

Errata

Title & Document Type: 3437A Voltmeter Operating Information

Manual Part Number: 03437-90012

Revision Date: October 1977

HP References in this Manual

This manual may contain references to HP or Hewlett-Packard. Please note that Hewlett-Packard's former test and measurement, semiconductor products and chemical analysis businesses are now part of Agilent Technologies. We have made no changes to this manual copy. The HP XXXX referred to in this document is now the Agilent XXXX. For example, model number HP8648A is now model number Agilent 8648A.

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OPERATING INFORMATION

F/D LAG

SYSTEM VOLTMETER

3437A

HEWLETT  PACKARD



OPERATING MANUAL

MODEL 3437A

SYSTEM VOLTMETER

Serial Numbers: 1630A00101 and greater

IMPORTANT NOTICE

This manual applies to instruments with serial numbers indicated on this page. If the instrument has been changed since this manual was printed, a yellow "Manual Change Sheet" (containing updating information) will be supplied with this manual.

WARNING

To prevent potential fire or shock hazard, do not expose equipment to rain or moisture.

Manual Part No. 03437-90012

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Printed: October 1977

SECTION I

GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. This section contains general information concerning the -hp- Model 3437A System DVM. Included is an instrument description, specifications, information concerning instrument and accessory information, and safety considerations.

1-3. DESCRIPTION.

1-4. The Model 3437A is a Microprocessor controlled $3\frac{1}{2}$ digit, successive approximation system voltmeter, capable of sampling voltages at rates up to 5700 samples per second.

1-5. Chassis isolated input terminals, a wideband input amplifier, auto-zero, auto-polarity, sample and hold, and 100% overrange on each of the input voltage ranges (.1 volt, 1 volt, and 10 volts) provide floating measurement capability (± 20 V) over the frequency range of DC through 1.0 MHz.

1-6. Hewlett-Packard Interface Bus is standard. All front panel functions are programmable. The output data format is selectable between an ASCII (8 byte) and Packed (2 byte) format. The packed data format allows the controller additional data storage as well as allowing the input voltage to be sampled at rates up to 5700 samples per second.

1-7. The 3437A digital delay logic is capable of delaying an external trigger from 0 to 1 second (100 ns steps), and of generating up to 9999 triggers (for each trigger received) at rates of 1 Hz through 5700 Hz. The internally generated triggers provide a burst sampling capability (up to 9999 samples) at a maximum rate of 5700 sampled per second. Figures 1-1 and 1-2 illustrate the delayed measurement and burst sampling capabilities of the 3437A.

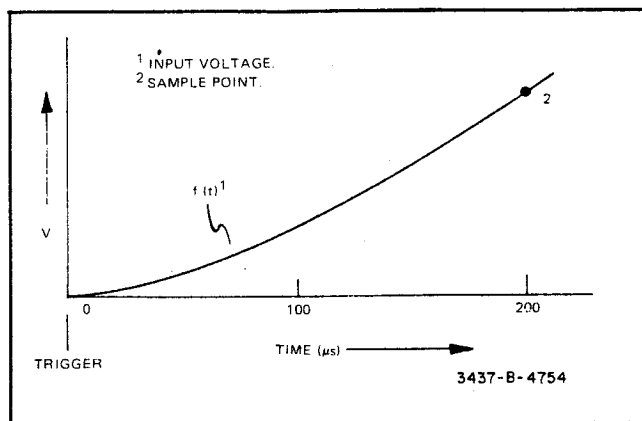


Figure 1-1. NRDGS = 1 DELAY = 200 μ s.

1-8. (Figure 1-1) 200 μ s after being triggered, the 3437A will sample and (after conversion) display the instantaneous value of the input voltage. If the 3437A is addressed to talk, the sampled input voltage will be output onto the HP-IB.

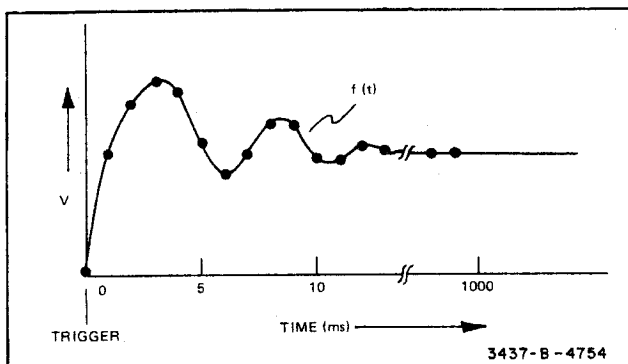


Figure 1-2. NRDGS = 1000 DELAY = 1 ms.

1-9. (Figure 1-2) When triggered, the 3437A will sample the input voltage 1000 times at 1 ms intervals. Between samples, the instantaneous value of the sampled input voltage is converted and output onto the HP-IB.

1-10. The Binary Program mode provides a means of programming the 3437A using an abbreviated program code. When interrogated in the Binary Program mode. The 3437A responds by writing 7 bytes (completely describing the programmed state of the instrument) onto the HP-IB. The controller can use these 7 bytes as an abbreviated program code to reprogram the 3437A to its previous configuration.

1-11. Model 3437A applications include:

- Fast multipoint data-acquisition.
- Repetitive-waveform analysis.
- Low frequency transient characterization.
- Low frequency True RMS measurements.

1-12. SPECIFICATIONS.

1-13. Instrument specifications are listed in Table 1-1. These specifications are the performance standards or limits against which the instrument is tested. Any change in the specifications due to manufacturing, design, or traceability to the U.S. National Bureau of Standards will be covered by revised pages, a change sheet, or both, to this manual. Addi-

Table 1-1. Specifications.

VOLTAGE MEASUREMENT CHARACTERISTICS.

Range	Bandwidth (3dB)	Display *	
10 Volt	1.0 MHz	± 19.98 (max)	± 99.99 (ovrld)
1 Volt	1.1 MHz	± 1.998	± 9.999
.1 Volt	40 kHz	$\pm .1998$	$\pm .9999$

Static Accuracy (90 days, $23^{\circ}\text{C} \pm 5^{\circ}\text{C}$)

10 Volt Range	$\pm 0.05\%$ of Reading	± 1.6 Digits
1 Volt Range	$\pm 0.03\%$ of Reading	± 1.6 Digits
.1 Volt Range	$\pm 0.06\%$ of Reading	± 1.8 Digits

Static Accuracy (1 year, $23^{\circ}\text{C} \pm 5^{\circ}\text{C}$)

10 Volt Range	$\pm 0.05\%$ of Reading	± 2.0 Digits
1 Volt Range	$\pm 0.03\%$ of Reading	± 2.0 Digits
.1 Volt Range	$\pm 0.06\%$ of Reading	± 2.2 Digits

Static Accuracy Temperature Coefficient (0°C to 50°C)
 $\pm 0.002\%$ reading/ $^{\circ}\text{C} \pm 0.05$ digits/ $^{\circ}\text{C}$

Dynamic Accuracy

Range	Step Input	mV within Final Value	Time
10 Volt	10 V	± 200 mV	700 ns
10 Volt	10 V	± 30 mV	7.5 μs
1 Volt	1 V	± 20 mV	700 ns
1 Volt	1 V	± 3 mV	1.5 μs
.1 Volt	.1 V	± 200 μV	25 μs

DELAY CHARACTERISTICS.

Delay

For NRDGS equal to 0 or 1
 0 to .9999999 sec in 100 ns steps

For NRDGS > 1

Data Format	Delay between readings
ASCII	277.8 μs to .9999999 sec
Packed	175.4 μs to .9999999 sec

Offset (actual delay with 0 delay programmed)
 100 ns \pm 25 ns

Accuracy

$\pm 0.008\%$ Delay + Delay offset

Repeatability (Jitter)

For NRDGS equal to 0 or 1

Delay

0 or 100 ns

200 ns to 50 ms

> 50 ms

Jitter

2 ns

10 ns + .002% of Delay

110 ns

NUMBER OF READINGS. (For each trigger received.)

From 0 to 9999

MAXIMUM READING RATE.¹

ASCII	3600 Readings per second
Packed	5700 Readings per second

¹Actual reading rate is given by:

ASCII	$\frac{3600 \times 7 \text{ Byte Listen Rate}}{3600 + 7 \text{ Byte Listen Rate}}$
Packed	$\frac{5700 \times 2 \text{ Byte Listen Rate}}{5700 + 2 \text{ Byte Listen Rate}}$

Where Listen Rate = Data acceptance rate of listener

PROGRAMMABILITY.

(In accordance with IEEE - 488-1975)

AH1	Acceptor	PP0	Parallel Poll
C0	Controller	RL1	Remote/Local
DC1	Device Clear	SR1	Service Request
DT1	Device Trigger	SH1	Source
L4	Listener	T5	Talker

COMMON MODE REJECTION RATIO.

≥ 75 dB (1 k Ω unbalance in low input lead at 60 Hz)

*Display will indicate overload if input is unterminated (.1 volt range).

Table 1-2. General Information.

