardware overflow condition.

Note

Never use the PO2 command to read answers for any of the TOTALIZE functions because the PO2 command will reset the count. Use the PO1 command to read the TOTALIZE answer either "on the fly" or after the STOP command (PE8), which is recommended for accurate answers. Example #8 in Programming Examples section demonstrates how this should be accomplished.

Information Output (Cont'd)

The PO2 command will not restart any of the auto-parameter measurements. PO1 and PO2 function alike when outputting auto-parameter information. When the controller read occurs, the 1980/1965A system will immediately return the answer if the measurement is finished, or it will "hold-up" the controller until the current measurement is complete. To reinitialize a new measurement, the PA# command must be executed once again, followed by either PO1 or PO2 and a read.

PO3 — REFERENCE OFFSET — Tells the 1965A to output the current reference offset value to the bus.

PO4 — T/DATE DATA — Tells the 1965A to output the current T/DATE data to the bus. This information is output as a string of 15 characters as follows: " hh:mm DDMMMYY<CR>".

PO5 — ARM DELAY — Tells the 1965A to output the current Arm Delay setting to the bus.

PO6 — GATE WIDTH — Tells the 1965A to output the current Gate Width setting to the bus.

PO7 — RESOLUTION SETTING — Tells the 1965A to output the current resolution setting to the bus after a controller read. This is useful in determining the resolution setting while the counter is set up in the AUTO-RESOLUTION mode.

OUTPUT	DATA SETTING
1	1 μs or 1 average
2	100 μs or 100 averages
3	10 ms or 10,000 averages
4	1 second or 1,000,000 averages

PO8 — HYSTERESIS/OFFSET VALUES — Tells the 1965A to output the 16 values of trigger hysteresis and offset for eight unique 1980 set ups. Example #9 in Programming Examples show how this may be accomplished. In order to output all 16 values, 16 read operations from the controller must be performed following the PO8 command. Hysteresis and offset values are in the units of divisions and are output from the 1980/1965A system in the following order:

1. OFFSET (DLYD TRIG, −SLOPE, NORMAL HYSTERESIS SETTING)
2. HYSTERESIS (DLYD TRIG, −SLOPE, NORMAL HYSTERSIS SETTING)
3. OFFSET (MAIN TRIG, −SLOPE, NORMAL HYSTERESIS SETTING)
4. HYSTERESIS (MAIN TRIG, −SLOPE, NORMAL HYSTERSIS SETTING)
5. OFFSET (DLYD TRIG, +SLOPE, NORMAL HYSTERESIS SETTING)
6. HYSTERESIS (DLYD TRIG, +SLOPE, NORMAL HYSTERSIS SETTING)
7. OFFSET (MAIN TRIG, +SLOPE, NORMAL HYSTERESIS SETTING)
8. HYSTERESIS (MAIN TRIG, +SLOPE, NORMAL HYSTERSIS SETTING)
9. OFFSET (DLYD TRIG, −SLOPE, HIGH HYSTERESIS SETTING)
10. HYSTERESIS (DLYD TRIG, −SLOPE, HIGH HYSTERSIS SETTING)
11. OFFSET (MAIN TRIG, −SLOPE, HIGH HYSTERESIS SETTING)
12. HYSTERESIS (MAIN TRIG, −SLOPE, HIGH HYSTERSIS SETTING)
13. OFFSET (DLYD TRIG, +SLOPE, HIGH HYSTERESIS SETTING)
14. HYSTERESIS (DLYD TRIG, +SLOPE, HIGH HYSTERSIS SETTING)
15. OFFSET (MAIN TRIG, +SLOPE, HIGH HYSTERESIS SETTING)
16. HYSTERESIS (MAIN TRIG, +SLOPE, HIGH HYSTERSIS SETTING)

Information Output (Cont'd)

Procedure Send a command to select the desired output data, then address the 1980A/B to talk.

Program Codes

Select parameter value to be output:

PO <code>

code::=
- **1** Last Answer
- **2** New Answer
- **3** Reference Offset
- **4** Clock Data
- **5** Arm Delay
- **6** Gate Width
- **7** Resolution Setting
- **8** Hysteresis/Offset Values

Example Select reference offset value as data output.

REMOTE (codes)	**PO 3** <CR><LF> — identifier (PO), code (3), EOS (<CR><LF>)

Comments The 1980/1965A outputs "E" (uppercase) as the delimiter between the mantissa and the exponent in exponential value.

Table 6. Data Message Output Format

<table>
<tr><th>Variable Function</th><th>Units</th><th>Output Format</th></tr>
<tr><td>Last Answer</td><td>Hz, s,or counts</td><td>depends on resolution
{<sp>|–}n.d[d...]E{<sp>|–}dd<CR><LF></td></tr>
<tr><td>New Answer</td><td>Hz, s,or counts</td><td>depends on resolution
{<sp>|–}n.d[d...]E{<sp>|–}dd<CR><LF></td></tr>
<tr><td>Reference Offset</td><td>Hz, s,or counts</td><td>depends on resolution
{<sp>|–}n.d[d...]E{<sp>|–}dd<CR><LF></td></tr>
<tr><td>Clock Data</td><td>Time</td><td><sp>HH:mm<sp>DDMMMYY<CR><LF></td></tr>
<tr><td>Arm Delay</td><td>s</td><td><sp>d.ddddE{<sp>|–}dd<CR><LF></td></tr>
<tr><td>Gate Width</td><td>s</td><td><sp>d.ddddE{<sp>|–}dd<CR><LF></td></tr>
<tr><td>Resolution Setting</td><td>Integer</td><td><sp>0n<CR><LF> (value is 01-04)</td></tr>
<tr><td>Hysteresis/Offset Values</td><td>divisions</td><td><sp>{+|–}dd.dd<CR><LF> (Offset hysteresis value)</td></tr>
</table>

Service Request Conditions

Description The 1965A has several conditions which may cause a Service Request to be issued. The plug-in option request bit is bit 6 (32) in the 1980 status byte. In order for the controller to detect a 1965A service request, the interrupt mask in the 1980 must be properly unmasked (IM32). Plug-in request information can be output to the controller with a read via the OQ6 output command. Only the information from the most recent service request condition is available. Plug-in request information is reset to "0" on power-on, when the HP-IB ADDRESS MODE menu is displayed, or after a controller read of the information. Example #6 in Programming Examples section demonstrates how to use the Service Request.

Note

It is not necessary to operate under interrupt in order to read service request conditions. The controller may poll the plug-in request service information with OQ6 output command at any time.

Table 7 includes the HP-IB codes for the plug-in service request conditions.

Indication When a Service Request Condition exists it is transmitted via the HP-IB to the controller.

Comments The interrupt mask in the 1980A/B is reset to "0" (no conditions enabled) at power-on and when the HP-IB ADDRESS MODE menu is displayed.

The Service Request Condition and related sections of the 1980A/B Operating and Programming Manual explain how to set the interrupt mask and read the Service Request message.

Hardware error codes may be output to a controller via the plug-in service request information output command (OQ6) or via the 1980 advisory/error information output command (OQ4). Information codes are different and it is recommended that the operator use the OQ4 command as more information of error analysis is available. Refer to Operator's Checks and Error Messages in Detailed Operating Instructions of this manual.

Service Request Conditions (Cont'd)

Table 7. Service Request Conditions

Service Request Condition	HP-IB Code (OQ6)
Advisory Messages	
FAILED CAL — If the instrument fails the hysteresis calibration.	01
TURN COUNTER VIEW OFF — If attempting to digitize with the COUNT view or ARM view waveform displayed.	02
MODE NOT VALID — When selecting invalid modes of operation.	03
COUNTER IS OFF — Selecting any counter keys when a counter function is not selected. Also when selecting any non-function counter keys if in Auto or Events menus.	04
ABORT — When an AUTO-parameter measurement is aborted because of a time out (30 seconds), due to too low repetition rate or because of a 1965A key closure during the measurement.	05
SIGNAL NOT FOUND — If signal is not properly triggering when beginning an Auto-parameter measurement.	06
LIMIT ERROR — If signal has too much DC offset or if signal is removed during an Auto-parameter measurement.	07
Hardware Errors	
CONFIDENCE TEST FAILED — LED display "Err -37"	11
RAM TEST FAILED — LED display "Err -67"	12
ROM CHECKSUM FAILURE — LED display "Err -16" or "Err -21"	13
Timer Information	
Timer Alarm — programmed timer setting is equal to the clock time.	21
Measurement Information	
Measurement Overflow — When one of the internal 32 bit counters overflows.	31
Measurement Finished is in response to an output answer command, PO2. This can be used to signal the controller when a measurement has been completed. After using an "OQ6" to read the status, a "PO1" must be used to read the answer and restart the counter.	32

Learn Mode

Description The 1965A has "LEARN" capability which uses the HP-IB controller memory to store 1965A configurations (controller learns). Alternately, the controller can use a previously learned and stored set-up to reteach the 1965A. This can be very useful in manually setting up several unique measurements and then using the stored set-ups in an automatic test program which can quickly step through the measurements.

The LEARN MODE command (PL) is similar to the INFORMATION OUTPUT command (PO#), in that it sets up the 1965A to output defined information/data when a controller read occurs. When the controller learns a 1965A set-up, it receives a character/data string 46 bytes long, which should be stored as a string variable.

To teach the 1965A a previously learned set-up configuration, the controller must output the stored string variable to the 1980/1965A system. The 1980 will recognize that the string is a 1965A set-up from the first two characters in the string, which is a unique "Plug-In Signature".

The 1965A LEARN MODE pertains to 1965A set-ups only. Most counter measurements depend upon 1980 set-ups as well. To LEARN and TEACH entire 1980/1965A set-ups, the 1980's LEARN mode (TE) must be executed as well, with its 80 byte character/data string stored as a separate variable. Example #7 in Programming Examples demonstrates the use of the 1980's and 1965's Learn Mode.

Procedure The learn string is transferred as binary data between the 1965A and the HP-IB system controller.

Program Codes

Command the 1965A to output a learn string:

PL

Then address the 1980A/B to talk. The 1965A learn string comprises 46, 8 bit bytes. End-of-String is indicated by setting the EOI bus control line true with the 46th byte.

To configure the 1965A using learn mode, send a previously acquired learn string as a Data message:

<46 byte string><CR><LF>

Comments The Learn String includes only those parameters that can be stored in the instrument's internal Save/Recall registers; the contents of the Save/Recall registers, however, are not included in the Learn String. Refer to the "Save/Recall" Detailed Operating Instruction in the 1980A/B Operating and Programming Manual for information about register limitations.

Note

The 46th byte of the Learn String is sent with the bus EOI line true to indicate end-of-string.

When the Measurement System is addressed to listen, the binary data can be returned to it in a 46 byte string. The Measurement System interprets the first two bytes to determining that this is a learn string. Following the 46th byte, the transfer must be terminated with <CR>, and <LF>. When the <LF> is received, the instrument changes state according to the Learn String contents.

Learn Mode (Cont'd)

Note

During the transfer of the Learn String, the instrument should not be readdressed. If it is, the transfer will be aborted. The 46 byte string should be sent or read by the controller using a technique that does not readdress bus devices.

The Learn String should not be mixed with any other HP-IB command on the same programming line.

The 1965A Control Knob information is not contained in the 1965A learn string; the 1965A Control Knob information is part of the 1980 learn string.

Initialize Counter

Description Initialize counter is a command to set the 1965A to the Frequency function, Unarmed mode, A SOURCE to MAIN TRIGGER, Resolution to automatic.

Procedure Initialize the 1965A.

HP-IB Program Codes

Execute 1965A initialize

PI

Example Initialize the 1965A.

REMOTE (codes)	PI <CR> <LF> identifier (PI) — EOS (<CR> <LF>)

Indication The 1965A changes to the Frequency function, unarmed mode, Trigger Source A to MAIN TRIG, and Auto Resolution.

Comments Initialize sets the 1965A to a known "starting point" for further commands.

Module Off

Description Shuts down the operation of the 1965A by turning off all functions that are selected, including the clock and timer.

Procedure Turn the 1965A off.

HP-IB **Program Codes**

Set the 1965A to off.

PMO

Example Set the 1965A to off.

REMOTE (codes)	**PMO** <CR> <LF> identifier (PMO) — EOS (<CR> <LF>)

Comments When the Module Off Command is sent, the 1965A is set to the same conditions as if an initialize command (PI) is executed, then the 1965A is turned off.

Control Knob

Description The Control Knob is used to change the value of variable function parameters. The knob is assigned to a variable function by pressing the corresponding key. As the knob is rotated, the value is immediately changed.

The Control Knob is a stepping control; either coarse or fine step resolution can be selected. In coarse, the speed of the knob rotation affects the step size so that changes can be quickly made. Fine provides vernier-like control where step size is set for maximum resolution.

Accidental changes to parameters can be prevented by selecting hold mode. In hold, the knob is not assigned to any variable function.

The Control Knob can be assigned to variable functions via the HP-IB. In this special case, the knob is enabled for local operation even if the 1980A/B is in remote mode. This allows the selected function to be adjusted from the front panel, while all other keys and functions remain in remote.

Procedure To assign the Control Knob to a 1965A function, press the corresponding variable function key.

[ARM DELAY]

[GATE WIDTH]

To toggle the Control Knob between FINE and COARSE step resolution, press [FINE / HOLD] .