INPUT CHARACTERISTICS.			Operating Temperature	
Input Impedance			0°C to 50°C	
Range	Impedance		Storage Temperature	
10 Volt	1 MΩ (± 20%)	< 75 pF	-40°C to 75°C	
1 Volt	> 10 ⁸ Ω	< 75 pF	Humidity Range	
.1 Volt	> 10 ⁸ Ω	< 75 pF	< 95% RH (0°C to 40°C)	
Maximum Input Voltage (All ranges)			Dimensions	
HI to LO	< ± 30 V Peak		212.7 mm wide x 88.9 mm high x 527.1 mm deep	
LO to CHASSIS	< ± 42 V Peak		Weight	
GENERAL.			Net 5.6 kg	
Power Requirements			Shipping 7.6 kg	
100 V, 120 V, 220 V, 240 V (+ 5% -10%, 48-440 Hz)			Model Number and Name	
≤ 42 VA			3437A System Voltmeter	

tional information describing the operating characteristics (Table 1-2) are not specifications but are supplemental information for the user.

1-14. OPTIONS.

1-15. The following options are available for the -hp- Model 3437A System Voltmeter:

Option	-hp- Part Number	Description
907	5061-0088	Front Handle Kit
908	5061-0076	Cabinet Assembly
909	5061-0082	Cabinet Assembly

1-16. ACCESSORIES.

1-17. The following accessories are available and can be ordered from your nearest -hp- Sales and Service Office:

1. DSA Test ROM -hp- 34115A
2. Performance Test Source Interface -hp- 34114A
3. Performance Test Trigger Interface -hp- 34113A

Table 1-3. Message Transfer Rates (Listen).


Listen	Handshake (μ s/Byte) ^A
Commands (ATN True)	
Addressed to Listen (ATL)	58
Addressed to Talk (ATT)	38
Group Execute Trigger (GET)	160
Local Lockout (LLO)	37
Selected Device Clear (SDC)	124
Serial Poll Enable (SPE)	35
Serial Poll Disable (SPD)	36
Unlisten (UNL)	36
Untalk (UNT)	36
Program Code (ATN False)	
Delay	100
" "	92
0	64
1	69
2	74
3	79
4	84
5	89
6	94
Store	176
NRDGS	112
1	94
2	68
3	68
4	68
Store	112
Enab RQS	108
7	59
Store	90

^ATypical

^BInitial

^CSubsequent—maximum rate (due to conversion time) $\geq 240 \mu$ s.

1-18. SAFETY CONSIDERATIONS.

1-19. If, to preserve the apparatus from damage, it is necessary for the user to refer to the instruction manual, the apparatus will be marked with the symbol .

1-20. INSTRUMENT IDENTIFICATION.

1-21. A three-section serial number (XXXXAXXXXX) is used to identify the Model 3437A. Figure 1-3 illustrates the meaning of the three parts of the number.

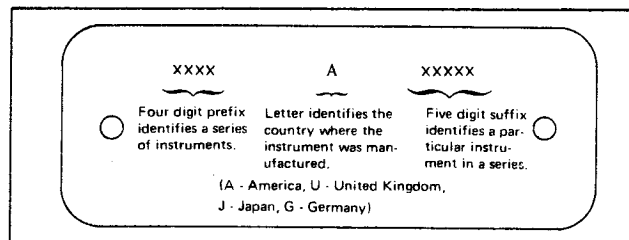


Figure 1-3. Instrument Serial Number.

Listen	Handshake (μ s/Byte) ^A
Program Code (ATN False)	
Cont'd	
Range	56
1	88
Range	56
2	89
Range	56
3	90
Trigger	56
1	97
Trigger	56
2	98
Trigger	56
3 ^B	90
Trigger	56
3 ^C	74
Format	56
1	98
Format	56
2	99
Binary Prgm	83
1st Byte	95
2nd Byte	78
3rd Byte	66
4th Byte	75
5th Byte	42
6th Byte	42
7th Byte	140

Table 1-4. Message Transfer Rates (Talk).

Talk	Handshake (μ s/Byte) ^A
Data Formats (ATN False)	
ASCII	22 μ s
Packed	20 μ s

SECTION II INSTALLATION

2-1. INTRODUCTION.

2-2. This section contains information and instructions pertaining to initial instrument set-up. Included are initial inspection procedures, power and grounding requirements, environmental information, bench and rack mounting instructions, a description of interface connectors, and repackaging instructions.

2-3. INITIAL INSPECTION.

2-4. This instrument was carefully inspected both mechanically and electrically before shipment. It should be free of marks or scratches and in perfect electrical order upon receipt. To confirm this, the instrument should be inspected for physical damage that might have occurred in transit, and the electrical performance should be tested using the performance tests outlined in Section V. If there is damage or deficiency, refer to the warranty inside the front cover of this manual.

2-5. POWER REQUIREMENTS.

2-6. This instrument can be operated from ac line voltages of 100 V, 120 V, 220 V, 240 V, at corresponding line frequencies of 48 through 440 Hz.

CAUTION

Verify that the 110 V/220 V Line Voltage Selection switch, (Figure 2-1) located on the rear panel of Model 3437A, is set to the ac source voltage to be used before inserting the power cord and turning the instrument on. Also insure that the proper fuse is installed.

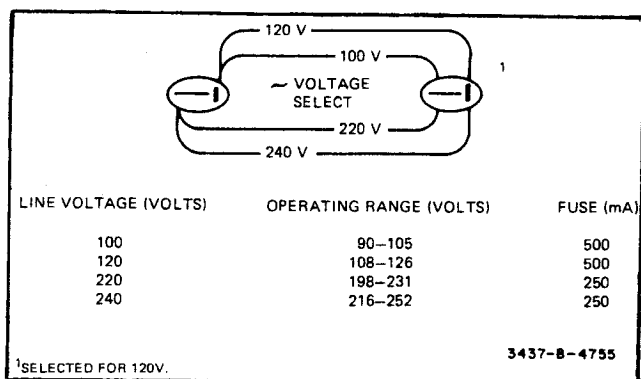


Figure 2-1. Line Voltage Selection.

2-7. Power Cords and Receptacles.

2-8. Figure 2-2 illustrates the various -hp- power cord configurations. If the appropriate power cord is not included with the instrument, notify the nearest -hp- Sales and Service Office and a replacement cord will be provided.

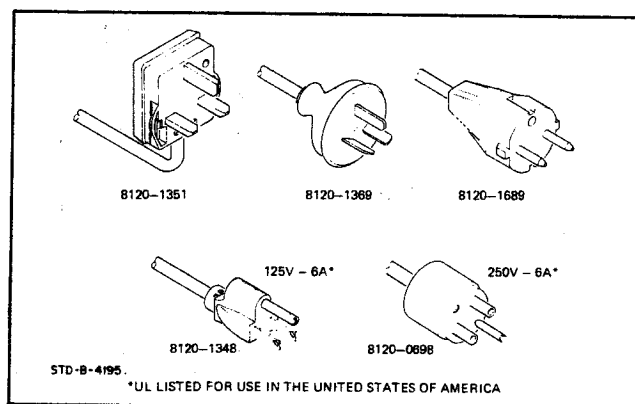


Figure 2-2. -hp- Power Cords.

2-9. Grounding Requirements.

2-10. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and cabinet be grounded. The Model 3437A is equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument. The offset pin on the power cable is the ground wire.

2-11. To preserve the protection feature when operating from a two-contact outlet, use a three-prong to two-prong adapter and connect the green pigtail on the adapter to power line ground.

2-12. ENVIRONMENTAL REQUIREMENTS.

2-13. The 3437A should not be operated where the ambient temperature exceeds 0°C to 50°C or stored where the ambient temperature exceeds -40°C to +75°C.

2-14. Humidity.

2-15. The instrument may be operated in environments with relative humidity of up to 95%. However, the instrument must be protected from temperature extremes which cause condensation within the instrument.

2-16. Altitude.

2-17. The instrument may be operated at altitudes up to 4573 meters (15,000 feet).

WARNING

*To prevent potential electrical or fire hazard,
do not expose equipment to rain or moisture.*

2-18. INSTRUMENT MOUNTING.

2-19. The Model 3437A is shipped with plastic feet and tilt stand in place, ready for use as a bench instrument. The front of the instrument may be elevated for convenience of operating and viewing by extending the tilt stand. The plastic feet are shaped to permit placing the instrument on top of other half-module Hewlett-Packard instruments.

2-20. Rack Mounting.