To select HOLD mode, press [ ] [FINE / HOLD] . Exit by assigning the Control Knob to a variable Function.

Program Codes

Assign the Control Knob to a 1965A variable function and set step resolution:

PY <entry>[,<mode>]

Entry ::=	**0**	HOLD
	1	ARM DELAY
	2	GATE WIDTH
mode ::=	**0**	Coarse
	1	Fine

Control Knob (Cont'd)

Example Assign the Control Knob to Gate Width function, fine step resolution.

LOCAL (keys)	[GATE WIDTH] [FINE HOLD]
REMOTE (codes)	**PY 2 , 1** <CR> <LF> identifier: PY; code: 2; step: 1; EOS: <CR> <LF>

Indication The Control Knob assignment is indicated by lighting the corresponding variable function key. Also, the LED readout displays the parameter value of the function.

The LED readout displays HOLD to indicate hold mode is selected. If the Control Knob is rotated while in hold, the advisory CONTROL KNOB IN HOLD is displayed.

[FINE HOLD] is lighted when FINE is selected.

Comments The Control Knob defaults to HOLD mode when the 1980A/B makes the remote-to-local transition.

Executing Autoscope or Selective Autoscope assigns the Control Knob to main sweep.

Executing preset (HP-IB "IN") in remote or local mode assigns the Control Knob to trace intensity.

Key

Description The remote operator can simulate the pressing of front panel keys using the key (PK) command. Although every operating function is addressable using the primary command set, the key command can be used as an alternative.

Procedure Send a series of key codes in the same order as keys would be pressed in local operation.

HP-IB **Program Codes**

Enter a key sequence:

PK<code>[,<code>]...

code::= integer
dd

Key codes are listed in tables 8 and 9.

Example Execute the keystroke sequence to select the FREQ mode, then select AUTO Resolution.

REMOTE (codes)	PK 83;KY7;PK72 <CR> <LF> identifier (PK) — key codes (83;KY7;PK72) — EOS (<LF>)

Note

KY code must be used for shift (Blue) Key.

Indication The PK and KY commands execute as front-panel keystrokes. The same indications result as in local operation.

Although the PK command is interpreted as a keystroke, it does not affect the "last key code" instrument status qualifier. Refer to Instrument Status (OQ2) in the Detailed Operating Instructions in the 1980 Operating and programming manual.

If the last key code is read when no key has been pressed since power-on, the code "64" is output by the 1980A/B.

Key (Cont'd)

Table 8. 1965A Counter Key to PK Code Conversion Table

Key	ASCII Code	Key	ASCII Code	Key	ASCII Code	Key	ASCII Code
FREQ A	83	ARM DELAY	79	MAIN TRIG (B SOURCE)	85	TIMER SET	77
PERIOD A	73	GATE WIDTH	82	DLYD TRIG (B SOURCE)	89	T/DATE SET	76
T INTVL A→B	86	ARMED A AND B	71	RESOLN AUTO	72	OSC probe	91
EVENTS (MENU)	87	GATED A THEN B	78	RESET SINGLE	84	TIMER probe	92
REF (MENU)	88	MAIN TRIG (A SOURCE)	80	COUNT ARM	74		
AUTO (MENU)	90	DLYD TRIG (A SOURCE)	81				

Table 9. PK Code to 1965A Counter Key Conversion Table

ASCII Code	Key	ASCII Code	Key	ASCII Code	Key	ASCII Code	Key
71	ARMED A AND B	76	T/DATE SET	81	DLYD TRIG A SOURCE)	86	T INTVL A→B
72	RESOLN AUTO	77	TIMER SET	82	GATE WIDTH	87	EVENTS (MENU)
73	PERIOD A	78	GATED A THEN B	83	FREQ A	88	REF (MENU)
74	COUNT ARM	79	ARM DELAY	84	RESET SINGLE	89	DLYD TRIG (B SOURCE)
		80	MAIN TRIG (A SOURCE)	85	MAIN TRIG (B SOURCE)	90	AUTO (MENU)
						91	OSC probe
						92	TIMER probe

NOTES

CLOCK/TIMER

This section of the Detailed Operating Instruction contains all the information needed to operate the battery backed real time clock and the 50 alarm timer.

Time/Date and Timer Control

Description Controls the display and set functions of the real time clock and the control and set functions of the timer.

When the T/DATE function is active, the time and date output of the clock is displayed on line three of the CRT in the format: hour, minute, day, month, year. To set the time and date, the set menu may be selected.

The TIMER function is an alarm feature that may have up to 50 sequential times programmed. If the TIMER is on (front panel TIMER key is lighted) and an alarm time is satisfied, the TIMER will produce an SRQ over the bus, a TTL pulse will be generated at the TIMER BNC output, and the key sequence operation programmed into the TIMER Probe Tag will be initiated if the PLOT/SEQUENCE ROM is installed and activated. All times must be in sequence from 1 to 50. Each time the timer is turned on, it will start at the first (#1) time that is programmed in the fifty time buffer.

When using the timer with more than one time, the user should be careful not to do a preset, a PMO (MODULE OFF) or reenter the TIMER SET menu as these will all reset the timer pointer to the first (#1) time in the programmed buffer, which may not be the desired action.

Procedure To toggle the clock display on and off, press T/DATE SET.

To start and stop the timer function, press TIMER SET.

To enter the set clock or set timer menu, press ▮, then the T/DATE SET or TIMER SET as desired. Then select the menu function to be changed and rotate the Control Knob for desired reading displayed in inverse video.

HP-IB **Program Code**

PC<mode>,<status>,[<setting>]

mode::= **1** T/DATE
2 TIMER
3 Sequence ROM Actuation (if installed)

status::= **0** off
1 on
2 Set Clock or Timer (not applicable if mode three "Sequence ROM Actuation" was selected.)

setting::= F1, F2
F1 = year,month,day,hour,minutes
F2 = time#,day,hour,minute,time#,...

Time/Date and Timer Control (Cont'd)

Example Set the clock time to 9:53 PM on May 18, 1999.

LOCAL **(keys)**	T/DATE SET 5 YEAR XX:XX XX XXX 99 4 MONTH XX: XX XX MAY 99 3 CHAR ON/OFF DAY XX :XX 18 MAY 99 2 CHAR INTEN HOUR 21 :XX 18 MAY 99 1 INTEN PANEL MINUTE 21: 53 18 MAY 99 7 RECALL START
REMOTE **(codes)**	**PC 1, 2, 83,05,18,21,53** <CR> <LF> identifier (PC), mode (1), status (2), Date/Time (83,05,18,21,53), EOS (<CR> <LF>)

Time/Date and Timer Control (Cont'd)

Example Set the timer to time out on the 3rd of the month at 10:15 PM and on the 4th of the month at 1:30 AM.

LOCAL (keys)	TIMER SET		
	2 CHAR INTEN	TIME #XX	TIME #01
	5	DAY	XX : XX DAY 03
	4	HOURS	22 : XX DAY : 03
	3 CHAR ON/OFF	MINUTES	22 : 15 DAY : 03
	2 CHAR INTEN	TIME #XX	TIME #02
	5	DAY	XX : XX DAY 04
	4	HOURS	01 : XX DAY : 04
	3 CHAR ON/OFF	MINUTES	01 : 30 DAY : 04
REMOTE (codes)	PC 2, 2, 1,3,22,15,2,4,1,30<CR><LF>	PC = identifier; 2 = mode; 2 = status; 1,3,22,15 = 1st Time; 2,4,1,30 = 2nd Time; <LF> = EOS	

The timer is now set. It must now be turned on by sending the HP-IB command, PC 2,1 or by pressing TIMER SET.

Comments If day is set to 0 via the HP-IB or to "ALL" manually, then the timer is enabled every day. If time # is set to 0 via the bus, then all current settings are cleared.

When the settings are cleared, the day will be displayed as "0". This is the reset condition and prevents that time from ever matching the clock. With the day set to "All", a match will be made every day.

When setting the timer over HP-IB, be sure that the timer is turned off prior to executing the set.

NOTES

HP-IB SUMMARY

This section contains a summary of the HP-IB program codes and format information.

HP-IB CODES AND FORMAT SUMMARY

General Input Data Message Format:

<program code>[;<program code>]...[;][<CR>]<LF>

format rules: The 1980A/B HP-IB sends and receives Data messages in standard ASCII code.

<LF> is used as the End-of-String (EOS) message for all input Data messages.

If several program codes are sent in a Data message, all but the last must be delimited by a semicolon (;).

Program codes consist of a two-character identifier (prefix) and a parameter field containing zero, one, or several parameters.

Unsigned parameters are interpreted as positive values.

In integer parameters, leading zeroes may be omitted.

Multiple parameters within a program code are delimited by a comma (,).

The character "E" or "e" is used to delimit the mantissa of exponential parameters.

Exponential parameters may be entered in scientific or engineering notation.

In Data messages, spaces (<sp>) are permitted only following program code identifiers and parameter delimiters.

The maximum Data message length is 127 characters including: <CR>, <LF>, <SP>, comma, and semicolon.

The instrument cannot be unaddressed during input or output Data message transfers. If the instrument is unaddressed and then readdressed, the data transfer is aborted and a syntax error is reported.

All valid program codes for the Gated Universal Counter are listed in Table 11. Specific format requirements and parameter descriptions are included.

General Output Data Message Format:

<sp><setting value><CR><LF>

During Learn String outputs, the instrument sets the EOI bus control line true with the last character of the string to indicate end of string. All other output Data messages use <LF> for the EOS message.

Table 11 includes specific descriptions of output Data message format.

Table 3-10. Program Code Prefix Function Quick Reference

Code Prefix	Function
PA	Auto Functions
PC	Clock and Timer Control
PD	Arm Delay
PE	Events Functions
PF	Frequency Function
PH	Hysteresis Control
PI	Initialize Counter
PK	Key
PL	Learn Mode
PM	Module Off
PN	Reference Offset
PO	Information Output
PP	Period Function
PQ	Operator's Checks
PR	Resolution
PS	Source Selection
PT	Time Interval Function
PU	Update Display
PV	View Selection
PW	Gate Width
PX	Oscillator Source Select
PY	Control Knob
PZ	Counter Reset