2-21. The Model 3437A is housed in a -hp- standard (½

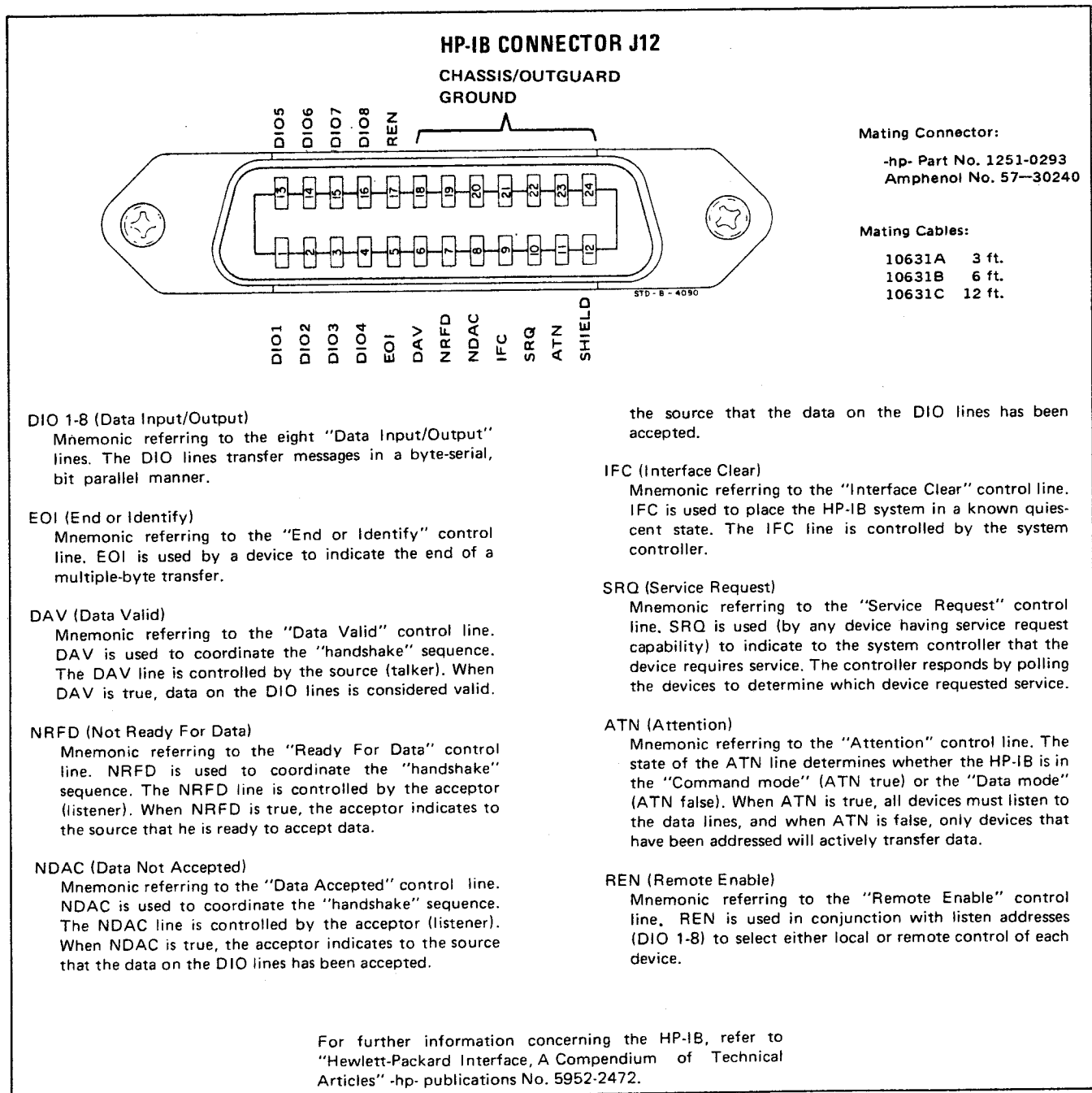


Figure 2-3. Hewlett-Packard Interface Bus Connector.

module) System II enclosure. Refer to the -hp- catalog for rack mounting accessories.

2-22. Interface Connectors.

2-23. Input. The voltage to be measured is applied to either the front or rear panel mounted (parallel connected) triax connector labeled INPUT.

2-24. Ext Trig and Delay Out. A standard (negative edge) TTL input applied to the rear panel mounted BNC connector labeled EXT TRIG causes the instrument to initiate one or more measurements and provide one or more corresponding delayed triggers at the rear panel mounted BNC connector labeled DELAY OUT.

2-25. Hewlett-Packard Interface Bus (HP-IB). Figure 2-3 illustrates the rear panel HP-IB connector, along with a brief description of each signal line.

2-26. Interface Cable Length. The maximum accumulative length of an HP-IB cable in any system must not exceed more than 2 meters of cable per device (up to 15 devices) or 20 meters, whichever is less.

2-27. REPACKAGING FOR SHIPMENT.

2-28. The following is a general guide for repackaging the instrument for shipment. If the original container is available, place the instrument in the container with appropri-

ate packing material and seal with strong tape or metal bands. If the original container is not available, proceed as follows:

a. Wrap the instrument in heavy paper or plastic before placing in an inner container.

b. Place packing material around all sides of the instrument and protect panel face with cardboard strips or plastic foam.

c. Place the instrument and inner container in a heavy carton and seal with strong tape or metal bands.

d. Mark shipping container "DELICATE INSTRUMENT." "FRAGILE." etc.

NOTE

If the instrument is to be shipped to Hewlett-Packard for service or repair, attach a tag to the instrument identifying the owner and indicating the service or repair to be accomplished. Include the model number and full serial number of the instrument. In any correspondence, identify the instrument by model number and full serial number. If you have any questions, contact your nearest -hp- Sales and Service Office.

SECTION III

OPERATING INSTRUCTIONS

3-1. INTRODUCTION.

3-2. This section contains complete operating instructions (both bench and system) for the Model 3437A Systems Voltmeter. Included is a description of the front and rear panel controls and indicators, programming instructions, and application examples.

3-3. Controls and Indicators.

3-4. Figure 3-1 identifies the 3437A displays, annunciators, controls, and connectors. The identification of each item is keyed to the drawing within the figure.

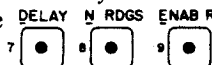
3-5. Front Panel Description.


3-6. **KEYBOARD.** The 3437A keyboard functions in two modes:

- a. Key per function.
- b. Numeric entry.

3-7. **Key Per Function.** The Key Per Function mode (each key representing instrument functions) occurs when the instrument is turned on.

3-8. **Numeric Entry.** The Numeric Entry mode (announced by blinking DELAY, NRDGS, or ENAB RQS annunciators) is a subset of the Key Per Function mode, and occurs when either the DELAY, N RDGS, or ENAB RQS keys are pressed.



ed while the keyboard is in the Key Per Function mode. Subsequent entries (displayed by the numeric entry display) correspond to the blue labeled numeric symbols 0-9 and decimal point. The Numeric Entry mode is terminated when the  is pressed.

3-9. **VOLTS DISPLAY.** Displays the sign and magnitude of the sampled input voltage ("+" is implied). The overload indication is ± 99.99 (Decimal point position corresponds to voltage range selected).

3-10. **NUMERIC ENTRY DISPLAY.** The contents of the numeric entry display are annunciated directly below the display.

3-11. **RQS STATUS.** The RQS STATUS annunciators annunciate the instrument status.

3-12. **Data Ready.** The DATA READY annunciator notifies the operator that the sampled input voltage has

been converted, displayed, and is ready to be output onto the HP-IB. The DATA READY annunciator remains on until the measurement data has been output onto the HP-IB, or until a new function is programmed.

3-13. **Ignore Trig.** The IGNORE TRIG annunciator notifies the operator that a second trigger occurred prior to completion of the measurement sequence/data transfer initiated by the first trigger, and that the second trigger was ignored. The IGNORE TRIG annunciator remains on until a new function is programmed.


3-14. **Invalid Prgm.** The INVALID PRGM annunciator notifies the operator that an invalid program condition has occurred. The annunciator becomes illuminated during the Remote and Local modes of operation, for the following reasons:

LOCAL:

a. **DELAY (0-.9999999).** The first entry into the delay field must be a decimal point. Any entry other than a decimal point (leading zeros ignored) results in an invalid program condition. When this occurs, the last valid delay entry is stored and the numeric entry mode is terminated. The INVALID PGM annunciator remains on until the key causing the invalid entry is released.

b. **NRDGS (0-9999).** A decimal point entry into the number of readings field results in an invalid program condition. When this occurs, the last valid NRDGS entry is stored and the numeric entry mode is terminated. The INVALID PGM annunciator remains on until the key causing the invalid entry is released.

c. **ENAB RQS (0-7).** Any entry other than 0-7 results in an invalid program condition. When this occurs, the last valid ENAB RQS entry is stored and the numeric entry mode is terminated. The INVALID PGM annunciator remains on until the key causing the invalid entry is released.

d. **STORE.** If the  key is pressed while the

keyboard is not in the Numeric Entry mode, an invalid program condition occurs. The INVALID PGM annunciator remains on until the key causing the invalid entry is released.