Table 11. Program Codes and Format Summary

<table>
<tr><th>FUNCTION</th><th>PROGRAM CODE (ASCII)</th><th></th><th></th></tr>
<tr><td>**ARM DELAY**</td><td>**PD**<value></td><td></td><td></td></tr>
<tr><td></td><td>value ::= exponential</td><td></td><td></td></tr>
<tr><td></td><td>[+]{d.dd|dd.d|ddd}[d...]{e|E}{−[d]d|+0}</td><td></td><td></td></tr>
<tr><td></td><td>$100e^{-9}$ to 9.999 999 999 9 s</td><td></td><td></td></tr>
<tr><td></td><td>maximum 11 digits resolution;</td><td></td><td></td></tr>
<tr><td></td><td>5 digits displayed</td><td></td><td></td></tr>
<tr><td>**AUTO FUNCTIONS**</td><td>**PA**<code>, <channel></td><td></td><td></td></tr>
<tr><td>Rise Time CH1</td><td>code ::=</td><td>1</td><td></td></tr>
<tr><td>Fall Time CH1</td><td></td><td>2</td><td></td></tr>
<tr><td>Pulse Width CH1</td><td></td><td>3</td><td></td></tr>
<tr><td>Duty Cycle CH1</td><td></td><td>4</td><td></td></tr>
<tr><td>Prop Delay CH1→CH2</td><td></td><td>5</td><td></td></tr>
<tr><td>Phase Shift</td><td></td><td>6</td><td></td></tr>
<tr><td>Channel 1 or 1→2</td><td>channel ::=</td><td>1</td><td></td></tr>
<tr><td>Channel 2 or 2→1</td><td></td><td>2</td><td></td></tr>
<tr><td>**CLOCK AND TIMER**</td><td>**PC**<mode>, <status>[,<setting>]</td><td></td><td></td></tr>
<tr><td>T/DATE</td><td>mode ::=</td><td>1</td><td></td></tr>
<tr><td>Timer</td><td></td><td>2</td><td></td></tr>
<tr><td>Sequence ROM Actuation</td><td></td><td>3</td><td></td></tr>
<tr><td>Off</td><td>status ::=</td><td>0</td><td></td></tr>
<tr><td>On</td><td></td><td>1</td><td></td></tr>
<tr><td>set clock or timer</td><td></td><td>2</td><td></td></tr>
<tr><td>set clock and date</td><td>setting ::=</td><td>year,month,day,hour,min</td><td></td></tr>
<tr><td>set timer</td><td></td><td>time#,day,hour,min,time#...
(up to 50 times)</td><td></td></tr>
<tr><td>**COUNTER RESET**</td><td>**PZ**</td><td></td><td></td></tr>
<tr><td>**CONTROL KNOB**</td><td>**PY**<entry>[,<mode>]</td><td></td><td></td></tr>
<tr><td>Assign control knob:</td><td></td><td></td><td></td></tr>
<tr><td>hold</td><td>entry ::=</td><td>0</td><td></td></tr>
<tr><td>Arm Delay</td><td></td><td>1</td><td></td></tr>
<tr><td>Gate Width</td><td></td><td>2</td><td></td></tr>
<tr><td>Select step resolution:</td><td></td><td></td><td></td></tr>
<tr><td>coarse steps</td><td>mode ::=</td><td>0</td><td></td></tr>
<tr><td>fine steps</td><td></td><td>1</td><td></td></tr>
<tr><td>**EVENTS**</td><td>**PE**<function>[,<Arming Mode>]</td><td></td><td></td></tr>
<tr><td>select function:</td><td></td><td></td><td></td></tr>
<tr><td>A(GATED)</td><td>function ::=</td><td>1</td><td></td></tr>
<tr><td>A DURING B</td><td></td><td>2</td><td></td></tr>
<tr><td>A/B</td><td></td><td>3</td><td></td></tr>
<tr><td>TOTALIZE A</td><td></td><td>4</td><td></td></tr>
<tr><td>TOTALIZE A+B</td><td></td><td>5</td><td></td></tr>
<tr><td>TOTALIZE A−B</td><td></td><td>6</td><td></td></tr>
<tr><td>TOTALIZE START</td><td></td><td>7</td><td></td></tr>
<tr><td>TOTALIZE STOP</td><td></td><td>8</td><td></td></tr>
<tr><td>set arming mode:</td><td></td><td></td><td></td></tr>
<tr><td>UNARMED</td><td>Arming Mode ::=</td><td>0</td><td></td></tr>
<tr><td>ARMED</td><td></td><td>1</td><td></td></tr>
<tr><td>GATED</td><td></td><td>2</td><td></td></tr>
<tr><td>**FREQUENCY**</td><td>**PF**<mode></td><td></td><td></td></tr>
<tr><td>set arming mode:</td><td></td><td></td><td></td></tr>
<tr><td>UNARMED</td><td>mode ::=</td><td>0</td><td></td></tr>
<tr><td>ARMED</td><td></td><td>1</td><td></td></tr>
<tr><td>GATED</td><td></td><td>2</td><td></td></tr>
<tr><td>**GATE WIDTH**</td><td>**PW**<value></td><td></td><td></td></tr>
<tr><td>enter gate width:</td><td>value ::= exponential</td><td></td><td></td></tr>
<tr><td></td><td>[+]{d.dd|dd.d|ddd}[d...]{e|E}{−[d]d|+0}</td><td></td><td></td></tr>
<tr><td></td><td>200 ns to 9.9999 seconds</td><td></td><td></td></tr>
<tr><td></td><td>greatest value must be<10 seconds</td><td></td><td></td></tr>
<tr><td>**HYSTERESIS CONTROL**</td><td>**PH**<status></td><td></td><td></td></tr>
<tr><td>Normal Hysteresis</td><td>status ::=</td><td>1</td><td></td></tr>
<tr><td>Double Hysteresis</td><td></td><td>2</td><td></td></tr>
<tr><td>Hysteresis Cal</td><td></td><td>3</td><td></td></tr>
<tr><td>**INFORMATION OUTPUT**</td><td>**PO**<code></td><td></td><td></td></tr>
<tr><td>select information output:</td><td></td><td></td><td>format #</td></tr>
<tr><td>last answer</td><td>code ::=</td><td>1</td><td>1</td></tr>
<tr><td>new answer</td><td></td><td>2</td><td>1</td></tr>
<tr><td>reference offset</td><td></td><td>3</td><td>1</td></tr>
<tr><td>clock data</td><td></td><td>4</td><td>2</td></tr>
<tr><td>**INFORMATION OUTPUT (Cont'd)**</td><td></td><td></td><td></td></tr>
<tr><td>Arm delay</td><td></td><td>5</td><td>3</td></tr>
<tr><td>Gate width</td><td></td><td>6</td><td>3</td></tr>
<tr><td>resolution</td><td></td><td>7</td><td>4</td></tr>
<tr><td>hysteresis/offset values</td><td></td><td>8</td><td>5</td></tr>
<tr><td>Format #</td><td>Output Format</td><td></td><td></td></tr>
<tr><td>1</td><td>{<sp>|−}m.d[d...]E{<sp>|−}dd<CR><LF></td><td></td><td></td></tr>
<tr><td>2</td><td><sp>HH:MM<sp>DDMMMYY<CR><LF></td><td></td><td></td></tr>
<tr><td>3</td><td><sp>d.ddddE{<sp>|}dd<CR><LF></td><td></td><td></td></tr>
<tr><td>4</td><td><sp>0n<CR><LF></td><td></td><td></td></tr>
<tr><td>5</td><td><sp>{+|−}dd.dd<CR><LF>,{+|−}dd.dd<CR><LF>,...</td><td></td><td></td></tr>
<tr><td>**INITIALIZE COUNTER**</td><td>**PI**</td><td></td><td></td></tr>
<tr><td>**KEY**</td><td>**KY**<code>[,<code>]...</td><td></td><td></td></tr>
<tr><td>valid key codes are</td><td>code ::=</td><td>integer</td><td></td></tr>
<tr><td>listed in table 3-4.</td><td></td><td>[d]d</td><td></td></tr>
<tr><td>**LEARN/TEACH MODE**</td><td>**PL**</td><td></td><td></td></tr>
<tr><td>specify learn string output:</td><td>output format: 46 eight bit bytes
EOS = EOI bus
control line true</td><td></td><td></td></tr>
<tr><td>configure the 1965A
using the learn string:</td><td><46 byte string><CR><LF></td><td></td><td></td></tr>
<tr><td></td><td>Note: The Learn String must be transferred without sending UNL or UNT.</td><td></td><td></td></tr>
<tr><td>**MODULE OFF**</td><td>**PM0**</td><td></td><td></td></tr>
<tr><td>**OSCILLATOR SOURCE**</td><td>**PX**<source></td><td></td><td></td></tr>
<tr><td>internal 10 MHz time base</td><td>source ::=</td><td>1</td><td></td></tr>
<tr><td>external input</td><td></td><td>2</td><td></td></tr>
<tr><td>**OPERATOR'S CHECKS**</td><td>**PQ**<test></td><td></td><td></td></tr>
<tr><td>Confidence Test</td><td>test ::=</td><td>1</td><td></td></tr>
<tr><td>RAM Test</td><td></td><td>2</td><td></td></tr>
<tr><td>ROM Checksum</td><td></td><td>3</td><td></td></tr>
<tr><td>**PERIOD FUNCTION**</td><td>**PP**<mode></td><td></td><td></td></tr>
<tr><td>Unarmed</td><td>mode ::=</td><td>0</td><td></td></tr>
<tr><td>Armed</td><td></td><td>1</td><td></td></tr>
<tr><td>Gated</td><td></td><td>2</td><td></td></tr>
<tr><td>**REFERENCE OFFSET**</td><td>**PN**<status>[,<reference>]</td><td></td><td></td></tr>
<tr><td>Clear reference</td><td>status ::=</td><td>0</td><td></td></tr>
<tr><td>Set Ref= Answer</td><td></td><td>1</td><td></td></tr>
<tr><td>Set Reference as defined</td><td></td><td>2</td><td></td></tr>
<tr><td></td><td>reference ::= exponential</td><td>{+|−}n.[d...]E[−d]d
1.00 p(units) to
9.999 999 99 E8(units)</td><td></td></tr>
<tr><td>**RESOLUTION**</td><td>**PR**<code></td><td></td><td></td></tr>
<tr><td>Automatic</td><td>code ::=</td><td>0</td><td></td></tr>
<tr><td>1 μs or 1 average</td><td></td><td>1</td><td></td></tr>
<tr><td>100 μs or 100 averages</td><td></td><td>2</td><td></td></tr>
<tr><td>10 ms or 10,000 averages</td><td></td><td>3</td><td></td></tr>
<tr><td>1 s or 1,000,000 averages</td><td></td><td>4</td><td></td></tr>
<tr><td>**SOURCE SELECTION**</td><td>**PS**<source(A)>[,<source(B)>]</td><td></td><td></td></tr>
<tr><td>no change</td><td>source ::=</td><td>0</td><td></td></tr>
<tr><td>main trigger</td><td></td><td>1</td><td></td></tr>
<tr><td>delayed trigger</td><td></td><td>2</td><td></td></tr>
<tr><td>**TIME INTERVAL**</td><td>**PT**[<mode>]</td><td></td><td></td></tr>
<tr><td>Unarmed</td><td>mode ::=</td><td>0</td><td></td></tr>
<tr><td>Armed</td><td></td><td>1</td><td></td></tr>
<tr><td>Gated</td><td></td><td>2</td><td></td></tr>
<tr><td>**UPDATE RATE**</td><td>**PU**<code></td><td></td><td></td></tr>
<tr><td>no wait for update</td><td>code ::=</td><td>0</td><td></td></tr>
<tr><td>normal 1/2 s wait for update</td><td></td><td>1</td><td></td></tr>
<tr><td>**VIEW SELECTION**</td><td>**PV**<code></td><td></td><td></td></tr>
<tr><td>Views off</td><td>code ::=</td><td>0</td><td></td></tr>
<tr><td>Count View</td><td></td><td>1</td><td></td></tr>
<tr><td>Arm View</td><td></td><td>2</td><td></td></tr>
</table>

Table 12. 1965A Counter Key to PK Code Conversion Table

Key	ASCII Code	Key	ASCII Code	Key	ASCII Code	Key	ASCII Code
FREQ A	83	ARM DELAY	79	MAIN TRIG (B SOURCE)	85	TIMER ↓SET	77
PERIOD A	73	GATE WIDTH	82	DLYD TRIG (B SOURCE)	89	T/DATE ↓SET	76
T INTVL A→B	86	ARMED A AND B	71	RESOLN ↓AUTO	72	OSC probe	91
EVENTS (MENU)	87	GATED A THEN B	78	RESET ↓SINGLE	84	TIMER probe	92
REF (MENU)	88	MAIN TRIG (A SOURCE)	80	COUNT ↓ARM	74		
AUTO (MENU)	90	DLYD TRIG (A SOURCE)	81				

Table 13. PK Code to 1965A Counter Key Conversion Table

ASCII Code	Key	ASCII Code	Key	ASCII Code	Key	ASCII Code	Key
71	ARMED A AND B	76	T/DATE ↓SET	81	DLYD TRIG (A SOURCE)	86	T INTVL A→B
72	RESOLN ↓AUTO	77	TIMER ↓SET	82	GATE WIDTH	87	EVENTS (MENU)
73	PERIOD A	78	GATED A THEN B	83	FREQ A	88	REF (MENU)
74	COUNT ↓ARM	79	ARM DELAY	84	RESET ↓SINGLE	89	DLYD TRIG (B SOURCE)
		80	MAIN TRIG (A SOURCE)	85	MAIN TRIG (B SOURCE)	90	AUTO (MENU)
						91	OSC probe
						92	TIMER probe

NOTATION CONVENTIONS AND DEFINITIONS

The following conventions are used in this manual in descriptions of remote (HP-IB) operation:

<> Angular brackets enclose descriptive words that are used to symbolize a program code parameter or an HP-IB command.

::= "is defined as". For example, <A> ::= <B> indicates that <A> can be replaced by <B> in any statement containing <A>.

[ ] Square brackets indicate that the enclosed items are optional.

When several items are enclosed by braces, one and only one, of these elements must be selected.

| "or": indicates a choice of exactly one element from a list. For example, <A>|<B> indicates <A> or <B> but not both.

... An ellipsis (trailing dots) is used to indicate that the preceding element may be repeated one or more times.

The following definitions are used:

d::= A single ASCII numeric character, 0-9.

n::= A single ASCII nonzero, numeric character, 1-9.

<LF>::= ASCII linefeed (decimal 10).

<CR>::= ASCII carriage return (decimal 13).

<SP>::= ASCII space (decimal 32).

PROGRAMMING EXAMPLES

This section gives several example programs demonstrating 1965A measurements executed over the HP-IB. All of the programs were written on the HP9826/36 controller in BASIC 2.0. In order to become acquainted with programming the 1965A, these programs may be executed using the 1980's calibrator signal from the rear panel. Other inputs may work, however, program modifications may be required for proper signal conditioning.

Example 1: FREQUENCY MEASUREMENT (USING "PO2")

This program takes measurements using the "PO2" command. The "PO2" command restarts the 1965A, takes one measurement, and then waits until the answer is read by the controller before releasing the counter for further measurements.

```
10      OUTPUT 707;"as;pf0"
20      OUTPUT 707;"po2"
30      ENTER 707;F
40      DISP "Frequency =";F;"Hz"
50      GOTO 20
60      END
```

Line #	Description
10	Performs an AUTOSCOPE to get signal on screen and then sets 1965A to FREQUENCY-UNARMED (pf0).
20	Tells 1965A to restart, take one measurement, and hold the answer until prompted by a read from the controller.
30	Reads the answer into variable F. If the 1965A has not completed the measurement initiated in line 20, the controller will wait at this line until the measurement is completed.
40	Displays the answer on the controller screen.
50	Repeats to take another measurement.
60	End of program.