REMOTE:

An invalid entry while in the Numeric Entry mode, or the use of an invalid program code, will result in an invalid

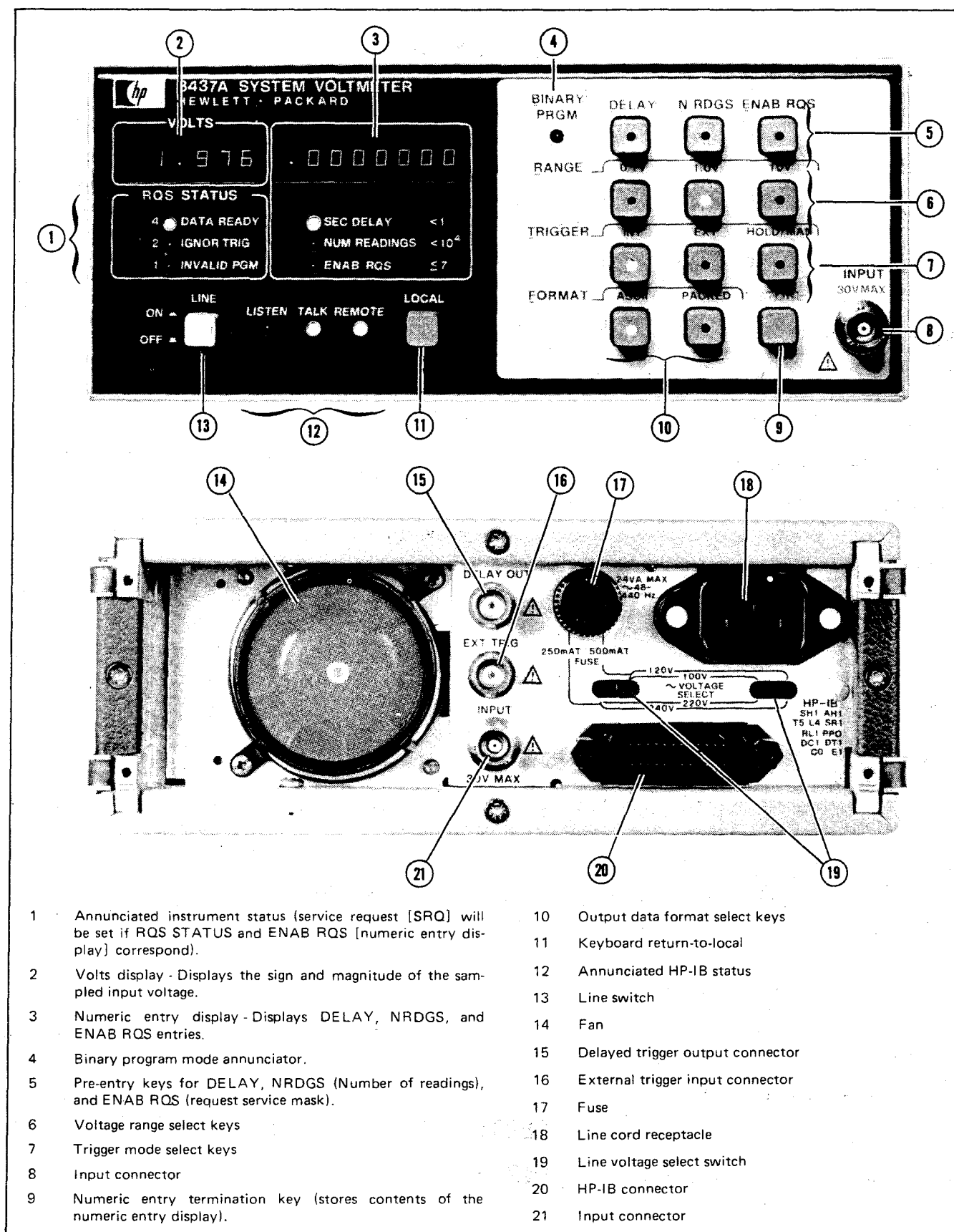








Figure 3-1. 3437A Front and Rear Panel Description.

program condition to occur. The INVALID PGM annunciator remains on until the 3437A is readdressed to listen.



3-15.  . The DELAY key (delay pre-entry) is used when entering either the delay between readings (NRDGS > 1) or the delay that occurs prior to sampling the input voltage after the 3437A is triggered (NRDGS=1).


EXAMPLE:

1. Press 
 - a. The Numeric Entry mode is annunciated by the (Flashing) DELAY annunciator.
 - b. The numeric entry display (annunciated by SEC DELAY) displays the previously stored delay.
2. Press  (Any entry other than a decimal point (leading zeros ignored) results in an invalid program condition.
3. Enter up to 7 integers corresponding to the specified delay (additional inputs are ignored). A partial delay field can be set to zeros by pressing .
4. Terminate DELAY entry (Numeric Entry mode) by pressing .

3-16.  . The NRDGS key (number of readings pre-entry) is used when entering the number of readings to be taken after the 3437A is triggered.

EXAMPLE:

1. Press 
 - a. The Numeric Entry mode is annunciated by the (Flashing) NRDGS annunciator.
 - b. The numeric entry display (annunciated by NUM READINGS) displays the previously stored number of readings.
2. Enter a 4 digit integer (0-9999) corresponding to the number of readings to be taken after the 3437A is triggered. (If a decimal point is entered into the number of readings field, an invalid program condition results.) Additional entries into a completed NRDGS field, cause previous entries to be shifted left.
3. Terminate NRDGS entry (Numeric Entry mode) by pressing .

3-17.  . The ENAB RQS key (enable request pre-entry) is used when entering the request service mask. (The request service mask is an octal number (0-7) identifying the conditions for which service request (SRQ) is initiated.) Table 3-1 shows the request service mask and corresponding conditions for which the 3437A will initiate a service request.

EXAMPLE:









1. Press 
 - a. The Numeric Entry mode is annunciated by the (Flashing) ENAB RQS annunciator.
 - b. The numeric entry display (annunciated by ENAB RQS) displays the previously stored request service mask.
2. Enter the request service mask (0-7). An invalid entry results in an invalid program condition to occur. (Additional entries override previous entries.)
3. Terminate ENAB RQS entry (numeric entry mode) by pressing .

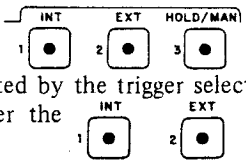

Table 3-1. SRQ Conditions.

RQS Mask ¹		Conditions for Initiating SRQ
(4 2 1)	(Octal)	
0 0 0	0	No SRQ Capabilities
0 0 1	1	Invalid Program
0 1 0	2	Trigger Ignore
0 1 1	3	Trigger Ignore or Invalid Program
1 0 0	4	Data Ready
1 0 1	5	Data Ready or Invalid Program
1 1 0	6	Data Ready or Trigger Ignore
1 1 1	7	Data Ready or Trigger Ignore or Invalid Program

- ¹
- a. Invalid PGM
 - b. Trig Ignore
 - c. Data Ready

3-18. RANGE    . The three voltage ranges (annunciated by the range select keys) are selected by pressing either the    key. (Each

range has 100% overrange capability.) The displayed decimal point position will not correspond to the selected voltage range until the 3437A has sampled the input voltage.

3-19. TRIGGER . The three trigger modes (annunciated by the trigger select keys) are selected by pressing either the  key.

INT.

a. Local - With zero delay programmed, the sample rate is approximately 10 samples per second.

b. Remote - To generate an internal trigger while in remote, the following conditions must exist:



1. Remote
2. Internal Trigger
3. Addressed to Talk
4. Not in Binary Prgm Mode
5. Not in Serial Poll Mode
6. Not in Numeric Entry Mode

With these conditions satisfied, the 3437A will generate an internal trigger on the transition of ATN false.

EXT.



The 3437A will sample the input voltage when triggered (TTL negative edge) at the external trigger input connector.


HOLD/MAN. (LOCAL & REMOTE)

The first time the  key is pressed, the 3437A holds the volts display of the last sampled voltage constant. The second time the  key is pressed (and each time thereafter), a manual trigger is generated. Manual triggers can be generated in this manner until a new function is programmed.

GROUP EXECUTE TRIGGER.

(Addressed HP-IB Command.) Each time the 3437A receives group execute trigger (GET) while addressed to listen, it will generate a trigger (regardless of trigger mode selected).

3-20. FORMAT  . The output data format is selectable between an ASCII (8-byte) and PACKED (2-byte) format.

3-21. . Each data transfer is output as 6 ASCII characters, followed by a carriage return (CR) and line feed (LF) concurrent with EOI true.

EXAMPLES:


a. Normal

- i. .1 volt range $\pm .1998$ (CR) (LF and EOI)
- ii. 1 volt range ± 1.998 (CR) (LF and EOI)
- iii. 10 volt range ± 19.98 (CR) (LF and EOI)

b. Overload

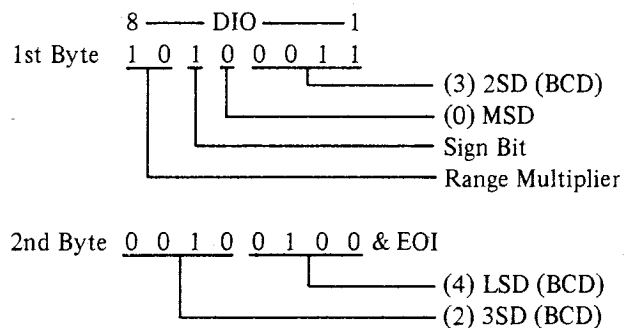
- i. .1 volt range $\pm .9999$ (CR) (LF and EOI)
- ii. 1 volt range ± 9.999 (CR) (LF and EOI)
- iii. 10 volt range ± 99.99 (CR) (LF and EOI)

For measurement data where $\text{NRDGS} > 1$, the (CR) and (LF and EOI) is suppressed (between the intermediate outputs) and the data is delimited by a comma.