Example 2: GATED TIME INTERVAL MEASUREMENT

In this program, Time Interval Gated is used. In the GATED mode the start of the measurement is enabled after the beginning of the delayed sweep (the intensified marker) and the end of the measurement is enabled after the end of the delayed sweep. By setting the delayed sweep with ARM DELAY and GATE WIDTH, the time interval is gated so that the measurement is made from the 2nd rising edge of Main Trigger to the 4th rising edge of Main Trigger.

```
10    OUTPUT 707;"as;pp0;pr1"
20    OUTPUT 707;"po2"
30    ENTER 707;P
40    OUTPUT 707 USING "2A,D.DDESZZ";"ms",.5*P
50    OUTPUT 707;"hm2"
60    OUTPUT 707 USING "2A,D.DDDDESZZ";"pd",.75*P
70    OUTPUT 707 USING "2A,D.DDDDESZZ";"pw",2*P
80    OUTPUT 707;"pt2;pr0;ps1,1;pv1"
90    OUTPUT 707;"po2"
100   ENTER 707;T
110   PRINT "Time interval from 2nd rising edge"
120   PRINT "to 4th rising edge =";T;"sec"
130   END
```

Line #	Description
10	Performs an AUTOSCOPE to set up 1980, turns 1965 on to PERIOD UNARMED (pp0), and selects Sample Time of 1 μs (pr1). The period of the signal will be used for later setups.
20	Starts a PERIOD measurement and tells the 1965A to output the answer when a controller read occurs.
30	Reads the period into variable P.
40	Sets the main sweep of the 1980 to get 5 periods of the signal on screen (5 periods desired ÷ 10 horizontal divisions of screen × P (measured period)). The USING statement formats the data as follows: 2A → 2 characters (for mnemonic). D.DD → 3 digits with decimal point. ESZZ → Exponential notation with signed 2 digit exponent.
50	Selects horizontal mode to INTENSIFIED to turn on the delayed sweep. This is done so that ARM DELAY and GATE WIDTH can be used.
60	Sets ARM DELAY to 3/4 of a period so the beginning of delayed sweep (intensified portion) occurs before the 2nd rising edge of the signal.
70	Sets GATE WIDTH to 2 periods so the end of the delayed sweep will occur after the 3rd rising edge and before the 4th rising edge of the waveform.
80	(pt2) Sets the 1965A to TIME INTERVAL GATED. The measurement will begin on the first trigger after the beginning of the delayed sweep, and end on the first trigger after the end of the delayed sweep. (pr0) Sets the RESOLUTION to automatic. The 1965A selects an optimum resolution for this measurement. (ps1,1) Sets the A SOURCE (start) to main trigger and the B SOURCE (stop) to main trigger. Main trigger was set to the rising edge by the AUTOSCOPE in line 10. (pv1) Turns on COUNT view so that the operator may verify the counting interval.
90	Takes a TIME INTERVAL measurement and tells the 1965A to output the answer when a controller read of the bus occurs.
100	Reads the answer into variable T.
110-120	Displays the result on the controller screen.
130	End of program.

Example 3: PULSE WIDTH MEASUREMENT USING TIME INTERVAL ARMED

This program uses Time Interval Armed to make a pulse width measurement. This differs from the previous program in that the start and stop of the measurement are both enabled after the beginning of the delayed sweep (the intensified marker). In addition, the slope on delayed trigger is set to falling, therefore the measurement is made from the first rising edge of MAIN TRIG after the beginning of the delayed sweep to the first falling edge of DLYD TRIG after the beginning of the delayed sweep.

```
10    OUTPUT 707;"as;pp0;pr1"
20    OUTPUT 707;"po2"
30    ENTER 707;P
40    OUTPUT 707 USING "2A,D.DDESZZ";"ms",.2*P
50    OUTPUT 707;"hm2"
60    OUTPUT 707 USING "2A,D.DDDDESZZ";"pd",.9*P
70    OUTPUT 707;"pt1;pr0;ps1,2;pv1"
80    OUTPUT 707;"mt0,0;dt-0,0"
90    OUTPUT 707;"po2"
100   ENTER 707;T
110   PRINT "Pulse width =";T;"sec"
120   END
```

Line #	Description
10	Performs an AUTOSCOPE to set up 1980, turns 1965A on to PERIOD UNARMED (pp0), and selects a Sample Time of 1 μs (pr1). The period of the signal will be used for later setups.
20	Starts a PERIOD measurement and tells the 1965A to output the answer when a controller read occurs.
30	Reads the period into variable P.
40	Sets the main sweep of the 1980 to get 2 periods of the signal on screen (2 periods desired ÷ 10 horizontal divisions of screen × P (measured period)). The USING statement formats the data as follows: 2A → 2 characters (for mnemonic). D.DD → 3 digits with decimal point. ESZZ → Exponential notation with signed 2 digit exponent.
50	Selects horizontal mode to INTENSIFIED to turn on the delayed sweep. This is done so that ARM DELAY and GATE WIDTH can be used. Also, the delayed trigger source will be used, which requires that the delayed sweep be on.
60	Sets ARM DELAY to 9/10 of a period to enable the start of the measurement after the 1st falling edge and before the 2nd rising edge.
70	(pt2) Sets the 1965A to TIME INTERVAL ARMED. The measurement will begin on the first trigger of the A SOURCE after the beginning of the delayed sweep (the intensified portion), and end on the first trigger of the B SOURCE after the beginning of the delayed sweep. (pr0) Sets the RESOLUTION to automatic so the 1965A will choose an optimum resolution for this measurement. (ps1,2) Sets the A SOURCE (start) to main trigger and the B SOURCE (stop) to delayed trigger. (pv1) Turns on COUNT VIEW so that the user may verify the counting interval.
80	(mt0,0) Sets main trigger to rising edge. (dt-0,0) Sets delayed trigger to falling edge.
90	Takes a TIME INTERVAL measurement and tells the 1965A to output the answer when a controller read of the bus occurs.
100	Reads the answer into variable T.
110	Displays the result on the controller screen.
120	End of program.

Example 4: AUTO PARAMETER MEASUREMENTS

This program shows how the different auto parameter measurements can be made over HP-IB. When performing auto parameter rise time and fall time measurements, the overshoot + undershoot must not exceed 10% of the peak-to-peak value of the signal. See the Specifications section and Detailed Operating Instructions for further details.

```
10    OUTPUT 707;"as"
20    OUTPUT 707;"pa1,1;po1"
30    ENTER 707;A
40    PRINT "RISE TIME =";A;"sec"
50    OUTPUT 707;"pa2;po1"
60    ENTER 707;A
70    PRINT "FALL TIME =";A;"sec"
80    OUTPUT 707;"pa3;po1"
90    ENTER 707;A
100   PRINT "PULSE WIDTH =";A;"sec"
110   END
```

Line #	Description
10	Performs an AUTOSCOPE to set up waveform.
20	Performs a RISE TIME measurement on channel 1 and then tells the 1965A to output the final answer when a read of the bus occurs. (A "po1" is used here since all Auto-parameter measurements are "single shot", and therefore the displayed answer will remain in the display buffer until a new measurement is performed. A PO2 could have been used with identical results.)
30-40	Reads the answer into A and prints it on the CRT.
50	Performs a FALL TIME measurement on channel 1 and then tells the 1965A to output the final answer when a read of the bus occurs.
60-70	Reads the answer into A and prints it on the CRT.
80	Performs a PULSE WIDTH measurement on channel 1 and then tells the 1965A to output the final answer when a read of the bus occurs.
90-100	Reads the answer into A and prints it on the CRT
110	End of program.

Example 5: PULSE WIDTH MEASUREMENT USING TIME INTERVAL UNARMED AND REFERENCE OFFSET

Some Time Interval measurements on complex waveforms may require utilizing the Unarmed mode in a two part measurement. Triggering the 1980 may require a sync pulse for main trigger; therefore, only delayed trigger is available for any timing measurements upon the complex pulse string. The following is an example of a pulse width measurement, illustrating the technique that would be used if the waveform under measurement were a complex waveform. The measurement is made from the beginning of main sweep to the beginning of delayed sweep. The delayed sweep mode is set to the TRIG'D mode. The slope on delayed trigger is then changed to falling and a second measurement is taken. Since the reference is subtracted internally, the final answer is the time between the rising and falling edges.

Note

The 1980 setup technique demonstrated in this example (lines 10 through 40) would not apply for complex waveforms.

```
10      OUTPUT 707;"as;pp0;pr1"
20      OUTPUT 707;"po2"
30      ENTER 707;P
40      OUTPUT 707 USING "2A,D.DDESZZ";"ms",.3*P
50      OUTPUT 707;"hm2;dm1"
60      OUTPUT 707 USING "2A,D.DDDDESZZ";"pd",.75*P
70      OUTPUT 707;"pt0;pr0;pv1"
80      OUTPUT 707;"po2"
90      ENTER 707
100     OUTPUT 707;"pn1"
110     OUTPUT 707;"dt-0,0"
120     OUTPUT 707;"po2"
130     ENTER 707;T
140     PRINT "Width of 2nd pulse =";T;"sec"
150     END
```

Line #	Description
10	Performs an AUTOSCOPE to set up 1980, turns 1965A on to PERIOD UNARMED (pp0), and selects a Sample Time of 1 μs (pr1). The period of the signal will be used for later setups.
20	Starts a PERIOD measurement and tells the 1965A to output the answer when a controller read occurs.
30	Reads the period into variable P.
40	Sets the main sweep of 1980 to get 3 periods of signal on screen (3 periods desired ÷ 10 horizontal divisions of screen × P (measured period)).
	The USING statement formats the data as follows:
	2A → 2 characters (for mnemonic).
	D.DD → 3 digits with decimal point.
	ESZZ → Exponential notation with signed 2 digit exponent.
50	(hm2) Selects horizontal mode to INTENSIFIED to turn on the delayed sweep so that ARM DELAY can be used.
	(dm1) Sets delayed sweep mode to TRIGD so that delayed sweep will begin at a trigger point.
60	Sets the ARM DELAY to 3/4 of a period to end the measurement at the 2nd rising edge.
70	(pt0) Sets the 1965A to TIME INTERVAL UNARMED.
	Note: This measurement starts at the beginning of main sweep and stops at the beginning of delayed sweep (the start of the intensified marker). We used (dm1) in line 50 to insure that the beginning of delayed sweep would be at the trigger point of delayed trigger.
	(pr0) Selects auto-resolution.
	(pv1) Turns on COUNT view so that the user may verify the counting interval.
80	The 1965A restarts the measurement and outputs the answer when a controller read occurs.
90	Reads the first time interval, but the data is not stored. This measurement data will never be used. This step is required in order to guarantee that a valid answer is ready to be used as a reference offset.
100	Sets the reference to the currently displayed answer.
110	Sets the delayed trigger source to falling.
120	Restarts counter and sets up for output.
130	Reads the 2nd answer into T. The reference is subtracted from the answer before displaying; therefore, the number read will be the time from the rising to the falling edge of the 2nd pulse.
140	Prints the answer on the controller screen.
150	End of program.

Example 6: MAKING MEASUREMENTS USING INTERRUPT

The "PO2" command is also useful for making measurements under interrupt, since it sends a Request For Service to the controller when the measurement it initiates is complete (if the SRQ's have been properly unmasked (line 10)). The advisories were unmasked in the program below to show how two (or more) different conditions can be handled at the same time.

When using the "PO2" command, the program would normally have to wait at the READ (enter) until the answer is ready. The method used in this example frees the controller while the measurement is being taken.

```
10    OUTPUT 707;"im40"
20    ON INTR 7 GOSUB Srq
30    OUTPUT 707;"pf0;pr0;po2"
40    DISP "WAITING FOR ACTION"
50    ENABLE INTR 7;2
60    GOTO 60
70 Srq:     !
80    BEEP 2000,.02
90    A=SPOLL(707)
100   IF BINAND(A,8) THEN
110      DISP "Advisory of Error"
120      WAIT 1
130   END IF
140   IF BINAND(A,32) THEN
150      OUTPUT 707;"oq6"
160      ENTER 707;Flag
170      IF Flag=31 THEN DISP "Measurement Overflow"
180      IF Flag=32 THEN
190         OUTPUT 707;"po1"
200         ENTER 707;Freq
210         DISP "Frequency =";Freq
220      END IF !   {Read frequency}
230   END IF     !   {1965A interrupt}
240   OUTPUT 707;"po2"
250   ENABLE INTR 7
260   RETURN
270   END
```

Line #	Description
10	Sets 1980 interrupt mask to unmask 1965A interrupts (bit 6,(32)) and unmask advisories (bit 4,(8)). Refer to 1980 Operating Manual, Service Request Conditions for information concerning the other bits in the interrupt mask.
20	Designates routine to jump to when an interrupt on select code 7 occurs.
30	Turns 1965A on to FREQUENCY UNARMED (pf0), selects auto resolution (pr0), and restarts 1965A to perform a measurement (po2). The "po2" command will generate an SRQ when the measurement is finished.
50	Enables service request interrupts (2) on select code 7.
60	Waits for interrupts here. This could be modified so that other operations could be performed while waiting for the answer, such as asking the user for input or setting up another instrument.
70	Start of interrupt routine.
80	Beeps to indicate an interrupt has been detected.
90	Reads the 1980 interrupt status into A so that the program can determine the type of interrupt.
100	Checks bit 3 to see if an Advisory or Error caused the interrupt (the user may have pushed a key which would cause a SCOPE UNDER REMOTE CONTROL advisory).
110-120	Displays this condition and holds display for 1 second.