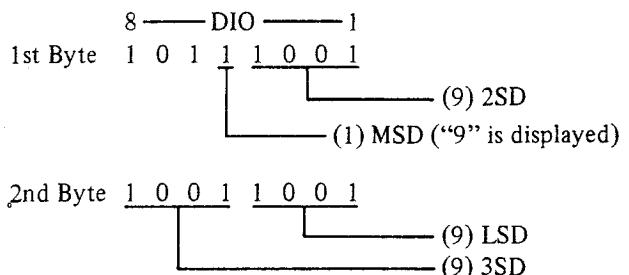
3-22. . Each data transfer is output as 2 binary bytes. The second byte is concurrent with EOI true.

EXAMPLES:


a. Normal (+ 3.24 volts, 10 volt range)



b. Overload (+25 volts, 10 volt range)



For measurement data where $\text{NRDGS} > 1$, EOI is suppressed (between intermediate outputs) and the data is not delimited. EOI true is sent concurrent with the second data-byte of the last data transfer. Table 3-2 shows the packed format designators.

3-23. LOCAL. When the 3437A is in remote (not local lockout), pressing  returns the 3437A keyboard from remote (HP-IB controlled) to local (front panel controlled).

3-24. Programming Instructions.

3-25. The 3437A is a systems instrument intended to be used with the HP-IB (IEEE STD 488-1975 or equivalent) system. The following paragraphs describe HP-IB operation.

Table 3-2. Packed Format Designators.

Byte	Function	DIO							Description
		8	7	6	5	4	3	2	
1st	Range Multiplier	0	1						.1 Volt Range
		1	1						1 Volt Range
		1	0						10 Volt Range
	Sign bit			1					Positive
				0					Negative
	MSD				1				Numeric Value of Sampled Input Voltage
2nd	2 SD					0			
	3 SD	X	X	X	X				
	LSD					X	X	X	X

3-26. The HP-IB transfers messages (data and commands) between the components of an instrumentation system on 16 signal lines. The interface functions for each system component are performed within the component so that only passive cabling is needed to connect the system. The cables connect all instruments, controllers, and other components of the system in parallel.

3-27. Eight of the lines (DIO 1-8) are reserved for the transfer of messages in a byte-serial, bit-parallel manner. Message transfer is asynchronous, coordinated by the three handshake lines (DAV, NRFD, and NDAC). The remaining five lines are for control of HP-IB activity.

3-28. Devices connected to the HP-IB may be talkers, listeners, or controllers. The controller dictates the roll of each of the other devices by setting the ATN (attention) line true and sending talk or listen addresses on the data lines (DIO 1-8).

3-29. Addresses are set into each device at the time of system configuration. (The 3437A HP-IB address select switch is located on the Logic board.) While the ATN line is true, all devices must listen to the data lines. When ATN is false, only devices that have been addressed will actively send or receive data. All other devices ignore the data lines.

3-30. Several listeners can be active simultaneously but only one talker can be active at a time. Whenever a talk address is put on the data lines (while ATN is true), all other talkers are automatically unaddressed.

3-31. Information is transmitted on the data lines under sequential control of the three handshake lines. No step in the sequence can be initiated until the previous step is completed. Information transfer can proceed as fast as devices can respond, but no faster than allowed by the slowest device presently addressed. This permits several devices to receive the same message byte concurrently.

3-32. The ATN line is one of the five control lines. When ATN is true, addresses and commands are transmitted on seven of the data lines using the ASCII code. When ATN is

false, any code of 8 bits (or less) understood by both talker and listener(s) may be used.

3-33. The other control lines are IFC, REN, SRQ, and EOI. IFC (interface clear) places the interface system in a known quiescent state (the 3437A becomes unaddressed to listen, unaddressed to talk, and the serial poll mode (SPM) is cleared). REN (remote enable) is used in conjunction with listen addresses to select either local or remote control of each device. Any device having service request capability can set service request (SRQ) true. This indicates to the system controller that a device on the bus requires attention. EOI (end or identify) is used by a device to indicate the end of a multiple-byte transfer (the 3437A sets EOI true concurrent with the last data-byte of a multiple data-byte transfer). For further information concerning the HP-IB, refer to "Hewlett-Packard Interface. A Compendium of Technical Articles" -hp- publications No. 5952-2472.

3-34. HP-IB Address Selection. A seven-bit binary code forms the complete TALK or LISTEN address of the 3437A. The first five bits of the code (selected by A2S1) are referred to as the instrument address. The remaining two bits (DIO 6-7) are controller originated and define the address to be either TALK or LISTEN. The seven-bit code forms as ASCII character (Table 3-3) that uniquely defines the selected TALK or LISTEN address. Figure 3-2 illustrates the address select switch and address code designators.

3-35. Program Code Set. Program code (an alpha-numeric code representing various instrument functions) is used to control the front panel while the 3437A is in the remote mode of operation. To implement the program code set (Table 3-4), it is necessary for the 3437A to be in remote and addressed to listen.

3-36. The 3437A front panel is designed to imply the program code set. The underlined alpha characters represent the program code alpha symbol for the corresponding instrument function.

EXAMPLE:

The program code string:

D.0025S, N100S, E0S, R3, T2, F1 reads:

- | | | |
|----|----------|----------|
| 1. | DELAY | 2.5 ms |
| 2. | NRDGS | 100 |
| 3. | ENAB RQS | 0 |
| 4. | Range | 10 Volts |
| 5. | Trigger | External |
| 6. | Format | ASCII |

It is not necessary to reprogram all functions each time a programming change is made. (The order of program code, and the use of commas is optional.)

Table 3-3. Address Codes.

ASCII CODE CHARACTER		BINARY CODE					OCTAL CODE		5 BIT DECIMAL ³ EQUIVALENT
Listen Address	Talk Address	b ₇ ¹	b ₆	A5 b ₅	A4 b ₄	A3 b ₃	A2 b ₂	A1 b ₁	
SP	@			0	0	0	0	0	0
!	A			0	0	0	0	1	1
"	B			0	0	0	1	0	2
#	C			0	0	0	1	1	3
\$	D			0	0	1	0	0	4
%	E			0	0	1	0	1	5
&	F			0	0	1	1	0	6
'	G			0	0	1	1	1	7
(	H			0	1	0	0	0	8
)	I			0	1	0	0	1	9
*	J			0	1	0	1	0	10
+	K			0	1	0	1	1	11
,	L			0	1	1	0	0	12
-	M			0	1	1	0	1	13
.	N			0	1	1	1	0	14
/	O			0	1	1	1	1	15
0	P			1	0	0	0	0	16
1	Q			1	0	0	0	1	17
2	R			1	0	0	1	0	18
3	S			1	0	0	1	1	19
4	T			1	0	1	0	0	20
5	U			1	0	1	0	1	21
6	V			1	0	1	1	0	22
7	W			1	0	1	1	1	23
8	X			1	1	0	0	0	24 ²
9	Y			1	1	0	0	1	25
:	Z			1	1	0	1	0	26
;	[			1	1	0	1	1	27
<	\			1	1	1	0	0	28
=	]			1	1	1	0	1	29
>	~			1	1	1	1	0	30

¹Only the first five bits of the binary code are listed. These bits (set by A2S1) are the same for both the TALK and LISTEN address. The sixth and seventh bits (controller originated) determine whether the instrument is being addressed to TALK or LISTEN.

²3437A factory preset address.

³Derived from the sum of the binary weighted value of the first five address bits.

Function	Bit	
	7	6
Talk	1	0
Listen	0	1

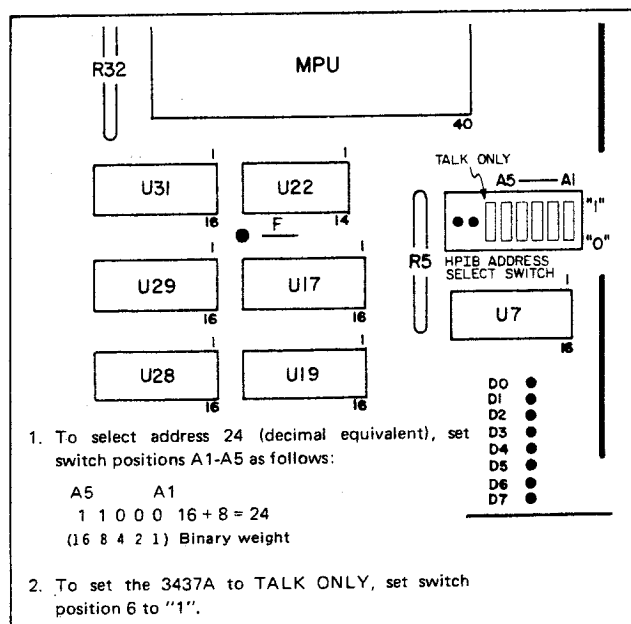


Figure 3-2. Address Select Switch and Address Code Designators.