140 Checks bit 5 to see if the 1965A has interrupted.
150 If yes, then it sends an "oq6" command to setup output of the specific 1965A interrupt condition.
160 Reads the 1965A interrupt number into the variable Flag.
170 If Flag=31, indicates an overflow occurred.
180 If Flag=32, this indicates a valid end of measurement.
(For other conditions and their associated code, see the SRQ section of this manual).
190 If it was "end of measurement", then tell 1965A to send its current displayed answer when a read of the bus occurs.
200-210 Reads the answer into the variable Freq and displays.
240 Restarts the 1965A and tells it to send another SRQ when done with the measurement.
250 Re-enables interrupts on 7 (see line 50).
260 Return from interrupt.
270 End of program.

Example 7: THE LEARN MODE

The learn mode is one of the easiest ways to set up the 1965A. A learn string consists of 46 8-bit bytes that completely define the 1965A configuration. When saving the setup of the 1965A, the 1980 setup should also be saved.

```
10    DIM Learn_80$[80],Learn_65$[46]
20    OUTPUT 707;"te"
30    ENTER 707 USING "#,80A";Learn_80$
40    OUTPUT 707;"pl"
50    ENTER 707 USING "#,46A";Learn_65$
60    BEEP
70    LOCAL 707
80    DISP "Mess-up scope, then CONTINUE to restore"
90    PAUSE
100   OUTPUT 707;Learn_80$
110   OUTPUT 707;Learn_65$
120   DISP "Configuration restored"
130   END
```

Line #	Description
10	The dimension statement reserves storage space in memory for the string variables Learn_80$ and Learn_65$.
20	The "TE" command instructs the 1980 to output its learn string.
30	Reads the configuration of the 1980 into the 80 bytes of Learn_80$. The image specifier "#,80A" allows the input of 80 characters, suppressing binary data which appears to be carriage return and line feed as terminators.
40	The "PL" command instructs the 1965A to output its learn string.
50	Reads the configuration of the 1965A into the 46 bytes of Learn_65$.
60	Beeps to let user know configuration has been saved.
70	Returns scope to local so user can press keys.
90	Pauses to allow user to "mess up" the configuration.
100-110	Restores original state of the 1980/1965A.
120	Displays final message.
130	End of program.

Note: Menu status is not saved in the learn strings.

Example 8: TOTALIZE USING OUTPUT DISPLAY ("PO1")

The "po1" command is useful for reading the display buffer without disturbing the current measurement. When performing totalize measurements a "po1" must be used instead of "po2" since the latter will reset and halt the measurement.

```
10     OUTPUT 707;"as"
20     OUTPUT 707;"pe4"
30     OUTPUT 707;"pe7"
40     OUTPUT 707;"po1"
50     ENTER 707;Events
60     IF Events<10000 THEN 40
70     OUTPUT 707;"pe8"
80     OUTPUT 707;"po1"
90     ENTER 707;Events
100    BEEP 2000,.5
110    END
```

Line #	Description
10	Performs an AUTOSCOPE.
20	Selects TOTALIZE A function.
30	Starts the measurement. The display should now change with each trigger event.
40	Tells the 1965A to output the answer in the display when a controller read occurs.
50	Reads the current display. (This does not affect current measurement in progress).
60	Checks the value against an upper limit of 10,000 and loops back for another read if less.
70	Stops the measurement. (The value in the display will not equal the limit value because of handshake time on the HP-IB bus).
80	Tells the 1965A to output the final answer in the display when a controller read occurs.
90	Reads the current and final answer in the display.
100	Beeps to let the user know that program is over.
110	End of program. (At this point some other operation could be performed which is conditional on the completion of the totalize measurement above).

Example 9: READING THE OFFSET AND THE HYSTERESIS OF THE SYSTEM ("PO8")

The "po8" command is used to read the internal offset and hysteresis of the 1965A/1980 system. After the "po8" command is executed, 16 reads are performed to enter the 16 different values.

```
10     DIM H(16)
20     OUTPUT 707;"PO8"
30     FOR I=1 TO 16
40        ENTER 707;H(I)
50        PRINT "H(";I;")=";H(I)
60     NEXT I
70     END
```

Line #	Description
10	Dimensions the array H() to hold the 16 different offset and hysteresis values.
20	Tells the 1965A to output the 16 values. One value will be output for each read.
30	Beginning of loop to read the information.
40	Reads a hysteresis or offset value.
50	Prints a label and a value.
60	Repeats the loop until all 16 values have been read.
70	End of program.

Appendix A

TIME INTERVAL SPECIFICATIONS

Counter time interval specifications are notoriously confusing because of their complexity. As an example, this is the worst case time interval error for the 1965A including error due to trigger level setting:

± Least Significant Digit ± Noise Error ± Time Base Error ± Hysteresis Error ± Systematic Error ± Trigger Level Error.

$$= \pm \frac{10 \text{ ns}}{\sqrt{\# \text{ of Averages}}}$$

$$\pm \frac{\sqrt{(0.02 \text{ div} \times \text{Input Sens(A)}^2 + en^2}}{(\text{Slew Rate of A}) \times \sqrt{\# \text{ of Averages}}} \pm \frac{\sqrt{(0.02 \text{ div} \times \text{Input Sens(B)}^2 + en^2}}{(\text{Slew Rate of B}) \times \sqrt{\# \text{ of Averages}}}$$

$$\pm (\text{Time Base Error}) \times (\text{Time Interval})$$

$$\pm \frac{(\text{Hysteresis} \div 2) \times (\text{Input Sens(A)})}{|\text{Slew Rate of A}|} - \frac{(\text{Hysteresis} \div 2) \times (\text{Input Sens(B)})}{|\text{Slew Rate of B}|}$$

$$\pm \text{SYS ERR}$$

$$\pm \frac{(\pm 3\% \text{ of TL(A)} \pm 0.4 \text{ div}) \times (\text{Input Sens(A)})}{(\text{Slew Rate of A})} - \frac{(\pm 3\% \text{ of TL(B)} \pm 0.4 \text{ div}) \times (\text{Input Sens(B)})}{(\text{Slew Rate of B})}$$

After understanding counter specifications, the need for the various components which make up a complete set of specifications becomes obvious. To the knowledgable user, it is fairly easy to omit various components of a specification to arrive at a worst case error analysis. We have simplified the matter by presenting the user with a set of graphs so that he may do a graphical interpolation to obtain a specification. The time interval specification has been divided into three major areas: Resolution, Time Interval Accuracy, and Trigger Level Error. Each of these is discussed to give the user a better feel for the various components of the entire specification, and how to eliminate certain components under various conditions. In addition, we have given techniques on how to compensate for and minimize some of the error components.

TIME INTERVAL RESOLUTION

The time interval resolution specification is made up of two components:

$$\text{Resolution} = \frac{\pm 10 \text{ ns}}{\sqrt{\# \text{ of Averages}}} \pm \frac{\text{START TRIG ERROR} \pm \text{STOP TRIG ERROR}}{\sqrt{\# \text{ of Averages}}}$$

The first component is the least significant digit (LSD) which is derived from the 1965A's system clock (10 ns) and statistical averaging. This is the predominant component for fast rise time signals as the graphs to the right show.

The second component to time interval resolution is the effective rms noise of the 1980's trigger circuitry, which is referred to as Noise Error (NE).

$$NE = \pm \frac{\text{START TRIGGER ERROR}}{\sqrt{\# \text{ of Averages}}} \pm \frac{\text{STOP TRIGGER ERROR}}{\sqrt{\# \text{ of Averages}}}$$

$$= \pm \frac{\sqrt{(0.02 \text{ div} \times \text{INPUT SEN A})^2 + en^2}}{(\text{Slew Rate of A}) \times \sqrt{\# \text{ of Averages}}} \pm \frac{\sqrt{(0.02 \text{ div} \times \text{Input Sen B})^2 + en^2}}{(\text{Slew Rate of B}) \times \sqrt{\# \text{ of Averages}}}$$

assuming input noise (en) is negligible,

$$NE = \pm \frac{(0.02 \text{ div}) \times (\text{Input Sensitivity (A)})}{(\text{Slew Rate of A}) \times \sqrt{\# \text{ of Averages}}} \pm \frac{(0.02 \text{ div}) \times (\text{Input Sensitivity (B)})}{(\text{Slew Rate of B}) \times \sqrt{\# \text{ of Averages}}}$$

If slew rate of A = slew rate of B, then

$$NE = \pm \frac{\sqrt{2} \times (0.02 \text{ div}) \times (\text{Input Sensitivity})}{(\text{Slew Rated}) \times \sqrt{\# \text{ of Averages}}}$$

For slow rise/fall time signals, error due to effective rms noise of the 1980's trigger circuitry is the predominant component in the time interval resolution specification.

The worst case rms noise specification is 0.02 divisions for both the main and delayed triggers in the 1980. The resultant error may be reduced by making the input signal conditioning more sensitive (make Volts/Div less). For example, if the input sensitivity is set at 2 mV/div, then the effective rms noise is 40 μV.

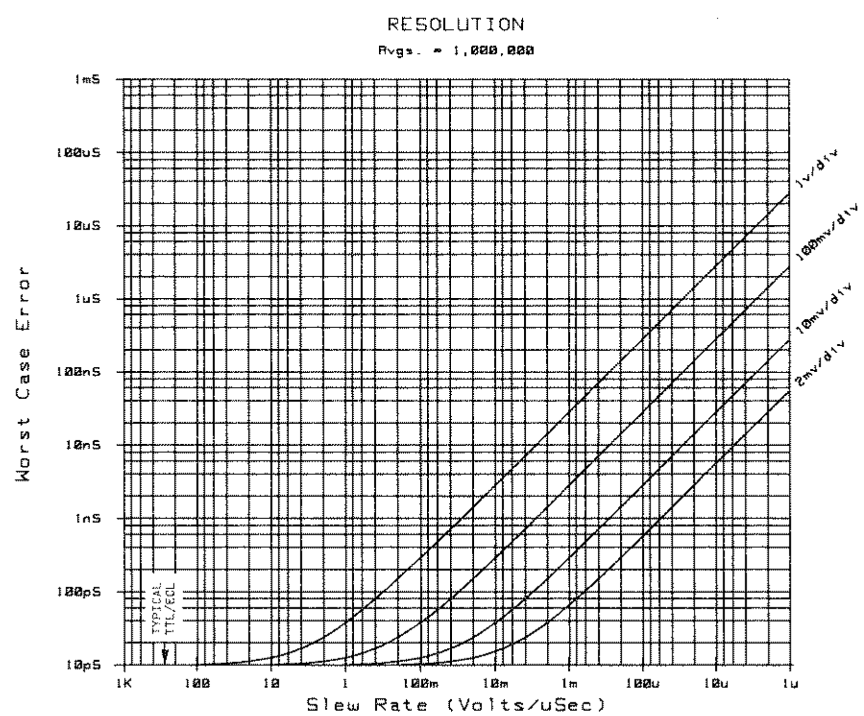
A method for reducing the effective rms noise error is to engage HIGH FREQ REJECT on the 1980 for either or both MAIN and DLYD triggers. This limits the 3 dB bandwidth of the trigger circuitry to approximately 30 kHz, so this technique is useful only in low frequency applications.

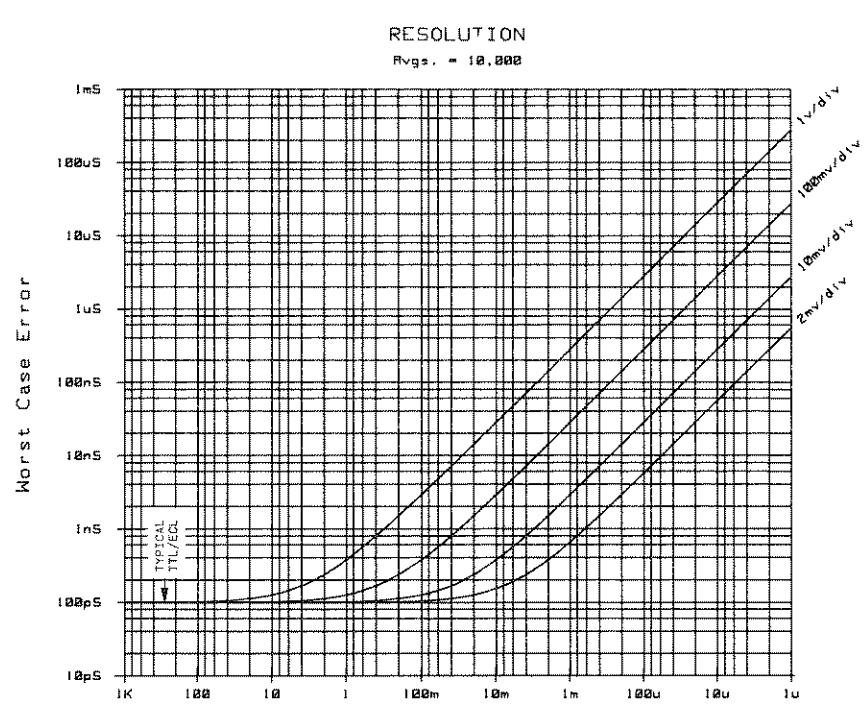
The actual rms noise for any 1980A/B is probably much less than 0.02 divisions. This may be measured by following the setup and directions as given in appendix B of this manual.

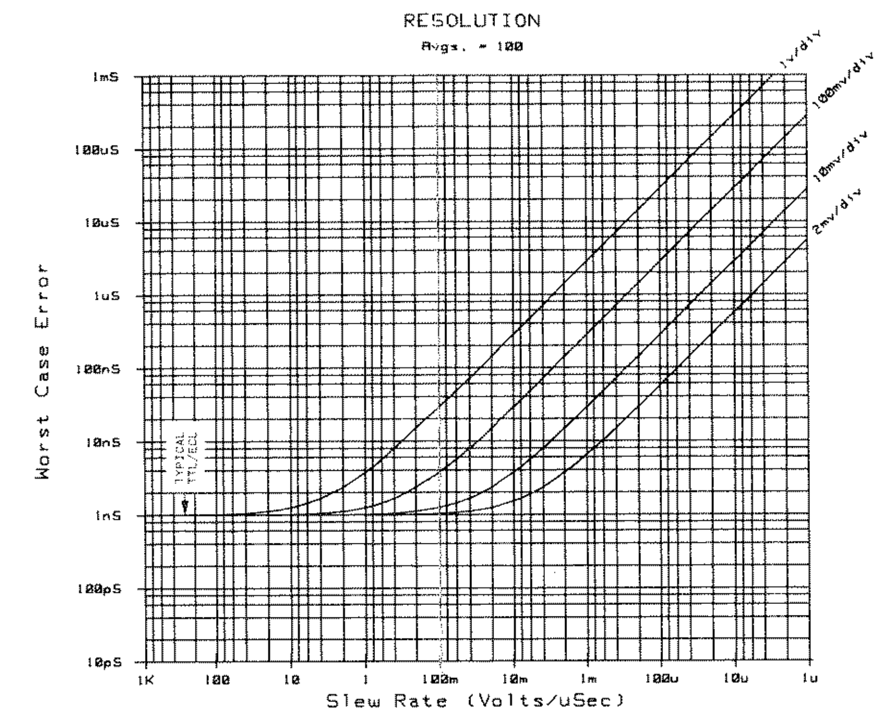
The following four graphs show the worst case time interval resolution for the conditions stated. Locate the appropriate graph according to the number of averages selected. If the input slew rate is known in volts/μs, simply move up on the graph until the slew rate intersects with the channel 1 and 2 input sensitivity setting (an interpolation may be required). The worst case resolution is then indicated on the vertical axis. The following is the equation used to derive these curves:

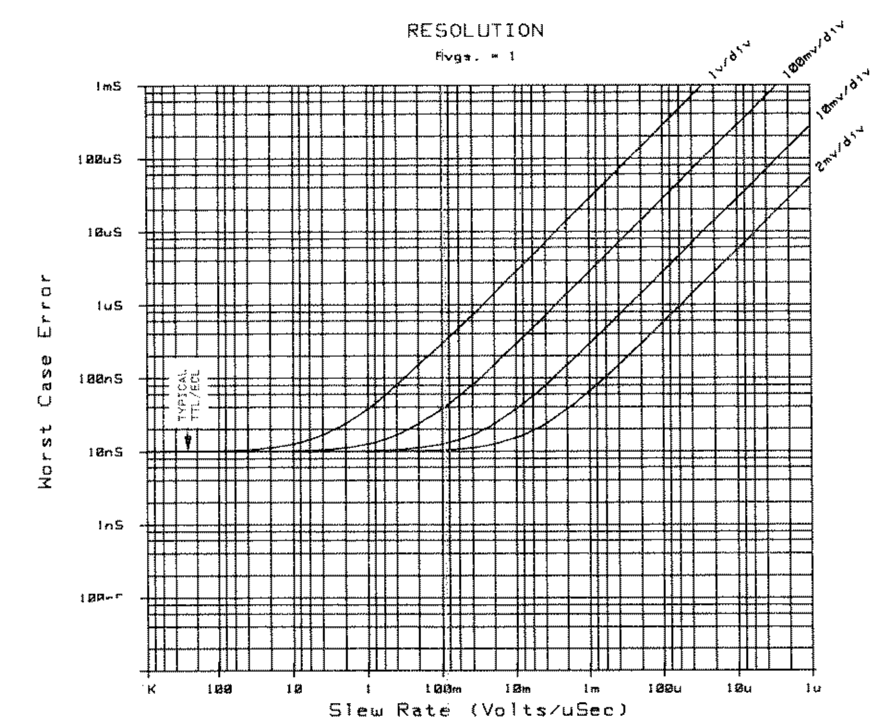
$$\text{Resolution} = \pm \frac{10\ \text{ns}}{\sqrt{\#\ \text{of Averages}}} \pm \sqrt{2} \times \frac{0.02\ \text{div} \times \text{Input Sensitivity}}{\text{Slew Rate} \times \sqrt{\#\ \text{of Averages}}}$$

Conditions: 1. A and B slew rates equal.
2. CH1 and CH2 input sensitivities equal.









TIME INTERVAL ACCURACY

The major components of the Time Interval Accuracy specification are the following:

±(Resolution) ± [(Time Base Error)X TI] ± (Hysteresis Error) ± (Systematic Error)

The components of Resolution are effects of statistical averaging and system rms noise. These were previously discussed.

Inaccuracy due to time base error is usually minimal, especially for short time intervals. For example:

Assume:

Time base error = 2 ppm
Input signal = 1 kHz, 1 V peak-to-peak, sine wave
TI measured = 1 period of input signal (1 ms)
Slew rate = 3.14 mV/μs at zero crossing
Avg = 100

Time error due to time base error for this example equals 500 ps. Time error due to resolution alone is approximately 100 ns with sensitivity at 100 mV/div.

Hysteresis Error (HE) is the timing error due to the effects of hysteresis, where the actual triggering points are not where the trigger level is set. This error component is referred to in the specifications as Trigger Level Timing Error.

$$HE = \frac{(HYS \div 2) \times (\text{Input Sensitivity}) \text{ of A}}{|SR(A)|} - \frac{(HYS \div 2) \times (\text{Input Sensitivity}) \text{ of B}}{|SR(B)|}$$

If both trigger source A and B are selected to be a common trigger source (both MAIN or both DYLD), this timing error will be exactly cancelled. If the absolute value of the slew rate of "A" and "B" are equal, then again the effects of this timing error tend to cancel.

Hysteresis Error can be compensated for and virtually cancelled by compensating the trigger level set due to hysteresis. Hysteresis of each trigger source and slope setting is calibrated and available over HP-IB with the PO8 command. This compensation technique is discussed under Trigger Level Error.

The last component that makes up time interval accuracy is the systematic error. Systematic error is the timing error due to channel propagation delays. The following is the systematic error for for the 1965A:

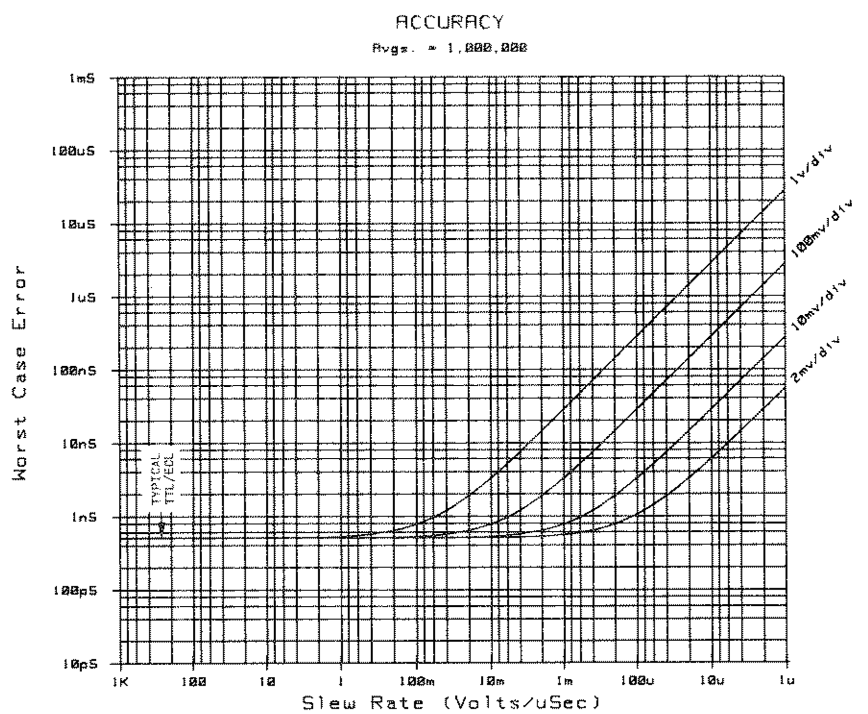
Common Source (Main to Main or Delayed to Delayed): 500 ps
Dual Source with equal vertical sensitivities: 1 ns
Dual Source with unequal vertical sensitivities: 2 ns

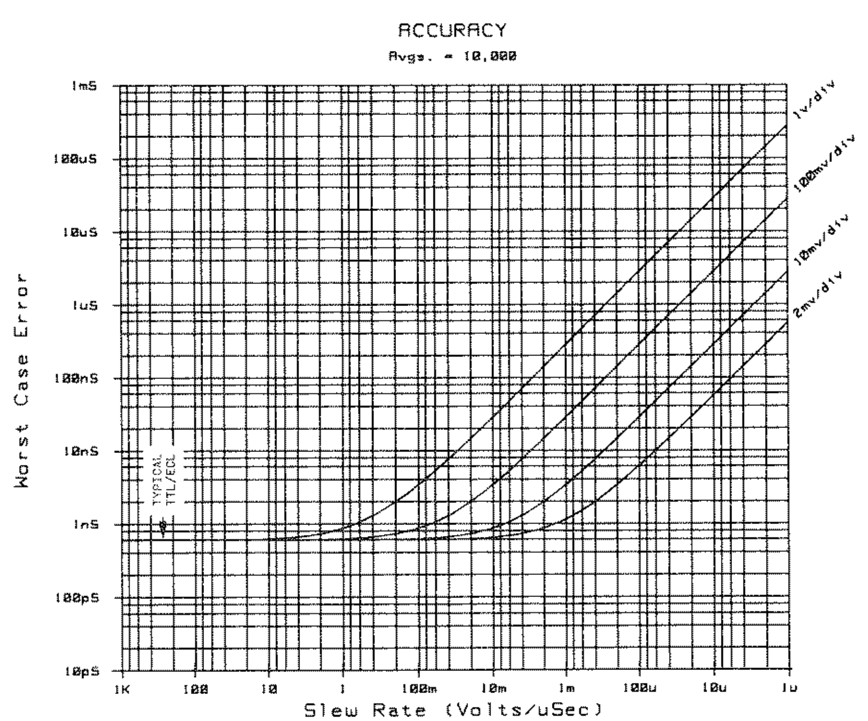
Systematic error can be measured and compensated for by using the REFERENCE OFFSET feature. Make a known time interval measurement (using a fast rise time signal) in the particular setup desired and offset the answer by using either "Reference = Answer" or "Manual Reference."

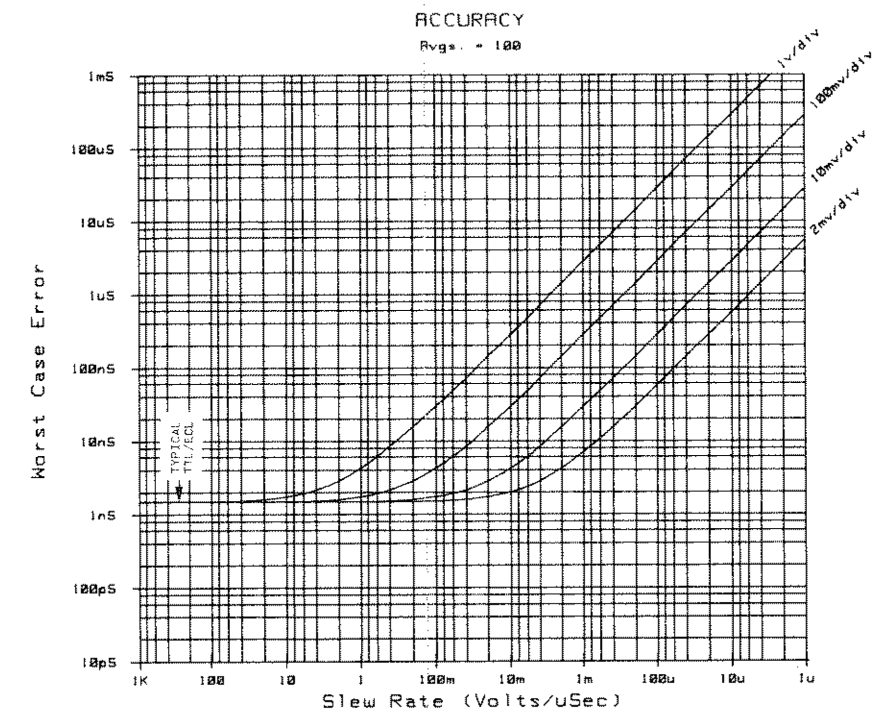
The following four graphs show the worst case time interval error for the conditions stated. Locate the appropriate graph according to the number of averages selected. If the input slew rate is known in volts/μs, simply move up on the graph until the slew rate intersects with the channel 1 and 2 input sensitivity setting (an interpolation may be required). The worst case time interval error is then indicated on the vertical axis. The following is the equation used to derive these curves:

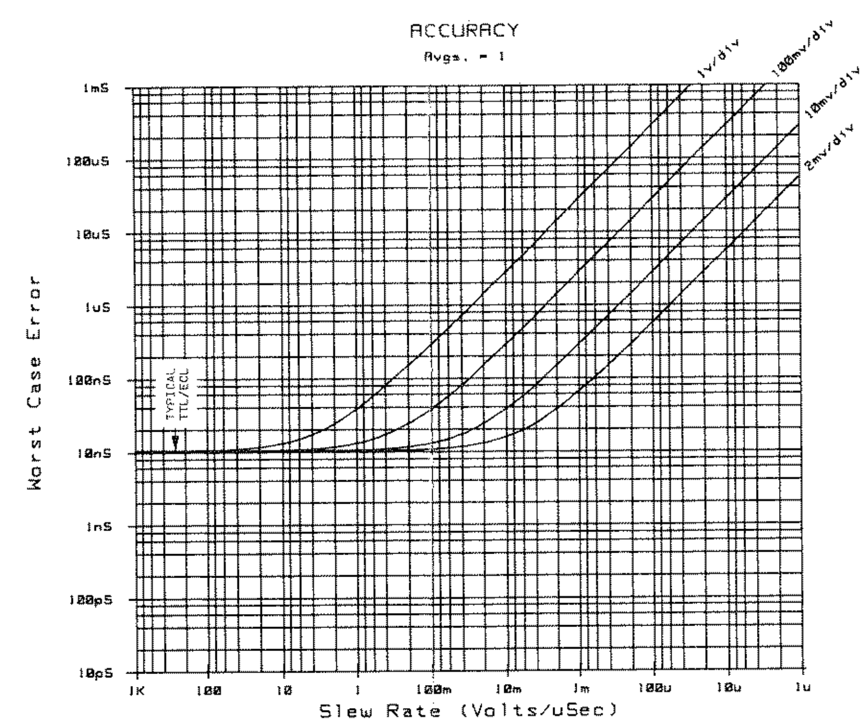
$$\text{TI ACCURACY} = \pm \frac{10\text{ ns}}{\sqrt{\#\text{ of Averages}}} \pm \frac{\sqrt{2} \times 0.02\text{ div} \times \text{Input Sensitivity}}{\text{Slew Rate} \times \sqrt{\#\text{ of Averages}}} \pm 500\text{ ps}$$

Conditions: 1. Common Source measurement (Main to Main, or Dlyd to Dlyd)









TRIGGER LEVEL ERROR

Trigger Level Error (TLE) is that timing error due to the inaccuracy of the trigger level settings. The computation of TLE is very similar to Hysteresis Error except the the START and STOP components do not cancel in dual source measurements (MAIN to DLYD or DLYD to MAIN). For common source measurements, they do exactly cancel.

$$TLE = \frac{\text{Trigger Level Acc of A}}{\text{Slew Rate of A}} - \frac{\text{Trigger Level Acc of B}}{\text{Slew Rate of B}}$$

$$= \frac{(\pm 3\% \text{ of TL(A) } \pm 0.4 \text{ div}) \times (\text{Input Sen})}{\text{Slew Rate of A}} - \frac{(\pm 3\% \text{ of TL(B) } \pm 0.4 \text{ div}) \times (\text{Input Sen})}{\text{Slew Rate of B}}$$

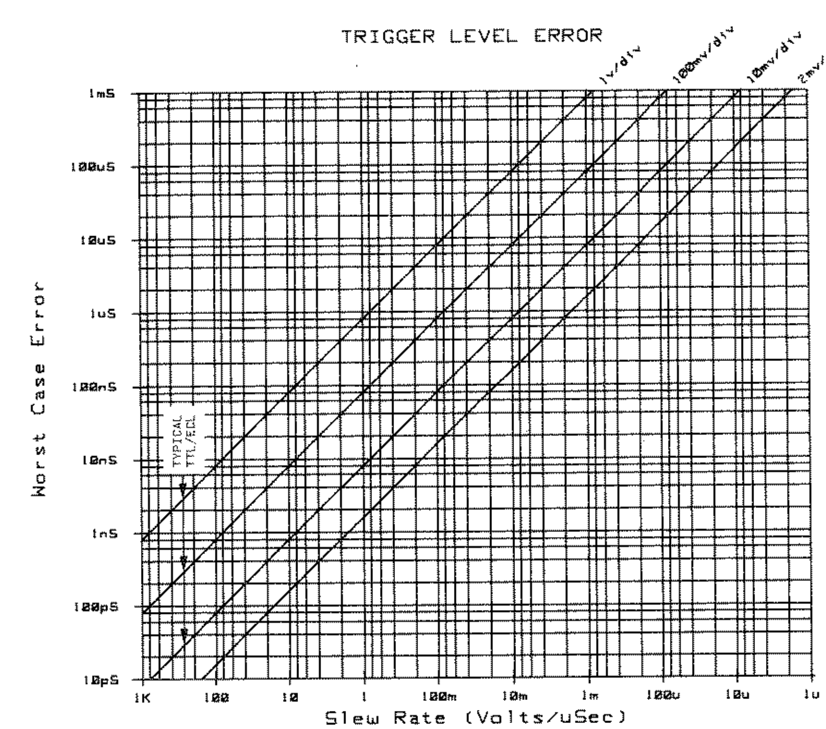
If the time interval measurement is of a common source (MAIN to MAIN or DYLD to DYLD), then the inaccuracy of the trigger level of both A and B will be in the same direction; either both positive or both negative. In addition, the slew rate of A will also be the slew rate of B; therefore, this component of time interval error will be zero.

If the slew rate of one of the trigger sources is much slower than the other trigger source, then only half of this specification will contribute significantly.

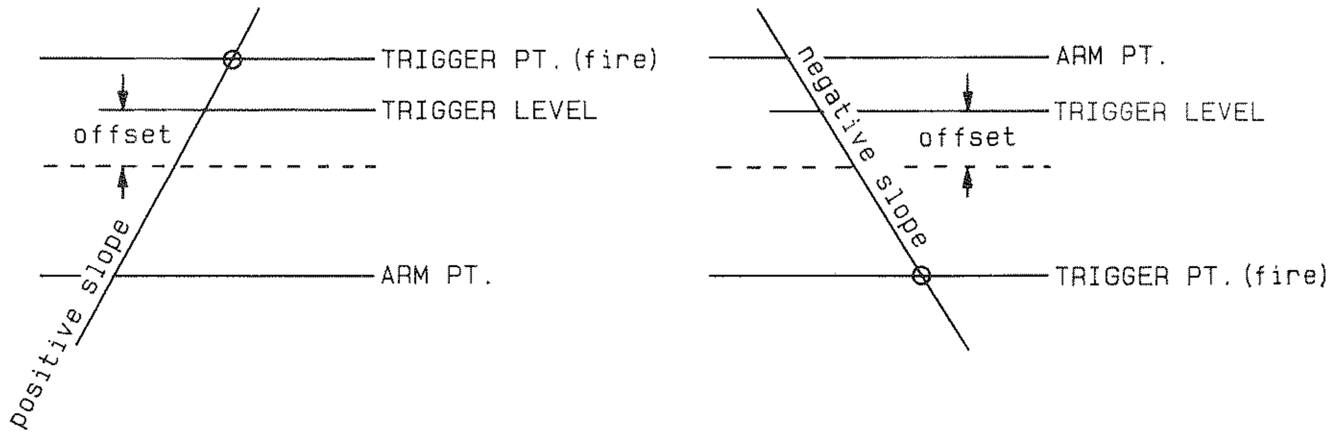
As an example of a typical dual source measurement, assume that the trigger level of both A and B are set to 0.00 divisions and the input sensitivities are equal with the slew rates of A and B equal. The component of the specification will be:

$$\pm \frac{(0.8 \text{ div}) \times (\text{Input Sensitivity})}{\text{Slew Rate}}$$

This is a worst case specification for a typical condition which is shown in the graph below.



Much of the Trigger Level Error and also error due to hysteresis (Trigger Level Timing Error) can be minimized. The 1965A has a feature which can be accessed over HP-IB to measure and output to the user trigger level offset and hysteresis for various conditions. This information can be used to compensate a trigger level setting so that actual triggering takes place closer to where the user desires it to be.



Hysteresis = |Trigger PT − Arm Pt|
Offset = Trigger Lvl − Hys/2

FOR POSITIVE SLOPE:
TP = TL − OS + HYS÷2
then, for triggering at desired trigger point,
TL(to set) = TP(desired) + OS - HYS÷2

FOR NEGATIVE SLOPE:
TP = TL − OS − HYS÷2
then, for triggering at desired trigger point,
TL(to set) = TP(desired) + OS + HYS÷2

Example number nine in Programming Examples shows how to input the various values of trigger level offset errors and hysteresis. These values are in units of divisions and are stored in the variables H[1] through H[16]. If the user wanted to compensate the main trigger level for a rising slope (_/‾) with a NORMAL hysteresis setting, H[7] gives the offset value and H[8] gives the hysteresis value. Refer to Information Output (PO8) in the "Additional HP-IB Control" section of the Detailed Operating Instructions.

Assume the following:

1. User wants to trigger a 0.5 volts
2. Main trigger assigned to channel 1 (MT=CH1)
3. Channel 1 is set to 200 mV/div
4. Offset, H[7] = −0.25 divisions
5. Hysteresis, H[8] = 0.18 divisions

then, Trigger point desired = 0.5 V/(200 mV/div) = 2.5 div

Trigger level to set = 2.5 div + H[7] − H[8]÷2

= 2.5 div − 0.25 div −0.09 div

= 2.16 divisions.

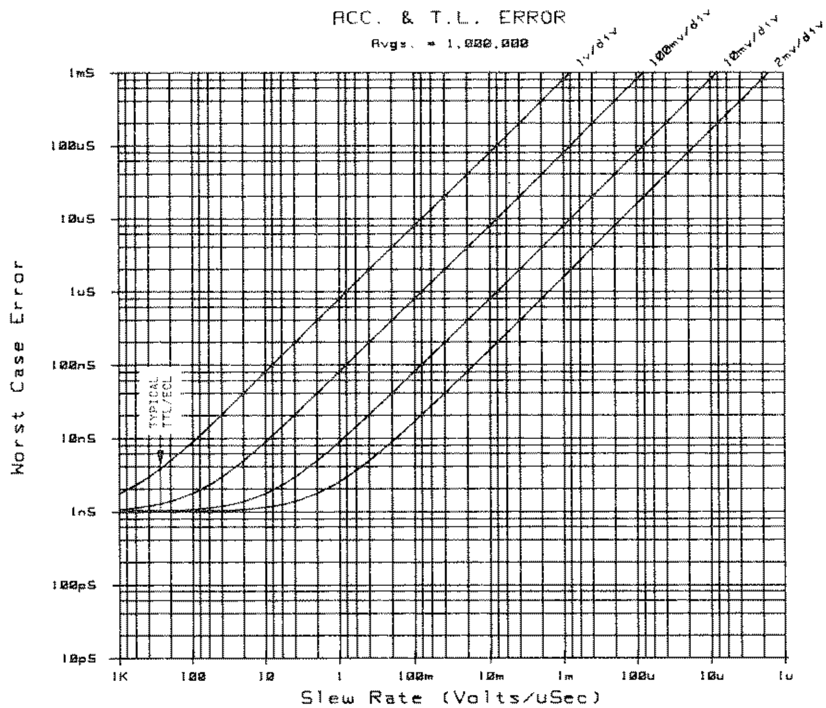
TIME INTERVAL ACCURACY WITH TRIGGER LEVEL ERROR

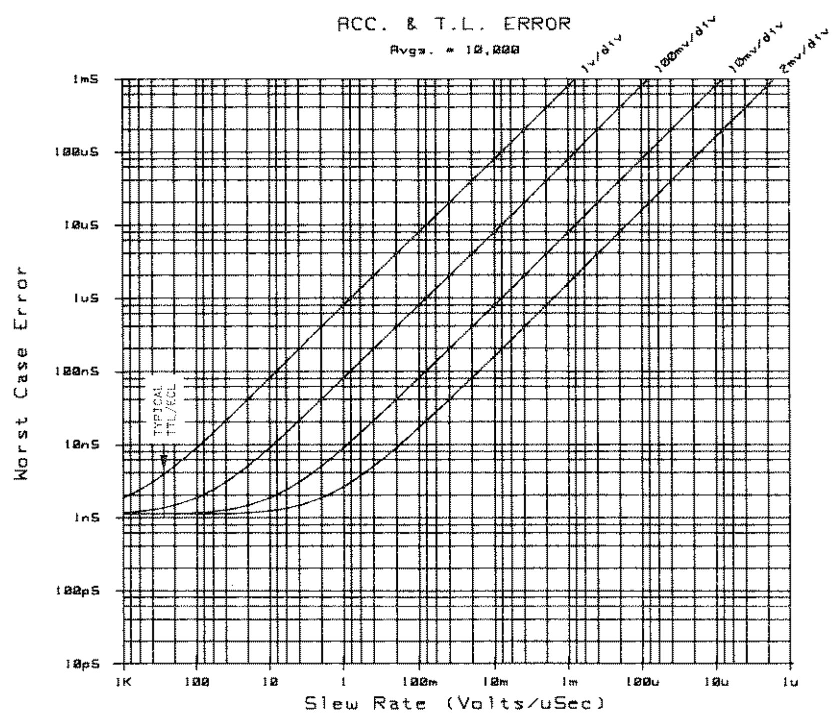
Although most time interval specifications do not include the error due to the uncertainty in setting trigger levels, for a true worst case error analysis, this error component must be added to the time interval specification.