Table 3-4. 3437A Program Code Summary.

PROGRAMMING CODES ¹		
Program Code (ASCII Character)	Description	Octal Code
D	Delay	104
N	NRDGS	116
E	ENAB RQS	105
S	Store	123
R	Range	122
1	.1 volt	061
2	1 volt	062
3	10 volts	063
T	Trigger	124
1	Internal	061
2	External	062
3	Hold/Man	063
F	Format	106
1	ASCII	061
2	Packed	062
B	Binary Prgm	102

¹Program Code Handshake occurs with the 3437A in Remote, Addressed to Listen, and ATN false.

3-37. Message Set. Bi-directional traffic over the HP-IB (including program code) is described in terms of messages.

The controller originated messages (commands) are described in Table 3-5 and categorized as follows:

1. Addressed (Directed to bus devices previously addressed to listen)
2. Universal (Directed to all bus devices capable of responding to the command)

EXAMPLE:

The system controller can configure the 3437A to its

initial turn-on state by sending the universal command, Device Clear (DCL), or the addressed command, Selected Device Clear (SDC).

3-38. The 3437A originated messages allow the 3437A to communicate with the system controller, and to participate in the handshake process involved in the data-byte transfer process.

EXAMPLE:

The 3437A can advise the system controller that it requires service by sending the service request (SRQ) message.

Table 3-5. 3437A Message Set Summary Sheet.

Message	Description	Class	Octal Code	R E N	I F C	Instrument Response
DCL	Device Clear	UC ²	024	T		The 3437A configures to its initial turn-on state. Volts display (sampled input voltage) Numeric entry display (SEC DELAY) RQS STATUS (DATA READY) DELAY (0) NRDGS (1) ENAB RQS (0) RANGE (10 volts) TRIGGER (INT) FORMAT (ASCII)
SDC	Selected Device Clear	AC ³	004			If addressed, the 3437A configures to its turn-on state.
GET	Group Execute Trigger	AC	010	T		Is triggered (regardless of trigger mode)
GTL	Go to Local	AC	001	T		Returns the 3437A from remote (HP-IB Controlled) to local (front panel controlled)
LLO	Local lockout	UC	021	T		Disables the Local Key From LLO to GTL to TREN = Remains in LLO From LLO to FREN to TREN = Exits LLO
MLA	My Listen Address	AC				Becomes addressed to listen.
MTA	My Talk Address	AC				Becomes addressed to talk.
UNL	Unlisten	AC	077			Becomes unaddressed to listen.
UNT	Untalk	AC	137			Becomes unaddressed to talk.
SPE	Serial Poll Enable	UC	030			Configures the 3437A into the serial poll mode.
SPD	Serial Poll Disable	UC	031			Exits serial poll mode.
IFC	Interface Clear	}	Single Line MSG		T	Unaddress the 3437A as a talker and as a listener and clears serial poll mode.
REN	Remote Enable			T F		Programs the 3437A to remote (concurrent with MLA). Returns the 3437A to local.

¹All multiline (DIO 1-8) messages are sent with ATN true.

²Universal command.

³Addressed command.

3-39. The capability of the 3437A as a systems instrument (in accordance with IEEE - 488-1975) is as follows:

SH1	Source	RL1	Remote/Local
AH1	Acceptor	PP0	Parallel Poll
T5	Talker	DC1	Device Clear
L4	Listener	DT1	Device Trigger
SR1	Service Request	CO	Controller

3-40. Binary Program.

3-41. Binary Programming, consisting of a learn mode (3437A to controller) and a program mode (controller to 3437A) provides the following programming capabilities.

3-42. **Learn.** The learn mode allows the system controller to determine (learn) the programmed state of the 3437A. When interrogated in the learn mode, the 3437A responds by handshaking 7 bytes (completely describing the programmed state of the instrument) onto the HP-IB. The controller, aware of the programmed state of the instru-

ment, identifies the 7 bytes with this programmed state (Table 3-6).

3-43. **Program.** The program mode allows the system controller to program the 3437A using an abbreviated program code (identical 7 bytes received in the learn mode). Since an abbreviated program code is used (compared to the normal ASCII string of up to 25 bytes to accomplish the same function), the 3437A can be reprogrammed in a minimum amount of time.

3-44. The following example illustrates Binary Program mode operation.

EXAMPLE:

1. The 3437A is preset as follows:

DELAY	500 μ s
NRDGS	9999
ENAB RQS	2
RANGE	10 Volt
TRIGGER	External
FORMAT	ASCII

Table 3-6. Binary Program Code Designators.

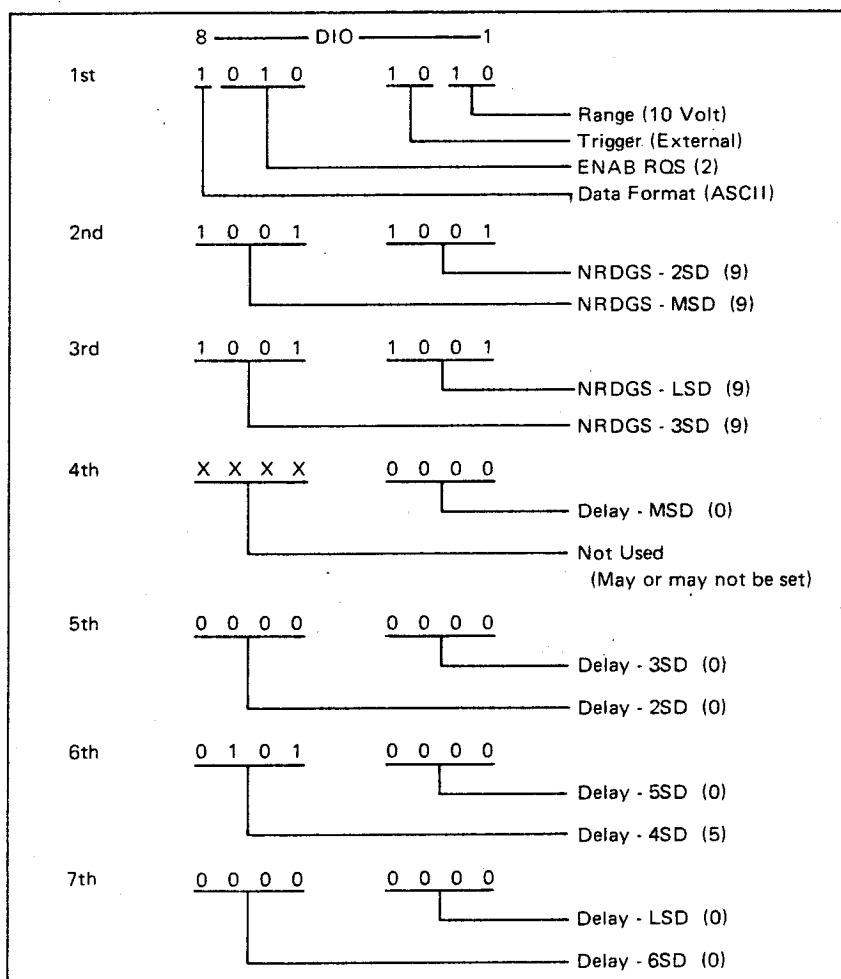
Byte	Function	DIO							Description
		8	7	6	5	4	3	2	
1	Range							0 0	Invalid
								0 1	.1 Volt
								1 0	10 Volt
								1 1	1 Volt
	Trigger					0	0		Invalid
						0	1		Internal
						1	0		External
						1	1		Hold/Man
	ENAB RQS	(4	2	1)					Does not request service
		0	0	0					Invalid Prgm
		0	0	1					Ignore Trig
		0	1	0					Invalid Prgm/Ignore Trig
		0	1	1					Data Ready
		1	0	0					Data Ready/Invalid Prgm
		1	0	1					Data Ready/Ignore Trig
		1	1	0					Data Ready/Ignore Trig/Invalid Prgm
	Data Format	0							Packed
		1							ASCII
2	NRDGS	(8	4	2	1)				MSD
		X	X	X	X				2SD
3						X	X	X	3SD
						X	X	X	LSD
4	Delay	X	X	X	X				Not Used (May or may not be set)
						X	X	X	MSD
5	Delay	X	X	X	X				2SD
						X	X	X	3SD
6	Delay	X	X	X	X				4SD
						X	X	X	5SD
7	Delay	X	X	X	X				6SD
						X	X	X	LSD

2. The system controller programs the 3437A to the Binary Program mode.
 - The 3437A is addressed to listen.
 - The controller handshakes the ASCII character B (102_8) into the 3437A. The Binary Program annunciator is illuminated.
3. The system controller interrogates the 3437A, and the 3437A responds by handshaking 7 bytes (completely describing the programmed state of the instrument) onto the HP-IB (Table 3-7).
 - The 3437A is addressed to talk.
 - When ATN becomes false, the 3437A outputs the 7 bytes onto the HP-IB.
 - The 3437A terminates the Binary Program mode after the 7th byte is output onto the HP-IB.
4. The controller stores the 7 bytes, then when required, reprograms the 3437A using the identical 7 bytes. The 3437A responds by reconfiguring to its previous state.
 - The 3437A is addressed to listen.
 - The controller handshakes the ASCII character B (102_8) into the 3437A. The Binary Program mode annunciator is illuminated.
 - The controller handshakes the 7 bytes into the 3437A, reconfiguring the instrument to its previous state.
 - The 3437A terminates the Binary Program mode after the 3437A handshakes the 7th byte.