Note

> Trigger level error does not apply for common source measurements (MAIN to MAIN, or DLYD to DLYD).

The following four graphs show the worst case time interval error, including error due to trigger level settability. Locate the appropriate graph according to the number of averages selected. If the input rate is known in volt/μs, simply move up on the

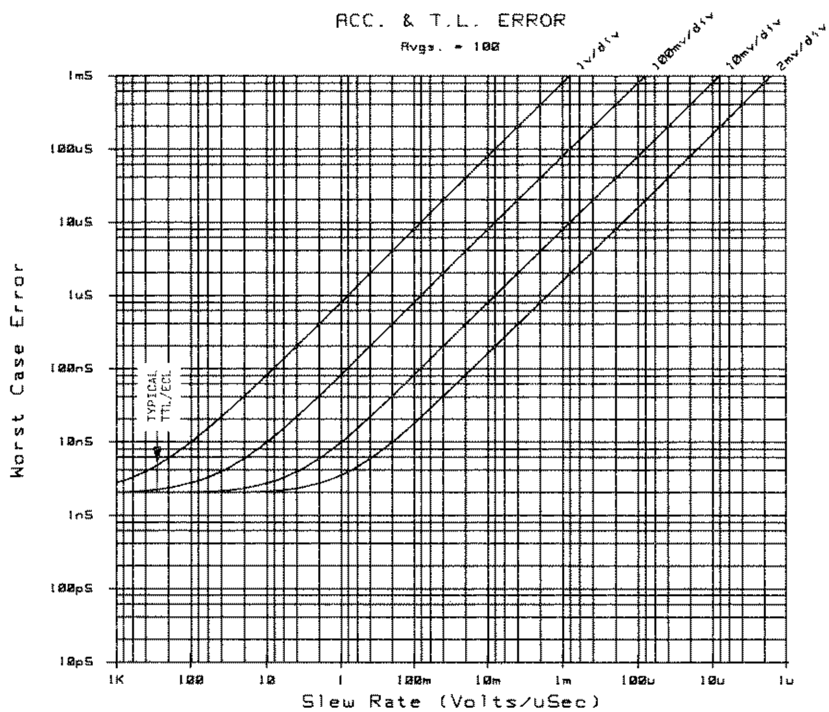


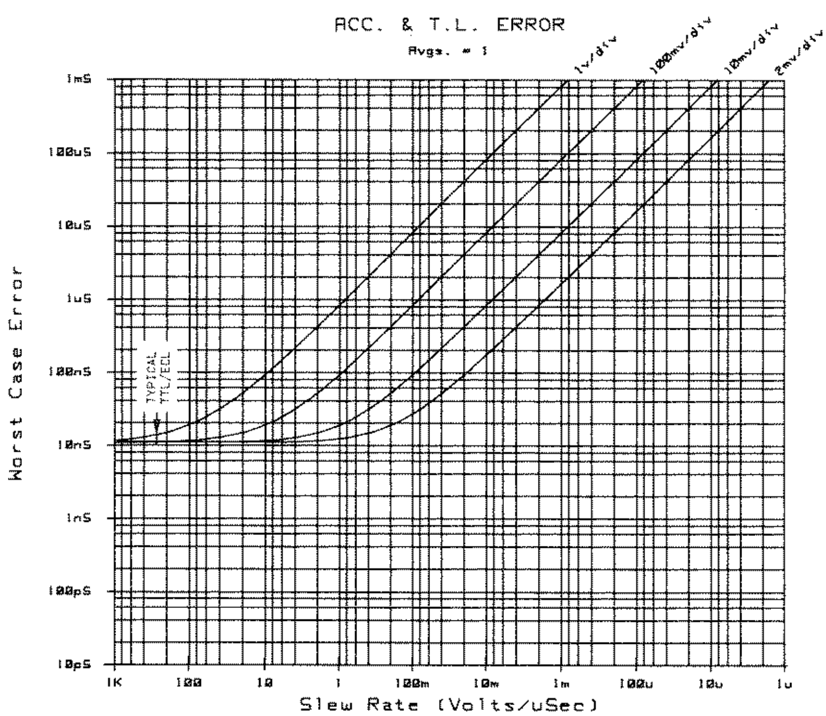


graph until the slew rate intersects with the channel 1 and 2 input sensitivity setting (an interpolation may be required). The worst case time interval error is then indicated on the vertical axis. The following is the equation used to derive these curves:

$$\text{TI ACCURACY} = \pm \frac{10\text{ ns}}{\sqrt{\#\text{ of Averages}}} \pm \frac{\sqrt{2} \times 0.02\text{ div} \times \text{Input Sensitivity}}{\text{Slew Rate} \times \sqrt{\#\text{ of Averages}}} \pm 1\text{ ns} \pm \frac{0.8\text{ div} \times \text{Input Sensitivity}}{\text{Slew Rate}}$$

Conditions:
1. Dual source measurement (MAIN to DLYD, or DLYD to MAIN).
2. A and B slew rates equal.
3. CH1 and CH2 input sensitivities equal.





NOTES

Appendix B

MEASUREMENT OF 1980/1965A SYSTEM NOISE

The specification for noise in the 1980/1965A system is 0.02 divisions rms for both main and delayed triggers. The actual noise for any 1980 system is typically much less and can be measured and calculated with the 1965A and an external controller. Once the measured noise is known, typical timing error due to noise (known as TRIGGER ERROR or NOISE ERROR) may be computed for the frequency and time interval specification. The following is the suggested technique for measuring the 1980/1965A system noise.

1. Apply a 1 V peak to peak, 100 Hz to 1 kHz sinusoidal waveform to the 1980 input. Terminate the signals as required.

2. Adjust the vertical sensitivity to 100 mV/div and adjust the trigger levels such that each trigger source is triggering at the zero crossing of the waveform.

3. Measure TIME INTVL A→B in the GATED mode using 1 average. Set ARM DELAY and GATE WIDTH such that only one cycle of the input is under measurement.

4. Collect a minimum of 100 samples of MAIN TRIG to MAIN TRIG time interval measurements, and 100 samples of DLYD TO DLYD time interval measurements.

5. Compute the standard deviation in second rms for each trigger source and calculate the effective rms noise in divisions as follows:

$$\text{NOISE (div rms)} = \frac{\text{STD DEV}}{\sqrt{2}} \text{ (second rms)} \times \text{SLEW RATE (div/second)}$$

Slew Rate (V/second) of 1 V peak to peak sine wave at zero crossing = $\pi \times$ FREQ (V/second)

$$\text{Slew Rate (div/second)} = \frac{\pi \times \text{FREQ}}{\text{sensitivity}}$$

$$= \frac{\pi \times \text{FREQ}}{0.1} \text{(div/second)}, \text{ @ 100 mV/div}$$

$$\text{then NOISE (div rms)} = \frac{\text{STD DEV}}{\sqrt{2}} \times \frac{\pi \times \text{FREQ}}{0.1} \text{(div rms)}$$

6. Make the test at other slew rates by varying the frequency of the input from 100 Hz to 1 KHz and check for a maximum. Various trigger coupling (slope, AC, DC) should also be tested.

The following programs were written for the HP9825 (HPL) and the HP9826/36 (BASIC). Each of these programs will measure and compute the effective rms noise of main and delayed triggers and display the result on the 1980 CRT.

Before running the program, the operator must assign main and delayed trigger to the proper input (MT=CH1, DT=CH1 or MT=CH2, DT=CH2) and the input signal must be 1 V p-p with zero DC offset. The program will set up the 1980/1965A for the measurement. Apply various frequency inputs with different trigger coupling and run the program several times checking for a maximum answer.

```
10 Frmt:IMAGE 2A,D.DDDDE,3A,D.DDDDE,3A,D.DDDDE
20 Text:IMAGE 21A,.DDDD,5A
30    OUTPUT 707;"tx;sa;vs1,1.00e-1;vs2,1.00E-1"
40    OUTPUT 707;"hm2;ml0;dl0;pp0;pr0;pv1"
50    OUTPUT 707;"po2"
60    ENTER 707;P
90    Sr=PI/(P*.1)
100   OUTPUT 707 USING Frmt;"ms",P/4,";pd",P/4,";pw",P
110   OUTPUT 707;"pt2;pr1"
120   FOR J=1 TO 2
130      OUTPUT 707;"ps";J;",";J
140      Sum=0
150      Sum_2=0
160      FOR I=1 TO 100
170         OUTPUT 707;"po2"
180         ENTER 707;Xi
190         Sum=Sum+Xi
200         Sum_2=Sum_2+Xi^2
210         IF I>1 THEN
220            Sdev=SQR(ABS(I*Sum_2-Sum^2)/(I*(I-1)))
230            N=Sr*Sdev/SQR(2)
240         END IF
250         DISP "NOISE=";N
260         IF J=1 THEN
270            OUTPUT 707 USING Text;"tx5,MAIN TRIG NOISE=",N," div."
280         ELSE
290            OUTPUT 707 USING Text;"tx6,DLYD TRIG NOISE=",N," div."
300         END IF
310      NEXT I
320   NEXT J
330   DISP "DONE"
340   BEEP
350   LOCAL 707
360   END
```

```
0: wrt 707,"tx;sa;vs1,1.00e-1;vs2,1.00e-1"
1: wrt 707,"hm2;ml0;dl0;pp0;pr0;pv1"
2: wrt 707,"po2"
3: red 707,P
4: π/(P*.1)→R
5: flt 4;wrt 707,"ms"&str(P/4)&";pd"&str(P/4)&";pw"&str(P)
6: wrt 707,"pt2;pr1"
7: for J=1 to 2
8: fxd 0
9: wrt 707,"ps"&str(J)&","&str(J)
10: 0→r11→r12
11: for I=1 to 100
12: wrt 707,"po2";red 707,X
13: r11+X→r11;r12+X^2→r12
14: if I>1;√(abs(I*r12-r11^2)/(I*(I-1)))→S
15: if I>1;R*S/√2→N
16: fxd 4;dsp "NOISE=",N
17: if J=1;wrt 707,"tx5,MAIN TRIG NOISE="&str(N)&" div."
18: if J=2;wrt 707,"tx6,DLYD TRIG NOISE="&str(N)&" div."
19: next I
20: next J
21: lcl 707
22: beep;dsp "DONE"
23: end
*10189
```

NOTES

Appendix C

SINGLE SHOT TIME INTERVAL MEASUREMENTS

The 1980 requires a repetitive waveform in order to properly trigger and sweep. This creates somewhat of a problem if the operator wants to measure the time interval of a single shot event. We have given two techniques here for completing this task.

ARMED MODE

Using the armed mode is the simplest method; however, there is one disadvantage. Until the single-shot event(s) occurs, the 1965A will repeatedly measure "overflow" conditions at a rate of one "overflow" every 10.7 seconds. If the measurement is set up and initialized (reset), and the events occur before the first 10.7 seconds expire, then the overflow condition will not occur. If the overflow condition does occur, it must be ignored until the true measurement is performed. The following is the required setup:

Function: T INTVL A→B
Arming Mode: ARMED
ARM DELAY: 100 ns
GATE WIDTH: 200 ns
A Source: MAIN TRIG or DLYD TRIG
B Source: MAIN TRIG or DLYD TRIG
RESOLN: 1
Main Sweep Mode: AUTO
Delayed Sweep Mode: AUTO
MAIN SEC/DIV: $<1 \mu s$/div

UNARMED MODE

The UNARMED mode requires several steps in a proper sequence; however, only one measurement will be taken with the correct answer (no overflow). Both main and dlyd sweep modes must be TRIG'D when the UNARMED mode is used. This creates a slight problem. With the sweep in the triggered mode, only one sweep will be generated. The 1965A requires one more sweep than the number of averages selected (i.e., two sweeps/one average, 101 sweeps/100 averages, etc.). Set up the 1980/1965 in the following sequence:

STEP 1. Function: T INTVL A→B
Arming Mode: UNARMED
ARM DELAY: 100 ns
GATE WIDTH: 200 ns
A Source: Non-Selectable
B Source: Non-Selectable
RESOLN: 1
Main Sweep Mode: AUTO
Delayed Sweep Mode: AUTO
MAIN SEC/DIV: 1s/DIV

STEP 2. Press counter RESET

STEP 3. Press main sweep RESET

STEP 4. Change: Main sweep mode to TRIG'D.
Delayed sweep mode to TRIG'D.

Note

This may be set up over HP-IB with each step programmed on a separate line.

Appendix D

TYPICAL TRIGGERING RANGE vs FREQUENCY

These two graphs illustrate the triggering range of a sinusoidal waveform based upon minimum pulse width specifications and 1980A/B trigger path bandwidth. The user must also take into account hysteresis and trigger level specifications when attempting to trigger on narrow pulse width/high frequency signals.