3-45. Service Request.

3-46. The following events describe the process involving service request (SRQ), serial poll enable (SPE), and serial poll disable (SPD).

Table 3-7. Binary Program Byte Sequence (Example).



a. The 3437A operator defines and programs the service request mask (ENAB RQS).

b. The 3437A sets SRQ true when ENAB RQS (0 - 7) and RQS STATUS (0 - 7) correspond.

c. The controller, programmed to respond to a service request, sets SPE true and conducts a serial poll. When the 3437A is in the serial poll mode and is addressed to talk, the 3437A responds by writing a serial poll status byte onto the HP-IB (Table 3-8).

When the serial poll status byte is output onto the HP-IB, the 3437A clears SRQ.

d. The controller clears SPE by sending SPD.

Table 3-8. Serial Poll Status Byte.

Function	DIO							Description
	8	7	6	5	4	3	2 1	
ENAB RQS					X	X	X	Binary Code (0-7) ¹
RQS STATUS			X	X	X			Binary Code (0-7)
RQS Bit			X					Identifies the 3437A as the instrument that set SRQ True. (1 & True and 0 & False)
Not Used	X							Don't care.

¹See Table 3-6.

3-47. APPLICATIONS.

3-48. Introduction.

3-49. The 3437A, although designed as a System DVM, is capable of performing numerous bench (stand-alone) as well as systems functions. The following paragraphs describe some 3437A bench applications.

3-50. Bench Measurements.

3-51. Variable Sample-Rate DVM.

a. The 3437A can be programmed to sample voltages at rates of 100 ms to 1 second. Program the 3437A keyboard as follows:

```

DELAY..... 100 ms to .9999999 second
NRDGS.....1
RANGE.....As required
TRIGGER.....INT

```

b. The 3437A will sample (and display) the instantaneous value of the input voltage at a rate specified by the programmed delay.

3-52. Time-Selective DVM.

3-53. Oscilloscope Accuracy Enhancement. Oscilloscope measurement accuracy can be enhanced to equal the voltage and delay accuracy of the 3437A. The technique requires that the oscilloscope main gate output (corresponding to start of sweep) externally trigger the 3437A, and that the 3437A Delay out modulate the oscilloscope Z-axis (video) input. The voltage to be measured is connected to both the oscilloscope and 3437A inputs. Each time the oscilloscope is triggered, the oscilloscope main gate output triggers the 3437A, and depending upon the programmed delay, the 3437A samples the input voltage sometime between reoccurring sweeps. Each time the 3437A samples the input voltage, the Delay out (connected to the oscilloscope Z-axis input) is forced low and intensifies the oscilloscope display for the time required to perform the conversion sequence.

3-54. The user views the oscilloscope display, then programs the 3437A delay to intensify the point of interest. The amplitude of the waveform and the lapsed time (from start of sweep to the leading edge of the intensified section) is displayed by the 3437A Volts and Numeric entry displays.

Example:

a. Connect the equipment as illustrated in Figure 3-2.

b. Program the 3437A keyboard as follows:

```

DELAY..... 3 ms
NRDGS.....1
RANGE.....10
TRIGGER.....EXT

```

c. Set the 3310A controls as follows:

```

FUNCTION.....SQ
RANGE.....10
DIAL.....25
DC OFFSET.....OFF
OUTPUT LEVEL.....MIN

```

d. Set the oscilloscope controls as follows:

```

TIME/DIV..... 1 ms
VOLTS/DIV.....1
TRIGGER..... INTERNAL

```

e. Adjust the 3310A output level, and the oscilloscope trigger and intensity levels to obtain a waveform as illustrated in Figure 3-3.

f. Program the 3437A Delay so that the intensified section appears at the point of interest then read the corresponding magnitude and delay displayed by the Volts and Numeric entry display.

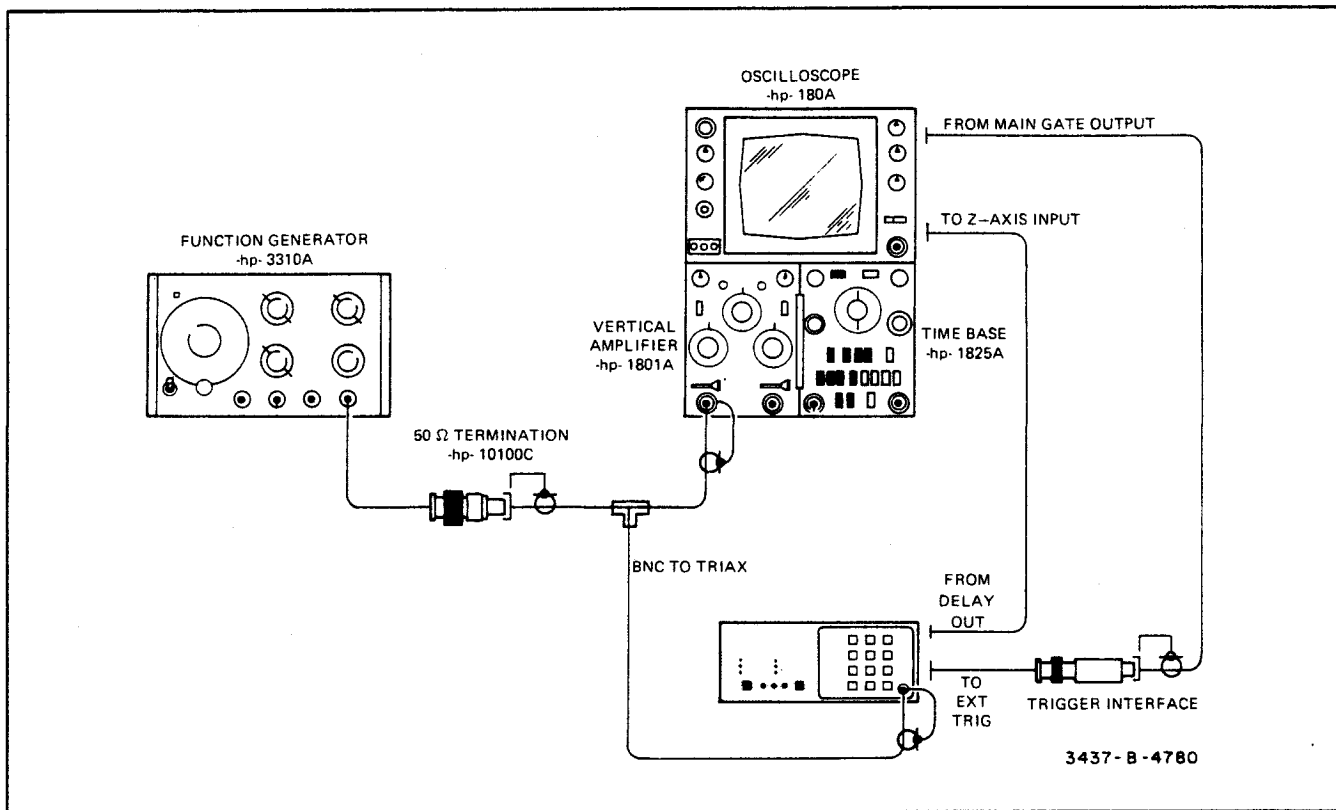


Figure 3-2. Oscilloscope Accuracy Enhancement.

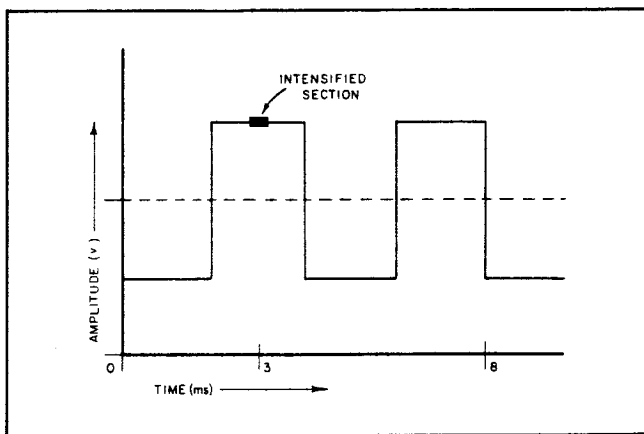


Figure 3-3. Intensified Waveform.

3-55. Delay Generator.

3-56. The 3437A can be programmed to delay an external trigger from 0 to .9999999 sec in 100 ns steps.

Example:

- a. Connect the equipment as illustrated in Figure 3-4.

- b. Program the 3437A keyboard as follows:

```

DELAY..... 800 ns
NRDGS..... .0
RANGE..... -
TRIGGER..... EXT
  
```

- c. Set the 3310A controls as follows:

```

FUNCTION..... SQ
RANGE..... 100
DIAL..... 10
DC OFFSET..... OFF
OUTPUT
LEVEL..... MINIMUM
  
```

- d. Set the oscilloscope controls as follows:

```

TIME/DIV..... 100 μs
VOLTS/DIV (A/B)..... 5/DC
TRIGGER..... EXTERNAL
  
```

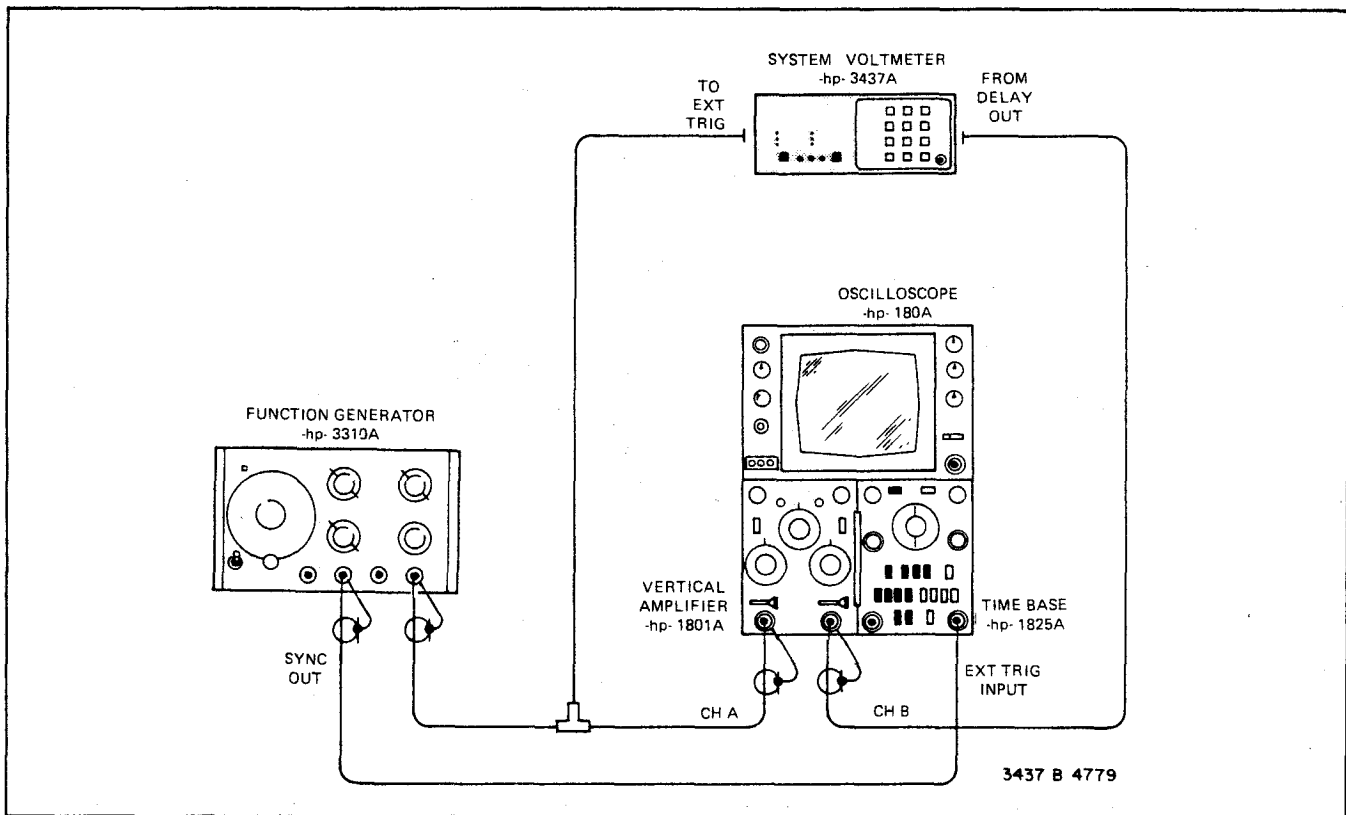


Figure 3-4. Delay Generator.

e. Adjust the 3310A output level and oscilloscope trigger level to obtain a display as illustrated in Figure 3-5. (Assure that the 3310A output is of sufficient amplitude to trigger the 3437A.)

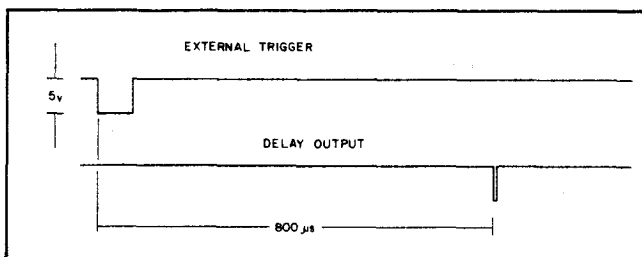


Figure 3-5. Delayed Output.

3-57. Trigger Generator.

3-58. The 3437A can be programmed to function as a trigger generator or as a burst trigger generator (up to 9999 triggers per burst).

3-59. Trigger Generator. Program the 3437A keyboard as follows:

```

DELAY.....0
NRDGS.....1
TRIGGER.....INT

```

a. The Delay out waveform is illustrated in Figure 3-6.

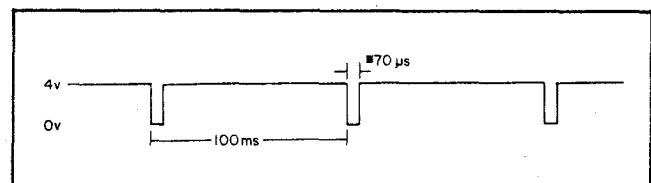


Figure 3-6. Delay Out Waveform.

b. The 3437A Delay can be programmed from 0 to .9999999 second (100 ns step) to provide continuous triggers at rates from 10 Hz to 1 Hz.

3-60. Burst Trigger Generator. Program the 3437A keyboard as follows:

```

DELAY.....500 μs
NRDGS.....5000
TRIGGER.....EXT/INT

```

a. For each trigger received, the 3437A will generate a burst of triggers (5000) at a 2000 Hz (1/500 μs) rate (Figure 3-7). Maximum Rate = 9 kHz.

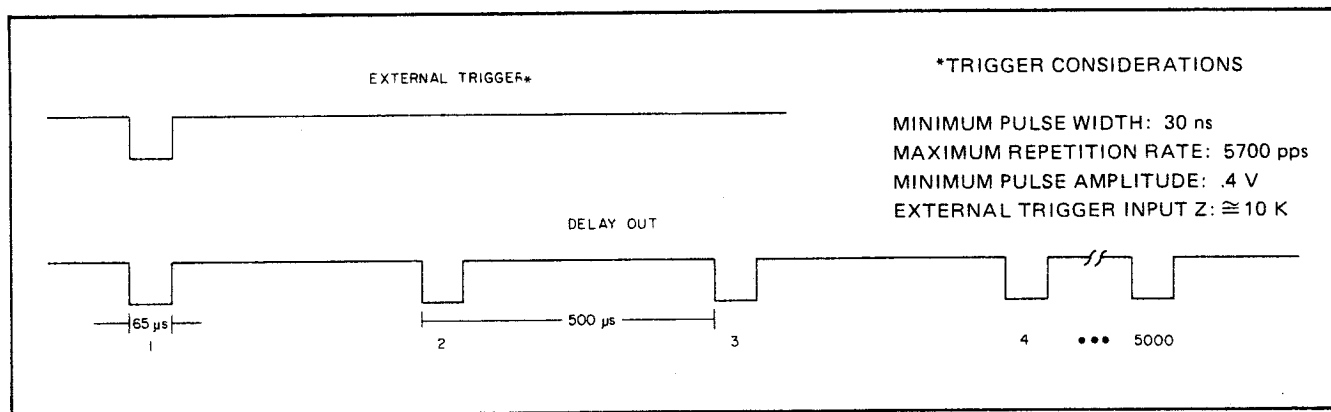


Figure 3-7. Burst Mode Delay Out.

3-61. System Measurements.

Systems Applications include:

- Waveform Analysis
 - Harmonic Content
 - Amplitude Characteristics

- Low Frequency True RMS Measurements
- Transient Characterization

3-62. For additional systems applications information, check with your local -hp- Field Engineer for the series 209 (3437A) application notes.